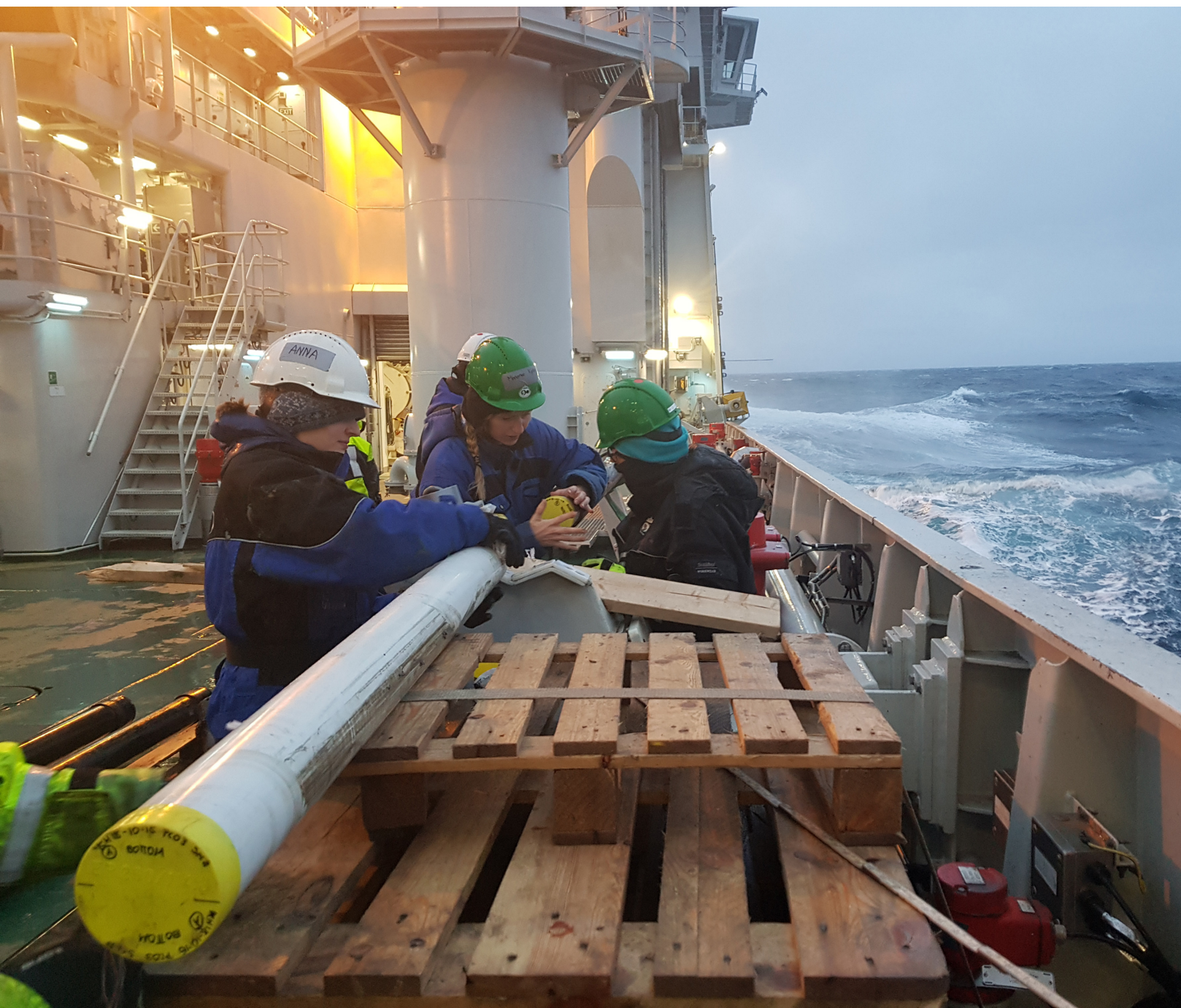
the Nansen LEGACY

Cruise Report

Paleo Cruise
[2510-2018710]
2018



Paleo Cruise 2018

Cruise 2018710

RV «Kronprins Haakon»

Longyearbyen-Longyearbyen

September 26 – October 19, 2018

Authors:

Katrine Husum

Ulysses Ninnemann

Tom Arne Rydningen

Elisabeth Alve

Naima E.B. Altuna

Anna Hauge Braaten

Vårin Eilertsen

Viviana Gamboa

Marianne R. Kjøller

Lisa Orme

Sunniva Rutledal

Allyson Tessin

Mark Zindorf

To be cited as: Katrine Husum, Ulysses Ninnemann, Tom Arne Rydningen, Elisabeth Alve, Naima E.B. Altuna, Anna Hauge Braaten, Vårin Eilertsen, Viviana Gamboa, Marianne R. Kjøller, Lisa Orme, Sunniva Rutledal, Allyson Tessin and Mark Zindorf (2020). Paleo Cruise 2018: Cruise Report. *The Nansen Legacy Report Series* 3/2020. DOI: https://doi.org/10.7557/nlrs.5502

ISSN 2703-7525

Publisher: Septentrio Academic Publishing, Tromsø, Norway

Summary

The Nansen Legacy paleo cruise was carried out from September 26 to October 20, 2018 with RV "Kronprins Haakon". The cruise took place in the northern Barents Sea and the Nansen Basin, and it went through the sea ice to 83.3 N. Four ocean moorings were deployed in northwest Barents Sea, where one ARGO float was also deployed. Twelve "paleo stations" were identified using multibeam and sub bottom profilers. At these stations, short and long sediment cores were obtained securing the material necessary for analysis of living and fossil foraminiferal faunas in addition to fossil diatoms and dinocysts. Geochemical analysis of sea ice biomarkers and analysis of ancient DNA originating from sea ice algae will also be carried out. Further extraordinary long sediment cores were obtained at three sites using the calypso corer. A new length record for Norwegian sediment coring operations was set with the retrieval of a 21.6 m long sediment core. At each paleo station plankton nets were also deployed obtaining planktic foraminifera and pteropods for ocean acidification studies. Water samples were also taken at each station for shore-based nutrient and stable isotope analyses (δD, δ^{18}O, and $\delta^{13}C_{DIC}$). In addition, water isotopes (δD, δ^{18}O) and carbon isotopes of DIC ($\delta^{13}C_{DIC}$) were analyzed onboard from both CTD bottles and sediment pore waters. The acquisition of isotope data at sea turned out to be extremely valuable. Real time results allowed the shipboard scientists to identify the novel and unexpectedly low pore water carbon isotope values present at many sites. Preliminary analysis of the sediment cores demonstrated that a good intra-station overlap was achieved between the multi and gravity cores. However, there were indications that as much as 9 cm was missing from the gravity core tops. Pore water isotope data also confirmed the good overlap achieved in recovery between the multi and gravity cores as both have similar (overlapping) pore water profiles with depth. The ability to correlate is encouraging with regard to post cruise work when multiple cores will be analysed at different institutions. In order to achieve a common chronostratigraphy between the cores, as many different physical and optical parameters as possible should be analysed on each core before sampling is initiated so that a common chronostratigraphy can be built for the sediment sequences (and individual cores taken) at each site. Overall, the cruise was highly successful, especially considering that many of the operations had not been carried out routinely before. There was additional time in the end of the cruise to carry out an unscheduled task, namely recovery of an additional Nansen ocean mooring at the Yermak Plateau. Its planned recovery on the previous cruise had not been possible due to bad weather

Contents

1. Background

The Nansen Legacy paleo cruise is part of the Nansen Legacy project which is investigating climate and ecosystem change of the Barents Sea and adjacent Arctic Basin. The project is building toward an integrated arctic perspective from physical processes to living resources and from understanding the past to predicting the future. The cruise mainly addresses objectives from the research foci RF1 (Natural Drivers), but also contributes to a better understanding of human impacts (RF2) and the Living Barents Sea (RF3). The overriding objective of the cruise is to reconstruct the natural variability and range of sea ice cover and Atlantic Water through flow in the Barents Sea on longer time scales. The Barents Sea and Arctic climates in general, exhibit strong natural variability. For any attempt to project and predict future changes in this environment, it is important to understand the range of this variability, its evolution over time, and its responsiveness to external drivers. The paleoclimate and paleoceanographic records provide this direly needed insight. The materials recovered here, together with the planned postcruise analysis, will enable assessment of the changes associated with prior intervals of diminished sea ice cover and higher temperatures than those experienced within the instrumental period. Anatomizing these past warmings, their frequency and rate, their driving mechanisms and physical, chemical, and biological responses will provide real world constraints and perspective for improved understanding of both the potential for, and the consequences of, future changes in the Barents Sea and wider Arctic.

2. Survey area

The AeN paleo cruise has targeted areas containing sediments from the past ~12,000 years using dedicated coring systems onboard RV Kronprins Haakon. The sediment cores will be analysed for proxies characterizing key components of the physical, chemical, and biological systems, including a detailed calibration exercise connecting the modern situation with the proxies. The latter detailed calibration is further linked to planned work at RF2 and RF3. For RF1 the objectives were to deploy ocean moorings (modern conditions), obtain sediment cores (time archives), and do calibration work for linking and comparing modern to past conditions using paleoceanographic proxy methods (Tasks T1-1, T1-3). Four ocean moorings and one ARGO float were deployed (Figure 1). An additional ocean mooring (YP3) was retrieved from the Yermak Plateau on the return transit to Longyearbyen as it had not been possible to retrieve due to bad weather on the previous Nansen cruise in the area. The deployed moorings (M1, M2, M3, M4) will collect oceanographic data over the next five years informing on Atlantic and Arctic water masses in the Barents Sea. Bathymetric mapping and sub bottom profiling were carried out near the sites of ocean moorings and the stations P3, P4, P6 and P7 on the Nansen transect in order to locate suitable locations for retrieving sediment cores for paleoceanographic records. Given the importance of linking modern process studies and instrumental data series with paleo records, an attempt was made to locate suitable sites proximal to the stations along the Nansen transect. The main criteria used for selecting site suitability were the presence of undisturbed sediments and (preferably) a relatively high sediment accumulation rate for the last 12,000 years. Previous studies have already shown that there was a good potential for paleo records near P1, however P1 is a test station, many paleoceanographic records already exist from this area, and the location is easy to reach even without an ice-class vessel, hence this area was not prioritized or sampled. The stations P2 and P5 were also not prioritized as they reside in difficult depositional environments and previous investigations have shown that these areas do not contain any suitable coring sites. After identifying a suitable site, a paleo station (abbreviation NPAL) was established. The site workflow then included a CTD cast with water sampling, sampling with plankton net, multicorer and gravity corer.

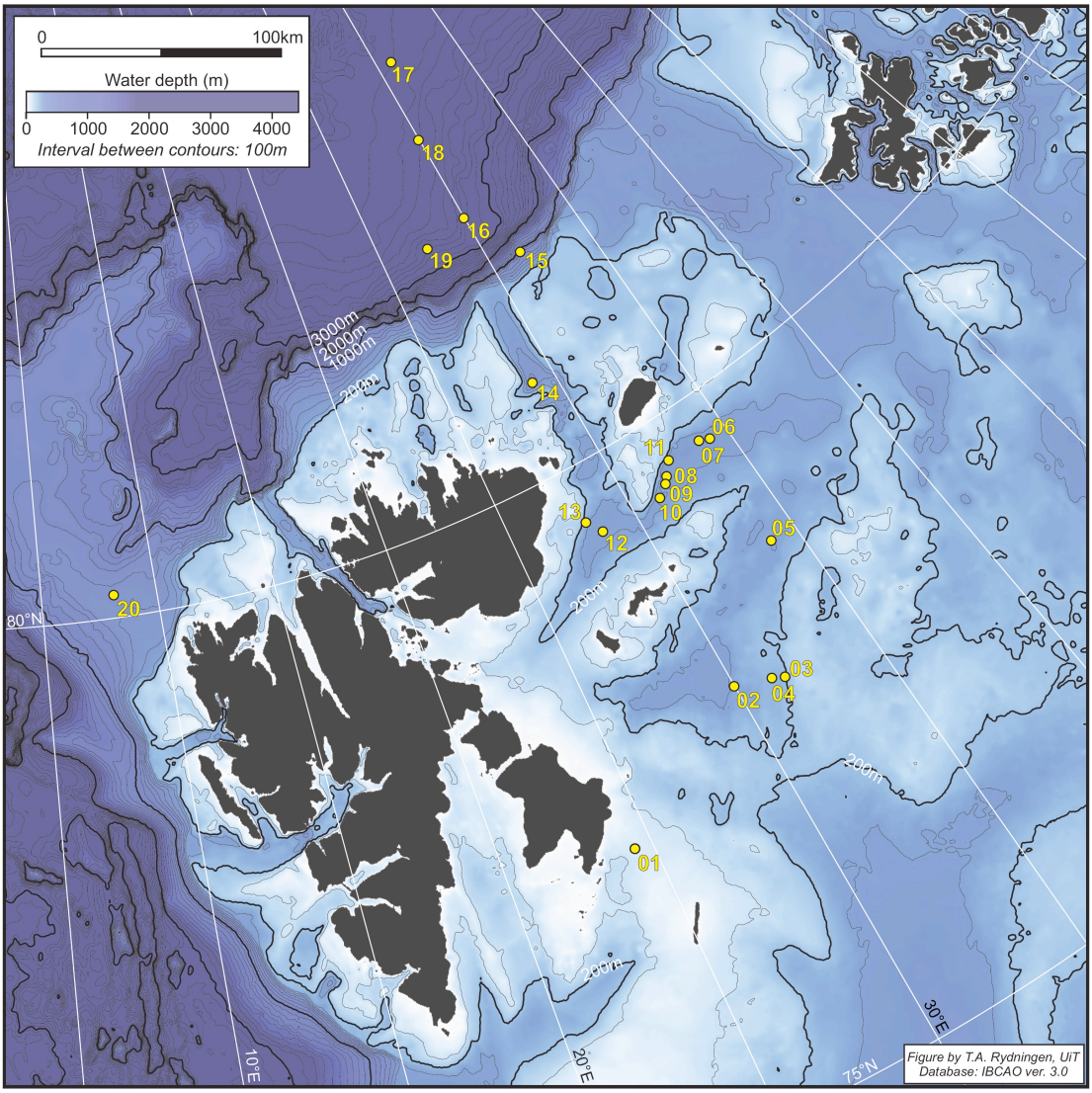


Figure 1. Bathymetric map showing the stations visited during the Nansen paleo cruise (NPAL01 – 20).

In addition, a few sites showed sufficiently thick sediment accumulation for longer sediment cores, and were sampled with the calypso corer (Table 1). The CTD casts on each sampling station provide a description of the oceanographic conditions, and water samples were obtained from each of the water masses present. These samples were collected from different water depth and analysed onboard with regard to stable isotopes ratios (δD, $\delta^{18}O$, $\delta^{13}C_{DIC}$) necessary for calibration of the paleoceanographic proxies. $\delta^{13}C_{DIC}$ was also analyzed in sediment pore waters for calibration of foraminifera carbon isotopes. Calibration work will also be carried out using living planktic and benthic foraminifera from plankton nets and surface sediments, which were collected on each paleo station. This calibration work is only one reason for collecting living plankton and benthic foraminifera; the main objectives are to investigate ocean acidification (RF2) and living organisms in the northern Barents Sea (RF3). For RF2, Ocean acidification (Task T2-1) the objectives were to collect living planktic foramininfera and pteropods with shells of calcium carbonate using plankton nets in addition to collect water samples for DIC analysis. For RF3 (Tasks T3-1 and T3-2) the objectives are to 1) study living benthic foraminifera and associated geochemical parameters from surface and sub-surface sediments and 2) to evaluate the trophic diversity of benthic foraminifera and their role in the structuring, function and interactions across trophic levels. The results from RF3 will aid interpretations of past changing environments in RF1. Longer pore water isotope profiles ($\delta^{13}C_{DIC}$) were also measured on selected

(gravity and piston) cores in order to investigate carbon cycling and transfer both within sediment and across the sediment water interface.

Super station	Ocean mooring	Paleo station	Calypso coring	Other	Comment
NPAL01	X				M4 (RSIP-2)
NPAL02	X				ARGO float
NPAL03	X				M3 (RSIP-1)
NPAL04		X			KH18-10-4
NPAL05		X			KH18-10-5
NPAL06				X	CTD (sound profiling)
NPAL07		X			KH18-10-7
NPAL08		X			KH18-10-8
NPAL09		X			KH18-10-9
NPAL10		X			KH18-10-10
NPAL11	X				M2
NPAL12		X			KH18-10-12
NPAL13	X				M1
NPAL14		X	X		KH18-10-14
NPAL15		X	X		KH18-10-15
NPAL16		X			KH18-10-16
NPAL17		X			KH18-10-17
NPAL18				X	Test of calypso winch
NPAL19		(X)	X		KH18-10-19
NPAL20	X				YP3

Table 1A. Overview of stations and activities during the Nansen paleo cruise. NPAL19 was not a full paleo station (X).

Super station	Latitude	Longitude	Water depth (m)
NPAL01	77,2686	24,4067	71
NPAL02	77,9985	30,0010	288
NPAL03	77,8677	31,7146	201
NPAL04	77,9109	31,2961	232
NPAL05	78,7681	33,9855	301
NPAL06	79,6467	34,2331	348
NPAL07	79,6787	33,8122	353
NPAL08	79,5865	31,9020	364
NPAL09	79,5430	31,6995	328
NPAL10	79,4768	31,2109	296
NPAL11	79,6789	32,3196	357
NPAL12	79,4709	28,5316	329
NPAL13	79,5894	28,0975	259
NPAL14	80,6879	28,9512	552
NPAL15	81,5706	31,6142	863
NPAL16	81,9999	30,0000	3278
NPAL17	83,2722	30,9459	3895
NPAL18	82,6697	29,9866	3699
NPAL19	81,9292	27,5190	3284
NPAL20	80,1784	8,1556	556

Table 1B. Position and average water depth for every station from the Nansen paleo cruise. Geographical position is average decimal latitude and longitude.

3. Activity reports

RV "Kronprins Haakon" left Longyearbyen September 26 in the late afternoon. The course was set for the mooring location M4 (Figure 2), where the mooring was successfully deployed on September

27 (Super station NPAL01). Course was then set for the locations of deployment of an ARGO float and the ocean mooring M3 while surveying with multibeam and sub bottom profiler. CTD casts with water sampling were carried out at the sites of M4 and the ARGO float in order to provide water for testing the onboard isotope systems. Near M3 (NPAL03) a suitable site for coring was identified and a full paleo station was sampled (NAPL04). A full paleo station includes CTD with water sampling, plankton net, multicorer and gravity corer. The gravity corer from Bergen was deployed using 2 m long barrels, however when attempting a longer barrel the core catcher and cutter were pulled off and were lost. The course was set towards P2 and after a survey a full paleo station was sampled at NPAL05 (Figure 2) using the Tromsø gravity corer. Following this success, and the difficulty ('stickiness') of the sediment, was decided to use the UiT gravity corer as the primary device for the rest of the gravity coring. During the next days paleo stations were identified and sampled near P4 (NPAL07), and M2 (NPAL08). Additional sediment cores (NPAL09, NPAL10) were obtained from what is assumed to be a grounding zone wedge. During this time the survey around M2 was abandoned for ca 12 hours as the high winds and swells reduced the data quality greatly, and the ship weathered out the storm. The ocean mooring M2 was deployed and the survey continued towards M1 where another paleo station (NPAL13) was obtained October 5.

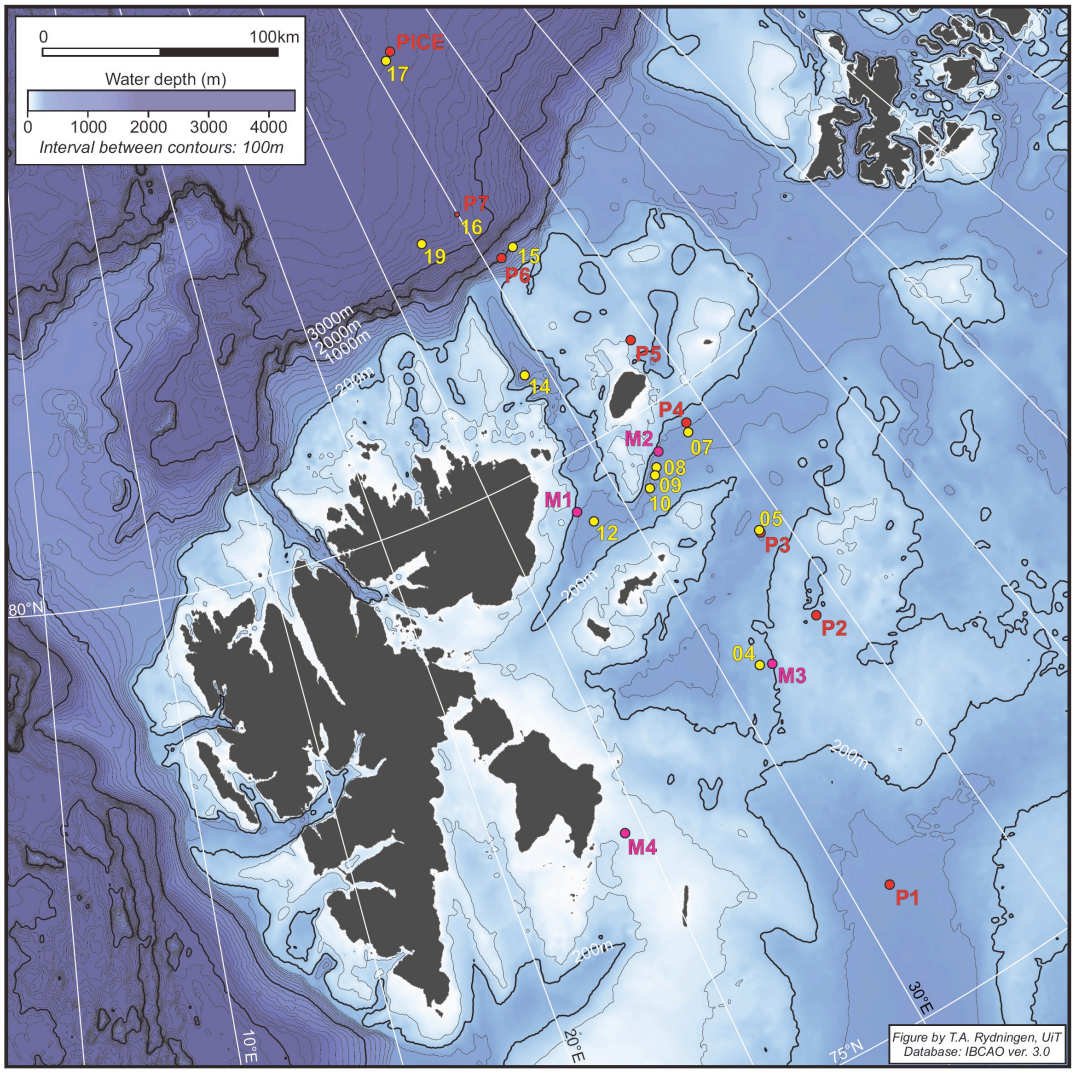


Figure 2. Bathymetric map showing Nansen process stations (P-stations), mooring sites (M stations) and paleo sites sampled during the Nansen paleo cruise (numbers referring to NPAL station number).

The survey continued into the Kvitøya Trough and northwards where two paleo sites showing potential for longer piston cores were identified (NPAL14 and NPAL15). The first piston coring took a while to obtain as it was time consuming to prepare the "Kronprins Haakon" for piston coring since hanger winch cables and blocks had to be re-rigged for the correct dimensions. In addition, upon reaching the seafloor, it took nine attempts to trigger the piston arm due to some debris lodged in the trigger arm mechanism (found upon recovery). However, the coring was an eventual success and ca. 10.6 m long core was obtained. The piston coring was supposed to continue at NPAL14 after breakfast, October 9. However, a crew member had fallen ill and was assessed via Medico radio. It was determined that he had to be evacuated, and the vessel sailed westwards in order to shorten the transport time for the helicopter coming out of Longyearbyen. The crew member was evacuated at 12:30, and the ship returned to NPAL14. The calypso corer was deployed twice. In the first attempt the upper barrel (0-5.8 m) was broken (imploded; perhaps due to weakness/fault in the liner and/or strong piston suction). The lower part was in good condition and four sections were obtained. During the second deployment, the calypso corer was deployed as a long gravity corer in order to penetrate possible harder sediments (but without the piston to prevent possible liner collapse in case of sticky sediments and poor recovery inside of the liner). Core penetration was good, however the corer got stuck in the seafloor and it took ca. 4 hours to get the barrel up again. To loosen the barrel the ship rotated and pulled from different angles in order to widen the hole and loosen the barrel. Only 4.5 m of sediments were obtained. The course was set for NPAL15 in order to obtain multicores and a gravity core for the ChAOS project.

After NPAL15 the course was set for the sea ice and the PICE station. A large sea ice lead near PICE was found October 11 and a paleo station was established here (NPAL17). Multicoring was carried out but eventually Sea ice closed in during the night and only one gravity core was obtained. NPAL15 was visited again in order to recover more of the thick sedimentary sequence present at this location. Two very successful piston coring deployments were carried out using 22 m long barrels, and a new Norwegian record was set getting a piston core of 21.6 m. The course was set for a coring site at 3000 m water depth (NPAL19) where a recent survey by University of Tromsø had identified a sedimentary sequence of ca 30 m. The wind had increased and coring had to be postponed until the morning. The wind had decreased somewhat and a reduced sampling program (multicorer, piston corer, CTD, multinet) was carried out in order to accomplish operations within the narrow window of improved weather. The wind picked up again, however piston coring was carried out safely in strong gale. The course was then set for the Yermak Plateau in order to retrieve a Nansen ocean rig on the way back to Longyearbyen. A routine test of the life boats was also carried out in Kongsfjorden, and visitors from Ny Ålesund came onboard. Crew and scientific personnel also came ashore in Ny Ålesund. Afterwards the transit to Longeyarbyen was continued. The cruise ended Friday October 19 in Longyearbyen.

3.1.Results from measurements and analyses conducted during the cruise

1.1.1. RF1. Bathymetric mapping and sub bottom profiling

The different acoustic acquisition systems onboard RV Kronprins Haakon can be operated simultaneously. We used four systems, of which maximum three operated at the same time. The systems are:

Kongsberg Maritime EM710 and EM302; hull-mounted multibeam echo sounders. These were used to map the seafloor topography.

Kongsberg Maritime Topas PS40 and Sub-bottom profiler 300 (SBP300); hull-mounted sub-bottom profilers. These were used to map the sediment distribution.

Multibeam systems

Swath bathymetry data were collected with two different multibeam echo sounder systems from Kongsberg Maritime: the EM710 and EM302 systems. Sound-velocity profiles of the water column for calibrating the equipment were recorded from CTD casts.

We used the EM710 system at the continental shelf and down to approximately 800 m water depth on the slope (near the NPAL15 site). This multibeam system sends out a fan consisting of up to 400 beams at an angle of up to 70˚ to each side (140˚ in total). In order to maintain a high density of returned echoes from the seabed, we commonly applied angles of 60 to 65˚ to each side. As a rule of thumb the EM710 swath with is four times the water depth.

On water depths exceeding approximately 600 meters (on the continental slope) we used the EM302 system, as this is allows mapping on greater water depth. This system sends out up to 432 beams, and the maximum beam angle is similar to the EM710 system. We commonly used a swath angle of 50˚, and this normally corresponds to a swath width of three times the water depth.

The quality of the returned echoes from the multibeam systems progressively decreases away from the center of the swath. We therefore made sure that there was an overlap between the swaths in areas of detailed multibeam mapping, and this overlap was usually between 200 and 300 meters. We extended the overlap on greater water depths, such as on the lower slope and in the abyssal plain, as well as in areas of challenging topography (i.e. the NPAL15 site).

Both the EM302 and EM701 systems gave best results at acquisition speed of 6 knots (and lower), but the quality was still good at around 7 knots. The gridded surfaces from the continental shelf and upper slope has a resolution of 10x10 and 20x20 meters, respectively. Deeper areas were gridded with a resolution of 30x30 m, due to less returned echoes per area. In general, the data from the abyssal plain is of low quality.

The EM302 system stopped working on the evening of the 14th as the transmitters shut down. The remaining part of the cruise took place on the continental slope, which unfortunately resulted in no multibeam from the NPAL19 and NPAL20 sites.

Seismic systems

High-resolution seismic profiles were collected using a Topas40 and SBP300 sub-bottom profiler systems, both from Kongsberg Maritime. Seismic profiles were collected along the ship tracks during transits between coring stations and within working areas. We used only the Topas system up until October 3. Following this both systems operated simultaneously, up until a fuse was blown on the Topas system on October 9. This could not be fixed, and no Topas seismic was acquired following this.

The systems use a linear FM-pulse with swept frequencies from 2 to 10 kHz (Topas) and 2.5 to 7.5 kHz (SBP300), and this allowed for a penetration of up to 50 m of sediments for both systems on this cruise. The shot rates of the systems are dynamic (dependent on the water depth), and are calculated automatically by the K-sync program. The multibeam system is setting the limit for the ping rates of the different systems. The length of the pulses are between 14 to 20 ms for the Topas and 20 ms for the SBP300 system. The source power varied between -10 and 0 decibel. The quality of the imaging of the subsurface from the sub bottom profilers were comparable, although the SBP300 generally gave a slightly better penetration and resolution.

Both systems produces a .RAW and .SGY-file during acquisition. The on-the-fly processing was kept to a minimum for both systems; only a matched filter was applied for the Topas, and a manual Time Varying Gain (TVG) for the display of both systems. A re-processing of the.RAW-files could be done if areas of particular interest are to be studied in the future.

We had some issues related to the automatically saving of the .SGY-files: the files were originally stored on the common area on the ship, and some files failed to save. These lines were corrected, i.e. they were re-saved as .SGY, and the following files were auto-saved in a different location, which fixed the problem. It should be noted that the SBP300 system sometimes generated slightly different file names for the .RAW and .SGY-files, and sometimes the .RAW files are split into several .SGY files. The line log in the appendix can be used as a guide if the .RAW files are to be located. The sizes of the .SGY files are kept below 500 MB (with some exceptions); this is done in order to make it easy to import and view them in seismic interpretation softwares such as Petrel.

The .SGY-files were used to decide coring locations; this was done both in the software provided by Kongsberg, and by importing the .SGY-files to Petrel. The latter gave us the possibility to evaluate both the lines and the surrounding seafloor bathymetry from the multibeam systems.

Preliminary results

The following present the preliminary results from the multibeam mapping and the sub-bottom profiling done on this cruise. In addition, the multibeam mapping done on the Joint Nansen Cruise, as well as multibeam survey and Chirp seismic profiles from the *Arctic Marine Geology and Geophysics* cruise by UiT contributed to our understanding of the geology. In particular, the UiT-data were key in choosing the NPAL19 core site. The multibeam data from other sources are marked on the figures.

All seismic profiles are listed in Appendix 3, table B2. Preliminary interpretations of the seabed morphology and seismic profiles across the coring site are presented in chronological order, i.e. from NPAL04 (first paleo station) to NPAL19 (final paleo station).

NPAL04

The NPAL04 station is situated in the southern part of the Olga Strait. Furrows that are around 5 m deep and ridges that are typically a couple meters high dominate the seabed morphology. Floating icebergs that scour the seabed most likely formed the furrows, and it is likely that grounded icebergs that push sediments also formed the ridges. The sediment cover in the area is generally low and confined to the deeper parts in the east, where the thickness is around 3 ms. The sediments are acoustically transparent and drape the underlying morphology, and they are interpreted to represent marine, Holocene sediments.

NPAL05

The NPAL15 site is situated in the northern part of the Olga Strait. Ridges that are elongated in the direction of the strait axis are 4 km long, around 100 meters wide and up to a couple meters high. These are interpreted to be mega-scale glacial lineations indicating a fast-flowing glacier in the strait during full-glacial conditions. Ridges oriented across the strait are observed in the north; these are typically 100 to 200 meters wide, 5 meters high, and a couple kilometers long. These are interpreted to be recessional moraines, indicating a stepwise retreat of the glacier during the deglaciation. Furrows that are more than 200 meter wide and 5 meter deep are likely iceberg ploughmarks.

A distinct base reflection with buried ridges is observed in the northern part of the surveyed area, and this most likely corresponds to a glacigenic till surface. An acoustically transparent unit with a weak internal reflection drapes the underlying topography in the same area. This unit is about 5 ms thick, and most likely corresponds to marine, Holocene sediments.

NPAL07

The NPAL07 site is situated in an unnamed strait southeast of Kvitøya. Ridges that are parallel to the strait are around 1 to 2 meters high, 50 meter wide and up to 5 kilometers long. These landforms are likely (mega-scale) glacial lineations indicating the former presence of a fast-flowing ice stream in the strait. Other observed ridges are oriented obliquely to transverse to the strait; these are between one and 5 meters high, 50 to 400 meters wide and they extend for more than 8 kilometers. Some of the transverse ridges superpose others, and some of them are arch shaped. These ridges are likely recessional moraines and push-moraines, indicating still-stands and ice margin advances during the deglaciation, respectively.

A seismic unit of approximately 5 ms thickness covers the area. The unit is transparent to chaotic in character, with a distinctive base reflection. The moraine ridges observed from the multibeam are not draped, meaning that the unit may consist of till or glacimarine sediments. Thus, there is a possibility that the Holocene cover is very thin or absent in this area.

NPAL 08-09-10

The NPAL08-09-10 sites are situated approximately 30 km southeast of the NPAL07 site. Transverse ridges that are arch shaped dominate the seabed. These are between 2 and 10 meters high, 50 and 400 meters wide and up to 10 kilometers long. Based on their shape and orientation, these are interpreted to be push moraines. A prominent wedge that is more than 60 meters high bury the moraines in the south. We have only mapped the northwestern part of this wedge, but it is likely that it extends across the width of the strait. This wedge is probably a grounding zone wedge formed during a still-stand or advance of the ice front during the deglaciation. A 10 meter and 200 m wide depression in the southeastern part of the mapped area is likely a subglacial channel.

On the seismic data, a prominent basal reflector is observed, and the unit above this is dominated by high-amplitude reflections with low continuity. This reflector forms the relief of the push moraines, and the unit therefore likely represents till. A unit that is around 4 ms thick drapes the area between the moraine ridges, and this unit is interpreted to be Holocene, marine sediments. The grounding zone wedge in the southern part of the surveyed area buries distinctive ridges; these are interpreted to be buried push moraines, likely of similar origin and close in age as the ones observed on the multibeam data. A thin cover of sediments (approximately 2 ms thick) drapes the wedge.

NPAL12

The NPAL12 site is situated in the Erik Eriksen Strait, between Nordaustlandet and Kvitøya. Two sets of ridges dominate the seabed morphology: the first set is oriented in a NNE-SSW direction, and the second superpose the first one in an east-west direction. The ridges are commonly between one and 5 meters high, with some larger ones exceeding 20 meters in height. The ridges are between 50 to 400 meters high, and the largest extend for more than 10 kilometers. These ridges are interpreted to be recessional moraines, or possibly push-moraines formed during the deglaciation. The moraine ridges indicate that the ice sheet first retreated from east to west (set one). This was followed by a re-advance, before the ice sheet finally retreated from north to south (set two).

On the seismic data, a strong reflection marks the base of the moraine ridges. This unit is approximately 8 ms thick, and is interpreted to be till. A transparent unit that is around 4 ms thick drapes the moraines, and this is likely Holocene, marine sediments.

NPAL14

The NPAL14 site is situated east of Nordaustlandet, on the inner part of the continental shelf. The inner part of the surveyed area has a rugged topography at around 100 to 250 meter water depth, and this corresponds to crystalline bedrock. North of this, the water depth increases to almost 600 meters, where elongated ridges that run parallel to the longest axis of the trough dominated the seabed morphology. These are up to 10 kilometers long and 400 meters wide, and they are narrowing northwards. The relief of the ridges are around 5 meters, with some being up to 50 meters high. These ridges are densely spaced compared to similar streamlined features from the other surveyed areas. The ridges are interpreted to be mega-scale glacial lineations, demonstrating that the Kvitøya Trough was an active ice stream outlet during full-glacial conditions.

A high-amplitude reflection defines the base of the seismic data. The surface consists of several ridges, corresponding to the mega-scale glacial lineations observed from the multibeam data, i.e. this surface is interpreted to represent till. A transparent unit that is up to 10 ms thick drapes the underlying topography, and this unit thins northwards. These sediments are likely Holocene, marine sediments.

NPAL15

The NPAL15 site is situated east of the Kvitøya Trough Mouth Fan, on the continental slope. This part of the continental slope is in an inter-fan setting, i.e. the surveyed area is situated between the Kvitøya and Franz Wictoria trough mouth fans. The seabed morphology is smooth down to about 1000 meter water depth. Several steep escarpments dominate the morphology at downslope of this, where the escarpment have gradients up to 20°. A complex morphology with ridges and depressions is observed further downslope, and the height difference between these are up to 200 meters. The depressions between the ridges merge downslope. The escarpments are interpreted to represent slide scars, and the seabed morphology of the area downslope is likely formed by mass-flows such as submarine slides, debris flows and turbidity currents.

A sedimentary unit that is up to 40 ms thick covers the area of smooth seabed morphology on the upper slope. This unit thins upslope, and it has an acoustically laminated seismic configuration, with internal onlaps. The continuities of the internal reflections are high. Most of the internal sub-units have a transparent character, while a few are more chaotic in character. This unit is interpreted to represent a contourite deposit. The slide scars downslope of the accumulation are likely related to failures that have occurred along weak planes in the contourite drift.

NPAL17

The NPAL17 site is situated on the abyssal plain at a water depth of more than 4000 m. There is uncertainty regarding the exact water depth at the site.

The quality of the seismic data in the abyssal plain varies; this is due to sea ice influencing the instruments during data acquisition. The quality of the seismic data at the coring site is fairly good, and shows that the site is covered with a minimum of 2 ms of sediments. There may be as much as 12 ms of sediments here, but this is difficult to validate.

NPAL19

The NPAL17 site is situated on the lower continental slope, at the distal part of the Kvitøya Trough Mouth Fan. No multibeam data was recorded at the site as the EM302 had stopped working before reaching the area.

The seismic data show that there is a sediment cover of up to more than 40 ms thickness. The internal configuration of the unit is acoustically laminated, with some chaotic intervals. The chaotic intervals were avoided when the coring site was decided. The sediments are interpreted to represent contourites, i.e. they represent a downslope part of the contourite from the NPAL15 site. The chaotic intervals are likely debris flow deposits.

1.1.2. RF1. Sediment cores

Sampling the sediment cores onboard is problematic due to carbonate dissolution which most probably will occur when the sediments are oxygenated. Regardless some sampling has to be carried out immediately in order to avoid deterioration of the parameter that is sampled, i.e. aDNA, pore water and living benthic foraminifera. Four short cores from each paleo station were sampled immediately for living benthic foraminifera (Table 2).

Core ID	Paleo sampling BF 0-40 cm	Sampling living BF 0-10 cm	Sampling living BF 0-4 cm
KH18-10-04- MC02 B		X	
KH18-10-04- MC02 C			X
KH18-10-04- MC03 A			X
KH18-10-04- MC03 C	X		
KH18-10-05- MC01 A			X
KH18-10-05- MC02 A			X
KH18-10-05- MC02 B	X		
KH18-10-05- MC02 D		X	
KH18-10-07- MC01 C			X
KH18-10-07- MC02 A	X		
KH18-10-07- MC02 C		X	
KH18-10-08- MC01 D	X		
KH18-10-08- MC02 B		X	
KH18-10-08- MC02 C			X
KH18-10-08- MC03 C			X
KH18-10-12- MC01 B			X
KH18-10-12- MC01 C			X
KH18-10-12- MC02 A	X		
KH18-10-12- MC02 D		X	
KH18-10-14- MC01 B			X
KH18-10-14- MC02 B	X		
KH18-10-14- MC03 A			X
KH18-10-14- MC03 B		X	
KH18-10-15- MC01 C	X		
KH18-10-15- MC02 A			X
KH18-10-15- MC02 D			X
KH18-10-15- MC03 A		X	
KH18-10-17- MC01 D			X
KH18-10-17- MC03 B			X
KH18-10-17- MC03 C	X		
KH18-10-17- MC03 D		X	
KH18-10-19- MC01 A	X		
KH18-10-19- MC01 C		X	
KH18-10-19- MC02 C			X
KH18-10-19- MC02 D			X

Table 2. Table showing which multicores that have been sampled for living benthic foraminifera.

Short or long sediment cores that were sampled for either porewater or aDNA were opened, described, photographed and logged (magnestic susceptibility, colour scan). They were also sampled for 14C dating (samples kept frozen), in addition to samples for HBIs (IP25) and dinocysts analysis (Table 3). For further details please refer to appendix.

Core ID	Porewater	aDNA	IP25 (HBIs)	Dinocysts	14C dating
KH18-10-04-MC01 A	X	X	X	X	X
KH18-10-04-GC1	X	X	X	X	X
KH18-10-05-MC01 D		X	X	X	X
KH18-10-07-MC01 D		X	X	X	X
KH18-10-08-MC01 A	X	X	X	X	X
KH18-10-08-GC4	X	X	X	X	X
KH18-10-12-MC02 B		X	X	X	X
KH18-10-14-MC02 C	X	X	X	X	X
KH18-10-14-GC3	X				X
KH18-10-15-MC01 A	X	X	X	X	X
KH18-10-15-GC2	X	X	X	X	X
KH18-10-15-PC3	X	X			
KH18-10-17-MC01 B	X	X	X	x	X

Table 3. Overview of sediment cores that have been sampled with regard to porewater, aDNA, IP25, dinocysts and 14C dating.

To accurately measure and describe the sediment properties, the cores were analysed immediately after splitting. Sediment cores were split and the thin surface layer of sediment carefully removed in order to eliminate any possible surface contamination due to splitting. A tape measure was placed along the core and kept in place through the following analyses (note- each gravity core section was measured from 0 cm). Initially photos along the 'archive' half of the core were taken at 5 cm intervals in a well-lit setting. Plastic film was then placed over the core section before colour measurements were taken at 1 cm intervals, starting from 1 cm. Following this, magnetic susceptibility was measured at 0.5 cm intervals on the cores from station NPAL04 until NPAL14, however after this point magnetic susceptibility was not measured due to failure of the detector. The sediment cores were described to identify the stratigraphic units, structures, colours, lithology and disturbances and smear slides were made on selected depths to verify and quantify the visual descriptions. Finally, samples for radiocarbon dating were sampled at approximately 5 cm from the top and bottom of each core or section (on the archive half), using material from half of the tube. Gravity cores had an additional dating sample taken from the mid-point of each section.

Presented in the following section are the summarised sediment descriptions and results for multicores and gravity cores. For NPAL14 and NPAL15 we present a comparison of the multicore and gravity core colour results. Full, original sediment descriptions are shown in the appendix.

Station: NPAL04

Latitude: 77.9109°N

Longitude: 31.2962°E

Water depth: 232 m

Core code: KH18-10-04-MC01A

Core sampling method: multicore

Sediment description:

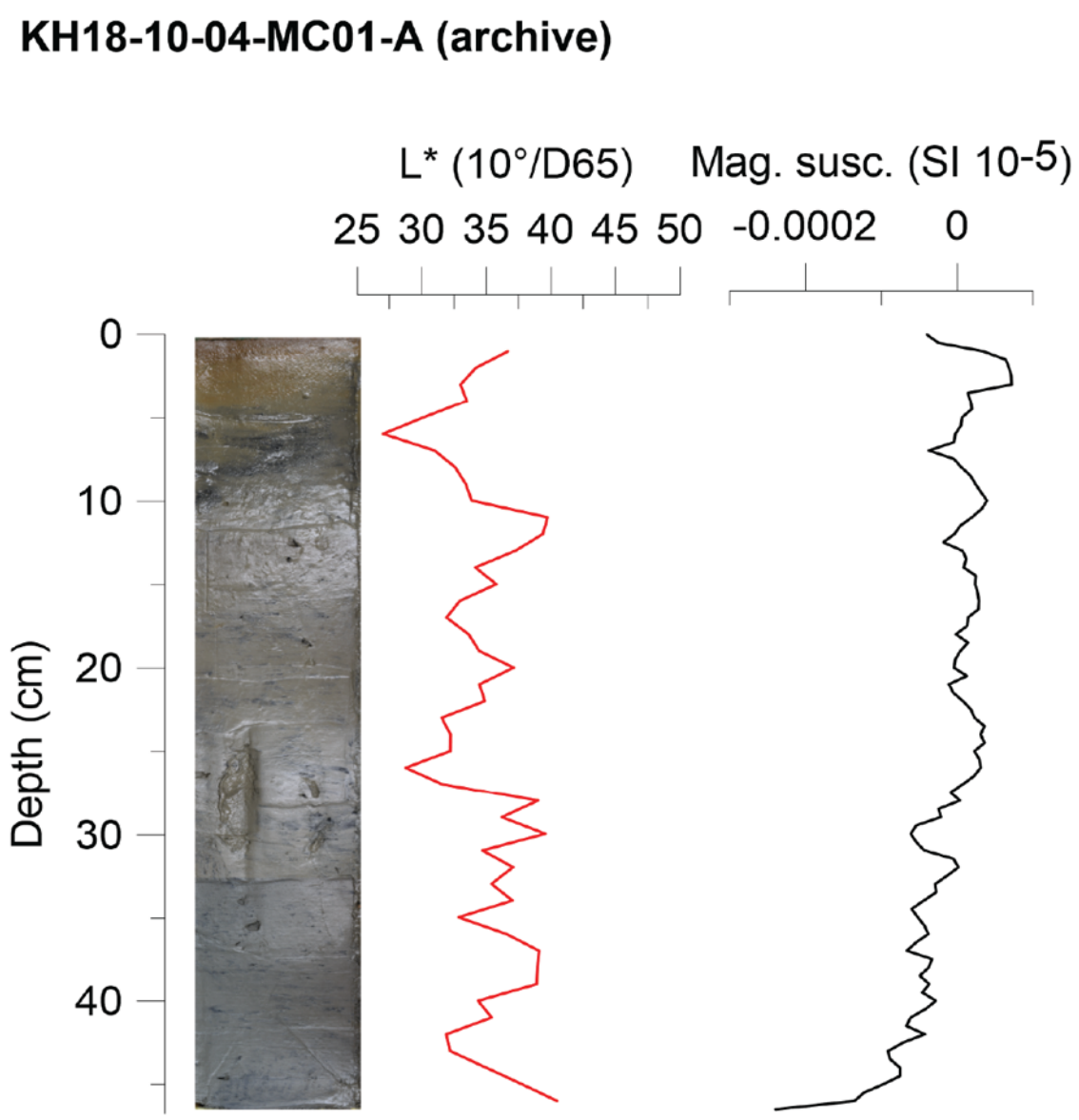
Sediment core KH18-10-04-MC01a (46 cm) consists of relatively homogeneous clay rich mud with a gradual transition from brown to grey colour in the upper 5 cm. Some black (sulphide) mottling and bioturbation throughout.

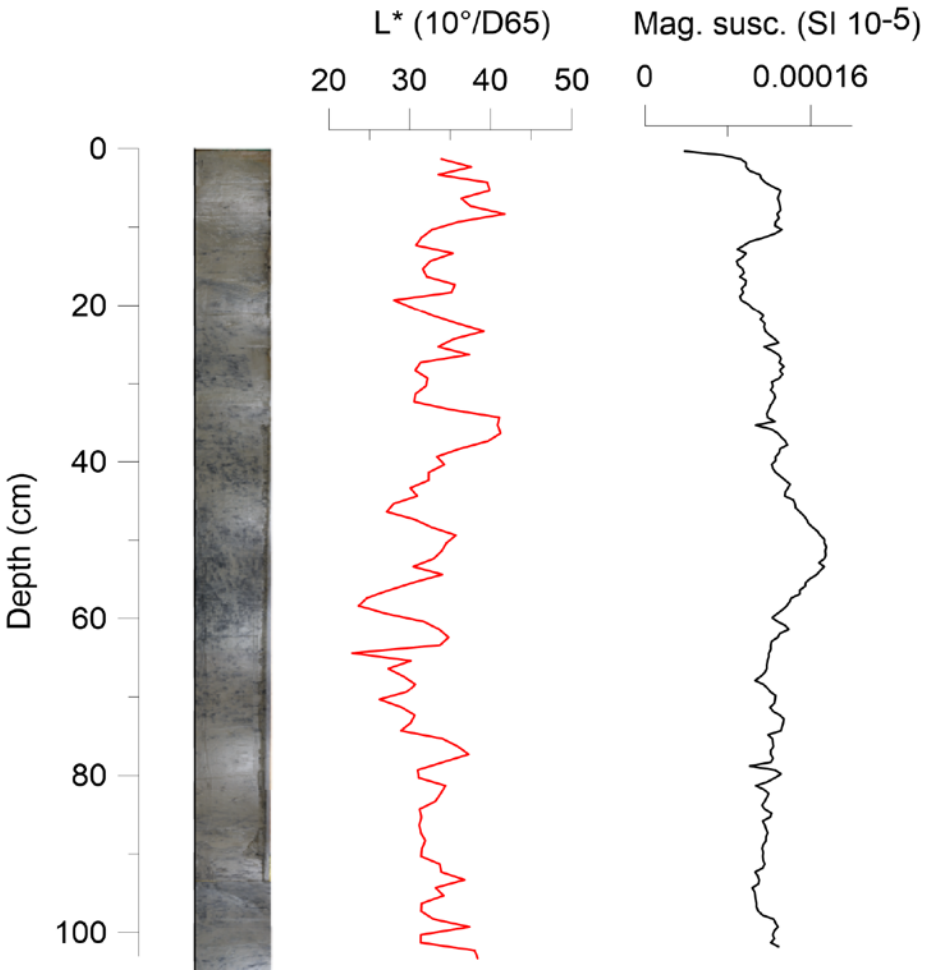
Core code: KH18-10-04-GC01a

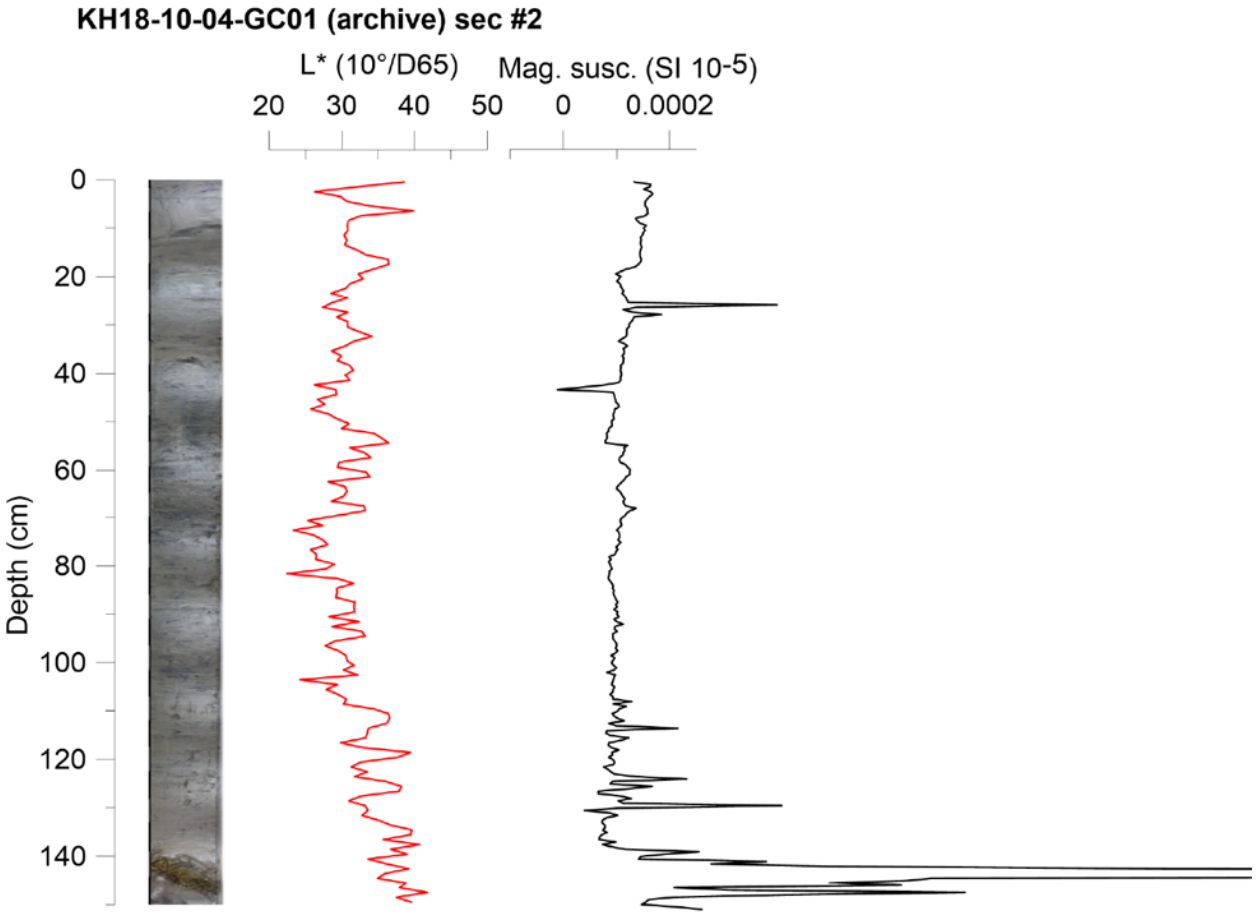
Core sampling method: gravity core

Sediment description:

Sediment core KH18-10-04-GC01a (255 cm) consists of homogeneous clay rich mud with a gradual transition in the upper 70 cm from brown grey colour to grey with an increasing amount of black (sulphide) mottling. A pocket of gravel with an undulating upper boundary and an erosive lower boundary is found between 40-50 cm.




KH18-10-04-GC01 (archive) sec #1
L* (10°/D65)
20
30
40
50
Mag. susc. (SI 10-5)
0
0.00016
Depth (cm)
0
20
40
60
80
100



[note – peak at 140 cm cropped]

Station: NPAL05

Latitude: 78.7679°N

Longitude: 33.9855°E

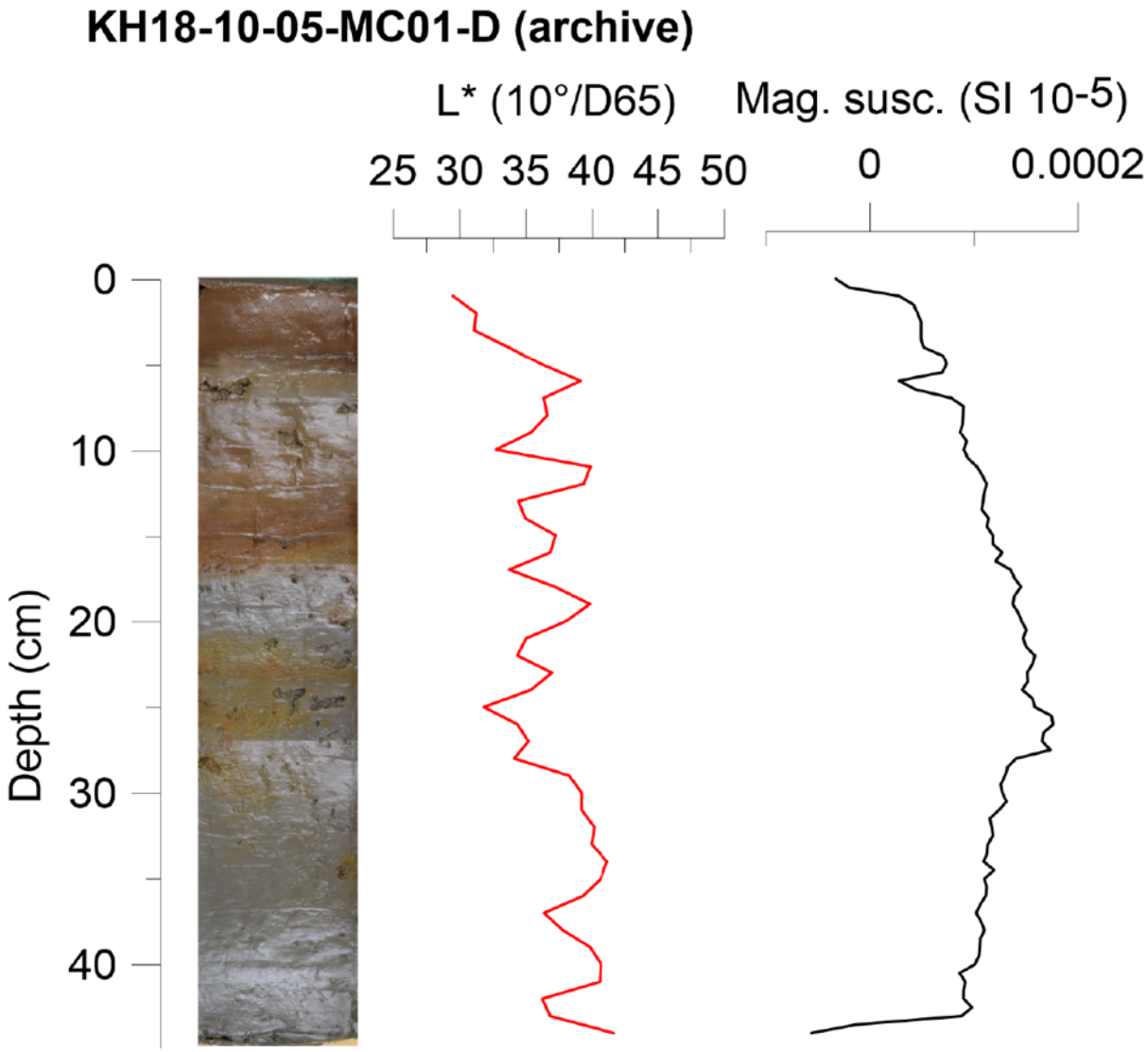
Water depth: 301 m

Core code: KH18-10-05-MC01D

Core sampling method: multicore

Sediment description:

Sediment core KH18-10-05-MC01Da (44cm) consists of silt bearing clay. It is relatively homogeneous and moderately bioturbated. A brown organic bed with a clear and undulating lower boundary is situated in the top 5 cm. The colour changes gradually from orange brown to grey between 5 and 17 cm. The rest of the core is grey with two orange brown beds at 22 and 24 cm.



Station: NPAL07

Latitude: 79.6788°N

Longitude: 33.8129°E

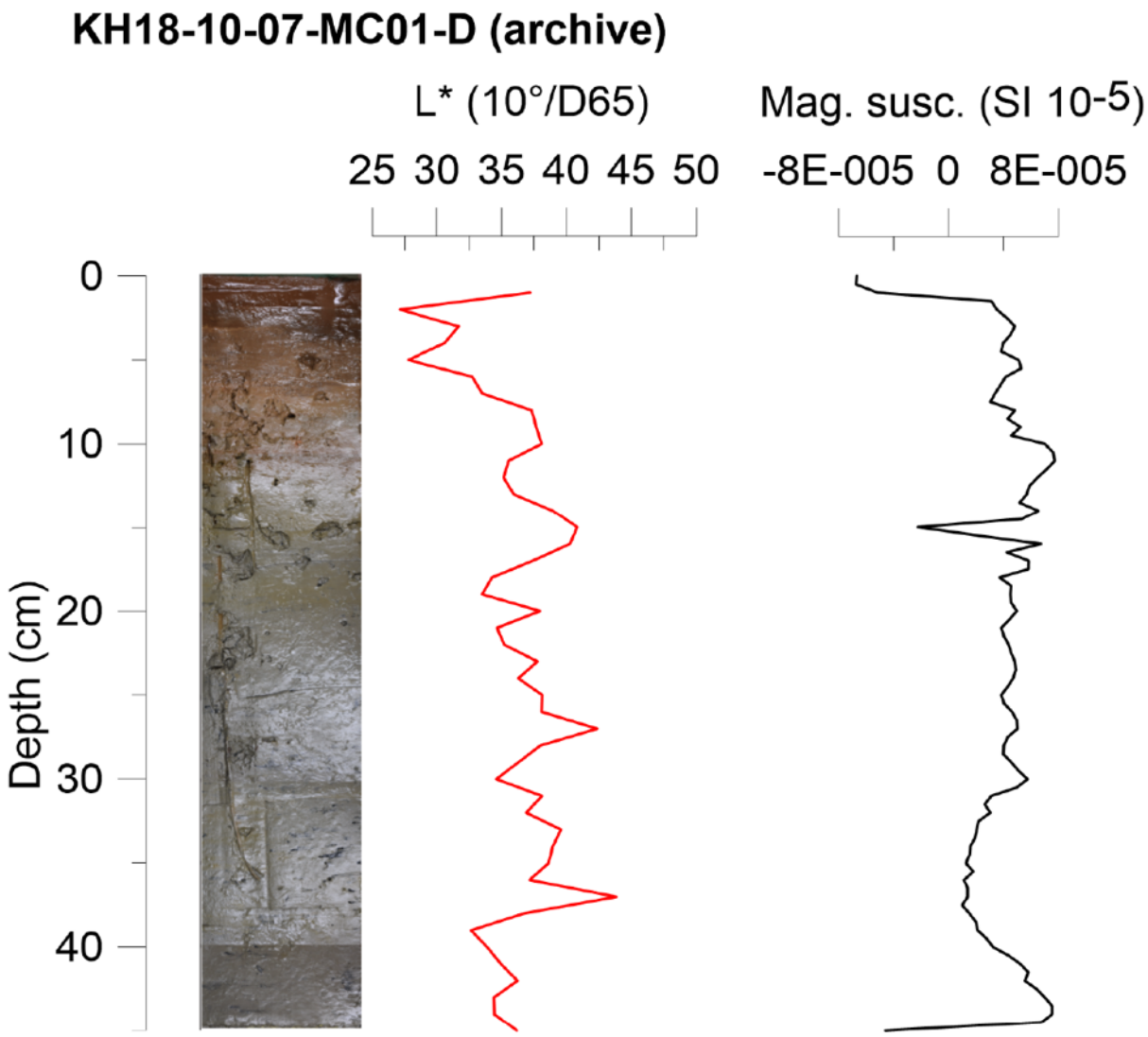
Water depth: 353 m

Core code: KH18-10-07-MC01D

Core sampling method: multicore

Sediment description:

Sediment core KH18-10-07-MC01Da (45 cm) is characterized by mud in the upper 7 cm. The lower 38 cm consists grey silt bearing clay. Living mollusc sampled in a bag. Minor black (sulphide) mottling and some polycake worm tubes are observed. One large foraminifera is found at 8.5 cm.



Station: NPAL08

Latitude: 79.5865°N

Longitude: 31.9017°E

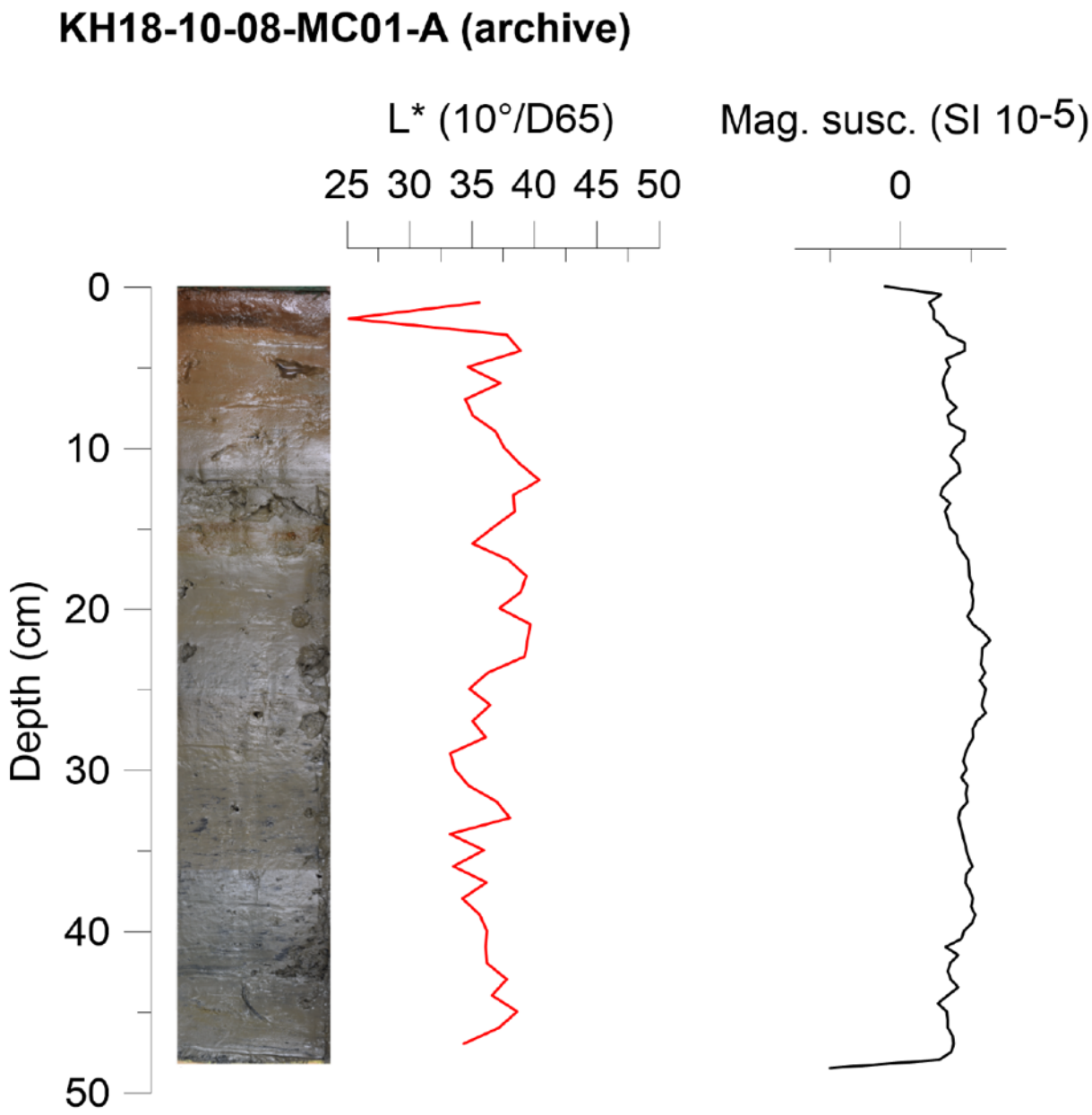
Water depth: 364 m

Core code: KH18-10-08-MC01A

Core sampling method: multicore

Sediment description:

Sediment core KH18-10-08-MC01Aa (48 cm) is a relatively homogeneous clay rich mud. A brown organic bed is situated in the top 3 cm. A transition from brown grey to grey is observed in the lower 10-48 cm. The core is moderately bioturbated. Minor black (sulphide) mottling throughout.



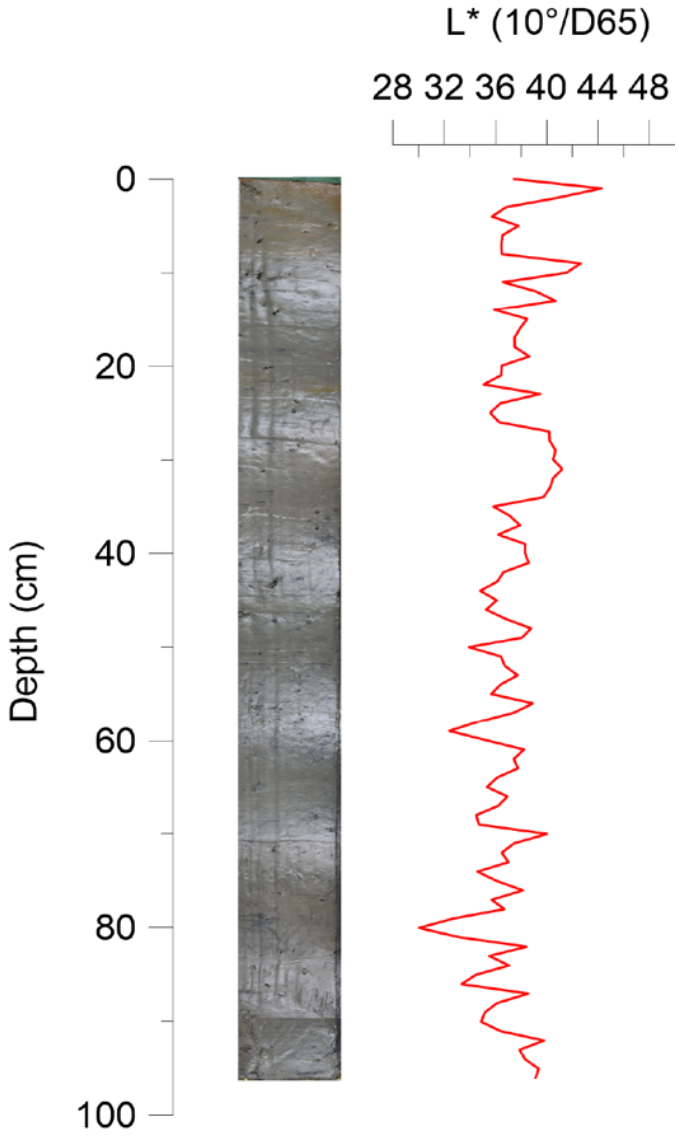
Core code: KH18-10-08-GC04a

Core sampling method: gravity core

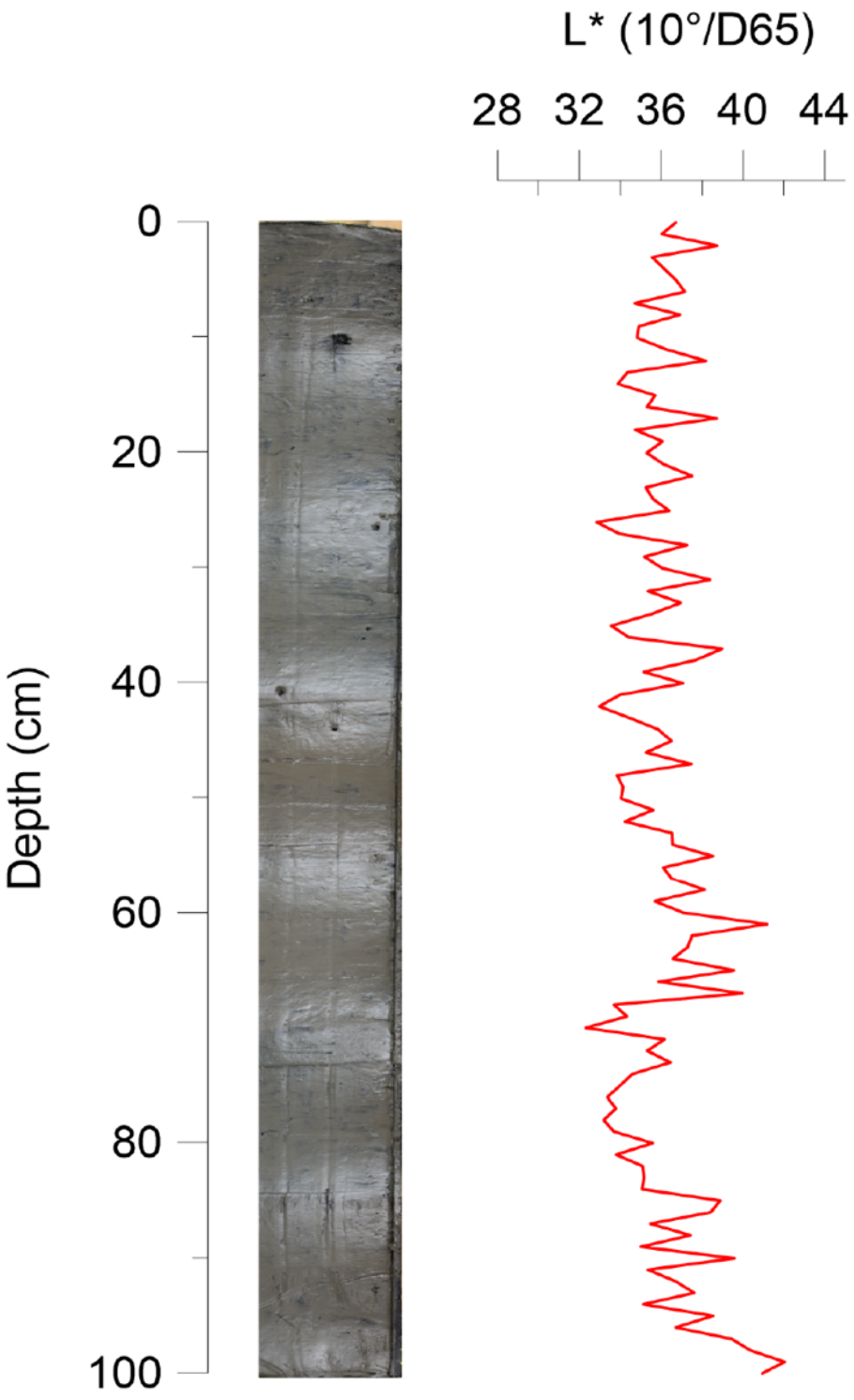
Core description:

Sediment core KH18-10-08-GC04a consists of three units. The first unit (0-283 cm) is characterized by relatively bioturbated and homogeneous clay rich mud of grey colour. Orange/brown pockets are observed in the upper 22 cm. Black (sulphide) mottling increase down core and is especially numerous between 110-283 cm. Unit 2 (283-370 cm) has a clear upper boundary and consists of soft and pink grey clay rich mud with crude laminations. Unit 3 (370-400 cm) has a gradual upper boundary with a 2x5 cm drop stone situated at the top. The unit is characterized by grey colour and probably clay rich mud. Crude lamination of laminas of brown grey and grey colour are observed.

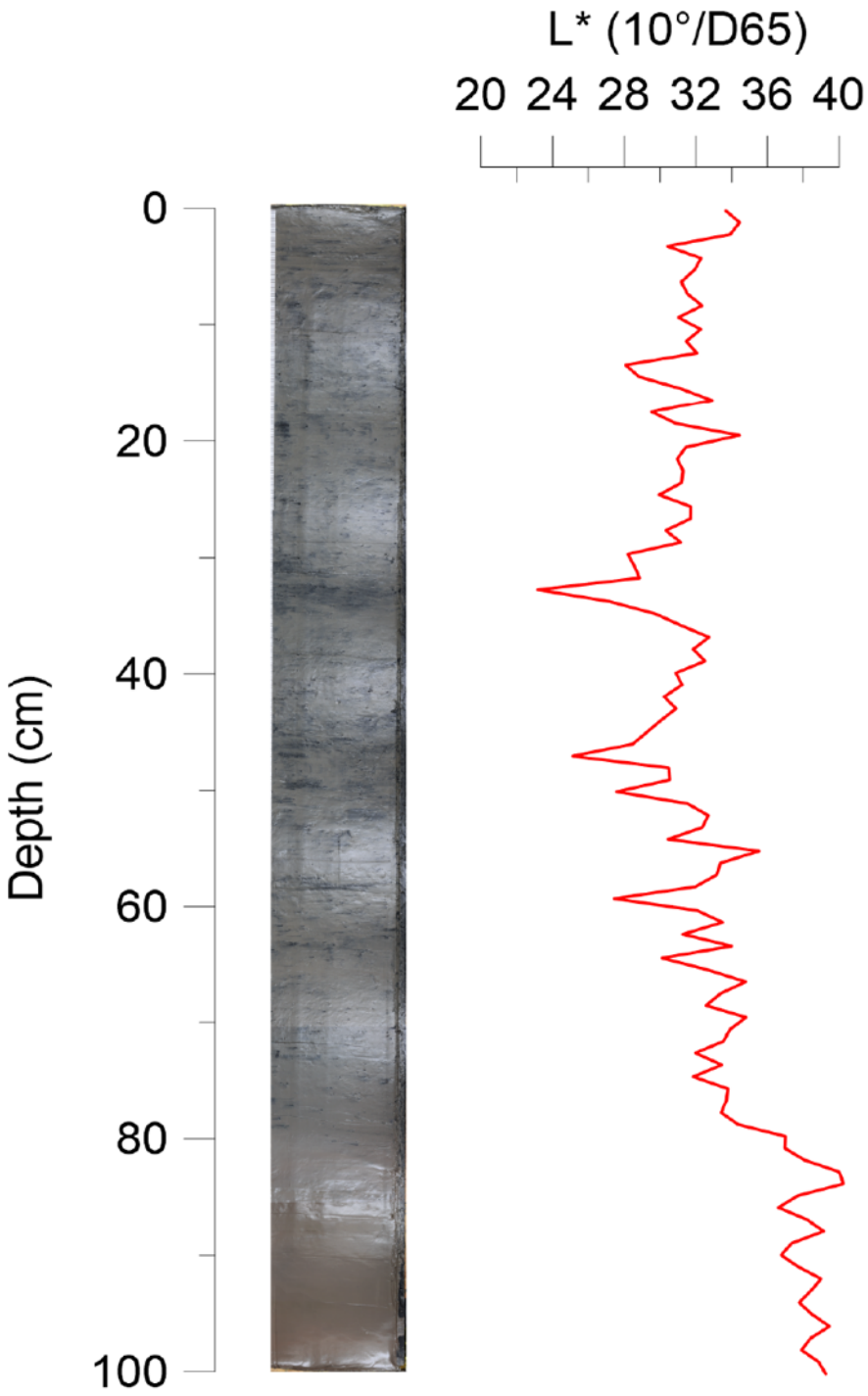
KH18-10-08-GC04 (archive) sec 1



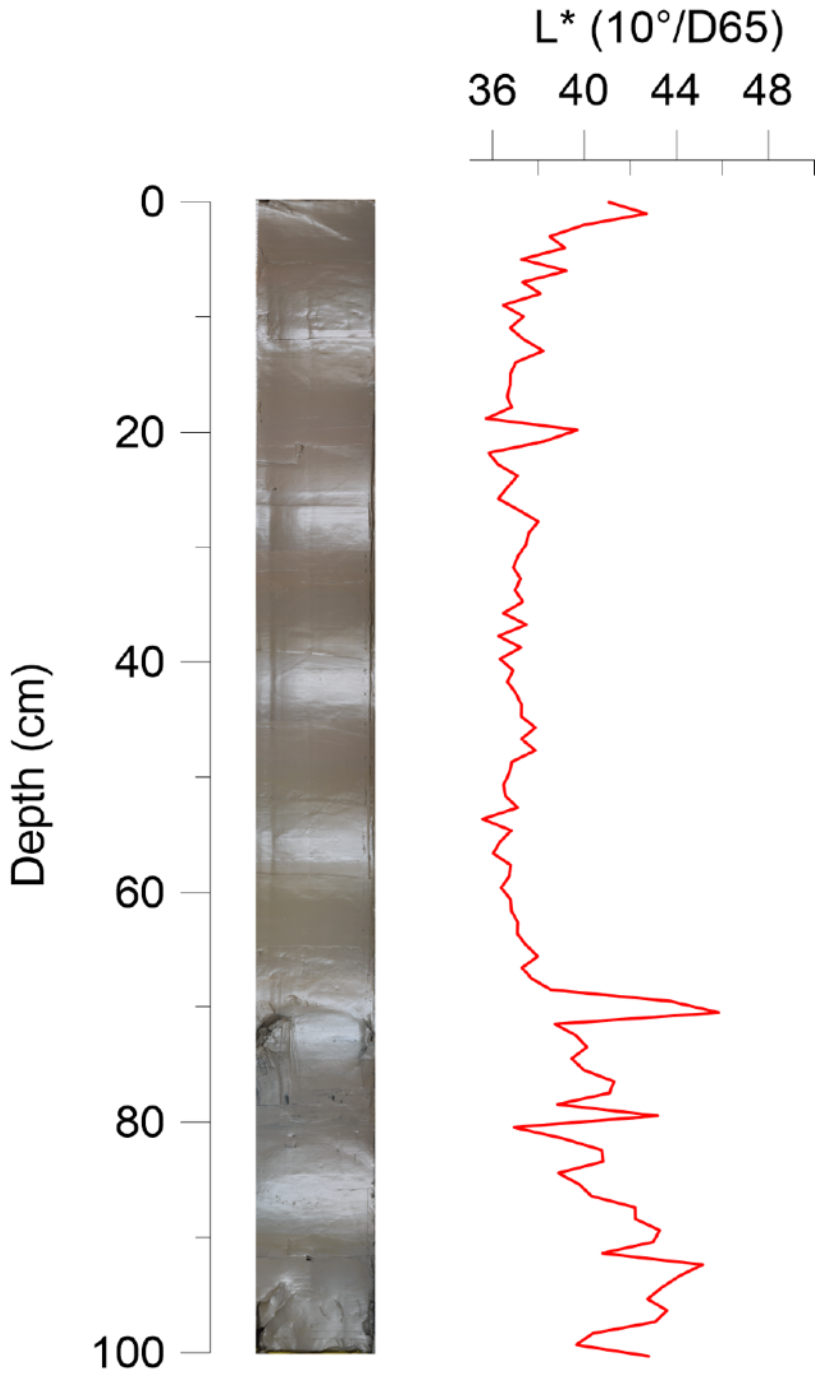
KH18-10-08-GC04 (archive) sec 2



KH18-10-08-GC04 (archive) sec 3



KH18-10-08-GC04 (archive) sec 4



Station: NPAL12

Latitude: 79.4709°N

Longitude: 28.5316°E

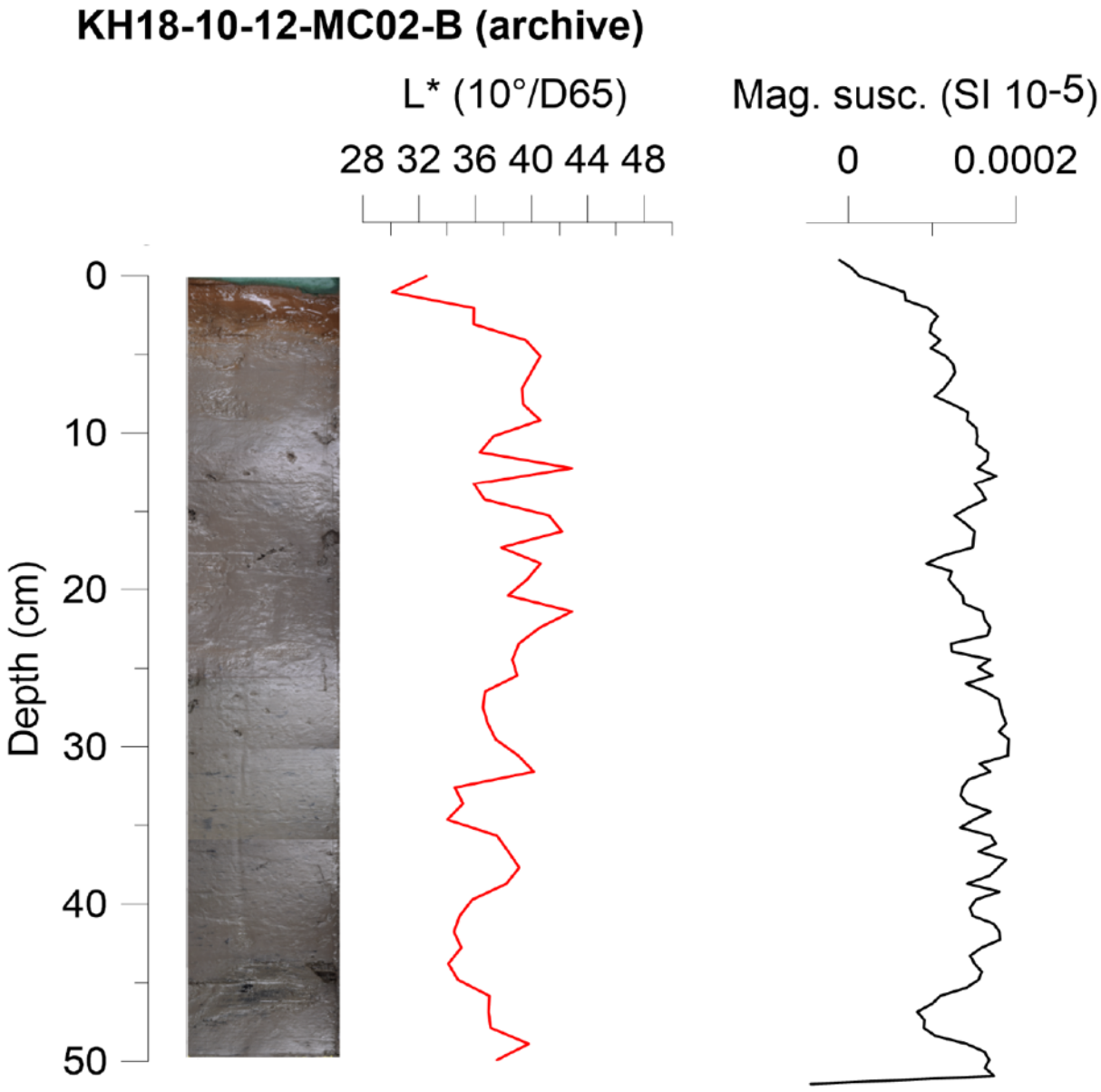
Water depth: 329 m

Core code: KH18-10-12-MC02B

Core sampling method: multicore

Sediment description:

Sediment core KH18-10-12-MC02Ba (51 cm) consists of one unit of relatively bioturbated and homogenous clay rich mud with an organic bed situated in the upper 3 cm. There is a gradual colour transition throughout the core from brown grey to grey with black (sulphide) mottling.



Station: NPAL14

Latitude: 80.6879°N

Longitude: 28.9511°E

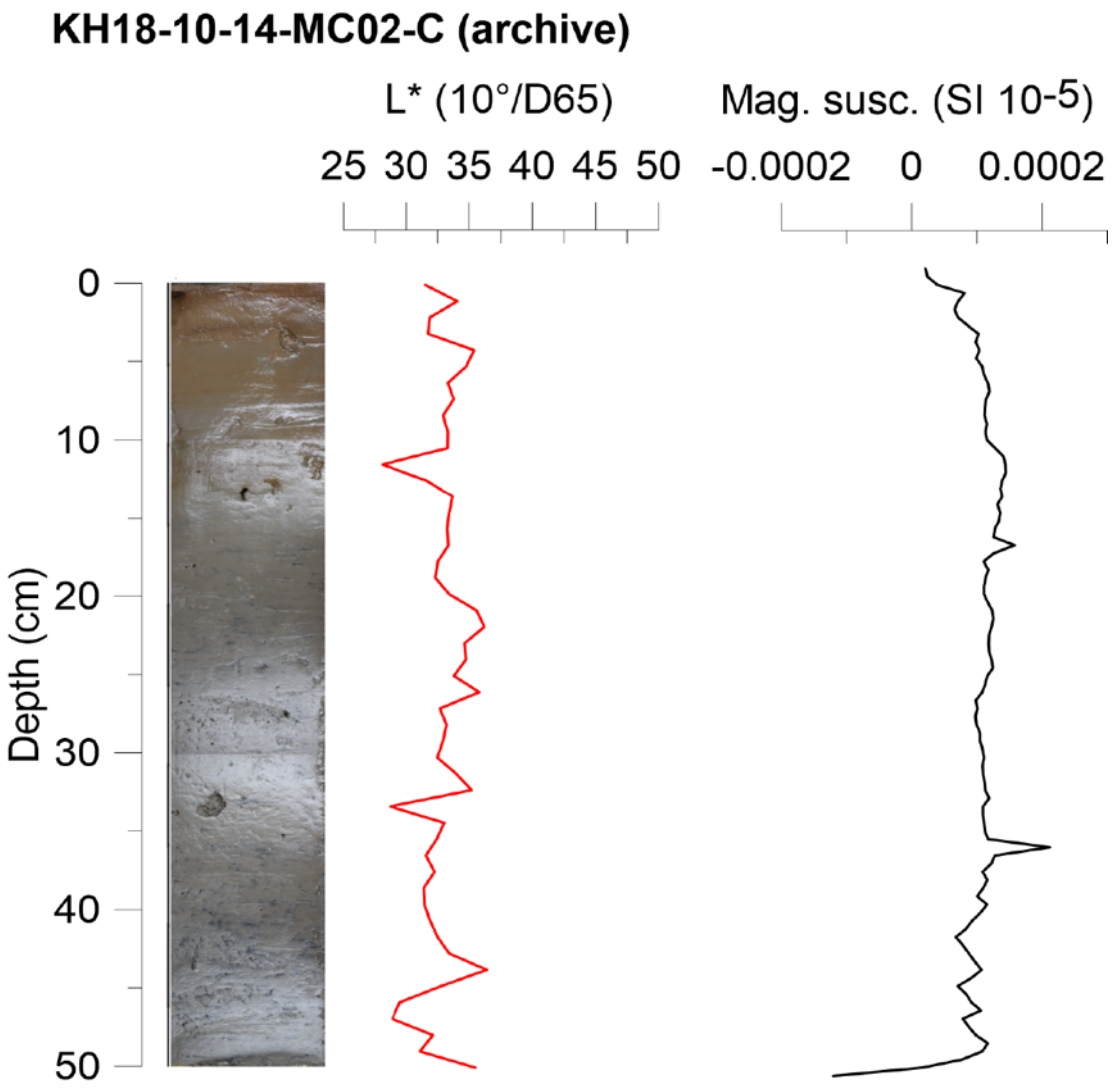
Water depth: 552 m

Core code: KH18-10-14-MC02C

Core sampling method: multicore

Sediment description:

Sediment core KH18-10-14-MC02Ca (50 cm) consists of homogeneous clay rich mud with a gradual transition from brown organic beds (0-14 cm) to grey clay rich mud with some black (sulphide) mottling and burrows.

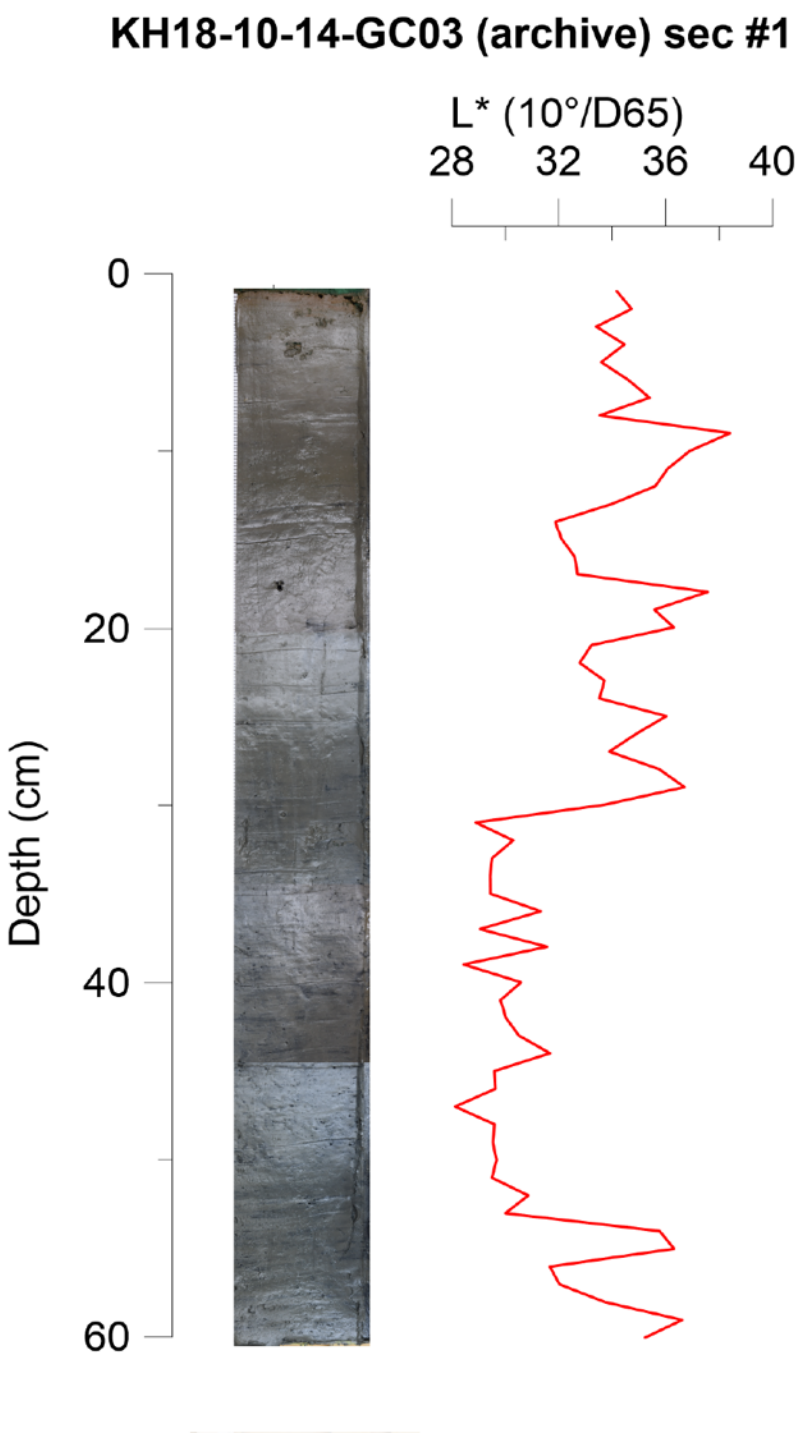


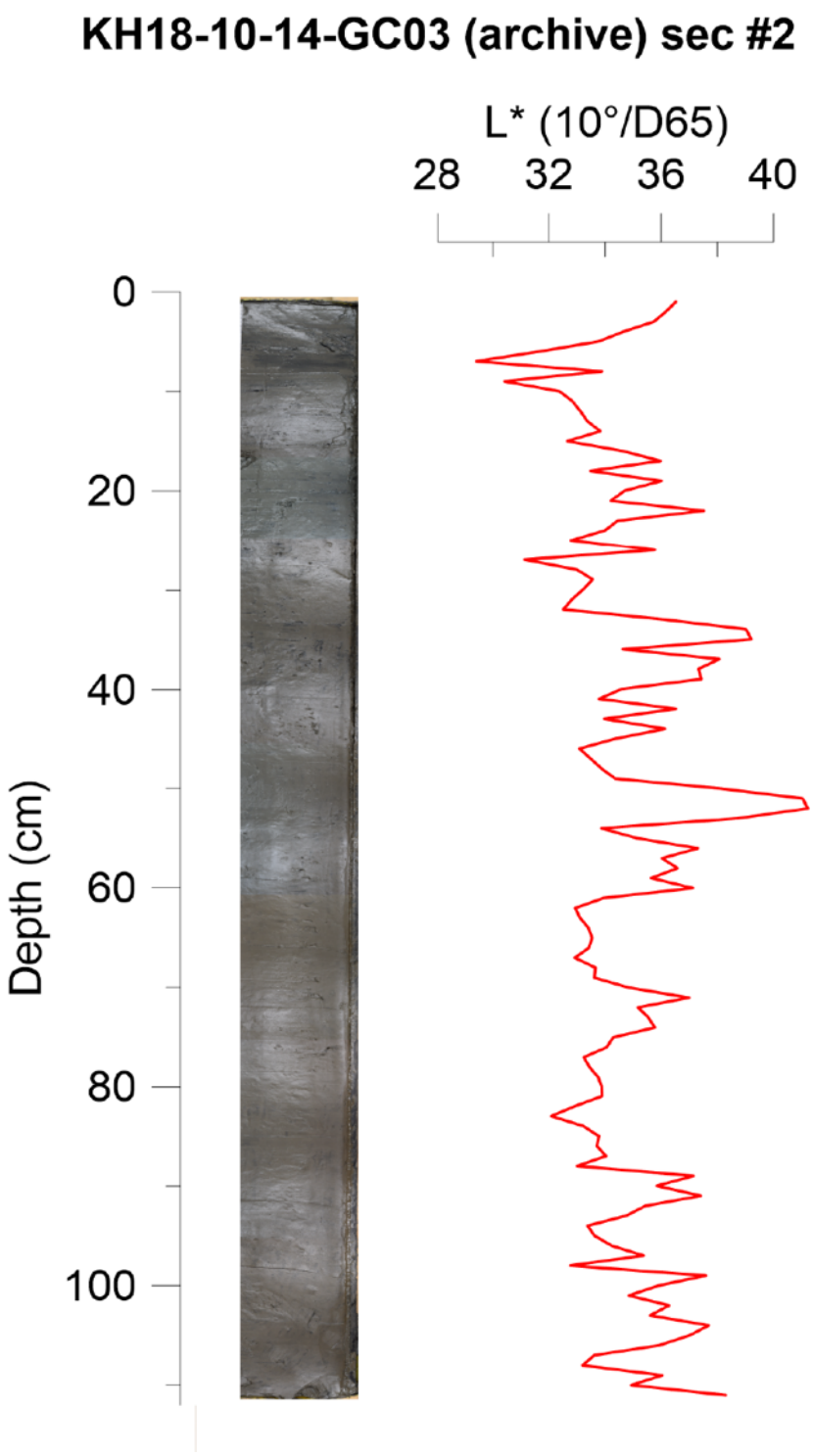
<u>Core code: KH18-10-14-GC03a</u>

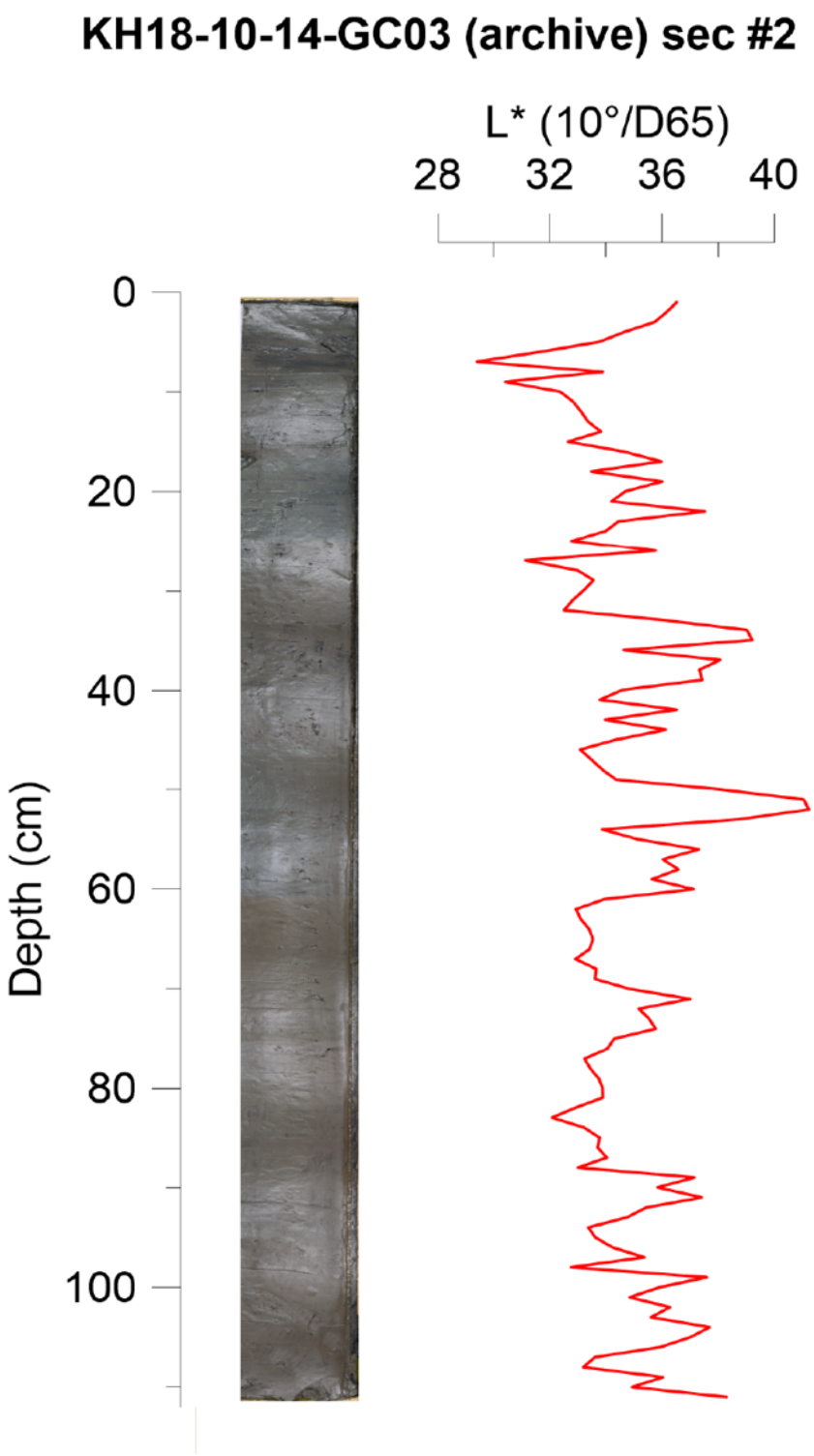
Core sampling method: gravity core

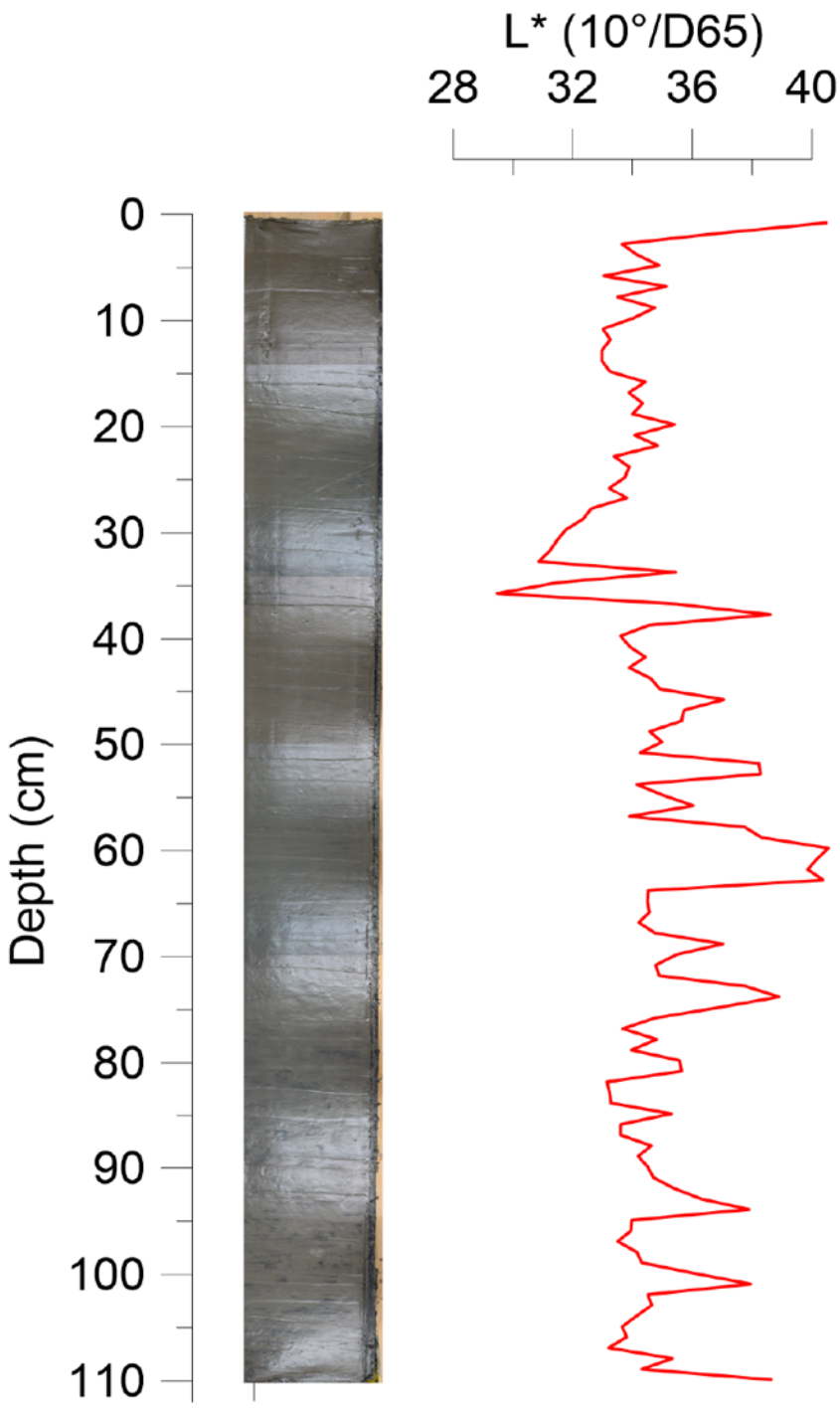
Sediment description:

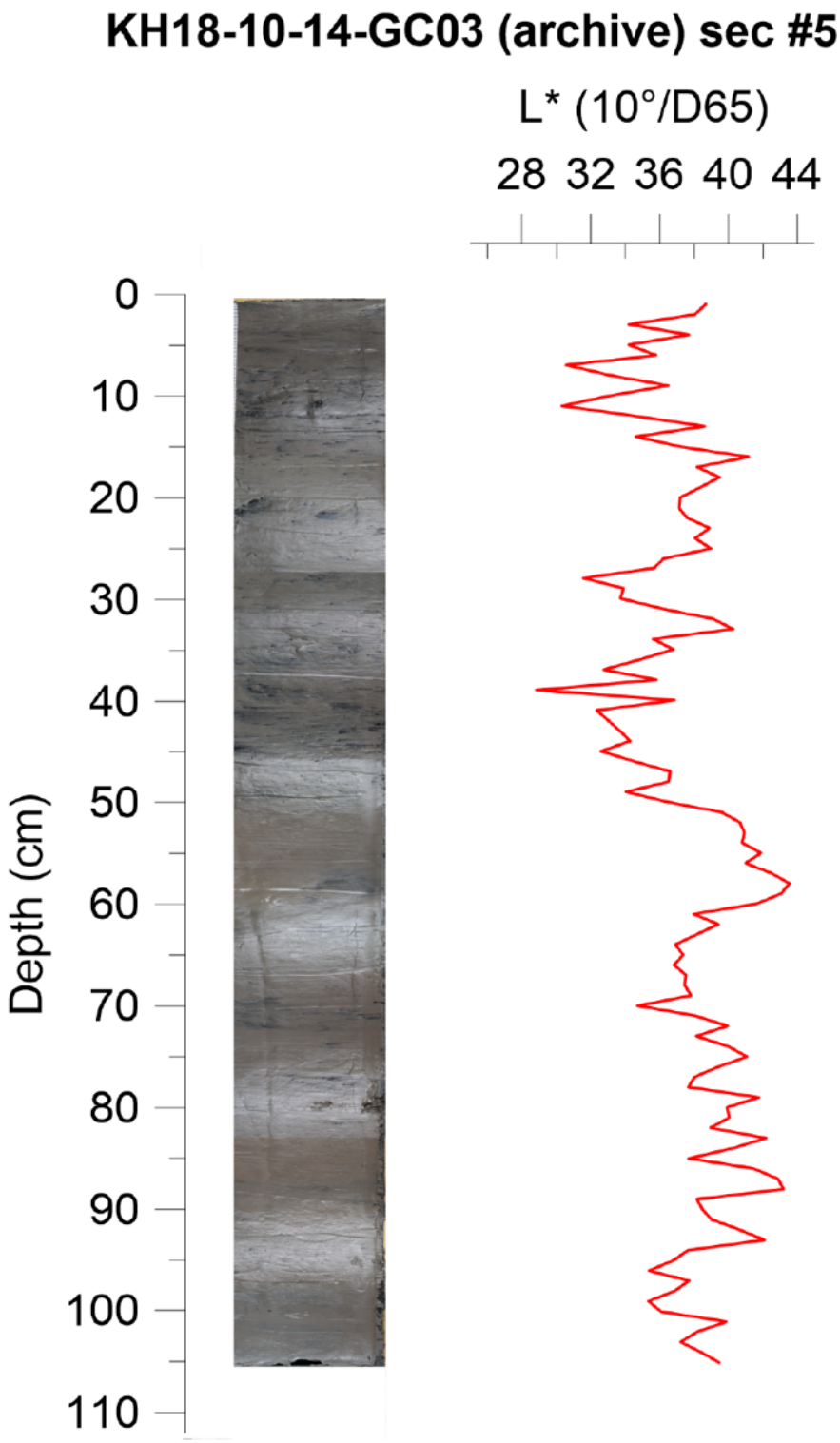
Sediment core KH18-10-14-GC03a (499 cm) consists of one unit of relatively homogeneous grey clay rich mud with some black (sulphide) mottling, burrows and shell fragments. Some parts are more mottled than others.


KH18-10-14-GC03 (archive) sec #1
L* (10°/D65)
28
32
36
40
0
20
40
60
Depth (cm)

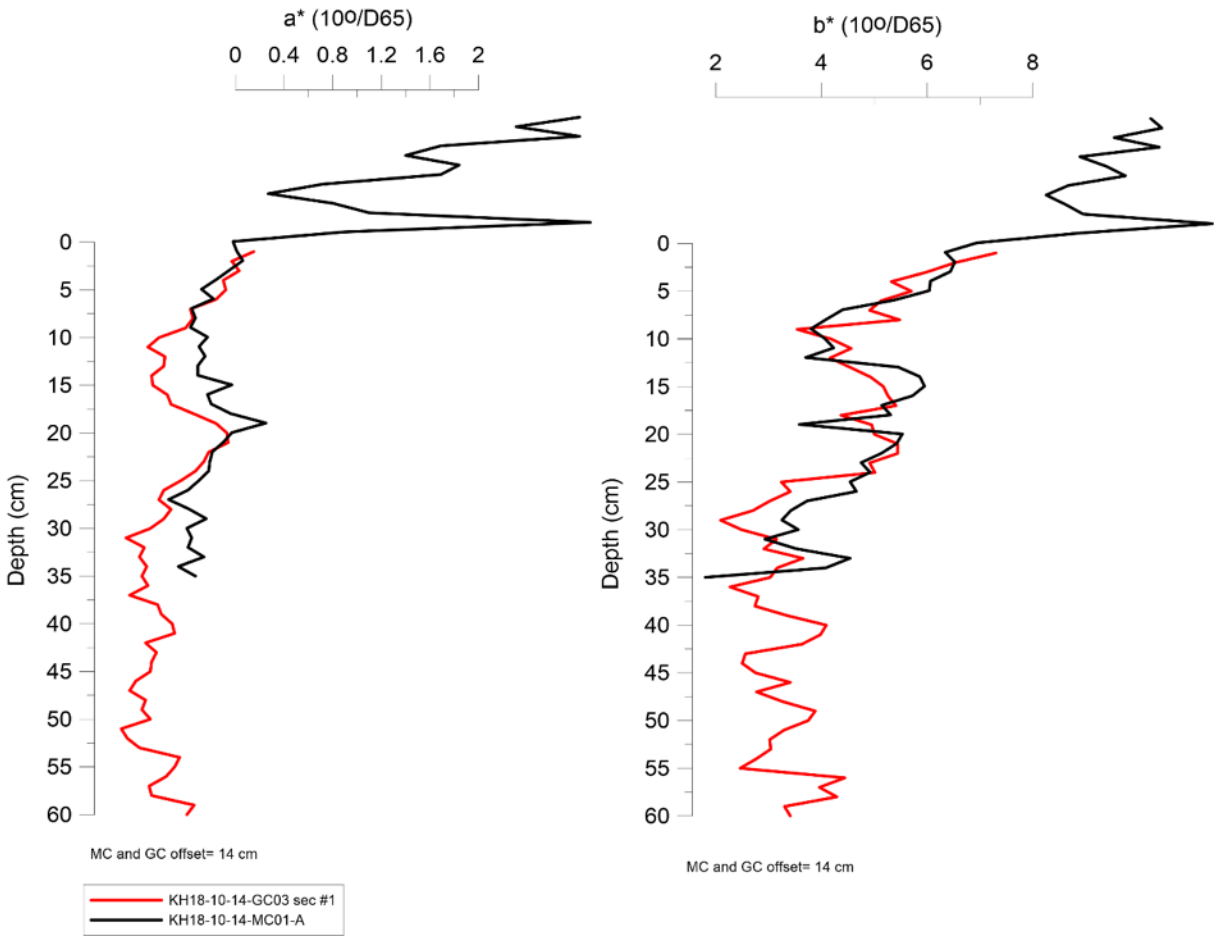

KH18-10-14-GC03 (archive) sec #2
L* (10°/D65)
28
32
36
40
0
20
40
60
80
100
Depth (cm)


KH18-10-14-GC03 (archive) sec #2
L* (10°/D65)
28
32
36
40
0
20
40
60
80
100
Depth (cm)


KH18-10-14-GC03 (archive) sec #4
L* (10°/D65)
28
32
36
40
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
110


KH18-10-14-GC03 (archive) sec #5
L* (10°/D65)
28 32 36 40 44
Depth (cm)
0
10
20
30
40
50
60
70
80
90
100
110

Comparison between multicore and gravity core colour results:



Station: NPAL15 (P6)

Latitude: 81.5707°N

Longitude: 31.6144°E

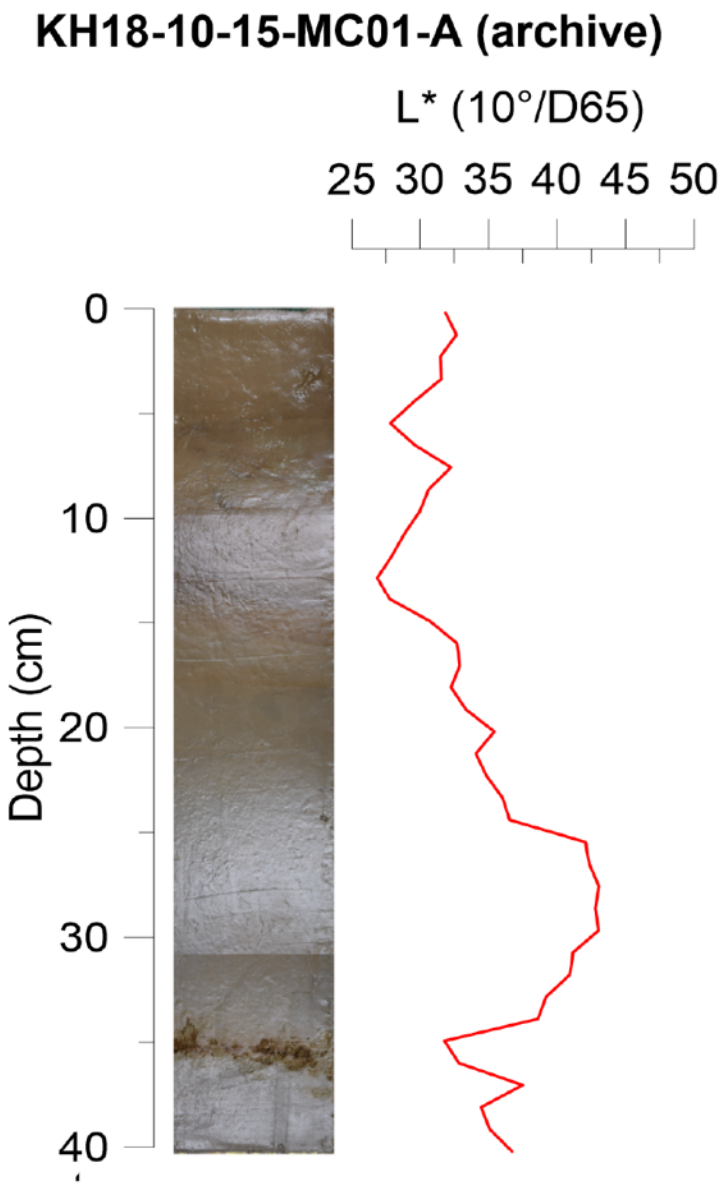
Water depth: 859 m

Core code: KH18-10-15-MC01A

Core sampling method: multicore

Sediment description:

Sediment core KH18-10-15-MC01a consists (40 cm) of two units. Unit 1 (0-13 cm) consists of brown organic beds with a 1 cm thick dark brown bed at the bottom with a clear and undulating lower boundary. Unit 2 (13-40 cm)) is characterized by a gradual transition in the upper part (16-22 cm) from light brown to grey. A dark brown silty sand bed is found at 35 cm.



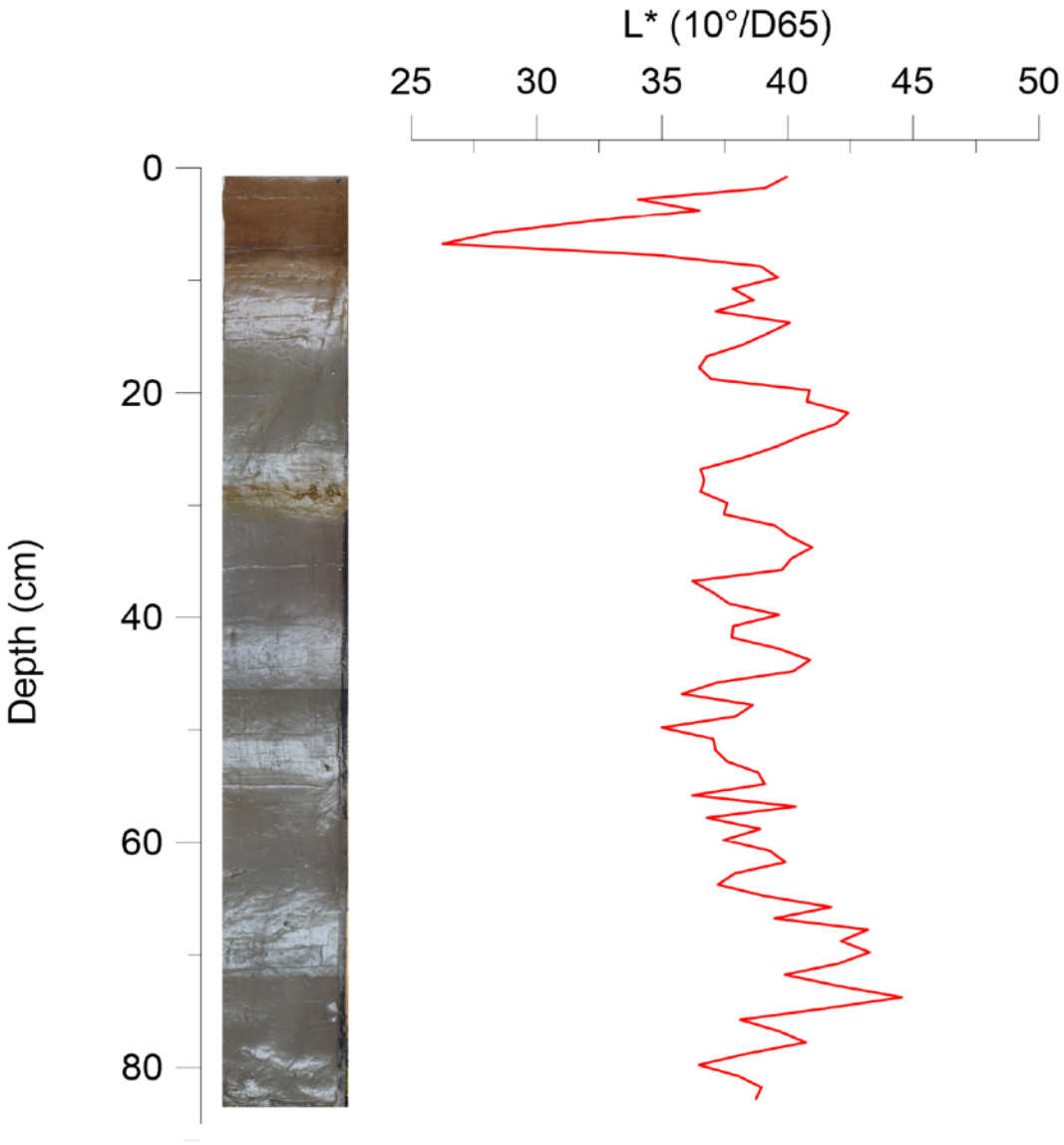
Core code: KH18-10-15-GC02a

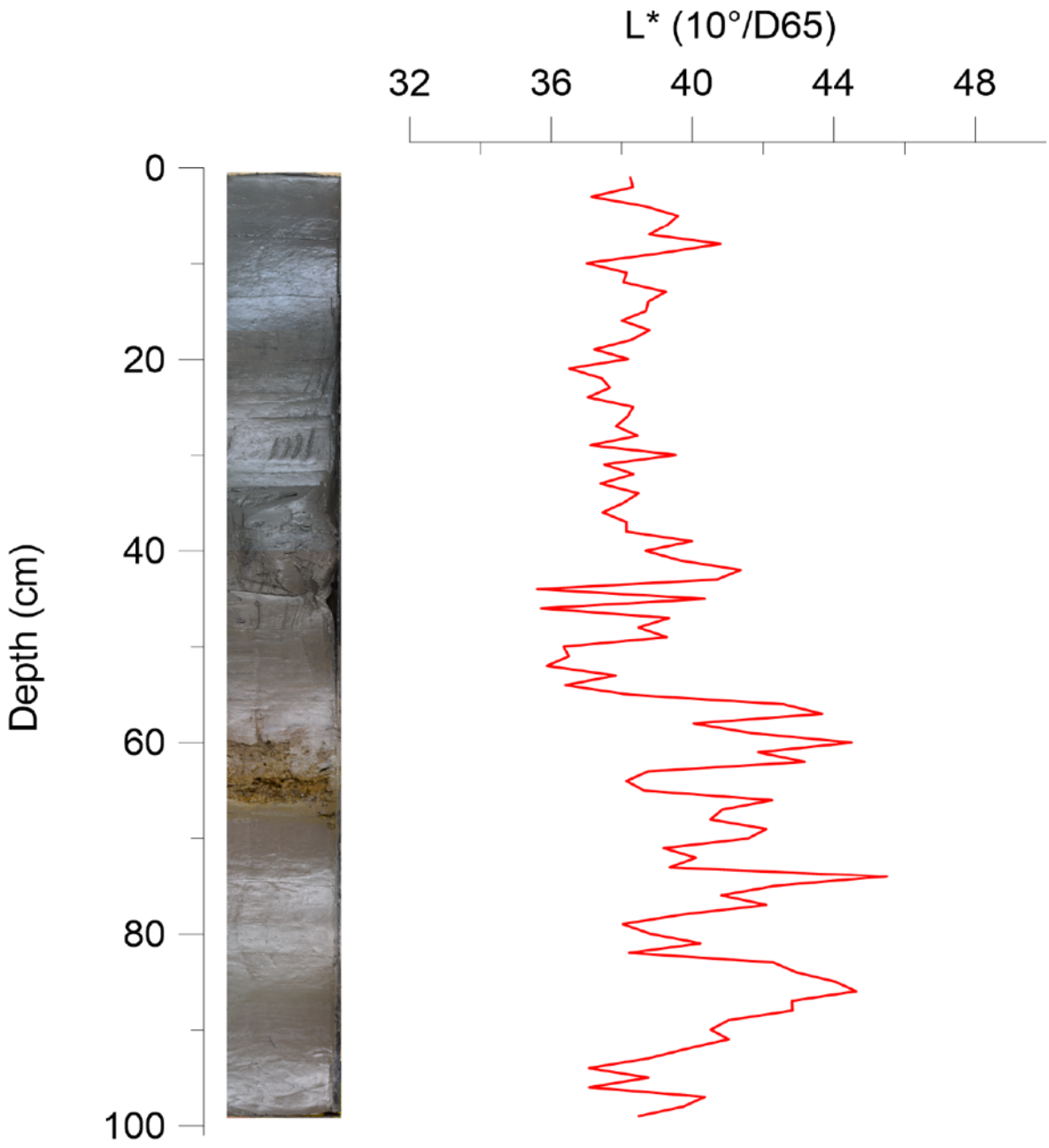
Core sampling method: gravity core

Sediment description:

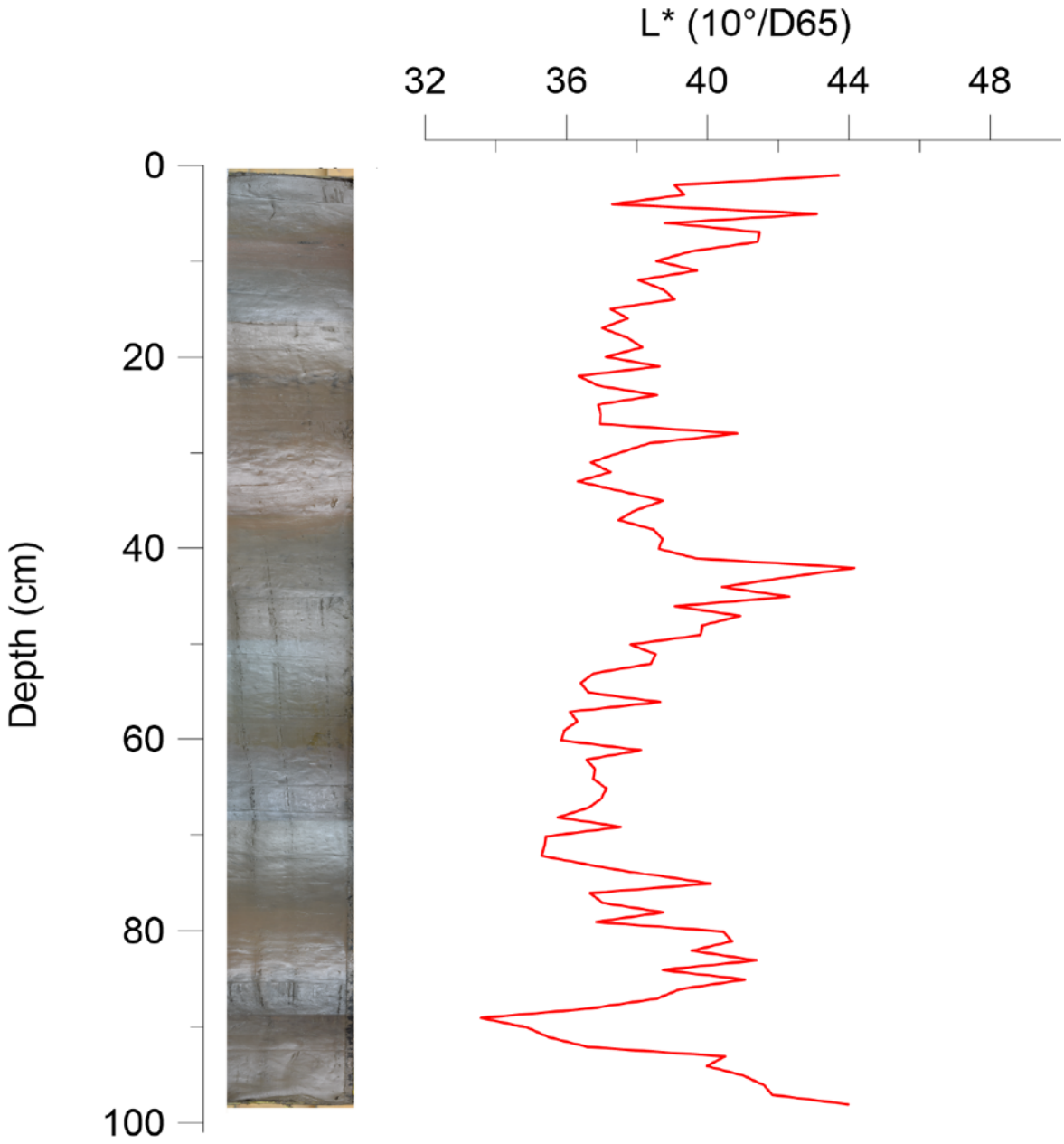
Sediment core KH18-10-15-GC02a consists of two units. Unit 1 (0-189 cm) consists of relatively homogeneous and grey clay rich mud. Organic brown and light brown beds are observed in the upper 69 cm. Minor black (sulphide) mottling and some bioturbation. A large drop stone is found between 36-44 cm and a bed of orange brown gravel bed is found between 64-67 cm. Unit 2 (189-382 cm) consists of mainly clay rich mud and is laminated. Pink, grey and olive green beds and laminas are found alternating throughout the unit. The boundary between each bed is gradual. The lamination becomes more frequent between 295 and 382 cm. A pink sandy bed with a drop stone is found between 43-51 cm. No pink beds are observed in the lower 55 cm.

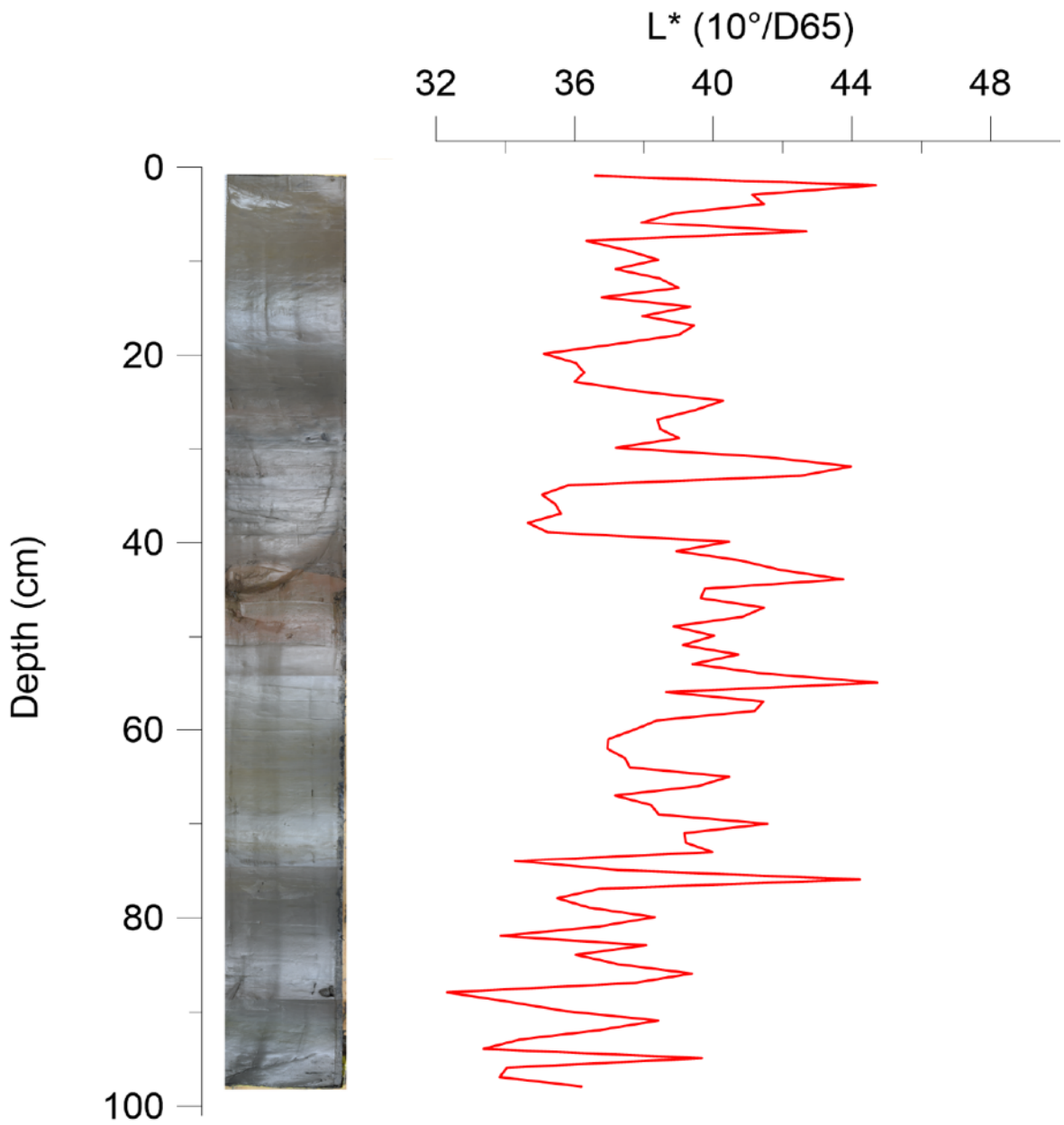
KH18-10-15-GC02 (archive) sec # 1



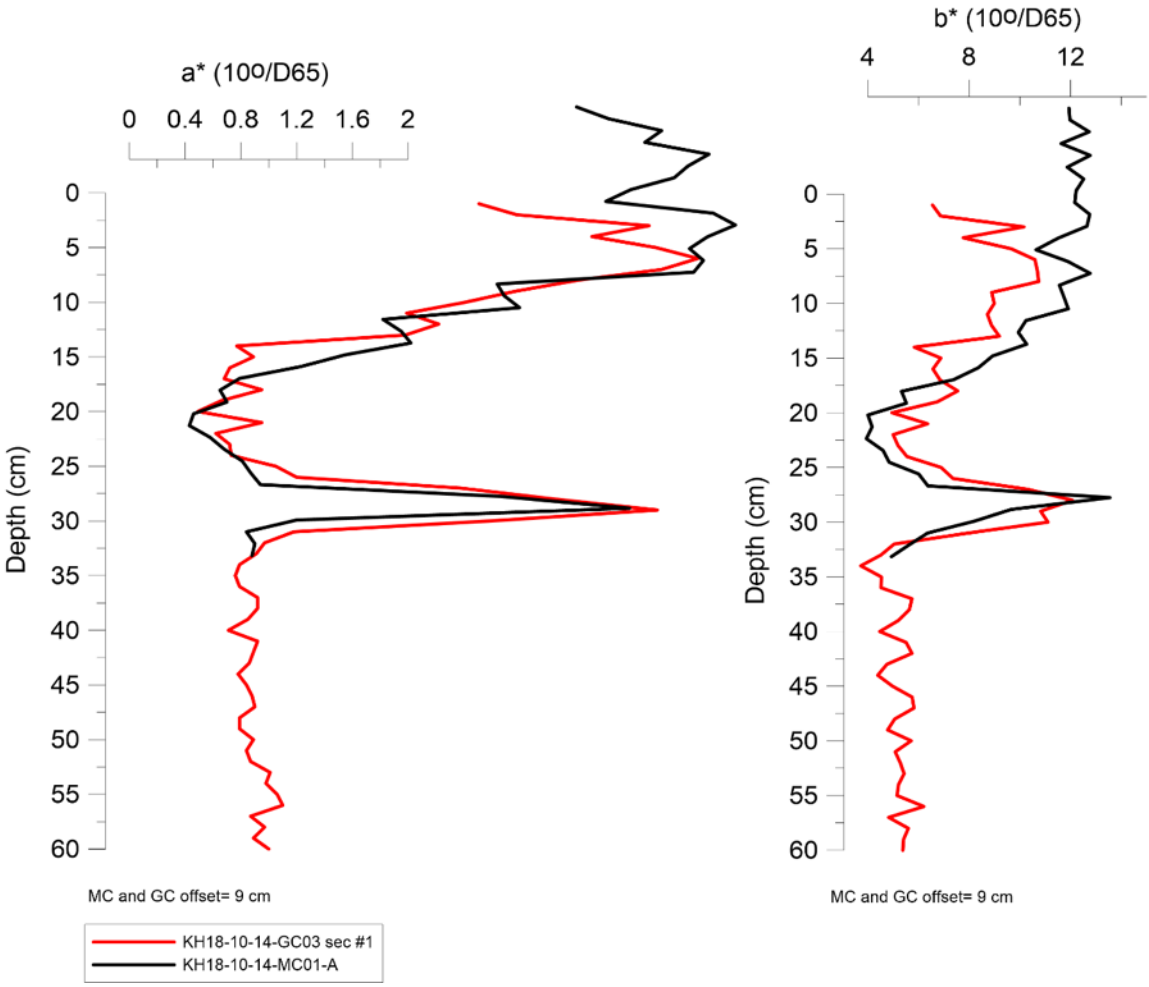

KH18-10-15-GC02 (archive) sec # 2
L* (10°/D65)
32
36
40
44
48
Depth (cm)
0
20
40
60
80
100

KH18-10-15-GC02 (archive) sec # 3




KH18-10-15-GC02 (archive) sec # 4
L* (10°/D65)
32
36
40
44
48
0
20
40
60
80
100
Depth (cm)

Comparison between multicore and gravity core colour results:



Station: NPAL17 (PICE)

Latitude: 83.2716 °N

Longitude: 30.9481 °E

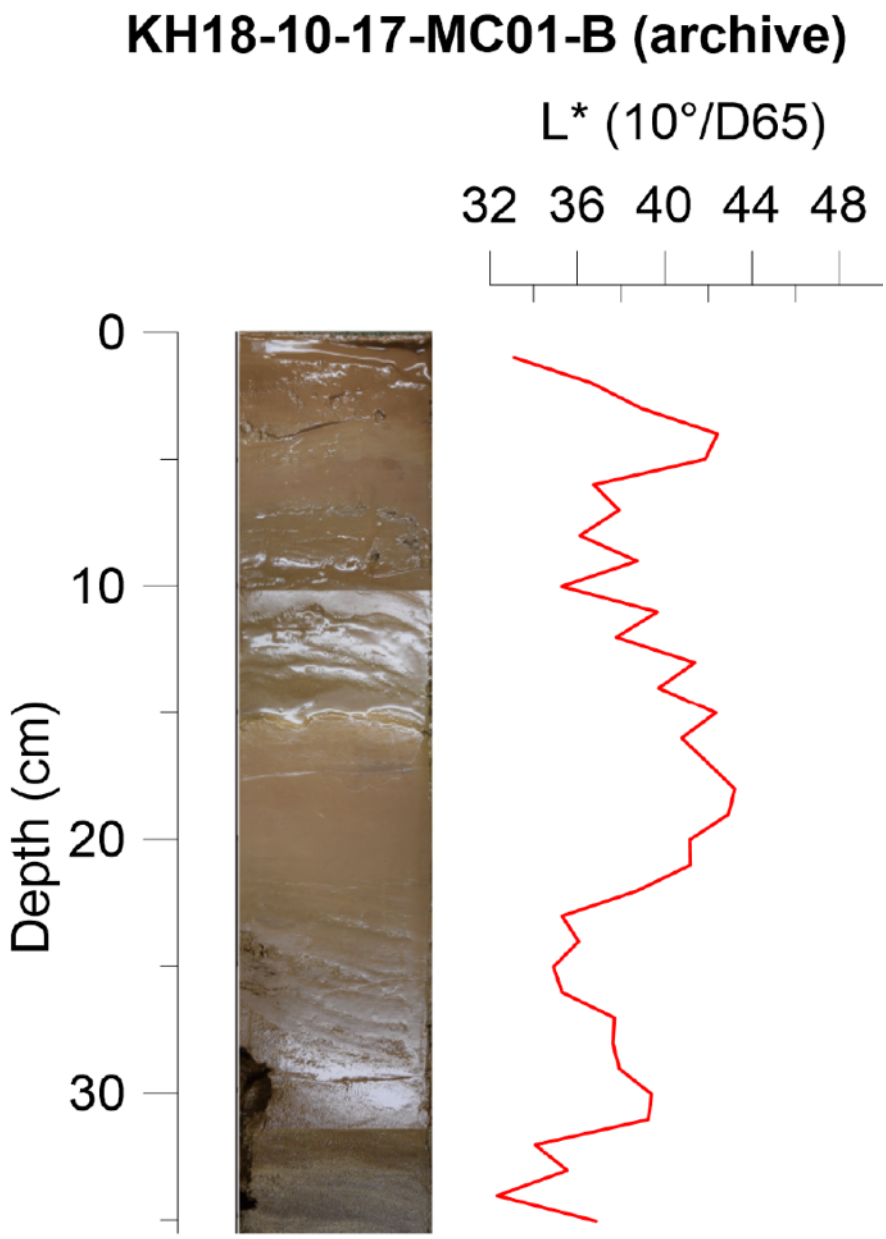
Water depth: 3896 m

Core code: KH18-10-17-MC01B

Core sampling method: multicore

Sediment description:

Sediment core KH18-10-17-MC01Ba (36 cm) consists of three units. Unit 1 (0-15 cm) is characterized by brown grey mud with some browner beds. The unit has a clear lower boundary. Unit 2 (15-29 cm) consists of light brown clay rich mud with a 0.5 cm thin (planktic foraminifera rich) sandy layer with clear upper boundaries at the top of the unit. Unit 3 (29-36 cm) is light brown fining upward muddy sand (foraminiferal ooze).



Summary comments on sedimentology:

Lithologically nearly all sites were clay rich and biogenic poor consistent with significant contribution from glaciogenic derived fine (clay) as well as the coarser (silt, sand, clasts) components. The exception was PICE (KH18-10-17) where foraminferal ooze was present in sections of the core.

The correlations done of colour variations between multi and gravity cores from the same site (see examples given for NPAL14 and NPAL15) demonstrates the good intra-station overlap achieved between the multi and gravity cores. However, there were indications that as much as 9cm (or more) was missing from the gravity core tops. Pore water isotope data (see isotope section) also confirm the good overlap achieved in recovery between the multi and gravity cores as both have similar (overlapping) pore water profiles with depth once the minor sediment loss during gravity coring is accounted for. The ability to correlate with optical properties is encouraging with regard to postcruise work when multiple cores will be analysed at different institutions. In order to achieve a common chronostratigraphy between the cores, as many different physical and optical parameters as possible

should be analysed on each core before sampling is initiated. Although the color parameters (cf a* and b*) are generally highly correlated between gravity and multi-cores, not all details are identical

1.1.3. RF1. CTD casts

During the cruise 21 CTD casts were carried out. The purpose was to collect data on the water masses (e.g. temperature), water samples and obtain sound velocity profiles in the water column for the bathymetric and sub bottom profiling.

1.1.4. RF1. Water sampling and stable isotope measurements

Water samples were taken for stable isotope analyses (δD, $\delta^{18}O$, and $\delta^{13}C_{DIC}$) from both CTD bottles and sediment pore waters (see water sample protocols). Samples were preserved for shore-based analysis at FARLAB (UiB). In addition water isotopes (δD, $\delta^{18}O$) and carbon isotopes of DIC ($\delta^{13}C_{DIC}$) were analyzed onboard using Picarro 2140-i and a Delta Ray and URI Connect, respectively. The analyzers, supplied by FARLAB (UiB), were run continuously and provided near real-time water column and sediment pore water isotope information. The acquisition of isotope data at sea turned out to be extremely valuable. Real time results allowed the shipboard scientists to identify the novel and unexpectedly low pore water carbon isotope values present at many sites. The low values were achieved quite shallow in the sediment and are difficult to explain by aerobic respiration of organic matter alone. A new sampling plan was created for retrieving and analyzing pore water isotopes. Overall the precision was excellent and rivalled that typically achieved in fixed laboratories (e.g. overall ⩽0.1 ‰ 1-σ of standard replicates with better intra-run precision achieved for $\delta^{13}C_{DIC}$). Despite the excellent results, duplicate samples were also taken for shore-based analyses for comparison. These will allow us to assess the precision and accuracy of results achieved shipboard versus those achieved in a fixed laboratory.

Samples were also taken for shore-based analysis of DIC concentration at most stations where plankton towing was carried out (see Table 4). Waters were generally sampled at regular intervals in the upper water column (e.g. 5m, 25m, 50m, 100m, 150m, 200m, 300m) with additional samples taken to resolve key features both in the upper water column (0-300m) and for deeper water masses.

Station name	CTD file name	Date / Time (UTC)	Location	Lat. [N] Long. [E]	Water depth [m]	CTD	$\delta^{13}C_{DIC}$ $\delta^{18}O$, δD (UiB)	Nutrients (ChAOS)	DIC (UiT)	Qty of bottles
NPAL01/M4	162	2018-09-27 23:56	SE of Edgeøya	77.2686° 24.4067°	70.27	X	X			5
NPAL02/ARGO	163	2018-09-28 11:49	Olga Basin	77.9985° 30.0009°	287.8	X	X			10
NPAL03/M3	164	2018-09-28 15:01	Olga Basin	77.8677° 31.7146°	200.65	X				0
NPAL04	165	2018-09-28 17:27	Olga Strait S	77.9110° 31.2942°	231.86	X				0
NPAL05	166	2018-09-29 13:16	Olga Basin NE	78.7692° 33.9906°	301.03	X	X	X	X	9
NPAL06	167	2018-09-30 01:37	SE Kvitøya, NE Eric Ericssen Strait	79.6467° 34.2331°	347.9	X				0

NPAL07	168	2018-09-30 12:57	SE Kvitøya	79.6788° 33.8139°	353.42	X	X	X	X	10
NPAL08	169	2018-10-02 06:44	SW Kvitøya-NE Eric Ericssen Strait	79.5859° 31.9045°	363.14	X	X	X	X	8
NPAL11	170	2018-10-03 11:17	SW Kvitøya-NE Eric Ericssen Strait (mooring station)	79.6789° 32.3196°	356.94	X				0
NPAL12	171	2018-10-04 06:38	SE Nordaustlandet-Kvitøya trough S	79.4709° 28.5317°	328.35	X	X			9
NPAL13/M1	172	2018-10-05 06:31	SE Nordaustlandet-Kvitøya trough S	79.5893° 28.0975°	258.4	X				0
99	173	2018-10-05 20:56	Kvitøya trough basin	80.7004° 28.8032°	499.44	X				0
NPAL14	174	2018-10-07 06:14	Kvitøya trough basin	80.6879° 28.9513°	552.09	X	X	X	X	10
P6 (NLEG21)	175	2018-10-07 17:44	Slope north of Kvitøya trough	81.5386° 30.6835°	964.24	X				0
NPAL15	176	2018-10-07 07:05	Slope north of Kvitøya trough	81.5707° 31.6146°	873	X	X	X		12
NPAL16	177	2018-10-10 16:48	Nansen Basin; Basin N of Kvitøya trough mouth fan	81.9999° 30°	3278.37	X	X	X	X	12
NPAL17	178	2018-10-11 14:39	Nansen Basin; P ICE	83.2737° 30.9512°	3894.13	X	X	X	X	11 (bottle #10 empty)
NPAL19	179	2018-10-15 20:08	Nansen Basin west; contourite 3000m station	81.9292°2 7.5191°	3284.55	X	X		X	12

Table 4. Table showing CTD casts and water sampling during the Nansen paleo cruise.

1.1.5. RF1. Mooring work at the Nansen Legacy Paleo Cruise

We have deployed four moorings and recovered one (Table 5). The deployment were scheduled to take place this summer. Due to cancellation of the first NL cruise this was the first opportunity to deploy these mooring that we hope will be useful for RF1. The recovery was of the AEN/UNIS mooring YP3.

ID	Latitude	Longitude
M1	79,5930N	28,1000E
M2	79,6790N	32,3300E
M3	79,8700N	31,7000E
M4	77,2690N	24,4100E

Table 5. Deployment sites.

The deployed moorings were two concrete and aluminium pyramids that we hope will be more trawl proof than a traditional mooring and also two traditional moorings north of the most popular fishing area.

All moorings have an acoustic release so they should be recovered without the help of an ROV. They were lowered down and released on the seafloor with the help of and winch and an extra acoustic release. The instruments are programmed for a 15 months deployment, but most have capacity for a longer period of time. The recovery is scheduled to take place in November 2019.

The pyramids measure temperature, salinity, water speed and -direction. The traditional moorings measure the same several places and also have ECO fluorometer, nitrate and whale sound recorder. According to the original drawings these moorings should also been equipped with sediment traps, but these were unfortunately delayed and did not make it to this first year of deployment.

All details about these moorings and instrumentation can be found in the Nansen Legacy database. Detailed drawing is also included in Appendix 5 of this cruise report.

The recovered mooring (YP3) were released about 07:58 UTC. Before release we located the mooring with the acoustic release and echo sounder (EK80). Drawing of the mooring and screen shot from EK80 to be found in Figure 3.

The mooring work was performed by Ceslav Czyz and Kristen Fossan from the Norwegian Polar Institute with excellent assistance from the crew of R/V Kronprins Haakon.

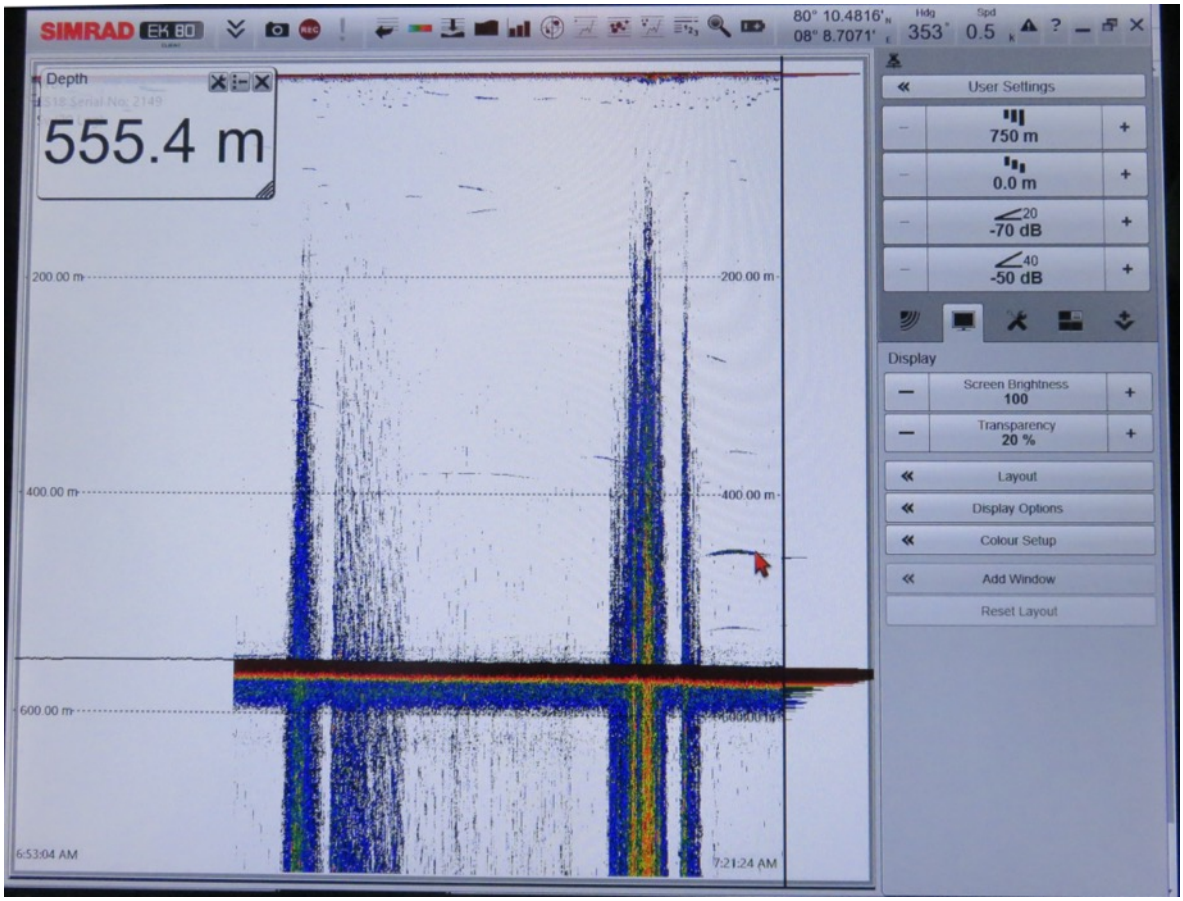


Figure 3. Screen shot from EK80 of mooring rig YP3. Photo Kristen Fossan.

1.1.6. RF2. Planktic foraminifera and pteropods

Plankton nets were cast at paleo stations in a south-north transect (Figure 4) to capture of planktic foraminifera and pteropods for investigations of ocean acidification (RF2). Nets mesh size was

64 µm and cup window mesh size was 90 µm; therefore, planktic organisms larger than 90 µm were collected in each station. WP2 net was used in stations NPAL5, NPAL7, NPAL8, NPAL12 and NPAL14, where samples were collected at four different depth intervals (300-200m, 200-100m, 100-50m, 50-0m). Multinet was used in stations NPAL15, NPAL16, NPAL17 and NPAL19, and at those stations samples were collected at 5 different depth intervals (300-200m, 200-150m, 150-100m, 100-50m, 50-0m).

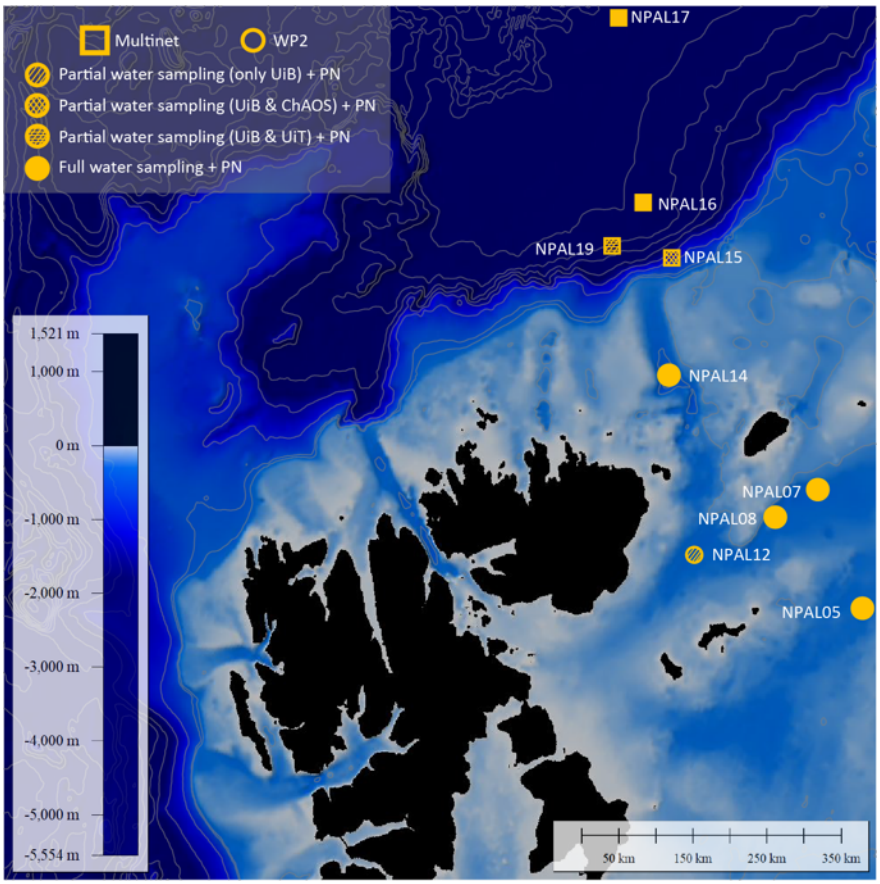


Figure 4. Plankton net (PN) stations indicating the type of water sampling carried out in each site. UiB sampling = water sampled for $\delta^{13}C_{DIC}$ $\delta^{18}O$, δD , ChAOS sampling = water sampled for nutrients; UiT sampling = water sampled for DIC. Map by Tom Arne Rydningen and Naima El bani Altuna.

After collection, the volume of the samples was reduced using a 64 µm sieve. The material was put together using water from the CTD at the respective station from 300-400 m depth. Samples were preserved in 96% ethanol buffered with hexamethyltetramine and kept in the cooling room at ~4°C. Planktic foraminifera and pteropods were not isolated from the samples due to time constraints. Samples collected at NPAL17 were photograph on board (Figure5).

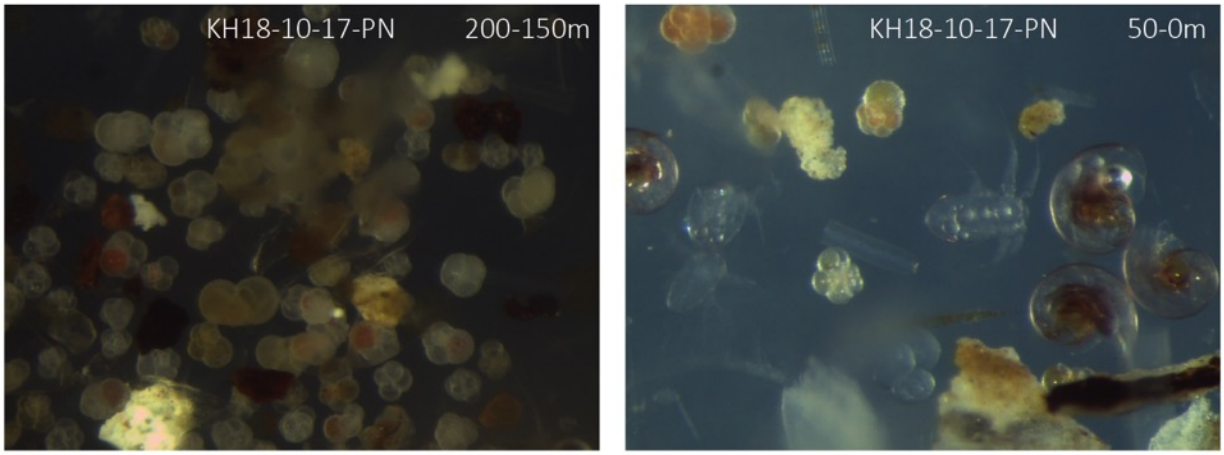


Figure 5. Micrographs of two water sample KH18-10-17-PN taken onboard. In station NPAL17, planktic foraminifera were observed in every depth interval and pteropods were present in samples 100-50m and 50-0m. Photos: Naima El bani Altuna.

1.1.7. RF3. Living (stained) and fossil benthic foraminifera

Sampling stations

Four multicores were collected at each of 9 stations (including one underneath sea ice, NPAL17); one core for paleoreconstructions (last 2 kyrs) and 3 replicate cores for study of live (stained) benthic foraminifera (Table 6). The samples will be processed and analyzed at UiO (benthic foraminifera) and UiT (planktonic foraminifera). A few additional samples were examined on board during the cruise (see preliminary observations). For GPS coordinates, water depth, and general description of sediment cores, see 7. Most sediment surfaces were horizontal. The exceptions were two cores from NPAL 04 (MC2-B and MC3-A), two cores from NPAL12 (MC2-D and MC1-C), and two cores from NPAL15 (MC2-D and MC2-A), with slight slope differences (less than 3 cm). The weather was challenging while sampling and slicing at station NPAL07 (waves on the deck). As a result, subsequent cores were sliced in the hangar deck. Pictures of sediment surfaces and noticeable biota and sediment surface characteristics are shown in Appendix 3. pH was also measured of each sub-layer for most of the rose Bengal stained samples (0-10 cm) – and one other core, KH18-10-14-MC3-D (**Figure 6.**6).

Station name	rB stained samples (0-4 cm)	rB stained samples (0-10 cm)	Paleo-core (0-40 cm)
NPAL04	MC3-A & MC2-C	MC2-B	MC3-C (0-39 cm)
NPAL05	MC2-A & MC1-A	MC2-D	MC2-B
NPAL07	MC1-C & MC2-D	MC2-C	MC2-A
NPAL08	MC2-C & MC3-C	MC2-B	MC1-D
NPAL12	MC1-B & MC1-C	MC2-D	MC2-A
NPAL14	MC3-A & MC1-B	MC3-B	MC2-B
NPAL15	MC2-D* & MC2-A	MC3-B	MC1-C (lost 15-16 cm)
NPAL17	MC3-B & MC1-D	MC3-D	MC3-C (0-26 cm)
NPAL19	MC2-C & MC2-D	MC1-C	MC1-A

Table 6. Sampling stations with core names. rB = rose Bengal. * = Due to irregular surface, sample 0-1 cm contained almost 1.5 cm slice, and sample 1-2 cm contained 0.5 cm.

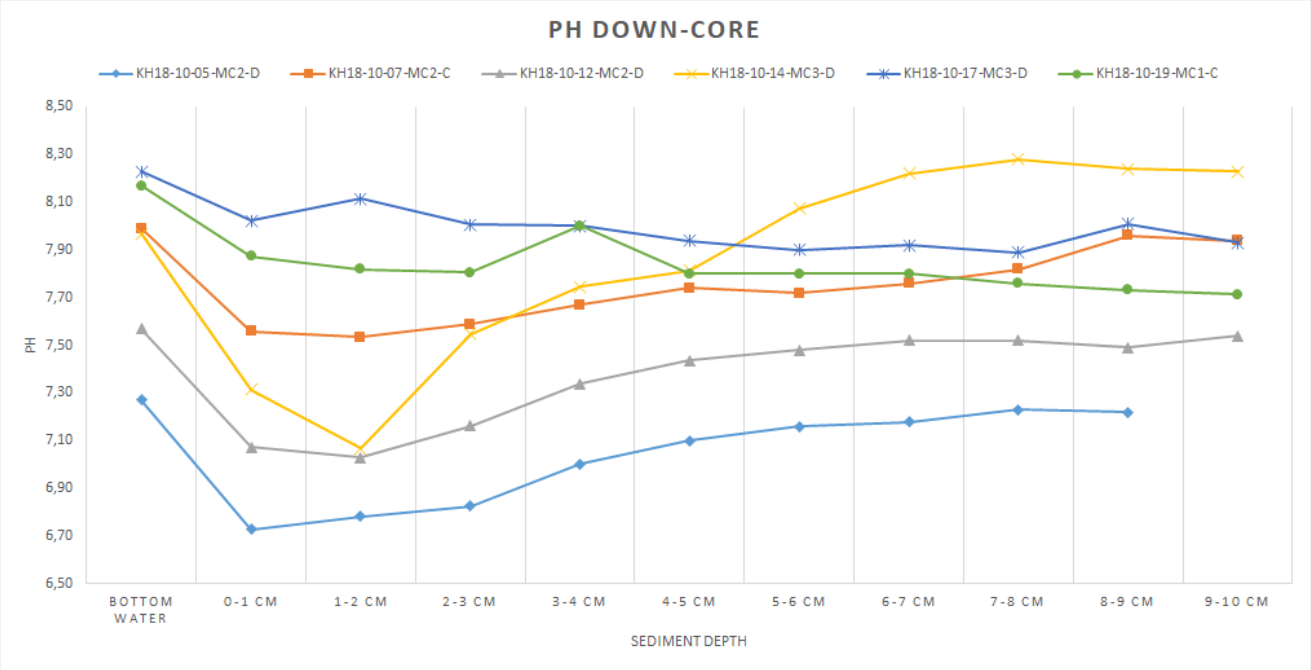


Figure 6. pH down-core of rose Bengal stained cores, 0-10 cm (KH18-10-05-MC2-D; KH18-10-07-MC2-C; KH18-10-12-MC2-D; KH18-10-17-MC3-D; KH18-10-19-MC1-C) and of core KH18-10-14-MC3-D.

Station name	Decimal Latitude	Decimal Longitude	Water Depth (m)	General description
NPAL04	77.9109	31.2962	232	Brown mud that gradually becomes grayer down-core. Polychaete tubes observed down to 40 cm depth (paleo-core). Some tubes were > 15 cm long. Some alive. Black mottles and iron oxides present.
NPAL05	78.7679	33.9855	301	Similar to NPAL04. Large living polychaete at 13 cm depth of MC2-A. Small gastropod at sediment surface of MC2-B.
NPAL07	79.6788	33.8129	353	Similar to NPAL04, but developed a milky-white layer at the sediment-water interface as we started extruding the sediment. Brittle star (c. 10 cm) in surface sediment of MC2-C.
NPAL08	79.5865	31.9017	365	Similar to the previous station with development of a milky-white layer at the sediment-water interface. Brittle star (c. 2 cm) on sediment surface of MC2-B and branching bryozoan (c. 0.5 cm) on the sediment surface of MC1-D.

NPAL12	79.4709	28.5316	329	Similar to previous stations, but generally fewer polychaete tubes and iron oxides. Milky-white layer at the sediment-water interface. Starfish (c. 1 cm) on sediment surface of MC1-C.
NPAL14	80.6879	28.9509	552	Similar to previous stations, but with no milky-white layer or iron oxides. Sediment surfaces generally get grayer at a shallower depth and are "soupier". Almost no polychaete tubes, but larger alive polychaetes (at 3-4 cm depth in core MC1-B). Strong H_2S-smell at 3-4 cm depth in core MC3-A.
NPAL15	81.5707	31.6144	859	More olive-green/brown mud and very "soupy". Less/no polychaete tubes. Many small sponge spicules. Starfish (c. 0.5 cm) and crustaceans on surface sediment of MC3-B. Starfish (c. 0.5 cm) and 3-4 sponges (c. 0.5 cm) on surface, and gravel pocket at 34-38 cm in core MC1-C.
NPAL17	83.2716	30.9481	3896	Medium brown mud. No sign of macro-benthos. Sand-sized particles on surfaces. Sand layer from 15-20 cm in core MC3-C.
NPAL19	81.9292	27.5191	3283	Pale brown mud. Some polychaete tubes. Transparent sea snail? (1-2 cm) on surface sediment. Sand layer from 25-29 cm and gravel at 32-33 cm of core MC1-A.

Table 7. Sampling stations with general description of the sediment cores. GPS coordinates and water depth are based on MC1.

1.1.8. RA-B. Data management and sample logging

Labelling and sample log

During the cruise the Nansen Legacy labelling system has been used. Based on the use of unique unique identifiers (UUIDs) in the form of Data Matrix codes (or QR codes) and an Excel sheet, based on a template generator, all the samples collected during the cruise have been logged. An offline version of the sampling database, running on a virtual server on the ship, was used to import and check the data. After the cruise, the sample log will be collected in a database on SIOS, available at: https://sios.metsis.met.no/reports/aen_multi

As in the August (2018707) cruise labelling of the samples has worked well, with most challenges solved. Similarly to the August cruise, marking of plastic bags intended for storage in -20 °C was a challenge. New labels intended to solve the issue were brought on the cruise, but these labels were not any better and some fell off in the freezer. The small 10 mm labels were used to mark samples

with supplementary labels and worked mostly ok for this. Around 5 000 samples have been marked with labels.

During the cruise individual gear cast were assigned IDs and logged by me. Most of the information logged came from the cruise logger with the UUIDs either generated or in the case of the CTD w/bottles, scanned from the A4 gear sheets. This log was then read into the database on the ship (running on a Nansen Legacy virtual machine) and the cruise participants could then access the log though a web page, giving them access to the parent IDs. Additionally, the cruise leader logged the individual cores. This included the multicore, gravity core and piston core sections, and the archive and work halves of the sections. These were also read into the database, making them searchable by the cruise participants.

Use of the Excel sheet for logging the samples worked well, and the reduced number of fields that the participants needed to fill out improved the work load.

For the open water stations, the station names used were NPAL01...NPAL20 (NPAL15 (P6) for stations with multiple names). These station names are not exactly the same as the stations in Nansen Legacy, but this was mostly due to their location being close by, but not on the Nansen Legacy stations.

When labelling cores, it was found convenient to print multiple labels with the same UUIDs and text. The duplicates were used to label both the core (on the plastic pipe) and the box for storing the core in, removing the need to open the box to scan or identify the core. In addition to the label, all the cores, sections and samples were marked by hand using permanent markers. This was both for redundancy and because sticking labels on in wet conditions on the deck did not work.

Data management

Data from the ship is collected in a structured file system designed by IMR. Data from both ship mounted instruments and scientists is placed in this file system. As the system is not directly accessible for the scientist, automated and manual procedures need to be run to make the desired data available to the scientist.

The data from the cruise will go through the official channels where it will be made available for the cruise leader after the cruise. In addition I will take a copy of the work folder with me in case participants have forgot something on it.

Regarding the computer systems on the ship, it is an issue that the ship is divided into different networks. These are separated by firewalls outside of the control of the instrumentation engineers on the ship, as the admins are located at IMR in Bergen. If something happens in the network when the ship is out of range from the IT department at IMR, there are no admins on board who can help with it.

The experience on the ship is that most things work, and the with some help from the instrumentation engineers on the ship solutions can be found.

Virtual Server

The possibility of having a virtual server on KPH was invaluable and it made it possible to keep track of all the samples and gear casts on the ship. It also gave the cruise participants a way of seeing and searching through the samples taken.

1.1.9. ChAOS

Two scientists (Drs. Allyson Tessin and Mark Zindorf) joined the cruise from the Changing Arctic Ocean Seafloor (ChAOS) project, which is funded by the UK National Environmental Research Council. The main goal of ChAOS is to quantify the effect of changing sea ice cover on organic matter quality, benthic biodiversity, biological transformations of carbon and nutrient pools, and resulting ecosystem functioning at the Arctic Ocean seafloor. ChAOS scientists collected samples for sediment and pore water geochemistry to study the amounts and types of organic material at the seafloor of the Barents Sea, the availability of electron acceptors (e.g., nitrate, Fe/Mn oxides, sulphate) for organic matter degradation, the recycling versus burial of nutrients released by organic matter degradation, and the interactions of sediment and pore water geochemistry with biological processes (e.g., bioturbation, microbial community structures).

Priority sites for the ChAOS project were Nansen sites on the shelf at depths 300-500 m that are near to the ChAOS transect at 30°E longitude. The primary ChAOS sites were chosed based on available sediment distribution maps of the Barents Sea, with the aim to sample settings with mainly muddy sediment for optimal recovery. In the Barents Sea, muddy sediments are prevalent within the deeper (~300-500 m) troughs carved by ice streams of the Eurasian ice sheet following the Last Glacial Maximum, while the shallower banks are often covered by coarse-grained material due to stronger currents.

CTD and sediment samples were taken at the stations listed below (Table 8). Multicore and gravity core sediment sampling was done at 1 cm intervals. Pore waters were sampled from multicores from the bottom water and then at 0.5 cm, 1.5 cm, 2.5 cm; 2 cm resolution down to 20.5 cm; 25.5 cm, 30.5 cm, 35.5 at all stations except at PAL14, where all samples are shifted by one cm below 1.5 cm. Gravity core pore waters were taken at between 15 and 30 cm resolution. Specific depths chosen were dependent on section breaks. Pore waters were divided for ICP analysis (acidified and stored in cool room), nutrient analysis (frozen), and onboard $d^{13}C$.

Station	CTD nutrients	Multicore	Gravity core	Piston core
PAL04		X	X	
PAL05	X			
PAL07	X			
PAL08	X	X	X	
PAL14	X	X	X	
PAL15	X	X	X	X
PAL16	X			
PAL17	X	X		

Table 8. ChAOS sampling.

3.2. Future work

All future work analysis will be coordinated as sediment cores and samples have to be shared between the research groups. It is the aim of the Nansen Legacy project to obtain an integrated national research effort uniting all involving research groups hence maximizing the scientific output and increase the international impact of the results. Each group has one or more specialty of which they are responsible of (Table 9), yet a coordinated effort is absolutely necessary.

Speciality & analysis	UiT (TLR)	UiO	UiB	NPI	UiT (MF)
AMS 14C	X	X	X	X	X
210Pb	X	X	X	X	X
BF 0 - 2 ka		X			
PF 0 - 2 ka	X				
BF > 2ka	X				
PF > 2ka	X				
BF d18O, d13C 0 - 2 ka		X			
Bulk sediment: org. C, N isotopes		X			
BF d18O, d13C > 2ka			X		
PF d18O, d13C 0 - 2 ka			X		
PF d18O, d13C > 2ka			X		
Water d18O, dD, $d13C_{DIC}$			X		
Mg/Ca			X		
Clumped isotopes			X		
HBIs (eg IP25)				X	
Diatoms				X	
Coccoliths				X	
Trace elements/Ca (not Mg/Ca)	X				
11B	X				
Seafloor and sub-seafloor mapping					X
Physical properties					X
X-radiographs					X
Colour imaging					X
XRF core scanning					X
Lithostratigraphy					X
Granulometry					X
IRD (flux and composition)					X

Table 9. TLR: Tine Rasmussen. MF: Matthias Forwick. BF: Benthic foraminfera. PF: Planktic foraminifera. BF d18O, d13 C: stable isotope analysis ($\delta^{18}O$, $\delta^{13}C$) measured on benthic foraminifera. PF d18O, d13 C: stable isotope analysis ($\delta^{18}O$, $\delta^{13}C$) measured on planktic foraminifera.

1.1.10. RF1.

The cruise has recovered multiple sediment archives for portraying variability within the past ~12,000 years. The transect of core sites is influenced both by Atlantic and Arctic water masses in addition to sea ice conditions ranging from some to extensive sea ice coverage during winter/no to some sea ice during summer. The sediment cores will be analysed for proxies characterizing key components of the system, including a detailed calibration exercise connecting the modern situation with the proxies. The latter detailed calibration is further linked to planned work at RF2 and RF3. In order to obtain robust paleoceanographic records a multidisciplinary and multiproxy approach is necessary. Vårin Eilertsen (Nansen PhD candidate) and the research group led by Matthias Forwick and Tom Arne Rydningen at UiT will map the bathymetry and identify the sedimentary processes of the study area. Marianne Kjøller (Nansen PhD candidate) and the research group at UiO (Elisabeth Alve) will establish records covering the last two millennia using benthic foraminifera (Table xz). This work will be coordinated with planned work within RF3. A third Nansen PhD candidate and the research group led by Tine Rasmussen at UiT will establish paleoceanographic records based on benthic foraminifera

covering the past 2,000-12,000 years and planktic foraminifera from 0 – 12,000 years in connection with RF2 (Table xz). A Nansen post doc and the research group at NPI (Katrine Husum and Arto Miettinen) will establish records of sea ice and sea surface temperatures using diatoms, biomarkers (IP_{25}, HBIs) and coccoliths. These records will be further strengthened by using dinocysts and testing the novel method of using ancient DNA indicative of sea ice algae. These latter two analyses will be led by Stijn de Schepper at UniRES within the project Agensi (A genetic view into past sea ice variability) funded by the EU(??). A second Nansen post doc and the research group at UiB (Ulysses Ninnemann and Eystein Jansen) will establish ocean temperature and salinity records using stable isotopes and trace metals of benthic and planktic foraminifera (Mg/Ca, $\delta^{18}O$). UiB will also use water column and pore water isotopes (d13CDIC, dD, d18O) obtained during the cruise to investigate the geochemistry of carbon cycling (fluxes, storage/turnover) and better characterize processes influencing freshwater in the region.

1.1.11. RF2.

Ocean acidification effects on calcareous planktonic organisms (foraminifera and pteropods) will be investigated by comparing current species composition of planktonic foraminifera and pteropods from plankton tows with the pre-industrial species composition estimated from fossilized assemblages in the sediment and surface sediment. For fossil records (RF1) preservation and species composition of planktonic foraminiferal faunas in relation to natural environmental/climatic changes will be analyzed using the same methods as for living specimens (shell weight and size analyses of juvenile and adult forms, SEM (Scanning Electron Microscope), Micro X-ray Tomography (CT) analyses and a dissolution index that will be calculated based on the degree of shell fragmentation and thickness), adding the relation of preservation to sediment and pore water chemistry (various sedimentological parameters such as sediment content of e.g., CaCO3, Total Organic Carbon, XRF-records of heavy minerals in the sediment and calcium carbonate saturation, pH and content of methane and sulfate in pore water).

1.1.12. RF3.

In RF3 we will characterize living benthic foraminifera in contrasting environments in the northern Barents Sea and adjacent slope in terms of biodiversity (including metabarcoding), abundance, biomass, distribution patterns etc . Environmental characteristics (e.g., water temperate, salinity, and chla, strength of stratification, ice cover and thickness, orgC fluxes, current velocity and direction, oxygen content, nutrient concentrations, pH, light conditions) in addition to water mass distributions will be related to foraminiferal community and trophic structure to identify major drivers along the south-north transect and between seasons. Habitat for benthic foraminiferal species or groups of species will be described and analysed in relation to environmental variation. The results will be used in the interpretation of the fossil assemblages in RF1.

Appendix I: Cruise log and tables

Table A1. Full station table with station locations and gears sampled.

Super station	Station Name	Gear Type	Sediment core #	Decimal Latitude	Decimal Longitude	Bottom Depth (m)	Event Date
01	M4 (NPAL01)	CTD w/bottles		77,2686	24,4067	70	Sept. 27
01	M4 (NPAL01)	RSIP-2		77,2686	24,4067	71	Sept. 28
02	NPAL02	ARGO		77,9985	30,001	288	Sept. 28
02	NPAL02	CTD w/bottles		77,9985	30,0009	288	Sept. 28
03	M3 (NPAL03)	CTD		77,8677	31,7146	201	Sept. 28
03	M3 (NPAL03)	RSIP-1		77,8677	31,7146	201	Sept. 28
04	NPAL04	CTD		77,911	31,2942	232	Sept. 28
04	NPAL04	Multicorer	KH18-10-04-MC1	77,9109	31,2962	232	Sept. 28
04	NPAL04	Multicorer	KH18-10-04-MC2	77,9109	31,2962	232	Sept. 28
04	NPAL04	Multicorer	KH18-10-04-MC3	77,9109	31,2962	232	Sept. 28
04	NPAL04	Gravity Corer	KH18-10-04-GC1	77,9109	31,2962	232	Sept. 28
04	NPAL04	Gravity Corer	KH18-10-04-GC2	77,9109	31,2962	232	Sept. 28
04	NPAL04	Gravity Corer	KH18-10-04-GC3	77,9109	31,2962	232	Sept. 28
04	NPAL04	Gravity Corer	KH18-10-04-GC4	77,9109	31,2962	232	Sept. 28
04	NPAL04	Gravity Corer	KH18-10-04-GC5	77,9109	31,2945	232	Sept. 28
05	NPAL05	CTD w/bottles		78,7692	33,9906	301	Sept. 29
05	NPAL05	WP2		78,7679	33,9856	301	Sept. 29
05	NPAL05	WP2		78,7679	33,9855	301	Sept. 29
05	NPAL05	WP2		78,7679	33,9855	302	Sept. 29
05	NPAL05	WP2		78,7679	33,9856	301	Sept. 29
05	NPAL05	Multicorer	KH18-10-05-MC1	78,7679	33,9855	301	Sept. 29
05	NPAL05	Multicorer	KH18-10-05-MC2	78,768	33,9857	301	Sept. 29
05	NPAL05	Gravity Corer	KH18-10-05-GC1	78,7682	33,9849	302	Sept. 29
05	NPAL05	Gravity Corer	KH18-10-05-GC2	78,7682	33,985	302	Sept. 29
06	NPAL06	CTD		79,6467	34,2331	348	Sept. 30
07	NPAL07	CTD w/bottles		79,6788	33,8139	353	Sept. 30

07	NPAL07	WP2		79,6788	33,8127	353	Sept. 30
07	NPAL07	WP2		79,6788	33,8129	353	Sept. 30
07	NPAL07	WP2		79,6788	33,8128	353	Sept. 30
07	NPAL07	WP2		79,6788	33,8129	353	Sept. 30
07	NPAL07	Multicorer	KH18-10-07-MC1	79,6788	33,8129	353	Sept. 30
07	NPAL07	Multicorer	KH18-10-07-MC2	79,6787	33,8118	353	Sept. 30
07	NPAL07	Gravity Corer	KH18-10-07-GC1	79,6787	33,8112	354	Sept. 30
07	NPAL07	Gravity Corer	KH18-10-07-GC2	79,6787	33,8116	354	Sept. 30
08	NPAL08	CTD w/bottles		79,5859	31,9045	363	Oct. 2
08	NPAL08	WP2		79,5863	31,9023	364	Oct. 2
08	NPAL08	WP2		79,5864	31,9021	364	Oct. 2
08	NPAL08	WP2		79,5865	31,9016	365	Oct. 2
08	NPAL08	WP2		79,5865	31,9016	364	Oct. 2
08	NPAL08	Multicorer	KH18-10-08-MC1	79,5865	31,9017	365	Oct. 2
08	NPAL08	Multicorer	KH18-10-08-MC2	79,5865	31,9017	365	Oct. 2
08	NPAL08	Multicorer	KH18-10-08-MC3	79,5867	31,901	365	Oct. 2
08	NPAL08	Gravity Corer	KH18-10-08-GC1	79,5865	31,9019	364	Oct. 2
08	NPAL08	Gravity Corer	KH18-10-08-GC2	79,5865	31,9018	364	Oct. 2
08	NPAL08	Gravity Corer	KH18-10-08-GC3	79,5865	31,9018	364	Oct. 2
08	NPAL08	Gravity Corer	KH18-10-08-GC4	79,5863	31,9026	363	Oct. 2
09	NPAL09	Gravity Corer	KH18-10-09-GC1	79,543	31,6995	328	Oct. 2
10	NPAL10	Gravity Corer	KH18-10-10-GC1	79,4768	31,2111	296	Oct. 2
10	NPAL10	Gravity Corer	KH18-10-10-GC2	79,4767	31,2106	296	Oct. 2
11	M2 (NPAL11)	CTD		79,6789	32,3196	357	Oct. 3
11	M2 (NPAL11)	Mooring M2		79,6789	32,3196	357	Oct. 3
12	NPAL12	CTD w/bottles		79,4709	28,5317	328	Oct. 4
12	NPAL12	WP2		79,471	28,5317	328	Oct. 4
12	NPAL12	WP2		79,4709	28,5317	328	Oct. 4
12	NPAL12	WP2		79,4709	28,5317	329	Oct. 4
12	NPAL12	WP2		79,471	28,5318	329	Oct. 4
12	NPAL12	Multicorer	KH18-10-12-MC1	79,4709	28,5316	329	Oct. 4
12	NPAL12	Multicorer	KH18-10-12-MC2	79,4709	28,5316	329	Oct. 4
12	NPAL12	Gravity Corer	KH18-10-12-GC1	79,4709	28,5317	329	Oct. 4
12	NPAL12	Gravity Corer	KH18-10-12-GC2	79,4709	28,5316	329	Oct. 4

12	NPAL12	Gravity Corer	KH18-10-12-GC3	79,4708	28,5316	329	Oct. 4
13	M1 (NPAL13)	CTD		79,5893	28,0975	258	Oct. 5
13	M1 (NPAL13)	Mooring M1		79,5894	28,0975	259	Oct. 5
	99	CTD		80,7004	28,8032	499	Oct. 5
14	NPAL14	Multicorer	KH18-10-14-MC1	80,6879	28,9509	552	Oct. 6
14	NPAL14	Multicorer	KH18-10-14-MC2	80,6879	28,9511	552	Oct. 6
14	NPAL14	Multicorer	KH18-10-14-MC3	80,6879	28,9511	552	Oct. 6
14	NPAL14	Gravity Corer	KH18-10-14-GC1	80,6879	28,9511	552	Oct. 6
14	NPAL14	Gravity Corer	KH18-10-14-GC2	80,6879	28,9511	552	Oct. 6
14	NPAL14	Gravity Corer	KH18-10-14-GC3	80,6879	28,9511	552	Oct. 6
14	NPAL14	CTD w/bottles		80,6879	28,9513	552	Oct. 7
14	NPAL14	WP2		80,6879	28,9511	553	Oct. 7
14	NPAL14	WP2		80,6879	28,9514	553	Oct. 7
14	NPAL14	WP2		80,6879	28,9511	553	Oct. 7
14	NPAL14	WP2		80,6879	28,9511	553	Oct. 7
	P6 (NLEG21)	CTD		81,5386	30,6835	964	Oct. 7
15	NPAL15 (P6)	CTD w/bottles		81,5707	31,6146	873	Oct. 8
15	NPAL15 (P6)	Multinett		81,5707	31,6146	859	Oct. 8
15	NPAL15 (P6)	Multicorer	KH18-10-15-MC1	81,5707	31,6144	859	Oct. 8
15	NPAL15 (P6)	Multicorer	KH18-10-15-MC2	81,5707	31,6146	859	Oct. 8
15	NPAL15 (P6)	Multicorer	KH18-10-15-MC3	81,5707	31,6145	858	Oct. 8
15	NPAL15 (P6)	Gravity Corer	KH18-10-15-GC1	81,5707	31,6145	859	Oct. 8
15	NPAL15 (P6)	Gravity Corer	KH18-10-15-GC2	81,5707	31,6146	859	Oct. 8
15	NPAL15 (P6)	Calypso	KH18-10-15-PC1	81,5707	31,6147	859	Oct. 8
14	NPAL14	Calypso	KH18-10-14-PC1	80,6877	28,9516	553	Oct. 9
14	NPAL14	Calypso	KH18-10-14-PC2	80,6877	28,9516	552	Oct. 9
15	NPAL15 (P6)	Multinett		81,5706	31,6148	859	Oct. 10
15	NPAL15 (P6)	Multicorer	KH18-10-15-MC4	81,5702	31,6116	858	Oct. 10
15	NPAL15 (P6)	Gravity Corer	KH18-10-15-GC3	81,5702	31,6116	858	Oct. 10
16	NPAL16 (P7)	CTD w/bottles		81,9999	30	3278	Oct. 10
16	NPAL16 (P7)	Multinett		81,9999	29,9999	3278	Oct. 10
17	NPAL17 (PICE)	CTD w/bottles		83,2737	30,9512	3894	Oct. 11

17	NPAL17 (PICE)	Multicorer	KH18-10-17-MC1	83,2716	30,9481	3896	Oct. 11
17	NPAL17 (PICE)	Multicorer	KH18-10-17-MC2	83,2715	30,9585	3894	Oct. 11
17	NPAL17 (PICE)	Multicorer	KH18-10-17-MC3	83,2704	30,9531	3896	Oct. 11
17	NPAL17 (PICE)	Multinett		83,275	30,923	3894	Oct. 12
17	NPAL17 (PICE)	Gravity Corer	KH18-10-17-GC1	83,2778	30,904	3895	Oct. 12
18	NPAL18	Multicorer	KH18-10-18-MC1	82,6697	29,9866	3699	Oct. 12
15	NPAL15 (P6)	Calypso	KH18-10-15-PC2	81,5707	31,6145	873	Oct. 13
15	NPAL15 (P6)	Calypso	KH18-10-15-PC3	81,5706	31,6142	871	Oct. 14
19	NPAL19	Multicorer	KH18-10-19-MC1	81,9292	27,5191	3283	Oct. 15
19	NPAL19	Multicorer	KH18-10-19-MC2	81,9292	27,519	3283	Oct. 15
19	NPAL19	Calypso	KH18-10-19-PC1	81,9292	27,519	3284	Oct. 15
19	NPAL19	CTD w/bottles		81,9292	27,5191	3285	Oct. 15
19	NPAL19	Multinett		81,9292	27,519	3288	Oct. 15
20	NPAL20	Mooring		80,1784	8,1556	556	Oct. 17

Table A2. Cruise participants.

#	AeN tasks	Affiliation	Name	RF
1	Cruise leader	NPI	Katrine Husum	RF1
2	Co-cruise leader	UiB	Ulysses Ninnemann	RF1
3	Coring, subsampling, sediment description	NPI	Lisa Orme	RF1
4	Coring, subsampling, sediment description	NPI	Viviana Gamboa	RF1
5	Coring, sotopes in water O, H, and DIC	UiB	Anna Hauge Braaten	RF1
6	Coring, subsampling, living forams	UiO	Elisabeth Alve	RF1/RF3
7	Coring, subsampling, living forams	UiO	Marianne R. Kjøller	RF1/RF3
8	Plankton nets, coring, subsampling	UiT	Naima E.B. Altuna	RF1/RF2
9	Coring, sea floor mapping/sub bottom profiling	UiT	Tom Arne Rydningen	RF1
10	Coring, subsampling, sediment description	UiT	Vårin Eilertsen	RF1
11	Data management	UNIS	Pål Gunnar Ellingsen	RA-B
12	Coring systems	UiB	Dag Inge Blindheim	RF1
13	Coring systems	UiB	Stig Monsen	RF1
14	Isotopes in water O18, H, and DIC	UiB	Pål Tore Mørkved	RF1
15	Coring, sea floor mapping/sub bottom profiling	UiT	Steinar Iversen	RF1
16	Ocean mooring	NPI	Ceslav Czyz	RF1
17	Ocean mooring	NPI	Kristen Fossan	RF1
18	Coring, subsampling, pore water, pH, nutrients	University of Leeds, UK	Allyson Tessin	RF1
19	Coring, subsampling, pore water, pH, nutrients	University of Leeds, UK	Mark Zindorf	RF1
20	Coring, subsampling, sediment description, sampling ancient DNA and dinocysts	UniRES	Sunniva Rutledal	RF1
21	Ship systems and instruments	IMR	Roy Holger Robertsen	
22	Instrument chief	IMR	Asgeir Steinsland	
23	Ship systems and instruments	IMR	Rune Strømme	
24	Calypso corer	IMR	Jarle Wangenstein	

Table A3. Working hours and cabins.

Shift A: 04-12 + 16-20	**Shift B: 12-16 + 20-04**	**Cabin**
Katrine Husum		605
	Ulysses Ninnemann	421
Pål Tore Mørkved (NB 08-20)		333
Pål Gunnar Ellingsen (NB 08-20)		335
Elisabeth Alve		377
Sunniva Rutledal (NB 08-20)		379
Tom Arne Rydningen	Mark Zindorf	380
Allyson Tessin	Vårin Eilertsen	382
Lisa Orme	Marianne R. Kjøller	383
Naima E.B. Altuna	Viviana Gamboa	385
	Anna Hauge Braaten	386

Table A4. Use of labs and space during Nansen Legacy Paleo cruise

Use on this cruise	**Lab no.**	**Name**
Collecting water from CTD	102	Clean seawater sample room
Not used	202	Gravity meter room
Not used	301	Chilled lab
Isotope analysis	302	Dry lab common
Description of sediment cores, subsampling dry samples, pore water extraction	303	Wet lab common
Not used	307	Isotopic lab
Not used	308/309	Wet lab biology
Ocean mooring assembly (using the floor)	310	Catch sample room
Not used	311	Environmental toxicology lab
Not used	316	Filtration lab
Microscope work, printing labels	317	Education lab
Preparing coring equipment and core liners	319	Wet lab geology/benthos
Clean lab, sampling for DNA	320	Microbiology lab
Not used	321	Dry lab
Not used	322	Ice lab
Subsampling wet samples	Main hangar, deck 3	

Appendix II: Outreach

Blog posts

«The Nansen paleo cruise», arvenetternansen.no and npolar.no

«Safety suit training», arvenetternansen.no

«Hvordan tar vi sedimentprøver fra havbunnen?», forskning.no

«Hvordan etablere bedre referanseverdier for sjøisvariasjoner i Barentshavet?», forskning.no

«Havbunnskartlegging – en forutsetning for å finne prøvestasjoner», forskning.no

«Arktisk havforsuring», forskning.no

«Havisens innflytelse på livet i havbunnen - fortid og nåtid», forskning.no

«Før var det ikke hav i Barentshavet, men is», forskning.no

«ChAOS blog», arvenetternansen.no

«Veiing av atomer i Arktis», forskning.no

«Hjemme fra Nansen paleo-tokt – veien videre», forskning.no

«The Nansen paleo cruise»

Katrine Husum, Senior Scientist, Norwegian Polar Institute.

The Nansen paleocruise, which starts Wednesday September 26, will investigate the natural variability and ranges of sea ice cover and Atlantic Water through flow in the Barents Sea. The cruise will collect different marine geological data as multibeam bathymetry and sediment samples from the sea floor along the "Nansen transect" in the Barents Sea from ca 76 N towards to Arctic Ocean ca 82 N. Today's rapid changes, such as warmer waters entering the Arctic Ocean, make it important to obtain information about natural variations in ocean currents and sea ice in this sensitive region. The geographical coverage of sea ice and the thickness of the sea ice has changed in recent years, and these changes have occurred quickly. Knowing the past sea cover and ocean temperatures are important for establishing natural reference values that are needed for improving the understanding of the causes and consequences of current changes. During the cruise ocean observatory systems will also be deployed in order to monitor the current ocean variations.

Picture caption: RV Kronprins Haakon in Longyearbyen getting ready for depature.

«Safety suit training»

Marianne Kjøller, stipendiat, Universitetet i Oslo

Prior to the Nansen paleo-cruise, some participants had a very effective and rather hilarious survival suit course lead by Jørn Dybdahl from Norwegian Polar Institute, Longyearbyen. The course is mandatory when working on Norwegian research vessels due to risk of hypothermia when immersed into cold waters after abandoning a sinking ship. We dressed up in "over-sized" and comfy specialized waterproof dry suits that protects the wearer from hypothermia. We were told about the different components and function of the suits. We then drove to the harbour and jumped in the freezing water (the suit kept us warm, luckily). We were told not to jump headfirst as the suit is filled with air and would thus have resulted in a rather odd counter-effective head jump (although perhaps hilarious for the audience!). We learned to swim in the suits, and we conducted group exercises by attaching our self with a "body liner" to each other in order to keep together as a group. Afterwards, we had to swim as a group towards the shore by forming a long "worm".

«Hvordan tar vi sedimentprøver fra havbunnen?»

Katrine Husum (seniorforsker), Norsk Polarinstitutt og Tom Arne Rydningen (førsteammuensis) Universitetet i Tromsø.

På dette Nansentoktet ønsker vi å samle inn sedimentprøver fra havbunnen. Dette omfatter både sedimenter som avsettes i dag, og avleiringer som er opp mot 10,000 år gamle. For å kunne hente opp materiale som strekker seg over såpass store alderspenn må vi ta i bruk ulike typer prøvetakere. For den øverste halvmeteren med avleiringer bruker vi en prøvetaker som kalles «multicorer», eller «flerprøvetaker» på norsk. Denne består av en ramme med fire plastrør som senkes til havbunnen. Så snart rammen treffer bunnen presses fire plastrør ned i sedimentene, og det føres en svingarm inn under disse som forhindrer at sedimentene faller ut når prøvetakeren heves om bord på dekk. Disse prøvene er rundt 40 cm lange, og gir oss full kontroll på overgangen mellom sjøvann, havbunn og de øverste avleiringene. Lengre kjerneprøver på opptil seks meter får vi med prøvetakere som har tunge lodd på toppen (på flere hundre kilo). Disse kaller vi for gravitasjonsprøvetakere da de bruker gravitasjonen, altså vekten av loddet, til å presse seg ned i sedimentene. Hvis vi ønsker enda lengre sedimentprøver kan vi ta i bruk en Calypsoprøvetaker, der et stempel inne i prøvetakeren skaper et vakuum som sedimenter suges inn i.

De ulike prøvetakerne veier fra 650 kg («multicorer») til to tonn (Calypso). Dette betyr at vi må bruke avanserte vinsjer og kraner for å få utstyret over rekka og ned til havbunnen. Våre prøvetakningsstasjoner kan i tillegg være på vanndyp opp mot 4000 m, og vi må derfor bruke lange kabler for å nå helt ned. Mannskapet på båten styrer denne operasjonen, men så snart prøvetakerne er sikret på dekk går forskerne i gang med merking av prøvene og videre analyser på disse. Kronprins Haakon har flere avanserte laboratorium med topp moderne instrumenter, og vi kan derfor starte på dette arbeidet så snart vi har åpnet kjerneprøvene. Her ser vi etter forskjeller i avleiringsmønstre, som for eksempel fargeforskjeller og endringer i tekstur til sedimentene. Vi velger også ut skjellmateriale som vi senere kan sende til radiokarbondatering.

Etter toktet vil det bli tatt ytterligere prøver fra kjernene som vil bli videre analysert. Ved å sammenlikne verdier fra de øverste avleiringene med de dypere delene kan vi derfra vurdere endringer av havbunnsmiljø og klima gjennom de siste 10,000 år og etablere referanseverdier for klimasystemet.

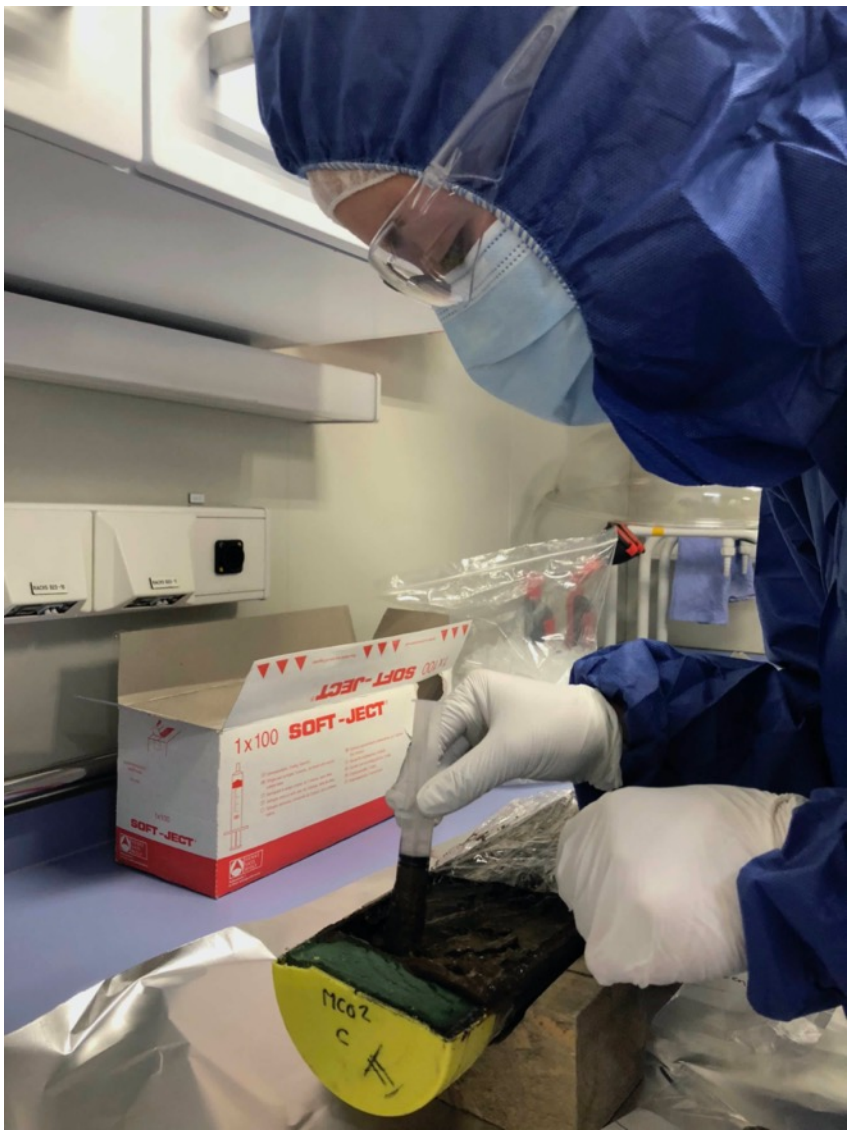
Bilde 1: «Gravity-kjernetaker» på dekk. Metallrøret er 6 m lang. Foto Katrine Husum.

«Hvordan etablere bedre referanseverdier for sjøisvariasjoner i Barentshavet?»

Katrine Husum (seniorforsker), Norsk Polarinstitutt, Sunniva Rutledal (stipendiat), Universitetet i Bergen og Stijn de Schepper (forsker), NORCE.

Utbredelsen og tykkelsen av sjøisen i Arktis har endret seg mye de siste årene, og dette påvirker verdens hav- og atmosfæresirkulasjon. Endringen av sjøis i Barentshavet på vinterstid er den mest tydelige endringen i sjøis som hittil er observert i Arktis. Kunnskap om dagens endringer er basert på observasjoner av sjøis fra de siste tre århundrer nedskrevet i skipsdagbøker og direkte satellittobservasjoner over de siste 40 år. Disse observasjonene dekker et relativt kort tidsrom og for å etablere bedre referanseverdier for variasjoner av sjøis i Barentshavet rekonstruerer vi hvor det har vært sjøis i Barentshavet flere tusen år tilbake i tid. Dette gjør vi ved å identifisere fossilt plankton og ved å gjøre geo/biokjemiske analyser av havavleiringer på et lite utsnitt av havbunnen, en sedimentkjerne. For å etablere disse referanseverdiene må det brukes flere metoder. Sammensetningen av fossilt plankton er avhengig av mange miljøfaktorer som for eksempel tilstedeværelsen av sjøis, og viser dermed påvirkningen fra sjøis på havmiljøet tilbake i tid. Vi har identifisert en såkalt «biomarkør» kalt IP25, som stammer fra en bestemt alge som bare finnes i sjøis. I tillegg er det brukt andre karakteristiske geokjemiske data som alle reflekterer sjøis. Ved å kombinere de geokjemiske parametere sammen med IP25 viser analysene ikke bare om det har vært sjøis på en plass eller ei, men det kan også estimeres hvor mye sjøis som finnes på våren. Det gjøres også DNA analyser av havavleiringene. En ny metode under utvikling viser at når alger fra sjøis løses opp og etterlater sitt DNA i havavleringene, kan funn av DNAet brukes til å rekonstruere utbredelsen av sjøis i Barentshavet tilbake i tid.

Bilde 1: Sjøis i Nansenbassenget sett fra R/V Kronprins Haakon. Foto Sunniva Rutledal.

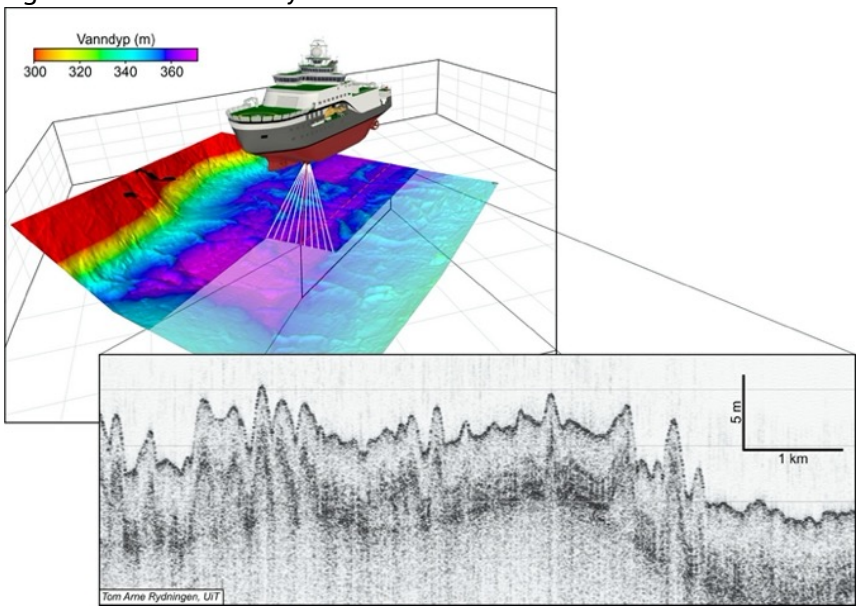


Bilde 2: Sunniva tar forsiktig ut DNA-prøver fra havavleiringene. Foto Sunniva Rutledal.

«Havbunnskartlegging – en forutsetning for å finne prøvestasjoner»

T.A. Rydningen (førsteamanuensis), UiT – Norges arktiske universitet

For å samle inn sedimentprøver fra havbunnen til «Arven etter Nansen»-prosjektet er vi avhengige av å finne gode prøvestasjoner. Slike gode prøvestasjoner ligger i områder der tykkelsen på avleiringer fra de siste 12,000 år er på flere meter – i beste fall flere titalls meter. Disse områdene kartlegger vi ved å bruke to ulike typer lydbølgekilder, nemlig *multistråle ekkolodd* og *penetrasjonsekkolodd*. *Multistråleekkoloddet* bruker vi til å kartlegge selve overflaten til havbunnen. Dette ekkoloddet har en lydkilde som sender ut over 400 signaler samtidig nedover i vannsøyla. Når disse lydbølgene treffer den harde havbunnen blir de reflektert, det vil si det skapes et ekko med lydbølger som returnerer til en mottaker som ligger under skroget på skipet. Dette ekkoet blir databehandlet om bord, noe som øyeblikkelig gir oss et bilde av hvordan havbunnens topografi ser ut, og vi kan fra dette oppdage former som undersjøiske daler, morenerygger og pløyespor fra isfjell. Slik informasjon er nyttig for oss, da løsmasser har en tendens til å avsettes i fordypninger. Dette har å gjøre med at havstrømmer ofte er så sterke langs grunne områder at de fjerner alt av løsmasser her. Penetrasjonsekkoloddet bruker vi når har funnet dype områder som vi tror kan være gunstige for prøvetaking. Dette ekkoloddet hjelper oss til å finne sedimentene vi er på jakt etter. Penetrasjonsekkoloddet fungerer på samme måte som et fiskeriekkolodd, der den viktigste forskjellen er at lydbølgen som sendes ut fra våre instrumenter går ned i sedimentene, og ekkoet som kommer tilbake gir oss et bilde av avleiringene i undergrunnen. Dersom sedimentene som ligger på havbunnen består av mye bløt marin leire vil vi kunne avbilde flere titalls meter med avleiringer avsatt de siste 12,000 år, og dette vil være gode prøvestasjoner for Nansenprosjektet. Innsamling av slike geofysiske data er en avansert prosess som krever moderne utstyr. I skroget på FF «Kronprins Haakon» er det installert to ulike typer penetrasjonsekkolodd, der begge gir oss detaljerte avbildninger av undergrunnen. Fartøyet er også utstyrt med to typer multistråleekkolodd, der det ene brukes på vanndyp ned mot 600 meter, og det andre i områder der vi gjør kartlegginger ned mot 5000 meter. Disse instrumentene er beskyttet av isvinduer, noe som gjør at vi kan gjøre kartlegginger også der vi bryter is – noe som er nødvendig på 83 grader nord.



Figur 1. Multistrålekkoloddet til FF «Kronprins Haakon» gir et tredimensjonalt bilde av havbunnen, mens penetrasjonsekkoloddet gir et snitt gjennom avleiringene i undergrunnen.

«Arktisk havforsuring»

Tekst: Naima El bani Altuna (PhD stipendiat, UiT) & Kasia Zamelczyk (Postdoktor, UiT)

Oversatt til norsk: Sunniva Rutledal (PhD stipendiat, UiB)

I de siste tiår har menneskelige aktiviteter ført til en økning av CO_2 i atmosfæren, men hvordan påvirker dette havet? På lang sikt er havet den viktigste lagringsplassen for atmosfærisk CO_2, og derfor vil økende atmosfærisk CO_2 også føre til økende mengder CO_2 i havet. Når CO_2 løses opp i havet endres kjemiske parametere i vannsøylen, slik som pH. PH-en synker og vannet blir mindre basisk og mer surt. Denne prosessen kaller vi havforsuring. Forsking på havforsuring er et av de viktigste fagområdene når det kommer til effekten av økende mengder atmosfærisk CO_2 på marine økosystem, spesielt med tanke på marine organismer som har skjell bestående av kalsiumkarbonat ($CaCO_3$).

Planktisk foraminifera og pteropoder er viktige komponenter i den arktiske vannsøylen. Disse mikroskopiske organismene har skjell bygget opp av kalsiumkarbonat og er svært sensitiv til endringer i havkjemien. Økende CO_2 i sjøvann kan dermed ha en dramatisk effekt på både mengden og deres skjell. I verste tilfelle kan de miste sitt beskyttende skall og på sikt dø ut. I tillegg er disse marine organismene viktige komponenter i globale biogeokjemiske sykluser og er vesentlig når det kommer til å modifisere den uorganiske og organiske karbonpumpen. Videre er andre marine organismer avhengig av dem for mat, og når de dør, begraves de på havbunnen hvor de lagrer karbon.

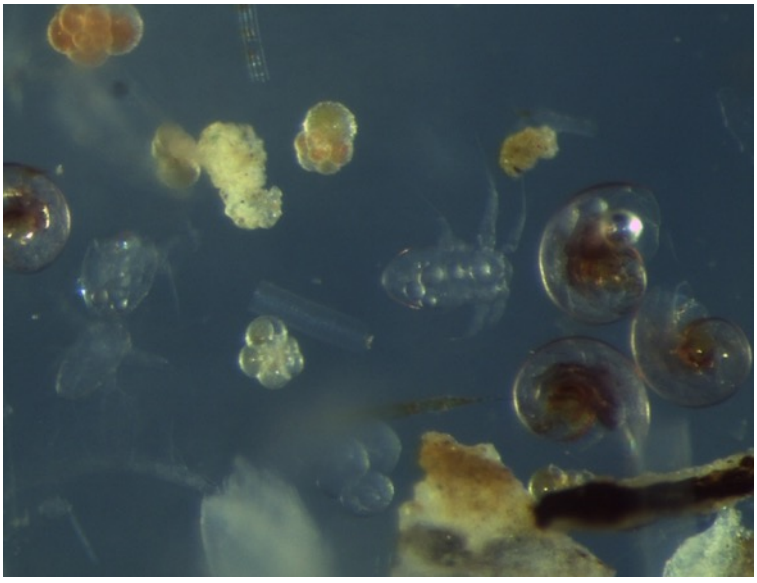


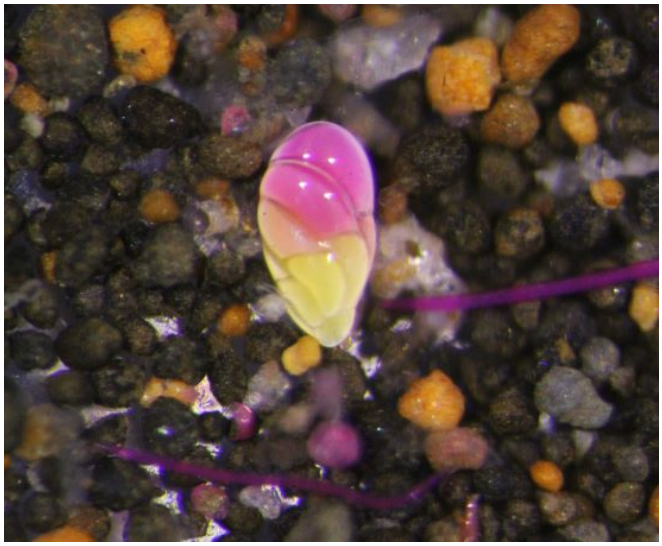
Figure 1. Planktisk foraminifera (popcornaktige, hvite skjell) og pteropoder (sneglaktige, gjennomsiktige skjell) i en vannprøve samlet inn ombord FF Kronprins Haakon. Den nye isbryteren har fasiliteter som inkluderer en undervisnings lab med mikroskoper utstyrt med kamera som tillater analyse av prøvene ombord. Foto: Naima El bani Altuna.

Som del av prosjektet Arven etter Nansen, har vår gruppe som mål å kvantifisere effekten av havforsuring på planktisk foraminifera og pteropoder som lever i det Arktiske og sub-Arktiske hav. Ombord på FF Kronprins Haakon samler vi inn planktiske foraminifera og pteropoder fra sør i Barentshavet til det Arktiske hav, og i områder med helårs sjøis. Disse levende organismene fra plankton nett vil bli sammenlignet med fossile organismer fra sedimentkjerner for å også studere variasjoner i mengde og skjellkomposisjon tilbake i tid. På samme tid tar vi vannprøver for å bedre forstå effekten av havforsuring på kjemien i havet. Vi måler blant annet konsentrasjonen av kalsiumkarbonat og pH. Stay tuned!

«Havisens innflytelse på livet i havbunnen - fortid og nåtid»

Marianne Risager Kjøller (stipendiat), Universitetet i Oslo og Elisabeth Alve (professor), Universitetet i Oslo

Den mørke havbunnen er full av liv, alt fra sjøstjerner til ormelignende dyr som kan grave dypt ned i sedimentet. Disse kan sees med det blotte øye. Det finnes i tillegg små organismer som ikke kan sees uten å bruke et mikroskop. Disse organismene representerer et av de første leddene i næringskjeden, og er dermed viktig for større dyr som fisk og marine pattedyr som vi mennesker spiser. Havbunnslevende foraminiferer er en gruppe av disse små organismene som finnes overalt i verden. De danner vakre skall som kan ligne på veldig små sneglehus, og disse skallene er så robuste at de kan bli bevart i sedimentene på havbunnen i millioner av år under de rette forholdene.



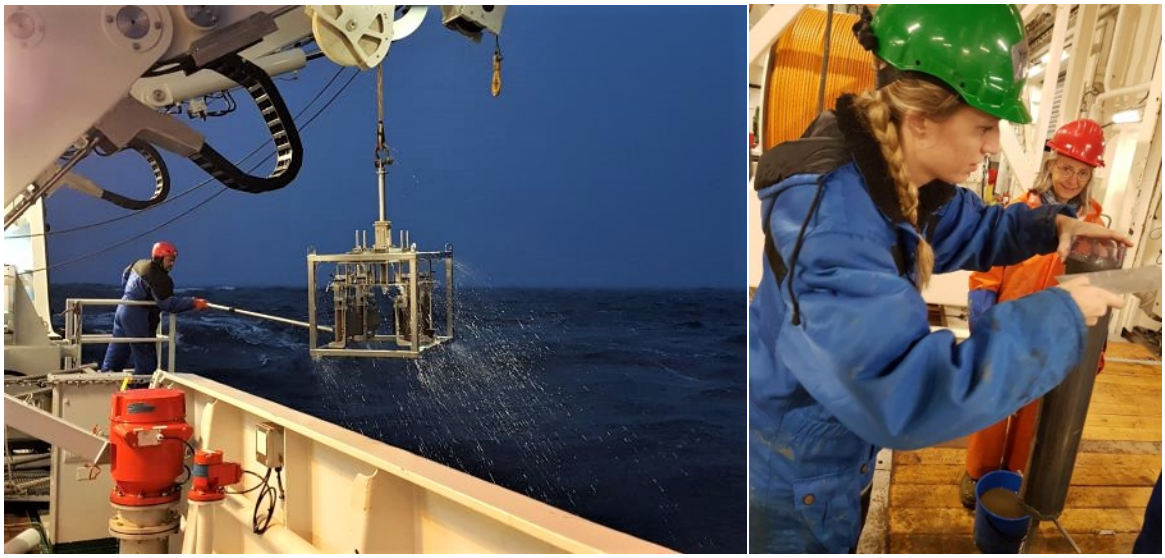
Havbunnslevende foraminifer sett i mikroskopet.

Foraminiferer lever av alt fra bakterier i sedimentet til små mikroskopiske dyr og alger som synker fra havoverflaten hele veien ned til havbunnen. Man kan si at de får maten «servert på et sølvfat».

Som ny doktorgradsstudent fra Institutt for geofag ved Universitetet i Oslo, skal jeg undersøke havisens sesongmessige variasjon og relatert faktorers innflytelse på utbredelsen av levende foraminiferer på havbunnen. Forståelsen av hvilke forhold disse organismene foretrekker kan brukes til å rekonstruerer det tidligere miljøet.

Hvordan?

Hvert sedimentlag representerer en bestemt periode i tid avsatt under et gitt miljø. Dette miljøet styrer hvilke foraminiferer som levde på det tidspunktet. Når man finner skall fra disse i ulike sedimentlag, kan man bruke den viten man har om de nålevende artenes foretrukne miljø som indikator for det forhistoriske miljøet. Vi skal også blant annet undersøke geokjemiske indikatorer fra sedimentet til å underbygge sin hypotese om hva som har hendt - en form for detektivarbeid.



Multicorer som dukker opp fra havets dyp med sedimentkjerner (venstre) og snitting av sedimentkjerne (høyre).

For å undersøke dette må vi samle inn sedimentkjerner fra ulike områder, som i vårt tilfelle er Barentshavet. Dette gjøres ved å senke rørformet utstyr ned i dypet, i vårt tilfeller en «multicorer», som da penetreres ned i havbunnen for å samle inn sedimentet. På hangardekket snitter vi på elegant og horisontalt vis kjernene våre i skiver. Det involverer ofte en masse gjørme som ender opp på klær og i ansiktet. Det er fra disse sedimentskivene vi skal utføre vårt detektivarbeid ved å se efter havbunnslevende foraminiferer, både levende og fossile.

«Før var det ikke hav i Barentshavet, men is»

Vårin T. Eilertsen, stipendiat, Universitetet i Tromsø

I dag er det hav i Barentshavet, men for over 10 000 år siden lå det et stort isdekke der som på sitt mektigste var over to kilometer tykt. Se for deg en hvitdekt massiv isbre så langt øye kan se. Hvis du besøker en isbre i dag ser du ofte gråaktige grushauger ligge foran breen. Det er fordi isbreer fungerer litt som skikkelig saktegående bulldosere. De beveger seg rolig framover mens de graver seg ned i underlaget og røsker med seg stein, grus og sand. Disse sedimentene blir så avsatt både under og foran breen i store hauger, og geologer kaller disse landformene for morener. Når breen smelter vekk blir disse moreneryggene liggende igjen som tydelige spor i landskapet, og bevis på at området en gang har vært dekt av en isbre. Akkurat slike morenerygger etterlot også det store isdekket som lå over Barentshavet. I dag finner vi dem helt ned på 600 meters vanndyp. Formen til de forskjellige moreneryggene og plasseringen av disse forteller noe om hvordan brefronten trakk seg tilbake, eller om den rykket framover. Dette kan hjelpe oss med å forstå hvordan bresmeltinga og tilbaketrekninga av det store isdekket som lå i Barentshavet var da det ble varmere og istida var over.

Over moreneryggene ligger det et lag med leire. Denne marine leira er avsatt etter istida og har blitt fraktet ut i havet av elver, vind og havstrømmer. Sakte men sikkert har den regnet ned gjennom vannsøyla og lagt seg på havbunnen. For å studere denne leira og sedimentene fra moreneryggene, kan vi hente de opp ved å bruke en gravitasjonsprøvetaker. Gravitasjonsprøvetakeren består av et jernrør med et tungt lodd på toppen som senkes ned mot havbunnen. Litt over havbunnen slippes den ned slik at den graver seg inn i havbunnen, og fanger sedimenter inne i jernrøret. Etterpå heises hele kjernen opp på dekk, klar til å bli undersøkt. Det er blant annet dette maringeologer og toktdeltakere på Nansen paleotoktet til det nordlige Barentshavet gjør. Når jernrøret med sedimenter endelig kommer opp på dekk stadfester toktlederen alltid henrykt «Jeei, vi har fått leire!», mens mannskapet til forskningsfartøyet Kronprins Haakons smiler lurt og rister litt på hodet over entusiasmen. Entusiasmen kommer av at disse sedimentene inneholder mye viktig informasjon om hvordan klimaet har utviklet seg de siste 10,000 år, og dette er viktig å forstå for å bedre kunne forutsi hvordan klimaet vil utvikle seg i framtida.

Dagens klimaendringer påvirker særlig de nordlige og sårbare områdene i Barentshavet og Polhavet. Derfor er dagens Nansen paleotokt med forskningsfartøyet Kronprins Haakon gull verdt, siden det vil bidra til å øke vår forståelse av konsekvensene av disse raske klimaendringene. Fortell gjerne dette til en klimaskeptisk onkel nær deg.

“ChAOS Blog”

Mark Zindorf and Allyson Tessin, University of Leeds, UK

The life at the seafloor receives a constant supply of food. It trickles down as marine snow, which consists of all the material which is produced in the upper, sunlit layers of the ocean: algae, fish-fecals, decayed animals and so on. About 98% of the produced material is consumed by organisms living in the water column and only the remaining few percent reach the seafloor. But this is still enough to support a variety of seafloor organisms, including a consortium of microorganisms.

Vast areas of the Arctic Ocean are covered year-round by a thick ice cover. This limits the production of organic matter underneath and thus the transport of organic material to the seafloor. Currently global climate change leads to a shrinking in ice cover in the arctic, leaving areas ice free that have previously constantly been covered by ice. In ice free waters, more algae can grow and produce more organic material which is deposited at the seafloor. Thus, climate change can lead to less sea ice and an increased supply of organic material to the seafloor, potentially supplying more organisms with food. However, these organisms will use more oxygen when they digest this additional food, which starves of oxygen organisms on the seafloor. Thus, a changing climate will have a direct effect on communities of microbes which have developed in the mud of the seafloor over the course of millennia.

The British ChAOS project – the abbreviation stands for Changes of the Arctic Ocean Seafloor – investigates the effect past and future climate changes have on the seafloor communities and their food sources. Thus, the aims of ChAOS and Nansen Legacy link up perfectly. For this reason, two ChAOS scientists, Allyson and Mark joined the Nansen Paleocruise 2018 to investigate this interesting subject on the same sites investigated by the Nansen Legacy.

They extract water from the marine mud from the drilled sediment cores. The chemical composition of these sedimentary pore-waters reflects the living conditions of the life in the seafloor. To avoid destruction of the sediment record, the pore-water sampling is done in a similar way as plant-roots extract water from soil. A rhizon, a filter-tube with a very small pore size, is inserted into the sediment and the water is sucked out by a vacuum created with a common syringe. In these pore-waters products of microbial organic matter degradation, as well as nutrients are analyzed and compared between different drill sites which are temporarily or year-round ice covered, or have recently become ice-free. By this, predictions can be made on how the decreasing ice cover will affect the turn-over of organic material in the seafloor and how life, especially microbial life will be living in the future.

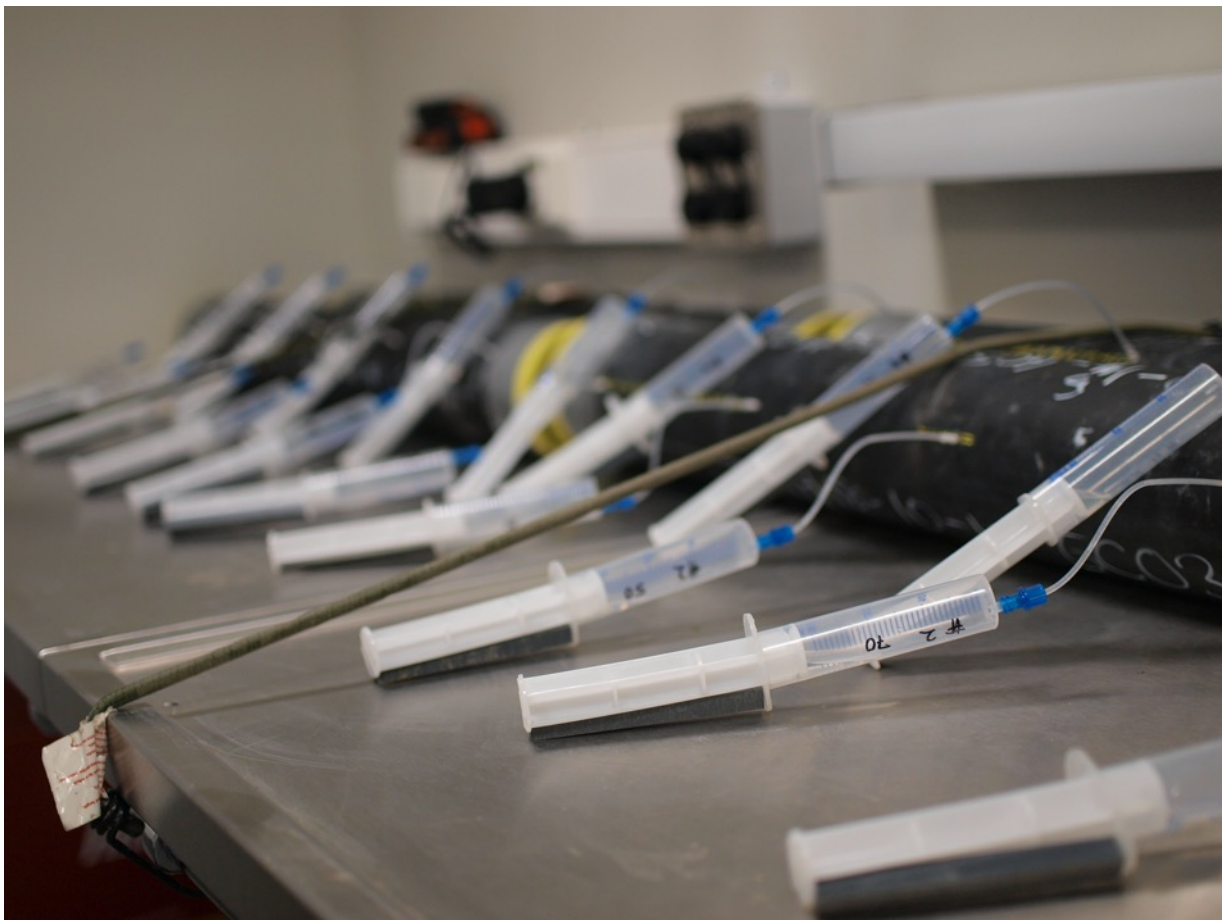
«Veiing av atomer i Arktis»

Ulysses Ninnemann og Pål Tore Mørkved, Universitetet i Bergen.

Havet i Arktis er et unikt økosystem som nærer de polare næringskjedene, utgjør en stor andel av den globale cryosfæren, og utøver en disproporsjonalt stor innflytelse på omsetning av karbon og dyphavssirkulasjon. Til tross for dette er syklusene av næringsstoffer, karbon og ferskvann, som gjør denne regionen viktig og unik, fortsatt relativt ukjent. Mye av grunnen til dette er Arktis utilgjengelighet og spesielle utfordringer en møter når en samler data fra dette ugjestmilde, isdekte miljøet. Uten disse dataene er det vanskelig å forutsi hvor sensitiv regionen responderer til pågående og framtidige klimaendring.

Vannprøvetaking fra dyphavet. Foto: Marianne Kjøller

I ånden til Fritjof Nansen, som utviklet nye metoder for utforskningen og forståelsen av den polare verden, gjør Nansenprosjektets forskere avanserte målinger på sjøen og i pakkisen som normalt bare kan gjøres i laboratoriet. Ved å bruke de nyeste instrumentene tilgjengelig er dette nå mulig og dette er en av de første ekspedisjonene som bruker slikt utstyr. For å studere de skjulte syklusene i Arktis måler vi forskjellig varianter av grunnstoffer som kalles isotoper. For eksempel analyserer vi små endringer i massen ($^{13}C/^{12}C$) av karbonatomer som kan både spore hvordan CO_2 forflytter seg mellom luft, vann, og havbunnen, og i tillegg identifisere hvorfor karbonet forflytter seg eller blir fanget i et spesifikt sted. På liknende vis forteller forholdet mellom lette og tunge varianter av hydrogen og oksygen i sjøvann oss om spesifikke kilder til ferskvann i Arktis, noe som er viktig for å forstå hvorfor sjøisen og ferskvannet her er i endring.



Vann som skal analyseres for isotoper dras ut fra dyphavskjerner. Foto: Ulysses Ninnemann

Vitenskapelige overraskelser

Fordelen ved å ta med avanserte instrumenter på tokt er at vi får resultater umiddelbart, slik at når det kommer ny og uventet informasjon kan vi endre justere planen våre, og utforske dette videre. Dette er spesielt viktig i områder der det kan være år før en kan komme tilbake for nye undersøkelser og hvor det er svært ressurskrevende å komme til. De første resultatene våre avdekket at karbonet i havbunnssedimentene var unikt på en måte som var helt uventet. Det er mye mer karbon som frigis enn det vi normalt ser i andre havområder. Siden vi kan observere dette mens vi fortsatt er på sjøen, kan vi tilpasse prøvetakingsplanen vår og begynne å undersøke hvorfor dette skjer akkurat her. Dette viser hvordan vi ved å undersøke nye steder med nye verktøy, får helt nye perspektiver og tvinger oss til å tenke nytt om velkjente vitenskapelige konsepter. I denne sammenhengen viser det hvor viktig de arktiske havene er for global biogeokjemi.

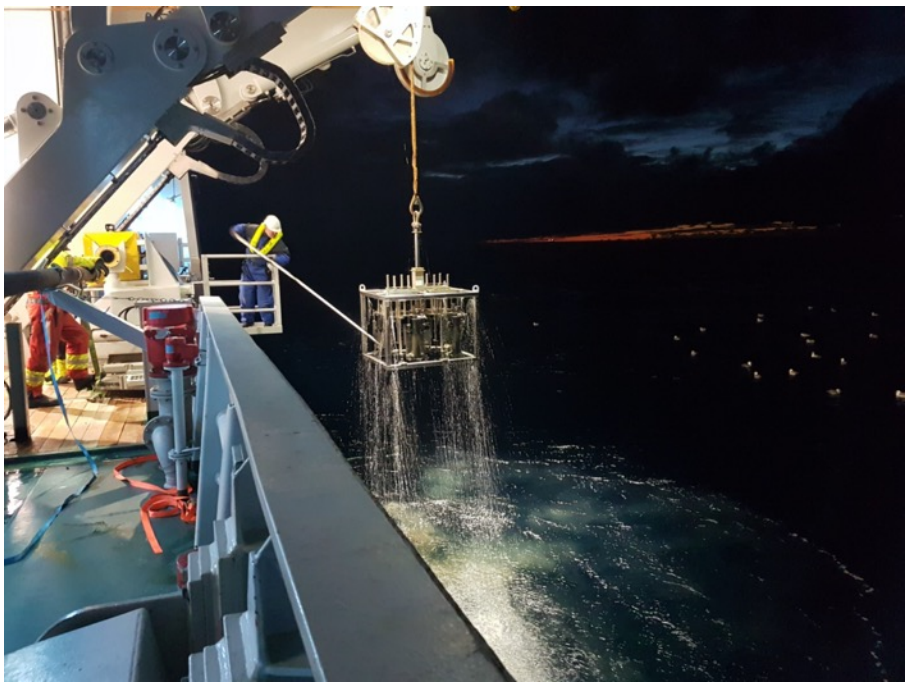
«På land igjen etter Nansen paleo-tokt – en fot i bakken og veien videre»

Katrine Husum (seniorforsker) Norsk Polarinstitutt, Ulysses Ninnemann (professor) Universitetet i Bergen, Elisabeth Alve (professor) Universitetet i Oslo, Tom Arne Rydningen (førsteamanuensis) UiT – Norges arktiske universitet

Vi er nå alle kommet vel hjem fra Nansentoktet etter en måneds tid til sjøs. Turen har gitt oss mange inntrykk og opplevelser, og vi har samlet inn data helt opp til Polhavet, nærmere bestemt i Nansenbassenget. Norges nye forskningsskip, «FF Kronprins Haakon», levde opp til forventingene som et utmerket fartøy for maringeologiske undersøkelser. Prøvetaking og datainnsamling lot seg gjøre både i dårlig vær og i isdekte områder, og vårt nordligste punkt var helt oppe ved 83.3° N.

I løpet av toktet satte vi ut fire målestasjoner på havbunnen øst og sørøst av Svalbard. Disse skal de neste fem årene måle ulike egenskaper til vannmassene, deriblant retning og styrke på havstrømmer. Våre kjerneprøvestasjoner ble identifisert ved hjelp av lydbølgekilder (multistråle ekkolodd og penetrasjonsekkolodd), som gir oss muligheten til å avbilde både havbunnens topografi samt hjelper oss å finne områder med løsmasser som vi kan hente opp med våre prøvetakere. Det første vi gjorde på prøvestasjonene vår å samle inn vann- og planktonprøver, noe vi gjorde blant annet for å undersøke havforsuring. Deretter samlet vi inn kjerneprøver for å undersøke moderne miljøforhold og økosystemer på havbunnen, det vil si hvilke forhold som råder i dag og i den nære fortid (opptil noen 1000 år gamle avleiringer). Lengre kjerneprøver på opptil 6 meter samlet ble samlet inn i områder der vi ønsker å få en bedre forståelse for utviklingen over et lengre geologisk perspektiv. Studier av disse avleiringene vil forhåpentligvis kunne fortelle oss om miljøet i området gjennom de siste 12,000 år.

For å innhente data om hvordan temperaturer i vannmassene har variert over tid bruker vi geokjemiske målinger av både marin leire, fossilt plankton og fossile dyr som vi finner i havbunnsavleiringene. Dette gir oss muligheten til å bedre forstå hvordan miljøet var bakover i tid, mye lengre tilbake enn det vi kan dekke med instrumentelle målinger. Vi kan da utarbeide referanseverdier for variasjoner av havtemperatur og sjøisdekke i Barentshavet og Polhavet. Dette vil vi gjøre ved å samarbeide på tvers av våre forskningsinstitusjoner og utnytte hverandre sine kompetansefelt. Vi kommer derfor de neste årene til å gjøre en rekke analyser på data samlet inn på dette Arven etter Nansen-toktet.



Sedimentprøver fra havbunnen på vei opp på dekk. Foto: Marianne Kjøller, Universitetet i Oslo.

Appendix III: Cruise data

Appendix 3-1. Station log

Super station	Station #	Core length	Planned analysis	Opened onboard	PI	Location	Comment
NPAL01	KH18-10-01- CTD		isotope analysis of sea water		UN	UiB	Deployment of M4, NPAL01
NPAL02	KH18-10-02- CTD		isotope analysis of sea water		UN	UiB	Deployment of Argo float, NPAL02
NPAL03	KH18-10-03- CTD						Deployment of M3, only CTD profile, no collection of water. NPAL03.
NPAL04	KH18-10-04-MC01 A	48,0	IP25, diatoms, aDNA, Dinocysts	yes	KH, SdS	NPI, UniRES	Work half processed onboard, depleted
NPAL04	KH18-10-04-MC01 B	50,5					Crack in top of core; loss of water. Core disregarded
NPAL04	KH18-10-04-MC01 C	49,0	Stable isotopes (PF)	no	UN, TLR	UiB	
NPAL04	KH18-10-04-MC01 D	46,0	pH measurements + TOC, quant. XRF, Fe/P sp.	yes	CM	Uni Leeds (ChAOS)	
NPAL04	KH18-10-04-MC02 A	43,5	Porewater, nutrients, major elements	yes	CM	Uni Leeds (ChAOS)	
NPAL04	KH18-10-04-MC02 B	47,0	Living BF	yes	EA	UiO	Sampling 0-10 cm (every cm) including pH measurements
NPAL04	KH18-10-04-MC02 C	38,0	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL04	KH18-10-04-MC02 D	46,0	Sedimentology	no	MF, TAR	UiT	
NPAL04	KH18-10-04-MC03 A	34,0	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL04	KH18-10-04-MC03 B	48,0	Reference	no	KH	NPI	
NPAL04	KH18-10-04-MC03 C	41,0	BF, stable isotopes (BF), Org. C, PF	yes	EA, TLR	UiO, UiT	Sampling 0- 40 cm (every cm)
NPAL04	KH18-10-04-MC03 D	41,0	Additional reference	no	UN, KH, TLR	UiB, NPI, UiT	
NPAL04	KH18-10-04-GC01	256,0	IP25, diatoms, aDNA,	yes	KH, SdS, CM	NPI	2 sections (0-106 106-156), stored at NPI. Sampled

			Dinocysts, porewater				with Bergen GC (3m). 1 core catcher sample. Work half sampled for aDNA onboard and pore water extracted
NPAL04	KH18-10-04-GC02	281	Stable isotopes (PF)	no	UN, TLR	UiB	2 sections (0-131; 131-281), stored at NPI. Sampled with Bergen GC (3m). 1 core catcher sample.
NPAL04	KH18-10-04-GC03	0					failed coring, empty barrels
NPAL04	KH18-10-04-GC04	0					failed coring, core catcher destroyed. Barrel stuck in sea floor.
NPAL04	KH18-10-04-GC05	0					failed coring, core catcher lost. Barrel stuck in sea floor.
NPAL05	KH18-10-05-CTD		isotope analysis of sea water, ocean acidification		UN, MC	UiB, IMR	NPAL05 (~P3)
NPAL05	KH18-10-05-PN		PF, pteropods		TLR		4 casts with WP2
NPAL05	KH18-10-05-MC01 A	41,0	Living BF, stable isotopes (BF), Org. C, PF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL05	KH18-10-05-MC01 B	42,0	Reference	no	KH	NPI	
NPAL05	KH18-10-05-MC01 C	44,0	Stable isotopes (PF)	no	UN	UiB	
NPAL05	KH18-10-05-MC01 D	44,0	IP25, diatoms, aDNA, Dinocysts	yes	KH, SdS	NPI	work half sampled in top (0-1; 1-2 cm aDNA, dinocyst, IP25)
NPAL05	KH18-10-05-MC02 A	42,0	BF, stable isotopes (BF), Org. C, PF	yes	EA, TLR	UiO, UiT	Sampling 0-4 cm (every cm)
NPAL05	KH18-10-05-MC02 B	47,0	Living BF	yes	EA	UiO	Sampling 0- 40 cm (every cm)
NPAL05	KH18-10-05-MC02 C	41,0	Sedimentology	no	MF, TAR	UiT	
NPAL05	KH18-10-05-MC02 D	44,0	Living BF	yes	EA	UiO	Sampling 0-10 cm (every cm) including pH measurements

NPAL05	KH18-10-05-GC1	324	Stable isotopes (PF), IP25, PF	no		UiB	3 sections (0-106; 106-206; 206-306). Sampled with UiT GC
NPAL05	KH18-10-05-GC2	304	Sedimentology	no		UiT	3 sections (0-104; 104-204; 204-304). Sampled with UiT GC
NPAL06	CTD						Sound profile before starting at grid. NPAL06
NPAL07	KH18-10-07- CTD		isotope analysis of sea water, ocean acidification		UN, MC	UiB, IMR	NPAL07 (~P4)
NPAL07	KH18-10-07- PN		PF, pteropods		TLR	UiT	4 casts with WP2
NPAL07	KH18-10-07-MC01 A	46	Stable isotopes (PF)	no	UN	UiB	
NPAL07	KH18-10-07-MC01 B	44	Reference	no	KH	NPI	
NPAL07	KH18-10-07-MC01 C	45	BF, stable isotopes (BF), Org. C, PF	yes	EA, TLR	UiO, UiT	Sampling 0-4 cm (every cm)
NPAL07	KH18-10-07-MC01 D	45	IP25, diatoms, aDNA, Dinocysts	yes	KH, SdS	NPI	Work half sampled in top (0-1; 1-2 cm aDNA, dinocyst, IP25). Pyrgo williamsoni at 8.5 cm.
NPAL07	KH18-10-07-MC02 A	43	Living BF	yes	EA	UiO	Sampling 0- 40 cm (every cm)
NPAL07	KH18-10-07-MC02 B	46	Sedimentology	no	MF, TAR	UiT	
NPAL07	KH18-10-07-MC02 C	44	Living BF	yes	EA	UiO	Sampling 0-10 cm (every cm) including pH measurements
NPAL07	KH18-10-07-MC02 D	44	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL07	KH18-10-07-GC1	250	Stable isotopes (PF), IP25, BF	no	UN, KH, TLR	UiB	3 sections (0-50; 50-150;150-250), 1 sample from core cutter
NPAL07	KH18-10-07-GC2	238	Sedimentology	no	MF, TAR	UiT	3 sections (0-120; 120-238, 1 sample from core cutter
NPAL08	KH18-10-08-CTD		isotope analysis of sea water, ocean acidification		UN, MC	UiB, IMR	NPAL08 (~M2)

NPAL08	KH18-10-08- PN		PF, pteropods		TLR	UiT	
NPAL08	KH18-10-08-MC01 A	49,00	IP25, diatoms, aDNA, Dinocysts	yes	KH, SdS	NPI, UniRES	Work half processed onboard, depleted
NPAL08	KH18-10-08-MC01 B	50,00	Stable isotopes (PF)	no	UN	UiB	
NPAL08	KH18-10-08-MC01 C	49,00	Reference	no	KH	NPI	
NPAL08	KH18-10-08-MC01 D	48,00	BF, stable isotopes (BF), Org. C, PF	yes	EA, TLR	UiO, UiT	Sampling 0- 40 cm (every cm)
NPAL08	KH18-10-08-MC02 A	48,5	Porewater, nutrients, major elements	yes	CM	Uni Leeds (ChAOS)	
NPAL08	KH18-10-08-MC02 B	45,00	Living BF	yes	EA	UiO	Sampling 0-10 cm (every cm) including pH measurements
NPAL08	KH18-10-08-MC02 C	49,00	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL08	KH18-10-08-MC02 D	50,00	Sedimentology	no	MF, TAR	UiT	
NPAL08	KH18-10-08-MC03 A	47,00	Additional reference	no	UN, KH	UiB	
NPAL08	KH18-10-08-MC03 B	47,5	Additional reference	no	UN, KH	UiB	
NPAL08	KH18-10-08-MC03 C	48	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL08	KH18-10-08-MC03 D	48	pH measurements + TOC, quant. XRF, Fe/P sp.	yes	CM	Uni Leeds (ChAOS)	
NPAL08	KH18-10-08-GC01	365	Porewater, sedimentology	yes	CM, MF, TAR	ChAOS/UiT	4 sections (0-65; 65-165; 165-265; 265-365), stored at UiT. Work half sampled for ChAOS.
NPAL08	KH18-10-08-GC02	448	Stable isotopes (PF), PF	no	UN, TLR	UiB	4 sections (0-108; 108-228; 228-348; 348-448), stored at UiB Sampled with UiT GC.
NPAL08	KH18-10-08-GC03	385	Chronology	no	UN, KH, TLR	UiB	4 sections (0-85; 85-185;185-285; 285-385), stored at UiB Sampled with UiT GC.

NPAL08	KH18-10-08-GC04	403	IP25, diatoms, aDNA, Dinocysts	yes	KH, SdS	NPI	4 sections (0-100;100-200;200-300;300-403), stored at NPI. Work half sampled for aDNA onboard
NPAL09	KH18-10-09-GC01	340	Sedimentology	no	MF, TAR	UiT	4 sections (0-40; 40-140; 140-240; 240-340), stored at UiT.
NPAL10	KH18-10-10-GC01	226	Sedimentology	no	MF, TAR	UiT	2 sections (0-110;110-226), stored at UiT.
NPAL10	KH18-10-10-GC02	268	Sedimentology	no	MF, TAR	UiT	3 sections (0-68;68-168:168-268), stored at UiT.
NPAL11							Deployment of M2, CTD cast, NPAL11
NPAL12	KH18-10-12- CTD		isotope analysis of sea water, ocean acidification		UN, MC	UiB, IMR	NPAL12 (~M1)
NPAL12	KH18-10-12- PN		PF, pteropods		TLR	UiT	4 casts with WP2
NPAL12	KH18-10-12-MC01 A	45	Sedimentology	no	MF, TAR	UiT	
NPAL12	KH18-10-12-MC01 B	49	BF, stable isotopes (BF), Org. C, PF	yes	EA, TLR	UiO, UiT	Sampling 0-4 cm (every cm)
NPAL12	KH18-10-12-MC01 C	48	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL12	KH18-10-12-MC01 D	49,5	Reference	no	KH	NPI	
NPAL12	KH18-10-12-MC02 A	48	Living BF	yes	EA	UiO	Sampling 0- 40 cm (every cm)
NPAL12	KH18-10-12-MC02 B	50,5	IP25, diatoms, aDNA, Dinocysts	yes	KH, SdS	NPI, UniRES	Work half sampled in top (0-1; 1-2 cm aDNA, dinocyst, IP25).
NPAL12	KH18-10-12-MC02 C	52	Stable isotopes (PF)	no	UN	UiB	
NPAL12	KH18-10-12-MC02 D	47	Living BF	yes	EA	UiO	Sampling 0-10 cm (every cm) including pH measurements
NPAL12	KH18-10-12-GC01	148	Chronology	no	UN, KH, TLR	UiB	2 sections (0-48;48-148), stored at UiB
NPAL12	KH18-10-12-GC02	149	Stable isotopes (PF), IP25, PF	no	UN, KH, TLR	UiB	2 sections (0-49;49-149), stored at UiB

NPAL12	KH18-10-12-GC03	115	Sedimentology	no	MF, TAR	UiT	1 section (0-115), stored at UiT
NPAL13							Deployment of M1, CTD cast, NPAL13
	CTD						Sound profile before starting at grid in Kvitøya Trough
NPAL14	KH18-10-14-MC01 A	50	Reference	no	KH	NPI	NPAL14, Kvitøya Trough
NPAL14	KH18-10-14-MC01 B	45	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL14	KH18-10-14-MC01 C	51		yes	EA	UiO	Uneven surface, 0-1 cm sampled by Alve, the rest disregarded.
NPAL14	KH18-10-14-MC01 D	48	Sedimentology	no	MF, TAR	UiT	
NPAL14	KH18-10-14-MC02 A	49	Porewater, nutrients, major elements	yes	CM	Uni Leeds (ChAOS)	
NPAL14	KH18-10-14-MC02 B	50	BF, stable isotopes (BF), Org. C, PF	yes	EA, TLR	UiO, UiT	Sampling 0- 40 cm (every cm)
NPAL14	KH18-10-14-MC02 C	50	IP25, diatoms, aDNA, Dinocysts	yes	KH, SdS	NPI, UniRES	
NPAL14	KH18-10-14-MC02 D	51	Stable isotopes (PF)	no	UN	UiB	
NPAL14	KH18-10-14-MC03 A	49	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL14	KH18-10-14-MC03 B	50	Living BF	yes	EA	UiO	Sampling 0-10 cm (every cm) including pH measurements 0-5 cm
NPAL14	KH18-10-14-MC03 C	50	Additional reference	no	UN/KH	UiB	
NPAL14	KH18-10-14-MC03 D	51	pH measurements + TOC, quant. XRF, Fe/P sp.	yes	CM	Uni Leeds (ChAOS)	
NPAL14	KH18-10-14-GC01	591	Stable isotopes (PF), IP25, BF	no	UN, KH, TLR	UiB	6 sections (0-100; 100-200; 200-300; 300-400; 400-500; 500-591), stored at UiB
NPAL14	KH18-10-14-GC02	538	Chronology	no	UN, KH, TLR	UiB	5 sections (0-100; 100-208; 208-318; 318-

							428; 428-538), stored at UiB
NPAL14	KH18-10-14-GC03	505	Porewater, sedimentology	yes	CM, MF, TAR	ChAOS/UiT	5 sections (0-65; 65-175; 175-285; 285-395; 395-505), stored at UiT. Work half sampled for ChAOS.
NPAL14	KH18-10-14-CTD		isotope analysis of sea water, ocean acidification		UN, MC	UiB, IMR	
NPAL14	KH18-10-14- PN		PF, pteropods		TLR	UiT	4 casts with WP2
NPAL14	KH18-10-14-PC1	587	Stable isotopes (PF), IP25, PF, BF, sedimentology	no	UN, KH, TLR, MF, TAR	UiB, NPI, UiT	4 sections (0-137; 137-287; 287-437;437-587). Stored at UiB. Upper barrel (0-5.8 m) destroyed. Only lower barrel ok and full. Labelled 0 cm from top and SEC 01 etc.
NPAL14	KH18-10-14-PC2	450	Stable isotopes (PF), IP25, PF, BF, sedimentology	no	UN, KH, TLR, MF, TAR	UiB, NPI, UiT	3 sections (0-150; 150-300; 300-450). Stored at UiB. Barrel got stuck in sea floor. Several attempts to get it free. The barrel would lift 2 m and not move. Hence the barrel was take several times up and down before it finally got free.
	CTD						Sound profile before starting survey around P6 (NPAL15)
NPAL15	KH18-10-15-CTD		isotope analysis of sea water, ocean acidification		UN, MC	UiB, IMR	~P6. Site shows a sediment package of 34 ms (25.5 m thick).
NPAL15	KH18-10-15- PN1		PF, pteropods		TLR	UiT	Multinet delpoyed for the first time. Appearantly empty. Another attempt with multinet will be carried out when returning to site.
NPAL15	KH18-10-15-MC01 A	41	IP25, diatoms, aDNA, Dinocysts	yes	KH, SdS	NPI, UniRES	

NPAL15	KH18-10-15-MC01 B	40	Reference	no	KH	NPI	
NPAL15	KH18-10-15-MC01 C	40	BF, stable isotopes (BF), Org. C, PF	yes	EA, TLR	UiO, UiT	Sampling 0- 40 cm (every cm)
NPAL15	KH18-10-15-MC01 D	42	Stable isotopes (PF)	no	UN	UiB	
NPAL15	KH18-10-15-MC02 A	11	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL15	KH18-10-15-MC02 B	empty					empty
NPAL15	KH18-10-15-MC02 C	empty					empty
NPAL15	KH18-10-15-MC02 D	10	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL15	KH18-10-15-MC03 A	12	Living BF	yes	EA	UiO	Sampling 0-10 cm (every cm) including pH measurements 0-5 cm
NPAL15	KH18-10-15-MC03 B	12			UN, KH	UiB	
NPAL15	KH18-10-15-MC03 C	empty					empty
NPAL15	KH18-10-15-MC03 D	empty					empty
NPAL15	KH18-10-15-GC01	401	Stable isotopes (PF), PF	no	UN, TLR	UiB, UiT	4 sections (0-101; 101-201; 201-301; 301-401), stored at UiB
NPAL15	KH18-10-15-GC02	385	IP25, diatoms, aDNA, Dinocysts	yes	KH, SdS	NPI, UniRES	4 sections (0-85; 85-185; 185-285; 285-385), stored at NPI
NPAL15	KH18-10-15- PC01	1055	Stable isotopes (PF), IP25, PF, BF, sedimentology	no	UN, KH, TLR, MF, TAR	NPI, UiB, UiT	8 sections (0-46; 46-159; 159-309;309-459;459-605;605-755;755-905;905-1055), stored at UiB.
NPAL15	KH18-10-15- PN2		PF, pteropods		TLR	UiT	Second deployment of multinet at NPAL15.
NPAL15	KH18-10-15- MC4 A	41	Porewater, nutrients, major elements	yes	CM	Uni Leeds (ChAOS)	
NPAL15	KH18-10-15- MC4 B	40	Sedimentology	no	MF, TAR	UiT	

NPAL15	KH18-10-15- MC4 C	40	pH measurements + TOC, quant. XRF, Fe/P sp.	yes	CM	Uni Leeds (ChAOS)	
NPAL15	KH18-10-15- MC4 D	41	Chronology	no	UN, KH	UiB	
NPAL15	KH18-10-15- GC3	396	Porewater, sedimentology	yes	CM, MF, TAR	ChAOS/UiT	4 sections (0-96; 96-196; 196-296; 296-396), stored at UiT. Work half sampled for ChAOS.
NPAL15	KH18-10-15-PC2	2155	Stable isotopes (PF), IP25, PF, BF	no	UN, KH, TLR	UiB, NPI, UiT	15 sections (0-66;66-216;216-366;366-512;512-662;662-812;812-962;962-1108; 1108-1258;1258-1408; 1408-1558; 1558-1705; 1705-1855; 1855-2005; 2005-2155) stored at UiB
NPAL15	KH18-10-15-PC3	2160	Porewater, sedimentology	yes	CM, MF, TAR	ChAOS/UiT	15 sections (0-72; 72-222; 222-372; 372-518; 518-668; 668-818; 818-969; 969-1114; 1114-1264; 1264-1414; 1414-1565; 1565-1709; 1709-1859; 1859-2009; 2009-2160) stored at UiT
NPAL16	KH18-10-16- CTD		isotope analysis of sea water, ocean acidification		UN, MC	UiB, IMR	
NPAL16	KH18-10-16- PN		PF, pteropods		TLR	UiT	
NPAL17	KH18-10-17-CTD						~PICE
NPAL17	KH18-10-17-MC01 A	40	Stable isotopes (PF)	no	UN	UiB	
NPAL17	KH18-10-17-MC01 B	37	IP25, diatoms, aDNA, Dinocysts	yes	KH, SdS	NPI, UniRES	
NPAL17	KH18-10-17-MC01 C	36	pH measurements + TOC, quant. XRF, Fe/P sp.	yes	CM	Uni Leeds (ChAOS)	
NPAL17	KH18-10-17-MC01 D	31,5	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL17	KH18-10-17-MC02 A	22					Pre-drilled core, tape fell off, no water on top of

							core when it came up.
NPAL17	KH18-10-17-MC02 B	37	Porewater, nutrients, major elements	yes	CM	Uni Leeds (ChAOS)	
NPAL17	KH18-10-17-MC02 C	35,5	Chronology	no	UN, KH	UiB	
NPAL17	KH18-10-17-MC02 D	37	Reference	no	KH	NPI	
NPAL17	KH18-10-17-MC03 A	31,5	Sedimentology	no	MF, TAR	UiT	
NPAL17	KH18-10-17-MC03 B	26	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL17	KH18-10-17-MC03 C	28	BF, stable isotopes (BF), Org. C, PF	yes	EA, TLR	UiO, UiT	Sampling 0- 40 cm (every cm)
NPAL17	KH18-10-17-MC03 D	31	Living BF	yes	EA	UiO	Sampling 0-10 cm (every cm) including pH measurements
NPAL17	KH18-10-17- PN1		PF, pteropods		TLR	UiT	multinet
NPAL17	KH18-10-17-GC01	71	Stable isotopes (PF), IP25, PF, BF, sedimentology	no	UN, KH, TLR, MF, TAR	UiB, NPI, UiT	Tromsø GC, deployed from the aft
NPAL18							test of calypso winch
NPAL19	KH18-10-19-MC01 A	42	BF, stable isotopes (BF), Org. C, PF	yes	EA, TLR	UiO, UiT	Sampling 0- 40 cm (every cm)
NPAL19	KH18-10-19-MC01 B	43	Reference	no	KH	NPI	
NPAL19	KH18-10-19-MC01 C	43	Living BF	yes	EA	UiO	Sampling 0-10 cm (every cm) including pH measurements
NPAL19	KH18-10-19-MC01 D	43	Sedimentology	no	MF, TAR	UiT	
NPAL19	KH18-10-19-MC02 A	44	Stable isotopes (PF)	no	UN	UiB	
NPAL19	KH18-10-19-MC02 B	44	IP25, diatoms	yes	KH	NPI	
NPAL19	KH18-10-19-MC02 C	42	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL19	KH18-10-19-MC02 D	43	Living BF	yes	EA	UiO	Sampling 0-4 cm (every cm)
NPAL19	KH18-10-19-PC1	1797	Sedimentology, stable isotopes	no	MF, TAR,	UiT, UIB, NPI	18 sections (0-46;46-157;157-

			(PF), IP25, PF, BF		UN, KH, TLR		268;268-379;379-490;490-600;600-648;648-758;758-868;868-978;978-1088;1088-1198;1198-1247;1247-1357;1357-1467;1467-1577;1577-1687;1687-1797) stored at UiT
NPAL20							retreiving mooring YP3

Appendix 3-2. Seismic profiles of paleo sites

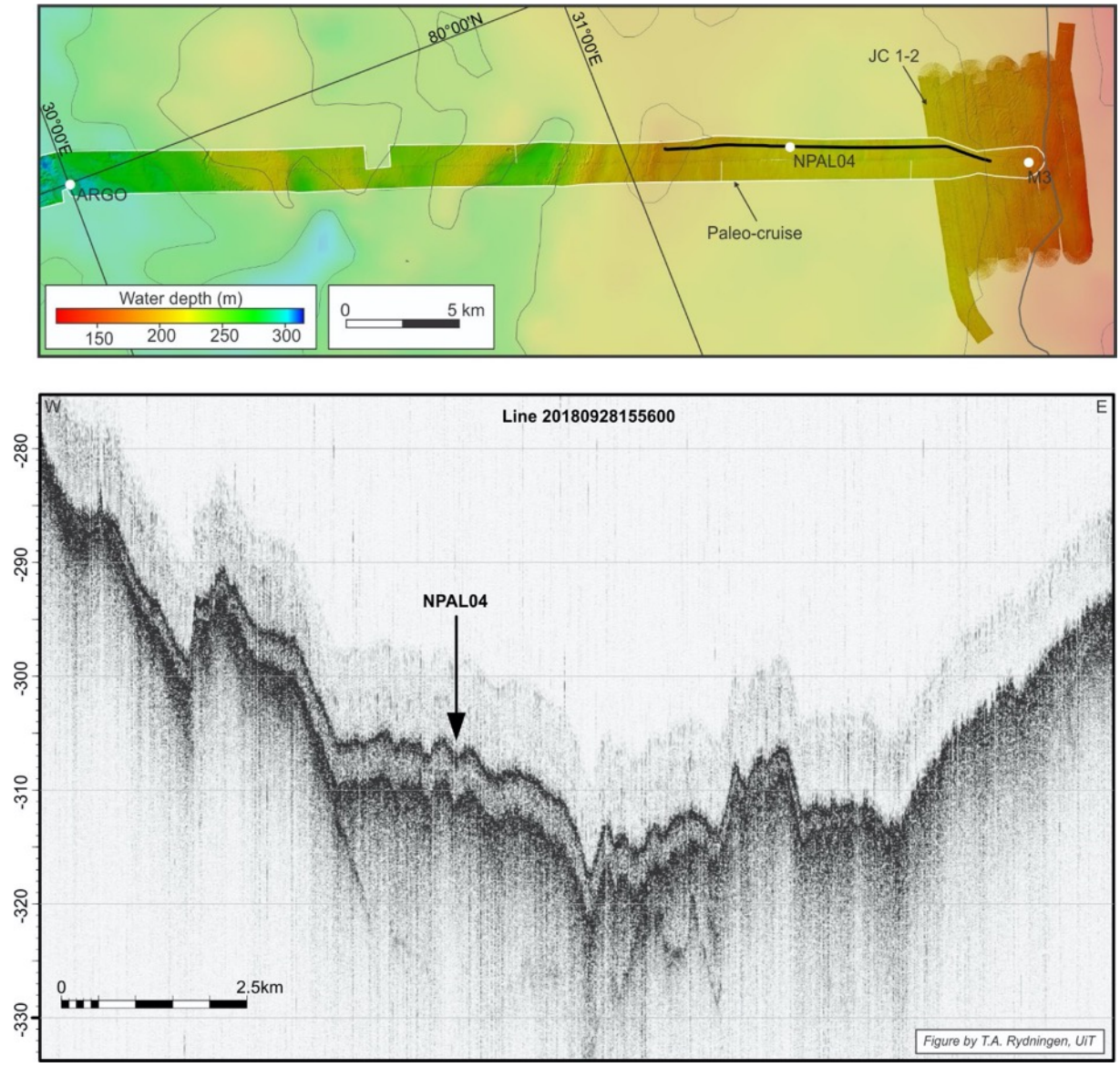


Figure 1: Multibeam bathymetry and selected seismic profile at the NPAL04 site.

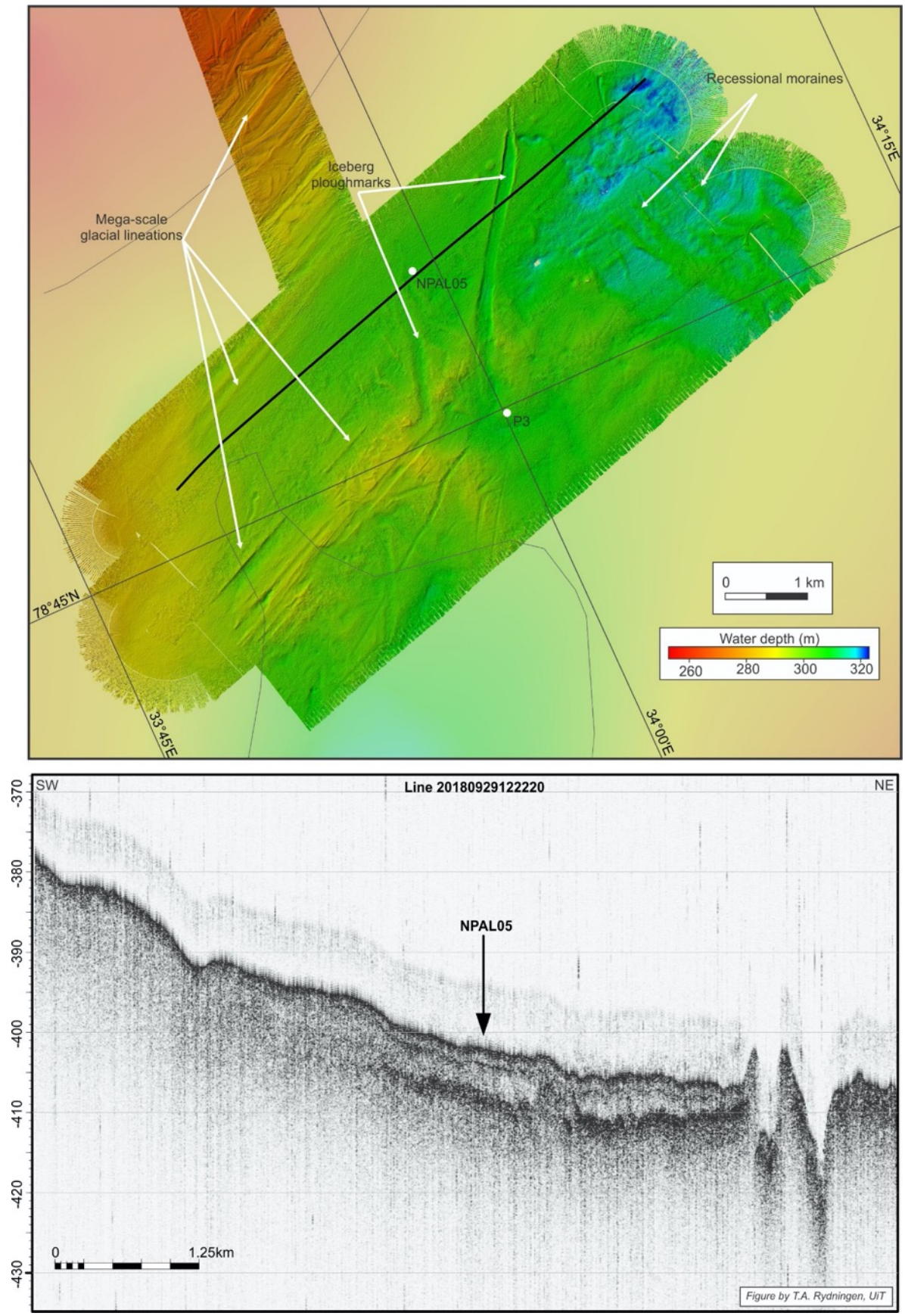


Figure 2: Multibeam bathymetry and selected seismic profile at the NPAL05 site.

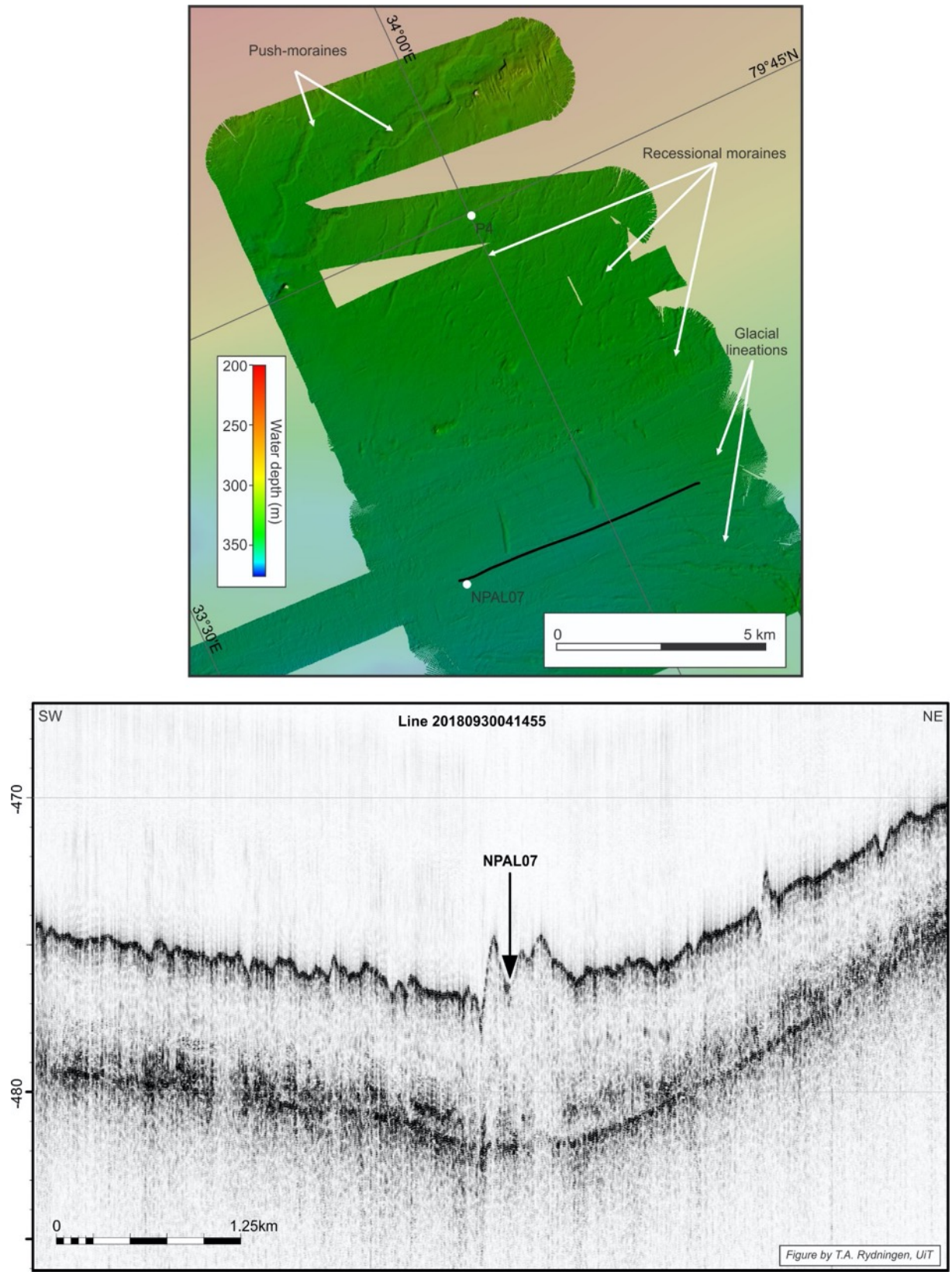


Figure 3: Figure 4: Multibeam bathymetry and selected seismic profile at the NPAL07 site.

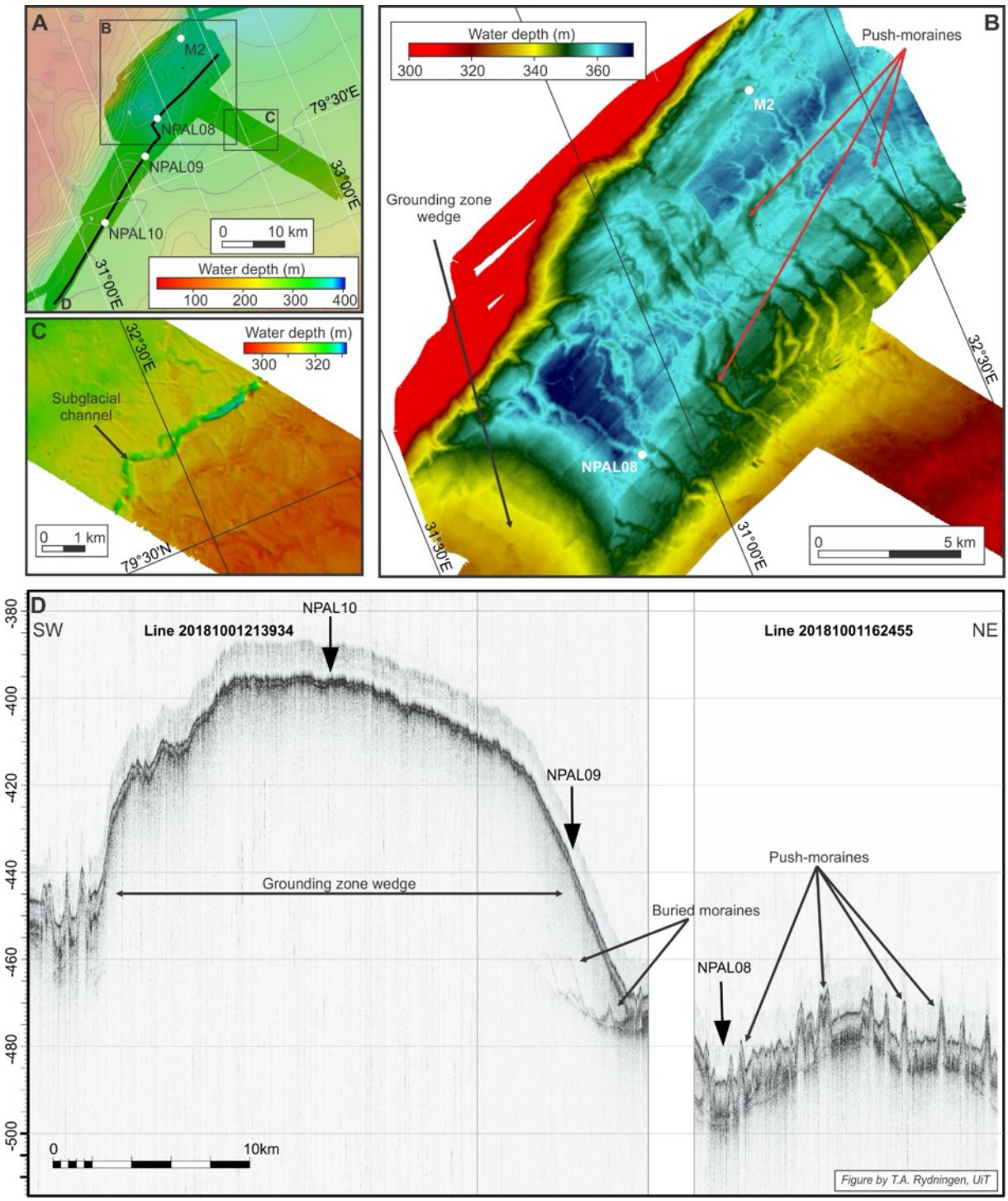


Figure 5: Multibeam bathymetry and selected seismic profile at the NPAL08, NPAL09 and NPAL10 sites.

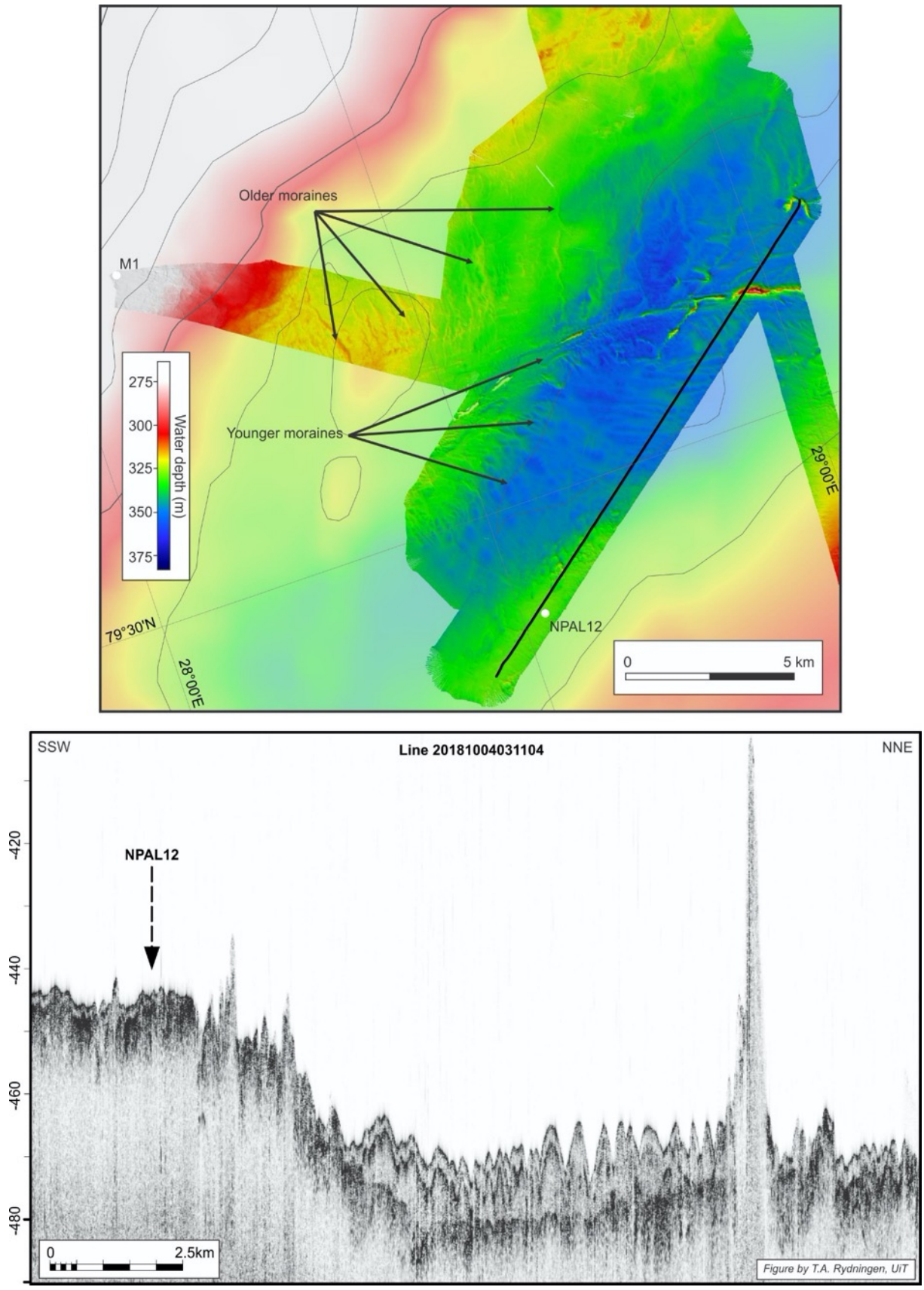


Figure 6: Multibeam bathymetry and selected seismic profile at the NPAL12 site.

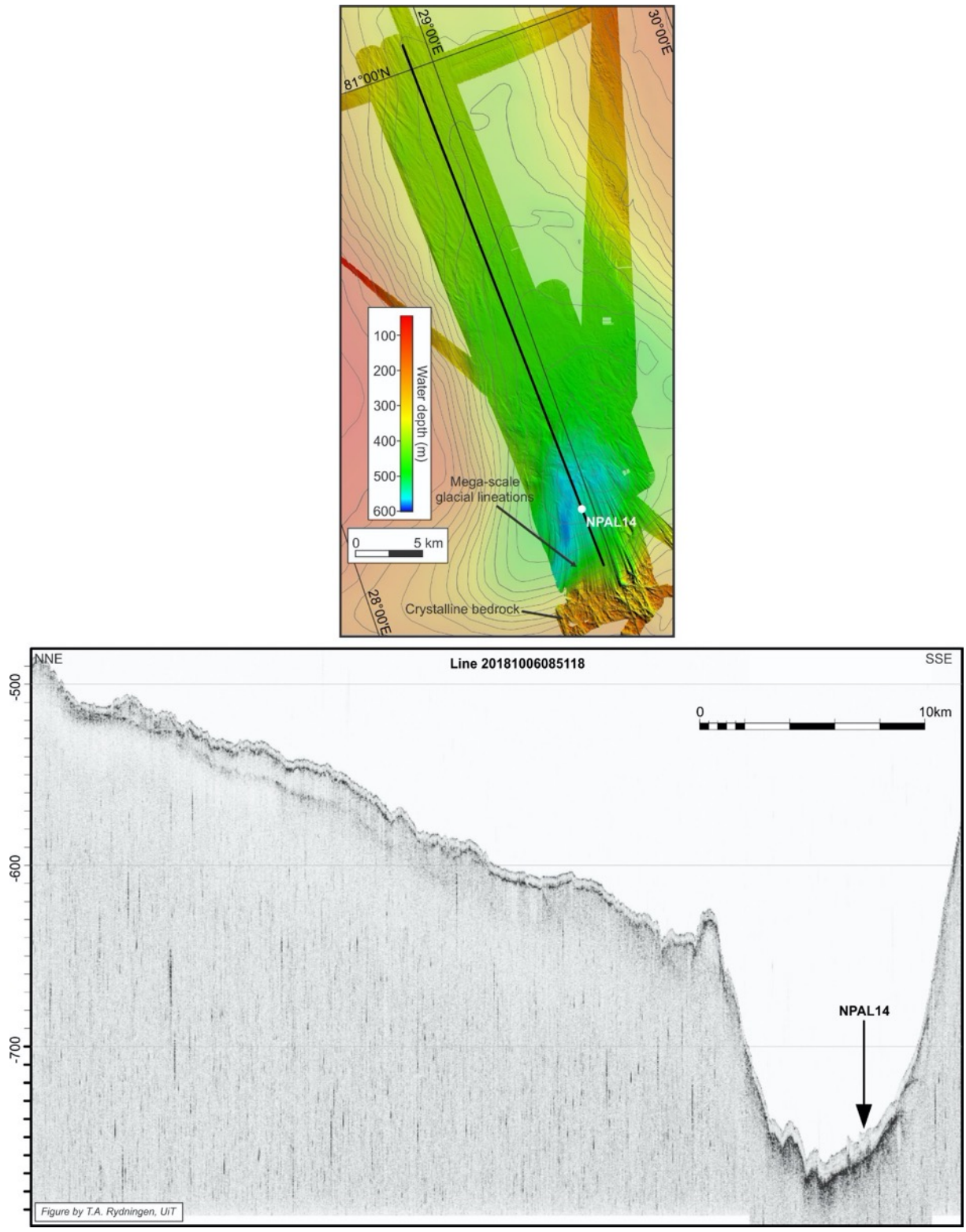


Figure 7: Multibeam bathymetry and selected seismic profile at the NPAL14 site.

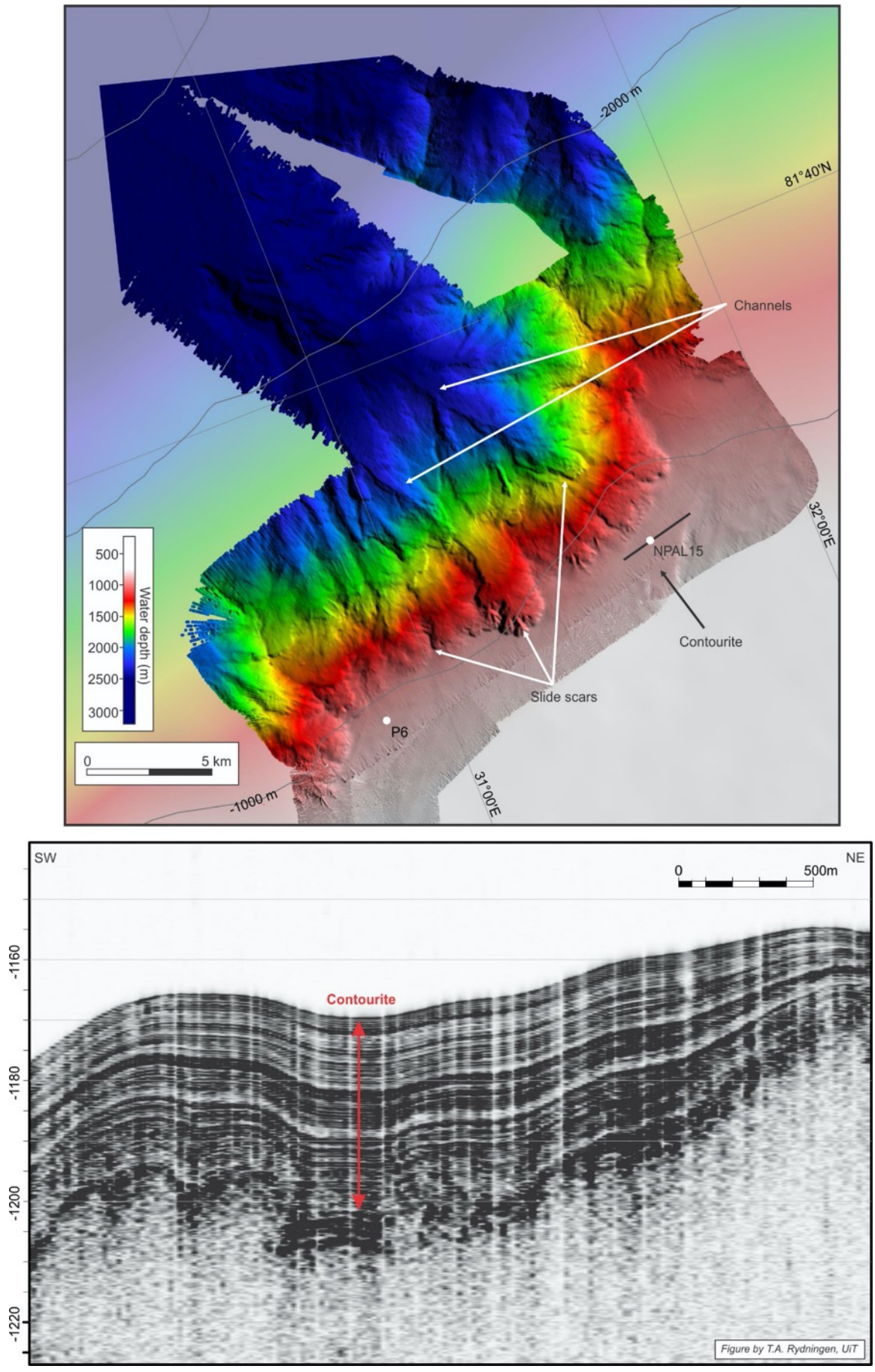


Figure 8: Multibeam bathymetry and selected seismic profile at the NPAL14 site.

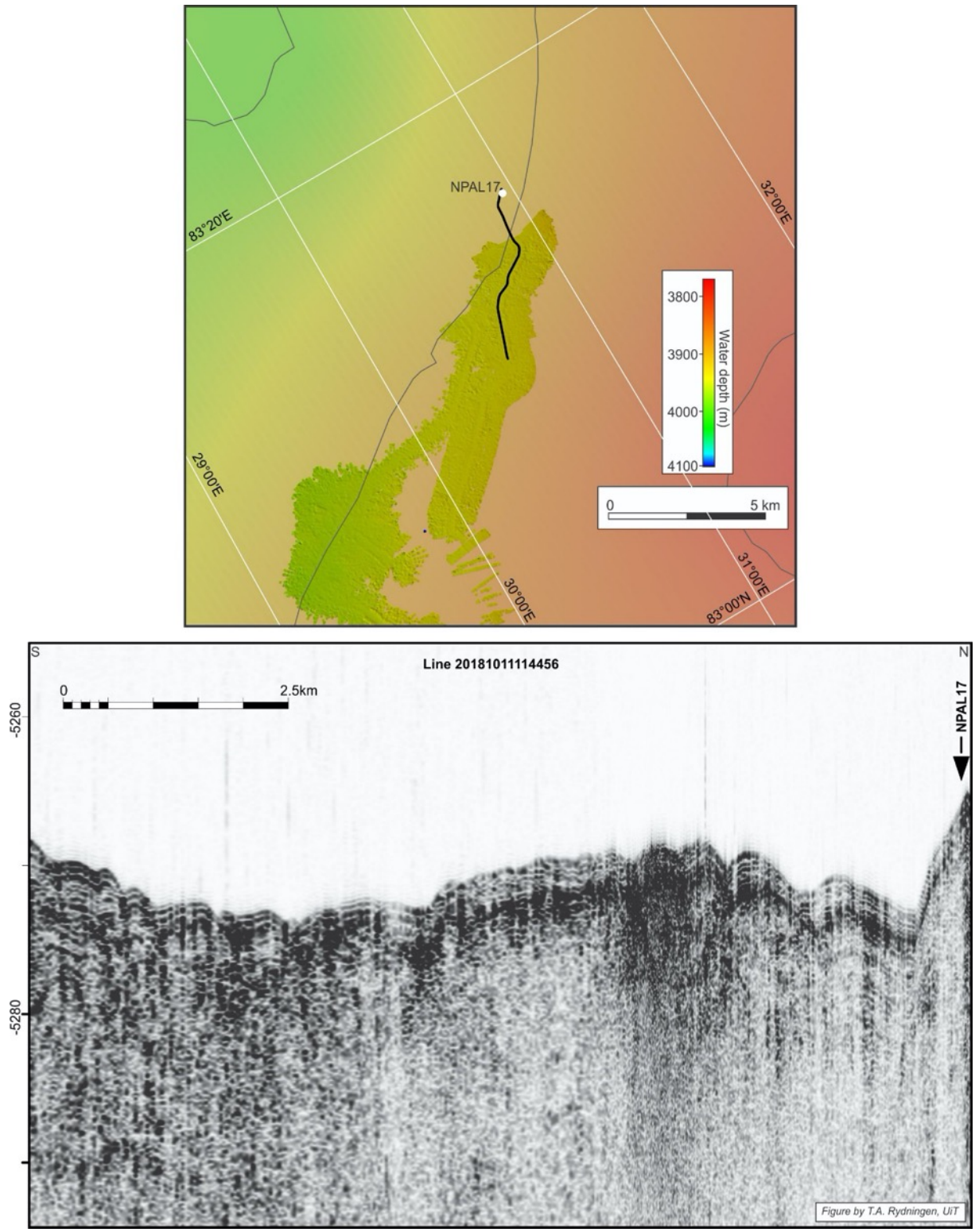


Figure 9: Multibeam bathymetry and selected seismic profile at the NPAL17 site.

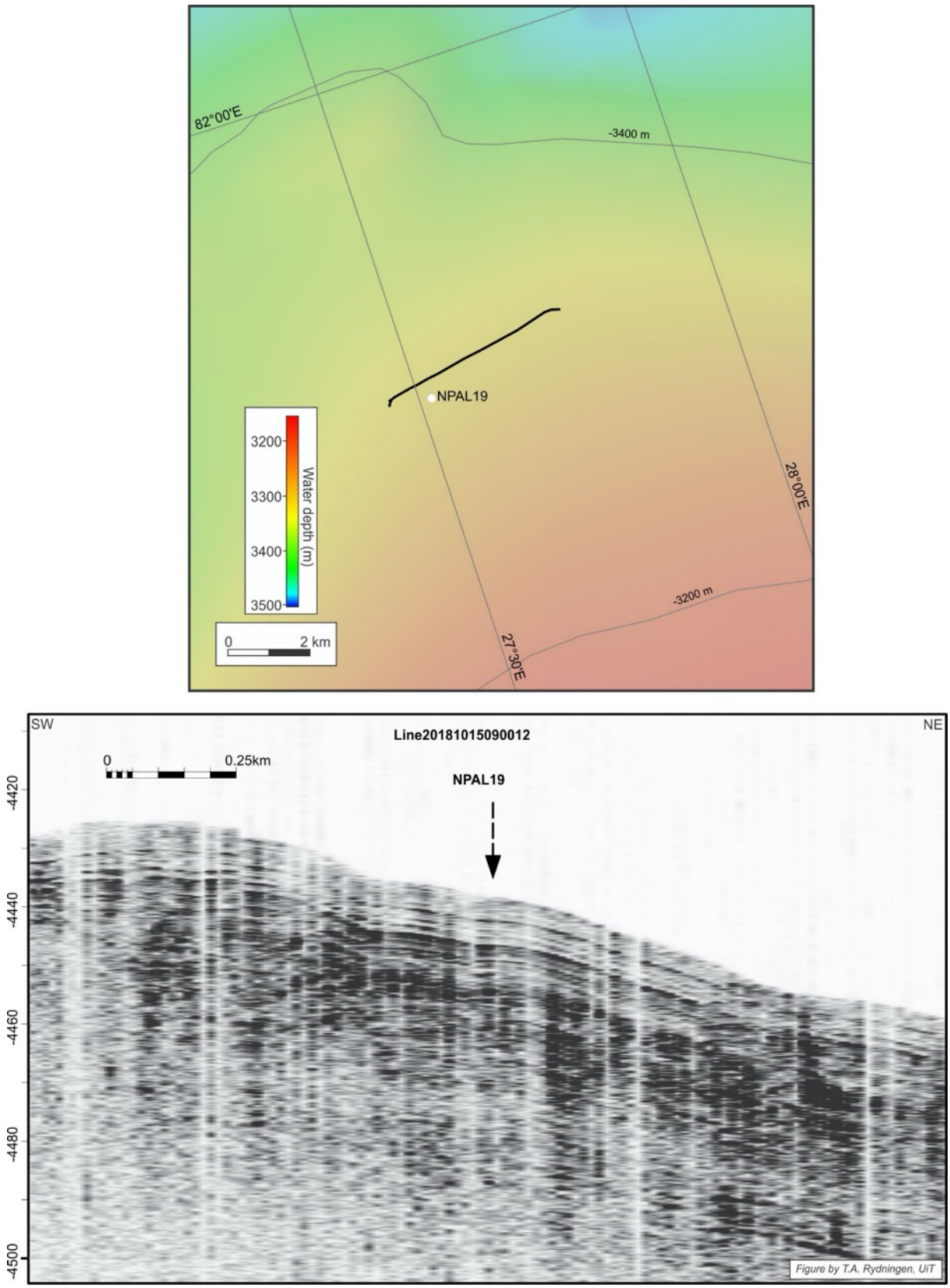


Figure 10: Background bathymetry and selected seismic profile at the NPAL19 site.

Appendix 3-3a. Sediment cores: sampling log aDNA

Station	Core	Sediment core/section length	Sampling interval	Total number of samples	Remarks
NPAL04	KH18-10-04-MC01-A (work)	0-47 cm	Every 3 cm	17	NORCE
NPAL04	KH18-10-04-GC01 (work)	Sec # 1 0-104 cm	Every 4 cm	26	NORCE
NPAL04	KH18-10-04-GC01 (work)	Sec # 2 0-151 cm	Every 4 cm	38	NORCE
NPAL05	KH18-10-05-MC01-D (work)	0-44 cm	Top 0-1.5 cm	2	NORCE
NPAL07	KH18-10-07-MC01-D (work)	0-45 cm	Top 0-1.5 cm	2	NORCE
NPAL08	KH18-10-08-MC01-A (work)	0-48.5 cm	Every 4 cm	14	NORCE
NPAL08	KH18-10-08-GC04 (work)	Sec # 1 0-96.5 cm	Every 5 cm	20	NORCE
NPAL08	KH18-10-08-GC04 (work)	Sec # 2 0-102 cm	Every 5 cm	20	NORCE
NPAL08	KH18-10-08-GC04 (work)	Sec # 3 0-101 cm	Every 5 cm	20	NORCE
NPAL08	KH18-10-08-GC04 (work)	Sec # 4 0-102 cm	Every 5 cm	21	NORCE
NPAL12	KH18-10-12-MC02-B (work)	0-51.2 cm	Top 0-1.5 cm	2	NORCE
NPAL14	KH18-10-14-MC02-C (work)		Top 0-1.5 cm	2	NORCE
NPAL15	KH18-10-15-MC01-A (work)	0-40 cm	Every 4 cm	12	NORCE
NPAL15	KH18-10-15-GC02 (work)	Sec # 1	Every 4 cm	22	NORCE
NPAL15	KH18-10-15-GC02 (work)	Sec # 2	Every 4 cm	25	NORCE
NPAL15	KH18-10-15-GC02 (work)	Sec # 3	Every 4 cm	25	NORCE
NPAL15	KH18-10-15-GC02 (work)	Sec # 4	Every 4 cm	25	NORCE
NPAL15	KH18-10-15-PC03 (work)	Sec # 1, 3, 5, 7, 9, 11, 13, 15	Top and Bottom of each section	15	NORCE

NPAL17	KH18-10-17-MC01-B (work)	0-36 cm	Every 1.5 cm	24	NORCE

Appendix 3-3b. Sediment cores: sampling log IP25 (HBIs)

Station	Core	Sediment core/section length	Sampling interval	Total number of samples	Remarks
NPAL04	KH18-10-04-MC01-A (work)	0-47 cm	Every 1 cm	47	NPI
NPAL04	KH18-10-04-GC01 (work)	Sec # 1	Every 1 cm		NPI
NPAL04	KH18-10-04-GC01 (work)	Sec # 2	Every 1 cm		NPI
NPAL05	KH18-10-05-MC01-D (work)	0-43 cm	Every 1 cm	43	NPI
NPAL07	KH18-10-07-MC01-D (work)	0-46 cm	Every 1 cm	46	NPI
NPAL08	KH18-10-08-MC01-A (work)	0-48.5 cm	Every 1 cm	49	NPI
NPAL08	KH18-10-08-GC04 (work)	Sec # 1	Every 1 cm		NPI
NPAL08	KH18-10-08-GC04 (work)	Sec # 2	Every 1 cm		NPI
NPAL08	KH18-10-08-GC04 (work)	Sec # 3	Every 1 cm		NPI
NPAL08	KH18-10-08-GC04 (work)	Sec # 4	Every 1 cm		NPI
NPAL12	KH18-10-12-MC02-B (work)	0-50 cm	Every 1 cm	50	NPI
NPAL14	KH18-10-14-MC02-C (work)	0-50 cm	Every 1 cm	50	NPI
NPAL15	KH18-10-15-MC01-A (work)	0-40 cm	Every 1 cm	39	NPI
NPAL15	KH18-10-15-GC02 (work)	Sec # 1 0-82.5 cm	Every 1 cm	82	NPI
NPAL15	KH18-10-15-GC02 (work)	Sec # 2 0-101 cm	Every 1 cm	101	NPI
NPAL15	KH18-10-15-GC02 (work)	Sec # 3 0-100 cm	Every 1 cm	100	NPI
NPAL15	KH18-10-15-GC02 (work)	Sec # 4 0-100 cm	Every 1 cm	100	NPI
NPAL17	KH18-10-17-MC01-B (work)	0-36 cm	Every 1 cm	36	NPI

Appendix 3-3c. Sediment cores: sampling log dinocysts

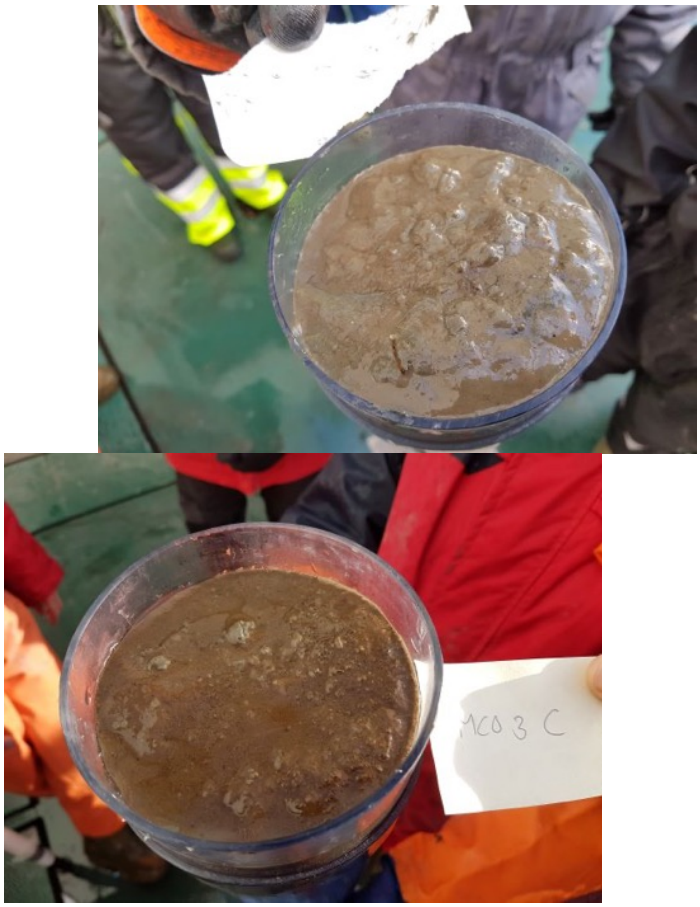
Station	Core	Sediment core/section length	Sampling interval	Total number of samples	Remarks
NPAL04	KH18-10-04-MC01-A (work)	0-47 cm	Every 1 cm	47	NORCE
NPAL04	KH18-10-04-GC01 (work)	Sec # 1	Every 1 cm		NORCE
NPAL04	KH18-10-04-GC01 (work)	Sec # 2	Every 1 cm		NORCE
NPAL05	KH18-10-05-MC01-D (work)	0-43 cm	Every 1 cm	43	NORCE
NPAL07	KH18-10-07-MC01-D (work)	0-46 cm	Every 1 cm	46	NORCE
NPAL08	KH18-10-08-MC01-A (work)	0-48.5 cm	Every 1 cm	49	NORCE
NPAL08	KH18-10-08-GC04 (work)	Sec # 1	Every 1 cm		NORCE
NPAL08	KH18-10-08-GC04 (work)	Sec # 2	Every 1 cm		NORCE
NPAL08	KH18-10-08-GC04 (work)	Sec # 3	Every 1 cm		NORCE
NPAL08	KH18-10-08-GC04 (work)	Sec # 4	Every 1 cm		NORCE
NPAL12	KH18-10-12-MC02-B (work)	0-50 cm	Every 1 cm	50	NORCE
NPAL14	KH18-10-14-MC02-C (work)	0-50 cm	Every 1 cm	50	NORCE
NPAL15	KH18-10-15-MC01-A (work)	0-40 cm	Every 1 cm	39	NORCE
NPAL15	KH18-10-15-GC02 (work)	Sec # 1 0-82.5 cm	Every 1 cm	82	NORCE
NPAL15	KH18-10-15-GC02 (work)	Sec # 2 0-101 cm	Every 1 cm	101	NORCE
NPAL15	KH18-10-15-GC02 (work)	Sec # 3 0-100 cm	Every 1 cm	100	NORCE
NPAL15	KH18-10-15-GC02 (work)	Sec # 4 0-100 cm	Every 1 cm	100	NORCE
NPAL17	KH18-10-17-MC01-B (work)	0-36 cm	Every 1 cm	36	NORCE

Appendix 3-3d. Sediment cores: sampling log 14C dating

Station	Core	Sediment core/section length	Sampling interval (depth within section)	Total number of samples
NPAL04	KH18-10-04-MC1 A (archive)	0-47 cm	5-6 cm 43-44 cm	2
NPAL04	KH18-10-04-GC1 (work)	Section 1, 0-104 cm	5-6 cm 97-98 cm	2
NPAL04	KH18-10-04-GC1 (work)	Section 2, 0-151 cm	5-6 cm 130-131 cm	2
NPAL05	KH18-10-05-MC1 D (work)	0-44 cm	5-6 cm 37-38 cm	2
NPAL07	KH18-10-07-MC01 D (work)	0-45 cm	5-6 cm 39-40 cm	2
NPAL08	KH18-10-08-MC01 A (archive)	0-48.5 cm	5-6 cm 43-44 cm	2
NPAL08	KH18-10-08-GC04	Section 1, 0-96.5 cm	5-6 cm 90-91 cm	2
NPAL08	KH18-10-08-GC04	Section 2, 0-102 cm	5-6 cm 95-96 cm	2
NPAL08	KH18-10-08-GC04	Section 3, 0-101 cm	5-6 cm 95-96 cm	2
NPAL08	KH18-10-08-GC04	Section 4, 0-102 cm	5-6 cm 95-96 cm	2
NPAL12	KH18-10-12-MC2-B (work)	0-51.2 cm	5-6 cm 45-46 cm	2
NPAL14	KH18-10-14-MC2-C (work)		5-6 cm 44-45 cm	2
NPAL14	KH18-10-14-GC03 (work)	Section 1, 0-65 cm	5-6 cm 54-55 cm	2
NPAL14	KH18-10-14-GC03 (work)	Section 2, 65-175 cm	5-6 cm 54-55 cm 104-105 cm	3
NPAL14	KH18-10-14-GC03 (work)	Section 3, 175-285 cm	176-177 cm 227-228 cm 277-278 cm	3
NPAL14	KH18-10-14-GC03 (work)	Section 4, 285-395 cm	5-6 cm 55-56 cm 104-105 cm	3
NPAL14	KH18-10-14-GC03 (work)	Section 5, 395-505 cm	406-407 454-455 493-494	3
NPAL15	KH18-10-15-MC1 A (archive)	0-40 cm	5-6 cm 33-34 cm 36-37 cm	3
NPAL15	KH18-10-15-GC02 (work)	Section 1, 0-85 cm	5-6 cm 42-43 cm 78-79 cm	3
NPAL15	KH18-10-15-GC02 (work)	Section 2, 85-185 cm	5-6 cm 50-51 cm 94-95 cm	3
NPAL15	KH18-10-15-GC02 (work)	Section 3, 185-285 cm	5-6 cm 50-51 cm 94-95 cm	3
NPAL15	KH18-10-15-GC02 (work)	Section 4, 285-385 cm	5-6 cm 50-51 cm 95-96 cm	3
NPAL17	KH18-10-17-MC01 B (archive)	0-36 cm	4-5 cm 19-20 cm 33-34 cm	3

Appendix 3-3e. Sediment surface samples: photos

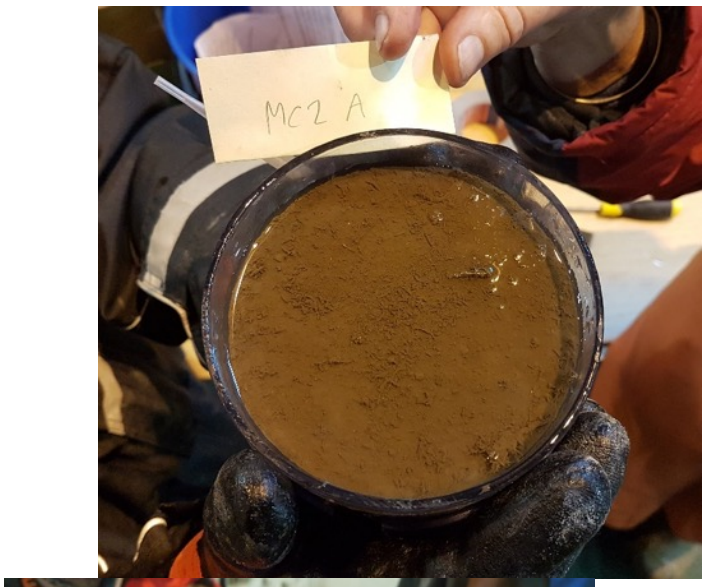
NPAL 04



Sediment surface of core MC3-A with polychaete tube (left) and core MC3-C (right).

Black mottles at 19-20 cm depth of core MC3-C.

NPAL 05



Sediment surface (left) and subsurface at 4 cm depth with large polychaete tube (right), core MC2-A.

Living polychaete (c. 5 cm) at 13 cm depth, core MC2-A.

NPAL 07

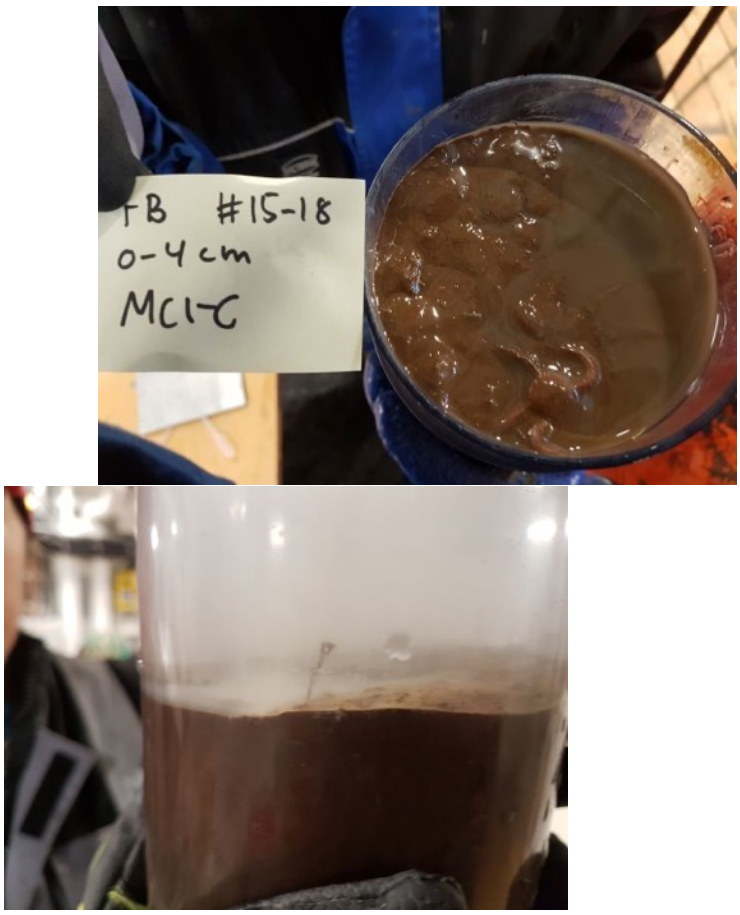
Sediment surface with milky-white layer visible, core MC1-C (left) and brittle star, core MC2-C (right).

NPAL 08

Sediment surface, MC3-C (left) and small brittle star from sediment surface, MC2-B (right).

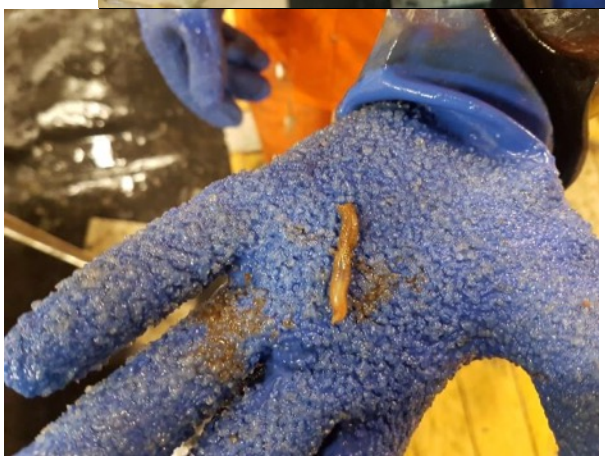
Large polychaete tubes and iron oxides at 21-22 cm depth, MC1-D (left) and large polychaete tube (> 20 cm in length) from 5-6 cm depth, MC1-D (right).

NPAL 12



Sediment surface of MC1-C with a small brittle star (left) and sediment surface with polychaete tube and milky-white layer visible on top of MC2-A (right).

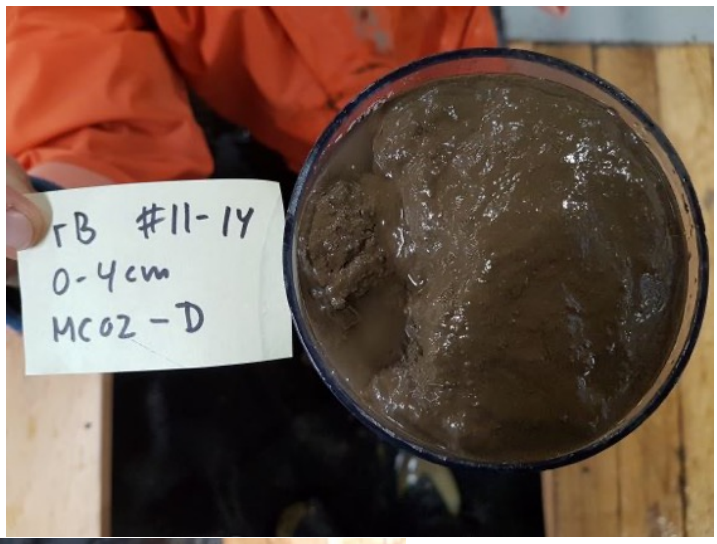
NPAL 14



Sediment surface of MC1-B (left) and polychaete from 3-4 cm depth, MC1-B.

3-4 cm depth, core MC3-A (H_2S-smell).

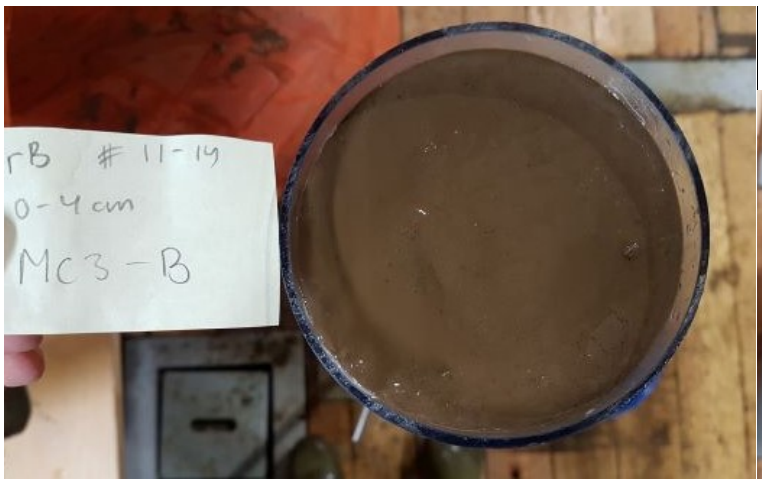
NPAL 15



Sediment surface, MC2-D (left) and gravel pocket at 36-37 cm depth, MC1-C (right).

Sediment surface with small starfish and white crustaceans, MC3-B.

NPAL 17



Sediment surface, MC3-B (left) and sand-sized particles on subsurface at 3-4 cm depth, MC3-B.

Sand layer at 15-16 cm, MC3-C.

NPAL 19


Sediment surface, MC2-C (left) and with polychaete tube, MC1-A (right).

Sand layer at 25-26 cm depth (left) and gravel at 32-33 cm depth (right), MC1-A.

Transparent sea snail? found at surface of core MC2-C.

Appendix IV: Sampling protocols.

CTD water sampling

-12 x 8L Niskin bottles (bottle #1 is from the deepest depth)

-Sensors: Chl & CDOM fluorescence, O2, transmissometer 660 nm, PAR, sPAR

-One cast whole water column for biology & chemistry

Sampling from ship CTD
Stable isotopes 60 ml serum vials with septa and crimpcaps

SAMPLING DEPTHS STABLE ISOTOPES (H, O, C)
Upper 150m: 150, 100, 50, 25, 10, 5, 0m (adjust depending on local mixed layer and near surface stratification features). Maximum 12 bottles

Lower resolution sampling to (and including as close as possible and within 10m of) seafloor to define any major water masses.

Stable Isotopes (_δ18O - δ _D)
Collecting the sample:
Sample evaporation and/or moisture condensation in the sample bottle must be avoided at all costs! Sampling from the Niskin bottles are done into 60 ml serum vials with butyl rubber septa and crimpcaps.

1) Rinse the vial and septum with sample three (3) times. This removes any water than may have condensed inside the bottle/cap.
2) Fill the vial and cap with seawater from the Niskin bottle (it is practical to use a silicon tube (i.d. 7mm), similar to the DIC sampling.
3) Apply the septum to the vial without touching the inside. Do not crimp the crimp cap. Press the septum sideways to release overpressure so the cap does not pop off.
4) Turn the bottle upside down and check for a small air bubble. If the bubble is too small loosen the septum and tighten it again.
5) When all the δ18O samples have been collected from one CTD, dry the vials, crimp the caps (and seal with Parafilm following the instructions below / on the next page.)
6) Store the δ18O samples at room temperature or in a fridge.

Alternative for onboard measurements with a Picarro:

4b) Bring the bottles to the lab. For each sample, transfer 1.7 ml to 2 ml labelled GC vials with screwcaps and PTFA lined butyl rubber septa using a 1 ml pipette. GC vials are stored upside down in boxes with lids in the fridge.
5b) Serum vials and septa can then be emptied, washed with DI water and dried for reuse or capped and crimped for refrigerated storing of sample for backup or further onshore measurements.

Sampling for $\delta^{13}C$ of DIC in seawater
SAMPLING DEPTHS (ocean acidification studies) are as above.

Equipment: Glass bottles 60 ml with butyl rubber septa and crimp caps, silicon tube (i.d. 7mm at KH), Mercury(II)chloride (in saturated solution in DI water, >7.4 g/100 mL, 20 °C), gloves.

1) Use gloves and goggles when handling the saturated Mercury(II)chloride and the fixed samples.
2) The bottles should be numbered before sampling, please use this number as reference.

3) Rinse the vial and septum with sample three (3) times. This removes any water than may have condensed inside the bottle/cap. Use the silicone tube to transfer water from the Niskin bottles to the sampling bottles.
4) The tube should be placed in the bottom of the sampling bottle when filling. Make sure there are no bubbles inside the tube when filling. This might require reducing the flow from the Niskin bottle.
5) Overfill the sample bottle with one bottle volume. Make sure no bubbles are trapped inside the sample bottle. Put the lid on so excess water runs out (squeeze sideways and down). When you have filled all sample bottles transfer them back to the laboratory.
6) Dry all the bottles with paper towel. Paper towels go in a black or clear waste bag (normal waste).
7) Using gloves and goggles and working in the fume hood add 5 drops of saturated Mercury(II)chloride from the small drop-bottle or using syringe w/needle to each bottle. Put the septum back on and secure it with a Crimp cap. Make a permanent, separate working area for Hg work (e.g. a fume hood) to avoid spreading Hg spill to the rest of the lab. Use bench paper and change gloves often to avoid spreading the mercury.
8) Dry of the bottles with paper towel in case of spillage. This paper goes in the zip bag labelled hazardous waste.

9) Put the dry bottles in the cooling room (NO FREEZING!). In case any spill dry with paper towel and put in the yellow plastic bag. All used gloves go in the hazardous waste.

For onboard analyses on a Thermo Delta Ray instrument:

5b) One extra bottle is sampled per sample. The vial is filled as in 5).

6b) as 6).

7b) Transfer 1 ml sample, using a 1 ml syringe, to each of 3 exetainers (Labco,UK) pre-prepared with 5 drops of 99-100% phosphoric acid each. Exetainers w/acid must be flushed with synthetic air before adding the sample (usually done onshore). No Hg is needed.

8b) stir (rotate glass) gently with vial remaining near vertical to mix water and acid and measure after the water reaches constant temperature (room temperature).

Updated 15/10 -18 by Pål Tore Mørkved

Plankton net protocols

1.1. Purpose

Pteropod (shelled butterfly snails) and planktic foraminifera collection will be performed on the process stations at the Nansen Legacy cruises. **Pteropods and planktonic foraminifera** are key indicators for ocean acidification effects (RF2).

- Planktonic foraminifera (Fig. 1A): study of species abundance and species composition, state of shell dissolution and shell thickness (shell weight and size analyses, SEM).
- Pteropods (Fig. 1B): study shell condition, shell density and size (thickness, mm; size, mm) using several techniques (SEM and MicroCTtomography). Species abundance and species composition.

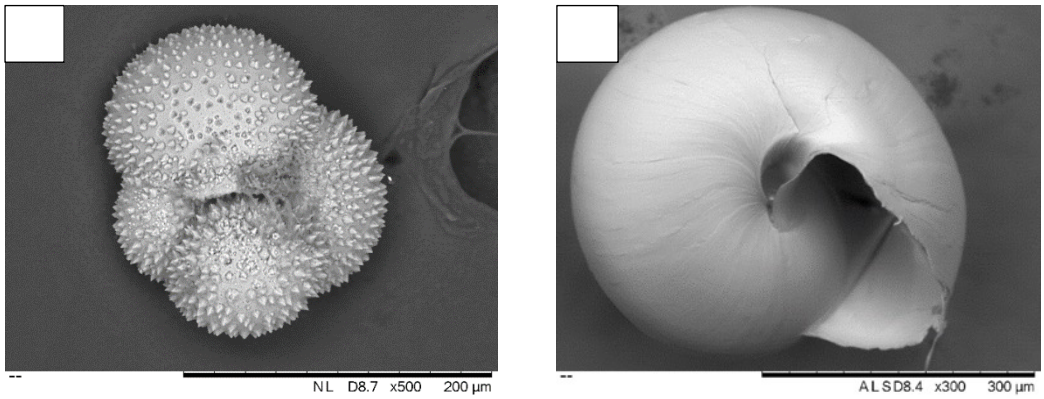


Figure 11. SEM images of planktic foraminifera (A) and pteropod (B). Images: Kasia Zamelczyk

1.2. Plankton net -zooplankton (Pteropod and Planktonic foraminifera) sampling depths

Sampling depths for planktic foraminifera and pteropods:

- WP2 (4 casts): 0-50, 50-100, 100-200, 200-300 m water depth
- Multinet (1 cast): 0-50, 50-100, 100-150, 150-200, 200-300 m water depth

In order to compare the plankton data to the water column chemistry, CTD data and water samples will be collected prior to plankton net casts and in parallel to plankton net stations. CTD data and water samples for zooplankton studies will be collected in the following depths: 0 m, 25 m, 50 m, 100 m, 150 m, 200 m and 300 m. These depths might slightly vary depending on the water column structure and distribution of water masses.

1.3. Equipment

- Type WP-2 net from HydroBios
- Multinet from HydroBios
- Plastic containers for storing samples (5 per station)
- 1 64µm sieve
- 2 beakers, 2 sprays bottles
- Pieces of net to repair net cup
- 1 screwdriver
- 2 tapes repair tissue
- Scissors
- Superglue
- Black markers
- 2 buckets
- Ethanol 96%

- Hexamethyltetramine

1.4. Sampling protocol

1.4.1. Preparation of the net equipment and

Mesh size for planktic foraminifera and pteropods: 90 µm mesh size window in the cup and 63 µm mesh size in the net (although ideally same mesh size should have been used).

1.4.1.1. WP2 (HydroBios model) setting

Steps for setting the WP2 net (Figure 2):

1. 1.Connect the ring to the net
2. Connect the cup to the net
3. Insert the cup in the metal box
4. Connect the box to the net

   Attention : Check if the net is free of holes (after each sampling) and if you find any use the tape to repair it.
5. Check the safety closure for the cup

Figure 12. Steps for setting the WP2 net. Photos: Kasia Zamelzyck

1.4.1.2. Multinet (HydroBios model) setting

Follow instructions in the multinet manual (blue folder) for setting the multinet structure. Then follow WP2 steps 1 to 5 to set the net and the cups in the multinet (see section 1.3.1.2.; Figure 2). Attention: make sure that cup 1 is connected to net 1 and so on.

For programming the net depth intervals use multinet instructions (blue folder) and OceanLab software. Set the unlocking depth at least 5 m below the first net depth interval (ex. If the first net collects plankton from 300 to 200 m, the unlocking depth has to be at least 305 m).

The multinet needs to be programmed before each deployment.

1.4.2. Collecting samples

Before and during net deployment: avoid twists (Figure 3).

Figure 13. Check always if the nets are twisted. Photos: Naima El bani Altuna.

Steps for sample collection:

1. The first net (net 1) is the deepest one.
2. Vertical speed velocity:, Downward speed 1m/sec, Upward (during collection) speed 0,5 m/sec. The speed must remain constant during the collection.
3. If multinet: before starting the collection, the multinet must be 15 m below the unlocking depth (ex. If the first net collects plankton from 300 to 200 m, the unlocking depth will be 305 m and the multinet has to sent first to 320 m at least)
4. Before the recovering, when the net is still out (before putting on the deck) wash it from outside to the inside with sea water pump in order to get all the sample into the cup

   Attention: no recovering the WP2 from the net but always from the metal box

1.4.3. Reducing Volume and Storage

Steps:

1. Prepare the storing bottles: add a quarter tea-spoon of hexamethyltetramine buffer to each bottle and label them
2. Reduce the volume of the sample: use a 63µm sieve to reduce the volume of the collected material
3. Recover all the material in the sieve using filtered sea water, preferentially from the same site; this can be done “sieving” water from 300 m Niskin bottle at the same station
4. Transfer the sample from the sieve into the bottle by using spray bottle and funnel
5. Add 96% ethanol. At the end the solution on the bottles have to be approximately 70% ethanol
6. Store the bottles in a cooling room at around 4°C

Sediment sampling

Short sediment cores – Multicores

The multi corer automatically gives four multicorer tubes. At least two casts will be carried out with multicorer in order to obtain sediment cores for the analyses and proxies (Table xA). Three casts will be carried out at stations where it is also planned to analysze porewater and sediment geochemistry (ChAOS). Samples from sediment cores that are sampled onboard will be kept frozen. Other cores will be stored cold (0-5° C). Further processing and analysis will be carried out onshore at NPI, UiB, UiO, UiT and UniRES (Table xA).

Proxy – parameters	Number of multicores	Partner
Paleo benthic foraminifera, planktic foraminifera	1	UiO, UiT
Living benthic foraminifera	3	UiO
Stable isotopes	1	UiB
IP25, diatoms, aDNA, dinocysts	1	NPI, UniRES
Sedimentology	1	UiT
Reference	1	UiO/UiT/UiB/NPI
Porewater, sediment geochemistry	2	ChAOS, UiT

Table xA. Overview of multi core sampling for proxies and parameters

Long sediment cores – gravity cores (GC) and piston cores (PC)

The long cores are cut for every m (GC) and every 1.5 m (PC) and carefully labelled. Those sediment cores that are sampled for pore water and/or for aDNA are opened and described onboard. Further sampling onboard is problematic due to carbonate dissolution which most probably will occur when the sediments are oxygenated. All cores will be logged with regard to magnetic susceptibility, colour and photographed.

Living (stained) and fossil benthic foraminifera sampling protocol

1.1 Materials

Stand with a piston.

Shorter section of the core tube graduated with 1 cm mark.

Slicing plates.

Siphon.

Plastic pipettes.

180 ml Joni plastic containers.

Zip log bags.

Ethanol (96 %).

Rose Bengal.

Notebook.

Camera.

Permanent marker pen.

Sampling of short multicores

Note down weather condition (if working outside) and sample process time.

Place the core on a stand with a piston that fits the plastic core tube (Figure 14).

Remove excess water above the sediment surface by using a siphon before pushing the core liner down on the piston in order to avoid sediment in suspension. Remove residual surface water using plastic pipettes.

Prior to sub-sampling, take a photograph of the surface with label.

Note down colour, texture, biota and possible disturbances, e.g. bioturbation, during slicing.

If the sediment surface is irregular, define the sub-sample as the midpoint between the highest and the lowest point (measure the distance between these) (Schönfeld *et al.* 2012).

Slice the sediment core using a slicing plate and a graduated, shorter section of the core tube (Figure 14).

It is important to move the plate and sample horizontally when slicing to avoid dragging up sediment from the lower layer.

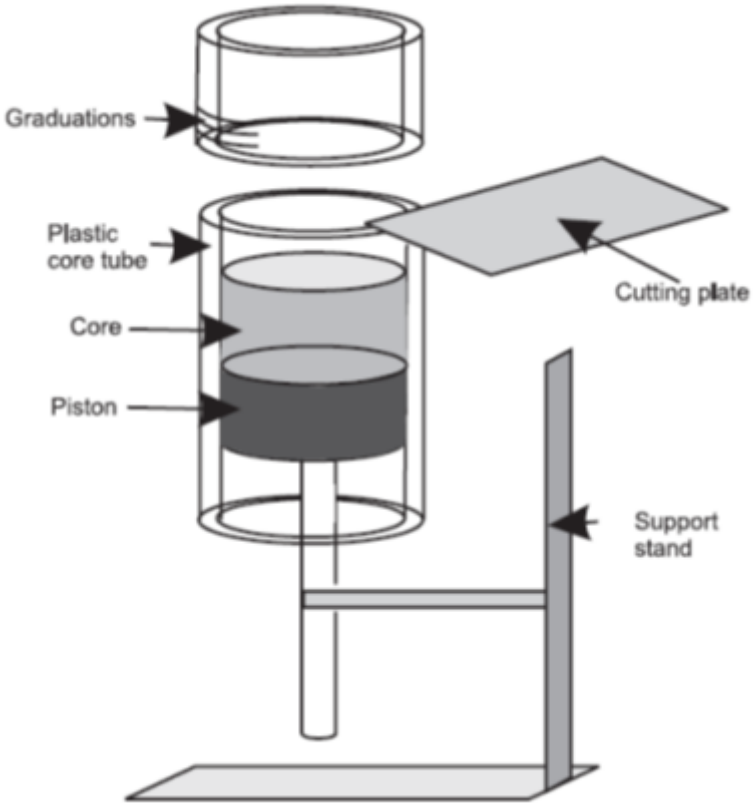


Figure 14: Schematic representation of a stand with a piston for sediment slicing (Murray 2006).

Sampling for palaeoceanographic and fossil benthic foraminifera analyses

Sub-sample one sediment core in 1 cm intervals down to 40 cm.

Due to high water content in the sediment surface, transfer samples down to 5 cm to 180 ml Joni plastic containers, and in zip log bags from 5-40 cm. Store the zip log bags in one large zip log bag to separate samples from the different stations.

Store the sub-samples frozen (- 20 °C).

It is important to avoid adding too much pressure on the lid when closing the plastic containers, as the containers might break. Instead, push the lid down in one place and drag your finger around until you hear a click.

Sampling for living (stained) benthic foraminifera

Sub-sample three sediment cores in 1 cm intervals;

One core down to 10 cm. pH may be measured in the sub-samples.

Two cores down to 4 cm.

Transfer the sub-samples to 180 ml Joni plastic containers and add at least an equal volume of rose Bengal (2 g/L) stained 80 % ethanol.

Mix the samples thoroughly (but gently) until homogenized - examine the bottom of the container to see if any sediment is still clumping together (Figure 15).

It is important to avoid adding too much pressure on the lid when closing the plastic containers, as the containers might break. Instead, push the lid down in one place and drag your finger around until you hear a click.

Figure 15: Well-mixed sample (left) and not sufficiently mixed sample (right).

References

Murray, J.W., 2006. Ecology and Applications of Benthic Foraminifera. Cambridge University Press, Cambridge.

Schönfeld, J., Alve, E., Geslin, E., Jorissen, F., Korsun, S., Spezzaferri, S., 2012. The FOBIMO (FOraminiferal BIo-MOnitoring) initiative — Towards a standardised protocol for soft-bottom benthic foraminiferal monitoring studies. *Marine Micropaleontology* 94-95: 1-13.

Ancient DNA (aDNA) sampling protocol

1.1 Purpose:

Sea ice reconstruction

1.2 Material

- single-use sterile 12ml polypropylene syringes (n= depends on sampling strategy)
- knife
- scissors
- disposable gloves (good to have both large and medium)
- single use large plastic spoons
- single use small plastic spoons
- -OR- metal spatula, wiped clean and flame-sterilised between samples
- sampling bags
- permanent marker for labelling
- sticky labels for sampling bags
- aluminum foil to work on a clean working desk and/or ethanol for cleaning workspace
- pre-cut "skumplast/oasis" (rubber foam) to fill in holes in sediment core
- Bunsen burner or lighter for flame-sterilizing knife

1.3 Sampling protocol

Amount: At least 10cc per, more if available and if sediment is "soupy". We need minimum 3 to 5 gram dry sediment for our DNA analyses.

Which interval:

Multicore: 2 samples at 0-1.5 cm, one to be stored in the freezer (-20- -30°C) and one to be stored in the fridge (ca. 4 °C). All samples are taken with syringes with 1.5 cm diameter. Multicores from sites where gravity cores also are taken are sampled downcore at same intervals as the gravity core to ensure overlap between the cores.

Calypso/gravity core: Sampled downcore at 1.5 cm slices in intervals reflecting ca. every 200-250 years.

Multicores were sampled at the top at every station. At station NPAL04, NPAL08, NPAL15 and NPAL17 one multicore half was sampled downcore.

Gravity cores from station NPAL04, NPAL08 and NPAL15 were sampled downcore.

One piston core (KH18-10-15-PC03) was sampled. Samples were taken at the top and bottom of each section (except for section 1, where we only took bottom samples). The length of the material was measured and represents the approx. sampling interval.

Pre-sampling.

1. Cores on deck are brought to the lab.
2. Cores are split using clean tools.
3. Split halves are cleaned by scraping off top sediment perpendicular to the main core axis, to avoid contamination from opening the core.
4. If needed for cleaning the core/core liner: use fresh water or sterile, filtered (<0.2 µm) sea water.

Preparation

On as clean workspace as possible (use aluminum foil as cover)

- Wear *clean* disposable gloves
- Label sample bags
- Label syringes with permanent marker on the tube
- Use unique labels that include cruise, station, site, core type and depth (cm): e.g. “SIMEP–XX–STATION–CORE–xx” or similar
- Keep a log of all sediment samples taken
- Remove top from syringe using a sterilized knife
- Pull up (not out!) inner part of syringe and put in a plastic bag.

Core sampling

5. Sampling control. Place an Eppendorf tube open, on the bench, close to the core and your sampling spot. Give the sampling control an ID and make sure to track which sample(s) while the tube was open.
6. Press syringe into sediment. Avoid to reach the core liner – i.e. leave some sediment – to prevent contamination from the core liner
7. Pull syringe out of sediment
8. When syringes do not work optimally (soupy sediments) use disposable spoons or metal spatula, wiped clean and flame-sterilised between samples
9. Fill hole in sediment core with “skumplast”
10. Close the sampling control (i.e. keep open during process of 1-3 samples (or what seems reasonable), and freeze the sampling controls in a tube/box (the same way you treat the syringes).

Storage

1. Put complete syringe with sediment into labeled sampling bag
2. Put syringe with sample into the -20˚C freezer asap

1.4 Transport

Samples should be transported to Bergen on dry ice. At least 5-6 kg dry ice will be necessary to keep samples frozen during transport.

IP25 and Dinocyst sampling protocol

1.1 Purpose

Sea ice reconstruction

1.2 Material

- Spatulas
- Plastic bags
- Marker

1.3 Sampling protocol

Amount: ca. 1/3 of opened core half.

Which interval:
Multicore and Gravity core: 1 cm slice samples in 1 cm intervals, starting at the top.

IP25 and Dinocyst samples were taken from multicores at stations NPAL04, NPAL05, NPAL07, NPAL08, NPAL12, NPAL14, NPAL15, NPAL17 and from gravity cores at stations NPAL04, NPAL08 and NPAL15.

No Calypso core was sampled on the cruise.

Diatoms were not sampled on the cruise. This is planned to be done in the same manner as IP25 and Dinocysts at a later stage (on archive half of the same cores).

Pre-sampling

11. Cores on deck are brought to the lab.
12. Cores are split. One half (work) is taken away for aDNA sampling. Another half is logged (archive). After aDNA sampling, the remaining material is sampled for IP25 and Dinocysts (multicores only).

Storage

Samples are stored in a cooling room at approx. 4 °C.

1.4 Transport

Bergen (NORCE): Dinocyst
Tromsø (NPI): IP25
Samples should be transported to Bergen/Tromsø in a cooling container. Sampling protocol for ^{14}C dating samples

1.1 Purpose

Dating the sediment

1.2 Material

- Spatulas
- Plastic bags
- Marker

1.3 Sampling protocol

Amount: ca. 1/3 of opened core half.

Which interval:

Multicore: 2 samples, 1 cm slices ca. 5 cm from the bottom and 5 cm from the top (or where it seems reasonable). Samples were taken from the archive half of multicores sampled for IP25 and Dinocysts.

Calypso/gravity core: 3 samples per section. 1 cm slices ca. 5 cm from the bottom, in the middle and 5 cm from the top (or where it seems reasonable). Samples were taken from the work half after aDNA-sampling, or pore water sampling (ChAOS)

Dating samples were taken from multicores at stations NPAL04, NPAL05, NPAL07, NPAL08, NPAL12, NPAL14, NPAL15, NPAL17 and from gravity cores at stations NPAL04, NPAL08, NPAL14 and NPAL15.

Pre-sampling.

13. Cores on deck are brought to the lab.
14. Cores are split. One half (work) is taken away for aDNA sampling or pore water sampling. Another half is logged (archive). After, the work sections are sampled for dating (GC only). For multicores, dating samples are taken from the archive half.

Storage

Samples are stored in a freezer at approx. -20 - -30 °C.

1.4 Transport
Samples should be transported to Tromsø on dry ice or in a freezing container to ensure that the samples remain frozen.

ChAOS (sea water, pore water, sediments)

CTD sampling for nutrients and ICP analysis

Supplies needed

12 MQW rinsed (5x) 500 mL or 1 L bottles

12 MQW rinsed 50 mL syringes

12 centrifuge tubes

12 60 mL Nalgene

12 syringe filters

HCl (conc.)

1. Label 12 acid washed and MQW rinsed (5x) Nalgene bottles (0.5 to 1 L) for sampling from the CTD Niskin bottles.

2. When sampling from the Niskin, rinse 3 times while sampling before filling the bottle.

3. In the lab, take a dry, MQW rinsed 50 mL syringe and using the CTD water, rinse the outside of the syringe.

4. Next, take up 10 mL of CTD water in the syringe. Hold the syringe vertically and pull down on the plunger to rinse the inside of the syringe 3 times.

5. Fill the syringe with CTD water and add the syringe filter to the syringe tip. Push out 10 mL of CTD water to rinse the syringe filter.

6. Rinse the Nalgene bottle with water from syringe 3x and then fill the bottle to just below the shoulder. Close the bottle and parafilm the cap. These samples will be flash frozen at -80C for several hours and then stored in -20C for the remainder of the cruise.

7. Rinse a centrifuge tube with water from the syringe 3x and then fill the tube. Ten uL of HCl will be added to each tube and they should be stored at 4C.

Multicore sampling

Pore waters

Supplies needed

Rhizons

Rhizon spacers

Syringes labelled with appropriate core depths

Centrifuge tubes (15 mL)

Nalgene bottles (1-60 mL and 15 mL for all sediment depths)

Isotope vials

HCl (conc.)

1. Core tubes should be drilled (0.4 cm) every 1 cm. The holes should be covered with clear office tape to avoid leaking.

2. Once cores are brought on deck, they should be cleaned and measured. The sediment core should then be transferred to the sink in the wet lab and secured with a bungee cord.

3. Using a pipette tip, a hole above the sediment water interface should be punctured and the rhizon inserted and attached with a syringe and a spacer. Once the syringe is filled, transfer water into the vials and tubes (and repeat) until a 60 mL Nalgene is filled for nutrients, a 15 mL centrifuge tube is filled for ICP work, a 15 mL centrifuge tube is filled for IC work, and 1 mL is transferred to the vial for isotopes. After these are full, remove the syringe and drain the remaining bottom water.

4. While bottom water is being removed, holes should be punctured and rhizons inserted starting from the bottom sample to 4.5 cm. Syringes can then be added. The 0.5 cm horizon will be set at the first sample below the sediment water interface. Once all overlying water has been removed, the holes at 2.5, 1.5 and 0.5 cm depth were opened, and rhizons were inserted very quickly to avoid the loss of pore water from the very water-rich uppermost sediment horizons. Rhizons will be left in the core tubes for up to ~2 hours, depending on the efficiency of pore water extraction (very fast in the top layers, much slower in deeper, clay-rich layers).

5. Once all rhizons have finished extracting water, the water should be divided as follows:

Sample type	**Min volume**	**Max volume**	**Storage**
ICP	3 mL	15 mL	10 uL HCl in centrifuge tube, stored at 4C
Nutrients	11 mL (6 for dilution)	12-13 mL	Nalgene, capped tightly and parafilmed, flash frozen at -80C standing up before storage at -20C
Isotopes	0.5 mL	0.8-1 mL NO MORE	Transferred by syringe to vial for dry lab for analysis

If less than 3 mL—all sample to ICP

If 3-8 mL—1 mL to isotopes (air); remainder to ICP

If 8-15 mL—3 mL to ICP; remainder to Nut

If 16 mL—3 mL to ICP, 12 mL to Nut; 1 mL to isotopes (air)

If >16 mL—12 mL to Nut; 1 mL to isotopes (air); 1 mL to isotopes (He); remainder to ICP

Sample depths: BW, 0.5, 1.5, 2.5, 4.5, 6.5, 8.5, 10.5, 12.5, 14.5, 16.5, 18.5, 20.5, 25.5, 30.5 etc.

Sediments

Supplies needed

Whirl pak bags

Sampling tools (plastic plates and rings)

pH meter (calibrated)

pH probe

DI bottle and Kim Wipes

1. Sediment samples for both multi- and gravity cores should be sampled and frozen soon after cores are opened to avoid oxidation of sulfides and Fe in pore waters.

2. The core should be transferred to a core extruder on deck. Remove most overlying water using a silicon tube. The pH meter should be calibrated prior to sampling. Clean pH probe with MQW water. Be sure to remove any salt from probe. Measure pH within the overlying water. The remaining water should be removed with a disposable pipette.

3. Prior to extruding core, measure pH on the surface 3 times and record by hand in notebook. Clean pH probe thoroughly with MQW water.

4. Extrude core 1 cm by turning the crank two full turns, slice and transfer to labelled bag. Sample entire core at 1 cm intervals. Samples should be stored at -20degC.

Gravity core sampling

Pore waters

Supplies needed

Drill and 0.4 cm drill bits

Rhizons

Rhizon spacers

Syringes labelled with appropriate core depths

Centrifuge tubes (15 mL)

Nalgene bottles (1-60 mL and 15 mL for all sediment depths)

Isotope vials

HCl (conc.)

1. Gravity core sections should be transferred to wet lab counters and secured using bungee cords.

2. Holes should be drilled every 15 to 30 cm (based on section length). A rhizon should be inserted into the hole and a syringe should be attached and a spacer added. Rhizons should be left for 2-3 hours.

3. Pore waters should be divided and treated in the same way as the multicore pore waters above.

Sediments

<u>Supplies needed</u>

Sample bags

Sampling tools (spatulas)

Sediment samples for both multi- and gravity cores should be sampled and frozen soon after cores are opened to avoid oxidation of sulfides and Fe in pore waters. Split core should be sampled at 1 cm intervals (a third to a half of the working half). Samples should be immediately frozen at -20degC.

The Nansen Legacy in numbers

6 years

The Nansen Legacy is a six-year project, running from 2018 to 2023.

1 400 000 km² of sea

The Nansen Legacy investigates the physical and biological environment of the northern Barents Sea and adjacent Arctic Ocean.

>10 fields

The Nansen Legacy includes scientists from the fields of biology, chemistry, climate research, ecosystem modelling, ecotoxicology, geology, ice physics, meteorology, observational technology, and physical oceanography.

>350 days at sea

The Nansen Legacy will conduct 15 scientific cruises and spend more than 350 days in the northern Barents Sea and adjacent Arctic Ocean between 2018 and 2022. Most of these cruises are conducted on the new Norwegian research icebreaker RV *Kronprins Haakon*.

250 people

There are about 210 researchers working with the Nansen Legacy, of which 50 are early career scientists. In addition, 40 persons are involved as technicians, project coordinators, communication advisers and board members.

10 institutions

The Nansen Legacy unites the complimentary scientific expertise of ten Norwegian institutions dedicated to Arctic research.

Norwegian Meteorological Institute

UNIS
The University Centre in Svalbard

NTNU

NERSC

Akvaplan niva

50/50 financing

The Nansen Legacy has a total budget of 740 million NOK. Half the budget comes from the consortiums' own funding, while the other half is provided by the Research Council of Norway and the Ministry of Education and Research.

Norwegian Ministry of Education and Research

With funding from The Research Council of Norway

nansenlegacy.org

nansenlegacy

nansenlegacy@uit.no

Photo cover: Vår in Trælvik Eilertsen