HEINCKE-Berichte

Marine-Geological Practical Training at Sea
Master Course LV 63-345

Cruise No. HE619

May 10 – May 16, 2023
Bremerhaven (Germany) – Bremerhaven (Germany)
UHH MARGEO

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2023

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1 Cruise Summary

(L. Dreyer)

1.1 Summary

Research cruise HE619 with the research vessel HEINCKE took place from May 10-16, 2023. The starting and ending point was the fishing port of Bremerhaven (Germany), and all samples were collected in the Norwegian EEZ. The training cruise took place as part of the Master program in Geosciences and was a component of the course 63-345 " Marin-Geologisches Praktikum auf See". Seven students of the Universität Hamburg had the opportunity to be trained in the standard methods of water, suspension and sediment sampling on board of a research vessel and to apply them independently. In addition, the students gained insight into geophysical measurement methods in the form of hydroacoustic water column and surface sediment surveys. The aim of the training cruise was to provide the students with knowledge about sedimentological, biogeochemical and ecological processes of the North Sea and to learn how to use common measuring gears and instruments. In total, 26 stations were approached and successfully sampled within five full days at sea. With a few exceptions, all measuring instruments could be used successfully at each station due to good weather and sea conditions. All data and samples obtained were distributed to the working groups of the Universität Hamburg for further analysis after the cruise.

1.2 Zusammenfassung

Die Forschungsfahrt HE619 mit dem Forschungsschiff HEINCKE fand vom 10. bis 16. Mai 2023 statt. Ausgangs- und Endpunkt war der Fischereihafen Bremerhaven (Deutschland), wobei sämtliche Proben in der norwegischen EEZ erhoben worden sind. Die Ausbildungsfahrt fand im Rahmen des Masterstudiengangs Geowissenschaften statt und war Teil der Lehrveranstaltung 63-345 „Marin-Geologisches Praktikum auf See“. Dabei bot sich sieben Studierenden der Universität Hamburg die Möglichkeit, in die Standardmethoden der Wasser-, Schwebstoff- und Sedimentbeprobung an Bord eines Forschungsschiffes eingearbeitet zu werden und diese selbständig anzuwenden. Darüber hinaus erhielten die Studierenden Einblicke in geophysikalische Messmethoden in Form von hydroakustischen Wassersäulen- und Oberflächensedimentaufnahmen. Ziel der Ausbildungsfahrt war es, den Studierenden Kenntnisse über sedimentologische, biogeochemische und ökologische Prozesse der Nordsee zu vermitteln und dabei auch den Umgang mit gängigen Messgeräten zu erlernen. Insgesamt wurden innerhalb von fünf vollen Tagen auf hoher See 26 Stationen angefahren und erfolgreich beprobt. Bis auf wenige Ausnahmen konnten aufgrund guter Wetter- und Seebedingungen alle Messgeräte bei jeder Station erfolgreich eingesetzt werden. Sämtliche gewonnene Daten und Proben wurden nach der Fahrt zur weiteren Analyse an die Arbeitsgruppen der Universität Hamburg verteilt.

2 Participants

(L. Kanzler)

2.1 Principal Investigators

Name	Institution
Lahajnar, Niko, Dr.	UHH, IfGeol
Lüdmann, Thomas, Dr.	UHH, IfGeol

2.2 Scientific Party

Name	Discipline	Institution
Lahajnar, Niko, Dr.	Chief Scientist, Biogeochemistry	UHH, IfGeol
Lüdmann, Thomas, Dr.	Hydroacoustics, Sequence Stratigraphy	UHH, IfGeol
Bartsch, Peggy	Technician	UHH, IfGeol
Dreyer, Lotta	Student (M.Sc.)	UHH, IfGeol
Gothmann, Marvin	Student (M.Sc.)	UHH, IfGeol
Kanzler, Louisa	Student (M.Sc.)	UHH, IfGeol
Müller, Julia	Student (M.Sc.)	UHH, IfGeol
Schönbeck, Frederik	Student (M.Sc.)	UHH, IfGeol
Schönbrunner, Benedikt	Student (M.Sc.)	UHH, IfGeol
Töpperwein, Leonie	Student (M.Sc.)	UHH, IfGeol

2.3 Participating Institutions

UHH, IfGeol Institut for Geology, Universität Hamburg

3 Research Program

3.1 Description of the Work Area

(F. Schönbeck)

The area investigated during RV HEINCKE cruise 619 was the northern part of the North Sea south of Norway (Fig. 3.1). All surveyed stations were situated within the EEZ (exclusive economic zone) of Norway. The sampling stations were conducted between 56°00.00'N – 58°00.00'N and 04°00.00'E – 05°00.00'E, while the hydroacoustic profiles extended further east being limited by the 6th meridian. The sediments encountered during HE619 include Pleistocene and Holocene fine and medium sands, as well as gravels and pebbles.

The North Sea is a shallow shelf sea in northwestern Europe spanning an area of 570,000 km^2 with an average depth of 94 m (Schwarzer et al., 2019). It is bordered by the countries of Norway, Sweden, Denmark, Germany, the Netherlands, Belgium, France, and parts of the United Kingdom (England, Scotland). The major bodies of water connected to the North Sea are the English Channel, which connects to the Atlantic Ocean, the Norwegian Sea, which borders the Arctic as well as the Atlantic Ocean, and the Skagerrak Strait, which is the only in- and outflow of the Baltic Sea.

The crystalline and metamorphic basement of the North Sea has its origins in the later stages of the Caledonian Orogeny some 420 – 390 Ma ago (Balson et al., 2001). Accumulated on top are Devonian sediments that today lay in depths of 8 – 10 km. Later during the Carboniferous period, the proto-basin of the North Sea was situated at the equator (Schwarzer et al., 2019). Shallow water sediments and coals that are source rocks for gas were deposited. Towards the end of the Carboniferous the Variscan Orogeny took place. The following Permian was marked by subsidence. Red sandstones, volcanoclastics, and evaporites that could reach up to 1000 m in thickness were accumulated (Balson et al., 2001). As a result of the just beginning Atlantic rifting during the Permian and Triassic Horst and Graben structures such as the Viking and Central grabens formed. Common sediments for the Triassic are red terrestrial sandstones and marine mudstones (Balson et al., 2001). The weight of those overlaying sediments on top of the Permian evaporites caused salt domes to rise by halokinesis. The Jurassic was marked by extensive rifting and faulting as a result of volcanic doming. Deposited sediments include shallow marine sediments that are rich in organic material (Cameron et al., 1993). Rifting ceased during the Cretaceous yet subsidence continued. Sediments that characterize this period are calcareous mudstones, chalk, and sandstones (Cameron et al., 1993). Most prominent for this time are the organic-rich Kimmeridge clays that have been deposited in the deeper parts of the basin such as the Viking and Central grabens (Schwarzer et al., 2019). The early Cenozoic was marked mostly by subsidence, the Alpine Orogeny, and seafloor spreading in the North Atlantic. Sediments include marine sandstones and shales which serve as important reservoir rocks for gas and oil. Later during the Cenozoic, the climate cooled off and large deltaic systems formed. In the Pleistocene the climate cooled further, the sea level fell, and during multiple glacial periods ice sheets pushed into the North Sea depositing glacial sediments and reworking the surface (Schwarzer et al., 2019). In more recent, post glacial times the North Sea has been experiencing a sea level rise and isostatic rebound, as well as the development of the Wadden Sea along the coasts of Denmark, Germany, and the Netherlands.

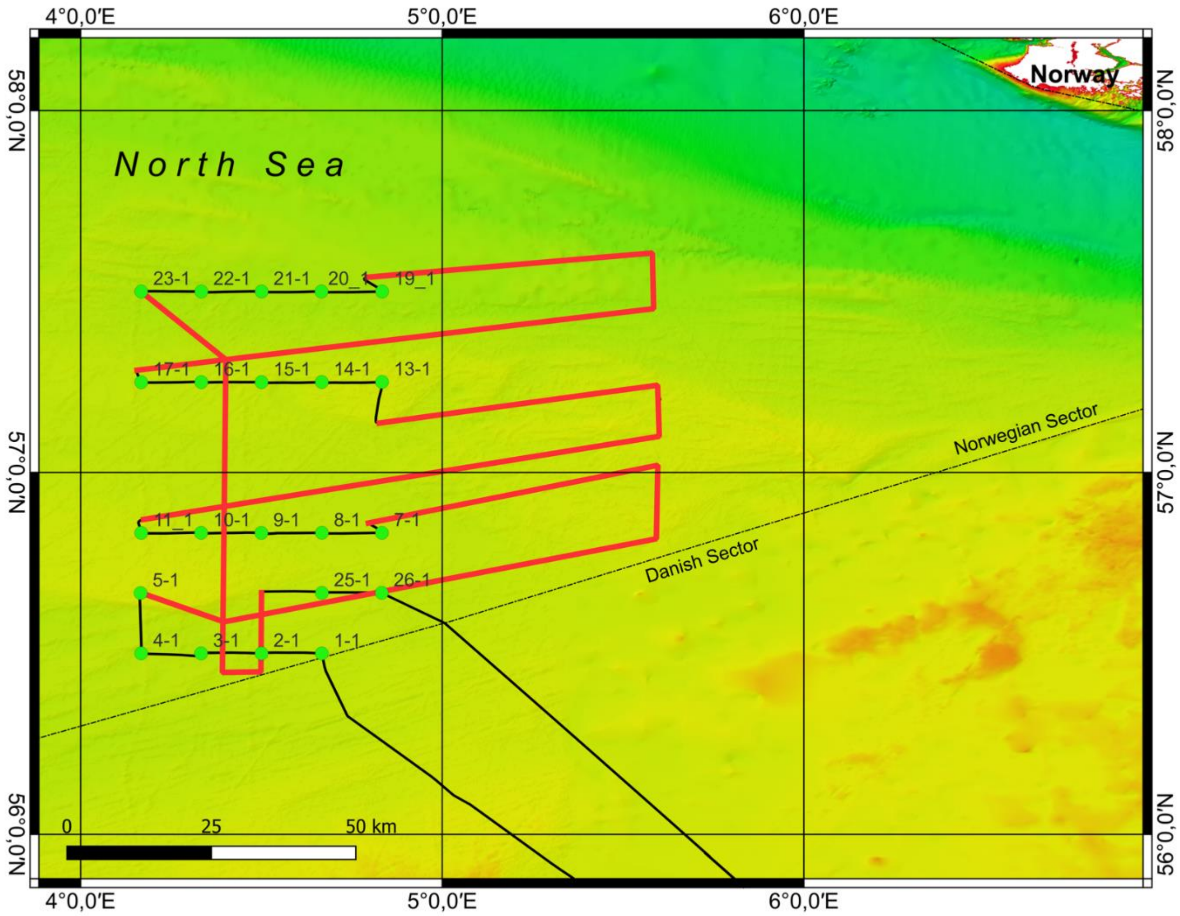

Fig. 3.1 Track chart of RV HEINCKE Cruise HE619 with bathymetric base map. The working area is situated in the Norwegian Sector of the North Sea. Green dots indicate sampling stations with the respective number. Red lines display the hydroacoustic profile tracks.

3.2 Aims of the Cruise

(L. Dreyer)

The main purpose of the educational cruise was to familiarise the students with marine sampling methods and to transfer the theoretical basics of the North Sea's marine geology and biogeochemistry into practice. Through the intensive and daily multiple use of common measuring instruments, the students learned how to independently apply standard methods and how to document them accurately. This also included, for example, assessing the weather conditions in order to be able to use the equipment safely, taking over entire stations independently, communicating properly with the bridge and the winch and remaining calm in difficult situations to manage them securely. The students strengthened their ability to overcome challenges and work together as a team.

Furthermore, the North Sea water column as well as the sediment and seabed in the Norwegian EEZ were sampled and processed. Therefore, the students first described the material right after sampling, which for example included the determination of organisms in the vVG and the APSTEIN-net or the application of the MUNSELL Color Chart. The material was then prepared and properly stored for more detailed analyses in the laboratory. In addition to scientific content, the students also gained their first experience of everyday life on board a research vessel, which included learning the most important seaman's knots and vocabulary. In an evening seminar, the students presented topics related to the North Sea in form of a scientific lecture and discussed them together to deepen their knowledge about marine geology.

3.3 Agenda of the Cruise

(L. Dreyer)

The practical training for the seven Master students from the Universität Hamburg started in Bremerhaven on Wednesday, May 10, 2023, with the vessel's departure in Bremerhaven. After leaving the lock, the students were briefed regarding the safety guidelines on board by the first officer. During the cruise to the final destination in the Norwegian EEZ, a test station was carried out in front of Helgoland. All measuring instruments had to be assembled and tested to confirm their successful operation and to provide the students with a first impression of the general process. They were also introduced in the upcoming technical and scientific tasks. Under the supervision of Niko Lahajnar and Peggy Bartsch, the equipment test started with the Secchi disk and the APSTEIN-net, followed by the CTD (Conductivity, Temperature, Depth), the Bottom Water Sampler (BWS), the van-Veen-Grab (vVG) and the OCTOPUS Multicorer (MUC), so that the testing order corresponded to the actual order of the station work. All devices were tested successfully. The test station was carried out as a whole group, while the official stations were executed by three groups of two and one individual in the following days. Each group took over one instrument per day, except for the group in charge of the station management; it was responsible for the Secchi disc, APSTEIN-net and vVG as well as the communication with the bridge. In this way, each group detailly dealt with one device for a whole day. On the evening of May 10, Thomas Lüdmann also gave a theoretical introduction into seismic and hydroacoustics, which provided the basis for recording hydroacoustic profiles at night, supervised by the students.

The agenda of the cruise including the exact time of each station was defined by chief scientist Niko Lahajnar in advance. In case of faster station work than presumed, some stations were brought forward during the cruise. The sampling of five stations daily and two stations on the last day, May 15, in the Norwegian EEZ started on May 11. Each group took over responsibility for one device or the station management for one day, leading to a thoroughly acquisition after four full days. The groups were supported and supervised by Niko Lahajnar and Peggy Bartsch and after a while performed most of the stations on their own. Two stations were always carried out before lunch at 11:15 am and three stations before dinner at 05:15 pm. After dinner, the samples were usually prepared for storage, deck and wet laboratory were cleaned up and if needed, stations were prepared for the next day, allowing a new group to take over a station the next morning without any issues. On the last day, May 15, the students successfully carried out the last two stations under their own responsibility, without the supervision of Peggy Bartsch and Niko Lahajnar. The exact station plan including the nightly routes for the seismic measurements are displayed in Fig. 3.1.

The station's procedure is very precisely defined and may not vary for reasons of measurement reliability, unless a device cannot be used, for example due to strong waves. After the station leader has announced the station, the Secchi disc is lowered into the water column as the first measuring device to determine the visibility depth, which varied between 8 and 18 m during the trip. The following APSTEIN-net with a mesh size of 25 µm was usually lowered 5 m into the water column to sample the phytoplankton of the surface water, which was later analysed under a microscope.

While these two devices are lowered manually, all other devices are lowered into the water with the winch. The CTD-Rosette, which measures conductivity, temperature and depth, includes 12 NISKIN bottles, six of which sample the surface water at a water depth of 5 m and the other six bottles sample the deep water a few meters above the seabed. Several liters of surface and bottom water are then filtered and the filters stored for upcoming analyses. In total, the samples with 2 filters per station yielded 44 filters. The CTD was followed by the BWS, which captures three water depths: 28.5 cm, 58 cm and 110.5 cm above the seabed surface. The BWS is stabilised by weights and aligned in flow direction by a stream vane. When having contact with the bottom, a timer in the electrical unit is triggered over a base plate so that the horizontal 5 L NISKIN bottles close after 2 minutes. At station 16, the BWS had to be run a second time after the closing mechanism failed to trigger on the first attempt. Presumably the base plate lost contact with the ground in the meantime, which caused the timer to start again. From station 23 onwards, the closing mechanism had to be triggered manually with a fishing rod, as the electrical unit was not intact and the fault could not be rectified on board. Nevertheless, the BWS was successfully deployed at all stations and a total of 65 filters were obtained. The last two devices are used to sample the sediment. Since sediment is stirred up in the process of sampling it, these take place after the water sampling. First, the vVG is lowered to the seabed for the first inspection of the sediment's composition, grain size and permeability. Before the sediment is poured onto a plate, the station leader takes a sample to test the permeability. Afterwards, macroorganisms and sediment are described. Particularly noticeable were stations 19 to 23, which had very coarse material compared to the other stations. The coarse-grained and rocky sediment from station 19 to 21 led to the decision not to run the MUC because it could damage the tubes. Surface samples were therefore taken from the vVG, otherwise the material from the vVG was dumped off the boat after the station was completed. When the sediment condition was considered as suitable, a station was completed with the MUC. It was lowered to the seabed, causing 8 Plexiglas tubes to excavate into the sediment. On board, 3 cores are carefully removed. One is being photographed and cut at 1 cm intervals and the samples are stored for biogeochemical studies. The top 2 cm of another core are being removed and stored for micropaleontological studies. The third core is kept for reinsurance until all samples are secured. With the MUC, cores with a length between 7 and 16 cm were drilled at 32 stations on the expedition HE619. Except for stations 19 to 21, where the MUC could not be run due to the coarse-grained sediment, and station 5, where the core collapsed during sampling and no further core could be recovered, the MUC was used successfully. After the MUC, a station was terminated by the station leader.

After independently and successfully finishing the last two stations on May 15, the return journey to Bremerhaven started at 09:00 am. Meanwhile, the students were given a guided tour of the engine room by the chief engineer. The entry into the fishing harbour of Bremerhaven took place on May 16 at 07:30 am. Due to the moderate weather conditions and the carefully executed work by both, crew and scientists, the training trip went very well and without any incidents or major breakdowns. A detailed description of each measuring device as well as the preliminary evaluation of first results can be found in chapter 5.

4 Narrative of the Cruise

(J. Müller)

On Tuesday May 09, 2023 at 11:30 UTC, five students arrived with the chief scientist and the technician in Bremerhaven (Germany), fishing port one, and boarded the RV HEINCKE. After a short meeting in the dry lab, the participants occupied their cabins and got a tour through the vessel. 13:30 UTC, the boxes with the equipment were unpacked and the wet lab was set up seaworthy. The last two students arrived with the hydroacoustic scientist just before dinner (15:00 UTC). During the day, all participants of the cruise were tested for Covid-19 by a rapid test. As the last preparation of the day, the filtration unit was set up at 16:15 UTC. After that, the rest of the evening was at leisure. The students made their last shore leave before the trip by exploring Bremerhaven together on a short walk.

RV HEINCKE left its pier at 06:00 UTC on Wednesday, May 10, passed the lock at 06:40 UTC and then headed on direct route towards the working area. The first day on sea was cloudy and rainy. At 7:00 UTC, a safety instruction was carried out by the 1st officer, as the 2nd officer (safety officer) was unable to attend for the first day. This briefing included a presentation, a tour of the vessel as well as the execution of a general alarm. At 08:05 UTC, the scientific equipment was set up ready for operation. The RV HEINCKE interrupted the course for a test station which took place at 11:30 UTC. All scientific equipment was successfully tested for functionality while the students got familiarized with the use of it. At 14:25 UTC, the students were divided into four groups during a meeting in the dry lab for the station work the following days. In the evening at 17:00 UTC, a lecture given by the scientist T. Lüdmann, introduced the topic of "Hydroacoustics: Water Column, Seafloor, Subsurface". Afterwards, 65 ship-specific words (ship jargon) were taught and the first three important knots were practiced.

Thursday, May 11 was the first station day of the expedition HE619. In the morning, RV HEINCKE arrived in the study area, located in the Norwegian EEZ. The weather during the day was overcast and visibility was poor. Stations HE619-01 to 05 took place from 06:00 to 15:30 UTC, with one hour of driving between each hour of station work. After the first station, which took about 15 minutes longer than planned, the students got into a routine and the station work was done faster and more efficiently with every new station. Each station on this expedition was conducted according to the same established sequence: first the deployment of near-surface equipment (Secchi-Disk and APN), then CTD and BWS, and last the sediment sampling equipment (vVG and MUC). At station 02 there was a false triggering of the 5th bottle at the CTD, but this did not affect the further processing as there were enough other bottles available. In addition to the above-mentioned sampling procedures, a vertical sound profile was recorded at station 03 by attaching a sound velocity probe from VALEPORT to the CTD. At the same station, sampling had to be repeated with the MUC because the only two usable cores collapsed during sample recovery. Due to the current, the Plankton Net drifted under the ship at station 04. At the end of each station, post-processing work was carried out such as filtration of the samples, evaluation of the plankton under the microscope and description as well as sample archiving of the taken sediment samples. In the evening (18:00 UTC), the regular seminar started with a presentation of "Marine Sampling Methods: Sediment and Water" by B. Schönbrunner. After a discussion, three more knots were taught. Station 06 took place during the night, starting from 16:00 to 5:00 UTC of the next day. During this time, hydroacoustic data were recorded in the course of a profiling run, whereby the night shift (22:00 to 5:00 UTC) was taken over by two students.

Station day 2 (Friday, May 12) started with a Covid-19 test for the entire crew. The weather was overcast and worsened during the day; the swell increased and the absolute wind speed got up to 9,0 m/s until the end of the day. The process at the stations HE619-07 to 11 was the same as the day before. During station work at 12:35 UTC, several dolphins were sighted near the vessel. A second velocity sound profile was recorded during station 09 by the VALEPORT-probe attached to the CTD. While the lower NISKIN-bottle of the BWS was not closed at station 08, the BWS had to be run again at station 11 because the mechanism had not triggered at all. At station 10, only one core could be sampled from the MUC. In the evening, two lectures were given during the seminar. The first one was "North Sea: Sediments/Basics of Sediment Movement" by M. Gothmann. A discussion round was followed by the topic "North Sea: Natural Gas and Oil, Deposits and Recovery", presented by L. Kanzler. Practicing two new knots was the last task for the day. The recording of hydroacoustic data (station 12) was again performed from 16:00 to 5:00 UTC with the night shift taken over by two students.

On Saturday (May 13), station day 3, the weather remained unsettled. Absolute wind speeds of 8 m/s were present during the day and it was cloudy throughout as usual. During daytime station work (HE619-13 to 17), the near-surface equipment (Secchi Disk and APN) almost always drifted with the current, sometimes under the ship. At station 15, the third sound velocity profile was recorded simultaneously as the CTD was lowered into the water. The BWS was not triggered at station 16 but was successful on the second attempt. All other work proceeded according to the plan. In the evening, L. Töpperwein introduced the topic of Hydrography, followed by L. Dreyer on Eutrophication and Environmental problems of the North Sea. Again, two new knots were taught. RV HEINCKE recorded hydroacoustic data until 5:00 UTC of the next day (station 18).

The 4th station day, Sunday May 14, station HE619-19 to 23 were carried out in the period between 6:00 and 15:15 UTC. The sky was overcast and the sea was calm again. At station 19 to 21, the MUC could not be run because the vVG displayed seabed sediment that was too coarse. For this reason, surface sediment samples were taken only from the vVG. At station 22, the BWS had to be deployed a second time because it did not trigger on the first attempt. At the following stations, the electronic trigger mechanism of the BWS for closing the NISKIN bottles no longer worked, so it had to be released manually by a fishing rod. A fourth and final time, the sound velocity probe was deployed simultaneously with the CTD at station 23. The regular seminar's lecture round in the evening was concluded with the presentation “North Sea: Phytoplankton and Zooplankton”, held by J. Müller. After a final discussion, the procedure for the last two expedition days was clarified. Hydroacoustic data were collected one last time in the course of station 24 from 16:00 to 3:00 UTC.

On Monday morning (May 15), the last two sampling stations of this expedition took place. The weather was overcast, visibility was good and the sea was calm (absolute wind speed 2.8 m/s). The whole station program on this last expedition day was carried out independently by the students without the help of the chief scientist or the technician. Station HE619-25 started at 3:55 UTC, HE619-26 after breakfast at 5:55 UTC. At both stations, everything went according to the plan. The MUC could be deployed and at least two usable cores were taken in each case; the BWS was released manually by the fishing rod, in both cases with success. At 6:45 UTC, the last station was finished, initiating the return trip to Bremerhaven, Germany. By 8:00 UTC, all work on deck and in the wet lab had been completed. Afterwards, all utensils were put back into the boxes and the wet lab was tidied up and cleaned. At 13:30 UTC, a tour of the engine room took place, conducted by the Chief (principal engineer on board). The evening program started at 18:00 UTC with a demonstration of the ship specific terms and knots: each student was tested on at least two terms and one knot. The swell increased once again in the night.

RV HEINCKE arrived in Bremerhaven in the morning of Tuesday May 16, passed the lock at around 5:30 UTC and went alongside at 06:05 UTC. By 7:00 UTC, all chambers and the dry lab were cleaned. The truck was loaded with the boxes and other equipment at 8:00 UTC and successfully returned from customs before lunch. Around 10:00 UTC, the chief scientist and the students started their journey back towards Hamburg. A stop was made to unload the truck in the storehouse. At 12:30 UTC, the trip ended at the Universität Hamburg.

5 Preliminary Results

5.1 Water Sampling

5.1.1 Secchi Disk

(B. Schönbrunner)

The Secchi disk is a metal disc measuring 20 cm - 50 cm in diameter, depending on the design. The one used during the HE619 expedition had a diameter of 30 cm (Fig. 5.1a). The top surface is divided into four equally sized sectors, with alternating black and white segments. In the center of the disk, there is a metal loop to which a rope is attached. This rope has length marks at regular intervals of 1 meter. A weight is attached to the bottom of the Secchi disk, facilitating its immersion into the water column and providing vertical stability to the disk.

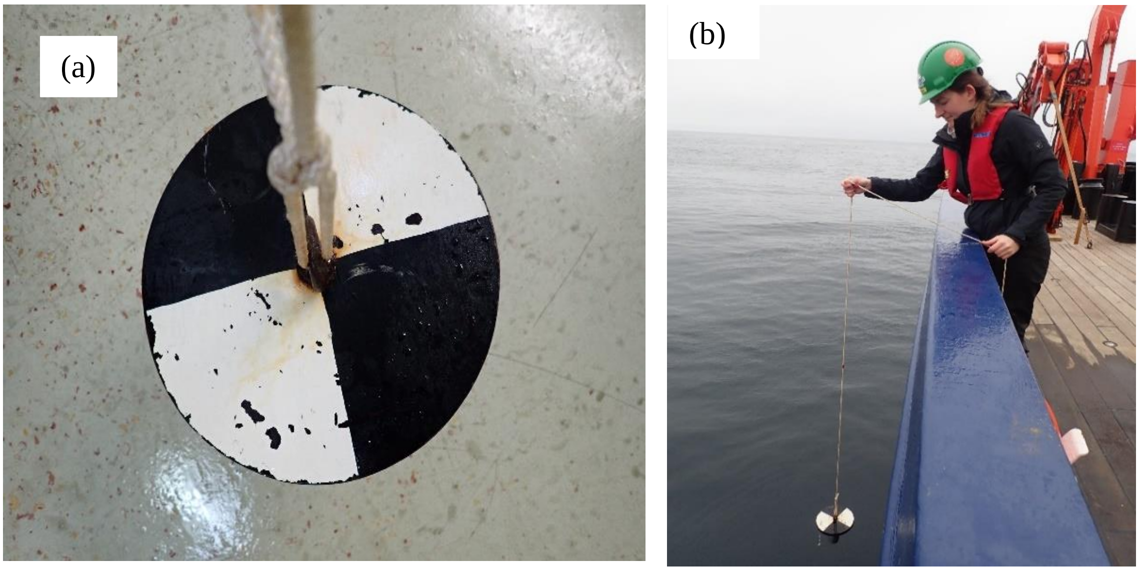

Fig. 5.1 (a) The Secchi disc used during the HE619 expedition, (b) lowering the Secchi disc into the water.

The Secchi disk is used for the manual determination of visibility depth of the upper water layer. By the resulting visibility depth, the size of the euphotic zone can be estimated. The euphotic zone refers to the upper water layer influenced by sunlight (Marra et. al., 2014). During the procedure, the disk is slowly lowered into the water (Fig. 5.1b). As the Secchi disk is lowered, the marks on the rope are counted as they reach the water surface, until the Secchi disk is no longer visible. If this point is in-between two marks, the difference to the mark before is estimated accordingly. Several factors need to be considered during the measurement of visibility depth using the Secchi disk. Factors such as rough sea condition, drifting of the disk due to increased currents, or light reflection on the water surface can significantly influence the measurement result. Any relevant influencing factors were recorded in the protocol when necessary.

At all 26 stations of the HE619 expedition, the visible water depth was determined using the Secchi Disk (Fig. 5.2). The deepest visible depths were measured at station 9 with 18 m and at station 10 with 15 m. The water depths at these two stations were 58.4 m and 55 m, respectively. Conversely, the shallowest readings were at station 2 and station 19 with 8 m each. The water depths at these stations were 65.5 m and 78.7 m, respectively. The ratios between visible depth and total depth (Fig. 5.1), show that there is no direct correlation. Roughly, the visibility depth increases slightly from south to north. However, the highest visibility depths are in the centre. Since the sea condition and the solar radiation were constantly low most of the time, the measurement results should not be influenced by this. The different current velocities at different stations could have influenced the measurement results due to drifting of the Secchi disk.

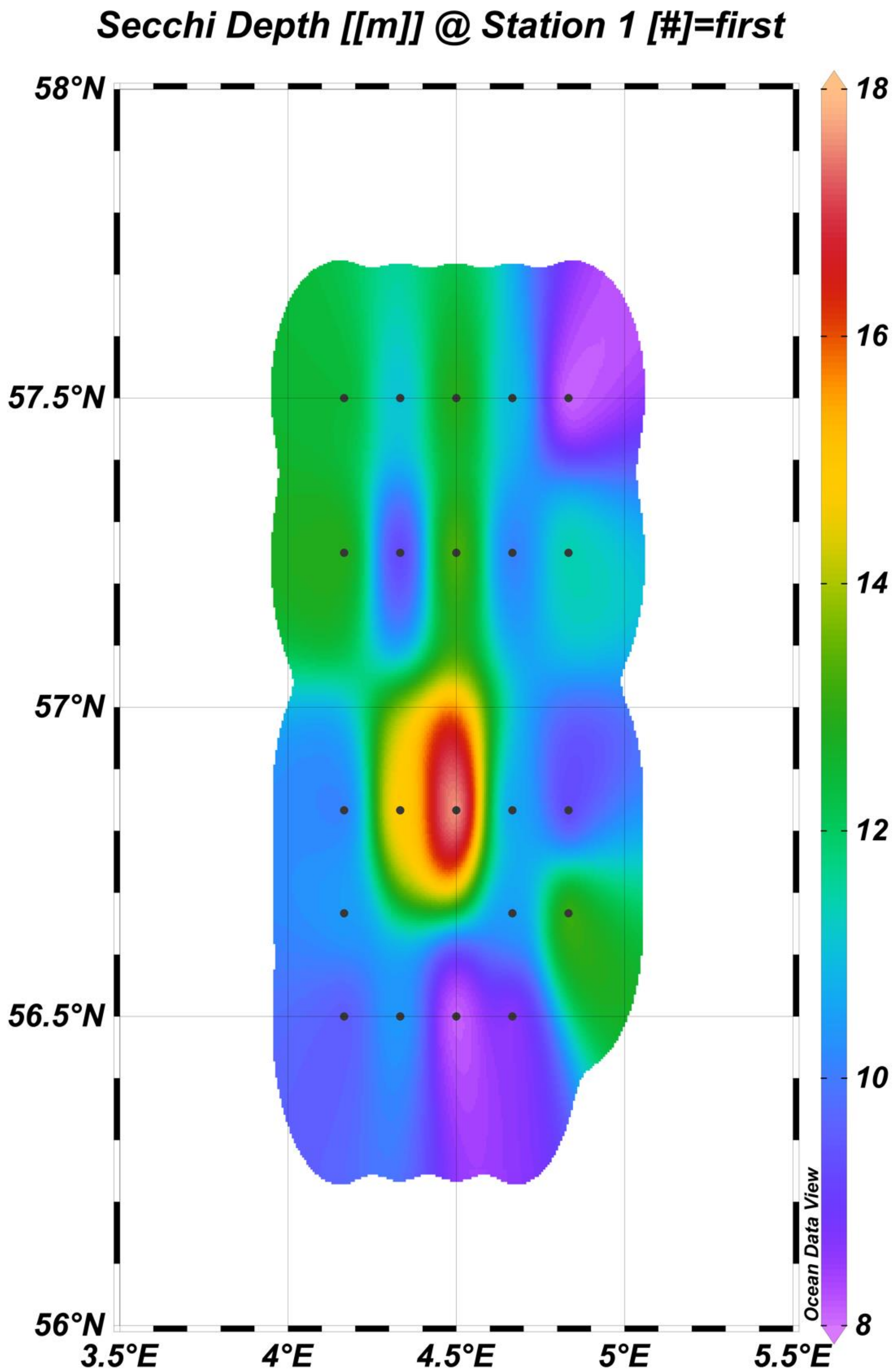

Fig. 5.2 Depth of visibility (Secchi Depth) in the study area.

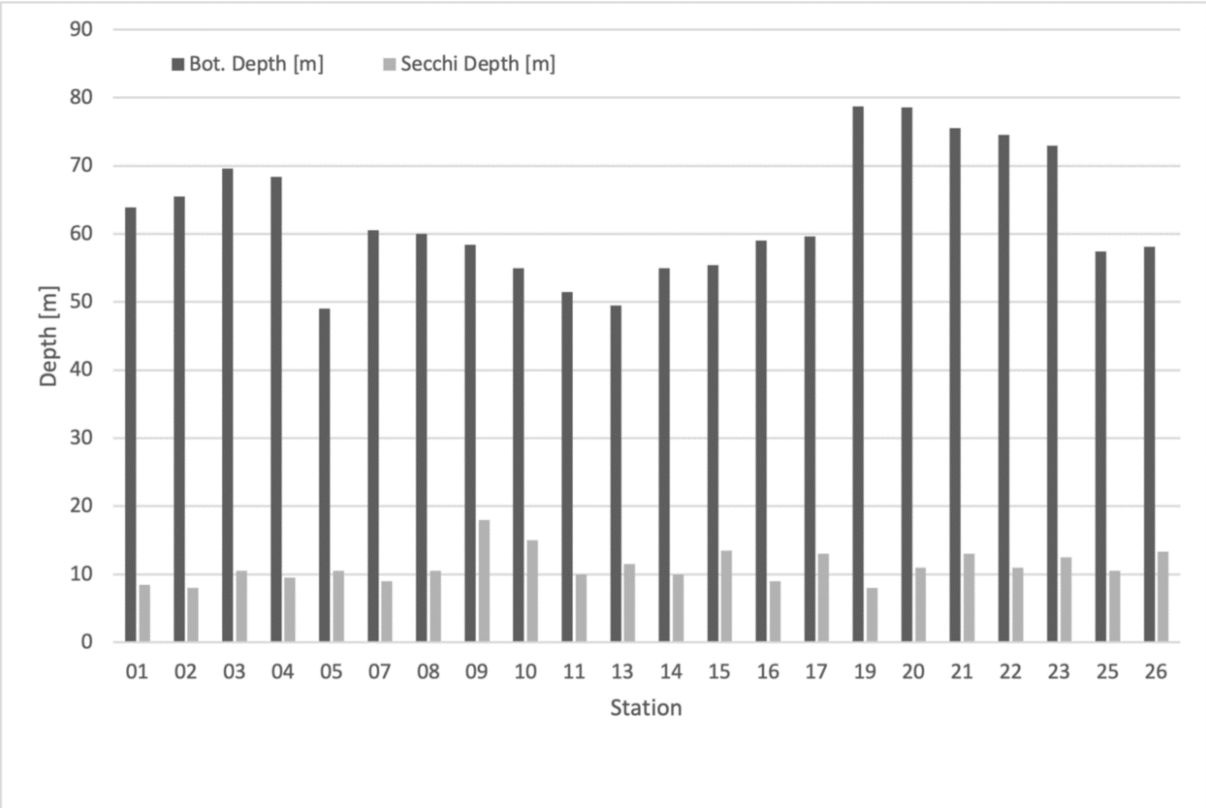

Fig. 5.3 Visible depth (Secchi Depth) and water depth in comparison at the stations of HE619.

5.1.2 Plankton Sampling

(B. Schönbrunner)

During the HE619 expedition, in addition to the CTD and the BWS, the APSTEIN-net was particularly used to sample the plankton occurring on site. The APSTEIN-net is a plankton net used to collect plankton samples from surface waters. During the work at the stations, the plankton net was used immediately after the Secchi disk. It consists of a net with a mesh size of 25 µm, has an inlet diameter of 30 cm and a length of 50 cm (Fig. 5.4). The APSTEIN-net closes in a funnel shape, with a collecting cylinder at the end, which is closed with a valve. The net is attached by a three-point suspension to a rope with marks at one meter intervals and a weight attached between the suspension and the rope. During the trip, this weight was used as an attachment for drying the APSTEIN-net, but primarily to ensure easy immersion in the water column.

The depth the plankton net was lowered to during the station work was related to the previous Secchi disk measurement. It was estimated how the spread of the euphotic zone is at the respective station, as there is usually the largest plankton bloom and therefore the best possible sample yield. The sampling depth with the APSTEIN-net was between 5 m up to a maximum of 14 m on the HE619 expedition. However, due to the current velocity, the net drifted under the ship at several stations, which led to the danger of it approaching the ship's propeller. For this reason, the optimum sampling depth could not be selected at each station and had to be adjusted and reduced accordingly (Table 11.1). After lowering, the net was slowly pulled back to the surface. On deck, the valve was opened and the sample was emptied into a beaker. To reduce sample loss, the inside of the net was rinsed with seawater.

Fig. 5.4 The APSTEIN-Net used during the HE619 expedition.

In the wet lab, a portion of the sample was transferred to a Petri dish using a pipette. The sample was then examined with a Stemi 508 model stereomicroscope (ZEISS) (Fig. 5.5) to obtain a general overview of the planktonic organisms at the stations. With the help of literature (Kraberg et al. 2010, Larink and Westheide 2011) the different species were identified. After the examination of the plankton, the sample was disposed as it was not needed for further analyses. Due to the movement of the ship, it was difficult and not always possible to clearly identify species, which is why some taxa were only described as genus, family or on class level. In a majority of samples dinoflagellates were found, especially from the genus Ceratium (*Ceratium fusus, Ceratium massiliense*). Due to uncertainties in accurate identification, these dinoflagellates were often described as *Ceratium* sp. At some stations, e.g. station 10, Crustacea were identified (*Decapoda* sp., *Copepoda* sp., *Cirripedia* sp.). Furthermore, Diatoms (*Chaetoceros debilis, Leptocylindrus minimus, Thalassiosira rotula, Guinardia delicatula*) were frequently found, but also Haptophyta (*Phaeocystis globosa*). Chlorophyta (*Halosphaera* sp.) were also identified sporadically, but a more precise classification was difficult. Overall, phytoplankton was abundant at all sampled stations showing different organism associations. The distribution is influenced by the catchment area of the Skagerrak. The warmer, freshwater-enriched water masses coming from the Baltic Sea to the north-eastern part of the North Sea favour the emergence of a plankton bloom and accordingly the observations in the samples. (Richardson, 1985).

The Echinodermata (Spartangus) that appear in stations 7 and 8, among others, belong to the meroplankton. Meroplankton are organisms that only count as plankton in a certain stage. In this case it is a larval stage. The non-larval stage of Echinodermata was frequently found in the sediment samples of the vVG (see chapter 5.2.1).

Since a high number of dinoflagellates and diatoms were found in all samples, it can be assumed that a plankton bloom has spread. Only occasionally neither dinoflagellates nor diatoms were present in the plankton samples, e.g. at stations 8, 9 and 10. At these locations the algal bloom was accordingly less developed.

The ratio between dinoflagellates and diatoms is well balanced throughout most stations. However, some stations, such as Station 1, have no diatoms and other stations, such as station 17, have no dinoflagellates. This can be an indicator for different silicate concentrations in the seawater, because silicate is needed for the build-up of diatoms shells. Due to the fact that only one sample per station was taken, this assumption would need a better data basis.

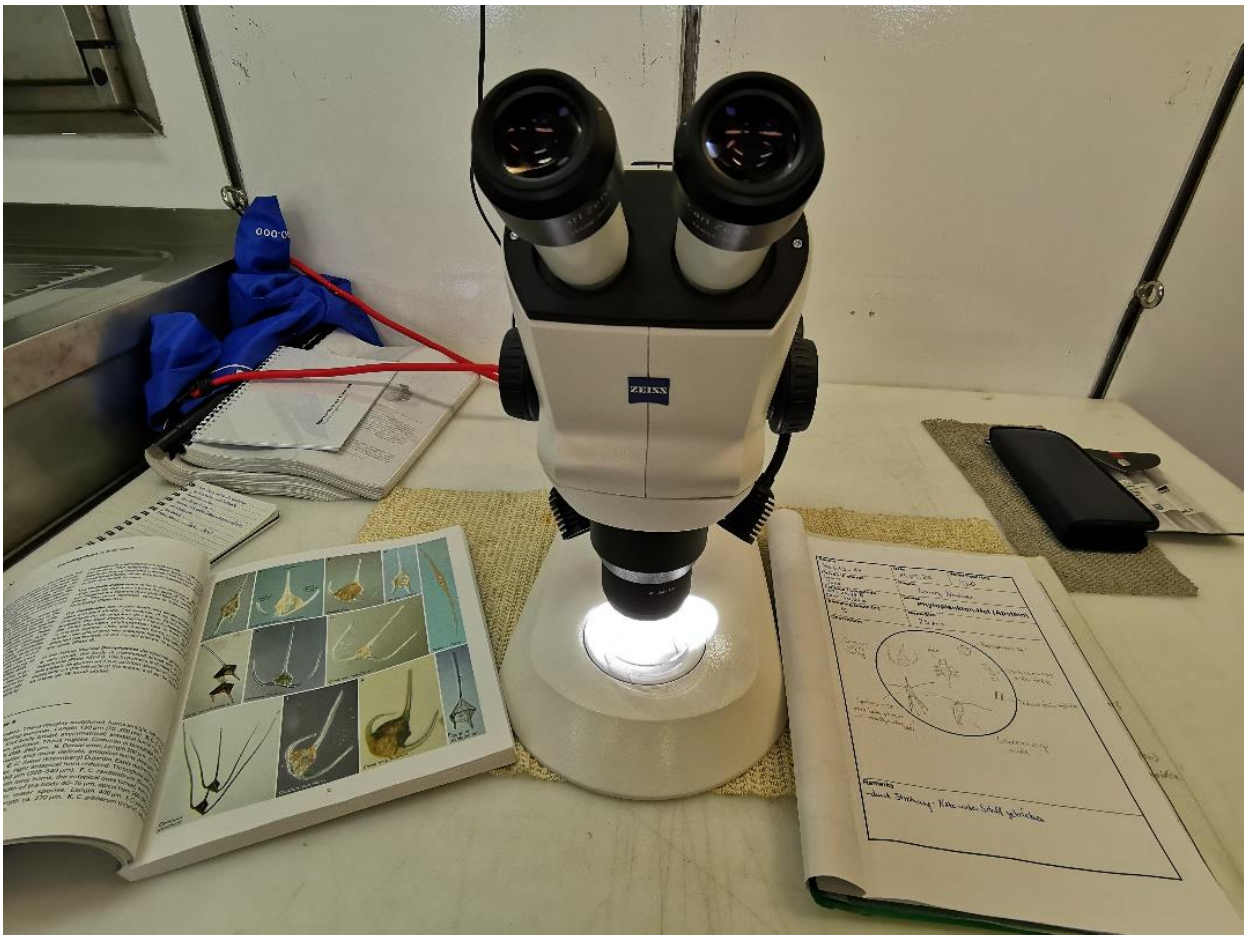

Fig. 5.5 Stemi 508 stereomicroscope and literature used during the HE619.

5.1.3 CTD-Rosette

(J. Müller)

The CTD-Rosette is an instrument used for conductivity, temperature and depth-measurements. The device itself can be divided into two different units: the lower part contains the actual CTD sonde. Above, 12 installed NISKIN-bottles act as water samplers in different water depths, each with a volume of five litres. The units are enclosed together in a cylindrical frame to prevent them from being damaged during operation in the water column (Fig. 5.6).

At all 22 day-time stations, the CTD was used during expedition HE619. In addition to the three parameters already mentioned, the salinity, dissolved oxygen concentration and chlorophyll fluorescence were also determined at the same time by means of additional sensors. The water samples taken were used for a subsequent filtration.

Before using the CTD while station work, the top and bottom caps of the bottles had to be clamped and all valves had to be closed. The program SEASAVEV7 was started on the computer and the key data for the station was saved. Right before deployment, the syringes on the pumps were removed. After the CTD was lowered into the surface water, the power of the control unit of the CTD-Rosette was turned on, so the sensors started measuring. Then, the device was lowered 5 m below the water surface. It was necessary to wait until the pumps were pressurized, so that the pump status was marked as "on" on the computer on board. The CTD then had to be lifted back just below the water surface to erase the plot that had already been recorded. Now the device could be lowered to 5 m above the seafloor to record a vertical profile of the parameters over the entire water column. Per remote-controlling software onboard of the RV HEINCKE, the first six NISKIN-bottles were closed here. On the way back to the surface, the last six NISKIN-bottles were fired 5 m below the water surface. When the CTD was below the surface, the program was terminated and the power was turned off. Back on deck, the device was secured on board with a rope and the sensors of the CTD were flushed with Milli-Q-water using the syringes. For the filtration, the water samples from NISKIN-bottles 1, 2 and 3 (bottom water) were evacuated through silicone tubes by opening the valves and filling them into a large canister (Fig. 5.6). For the surface water samples, bottles 9, 10 and 11 were always filled into one canister.

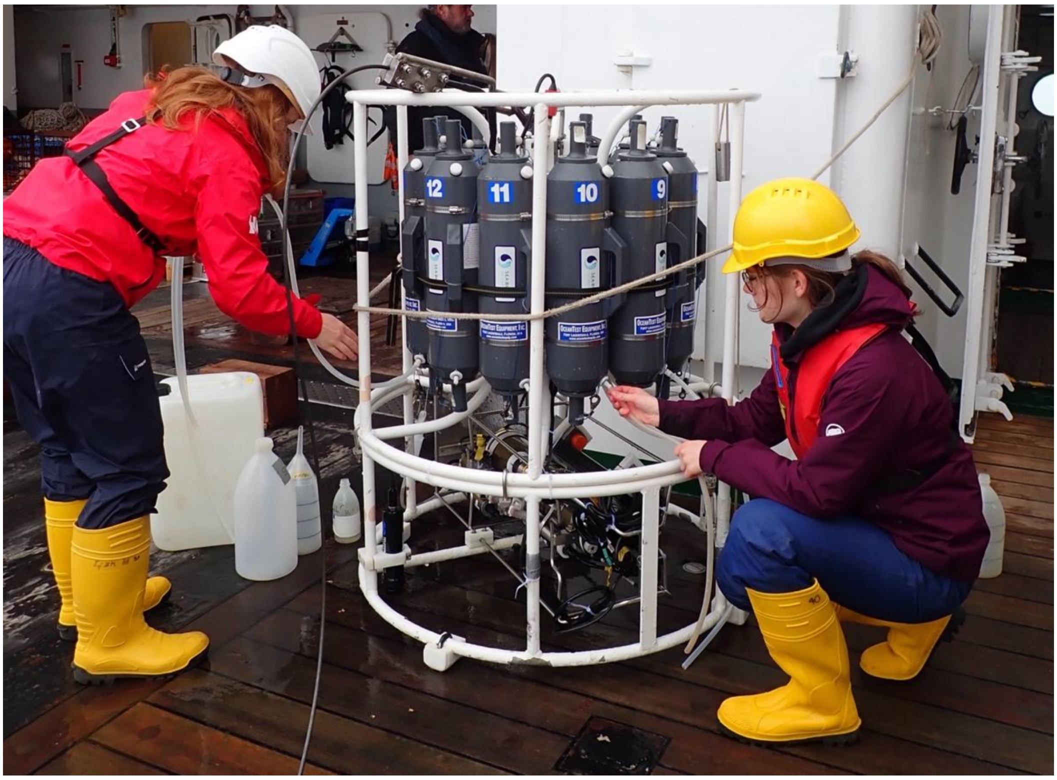

Fig. 5.6 CTD-Rosette after use in the water column. The water samples of the closed NISKIN-bottles are filled into plastic bottles for filtration.

Both water samples could be filtered simultaneously side by side on the filtration unit (Fig. 11.9). The filtration setup contains five units, consisting of a funnel, an insert for the filter and a clamp. For each station, two filters were clamped into the filtration unit. They consist of glass fibres (WHATMAN GF/F), have a mesh-size of ~ 0.7 µm and a diameter of 47 mm. The empty weight of the used filters (pre-combusted at 450 °C) ranged between 122.06 and 131.35 mg. Using a 2 L bottle, the sampled water was transferred into the funnel placed above the filter. Driven by a membrane pump with 800 mbar suction pressure, the filtered water was transported through a common pipe and hose into a 26 litres tank. The average filtration volume was 7.1 litres for the bottom water samples and 6.3 litres for the surface water samples. The amount of filtration depended on the flow rate through the filters. After filtration, the filters which caught the suspended particulate matter, were packed back with tweezers into a storage box and stored in the refrigerator until the end of the expedition (Fig. 11.8).

In order to visualize the first results, a SW-NE section was made through the study area, including stations 04, 09, 14, and 19 (Fig. 5.7). This section can be described in terms of the four different parameters that were measured (Fig. 5.8). The temperature section shows essentially that there is a warmer water layer near the surface, which is replaced by a larger underlying colder water layer with a relatively constant temperature in the central part of the study area (around 7 °C at stations 09 and 14). In the peripheral zones of the investigated area, deviating differentiations in the water column are recognizable. At station 04 there is additionally a colder bottom water layer. At station 19, which is characterized by a greater water depth in general, the predominant part of the water column is characterized by constantly colder temperatures.

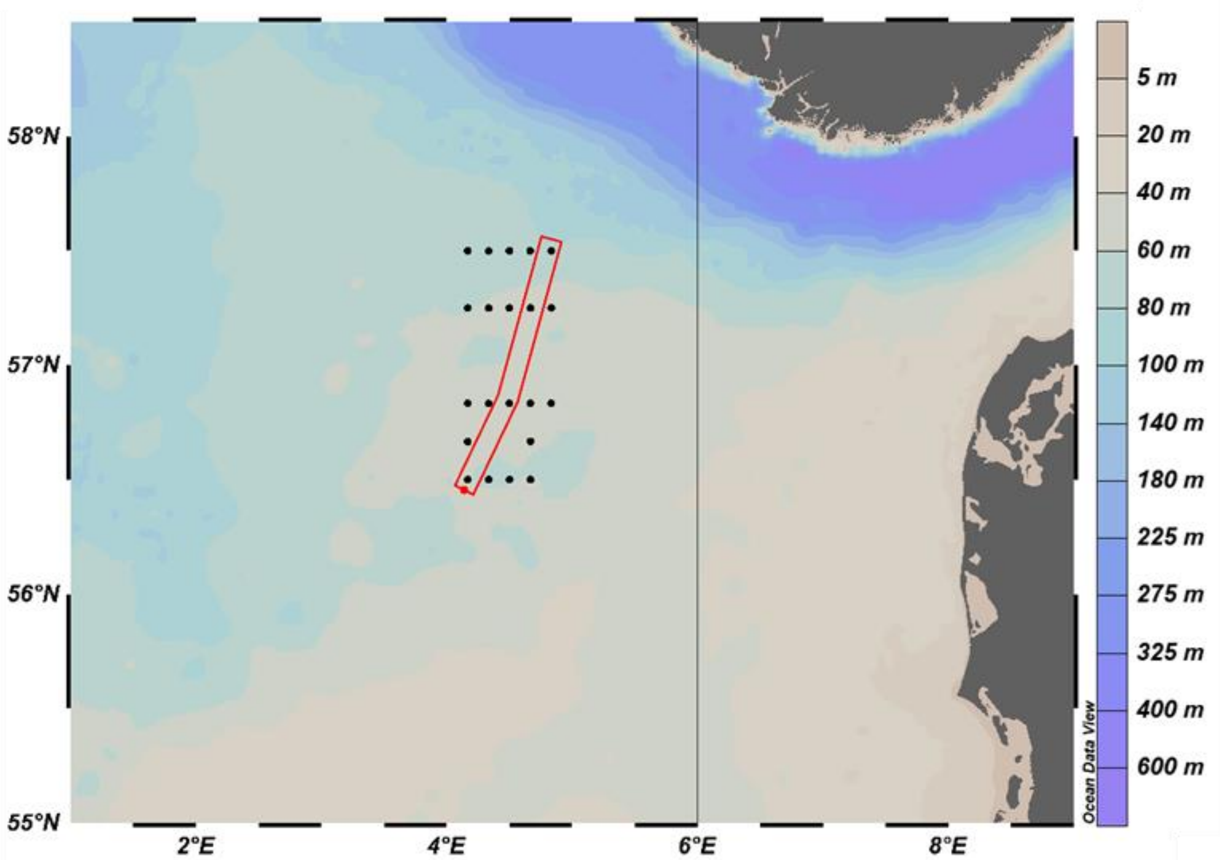

Fig. 5.7 Map of the working area and stations of cruise HE619 with registered water depths. The selected section is framed in red and includes the stations 04, 09, 14 and 19.

The salinity cross section shows a trend of slightly lower values near the sea surface compared to the average (Fig. 5.8). The measured values for the entire area vary around 35 PSU. Station 14 shows higher salinity values in the water column, while at station 04 the values are slightly higher in the bottom water.

The measured chlorophyll fluorescence is generally very low just below the water surface (Fig. 5.8). Station 14 shows notably elevated values in the water column, suggesting the presence of an algal bloom. More organic material being present in the water column is also confirmed by preliminary results of determining suspension volumes using the filters of the water samples from the CTD. The suspension amount for the upper water sample at this station shows a significantly higher value in comparison to all other measured values. In the section, however, slightly increased values for fluorescence can also be detected at station 04 and 09 in different water depths.

The dissolved oxygen concentration is generally slightly higher (7 - 7.5 ml/l) in the upper water layer than in the layer below, which usually presents values around 6.5 ml/l in this section (Fig. 5.8). At stations 04 and 14 however, the oxygen concentration in the surface water is strikingly elevated, which can be attributed to the increased activity of phototrophic organisms (phytoplankton). Lower values have been detected in the bottom water at station 04 and in the water column at station 09.

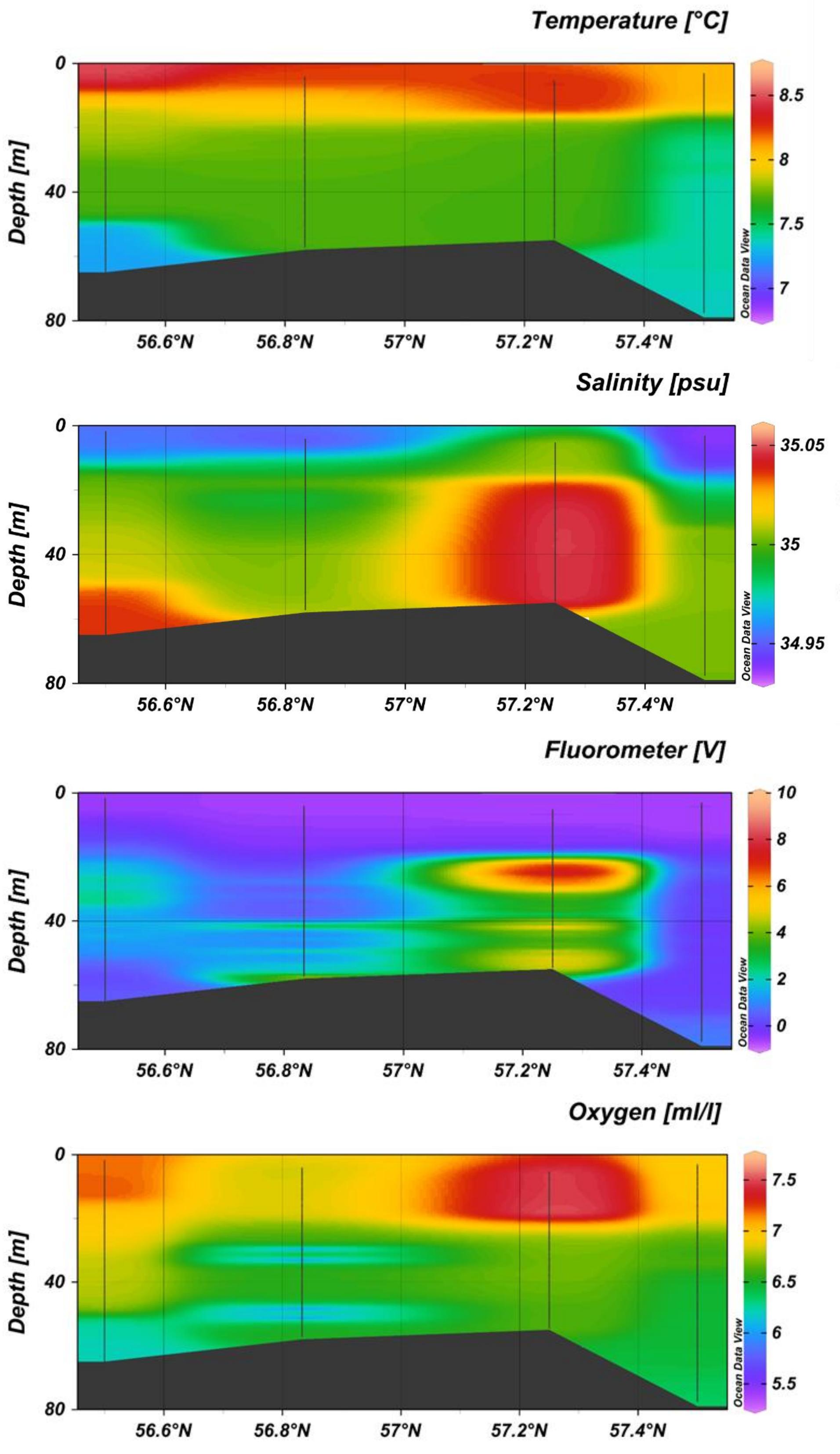

Fig. 5.8 Profiles from the SW-NE section, showing the change in temperature (°C), salinity (PSU), fluorescence (V) and dissolved oxygen concentration (ml/l). The vertical black lines indicate the positions of the four included stations.

The SW-NE section shows that algal blooms in the North Sea can vary regionally in intensity and visibly influence parameters such as the dissolved oxygen concentration in the water column. While the structure of the water column seems to be relatively uniform in the working area without the influence of pronounced primary productivity, the studied marginal areas are characterized by larger differences. The recorded individual vertical profiles of stations 04 and 19 show a more precise resolution of the conditions in the North Sea.

Station 04 is the station furthest, 19 the station closest to the Norwegian coast (see Fig. 5.7). Station 19 illustrates the typical stratification of the North Sea during spring/summer (Fig. 5.8, bottom profiles), which is generally characterized by a thermocline between 10 - 40 m depth (Becker et al., 2005). At this location, the temperature jump is visible at about 20 m water depth. Above the thermocline is the warm surface layer, below, the values of the winter temperature minimum are largely maintained (Becker et al., 2005). The thermocline correlates with the visible halocline and is also reflected in the decrease of oxygen, as mass transfer may be prevented.

In contrast, the profile of station 04 (Fig. 5.9, upper profiles) shows two thermoclines, one at about 10 m and a second at about 50 m water depth. This is also reflected in the salinity and oxygen data. The expression of two thermoclines could be due to the influence of the Atlantic water at this location, which flows into the North Sea. This water mass is characterized by higher salinity and colder temperatures. Stations closer to the Norwegian coast like station 19, however, are more influenced by the Norwegian coastal water.

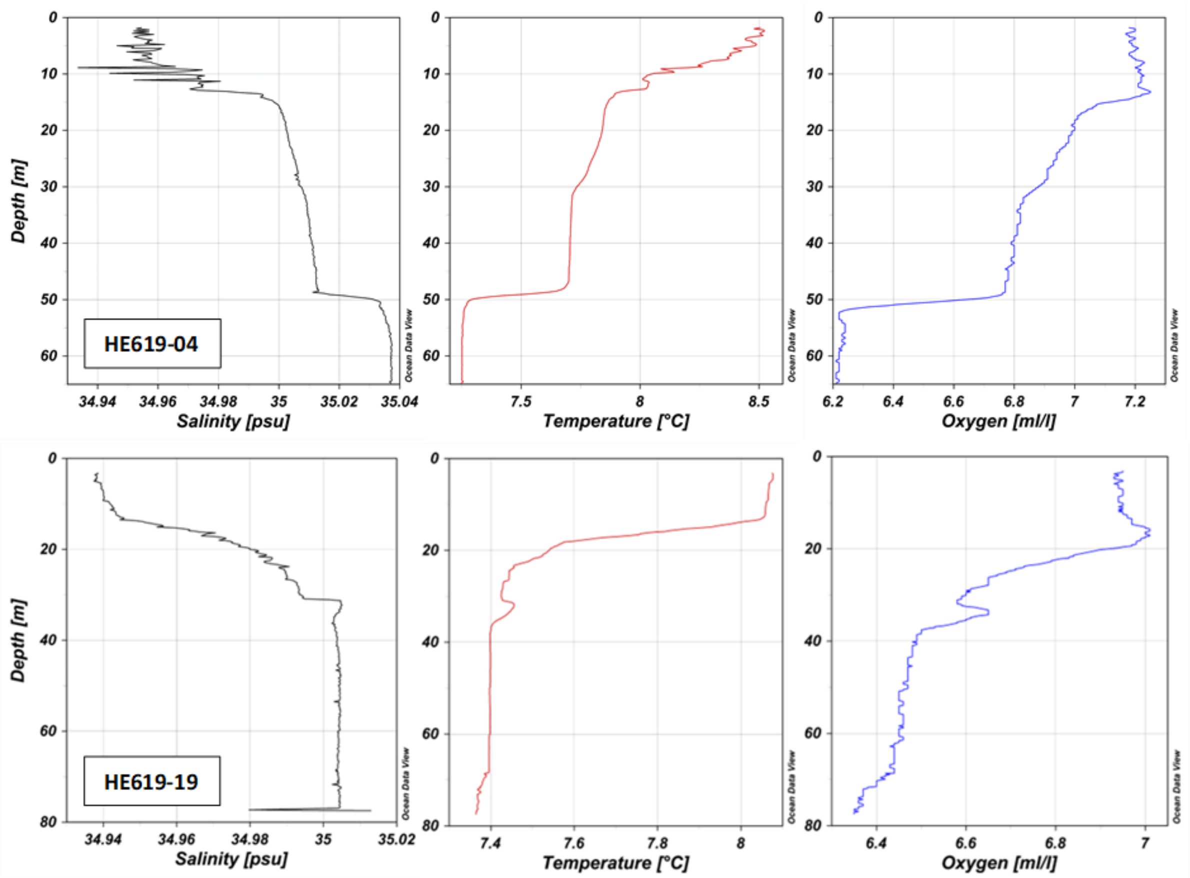

Fig. 5.9 Results from stations HE 619-04 and 19. The change in salinity is shown in PSU, temperature in °C and dissolved oxygen concentration in ml/l in the section through the water column.

5.1.4 Bottom Water Sampler

(L. Töpperwein)

The BWS is a device to take water samples directly above the seafloor in depths, where the CTD cannot be used. The goal was to study the suspended particles and organisms in the water with the BWS. The device used on the HE619 expedition is made by the company KUM Kiel.

In the centre of the BWS a maximum of five NISKIN bottles can be attached to a rotatable metal rod in different heights between 10 cm and 155 cm above seafloor (Fig. 5.10). Each bottle has a volume of 5 litres. During this cruise, 3 bottles were attached at 28.5 cm, 58 cm and 110.5 cm above seafloor. The central rod can rotate up to 120°. Streaming fins attached to the central rod and to the outer frame ensure that the BWS aligns itself in the water with the current flow so that the bottles are aligned in the flow direction (Fig. 5.10). Weights are attached to keep the device stable on the ground (Fig. 5.10).

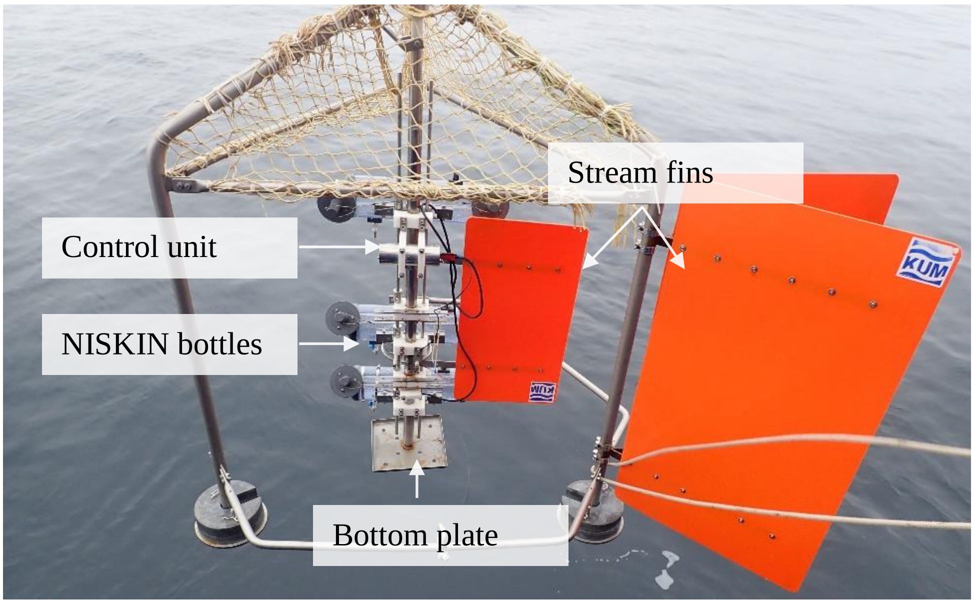

Fig. 5.10 The bottom water sampler in use during the cruise HE619.

An electric control unit is used to close the bottles (Fig. 5.11). By contact of the BWS with the seafloor, sediment is swirled up, which can enter the bottles and contaminate the samples. Therefore, a timer is used so that the bottles are not closed immediately. A plate is mounted to the lower end of the central rod which is pushed up when it is placed on the ground. This activates the timer which triggers the actual closing mechanism. Depending on local conditions, the timer can be set between 60 seconds and 6 hours. Due to the relatively high flow velocities in the North Sea, the timer was set to three minutes during this cruise. A loop of wire is attached to the closing mechanism holding the bottles open and is connected to the control unit via a cable. A small part of the wire is free of insulation (Fig. 5.12). When the timer expires, the wire is electrically powered. It burns through at the uninsulated point and breaks, allowing the bottles to close. Depending on the salinity of the water, this process may take longer or shorter. The wire loop and cable must be remade and reattached together with the electric control unit as well as the set timer before each station. To ensure that the bottles were closed properly, the BWS was left on the ground for about 6 minutes.

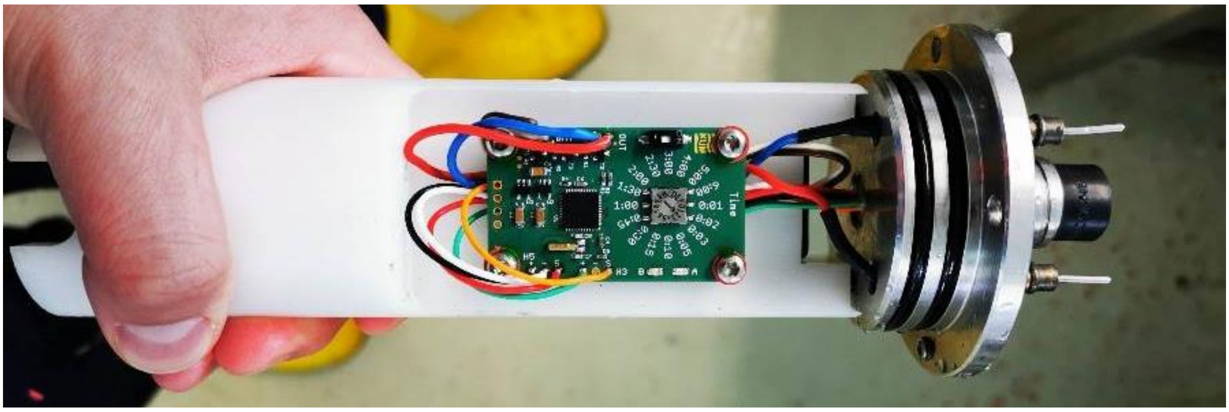

Fig. 5.11 The electronic control unit of the BWS.

The BSW worked without any problems most of the time. However, at stations 11, 16 and 22 the closing mechanism was not triggered on the first try. That's why the sampling had to be repeated. Additionally, the bottle at 28.5 cm did not close at station 8. Due to a defect in the electric control unit, the closing mechanism was not activated at station 23. Hence, the closing mechanism was activated manually by using a fishing rod at stations 23 to 26 (Fig. 5.13). Therefore, the fishing rod was attached directly to the wire loop and the loop was removed by the fishing rod after the BWS was located on the seafloor.

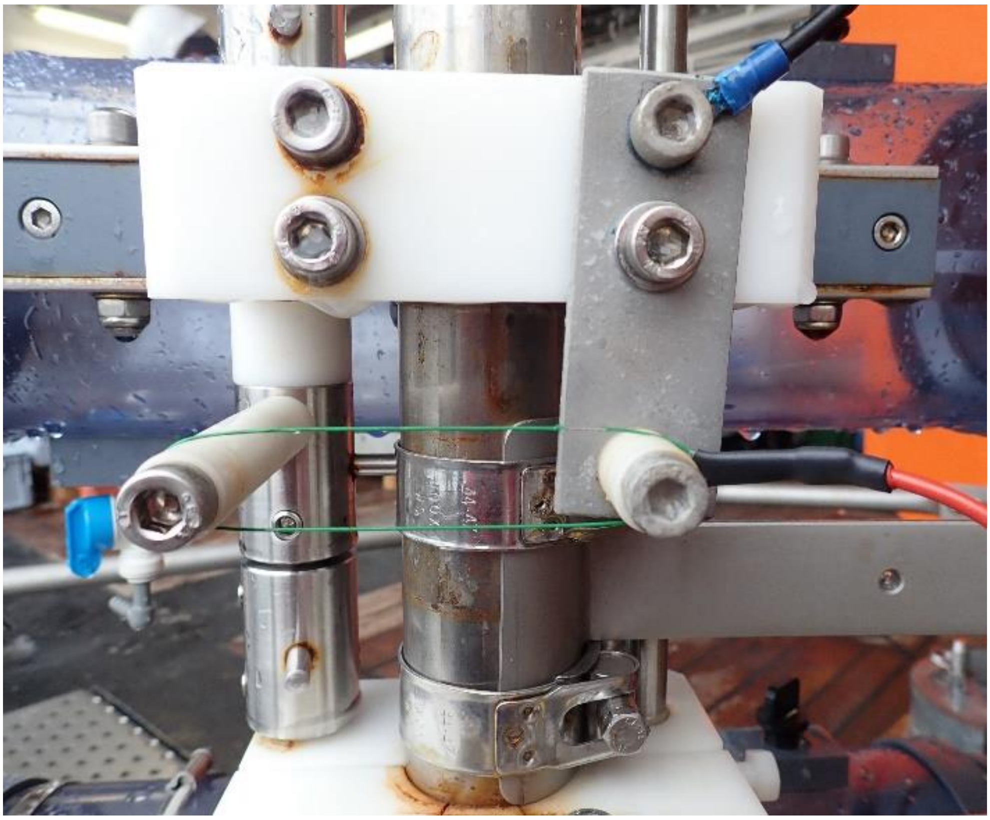

Fig. 5.12 The wire loop with an uninsulated part which is used to close the NISKIN bottles.

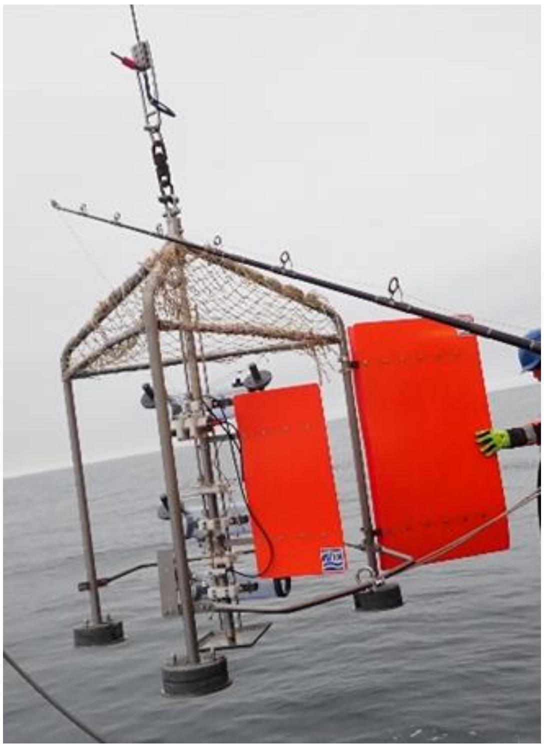

Fig. 5.13 BWS with fishing rod to trigger closing mechanism.

After returning the BWS on deck, the water is drained from the bottles and filtered (Fig. 11.9). For this purpose, previously weighted filters were used. The process is the same as used for the samples taken by the CTD (see Chapter 5.1.3). The suspended particles were then further investigated after the cruise. In the Laboratory of the Institut for Geology at the Universität Hamburg, the samples were first dried. The dried filters were weighted and considering the amount of filtered water and the weight of the empty filters the suspended matter was calculated by using the following formula:

$$suspended\ matter\ \left[\frac{mg}{l}\right] = \frac{m_{dried\ sample} - m_{empty\ filter}}{filtered\ water\ [l]}$$

In the depth of 28.5 cm above ground the amount of suspended matter varies between 0.92 mg/l at station 4 and 22.75 mg/l at station 15. At 58 cm above ground, the smallest amount is 0.81 mg/l at station 5 and the largest is 18.44 mg/l at station 15. In the depth of 110.5 cm above ground the suspension varies between 0.84 mg/l at station 5 and 20.35 mg/l at station 15.

On average the highest amount can be observed in the lowest layer at 28.5 cm above ground while the lowest amounts were measured in the highest layer at 110.5 cm above ground (Fig. 5.14). Additionally, the amount observed at stations 15 and 16 are significantly higher than at the other stations. The station with the highest suspension at all depths is station 15 (Fig. 5.14). Higher amounts of suspended matter can be explained by a higher primary productivity. Current velocities also have an impact on the amount of suspended matter. At the stations 15 and 16 there must be a local factor influencing the suspended matter, that does not exist or is less dominant at the other stations; one possibility would be a local plankton bloom. However more data and analyses would be necessary to clarify the reason for this spike.

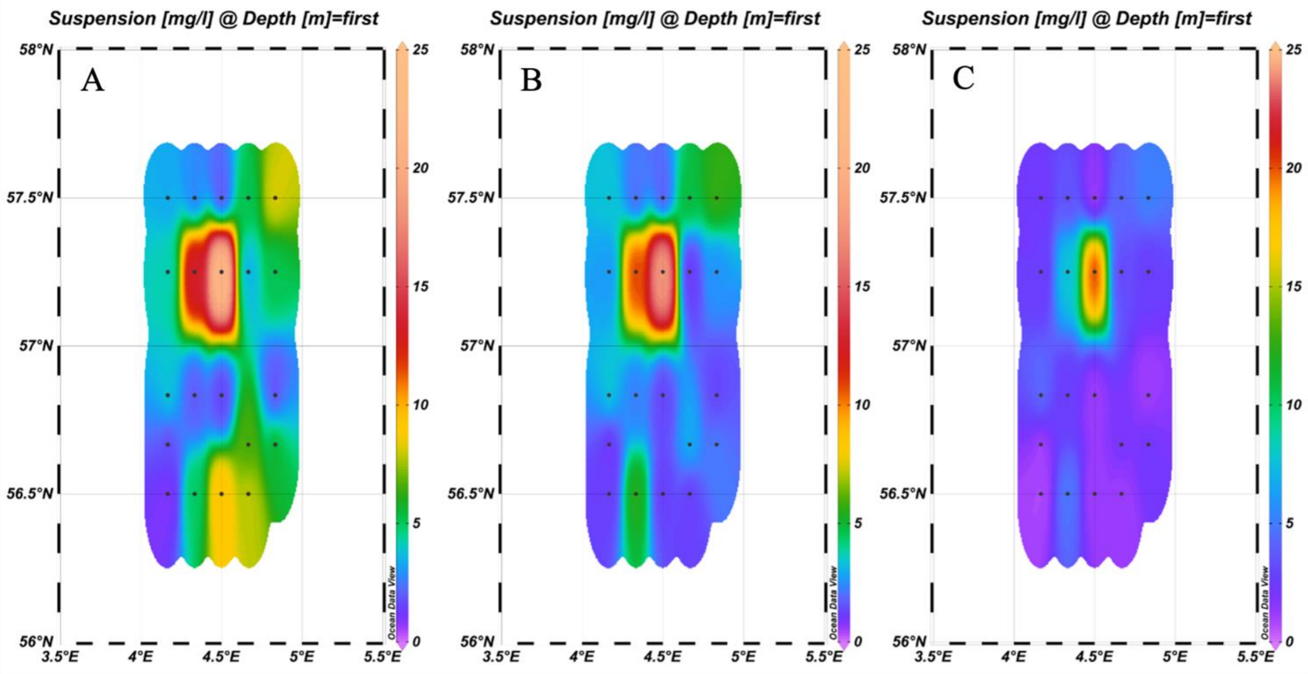

Fig. 5.14 Suspended matter in mg/L at 28.5 cm (A), 58 cm (B) and 110.5 cm above ground (C).

5.1.5 Thermosalinograph

(B. Schönbrunner)

The Thermosalinograph (TSG) is a hull mounted instrument of RV HEINCKE (SEABIRD SB-21) with an externally mounted temperature sensor (SB-38). This instrument is able to continuously measure and document temperature and conductivity of the surface water up to a water depth of about four meters. The seawater was therefore continuously sucked into the ship's hull at a flow rate of about 30 l/min and continuously measured there. From these measurements, both, the salinity and the sound velocity in the water body, can be derived. The salinity in this case was given in the unit PSU. Since the TSG is an online system, measurement data could be collected over the entire period of the HE619 expedition. Measurements were therefore not tied to station work, which meant, a good overview of the general temperature and salinity values could be obtained (Fig. 5.15).

The salinity plot shows that there is an increase in salinity with increasing distance to the coast (Fig. 5.15a). The lowest values of about 32 PSU were measured close to the German coast. During the station work, the values were constantly between 34.5 PSU and 35 PSU. Exceptions was the NNE of the work area, where the salinity decreased very fast to a value of 31 PSU (Fig. 5.15a). The reason for this is assumed to be the freshwater input from the Baltic Sea via the Skagerrak (Richardson, K., 1985).

The water temperatures measured on the HE619 expedition show similar gradients as the salinity (Fig. 5.15b). With increasing distance to the German coast, the water temperature decreases from 11 °C as the maximum water temperature. During the station work, the water temperature varied only slightly between 8 ˚C and 9 ˚C. In this case, the influence of the Skagerrak can also be observed in the NNE of the work area, where the water temperature rises permanently above 9 ˚C. Altogether, the water temperature range in the work and transit area of the HE619 expedition varies between 8 °C and 11 °C (Fig. 5.15 (b)).

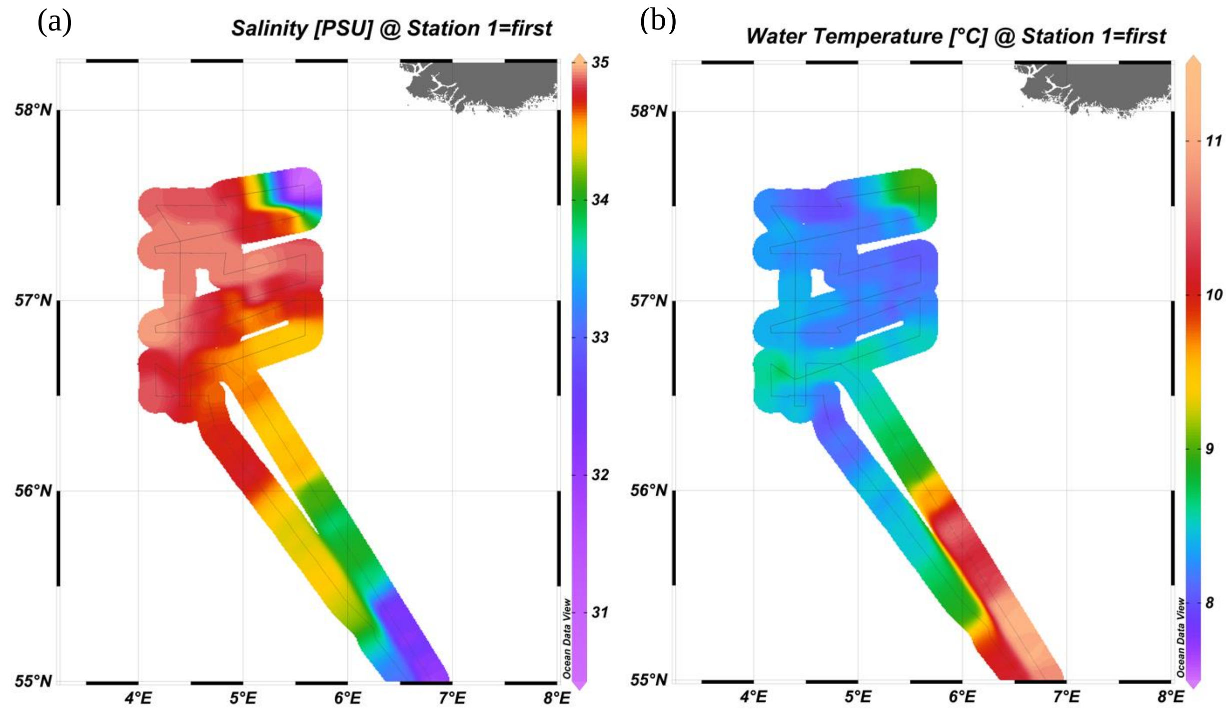

Fig. 5.15 (a) Salinity (in PSU) and (b) water temperature (in °C) distribution derived from measurements of the Thermosalinograph.

5.2 Sediment Sampling

(M. Gothmann)

In addition to the sampling of the water column, samples of the sediment were taken. A total of 22 stations was sampled, all in the Norwegian EEZ. A vVG and an OCTOPUS MUC were used to collect the sediment samples. The vVG was used at every station, while the MUC could not be operated at three stations because the sediment was too coarse. The sediment sampling starts immediately after sampling of the water column with the CTD-Rosette and the BWS. The reason for this is that by taking the sediment samples, a lot of sediment can be stirred up and subsequent sampling of the water column would give disturbed results.

5.2.1 Surface Sediment Sampling (van-Veen-Grab)

The first device for sediment sampling is the vVG (Fig. 5.16). It is used to sample the top 10 cm of the seabed to get an overview of the sediment texture (Fig. 11.10). However, this is a disturbed sample in which the stratification of the sediment is not as good as from the MUC. Furthermore, the vVG is used to examine the permeability and for a first insight into the grain size. This is important to know for the operation of the MUC, as too gravely or coarse-grained sediment could damage the device.

To retrieve the sediment, the vVG is lowered to the seabed where it digs into the sediment by its own weight. When the device is heaved again, the scoops close and capture the sediment. As soon as the vVG is back on deck, it is opened at the top to take a sediment sample for the permeability measurement using a small acrylic glass tube (Fig. 11.11). To do this, the tube is inserted into the sediment and then closed with a stopper at the upper end. This creates a negative pressure, which makes it easier for the sediment to remain in the tube when it is pulled out. The lower end is then sealed in the same way and the tube is taken to the laboratory. The lower plug is replaced by a different one, which has a rubber tube in its centre and a valve at the end of the tube. A piece of filter paper has to be placed on the top of the plug before exchanging them, to prevent sediment from flowing into the tube. Then the acrylic glass tube is filled with about as much sea water as the sediment it contains. Afterwards, the valve is opened and the time measurement is started (Fig. 11.4). The measurement ends at the latest as soon as the water has drained away. The permeability is calculated in cm/s (Table 11.5).

The results from these measurements show the highest permeability at station 21 (Fig. 5.17). This could be due to the gravely grain size throughout. In general, the permeability results correlate with the grain sizes at the different stations (Fig. 5.19).

After the sample for the permeability measurement is taken from the vVG, the sediment is disposed on a wooden plank. Then a picture of the material is taken (Fig. 11.1 – 11.3) and the sediment is described, including grain size, organism relicts, smell, layering and colour, determined with the MUNSELL Color Chart (Fig. 11.10).

Regarding the odour, stations 3, 5, 25, and 26 smelled of a sulphurous smell. Dark colours were also registered at these stations, which are probably due to reduction processes. This means, that at those stations, reduction already takes place in the upper sediment layers and the ventilation of oxygen is low, which is presumed to be caused by fine-grained material. In other stations, as e.g. station 20 – 22, the grain size of the sediment was much coarser, leading to a better ventilation and no reduction marks or smells.

The results in terms of the organisms show the presence of annelids, molluscs, echinoderms, scaphopods and gastropods. Shell fragments from molluscs made up the most common organism and appear at each station. At the stations where the sulphurous smell was detected, annelids were found in addition to the molluscs, except for station 4. Gastropods and scaphopods accounted for a smaller proportion among the organisms. Gastropods appear at stations 7, 8 and 9 and scaphopods at stations 2 and 4. In contrast, annelids and echinoderms were found at several stations, but did also not occur at stations 20-22, where the sediment was rather coarse.

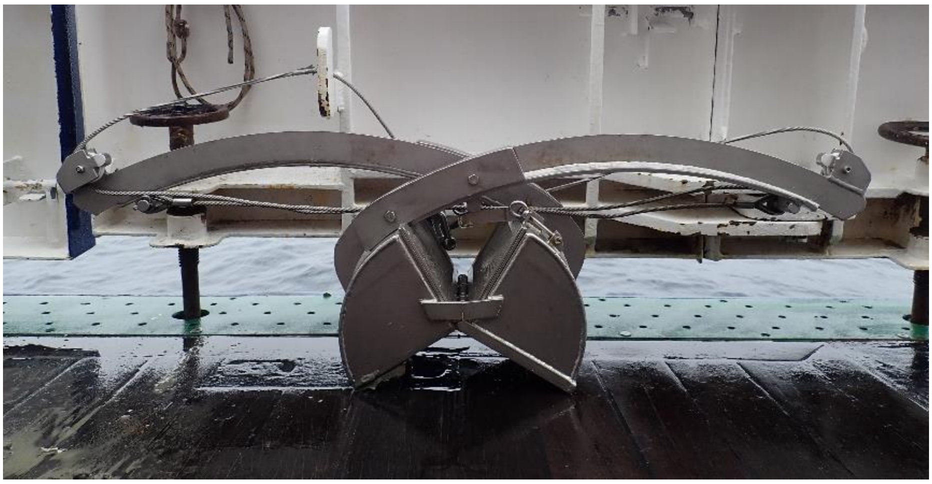

Fig. 5.16 The vVG on deck before deployment at a station.

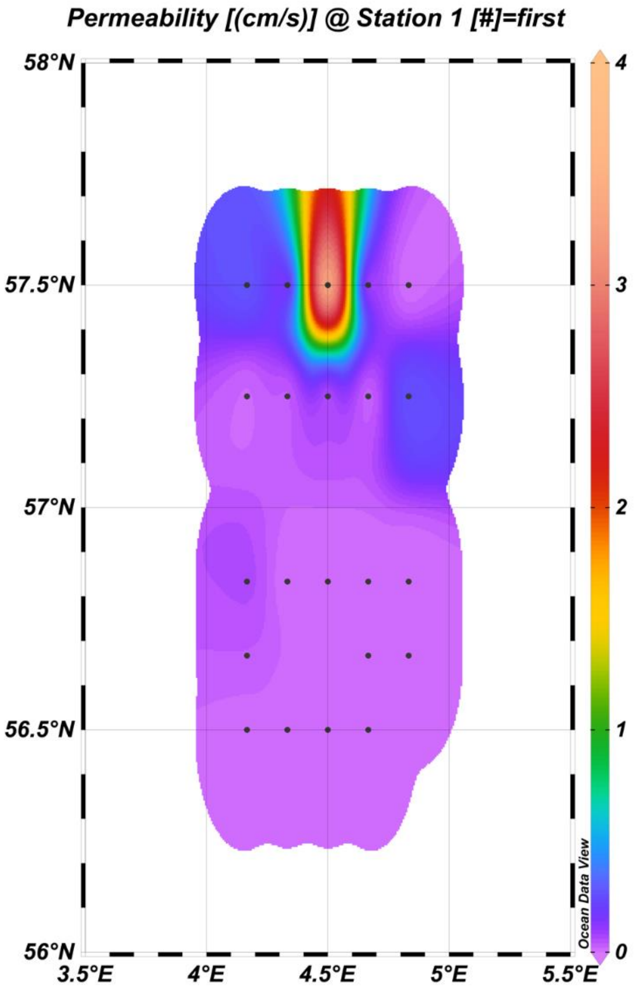

Fig. 5.17 Map of the permeability (cm/s) in the work area of HE619.

5.2.2 Multicorer

(M. Gothmann)

A MUC was used to take undisturbed sediment samples during HE619 expedition (Fig. 5.18). The MUC allows sampling from the top 20 cm of the sediment. During use, the metal frame of the MUC is covered with a net to prevent the cable from winding around the tubes.

To operate it, the MUC is tied to the winch at the top, which then lifts it up. In the next step, two metal rods (“pistols”) are pulled out of the central rail, which previously prevented the inner part with the tubes from falling and touching the ground. (Fig. 5.18) After that, the MUC is lowered into the water to 5 m above the sea floor so the device can settle and stop turning or moving in the water column. After waiting for two minutes, the MUC is lowered to the seabed with 0.3 m/s. Once the MUC reaches the bottom, the sediment cores are pushed into the ground by its own weight. After waiting a few minutes, the MUC is pulled back up, triggering a mechanism that seals the sediment cores at the top and bottom. On deck, the metal rods are pushed back into the central rail. The sediment cores are then sealed at the top and bottom with a plug and removed from the MUC to be available for further sampling. Two sediment cores are needed for further investigation. First, one core is chosen to take a photo and describe the sediment, visible layers and organisms (Fig. 11.5 – 11.7, Table 11.6). Then the cores are placed on a steel cylinder and pushed down to sample the sediment. One of the sediment cores is cut in 1 cm intervals and packed in plastic bags. These plastic bags are then sealed and stored in the freezer. From the other sediment core, only the top 2 cm were removed and stored in a plastic container in the fridge. This sediment sample was taken for the micropaleontology department of the Universität Hamburg (Gerhard Schmiedl) to study benthic foraminifera. Due to coarse and gravely sediment the MUC could not be run on the stations 19, 20 and 21. The MUC results show a tendency for the sediment to become coarser in the northern stations and finer towards the south (Fig. 5.19). At stations 5, 11, 13, 15, 22 and 23, lighter colours were observed and the sediment cores show little or no colour changes within their whole length. In comparison, clearly recognizable colour gradients can be seen at all other stations, going from a lighter upper part to a darker area at the bottom. The darker areas indicate reduction processes, which were already perceived in the results of the vVG.

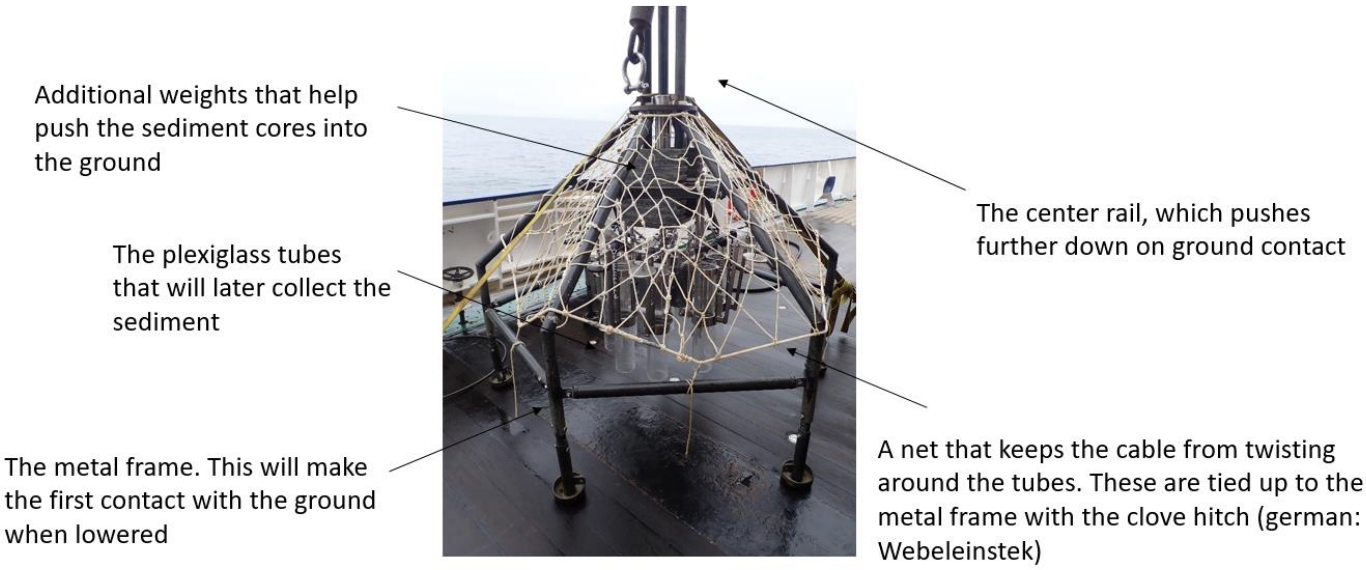

Fig. 5.18 The Multicorer with a brief description of the components.

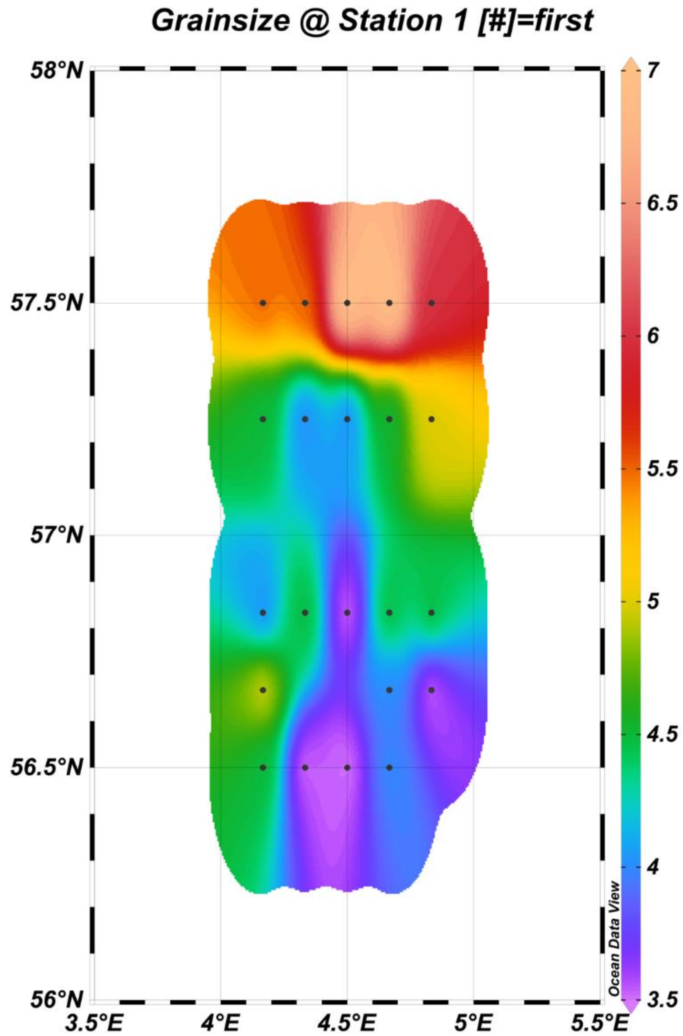

Fig. 5.19 Map of the grain size (arbitrary values) distribution in the study area of HE619.

5.3 Underway Hydroacoustics

(F. Schönbeck, T. Lüdmann)

For the hydroacoustic survey of the sea floor and the water column, the RV HEINCKE used four types of devices. Installed at the bottom of the hull are the KONGSBERG EM712 multibeam echo sounder (MBES) as well as the INNOMAR SES-2000 narrow-beam parametric sub-bottom profiler (SBES). Two TELEDYNE RDI WORKHORSE MARINER acoustic doppler current profilers (ADCP) (600 & 150 kHz) were hull mounted in the keel of the vessel. The hydroacoustic survey profiles using the MBES and the SBES were split into four blocks and were conducted during nighttime so they could record uninterrupted by any tool sampling stations during the day. Nighttime survey was usually conducted between 15:30 and 05:00 UTC. The last survey block (4) started an hour earlier than usual (approx.14:30 UTC) and ended two hours earlier (approx. 03:00 UTC). The vessel's profiling speed while the MBES and SBES were recording was 6 – 8 knots. The locations of the blocks are shown in Fig. 5.20. The ADCP was recording continuously during daytime and nighttime operations. Aim of the hydroacoustic survey was to record the North Sea bathymetry and sediment surface roughness using the MBES, to record water current velocities and directions as well as water mass boundaries using the ADCP, and to uncover subsurface sediment structures utilizing the SBES. During the cruise the hydroacoustic data was acquired only in the Norwegian sector. All four hydroacoustic profiles sum up to a total distance of ca. 969.4 km.

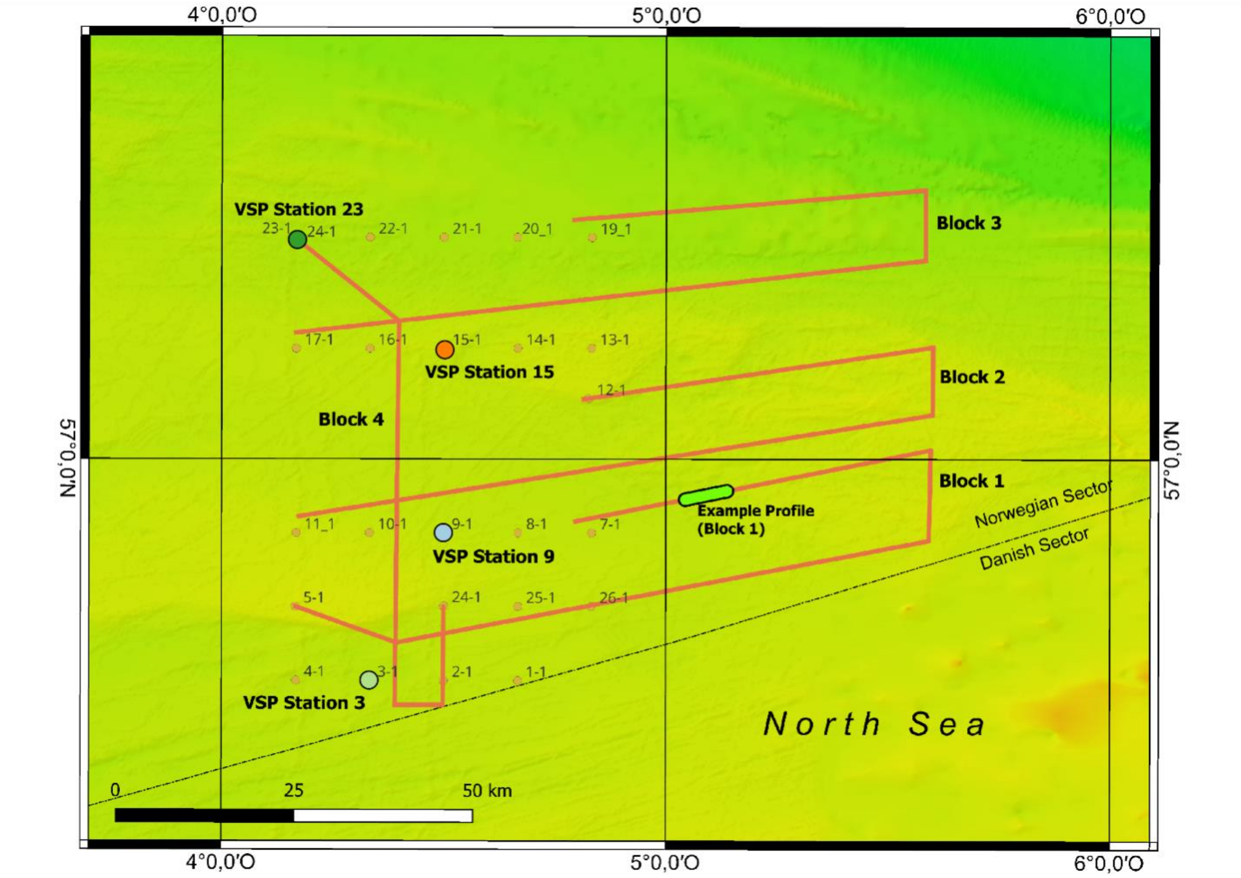

Fig. 5.20 Locations of the nighttime hydroacoustic survey blocks (red lines), the sampling stations (orange circles), and the locations of vertical sound profiles (large circles).

The KONGSBERG EM712 MBES utilized during cruise HE619 recorded the sea floor morphology and sediment backscatter along the vessel's track. The device sends out equidistant electromagnetic waves in a fan configuration perpendicular to the direction the vessel is moving. The device was configured to run in dual swath mode with a variable ping frequency between 50 – 100 kHz. The opening aperture was set to 130° on the EM712. This means that the swath width is about 4.3 times the water depth. At a water depth of about 50 m this would mean a swath of 214 m width could be acquired. Acquisition depth ranges from 3 m below the transducer up to 3500 m. The emitted beams are stabilized for the vessel's roll, pitch, and yaw. Incoming beams are adjusted for roll motions. The MBES bathymetry data was processed with QPS QIMERA software while the backscatter data was processed with QPS FM GEOCODER TOOLBOX.

A 3.5 km long example profile of the data recorded with the MBES during the first block shows the sea floor morphology in a water depth between approximately 55 – 66 m (Fig. 5.21). The same example profile is shown with the backscatter intensity (Fig. 5.22). The intensity relates to sediment roughness and density. A higher (brighter) intensity means the sediment is either dense or rough (sand, gravel, rocks, bivalve banks). A lower (darker) response relates to a smoother or less dense sediment (silt, mud).

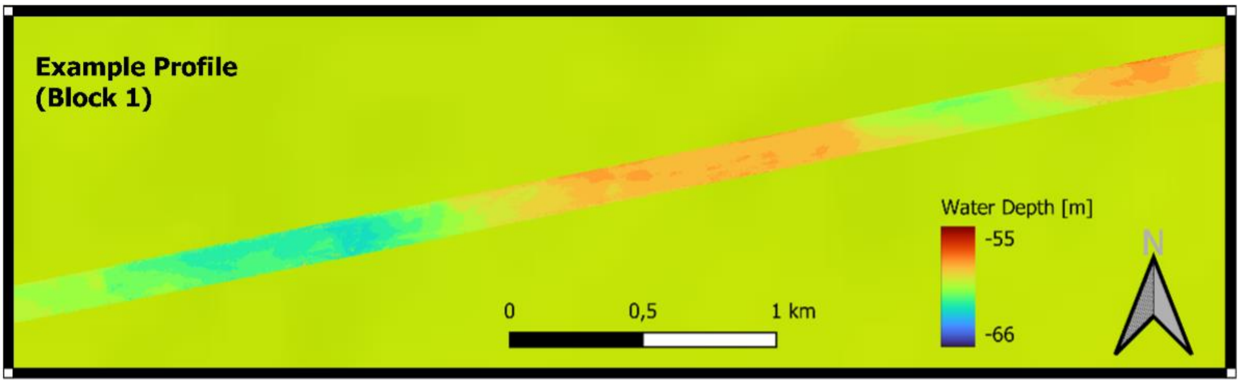

Fig. 5.21 Sea floor morphology along an example profile in survey block 1.

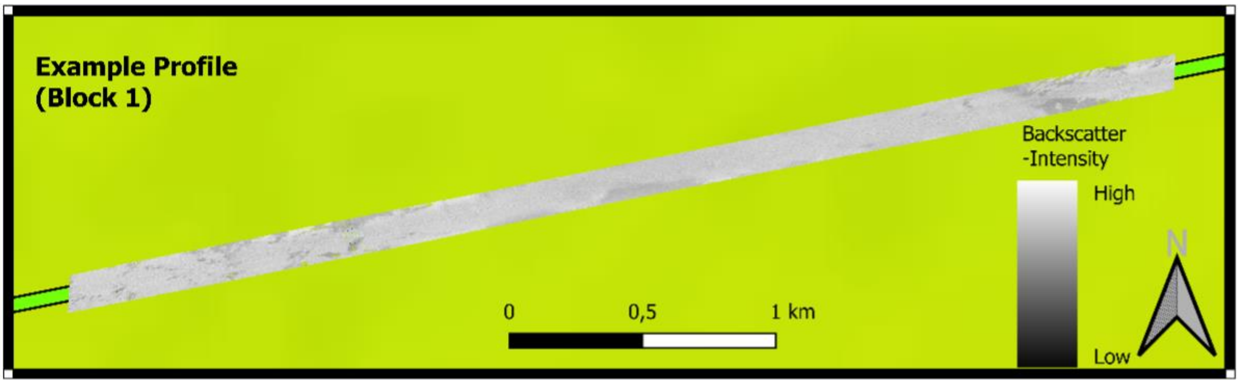

Fig. 5.22 Sediment backscatter along an example profile in survey block 1.

An INNOMAR SES-2000 SBES was used to record the sea floor and underlaying sediment structures parallel to the vessels path. The device was configured to a primary frequency of 100 kHz. Through the parametric effect a secondary frequency of 6 kHz, that could penetrate the sediment, was generated. The ship's SBES has a maximum sediment penetration depth of 70 m with a vertical resolution of about 5 cm. The ship's SBES was run to alternate with its MBES to avoid signal interference. In the SBES profile of the aforementioned example, multiple sedimentary structures are visible (Fig. 5.23). A supposed erosional surface from the last glacial maximum (LGM) stretches over a large part of the frame (Fig. 5.23). Overlaying are glacial sediments with no distinct layering. These sediments are assumed to be glacial till. On top of that are recent marine sediments. In the eastern part of the frame glacial or fluvial channels that have been infilled with sediments are visible (Fig. 5.23). Above that are assumed to be sub-parallel marine sediments filling a depression from the underlying sediment (Fig. 5.23). The recorded SBES data was processed and presented with SCHLUMBERGER PETREL software.

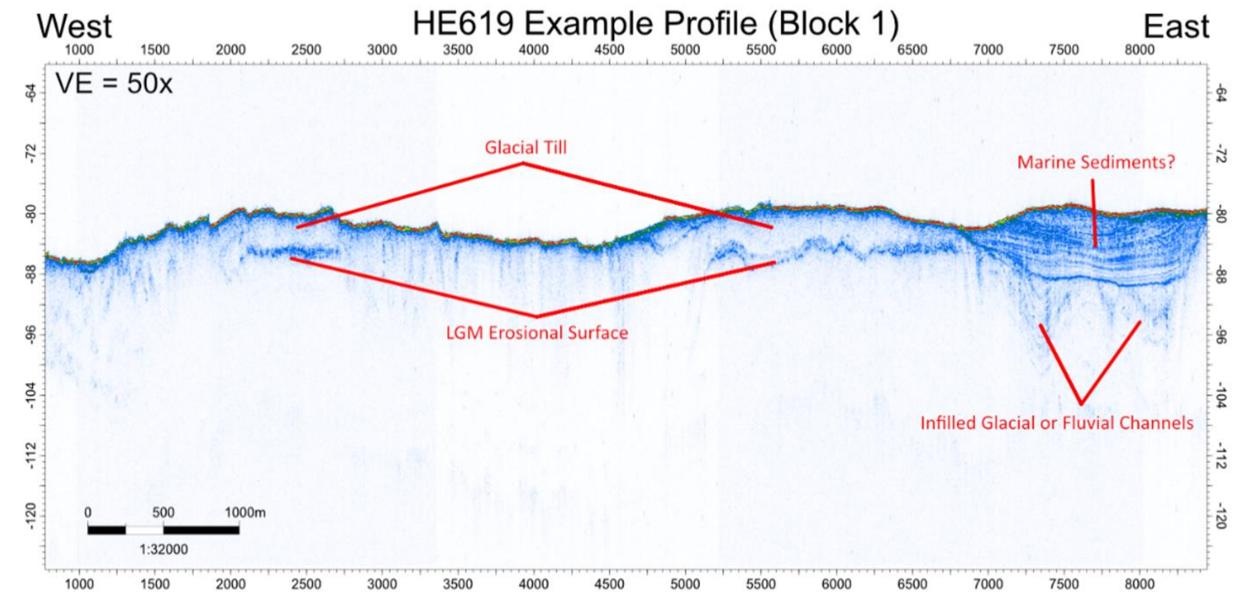

Fig. 5.23 SBES line along an example profile in survey block 1 in Norwegian waters. Glacial features and sediments are present.

The ship's TELEDYNE RDI WORKHORSE MARINER 600 and 150 kHz ADCPs were used to measure water current direction and velocity within predefined bins. The 600 kHz device was configured to a water depth of up to 46 m with the first bin starting at a depth of 3.20 m. 40 vertical bins with a size of 2 m were configured. The 150 kHz device was configured to measure 70 bins at a size of 2 m, starting from a depth of 4.74 m up to a maximum depth of about 400 m. The two devices were not used at the same time but in an alternating fashion. At times the 600 kHz device would stop working. This is when the 150 kHz device was used to continue operations. The ADCPs work by principle of the doppler effect. Acoustic pulses are emitted and reflected by particles within a specific bin. When receiving the reflected signal, a shift in frequency (the doppler shift) is calculated and through this a specific direction can be determined. By continuously recording and analyzing all bins, the direction, speed, and boundary of a water mass can be determined.

To verify the accuracy of the ADCPs, MBES, and SBES a vertical sound profile (VSP) of the water column was measured. The sampling procedure is explained in chapter 4. In total 4 VSPs were recorded (at stations 3, 9, 15, 23). Two such profiles are displayed in Fig. 5.24 for stations 3 and 9. In the chart distinct differences in water mass boundaries can be observed. Station 3 has two clear jumps between 5 – 10 m and 45 – 50 m where the sound velocity decreases. Station 9 has a slowdown zone between 5 – 20 m where the sound velocity only decreases in small steps.

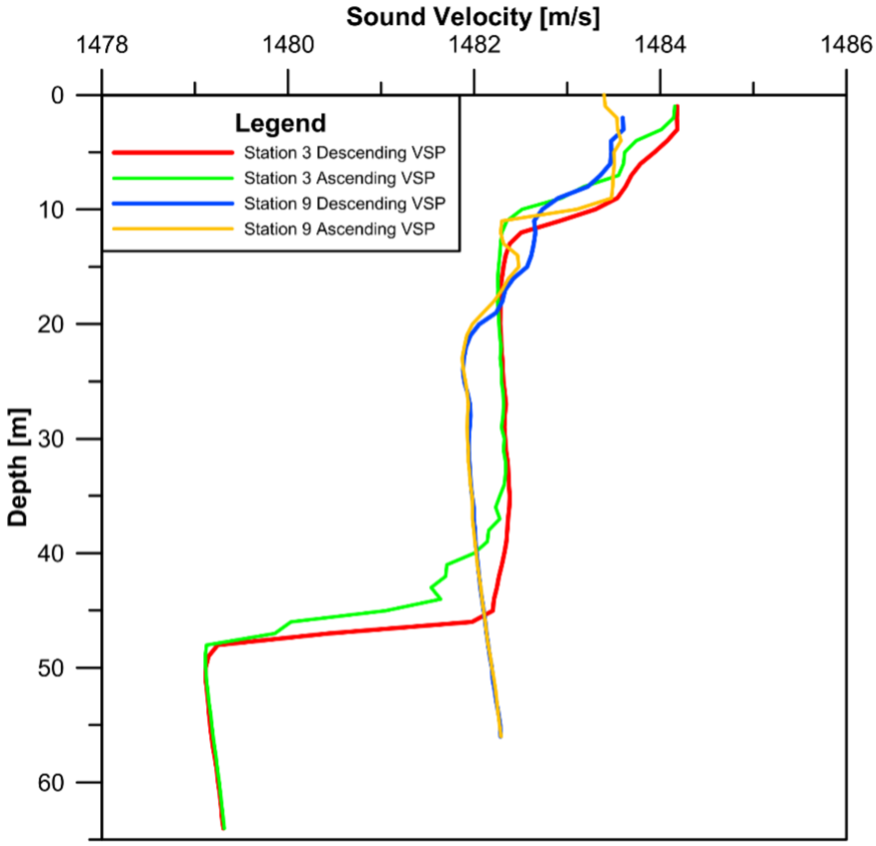

Fig. 5.24 Ascending and descending velocity sound profiles of stations 3 and 9.

6 Station List HE619

Table 6.1 Station List of HE619 giving an overview on time and date of action at stations. WST: Weather Station; TSG: Thermosalinograph; Secdisk: Secchi-Disk; APN: Plankton-Net (APSTEIN); CTD: CTD-Rosette; BWS: Bottom Water Sampler; GRAB: van Veen Grab; MUC: Multicorer; MB/SES/ADCP: Multibeam / SES 2000 / ADCP.

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Action
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE619_0_Underway-5	10.05.23	WST	06:32:15	53° 31.933' N	008° 34.701' E	3	station start
HE619_0_Underway-3	10.05.23	TSG	09:00:01	53° 53.101' N	008° 05.666' E	14	station start
HE619_1-1	11.05.23	Secdisk	06:00:51	56° 29.995' N	004° 40.014' E	61	station start
HE619_1-2	11.05.23	APN	06:07:15	56° 30.000' N	004° 40.002' E	61	in the water
HE619_1-3	11.05.23	CTD	06:13:57	56° 29.992' N	004° 39.987' E	61	in the water
HE619_1-3	11.05.23	CTD	06:24:32	56° 29.998' N	004° 40.020' E	61	max depth/on ground
HE619_1-4	11.05.23	BWS	06:39:09	56° 29.993' N	004° 40.052' E	61	max depth/on ground
HE619_1-5	11.05.23	GRAB	06:54:56	56° 30.007' N	004° 40.115' E	61	max depth/on ground
HE619_1-6	11.05.23	MUC	07:06:50	56° 29.982' N	004° 40.150' E	61	max depth/on ground
HE619_2-1	11.05.23	Secdisk	08:01:39	56° 29.995' N	004° 30.011' E	62	in the water
HE619_2-2	11.05.23	APN	08:05:18	56° 29.993' N	004° 30.023' E	62	in the water
HE619_2-3	11.05.23	CTD	08:08:56	56° 29.992' N	004° 30.034' E	62	in the water
HE619_2-3	11.05.23	CTD	08:17:53	56° 29.992' N	004° 30.024' E	62	max depth/on ground
HE619_2-4	11.05.23	BWS	08:30:30	56° 29.985' N	004° 30.036' E	62	max depth/on ground
HE619_2-5	11.05.23	GRAB	08:43:59	56° 29.982' N	004° 30.038' E	62	max depth/on ground
HE619_2-6	11.05.23	MUC	08:54:30	56° 29.989' N	004° 30.016' E	62	max depth/on ground
HE619_3-1	11.05.23	Secdisk	10:12:18	56° 29.999' N	004° 19.978' E	67	in the water
HE619_3-1	11.05.23	Secdisk	10:13:33	56° 30.000' N	004° 19.981' E	67	on deck
HE619_3-2	11.05.23	APN	10:15:46	56° 30.005' N	004° 19.990' E	66	in the water
HE619_3-3	11.05.23	CTD	10:19:42	56° 30.017' N	004° 20.007' E	67	in the water
HE619_3-3	11.05.23	CTD	10:26:55	56° 30.022' N	004° 20.017' E	67	max depth/on ground
HE619_3-4	11.05.23	BWS	10:38:49	56° 30.006' N	004° 20.028' E	67	max depth/on ground
HE619_3-5	11.05.23	GRAB	10:51:23	56° 30.010' N	004° 20.026' E	66	max depth/on ground
HE619_3-6	11.05.23	MUC	11:23:32	56° 30.015' N	004° 20.035' E	67	max depth/on ground
HE619_4-1	11.05.23	Secdisk	12:32:11	56° 30.010' N	004° 10.074' E	65	in the water
HE619_4-2	11.05.23	APN	12:35:15	56° 29.998' N	004° 10.075' E	65	in the water
HE619_4-3	11.05.23	CTD	12:39:25	56° 29.997' N	004° 10.066' E	65	in the water
HE619_4-3	11.05.23	CTD	12:46:00	56° 29.997' N	004° 10.058' E	65	max depth/on ground
HE619_4-4	11.05.23	BWS	12:56:53	56° 29.993' N	004° 10.039' E	65	max depth/on ground
HE619_4-5	11.05.23	GRAB	13:08:08	56° 29.986' N	004° 10.015' E	65	max depth/on ground
HE619_4-6	11.05.23	MUC	13:18:26	56° 29.989' N	004° 10.029' E	65	max depth/on ground
HE619_5-1	11.05.23	Secdisk	14:41:28	56° 39.999' N	004° 09.953' E	46	on deck
HE619_5-2	11.05.23	APN	14:42:57	56° 39.997' N	004° 09.951' E	46	in the water
HE619_5-3	11.05.23	CTD	14:52:35	56° 39.982' N	004° 09.959' E	46	max depth/on ground
HE619_5-4	11.05.23	BWS	15:03:54	56° 39.999' N	004° 09.968' E	46	max depth/on ground

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Action
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE619_5-5	11.05.23	GRAB	15:12:22	56° 40.000' N	004° 09.967' E	46	max depth/on ground
HE619_5-6	11.05.23	MUC	15:22:27	56° 40.004' N	004° 09.977' E	46	max depth/on ground
HE619_6-1	11.05.23	MB/SES/ADCP	15:39:18	56° 40.028' N	004° 10.102' E	46	station start
HE619_6-1	11.05.23	MB/SES/ADCP	15:39:25	56° 40.025' N	004° 10.111' E	46	profile start
HE619_6-1	12.05.23	MB/SES/ADCP	04:59:54	56° 51.574' N	004° 47.784' E	61	profile end
HE619_6-1	12.05.23	MB/SES/ADCP	05:00:05	56° 51.578' N	004° 47.764' E	61	station end
HE619_7-1	12.05.23	Secdisk	06:02:23	56° 49.997' N	004° 49.979' E	61	in the water
HE619_7-2	12.05.23	APN	06:05:35	56° 49.999' N	004° 49.961' E	61	in the water
HE619_7-3	12.05.23	CTD	06:16:43	56° 49.995' N	004° 49.962' E	61	max depth/on ground
HE619_7-4	12.05.23	BWS	06:29:25	56° 49.998' N	004° 49.981' E	60	max depth/on ground
HE619_7-5	12.05.23	GRAB	06:42:52	56° 50.006' N	004° 50.002' E	61	max depth/on ground
HE619_7-6	12.05.23	MUC	06:56:29	56° 50.015' N	004° 50.005' E	61	max depth/on ground
HE619_8-1	12.05.23	Secdisk	08:02:57	56° 50.003' N	004° 40.024' E	60	in the water
HE619_8-2	12.05.23	APN	08:05:15	56° 50.007' N	004° 40.023' E	60	in the water
HE619_8-3	12.05.23	CTD	08:08:10	56° 50.004' N	004° 40.021' E	60	in the water
HE619_8-3	12.05.23	CTD	08:15:27	56° 50.018' N	004° 39.927' E	60	max depth/on ground
HE619_8-4	12.05.23	BWS	08:27:33	56° 50.000' N	004° 39.946' E	60	max depth/on ground
HE619_8-5	12.05.23	GRAB	08:41:16	56° 50.008' N	004° 39.981' E	60	max depth/on ground
HE619_8-6	12.05.23	MUC	08:52:15	56° 50.002' N	004° 39.991' E	60	max depth/on ground
HE619_9-1	12.05.23	Secdisk	10:16:47	56° 49.972' N	004° 29.996' E	58	in the water
HE619_9-2	12.05.23	APN	10:22:05	56° 49.979' N	004° 29.979' E	58	in the water
HE619_9-3	12.05.23	CTD	10:24:50	56° 49.978' N	004° 29.998' E	58	in the water
HE619_9-3	12.05.23	CTD	10:30:59	56° 49.985' N	004° 29.978' E	58	max depth/on ground
HE619_9-4	12.05.23	BWS	10:41:09	56° 49.986' N	004° 29.990' E	58	max depth/on ground
HE619_9-5	12.05.23	GRAB	10:50:57	56° 49.991' N	004° 29.997' E	58	max depth/on ground
HE619_9-6	12.05.23	MUC	11:00:32	56° 49.989' N	004° 29.994' E	58	max depth/on ground
HE619_10-1	12.05.23	Secdisk	12:11:50	56° 49.985' N	004° 19.984' E	55	in the water
HE619_10-2	12.05.23	APN	12:14:22	56° 49.974' N	004° 19.993' E	55	in the water
HE619_10-3	12.05.23	CTD	12:18:42	56° 49.966' N	004° 20.037' E	55	in the water
HE619_10-3	12.05.23	CTD	12:24:14	56° 49.973' N	004° 19.953' E	55	max depth/on ground
HE619_10-4	12.05.23	BWS	12:33:40	56° 49.986' N	004° 19.963' E	55	max depth/on ground
HE619_10-5	12.05.23	GRAB	12:44:40	56° 49.982' N	004° 19.956' E	55	max depth/on ground
HE619_10-6	12.05.23	MUC	12:53:57	56° 49.983' N	004° 19.970' E	55	max depth/on ground
HE619_11-1	12.05.23	Secdisk	14:05:11	56° 49.986' N	004° 10.043' E	52	in the water
HE619_11-2	12.05.23	APN	14:07:48	56° 49.985' N	004° 10.018' E	51	in the water
HE619_11-3	12.05.23	CTD	14:15:50	56° 49.994' N	004° 10.008' E	51	max depth/on ground
HE619_11-4	12.05.23	BWS	14:37:33	56° 50.007' N	004° 09.983' E	52	max depth/on ground
HE619_11-5	12.05.23	GRAB	14:47:26	56° 50.009' N	004° 09.974' E	51	max depth/on ground
HE619_11-6	12.05.23	MUC	14:55:49	56° 50.007' N	004° 09.971' E	51	max depth/on ground
HE619_12-1	12.05.23	MB/SES/ADCP	15:37:31	56° 52.157' N	004° 10.257' E	54	station start
HE619_12-1	12.05.23	MB/SES/ADCP	15:37:36	56° 52.161' N	004° 10.275' E	54	profile start
HE619_12-1	13.05.23	MB/SES/ADCP	04:29:35	57° 08.192' N	004° 49.578' E	52	profile end
HE619_12-1	13.05.23	MB/SES/ADCP	04:29:45	57° 08.190' N	004° 49.543' E	52	station end

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Action
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE619_13-1	13.05.23	Secdisk	06:00:12	57° 15.004' N	004° 50.004' E	50	in the water
HE619_13-2	13.05.23	APN	06:12:28	57° 15.005' N	004° 50.016' E	50	in the water
HE619_13-3	13.05.23	CTD	06:18:10	57° 15.005' N	004° 50.019' E	50	in the water
HE619_13-3	13.05.23	CTD	06:20:32	57° 15.004' N	004° 50.019' E	50	max depth/on ground
HE619_13-4	13.05.23	BWS	06:30:54	57° 15.007' N	004° 49.987' E	50	max depth/on ground
HE619_13-5	13.05.23	GRAB	06:43:11	57° 15.008' N	004° 49.991' E	50	max depth/on ground
HE619_13-6	13.05.23	MUC	06:55:05	57° 15.004' N	004° 50.000' E	51	max depth/on ground
HE619_14-1	13.05.23	Secdisk	08:02:15	57° 15.006' N	004° 39.999' E	56	in the water
HE619_14-2	13.05.23	APN	08:07:20	57° 14.996' N	004° 39.994' E	55	in the water
HE619_14-3	13.05.23	CTD	08:11:23	57° 14.991' N	004° 40.011' E	55	in the water
HE619_14-3	13.05.23	CTD	08:15:44	57° 14.997' N	004° 39.993' E	55	max depth/on ground
HE619_14-4	13.05.23	BWS	08:25:03	57° 14.973' N	004° 39.968' E	56	max depth/on ground
HE619_14-5	13.05.23	GRAB	08:36:50	57° 14.967' N	004° 39.954' E	55	max depth/on ground
HE619_14-6	13.05.23	MUC	08:46:48	57° 14.983' N	004° 39.981' E	55	max depth/on ground
HE619_15-1	13.05.23	Secdisk	10:13:05	57° 14.976' N	004° 30.018' E	56	in the water
HE619_15-2	13.05.23	APN	10:17:13	57° 14.987' N	004° 30.009' E	55	in the water
HE619_15-3	13.05.23	CTD	10:21:05	57° 14.979' N	004° 29.997' E	56	in the water
HE619_15-3	13.05.23	CTD	10:26:34	57° 14.983' N	004° 29.993' E	56	max depth/on ground
HE619_15-4	13.05.23	BWS	10:36:32	57° 14.970' N	004° 30.013' E	56	max depth/on ground
HE619_15-4	13.05.23	BWS	10:45:09	57° 14.974' N	004° 29.998' E	55	on deck
HE619_15-5	13.05.23	GRAB	10:47:31	57° 14.973' N	004° 29.977' E	55	max depth/on ground
HE619_15-6	13.05.23	MUC	10:56:22	57° 14.984' N	004° 29.968' E	56	max depth/on ground
HE619_16-1	13.05.23	Secdisk	12:11:28	57° 14.977' N	004° 20.015' E	59	in the water
HE619_16-2	13.05.23	APN	12:15:22	57° 14.977' N	004° 20.038' E	59	in the water
HE619_16-3	13.05.23	CTD	12:21:28	57° 14.982' N	004° 20.019' E	58	in the water
HE619_16-3	13.05.23	CTD	12:26:23	57° 14.993' N	004° 20.002' E	59	max depth/on ground
HE619_16-4	13.05.23	BWS	12:57:24	57° 14.995' N	004° 19.978' E	59	max depth/on ground
HE619_16-5	13.05.23	GRAB	13:10:58	57° 14.997' N	004° 19.997' E	59	max depth/on ground
HE619_16-6	13.05.23	MUC	13:19:56	57° 15.010' N	004° 19.977' E	59	max depth/on ground
HE619_17-1	13.05.23	Secdisk	14:13:11	57° 14.975' N	004° 10.029' E	60	in the water
HE619_17-2	13.05.23	APN	14:19:23	57° 14.967' N	004° 10.017' E	59	in the water
HE619_17-3	13.05.23	CTD	14:29:20	57° 14.978' N	004° 10.006' E	59	max depth/on ground
HE619_17-4	13.05.23	BWS	14:38:42	57° 14.973' N	004° 10.000' E	59	max depth/on ground
HE619_17-5	13.05.23	GRAB	14:50:15	57° 14.994' N	004° 09.978' E	59	max depth/on ground
HE619_17-6	13.05.23	MUC	14:58:38	57° 14.969' N	004° 09.974' E	60	max depth/on ground
HE619_18-1	13.05.23	MB/SES/ADCP	15:39:23	57° 17.090' N	004° 10.213' E	59	station start
HE619_18-1	13.05.23	MB/SES/ADCP	15:39:30	57° 17.092' N	004° 10.236' E	60	profile start
HE619_18-1	14.05.23	MB/SES/ADCP	04:58:05	57° 32.354' N	004° 47.446' E	79	profile end
HE619_18-1	14.05.23	MB/SES/ADCP	04:58:25	57° 32.343' N	004° 47.390' E	79	station end
HE619_19-1	14.05.23	Secdisk	06:02:51	57° 30.001' N	004° 50.015' E	79	in the water
HE619_19-2	14.05.23	APN	06:06:47	57° 30.009' N	004° 50.020' E	79	in the water
HE619_19-3	14.05.23	CTD	06:11:15	57° 30.003' N	004° 50.025' E	79	in the water
HE619_19-3	14.05.23	CTD	06:18:10	57° 30.001' N	004° 50.031' E	79	max depth/on ground

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Action
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE619_19-4	14.05.23	BWS	06:29:15	57° 30.008' N	004° 50.017' E	79	max depth/on ground
HE619_19-5	14.05.23	GRAB	06:42:00	57° 30.010' N	004° 50.018' E	79	max depth/on ground
HE619_19-6	14.05.23	GRAB	06:49:50	57° 30.009' N	004° 50.030' E	79	max depth/on ground
HE619_20-1	14.05.23	Secdisk	07:51:51	57° 30.008' N	004° 39.945' E	79	in the water
HE619_20-2	14.05.23	APN	07:54:53	57° 30.009' N	004° 39.949' E	79	in the water
HE619_20-3	14.05.23	CTD	07:58:36	57° 30.013' N	004° 39.945' E	79	in the water
HE619_20-3	14.05.23	CTD	08:05:02	57° 30.011' N	004° 39.953' E	79	max depth/on ground
HE619_20-4	14.05.23	BWS	08:16:54	57° 30.008' N	004° 39.973' E	78	max depth/on ground
HE619_20-5	14.05.23	GRAB	08:30:05	57° 30.001' N	004° 39.984' E	78	max depth/on ground
HE619_20-6	14.05.23	GRAB	08:36:26	57° 30.003' N	004° 40.000' E	78	max depth/on ground
HE619_21-1	14.05.23	Secdisk	09:59:12	57° 30.002' N	004° 30.016' E	76	in the water
HE619_21-2	14.05.23	APN	10:02:11	57° 30.002' N	004° 30.018' E	75	in the water
HE619_21-3	14.05.23	CTD	10:05:18	57° 30.002' N	004° 30.012' E	76	in the water
HE619_21-3	14.05.23	CTD	10:11:03	57° 30.003' N	004° 29.996' E	76	max depth/on ground
HE619_21-4	14.05.23	BWS	10:18:14	57° 30.011' N	004° 29.986' E	76	in the water
HE619_21-4	14.05.23	BWS	10:20:48	57° 30.011' N	004° 29.984' E	76	max depth/on ground
HE619_21-5	14.05.23	GRAB	10:32:34	57° 30.010' N	004° 29.987' E	76	max depth/on ground
HE619_22-1	14.05.23	Secdisk	11:36:07	57° 30.003' N	004° 20.017' E	75	in the water
HE619_22-2	14.05.23	APN	11:39:36	57° 30.008' N	004° 19.982' E	75	in the water
HE619_22-3	14.05.23	CTD	11:42:22	57° 30.005' N	004° 19.994' E	75	in the water
HE619_22-3	14.05.23	CTD	11:48:16	57° 29.991' N	004° 20.037' E	75	max depth/on ground
HE619_22-4	14.05.23	BWS	12:18:03	57° 29.969' N	004° 20.089' E	75	max depth/on ground
HE619_22-5	14.05.23	GRAB	12:28:28	57° 29.958' N	004° 20.122' E	75	max depth/on ground
HE619_22-6	14.05.23	MUC	12:38:45	57° 29.946' N	004° 20.111' E	75	max depth/on ground
HE619_23-1	14.05.23	Secdisk	13:40:23	57° 30.004' N	004° 10.046' E	73	in the water
HE619_23-2	14.05.23	APN	13:44:44	57° 29.995' N	004° 10.028' E	73	in the water
HE619_23-3	14.05.23	CTD	13:55:29	57° 29.992' N	004° 10.044' E	73	max depth/on ground
HE619_23-4	14.05.23	BWS	14:05:45	57° 30.006' N	004° 10.044' E	73	max depth/on ground
HE619_23-5	14.05.23	GRAB	14:16:29	57° 29.999' N	004° 10.042' E	73	max depth/on ground
HE619_23-6	14.05.23	MUC	14:24:39	57° 30.000' N	004° 10.053' E	73	max depth/on ground
HE619_24-1	14.05.23	MB/SES/ADCP	14:39:38	57° 29.563' N	004° 10.339' E	74	station start
HE619_24-1	14.05.23	MB/SES/ADCP	14:39:47	57° 29.549' N	004° 10.354' E	73	profile start
HE619_24-1	15.05.23	MB/SES/ADCP	03:04:35	56° 40.080' N	004° 30.012' E	56	profile end
HE619_24-1	15.05.23	MB/SES/ADCP	03:04:45	56° 40.097' N	004° 30.020' E	57	station end
HE619_25-1	15.05.23	Secdisk	03:56:36	56° 40.022' N	004° 40.027' E	57	in the water
HE619_25-2	15.05.23	APN	03:58:15	56° 40.016' N	004° 40.031' E	57	in the water
HE619_25-3	15.05.23	CTD	04:07:49	56° 40.013' N	004° 40.040' E	57	max depth/on ground
HE619_25-4	15.05.23	BWS	04:17:29	56° 40.013' N	004° 40.030' E	57	max depth/on ground
HE619_25-5	15.05.23	GRAB	04:25:35	56° 40.006' N	004° 40.023' E	57	max depth/on ground
HE619_25-6	15.05.23	MUC	04:33:45	56° 39.997' N	004° 40.007' E	57	max depth/on ground
HE619_26-1	15.05.23	Secdisk	05:52:01	56° 40.029' N	004° 49.959' E	58	in the water
HE619_26-2	15.05.23	APN	05:56:21	56° 40.022' N	004° 49.962' E	58	in the water
HE619_26-3	15.05.23	CTD	05:58:50	56° 40.021' N	004° 49.965' E	58	in the water

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Action
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE619_26-3	15.05.23	CTD	06:04:34	56° 40.026' N	004° 49.957' E	58	max depth/on ground
HE619_26-4	15.05.23	BWS	06:13:43	56° 40.002' N	004° 49.967' E	58	max depth/on ground
HE619_26-5	15.05.23	GRAB	06:21:13	56° 39.993' N	004° 49.975' E	58	max depth/on ground
HE619_26-6	15.05.23	MUC	06:29:40	56° 40.006' N	004° 49.964' E	58	max depth/on ground
HE619_26-6	15.05.23		06:35:12	56° 39.996' N	004° 49.983' E	58	station end

7 Data and Sample Storage and Availability

The Seismic data (Multibeam and Parasound) will be transferred to the Norwegian authorities with a moratorium of two years; other than that, they will not be published.
The hydrographic raw data from the CTD-Rosette and the Thermosalinograph will be transferred to the PANGAEA database. Filtration and sediment data are planned to be transferred to PANGAEA after their analysis.

Table 7.1 Overview of data availability

Type	Database	Available	Free Access	Contact
Hydrography raw data (CTD, TSG)	PANGAEA	Sep 2023	Dec 2023	niko.lahajnar@uni-hamburg.de
Seismic data (Multibeam, Parasound)	Upon request	Dec 2023	May 2025	thomas.luedmann@uni-hamburg.de

8 Acknowledgements

We hereby thank our captain and the whole crew of the RV HEINCKE who supported us in all situations and allowed for a comfortable atmosphere on board. Furthermore, we would like to thank our chief scientist, Dr. Niko Lahajnar, for the organization of the cruise as well as his support and instructions during the cruise, which included an introduction to the devices, support during station work, after-work lessons on ship jargon and knots and many more. A big thank you must be expressed to Peggy Bartsch, who was on board as our lab technician and support with devices, especially the CTD-Rosette and the filtration device, but this was by far not the only thing she did for our team. Additionally, we would like to thank the DFG (Deutsche Forschungsgemeinschaft) for the funds to enable this research cruise. Finally, we thank the Norwegian and Danish authorities for the permission to conduct our research in the Norwegian and Danish EEZ, respectively. We would like to acknowledge the valuable support of the AWI Schiffskoordination (Ingo Schewe, Sanne Bochert, Marius Hirsekorn, Bjela König, Claudia Klages, Sandra Tippenhauer, Ralf Krocker, Stefanie Klüver, and all other supporters).

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10 Abbreviations

ADCP - Acoustic Doppler Current Profiler
APN - APSTEIN net (Plankton net)
BWS - Bottom Water Sampler
CTD - Conductivity Temperature Depth Sampler
EEZ - Exclusive Economic Zone
Ma - Million years
MBES - Multibeam Echosounder
SBES - Singlebeam Echosounder
TSG - Thermosalinograph
UTC - Coordinated Universal Time
vVG - Van Veen Grab Sampler

11 Appendices

11.1 Secchi Disk depth

Table 11.1 List of the Secchi Disk depth at the different stations.

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Secchi Depth
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[m]
HE619	01	11.05.23	06:00	004°40.01'	56°29.99'	63.9	8.5
HE619	02	11.05.23	08:01	004°30.03'	56°29.99'	65.5	8.0
HE619	03	11.05.23	10:12	004°20.03'	56°30.01'	69.6	10.5
HE619	04	11.05.23	12:32	004°10.04'	56°30.01'	68.4	9.5
HE619	05	11.05.23	14:41	004°09.94'	56°40.01'	49.0	10.5
HE619	07	12.05.23	06:02	004°49.97'	56°50.00'	60.5	9.0
HE619	08	12.05.23	08:02	004°39.99'	56°50.01'	60.0	10.5
HE619	09	12.05.23	10:16	004°30.00'	56°49.97'	58.4	18.0
HE619	10	12.05.23	12:11	004°19.98'	56°49.96'	55.0	15.0
HE619	11	12.05.23	14:05	004°10.01'	56°49.95'	51.5	10.0
HE619	13	13.05.23	06:00	004°50.02'	57°15.00'	49.5	11.5
HE619	14	13.05.23	08:02	004°40.01'	57°14.99'	55.0	10.0
HE619	15	13.05.23	10:13	004°29.99'	57°14.98'	55.4	13.5
HE619	16	13.05.23	12:11	004°20.00'	57°14.99'	59.0	9.0
HE619	17	13.05.23	14:13	004°10.01'	57°14.99'	59.6	13.0
HE619	19	14.05.23	06:02	004°50.03'	57°30.00'	78.7	8.0
HE619	20	14.05.23	07:51	004°39.99'	57°29.99'	78.6	11.0
HE619	21	14.05.23	09:59	004°30.01'	57°30.00'	75.5	13.0
HE619	22	14.05.23	11:36	004°20.07'	57°29.89'	74.5	11.0
HE619	23	14.05.23	13:40	004°10.03'	57°29.99'	72.9	12.5
HE619	25	15.05.23	03:56	004°40.05'	56°40.01'	57.4	10.5
HE619	26	15.05.23	05:52	004°49.96'	56°40.02'	58.1	13.5

11.2 Plankton Net (APSTEIN Net)

Table 11.2 List and detailed protocols of the plankton samples taken with the APSTEIN NET at the different stations.

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Sample Depth	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[m]	
HE619	01	11.05.23	06:07	004°40.01'	56°29.99'	63.9	5	Dinoflagellata (high abundance): *Protoperidinium* sp., *Ceratium* sp.; Crustacea: *Vettoria* sp. (Copepoda)
HE619	02	11.05.23	08:05	004°30.03'	56°29.99'	65.5	5	Dinoflagellata (high abundance): *Ceratium* sp., *Protoperidinium* sp.; Diatoms: *Bacillariophyceae centrales / pennales*; Haptophyta: *Phaeocystis globosa* (Prymnesiomonada) (very high abundance)
HE619	03	11.05.23	10:15	004°20.03'	56°30.01'	69.6	5	Haptophyta: *Phaeocystis globosa* (Prymnesiomonada) (very high abundance); Dinoflagellata: *Ceratium tripos, Dissodinium pseudolunula*; Diatoms: *Chaetoceros debilis* (high abundance), *Bacillariophyceaea pennales, Chaetoceros affinis*
HE619	04	11.05.23	12:35	004°10.04'	56°30.01'	68.4	5	Diatoms: *Chaetoceros debilis, Leptocylindrus minimus, Thalassiosira rotula, Guinardia delicatula* (Bacillariophyceae - high abundance); Dinoflagellata: *Ceratium tripos*; Haptophyta: *Phaeocystis globosa* (Prymnesiomonada) (very high abundance)
HE619	05	11.05.23	14:42	004°09.94'	56°40.01'	49.0	5	Dinoflagellata: *Protoperidinium* sp., *Ceratium fusus, Ceratium massiliense;* Diatoms: *Chaetoceros debilis;* Haptophyta*: Phaeocystis globosa* (very high abundance); Cnidaria sp.; piece of plastic cord in sample
HE619	07	12.05.23	06:05	004°49.97'	56°50.00'	60.5	6	Crustacea: *Decapoda* sp., *Copepoda* sp., *Cladocera* sp.; *Dinoflagellata* sp.; Echinoidea: *Spatangus* sp. *pluteus*; Haptophyta: *Phaeocystis globosa*
HE619	08	12.05.23	08:05	004°39.99'	56°50.01'	60.0	6	Crustacea: *Pagurus bernhardus* (Pleocyemata); Echinoidea: *Spatangus* sp. *pluteus*; Haptophyta: *Phaeocystis globosa*; generally: high amount of phytoplankton
HE619	09	12.05.23	10:22	004°30.00'	56°49.97'	58.4	14	Echinoidea: *Spatangus* sp. *pluteus* (very high abundance); Crustacea: *Copepoda* sp., *Cladocera* sp.
HE619	10	12.05.23	12:14	004°19.98'	56°49.96'	55.0	12	Crustacea: *Decapoda* sp., *Copepoda* sp., *Cirripedia* sp.; Echinoidea: *Spatangus* sp. *pluteus* (very high abundance); Haptophyta: *Phaeocystis globosa*
HE619	11	12.05.23	14:07	004°10.01'	56°49.95'	51.5	8	Echinoidea: *Spatangus* sp. *pluteus* (very high abundance); Diatoms: *Bacillariophyceaea pennales;* Haptophyta: *Prymnesiomonada* sp., *Prasinophyceae* sp.
HE619	13	13.05.23	06:12	004°50.02'	57°15.00'	49.5	5	Echinoidea: *Spatangus* sp. *pluteus* (very high abundance); Crustacea: *Calocalanus* sp. (Copepoda) (very high abundance); Diatoms: *Thalassiosira nordenskioeldii* (very high abundance); Haptophyta: *Phaeocystis globosa* (rare)
HE619	14	13.05.23	08:07	004°40.01'	57°14.99'	55.0	5	Echinoidea: *Spatangus* sp. *pluteus* (high abundance); Diatoms: *Thalassiosira rotula, Thalassiosira* sp. (very high abundance); Crustacea: *Calocalanus* sp. (high abundance); Dinoflagellata: *Ceratium tripos* (rare); Chlorophyta: *Halosphaera* sp.
HE619	15	13.05.23	10:17	004°29.99'	57°14.98'	55.4	5	Crustacea: *Calanus* sp.; Echinoidea: *Spatangus* sp.; Diatoms: *Thalassiosira constricta*; Dinoflagellata: *Ceratiums tripos;* Chlorophyta: *Halosphaera* sp.; generally: small amount of plankton, no dominant species recognizable

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Sample Depth	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[m]	
HE619	16	13.05.23	12:15	004°20.00'	57°14.99'	59.0	5	Echinoidea: *Spatangus* sp. (very high abundance); Crustacea: *Calocalanus* sp. (very high abundance); Dinoflagellata: *Ceratium tripos*; Diatoms: *Chaetoceras* sp.
HE619	17	13.05.23	14:19	004°10.01'	57°14.99'	59.6	5	Echinoidea: *Spatangus* sp. (very high abundance); Crustacea: *Calocalanus* sp., *Calanus* sp. (very high abundance); Chlorophyta: *Halosphaera* sp.; Diatoms: *Proboscia alata*
HE619	19	14.05.23	06:06	004°50.03'	57°30.00'	78.7	5	Dinoflagellata: *Ceratium tripos, Ceratium concilians, Gonyaulax polygramma*; Diatoms: *Thalassiosira rotula, Eucampia zodiacus, Odontella sinensis*
HE619	20	14.05.23	07:54	004°39.99'	57°29.99'	78.6	5	Diatoms: *Thalassiosira rotula, Eucampia zodiacus* (high abundance), *Odontella sinensis;* Dinoflagellata: *Ceratium horridum;* Chlorophyta: *Halosphaera* sp.; Crustacea: *Calanoida* sp., *Oithona helgolandica* (Copepoda); Haptophyta: *Phaeocystis globosa*
HE619	21	14.05.23	10:02	004°30.01'	57°30.00'	75.5	5	Dinoflagellata: *Ceratium concilians*; Crustacea: *Oithona helgolandica, Copepoda* sp.; Diatoms: *Thalassiosira rotula, Odontella sinensis, Coscinodiscus concinnus;* Echinoidea: *Echinopluteus*
HE619	22	14.05.23	11:39	004°20.07'	57°29.89'	74.5	5	Diatoms: *Odontella sinensis, Eucampia zodiacus, Leptocylindrus* sp.; Chlorophyta: *Halosphaera* sp.; Crustacea: *Calanoida* sp.; Dinoflagellata: *Ceratium concillians*
HE619	23	14.05.23	13:44	004°10.03'	57°29.99'	72.9	5	Chlorophyta: *Halosphaera* sp.; Diatoms: *Eucampia zodiacus, Chaetocerus protuberans, Nitzschia* cf. *longissima, Rhizosolenia imbricata*; Haptophyta: *Phaeocystis globosa*; Dinoflagellata: *Protoperidinium depressum, Ceratium horridum, Ceratium concilians*
HE619	25	15.05.23	03:58	004°40.05'	56°40.01'	57.4	5	Dinoflagellata: *Ceratium tripos, Protoperidinium* sp.; Crustacea: *Oncaea* sp. (Copepoda), Evadne nordmanni; Cnidaria: *Siphonula*; Mollusca: *Mytilus galloprovinciales*; Chlorophyta: *Halosphaera* sp.
HE619	26	15.05.23	05:56	004°49.96'	56°40.02'	58.1	5	Dinoflagellata: *Ceratium tripos* (high abundance); Diatoms: *Chaetoceros affinis;* Crustacea: *Evadne nordmanni* (male / female), *Calocalanus* sp., *Microsetella norvegica* (Copepoda); Rhizopoda: *Heliozoa*

11.3 CTD-Rosette

Table 11.3 List of sampled stations, depths sampled in the water column and amount of filtrated sample with the CTD-Rosette.

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Sample Depth	Filtrated Amount
		mm/dd/yyyy	[UTC]	[°E]	[°N]	[m]	[m]	[l]
HE619	_01	05/11/2023	06:11	004° 40.02' E	56° 30.00' N	65.0	62.0	10.0
HE619	_01	05/11/2023	06:11	004° 40.02' E	56° 30.00' N	65.0	3.0	8.0
HE619	_02	05/11/2023	08:08	004° 30.03' E	56° 29.99' N	66.4	61.3	8.0
HE619	_02	05/11/2023	08:08	004° 30.03' E	56° 29.99' N	66.4	5.0	6.0
HE619	_03	05/11/2023	10:21	004° 20.02' E	56° 30.02' N	70.5	65.0	8.0
HE619	_03	05/11/2023	10:21	004° 20.02' E	56° 30.02' N	70.5	5.0	6.0
HE619	_04	05/11/2023	12:52	004° 10.06' E	56° 30.01' N	69.3	65.9	8.0
HE619	_04	05/11/2023	12:52	004° 10.06' E	56° 30.01' N	69.3	5.0	6.0
HE619	_05	05/11/2023	14:04	004° 09.95' E	56° 40.00' N	49.6	46.4	9.0
HE619	_05	05/11/2023	14:04	004° 09.95' E	56° 40.00' N	49.6	5.0	6.0
HE619	_07	05/12/2023	06:20	004° 50.01' E	56° 50.01' N	60.0	57.0	10.0
HE619	_07	05/12/2023	06:20	004° 50.01' E	56° 50.01' N	60.0	5.0	4.0
HE619	_08	05/12/2023	8:06	004° 39.94' E	56° 50.01' N	58.0	54.4	12.0
HE619	_08	05/12/2023	8:06	004° 39.94' E	56° 50.01' N	58.0	5.0	6.0
HE619	_09	05/12/2023	10:34	004° 29.97' E	56° 48.98' N	58.2	54.4	7.0
HE619	_09	05/12/2023	10:34	004° 29.97' E	56° 48.98' N	58.2	5.0	9.0
HE619	_10	05/12/2023	12:30	004° 19.98' E	56° 48.98' N	54.8	48.4	3.0
HE619	_10	05/12/2023	12:30	004° 19.98' E	56° 48.98' N	54.8	5.0	9.0
HE619	_11	05/12/2023	14:14	004° 09.99' E	56° 49.99' N	51.6	44.3	3.0
HE619	_11	05/12/2023	14:14	004° 09.99' E	56° 49.99' N	51.6	5.0	8.0
HE619	_13	05/13/2023	06:15	004°50.01' E	57°14.99' N	53.3	5.0	3.0
HE619	_13	05/13/2023	06:15	004°50.01' E	57°14.99' N	53.3	49.3	3.0
HE619	_14	05/13/2023	08:25	004°40.00' E	57°15.00' N	58.3	5.0	4.0
HE619	_14	05/13/2023	08:25	004°40.00' E	57°15.00' N	58.3	54.3	3.0

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Sample Depth	Filtrated Amount
		mm/dd/yyyy	[UTC]	[°E]	[°N]	[m]	[m]	[l]
HE619	_15	05/13/2023	10:25	004°30.04 E	57°14.92' N	58.7	5.0	5.0
HE619	_15	05/13/2023	10:25	004°30.04 E	57°14.92' N	58.7	50.0	1.4
HE619	_16	05/13/2023	12:20	004°20.02' E	57°14.98' N	61.9	5.0	9.0
HE619	_16	05/13/2023	12:20	004°20.02' E	57°14.98' N	61.9	53.0	1.5
HE619	_17	05/13/2023	14:25	004°10.02' E	57°14.98' N	58.1	5.0	7.0
HE619	_17	05/13/2023	14:25	004°10.02' E	57°14.98' N	58.1	54.0	2.0
HE619	_19	05/14/2023	06:30	004°50.02' E	57°30.00'N	78.5	5.0	9.0
HE619	_19	05/14/2023	06:30	004°50.02' E	57°30.00'N	78.5	73.0	7.0
HE619	_20	05/14/2023	08:03	004°39.95'E	57°30.01'N	78.6	5.0	8.0
HE619	_20	05/14/2023	08:03	004°39.95'E	57°30.01'N	78.6	73.0	9.5
HE619	_21	05/14/2023	10:08	004°30.01'E	57°30.00'N	75.7	5.0	6.0
HE619	_21	05/14/2023	10:08	004°30.01'E	57°30.00'N	75.7	70.0	8.0
HE619	_22	05/14/2023	11:40	004°20.02'E	57°30.00'N	74.8	5.0	8.0
HE619	_22	05/14/2023	11:40	004°20.02'E	57°30.00'N	74.8	70.0	10.0
HE619	_23	05/14/2023	13:45	004°10.03'E	57°29.99'N	73.0	5.0	8.0
HE619	_23	05/14/2023	13:45	004°10.03'E	57°29.99'N	73.0	68.0	6.0
HE619	_25	05/15/2023	04:05	004° 40.03' E	56° 40.01' N	57.0	5.0	6.0
HE619	_25	05/15/2023	04:05	004° 40.03' E	56° 40.01' N	57.0	53.0	10.0
HE619	_26	05/15/2023	06:00	004° 49.96' E	56° 40.02' N	58.1	5.0	6.0
HE619	_26	05/15/2023	06:00	004° 49.96' E	56° 40.02' N	58.1	52.0	10.0

11.4 Bottom Water Sampler

Table 11.4 List of the location of stations and sampled depth above the seafloor from the BWS.

Cruise	Station	Date	Time	Longitude	Latitude	Waterdepth	Depth above Seafloor	Filtrated Amount
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[cm]	[l]
HE619	_01	11.05.23	6:35	004°40.01'	56°29.99'	63.9	28.5	4.0
HE619	_01	11.05.23	6:35	004°40.01'	56°29.99'	63.9	58.0	4.0
HE619	_01	11.05.23	6:35	004°40.01'	56°29.99'	63.9	110.5	4.0
HE619	_02	11.05.23	8:28	004°30.04'	56°29.99'	65.5	28.5	4.0
HE619	_02	11.05.23	8:28	004°30.04'	56°29.99'	65.5	58.0	5.0
HE619	_02	11.05.23	8:28	004°30.04'	56°29.99'	65.5	110.5	5.0
HE619	_03	11.05.23	10:37	004°20.03'	56°30.01'	69.6	28.5	5.0
HE619	_03	11.05.23	10:37	004°20.03'	56°30.01'	69.6	58.0	5.0
HE619	_03	11.05.23	10:37	004°20.03'	56°30.01'	69.6	110.5	5.0
HE619	_04	11.05.23	12:45	004°10.03'	56°29.99'	68.3	28.5	5.0
HE619	_04	11.05.23	12:45	004°10.03'	56°29.99'	68.3	58.0	5.0
HE619	_04	11.05.23	12:45	004°10.03'	56°29.99'	68.3	110.5	5.0
HE619	_05	11.05.23	15:01	004°09.97'	56°40.00'	49.0	28.5	4.0
HE619	_05	11.05.23	15:01	004°09.97'	56°40.00'	49.0	58.0	5.0
HE619	_05	11.05.23	15:01	004°09.97'	56°40.00'	49.0	110.5	5.0
HE619	_07	12.05.23	6:30	004°49.97'	56°50.01'	63.6	28.5	5.0
HE619	_07	12.05.23	6:30	004°49.97'	56°50.01'	63.6	58.0	5.0
HE619	_07	12.05.23	6:30	004°49.97'	56°50.01'	63.6	110.5	5.0
HE619	_08	12.05.23	8:35	004°40.02'	56°50.00'	62.9	58.0	5.0
HE619	_08	12.05.23	8:35	004°40.02'	56°50.00'	62.9	110.5	5.0
HE619	_09	12.05.23	10:35	004°29.97'	56°49.98'	61.4	28.5	4.0
HE619	_09	12.05.23	10:35	004°29.97'	56°49.98'	61.4	58.0	5.0
HE619	_09	12.05.23	10:35	004°29.97'	56°49.98'	61.4	110.5	5.0

Cruise	Station	Date	Time	Longitude	Latitude	Waterdepth	Depth above Seafloor	Filtrated Amount
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[cm]	[l]
HE619	_10	12.05.23	12:34	004°20.02'	56°49.97'	57.9	28.5	1.5
HE619	_10	12.05.23	12:34	004°20.02'	56°49.97'	57.9	58.0	2.0
HE619	_10	12.05.23	12:34	004°20.02'	56°49.97'	57.9	110.5	1.5
HE619	_11	12.05.23	14:40	004°10.05'	56°49.96'	54.7	28.5	2.0
HE619	_11	12.05.23	14:40	004°10.05'	56°49.96'	54.7	58.0	2.0
HE619	_11	12.05.23	14:40	004°10.05'	56°49.96'	54.7	110.5	2.0
HE619	_13	13.05.23	6:10	004° 50.00'	57° 14.99'	50.4	28.5	2.0
HE619	_13	13.05.23	6:10	004° 50.00'	57° 14.99'	50.4	58.0	2.5
HE619	_13	13.05.23	6:10	004° 50.00'	57° 14.99'	50.4	110.5	2.5
HE619	_14	13.05.23	8:25	004° 40.00'	57° 15.00'	55.6	28.5	2.7
HE619	_14	13.05.23	8:25	004° 40.00'	57° 15.00'	55.6	58.0	3.2
HE619	_14	13.05.23	8:25	004° 40.00'	57° 15.00'	55.6	110.5	2.9
HE619	_15	13.05.23	10:30	004° 30.01'	57° 14.97'	55.4	28.5	1.0
HE619	_15	13.05.23	10:30	004° 30.01'	57° 14.97'	55.4	58.0	1.4
HE619	_15	13.05.23	10:30	004° 30.01'	57° 14.97'	55.4	110.5	1.3
HE619	_16	13.05.23	12:58	004° 20.02'	57° 14.99'	59.1	28.5	0.9
HE619	_16	13.05.23	12:58	004° 20.02'	57° 14.99'	59.1	58.0	1.0
HE619	_16	13.05.23	12:58	004° 20.02'	57° 14.99'	59.1	110.5	1.1
HE619	_17	13.05.23	14:35	004° 10.04'	57° 14.97'	59.4	28.5	1.5
HE619	_17	13.05.23	14:35	004° 10.04'	57° 14.97'	59.4	58.0	1.9
HE619	_17	13.05.23	14:35	004° 10.04'	57° 14.97'	59.4	110.5	1.9
HE619	_19	14.05.23	6:40	004°50.01'	57° 29.99'	78.9	28.5	4.0
HE619	_19	14.05.23	6:40	004°50.01'	57° 29.99'	78.9	58.0	5.0
HE619	_19	14.05.23	6:40	004°50.01'	57° 29.99'	78.9	110.5	5.0
HE619	_20	14.05.23	8:20	004°39.97'	57° 29.99'	79.0	28.5	5.0
HE619	_20	14.05.23	8:20	004°39.97'	57° 29.99'	79.0	58.0	6.0

Cruise	Station	Date	Time	Longitude	Latitude	Waterdepth	Depth above Seafloor	Filtrated Amount
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[cm]	[l]
HE619	_20	14.05.23	8:20	004°39.97'	57° 29.99'	79.0	110.5	6.0
HE619	_21	14.05.23	10:11	004° 30.02'	57° 30.00'	75.5	28.5	5.0
HE619	_21	14.05.23	10:11	004° 30.02'	57° 30.00'	75.5	58.0	5.5
HE619	_21	14.05.23	10:11	004° 30.02'	57° 30.00'	75.5	110.5	5.5
HE619	_22	14.05.23	11:50	004° 19.98'	57° 30.01'	74.6	28.5	4.0
HE619	_22	14.05.23	11:50	004° 19.98'	57° 30.01'	74.6	58.0	5.0
HE619	_22	14.05.23	11:50	004° 19.98'	57° 30.01'	74.6	110.5	5.0
HE619	_23	14.05.23	13:55	004° 10.07'	57° 30.04'	73.0	28.5	3.5
HE619	_23	14.05.23	13:55	004° 10.07'	57° 30.04'	73.0	58.0	4.0
HE619	_23	14.05.23	13:55	004° 10.07'	57° 30.04'	73.0	110.5	5.0
HE619	_25	15.05.23	04:15	004° 40.04'	56° 40.01'	57.3	28.5	4.0
HE619	_25	15.05.23	04:15	004° 40.04'	56° 40.01'	57.3	58.0	5.0
HE619	_25	15.05.23	04:15	004° 40.04'	56° 40.01'	57.3	110.5	5.0
HE619	_26	15.05.23	06:10	004° 49.96'	56° 40.03'	58.1	28.5	5.0
HE619	_26	15.05.23	06:10	004° 49.96'	56° 40.03'	58.1	58.0	5.0
HE619	_26	15.05.23	06:10	004° 49.96'	56° 40.03'	58.1	110.5	5.0

11.5 Van Veen Grab and Sediment Permeability

Table 11.5 List and protocols of the sediment samples from the VAN VEEN GRAB and the permeability. Sediment colours were determined with the MUNSELL Color Chart. Key for Grain size: 1=clay, 2=fine silt, 3=coarse silt, 4=fine sand, 5=middle sand, 6=coarse sand, 7=gravel/rubble.

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Grain size	Permeability	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]		[cm/s]	
HE619	1	11.05.23	6:00	004°40.01'	56°29.99'	60.8	4	0.00009	Homogeneous, contains shell fragments (up to 3 cm), echinodermata fragments, small worms, upper 1-2 cm differ in colour (5Y 5/2, light olive grey) from lower area, which is punctuated by reduction spots (5GY 3/2).
HE619	2	11.05.23	8:00	004°30.03'	56°29.99'	65.5	3-4	0.00229	Cohesive (mouldable), shells and shell fragments, scaphopods, burrows, upper 2 cm differ in colour (5Y 5/2) from lower area with dark reduction spots (darker area: 5G 3/2, lighter area: 5GY 3/2).
HE619	3	11.05.23	10:10	004°20.03'	56°30.01'	69.6	3-4	0.00345	Homogeneous material, echinodermata, large bivalves (preserved in one piece, Cardiidae), worms (Annelida), burrows, upper 2 cm differ in colour (7.5Y 4/3) from lower area (5GY 3/1), lower part is marked by reduction spots (7.5GY 3/1), partly black (N2/) with sulphur odour.
HE619	4	11.05.23	11:35	004°10.04'	56°30.01'	68.4	4-5	0.00138	Homogeneous, not as cohesive as previously, burrows, small worms, many fragments (bivalves, Echinodermata, Scaphopoda, bivalves even preserved in two valves and filled in with sediment), upper 2 cm (5Y 4/3) differ in colour from lower area (5BG 3/2) which has reduction spots.
HE619	5	11.05.23	14:45	004°09.94'	56°40.01'	49.0	5.0	0.03446	Upper 1-2 cm medium sand, no silt, non-cohesive, colour 2.5Y 4/4, homogeneous; below: Shell layer several cm thick, very large to small shells and fragments (Cardiidae) aligned in one layer; below: intense reduction, sulphur smell, cohesive, slightly silty, fine sand, dark colours: 10Y 3/2, 10Y 2/1, contains large components (gravel) which are presumably dropstones (reddish colour).
HE619	7	05.12.23	6:40	004°49.97'	56°50.00'	60.5	4-5	0.00372	Contains shell fragments (up to 3 cm) and worms (small, filamentous) in lower part; gastropoda fragments (large, ca. 5 cm); few worm cases/echinodermata needles; surface colour: 10Y 6/2, up to ca. 1-2 cm; substrate (lower part): 5Y 4/1, slightly anoxic.
HE619	8	05.12.23	8:38	004°39.99'	56°50.01'	60.0	4-5	0.00913	Shells, gastropods, worms, echinoid needles, lower layer contains organic matter; colours: upper layer 5Y 4/2, lower layer 7.5Y 3/2.
HE619	9	05.12.23	10:51	004°29.97'	56°49.98'	58.2	3-4	0.00902	Echinoids, shell fragments, asteroidea, snails, worms; colours: top 2.5Y 3/3, bottom 7.5Y 3/2.
HE619	10	05.12.23	12:45	004°19.97'	56°49.97'	55.0	4-5	0.00646	Shell fragments, various worms, echinoids, worm burrows, bioturbation burrows darker than lower layer (anoxic?); colours: top (ca. 0-5 cm): 10Y 5/2, bottom (5cm-end): 7.5Y 4/1.
HE619	11	05.12.23	14:35	004°10.01'	56°49.99'	51.5	4	0.05972	Homogeneous sediment, respectively little to no difference between upper and lower layer; echinoids and worm burrows, high water saturation, burrows dark (anoxic?), shell fragments; colour: 5Y 4/2.
HE619	13	13.05.23	6:50	004°50.02'	57°15.00'	49.7	5	0.26568	homogeneous, no stratification, completely oxic sediment, occasionally small shell fragments, colour: 10YR 6/4.

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Grain size	Permeability	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]		[cm/s]	
HE619	14	13.05.23	8:40	004°39.94'	57°14.98'	55.0	4-5	0.00954	Upper layer: oxic, living echinoid, shell fragments, colour: 2.5Y 4/4; lower layer: darker, complete shells and fragments, colour: 5Y 3/2, dark lenses under large shells, colour: 10D 2/1; overall finer than station 13.
HE619	15	13.05.23	10:45	004°30.00'	57°14.98'	55.4	4	0.02118	Upper layer: small, thin worms or burrows, colour: 2.5Y 4/4; lower layer: colour: 5Y 5/2; small bivalves in the entire sediment.
HE619	16	13.05.23	13:10	004°20.00'	57°14.99'	59.0	4	0.01982	upper layer: very thin, colour: 2.5Y 4/4, small thin worm burrows; lower layer: dark stained, colour: 5Y 3/2, stains colour: 7.5Y 2/1.
HE619	17	13.05.23	14:30	004°10.01'	57°14.98'	59.9	4-5	0.01075	Upper layer: colour: 5Y 4/3, echinoid and shell fragments; lower layer: 10Y 3/2, shell fragments.
HE619	19	14.05.23	7:00	004°50.03´	57°30.00´	60.5	6	0.00071	very coarse-grained, upper lighter area: 2.5Y 4/3, with shell fragments, worms, bioturbation
HE619	20	14.05.23	8:40	004°39.99´	57°29.99´	78.6	>6, 7	0.00198	very coarse-grained and pebbly, shells and schill, bed-load material, lighter upper layer: 5YR 4/3; lower slightly darker layer: 5Y 3/2; Two attempts with vVG necessary, as grab could not close on 1st try due to large gravel.
HE619	21	14.05.23	10:00	004°30.01´	57°30.00´	75.7	>6, 7	3.60127	Gravelly throughout, overall appearance colour: 10YR 4/4, shell fragments.
HE619	22	14.05.23	12:00	004°20.07´	57°29.89´	74.5	5-6	0.07392	homogeneous, occasionally shell fragments, unicoloured: 10YR 4/4.
HE619	23	14.05.23	14:00	004°10.03´	57°29.99´	72.9	5-6	0.27329	uniform colouration 10YR 4/3, occasionally darker spots (5Y 3/2), some shell fragments, worms and echinoids.
HE619	25	15.05.23	4:25	004°40.04'	56°40.04'	57.3	3-5	0.00175	upper layer (1-2 cm): light fine/medium sand, colour 5Y 4/2; lower layer: fine sand - silt, reductive conditions, partly stained, strong smell of sulphur, colour 10Y 3/2; shells mostly preserved in one piece, tubeworms, worm burrows, worms, partly decomposed shell residues.
HE619	26	15.05.23	6:20	004°49.96'	56°40.02'	58.1	3-4	0.00168	many thin worms (on the surface), shells (especially fragments); colour (upper 2 cm): 2.5Y 2/3; lower part: slightly finer than upper part, cohesive, darker, reduction, smell of sulphur, colour: 7.5Y 3/2.

11.6 Multicorer

Table 11.6 List and protocols of the sediment samples taken with the OCTOPUS MUC. Sediment colours were determined with the MUNSELL Color Chart. Key for Grain size: 1=clay, 2=fine silt, 3=coarse silt, 4=fine sand, 5=middle sand, 6=coarse sand, 7=gravel/rubble.

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Sample Depth	Penetration depth	Grain size	Description
		dd/mm/yyyy	[UTC]	[°E]	[°N]	[m]	[cm]	[m]		
HE-619	1	11/05/2023	7:03	004°40.00'	56°29.99'	64	0-3	0.15	4-5	Colour: 2.5Y 4/3, orange-brown.
HE-619	1	11/05/2023	7:03	004°40.00'	56°29.99'	64	3-15	0.15	4-5	Colour: 5Y 4/1, shell fragments, worm, dark stains colour: 5Y 2/1.
HE-619	2	11/05/2023	8:45	004°30.04'	56°29.99'	65.5	0-3	0.15	4	Colour: 2.5Y 4/3, orange-brown.
HE-619	2	11/05/2023	8:45	004°30.04'	56°29.99'	65.5	3-15	0.15	4	Colour: 5Y 4/1, shell fragments, worm, dark stains colour: 5Y 2/1.
HE-619	3	11/05/2023	10:55	004°20.04'	56°30.02'	69.6	0-3	0.13	2, 4	Colour: 2.5Y 4/3, occasionally dark grey stains.
HE-619	3	11/05/2023	10:55	004°20.04'	56°30.02'	69.6	0-13	0.13	2, 4	Colour: 5Y 2/1 and 5Y 4/1 (bright grey).
HE-619	4	11/05/2023	13:10	004°10.06	56°30.00'	68.3	0-2	0.11	2, 4	Colour: 2.5Y 4/3, occasionally dark grey stains.
HE-619	4	11/05/2023	13:10	004°10.06	56°30.00'	68.3	2-11	0.11	2, 4	Colour: 5Y 2/1 and 5Y 4/1 (bright grey), echinoid, can be rolled out.
HE-619	5	11/05/2023	14:50	004°09.95'	56°39.99'	48.9	0-2	0.02	5-6	No detailed description and sampling possible, as core flowed away immediately. One sample of about 1-2 cm thickness preserved for the micropaleontological department; colour: 2.5Y 4/3, contains a lot of shill.
HE-619	7	12/05/2023	6:45	004°49.97'	56°50.01'	63.6	0-7	0.2	4-5	Colour: 5Y 5/4, clear boundary to layer below.
HE-619	7	12/05/2023	6:45	004°49.97'	56°50.01'	63.6	7-20	0.2	4-5	Colour: 5Y 3/1, shell fragments, dark stains.
HE-619	8	12/05/2023	8:40	004°39.98'	56°50.01'	62.9	0-6	0.18	2-4	Colour: 5Y 5/4.
HE-619	8	12/05/2023	8:40	004°39.98'	56°50.01'	62.9	6-18	0.18	2-4	Colour: 5Y 4/2, shells and gastropods in one piece, dark stains, finer sediment than at station 7.
HE-619	9	12/05/2023	10:45	004°29.99'	56°49.99'	58.4	0-7	0.1	4	Colour: 5Y 5/4.
HE-619	9	12/05/2023	10:45	004°29.99'	56°49.99'	58.4	7-10	0.1	4	Colour: 5Y 3/2, dark stains, living worm, shell fragments; only two cores with little sediment could be evacuated.
HE-619	10	12/05/2023	13:00	004°19.98'	56°49.99'	54.8	0-7	0.08	4	Colour: 5Y 5/3.
HE-619	10	12/05/2023	13:00	004°19.98'	56°49.99'	54.8	7-8	0.08	4	Colour: 2.5Y 4/2, transition between layers not clearly visible, worms; only one core evacuated, therefore no sampling for the micropalaeontological department.
HE-619	11	12/05/2023	15:00	004°09.98'	56°50.01'	51.5	0-7	0.07	4-5	Colour: 5Y 5/3, shell fragments and in one piece, shill.

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Sample Depth	Penetration depth	Grain size	Description
		dd/mm/yyyy	[UTC]	[°E]	[°N]	[m]	[cm]	[m]		
HE-619	13	05/13/2023	6:51	004°50.02'	57°14.99'	53.3	0-13	0.13	4-5	Colour: 10YR 4/6, shill layer with shell fragments, no further layering, homogeneous, very water-saturated.
HE-619	14	05/13/2023	8:45	004°40.01'	57°15.00'	55.5	0-11	0.13	5	Colour: 2.5Y 4/4, sandy, homogeneous, very porous and permeable.
HE-619	14	05/13/2023	8:45	004°40.01'	57°15.00'	55.5	11-13	0.13	5	Colour: 2.5Y 3/1, darker, contains organic matter, shell fragments, very porous and permeable.
HE-619	15	05/13/2023	10:45	004°30.00'	57°14.98'	55.4	0-9	0.14	4-5	Colour: 2.5Y 4/3, very permeable, homogeneous, high water-saturation.
HE-619	15	05/13/2023	10:45	004°30.00'	57°14.98'	55.4	9-14	0.14	4-5	Colour: 5Y 3/2, dark coloured, shells and shell fragments.
HE-619	16	05/13/2023	13:20	004°20.01'	57°14.99'	59	0-10	0.15	4-5	Colour: 2.5Y 4/4, very homogeneous.
HE-619	16	05/13/2023	13:20	004°20.01'	57°14.99'	59	10-15	0.15	4-5	Colour: 5Y 3/2, homogeneous, some shell fragments.
HE-619	17	05/13/2023	14:45	004°10.01'	57°14.98'	59.3	0-8	0.12	4-5	Colour: 5Y 4/3, shell fragments, echinoid.
HE-619	17	05/13/2023	14:45	004°10.01'	57°14.98'	59.3	8-12	0.12	4-5	Colour: 10Y 3/2, homogeneous, bioturbation, burrows.
HE-619	19	14/05/2023	6:40	004°50.03'	57°30.00'	81.5	-	-	-	MUC could not be run because seafloor was too gravelly; therefore only surface samples were taken from vVG; for sediment description see protocol vVG.
HE-619	20	14/05/2023	8:40	004°39.98'	57°29.99'	81.3	-	-	-	MUC could not be run because seafloor was too gravelly; therefore only surface samples were taken from vVG; for sediment description see protocol vVG.
HE-619	21	14/05/2023	10:45	004°30.02'	57°30.02'	75.5	-	-	-	MUC could not be run because seafloor was too gravelly; therefore only surface samples were taken from vVG; for sediment description see protocol vVG.
HE-619	22	14/05/2023	12:55	004°20.02'	57°30.00'	77.5	0-8	0.1	6	Colour: 10YR 4/4, no layering, shell fragments, organics/algae on sediment surface.
HE-619	23	14/05/2023	14:55	004°10.03'	57°29.99'	75.8	0-12	0.12	6	Colour coarse sand (main component of core): 10YR 4/4, organics/algae on sediment surface; lower part: ca. 3 cm with some darker, fine, cohesive material with sulphur smell, contains some sponge needles, colour: 10Y 5/1.
HE-619	25	15/05/2023	4:30	004°40.00'	56°40.01'	57.3	0-5	0.11	4-5	Colour: 5Y 4/2, shell fragments, tube sponges.
HE-619	25	15/05/2023	4:30	004°40.00'	56°40.01'	57.3	5-11	0.11	2-4	Colour: 10Y 3/2, bioturbation, sulphur smell.
HE-619	26	15/05/2023	6:20	004°49.96'	56°40.02'	58	0-3	0.16	4	Colour: 2.5Y 2/3, homogeneous, gradual transition to darker part.
HE-619	26	15/05/2023	6:20	004°49.96'	56°40.02'	58	3-16	0.16	4	Colour: 7.5Y 3/2, bioturbation, reduction stains, little shill.

11.7 Selected Pictures of Samples

(L. Kanzler)

Fig. 11.1 vVG samples from stations HE619-01 - HE619-09.

Fig. 11.2 vVG samples from stations HE619-10 - HE619-19.

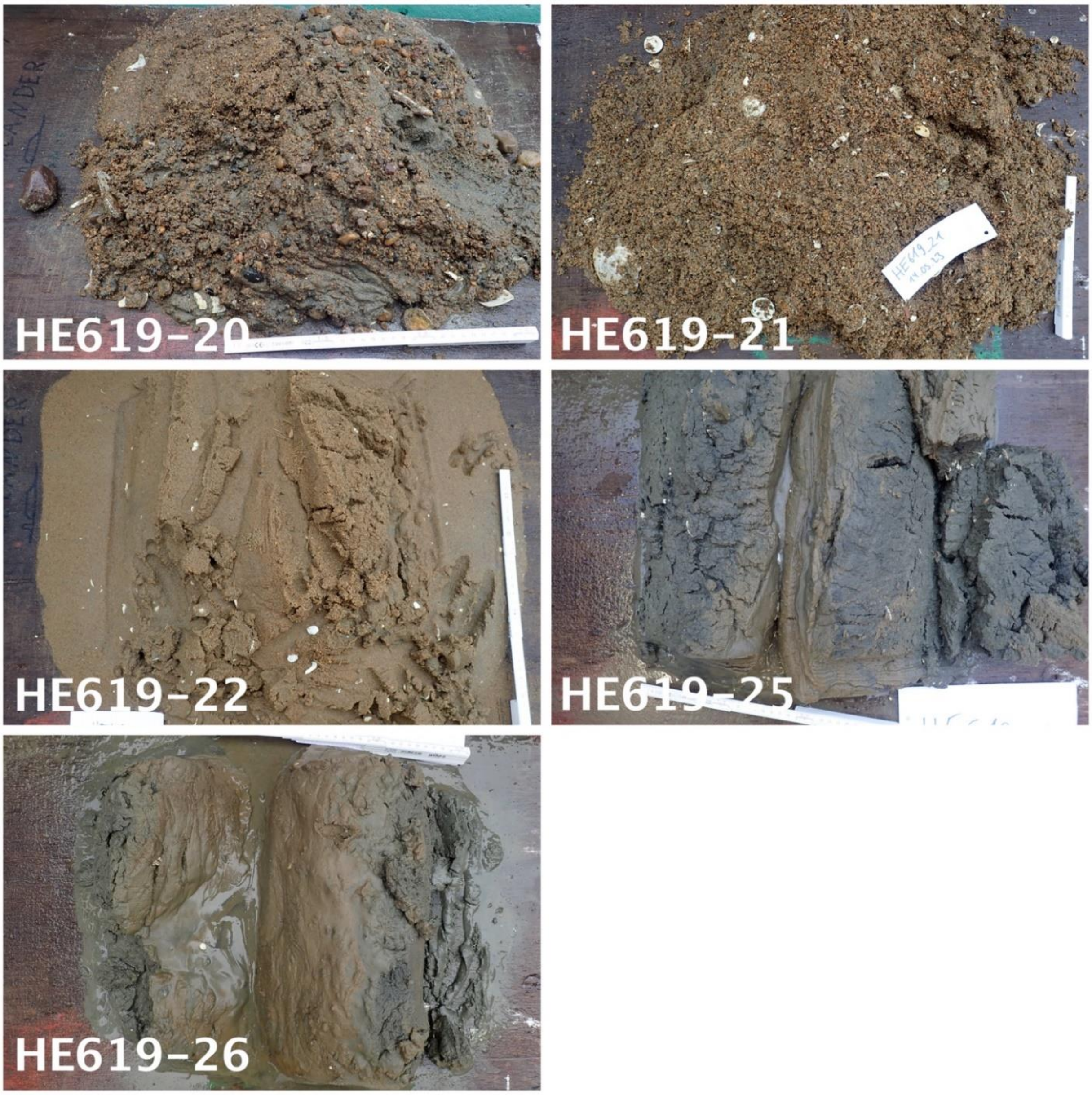

Fig. 11.3 vVG samples from stations HE619-20 - HE619-26.

Fig. 11.4 Sediment sample from the vVG for the permeability measurement at station 26.

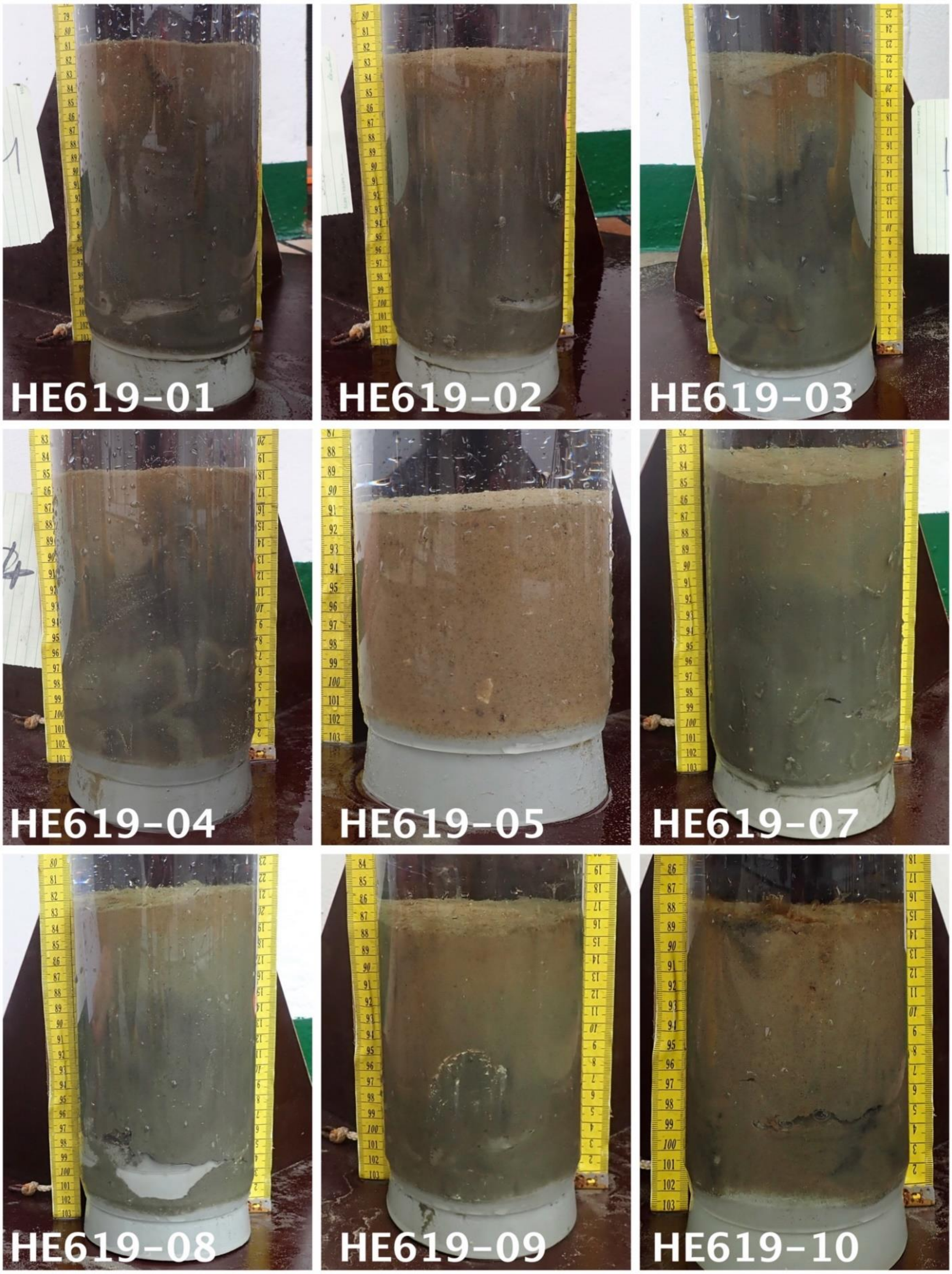

Fig. 11.5 MUC samples from stations HE619-01 - HE619-10.

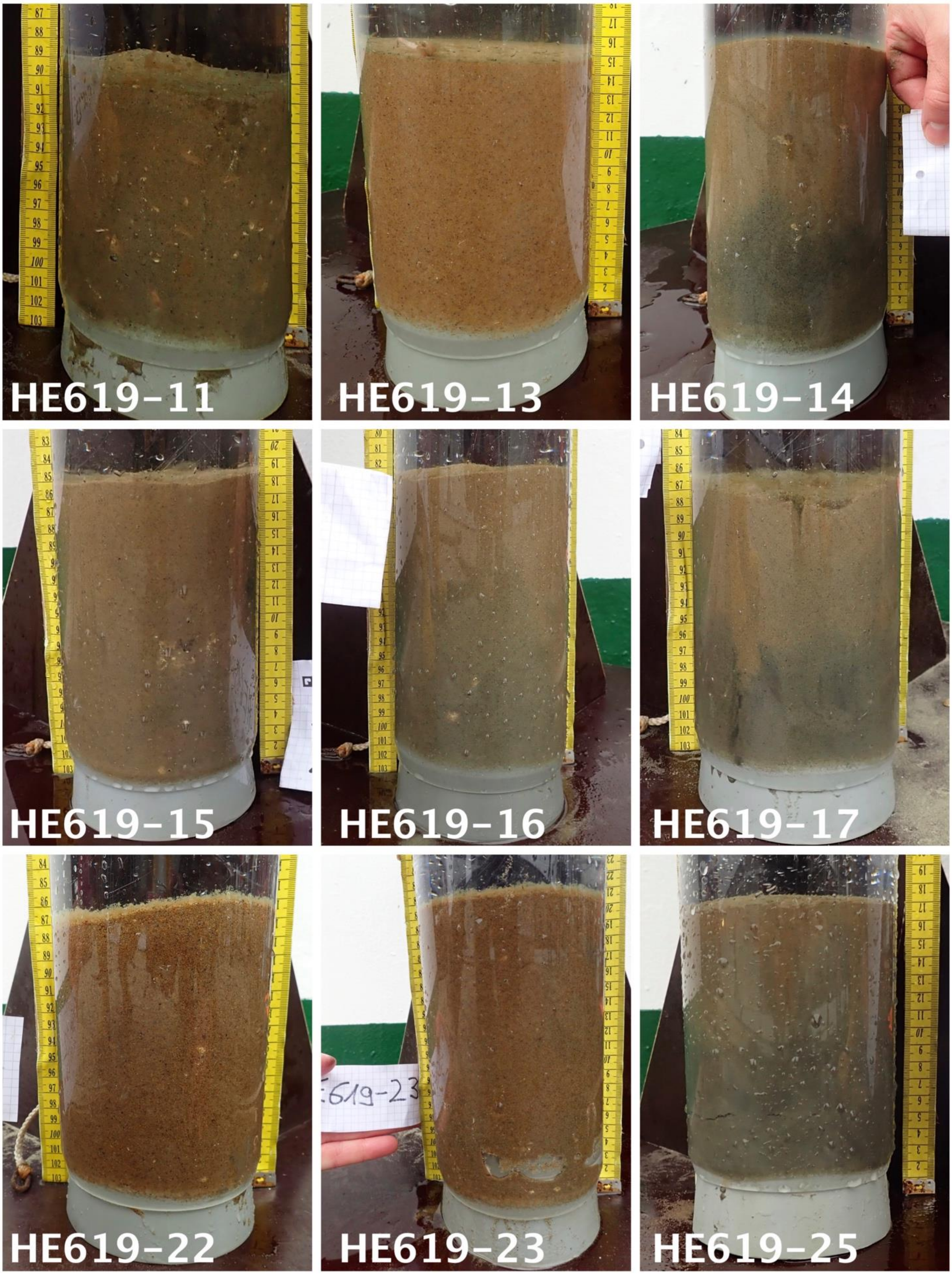

Fig. 11.6 MUC samples from stations HE619-11 - HE619-25.

Fig. 11.7 MUC sample from station HE619-26.

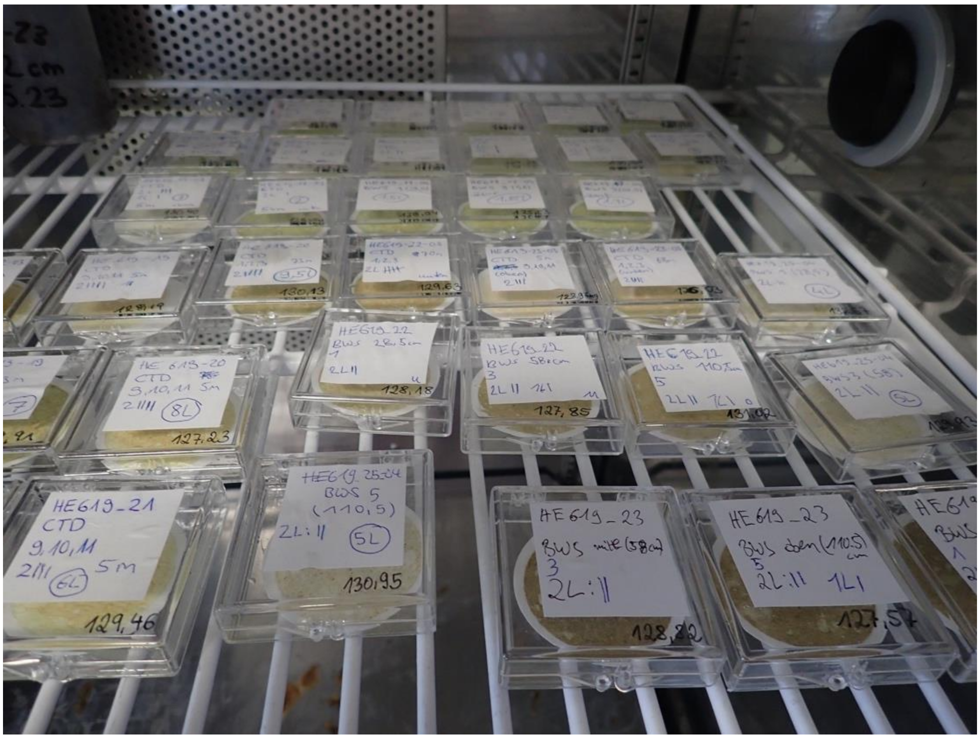

Fig. 11.8 Storage of filter samples in the fridge of the wet lab.

11.8 Selected Pictures of Shipboard Operations

(L. Kanzler)

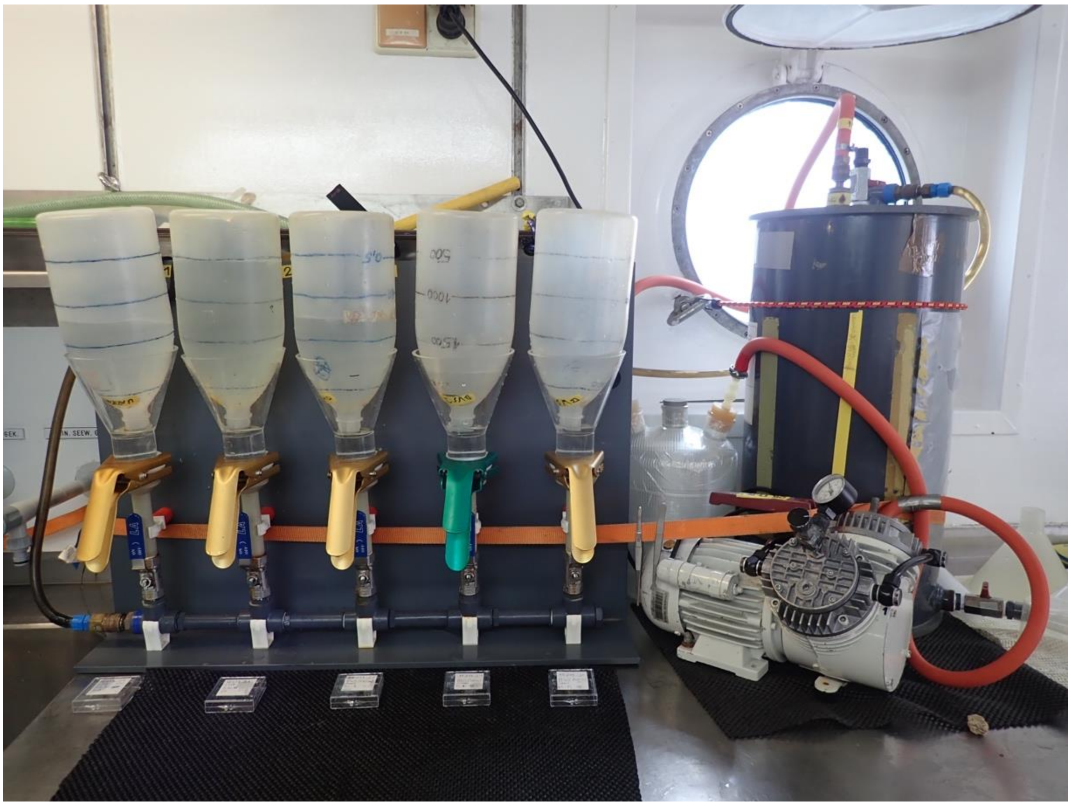

Fig. 11.9 Filtration unit in the wet lab on RV HEINCKE during cruise HE-619.

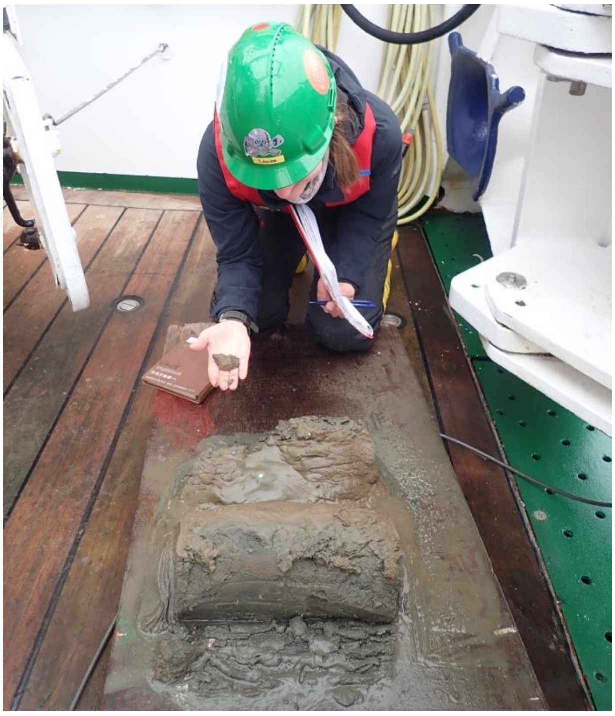

Fig. 11.10 Student examining and describing a sample from the vVG.

Fig. 11.11 Student taking a sample from the vVG for the permeability measurement.