HEINCKE-Berichte

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

Cruise No. HE639

May 8 – May 14, 2024

Bremerhaven (Germany) - Bremerhaven (Germany)

UHH MARGEO

Niko Lahajnar, Louisa Bollbuck, Georg Fehr, Hanna Firrincieli, Thomas Lüdmann, Marc Metzke, Constantin Mey, Jan Möller, Jan Penopp, Jasmin Pense, Cara Rausch, Patrick Schwoch, Lena Willmott

Niko Lahajnar

Institute for Geology, Universität Hamburg

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1 Cruise Summary

(J. Penopp)

1.1 Summary in English

The research cruise HE639 with the research vessel HEINCKE took place from May 8 to May 14, 2024. The starting and ending port was the trading port of Bremerhaven (Germany). All research activities were conducted within the Norwegian Exclusive Economic Zone (EEZ). The cruise was part of the Master's program in Geosciences as part of the course 63-345 "Marin-Geologisches Praktikum auf See". During the training cruise, nine students from the Universität Hamburg had the opportunity to gain insights into life and work on a research vessel. Various scientific methods in the fields of water, suspension, sediment sampling, and hydroacoustics were learned and applied during the cruise. The goal of the research cruise was not only practical work but also to better understand the North Sea from a biogeochemical and sedimentological perspective. Due to good weather conditions and sea states, all stations could be approached. The data recording of the ADCP did not function continuously due to technical problems. In total, 24 stations were sampled during the research cruise. All collected data and samples were handed over to various research groups at the Universität Hamburg for further analysis after the cruise.

1.2 Zusammenfassung

Die Forschungsfahrt HE639 mit dem Forschungsschiff HEINCKE fand vom 08. Bis zum 14. Mai 2024 statt. Start- und Endhafen war der Handelshafen Bremerhaven (Deutschland). Sämtliche Forschungsarbeiten wurden dabei in der Ausschließlichen Wirtschaftszone (AWZ) von Norwegen durchgeführt. Die Fahrt fand im Rahmen des Masterstudienganges Geowissenschaften als Teil der Lehrveranstaltung 63-345 „Marin-Geologisches Praktikum auf See" statt. Während der Ausbildungsfahrt hatten neun Studierende der Universität Hamburg die Möglichkeit Einblicke in das Leben und die Arbeit auf einem Forschungsschiff zu erhalten. Während der Fahrt wurden dafür verschiedene wissenschaftliche Arbeitsmethoden in den Bereichen der Wasser, Suspensions- und, Sedimentbeprobung sowie Hydroakustik erlernt und angewendet. Ziel der Forschungsfahrt war neben der praktischen Arbeit auch, die Nordsee aus biogeochemischer und sedimentologischer Betrachtung besser zu verstehen. Aufgrund der guten Wetterlage und den Seebedingungen konnten alle Stationen angefahren werden. Die Datenaufzeichnung des ADCP funktionierte in Folge von technischen Problemen nicht durchgängig. In Summe wurden während der Forschungsfahrt 24 Stationen beprobt. Sämtliche gewonnenen Daten und Proben wurden nach der Fahrt zur weiteren Analyse an verschiedene Arbeitsgruppen der Universität Hamburg übergeben.

2 Participants

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
Metzke, Marc	Technician	UHH, IfGeol
Bollbuck, Louisa	Student (M.Sc.)	UHH, IfGeol
Fehr, Georg	Student (M.Sc.)	UHH, IfGeol
Firrincieli, Hanna	Student (M.Sc.)	UHH, IfGeol
Mey, Constantin L.	Student (M.Sc.)	UHH, IfGeol
Möller, Jan C.	Student (M.Sc.)	UHH, IfGeol
Pense, Jasmin	Student (M.Sc.)	UHH, IfGeol
Rausch, Cara	Student (M.Sc.)	UHH, IfGeol
Schwoch, Patrick J.	Student (M.Sc.)	UHH, IfGeol
Willmott, Lena A.	Student (M.Sc.)	UHH, IfGeol

Fig. 2.1 Participants of HE639.

2.3 Participating Institutions

UHH, IfGeol Institute for Geology, Universität Hamburg

3 Research Program

(L. Willmott)

3.1 Description of the Work Area

The area investigated during Research Cruise 639 was located in the northern part of the North Sea south of Norway. All the stations were situated within the Norwegian exclusive economic zone (EEZ) between 56°00.00'N – 58°00.00'N and 02°00.00'E – 05°00.00'E (Fig. 3.1). Throughout all the sampling areas the sediments encountered were mostly of Pleistocene and Holocene age.

The North Sea is a shallow semi-enclosed shelf sea which is divided into a northern, central and southern part. It is surrounded by Norway, Sweden, Denmark, Germany, Netherlands, Belgium, France, and parts of Great Britain (England, Scotland). It has an average depth of 94 m however the southern part of the North Sea is not deeper than 50 m. The deepest area within the North Sea can be found within the Norwegian Trench with a depth of 700 m (Schwarze et al. 2019). It has two connections to the Atlantic Ocean, one in the south via the Dover Strait to the English Channel, and the other one in the north between Scotland and Norway. In addition to this, it is also connected to the Baltic Sea via Skagerrak and Kattegat in the east (Howarth 2001).

The basement rocks underlying the sediment basin of the North Sea is of Devonian age and has its origin in the Caledonian orogeny which took place through the Ordovician and ended in the upper period of the Silurian (420 – 390 Ma) (Balson 2002). After the orogeny, the Caledonides experienced erosion which led to an accumulation of mainly slate, clay and sandstone. These materials were then deposited east of Scotland and west of Norway. Several different tectonic processes occurred which resulted in a metamorphic solidification of those rocks (Schwarze et al. 2019). During the Carboniferous, the predecessor of the North Sea basin was situated close to the equator. There, the presence of tropic swamps led to widespread coal deposits in today's Great Britain, the southern North Sea and western Germany. Throughout the Late Carboniferous the Variscan Orogeny (300 – 290 Ma) led to great depositions of red Sandstone in parts of the North Sea. The Permian period was shaped by its intense volcanism which was a result of previous extension movement. These movements also led to the formation of Horst and Graben structures such as the Viking-Graben and the Central-Graben. The Mesozoic (251 – 65.5 Ma) was characterized by alternating shallow marine and terrestrial conditions as well as strong tectonic activity (Schwarze et al. 2019). By the end of the Triassic, fully marine conditions were then re-established in the southern North Sea (Balson et al. 2002). Throughout the Eocene the North Sea basin developed its current shape and was filled with shallow marine and siliciclastic deposits over time. The Pleistocene was characterized by several cold and warm periods. At the beginning of the last cold period, the Weichsel Ice Age, parts of the North Sea were dry. This changed throughout the Weichsel Ice Age and by the end of it, only the southern part of the North Sea was still mainland which connected Great Britain with Jutland. Due to the ending of the ice age, the sea level began to rise in the Holocene. This resulted in the flooding of the southern part of the North Sea which interrupted the land bridge from Great Britain to Jutland.

In the future, a continued increase in the sea level is to be expected due to the constantly changing conditions of the North Sea (Schwarze et al. 2019).

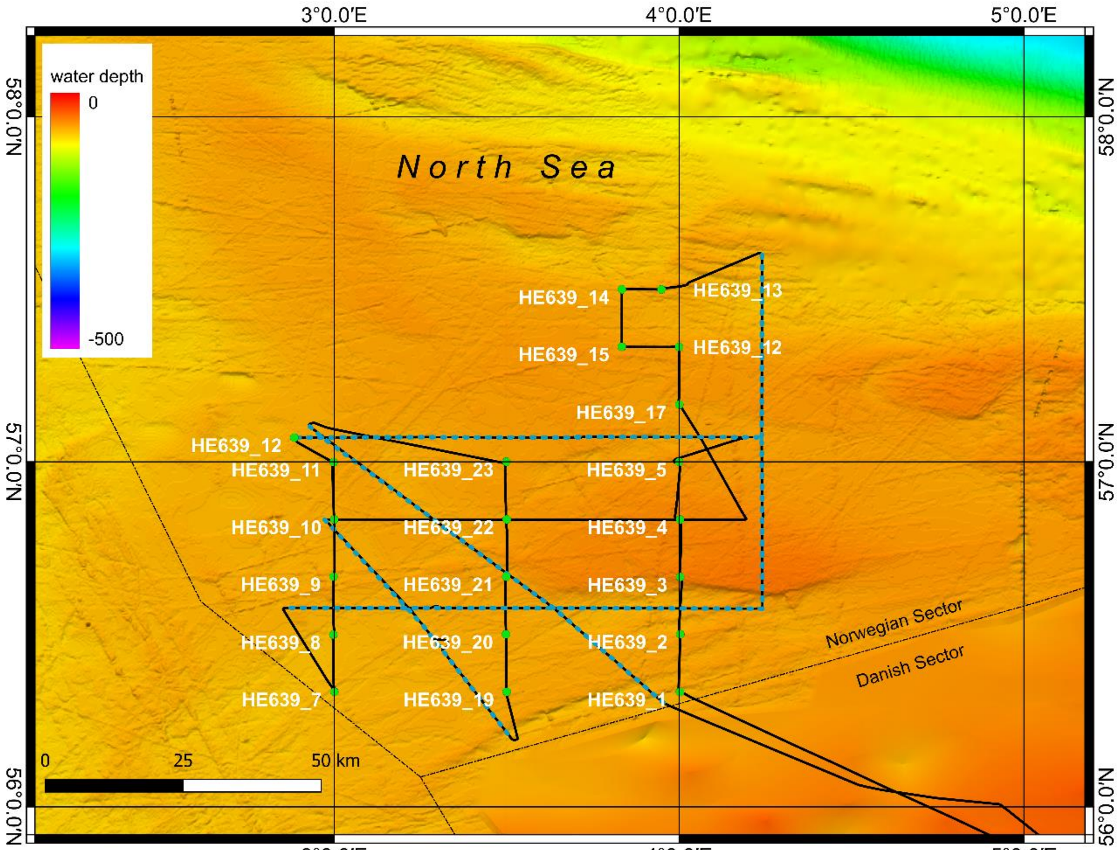

Fig. 3.1 Main working area of research cruise HE639 with the sampling Stations (green), the route of the cruise (black lines) and the night time hydroacoustics (blue lines) shown. Map created with Q-GIS.

3.2 Aims of the Cruise

The purpose of this research cruise was to introduce the students to new marine sampling methods and procedures. The focus of the research cruise was on marine geology as well as biogeochemistry, where the students were able to use their previously gained knowledge in a practical setting. This was done with the collection and examination of water and sediment samples and with the usage of hydroacoustic devices which created images of the marine geological structures. Since the groups were each responsible for a certain device for several stations, the students gained experience on how to operate them and document their results independently and safely. In the evenings a seminar was held where the students learned nautical terminology, knots and held scientific presentations with discussions to expand their knowledge relating to different topics about the North Sea. Apart from learning different knots and vocabulary, the students experienced the routines on a research vessel and the work that goes into a successful cruise like the HE639.

3.3 Agenda of the Cruise

Research Cruise 639 started Wednesday morning May 8, 2024, with nine M.Sc. students from the Universität Hamburg. The day started off after the vessel left Bremerhaven, with a safety briefing carried out by the 2nd Officer. This briefing started off with an explanation of the general rules on the ship. Afterwards, the students were shown around the ship and told what to do in case of an emergency and where certain equipment such as survival suits can be found. During the 23-hour journey to the working area in the Norwegian EEZ, a test station was carried out in the vicinity of Helgoland. This was done so that the different devices like the Multicorer could be properly assembled and tested before the first actual station was reached. In addition, the students were able to get accustomed to the way the devices worked and had to be handled. The introduction to the different devices was carried out by the Technician Marc Metzke and Chief Scientist Niko Lahajnar. The students worked together as a group and successfully tested the CTD (Conductivity, Temperature, Depth), Bottom Water Sampler (BWS), van-Veen-Grab (vVG) and the Multicorer (MUC). In the following days the nine students were divided into three groups of two and one group of three, with each group being responsible for a certain task for the day. The group leading the stations for the day was responsible for the SECCHI-Disk, the APSTEIN-net, the vVG as well as the communication with the bridge. All the other groups were responsible for either the CTD, the BWS or the MUC and the individual communication with the winch regarding the movement of the devices. On the evening of May 9, 2024, Thomas Lüdmann introduced the first group to the different devices that recorded the data for the hydroacoustic profiles which the students then had to supervise during their night shift. This was to ensure that the data recording for the hydroacoustic profiles did not get paused or entirely stopped. For the data collection the Acoustic Doppler Current Profiler (ADCP), the Multi Beam Echo Sounder (MBES), and the Single Beam Echo Sounder (SBES) were used which collected data from the water column, bathymetry as well as from the underground. During the Cruise one of the hydroacoustic devices, the ADCP stopped working and could not be fixed.

The station plan for the day was always presented to the students by the Chief Scientist the evening before. Afterwards, the different groups discussed who would take over which task during the day and who would be on the night shift for the hydroacoustic devices. The only time the station plan deviated from the original was at Stations 13 and 18 to avoid a submarine cable and an oil platform. During the seminars, the students learned about nautical terminology and were taught ten different knots which are essential on a ship. On the last evening the students were each given one nautical term and a knot which they had to present in front of the others as a test. From May 9, 2024, until May 12, 2024, a total of 24 Stations were surveyed. Every day, five sampling stations were carried out during the day and one during the night. It was originally planned that the students operate one or two stations without the help of Technician Marc Metzke and Chief Scientist Niko Lahajnar on the last day (May 13, 2024). Due to changing weather conditions, the sampling station plan had to be adjusted because the ship had to start its journey back to Bremerhaven in the morning of May 13, 2024, instead of midday.

This meant that the last station on May 12, 2024 (Station 23) was carried out independently by the students while the Chief Scientist and the Technician watched. On May 14, 2024, the research vessel returned to Bremerhaven at 8 am where the students prepared the equipment and the samples for transport.

The daily agenda was that two stations took place before lunch at 11:15 am and three stations before dinner at 05:15 pm. Following dinner, the students returned to the laboratory and finished preparing the individual samples. Afterwards, each group cleaned their workstation so that the group taking over did not encounter any issues on the next day.

Each station started off with an announcement to the bridge by the station leaders. The stations started off with two manually deployed devices, the SECCHI-Disk and the APSTEIN-net. Following the announcement, the group began with the operation of the SECCHI-Disk, which was lowered into the water in order to determine the visibility with increasing depth. Throughout the cruise, the visibility varied between 4 m (Station 1 and 11) and 11 m in depth (Station 15). After this, the APSTEIN-net with a net size of 25 µm was lowered five meters into the water. This net was used to retrieve phytoplankton. Once the net was pulled back onto the deck, it was brought into the laboratory where it was rinsed with sea water and the remaining microorganisms were filled into a bottle for further investigation under the microscope. After this, the remaining four devices (CTD, BWS, vVG, MUC) had to be put into the water with the help of the winch and the crewmembers. The first one to go into the water was the CTD-Rosette which measures the conductivity, temperature and depth. It holds 12 bottles of which numbers 1-6 were filled with water once the device was lowered close to the seafloor, and numbers 7-12 were filled closer to the surface. Once the device was back on deck, the water from the two depths were run through filters separately, until the filter would not let any more water drain. A total of 40 filters were collected between all the stations. The next device was the BWS (Bottom Water Sampler), which had three 5 l horizontal bottles placed at a height of 28.5 cm, 58 cm and 110.5 cm above the sea floor. After the device was put into the water and left to sit close below the surface so it could move into the direction of the waterflow, it was lowered down to the seabed surface. Once the base plate had made contact with the ground, a timer was triggered within an electrical unit connected to the device. Three minutes after the contact, a wire within the electrical unit burned through and the bottles snapped shut. The device was lifted back up onto the deck slowly and the water was put into three separate bottles so that it could be filtered. In most cases, the bottle with the height of 28.5 cm above the ground was not filled entirely and only 3.5 – 4 l could be filled into a bottle. In total 54 filters were used for all the stations, however Stations 9 and 17 could not be carried out since the electrical unit malfunctioned and the procedure could not be repeated due to the time it took to fix the problem and the station schedule. The next device used was the vVG (van-Veen-Graber) which is used to retrieve a sediment sample of the seafloor. Once the vVG was lifted back up onto the deck, a tube was put into the sediment and a sample was collected for a permeability test. Then the rest of the sample was put onto a wooden board and the students began to describe characteristics of the sample such as the coarseness, cohesiveness and the bycatch. Lastly, the MUC (Multicorer) was used to retrieve eight sediment cores from the seafloor. The MUC was lowered into the water and then onto the ground of the seabed. Once it had reached the ground, it sat there for two minutes to ensure that the eight Plexiglas tubes had enough time to sink into the sediment. As it was lifted back up, the tubes were automatically shut to preserve the cores. Immediately after the MUC was back on deck and secured by the crew, the students chose two cores to extract and work with. The first core was photographed, and the different layers and general characteristics were described with the help of the MUNSELL Colour Chart. Afterwards, the first 5 cm were cut into 1 cm thick slices and secured for further examination at a later point.

With the second one, the students took the first 2 cm of the core and scooped the sediment into a bottle for micropaleontological studies carried out at the University Hamburg. However, there were some issues throughout the cruise. At Station 2 only two cores made it back onto deck since the other tubes had not shut properly and at Station 15 only 3 cm could be retrieved. At Station 16 only the core for the micropaleontological studies was retrieved since the sediments within the cores were mixed up during the lifting process so that the layering was lost. On the last day, Station 20 needed to be done twice, while Station 22 did not work at all. The cores at Station 23 were only partially filled. After closer investigation it turned out that it had always been the same side of the MUC that had problems which suggests that the MUC had developed a defect towards the end of the cruise.

Despite the problems with some of the devices and the earlier departure from the working area, the cruise was a success. The good weather conditions made it easier for the students to work with the different pieces of equipment and to gain experience regarding the different sampling methods.

All work conducted during HEINCKE cruise 639 was in full compliance with the “Code of Conduct for Responsible Marine Research in Deep Seas and High Seas of the OSPAR Maritime Area” and with the “Declaration on Responsible Marine Research” of the Senate Commission on Oceanography of the German Research Foundation and the German Marine Research Consortium (KDM). Research was performed under the good practice for responsible marine research. The operations were coordinated in such a way that they had as little impact as possible on the environment; the disturbance of habitats and populations was limited to the necessary minimum. All sampling was restrained to the lowest degree deemed necessary for the investigation. Prior to the start of the hydroacoustic surveys, observations of marine mammals were conducted and the recordings always began with a soft start. We will share our data with national and international collaborators and publish our results as much as possible as open access reports.

4 Narrative of the Cruise

(H. Firrincieli)

On Tuesday 7th of May 2024 at midday three students and a hydroacoustic scientist of the Universität Hamburg started the preparation for the cruise on the RV HEINCKE in Bremerhaven (Germany) with the loading of the institute's own equipment. This included boxes and the large devices MUC and BWS. Two hours later the chief scientist and a technician boarded with six more students, completing the scientific crew.

The wet lab was set up and all equipment was secured with straps against slipping. After everybody occupied their cabins, the first night was spent still docked at the trading port in Bremerhaven.

On Wednesday 8th of May in the morning at 4:45 UTC the RV HEINCKE left the trading port and started the cruise towards the working area. At 6:15 UTC the 2nd officer gave a theoretical and practical safety instruction that also included a guided tour of the ship and a test alarm. After that the technician gave the students first instructions for setting up a MUC. At 11:00 UTC near Helgoland (Germany) a test station was run without collecting data. CTD, BWS, vVG and MUC were tested. For the BWS a malfunctioning valve was identified and changed afterwards by the technician for a spare one. At 13:15 UTC the chief scientist gave instructions about creating analogue data protocols and how to digitalise them on board. Also, many nautical terms were explained so that the students could use them accordingly. In the evening at 17:00 UTC the first seminar started in the dry lab. There was an introduction on the material of rope and how to tie three useful knots.

After that for station work of the coming days the students were divided into four small groups with two persons each and one group including a third student. Each group was supposed to oversee a specific scientific device for a day. One group in exception was to oversee three of the simpler devices SECCHI-Disk, APN and vVG. Additionally, this group was also responsible for coordinating the stations of this day and communication with the bridge. Because there were four planned workdays in the working area, every small group was enabled to work intensively with every device for at least one day, so a long-lasting learning effect was ensured.

The next day, 9th of May, the RV HEINCKE arrived at the first station in the southern Norwegian EEZ at 5:50 UTC. The weather was overcast but there were only a few waves. Over the day the weather remained stable. After putting on safety clothes and preparing the devices, the first station began with the SECCHI-Disk followed by the APN. Each start and end of a device was announced at the bridge for logging via radio, as well as start and end of each station itself. Then the CTD, BWS and vVG were utilized without any problems. The sediment sample of the vVG showed a fine-grained sediment, so using the MUC after vVG was greenlit. First station was successfully finished, and course was set for station 2. Simultaneously while other small working groups deployed their devices, groups that already finished their sample taking started with sample processing in the wet lab. This included microscopic examination of plankton assemblages, filtering of water samples, sediment descriptions and permeability measurements. Heading towards the next station, remaining sample processing was finished and the wet lab, all devices and the working deck were cleaned and prepared for upcoming use. All stations of this cruise were executed in the same order as station 1. Once a day, the group responsible for BWS also learned fabrication of the burn wire that the device required. Day work finished at 15:40 UTC with station 5. The sediment descriptions of the MUC cores from station 5 had to be carried out after dinner due to time scheduling issues. In the evening seminar two presentations were held. J. Pense started with a talk about marine sampling methods for sediment and water. C. Mey expanded this knowledge with a presentation about hydroacoustic methods. Also, three additional knots were taught by the chief scientist and there was a reflection on where the students used the learned knots during their first hands-on workday. During the night, first hydroacoustic profiles were run by two students in a night shift. Both were instructed by the hydroacoustic scientist to oversee the used devices Multi-beam and Sub-Bottom Profiler. Unfortunately, the ADCP partly failed to connect to the computer during the whole cruise, presumably caused by modern software incompatibility. This led to incomplete data.

Friday, 10th of May, work started with station 7 at 5:55 UTC. The weather was foggy and there were little to almost no waves. The routine for each station of the day was carried out as the day before. At station 9 the BWS did not trigger but no second attempt was started. At station 11 again the time schedule was tight, so SECCHI-Disk, APN and CTD were run mostly parallel. The evening seminar started with task division for the next day. After that L. Willmott gave a presentation about the geology and tectonics of the North Sea. H. Firrincieli narrowed the topic further down with a presentation about petroleum reservoirs and industry in the North Sea. In the night again hydroacoustic data was collected.

On Saturday, 11th of May, station 13 started at 6:00 UTC. The sky was only partly cloudy and there were few waves. The position of station 13 was slightly changed from the initial station plan due to a Norwegian submarine cable that was not to be endangered by damage from the devices in need of seafloor contact. During the work for station 15 a small bird the size of a finch landed on the ship and flew seemingly disoriented through the wet lab. Later it found its way out again and flew off the ship after some time spent on the main deck. At the end of station 16, there was a sudden cumulating fog that hung over the water for the rest of the day. At station 17 the BWS once again did not trigger and a second attempt was started, alas again not successful. This resulted in no samples taken from the BWS for this station. The chief scientist repaired the electronic control unit of the BWS while the MUC was run. Two levers of the MUC did not trigger but in total there were enough intact cores. In the evening seminar G. Fehr held a presentation about hydrography of the North Sea. P. Schwoch followed up with a presentation about eutrophication and other marine environmental issues. After that C. Rausch talked about phytoplankton and zooplankton in the North Sea. In the night from around 10:00-01:00 UTC due to a cleared sky, aurora borealis was slightly visible for the students on shift for hydroacoustics. Also, the profile course had to be changed by a few hundred meters because of a large oil platform whose position intersected with the initial course. In the early morning some low booming from another nearby seismic vessel could be registered.

Station 19 began on 12th of May at 5:55 UTC. The weather was partly cloudy with a few small waves. Whilst the BWS was prepared to put into water, on the winch a small tube loosened. The problem was quickly fixed by the boatswain and the BWS was successfully run. At station 20 the net that covers the MUC got caught in a shackle of the device during veering so that it did not trigger at sea floor contact. A second try was successful. Station 22 had to be carried out in a slightly changed position due to another submarine cable. The MUC triggered but only water and no sediment was recovered in the tubes. No second attempt was started. Station 23 was the last station (besides hydroacoustics) of the cruise. It was executed autonomously by the students without any assistance from the chief scientist or technician. The MUC again triggered only partially and just one core was recovered intact. Beside this technical incident, all work was carried out in a flawless manner.

After last sample processing, the wet lab was cleaned and all equipment washed with freshwater so that they could be packed the next day. In the evening seminar the last two presentations were held, beginning with J. Möller talking about sediment movement in the North Sea. L. Bollbuck ended the presentation series with a talk about offshore wind-parks. During the night the last hydroacoustic profiles were run. In the early morning the waves started to rise and the ship was exposed to more intensified pitching than all days before.

Monday, 13th of May, started with packing the boxes with equipment and cleaning the labs. After a short time, most of the scientific crew was at least a little bit seasick. The chief offered a guided tour of the engine room which seven of the nine students attended. Throughout the day, the majority slept due to seasickness. In the afternoon when the waves calmed down, except for the MUC packing was completed and all surfaces cleaned. Instead of the usual evening seminar each student was tested about nautical terms and knots. After that the last evening was celebrated in a casual way. In the night at about 21:00 UTC (23:00 local time) near Helgoland RV HEINCKE met the operating RV MARIA S. MERIAN, greeting each other with the ship horn.

On Tuesday, 14th of May at 6:00 UTC in the morning, the ship passed the lock of Bremerhaven and docked at the trading port next to the building of the Alfred-Wegener-Institute. The cabins were cleaned and all institute owned equipment readied for loading. This included finally taking the weights of the MUC. The hydroacoustic scientist, the technician and two students already drove back to Hamburg by car. At midday the remaining students and the chief scientist helped to load the equipment on a truck and drove to Hamburg, where the truck was unloaded in the institute's storehouse. The cruise ended at the Geomatikum in Hamburg.

5 Preliminary Results

5.1 Water Sampling

5.1.1 SECCHI Disk

(P. Schwoch)

The SECCHI disk used during the HE639 expedition measured 30 cm in diameter, fitting within the typical range of 20 cm to 50 cm depending on the design (Fig. 5.1). Its top surface is divided into four equal sectors with alternating black and white segments. A metal loop is located at the center of the disk, allowing a rope to be attached. This Rope is marked at 1-meter intervals for measurement purposes. To ensure the disk remains vertically stable and can be easily immersed in the water column, a weight is attached to the bottom.

Fig. 5.1 The SECCHI disk used during the HE639 expedition and lowering the SECCHI disk 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 and is influenced by the sunlight, a factor for photosynthetic processes (Marra et al. 2014). Throughout the procedure, the disk is slowly lowered into the water (Fig. 5.1) The marks on the rope are counted as they reach the water surface until the SECCHI disk is no longer visible. If the disk disappears between two marks, the distance to the previous mark is estimated. Several factors can significantly influence the measurement of visibility depth using the SECCHI disk, including rough sea conditions, disk drifting due to strong currents, and light reflection on the water surface. Any relevant factors were recorded in the protocol.

At all 24 Stations except the stations 6, 12, 18 and 24 of the HE639 expedition, the visible water depth was determined using the SECCHI disk (Fig. 5.2). The deepest visible water depths were recorded at station 15 with 11 m and at station 16 with 10.8 m. The water depth at these stations were 60.3 m and 61.3 m, respectively. In contrast, the shallowest visibility readings were at station 1 and 11 with 4 m each. The water depths at these stations were 66.5 m, respectively.

The proportion of the visible depth and total depth (Fig. 5.3), show that there is no direct connection. Roughly, the visibility depth increases moderately from south to north. Nevertheless, the highest visibility depths are in the northern region, with a small peak at southern center at station 21 with a visibility depth of 10 m. Since the solar radiation was changing during the stations it is possible that the measurement results could be influenced by this. Additionally, the sea conditions were calm most of the time and should not influence the measurement results. But it could be possible that the different current velocities at these stations could have influenced the results due to drifting of the SECCHI disk.

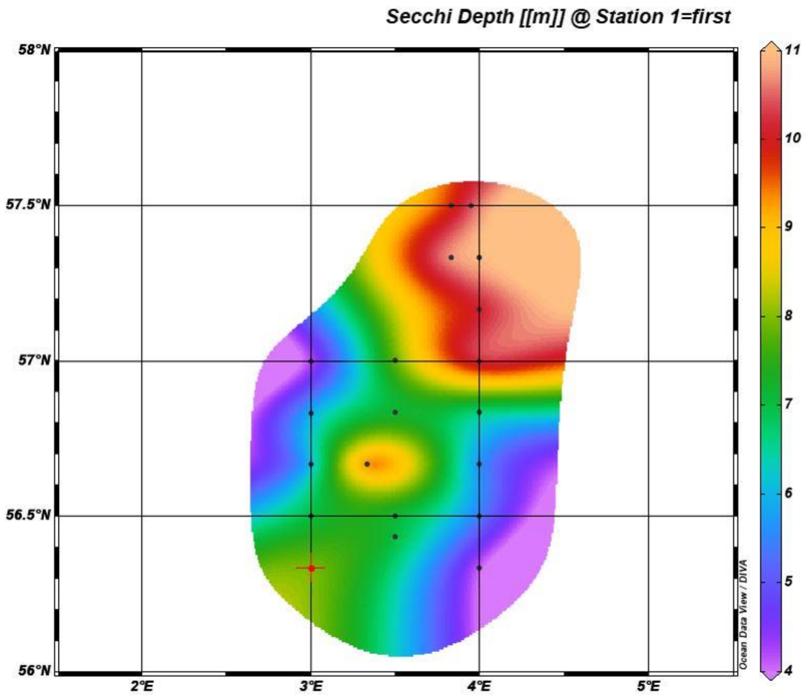

Fig. 5.2 Depth of visibility (SECCHI Depth) in the study area.

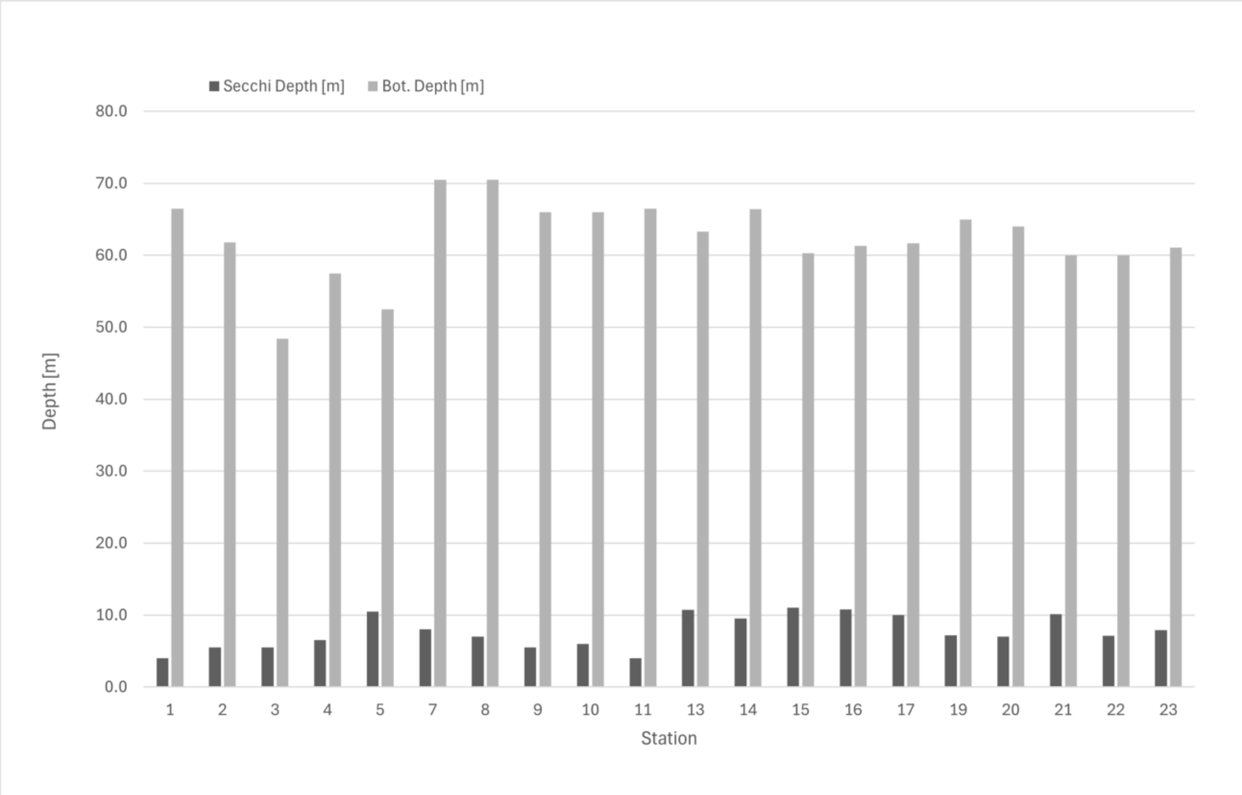

Fig. 5.3 Visible depth (SECCHI Depth) and water depth in comparison at the stations of HE639.

5.1.2 Plankton Sampling

(G. Fehr)

The collection of plankton samples with the so-called APSTEIN phytoplankton net at the individual stations always took place after using the SECCHI disk. The phytoplankton net, which tapers downwards in a funnel shape, has a mesh size of 25 µm, a length of 50 cm and an inlet diameter of 30 cm. At the end of the net there is a cylinder closed with a valve, where the plankton accumulates. The APSTEIN-net is connected to three suspension points with a weight and a rope with markings at one-meter-intervals. The weight makes the plankton net sink more easily into the water column. During the sampling, however, the net sometimes drifted under the ship, due to the prevailing current speed.

All station samples were taken from a water depth of 5 m for better comparability of the data. The sample obtained was then transferred into a bottle by opening the valve. To avoid losses, the inside of the net was also flushed with seawater. Immediately after they were taken, all station samples were examined in the laboratory in more detail in a Petri dish under a ZEISS STEMI 508 stereo microscope.

Plankton guides from Kraberg et al. (2010) and Larink and Westheide (2011) were used to identify the individual planktonic species. However, clear identification was not possible in every case. For this reason, some taxa could only be identified at the genus or family level.

Fig. 5.4 STEMI 508 stereomicroscope used during the HE639.

As a result of the microscopic examinations, many plankton forms typical of the North Sea were identified in different densities and species compositions. The red-pigmented genus *Spatangus sp.* (Echinodermata), a meroplanktic form which only exists as plankton in the larval stage, was particularly dominant. It could be found at almost all stations in medium to high density, particularly clustered at station 23.

Diatoms were also frequently found and often dominant in the individual samples, especially individuals of the genera *Rhizosolenia sp.* (especially *R. imbricata*), *Thalassiosira sp.* and *Chaetoceros sp.*, sometimes *Coscinodiscus radiatus* and *Coscinodiscus concinnus*. Other forms like *Guinardia delicatula* and *Guinardia flaccida* occurred less frequently, as well as *Halosphaera sp.* (Chlorophyta) and *Phaeocystis globosa* (Haptophyta).

At some stations (e.g. 13, 17 and 21) dinoflagellates (*Ceratium sp.*) and crustaceans (*Cirripedia sp., Copepoda sp., including Calanus sp.*) were also found in smaller numbers. The dominance of diatoms over dinoflagellates in most of the samples could perhaps be explained by an increased silicate concentration in the water. This factor is an important requirement for the structure of diatom shells.

Overall, during the HE639 expedition, a medium to highly developed plankton bloom was observed at most locations (exception: station 20), probably favored by a higher nutrient concentration in the water column and a warming of surface water in May. In particular at station 4 there was a greatly increased phytoplankton density with a high species diversity.

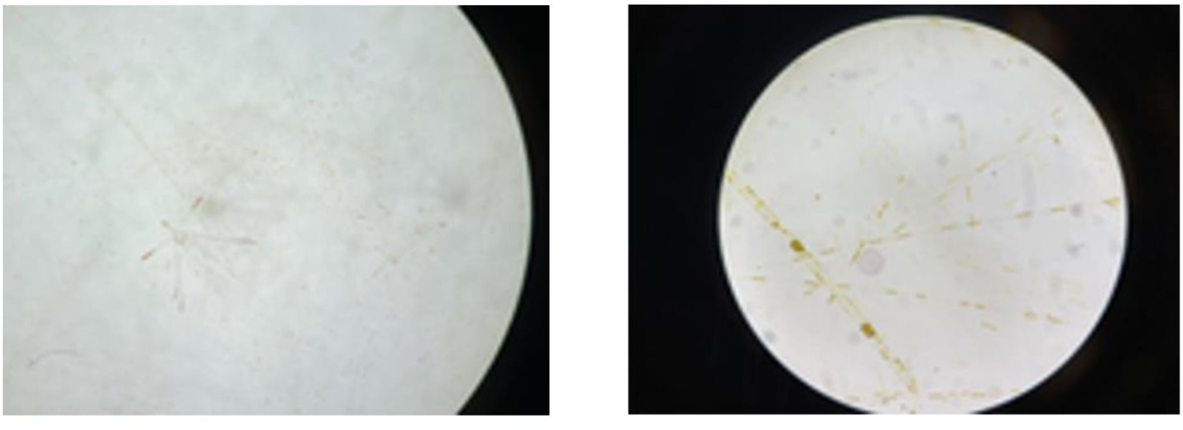

Fig. 5.5 *Spatangus sp.* (Echinodermata) in the larval stage (left) and Diatom species under the microscope (right).

5.1.3 CTD-Rosette

(J. Pense, C. Rausch)

The CTD-Rosette is an instrument used for measuring conductivity, temperature, and depth. It is divided into an upper and a lower part. The upper part houses the CTD sonde. The lower part contains instruments for measuring temperature, conductivity, and pressure. Additionally, other devices and sensors can be attached to the lower and upper part to determine further parameters. The upper part holds the rosette with 12 NISKIN bottles, each with a five liter capacity, that act as water samplers at various depths. Both units are enclosed in a cylindrical frame to protect them from damage during deployment in the water column.

The CTD system includes an electronic control unit, which is connected to a computer on board the ship. The control unit and the rosette are connected by a cable. The parameters are measured and displayed on the computer throughout the entire journey of the device.

The top and bottom lids of the NISKIN bottles are connected by a wire. This wire can be tightened and held open with a hook at the top center of the rosette. In the computer program, a button can be pressed at the desired depth to release the individual hooks and close the lids. This allows for water samples to be taken at different depths (Fig. 5.6).

Fig. 5.6 CTD-Rosette with a description of the components.

The CTD was used at all 20 daily stations during the HE639 cruise. In addition to the parameters mentioned above, salinity, dissolved oxygen concentration, and fluorescence were measured using additional sensors.

Before using the CTD, the top and bottom lids of each NISKIN bottle had to be opened and held open by a tensioned wire. Additionally, all valves on the NISKIN bottles had to be closed. Before the initial use of the CTD, the syringes on the pumps had to be removed.

After the CTD was deployed into the water, just below the surface, the control unit was activated to power the sensors. The device was then lowered to 5 meters below the surface. It was necessary to wait until the pumps were pressurized, so the pump status was marked as "on" on the onboard computer and all measured parameters had stabilized. Once the pump status was "on" and the parameters were stable, the device was lowered to about five meters above the seabed. The CTD should not touch the seabed to prevent the measuring instruments from being damaged by the sediment. On the way down a vertical profile of the water column was recorded. The first six NISKIN bottles were closed five meters above the seabed. On the way to the surface, the next six NISKIN bottles were closed at thermoclines. When the device was just below the surface, the measurement was completed, the collected data was reset and the power was turned off. Following this, the device was brought back on deck.

After the CTD was turned off, the caps at the top of the NISKIN bottles were opened to allow air into the bottles. For filtration, water samples were taken from the first six NISKIN bottles (bottom water) and from bottles 7 to 12 (surface water) by opening the valves at the bottom and draining through silicone tubes into 5 l and 2 l bottles.

Both water samples were filtered simultaneously in the filtration unit. The filtration setup consisted of five units, each comprising a funnel, a filter holder, and a clamp. At each station, two filters were placed in the filtration unit. These filters were made of glass fibers (WHATMAN GF/F), had a mesh size of approximately 0.7 µm, and a diameter of 47 mm. The tare weight of the used pre-combusted filters (at 450 °C) ranged between 120.13 and 141.42 mg.

The water samples were poured from the 5 l and 2 l bottles into the funnel, and the suspended particles were collected by the filter placed underneath. A membrane pump with a suction pressure of 750 mbar directed the filtered water through a common pipe and hose into a 26-liter tank.

The average filtration volume was 7.47 liters for the bottom water samples and 7.35 liters for the surface water samples. The amount of filtered liquid depended on the flow rate through the filters.

After filtration, the filters were removed with tweezers and placed in a storage box. The storage boxes were kept in the refrigerator until the end of the expedition. After the expedition, the filters were brought to the Institute of Geology at the Universität Hamburg, where they were stored in a drying cabinet for 1-2 days at 40 °C and then weighed. With this data, the suspension for the two sampled depths at the stations could be calculated. First, the weight of the empty filter was subtracted from the weight of the filter after filtration, and then divided by the volume of filtered water.

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

To illustrate the initial results, an S-N transect through the study area was created, encompassing stations 1, 2, 3, 4, 5, 13, 16 and 17 (Fig. 5.7).

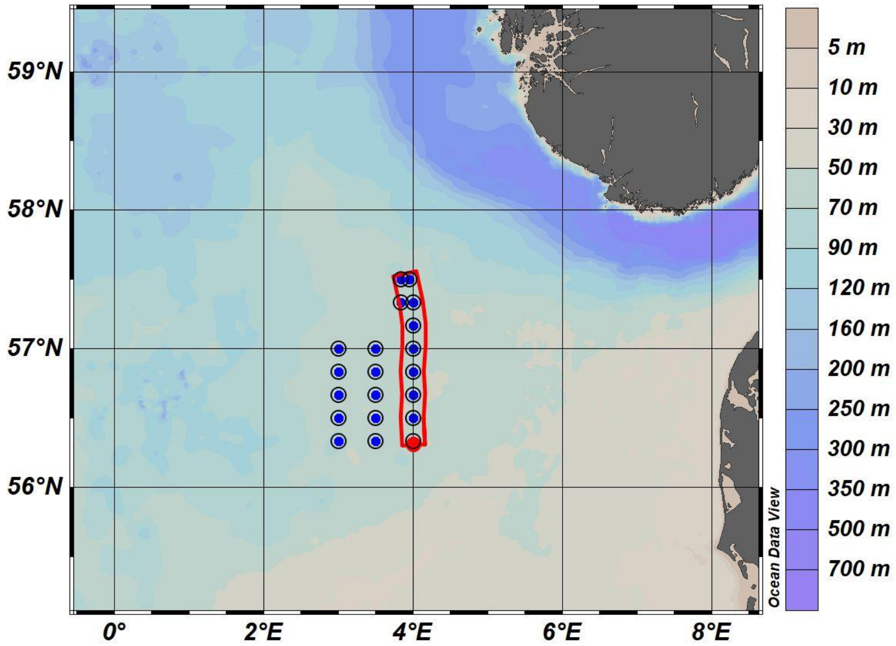

Fig. 5.7 Map of the study area and the stations of cruise HE639 with the measured water depths. The selected stations for the S-N transect are outlined in red.

The temperature in the water column ranges from approximately 9.7 to 6.7 °C, with a warmer surface layer, illustrated in Fig. 5.8. Beneath the surface layer is a thermocline, always within the upper 20 m of the water column. The North Sea is typically characterized by a seasonal thermocline, which develops in spring (Meyer et al., 2011). At station 3, the temperature below the warmer surface layer remains constant down to the seabed and is slightly warmer than at the other stations. Station 14 is characterized by greater water depth, with the majority of the water column exhibiting consistently colder temperatures.

The salinity in the area ranges between 34.96 and 34.77 PSU. Station 1 has the highest values, while station 5 has the lowest values in the water column. The salinity exhibits stratification at depths of approximately 10 - 15 m and below 38 m. The salinity in the bottom water is higher than in the surface water (Fig. 5.8).

The oxygen concentration is generally higher in the upper water layer, with concentrations ranging from 7 to 7.5 ml/l, compared to the bottom water, which typically has values around 6.8 ml/l. At stations 3 and 13, the oxygen concentration in the surface water is higher than at other stations, which can be attributed to an increased presence of phototrophic organisms (Fig. 5.8).

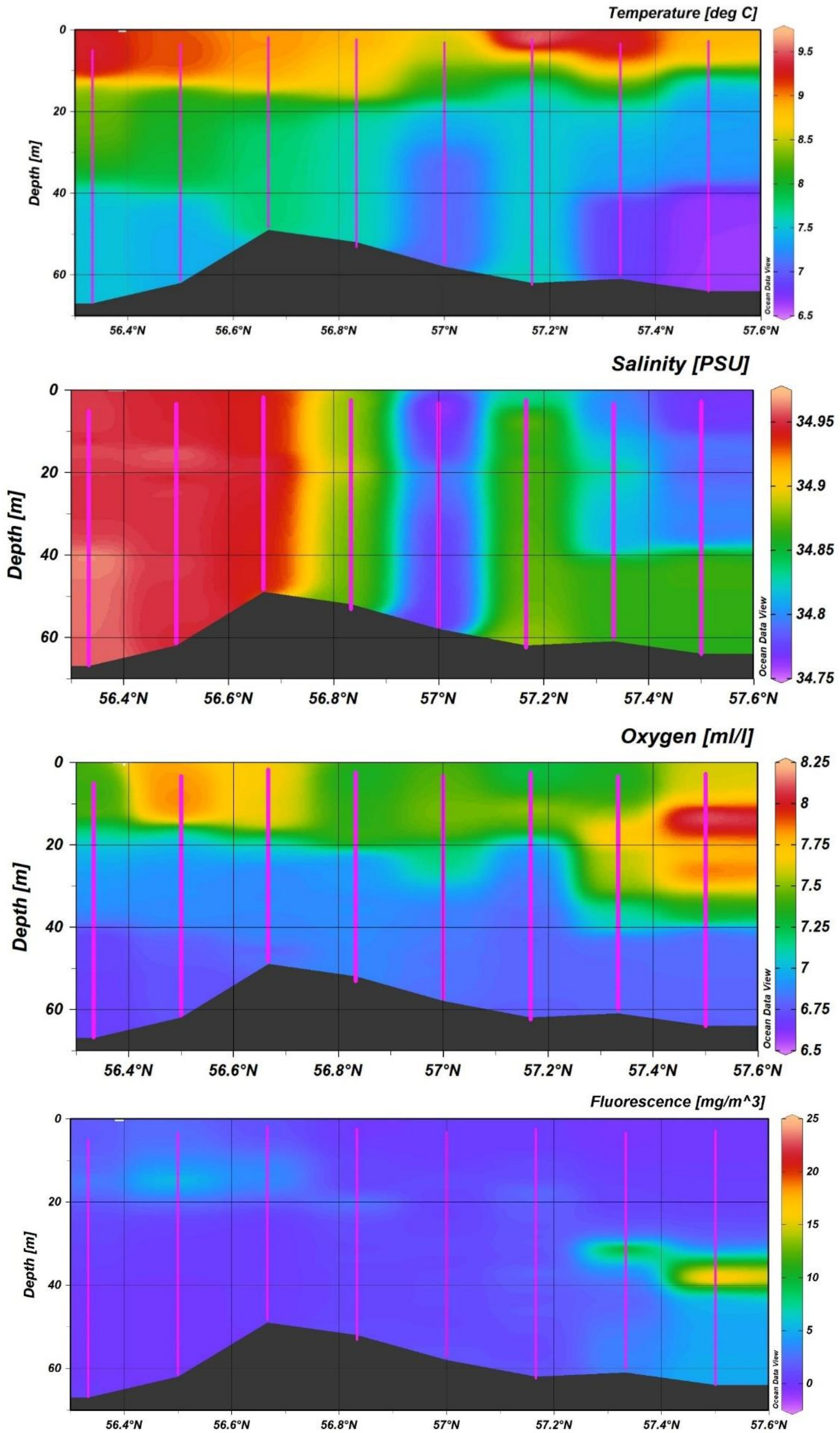

Fig. 5.8 Profiles from the S-N section, showing the change in temperature (°C), salinity (PSU), oxygen concentration (ml/l) and fluorescence (mg/m^3). The vertical pink lines indicate the positions of the eight included stations.

The measured fluorescence is very low below the surface. However, stations 13 and 16 show higher concentrations in the water column, ranging from approximately 10 to 18 mg/m^3, indicating an algal bloom. The increased amount of organic material in the water column at station 13 is also confirmed by preliminary results from determining the suspension volumes by filtered CTD water samples. The suspension amount, 53.05 mg/l, in the upper water sample of this station is higher compared to all other measured values. Overall, the suspension decreases with increasing depth (Fig. 5.9).

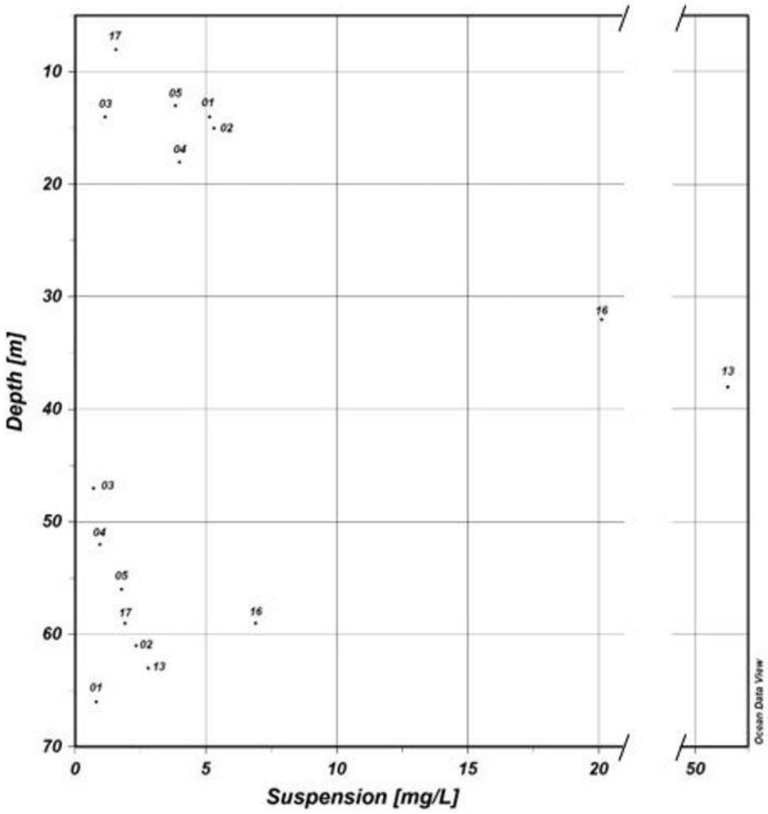

Fig. 5.9 The calculated suspension (mg/m^3) from the S-N sector in the bottom water and surface water. The gap between 21 and 49 mg/L shows that there are no results in the area.

From the S-N section, it is apparent that algal blooms occur with varying intensity in different regions of the North Sea. This significantly influences the oxygen content in the water column (Rovelli et al., 2016).

A thermocline in the water column can be observed for the stations both in the north and the south. At station 1, which is located in the south, a temperature drop from about 9.3 to 8.4 °C is visible at a depth between 10 and 15 m. This station shows a typical stratification with higher temperatures above the thermocline. Another temperature drop to 7.5 °C occurs between 35 and 40 m of water depth.

Station 13, in the north, also has two thermoclines at the same depths. This is also reflected in the salinity and partially in the oxygen content. The thermoclines show some overlap with Rovelli et al. (2016). They also identified two thermoclines, in the upper layer (27-30 m) and lower layer (36-39 m) of the North Sea (Rovelli et al., 2016). The cause of the two thermoclines could be the convergence of two water masses with different temperatures. In this case, it would be the inflow of the saltier Atlantic Ocean into the North Sea. Another explanation could be ocean currents and winds, which also contribute to mixing.

The thermocline corresponds with the observable halocline and is also indicated by a reduction in oxygen levels (Fig. 5.10).

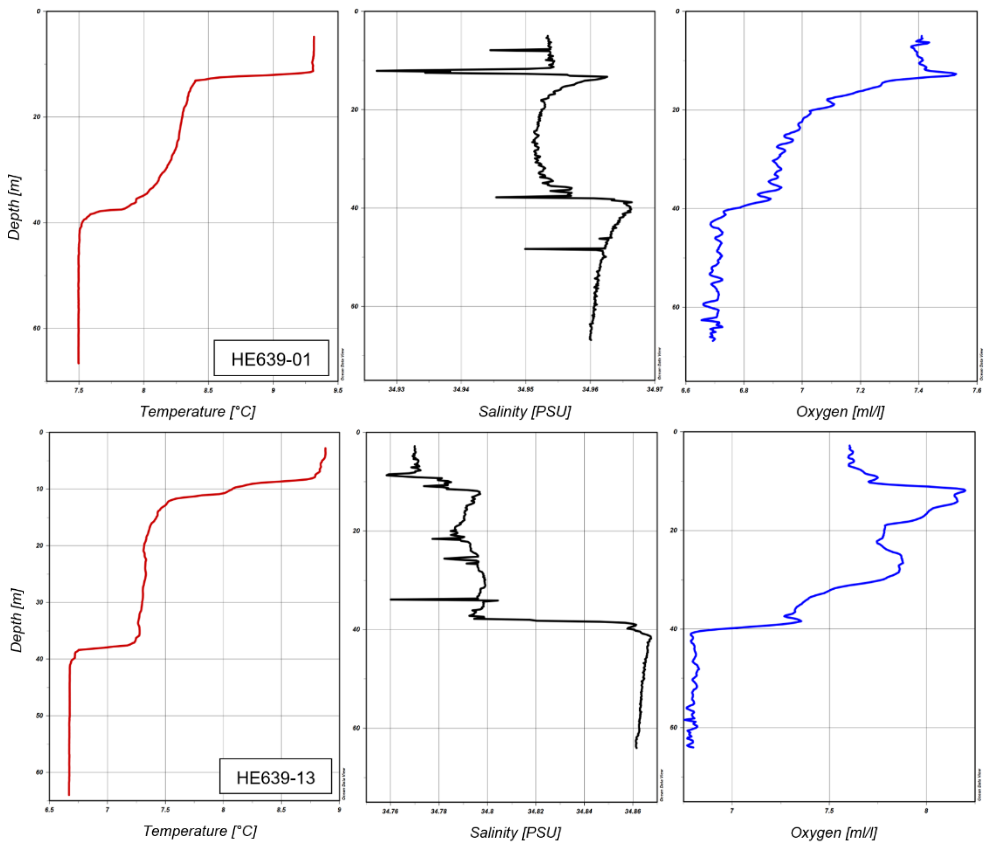

Fig. 5.10 The results from station 1 and 13 present the changes in temperature in °C, salinity in PSU, and the concentration of oxygen in ml/l along the vertical section through the water column.

5.1.4 Bottom Water Sampler

(L. Bollbuck)

The bottom water sampler (BWS) is designed to collect water samples from different heights above the seafloor. A maximum of five NISKIN bottles can be horizontally mounted on the rotatable central axis and are adjustable between 10 cm and 155 cm above seafloor (Fig. 5.11). The water sampling of the BWS used on this cruise, manufactured by KUM Kiel, is carried out by three NISKIN sample bottles with a volume of five liters each. On this cruise, the NISKIN bottles were set at heights of 28.5 cm, 58 cm, and 110.5 cm above bottom. The axis of the bottom water sampler is rotatably attached to the outer frame (up to 120 degrees) and is aligned with the current by a streaming fin before being lowered to the seafloor. The outer frame itself is also equipped with a streaming fin to rotate the entire device in the current. Additionally, weights are attached to the feet of the outer frame to keep the BWS on the seafloor.

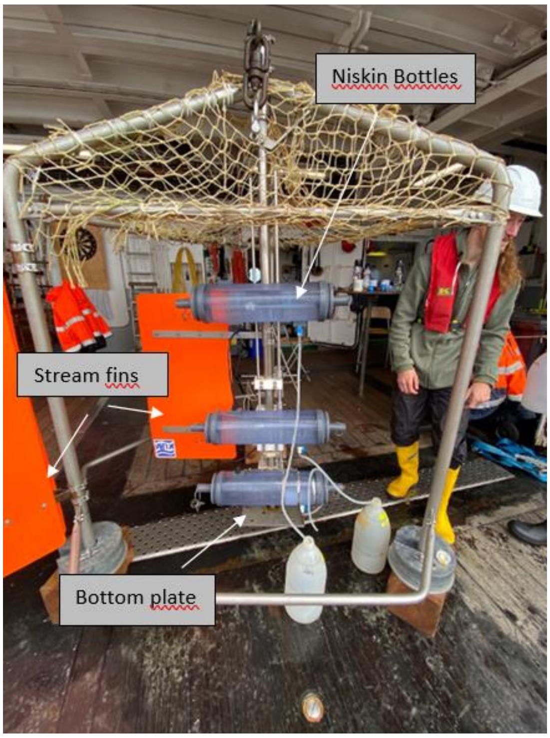

Fig. 5.11 The Bottom Water Sampler (BWS) used during cruise HE639.

For the closing mechanism, which is controlled by an electric control unit, a loop of wire (Fig. 5.12) is attached to a mechanical locking system. The wire is partially insulated and connected to the control unit via a cable. Both the control unit and the wire need to be set up before each deployment. The bottle caps have to be connected to the base frame before each deployment. When the device lands on the seafloor, a plate in the base frame is pushed upwards. This activates a timer which triggers the autonomous closing mechanism. The device then applies an electrical voltage to the cable connected to the wire after the timer has elapsed. The tension causes the wire to break and the bottles to close. The timer can be variably set between 1 minute and 6 hours. In strong currents, the BWS needs more time to settle on the seafloor, as it can lift off again after the initial landing, causing the plate that triggers the mechanism to lose contact with the bottom. In such cases, a longer time setting is selected, while weaker currents allow for a shorter time. Additionally, suspended sediment can settle during this time, preventing it from entering the NISKIN bottles. To ensure enough time, the timer was set to three minutes for each deployment on this cruise. During each deployment, the block through which the rope that lowers the BWS into the water passes was observed to check if the BWS remained on the seafloor or lifted off. In case of loss of bottom contact, the timer would restart. This was particularly the case during stronger swells. In any case, the BWS was left on the seafloor for at least six minutes to ensure the bottles closed properly. The BWS could be deployed at all stations on this cruise, except for stations 9 and 17, where it was not triggered, and no samples were taken.

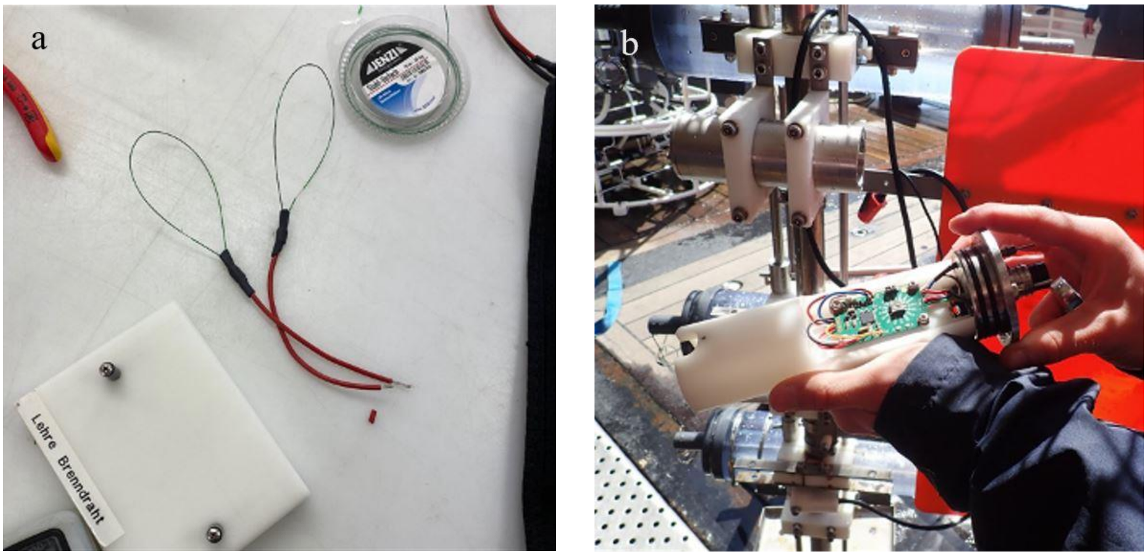

Fig. 5.12 a) Wire loop which is used to activate the closing mechanism b) Electronic control unit

The water samples were filled into 5 l or 2 l bottles through a hose attached to the outlet and given for filtration. The samples were then filtered through a glass fiber filter, following the same procedure as with the CTD rosette (Chapter 5.1.3). The filtered water was pumped into a 26-liter tank using a membrane pump with a suction pressure of 800 mbar. The tank was emptied before it became full, and the pump was vented regularly. The volume of filtered water varied between 1.4 l and 5.5 l. The filtration was stopped once little or no water flowed through the filter.

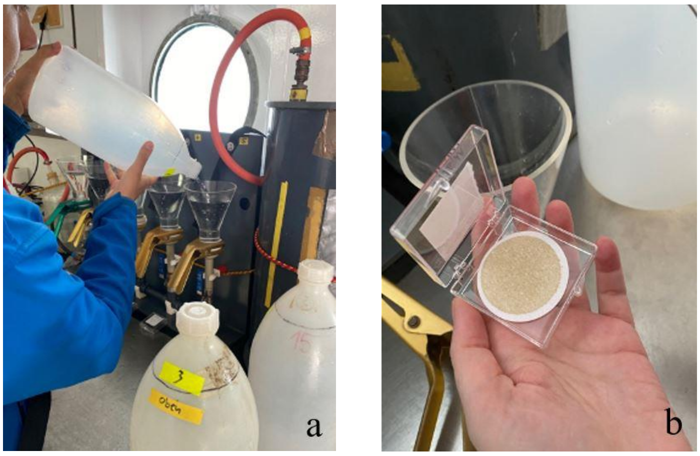

Fig. 5.13 a) Filtration in the laboratory b) Glass fiber filter after filtration

The filters were stored in a refrigerator until the end of the cruise and further analysed at the Institute of Geology at the Universität Hamburg after the cruise. The goal was to examine suspended particles and organisms in the water. For this, the filters were dried and weighed. With the initial weight of the filter, the filtered water amount, and the weight of the dried filter, the suspension amount of the water samples from the different stations could be calculated. First, the empty filter weight was subtracted from the filter weight after filtration and then divided by the amount of filtered water. The following formula was used for the calculation:

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

To determine the suspension amounts of water samples, samples were taken and analysed at a total of 18 stations at three different depths (28.5 cm, 58 cm, and 110.5 cm). The results show significant fluctuations between stations and depths. At the depth of 28.5 cm, the suspension amounts vary between 0.88 mg/l (Station 13) and 9.68 mg/l (Station 16). The average value at this depth is 2.45 mg/l, which is the highest average among the three depths studied. At a depth of 58 cm, the suspension amounts range from 0.80 mg/l (Station 5) to 9.39 mg/l (Station 16). The average value here is 2.21 mg/l. The samples from the depth of 110.5 cm show the largest range, with values from 0.73 mg/l (Station 8) to 13.01 mg/l (Station 16). Despite these large fluctuations, the samples from this depth have the lowest average value of 2.03 mg/l. These observations align with findings from other studies conducted in the North Sea and similar marine environments, which showed that the concentration of suspended particulate matter is often higher in surface waters due to increased primary production (Holt et al., 2010). Specifically, higher suspension amounts at shallower depths are typically due to the influence of sunlight, which promotes the growth of phytoplankton, thereby increasing the amount of organic matter in suspension (Reid et al., 1990).

Particularly notable is Station 16, which shows the highest suspension amounts at all three depths, especially at the depth of 110.5 cm with a peak value of 13.01 mg/l. In contrast, Station 8 shows the lowest measured value at 0.73 mg/l at the same depth. The variability observed at different depths and stations can also be attributed to physical processes such as mixing, sedimentation and local hydrodynamic conditions (Ridderinkhof et al., 1990). The lower suspension amounts observed at greater depths may be due to the settling of particles, which is influenced by water density gradients and reduced turbulent mixing. It suggests that fewer particles enter the deeper layer.

The higher values at Station 16 could indicate specific local conditions causing higher suspension amounts. Further investigations would be necessary to identify and understand the exact causes of the observed variations.

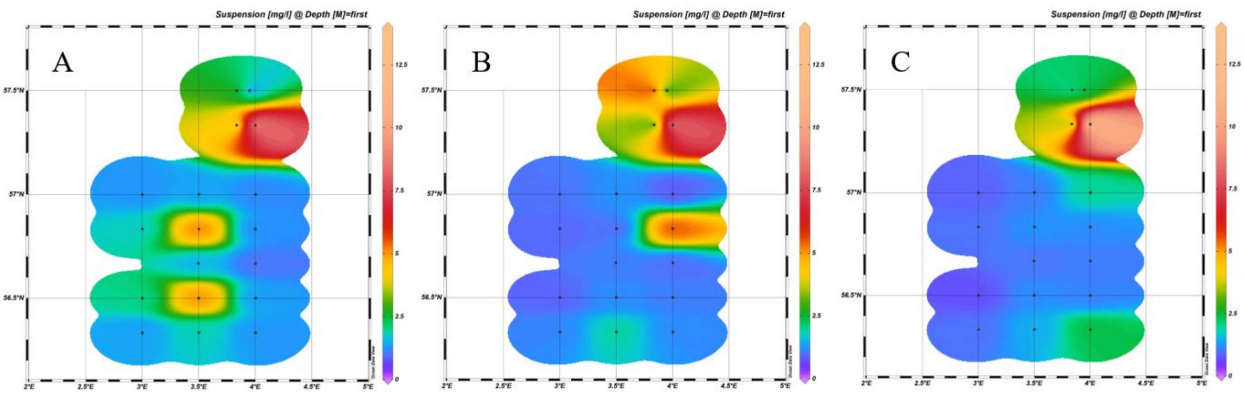

Fig. 5.14 Suspended Matter (mg/l) at (A) 28.5 cm (B) 58 cm and (C) 110.5 cm above ground

5.1.5 Thermosalinograph

(J. Penopp)

The thermosalinograph (TSG) is an instrument which is mounted at the hull of the RV HEINCKE. The TSG constantly measures the water temperature and conductivity at a depth of about 4 m. Sea Water is pumped into the hull at a flow rate of approximately 30 l/min. During the cruise, a Seabird thermosalinograph (SBE21) with an external temperature sensor (SBE38) was employed. Temperature is measured directly at the intake from the external temperature sensor to ensure pristine values. The Salinity is calculated using the temperature measured by the internal temperature sensor as the conductivity is strongly temperature dependent. From the obtained temperature and conductivity, salinity and sound velocity can be calculated. The salinity is given in practical salinity unit (PSU). Since TSG is an online system, it can measure constantly and independently from station work. Over the cruise, a total of 8289 measurements were taken by the TSG providing a comprehensive overview of the temperature and salinity in the working area. The Thermosalinograph (TSG) measurements for temperature and salinity were analyzed separately for the approach area and the working area to give a better resolution. The working area is entirely within the Norwegian EEZ, while the approach lies within the German and Danish EEZs.

The results of the TSG measurements are presented in Fig. 5.15. Water temperature exhibits a maximum of 15.4 °C near the shore, decreasing with distance from the shore. Within the working area, temperatures range between 8.4 °C and 10.7 °C, with higher temperatures observed in the western part of this area.

The salinity distribution shows the lowest concentrations near the shore, which can be attributed to fluvial input from the Weser and Elbe rivers (Emeis et al., 2015). The lowest salinity values, approximately 26 PSU, were recorded in the Weser estuary. In the working area, salinity values ranged from 33.6 to 34.91 PSU. Most stations recorded salinity values above 34.5 PSU, approaching the salinity of Atlantic Water, which exceeds 35 PSU and enters the North Sea through the northern boundary (Otto et al., 1990; Winther and Johannessen, 2006). Stations in the northeast exhibited slightly lower salinity concentrations, indicating influence from Baltic Sea outflow via the Skagerrak (Otto et al., 1990; Winther and Johannessen, 2006). Values below 34 PSU in the working area were isolated measurements, suggesting either measurement errors or possible freshwater input from the vessel.

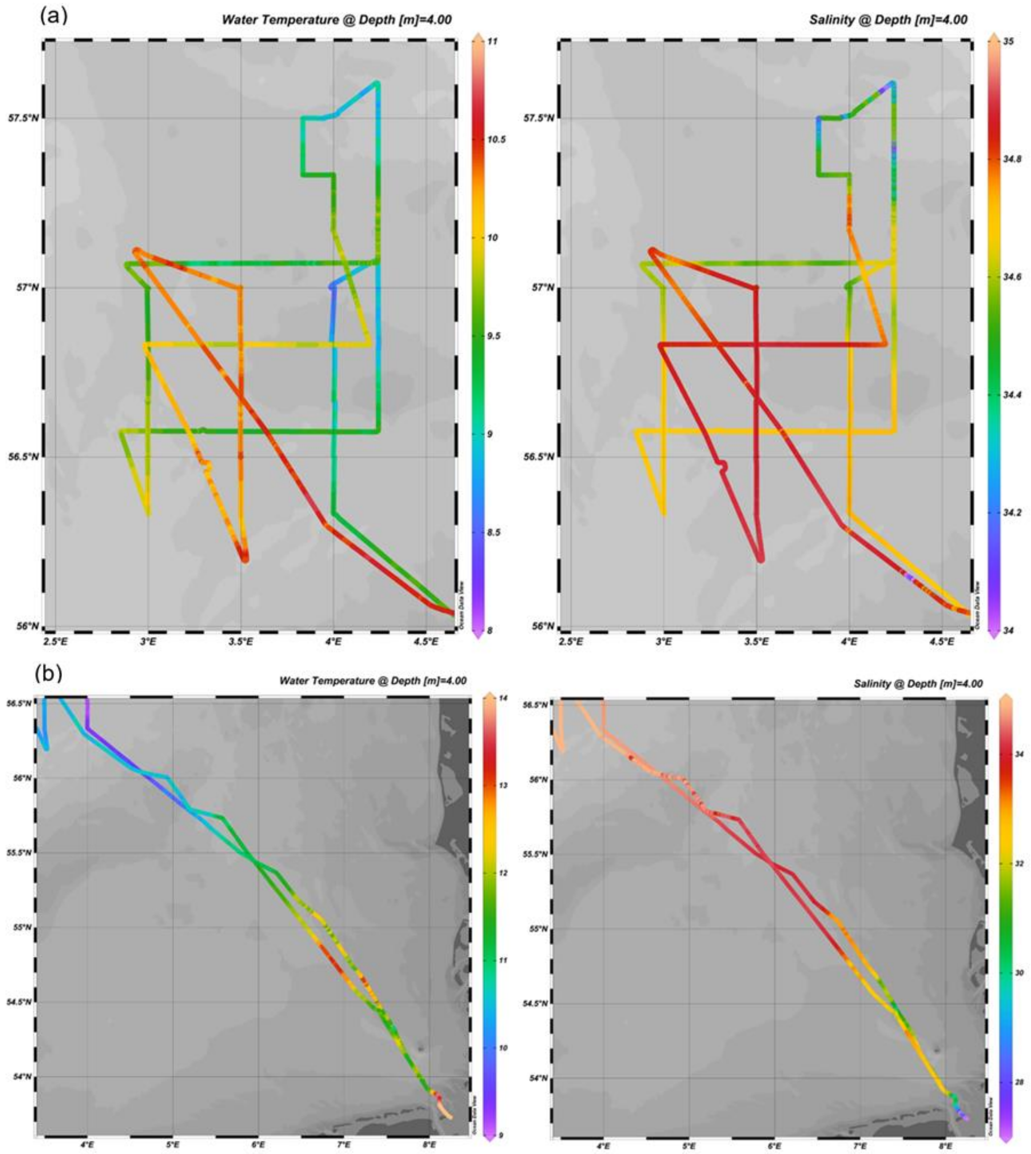

Fig. 5.15 Water temperature (in °C) (a) and Salinity (in PSU) (b) distribution derived from measurements of the Thermosalinograph for the approach and working area.

5.2 Sediment Sampling

(J. Möller)

Sampling the sediment is another important part of analysing the sea, along with sampling the water. It provides information on the grain size, organic content and other important data on the formation and condition of the soil.

Samples of the near-surface sediment were taken at a total of 20 stations in the Norwegian sector. The devices used for this were the van Veen grab (vVG) and a multicorer (MUC). While the van Veen grab takes a sample of the sediment using grab buckets, the multicorer takes an undisturbed sediment core.

After sampling the water, the Vaan Veen grab was used successfully at all 20 stations. The Multicorer, on the other hand, had one failed attempt.

5.2.1 Surface Sediment Sampling (van-Veen-Grab)

(J. Möller)

After sampling the water, the van Veen Grab is the first device to take sediment samples. This is only used after the CTD and the bottom water sampler, as removing the sediment would cause it to enter the water column and contaminate the water samples.

The van Veen Grab is a device for extracting the soil near the surface. A sample is taken with two excavator shovels. These shovels are connected with a hinge and are opened and fastened before being inserted into the water. On contact with the bottom, the attachment loosens and the two buckets snap shut. These now enclose the sediment and the grab can be pulled back on board.

Fig. 5.16 The van Veen grab on deck, with the multicorer to the right.

The disadvantage is that with the van Veen Grab it is not possible to take an undisturbed sample of the sediment. Mixing occurs during snapping. For this reason, the penetration depth cannot be determined precisely. However, it is important to know the structure of the sediment, as if the sediment is too coarse, the subsequent sampling with the multicorer is difficult or impossible.

Once the grab has been brought on board, a sample of the sediment is taken with a glass tube to determine the permeability. This sample is taken in the grab itself before it is emptied so that the relatively undisturbed stratification can be sampled. To ensure that the sample remains in the glass tube, the top of the tube is sealed with a stopper, creating a vacuum and the sediment remains in the tube when it is pulled out. The tube is then also closed at the bottom with a stopper.

The remaining sediment in the grab is poured onto a wooden plank, photographed and analyzed. Characteristics and special features are described. Important features here are the grain size, colour, smell, stratification and whether organic remains such as mussels are present. Once all this has been determined, the sediment is thrown back overboard.

Most of the samples contained fine sand with proportions of finer or coarser material. Some of the samples also had black sediment, which indicates anoxic conditions. In addition, all samples contained shells or broken shells. Furthermore, a few worms, sea urchins, crabs, molluscs, scaphopods and even plastic were found.

The sample in the glass tube is then analysed for permeability. To do this, the lower stopper is replaced by a stopper with a rubber tube and valve attached. A filter paper is attached to the hole so that only water can pass through the tube. The tube is then filled with seawater. Before the valve is opened, the height of the sediment layer and the water layer is measured. The valve can now be opened and a time measurement begins. The speed at which the water passes through the sediment is now measured (Fig. 5.17).

Fig. 5.17 Measuring the water level in the glass tube.

The permeability is calculated by calculating the difference between the water levels in centimetres and then dividing this by the time in seconds. The highest permeability was measured at station 3. This could have been due to the relatively coarse-grained material. No value could be determined at station 21 because there was no flow in the hose.

$$permeability = \frac{waterlevel_{start} - waterlevel_{end}}{time}$$

Fig. 5.18 shows the distribution of permeability in the study area. It can be seen that the permeability is higher in the east and north than in the rest of the area. Compared with Fig. 5.20, it is visible that this is directly related to the grain size. A coarser grain size can be found in the east, which leads to a higher permeability.

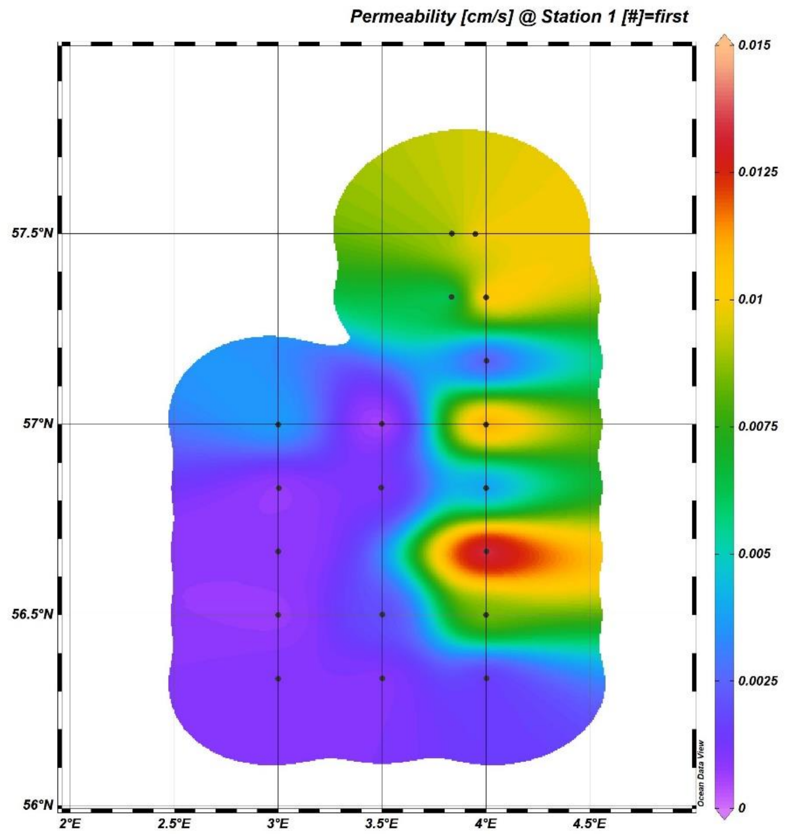

Fig. 5.18 Map of the permeability in the study area of HE639.

5.2.2 Multicorer

(J. Pense, C. Rausch)

During cruise HE639, a multicorer (MUC) was deployed to collect undisturbed sediment samples from the seafloor (Fig. 5.19). The MUC consists of eight polycarbonate tubes, arranged in a circle around the center, which have a length of 62 cm and a diameter of 10 cm. The tubes have lids on the top and bottom which can be closed by a locking mechanism. The MUC allows sediment samples up to a length of 20 cm to be taken. The tubes are surrounded by a metal frame which stands on six feet. Before the MUC is used, a net is stretched over the frame to prevent cables from wrapping around the tubes.

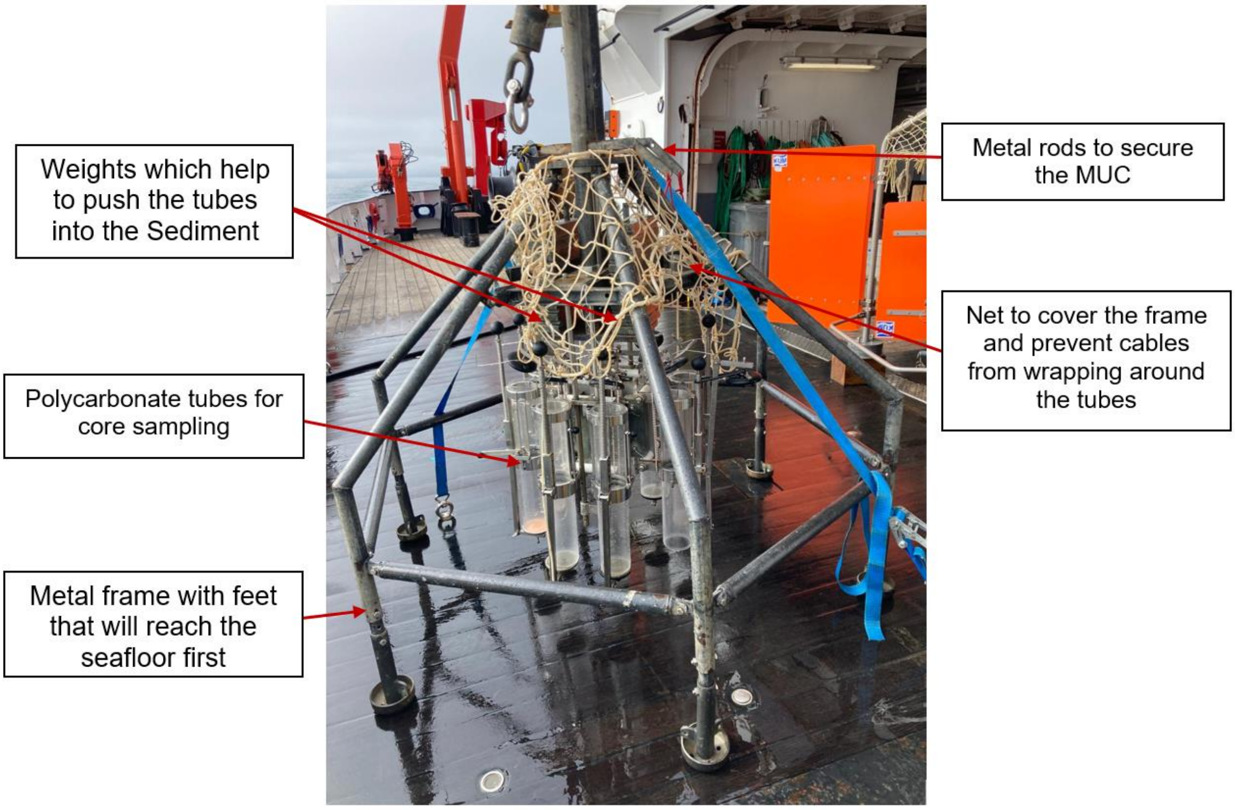

Fig. 5.19 The multicorer with a description of the components.

To operate the MUC, it is attached to a winch and raised. Two metal rods must be pulled out of the rail above the frame, preventing the inner part with the tubes from falling and touching the ground. The lids of the tubes must be clamped to be held open, so that the water can flow through the tubes during deployment. The device can now be lowered into the water to ~ 6 m above the seabed. The device will stay at that height for approximately one minute, to let it settle. After that it is slowly lowered with 0.3 to 0.5 m/s to the seabed, till the outer frame touches the ground with its feet. The inner part with the tubes continues to move due to the mounted weights and presses the tubes into the sediment under its own weight. After waiting a few minutes, the MUC is slowly pulled out of the sediment, triggering the locking mechanism and closing the upper and lower lids of the tubes. The upper lids are closed first, creating a vacuum in the tubes and keeping the sediment in the tubes while pulling out. When the tubes are pulled out of the sediment, the lower lids swing down and close the tubes from the bottom.

The MUC is pulled out of the water and the two metal rods are put back into the rail above the tubes to secure it. Two cores that are as long and undisturbed as possible are selected for sampling. These are removed and closed at the top and bottom ends with a plug. One core is selected to be photographed and the sediment, layers and organisms contained are described. The sample tubes are then opened from below and pushed onto a steel cylinder with the same diameter as the tubes. One core is sampled at 1 cm intervals and packed in plastic bags. From the other core, only the first 2 cm are sampled and filled into a sample bottle with additional supernatant water from the tubes. The sample bags were sealed with a film welding machine and stored in the freezer with the bottle. The samples from the first core were taken for the Biogeochemistry working group and the sample from the second core for the micropaleontology department of the Universität Hamburg.

The device could be used at all stations. However, the MUC did not trigger at station 22 due to technical problems and no samples could be taken. The grain sizes of the sediment vary between fine sand and medium sand. In the northeastern and eastern stations, the sediment gets increasingly coarser. The sediment samples of stations 3, 5 and 16 are medium sand. The stations 13, 14 and 17 show a mixture of fine sand and medium sand (Fig. 5.20). The rest of the stations have fine sand sediment. The colours of the sediment were visually estimated using the Munsell colour chart. A colour scan was performed using a MINOLTA CM-2002 spectrophotometer. Stations 3, 15, 16, 21 and 23 show a uniform colour throughout. All other stations show two to three different colours, mostly as a layering from the lighter colours on the surface to darker ones in the depths. The dark gray areas indicate reduction processes. All sampled cores show traces of bivalve components, except the cores from station 2.

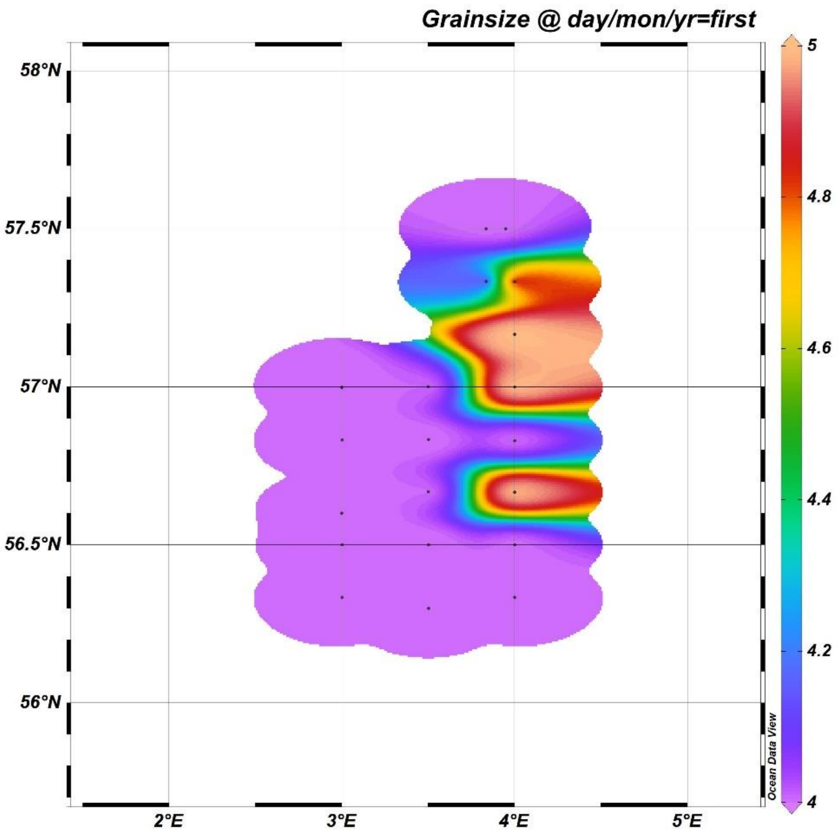

Fig. 5.20 Map of the grain size distribution in the study area of HE639.

5.3 Underway Hydroacoustics

(C. Mey, T. Lüdmann)

For the hydroacoustic survey of the seafloor and the water column, the RV HEINCKE is equipped with four types of devices. Mounted at the bottom of the hull were the KONGSBERG EM712 MULTIBEAM echo sounder (MBES) and the INNOMAR SES-2000 medium parametric sub-bottom profiler (SBES). Additionally, the 150kHz version of a TELEDYNE RDI WORKHORSE MARINER acoustic Doppler current profiler (ADCP) was installed in the keel of the vessel. The MBES and SBES hydroacoustic survey profiles were divided into four blocks and conducted at night, starting at 16:30, 16:14, 17:10 and 17:46 UTC and ending at 03:39, 04:29, 04;48 and 02:23

UTC respectively. The vessel's profiling speed during these recordings was 6 to 8 knots. Fig. 5.21 shows the locations of the survey blocks. The ADCP recorded both day and night but experienced software issues preventing it from running continuously throughout the entire cruise. The hydroacoustic survey aimed to map the North Sea bathymetry and sediment surface roughness with the MBES, measure water current velocities and directions and identify water mass boundaries with the ADCP, and reveal subsurface sediment structures with the SBES. All of the aforementioned hydroacoustic data was collected exclusively in the Norwegian sector of the North Sea.

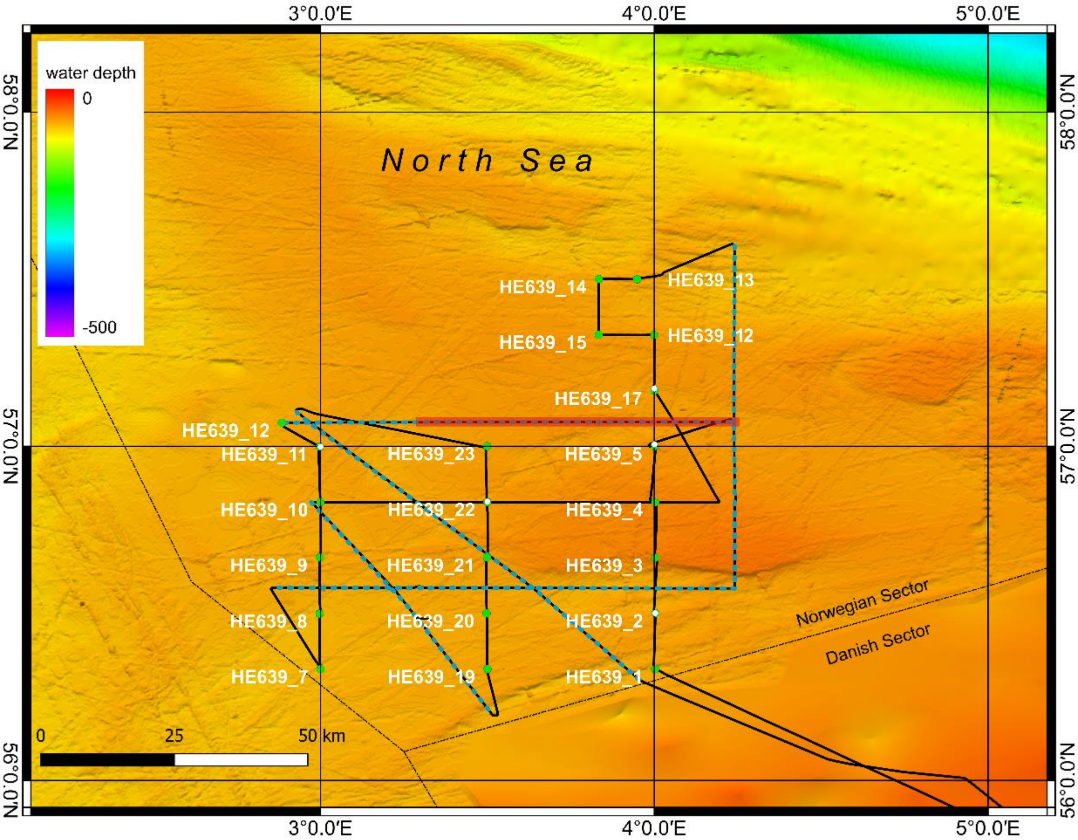

Fig. 5.21 Locations of the cruise route (black line), nighttime hydroacoustics (blue line), sampling stations (green dots), VSP locations (white dots) and example profile line (red line).

The KONGSBERG EM712 MBES used during cruise HE639 recorded seafloor morphology and sediment backscatter along the vessel's track. This device emits electromagnetic waves in a fan configuration perpendicular to the vessel's direction of movement. It operated in equidistant single swath mode with a variable ping frequency between 75 and 100 kHz and had an opening aperture set to 130°, providing a swath width about 4.3 times the water depth. At a water depth of approximately 60 meters typical for the work area, this equates to a swath width of 257 meters. The acquisition depth ranges from 3 meters below the transducer to 3500 meters. The MBES is coupled with the ships Inertial Navigation System (IXSEA PHINS III) and Primary Positioning Sensor (Trimble SP461) allowing the emitted beams to be stabilized for the vessel's roll, pitch, and yaw, while incoming beams are adjusted for roll motions. The MBES bathymetry data was processed using QPS QIMERA software, and the backscatter data was processed using the QPS FM GEOCODER TOOLBOX.

A 24 km long example profile of the data recorded with the MBES during the second block is shown below. Fig. 5.22 depicts the seafloor morphology at a water depth between approximately 60 and 69 meters as well as the recorded backscatter intensity, which relates to sediment roughness and density. Higher (brighter) intensity indicates denser or rougher sediment (such as sand, gravel, bivalve shells), while lower (darker) intensity indicates smoother or less dense sediment (such as silt or mud).

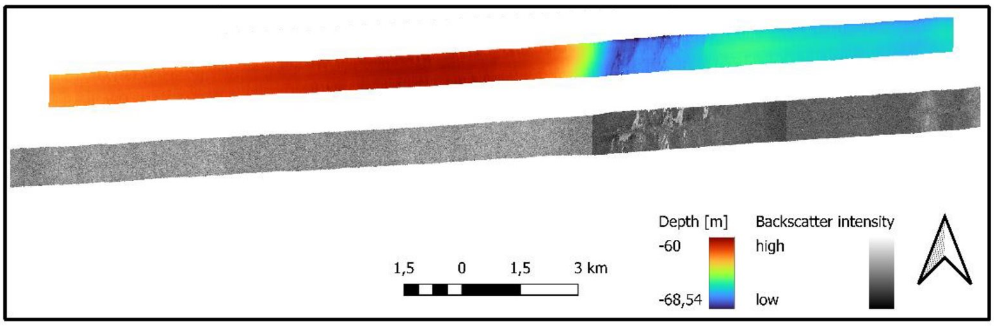

Fig. 5.22 Bathymetry and Backscatter along an example survey block (vertically stretched by a factor of 4).

An INNOMAR SES-2000 SBES was used to record the sea floor and underlying sediment structures parallel to the vessel's path. The device was set to a primary frequency of 100 kHz. Utilizing the parametric effect, a secondary frequency of 6 kHz, capable of penetrating the sediment, was generated. The SBES on the ship has a maximum sediment penetration depth of 70 meters with a vertical resolution of about 5 cm. The SBES was alternated with the MBES to avoid signal interference. Fig. 5.23 shows the SBES profile of the aforementioned example. Multiple sedimentary structures are visible, including a supposed erosional surface from the last glacial maximum (LGM) that stretches over a large part of the frame. Overlaying this are glacial sediments with no distinct layering, assumed to be glacial till. A backstepping moraine with clinoform layering is visible in the center, with glacial or fluvial channels filled with sediments visible to the east and west of this feature. The recorded SBES data was processed and presented using the SCHLUMBERGER PETREL software.

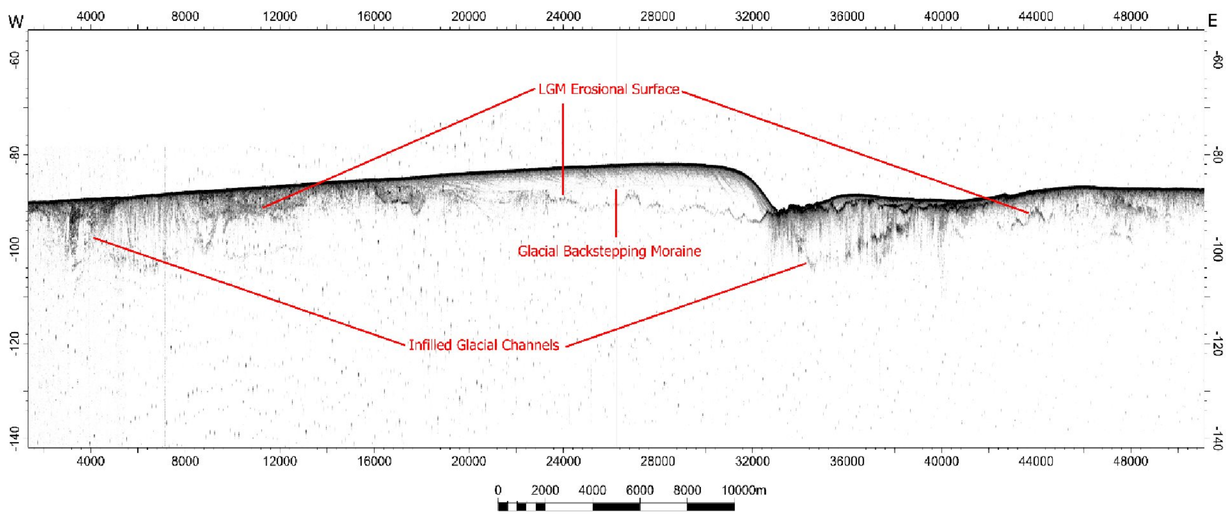

Fig. 5.23 SBES profile along the example survey block. Multiple glacial features are present.

The ship's TELEDYNE RDI WORKHORSE MARINER 150 kHz ADCP was used to measure water current direction and velocity within predefined bins. The device was set to measure 22 bins, each 4 meters in size, and is able to survey from a depth of 4.74 meters up to a maximum depth of about 400 meters. During the cruise, software problems caused significant data loss on numerous days. The ADCP operates based on the Doppler effect. It emits acoustic pulses that are reflected by particles within a specific bin. Upon receiving the reflected signal, a frequency shift (the Doppler shift) is calculated to determine the direction. Through the use of multiple beams spanning open a 3D-Volume, the direction, speed and water mass boundaries inside the bins can be reconstructed.

An example ADCP water current profile is shown in Fig. 5.24 and Fig. 5.25, indicating no vertical water mass boundaries and a slight change in current direction and velocity in the eastern part of the observed survey block. This is typical for this part of the North Sea during spring and early summer before the rising temperatures during summer cause a stratification of the water column.

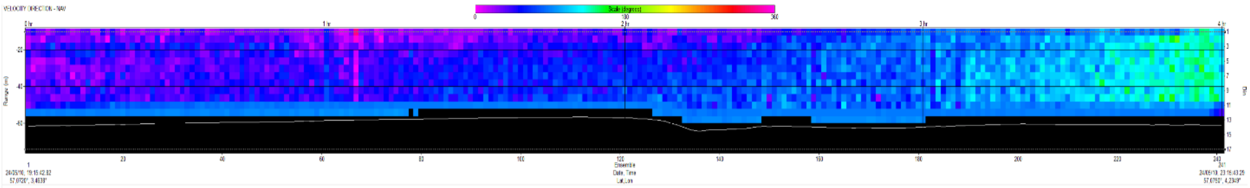

Fig. 5.24 ADCP-Profile along the example survey block showing the water current direction. The white line indicates the sea floor.

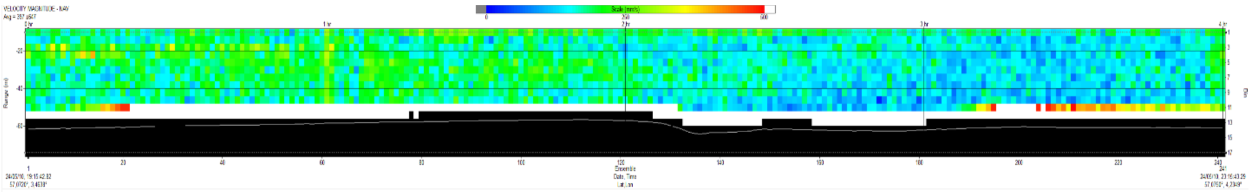

Fig. 5.25 ADCP-Profile along the example survey block showing the water current speed. The white line indicates the sea floor.

To verify the accuracy of the ADCPs, MBES, and SBES multiple vertical sound profiles (VSP) of the water column were measured. For this a VALEport MIDAS SVP was attached to the CTD-Rosette measuring the sound velocity. In total 5 VSPs were recorded prior to the nighttime hydroacoustic surveys (at stations 2, 5, 11, 17, 22). The VSP of Station 2 and 5 show the two dominating trends seen in the work area and are shown in Fig. 5.26. The sound velocity shows an initial decrease during the upper 10 to 20 meters and a second decrease in greater depths, before showing a very slight increase towards the sea floor. This decrease can be more sudden as seen for station 2 or more gradual as seen for station 5.

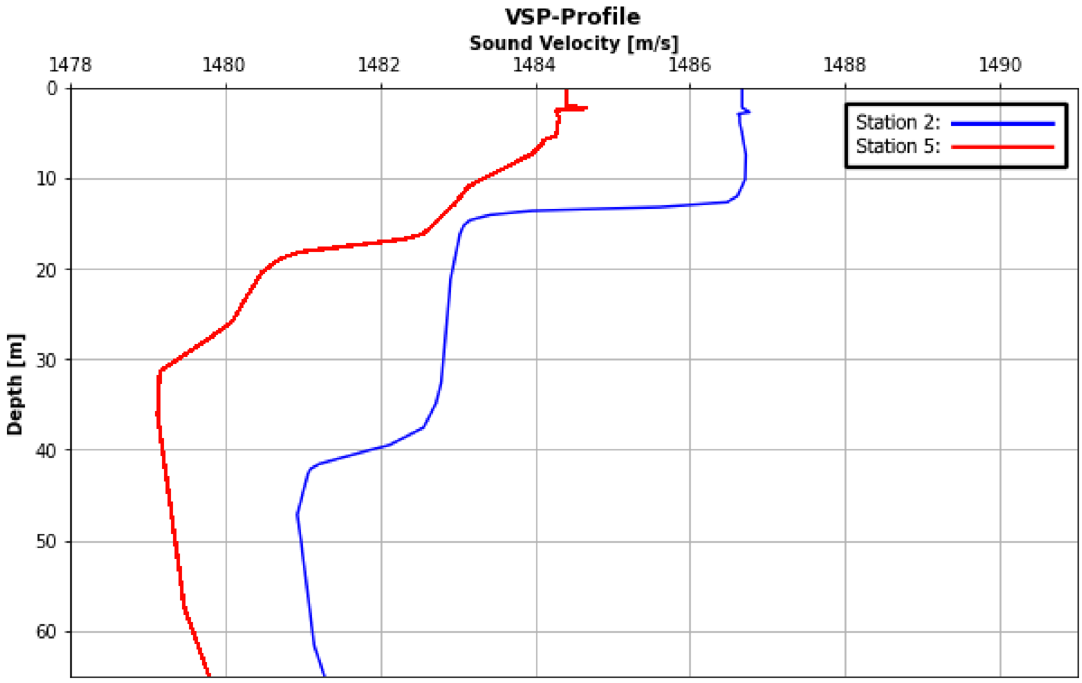

Fig. 5.26 VSP-Profile of stations 2 and 5.

6 Station List HE639

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/Recovery
Heincke	dd.mm.yy		[UTC]	[°N]	[°W]	[m]	
HE639_0_Underway-4	08.05.2024	WST	4:26	53° 31,988' N	008° 34,861' E	2	station start
HE639_0_Underway-3	08.05.2024	TSG	8:30	53° 55,089' N	007° 59,884' E	12	station start
HE639_1-1	09.05.2024	Secdisk	5:49	56° 19,990' N	004° 00,152' E	67	station start
HE639_1-1	09.05.2024	Secdisk	6:01	56° 20,004' N	004° 00,067' E	67	in the water
HE639_1-2	09.05.2024	PLA	6:05	56° 20,011' N	004° 00,060' E	67	in the water
HE639_1-3	09.05.2024	CTD	6:29	56° 19,992' N	004° 00,017' E	67	max depth/on ground
HE639_1-4	09.05.2024	BWS	6:43	56° 19,997' N	004° 00,019' E	67	max depth/on ground
HE639_1-5	09.05.2024	GRAB	6:55	56° 19,997' N	004° 00,022' E	67	max depth/on ground
HE639_1-6	09.05.2024	MUC	7:08	56° 19,990' N	004° 00,006' E	67	max depth/on ground
HE639_2-1	09.05.2024	Secdisk	8:25	56° 30,003' N	004° 00,044' E	62	in the water
HE639_2-2	09.05.2024	PLA	8:29	56° 30,001' N	004° 00,021' E	62	in the water
HE639_2-3	09.05.2024	CTD	8:37	56° 30,007' N	004° 00,029' E	62	max depth/on ground
HE639_2-4	09.05.2024	BWS	8:48	56° 30,007' N	004° 00,027' E	62	max depth/on ground
HE639_2-5	09.05.2024	GRAB	9:00	56° 30,008' N	004° 00,011' E	62	max depth/on ground
HE639_2-6	09.05.2024	MUC	9:09	56° 30,005' N	004° 00,008' E	62	max depth/on ground
HE639_3-1	09.05.2024	Secdisk	10:30	56° 39,993' N	004° 00,085' E	49	in the water
HE639_3-2	09.05.2024	PLA	10:38	56° 39,977' N	004° 00,067' E	49	in the water
HE639_3-3	09.05.2024	CTD	10:47	56° 39,982' N	004° 00,056' E	49	max depth/on ground
HE639_3-4	09.05.2024	BWS	10:58	56° 39,988' N	004° 00,056' E	49	max depth/on ground
HE639_3-5	09.05.2024	GRAB	11:09	56° 39,978' N	004° 00,061' E	48	max depth/on ground
HE639_3-6	09.05.2024	MUC	11:22	56° 39,990' N	004° 00,057' E	49	max depth/on ground
HE639_4-1	09.05.2024	Secdisk	12:41	56° 49,976' N	004° 00,076' E	52	in the water
HE639_4-2	09.05.2024	PLA	12:44	56° 49,985' N	004° 00,047' E	52	in the water
HE639_4-3	09.05.2024	CTD	12:52	56° 49,987' N	004° 00,020' E	52	max depth/on ground
HE639_4-4	09.05.2024	BWS	13:04	56° 49,989' N	003° 59,986' E	52	max depth/on ground
HE639_4-5	09.05.2024	GRAB	13:19	56° 49,998' N	003° 59,970' E	52	max depth/on ground
HE639_4-6	09.05.2024	MUC	13:28	56° 49,996' N	003° 59,981' E	52	max depth/on ground
HE639_5-1	09.05.2024	Secdisk	14:43	56° 59,998' N	004° 00,006' E	57	in the water
HE639_5-2	09.05.2024	PLA	14:47	56° 59,996' N	003° 59,994' E	58	in the water
HE639_5-3	09.05.2024	CTD	14:54	57° 00,003' N	003° 59,994' E	58	max depth/on ground
HE639_5-4	09.05.2024	BWS	15:06	56° 59,993' N	003° 59,990' E	58	max depth/on ground
HE639_5-5	09.05.2024	GRAB	15:17	56° 59,983' N	004° 00,003' E	58	max depth/on ground

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
Heincke	dd.mm.yy		[UTC]	[°N]	[°W]	[m]	
HE639_5-6	09.05.2024	MUC	15:26	56° 59,999' N	003° 59,991' E	58	max depth/on ground
HE639_6-1	09.05.2024	MB	16:30	57° 04,783' N	004° 13,354' E	62	station start
HE639_6-1	09.05.2024	MB	16:36	57° 04,402' N	004° 14,308' E	62	profile start
HE639_6-1	09.05.2024	MB	21:01	56° 34,884' N	004° 14,515' E	62	alter course
HE639_6-1	10.05.2024	MB	1:28	56° 34,584' N	003° 18,825' E	65	information
HE639_6-1	10.05.2024	MB	1:40	56° 34,609' N	003° 16,722' E	66	information
HE639_6-1	10.05.2024	MB	3:39	56° 34,625' N	002° 51,713' E	67	profile end
HE639_6-2	09.05.2024	PS	16:36	57° 04,403' N	004° 14,307' E	62	profile start
HE639_6-2	09.05.2024	PS	21:01	56° 34,882' N	004° 14,515' E	62	alter course
HE639_6-2	10.05.2024	PS	1:28	56° 34,584' N	003° 18,821' E	66	information
HE639_6-2	10.05.2024	PS	1:40	56° 34,609' N	003° 16,725' E	66	information
HE639_6-2	10.05.2024	PS	3:39	56° 34,625' N	002° 51,716' E	67	profile end
HE639_6-2	10.05.2024	PS	3:40	56° 34,625' N	002° 51,630' E	68	station end
HE639_7-1	10.05.2024	Secdisk	5:55	56° 20,005' N	003° 00,024' E	70	in the water
HE639_7-2	10.05.2024	PLA	6:00	56° 19,999' N	003° 00,023' E	71	in the water
HE639_7-3	10.05.2024	CTD	6:10	56° 19,994' N	003° 00,015' E	71	max depth/on ground
HE639_7-4	10.05.2024	BWS	6:25	56° 19,995' N	003° 00,031' E	71	max depth/on ground
HE639_7-5	10.05.2024	GRAB	6:40	56° 19,987' N	003° 00,015' E	70	max depth/on ground
HE639_7-6	10.05.2024	MUC	6:54	56° 19,978' N	003° 00,012' E	70	max depth/on ground
HE639_8-1	10.05.2024	Secdisk	8:12	56° 30,004' N	002° 59,983' E	70	in the water
HE639_8-2	10.05.2024	PLA	8:17	56° 30,009' N	002° 59,998' E	70	in the water
HE639_8-3	10.05.2024	CTD	8:25	56° 30,006' N	002° 59,993' E	70	max depth/on ground
HE639_8-4	10.05.2024	BWS	8:40	56° 30,007' N	002° 59,985' E	71	max depth/on ground
HE639_8-5	10.05.2024	GRAB	8:54	56° 30,004' N	002° 59,983' E	70	max depth/on ground
HE639_8-6	10.05.2024	MUC	9:08	56° 30,006' N	002° 59,977' E	70	max depth/on ground
HE639_9-1	10.05.2024	Secdisk	10:24	56° 40,004' N	002° 59,913' E	66	in the water
HE639_9-2	10.05.2024	PLA	10:28	56° 40,002' N	002° 59,935' E	66	in the water
HE639_9-3	10.05.2024	CTD	10:37	56° 40,003' N	002° 59,944' E	66	max depth/on ground
HE639_9-4	10.05.2024	BWS	10:50	56° 39,988' N	002° 59,950' E	66	max depth/on ground
HE639_9-5	10.05.2024	GRAB	11:10	56° 39,987' N	002° 59,952' E	66	max depth/on ground
HE639_9-6	10.05.2024	MUC	11:23	56° 39,981' N	003° 00,008' E	66	max depth/on ground
HE639_10-1	10.05.2024	Secdisk	12:35	56° 49,952' N	002° 59,999' E	66	in the water
HE639_10-2	10.05.2024	PLA	12:38	56° 49,948' N	003° 00,009' E	66	in the water
HE639_10-3	10.05.2024	CTD	12:46	56° 49,936' N	003° 00,017' E	66	max depth/on ground
HE639_10-4	10.05.2024	BWS	12:59	56° 49,907' N	003° 00,027' E	66	max depth/on ground
HE639_10-5	10.05.2024	GRAB	13:13	56° 49,884' N	003° 00,094' E	66	max depth/on ground
HE639_10-6	10.05.2024	MUC	13:25	56° 49,854' N	003° 00,153' E	66	max depth/on ground
HE639_11-2	10.05.2024	Secdisk	14:38	56° 59,950' N	002° 59,898' E	64	in the water
HE639_11-3	10.05.2024	PLA	14:40	56° 59,955' N	002° 59,907' E	64	in the water

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
Heincke	dd.mm.yy		[UTC]	[°N]	[°W]	[m]	
HE639_11-1	10.05.2024	CTD	14:50	56° 59,943' N	002° 59,982' E	64	max depth/on ground
HE639_11-4	10.05.2024	BWS	14:57	56° 59,934' N	003° 00,020' E	64	max depth/on ground
HE639_11-5	10.05.2024	GRAB	15:11	56° 59,930' N	003° 00,040' E	64	max depth/on ground
HE639_11-6	10.05.2024	MUC	15:17	56° 59,921' N	003° 00,016' E	64	max depth/on ground
HE639_12-1	10.05.2024	MB	16:14	57° 04,248' N	002° 53,522' E	66	profile start
HE639_12-1	10.05.2024	MB	23:15	57° 04,500' N	004° 14,094' E	62	alter course
HE639_12-1	11.05.2024	MB	4:29	57° 36,026' N	004° 14,417' E	71	profile end
HE639_12-2	10.05.2024	PS	16:14	57° 04,247' N	002° 53,519' E	67	profile start
HE639_12-2	10.05.2024	PS	23:15	57° 04,500' N	004° 14,094' E	62	alter course
HE639_12-2	11.05.2024	PS	4:29	57° 36,026' N	004° 14,417' E	71	profile end
HE639_12-2	11.05.2024	PS	4:30	57° 36,155' N	004° 14,378' E	70	station start
HE639_13-1	11.05.2024	Secdisk	6:01	57° 29,994' N	003° 56,911' E	63	in the water
HE639_13-2	11.05.2024	PLA	6:06	57° 29,992' N	003° 56,913' E	63	in the water
HE639_13-3	11.05.2024	CTD	6:16	57° 29,998' N	003° 56,914' E	64	max depth/on ground
HE639_13-4	11.05.2024	BWS	6:32	57° 29,999' N	003° 56,914' E	63	max depth/on ground
HE639_13-5	11.05.2024	GRAB	6:44	57° 29,992' N	003° 56,908' E	63	max depth/on ground
HE639_13-6	11.05.2024	MUC	6:56	57° 29,996' N	003° 56,929' E	64	max depth/on ground
HE639_14-1	11.05.2024	Secdisk	7:32	57° 30,005' N	003° 50,049' E	66	in the water
HE639_14-2	11.05.2024	PLA	7:36	57° 30,006' N	003° 50,056' E	67	in the water
HE639_14-3	11.05.2024	CTD	7:45	57° 30,008' N	003° 50,058' E	66	max depth/on ground
HE639_14-4	11.05.2024	BWS	8:00	57° 30,003' N	003° 50,063' E	66	max depth/on ground
HE639_14-5	11.05.2024	GRAB	8:12	57° 29,999' N	003° 50,065' E	67	max depth/on ground
HE639_14-6	11.05.2024	MUC	8:24	57° 29,998' N	003° 50,063' E	66	max depth/on ground
HE639_15-1	11.05.2024	Secdisk	9:55	57° 20,032' N	003° 50,028' E	60	in the water
HE639_15-2	11.05.2024	PLA	9:59	57° 20,029' N	003° 50,035' E	60	in the water
HE639_15-3	11.05.2024	CTD	10:07	57° 20,024' N	003° 50,029' E	60	max depth/on ground
HE639_15-4	11.05.2024	BWS	10:19	57° 20,024' N	003° 50,014' E	60	max depth/on ground
HE639_15-5	11.05.2024	GRAB	10:33	57° 20,011' N	003° 50,022' E	60	max depth/on ground
HE639_15-6	11.05.2024	MUC	10:43	57° 20,001' N	003° 50,031' E	60	max depth/on ground
HE639_16-1	11.05.2024	Secdisk	11:46	57° 19,988' N	003° 59,975' E	61	in the water
HE639_16-2	11.05.2024	PLA	11:50	57° 19,988' N	003° 59,973' E	61	in the water
HE639_16-3	11.05.2024	CTD	11:57	57° 19,988' N	003° 59,983' E	61	max depth/on ground
HE639_16-4	11.05.2024	BWS	12:09	57° 19,982' N	003° 59,979' E	62	max depth/on ground
HE639_16-5	11.05.2024	GRAB	12:23	57° 19,982' N	003° 59,969' E	61	max depth/on ground
HE639_16-6	11.05.2024	MUC	12:35	57° 19,980' N	003° 59,960' E	61	max depth/on ground
HE639_17-1	11.05.2024	Secdisk	13:51	57° 09,967' N	004° 00,037' E	62	in the water
HE639_17-2	11.05.2024	PLA	13:56	57° 09,985' N	004° 00,020' E	62	in the water
HE639_17-3	11.05.2024	CTD	14:04	57° 09,966' N	004° 00,059' E	62	max depth/on ground
HE639_17-4	11.05.2024	BWS	14:37	57° 09,914' N	004° 00,091' E	62	max depth/on ground

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
Heincke	dd.mm.yy		[UTC]	[°N]	[°W]	[m]	
HE639_17-5	11.05.2024	GRAB	14:49	57° 09,926' N	004° 00,102' E	62	max depth/on ground
HE639_17-6	11.05.2024	MUC	14:59	57° 09,936' N	004° 00,108' E	62	max depth/on ground
HE639_18-1	11.05.2024	MB	17:10	56° 49,927' N	004° 11,453' E	52	station start
HE639_18-1	11.05.2024	MB	17:14	56° 49,899' N	004° 10,614' E	52	profile start
HE639_18-1	11.05.2024	MB	23:40	56° 43,941' N	003° 04,081' E	66	alter course
HE639_18-1	12.05.2024	MB	1:14	56° 33,972' N	003° 13,551' E	3	alter course
HE639_18-1	12.05.2024	MB	1:58	56° 29,177' N	003° 17,318' E	67	information
HE639_18-1	12.05.2024	MB	2:25	56° 27,260' N	003° 18,834' E	67	information
HE639_18-1	12.05.2024	MB	4:48	56° 11,859' N	003° 30,855' E	72	profile end
HE639_18-2	11.05.2024	PS	17:14	56° 49,899' N	004° 10,610' E	52	profile start
HE639_18-2	11.05.2024	PS	23:40	56° 43,941' N	003° 04,081' E	66	alter course
HE639_18-2	12.05.2024	PS	1:14	56° 33,972' N	003° 13,551' E	3	alter course
HE639_18-2	12.05.2024	PS	1:58	56° 29,177' N	003° 17,318' E	67	information
HE639_18-2	12.05.2024	PS	2:25	56° 27,260' N	003° 18,834' E	67	information
HE639_18-2	12.05.2024	PS	4:48	56° 11,859' N	003° 30,855' E	72	profile end
HE639_18-2	12.05.2024	PS	4:49	56° 11,850' N	003° 30,862' E	72	station end
HE639_19-1	12.05.2024	Secdisk	5:54	56° 20,008' N	003° 30,017' E	66	in the water
HE639_19-2	12.05.2024	PLA	6:00	56° 20,007' N	003° 30,032' E	66	in the water
HE639_19-3	12.05.2024	CTD	6:09	56° 20,006' N	003° 30,035' E	66	max depth/on ground
HE639_19-4	12.05.2024	BWS	6:26	56° 20,008' N	003° 30,034' E	65	max depth/on ground
HE639_19-5	12.05.2024	GRAB	6:40	56° 20,003' N	003° 30,042' E	65	max depth/on ground
HE639_19-6	12.05.2024	MUC	6:52	56° 20,005' N	003° 30,062' E	65	max depth/on ground
HE639_20-1	12.05.2024	Secdisk	8:04	56° 30,014' N	003° 29,982' E	65	in the water
HE639_20-2	12.05.2024	PLA	8:11	56° 30,016' N	003° 30,000' E	65	in the water
HE639_20-3	12.05.2024	CTD	8:20	56° 30,022' N	003° 30,021' E	64	max depth/on ground
HE639_20-4	12.05.2024	BWS	8:32	56° 30,032' N	003° 30,021' E	64	max depth/on ground
HE639_20-5	12.05.2024	GRAB	8:45	56° 30,033' N	003° 30,026' E	64	max depth/on ground
HE639_20-6	12.05.2024	MUC	8:55	56° 30,036' N	003° 30,027' E	64	max depth/on ground
HE639_20-6	12.05.2024	MUC	9:11	56° 30,035' N	003° 30,033' E	64	max depth/on ground
HE639_21-1	12.05.2024	Secdisk	10:25	56° 40,045' N	003° 29,973' E	61	in the water
HE639_21-2	12.05.2024	PLA	10:32	56° 40,057' N	003° 29,971' E	61	in the water
HE639_21-3	12.05.2024	CTD	10:38	56° 40,065' N	003° 29,967' E	61	max depth/on ground
HE639_21-4	12.05.2024	BWS	10:53	56° 40,051' N	003° 29,981' E	61	max depth/on ground
HE639_21-5	12.05.2024	GRAB	11:07	56° 40,043' N	003° 29,984' E	61	max depth/on ground
HE639_21-6	12.05.2024	MUC	11:18	56° 40,043' N	003° 29,984' E	61	max depth/on ground
HE639_22-1	12.05.2024	Secdisk	12:33	56° 49,992' N	003° 29,990' E	60	in the water
HE639_22-2	12.05.2024	PLA	12:36	56° 49,988' N	003° 29,986' E	60	in the water
HE639_22-3	12.05.2024	CTD	12:45	56° 49,998' N	003° 30,038' E	60	max depth/on ground
HE639_22-4	12.05.2024	BWS	12:57	56° 49,993' N	003° 30,057' E	60	max depth/on ground

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
Heincke	dd.mm.yy		[UTC]	[°N]	[°W]	[m]	
HE639_22-5	12.05.2024	GRAB	13:19	56° 50,021' N	003° 29,743' E	60	max depth/on ground
HE639_22-6	12.05.2024	MUC	13:29	56° 50,017' N	003° 29,737' E	60	max depth/on ground
HE639_23-1	12.05.2024	Secdisk	14:46	57° 00,029' N	003° 29,959' E	61	in the water
HE639_23-2	12.05.2024	PLA	14:48	57° 00,033' N	003° 29,969' E	62	in the water
HE639_23-3	12.05.2024	CTD	14:55	57° 00,051' N	003° 29,990' E	62	max depth/on ground
HE639_23-4	12.05.2024	BWS	15:06	57° 00,051' N	003° 29,998' E	61	max depth/on ground
HE639_23-5	12.05.2024	GRAB	15:19	57° 00,047' N	003° 30,000' E	61	max depth/on ground
HE639_23-6	12.05.2024	MUC	15:36	57° 00,052' N	003° 30,001' E	61	station end
HE639_24-1	12.05.2024	MB	17:46	57° 06,197' N	002° 55,742' E	66	station start
HE639_24-1	12.05.2024	MB	17:46	57° 06,183' N	002° 55,757' E	66	profile start
HE639_24-1	13.05.2024	MB	2:34	56° 18,121' N	003° 57,272' E	68	profile end
HE639_24-2	12.05.2024	PS	17:47	57° 06,075' N	002° 55,896' E	66	profile start
HE639_24-2	13.05.2024	PS	2:34	56° 18,121' N	003° 57,272' E	68	profile end
HE639_24-2	13.05.2024	PS	2:36	56° 18,046' N	003° 57,376' E	68	station end

7 Data and Sample Storage and Availability

The hydrographic raw data collected by the CTD and the data from the thermosalinograph will be uploaded to the PANGAEA database. Data from analysis of Filtration and sediment samples will be shared on PANGAEA later on.

The Seismic Data (MULTIBEAM, PARASOUND) will be transferred to the Norwegian authorities and will not be published. Seismic and ADCP data will be shared upon request. Contact information can be found in table Table 7.1 below.

Table 7.1 Overview of data availability

Type	Database	Contact
Hydrography data (CTD & TSG)	PANGAEA	niko.lahajnar@uni-hamburg.de
Sediment Data (vVG, MUC)	PANGAEA	niko.lahajnar@uni-hamburg.de
Seismic (MULTIBEAM, PARASOUND) & ADCP data	Upon request	thomas.luedmann@uni-hamburg.de

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10 Abbreviations

ADCP - Acoustic Doppler Current Profiler

APN - APSTEIN net (Plankton net)

AWZ – Ausschließliche Wirtschaftszone

BWS - Bottom Water Sampler

CTD - Conductivity Temperature Depth Sampler

EEZ - Exclusive Economic Zone

IfGeol – Institut für Geologie

LGM – Last glacial maximum

M. Sc. Master of Science

Ma - Million years

MBES - MULTIBEAM Echosounder

MUC – Multicorer

PSU – Pracitcal salinity unit

RV – Research vessel

SBES - Singlebeam Echosounder

TSG - Thermosalinograph

UHH – Universität Hamburg

UTC - Coordinated Universal Time

VSP – Vertical sound profiles

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	Latitude	Longitude	Bot. Depth	SECCHI Depth
		dd.mm.yy	[UTC]	[°N]	[°E]	[m]	[m]
HE639	01	09.05.2024	05:49	56°20.01'	4°00.08'	66.5	4.0
HE639	02	09.05.2024	08:25	56°30.00'	4°00.04'	61.8	5.5
HE639	03	09.05.2024	10:30	56°39.99'	4°00.09'	48.4	5.5
HE639	04	09.05.2024	12:41	56°49.97'	4°00.01'	57.5	6.5
HE639	05	09.05.2024	14:43	57°00.00'	4°00.08'	52.5	10.5
HE639	07	10.05.2024	05:55	56°19.99'	3°00.01'	70.5	8.0
HE639	08	10.05.2024	08:12	56°30.01'	3°00.00'	70.5	7.0
HE639	09	10.05.2024	10:24	56°40.00'	2°59.97'	66.0	5.5
HE639	10	10.05.2024	12:35	56°49.94'	3°00.01'	66.0	6.0
HE639	11	10.05.2024	14:50	56°59.94'	3°00.00'	66.5	4.0
HE639	13	11.05.2024	06:01	57°29.99'	3°56.92'	63.3	10.7
HE639	14	11.05.2024	07:32	57°30.00'	3°50.05'	66.4	9.5
HE639	15	11.05.2024	09:55	57°20.03'	3°50.03'	60.3	11.0
HE639	16	11.05.2024	11:46	57°19.99'	3°59.99'	61.3	10.8
HE639	17	11.05.2024	13:51	57°09.97'	4°00.05'	61.7	10.0
HE639	19	12.05.2024	05:54	56°26.01'	3°30.04'	65.0	7.2
HE639	20	12.05.2024	08:04	56°30.02'	3°30.02'	64.0	7.0
HE639	21	12.05.2024	10:25	56°40.07'	3°19.97'	60.0	10.1
HE639	22	12.05.2024	12:33	56°50.00'	3°30.04'	60.0	7.1
HE639	23	12.05.2024	14:46	57°00.05'	3°29.98'	61.1	7.9

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	Bottom Depth	Sample Depth	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[m]	
HE639	01	09.05.2024	06:00	004°00.08'	56°20.01'	66.5	5	Echinoidea: *Spatangus sp.* (high abundance), Diatoms: *Rhizosolenia sp.*, *Coscinodiscus radiatus*, Chlorophyta: *Halosphaera sp*., radiolarite?
HE639	02	09.05.2024	08:24	004°00.04'	56°30.00'	61.8	5	Echinoidea: *Spatangus* sp. (high abundance), Diatoms (very high abundance): *Chaetoceros sp.*, *Thalassiosira sp.,* Chlorophyta: *Halosphaera sp.*
HE639	03	09.05.2024	10:28	004°00.09'	56°39.99'	48.4	5	Echinoidea: *Spatangus sp.* (very high abundance), Diatoms: *Chaetoceros sp.*, *Thalassiosira sp*. (very high abundance), *Coscinodiscus radiatus*, generally: very high amount of phytoplankton, high diversity
HE639	04	09.05.2024	12:40	004°00.08'	56°49.97'	52.5	5	Echinoidea: *Spatangus sp*. (high abundance), Diatoms: *Chaetoceros sp*., *Thalassiosira sp*., *Rhizosolenia sp.* (high abundance), *Coscinodiscus concinnus, Actinoptychus senarius*?
HE639	05	09.05.2024	14:42	004°00.01'	57°00.00'	57.5	5	Echinoidea: *Spatangus sp.* (medium abundance), Diatoms (high abundance): *Chaetoceros sp.*, *Thalassiosira sp.*, *Coscinodiscus concinnus,* Crustacea: Cirripedia sp.
HE639	07	10.05.2024	06:00	003°00.01'	56°19.99'	70.5	5	Echinoidea: *Spatangus sp.* (medium abundance), Diatoms: *Rhizosolenia imbricata* (high abundance), *Coscinodiscus radiatus, Ditylum brightwelli*, Crustacea: *Oncaea sp.* (Copepoda)

Cruise	Station	Date	Time	Longitude	Latitude	Bottom Depth	Sample Depth	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[m]	
HE639	08	10.05.2024	08:00	002°59.98'	56°30.01'	70.4	5	Diatoms: *Rhizosolenia imbricata* (high abundance), *Coscinodiscus radiatus, Coscinodiscus concinnus, Guinardia delicatula*, Dinoflagellata: *Protoperidinium divergens* (rare)
HE639	09	10.05.2024	10:20	002°59.97'	56°39.99'	66.1	5	Echinoidea: *Spatangus sp.* (very high abundance), Diatoms: *Rhizosolenia sp.* (high abundance), *Coscinodiscus concinnus*,
HE639	10	10.05.2024	ca.12:30	003°00.01'	56°49.94'	66	5	Echinoidea: *Spatangus sp.* (very high abundance), Diatoms: *Rhizosolenia sp.* (high abundance), *Coscinodiscus concinnus, Guinardia flaccida, Ophiura sp.*?
HE639	11	10.05.2024	14:30	003°00.01'	56°59.94'	64.2	5	Echinoidea: *Spatangus sp.* (very high abundance), Diatoms: *Rhizosolenia sp.* (high abundance), *Coscinodiscus concinnus* (high abundance), *Guinardia flaccida*?
HE639	13	11.05.2024	06:00	003°56.92'	57°29.99'	63.3	5	Echinoidea: *Spatangus sp.* (very high abundance), Diatoms: *Rhizosolenia imbricata, Coscinodiscus concinnus* (high abundance), Dinoflagellata: *Ceratium sp.*, Haptophyta: *Phaeocystis globosa*
HE639	14	11.05.2024	07:31	003°50.05'	57°30.00'	66.5	5	Echinoidea: *Spatangus sp.*, Diatoms: *Rhizosolenia imbricata, Thalassiosira sp., Coscinodiscus concinnus*, Dinoflagellata: *Ceratium sp.*, Haptophyta: *Phaeocystis globosa*
HE639	15	11.05.2024	09:53	003°50.03'	57°20.03'	60.3	5	Echinoidea: *Spatangus sp.*, Diatoms: *Rhizosolenia imbricata, Thalassiosira sp.* (very high abundance), *Coscinodiscus concinnus, Detonula pumila*, Dinoflagellata: *Ceratium sp.*, Haptophyta: *Phaeocystis globosa*
HE639	16	11.05.2024	11:44	003°59.99'	57°19.99'	61.3	5	Diatoms: *Rhizosolenia imbricata, Thalassiosira sp.* (very high abundance), Echinoidea: *Spatangus sp.*, Crustacea: *Copepoda sp.*, Chloropyta: *Halosphaera sp.*

Cruise	Station	Date	Time	Longitude	Latitude	Bottom Depth	Sample Depth	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[m]	
HE639	17	11.05.2024	14:51	004°00.05'	57°09.97'	61.7	5	Diatoms: *Thalassiosira nordenskioeldii, Coscinodiscus concinnus*, *Leptocylindus minimus*, Echinoidea: *Spatangus sp.*, Dinoflagellata: *Ceratium sp.*, Copepoda: *Oncaeidae sp.*, Chloropyta: *Halosphaera sp.*
HE639	19	12.05.2024	05:55	003°30.04'	56°20.01'	65	5	Echinoidea: *Spatangus sp*., Diatoms: *Rhizosolenia sp.* (high abundance), Chloropyta: *Halosphaera sp*., *Ctenophora sp*.; *Nemertea Paleonemertidae*?
HE639	20	12.05.2024	08:10	003°30.02'	56°30.02'	64	5	Dinoflagellata: *Ceratium sp.* (rare), Chlorophyta: *Halosphaera sp.*, Annelida: *Poychaeta hesionidae*, generally: small amount of plankton, no diatoms
HE639	21	12.05.2024	10:24	003°29.97'	56°40.07'	60	5	Echinoidea: *Spatangus sp.* (very high abundance), Diatoms: *Rhizosolenia sp.*, Chloropyta: *Halosphaera sp*., Crustacea: *Calanus sp.* (Copepoda)
HE639	22	12.05.2024	ca.12:30	003°30.04'	56°50.00'	60	5	Echinoidea: *Spatangus sp*. (high abundance), Diatoms: *Rhizosolenia sp., Thalassiosira nordenskioeldii, Coscinodiscus radiatus,* Dinoflagellata, piece of plastic?
HE639	23	12.05.2024	14:45	003°29.98'	57°00.04'	61.1	5	Echinoidea: *Spatangus sp.* (extremely high abundance), Diatoms: *Coscinodiscus radiatus*, *Coscinodiscus concinnus*, Chloropyta: *Halosphaera sp.*, Haptophyta: *Phaeocystis globosa*, Crustacea: *Calanus sp.* (Copepoda)

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
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[m]	[l]
HE639	01	09.05.2024	06:31	004° 00.03' E	56° 20.00' N	70.00	66.0	12.00
HE639	01	09.05.2024	06:31	004° 00.03' E	56° 20.00' N	70.00	14.0	5.00
HE639	02	09.05.2024	8:37	004° 00.04' E	56° 30.00' N	64.50	61.0	12.00
HE639	02	09.05.2024	8:37	004° 00.04' E	56° 30.00' N	64.50	15.0	5.50
HE639	03	09.05.2024	10:45	004° 00.09' E	56° 39.99' N	51.00	47.0	12.00
HE639	03	09.05.2024	10:45	004° 00.09' E	56° 39.99' N	51.00	14.0	6.50
HE639	04	09.05.2024	12:54	004° 00.08' E	56° 49.97' N	55.00	52.0	8.10
HE639	04	09.05.2024	12:54	004° 00.08' E	56° 49.97' N	55.00	18.0	7.00
HE639	05	09.05.2024	15:55	004° 00.01' E	57° 00.00' N	60.00	56.0	7.00
HE639	05	09.05.2024	15:55	004° 00.01' E	57° 00.00' N	60.00	13.0	7.00
HE639	07	10.05.2024	6:00	003° 00.02' E	56° 20.00' N	79.50	70.0	9.00
HE639	07	10.05.2024	6:00	003° 00.02' E	56° 20.00' N	79.50	18.0	7.00
HE639	08	10.05.2024	8:16	002° 59.98' E	56° 29.99' N	70.50	68.0	7.00
HE639	08	10.05.2024	8:16	002° 59.98' E	56° 29.99' N	70.50	21.0	5.50
HE639	09	10.05.2024	10:25	002° 59.91' E	56° 40.00' N	66.00	64.0	5.00
HE639	09	10.05.2024	10:25	002° 59.91' E	56° 40.00' N	66.00	20.0	6.00
HE639	10	10.05.2024	12:34	003° 00.00' E	56° 49.95' N	66.00	63.0	5.00
HE639	10	10.05.2024	12:34	003° 00.00' E	56° 49.95' N	66.00	16.0	2.00
HE639	11	10.05.2024	14:37	002° 59.89' E	56° 59.95' N	64.30	63.0	7.00
HE639	11	10.05.2024	14:37	002° 59.89' E	56° 59.95' N	64.30	19.0	5.00
HE639	13	11.05.2024	6:16	003° 56.91' E	57° 30.00' N	63.60	63.0	1.60

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Sample Depth	Filtrated Amount
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[m]	[l]
HE639	13	11.05.2024	6:16	003° 56.91' E	57° 30.00' N	63.60	38.0	0.65
HE639	14	11.05.2024	7:50	003° 50.06' E	57° 30.01' N	66.10	65.0	1.10
HE639	14	11.05.2024	7:50	003° 50.06' E	57° 30.01' N	66.10	39.0	0.45
HE639	15	11.05.2024	10:10	003° 50.03' E	57° 20.03' N	59.90	56.0	2.75
HE639	15	11.05.2024	10:10	003° 50.03' E	57° 20.03' N	59.90	33.0	2.70
HE639	16	11.05.2024	11:57	003° 59.98' E	57° 29.98' N	61.10	59.0	4.00
HE639	16	11.05.2024	11:57	003° 59.98' E	57° 29.98' N	61.10	32.0	1.45
HE639	17	11.05.2024	14:05	004° 00.03' E	57° 09.98' N	61.80	59.0	4.55
HE639	17	11.05.2024	14:05	004° 00.03' E	57° 09.98' N	61.80	8.0	7.50
HE639	19	12.05.2024	6:12	003° 30.04' E	56° 20.01' N	68.40	66.0	12.60
HE639	19	12.05.2024	6:12	003° 30.04' E	56° 20.01' N	68.40	20.0	6.00
HE639	20	12.05.2024	8:20	003°30.02 E'	56°30.00' N	67.00	63.7	8.50
HE639	20	12.05.2024	8:20	003°30.02' E	56°30.00 ' N	67.00	21.0	7.50
HE639	21	12.05.2024	10:39	003°29.96' E	56°40.07' N	64.00	64.0	12.00
HE639	21	12.05.2024	10:39	003°29.96' E	56°40.07' N	64.00	22.6	6.00
HE639	22	12.05.2024	12:45	003°30.04' E	56°50.00' N	62.80	59.0	16.00
HE639	22	12.05.2024	12:45	003°30.04' E	56°50.00' N	62.80	23.0	14.00
HE639	23	12.05.2024	14:55	003°30.00' E	57°00.05' N	61.30	56.0	12.00
HE639	23	12.05.2024	14:55	003°30.00' E	57°00.05' N	61.30	12.0	7.50

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	Bot. Depth	Depth above Seafloor	Filtrated Amount	Filter empty	Filter dried	Filtrate	Concentration
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[cm]	[l]	[mg]	[mg]	[mg]	[mg/l]
HE639	01	09.05.2024	6:40	004°00.01'	56°19.99'	65.0	28.5	5.00	126.11	132.45	6.34	1.27
HE639	01	09.05.2024	6:40	004°00.01'	56°19.99'	65.0	58.0	5.00	123.18	129.09	5.91	1.18
HE639	01	09.05.2024	6:40	004°00.01'	56°19.99'	65.0	110.5	5.50	128.15	141.04	12.89	2.34
HE639	02	09.05.2024	8:45	004°00.02'	56°30.00'	57.0	28.5	4.50	130.24	136.13	5.89	1.31
HE639	02	09.05.2024	8:45	004°00.02'	56°30.00'	57.0	58.0	5.00	126.86	132.23	5.37	1.07
HE639	02	09.05.2024	8:45	004°00.02'	56°30.00'	57.0	110.5	5.00	126.18	131.66	5.48	1.10
HE639	03	09.05.2024	10:54	004°00.05'	56°39.98'	51.0	28.5	5.00	125.75	130.75	5.00	1.00
HE639	03	09.05.2024	10:54	004°00.05'	56°39.98'	51.0	58.0	5.00	133.30	138.00	4.70	0.94
HE639	03	09.05.2024	10:54	004°00.05'	56°39.98'	51.0	110.5	5.00	126.15	131.52	5.37	1.07
HE639	04	09.05.2024	13:05	003°59.98'	56°49.98'	52.2	28.5	5.00	137.03	142.99	5.96	1.19
HE639	04	09.05.2024	13:05	003°59.98'	56°49.98'	52.2	58.0	5.00	126.02	153.72	27.70	5.54
HE639	04	09.05.2024	13:05	003°59.98'	56°49.98'	52.2	110.5	5.00	138.82	144.77	5.95	1.19
HE639	05	09.05.2024	15:05	004°00.06'	57°00.01'	57.8	28.5	5.00	124.81	130.62	5.81	1.16
HE639	05	09.05.2024	15:05	004°00.06'	57°00.01'	57.8	58.0	5.00	124.89	128.90	4.01	0.80
HE639	05	09.05.2024	15:05	004°00.06'	57°00.01'	57.8	110.5	5.00	126.51	136.21	9.70	1.94
HE639	07	10.05.2024	6:25	003°00.03'	56°19.99'	70.5	28.5	4.00	125.79	131.14	5.35	1.34
HE639	07	10.05.2024	6:25	003°00.03'	56°19.99'	70.5	58.0	5.00	127.76	133.44	5.68	1.14
HE639	07	10.05.2024	6:25	003°00.03'	56°19.99'	70.5	110.5	5.00	125.00	129.87	4.87	0.97
HE639	08	10.05.2024	8:40	002°59.99'	56°30.00'	70.4	28.5	3.50	131.39	138.35	6.96	1.99
HE639	08	10.05.2024	8:40	002°59.99'	56°30.00'	70.4	58.0	5.00	136.92	141.39	4.47	0.89

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Depth above Seafloor	Filtrated Amount	Filter empty	Filter dried	Filtrate	Concentration
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[cm]	[l]	[mg]	[mg]	[mg]	[mg/l]
HE639	08	10.05.2024	8:40	002°59.99'	56°30.00'	70.4	110.5	5.00	130.74	134.37	3.63	0.73
HE639	09	10.05.2024	-	-	-	-	28.5	-	-	-	-	-
HE639	09	10.05.2024	-	-	-	-	58.0	-	-	-	-	-
HE639	09	10.05.2024	-	-	-	-	110.5	-	-	-	-	-
HE639	10	10.05.2024	13:00	003°00.00'	56°49.99'	66.0	28.5	4.00	129.20	136.28	7.08	1.77
HE639	10	10.05.2024	13:00	003°00.00'	56°49.99'	66.0	58.0	5.00	129.66	134.33	4.67	0.93
HE639	10	10.05.2024	13:00	003°00.00'	56°49.99'	66.0	110.5	5.00	135.99	140.86	4.87	0.97
HE639	11	10.05.2024	14:59	003°00.01'	56°59.94'	64	28.5	5.00	137.00	143.24	6.24	1.25
HE639	11	10.05.2024	14:59	003°00.01'	56°59.94'	64	58.0	5.00	139.09	144.11	5.02	1.00
HE639	11	10.05.2024	14:59	003°00.01'	56°59.94'	64	110.5	5.00	137.51	141.86	4.35	0.87
HE639	13	11.05.2024	6:29	003°56.91'	57°29.99'	63	28.5	2.00	140.39	142.15	1.76	0.88
HE639	13	11.05.2024	6:29	003°56.91'	57°29.99'	63	58.0	2.00	139.26	143.23	3.97	1.99
HE639	13	11.05.2024	6:29	003°56.91'	57°29.99'	63	110.5	2.00	139.64	144.26	4.62	2.31
HE639	14	11.05.2024	7:57	003°50.06'	57°30.01'	66.0	28.5	2.00	137.35	143.55	6.20	3.10
HE639	14	11.05.2024	7:57	003°50.06'	57°30.01'	66.0	58.0	1.40	123.44	132.54	9.10	6.50
HE639	14	11.05.2024	7:57	003°50.06'	57°30.01'	66.0	110.5	1.40	140.70	143.38	2.68	1.91
HE639	15	11.05.2024	10:13	003°50.03'	57°20.03'	60.0	28.5	2.00	138.81	145.17	6.36	3.18
HE639	15	11.05.2024	10:13	003°50.03'	57°20.03'	60.0	58.0	3.00	141.45	147.69	6.24	2.08
HE639	15	11.05.2024	10:13	003°50.03'	57°20.03'	60.0	110.5	2.00	140.13	144.36	4.23	2.12
HE639	16	11.05.2024	12:08	003°59.97'	57°19.99	61.0	28.5	3.00	138.31	167.35	29.04	9.68
HE639	16	11.05.2024	12:08	003°59.97'	57°19.99	61.0	58.0	3.00	138.37	166.55	28.18	9.39
HE639	16	11.05.2024	12:08	003°59.97'	57°19.99	61.0	110.5	2.00	138.50	164.52	26.02	13.01
HE639	17	13.05.2023	-	-	-	-	28.5	-	-	-	-	-

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Depth above Seafloor	Filtrated Amount	Filter empty	Filter dried	Filtrate	Concentration
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[cm]	[l]	[mg]	[mg]	[mg]	[mg/l]
HE639	17	13.05.2023	-	-	-	-	58.0	-	-	-	-	-
HE639	17	13.05.2023	-	-	-	-	110.5	-	-	-	-	-
HE639	19	14.05.2023	6:26	003°30.03'	56°20.01'	65.5	28.5	5.0	138.44	147.48	9.04	1.81
HE639	19	14.05.2023	6:26	003°30.03'	56°20.01'	65.5	58.0	5.0	137.71	147.25	9.54	1.91
HE639	19	14.05.2023	6:26	003°30.03'	56°20.01'	65.5	110.5	5.0	139.19	146.49	7.30	1.46
HE639	20	14.05.2023	8:25	003°29.92'	56°30.01'	64.3	28.5	5.0	137.12	162.53	25.41	5.08
HE639	20	14.05.2023	8:25	003°29.92'	56°30.01'	64.3	58.0	5.0	139.71	145.71	6.00	1.20
HE639	20	14.05.2023	8:25	003°29.92'	56°30.01'	64.3	110.5	5.0	139.14	145.12	5.98	1.20
HE639	21	14.05.2023	10:36	003°29.7'	56°40.04'	61.0	28.5	5.0	137.67	145.33	7.66	1.53
HE639	21	14.05.2023	10:36	003°29.7'	56°40.04'	61.0	58.0	5.0	134.72	140.01	5.29	1.06
HE639	21	14.05.2023	10:36	003°29.7'	56°40.04'	61.0	110.5	5.0	137.40	142.43	5.03	1.01
HE639	22	14.05.2023	12:34	003°29.99'	56°49.99'	59.6	28.5	4.8	135.33	160.05	24.72	5.20
HE639	22	14.05.2023	12:34	003°29.99'	56°49.99'	59.6	58.0	5.0	137.52	142.28	4.76	0.95
HE639	22	14.05.2023	12:34	003°29.99'	56°49.99'	59.6	110.5	5.0	139.69	145.80	6.11	1.22
HE639	23	14.05.2023	15:06	003°30.00'	57°00.05'	61.1	28.5	4.1	135.16	140.60	5.44	1.33
HE639	23	14.05.2023	15:06	003°30.00'	57°00.05'	61.1	58.0	5.0	136.71	142.80	6.09	1.22
HE639	23	14.05.2023	15:06	003°30.00'	57°00.05'	61.1	110.5	5.0	137.31	142.72	5.41	1.08

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 Colour 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	Permability	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]		[m]	
HE639	01	09.05.2024	7:08	004°00.08'	56°20.01'	67.0	4	0.00136	Silty sand (5Y 3/2) underneath fine sand (5Y 5/2) shell fragments (poor preservation), worms, reducing conditions, slight black colouring
HE639	02	09.05.2024	8:59	004°00.01'	56°30.01'	62.0	3-4	0.00863	Fine sand (5YR 6/4), merging into more silt (10YR 4/2), slight cohesiveness, many shells (often well preserved), snails, worms
HE639	03	09.05.2024	11:16	004°00.09'	56°39.99'	48.4	5 & 3	0.01400	Coarse-grained sand, low silt content (2.5Y 5/4), occasional black colouring (2.5Y 3/1), shells (including cockles, some in good condition)
HE639	04	09.05.2024	12:53	004°00.02'	56°49.99'	52.0	5 & 3	0.00337	Coarse-grained sand, but also silt (2.5Y 5/4), black parts (2.5Y 3/1), occasional shells (poor preservation)
HE639	05	09.05.2024	15:05	003°59.99'	56°59.99'	58.0	6	0.01183	Coarse-grained (10YR 5/4), very little silt, little black content (2.5 Y 3/1), very shelly, partly well preserved

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Grain size	Permability	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]		[m]	
HE639	07	10.05.2024	6:50	003°00.01'	56°19.99'	70.5	4 & 2	0.00106	Fine sand with silt content, light-coloured portion (5Y 3/2) less than darker portion (5Y 2/2), shell-bearing (shell fragments not well preserved), sea urchins
HE639	08	10.05.2024	8:45	002°59.99'	56°30.00'	70.5	4 & 2	0.00074	Filty fine sand (5Y 3/2 and 5Y 2/2), worms, occasional shell fragments (one well-preserved shell)
HE639	09	10.05.2024	11:15	002°59.97'	56°40.00'	66.0	4 & 2	0.00086	Silty fine sand (top: 5Y 4/3, centre: 5Y 3/1, bottom: 5Y 3/2), crab, sea urchin, worm, shell fragments only in the lowest third
HE639	10	10.05.2024	13:10	003°00.12'	56°49.87'	66.0	4 & 2	0.00068	Silty fine sand, (top; 5Y 4/2, bottom: 7.5Y 3/2), worm, bottom shell fragments
HE639	11	10.05.2024	15:10	003°00.00'	56°59.99	64.5	4 & 2	0.00386	Silty fine sand (top: 5Y 4/2, bottom: 10Y 3/1), shell fragments at the bottom (occasional whole shells), sea urchin, worm
HE639	13	11.05.2024	6:45	003°56.91'	57°29.99'	63.7	5	0.01050	Medium sand (5Y 5/4), shells (arctica islandica), scaphopods, little organic matter, in the lower part partly dark patches (anoxic)
HE639	14	11.05.2024	8:12	003°50.07	57°30.00'	66.5	5 & 4	0.00840	Medium sand with fine sand content (5Y 4/4), no silt, dark patches (anoxia) in the lower area

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Grain size	Permability	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]		[m]	
HE639	15	11.05.2024	10:32	003°50.02'	57°20.01'	60.2	4-5	0.00483	Medium-fine sand (2.5Y 4/3 and 5Y 3/2), partly dark patches (anoxic), shells (artica islandica), worm
HE639	16	11.05.2024	12:23	003°59.97'	57°19.98'	61.2	4-5	0.01208	Fine-medium sand (2.5 Y 4/4), partly dark colouring (anoxic, 5 Y 4/2), shells (many, not all well preserved), snail, scaphopods, plastic
HE639	17	11.05.2024	14:49	004°00.10'	57°09.93'	61.9	4-5	0.00177	Fine-medium sand (5Y 5/3), partly anoxic (5Y 3/1), plastic, scaphopods. Bristle worm, occasional shill
HE639	19	12.05.2024	6:38	003°30.04'	56°20.01'	65.0	4-5	0.00097	Medium fine sand (top: 10YR 5/4), partly anoxic at the bottom with 2.5YR 3/1, sea urchins, shells, plastic
HE639	20	12.05.2024	8:45	003°30.03'	56°30.03'	64.0	4	0.00191	Feinsand (oben: 2.5Y 5/3), tlw. Anoxisch (2.5Y 4/1; 2.5Y 3/1), arctica islandica, Borstenwürmer
HE639	21	12.05.2024	11:07	003°29.97'	56°40.07'	60.0	4 & 2	0.00000	Silty fine sand (top: 2.5Y 5/4 bottom: 2.5Y 3/1), lower area anoxic, shells well preserved including arctica islandica
HE639	22	12.05.2024	13:19	003°29.74'	56°50.02'	60.0	4	0.00102	Fine sand (top: 10YR 5/6; bottom: 10YR 2/1), lower area anoxic, shells and worms
HE639	23	12.05.2024	15:18	003°30.00'	57°00.05'	61.0	4	0.00033	Fine sand (5Y 4/4) and higher silt content, underlying dark layer (10GY 2/1)

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 Colour 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.yy	[UTC]	[°E]	[°N]	[m]	[cm]	[m]		
HE639	01	09.05.2024	7:07	004°00.03'	56°20.01'	67.0	0-2	0.165	4	Fine sand with low silt content, 0 - 6 cm colour 5Y 5/6, 6 - 10 cm colour 7.5Y 2/1, 10 - 16.5 colour 10Y 4/1, shill/bivalve fragments, scaphopods, echinodermata
HE639	01	09.05.2024	7:07	004°00.03'	56°20.01'	67.0	0-5	0.165	4	
HE639	02	09.05.2024	9:10	004°00.06'	56°30.04'	61.5	0-2	0.12	4	Fine sand with silt content, colours: 2.5Y 5/3 in the first 2 - 4 cm, below 5Y 4/3 and 2.5Y 3/1
HE639	02	09.05.2024	9:10	004°00.06'	56°30.04'	61.5	0-5	0.12	4	
HE639	03	09.05.2024	11:22	004°00.06'	56°39.99'	48.7	0-2	0.18	5	Medium sand with the colours 2.5Y 5/4 from 0 - 10 cm and 5Y 4/1 from 10 - 18 cm, coarse bivalve shill
HE639	03	09.05.2024	11:22	004°00.06'	56°39.99'	48.7	0-5	0.18	5	
HE639	04	09.05.2024	13:28	003°59.97'	56°50.00'	52.0	0-2	0.165	4	Fine sand with low silt content, shill
HE639	04	09.05.2024	13:28	003°59.97'	56°50.00'	52.0	0-5	0.165	4	Fine sand with low silt content, shill, echinodermata
HE639	05	09.05.2024	15:26	003°59.99'	56°59.99'	57.7	0-2	0.19	5	Medium sand with lots of shill, colours: 0 - 4 cm 5Y 5/4, 4 - 19 cm alternating 5Y 3/4 and 5Y 3/1
HE639	05	09.05.2024	15:26	003°59.99'	56°59.99'	57.7	0-5	0.19	5	
HE639	07	10.05.2024	6:54	003°00.02'	56°20.01'	70.5	0-2	0.18	4	fluffy on the surface, fine sand with colour 5Y 5/3

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Sample Depth	Penetration Depth	Grain size	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[cm]	[m]		
HE639	07	10.05.2024	6:54	003°00.02'	56°20.01'	70.5	0-5	0.18	4	fluffy on the surface, fine sand with colour 5Y 5/3, dark layer (anoxia) 12-16 cm 5Y 5/1, layer with shill 16-20 cm 5Y 6/2
HE639	08	10.05.2024	09:09	002°59.98'	56°30.00	70.5	0-2	0.17	4	fluffy on the surface, fine sand with colour 2.5Y 5/3
HE639	08	10.05.2024	09:09	002°59.98'	56°30.00	70.5	0-5	0.17	4	fluffy on the surface, fine sand with colour 2.5Y 5/3, dark layer at ~ 9 cm, shill/bivalve fragments
HE639	09	10.05.2024	11:23	002°59.93'	56°40.00'	66.0	0-2	0.18	4	Fine sand with silt content and bivalve fragments of colour 10YR 5/3
HE639	09	10.05.2024	11:23	002°59.93'	56°40.00'	66,0	0-5	0.18	4	Fine sand with silt content and bivalve fragments of colour 10YR 5/3, dark grey (anoxic) with colour 7.5YR 4/1 with bivalve fragments
HE639	10	10.05.2024	13:25	002°60.00'	56°49.95'	65.6	0-2	0.18	4	fluffy on the surface, fine sand with colour 2.5Y 6/3
HE639	10	10.05.2024	14:25	002°60.00'	56°49.95'	65.6	0-5	0.18	4	fluffy on the surface, fine sand with colour 2.5Y 6/4, bivalve fragments, fine sand with silt content dark grey (anoxic) with the colour 2.5Y 4/1
HE639	11	10.05.2024	15:14	002°59.95'	56°59.95'	64.0	0-2	0.14	4	Fine sand with the colour 2.5Y 6/3, bivalve fragments

Cruise	Station	Date	Time	Longitude	Latitude	Bot. Depth	Sample Depth	Penetration Depth	Grain size	Description
		dd.mm.yy	[UTC]	[°E]	[°N]	[m]	[cm]	[m]		
HE639	11	10.05.2024	15:14	002°59.95'	56°59.95'	64.0	0-5	0.14	4	Fine sand with the colour 2.5Y 6/3, bivalve fragments, silty fine sand dark grey (anoxic) of the colour 2.5Y 4/1 with bivalve components and echinodermata
HE639	13	11.05.2024	07:03	003°56.91'	57°29.99'	63.4	0-2	0.14	4&5	Fine sand with colour 2.5Y 5/4 and medium sand with 2.5Y 4/4, crushed bivalves
HE639	13	11.05.2024	07:03	003°56.91'	57°29.99'	63.4	0-5	0.14	4&5	
HE639	14	11.05.2024	08:01	003°50.07'	57°30.00'	66.4	0-2	0.14	4&5	Fine and medium sand with two colours (5Y 5/4 and 5Y 4/3), bivalves, lugworm on surface
HE639	14	11.05.2024	08:01	003°50.07'	57°30.00'	66.4	0-5	0.14	4&5	
HE639	15	11.05.2024	09:50	003°50.03'	57°20.03'	60.0	0-2	0.08	4&5	one layer (5Y 6/4) lots of bivalve shill
HE639	15	11.05.2024	09:50	003°50.03'	57°20.03'	60.0	0-3	0.08	4&5	one layer (5Y 6/4) a lot of bivalve shill only 3 cm could be taken
HE639	16	11.05.2024	11:45	003°59.98'	57°19.99'	61.4	0-2	0.08	5	2.5Y 5/3, few bivalve shill
HE639	16	11.05.2024	11:45	003°59.98'	57°19.99'	61.4	0-5	0.08	5	
HE639	17	11.05.2024	14:59	004°00.03'	57°09.97'	61.8	0-2	0.18	4&5	two layers (top: 2.5Y 5/3, bottom: 2.5Y 3/2), bivalves, light stripe pattern
HE639	17	11.05.2024	14:59	004°00.03'	57°09.97'	61.8	0-5	0.18	4&5	
HE639	19	12.05.2024	6:56	003°30.03'	56°20.00'	65.6	0-2	0.20	4	fluffy, 2 layers (top: 5Y 4/3, bottom: 5Y 3/1), little shill
HE639	19	12.05.2024	6:56	003°30.03'	56°20.00'	65.6	0-5	0.20	4	
HE639	20	12.05.2024	9:11	003°30.03'	56°30.03'	64.0	0-2	0.16	4	two layers (top: 7.5Y 3/2, bottom 7.5Y 2/1), few bivalve fragments
HE639	20	12.05.2024	9:11	003°30.03'	56°30.03'	64.0	0-5	0.16	4	
HE639	21	12.05.2024	11:19	003°29.97'	56°40.07'	60.0	0-2	0.09	4	fluffy, 2.5Y 3/3, lots of shill
HE639	21	12.05.2024	11:19	003°29.97'	56°40.07'	60.0	0-5	0.09	4	
HE639	22	12.05.2024	13:29	003°30.04'	56°50.00'	60.0	-	-	-	Failed attempt
HE639	23	12.05.2024	15:29	003°30.00'	57°00.05'	61.3	0-2	0.06	4	5Y 5/3, bivalves, silt content
HE639	23	12.05.2024	15:29	003°30.00'	57°00.05'	61.3	0-5	0.06	4	

11.7 Selected Pictures of Samples

Fig. 11.1 vVG samples from stations HE639-01 - HE639-09.

Fig. 11.2 vVG samples from stations HE639-10 - HE639-19.

Fig. 11.3 vVG samples from stations HE639-20 - HE639-23.

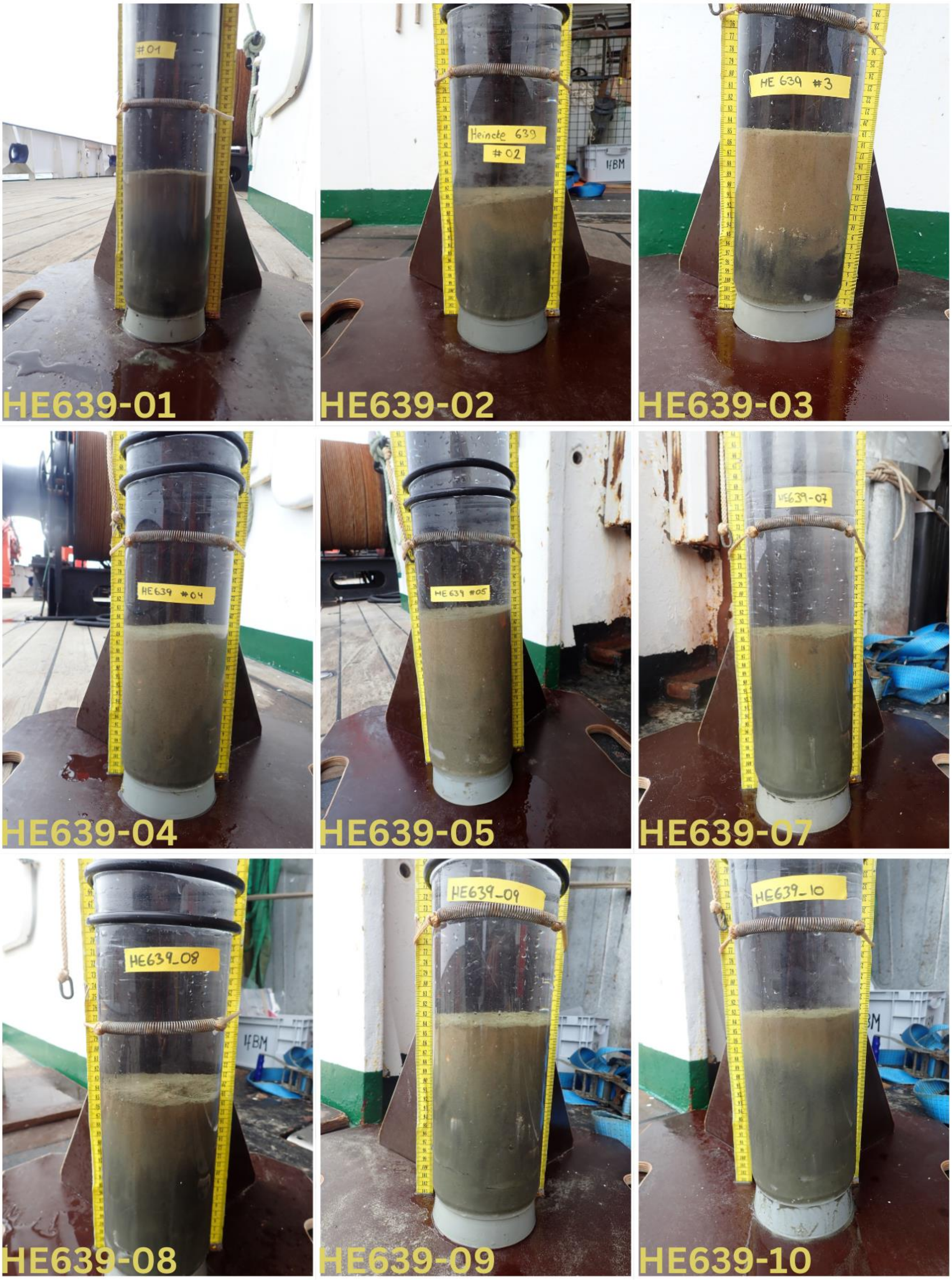

Fig. 11.4 MUC samples from stations HE639-01 - HE639-10.

Fig. 11.5 MUC samples from stations HE639-11 - HE639-21.

Fig. 11.6 MUC sample from station HE639-23.

11.8 Selected Pictures of Shipboard Operations

Fig. 11.7 Filling bottles with the CTD samples.

Fig. 11.8 Filtration.

Fig. 11.9 Filling bottles with the BWS samples.

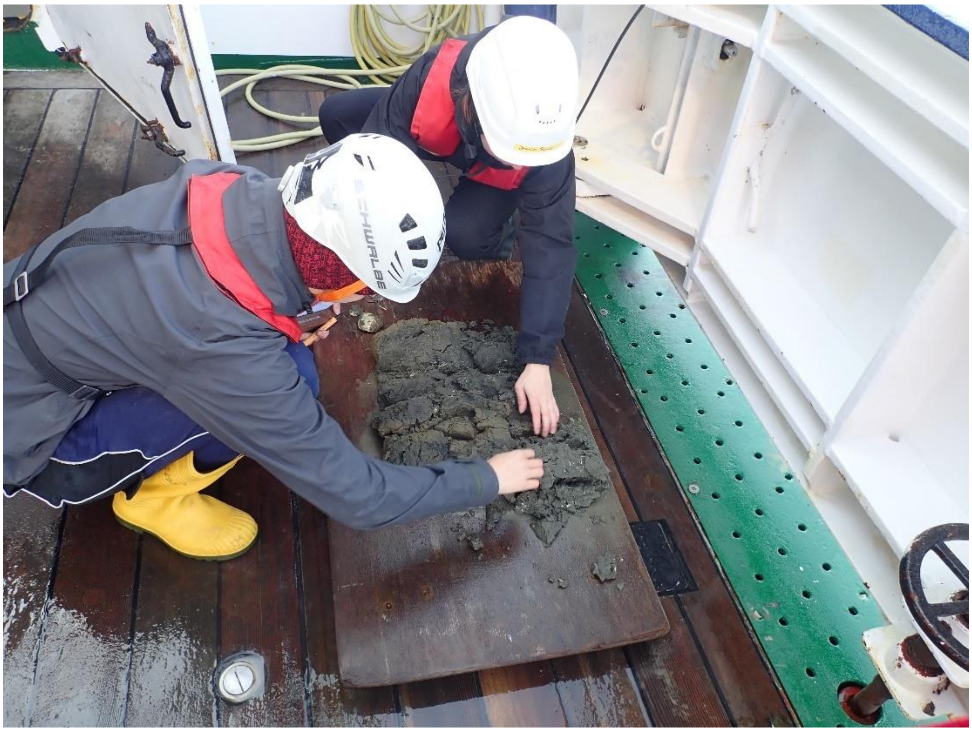

Fig. 11.10 Student examining and describing a sample from the vVG.

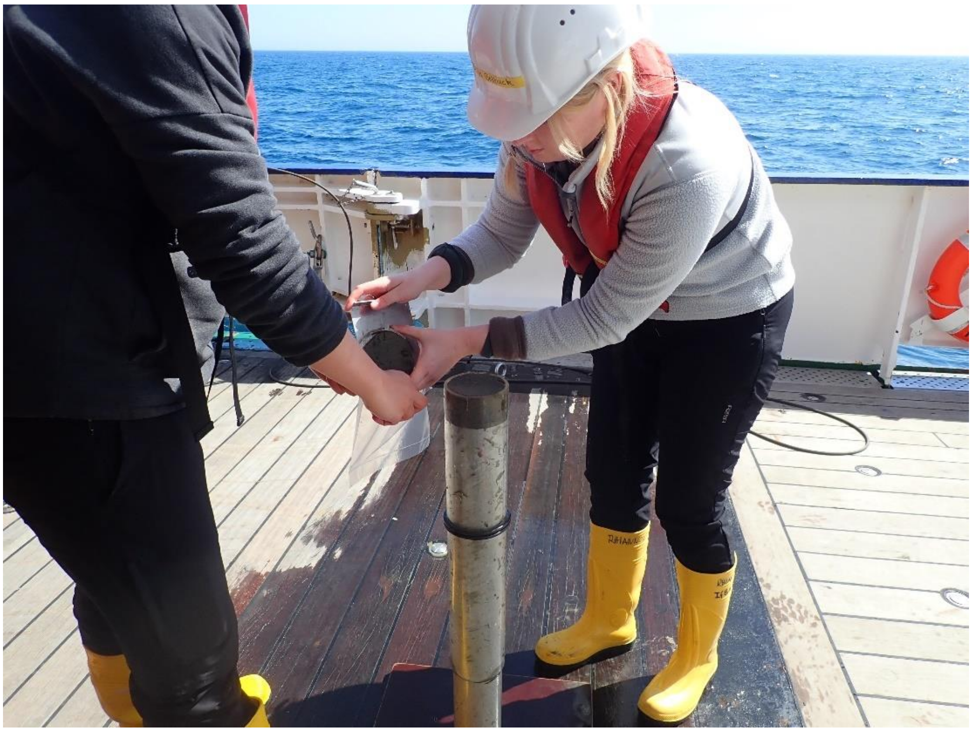

Fig. 11.11 Processing of the MUC sample.

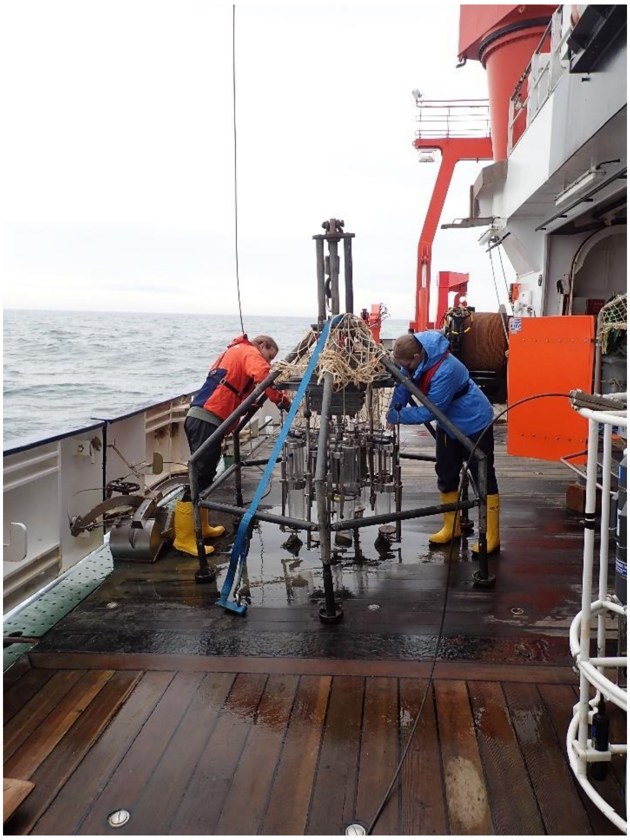

Fig. 11.12 Preparing the MUC.

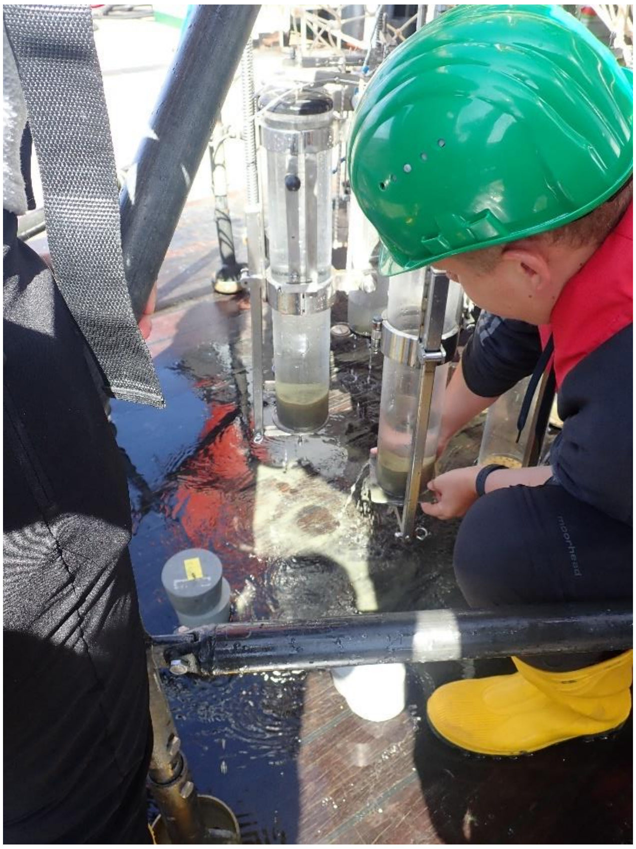

Fig. 11.13 Processing of the MUC sample.