HEINCKE-Berichte

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

Cruise No. HE577

25.05.2021 – 01.06.2021,
Bremerhaven (Germany) – Bremerhaven (Germany)

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2021

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1 Cruise Summary

1.1 Summary in English

(R. S. Breider, L. Budke)

The cruise HE577 was conducted with the German research vessel RV HEINCKE. The cruise started on Wednesday, May 26, 2021, and ended on Tuesday, June 01, 2021, both in Bremerhaven, Germany. The objective of the cruise was to learn and perform marine sampling procedures of the water column and seafloor surface sediment. Furthermore, seismic profiling was performed to extend and complete the bathymetry of the North Sea.

The research cruise is implemented in the Master's program in Geosciences at the Universität Hamburg (course "Marine-geological practical course" (LV 63-345)). During the cruise, eight students learned the standard methods of water sampling (more specifically: suspended matter sampling), sediment sampling and gained first impressions and knowledge of marine research. Moreover, the training included insights into geophysical measurement methods (more precisely: hydroacoustic methods of sediment mapping). For this purpose, the multibeam echosounder EM710 from KONGSBERG and the INNOMAR sediment echosounder SES-2000 were used. In addition to the technical aspects of the equipment and sampling procedures, the participants learned about the life on board of a research vessel.

The research area was located in the in the exclusive economic zone (EEZ) of Germany, Denmark, and Norway. In the German EEZ, only hydroacoustic data was collected. In six working days, a total of 22 stations were sampled. Furthermore, six profiling surveys were performed (962 km Multibeam and SES, 1634 km ADCP). Station sampling always started with a Secchi Disk to record the depth of visibility and an Apstein phytoplankton net (mesh size 25 µm), which were both lowered into the water by hand. As the station progressed, plankton samples were described and determined using a stereomicroscope. The depth of view varied between 6 and 12.5 m, and the Apstein plankton net was used at depths of up to 12 m. In addition, a CTD-rosette was used to sample the water column. Due to the often minor differences in the water column, only two depths of the water column were sampled (Surface: 2 to 5 m; Bottom: 34 to 66 m depending on water depth). The bottom water sampler (BWS) was successfully deployed at 20 stations, followed by a van-Veen-Grab (vVG) (22 stations) to get a first impression of the sediment and its composition. Afterward, if possible, a Multi-Corer (MUC) was deployed (at 17 stations). The Secchi Disk, the Apstein phytoplankton net, the CTD-rosette, and the vVG worked properly at all stations. The BWS had to be triggered mechanically with a fishing rod from station 21 onwards due to a technical defect. The MUC was not deployed at 5 stations due to coarse sediments. Over the cruise, a total of 44 suspended matter samples were collected with the CTD. Additionally, 58 samples of the BWS were filtered. The sediment was sampled 22 times with the vVG and a permeability test was performed 18 times. The MUC extracted 192 sediment samples (1-cm-intervals). These samples are available to the working group's Biogeochemistry and Micropalaeontology of the Universität Hamburg for further scientific work.

1.2 Zusammenfassung

(R. S. Breider, L. Budke)

Die Fahrt HE577 wurde mit dem deutschen Forschungsschiff FS HEINCKE durchgeführt. Sie begann am Mittwoch, den 26.05.2021 und endete am Dienstag, den 01.06.2021, jeweils in Bremerhaven, Deutschland. Ziel der Ausfahrt waren die Erlernung und Durchführung mariner Beprobungsverfahren der Wassersäule und des Oberflächensediments sowie die seismische Profilaufnahme zur Erweiterung und Vervollständigung der Bathymetrie der Nordsee. Die Ausfahrt ist Teil des Masterstudienganges Geowissenschaften der Universität Hamburg (Lehrveranstaltung „Marin-geologisches Praktikum" (LV 63-345)). Im Rahmen der Fahrt lernten acht Studierende die Standardmethoden der Wasser-, Schwebstoff-, und Sedimentbeprobung kennen und erhielten erste Eindrücke und Kenntnisse der marinen Forschungslandschaft. Die Ausbildung wurde zudem durch Einblicke in geophysikalische Messmethoden (hydroakustische Methoden) der Sedimentkartierung erweitert. Dafür wurden das Fächerecholot EM710 von KONGSBERG und das INNOMAR Sedimentecholot SES-2000 verwendet. Neben der technischen Auseinandersetzung mit den Geräten und den Beprobungsverfahren lernten die Teilnehmer das Leben an Bord eines Forschungsschiffes kennen.

Das Forschungsgebiet befand sich in der Ausschließlichen Wirtschaftszone (AWZ) Deutschlands, Dänemarks und Norwegens, wobei in der deutschen AWZ ausschließlich hydroakustische Daten erhoben wurden. In sechs Arbeitstagen wurden insgesamt 22 Stationen beprobt, weiterhin fanden sechs Profilfahrten statt (962 km Multibeam und SES, 1634 km ADCP).

Die Beprobung erfolgte zunächst mithilfe einer Secchi-Scheibe zur Erfassung der Sichttiefe und einem Apstein-Phytoplanktonnetz (Maschenweite 25 μm), welche händisch zu Wasser gelassen wurden. Im weiteren Stationsverlauf wurden die Planktonproben mithilfe eines Stereomikroskops beschrieben und bestimmt. Die Sichttiefe variierte zwischen 6 und 12.5 m, das Apstein-Planktonnetz wurde in Tiefen bis zu 12 m eingesetzt. Folgend wurde mit einer CTD-Rosette die Wassersäule beprobt. Wegen der geringen Ausprägung von Unterschieden (eine Tiefwasserschicht und eine Oberflächenwasserschicht) wurden lediglich zwei verschiedene Tiefen der Wassersäule beprobt (Oberfläche: 2-5 m; Tiefe: 34-66 m je nach Wassertiefe). Der Bodenwasserschöpfer (BWS) kam an 20 Stationen erfolgreich zum Einsatz, darauffolgend wurde ein van-Veen-Greifer (vVG) genutzt (22 Stationen), um einen ersten Eindruck über das Sediment und dessen Beschaffenheit zu erhalten. Daraufhin wurde, wenn möglich, ein Multi-Corer (MUC) eingesetzt (17 Stationen). Die Secchi-Scheibe, das Apstein-Phytoplanktonnetz, die CTD-Rosette und der vVG wurden bei allen Stationen erfolgreich verwendet. Der BWS musste ab Station 21 aufgrund eines technischen Defekts mechanisch mit einer Angel ausgelöst werden. Der MUC wurde an fünf Stationen wegen zu groben Sedimenten nicht eingesetzt. Über die Ausfahrt hinweg wurden insgesamt 44 Proben mit der CTD-Rosette entnommen und die Suspension filtriert. Zusätzlich konnten 58 BWS Proben filtriert werden. Mit dem vVG wurde 22 mal das Sediment beprobt und 18 mal ein Permeabilitätsversuch durchgeführt. Mit dem MUC konnten 192 Sedimentproben entnommen werden. Die Proben wurden im Labor an Bord für weitere Analysen aufbereitet und stehen nach Fahrtende den Arbeitsgruppen Biogeochemie sowie der Mikropaläontologie der Universität Hamburg zur Verfügung.

2 Participants

(R. S. Breider, L. Budke)

Tab. 2.1 List of the participating members and their position on board.

Name	Discipline	Institution
Lahajnar, Niko, Dr.	Chief scientist, Biogeochemistry	Universität Hamburg
Lüdmann, Thomas, Dr.	Hydroacustics, Sequence Stratigraphy	Universität Hamburg
Metzke, Marc	Technician	Universität Hamburg
Artschwager, Maike Frederike	Student (M.Sc. student)	Universität Hamburg
Bonow, Christoph	Student (M.Sc. student)	Universität Hamburg
Breider, Rhiannon Samsara	Student (M.Sc. student)	Universität Hamburg
Budke, Linus	Student (M.Sc. student)	Universität Hamburg
Knauer, Talitha	Student (M.Sc. student)	Universität Hamburg
Maak, Joely Marie	Student (M.Sc. student)	Universität Hamburg
Maier, Jan	Student (M.Sc. student)	Universität Hamburg
Stoldt, Finja	Student (M.Sc. student)	Universität Hamburg

The participating institution is:
UHH, IfGeo Universität Hamburg, Institute for Geology, working group Biogeochemistry.

3 Research Program

3.1 Description of the Work Area

(T. Knauer, J. M. Maak)

The cruise HE577 investigated the northern part of the North Sea. The North Sea is a shallow continental shelf sea with a total north-south extension of 900 km and an east-west extension of 500 km. Generally, the North Sea has an area of 570 000 km^2 and is restricted by the European mainland in the south, by Scandinavia in the east, and by Great Britain in the west. (Schwarzer et al., 2019).

The geological development of the North Sea has its origin in the Devonian (400 Ma before present) in which the Caledonian orogeny takes place. In the Carboniferous (360 Ma before present) the North Sea existed as a shallow depression with swamp deposits. The majority of the petroleum and natural gas parent rocks in the recent area of the North Sea originated in this geological area. In the late Carboniferous and the early Permian, horst-graben structures developed in the North Sea. Two of the most important horst-graben structures are the Vikingrift and the Centralrift. The Alpine Orogeny in the early Paleogene led to a subsidence of the rift systems in the North Sea. The Pleistocene (2.588 Ma – 11 700 a before present) is characterized by a change of glacial and interglacial periods which had a significant influence on the development of the North Sea. Due to the change between glacial and interglacial periods the sea level changed over that period (Streif, 2004, Zeiler et al., 2008, Schwarzer et al., 2019).

During the cruise, most of the work has been done in the Danish Exclusive Economic Zone (EEZ). However, seven stations were located in the Norwegian EEZ further north (Fig. 3.1a, stations 17 to 19 and 21 to 25). Moreover, hydroacoustic information about the seabed was recorded during the cruise (Fig. 3.1b, Fig. 5.21).

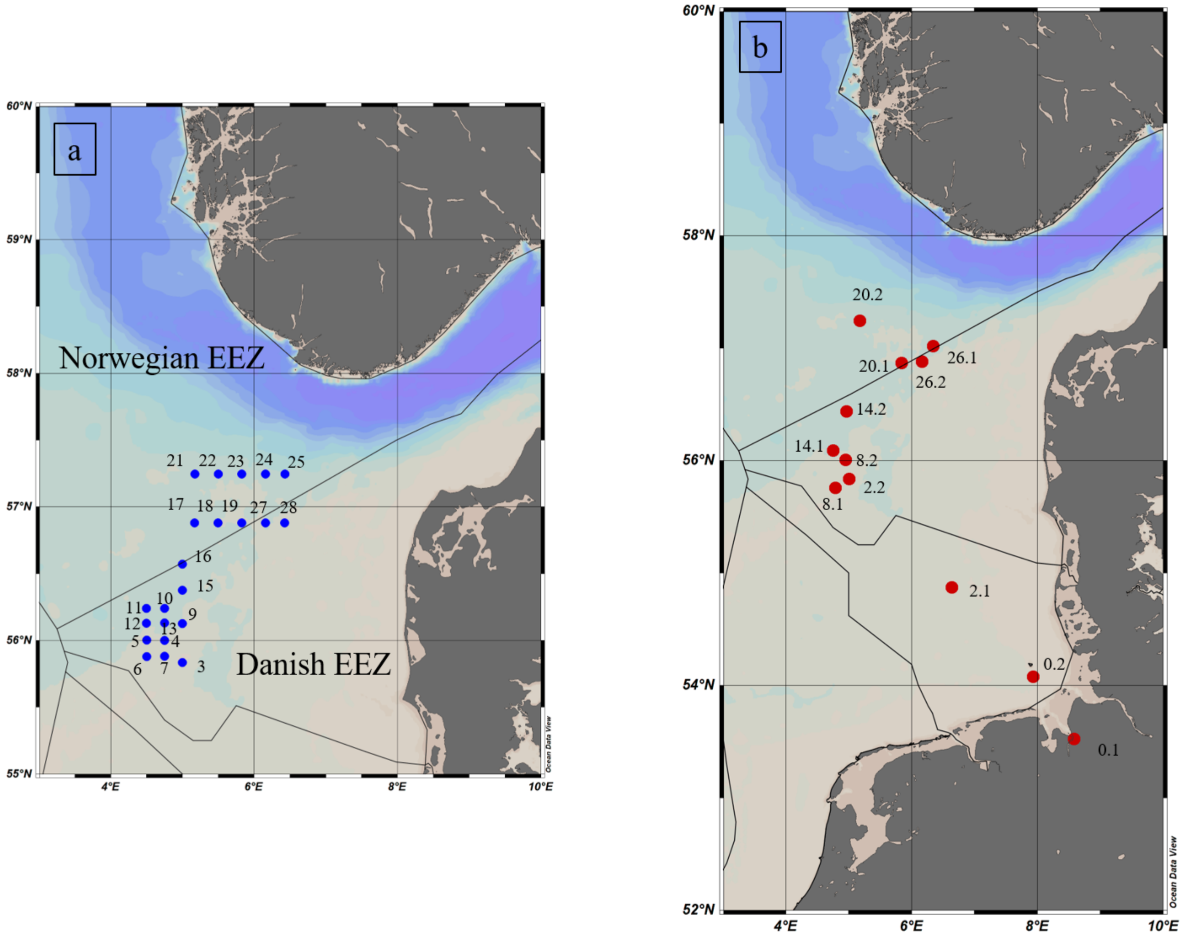

Fig. 3.1 Working area of cruise HE577. a: stations (blue points) where sediment and water samples were taken (including station numbers), b: stations (red points) where hydroacoustic information of the seabed was recorded. x.1: profile start, x.2: profile end, plotted with Ocean Data View. Station 1 is not shown since it was only a test station for the operability of the equipment. However, it is located near Point 0.2 (b). The shapefile containing the information about the Exclusive Economic Zone (EEZ) positions is from Flanders Marine Institute (2019).

The mean bottom depth of the working area was about 55 meters, with the deepest area in the northern part close to the Norwegian trench (up to the maximum of 73 m bottom depth at station 24). The expected sediment type of the seabed is mostly fine sand (see Bockelmann et al. (2018)).

3.2 Aims of the Cruise

(R. S. Breider, L. Budke)

The overall objective of the HE577 cruise was to teach master students from the Universität Hamburg the basics of geoscientific research in the field of marine geology and biogeochemistry. The methods but also the technical functioning and operation of the equipment were discussed and learned. Moreover, the students also gained experience concerning operational skills and daily life on board.

In addition to the educational aim, the scientific focus of the cruise was to investigate the water column and the sediments in the northern part of the North Sea as well as the mapping of the Paleo Elbe valley. The research area of cruise HE577 included the Danish EEZ and the Norwegian EEZ. This cruise was an expansion of the research area as the previous practical courses of the Universität Hamburg only took place in the German and Danish sectors of the North Sea.

3.3 Agenda of the Cruise

(R. S. Breider, L. Budke)

First, the students were introduced to the upcoming technical and scientific tasks on board. The briefing was done on 25.05.21 by Marc Metzke and the following day by Dr. Niko Lahajnar. The participating students were divided into teams of two based on their cabin distribution so that each team was responsible for one sampling device for an entire expedition day. This allowed each team to become familiar with the instruments on board and to internalize its operation and handling through repeated work at the stations. The different tasks included the station management (the Secchi Disk, the Apstein-net, and the van-Veen-Grab (vVG)), the CTD-rosette (**c**onductivity, **t**emperature, and **d**epth are measured with this device), the bottom water sampler (BWS), or the Multi-Corer (MUC). On the first expedition day (26.05.2021), all instruments – except for the MUC - were tested during a test station in the German sector (near Helgoland) concerning their functionality.

During the cruise, the scientific station work was continued for four days by the students under the supervision of Marc Metzke and Dr. Niko Lahajnar. The last two stations on the fifth day (31.05.21) were sampled independently by the students.

The general workflow at the station always started by determining the depth of visibility using a Secchi Disk (also called Secchi depth). The Disk was lowered into the water by hand and guided according to the 4-eyes principle until it could no longer be seen. In the next step, also manually, an Apstein phytoplankton net was used at depths of up to 12 m. After the phytoplankton samples were extracted, the samples were then analyzed and described with a stereomicroscope. Afterward, the investigation of the water column continued by the usage of the CTD-rosette. In addition to the eponymous characteristic parameters conductivity, temperature, and depth, the instrument's sensors also recorded the dissolved oxygen concentration and chlorophyll fluorescence. Since only minor differences could be detected across stations during the instrument's veering, the water column was sampled at two depths (above the seafloor and in the surface water) during the heaving process. Subsequently, the suspension load obtained by the water samples was filtered onto GF/F glass fiber filters (pre-combusted at 450 °C). The sensors of the CTD-rosette are very sensitive concerning bottom contact, which is why samples were taken a few meters above the seafloor. However, in the deepest zone of the water body, close to the sediment surface, many interesting geochemical processes occur. To fill the data gap that appears due to the fragility of the CTD-rosette, the next step was to sample the near-bottom water column using the BWS. Sampling was conducted at three heights: 28 cm, 57 cm, and 110 cm above the seafloor. After sampling, the samples from the BWS were treated with the same procedure as the CTD samples. From station 18 onwards, the BWS had an electronic defect. Therefore, the BWS could no longer be operated by bottom contact only because the sampling bottles would not close. After unsuccessful attempts to repair the electronics, the BWS was mechanically released with a fishing rod starting at station 21. Next, the surface sediment was examined first by the vVG to get an impression of sediment composition, grain size, and epifauna and to take a sample for the permeability test. Furthermore, this first observation of the sediment served as a basis for deciding whether the MUC can be deployed in the next step. If the sediment sampling with the vVG only showed fine to medium-sized sediment, the MUC was deployed as the last instrument of the station run. When deploying this device, up to eight sediment cores with a length of up to 60 cm can be taken. The sampling of the individual core layers was done in either 1-cm-intervals (for the working group Biogeochemistry), or only the upper 2 cm and some of the bottom water were taken (for the working group Micropalaeontology). From station 10 on, the MUC was used with more weight to generate a better core yield. The samples of suspension and sediment, which were taken during this cruise, are available to the working group's Biogeochemistry and Micropalaeontology of the Universität Hamburg for further scientific work.

The evening program on board was characterized by a scientific seminar. There, scientific presentations on topics related to the North Sea were held by the students and were discussed. The program was completed by operational communication on board of a research vessel and knot theory. Moreover, hydroacoustic profiles intended for the mapping of the seafloor (Paleo Elbe valley) were recorded during the cruise. The KONGSBERG EM710 multibeam echosounder and the SES-2000 sediment echosounder were used for this purpose. After a short introduction by Dr. Thomas Lüdmann, the students were able to continue the profiling independently during a night shift.

4 Narrative of the Cruise

(R. S. Breider, L. Budke, F. Stoldt)

On the 25th of May 2021, by 11:00 UTC, all participants of the cruise had arrived at RV HEINCKE in Bremerhaven, Germany. In the beginning, participants were tested for Covid-19 and were able to move into their cabins after the negative test result. Afterward, the boxes with the scientific equipment were unpacked and the laboratories were set up so that everything was made seaworthy. Marc Metzke (technician) then gave a short introduction to the students concerning the scientific equipment which will be used on the cruise. In the evening, all students were able to mentally prepare for the trip and spent the evening at their leisure.

On the next day, at 7:00 UTC, RV HEINCKE departed. From Bremerhaven, a course was set towards Helgoland. At 8:00 UTC, a safety briefing and a safety exercise were conducted by the second officer (Yannis Branny). At 13:20 UTC we reached the first station close to Helgoland where the primary goal was to test the equipment. After the Secchi Disk (4 m visibility was detected, the water column was strongly mixed) was deployed and a plankton sample was taken, the CTD-rosette was the first major device to be tested. Afterward, the BWS was deployed twice without successfully delivering sample material to the deck. Since the vVG was carrying very coarse material on deck (coarse sand and gravel), a test of the MUC was not conducted. Throughout the day and with increasing distance to the mainland, the wind and wave intensity continued to increase. While wind speeds of around 8 m s^{-1} prevailed at the time of the departure, wind speeds of around 14 m s^{-1} were reached in the afternoon, which led to the correspondingly high waves. The average day temperature was 9.8 °C under overcast skies with sporadic precipitation. Most participants became seasick during the day, so only a short briefing was held in the evening.

By the night of the 26th to 27th of May, RV HEINCKE left the German territorial waters to continue its course in the Danish Exclusive Economic Zone (EEZ). On the morning of the 27th of May, the sky was very cloudy. In the afternoon it cleared up and it was partly sunny. The wind speed was between 4.9 and 13.2 m s^{-1}. The air temperature was between 7.9 and 10.9 °C. At 6:00 UTC, the work at the first station started. Five stations were sampled on that day (stations 3 to 7), all in the Danish EEZ. All devices were successfully used at all stations. Only at station 7, the BWS and the MUC had to be deployed a second time, because the devices did not work properly the first time. At each station, first, the Secchi Disk and the plankton net were used to determine the depth of visibility and to take samples of the plankton. After that, water samples were taken with the CTD-rosette and the BWS. The vVG was used to take a sample of the seafloor. All samples showed fine sandy material, so the MUC could be deployed to take sediment cores. At 17:00 UTC the evening seminar started with Jan Maier first giving a presentation about the topic “Marine sampling methods: Sediment and Water”, followed by Maike Artschwager giving a presentation about: “Marine sampling methods: Acoustic methods”. Both topics were discussed after the respective presentation. After that, the students learned three knots and some vocabulary that is used on ships.

On expedition day 3 (28.05.2021), five stations were sampled (9-13). The work at the first station (station 9) started at 6:00 UTC. All stations were located in the Danish EEZ. The wind speed was lower compared to the day before and had its maximum at 8 m s^{-1}. The air temperature was up to 9.4 °C. It was partly cloudy, partly sunny with no rain. All devices were used at all stations in the same order as described for day 2. At stations 9 to 11, every device worked well on the first try. At station 10, more weight was attached to the MUC. At station 12, only two of the three Niskin-Bottles attached to the BWS closed, the NISKIN-Bottle at 28 cm above seafloor did not close. This happened at station 13 as well (the NISKIN-Bottle at 57 cm above seafloor did not close). At both stations, the BWS was not deployed for a second time. In the seminar which started at 17:00 UTC, Finja Stoldt gave a presentation about Phytoplankton and Zooplankton in the North Sea. After that, Christoph Bonow presented the topic: "North Sea: Geological Development and Tectonics." Analogous to the day before, both topics were discussed after the respective presentation. After that, the students learned three more knots and more vocabularies.

Expedition day 4 (29.05.21) started with partly clouded weather conditions until 8:00 UTC. Afterward, it was mostly sunny with fewer or no clouds. The sea was very calm and the average wind speed was about 8.8 m s^{-1} between 6 and 16 UTC. The average temperature at this time was 9.6 °C. Stations 15 to 19 were sampled on the fourth expedition day. During the day (after the second station, station 16) RV HEINCKE reached the Norwegian EEZ. There, station 17 was the first station in the Norwegian sector. There were two main challenges concerning the station procedure and work on this day. One problem was a technical defect on the BWS at stations 18 and 19, where no samples were taken with the BWS. The electronic trigger mechanism to close the sample bottles was not working anymore so that there was no possibility to get samples from the bottom water at these two stations. Another challenge was the varying grain sizes of the surface sediment. In comparison to samples taken the stations before, textures were coarser at stations 18 and 19, so that the MUC was not deployed there. As the evening started with the seminar at 17:00 UTC, the first presentation topic was "North Sea: Eutrophication and Environmental Problems" given by Rhiannon Breider. After the group discussion of the topic, Linus Budke presented "North Sea: Sediments and Fundamentals of Sediment Movement". The topic was discussed together as well and more knots and vocabularies followed.

On the morning of the 30th of May, 2021 (expedition day 5) relatively heavy clouds and windy conditions were predominant. However, from noon on the weather was sunnier and less windy. The average wind speed was 8.7 m s^{-1} between 6 and 16 UTC, temperature average was about 10 °C. After unsuccessful repair attempts of the electronic trigger mechanism of the BWS during the evening of expedition day 4, it was decided to release the closing mechanism of the sample bottles mechanically by a fishing rod from station 21 onwards. The fishing line of the rod was fastened on the BWS and hold very loosely until the BWS reached the seafloor. Then the line of the fishing rod was rolled back until it was stretched. This was the moment when the NISKIN-bottles closed. Thus, samples could be taken although the electronic defects were still not solved. During the whole day, stations 21 to 25 were carried out successfully in the Norwegian EEZ. Presentation topics in the seminar at the evening were first "Offshore Wind Parks in the North Sea", given by Joely Maak, followed by "North Sea: Oil and Natural Gas: Deposits and Extraction" by Talitha Knauer. As usual, the topics were discussed together and knot theory, as well as vocabulary, completed the seminar program.

On the last expedition day (31.05.21), two stations were sampled in the morning (stations 27 and 28). These were carried out independently by the students. At station 28, the vVG mainly sampled very coarse sediment (almost exclusively rocks). The rocks blocked the mechanism so that the jaws of the bucket were not fully closed and most of the finer sediment was lost. Because of the rocks in the sediment, the students decided to not deploy the MUC. The last sampling station (station 28) was then finished at 8:00 UTC. Afterward, RV HEINCKE set course towards Bremerhaven, Germany. The weather on this day was sunny and almost windless and waveless. During the time of the station work, the average temperature was 8.2 °C, while the wind speed was around 5.6 m s^{-1}. Starting at 11:00 UTC, the students had the opportunity to participate in an engine room tour. Afterward, the labs were cleaned up and the scientific equipment was stowed back in the boxes. In the evening, the cruise was reviewed and the nautical terminology, as well as knots and their use, were discussed.

At around 9:00 UTC on the 1st of June, 2021, RV HEINCKE reached the harbor in Bremerhaven, Germany. After loading the equipment into the truck, the participants made their way back to Hamburg. The whole track of the cruise is shown in Fig. 5.21.

5 Preliminary Results

5.1 Water Sampling

5.1.1 Secchi Disk

(J. Maier)

The Secchi Disk is a circular metal Disk with a diameter between 20 to 50 cm. The Disk is divided into 4 sectors and painted alternately in black and white (Fig 5.1). It is a scientific tool for the quick and easy determination of the visibility depth in a water body. The depth of visibility is used to estimate the depth of the trophogenic zone or – more generally – to characterize the turbidity of surface waters. A rope with length marks is attached at the center point on top of the Disk. A weight is attached on the backside for better stability in the water column.

Fig. 5.1 The Secchi Disk is divided into 4 sectors (painted black and white) and is a limnological tool for a quick determination of the visibility depth in surface waters.

The Secchi Disk was deployed at all 22 stations. The Disk is lowered into the water until it visually disappears. The precise depth of visibility is determined by raising and lowering the Secchi Disk several times. The visible depth varied between 6.5 and 12.5 m (Fig. 5.2). The results of the Secchi Disk, however, do not provide an exact measure of transparency. The measurement can be influenced by different weather conditions like the sun´s glare on the water or higher current and wave energy.

The greatest visible depth was measured at station 11. The visible depth decreased from this location in southeastern and in northeastern direction. Besides different weather conditions, decreasing water depth may also be an additional reason for the changes. Higher wave energies can be observed in coastal regions, which can have an impact on the depth of visibility. At station 11 the bottom water depth is 68 m. The bottom water depth at stations 3 (36 m) and 28 (38 m) are only about half as deep. In summary, there is a trend visible in the data, that the visible depth increases with increasing distance to the coast.

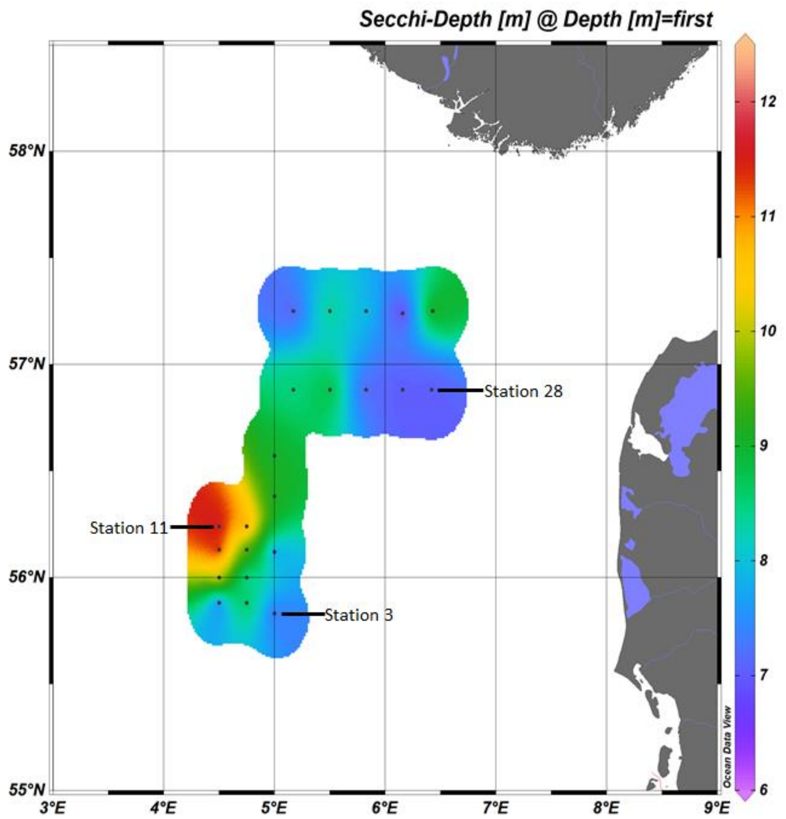

Fig. 5.2 The different visibility depths measured with the Secchi Disk are shown. Black marks symbolize the stations. Red areas symbolize the greatest (12 m) and blue the lowest depths of visibility (6.5 m).

5.1.2 Plankton Sampling

(F. Stoldt)

The plankton net (Apstein net) is used to sample the plankton of the surface water. During the station work, the plankton net was used right after the Secchi Disk. It consists of a net with a mesh size of 25 µm (collecting diameter of the inlet: 40 cm, length: 100 cm) and a collecting cylinder at the cod end of the net with a valve for open and closing. The net is attached with a three-point bridle to a towing line with marks in 1-meter intervals. Additionally, a weight is attached to the net. Consequently, the plankton net can be easily lowered into the water column.

Ideally, the net is lowered into a water depth of about 10 meters. However, at some stations the current velocity caused the net to drift under the ship. Therefore, the risk that it might get near the propeller of the ship caused the students to lower the net for less than 10 m. Normally, the net was then lowered to a depth of about 5 m. In Table 9.2 more information on the exact water depth of the plankton net at each station can be found. After lowering the net into the water, it was slowly pulled up to the surface (Fig. 5.3). Back on deck, the valve was opened and the sample was extracted into a bucket.

With a pipette, a part of the sample was extracted to a sample pan. Then the sample was investigated with a stereomicroscope of the model Stemi 508 (ZEISS) to get a general overview of the planktonic world at the stations. With the help of literature (Kraberg et al., 2010, Larink and Westheide, 2011) the different species were identified. Afterward, the sample was put back into the water before arriving at the next station. Often the name of a species could not be identified, so some taxa were only described as genus, family, or even just as a class. Some taxa could not be identified at all and were only described.

Fig. 5.3 The plankton net is pulled back to the ship.

Dinoflagellates were found in many samples (except for stations 11 to 18, and 21), especially of the genus *Ceratium* (for example, *C. tripos* or *C. fusus*). Due to uncertainties in the exact identification, these dinoflagellates were often described as *Ceratium* sp.. In many samples, Late pluteus (*Echinocardium cordatum*) (Fig. 5.4) and *Cnidaria antipathula* were found. In some samples, diatoms were identified. In most of the samples, small green and red dots were found, that were possibly diatoms or dinoflagellates. However, these were often undefinable. In two samples (stations 21 and 23) individuals of the copepods *Lalonus* sp. were found and in two other samples (stations 25 and 26), individuals of *Cladocera* sp. were identified. Also worth mentioning is, that in many samples (except for stations 09, 12, 13, 15, and 19), particles of microplastics were found.

Fig. 5.4 Late pluteus under the microscope. The diameter of the depicted late pluteus is about 2 mm.

5.1.3 Water Sampling with CTD

(J. Maier)

A CTD-rosette (conductivity (salinity), temperature, depth) is a device for deep-sea investigations (Fig. 5.5). A CTD-rosette is obtained with a cylindrical frame. This frame is made of steel and protects the CTD-rosette from damage. On the upper part of the CTD-rosette, the device is equipped with 12 NISKIN-bottles to extract water samples. The volume of the NISKIN-bottles can vary in different water sampler types. The CTD-rosette which was used during cruise HE577 contains NISKIN-bottles with a volume of 5 liters. Every NISKIN-bottle can be closed separately via the data wire of the winch cable. The mechanism of each bottle must be connected with the controlling device on board. When triggered via computer, the collecting bottle will close immediately. Due to this mechanism, it is possible to take water samples from different water depths in one deployment. Different sensors are attached below the NISKIN-bottles. They allow obtaining data about the vertical water column profiles from different parameters. In addition to the eponymous characteristic parameters conductivity, temperature, and depth, the instrument's sensors also recorded the dissolved oxygen concentration and chlorophyll fluorescence.

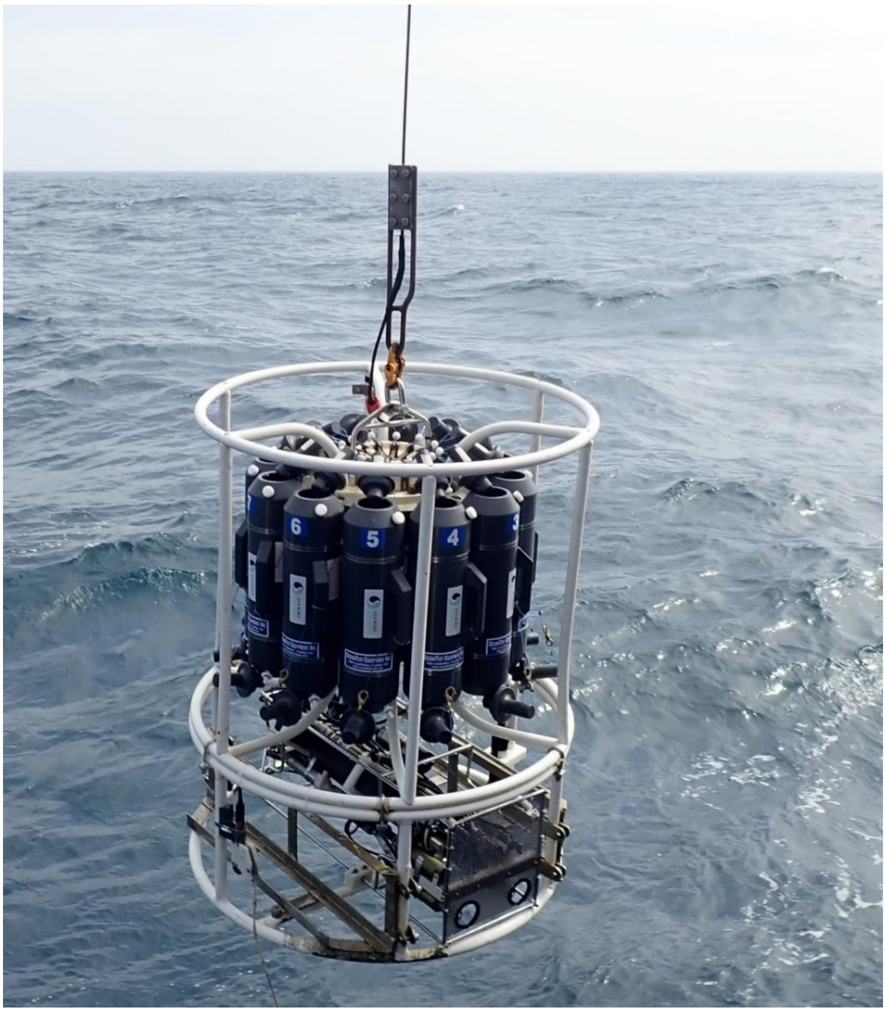

Fig. 5.5 The CTD-rosette is equipped with a cylindrical frame, 12-5l-NISKIN-bottles, and sensors to measure the following parameters: temperature, conductivity, depth, oxygen, and chlorophyll fluorescence. The CTD is in contact with the board computer through the winch cable.

During the HE577 expedition, the CTD-rosette was deployed at all 22 Stations (Fig. 3.1a). Before deployment, all bottles must be opened on board. After deployment into the water, the CTD-rosette is turned on and the sensors started measuring. The CTD-rosette is then lowered until about 3 to 5 meters above the seafloor. While lowering the CTD-rosette, the sensors collect data from the vertical water column profile it passes through. Two sampling depths were chosen during the cruise HE577: one close to the seafloor, the other one a few meters below the water surface. This was done since most of the vertical water profiles showed only one thermocline. A relatively homogenous upper water layer (warmer, slightly lower salinity) and a homogenous lower water layer were found. Both layers were sampled in the following heaving process. A few meters (typically about 4 meters) above the seafloor the first 6 bottles were closed per controlling software of the board unit. Afterward, the CTD was heaved near the water surface and the board unit closed the next 6 bottles. The CTD-device was then turned off. Subsequently, the CTD was heaved back on board. The procedure of collecting water samples from the surface and near the bottom was repeated at all 22 stations without any exceptions.

The collected water samples in the NISKIN-bottles were taken for filtration. In all sampling points, bottles 1 to 6 contained water samples from the ground while bottles 7 to 12 contained water samples from the surface area. For water extraction, the air vent on top of each bottle must be opened first. The water samples were filtered on glass fiber filters (WHATMAN GF/F, 0.7 µm mesh-size, 47 mm diameter, pre-combusted at 450 °C). A membrane pump transferred the filtered water to a tank (26 liters volume). The volume of filtered water varied at every station and depends on the amount of suspension in the samples. The filtration was stopped when the water passed the filter very slowly. The filtered volume was between 5 and 14 liters. Subsequently, the color of the filter was estimated using a spectrophotometer. A detailed explanation of the color estimation can be found in chapter 5.2.2. A part of the results of the color estimation can be found in chapter 5.2.2 in Fig. 5.20. Thereafter the filters were stored in a fridge at about 4 °C.

Measured values of CTD casts are shown graphically in Figures 5.6 and 5.7. The parameters temperature and salinity were considered.

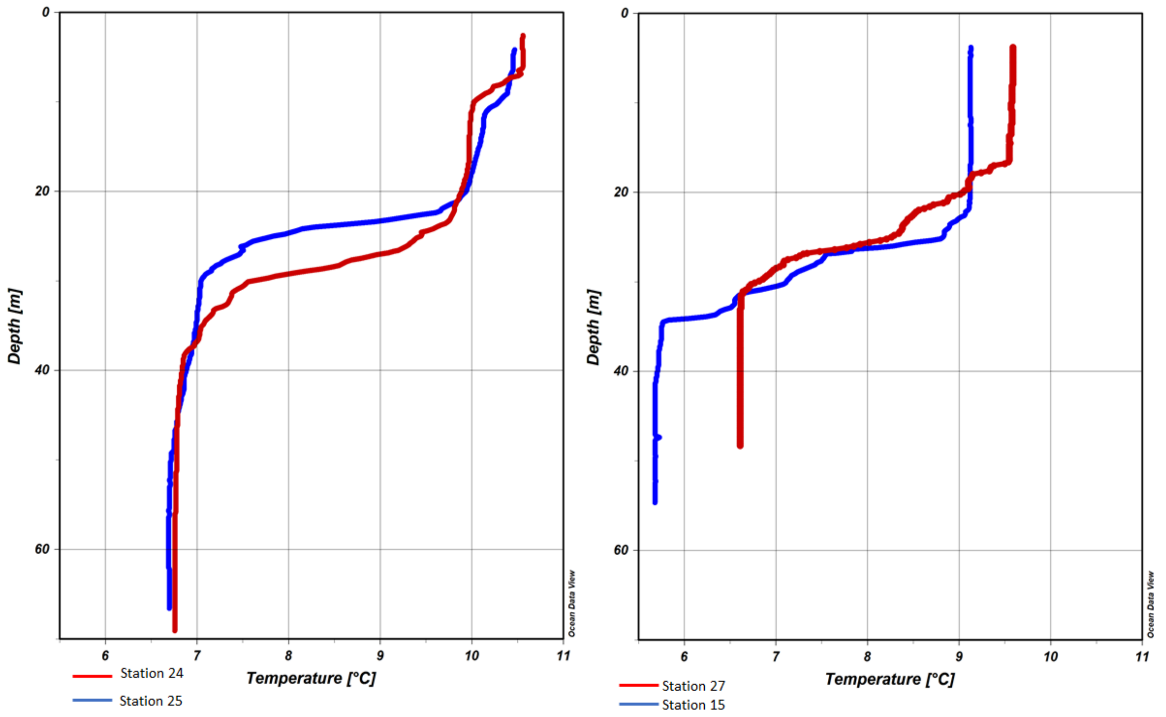

Fig. 5.6 Vertical temperature water column profile from the water surface to the seabed given in °C. Red: Station 24 and Station 27; Blue: Station 25 and Station 15 (ODV, Reiner Schlitzer, 2021). Locations can be found in Fig. 3.1.

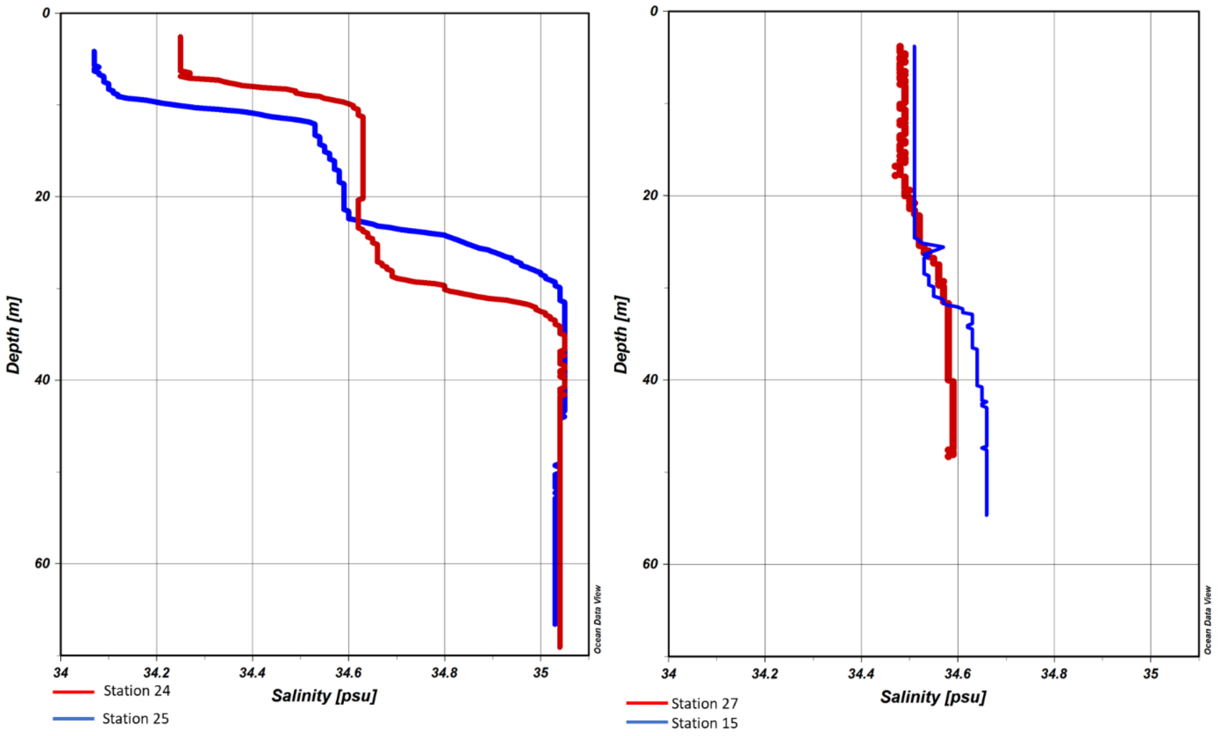

Fig. 5.7 Vertical salinity water column profile from the water surface to the seabed given in PSU. Red: Station 24 and Station 27; Blue: Station 25 and Station 15. Locations can be found in Fig. 3.1.

The temperature values are given in degrees Celsius (°C). The range of the observed temperature was between a minimum of 5.68 °C (station 15, 54.7 m) and a maximum of 10.56 °C (station 24, 2.6 m). Maximum temperature values were usually measured in surface waters. The temperature shows relatively constant values in the surface area. Below the upper part of the water column, the temperature values drop sharply and reach the minimum at the shallowest measuring point of the respective station. This decrease in temperature can be observed at each station and is also called a thermocline. The thermocline is approximately located between 16 and 35 meters and the temperature difference is about 3 °C (Station 27: 16.4 m and 9.55 °C; 31.5 m and 6.62 °C). A notable feature was that the stations closer to the Norwegian mainland (station 24: 10.56 °C, station 25: 10.47 °C) had higher surface water temperatures than those further away (station 15: 9.13 °C, station 27: 9.59 °C). Furthermore, a second thermocline was found at station 24 and station 25 between 7 m and 12 m (station 24: 7.1 m, 10.51 °C; 11.1 m, 10.0 °C; station 25: 9.1 m, 10.39 °C; 11.5 m, 10.14 °C; Fig. 5.6). The temperature decrease is significantly lower but still visible.

The salinity values are given in practical salinity units (PSU - dimensionless). The salinity values of stations 25 and 24 show a minimum value of 34.07 PSU (station 25: 4.2 m) and a maximum value of 35.04 PSU (station 24: 69.1 m). Salinity minimum values are usually measured in surface waters and maximum usually at the shallowest measuring point. Figures 5.6 and 5.7 clearly show that stations 24 and 25 differ significantly from stations 15 and 27. The salinity values at stations 15 and 27 decrease slightly from the water surface to the seafloor (station 15: 3.8 m, 34.51 PSU; 54.5 m, 34.66 PSU; station 27: 3.8 m, 34.48 PSU; 48.1 m, 34.58 PSU). Similar to temperature, two transition zones can also be observed for salinity at stations 24 and 25. The first transition zone is between 7 and 12 m (station 24: 7.1 m, 34.27 PSU; 9.9 m, 34.60 PSU; station 25: 9.3 m 34.14 PSU, 11.9 m, 34.52 PSU). The second transition zone is between 22 and 33 m (station 24: 24.4 m, 34.64 PSU; 32.5 m 35.00 PSU; station 25: 22.4 m, 34.60 PSU; 28.3 m, 35.00 PSU).

From the temperature and salinity depth profiles, it is clear that stations 24 and 25 (or in general the stations closer to the Norwegian mainland) are influenced by lower salinities and higher temperatures in the surface water. A reason for the variability of salinity and temperature could be the inflow of fresh surface water from the Skagerrak and the Baltic Sea. Another reason could be the coastal fluvial outflow from Norwegian rivers.

5.1.4 Water Sampling with the Bottom Water Sampler (BWS)

(C. Bonow)

The bottom water sampler (BWS) is a research device, which is used to analyze water near the seafloor. The BWS was constructed by KUM Kiel and can collect water in NISKIN-bottles with a volume of up to 5 liters. Three NISKIN-bottles were used on the cruise HE577. These bottles are separately attached along a metal rod which is the rotatable center axis. The bottles can be mounted at different heights on the center axis above the seafloor between 10 cm to 155 cm. On this research cruise, the heights were fixed at 28 cm, 57 cm, and 110 cm (Fig. 5.8).

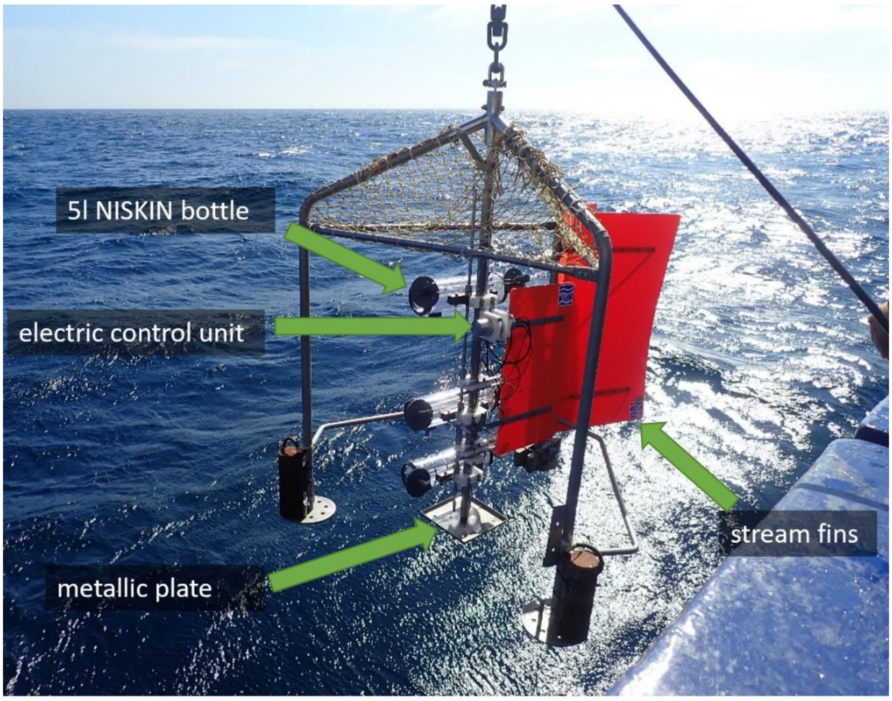

Fig. 5.8 Depicted is the BWS that was used during the cruise HE577. The main features are marked.

The BWS has three streaming fins which allows it to align itself along with the local flow direction. Subsequently, the NISKIN-bottles are ideally positioned to the ambient current regime. To ensure the possibility to align in relation to the flow direction, the BWS can rotate its center axis up to 120°. After seafloor contact, the electric system of the BWS is activated through to a metallic plate at the bottom on the center axis, on which the bottles are attached. Within the electronic control unit of the BWS is a timer that is activated by contact to the seafloor. Before deploying the BWS into the sea, the timer must be manually set at the electronic control unit on deck. The timer is used since many sediment particles are swirled up when the BWS reaches the seafloor. Thus, there is a possibility that the swirled-up sediment particles remain in the sampling bottles if the bottles close too soon. Hence, the risk of falsifying the data is strongly reduced when a timer is used. Therefore, the timer is set to a time that can vary between one minute and six hours. During the cruise HE577, the timer was set to three minutes at every station. The reason for the comparably short time frame is the relatively high current velocity in the North Sea. In deep-sea situations, a longer time frame would be needed to remove the sediment particles out of the sampling bottles. After the activation of the timer by seafloor contact (triggered by the metallic plate being pushed into the device), a wire is put under electrical voltage, which has previously been freed of insulation in one place. Exactly at this point, the wire begins to burn through and ultimately tears apart. (Fig. 5.9). This process then causes all NISKIN-bottles to close. However, at some stations during the cruise HE577, not all bottles were closed properly.

Overall, the BWS initially ran almost without problems. Nevertheless, at stations 4 and 8, the BWS had to be deployed two times to be able to extract samples from the bottom water. At stations 12 and 13, respectively one bottle failed to close (at station 12, the 28 cm NISKIN-bottle, and at station 13 the 57 cm NISKIN-bottle). From stations 18 onward, there was a technical defect in the device which meant that it had to be triggered manually utilizing a fishing rod (from station 21 onward). Therefore, it was not possible to extract samples from stations 18 and 19 (see Fig. 3.1 for locations). Triggering the BWS with a fishing rod was done by deploying the BWS into the sea until contact with the seafloor has been reached. Afterward, the fishing hook was pulled. This caused the wire to be dragged off the device, which also triggered the closing mechanism (Fig. 5.9).

Afterward, the samples were extracted from the various NISKIN-bottles. These could be filtered through glass fiber filters with previously measured weight (WHATMAN GF/F, 0.7 µm mesh-size, 47 mm diameter, pre-combusted at 450 °C). The filtration method is the same as described in the previous chapter (chapter 5.1.3). Thus, the suspended matter within the water column can be weighted and the different depths can be compared (Fig. 3.1a shows the location of the sampling stations). The colors of the filters were estimated using the MINOLTA CM-2002 spectrophotometer after the filters had dried (see chapter 5.2.2 for more detailed information on the color estimation). A part of the results of the color estimation can be found in chapter 5.2.2 in Fig. 5.20.

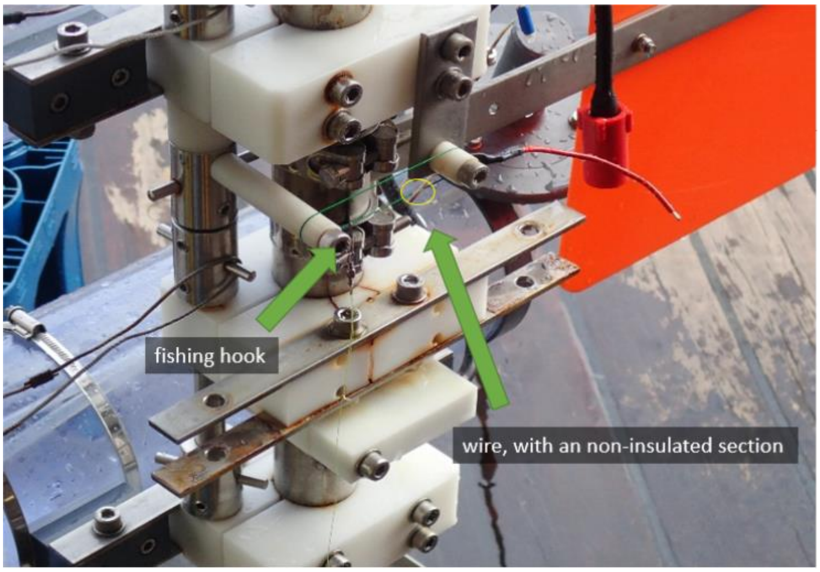

Fig. 5.9 The wire, with a non-insulated section, which is normally bonded to the electronic control unit. The fishing hook is depicted in this figure as well.

5.1.5 Thermosalinograph

(M. F. Artschwager, J. M. Maak, J. Maier)

The thermosalinograph (TSG) is a hull-mounted instrument on RV HEINCKE, which measures the temperature and conductivity of the surface water (approx. 4 m water depth). The instrument, which was used during HE577 was a Seabird Thermosalinograph SBE21 (serial number: SN-3333) with an external temperature sensor SBE38 (serial number: SN-0477).

The seawater is constantly sucked into the ship's hull at a flow of approximately 30 l min^{-1} to measure the temperature and conductivity with two sensors (one internal within the SBE21 and one external SBE38). These measurements can be used to calculate salinity and the sound velocity of the water. The salinity is calculated by applying the PSS-78 equation by Lewis and Perkin (1981). The unit of the salinity is the practical salinity unit (PSU). Since the TSG is an online system that is hull-mounted, the system can measure the temperature and conductivity continuously and independently from station work. Subsequently, about 7583 TSG measurements were taken during the cruise HE577.

The results of the measurements of the TSG are depicted in Fig. 5.10. The temperature shows a strong increase close to the German coast. The surface temperature is generally mostly influenced by meteorological conditions. Fig. 5.10 indicates that the coastal regions warmed up faster during spring 2021 compared to the areas further offshore. There is a clear trend visible in the data: the highest surface temperatures were reached close to the German coast, where major German rivers drain into the German Bight (up to 14 °C). The values then decreased further northward with values of around 9 °C (in offshore situations). Afterward, the surface temperatures slightly increased in the northern part of the North Sea with values of up to 11 °C. This increase might be caused by warmer riverine input from Denmark or Norway. The salinity values show a similar distribution. Close to the German coast and close to the Skagerrak (which is the connection between the Baltic Sea and the North Sea) the salinity values decrease. The values indicate a strong influence of riverine drainage and Baltic Sea Outflow. In the areas further offshore, salinity values reached oceanic conditions of around 35 PSU. The lowest measured values were found close to the German coast of around 32 PSU.

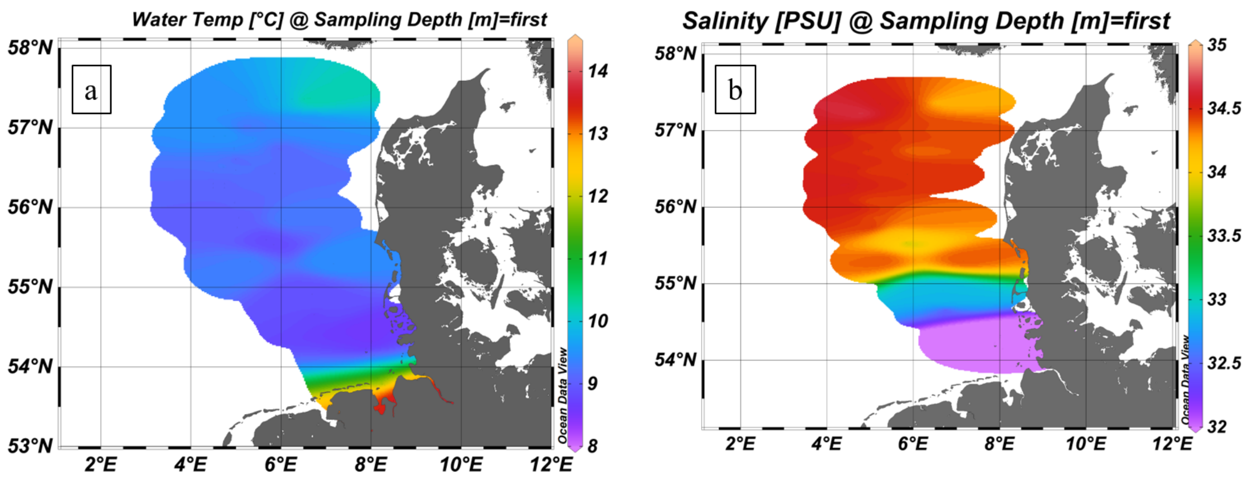

Fig. 5.10 Temperature (a, in °C) and salinity (b, in PSU) distribution derived from measurements of the thermosalinograph.

5.2 Sediment Sampling

(J. M. Maak)

Sediment sampling was carried out at 22 stations with varying success. The van-Veen-Grab (vVG) was used at every station to inspect the condition of the seafloor before deploying the more fragile Multi-Corer (MUC). At 17 stations, the MUC was used and sediment samples were extracted for further analysis (Fig. 5.18 indicates the sampling locations). In total, 192 sediment samples of 1-cm-intervals were taken with the MUC (Tab. 9.6 and 9.7). Due to very stony or coarse sediment, permeability measurements were only possible at 18 stations (Fig. 5.13).

The sediment samples were taken after sampling and examination of the ocean water with the Secchi Disk, the Plankton Net, the CTD-Rosette, and the Bottom Water Sampler. This was done to avoid disturbances in the water column and contamination of the water samples taken.

Only the Danish and Norwegian EEZ were sampled during the cruise HE577. Sampling points 17 to 19 and 21 to 25 were inside the Norwegian EEZ, sampling point 16 was in the Danish EEZ but very close to the border to the Norwegian EEZ. All other sampling points were found inside the Danish EEZ (Fig. 3.1a). Compared with the data from Bockelmann et al. (2018), stations 25 and 28 are expected to show very coarse sediment. All other stations should show fine sand as sediment (Bockelmann et al., 2018).

5.2.1 Surface Sediment Sampling (van-Veen-Grab)

(T. Knauer)

The van-Veen-Grab (vVG) is a device used to sample the upper sediment layer of the seafloor. Before deploying, the vVG needs to be opened and locked (Fig. 5.11a) and is then picked up by the winch wire and lowered into the sea. When the vVG touches the ground, the device gets unlocked. During the heaving process, the bucket closes and collects the sediment load from the seafloor (Fig. 5.11b). The capacity of the vVG used during the cruise HE577 is about 0.1 m^3, a penetration depth of 20 cm is possible. This device aims to get a first impression of the sediment type (e.g grain size and sediment texture) in the sampling area. It is not possible to gain any information about the stratigraphy in the area, since the samples taken with the vVG are potentially disturbed.

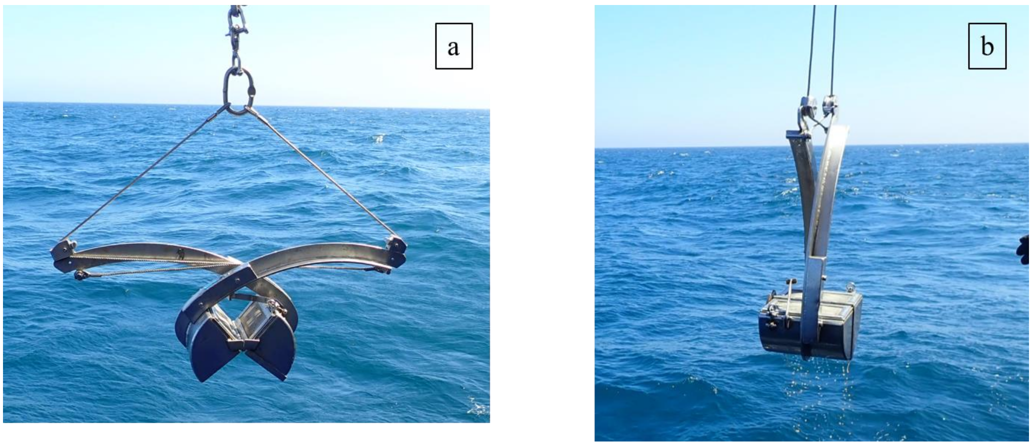

Fig. 5.11 Set up of the van-Veen-Grab: a before deployment. b: after deployment.

Another aim of this sampling method is to examine the permeability. To extract the sample, the top aperture of the vVG is opened once the device is back on deck and a tube (with a diameter of 5 cm and length of 20 cm) is used to collect the sample (Fig. 5.12). The tube is then pressed into the seabed sample (in a comparably undisturbed area of the sediment load) of the vVG and a rubber stopper is used to seal the tube from the top. When the tube is carefully lifted out of the sediment, the bottom side of the tube is sealed with a rubber stopper as well. To measure the permeability, water is poured on top of the sediment in the tube. To estimate the permeability under natural sediment surface conditions, the water for the permeability measurements is taken from the CTD-rosette. Hereby, the water from the deepest sampled water layer is taken (normally about 3 meters above the seafloor, see chapter 5.1.3/Tab. 9.3). Afterward, the time which the water needs to flow through the sediment sample is measured.

Fig. 5.12 Extracting sediment material after the vVG is on deck for the permeability test.

Out of the 22 stations which were sampled during the cruise, only sediments from 18 stations could be used to examine the permeability (Fig. 5.13). The other four stations – stations 3, 18, 19, and 28 – consisted of a very coarse sediment bed (mainly rocks). These rocks consisted mainly of plutonic igneous rocks, sandstones, and till. Due to the coarse sediment, only very disturbed sediment samples were taken. The rocks blocked the mechanism so that the jaws of the bucket were not fully closed and most of the sample was lost. Compared to the data from Bockelmann et al. (2018) all stations, except for stations 25 and 28, should show fine sand as sediment. However, our results of the sediment examinations show that stations 18, 19, 22, 24, 25, 27, and 28 consist of coarser sediment than fine sand. In accordance with the data of Bockelmann et al. (2018), all other stations consist of fine sand. The permeability in the center of the sampling area is slightly lower than in the southern and northern parts of the sampling area (Fig. 5.13). There is also a maximum in the permeability in the northern part of the Danish EEZ where the permeability was 0.1 cm s^{-1}. Through the permeability, it is possible to draw conclusions about the porosity of the rock or sediment and the connectivity of the individual pores. Sediments and rocks with high porosity and permeability have a higher potential of becoming (for example) aquifers or petroleum storage rocks. In comparison to the average grain size (Fig. 5.14), lower permeability was measured in areas of lower average grain size. A reason for that is that pure, sandy sediment has bigger pores compared to silty or clayey sediment (e.g., Cathles (1999)). Therefore, better connectivity of the individual pores and a better flow through the sediment (= permeability) can be expected if the average grain size is greater.

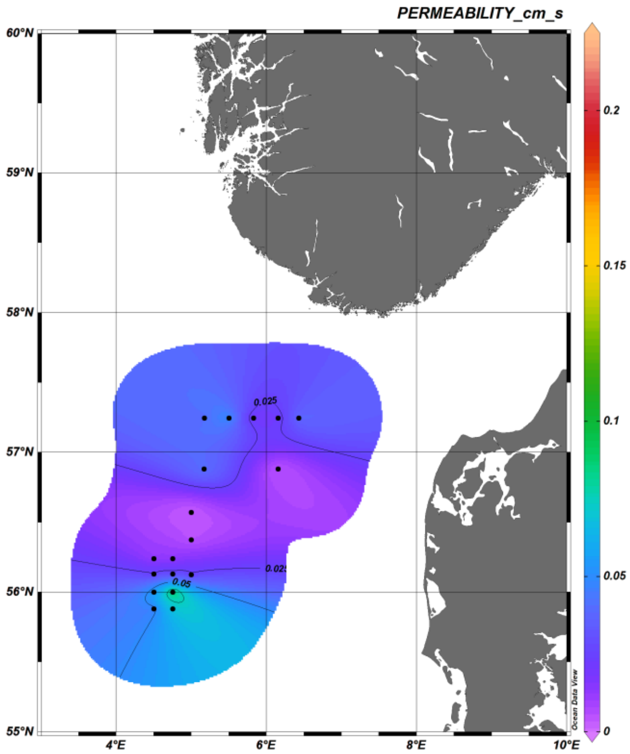

Fig. 5.13 Sampling points of the van-Veen-Grab where permeability measurements were possible (black dots) and the results of the permeability measurements gridded in Ocean Data View. Permeability was measured in cm s^{-1}.

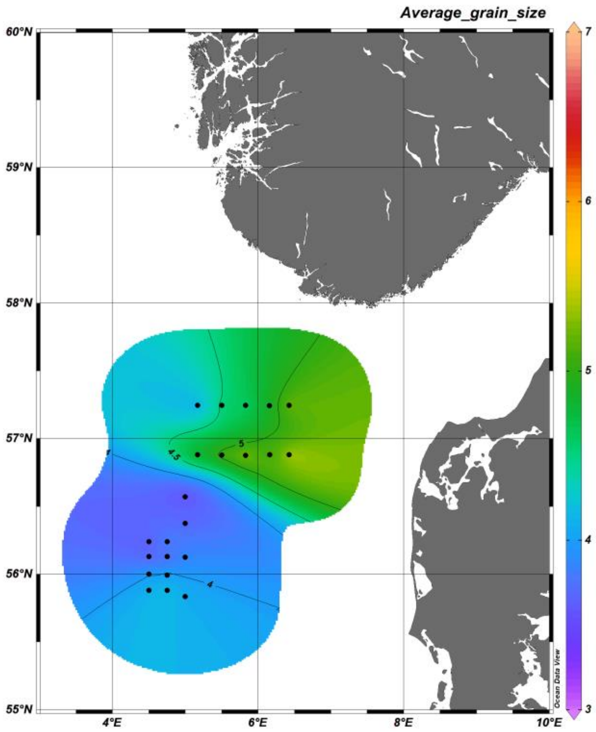

Fig. 5.14 Sampling points of the van-Veen-Grab (black dots) and the results of the average grain size gridded in Ocean Data View. Average grain size: 1=clay, 2=fine silt, 3=coarse silt, 4=fine sand, 5=medium sand, 6=coarse sand, 7=gravel.

Almost all sediment samples that were taken with the vVG contained epibenthic or endobenthic organisms. These organisms belong to the group of Bivalvia (shells and shell fragments), worms (Phylum: Annelida), and Echinodermata (mostly sea urchins: Echinoidea and sea stars: Asteroidea) (Fig. 5.15). Only at stations 13 and 19, it was not possible to find any larger organisms. The reason for this could be the presumable large anoxic layer that the samples of these stations indicated (the darker colors indicated an anoxic area in the seafloor-sediment). Contrary to this hypothesis is that stations 5, 9, 10, 11, and 27 also had indications for minor anoxic layers, however, some larger organisms were found in the samples. The sediment samples from these stations contained endobenthic organisms like shells. Nevertheless, at these stations (5, 9, 10, 11, and 27) the anoxic layers presumably only started at a depth of 5 to 9 cm. Therefore, the upper 5 cm still contained enough O_2 for the life of endobenthic organisms that were present in the samples. Since almost all samples contained organisms, it can be assumed that there is probably a high concentration of O_2 in the topmost layer of the seafloor in the sampled area of the North Sea (this is also indicated by the mostly brighter colors of the sediment, see color values Tab. 9.7).

Fig. 5.15 Sediment load of the van-Veen-Grab from station 19 that contains epibenthic and endobenthic organisms. 1: sea urchin. 2: Echinodermata.

5.2.2 Sediment Coring (Multi-Corer)

(J. M. Maak)

A Multi-Corer (MUC) can take multiple cores during every deployment. Up to eight cores at one drop are possible (see Fig. 5.16a). The mechanism consists of gravity and moving parts within the construction. During the HE577 cruise, an OCTOPUS MUC was used. The purpose of the device is to recover undisturbed samples of seafloor sediments. The function and setup of the MUC are depicted in Fig. 5.16. The different tubes are fit into a housing that has a hinged rubber stopper at the top and a shovel at the bottom (Fig. 5.16b). When deploying the MUC, the device is picked up by the winch wire and lowered into the sea until the device reached about 10 meters above the seafloor. About a minute should pass to allow the device to stabilize its position in the water column before continuing. The MUC is then lowered until its frame reaches the seafloor.

Afterward, the middle center rail, equipped with multiple weights (Fig. 5.16: 1), continues to lower. The tubes, which are attached to the center part of the MUC, sink into the seafloor sediment, recovering undisturbed sediment and water samples (Fig. 5.16c). After one to two minutes, the winch heaves the MUC out of the sediment. Subsequently, the stopper on the top of each tube falls and seals the tubes, creating a vacuum that should hold the sample inside the tubes. After the tubes are raised out of the sediment, the shovel then swings down and closes the tubes from the bottom. Once the MUC is on deck and moored, the tubes can be taken off and the samples can be extracted. The OCTOPUS MUC used during the HE577 cruise is equipped with eight tubes with a length of around 62 cm and a diameter of around 10 cm (Fig. 5.16a, b, and c).

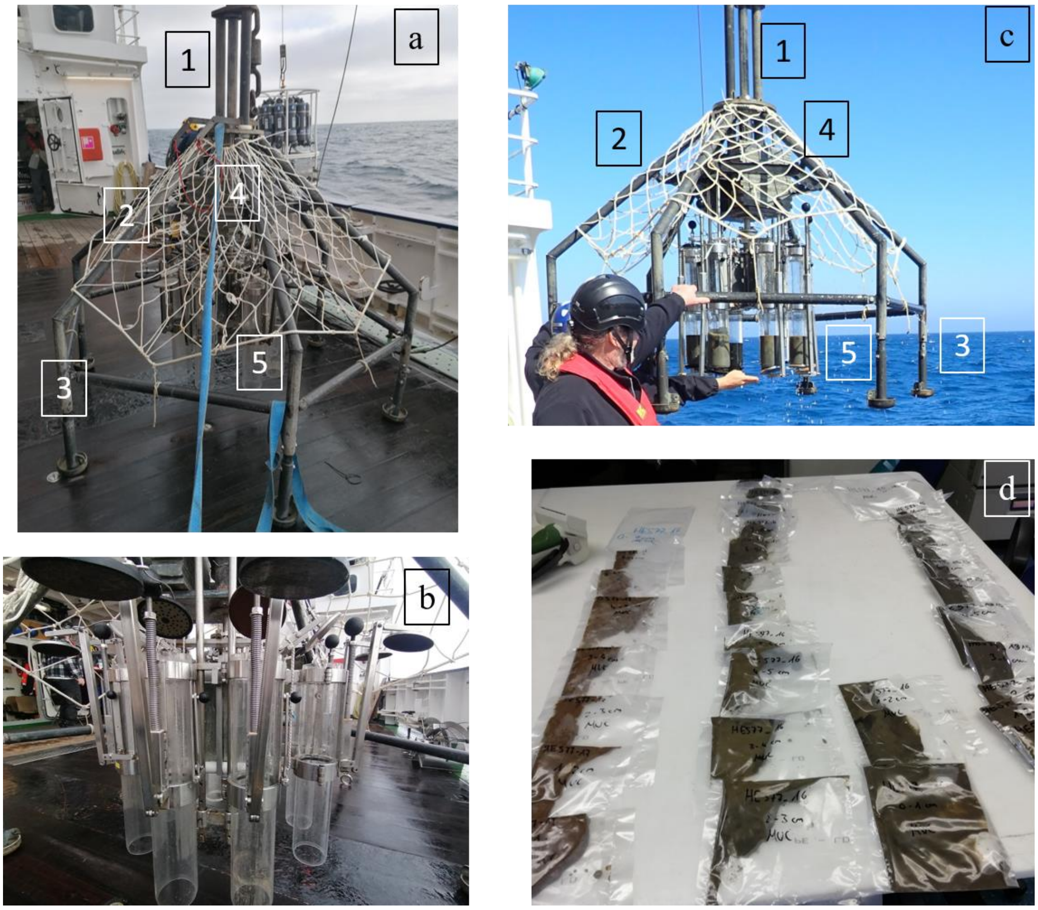

Fig. 5.16 Function and Setup of the Multi-Corer. a/b: Multi-Corer and tubes before deployment. c: Multi-Corer after deployment containing undisturbed sediment samples. d: sample preparation for archiving. In a and c the different parts of the Multi-Corer are marked. 1: Center rail that continues to fall when the frame reached the seafloor. 2: Mesh net to keep the cable away from being tangled around the tubes. The net is tied to the frame via a specific knot (German: “Webeleinstek” or eng.: “Clove hitch”). 3: Framing of the Multi-Corer. 4: The weight to press the acrylic glass tubes into the seafloor. 5: The assembly of core sampling tubes.

Out of the 22 stations, which were sampled during the cruise HE577, only 17 stations had optimal conditions for the deployment of the MUC (see Tab. 9.6). Since the MUC is equipped with eight acrylic glass tubes, they are prone to scratches and ruptures. Also, only very fine sediment (which causes a very good suction effect) can lead to an optimal sampling result. Therefore, when the vVG showed a very coarse sediment bed, the MUC was not deployed. This happened at stations 6, 18, 19, and 28 with a very coarse and stony sediment bed or large seashells. However, also stations such as station 22 were not sampled. Here the sediment consisted mostly of very coarse sand. The location of all stations sampled can be found in Fig. 5.18 (Fig. 5.18 indicates all station points where the MUC could be deployed and samples could be extracted, Fig. 3.1 shows the locations of all sampling points).

At the 17 stations, the success of the MUC sampling varied strongly. At station 23, the longest core was taken (17 cm). However, the average core consisted of a length of 10.6 cm. The smallest cores were taken at stations 3, 5, and 7 (5 cm). The average grain size varied between coarse silt and coarse sand. Due to the poor sampling results of the sediment cores at the beginning of the cruise, the weights of the center rail were increased from station 10 on.

After the cores were taken with the MUC, two undisturbed cores were chosen. The samples inside the cores were then extracted by pushing the core “bottom-up” on a steel cylinder with the same diameter as the inner tube. The sediment of the longer core was then sampled in 1-cm-intervals for the working group Biogeochemistry. Of one other undisturbed core, only the first 2 cm and about 30 ml of the ocean bottom water in the core were sampled for benthic foraminifera analysis of the working group Micropalaeontology. Both working groups belong to the Institute for Geology of the Universität Hamburg.

The samples for the working group Biogeochemistry were packed in transparent plastic bags (Fig. 5.16d), which were then sealed with a film welding machine. Afterward, a visual description of the sediment was performed. Two visual description methods were used. A Munsell color chart was used to visually estimate the fitting color for each 1-cm-interval of the sediment. Additionally, a spectral analysis was carried out using the MINOLTA CM-2002 spectrophotometer. The optical properties were documented as coordinates within the CIE 1976 L*a*b* (CIELAB) color space (Fig. 5.17, and Fig. 5.18; Tab. 9.7). Hereby L* indicates whiteness (brightness) of the color (100= white, 0= black), while a* indicates the position between magenta (positive values) and green (negative values). b* differs between yellow (positive) and blue (negative values).

The spectral analysis with the MINOLTA CM-2002 spectrophotometer and the visual estimation using the Munsell color chart were both conducted through transparent plastic bags (see Fig. 5.16d). Therefore, the real result might slightly differ due to an interference of the plastic bag with the real colors of the sediment (e.g. due to reflections). The 1-cm-intervals for the working group Biogeochemistry were then stored at -20 °C. The 2-cm-intervals for the working group Micropalaeontology were sampled in plastic containers and stored at +4 °C. No further color estimation was carried out.

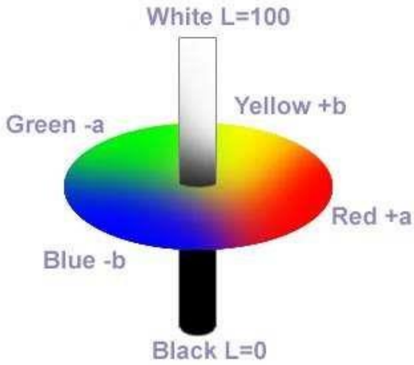

Fig. 5.17 The CIE 1976 L*a*b* (CIELAB) color space (Lovetskiy et al., 2018). This figure is not the subject of copyright.

The results of the measurements using the MINOLTA CM-2002 spectrophotometer are depicted in Fig. 5.18. The L* value was shown to correlate to photosynthetic performance (Hosono et al., 2012), while a* and b* serve as an indicator for photopigment content (Stuhr et al., 2021). The relationship between the L*a*b* values and the chlorophyll content has been investigated in numerous studies (e.g., Hu et al. (2010), Hu et al. (2013), Liang et al. (2017), Stuhr et al. (2021)).

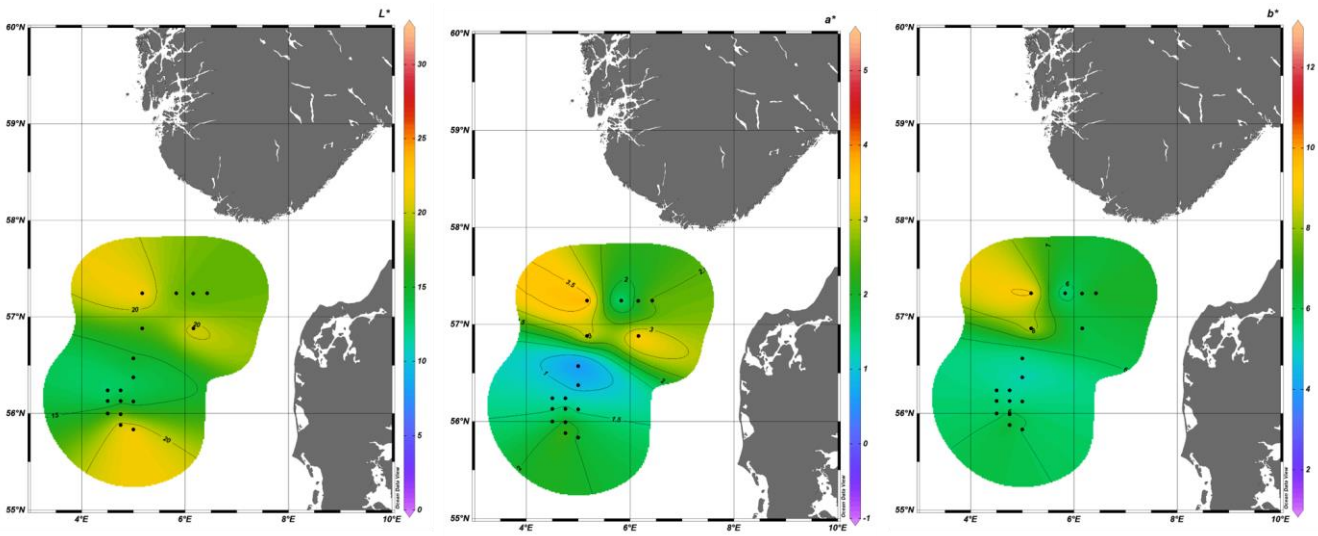

Fig. 5.18 Results of the spectral analysis (L* value left, a* value middle, b* value right) of the sampling from the Multi-Corer (MUC) gridded in Ocean Data View. The MINOLTA CM-2002 spectrophotometer was used. Locations of the sampling points of the MUC are indicated by black dots in the individual figures.

Especially in the central region of the sampling area during the cruise HE577, lower values of L*, a*, and b* were found. Therefore, a comparably high concentration of chlorophyll in the central region of the sampling area can be expected. The core of one of the stations with lower values of L*, a*, and b* (station 23) is shown in Fig. 5.19.

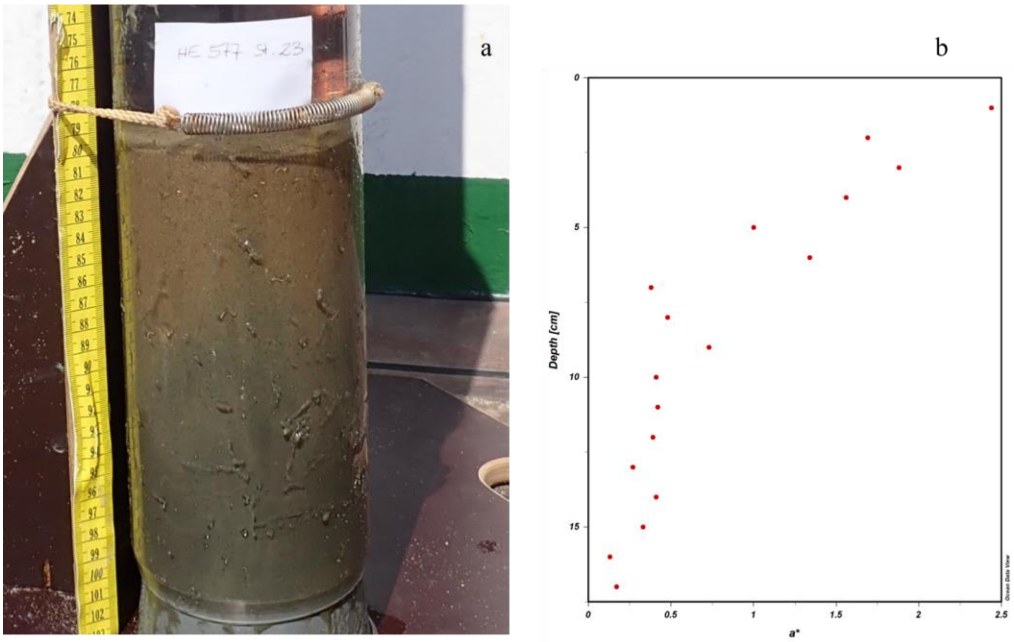

Fig. 5.19 The core of station 23 (a) and differences in the color value a* throughout the core (b). The location of station 23 can be seen in Fig. 3.1.

Throughout the core, the a* values changed strongly (Fig. 5.19b). Especially low values were found in the lower section of the core, with the lowest a* value in 16 cm depth (Fig. 5.19b). Only the core of station 16 at 56.570 °N and 5.000 °E showed lower a* values (a* values at -0.58, location can be found in Fig. 3.1). The L* and b* values did not show a strong change throughout the core, but the values were overall also very low (Fig. 5.18).

An overview of the results of the spectral analysis (including measurements of the suspended matter sampled with the BWS and the CTD, as well as measurements from sediment samples taken with the MUC) is depicted in Fig. 5.20. Within the water column, there are strong changes in the color values of the suspended matter. This might be due to differences in the local current velocity. L* values showed the lightest colors in the upper part of the water column (Fig. 5.20a). a* values showed high fractions of green colors within the suspended matter in the upper water column (Fig. 5.20b). b* values showed a strong influence of yellow in the whole water column. However, especially strong yellow-influenced color values are found in the upper water column area as well (Fig. 5.20c).

In general, these values indicate a strong photopigment content in the upper area of the water column (compare to Stuhr et al. (2021)), while these samples show the lightest values (see the L* values).

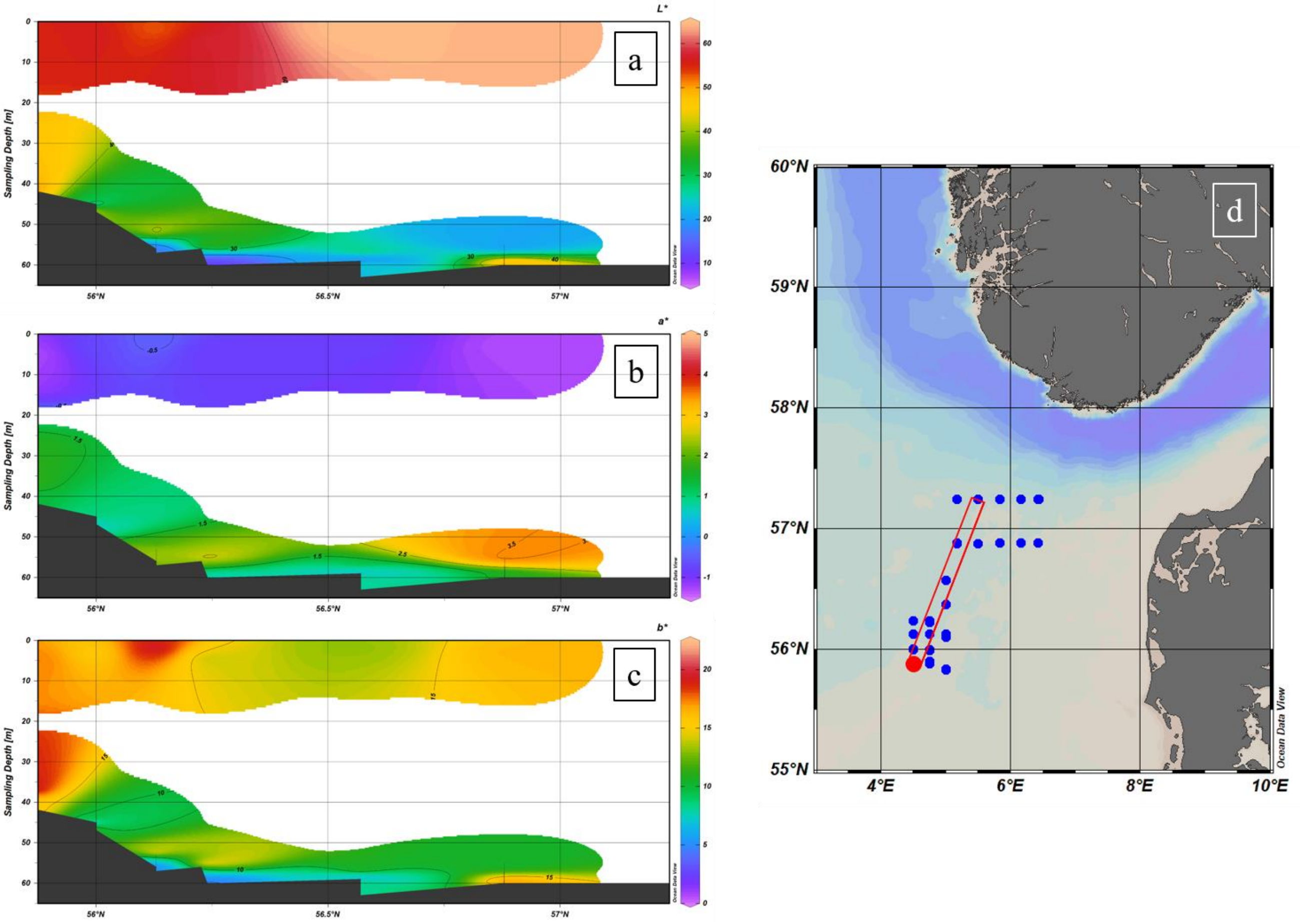

Fig. 5.20 Results of the spectral analysis gridded in Ocean Data View. The color values include the colors of the measurements of the suspended matter on the glass fiber filters from the sampling of the BWS and the CTD. Color values of the sediment samples taken with the MUC are included as well. a: L* color value, b: a* color value, c: b* color value, d: position of the section. Since most of the samples were taken either in the area close to the water surface or the area close to the seafloor, the colors of the suspended matter in the central water column cannot be indicated.

5.3 Underway Hydroacoustics

(M. F. Artschwager, T. Lüdmann)

For Hydroacoustic surveys, the KONGSBERG EM710 Multibeam Echosounder (MBES), the INNOMAR Sediment Echosounder SES-2000, and the TELEDYN RDI WORKHORSE MARINER 600 kHz Acoustic Doppler Current Profiler (ADCP) were used during HE577. The locations of the survey profiles are shown in Fig. 5.21.

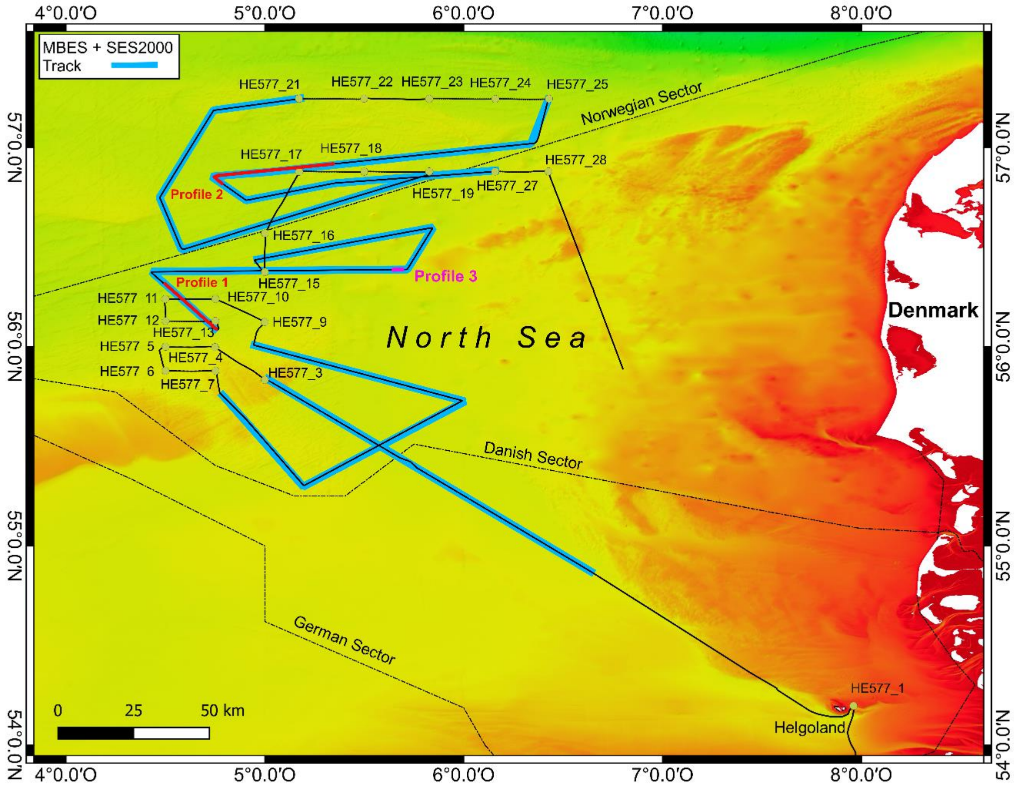

Fig. 5.21 Map of Stations and survey profiles of HE577. Red lines mark the shown SES and MBES profiles, the pink line marks the backscatter profile.

The KONGSBERG EM710 is a high-resolution seabed mapping system, operating at frequencies between 70 and 100 kHz. The system can acquire good data in depths between 10 to 1200 m. The MBES consists of a hull-mounted transmitting and receiving transducer, a transceiver unit, and an operator station. A transducer sends out multiple sound beams, that form an acoustic fan. The MBES swath is divided into three sectors to maximize range capacity and minimize interference from strong seafloor echoes. It has a maximum opening angle of 140°, but during HE577 it was only operated at an angle of 130° (65° on each side). The system can generate two pings simultaneously, one slightly tilted forward and one backward (dual swath). Therefore it produces up to 800 soundings, resulting in higher data density. The ping mode was set to “shallow” during recording. Another important feature of the EM710 is the stabilization of transmitted beams for ship movement (heave, pitch, and yaw). In addition to Bathymetric data, Backscatter data was collected, which shows the amplitude of the beam reflection. This amplitude indicates the relative nature of the seabed. The Bathymetry data was processed with the QPS Qimera v2.3.5 software. The Backscatter Data was processed with QPS FMGeocoder Toolbox. Multibeam surveying aimed to show different sedimentary structures of the seabed.

Figure 5.22 shows the Bathymetry of Profile 1, where you can see two small and one larger elevation. These structures are also shown in Fig. 5.24 and will be explained in the next section about the SES.

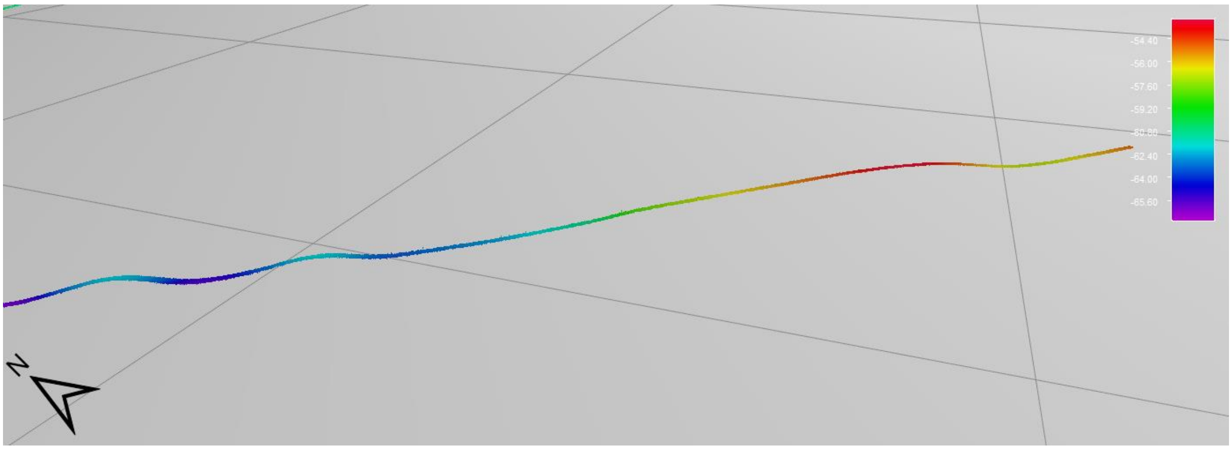

Fig. 5.22 MBES Data of Profile 1. For location see Fig 5.21.

Figure 5.23 shows backscatter data of a profile in the Danish sector. In the shown profile, parallel furrow structures can be seen. These can be identified by a lower backscatter strength (dark grey). The furrows are evidence of demersal trawling activity and show the traces of the used trawling nets (Lüdmann et al., 2021).

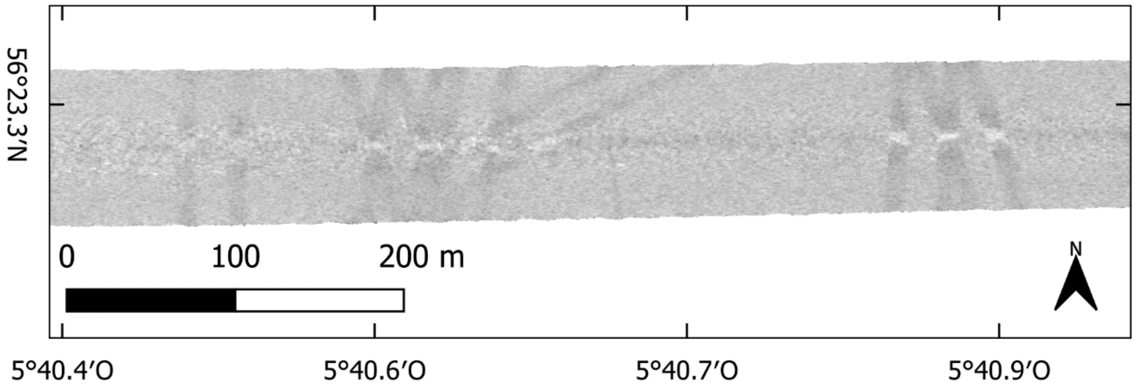

Fig. 5.23 Backscatter data of profile 3. Dark grey: low backscatter strength, light grey: high backscatter strength. For location see Fig. 5.21.

Data of the upper sediment layers were collected with the Sediment Echosounder SES-2000. The system transmits two primary signals with high frequencies (~ 100 kHz) which produces additional frequencies through nonlinear acoustic interaction of the waves. Through interaction, secondary low-frequency waves are formed, which can be adjusted between 4 and 10 kHz. During HE577 the low frequency was set to 6 kHz while recording. The advantage of this parametric effect is the creation of short pulses, a narrow beam, and the absence of sidelobes, which results in a better noise-to-signal ratio (Wunderlich and Wendt, 2001). Due to the glacially influenced sediments in the study area, the penetration depth was only between 30 to 40 m. During the cruise, the SES and the MBES were operating alternatingly. The SES data was processed and displayed with Petrel 2019 (Schlumberger).

The aim of sub-bottom profiling was to further investigate the path of the Elbe Paleo Valley (EPV), as well as displaying the glacially influenced sediments. The EPV played an important role during the Weichselian, where it drained the coastal lowlands. During the Holocene transgression, the EPV was drowned by the advancing North Sea (Hepp et al., 2019). As preliminary results, two profiles are shown in this report. One profile is from the Danish (Fig. 5.24) and one from the Norwegian sector (Fig. 5.25). The profiles show sedimentary structures, which show a complex interaction of glacier advance and retreat, glaciotectonic influence, transgression, and regression. Profile 1 (Fig. 5.24) shows prograding structures with parallel oblique layering. In the DGM you can see these structures as parallel lines with several tens of kilometers in length. These structures can be interpreted as moraine deposits that were formed in front of the glacier during the Weichselian, where glaciers shaped the seabed of the North Sea. Underneath the moraine deposits (from 80 ms TWT) a tunnel valley can be seen. Tunnel valleys are U-shaped channels, that are formed due to subglacial erosion by melting water. The southernmost structure partly shows chaotic layering, this may have been caused by glaciotectonic influence. The bigger structure is approximately 10 m high; the smaller ones 3 to 4 m.

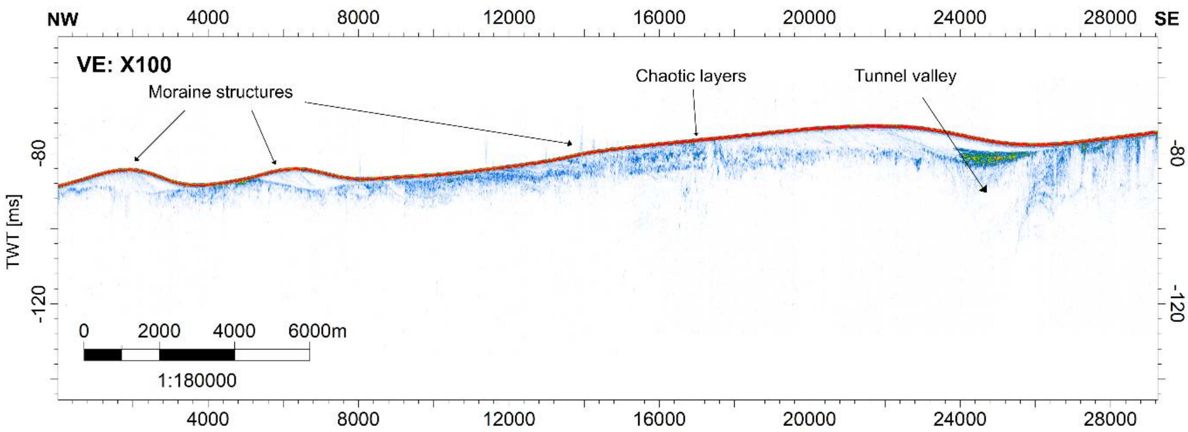

Fig. 5.24 Profile 1: SBES line from the Danish sector. For location see Fig. 5.21.

Similar to profile 1, profile 2 (Fig. 5.25) shows glacial-influenced sediment and several channel structures. Late Pleistocene sediments which are limited by an erosional surface are depicted in the figure (Fig. 5.25). The western part of the profile is covered with Holocene marine sediments. Detail A shows smaller channels with diameters of ~100 m and high amplitude layers. Detail B shows a thin layered filling structure of a bigger glacial river valley (~ 1500 m). West of the bigger river valley, tunnel valleys are present.

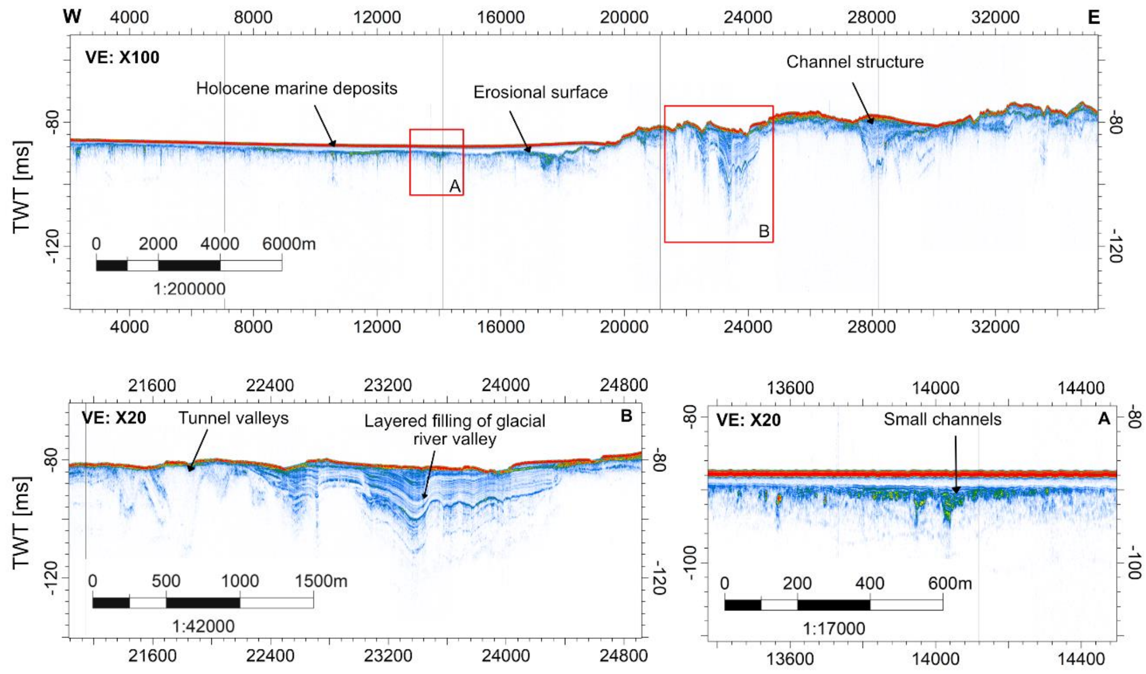

Fig. 5.25 Profile 2: SBES line from the Norwegian sector. For location see Fig. 5.21.

The ADCP is also mounted in the hull of RV HEINCKE and measures current velocity and direction by using the principle of the acoustic Doppler effect. It sends out four high frequency (600 kHz), independently working acoustic beams, divided into range cells (bins) to get data in different water depths. The acoustic beams are reflected by moving particles in the water column (e.g. Plankton) and sent back to the receiver. Due to the Doppler effect, there is a frequency shift between the sent and detected signal. This frequency shift can be calculated as current direction and velocity. During HE577, the ADCP is configured for high resolution which results in a bin size of 1 m. Therefore a water depth of 46 m could be displayed with the device.

Sound velocity data was determined by measurements of the thermosalinograph (TSG) and the CTD. Good sound velocity data is indispensable for accurate acoustic data. The sound beams of the different instruments can be reflected and refracted at boundary surfaces where the speed of sound propagation changes. Through the available data, these changes can be calculated and corrected. Figure 5.26 shows the sound velocity data, calculated by the conductivity and temperature measurements of the CTD-rosette at different stations. All sound velocity profiles show a rapid change of sound propagation between 15 and 25 m, because of the rapid temperature change at the thermocline, which influences the sound velocity.

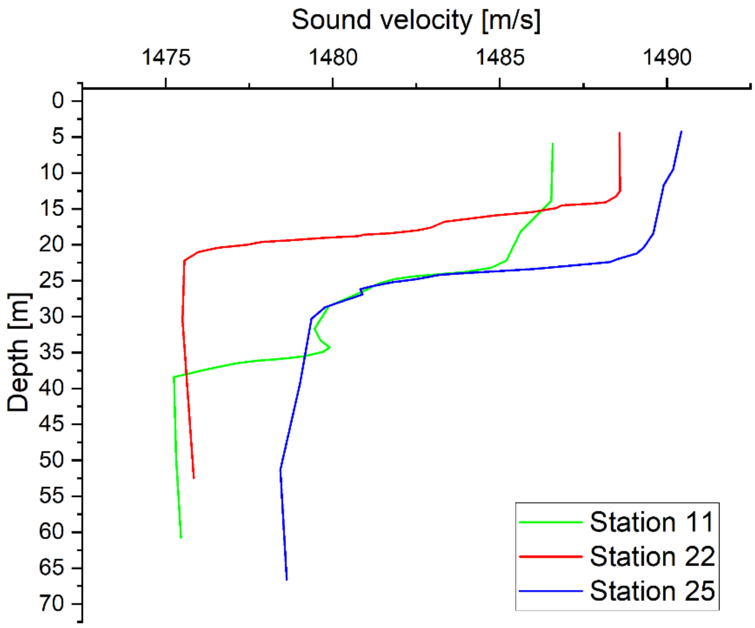

Fig. 5.26 Sound velocity profiles at stations 11, 22, and 25. For locations see Fig 3.1 or 5.21.

Throughout the cruise, 962 km of Multibeam and SES Data, as well as 1634 km of ADCP data were collected in German, Danish and Norwegian territory. The surveys took place from the 26.05.2021 until the 31.05.2021 every day between 3.30 pm (UTC) and 6:00 am (UTC). During the surveys, the ship had a speed of approx. 6-7 kn.

6 Overall Station List HE577

Tab. 6.1 Detailed Station list of the cruise HE577. Station 1 was a test station to check the equipment. All other locations of sampling stations and stations for the hydroacoustic profiles are shown in Fig. 3.1 a and b and Fig. 5.21.

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE577_0_Underway-5	26.05.2021	WST	4:26	53° 31,381' N	008° 34,837' E	33.5	profile start
HE577_0_Underway-6	26.05.2021	TSG	12:30	54° 04,640' N	007° 56,028' E	33.8	profile start
HE577_1-1	26.05.2021	SecDisk	13:18	54° 11,813' N	007° 57,610' E	18	in the water
HE577_1-2	26.05.2021	PLA	13:25	54° 11,828' N	007° 57,502' E	17.4	max depth/on ground
HE577_1-3	26.05.2021	CTD	13:31	54° 11,847' N	007° 57,392' E	15.8	max depth/on ground
HE577_1-4	26.05.2021	BWS	13:44	54° 11,826' N	007° 57,398' E	15.7	max depth/on ground
HE577_1-5	26.05.2021	GRAB	14:08	54° 11,806' N	007° 57,382' E	15.3	max depth/on ground
HE577_2-2	26.05.2021	PS	21:51	54° 52,384' N	006° 38,138' E	40.1	profile start
HE577_2-2	27.05.2021	PS	5:38	55° 50,290' N	005° 00,306' E	33.1	profile end
HE577_3-1	27.05.2021	SecDisk	6:00	55° 49,994' N	004° 59,977' E	33.7	station start
HE577_3-2	27.05.2021	PLA	6:05	55° 49,991' N	004° 59,974' E	33.6	in the water
HE577_3-3	27.05.2021	CTD	6:13	55° 50,002' N	004° 59,970' E	34.2	max depth/on ground
HE577_3-4	27.05.2021	BWS	6:21	55° 50,003' N	004° 59,984' E	33.2	max depth/on ground
HE577_3-5	27.05.2021	GRAB	6:34	55° 50,011' N	004° 59,994' E	31.7	max depth/on ground
HE577_3-6	27.05.2021	MUC	6:46	55° 50,004' N	005° 00,065' E	32.9	max depth/on ground
HE577_4-1	27.05.2021	SecDisk	8:20	55° 59,888' N	004° 44,965' E	39.6	station start
HE577_4-2	27.05.2021	PLA	8:30	55° 59,972' N	004° 44,989' E	39.3	on deck
HE577_4-3	27.05.2021	CTD	8:35	55° 59,999' N	004° 45,003' E	40	max depth/on ground
HE577_4-4	27.05.2021	BWS	9:02	55° 59,997' N	004° 44,986' E	39.3	max depth/on ground
HE577_4-5	27.05.2021	GRAB	9:13	55° 59,996' N	004° 44,983' E	38.3	max depth/on ground
HE577_4-6	27.05.2021	MUC	9:22	55° 59,998' N	004° 44,968' E	40.4	max depth/on ground
HE577_5-1	27.05.2021	SecDisk	10:37	56° 00,038' N	004° 30,043' E	44.6	in the water
HE577_5-2	27.05.2021	PLA	10:42	56° 00,072' N	004° 30,045' E	46.1	max depth/on ground
HE577_5-3	27.05.2021	CTD	10:46	56° 00,081' N	004° 30,054' E	44.9	max depth/on ground
HE577_5-4	27.05.2021	BWS	10:55	56° 00,097' N	004° 30,049' E	45.3	max depth/on ground
HE577_5-5	27.05.2021	GRAB	11:06	56° 00,115' N	004° 30,030' E	45.9	max depth/on ground
HE577_5-6	27.05.2021	MUC	11:15	56° 00,151' N	004° 29,995' E	44.3	max depth/on ground
HE577_6-1	27.05.2021	SecDisk	12:16	55° 52,763' N	004° 29,977' E	38.6	in the water
HE577_6-2	27.05.2021	PLA	12:20	55° 52,763' N	004° 30,001' E	38	max depth/on ground

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE577_6-3	27.05.2021	CTD	12:27	55° 52,738' N	004° 30,070' E	39.4	max depth/on ground
HE577_6-4	27.05.2021	BWS	12:36	55° 52,762' N	004° 30,084' E	38.5	max depth/on ground
HE577_6-5	27.05.2021	GRAB	12:48	55° 52,757' N	004° 30,102' E	38.2	max depth/on ground
HE577_6-6	27.05.2021	MUC	12:57	55° 52,781' N	004° 30,096' E	39.9	max depth/on ground
HE577_7-1	27.05.2021	SecDisk	14:05	55° 52,779' N	004° 44,993' E	36.6	in the water
HE577_7-2	27.05.2021	PLA	14:08	55° 52,777' N	004° 45,000' E	36.8	in the water
HE577_7-3	27.05.2021	CTD	14:14	55° 52,795' N	004° 45,002' E	37.1	max depth/on ground
HE577_7-4	27.05.2021	BWS	14:37	55° 52,805' N	004° 45,004' E	37.6	max depth/on ground
HE577_7-5	27.05.2021	GRAB	14:50	55° 52,798' N	004° 45,012' E	36.6	max depth/on ground
HE577_7-6	27.05.2021	MUC	14:58	55° 52,793' N	004° 44,986' E	37.1	max depth/on ground
HE577_8-1	27.05.2021	PS	16:00	55° 45,500' N	004° 47,023' E	35.5	profile start
HE577_8-1	28.05.2021	PS	4:59	56° 00,374' N	004° 57,080' E	41.8	profile end
HE577_8-2	27.05.2021	MB	16:00	55° 45,449' N	004° 47,073' E	35.1	profile start
HE577_8-2	28.05.2021	MB	5:00	56° 00,393' N	004° 56,999' E	41.6	profile end
HE577_9-1	28.05.2021	SecDisk	6:00	56° 07,481' N	004° 59,961' E	47.4	station start
HE577_9-2	28.05.2021	PLA	6:02	56° 07,478' N	004° 59,985' E	47.3	in the water
HE577_9-3	28.05.2021	CTD	6:12	56° 07,497' N	005° 00,002' E	47.5	max depth/on ground
HE577_9-4	28.05.2021	BWS	6:23	56° 07,493' N	004° 59,972' E	46.9	max depth/on ground
HE577_9-5	28.05.2021	GRAB	6:37	56° 07,491' N	004° 59,966' E	47.1	max depth/on ground
HE577_9-6	28.05.2021	MUC	6:46	56° 07,514' N	004° 59,986' E	47.5	max depth/on ground
HE577_10-1	28.05.2021	GRAB	8:00	56° 14,371' N	004° 45,087' E	57.3	station start
HE577_10-2	28.05.2021	SecDisk	8:00	56° 14,381' N	004° 45,065' E	57.1	station start
HE577_10-3	28.05.2021	PLA	8:11	56° 14,400' N	004° 45,037' E	58	on deck
HE577_10-4	28.05.2021	CTD	8:17	56° 14,404' N	004° 45,010' E	57.2	max depth/on ground
HE577_10-5	28.05.2021	BWS	8:35	56° 14,398' N	004° 44,974' E	57.3	information
HE577_10-6	28.05.2021	GRAB	8:41	56° 14,386' N	004° 44,971' E	57.3	max depth/on ground
HE577_10-7	28.05.2021	MUC	8:49	56° 14,384' N	004° 44,975' E	57.2	max depth/on ground
HE577_11-1	28.05.2021	SecDisk	10:29	56° 14,386' N	004° 29,972' E	60.1	in the water
HE577_11-3	28.05.2021	PLA	10:34	56° 14,393' N	004° 29,948' E	60.6	max depth/on ground
HE577_11-4	28.05.2021	CTD	10:44	56° 14,401' N	004° 29,935' E	60	max depth/on ground
HE577_11-5	28.05.2021	BWS	10:52	56° 14,409' N	004° 29,929' E	60.7	max depth/on ground
HE577_11-6	28.05.2021	GRAB	11:04	56° 14,442' N	004° 29,902' E	60.9	max depth/on ground
HE577_11-7	28.05.2021	MUC	11:15	56° 14,487' N	004° 29,855' E	60.2	max depth/on ground
HE577_12-1	28.05.2021	SecDisk	12:14	56° 07,766' N	004° 29,977' E	53.9	on deck
HE577_12-2	28.05.2021	PLA	12:19	56° 07,764' N	004° 29,913' E	53.6	max depth/on ground

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE577_12-3	28.05.2021	CTD	12:24	56° 07,762' N	004° 29,937' E	53.6	max depth/on ground
HE577_12-4	28.05.2021	BWS	12:36	56° 07,741' N	004° 29,988' E	53.9	max depth/on ground
HE577_12-5	28.05.2021	GRAB	12:49	56° 07,740' N	004° 29,954' E	54.5	max depth/on ground
HE577_12-6	28.05.2021	MUC	13:01	56° 07,730' N	004° 29,844' E	54.3	max depth/on ground
HE577_13-1	28.05.2021	SecDisk	14:09	56° 07,785' N	004° 45,019' E	53.2	in the water
HE577_13-2	28.05.2021	PLA	14:11	56° 07,783' N	004° 45,015' E	53.8	in the water
HE577_13-3	28.05.2021	CTD	14:18	56° 07,773' N	004° 44,970' E	53.4	max depth/on ground
HE577_13-4	28.05.2021	BWS	14:28	56° 07,784' N	004° 44,966' E	53.4	max depth/on ground
HE577_13-5	28.05.2021	GRAB	14:42	56° 07,778' N	004° 44,937' E	52.7	max depth/on ground
HE577_13-6	28.05.2021	MUC	14:50	56° 07,782' N	004° 44,945' E	54.1	max depth/on ground
HE577_14-1	28.05.2021	PS	15:24	56° 05,466' N	004° 44,994' E	50.6	profile start
HE577_14-1	29.05.2021	PS	4:50	56° 26,271' N	004° 57,568' E	52.1	profile end
HE577_14-2	28.05.2021	MB	15:24	56° 05,477' N	004° 44,981' E	51.7	profile start
HE577_14-2	29.05.2021	MB	4:50	56° 26,270' N	004° 57,565' E	55.1	profile end
HE577_15-1	29.05.2021	SecDisk	6:00	56° 22,517' N	004° 59,980' E	55.4	station start
HE577_15-2	29.05.2021	PLA	6:03	56° 22,511' N	004° 59,968' E	54.8	in the water
HE577_15-3	29.05.2021	CTD	6:14	56° 22,494' N	004° 59,968' E	55.3	max depth/on ground
HE577_15-4	29.05.2021	BWS	6:23	56° 22,497' N	004° 59,970' E	54.8	max depth/on ground
HE577_15-5	29.05.2021	GRAB	6:36	56° 22,493' N	004° 59,953' E	54.5	max depth/on ground
HE577_15-6	29.05.2021	MUC	6:43	56° 22,495' N	004° 59,907' E	54.9	max depth/on ground
HE577_16-1	29.05.2021	SecDisk	8:05	56° 34,177' N	005° 00,009' E	60.3	station start
HE577_16-2	29.05.2021	PLA	8:13	56° 34,186' N	004° 59,967' E	59.4	in the water
HE577_16-3	29.05.2021	CTD	8:21	56° 34,184' N	004° 59,965' E	59.6	max depth/on ground
HE577_16-4	29.05.2021	BWS	8:46	56° 34,199' N	004° 59,976' E	60	max depth/on ground
HE577_16-5	29.05.2021	GRAB	8:59	56° 34,198' N	004° 59,989' E	59.7	max depth/on ground
HE577_16-6	29.05.2021	MUC	9:22	56° 34,202' N	004° 59,957' E	58.8	max depth/on ground
HE577_17-1	29.05.2021	SecDisk	11:23	56° 52,769' N	005° 10,296' E	56.2	in the water
HE577_17-2	29.05.2021	PLA	11:28	56° 52,789' N	005° 10,260' E	56.2	max depth/on ground
HE577_17-3	29.05.2021	CTD	11:36	56° 52,815' N	005° 10,198' E	56.2	max depth/on ground
HE577_17-4	29.05.2021	BWS	11:48	56° 52,813' N	005° 10,146' E	56.4	max depth/on ground
HE577_17-5	29.05.2021	GRAB	12:02	56° 52,819' N	005° 10,089' E	55.9	max depth/on ground
HE577_17-6	29.05.2021	MUC	12:12	56° 52,802' N	005° 10,061' E	55.5	max depth/on ground
HE577_18-1	29.05.2021	SecDisk	13:29	56° 52,750' N	005° 29,942' E	47.2	in the water
HE577_18-2	29.05.2021	PLA	13:32	56° 52,746' N	005° 29,937' E	47.7	in the water
HE577_18-3	29.05.2021	CTD	13:39	56° 52,750' N	005° 29,919' E	47.6	max depth/on

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
HEINCKE			[UTC]	[°N]	[°E]	[m]	
							ground
HE577_18-4	29.05.2021	BWS	13:47	56° 52,775' N	005° 29,905' E	48.2	max depth/on ground
HE577_18-5	29.05.2021	GRAB	14:09	56° 52,779' N	005° 29,885' E	48.6	max depth/on ground
HE577_19-1	29.05.2021	SecDisk	15:33	56° 52,803' N	005° 49,611' E	54.1	in the water
HE577_19-2	29.05.2021	PLA	15:35	56° 52,809' N	005° 49,606' E	54.2	in the water
HE577_19-3	29.05.2021	CTD	15:42	56° 52,806' N	005° 49,593' E	54.5	max depth/on ground
HE577_19-4	29.05.2021	GRAB	15:50	56° 52,805' N	005° 49,598' E	52.2	max depth/on ground
HE577_19-5	29.05.2021	BWS	16:15	56° 52,799' N	005° 49,518' E	53.1	max depth/on ground
HE577_20-1	29.05.2021	PS	16:40	56° 52,112' N	005° 50,222' E	52.5	profile start
HE577_20-1	30.05.2021	PS	5:44	57° 14,706' N	005° 10,410' E	55.6	profile end
HE577_20-2	29.05.2021	MB	16:40	56° 52,109' N	005° 50,215' E	52.7	profile start
HE577_20-2	30.05.2021	MB	5:44	57° 14,717' N	005° 10,438' E	55.4	profile end
HE577_21-1	30.05.2021	SecDisk	6:03	57° 14,753' N	005° 10,250' E	54.7	in the water
HE577_21-2	30.05.2021	PLA	6:06	57° 14,753' N	005° 10,227' E	54.8	in the water
HE577_21-3	30.05.2021	CTD	6:14	57° 14,748' N	005° 10,331' E	54.2	max depth/on ground
HE577_21-4	30.05.2021	BWS	6:31	57° 14,766' N	005° 10,276' E	53.8	max depth/on ground
HE577_21-5	30.05.2021	GRAB	6:42	57° 14,768' N	005° 10,275' E	54.9	max depth/on ground
HE577_21-6	30.05.2021	MUC	6:51	57° 14,780' N	005° 10,226' E	53.7	max depth/on ground
HE577_22-1	30.05.2021	SecDisk	8:10	57° 14,760' N	005° 29,956' E	53.4	in the water
HE577_22-2	30.05.2021	PLA	8:16	57° 14,759' N	005° 29,979' E	53.1	in the water
HE577_22-3	30.05.2021	CTD	8:23	57° 14,756' N	005° 29,982' E	52.2	max depth/on ground
HE577_22-4	30.05.2021	BWS	8:35	57° 14,758' N	005° 29,977' E	53.4	information
HE577_22-5	30.05.2021	GRAB	8:39	57° 14,758' N	005° 29,994' E	53	max depth/on ground
HE577_22-6	30.05.2021	MUC	8:45	57° 14,774' N	005° 29,990' E	51.9	station end
HE577_23-1	30.05.2021	SecDisk	10:26	57° 14,692' N	005° 49,605' E	65.3	in the water
HE577_23-2	30.05.2021	PLA	10:32	57° 14,703' N	005° 49,661' E	64.6	max depth/on ground
HE577_23-3	30.05.2021	CTD	10:38	57° 14,738' N	005° 49,694' E	64.5	max depth/on ground
HE577_23-4	30.05.2021	BWS	10:53	57° 14,735' N	005° 49,715' E	64.9	max depth/on ground
HE577_23-5	30.05.2021	GRAB	11:05	57° 14,724' N	005° 49,733' E	63.6	max depth/on ground
HE577_23-6	30.05.2021	MUC	11:17	57° 14,708' N	005° 49,769' E	64.6	max depth/on ground
HE577_24-1	30.05.2021	SecDisk	12:25	57° 14,668' N	006° 09,556' E	67.3	in the water
HE577_24-2	30.05.2021	PLA	12:28	57° 14,669' N	006° 09,527' E	69	max depth/on ground
HE577_24-3	30.05.2021	CTD	12:36	57° 14,664' N	006° 09,450' E	69.4	max depth/on ground
HE577_24-4	30.05.2021	BWS	12:45	57° 14,669' N	006° 09,443' E	69.2	max depth/on ground
HE577_24-5	30.05.2021	GRAB	12:54	57° 14,647' N	006° 09,416' E	69.4	max depth/on ground
HE577_24-6	30.05.2021	MUC	13:02	57° 14,654' N	006° 09,319' E	69.2	max depth/on

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/Recovery
HEINCKE			[UTC]	[°N]	[°E]	[m]	
							ground
HE577_25-1	30.05.2021	SecDisk	14:03	57° 14,716' N	006° 25,732' E	67.7	in the water
HE577_25-2	30.05.2021	PLA	14:06	57° 14,715' N	006° 25,707' E	67.1	in the water
HE577_25-3	30.05.2021	CTD	14:13	57° 14,730' N	006° 25,662' E	66.1	max depth/on ground
HE577_25-4	30.05.2021	BWS	14:25	57° 14,739' N	006° 25,643' E	66.6	max depth/on ground
HE577_25-5	30.05.2021	GRAB	14:35	57° 14,735' N	006° 25,625' E	66.6	max depth/on ground
HE577_25-6	30.05.2021	MUC	14:47	57° 14,734' N	006° 25,611' E	66.4	max depth/on ground
HE577_26-1	30.05.2021	PS	16:10	57° 01,207' N	006° 20,332' E	51.3	profile start
HE577_26-1	31.05.2021	PS	5:38	56° 52,809' N	006° 09,651' E	46.4	profile end
HE577_26-2	30.05.2021	MB	16:10	57° 01,206' N	006° 20,324' E	51.4	profile start
HE577_26-2	31.05.2021	MB	5:40	56° 52,809' N	006° 09,651' E	46.5	profile end
HE577_27-1	31.05.2021	SecDisk	6:00	56° 52,775' N	006° 09,498' E	47	in the water
HE577_27-2	31.05.2021	PLA	6:03	56° 52,761' N	006° 09,498' E	47.2	in the water
HE577_27-3	31.05.2021	CTD	6:09	56° 52,789' N	006° 09,512' E	47.3	max depth/on ground
HE577_27-4	31.05.2021	BWS	6:16	56° 52,790' N	006° 09,527' E	47.5	max depth/on ground
HE577_27-5	31.05.2021	GRAB	6:25	56° 52,793' N	006° 09,544' E	47	max depth/on ground
HE577_27-6	31.05.2021	MUC	6:32	56° 52,784' N	006° 09,526' E	47.5	max depth/on ground
HE577_28-1	31.05.2021	SecDisk	7:32	56° 52,799' N	006° 25,515' E	42	in the water
HE577_28-2	31.05.2021	PLA	7:35	56° 52,779' N	006° 25,452' E	39.6	in the water
HE577_28-3	31.05.2021	CTD	7:41	56° 52,772' N	006° 25,436' E	39.6	max depth/on ground
HE577_28-4	31.05.2021	BWS	7:48	56° 52,784' N	006° 25,475' E	40.1	max depth/on ground
HE577_28-5	31.05.2021	GRAB	7:57	56° 52,774' N	006° 25,442' E	39.9	max depth/on ground
HE577_28-5	31.05.2021	GRAB	8:00	56° 52,784' N	006° 25,467' E	39.8	max depth/on ground
HE577_28-5	31.05.2021	GRAB	8:00	56° 52,785' N	006° 25,483' E	40.9	station end

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8 References

Bockelmann, F. D., Puls, W., Kleeberg, U., Muller, D., Emeis, K. C., 2018. Mapping mud content and median grain-size of North Sea sediments - A geostatistical approach. Marine Geology 397**,** 60-71.

Cathles, L., 1999. Permeability of Shaly Sands. Water Resources Research - WATER RESOUR RES 35**,** 651-662.

Flanders Marine Institute, 2019. Maritime Boundaries Geodatabase: Maritime Boundaries and Exclusive Economic Zones (200NM), version 11. Available online at https://www.marineregions.org/.

Hepp, D. A., Romero, O. E., Morz, T., De Pol-Holz, R., Hebbeln, D., 2019. How a river submerges into the sea: a geological record of changing a fluvial to a marine paleoenvironment during early Holocene sea level rise. Journal of Quaternary Science.

Hosono, T., Fujita, K., Kayanne, H., 2012. Estimating photophysiological condition of endosymbiont-bearing Baculogypsina sphaerulata based on the holobiont color represented in CIE L*a*b* color space. Marine Biology 159**,** 2663-2673.

Hu, H., Liu, H.-q., Zhang, H., Zhu, J.-h., Yao, X.-g., Zhang, X.-b., Zheng, K.-f., 2010. Assessment of Chlorophyll Content Based on Image Color Analysis, Comparison with SPAD502. 2nd International Conference on Information Engineering and Computer Science - Proceedings, ICIECS 2010**,** 1-3.

Hu, H., Zhang, J. Z., Sun, X. Y., Zhang, X. M., 2013. Estimation of leaf chlorophyll content of rice using image color analysis. Canadian Journal of Remote Sensing 39**,** 185-190.

Kraberg, A., Baumann, M., Dürselen, C. D. 2010., Coastal Phytoplankton: Photo Guide for Northern European Seas, Verlag Dr. Friedrich Pfeil, München.

Larink, O., Westheide, W., 2011. Coastal Plankton: Photo Guide for European Seas, Verlag Dr. Friedrich Pfeil, München.

Lewis, E. L., Perkin, R. G., 1981. The Practical Salinity Scale 1978 - Conversion of Existing Data. Deep-Sea Research Part a-Oceanographic Research Papers 28**,** 307-328.

Liang, Y., Urano, D., Liao, K. L., Hedrick, T. L., Gao, Y. J., Jones, A. M., 2017. A nondestructive method to estimate the chlorophyll content of Arabidopsis seedlings. Plant Methods 13.

Lovetskiy, K., Sevastyanov, L., Nikolaev, N., 2018. Numerical modeling of color perception of optical radiation. Mathematical Modelling and Geometry 6.

Lüdmann, T., Saitz, Y. M., Metzing, J., Emeis, K. C., 2021. Acoustic backscatter analysis of ground-fishing activity in the German North Sea sector. Continental Shelf Research 212.

Schlitzer, R., 2021 Ocean data view, https://odv.awi.de.

Schwarzer, K., Ricklefs, K., Lohrberg, A., Valerius, J., 2019. Die geologische Entwicklung von Nord- und Ostsee.

Streif, H., 2004. Sedimentary record of Pleistocene and Holocene marine inundations along the North Sea coast of Lower Saxony, Germany. Quaternary International 112**,** 3-28.

Stuhr, M., Cameron, L. P., Blank-Landeshammer, B., Reymond, C. E., Doo, S. S., Westphal, H., Sickmann, A., Ries, J. B., 2021. Divergent Proteomic Responses Offer Insights into Resistant Physiological Responses of a Reef-Foraminifera to Climate Change Scenarios. Oceans 2**,** 281-314.

Wunderlich, J., Wendt, G., 2001. Advantages of parametric acoustics for the detection of the dredging level in areas with siltation. 7th Workshop on Dredging and Surveying, Scheveningen (The Haag), June 07th-08th 2001, 1–8.

Zeiler, M., Schwarzer, K., Ricklefs, K., 2008. Seabed Morphology and Seabed Sediments. Die Küste 74, 31–44, 2008.

9 Appendices

9.1 Secchi Disk depth

Tab. 9.1 List of the Secchi Disk depth at the different stations.

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bottom depth (m)	Secchi depth (m)
HE577	3	27.05.2021	6:00	5.000	55.833	33.0	7
HE577	4	27.05.2021	8:30	4.750	56.000	39.0	7.5
HE577	5	27.05.2021	10:35	4.501	56.001	45.0	11
HE577	6	27.05.2021	12:17	4.502	55.879	38.0	6
HE577	7	27.05.2021	14:05	4.750	55.880	40.0	9
HE577	9	28.05.2021	06:00	5.000	56.125	50.2	7
HE577	10	28.05.2021	08:30	4.750	56.240	57.1	12
HE577	11	28.05.2021	10:30	4.500	56.240	64.0	12
HE577	12	28.05.2021	12:15	4.500	56.130	57.0	12.5
HE577	13	28.05.2021	14:00	4.750	56.130	53.5	9
HE577	15	29.05.2021	06:20	4.998	56.375	58.0	9
HE577	16	29.05.2021	08:25	5.000	56.570	63.0	9
HE577	17	29.05.2021	11:20	5.171	56.880	59.0	8.5
HE577	18	29.05.2021	13:27	5.500	56.879	51.0	9
HE577	19	29.05.2021	15:30	5.827	56.877	59.0	7
HE577	21	30.05.2021	6:35	5.173	57.246	54.0	8
HE577	22	30.05.2021	8:35	5.500	57.246	55.0	8.5
HE577	23	30.05.2021	11:05	5.828	57.246	65.0	8
HE577	24	30.05.2021	12:55	6.158	57.245	73.0	6.5
HE577	25	30.05.2021	14:35	6.429	57.245	70.0	9.5
HE577	27	31.05.2021	6:15	6.158	56.880	51.0	7
HE577	28	31.05.2021	07:30	6.425	56.880	41.0	7

9.2 Plankton Net (Apstein Net)

Tab. 9.2 List and detailed protocols of the plankton diversity in the sampled stations.

Cruise	Station	Date	Longitude	Latitude	Bot. Depth [m]	Sample Depth [m]	Description
HE577	3	05/27/21	004°59,98'E	55°50,08'N	33	6	*Ceratium* sp.; Late pluteus (*Echinocardium cordatum*); Thaliacea; Cnidaria polyps; Pleurosigma/Gyrosigma, *Eunotogramma dubium* Hhystedt, pennate diatoms and other diatoms; green and red dots (indefinable); Foraminifera?; Radians?; microplastic
HE577	4	05/27/21	004°45,00'E	55°59,98'N	39	4	many *Ceratium* sp.; many Late pluteus; *Cnidaria antipathula*; Gastropoda; fish eggs?; green dots (indefinable); microplastic
HE577	5	05/27/21	004°30,05'E	56°00,08'N	45	4	many *Ceratium* sp.; Late pluteus; green dots (indefinable); fish eggs; microplastic
HE577	6	05/27/21	004°30,09'E	55°52,74'N	38	7	*Ceratium* sp.; Late pluteus; *Cnidaria antipatula*; Proboscia truncata; Thaliacea; micropastic
HE577	7	05/27/21	004°45,00'E	55°52,78'N	36	9	*Ceratium* sp.; Late pluteus; Pleurosigma/Gyrosigma, *Odontella mobiliensis*, *Leptocylindrus* sp., centric diatoms; Thaliacea; fish eggs; microplastic
HE577	9	05/28/21	005°00,00'E	56°07,50'N	50	10	*Ceratium* sp., Late pluteus; *Cnidaria antipathula*; *Corystes* sp.; green dots (indefinable); polls?
HE577	10	05/28/21	004°45,00'E	56°14,40'N	57	10	*Ceratium* sp.; many Late pluteus; *Rathcea octopunctata*; microplastic
HE577	11	05/28/21	004°30,00'E	56°14,40'N	60	10	Late pluteus; Cnidaria; red & green dots (indefinable); microplastic
HE577	12	05/28/21	004°30,00'E	56°07,80'N	57	10	Late pluteus; red & green dots (indefinable)
HE577	13	05/28/21	004°45,00´E	56°07,80´N	53	12	Late pluteus; red & green dots (indefinable)

Cruise	Station	Date	Longitude	Latitude	Bot. Depth [m]	Sample Depth [m]	Description
HE577	15	05/29/21	004°45,00´E	56°22,49´N	58	10	*Cnidaria antipathula*; Diatoms; *Phaeocystis globosa*; Crustacea; Foraminifera?; red/brownish points (indefinable)
HE577	17	05/29/21	005°10,23´E	56°52,80´N	59	7	many Late pluteus; many *Cnidaria antipathula* (big); *Phaeocystis globosa*; red & green dots (indefinable); much microplastic
HE577	18	05/29/21	005°29,98´E	56°52,75´N	53	5	*Cnidaria antipathula*; red, brown & green dots (indefinable); Algae?; microplastic
HE577	19	05/29/21	005°49,59´E	56°52,81´N	59	7	many *Ceratium* sp.; *Cnidaria antipathula*; Rotifera?; many red/brown dots (indefinable); microplastic
HE577	21	05/30/21	005°10,55´E	57°14,74´N	54	5	Late pluteus; *Lalonus* sp.; green/brown & red dots (indefinable); microplastic
HE577	22	05/30/21	005°29,97´E	57°14,75´N	55	10	*Ceratium* sp., *Gonyaulax* sp.; Late pluteus, *Echinocardium cordatum*; Diatoms (Hexandrium sp?); microplastic
HE577	23	05/30/21	005°49,70´E	57°14,74´N	65	10	*Ceratium* sp.; Late pluteus; Cnidaria polyps; Lalonus sp.; Diatoms; microplastic
HE577	24	05/30/21	005°09,47´E	57°14,67´N	70	5	many *Ceratium* sp., other dinoflagellata; *Cladocera* sp.; *Coscinodiscus concinnus* and other diatoms; Leprocreatiidae; microplastic
HE577	25	05/30/21	006°25,73´E	57°14,74´N	70	5	many *Ceratium* sp., Protoperidinium depressum; many Cnidaria polyps; Cladocera; *Coscinodiscus concinnus*; Leprocreatiidae; microplastic
HE577	27	05/31/21	006°09,49´E	56°52,80´N	51	10	Late Pluteus; *Cnidaria Antipathula*, *Rathlea octopunctata*; red & green dots (indefinable); microplastic

Cruise	Station	Date	Longitude	Latitude	Bot. Depth [m]	Sample Depth [m]	Description
HE577	28	05/31/21	006°25,48´E	56°52,80´N	45	11	*Ceratium fusus*, *Ceratium lineatum*, *Ceratium tripos*; *Cnidaria antipatula*; red & green dots (indefinable); microplastic

9.3 Water Sampling with CTD-Rosette

Tab. 9.3 List of sampled stations and depth sampled in the water column with the CTD-rosette.

Cruise	Station	Type	Date and time (UTM)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sampled depth [m]
HE577	3	CTD	05/27/21 06:10	5,000	55,834	36,00	34
HE577	3	CTD	05/27/21 06:10	5,000	55,834	36,00	2
HE577	4	CTD	05/27/21 08:40	4,750	56,000	43,00	37
HE577	4	CTD	05/27/21 08:40	4,750	56,000	43,00	2
HE577	5	CTD	05/27/21 10:48	4,501	56,001	47,00	44
HE577	5	CTD	05/27/21 10:48	4,501	56,001	47,00	3
HE577	6	CTD	05/27/21 12:24	4,500	55,879	42,00	37
HE577	6	CTD	05/27/21 12:24	4,500	55,879	42,00	5
HE577	7	CTD	05/27/21 14:10	4,750	55,880	40,00	37
HE577	7	CTD	05/27/21 14:10	4,750	55,880	40,00	3
HE577	9	CTD	05/28/21 05:56	5,000	56,125	50,30	46
HE577	9	CTD	05/28/21 05:56	5,000	56,125	50,30	4
HE577	10	CTD	05/28/21 08:06	4,751	56,240	60,10	55
HE577	10	CTD	05/28/21 08:06	4,751	56,240	60,10	4,5
HE577	11	CTD	05/28/21 10:28	4,416	56,240	64,00	60
HE577	11	CTD	05/28/21 10:28	4,416	56,240	64,00	5
HE577	12	CTD	05/28/21 12:17	4,499	56,129	57,00	53
HE577	12	CTD	05/28/21 12:17	4,499	56,129	57,00	4,5
HE577	13	CTD	05/28/21 14:10	4,750	56,130	57,00	52
HE577	13	CTD	05/28/21 14:10	4,750	56,130	57,00	2
HE577	15	CTD	05/29/21 06:15	4,100	56,375	58,00	54
HE577	15	CTD	05/29/21 06:15	4,100	56,375	58,00	4
HE577	16	CTD	05/29/21 08:20	4,100	56,570	63,00	57
HE577	16	CTD	05/29/21 08:20	4,100	56,570	63,00	2
HE577	17	CTD	05/29/21 11:36	5,172	56,879	60,00	55
HE577	17	CTD	05/29/21 11:36	5,172	56,879	60,00	3
HE577	18	CTD	05/29/21 13:39	5,499	56,879	51,00	47
HE577	18	CTD	05/29/21 13:39	5,499	56,879	51,00	2
HE577	19	CTD	05/29/21 15:41	5,827	56,880	58,00	53
HE577	19	CTD	05/29/21 15:41	5,827	56,880	58,00	3
HE577	21	CTD	05/30/21 06:00	5,173	57,246	57,00	54

Cruise	Station	Type	Date and time (UTM)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sampled depth [m]
HE577	21	CTD	05/30/21 06:00	5,173	57,246	57,00	3
HE577	22	CTD	05/30/21 08:10	5,500	57,246	55,00	51
HE577	22	CTD	05/30/21 08:10	5,500	57,246	55,00	4
HE577	23	CTD	05/30/21 10:30	5,828	57,246	68,00	64
HE577	23	CTD	05/30/21 10:30	5,828	57,246	68,00	4
HE577	24	CTD	05/30/21 12:25	6,159	57,246	73,00	65
HE577	24	CTD	05/30/21 12:25	6,159	57,246	73,00	4
HE577	25	CTD	05/30/21 14:05	6,427	57,246	70,00	66
HE577	25	CTD	05/30/21 14:05	6,427	57,246	70,00	3
HE577	27	CTD	05/31/21 06:10	6,158	56,880	51,00	49
HE577	27	CTD	05/31/21 06:10	6,158	56,880	51,00	3,5
HE577	28	CTD	05/31/21 07:39	6,425	56,880	41,00	37
HE577	28	CTD	05/31/21 07:39	6,425	56,880	41,00	3,5

9.4 Bottom Water Sampler (BWS)

Tab. 9.4 List of the location of stations and sampled depth above the seafloor.

Cruise	Station	Type	Date time (UTM)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sampled depth above seafloor [cm]
HE577	3	BWS	05/27/21 06:40	5,000	55,833	36,0	28
HE577	3	BWS	05/27/21 06:40	5,000	55,833	36,0	57
HE577	3	BWS	05/27/21 06:40	5,000	55,833	36,0	110
HE577	4	BWS	05/27/21 08:56	4,750	56,000	43,0	28
HE577	4	BWS	05/27/21 08:56	4,750	56,000	43,0	57
HE577	4	BWS	05/27/21 08:56	4,750	56,000	43,0	110
HE577	5	BWS	05/27/21 10:57	4,501	56,002	47,0	28
HE577	5	BWS	05/27/21 10:57	4,501	56,002	47,0	57
HE577	5	BWS	05/27/21 10:57	4,501	56,002	47,0	110
HE577	6	BWS	05/27/21 12:55	4,502	55,880	42,0	28
HE577	6	BWS	05/27/21 12:55	4,502	55,880	42,0	57
HE577	6	BWS	05/27/21 12:55	4,502	55,880	42,0	110
HE577	7	BWS	05/27/21 14:20	4,750	55,880	40,0	28
HE577	7	BWS	05/27/21 14:20	4,750	55,880	40,0	57
HE577	7	BWS	05/27/21 14:20	4,750	55,880	40,0	110
HE577	9	BWS	05/28/21 06:20	5,000	55,130	47,0	28
HE577	9	BWS	05/28/21 06:20	5,000	55,130	47,0	57
HE577	9	BWS	05/28/21 06:20	5,000	55,130	47,0	110
HE577	10	BWS	05/28/21 08:30	4,751	56,240	56,0	28
HE577	10	BWS	05/28/21 08:30	4,751	56,240	56,0	57
HE577	10	BWS	05/28/21 08:30	4,751	56,240	56,0	110
HE577	11	BWS	05/28/21 10:48	4,500	56,240	60,0	28
HE577	11	BWS	05/28/21 10:48	4,500	56,240	60,0	57

Cruise	Station	Type	Date time (UTM)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sampled depth above seafloor [cm]
HE577	11	BWS	05/28/21 10:48	4,500	56,240	60,0	110
HE577	12	BWS	05/28/21 12:33	4,500	56,130	53,0	Not closed
HE577	12	BWS	05/28/21 12:33	4,500	56,130	53,0	57
HE577	12	BWS	05/28/21 12:33	4,500	56,130	53,0	110
HE577	13	BWS	05/28/21 14:30	4,750	56,130	53,0	28
HE577	13	BWS	05/28/21 14:30	4,750	56,130	53,0	Not closed
HE577	13	BWS	05/28/21 14:30	4,750	56,130	53,0	110
HE577	15	BWS	05/29/21 06:00	5,000	56,375	58,0	28
HE577	15	BWS	05/29/21 06:00	5,000	56,375	58,0	57
HE577	15	BWS	05/29/21 06:00	5,000	56,375	58,0	110
HE577	16	BWS	05/29/21 08:07	5,000	56,570	60,0	28
HE577	16	BWS	05/29/21 08:07	5,000	56,570	60,0	57
HE577	16	BWS	05/29/21 08:07	5,000	56,570	60,0	110
HE577	17	BWS	05/29/21 11:20	5,173	56,880	60,0	28
HE577	17	BWS	05/29/21 11:20	5,173	56,880	60,0	57
HE577	17	BWS	05/29/21 11:20	5,173	56,880	60,0	110
HE577	18	BWS	05/29/21 13:30	5,499	56,880	59,0	28
HE577	18	BWS	05/29/21 13:30	5,499	56,880	59,0	57
HE577	18	BWS	05/29/21 13:30	5,499	56,880	59,0	110
HE577	19	BWS	05/29/21 15:30	5,826	56,880	54,5	28
HE577	19	BWS	05/29/21 15:30	5,826	56,880	54,5	57
HE577	19	BWS	05/29/21 15:30	5,826	56,880	54,5	110
HE577	21	BWS	05/30/21 06:34	5,171	57,246	57,0	28
HE577	21	BWS	05/30/21 06:34	5,171	57,246	57,0	57
HE577	21	BWS	05/30/21 06:34	5,171	57,246	57,0	110
HE577	22	BWS	05/30/21 08:32	5,499	57,246	56	28
HE577	22	BWS	05/30/21 08:32	5,499	57,246	56	57
HE577	22	BWS	05/30/21 08:32	5,499	57,246	56	110
HE577	23	BWS	05/30/21 10:54	5,827	57,245	68	28
HE577	23	BWS	05/30/21 10:54	5,827	57,245	68	57
HE577	23	BWS	05/30/21 10:54	5,827	57,245	68	110
HE577	24	BWS	05/30/21 12:46	6,159	57,245	73,0	28
HE577	24	BWS	05/30/21 12:46	6,159	57,245	73,0	57
HE577	24	BWS	05/30/21 12:46	6,159	57,245	73,0	110
HE577	25	BWS	05/30/21 14:27	6,428	57,245	70,0	28
HE577	25	BWS	05/30/21 14:27	6,428	57,245	70,0	57
HE577	25	BWS	05/30/21 14:27	6,428	57,245	70,0	110
HE577	27	BWS	05/31/21 06:18	6,158	56,880	50,0	28
HE577	27	BWS	05/31/21 06:18	6,158	56,880	50,0	57
HE577	27	BWS	05/31/21 06:18	6,158	56,880	50,0	110
HE577	28	BWS	05/31/21 07:49	6,425	56,880	41,0	28
HE577	28	BWS	05/31/21 07:49	6,425	56,880	41,0	57
HE577	28	BWS	05/31/21 07:49	6,425	56,880	41,0	110

9.5 Van-Veen-Grab and Sediment Permeability

Tab. 9.5 List and detailed protocols of the sediment samples taken with the van-Veen-Grab (vVG). 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	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth for Permeability [cm]	Grain size	Permeability [cm/s]	Description
HE577	3	27.05.2021	6:00	5.000	55.833	33.0	not determined	4	not determined	shells & shell fragments, vVG half full, darker layer 5GY2/1 (Munsell); brighter layer HUE 2,5 Y 5/4 (standard soil cholor chart)
HE577	4	27.05.2021	8:30	4.750	56.000	39.0	12.0	5	0.21412	homogeneous color accept some darker spots, shell and shell fragments, vVG almost full, Munsell 10YR5/4
HE577	5	27.05.2021	10:35	4.501	56.001	45.0	6.6	4	0.04952	big shells (11cm) & shell fragments, brighter layer 10YR 4/2 & darker layer N3 (Munsell), darker sediments smells slightly sulphurous --> H2S
HE577	6	27.05.2021	12:17	4.502	55.879	38.0	9.5	4	0.01283	shells (small-medium sized) and shel fragments from bigger shells, brigther layer 10YR4/2, darker layer 5Y3/2
HE577	7	27.05.2021	14:05	4.750	55.880	40.0	13.1	4	0.07109	mS, small shell fragments, homogeneous,well sorted, 10YR5/4 (Munsell)
HE577	9	28.05.2021	06:00	5.000	56.125	50.2	7.3	3-4	0.00158	fS (50%); U (50%) (Munsell Soil Color: 5 Y 3/2); from 4,5 cm anoxic layer (Munsell Soil Color: 5 GY 3/2); few shell fragments
HE577	10	28.05.2021	08:30	4.750	56.240	57.1	7.3	3-4	0.00081	fS(35%); U (65%) (Munsell Soil Color: 5 Y 4/4); two worms in the sample, from 4,8 cm anoxic layer (Munsell Soil Color: 5 GY 2/1); few small shell fragments
HE577	11	28.05.2021	10:30	4.500	56.240	64.0	14.0	3-4	0.00065	fS (20%); U (70%); T (10%) (Munsell Soil Color: 5 Y 3/2); from 9 cm anoxic layer (Munsell Soil Color: 5 G 2/1); shell fragments
HE577	12	28.05.2021	12:15	4.500	56.130	57.0	8.5	3-4	0.00227	fS (40%); U (50%); T (10%) (Munsell Soil Color: 10 Y 4/2); homogeneous; shell fragments (partially whole shells)
HE577	13	28.05.2021	14:00	4.750	56.130	53.5	8.5	4;5	0.00196	fS (30%); U (60%); T (10%) (Munsell Soil Color: 5 Y 3/2); from 5 cm anoxic layer (Munsell Soil Color: 5 GY 3/2); H_2S-smell
HE577	15	29.05.2021	06:20	4.998	56.375	58.0	8.1	2; 3; 4; 1	0.00019	fS (50%); U (47); T (3%); relative homogeneous; many shell fragments and one worm in the sample; color(Standard soil color chart: 5Y 3/2 - olive black)
HE577	16	29.05.2021	08:25	5.000	56.570	63.0	6.1	2; 3; 4; 1	0.00063	U (80%); rest: fS und T; relative homogeneous, partially darker area; few shell frgaments and one worm; color: (Standard soil color chart:) 10 Y 4/2 / olive grey (Grundsediment); dunkleres Band im Sediment: 10Y 3/1 (olive black)
HE577	17	29.05.2021	11:20	5.171	56.880	59.0	13.1	5	0.04420	mS (nearly 100%), homogeneous; color (Standard soil color chart): 10YR 4/3 - dull yellowish brown in the main sediment;

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth for Permeability [cm]	Grain size	Permeability [cm/s]	Description
										10YR 2/1 (black) in some tiny discoloration
HE577	18	29.05.2021	13:27	5.500	56.879	51.0	not determined	6, 7; 5, 2/3	not determined	main sediment: Schluff and Sand (80%) ; many rocks up to 5 cm and more in diameter (plutonic igneous rocks, sandstone); all in all this sediments is called a till. Shell fragments, Echinodermata (3 cm diameter); color: 5Y 3/2 (olive black)
HE577	19	29.05.2021	15:30	5.827	56.877	59.0	not determined	6, 7, 1, 3	not determined	T (70%), U (30%) as main sediment; many rocks: especially sedimentite; no shell fragments, anoxic: hydrogen sulfide smell, color indicates monosulfide; color: 2,5 GY 2/1 (predominantly available, black); partially: 2,5 Y 3/2 (brownish black)
HE577	21	30.05.2021	6:35	5.173	57.246	54.0	10.6	5	0.03551	sea urchin, shells, agglutinating organism, Munsell color: 10YR4/2
HE577	22	30.05.2021	8:35	5.500	57.246	55.0	10.3	6	0.07203	shell fragments, Munsell color: 10YR4/2
HE577	23	30.05.2021	11:05	5.828	57.246	65.0	10.5	4-5	0.00168	darker layer at the top, putrid smell, finer sediment; sea urchin & shell fragments & shells; darker layer 5GY 2/1; brighter layer 5Y3/2
HE577	24	30.05.2021	12:55	6.158	57.245	73.0	10.5	5	0.01330	well sorted, shells, darker layer 5Y 2/1, brighter layer 10YR 4/2, both layers are spotted
HE577	25	30.05.2021	14:35	6.429	57.245	70.0	11.0	5-6	0.05090	shells, worms, badly sorted, much gravel, 5YR3/2
HE577	27	31.05.2021	6:15	6.158	56.880	51	9.5	7	0.00130	shells & shell fragments, divers minerals, badly sorted, brighter layer 5YR3/4, anoxic darker layer N2 (better sorted, finer), smells outrid
HE577	28	31.05.2021	07:30	6.425	56.880	41	not determined	7++	not determined	rocks with a diameter of 20 cm +, partially populated (sea urchin, worms)

9.6 Multi-Corer: Description and Sampling

Tab. 9.6 List and detailed protocols of the sediment samples taken with the Multi-Corer. The colors were determined with a Munsell Color Chart. Key for Grain size: 1 clay. 2 fine silt. 3 coarse silt. 4 fine sand. 5 middle sand. 6 coarse sand. 7 gravel/rubble.

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	Grain size	Description
HE577	3	27/05/21	8:00	5.000	55.833	33.2	0	5	4	fS with grey lentil like structures of a size of <1 cm , Munsell Soil Color: 2,5Y 6/2, "fluffy layer", crushed shells
HE577	3	27/05/21	8:00	5.000	55.833	33.2	1	5	4	fS with grey lentil like structures of a size of <1 cm , Munsell Soil Color: 2,5Y 6/2, "fluffy layer", crushed shells
HE577	3	27/05/21	8:00	5.000	55.833	33.2	2	5	4	fS with grey lentil like structures of a size of <1 cm , Munsell Soil Color: 2,5Y 6/2, "fluffy layer", crushed shells
HE577	3	27/05/21	8:00	5.000	55.833	33.2	3	5	4	fS with grey lentil like structures of a size of <1 cm , Munsell Soil Color: 2,5Y 6/2, "fluffy layer", crushed shells
HE577	3	27/05/21	8:00	5.000	55.833	33.2	4	5	4	fS with grey lentil like structures of a size of <1 cm , Munsell Soil Color: 2,5Y 6/2, "fluffy layer", crushed shells
HE577	3	27/05/21	8:00	5.000	55.833	33.2	5	5	4	fS with grey lentil like structures of a size of <1 cm , Munsell Soil Color: 2,5Y 6/2, "fluffy layer", crushed shells
HE577	4	27/05/21	10:30	4.750	55.993	39.5	0	7	4-5	uU-fS, Munsell Soil Color: 10YR 5/4, possible worm hole, crushed shells
HE577	4	27/05/21	10:30	4.750	55.993	39.5	1	7	4-5	uU-fS, Munsell Soil Color: 10YR 5/4, possible worm hole, crushed shells
HE577	4	27/05/21	10:30	4.750	55.993	39.5	2	7	4-5	uU-fS, Munsell Soil Color: 10YR 5/4, possible worm hole, crushed shells
HE577	4	27/05/21	10:30	4.750	55.993	39.5	3	7	4-5	uU-fS, Munsell Soil Color: 10YR 5/4, possible worm hole, crushed shells
HE577	4	27/05/21	10:30	4.750	55.993	39.5	4	7	4-5	uU-fS, Munsell Soil Color: 10YR 5/4, possible worm hole, crushed shells
HE577	4	27/05/21	10:30	4.750	55.993	39.5	5	7	4-5	uU-fS, Munsell Soil Color: 10YR 5/4, possible worm hole, crushed shells
HE577	4	27/05/21	10:30	4.750	55.993	39.5	6	7	4-5	uU-fS, Munsell Soil Color: 10YR 5/4, possible worm hole, crushed shells
HE577	4	27/05/21	10:30	4.750	55.993	39.5	7	7	4-5	uU-fS, Munsell Soil Color: 10YR 5/4, possible worm hole, crushed shells
HE577	5	27/05/21	12:30	4.501	56.001	45	0	5	3-4	uU-fS, Munsell Soil Color: 5 Y 4/4, crushed shells
HE577	5	27/05/21	12:30	4.501	56.001	45	1	5	3-4	uU-fS, Munsell Soil Color: 5 Y 4/4, crushed shells
HE577	5	27/05/21	12:30	4.501	56.001	45	2	5	3-4	uU-fS, Munsell Soil Color: 5 Y 4/4, crushed shells
HE577	5	27/05/21	12:30	4.501	56.001	45	3	5	3-4	uU-fS,Munsell Soil Color: 5 GY 5/2 (propably anoxic sediment), crushed shells
HE577	5	27/05/21	12:30	4.501	56.001	45	4	5	3-4	uU-fS,Munsell Soil Color: 5 GY 5/2 (propably anoxic sediment),

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	Grain size	Description
										crushed shells
HE577	5	27/05/21	12:30	4.501	56.001	45	5	5	3-4	uU-fS,Munsell Soil Color: 5 GY 5/2 (propably anoxic sediment), crushed shells
HE577	6	27/05/21	14:15	4.500	55.879	38.3	0	0	3-4	uU-fS, Munsill Soil Color: 10 YR 4/2, probably anoxic sediment (Munsell Soil Color: 5 Y 3/2), crushed shells (sometimes whole shells), MUC was not deployed
HE572	7	27/05/21	16:00	4.750	55.880	37.4	0	5	4-5	fS-mS, Musell Soil Color: 10 YR 5/4, probably anoxia, crushed shells
HE573	7	27/05/21	16:00	4.750	55.880	37.4	1	5	4-5	fS-mS, Musell Soil Color: 10 YR 5/4, probably anoxia, crushed shells
HE574	7	27/05/21	16:00	4.750	55.880	37.4	2	5	4-5	fS-mS, Musell Soil Color: 10 YR 5/4, probably anoxia, crushed shells
HE575	7	27/05/21	16:00	4.750	55.880	37.4	3	5	4-5	fS-mS, Musell Soil Color: 10 YR 5/4, probably anoxia, crushed shells
HE576	7	27/05/21	16:00	4.750	55.880	37.4	4	5	4-5	fS-mS, Musell Soil Color: 10 YR 5/4, probably anoxia, crushed shells
HE577	7	27/05/21	16:00	4.750	55.880	37.4	5	5	4-5	fS-mS, Musell Soil Color: 10 YR 5/4, probably anoxia, crushed shells
HE577	9	28/05/21	6:30	4.999	56.125	50.0	0	11	4	brownish fine to medium sand, crushed shells, no difference within the entire core/ no horizons, Munsell color: 10YR 3/4
HE577	9	28/05/21	6:30	4.999	56.125	50.0	1	11	4	brownish fine to medium sand, crushed shells, no difference within the entire core/ no horizons, Munsell color: 10YR 3/4
HE577	9	28/05/21	6:30	4.999	56.125	50.0	2	11	4	brownish fine to medium sand, crushed shells, no difference within the entire core/ no horizons, Munsell color: 10YR 3/4
HE577	9	28/05/21	6:30	4.999	56.125	50.0	3	11	4	brownish fine to medium sand, crushed shells, no difference within the entire core/ no horizons, Munsell color: 10YR 3/4
HE577	9	28/05/21	6:30	4.999	56.125	50.0	4	11	4	greyish to dark grayish clayey silt, Munsell color: 5Y 2/1
HE577	9	28/05/21	6:30	4.999	56.125	50.0	5	11	4	greyish to dark grayish clayey silt, Munsell color: 5Y 2/2
HE577	9	28/05/21	6:30	4.999	56.125	50.0	6	11	4	greyish to dark grayish clayey silt, Munsell color: 5Y 2/3
HE577	9	28/05/21	6:30	4.999	56.125	50.0	7	11	4	greyish to dark grayish clayey silt, Munsell color: 5Y 2/4
HE577	9	28/05/21	6:30	4.999	56.125	50.0	8	11	4	greyish to dark grayish clayey silt, Munsell color: 5Y 2/5
HE577	9	28/05/21	6:30	4.999	56.125	50.0	9	11	4	greyish to dark grayish clayey silt, Munsell color: 5Y 2/6
HE577	9	28/05/21	6:30	4.999	56.125	50.0	10	11	4	greyish to dark grayish clayey silt, Munsell color: 5Y 2/7
HE577	9	28/05/21	6:30	4.999	56.125	50.0	11	11	4	greyish to dark grayish clayey silt,

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	Grain size	Description
										Munsell color: 5Y 2/8
HE577	10	28/05/21	8:30	4.750	56.240	60	0	15	4	brown and massive fS, Munsell color: 2.5 Y 4/3
HE577	10	28/05/21	8:30	4.750	56.240	60	1	15	4	brown and massive fS, Munsell color: 2.5 Y 4/3
HE577	10	28/05/21	8:30	4.750	56.240	60	2	15	4	brown and massive fS, Munsell color: 2.5 Y 4/3
HE577	10	28/05/21	8:30	4.750	56.240	60	3	15	4	brown and massive fS, Munsell color: 2.5 Y 4/3
HE577	10	28/05/21	8:30	4.750	56.240	60	4	15	4	brown and massive fS, Munsell color: 2.5 Y 4/3
HE577	10	28/05/21	8:30	4.750	56.240	60	5	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	10	28/05/21	8:30	4.750	56.240	60	6	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	10	28/05/21	8:30	4.750	56.240	60	7	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	10	28/05/21	8:30	4.750	56.240	60	8	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	10	28/05/21	8:30	4.750	56.240	60	9	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	10	28/05/21	8:30	4.750	56.240	60	10	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	10	28/05/21	8:30	4.750	56.240	60	11	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	10	28/05/21	8:30	4.750	56.240	60	12	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	10	28/05/21	8:30	4.750	56.240	60	13	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	10	28/05/21	8:30	4.750	56.240	60	14	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	10	28/05/21	8:30	4.750	56.240	60	15	15	4	greyish to dark grayish clayey silt, Munsell color: 2.5Y 3/1
HE577	11	28/05/21	10:30	4.499	56.240	63	0	14	3-4	brown, massive fS to mS, Munsell color: 2.5 Y 4/3
HE577	11	28/05/21	10:30	4.499	56.240	63	1	14	3-4	brown, massive fS to mS, Munsell color: 2.5 Y 4/3
HE577	11	28/05/21	10:30	4.499	56.240	63	2	14	3-4	brown, massive fS to mS, Munsell color: 2.5 Y 4/3
HE577	11	28/05/21	10:30	4.499	56.240	63	3	14	3-4	brown, massive fS to mS, Munsell color: 2.5 Y 4/3
HE577	11	28/05/21	10:30	4.499	56.240	63	4	14	3-4	dark grayish clayey silt with lentil like-sandy structures, Munsell color: 2.5 Y 2/1
HE577	11	28/05/21	10:30	4.499	56.240	63	5	14	3-4	dark grayish clayey silt with lentil like-sandy structures, Munsell color: 2.5 Y 2/1
HE577	11	28/05/21	10:30	4.499	56.240	63	6	14	3-4	dark grayish clayey silt with lentil like-sandy structures, Munsell color: 2.5 Y 2/1
HE577	11	28/05/21	10:30	4.499	56.240	63	7	14	3-4	dark grayish clayey silt with lentil like-sandy structures, Munsell color: 2.5 Y 2/1
HE577	11	28/05/21	10:30	4.499	56.240	63	8	14	3-4	dark grayish clayey silt with lentil like-sandy structures, Munsell color: 2.5 Y 2/1
HE577	11	28/05/21	10:30	4.499	56.240	63	9	14	3-4	dark grayish clayey silt with lentil like-sandy structures,

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	Grain size	Description
										Munsell color: 2.5 Y 2/1
HE577	11	28/05/21	10:30	4.499	56.240	63	10	14	3-4	dark grayish clayey silt with lentil like-sandy structures, Munsell color: 2.5 Y 2/1
HE577	11	28/05/21	10:30	4.499	56.240	63	11	14	3-4	dark grayish clayey silt with lentil like-sandy structures, Munsell color: 2.5 Y 2/1
HE577	11	28/05/21	10:30	4.499	56.240	63	12	14	3-4	dark grayish clayey silt with lentil like-sandy structures, Munsell color: 2.5 Y 2/1
HE577	11	28/05/21	10:30	4.499	56.240	63	13	14	3-4	dark grayish clayey silt with lentil like-sandy structures, Munsell color: 2.5 Y 2/1
HE577	11	28/05/21	10:30	4.499	56.240	63	14	14	3-4	dark grayish clayey silt with lentil like-sandy structures, Munsell color: 2.5 Y 2/1
HE577	12	28/05/21	13:30	4.499	56.129	57	0	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	1	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	2	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	3	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	4	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	5	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	6	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	7	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	8	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	9	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	10	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	11	16	3-4	brown, massive fS to mS with vertical dark grey/red-brownish lentil like structures, Munsell color: 2.5 Y 3/3
HE577	12	28/05/21	13:30	4.499	56.129	57	12	16	3-4	dark grey clayey silt, Munsell color: 2.5 Y 3/1
HE577	12	28/05/21	13:30	4.499	56.129	57	13	16	3-4	dark grey clayey silt, Munsell color: 2.5 Y 3/1
HE577	12	28/05/21	13:30	4.499	56.129	57	14	16	3-4	dark grey clayey silt, Munsell color: 2.5 Y 3/1
HE577	12	28/05/21	13:30	4.499	56.129	57	15	16	3-4	dark grey clayey silt, Munsell color: 2.5 Y 3/1

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	Grain size	Description
HE577	12	28/05/21	13:30	4.499	56.129	57	16	16	3-4	dark grey clayey silt, Munsell color: 2.5 Y 3/1
HE577	13	28/05/21	14:30	4.751	56.130	56	0	13	3-4	brown-orange, massive mS, Munsell color: 2.5 Y 4/3
HE577	13	28/05/21	14:30	4.751	56.130	56	1	13	3-4	brown-orange, massive mS, Munsell color: 2.5 Y 4/3
HE577	13	28/05/21	14:30	4.751	56.130	56	2	13	3-4	brown-orange, massive mS, Munsell color: 2.5 Y 4/3
HE577	13	28/05/21	14:30	4.751	56.130	56	3	13	3-4	brown-orange, massive mS, Munsell color: 2.5 Y 4/3, crushed shells
HE577	13	28/05/21	14:30	4.751	56.130	56	4	13	3-4	brown-orange, massive mS, Munsell color: 2.5 Y 4/3, crushed shells
HE577	13	28/05/21	14:30	4.751	56.130	56	5	13	3-4	brown/greyish fS, Munsell color: 2.5 Y 3/4
HE577	13	28/05/21	14:30	4.751	56.130	56	6	13	3-4	brown/greyish fS, Munsell color: 2.5 Y 3/4
HE577	13	28/05/21	14:30	4.751	56.130	56	7	13	3-4	brown/greyish fS, Munsell color: 2.5 Y 3/4
HE577	13	28/05/21	14:30	4.751	56.130	56	8	13	3-4	brown/greyish fS, Munsell color: 2.5 Y 3/4
HE577	13	28/05/21	14:30	4.751	56.130	56	9	13	3-4	black clayey silt, Munsell color: 10 YR 1.7/1
HE577	13	28/05/21	14:30	4.751	56.130	56	10	13	3-4	black clayey silt, Munsell color: 10 YR 1.7/1
HE577	13	28/05/21	14:30	4.751	56.130	56	11	13	3-4	black clayey silt, Munsell color: 10 YR 1.7/1
HE577	13	28/05/21	14:30	4.751	56.130	56	12	13	3-4	black clayey silt, Munsell color: 10 YR 1.7/1
HE577	13	28/05/21	14:30	4.751	56.130	56	13	13	3-4	black clayey silt, Munsell color: 10 YR 1.7/1
HE577	15	29/05/21	6:45	5.000	56.375	54	0	14	4	in between light layers, Munsell Soil Color: 5Y 3/2
HE577	15	29/05/21	6:45	5.000	56.375	54	1	14	4	in between light layers, Munsell Soil Color: 5Y 3/2
HE577	15	29/05/21	6:45	5.000	56.375	54	2	14	4	in between light layers, Munsell Soil Color: 5Y 3/2
HE577	15	29/05/21	6:45	5.000	56.375	54	3	14	4	in between light layers, Munsell Soil Color: 5Y 3/2
HE577	15	29/05/21	6:45	5.000	56.375	54	4	14	4	in between light layers, Munsell Soil Color: 5Y 3/2
HE577	15	29/05/21	6:45	5.000	56.375	54	5	14	4	in between light layers, Munsell Soil Color: 5Y 3/2
HE577	15	29/05/21	6:45	5.000	56.375	54	6	14	3	fine material, grey/black, Munsell Soil Color: 5GY 2/1
HE577	15	29/05/21	6:45	5.000	56.375	54	7	14	3	fine material, grey/black, Munsell Soil Color: 5GY 2/1
HE577	15	29/05/21	6:45	5.000	56.375	54	8	14	3	fine material, grey/black, Munsell Soil Color: 5GY 2/1
HE577	15	29/05/21	6:45	5.000	56.375	54	9	14	3	fine material, grey/black, Munsell Soil Color: 5GY 2/1
HE577	16	29/05/21	5:53	5.000	56.570	59	0	14	3-4	brown, crushed shells, black "smudges" in between, worm holes, Munsell color: 5Y 4/1
HE577	16	29/05/21	8:30	5.000	56.570	59	1	14	3-4	brown, crushed shells, black "smudges" in between, worm holes, Munsell color: 5Y 4/1

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	Grain size	Description
HE577	16	29/05/21	8:30	5.000	56.570	59	2	14	3-4	brown, crushed shells, black "smudges" in between, worm holes, Munsell color: 5Y 4/1
HE577	16	29/05/21	8:30	5.000	56.570	59	3	14	3-4	brown, crushed shells, black "smudges" in between, worm holes, Munsell color: 5Y 4/1
HE577	16	29/05/21	8:30	5.000	56.570	59	4	14	3-4	brown, crushed shells, black "smudges" in between, worm holes, Munsell color: 5Y 4/1
HE577	16	29/05/21	8:30	5.000	56.570	59	5	14	3-4	brown, crushed shells, black "smudges" in between, worm holes, Munsell color: 5Y 4/1
HE577	16	29/05/21	8:30	5.000	56.570	59	6	14	3-4	brown, crushed shells, black "smudges" in between, worm holes, Munsell color: 5Y 4/1
HE577	16	29/05/21	8:30	5.000	56.570	59	7	14	3-4	grey, silt, Munsell color: 5Y 3/2
HE577	16	29/05/21	10:30	5.000	56.570	59	8	14	3-4	grey, silt, Munsell color: 5Y 3/2
HE577	16	29/05/21	10:30	5.000	56.570	59	9	14	3-4	grey, silt, Munsell color: 5Y 3/2
HE577	16	29/05/21	10:30	5.000	56.570	59	10	14	3-4	grey, silt, Munsell color: 5Y 3/2
HE577	16	29/05/21	10:30	5.000	56.570	59	11	14	3-4	grey, silt, Munsell color: 5Y 3/2
HE577	16	29/05/21	10:30	5.000	56.570	59	12	14	3-4	grey, silt, Munsell color: 5Y 3/2
HE577	16	29/05/21	10:30	5.000	56.570	59	13	14	3-4	grey, silt, Munsell color: 5Y 3/2
HE577	16	29/05/21	10:30	5.000	56.570	59	14	14	3-4	grey, silt, Munsell color: 5Y 3/2
HE577	17	29/05/21	10:30	5.170	56.880	55	1	7	5	fS, reducing environment, Munsell Soil Color: 2,5Y2/1, many crushed shells (Schill)
HE577	17	29/05/21	10:30	5.170	56.880	55	2	7	5	fS, reducing environment, Munsell Soil Color: 2,5Y2/1, many crushed shells (Schill)
HE577	17	29/05/21	10:30	5.170	56.880	55	3	7	5	fS, reducing environment, Munsell Soil Color: 2,5Y2/1, many crushed shells (Schill)
HE577	17	29/05/21	12:40	5.170	56.880	55	4	7	5	fS-mS, orange
HE577	17	29/05/21	12:40	5.170	56.880	55	5	7	5	fS-mS, orange
HE577	17	29/05/21	12:40	5.170	56.880	55	6	7	5	fS-mS, orange
HE577	17	29/05/21	12:40	5.170	56.880	55	7	7	5	fS-mS, orange
HE577	18	29/05/21	13:40	5.4997	56.879	59		0	7	MUC was not used since the seabed was very coarse: gravel
HE577	19	29/05/21	15:40	5.827	56.877	59		0	7	MUC was not used since the seabed was very coarse: gravel
HE577	21	30/05/21	6:50	5.172	57.246	59	1	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	2	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	3	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	4	14	4	mS, dark yellowish brown

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	Grain size	Description
HE577	21	30/05/21	6:50	5.172	57.246	59	5	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	6	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	7	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	8	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	9	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	10	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	11	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	12	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	13	14	4	mS, dark yellowish brown
HE577	21	30/05/21	6:50	5.172	57.246	59	14	14	4	mS, dark yellowish brown
HE577	22	30/05/21	08:40	5.500	57.246	58		0	6	gS, bigger crushed shells, MUC could not be deployed
HE577	23	30/05/21	10:40	5.8272	57.246	68	1	17	4, 5	mS, fS, crushed shells in between, Munsell color: 10YR 4/4 brown
HE577	23	30/05/21	10:40	5.8272	57.246	68	2	17	4,5	mS, fS, crushed shells in between, Munsell color: 10YR 4/4 brown
HE577	23	30/05/21	10:40	5.8272	57.246	68	3	17	4,5	mS, fS, crushed shells in between, Munsell color: 10YR 4/3 dull yellowish brown
HE577	23	30/05/21	10:40	5.8272	57.246	68	4	17	4,5	mS, fS, crushed shells in between, Munsell color: 2,5YR 4/4 olive brown
HE577	23	30/05/21	10:40	5.8272	57.246	68	5	17	4,5	mS, fS, crushed shells in between, Munsell color: 2,5YR 4/4 olive brown
HE577	23	30/05/21	10:40	5.8272	57.246	68	6	17	4,5	mS, fS, crushed shells in between, Munsell color: 2,5YR 4/3 olive brown
HE577	23	30/05/21	10:40	5.8272	57.246	68	7	17	4,5	mS, fS, crushed shells in between, Munsell color: 2,5YR 4/3 olive brown
HE577	23	30/05/21	10:40	5.8272	57.246	68	8	17	4,5	mS, fS, crushed shells in between, Munsell color: 2,5YR 4/3 olive brown
HE577	23	30/05/21	10:40	5.8272	57.246	68	9	17	4,5	mS, fS, crushed shells in between, Munsell color: 5Y 4/3 dark olive
HE577	23	30/05/21	10:40	5.8272	57.246	68	10	17	4,5	mS, fS, crushed shells in between, Munsell color: 5Y 4/3 dark olive
HE577	23	30/05/21	10:40	5.8272	57.246	68	11	17	4,5	mS, fS, crushed shells in between, Munsell color: 5Y 4/3 dark olive
HE577	23	30/05/21	10:40	5.8272	57.246	68	12	17	4,5	mS, fS, crushed shells in between, Munsell color: 5Y 4/2 greyish olive
HE577	23	30/05/21	10:40	5.8272	57.246	68	13	17	4,5	mS, fS, crushed shells in between, Munsell color: 5Y 4/2 greyish olive

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	Grain size	Description
HE577	23	30/05/21	10:40	5.8272	57.246	68	14	17	4,5	mS, fS, crushed shells in between, Munsell color: 5Y 4/2 greyish olive
HE577	23	30/05/21	10:40	5.8272	57.246	68	15	17	4,5	mS, fS, crushed shells in between, Munsell color: 5Y 3/2 olive black
HE577	23	30/05/21	10:40	5.8272	57.246	68	16	17	4,5	mS, fS, crushed shells in between, Munsell color: 5Y 3/2 olive black
HE577	23	30/05/21	10:40	5.8272	57.246	68	17	17	4,5	mS, fS, crushed shells in between, Munsell color: 5Y 3/2 olive black
HE577	24	30/05/21	12:45	6.1574	57.244	72	1	12	5	mS, very homogenous, crushed shells, Munsell color: 10YR 3/4 dark brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	2	12	5	mS, very homogenous, crushed shells, Munsell color: 10YR 3/4 dark brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	3	12	5	mS, very homogenous, crushed shells, Munsell color: 10YR 4/3 dull yellowish brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	4	12	5	mS, very homogenous, crushed shells, Munsell color: 10YR 4/3 dull yellowish brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	5	12	5	mS, very homogenous, crushed shells, Munsell color: 2,5Y 4/4 olive brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	6	12	5	mS, very homogenous, crushed shells, Munsell color: 2,5Y 4/4 olive brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	7	12	5	mS, very homogenous, crushed shells, Munsell color: 2,5Y 4/4 olive brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	8	12	5	mS, very homogenous, crushed shells, Munsell color: 2,5Y 4/4 olive brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	9	12	5	mS, very homogenous, crushed shells, Munsell color: 2,5Y 4/4 olive brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	10	12	5	mS, very homogenous, crushed shells, Munsell color: 2,5Y 4/4 olive brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	11	12	4,5	mS to fS, sometimes with minimal lamination, Munsell color: 2,5Y 4/3 olive brown
HE577	24	30/05/21	12:45	6.1574	57.244	72	12	12	4,5	mS to fS, sometimes with minimal lamination, Munsell color: 2,5Y 4/3 olive brown
HE577	25	30/05/21	14:23	6.4273	57.246	70	1	9	5,6	mS, sometimes gS, very homogenous,crushed shells, Munsell color: 2,5 Y 4/4 olive brown
HE577	25	30/05/21	14:23	6.4273	57.246	70	2	9	5,6	mS, sometimes gS, very homogenous,crushed shells, Munsell color: 2,5 Y 4/4 olive brown
HE577	25	30/05/21	14:23	6.4273	57.246	70	3	9	5,6	mS, sometimes gS, very homogenous,crushed shells, Munsell color: 2,5Y 3/3 dark olive brown
HE577	25	30/05/21	14:23	6.4273	57.246	70	4	9	5,6	mS, sometimes gS, very homogenous,crushed shells, Munsell color: 2,5 Y 4/4 olive brown
HE577	25	30/05/21	14:23	6.4273	57.246	70	5	9	5,6	mS, sometimes gS, very homogenous,crushed shells, Munsell color: 2,5Y 3/3 dark olive brown

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	Grain size	Description
HE577	25	30/05/21	14:23	6.4273	57.246	70	6	9	5,6	mS, sometimes gS, very homogenous,crushed shells, Munsell color: 2,5Y 3/3 dark olive brown
HE577	25	30/05/21	14:23	6.4273	57.246	70	7	9	5,6	mS, sometimes gS, very homogenous,crushed shells, Munsell color: 2,5Y 4/3 olive brown
HE577	25	30/05/21	14:23	6.4273	57.246	70	8	9	5,6	mS, sometimes gS, very homogenous,crushed shells, Munsell color: 2,5Y 4/3 olive brown
HE577	25	30/05/21	14:23	6.4273	57.246	70	9	9	5,6	mS, sometimes gS, very homogenous,crushed shells, Munsell color: 2,5Y 4/4 olive brown
HE577	27	31/05/21	06:28	6.1588	56.88	51	1	7	5	mS, homogenous, no crushed shells, Munsell color: 2,5Y 5/4 yellowish brown
HE577	27	31/05/21	06:28	6.1588	56.88	51	2	7	5	mS, homogenous, no crushed shells, Munsell color: 2,5Y 4/3 olive brown
HE577	27	31/05/21	06:28	6.1588	56.88	51	3	7	5	mS, homogenous, no crushed shells, Munsell color: 2,5Y 4/3 olive brown
HE577	27	31/05/21	06:28	6.1588	56.88	51	4	7	5	mS, homogenous, no crushed shells, Munsell color: 2,5Y 4/3 olive brown
HE577	27	31/05/21	06:28	6.1588	56.88	51	5	7	5	mS, homogenous, no crushed shells, Munsell color: 2,5Y 3/3 dark olive
HE577	27	31/05/21	06:28	6.1588	56.88	51	6	7	5	mS, homogenous, no crushed shells, Munsell color:, 2,5Y 3/3 dark olive
HE577	27	31/05/21	06:28	6.1588	56.88	51	7	7	5	mS, homogenous, no crushed shells, Munsell color: 2,5Y 3/3 dark olive
HE577	28	31/05/21	07:45	6.4255	56.88	45		0	7	MUC was not used since the seabed was very coarse: gravel

9.7 Multi-Corer and Spectrophotometry

Tab. 9.7 Results from the spectrophotometric measurements using the MINOLTA CM-2002 spectrophotometer of the samples taken with the Multi-Corer in 1-cm-intervals. L*: brightness/whiteness, a*: magenta/green value, b*: yellow/blue value coordinates within the within the CIE 1976 L*a*b* (CIELAB) color space.

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	L*	a*	b*
HE577	3	27/05/21	8:00	5.000	55.833	33.2	0	5	24.25	1.64	5.49
HE577	3	27/05/21	8:00	5.000	55.833	33.2	1	5	23.86	1.63	5.02
HE577	3	27/05/21	8:00	5.000	55.833	33.2	2	5	24.88	1.66	5.75
HE577	3	27/05/21	8:00	5.000	55.833	33.2	3	5	26.73	1.07	5.35
HE577	3	27/05/21	8:00	5.000	55.833	33.2	4	5	23.81	0.81	4.47
HE577	3	27/05/21	8:00	5.000	55.833	33.2	5	5	24.28	0.59	5.41

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	L*	a*	b*
HE577	4	27/05/21	10:30	4.750	55.993	39.5	0	7	22.33	2.68	5.01
HE577	4	27/05/21	10:30	4.750	55.993	39.5	1	7	24.51	3.71	7.53
HE577	4	27/05/21	10:30	4.750	55.993	39.5	2	7	25.52	3.92	8.10
HE577	4	27/05/21	10:30	4.750	55.993	39.5	3	7	24.25	3.45	6.91
HE577	4	27/05/21	10:30	4.750	55.993	39.5	4	7	24.65	3.53	6.96
HE577	4	27/05/21	10:30	4.750	55.993	39.5	5	7	23.87	3.17	6.96
HE577	4	27/05/21	10:30	4.750	55.993	39.5	6	7	24.05	3.74	7.69
HE577	4	27/05/21	10:30	4.750	55.993	39.5	7	7	30.58	4.11	11.58
HE577	5	27/05/21	12:30	4.501	56.001	45	0	5	14.3	2.14	10.34
HE577	5	27/05/21	12:30	4.501	56.001	45	1	5	21.09	1.32	4
HE577	5	27/05/21	12:30	4.501	56.001	45	2	5	19.95	0.82	3.3
HE577	5	27/05/21	12:30	4.501	56.001	45	3	5	21.71	0.74	2.86
HE577	5	27/05/21	12:30	4.501	56.001	45	4	5	20.6	0.81	3.02
HE577	5	27/05/21	12:30	4.501	56.001	45	5	5	14.38	0.71	6.54
HE577	6	27/05/21	14:15	4.500	55.879	38.3	0	0			
HE572	7	27/05/21	16:00	4.750	55.880	37.4	0	5	24.76	3.43	7.62
HE573	7	27/05/21	16:00	4.750	55.880	37.4	1	5	25.84	3.87	9.18
HE574	7	27/05/21	16:00	4.750	55.880	37.4	2	5	26.34	3.34	7.89
HE575	7	27/05/21	16:00	4.750	55.880	37.4	3	5	25.19	3.36	7.43
HE576	7	27/05/21	16:00	4.750	55.880	37.4	4	5	29.9	4.12	4.65
HE577	7	27/05/21	16:00	4.750	55.880	37.4	5	5	27.71	4.02	9.23
HE577	9	28/05/21	6:30	4.999	56.125	50.0	0	11	11.91	2.02	9.77
HE577	9	28/05/21	6:30	4.999	56.125	50.0	1	11	21.38	1.7	4.64
HE577	9	28/05/21	6:30	4.999	56.125	50.0	2	11	12.92	1.82	8.95
HE577	9	28/05/21	6:30	4.999	56.125	50.0	3	11	12.93	0.84	6.87
HE577	9	28/05/21	6:30	4.999	56.125	50.0	4	11	12.02	0.55	5.48
HE577	9	28/05/21	6:30	4.999	56.125	50.0	5	11	10.420	0.44	4.58
HE577	9	28/05/21	6:30	4.999	56.125	50.0	6	11	11.81	0.44	5.05
HE577	9	28/05/21	6:30	4.999	56.125	50.0	7	11	10.24	0.50	4.73

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	L*	a*	b*
HE577	9	28/05/21	6:30	4.999	56.125	50.0	8	11	11.62	0.41	5.15
HE577	9	28/05/21	6:30	4.999	56.125	50.0	9	11	9.56	0.61	4.88
HE577	9	28/05/21	6:30	4.999	56.125	50.0	10	11	10.09	0.6	4.24
HE577	9	28/05/21	6:30	4.999	56.125	50.0	11	11	9.06	0.51	4.62
HE577	10	28/05/21	8:30	4.750	56.240	60	0	15	18.69	1.48	3.44
HE577	10	28/05/21	8:30	4.750	56.240	60	1	15	13.31	1.17	6.77
HE577	10	28/05/21	8:30	4.750	56.240	60	2	15	12.73	0.97	6.86
HE577	10	28/05/21	8:30	4.750	56.240	60	3	15	8.36	0.54	4.05
HE577	10	28/05/21	8:30	4.750	56.240	60	4	15	11.92	0.79	6.08
HE577	10	28/05/21	8:30	4.750	56.240	60	5	15	10.27	0.32	4.76
HE577	10	28/05/21	8:30	4.750	56.240	60	6	15	10.89	0.78	5.67
HE577	10	28/05/21	8:30	4.750	56.240	60	7	15	13.75	0.73	5.19
HE577	10	28/05/21	8:30	4.750	56.240	60	8	15	9.72	0.45	4.34
HE577	10	28/05/21	8:30	4.750	56.240	60	9	15	10.87	0.71	5.47
HE577	10	28/05/21	8:30	4.750	56.240	60	10	15	19.38	0.74	2.04
HE577	10	28/05/21	8:30	4.750	56.240	60	11	15	11.01	0.57	4.85
HE577	10	28/05/21	8:30	4.750	56.240	60	12	15	11.28	0.5	4.93
HE577	10	28/05/21	8:30	4.750	56.240	60	13	15	8.9	0.47	4.55
HE577	10	28/05/21	8:30	4.750	56.240	60	14	15	7.81	0.56	4.18
HE577	10	28/05/21	8:30	4.750	56.240	60	15	15	6.96	0.53	4.72
HE577	11	28/05/21	10:30	4.499	56.240	63	0	14	16.02	2.29	8.54
HE577	11	28/05/21	10:30	4.499	56.240	63	1	14	20.66	2.26	5.91
HE577	11	28/05/21	10:30	4.499	56.240	63	2	14	13.35	1.61	6.78
HE577	11	28/05/21	10:30	4.499	56.240	63	3	14	11.01	0.84	4.78
HE577	11	28/05/21	10:30	4.499	56.240	63	4	14	8.11	1.01	4.81
HE577	11	28/05/21	10:30	4.499	56.240	63	5	14	9.81	1.32	5.99
HE577	11	28/05/21	10:30	4.499	56.240	63	6	14	11.34	0.69	5.49
HE577	11	28/05/21	10:30	4.499	56.240	63	7	14	9.54	0.67	7.62
HE577	11	28/05/21	10:30	4.499	56.240	63	8	14	9.59	0.82	4.43

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	L*	a*	b*
HE577	11	28/05/21	10:30	4.499	56.240	63	9	14	6.96	0.76	5.52
HE577	11	28/05/21	10:30	4.499	56.240	63	10	14	11.22	0.68	4.26
HE577	11	28/05/21	10:30	4.499	56.240	63	11	14	9.82	0.68	4.56
HE577	11	28/05/21	10:30	4.499	56.240	63	12	14	17.99	0.89	1.97
HE577	11	28/05/21	10:30	4.499	56.240	63	13	14	10.96	0.79	4.71
HE577	11	28/05/21	10:30	4.499	56.240	63	14	14	11.87	0.73	6.04
HE577	12	28/05/21	13:30	4.499	56.129	57	0	16	15.17	2.17	8.71
HE577	12	28/05/21	13:30	4.499	56.129	57	1	16	12.46	2.18	8.07
HE577	12	28/05/21	13:30	4.499	56.129	57	2	16	12.26	2.11	7.76
HE577	12	28/05/21	13:30	4.499	56.129	57	3	16	12.33	1.71	7.01
HE577	12	28/05/21	13:30	4.499	56.129	57	4	16	11.05	1.94	7.09
HE577	12	28/05/21	13:30	4.499	56.129	57	5	16	7.51	1.29	5.05
HE577	12	28/05/21	13:30	4.499	56.129	57	6	16	10.01	1.67	7.21
HE577	12	28/05/21	13:30	4.499	56.129	57	7	16	18.35	1.05	3.28
HE577	12	28/05/21	13:30	4.499	56.129	57	8	16	12.92	1.26	7.24
HE577	12	28/05/21	13:30	4.499	56.129	57	9	16	12.85	1.52	7.62
HE577	12	28/05/21	13:30	4.499	56.129	57	10	16	11.94	1.41	6.63
HE577	12	28/05/21	13:30	4.499	56.129	57	11	16	11.39	1.05	6.09
HE577	12	28/05/21	13:30	4.499	56.129	57	12	16	0.8	0.9	4.83
HE577	12	28/05/21	13:30	4.499	56.129	57	13	16	10.56	1.01	5.82
HE577	12	28/05/21	13:30	4.499	56.129	57	14	16	11.52	0.88	5.57
HE577	12	28/05/21	13:30	4.499	56.129	57	15	16	10.77	1.01	5.38
HE577	12	28/05/21	13:30	4.499	56.129	57	16	16	8.75	0.82	4.36
HE577	13	28/05/21	14:30	4.751	56.130	56	0	13	15.92	3.52	5.37
HE577	13	28/05/21	14:30	4.751	56.130	56	1	13	15.09	3.46	5.24
HE577	13	28/05/21	14:30	4.751	56.130	56	2	13	19.84	2.87	4.29
HE577	13	28/05/21	14:30	4.751	56.130	56	3	13	19.5	4.06	7.94
HE577	13	28/05/21	14:30	4.751	56.130	56	4	13	20.05	3.3	5.73
HE577	13	28/05/21	14:30	4.751	56.130	56	5	13	19.1	2.34	5.2

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	L*	a*	b*
HE577	13	28/05/21	14:30	4.751	56.130	56	6	13	11.94	3.05	9.07
HE577	13	28/05/21	14:30	4.751	56.130	56	7	13	19.25	1.73	3.7
HE577	13	28/05/21	14:30	4.751	56.130	56	8	13	17.6	2.1	4.87
HE577	13	28/05/21	14:30	4.751	56.130	56	9	13	17.17	1.8	3.08
HE577	13	28/05/21	14:30	4.751	56.130	56	10	13	20.23	2.04	4.68
HE577	13	28/05/21	14:30	4.751	56.130	56	11	13	16.14	0.72	2.27
HE577	13	28/05/21	14:30	4.751	56.130	56	12	13	8.48	0.42	3.52
HE577	13	28/05/21	14:30	4.751	56.130	56	13	13	9.74	0.36	2.57
HE577	15	29/05/21	6:45	5.000	56.375	54	0	14	14.8	1.6	7.34
HE577	15	29/05/21	6:45	5.000	56.375	54	1	14	15.48	1.73	8.26
HE577	15	29/05/21	6:45	5.000	56.375	54	2	14	14.52	0.24	4.29
HE577	15	29/05/21	6:45	5.000	56.375	54	3	14	13.05	0.25	3.65
HE577	15	29/05/21	6:45	5.000	56.375	54	4	14	13.32	0.28	3.67
HE577	15	29/05/21	6:45	5.000	56.375	54	5	14	14.73	0.19	3.61
HE577	15	29/05/21	6:45	5.000	56.375	54	6	14	13.16	0.18	3.72
HE577	15	29/05/21	6:45	5.000	56.375	54	7	14	13.81	0.35	3.96
HE577	15	29/05/21	6:45	5.000	56.375	54	8	14	13.96	0.15	4.2
HE577	15	29/05/21	6:45	5.000	56.375	54	9	14	11.94	0.28	4.27
HE577	16	29/05/21	5:53	5.000	56.570	59	0	14	12.69	1.06	5.66
HE577	16	29/05/21	8:30	5.000	56.570	59	1	14	13.05	0.58	5.15
HE577	16	29/05/21	8:30	5.000	56.570	59	2	14	15.97	1.28	7.84
HE577	16	29/05/21	8:30	5.000	56.570	59	3	14	16.01	1.5	8.72
HE577	16	29/05/21	8:30	5.000	56.570	59	4	14	14.01	0.47	6
HE577	16	29/05/21	8:30	5.000	56.570	59	5	14	16.36	0.72	6.71
HE577	16	29/05/21	8:30	5.000	56.570	59	6	14	14.97	0.4	6.55
HE577	16	29/05/21	8:30	5.000	56.570	59	7	14	13.85	0.82	7.24
HE577	16	29/05/21	10:30	5.000	56.570	59	8	14	16.4	0	4
HE577	16	29/05/21	10:30	5.000	56.570	59	9	14	15.39	0.14	4.18
HE577	16	29/05/21	10:30	5.000	56.570	59	10	14	15.56	-0.09	3.76

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	L*	a*	b*
HE577	16	29/05/21	10:30	5.000	56.570	59	11	14	15.6	-0.46	3.56
HE577	16	29/05/21	10:30	5.000	56.570	59	12	14	16.3	-0.48	4.09
HE577	16	29/05/21	10:30	5.000	56.570	59	13	14	15.95	-0.6	4.15
HE577	16	29/05/21	10:30	5.000	56.570	59	14	14	15.66	-0.58	3.94
HE577	17	29/05/21	10:30	5.170	56.880	55	1	7	15.29	3.84	9.37
HE577	17	29/05/21	10:30	5.170	56.880	55	2	7	16.32	3.35	9.1
HE577	17	29/05/21	10:30	5.170	56.880	55	3	7	20.26	4.02	8.28
HE577	17	29/05/21	12:40	5.170	56.880	55	4	7	16.36	3.71	9
HE577	17	29/05/21	12:40	5.170	56.880	55	5	7	16.47	3.23	9.33
HE577	17	29/05/21	12:40	5.170	56.880	55	6	7	16.74	4.83	10.36
HE577	17	29/05/21	12:40	5.170	56.880	55	7	7	18.18	2.9	8.65
HE577	18	29/05/21	13:40	5.4997	56.879	59		0			
HE577	19	29/05/21	15:40	5.827	56.877	59		0			
HE577	21	30/05/21	6:50	5.172	57.246	59	1	14	23.48	3.14	6.96
HE577	21	30/05/21	6:50	5.172	57.246	59	2	14	26.31	4.05	8.97
HE577	21	30/05/21	6:50	5.172	57.246	59	3	14	25.03	3.68	7.32
HE577	21	30/05/21	6:50	5.172	57.246	59	4	14	25.42	3.86	8.92
HE577	21	30/05/21	6:50	5.172	57.246	59	5	14	22.42	4.37	10.09
HE577	21	30/05/21	6:50	5.172	57.246	59	6	14	24.02	4.11	8.01
HE577	21	30/05/21	6:50	5.172	57.246	59	7	14	24.94	3.73	10.03
HE577	21	30/05/21	6:50	5.172	57.246	59	8	14	23.57	3.98	8.85
HE577	21	30/05/21	6:50	5.172	57.246	59	9	14	19.23	4.86	12.51
HE577	21	30/05/21	6:50	5.172	57.246	59	10	14	19.07	4.66	11.68
HE577	21	30/05/21	6:50	5.172	57.246	59	11	14	23.91	4.15	8.9
HE577	21	30/05/21	6:50	5.172	57.246	59	12	14	19.81	4.93	11.84
HE577	21	30/05/21	6:50	5.172	57.246	59	13	14	19.78	4.98	12.43
HE577	21	30/05/21	6:50	5.172	57.246	59	14	14	19.72	4.84	11.98
HE577	22	30/05/21	08:40	5.500	57.246	58		0			
HE577	23	30/05/21	10:40	5.8272	57.246	68	1	17	20.14	2.44	7.97

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	L*	a*	b*
HE577	23	30/05/21	10:40	5.8272	57.246	68	2	17	21.65	1.69	5.23
HE577	23	30/05/21	10:40	5.8272	57.246	68	3	17	16.4	1.88	8.68
HE577	23	30/05/21	10:40	5.8272	57.246	68	4	17	18.37	1.56	5.85
HE577	23	30/05/21	10:40	5.8272	57.246	68	5	17	17.97	1	4.62
HE577	23	30/05/21	10:40	5.8272	57.246	68	6	17	21.72	1.34	4.73
HE577	23	30/05/21	10:40	5.8272	57.246	68	7	17	20.1	0.38	3.67
HE577	23	30/05/21	10:40	5.8272	57.246	68	8	17	21.08	0.48	3.36
HE577	23	30/05/21	10:40	5.8272	57.246	68	9	17	15.54	0.73	6.46
HE577	23	30/05/21	10:40	5.8272	57.246	68	10	17	15.51	0.41	4.93
HE577	23	30/05/21	10:40	5.8272	57.246	68	11	17	15.17	0.42	4.64
HE577	23	30/05/21	10:40	5.8272	57.246	68	12	17	18.14	0.39	2.85
HE577	23	30/05/21	10:40	5.8272	57.246	68	13	17	16.22	0.27	3.16
HE577	23	30/05/21	10:40	5.8272	57.246	68	14	17	19.13	0.41	2.35
HE577	23	30/05/21	10:40	5.8272	57.246	68	15	17	20.45	0.33	3.58
HE577	23	30/05/21	10:40	5.8272	57.246	68	16	17	15.93	0.13	3.98
HE577	23	30/05/21	10:40	5.8272	57.246	68	17	17	15.79	0.17	5.4
HE577	24	30/05/21	12:45	6.1574	57.244	72	1	12	13.14	3.06	7.87
HE577	24	30/05/21	12:45	6.1574	57.244	72	2	12	20.5	2.47	4.97
HE577	24	30/05/21	12:45	6.1574	57.244	72	3	12	16.12	2.75	8
HE577	24	30/05/21	12:45	6.1574	57.244	72	4	12	20.51	2.39	5.72
HE577	24	30/05/21	12:45	6.1574	57.244	72	5	12	19.02	2.48	5.37
HE577	24	30/05/21	12:45	6.1574	57.244	72	6	12	16.59	2.3	7.59
HE577	24	30/05/21	12:45	6.1574	57.244	72	7	12	17.35	2.62	5.1
HE577	24	30/05/21	12:45	6.1574	57.244	72	8	12	14.83	2.47	8.15
HE577	24	30/05/21	12:45	6.1574	57.244	72	9	12	16.77	1.97	7.36
HE577	24	30/05/21	12:45	6.1574	57.244	72	10	12	15.53	1.83	6.79
HE577	24	30/05/21	12:45	6.1574	57.244	72	11	12	20.16	2.04	5.38
HE577	24	30/05/21	12:45	6.1574	57.244	72	12	12	13.49	2.24	7.55
HE577	25	30/05/21	14:23	6.4273	57.246	70	1	9	14.06	2.82	7.00

Cruise	Station	mon/day/yr	hh:mm (UTC)	Lon (dE)	Lat (dN)	Bot. Depth [m]	Sample Depth [cm]	Penetration depth [cm]	L*	a*	b*
HE577	25	30/05/21	14:23	6.4273	57.246	70	2	9	17.09	3.52	8.9
HE577	25	30/05/21	14:23	6.4273	57.246	70	3	9	16.38	3.66	9.72
HE577	25	30/05/21	14:23	6.4273	57.246	70	4	9	18.87	2.58	4.4
HE577	25	30/05/21	14:23	6.4273	57.246	70	5	9	21.08	2.37	5.97
HE577	25	30/05/21	14:23	6.4273	57.246	70	6	9	19.55	2.62	5.52
HE577	25	30/05/21	14:23	6.4273	57.246	70	7	9	22.39	2.45	5.35
HE577	25	30/05/21	14:23	6.4273	57.246	70	8	9	15.85	2.84	7.6
HE577	25	30/05/21	14:23	6.4273	57.246	70	9	9	15.49	4.18	9.08
HE577	27	31/05/21	06:28	6.1588	56.88	51	1	7	20.09	3.69	6.61
HE577	27	31/05/21	06:28	6.1588	56.88	51	2	7	21.69	5.03	9.07
HE577	27	31/05/21	06:28	6.1588	56.88	51	3	7	20.96	4.09	6.06
HE577	27	31/05/21	06:28	6.1588	56.88	51	4	7	20.21	4.11	5.49
HE577	27	31/05/21	06:28	6.1588	56.88	51	5	7	22.18	3.61	5.73
HE577	27	31/05/21	06:28	6.1588	56.88	51	6	7	19.72	3.03	3.92
HE577	27	31/05/21	06:28	6.1588	56.88	51	7	7	25.99	3.83	5.64
HE577	28	31/05/21	07:45	6.4255	56.88	45		0			