HEINCKE-Berichte

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

Cruise No. HE606

08.09.2022 – 14.09.2022

Bremerhaven (Germany) – Bremerhaven (Germany)

UHH MARGEO

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2022

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1 Cruise Summary

1.1 Summary

(Y. Ristow, K. Spille)

In the period from 08.09.2022 to 14.09.2022, the cruise HE606 with the research vessel FS HEINCKE took place in the Exclusive Economic Zone of Norway. Start and end of the cruise were the fishing port of Bremerhaven, Germany. This research cruise was part of the Master program in Geosciences at the Universität Hamburg, in the form of a Marine Geology practical training (LV 63-345). The objective of this exercise was to conduct marine sampling procedures, examining the water column as well as surface sediments. The students participated from the setup of the equipment to the independent execution of the station work. A total of 20 stations were sampled over five days. Sampling was done with the following equipment: Secchi disc for turbidity determination, plankton net for phytoplankton description, CTD water sampler for hydrographic water column description, bottom water sampler for sediment-water processes, van Veen grab and multicorer for surface sediment sampling. Secchi disc and phytoplankton net as well as the van Veen grab could be used at all 20 stations. The multicorer (7 samples) and bottom water sampler (9 samples) were not run after station 15 due to bad weather conditions. The CTD (7 samples) failed from station 10 due to technical problems and was replaced by sampling the water surface using a water bucket (8 samples). Another part of the practical training was the seismic profiling of surface sediments, which mostly took place overnight. It was done with the multibeam echo sounder EM712 KONGSBERG and the sediment echo sounder SES2000 INNOMAR.

1.2 Zusammenfassung

(Y. Ristow, K. Spille)

In dem Zeitraum vom 08.09.2022 bis zum 14.09.2022 fand die Fahrt HE606 mit dem Forschungsschiff FS HEINCKE in der Ausschließlichen Wirtschaftszone von Norwegen statt. Start und Ende der Fahrt waren der Fischereihafenhafen von Bremerhaven, Deutschland. Diese Forschungsfahrt war Teil des Masterstudiengangs Geowissenschaften der Universität Hamburg, in der Form eines Marin-Geologischen Praktikums (LV 63-345). Ziel dieses Praktikums war die Durchführung mariner Beprobungsverfahren, bei der die Wassersäule sowie die Oberflächensedimente untersucht wurden. Die Studierenden wirkten dabei von dem Aufbau der Geräte bis hin zur eigenständigen Durchführung der Stationsarbeit mit. An fünf Tagen erfolgte eine Beprobung von insgesamt 20 Stationen. Die Probennahme wurde mit folgenden Geräten durchgeführt: Secchi-Scheibe zur Trübebestimmung, Planktonnetz für die Phytoplanktonbeschreibung, CTD-Wasserschöpfer für die hydrographische Wassersäulenbeschreibung, Bodenwasserschöpfer für Sediment-Wasser-Prozesse, van-Veen-Greifer und Multicorer für die Beprobung von Oberflächensedimenten. Secchi-Scheibe und Phytoplanktonnetz sowie der van-Veen-Greifer konnten an allen 20 Stationen eingesetzt werden. Der Multicorer (7 Proben) und der Bodenwasserschöpfer (9 Proben) konnten wegen Schlechtwetterbedingungen ab Station 15 nicht mehr gefahren werden. Die CTD (7 Proben) fiel ab Station 10 aufgrund technischer Probleme aus und wurde durch eine Beprobung der Wasseroberfläche mittels einer Pütz (8 Proben) ersetzt. Ein weiterer Bestandteil des Praktikums war die seismische Profilaufnahme von Oberflächensedimenten, die meist über Nacht stattfand. Sie erfolgte mit dem Fächerecholot EM712 KONGSBERG und dem Sedimentecholot SES2000 INNOMAR.

2 Participants

2.1 Principal Investigators

Name	Institution
Lahajnar, Niko, Dr.	IfGeol

2.2 Scientific Party

Name	Discipline	Institution
Dr. Niko Lahajnar	Chief scientist, Biogeochemistry	IfGeol
Dr. Thomas Lüdmann	Hydroacustics, Sequence Stratigraphy	IfGeol
Marc Metzke	Technician	IfGeol
Berit Gohr	Student	IfGeol
Inken Heinrich	Student	IfGeol
Manja Oldhaver	Student	IfGeol
Yannick Ristow	Student	IfGeol
Keno Spille	Student	IfGeol
Maryse Schmidt	Student	IfG

2.3 Participating Institutions

IfGeol Institut für Geologie, Universität Hamburg
IfG Institut für Geophysik, Universität Hamburg

3 Research Program

3.1 Description of the Work Area

(M. Oldhaver, K. Spille)

The investigation area of the cruise HE606 was located in the northern part of the North Sea (s. Fig. 3.1). The North Sea is a shallow shelf sea bordered by the British Isles in the west, continental Europe in the south/southeast and West Scandinavia in the East. The maximum north-south extension is about 900 km and the east-west extension up to 500 km. In the Northwest the North Sea opens funnel-like into the North Atlantic, in the south it connects to the Atlantic Ocean via the English Channel (Schwarzer et al., 2019). The geological development of the North Sea started with the formation of the basement which developed during the Caledonian orogeny (Ordovician – Silurian). This basement now is lying in 8 – 10 km depths. Subsequently during the Variscan orogeny (Devonian – Permian) the Variscan mountain range formed south of the North Sea region. During the Carboniferous (359 – 299 Ma BP) the North Sea Basin had lain near the equator and it was formed like a shallow depression in which swamp deposits formed. These represent an important source rock for the natural gas within the North Sea region. In the lower Permian (299 – 273 Ma BP) the detrital material of the Variscan mountains were deposited in the North Sea Basin as a red sandstone. During this period the development of a rift system with horst-graben structures started to form with two important graben structures, the Viking Graben and the Central Graben. In the following periods the North Sea region was characterized by shallow marine and terrestrial deposition conditions in connection with the early rifting of the North Atlantic. During the Jurassic and Cretacous organic rich sediments were deposited in the deepest parts of the North Sea and are forming today´s important source rocks for the oil reservoirs in the North Sea. In the beginning of the Cenozoic the Alpine Orogeny led to a subsidence of the rift structures in the North Sea. During the Pleistocene (2.588 Ma – 11,650 a BP) the climate is characterized by the change between glacial and interglacial periods with simultaneous changing sea level. The glaciers from Scandinavia were also reaching the North Sea Basin and left their traces on the sea floor (Schwarzer et al., 2019; Streif, 2004). The investigation area of the Cruise HE606 was located in the Norwegian EEZ (Exclusive Economic Zone) close to the south coast of Norway and the Norwegian trench. The mean bottom depth within the working area is about 65 m. The deepest water depth was close to the Norwegian trench with 113.7 m. Generally, the sediments within the North Sea Basin are young Holocene or Pleistocene deposits. Due to the close position of the investigation area to Norway and thus presumably located in a region that was strongly influenced by the glaciers, the expected sediment type for the region varies strongly between fine sediments like clay or silt and coarse sediments like gravel.

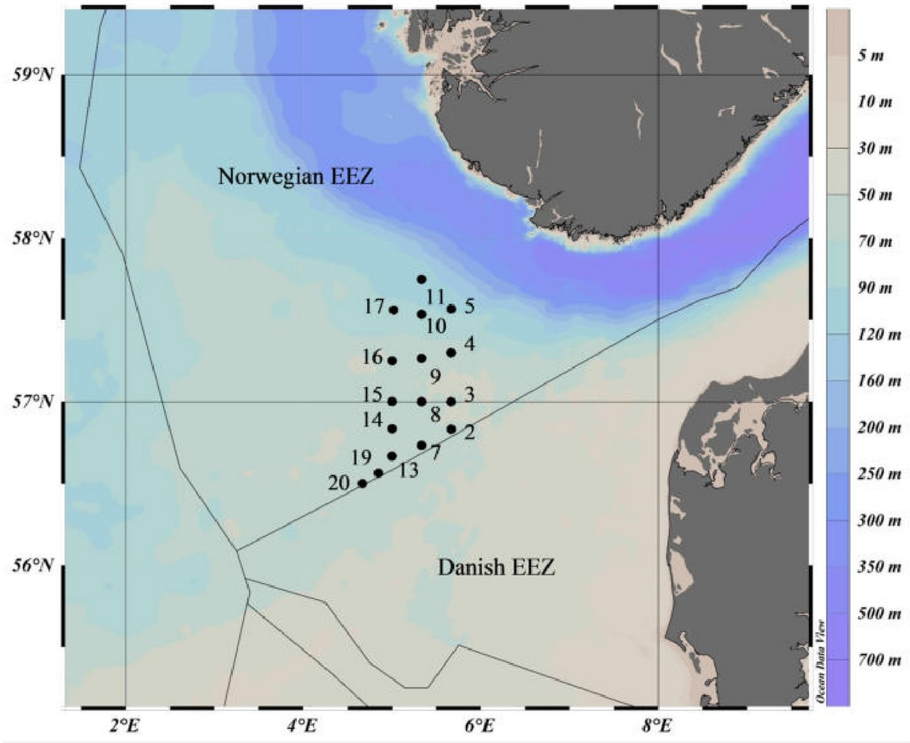


Fig. 3.1 Investigation area of the cruise HE606 where water and sediment samples were taken, plotted with Ocean Data View. The test station was located near Helgoland in the German EEZ, but it is not shown in this map. At the Stations 1, 6, 12 and 18 hydroacoustic information of the seabed were recorded. The shapefile containing the information about the Exclusive Economic Zone (EEZ) positions is from Flanders Marine Institute (2019).

3.2 Aims of the Cruise

(Y. Ristow, K. Spille)

The goal of the research cruise HE606 with the RV HEINCKE was to teach the students in research on a ship. In addition to gaining insight into life on a research vessel, the students learned and conducted marine sampling procedures. Marine geology and biogeochemistry were the central points of the research. Using standard methods, water and sediment sampling was conducted. In the course of the seismics, marine geological structures of the younger North Sea were to be imaged. It was mainly characterized by ice age cycles. The students got to know the structure as well as the functioning of the equipment. They were also taught how to use the equipment, so that in conclusion they were able to manage the stations independently.

3.3 Agenda of the Cruise

(Y. Ristow, K. Spille)

The training began on 08.09.2022 in the morning with a safety briefing on board by the 2nd officer. He showed us escape routes and explained what to do in an emergency. This was followed by the installation of the laboratory and the technical equipment (Secchi disk, Apstein phytoplankton net, CTD, Bottom Water Sampler (BWS), van Veen Grab (vVG) and Multicorer (MUC)) by Marc Metzke (technician) and Dr. Niko Lahajnar (chief scientist). Also the functionality of the MUC and the CTD were explained in detail. After the setup was completed, a test station was run to demonstrate the equipment in operation and to check its functionality. In the afternoon Thomas Lüdmann gave an introduction to hydroacoustics on the bridge of the ship. There, during the research cruise, 4 profiles were run with the multibeam echo sounder EM712 KONGSBERG and the sediment echo sounder SES2000 INNOMAR.

On 09.09.2022 no sampling could take place, since safety concerns did not allow for any work on deck in these weather and sea conditions. Some persons of the science team and the crew were seasick. The following 4 days followed the same pattern, with up to 5 stations per day being sampled by the students under the guidance of Marc Metzke and Dr. Niko Lahajnar. The students were divided into three groups of two persons each. Each group was assigned to specific instruments, which changed daily. In this way, the students familiarized themselves with all the instruments during the entire cruise, so that on the last sampling day (13.09.2022) two stations (19 and 20) could be carried out independently.

To start one station, the Secchi disc was used. It is lowered into the water by hand to determine the visibility depth. There were always at least 2 persons in use, who documented the optical disappearance of the Secchi disc. The highest visibility depths reached at least 14 meters, because the limited length of the rope prevented a further sinking. The second device is the Apstein phytoplankton net with 25 μm mesh. It was also lowered by hand to a depth of 5 m to capture phytoplankton. This was then bottled and examined and determined under a stereomicroscope. The CTD rosette was then used to take water samples. With 12 bottles water samples from two different depths were taken (near the water surface and near the seafloor) were sampled. Between these two depths the conditions in the water column changed. In addition to the water samples, small sensors measured conductivity, temperature, depth, as well as the chlorophyll and dissolved oxygen levels. Because these sensors are very sensitive, the CTD must not come into contact with the seafloor. In order to take water samples of the bottom water the CTD cannot reach, the BWS is used. It samples the water near the seafloor at 27 cm, 57 cm and 109 cm above the seafloor. The samples from CTD and BWS, taken from a total of 5 depths, were then filtered using a previously weighed fiberglass filter. A major problem for data collection was the failure of the CTD from station 10 due to technical problems that could not be resolved. Also BWS could not be run from station 15 because weather conditions did not allow it (At station 3 BWS failed).

The next step was to sample the seafloor with the vVG. This was lowered to the seafloor and brought the top centimeters of the seafloor to the deck. This allowed determination of the texture and the composition of sediment and organisms. In addition, a measurement of permeability was made in the laboratory. The analysis of the vVG sample will then determine the further use of the MUC, which will only be used for fine to medium grained sediment (max. coarse sand). The MUC has eight plexiglass cores with a length of 60 cm which penetrate into the seafloor. For sampling, the top 5 cm was split into five samples (1 cm intervals). In addition, from another core, bottom water and the top 2 cm were taken for micropaleontology. The MUC also could not be run from Station 15 due to weather conditions, and at Stations 5, 8, and 9 the sediment composition made it impossible to use. The MUC finished a station if it could be used.

Seminars were held in the evenings with scientific presentations and discussions. Knots and nautical terminology were also discussed and learned. During nights the hydroacoustic profiles were run, for which Thomas Lüdmann had given a briefing on the first day (08.09.2022).

4 Narrative of the Cruise

(Y. Ristow, K. Spille)

For the students of the marine-geological training HE606 expedition on board the research vessel RV HEINCKE started at 10:00 UTC on Wednesday the 7th of September 2022. After some last-minute changes, the participants arrived in the harbour of Bremerhaven at around 13:00 UTC to get tested for covid. Under the supervision of technician Marc Metzke, the scientific equipment was unpacked, the laboratories prepared and readied for rough seas before the ship could be explored with masks. Now the cabins could be readied by the students. The first introductions and instructions were followed by dinner at quarter past 15:00 UTC.

September 8th was the first day of the marine expedition HE606. Everyone began the day with a daily covid test before breakfast at quarter past 5:00 UTC. The ship left its pier at 5:45 UTC and passed through the new double lock in Bremerhaven at 6:10 UTC. The scientific personnel had a safety briefing at 6:45 UTC from the second officer after a test of the general alarm. At 7:30 UTC the introduction to the equipment started. Beginning with checking the rope and markings of the Secchi disc and plankton net. Followed by an instruction to the associated Zeiss Stemi 508 stereomicroscope, to the various paper logs and the bigger instruments such as the MUC and CTD rosette. After lunch from 9:15 to 9:45 UTC a trial station was reached close to the island of Helgoland at 10:00 UTC where all devices could be tested. The weather conditions at that time were cloudy with wind speeds of 8 m/s from the southeast and around one-meter-tall waves. First up are the smaller devices with the Secchi disc at 10:00 UTC and Apstein plankton net (APN) at 10:05 UTC. Following that the CTD was tried at 10:10 UTC, the BWS at 10:25 UTC, the vVG at 10:40 UTC, the MUC at 10:50 UTC, and three Frahm corer tries at 11:00, 11:05 and 11:10 UTC respectively with the last try successful. At 11:20 UTC the first cores of the trip were prepared. From 13:40 UTC on the hydro acoustics were introduced in groups of three. After dinner from 15:15 to 15:45 UTC the first regular evening meeting was held at 17:30 UTC. In the following days this time was dedicated to previously prepared scientific presentations by the students as well as learning about unfamiliar German naval words and knots. The latter knowledge would be tested at the end of the expedition.

The second day was Friday the 9th of September and after the daily covid test all stations for the day were cancelled by breakfast at 5:30 UTC due to the particularly rough seas and prevailing sea sickness in large parts of the scientific personnel and crew. Wind speeds of more than 17 m/s and wave heights of five meters prevailed throughout the day. For those who were capable to go there was lunch from 9:15 to 9:45 UTC, dinner from 15:15 to 15:45 UTC and the meeting at 17:30 UTC. A hydro acoustic profile was the first station for the expedition starting at 21:40 UTC. This was supervised on the bridge and were partly looked after by the students at night.

A covid test and breakfast at 5:15 UTC started the third expedition day, September 10th. At 5:57 UTC station two concluded the profile during the night. This station had a similar order as the trial and began with the Secchi disc and APN until 6:03 UTC and continued with the CTD at 6:10 UTC, the BWS at 6:26 UTC and the vVG at 6:41 UTC. End of station was after the MUC at 6:50 UTC. Station three began at 8:08 UTC with the Secchi disc and the APN at 8:12 UTC. The CTD, BWS twice, vVG and MUC continued until 9:08 UTC. After lunch at 9:15 UTC the fourth station began at 11:00 UTC with the same order of Secchi disc, APN, CTD, BWS, vVG and finally

MUC at 11:47 UTC. Station five was the last of the day and began at 14:02 UTC with the Secchi disc, APN, CTD and BWS. The vVG had to be lowered twice at 14:43 and 14:48 UTC due to very coarse grain size. Recovering only a single large rock it was decided not to lower the MUC. Following dinner at 15:15 UTC on this day's meeting at 17:00 UTC the first student´s presentations were held. Maryse Schmidt talked about marine sampling equipment for water and sediment and Inken Heinrich presented acoustic marine sampling equipment. Student profile night shift started at 22:00 UTC and finished with profile end at 4:50 UTC the next day.

September 11th started with a covid test and breakfast at 5:15 UTC. The seventh station began at 5:54 UTC and ended after successful operations of the Secchi disc, APN, CTD, BWS, vVG and MUC at 6:46 UTC. Station eight began with the Secchi disc at 8:28 UTC and ended after the APN, CTD, BWS and vVG at 9:05 UTC without the MUC due to coarse sediment. Lunch at 9:15 UTC was followed by station nine at 11:00 UTC. Again, only the Secchi disc, APN, CTD, BWS and vVG could be deployed. Ending the ninth station at 11:42 UTC. Station ten began at 13:27 UTC with the Secchi disc and APN. While the CTD was deployed at 13:39 UTC it had a fatal connection error that could not be resolved even on another descent after the BWS, vVG and MUC at 14:30 UTC. After dinner at 15:15 UTC the station eleven was - ignoring the beginnings of the hydro acoustic profiles 2 (station 6), 3 (station 12) and 4 (station 18) – the northernmost station the expedition would visit. It began at 16:08 UTC with the Secchi disc and APN. Since the CTD could still not be operated properly a bucket was lowered to collect surface water instead. This method was used from this point on instead of the CTD. After the BWS, vVG and MUC the station was ended at 16:52 UTC with the MUC only able to retrieve a small sample instead of a full core. This evening Yannick Ristow held a presentation about offshore wind parks in the North Sea and Manja Oldhaver explained the geological development and tectonics in the North Sea.

September 12th was the first day without a covid test requirement and began with breakfast at 5:15 UTC. RV HEINCKE reached station 13 at 5:59 UTC. The Secchi disc, APN, Bucket, BWS, vVG and MUC were all successfully deployed. Station 14 started at 7:59 UTC. Due to high waves the Secchi disc was not reliable. The APN was launched three times in total. Once from all accessible sides of starboard, portside, and astern. The bucket, BWS, vVG and MUC however were successful and ended the station at 8:41 UTC. Lunch at 9:15 UTC was followed by station 15 at 10:14 UTC. The Secchi disc, APN, bucket and vVG at 10:27 UTC were the only deployed equipment here. The waves were too high for the deployment of the BWS and MUC. As to not risk damage this is true for all following stations. Station 16 at 12:10 UTC saw the use of the Secchi disc, APN, bucket and vVG until 12:24 UTC. At station 17 from 14:33 to 14:54 UTC the Secchi disc, APN, bucket and vVG were deployed. After dinner at 15:15 UTC the evening's presentations were about the hydrography of the North Sea by Berit Gohr and about the phyto- and zooplankton in the North Sea by Keno Spille. This concluded all presentations by the students.

The last day in the Norwegian EEZ was the 13th of September. In order to get to Bremerhaven in time and escaping the coming storm station 19 began at 4:03 UTC before breakfast at 5:15 UTC. Though with increased challenge of darkness and high waves the Secchi disc, APN, bucket and vVG were deployed. The last stop of the expedition - station 20 – began at 6:02 UTC and the Secchi disc, APN, bucket and vVG were used, finishing up the last station of expedition HE606 at 6:12 UTC on Tuesday. Following lunch at 9:15 UTC the students were given an opportunity to attend a guided tour of the ship's engine room at 13:15 UTC. After dinner at 15:15 UTC the students passed the exam for knots and naval vocabulary. All throughout the day the logs were digitalized, and instruments stowed away for travel.

On September 14th the students began cleaning up their cabins after breakfast at 5:15 UTC. The laboratories were cleaned, and the equipment was properly packed to be ready for customs at 10:00 UTC. Departure to Hamburg started at 11:00 UTC and they arrived at the university's equipment storage at 13:00 UTC which concluded the expedition for the students.

5 Preliminary Results

5.1 Water Sampling

5.1.1 Secchi Disc

(I. Heinrich, B. Gohr)

The Secchi disc, as shown in Fig. 5.1a, is a round metal disc with a diameter of 20-50 cm. The top of the disc is either white or divided into four equal-sized circle segments that are alternately filled with black and white paint. In addition, a rope is attached to the centre, which has a mark at regular intervals. On the underside of the disc a weight is attached to the centre point to prevent the disc from tilting and to keep it vertically.

(a)

(b)

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

The Secchi disc is used in oceanography and limnology to manually determine the depth of visibility in the water. To do this, the disc is slowly lowered into the water by hand until the disc is no longer visible in the water (Fig. 5.1b). The marks on the rope that are immersed in the water are counted while the disc is being lowered and the remaining distance to the next mark is estimated when the visibility depth is reached. This results in the visibility depth. The depth of the trophogenic zone can be estimated from the measured visibility depth. It should be noted that the Secchi disc is not an exact method of measuring visibility depth and only an approximate depth can be read off the rope. In addition, the weather, the swell, the light conditions and the displacement of the disc in the water column, among other factors, have a great influence on the visibility of the disc in the water.

During the HE606 expedition, the Secchi disc was used aft on the starboard side of the ship. The rope attached to the Secchi disc had a length of 20 metres and was marked every metre with coloured tape. The rope length of 20 metres resulted in a maximum possible penetration depth of the disc into the water of 14 metres. The disc was secured to the ship by attaching a cleat to the free end of the rope.

At all 16 stations (2, 3, 4, 5, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 19, and 20), the Secchi disc was used to determine the depth of visibility in the water. The results are shown in Figure 5.2. The deepest depth was measured at stations 8 and 9 with more than 14 metres at a water depth of 49.8 metres and 54.6 metres, the shallowest depth at station 14 with a depth of 5 metres at a water depth of 59 metres. As can be seen in Fig. 5.3, no correlation can be derived between water depth and visibility depth. Nor can any correlation be established between the distance to the mainland and the visibility depth based on Fig. 5.2. Rather, the measured data seem to reflect the very fluctuating weather conditions of this cruise (see chapter 3.3). From station 2 to 5 we had bad weather and swell, the visibility depth here was between 8.5 and 9.5 metres. Stations 7 to 11 were in sunny conditions and no swell, the depth of visibility was 11 metres to more than 14 metres. At stations 2 to 5 and 13-17 we had increasingly bad weather and swell, the visibility depth was between 5 and 10 metres. The last two stations were sailed in heavy swell and still at dusk, the visibility depth here was 6 and 6.5 metres.

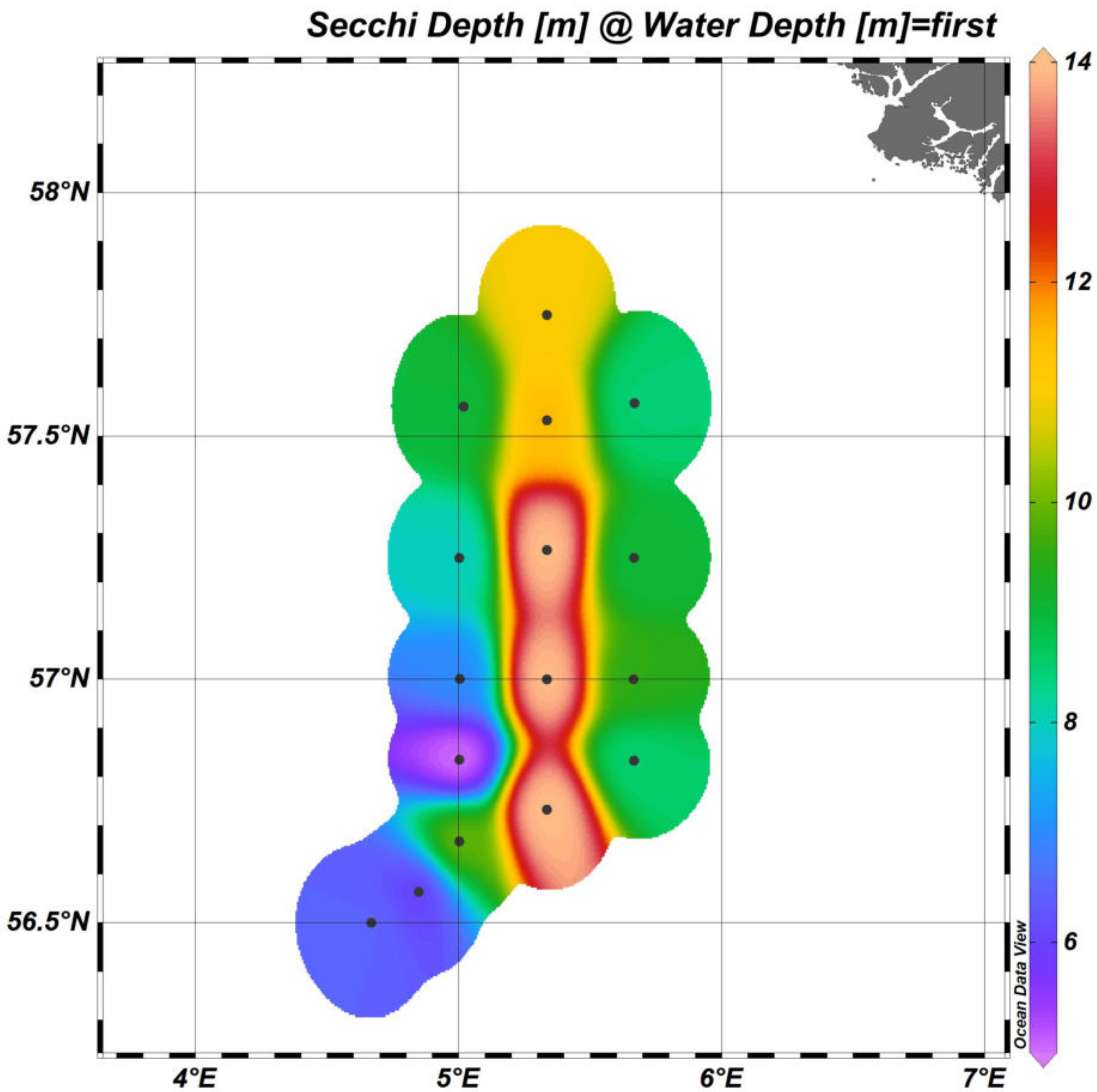


Fig. 5.2 Depth of visibility (Secchi Depth) in the study area.

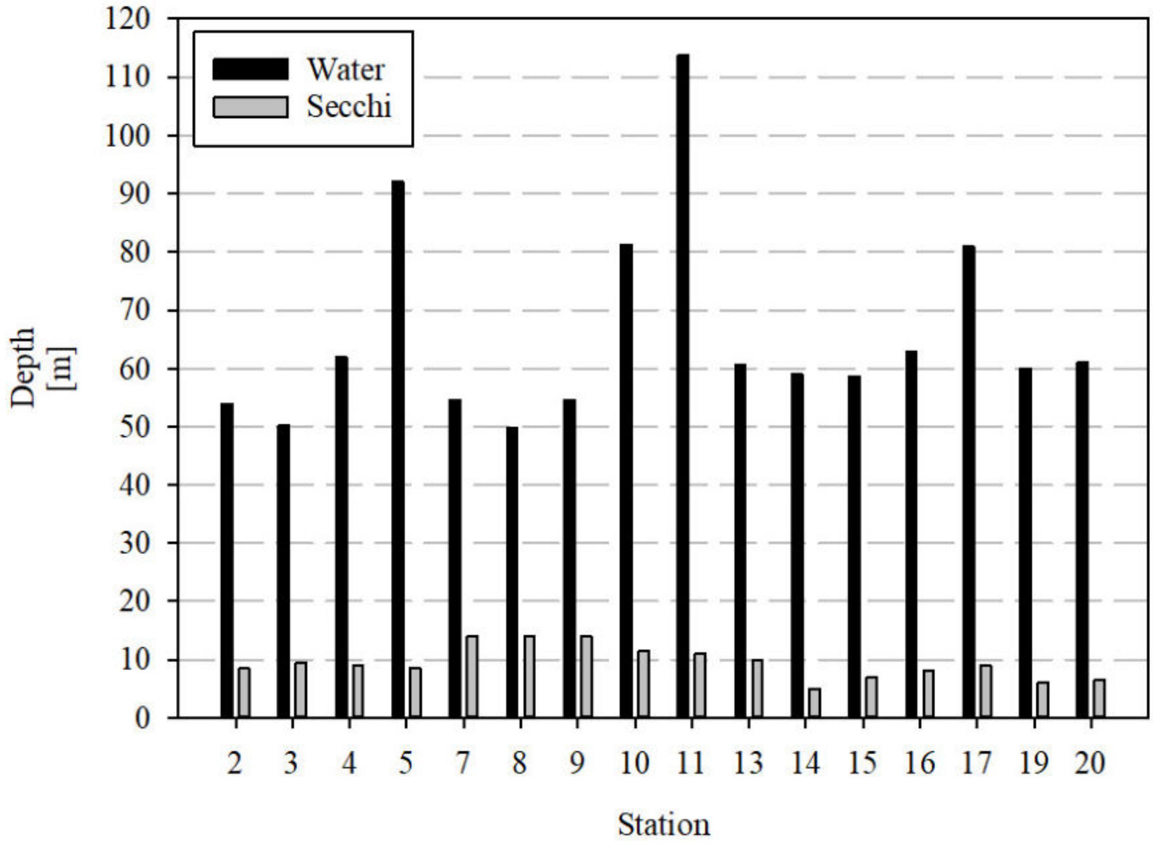
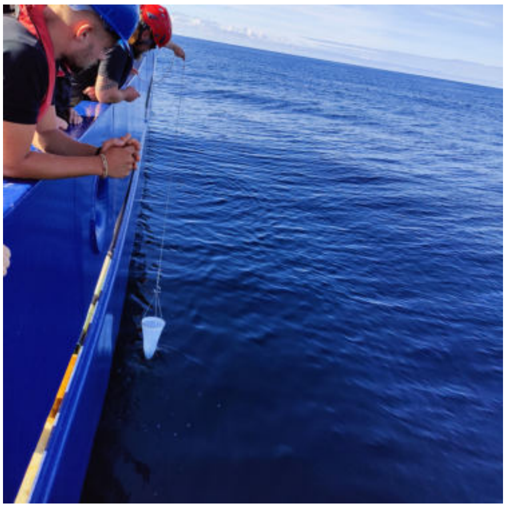


Fig. 5.3 Visible depth (Secchi Depth) and water depth in comparison at the stations.

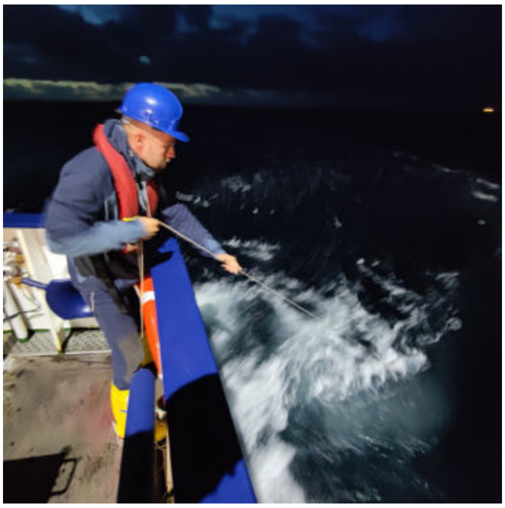
5.1.2 Plankton Sampling

(K. Spille)

During the expedition HE606 there were multiple instruments used in order to investigate plankton. Water samples from the CTD, BWS and bucket can include plankton. However, the most direct investigation of plankton diversity and abundance was with the Apstein plankton net. It is a 50 cm long cone shaped net on a rope held open with a 30 cm diameter ring. The end is closed off with a metal valve and an outlet with a 25 µm mesh size filter. Such a small filter size was chosen to be able to catch the usually smaller phytoplankton as well as zooplankton. This net was lowered at all standstill stations until five meters of the rope were underwater (see Fig.5.4 a and b). The desired depth was therefore not reached reliably in high wave or flow conditions.



(a)



(b)

Fig. 5.4 Retrieving the plankton net at (a) good conditions and (b) challenging conditions.

The retrieved sample was extracted into a beaker by washing it out. A small part was taken under the stereomicroscope with a pipette (see Fig. 5.5). An estimation of abundance and diversity could be made immediately. Fast movement of zooplankton and constant movement of the ship impeded the ability to discern and describe the plankton greatly. Even with literature on hand some taxa could be described only with class or genus. In all samples dinoflagellates were predominantly observed. Ceratium tripos and Ceratium fusus are the most abundant identified dinoflagellates as well as plankton overall. Usually, diatoms and various colonies of green algae were found. Sometimes Radiolaria with translucent, radial spikes were seen. All samples included some crustaceans with the copepod Calanus finmarchicus being identified. Two samples (station 16 and especially station 8) had chaetognaths. Sometimes gastropods were seen and only a few times cnidaria, ctenophores, pteropods and phoronids were observed. Additionally, many samples included colourful particles of plastics, fibre, and lustrous particles of sediment.

Lastly RV HEINCKE is equipped with a measurement array to constantly sample the water close the surface. This thermosalinograph (TSG) data includes date, geographical location, conductivity, density, salinity, temperature, sound velocity and importantly for this chlorophyll a concentration. As phototrophic organisms need this molecule to harness the energy from the sun this concentration

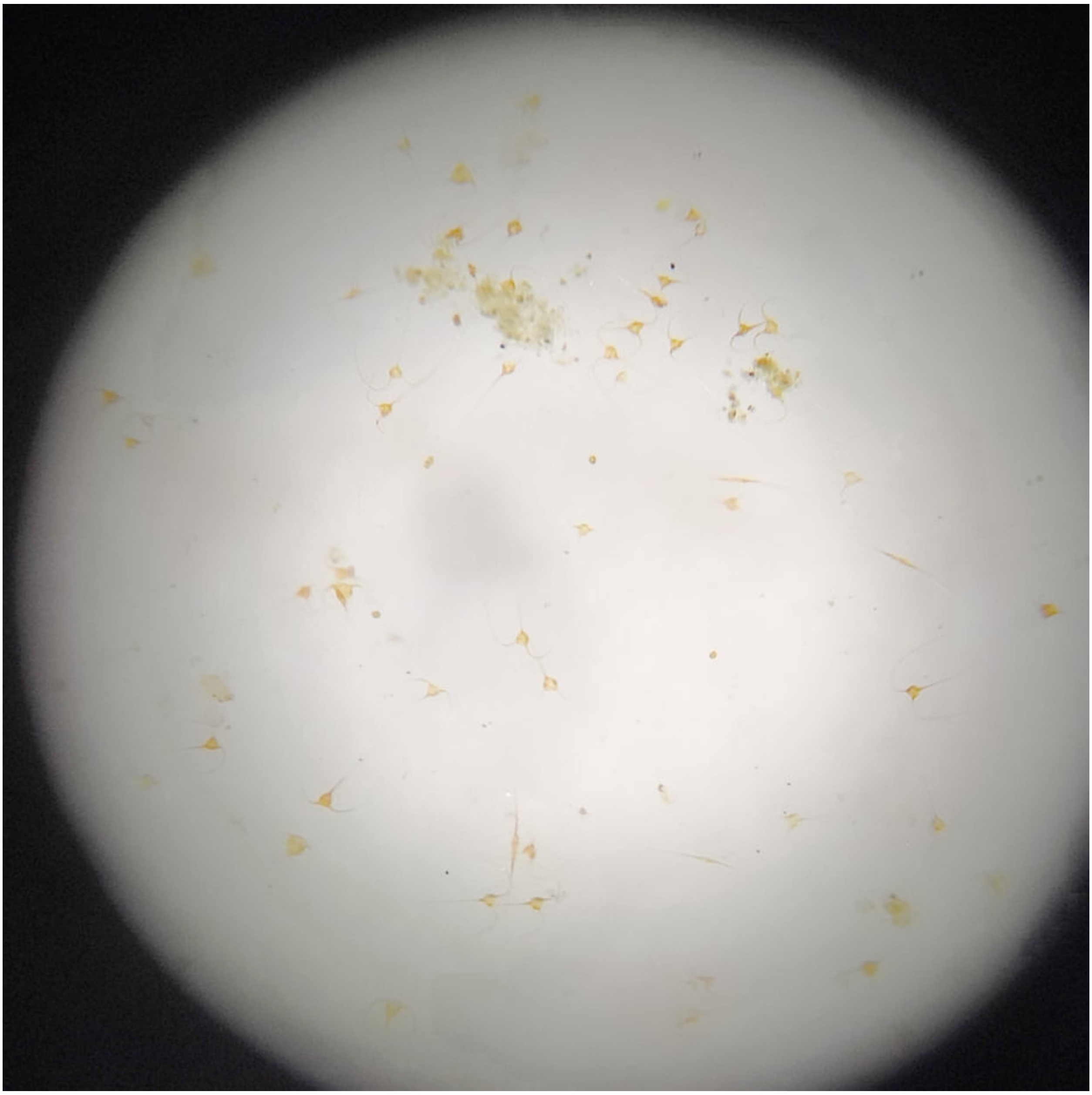


Fig. 5.5 Dinoflagellates and green algae of a sample through the stereomicroscope.

describes a close correlation with phytoplankton concentration.

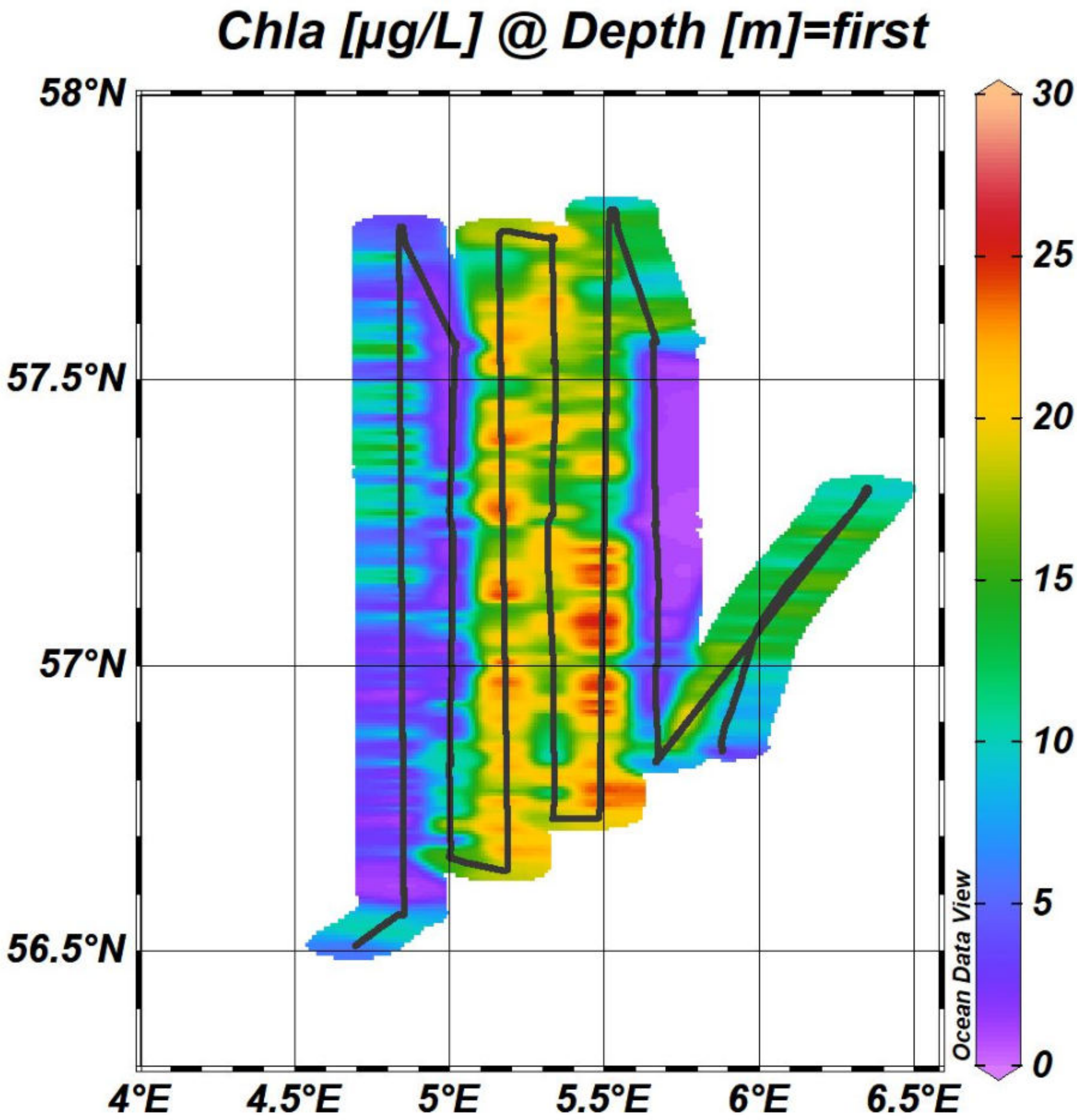


Fig. 5.6 Chlorophyll a concentration along the expedition route inside the Norwegian EEZ in µg/L as measured by the ships integrated instruments every minute.

Throughout the expedition the measured data points fluctuated in magnitude of tens of thousands of µm/L in minutes. The all-time lowest concentration was 0.27 µg/L during September 11th, 8:38 UTC. The following lowest concentrations are upwards of 0.33 µg/L around 5:30 UTC on September 13th. The highest recorded value is 71,843 µg/L at 15:05 UTC on September 12th. The next highest concentrations do not exceed 56,000 µg/L with most of them recorded on the 9th of September. The average concentration is just under 11,000 µg/L with a median of 10,910 µg/L and a mean of 10,782 µg/L.

As seen in Figure 5.6 there are clear maxima visible inside the research area which correlates with the stations 6 to 12 or all of the 11th of September. This was a calm and sunny day showing the influence of warm temperatures and high light availability. Equally the lower concentrations were recorded on days with cloudier conditions and the roughest seas.

5.1.3 Water Sampling with the CTD

(I. Heinrich)

The CTD consists of an electronic control unit connected to a computer on board the ship and a rosette, a cylindrical steel frame equipped with measuring instruments and NISKIN bottles, which is moved in the water to take samples. The control unit and the rosette are connected to each other via a cable.

The CTD rosette (Fig. 5.7) is divided into an upper and a lower section. In the lower section are the measuring instruments for temperature, conductivity and pressure. The salinity and depth are then calculated from these parameters. Additional sensors can be attached to determine other environmental parameters. The parameters are measured and displayed live in a programme on the computer throughout the entire journey of the device.
In the upper part of the rosette, 12 NISKIN bottles for water sampling are mounted in a circle around the centre. The upper and lower lid of each NISKIN bottle are connected to each other by a wire rope and can be tightened and held open by means of this to a hook in the middle. By pressing a button on the computer, the wire ropes can be released from the hooks and the bottles can be closed individually. This makes it possible to take water samples at different depths in the water column.

Fig. 5.7 CTD rosette with 12 6L NISKIN bottles and the measuring instruments below.

First the NISKIN bottles are opened and tensioned, then the CTD is deployed just below the water surface and switched on. After the instruments have acclimatised and are showing constant values, the CTD is lowered to just above the seabed. When the CTD is hoisted, the water sampling bottles are closed. Just below the water surface, the CTD is switched off and then hoisted back on board. The sample water is taken from an outlet at the bottom of the bottle. It should be noted that a valve is also opened at the top so that air can flow into the bottle.

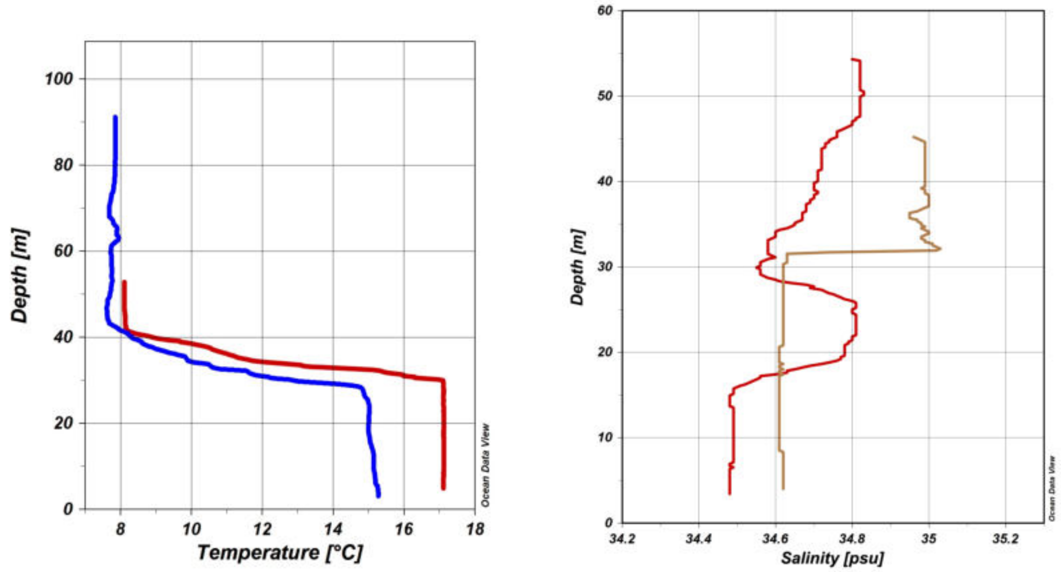
NISKIN bottles with a volume of 6 litres were used on the HE606 exit and the oxygen content and fluorescence were also measured. The water column was sampled at two depths, once in the layer above the thermocline and once in the water layer below. The water samples were never taken directly on the seabed, as the measuring instruments could otherwise be damaged by the sediment. Therefore, the deep water samples were taken at about 4 metres above the seabed with bottles 1-6. Bottles 7-12 were closed at a depth of 8-19 m below the water surface. An exception is station 8, where bottles 7-12 were closed at 30 m below the water surface.

The two water samples obtained with the CTD were transferred into 5 L and 2 L plastic bottles using a hose attached to the bottom of the outlet. The samples were then each filtered with a glass fibre filter (WHATMAN GF/F, 0.7 µm mesh size, 47 mm diameter, pre-combusted at 450 °C). The filtered water was pumped into a 26 litre tank via a membrane pump with a suction pressure of 800 mbar. When the tank was filled to a level of about 20 litres, it was emptied and the pump was vented. The volume of filtered water varied, 9 to 16 litres per sample were filtered. The filtration was stopped as soon as hardly any or no more water flowed through the filter. The colour of the filters was then analysed using the spectroscope described in chapter 5.2.2. The filters were stored in a 4 °C refrigerator until the end of the trip. After the trip, the filters were balanced at the Institut für Geologie at the Universität Hamburg. With this data, the suspension for the two sampled depths at the stations could then be calculated. To do this, the empty filter weight m_{empty} was first subtracted from the filter weight after filtration m_{after} and then divided by the amount of filtered water V_{water}.

$$Suspension[\frac{mg}{L}] = \frac{m_{after}[mg] - m_{empty}[mg]}{V_{water}[L]} \tag{1}$$

The CTD was run at stations 2, 3, 4, 5, 6, 8 and 9. At station 10 the electronics of the CTD suffered a short circuit and failed for the remaining stations. As a replacement, the Pütz was used from station 11 (see chapter 5.1.4).

Of the data collected with the measuring instruments, only the parameters temperature and salinity are considered in the results. The temperature values were measured in degree Celsius and ranged from 17.13 °C (station 2 at a depth of 7.7 m) to 7.70 °C (station 4 at a depth of 49.9 m). At all stations, the respective maximum temperatures were recorded in the upper water layer and minimum temperatures in the deeper water layer just above the seabed. Figure 8a shows the temperature curves of stations 2 (red) and 5 (blue) as examples for all stations. Initially, the temperature in the upper water layer remains constant. From a depth of 25-30 metres, the temperature drops rapidly until it reaches 8 °C at a depth of about 40 metres. This sudden drop in temperature is called a thermocline. Below this thermocline, the temperature remains constant at around 8 °C until it reaches the seabed. In contrast to the same constant temperature in the deep water layer at all stations, the temperature in the upper water layer varies. For example, the temperature at station 2 in the upper water layer is 17.13 °C, and at station 5 it is 15.28 °C. A decreasing temperature curve can be seen from south to north. One possible explanation is the increasing proximity to the Norwegian Trench, which is fed by a current from the colder North Atlantic.



(a) (b)

Fig. 5.8 (a) Vertical temperature curve at stations 2 (red) and 5 (blue). (b) Vertical salinity profile at stations 3 (ochre) and 7 (red).

Salinity follows a similar course as temperature in the water column. Salinity is expressed in PSU (Practical Salinity Unit), a dimensionless unit. Initially, salinity remains constant, but at a depth of about 30 metres, salinity rises sharply in contrast to temperature and then remains constant at around 35 PSU. The course of station 3 (ochre) in Figure 5.8b is exemplary for all stations except for stations 5, 7 and 8. At station 5, salinity continues to rise slowly after the sudden increase to 35.2 PSU and then remains constant until it reaches the seabed. A possible explanation for this could be the significantly deeper water depth and the proximity to the Norwegian Channel. Stations 7 and 8 are exemplified by station 7 (red) in Figure 5.9b. After a clear earlier jump, the salinity at both stations drops rapidly, then slowly rises again and stabilises at around 34.8 PSU. Salinity values ranging from 35.2 PSU (station 5 at 79.8 m depth) to 34.4 PSU (station 5 at 3 m depth) were measured. At all stations, the maximum values were reached in the deep water layer and the minimum values in the upper water layer.

In the following, the results of the suspension and the spectroscopy are included in the results of the Pütz. The suspension values calculated from the results of the filtration of the water samples are shown in Figure 5.9. Blue bordered are the results of the samples from the deeper water layer, green bordered are the results of the samples from the upper water layer and red bordered are the samples from the water surface, which were taken with the Pütz. The suspension values from the water samples from the upper water layer range between 0.39 mg/L (station 5 at 19 m depth) and 0.76 mg/L (station 4 at 9 m depth). The samples from the lower water layer show slightly higher values of 0.53 mg/L (station 8 at 50 m depth) to 0.84 mg/L (station 7 at 53 m depth). An exception is station 5 with a significantly higher value of 2.09 mg/L (at 90 m depth). A possible explanation could lie in the filter not being used correctly or in the significantly deeper water depth at this station. The suspension values resulting from the Pütz samples, however, are much higher with 1.19 mg/L (station 20 at 0 m depth) to 1.70 mg/L (station 17 at 0 m depth). An exception is station 11 with a value of 4.90 mg/L (at 0 m depth).

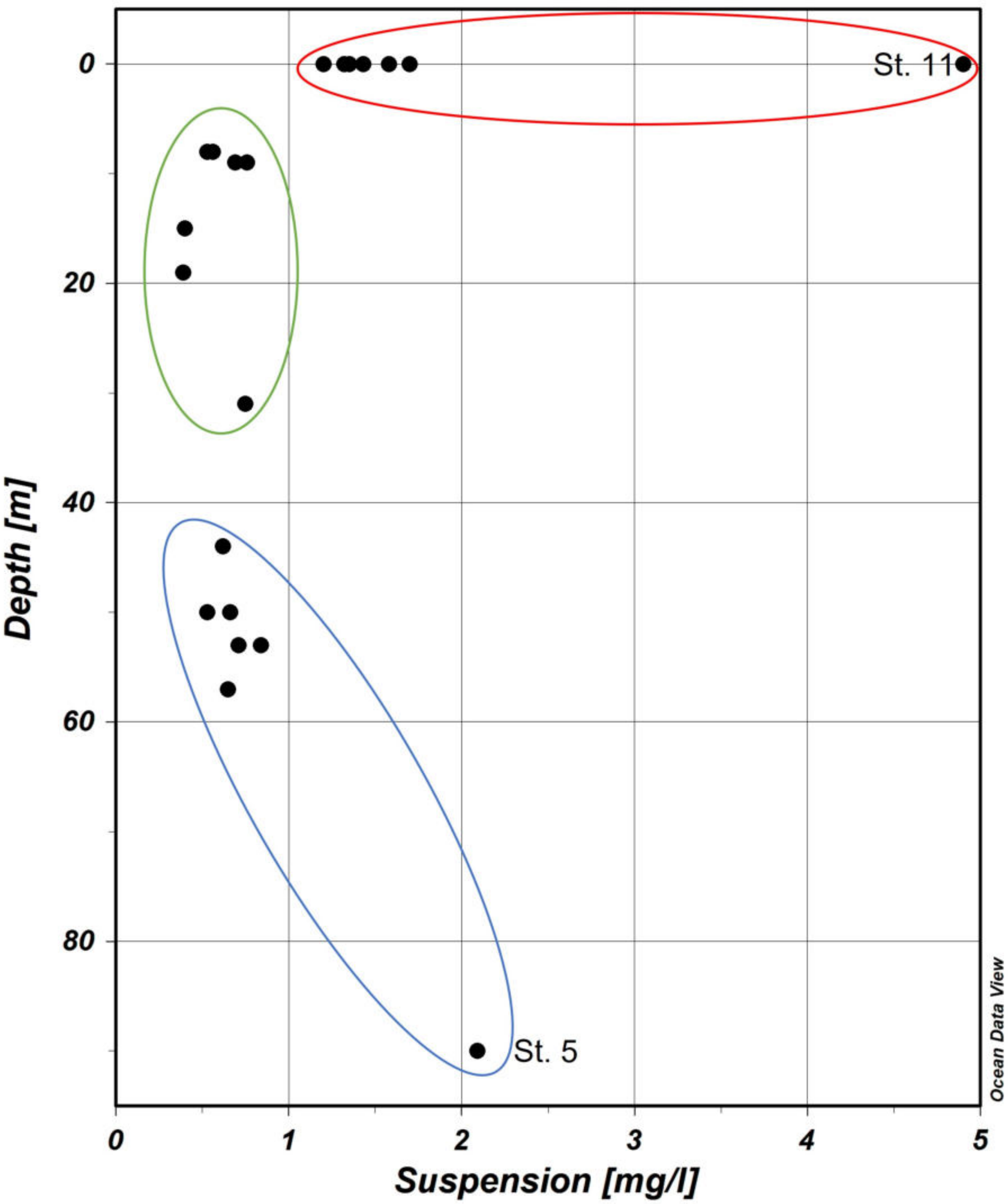


Fig. 5.9 Suspension value distribution for the deep water layer (outlined in blue), upper water layer (outlined in green) and the surface water (outlined in red).

As can be seen in Figure 5.10 and Figure 5.11, there is a similar distribution for the colour value L* in the deep water layer and in the upper water layer. The lowest L* values are in the southwest (stations 7 and 8) and the highest in the north/northwest (stations 5 and 9). The distribution of the a* value is exactly the opposite, with the lowest values in the northeast at station 5 and the highest values in the southwest at stations 7 and 8. The distribution of the b* value, however, is slightly different in the two depths. In the deeper layer the minimum value is in the northeast at station 5 and the maximum in the southeast at station 8, whereas in the upper water layer the minimum is in the east at station 3. The maximum is also found in the southwest at station 7. In general, it can be said that the filters in the southwest have a darker yellow-reddish colour than the filters in the northeast. It can also be seen that the values for L* as well as a* and b* are lower in the deeper water layer compared to those from the upper water layer and are therefore darker. The L* values in the deeper water layer are between 38.62 and 54.16, the a* values between 1.23 and 3.98 and for b* between 18.65 and 22.11. The L* values in the upper water layer are between 49.56 and 56.67, a* between 1.42 and 5.85 and b* between 22.08 and 25.08. Figure 5.13 shows the colour value distributions for the Pütz samples. Here, too, a south-north trend can be seen in the L* values and an opposite north-south trend in the a* values. For b*, however, the minimum is in the south at stations 19 and 20, while the maximum is in the middle at station 15. The measured L* values range between 28.13 (station 19) and 52.58 (station11), the a* values between 0.48 (station 11) and 3.25 (station 15) and the b* values between 15.72 (station 19) and 20.17 (station 15). This means that the filters of the contactor samples show a similar or partly even darker colouring than the samples from the deep water layer.

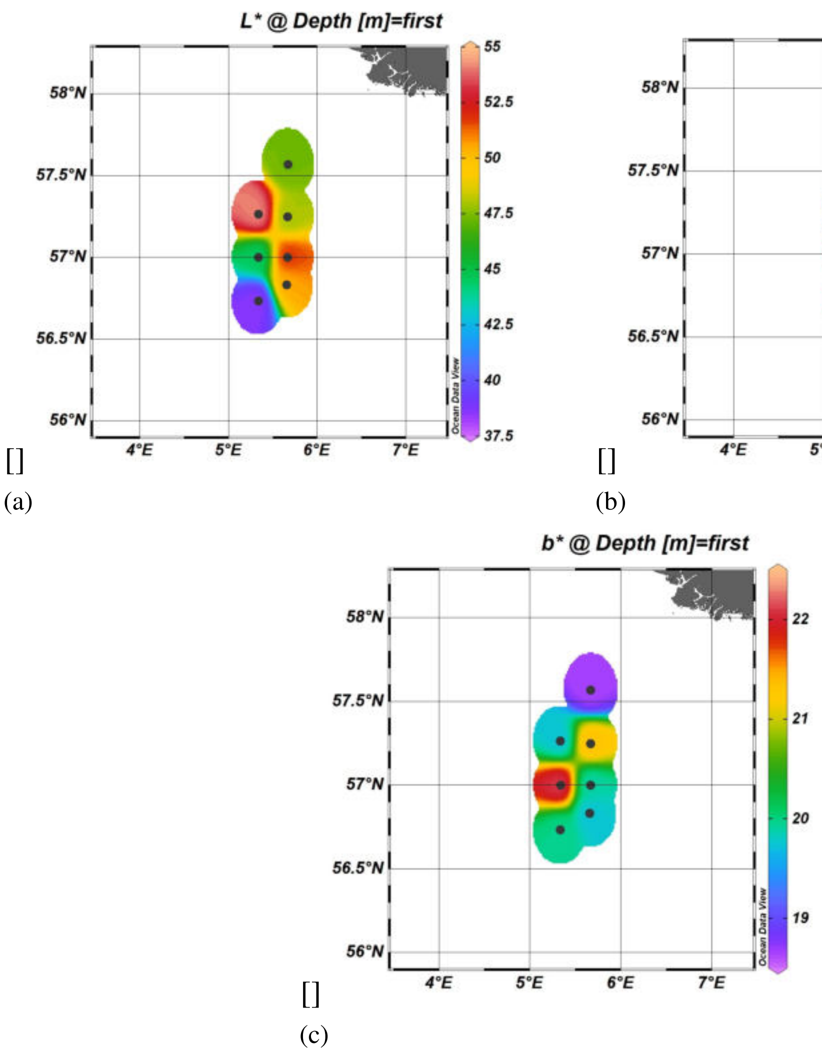


Fig. 5.10 The colour value distribution of the filters for the deep water layer. Sampling was done with the CTD.

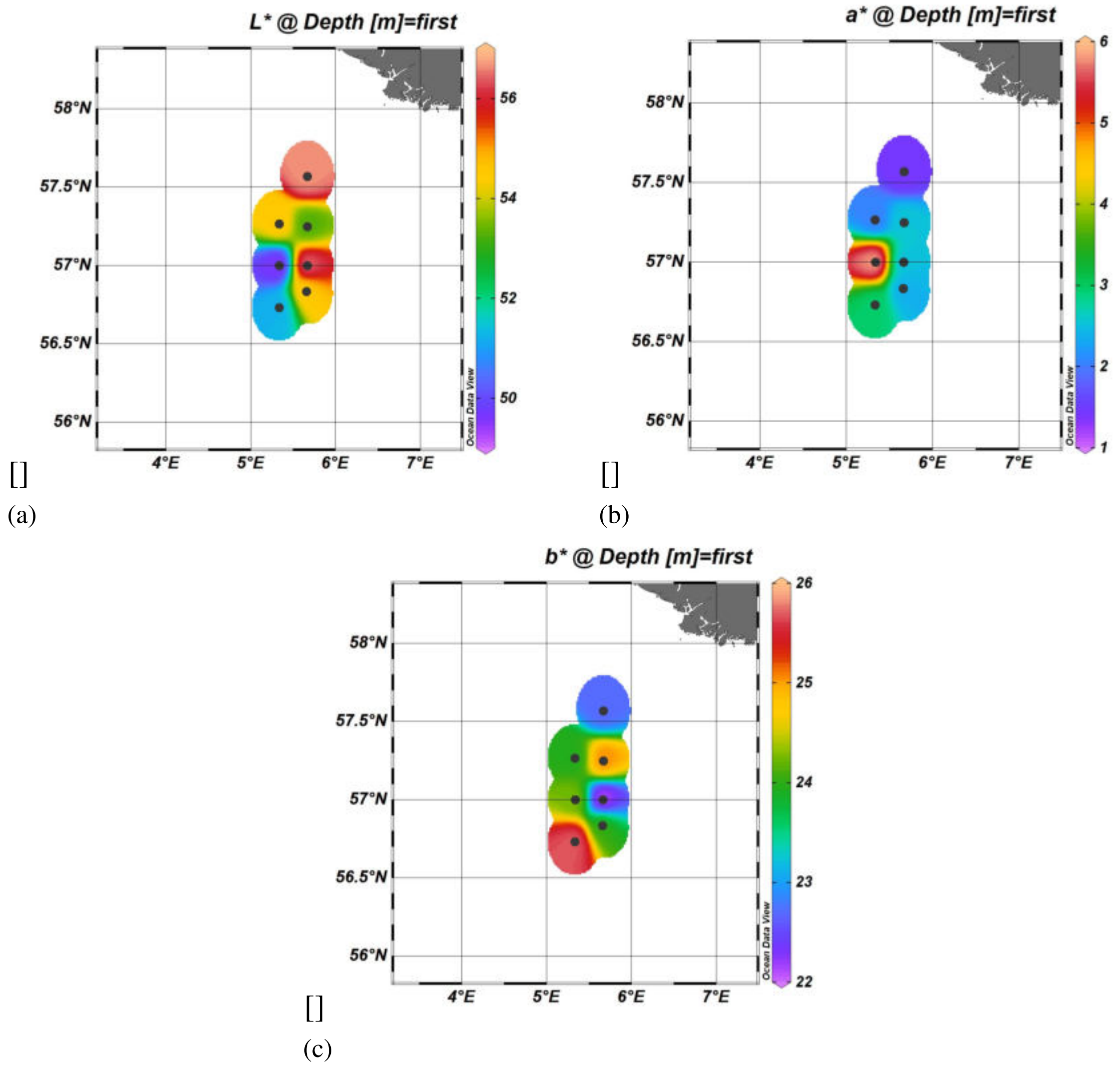
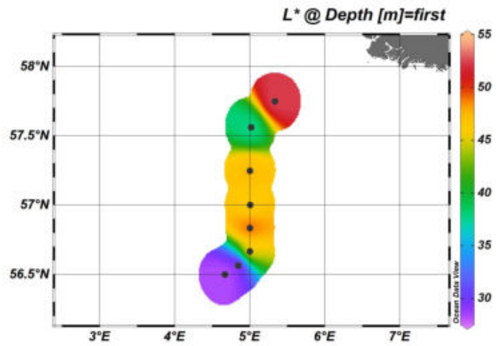
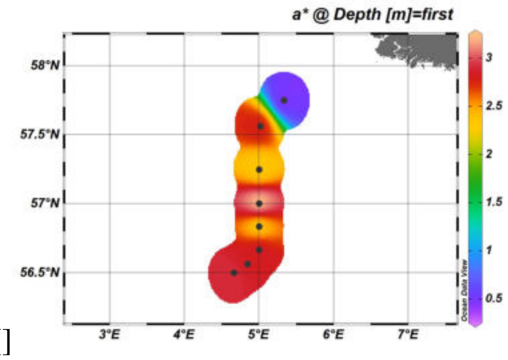


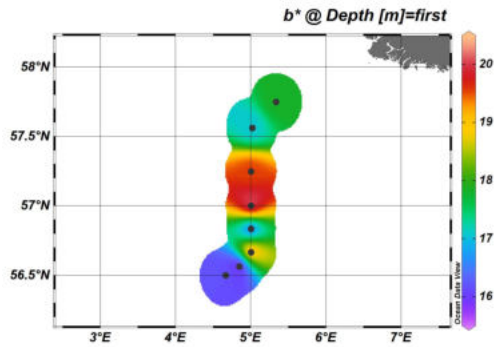
Fig. 5.11 The colour value distribution of the filters for the upper water layer. Sampling was done with the CTD.



[]
(a)



[]
(b)



[]
(c)

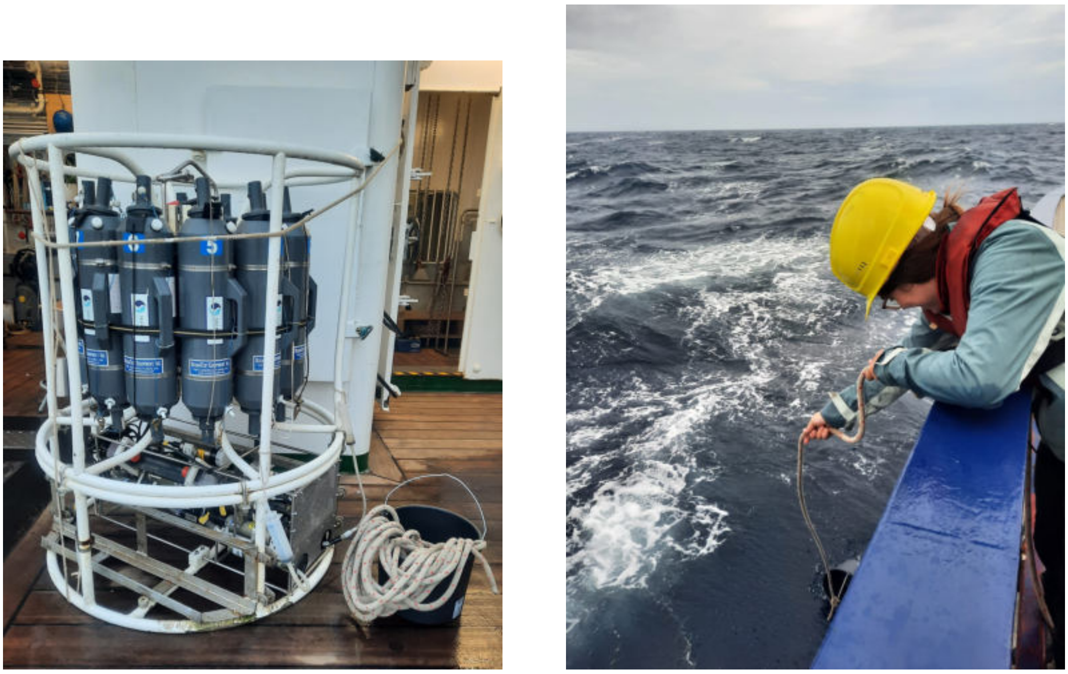
Fig. 5.12 The colour value distribution of the filters for the water surface. Sampling was done with the Pütz.

5.1.4 Water Sampling with a Bucket (Pütz)

(I. Heinrich, L. Lisitano)

The Pütz is a method of scooping surface water samples by hand. A rope is tied to the handle of a standard bucket and the bucket is lowered to the water surface. With a hand movement, the rope is pulled so that the bucket turns with the open side towards the sea surface, dips into the water and fills with water. On the HE606 expedition, the unit was driven aft on the starboard side, and the contactor was secured to the ship by tying a cleat to the free end of the rope.

The Pütz was used from station 11 as a replacement for the CTD that failed at station 10 (see chapter 5.1.3). This made it possible to obtain at least surface water samples at stations 11, 13, 14, 15, 16, 17, 19 and 20.



(a) (b)

Fig. 5.13 (a) The CTD next to the pütz, which served as its replacement, (b) water colletion with the pütz.

The water obtained with the Pütz was transferred into a 25 litre canister with the help of a funnel. The canister was first rinsed with the sample water and then completely filled with the water. To fill the canister completely, several passes of the Pütz had to be made. Subsequently, the surface water sample was filtered like the water samples from the CTD according to the procedure described in chapter CTD and the colour of the filters were analysed with the spectroscope described in chapter 5.2.2. The filters were stored in a 4 °C refrigerator until the end of the cruise. The filters were weighed after the trip at the Institut für Geologie at the Universität Hamburg.

The results of the spectroscopy are presented both in chapter 5.1.3.

5.1.5 Bottom Water Sampler (BWS)

(B. Gohr)

The bottom water sampler (BWS) is a device for sampling water close to the bottom where the CTD rosette would be to close to the seabed. The bottom water is used to examine its containing particles and organisms. Due to its construction which is shown in Fig. 5.14, the BWS is able to reach the waters which can‘t be reached by the CTD.

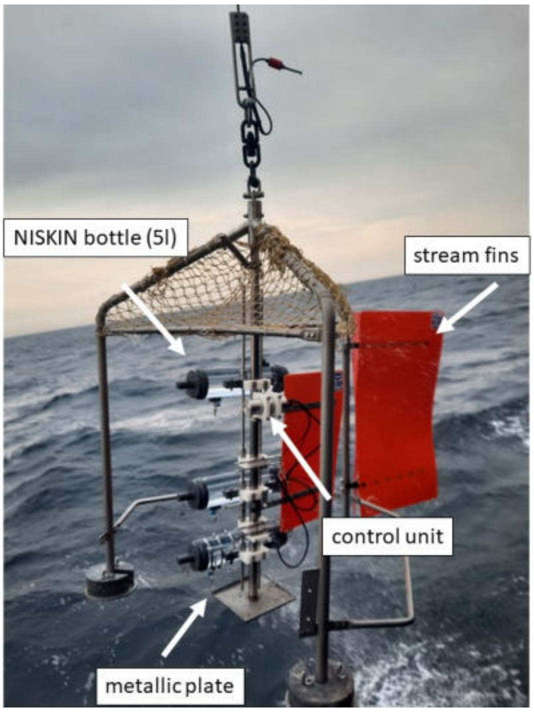


Fig. 5.14 The BWS used in this cruise during the lifting process.

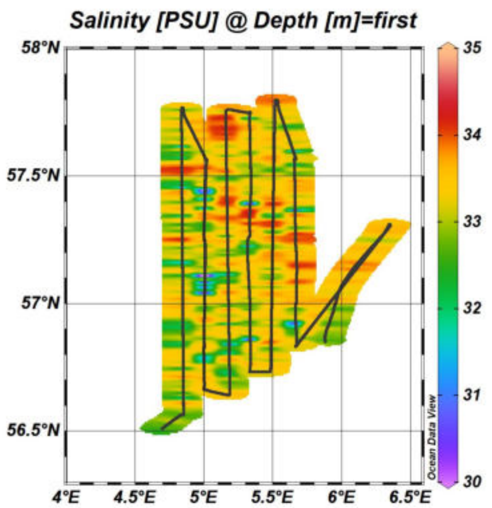
The BWS consists of a strong metal framework to which a metal bar is attached. This rod is the rotatable center axis and also the carrier oft the NISKIN bottles which collect the water. At this cruise three 5 liter bottles were horizontally mounted. The exact height of the bottles can be adjusted between 10 cm to 155 cm above the seafloor. For this cruise the bottles were adjusted to 27 cm, 57 cm and 109 cm. There are fins on both the framework and the center pole. These serve the BWS to align with the water flow. The rotation axis covers up to 120 degrees to ensure ideal alignment of the bottles with the direction of the current. At the end of the rod a metal plate is mounted, which can be pushed upwards. This mechanism, together with an electric control unit, triggers the closing of the bottles. For the closing mechanism a loop of steel wire (for fishing) is wrapped around a mechanical closing system. The steel wire is partially stripped an connected to the control unit via cable. Both the control unit and the steel wire need to be reinstalled before each run. As soon as the plate is pushed up due to the seafloor, a timer starts in the control unit. After the timer expires an electric voltage is applied by the unit to the cable which is connected to the steel wire. Due to the voltage the wire tears apart and the bottles are getting closed. The timer can be set variably as it is adjusted depending on the seafloor situation. It is mainly used to avoid swirled up sediment getting into the water bottles. Since the North Sea has relatively turbulent bottom waters, and thus the sediment is stirred up anyway, the timer is set to only 3 min for this cruise. Due to turbulent bottom waters the BWS was left on the bottom for a total of about 6 minutes to increase the probability of the bottles closing safely.

The BWS was only used for the first 3 days due to the bad weather conditions, 10 stations were sampled. Overall, it worked fine, but at station 3 no samples were taken, because the BWS got tangled in the winch cable at the first try and did not released the second try. The reason for this were probably the bad weather conditions, as a technical failure was excluded during later analysis. The collected water was subsequently bottled and taken to filtration as described in chapter 5.1.3.

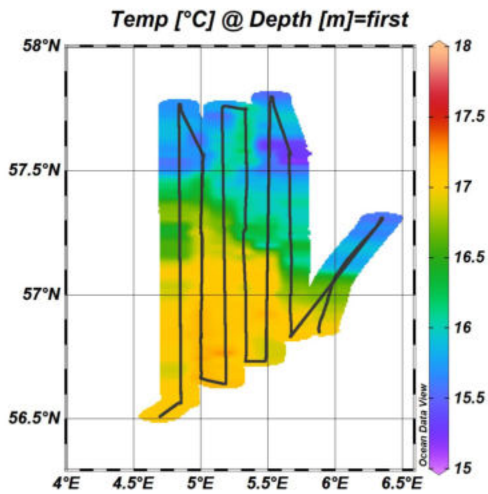
5.1.6 Thermosalinograph (TSG)

(L. Lisitano)

The thermosalinograph (TSG) is an instrument, which is placed in the hull of RV HEINCKE ship. It measures constantly the temperature in degree Celsius and the conductivity in mS/cm of the surface water until a depth of 4 m. On RV HEINCKE the Seabird TGS SBE21 with the temperature sensor SBE38 was used. It is an online system, which can measure the salinity and the conductivity independently from the other station work. Overall the seawater was measured the whole cruise HE606. The surface water is getting persistently sucked in the hull of the ship and is measured by two sensors, one internal and one external sensor. Thru the data of the measured seawater the salinity and the sound velocity of the water can be calculated. The salinity is calculated into the practical salinity unit (PSU). The results of the measured seawater are shown in Fig. 5.15a. They are showing a higher temperature on the first day, 08.09.2022, of the cruise around 17.9 °C. On the second and the third day, 09.09.2022 and 10.09.2022, of the cruise the results point out a slightly decrease of the temperature till 16.17 °C. The data shows an increase of the temperature over the forth, the fifth and the sixth day, 11.09.2022, 12.09.2022 and 13.09.2022, of the cruise till an temperature around 17 °C. The results of the salinity (Fig. 5.15b) showing an increase from the first to the third day. The salinity increases averagely from 32.51 PSU to 33.45 PSU. In the following last three days the salinity decreases from averagely 33.36 PSU to 33.04 PSU. These results of the average seawater temperatures and the salinity reflecting the change of the temperature and the salinity depending on the route from the cruise and where the different stations were measured. The results showing higher temperature closer to the german coast and lower temperature with a higher distance to the german coast. The salinity data reached higher vales while the cruise was going northwards to the stations and decreased slightly in the following days.



(a)



(b)

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

5.2 Sediment Sampling

(J. Maul)

The sediment was sampled at 16 Stations using the van-Veen-Grab and the Multicorer. The van-Veen-Grab (vVG) was not primarily used for the sediment-samples, but to show, if sediment-coring with the fragile Multicorer (MUC) was possible. Therefore, the vVG was used 18 times and the MUC only 8. Only samples from the MUC were extracted for further analysis. At every station, water and sediment was sampled. To avoid disturbances in the water column, a chronological sampling order was followed. First the Secchi disc, the Plankton net, the CTD-Rosette, the Bottom Water Sampler, then the vVG and if possible, the MUC. In total, 35 sediment samples were taken with the MUC. Five stations could not be sampled due to bad weather conditions, and three could not be sampled with the MUC, due to very coarse grained sediment.

5.2.1 Surface Sediment Sampling: van-Veen-Grab

(J. Maul)

The van Veen grab (vVG) is suitable to get a first overview of the sediment conditions in order to estimate the use of further equipment. Furthermore, one can carry out a permeability measurement. The vVG is opened and the levers are locked as shown in Fig. 5.16a. When the grab sinks into the seabed, the lock is released and the blades completely enclose the sediment sample as it is lifted. On deck, a sample is taken via an acrylic glass tube for the permeability measurement. The tube is filled with seawateras shown in Fig. 5.16b and the time is stopped until the water has run out. The remaining sediment is then described.

(a) (b)

Fig. 5.16 Figure (a) on the left shows a van-Veen-grab, the figure (b) on the right a measurement of permeability.

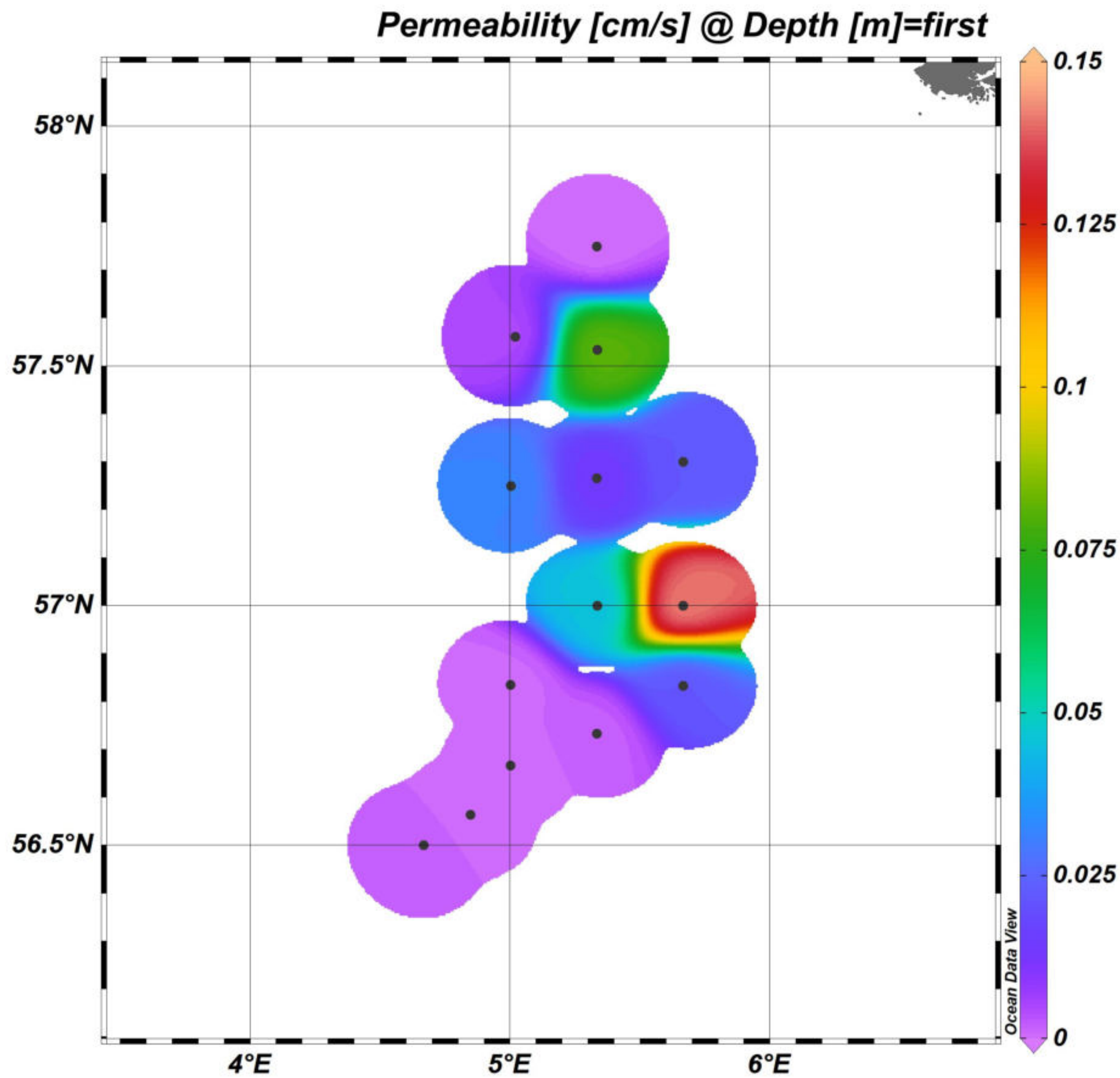


Fig. 5.17 The plotted results of the permeability measurements. Black dots indicating the stations.

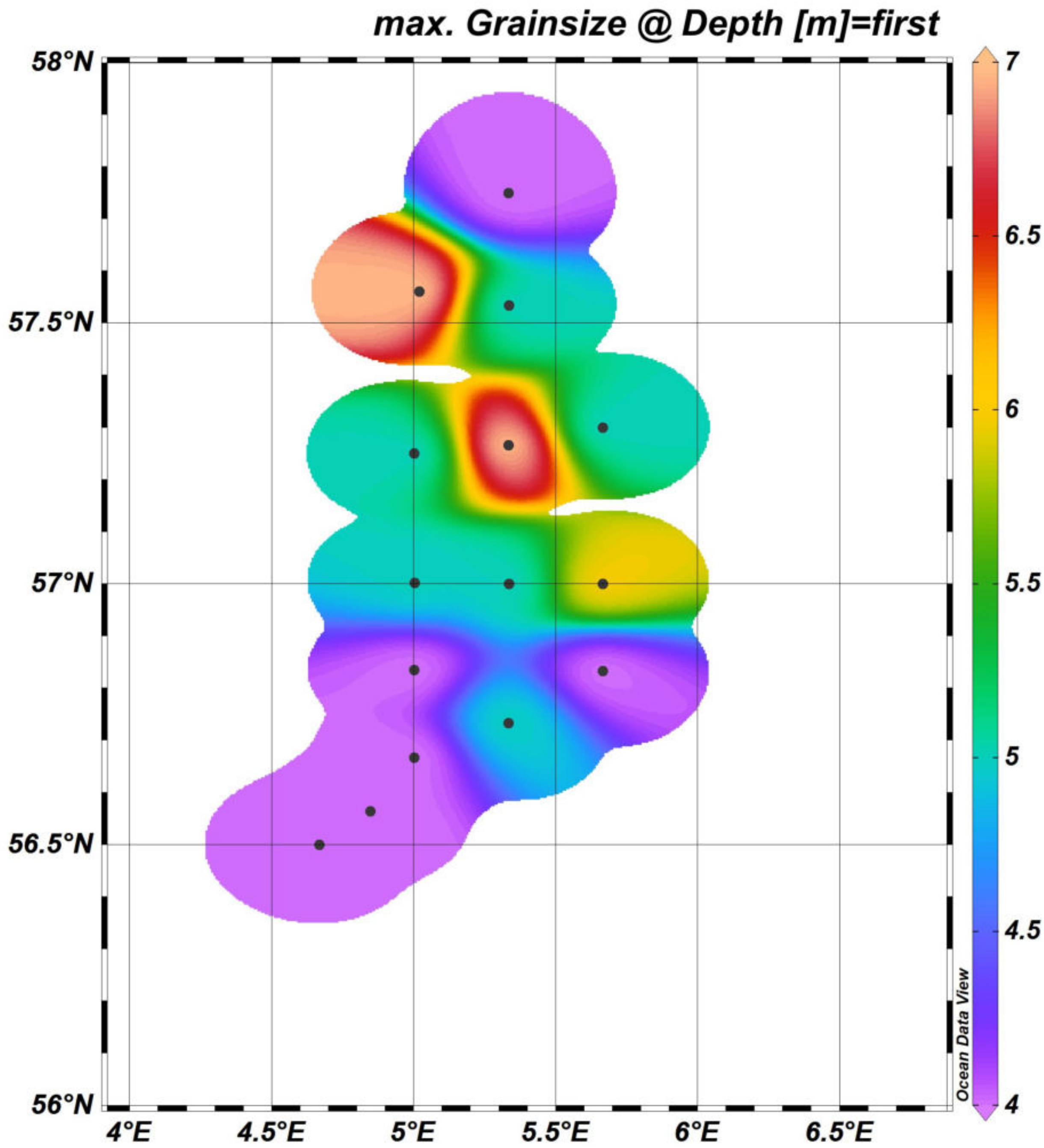


Fig. 5.18 The plotted results of the maximal grain size of the samples collected with the van-Veen-grab.Black dots indicating the stations. The key for grain size: 1 clay. 2 fine silt. 3 coarse silt. 4 fine sand. 5 middle sand. 6 coarse sand. 7ngravel/rubble.

5.2.2 Sediment Coring: Multi-Corer

(J. Maul)

On the Cruise HE606, the OCTOPUS Multi-Corer (MUC) was used. The MUC is used to retrieve sediment samples from the seafloor. The Multi-Corer consists of a metal frame with eight acrylic glass tubes inside, arranged circular around the center. Each tube has a length of 62 cm, and a diameter of 10 cm, and is equipped with a weighted seal on the top and a lid on the bottom. Before deployment, the MUC has to be connected to the winch and loaded. The loading process allows the frame to raise above the tubes if lifted off the ground. Only then, the tubes are also not sealed, allowing water to flow through when put into the ocean. The MUC is then lowered into the water. At 10 m above the seafloor, the winch is stopped until the MUC stops oscillating. Then, it is lowered with 0.3 to 0.5 m/s till the MUC hits the sediment. The tubes are then being pushed in the sediment by the weight of the MUC causing the sealing mechanism to go off. First, the top seal is shutting the tubes, creating a vacuum inside. The vacuum keeps the sediment inside the tubes during the lift up of the MUC. When the tubes reach over sediment surface, the tubes are also shut with a lit on the bottom, securing the samples. The MUC is lifted onto the ship, secured and the samples can be retrieved out of the tubes. Two ideally undisturbed cores were chosen to be sampled for the Biogeochemistry and the Micropalaeontology of the Universität Hamburg. The samples were extracted from the tubes, by pushing the cores "bottom up" onto a steel cylinder with the same diameter. The longer sediment core was sampled in 1 cm intervals for the Biogeochemistry. After that, the samples and the core were packed in plastic bags and sealed. Then, a color scan was performed using the MINOLTA CM-2002 spectrophotometer. The optical properties are stored within the CIE 1976 L*a*b* (CIELAB) color space. Additionally, the color was visually estimated every Centimeter using the Munsell color chart. Nevertheless, the colors visually estimated and the optical properties using the MINOLTA CM-2002 spectrophotometer will slightly differ from the actual result due to the optical interference of the sediment color with the plastic bag. After that, the samples for the Biogeochemistry were stored at +4 °C. The shorter core was sampled for the Micropalaeontology, using the first 2 cm of sediment and 30 mL of ocean bottom water for benthic foraminifera analysis. The samples were packed and stored at +4 °C.

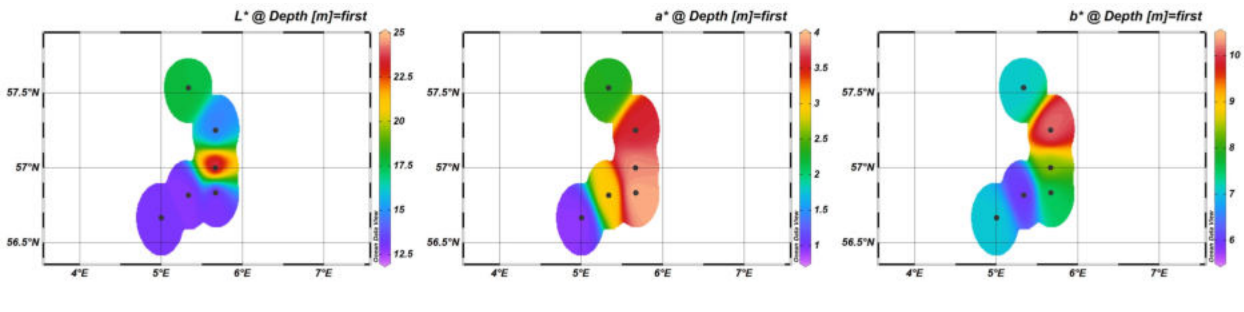


Fig. 5.19 The colour value distribution of the sediment samples taken with the MUC.

5.3 Underway Hydroacoustics

(T. Lüdmann, M. Schmidt)

Various devices were used during the hydroacoustic survey on the HE606 cruise: the EM712 KONGSBERG multibeam sonar (MBES), SES2000 INNOMAR parametric subbottom profiler and 600 kHz TELEDYNE RD Instruments acoustic doppler current profiler (ADCP). The recorded profiles of the hydroacoustic survey are shown in Figure 20.

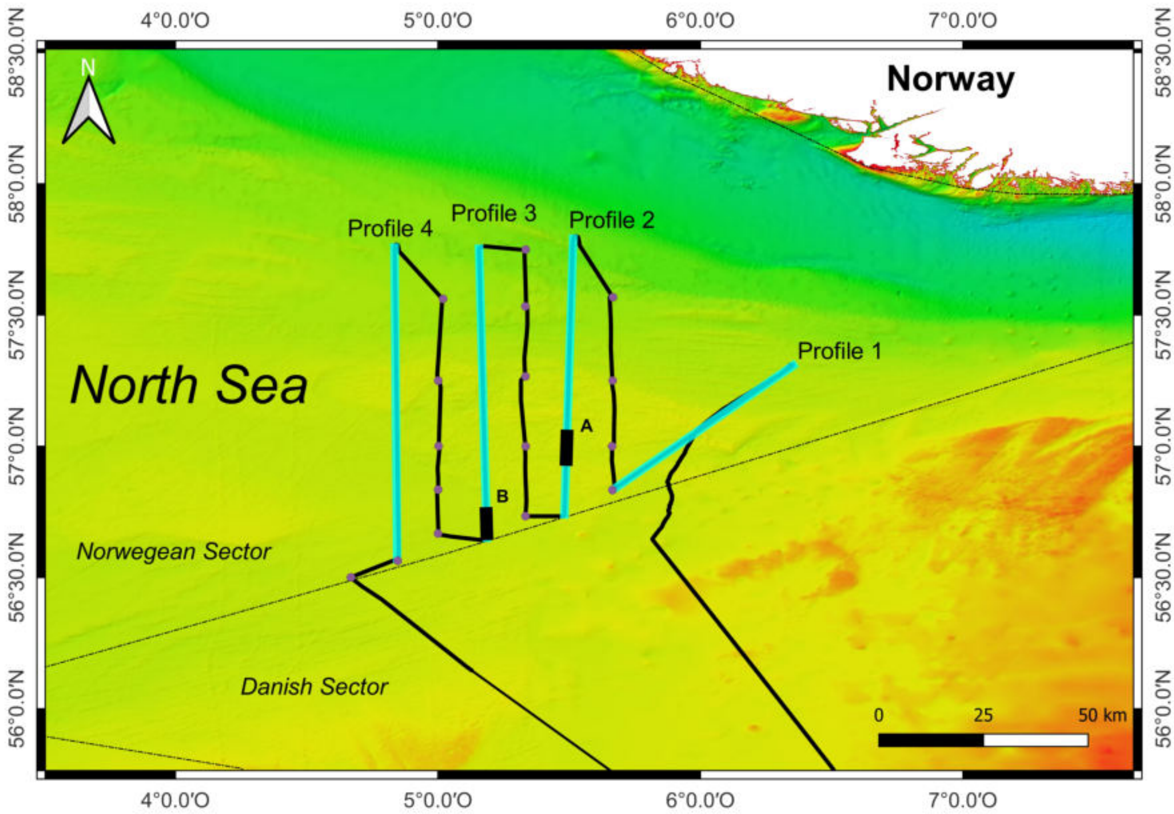


Fig. 5.20 Profiles of the hydroacoustic survey.

The KONGSBERG EM712 multibeam sonar is a ship mounted echo sounder operating at frequencies between 70 and 100 kHz. This multibeam sonar maps the seabed with a very high resolution (depth resolution of 1 cm) with a fan width of 140° and is suitable for water depths up to 2000 m. The MBES consists of a transmitter and receiver unit integrated in the hull of the RV HEINCKE. The transducer sends out several equidistant acoustic signals in a fan, which are reflected on objects above or on the seabed. To increase the density of the data, the multibeam emits two pings simultaneously, one slightly bent forward while the second is slightly bent backward (Dual Swath). Furthermore, the amplitude of the backscatter of the seabed is recorded, which indicates the nature of the surface of the seabed. In this way, the sediment composition can be inferred.

The parametric sediment echo sounder SES2000 INNOMAR was used to image near-surface sediment layers. The device used during this cruise records two frequencies. A primary frequency of 100 kHz and a selected secondary frequency of 6 kHz which can be adjusted. The SES2000 is a high-resolution echo sounder with a resolution of ± 6 cm and a penetration depth of severar 10 m. The high resolution is supported by the aperture angle of 3.6°. Another advantage of this system is

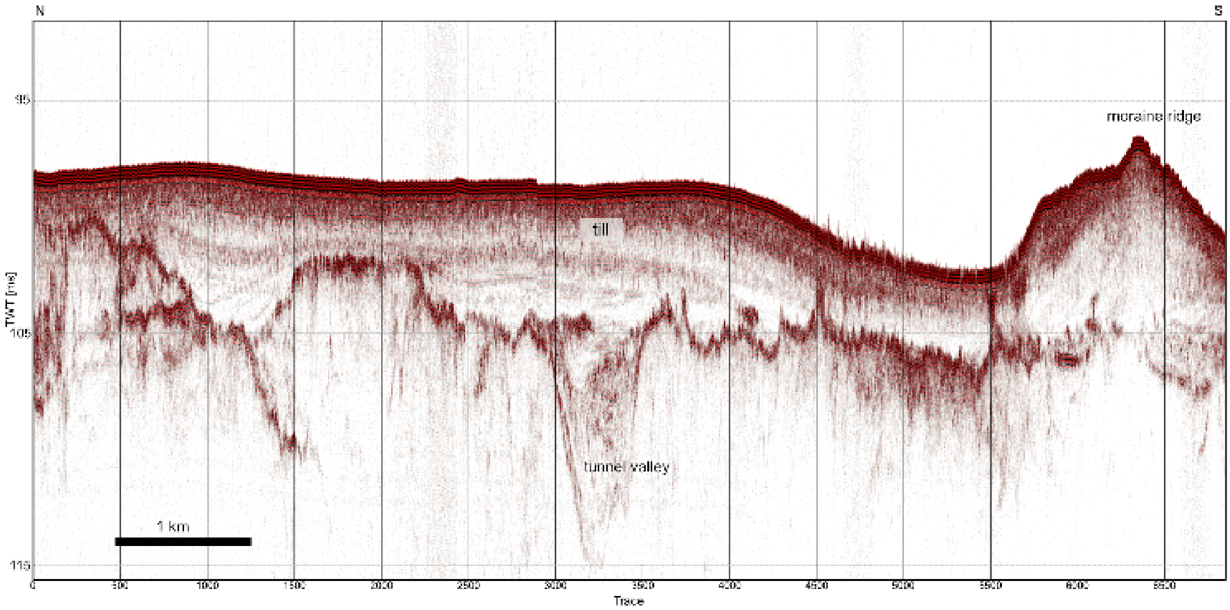


Fig. 5.21 Second profile of the hydroacoustic survey, recorded by the sediment echo sounder SES2000 Innomar.

that it compensates the movements of the vessel (roll, pitch, yaw) by measuring the movement with a motion sensor and adjusting it through electronic beam steering. The SES2000 is syncronized with the multibeam echosounder EM712 over a trigger unit to avoid interferences of the acoustic waves because of the same frequency of 100 kHz. Therefore, the SES2000 is externally triggered by the MBES.

A part of the second and third profile recorded with the sediment echo sounder is shown in Figures 21 and 22. In the second profile, a tunnel valley can be seen at a depth of about 110 ms, which is overlaid by till. A moraine ridge is visible further to the south. Profile 3 shows glacimarine deposits and the last glacial maximum surface (LGM). Below the glacimarine deposits another layer is visible, which could be Late Weichselian lake deposits.

The TELEDYNE RD Instruments acoustic doppler current profiler (ADCP) captures flow profiles by measuring the velocity and movement of particles in the water column. This method uses ultrasonic Doppler technology. The transmitted acoustic signal is reflected by suspended matter and due to the Doppler effect there is a frequency shift between the transmitted and received signal. In this way, information can be obtained about particle movements in the water column. The 600 kHz transducers are hull mounted and emit four independent beams. These are divided into bins so that data acquisition from different depths is possible. With the built-in ADCP, the blank distance is 2 m and there are 23 depth cells of 2 m and therefore, the depth range is 46 m.

Another relevant measurement is the sound velocity, especially for the MBES to prevent the misinterpretation of the seabed. A sound probe is attached to a CTD and measures a sound velocity profile of the water column. The recorded data is shown in Figure 23. The profiles show a strong negative acceleration of the sound velocity at about 25 m and another change at 40 m. This can be explained due to rapid changes in temperature (thermocline).

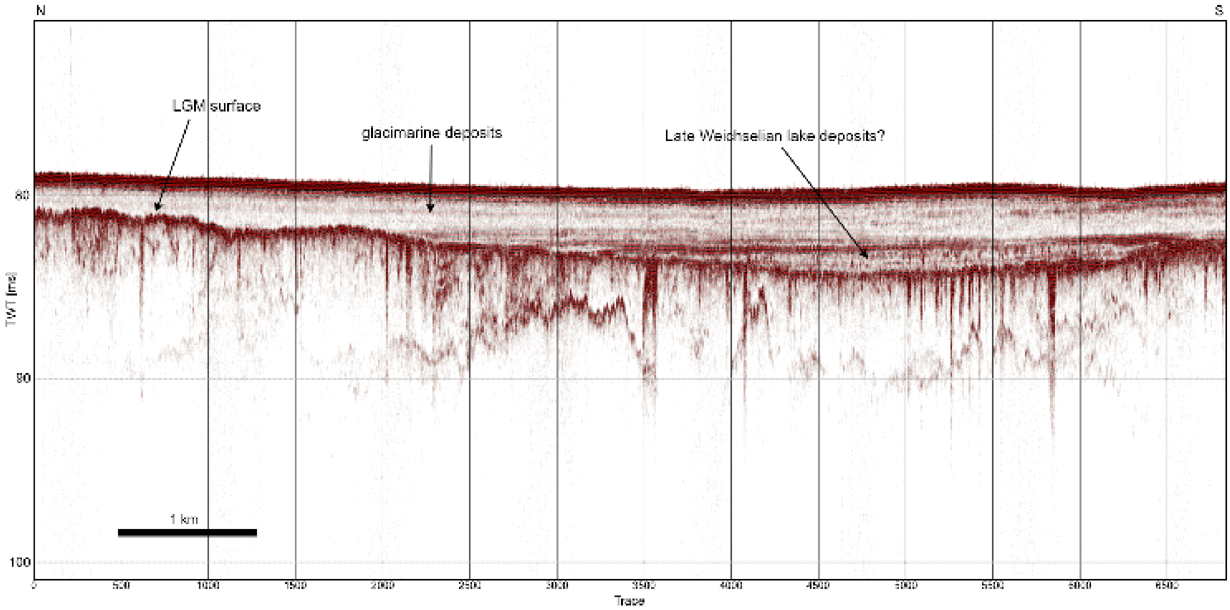


Fig. 5.22 Third profile of the hydroacoustic survey, recorded by the sediment echo sounder SES2000 Innomar.

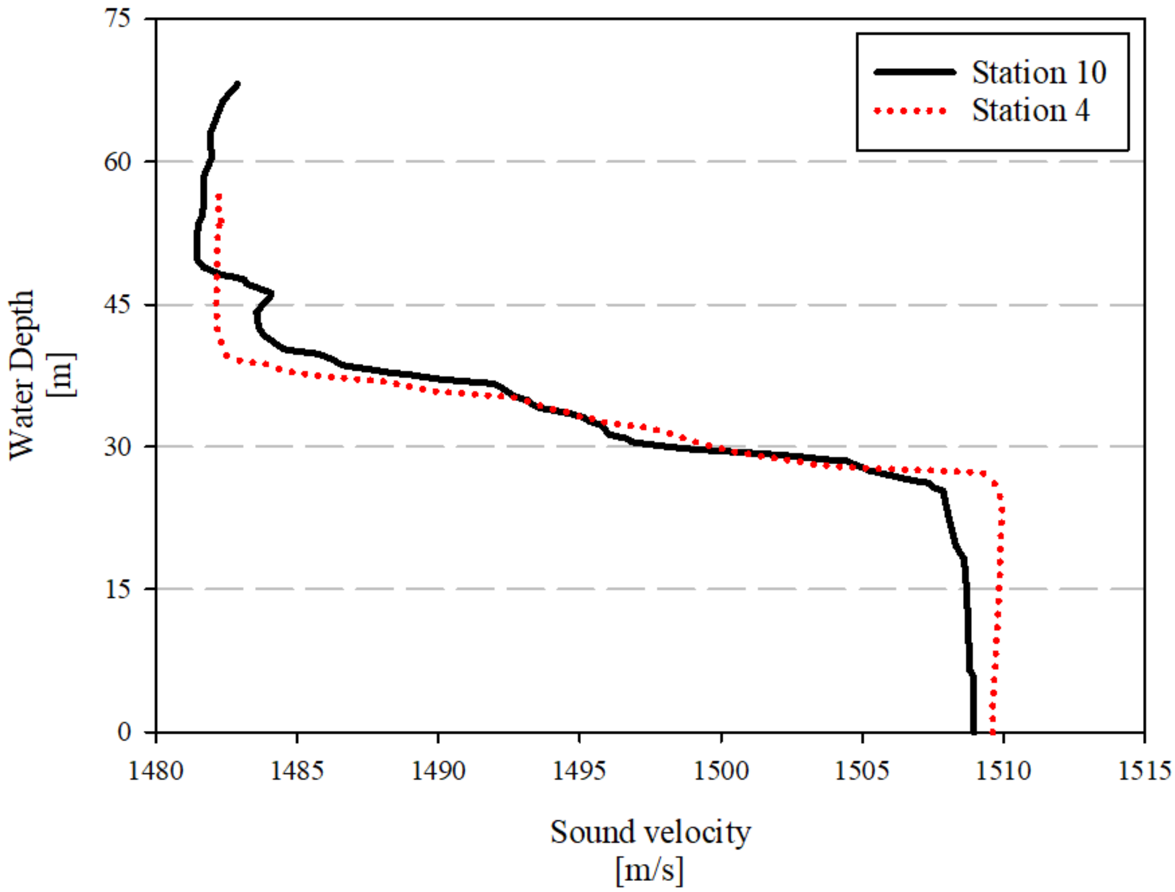


Fig. 5.23 Soundvelocity profile of the water column at CTD station 4 and 10.

6 Station List HE606

Station Number	Date	Device	Time	Latitude	Longitude	Water Depth	Action
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE606_0_Underway-5	08.09.2022	WST	06:00	53° 31.946'	008° 34.703'		station start
HE606_0_Underway-3	08.09.2022	TSG	08:57	53° 48.786'	008° 07.608'	14.2	station start
HE606_1-1	09.09.2022	ADCP+ SES	23:40	57° 18.678'	006° 20.710'	72.3	station start
HE606_1-1	09.09.2022	ADCP+ SES	23:45	57° 18.401'	006° 21.136'	70.6	profile start
HE606_1-1	10.09.2022	ADCP+ SES	05:41	56° 50.010'	005° 39.991'	49.2	profile end
HE606_1-1	10.09.2022	ADCP+ SES	05:41	56° 49.997'	005° 39.971'	48.8	station end
HE606_2-1	10.09.2022	Secdisk	05:57	56° 49.982'	005° 39.961'	50.2	in the water
HE606_2-2	10.09.2022	APN	05:59	56° 49.977'	005° 39.962'	49.1	in the water
HE606_2-2	10.09.2022	APN	06:03	56° 49.997'	005° 39.976'	50.0	on deck
HE606_2-3	10.09.2022	CTD	06:10	56° 50.005'	005° 39.902'	49.1	max depth/on ground
HE606_2-4	10.09.2022	BWS	06:26	56° 50.032'	005° 40.018'	48.9	max depth/on ground
HE606_2-5	10.09.2022	GRAB	06:41	56° 50.031'	005° 40.043'	50.7	max depth/on ground
HE606_2-6	10.09.2022	MUC	06:50	56° 50.029'	005° 40.054'	50.0	max depth/on ground
HE606_3-1	10.09.2022	Secdisk	08:08	56° 59.986'	005° 39.829'	47.2	in the water
HE606_3-2	10.09.2022	APN	08:12	56° 59.993'	005° 39.830'	46.1	in the water
HE606_3-2	10.09.2022	APN	08:14	57° 00.002'	005° 39.821'	46.5	on deck
HE606_3-3	10.09.2022	CTD	08:19	56° 59.989'	005° 39.866'	45.5	max depth/on ground
HE606_3-4	10.09.2022	BWS	08:30	57° 00.005'	005° 39.970'	45.9	max depth/on ground
HE606_3-5	10.09.2022	BWS	08:47	57° 00.037'	005° 39.948'	46.4	max depth/on ground
HE606_3-6	10.09.2022	GRAB	08:59	57° 00.059'	005° 39.964'	45.5	max depth/on ground
HE606_3-7	10.09.2022	MUC	09:08	57° 00.053'	005° 39.947'	47.3	max depth/on ground
HE606_4-1	10.09.2022	Secdisk	11:00	57° 15.004'	005° 39.952'	57.3	in the water
HE606_4-2	10.09.2022	APN	11:03	57° 15.004'	005° 39.961'	57.4	in the water
HE606_4-3	10.09.2022	CTD	11:12	57° 15.006'	005° 39.960'	58.2	max depth/on ground
HE606_4-4	10.09.2022	BWS	11:24	57° 15.006'	005° 39.966'	58.5	max depth/on ground
HE606_4-5	10.09.2022	GRAB	11:38	57° 15.001'	005° 39.980'	57.0	max depth/on ground
HE606_4-6	10.09.2022	MUC	11:47	57° 15.004'	005° 39.981'	57.4	max depth/on ground
HE606_5-1	10.09.2022	Secdisk	14:02	57° 34.063'	005° 40.059'	92.1	in the water
HE606_5-2	10.09.2022	PLA	14:05	57° 34.064'	005° 40.050'	91.7	in the water

Station Number	Date	Device	Time	Latitude	Longitude	Water Depth	Action
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE606_5-3	10.09.2022	CTD	14:14	57° 34.064'	005° 40.069'	91.8	max depth/on ground
HE606_5-4	10.09.2022	BWS	14:25	57° 34.058'	005° 40.061'	91.5	max depth/on ground
HE606_5-5	10.09.2022	GRAB	14:43	57° 34.060'	005° 40.086'	92.1	max depth/on ground
HE606_5-5	10.09.2022	GRAB	14:48	57° 34.065'	005° 40.088'	91.6	max depth/on ground
HE606_6-1	10.09.2022	ADCP+ SES	16:25	57° 47.816'	005° 31.028'	115.2	station start
HE606_6-1	10.09.2022	ADCP+ SES	16:28	57° 47.259'	005° 30.945'	117.1	profile start
HE606_6-1	11.09.2022	ADCP+ SES	04:50	56° 44.370'	005° 28.907'	52.4	profile end
HE606_6-1	11.09.2022	ADCP+ SES	04:50	56° 44.353'	005° 28.907'	52.4	station end
HE606_7-1	11.09.2022	Secdisk	05:54	56° 44.022'	005° 20.024'	54,6	in the water
HE606_7-2	11.09.2022	APN	06:00	56° 44.005'	005° 20.047'	54,6	in the water
HE606_7-3	11.09.2022	CTD	06:07	56° 44.000'	005° 20.056'	54.5	max depth/on ground
HE606_7-4	11.09.2022	BWS	06:19	56° 43.988'	005° 20.055'	54.6	max depth/on ground
HE606_7-5	11.09.2022	GRAB	06:35	56° 43.980'	005° 20.058'	54.5	max depth/on ground
HE606_7-6	11.09.2022	MUC	06:46	56° 43.964'	005° 20.063'	54.6	max depth/on ground
HE606_8-1	11.09.2022	Secdisk	08:28	56° 59.985'	005° 20.086'	49.8	in the water
HE606_8-2	11.09.2022	APN	08:31	56° 59.978'	005° 20.094'	49.7	in the water
HE606_8-3	11.09.2022	CTD	08:39	56° 59.974'	005° 20.064'	49.8	max depth/on ground
HE606_8-4	11.09.2022	BWS	08:52	56° 59.976'	005° 20.063'	50.0	max depth/on ground
HE606_8-5	11.09.2022	GRAB	09:05	56° 59.975'	005° 20.076'	50.1	max depth/on ground
HE606_9-1	11.09.2022	Secdisk	11:00	57° 15.968'	005° 20.028'	54.1	station start
HE606_9-2	11.09.2022	APN	11:05	57° 15.972'	005° 20.026'	54.2	in the water
HE606_9-3	11.09.2022	CTD	11:18	57° 15.986'	005° 20.017'	54.7	max depth/on ground
HE606_9-4	11.09.2022	BWS	11:28	57° 15.990'	005° 20.000'	54.9	max depth/on ground
HE606_9-5	11.09.2022	GRAB	11:42	57° 15.983'	005° 20.014'	54.7	max depth/on ground
HE606_10-1	11.09.2022	Secdisk	13:27	57° 31.985'	005° 19.982'	81.3	in the water
HE606_10-2	11.09.2022	PLA	13:31	57° 31.997'	005° 19.989'	81.4	in the water
HE606_10-3	11.09.2022	CTD	13:39	57° 32.006'	005° 20.039'	81.4	max depth/on ground
HE606_10-4	11.09.2022	BWS	13:53	57° 32.014'	005° 20.106'	81.8	max depth/on ground
HE606_10-5	11.09.2022	GRAB	14:08	57° 32.046'	005° 20.105'	81.6	max depth/on ground
HE606_10-6	11.09.2022	MUC	14:19	57° 32.072'	005° 20.156'	80.6	max depth/on ground
HE606_10-7	11.09.2022	CTD	14:30	57° 32.112'	005° 20.192'	80.6	max depth/on ground

Station Number	Date	Device	Time	Latitude	Longitude	Water Depth	Action
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE606_11-1	11.09.2022	Secdisk	16:08	57° 44.958'	005° 20.070'	113.8	in the water
HE606_11-2	11.09.2022	PLA	16:11	57° 44.958'	005° 20.067'	113.6	in the water
HE606_11-3	11.09.2022	BUCKET	16:13	57° 44.958'	005° 20.072'	113.6	in the water
HE606_11-3	11.09.2022	BUCKET	16:17	57° 44.950'	005° 20.083'	113.6	on deck
HE606_11-4	11.09.2022	BWS	16:23	57° 44.958'	005° 20.051'	113.9	max depth/on ground
HE606_11-5	11.09.2022	GRAB	16:39	57° 44.981'	005° 20.029'	114.0	max depth/on ground
HE606_11-6	11.09.2022	MUC	16:52	57° 44.945'	005° 20.063'	113.5	max depth/on ground
HE606_12-1	11.09.2022	ADCP+ SES	17:49	57° 45.062'	005° 09.468'	103.7	station start
HE606_12-1	11.09.2022	ADCP+ SES	17:49	57° 45.049'	005° 09.469'	103.8	profile start
HE606_12-1	12.09.2022	ADCP+ SES	04:46	56° 38.833'	005° 11.204'	57.5	profile end
HE606_12-1	12.09.2022	ADCP+ SES	04:50	56° 38.537'	005° 10.878'	57.4	station end
HE606_13-1	12.09.2022	Secdisk	05:59	56° 40.029'	005° 00.054'	60.4	in the water
HE606_13-2	12.09.2022	APN	06:02	56° 40.030'	005° 00.059'	60.4	in the water
HE606_13-3	12.09.2022	BUCKET	06:07	56° 40.027'	005° 00.067'	60.2	max depth/on ground
HE606_13-4	12.09.2022	BWS	06:15	56° 40.033'	005° 00.075'	60.5	max depth/on ground
HE606_13-5	12.09.2022	GRAB	06:30	56° 40.027'	005° 00.086'	60.7	max depth/on ground
HE606_13-6	12.09.2022	MUC	06:40	56° 40.035'	005° 00.096'	60.5	max depth/on ground
HE606_14-1	12.09.2022	Secdisk	07:59	56° 50.094'	005° 00.077'	59.3	in the water
HE606_14-2	12.09.2022	APN	08:06	56° 50.087'	005° 00.091'	60.2	in the water
HE606_14-3	12.09.2022	BUCKET	08:12	56° 50.094'	005° 00.103'	59.6	max depth/on ground
HE606_14-4	12.09.2022	BWS	08:17	56° 50.087'	005° 00.124'	60.5	max depth/on ground
HE606_14-5	12.09.2022	GRAB	08:32	56° 50.071'	005° 00.145'	60.1	max depth/on ground
HE606_14-6	12.09.2022	MUC	08:41	56° 50.071'	005° 00.165'	59.4	max depth/on ground
HE606_15-1	12.09.2022	Secdisk	10:14	57° 00.036'	005° 00.159'	53.9	in the water
HE606_15-2	12.09.2022	APN	10:18	57° 00.014'	005° 00.208'	54.3	in the water
HE606_15-3	12.09.2022	BUCKET	10:20	57° 00.000'	005° 00.231'	54.4	in the water
HE606_15-3	12.09.2022	BUCKET	10:23	56° 59.964'	005° 00.240'	55.3	on deck
HE606_15-4	12.09.2022	GRAB	10:27	56° 59.963'	005° 00.270'	55.2	max depth/on ground
HE606_16-1	12.09.2022	Secdisk	12:10	57° 14.994'	005° 00.084'	58.9	in the water
HE606_16-2	12.09.2022	APN	12:14	57° 14.974'	005° 00.144'	57.6	in the water
HE606_16-3	12.09.2022	BUCKET	12:18	57° 14.926'	005° 00.174'	59.9	in the water
HE606_16-4	12.09.2022	GRAB	12:24	57° 14.905'	005° 00.210'	60.5	max depth/on ground
HE606_17-1	12.09.2022	Secdisk	14:33	57° 33.639'	005° 01.167'	81.9	in the water
HE606_17-2	12.09.2022	APN	14:35	57° 33.614'	005° 01.169'	81.4	in the water

Station Number	Date	Device	Time	Latitude	Longitude	Water Depth	Action
HEINCKE			[UTC]	[°N]	[°E]	[m]	
HE606_17-3	12.09.2022	BUCKET	14:37	57° 33.607'	005° 01.217'	81.4	in the water
HE606_17-4	12.09.2022	SVP	14:44	57° 33.584'	005° 01.295'	79.6	max depth/on ground
HE606_17-5	12.09.2022	GRAB	14:54	57° 33.549'	005° 01.311'	81.2	max depth/on ground
HE606_18-1	12.09.2022	ADCP+ SES	16:30	57° 45.914'	004° 50.167'	96.7	station start
HE606_18-1	12.09.2022	ADCP+ SES	16:32	57° 45.545'	004° 50.116'	97.7	profile start
HE606_18-1	13.09.2022	ADCP+ SES	03:50	56° 34.212'	004° 51.050'	58.4	profile end
HE606_18-1	13.09.2022	ADCP+ SES	03:50	56° 34.187'	004° 51.046'	59.5	station end
HE606_19-1	13.09.2022	Secdisk	04:03	56° 33.812'	004° 50.812'	59.2	in the water
HE606_19-2	13.09.2022	APN	04:05	56° 33.814'	004° 50.792'	59.0	in the water
HE606_19-3	13.09.2022	BUCKET	04:09	56° 33.819'	004° 50.828'	61.3	in the water
HE606_19-4	13.09.2022	GRAB	04:15	56° 33.810'	004° 50.784'	58.2	max depth/on ground
HE606_19-4	13.09.2022	GRAB	04:20	56° 33.809'	004° 50.785'	60.2	station end
HE606_20-1	13.09.2022	Secdisk	06:02	56° 30.013'	004° 40.018'	60.9	in the water
HE606_20-2	13.09.2022	APN	06:04	56° 30.025'	004° 40.039'	62.0	in the water
HE606_20-3	13.09.2022	BUCKET	06:09	56° 30.018'	004° 40.013'	61.3	max depth/on ground
HE606_20-4	13.09.2022	GRAB	06:12	56° 30.016'	004° 39.984'	59.5	max depth/on ground

7 Data and Sample Storage and Availability

Hydrographic data (CTD) as well as hydroacoustic data (ADCP and SES2000) will be transferred to the PANGAEA database (see Tab. 7.1). Seismic data (KONGSBERG EM712 surface seafloor mapping) will be shared upon request as there is no easily-accessible database available for this kind of data set.

Table 7.1 Overview of data availability.

Type	Database	Available	Free Access	Contact
Hydrography (CTD)	PANGAEA	September 2023	September 2023	niko.lahajnar@uni-hamburg.de
ADCP and SES2000	PANGAEA	September 2024	September 2024	thomas.luedmann@uni-hamburg.de
Kongsberg EM712	Upon request	September 2024	September 2024	thomas.luedmann@uni-hamburg.de

8 Acknowledgements

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10 Appendix

10.1 Secchi Disk depth

Table 10.1 List of the Secchi Disk depth at the different stations.

Cruise	Station	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Depth
		mon/day/yr	[UTC]			[m]	[m]
HE-606	2	09/10/2022	05:53	5.666	56.833	53.8	8.5
HE-606	3	09/10/2022	08:10	5.664	57.000	50.2	9.5
HE-606	4	09/10/2022	11:30	5.666	57.250	62	9.0
HE-606	5	09/10/2022	14:00	5.668	57.568	92	8.5
HE-606	7	09/11/2022	06:00	5.334	56.733	54.6	14.0
HE-606	8	09/11/2022	08:30	5.335	57.000	49.8	14.0
HE-606	9	09/11/2022	11:00	5.334	57.266	54.6	14.0
HE-606	10	09/11/2022	13:30	5.334	57.533	81.3	11.5
HE-606	11	09/11/2022	16:10	5.334	57.749	113.7	11.0
HE-606	13	09/12/2022	05:58	5.001	56.667	60.7	10.0
HE-606	14	09/12/2022	08:00	5.001	56.835	59	5.0
HE-606	15	09/12/2022	10:15	5.003	57.001	58.6	7.0
HE-606	16	09/12/2022	12:10	5.002	57.250	62.8	8.0
HE-606	17	09/12/2022	14:30	5.019	57.561	81	9.0
HE-606	19	09/13/2022	04:02	4.847	56.564	59.9	6.0
HE-606	20	09/13/2022	06:01	4.667	56.500	61	6.5

10.2 Plankton Net (Apstein Net)

Table 10.2 List and detailed protocols of the plankton diversity in the sampled stations.

Cruise	Station	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Depth	Discription
		mon/day/yr	[UTC]			[m]	[m]	
HE-606	2	09/10/2022	06:20	5.666	56.733	50	5	Dinoflagellata: *Ceratium tripos* & *Ceratium fusus,* Diatomeen, Rotifera/Copepoda; mostly dinoflagellates and green algea colonies, some bigger zooplankton
HE-606	3	09/10/2022	08:15	5.665	57.000	45	5	Dinoflagellata, Diatomeen, Radiolaria: *Phyllostarus siculus*, Pteropoda, Rotifera/Copepoda, Crustaceen; many Dinoflagellata and Diatomeen colonies, bigger crustaceans
HE-606	4	09/10/2022	11:20	5.666	57.250	58	5	Dinoflagellata, Diatomeen, Radiolaria, Gastropoda, Copepoda: *Calanus finnarcticus*; mostly dinoflagellata, less population
HE-606	5	09/10/2022	14:08	5.668	57.568	91	5	Dinoflagellata: *Ceratium tripos* & *Ceratium fusus*, Radiolaria: *Phyllostarus siculus*, Diatomeen; very little population, mostly green algea colonies
HE-606	7	09/11/2022	06:04	5.334	56.733	54.7	5	Dinoflagellata: *Ceratium spp.* & *Ceratium fusus*, Crustacea, Diatomeen, Ctenophora, Gastropoda, Chratognatha, indefinite; many Dinoflagellata & Crustacea
HE-606	8	09/11/2022	08:33	5.335	57.000	49.8	5	Dinoflagellata: *Ceratium spp.*, *Ceratium fusus, Ceratium lireatum* & *Ceratium massiliare*, Diatomeen, Crustacea, Chratognatha; mostly Dinoflagellata

Cruise	Station	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Depth	Discription
HE-606	9	09/11/2022	11:05	5.334	57.266	54.5	5	Dinoflagellata, Crustecea, Radiolaria: *Phyllostarus siculus*; mostly Dinoflagellata
HE-606	10	09/11/2022	13:33	5.334	57.534	81.5	5	Dinoflagellata: *Ceratium spp.* & *Ceratium massiliase*, Diatomeen, Gastropoda
HE-606	11	09/11/2022	16:15	5.334	57.739	113.7	5	Dinoflagellata, Copepoda, Crustacea, Diatomeen, Radiolaria
HE-606	13	09/12/2022	06:00	5.001	56.667	60.7	5	Dinoflagellata, Crustacea, Copepoda
HE-606	14	09/12/2022	08:04	5.001	56.835	59	5	Dinoflagellata, Gastropoda, Copepoda, Crustacea, Diatomeen; sampling aft, three tries
HE-606	15	09/12/2022	10:16	5.003	57.001	58.6	5	Dinoflagellata: *Ceratium tripes* & *ceratium fusus*, Gastropoda, Diatomeen, Radialaria, Crustacea shale, Rotifera/Copepoda; many Dinoflagellata, sampling aft
HE-606	16	09/12/2022	12:15	5.000	57.250	62.8	5	Dinoflagellata: *Ceratium tripes* & *ceratium fusus*, Gastropoda, Radiolaria, Crustacea, Cnidaria, Chaetognatia, Phoronida; sampling aft
HE-606	17	09/12/2022	14:35	5.022	57.560	81	5	Dinoflagellata: *Ceratium tripes* & ceratium fusus, Copepoda, Radiolaria, Gastropoda; sampling aft, isolated zooplanton
HE-606	19	09/13/2022	04:06	4.846	56.564	59	0	Dinoflagellata: *Ceratium tripes* & *ceratium fusus*, Gastropoda, Diatomeen, Crustacea, Copepoda; sampling aft, medium abundance
HE-606	20	09/13/2022	06:05	4.677	56.500	60	5	Dinoflagellata: *Ceratium tripes* & *ceratium fusus*, Gastropoda, Copepoda, Crustacea, Diatomeen; sampling aft

10.3 Water Sampling with CTD-Rosette

Table 10.3 List of sampled stations and depth sampled in the water column with the CTD-rosette.

Cruise	Cruise	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Depth
		mon/day/yr	[UTC]			[m]	[m]
HE-606	2	09/10/2022	06:14	5.656	56.834	53.8	50
HE-606	2	09/10/2022	06:14	5.656	56.834	53.8	15
HE-606	3	09/10/2022	08:20	5.665	57.000	50.0	44
HE-606	3	09/10/2022	08:20	5.665	57.000	50.0	9
HE-606	4	09/10/2022	11:13	5.666	57.250	61.0	57
HE-606	4	09/10/2022	11:13	5.666	57.250	61.0	9
HE-606	5	09/10/2022	14:14	5.668	57.568	95.0	90
HE-606	5	09/10/2022	14:14	5.668	57.568	95.0	19
HE-606	7	09/11/2022	06:08	5.334	56.733	54.0	53
HE-606	7	09/11/2022	06:08	5.334	56.733	54.0	8
HE-606	8	09/11/2022	08:35	5.335	57.000	50.0	50
HE-606	8	09/11/2022	08:35	5.335	57.000	50.0	31
HE-606	9	09/11/2022	11:10	5.334	57.266	54.0	53
HE-606	9	09/11/2022	11:10	5.334	57.266	54.0	8
HE-606	10	09/11/2022	13:35	5.333	57.533	81.0	/
HE-606	10	09/11/2022	13:35	5.333	57.533	81.0	/

10.4 Pütz

Table 10.4 List of sampeld stations with the Pütz.

Cruise	Station	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Depth
		mon/day/yr	[UTC]			[m]	[m]
HE-606	11	09/11/2022	16:20	5.334	57.749	130.00	0
HE-606	13	09/12/2022	05:58	5.001	56.667	60.70	0
HE-606	14	09/12/2022	08:09	5.001	56.835	59.00	0
HE-606	15	09/12/2022	10:18	5.003	57.001	58.20	0
HE-606	16	09/12/2022	12:20	5.002	57.248	62.80	0
HE-606	17	09/12/2022	14:40	5.019	57.561	81.00	0
HE-607	19	09/13/2022	04:12	4.847	56.564	59.50	0
HE-608	20	09/13/2022	06:15	4.667	56.334	61.00	0

10.5 Bottom Water Sampler (BWS)

Table 10.5 List of the location of stations and sampled depth above the seafloor

Cruise	Station	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Depth
		mon/day/yr	[UTC]			[m]	[m]
HE-606	2	09/10/2022	06:30	5.668	56.834	53.9	27
HE-606	2	09/10/2022	06:30	5.668	56.834	53.9	57
HE-606	2	09/10/2022	06:30	5.668	56.834	53.9	109
HE-606	3	09/10/2022	08:30	5.666	57.001	/	/
HE-606	3	09/10/2022	08:30	5.666	57.001	/	/
HE-606	3	09/10/2022	08:30	5.666	57.001	/	/
HE-606	4	09/10/2022	11:25	5.666	57.250	58.1	27
HE-606	4	09/10/2022	11:25	5.666	57.250	58.1	57
HE-606	4	09/10/2022	11:25	5.666	57.250	58.1	109
HE-606	5	09/10/2022	14:26	5.668	57.568	91.9	27
HE-606	5	09/10/2022	14:26	5.668	57.568	91.9	57
HE-606	5	09/10/2022	14:26	5.668	57.568	91.9	109
HE-606	7	09/11/2022	06:24	5.334	56.733	54.6	27
HE-606	7	09/11/2022	06:24	5.334	56.733	54.6	57
HE-606	7	09/11/2022	06:24	5.334	56.733	54.6	109
HE-606	8	09/11/2022	08:52	5.335	57.000	49.0	27
HE-606	8	09/11/2022	08:52	5.335	57.000	49.0	57
HE-606	8	09/11/2022	08:52	5.335	57.000	49.0	109
HE-606	9	09/11/2022	11:28	5.334	57.266	54.0	27
HE-606	9	09/11/2022	11:28	5.334	57.266	54.0	57
HE-606	9	09/11/2022	11:28	5.334	57.266	54.0	109
HE-606	10	09/11/2022	13:53	5.334	57.533	81.0	27
HE-606	10	09/11/2022	13:53	5.334	57.533	81.0	57

Cruise	Station	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Depth
		mon/day/yr	[UTC]			[m]	[m]
HE-606	10	09/11/2022	13:53	5.334	57.533	81.0	109
HE-606	11	09/11/2022	16:23	5.334	57.749	113.7	27
HE-606	11	09/11/2022	16:23	5.334	57.749	113.7	57
HE-606	11	09/11/2022	16:23	5.334	57.749	113,7	109
HE-606	13	09/12/2022	06:26	5.001	56.667	60.0	27
HE-606	13	09/12/2022	06:26	5.001	56.667	60.0	57
HE-606	13	09/12/2022	06:26	5.001	56.667	60.0	109
HE-606	14	09/12/2022	08:23	5.002	56.835	59.0	27
HE-606	14	09/12/2022	08:23	5.002	56.835	59.0	57
HE-606	14	09/12/2022	08:23	5.002	56.835	59.0	109

10.6 Van-Veen-Grab and Sediment Permeability

Table 10.6 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	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Sample Depth for Permeability	Grain size	Permeability	Description
		mon/day/yr	[UTC]			[m]	[cm]		[cm/s]	
HE606	2	09/10/2022	06:45	5.666	56.833	53.0	8.3	4	0.02152	Reddish-brown colour, black anoxic layers, well sorted, fine sand, few shell fragments
HE606	3	09/10/2022	09:00	5.666	57.000	47.0	8.1	6	0.14239	Reddish-brown colour, well sorted, medium sand, very few shell fragments, benthic worms
HE606	4	09/10/2022	11:35	5.666	57.300	58.0	9.5	5	0.02195	Light brown colour, some dark anoxic spots, well sorted, medium sand, many shell fragments, benthic worms
HE606	5	09/10/2022	14:45	5.668	57.568	92.0	/	/	/	Lowered twice: too coarse, coarse gravel and medium sand, light brown colour, shells, shell fragments; one cobble, mafic igneous rock, benthic overgrowth, bivalve and filter feeder

Cruise	Station	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Sample Depth for Permeability	Grain size	Permeability	Description
		mon/day/yr	[UTC]			[m]	[cm]		[cm/s]	
HE606	7	09/11/2022	06:45	5.334	56.733	54.0	10.5	4-5	0.00222	Well sorted, zoning: brownish top, dark grey to black bottom, few shell fragments, benthic worms and molluscs
HE606	8	09/11/2022	09:10	5.335	57.000	49.0	/	5	0.04512	Zoning: brownish top, dark grey bottom, many shell fragments, poorly sorted, up to coarse gravel, partly well rounded
HE606	9	09/11/2022	11:45	5.334	57.266	54.0	9.8	7	0.01425	Shell fragments, not layered, dark spots, gravel with serpent stars (ophiuroids) and benthic worms
HE606	10	09/11/2022	14:15	5.335	57.534	81.0	13.8	4+5	0.08135	Few shell fragments, benthic worms, clay lenses, zoning: brownish colour, medium sand at the top, grey brownish colour, fine to medium sand on the bottom
HE606	11	09/11/2022	16:45	5.334	57.749	113.7	12.7	1-4	0.00009	Few shell fragments, few endobenthic organisms, no zoning, even light grey colour, darker tubes, one lens with many shell fragments

Cruise	Station	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Sample Depth for Permeability	Grain size	Permeability	Description
		mon/day/yr	[UTC]			[m]	[cm]		[cm/s]	
HE606	13	09/12/2022	06:30	5.001	56.667	60.7	14.0	3-4	0.00048	Light brown surface, grey colour, black anoxic spots, big bivalves, big worms
HE606	14	09/12/2022	08:35	5.001	56.835	59.0	12.0	4	0.00102	Brown surface, grey colour, anoxic, big bivalves, big worms
HE606	15	09/12/2022	10:25	5.003	57.002	58.6	12.0	4+5	/	Well sorted, brownish top, light grey to brownish bottom with black lenses, soft zoning, few shell fragments, few benthic worms, oxidized tubes, catworm (*Nephtys hombergii*), live peppery furrow shell (Scrobicularia plana)
HE606	16	09/12/2022	12:35	5.002	57.250	62.8	13.0	4+5	0.03160	Brownish coloured fine sand surface, grey colour, anoxic black lenses, silt, shell fragments, benthic worms, sea urchin
HE606	17	09/12/2022	14:50	5.019	57.561	81.0	11.6	4+5+7	0.00482	Brownish coloured medium sand and gravel surface, fine sand, few pebbles, black anoxic lenses, tube worm, shell fragments

Cruise	**Station**	**Date**	**Time**	**Lon (dE)**	**Lat (dN)**	**Bot. Depth**	**Sample Depth for Permeability**	**Grain size**	**Permeability**	**Description**
		mon/day/yr	**[UTC]**			**[m]**	**[cm]**		**[cm/s]**	
HE606	19	09/13/2022	04:19	4.847	56.564	59.9	15.9	3+4	0.00071	Little fauna, one worm, shell fragments, colour gradient from light brownish to grey, not layered
HE606	20	09/13/2022	06:10	4.667	56.334	61.0	13.2	3+4	0.00198	Light grey surface, dark grey, darker streaks, well sorted, no zoning, many worms, sea urchin, shell fragments

10.7 Multi-Corer: Description and Sampling

Table 10.7 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	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Depth	Penetration Depth	Grain size	L*	a*	b*	Description
		mon/day/yr	[UTC]			[m]	[m]	[m]					
HE-606	2	09/10/2022	06:48	5.667	56.834	50	0-1	0.13	4	12.61	3.94	7.51	0-1 cm reddish colour, 1-5 cm brownish colour, 5-13 cm brownish with grey spots, reddish oxidized tube
HE-606	2	09/10/2022	06:48	5.667	56.834	50	1-2	0.13	4	16.89	3.31	7.40	
HE-606	2	09/10/2022	06:48	5.667	56.834	50	2-3	0.13	4	20.77	2.63	5.78	
HE-606	2	09/10/2022	06:48	5.667	56.834	50	3-4	0.13	4	14.68	2.87	7.43	
HE-606	2	09/10/2022	06:48	5.667	56.834	50	4-5	0.13	4	15.03	2.82	7.92	
HE-606	3	09/10/2022	09:10	5.664	57.000	48	0-1	0.15	5-6	24.11	3.86	8.39	Well sorted, shell fragments, light brown colour, no zoning, small starfish
HE-606	3	09/10/2022	09:10	5.664	57.000	48	1-2	0.15	5-6	23.96	4.37	9.28	
HE-606	3	09/10/2022	09:10	5.664	57.000	48	2-3	0.15	5-6	25.17	3.77	7.59	
HE-606	3	09/10/2022	09:10	5.664	57.000	48	3-4	0.15	5-6	24.88	3.62	7.58	
HE-606	3	09/10/2022	09:10	5.664	57.000	48	4-5	0.15	5-6	25.57	3.94	8.18	
HE-606	4	09/10/2022	11:45	5.666	57.250	58	0-1	0.2	5	14.71	3.61	10.18	0-7 cm light brown colour, partially reddish, 7-12 cm light grey to brownish, 12-20 cm brown to grey-black colour, anoxic, many shell fragments (*Arctica islandica, Cerastoderma edule, Chamelea galina, Venerupis senescens*)
HE-606	4	09/10/2022	11:45	5.666	57.250	58	1-2	0.2	5	18.15	2.48	8.83	
HE-606	4	09/10/2022	11:45	5.666	57.250	58	2-3	0.2	5	23.78	1.70	7.56	
HE-606	4	09/10/2022	11:45	5.666	57.250	58	3-4	0.2	5	22.92	1.95	5.80	
HE-606	4	09/10/2022	11:45	5.666	57.250	58	4-5	0.2	5	23.78	1.61	5.79	
HE-606	5	09/10/2022	/	5.668	57.568	91	0-1	/	/	/	/	/	Not deployed, too coarse
HE-606	5	09/10/2022	/	5.668	57.568	91	1-2	/	/	/	/	/	

Cruise	Station	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Depth	Penetration Depth	Grain size	L*	a*	b*	Description
		mon/day/yr	[UTC]			[m]	[m]	[m]					
HE-606	5	09/10/2022	/	5.668	57.568	91	2-3	/	/	/	/	/	
HE-606	5	09/10/2022	/	5.668	57.568	91	3-4	/	/	/	/	/	
HE-606	5	09/10/2022	/	5.668	57.568	91	4-5	/	/	/	/	/	
HE-606	7	09/11/2022	07:00	5.334	56.817	54	0-1	0.18	5	12.86	2.97	5.97	0-10 cm yellow brownish, 10-18 cm black grey, anoxic, sea urchin, worm, shrimp
HE-606	7	09/11/2022	07:00	5.334	56.817	54	1-2	0.18	5	11.63	2.97	6.12	
HE-606	7	09/11/2022	07:00	5.334	56.817	54	2-3	0.18	5	13.58	2.84	5.76	
HE-606	7	09/11/2022	07:00	5.334	56.817	54	3-4	0.18	5	12.65	2.37	5.20	
HE-606	7	09/11/2022	07:00	5.334	56.817	54	4-5	0.18	5	15.21	2.85	6.25	
HE-606	8	09/11/2022	/	5.335	57.000	49	0-1	/	/	/	/	/	Not deployed, too coarse
HE-606	8	09/11/2022	/	5.335	57.000	49	1-2	/	/	/	/	/	
HE-606	8	09/11/2022	/	5.335	57.000	49	2-3	/	/	/	/	/	
HE-606	8	09/11/2022	/	5.335	57.000	49	3-4	/	/	/	/	/	
HE-606	8	09/11/2022	/	5.335	57.000	49	4-5	/	/	/	/	/	
HE-606	9	09/11/2022	/	5.334	57.266	54	0-1	/	/	/	/	/	Not deployed, too coarse(gravel)
HE-606	9	09/11/2022	/	5.334	57.266	54	1-2	/	/	/	/	/	
HE-606	9	09/11/2022	/	5.334	57.266	54	2-3	/	/	/	/	/	
HE-606	9	09/11/2022	/	5.334	57.266	54	3-4	/	/	/	/	/	
HE-606	9	09/11/2022	/	5.334	57.266	54	4-5	/	/	/	/	/	
HE-606	10	09/11/2022	14:20	5.333	57.533	81	0-1	0.15	5-6	20.7	3.58	6.62	0-2 cm coarse sand, shell fragments, brown reddish colour, 2-15 cm medium and coarse sand, brown reddish colour with grey streaks, well sorted
HE-606	10	09/11/2022	14:20	5.333	57.533	81	1-2	0.15	5-6	21.46	3.46	6.9	
HE-606	10	09/11/2022	14:20	5.333	57.533	81	2-3	0.15	5-6	19.61	3.29	6.94	
HE-606	10	09/11/2022	14:20	5.333	57.533	81	3-4	0.15	5-6	21.34	3.21	5.63	
HE-606	10	09/11/2022	14:20	5.333	57.533	81	4-5	0.15	5-6	22.81	3.52	6.94	

Cruise	Station	Date	Time	Lon (dE)	Lat (dN)	Bot. Depth	Depth	Penetration Depth	Grain size	L*	a*	b*	Description
		mon/day/yr	[UTC]			[m]	[m]	[m]					
HE-606	11	09/11/2022	17:20	5.335	57.749	113	0-1	0.09	3-4	/	/	/	0-9 cm fine sand with silt, brown greyish, well sorted, sample for Schmiedl only
HE-606	11	09/11/2022	17:20	5.335	57.749	113	1-2	0.09	3-4	/	/	/	
HE-606	11	09/11/2022	17:20	5.335	57.749	113	2-3	0.09	3-4	/	/	/	
HE-606	11	09/11/2022	17:20	5.335	57.749	113	3-4	0.09	3-4	/	/	/	
HE-606	11	09/11/2022	17:20	5,335	57.749	113	4-5	0.09	3-4	/	/	/	
HE-606	13	09/12/2022	06:45	5.001	56.667	60	0-1	0.2	3-4	13.06	0.95	7.06	0-1 cm brown (10YR 5/4), 1-3 cm grey (5Y 5/2), 3-7 cm black (5GY 4/1), 7-16 cm grey (5Y 5/2), 16-17 cm black (5GY 4/1), 17-20 cm grey (5Y 5/2), silt to fine sand, few bivalves
HE-606	13	09/12/2022	06:45	5.001	56.667	60	1-2	0.2	3-4	14.20	0.79	6.10	
HE-606	13	09/12/2022	06:45	5.001	56.667	60	2-3	0.2	3-4	16.22	0.39	4.34	
HE-606	13	09/12/2022	06:45	5.001	56.667	60	3-4	0.2	3-4	11.74	0.18	4.25	
HE-606	13	09/12/2022	06:45	5.001	56.667	60	4-5	0.2	3-4	11.60	0.10	3.10	
HE-606	14	09/12/2022	08:40	5.334	57.534	81	0-1	0.16	3-4	14.71	1.06	7.64	0-2 cm (5Y 6/4), 2-8 cm (5YR 5/2), 8-16 cm (56Y 2/1), silt to fine sand, few shell fragments
HE-606	14	09/12/2022	08:40	5.334	57.534	81	1-2	0.16	3-4	12.35	-0.03	3.66	
HE-606	14	09/12/2022	08:40	5.334	57.534	81	2-3	0.16	3-4	10.91	-0.05	3.27	
HE-606	14	09/12/2022	08:40	5.334	57.534	81	3-4	0.16	3-4	12.96	-0.03	3.64	
HE-606	14	09/12/2022	08:40	5.334	57.534	81	4-5	0.16	3-4	12.09	0.08	4.92	