ALKOR-Berichte

Baltic Sea Geophysical Student Field Trip

Cruise No. AL565

23.09.2021 – 30.09.2021,
Kiel (Germany) – Kiel (Germany)
Seegeophys. GÜ Uni Kiel

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2021

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Preface (Jacob Geersen, Philipp Held, Jasper Hoffmann)

Alkor cruise AL565 served as a marine geophysical field course for 'Physics of the Earth System' bachelor students at Kiel University. Beside taking an active role in planning and realization of the individual geophysical measurements, the students also did some first processing and interpretation of the obtained data. This work had to be documented in form of a scientific presentation as well as writing of the respective chapter in this cruise report. For the following chapters, we (Jacob Geersen, Philipp Held, Jasper Hoffmann) decided to only slightly modify the text and figures provided by the students. This should emphasize the student's achievements, and underline the overarching aim of the cruise to train the students in acquisition, processing, and documentation of marine geophysical data.

1 Cruise Summary

1.1 Summary in English (Julia Noack)

The cruise AL565 was carried out as a marine geophysical field trip for students of the BSc degree program 'Physics of the Earth System' at Kiel University. The purpose of this cruise was for the students to gain experience in collecting marine geophysical data including the handling of measurement devices, processing the data as well as interpreting and presenting the results.

The cruise took place in the western part of the Baltic Sea during 23. - 30. September 2021 starting and ending at the GEOMAR Pier, Kiel. One stopover was made near Eckernförde harbor to collect one senior scientists (24.09.2021). Survey areas were Bay of Strande, Bay of Eckernförde, parts near western and northern Fehmarn and the Bay of Mecklenburg. The first survey area was the Bay of Strande where multibeam data was collected to detect anchor tracks at the seafloor. The survey was interrupted due to other ships anchoring too close to the survey area but was continued two days later. In the Eckernförde Bay the echo sounder EK80 was used to investigate possible gas seepage. Two profiles were taken during different sea levels. Furthermore, bathymetric data was recorded at Mittelgrund to survey pockmarks, and east of Mittelgrund as well as at southern parts of Eckernförde Bay in order to map benthic habitat. Additionally, five seafloor samples were taken with the grab there. The next survey area was west of Fehmarn where multibeam data was used to search for seabed pockmarks. Afterwards, in the Bay of Mecklenburg, six grab samples were taken at the 'Blinkerhügel' as well as images of the seafloor using an underwater drone to find manganese crusts. Two more multibeam surveys were recorded in this region. At a neighboring mound seven additional grab samples were taken and the drone took images of the seafloor for a second time. After that a multibeam survey area was recorded to map a dune field North of Fehmarn. During the last night, the long EK80 profile from the Bay of Eckernförde was acquired for a third time. Multiple CTD measurements were taken during the entire cruise for postprocessing of the multibeam data.

1.2 Zusammenfassung

Die Forschungsfahrt AL565 fand im Rahmen des Bachelor-Studiengangs „Physik des Erdsystems“ der Universität Kiel als seegeophysikalisches Praktikum für die Studierenden statt. Ziel der Fahrt war es, dass die Studierenden Erfahrungen in der Aufzeichnung mariner geophysikalischer Daten sammeln, den Umgang mit den Messgeräten erlernen sowie die Daten verarbeiten und in der Gruppe diskutieren. Die Fahrt fand in der westlichen Ostsee im Zeitraum vom 23. - 30. September 2021 statt beginnend und endend an der GEOMAR Pier in Kiel. Am 24.09.2021 wurde ein Zwischenhalt in der Nähe des Hafens von Eckernförde gemacht um einen weiteren Wissenschaftler einzuschiffen.

Untersuchungsgebiete waren die Strander Bucht, die Eckernförder Bucht, Gebiete nördlich und westlich von Fehmarn und die Mecklenburger Bucht. Das erste Untersuchungsgebiet war die Strander Bucht, wo mittels Multibeam Messungen Ankerspuren am Meeresboden detektiert wurden. Aufgrund von anderen ankernden Schiffen in der Bucht musste die Messung unterbrochen werden und wurde zwei Tage später weitergeführt. In der Eckernförder Bucht wurde das Sedimentecholot EK80 verwendet, um mögliche Gasaustritte zu untersuchen. Dafür wurden zwei

Profile bei unterschiedlichem Meeresspiegel abgefahren. Darüber hinaus wurden bathymetrische Daten am Mittelgrund erhoben, um mögliche Pockmarkstrukturen zu vermessen, und östlich des Mittelgrunds sowie in südlichen Teilen der Bucht wurden Daten erhoben, um Informationen über benthische Lebensräume zu gewinnen. Zusätzlich wurden fünf Bodenproben mit dem Greifer genommen. Das nächste Untersuchungsgebiet befand sich westlich von Fehmarn. Dort wurde das Multibeam eingesetzt, um Pockmarks am Meeresboden zu untersuchen. In der Mecklenburger Bucht wurden am „Blinkerhügel“ sechs Bodenproben entnommen sowie eine Unterwasser Drohne zur Aufnahme von Bildern des Meeresbodens eingesetzt. Zusätzlich wurden zwei weitere Multibeam Vermessungen in dieser Region aufgezeichnet. An einem benachbarten Hügel wurden sieben weitere Bodenproben entnommen sowie die Drohne ein weiteres Mal eingesetzt. Daraufhin wurde nördlich von Fehmarn Multibeam eingesetzt, um ein Dünenfeld zu kartieren. Zahlreiche CTD - Messungen wurden während der Fahrt durchgeführt, um Wasserschallprofile für ein Prozessing der Multibeam Daten aufzuzeichnen.

2 Participants

2.1 Principal Investigator

Name	Institution
Geersen, Jacob, Dr.	CAU

2.2 Scientific Party

Name	Discipline	Institution
Geersen, Jacob, Dr.	Geophysics / Chief Scientist	CAU
Held, Philipp, Dr.	Geophysics / Senior Scientist	CAU
Hoffmann, Jasper, Dr.	Geophysics / Senior Scientist	AWI
Filbrandt, Christian	Geophysics / Master Student	CAU
Kallinich, Nina,	Geophysics / Bachelor Student	CAU
Knüppel, Julia	Geophysics / Bachelor Student	CAU
Lürßen, Paula	Geophysics / Bachelor Student	CAU
Noack, Julia	Geophysics / Bachelor Student	CAU
Rollwage, Luisa	Geophysics / Bachelor Student	CAU
Schmalen, Andrea	Geophysics / Master Student	CAU
Stein, Oliver	Geophysics / Bachelor Student	CAU
Wegehaupt, Swantje	Geophysics / Bachelor Student	CAU

2.3 Participating Institutions

CAU Christian-Albrechts-Universität zu Kiel
AWI Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung

3 Research Program

3.1 Description of the Work Area (Julia Noack)

The Baltic Sea, as it is known now, exists approximately for 8000 years. Its formation history is affected by postglacial uplift movements and eustatic sea level changes determining the salinity of the Baltic Sea by regulating if or how much sea water can enter. Therefore, the formation history can be divided into four main phases (Baltic Ice Lake, Yoldia Sea, Ancylus Lake, Littorina Sea, Fig. 3.1) (Harff et al., 2011; Schwarzer et al., 2019).

During the last glacial era, the Weichselian ice age (ca. 115 - 11.5 ka BP), the whole Baltic basin was covered by a glacier shaping the morphology of the basin as well as the coastlines creating the prominent bays. When the glacier began to melt, several small ice lakes were formed which eventually merged. Due to the high lake level resulting from the melting glacier the water ultimately found its way to the open sea through Sweden. Thereby salt water was able to enter for some time leading to a brackish water in the now called 'Yoldia sea' (ca. 10.3 - 9.5 ka BP). With more and more of Scandinavia uncovered from the glacier the land began to lift and the connection to the open ocean dissolved. No more salt water could enter and the still melting glacier led to a fresh water sea, the 'Ancylus sea' (ca. 9.5 - 8 ka BP). The lake was even larger as today's Baltic Sea at times but parts in the southern basin like those at the coastlines of Germany, Denmark and Poland were still mainland. With still rising eustsatic sea level a new connection to the open sea was formed allowing salt water to enter again for a second time (ca. 8 ka BP) and the southern areas were flooded in the process. Thus, the now developed 'Littorina sea' consisted of brackish water (ca. 8 - 4 ka BP). Since then the salinity decreased leading to the state of today's Baltic Sea (Harff et al., 2011; Schwarzer et al., 2019).

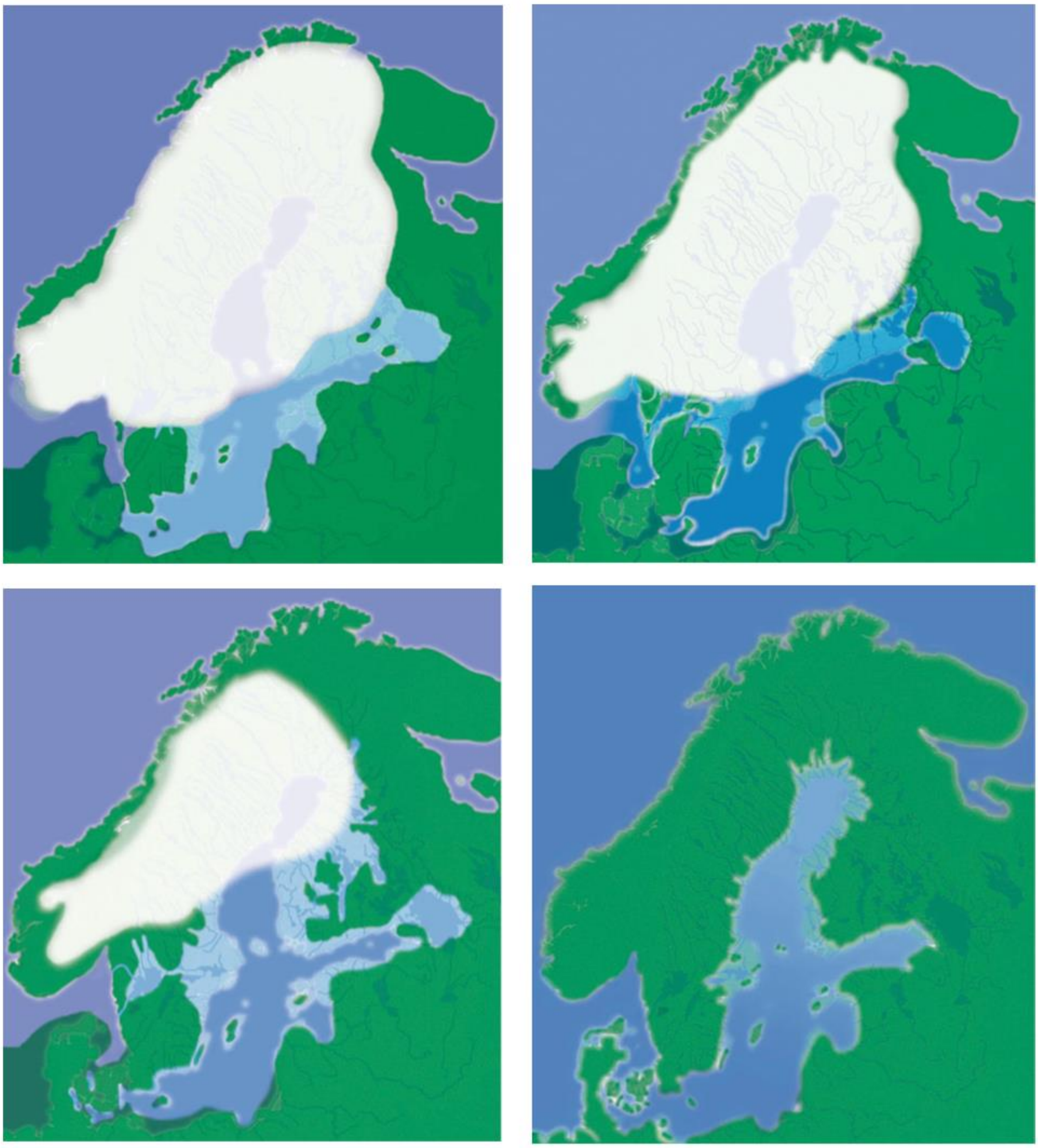

Fig. 3.1 The four main phases during which the Baltic Sea developed into its current shape. Image modified from Harff et al. (2011).

3.2 Aims of the Cruise

Alkor cruise AL565 was realized as a one-week long marine geophysical field lecture. The cruise is an integral part of the geophysical Bachelor and the Master programs offered by Kiel University. It is designed to offer the students a first insight into state-of-the-art marine geophysical methods and data and to sharpen the senses for some of the current questions and challenges related to marine science in the region of the Baltic Sea.

Onboard training included survey planning, acquisition, processing, and first interpretation of the different datasets. The latter included multibeam echo sounding, sub bottom profiling, water column physical properties, geological ground-truthing and video imaging of the seafloor. Next to the technical challenges of getting used to various geophysical methods and the workflow at sea, the students work on small scientific projects based on data collected during the cruises. Scientific topics that were investigated during the cruise range from shallow gas accumulation and seafloor seepage of gas from the sediment into the water column, seafloor morphology as consequence of natural and anthropogenic processes, benthic habitat characterization, and long-term geologic processes such as manganese crust formation.

3.3 Agenda of the Cruise

Alkor cruise AL565 took place in the German sector of the Baltic Sea (Fig. 3.3). The three main survey areas that were visited during the cruise include the Bays of Strande and Eckernförde, the region around Fehmarn, and the Blinkerhügel in the Bay of Mecklenburg (Fig. 3.3). The first few days were spent for multibeam mapping and EK80 echosounder profiling in the Bay of Strande and the Bay of Eckernförde. Scientific topics included mapping of anchor tracks at the seafloor, the characterization of shallow gas seepage in response to sea-level changes, the morphologic characterization of fluid escape structures at the seafloor (pockmarks) as well as the characterization of benthic habitats between 8-12 m water depths. While sailing to the Bay of Mecklenburg as well as on the way back, we investigated the seafloor morphology around Fehmarn. Target areas included a Field of dunes in the North of Fehmarn as well as a previously un-surveyed region to the west of Fehmarn. In the Bay of Mecklenburg, the Blinkerhügel as well as a neighboring hill with a similar morphology, were the main scientific targets.

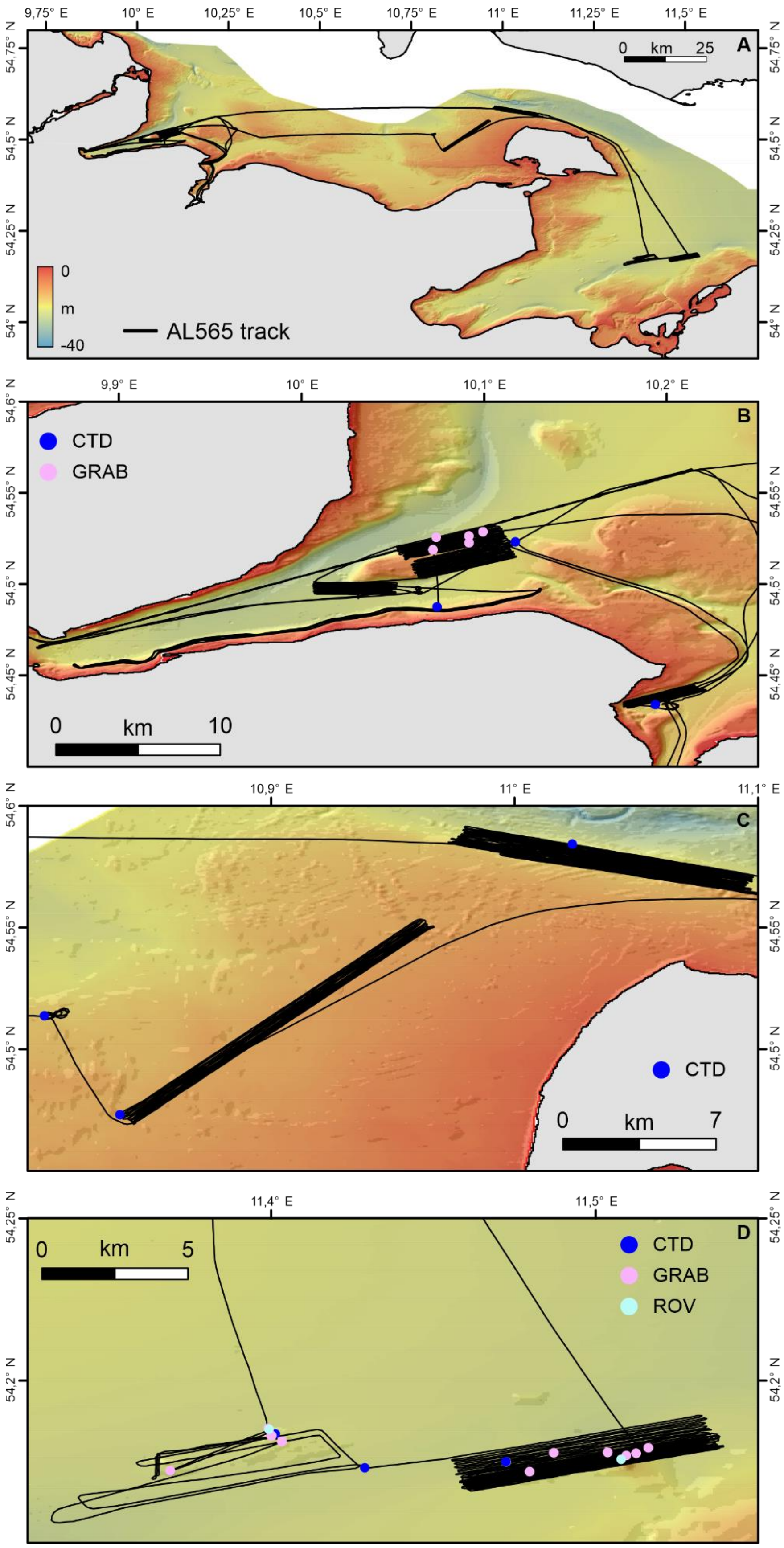

Fig. 3.3 (A) Track chart of R/V Alkor Cruise AL565. The three main working area were: (B) Bay of Strande and Bay of Eckernförde; (C) Around Fehmarn; (D) Blinkerhügel in the Bay of Mecklenburg.

4 Narrative of the Cruise (Julia Knüppel)

Thursday 23 September 2021

Research cruise FS ALKOR 565, to the German sector of the Baltic Sea, started on Thursday, 23 September in Kiel. Around 08:00, 2 senior scientists and 9 undergraduate students met at the GEOMAR pier at the Kiellinie for boarding of the vessel. Before leaving the port, we set up the computer laboratory and different instruments in order to prepare for the first measurement in the Bay of Strande. First of all, there were the two GPS antennas, which were installed on the top deck of the ship and connected with the computer laboratory. For the multibeam system, we attached the transducer and tested it in a tub of water.

At 12:45, ALKOR left the port of Kiel heading to the Bay of Strande where we aimed to collect multibeam bathymetric data across some anchor tracks, which are seen as morphologic furrows within the uppermost sediments. After arriving offshore Strande, the multibeam system was lowered through the moonpool and the relative position of the transducer to the GPS antennas was defined. To calibrate the motion sensor of the multibeam system, the ship had to sail a series of loops, which took about half an hour. At 15:45, we took the first conductivity, temperature, depth CTD-measurement to determine the sound velocity of the water. The CTD was manually lowered over the starboard side of the ship. Measurements were stopped at about 2 m above the seafloor. The determined conductivity (salinity), temperature and depth (through pressure measurements) are used to calculate the sound velocity of the water, which is needed for the processing of the multibeam data. After the CTD measurement, the multibeam survey commenced. We had to abandon the survey after about 1 hour, when two large ships decided to use the Bay of Strande for anchoring as storm was forecasted for the afternoon. We then settled to sail northwards and started a long echo sounder EK 80 profile into the Bay of Eckernförde. The survey was designed for the possible detection of gas seepage during a rapid sealevel drop following the storm in the afternoon. The EK 80 survey, which was shot in both directions, took multiple hours until Friday morning. During the survey, multiple gas flares were visible in the water column.

Friday 24 September 2021

At 8:15 on Friday morning, the multibeam system was lowered into the water for the next multibeam survey at Mittelgrund in the Bay of Eckernförde. We surveyed an area of the seafloor, where multiple pockmarks are located and further tested whether the sediment echosounder system can be used parallel to the multibeam without signal interference. After the first few profiles were collected successfully, we took another CTD. Around noon, the multibeam survey was interrupted and ALKOR sailed towards Eckernförde harbour in order to pick up another senior scientist to assist with the cruise and supervision of the students. All scientific instruments were turned off during the transit to the harbour and the students got a short training lesson about working with nautical charts. After the new member of the scientific crew was collected via the small ships boat, the pockmark survey continued at 13:00 from the same position where it was interrupted. While the students were taught a lesson about how to give scientific presentations, the multibeam survey was finished successfully. The recovery of another CTD failed due to malfunction of the battery. At 16:40, we started once again to search for gas seepage with the EK 80 system along the same long profile from the previous day. The time window was chosen in order to cover another rapid sea level drop. After having reached the end of the profile, the next multibeam survey started on the eastern side of Mittelgrund with the aim to collect data for a characterisation of the benthic habitat.

Saturday 25 September 2021

At 6:30, the survey was interrupted and the ALKOR headed back to the Bay of Strande to continue the multibeam survey across the anchor tracks, that had to be abandoned on Thursday. We were able to collect data for about 4 hours until the area was flooded with sailing boats that were leaving the harbour in Strande. At the end of the survey, the CTD was deployed in the water and lowered in order to derive a sound velocity profile for the Bay of Strande. ALKOR then sailed northwards to Mittelgrund in the Bay of Eckernförde while the scientific crew had a meeting to summarise the obtained data. After finishing the benthic habitat mapping at Mittelgrund, the students used the backscatter results to choose locations for grab samples that should be used for ground truthing of the geophysical data. After a short calibration survey for the multibeam, the ship sailed towards the southern coast of the Bay of Eckernförde to start a multibeam survey along the 10 m depth contour line for benthic habitat mapping. There happened to be some incidents with fishing buoys on the way that must be avoided to cross.

Sunday 26 September 2021

At 8:10 in the next morning, the multibeam survey was finished and another CDT was recorded to the south of Mittelgrund. Afterwards, five grab samples were taken with the Van Veen grab of ALKOR. The recovered sediments ranged from mud to centimetre sized stones and gravel. At 10:00, ALKOR left the Bay of Eckernförde and headed for Fehmarn. At the arrival around 12:00, another CTD was taken in the new survey area to the West of Fehmarn. We conducted a seafloor survey with the multibeam in attempt to image seabed pockmarks. After calibration of the motion sensor, data collection started around 13:30.

Monday 27 September 2021

During the night, many parallel multibeam profiles were recorded until 7:30 in the morning followed by another CTD profile to determine the sound velocity around 8:00. We lifted the multibeam system so that the ship could sail with maximum speed from West of Fehmarn to the next survey area. Our destination was the Bay of Mecklenburg where manganese nodules had been found at one specific location referred to as the Blinkerhügel. At 12:15, the first students gave a seminar talk about some of the individual methods and results obtained so far. The underwater drone for under water motion pictures was prepared for the first time during the cruise and deployed in the water at 13:30. Carefully flown by Phillip, the drone successfully recorded the seafloor at 18m depth, showing multiple boulders and smaller rocks, possibly the manganese nodules. After the visual exploration, the Van Veen grab took 6 seafloor samples across the Blinkerhügel. The second half of the day was used to collect multibeam data filling some data gaps from last years survey. In addition, a new grid was placed across a neighbouring mound that shows a similar morphologic structure as the Blinkerhügel. At 19:00, the next CTD was taken before sailing along the mentioned new grid.

Tuesday 28 September 2021

The multibeam profiles were continued during the night and morning. At 10:00, the drone was turned on and let into the water in order to image the seafloor at the Blinkerhügel. Half an hour later, after successful recovery of the drone, the profiles were continued for three hours until we reached the next point for CTD survey. During this time we had another seminar talk. At 13:50, we started to take some ground truthing samples with the grab at seven different locations across the Blinkerhügel. There was only one but large stone that possibly had some manganese crust, while other grabs came up without recovery, possibly due to the hard seafloor. After thoroughly analysing the samples, ALKOR headed to the northwest of Fehmarn, where a large field of dunes had been found during previous surveys. The multibeam survey was started at 18:30, after having taken another CTD. The students continued with the seminar talks.

Wednesday 29 September 2021

At 14:00, the chief machinist showed us the engine room. The profiles of the day before were continued until 16:00. Another CTD was taken and then we took course to Eckernförde. We heard the last seminar talk. During the transit we cleaned the laboratories and stored all instrument back in their cases. Back in the Bay of Eckernförde we started the EK80 echosounder profile from the first days of the cruise to look for gas seepage.

Thursday 30 September 2021

After finishing the EK 80 survey in the early morning, Alkor headed back to the GEOMAR east shore pier. The ship arrived around 8:00 and the students left the vessel while the geophysical instruments were unloaded.

5 Preliminary Results

5.1 NORBIT Multibeam System (Swantje Wegehaupt)

The majority of the surveys during the cruise were carried out with the NORBIT Multibeam iWBMS system, which is designed for swath mapping of the seafloor (Fig. 5.1). The system is especially designed for shallow water mapping (100 m water depth) and works with frequencies between 200 - 700 kHz and a bandwidth of up to 80 kHz. The transducer of the multibeam was attached to a metal frame and deployed through the moon pool in the middle of the ship, about 4 meters below the water surface. The system sends and records acoustic signals in form of a fan which are reflected/scattered at the seafloor. In addition to the traveltime, which is transferred into depth, the system also records the strength of the reflected/scattered signal. The backscatter strength correlates with the structure and the composition of the seafloor. The rougher the seafloor, in relation to the used acoustic wave length, the more energy is scattered back.

The greater the water depth and greater the selected opening angle of the acoustic fan, the wider is the area mapped on the seafloor. The multibeam also includes a motion sensor which measures the roll, pitch and heading of the ship. This information is required for geolocation of the recorded echoes. During the cruise, multiple CTD measurements, usually at the start and end of each survey, were conducted. The obtained data were translated into sound velocity which is used for processing of the multibeam data. After the instrument had been lifted in the moon pool (for transit) and lowered (for the next survey) a series of calibration profiles were usually taken in order to correct for small misalignments between the multibeam and the motion sensor.

First processing of the recorded multibeam data was performed on board by the students. The following processing steps were performed: patch test, applying of the measured sound speed profiles to the data, corrections of water level variations, and data cleaning. These processing was performed with the software Qimera.

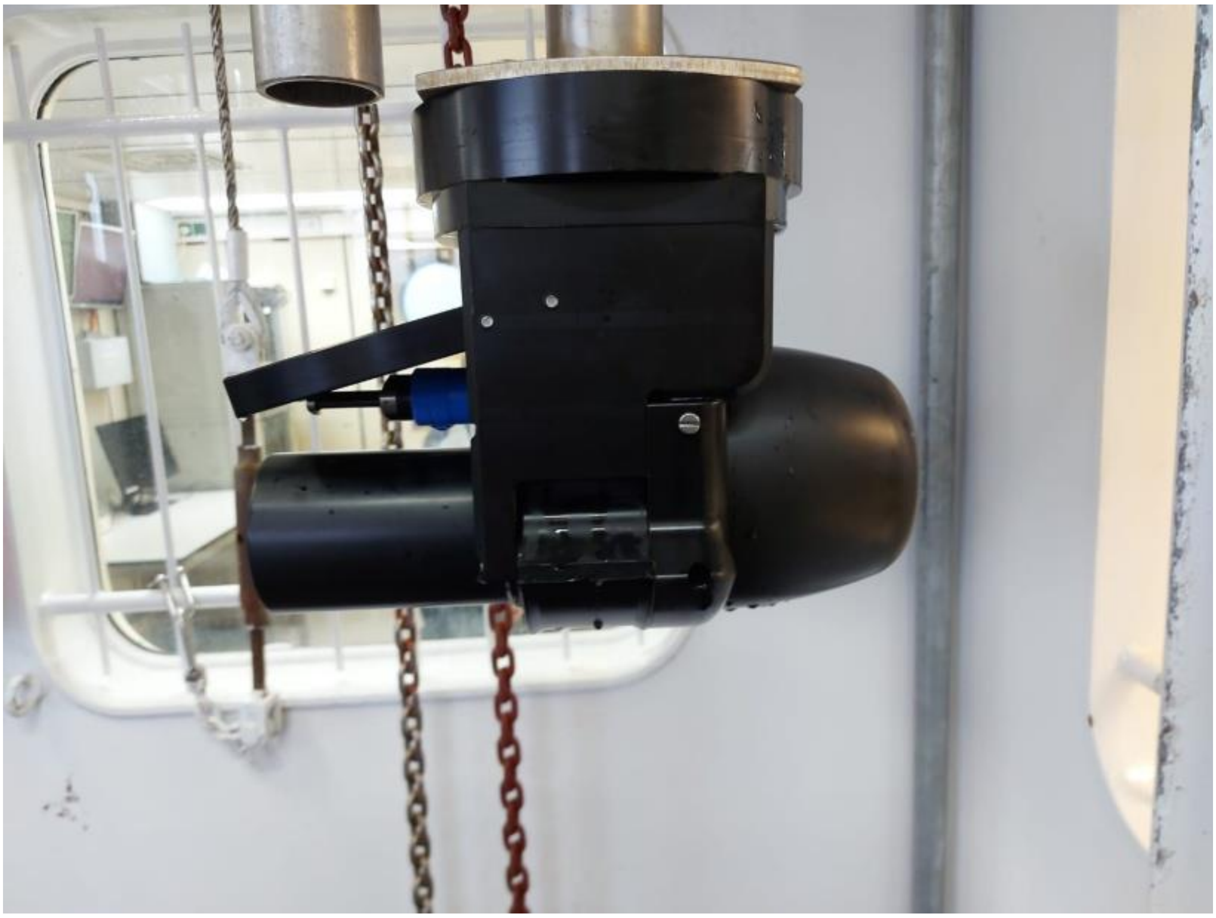

Fig. 5.1: NORBIT Multibeam iWBMS over the moonpool.

5.1.1 First results from the anchor tracks in the Bay of Strande (Paula Lürßen)

We started multibeam mapping in the Bay of Strande on Thursday 23.09.2021 and continued the survey on the 25.09.2021. The aim of examining the seafloor in the bay was to image anchor tracks. There seems to be a high morphologic similarity between anchor tracks and the tracks of bottom trawls, which are widespread in the Baltic Sea. Mapping of these tracks, especially when conducted in a repeated manner, can help to better understand the conservation period of such anchor tracks within shallow sediments. Generally, there is little information available on how long anchor tracks or bottom trawling marks last, despite them being widespread in the Baltic Sea. Establishing a time series in this area of the Bay of Strande could be useful for further understanding. The survey was conducted with the multibeam using the equidistance setting.

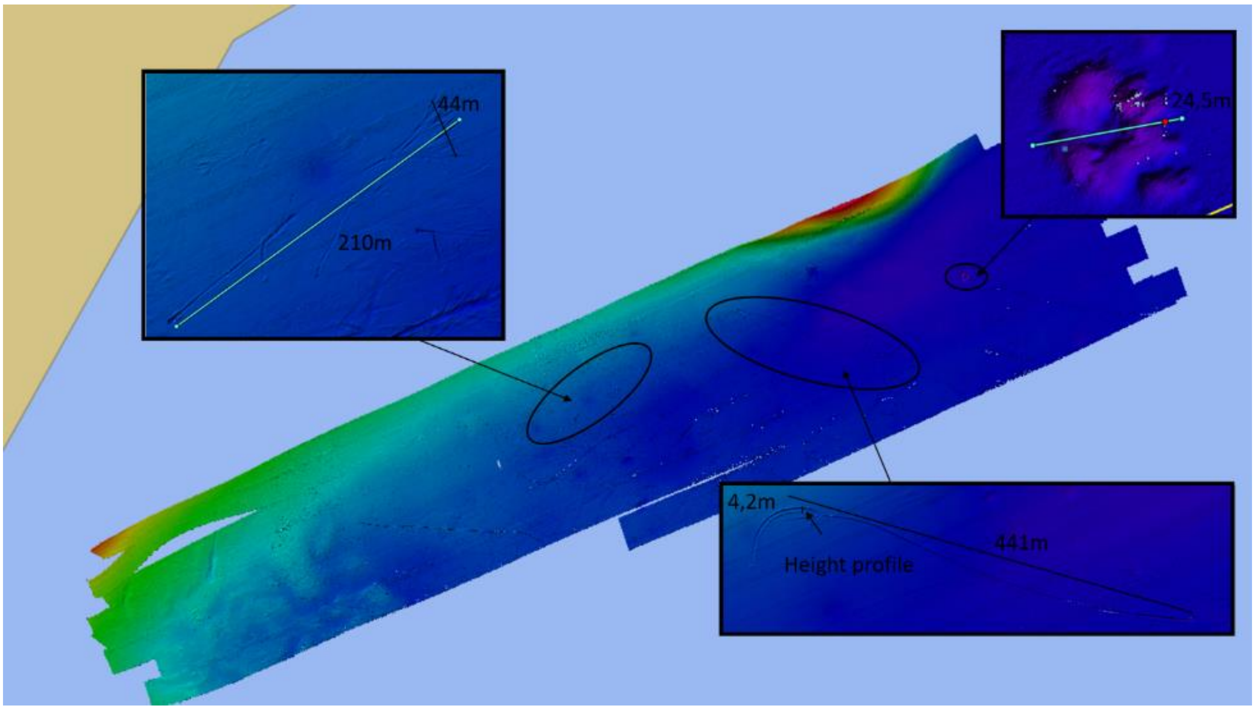

Fig. 5.1.1.1: Area covered with multibeam data during AL565 cruise in the Bay of Strande.

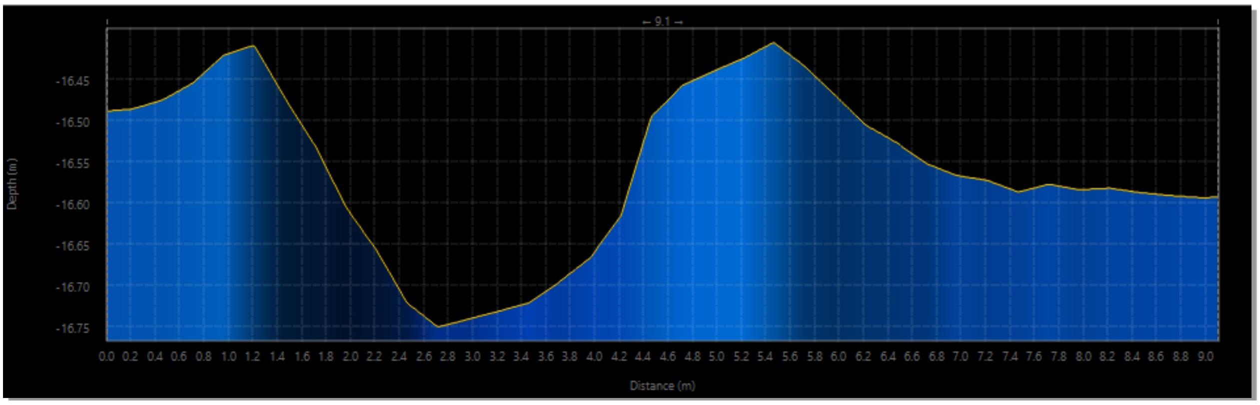

Figure 5.1.1.2: Depth profile across the bigger track.

A bathymetric map of the entire survey is shown in Figure 5.1.1.1. The visible elongated depressions are typical for anchor chain tracks. The length of the track shown above is about 210 m and the width usually ranges around 1 m. The tracks cut about 5cm-10cm into the seafloor. At the northern end, the single-track separates into a fan of multiple tracks that spread over a width of 44 m. The larger tracks do not show a typical anchor structure, this could be an indicator that these tracks are generated by very large ships. The length was more than 441m, the width was about 4.2m and the penetration depth was about 35cm. The evening of the 23.09.2021 was quite stormy and the bay was used by a few ships for anchoring during the storm. It therefore seems possible that the imaged tracks are from large ships waiting for better weather during the past 2 days prior to our recording. The steep edges, visible in the multibeam profiles, could be an indication that the tracks have been generated recently (Fig. 5.1.1.2). Furthermore, a rounded structure (depression) can be recognized in the data which may represent an evolving pockmark (Fig. 5.1.1.1), although this needs further analysis.

5.1.2 First results from the pockmarks in the Bay of Eckernförde (Nina Kallinich)

A pockmark is a depression in the seafloor that is usually related to fluids erupting through the subsurface. They can reach width of several kilometers and a depth of up to 45 m. They were originally described in 1970 offshore Nova Scotia by King and MacLean (1970).

Some pockmarks are filled with coarser and harder material compared to the surrounding sediments, e.g. authigenic carbonate, biological remnants or sand. In this case the acoustic waves from the multibeam echosounder are scattered stronger and the pockmarks appear as bright spots in the backscatter plot. These kinds of pockmarks with high reflective objects in their centre are generally referred to as 'eyed pockmarks' (Hovland et al. 2002).

In Eckernförde Bay, southwest from Mittelgrund (Fig. 5.1.2.1), where the sediment is dominated by silt and clay with microbial gas forming in the sediment, we mapped pockmarks, using the Norbit multibeam system in multi-frequency mode, meaning that 190 kHz and 370 kHz are recorded simultaneous.

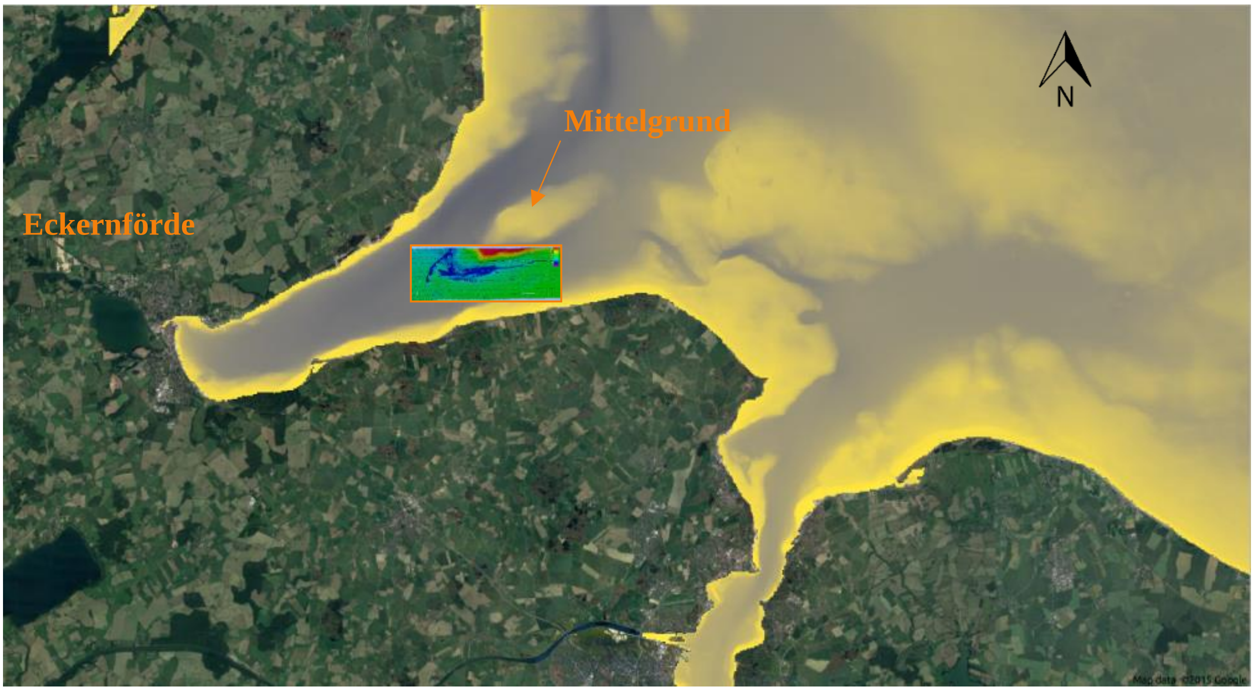

Fig. 5.1.2.1: Location of the study area near Mittelgrund in the Eckernförde Bay.

The bathymetric map of this area in Figure 5.1.2.2 shows the relatively small intrapockmarks, which are located at the bottom of large-scale pockmarks. Comparing the bathymetry map and the backscatter map of this area, one can see that the intrapockmarks appear as eyed pockmarks.

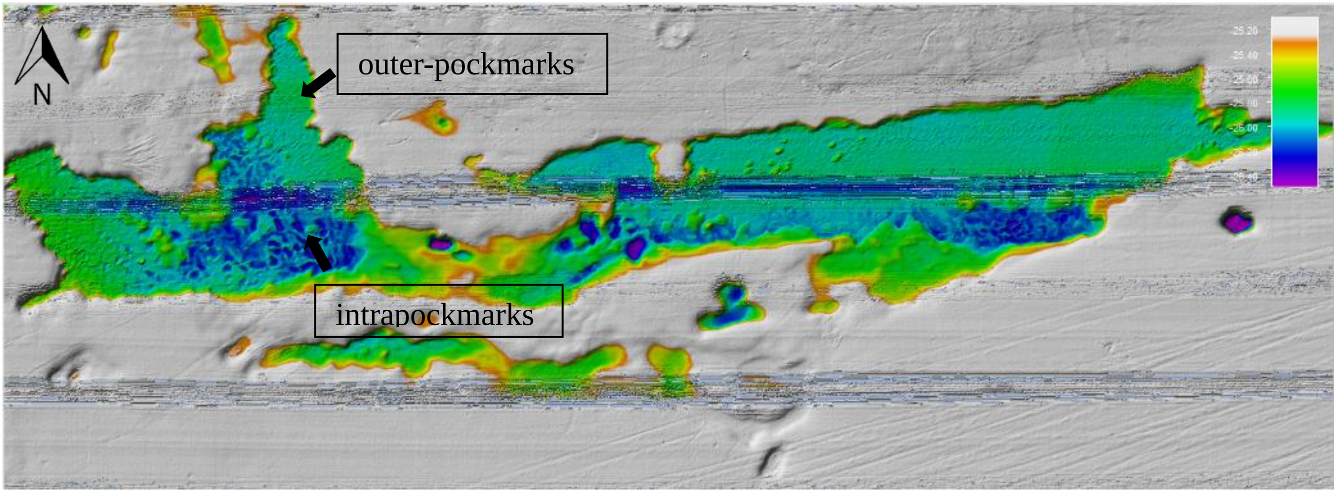

Fig. 5.1.2.2: Bathymetry map of the outer-pockmarks and the intrapockmarks.

Between 2014 – 2020, Hoffmann et al. (2020) examined this area by taking sediment and water samples and hydroacoustic data. They found that none of the usually expected processes for the formation of eyed pockmarks occur in this area. Instead, they discovered that terrestrial groundwater ascending through the subsurface, discharges through the intrapockmarks. This pushes the methane gas in the underlying sediments so that it accumulates near the seafloor. This leads to strong backscatter, shown Figure 5.1.2.3.

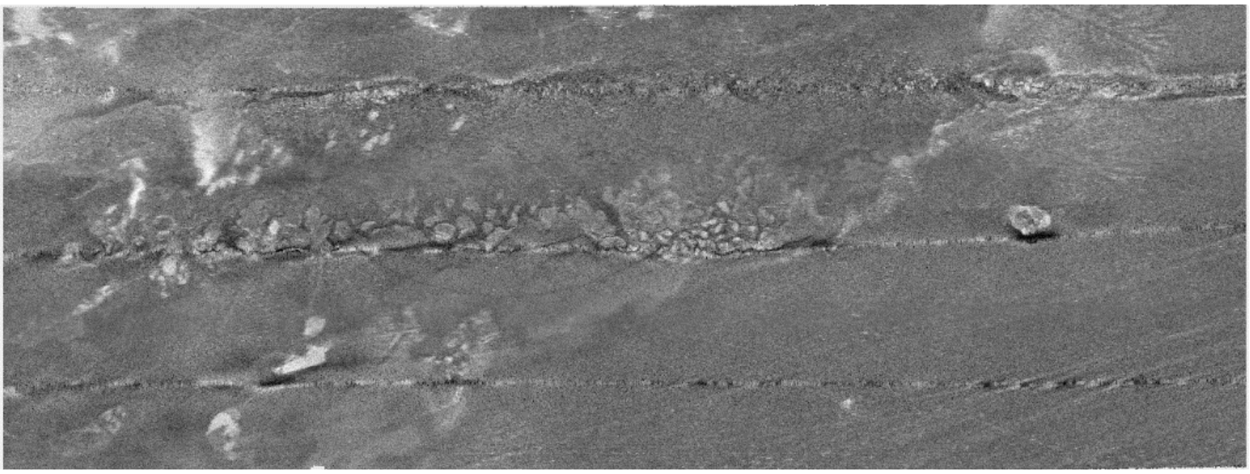

Fig. 5.1.2.3: Zoom-in of the backscatter plot from the examined area in Eckernförde Bay.

5.1.3 First results from the Blinkerhügel (Luisa Rollwage)

The bathymetry (Fig. 5.1.3.1) and backscatter signal strength (Fig. 5.1.3.2) of the concentrically shaped hill, located east of the Blinkerhügel, are presented below. On the western side of the hill, another submarine topographic high, that stretches in a south-westerly direction, is visible. Higher backscatter signal strength indicates rougher surface and is illustrated in brighter colour while lower backscatter signal strength indicates smoother surface and is illustrated in darker colour. From the Van Veen Grab samples one can conclude that the rougher surface consists of medium to coarse grained sand, mussels and stones. In comparison, the surface is smoother due to silt and fine-grained sand.

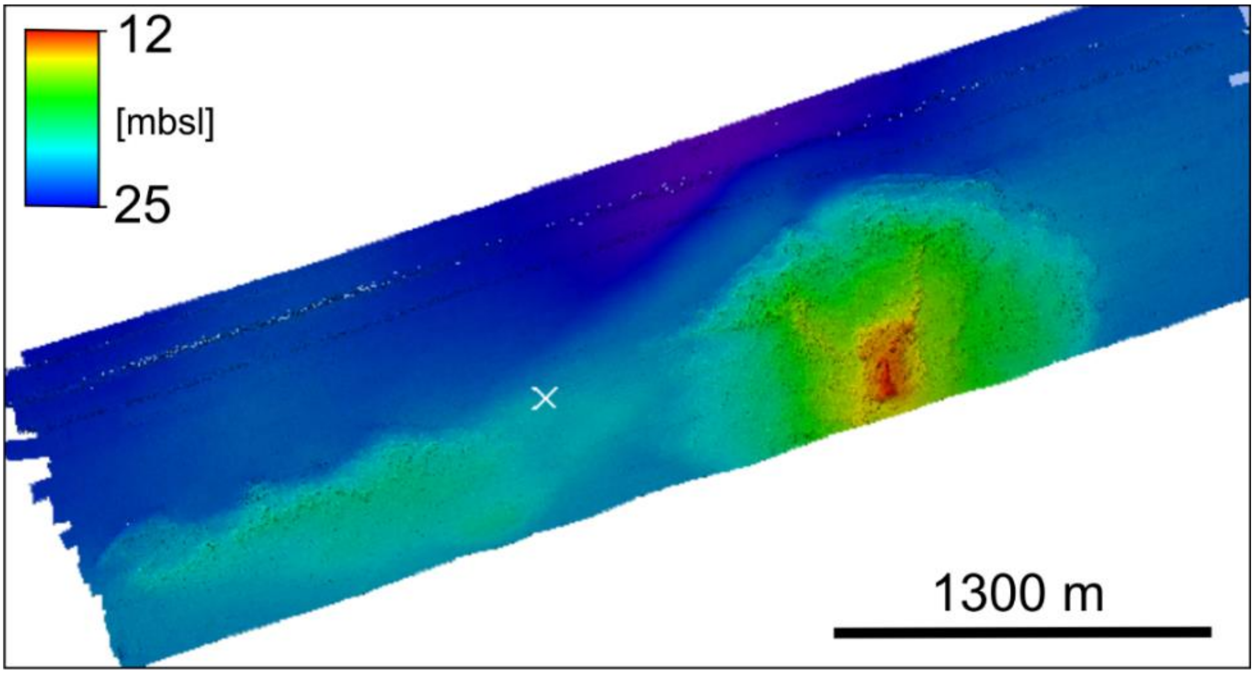

Fig. 5.1.3.1: Bathymetric map from the neighbouring hill next to the Blinkerhügel. The white cross marks the location where a CTD was taken.

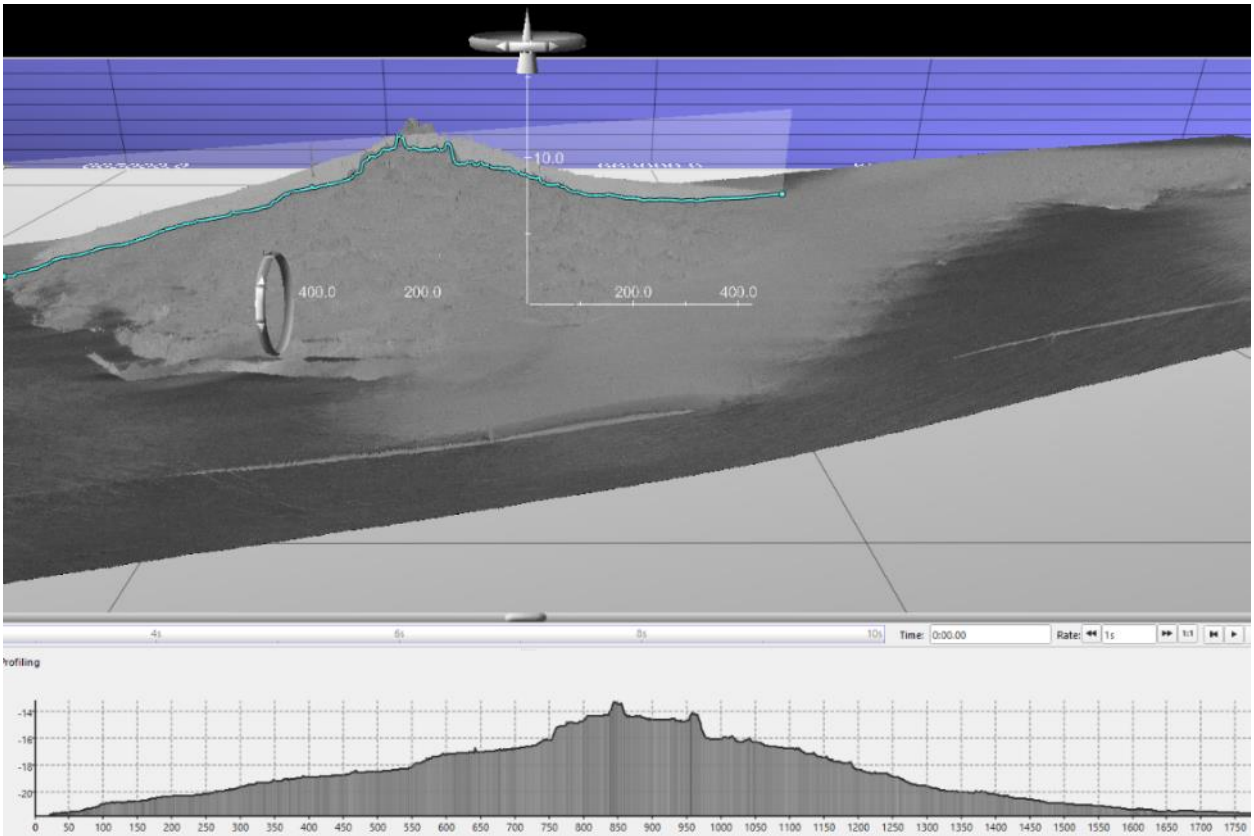

Fig. 5.1.3.2: Backscatter signal strength combined with bathymetry data and elevation profile of the neighbour hill next to the Blinkerhügel.

5.1.4 First results from the West of Fehmarn (Andrea Schmalen)

The seafloor to the west of Fehmarn has not been in the focus of previous student cruises on ALKOR. One aim of the survey conducted this year was to investigate if pockmarks are present in this region. Furthermore, the area is known as a hotspot for harbour porpoises. Fixed hydrophones on the seafloor recorded the click noises of the whales.

Studies by Herzing and Rossbach, 1997 and Kaplan et al., 2019, respectively, show that bottlenose dolphins do so called benthic „crater feeding“ at the Bahama Banks, which leaves depressions with a similar morphologic expression compared to pockmarks at the seafloor. We were therefore interested to see if there are any indications for benthic feeding of these animals preserved in the seafloor morphology to the west of Fehmarn.

We used the Norbit multibeam echosounder to create a bathymetric map of an 11.5 x 0.5 km area (zoom shown in Fig. 5.1.4). The results show no depressions. But we found that the area is covered with coarse sand, gravel and stones. This may not be an ideal environment to find pockmarked depressions as the sediments are too coarse.

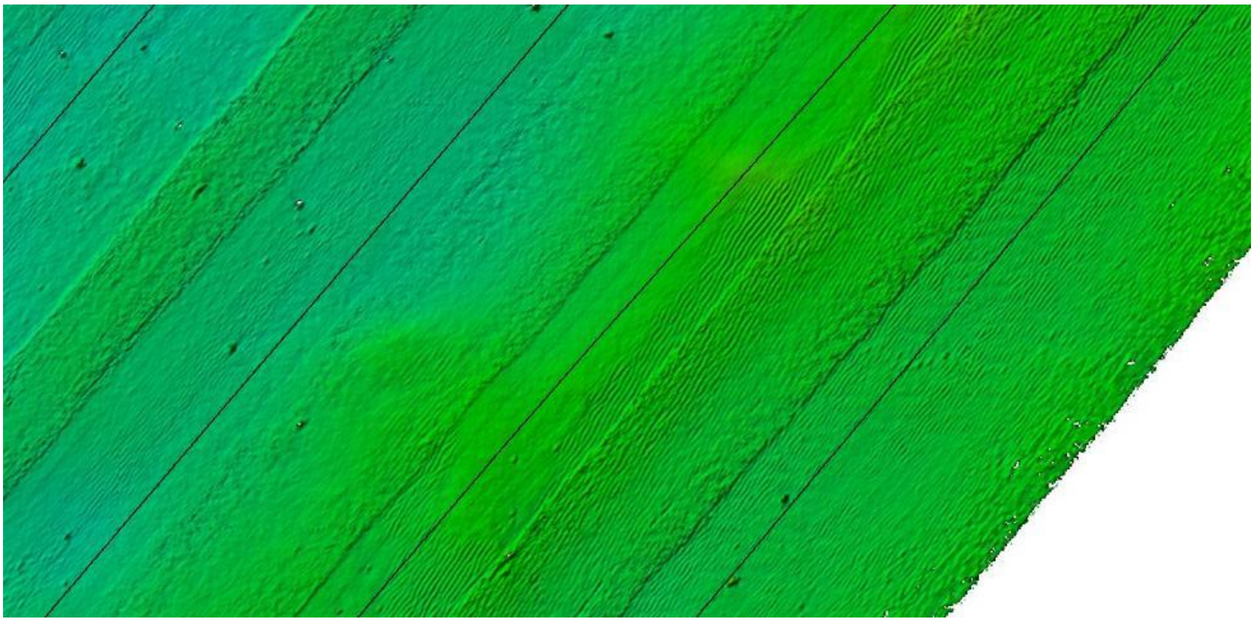

Fig. 5.1.4: Snipped of Bathymetric map. It shows wave ripples in the sand and scattered stones.

5.2 SIMRAD EK 80 (Oliver Stein)

The SIMRAD EK80 is a fishery echo-sounder, which is optimized for imaging of the water column. It is further used as a device for measuring water depths. The unit can transmit different signals on two channels. During the cruise, the frequencies of 38 kHz and 70 kHz were used. Due to the high frequencies the acoustic waves do not penetrate into the seafloor. The signals are reflected and scattered at interfaces with an impedance contrast. Acoustic impedance is the product of density and sound velocity. We used the EK80 to detect acoustic targets such as fish, gas and density contrast between individual water layers.

5.2.1 First results from the SIMRAD EK 80 (Oliver Stein)

In Eckernförde Bay, the EK80 was used to detect gas seepage from the seafloor. Measurements were taken at three different time-intervals along a 25 km long profile in Eckernförde Bay (First measurement: 23/24.09.2021; Second measurement: 24.09.2021; Third measurement: 29/30.09.2021). The first measurement started on the evening of 23.09.2021 shortly after a storm event. During this first survey the water level was at its lowest point. The second measurement on the 24.09.2021 was taken during a falling sea level (Fig. 5.2.1.1). Basically, the data show that a lot of gas, possibly methane, was seeping from the seabed during the storm event on the 23.09.2021/24.09.2021 (Fig. 5.2.1.2). During the second measurement, only very few bubble chains were detected.

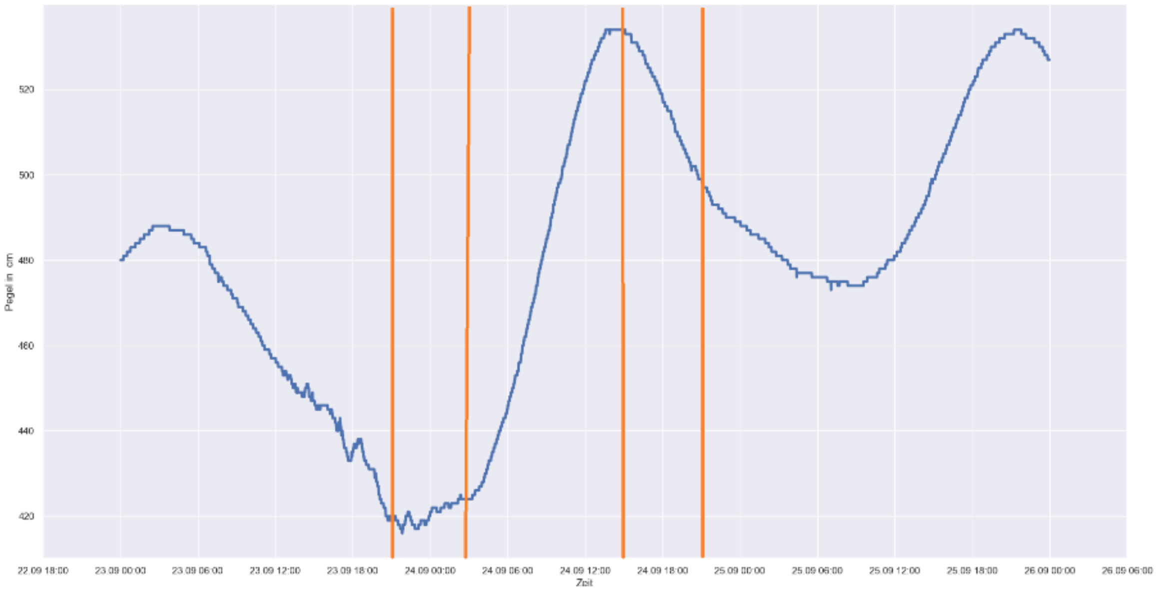

Fig. 5.2.1.1: Water level of the Baltic Sea near Eckernförde Bay from 23./24.09.2021. Orange lines show the times during which the first two EK80 measurements were conducted in the Bay of Eckernföde.

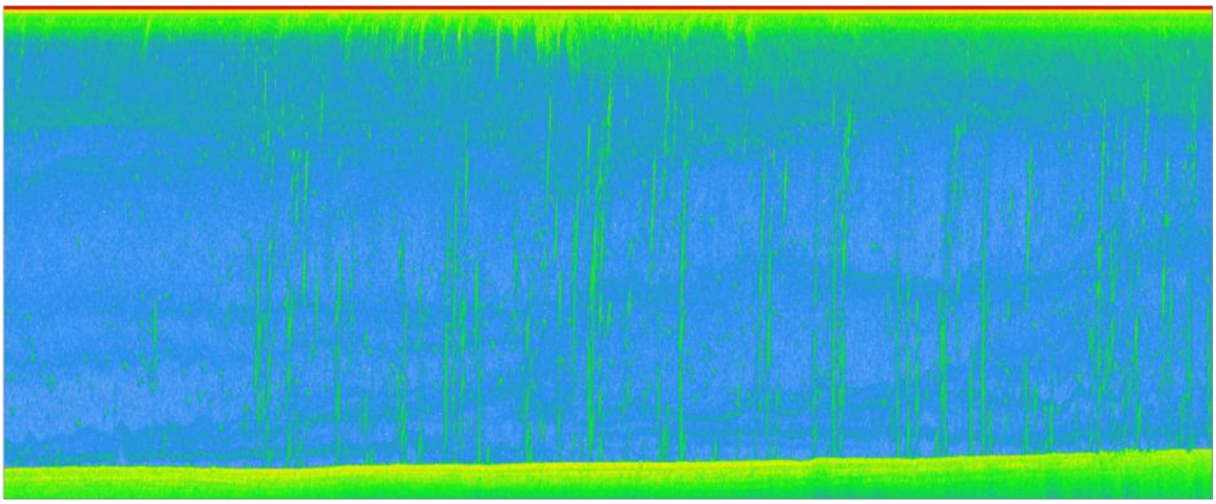

Fig. 5.2.1.2: Gas seeping from the seafloor during the first EK80 measurement on 23/24.09.2021).

5.3 **Chasing Innovation M2 ROV** (Julia Knüppel, Luisa Rollwage)

The Chasing Innovation M2 ROV that we used during the cruise was connected to the ship via a cable. In order to prevent the ROV from drifting away the cable was tied to a yellow rope that was lowered to the seafloor using an extra weight. This configuration allowed the ROV to move within a radius of 5 m around the yellow rope. This is further useful for determining the locations of the ROV which is not provided with a positioning system.

We were surprised of how well the camera focused on the seafloor and how well the images were resolved. While the ROV moved through the water one can watch the live recording on a mobile phone which is connected to a network created by the remote control of the ROV (linked to the cable) as well as on a second screen which can be connected to the remote control with a HDMI cable.

After recovery of the drone, which was conducted using a long scoop, the video was transferred to an external hard disk to examine the recordings in detail. We used the drone twice. It surveyed the seafloor each time for approximately 15 minutes. Both locations were in the near surrounding of the Blinkerhügel in the Bay of Mecklenburg.

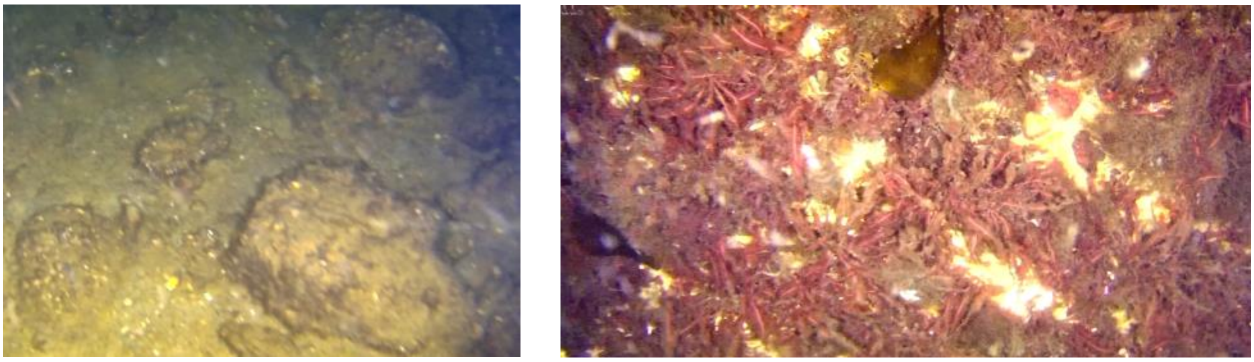

Fig. 5.3: Seafloor images from the Chasing Innovation M2 ROV.

5.4 **Grab** (Julia Knüppel, Luisa Rollwage)

The Van Veen Grab is a sampling device to take geological samples up to a volume of around 10l from the seafloor. It is part of the equipment of the RV ALKOR. During our cruise the grab was used 18 times in total in the Bay of Eckernförder and the Bay of Mecklenburg. With the help of the crew it was lowered down until it hit the ground and penetrated the sediment with its own weight. The samples were brought back on deck and were then observed and first described by the students.

5.5 CTD (Julia Knüppel)

The abbreviation CTD stands for Conductivity, Temperature and Depth. After deploying in the water, the shipbased instrument is halted at the surface for about 2 minutes in order to allow the sensors to adjust to the water. Afterwards it is lowered with a constant vertical velocity of 0.2 m/s. It consists of 12 niskin bottles that are used to take water samples at different depths. We didn’t use this feature and only recorded the inner device that determines the physical properties of the water. Measurements are taken at 1 s intervals. The three parameters, that interest us in order to calculate the sound speed for processing of the multibeam data, are conductivity, temperature and pressure. The atmospheric pressure gets automatically subtracted. From the conductivity we can easily get the value of salinity. With knowledge about salinity, temperature and pressure, the density of the water can be determined. Finally, we have the main three values to calculate the sound velocity. As it changes with depth the system creates a depth-dependent profile. With this profile the multibeam data can be processed. Over the entire cruise we took 10 sound velocity profiles.

Fig. 5.4.1: The ship’s CTD used for most of the CTD surveys.

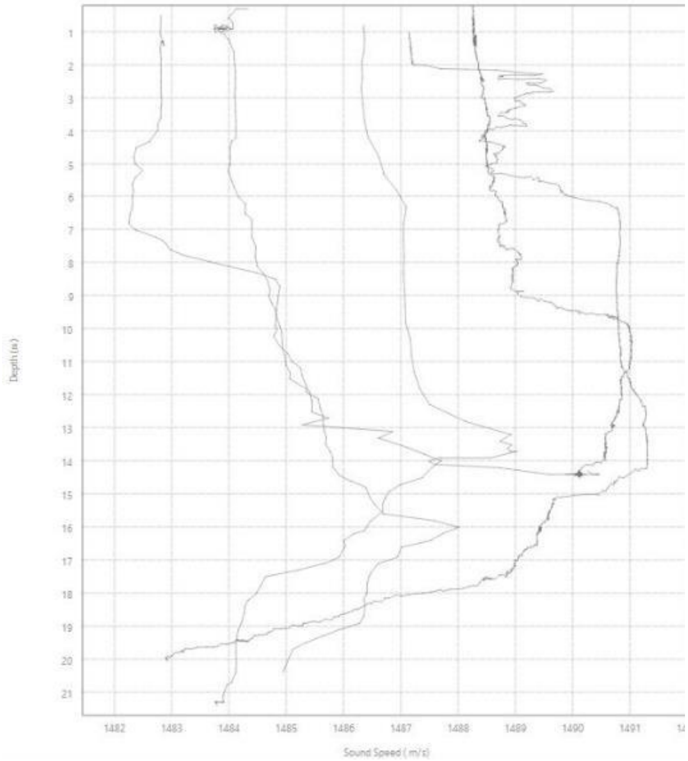

Fig. 5.4.2: Sound velocity profiles derived from selected CTD measurements.

6 Station List AL565

6.1 Overall Station List

Activity - Device Operation	Device	Timestamp	Action	Latitude	Longitude
AL565_1-1	MB	2021-09-23 14:07:53	profile start	54° 26,072' N	010° 10,739' E
AL565_1-1	MB	2021-09-23 15:06:47	profile end	54° 26,261' N	010° 11,531' E
AL565_2-1	EK60	2021-09-23 16:18:41	profile start	54° 33,716' N	010° 12,837' E
AL565_2-1	EK60	2021-09-23 22:38:11	profile end	54° 27,937' N	009° 51,454' E
AL565_2-2	EK60	2021-09-23 22:46:17	profile start	54° 27,910' N	009° 51,437' E
AL565_2-2	EK60	2021-09-24 04:24:24	profile end	54° 33,715' N	010° 12,748' E
AL565_3-1	MB	2021-09-24 06:17:26	in Moonpool	54° 29,734' N	010° 03,893' E
AL565_3-1	MB	2021-09-24 07:12:56	profile start	54° 29,675' N	010° 02,937' E
AL565_3-1	MB	2021-09-24 08:39:35	profile end	54° 29,790' N	010° 02,881' E

AL565_3-1	MB	2021-09-24 11:01:13	profile start	54° 29,825' N	010° 02,940' E
AL565_3-1	MB	2021-09-24 13:54:23	profile end	54° 30,050' N	010° 00,561' E
AL565_4-1	EK60	2021-09-24 14:38:45	profile start	54° 31,127' N	010° 03,201' E
AL565_4-1	EK60	2021-09-24 18:19:31	profile end	54° 27,952' N	009° 51,504' E
AL565_4-1	EK60	2021-09-24 18:27:45	profile start	54° 27,934' N	009° 51,510' E
AL565_4-1	EK60	2021-09-24 20:45:09	profile end	54° 31,060' N	010° 02,934' E
AL565_5-1	MB	2021-09-24 21:01:30	profile start	54° 31,257' N	010° 03,234' E
AL565_5-1	MB	2021-09-25 04:30:50	profile end	54° 31,369' N	010° 06,763' E
AL565_6-1	MB	2021-09-25 06:00:35	profile start	54° 26,704' N	010° 12,834' E
AL565_6-1	MB	2021-09-25 09:21:24	profile end	54° 26,144' N	010° 11,845' E
AL565_6-2	CTD water	2021-09-25 10:04:39	in the water	54° 26,042' N	010° 11,621' E
AL565_6-2	CTD water	2021-09-25 10:09:25	on deck	54° 26,038' N	010° 11,629' E
AL565_7-1	CTD water	2021-09-25 12:16:50	in the water	54° 31,377' N	010° 07,040' E
AL565_7-1	CTD water	2021-09-25 12:19:21	on deck	54° 31,382' N	010° 07,031' E
AL565_8-1	MB	2021-09-25 12:30:56	profile start	54° 31,194' N	010° 05,991' E
AL565_8-1	MB	2021-09-25 18:40:28	profile end	54° 30,212' N	010° 04,093' E
AL565_9-1	MB	2021-09-25 19:14:00	profile start	54° 29,918' N	010° 01,830' E
AL565_9-1	MB	2021-09-25 19:32:01	profile end	54° 29,724' N	010° 01,858' E
AL565_10-1	MB	2021-09-25 20:24:26	profile start	54° 29,794' N	010° 07,627' E
AL565_10-1	MB	2021-09-26 06:03:03	profile end	54° 29,194' N	010° 04,443' E
AL565_11-1	CTD water	2021-09-26 06:09:47	in the water	54° 29,249' N	010° 04,444' E
AL565_11-1	CTD water	2021-09-26 06:12:16	on deck	54° 29,246' N	010° 04,458' E
AL565_12-1	GRAB	2021-09-26 06:37:22	in the water	54° 31,117' N	010° 04,323' E
AL565_12-1	GRAB	2021-09-26 06:39:01	on deck	54° 31,125' N	010° 04,323' E
AL565_12-2	GRAB	2021-09-26 06:39:55	in the water	54° 31,125' N	010° 04,328' E

AL565_12-2	GRAB	2021-09-26 06:42:02	on deck	54° 31,124' N	010° 04,328' E
AL565_13-1	GRAB	2021-09-26 06:55:20	in the water	54° 31,531' N	010° 04,430' E
AL565_13-1	GRAB	2021-09-26 06:57:21	on deck	54° 31,535' N	010° 04,432' E
AL565_14-1	GRAB	2021-09-26 07:10:29	in the water	54° 31,356' N	010° 05,502' E
AL565_14-1	GRAB	2021-09-26 07:12:02	on deck	54° 31,355' N	010° 05,509' E
AL565_15-1	GRAB	2021-09-26 07:22:01	in the water	54° 31,573' N	010° 05,502' E
AL565_15-1	GRAB	2021-09-26 07:23:55	on deck	54° 31,577' N	010° 05,507' E
AL565_16-1	GRAB	2021-09-26 07:35:27	in the water	54° 31,712' N	010° 05,964' E
AL565_16-1	GRAB	2021-09-26 07:35:53	on deck	54° 31,713' N	010° 05,966' E
AL565_17-1	CTD water	2021-09-26 10:15:17	in the water	54° 30,787' N	010° 48,441' E
AL565_17-1	CTD water	2021-09-26 10:19:42	on deck	54° 30,821' N	010° 48,419' E
AL565_18-1	MB	2021-09-26 10:31:00	profile start	54° 30,830' N	010° 48,876' E
AL565_18-1	MB	2021-09-26 11:26:53	profile end	54° 30,884' N	010° 48,646' E
AL565_18-2	MB	2021-09-26 12:10:52	profile start	54° 28,247' N	010° 50,742' E
AL565_18-2	MB	2021-09-27 05:45:52	profile end	54° 28,442' N	010° 50,409' E
AL565_19-1	CTD water	2021-09-27 05:50:19	in the water	54° 28,380' N	010° 50,285' E
AL565_19-1	CTD water	2021-09-27 05:52:36	on deck	54° 28,384' N	010° 50,277' E
AL565_20-1	CTD water	2021-09-27 10:01:47	in the water	54° 11,007' N	011° 24,086' E
AL565_20-1	CTD water	2021-09-27 10:04:49	on deck	54° 11,010' N	011° 24,078' E
AL565_21-1	MB	2021-09-27 10:31:40	profile start	54° 10,497' N	011° 21,874' E
AL565_21-1	MB	2021-09-27 11:01:15	profile end	54° 10,540' N	011° 21,898' E
AL565_22-1	ROV	2021-09-27 11:33:20	in the water	54° 11,014' N	011° 24,014' E
AL565_22-1	ROV	2021-09-27 12:11:38	on deck	54° 11,096' N	011° 23,966' E
AL565_23-1	GRAB	2021-09-27 12:18:38	in the water	54° 11,110' N	011° 23,950' E
AL565_23-1	GRAB	2021-09-27 12:21:13	on deck	54° 11,112' N	011° 23,948' E

AL565_24-1	GRAB	2021-09-27 12:40:54	in the water	54° 10,330' N	011° 22,139' E
AL565_24-1	GRAB	2021-09-27 12:43:08	on deck	54° 10,332' N	011° 22,139' E
AL565_25-1	GRAB	2021-09-27 13:04:54	in the water	54° 10,977' N	011° 23,997' E
AL565_25-1	GRAB	2021-09-27 13:07:00	on deck	54° 10,978' N	011° 24,016' E
AL565_25-2	GRAB	2021-09-27 13:11:03	on deck	54° 10,975' N	011° 24,014' E
AL565_26-1	GRAB	2021-09-27 13:18:38	in the water	54° 10,876' N	011° 24,197' E
AL565_26-1	GRAB	2021-09-27 13:20:36	on deck	54° 10,873' N	011° 24,203' E
AL565_26-2	GRAB	2021-09-27 13:25:33	in the water	54° 10,868' N	011° 24,201' E
AL565_26-2	GRAB	2021-09-27 13:27:17	on deck	54° 10,866' N	011° 24,201' E
AL565_27-1	MB	2021-09-27 14:12:30	profile start	54° 09,400' N	011° 20,378' E
AL565_27-1	MB	2021-09-27 17:20:21	profile end	54° 10,432' N	011° 25,470' E
AL565_28-1	CTD water	2021-09-27 17:24:29	in the water	54° 10,400' N	011° 25,707' E
AL565_28-1	CTD water	2021-09-27 17:28:20	on deck	54° 10,384' N	011° 25,734' E
AL565_29-1	MB	2021-09-27 17:39:06	profile start	54° 10,515' N	011° 26,909' E
AL565_29-1	MB	2021-09-28 07:53:51	profile end	54° 10,536' N	011° 30,664' E
AL565_30-1	ROV	2021-09-28 08:05:26	in the water	54° 10,530' N	011° 30,483' E
AL565_30-1	ROV	2021-09-28 08:27:52	on deck	54° 10,541' N	011° 30,473' E
AL565_31-1	MB	2021-09-28 08:35:40	profile start	54° 10,541' N	011° 30,637' E
AL565_31-1	MB	2021-09-28 11:26:09	profile end	54° 09,970' N	011° 27,793' E
AL565_32-1	CTD water	2021-09-28 11:40:15	in the water	54° 10,501' N	011° 28,335' E
AL565_32-1	CTD water	2021-09-28 11:43:07	on deck	54° 10,497' N	011° 28,341' E
AL565_32-2	GRAB	2021-09-28 11:48:16	in the water	54° 10,492' N	011° 28,350' E
AL565_32-2	GRAB	2021-09-28 11:50:00	on deck	54° 10,493' N	011° 28,347' E
AL565_33-1	GRAB	2021-09-28 12:01:58	in the water	54° 10,661' N	011° 29,222' E

AL565_33-1	GRAB	2021-09-28 12:03:41	on deck	54° 10,660' N	011° 29,229' E
AL565_34-1	GRAB	2021-09-28 12:14:58	in the water	54° 10,315' N	011° 28,779' E
AL565_34-1	GRAB	2021-09-28 12:16:31	on deck	54° 10,309' N	011° 28,781' E
AL565_35-1	GRAB	2021-09-28 12:33:25	in the water	54° 10,675' N	011° 30,221' E
AL565_35-1	GRAB	2021-09-28 12:34:44	on deck	54° 10,671' N	011° 30,224' E
AL565_35-2	GRAB	2021-09-28 12:35:47	in the water	54° 10,667' N	011° 30,226' E
AL565_35-2	GRAB	2021-09-28 12:37:04	on deck	54° 10,666' N	011° 30,223' E
AL565_36-1	GRAB	2021-09-28 12:45:23	in the water	54° 10,610' N	011° 30,563' E
AL565_36-1	GRAB	2021-09-28 12:46:42	on deck	54° 10,610' N	011° 30,570' E
AL565_37-1	GRAB	2021-09-28 12:55:25	in the water	54° 10,653' N	011° 30,746' E
AL565_37-1	GRAB	2021-09-28 12:56:57	on deck	54° 10,651' N	011° 30,753' E
AL565_38-1	GRAB	2021-09-28 13:05:38	in the water	54° 10,754' N	011° 30,970' E
AL565_38-1	GRAB	2021-09-28 13:07:12	on deck	54° 10,753' N	011° 30,977' E
AL565_39-1	CTD water	2021-09-28 16:00:52	in the water	54° 33,892' N	011° 07,638' E
AL565_39-1	CTD water	2021-09-28 16:03:54	on deck	54° 33,890' N	011° 07,662' E
AL565_40-1	MB	2021-09-28 16:24:58	profile start	54° 34,287' N	011° 05,883' E
AL565_40-1	MB	2021-09-29 13:39:59	profile end	54° 34,559' N	011° 02,531' E
AL565_41-1	CTD water	2021-09-29 13:56:13	in the water	54° 35,056' N	011° 01,422' E
AL565_41-1	CTD water	2021-09-29 13:59:52	on deck	54° 35,056' N	011° 01,427' E
AL565_42-1	EK60	2021-09-29 17:04:32	profile start	54° 33,542' N	010° 12,063' E
AL565_42-1	EK60	2021-09-30 01:54:37	profile end	54° 33,714' N	010° 12,715' E

7 Data and Sample Storage and Availability

All data and samples collected during the cruise will be stored and archived at Kiel University. Contact person is Sebastian Krastel (Sebastian.krastel@ifg.uni-kiel.de).

8 **Acknowledgements** (all students)

We would like to thank the Captain of the ALKOR Jan Peter Lass and his officers for safely navigating us to our destinations. Also, we want to thank the rest of the crew for their friendly support and instructions. Especially, we appreciated the delicious food and want to thank Stefan for the excellent job he did. Applying geophysical methods was interesting and fascinating. It was a great opportunity to learn about doing research. All of us had a lot of fun and got some inspiration for our future ways. Thanks to Jacob, Phillip and Jasper, who made this great experience possible.

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10 Appendices

10.1 Selected Pictures of Van Veen Grab Samples (Luisa Rollwage)

Grab01

Date: 2021/09/26

Time: 08:41

Position: Mittelgrund Eckernförde

Coordinates: 54°31,124‘N, 010°04,329‘E

Filling quantity: 60-70% filled with material

Material: lighter sand above, darker sand below, coarse stones

Grain Size: medium to coarse-grained (sand)

Sorting: heterogenous

Smell: conchoidal

Biogenic material: shells, algae growth on stones




Grab02

Date: 2021/09/26

Time: 08:56

Position: Mittelgrund Eckernförde

Coordinates: 54°31,535'N, 010°04,434'E

Filling quantity: 100% filled with material

Material: black silt

Grain size: fine matrix, sporadic coarse grains

Sorting: relative homogenous

Smell: H_2S

Biogenic material: some algaes

Grab03

Date: 2021/09/26

Time: 09:11

Position: Mittelgrund Eckernförde

Coordinates: 54°31,353’N, 010°05,516‘E

Filling quantity: 50% material, 50% water

Material: lighter and darker sand

Grain size: medium to coarse sand, some fine sand

Sorting: heterogeneous

Smell: H_2S

Biogenic material: mussels and fracture pieces of mussels



Grab04

Date: 2021/09/26

Time: 09:22

Position: Mittelgrund Eckernförde

Coordinates: 54°31,573’N, 010°05,511‘E

Filling quantity: 100% filled with material, partly water

Material: non formable silt, fine sand in the middle

Grain size: very fine

Sorting: relatively homogeneous

Smell: H_2S

Biogenic material: mussels and fracture pieces of mussels

Grab05

Date: 2021/09/26

Time: 09:34

Position: Mittelgrund Eckernförde

Coordinates: 54°31,708‘N, 010°05,970‘E

Filling quantity: 100% filled with material

Material: formable/sticky silt (brighter than silt from „Grab03“) solid core in the middle, stones

Grain size: very fine silt and sand

Sorting: relatively homogeneous, but some stones

Smell: H_2S

Biogenic material: fracture pieces of mussels

Grab06

Date: 2021/09/27

Time: 14:20

Position: Mecklenburger Bucht

Coordinates: 54°11,108’N, 011°23,951‘E

Filling quantity: 100% filled with material

Material: very dark silt

Grain size: very fine

Sorting: homogenous

Smell: H_2S

Biogenic material: many mussels

Grab07

Date: 2021/09/27

Time: 14:41

Position: Mecklenburger Bucht

Coordinates: 54°10,326'N, 011°22,140'E

Filling quantity: not entirely full, grab not closed while lifting

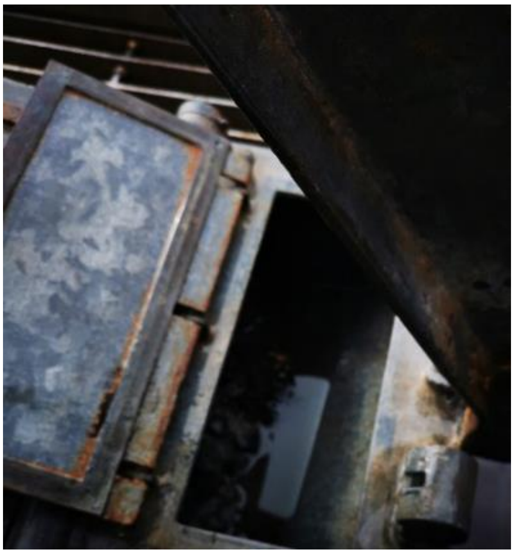
Material: sand, stones

Grain size: middle to coarse-grained (sand), coarse (Stones)

Sorting: heterogeneous

Smell: no

Biogenic material: no



Grab08

Date: 2021/09/27

Time: 15:05

Position: Mecklenburger Bucht

Coordinates: 54°10,973’N, 011°24,011‘E

Filling quantity: almost empty

Material: some grains of sand

Grain size: fine

Sorting: homogeneous

Smell: no

Biogenic material: no

Grab09

Date: 2021/09/27

Time: 15:09

Position: Mecklenburger Bucht

Coordinates: 54°10,971'N, 011°24,018'E

Filling quantity:

Material: solid sand, stones

Grain size: medium grained sand, coarse stones

Sorting: heterogeneous

Smell: no

Biogenic material: mussels, algaes and stones

Grab10

Date: 2021/09/27

Time: 15:19

Position: Mecklenburger Bucht

Coordinates: 54°10,871’N, 011°24,202‘E

Filling quantity: half full

Material: clay

Grain size: very fine

Sorting: homogeneous

Smell: clayey

Biogenic material: some mussels

Grab11

Date: 2021/09/27

Time: 15:27

Position: Mecklenburger Bucht

Coordinates: 54°10862’N, 011°24,205’E

Filling quantity: full

Material: stones, clay

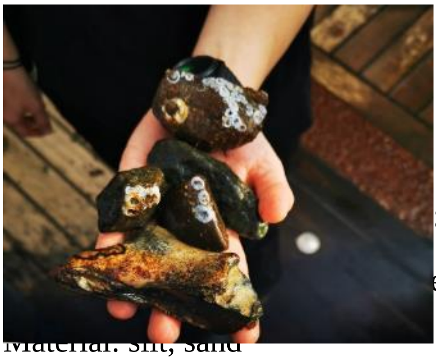
Grain size: stones (big and medium), clay (fine)

Sorting: heterogeneous

Smell: clay

Biogenic material: mussels

Grab 12



Material: silt, sand

Grab 13

Date: 2021/09/28

Time: 14:02

Position: Blinkerhügel

Coordinates: 54°10,657‘N, 011°29,225‘E

Filling quantity: 100% filled

Material: silt

Grain Size: silt

Sorting: homogenous

Smell: H_2S

Biogenic material: -

Grab 14

Date: 2021/09/28

Time: 14:15

Position: Blinkerhügel

Coordinates: 54°10,308‘N, 011°28,7800‘E

Filling quantity: 40% filled, grab not closed

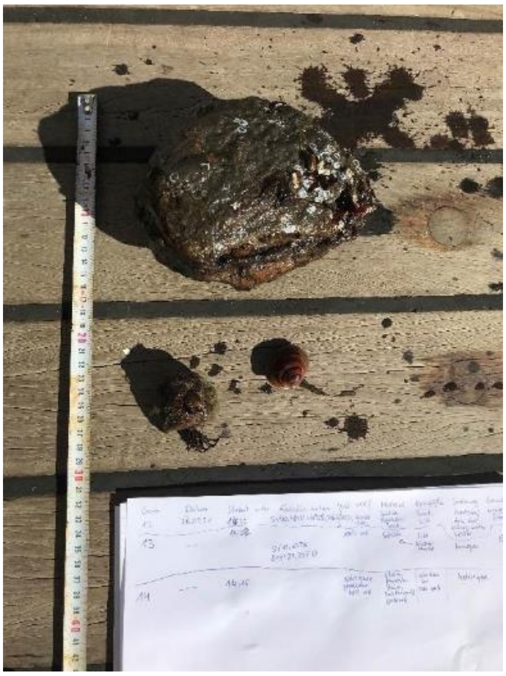
Material: silt, stones (Mangan?), coarse sand

Grain Size: very fine (silt) to very coarse (stones)

Sorting: heterogenous

Smell: -

Biogenic material: mussels



Grab 15.1

Date: 2021/09/28

Time: 14:34

Position: Blinkerhügel

Coordinates: 54°10,671‘N, 011°30,2220‘E

Filling quantity: almost empty

Material: -

Grain Size: silt

Sorting:-

Smell: -

Biogenic material: mussels

Grab 15.2

Date: 2021/09/28

Time: 14:35

Position: Blinkerhügel

Coordinates: 54°10,662‘N, 011°30,223‘E

Filling quantity: almost empty

Material: -

Grain Size: -

Sorting: -

Smell: -

Biogenic material: mussels

Grab 16

Date: 2021/09/28

Time: 14:45

Position: Blinkerhügel

Coordinates: 54°10,604‘N, 011°30,566‘E

Filling quantity: 100% filled, water on top

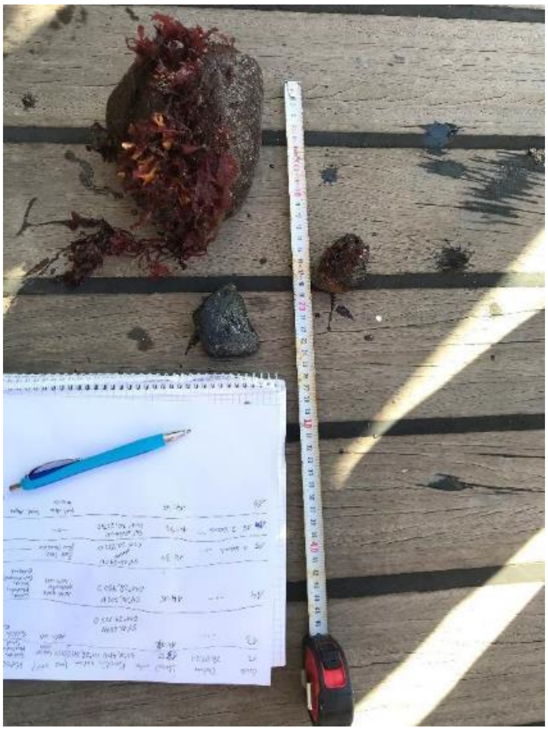
Material: sand, stones

Grain Size: coarse sand, middle to coarse sand, big stones

Sorting: heterogenous

Smell: -

Biogenic material: algaes



Grab 17

Date: 2021/09/28

Time: 14:55

Position: Blinkerhügel

Coordinates: 54°10,646‘N, 011°30,740‘E

Filling quantity: 70% filled with material, water on top

Material: stones

Grain Size: coarse sand, stones

Sorting: heterogenous

Smell: algaes

Biogenic material: algaes, mussels

Grab 18

Date: 2021/09/28

Time: 15:06

Position: Blinkerhügel

Coordinates: 54°10,750‘N, 011°30,974‘E

Filling quantity: 50% filled, plenty water

Material: coarse sand (on top), medium grained sand (middle), fine sand (bottom), stones and mussels (everywhere)

Grain Size: fine to coarse

Sorting: homogenous

Smell: -

Biogenic material: mussels