ALKOR – Reports

Mine Monitoring in the German Baltic Sea 2022;

AL583

18th – 31st October 2022,
Kiel (Germany) – Kiel (Germany)
„MineMoni-IV 2022“

Boost **A**pplied munition detection through
Smart data in**T**egration and **AI** workflows

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1. Cruise Summary

1.1 Summary

ALKOR cruise AL583 took place as part of the EMFF (European Maritime and Fisheries Fund)-funded projects BASTA (**B**oost **A**pplied munition detection through **S**mart data detection in and **A**I workflows; https://www.basta-munition.eu) and ExPloTect (**Ex**-situ, near-real-time detection compound detection in seawater) (also EMFF-funded). It was the continuation of the munition monitoring started within the BMBF-funded project UDEMM (Environmental Monitoring for the Delaboration of Munition in the Sea; https://udemm.geomar.de/) and is already part of the new project CONMAR (https://conmar-munition.eu/) as part of the DAM mission sustainMare (https://www.sustainmare.de/). Additional sampling supported chemical analysis method development within the MarTERA project AMMOTRACe (Marine AMMunitiOn dump site exploration by surface- and underwater-based laser mass spectrometric TRACing technology; https://www.geomar.de/en/ammotrace).

The original plan was to first work for one week in the North Sea and have a crew change after one week in Kiel and continue working in the Baltic Sea. This plan changed; ALKOR worked instead in Baltic Sea in support of for the Federal Public Prosecutor General and the Federal Police during the first week. The change of crew happened on 18th October in Kiel and the original Baltic Sea cruise was conducted as planned.

1.2 Zusammenfassung

Die ALKOR-Fahrt AL583 fand im Rahmen der vom EMFF (European Maritime and Fisheries Fund) finanzierten Projekts BASTA (**B**oost **A**pplied munition detection through **S**mart data detection in and **A**I workflows; https://www.basta-munition.eu) und ExPloTect (**Ex**-situ, near-real-time detection compound detection in seawater) statt. Es war auch die Fortsetzung der Munitionsüberwachung, die im Rahmen des BMBF-geförderten Projekts UDEMM (Environmental Monitoring for the Delaboration of Munition in the Sea; https://udemm.geomar.de/) begonnen wurde und ist bereits Teil des neuen Projekts CONMAR (https://conmar-munition.eu/) das eines von fünf Verbundprojekten der DAM-Mission sustainMare ist (https://www.sustainmare.de/). Weiter konnte die Beprobung von sprengstofftypischen Verbindungen durch die im AMMOTRACe entwickelten Methoden und Geräte verbessert werden (Marine AMMunitiOn dump site exploration by surface- and underwater-based laser mass spectrometric TRACing technology; https://www.geomar.de/en/ammotrace).

Ursprünglich war geplant, zunächst eine Woche in der Nordsee zu forschen und nach einer Woche in Kiel einen Besatzungswechsel vorzunehmen und in der Ostsee weiterzuarbeiten. Dieser Plan wurde geändert; ALKOR arbeitete stattdessen in der ersten Woche in der Ostsee zur Unterstützung des Generalbundesanwalts und der Bundespolizei. Der Besatzungswechsel fand am 18. Oktober in Kiel statt und die ursprüngliche Ostseereise wurde wie geplant durchgeführt.

2 Participants

2.1 Principal Investigators

Table 1: Principal investigators of AL567.

Name	Institution
Beck, Aaron J., Dr.	GEOMAR
Greinert, Jens, Prof.	GEOMAR
Vedenin, Andrej, Dr.	Senckenberg

2.2 Scientific Party

Table 2: Scientific party of AL583-2.

Name	Discipline	Institution
Greinert, Jens	Marine Geology / Chief Scientist	GEOMAR
Kampmeier, Mareike	Marine Geology / Senior Scientist	GEOMAR
Seidel, Marc A.	Marine Geophysicist; Magnetic	GEOMAR
von See, Benedikt	AUV Robotic	GEOMAR
Vedenin, Andry	Biology/Ecology	Senckenberg
Henkel, Daniela	Biology/Ecology	GEOMAR
Weiß, Tim	Data Management, Technical Support	GEOMAR
Mohrmann, Jochen	Photogrammetry	GEOMAR
Beck, Aaron J.	Marine Geochemistry	GEOMAR
Arinaitwe, Kenneth	Marine Geochemistry	GEOMAR
Raupers, Björn	Marine Geochemistry	GEOMAR
Diller, Nikolaj	AUV Team	GEOMAR
Reißmann, Sylvia	AUV Team	GEOMAR

2.3 Participating Institutions

GEOMAR GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel Germany
Senckenberg Senckenberg am Meer, Wilhelsmhaven, Germany

3 Research Program

3.1 Aims of the Cruise

- Continuation of spatial mapping of munition dumpsites outside of official borders to identify the extent of contamination
- Ground truthing of potential munition objects with visual means (AUV) und magnetic (AUV)
- Water sampling for munition compound determination
- Biological sampling in munition dumpsites

3.2 Agenda of the Cruise

The 1st half of the cruise from 18. to 23. October 2023 was dedicated for investigations at the Swedish Nord Stream leakages in cooperation with the German Federal Police (Figure 1). The 2nd half of the cruise followed a similar track as the cruise AL567 one year before. A short MBES mapping survey was conducted in the restricted area of Schönhagen where later the year the German Navy, also in cooperation with GEOMAR, planned to perform dedicated detonation of German sea mines with and with a double bubble curtain. The idea was to map the seafloor before and after the detonations. Leaving Schönhagen the cruise continued in Lübeck Bay, taking CTDs for water sampling on the track. In Lübeck Bay we got visitors from the EID Service of SH and the CEO of SeaTerra GmbH on 26th October. Leaving Lübeck Bay the same CTD stations as during AL567 were taken as far as east of Rostock and into the Flensburger Förde.

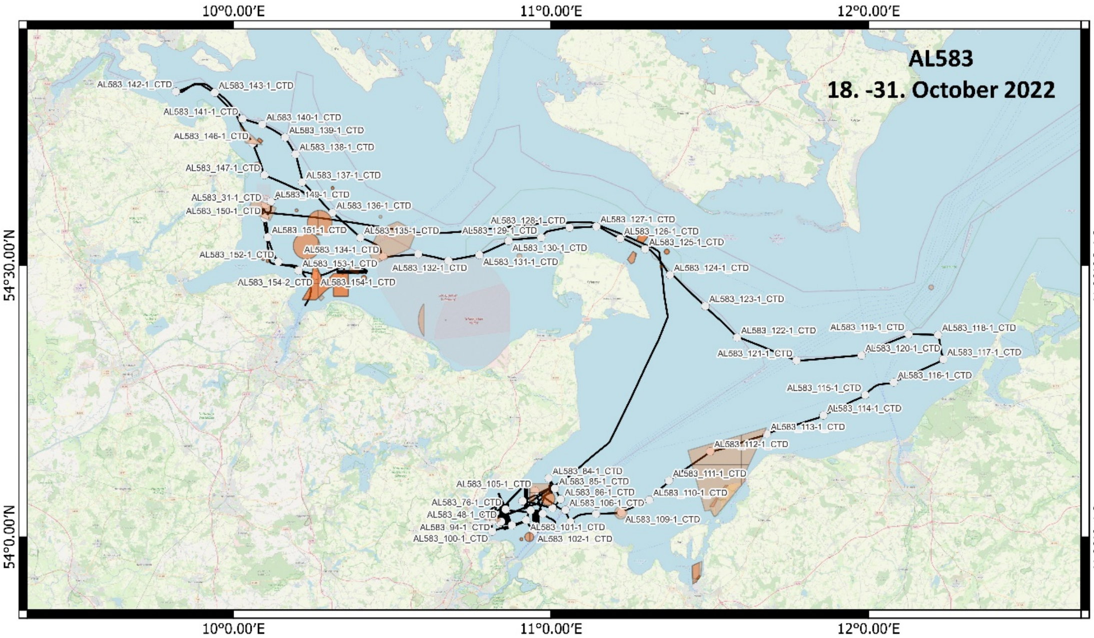

Figure 1: Overall cruise track of the 2nd Leg of AL583 in 2023. Indicated are the CTD locations during the track, as well as munition contaminated areas (data source BSH).

Table 3: Cruise agenda and deployed scientific equipment.

Area	Date	Scientific Program
Swedish waters	18. – 23.10.2022	Kiel - Kiel
Schönhagen	24.10.2022	MBES, CTD
Transit to Lübeck Bay	24.10.2022	CTD
Lübeck Bay	24.10.2022	CTD, MBES, AUV, VV-Grab, Mini-MUC
Transit towards Rostock	29.10.2022	CTD
Transit to Flensburger Förde	29. – 30.10.2022	CTD, AUV
Transit to Kolberger Heide	30.10.2022	CTD
Kolberger Heide	30. – 31.10.2022	MBES

4 Methods and devices

4.1 Acoustic seafloor mapping via ship based multibeam

High resolution mapping had been executed in the dumpsites Kolberger Heide and Lübeck Bay on previous cruises: POS530, L13-20, AL548 and AL567. On AL583 existing data was amended with additional mapping to find the borders of contaminated areas, which might not be congruent with their extensions on nautical charts. Working areas are generally required to be deeper than 10 m, in order to be able to operate RV ALKOR. A RESON T51 multibeam echo sounder was rented from MacArtney Germany and installed in the ship's moon pool. RTK correction for the GPS position was provided via GSM NTRIP (AxioNet). Motion compensation was provided by an SBG Apogee-U INS system (installed on a fixed mounting plate near the moon pool). Sound speed profiles were collected using a Valeport Swift SVP profiler. GPS and RTK data were controlled via the Septentrio AsteRx-U Marine Full Multi-Frequency (GPS, GLONASS, Galileo, Beidou) GNSS receiver. The two Septentrio GNSS antennas were mounted on the monkey deck orthogonally to the vessel length at a distance of 2 m to each other (Figure 2). Since the mounting places are fixed and precisely measured, the offsets are static and the same as the previous cruises.

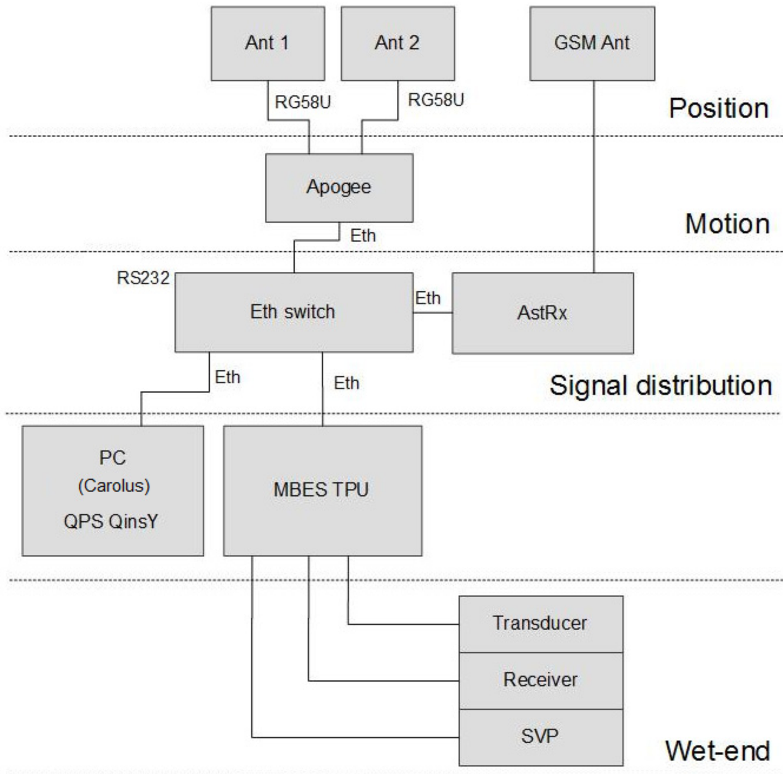

Figure 2: System overview of RESON T50 MBES system used on AL548.

Data acquisition was done with the software QPS QINSy (in UTM32) and processing with QPS Qimera and QPS FMGT to derive multibeam and backscatter information, which was further processed with the geoinformation software SAGA and QGIS. The publicly available Baltic Sea bathymetric data set Emodnet was used for survey planning. The time needed to complete each survey was based on a 3.5 kn survey speed. This guarantees dense soundings in the along-track direction. Profile spacing had to be chosen as densely as possible, but also in a way that it could be navigated by the vessel crew. Therefore, the spacing had to be 20 m minimum, which did not always lead to the targeted 50 % overlap (depending on the water depth). Multibeam data were cleaned and gridded to 0.25 cm raster and loaded into the QGIS project for initial contact picking as part of the workflow for munition site investigation (Figure 3).

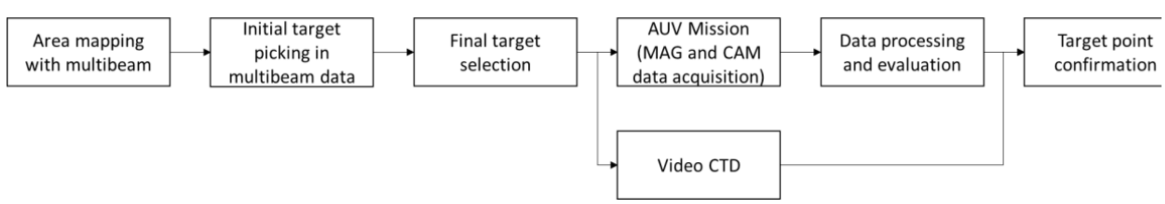

Figure 3: Workflow for munition site investigation.

4.3 Detailed optical and magnetic mapping with AUV

ANTON and LUISE are reconfigurable autonomous underwater vehicles (AUV) of the type Girona 500. They are designed for a maximum operating depth of up to 500m. The vehicles are composed of an aluminium frame, which supports three torpedo-shaped hulls of 0.3m in diameter and 1.5m in length as well as other elements like the thrusters. This design offers a good hydrodynamic performance as long as the space in between is not too occupied with additional payload. Nevertheless, it also offers a large space for housing the equipment while maintaining a compact size, which allows operating the vehicle from small boats.

The overall dimensions of the vehicle are 1m in height, 1m in width, 1.5m in length and a weight of less than 200kg. The two upper hulls, which contain the flotation foam and the electronics housing, are positively buoyant, while the lower one contains the heavier elements such as the batteries and the payload. This particular arrangement of the components makes the separation between the centre of gravity and the centre of buoyancy about 11 cm, which is significantly more than any typical torpedo shape design. This provides the vehicle with passive stability in pitch and roll even at low speeds, making it suitable for imaging surveys. One characteristic of the Girona 500 is its capability to reconfigure for different tasks.

The COLA2 infrastructure on those AUVs is the central control software, developed by IQUA Robotics (Girona, Spain). The communication under and above water is controlled by BELUGA. This marine command and control software is developed by the AUV group of GEOMAR. It also includes the USBL (Ultrashort Baseline) positioning. The belonging transducer/modem is mounted on the ship and is part of the BELUGA ad hoc network.

Besides the navigational sensors like INS (Inertial Navigation System), DVL (Doppler Velocity Log), Pressure Sensor, USBL and GPS it has a CTD (Conductivity, Temperature, Depth) type Seabird FastCAT SBE49 mounted by default. As one optional payload a CoraMo mk II Camera (GEOMAR), is mounted on both vehicles. This down- or forward-looking camera system for photographic surveys can take up to two images per second with a resolution of 12.34MP. CoraMo supports connections for eight high power LEDs. There are several other payload sensors available like a DeltaT multibeam or a magnetometer. During AL567 AUV LUISE was equipped with Sensys magnetometers as standard configuration (Table 4). Missions can have a duration of up to 9 hours and a total length of about 10 kilometres, depending on settings, payload and environmental conditions like currents. The maximum speed is 1m/s while the minimum speed is not limited, even hovering at one point for an arbitrary amount of time is possible.

Table 4: Overview of the AUV-based sensors for navigation and payload.

System	Device	Description
Navigation	INS: iXblue Phins Combat C3	The internal navigation unit that processes sensor data and provides position information. The error of this INS is in range of 0.15° for heading and 0.05° for roll and pitch. This leads to a 0.3% DT position accuracy
	DVL: Teledyne RDI Explorer 600kHz	This device measures the velocity relative to the sea floor and its altitude.
	Pressure sensor: Valeport ultraP	This sensor measures the pressure and converts it to water depth.
	USBL: Evologics S2CR 18/34	The Evologics S2CR 18/34 modem combines underwater communications and positioning.
	GPS: Quectel l86 GNSS module	The GPS is used to determine the absolute position at the surface.

Payload	CTD: Sea-Bird SBE 49 FastCAT	This measurement device acquires the conductivity, temperature and the pressure of the surrounding water and calculates the sound velocity. A csv file with the data is produced for each mission and can be found in the missions “exports” directory. Each line contains a timestamp in UTC, the position (latitude and longitude as decimal degrees) and the CTD data itself: pressure [dBar], salinity [psu], temperature [°C], conductivity [S/m] and sound velocity [m/s].
	Camera: CoraMo mk II Camera	The images and the corresponding metadata can be found in the missions “pictures” directory. The camera has an number of parameters that can be set for every dive. For each image a csv file containing information about parameter settings of the camera and the CoraMo system in total as well as navigational and environmental information (e.g. position and temperature) from the time the image was taken is written. It has the same name as the corresponding image. Additionally, one combining file containing each single csv files data line is created after a dive (images_metadata.csv) and can also be found in the pictures directory. Depending on the settings, a second file with metadata (metadata_information.csv) is written during the dive. It contains some information about camera and system parameters and focuses more on the information needed to build mosaics from the images like position, rotation and general information about the camera equipment.
	Magnetometer: Sensys MX3D UW	This system consists of up to five single magnetometers connected to one data acquisition unit. In the currently used configuration, three magnetometers are mounted in a triangular gradiometer configuration about two meters ahead of the AUV. Each magnetometer is sampling three dimensions with a rate of 200 Hz. The data is saved to the mission bag and can be extracted to a csv file, together with the navigation data of the AUV.
	Oxygen Optode: Aanderaa Optode 4330	AUV LUISE is able to carry an additional oxygen optode and collect its data. The optode used has been borrowed from the ARCHES Project (Sascha Flögel) for this cruise by the DSM group. The device provides dissolved oxygen [µM], relative air saturation [%] and ambient temperature [°C], as well as the raw data the final sensor values are based on.

4.2 AUV-based magnetometer measurements

The vast majority of munition objects contain significant quantities of ferromagnetic materials and are therefore detectable by magnetic sensors. In the field of systematic munition detection, the operation of AUVs can generally assist in improving precision and reliability of the acquired magnetic data. Here, the utilized magnetic sensors are FGM3D/100 UW II 3-axis fluxgate magnetometers from SENSYS GmbH, integrated into GEOMAR’s Girona 500 AUV LUISE. The magnetometers are attached to the AUV via an aluminium arm, which allows for a maximum distance of up to 2 m between the sensors and the nose of the AUV. Since the main thrusters of the AUV, which are considered to be the primary source of electromagnetic noise, are located in the back of the AUV, the distance of the sensors to the main thrusters is up to 3 m.

Arranging the sensors in the shape of a vertical triangle perpendicular to the direction of travel allows for the measurements of all three spatial magnetic gradients. In the triangle, the two lower sensors act as a horizontal gradiometer (first gradient) while the third magnetometer is located above, to act as the upper sensor of a vertical gradiometer (second gradient). The third gradient, is obtained by comparing acquired values while moving forward. The magnetometers are sampling at frequencies of up to 200 Hz.

Operational flight altitudes of the new system vary between 1 and 2 m. The surveys are usually conducted at velocities around 0.4 m/s. A camera system including illumination is also attached to the AUV for ground-truthing purposes. With the current solution, noise floors as low as 2 to 3 nT can be achieved. Figure 4 shows AUV LUISE carrying the magnetometer construction and a camera system.

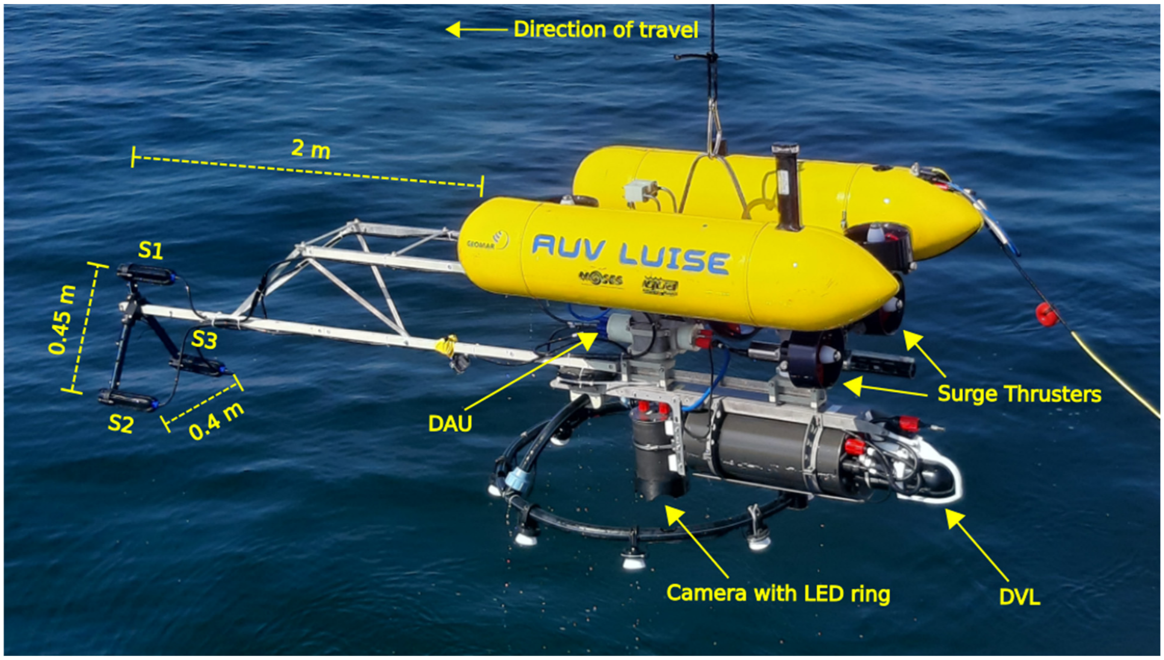

Figure 4: GEOMAR's Girona 500 AUV LUISE with submersible magnetometers and camera system

4.3 SMART AUV missions

Usually, AUVs are autonomously conducting pre-programmed missions, which have been designed by the AUV operating crew beforehand. In order to enhance UXO detection capabilities and to reduce the overall mapping time of the Girona500 AUVs, the first version of “smart” backseat-driver (BSD) was developed and successfully tested. The BSD is an AUV working mode in which arbitrary AUV missions or navigation vectors can be generated by autonomous algorithms and go beyond the classical lawn-mover patterns. It can be triggered during the pre-planned mission e.g. at certain waypoints but also by in-situ recorded, environmental data such as magnetic anomalies. If the trigger condition is met, the pre-planned mission is paused and the BSD takes over. When the BSD finished operation, the pre-planned mission is resumed. In the future, this will allow to perform sparse surveys in which dense search patterns are performed only in specific regions of interest. Doing so, larger areas can be covered without missing features in shorter times. Furthermore, this is a step towards a higher degree of autonomy of the vehicles as this working mode allows to react to sensor data in (near) real time.

4.4 Water sampling and pre-concentrating of water for munition compound analyses

Water samples were collected to determine the spatial distribution of munition compounds (MCs) in the water column of the Baltic Sea (Figure 5). The samples will be used to monitor the spread of MCs along the German coastline (in the context of the CONMAR project) and to validate existing and newly developed sample processing methods (within the AMMOTRACe project). Samples were collected from 62 sampling points for spatial and depth profiling of the targeted MCs in the water column. Samples were collected from the CTD-Niskin rosette (Figure 6; top left image) at three depths, namely, deep or bottom (about 1-2 m above sediment), mid-depth in the water column, and near-surface (about 1.5 m below surface). Deep and near-surface samples were taken in duplicate. All samples were spiked with internal standard to account for losses during the storage or sample processing. Solid phase extraction (SPE) cartridges were used to extract MCs from the water samples, kept frozen and brought back to GEOMAR for further processing. About 50% of the samples were filtered prior to extraction onto SPE cartridges. The filters were also kept frozen, to be processed and analysed later to facilitate investigation of partitioning of MCs between water and suspended particles.

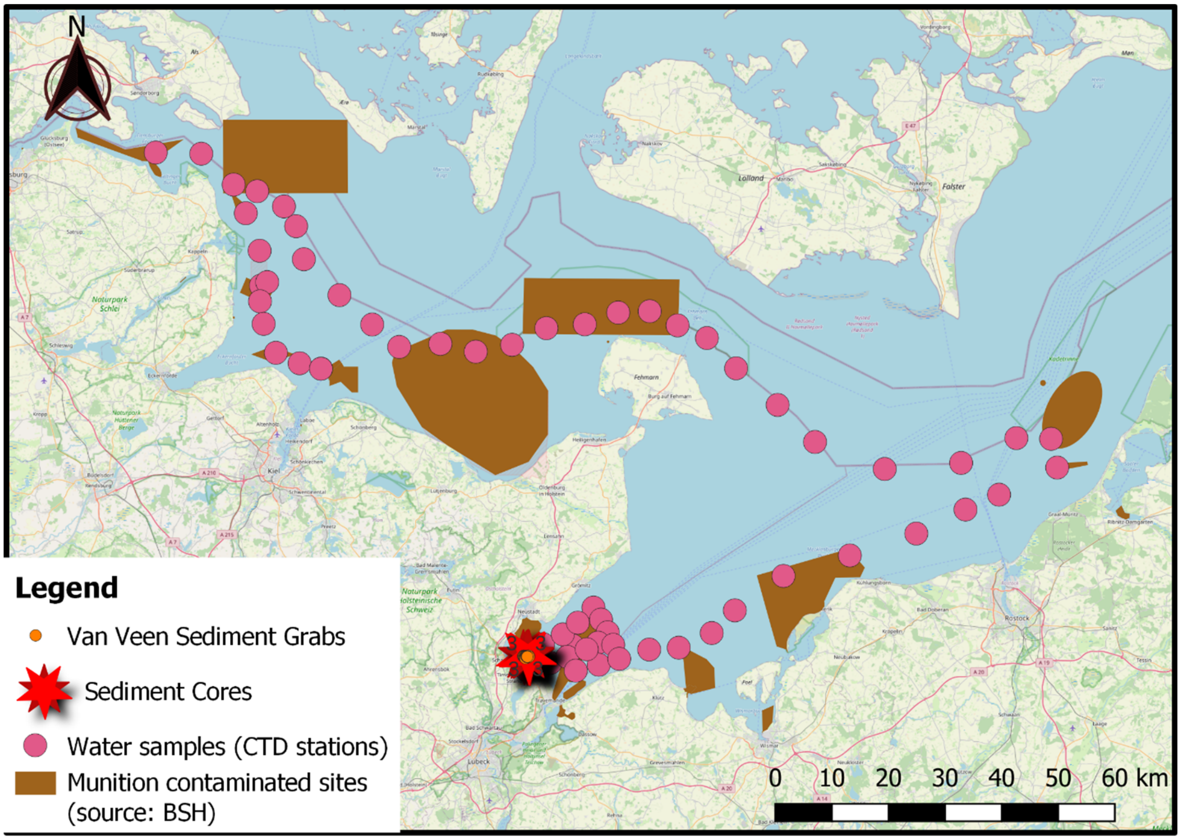

Figure 5. Map of Sampling sites for sediment and water samples collected during AL583 cruise for munition compound analysis.

Figure 6. Water and sediment sampling activities during the AL583 cruise

4.5 Sediment sampling for munition compound analyses

Surface sediment samples (34 Van Veen Grabs) were collected with a Van Veen-type grab sampler for spatial profiling of MCs. The surface sediments were collected in tandem with the sampling of biological communities in sediment in order to enable supportive MC analysis. Additional 5 sediment cores were collected from Lübeck Bay (Haffkrug) for the investigation of sediment-pore water partitioning of the MCs in the sediment column. Porewater samples were collected at 1 and 2 cm intervals down the sediment core. The cores were sliced for profiling levels of MCs in the sediment column. Both pore water and sediment slices were stored frozen and brought back to GEOMAR for further processing and analysis.

4.6 Munition compound degradation experiment

A degradation experiment was carried out at room temperature (about 21°C) during the cruise. Duplicate 2.5 L whole water samples (taken at station location AL583_031_CTD_006 from a depth of 2 meters below surface) were spiked with 50 ng of RDX, DNB and TNT (final concentration 20 ng/L), and sub-sampled daily over a 10-day period to monitor the MC degradation rate. Subsamples (200 mL) were collected at each time point, extracted onto SPE columns, and brought back to GEOMAR for further processing and analysis.

4.7 Macrofauna sampling with VanVeen Grab

The samples for macrofaunal analysis were sieved through 1-mm mesh size using a washing-machine with several cross-oriented water jets, capable of milling dense mud sediment (Figure 77) and fixed with 4% formaldehyde buffered with hexamethylentetramin. Further in the laboratory all the macrobenthic taxa will be identified, calculated and weighted to collect raw data on the macrofauna. Samples for the sediment analysis were taken for further grain-size analysis. Specifically, small amount of sediment (~200 g) was taken from each sediment grab, packed in zip-bags and frozen. The data on the grain size will be collected in the laboratory.

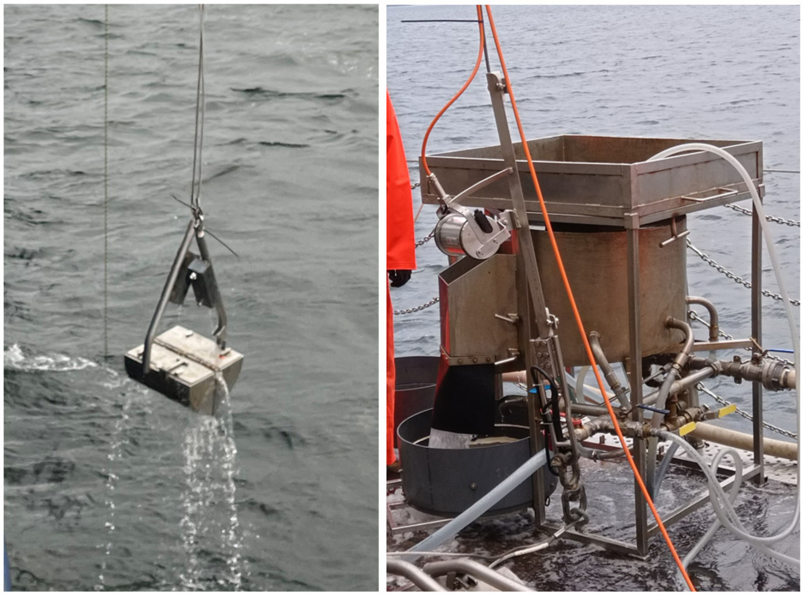

Figure 7: VanVeen Grab sampling. Left – 0.1 m^2 van-Veen grab sample taken out of water; right – washing the sample through the washing machine to the sieve. The grab was live-video-guided with an OCTOPUS camera from GEOMAR.

5 Description of the Work Areas

In total of four work areas were investigated and during transits water samples were taken as repetition of previous sampling during AL567. Two maps show the working areas in Kiel Bay (Figure 8) and Lübeck Bay (Figure 9).

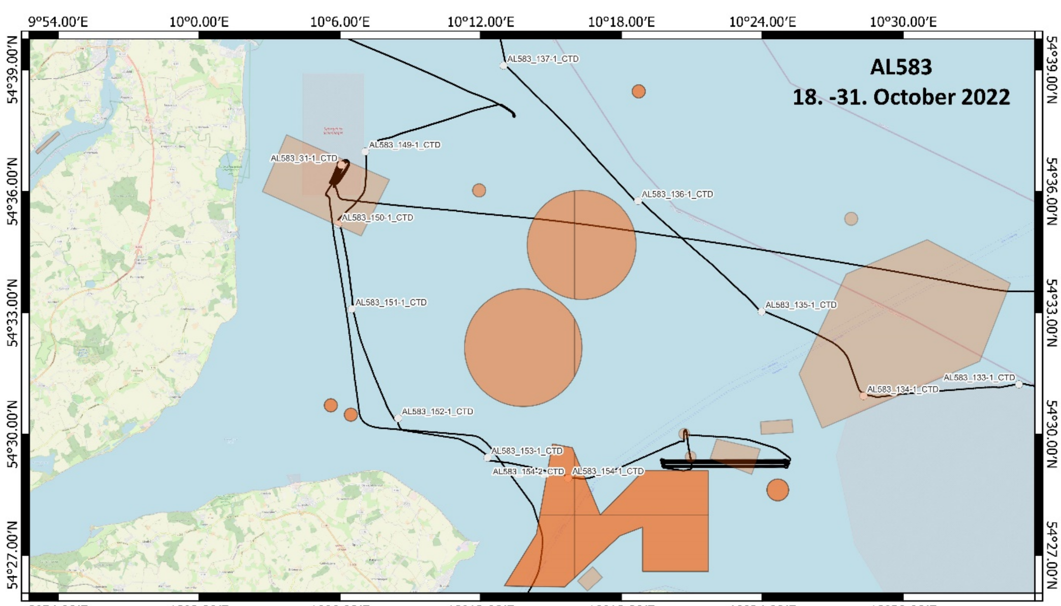

Figure 8: Cruise track of AL583 in the Kiel Bay area. White circles indicate water samples taken by CTD along the track.

Area 1 – Schönhagen – appr. 2.5 nm east of Schönhagen. This area is in use as a testing range area for military exercise. The seafloor of this area shall be mapped before blasting tests in November 2022 are performed.

Area 2 – Lübeck Bay Haffkrug: Inner Lübeck Bay, appr. 3.5 nm of Neustadt. This area was used as a munition dumpsite after WWII. All types of German as well as Allied munition were dumped here.

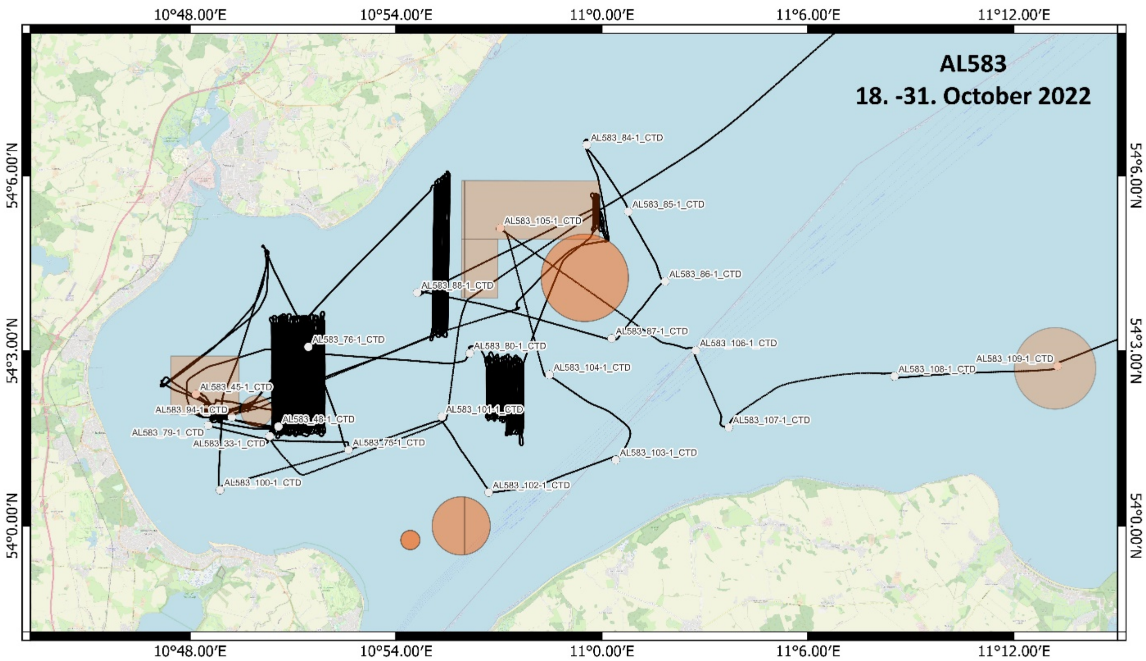

Figure 9: Cruise track of AL583 in the Lübeck Bay area. White circles indicate water samples taken by CTD along the track.

Area 3 – Lübeck Bay Pelzerhaken: Inner Lübeck Bay, appr. 3.4 nm of Pelzerhaken. It was used as munition dumpsite after WWII where various types of German as well as Allied munition were dumped. In 1971 heavy metal rich blast furnace slag and fly ash was dumped from a metal smelter, possibly covering up some of the munition (Leipe et al., 2017; Leipe et al., 2005).

Area 4 – Kolberger Heide: Kolberger Heide is a munition dumpsite where munition was dumped after WWII and munition is stored by the EOD squad of the state of Schleswig-Holstein. All types of munition are found in the area, such as ground mines, torpedoes, torpedo heads, naval mines, depth charges and grenades. The seafloor is characterized by glacial lag sediments, such as fine to medium sands partly mixed with gravel and rocks (Mareike Kampmeier et al., 2020).

6 Narrative of the Cruise

Leg I: 18th – 24th October 2022: The cruise started in the morning of 18th October. On board were scientist ad technicians from GEOMAR as well as members of the Bundeskriminalamt (Federal Criminal Police Office). Studies were performed at the Nord Stream leakages in Swedish waters. The cruise was very successful, unfortunately no data and other details can be presented.

Leg II: 24th – 31th October 2022: The work continued on 24th in the morning when sailing out to the Schönhagen area for a first multibeam survey. After that we continued to Lübeck Bay and took several CTDs on the way. We arrived in Lübeck Bay at about 1am on 25th and started multibeam mapping in Haffkrug. The next morning both AUVs ANTON and LUISE were deployed and during their missions, we started a VanVeen Grab sampling transect in Haffkrug. Until noon the 29th we worked in Lübeck Bay in the Haffkrug and Pelzerhaken area by swapping between AUV, VV-Grabs and CTDs during the day while mapping more of the seafloor during the night. The rest of the cruise was used to complete the CTD transect first towards Rostock and then into Flensburger Förde. Two short AUV missions around Falshöft were conducted to test the AUV backseat driver capacities before we headed back towards Kiel, spending the night from 30th to 31st mapping deeper areas in the North of Kolberger Heide. The cruise ended on 31st at 8:00 on the GEOMAR pier, east shore.

7 Preliminary Results

7.1 Area 1 – Schönhagen

The area of Schönhagen is a military testing site, which is used for blasting experiments. In order to monitor the seafloor seafloor mapping was performed prior to experiments in November 2022. The seafloor is composed of homogeneous sediments with a number of crater structures (Figure 10). It is not clear if they origin from blastings or buoy anchors.

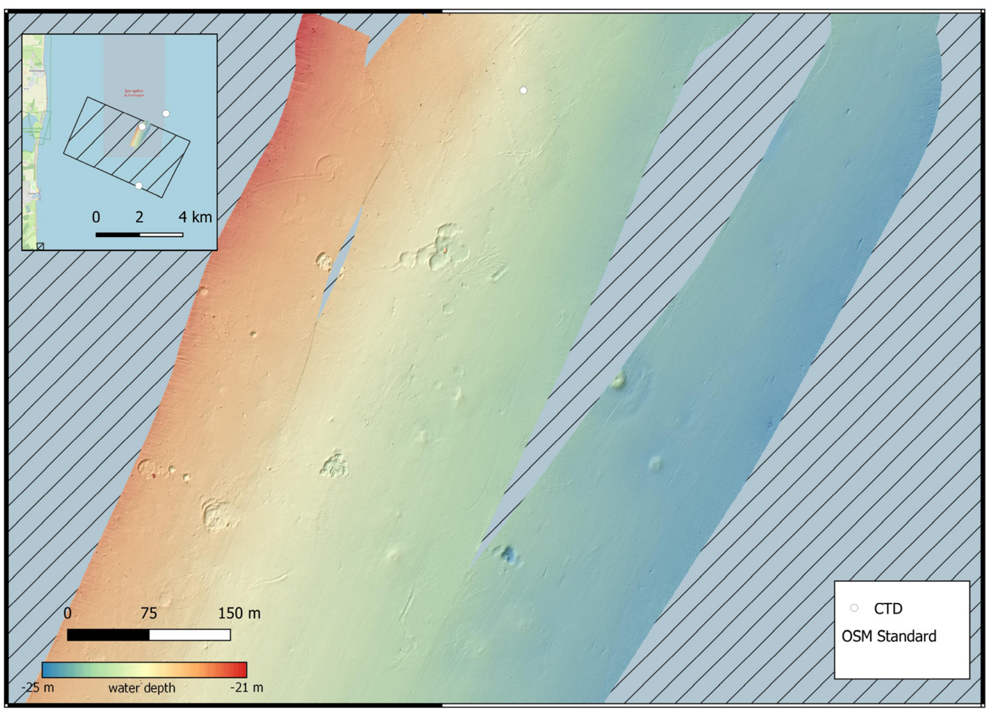

Figure 10: Mapped area during AL567 with multibeam, MUC and AUVs stations.

7.2 Area 2 – Haffkrug

In order to map the real extent of the munition dumpsite, mapping was continued towards the east of the official area (Figure 11). Thereby no potential munition piles were detected.

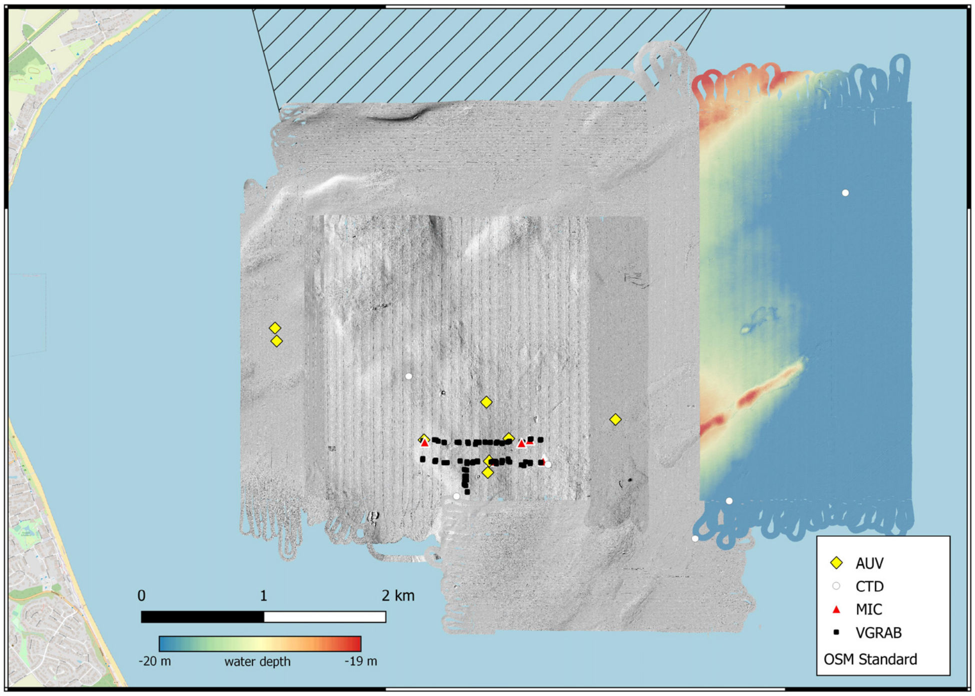

Figure 11: Mapped area in Haffkrug in Lübeck Bay during AL583 with CTD, AUV and VanVeen grab stations. The coloured multibeam data was acquired on AL583, the grey-shaded data was recorded on previous surveys.

MBES

The previously mapped area was extended towards the east. Shallow ridges are covered with rocks and form a contrast to the surrounding predominantly flat and homogenous seafloor. Fishing trawl marks witness from bottom fishing within the easterly part.

AUV

During the 2nd leg of the cruise, AUV LUISE conducted 4 regular missions in Lübeck Bay acquiring magnetic and photographic data. The covered area during each mission was relatively large compared to the missions of previous cruises (LUISE 248 (Station 35): 170 x 25 m²; LUISE 252 (Station 50): 140 x 28 m²; LUISE 258 (Station 78): 50 x 30 m²; LUISE 259 (Station 83): 80 x 54 m²). The first three missions (LUISE 248, 252 and 258) were conducted in the area of Haffkrug, only LUISE mission #259 took place near Pelzerhaken.

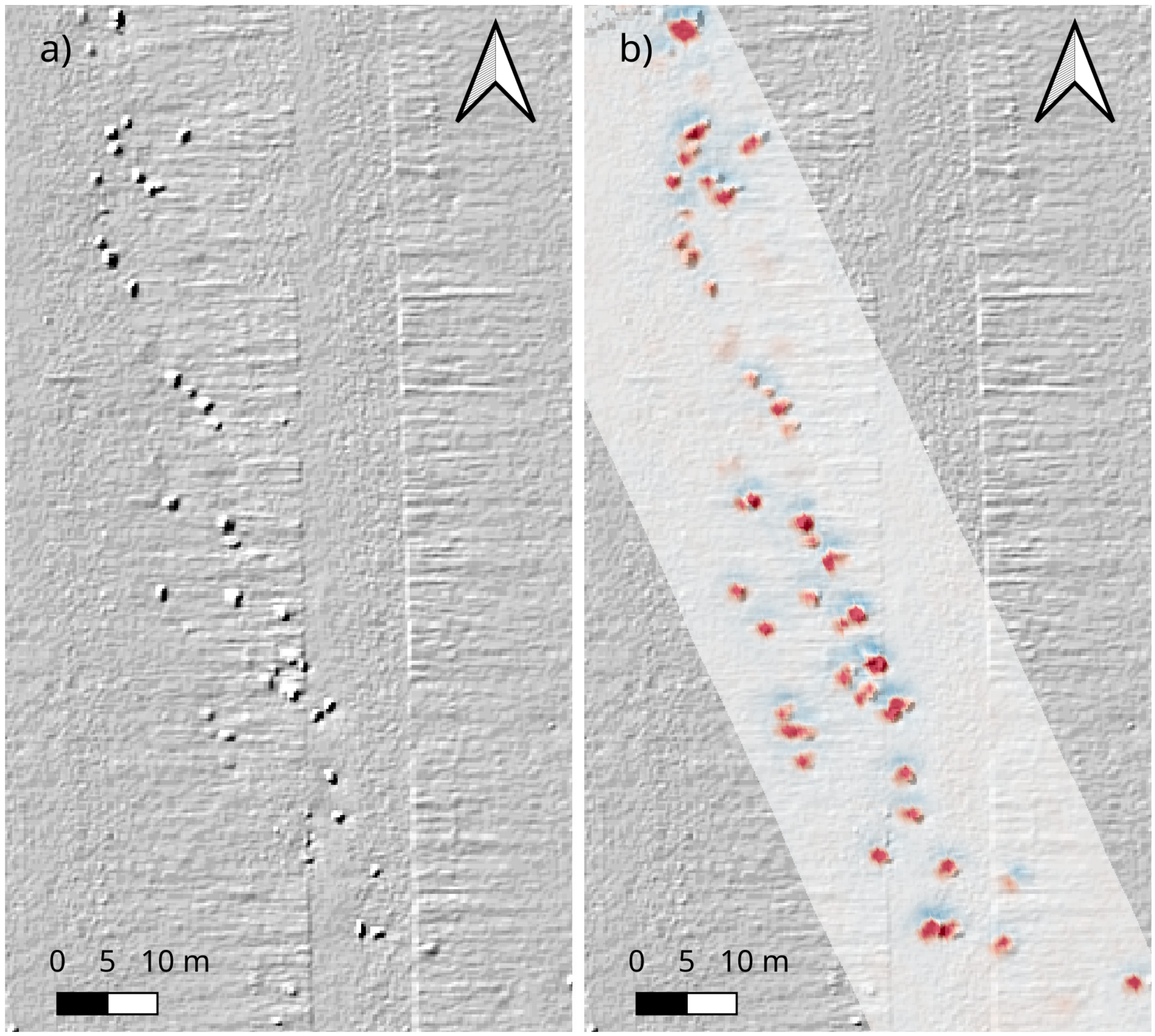

Figure 12: a) Hillshade derivative of a munitions dumping area near Haffkrug. b) Magnetic results (vertical magnetic gradient) projected on top of the same image. Color scales denote magnetic gradients from -75 to +75 nT/m.

Figure 12a shows the bathymetry hillshade derivative of an approximately 100 x 50 m² area near Haffkrug showing several meter-sized objects. Figure 12b shows the projected magnetic results (vertical magnetic gradient) of LUISE mission #252. Interestingly, this area is located west, i.e. outside of the official Haffkrug dumping ground. The blue-red color scale denotes magnetic gradients from -75 to +75 nT/m. Total mission time was 3 hours and 22 minutes covering an area of almost 4,000 m². The average flight altitude was 1.5 m and the velocity 0.4 m/s.

SMART AUV

In Lübeck Bay we tested the marine boundary layer detection and tracking algorithm described in von See et al., (2021). The AUV used the Backseat Driver mode to drive a small lawnmower grid while simultaneously running the Unscented Kalman Filter (UKF) based extremum seeking control (ESC) to detect and track the boundary layer in z-direction. In Figure 13 a scatter plot of the AUV depth over temperature for the AUV Mission ANTON244 is shown. It can be seen that there was no classical thermocline but two boundary layers with cold water at the top, warm water in the middle and again cold water close to the seafloor. This is a quite challenging situation. By tuning of the ESC parameters, we were able to let the AUV track the upper and lower boundary layer separately.

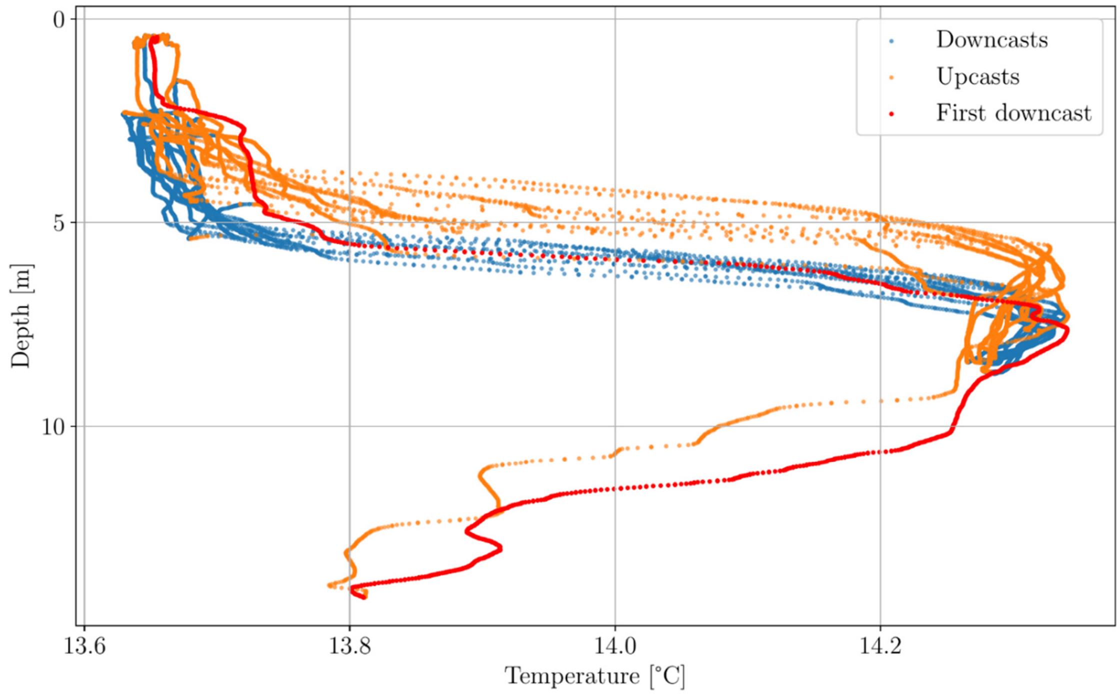

Figure 13: Depth-temperature profile as a scatter plot of the AUV thermocline tracking dive ANTON244.

What can be also be observed is that the variance of the measurement while driving upward (orange dots) is much higher than when driving downward (blue dots). This is mostly due to the fact that when the AUV is driving downward, the CTD can measure the undisturbed water column due to its mounting position while when the AUV is driving upward the two hulls at the top are pushing water upward and thereby create mixing and turbulence of the water. This results in a kind of hysteresis effect that leads to an undesired smoothing of the gradient in the turning points of the AUV. Thus, the ESC amplitude has to be chosen larger than the boundary layer thickness to ensure correct capturing.

The depth and temperature data over time for tracking the upper layer in the AUV mission ANTON244 are shown in Figure 14. It can be seen that the AUV started by driving one complete depth profile and on the upcast it activated the ESC at approximately 5 m depth. At $t \approx 200$ s the ESC misinterpreted the data and drove the AUV very close to the surface but quickly managed to drive the AUV back to the desired boundary layer where it fine-tuned the depth.

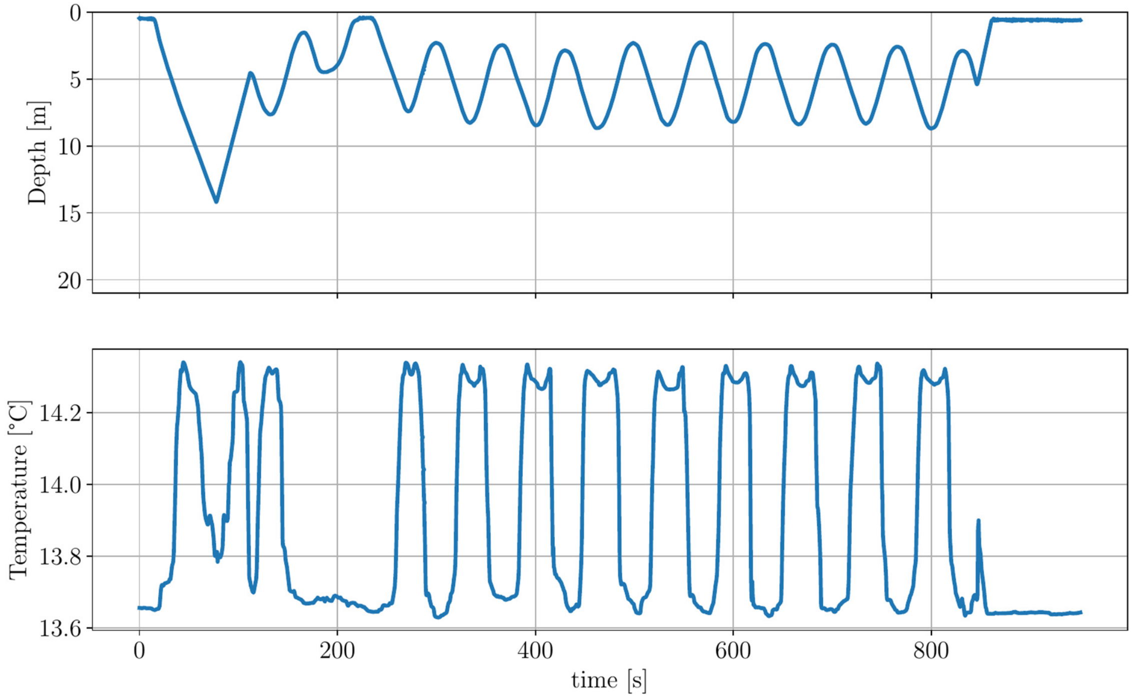

Figure 14: Depth and temperature over time for the thermocline tracking AUV dive ANTON244.

Macrofauna sampling

During the expedition of AL583 a total of 34 stations were taken along three transects in the Haffkrug area (Figure 15). Transects were chosen to match the collected data on multibeam and magnetic surveys with all the munition objects mapped. Sampling was performed using 0.1 van-Veen grab, with three replicates per station. Two replicates were used for the biological analysis of macrofauna, and one for the sediment analysis.

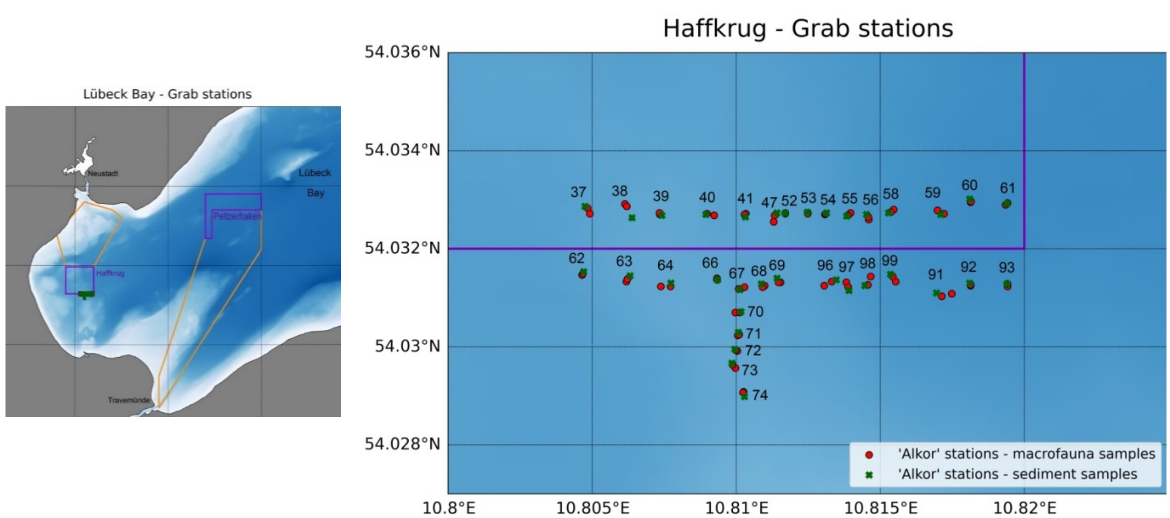

Figure 15: Grab stations taken in Haffkrug area from during AL583. Left – position within the Lübeck Bay area; right – enclosed area with stations. Red dots mark the macrofauna samples; green dots mark the sediment samples. Orange lines mark munition suspect sites; violet lines mark confirmed munition dumpsites.

7.3 Area 3 – Pelzerhaken

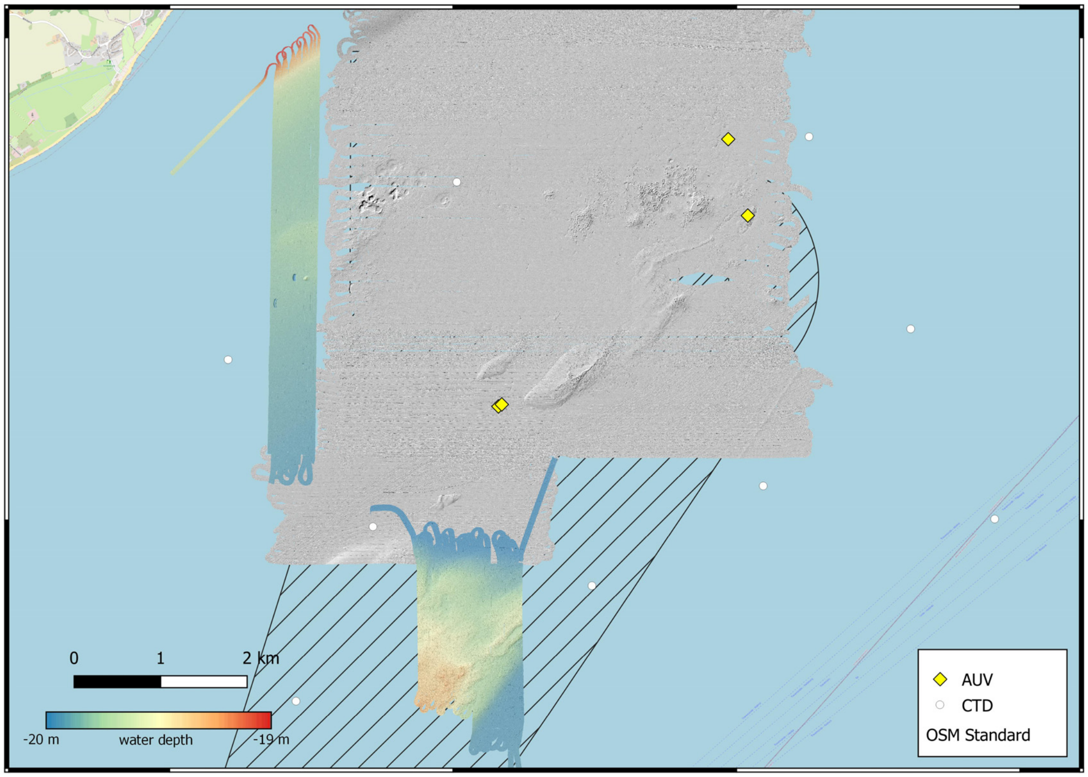

Figure 16: Mapped area in Pelzerhaken in Lübeck Bay during AL567 with CTD and AUV stations. The colored multibeam data was acquired on AL583, the grey-shaded data was recorded on previous surveys

MBES

In Pelzerhaken, more mapping was done towards the west and south (Figure 16). By creating derivatives (here: TPI of the surface area), objects become more visible. Within the western dataset, seven potential munition piles, three torpedo-like objects and one on-route dumping track were spotted (Figure 17). The south-eastern part, is characterized by rocky seafloor on one hand, and flat and highly disturbed by trawl marks seafloor on the other hand, but no clear munition findings.

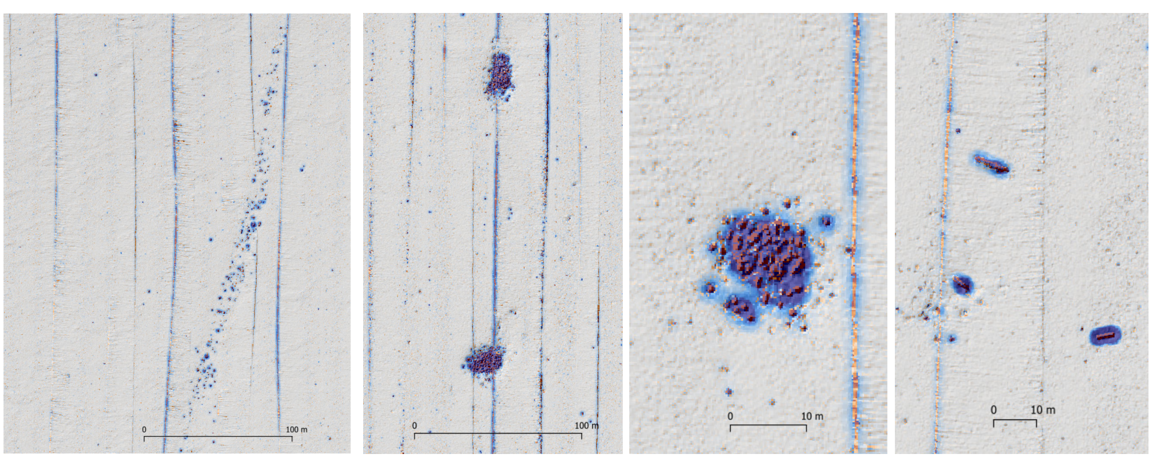

Figure 17: Derivatives (here: TPI of the Real Surface Area) enhance morphological features on the seafloor. While minor elevations and the waterdepth are neglected, object patterns become clearly more visible.

AUV

Figure 18 shows an interpolated 2D map the analytic magnetic signal, a value derived from the three spatial magnetic gradients that assists in the precise localization of magnetic objects. The covered area is approximately 4,300 m² and it is located in the eastern region of the Pelzerhaken dumping ground. Several magnetically objects, to some extent very prominent (> 100 nT/m), can easily be spotted. The two elongated structures in the middle part and right from the center could be cables or metallic chains. Total mission time of LUISE #259 was 4 hours and 33 minutes, flight altitude and velocity were 1.8 m and 0.4 m/s respectively.

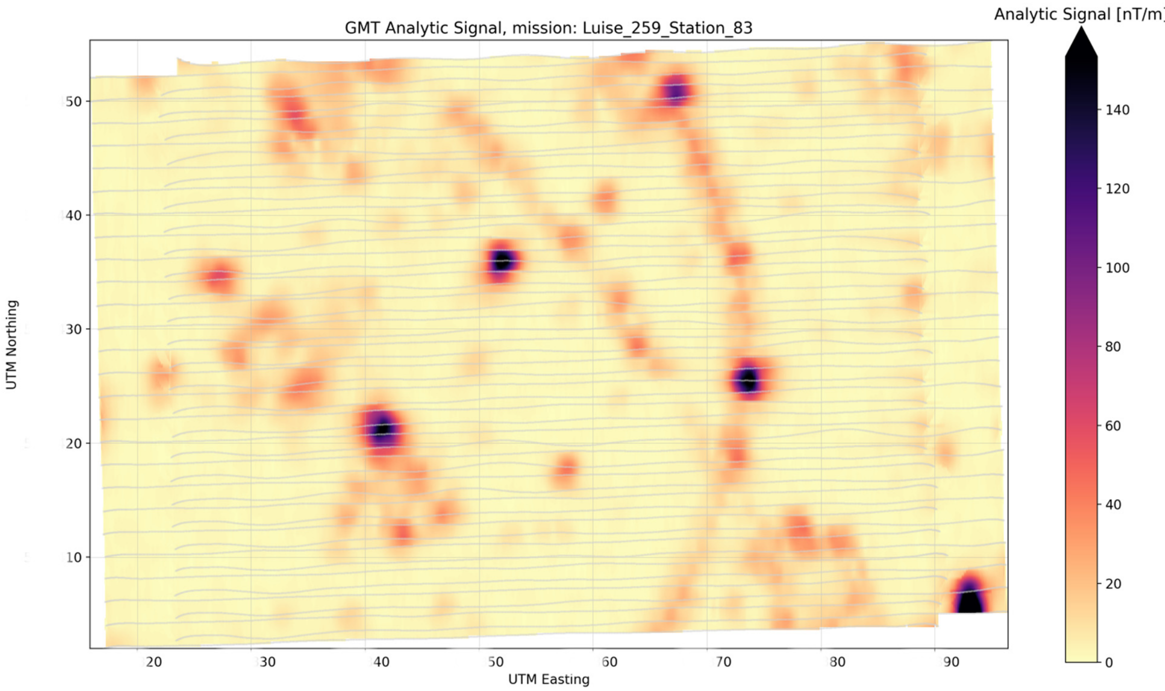

Figure 18: 2-D interpolated analytic magnetic signal of a 80 x 54 m² area in the eastern regions of the Pelzerhaken dumping ground.

SMART AUV

During the AL583 cruise, we conducted the first successful test of the backseat driver (BSD) algorithm. The AUV was sent on south-to-north single-line mission of 50 m length flying with 0.5 m/s in 2 m altitude. When the AUV finished this single-line mission, the magnetic data was autonomously investigated and assessed by the BSD. The algorithm detected a magnetic anomaly and calculated a dense lawn-mowing pattern mission to cover the area around the estimated anomaly. This dense mission consisted of 6 lines a 15 m. Figure 19 shows the single-line mission track along with the strong magnetic signal of the detected object (dense mission, analytic signal in nT/m). During the single-line mission, the AUV missed the object by approximately 3 m. Nevertheless, the magnetic anomaly created by the object was strong enough to be detected at this distance and the BSD could manage to estimate its position of the object. Figure 20 shows an image of this partially buried, unknown object taken by the AUV onboard camera.

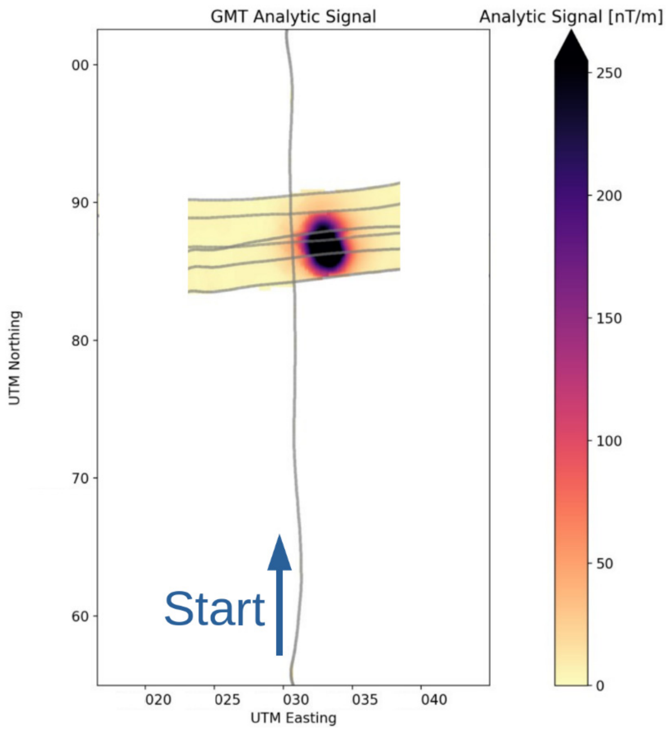

Figure 19: External single-line mission and 2D magnetic results of an autonomously generated dense mission above a magnetically prominent object. The position of the dense mission was calculated by the backseat driver algorithm autonomously, purely based on in-situ measurements.

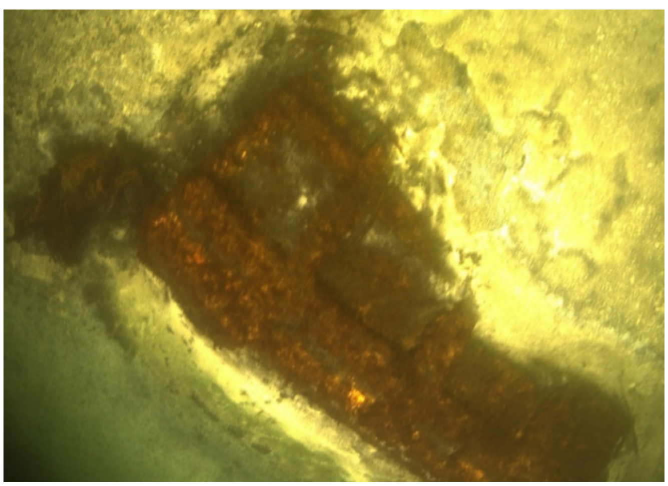

Figure 20: Image of the unknown object detected by the backseat driver algorithm. The image was taken by the AUV onboard camera system.

On dive, ANTON 256, we increased the ESC amplitude so that the whole depth range with a significant gradient of temperature with respect to depth could be tracked, the depth and temperature data over time are shown in Figure 21. Here, the fine tuning of the AUV depth to the mean boundary layer can be observed much clearer. The ESC mean depth at the start is ca. 5 m and after fine tuning it is ca. 10 m. At first only the upper boundary layer from 3 to 7.5 m was tracked where the larges gradient is from 6.5 to 7.5 m. From t>600s on also the lower boundary layer from 13.5 m to 15.5 m was covered so that in the steady state the range from ca. 5 to ca. 15 m is covered, thus the complete lower boundary layer and the steepest part of the upper boundary layer. Furthermore, we used the Backseat driver mode to implement a vertical descent while holding the latitude and longitude constant to acquire an almost purely vertical downcast for our colleges in the Oceanic Machine Vision group. This data can be used for water property estimation and afterwards for colour correction of the pictures taken during that mission.

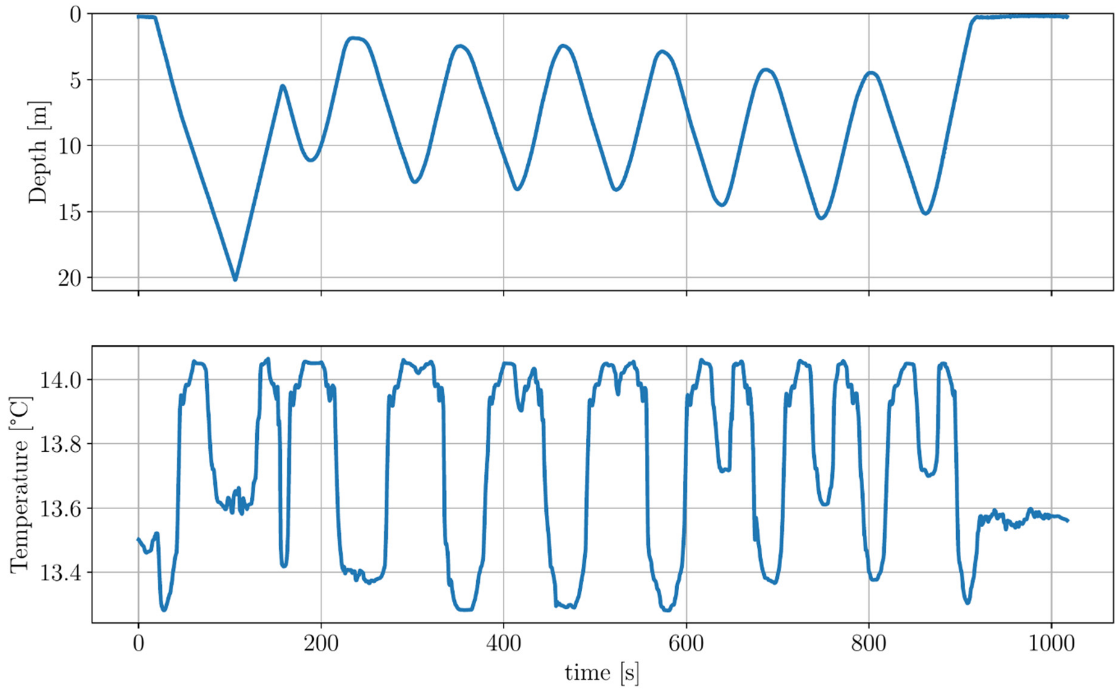

Figure 21: Depth and temperature over time for the thermocline tracking AUV dive ANTON256.

7.4 Area 4 – Kolberger Heide

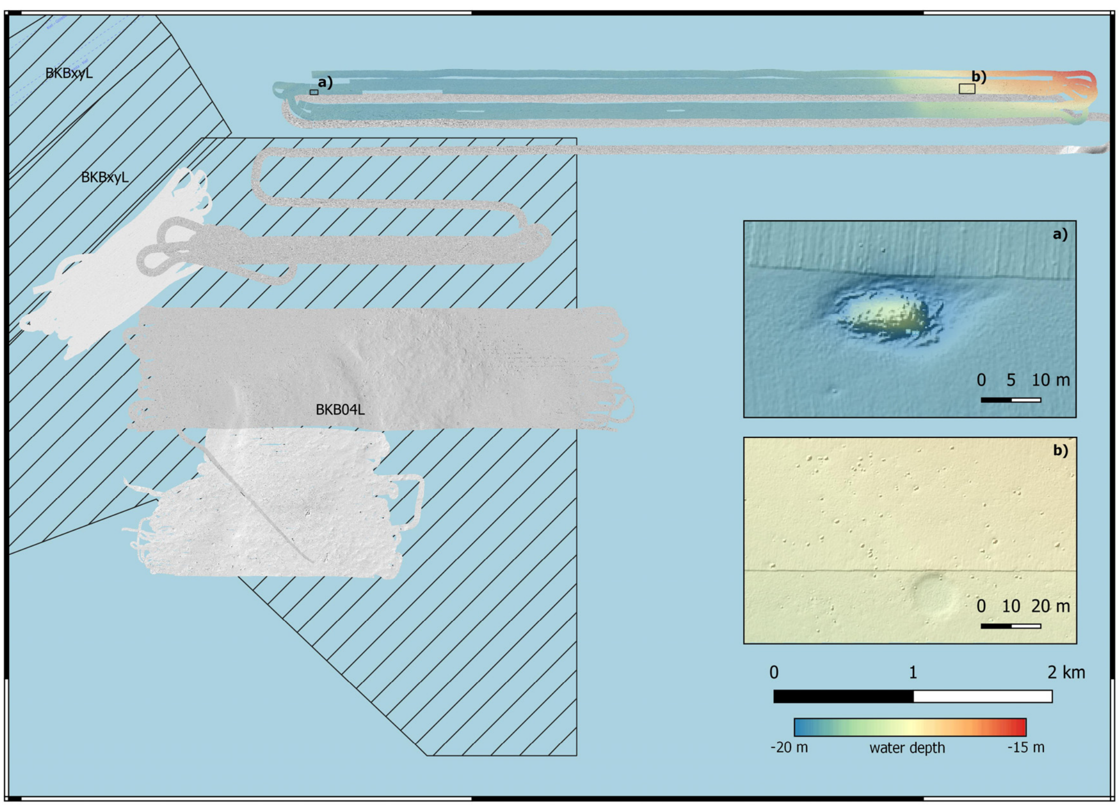

Figure 22: Mapped area in Kolberger Heide during AL583 with CTD and AUV stations. The coloured multibeam data was acquired on AL583, the grey-shaded data was recorded on previous surveys. Subfigure a) shows an unidentified object of more than 10 m length. In subfigure b) a centric crater of ca 15 m diameter and several unidentified objects on a flat seafloor are visible.

The cruise ended with mapping an area in Kolberger Heide. East-west profiles from the previous cruise AL567 in the north of the dumpsite were extended (Figure 22). In the eastern part some suspicious objects next to a centric sediment crater can be identified. None of the objects have been ground truthed yet.

7.5 Water Property Overview

Figure 23 and Figure 24 show temperature, salinity and dissolved oxygen for two sections of the AL583 CTD station coverage. There profiles show increased stratification of salinity from West to East with significantly elevated salinity and anoxia in the Lübeck-Mecklenburg Bay. These profiles will be analysed further, in conjunction with the concentration profiles of munition compounds measured in water samples collected at these CTD stations. Analysis of these samples is ongoing and is expected to be completed by the end June 2023.

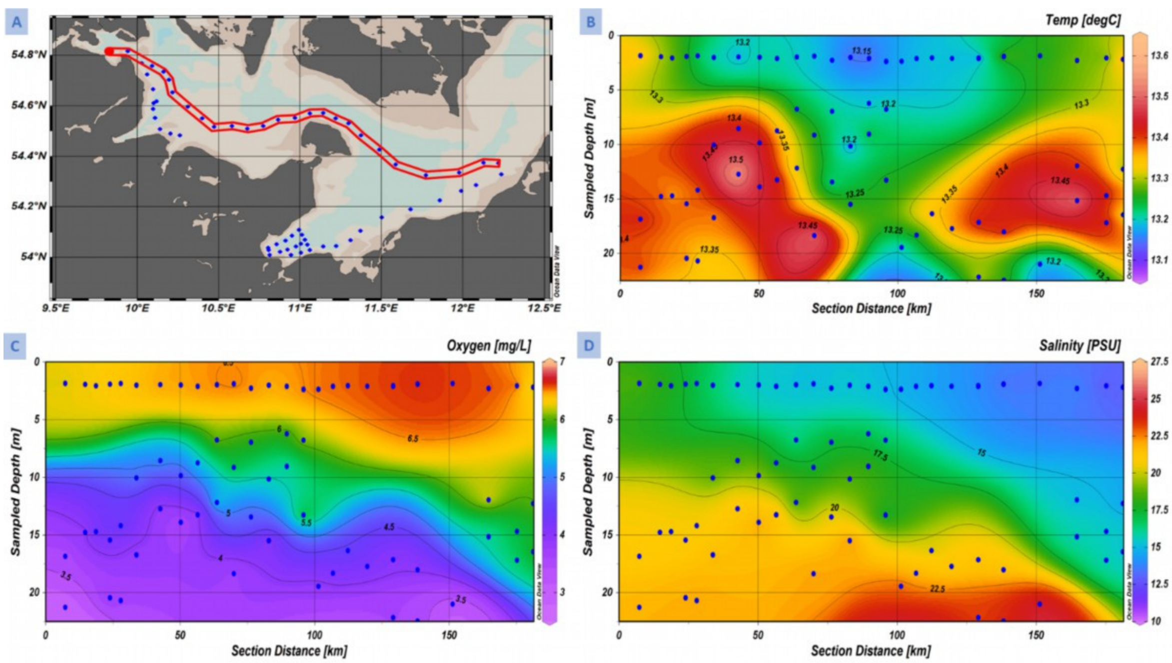

Figure 23. West-to-East Section of the AL583 CTD stations (A) showing water column profiles of Temperature (B), Dissolved Oxygen (C), and Salinity (D) and depths of individual samples collected within the selected section (B-D).

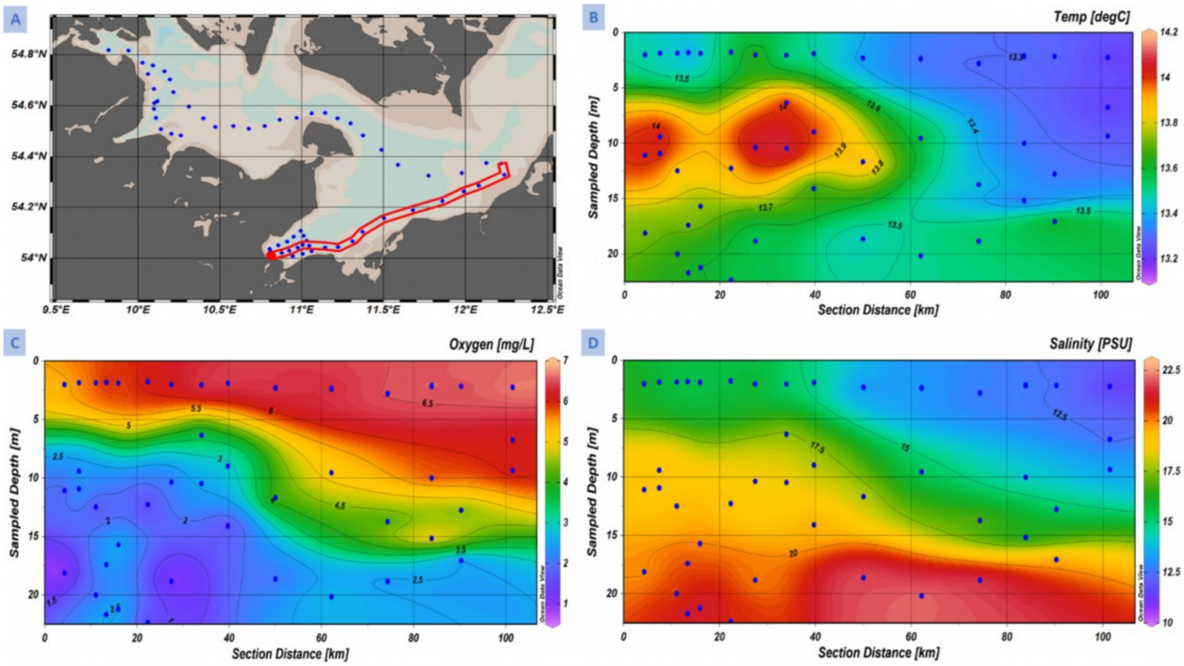

Figure 24. A coastal section of the AL583 CTD stations from Lübeck Bay to Rostock (A) showing water column profiles of Temperature (B), Dissolved Oxygen (C), Salinity (D) and depths of individual samples collected within the selected section (B-D).

7.6 Degradation Experiments

Preliminary results showed that TNT concentration rapidly decreased over the monitoring period than RDX and DNB whose concentrations did not significantly reduce (Figure 25). The rapid decrease of TNT was accompanied by a slow build-up of the 4-ADNT and 2-ADNT which are transformation products of TNT. Further investigation of this mass imbalance will be done and degradation rates will be computed.

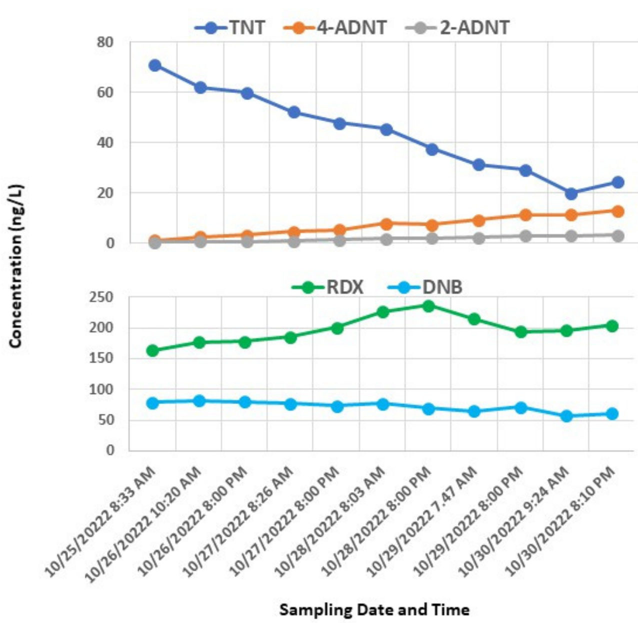

Figure 25: Temporal Profiles of munition compound concentrations in sea water samples at room temperature (about 21°C).

8 Data and Sample Storage and Availability

Mapping data (multibeam, photographs, magnetic and GIS projects) are stored on GEOMAR servers with access control and are only available to project internal staff. Munition findings will be reported to corresponding authorities (EOD squads and the Navy underwater data centre in Rostock). Data will be provided to project members if required. Data including navigation data from munition findings will not be made publicly available. Position data from munition locations will not be uploaded onto the GEOMAR data management server OSIS. Access to such sensitive data is restricted.

9 Acknowledgements

We thank the master and crew of RV ALKOR for their excellent support during the scientific campaign of AL583 and MacArtney Germany GmbH for the reliable installation and set-up of the multibeam system. This cruise was performed within the framework of the EU-funded project BASTA (EMFF-Blue Economy 2018 program, project nr. 863702; www.basta-munition.eu) and DAM project CONMAR (https://conmar-munition.eu/) funded through BMBF (grant number 03F0912A).

10 References

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Leipe, T., Naumann, M., Tauber, F., Radtke, H., Friedland, R., Hiller, A., & Arz, H. W. (2017). Regional distribution patterns of chemical parameters in surface sediments of the south-western Baltic Sea and their possible causes. Geo-Marine Letters, 37(6), 593–606. https://doi.org/10.1007/s00367-017-0514-6

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11 Appendix

11.1 AUV Missions Overview

11.2 Overall Station List

Reduced navigation precision due to confidential position data.

11.3 VanVeen Grab stations and samples taken

Reduced navigation precision due to confidential position data.

AUV Missions Overview

AUV platform	Mission	Station	Date	Start (UTC)	Ende (UTC)	Duration	Gebiet	Sensors	Aim	Name	Comments	Photomosaic
Luise	**248**	**035**	25.10.2022	6:29	10:00	3:31	Haffkrug	Coramo-Piefke - CTD - Magnetometer	Photomosaic and Magnetics	AL583_035_AUV-Luise_248	bad visibility	No
Anton	**241**	**036**	25.10.2022	7:18	7:28	0:10	Haffkrug	CTD	IBox Test Thermocline	AL583_036_AUV-Anton_241		
Anton	**242**	**036**	25.10.2022	7:42	8:00	0:18	Haffkrug	CTD	IBox Test Thermocline	AL583_036_AUV-Anton_242		
Anton	**243**	**036**	25.10.2022	8:18	8:37	0:19	Haffkrug	CTD	IBox Test Thermocline	AL583_036_AUV-Anton_243		
Anton	**244**	**036**	25.10.2022	8:58	9:16	0:18	Haffkrug	CTD	IBox Test Thermocline	AL583_036_AUV-Anton_244		
Anton	**245**	**036**	25.10.2022	9:27	9:40	0:13	Haffkrug	CTD	IBox Test Thermocline	AL583_036_AUV-Anton_245		
Luise	**249**	**035**	25.10.2022	13:37	13:50	0:13	Haffkrug	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_035_AUV-Luise_249		
Luise	**250**	**035**	25.10.2022	13:51	14:04	0:13	Haffkrug	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_035_AUV-Luise_250		
Luise	**251**	**035**	25.10.2022	14:08	14:40	0:32	Haffkrug	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_035_AUV-Luise_251		
Luise	**252**	**050**	26.10.2022	8:20	11:20	3:00	Haffkrug	Coramo-Piefke - CTD - Magnetometer	Photomosaic and Magnetics	AL583_050_AUV-Luise_252		Yes
Anton	**246**	**051**	26.10.2022	8:30	11:13	2:43	Haffkrug	Coramo-Berta - CTD	Photomosaic	AL583_051_AUV-Anton_246		Yes
Anton	**247**	**057**	26.10.2022	13:22	13:40	0:18	Haffkrug	CTD	IBox Test Thermocline	AL583_057_AUV-Anton_247		
Anton	**248**	**057**	26.10.2022	13:47	14:05	0:18	Haffkrug	Coramo-Berta - CTD	IBox Test Photo Survey	AL583_057_AUV-Anton_248		Yes
Anton	**249**	**057**	26.10.2022	14:32	14:53	0:21	Haffkrug	Coramo-Berta - CTD	IBox Test Photo Survey	AL583_057_AUV-Anton_249		Yes
Anton	**250**	**077**	27.10.2022	10:56	14:16	3:20	Haffkrug	Coramo-Berta - CTD	Photomosaic	AL583_077_AUV-Anton_250	photomosaic incomplete	Yes
Luise	**253**	**078**	27.10.2022	11:32	11:37	0:05	Haffkrug	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_078_AUV-Luise_253		
Luise	**254**	**078**	27.10.2022	12:02	12:07	0:05	Haffkrug	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_078_AUV-Luise_254		
Luise	**255**	**078**	27.10.2022	12:09	12:23	0:14	Haffkrug	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_078_AUV-Luise_255		
Luise	**256**	**078**	27.10.2022	12:28	12:34	0:06	Haffkrug	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_078_AUV-Luise_256		
Luise	**257**	**078**	27.10.2022	12:43	12:56	0:13	Haffkrug	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_078_AUV-Luise_257		Yes
Luise	**258**	**078**	27.10.2022	13:16	14:40	1:24	Haffkrug	Coramo-Piefke - CTD - Magnetometer	Photomosaic and Magnetics	AL583_078_AUV-Luise_258		Yes
Anton	**251**	**082**	28.10.2022	6:22	10:05	3:43	Pelzerhaken	Coramo-Berta - CTD	Photomosaic	AL583_082_AUV-Anton_251		Yes
Luise	**259**	**083**	28.10.2022	6:47	10:23	3:36	Pelzerhaken	Coramo-Piefke - CTD - Magnetometer	Photomosaic and Magnetics	AL583_083_AUV-Luise_259	All pictures black	No
Anton	**252**	**089**	28.10.2022	11:07	11:29	0:22	Pelzerhaken	CTD	IBox Test Thermocline	AL583_089_AUV-Anton_252		
Anton	**253**	**089**	28.10.2022	11:38	11:52	0:14	Pelzerhaken	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_089_AUV-Anton_253		

Luise	**260**	**090**	28.10.2022	12:03	12:29	0:26	Pelzerhaken	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_090_AUV-Luise_260		Yes
Anton	**254**	**089**	28.10.2022	12:14	12:32	0:18	Pelzerhaken	CTD	IBox Test Thermocline	AL583_089_AUV-Anton_254		
Luise	**261**	**090**	28.10.2022	12:30	12:36	0:06	Pelzerhaken	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_090_AUV-Luise_261		
Luise	**262**	**090**	28.10.2022	12:38	12:58	0:20	Pelzerhaken	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_090_AUV-Luise_262		Yes
Anton	**255**	**089**	28.10.2022	12:39	12:50	0:11	Pelzerhaken	CTD	IBox Test Thermocline	AL583_089_AUV-Anton_255		
Anton	**256**	**089**	28.10.2022	12:57	13:14	0:17	Pelzerhaken	CTD	IBox Test Thermocline	AL583_089_AUV-Anton_256		
Luise	**263**	**090**	28.10.2022	13:09	13:28	0:19	Pelzerhaken	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_090_AUV-Luise_263		Yes
Anton	**257**	**089**	28.10.2022	13:20	13:37	0:17	Pelzerhaken	CTD	IBox Test Thermocline	AL583_089_AUV-Anton_257		
Luise	**264**	**144**	30.10.2022	11:57	12:15	0:18	Falshöft	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_144_AUV-Luise_264		
Luise	**265**	**144**	30.10.2022	12:21	12:40	0:19	Falshöft	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_144_AUV-Luise_265		
Anton	**258**	**145**	30.10.2022	12:23	12:36	0:13	Falshöft	CTD	IBox Test Thermocline	AL583_145_AUV-Anton_258		
Luise	**266**	**144**	30.10.2022	12:44	12:49	0:05	Falshöft	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_144_AUV-Luise_266	no data recorded	
Anton	**259**	**145**	30.10.2022	12:54	13:06	0:12	Falshöft	CTD	IBox Test Thermocline	AL583_145_AUV-Anton_259		
Luise	**267**	**144**	30.10.2022	12:58	13:03	0:05	Falshöft	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_144_AUV-Luise_267	no data recorded	
Luise	**268**	**144**	30.10.2022	13:04	13:21	0:17	Falshöft	Coramo-Piefke - CTD - Magnetometer	IBox Test Magnetics	AL583_144_AUV-Luise_268	no data recorded	

Overall Station List

Working area	Event Time	Station	Latitude (deg)	Longitude (deg)	Depth (m)	Action	Comment	Device
Schönhagen	10/24/2022 13:43	AL583_31-1_CTD	54.6109	10.1012	23	in the water		CTD
	10/24/2022 13:58	AL583_32-1_MB	54.6117	10.0986	22	profile start		MB
	10/25/2022 0:59	AL583_33-1_CTD	54.0256	10.8387	20	in the water		CTD
	10/25/2022 1:25	AL583_34-1_MB	54.0284	10.8398	20	profile start		MB
	10/25/2022 6:07	AL583_35-1_AUV	54.0357	10.8126	17	in the water	Luise photomosaic and magnetics (no pm, bad visibility) #248 - 251	AUV
	10/25/2022 7:10	AL583_36-1_AUV	54.0329	10.8048	16	in the water	Anton IBox Test Thermocline #241 - 245	AUV
	10/25/2022 7:30	AL583_37-1_VGRAB	54.0328	10.8048	16	in the water		VGRAB
	10/25/2022 7:36	AL583_37-2_VGRAB	54.0327	10.8049	16	in the water		VGRAB
	10/25/2022 7:40	AL583_37-3_VGRAB	54.0329	10.8047	16	in the water		VGRAB
	10/25/2022 8:09	AL583_38-1_VGRAB	54.0329	10.8063	16	in the water		VGRAB
	10/25/2022 8:12	AL583_38-2_VGRAB	54.0329	10.8061	16	in the water		VGRAB
	10/25/2022 8:18	AL583_38-3_VGRAB	54.0328	10.8066	16	in the water		VGRAB
	10/25/2022 8:37	AL583_39-1_VGRAB	54.0327	10.8074	15	in the water		VGRAB
	10/25/2022 8:38	AL583_39-2_VGRAB	54.0327	10.8074	15	in the water		VGRAB
	10/25/2022 8:42	AL583_39-3_VGRAB	54.0327	10.8073	15	in the water		VGRAB
	10/25/2022 9:01	AL583_40-1_VGRAB	54.0327	10.8092	16	in the water		VGRAB
	10/25/2022 9:03	AL583_40-2_VGRAB	54.0327	10.8092	16	in the water		VGRAB
	10/25/2022 9:06	AL583_40-3_VGRAB	54.0327	10.8091	16	in the water		VGRAB
	10/25/2022 9:09	AL583_40-4_VGRAB	54.0327	10.8090	16	in the water		VGRAB
	10/25/2022 9:54	AL583_41-1_VGRAB	54.0327	10.8104	16	in the water		VGRAB
	10/25/2022 9:59	AL583_41-2_VGRAB	54.0327	10.8103	16	in the water		VGRAB
	10/25/2022 10:03	AL583_41-3_VGRAB	54.0326	10.8104	16	in the water		VGRAB
	10/25/2022 10:20	AL583_36-1_AUV	54.0329	10.8101	16	on deck	Anton IBox Test Thermocline	AUV
	10/25/2022 10:25	AL583_35-1_AUV	54.0328	10.8102	16	on deck	Luise photomosaic and magnetics (no photomosaic, bad visibility)	AUV
	10/25/2022 10:47	AL583_42-1_MIC	54.0327	10.8049	16	in the water		MIC
	10/25/2022 11:05	AL583_43-1_MIC	54.0314	10.8132	17	in the water		MIC
	10/25/2022 11:23	AL583_44-1_MIC	54.0315	10.8198	18	in the water		MIC
	10/25/2022 11:30	AL583_44-2_MIC	54.0314	10.8198	18	in the water		MIC
	10/25/2022 11:38	AL583_44-3_MIC	54.0314	10.8197	18	in the water		MIC
	10/25/2022 12:20	AL583_45-1_CTD	54.0376	10.8029	16	in the water		CTD
	10/25/2022 12:50	AL583_46-1_AUV	54.0305	10.8128	16	in the water	Luise IBox Test Magnetics	AUV
	10/25/2022 13:15	AL583_47-1_VGRAB	54.0327	10.8114	16	in the water		VGRAB
	10/25/2022 13:19	AL583_47-2_VGRAB	54.0326	10.8113	16	in the water		VGRAB
	10/25/2022 13:26	AL583_47-3_VGRAB	54.0327	10.8113	16	in the water		VGRAB
	10/25/2022 14:46	AL583_46-1_AUV	54.0301	10.8136	16	on deck	Luise IBox Test Magnetics	AUV
	10/25/2022 15:40	AL583_48-1_CTD	54.0284	10.8430	20	in the water	SVP	CTD
	10/25/2022 16:05	AL583_49-1_MB	54.0270	10.8440	20	profile start		MB

	10/26/2022 8:17	AL583_50-1_AUV	54.0402	10.7864	17	in the water	Luise Photomosaic and Magnetics #252	AUV
	10/26/2022 8:25	AL583_51-1_AUV	54.0412	10.7862	17	in the water	Anton Photomosaic #246	AUV
	10/26/2022 9:27	AL583_52-1_VGRAB	54.0327	10.8117	16	in the water		VGRAB
	10/26/2022 9:32	AL583_52-2_VGRAB	54.0327	10.8117	16	in the water		VGRAB
	10/26/2022 9:35	AL583_52-3_VGRAB	54.0327	10.8117	16	in the water		VGRAB
	10/26/2022 9:48	AL583_53-1_VGRAB	54.0327	10.8125	17	in the water		VGRAB
	10/26/2022 9:50	AL583_53-2_VGRAB	54.0327	10.8125	17	in the water		VGRAB
	10/26/2022 9:53	AL583_53-3_VGRAB	54.0327	10.8125	17	in the water		VGRAB
	10/26/2022 10:00	AL583_54-1_VGRAB	54.0327	10.8131	17	in the water		VGRAB
	10/26/2022 10:03	AL583_54-2_VGRAB	54.0327	10.8131	17	in the water		VGRAB
	10/26/2022 10:05	AL583_54-3_VGRAB	54.0327	10.8131	17	in the water		VGRAB
	10/26/2022 10:22	AL583_55-1_VGRAB	54.0327	10.8140	18	in the water		VGRAB
	10/26/2022 10:25	AL583_55-2_VGRAB	54.0327	10.8139	17	in the water		VGRAB
	10/26/2022 10:28	AL583_55-3_VGRAB	54.0327	10.8138	17	in the water		VGRAB
	10/26/2022 10:35	AL583_56-1_VGRAB	54.0327	10.8146	18	in the water		VGRAB
	10/26/2022 10:38	AL583_56-2_VGRAB	54.0326	10.8146	18	in the water		VGRAB
	10/26/2022 10:40	AL583_56-3_VGRAB	54.0327	10.8145	18	in the water		VGRAB
	10/26/2022 11:19	AL583_51-1_AUV	54.0414	10.7861	17	on deck	Anton Photomosaic	AUV
	10/26/2022 11:52	AL583_50-1_AUV	54.0400	10.7872	17	on deck	Luise Photomosaic and Magnetics	AUV
	10/26/2022 13:07	AL583_57-1_AUV	54.0330	10.8154	18	in the water	Anton IBox Test Thermocline #247 - 249	AUV
	10/26/2022 13:15	AL583_58-1_VGRAB	54.0328	10.8155	18	in the water		VGRAB
	10/26/2022 13:18	AL583_58-2_VGRAB	54.0328	10.8154	18	in the water		VGRAB
	10/26/2022 13:25	AL583_58-3_VGRAB	54.0327	10.8153	18	in the water		VGRAB
	10/26/2022 13:40	AL583_59-1_VGRAB	54.0328	10.8170	19	in the water		VGRAB
	10/26/2022 13:43	AL583_59-2_VGRAB	54.0327	10.8171	18	in the water		VGRAB
	10/26/2022 13:46	AL583_59-3_VGRAB	54.0327	10.8172	19	in the water		VGRAB
	10/26/2022 13:53	AL583_59-4_MIC	54.0327	10.8170	19	in the water		MIC
	10/26/2022 14:09	AL583_60-1_MIC	54.0329	10.8180	18	in the water		MIC
	10/26/2022 14:13	AL583_60-2_VGRAB	54.0329	10.8181	19	in the water		VGRAB
	10/26/2022 14:16	AL583_60-3_VGRAB	54.0330	10.8181	19	in the water		VGRAB
	10/26/2022 14:19	AL583_60-4_VGRAB	54.0330	10.8182	19	in the water		VGRAB
	10/26/2022 14:33	AL583_61-1_VGRAB	54.0329	10.8193	19	in the water		VGRAB
	10/26/2022 14:36	AL583_61-2_VGRAB	54.0329	10.8194	19	in the water		VGRAB
	10/26/2022 14:39	AL583_61-3_VGRAB	54.0329	10.8194	19	in the water		VGRAB
	10/26/2022 14:58	AL583_57-1_AUV	54.0329	10.8193	19	on deck	Anton IBox Test Thermocline	AUV
	10/26/2022 15:30	AL583_62-1_VGRAB	54.0315	10.8047	16	in the water		VGRAB
	10/26/2022 15:32	AL583_62-2_VGRAB	54.0315	10.8047	16	in the water		VGRAB
	10/26/2022 15:34	AL583_62-3_VGRAB	54.0315	10.8047	16	in the water		VGRAB
	10/26/2022 15:49	AL583_63-1_VGRAB	54.0313	10.8062	16	in the water		VGRAB
	10/26/2022 15:52	AL583_63-2_VGRAB	54.0314	10.8062	16	in the water		VGRAB
	10/26/2022 15:54	AL583_63-3_VGRAB	54.0314	10.8063	16	in the water		VGRAB
	10/26/2022 16:04	AL583_64-1_VGRAB	54.0312	10.8073	16	in the water		VGRAB
	10/26/2022 16:09	AL583_64-2_VGRAB	54.0312	10.8077	15	in the water		VGRAB

Lübeck Bay	10/26/2022 16:11	AL583_64-3_VGRAB	54.0313	10.8077	15	in the water		VGRAB
	10/26/2022 17:06	AL583_65-1_MB	54.0285	10.8566	22	profile start		MB
	10/27/2022 5:36	AL583_66-1_VGRAB	54.0314	10.8094	16	in the water		VGRAB
	10/27/2022 5:41	AL583_66-2_VGRAB	54.0314	10.8093	16	in the water		VGRAB
	10/27/2022 5:44	AL583_66-3_VGRAB	54.0314	10.8093	16	in the water		VGRAB
	10/27/2022 5:57	AL583_67-1_VGRAB	54.0313	10.8102	16	in the water		VGRAB
	10/27/2022 6:02	AL583_67-2_VGRAB	54.0312	10.8102	16	in the water		VGRAB
	10/27/2022 6:05	AL583_67-3_VGRAB	54.0312	10.8102	16	in the water		VGRAB
	10/27/2022 6:13	AL583_68-1_VGRAB	54.0313	10.8110	16	in the water		VGRAB
	10/27/2022 6:17	AL583_68-2_VGRAB	54.0312	10.8109	16	in the water		VGRAB
	10/27/2022 6:21	AL583_68-3_VGRAB	54.0313	10.8109	16	in the water		VGRAB
	10/27/2022 6:31	AL583_69-1_VGRAB	54.0314	10.8115	16	in the water		VGRAB
	10/27/2022 6:34	AL583_69-2_VGRAB	54.0313	10.8115	16	in the water		VGRAB
	10/27/2022 6:38	AL583_69-3_VGRAB	54.0314	10.8115	16	in the water		VGRAB
	10/27/2022 6:47	AL583_70-1_VGRAB	54.0307	10.8099	16	in the water		VGRAB
	10/27/2022 6:51	AL583_70-2_VGRAB	54.0307	10.8101	16	in the water		VGRAB
	10/27/2022 6:54	AL583_70-3_VGRAB	54.0307	10.8102	16	in the water		VGRAB
	10/27/2022 7:02	AL583_71-1_VGRAB	54.0303	10.8099	15	in the water		VGRAB
	10/27/2022 7:06	AL583_71-2_VGRAB	54.0302	10.8101	15	in the water		VGRAB
	10/27/2022 7:09	AL583_71-3_VGRAB	54.0303	10.8101	15	in the water		VGRAB
	10/27/2022 7:43	AL583_72-1_VGRAB	54.0300	10.8101	15	in the water		VGRAB
	10/27/2022 7:46	AL583_72-2_VGRAB	54.0299	10.8100	15	in the water		VGRAB
	10/27/2022 7:49	AL583_72-3_VGRAB	54.0299	10.8099	15	in the water		VGRAB
	10/27/2022 7:59	AL583_73-1_VGRAB	54.0295	10.8100	15	in the water		VGRAB
	10/27/2022 8:02	AL583_73-2_VGRAB	54.0296	10.8099	15	in the water		VGRAB
	10/27/2022 8:04	AL583_73-3_VGRAB	54.0296	10.8099	15	in the water		VGRAB
	10/27/2022 8:15	AL583_74-1_VGRAB	54.0291	10.8102	15	in the water		VGRAB
	10/27/2022 8:17	AL583_74-2_VGRAB	54.0291	10.8102	15	in the water		VGRAB
	10/27/2022 8:19	AL583_74-3_VGRAB	54.0291	10.8102	15	in the water		VGRAB
	10/27/2022 8:53	AL583_75-1_CTD	54.0217	10.8770	20	in the water	CTD 3	CTD
	10/27/2022 9:51	AL583_76-1_CTD	54.0511	10.8575	20	in the water	CTD 4	CTD
	10/27/2022 10:49	AL583_77-1_AUV	54.0344	10.8288	18	in the water	Anton Photomosaic #250	AUV
	10/27/2022 11:27	AL583_78-1_AUV	54.0314	10.8130	17	in the water	Luise IBox Test Magnetics, Photomosaic and Magnetics #253 - 258	AUV
	10/27/2022 13:35	AL583_79-1_CTD	54.0287	10.8089	16	in the water		CTD
	10/27/2022 14:06	AL583_77-1_AUV	54.0341	10.8290	19	on deck	Anton Photomosaic	AUV
	10/27/2022 14:49	AL583_78-1_AUV	54.0314	10.8158	18	on deck	Luise IBox Test Magnetics and Photomosaic and Magnetics	AUV
	10/27/2022 15:57	AL583_80-1_CTD	54.0493	10.9359	25	in the water	SVP	CTD
	10/27/2022 16:15	AL583_81-1_MB	54.0478	10.9432	23	profile start		MB
	10/28/2022 6:16	AL583_82-1_AUV	54.0895	10.9985	22	in the water	Anton Photomosaic #251	AUV
	10/28/2022 6:43	AL583_83-1_AUV	54.0816	11.0020	22	in the water	Luise Photomosaic and Magnetics, no pics #259	AUV
	10/28/2022 7:24	AL583_84-1_CTD	54.1087	10.9926	22	in the water		CTD
	10/28/2022 7:51	AL583_85-1_CTD	54.0897	11.0128	23	in the water	CTD 12	CTD

	10/28/2022 8:17	AL583_86-1_CTD	54.0698	11.0307	23	in the water	CTD 13	CTD
	10/28/2022 8:39	AL583_87-1_CTD	54.0535	11.0047	23	in the water	CTD 14	CTD
	10/28/2022 9:15	AL583_88-1_CTD	54.0666	10.9103	22	in the water	CTD 5	CTD
	10/28/2022 10:05	AL583_82-1_AUV	54.0887	10.9992	22	on deck	Anton Photomosaic #251	AUV
	10/28/2022 10:28	AL583_83-1_AUV	54.0814	11.0016	22	on deck	Luise Photomosaic and Magnetics, no pics	AUV
	10/28/2022 11:00	AL583_89-1_AUV	54.0618	10.9580	23	new mission	Anton IBox Test Thermocline #252 - 257	AUV
	10/28/2022 11:52	AL583_90-1_AUV	54.0620	10.9586	23	in the water	Luise IBox Test Magnetics #260 - 263	AUV
	10/28/2022 13:41	AL583_90-1_AUV	54.0623	10.9596	23	on deck	Luise IBox Test Magnetics	AUV
	10/28/2022 13:44	AL583_89-1_AUV	54.0623	10.9596	23	on deck	Anton IBox Test Thermocline	AUV
	10/28/2022 14:28	AL583_91-1_VGRAB	54.0313	10.8175	18	in the water		VGRAB
	10/28/2022 14:34	AL583_91-2_VGRAB	54.0310	10.8173	18	in the water		VGRAB
	10/28/2022 14:37	AL583_91-3_VGRAB	54.0311	10.8170	18	in the water		VGRAB
	10/28/2022 14:47	AL583_92-1_VGRAB	54.0312	10.8181	19	in the water		VGRAB
	10/28/2022 14:50	AL583_92-2_VGRAB	54.0313	10.8181	19	in the water		VGRAB
	10/28/2022 14:53	AL583_92-3_VGRAB	54.0313	10.8181	19	in the water		VGRAB
	10/28/2022 15:29	AL583_93-1_VGRAB	54.0312	10.8194	19	in the water		VGRAB
	10/28/2022 15:33	AL583_93-2_VGRAB	54.0313	10.8194	19	in the water		VGRAB
	10/28/2022 15:36	AL583_93-3_VGRAB	54.0313	10.8194	19	in the water		VGRAB
	10/28/2022 15:39	AL583_93-4_VGRAB	54.0313	10.8194	19	in the water		VGRAB
	10/28/2022 15:52	AL583_94-1_CTD	54.0311	10.8203	18	in the water	SVP	CTD
	10/28/2022 16:27	AL583_95-1_MB	54.0281	10.8565	21	profile start		MB
	10/29/2022 6:01	AL583_96-1_VGRAB	54.0313	10.8132	17	in the water		VGRAB
	10/29/2022 6:06	AL583_96-2_VGRAB	54.0313	10.8132	17	in the water		VGRAB
	10/29/2022 6:09	AL583_96-3_VGRAB	54.0313	10.8134	17	in the water		VGRAB
	10/29/2022 6:20	AL583_97-1_VGRAB	54.0314	10.8138	17	in the water		VGRAB
	10/29/2022 6:24	AL583_97-2_VGRAB	54.0313	10.8139	17	in the water		VGRAB
	10/29/2022 6:27	AL583_97-3_VGRAB	54.0312	10.8139	17	in the water		VGRAB
	10/29/2022 6:33	AL583_98-1_VGRAB	54.0314	10.8146	18	in the water		VGRAB
	10/29/2022 6:38	AL583_98-2_VGRAB	54.0314	10.8147	18	in the water		VGRAB
	10/29/2022 6:41	AL583_98-3_VGRAB	54.0312	10.8145	18	in the water		VGRAB
	10/29/2022 6:49	AL583_99-1_VGRAB	54.0313	10.8155	18	in the water		VGRAB
	10/29/2022 6:54	AL583_99-2_VGRAB	54.0313	10.8154	18	in the water		VGRAB
	10/29/2022 6:59	AL583_99-3_VGRAB	54.0315	10.8153	18	in the water		VGRAB
	10/29/2022 7:27	AL583_100-1_CTD	54.0103	10.8146	14	in the water		CTD
	10/29/2022 8:07	AL583_101-1_CTD	54.0312	10.9223	13	in the water	CTD 6	CTD
	10/29/2022 8:30	AL583_102-1_CTD	54.0096	10.9450	20	in the water	CTD 7	CTD
	10/29/2022 8:58	AL583_103-1_CTD	54.0188	11.0067	23	in the water	CTD 8	CTD
	10/29/2022 9:45	AL583_104-1_CTD	54.0432	10.9745	22	in the water	CTD 9	CTD
	10/29/2022 10:14	AL583_105-1_CTD	54.0850	10.9507	21	in the water	CTD_10	CTD
	10/29/2022 10:50	AL583_106-1_CTD	54.0501	11.0455	23	in the water	CTD_15	CTD
	10/29/2022 11:10	AL583_107-1_CTD	54.0281	11.0616	17	in the water	CTD_16	CTD
	10/29/2022 11:43	AL583_108-1_CTD	54.0427	11.1420	24	in the water	CTD_Transect_1	CTD
	10/29/2022 12:22	AL583_109-1_CTD	54.0457	11.2212	21	in the water	CTD_Transect_2	CTD

	10/29/2022 13:06	AL583_110-1_CTD	54.0687	11.3096	13	in the water	CTD_Transect_3	CTD
	10/29/2022 13:40	AL583_111-1_CTD	54.1043	11.3715	16	in the water	CTD_Transect_4	CTD
	10/29/2022 14:25	AL583_112-1_CTD	54.1583	11.5018	20	in the water	CTD_Transect_5	CTD
	10/29/2022 15:11	AL583_113-1_CTD	54.1904	11.6798	21	in the water	CTD_Transect_6	CTD
	10/29/2022 16:02	AL583_114-1_CTD	54.2247	11.8579	20	in the water	CTD_Transect_7	CTD
	10/29/2022 16:42	AL583_115-1_CTD	54.2622	11.9898	16	in the water	CTD_Transect_8	CTD
	10/29/2022 17:16	AL583_116-1_CTD	54.2855	12.0797	18	in the water	CTD_Transect_9	CTD
	10/29/2022 18:02	AL583_117-1_CTD	54.3278	12.2355	12	in the water	CTD_Transect_10	CTD
	10/29/2022 18:29	AL583_118-1_CTD	54.3726	12.2191	19	in the water	CTD_Transect_11	CTD
	10/29/2022 19:04	AL583_119-1_CTD	54.3738	12.1262	19	in the water	CTD_Transect_12	CTD
	10/29/2022 19:49	AL583_120-1_CTD	54.3351	11.9780	18	in the water	CTD_Transect_13	CTD
	10/29/2022 20:43	AL583_121-1_CTD	54.3256	11.7733	25	in the water	CTD_Transect_14	CTD
	10/29/2022 21:38	AL583_122-1_CTD	54.3677	11.5865	25	in the water	CTD_Transect_15	CTD
	10/29/2022 22:16	AL583_123-1_CTD	54.4255	11.4862	24	in the water	CTD_Transect_16	CTD
	10/29/2022 22:59	AL583_124-1_CTD	54.4825	11.3750	27	in the water	CTD_Transect_17	CTD
	10/29/2022 23:39	AL583_125-1_CTD	54.5295	11.2967	28	in the water	CTD_Transect_18	CTD
	10/30/2022 0:07	AL583_126-1_CTD	54.5492	11.2180	27	in the water	CTD_Transect_19	CTD
	10/30/2022 0:35	AL583_127-1_CTD	54.5711	11.1434	26	in the water	CTD_Transect_20	CTD
	10/30/2022 1:03	AL583_128-1_CTD	54.5691	11.0588	16	in the water	CTD_Transect_21	CTD
	10/30/2022 1:36	AL583_129-1_CTD	54.5508	10.9693	12	in the water	CTD_Transect_22	CTD
	10/30/2022 2:05	AL583_130-1_CTD	54.5448	10.8664	18	in the water	CTD_Transect_23	CTD
	10/30/2022 2:36	AL583_131-1_CTD	54.5191	10.7745	16	in the water	CTD_Transect_24	CTD
	10/30/2022 3:08	AL583_132-1_CTD	54.5083	10.6771	22	in the water	CTD_Transect_25	CTD
	10/30/2022 3:40	AL583_133-1_CTD	54.5206	10.5822	16	in the water	CTD_Transect_26	CTD
CTD Transit	10/30/2022 4:10	AL583_134-1_CTD	54.5158	10.4718	16	in the water	CTD_Transect_27	CTD
	10/30/2022 4:46	AL583_135-1_CTD	54.5505	10.3996	18	in the water	CTD_Transect_28	CTD
	10/30/2022 5:24	AL583_136-1_CTD	54.5961	10.3118	16	in the water	CTD_Transect_29	CTD
	10/30/2022 6:03	AL583_137-1_CTD	54.6518	10.2163	20	in the water	CTD_Transect_30	CTD
	10/30/2022 6:59	AL583_138-1_CTD	54.7029	10.1956	23	in the water	CTD_Transect_31	CTD
	10/30/2022 7:32	AL583_139-1_CTD	54.7335	10.1629	24	in the water	CTD_Transect_32	CTD
	10/30/2022 8:11	AL583_140-1_CTD	54.7569	10.0913	28	in the water	CTD_Transect_33	CTD
	10/30/2022 8:45	AL583_141-1_CTD	54.7671	10.0281	27	in the water	CTD_Transect_34	CTD
	10/30/2022 9:56	AL583_142-1_CTD	54.8167	9.8193	23	in the water	CTD_Transect_35	CTD
	10/30/2022 10:43	AL583_143-1_CTD	54.8149	9.9414	25	in the water	CTD_Transect_36	CTD
	10/30/2022 11:54	AL583_144-1_AUV	54.7185	10.0713	14	in the water	Luise IBox Test Magnetics, no data recorded #264 - 267	AUV
	10/30/2022 12:18	AL583_145-1_AUV	54.7178	10.0718	14	in the water	Anton IBox Test Thermocline #258 - 259	AUV
	10/30/2022 13:18	AL583_145-1_AUV	54.7178	10.0704	14	on deck	Anton IBox Test Thermocline	AUV
	10/30/2022 13:29	AL583_144-1_AUV	54.7183	10.0710	14	on deck	Luise IBox Test Magnetics, no data recorded	AUV
	10/30/2022 13:47	AL583_146-1_CTD	54.7230	10.0607	13	in the water	CTD_Transect_37	CTD
	10/30/2022 14:25	AL583_147-1_CTD	54.6649	10.0977	14	in the water	CTD_Transect_38	CTD
	10/30/2022 15:24	AL583_148-1_MB	54.6353	10.2147	22	profile start	Wrack	MB
	10/30/2022 16:58	AL583_149-1_CTD	54.6164	10.1182	25	in the water	CTD_Transect_39	CTD
	10/30/2022 17:29	AL583_150-1_CTD	54.5865	10.0988	26	in the water	CTD_Transect_40	CTD

	10/30/2022 18:01	AL583_151-1_CTD	54.5516	10.1085	24	in the water	CTD_Transect_41	CTD
	10/30/2022 18:33	AL583_152-1_CTD	54.5066	10.1414	10	in the water	CTD_Transect_42	CTD
	10/30/2022 18:57	AL583_153-1_CTD	54.4903	10.2049	12	in the water	CTD_Transect_43	CTD
	10/30/2022 19:28	AL583_154-1_CTD	54.4820	10.2625	19	in the water	CTD_Transect_44, failed	CTD
	10/30/2022 19:37	AL583_154-2_CTD	54.4818	10.2621	19	in the water	CTD_Transect_44 , 2nd try	CTD
Kolberger Heide	10/30/2022 20:14	AL583_155-1_MB	54.4971	10.3442	19	profile start		MB

VanVeen Grab positions and samples taken during AL583

Expedition	Date	Station	Label	Area	Latitude	Longitude	Depth	Grab	Type of item	No. of items	Comments
Alkor 583	25.10.2022	37-1	1.1.	Haffkrug	54.0328	10.8048	16	1	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	37-2	1.2.	Haffkrug	54.0327	10.8049	16	2	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	37-3	1.3.	Haffkrug	54.0329	10.8048	16	3	sediment (zip-bag)	1	
Alkor 583	25.10.2022	38-1	2.1.	Haffkrug	54.0329	10.8061	16	1	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	38-2	2.2.	Haffkrug	54.0329	10.8062	16	2	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	38-3	2.3.	Haffkrug	54.0326	10.8064	16	3	sediment (zip-bag)	1	
Alkor 583	25.10.2022	39-1	3.1.	Haffkrug	54.0327	10.8074	15	1	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	39-2	3.2.	Haffkrug	54.0327	10.8073	15	2	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	39-3	3.3.	Haffkrug	54.0327	10.8074	15	3	sediment (zip-bag)	1	
Alkor 583	25.10.2022	40-1	4.1.	Haffkrug	54.0327	10.8092	16	1	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	40-3	4.2.	Haffkrug	54.0327	10.8090	16	2	bio (kautex 1 l)	2	
Alkor 583	25.10.2022	40-4	4.3.	Haffkrug	54.0327	10.8090	16	3	sediment (zip-bag)	1	
Alkor 583	25.10.2022	41-1	5.1.	Haffkrug	54.0327	10.8103	16	1	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	41-2	5.2.	Haffkrug	54.0327	10.8103	16	2	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	41-3	5.3.	Haffkrug	54.0327	10.8103	16	3	sediment (zip-bag)	1	
Alkor 583	25.10.2022	47-1	6.1.	Haffkrug	54.0326	10.8113	16	1	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	47-2	6.2.	Haffkrug	54.0327	10.8113	16	2	bio (kautex 1 l)	1	
Alkor 583	25.10.2022	47-3	6.3.	Haffkrug	54.0327	10.8114	16	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	52-1	7.1.	Haffkrug	54.0327	10.8117	16	1	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	52-2	7.2.	Haffkrug	54.0327	10.8117	16	2	bio (kautex 1 l)	1	a bit was lost
Alkor 583	26.10.2022	52-3	7.3.	Haffkrug	54.0327	10.8117	16	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	53-1	8.1.	Haffkrug	54.0327	10.8125	17	1	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	53-2	8.2.	Haffkrug	54.0327	10.8125	17	2	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	53-3	8.3.	Haffkrug	54.0328	10.8125	17	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	54-1	9.1.	Haffkrug	54.0327	10.8131	17	1	bio (kautex 1 l)	2	
Alkor 583	26.10.2022	54-2	9.2.	Haffkrug	54.0327	10.8131	17	2	bio (kautex 1 l)	2	
Alkor 583	26.10.2022	54-3	9.3.	Haffkrug	54.0327	10.8131	17	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	55-1	10.1.	Haffkrug	54.0327	10.8140	18	1	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	55-2	10.2.	Haffkrug	54.0327	10.8139	17	2	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	55-3	10.3.	Haffkrug	54.0327	10.8138	17	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	56-1	11.1.	Haffkrug	54.0326	10.8146	18	1	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	56-2	11.2.	Haffkrug	54.0327	10.8146	18	2	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	56-3	11.3.	Haffkrug	54.0327	10.8145	18	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	58-1	12.1.	Haffkrug	54.0328	10.8155	18	1	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	58-2	12.2.	Haffkrug	54.0328	10.8154	18	2	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	58-3	12.3.	Haffkrug	54.0327	10.8153	18	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	59-1	13.1.	Haffkrug	54.0328	10.8170	19	1	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	59-2	13.2.	Haffkrug	54.0327	10.8172	19	2	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	59-3	13.3.	Haffkrug	54.0327	10.8171	19	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	60-2	14.1.	Haffkrug	54.0330	10.8181	19	1	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	60-3	14.2.	Haffkrug	54.0330	10.8182	19	2	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	60-4	14.3.	Haffkrug	54.0330	10.8181	19	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	61-1	15.1.	Haffkrug	54.0329	10.8194	19	1	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	61-2	15.2.	Haffkrug	54.0329	10.8194	19	2	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	61-3	15.3.	Haffkrug	54.0329	10.8194	19	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	62-1	16.1.	Haffkrug	54.0315	10.8047	16	1	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	62-2	16.2.	Haffkrug	54.0315	10.8047	16	2	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	62-3	16.3.	Haffkrug	54.0315	10.8047	16	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	63-1	17.1.	Haffkrug	54.0313	10.8062	16	1	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	63-2	17.2.	Haffkrug	54.0314	10.8062	16	2	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	63-3	17.3.	Haffkrug	54.0315	10.8063	16	3	sediment (zip-bag)	1	
Alkor 583	26.10.2022	64-1	18.1.	Haffkrug	54.0312	10.8074	16	1	bio (kautex 1 l)	4	a lot of peat, some lost
Alkor 583	26.10.2022	64-2	18.2.	Haffkrug	54.0312	10.8077	15	2	bio (kautex 1 l)	1	
Alkor 583	26.10.2022	64-3	18.3.	Haffkrug	54.0313	10.8077	16	3	sediment (zip-bag)	1	
Alkor 583	27.10.2022	66-1	19.1.	Haffkrug	54.0314	10.8093	16	1	bio (kautex 1 l)	2	
Alkor 583	27.10.2022	66-2	19.2.	Haffkrug	54.0314	10.8093	16	2	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	66-3	19.3.	Haffkrug	54.0314	10.8094	16	3	sediment (zip-bag)	1	
Alkor 583	27.10.2022	67-1	20.1.	Haffkrug	54.0312	10.8101	16	1	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	67-2	20.2.	Haffkrug	54.0312	10.8103	16	2	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	67-3	20.3.	Haffkrug	54.0312	10.8101	16	3	sediment (zip-bag)	1	
Alkor 583	27.10.2022	68-1	21.1.	Haffkrug	54.0313	10.8110	16	1	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	68-2	21.2.	Haffkrug	54.0312	10.8109	16	2	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	68-3	21.3.	Haffkrug	54.0313	10.8109	16	3	sediment (zip-bag)	1	
Alkor 583	27.10.2022	69-1	22.1.	Haffkrug	54.0313	10.8115	16	1	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	69-2	22.2.	Haffkrug	54.0313	10.8115	16	2	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	69-3	22.3.	Haffkrug	54.0314	10.8114	16	3	sediment (zip-bag)	1	
Alkor 583	27.10.2022	70-1	23.1.	Haffkrug	54.0307	10.8100	16	1	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	70-2	23.2.	Haffkrug	54.0307	10.8101	16	2	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	70-3	23.3.	Haffkrug	54.0307	10.8102	16	3	sediment (zip-bag)	1	
Alkor 583	27.10.2022	71-1	24.1.	Haffkrug	54.0302	10.8101	15	1	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	71-2	24.2.	Haffkrug	54.0303	10.8101	15	2	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	71-3	24.3.	Haffkrug	54.0303	10.8101	15	3	sediment (zip-bag)	1	
Alkor 583	27.10.2022	72-1	25.1.	Haffkrug	54.0299	10.8100	15	1	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	72-2	25.2.	Haffkrug	54.0299	10.8100	15	2	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	72-3	25.3.	Haffkrug	54.0300	10.8100	15	3	sediment (zip-bag)	1	
Alkor 583	27.10.2022	73-1	26.1.	Haffkrug	54.0296	10.8100	15	1	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	73-2	26.2.	Haffkrug	54.0296	10.8099	15	2	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	73-3	26.3.	Haffkrug	54.0297	10.8099	15	3	sediment (zip-bag)	1	
Alkor 583	27.10.2022	74-1	27.1.	Haffkrug	54.0291	10.8103	15	1	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	74-2	27.2.	Haffkrug	54.0291	10.8102	15	2	bio (kautex 1 l)	1	
Alkor 583	27.10.2022	74-3	27.3.	Haffkrug	54.0290	10.8103	15	3	sediment (zip-bag)	1	
Alkor 583	28.10.2022	91-1	28.1.	Haffkrug	54.0311	10.8175	18	1	bio (kautex 1 l)	1	
Alkor 583	28.10.2022	91-2	28.2.	Haffkrug	54.0310	10.8171	18	2	bio (kautex 1 l)	1	
Alkor 583	28.10.2022	91-3	28.3.	Haffkrug	54.0311	10.8170	18	3	sediment (zip-bag)	1	
Alkor 583	28.10.2022	92-1	29.1.	Haffkrug	54.0313	10.8181	19	1	bio (kautex 1 l)	1	
Alkor 583	28.10.2022	92-2	29.2.	Haffkrug	54.0313	10.8181	19	2	bio (kautex 1 l)	1	
Alkor 583	28.10.2022	92-3	29.3.	Haffkrug	54.0313	10.8181	19	3	sediment (zip-bag)	1	
Alkor 583	28.10.2022	93-1	30.1.	Haffkrug	54.0312	10.8194	19	1	bio (kautex 1 l)	1	
Alkor 583	28.10.2022	93-3	30.2.	Haffkrug	54.0313	10.8194	19	2	bio (kautex 1 l)	1	Siboglinids present
Alkor 583	28.10.2022	93-4	30.3.	Haffkrug	54.0313	10.8194	19	3	sediment (zip-bag)	1	
Alkor 583	29.10.2022	96-1	31.1.	Haffkrug	54.0313	10.8131	17	1	bio (kautex 1 l)	3	a lot of peat
Alkor 583	29.10.2022	96-2	31.2.	Haffkrug	54.0313	10.8133	17	2	bio (kautex 1 l)	1	
Alkor 583	29.10.2022	96-3	31.3.	Haffkrug	54.0314	10.8135	17	3	sediment (zip-bag)	1	
Alkor 583	29.10.2022	97-1	32.1.	Haffkrug	54.0313	10.8138	17	1	bio (kautex 1 l)	1	
Alkor 583	29.10.2022	97-2	32.2.	Haffkrug	54.0312	10.8139	17	2	bio (kautex 1 l)	1	
Alkor 583	29.10.2022	97-3	32.3.	Haffkrug	54.0312	10.8139	17	3	sediment (zip-bag)	1	
Alkor 583	29.10.2022	98-1	33.1.	Haffkrug	54.0314	10.8147	18	1	bio (kautex 1 l)	1	
Alkor 583	29.10.2022	98-2	33.2.	Haffkrug	54.0313	10.8146	18	2	bio (kautex 1 l)	1	
Alkor 583	29.10.2022	98-3	33.3.	Haffkrug	54.0313	10.8145	17	3	sediment (zip-bag)	1	
Alkor 583	29.10.2022	99-1	34.1.	Haffkrug	54.0313	10.8155	18	1	bio (kautex 1 l)	1	
Alkor 583	29.10.2022	99-2	34.2.	Haffkrug	54.0314	10.8154	18	2	bio (kautex 1 l)	1	
Alkor 583	29.10.2022	99-3	34.3.	Haffkrug	54.0315	10.8154	18	3	sediment (zip-bag)	1	