ALKOR-Berichte

Monitoring ecological consequences of marine munition in the Baltic Sea 2024

Cruise No. AL622

14th – 21st October 2024,
Kiel (Germany) – Kiel (Germany)
„POST-Clear“

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2024

Table of Contents

1 Cruise Summary

1.1 Summary in English

ALKOR cruise AL622 took place as part of the project CONMAR (https://conmarmunition.eu/) which is part of the DAM mission sustainMare (https://www.sustainmare.de/). 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/), the EMFF (European Maritime and Fisheries Fund) -funded projects BASTA (Boost Applied munition detection through Smart data detection in and AI workflows; https://www.basta-munition.eu) and ExPloTect (Ex-situ, near-real-time detection compound detection in seawater).

ALKOR worked for one week in the Baltic Sea in the munition dumpsites Kolberger Heide, Lübeck Bight and the military training area of Schönhagen. Munition sites were mapped via hydroacoustic (subbottom profiler and synthetic aperture sonar) and visual (AUV, ROV and towed camera) methods. Water samples were taken for explosive-type compounds analysis and sediment samples for macro faunal distribution studies. Beam-trawl fishing was done for analyzing explosive-type compounds in local fish species and mussel moorings next to munition objects are part of an environmental monitoring. A change of crew happened on the 16th and 18th October in Neustadt i.H. with support of the munition clearance company SeaTerra.

1.2 Zusammenfassung

Die ALKOR-Fahrt AL622 fand im Rahmen des Projekts CONMAR (https://conmarmunition.eu/) als Teil der DAM-Mission sustainMare (https://www.sustainmare.de/) statt. Sie war die Fortsetzung der Munitionsüberwachung, die im Rahmen des BMBF-geförderten Projekts UDEMM (Umweltmonitoring für die Delaborierung von Munition im Meer; https://udemm.geomar.de/) und der vom EMFF (Europäischer Meeres- und Fischereifond) geförderten Projekte BASTA (Boost Applied munition detection through Smart data detection in and AI workflows; https://www.basta-munition.eu) und ExPloTect (Ex-situ, near-real-time detection compound detection in seawater) begonnen wurde.

ALKOR arbeitete eine Woche lang in der Ostsee in den Munitionsversenkungsgebieten Kolberger Heide, Lübecker Bucht und dem militärischen Trainingsgebiets Schönhagen. Die Munitionsversenkungsgebiete wurden mit hydroakustischen- (Sedimentecholot und SAS - Sonar mit synthetischer Apertur), sowie visuellen (AUV, ROV und Schleppkamera) Methoden kartiert. Darüberhinaus wurden Wasserproben für die Untersuchung von explosiven Verbindungen, sowie Sedimentproben für die Untersuchung der Verteilung von Makrofauna genommen. Die Baumkurrenfischerei wurde zur Analyse von explosiven Verbindungen in Fischen durchgeführt und Muschelverankerungen in der Nähe von Munitionsobjekten sind Teil einer Umweltüberwachung. Der Wechsel der Besatzung fand am 16. Und 18. Oktober in Neustadt i.H. mit Unterstützung der Räumfirma SeaTerra statt.

2 Participants

2.1 Principal Investigators

Name	Institution
Beck, Aaron J., Dr.	GEOMAR
Greinert, Jens, Prof.	GEOMAR
Vedenin, Andrej, Dr.	Senckenberg
Scharsack, Jörn, Dr.	Thünen Institut

2.2 Scientific Party

Name	Discipline	Institution
Greinert, Jens, Prof. Dr.	Marine Geology / Chief Scientist	GEOMAR
Keller, Mareike	Marine Geology / Senior Scientist	GEOMAR
Vedenin, Andrey, Dr.	Biology/Ecology	Senckenberg
Weiß, Tim	Data Management, Technical Support	GEOMAR
Nolte, Gabriel	Technical Support	GEOMAR
Knieschewski, Pia	Technical Support	GEOMAR
Preuss, Inken, Dr.	Biology/Ecology	GEOMAR
Beck, Aaron J., Dr.	Marine Geochemistry	GEOMAR
Esposito, Mario	Marine Geochemistry	GEOMAR
Scharsack, Jörn, Dr.	Beam-trawl Fishing / Fish analysis	Thünen Institut
Riemeier, Lea	Beam-trawl Fishing / Fish analysis	Thünen Institut
Scheer, Lars	Mussel Moorings	CAU Kiel
Diller, Nikolaj	AUV	GEOMAR
Lelie, Luca	AUV	GEOMAR
Starckjohann, Melf	AUV	GEOMAR

2.3 Participating Institutions

GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel Germany
Senckenberg am Meer, Wilhelmshaven, Germany
Thünen Fischereiinstitut, Bremerhaven, Germany

3 Research Program

3.1 Description of the Work Areas

Two working areas were investigated. The work inside the third area of Schönhagen was accompanying a military detonation exercise.

Area 1 – 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. **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 2 – **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 (Kampmeier et al., 2020).

Area 3 – **Schönhagen military exercise area**: The area of Schönhagen is about 16 km² in size and water depth is between 15 to 25 meters. Access to the area is only permitted with special authorisation, as military exercises are carried out here.

3.2 Aims of the Cruise

- Documentation of munition clearance activities prior to the cruise
- Ground truthing of potential munition objects with visual means (AUV and ROV)
- Water-, sediment- and biological sampling for munition compound determination and physical properties characterisation
- Biological sampling (including fishing) in munition dumpsites

3.3 Agenda of the Cruise

Day 1: Transit from Kiel to Schönhagen

- Departure from Kiel
- Deployment of OBS landers in the military exercise area
- Start of data logging for sound emissions

Day 2-3: Lübeck Bay

- Subbottom profiling with SES-2000 INNOMAR
- Mapping of munition sites via hydroacoustic and visual methods
- Water, sediment, and biological sampling

Day 4-6: Lübeck Bay

- AUV-based sidescan sonar, photo camera, and ROV-based video mapping of munition piles
- Fishing along beam-trawl lines
- Deployment of mussel moorings
- CTD water sampling and VanVeen grabbing
- Grid of CTD stations for water sampling

Day 7: Lübeck Bay

- Recovery of small landers with ADCP and ADP sensors
- Finalization of work in Lübeck Bay

Day 8: Transit to Kolberger Heide

- Transit to Kolberger Heide
- AUV- and ROV dives

Day 9: Schönhagen

- Military detonation experiments
- Water sampling for explosive-type compounds analysis

Day 10: Return to Kiel

- Return to Kiel
- End of the cruise

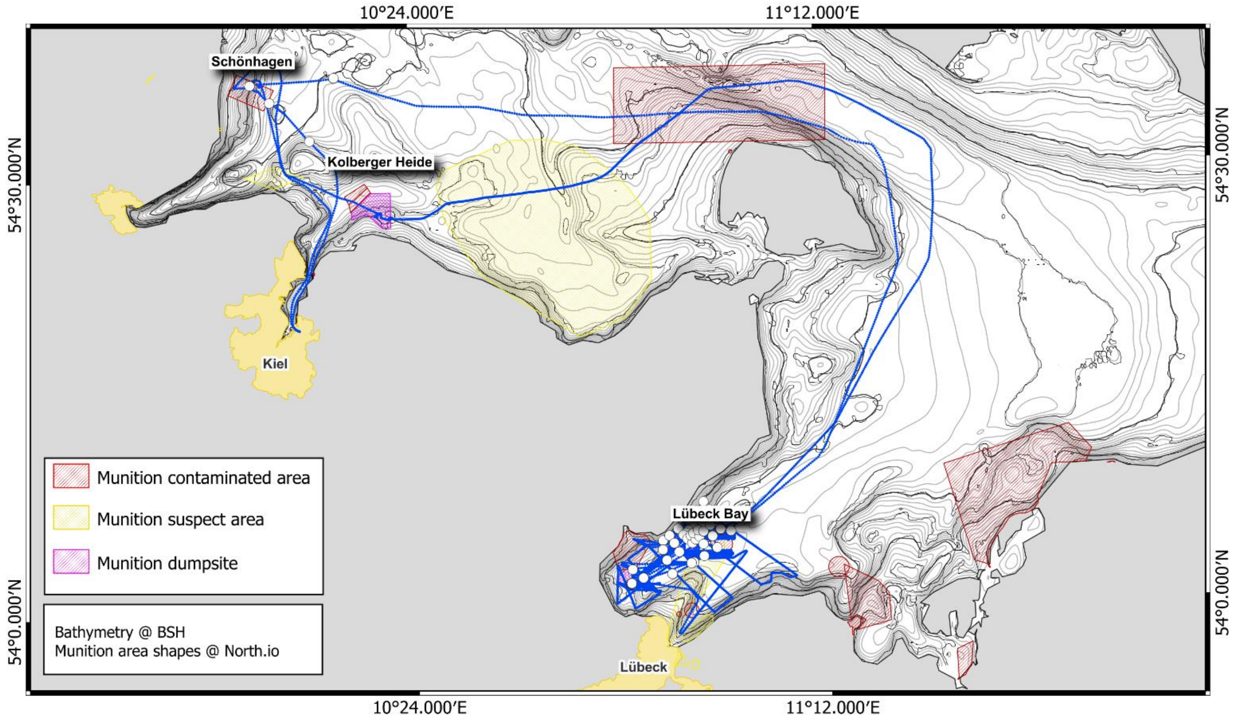

Fig. 3.1 Overall cruise track of AL622 in October 2024. Indicated are the CTD locations during the track (white dots), as well as munition contaminated areas.

Table 3.1 Cruise agenda and deployed scientific equipment.

Area	Date	Scientific Program
Transit to Schönhagen	14.10.2024	
Schönhagen	14.10.2024	CTD, OBS
Transit to Lübeck Bay	14.10.2024	
Lübeck Bay	14. – 20.10.2024	CTD, VanVeen grab, SBP, AUV (camera, sidescan sonar, magnetic, multibeam), ROV, mussel moorings, beam trawl, lander. ADCP/ADP, SAS
Transit to Kolberger Heide	20.10.2024	
Kolberger Heide	21.10.2024	AUV (camera, sidescan sonar, magnetic, multibeam), ROV
Transit to Schönhagen	21.10.2024	
Schönhagen	21.10.2024	Water sample
Transit to Kiel	21.10.2024	

3.4 Measures to conduct responsible marine research

All measures were taken with regard to the Declaration of Responsible Marine Research, the Code of Conduct for Responsible Marine Research in the Deep Seas and High Seas of the OSPAR Maritime Area, and the Mitigation measures for the operation of seismic and hydroacoustic sources with pulsed sound emissions. During the cruise only high frequency, low energy hydroacoustic systems like SAS and SBP were in use. All these systems can and will be started with low energy (soft start). Mammals, particularly porpoises, could be scared away in such a way. During the entire cruise, we paid attention to any sightings of mammals in the working area. During measurements, no harmful chemicals were released.

4 Narrative of the Cruise

The cruise started on Monday with the transit from Kiel to Schönhagen and first station was the deployment of OBS landers, which were equipped with hydrophones inside the military exercise area. They should monitor sound emissions caused by a military detonation experiment. To get a reliable background measurement, they were already deployed at the beginning of the cruise and already started logging data one week prior to the experiments.

After their deployment the cruise continued to the Lübeck Bay and the first night was used for subbottom profiling with the onboard SBP system (SES-2000 INNOMAR). So far, most munition was detected on the seafloor inside the dumping sites, but magnetic surveys show extensive magnetic anomalies where no munition is visible in previously generated data of the seafloor. On the one hand the sedimentary structure of the subseafloor should be displayed. On the other hand, the data should be compared to the magnetic anomalies in order to find possible buried munition clusters. Unfortunately, the SBP failed after three days due to a power issue, which could not be fixed during the cruise. In the following days, those munition piles, that were subject to the pilot clearing activities in September/October 2024, were mapped via AUV-based sidescan sonar, photo camera and ROV-based video. Fishing was done along the same beam-trawl lines as on cruise AL603 in March 2024 and mussel moorings were deployed next to the cleared munition piles and additional sites that contain open explosives. The same sampling schemes as on previous cruises was performed for CTD water sampling and VanVeen grabbing around those cleared piles. Additionally, a grid of CTD stations for water sampling is supposed to give a better picture for explosive-type compounds concentration distribution throughout the area of Pelzerhaken. Since a number of corroded munition objects with decomposing explosives have been detected, their influence on the local explosive type compound distribution shall be investigated. Furthermore, small landers with ADCP and ADP sensors were recovered, after they were deployed on AL615 in July 2024. They logged the water turbidity during clearance activities.

On Sunday 20th October 2024 the work in Lübeck Bay was finalized and we started the transit to Kolberger Heide. On Monday morning one AUV- and two ROV dives were performed before heading to Schönhagen. In the afternoon the military detonation experiments took place. Therefore, a smaller detonation was performed first, followed by 50 kg TNT equivalent explosives. Naval divers set up the charges inside a double ring bubble curtain. After the second detonation, researchers from AL622 were allowed to enter and take water samples for the analysis of explosive-type compounds in the water.

After the sampling ALKOR went back to Kiel and the cruise was finished on Monday evening.

5 Preliminary Results

5.1 AUV-Based Mapping

(N. Diller[1], L. Lelie[1], M. Starckjohann[1], M. Keller[1], M. Seidel, T. Weiß[1], J. Greinert[1])
[1]GEOMAR Helmholtz Center for Ocean Research Kiel

Description IQUA Robotics AUVs

ANTON, LUISE and KALLE are configurable autonomous underwater vehicles (AUVs) of the type Girona500/Girona1000 by IQUA Robotics. The general structure of the Girona1000 is very similar to the Girona500, but several improvements have been made to allow missions with depths of up to 1000 m instead of 500 m. Both types comprise of three torpedo-shaped hulls with 0.3 m in diameter and 1.5 m in length, are hold together by an aluminum frame, provide a good hydrodynamic performance and offer sufficient space for five thrusters, an advanced integrated navigation system, several means for communication and sensor payloads. The overall dimensions of these vehicles are 1 m in height, 1 m in width, 1.5 m in length and a weight of less than 200kg. The two upper hulls, which contain most of the buoyancy foam and the electronics housing, are positively buoyant, while the lower one contains 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 passive stability in pitch and roll even at low speeds, making it suitable for imaging surveys. Another advantage of the Girona500/Girona1000 is its capability to be easily reconfigurable for different tasks.

The COLA2 infrastructure on the Girona AUVs is the central control software, developed by IQUA Robotics (Girona, Spain). The communication between ship and AUVs under and above water is controlled by BELUGA, developed by the GEOMAR AUV group.

In addition to the navigational sensors like INS (Inertial Navigation System), DVL (Doppler Velocity Log), Pressure Sensor, USBL and GPS, a CTD (Conductivity, Temperature, Depth) type Seabird FastCAT SBE49 is mounted by default.

An overview of all components for navigation and optional payload can be found in Table 5.1.

Table 5.1. Overview of components for navigation and optional payload

System	Device	Description
Navigation	INS: iXblue Phins Compact 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% position accuracy
	DVL: Teledyne RDI Explorer 600 kHz (ANTON/LUISE) DVL: Teledyne Tasman 300 kHz (KALLE)	The device measures the velocity relative to the sea floor and its altitude.
	Pressure sensor: Valeport ultraP	The 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 and enables the vehicle‘s integration into the BELUGA network.

	GPS: Quectel L86 GNSS (ANTON/LUISE) GPS: U-Blox ZED-F9P (KALLE)	The GPS is used to determine the absolute position at the surface.
	Sonar: Tritech Gemini 720im	Multibeam imaging sonar in a compact housing that has a depth rating of 750 m. Mounted forward-looking at the top edge of the AUV as a preparation of obstacle avoidance
Payload	Sea-Bird SBE 49 FastCAT	The device acquires the conductivity, temperature and pressure of the surrounding water and calculates the sound velocity.
	CoraMo mk II Camera	CoraMo mk II camera is a down- or forward-looking camera system for photographic surveys, built by the AUV team of GEOMAR. It can take up to two images per second with a resolution of 12.34 MP. CoraMo supports connections for eight high power LEDs that are arranged in a ring around the camera.
	Norbit Wideband Multibeam Sonar WBMS	Compact wideband multibeam sonar for high resolution bathymetry. With a flexible swath coverage of 5 – 210° and 256 – 512 beams. The nominal operating frequency is 400 kHz (frequency agility 200 – 700 kHz) with an adaptive ping rate of up to 60 Hz.
	Fluorometer Seabird ECO FLNTURTD	Chlorophyll and turbidity sensor with 6000 m depth rating. Fluorescence is measured with an excitation wavelength of 470 nm, an emission wavelength of 695 nm and a typical range of 0 to 50 µg/l Chl. Turbidity is measured with a wavelength of 700 nm and a sensitivity of 0.013 NTU. The sample rate of up to 8 Hz is user selectable.
	Optode: Aanderaa Optode 4330	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.
	Magnetometer: Sensys MX3D UW	The system consists of up to five single magnetometers connected to one data acquisition unit. Each magnetometer is sampling three dimensions with a rate of 200 Hz.
	Sidescan: Marine Sonic Arc Scout MKII	Sidescan Sonar with operating frequencies of 900 kHz, 80 m range with 10 cm along track resolution and 1800kHz, 25m range with 5 cm along track resolution.

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 and diving depth. 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 5.2. Stationlist of AUV dives with processing status of AUV data products.

Station	Products	Comment	Quality	Area
AL622_018_AUV_Kalle_046	SSS mosaic	test		Haffkrug
AL622_018_AUV_Kalle_047	SSS mosaic	Haf_00002	good	Haffkrug
AL622_018_AUV_Kalle_048	SSS mosaic		good	Haffkrug
AL622_018_AUV_Kalle_049	SSS mosaic	Haf_00002	good	Haffkrug
AL622_040_AUV_Kalle_050	SSS mosaic	Pzh_0037	good	Pelzerhaken
AL622_042_AUV_Anton_330	none	Haf_00002	bad	Haffkrug
AL622_066_AUV_Kalle_051	SSS mosaic	Pzh_0012	good	Pelzerhaken

AL622_078_AUV_Luise_386	none	Magn. Anomaly	bad	Pelzerhaken
AL622_094_AUV_Anton_331	DEM, Mosaic	Pzh_0012	good	Pelzerhaken
AL622_104_AUV_Luise_387	DEM, Mosaic	Magn. Anomaly	good	Pelzerhaken
AL622_107_AUV_Luise_388	DEM, Mosaic	Magn. Anomaly	good	Pelzerhaken
AL622_148_AUV_Kalle_053	SSS mosaic		good	Pelzerhaken
AL622_148_AUV_Kalle_054	not processed yet	MBES		Pekzerhaken
AL622_149_AUV_Luise_389	DEM, Mosaic	large boxes	good	Pelzerhaken
AL622_166_AUV_Anton_333	DEM, mosaic	Haf_00002	good	Haffkrug
AL622_167_AUV_Kalle_055	not processed yet			Launcher Test
AL622_171_AUV_Luise_390	Magnetic, no DEM, Mosaic	Magn. anomaly	bad	Pelzerhaken
AL622_172_AUV_Kalle_056	not processed yet	MBES		Pelzerhaken
AL622_172_AUV_Kalle_057	SSS mosaic		good	Pelzerhaken
AL622_175_AUV_Luise_391	DEM, mosaic		good	Kolberger Heide
AL622_176_AUV_Kalle_058	SSS mosaic		good	Kolberger Heide

AUV-based Magnetics

The vast majority of munition objects contain significant quantities of ferromagnetic materials and thus are detectable by magnetometers. In the field of systematic marine munition detection, AUVs are more and more utilized for acquiring magnetic data to reliably detect hazardous objects. The utilized magnetic sensors are FGM3D/100 UW II 3-axis fluxgate magnetometers from SENSYS GmbH, integrated into GEOMAR's Girona 500 AUV *LUISE*. In the present configuration (used during AL622), four magnetometers are attached to the AUV in a distance of 1.5 m between the sensors and the nose of the AUV. Three magnetometers are arranged side-by-side on the lower level to acquire three parallel tracks of magnetic data simultaneously. A fourth magnetometer is positioned above the central lower magnetometer to allow for the measurement of the vertical magnetic gradient. Arranging the sensors in the displayed configuration allows for the measurements of all three spatial magnetic gradients. The two outer lower sensors act as a horizontal gradiometer while the third gradient is obtained by comparing acquired values from the lower central sensor while moving forward a fixed distance.

Fig. 5.1 shows AUV *LUISE* carrying the magnetometer construction and a camera system including illumination for ground truthing and to eventually create photo mosaics of the seafloor when the underwater visibility is sufficient. The construction that carries the sensors is made of the thermoplastic polymer ABS (Acrylonitrile butadiene styrene). 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 approximately 2.5 m, yielding a sufficient data quality. The magnetometers are sampling at frequencies of up to 200 Hz but the data is usually down sampled to 20 Hz for plotting and data interpretation. Operational flight altitudes of the current system vary between 1 and 2.5 m. The surveys are usually conducted at velocities around 0.4 – 0.5 m/s. With a sampling rate of 20 Hz and an AUV velocity of 0.5 m/s, the data point spacing along track is 2.5 cm. If the production of detailed and interpolated 2D magnetic maps is desired, line spacings of magnetic AUV missions should not exceed 2 m (0.8 m - 1 m is recommended). AUV velocities should be around 0.35 or 0.4 m/s to prevent blurring effects at flight altitudes way below 2 m, depending on the underwater visibility.

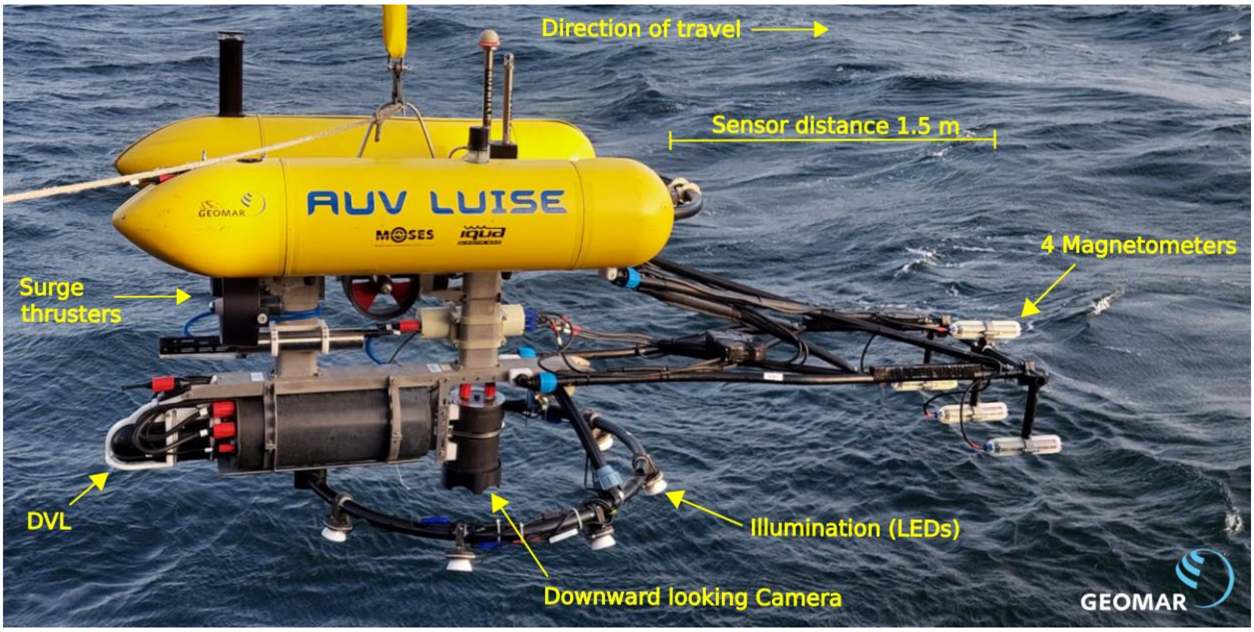

Fig. 5.1 GEOMAR's Girona 500 AUV LUISE with four submersible SENSYS fluxgate magnetometers and a camera system including illumination in the configuration of 2024.

Magnetics Results

We conducted a total of six missions with AUV *Luise* using Magnetometers during AL622, listed in the following table:

Table 5.3 List of missions of AUV Luise using magnetometers during the AL622 cruise in the Baltic.

Luise Mission #	Date	AL622 Station	Area	Comment
386	2024-10-17	078	Pelzerhaken	65 x 103 m²
387	2024-10-18	104	Pelzerhaken	48 x 72 m²
388	2024-10-18	107	Pelzerhaken	70 x 63 m²
389	2024-10-19	149	Pelzerhaken	46 x 49 m²
390	2024-10-19	171	Pelzerhaken	46 x 49 m²
391	2024-10-19	175	Kolberger Heide	45 x 53 m²

In the region of Pelzerhaken, we investigated several munition hotspots. Figure XXX exemplarily shows results of *Luise* mission # 386. The flight altitude and velocity of the AUV were 1.4 m and 0.5 m/s. The line spacing was set to 2.5 m. During this mission, we discovered an extremely large magnetic anomaly reaching TMI (Total Magnetic Intensity) values of > 110.000 nT, a value which has not been measured since the first AUV dives using magnetometers at the GEOMAR in April 2020. The video footage of that missions indicates that this anomaly is related to an unknown though relatively large metallic body (probably non-UXO) that stands out ~1 m above the seafloor.

Thus, the magnetometers were passing by the object only ~0.4 m which explains the magnitude of the anomaly at least partially.

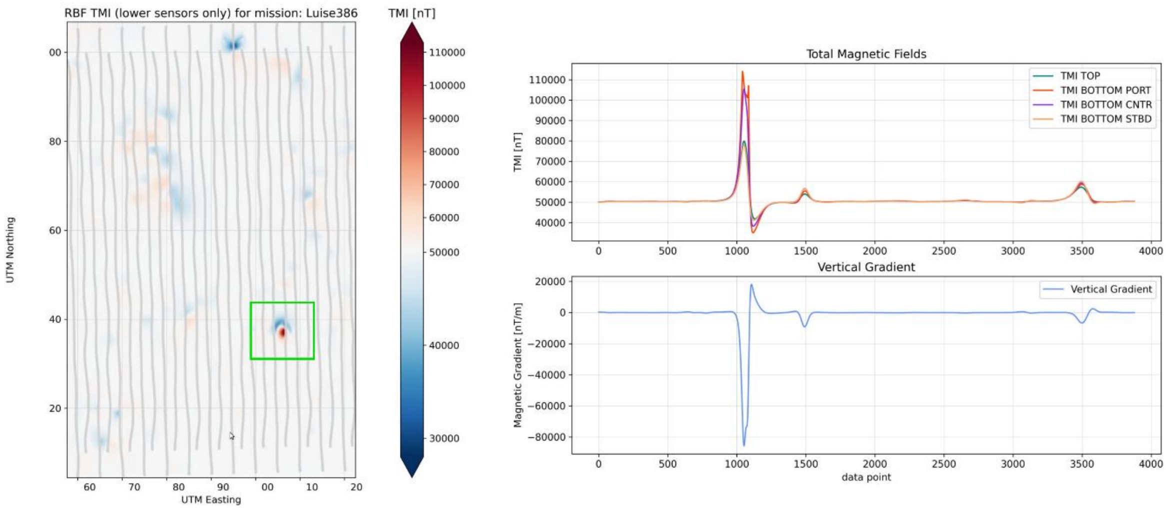

Fig. 5.2 Left: Interpolated 2D magnetic map (TMI) of Luise mission # 386. Right: 1D time series data (TMI and vertical magnetic gradient) of a flight line crossing the anomaly marked as a green square in the left image. The anomaly reached extremely high values > 110.000 nT.

Photo mosaic results

Three munition piles have been subject of clearing so far. For an optical monitoring, they have been mapped on previous cruises and were re-mapped on AL622. However, a photo survey on Pzh_0037 was not possible due to ropes interconnecting the wet storage underwater containers.

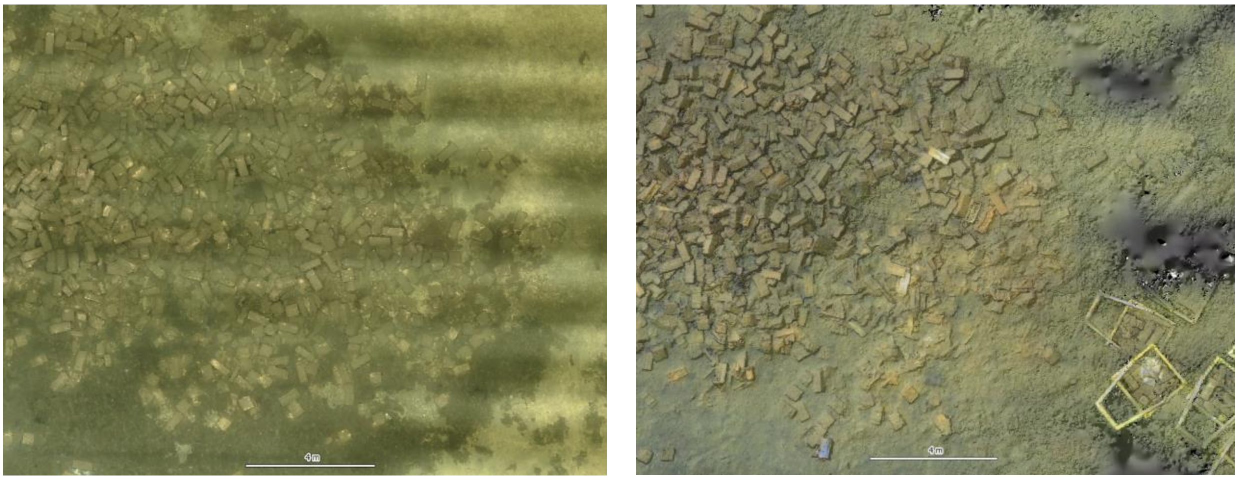

Fig. 5.3 Two photomosaics from the munition pile Haf_00002 in Lübeck Bay. On the left side: A mosaic from July 2024 prior to clearance activities. On the right side: a mosaic in October 2024, after clearance activities.

In Haffkrug the effect of the clearance activities is clearly visible. Approximately 1/3 of the pile is disturbed and munition boxes are open and their content is loose. Some items have been stored in 1.5 x 1.5 m large metal mesh boxes, which are placed on the south-eastern end of the pile. Phosphorus ammunition has been securely stored inside a barrel at the southern edge of the pile.

Less distinct changes are in pile Pzh_00012. Two large containers have been placed north and south of the pile, which are closed with a lid. A few munition boxes seem to have been cleared and relocated into the wet storage containers (Fig. 5.4). While the other parts of the ammunition do not appear to be affected, it is noticeable that the large aerial mine is heavily corroded (Fig. 5.4). A large hole is visible on its top, which was not present in July 2024. The cause of this is unclear.

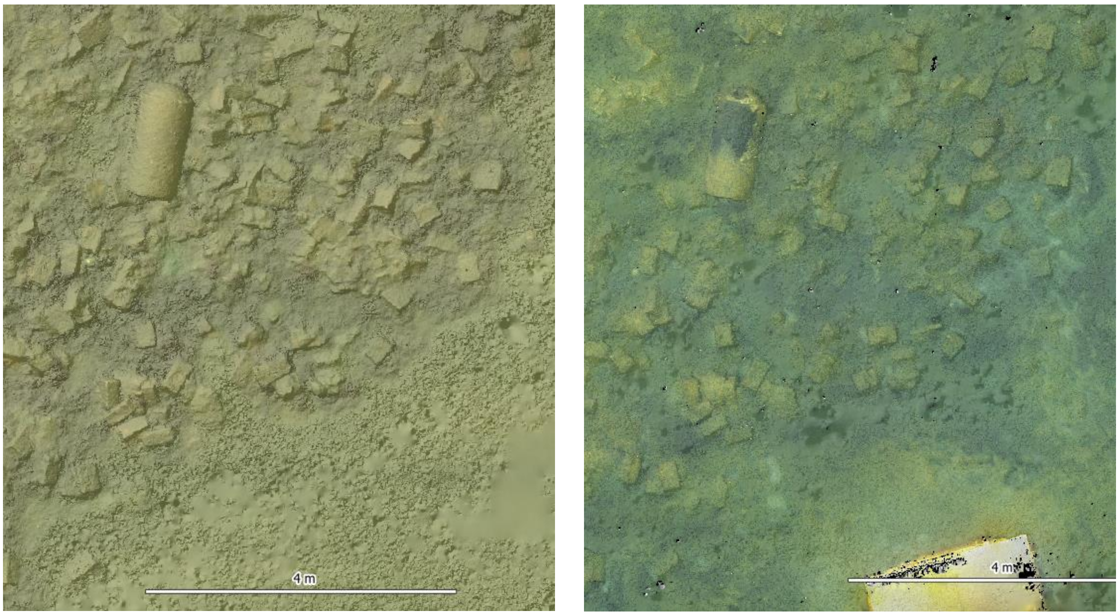

Fig. 5.4 Two photomosaics from the munition pile Pzh_00012 in Lübeck Bay. On the left side: A mosaic from July 2024 prior to clearance activities. On the right side: a mosaic in October 2024, after clearance activities.

In addition to the partially cleared piles, photomosaics of large-scale magnetic anomalies were created. The mosaic does not show any object on the seabed that would explain such a large anomaly, but shows several almost completely buried munitions objects (crates and tail units of bombs) (Fig. 5.5). This suggests that more munitions could be buried in the sediments than previously assumed.

Fig. 5.5 Buried munition items in Lübeck Bay. To explain a large magnetic anomaly, even more munition has to be completely buried inside the sediment.

Sidescan sonar results

All cleared piles have been explored with AUV KALLE; first to make sure that no obstacles endanger the lower-diving AUVs ANTON and LUISE. On the sidescan mosaics the traces from the clearance equipment which was used by the clearance companies are visible (Fig. 5.6). Furthermore, the sidescan reveals numerous new objects that were not detected with ship-based multibeam sonar on previous cruises.

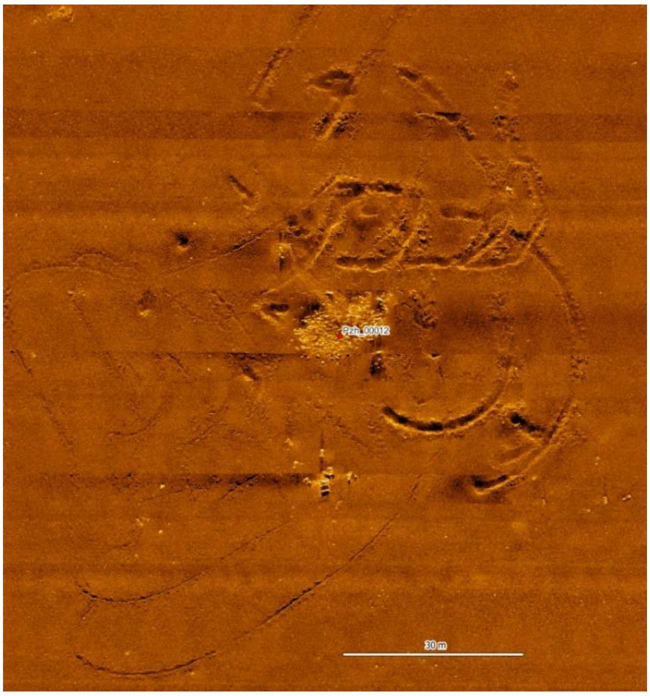

Fig. 5.6 AUV-based sidescan sonar mosaic showing tracks from UXO clearance gear on the seafloor in Lübeck Bay.

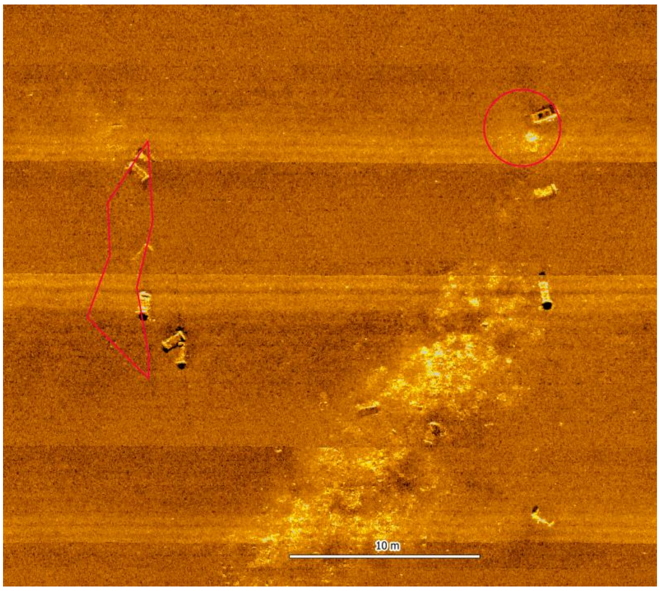

Fig. 5.7 AUV-based sidescan sonar mosaic, showing several large munition boxes. Red polygons indicate munition contacts that were annotated based on ship-based multibeam data. Not all of the boxes could be detected inside the multibeam data.

5.2 AUV-Launching System

(G. Nolte[1], N. Diller[1], M. Keller[1])
[1]GEOMAR Helmholtz Center for Ocean Research Kiel

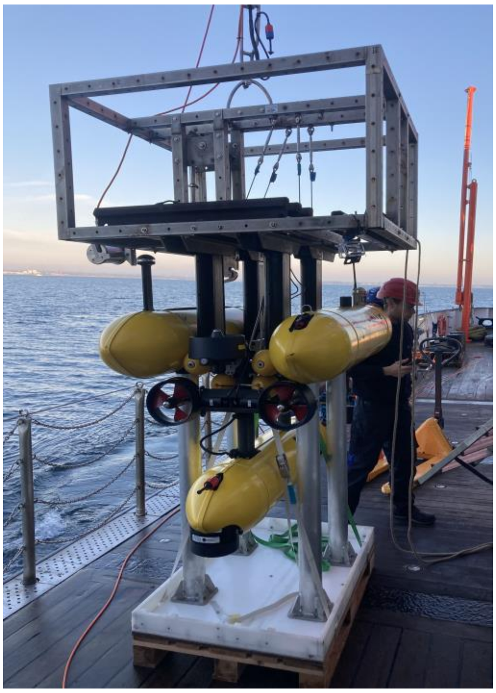

Fig. 5.8 GIRONA1000 AUV KALLE attached to a launching system.

During AL622, the Girona1000 was deployed for the first time using a launcher system. A launcher frame from GEOMAR's BIGO lander serves as the basis for this (Fig. 5.8). Supports were installed on this frame, which engage in the corresponding mount of the AUV. Using a GEOMAR quick release, the AUV is clamped to the launcher with a steel cable and held in place until the quick release is triggered and the AUV separates from the launcher. To launch the AUV it was first kept in idle mode. By reaching the required water depth, the thrusters were enabled and the mission started. Only after checking that the thrusters are active, the AUV was released.

In addition, 280 kg of railway tracks were installed on the launcher so that the system can be anchored stably. A test showed that the AUV moved 2° in roll and pitch at a speed of 0.5 m/s at 10 m.

5.3 ROV Mapping and Recovery

(T. Weiß[1], G. Nolte[1], P. Knieschewski[1], J. Greinert[1], M. Keller[1])
[1]GEOMAR Helmholtz Center for Ocean Research Kiel

„Käpt'n Blaubär" is a small sized ROV (BlueROV 2) which was used for visual surveys of ammuntion dump sites. The ROV is connected via a 300m long cable spool. It was deployed using a rope and on a quick release. During a survey one person controlled the winch and obeyed the cable in the water, a second person controlled the navigation- and sonar software (OFOP, Pingviewer) and a third person was the ROV pilot. The pilot used the QGroundControl-software and a standard game pad to control the vehicle.

The ROV is equipped with a HD Camera (1920 x 1080 px). The video stream was recorded on the control laptop in h264-format (mkv-container). A 360° scanning sonar and an Evologics USBL transponder was installed on the top side of the vehicle for navigation purposes. Hence it was possible to precisely navigate to points of interest at different sites even in conditions of low visibility and in far distances. The USBL signals were processed by Evologics Sinaps software package on a standard laptop. The calculated positions were forwarded to OFOP and displayed on a multibeam map.

It is powered by battery. One battery package supplies the ROV with energy for dive times between 30 to 60 minutes. An additional battery was used as a power supply for the USBL transponder.

The DVL was used to enable „keep position" which improves the overall navigation and video results as the ROV is much more stable.

A pump to suck the water through the water sampling tubes realizes water sampling without ROV movements.

A line threader „Jolly Hook" was added to pick up moorings (e.g. ADCPs, ADPs) in the front of the ROV (Fig. 5.9).

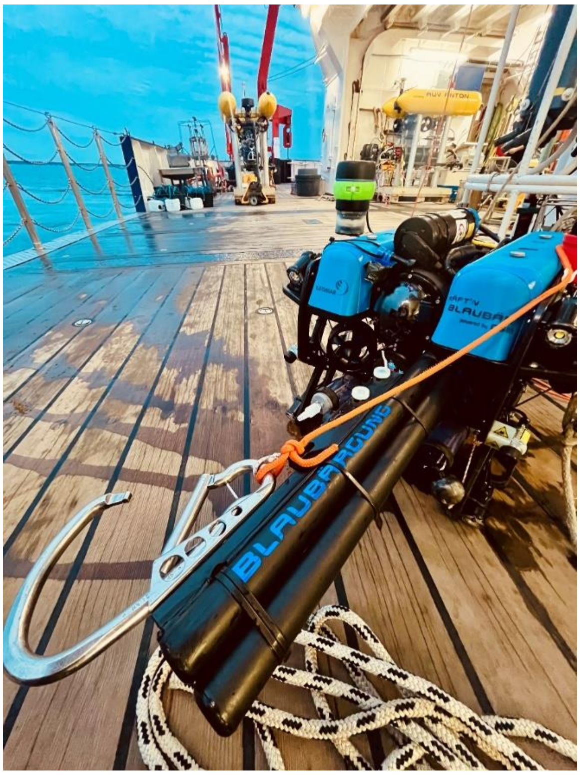

Fig. 5.9 ROV Blaubär with attached recovery tool for picking up moorings on the seafloor.

On this cruise, the ROV was used to deploy and recover mussel moorings in vicinity to munition piles, recovering ADCP and ADP's, which were deployed on AL615 in July 2024 and to groundtruth munition contacts and taking water samples close to open explosives (Fig. 5.10).

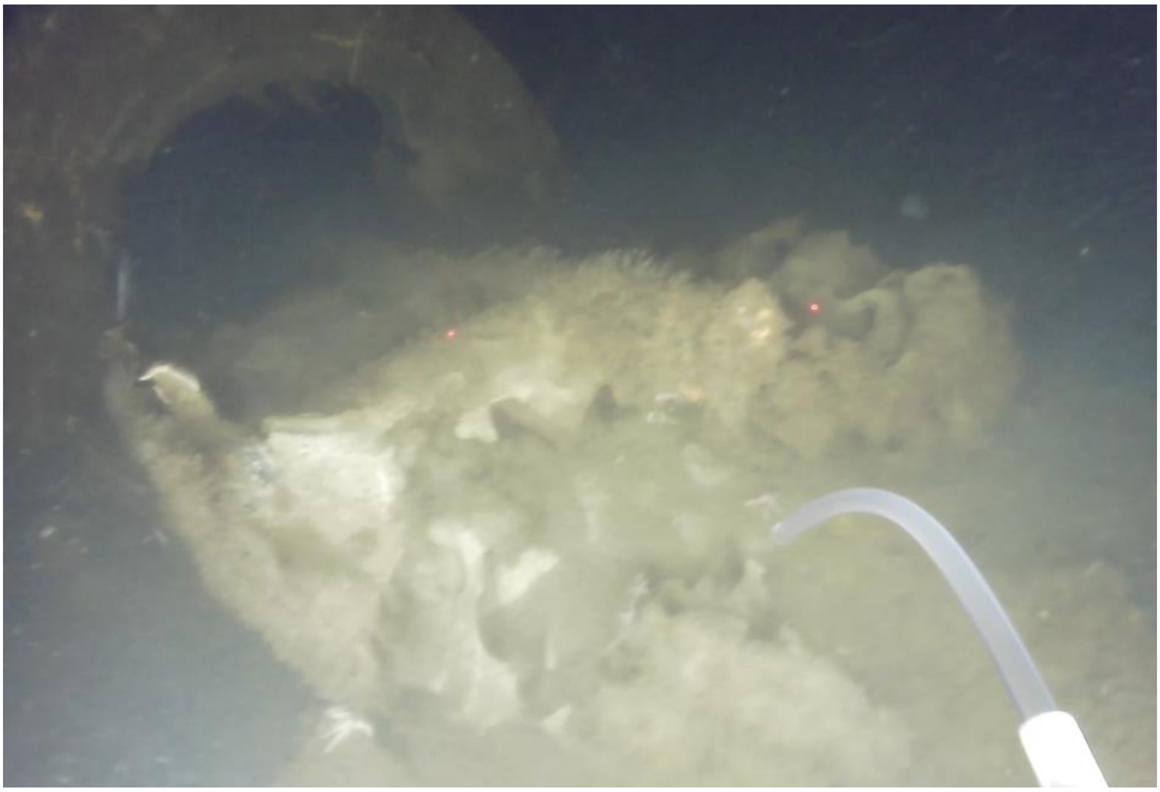

Fig. 5.10 Watersampling via ROV Blaubär for EC analysis directly at open explosive.

5.4 OBS Moorings

(M. Seidel[1], J. Greinert[1])
[1]GEOMAR Helmholtz Center for Ocean Research Kiel

In the context of the forthcoming project TRANKIEL (Techniques for Reducing hydro-Acoustic Noise from underwater explosions in KIEL Bay), five ocean bottom seismometers (OBS) have been deployed in the western regions of Kiel Bay. The OBSs are utilized to obtain seismo-acoustic data during a series of controlled underwater explosions conducted by the German Navy and the WTD (Wehrtechnische Dienststelle der Bundeswehr) 71 between 21st and 28th October.

An ocean bottom seismometer (OBS) is a device utilized for the measurement of seismic activity on the ocean floor. The device is equipped with sensors that are capable of detecting vibrations resulting from earthquakes, volcanic activity, and other seismic events. The sensors are encased in a waterproof housing and deployed on the seafloor. The data collected by the OBS is retrieved when the device is recovered. In addition to the seismic sensors, the OBS contains a hydrophone, which is used to acquire acoustic activity in the water column. A hydrophone is an underwater microphone that is designed to detect and record sounds in water. It is capable of picking up acoustic signals, such as the sounds of marine life, ship movements, and underwater earthquakes. The device then converts the sound waves into electrical signals, which can then be analysed.

It is anticipated that the OBS will be recovered on 11 November 2024, during an ALKOR cruise in November, 2024. The recovery operation will be conducted using GEOMAR's BlueROV, the

Käpt'n Blaubär. Consequently, there was no requirement to equip the OBS systems with floating bodies.

Table 5.4 Geographical coordinates of five OBS systems that have been deployed during AL622 for the new project TRANKIEL.

Name	Longitude E	Latitude N
OBS-1	10.20424	54.54574
OBS-2	10.15377	54.57898
OBS-3	10.12645	54.59037
OBS-4	10.10452	54.60406
OBS-5	10.25362	54.61769

5.5 Subbottom-Profiling

(M. Seidel[1], M. Keller[1])
[1]GEOMAR Helmholtz Center for Ocean Research Kiel

A sub-bottom profiler operates by emitting sound waves that penetrate the seafloor. The sound waves are produced by a transducer, which acts as a speaker to send out the sound and as a microphone to receive the echoes.

The transducer sends out a series of sound pulses, typically in the frequency range < 100 kHz. These sound waves travel downwards through the water column until they hit the seafloor. Here, the sound waves are partially reflected by the density contrast between the water and the seabed while the remaining energy of the waves continue to travel through the sediments and rock layers beneath it. Each type of sediment or rock has a different density, which affects how the sound waves are reflected or travel through it.

Reflected echoes are picked up by the transducer (which now functions as a receiver). The time it takes for the sound waves to travel down, hit a boundary, and return to the receiver is recorded. Knowing the speed of sound in water (approximately 1500 m/s) and in the sediments (usually between 1500 and 2000 m/s) allows for the calculation of the depths of the reflecting layers. Different sediment types alter the speed, so travel time corrections are sometimes necessary.

The two different high-frequency beams produced by the transmitter intersect in the water, they interact nonlinearly. This interaction results in the generation of a low-frequency differential signal, also known as the *parametric* signal. This process is called parametric conversion. The low-frequency signal created through parametric conversion has a much longer wavelength compared to the original high-frequency beams. Thus, the low-frequency signal can penetrate the seabed more effectively. The reflected low-frequency signals are then processed to create a detailed image of the sub-seabed structures.

Advantages of the Parametric Sub-Bottom Profiler

- High Resolution: The use of high-frequency beams for generating low-frequency signals results in sharper sound pulses and better vertical resolution compared to traditional low-frequency systems
- Deep Penetration: The low-frequency signal can penetrate deeper into the seabed, allowing for the detection of deeper structures

- Narrow Beams: The parametric process creates narrow beams, which help in achieving high-resolution imaging

GEOMAR's RV ALKOR has a built-in SBP system SES2000 "Medium-100" from Innomar GmbH. The Innomar Medium 100 represents an advanced parametric sub-bottom profiler, engineered for a wide range of offshore applications. It operates efficiently across water depths from 2 meters up to 2,000 meters, with the capability of penetrating sub-seafloor sediment to depths of up to 70 meters, contingent on the sediment type and ambient noise conditions. This profiler delivers high-resolution sub-bottom imaging with a vertical resolution superior to 10 cm. The transducer is integrated into the hull of the vessel. The system is capable of acquiring full-waveform data at a 24-bit resolution, suitable for processing with standard seismic software (format: SEG-Y). The Innomar Medium 100 features multi-frequency signal capabilities, offering selectable pulse types (Ricker, continuous wave (CW), and frequency modulation (FM) chirp), and incorporates heave, roll, and pitch compensation mechanisms to ensure stability in data acquisition. Remote control is facilitated via COM or Ethernet (UDP), with options for extended remote control through Ethernet. The profiler is bundled with SESWIN data acquisition software and ISE post-processing software for comprehensive data management.

In terms of technical specifications, the primary frequency range is centered around 100 kHz (bandwidth: 85 – 115 kHz), while the secondary low-frequency signal can be user-selected within a range of 4 kHz to 15 kHz. The system produces a narrow beam width of approximately 2° (±1°) for all frequencies and achieves a maximum ping rate of 40 Hz, supporting multi-ping operations. Data files are recorded in the Innomar SES3 (24-bit) format and can be converted to SEG-Y using SESConvert.

The Innomar Medium 100 is particularly well-suited for diverse applications, including offshore engineering for locating buried pipelines and cables, geological surveys for sediment and geological feature analysis, marine archaeology for underwater site detection and mapping, and environmental studies assessing anthropogenic impacts on the seabed like UXO.

SBP Results

During AL622, a total of 23 east-west oriented SBP profiles have been measured near and across the munitions dump site of Pelzerhaken using ALKOR's built-in SES2000 SBP device. The profile length was approximately 5 km and the average water depth was 21 m. Though it was very difficult to reliably locate UXO objects in the seismic data, marine sediments of the first 5-15 m have been detected.

During data acquisition, the files are saved in the .raw and .ses formats and are subsequently converted into the SEG-Y format using the software SESCONVERT. Data was then processed using the SonarWiz 7 software. Figure 5.11 shows a 3D projection of all SBP profiles together with a bathymetry map of the survey area. The vertical exaggeration of the scene is factor 90.

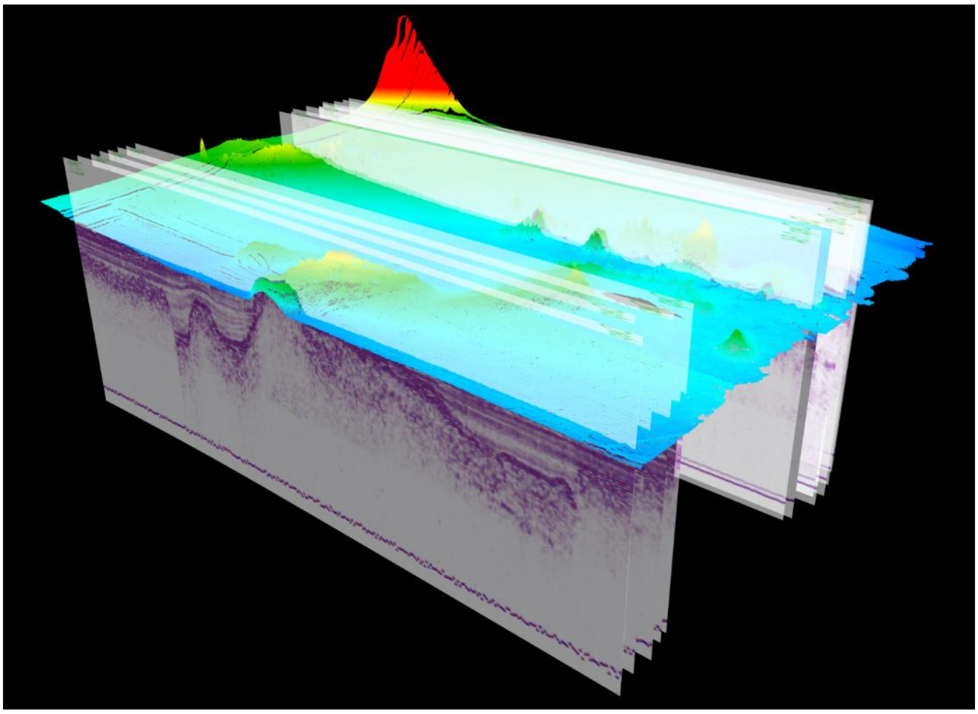

Fig. 5.11 3D projection of the SBP results and a bathymetry map of the survey area near Pelzerhaken.

Unfortunately, the SES2000 device was not working properly after two nights of measurements. The receiver seemed to work properly but the transmitting signal faded away after a few seconds each time, the transmitter has been turned on. After the AL622 cruise, technicians of the Innomar GmbH investigated the malfunction and repaired the device. The system's power supply was broken.

5.6 Distribution and Sources of Dissolved Munition Compounds in the Water Column

(A. J. Beck[1], M. Esposito[1])
[1]GEOMAR Helmholtz Center for Ocean Research Kiel

Background and Objectives

The primary explosives of concern at historical munitions dumpsites include 2,4,6-trinitrotoluene (TNT), 1,3,5-Trinitro-1,3,5-triazinane (or "Royal Demolition Explosive", RDX), and 1,3-dinitrobenzene (DNB). Two metabolites of TNT, 2-amino-4,6-dinitrotoluene (2-ADNT) and 4-amino-2,6-dinitrotoluene (4-ADNT), are formed during biotic transformation in the environment through the reduction of the respective nitro group to an amino group (Juhasz and Naidu, 2007). Although low levels of MC (sub µg/l) have been occasionally detected at some sites directly adjacent to submerged munitions (Darrach et al., 1998; Rodacy et al., 2001; Porter et al., 2011), the majority of studies have not detected measurable concentrations of MC in seawater and sediments (Hoffsommer and Rosen, 1972; Hoffsommer et al., 1972; Ampleman et al., 2004; Ek et al., 2006; NOAA and Ridolfi, 2006; Simmons et al., 2007; CH2M HILL, 2015). This is because analytical sensitivities are often insufficient to detect the very low MC concentrations present in the marine environment.

To better understand the distribution, cycling, and fate of MC from submerged munitions, Gledhill and colleagues (2019) developed a new method for determination of MC in seawater. The method uses ultra-high-performance liquid chromatography coupled to mass spectrometric detection to provide unequivocal compound identification and exceptional sensitivity. This method was adapted for shipboard analyses by Esposito and colleagues (2023), and a prototype system developed that employs the adapted method.

Measured concentrations of dissolved MC in the Baltic Sea generally range between 1 and 10 ng/L (Gledhill et al., 2019), although TNT concentrations as high as 3 mg/L were measured in one sample collected directly at the surface of exposed explosive solids (Beck et al., 2019). Other munition-surface analyses reached a maximum of 50, 2, and 20 µg/L for TNT, RDX, and DNB, respectively (Beck et al., 2019). Microbial biotransformation products of munition compounds (i.e., ADNTs) have also been detected in the water column, indicating that low measured concentrations of the primary explosives may be controlled by dissolution and release as well as degradation and removal processes.

The goal of the current work was to map the distribution of dissolved explosive chemicals in the study region and perform targeted analysis of water samples near munition objects to evaluate potential contamination sources to the water column.

Methods

Discrete water samples for laboratory analysis

Discrete water samples were collected from the Niskin rosette at the sea surface and above the seafloor at 1-2 m height. Discrete samples were filtered through a glass fiber filter membrane (1.2 µm) before solid-phase extraction (SPE) preconcentration. Dissolved MC will be measured in the current work using the method of Gledhill and colleagues (2019), which relies on ultra-high-performance liquid chromatography coupled to mass spectrometric detection to provide unequivocal compound identification and exceptional sensitivity. In addition, this method can quantify the primary compounds resulting from MC degradation and transformation, allowing evaluation of biogeochemical processes affecting the cycling and fate of MC in marine systems. Seawater was preconcentrated 1000-fold before analysis on Chromabond EASY SPE columns, with detection limits for the most abundant MC on the order of 1-10 pg/L. A simple method was developed at GEOMAR in 2018 that uses infusion bags to preconcentrate explosives via SPE using passive gravity flow (in Greinert et al., 2019). This method enables the rapid collection of many samples, allowing for the high-resolution spatial coverage necessary to observe spatial patterns around individual munitions piles on the seafloor.

Shipboard MC analysis

Discrete samples for shipboard analysis were also collected from the CTD Niskin bottles (bottom water only) and from Niskin or similar water samplers mounted on a small ROV and on a towed video platform (XOFOS, eXtended Ocean Floor Observation System). These samples were measured onboard during AL22 using the Xplotector lab-in-a-box system (Fig. 5.12). Details of the system have been previously reported (Esposito et al., 2023). Briefly, the system consists of a fluidics module coupled to an analytical module. The fluidics module uses several HPLC pumps and switching valves to automate explosive chemical preconcentration from seawater, including inline particle filtration (0.5 µm). The preconcentrated sample is then injected into the analytical module, which performs HPLC chromatography and analysis of target compounds by UV spectroscopy and mass spectrometry. As part of the VAMOS project (BMBF project number 03F0942A), the Xplotector system was improved with a higher-sensitivity compact mass spectrometer, the Advion expression CMS, with an improved detection limit for TNT and detection capabilities also for ADNT, RDX, and DNB. The integration of the CMS into the Xplotector system was tested and demonstrated during cruises AL603 (October 2023) and AL615 (July 2024).

Fig. 5.12 The Xplotector analysis system installed in the wet lab on RV Alkor on AL622.

In-situ MC sample collection

A simple lander was constructed for collection of time-series dissolved MC samples (Fig. 5.13). The lander consisted of the XploTaker device, which is housed in an underwater pressure housing and pumps water over SPE columns to preconcentrate dissolved MC. Up to ten samples can be collected in one deployment according to a preset time program. The samples are analyzed after recovery by connection to the Xplotector system. The lander also contained a battery for powering the XploTaker. The XploTaker lander was deployed twice in Lübeck Bay.

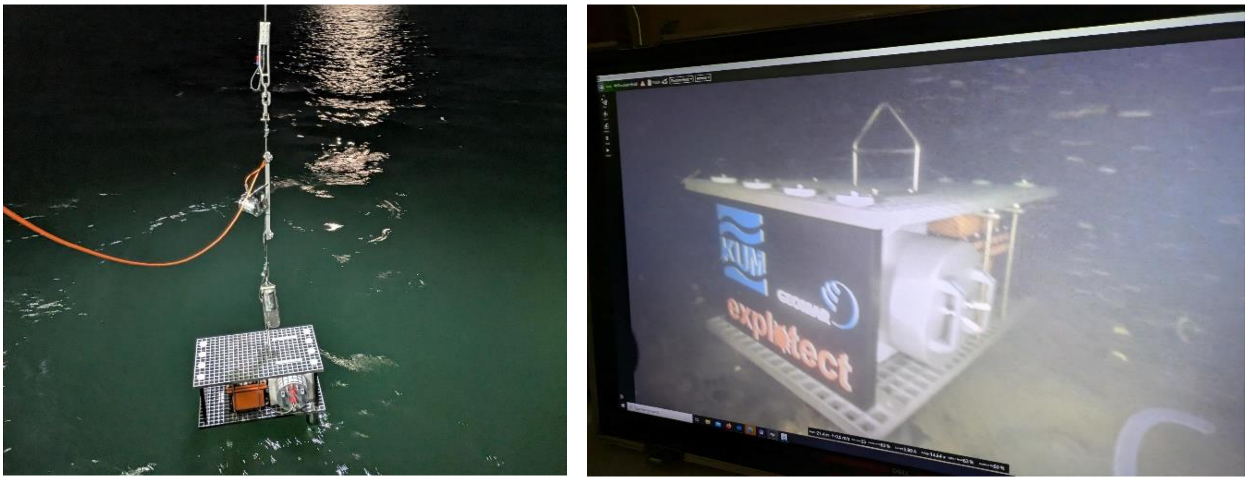

Fig. 5.13 (left) Deployment of the XploTaker lander in Lübeck Bay. The pressure tube on the righthand side is the XploTaker device, powered by the orange battery in the middle. (Right) The lander on the seafloor, viewed from the Käpt’n Blaubär ROV.

Preliminary results and discussion

Dissolved MC distribution in Pelzerhaken

High resolution sampling was conducted with 34 CTD casts in the Pelzerhaken region where previous work has shown particularly high levels of MC contamination (Arinaitwe et al., 2024). Numerous large munitions with extensive areas of exposed explosive material have been identified in this region, and been nicknamed after various types of cheese given their similar appearance. Samples were analyzed on board with the Xplotector system. Results show relatively low concentrations of dissolved TNT and RDX around the borders of the study region, and a zone of higher concentrations in the center and southwestern areas (Fig. 5.14). Modeled bottom currents during the sampling period show slow current transport from the north and east toward the southwest. The spatial distribution suggests that these open explosive objects indeed represent the major MC source in Pelzerhaken, and currents carry a plume of dissolved MCs away from the objects.

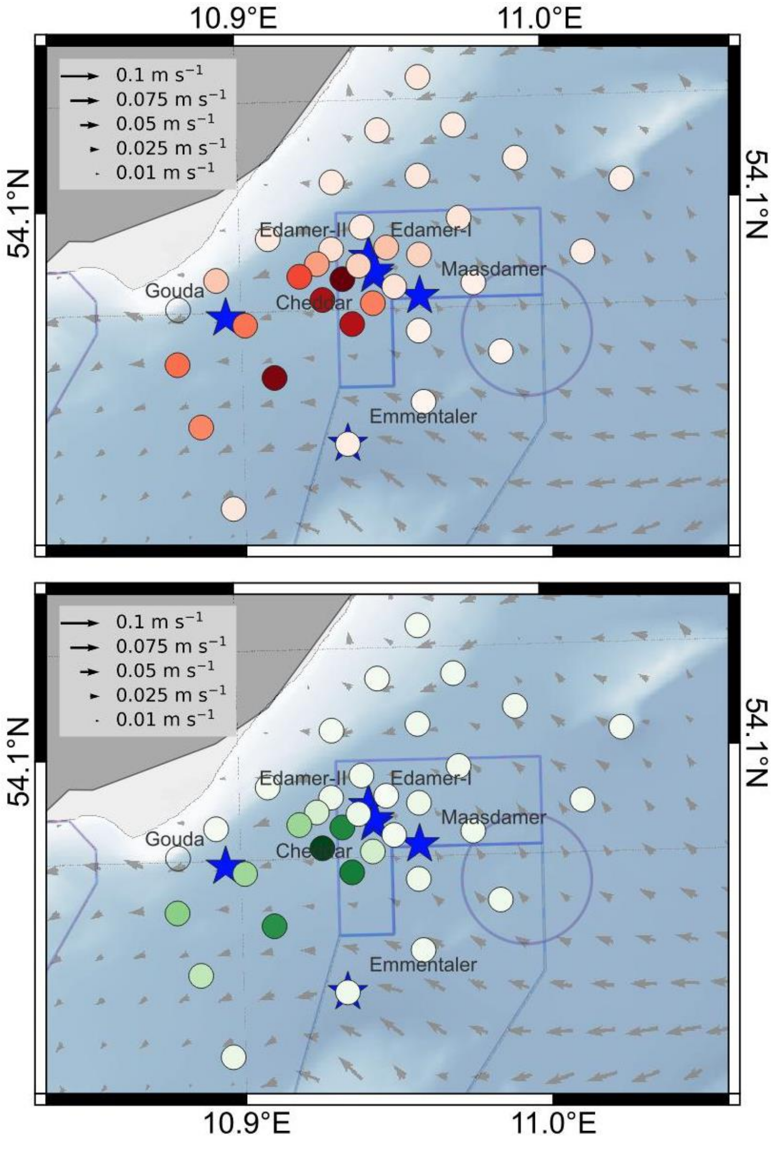

Fig. 5.14 Spatial distribution of TNT (above) and RDX (below) in bottom water in Pelzerhaken during cruise AL622. Color shading indicates relative concentration within the range 2-10 ng/L (TNT) and 10-250 ng/L (RDX). Blue stars show the location of large open explosives, with their nicknames. The underlying image layer with arrows indicates average bottom current direction and speed during 19-21 Oct. 2024 (data from BSH, 2024; drawn by A. Vedenin).

XploTaker lander results

The first XploTaker deployment was completed successfully. Unfortunately, after the lander was retrieved from the second deployment, it was found to be flooded with seawater. This damaged the electronic components beyond repair, and no further operation was possible.

Work to be conducted in the home laboratory

Discrete samples that were manually preconcentrated on board will be processed further in the home laboratory and analyzed by high resolution mass spectrometry.

Data availability

Table 5.5 Overview of data availability.

Type	Database	Available Date	Free Access Date	Contact E-Mail
Raw & processed data CTD	OSIS	01.12.2024	01.12.2024	ajbeck@geomar.de
Explosive chemicals data – shipboard analysis	OSIS	01.11.2024	Upon publication	ajbeck@geomar.de
Explosive chemicals data – laboratory analysis	OSIS	01.04.2025	Upon publication	ajbeck@geomar.de

5.7 Benthic Macrofauna Sampling

(A. Vedenin[1], I. Kroenke[1])
[1]Senckenberg Institute Wilhelmshaven

During the expedition of AL622 a total of 23 stations were taken at three locations in the dumping areas of Haffkrug and Pelzerhaken in the Lübeck Bay (Fig. 5.15). The locations are the ones cleared according to the “Immediate Program for Munition Remediation” (Sofortprogramm Munitionsbergung) initiated by the German BMUV (Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection) in 2022. The same locations were previously sampled before the clearance in March 2024 (Al609 expedition).

Stations were arranged around each of the three cleared piles of munition at the distance ca. 100 m with 8 (in Peltzerhaken) to 12 (in Haffkrug) stations for each location. 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 (grain-size and munition compounds). Complete list of the samples with coordinates, depth and sampling units is present in the Table 11.1.

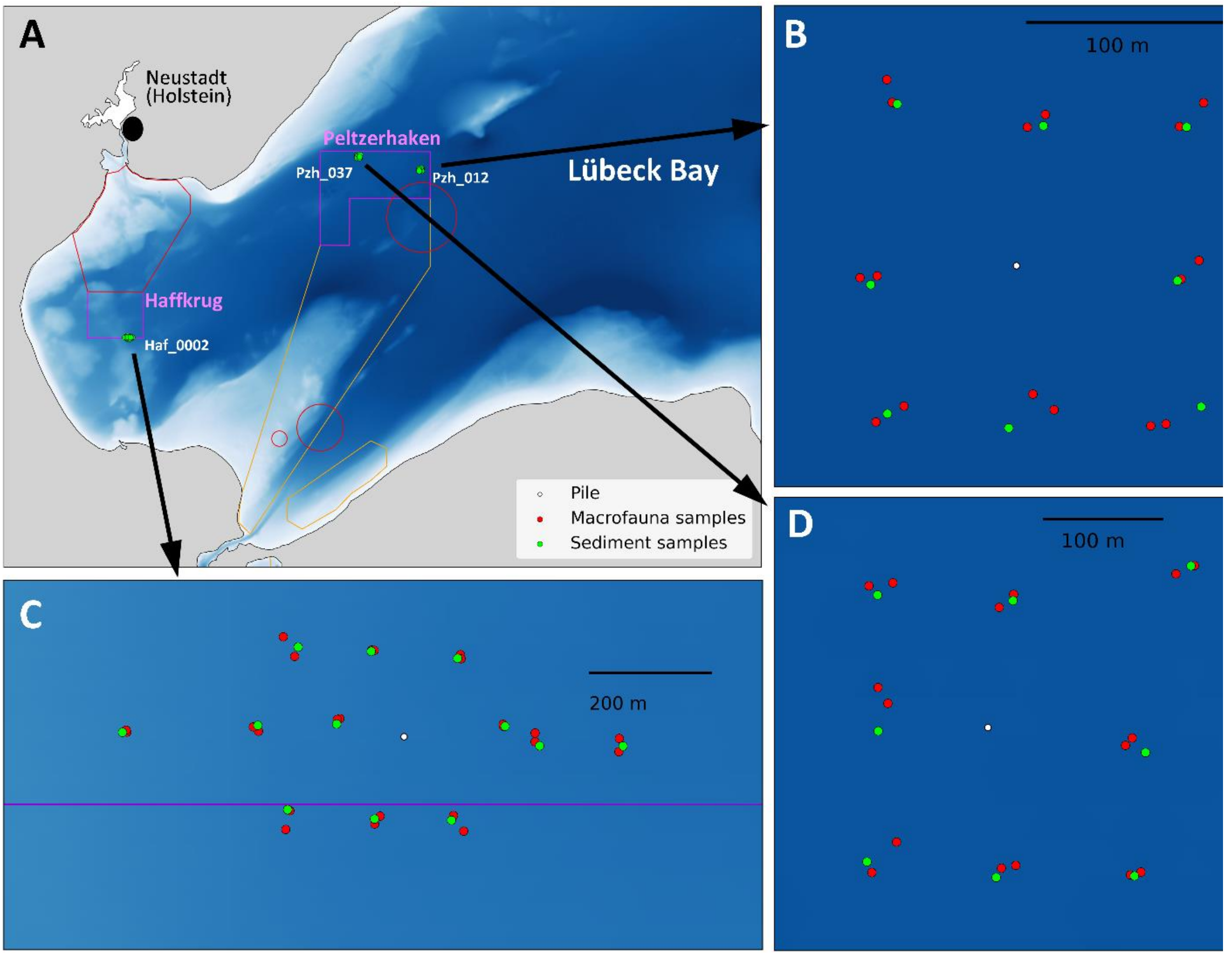

Fig. 5.15 Grab stations taken in Lübeck Bay during AL622. Above left – Lübeck Bay with marked individual samples and munition dumpsites; Other – enclosed areas of each location. Macrofauna samples are marked with red; Sediment samples are marked with green; Piles are marked with white.

The samples for macrofaunal analysis were sieved through 0.5-mm mesh size by hand 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 and for the content of munition compounds. 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 and munition compounds will be collected in the laboratory. The rest of the sediment from these samples was washed through the same washing machine and sieves and watched immediately after sampling under the stereomicroscope (Leica MZ95). All living macrofauna organisms were taken and frozen individually for further analysis on the munition compounds in tissue. The analysis will be provided by the Institute of Toxicology und Pharmacology in the University Clinic of Schleswig-Holstein. List of frozen samples is presented in Table 11.2.

5.8 Sampling of Fish Near Marine Dumped Munition in Lübeck Bay, Short After Munition Clearance Activity

(J. Scharsack[1], L. Riemeier[1])
[1]Thünen Fischereiinstitut, Bremerhaven

Background

It is known from previous studies, that fish take up organic munition compounds such as trinitrotoluene (TNT) that is leaking from marine dumped munition (Koske, Straumer et al. 2020, Kammann, Töpker et al. 2024). Particularly bottom dwelling flat fish such as common dab (*Limanda limanda*), which display relatively low migratory activity, are a suitable model species to monitor contamination of fish with munition compounds (MC) (Koske, Straumer et al. 2020).

Depending on the concentration of MC in water, sediment and food items, health status and body condition of exposed fish might be affected. We therefore propose a two-sided monitoring of fish near marine dumped munition, which on the one hand investigates the health status and body condition parameters of fish and on the other measures residual MC such as TNT in body fluids and tissues of fish.

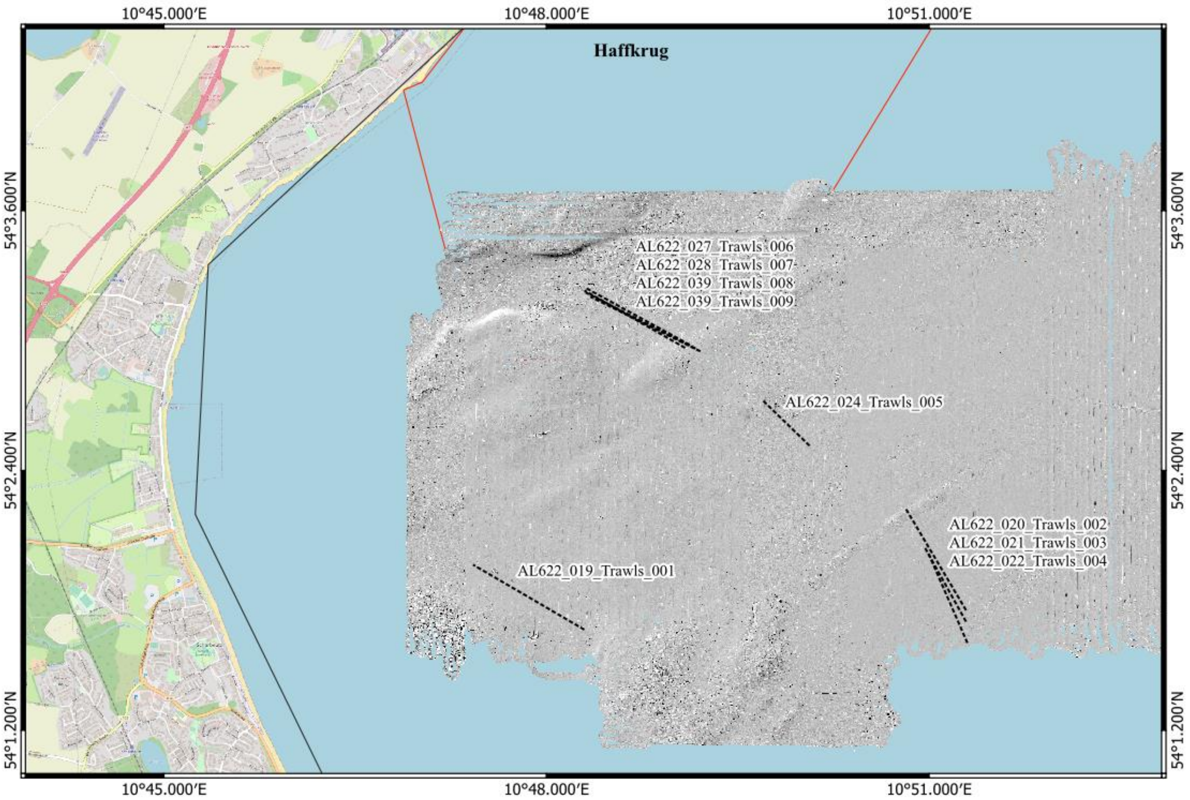

Fig. 5.16 Map of the munition dumpsite Haffkrug, showing the trawl lines during AL622 (black dotted lines).

Methods

During the AL622 cruise, bottom dwelling fish were collected by means of beam trawling. The beam trawl was a 3 m beam without chasing chains and a flatfish net with 4 cm mesh width. To operate the beam trawl in close proximity to the dumped munition, in this case the spots that were selected for test clearance activity, high resolution imaging of the seafloor provided by GEOMAR was used to identify trawl lines of approx. 500m that were free of dumped munition or other obstacles. In total 4 sites (trawl lines) were selected and trawled between October 14-16th 2024 (Fig. 5.16).

After the trawl, flat fish (dab, flounder, plaice) were immediately sorted from the catch and placed in a tank with sea water flow through. For sampling fish where anaesthetised with clove oil, weighed and length measured and inspected for externally visible diseases. Blood was collected from the caudal vein and fish were killed by cutting the vertebral column. Otoliths were dissected out for later age determination. Bile fluid and urine were collected, as well as tissue samples from liver, gonads and muscle. Tissue and body fluid samples were frozen for later analysis for MC in the laboratory.

Preliminary results

Collection of fish with the beam trawl was generally successful and the desired numbers of ten fish per site was reached. Due to short trawling times (500m) fish reached the ship alive, which is essential for the sampling of blood and other body fluids. Visual inspection of fish for health parameters did not reveal any obvious disorders that might have been caused by toxic MC.

Work to be conducted in home laboratory:

Frozen body fluids and tissues of sampled fish will be processed in the laboratory and subjected to mass spectrometry analysis for MC. Data will be used to define the contamination status of fish with MC in comparison to samples collected in March 2024 before the munition clearance started.

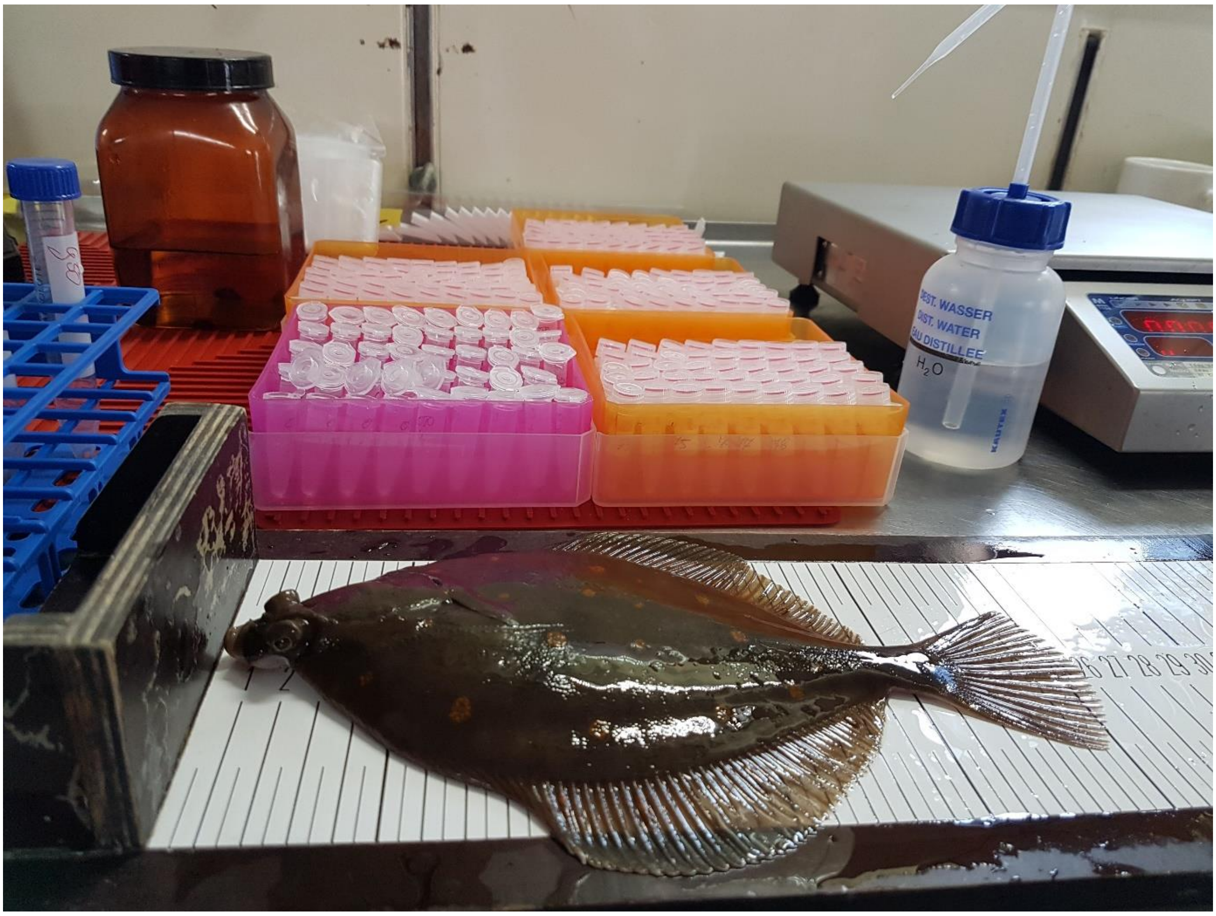

Fig. 5.17 Length measurement of a plaice (Pleuronectes platessa).

5.9 Mussel and Passive Sampler Monitoring for Dissolved Energetic Compounds

(T. Buenning[1], J. Strehse[1], M. Gundlach[1], L. Scheer[1], J. Lindemeyer[1], E. Maser[1])
[1] Institute of Toxicology and Pharmacology for Natural Scientists, University Medical Center Schleswig-Holstein, Kiel, Germany

Biomonitoring with blue mussels established in the UDEMM project (Strehse et al. 2017, Appel et al. 2018) has proven its suitability for investigating the contamination of waters with energetic compounds. In contrast to water and sediment samples, which only ever provide a snapshot of the situation at the time of sampling, mussels allow longer periods of time to be observed. As sedentary organisms, blue mussels feed by filtering nutrients from the surrounding water. In this process, they also absorb pollutants which, depending on the substance, are either metabolized or unmetabolized and accumulate in their tissues (Strehse and Maser 2020).

Passive samplers are used to supplement biomonitoring. As a kind of artificial mussels, they adsorb energetic compounds (EC) from the passing water in membranes. Since, unlike mussels, they have no metabolizing potential, passive samplers reflect the composition of EC in the water column. They can also be used in conditions in which mussels cannot survive (such as low oxygen content of water). However, they only allow a statement to be made about which compounds are present in the water and a rough estimate of whether a lot or a little are present. Reliable quantification is not possible.

Mussels are attached in nets to a 1.5 m long rope with a ground anchor (approx. 20 kg of concrete or sand-lime bricks) and buoyancy bodies at seafloor level and 1 m above the seabed. Passive samplers are attached at seafloor level (Fig. 5.18). This setup is called mooring. The moorings that have now been deployed and recovered will be used as part of the CONMAR project to investigate the burden of energetic compounds around three selected munitions piles in the Bay of Lübeck after they were partially cleared in the middle of the year 2024 as part of the federal government's emergency program. The amount of EC in mussels and passive samplers will further be compared to the amount found in samples taken before the clearing of the munition sites (AL609 and L24-06).

Methods

At three munition piles, two mussel moorings were deployed each, approximately 15 m to the southwest and to the northeast of the piles. Additionally, a total of six moorings were deployed next to interesting munition objects with exposed explosives. Each mooring was equipped with two nets containing 20 blue mussels each (one at the bottom and one 1m above the ground), and two passive samplers at the bottom. Blue mussels were obtained from the Kieler Meeresfarm on Thursday 10.10.24.

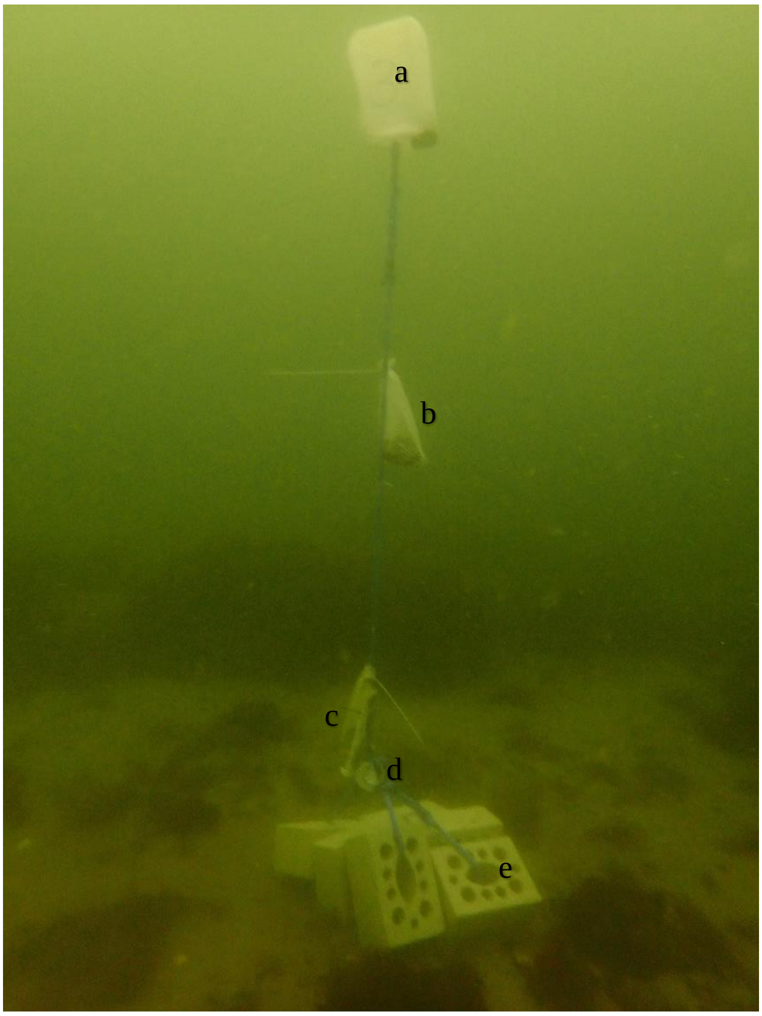

Fig. 5.18. Deployed mooring next to a munition object, consisting of buoyancy body **a**, mussel net 1 m **b**, mussel net sea floor **c**, passive sampler **d**, anchor **e**.

Deployment of the moorings (Mon 14.10.24 & Tue 15.10.24) was supervised by Lars Scheer (Institute of Toxicology and Pharmacology for Natural Scientists, UKSH Kiel). Recovery of the moorings (Sa 19.10.24 - Sun 20.10.24) was supervised by Andrey Vedenin (Senckenberg Society for Natural Research). Mussels and passive samplers were immediately frozen at -20°C on board. Mussels and passive samplers will be analyzed for the presence of energetic compounds.
Results will be available after the mussels and passive samplers have been examined in the laboratory.

Work to be conducted in home laboratory

The mussels and passive samplers will be processed in the Institute of Toxicology and Pharmacology for Natural Scientists according to Buenning et al. 2021. They will be freeze-dried, extracted and purified and concentrated using solid phase extraction. The samples will be analyzed using GC-MS/MS and UHPLC-MS/MS.

5.10 Septentrio Navigation System

(J. Greinert[1], M. Keller[1])
[1]GEOMAR Helmholtz Center for Ocean Research Kiel

A new GNSS antenna system was installed and tested for the use with the SAS. The Septentrio system comprises 2 antennas, installed on the monkey deck which give heading. In the following the recommended settings are given:

Mounting
Antennas to the left & right of the Trimble antenna; port side = main. North arrow points aft!
Position is calculated for the position between the antennas (=trimble antenna)
Antenna heading is rotated by +90

Connection settings to the septentrio
Via the webpage browser with connections via USB or Ethernet
A: Connection to the Septentrio via USB -> opens a server with IP 192.168.3.1 -> Config Webpage opens
B: with Ethernet to 192.168.1.150 -> Config Webpage opens

Data Output
A: COM port 2 with 38400 sends NMEA strings
B: TCP-IP port 34567 sends NMEA strings

WIFI
WIFI is dynamic, connects to Alkor network (192.168.135.xxx). A new WIFI connection may have to be established. Ethernet output is then also possible via this WIFI connection, the server can also be via e5n Access -65nt and thus send data locally.

5.11 Synthetic Aperture Sonar

(T. Weiß[1], G. Nolte[1], J. Greinert[1])
[1]GEOMAR Helmholtz Center for Ocean Research Kiel

The newly bought Aquapix Mini RTSAS from Kraken Robotics is a synthetic aperture sonar that was installed inside the moonpool (Fig. 5.19). The navigation and heading was provided via a Septentrio GNS.

For the survey the following settings were used:

- Altitude 15 m
- Speed 1.7 m/s
- SoundSpeed: 1486 m/s
- WaterTemp: 9 degC
- PRI: 100 ms
- PulseLength: 1ms

This resulted in a range of approximately 65 m - 70 m to each side.

During post processing it turned out that the geometry settings of the transducer needed to be adjusted to the following values:

0.00675 0.05 10 10 0 0.004

This caused errors in the beam forming during the immediate processing of the files. However, the data could be reprocessed with the correct settings. The Fig. 5.20 shows an example target during AL622.

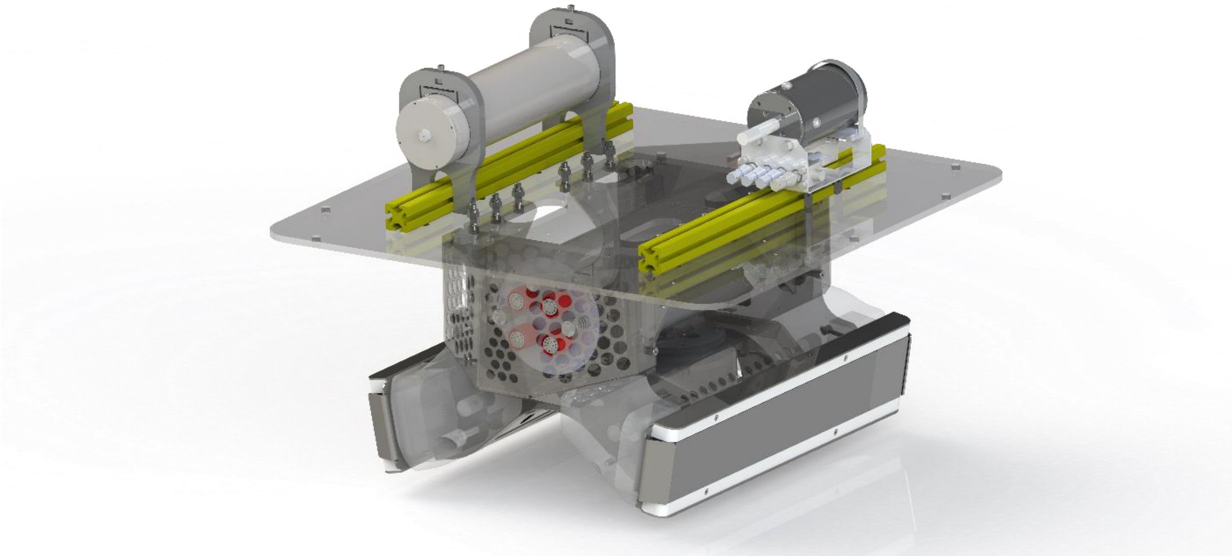

Fig. 5.19 The RTSAS installed on the moonpool mounting plate for RV ALKOR together with a datapod, oil compensator on top of the plate and the sonarpod below the plate and the downward facing DVL.

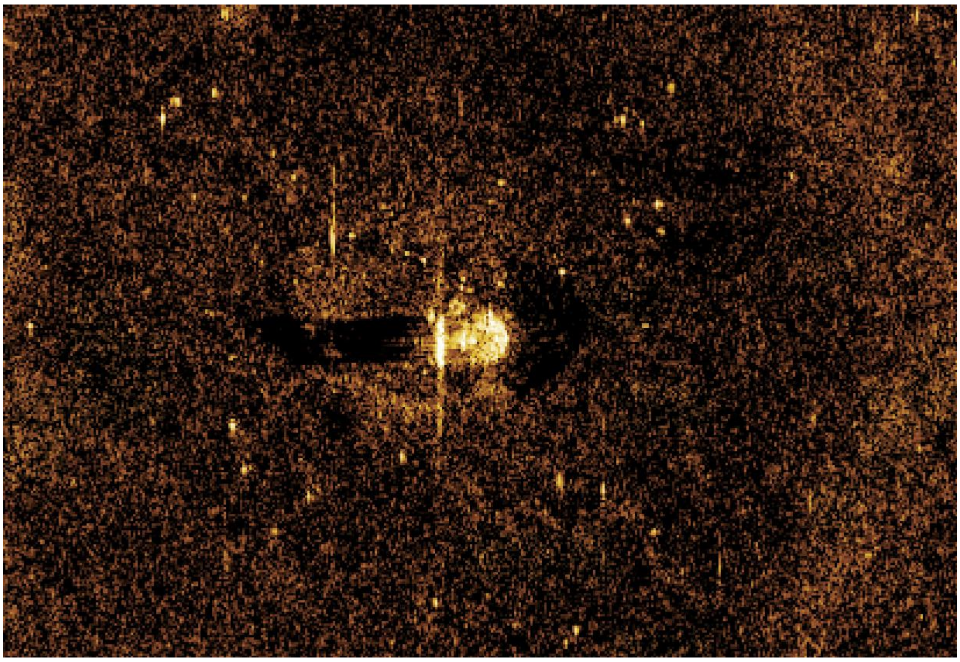

Fig. 5.20 Example SAS data on AL622 showing a munition object lying in a sediment scour.

6 Data and Sample Storage and Availability

Seafloor 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.

7 Station List AL622

7.1 Overall Station List

Table 7.1 Overall Station List

Station	Device Shortname	Latitude (deg)	Longitude (deg)
AL622_000_TSG_001	TSG	54.455	10.244
AL622_001_CTD_001	CTD	54.546	10.204
AL622_002_OBS_001	OBS	54.546	10.204
AL622_003_OBS_002	OBS	54.579	10.154
AL622_004_CTD_002	CTD	54.590	10.127
AL622_005_OBS_003	OBS	54.590	10.126
AL622_006_OBS_004	OBS	54.604	10.105
AL622_007_CTD_003	CTD	54.611	10.089
AL622_008_CTD_004	CTD	54.617	10.254
AL622_009_OBS_005	OBS	54.618	10.254
AL622_010_OBS_006	OBS	54.618	10.253
AL622_011_Mooring_001	MOOR	54.032	10.815
AL622_012_Mooring_002	MOOR	54.032	10.816
AL622_013_Mooring_003	MOOR	54.097	10.954
AL622_014_Mooring_004	MOOR	54.097	10.955
AL622_015_Mooring_005	MOOR	54.092	10.992
AL622_016_Mooring_006	MOOR	54.092	10.993
AL622_017_SBP_001	SBP	54.081	11.010
AL622_018_AUV_KALLE_Mission-047	AUV K	54.031	10.814
AL622_018_AUV_KALLE_Mission-048	AUV K	54.031	10.814
AL622_019_Trawl_001_start	TRAWL	54.028	10.805
AL622_019_Trawl_001_end	TRAWL	54.033	10.791
AL622_020_Trawl_002_start	TRAWL	54.028	10.855
AL622_020_Trawl_002_end	TRAWL	54.034	10.849
AL622_021_Trawl_003_start	TRAWL	54.029	10.855
AL622_021_Trawl_003_end	TRAWL	54.037	10.847
AL622_022_Trawl_004_start	TRAWL	54.034	10.850
AL622_022_Trawl_004_end	TRAWL	54.027	10.855
AL622_023_CTD_005	CTD	54.039	10.840
AL622_024_Trawl_005_start	TRAWL	54.042	10.834
AL622_024_Trawl_005_end	TRAWL	54.045	10.828
AL622_025_BB-002	ROV	54.032	10.815
AL622_026_CTD_006	CTD	54.049	10.819
AL622_027_Trawl_006_start	TRAWL	54.049	10.818
AL622_027_Trawl_006_end	TRAWL	54.054	10.805
AL622_028_Trawl_007_start	TRAWL	54.054	10.805
AL622_028_Trawl_007_end	TRAWL	54.050	10.819
AL622_029_Mooring_007	MOOR	54.054	10.934
AL622_030_Mooring_008	MOOR	54.079	10.895
AL622_031_Mooring_009	MOOR	54.082	10.959
AL622_032_Mooring_010	MOOR	54.082	10.959

AL622_033_Xplotaker_001	X_LANDER	54.087	10.944
AL622_034_Mooring_011	MOOR	54.090	10.942
AL622_035_Mooring_012	MOOR	54.090	10.942
AL622_036_BB-003	ROV	54.087	10.944
AL622_037_SBP_002	SBP	54.116	10.956
AL622_038_CTD_007	CTD	54.055	10.939
AL622_039_Trawl_008_start	TRAWL	54.054	10.805
AL622_039_Trawl_008_end	TRAWL	54.049	10.819
AL622_039_Trawl_009_start	TRAWL	54.053	10.806
AL622_039_Trawl_009_end	TRAWL	54.049	10.820
AL622_040_AUV_KALLE_Mission-050	AUV K	54.098	10.953
AL622_041_BB-004	ROV	54.092	10.992
AL622_042_AUV_ANTON_Mission-330	AUV A	54.033	10.815
AL622_043_VVGrab_001	VVGrab	54.032	10.815
AL622_043_VVGrab_002	VVGrab	54.032	10.815
AL622_043_VVGrab_003	VVGrab	54.032	10.815
AL622_044_VVGrab_004	VVGrab	54.032	10.815
AL622_044_VVGrab_005	VVGrab	54.032	10.815
AL622_044_VVGrab_006	VVGrab	54.032	10.815
AL622_045_VVGrab_007	VVGrab	54.032	10.816
AL622_045_VVGrab_008	VVGrab	54.032	10.816
AL622_045_VVGrab_009	VVGrab	54.032	10.816
AL622_046_VVGrab_010	VVGrab	54.032	10.818
AL622_046_VVGrab_011	VVGrab	54.032	10.818
AL622_046_VVGrab_012	VVGrab	54.032	10.818
AL622_047_VVGrab_013	VVGrab	54.032	10.817
AL622_047_VVGrab_014	VVGrab	54.032	10.817
AL622_047_VVGrab_015	VVGrab	54.032	10.817
AL622_048_VVGrab_016	VVGrab	54.033	10.816
AL622_048_VVGrab_017	VVGrab	54.033	10.816
AL622_048_VVGrab_018	VVGrab	54.033	10.816
AL622_049_VVGrab_019	VVGrab	54.033	10.815
AL622_049_VVGrab_020	VVGrab	54.033	10.815
AL622_049_VVGrab_021	VVGrab	54.033	10.815
AL622_049_VVGrab_022	VVGrab	54.033	10.815
AL622_049_VVGrab_023	VVGrab	54.033	10.815
AL622_050_VVGrab_024	VVGrab	54.033	10.815
AL622_050_VVGrab_025	VVGrab	54.033	10.815
AL622_050_VVGrab_026	VVGrab	54.033	10.815
AL622_050_VVGrab_027	VVGrab	54.033	10.815
AL622_051_VVGrab_028	VVGrab	54.032	10.813
AL622_051_VVGrab_029	VVGrab	54.032	10.813
AL622_051_VVGrab_030	VVGrab	54.032	10.813
AL622_052_VVGrab_031	VVGrab	54.032	10.814
AL622_052_VVGrab_032	VVGrab	54.032	10.814
AL622_052_VVGrab_033	VVGrab	54.032	10.814
AL622_053_VVGrab_034	VVGrab	54.032	10.815

AL622_053_VVGrab_035	VVGrab	54.032	10.815
AL622_053_VVGrab_036	VVGrab	54.032	10.815
AL622_054_VVGrab_037	VVGrab	54.032	10.817
AL622_054_VVGrab_038	VVGrab	54.032	10.817
AL622_054_VVGrab_039	VVGrab	54.032	10.817
AL622_055_CTD_008	CTD	54.032	10.815
AL622_056_CTD_009	CTD	54.032	10.816
AL622_057_CTD_010	CTD	54.032	10.817
AL622_058_CTD_011	CTD	54.032	10.817
AL622_059_CTD_012	CTD	54.032	10.816
AL622_060_CTD_013	CTD	54.032	10.815
AL622_061_CTD_014	CTD	54.033	10.815
AL622_062_CTD_015	CTD	54.033	10.816
AL622_063_CTD_016	CTD	54.033	10.817
AL622_064_SBP_003	SBP	53.975	10.913
AL622_065_SBP_004	SBP	54.059	11.007
AL622_066_AUV_KALLE_Mission-051	AUV K	54.092	10.993
AL622_067_BB-005	ROV	54.097	10.955
AL622_068_VVGrab_040	VVGrab	54.097	10.954
AL622_068_VVGrab_041	VVGrab	54.097	10.954
AL622_068_VVGrab_042	VVGrab	54.097	10.954
AL622_069_VVGrab_043	VVGrab	54.097	10.955
AL622_069_VVGrab_044	VVGrab	54.097	10.955
AL622_069_VVGrab_045	VVGrab	54.097	10.955
AL622_070_VVGrab_046	VVGrab	54.097	10.956
AL622_070_VVGrab_047	VVGrab	54.097	10.956
AL622_070_VVGrab_048	VVGrab	54.097	10.956
AL622_071_VVGrab_049	VVGrab	54.097	10.954
AL622_072_VVGrab_050	VVGrab	54.097	10.954
AL622_073_VVGrab_051	VVGrab	54.097	10.954
AL622_074_VVGrab_052	VVGrab	54.096	10.954
AL622_074_VVGrab_053	VVGrab	54.096	10.954
AL622_074_VVGrab_054	VVGrab	54.096	10.954
AL622_075_BB-006	ROV	54.054	10.935
AL622_076_BB-007	ROV	54.033	10.816
AL622_077_BB-008	ROV	54.032	10.816
AL622_078_AUV_LUISE_Mission-386	AUV L	54.088	10.947
AL622_079_VVGrab_055	VVGrab	54.096	10.955
AL622_079_VVGrab_056	VVGrab	54.096	10.955
AL622_079_VVGrab_057	VVGrab	54.096	10.955
AL622_080_VVGrab_058	VVGrab	54.096	10.956
AL622_080_VVGrab_059	VVGrab	54.096	10.956
AL622_080_VVGrab_060	VVGrab	54.096	10.956
AL622_081_VVGrab_061	VVGrab	54.097	10.956
AL622_081_VVGrab_062	VVGrab	54.097	10.956
AL622_081_VVGrab_063	VVGrab	54.097	10.956
AL622_082_CTD_017	CTD	54.096	10.956

AL622_083_CTD_018	CTD	54.096	10.955
AL622_084_CTD_019	CTD	54.096	10.954
AL622_085_CTD_020	CTD	54.097	10.954
AL622_086_CTD_021	CTD	54.097	10.955
AL622_087_CTD_022	CTD	54.097	10.956
AL622_088_CTD_023	CTD	54.097	10.954
AL622_089_CTD_024	CTD	54.097	10.955
AL622_090_CTD_025	CTD	54.097	10.956
AL622_091_MBES_SB3050_001	MB	54.081	10.966
AL622_092_BB-009	ROV	54.097	10.956
AL622_093_BB-010	ROV	54.092	10.993
AL622_094_AUV_ANTON_Mission-331	AUV A	54.092	10.993
AL622_095_CTD_026	CTD	54.092	10.993
AL622_096_CTD_027	CTD	54.092	10.992
AL622_097_CTD_028	CTD	54.092	10.992
AL622_098_CTD_029	CTD	54.092	10.992
AL622_099_CTD_030	CTD	54.092	10.992
AL622_100_CTD_031	CTD	54.093	10.992
AL622_101_CTD_032	CTD	54.092	10.993
AL622_102_CTD_033	CTD	54.092	10.993
AL622_103_CTD_034	CTD	54.092	10.992
AL622_104_AUV_LUISE_Mission-387	AUV L	54.085	10.950
AL622_105_BB-011	ROV	54.084	10.954
AL622_106_AUV_ANTON_Mission-332	AUV A	54.084	10.955
AL622_107_AUV_LUISE_Mission-388	AUV L	54.088	10.943
AL622_108_BB-012	ROV	54.084	10.943
AL622_109_BB-013	ROV	54.091	10.937
AL622_110_BB-014	ROV	54.083	10.927
AL622_111_BB-015	ROV	54.093	10.962
AL622_112_BB-016	ROV	54.092	10.965
AL622_113_CTD_035	CTD	54.081	10.880
AL622_114_CTD_036	CTD	54.086	10.892
AL622_115_CTD_037	CTD	54.094	10.909
AL622_116_CTD_038	CTD	54.104	10.931
AL622_117_CTD_039	CTD	54.114	10.946
AL622_118_CTD_040	CTD	54.124	10.960
AL622_119_CTD_041	CTD	54.114	10.970
AL622_120_CTD_042	CTD	54.105	10.959
AL622_121_CTD_043	CTD	54.096	10.940
AL622_122_CTD_044	CTD	54.092	10.930
AL622_123_CTD_045	CTD	54.089	10.925
AL622_124_CTD_046	CTD	54.086	10.919
AL622_125_CTD_047	CTD	54.077	10.901
AL622_126_CTD_048	CTD	54.070	10.879
AL622_127_CTD_049	CTD	54.058	10.886
AL622_128_CTD_050	CTD	54.067	10.911
AL622_129_CTD_051	CTD	54.082	10.927

AL622_130_CTD_052	CTD	54.077	10.937
AL622_131_CTD_053	CTD	54.086	10.934
AL622_132_CTD_054	CTD	54.081	10.944
AL622_133_CTD_055	CTD	54.089	10.939
AL622_134_CTD_056	CTD	54.085	10.951
AL622_135_CTD_057	CTD	54.092	10.949
AL622_136_CTD_058	CTD	54.090	10.959
AL622_137_CTD_059	CTD	54.097	10.972
AL622_138_CTD_060	CTD	54.109	10.991
AL622_139_CTD_061	CTD	54.104	11.026
AL622_140_CTD_062	CTD	54.090	11.012
AL622_141_CTD_063	CTD	54.085	10.976
AL622_142_CTD_064	CTD	54.071	10.984
AL622_143_CTD_065	CTD	54.076	10.958
AL622_144_CTD_066	CTD	54.062	10.959
AL622_145_CTD_067	CTD	54.054	10.934
AL622_146_CTD_068	CTD	54.042	10.896
AL622_147_AUV_KALLE_Mission-052	AUV K	54.090	10.988
AL622_148_AUV_KALLE_Mission-	AUV K	54.090	10.987
AL622_149_AUV_LUISE_Mission-389	AUV L	54.089	10.989
AL622_150_VVGrab_064	VVGrab	54.093	10.992
AL622_150_VVGrab_065	VVGrab	54.093	10.992
AL622_150_VVGrab_066	VVGrab	54.093	10.992
AL622_151_VVGrab_067	VVGrab	54.092	10.992
AL622_151_VVGrab_068	VVGrab	54.092	10.993
AL622_151_VVGrab_069	VVGrab	54.092	10.993
AL622_152_VVGrab_070	VVGrab	54.092	10.993
AL622_152_VVGrab_071	VVGrab	54.092	10.993
AL622_152_VVGrab_072	VVGrab	54.092	10.993
AL622_153_VVGrab_073	VVGrab	54.092	10.993
AL622_153_VVGrab_074	VVGrab	54.092	10.993
AL622_153_VVGrab_075	VVGrab	54.092	10.993
AL622_154_VVGrab_076	VVGrab	54.092	10.993
AL622_154_VVGrab_077	VVGrab	54.092	10.993
AL622_154_VVGrab_078	VVGrab	54.092	10.993
AL622_155_VVGrab_079	VVGrab	54.092	10.993
AL622_155_VVGrab_080	VVGrab	54.092	10.993
AL622_155_VVGrab_081	VVGrab	54.092	10.992
AL622_156_VVGrab_082	VVGrab	54.092	10.992
AL622_156_VVGrab_083	VVGrab	54.092	10.992
AL622_156_VVGrab_084	VVGrab	54.092	10.992
AL622_157_VVGrab_085	VVGrab	54.092	10.992
AL622_157_VVGrab_086	VVGrab	54.092	10.992
AL622_157_VVGrab_087	VVGrab	54.092	10.992
AL622_158_BB-017	ROV	54.097	10.956
AL622_159_BB-018	ROV	54.097	10.956
AL622_160_BB-019	ROV	54.097	10.955

AL622_161_BB-020	ROV	54.097	10.955
AL622_162_BB-021	ROV	54.079	10.896
AL622_163_BB-022	ROV	54.090	10.943
AL622_164_BB-023	ROV	54.082	10.960
AL622_165_BB-024	ROV	54.054	10.935
AL622_166_AUV_ANTON_Mission-333	AUV A	54.032	10.817
AL622_167_	AUV K	54.031	10.870
AL622_167_AUV_KALLE_Mission-047	AUV K	54.031	10.870
AL622_167_AUV_KALLE_Mission-047	AUV K	54.031	10.870
AL622_168_BB-025	ROV	54.032	10.816
AL622_169_BB-026	ROV	54.032	10.817
AL622_170_BB-027	ROV	54.032	10.816
AL622_171_AUV_LUISE_Mission-390	AUV L	54.087	10.949
AL622_172_AUV_KALLE_Mission-055	AUV K	54.084	10.959
AL622_172_AUV_KALLE_Mission-056	AUV K	54.085	10.959
AL622_172_AUV_KALLE_Mission-057	AUV K	54.085	10.959
AL622_173_BB-028	ROV	54.087	10.945
AL622_174_BB-029	ROV	54.092	10.994
AL622_175_AUV_LUISE_Mission-391	AUV L	54.462	10.341
AL622_176_AUV_KALLE_Mission-058	AUV K	54.459	10.331
AL622_177_BB-030	ROV	54.458	10.334
AL622_178_BB-031	ROV	54.459	10.331

8 Abbreviations

TNT	2,4,6-trinitrotoluene (
RDX	1,3,5-Trinitro-1,3,5-triazinane (or “Royal Demolition Explosive”)
DNB	1,3-dinitrobenzene
2-ADNT	2-amino-4,6-dinitrotoluene
4-ADNT	4-amino-2,6-dinitrotoluene (4-ADNT)
SPE	Solid phase extraction
MC	Munition compound
XOFOS	eXtended Ocean Floor Observation System
ROV	Remotly operated vehicle
HPLC	High performance liquid chromatography

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10 Acknowledgements

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11 Appendix

11.1 Macrofauna Sampling

Table 11.1 Macrofauna sampling list

Area	Station	Device	Device Shortname	Event Time	Depth (m)	Type of item	No. of items	Comment
Haf_00001	43	AL622_43-1	VGRAB	10/16/2024 12:30	18	bio (kautex 1 l)	1	Sand + Schlick?
Haf_00001	43	AL622_43-2	VGRAB	10/16/2024 12:33	18	sediment (zip-bags)	2	Sand (+ UKSH)
Haf_00001	43	AL622_43-3	VGRAB	10/16/2024 12:38	18	bio (kautex 1 l)	1	Sand, Sieb ist Kaputt
Haf_00001	44	AL622_44-1	VGRAB	10/16/2024 12:48	18	bio (kautex 1 l)	1	Sand
Haf_00001	44	AL622_44-2	VGRAB	10/16/2024 12:51	18	sediment (zip-bags)	2	Sand
Haf_00001	44	AL622_44-3	VGRAB	10/16/2024 12:55	18	bio (kautex 1 l)	1	Sand
Haf_00001	45	AL622_45-1	VGRAB	10/16/2024 13:19	19	bio (kautex 1 l)	1	Sand
Haf_00001	45	AL622_45-2	VGRAB	10/16/2024 13:23	19	sediment (zip-bags)	2	Sand
Haf_00001	45	AL622_45-3	VGRAB	10/16/2024 13:27	19	bio (kautex 1 l)	1	Sand
Haf_00001	46	AL622_46-1	VGRAB	10/16/2024 13:35	19	bio (kautex 1 l)	1	Sand
Haf_00001	46	AL622_46-2	VGRAB	10/16/2024 13:39	19	sediment (zip-bags)	2	Sand
Haf_00001	46	AL622_46-3	VGRAB	10/16/2024 13:44	19	bio (kautex 1 l)	1	Sand
Haf_00001	47	AL622_47-1	VGRAB	10/16/2024 13:52	18	bio (kautex 1 l)	1	Sand
Haf_00001	47	AL622_47-2	VGRAB	10/16/2024 13:56	19	sediment (zip-bags)	2	Sand
Haf_00001	47	AL622_47-3	VGRAB	10/16/2024 14:01	19	bio (kautex 1 l)	2	Sand
Haf_00001	48	AL622_48-1	VGRAB	10/16/2024 14:08	19	bio (kautex 1 l)	2	Sand
Haf_00001	48	AL622_48-2	VGRAB	10/16/2024 14:12	19	sediment (zip-bags)	2	Sand
Haf_00001	48	AL622_48-3	VGRAB	10/16/2024 14:17	19	bio (kautex 1 l)	1	Sand
Haf_00001	49	AL622_49-1	VGRAB	10/16/2024 14:23	18	bio (kautex 1 l)	2	Sand
Haf_00001	49	AL622_49-2	VGRAB	10/16/2024 14:25	18	sediment (zip-bags)	2	Sand (+ UKSH)
Haf_00001	49	AL622_49-3	VGRAB	10/16/2024 14:28	18	-	-	empty
Haf_00001	49	AL622_49-4	VGRAB	10/16/2024 14:32	18	-	-	empty
Haf_00001	49	AL622_49-5	VGRAB	10/16/2024 14:35	18	bio (kautex 1 l)	2	Sand
Haf_00001	50	AL622_50-1	VGRAB	10/16/2024 14:42	18	bio (kautex 1 l)	2	Sand + Schlick?
Haf_00001	50	AL622_50-2	VGRAB	10/16/2024 14:45	18	sediment (zip-bags)	2	Sand + Schlick?
Haf_00001	50	AL622_50-3	VGRAB	10/16/2024 14:49	18	-	-	empty

Haf_00001	50	AL622_50-4	VGRAB	10/16/2024 14:52	18	bio (kautex 1 l)	2	Sand + Schlick?
Haf_00001	51	AL622_51-1	VGRAB	10/16/2024 15:14	17	bio (kautex 1 l)	1	Sand + Schlick? Dekantiert
Haf_00001	51	AL622_51-2	VGRAB	10/16/2024 15:17	17	sediment (zip-bags)	2	Sand + Schlick?
Haf_00001	51	AL622_51-3	VGRAB	10/16/2024 15:21	17	bio (kautex 1 l)	1	Sand + Schlick? Dekantiert
Haf_00001	52	AL622_52-1	VGRAB	10/16/2024 15:33	18	bio (kautex 1 l)	1	Sand + Schlick? Dekantiert
Haf_00001	52	AL622_52-2	VGRAB	10/16/2024 15:35	18	sediment (zip-bags)	2	Sand + Schlick?
Haf_00001	52	AL622_52-3	VGRAB	10/16/2024 15:40	18	bio (kautex 1 l)	1	Sand + Schlick? Dekantiert
Haf_00001	53	AL622_53-1	VGRAB	10/16/2024 15:46	18	bio (kautex 1 l)	1	Sand + Schlick? Dekantiert
Haf_00001	53	AL622_53-2	VGRAB	10/16/2024 15:50	18	sediment (zip-bags)	2	Sand + Schlick?
Haf_00001	53	AL622_53-3	VGRAB	10/16/2024 15:54	18	bio (kautex 1 l)	1	Sand + Schlick? Dekantiert
Haf_00001	54	AL622_54-1	VGRAB	10/16/2024 16:04	19	bio (kautex 1 l)	1	Sand + Schlick? Dekantiert
Haf_00001	54	AL622_54-2	VGRAB	10/16/2024 16:07	19	sediment (zip-bags)	2	Sand + Schlick?
Haf_00001	54	AL622_54-3	VGRAB	10/16/2024 16:12	19	bio (kautex 1 l)	1	Sand + Schlick? Dekantiert
Pzh_037	68	AL622_68-1	VGRAB	10/17/2024 8:42	21	bio (kautex 1 l)	1	Schlick
Pzh_037	68	AL622_68-2	VGRAB	10/17/2024 8:46	21	sediment (zip-bags)	2	Schlick (+ UKSH)
Pzh_037	68	AL622_68-3	VGRAB	10/17/2024 8:51	21	bio (kautex 1 l)	1	Schlick
Pzh_037	69	AL622_69-1	VGRAB	10/17/2024 8:59	21	bio (kautex 1 l)	1	Schlick
Pzh_037	69	AL622_69-2	VGRAB	10/17/2024 9:03	21	sediment (zip-bags)	2	Schlick
Pzh_037	69	AL622_69-3	VGRAB	10/17/2024 9:08	21	bio (kautex 1 l)	1	Schlick
Pzh_037	70	AL622_70-1	VGRAB	10/17/2024 9:16	21	bio (kautex 1 l)	1	Schlick
Pzh_037	70	AL622_70-2	VGRAB	10/17/2024 9:19	21	sediment (zip-bags)	2	Schlick
Pzh_037	70	AL622_70-3	VGRAB	10/17/2024 9:35	21	bio (kautex 1 l)	1	Schlick
Pzh_037	71	AL622_71-1	VGRAB	10/17/2024 9:58	21	bio (kautex 1 l)	1	Schlick
Pzh_037	72	AL622_72-1	VGRAB	10/17/2024 10:03	21	sediment (zip-bags)	2	Schlick
Pzh_037	73	AL622_73-1	VGRAB	10/17/2024 10:15	21	bio (kautex 1 l)	1	Schlick
Pzh_037	74	AL622_74-1	VGRAB	10/17/2024 10:26	21	bio (kautex 1 l)	1	Schlick
Pzh_037	74	AL622_74-1	VGRAB	10/17/2024 10:30	21	sediment (zip-bags)	2	Schlick (+ UKSH)
Pzh_037	74	AL622_74-1	VGRAB	10/17/2024 10:34	21	bio (kautex 1 l)	1	Schlick

Pzh_037	79	AL622_79-1	VGRAB	10/17/2024 14:45	21	bio (kautex 1 l)	1	Schlick
Pzh_037	79	AL622_79-2	VGRAB	10/17/2024 14:49	21	sediment (zip-bags)	2	Schlick
Pzh_037	79	AL622_79-3	VGRAB	10/17/2024 14:54	21	bio (kautex 1 l)	1	Schlick
Pzh_037	80	AL622_80-1	VGRAB	10/17/2024 15:02	21	bio (kautex 1 l)	1	Schlick
Pzh_037	80	AL622_80-2	VGRAB	10/17/2024 15:06	21	sediment (zip-bags)	2	Schlick
Pzh_037	80	AL622_80-3	VGRAB	10/17/2024 15:10	21	bio (kautex 1 l)	1	Schlick
Pzh_037	81	AL622_81-1	VGRAB	10/17/2024 15:17	21	bio (kautex 1 l)	1	Schlick
Pzh_037	81	AL622_81-2	VGRAB	10/17/2024 15:21	21	sediment (zip-bags)	2	Schlick
Pzh_037	81	AL622_81-3	VGRAB	10/17/2024 15:29	21	bio (kautex 1 l)	1	Schlick
Pzh_012	150	AL622_150-1	VGRAB	10/19/2024 8:40	22	bio (kautex 1 l)	2	Schlick
Pzh_012	150	AL622_150-2	VGRAB	10/19/2024 8:44	22	sediment (zip-bags)	2	Schlick
Pzh_012	150	AL622_150-3	VGRAB	10/19/2024 8:50	22	bio (kautex 1 l)	1	Schlick
Pzh_012	151	AL622_151-1	VGRAB	10/19/2024 8:57	22	bio (kautex 1 l)	1	Schlick
Pzh_012	151	AL622_151-2	VGRAB	10/19/2024 9:01	22	sediment (zip-bags)	2	Schlick
Pzh_012	151	AL622_151-3	VGRAB	10/19/2024 9:06	22	bio (kautex 1 l)	1	Schlick
Pzh_012	152	AL622_152-1	VGRAB	10/19/2024 9:12	22	bio (kautex 1 l)	1	Schlick
Pzh_012	152	AL622_152-2	VGRAB	10/19/2024 9:15	22	sediment (zip-bags)	2	Schlick
Pzh_012	152	AL622_152-3	VGRAB	10/19/2024 9:21	22	bio (kautex 1 l)	1	Schlick
Pzh_012	153	AL622_153-1	VGRAB	10/19/2024 9:30	22	bio (kautex 1 l)	1	Schlick
Pzh_012	153	AL622_153-2	VGRAB	10/19/2024 9:32	22	sediment (zip-bags)	2	Schlick
Pzh_012	153	AL622_153-3	VGRAB	10/19/2024 9:36	22	bio (kautex 1 l)	1	Schlick
Pzh_012	154	AL622_154-1	VGRAB	10/19/2024 10:02	22	bio (kautex 1 l)	2	Schlick
Pzh_012	154	AL622_154-1	VGRAB	10/19/2024 10:05	22	sediment (zip-bags)	2	Schlick
Pzh_012	154	AL622_154-1	VGRAB	10/19/2024 10:11	22	bio (kautex 1 l)	1	Schlick
Pzh_012	155	AL622_155-1	VGRAB	10/19/2024 10:27	22	bio (kautex 1 l)	1	Schlick
Pzh_012	155	AL622_155-2	VGRAB	10/19/2024 10:48	22	sediment (zip-bags)	2	Schlick
Pzh_012	155	AL622_155-3	VGRAB	10/19/2024 10:52	22	bio (kautex 1 l)	1	Schlick
Pzh_012	156	AL622_156-1	VGRAB	10/19/2024 12:11	22	bio (kautex 1 l)	1	Schlick
Pzh_012	156	AL622_156-2	VGRAB	10/19/2024 12:15	22	sediment (zip-bags)	2	Schlick
Pzh_012	156	AL622_156-3	VGRAB	10/19/2024 12:19	22	bio (kautex 1 l)	1	Schlick
Pzh_012	157	AL622_157-1	VGRAB	10/19/2024 12:25	22	bio (kautex 1 l)	1	Schlick
Pzh_012	157	AL622_157-2	VGRAB	10/19/2024 12:29	22	sediment (zip-bags)	2	Schlick
Pzh_012	157	AL622_157-3	VGRAB	10/19/2024 12:33	22	bio (kautex 1 l)	1	Schlick

Table 11.2 Species list.

Macrotaxon	**Species**	**Label**	**Alkor 622**						
			St. 1 Haff	St. 7 Haff	St. 1 Pzh37	St. 5 Pzh37	St. 110 BB S.4	St. 1 Pzh12	St. 5 Pzh12
Cnidaria	Hydractinia sp.						~10		
Polychaeta	Scoloplos armiger	Sco	10	9					
	Polydora cornuta	Pol	2						
	Dipolydora quadrilobata			10					
	Pygospio elegans								
	Eteone longa								
	Bylgides elegans								
	Nereimyra punctata	Ner	1				1		
	Nephtys caeca								
	Nephtys hombergii								
	Capitella spp.	Cap	3	7			1		
	Terebellides sp.	Ter	1	3					
	Ampharete baltica	Amp	5						
	Alitta succinea	Ali		2					
	Lagis koreni								
Oligochaeta	Tubificoides benedii	Tub	1						
	Oligochaeta gen.sp.								
Mollusca	Arctica islandica	Arctica islandica							
	Macoma balthica	Macoma balthica	4	2					
	Kurtiella bidentata	Kur	4	1					
	Mya arenaria	Mya		1					
	Mytilus edulis	Myt		1					
	Peringia ulvae	Per	3	28					
	Philine subquadrata	Phi		1					
Crustacea	Amphibalanus improvisus								
	Nippoleucon japonicus								
	Diastylis ratkei	Dia	3	4					
Priapulida	Halicryptus spinulosus								
Phoronida	Phoronis muelleri								
	Comments				empty	empty		empty	empty

11.2 List of AUV Missions

Altitude from base link (centre of the AUV, approx. 0.6 m from DVL)

Kalle Norbit MB Leverarms from base link: xyz="0.435 0.000 0.4355"

Missions ANTON:
Anton330 - 240706_Luise_Haf_002.xml

Altitude: 2.6 m
Linespacing: 1 m
Speed: 0.42 m/s

Anton331 - 240706_Pzh_012.xml

Altitude: 2.6 m
Linespacing: 0.93 m
Speed: 0.42 m/s

Anton332 - 241018123809_Spurversatz.xml

Altitude: 1.9 m
Linespacing: 0.8 m
Speed: 0.4 m/s

Anton333 - 240706_Anton_Haf_003.xml

Altitude: 2.3 m
Linespacing: 0.8 m
Speed: 0.33 m/s

Missions LUISE:
Luise386 - 241016180251_Pzh_Magn_Anomalie.xml

Altitude: 2.0 m
Linespacing: 2.5 m
Speed: 0.5 m/s

Luise387 - 2410181130_Pzh_Magn_Anomaly1.xml

Altitude: 2.0 m
Linespacing: 2.5 m
Speed: 0.5 m/s

Luise388 - 2410181300_Pzh_Magn_Anomaly2.xml

Altitude: 2.0 m
Linespacing: 2.5 m
Speed: 0.5 m/s

Luise389 - 241019064415_Pzh_Moewe2.xml

Altitude: 1.6 m

Linespacing: 0.8 m
Speed: 0.35 m/s

Luise390 - 241020101515_Pzh_Magn_Anom_4.xml

Altitude: 1.6 m
Linespacing: 0.8 m
Speed: 0.35 m/s

Luise391 - 241020102004_KohlbergerHeide_X.xml

Altitude: 1.6 m
Linespacing: 0.8 m
Speed: 0.35 m/s

Missions KALLE:

Sidescan settings (**for all missions**):
enable_high_frequency: true
enable_low_frequency: true
range_delay_high: 0.0
range_delay_low: 0.0
range_high: 30.0
range_low: 30.0

Norbit wbms multibeam settings (Mission **Kalle46 - Kalle49**):
beam_distribution: 3
center_beam_direction_deg: 0.0
gain: 30.0
gate_mode: 2
horizontal_resolution: 512
ip: 192.168.1.11
max_depth: 10.0
max_range: 45.0
max_s7k_file_size_mb: 0
min_depth: 1.0
min_range: 1.0
ntp_server_ip: 192.168.1.50
opening_angle_deg: 130
rate: -1.0
sidescan_mode: 0
store_path: logs/norbit_wbms_multibeam
time_source: 1
trigger_mode: 3
tx_amplitude: 15
tx_bandwidth_khz: 80.0
tx_frequency_khz: 800.0
tx_length_us: 30.0
vertical_resolution: 2048
vga_ramp: 50.0

Norbit wbms multibeam settings (Mission **Kalle50 - Kalle58**):
beam_distribution: 2
center_beam_direction_deg: 0.0

gain: 30.0
gate_mode: 2
horizontal_resolution: 512
ip: 192.168.1.11
max_depth: 100.0
max_range: 100.0
max_s7k_file_size_mb: 0
min_depth: 1.0
min_range: 1.0
ntp_server_ip: 192.168.1.50
opening_angle_deg: 90
rate: -1.0
sidescan_mode: 0
store_path: logs/norbit_wbms_multibeam
time_source: 1
trigger_mode: 3
tx_amplitude: 15
tx_bandwidth_khz: 80.0
tx_frequency_khz: 400.0
tx_length_us: 200.0
vertical_resolution: 2048
vga_ramp: 50.0

Kalle46 - 241014140722_Haff002_Crates_Test.xml - Emergency surface

Altitude: 3 m
Linespacing: 10 m
Speed: 0.6 m/s

Kalle47 - 241014140722_Haff002_Crates.xml

Altitude: 3 m
Linespacing: 10 m
Speed: 0.6 m/s

Kalle48 - 241015053219_Haff002_Wetstorage.xml

Altitude: 3 m
Linespacing: 10 m
Speed: 0.7 m/s

Kalle49 - 241015114822_Haff002_Crates_5m_alt.xml

Altitude: 5 m
Linespacing: 10 m
Speed: 0.6 m/s

Kalle50 - 241016062235_Pzh_37.xml

Altitude: 5 m
Linespacing: 10 m
Speed: 0.7 m/s

Kalle51 - 241016064641_Pzh_12.xml

Altitude: 5 m
Linespacing: 10 m
Speed: 0.7 m/s

Kalle52 - 241018064641_Pzh_Moewe.xml - Emergency surface

Altitude: 3 m
Linespacing: 10 m
Speed: 0.7 m/s

Kalle53 - 241018064641_Pzh_Moewe.xml

Altitude: 3 m
Linespacing: 10 m
Speed: 0.7 m/s

Kalle54 - 241018064641_Pzh_Moewe_MBtest.xml

Altitude: 3 m
Linespacing: 10 m
Speed: 0.7 m/s

Kalle55 - 241020062810_Launcher-Test.xml

Altitude: 3 m
Linespacing: - m
Speed: 0.5 m/s

Kalle56 - 241016064641_Kalle_am_Sonntag.xml - Emergency surface

Altitude: 6 m
Linespacing: 10 m
Speed: 0.7 m/s

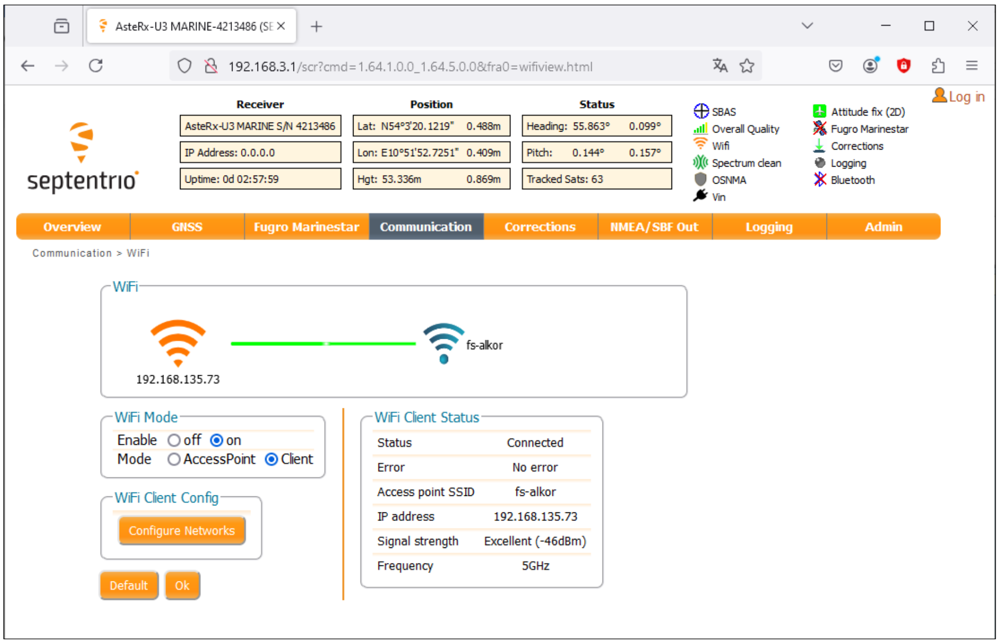
Kalle57 - 241016064641_Kalle_am_Sonntag.xml

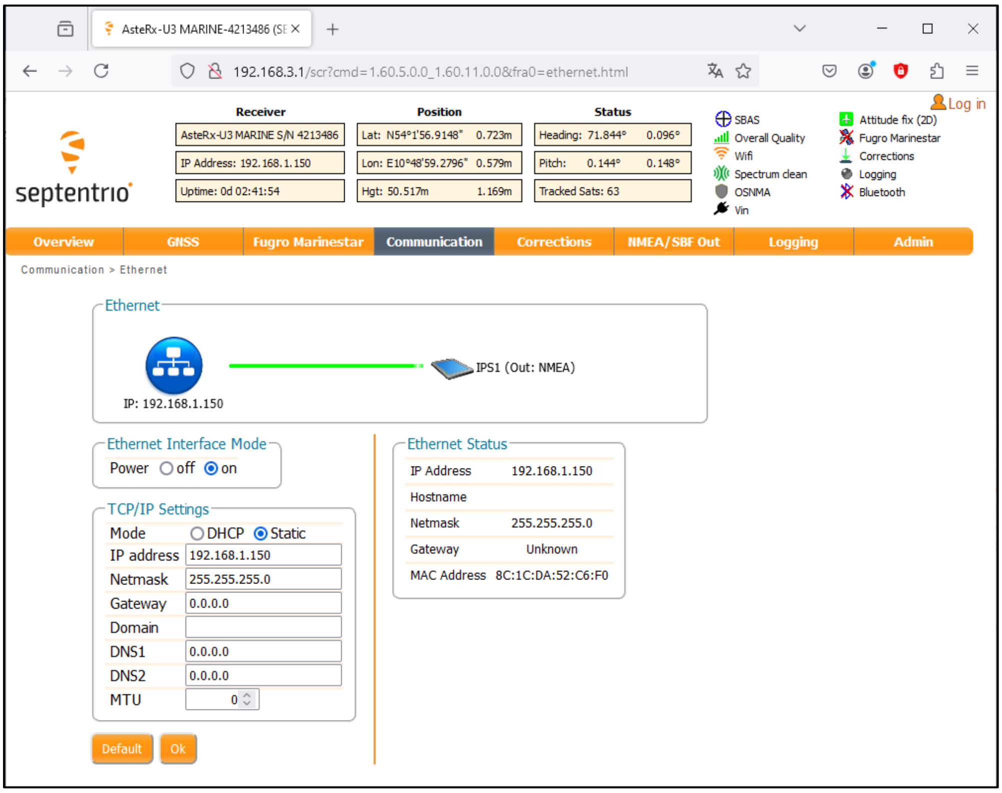
Altitude: 6 m
Linespacing: 10 m
Speed: 0.7 m/s

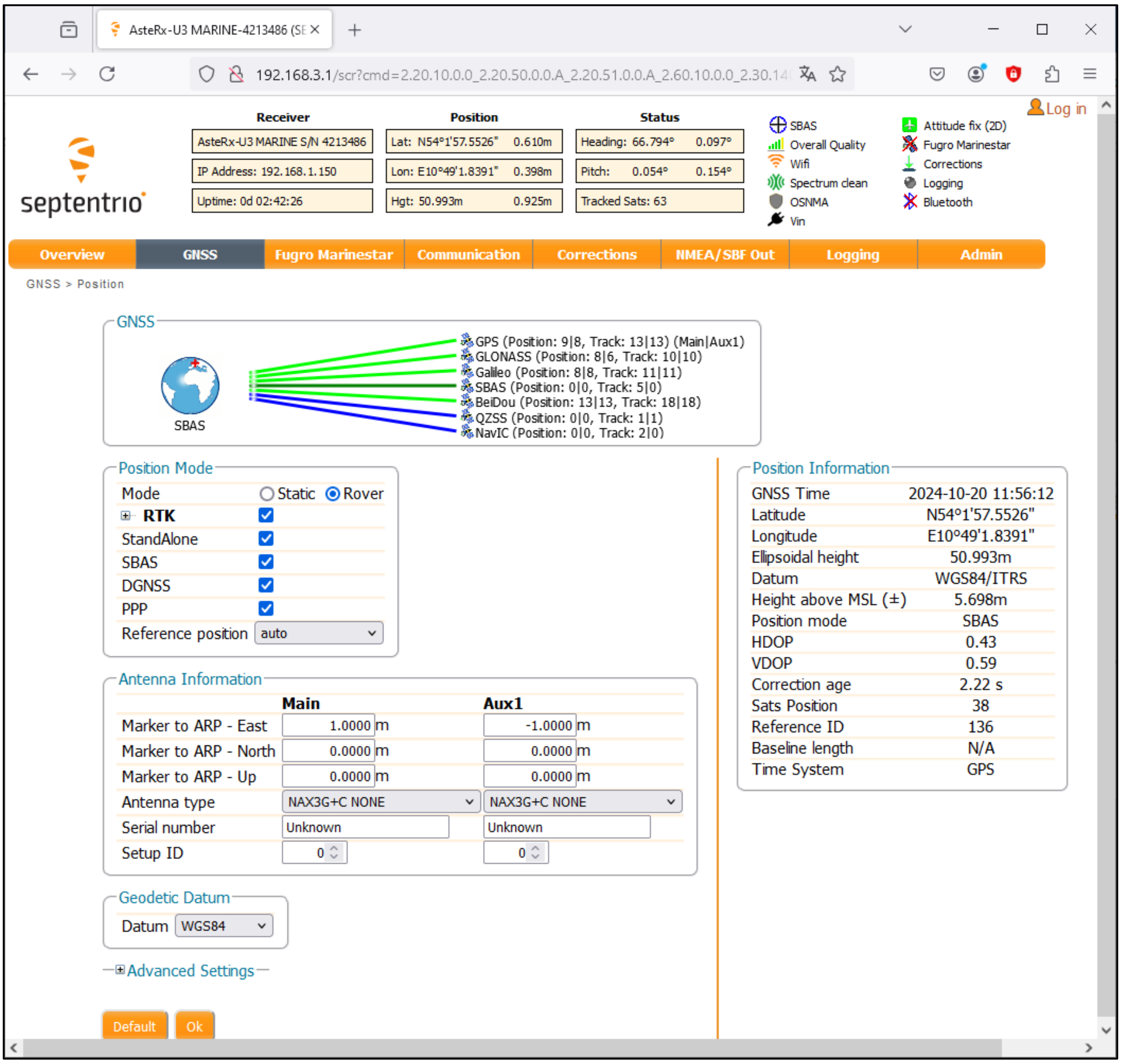
Kalle58 - 241020195352_KolbergerHeide_Kalle.xml

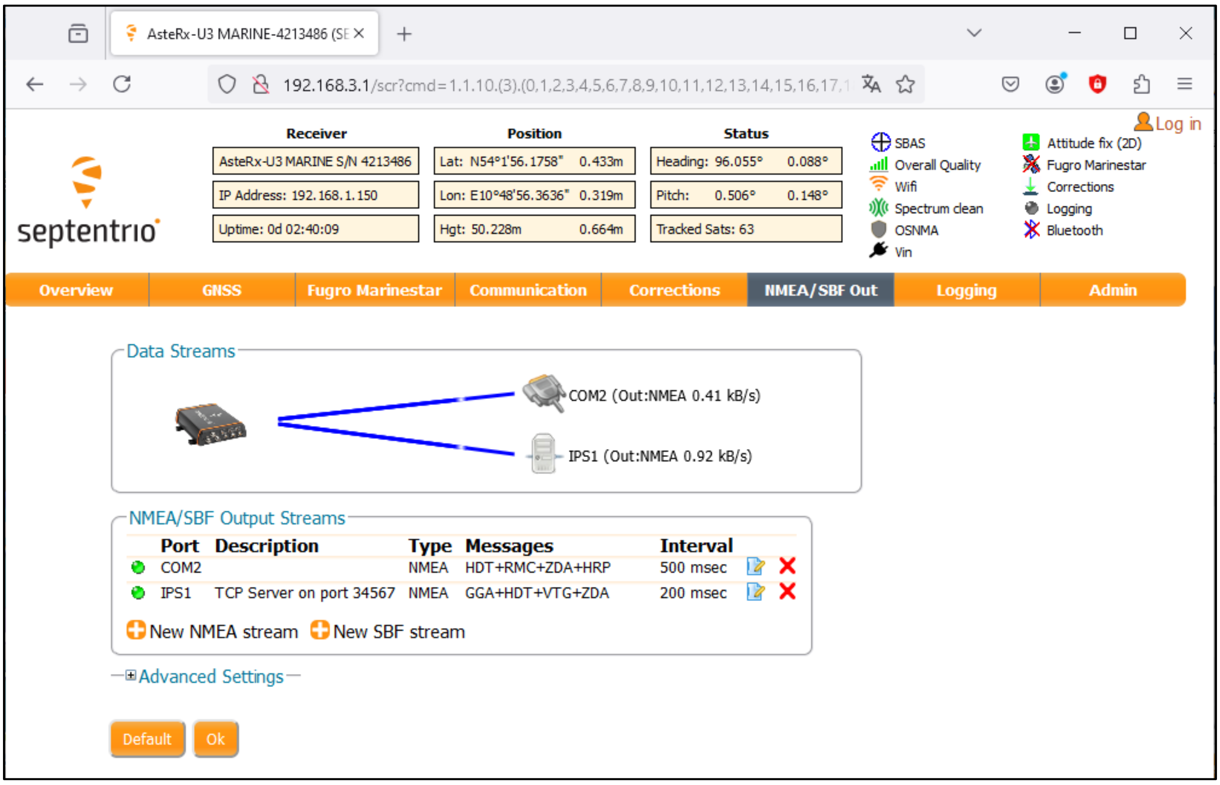
Altitude: 3.6 m
Linespacing: 5 m
Speed: 0.7 m/s

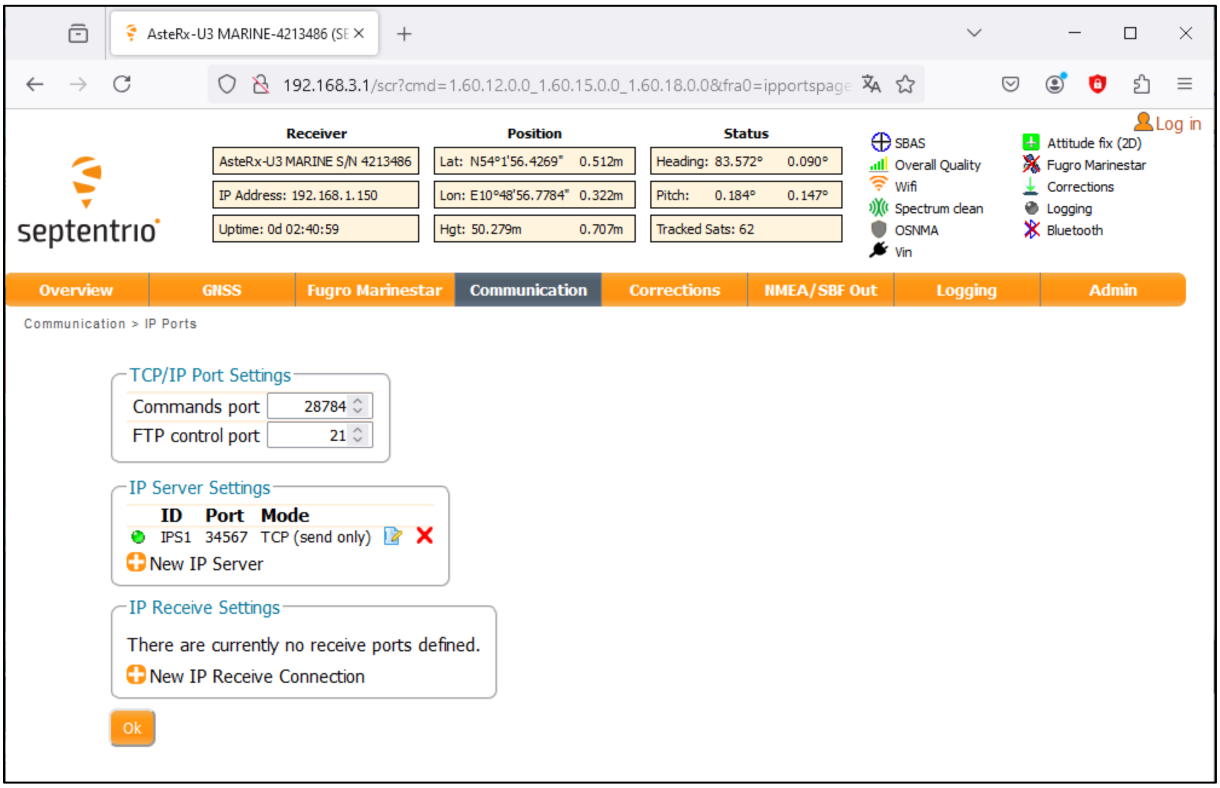
11.3 Septentrio Settings

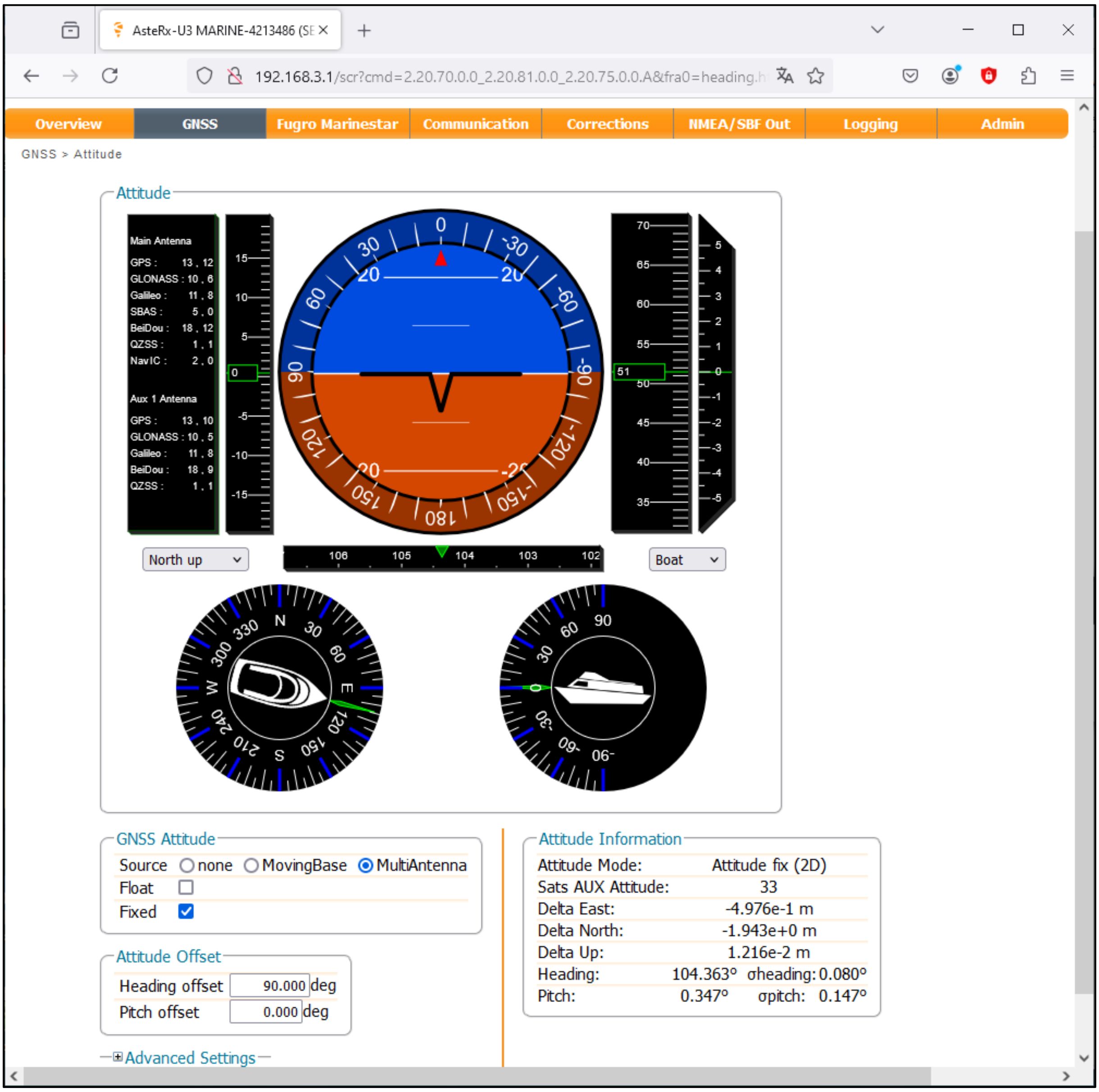





AsteRx-U3 MARINE-4213486
192.168.3.1/scr?cmd=2.20.10.0.0_2.20.50.0.0.A_2.20.51.0.0.A_2.60.10.0.0_2.30.14
septentrio
Receiver
AsteRx-U3 MARINE S/N 4213486
IP Address: 192.168.1.150
Uptime: 0d 02:42:26
Position
Lat: N54°1'57.5526" 0.610m
Lon: E10°49'1.8391" 0.398m
Hgt: 50.993m 0.925m
Status
Heading: 66.794° 0.097°
Pitch: 0.054° 0.154°
Tracked Sats: 63
SBAS
Overall Quality
Wifi
Spectrum clean
OSNMA
Vin
Attitude fix (2D)
Fugro Marinestar
Corrections
Logging
Bluetooth
Log in
Overview
GNSS
Fugro Marinestar
Communication
Corrections
NMEA/SBF Out
Logging
Admin
GNSS > Position
GNSS
GPS (Position: 9|8, Track: 13|13) (Main|Aux1)
GLONASS (Position: 8|6, Track: 10|10)
Galileo (Position: 8|8, Track: 11|11)
SBAS (Position: 0|0, Track: 5|0)
BeiDou (Position: 13|13, Track: 18|18)
QZSS (Position: 0|0, Track: 1|1)
NavIC (Position: 0|0, Track: 2|0)
SBAS
Position Mode
Mode Static Rover
RTK
StandAlone
SBAS
DGNSS
PPP
Reference position auto
Position Information
GNSS Time 2024-10-20 11:56:12
Latitude N54°1'57.5526"
Longitude E10°49'1.8391"
Ellipsoidal height 50.993m
Datum WGS84/ITRS
Height above MSL (±) 5.698m
Position mode SBAS
HDOP 0.43
VDOP 0.59
Correction age 2.22 s
Sats Position 38
Reference ID 136
Baseline length N/A
Time System GPS
Antenna Information
Main Aux1
Marker to ARP - East 1.0000 m -1.0000 m
Marker to ARP - North 0.0000 m 0.0000 m
Marker to ARP - Up 0.0000 m 0.0000 m
Antenna type NAX3G+C NONE NAX3G+C NONE
Serial number Unknown Unknown
Setup ID 0 0
Geodetic Datum
Datum WGS84
Advanced Settings
Default
Ok


AsteRx-U3 MARINE-4213486 (SE
192.168.3.1/scr?cmd=1.1.10.(3).(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,1
Log in
septentrio
Receiver
AsteRx-U3 MARINE S/N 4213486
IP Address: 192.168.1.150
Uptime: 0d 02:40:09
Position
Lat: N54°1'56.1758" 0.433m
Lon: E10°48'56.3636" 0.319m
Hgt: 50.228m 0.664m
Status
Heading: 96.055° 0.088°
Pitch: 0.506° 0.148°
Tracked Sats: 63
SBAS
Overall Quality
Wifi
Spectrum clean
OSNMA
Vin
Attitude fix (2D)
Fugro Marinestar
Corrections
Logging
Bluetooth
Overview
GNSS
Fugro Marinestar
Communication
Corrections
NMEA/SBF Out
Logging
Admin
Data Streams
COM2 (Out:NMEA 0.41 kB/s)
IPS1 (Out:NMEA 0.92 kB/s)
NMEA/SBF Output Streams
Port Description Type Messages Interval
COM2 NMEA HDT+RMC+ZDA+HRP 500 msec
IPS1 TCP Server on port 34567 NMEA GGA+HDT+VTG+ZDA 200 msec
New NMEA stream
New SBF stream
Advanced Settings
Default
Ok


AsteRx-U3 MARINE-4213486 (SE
192.168.3.1/scr?cmd=1.60.12.0.0_1.60.15.0.0_1.60.18.0.0&fra0=ipportspage
Log in
septentrio
Receiver
AsteRx-U3 MARINE S/N 4213486
IP Address: 192.168.1.150
Uptime: 0d 02:40:59
Position
Lat: N54°1'56.4269" 0.512m
Lon: E10°48'56.7784" 0.322m
Hgt: 50.279m 0.707m
Status
Heading: 83.572° 0.090°
Pitch: 0.184° 0.147°
Tracked Sats: 62
SBAS
Overall Quality
Wifi
Spectrum clean
OSNMA
Vin
Attitude fix (2D)
Fugro Marinestar
Corrections
Logging
Bluetooth
Overview
GNSS
Fugro Marinestar
Communication
Corrections
NMEA/SBF Out
Logging
Admin
Communication > IP Ports
TCP/IP Port Settings
Commands port 28784
FTP control port 21
IP Server Settings
ID Port Mode
IPS1 34567 TCP (send only)
New IP Server
IP Receive Settings
There are currently no receive ports defined.
New IP Receive Connection
Ok


AsteRx-U3 MARINE-4213486
192.168.3.1/scr?cmd=2.20.70.0.0_2.20.81.0.0_2.20.75.0.0.A&fra0=heading.h
Overview
GNSS
Fugro Marinestar
Communication
Corrections
NMEA/SBF Out
Logging
Admin
GNSS > Attitude
Attitude
Main Antenna
GPS : 13 , 12
GLONASS : 10 , 6
Galileo : 11 , 8
SBAS : 5 , 0
BeiDou : 18 , 12
QZSS : 1 , 1
NavIC : 2 , 0
Aux 1 Antenna
GPS : 13 , 10
GLONASS : 10 , 5
Galileo : 11 , 8
BeiDou : 18 , 9
QZSS : 1 , 1
North up
Boat
GNSS Attitude
Source none MovingBase MultiAntenna
Float
Fixed
Attitude Offset
Heading offset 90.000 deg
Pitch offset 0.000 deg
Advanced Settings
Attitude Information
Attitude Mode: Attitude fix (2D)
Sats AUX Attitude: 33
Delta East: -4.976e-1 m
Delta North: -1.943e+0 m
Delta Up: 1.216e-2 m
Heading: 104.363° σheading: 0.080°
Pitch: 0.347° σpitch: 0.147°