ELISABETH MANN BORGESE – Berichte

Baltic Sea Long-term Observation Programme

Cruise No. EMB 305

5 November – 18 November 2022,

Rostock – Sassnitz – Kiel - Rostock (Germany)

HELCOM/long-term

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Leibniz-Institute for Baltic Sea Research Warnemünde

2022

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1 Cruise Summary

1.1 Summary in English

The cruise of r/v Elisabeth Mann Borgese No. 305 from November 5th to 18th 2022 was carried out in the frame of the HELCOM monitoring and the IOW long-term observation of the Baltic Sea. The cruise was done in autumn weather conditions with partly strong winds with gusts up to 9 wind forces. During the first ten days we had relative mild temperatures of about 12°C but the air temperature dropped clearly afterwards. The station grid of 92 stations was completed. Three moorings were deployed on one day in fair weather conditions. Preliminary results and observations showed that also the water of the mixed layer was still relatively warm with about 12°C in November 2022. In the western Baltic Sea an autumn bloom was indicated, but the oxygen condition in bottom waters was basically recovered after the summer. In the area of the Słupsk Furrow and at the southern slope of the eastern Gotland Basin, oxygenated water intrusions were determined in the deep water. However, Gotland Deep and Fårö Deep reflected the ongoing accumulation of the hydrogen sulphide in bottom waters. In deep waters of the central basins also the continuation of perennial phosphate enrichment was documented for November 2022. Redox sensitive nitrate had disappeared at euxinic conditions of the deep waters. However, strong temporal variability of nitrate in the bottom waters of the Bornholm Deep is documented according to its variable oxygen state and its rapid transitions between oxic and euxinic. The weak declining tendency of salinity in Gotland Sea deep water is going on and may increase the probability of re-oxygenation by an inflow.

1.2 Zusammenfassung

Die Reise des F/S Elisabeth Mann Borgese Nr. 305 vom 5. bis 18. November 2022 wurde im Rahmen des HELCOM Monitorings und der IOW Langzeit Überwachung der Ostsee durchgeführt. Die Fahrt wurde bei herbstlichen Wetterbedingungen mit stürmischen Winden und Böen bis zu 9 Windstärken durchgeführt. Die ersten 10 Tage herrschten milde Lufttemperaturen von etwa 12°C, dann fiel die Temperatur aber deutlich ab. Das Stationsnetz von 92 Stationen wurde absolviert. An einem Tag mit guten Wetterbedingungen wurden drei Verankerung ausgebracht. Vorläufige Ergebnisse und Beobachtungen zeigen, dass auch das Wasser der durchmischten Oberflächenschicht mit etwa 12°C im November 2022 noch relativ warm war. In der westlichen Ostsee wurden noch Anzeichen einer Herbstblüte vorgefunden, aber die Sauerstoffsituation im Bodenwasser hatte sich im Wesentlichen nach dem Sommer erholt. Im Bereich der Słupsker Rinne und am südlichen Hang des Gotlandbeckens wurden Einschübe von sauerstoffhaltigem Wasser in der Tiefe vorgefunden. Unabhängig davon zeigten das Gotland- und das Fårötief fortschreitende Akkumulierung von Schwefelwasserstoff. Im Tiefenwasser der zentralen Becken wurde auch die Anreicherung von Phosphat über viele Jahre im November 2022 bestätigt. Das redoxsensitive Nitrat war aus dem Tiefenwasser verschwunden. Die Messungen von Nitrat im Bodenwasser zeigen für das Bornhomtief eine starke Variabilität, die durch veränderte Sauerstoffbedingungen und schnelle Übergänge zwischen dem oxischen und dem euxinischen Zustand über die letzten Jahre verursacht wurde. Die leichte Abnahme des Salzgehalts im Bodenwasser des Gotlandtiefs setzte sich weiter fort, womit sich die Wahrscheinlichkeit einer Belüftung durch einen Einstrom erhöht.

2 Participants

2.1 Principal Investigators

Name	Institution
Kuss, Joachim, Dr. (Marine Chemistry)	IOW
Mohrholz, Volker, Dr. (Hydrography)	IOW
Dutz, Jörg, Dr. (Zooplankton)	IOW
Kremp, Anke, Dr. (Phytoplankton)	IOW
Zettler, Michael, Dr. (Macrozoobenthos)	IOW

2.2 Scientific Party

Name	Discipline	Institution
Kuss, Joachim, Dr.	Marine Chemistry, Chief Scientist	IOW
Ruickoldt, Johann	Phys. Oceanography, CTD	IOW
Markfort, Greta	Phys. Oceanography, CTD	IOW
Sadkowiak, Birgit	Marine Chemistry, Nutrients	IOW
Dierken, Madleen	Marine Chemistry, Oxygen	IOW
Hand, Ines	Marine Chemistry, Nutrients	IOW
Hehl, Uwe	Biol. Oceanogr., Moorings and Benthos	IOW
Schubert, Stefanie	Biol. Oceanogr., Benthos organisms	IOW
Reddy, Kaylim	Biol. Oceanogr., Microbiology	IOW
Guilleaume, Julia	Marine Chemistry, Analytical support	IOW
Heins, Anneke, Dr.	Microbiology, eDNA Archive	MPI-MM
Fechtel, Christin	Biol. Oceanogr., Plankton and Microbiol.	IOW

2.3 Participating Institutions

IOW	Leibniz Institute for Baltic Sea Research Warnemünde
MPI-MM	Max Planck Institute for Marine Microbiology

3 Research Program

3.1 Description of the Work Area

The contribution of the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) to the HELCOM monitoring comprised measurements in German territorial waters with the German Exclusive Economic Zone and bordering sea areas. Therefore, basic hydrographic data, major nutrients, phytoplankton, zooplankton and benthos parameters were determined. Moreover, IOW extends the investigated sites by its long-term observation programme of the Baltic Sea. This contributes with station work in parts of the Danish, Swedish, Polish, and Latvian territorial waters and their respective Exclusive Economic Zones. Thereby, the major focus is always on the thalweg transect, which reflects the main path of inflowing North Sea water through the belts and sounds, via Darss Sill and Drogden Sill to the Arkona Sea, subsequently to the Bornholm Basin, along the Słupsk channel to the eastern Gotland Basin. The inflow may proceed within several months further to the northern and western Gotland Sea, episodically bringing oxygenated haline water to the central basins. An overview of the locations of CTD stations are shown in Fig. 3.1. The list of stations is given in Chapter 6 for the detailed time table of stations and activities.

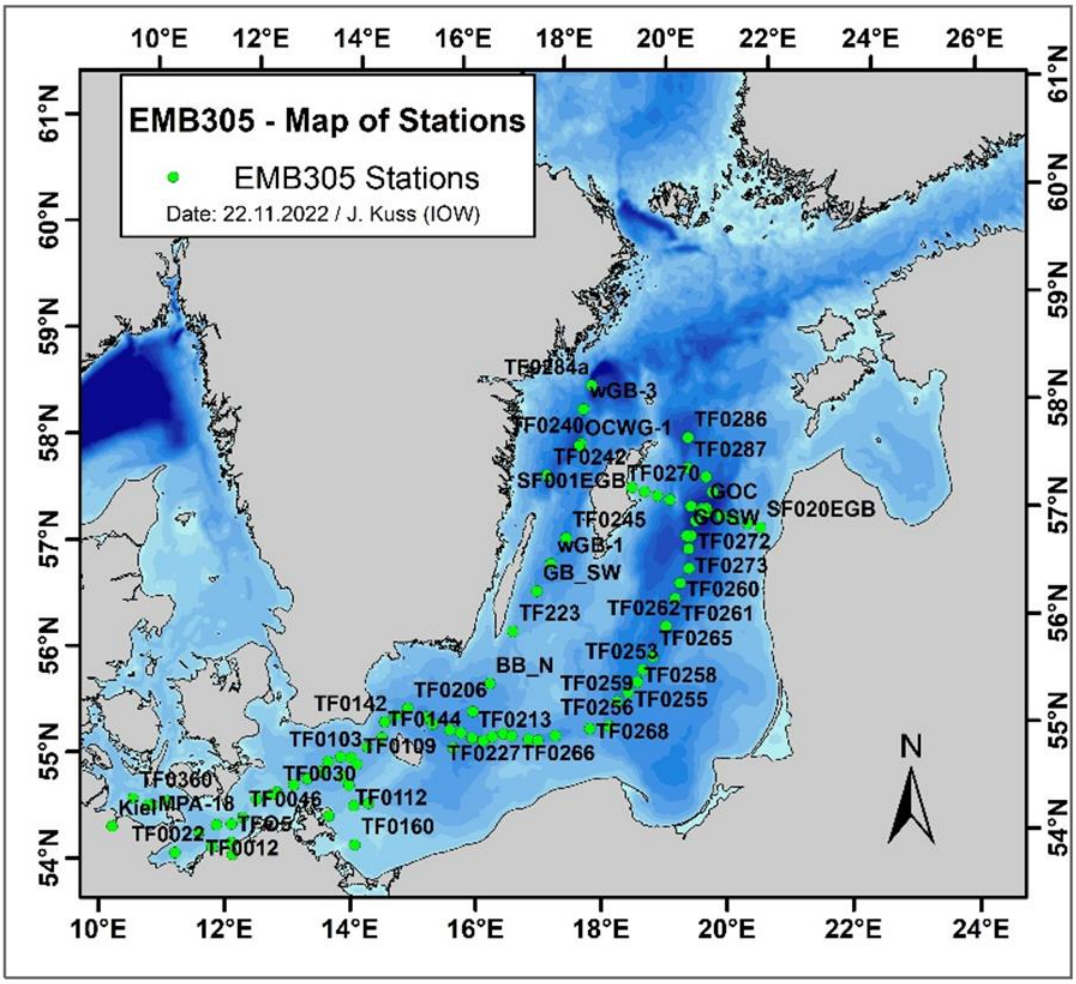

Fig. 3.1 Map of stations (green dots) of the cruise EMB 305 from 5th – 18th November 2022; the details of the investigated stations are listed in Chapter 6.

3.2 Aims of the Cruise

The cruise EMB 305 was carried out as a campaign of the environmental monitoring programme of the Federal Maritime and Hydrographic Agency (BSH) and the Baltic Sea long-term observation programme of IOW. It was the last campaign in 2022 of five cruises performed annually. The acquired data are used for the regular national and international assessments of the state of the Baltic Sea, and provide the scientific basis for measures to be taken for the protection of the Baltic Sea ecosystem. The hydrographic and hydrochemical conditions as well as the development status of phytoplankton and zooplankton abundances are investigated. Microbiological aspects, acidification, and trace gases were additionally studied in the frames of the long-term observation of the Baltic Sea. A special focus of the long-term observation is always the occurrence or absence of inflow events that both have major consequences for the state of the Baltic Sea's hydrochemistry and its ecosystem. The stagnation phase continued and oxygen depletion in deep waters intensified in the last five years by ongoing accumulation of hydrogen sulphide in deep waters of the central basins.

3.3 Agenda of the Cruise

The station work in general commenced by a CTD cast and already programmed sampling on standard depth levels. Manual releases in near-bottom waters and close to the sea surface completed the sampling. Then other CTD casts followed on demand to meet the additional water sample requirements. On selected stations, water sampling was carried out for oxygen, basic dissolved inorganic nutrients, total nutrient concentrations, as well as net sampling for phytoplankton and zooplankton species were carried out. Determinations of chlorophyll and the depth of visibility by means of a Secci disk were also done. During autumn cruises, an additional extensive benthos work programme for the western Baltic Sea is on the schedule.
Moreover, surface water was sampled in German territorial and EEZ waters for a DAM initiative that plans to establish an eDNA sample archive and investigates the metabolic pathways of bacteria by a metagenomic and metaproteomic approach. For the detailed list of deployed gears see list of stations in Chapter 6.

CTD and Sampling

The CTD-system "SBE 911plus" (SEABIRD-ELECTRONICS, USA) was used to measure the variables: Pressure, Temperature (2x SBE 3), Conductivity (2x SBE 4), Oxygen concentration (2x SBE 43), Chlorophyll-a fluorescence (683 nm), Turbidity, Photosynthetic active radiation in water (PAR), and above the sea (SPAR).

The rosette water sampler was equipped with 13 Free Flow bottles of 5 L volume each. The CTD sensors were checked during the cruise by comparison measurements. In detail, for temperature a high precision thermometer SBE RT35 was used. Salinity samples were taken for measurement after the cruise by means of a salinometer. Slope and offset of the oxygen sensors SBE 43 are checked daily by potentiometrically titrated water samples according to Winkler (1888).

Nutrients

Nitrate, nitrite, phosphate, and silicate were analyzed on filtered water samples using standard spectrophotometric methods by means of an autoanalyser (FlowSys, Alliance-Instruments, Ainring, Germany) and ammonium was determined manually as indophenole blue (Grasshoff *et al.*, 1999) from unfiltered water on-board. Total and total dissolved nitrogen and phosphorous samples as well as particulate and dissolved organic matter samples were prepared and stored deep frozen for digestion and analysis in the IOW nutrients and natural organic matter labs, respectively.

Oxygen and hydrogen sulphide

Oxygen was analyzed by Winkler titration and hydrogen sulphide was determined spectrophotometrically by the methylene blue reaction (Grasshoff *et al.*, 1999). To continue the oxygen profiles in anoxic waters and for comparison, H_2S concentration was converted to negative oxygen values according to its reduction capacity: $H_2S + 2\ O_2 \rightarrow H_2SO_4$. During CTD casts the SBE 43 oxygen sensor (duplicate installation) recorded oxygen values that are validated by daily Winkler titration of triple samples from each of 3 water sampling bottles released according to a specific time-regime in the same depth.

Plankton sampling

Plankton sampling was performed by means of a rosette sampler (combined with CTD) as well as with a small phytoplankton net and the zooplankton nets WP2 and Apstein by whole water column hauls. Samples were taken in a tight follow up of depths levels in order to get representative data from the euphotic zone. The traditional method to estimate water transparency/primary production by means of a Secci disk is also applied here. (Responsible scientists: Dr. Anke Kremp, Dr. Jörg Dutz).

Benthos work

On selected stations in the western Baltic Sea, the species composition of macrozoobenthos (MZB) was determined by two different approaches. By using a Van-Veen grab, samples of defined surface area and volume were obtained to enable quantitative analyses. Therefore, the sediment sample is flushed through a sieve of 1 mm mesh size. The retained organisms are conserved by application of 4%-formaldehyde solution. The final microscopic evaluation is done in the IOW lab after return. Three hauls were analysed on each station. In addition, one sample is used to obtain the upper sediment layer of 1-2 cm thickness. The sample is stored cool at about 8°C. By means of sieving of the dry sample or by laser method dependent on the sediment type a particle size analysis is done in the lab.

An overview of the species composition of an area is achieved by sampling with a dredge. This qualitative method required sampling transects of 0.5 to 5 minutes at about 1 knot ship's speed. The obtained animals are as well fixed by 4%-formaldehyde solution. The abundance of species is classified from abundant (A= >100 animals) to rare (R= 0-5 animals). On each station the auxiliary parameters temperature and salinity (CTD-data) as well as oxygen (by Winkler titration) are documented. (Responsible scientist: Dr. Michael Zettler)

Long-term observation of the microbiological habitat of the redoxcline

Insights into the changes of the microbial food web of the redoxcline is obtained by well resolved sampling of the range of the redoxcline at Gotland Deep and Landsort Deep stations on each monitoring cruise. Therefore, in the redoxcline as well as 6 depths above and below, respectively, in depth intervals of 2 m, samples were taken by CTD/water sampling bottles and prepared for microbiological analysis (FISH and DNA) and determination of pigments. (Responsible scientist: Prof. Dr. Klaus Jürgens)

Long-term investigations of CH_4, N_2O and the marine carbonate system

Sampling for simultaneous CH_4 and N_2O observation is carried out on 4 stations (TF0113, TF0213, TF0271, TF0286) in the frame of the accompanying project for long term data collection. All samples were taken in septum-sealed 250 mL water bottles and fixed with 200 µL or in case of hydrogen sulphide presence with 500 µL saturated $HgCl_2$-solution to prevent microbiological activity and stored dark. On the same stations and depths also CT, AT, and pH were sampled for their long-term observation. These samples were fixed by the same method and were also stored dark. (Responsible scientist: Prof. Dr. Gregor Rehder).

Sensor tests in the frame of the projects DArgo2025 and C-SCOPE
As part of the research project DArgo2025, optical nitrate and hydrogen sulphide data were acquired with two sensors (OPUS, TriOS GmbH; SUNA, Sea-Bird Scientific). Both were tested during CTD casts as well as underway by using the ship's clean seawater supply system. Sensors' stability was controlled through daily Milli-Q water measurements. Moreover, a HydroC pCO_2 sensor was attached to the CTD in preparation for analyses within the C-SCOPE research project. Data from these sensors will be made available by the respective research project's data management upon publication of the intended analyses. (Responsible scientists: Dr. Henry Bittig and Malin Waern).

Establishment of an eDNA-archive and Metaproteogenomic analyses (DAM project)
For a bio-archive of microorganisms and metazoans in the North and the Baltic Sea, biomass is collected by filtering seawater either through a 0.2 µm or a 0.45 µm filter to obtain respectively bacterial and metazoan DNA (CREATE project). All samples are frozen directly and stored at -20 °C and are available for further processing like DNA extraction and sequencing.
For metaproteogenomic analyses, surface water samples of 60 L were taken by a CTD-Rosette system. Subsequently, the water was filtered through 10 µm, 3 µm and 0.2 µm filters, respectively. Filters were stored at -80 °C. Macro- and microalgae were found on the 10 µm and 3 µm filters and bacteria were harvested on the 0.2 µm filter for metagenomic and metaproteomic analyses and furthermore for the determination of bacterial metabolic activity. (Responsible scientists: Prof. Dr. Matthias Labrenz, IOW, Dr. Alexandra Dürwald, Uni-Greifswald, Dr. Anneke Heins, MPI-Bremen).

Just a Surface water Monitoring Box (JSMB)
The JSMB system (Krüger and Ruickoldt, 2021) is used for continuous measurements in a pumped sea surface water flow of temperature salinity conductivity, calculated sound velocity, real sound velocity, Chl_a, turbidity and optional many more parameters. The measurement ranges, the accuracy or alternatively the sensitivity of the measurements are as follows: conductivity with a range of 0 to 70 mS/cm, and an accuracy of 0.003 mS/cm, temperature (-3 to 35 °C, 0.002 °C), salinity (2 to 42, 0.005), sound velocity (1375 to 1625 m/s, 0.025 m/s), turbidity (0 to 25 NTU, 0.013 NTU sensitivity), and chlorophyll_a (0 to 50 µg/L, 0.025 µg/L sensitivity). The system was used during transect for recording of these parameters in surface water that was pumped from below the ship's hull. Preliminary data of temperature, salinity, chlorophyll_a and turbidity are shown in Figure 5.2 (Responsible scientists: Dr. Robert Wagner, Johann Ruickoldt).

4 Narrative of the Cruise

This paragraph is a day by day report that includes the forecasted weather and sea condition as predicted by Deutscher Wetterdienst (DWD, 2022) for the respective days. It is aimed to give an impression of the work on board during the campaign.

Saturday, 5th November 2022: The forecast of the day was westerly winds of 4 to 5 bft, shifting slowly south and increasing a little at a sea state of 1.5 meter wave height. At 8:00 in the morning we left the pier on a sunny and relative cold morning and headed North via the Warnow river mouth. We reached the first station TFO5 at 9:25 o'clock after a completion of the mandatory security exercise. A successful second attempt of the CTD cast provided the required water samples for the nutrients nitrate, nitrite, phosphate and silicate, total nitrogen and total phosphorus as well as samples for natural organic matter determination. Secci depth measurement was used to figure out the turbidity that was also used for adjusting the filtration volume for the chemical particle analysis. The next four stations, TF0012, TF0046 in the Cadet Channel, TF0030 and TF0113 were biological stations with net hauls and water sampling for chlorophyll and micro algae sampling. These stations are usually done at the end of the cruise to get a biological comparison measurement to the first sampling. However, during this cruise the sequence of the western Baltic Sea stations was reversed and shifted the chemical investigations of the western Baltic Sea to the end of the cruise. Late in the evening, we completed the TF0113.

Sunday, 6th November 2022: The weather forecast read wind from southwest of 5 to 6 bft, shifting south and later increasing a little, at times misty at a sea of 2.5 meter wave height. Late in the night at 1:30 o'clock, we fulfilled a CTD cast and sampling for oxygen measurements in the level of the oxygen sensors of the MARNET platform ABBoje. Then we headed to Sassnitz to exchange an officer. At 8:00 o'clock the captain during many years left the ship and a new 1st officer was picked up in Sassnitz and brought to the ship with 480 additional half litre mineral water bottles for supply. Then we first went to the TF0214 to start a series of stations downwind of the Island of Bornholm. Then the major station Bornholm Deep TF0213 was on the schedule. We sampled water for nutrient analyses of standard dissolved inorganic nutrients, ammonium, total nitrogen, total phosphorus, and organic matter, as well as for the analysis of greenhouse gases. Secci depth determination and net hauls for phytoplankton and zooplankton determinations were also on the schedule. However, it turned out that the waves were too high and the wind was too strong to reliably carry out net sampling. So we postponed this part of the station work and tried to reach TF0200 as we hope to find somehow calmer conditions there, but wind increased with gusts of 9 bft and we stopped the working programme and looked for a calmer region closer to the Island of Bornholm overnight.

Monday, 7th November 2022: The weather was expected to be with wind from south of 6 bft, shifting southwest and decreasing a little with shower squalls at a sea state of 2.5 meter wave height. After breakfast we headed to a north-eastern direction to reach the squibbed stations TF0208, TF0200, TF0211 and TF0212. TF0208 and TF0212 were selected to carry out additional sampling for the greenhouse gas methane and the co-parameter dissolved inorganic nutrients to look for peculiarities caused by the leaky Nordstream pipelines. Then a second try of the Bornholm Deep station was on the schedule to carry out the missed net hauls. Then we headed to the south-eastern part of the Bornholm Basin to continue the thalweg transect on station TF0221, TF0225, TF0224, TF0227 and TF0229. Late in the evening we fulfilled the TF0222 in the Słupsk furrow with dissolved inorganic nutrients and some more samples for methane analysis.

Tuesday, 8th November 2022: It was a typical November day, grey and misty, but with still about 12°C air temperature. Wind was forecasted from south to southwest of 5 to 6 bft, for a time decreasing to about 4 bft with shower squalls, locally even thunderstorms at a sea of 2.5 meter wave height. In the night we completed TF0266, TF0268 and early in the morning the TF0256 as part of the eastern directed thalweg transect. Then we headed North to the TF0259 with a comprehensive chemical programme with nutrients and natural organic matter, oxygen and hydrogen sulphide. Further North we made a CTD cast on each of the stations TF0255, TF0253, TF0265, TF0262, TF0261, TF0260, TF0274, TF0273 and TF0272 with some oxygen comparison measurements.

Wednesday, 9th November 2022: For the Central Baltic the weather forecast read wind from south to southwest of 4 to 5 bft, at times shower squalls, at a sea 1.5 meter wave height. During the night we completed the TF0275, then we turned west to reach the near coastal start location SF001EGB at the Island of Gotland of the ScanFish transect. After a CTD-cast the ScanFish was deployed at 8:00 o’clock. The bay was calm and the morning was sunny but also a bit hazy. However, after one and a half hour the contact to the ScanFish got lost and it had to be recovered. So the ScanFish transect was continued by CTD-casts on the stations SF003EGB, SF005EGB, SF007EGB and SF010EGB until the centre of the eastern basin. We approached the Gotland Deep station in the afternoon and started the comprehensive programme with 8 CTD casts and net hauls with the small phytoplankton net. After completing the main Gotland Deep station, we continued to do ScanFish stations SF012EGB, SF014EGB, SF016EGB, SF018EGB, SF020EGB by CTD casts. We cancelled the SF022EGB to be early the next morning in the centre of the basin to do the comprehensive mooring work.

Thursday, 10th November 2022: The weather for the day in the central Baltic was expected to be with moderate wind from west to southwest of 4 to 5 bft and relative small waves, later increasing to 6 bft for a time, shifting west with shower squalls, at a sea of 2.5 meter wave height. The day was chosen for the mooring work already a couple of days before. We started at 7 o’clock with a CTD cast and then deployed the GODESS. Afterwards the mooring Gotland Central was recovered and re-deployed. This worked very well and we saved some time that we headed in south-western direction to release the Gotland Southwest mooring, because it was already deployed in March and was more urgent to be exchanged compared to the nearby Gotland Northeast mooring. After completing the third deployment we headed North to reach the TF0276, the TF0270 and the TF0278 each for a CTD cast, before we reached the next major station, the Fårö Deep.

Friday, 11th November 2022: The weather forecast for the day was wind from southwest of about 6 bft, shifting west, at a sea with increasing wave height of 3 meter. The Fårö Deep station TF0286 with a comprehensive chemistry and biological programme including greenhouse gases, nutrient parameters and net hauls was started at one o’clock with the first of two CTD casts. After completing the station, we had to look for a sheltered bay because strong winds with waves, too high to continue the work programme were expected. In the morning the situation was not better, and we stayed in coastal waters at the Island of Gotland. We had to skip a few northern stations and planned to start to the next station in the afternoon. We estimated to reach the TF0284a in the Landsort Deep area with 360 m water depth in the evening. At about 20:30 o’clock the comprehensive work programme of this major station was begun.

Saturday,12th November 2022: Wind was forecasted from southwest to west of about 6 bft, shifting northwest, abating, at a sea of first 3 meter. In the night a CTD cast on wGB-3 was completed. At 6:30 o'clock in the morning we carried out a CTD cast with water sampling for nutrients an oxygen/H2S profile and then tried to get surface sediment samples on OCWG-1 but unfortunately the sediment was too soft to recover a complete core. The station TF0242 followed with just a CTD profile and then we headed further South to the Karlsö Deep TF0245, a major station with various nutrient parameters and an oxygen/hydrogen sulphide profile. The stations wGB-1, GB_SW and the TF223 around midnight only required a CTD profile without additional water sampling.

Sunday, 13th November 2022: The weather forecast was light and variable winds, shifting southeast, increasing slowly from 4 to 5 bft, at times misty with fog patches, sea state with increasing wave height to 1 meter. Early in the morning the BB_N and after breakfast TF0220 with respective CTD casts were done. The major station TF0213 was next on the schedule that was reached at 10:00 o'clock in the morning. It was the first repetition station with a sampling programme focussed on the biological parameters but included the major nutrients. Then we had a transit again further North to fulfil the stations that had been cancelled a couple of days before due to bad weather. It started with the TF0206, TF0140, TF0142, TF0144, TF0145, either with nutrients and/or oxygen determinations. This part of the Thalweg reflects the transit of the water from the Arkona Basin via the Bornholmsgat to the Bornholm Basin. In the evening we had a party with mulled wine, also a farewell to two people who had to leave the ship on the next day.

Monday, 14th November 2022: Wind was forecasted from southeast of about 4 bft, later decreasing a little, and a sea of 1 meter wave height. Early in the morning we completed the TF0150 with a CTD cast and sampling for a bottom water oxygen determination. At 8:00 o'clock in the morning we stopped in front of Sassnitz harbour and set the rubber boat into the water to bring two persons of the scientific crew to the harbour and pick up two persons for the second part of the cruise in the western Baltic Sea. They were tested negative for Covid-19 and could embark the ship without delay. We headed in south-eastern direction to reach the TF0160 with the first sampling on the cruise for benthos organisms by a Van-Veen grab as well as by a dredge. In addition, an oxygen and a nutrient profile was done. The same programme followed on the TF0152 about three hours later. After the TF0112 with the first sampling for a DAM initiative to establish an archive of eDNA samples. The next station was the major station TF0113 with a comprehensive sampling programme for nutrients, oxygen, phytoplankton and zooplankton as well as the last greenhouse gas station of the cruise. Late in the evening the TF0105 followed with a CTD cast and nutrients and an oxygen determination at 10 m depth.

Tuesday, 15th November 2022: In the western Baltic Sea wind was expected from southeast to east of 4 bft, but then increasing to 6 and 7 bft, locally misty, with a sea of increasing wave height of 2 meters. TF0104 and TF0103 were completed in the night with CTD casts and sampling for nutrients and oxygen analysis and after breakfast the major benthos station with Van-Veen grab and a dredge transect was done. After breakfast we started with the biological station TF0109 with net hauls, Van-Veen grab sampling and a dredge transect, of course, after a CTD cast with sampling for nutrients, including total nitrogen and phosphorus and natural organic matter. The stations TF0114 and TF0115 with just a CTD cast and sampling for dissolved inorganic nutrients and oxygen. Then again the important biological station TF0030 on Darss Sill was completed. The station series across the sill was continued with CTD casts on TF0001, TF0002, and TF0046. The latter station was again a major station with net hauls for phytoplankton and zooplankton. Late in the evening we completed the TF0041. Thereby, station in German territorial or EEZ waters were sampled for the DAM initiative.

Wednesday, 16th November 2022: For the Western Baltic Sea wind was forecasted from southeast to east of 6 to 7 bft, increasing a little at a sea state of 2.5 meter wave height. After midnight the TF0017 with a CTD cast only, and the TF0022 with sampling for an oxygen profile followed, as this area often shows hypoxic bottom water during late summer. After breakfast the TF0018 required some grab sampling and a dredge transect at daylight. Then we moved to the TF0012 with a complete chemical and biological programme including a surface water CTD for metatranscriptomics analysis in the frame of the DAM project, Fehmarn Belt stations TF0010 was cancelled, because of high waves. A CTD cast was possible on TF0014, MPA-18, oMPA-17, but further benthos sampling could not be done, because of the strong wind and high waves. Then we went straight to the Kiel Bight station TF0360 to complete a CTD cast for final nutrients and oxygen measurements, as we had to cancel the further off-shore station TF0361 because of the high waves there. As well, water sampling for a biological profile of chlorophyll and algae species composition was done on this final station.

Thursday, 17th November 20228: Wind was forecasted from southeast to east 6 to 7 bft, for a time increasing a little at a sea of 2.5 meter wave height. We entered the Kiel harbour early in the morning and tied up to the pier at 8:00 o'clock. The German Science and Humanities Council (WR) was scheduled for a visit of the r/v Elisabeth Mann Borgese in the afternoon that required some preparation work. The visit was carried out in the frame of an evaluation of the German fleet of medium-size research vessels to figure out future demands and planning. A lecture event was combined with the visitation of the r/v Alkor and the r/v Elisabeth Mann Borgese with an exhibition of large devices for marine research. At 18:00 o'clock we left Kiel harbour after a successful presentation.

Friday, 18th November 2022: Overnight we steamed in homeward direction through the waves and against the wind. In the morning we entered the port and docked at the pier of Rostock-Marienehe at about 8 o'clock. The research equipment stowed in a container, the water samples as well as the cool boxes with either frozen or cooled sampled were taken to the institute. The large data set was safely stored on local computers and a server.

5 Preliminary Results

The results presented in the following section are preliminary and many samples taken are to be analysed and interpreted during the next weeks and months. The aim of this section is to give a first impression on the collected data set. An advanced data analysis will follow when the validated data sets are available.

5.1 Meteorological conditions

From 5th to 9th November we had a south-western setting (Deutscher Wetterdienst, 2022). Between high pressure over the Ukraine with an extension reaching the Mediterranean Sea and North Africa as well as a low pressure over the central North Atlantic until Ireland, a north-eastward directed frontal zone situated from a sea area north of the Azores Islands via the English Channel to the southern Arctic Ocean and until the Baltic region. The frontal zone determined the weather in Europe significantly with single disturbances that passed the Bay of Biscay, the British Isles and Scandinavia until the Arctic Sea. Then central Europe was influenced by high pressure (10th to 12th November). Between a high-pressure over western Russia and a low pressure system over the central North Atlantic a frontal zone extended from Southwest to Northeast. It stretched from the sea area southwest of Ireland to the Baltic region. An extended high-pressure area established over eastern Europe, at elevated height it appeared intermittently only as a meridional extension. Low pressure controlled the eastern Atlantic and parts of western Europe between 13th and 15th November at an anticyclonic southern setting. A frontal zone extended from the sea area north of the Azores Islands to south-western Europe. Between a blocking high-pressure system over central and northern Fennoscandia and a high-pressure system over southern central Europe and the Mediterranean Sea established an eastern air flow from central Russia via central Europe to the British Islands between the 16th and 19th November (Deutscher Wetterdienst, 2022).

The weather conditions were stormy and cloudy during the cruise EMB 305, as could be expected in the autumn season. The detailed investigation of the western Baltic Sea was scheduled for the last four days of the cruise. The plan was to finish the sampling in the Kiel Bight to present the ship and its contribution to the German marine research to the German Science and Humanities Council (WR) on behalf of DAM (Deutsche Allianz Meeresforschung) in Kiel harbour on the afternoon of the 17th November. Afterwards, a final transit to Rostock harbour was scheduled. So we started with a quick rush through Mecklenburg Bight to the Arkona Sea to fulfil a few selected stations for comparison measurements with the biological investigations on the way back. On the second day we already had some higher waves at 7 bft wind in the central Arkona Sea. Air and water temperatures were very similar and scattered around 12°C during the first 10 days. Except in the early morning, when the air temperature reached 6°C on the first day and 8°C on the second day, respectively (Fig. 5.1, upper panel). On the last four days the air temperature dropped clearly, reaching almost freezing conditions on 18th November. Wind speed was mostly between 10 and 15 m/s but was clearly lower between 12th and 15th November when the wind direction changed from a western to an eastern direction (Fig. 5.1, lower panel). Humidity scattered around 90% in open waters, but was around 80% in the western Baltic Sea.

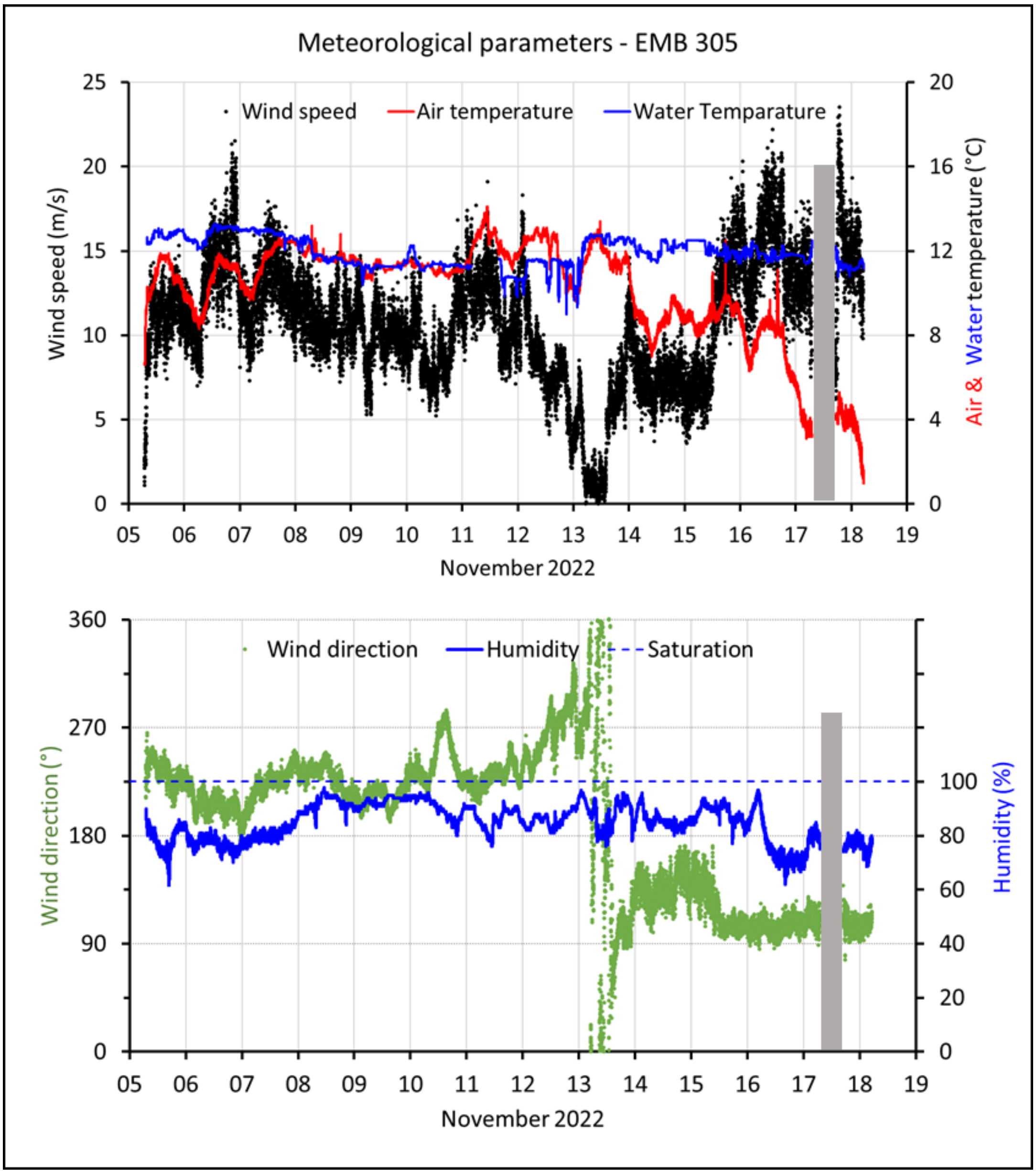

Fig. 5.1 Surface water temperature, air temperature, and wind speed (upper panel) as well as humidity and wind direction (lower panel) measured on-board by the automatic weather station of the DWD; surface water temperature was measured by the JSMB-thermosalinograph; grey bars indicate the stay in Kiel harbour on 17th November.

In the Belt Sea, Arkona Sea and the Bornholm Sea a slightly elevated chlorophyll_a concentration of between 1.5 and 2 µg/L indicated remains of an autumn bloom. Whereas in the Gotland Sea the chlorophyll_a concentration scattered around 1 µg/L in surface waters. However, the strong spatial variability with clear concentration peaks likely showed local algae bloom events (Fig. 5.2). High turbidity in surface waters and a salinity above 20 reflected resuspension and storm induced mixing at strong easterly winds and relative high waves in the last two days of the cruise.

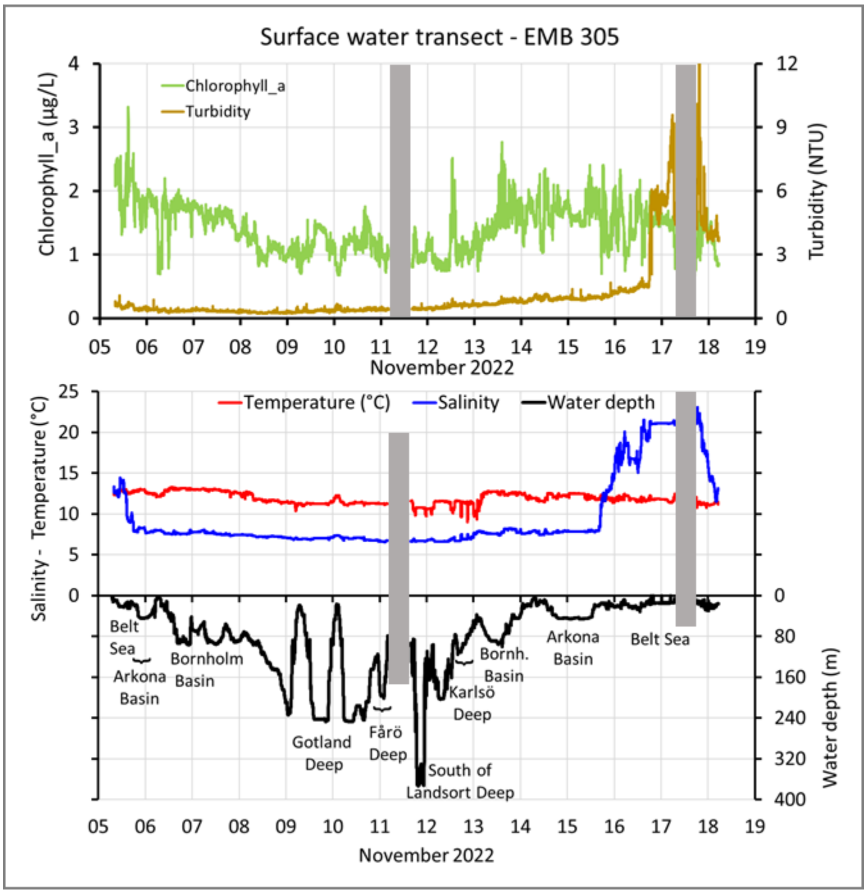

Fig. 5.2 Recording of not finally validated data of chlorophyll, turbidity (upper panel), temperature, and salinity in surface waters with the corresponding water depth and sea area (lower panel) during the cruise EMB 305 of r/v Elisabeth Mann Borgese from November 5th to 18th in 2022; grey bars indicate near coastal sites at the Island of Gotland on 11th November and the stay in Kiel harbour on 17th November.

5.2 Nutrient situation in the western Baltic Sea in November 2022

The nutrients development in autumn in the Baltic Sea is characterized by the replenishment of nutrient concentrations in surface waters after the depletion during spring and summer. The cooling of surface water and the subsequent break-up of the thermocline, enables mixing of nutrient enriched subsurface waters into the surface layer by wind. This had happened only partially during EMB 305 as the thermocline was mostly present. Only in the western Baltic Sea nutrient concentrations exceeded locally 0.5 µmol/L nitrate and 0.25 µmol/L phosphate, clearly above the summer minima. This was especially visible in Kiel Bight and Mecklenburg Bight during the stormy times in last days of the cruise. In comparison, surface waters of the deeper basins still showed low nutrient concentrations during our campaign.

In deep waters and especially in the bottom layer continuation of perennial phosphate enrichment was again documented for November 2022. Redox sensitive nitrate behaves differently as it accumulates in oxic waters, but disappears at hypoxic conditions. So there is a strong temporal variability of nitrate in the bottom waters of the Bornholm Deep with partly high nitrate concentration under weak oxic conditions as during November 2022 and in November 2018 (Table 5.1) and total depletion under clear sulphidic conditions (Oct 2019) or during transition between oxic and euxinic, or vice versa (Nov 2020), and still detectable nitrate in 2021. In the less dynamic Gotland Deep, Fårö Deep, Landsort Deep, and Karlsö Deep no nitrate was detected in bottom waters at prevailing sulphidic conditions in recent years.

Table 5.1 Nitrate (upper part) and phosphate concentrations (lower part) in the bottom layer (µmol/L) in October/November: 2021 in comparison to former years.

Area	Nov 2018	Oct 2019	Nov 2020	Nov 2021	**Nov 2022**
Kiel Bight (TF0360)	1.76	n.d.	2.62	2.02	**4.11**
Meckl.Bight (TF0012)	0.76	2.97	3.07	1.08	**4.66**
Darss Sill (TF0030)	0.23	0.21	3.17	3.74	**3.04**
Arkona Basin (TF0113)	3.04	4.94	2.55	4.97	**7.03**
Bornh. Deep (TF0213)	8.56	n.d.	n.d.	0.73	**9.30**
Gotland Deep (TF0271)	n.d.	n.d.	n.d.	n.d.	**n.d.**
Fårö Deep (TF0286)	n.d.	n.d.	-	n.d.	**n.d.**
Landsort Deep (TF0284)	n.d.	n.d.	-	-	**n.d.***
Karlsö Deep (TF0245)	n.d.	n.d.	-	n.d.	**n.d.**

Area	Nov 2018	Oct 2019	Nov 2020	Nov 2021	**Nov 2022**
Kiel Bight (TF0360)	0.76	0.55	0.82	0.56	**1.21**
Meckl.Bight (TF0012)	0.77	2.51	0.91	0.61	**0.91**
Darss Sill (TF0030)	0.39	0.33	0.81	0.64	**0.69**
Arkona Basin (TF0113)	0.82	1.35	0.74	0.89	**1.23**
Bornh. Deep (TF0213)	4.33	8.73	3.75	7.15	**3.36**
Gotland Deep (TF0271)	5.08	5.17	5.63	5.93	**6.45**
Fårö Deep (TF0286)	4.75	4.40	-	4.85	**5.33**
Landsort Deep (TF0284)	3.44	3.63	-	-	**3.90***
Karlsö Deep (TF0245)	3.88	3.75	-	4.00	**3.93**

* In 2022 the alternative station TF0284a further south was sampled (360 m deep).

n.d.: below detection limit - : no data

Phosphate is redissolved from particles and kept in solution under euxinic conditions. So phosphate concentration shows accumulation in bottom waters during stagnation, as in the Gotland Deep from 5.08 µmol/L in November 2018 to 6.45 µmol/L in November 2022. Stronger changes were measured in the variable Bornholm Deep from 3.75 in Nov 2020 and 8.73 in Oct 2019. Smaller changes with an increasing trend were observed in the Fårö Deep and the Landsort Deep, whereas in the Karlsö Deep an up and down between 3.75 and 4.00 µmol/L phosphate was determined during the autumn cruises of the recent years. Also the Kiel and Mecklenburg Bights are prone for some variability, as on one side, these are eutrophied areas with strong oxygen consumption processes in bottom waters. On the other side, the Belt Sea is a region of dynamic water exchange between the Kattegat and the Arkona Sea. In October 2019 oxygen was still low in the bottom water of Mecklenburg Bight (Table 5.1) and likely dissolution of phosphate from particles and anoxic sediments led to a relatively high concentration of 2.5 µmol/L phosphate at that time.

5.3 Baltic thalweg transect

The status of temperature, salinity and of the oxygen concentration in the water column along the thalweg between the Kiel Bight (TF0360) to the Fårö Deep (TF0286) in the eastern Gotland Basin and further through the western Gotland Basin (Map, Fig. 3.1) is always a focus of the monitoring campaigns (Fig. 5.3). This paragraph presents an overview of the hydrographic and the hydrochemical state of the western and central Baltic Sea during the cruise EMB 305.

In November 2022, the autumn cooling of surface waters was clearly visible but the temperatures still appeared relative high. In the Mecklenburg and the Kiel Bights we measured a significant lower temperature ~11.6°C in the mixed layer compared to the saline bottom water of up to 13.2°C and even 13.5°C in the Arkona Sea (Fig. 5.3b). In terms of stratification, this is compensated by a clearly higher salinity in bottom waters of partly almost 25 in the Belt Sea and about 18 in the Arkona Basin, at corresponding surface water salinity of ~18 and 8, respectively (Fig. 5.3a). The temperature structure of the Bornholm Sea was complex with a surface mixed layer of about 12.5°C until a depth of about 30 m. Some old winter water of 6 to 7.5°C was present in the centre of the basin and was cooler in the southeast of 5°C at about 50 m depth. This water was depleted of oxygen (Fig. 5.3c). A larger warm water intrusion of up to ~13.5°C was below 50 m down to the bottom bearing considerable amounts of oxygen. However, a strong salinity gradient from 7.6 in surface waters and up to 17 close to the bottom caused a stable stratification. The layer of winter water of about 4.5°C (the blue ribbon in Fig. 5.3b) further stretched at ~50 ± 15 m depth via the Słupsk furrow to the eastern Gotland Sea. In the western Basin the slightly warmer winter water of about 5°C was locally closer to the surface up to a depth of 30 m. An east-west temperature gradient of the Gotland Sea deep water is indicated by a greenish to blueish shading of the Gotland Basin, indicating a roughly 1°C lower temperature of the western basin compared to the eastern basin.

The oxygen concentration in the mixed layer was close to the equilibrium with the atmosphere, at the respective surface water temperature and almost reached the depth level of the halocline. Within the steep salinity gradient, the oxygen concentration decreased sharply to an undetectable level that persisted down to the seafloor at that time (Fig. 5.3c). It should be mentioned that H_2S is not considered in this figure, since the oxygen sensor is unable to record "negative oxygen". So the area shaded magenta reflected the deep water with an oxygen concentration close to or below 0 mL/L. The hydrogen sulphide concentration is given as negative oxygen concentration in Table 5.4 and Fig. 5.4.

The interesting deep water structure in the Bornholm Sea deduced from the temperature distribution is also reflected in the oxygen concentration. The warmer water of 12.8 to 13.5°C also showed an elevated oxygen concentration of 2 to 4 mL/L oxygen. Also in the area of the Słupsk Furrow between 60 and 70 m a water intrusion of elevated oxygen concentration (~1.5-3 mL/L) is visible. Some remains of oxygen in bottom waters at the southern slope of the eastern Gotland Basin that originated from the Bornholm Sea were still detectable in November 2022.

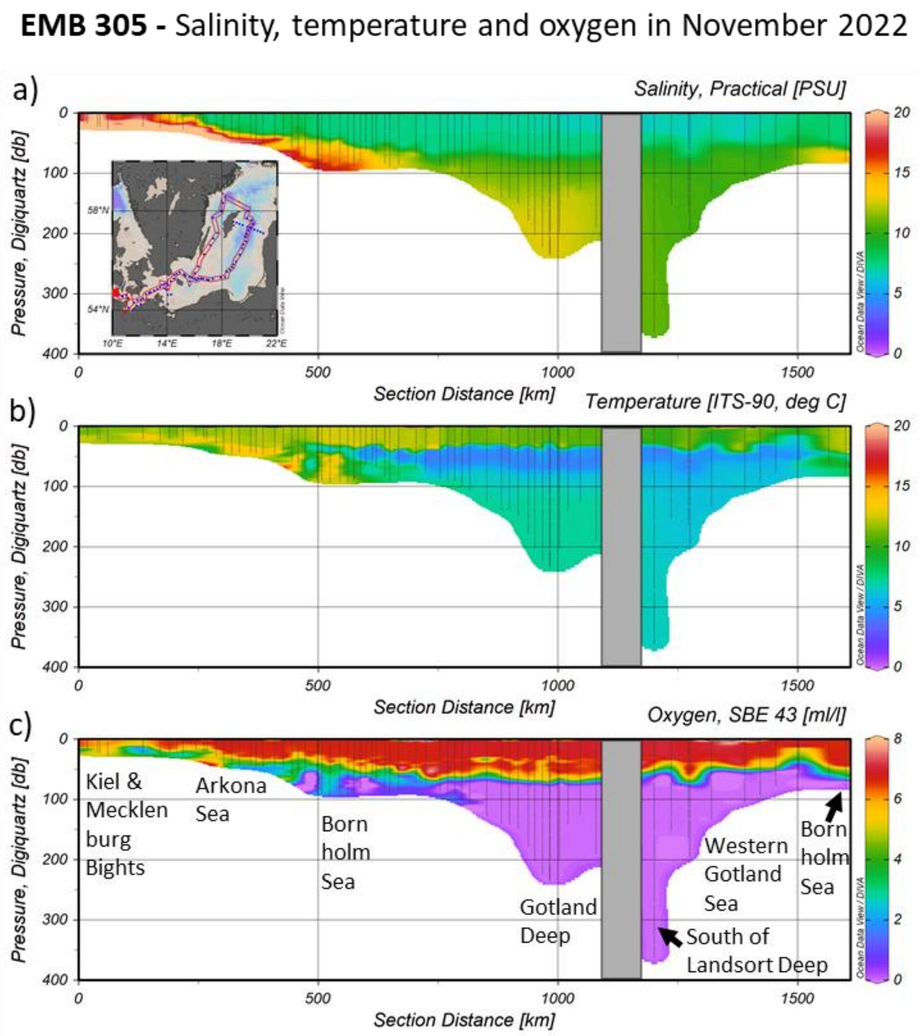

Fig. 5.3 Distribution of temperature (a), salinity (b) and oxygen concentration (c) along the thalweg of the Baltic Sea from the Kiel Bight to the western Gotland Basin (the sampling gap is shaded grey). The figure is based on not finally validated CTD data on selected stations measured between 5th and 17th November 2022.

5.4 Development of Baltic Sea water masses – comparison to previous cruises

5.4.2 Temperature and salinity in bottom water

On selected stations in the western Baltic Sea and the Baltic Proper, the temperatures and salinity of bottom waters measured on the Cruise EMB 305 are compared to the autumn monitoring cruises of previous years (Tables 5.2 and 5.3). It is obvious for the western Baltic Sea that November 2022 was a relatively warm month. The temperatures of the bottom water in the western Baltic Sea in November 2022 were the second warmest after the October values of 2019. The temperatures in the Gotland Deep and the Fårö Deep were close to the values in recent years. The Bornholm Deep showed with 11.05°C the highest temperature in the last five years – higher than in November 2018 and almost three degrees higher than last year. Similarly, the bottom water of the Karlsö Deep (6.22°C), but here it was only half a tenth degree higher than in November 2021.

Table 5.2 Temperature in the bottom water layer (°C) in October/November: 2022 (in bold) compared to former years.

Area	Nov 2018	Oct 2019	Nov 2020	Nov 2021	**Nov 2022**
Kiel Bight (TF0360)	11.25	13.13	12.08	11.77	**12.43**
Meckl.Bight (TF0012)	11.89	14.03	12.13	11.97	**12.49**
Darss Sill (TF0030)	10.87	13.56	11.95	11.96	**13.37**
Arkona Basin (TF0113)	11.62	14.88	11.81	12.25	**12.45**
Bornh. Deep (TF0213)	10.61	8.58	8.33	8.15	**11.05**
Gotland Deep (TF0271)	6.90	7.33	7.20	7.21	**7.22**
Fårö Deep (TF0286)	6.73	7.19	-	7.24	**7.19**
Landsort Deep (TF0284)	6.25	6.55	-	-	**6.60***
Karlsö Deep (TF0245)	5.72	5.74	-	6.17	**6.22**

* In 2022 the alternative station TF0284a further south was sampled (360 m deep).

In terms of salinity, the western Baltic Sea is characterized by a strong variability in bottom waters in autumn. Rapid cooling of surface waters and the partly strong winds cause alternating inflow of Kattegat/North Sea water and outflow of upper waters of the Baltic Proper. In recent years, salinity values ranged on the selected stations of the shallow Belt Sea area between 19.4 in the Mecklenburg Bight in 2018 and 24.6 in 2022 during EMB 305. On Darss Sill, we measured roughly an average salinity of the last four years in November 2022. Further east in the Arkona Basin the salinity was relatively high, showing 19.1 like in 2019 and 2020. In the Bornholm Deep the bottom showed a similar value as in recent years, a bit lower than in 2018 and 2019. The weak declining tendency since November 2018 in the deep basins still could be attributed to the dilution of haline inflow water of 2014/2015 over the years.

Table 5.3 Salinity in the bottom layer in October/November: 2022 in comparison to former years.

Area	Nov 2018	Oct 2019	Nov 2020	Nov 2021	**Nov 2022**
Kiel Bight (TF0360)	21.02	19.79	24.47	23.17	**23.69**
Meckl.Bight (TF0012)	19.41	24.15	22.13	20.81	**24.55**
Darss Sill (TF0030)	9.82	14.99	12.64	15.12	**12.85**
Arkona Basin (TF0113)	20.16	18.93	19.30	16.33	**19.12**
Bornh. Deep (TF0213)	17.74	16.68	16.04	15.78	**16.06**
Gotland Deep (TF0271)	13.25	13.25	13.11	12.98	**12.86**
Fårö Deep (TF0286)	12.63	12.61	-	12.31	**12.11**
Landsort Deep (TF0284)	11.41	11.41	-	-	**10.94***
Karlsö Deep (TF0245)	10.55	10.54	-	10.52	**10.51**

* In 2022 the alternative station TF0284a further south was sampled (360 m deep).

5.4.3 Oxygen in bottom water

The variability of oxygen in the western Baltic Sea bottom water is less pronounced in autumn as the decline of the summer thermocline enables deeper mixing and supply of oxygen from the near surface into the deeper waters (Table 5.4). However, it is also the season between summer and winter conditions and often it depends on how far the season has proceeded. Therefore, the exceptional low oxygen value of 1.4 mL/L in the Mecklenburg Bight in October 2019 is an example, as this still reflected late summer conditions. In November 2022 the oxygen condition in bottom waters of the western Baltic Sea was good, according to the selected stations. The concentrations were a bit lower than in previous two years but clearly above the values of October 2019. However, the map of some more station (Fig. 5.4) shows that the south-eastern part of the Mecklenburg Bight was only in a moderate oxygen condition. Bornholm Deep was weak oxic and showed the highest value of the last five autumn cruises. Moreover, the stations TF0200 further west in the Bornholm Sea and the TF0222 in the Słupsk Furrow showed considerable 2.34 mL/L and 0.87 mL/L oxygen (Fig. 5.4).

Table 5.4 Bottom water oxygen concentration (mL/L) in November: Comparison of 2022 to former years.

Area:	Nov 2018	Oct 2019	Nov 2020	Nov 2021	**Nov 2022**
Kiel Bight (TF0360)	6.01	6.13	4.83	4.79	**4.13**
Meckl.Bight (TF0012)	6.11	1.39	5.16	5.69	**4.04**
Darss Sill (TF0030)	6.66	5.24	6.14	5.43	**-**
Arkona Basin (TF0113)	4.88	2.85	5.64	5.19	**3.56**
Bornh. Deep (TF0213)	0.50	-0.63	0.06	-1.57	**0.57**
Gotland Deep (TF0271)	-4.42	-6.59	-8.15	-7.07	**-8.90**
Fårö Deep (TF0286)	-5.02	-4.29	-	-4.30	**-6.57**
Landsort Deep (TF0284)	-1.51	-2.13	-	-	**-2.45***
Karlsö Deep (TF0245)	-3.58	-3.66	-	-1.97	**-2.85**

* In 2022 the alternative station TF0284a further south was sampled (360 m deep).

Gotland Deep and Fårö Deep reflected the ongoing accumulation of the hydrogen sulphide in bottom waters and reached equivalents of -8.9 and -6.6 mL/L, respectively, showing the worst oxygen values since 2018 (Table 5.4). This is also indicated by the oxygen data of the Landsort Deep bottom water. However, the gaps in 2020 and 2021, as well as a slightly different location in 2022 requires a cautious conclusion. For the bottom water in the Karlsö Deep, we determined -2.9 mL/L oxygen equivalents which was worse as in 2021, but better than in 2018 and 2019.

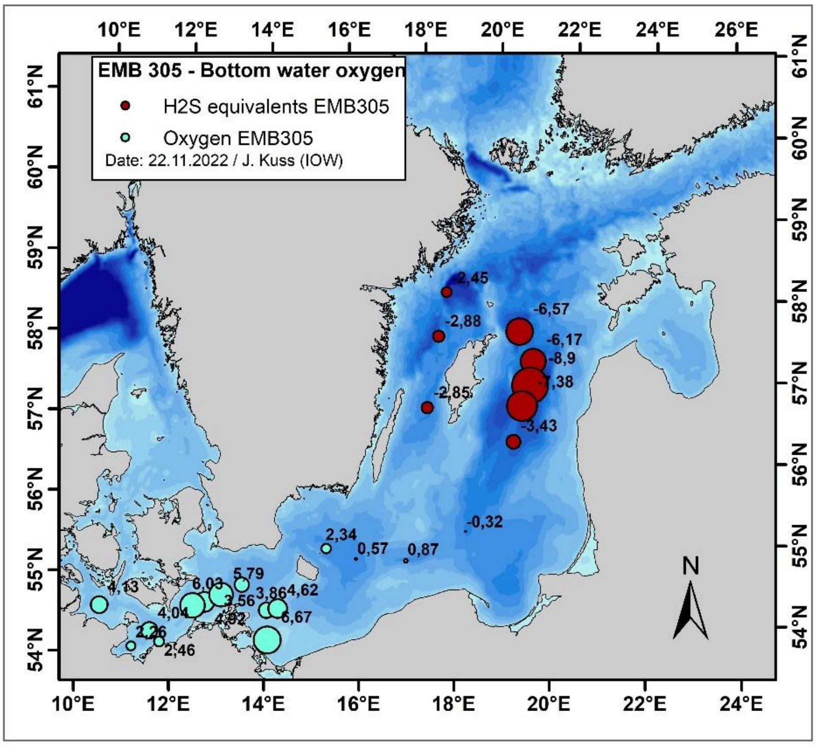

Fig. 5.4 Oxygen concentration (mL/L) in bottom waters of selected Baltic Sea stations (H_2S is included as equivalents of negative oxygen).

Moreover, it is also interesting to investigate the turbidity zones in intermediate and deeper waters in comparison to low oxygen waters, as it was observed that turbidity often marks the mixing or diffusion zones between sulphidic and oxygenated waters (Fig. 5.5c). Partly this is caused by precipitation of fine particles of elemental sulphur (Kamyshny *et al.*, 2013) and likely manganese(IV) and iron(III) oxyhydroxides and phosphates play a role too (Dellwig *et al.*, 2010). The density distribution (Fig. 5.5a) is basically determined by salinity (Fig. 5.3a), but also the still warm mixed layer in the Baltic Proper (Fig. 5.3b) can be distinguished by its lower density. Interestingly, down the slope of the Gotland Basin and along the permanent halocline, the turbidity maxima can be seen that likely indicate former supply of oxygenated water (Fig. 5.5, lower panel). The patchiness of the chlorophyll_a fluorescence maxima in surface waters is especially visible in western Baltic Sea (Fig. 5.5b) and suggests that some supply of nutrients by autumn mixing in 2022 kept the primary production active there.

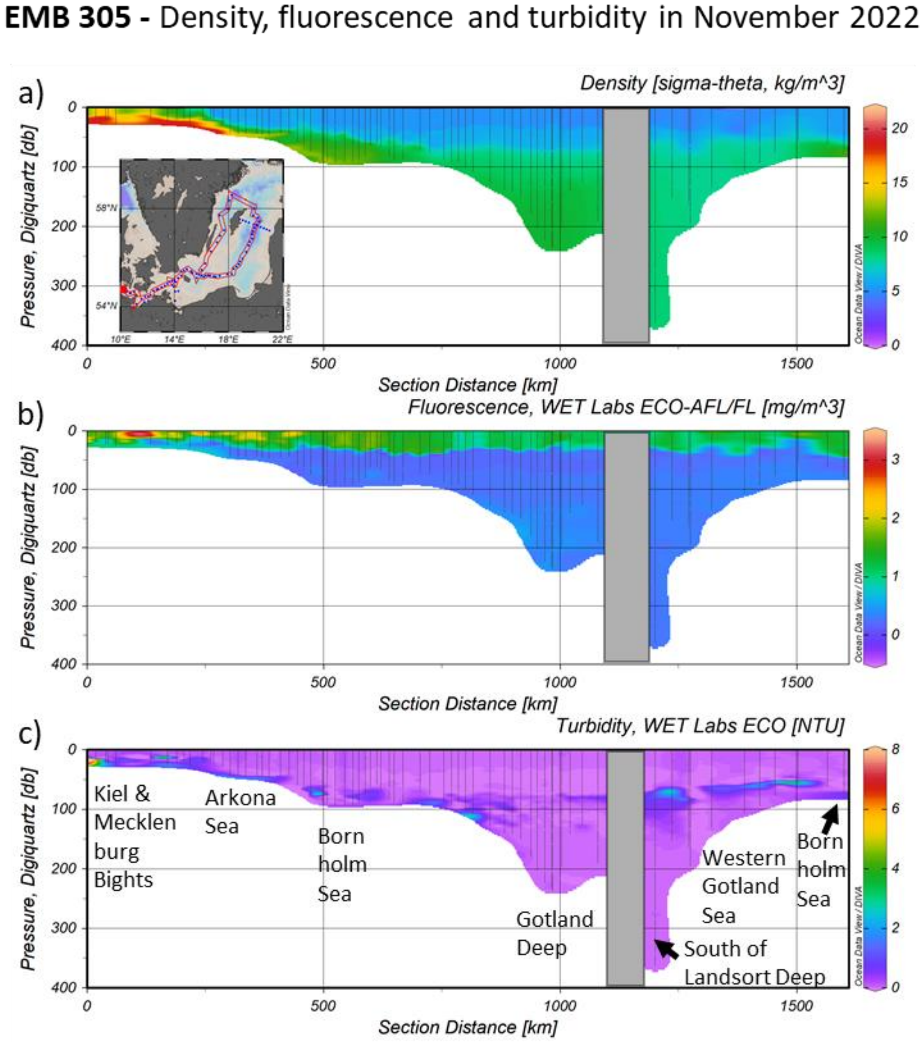

Fig. 5.5 Calculated density (a), fluorescence (b) and turbidity (c) determined from sensor measurements along the thalweg transect (see Fig. 5.3, the sampling gap is shaded grey). The figure is based on the preliminary data of the CTD casts (vertical grey lines) by using ODV 5 (Schlitzer, 2018).

6 Station List of EMB 305

6.1 Overall Station List

Station No.		**Date**	**Gear**	**Time**	**Latitude**	**Longitude**	**Water Depth**	**Remarks/ Recovery**
Elisabeth Mann Borgese	**IOW**	**2022**		**[UTC]**	**[°N]**	**[°E]**	**[m]**	Max sampl. depth
EMB305_1-2	TFO5	05 Nov	SD	08:18	54.2312	12.0755	9	
EMB305_1-1	TFO5	05 Nov	CTD	09:14	54.2311	12.0744	10	CLmax: 11m
EMB305_2-1	TF0012	05 Nov	CTD	11:55	54.3138	11.5505	22	CLmax: 23m
EMB305_2-2	TF0012	05 Nov	PLA	11:44	54.3140	11.5506	22	3-times ML
EMB305_2-3	TF0012	05 Nov	WP2	12:09	54.3141	11.5500	22	CLmax: 15 m
EMB305_2-4	TF0012	05 Nov	WP2	12:16	54.3142	11.5494	22	CLmax: 22 m
EMB305_2-5	TF0012	05 Nov	WP2	12:26	54.3145	11.5487	22	CLmax 22 m
EMB305_3-1	TF0046	05 Nov	CTD	15:34	54.4698	12.2427	26	CLmax: 27 m
EMB305_3-2	TF0046	05 Nov	WP2	15:29	54.4697	12.2433	25	
EMB305_3-3	TF0046	05 Nov	SD	15:31	54.4697	12.2430	26	
EMB305_3-4	TF0046	05 Nov	WP2	15:49	54.4696	12.2414	25	CLmax: 25 m
EMB305_4-1	TF0030	05 Nov	CTD	18:50	54.7233	12.7843	20	CLmax: 21 m
EMB305_4-2	TF0030	05 Nov	PLA	18:34	54.7237	12.7847	20	3-times ML
EMB305_5-1	TF0113	05 Nov	CTD	22:09	54.9249	13.5009	45	CLmax: 45 m
EMB305_5-2	TF0113	05 Nov	PLA	22:15	54.9250	13.5002	45	3-times ML
EMB305_5-3	TF0113	05 Nov	WP2	22:36	54.9249	13.4997	44	CLmax: 23 m
EMB305_5-4	TF0113	05 Nov	WP2	22:41	54.9249	13.4997	44	CLmax: 44 m
EMB305_5-5	TF0113	05 Nov	WP2	22:51	54.9249	13.4998	44	CLmax 44 m
EMB305_6-1	ABBOJE	06 Nov	CTD	00:55	54.8802	13.8565	43	CLmax: 44 m
EMB305_7-1	TF0214	06 Nov	CTD	16:52	55.1597	15.6599	92	CLmax: 92 m
EMB305_8-1	TF0213	06 Nov	CTD	19:00	55.2498	15.9835	91	CLmax: 88 m
EMB305_8-2	TF0213	06 Nov	CTD	19:57	55.2497	15.9834	88	CLmax: 25 m
EMB305_9-1	TF0208	07 Nov	CTD	08:13	55.4525	15.2337	91	CLmax: 90 m
EMB305_10-1	TF0200	07 Nov	CTD	09:33	55.3833	15.3336	90	CLmax: 90 m
EMB305_11-1	TF0211	07 Nov	CTD	11:34	55.3308	15.6160	94	CLmax: 93 m
EMB305_12-1	TF0212	07 Nov	CTD	12:51	55.3013	15.7975	94	CLmax: 93 m
EMB305_13-1	TF0213	07 Nov	PLA	14:08	55.2500	15.9832	89	3-times ML
EMB305_14-1	TF0221	07 Nov	CTD	15:30	55.2216	16.1668	82	CLmax: 80 m
EMB305_15-1	TF0225	07 Nov	CTD	16:34	55.2586	16.3210	64	CLmax: 64 m
EMB305_16-1	TF0224	07 Nov	CTD	17:41	55.2833	16.5000	60	CLmax: 60 m
EMB305_17-1	TF0227	07 Nov	CTD	18:42	55.2615	16.6390	69	CLmax: 66 m
EMB305_18-1	TF0229	07 Nov	CTD	20:22	55.2280	16.9131	84	CLmax: 83 m
EMB305_19-1	TF0222	07 Nov	CTD	22:11	55.2167	17.0661	91	CLmax: 89 m
EMB305_20-1	TF0266	07 Nov	CTD	23:57	55.2511	17.3584	88	CLmax: 86 m
EMB305_21-1	TF0268	08 Nov	CTD	02:36	55.3075	17.9293	73	CLmax: 72 m
EMB305_22-1	TF0256	08 Nov	CTD	04:19	55.3264	18.2518	77	CLmax: 76 m
EMB305_23-1	TF0259	08 Nov	CTD	06:25	55.5496	18.4000	89	CLmax: 87 m
EMB305_23-2	TF0259	08 Nov	PLA	06:29	55.5495	18.3998	89	3-times ML
EMB305_24-1	TF0255	08 Nov	CTD	08:05	55.6330	18.6001	96	CLmax: 93 m
EMB305_25-1	TF0258	08 Nov	CTD	09:29	55.7270	18.7653	90	CLmax: 90 m
EMB305_26-1	TF0253	08 Nov	CTD	10:50	55.8397	18.8664	101	CLmax: 99 m
EMB305_27-1	TF0265	08 Nov	CTD	12:25	55.9588	19.0481	111	CLmax: 108 m
EMB305_28-1	TF0262	08 Nov	CTD	14:54	56.2342	19.3014	132	CLmax: 128 m
EMB305_29-1	TF0261	08 Nov	CTD	17:17	56.4918	19.4811	144	CLmax: 140 m
EMB305_30-1	TF0260	08 Nov	CTD	19:08	56.6334	19.5839	145	CLmax: 141 m
EMB305_31-1	TF0274_	08 Nov	CTD	20:49	56.7677	19.7518	155	CLmax: 150 m
EMB305_32-1	TF0273	08 Nov	CTD	22:37	56.9519	19.7701	185	CLmax: 179 m
EMB305_33-1	TF0272	08 Nov	CTD	00:10	57.0717	19.8299	209	CLmax: 204 m
EMB305_34-1	TF0275	09 Nov	CTD	01:48	57.2100	19.9316	231	CLmax 225 m
EMB305_35-1	SF001EGB	09 Nov	CTD	06:56	57.5627	18.8509	19	CLmax: 20 m

EMB305_35-2	SF001EGB	09 Nov	SCF	07:10	57.5620	18.8538	21	Deployed
EMB305_36-1	SF003EGB	09 Nov	SCF	08:25	57.5185	19.0653	39	Recovered
EMB305_36-1	SF003EGB	09 Nov	CTD	08:54	57.5176	19.0655	39	CLmax: 38 m
EMB305_37-1	SF005EGB	09 Nov	CTD	10:09	57.4710	19.2900	78	CLmax: 78 m
EMB305_38-1	SF007EGB	09 Nov	CTD	11:34	57.4252	19.5093	120	CLmax: 116 m
EMB305_39-1	SF010EGB	09 Nov	CTD	13:26	57.3532	19.8640	211	CLmax: 205 m
EMB305_40-1	TF0271	09 Nov	CTD	14:57	57.3201	20.0506	243	CLmax: 235 m
EMB305_40-2	TF0271	09 Nov	SD	14:34	57.3203	20.0510	243	
EMB305_40-3	TF0271	09 Nov	PLA	14:45	57.3204	20.0513	242	3-times ML
EMB305_40-4	TF0271	09 Nov	CTD	15:45	57.3197	20.0503	242	CLmax: 156 m
EMB305_40-5	TF0271	09 Nov	CTD	16:20	57.3199	20.0501	241	CLmax: 88 m
EMB305_40-6	TF0271	09 Nov	CTD	17:00	57.3200	20.0499	241	CLmax: 30 m
EMB305_40-7	TF0271	09 Nov	CTD	17:40	57.3198	20.0502	241	CLmax: 115 m
EMB305_40-8	TF0271	09 Nov	CTD	18:20	57.3199	20.0502	241	CLmax: 50 m
EMB305_40-9	TF0271	09 Nov	CTD	19:09	57.3199	20.0505	241	CLmax: 25 m
EMB305_40-10	TF0271	09 Nov	CTD	19:37	57.3202	20.0501	241	CLmax: 105 m
EMB305_41-1	SF012EGB	09 Nov	CTD	21:10	57.2855	20.1653	244	CLmax: 238 m
EMB305_42-1	SF014EGB	09 Nov	CTD	22:32	57.2394	20.3841	147	CLmax: 143 m
EMB305_43-1	SF016EGB	09 Nov	CTD	23:53	57.1939	20.6037	97	CLmax: 95 m
EMB305_44-1	SF018EGB	10 Nov	CTD	01:09	57.1479	20.8216	46	CLmax: 45 m
EMB305_45-1	SF020EGB	10 Nov	CTD	02:22	57.1007	21.0393	21	CLmax: 21 m
EMB305_46-1	GODESS	10 Nov	CTD	06:49	57.3200	20.1298	245	CLmax: 238 m
EMB305_46-2	GODESS	10 Nov	MOOR	07:39	57.3166	20.1253	246	Deployed
EMB305_47-1	GOC	10 Nov	MOOR	08:03	57.3093	20.0896	247	Recovered
EMB305_47-2	GOC	10 Nov	MOOR	10:08	57.3062	20.0815	246	Deployed
EMB305_47-3	GOSW	10 Nov	MOOR	12:40	57.0752	19.7526	216	Recovered
EMB305_47-4	GOSW	10 Nov	MOOR	13:49	57.0756	19.7524	216	Deployed
EMB305_48-1	TF0276	10 Nov	CTD	18:15	57.4696	20.2595	209	CLmax: 202 m
EMB305_49-1	TF0270	10 Nov	CTD	20:37	57.6167	20.1665	144	CLmax: 140 m
EMB305_50-1	TF0287	10 Nov	CTD	22:32	57.7150	19.8536	130	CLmax: 126 m
EMB305_51-1	TF0286	11 Nov	CTD	00:59	57.9999	19.8998	196	CLmax: 190 m
EMB305_51-2	TF0286	11 Nov	CTD	01:40	57.9996	19.9004	196	CLmax: 30 m
EMB305_52-1	TF0284a	11 Nov	CTD	19:34	58.5449	18.2345	355	CLmax: 366 m
EMB305_52-2	TF0284a	11 Nov	CTD	20:38	58.5445	18.2343	365	CLmax: 130 m
EMB305_52-3	TF0284a	11 Nov	CTD	21:30	58.5446	18.2347	345	CLmax: 20 m
EMB305_52-4	TF0284a	11 Nov	CTD	22:10	58.5447	18.2349	340	CLmax: 90 m
EMB305_53-1	wGB-3	12 Nov	CTD	01:23	58.3263	18.0680	158	CLmax: 153 m
EMB305_54-1	TF0240	12 Nov	CTD	05:45	58.0000	17.9998	168	CLmax: 163 m
EMB305_55-1	OCWG-1	12 Nov	CTD	06:44	57.9773	17.9556	201	CLmax: 197 m
EMB305_55-2	OCWG-1	12 Nov	MUC	07:11	57.9770	17.9559	202	CLmax: 200 m
EMB305_55-3	OCWG-1	12 Nov	MUC	07:41	57.9772	17.9559	203	CLmax: 204 m
EMB305_55-4	OCWG-1	12 Nov	FC	08:27	57.9768	17.9559	202	CLmax: 200 m
EMB305_56-1	TF0242	12 Nov	CTD	12:09	57.7161	17.3645	140	CLmax: 135 m
EMB305_57-1	TF0245	12 Nov	CTD	16:40	57.1162	17.6661	110	CLmax: 107 m
EMB305_58-1	wGB-1	12 Nov	CTD	19:00	56.8776	17.3897	96	CLmax: 93 m
EMB305_59-1	GB_SW	12 Nov	CTD	21:48	56.6251	17.1303	77	CLmax: 76 m
EMB305_60-1	TF223	13 Nov	CTD	01:03	56.2505	16.7011	55	CLmax: 54 m
EMB305_61-1	BB_N	13 Nov	CTD	04:51	55.7618	16.2903	61	CLmax: 60 m
EMB305_62-1	TF0220	13 Nov	CTD	07:16	55.5000	16.0002	79	CLmax: 78 m
EMB305_63-1	TF0213	13 Nov	CTD	09:25	55.2499	15.9836	89	CLmax: 88 m
EMB305_63-2	TF0213	13 Nov	SD	09:09	55.2495	15.9835	89	
EMB305_63-3	TF0213	13 Nov	PLA	09:15	55.2497	15.9830	89	3-times ML
EMB305_63-4	TF0213	13 Nov	WP2	09:46	55.2499	15.9832	89	CLmax:3x85m;38m
EMB305_63-5	TF0213	13 Nov	APNET	10:34	55.2500	15.9832	89	CLmax: 86 m
EMB305_63-6	TF0213	13 Nov	APNET	10:52	55.2500	15.9833	89	CLmax: 86 m
EMB305_63-7	TF0213	13 Nov	APNET	11:09	55.2502	15.9830	89	CLmax 86 m
EMB305_63-8	TF0213	13 Nov	APNET	11:26	55.2498	15.9836	89	CLmax 86 m
EMB305_64-1	TF0206	13 Nov	CTD	16:08	55.5329	14.9150	74	CLmax: 73 m

EMB305_65-1	TF0140	13 Nov	CTD	17:29	55.4666	14.7170	68	CLmax: 67 m
EMB305_66-1	TF0142	13 Nov	CTD	18:37	55.4052	14.5364	58	CLmax: 58 m
EMB305_67-1	TF0144	13 Nov	CTD	20:21	55.2571	14.4894	41	CLmax: 42 m
EMB305_68-1	TF0145	13 Nov	CTD	22:27	55.1668	14.2505	44	CLmax: 44 m
EMB305_69-1	TF0150	14 Nov	CTD	02:41	54.6119	14.0426	19	CLmax: 20 m
EMB305_70-1	TF0160	14 Nov	CTD	10:36	54.2401	14.0684	12	CLmax: 12 m
EMB305_70-2	TF0160	14 Nov	VVG	10:45	54.2399	14.0688	12	CLmax: 15 m
EMB305_70-3	TF0160	14 Nov	VVG	10:51	54.2399	14.0689	11	CLmax: 15 m
EMB305_70-4	TF0160	14 Nov	VVG	10:55	54.2400	14.0692	11	CLmax: 15 m
EMB305_70-5	TF0160	14 Nov	VVG	10:59	54.2399	14.0692	11	CLmax: 15 m
EMB305_70-6	TF0160	14 Nov	DRG	11:11	54.2385	14.0722	11	CLmax: 50 m
EMB305_71-1	TF0152	14 Nov	CTD	14:15	54.6330	14.2831	28	CLmax: 28 m
EMB305_71-2	TF0152	14 Nov	VVG	14:24	54.6330	14.2831	28	CLmax: 31 m
EMB305_71-3	TF0152	14 Nov	VVG	14:30	54.6331	14.2830	28	CLmax: 31 m
EMB305_71-4	TF0152	14 Nov	VVG	14:35	54.6330	14.2829	28	CLmax: 31 m
EMB305_71-5	TF0152	14 Nov	VVG	14:40	54.6329	14.2830	28	CLmax: 31 m
EMB305_71-6	TF0152	14 Nov	DRG	14:53	54.6319	14.2857	28	CLmax: 90 m
EMB305_72-1	TF0112	14 Nov	CTD	16:51	54.8034	13.9587	38	CLmax: 38 m
EMB305_72-2	TF0112	14 Nov	CTD	17:19	54.8032	13.9593	38	CLmax: 5 m
EMB305_72-3	TF0112	14 Nov	CTD	17:42	54.8026	13.9596	38	CLmax: 10 m
EMB305_73-1	TF0113	14 Nov	CTD	20:12	54.9253	13.5008	45	CLmax: 45 m
EMB305_73-3	TF0113	14 Nov	WP2	20:36	54.9250	13.5002	45	CLmax: 26 m; 41 m
EMB305_73-4	TF0113	14 Nov	CTD	21:01	54.9249	13.5003	45	CLmax: 25 m
EMB305_74-1	TF0105	14 Nov	CTD	22:16	55.0249	13.6085	44	CLmax: 44 m
EMB305_75-1	TF0104	14 Nov	CTD	23:33	55.0671	13.8121	44	CLmax: 44 m
EMB305_76-1	TF0103	15 Nov	CTD	00:33	55.0637	13.9882	45	CLmax: 45 m
EMB305_77-1	TF0109	15 Nov	CTD	06:43	54.9999	14.0837	45	CLmax: 46 m
EMB305_77-2	TF0109	15 Nov	PLA	06:35	54.9999	14.0833	45	3-times ML
EMB305_77-3	TF0109	15 Nov	SD	06:44	55.0000	14.0838	46	
EMB305_77-4	TF0109	15 Nov	WP2	07:09	54.9997	14.0833	46	CLmax: 32 m; 45 m
EMB305_77-5	TF0109	15 Nov	CTD	07:23	55.0001	14.0837	46	CLmax: 25 m
EMB305_77-6	TF0109	15 Nov	VVG	07:36	54.9999	14.0834	46	CLmax: 4x 49 m
EMB305_77-7	TF0109	15 Nov	DRG	08:10	54.9981	14.0852	46	CLmax: 120 m
EMB305_78-1	TF0114	15 Nov	CTD	11:47	54.8586	13.2759	42	CLmax: 42 m
EMB305_79-1	TF0115	15 Nov	CTD	13:23	54.7952	13.0571	27	CLmax: 27 m
EMB305_80-2	TF0030	15 Nov	PLA	14:53	54.7234	12.7813	20	3-times ML
EMB305_80-1	TF0030	15 Nov	CTD	14:49	54.7235	12.7812	20	CLmax: 18 m
EMB305_80-3	TF0030	15 Nov	CTD	15:07	54.7233	12.7832	20	CLmax: 5 m
EMB305_80-4	TF0030	15 Nov	VVG	15:15	54.7232	12.7832	20	CLmax: 23 m
EMB305_80-5	TF0030	15 Nov	VVG	15:19	54.7233	12.7832	20	CLmax: 23 m
EMB305_80-6	TF0030	15 Nov	VVG	15:23	54.7233	12.7832	20	CLmax: 23 m
EMB305_80-7	TF0030	15 Nov	VVG	15:26	54.7233	12.7833	20	CLmax: 23 m
EMB305_80-8	TF0030	15 Nov	DRG	15:36	54.7228	12.7873	20	CLmax: 60 m
EMB305_81-1	TF0001	15 Nov	CTD	16:30	54.6974	12.6986	19	CLmax: 19 m
EMB305_81-1	TF0001	15 Nov	CTD	16:35	54.6974	12.6984	18	CLmax: 19 m
EMB305_82-1	TF0002	15 Nov	CTD	18:00	54.6500	12.4497	15	CLmax: 16 m
EMB305_83-1	TF0046	15 Nov	CTD	20:23	54.4696	12.2406	26	CLmax: 26 m
EMB305_83-2	TF0046	15 Nov	PLA	20:24	54.4696	12.2406	26	3-times ML
EMB305_83-3	TF0046	15 Nov	WP2	20:40	54.4696	12.2410	26	CLmax: 2x 22 m
EMB305_84-1	TF0041	15 Nov	CTD	22:00	54.4211	12.0608	16	CLmax: 17 m
EMB305_85-1	TF0017	15 Nov	CTD	23:32	54.3923	11.8223	20	CLmax: 20 m
EMB305_86-1	TF0022	16 Nov	CTD	02:57	54.1100	11.1754	21	CLmax: 20 m
EMB305_87-1	TF0018	16 Nov	CTD	06:22	54.1833	11.7667	17	CLmax: 18 m
EMB305_87-2	TF0018	16 Nov	VVG	06:35	54.1831	11.7665	17	CLmax: 20 m
EMB305_87-3	TF0018	16 Nov	VVG	06:39	54.1832	11.7665	18	CLmax: 20 m
EMB305_87-4	TF0018	16 Nov	VVG	06:44	54.1833	11.7668	18	CLmax: 20 m
EMB305_87-5	TF0018	16 Nov	VVG	06:48	54.1833	11.7668	18	CLmax: 19 m
EMB305_87-6	TF0018	16 Nov	DRG	06:58	54.1829	11.7685	17	CLmax: 60 m

EMB305_88-1	TF0012	16 Nov	CTD	08:38	54.3148	11.5499	22	CLmax: 23 m
EMB305_88-2	TF0012	16 Nov	CTD	09:13	54.3150	11.5501	22	CLmax: 7 m
EMB305_89-1	TF0014	16 Nov	CTD	13:30	54.5945	11.0142	25	CLmax: 25 m
EMB305_90-1	MPA-18	16 Nov	CTD	14:53	54.5486	10.7697	21	CLmax: 21 m
EMB305_91-1	oMPA-17	16 Nov	CTD	15:37	54.5416	10.6859	21	CLmax: 20 m
EMB305_92-1	TF0360	16 Nov	CTD	17:04	54.5987	10.4493	15	CLmax: 16 m

CLmax: Maximum rope/cable length
Secchi disk (SD): Defined white disk with bore holes to determine water transparency
WP-2 net (WP2): Plankton net with closing mechanism and removable net bucket for zooplankton sampling
Plankton Net (PLA) Small hand-thrown net for phytoplankton sampling in the Mixed Layer (ML)
CTD: CTD rosette system with fluorimeter, oxygen sensor, water sampler, and video camera
Apstein Net (APNET) Net for phytoplankton sampling equipped with plastic cowls, reducing the mouth opening of the net and thus enabling a higher filtering efficiency in the attached conical net bag
ScanFish (SCF) CTD mounted in an undulating wing dragged behind the ship
Van-Veen grab (VVG) Grab to sample defined surface area and volume to enable quantitative analyses
Dredge (DRG) Overview of the benthos species composition of an area is achieved by dragging a metal frame with a net behind the slowly moving ship for a couple of minutes.
Frahm Corer (FC) A single corer for sampling stratified surface sediment.
Multicorer (MUC) Parallel sampling of stratified surface sediment with a couple of tubes punching the upper sediment range.

7 Data and Sample Storage and Availability

All data gathered are saved on a data repository in the IOW immediately after the cruise. The processed and validated data will be stored in the ODIN data base (https://odin2.io-warnemuende.de) in due time after the cruise. According to the IOW data policy and to facilitate the international exchange of data, all metadata will be made available under the international ISO 19115 standards for georeferenced metadata. Data of macrozoobenthos is delivered directly to MUDAB (German Environment Agency, 2021) and to the ICES Data Centre.

The access to the data will be restricted for three years after the data acquisition, to protect the research process, including scientific analysis and publication. After that time the data will become openly available to any person or any organization who requests them, under the international Creative Commons (CC) data license of type CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/). For further details, refer to the IOW data policy document.

Table 7.1 Overview of data availability

Type	Database	Available	Free Access	Contact
Hydrographic data	ODIN	01.12.2021	01.12.2024	volker.mohrholz@io-warnemuende.de
Nutrient data	ODIN	01.06.2022	01.06.2025	joachim.kuss@io-warnemuende.de
Zooplankton results	ODIN	01.11.2022	01.11.2025	joerg.dutz@io-warnemuende.de
Phytoplankton results	ODIN	01.11.2022	01.11.2025	anke.kremp@io-warnemuende.de
Macrozoobenthos	MUDAB /ICES	01.11.2022	01.11.2025	michael.zettler@io-warnemuende.de

8 Acknowledgements

We thank the captain and the crew of the r/v Elisabeth Mann Borgese for their effort and support during the cruise at partly harsh conditions, as well as the cruise participants of the Leibniz Institute for Baltic Sea Research in Warnemünde (IOW), who carried out the measurements as part of the HELCOM’s Baltic Sea monitoring program and the IOW’s long-term measuring program. We are grateful to all people who helped to prepare, conduct and finalize the cruise. The cruise was carried out by IOW on behalf of the Federal Maritime and Hydrographic Agency in Hamburg and Rostock.

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