ELISABETH MANN BORGESE – Berichte

Baltic Sea Long-term Observation Programme

Cruise No. EMB 280

4 November – 15 November 2021,

Rostock – Sassnitz - Rostock (Germany)

HELCOM/long-term

BALTIC SEA LONG-TERM OBSERVATION PROGRAMME
OF THE
LEIBNIZ INSTITUTE FOR
BALTIC SEA RESEARCH
WARNEMÜNDE

EMB 280

iow

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1 Cruise Summary

1.1 Summary in English

The cruise of r/v Elisabeth Mann Borgese No. 280 from November 4th to 15th 2021 was carried out in the frame of the HELCOM monitoring and the IOW long-term observation of the Baltic Sea. At autumn weather with moderate to stormy wind and mostly cloud covered sky, the work programme on 69 stations was accomplished. The focus was on the hydrographic, biological, and hydrochemical measurements and sampling. On 4 of 5 annual cruises, biological activity is restricted to phytoplankton and zooplankton analyses, but on November cruises also the determination of macrozoobenthos on surface sediment samples is conducted. During selected favourable weather conditions in the central eastern Gotland Basin, two moorings (GOCent, GONE) were recovered for maintenance and redeployed, as well, an Argo Float was recovered. Preliminary results and observations show that the surface water temperature varied between 9 and 12 °C. The air temperature was usually lower and reached temperatures below 6°C in northern part of the study area. The decline of the seasonal thermocline was almost completed in the western and central Baltic Sea. However, the replenishment of nutrients in surface waters was observed in the Kiel and Mecklenburg Bights and in the Arkona Sea in November 2021, as locally the concentration of nitrate exceeds 0.5 µmol/L and of phosphate 0.25 µmol/L. Surface waters in the central Baltic still showed low nutrient concentrations. Nutrient availability caused an autumn bloom that was indicated by elevated chlorophyll_a concentration of between 2 and 3.5 µg/L west of Darss Sill. Further east in the Baltic Proper concentrations of about 1 µg/L Chl_a were measured in surface water after the storm.

In deep waters, continuation of perennial phosphate enrichment was also measured during this cruise, whereas nitrate was depleted in the euxinc environment at depth. The presence of old winter water of about 5°C in the Bornholm Sea and the Gotland Sea was still observed between about 45 and 70 m depth. Significant amounts of intruded waters from the Belt Sea that frequently transports some oxygen via the Arkona Sea and the Bornholm Sea to the halocline range of the eastern Gotland Basin, was not found in November 2021. However, the Karlsö Deep seemed to have received a considerable amount of oxygenated water in winter 2020/2021 to its bottom water that roughly halved the hydrogen sulphide burden, but the source remained unclear.

1.2 Zusammenfassung

Die Reise des F/S Elisabeth Mann Borgese Nr. 280 vom 4. bis 15. November 2021 wurde im Rahmen des HELCOM Monitorings und der IOW Langzeit Überwachung der Ostsee durchgeführt. Bei herbstlichen Wetterbedingungen mit mäßigen bis stürmischen Winden und meistens geschlossener Wolkendecke wurde das Arbeitsprogramm auf 69 Stationen erfüllt. Der Fokus lag auf den hydrographischen, biologischen und hydrochemischen Messungen und Beprobungen. Auf 4 der 5 jährlichen Fahrten beschränken sich die biologischen Untersuchungen auf Phyto- und Zooplankton, aber auf den Ausfahrten im November werden auch Makrozoobenthos Bestimmungen anhand von Proben des Oberflächensediments durchgeführt. Bei ausgewählten günstigen Wettersituationen wurden zwei Verankerungen geborgen, gewartet und wieder verankert, ebenso wurde ein "Argo Float" aufgenommen.

Vorläufige Ergebnisse und Beobachtungen zeigen, dass Oberflächenwassertemperaturen zwischen 9 und 12°C vorherrschten. Die Lufttemperatur war in der Regel niedriger und erreichte Temperaturen unter 6°C in dem nördlichen Teil des Untersuchungsgebiets. Der Abbau der sommerlichen Thermokline war in der westlichen und zentralen Ostsee abgeschlossen. Wogegen die Auffüllung der Nährstoffvorräte im Oberflächenwasser nur in der Kieler und Mecklenburger Bucht, sowie in der Arkonasee im November 2021 beobachtet wurde, da lokal die Konzentrationen von Nitrat 0.5 µmol/L und von Phosphat 0.25 µmol/L überschritten wurden. In der zentralen Ostsee waren die Nährstoffkonzentrationen im Oberflächenwasser aber noch niedrig. Die Verfügbarkeit von Nährstoffen westlich der Darsser Schwelle löste noch eine Herbstblüte aus mit Chlorophyll_a Konzentrationen von 2 bis 3.5 µg/L. Weiter östlich, im Bereich der zentralen Ostsee wurden Chlorophyll_a Konzentrationen von etwa 1 µg/L nach dem Sturm gemessen.

Im Tiefenwasser wurde eine Fortsetzung der mehrjährigen Anreicherung von Phosphat auch während dieser Fahrt vorgefunden, wogegen Nitrat unter den euxinischen Bedingungen in der Tiefe nicht vorhanden war. Das alte Winterwasser von etwa 5°C konnte noch in der Bornholmsee und der Gotlandsee zwischen etwa 45 und 70 m beobachtet werden. Eine bedeutsame Menge von eingeschichtetem Wasser aus der Beltsee, die häufig Sauerstoff über die Arkona- und Bornholmsee in den Bereich der Haloklinen im östlichen Gotlandbecken einträgt, wurde im November 2021 nicht vorgefunden. Wogegen das Karlsö Tief anscheinend einen beträchtlichen Schub von sauerstoffhaltigem Wasser, wahrscheinlich im Winter 2020/2021, ins Bodenwasser bekommen hatte, welcher die Schwefelwasserstofflast etwa halbierte, dessen Herkunft aber ungeklärt blieb.

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
Wagner, Robert, Dr.-Ing.	Phys. Oceanography, CTD	IOW
Sadkowiak, Birgit	Marine Chemistry, Nutrients	IOW
Kreuzer, Lars	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
Gründling-Pfaff, Sigrid	Biol. Oceanogr., Benthos organisms	IOW

Floth-Peterson, Mareike	Marine Chemistry, GODESS mooring	IOW
Waern, Malin	Marine Chemistry, Nutrient Sensors	IOW
Sommer, Marcel	Marine Chemistry, Greenhouse gases	IOW
Döllikes, Lukas	Phys. Oceanography, CTD	IOW
Fechtel, Christin	Biol. Oceanogr., Plankton and Microbiol.	IOW

2.3 Participating Institutions

IOW Leibniz Institute for Baltic Sea Research Warnemünde

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 and zooplankton 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 to the Arkona Sea, via the Bornholmsgat to the Bornholm Basin, along the Słupsk channel (Bornholm Sea) to the eastern Gotland Basin. The inflow may proceed within several months further to the northern and western Gotland Sea, episodically bringing haline oxygen rich water to the central basins. Both foreseen east-west ScanFish transects in the eastern and western Gotland Basin to provide data for hydrographic modelling purposes had to be cancelled because of bad weather. An overview of the locations of CTD stations are shown in Fig. 3.1. For the detailed follow-up of stations and the respective work programme, the list of stations is given in Chapter 6.

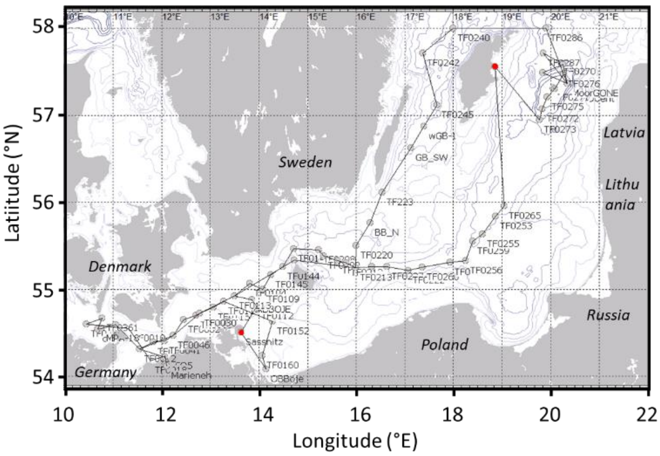

Fig. 3.1 Map of stations (grey dots) with indicated cruise track of the cruise EMB 280 from 4th – 15th November 2021 (positions occupied during bad weather are given in red); the details of the sampled stations are listed in Chapter 6.

3.2 Aims of the Cruise

The cruise EMB 280 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 cruise in 2021 of five expeditions 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 oxygen entrained by the Major Baltic Inflows (MBI) that occurred between 2014 and 2016 vanished and euxinic conditions prevail in deep waters.

3.3 Agenda of the Cruise

3.3.1 Station work

The work on the stations usually started with 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. Moreover, determinations of chlorophyll and the depth of visibility by means of a Secci disk were also done. 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. 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. 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)

3.3.2 Continuous underway measurements

Self-cleaning monitoring box (SMB)
The SMB (4H-Jena) system (Leibniz Institute for Baltic Sea Research4H-Jena, 2020) is aimed to improve standard thermosalinograph measurements by regular cleaning intervals. Therefore, the shape of the sensor enclosure is constructed to enable effective automatic cleaning. 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 Fig. 5.2 (Responsible scientists: Dr.-Ing. Robert Wagner, Johann Ruickoldt).

4 Narrative of the Cruise

This paragraph is aimed to give an impression of the work on board during the campaign. It is a day by day report that includes the forecasted weather and sea condition as predicted by Deutscher Wetterdienst (DWD, 2021) for the respective days.

Thursday, 04 November 2021: The weather forecast predicted moderate wind from east 3 to 4 bft, shifting counter clockwise northwest to west, slightly increasing at a wave height of 1 m. We left the pier of Rostock-Marienehe at 8:15 o'clock at a cloudy November morning. After the mandatory safety instruction, we passed the Warnemünde lighthouse and then headed north. Already at half past ten, we started the first station TFO5 with the complete chemistry sampling programme. So water sampling was done for oxygen determinations, the inorganic nutrients nitrate, nitrite, phosphate, silicate, ammonium, total as well as total dissolved nitrogen and phosphorous, and for dissolved and particulate natural organic matter analyses. The visibility depth was determined by the traditional method by using a Secci disk. The value is also used to optimize the filtration volume for organic matter analysis. Eastward along the coast we reached station TF0018. For the first time on this cruise a Van Veen grab and a dredge were deployed for sampling of benthos organisms. The CTD cast was already used to take a bottom water oxygen sample to determine the available oxygen for the organisms in waters close to the sediment. After a longer transit of 30 n.m., we arrived on the Fehmarn Belt station TF0010 for a CTD cast and Benthos sampling. Subsequently, a transit to the Kiel Bight with station TF0360 followed. The sampling and sample preparation for the larger set of nutrient parameters, similar as investigated on the second station, was done. The samples were partly measured on-board or in the IOW labs after the cruise. First plankton net hauls were accomplished by using the small phytoplankton net and the WP2 plankton net with a closing mechanism. Moreover, benthos samples were taken by the Van Veen grab and the dredge also on this station. The station TF0361 followed in the evening, still in the Kiel Bight with a CTD cast. Then two project stations have been included in the schedule for Van Veen grab sampling until midnight: oMPA-17, MPA-18. The deserved night's rest followed and the continuation of the work was scheduled to early morning after the transit.

Friday, 05 November 2021: The wind was announced to be from northwest with 5 to 6 bft, shifting fast west, for a time decreasing a little, sea was expected to be of 1.5 meter wave height. Back in the Mecklenburg Bight, we began the work at 7:00 o'clock in the morning to fulfil the requirement to sample the Benthos organisms as far as possible during daylight. So, we started on TF0012 by a CTD cast with water sampling for chemical parameters accompanied by Secci depth. Then we continued with grab samples and the dredge as well as net sampling of phytoplankton and zooplankton. Afterwards we completed the TF0017 and TF0041, each with a CTD cast only. On the next station TF0046 in addition to the CTD cast, plankton net hauls and Secci depth determination completed the station work. After the passage of Darss Sill we reached TF0002, with a standard CTD cast and a CTD comparison measurement for pressure, salinity, temperature, and oxygen with 9 oxygen samples from 3 water sampling bottles. Some sunny periods were recognized, but it felt still windy and cold. After fulfilling the TF0001, again a station with the complete chemical and biological programme followed on TF0030, including water sampling, net hauls and grab samples. Then TF0115 and TF0114 with sampling for oxygen and inorganic nutrients were done. Because of wind of 7 bft and partly high waves in the central Arkona Basin, the station TF0113 was postponed and it was decided to move to a more protected sea area further south.

Saturday, 06 November 2021: According to the weather forecast for the Western Baltic Sea wind was expected from west to southwest of about 5, increasing 6 to 7, with shower squalls, for a time misty, sea was expected to increase to 2 meter. After breakfast, we started the work by a CTD cast on station TF0152 at 7:30 with water sampling for nutrients and bottom water oxygen. Benthos sampling followed by several Van Veen grab hauls and dredge transects. Then we headed further south to station TF0160 repeating the work plan of the previous station. To finish the work of the day, we sailed to the MARNET station OBBoje to do comparison measurements for sensors installed in 3 and 12 m depth attached to the buoy. However, the

Oder Bank buoy was not the usually present discus buoy, but was an ice resistant buoy. Then we headed northwest to reach Sassnitz harbour. Initially foreseen for an exchange of scientists, but was prolonged to one day to avoid the stormy conditions in the Arkona Sea.

Sunday, 07 November 2021: The weather is expected to be improving with winds from southwest of about 6 bft, shifting slowly north and decreasing to between 3 bft and 4 bft. However, at times thundery gusts occured and the sea still showed up with a wave height of 2.5 meter. While waiting for a calming down of the wind, we welcomed the new members of the scientific staff and bid two disembarking colleagues farewell, which accomplished their work already on the first part of our cruise. However, we still had to wait until the weather was improved to be able to continue the station work. Finally, the next station was scheduled for midnight.

Monday, 08 November 2021: The weather forecast reads: westerly winds of 3 to 4, veering slowly south, increasing a little, at a sea state of 1 meter. Around midnight we did a CTD cast with water sampling for oxygen and nutrient determinations on TF0112. Afterwards, the next MARNET station was on the schedule. At the spar buoy “Arkona Basin” the standard oxygen levels at 7 m and 40 m depth were sampled for oxygen comparison measurements by Winkler titration. Then the laborious station TF0113 followed with all nutrient parameter including the dissolved inorganic nutrients, nitrate, nitrite, phosphate, silicate, ammonium as well as the total and total dissolved nitrogen and phosphorous. Moreover, for the first time greenhouse gases carbon dioxide, methane and dinitrogen oxide were sampled for analysis in the IOW. Subsequently, net hauls by the small phytoplankton net as well as whole water column casts by the larger WP2 net were done. The TF0104 was next with a CTD cast and standard inorganic nutrients and oxygen determinations. On TF0109, we did a last benthos sampling with three Van Veen grab hauls and a dredge sample. Then we headed northeast to TF0145, TF0144 and afterwards via the Bornholmsgat to stations TF0140 and TF0208. The latter with comparison measurements of salinity, temperature, and oxygen for the duplicate sensor set of the CTD rosette system. Then we headed further southeast to station TF0200 for a CTD cast and nutrients and oxygen measurements. On the following stations TF0211 and TF0212 we only carried out CTD casts with an oxygen sample at 10 m depth for oxygen data validation purposes. In the evening we arrived at the Bornholm Deep station TF0213 which was again a major station with several activities. We sampled water for nutrient analyses of standard dissolved inorganic nutrients, ammonium, total nitrogen, total phosphorous, 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.

Tuesday, 09 November 2021: Wind forecast was south-easterly winds of about 4 bft, shifting southwest thereby increasing to 5-6 bft, locally misty, at a sea of 2 meter. We continued the thalweg chain of stations after midnight on TF0225, TF0227, with some water samples on TF0222 for nutrients and oxygen determinations. Basically the purpose of the CTD profiles is to investigate the distribution of salinity, temperature and oxygen along the path into the deep eastern Gotland basin. Over the day we had changing cloud coverage with partly sunny periods. The next CTD stations TF0266, TF0268, TF0256, TF0259, TF0255, TF0253 and TF0265 followed. The latter was completed at 3 o’clock in the afternoon as wind increased to 7 bft. We postponed the next stations and moved to a wind protected area in a bay of the island of Gotland. However, the bay was 80 n.m. away and it took until 1 o’clock to reach the sheltered bay. Meanwhile the wind increased to 8 bft with a sea of 2.5 m. In the central eastern Gotland Basin the situation was even worse. The sea reached a wave height of 3.5 m there.

Wednesday, 10 November 2021: Based on the weather forecast, the wind and sea state conditions were expected to improve. However, wind force between 7 and 8 bft and a wave height of above 2.5 metres still didn't allow to work in the central basin. At 8:00 o'clock PM, we headed to TF0273, which we hoped to reach soon after midnight, but this was unclear because of the present higher waves.

Thursday, 11 November 2021: For the central Baltic, westerly winds of 4 bft, increasing to 5-6 bft, at times misty, sea 2,5 meter. Already a few days before, this day was selected for mooring operations. But first we continued the thalweg transect accepting a certain gap with the stations TF0273, TF0272, TF0275 until breakfast. Then we reached the first mooring station "Gotland Central" (GOCent) at 8:00 o'clock at adequate wind conditions of 3 bft.
The releaser was activated at 7:55 o'clock. 5 minutes later the signal-red buoys were in sight, at 8:10 the floats were hooked and the mooring rope with the instruments were heaved on board. Piece by piece the sensors were unshackled and both rope ends were connected by a shackle to further wind the rope up. Then we moved over to the nearby Gotland Deep station TF0271. We had 6 CTD casts and net hauls on the schedule. So the water column with a focus on the redoxcline was investigated in detail in terms of oxygen/hydrogen sulphide, nutrients, organic matter, plankton and microbiology. After lunch the mooring Gotland Central with a sediment trap was re-deployed almost within half an hour. Afterwards the foreseen recovery of two Argo Floats was postponed, because the wind force approached 6-7 bft again and the wave height didn't allow to use the necessary rubber boat for the recovery.

Friday, 12 November 2021: We expected wind from west of about 5 bft with a wave height of 2 meter. The wind was expected later to decrease to 3 and 4 bft, thereby shifting southeast. The recovery of the mooring "Gotland Northeast" (GONE) was foreseen for early morning. However, the sea still showed high waves and the wind speed was declining slowly. Finally, the releaser of the mooring was activated at 10:30 o'clock and the red buoys appeared at the surface 4 minutes later. The mooring was completely on deck at 11:00 o'clock. All instruments were exchanged and after lunch at 12:30 the anchor stone was lifted from the ship and slowly veered to the seafloor. Several stops enabled to attach the instruments at the rope. At 12:45 the mooring was deployed. Subsequently, we headed in western direction to find the Argo Float that was already kept at the surface and finally was found at half past two. The rubber boat was heaved in the water with two crew members and a scientist. The relatively heavy float was pulled into the boat. The boat went alongside ship and was heaved on deck with the crew and the recovered float. With this activity, the recovery and deployments of two moorings and a float were finished for the cruise, and we headed North to the Fårö Deep station (TF0286). This station was accomplished in the evening by sampling of water for analyses of oxygen, nutrients, phytoplankton, and greenhouse gases.

Saturday, 13 November 2021: The forecast for the day was wind from southeast of about 4 bft, for a time decreasing a little, shifting east to northeast at a sea of 1 meter wave height. Over the night, we made a transit from the eastern to the western Gotland Basin and started at 2 o'clock in the morning on the station wGB-3 with a CTD cast for the recording of hydrographic parameters, then TF0240 followed at 4:30 o'clock with oxygen/hydrogen sulphide and dissolve inorganic nutrients. On the station TF0242 again only a CTD cast was done. Then the Karlsö Deep TF0245 was on the schedule with oxygen/hydrogen sulphide, inorganic nutrients nitrate, nitrite, phosphate and silicate with ammonium. It was completed after noon. On wGB-1, GB_SW, TF223, BB_N, and TF0220 again only CTD casts with conductivity, temperature, oxygen, turbidity and Chlorophyl_a sensor measurements were done. For dinner, before reaching the TF223 we did a barbeque on the working deck. The people in a non-working shift enjoyed a glass of hot wine.

Sunday, 14 November 2021:
At a cloud covered sky, we were pushed home by winds of 5 to 6 bft from eastern direction. On 1:45 in the morning, we reached the first repetition station TF0213 Bornholm Deep. The CTD cast was used to sample water for basic inorganic nutrients, oxygen and for hydrogen sulphide in 80 m depth and close to the bottom, as well as for chlorophyll_a samples. By several net hauls samples for phytoplankton and zooplankton analyses were caught. Before noon we accomplished the skipped station TF0103 and then the TF0105. The repetition stations TF0113, TF0030, TF0046, and TF0012 followed. The latter already after passing Warnemünde at the entrance of Rostock harbour going further West in the Mecklenburg Bight.

Monday, 15 November 2021: We entered the port in the morning and docked at the pier of Rostock-Marienehe at about 8 o'clock. The mobile winches and boxes with mooring equipment were brought to the store hall in Marienehe. The large data set of the cruise, the container with the lab stuff and water samples as well as the cool boxes with either frozen or cooled sampled were taken to the institute.

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

Between the north-eastward shifted Azores High and an Eastern European high, a high pressure bridge developed across Central Europe. In the frontal zone north of the high pressure bridge, single disturbances moved eastward and influenced with their front lines the northern part of Europe (Deutscher Wetterdienst, 2021). After the 9th November, between a high pressure zone that stretched from southeast Europe to western Russia and a low pressure system over the central North Atlantic and the western Arctic Ocean, a frontal zone developed that orientated from southwest to northeast. The fronts moved from the sea area southwest of Ireland to the Baltic states. After the 13th November, a high pressure area extended from south-east Europe over the Baltic Sea to the North Sea.
The weather conditions were stormy and cloudy as could be expected in the autumn season. During the first three days, we accomplished the station work in the Belt Sea, the western Arkona Sea and east of the Island of Rügen until Sassnitz (Fig. 3.1). At wind speeds between 8 and 17 m/s (6 to 7 bft) this was only possible because the study sites were so far comparatively sheltered. From 6th November in the evening to 7th in the evening, the continuation of the work in the open Arkona Sea was impossible and we stayed in Sassnitz harbour until the wind calmed down (Fig. 5.1). At moderate wind speed between 8 and 12 m/s of about 6 bft we continued the work in the Arkona Sea, then in the Bornholm Sea and the southern Gotland Sea. Wind was between 5 and 7 bft with gusts of partly up to 8 bft. On 10th November we again stopped the station work and steamed to a sheltered bay at the east coast of the Island of Gotland (Fig. 3.1). The subsequent periods of calm wind on 11th and 12th November were used for mooring operations and the Argo float recovery. During the transect from the western Gotland Basin

through the Bornholm Sea and the Arkona Basin back home, the wind blew from northern and eastern directions of 5 to 6 bft.

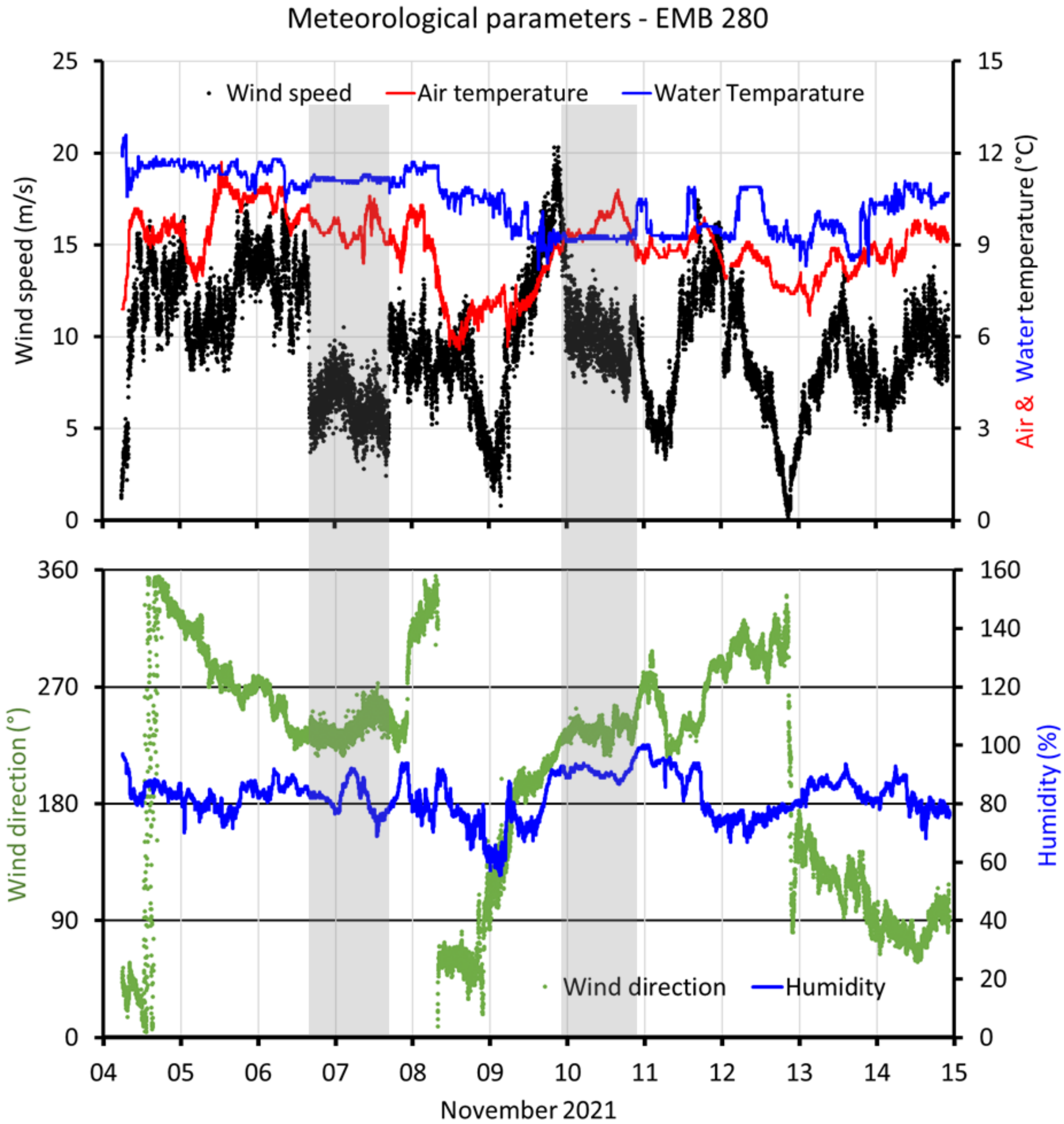

Fig. 5.1 Surface water temperature, air temperature, and wind speed (upper panel) as well as humidity and wind direction measured on-board by the automatic weather station of the DWD; the time r/v Elisabeth Mann Borges was in sheltered areas is shaded grey; surface water temperature was measured by the SMB-thermosalinograph.

The surface water temperature varied between 9 and 12 °C. The air temperature was usually lower and reached temperatures below 6°C on 9th and 10th November. We had almost 12°C in in surface water of the Belt Sea in the beginning of the cruise and usually about 9°C in the Gotland Sea in the middle of the cruise (Fig. 5.1, upper panel). Humidity scattered around 80%. The wind turned from North to south during the first 3 days, remained eastern for one day. Subsequently the wind changed to northern direction and then slowly turned between 9th and 13th from northern, via eastern, southern and western directions back to a northern wind flow. On the last two days, wind was basically from eastern directions (Fig. 5.1, lower panel).

The elevated chlorophyll_a concentration of between 2 and 3.5 µg/L west of Darss Sill indicate the presence of an autumn bloom. Further on in the Baltic Proper only low concentration of about 1 µg/L Chl_a were measured in surface water after the storm (Fig. 5.2).

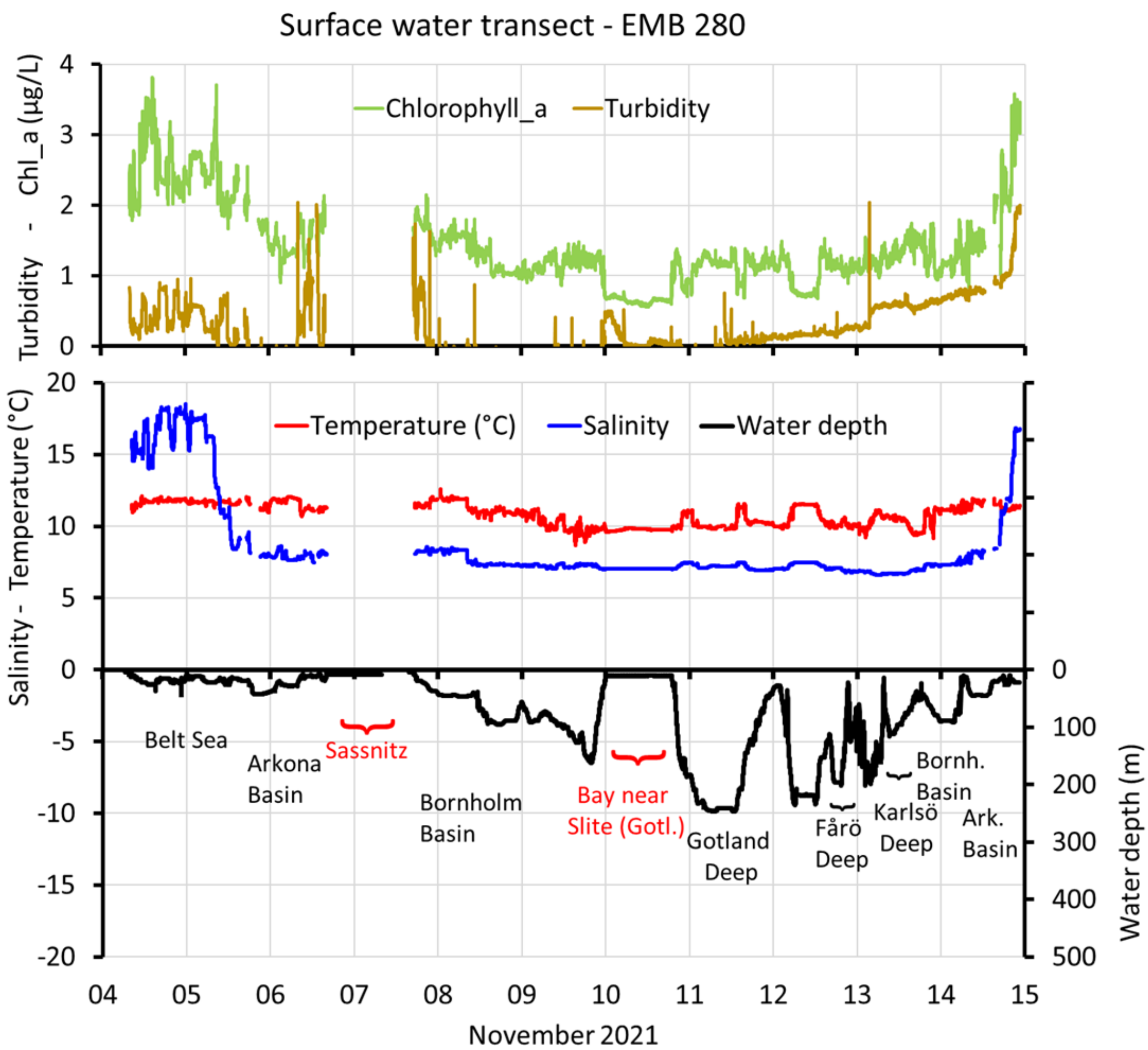

Fig. 5.2 Recording of not finally validated data of chlorophyll, turbidity, temperature, and salinity in surface waters with the corresponding water depth and sea area (interruptions due to bad weather are given in red) during the cruise EMB 280 of r/v Elisabeth Mann Borgese from November 4th to 15th in 2021; the time r/v Elisabeth Mann Borges was in sheltered areas is indicated in red

5.2 Nutrient situation in the western Baltic Sea in November 2021

The nutrients condition in autumn in the Baltic Sea is characterized by the replenishment of nutrient concentrations in surface waters after the depletion during spring and summer. After the cooling of surface water and the break-up of the thermocline, nutrient enriched subsurface water is mixed into the surface layer by wind. This was confirmed for the Kiel and Mecklenburg Bights and in the Arkona Basin in November 2021, as locally nutrient concentrations exceed 0.5 µmol/L nitrate and 0.25 µmol/L phosphate, clearly above the summer minima, while surface waters of the deeper basins still showed low concentrations. In the Bornholm Basin the development was less proceeded as well as in the Gotland Basin, where only weak indications of nutrients supply by deeper mixing were identified at that time.

In deep waters and especially in the bottom layer continuation of perennial nutrient enrichment was also documented for November 2021. Nitrate reflects an exception in this case, because in transition to anoxia, also nitrate is consumed as an oxidant by nitrate reducing microorganisms. So there is a strong temporal variability of nitrate in the Bornholm Deep bottom waters with partly high nitrate concentration under weak oxic conditions (Nov 2018, Table 5.4) and total depletion under clear sulphidic conditions (Oct 2019) or other values during transition (Nov 2020 and 2021). In the less dynamic Gotland Deep, Fårö Deep, Landsort Deep, and Karlsö Deep in recent years no nitrate was detected in bottom waters at prevailing sulphidic conditions.

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	2018	2019	2020	**2021**
Kiel Bight (TF0360)	1.76	n.d.	2.62	**2.02**
Meckl.Bight (TF0012)	0.755	2.97	3.07	**1.08**
Darss Sill (TF0030)	0.225	0.21	3.17	**3.74**
Arkona Basin (TF0113)	3.035	4.94	2.55	**4.97**
Bornh. Deep (TF0213)	8.56	n.d.	n.d.	**0.73**
Gotland Deep (TF0271)	n.d.	n.d.	n.d.	**n.d.**
Fårö Deep (TF0286)	n.d.	n.d.	-	**n.d.**
Landsort Deep (TF0284)	n.d.	n.d.	-	**-**
Karlsö Deep (TF0245)	n.d.	n.d.	-	**n.d.**

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

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

Vice versa was the situation for phosphate as it is dissolvable under euxinic conditions. So phosphate concentration could well show accumulation in bottom waters during stagnation, as in the Gotland Deep from 5.08 µmol/L in November 2018 to 5.93 µmol/L in November 2021. Stronger changes were measured in the variable Bornholm Deep and small changes in the Fårö Deep and Karlsö Deep. Also Kiel and Mecklenburg Bights are prone for some variability, as it is the 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 5.5) and likely dissolution of phosphate from 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 (Map, Fig. 3.1) is always a focus of the monitoring campaigns (Fig. 5.3). It is aimed as an overview of the hydrographic and the hydrochemical state of the western and central Baltic Sea during the cruise EMB 280.

In November 2021, in the Belt Sea and especially in the Arkona Sea it was apparent that surface water was slightly cooler (~11.2°C) as the saline bottom water of about 12°C (Fig. 5.3a). In terms of stratification this is compensated by a clearly higher salinity in bottom waters of above 22 in the Belt Sea and about 16 in the Arkona Basin, at corresponding surface water salinity of ~17 and 8, respectively (Fig. 5.3b). The Bornholm Sea also showed a strong salinity gradient from 7.3 in surface waters and 15.7 close to the bottom, whereas the temperature structure was complex with surface water of about 10°C mixed to about 30 m depth after the storm. Some old winter water of 5°C was present at 50 m depth, the water mass at 70 m reflected a temperature of about 10°C, and the bottom water was cooler again at about 8°C. The layer of winter water of about 5°C (the blue ribbon in Fig. 5.3) further stretched at ~50 m depth via the Słupsk furrow to the eastern Gotland Sea at 60 m depth and occupied a depth range of about 20 m. Below the cold layer, the water showed a temperature of 7 to 8°C, at corresponding elevated salinity of 10 to almost 14. It should be mentioned that the temperature structure of upper water in the central eastern Gotland Basin was complex after the storm, as vertical mixing was deep, partly down to 50 m depth, but it showed a broad lateral temperature variability between 7 and 11°C.

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 pink reflected the deep water with an oxygen concentration below 1 mL/L. The hydrogen sulphide concentrations are given as negative oxygen concentration in Table 5.4 and Fig. 5.4. Significant amounts of intruded waters from the Belt Sea, that passed the Arkona Sea and the Bornholm Sea that usually transported some oxygen to the halocline range of the eastern Gotland Basin were not found in November 2021.

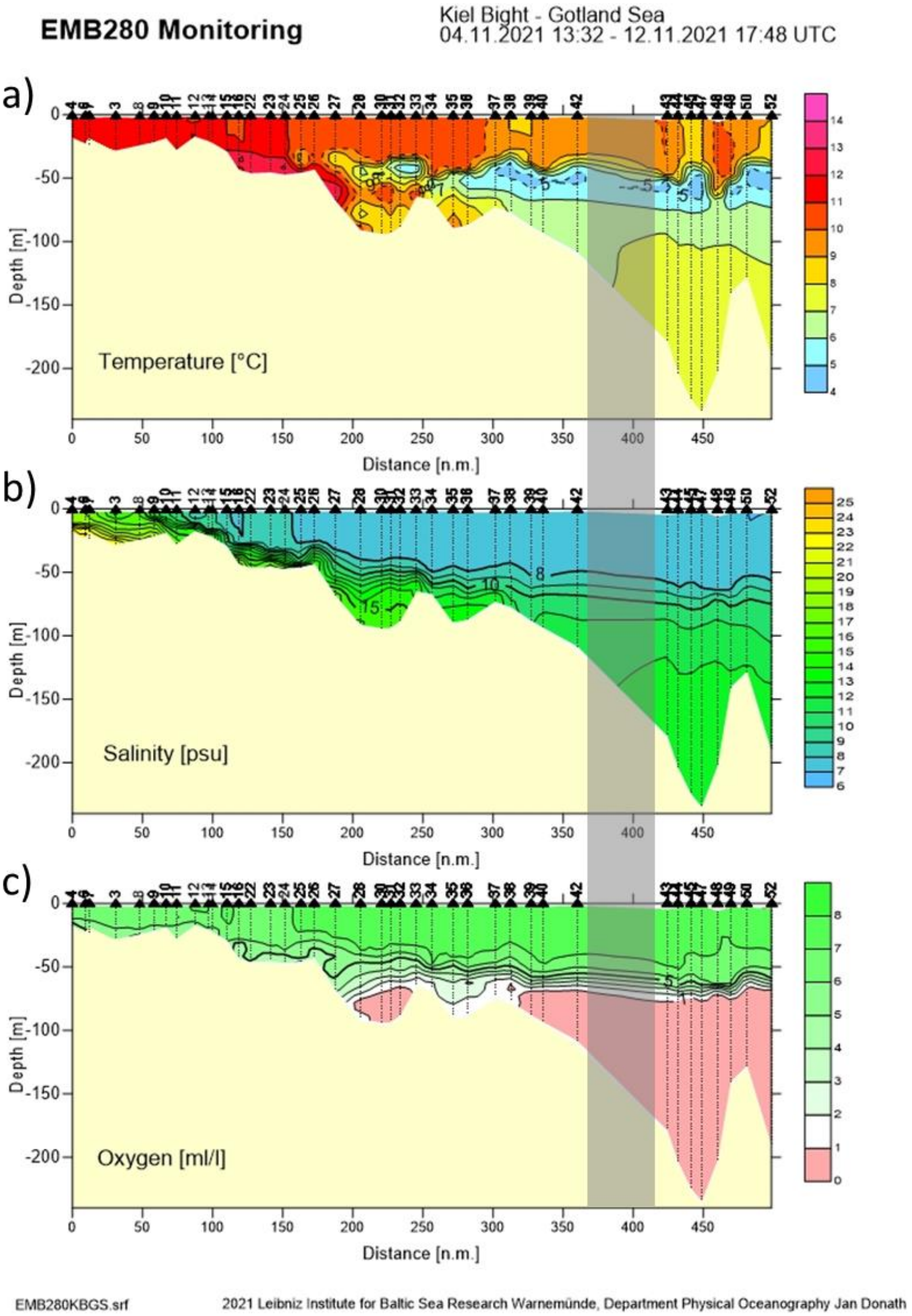

Fig. 5.3 Distribution of temperature (a), salinity (b) and oxygen concentration (c) along the thalweg of the Baltic Sea from the Kiel Bight to the western Gotland Basin (the sampling gap is shaded grey). The figure is based on not finally validated CTD data on selected stations measured between 4th and 12th November 2021.

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 280 is compared to the autumn monitoring cruises of previous years (Tables 5.2 and 5.3). The temperature of bottom water in the western Baltic Sea in November 2021 was similar to the former years. Except in 2019, when the temperature was clearly higher in the shallow part of the Baltic Sea. But this can likely be attributed to the time of the cruise that was carried out in October. In the Arkona Sea, the bottom water temperature was almost half a degree warmer than in the last year, but still about 2.5 °C colder than in 2019. The temperature recorded in autumn in the Bornholm Deep showed a decrease from 2018 of 10.6 to 2021 of 8.2 °C. However, this is likely within the strong variability of the basin. In the Fårö Deep and Karlsö Deep a slight perennial warming since 2018 is seen that could be the warming after the distribution of colder inflow water in 2014/2015 and in subsequent years. Unfortunately, no data are available for the Landsort Deep in November 2020 and 2021.

Table 5.2 Temperature in the bottom layer (°C) in November: 2021 in comparison to former years.

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

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 selected stations of the shallow Belt Sea area between 19.4 in the Mecklenburg Bight in 2018 and 24.5 in the Kiel Bight in 2021 during EMB 280. Behind Darss Sill, we measured the lowest salinity in November 2021 compared to recent years: 16.3 in the Arkona Sea, 15.8 in the Bornholm Deep. 13.0 in the Gotland Deep, 13.3 in the Fårö Deep and 10.5 in the Karlsö Deep. However, in the Arkona Sea the salinity difference was almost 4 whereas in the Karlsö Deep, furthest away on the thalweg from the Darss Sill, the salinity difference was just 0.03 compared to 2018. The changes in the Gotland Basin 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 November: 2021 in comparison to former years.

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

5.4.3 Oxygen in bottom water

The variability of oxygen in the western Baltic Sea is less pronounced in autumn as the decline of the summer thermocline enables deeper mixing and supply of oxygen from the surface into the deeper waters (Table 5.4). For oxygen an already mentioned striking exception is documented for the Mecklenburg Bight where late summer conditions prevailed in October 2019 with an oxygen value of only 1.4 mL/L. Also the deeper mixing did not have efficiently reached the bottom waters in the Arkona Basin at that time, as oxygen was 2.9 mL/L. Otherwise in the western part, the concentrations were close to 5 mL/L up to about 6 mL/L oxygen (Fig. 5.4 for November 2021). In the Bornholm Sea the oxygen status changed over the years between slightly oxic (0.5 mL/L oxygen) to clearly euxinc with a mean of -1.57 mL/L oxygen equivalents (-1.25 mL/L on 8th November, -1.88 mL/L on 14th November 2021). Interestingly, the transition between the Bornholm Deep via the Słupsk Furrow to the deep eastern Gotland Basin, showed some variability along the thalweg (Fig. 5.4). Frequently batches of inflowing water move down the thalweg with varying oxygen, salinity and temperature properties. The deeper basins were clearly euxinic showing equivalents of hydrogen sulphide of -7.1 mL/L oxygen in the Gotland Deep, -4.3 mL/L in the Fårö Deep, -2.0 mL/L in the Karlsö Deep (Table 5.4). It should be noted that the latter was clearly improved as in 2018 and 2019 the concentration was about -3.6 mL/L oxygen equivalents. Likely the considerable oxygen supply to the Karlsö Deep bottom water happened in winter 2020/2021 as oxygen equivalents of hydrogen sulphide were only -1.44 mL/L in March 2021, whereas in July 2020 it was still -3.48 mL/L. No values for the Landsort Deep are available in November 2020 and 2021.

Table 5.4 Bottom water oxygen concentration (mL/L) in November: Comparison of 2021 to former years.

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

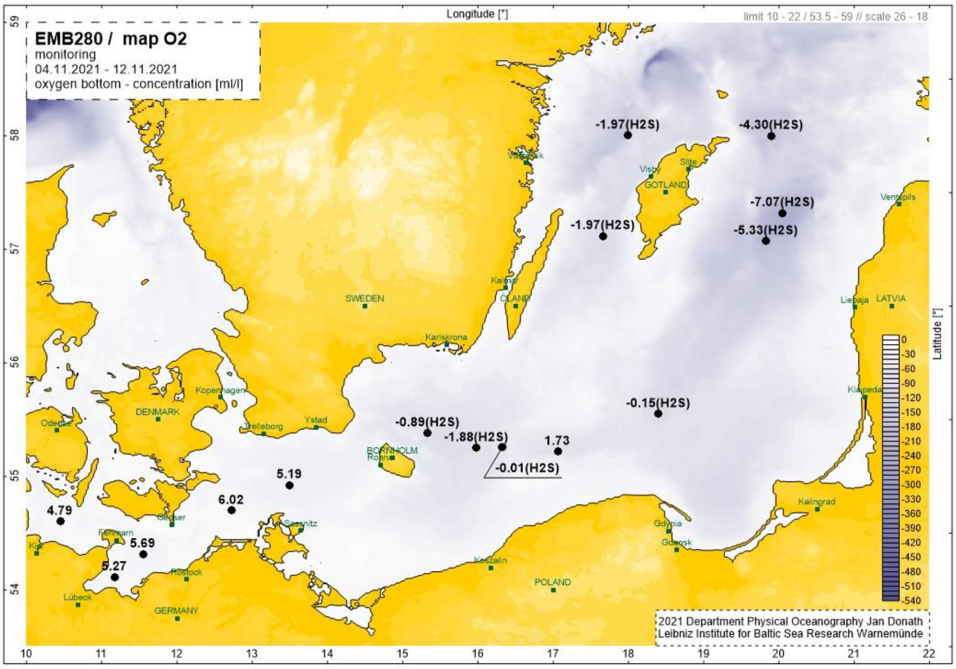

Fig. 5.4 Oxygen concentration (mL/L) in bottom waters of selected Baltic Sea stations (H_2S is included as negative oxygen).

6 Station List of EMB280

6.1 Overall Station List

Station No.		Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/ Recovery
Elisabeth Mann Borgese	**IOW**	**2021**		**[UTC]**	**[°N]**	**[°E]**	**[m]**	Max sampl. depth
EMB280_1-1	TFO5	04 Nov	CTD	8:32	54.2310	12.0732	9.9	CLmax: 11 m
EMB280_1-2	TFO5	04 Nov	Secchi disk	8:46	54.2315	12.0747	9.6	
EMB280_2-1	TF0018	04 Nov	CTD	9:55	54.1826	11.7622	17.3	CLmax: 18 m
EMB280_2-2	TF0018	04 Nov	Van Veen grab	10:17	54.1832	11.7662	17.3	CLmax: 18 m
EMB280_2-3	TF0018	04 Nov	Van Veen grab	10:20	54.1831	11.7662	17.4	CLmax: 20 m
EMB280_2-4	TF0018	04 Nov	Van Veen grab	10:26	54.1831	11.7661	17.2	CLmax: 20 m
EMB280_2-5	TF0018	04 Nov	Van Veen grab	10:28	54.1832	11.7664	17.3	CLmax: 20 m
EMB280_2-6	TF0018	04 Nov	Dredge	10:38	54.1835	11.7669	17.2	CLmax: 60 m
EMB280_3-1	TF0010	04 Nov	CTD	13:25	54.5601	11.3188	25.7	CLmax: 27 m
EMB280_3-2	TF0010	04 Nov	Van Veen grab	13:42	54.5602	11.3185	25.9	CLmax: 27 m
EMB280_3-3	TF0010	04 Nov	Van Veen grab	13:46	54.5602	11.3184	25.9	CLmax: 27 m
EMB280_3-4	TF0010	04 Nov	Van Veen grab	13:51	54.5602	11.3184	25.8	CLmax: 27 m
EMB280_3-5	TF0010	04 Nov	Van Veen grab	13:54	54.5602	11.3186	25.8	CLmax: 27 m
EMB280_3-6	TF0010	04 Nov	Dredge	14:02	54.5604	11.3193	25.9	CLmax: 75 m
EMB280_4-1	TF0360	04 Nov	CTD	16:57	54.5998	10.4504	15.1	CLmax: 16 m
EMB280_4-2	TF0360	04 Nov	Plankton Net	17:04	54.5998	10.4501	15.1	
EMB280_4-3	TF0360	04 Nov	WP-2 Plank. net	17:26	54.6003	10.4493	15.3	CLmax: 15 m
EMB280_4-4	TF0360	04 Nov	CTD	17:43	54.6005	10.4492	15.6	CLmax: 5 m
EMB280_4-5	TF0360	04 Nov	Van Veen grab	18:00	54.6006	10.4488	15.4	CLmax: 18 m
EMB280_4-6	TF0360	04 Nov	Van Veen grab	18:04	54.6007	10.4484	15.4	CLmax: 18 m
EMB280_4-7	TF0360	04 Nov	Van Veen grab	18:07	54.6008	10.4485	15.4	CLmax: 19 m
EMB280_4-8	TF0360	04 Nov	Van Veen grab	18:11	54.6008	10.4483	15.6	CLmax: 18 m
EMB280_4-9	TF0360	04 Nov	Dredge	18:18	54.6009	10.4479	15.7	CLmax: 60 m
EMB280_5-1	TF0361	04 Nov	CTD	20:04	54.6639	10.7775	22.8	CLmax: 23 m
EMB280_6-1	oMAPA-17	04 Nov	CTD	21:11	54.5408	10.6868	20.6	CLmax: 21 m
EMB280_6-2	oMAPA-17	04 Nov	Van Veen grab	21:28	54.5412	10.6865	20.4	CLmax: 23 m
EMB280_6-3	oMAPA-17	04 Nov	Van Veen grab	21:32	54.5412	10.6863	20.2	CLmax: 23 m

EMB280_6-4	oMAPA-17	04 Nov	Van Veen grab	21:36	54.5411	10.6857	20.3	CLmax: 23 m
EMB280_6-5	oMAPA-17	04 Nov	Van Veen grab	21:39	54.5412	10.6858	20.9	CLmax: 23 m
EMB280_7-1	MPA-18	04 Nov	CTD	22:21	54.5470	10.7674	20.6	CLmax: 21 m
EMB280_7-2	MPA-18	04 Nov	Van Veen grab	22:42	54.5482	10.7683	20.4	CLmax: 21 m
EMB280_7-3	MPA-18	04 Nov	Van Veen grab	22:46	54.5485	10.7681	21.2	CLmax: 21 m
EMB280_7-4	MPA-18	04 Nov	Van Veen grab	22:49	54.5486	10.7680	21.1	CLmax: 21 m
EMB280_7-5	MPA-18	04 Nov	Van Veen grab	22:53	54.5486	10.7682	20.6	CLmax: 21 m
EMB280_8-1	TF0012	05 Nov	CTD	6:06	54.3148	11.5507	21.9	CLmax: 23m
EMB280_8-2	TF0012	05 Nov	Secchi disk	6:19	54.3150	11.5498	22.1	
EMB280_8-3	TF0012	05 Nov	Plankton Net	6:21	54.3151	11.5499	21.4	
EMB280_8-4	TF0012	05 Nov	WP-2 Plank. net	6:44	54.3152	11.5492	21.9	CLmax: 22m
EMB280_8-5	TF0012	05 Nov	Van Veen grab	6:54	54.3151	11.5497	21.9	CLmax: 24 m
EMB280_8-6	TF0012	05 Nov	Van Veen grab	6:59	54.3150	11.5500	21.8	CLmax: 24 m
EMB280_8-7	TF0012	05 Nov	Dredge	7:23	54.3150	11.5498	21.7	CLmax: 70 m
EMB280_9-1	TF0017	05 Nov	CTD	8:42	54.3914	11.8270	19.1	CLmax: 20 m
EMB280_10-1	TF0041	05 Nov	CTD	9:51	54.4065	12.0637	16.2	CLmax: 17m
EMB280_11-1	TF0046	05 Nov	CTD	10:58	54.4692	12.2413	25.4	CLmax: 26 m
EMB280_11-2	TF0046	05 Nov	Secchi disk	11:15	54.4696	12.2407	25.4	
EMB280_11-3	TF0046	05 Nov	Plankton Net	11:17	54.4696	12.2406	25.3	
EMB280_11-4	TF0046	05 Nov	WP-2 Plank. net	11:34	54.4696	12.2408	25.1	CLmax: 26 m
EMB280_12-1	TF0002	05 Nov	CTD	13:23	54.6498	12.4502	14.9	CLmax: 16 m
EMB280_12-2	TF0002	05 Nov	CTD	13:48	54.6504	12.4496	15.1	CLmax: 19m
EMB280_13-1	TF0001	05 Nov	CTD	15:07	54.6963	12.7071	18.1	CLmax: 19m
EMB280_14-1	TF0030	05 Nov	CTD	15:51	54.7232	12.7838	19.6	CLmax: 20m
EMB280_14-2	TF0030	05 Nov	Plankton Net	16:06	54.7233	12.7838	20.3	
EMB280_14-3	TF0030	05 Nov	Van Veen grab	16:21	54.7231	12.7830	20.0	CLmax: 23 m
EMB280_14-4	TF0030	05 Nov	Van Veen grab	16:25	54.7231	12.7832	20.4	CLmax: 23 m
EMB280_14-5	TF0030	05 Nov	Van Veen grab	16:29	54.7232	12.7830	19.8	CLmax: 23 m
EMB280_14-6	TF0030	05 Nov	Van Veen grab	16:33	54.7232	12.7829	20.4	CLmax: 23 m
EMB280_14-7	TF0030	05 Nov	Dredge	16:42	54.7232	12.7825	20.1	CLmax: 70m
EMB280_15-1	TF0115	05 Nov	CTD	18:17	54.7948	13.0593	27.0	CLmax: 28m
EMB280_16-1	TF0114	05 Nov	CTD	19:28	54.8604	13.2778	42.0	CLmax: 42 m
EMB280_17-1	TF0152	06 Nov	CTD	6:50	54.6283	14.3087	27.4	CLmax: 28 m
EMB280_17-2	TF0152	06 Nov	Van Veen grab	7:09	54.6290	14.3089	28.0	CLmax: 30 m
EMB280_17-3	TF0152	06 Nov	Van Veen grab	7:13	54.6289	14.3088	28.8	CLmax: 30 m
EMB280_17-4	TF0152	06 Nov	Van Veen grab	7:17	54.6289	14.3088	27.5	CLmax: 30 m
EMB280_17-5	TF0152	06 Nov	Van Veen grab	7:20	54.6290	14.3087	27.9	CLmax: 30 m
EMB280_17-6	TF0152	06 Nov	Dredge	7:30	54.6294	14.3084	28.3	CLmax: 90 m
EMB280_18-1	TF0160	06 Nov	CTD	10:12	54.2413	14.0733	11.1	CLmax: 12 m
EMB280_18-2	TF0160	06 Nov	CTD	10:34	54.2402	14.0689	11.6	CLmax: 12 m
EMB280_18-3	TF0160	06 Nov	Van Veen grab	10:51	54.2402	14.0689	11.5	CLmax: 13 m
EMB280_18-4	TF0160	06 Nov	Van Veen grab	10:54	54.2403	14.0691	11.4	CLmax: 13 m
EMB280_18-5	TF0160	06 Nov	Van Veen grab	10:57	54.2402	14.0688	11.3	CLmax: 13 m
EMB280_18-6	TF0160	06 Nov	Van Veen grab	11:00	54.2401	14.0688	11.4	CLmax: 13 m
EMB280_18-7	TF0160	06 Nov	Dredge	11:07	54.2398	14.0682	11.5	CLmax: 60 m
EMB280_19-1	OBBoje	06 Nov	CTD	12:19	54.0761	14.1552	11.5	CLmax: 12 m
EMB280_19-2	OBBoje	06 Nov	CTD	12:43	54.0754	14.1547	11.6	CLmax: 5 m
EMB280_20-1	TF0112	07 Nov	CTD	22:57	54.7961	13.9651	37.1	CLmax: 38 m
EMB280_20-2	TF0112	07 Nov	CTD	23:16	54.7964	13.9648	38.0	CLmax: 38 m
EMB280_21-1	ABBoje	08 Nov	CTD	0:18	54.8798	13.8576	43.5	CLmax: 43 m
EMB280_22-1	TF0113	08 Nov	CTD	1:56	54.9247	13.5006	45.0	CLmax: 45 m
EMB280_22-2	TF0113	08 Nov	Plankton Net	2:11	54.9249	13.5000	45.0	
EMB280_22-3	TF0113	08 Nov	WP-2 Plank. net	2:26	54.9250	13.4999	45.2	CLmax: 28 m
EMB280_22-4	TF0113	08 Nov	WP-2 Plank. net	2:31	54.9249	13.5000	45.4	CLmax: 44 m
EMB280_22-5	TF0113	08 Nov	CTD	2:48	54.9253	13.4997	44.8	CLmax: 45 m
EMB280_23-1	TF0104	08 Nov	CTD	4:35	55.0681	13.8136	44.3	CLmax: 44 m
EMB280_24-1	TF0109	08 Nov	CTD	5:56	54.9995	14.0837	46.1	CLmax: 46 m
EMB280_24-2	TF0109	08 Nov	Plankton Net	6:11	55.0000	14.0833	46.1	
EMB280_24-3	TF0109	08 Nov	WP-2 Plank. net	6:26	55.0001	14.0832	46.1	CLmax: 31 m
EMB280_24-4	TF0109	08 Nov	WP-2 Plank. net	6:33	55.0000	14.0831	45.7	CLmax: 45 m
EMB280_24-5	TF0109	08 Nov	Grab	6:48	55.0001	14.0825	46.1	CLmax: 49 m
EMB280_24-6	TF0109	08 Nov	Van Veen grab	6:54	55.0002	14.0830	45.9	CLmax: 49 m
EMB280_24-7	TF0109	08 Nov	Van Veen grab	7:02	55.0002	14.0835	46.2	CLmax: 49 m
EMB280_24-8	TF0109	08 Nov	Van Veen grab	7:11	55.0001	14.0832	46.0	CLmax: 49 m

EMB280_24-9	TF0109	08 Nov	Dredge	7:27	55.0006	14.0830	46.1	CLmax: 150 m
EMB280_25-1	TF0145	08 Nov	CTD	9:00	55.1661	14.2487	45.0	CLmax: 45 m
EMB280_26-1	TF0144	08 Nov	CTD	10:25	55.2569	14.4898	41.5	CLmax: 42 m
EMB280_27-1	TF0140	08 Nov	CTD	12:13	55.4665	14.7158	67.9	CLmax: 67 m
EMB280_28-1	TF0208	08 Nov	CTD	14:20	55.4532	15.2334	91.9	CLmax: 90 m
EMB280_29-1	TF0200	08 Nov	CTD	15:36	55.3831	15.3327	91.0	CLmax: 90 m
EMB280_30-1	TF0211	08 Nov	CTD	17:01	55.3296	15.6145	94.2	CLmax: 93 m
EMB280_31-1	TF0212	08 Nov	CTD	18:06	55.3013	15.7958	94.6	CLmax: 93 m
EMB280_32-1	TF0213	08 Nov	CTD	19:15	55.2493	15.9806	89.3	CLmax: 87 m
EMB280_32-2	TF0213	08 Nov	Plankton Net	19:18	55.2495	15.9811	89.1	
EMB280_32-3	TF0213	08 Nov	WP-2 Plank. net	19:44	55.2499	15.9829	89.2	CLmax: 84 m
EMB280_32-4	TF0213	08 Nov	WP-2 Plank. net	19:52	55.2497	15.9829	89.0	CLmax: 84 m
EMB280_32-5	TF0213	08 Nov	WP-2 Plank. net	20:02	55.2499	15.9829	89.1	CLmax: 84 m
EMB280_32-6	TF0213	08 Nov	WP-2 Plank. net	20:11	55.2499	15.9832	88.8	CLmax: 35 m
EMB280_32-7	TF0213	08 Nov	WP-2 Plank. net	20:16	55.2502	15.9827	89.3	CLmax: 84 m
EMB280_32-8	TF0213	08 Nov	CTD	20:33	55.2502	15.9825	89.2	CLmax: 20 m
EMB280_32-9	TF0213	08 Nov	Apstein Net	20:52	55.2498	15.9828	89.3	CLmax: 85 m
EMB280_32-10	TF0213	08 Nov	Apstein Net	21:13	55.2499	15.9829	89.3	CLmax: 85 m
EMB280_32-11	TF0213	08 Nov	Apstein Net	21:36	55.2504	15.9836	89.3	CLmax: 85 m
EMB280_33-1	TF0225	08 Nov	CTD	23:19	55.2589	16.3206	64.7	CLmax: 64 m
EMB280_34-1	TF0227	09 Nov	CTD	0:44	55.2613	16.6380	67.4	CLmax: 66 m
EMB280_35-1	TF0222	09 Nov	CTD	2:29	55.2168	17.0656	90.7	CLmax: 89 m
EMB280_36-1	TF0266	09 Nov	CTD	3:53	55.2523	17.3599	88.1	CLmax: 87m
EMB280_37-1	TF0268	09 Nov	CTD	6:07	55.3077	17.9313	75.3	CLmax: 72 m
EMB280_38-1	TF0256	09 Nov	CTD	7:32	55.3280	18.2528	77.5	CLmax: 76 m
EMB280_39-1	TF0259	09 Nov	CTD	9:20	55.5507	18.4008	89.3	CLmax: 87 m
EMB280_39-2	TF0259	09 Nov	Secchi disk	9:22	55.5507	18.4006	89.3	
EMB280_39-3	TF0259	09 Nov	Plankton Net	9:24	55.5507	18.4007	89.3	
EMB280_40-1	TF0255	09 Nov	CTD	10:35	55.6340	18.6011	94.0	CLmax: 93 m
EMB280_41-1	TF0253	09 Nov	CTD	12:33	55.8402	18.8668	101.6	CLmax: 98 m
EMB280_42-1	TF0265	09 Nov	CTD	14:11	55.9592	19.0471	111.2	CLmax: 108 m
EMB280_43-1	TF0273	10 Nov	CTD	23:48	56.9518	19.7702	184.8	CLmax: 179 m
EMB280_44-1	TF0272	11 Nov	CTD	1:13	57.0712	19.8303	208.6	CLmax: 204 m
EMB280_45-1	TF0275	11 Nov	CTD	2:53	57.2101	19.9305	230.9	CLmax: 224 m
EMB280_46-1	MoorGOCent	11 Nov	Mooring	6:55	57.3075	20.0823	245.7	Recovery
EMB280_47-1	TF0271	11 Nov	CTD	8:06	57.3205	20.0508	241.4	CLmax: 235 m
EMB280_47-2	TF0271	11 Nov	Plankton Net	8:12	57.3204	20.0508	241.4	
EMB280_47-3	TF0271	11 Nov	CTD	9:08	57.3204	20.0501	241.4	CLmax: 103 m
EMB280_47-4	TF0271	11 Nov	CTD	10:04	57.3201	20.0503	241.4	CLmax: 20 m
EMB280_47-5	TF0271	11 Nov	CTD	10:39	57.3200	20.0500	241.4	CLmax: 21 m
EMB280_47-6	TF0271	11 Nov	CTD	11:01	57.3201	20.0501	241.4	CLmax: 114 m
EMB280_47-7	TF0271	11 Nov	CTD	11:36	57.3202	20.0504	241.4	CLmax: 112 m
EMB280_46-2	MoorGOCent	11 Nov	Mooring	12:30	57.3065	20.0814	245.9	deployment
EMB280_48-1	TF0276	11 Nov	CTD	14:20	57.4698	20.2606	208.0	CLmax: 202 m
EMB280_49-1	TF0270	11 Nov	CTD	16:09	57.6169	20.1679	144.3	CLmax: 140 m
EMB280_50-1	TF0287	11 Nov	CTD	17:51	57.7150	19.8542	129.0	CLmax: 127m
EMB280_51-1	MoorGONE	12 Nov	Mooring	9:30	57.3660	20.3448	217.1	Recov./Deploym.
EMB280_52-1	ARGO4117	12 Nov	Boat	14:00	57.4784	19.8558	152.1	Recovery
EMB280_53-1	TF0286	12 Nov	CTD	17:38	57.9998	19.9003	195.8	CLmax: 190 m
EMB280_53-2	TF0286	12 Nov	CTD	18:35	58.0000	19.8998	196.1	CLmax: 20 m
EMB280_53-3	TF0286	12 Nov	CTD	19:02	57.9999	19.8999	195.8	CLmax: 10 m
EMB280_54-1	wGB-3	13 Nov	CTD	0:52	58.3266	18.0682	152.3	CLmax: 152 m
EMB280_55-1	TF0240	13 Nov	CTD	3:12	58.0003	18.0004	167.6	CLmax: 163 m
EMB280_56-1	TF0242	13 Nov	CTD	6:04	57.7168	17.3670	141.5	CLmax: 138 m
EMB280_57-1	TF0245	13 Nov	CTD	9:37	57.1172	17.6651	110.0	CLmax: 107 m
EMB280_58-1	wGB-1	13 Nov	CTD	11:40	56.8776	17.3891	95.7	CLmax: 93 m
EMB280_59-1	GB_SW	13 Nov	CTD	13:58	56.6255	17.1297	77.5	CLmax: 75 m
EMB280_60-1	TF223	13 Nov	CTD	17:58	56.1168	16.5334	47.4	CLmax: 47 m
EMB280_61-1	BB_N	13 Nov	CTD	20:30	55.7623	16.2895	61.6	CLmax: 60 m
EMB280_62-1	TF0220	13 Nov	CTD	22:37	55.5003	15.9977	79.3	CLmax: 78 m
EMB280_63-1	TF0213	14 Nov	CTD	0:28	55.2503	15.9825	89.3	CLmax: 87 m
EMB280_63-2	TF0213	14 Nov	Plankton Net	0:32	55.2502	15.9831	88.9	
EMB280_63-3	TF0213	14 Nov	WP-2 Plank. net	0:55	55.2502	15.9830	88.9	CLmax: 87 m
EMB280_63-4	TF0213	14 Nov	WP-2 Plank. net	1:05	55.2501	15.9832	88.9	CLmax: 86 m

EMB280_63-5	TF0213	14 Nov	WP-2 Plank. net	1:14	55.2501	15.9829	88.9	CLmax: 36 m
EMB280_63-6	TF0213	14 Nov	WP-2 Plank. net	1:21	55.2501	15.9830	88.9	CLmax: 86 m
EMB280_63-7	TF0213	14 Nov	Apstein Net	1:37	55.2501	15.9830	88.9	CLmax: 88 m
EMB280_63-8	TF0213	14 Nov	Apstein Net	1:57	55.2502	15.9832	88.9	CLmax: 88 m
EMB280_63-9	TF0213	14 Nov	Apstein Net	2:19	55.2501	15.9833	88.9	CLmax: 88 m
EMB280_64-1	TF0103	14 Nov	CTD	9:33	55.0631	13.9863	44.6	CLmax: 45 m
EMB280_65-1	TF0105	14 Nov	CTD	11:11	55.0250	13.6064	44.0	CLmax: 44 m
EMB280_66-1	TF0113	14 Nov	CTD	12:13	54.9253	13.4990	45.3	CLmax: 45 m
EMB280_66-2	TF0113	14 Nov	Secchi disk	12:14	54.9253	13.4991	45.2	
EMB280_66-3	TF0113	14 Nov	Plankton Net	12:17	54.9252	13.4992	44.8	
EMB280_66-4	TF0113	14 Nov	WP-2 Plank. net	12:35	54.9253	13.4993	45.0	CLmax: 33 m
EMB280_66-5	TF0113	14 Nov	WP-2 Plank. net	12:41	54.9251	13.4994	45.1	CLmax: 44 m
EMB280_67-1	TF0030	14 Nov	CTD	15:29	54.7233	12.7825	19.7	CLmax: 20 m
EMB280_67-2	TF0030	14 Nov	Plankton Net	15:55	54.7239	12.7836	20.4	
EMB280_67-3	TF0030	14 Nov	CTD	16:07	54.7241	12.7838	20.1	CLmax: 20 m
EMB280_68-1	TF0046	14 Nov	CTD	18:55	54.4699	12.2380	25.9	CLmax: 26 m
EMB280_68-2	TF0046	14 Nov	WP-2 Plank. net	18:58	54.4697	12.2381	25.6	CLmax: 25 m
EMB280_69-1	TF0012	14 Nov	CTD	21:46	54.3147	11.5485	21.8	CLmax: 22 m
EMB280_69-2	TF0012	14 Nov	Plankton Net	21:47	54.3147	11.5488	22.0	
EMB280_69-3	TF0012	14 Nov	WP-2 Plank. net	22:05	54.3148	11.5505	22.0	CLmax: 22 m

CLmax: Maximum rope/cable length
Secchi disk: Defined white disk with bore holes to determine water transparency
WP-2 net: Plankton net with closing mechanism and removable net bucket for zooplankton sampling
Plankton Net Small hand-thrown net for phytoplankton sampling
CTD: CTD rosette system with fluorimeter, oxygen sensor, water sampler, and video camera
Apstein Net Net for phytoplankton sampling equipped with plastic cowls, reducing the mouth opening of the net and thus caring for a higher filtering efficiency in the attached conical net bag

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

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