ELISABETH MANN BORGESE – Berichte

Baltic Sea Long-term Observation Programme

Cruise No. EMB 218

29 July – 09 August 2019,

Rostock – Rostock (Germany)

HELCOM/long-term

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2019

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1 Cruise Sammary

1.1 Summary in English

During the research campaign of r/v Elisabeth Mann Borgese No. 218 from 29th July to 9th August 2019 a typical summer situation in the western and central Baltic Sea was investigated in the frame of the Helcom monitoring and the IOW long-term observation of the Baltic Sea. The western Baltic Sea showed nutrient depletion in surface waters and already low oxygen concentration in bottom waters of the deeper stations. The long-term observation comprised temperature, salinity and oxygen distributions in the central basins to assess current and previous inflow events, the microbiological habitat of the redoxcline, non-CO_2 greenhouse gases, inorganic carbon and CO_2 on selected stations in detail. In addition, surface water samples were taken to investigate the analyses of contaminants of emerging concern. During fair weather condition a station grid of 100 stations (4 repetitions) was completed. Surface and intermediate waters was characterized by high abundance of particulate organic matter, likely caused by cyanobacteria or flocculated remains of cyanobacteria visible by camera attached to the CTD rosette system. Surface water as well as deep water showed a continuation of warming in recent years by excluding the anomalously high surface water temperatures observed in 2018, on-going stagnation in the deep waters of the central basins and accumulation of hydrogen sulphide in the eastern and northern Gotland Sea is documented. The depths range between 80 m and 140 m showed slightly positive oxygen concentrations which might be originated from less dense but oxygen enriched waters that was entrained in the intermediate waters of the southern and central eastern Gotland Sea.

1.2 Zusammenfassung

Während der Forschungskampagne 218 von F/S Elisabeth Mann Borgese vom 29. Juli bis 9. August 2019 wurde eine typische Sommersituation in der westlichen und zentralen Ostsee im Rahmen des Helcom Monitorings und der IOW Langzeit-Beobachtung der Ostsee vorgefunden. Die westliche Ostsee zeigte den vollständigen Nährstoffverbrauch im Oberflächenwasser und bereits niedrige Sauerstoffkonzentrationen im Bodenwasser der tieferen Stationen. Die Langzeitbeobachtung umfasste Salzgehalts-, Temperatur- und Sauerstoffverteilungen der zentralen Ostseebecken, um aktuelle und vorausgegangene Einstromereignisse zu bewerten, das mikrobiologische Habitat der Redoxkline zu beobachten, CO_2 und den anorganischen Kohlenstoff sowie andere Treibhausgase auf ausgewählten Stationen detailliert zu untersuchen. Zusätzlich wurden Oberflächenwasserproben für die Entwicklung der Analyse von organischen Schadstoffen genommen, die neuerdings zur Sorge Anlass geben. Bei guten Wetterbedingungen wurde ein Stationsnetz von 100 Stationen (4 Wiederholstationen) untersucht. Oberflächen- und Zwischenwasser zeigten hohe Abundanz von partikulärem organischem Material, das wahrscheinlich aus Cyanobakterien und aggregierte Rückständen von Cyanobakterienblüten bestand und auf allen Stationen der zentralen Ostsee mit der Kamera, die an das CTD/Rosettensystem angebaut war, beobachtet werden konnte. Oberflächen- und Tiefenwasser zeigten eine Zunahme der Temperaturen in den letzten Jahren, die nur von den Werten aus dem Jahr 2018 für das Oberflächenwasser übertroffen wurden, und grundsätzlich die Fortsetzung der Stagnationsphase und der Akkumulation von Schwefelwasserstoff in dem Tiefenwasser der östlichen und nördlichen Gotlandsee dokumentieren. Der Tiefenbereich zwischen 80 und 140 m

wies allerdings teilweise positive Sauerstoffkonzentrationen auf, die auf den Einschub weniger dichtem aber sauerstoffreichem Wasser in die südliche und zentrale Gotlandsee beruhten.

2 Participants

2.1 Principal Investigators

Name	Institution
Kuss, Joachim, Dr. (Marine Chemistry)	IOW
Mohrholz, Volker, Dr. (Hydrography)	IOW
Dutz, Jörg, Dr. (Biology)	IOW

2.2 Scientific Party

Name	Discipline	Institution
Kuss, Joachim, Dr.	Marine Chemistry, Chief Scientist	IOW
Weinreben, Stefan	Phys. Oceanography, CTD	IOW
Donath, Jan	Phys. Oceanography, CTD	IOW
Dierken, Madleen	Marine Chemistry, Nutrients	IOW
Hand, Ines	Marine Chemistry, Organic pollutants	IOW
Schöne, Susanne	Marine Chemistry, Oxygen	IOW
Pötzsch, Michael	Biological Oceanogr., Plankton	IOW
Rosenboom, Jan	Marine Chemistry, Assistent	IOW

2.3 Participating Institutions

IOW Leibniz Institute for Baltic Sea Reasrch Warnemuende

2.4 Crew

Name	Rank
Scholz, Uwe	Master/Captain
Kasch, Gunnar	Chief mate
Sauerland, Oliver	2nd Nautical Officer
Klück, Torsten	Chief Engineer
Renken, Bernd	Electrician
Müller, Leif-Erik T.	SM/Decksmen
Wagner, Knut	Bosun
Martens, Ulf	Decksmen
Wurm, Wolfgang	Decksmen
Wegner, Erdmann	Decksmen
Langhof, Maik	Cook

3 Research Program

3.1 Description of the Work Area

The thalweg stretches from the Belt Sea via Darss sill through the Arkona Sea, the Bornholm Sea, to the eastern Gotland Sea basin along the southern rim, to the northern Gotland Sea across the central eastern Gotland Sea basin, and further to the Landsort Deep. The thalweg transect was supplemented by two west-east transects of CTD casts. The aim was to gather information about the spatial distribution of salinity and temperature in addition to the thalweg development on its latitudinal extension. Subsequently, a number of CTD casts were carried out at stations in the northern Gotland Sea to figure out how far any influence of oxygenated water could be detected. An overview of the location of CTD stations is given in Fig. 3.1, basically showing stations along the thalweg from the Belt Sea to the northern Gotland Sea with two longitudinal transects in the centre of the eastern Gotland Sea basin, the transect along the western Gotland Sea basin and further south to the Bornholm Sea. In addition, the list of stations is given in Chapter 6.

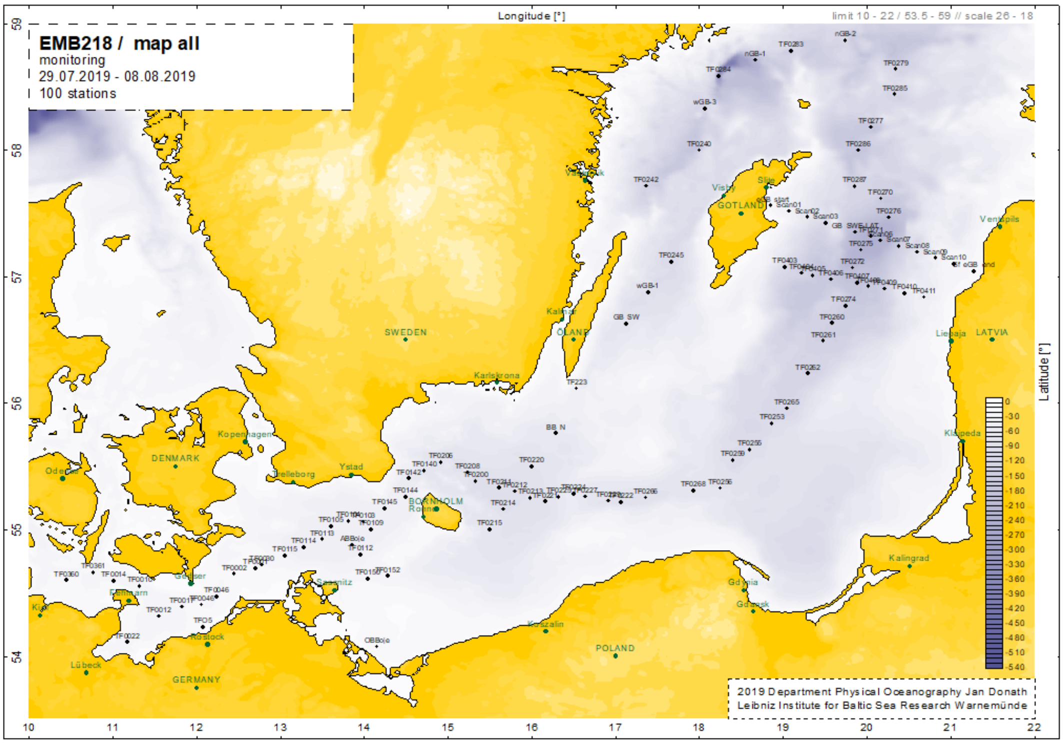


Fig. 3.1 Map of stations of the cruise EMB 218 from 29th – 9th August 2019.

3.2 Aims of the Cruise

The cruise EMB 218 was carried out as a joined cruise of the environmental monitoring programme of the Federal Maritime and Hydrographic Agency (BSH) and the Baltic Sea long-term observation programme of the Leibniz Institute for Baltic Sea Research Warnemünde (IOW). It was the fourth cruise in 2019 in a series 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. A special focus in the long-term observation of the Baltic Sea done by

IOW are the inflow events, so the consequences of the series of Major Baltic Inflows that occurred between 2014 and 2016 and subsequent inflow events on the environmental conditions of the central Baltic were investigated.

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 and manual releases in near-bottom waters and close to the sea surface. Then other CTD casts follow to meet the additional water sample requirements on the respective stations. Net sampling and depth of visibility determinations by means of a Secci disk were done on selected stations. For details 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 (683nm), Turbidity, Photosynthetic active radiation in water (PAR), and above the sea (SPAR).
The Rosette water sampler was equipped with 13 Free Flow bottles of 5l 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 determined by comparison with Winkler titration.

Inorganic nutrients
Nitrate, nitrite, phosphate, and silicate were analyzed using standard colorimetric methods by means of an autoanalyser (Evolution III, Alliance-Instruments, Ainring, Germany) and Ammonium was determined manually as indophenole blue (Grasshoff, Kremling et al. 1999) from unfiltered water.

Oxygen and hydrogen sulfide
Oxygen was analyzed by Winkler titration and hydrogen sulfide was determined spectrophotometrically by the methylene blue reaction (Grasshoff, Kremling et al. 1999). 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 daily by Winkler titration of triplicate samples from 3 water sampling bottles each.

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. Samples were taken in a tight follow up of depths levels in order to get representative data from the euphotic zone. Additionally, samples for micro biological analyses were taken at selected stations in the central Baltic: Gotland Deep and Landsort Deep station.

Long-term observation of the microbiological habitat of the redoxcline

Insights in the redoxcline microbial food web is obtained by regular well resolved sampling of the range of the redoxcline 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. (Responsible scientists: Prof. Klaus Jürgens)

Long-term investigations of CH_4, N_2O and CO_2 distribution

Sampling for simultaneous CH_4 and N_2O observation was carried out on 4 stations (TF0113, TF0213, TF0271, TF0286) in the frame of an accompanying project for long term data collection. All samples were taken in septum-sealed 250 mL water bottles and fixed with 0.6 mL 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 with 200 µL for oxygenated and with 500 µL saturated $HgCl_2$-solution for sulfidic waters to prevent microbiological activity and stored dark. (Responsible scientists: Prof. Gregor Rehder).

Modern organic pollutants

For analytical investigations on organic pollutants of emerging concern (UV-filter, 12 samples; hormones, 7 samples; polar pesticides, 7 samples) water was sampled from the upper mixed layer in various basins and in near-coastal areas (responsible scientists: Dr. K. Fisch, Prof. D. Schulz-Bull).

3.3.2 Continuous measurements on transect

VM-ADCP

An Acoustic Doppler Current Profiler (VM-ADCP, Ocean Surveyor, frequency 150 kHz, beam angle 30deg, RD-Instruments), was mounted downward looking at the ship hull. The data output of the ADCP was merged online with the corresponding navigation data and stored on the hard disc using the program VM-DAS. Pitch, roll and heading data are converted from TCPTIP to UDP protocol with an own program, running on the VM-ADCP control PC. Current data are collected in beam coordinates to apply all corrections during post processing. The VM-ADCP was operated continuously during the entire cruise. (Responsible Scientist: Dr. Volker Mohrholz)

4 Narrative of the Cruise

29/07/2019: Embarkation of the scientific crew was on 29th July at 7:00 AM. The research campaign started at 8:00 AM in Rostock-Marienehe at calm and hazy weather with low wind speed of 2-4 bft. We began on station TF05 at about 9:00 o'clock. Beside the routinely fulfilled monitoring program on each station, on the next station TF0012 a new glass-bottle-water-sampler was used for organic trace analysis. Thereby, a closed glass bottle is deployed to 5 m depth, subsequently the submerged tethered float pulled the plug, then a few minutes were given to fill up the glass bottle. First attempts revealed that the plug was not properly released. A new plug lead to a significant improvement. The work of the day was then continued on stations TF0022, TF0010, TF0361, and TF0360 in the Kiel Bight.

30/07/2019: Northerly winds of 5-6 bft with gusts of 7 bft lead to waves with white caps in the western Baltic Sea. But the wave height still didn’t bias our work program in that area. The stations from the Kiel Bight to the eastern Arkona Sea Basin were on the schedule for the day: TF0014, TF0017, TF0041, TF0046, TF0002, TF0001,TF0030, TF0115, TF0114, TF0113, TF0105, TF0104, TF0103, TF0109, ABBoje and TF0112 at about 22:00 o´clock. The surface water temperature, conductivity, fluorescence and turbidity measurement system (SMB: Self Monitoring Box, co. 4H-Jena) failed to give reliable data because of incorrect control of the water supply flow. After some unsuccessful trials to recover the system, the system had to be switched off. Subsequently a longer transect to the Odra Bank area followed during the night.

31/07/2019: The forecast of the day for the Southern Baltic expected wind from east to northeast of about 4 bft, turn to westerly direction while decreasing a little. The sea was estimated to show a wave height of 1,5 m (Deutscher Wetterdienst (DWD) 2019). We completed the Oder Bank Buoy (OBBoje) station early in the morning at 5 bft wind and light rain. Then the stations TF0150 and TF152 near the island of Rügen followed. The latter with the last sampling by the glass-bottle-water-sampler that was successfully done. The next stations were TF0145, TF0144, and subsequently, the first stations (TF0142, TF0140) of the northwestern part of the Bornholm Sea. Both showed a relatively low salinity in bottom waters of about 14.35 and 15.30, at temperatures of 11.60°C and 12.72°C, oxygen concentrations of 3.86 mL/L and 3.49 mL/L, and 59 m and 68 m depth, respectively. On the next station TF0206 almost no oxygen was measured in bottom waters at 72-73 m depth. At TF0208 hydrogen sulfide was indicated by sudden increase of turbidity in the layer between 79-89 m depth reaching the bottom. This was supported on TF0200 between 82.5 m and 89 that also reflected high turbidity values. Hydrogen sulfide was subsequently determined to 0.5 mg/L H_2S in the bottom waters. TF0211 reflected the final station of the day.

01/08/2019: We began in the morning with station TF0215 at covered sky and episodic rain events. After breakfast the laborious TF0213 was on schedule with several CTD casts and net hauls. Then followed by TF0221 surprisingly showing 1 mL/L oxygen in the bottom water at 80 m depth, TF0225 with 1.5 mL/L at 65 m depth, TF0224 3.3 mL/L oxygen at 60 m depth, TF0227 about 4mL/L at 65 m, TF0229 3.9 mL/L at 83 m, and even on TF0222 2.3 mL/L at 90 m depth, TF0266 2.7 mL/L at 86 m, and TF0268 3.8 mL/L in 73 m depth along the thalweg. The oxygen profiles showed the winter water with elevated oxygen concentration of about 5.5-6.5 mL/L and temperatures of 5-6 °C in a depth range between 25 and 60 m. Below, oxygen was clearly decreasing, especially at deeper stations of 80-90 m close to anoxic conditions.

02/08/2019: The weather still supported our work program to be in time with northwesterly winds of only 2 to 3 bft and a low wave height of 0.5 m (Deutscher Wetterdienst (DWD) 2019). Sunny and bright sky let the water appears greenish with high concentration of aggregates at calm condition, likely from cyanobacteria blooms. It has to be mentioned that these flocks have

been observed in the water column of the Gotland Sea recorded by camera during CTD casts. Early morning the TF0256 was fulfilled with nets as well as a CTD cast for biological and chemical parameters. The station work was finalized by a CTD with sampling for comparison of the sensors for oxygen, salinity, temperature and pressure.
In the following, deep waters reflected a clear sign of oxygenated water subsiding below the oxygen depleted/anoxic waters along the bottom. The inflow layer shows a thickness of 1.5 m, 8-11 m, 5 m, an oxygen concentration of 3 mL/L, 3 mL/L, 1.8 mL/L, and a salinity of 11.8, 12.6, 11.5 on stations TF0259, TF0255, and TF0253, respectively. The inflow pattern at the bottom proceeded during the next stations TF0265, … TF0261. However, the deep water of the deeper stations >120 m showed a complex intrusion pattern at several depth layers, finally detached from the bottom of about 7 m above the sediment on TF0261 and 10 m above ground on TF0260 that were both about 140 m deep. On TF0274 the anoxic bottom water layer reached a thickness of 20 m. Subsequently, we proceeded to the first latitudinal transect across the eastern Gotland Sea basin, starting at the eastern end on station TF0411 in the evening. The deeper stations TF0408, TF0407, TF0273, reflect the maximum influence of oxygen enriched water between 90 and 130 m depth that generally decreased further to the west (Fig. 5.4): stations TF0406, TF0405. But shows slightly more influence on TF0404 again between 90 and 110 m depth. The transect was finalized on TF0403 by a comparison measurement early morning.

03/08/2019: On the 6th day of the cruise we had a cloud covered sky, low wind speed and a calm sea in the morning and in the afternoon sunny and warm weather conditions. However, the wind speed was increasing up to 6 bft. After the first lateral transect the station TF0272 and TF0275 of the thalweg were on schedule before we reached the central station for Baltic Sea monitoring at the Gotland Deep TF0271 with several CTDs and net hauls. In the evening, the second latitudinal transect started close to the coast of Gotland and finally we reached coastal waters of Latvia early in the morning. 11 stations completed by the Gotland Deep station on the track are aimed to elucidate temperature and salinity stratification cross the eastern Gotland Sea and deduced water movements. This was aimed to be supplemented by continuous vessel mounted Acoustic Doppler Current Profiler (VM-ADCP) measurements that were done all through the cruise. In the evening a nice barbecue of the scientists with the captain and his crew was done, still completing the transect of CTD casts.

04/08/2019: After finalizing the second latitudinal transect close to the coast of Latvia, the ship headed north to TF0276, TF0270, TF0276, TF0270, TF0287, TF0286, TF0277, TF0285, TF0279 on the thalweg at northerly winds of 3 to 4 bft and a sea of 1 m wave height. The weak signs of oxygen containing water in a range of 90 to 140 m disappeared on TF0285 in northern Gotland Sea indicating euxinic conditions below 80 m to the bottom at ~ 160 m depth.

05/08/2019: At sunny and only partly cloudy weather conditions the day was started with the comparison measurements for salinity, temperature, oxygen, pressure on TF0282 followed by nGB-2 on the west-southwestern way to the Landsort Deep. Both stations indicated sulfidic conditions between 80 m and the bottom at about 160 m depth. Landsort Deep station (TF0284) was scheduled for the afternoon. It is with 459 m depth the deepest station in the Baltic Sea and a laborious amount of samples is required for its characterization. Then we headed south to reach the next stations wGB-3 and TF0240 in the western Gotland Sea.

06/08/2019: Early in the morning we started on TF0242 with a CTD profile at a smooth sea state. The profiles in the western Gotland Sea also show clear anoxic conditions in the deep waters as in the western part of the northern Gotland Sea. The sulfidic range was usually below a depth of 80 m here. Then we reached Karlsö Deep (TF0245) with sampling for chemical parameters by a cast of the CTD/water sampling bottles. Then the stations wGB-1, GB_SW, and TF223 in the southern western Gotland Sea were done until we reached the northern Bornholm Sea on BB_N later in the evening.

07/08/2019: The sea was again smooth with waves of 0.5 m at southwesterly winds of about 3 bft. We started on TF0220 in the central Bornholm Sea by taking a profile and doing the sensor comparison measurements. Then we continued our way to the Bornholm Deep, the last of the main deeps of the central Baltic Sea (TF0213) on this cruise. This station and the next ones TF0113, TF0030, TF0046, and TF0012 were sampled a second time for plankton studies by CTD casts as well as net hauls.

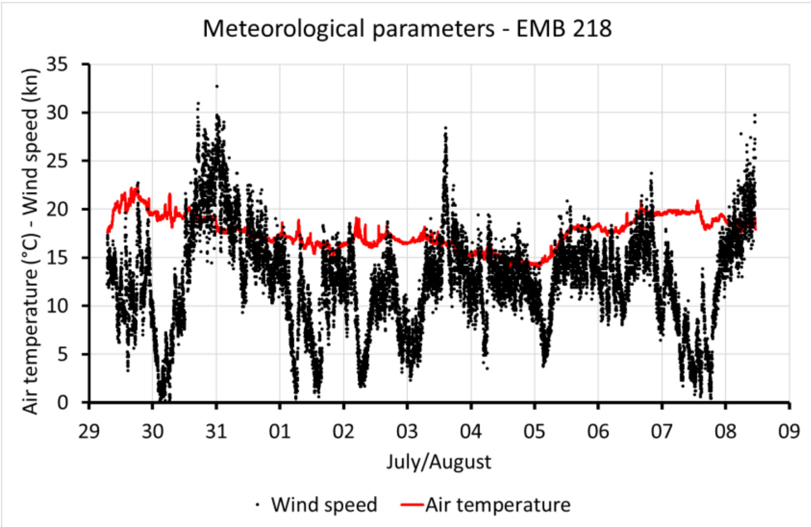
08/08/2019: The last three stations TF0030, TF0046, and TF0012 were completed on the arrival day at slightly elevated wind speed of 5 bft and variable weather conditions with cloudy and sunny phases. The station work was determined by repetition of the biological sampling 10 days later to identify the planktic succession happened in the meantime. Surprisingly low oxygen concentrations of 1.3 mL/L were measured in the bottom waters (27 m depth) of TF0046 at the cadet furrow. At the first visit we couldn't get so far into the furrow because of ship traffic and sampled bottom water just below 20 m depth.
The ship was moored on the quay early in the evening, slightly earlier as scheduled, due to the fair weather conditions throughout the research campaign EMB-218. Unloading of the scientific equipment and disembarkation of the scientific crew was then done on the next day, Friday 9th August.

5 Preliminary Results

The results presented in the following section are preliminary and many samples taken are to be analyzed 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 after all validated data sets are available.

5.1 Meteorological conditions

The development of the on-board measured wind speed and direction as well as air temperature and humidity during the cruise is shown in Fig. 5.1. The meteorological surface water temperature together with the actual depth measurements are given in Fig. 5.2, instead of the usually given thermosalinograph measurements, which was not operational due to flow control problems.



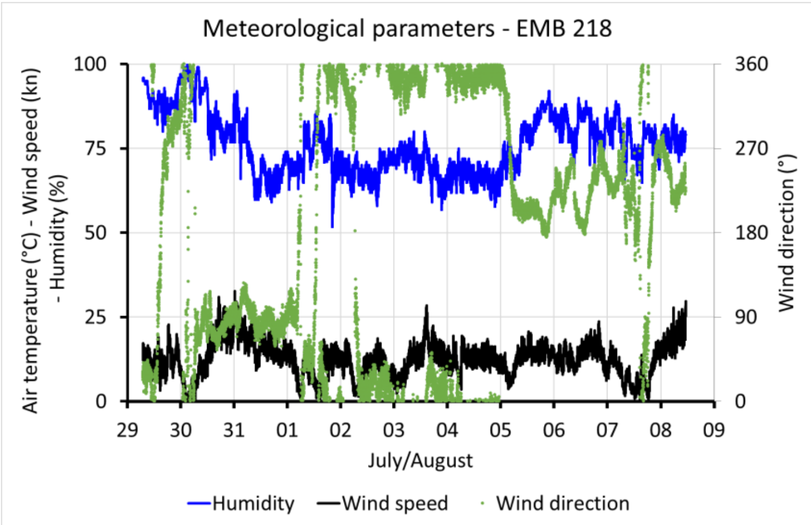


Fig. 5.1 Air temperature, wind speed, humidity, and wind direction measured on-board by the DWD automatic measurement platform.

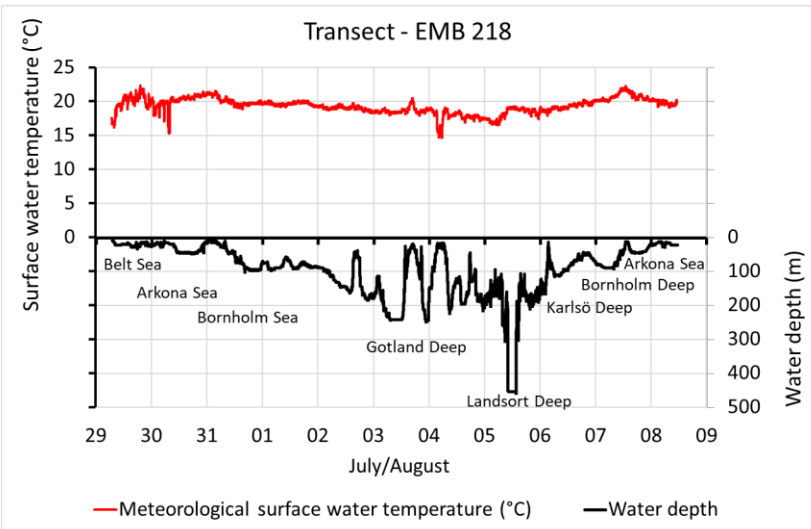


Fig. 5.2 Surface water temperature and corresponding water depth during the cruise EMB 218 of FS Elisabeth Mann Borgese from July 29th to August 8th.

5.2 Nutrient situation in the western Baltic Sea in Summer 2019

In the western Baltic Sea, the nutrient situation was characterized by depletion of nitrate and phosphate in surface waters as expected for July and early August. In deeper layers below the thermocline and in bottom waters elevated values were measured. On the shallow station TF0360 in the Kiel Bight nitrate and phosphate were depleted throughout the water column, whereas in the deeper Fehmarn Belt station TF0010 bottom waters sampled at 28 m depth showed 1.6 µmol/L nitrate and 0.9 µmol/L phosphate, and still some phosphate in 20 m depth (0.4 µmol/L) with no significant amounts of nitrate. Similarly, in the Mecklenburg Bight on station TF0012 low nitrate concentrations were determined even in bottom waters of 0.3 µmol/L and elevated phosphate values of about 0.5 µmol/L in 20 m and 24 m depths. Also the Arkona Sea surface water shows nitrate and phosphate depletion at least until a depth of 10 m as usually observed during mid-summer.

5.3 Baltic thalweg transect

The profiles of the stations that were aligned along the thalweg during the cruise EMB-218 from the Danish straits, through the western Baltic Sea, and further towards the northern Gotland basin were combined to a respective contour map for salinity, temperature, and oxygen (Fig. 5.3). This transect gives a good overview of the hydrographic and environmental state of the entire Baltic Sea. The mixed layer oxygen concentration is close to the equilibrium with the atmosphere, at the respective surface water temperature. By comparison of the plot for temperature and oxygen, it is obvious that a large cold and oxygen rich water body is situated between the mixed layer and the halocline in the Bornholm and the eastern Gotland Sea. Below this cold water mass, the oxygen concentration decreased sharply within the halocline. However, some water bodies reflected slightly positive oxygen values of ~ 1 mL/L that is visible in Fig. 5.3 in the bottom panel as a white area. Thus the oxygen consumption during stagnation was partly compensated in that regions. This could be explained by supply of water with oxygen remains reflecting the respective density to be intruded at a depth interval of 80 to 140 m in southern part of the Eastern Gotland Sea in a distance of 310-400 km from the Kiel Bight (Fig. 5.3). It should be mentioned that H_2S is ignored since the oxygen sensor is unable to record “negative oxygen”. Similar situations have been described in reports of previous campaigns (Dutz 2019, Mohrholz, Donath et al. 2019, Naumann 2019). It seems that the current oxygen distribution of August 2019 could be a proceeding development of the oxygenated water supply found in May 2019 (Dutz 2019) that now entered regions further north, in combination with some vertical mixing combined with longitudinal spreading of water masses and of course consumption of oxygen.

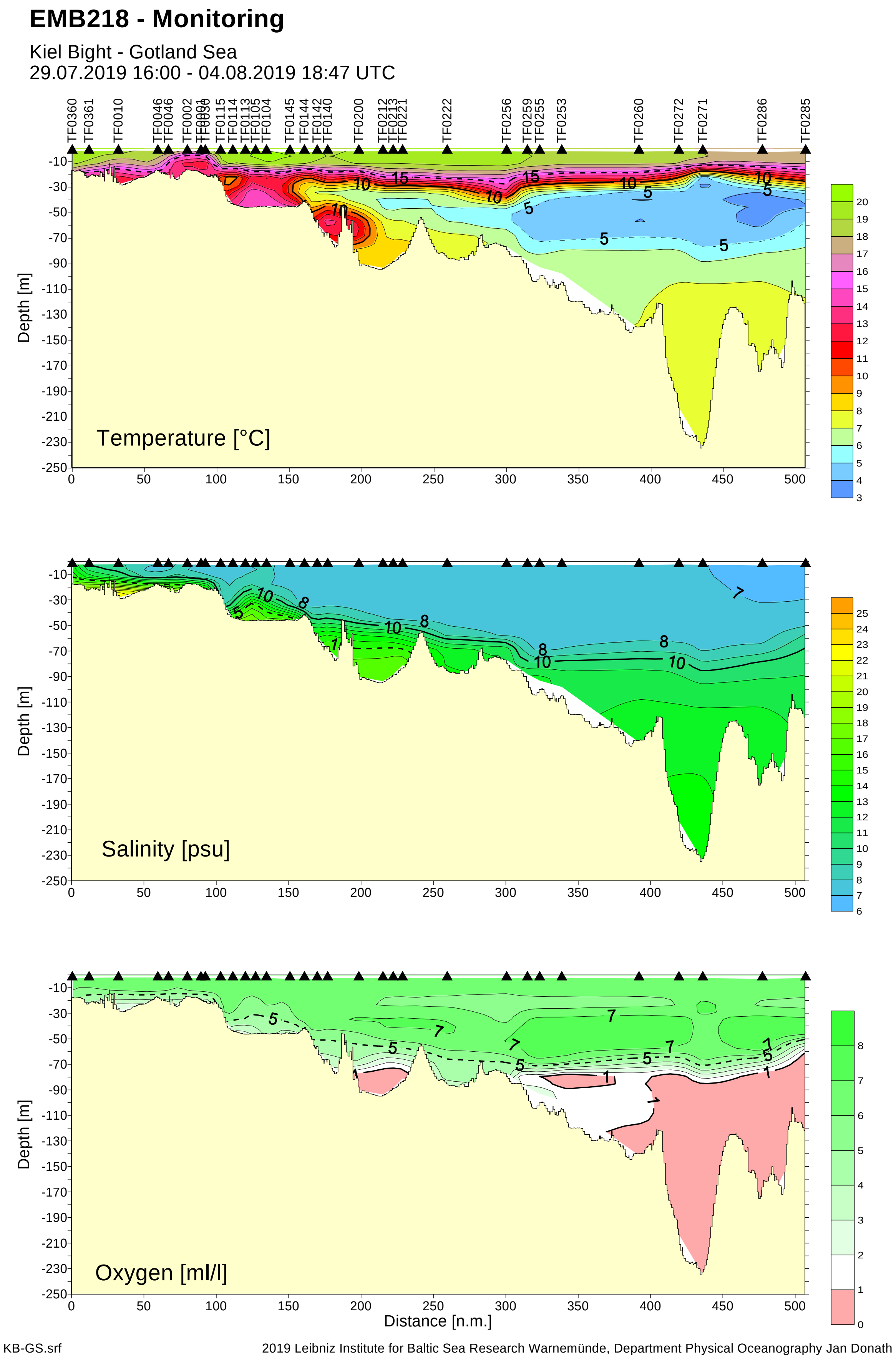


Fig. 5.3 Distribution of temperature, salinity and oxygen along the thalweg of the Baltic Sea from the Kiel bight to the northern Gotland Basin. The figure is based on the preliminary CTD data, measured between July 29th and August 4th.

Interesting was then the information how this might be distributed in longitudinal direction. Therefore, the first transect consisting of the stations 403-411 was plotted for oxygen measurements versus pressure from west to east (Fig. 5.4). Oxygen enriched water flowing northward seemed to have spread from the centre in mainly eastern direction, at around 100 m depth, thereby the water layer appeared to fan out to various thinner layers above and below the original depth.

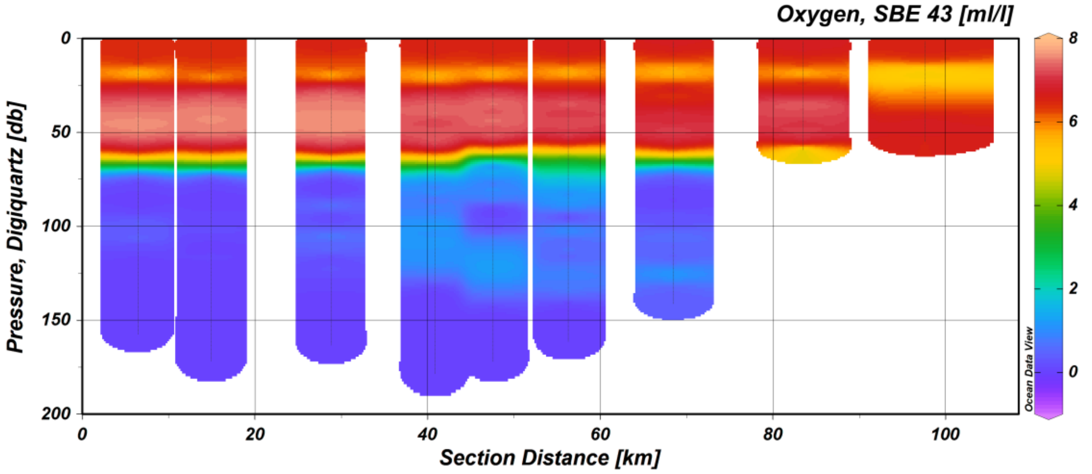


Fig. 5.4 Latitudinal transect (TF0403-TF0411, see map Fig. 3.1) as an example of the lateral oxygen concentration distribution in the Gotland Sea plotted by using ODV 5 (Schlitzer 2018).

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

5.4.1 Surface water temperature

The surface water temperatures of selected Baltic Sea areas during this cruise are compared to July/August values from 2014 to 2018, and long-term mean values 1971-1990 measured during our Summer (July/August) cruises in the 1970s and 1980s (Table 5.1). Surface water temperatures in July/August 2019 appear generally within the scatter of recent years. However, these temperatures were clearly lower than the exceptionally high temperatures in summer 2018, but were on average 1.1 K (-0.1 K to 2.9 K) higher than the long-term averages determined for 1971-1990.

Table 5.1 Surface water temperature (°C) of Baltic Sea areas of this cruise (Aug-19) compared to the last two years and to a former long-term average.

Temperature (°C)	Jul-14	Jul-15	Aug-16	Aug-17	Aug-18	**Aug-19**	1971-1990
Mecklenb. Bight (TF0012)	18.8	18.3	19.3	18.2	22.5	18.90	17.7
Arkona Basin (TF0113)	19.4	16.3	18.8	17.3	21.7	19.90	17.0
Bornholm Deep (TF0213)	19.4	15.6	19.2	17.6	22.0	18.89	17.6
Gotland Deep (TF0271)	19.4	16.2	18.9	17.5	23.0	17.78	17.1
Farö Deep (TF0286)	20.4	16.8	-	18.2	23.1	16.91	17.0
Landsort Deep (TF0284)	21.8	15.2	18.0	16.8	23.1	18.49	18.2
Karlsö Deep (TF0245)	21.9	16.7	18.4	16.9	24.5	18.57	16.9

5.4.2 Deep waters

The salinity in the bottom layer measured in August 2019 is shown in comparison to data from the cruises in July 2014 to August 2018 Table 5.2 below. It appears that the salinity is generally decreasing since the strong inflow, in the Farö Deep, the Landsort Deep, and the Gotland Deep. However, in the Gotland Deep bottom water salinity in August 2018 and August 2019 were almost equal. Lower salinity would improve the chance of water of a certain density to reach the bottom water layer. But in comparison to the strong oxygen deficits, the salinity appeared fairly high with respect to 2014.

Table 5.2 Bottom water salinity of Baltic Sea deeps of this cruise (Aug-19) compared to the last 5 years.

Salinity	Jul-14	Jul-15	Aug-16	Aug-17	Aug-18	**Aug-19**
Gotland Deep	12.25	13.42	13.80	13.47	13.27	**13.28**
Farö Deep	11.58	12.23	-	12.82	12.75	**12.63**
Landsort Deep	10.41	10.86	11.26	11.54	11.46	**11.38**
Karlsö Deep	9.58	9.65	10.32	10.39	10.70	**10.45**

The temperatures increased in the bottom waters of the Gotland, Farö, and Landsort Deeps by about 0.5 K since summer last year (Table 5.3). The Bornholm Deep bottom water temperature raised by even 1.5 K compared to 2018. These temperatures of August 2019 reflect maxima since 2014. The bottom water in Karlsö Deep showed a slight cooling by 0.15 K since August 2018, but was still 0.1 K higher than in August 2017. Thus, the long-term trend of increasing water temperature (°C) in the bottom waters of the central deeps of the Baltic Proper are confirmed by the recent measurements during EMB 218. Only the Karlsö Deep bottom water constituated an exception in this issue. The conclusions from recent years was confirmed by the finding that the temperatures of August 2019 are 1.5 to 2.4 K above the long-term averages of 1971-1990.

Table 5.3 Bottom water temperature (°C) of Baltic Sea deeps of this cruise (Aug-19) compared to the last 5 years and to a former long-term average.

Temperature (°C)	Jul-14	Jul-15	Aug-16	Aug-17	Aug-18	**Aug-19**	1971-1990
Bornholm Deep	5.90	7.01	6.56	6.97	6.97	**8.54**	6.12
Gotland Deep	6.00	6.87	7.50	6.95	6.90	**7.37**	5.62
Farö Deep	5.90	6.58	-	6.98	6.76	**7.19**	5.20
Landsort Deep	5.20	5.68	6.02	6.36	6.28	**6.50**	4.76
Karlsö Deep	5.20	5.02	5.43	5.58	5.83	**5.68**	4.18

5.4.3 Oxygen

The oxygen concentration in the bottom water clearly worsen since August 2017 in the Gotland Deep to -6.15 mL/L, the Farö Deep to -4.68 mL/L, and the Landsort Deep to -2.08 mL/L (Fig. 5.5) and now have reached oxygen deficits similar to pre-inflow times of July 2014 for the latter three (Table 5.4).

Table 5.4 Bottom water oxygen concentration (ml/l) of Baltic Sea deeps of this cruise (Aug 19) compared to the summer values of the last five years.

Oxygen (mL/L)	Jul-14	Jul-15	Aug-16	Aug-17	Aug-18	**Aug-19**
Gotland Deep	0.37	0.86	-0.79	0.06	-4.29	**-6.15**
Farö Deep	-5.33	-1.54	-	0.00	-3.52	**-4.68**
Landsort Deep	-3.29	-0.88	-0.92	0.00	-0.82	**-2.08**
Karlsö Deep	-2.44	-1.22	-1.82	0.01	-3.10	**-2.93**

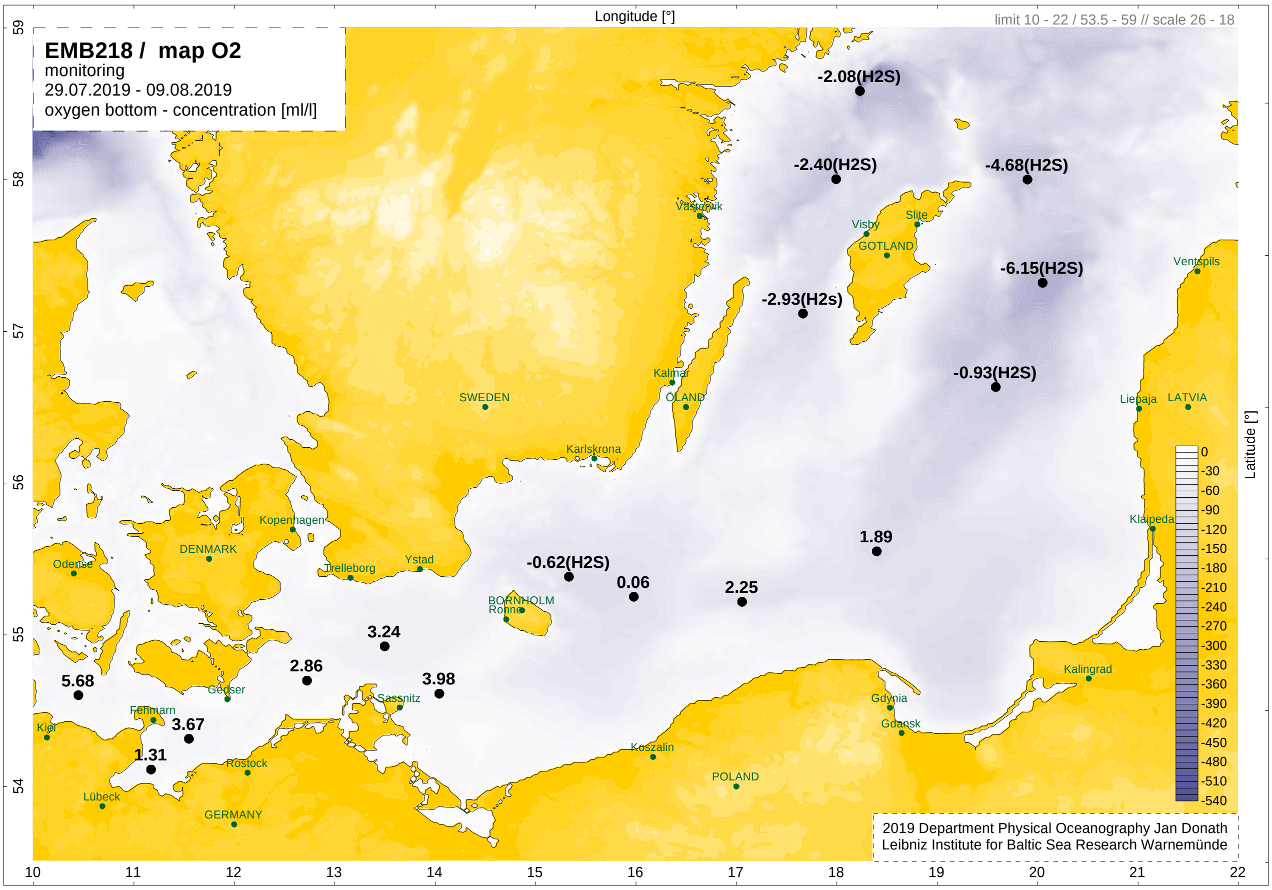


Fig. 5.5 Oxygen concentration (mL/L) in bottom waters of selected Baltic Sea stations (H_2S is included as negative oxygen).

5.4.4 Nutrients

Reactive nitrogen species are almost depleted in the upper water column of the Baltic Proper in summer situations, whereas remains of phosphorus are still available. Due to the relative deficit of nitrogen compared to phosphorus according to the Redfield ratio, diazotrophic cyanobacteria are favoured by this nutrient composition. Intermittently in the bottom-near layer, the situation had changed strongly due to the inflow of oxygenated water in the Gotland Deep in the year 2014-2016. Thus the nitrate concentration had increased in deep water layers intermittently. Because of the new stagnation phase and subsequent oxygen depletion and increase of hydrogen sulfide in deep waters, nitrate was also depleted and phosphate was accumulated there again (Table 5). Anoxic condition lead on one side to remineralisation of organic matter until the oxidation state of ammonium only, and on the other side remaining nitrate is used as oxidant until its depletion. So nitrate is usually at its detection limit under anoxic condition. Landsort Deep and Karlsö Deep didn't show such drastic changes since August 2017.

Table 5.5 Bottom water Nitrate (upper part) and phosphate (lower part) concentration (µM) of Baltic Sea deeps of this cruise (Aug-19) compared to the last 5 years.

Nitrate (µM)	Jul-14	Jul-15	Aug-16	Aug-17	Aug-18	**Aug-19**
Bornholm Deep	11.2	13.8	10.7	1.1	0.0	**2.25**
Gotland Deep	0.0	12.3	0.00	0.0	0.0	**0.0**
Farö Deep	0.0	0.0	-	0.0	0.0	**0.0**
Landsort Deep	0.0	0.0	0.00	0.0	0.0	**0.0**
Karlsö Deep	0.0	0.0	0.00	0.00	0.00	**0.0**

Phosphate (µM)	Jul-14	Jul-15	Aug-16	Aug-17	Aug-18	**Aug-19**
Bornholm Deep	1.2	2.0	2.2	2.7	8.3	**7.0**
Gotland Deep	2.5	2.4	3.9	4.7	5.3	**4.7**
Farö Deep	4.3	3.0	-	3.4	4.4	**4.6**
Landsort Deep	3.3	3.3	3.1	2.8	3.0	**3.4**
Karlsö Deep	3.1	3.6	4.3	3.8	3.8	**3.8**

6 Station List EMB218

6.1 Overall Station List

Station No.		Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/ Recovery
Mann-Borgese	**IOW**	**2019**		**[UTC]**	**[°N]**	**[°E]**	**[m]**	Max sampl. depth
EMB218_1-1	TFO5	29.07.	CTD	08:00	54.2314	12.0745	12.0	11 m
EMB218_2-1	TF0012	29.07.	CTD	09:57	54.3152	11.5499	21.4	23 m
EMB218_2-2	TF0012	29.07.	Plankton Net	10:05	54.3153	11.5500	21.3	10 m
EMB218_2-2	TF0012	29.07.	Plankton Net	10:10	54.3154	11.5502	21.3	20 m
EMB218_2-2	TF0012	29.07.	Glass sampler	10:22	54.3153	11.5500	21.4	5 m
EMB218_3-1	TF0022	29.07.	CTD	12:37	54.1109	11.1754	20.0	21 m
EMB218_4-1	TF0010	29.07.	CTD	16:02	54.5518	11.3201	25.0	26 m
EMB218_4-2	TF0010	29.07.	Glass sampler	16:14	54.5519	11.3199	25.1	5 m
EMB218_5-1	TF0361	29.07.	CTD	18:29	54.6600	10.7678	20.0	21 m
EMB218_6-1	TF0360	29.07.	CTD	19:57	54.6001	10.4510	14.7	16 m
EMB218_6-2	TF0360	29.07.	Glass sampler	20:09	54.6000	10.4506	14.7	5 m
EMB218_6-3	TF0360	29.07.	WP-2 Pl. Net	20:18	54.6000	10.4504	14.6	14 m
EMB218_7-1	TF0014	29.07.	CTD	22:24	54.5944	11.0137	23.1	25 m
EMB218_8-1	TF0017	30.07.	CTD	01:39	54.3920	11.8236	19.0	20 m
EMB218_9-1	TF0041	30.07.	CTD	02:58	54.4066	12.0611	15.9	17 m
EMB218_10-1	TF0046	30.07.	CTD	04:16	54.4698	12.2409	25.4	26 m
EMB218_10-2	TF0046	30.07.	Plankton Net	04:26	54.4697	12.2413	25.5	14 m
EMB218_10-2	TF0046	30.07.	Plankton Net	04:26	54.4697	12.2413	25.6	25 m
EMB218_10-3	TF0046	30.07.	Glass sampler	04:41	54.4701	12.2413	25.3	5 m
EMB218_11-1	TF0002	30.07.	CTD	06:19	54.6499	12.4501	14.7	15 m
EMB218_12-1	TF0001	30.07.	CTD	07:49	54.6961	12.7066	18.1	19 m
EMB218_13-1	TF0030	30.07.	CTD	08:34	54.7232	12.7826	19.7	21 m
EMB218_13-2	TF0030	30.07.	Glass sampler	08:44	54.7232	12.7831	19.6	5 m
EMB218_13-3	TF0030	30.07.	Glass sampler	08:47	54.7232	12.7831	19.7	5 m
EMB218_14-1	TF0115	30.07.	CTD	10:07	54.7952	13.0586	26.7	28 m

EMB218_15-1	TF0114	30.07.	CTD	11:20	54.8607	13.2778	42.1	43 m
EMB218_16-1	TF0113	30.07.	CTD	12:42	54.9248	13.5002	43.9	45 m
EMB218_16-2	TF0113	30.07.	CTD	13:12	54.9248	13.5001	43.9	25 m
EMB218_16-3	TF0113	30.07.	Plankton Net	13:30	54.9248	13.5000	44.1	40 m
EMB218_16-3	TF0113	30.07.	Glass sampler	13:30	54.9248	13.5000	44.1	5 m
EMB218_17-1	TF0105	30.07.	CTD	14:41	55.0250	13.6060	43.2	44 m
EMB218_18-1	TF0104	30.07.	CTD	15:44	55.0683	13.8128	43.6	44 m
EMB218_19-1	TF0103	30.07.	CTD	16:41	55.0633	13.9879	44.3	44 m
EMB218_20-1	TF0109	30.07.	CTD	17:46	55.0000	14.0828	45.4	46 m
EMB218_20-3	TF0109	30.07.	Glass sampler	17:56	55.0003	14.0833	44.9	6 m
EMB218_20-4	TF0109	30.07.	Glass sampler	17:59	55.0004	14.0831	45.0	6 m
EMB218_20-5	TF0109	30.07.	WP-2 Pl. Net	18:07	55.0004	14.0825	44.8	30 m
EMB218_20-6	TF0109	30.07.	WP-2 Pl. Net	18:13	55.0005	14.0827	45.0	44 m
EMB218_21-1	ABBoje	30.07.	CTD	19:38	54.8808	13.8577	43.1	43 m
EMB218_22-1	TF0112	30.07.	CTD	20:38	54.8033	13.9581	37.1	38 m
EMB218_23-1	OBBoje	31.07.	CTD	01:45	54.0845	14.1490	12.5	13 m
EMB218_23-2	OBBoje	31.07.	Glass sampler	01:55	54.0844	14.1491	12.2	5 m
EMB218_24-1	TF0150	31.07.	CTD	05:07	54.6118	14.0427	18.9	20 m
EMB218_25-1	TF0152	31.07.	CTD	06:22	54.6334	14.2827	28.7	28 m
EMB218_25-2	TF0152	31.07.	Glass sampler	06:46	54.6332	14.2835	27.7	4 m
EMB218_26-1	TF0145	31.07.	CTD	10:00	55.1671	14.2507	43.8	44 m
EMB218_27-1	TF0144	31.07.	CTD	11:16	55.2591	14.4935	41.8	42 m
EMB218_28-1	TF0142	31.07.	CTD	12:50	55.4052	14.5364	57.7	58 m
EMB218_29-1	TF0140	31.07.	CTD	14:02	55.4667	14.7174	67.4	67 m
EMB218_30-1	TF0206	31.07.	CTD	15:05	55.5333	14.9164	74.2	74 m
EMB218_31-1	TF0208	31.07.	CTD	16:37	55.4535	15.2335	90.7	90 m
EMB218_32-1	TF0200	31.07.	CTD	17:33	55.3833	15.3329	89.8	89 m
EMB218_33-1	TF0211	31.07.	CTD	19:02	55.3301	15.6147	94.3	93 m
EMB218_34-1	TF0215	01.08.	CTD	01:10	55.0000	15.4997	74.1	74 m
EMB218_35-1	TF0214	01.08.	CTD	02:39	55.1604	15.6613	92.1	91 m
EMB218_35-2	TF0214	01.08.	CTD	03:04	55.1599	15.6615	92.4	5 m
EMB218_36-1	TF0212	01.08.	CTD	04:29	55.3018	15.7957	93.6	92 m
EMB218_37-1	TF0213	01.08.	CTD	05:32	55.2500	15.9830	88.2	87 m
EMB218_37-2	TF0213	01.08.	WP-2 Pl. Net	05:47	55.2500	15.9831	88.3	85 m
EMB218_37-3	TF0213	01.08.	WP-2 Pl. Net	05:56	55.2499	15.9832	88.2	85 m
EMB218_37-4	TF0213	01.08.	WP-2 Pl. Net	06:06	55.2499	15.9834	88.2	85 m
EMB218_37-5	TF0213	01.08.	WP-2 Pl. Net	06:13	55.2500	15.9830	88.2	18 m
EMB218_37-6	TF0213	01.08.	WP-2 Pl. Net	06:20	55.2504	15.9838	88.2	48 m
EMB218_37-7	TF0213	01.08.	WP-2 Pl. Net	06:31	55.2503	15.9831	88.4	85 m
EMB218_37-8	TF0213	01.08.	CTD	06:51	55.2498	15.9826	88.2	24 m
EMB218_37-9	TF0213	01.08.	Apstein Net	07:03	55.2498	15.9841	88.2	85 m
EMB218_37-10	TF0213	01.08.	Apstein Net	07:15	55.2507	15.9833	88.2	85 m
EMB218_37-11	TF0213	01.08.	Apstein Net	07:27	55.2505	15.9833	88.5	85 m
EMB218_38-1	TF0221	01.08.	CTD	08:35	55.2222	16.1663	81.3	80 m
EMB218_39-1	TF0225	01.08.	CTD	09:30	55.2588	16.3213	64.0	64 m
EMB218_40-1	TF0224	01.08.	CTD	10:28	55.2832	16.5002	60.5	60 m
EMB218_41-1	TF0227	01.08.	CTD	11:20	55.2619	16.6389	65.9	65 m
EMB218_42-1	TF0229	01.08.	CTD	12:41	55.2289	16.9137	83.9	84 m
EMB218_43-1	TF0222	01.08.	CTD	13:37	55.2166	17.0675	90.0	89 m
EMB218_44-1	TF0266	01.08.	CTD	14:52	55.2519	17.3601	87.2	87 m
EMB218_45-1	TF0268	01.08.	CTD	17:01	55.3076	17.9299	72.0	73 m
EMB218_46-1	TF0256	01.08.	CTD	18:30	55.3272	18.2508	77.0	77 m
EMB218_47-1	TF0259	02.08.	CTD	01:10	55.5497	18.3998	88.6	87 m
EMB218_48-1	TF0255	02.08.	CTD	02:57	55.6330	18.6003	94.3	93 m
EMB218_49-1	TF0253	02.08.	CTD	04:44	55.8397	18.8664	98.2	97 m
EMB218_50-1	TF0265	02.08.	CTD	06:03	55.9591	19.0464	110.7	109 m
EMB218_51-1	TF0262	02.08.	CTD	08:08	56.2351	19.3005	131.2	128 m
EMB218_52-1	TF0261	02.08.	CTD	10:08	56.4919	19.4812	142.9	140 m
EMB218_53-1	TF0260	02.08.	CTD	11:30	56.6333	19.5831	144.3	141 m
EMB218_54-1	TF0274_	02.08.	CTD	13:00	56.7676	19.7514	153.6	150 m
EMB218_55-1	TF0411	02.08.	CTD	16:14	56.8373	20.6812	54.3	54 m
EMB218_56-1	TF0410	02.08.	CTD	17:15	56.8663	20.4532	59.5	58 m
EMB218_57-1	TF0409	02.08.	CTD	18:37	56.9054	20.2161	145.1	141 m
EMB218_58-1	TF0408	02.08.	CTD	19:42	56.9230	20.0184	165.7	161 m

EMB218_59-1	TF0407	02.08.	CTD	20:40	56.9501	19.8837	176.8	172 m
EMB218_60-1	TF0273	02.08.	CTD	21:30	56.9519	19.7697	183.6	179 m
EMB218_61-1	TF0406	02.08.	CTD	22:32	56.9797	19.5771	167.2	163 m
EMB218_62-1	TF0405	02.08.	CTD	23:45	57.0084	19.3539	176.8	172 m
EMB218_63-1	TF0404	03.08.	CTD	00:39	57.0287	19.2212	161.6	158 m
EMB218_64-1	TF0403	03.08.	CTD	01:44	57.0732	19.0250	112.0	111m
EMB218_65-1	TF0272	03.08.	CTD	04:57	57.0716	19.8290	208.6	203 m
EMB218_66-1	TF0275	03.08.	CTD	06:17	57.2106	19.9298	230.0	224 m
EMB218_67-1	TF0271	03.08.	CTD	07:47	57.3200	20.0497	241.4	235 m
EMB218_67-2	TF0271	03.08.	CTD	08:38	57.3201	20.0496	241.4	109 m
EMB218_67-3	TF0271	03.08.	CTD	09:18	57.3198	20.0503	241.4	30 m
EMB218_67-4	TF0271	03.08.	CTD	10:24	57.3199	20.0495	241.4	70 m
EMB218_67-5	TF0271	03.08.	CTD	11:23	57.3200	20.0503	241.4	179 m
EMB218_68-1	Sf_eGB_start	03.08.	CTD	16:53	57.5631	18.8513	18.9	19 m
EMB218_69-1	Scan01	03.08.	CTD	17:54	57.5173	19.0718	38.9	39 m
EMB218_70-1	Scan02	03.08.	CTD	18:58	57.4711	19.2899	76.2	75 m
EMB218_71-1	Scan03	03.08.	CTD	20:04	57.4249	19.5096	119.3	117 m
EMB218_72-1	Sf_eGB_SW E-LAT	03.08.	CTD	21:39	57.3530	19.8641	210.0	205 m
EMB218_73-1	Scan06	03.08.	CTD	23:07	57.2859	20.1654	244.3	238 m
EMB218_74-1	Scan07	04.08.	CTD	00:17	57.2398	20.3840	147.1	143 m
EMB218_75-1	Scan08	04.08.	CTD	01:54	57.1934	20.6035	96.2	94 m
EMB218_76-1	Scan09	04.08.	CTD	02:57	57.1476	20.8222	46.1	46 m
EMB218_77-1	Scan10	04.08.	CTD	03:59	57.1007	21.0398	20.6	21 m
EMB218_78-1	Sf_eGB_end	04.08.	CTD	05:01	57.0416	21.2747	18.6	19 m
EMB218_79-1	TF0276	04.08.	CTD	09:21	57.4700	20.2598	201.4	202 m
EMB218_80-1	TF0270	04.08.	CTD	10:39	57.6167	20.1666	143.6	140 m
EMB218_81-1	TF0287	04.08.	CTD	12:17	57.7150	19.8532	130.7	127 m
EMB218_82-1	TF0286	04.08.	CTD	14:35	57.9999	19.8996	195.7	190 m
EMB218_82-2	TF0286	04.08.	CTD	15:10	58.0001	19.9004	195.4	20 m
EMB218_83-1	TF0277	04.08.	CTD	16:47	58.1833	20.0512	162.7	158 m
EMB218_84-1	TF0285	04.08.	CTD	18:53	58.4419	20.3336	122.1	119 m
EMB218_85-1	TF0279	04.08.	CTD	20:30	58.6416	20.3449	164.6	160 m
EMB218_86-1	TF0282	05.08.	CTD	01:11	58.8832	20.3166	165.0	5 m
EMB218_86-1	TF0282	05.08.	CTD	01:42	58.8835	20.3166	164.6	160 m
EMB218_87-1	nGB-2	05.08.	CTD	03:34	58.8654	19.7451	158.6	156 m
EMB218_88-1	TF0283	05.08.	CTD	06:13	58.7829	19.0997	130.0	125 m
EMB218_89-1	nGB-1	05.08.	CTD	08:09	58.7119	18.6697	245.7	239 m
EMB218_90-1	TF0284	05.08.	CTD	10:30	58.5835	18.2334	452.8	440 m
EMB218_90-1	TF0284	05.08.	CTD	11:14	58.5835	18.2335	452.8	127 m
EMB218_90-1	TF0284	05.08.	CTD	11:41	58.5834	18.2335	452.8	10 m
EMB218_90-1	TF0284	05.08.	CTD	13:15	58.5835	18.2337	452.8	88 m
EMB218_91-1	wGB-3	05.08.	CTD	16:18	58.3261	18.0685	156.4	151 m
EMB218_92-1	TF0240	05.08.	CTD	19:50	57.9992	17.9992	168.6	165 m
EMB218_93-1	TF0242	06.08.	CTD	01:17	57.7166	17.3666	140.9	138 m
EMB218_94-1	TF0245	06.08.	CTD	06:49	57.1163	17.6661	109.3	107 m
EMB218_94-2	TF0245	06.08.	CTD	07:25	57.1152	17.6671	109.3	107 m
EMB218_95-1	wGB-1	06.08.	CTD	10:44	56.8772	17.3898	94.6	93 m
EMB218_96-1	GB_SW	06.08.	CTD	13:40	56.6253	17.1304	76.8	76 m
EMB218_97-1	TF223	06.08.	CTD	19:01	56.1171	16.5339	45.5	47 m
EMB218_98-1	BB_N	06.08.	CTD	22:14	55.7623	16.2899	60.4	60 m
EMB218_99-1	TF0220	07.08.	CTD	01:11	55.4999	16.0002	78.8	78 m
EMB218_100-1	TF0213	07.08.	CTD	04:04	55.2501	15.9841	88.2	88 m
EMB218_100-2	TF0213	07.08.	CTD	04:31	55.2498	15.9835	88.2	69 m
EMB218_100-3	TF0213	07.08.	WP-2 Pl. Net	04:42	55.2500	15.9839	88.2	85 m
EMB218_100-4	TF0213	07.08.	Apstein Net	05:43	55.2499	15.9830	88.2	85 m
EMB218_100-5	TF0213	07.08.	Apstein Net	05:49	55.2497	15.9825	88.2	85 m
EMB218_101-1	TF0113	07.08.	CTD	17:57	54.9247	13.5024	43.9	45 m
EMB218_101-2	TF0113	07.08.	WP-2 Pl. Net	18:11	54.9243	13.5020	43.9	15 m
EMB218_101-3	TF0113	07.08.	WP-2 Pl. Net	18:16	54.9243	13.5018	44.1	43 m
EMB218_102-1	TF0030	08.08.	CTD	01:08	54.7231	12.7838	19.3	21 m
EMB218_103-1	TF0046	08.08.	CTD	05:03	54.4701	12.2431	25.1	26 m
EMB218_103-2	TF0046	08.08.	WP-2 Pl. Net	05:15	54.4702	12.2420	25.1	25 m
EMB218_103-3	TF0046	08.08.	CTD	05:30	54.4701	12.2419	25.1	3 m

EMB218_104-1	TF0012	08.08.	CTD	09:43	54.3149	11.5501	21.4	22 m
EMB218_104-2	TF0012	08.08.	WP-2 Pl. Net	09:53	54.3151	11.5503	21.3	6 m
EMB218_104-2	TF0012	08.08.	WP-2 Pl. Net	09:58	54.3150	11.5502	21.2	20 m

7 Data and Sample Storage and Availability

All data gathered will be stored 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). 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.

The access to the data itself will be restricted for three years after data acquisition to protect the research process, including scientific analysis and publication. After that period the data becomes 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	01.10.2019	01.10.2022	volker.mohrholz@io-warnemuende.de
Nutrient data	ODIN	01.08.2020	01.08.2023	joachim.kuss@io-warnemuende.de
Biological results	ODIN	01.08.2020	01.08.2023	joerg.dutz@io-warnemuende.de

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