ELISABETH MANN BORGESE-Berichte

Baltic Sea Long-term Observation Programme

Cruise No. EMB356

06. – 21. February 2024
Rostock – Rostock
BMP

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2024

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1 Cruise Summary

1.1 Summary in English

The cruise EMB356 was carried out in frame of the IOWs Baltic Sea long-term observation program. The work program consisted of field data acquisition for the national environmental monitoring in the German EEZ, which is performed in context with the Helsinki Commission (HELCOM) and federal programs to evaluate the status of coastal regions in North and Baltic Sea (BMLP). This work package is based on contract between the Federal Maritime Agency (BSH) and IOW as administrative agreement since 1991. The second work package is part of IOW's Baltic Sea long-term observation program, related to the institutes research area two "Coastal Seas in Transition" of the new research program "Perspectives of Costal Seas", running from 2024 to 2033. The central task is a continuously ongoing data collection of time series at key stations spanning from the western to central Baltic Sea, initiated since 1969. Since 1997 it is complemented by permanent moorings in the Eastern Gotland Basin. The gathered data are the back bone of research on the natural variability of the ecosystem, anthropogenic influences and the impact of climate change on the Baltic Sea. The overall weather conditions during the cruise were characterized by medium to occasionally strong winds and very cloudy conditions. We lost three working days due to bad weather. The intended scientific program of the cruise could be almost completed, although a few stations could not be worked. The majority of the work was performed along the Thalweg of the Baltic from the Darss Sill to the Northern Gotland Basin. The gathered data depict a snapshot of the late winter conditions in the Baltic after a medium size Major Baltic Inflow.

1.2 Zusammenfassung

Die Expedition EMB356 wurde im Rahmen des Ostsee Langzeitbeobachtungsprogramms. Das wissenschaftliche Programm beinhaltet die Felddatenerfassung für die nationale Umweltüberwachung in der deutschen AWZ, die im Rahmen der Helsinki-Kommission (HELCOM) und des nationalen Programmes zur Zustandsbewertung von Küstenregionen in Nord- und Ostsee (BMLP) durchgeführt wird. Dieses Arbeitspaket basiert auf einem Vertrag zwischen dem Bundesamt für Seeschifffahrt und Hydrographie (BSH) und dem IOW als Verwaltungsvereinbarung seit 1991. Das zweite Arbeitspaket der Expedition ist Teil des Ostsee-Langzeitbeobachtungsprogramms des IOW, das im Rahmen des IOW Forschungsgebietes "Küstenmeere im Wandel" bearbeitet wird. Zentrales Element des Programmes ist eine seit 1969 initiierte, kontinuierlich durchgeführte Datenerhebung von Schlüsselparametern an Stationen in der westlichen und zentralen Ostsee. Seit 1997 wird das Programm durch permanente Verankerungen in der Gotland See ergänzt. Die gewonnenen Daten bilden die Basis der Forschung zur natürlichen Variabilität des Ostsee-Ökosystems, zu anthropogenen Einflüssen und zu den Auswirkungen des Klimawandels auf die Ostsee. Die Wetterbedingungen während der Expedition waren durch mäßigen bis zeitweise starken Wind und meist sehr starke Bewölkung geprägt. Wegen schlechten Wetters konnten an drei Tagen keine Geräteeinsätze durchgeführt werden. Das vorgesehene wissenschaftliche Programm der Reise wurde jedoch fast vollständig umgesetzt, auch wenn einige wenige Stationen nicht bearbeitet werden konnten. Dabei wurde der Großteil der Messungen entlang des Talweges der Ostsee von der Darßer Schwelle bis zur nördlichen Gotlandsee durchgeführt.

2 Participants

2.1 Principal Investigators

Name	Program	Institution
Mohrholz, Volker, Dr.	Hydrography	IOW
Kuss, Joachim, Dr.	Marine Chemistry	IOW
Dutz, Jörg, Dr.	Biology	IOW
Rehder, Gregor, Prof.	Trace gasses	IOW
Fisch, Kathrin, Dr.	Organic hazardous substances	JKI

2.2 Scientific Party

Name	Discipline	Institution
Mohrholz, Volker, Dr.	Phys. Oceanogr. / Chief Scientist	IOW
Faber, Jens, Dr.	Phys. Oceanogr.	IOW
Michels, Emil	Phys. Oceanogr. / Instrumentation.	IOW
Ruickholdt, Johann	Phys. Oceanogr. / Instrumentation.	IOW
Hand, Ines	Marine Chemistry	IOW
Jeschek, Jenny	Marine Chemistry	IOW
Otto, Stefan, Dr.	Marine Chemistry	IOW
Sadkowiak, Birgit	Marine Chemistry	IOW
Fechtel, Christin	Biology	IOW
Floth-Peterson, Mareike	GODESS mooring	IOW
Fisch, Kathrin, Dr.	Organic hazardous substances	JKI

Dr. Volker Mohrholz embarked on 8th February in Warnemünde.

2.3 Participating Institutions

IOW	Leibniz-Institute for Baltic Sea Research Warnemünde, Germany
JKI	Julius Kühn Institute Berlin, Germany

3 Research Program

3.1 Description of the Work Area

Data collection covered the western and central Baltic from the Kiel Bight to the northern Gotland Basin. The majority of stations was located along the thalweg transect of the Baltic Sea, crossing the Arkona basin, the Bornholm Basin, and the Slupsk Furrow. The station work was extended to the western part of the Pomeranian Bight, and some additional stations in the Arkona Basin and Bornholm Basin to cover the water masses of the saline inflow from December 2023. The possible northwestern pathway of saline water from the Bornholm Basin to the western Gotland Basin was not sampled, since the probability was very low that parts of the inflow taking that way.

A core area of the cruise was Baltic Thalweg from the Bornholm Basin, via the Slupsk Furrow towards the southern Gotland Basin (EGB). Here high resolution ScanFish transects were performed, in order to gather information about the inflowing saline waters of the recent MBI, and their mixing with the ambient warm water masses from the barocline summer inflows 2023. Additional CTD casts were carried out at some key stations in the western Gotland Basin, namely in the Karlsö Deep and the Landsort Deep. An overview of the locations of CTD stations, mooring positions, and the cruise track is given in Fig. 3.1. A station list is given in Table 7.1.

3.2 Aims of the Cruise

The cruise EMB356 was carried out as a joined cruise of the Baltic Sea long term observation program of the Leibniz-Institute for Baltic Sea Research Warnemünde (IOW) and the environmental monitoring program of the Federal Maritime and Hydrographic Agency (BSH). It was the first cruise in a series of five expeditions performed annually.

The data acquired 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. For this purpose, hydrographic, chemical and biological data were gathered along the Baltic thalweg transect. The major focus was on the state of ecosystem during late winter conditions as base line for the onset of phytoplankton bloom after the deep mixing in winter. The observations will also deliver data about the state of the deep-water stagnation in the central Baltic basins.

A further goal of the cruise was to gather data about the spreading of saline water from the Major Baltic inflow in December 2023. This event transported about 85km³ saline water with a total salt mass of 1.7Gt into the western Baltic. It was expected that the saline waters of this inflow have reached the Slupsk Furrow at the time of the cruise. Special focus of the inflow related investigations was on oxygen supply to the deep-water layer.

3.3 Agenda of the Cruise

The work packages of the cruise were subsequently conducted. We started with the BSH environmental monitoring program in the western Baltic, which was continued with the IOW's Baltic Sea long-term observation program in the southern and central Baltic Sea. Both consist mainly of CTD casts, water sampling for nutrient analysis, trace gas measurements and net sampling of phytoplankton and zooplankton. During this February cruise additional sampling of surface water and surface sediments was performed for investigation of organic hazardous substances. The station work is complemented by the maintenance of the GODESS mooring in the eastern Gotland Basin. Additionally, some extra hydrographic stations were covered to explore the spreading of saline inflow from December 2024 in more detail.

In the southern Gotland basin and through the Slupsk Sill ScanFish transects were planned, that deliver high resolution hydrographic data of the upper 140m, covering the active inflow patterns. On the way back to Rostock some CTD stations were repeated to gather further data for the long-term observation program.

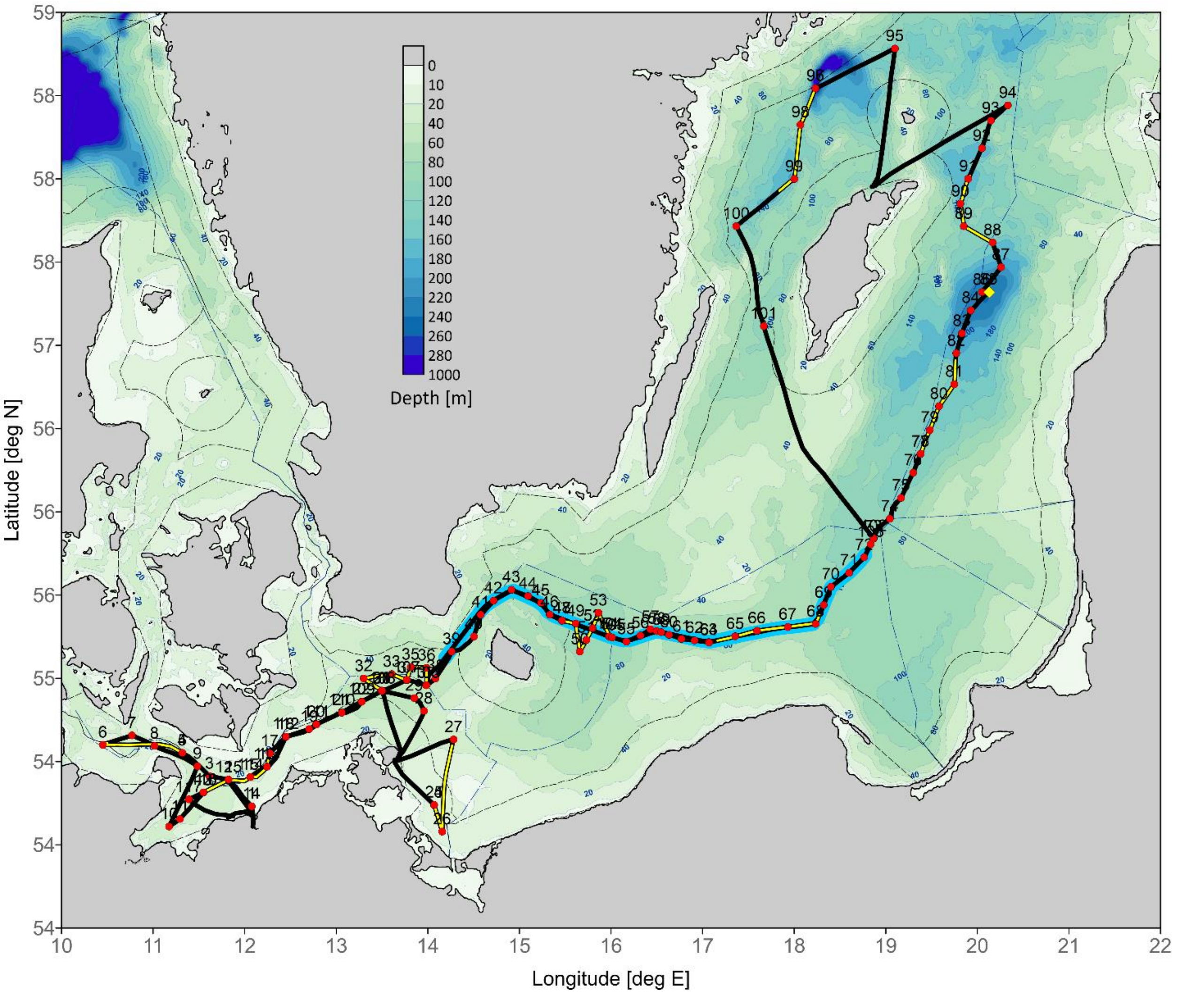

Fig. 3.1 Map of stations and ship track of cruise EMB356 from 06. – 21. February 2024. Red dots and black labels indicate the positions and names of CTD stations. The yellow sections along the cruise track show the sampling transects for organic pollutants. The blue shaded line depicts the ScanFish transects along the inflow water pathway. The yellow diamond marks the location of GODESS mooring in the eastern Gotland basin.

Two extra sampling programs were conducted for sampling of organic pollutants in German waters, and for trace gas long term observations at the Baltic main stations in the Arkona Basin, the Bornholm basin, the Eastern Gotland basin, and in the Faro Deep.

The marine environment was less disturbed by performed scientific tasks. No sampling in marine protected areas was carried out. Mainly sensor measurements and water sampling in the water column for chemical analysis were done. High frequency hydro acoustic measurements were done by current profilers along the ship track and at mooring systems. These moorings are installed in the deep anoxic part of the eastern Gotland Basin. Due to the high frequency (>150kHz) of the used devices Marine mammals were not affected by these measurements

Equipment

Data acquisition was carried out using the following devices and measuring platforms.

At stations and transects:

- CTD SBE 911+ with rosette water sampler (CTD)
- GODESS Oceanographic mooring (Moor)
- Towed CTD ScanFish (SCF)
- EK80 water column echo sounder
- Phytoplankton net (APNET)
- Zooplankton net (WP2)
- Multicorer (MUC)
- In-Situ Pump (ISP)
- Secci desk (SD)
- Microstructure Profiler (MSS)

(The abbreviations in brackets indicate the device short names used in the DSHIP data base)

Continuous measurements:

- Vessel mounted ADCP 150kHz Ocean Surveyor (at selected transects)
- Vessel mounted ADCP 300kHz WorkHorse (at selected transects)
- Underway measurements of surface water properties
- Ship weather station

4 Narrative of the Cruise

The cruise EBM356 was the first cruise after the ship has left the shipyard, where biannual maintenance was carried out. On 5th February 2024 the final preparations for the cruise started with the loading of scientific equipment and with installing the lab devices on the ship in port of Rostock. The initial plan to leaving the port on the next morning, was skipped in the afternoon. Due to prediction of heavy westerly winds for the 6th February the start of the journey was shifted by one day. The 6th February was used to complete the cruise preparation and to carry out extensive testing of the scientific equipment. On the morning of the 7th February, the participants have embarked by 7:30 am. The chief scientist Volker Mohrholz has been ill and could not embark that day. Jens Faber has been designated as the representative. Due to the still heavy westerly winds and high swell off Warnemünde, departure was set to 12 am after the safety drill. Sea conditions eased in the early evening which allowed for a seamless implementation of the monitoring program in the Western Baltic Sea. In the Kiel bight an unusual high surface salinity above 20 was detected. Most properly this water are the remains of the Major Baltic inflow from December 2023. During the night the transect for organic hazardous substances was worked. The 8th February started with calm winds and sunny conditions. We performed the planned stations in the Mecklenburg Bay and repeated station TFO5 off Warnemünde to replace faulty data. Volker Mohrholz had recovered, and was picked up at Warnemünde on the late afternoon that day. He took over as leader of the scientific party on board. During the night we continued our station work along the Kadet Trench towards the Darss Sill. In the early morning of the 9th February the wind switched from west to east and increased rapidly. After station TF0113 in the center of the Arkona Basin we declined our station work and called the port of Sassnitz to get shelter from the heavy winds. We reached the port around noon. At that time the wind has increased 8Bft. The wind was still high during the night and decreased only slightly in the early morning of the 10th February. The wind forecast showed a short period of medium wind speed for the southern part of the Pomeranian Bight. Thus, we decided to leave the port at eight am and work the stations near the Marnet OderBuoy. Here we performed the third transect for sampling organic hazardous substances. In the afternoon wind speed and wave height increased again to a level that prevented save device operation. We declined the station work at 16:30 and steamed back to the port of Sassnitz, where we arrived at half past six. During the following day the wind conditions sea state in the Arkona Basin were too bad for work. The forecast promised a decreasing wind speed for the early morning of the 12th February.

We left the port of Sassnitz on the morning of the 12th at 6 a clock. Half past eight we arrived at station TF0112 in the southern Arkona Basin and resumed the station work. The decreasing swell allowed for CTD operations. The wind calmed further down at noon when we started the work at the central station TF0113. For using the multi corer the situation was a bit worse since swell and wind came from opposite directions. We continued the station work in the central Arkona Basin. Onwards from evening we worked along the thalweg eastward, passing the Bornholm gat on the next morning at three a.m. The wind had turned to westerly directions at strength of about 4Bft. During the 13th February we performed the station work along the thalweg in the Bornholm Basin. A short perpendicular transect was gathered in the central part of the basin to collect data of the spatial distribution of the saline inflow water. Here also organic hazardous substances were sampled in surface waters. The central station TF0213 was worked in the evening hours. The extensive biological sampling here took about three hours. After finishing the station TF0213 we worked stations towards the Slupsk Furrow. We crossed the Slupsk Sill short after midnight. There was a active overflow of the Sill observed, covering a 5 to 7m thick bottom layer. We continued with station work along the Baltic thalweg through the Slupsk Furrow. The was slowly decreasing to about 3Bft. It direction changed to southeast. Around noon we arrived the eastern end of the Slupsk Furrow. Here we detected the eastern tip of the saline inflow waters. The station work along the thalweg transect was continued towards north, to the Eastern Gotland Basin (EGB). At the southern rim of the EGB we detected the first anoxic water bodies below the permanent halocline. Till the evening of 14th February we reached the latitude of 56°N. The wind and sea state were still fair.

During the night and the morning of the 15th February we performed the stations in the southern part of the EGB. Shortly before noon we arrived at the mooring position of the GODESS mooring in the central EGB. The main release of the mooring responded without any delay. So, the mooring was released and was sighted 10 minutes later at the surface at its original position. It took nearly an hour the get all parts of the mooring on deck. The ropes of the mooring have cached some plastic waste during the deployment period. At one pm the mooring was completely recovered without any losses. Afterwards we traveled to the central station TF0271 of the EGB, also called 'Gotland Deep'. Here an intensive sampling program started. Consisting of six CTD casts, an in-situ pump deployment and several plankton net samplings. Wind and sea were low and in the evening fog appeared. The program on this station kept us busy till midnight. In the very morning of the 16th February we resumed or work along the thalweg towards the Farö Deep and the northern Gotland Basin. The weather forecast predicted increasing wind and swell in the northern Gotland Basin. It was not sure at this time whether we are able to complete the Thalweg transect in its full extent. At station TF0270 we started the next transect for sampling organic hazardous substances. We reached the Farö Deep (TF0286) at 8 am and performed the station work. During the morning the wins has increased to about 5Bft from southeast directions. The was still fog with visibility width of about hundred meters. The sea state was slowly increasing. Short after lunch we arrived at station TF0285 in the northern Gotland Basin. The wind speed has reached a strength of 7Bft. The wave height was steadily increasing. After performing the CTD cast at this station we cancelled the remaining 4 stations of the thalweg transect and turned to the northern coast of Gotland for shelter. During the night the wind changed from southerly to westerly directions. Thus, the decreasing sea state in the western Gotland Basin allowed deployments of CTD. We left our shelter in the early morning of the 17th February and resumed the station work at half past six at station TF0283. At ten we arrived at the Landsort Deep. Here the original position TF0284 could not be sampled since we did not got the allowance to work in the Swedish territorial waters on the western side of Gotland. Instead, we sampled the nearby station TF0284a that is in the EEZ. The wind has decreased to 5Bft. After the Landsort Deep station we were heading southward to additional stations in the western Gotland Basin. We finished the station work with a station in the Karlsö Deep in the early morning of the 18th February. From here we went southward to the southern Gotland Basin where we arrived about noon. To cover the most active parts of the inflowing saline waters with high resolution hydrographic measurements we started a ScanFish transect along the Thalweg towards the Bornholm Basin. The wind, that had calmed down in the morning, increased again. It reached 5Bft from southeast directions in the late afternoon. The ScanFish worked well without technical fails. We passed the Slupsk Furrow and reached the Slupsk Sill short after midnight. In the morning of 19th February we arrived at the central station of the Bornholm Basin (TF0213). Here we interrupted the ScanFish transect for repeating the CTD and biological observations. This lasted until noon. The weather was good. Wind and sea state allowed for safe device operations. After the station work was done, we resumed the ScanFish transect along the spreading path of the inflowing saline waters. The wind was slightly increasing to 5Bft. In the late evening we entered the Bornholmgat. At 3am on the 20th February we finished the ScanFish transect at station TF0110a in the central Arkona Basin. Here surface sediment sampling was done with a multicorer. During the day we worked a number of CTD stations along the Thalweg transect towards the Mecklenburg Bight. The weather conditions were still feasible. We finished the scientific observations of the cruise in the late evening of the 20th February at station TF0023. Afterwards we started the transit back to Rostock.

On 21st February at 8am we arrived at the Pier in Marienehe. After custom procedure we were packing and unloading the scientific equipment. The cruise was finished with the disembarking of scientific crew in the late afternoon.

5 Preliminary Results

The results presented in the following section are preliminary and not comprehensive, since they are based in most cases on unevaluated raw data! 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 meteorological conditions during the cruise were characterized by a by windy weather conditions, interrupted by shorter periods of lower wind speed. The cruise start was delayed by one day due to strong winds. During the cruise another three periods occurred when the wind was too strong for safe device operations. It was a normal situation for February and late winter.

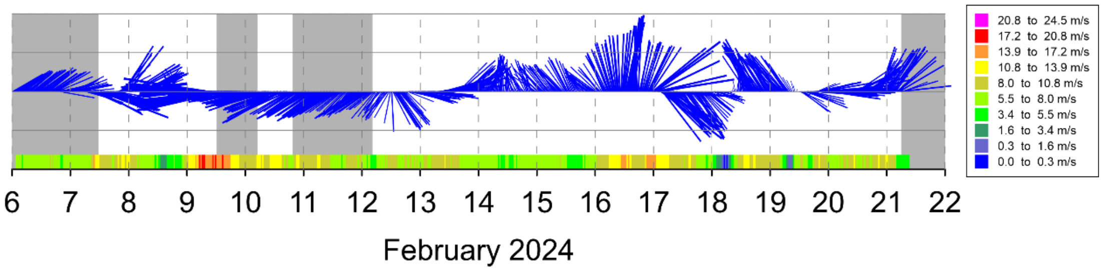

Fig. 5.1 Stick plot of wind vector measured by the ship weather station of RV ELISABETH MANN BORGESE. The grey shaded areas indicate periods when the ship was in port.

The cruise started on 7th February with windy conditions. The mean wind speed ranged between 8 and 12 ms^{-1} with mostly westerly wind directions. We could only work for a bit more than a day before the wind changed to east and increased rapidly in strength. On 9th February the maximum windspeed around noon was 17 to 18 ms^{-1}. This led to an interruption of the work in the Arkona Basin. For a short period the wind decreased on 10th February before it increased again to gale force during the 11th February. This is not reflected in the observations of the ships weather station, since high coast at the port of Sassnitz sheltered the ship during the stay there.

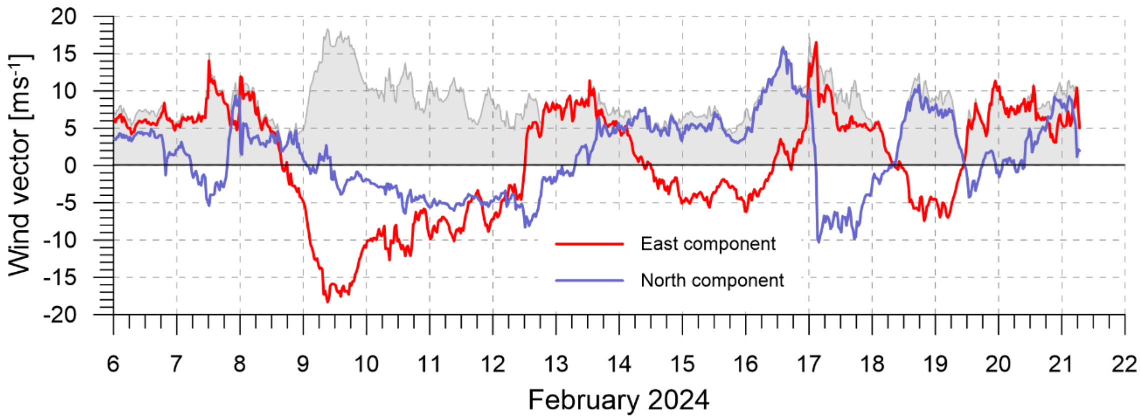

Fig. 5.2 Wind vector east and north measured by the ship weather station of RV ELISABETH MANN BORGESE (30 min averaged values).

After passing of the low-pressure cell the wing changed again to westerly directions. The wind speed decreased significantly to 6 to 10 ms^{-1}. Around the 14th February the wind direction turned to south east. However, the wind strength remained at a moderate level till the 16th February when the ship was working in the northern Gotland Basin. On that day, at noon we had to interrupt the work again, due to wind speeds up to 15 ms^{-1}. The wind direction changed to north west. On the 17th February the wind decreased and remained at a moderate level till the end of the cruise with occasionally changing (Figure 5.1 and Figure 5.2).

The air temperature in the Baltic was slightly above the long-term average for February. In the western Baltic air temperature ranged between 4 and 8°C due to the impact of warm air masses from the west wind system. In the central Baltic values of 1 to 4°C were observed. Due to the very cloudy condition no strong diurnal cycle of air temperature was present (Fig. 5.3). On the afternoon of the 16^{th} February a passing warm front caused a short period if elevated air temperature (7°C) while the ship was operating in the northern Gotland Basin. The general behavior of air temperature was mainly controlled by the sequence of passing pressure systems.

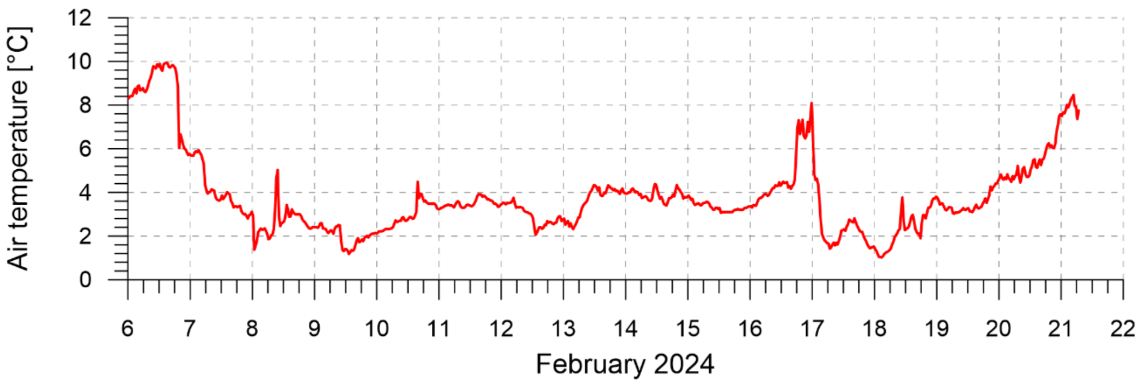

Fig. 5.3 Air temperature measured by the ship weather station of RV ELISABETH MANN BORGESE (30 min averaged values).

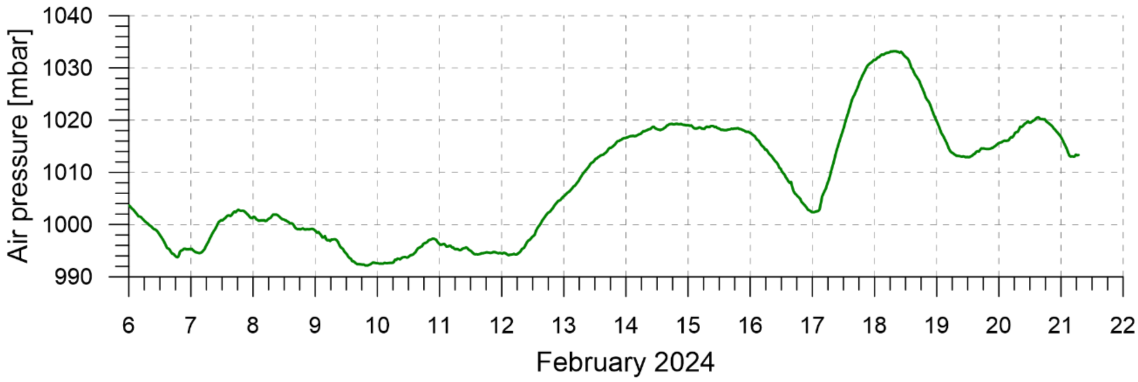

Fig. 5.4 Air pressure measured by the ship weather station of RV ELISABETH MANN BORGESE (30 min averaged values).

The air pressure variations during the cruise were characterized by a period of low pressure during the first week of the cruise. Then also the minimum air pressure of 992mbar was observed (10^{th} February). From the 12^{th} February onwards, it was followed by generally higher air pressure in the second half of the cruise. Superimposed to this general pattern the variability is controlled by the typical time scale of passing low- and high-pressure systems of 2 to 3 days duration. The air pressure maximum of 1033mbar was observed on 18th February. Afterwards the air pressure dropped rapidly to about 1015mbar. It remained at this level till the end of the cruise.

The humidity was relatively high, but typical for the winter conditions varying between 60 and nearly 100% (Fig. 5.5). Remarkably was long period of high humidity of 90 to 00% when the ship was operating in the southern and eastern Gotland Basin. Here sometimes fog could develop due to evaporation and cooling by surface water. Occasionally, rain was observed during the entire cruise.

The global radiation was strongly related to the cloud coverage. In the first two days of the cruise the sky was relatively open, and the sunny conditions led to higher values of global radiation of about 250 to 450Wm^{-2}. Between the 9th and 12th March the cloud coverage was 100%. Thus, the global radiation dropped rapidly to low daily peak values of 50 to 100Wm^{-2}. During the second half of the cruise the clods were less dense than before. The maximum global radiation of 400Wm^{-2} was observed at noon on the sunny 16th February. During the cruise the long wave radiation ranged between 280 and 380 Wm^{-2} (Fig. 5.6). The lower values were observed on sunny days with less clouds. Generally, the overall radiation budget was negative and led to ongoing cooling of the surface water.

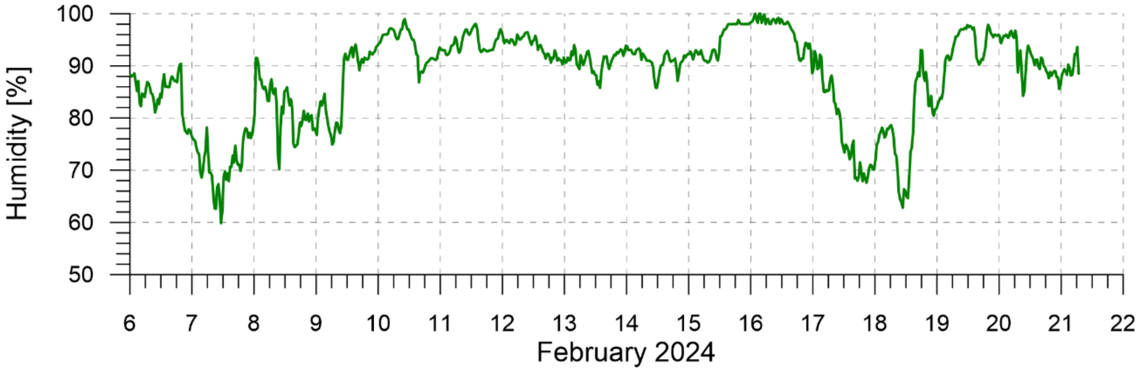

Fig. 5.5 Air humidity measured by the ship weather station of RV ELISABETH MANN BORGESE (30 min averaged values).

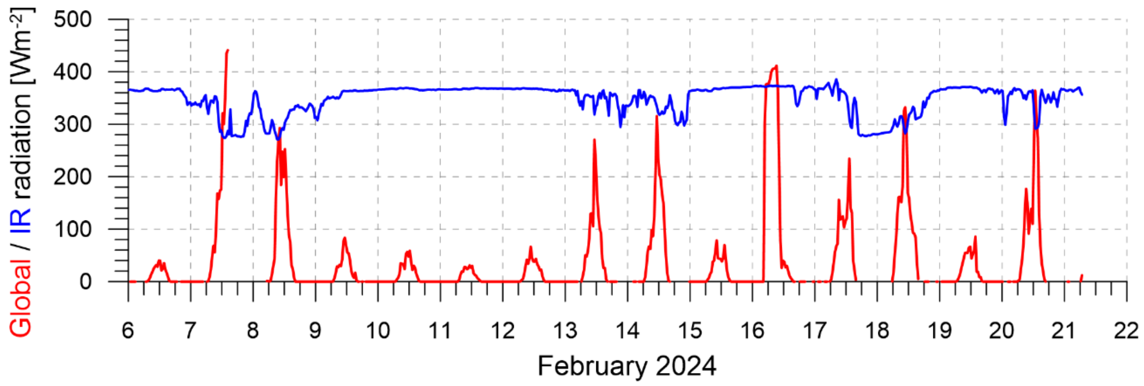

Fig. 5.6 Global and infrared radiation measured by the ship weather station of RV ELISABETH MANN BORGESE (10 min averaged values).

5.2 Properties of Surface Waters

Sea surface temperature, salinity, chlorophyll-a fluorescence and turbidity distributions in the investigation area were compiled from data gathered with the Surface water Monitoring Box (JSMB). The distributions shown in Fig. 5.7 and Fig. 5.10 are based on unvalidated data. The sea surface temperatures (SST) exceed the climatological mean value for February in the western Baltic by about 1K and 0.5K in the central Baltic, respectively. From the Kiel Bight and the Mecklenburg Bight to the Darss Sill the SST was 3.5 to 4.0 °C. It decreased towards the Arkona basin and the Bornholm Basin were temperatures between 3.0 and 3.5 °C were observed. (Fig. 5.7). A similar range of the SST was also detected in the Slupsk Furrow and the southern Gotland Basin. In the eastern Gotland Basin the surface temperature was about 2.5 to 3.0°C.

Minimum SST were found during the cruise in the western Gotland basin where the SST dropped to 1.8 to 2.2°C, close to the climatological mean for February. Here the SST was below the temperature of maximum density, which caused the onset of winter surface stratification, that stops the ventilation of deeper layers by thermal convection.

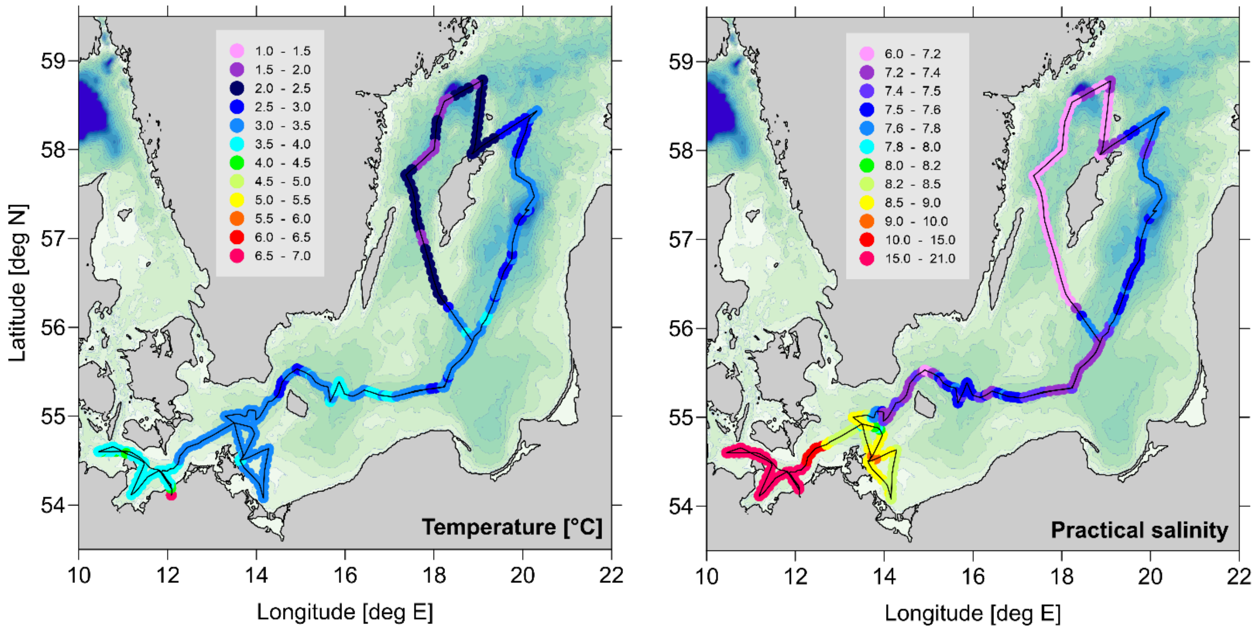

Fig. 5.7 Surface temperature distribution (left) and surface salinity distribution of cruise EMB356 (right). Based on 30 min averaged values.

The surface salinity (SSS) depicted its maximum of 20g/kg in the Belt Sea west of Fehmarn in the transition zone to the North Sea. Between the Fehmarn Belt and the Darss Sill surface salinities of 16 g/kg were detected (Fig. 5.9). The SSS dropped rapidly to about 8.5g/kg at the Darss Sill. The western Arkona Basin and the western part of the Pomeranian Bight depicted SSS values between 8.2 and 8.7 g/kg. These higher-than-normal values were caused by the medium size MBI from December 2024. The area from the eastern Arkona Basin till the southern Gotland Basin depicted lower SSS values of about 7.3 to 7.5 g/kg. This slightly increased in the Eastern Gotland basin to SSS of 7.6 g/kg. The minimum surface salinity was observed in the western Gotland basin with about 7.0g/kg, which was 0.2g/kg below the climatological mean value for February.

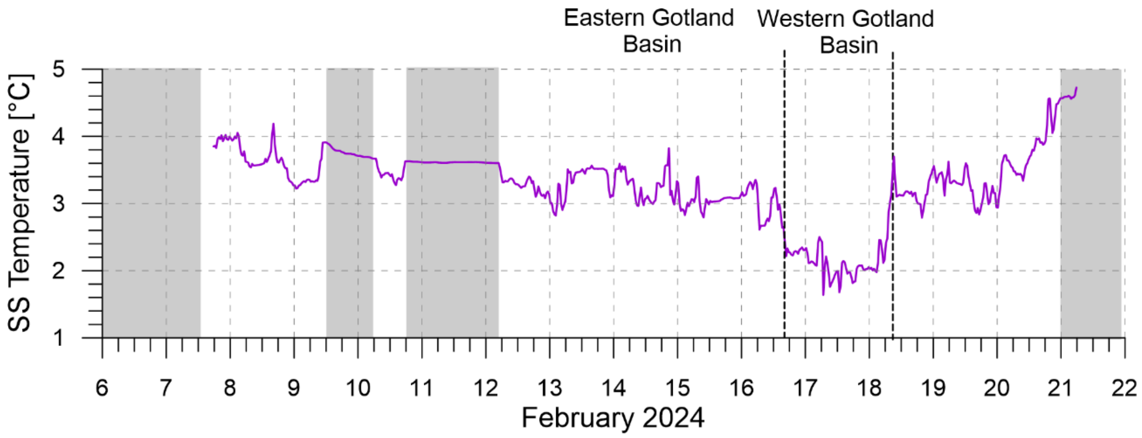

Fig. 5.8 Surface temperature measured with the ship thermosalinograph of RV ELISABETH MANN BORGESE. The gray shaded area indicates the range below the density maximum at the sea surface.

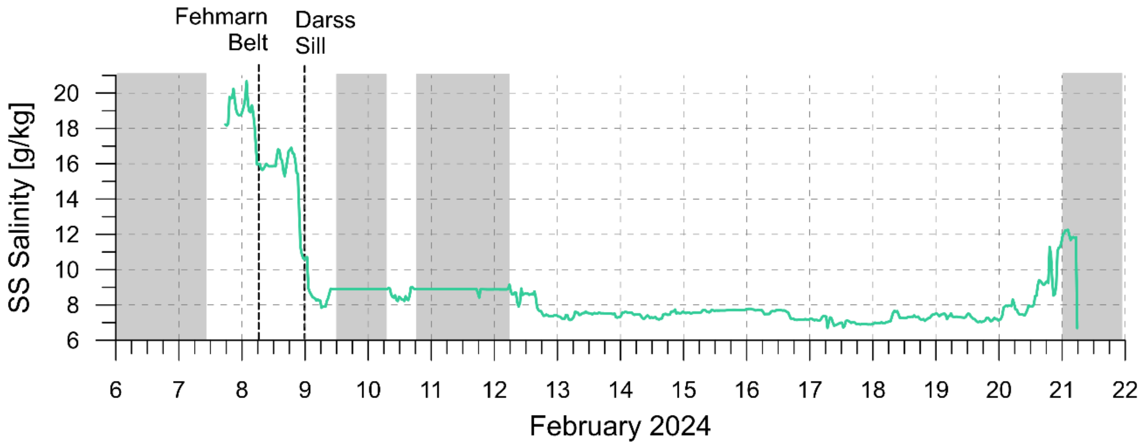

Fig. 5.9 Surface salinity measured with the ship thermosalinograph of RV ELISABETH MANN BORGESE.

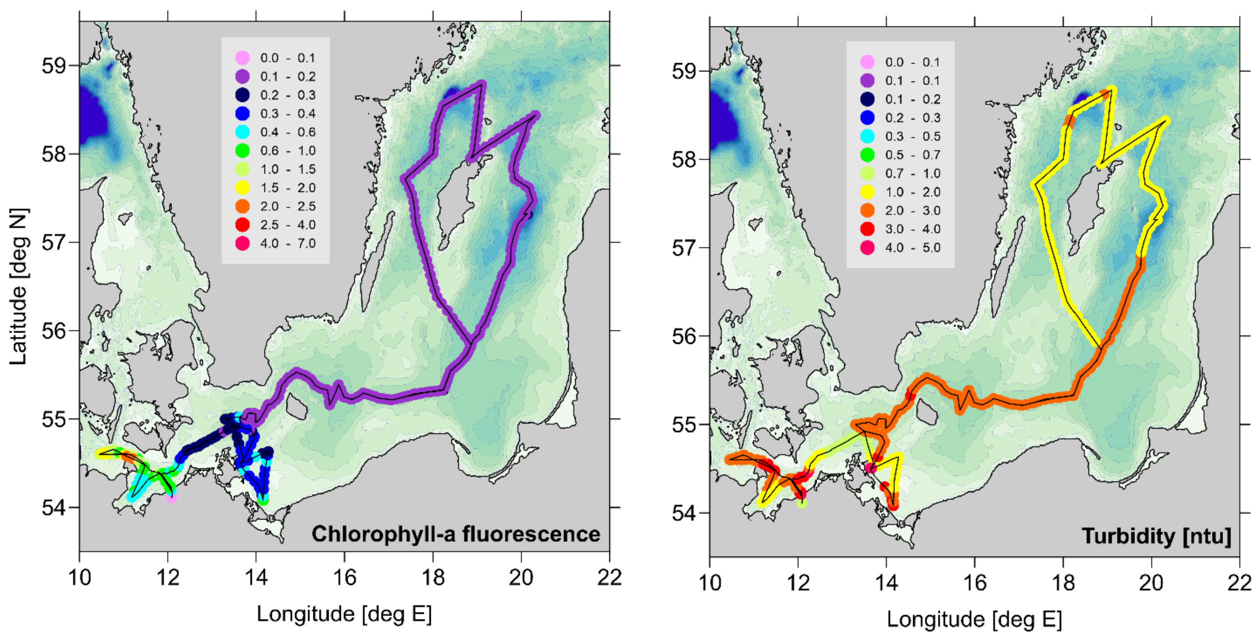

Fig. 5.10 Surface chlorophyll-a fluorescence distribution (left) and distribution of surface turbidity (right) along the cruise track of EMB356 in the Baltic (30 min averaged values).

The surface distribution of Chlorophyll-a fluorescence depicts a typical pattern (Fig. 5.10 and Fig. 5.11). Only in the western Baltic between the Kiel bight and the Pomeranian Bight significant levels of Chlorophyll-a fluorescence were observed. East of the Bornholmgat no signs of phytoplankton primary production were detected. Highest Chlorophyll-a fluorescence were observed in the Kiel Bight, decreasing eastward in the Fehmarn Belt. A further steep drop was observed at the Darss Sill. The Chlorophyll-a fluorescence was highly correlated with the surface salinity. This indicates that the phytoplankton was imported from the North Sea with inflowing saline water. The spring bloom in the Baltic has not started jet. The surface turbidity distribution depicted a puzzling pattern, with higher values in the Belt Sea and a slightly decreasing trend throughout the major part of the cruise (Fig. 5.12). It might be biased by growing biofilms in the measuring chamber of the measuring box.

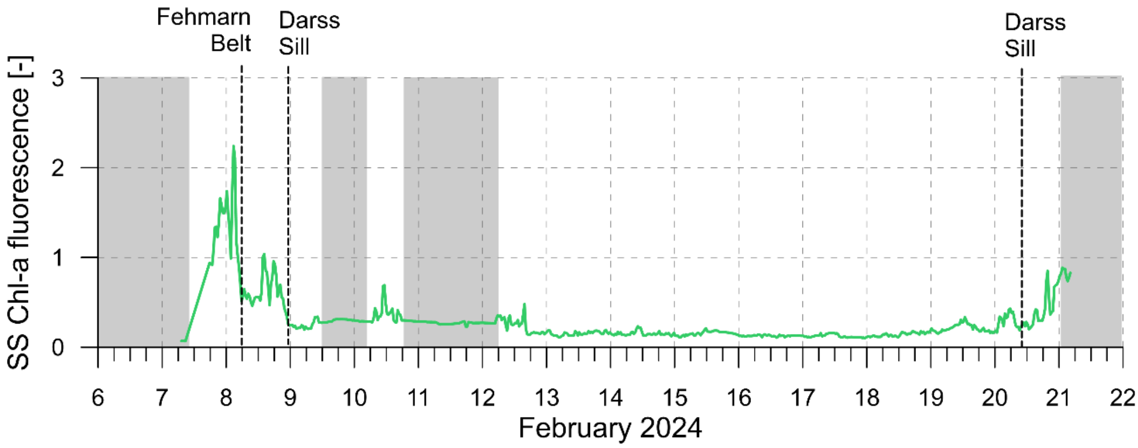

Fig. 5.11 Surface chlorophyll-a fluorescence measured with the flow through fluorometer of RV ELISABETH MANN BORGESE.

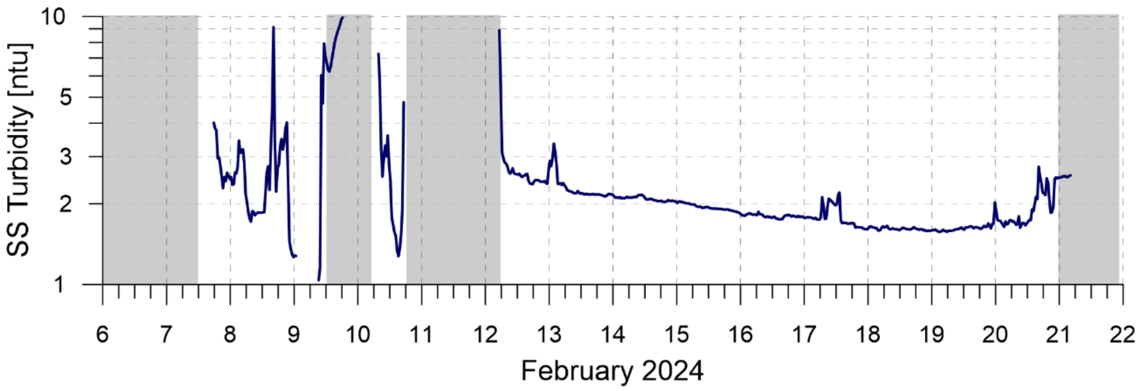

Fig. 5.12 Surface turbidity measured with the flow through fluorometer of RV ELISABETH MANN BORGESE.

5.3 Observations at Main Stations

The following tables list the surface (Table 5.1) and bottom values (Table 5.2) of the most important hydrographic and chemical parameters measured at the main stations of the Baltic long term observation program. For positions of the particular stations refer to Fig. 3.1 and Table 7.1. In the depth-column the italic number in brackets shows the BottleID of the corresponding sample. Blue colored values in the oxygen column are hydrogen sulfide concentrations. The italic oxygen values in brackets depict the raw readings of the CTD oxygen sensor 0.

Conversion factors:

µmol l^{-1} H_2S * -0.0448 = negative oxygen equivalent ml l^{-1} O_2

µmol l^{-1} O_2 * 0.0224 = ml l^{-1} O_2

The nutrient concentrations depicted the typical high winter values in surface water. The phosphate concentrations increased along the Baltic Thalweg from the Kiel Bight towards east and reached its maximum in the eastern Gotland Basin. The western Gotland Basin depicted a similar high value. Nitrate and silicate concentrations in the Kiel Bight and the Mecklenburg Bight were impacted by the saline inflow waters. East of the Darss Sill the nitrate and silicate surface concentrations followed the same increasing trend as phosphate.

Table 5.1 Surface values of main hydrographic parameters at the main stations.

Area **Date**	**St. name** **St. no.**	**Depth** **[m]**	**Temp** **[°C]**	**Sal** **[psu]**	**O_2 / H_2S** **[µmol l^{-1}]**	**PO_4** **[µmol l^{-1}]**	**NO_3** **[µmol l^{-1}]**	**SiO_4** **[µmol l^{-1}]**
Kiel Bight 07.02.2024	TF0360 EMB356_6	0.8 *(126)*	3.95	18.62	368 *(357)*	0.52	4.55	10.6
Meckl. Bight 08.02.2024	TF0012 EMB356_12	1.1 *(276)*	3.56	15.74	374 *(363)*	0.63	6.43	16.3
Darss Sill 09.02.2024	TF0030 EMB356_20	0.9 *(526)*	3.26	8.50	- *(381)*	0.59	3.52	15.7
Arkona Basin 09.02.2024	TF0113 EMB356_23	3.02 *(601)*	3.33	7.79	394 *(382)*	0.60	3.29	16.6
Bornholm Deep 13.02.2024	TF0213 EMB356_54	2.53 *(1426)*	3.51	7.44	389 *(379)*	0.61	3.05	15.9
Slupsk Furrow 14.02.2024	TF0222 EMB356_63	1.53 *(1726)*	3.53	7.47	388 *(377)*	0.63	3.01	16.9
SE Gotland Basin 14.02.2024	TF0259 EMB356_70	1.03 *(1876)*	3.13	7.19	395 *(380)*	0.68	3.65	17.3
SC Gotland Basin 15.02.2024	TF0260 EMB356_80	1.35 *(2126)*	2.91	7.47	393 *(375)*	0.75	3.88	17.9
Gotland Deep 15.02.2024	TF0271 EMB356_86	1.48 *(2377)*	3.03	7.59	389 *(372)*	0.72	3.76	17.7
Farö Deep 16.02.2024	TF0286 EMB356_91	1.7 *(2576)*	2.66	7.39	396 *(380)*	0.70	4.82	17.9
Landsort Deep 17.02.204	TF0284a EMB356_96	1.47 *(2801)*	1.97	6.88	405 *(390)*	0.70	4.94	18.9
W Gotland Basin 17.02.2024	TF0240 EMB356_99	2.73 *(2876)*	1.98	6.93	405 *(388)*	0.70	4.66	18.7
Karlsö Deep 18.02.2024	TF0245 EMB356_101	1.52 *(2976)*	2.00	6.85	409 *(389)*	0.70	4.53	18.5

The bottom concentrations of nutrients are controlled mainly by the vertical position of the redox cline and the oxygen conditions. In the Bornholm Deep and the Slupsk Furrow the nitrate bottom concentration were twice as high as in the western Baltic. A significant increase was also detected for silicate. In the anoxic basins north of the Slupsk Furrow the phosphate bottom concentration increased dramatically, and reached the maximum of 6.85µmol l^{-1} in the Gotland Deep, where also the highest silicate concentrations were detected. The nitrate was completely removed from waters below the redox cline in the central Baltic.

Table 5.2 Bottom values of main hydrographic parameters at the main stations.

Area **Date**	**St. name** **St. no.**	**Depth** **[m]**	**Temp** **[°C]**	**Sal** **[psu]**	**O_2 / H_2S** **[µmol l^{-1}]**	**PO_4** **[µmol l^{-1}]**	**NO_3** **[µmol l^{-1}]**	**SiO_4** **[µmol l^{-1}]**
Kiel Bight 07.02.2024	TF0360 EMB356_6	17.18 *(128)*	4.10	20.13	368 *(348)*	0.52	4.61	10.8
Meckl. Bight 08.02.2024	TF0012 EMB356_12	23.37 *(279)*	3.79	18.86	362 *(350)*	0.60	6.25	14.7
Darss Sill 09.02.2024	TF0030 EMB356_20	21.55 *(529)*	3.54	15.57	- *(360)*	0.69	6.58	16.5
Arkona Basin 09.02.2024	TF0113 EMB356_23	44.40 *(607)*	3.88	21.23	347 *(335)*	0.66	6.93	13.6
Bornholm Deep 13.02.2024	TF0213 EMB356_54	87.79 *(1435)*	7.39	14.93	154 *(149)*	1.68	6.04	39.9
Slupsk Furrow 14.02.2024	TF0222 EMB356_63	89.18 *(1732)*	7.66	13.51	191 *(184)*	1.38	6.42	32.8
SE Gotland Basin 14.02.2024	TF0259 EMB356_70	87.38 *(1882)*	6.61	10.57	**9** *(0)*	3.50	0	59.5
SC Gotland Basin 15.02.2024	TF0260 EMB356_80	138.35 *(2134)*	7.39	11.73	**47** *(0)*	4.10	0.0	68.5
Gotland Deep 15.02.2024	TF0271 EMB356_86	234.21 *(2286)*	7.23	12.68	**376** *(0)*	6.85	0.0	108.3
Farö Deep 16.02.2024	TF0286 EMB356_91	189.74 *(2613)*	7.31	12.05	**138** *(0)*	5.10	0.0	84.0
Landsort Deep 17.02.204	TF0284a EMB356_96	363.21 *(2737)*	6.50	10.77	**67** *(0)*	4.05	0.0	68.75
W Gotland Basin 24.03.2023	TF0240 EMB356_99	162.66 *(2885)*	6.05	10.25	**69** *(0)*	4.13	0.0	69.75
Karlsö Deep 18.02.2024	TF0245 EMB356_101	107.29 *(2983)*	5.97	10.14	**58** *(0)*	4.03	0.0	67.7

The spatial distribution of bottom oxygen conditions derived from water bottle samples is given in Fig. 5.13. Due to the recent inflow activity the bottom water in the western Baltic was well oxygenated. Bottom oxygen concentrations in the Bornholm basin and Slupsk Furrow were considerable reduced. There the bottom water is a mixture of older anoxic water and oxygenated saline water from the medium size saline inflows of December 2023. The bottom waters in the central Baltic were still anoxic, containing high concentrations of hydrogen sulphide. Highest H_2S concentrations were found in the Eastern Gotland Basin with about 376 µmol l^{-1} in the Gotland Deep.

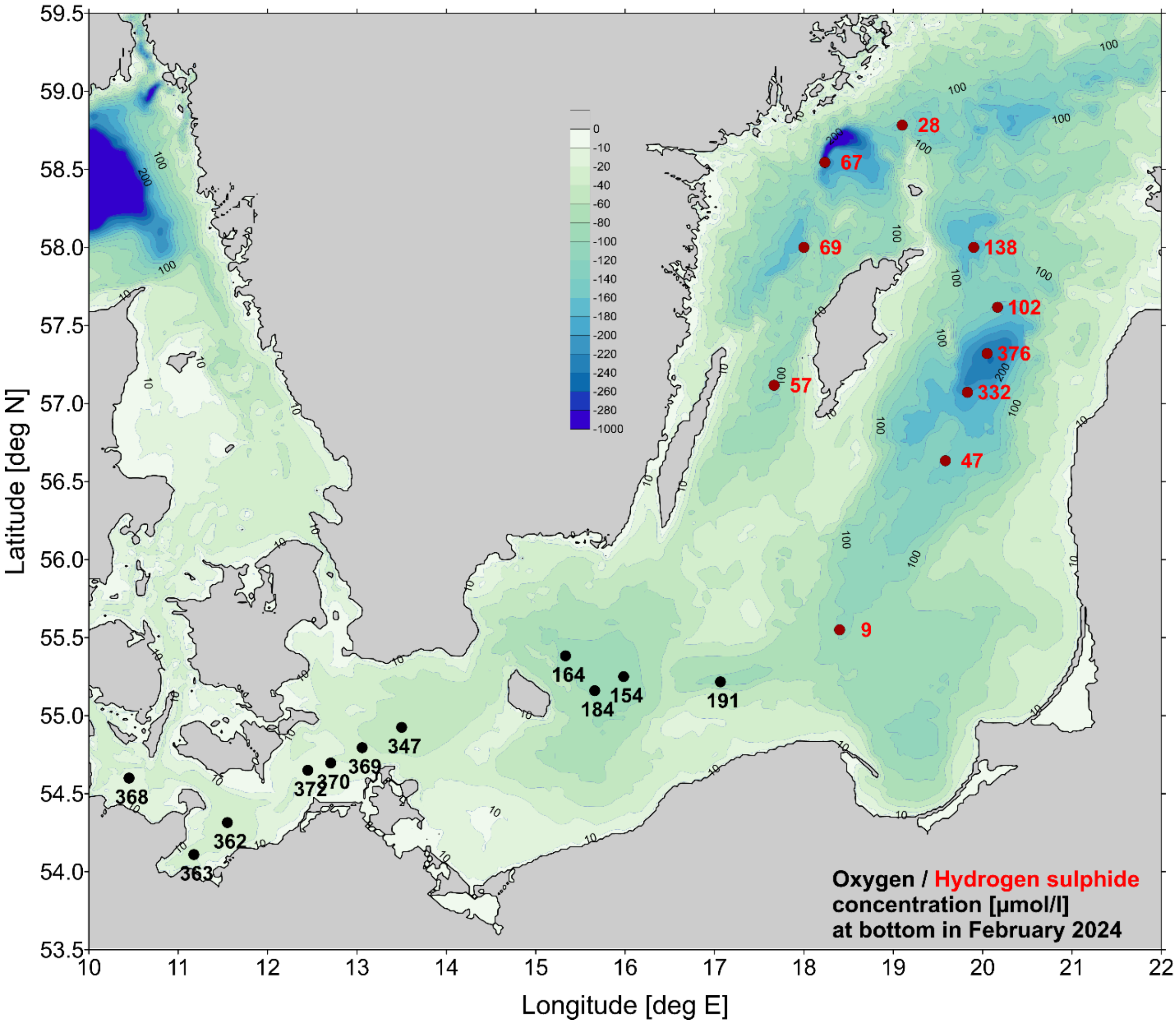

Fig. 5.13 Distribution of oxygen (black labels) and hydrogen sulfide concentrations (red labels) near bottom at main stations of the long-term observation program.

5.4 Baltic Thalweg Transect

During the cruise 68 CTD stations were aligned along the thalweg transect from the Danish straits, through the western Baltic Sea, and further towards the northern Gotland basin. This transect supplies an excellent overview about the hydrographic and environmental state of the entire Baltic Sea. And thus, it is worked as standard transect of the IOW long term observation program. Beside a three days interruption when the ship called the port of Sassnitz the transect was worked as a continuous sequence of stations, starting on 7th February in the Belt Sea and finished at 17th February in the northern Gotland Basin. Due to bad weather conditions the four northernmost stations could not be sampled. The data supplies a quasi-synoptic picture of the hydrographic patterns along the Thalweg.

The observations show the late winter conditions just before the start of the spring bloom (Fig. 5.14 and Fig. 5.15). The temperature in the upper layer depicted almost no vertical gradient down to the permanent halocline. Since the global radiation during the cruise was rather low and much less than the outgoing long wave radiation, the surface layer is still cooling due to the heat loss to the atmosphere. The temperatures in the surface layer of the entire Baltic were at higher-than-normal levels for February. In the western Baltic about 3.7°C in the Belt Sea and 3.3°C in the Arkona Basin were observed. The climatological mean for both positions is about 1.9°C. The sea surface temperatures (SST) decreasing slightly towards east and north. SST of about 3.5°C was found in the Bornholm basin, 1K above the climatological mean. The SST in the eastern Gotland Basin dropped to 3.0°C at the station TF0271, and below 3°C further north. At the Farö Deep 2.7°C were measured, which was about 0.5K above the climatological mean. Below the halocline the water temperature increased and varied between 6 and nearly 10°C. The highest temperatures were observed in the halocline water of the Bornholm Basin (9.5°C) and at the bottom of the eastern end of the Slupsk Furrow with about 9.3°C. These water bodies are a mixture of the extreme warm water that entered the Baltic with barocline summer inflows and the saline inflow water from the medium size MBI in December 2023. Another warm water patch was found at 100m depth in the rim of the southern Gotland Basin. It also carried warm water from the summer inflows.

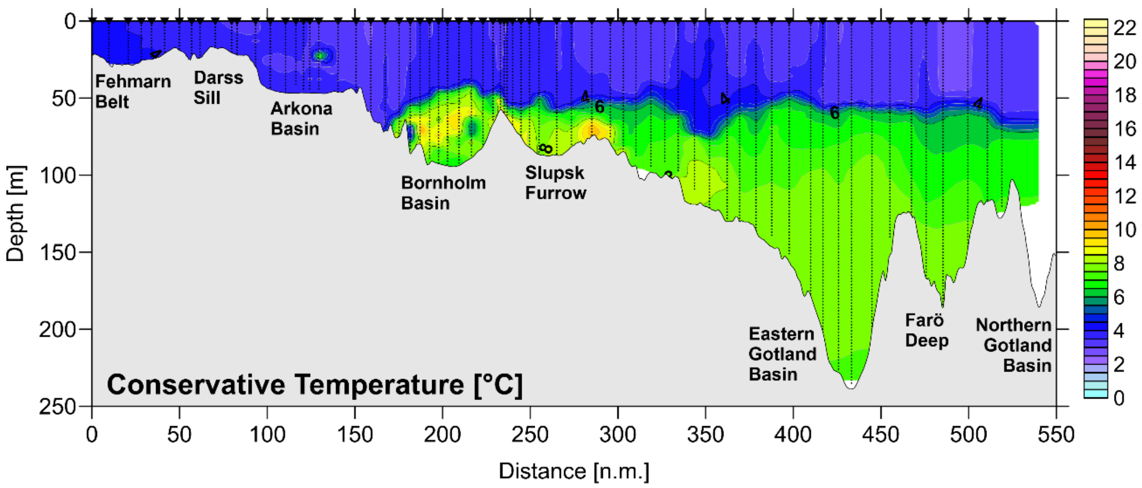

Fig. 5.14 Distribution of conservative temperature along the talweg of the Baltic Sea from the Kiel bight to the northern Gotland Basin. The figure is based on the preliminary CTD data gathered from 07.02. - 16.02.2024.

The temperature maximum in the eastern Gotland Basin was found at 115m with 7.45°C. Towards the bottom the temperature decreased very slightly and was constant at 7.23°C in a 12m thick bottom layer of the Gotland deep. This value was rather persistent during the recent month, indicating long lasting stagnation. The bottom water in the Farö Deep was a bit warmer (7.29°C) than in the Gotland deep. Above the four meter thick bottom layer an intrusion of halocline water from the Gotland Deep was found which formed a 15m thick well mixed layer of water with 7.32°C.

The salinity distribution in the western Baltic depicted the typical pattern shortly after a barotropic inflow event. The highest salinity along the thalweg was observed west of the Fehmarn Belt at station TF0361 with a bottom salinity of 23.1gkg^{-1}. Towards the Darss Sill the salinity decreased to about 16 gkg^{-1}. There was still an overflow at the Darss Sill were water with 12 to 15gkg^{-1} salt entered the Arkona Basin. There a patch of dense saline water bottom water of 7 to 10m thickness was found. Showing a maximum bottom salinity of 21.2gkg^{-1} at the central station TF0113. The low temperature of the water body of 3.9°C indicated an origin of these water mass from the recent inflow at the Öresund.

Despite the larger amount of saline water that entered the Baltic in December 2023 the Bottom salinity in the Bornholm Basin is not at extreme levels. The inflow waters could not replace the former bottom water completely (Fig. 5.15). Instead, we found a mixture of old deep water and new inflow water. The temperature signature indicates an increasing fraction of new inflow water towards the bottom of the Bornholm Basin where the salinity was about 16gkg^{-1}. The mixture of saline inflow water and old deep water filled the eastern Bornholm well above the sill depth of the Slupsk Sill. Thus, we found an active overflow of the Slupsk Sill. A significant part of the warm saline water has passed the Slupsk Sill and covers the entire deep layer of the Slupsk Furrow. The halocline in this basin is also well above its eastern sill depth, and the overflow of the eastern outlet of the Slupsk Furrow has just started at the time of the cruise. The warm water patch at the entrance to the southern Gotland Basin seen in the temperature distribution was not reflected in salinity pattern. This water has reached its equilibrium density interface and will further spread into the halocline layer of the Eastern Gotland Basin.

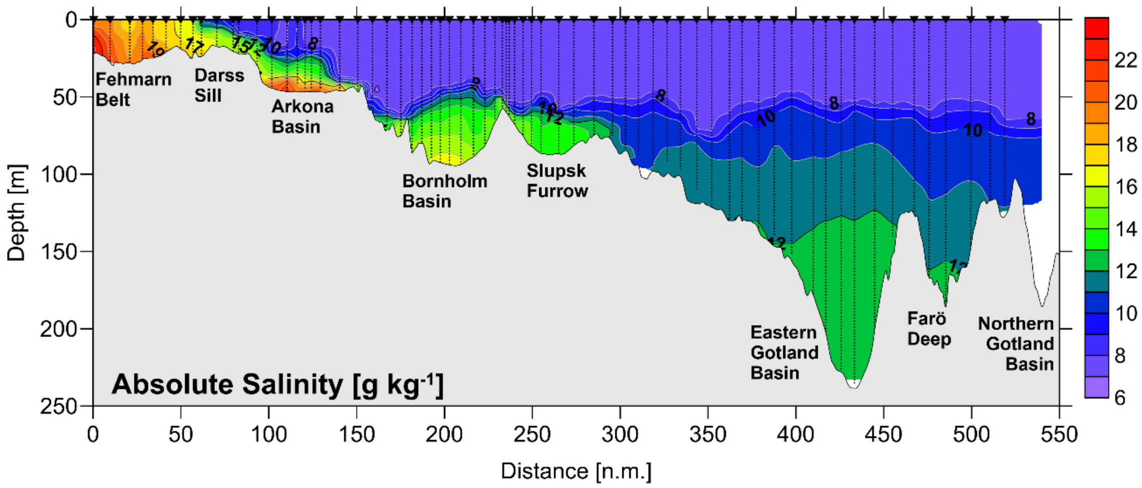

Fig. 5.15 Distribution of Absolute salinity along the talweg of the Baltic Sea from the Kiel bight to the northern Gotland Basin. The figure is based on the preliminary CTD data gathered from 07.02. - 16.02.2024.

The deep and bottom layer of the eastern Gotland basin is covered by high saline waters from inflow series of the recent years. In the Gotland Deep bottom salinity of 12.8gkg^{-1} was observed. This is 0.12gkg^{-1} less than a year ago. The bottom salinity here decreased slowly, but continuously because of the recent lack of high-density inflows.

The halocline in the central Baltic was found at a depth 60m in the eastern Gotland Basin and at about 70m in the western Gotland Basin (Landsort Deep). The vertical salinity gradient of the halocline decreases towards northern end of the transect.

The oxygen distribution along the central transect is shown in Fig. 5.16. Due to the moderate barotropic inflow in December 2023 the western Baltic was well ventilated. The oxygen rich inflow waters mixed up with the bottom water in the Bornholm Basin. The mixing process was not finished, which is seen in the patchy distribution of oxygen concentration. The bottom layer in the Bornholm basin is covered by a 10 to 15m thick water body with about 180 µmol kg^{-1} dissolved oxygen. The minimum oxygen concentration of about 180 µmol kg^{-1} was found in depth between 65 and 80m, indicating a high fraction of former deep water of the basin. A similar patchy oxygen distribution was also found in the Slupsk Furrow deep water. Here the oxygen concentrations ranged between 100 and 200 µmol kg^{-1}.

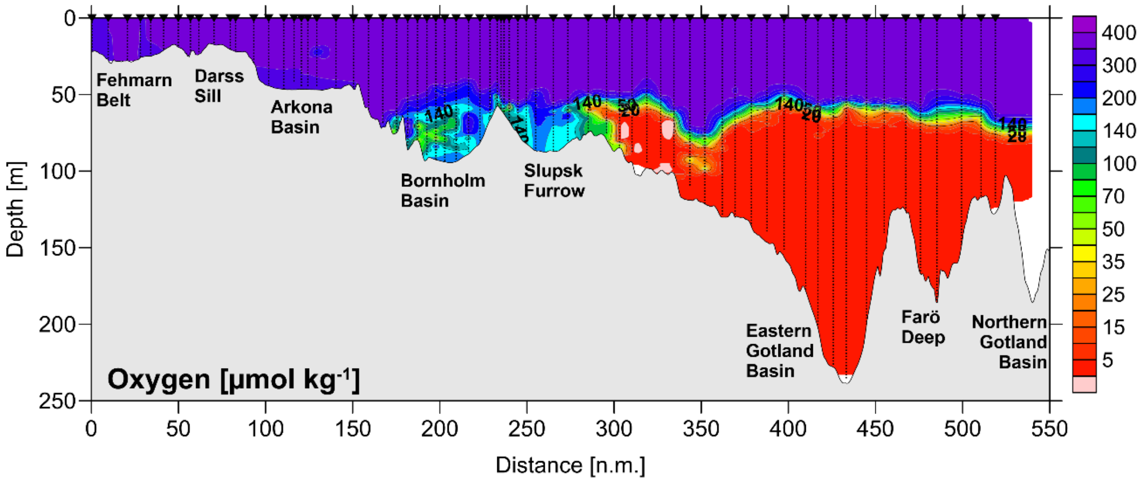

Fig. 5.16 Distribution of oxygen concentration along the talweg of the Baltic Sea from the Kiel bight to the northern Gotland Basin. The figure is based on the preliminary CTD data gathered from 07.02. - 16.02.2024.

The tip eastward traveling saline water has reached the eastern outlet of the Slupsk Furrow and is also visible in the oxygen distribution. Their higher oxygen concentrations are in contrast to the ambient anoxic water. However, due to mixing with ambient water and ongoing oxygen consumption, the oxygen concentration in the eastward advected plumes is decreasing rapidly.

In the southern and eastern Gotland Basin an extremely sharp oxycline was observed that coincided with the upper halocline. Within about ten meters the conditions changed from saturated upper layer to anoxic conditions below the upper halocline. At station Gotland Deep (TF0271) oxygen was exhausted below 60m depth. Free hydrogen sulfide was detected in deeper water samples. In the Faro deep and the northern Gotland Basin the anoxic waters start also at the upper halocline at about the same depth as in the Gotland Deep.

The surface layer of the Baltic is well ventilated, due to wind induced deep mixing during the winter season. The oxygen concentration in the upper layer was in balance with the atmosphere since the spring bloom has not started at the time of the cruise.

The chlorophyll-a fluorescence along the transect was extremely low. There were no signs of an early start of the spring bloom (Fig. 5.17). Chlorophyll-a fluorescence maximum was detected in the western Baltic in a surface layer of about 15m thickness in the Fehmarn Belt. This patch consists of inflowing North Sea water.

The turbidity distribution in the Fehmarn Belt and Darss Sill area is confined to the pattern of high saline water. High turbidity values indicate the inflow water. This continued to the east where high turbidity indicated the spreading of inflow water along the bottom of the Arkona Basin, through the Bornholmgat, and further into the western Bornholm Basin. In the eastern Bornholm Basin and in the central Baltic the patterns of high turbidity were found at locations of interfaces between oxic, suboxic and anoxic waters. These turbidity patches indicate the depth level of the redoxcline between 70 and 120m. (Fig. 5.18).

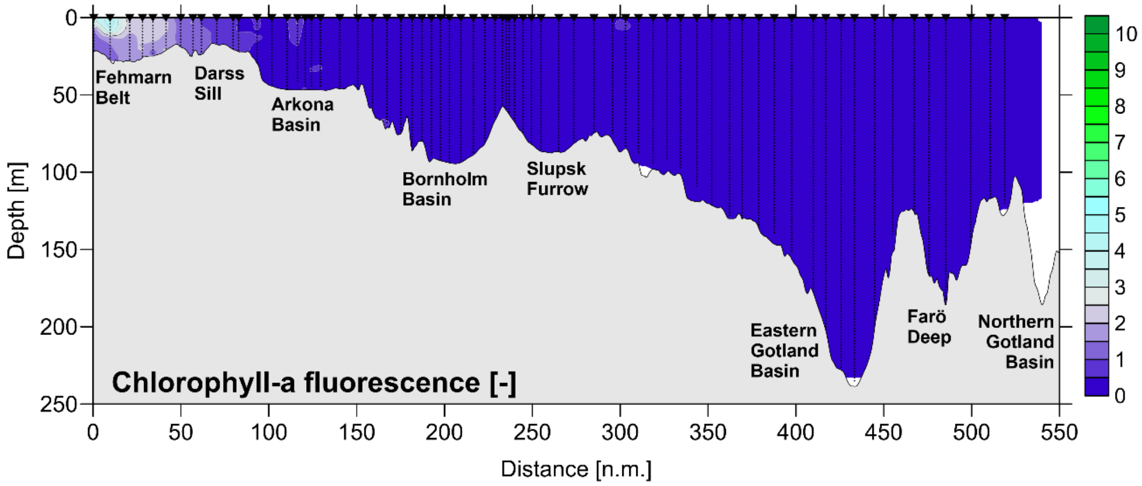

Fig. 5.17 Distribution of Chlorophyll-a fluorescence along the talweg of the Baltic Sea from the Kiel bight to the northern Gotland Basin. The figure is based on the preliminary CTD data gathered from 07.02. - 16.02.2024.

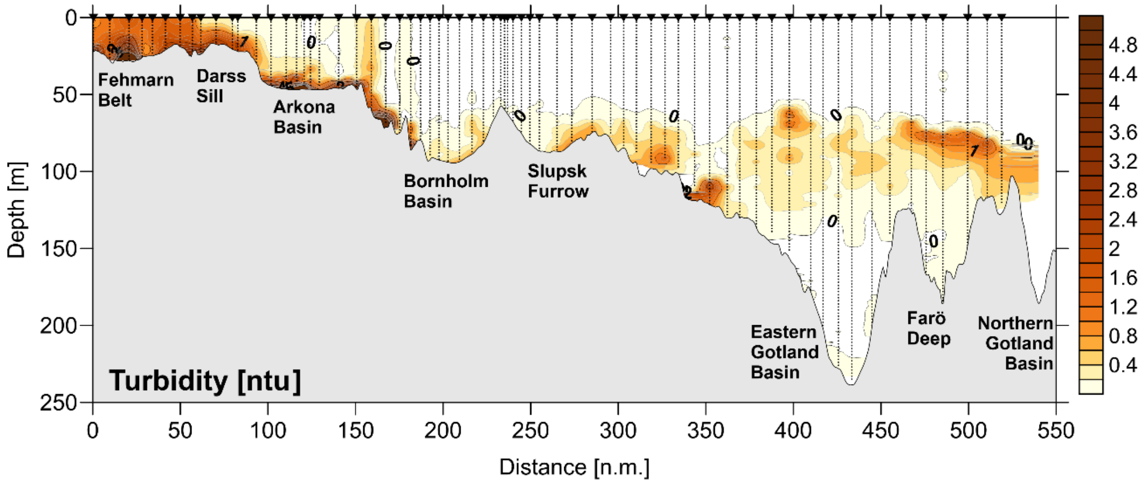

Fig. 5.18 Distribution of turbidity along the talweg of the Baltic Sea from the Kiel bight to the northern Gotland Basin. The figure is based on the preliminary CTD data gathered from 07.02. - 16.02.2024.

Fig. 5.19 depicts the vertical profiles of temperature, salinity and oxygen concentration at the four main stations in the central Baltic. The surface water temperature decreases from 3.0°C in the eastern Gotland basin to 1.75°C at the Landsort Deep (A). At the Gotland Deep and the Farö Deep the surface layer is well mixed down to the local halocline. An extreme thermohaline gradient was established at the bottom of the mixed layer at the Gotland Deep (B). This is caused by the ongoing deep winter convection in the upper layer where the temperature is still above the temperature of maximum density. The surface layer in the western Gotland Basin at the Karlsö Deep and the Landsort Deep depicted a significant vertical gradient. Here the surface is covered by cooler and fresher water originating from fresh water input at the Swedish coast. A weak secondary pycnocline was found at 20m depth. The vertical gradients in the halocline layer varied strongly between the four stations (D). The weakest vertical Gradient was found at Landsort Deep. The current hydrographic conditions in the deep water of the central Baltic were established in the course of moderate inflow events since the strong MBI in December 2014. Since 2017 no fresh saline water has reached the deep water. The temperatures and the salinities at all stations are considerably higher than average (C). Recent inflows have only reached the halocline layer down to 150m depth, indicated by the higher variability of temperature and salinity in this layer (D). The oxycline was found between 60m at Gotland deep and 95m depth at Landsort Deep. The deep-water layer in the central Baltic is characterized by the long-lasting stagnation and euxinic conditions (E).

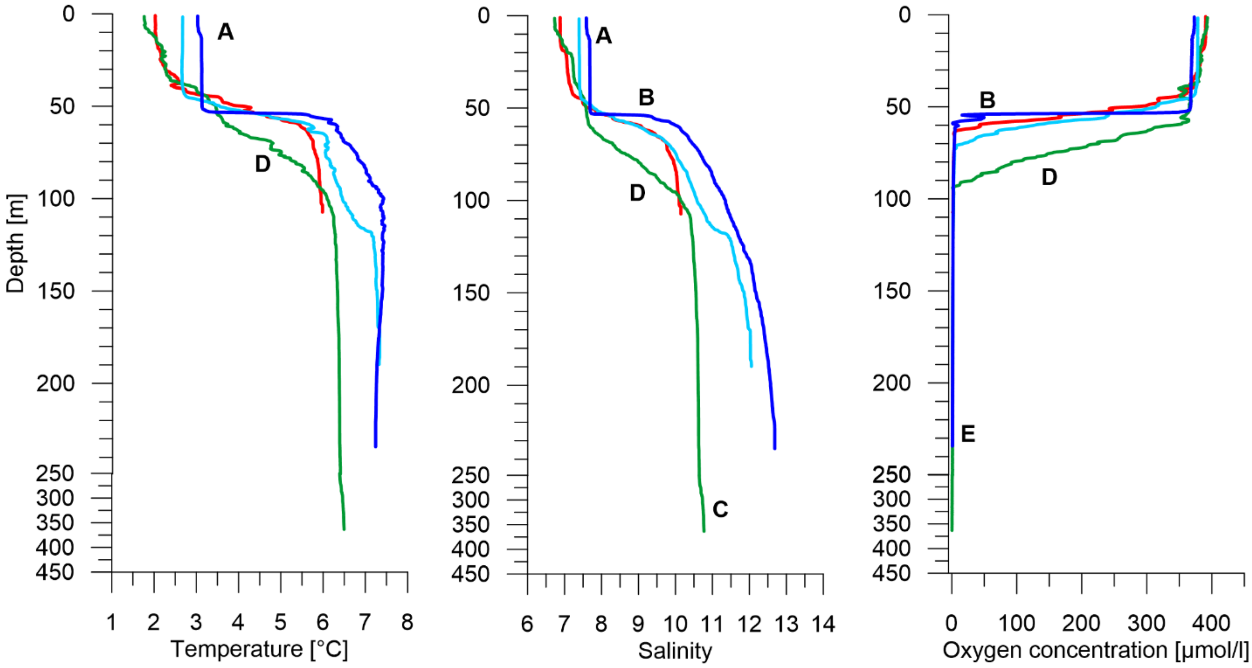

Fig. 5.19 Vertical profiles of temperature, salinity and oxygen concentration (CTD data) at the main stations in the central Baltic. Gotland Deep TF0271 (blue), Farö Deep TF0286 (cyan), Landsort Deep TF0284 (green), and Karlsö Deep TF0245 (red).

The different water masses observed during the cruise can be clearly identified using its temperature, salinity and oxygen signature. Fig. 5.20 gives an overview about the different water masses in two state diagrams. The following water bodies were identified and depicted in the figure:

A - Western Baltic surface water
B – Fehmarn Belt bottom water
C - Central Baltic surface water
D - Bornholm Basin bottom water
E - Bornholm Basin halocline water
F - Slupsk Furrow bottom water
G - EGB halocline water
H - EGB deep water
I - EGB bottom water

The waters of the December 2023 inflow cannot be clearly distinguished from ambient water bodies since they were mixed up with the warm waters of the barocline summer inflows. Only the Bornholm Basin bottom water depicted a relatively high fraction of saline water from the December 2023 MBI (D). The water mass with highest density was found at the bottom of the Fehmarn Belt (B) and the Arkona Basin, originating from minor inflow events in January 2024.

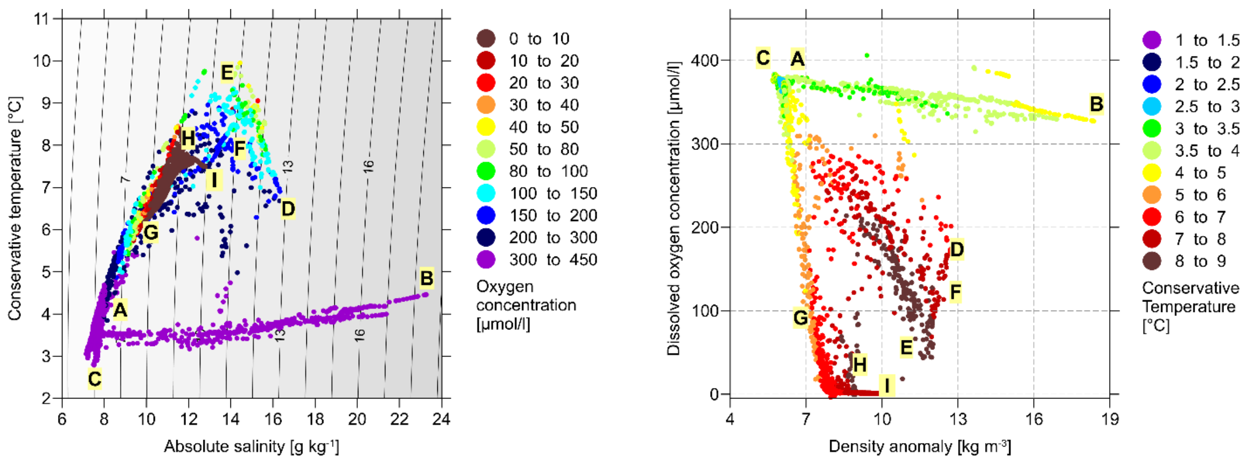

Fig. 5.20 TS-diagram (left) and Oσ-diagram (right) of the Baltic transect. The capital letters indicate the different water masses (see text).

5.5 GODESS Time-Series Observations

In frame of its Baltic Long-Term Observation Program the IOW operates permanent moorings in the Eastern Gotland Basin. One of these moorings, the GODESS, was recovered during the cruise. The recovering was successful performed on 15th February. Twice a day the GODESS gathered profiles of the main hydrographic parameters in the center of the Eastern Gotland Basin. The mooring consists of a fast-sampling sensor package and an underwater winch that moves the sensor package through the water column. The sensor package consists of a SST CTD with temperature, conductivity and oxygen sensors. Additionally, sensors for Chlorophyll-a fluorescence, turbidity and pH value were mounted, together with a Nortek Aquadopp current. At the bottom weight of the mooring a pressure sensor provided information about the sea level variability. The mooring was deployed on 12.11.2023 and collected data till 20.01.2024. It covered the depth range between 30 and 210 m depth. The detailed mooring setup is given Prien and Schulz-Bull (2016). Due to some technical issues the mooring could not be deployed after maintenance on board. This will be done during the March cruise of EMB. Some preliminary data of the GODESS mooring are depicted in Fig. 5.21.

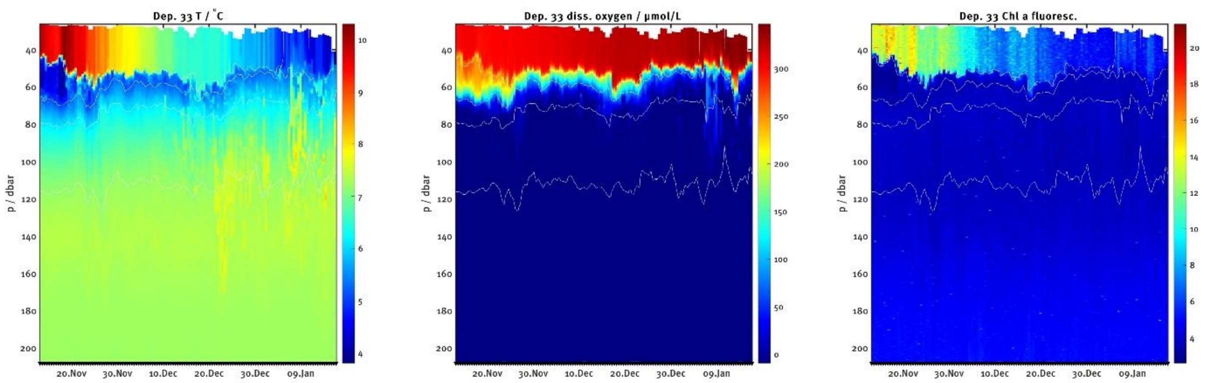

Fig. 5.21 Time series of temperature (left), dissolved oxygen concentration (center) and chlorophyll-a (right) at the Gotland Deep gathered with the GODESS mooring from November 2023 till January 2024.

5.6 Organic Pollutants

Surface water samples, surface sediment samples and a deep-water sample were taken for analysis of chlorinated hydrocarbons (CHC) as well as polycyclic aromatic hydrocarbons (U.S. EPA PAH) and also for organotin (OT) in the sediment samples.

For transect samples the clean water line was used to continuously pump surface water from 5 m below surface trough a pump/filtration system. For deep water sampling an in-situ pump system was used. Sediment surface samples were obtained by Multi Corer respectively Van Veen Grap.

In summery for organic compounds nine surface water samples from sites in the Fehmarn Belt/Kiel Bight (T1), Mecklenburg Bight (T2), Arkona Sea (T3), Pomeranian Bight (T4), Bornholm Sea (T5), Central Baltic Sea (T6), Eastern Gotland Sea (North and South, T7 and T8) and the Western Gotland Sea (T9) were obtained by transect sampling in the respective Baltic Sea area (Table 7.2). Surface water by using the clean water line and deep water at 225 m via in-situ pump were sampled at station TF0271. Surface sediment samples were taken at stations in the Fehmarn Belt (TF0010), Mecklenburg Bight (TF0012), Arkona Basin (TF0069 and TF0110) and Pomeranian Bight (OBBOJE), see also Table 7.6.

5.7 Long-Term Investigations of CH_4, N_2O and CO_2 Distribution

Sampling for simultaneous CH_4, N_2O and CO_2 observation was carried out in frame of an extension to the long-term data collection program at the four central stations of the Arkona Basin, the Bornholm Basin, the Eastern Gotland Basin and the Farö Deep. The sampled stations are indicated in Table 7.1 with the abbreviation "TG". One complete depth profile was sampled at station TF0271 for the long-term data collection of CT, AT, and pH.
These samples were fixed with 500 µL saturated $HgCl_2$-solution to prevent microbiological activity and stored dark.

5.8 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 vertical high resolution sampling of the range of the redoxcline at Gotland Deep (TF0271) and Landsort Deep (TF0284a) 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. The responsible scientist at IOW is Prof. Dr. Klaus Jürgens.

5.9 Plankton Sampling

Plankton sampling was performed by means of a rosette sampler (combined with CTD) as well as with small phytoplankton nets (PLA, APNET) and a zooplankton net (WP2). Samples were taken from different depths in order to get representative data from the euphotic zone. Additionally, samples for micro biological analyses were taken at some stations in the central Baltic. The analysis of these samples will be performed after the cruise. Thus, no preliminary results of this program are presented here. Responsible scientists at IOW are Dr. Anke Kremp (phytoplankton) and Dr. Jörg Dutz (zooplankton).

5.10 Organic UV-Filter Sampling

The study "Identification of UV Filter enrichment areas in the Baltic Sea - Investigation of transport processes and long-term sinks in water and sediment" is a cooperation between the Julius Kühn-Institute Berlin and the IOW. The involved scientists are Dr. Kathrin Fisch and Harshada Sakpal (JKI), and Prof. Detlef Schulz-Bull and Dr. Marion Kanwischer, (IOW).

The primary objective of this study is to contribute to a better understanding of organic UV Filter distribution and fate in the marine environment. This project aims to help identify UV Filter enrichment areas, as well as, which transport processes contribute to the introduction of UV Filters into the open Baltic Sea. The sampling time is critical in determining and evaluating UV Filters, especially during the summer when the distribution of UV Filters in water varies significantly during the day or week. As opposed to summer season, minimal concentrations are expected during the wintertime. Thus, seasonal sampling is carried out in spring, summer, and winter to evaluate the variability of UV Filter occurrence and their regional and temporal distribution. The current project will study a considerably more comprehensive variety of UV Filters and their simultaneous detection in water, sediment and algae blooms. Biota analysis will help determine whether algae blooms are a source for introducing UV Filters into sediments and whether sediment serves as a sink for UV Filters in the environment and can be traced back to the beginning of their application. Seasonal sampling will help determine if there is a link between UV Filters in the water and sediment phase and algae blooms.

The sampling aims to identify enrichment areas for homogeneous or heterogeneous distribution of UV Filters across the coastal areas, bays and the open Baltic Sea. Also, identify the transport processes for the occurrence of UV Filters in the Baltic Sea. Given the importance of seasonal variations in concentrations of UV Filters in the Baltic Sea, this winter cruise will aid in providing crucial information. This is the fourth of seven cruises. The sediment samples of this cruise will give us a first insight, whether they serve as a sink for UV Filters or not.

Sampling at stations:

Water samples were taken at the surface, "ChlAmax", and near bottom layer for the following stations (Tab. 1). The collection of samples from various depths will assist us in determining the variation in distribution of UV Filters in the Baltic Sea at different depths. ChlAmax is being collected specifically to help us correlate the UV Filter concentration in algae and whether they act as a link for UV Filter deposition in sediment. During this cruise, no ChlAmax layer could be identified at the stations, so a middle depth between surface and bottom was taken as a substitute.

Solid phase extraction done to analyze the UV Filters. The samples were filtered using Chromabond HLB cartridges on board. Further, extractions and analysis using LC-MS/MS will be carried out at Julius Kühn-Institut, Berlin. Additional samples were taken for Titaniumdioxid, as a marker for mineral UV Filters, as a comparison for the organic UV Filers.

During this cruise, sediment samples for the investigation of UV Filter sinks were taken. The samples were taken with MUC (Tab. 2). The supernatant of the MUC sample was also extracted and will be analyzed. Of each MUC, the first 10 cm were cut into slices by 1 cm.

The lists of water samples and surface sediment samples are given in Table 7.5 and Table 7.6, respectively.

6 Ship's Meteorological Station

Not applicable on EMB. The meteorological conditions during the cruise are described in section 5.1, based on data of the automatic weather station of the ship.

7 Station Lists EMB356

7.1 Overall Station List

Table 7.1 list all stations and deployments carried out during the cruise EMB356. Standard sampling consisted of a single CTD cast. Nutrient samples at fixed standard depth were taken at selected stations, indicated by N. At some stations a number of additional chemical and biological samplings were performed. These tasks are indicated in the last column of Table 7.1.

Used gears:

CTD	- CTD probe with rosette water sampler
SD	- Secci disk
PLA	- Phytoplankton net
WP2	- WP2 net for Zooplankton sampling
SCF	- ScanFish undulating CTD deployment
ISP	- In-situ pump

Additional sampling program on selected stations:

CC	- Comparison measurements for CTD data quality assurance
Moor	- Mooring maintenance for IOW long term observation program
N	- Nutrient sampling (NO_3, NO_4, NH_4, PO_4, SiO_4, O_2)
HS	- H_2S sampling
TG	- Trace gas sampling (CH_4, N_2O and CO_2)
OH	- organic hazardous substances

Table 7.1 List of stations and gears

Station No.	Station name	Gear	Date/Time	Latitude	Longitude	Water Depth	Remarks
EMB	IOW		[UTC]			[m]	
EMB356_1-1	TFO5	CTD	07.02.2024 12:39	54° 13.86'N	012° 04.56'E	10.0	
EMB356_1-2	TFO5	SD	07.02.2024 12:40	54° 13.87'N	012° 04.55'E	10.0	
EMB356_2-1	TF0017	CTD	07.02.2024 14:33	54° 23.46'N	011° 49.39'E	20.0	
EMB356_3-1	TF0011	CTD	07.02.2024 15:56	54° 24.77'N	011° 37.00'E	23.0	
EMB356_4-1	TF0010	CTD	07.02.2024 17:39	54° 33.10'N	011° 19.23'E	26.0	N
EMB356_4-2	TF0010	MUC	07.02.2024 18:14	54° 33.11'N	011° 19.21'E	26.0	
EMB356_5-1	SS-trans	ISP	07.02.2024 18:45	54° 33.12'N	011° 19.15'E	26.0	OH
EMB356_6-1	TF0360	CTD	07.02.2024 22:39	54° 36.02'N	010° 27.07'E	16.0	N
EMB356_6-2	TF0360	PLA	07.02.2024 22:39	54° 36.02'N	010° 27.07'E	16.0	
EMB356_6-3	TF0360	WP2	07.02.2024 23:16	54° 36.02'N	010° 27.11'E	16.0	
EMB356_6-4	TF0360	WP2	07.02.2024 23:23	54° 36.02'N	010° 27.11'E	16.0	
EMB356_7-1	TF0361	CTD	08.02.2024 00:59	54° 39.44'N	010° 46.17'E	21.0	
EMB356_8-1	TF0014	CTD	08.02.2024 02:16	54° 35.67'N	011° 00.92'E	26.0	

Station No.	Station name	Gear	Date/Time	Latitude	Longitude	Water Depth	Remarks
EMB	IOW		[UTC]			[m]	
EMB356_9-1	TF0013	CTD	08.02.2024 04:23	54° 28.39'N	011° 29.09'E	24.0	
EMB356_10-1	TF0022	CTD	08.02.2024 07:26	54° 06.59'N	011° 10.52'E	21.0	N
EMB356_11-1	TF0021	CTD	08.02.2024 08:23	54° 09.32'N	011° 17.61'E	22.0	
EMB356_12-1	TF0012	CTD	08.02.2024 10:07	54° 18.89'N	011° 33.01'E	22.0	N
EMB356_12-2	TF0012	PLA	08.02.2024 10:08	54° 18.89'N	011° 33.00'E	22.0	
EMB356_12-3	TF0012	SD	08.02.2024 10:22	54° 18.89'N	011° 33.05'E	22.0	
EMB356_12-4	TF0012	WP2	08.02.2024 10:57	54° 18.88'N	011° 33.00'E	22.0	
EMB356_12-5	TF0012	WP2	08.02.2024 11:07	54° 18.88'N	011° 33.02'E	22.0	
EMB356_12-6	TF0012	WP2	08.02.2024 11:12	54° 18.88'N	011° 33.00'E	22.0	
EMB356_12-7	TF0012	WP2	08.02.2024 11:19	54° 18.89'N	011° 33.01'E	22.0	
EMB356_12-9	TF0012	MUC	08.02.2024 12:07	54° 18.87'N	011° 33.02'E	22.0	
EMB356_13-2	SS-trans	ISP	08.02.2024 12:41	54° 18.82'N	011° 32.93'E	22.0	OH
EMB356_14-2	TFO5	SD	08.02.2024 15:18	54° 13.89'N	012° 04.54'E	10.0	
EMB356_14-1	TFO5	CTD	08.02.2024 15:19	54° 13.89'N	012° 04.53'E	10.0	N
EMB356_15-1	TF0041	CTD	08.02.2024 19:11	54° 24.39'N	012° 03.65'E	17.0	N
EMB356_16-1	TF0046	CTD	08.02.2024 20:27	54° 28.19'N	012° 14.43'E	26.0	
EMB356_16-2	TF0046	PLA	08.02.2024 20:29	54° 28.19'N	012° 14.44'E	26.0	
EMB356_16-3	TF0046	WP2	08.02.2024 21:01	54° 28.20'N	012° 14.49'E	26.0	
EMB356_16-4	TF0046	CTD	08.02.2024 21:16	54° 28.20'N	012° 14.50'E	26.0	N
EMB356_17-1	TF0083	CTD	08.02.2024 22:07	54° 32.98'N	012° 16.47'E	24.0	
EMB356_18-1	TF0002	CTD	08.02.2024 23:23	54° 38.96'N	012° 26.98'E	16.0	N
EMB356_19-1	TF0001	CTD	09.02.2024 01:22	54° 41.72'N	012° 42.30'E	19.0	N
EMB356_20-1	TF0030	CTD	09.02.2024 02:05	54° 43.41'N	012° 46.88'E	21.0	N
EMB356_20-2	TF0030	PLA	09.02.2024 02:07	54° 43.42'N	012° 46.88'E	21.0	
EMB356_21-1	TF0115	CTD	09.02.2024 03:47	54° 47.69'N	013° 03.45'E	28.0	N
EMB356_22-1	TF0114	CTD	09.02.2024 05:06	54° 51.61'N	013° 16.50'E	43.0	N
EMB356_23-1	TF0113	CTD	09.02.2024 06:27	54° 55.49'N	013° 29.95'E	45.0	TG, N
EMB356_23-2	TF0113	PLA	09.02.2024 06:28	54° 55.49'N	013° 29.95'E	46.0	
EMB356_23-3	TF0113	CTD	09.02.2024 07:03	54° 55.49'N	013° 30.00'E	46.0	
EMB356_24-1	TF0160	ISP	10.02.2024 09:14	54° 14.41'N	014° 04.08'E	12.0	OH
EMB356_25-1	TF0160	CTD	10.02.2024 09:20	54° 14.41'N	014° 04.10'E	12.0	N
EMB356_26-1	OBBoje	CTD	10.02.2024 10:50	54° 04.74'N	014° 09.44'E	13.0	N
EMB356_27-1	TF0152	CTD	10.02.2024 15:05	54° 38.00'N	014° 16.95'E	30.0	N
EMB356_28-1	TF0112	CTD	12.02.2024 07:30	54° 48.23'N	013° 57.47'E	38.0	
EMB356_28-2	TF0112	CTD	12.02.2024 08:01	54° 48.22'N	013° 57.57'E	39.0	N
EMB356_29-1	ABBoje	CTD	12.02.2024 09:06	54° 52.89'N	013° 51.15'E	44.0	
EMB356_30-1	TF0113	SD	12.02.2024 10:53	54° 55.46'N	013° 29.96'E	46.0	
EMB356_30-2	TF0113	CTD	12.02.2024 10:54	54° 55.46'N	013° 29.96'E	46.0	
EMB356_30-3	TF0113	WP2	12.02.2024 11:21	54° 55.48'N	013° 29.95'E	46.0	
EMB356_31-1	TF0113	ISP	12.02.2024 12:14	54° 55.59'N	013° 29.70'E	46.0	OH
EMB356_32-1	TF0069	CTD	12.02.2024 13:15	54° 59.94'N	013° 18.00'E	45.0	
EMB356_32-2	TF0069	MUC	12.02.2024 13:38	54° 59.97'N	013° 18.00'E	45.0	
EMB356_33-1	TF0105	CTD	12.02.2024 15:27	55° 01.50'N	013° 36.39'E	45.0	
EMB356_34-1	TF0122	CTD	12.02.2024 16:29	54° 59.32'N	013° 46.25'E	46.0	
EMB356_35-1	TF0104	CTD	12.02.2024 17:22	55° 04.09'N	013° 48.75'E	45.0	N
EMB356_36-1	TF0103	CTD	12.02.2024 18:24	55° 03.77'N	013° 59.26'E	45.0	N
EMB356_37-1	TF0110a	CTD	12.02.2024 19:33	54° 57.52'N	013° 59.01'E	46.0	
EMB356_38-1	TF0109	CTD	12.02.2024 20:53	54° 59.97'N	014° 05.04'E	47.0	N
EMB356_38-2	TF0109	PLA	12.02.2024 20:56	54° 59.97'N	014° 05.02'E	47.0	
EMB356_38-3	TF0109	WP2	12.02.2024 21:22	54° 59.98'N	014° 05.03'E	47.0	
EMB356_38-4	TF0109	WP2	12.02.2024 21:30	54° 60.00'N	014° 04.97'E	47.0	
EMB356_39-1	TF0145	CTD	12.02.2024 23:06	55° 09.64'N	014° 15.58'E	46.0	N
EMB356_40-1	TF0144	CTD	13.02.2024 00:38	55° 15.11'N	014° 30.16'E	45.0	

Station No.	Station name	Gear	Date/Time	Latitude	Longitude	Water Depth	Remarks
EMB	**IOW**		**[UTC]**			**[m]**	
EMB356_41-1	TF0142	CTD	13.02.2024 02:13	55° 22.94'N	014° 34.64'E	67.0	N
EMB356_42-1	TF0140	CTD	13.02.2024 03:21	55° 27.96'N	014° 43.01'E	69.0	N
EMB356_43-1	TF0206	CTD	13.02.2024 04:35	55° 31.95'N	014° 54.85'E	76.0	
EMB356_44-1	TF0207	CTD	13.02.2024 05:42	55° 29.70'N	015° 05.65'E	85.0	
EMB356_45-1	TF0208	CTD	13.02.2024 06:44	55° 27.18'N	015° 13.99'E	92.0	
EMB356_46-1	TF0200	CTD	13.02.2024 08:30	55° 22.96'N	015° 19.96'E	91.0	N
EMB356_47-1	TF0209	CTD	13.02.2024 09:31	55° 20.78'N	015° 27.89'E	94.0	
EMB356_48-1	TF0209	ISP	13.02.2024 09:54	55° 20.83'N	015° 27.86'E	94.0	OH
EMB356_49-1	TF0211	CTD	13.02.2024 10:35	55° 19.75'N	015° 36.94'E	95.0	
EMB356_50-1	TF0214	CTD	13.02.2024 12:05	55° 09.62'N	015° 39.61'E	94.0	N
EMB356_51-1	BB09	CTD	13.02.2024 13:00	55° 13.84'N	015° 43.89'E	94.0	
EMB356_52-1	TF0212	CTD	13.02.2024 13:55	55° 18.10'N	015° 47.88'E	95.0	
EMB356_53-1	BB08	CTD	13.02.2024 14:57	55° 23.60'N	015° 51.80'E	90.0	
EMB356_54-1	TF0213	CTD	13.02.2024 16:29	55° 15.06'N	015° 59.07'E	89.0	TG, N
EMB356_54-2	TF0213	WP2	13.02.2024 17:05	55° 14.99'N	015° 59.03'E	90.0	
EMB356_54-3	TF0213	WP2	13.02.2024 17:18	55° 14.99'N	015° 59.01'E	90.0	
EMB356_54-4	TF0213	WP2	13.02.2024 17:29	55° 15.00'N	015° 58.99'E	90.0	
EMB356_54-5	TF0213	WP2	13.02.2024 17:39	55° 15.00'N	015° 59.01'E	89.0	
EMB356_54-6	TF0213	CTD	13.02.2024 17:56	55° 15.01'N	015° 58.99'E	89.0	
EMB356_54-7	TF0213	PLA	13.02.2024 17:57	55° 15.01'N	015° 58.99'E	89.0	
EMB356_55-1	TF0221	CTD	13.02.2024 20:56	55° 13.26'N	016° 10.04'E	82.0	
EMB356_56-1	TF0225	CTD	13.02.2024 22:00	55° 15.44'N	016° 19.28'E	65.0	
EMB356_57-1	TF0226	CTD	13.02.2024 22:54	55° 17.68'N	016° 25.84'E	57.0	
EMB356_58-1	TF0224	CTD	13.02.2024 23:55	55° 17.02'N	016° 29.98'E	62.0	
EMB356_59-1	SSmoor	CTD	14.02.2024 00:30	55° 16.61'N	016° 33.02'E	66.0	
EMB356_60-1	TF0227	CTD	14.02.2024 01:13	55° 15.71'N	016° 38.09'E	69.0	
EMB356_61-1	TF0228	CTD	14.02.2024 02:09	55° 14.17'N	016° 46.19'E	77.0	
EMB356_62-1	TF0229	CTD	14.02.2024 03:02	55° 13.70'N	016° 54.72'E	85.0	
EMB356_63-1	TF0222	CTD	14.02.2024 04:01	55° 13.02'N	017° 04.05'E	91.0	N
EMB356_64-1	TF0222	ISP	14.02.2024 04:24	55° 12.92'N	017° 04.24'E	91.0	OH
EMB356_65-1	TF0266	CTD	14.02.2024 05:34	55° 15.13'N	017° 21.35'E	89.0	
EMB356_66-1	TF0267	CTD	14.02.2024 06:55	55° 17.19'N	017° 35.61'E	84.0	
EMB356_67-1	TF0268	CTD	14.02.2024 08:31	55° 18.53'N	017° 55.83'E	75.0	
EMB356_68-1	TF0256	CTD	14.02.2024 10:01	55° 19.60'N	018° 14.06'E	78.0	
EMB356_69-1	TF0257	CTD	14.02.2024 11:14	55° 26.41'N	018° 19.37'E	87.0	
EMB356_70-1	TF0259	SD	14.02.2024 12:22	55° 33.02'N	018° 24.03'E	90.0	
EMB356_70-2	TF0259	PLA	14.02.2024 12:23	55° 33.01'N	018° 24.03'E	90.0	
EMB356_70-3	TF0259	CTD	14.02.2024 12:24	55° 33.00'N	018° 24.03'E	90.0	HS, N
EMB356_71-1	TF0255	CTD	14.02.2024 13:49	55° 38.02'N	018° 36.00'E	96.0	
EMB356_72-1	TF0258	CTD	14.02.2024 15:04	55° 43.60'N	018° 45.89'E	91.0	
EMB356_73-1	TF0253	CTD	14.02.2024 16:22	55° 50.36'N	018° 52.02'E	100.0	
EMB356_74-1	TF0265	CTD	14.02.2024 17:54	55° 57.50'N	019° 02.76'E	112.0	
EMB356_75-1	TF0250	CTD	14.02.2024 19:19	56° 05.03'N	019° 10.05'E	125.0	
EMB356_76-1	TF0262	CTD	14.02.2024 21:33	56° 14.10'N	019° 17.98'E	132.0	
EMB356_77-1	TF0263	CTD	14.02.2024 22:44	56° 20.82'N	019° 22.68'E	134.0	
EMB356_78-1	TF0263	ISP	14.02.2024 23:06	56° 20.89'N	019° 22.85'E	134.0	OH
EMB356_79-1	TF0261	CTD	15.02.2024 00:12	56° 29.48'N	019° 28.91'E	144.0	
EMB356_80-1	TF0260	CTD	15.02.2024 01:36	56° 38.01'N	019° 34.90'E	145.0	HS, N
EMB356_81-1	TF0274	CTD	15.02.2024 03:26	56° 46.03'N	019° 44.97'E	155.0	
EMB356_82-1	TF0273	CTD	15.02.2024 05:05	56° 57.13'N	019° 46.16'E	185.0	
EMB356_82-2	TF0273	CTD	15.02.2024 05:48	56° 57.14'N	019° 46.17'E	185.0	
EMB356_83-1	TF0272	CTD	15.02.2024 07:18	57° 04.32'N	019° 49.84'E	210.0	HS

Station No.	Station name	Gear	Date/Time	Latitude	Longitude	Water Depth	Remarks
EMB	IOW		[UTC]			[m]	
EMB356_84-1	TF0275	CTD	15.02.2024 08:51	57° 12.65'N	019° 55.75'E	231.0	
EMB356_85-1	GODESS	MOOR	15.02.2024 10:34	57° 19.30'N	020° 07.40'E	246.0	moor
EMB356_86-1	TF0271	SD	15.02.2024 12:31	57° 19.17'N	020° 02.98'E	241.0	HS
EMB356_86-2	TF0271	ISP	15.02.2024 12:32	57° 19.17'N	020° 02.97'E	241.0	OH
EMB356_86-3	TF0271	CTD	15.02.2024 12:32	57° 19.18'N	020° 02.97'E	241.0	N
EMB356_86-4	TF0271	PLA	15.02.2024 12:32	57° 19.18'N	020° 02.97'E	242.0	
EMB356_86-5	TF0271	CTD	15.02.2024 13:39	57° 19.19'N	020° 03.00'E	242.0	N
EMB356_86-6	TF0271	CTD	15.02.2024 14:20	57° 19.20'N	020° 03.00'E	241.0	N
EMB356_86-7	TF0271	CTD	15.02.2024 15:00	57° 19.20'N	020° 03.01'E	241.0	N
EMB356_86-8	TF0271	CTD	15.02.2024 15:55	57° 19.20'N	020° 02.99'E	241.0	TG
EMB356_86-9	TF0271	CTD	15.02.2024 16:15	57° 19.21'N	020° 02.99'E	241.0	OH
EMB356_86-10	TF0271	ISP	15.02.2024 17:04	57° 19.21'N	020° 02.99'E	242.0	
EMB356_87-1	TF0276	CTD	16.02.2024 00:50	57° 28.21'N	020° 15.55'E	209.0	
EMB356_88-1	TF0270	ISP	16.02.2024 02:20	57° 37.05'N	020° 09.99'E	145.0	OH
EMB356_88-2	TF0270	CTD	16.02.2024 02:21	57° 37.04'N	020° 09.99'E	145.0	HS
EMB356_89-1	TF0287	CTD	16.02.2024 04:11	57° 42.95'N	019° 51.13'E	129.0	
EMB356_90-1	TF0290	CTD	16.02.2024 05:32	57° 51.02'N	019° 48.94'E	173.0	HS
EMB356_91-1	TF0286	CTD	16.02.2024 07:08	58° 00.03'N	019° 54.03'E	196.0	N
EMB356_91-2	TF0286	CTD	16.02.2024 07:34	58° 00.01'N	019° 54.02'E	196.0	TG, N
EMB356_92-1	TF0277	CTD	16.02.2024 09:26	58° 11.04'N	020° 02.98'E	163.0	
EMB356_93-1	TF0278	CTD	16.02.2024 11:05	58° 21.03'N	020° 08.86'E	122.0	
EMB356_94-1	TF0285	CTD	16.02.2024 12:22	58° 26.53'N	020° 20.05'E	124.0	
EMB356_95-1	TF0283	CTD	17.02.2024 05:27	58° 46.99'N	019° 05.97'E	127.0	HS
EMB356_96-1	TF0284a	CTD	17.02.2024 09:10	58° 32.65'N	018° 13.97'E	375.0	HS
EMB356_96-2	TF0284a	SD	17.02.2024 09:50	58° 32.68'N	018° 13.97'E	377.0	N
EMB356_96-3	TF0284a	CTD	17.02.2024 10:18	58° 32.67'N	018° 13.97'E	377.0	
EMB356_96-4	TF0284a	CTD	17.02.2024 11:10	58° 32.68'N	018° 14.02'E	375.0	N
EMB356_96-5	TF0284a	CTD	17.02.2024 11:40	58° 32.68'N	018° 14.04'E	368.0	N
EMB356_97-1	TF0284a	ISP	17.02.2024 12:05	58° 32.66'N	018° 13.98'E	374.0	OH
EMB356_98-1	wGB-3	CTD	17.02.2024 13:40	58° 19.53'N	018° 04.17'E	147.0	
EMB356_99-1	TF0240	CTD	17.02.2024 16:15	57° 59.97'N	018° 00.05'E	168.0	HS, N
EMB356_100-1	TF0242	CTD	17.02.2024 19:55	57° 42.94'N	017° 22.06'E	142.0	
EMB356_101-1	TF0245	CTD	18.02.2024 01:23	57° 06.95'N	017° 40.11'E	111.0	HS, N
EMB356_102-1	TF0253	CTD	18.02.2024 10:08	55° 50.41'N	018° 52.06'E	102.0	
EMB356_102-2	TF0253	SCF	18.02.2024 11:16	55° 50.48'N	018° 52.02'E	101.0	
EMB356_103-1	TF0253	SCF	18.02.2024 12:00	55° 48.31'N	018° 50.13'E	96.0	
EMB356_104-1	TF0213	CTD	19.02.2024 07:51	55° 15.06'N	015° 58.89'E	90.0	
EMB356_104-2	TF0213	PLA	19.02.2024 07:54	55° 15.05'N	015° 58.91'E	90.0	
EMB356_104-3	TF0213	SD	19.02.2024 08:17	55° 15.01'N	015° 58.98'E	90.0	
EMB356_104-4	TF0213	WP2	19.02.2024 08:22	55° 15.01'N	015° 58.98'E	90.0	
EMB356_104-5	TF0213	WP2	19.02.2024 08:33	55° 15.00'N	015° 59.00'E	90.0	
EMB356_104-6	TF0213	WP2	19.02.2024 08:44	55° 15.00'N	015° 59.01'E	90.0	
EMB356_104-7	TF0213	WP2	19.02.2024 08:53	55° 14.99'N	015° 59.02'E	91.0	
EMB356_105-1	TF0213	SCF	19.02.2024 10:52	55° 14.72'N	016° 00.71'E	89.0	
EMB356_106-1	TF0110a	CTD	20.02.2024 02:16	54° 57.54'N	013° 59.16'E	46.0	
EMB356_106-2	TF0110a	SCF	20.02.2024 02:34	54° 57.55'N	013° 59.11'E	46.0	
EMB356_106-3	TF0110a	MUC	20.02.2024 02:47	54° 57.58'N	013° 59.02'E	46.0	
EMB356_107-1	TF0122	CTD	20.02.2024 04:18	54° 59.43'N	013° 46.22'E	46.0	
EMB356_108-1	TF0113	CTD	20.02.2024 06:03	54° 55.50'N	013° 30.10'E	46.0	
EMB356_108-2	TF0113	PLA	20.02.2024 06:04	54° 55.50'N	013° 30.10'E	46.0	
EMB356_108-3	TF0113	WP2	20.02.2024 06:36	54° 55.48'N	013° 30.02'E	45.0	
EMB356_108-4	TF0113	WP2	20.02.2024 06:45	54° 55.48'N	013° 30.03'E	46.0	

Station No.	Station name	Gear	Date/Time	Latitude	Longitude	Water Depth	Remarks
EMB	IOW		[UTC]			[m]	
EMB356_108-5	TF0113	SD	20.02.2024 06:59	54° 55.48'N	013° 30.01'E	46.0	
EMB356_109-1	TF0114	CTD	20.02.2024 08:09	54° 51.57'N	013° 16.68'E	43.0	
EMB356_110-1	TF0115	CTD	20.02.2024 09:30	54° 47.68'N	013° 03.67'E	28.0	
EMB356_111-1	TF0030	SD	20.02.2024 11:00	54° 43.41'N	012° 47.01'E	20.0	
EMB356_111-2	TF0030	PLA	20.02.2024 11:01	54° 43.41'N	012° 47.01'E	20.0	
EMB356_111-3	TF0030	CTD	20.02.2024 11:02	54° 43.42'N	012° 47.00'E	20.0	
EMB356_111-4	TF0030	CTD	20.02.2024 11:15	54° 43.32'N	012° 47.01'E	20.0	
EMB356_112-1	TF0102	CTD	20.02.2024 13:06	54° 39.00'N	012° 27.01'E	15.0	
EMB356_113-1	TF0046	CTD	20.02.2024 14:51	54° 28.19'N	012° 14.55'E	26.0	
EMB356_113-2	TF0046	PLA	20.02.2024 14:53	54° 28.18'N	012° 14.53'E	26.0	
EMB356_113-3	TF0046	SD	20.02.2024 15:06	54° 28.19'N	012° 14.52'E	26.0	
EMB356_113-4	TF0046	WP2	20.02.2024 15:13	54° 28.19'N	012° 14.50'E	26.0	
EMB356_113-5	TF0046	WP2	20.02.2024 15:19	54° 28.19'N	012° 14.50'E	26.0	
EMB356_114-1	TF0041	CTD	20.02.2024 16:43	54° 24.41'N	012° 03.76'E	17.0	
EMB356_115-1	TF0017	CTD	20.02.2024 18:01	54° 23.52'N	011° 49.44'E	20.0	
EMB356_116-1	TF0012	CTD	20.02.2024 19:28	54° 18.94'N	011° 33.08'E	22.0	
EMB356_116-2	TF0012	PLA	20.02.2024 19:29	54° 18.93'N	011° 33.07'E	22.0	
EMB356_116-3	TF0012	WP2	20.02.2024 19:49	54° 18.89'N	011° 33.02'E	22.0	
EMB356_117-1	TF0026	CTD	20.02.2024 20:43	54° 16.38'N	011° 23.44'E	19.0	

7.2 Organic Pollutants Sampling List

Table 7.2 List of sampling of organic pollutants during the cruise EMB356

Deployment		time	Latitude	Longitude	Depth	Remarks
EMB		[UTC]	[UTC]	No.	[m]	
EMB356_5-1	begin	07.02.2024 18:45	54° 33.12'N	011° 19.15'E	26.0	Kiele Bight →Fehmarn Belt
	end	07.02.2024 23:53	54° 37.01'N	010° 32.04'E	16.0	
EMB356_13-2	begin	08.02.2024 12:41	54° 18.82'N	011° 32.93'E	22.0	Meckl. Bight → Darss Sill
	end	08.02.2024 22:09	54° 32.98'N	012° 16.49'E	23.0	
EMB356_24-1	begin	10.02.2024 09:14	54° 14.41'N	014° 04.08'E	12.0	Arkona basin
	end	10.02.2024 14:55	54° 37.34'N	014° 16.50'E	27.0	
EMB356_31-1	begin	12.02.2024 12:14	54° 55.59'N	013° 29.70'E	46.0	Pomeranian Bight
	end	12.02.2024 19:22	54° 57.92'N	013° 59.11'E	46.0	
EMB356_48-1	begin	13.02.2024 09:54	55° 20.83'N	015° 27.86'E	94.0	Bornholm Basin
	end	13.02.2024 16:15	55° 16.14'N	015° 58.34'E	91.0	
EMB356_64-1	begin	14.02.2024 04:24	55° 12.92'N	017° 04.24'E	91.0	Slupsk Furrow → Southern Gotland Basin
	end	14.02.2024 10:53	55° 24.11'N	018° 17.55'E	86.0	
EMB356_78-1	begin	14.02.2024 23:06	56° 20.89'N	019° 22.85'E	134.0	Eastern Gotland Basin
	end	15.02.2024 04:56	56° 56.52'N	019° 45.92'E	183.0	
EMB356_86-2	begin	15.02.2024 12:32	57° 19.17'N	020° 02.97'E	241.0	Gotland Deep surface-water
	end	15.02.2024 18:29	57° 19.19'N	020° 03.02'E	241.0	
EMB356_86-10	begin	15.02.2024 17:04	57° 19.21'N	020° 02.99'E	242.0	Gotland Deep deep-water
	end	15.02.2024 23:22	57° 19.18'N	020° 03.02'E	242.0	
EMB356_88-1	begin	16.02.2024 02:20	57° 37.05'N	020° 09.99'E	145.0	Northern Gotland Basin
	end	16.02.2024 08:15	58° 01.00'N	019° 55.00'E	191.0	
EMB356_97-1	begin	17.02.2024 12:05	58° 32.66'N	018° 13.98'E	374.0	Western Gotland Basin
	end	17.02.2024 17:48	57° 55.37'N	017° 49.61'E	176.0	

7.3 ScanFish Deployment List

Table 7.3 List of ScanFish deployments during the cruise EMB356

Deployment		time	Latitude	Longitude	Depth	Remarks
EMB		[UTC]	[UTC]	No.	[m]	
EMB356_102-2	begin	18.02.2024 11:16	55° 50.48'N	018° 52.02'E	101	Device test
	end	18.02.2024 11:44	55° 48.44'N	018° 50.24'E	95	
EMB356_103-1	begin	18.02.2024 12:00	55° 48.31'N	018° 50.13'E	96	Slupsk Sill transect
	end	19.02.2024 07:25	55° 15.47'N	015° 56.31'E	91	
EMB356_105-1	begin	19.02.2024 10:52	55° 14.72'N	016° 00.71'E	89	Bornholm Basin transect
	end	20.02.2024 02:00	54° 57.13'N	013° 59.07'E	46	
EMB356_106-2	begin	20.02.2024 02:34	54° 57.55'N	013° 59.11'E	46	Field calibration
	end	20.02.2024 02:42	54° 57.57'N	013° 59.02'E	46	

7.4 Mooring Deployment List

Table 7.4 List of mooring deployments during the cruise EMB356

Name	Latitude	Longitude	Deployed	Recovered	Depth	Remarks
			[UTC]	[UTC]	[m]	
GODESS	57°19.172‘N	20°08.002E	*12.11.2023*	15.02.2024 11:30	246	First release was successful, All devices recovered

7.5 Organic UV-Filter Sampling List

Table 7.5 List of UV Filter sampling stations (water) during the cruise EMB356

Deployment	Station	Organic UV-Filter			TiO_2	
EMB	IOW	Surface (1 l)	Chl-a Max (1 l)	Bottom (1 l)	Surface (0.1 l)	Bottom (0.1 l)
EMB356_14-1	TFO5 (+ QS)	X	X	X	X	X
EMB356_12-1	TF0012	X	X	X	X	X
EMB356_10-1	TF0022	X	X	X		
EMB356_4-1	TF0010	X	X	X		
EMB356_6-1	TF0360	X	X	X		
EMB356_16-1	TF0046	X	X	X		
EMB356_23-1	TF0113	X	X	X		
EMB356_38-1	TF0109	X	X	X	X	X
EMB356_26-1	OBBoje	X	X	X	X	X
EMB356_86-3	TF0271 (+ QS)	X			X	X

7.6 Surface Sediment Sampling List

Table 7.6 List of surface sediment sampling stations during the cruise EMB356

Deployment	Station	Device	Organic UV-Filter	
EMB	IOW		Surface Sediment water (1 l)	Sediment (g)
EMB356_12-9	TF0012	MUC	X	X
EMB356_4-2	TF0010	MUC	X	X
EMB356_106-3	TF0110a	MUC	X	X

Deployment	Station	Device	Organic UV-Filter	
EMB	IOW		Surface Sediment water (1 l)	Sediment (g)
EMB356_32-2	TF0069	MUC		X
EMB356_26-1	OBBoje	Van-Veen Grap		X

8 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. Date from German waters will be stored additionally in the BSH MUDAB data base.
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 8.1 Overview of data availability

Type	Database	Available	Free Access	Contact
Hydrographic data	ODIN	01.05.2024	01.03.2026	volker.mohrholz@io-warnemuende.de
Nutrient samples	ODIN	01.05.2024	01.03.2027	joachim.kuss@io-warnemuende.de
Biological samples	ODIN	01.10.2024	01.03.2027	joerg.dutz@io-warnemuende.de

The underway sampling data set of navigation, meteorological and surface water sensors will be public available shortly after the cruise from the DSHIP webpage of the BSH (http://dship.bsh.de).

9 Acknowledgements

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11 Appendix

11.1 Station Labels

A station name and a station number were assigned to all stations, where scientific equipment was used. The station name, also referred as position alias, identifies a geographical position. The station number is an alphanumerical value that is incremented for each new station. Each device deployment is indicated by numerical extension of the station number. The station number was applied according the station number rules of the DSHIP. For the cruise EMB356 the first station number is EMB356_1.

11.2 CTD-Operation

The CTD-system "SBE 911plus", SN-1385, (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
- Nitrate concentration (SUNA, OPUS)
- PAR
- SPAR

The CTD was equipped with a redundant sensor system sensor system for temperature, conductivity and oxygen. The temperature is given in ITS-90 temperature scale. Salinity is calculated from the Practical Salinity Scale (1978) equations. To minimize salinity spiking, temperature- (SBE 3), conductivity (SBE 4) and oxygen sensors (SBE 43) are arranged within a tube system, where seawater is pumped through with constant velocity. Fluorescence and turbidity are measured with a downward looking WET Labs fluorimeter. Pressure is determined with a Paroscientific Digiquartz pressure sensor, maximum range 6800 dbar.

Data were monitored during the casts and stored on hard disk with Seasave Version 7. For each station a configuration file (stationname.xmlcon) was written which contains the complete parameter set, especially sensor coefficients used for the conversion of raw data (frequencies) to standard output format.

The CTD-probe was equipped with a Rosette water sampler with 13 Free Flow bottles of 5l volume each. This design allows for closing of bottles automatically at predefined depths during down-casts. Closing depth and sensor values are aligned by appropriate choice of parameters of the CTD software generating the “bottle files”. Additionally, a self-contained SUNA nitrate sensor was mounted on the rosette frame. The CTD is attached to a heave-compensating winch, enabling the CTD during a cast to be nearly completely decoupled from the ships heave and roll movements.

Sampling

A CTD cast was started below the sea surface with the pressure sensor usually at about 5m depth to prevent a contamination of the CTD pumping system with air bubbles. Data were collected down to 0.5m above the bottom at all stations. An attached altimeter and a down-facing underwater camera including LED spotlights and laser were used to determine the bottom distance. Sampling rate of the CTD probe was 24Hz. Data were displayed online to determine appropriate sampling depth and stored on a PC hard drive.

The probe sheds water in its wake over a long distance. Hence, only downcast registration was reliable. Upcast registration was used only for water sampling, if the closing depth was determined during the downcast. At downcast bottles were closed while fiering in an auto-fire mode. For sampling during upcast, the CTD was stopped and bottles closed manually after a 30 second adjustment period. When the device was back on deck oxygen and/or hydrogen sulfide samples were taken first, followed by water samples for salinity, nutrients and water for several biogeochemical analyses.

Field sensor check

The CTD sensors were checked during the cruise by comparison measurements. At stations with well mixed water layers temperature was measured with a high precision thermometer SBE 35. Salinity samples were taken every day. The samples were stored in white glass bottles and will be analyzed after the cruise by means of a salinometer AUTOSAL Model 8400B (accuracy of 0.002). Most samples were taken from near surface layers, only a few deep well mixed layers could be found.

Slope and offset of the oxygen sensors SBE 43 were determined by help of water samples. Oxygen content of the samples was determined with a titration set (Winkler method, accuracy of 0.02ml/l). Oxygen concentration is calculated using Seasoft, oxygen formula “1”,

The pressure sensor was checked by measuring pressure on deck before the cast. Calibration measurements for the fluorometer data have not been done, since no quantitative phytoplankton analysis was performed, and no SPM samples were taken during the cruise.

Table 11.1 Type and serial numbers of mounted CTD sensors

Sensor	Type	SN	Last calibration
Pressure	Digiquartz	1385	02.05.2019
Temperature 0	SBE 3	5492	18.12.2023
Temperature 1	SBE 3	4451	18.12.2023
Conductivity 0	SBE 4	4497	18.12.2023
Conductivity 1	SBE 4	4007	18.12.2023
Oxygen 0	SBE 43	3619	31.01.2024
Oxygen 1	SBE 43	3826	31.01.2024
Chl-a fluorescence / Turbidity	WET Labs - FLNTURTD	22029	28.09.2010
PAR sensor	Biospherical Licor Chelsea	70256	08.12.2009
SPAR	SPAR/Surface Irradiance	6307	27.02.2017
SUNA	SBE		

11.3 Vessel Mounted ADCPs

Two VMADCPs were used during the cruise. The ships own vessel mounted current meter OceanSurveyor 150kHz and a 300kHz Acoustic Doppler Current Profiler (Work Horse, beam angle 20deg), manufactured by RD-Instruments, was mounted downward looking at the ships moon pool. The data output of the ADCPs were merged online with the corresponding navigation data and stored on the hard disc using the program VMDAS. Pitch, roll and heading data are converted from TCP/IP to UDP protocol with an own program, running on the VMADCP control PC. Current data are collected in beam coordinates to apply all corrections during post processing. The VMADCPs were operated on selected transects along the cruise track. The following configurations were used for data acquisition in the western and central Baltic.

Table 11.2 Configuration of 150kHz and the 300kHz VMADCP

Command	Parameter	150kHz	300kHz
WP	Broad band pings	1 ping/ens	1 ping/ens
WN	number of depth cells	65	80
WS	bin length	4m	2m
WF	blank after transmit	2m	1m
WV	Ambigiuity velocity	6.5m/s	6.5m/s
BP	bottom track	1 ping/ens	1 ping/ens
BX	max bottom distance	300m	260m
WD	data output	u, corr, amp, PG	u, corr, amp, PG
TP	time between pings	0	0
EZ	sensor source	temp	temp
EX	co-ordinates (ENX)	beam	beam
ED	transducer depth	4m	4m
ES	salinity	10	10
Data option dialog of VMADAS software	heading source	Ext. Gyro	Ext. Gyro
	pitch / roll source	Ext. Phins	Ext. Phins
	navigation source	Ext. GPS	Ext. GPS
	time per ensemble	2s	2s
	time between pings	1s	1s

	heading alignment	0 deg	0 deg
	heading bias	0 deg	0 deg
	short term average	60s	60s
	long term average	300s	300s
	data screening	off	off

Post-processing of the VMADCP data was carried out using the Matlab® ADCP toolbox of IOW. The final profiles are 120s and 300s averages of the single ping profiles. At sections where bottom tracking was available the heading bias of the instrument was calculated. This value and the magnetic deviation were applied during post processing.

11.4 ScanFish Towed CTD

A high resolution hydrographic transect with the ScanFish towed CTD (SF) was performed along the Baltic Thalweg from the southern Gotland Basin to the Arkona Basin. The ScanFish consists of a Seabird 911+ CTD mounted on a wing shaped body undulating between sea surface and about 130m depth when towed behind the ship. Additionally, to the usual CTD sensors, the probe is equipped with sensors for dissolved oxygen concentration, turbidity and Chlorophyll-a fluorescence. At the bottom side of the ScanFish a 300kHz ADCP Monitor was installed to gather current data. The details of the used sensors are given in Table 11.3.
Hydrographic data are transmitted via a multi-conductor cable and stored in the lab on a computer disc. The instrument was be deployed over the stern of the ship and was operated with a separate winch, mounted at the aft deck. The cable is guided by a pulley block mounted below the A-crane. The A-crane will be used for deployment and recovery. The device is towed with about 6 knots, the undulation depth is steered from the lab. Control commands are transmitted via the cable.

Table 11.3 Type and serial numbers of CTD sensors and the ADCP mounted on ScanFish

Sensor	Type	SN	Calibration date
Pressure	Digiquartz	0973	10.12.2010
Temperature 0	SBE 3	4525	08.01.2024
Temperature 1	SBE 3	5605	08.01.2024
Conductivity 0	SBE 4	3724	08.01.2024
Oxygen 0	SBE 43	3972	31.01.2024
Chl-a fluorescence / Turbidity	WET Labs - FLNTURTD	3274	10.06.2009
Current meter	ADCP 300kHz Monitor	24519	

11.5 Underway Measurements

The RV ELISABETH MANN BORGESE is equipped with numerous sensors, which continuously provide important environmental and navigation parameters. The available data set consists of weather parameters, surface water properties, navigation information, rope length, winch speed and more. The data are collected by a data acquisition system DSHIP3 manufactured by WERUM. All data are stored in a data base and can be extracted by a web interface. A description of all collected parameters is given in the ship specific DSHIP3 manual.

All data are snapshots taken and stored every second. After the cruise the full data set was extracted. During the cruise a subset of the parameters was processed.

This data set consists of 30 minutes averages of:

- time (UTC)
- latitude and longitude
- ships heading
- depth
- air pressure
- air temperature
- humidity
- global radiation
- infrared radiation
- Surface conductivity
- Surface salinity (SSS)
- Surface water temperature (SST)
- Surface chlorophyll-a fluorescence
- Surface turbidity
- Wind direction
- Wind speed