ELISABETH MANN BORGESE

Baltic Monitoring Programm (BMP)

Cruise No. EMB311

03.2.2023 – 16.02.2023,
Rostock-Marienehe (Germany) – Rostock-Marienehe (Germany)
HELCOM/long-term

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2023

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1 Cruise Summary

1.1 Summary in English

The cruise of r/v Elisabeth Mann Borgese No. 311 from February 3th to 16th 2023 was carried out in the frame of the HELCOM monitoring and the IOW long-term observation of the Baltic Sea (BMP). The cruise was conducted during the end of the winter season. The weather conditions included strong winds that postponed the start of the cruise by one day, from the February 3th to the 4th, as well as the period between the afternoon of the 8th and noon of the 11th, where shelter was seek in the Kalmarsund, Sweden. These periods reduced the available work time by 3 days. Due to a technical malfunction both the assistant crane and the mooring winch were not operable. The mooring winch was replaced by an hydraulic version and the main crane was used instead of the assistant crane. This combination required two instead of one sailors for the operation and omitted night shifts for some measurements.
Despite these boundary conditions, the main task of the monitoring program could be achieved, namely the measurements of the BMP transect from the western Baltic Sea towards the central Baltic Sea. A small time window of fair weather allowed the recovery of the GODESS-Mooring in the eastern Gotland Basin. Additional work like Scanfish transects in the central Baltic Sea had to be cancelled.

1.2 Zusammenfassung

Die Forschungsfahrt Nr. 311 des Forschungsschiffes Elisabeth Mann Borgese vom 3. bis 16. Februar 2023 wurde im Rahmen des HELCOM-Monitorings und der IOW-Langzeitbeobachtung der Ostsee (BMP) durchgeführt. Die Fahrt fand am Ende der Wintersaison statt. Durch schlechte Wetterbedingungen wurde der Beginn der Fahrt vom 3. auf den 4. Februar verschoben, weiterhin musste im Zeitraum zwischen dem Nachmittag des 8. und dem Mittag des 11. Februar im Kalmarsund ein Sturm abgewettert werden. Diese Zeiträume reduzierten die verfügbare Arbeitszeit um 3 Tage. Aufgrund einer technischen Störung waren sowohl der Hilfskran als auch die Verankerungswinde nicht funktionsfähig. Die Verankerungswinde wurde durch eine hydraulische Version ersetzt und der Hauptkran wurde anstelle des Hilfskrans eingesetzt. Diese Kombination erforderte zwei statt einem Matrosen für den Betrieb. Dieser Mehraufwand bedeutete, dass Arbeiten, die diese Geräte erforderten, nicht in der Nacht ausgeführt werden konnten.
Trotz dieser Randbedingungen konnte die Hauptaufgabe des Monitoringprogramms, die Messungen des BMP-Transekts von der westlichen Ostsee zur zentralen Ostsee, erfüllt werden. Ein kleines Zeitfenster mit ausreichend ruhigen Wetters ermöglichte die Wiederaufnahme der GODESS-Mooring im östlichen Gotlandbecken. Zusätzliche Arbeiten, wie Scanfish-Transekte in der zentralen Ostsee, mussten durch den oben beschriebenen Zeitmangel abgesagt werden.

2 Participants

2.1 Principal Investigators

Name	Institution

Holtermann, Peter, Dr. (Chief Scientist)	IOW
Mohrholz, Volker, Dr. (Hydrography)	IOW
Dutz, Jörg, Dr. (Zooplankton)	IOW
Kremp, Anke, Dr. (Phytoplankton)	IOW
Kuss, Joachim, Dr. (Marine Chemistry)	IOW
Kanwischer, Marion, Dr. (Contaminants)	IOW
Dürwald, Alexandra, Dr. (*eDNA-archive)*	Univ. Greifswald

2.2 Scientific Party

Name	Discipline	Institution
Holtermann, Peter, Dr.	Physical Oceanography / Chief Scientist	IOW
Söder, Jens, Dr.	Physical Oceanography / CTD	IOW
Sass, Martin	Physical Oceanography / CTD	IOW
Fechtel, Christin	Biol. Oceanogr., Plankton and Microbiol.	IOW
Otto, Stefan, Dr.	Marine Chemistry, Nutrients	IOW
Kreuzer, Lars	Marine Chemistry, Oxygen	IOW
Jeschek, Jenny	Marine Chemistry, Nutrients, Contaminants	IOW
Hand, Ines	Marine Chemistry, Nutrients, Contaminants	IOW
Klostermann, Birgit	Marine Chemistry, Nutrients	IOW
Barghorn, Leonie	Physical Oceanography / CTD	IOW
Floth-Peterson, Mareike	Marine Chemistry, GODESS	IOW
Dürwald, Alexandra, Dr.	Biol. Oceanogr., eDNA-Archive	Uni-Greifs.

2.3 Participating Institutions

IOW Leibniz Institute for Baltic Sea Research, Warnemünde
Uni-Greifs. University of Greifswald

3 Research Program

3.1 Description of the Work Area

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

surface water samples and CTD stations are shown in Figures 3.1 to 3.3. The list of stations is given in Chapter 6 for the detailed time table of stations and activities.

3.2 Aims of the Cruise

The cruise EMB 311 was carried out as a joint campaign of the environmental monitoring programme of the Federal Maritime and Hydrographic Agency (BSH) and the Baltic Sea long-term observation programme of IOW. It was the first of five planned campaigns in 2023. The acquired data are used for the regular national and international assessments of the state of the Baltic Sea, and provide the scientific basis for measures to be taken for the protection of the Baltic Sea ecosystem. The hydrographic and hydrochemical conditions as well as the development status of phytoplankton and zooplankton abundances are investigated. Microbiological aspects, acidification, and trace gases were additionally studied in the frames of the long-term observation of the Baltic Sea. A special focus of the long-term observation is always the occurrence or absence of inflow events that both have major consequences for the state of the Baltic Sea's hydrochemistry and its ecosystem. The stagnation phase continued and oxygen depletion in deep waters intensified in the last five years by ongoing accumulation of hydrogen sulphide in deep waters of the central basins.

3.3 Agenda of the Cruise

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

CTD and Sampling

The CTD-system "SBE 911plus" (SEABIRD-ELECTRONICS, USA) was used to measure the variables: Pressure (SN: 1385), Temperature (2x SBE 3, primary: SN5492, secondary: SN4451), Conductivity (2x SBE 4, primary: SN2936, secondary: 4007), Oxygen concentration (2x SBE 43, primary: 1341, secondary: 1733, after station TF0226: primary: 1732, secondary: 1733), Chlorophyll-a fluorescence (WET Labs ECO-AFL/FL, 683 nm, SN: FL_22029_5V), Turbidity (WET Labs, ECO-NTU, SN: NTU_2029_5V), Photosynthetic active radiation in water (PAR, Biospherical/Licor, SN: PAR_70256_5V), and above the sea (SPAR, Biospherical/Licor, SN: 6307).

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

Nutrients

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

Oxygen and hydrogen sulphide

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

Plankton sampling

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

Long-term observation of the microbiological habitat of the redoxcline

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

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

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

Sensor tests in the frame of the projects DArgo2025 and C-SCOPE

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

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

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

Contaminants
To collect water samples for organic compounds such as Polychlorinated Biphenyls (PCB), Dichlorodiphenyl trichloroethane (DDT) and its metabolites as well as Polycyclic aromatic hydrocarbons (PAH) a pump/filtration system drawing water from the clean water lines of the research vessels were used along nine defined transects. Hereby an in-situ pump system separated dissolved and SPM-associated contaminants.
For Hexachlorocyclohexane (HCH) samples were collected at selected stations with a 10 l glass bowl sampler from 5 meter depth and additionally at 80 m depth at the station TF271.

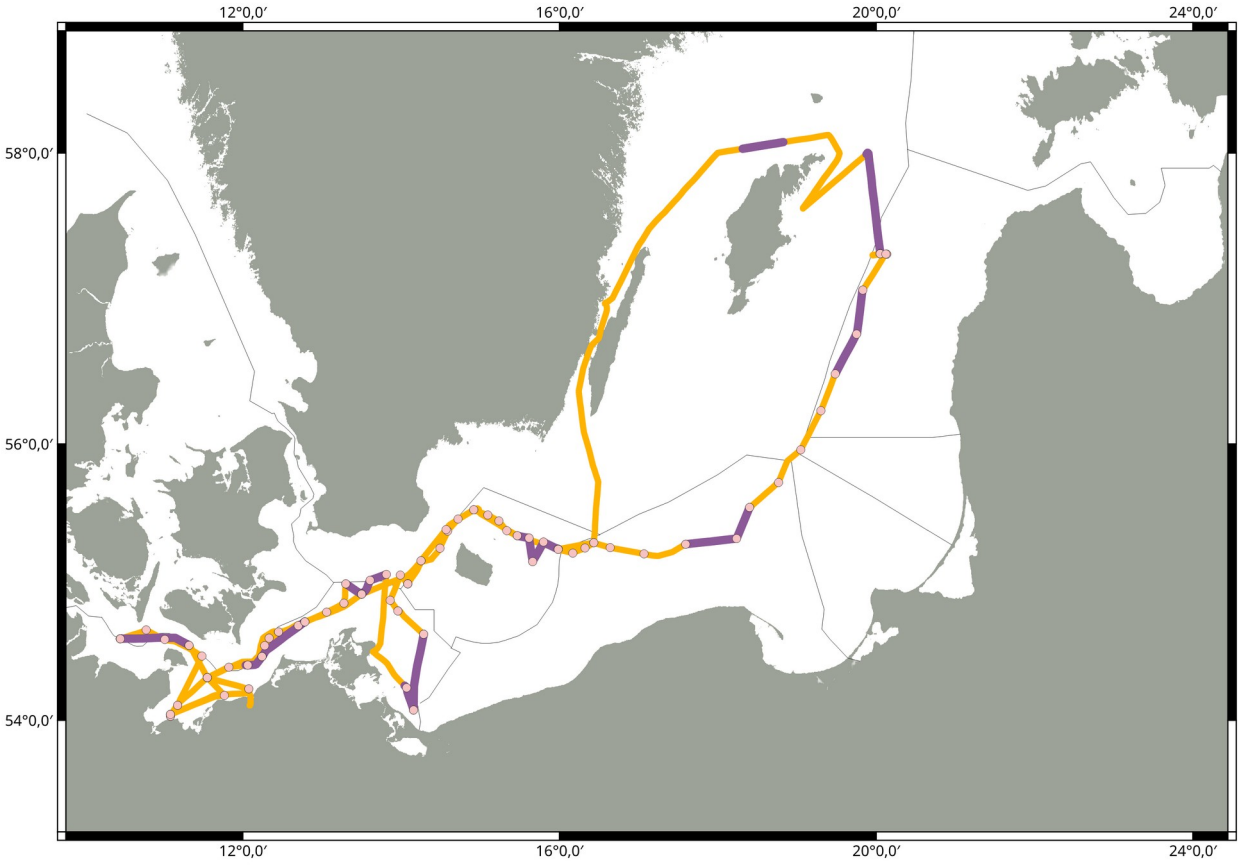

Fig. 3.1 Track chart of R/V Elisabeth Mann Borgese Cruise EMB311. Track in orange. Borders of EEZ in black. Marked in purple are samples of contaminants using the througflow system of the EMB. CTD stations as light red dots.

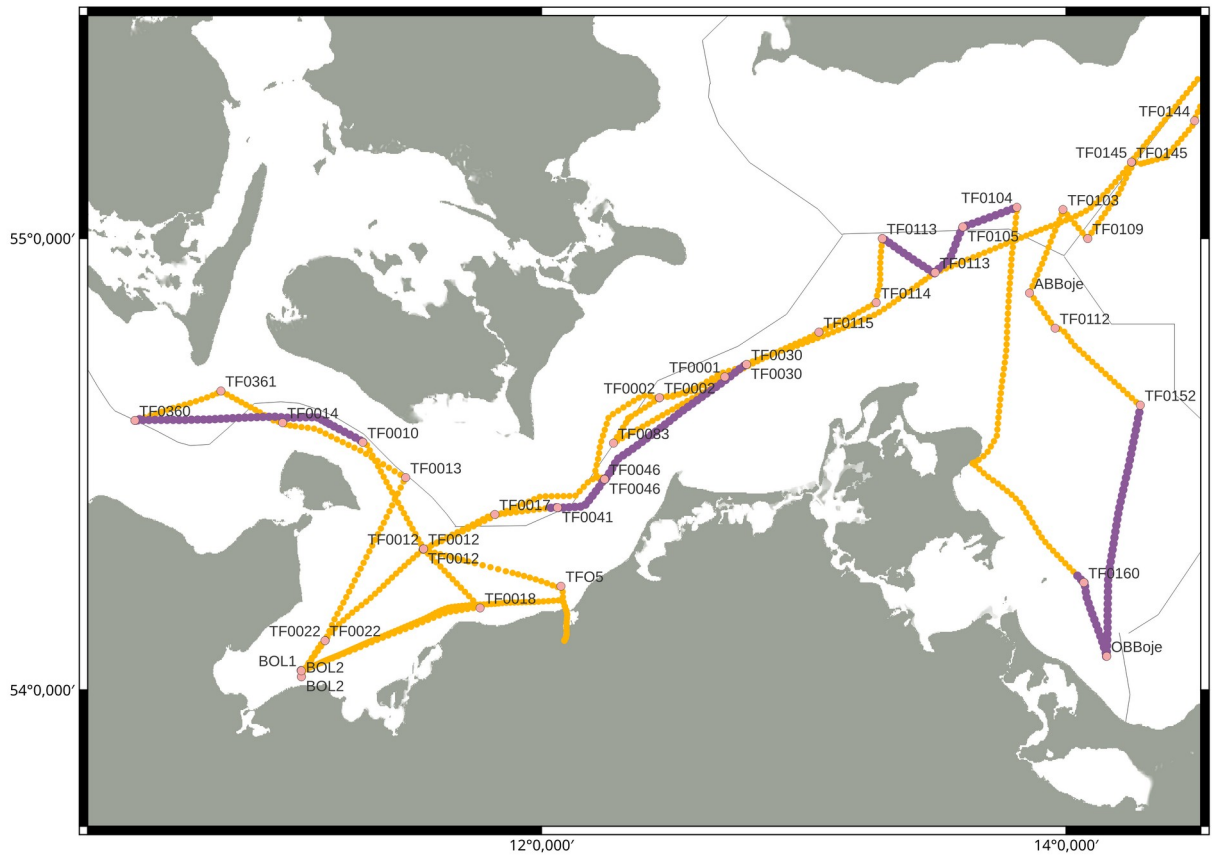

Fig. 3.2 Track chart of R/V Elisabeth Mann Borgese Cruise EMB311, detail of the western Baltic Sea. Track in orange. Borders of EEZ in black. Marked in purple are samples of contaminants using the througflow system of the EMB. CTD stations as light red dots with station names.

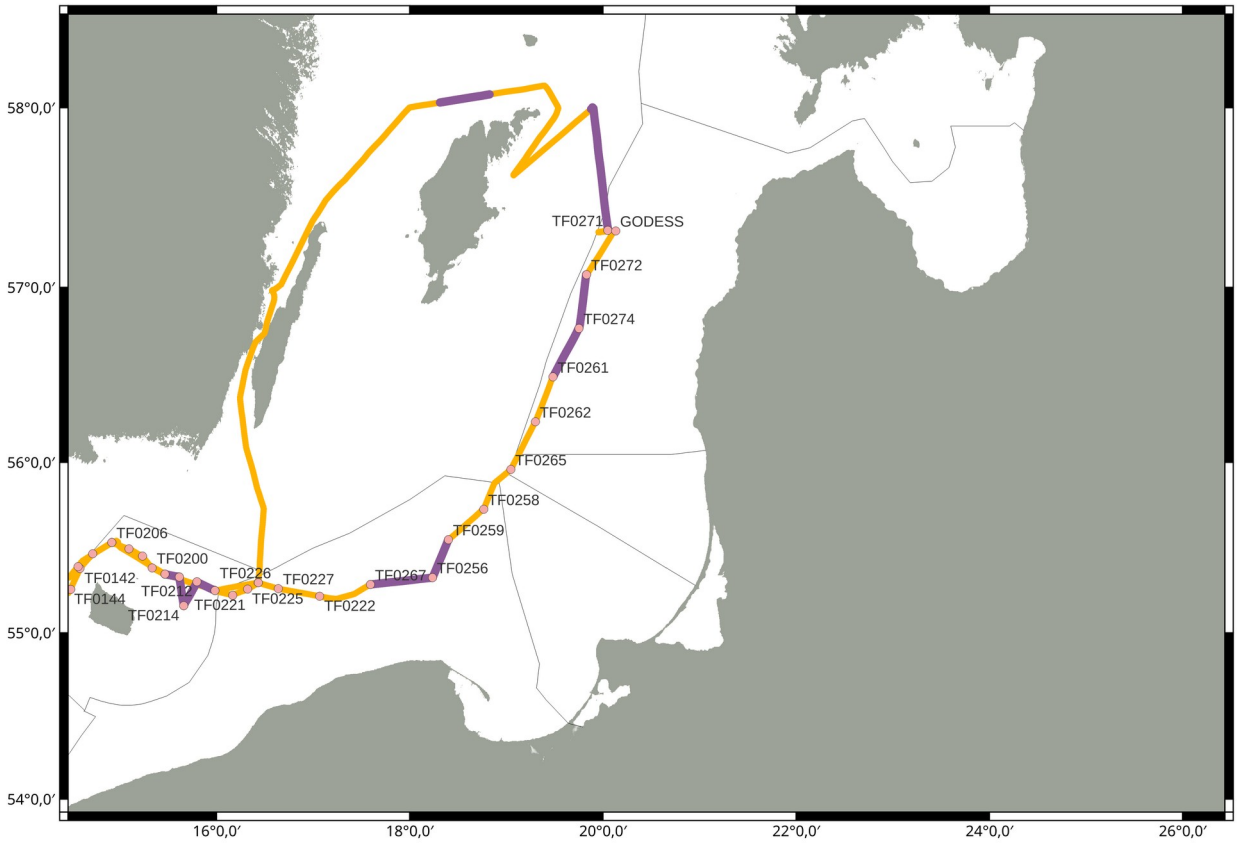

Fig. 3.3 Track chart of R/V Elisabeth Mann Borgese Cruise EMB311, detail of the central Baltic Sea. Track in orange. Borders of EEZ in black. Marked in purple are samples of contaminants using the througflow system of the EMB. CTD stations as light red dots with station names.

4 Narrative of the Cruise

3.2.2023:

Due to a technical malfunction both the assistant crane and the mooring winch were not operable and could not be repaired due to long delivery times of the replacement parts. The mooring winch could fortunately replaced by an hydraulic version and the main crane was used instead of the assistant crane. This combination required two instead of one sailors for the operation. This extra amount of work omitted some measurements during the night shifts and caused additional stress on the ships hydraulic system, that caused a temporarily malfunction of the hydraulics at the end of the cruise. Due to bad weather the start of the cruise had to be postponed by one day. 4.2.2023: Departure from Marienehe at 8:00 local time, begin of station work at station TF05 and the sampling area of the western Baltic Sea. Station work at station TF0012 was done without the Zooplanktonnet (WP2) due to unknown sampling procedure with the new combination of main crane and the mooring winch. This is mainly caused by the fact that the rope speed of mooring winch cannot be adjusted and was unknown. For this reason first tests of the winch speed had to be performed together with consultance from shore if the speed combination is feasible. This work was done during the day and in the evening the WP2 was successfully deployed. WP2 measurements at station TF0012 were done later during the cruise. The following stations in the western Baltic Sea were routinely. 5.2.2023: Additionally to the

stations of the BMP, two stations near the village Boltenhagen were sampled (BOL1, BOL2). These stations will be used for the intercalibration of moored devices very near to the CTD casts. A comparison of the oxygen sensors was done at stations TF0046. On the 6.2.2023 a transfer of Dr. Alexandra Dürwald from the ship to the harbour of Sassnitz was performed. By routine checks of the oxygen sensors a pressure dependent drift was noticed on the primary sensor on the 7.2.2023. For this reason SBE-43 #1341 was changed by #1732 before stations TF207. Due to coming bad weather conditions the profiles were paused after TF0226 at 5:30 on the 8.2.2023 and it was decided to weather the upcoming storm in the Kalmasund. At 15:00 ship was moored. On the 10.02.2023 at 14:00 a floating test of the ARGO float was performed with the help of the main ship crane. The anchor was lifted on the 11.02.2023 at 11:00. The weather with wind speeds of up to 9 Bft in the Landsort Deep as well as the Gotland Basin did not allow for CTD sampling and stations in the Landsort deep had to be omitted. The pumping method used for the surface contaminant measurements could still be used and was used to sample the northern transect of the eastern Gotland Basin. The central station TF271 was reached on Feb. 12 and station work started immediately. Several CTD casts and the subsequent work on the samples were performed over the day and during the night. The first work task on the morning of Feb. 13 was the recovery of the GODESS winch system, which was on deck at 7:56 UTC. Only the winch was recovered, since the profiling instrument platform (PIP) was cut from the system earlier this year. The potential reason for this malfunction was the presence of several waste plastic sheets, bags and garbage in the winch and the rope system of the GODESS. Shortly after the recovery of the GODESS the BGC-ARGO Float was deployed at 8:40 UTC in the very vicinity of the former GODESS mooring location. After the ARGO deployment the routine BMP measurements were continued. Due to the abort of the transect on Feb. 8 after station TF0226 it was decided to sample the whole transect towards the western Baltic Sea with a somewhat coarser grid, allowing a quasi-synoptic picture of the Thalweg from the western Baltic Sea to the eastern Gotland Basin. The work was continued without any major difficulties until the hydraulic system of the ship had to be shutdown on the 15.02.2023 at 10:30, due to a contamination of the hydraulic oil with sea water caused by the mooring winch. This caused the abortion of the Planktonnet operations on this last day of the cruise.

5 Preliminary Results

5.1 CTD Thalweg

(P. Holtermann)

The general vertical structure of the Baltic Sea during EMB311 is governed by a two layer winter structure (Reissmann et al. 2009), with the cold upper layer and the warmer deep water below the halocline, Fig. 5.1 upper panel. The oxygen concentration in the deep Gotland Basin is governed by anoxic conditions, pointing to a stagnation period, Fig. 5.1, lower panel. Interesting is the slightly enhanced oxygen at distance ~250 km, in the vicinity of the Bornholm Basin which correlates with colder temperatures. This water might be a sign of new water entering the Baltic Sea.

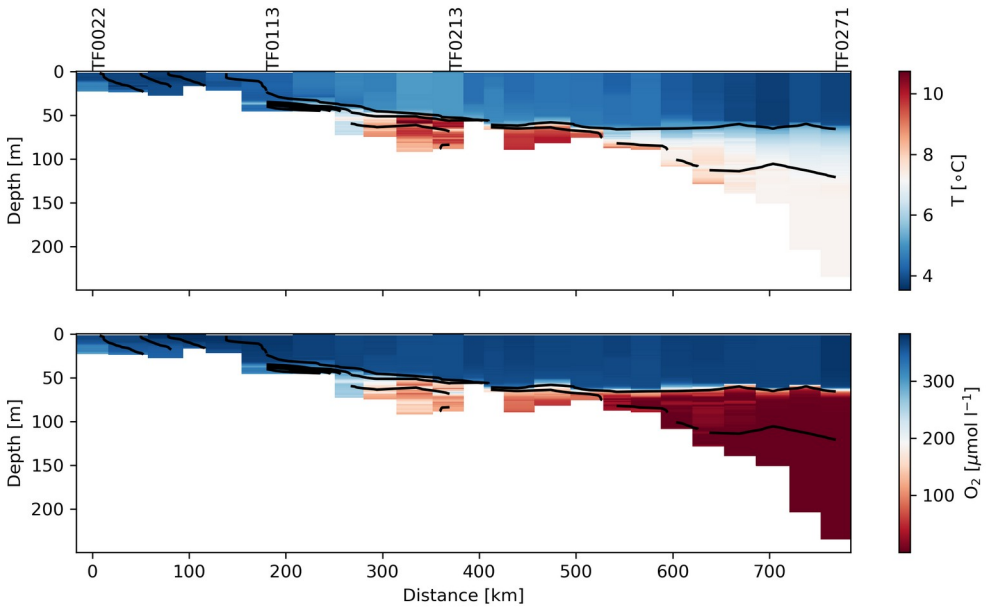

Figure 5.1: Temperature and oxygen concentrations along the thalweg of the BMP monitoring stations. Stations names are marked at the top. Density contours in black every 2 kg m^{-3}.

5.2 GODESS Recovery

(P. Holtermann and M. Floth-Peterson)

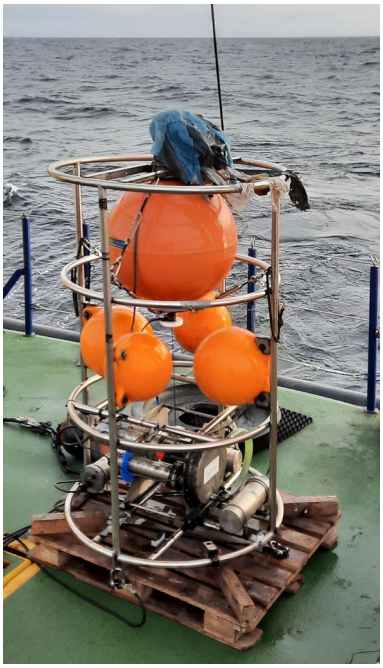

Figure 5.2: Winch Part of the GODESS after recovery on the Feb. 13. Notice the plastic garbage at the top.

During this cruise, which was the first ship of opportunity after the detachment of the profiling part (PIP) from the winch was noticed, the winch system of the GODESS (Prien & Schulz-Bull, 2016) was recovered on Feb. 13. 2023. Apart from the recovery of the hardware the investigation of the reason, that caused the detachment of the profiler was one of the goals during recovery. By visual inspection it is very likely that entangled plastic caused a clogging of the part where the PIP attaches to the winch system. Since the winch pulls as long as a sensor within the clogged

part is triggered, the winch never stopped to try to pull down the PIP which drained eventually the batteries. Without power the winch loosened the rope holding the PIP which ascended to the surface where the rope probably broke due to wave motions.

6 Station List EMB311

6.1 Overall Station List

Station No.		Date	Gear	Time	Latitude	Longitude	Water Depth	Remarks/ Recovery
EMB	IOW	MM/ DD 2023		[UTC]	[°N]	[°W]	[m]	
EMB311_1-1	TFO5	02/04	CTD	08:19:12	54.231920	12.074557	10	
EMB311_1-2	TFO5	02/04	SD	08:21:11	54.231964	12.074664	10	
EMB311_2-1	TF0012	02/04	CTD	11:21:00	54.314990	11.549920	22	
EMB311_2-2	TF0012	02/04	SD	11:21:09	54.314995	11.549919	22	
EMB311_2-3	TF0012	02/04	PLA	11:22:03	54.315022	11.549919	22	
EMB311_2-4	TF0012	02/04	CTD	11:56:15	54.315043	11.550124	22	
EMB311_2-5	TF0012	02/04	GLASSPHERE	12:25:57	54.315081	11.549949	22	
EMB311_3-1	TF0010	02/04	CTD	14:28:49	54.551484	11.319208	26	
EMB311_3-2	TF0010	02/04	GLASSPHERE	14:49:02	54.551572	11.319714	26	
EMB311_3-3	TF0010	02/04	GLASSPHERE	14:57:56	54.551716	11.319852	26	
EMB311_4-1	TF0360	02/04	CTD	18:33:56	54.600025	10.450413	15	
EMB311_4-2	TF0360	02/04	PLA	18:43:35	54.599894	10.450071	15	
EMB311_4-3	TF0360	02/04	WP2	19:04:12	54.599688	10.450978	15	
EMB311_4-4	TF0360	02/04	GLASSPHERE	19:12:56	54.599697	10.452006	15	
EMB311_5-1	TF0361	02/04	CTD	20:58:34	54.665049	10.778334	21	
EMB311_6-1	TF0014	02/04	CTD	22:32:16	54.594938	11.013453	25	
EMB311_7-1	TF0013	02/05	CTD	00:47:29	54.473423	11.482695	24	
EMB311_8-1	TF0022	02/05	CTD	03:30:07	54.110680	11.175707	20	
EMB311_9-1	BOL2	02/05	CTD	04:31:38	54.029667	11.085242	10	
EMB311_10-1	BOL1	02/05	CTD	05:06:24	54.043560	11.083878	24	
EMB311_11-1	TF0018	02/05	CTD	08:11:50	54.183394	11.766423	18	
EMB311_12-1	TF0012	02/05	CTD	09:52:46	54.314732	11.550388	22	
EMB311_12-2	TF0012	02/05	WP2	10:09:04	54.314696	11.550902	22	
EMB311_12-3	TF0012	02/05	WP2	10:15:29	54.314710	11.550766	22	
EMB311_13-1	TF0017	02/05	CTD	11:37:25	54.391692	11.822699	19	
EMB311_14-1	TF0041	02/05	CTD	12:50:24	54.406885	12.061723	16	
EMB311_15-1	TF0046	02/05	CTD	14:03:21	54.469890	12.241677	26	
EMB311_15-2	TF0046	02/05	SD	14:05:07	54.469773	12.242014	26	
EMB311_15-3	TF0046	02/05	PLA	14:06:44	54.469726	12.242243	26	
EMB311_15-4	TF0046	02/05	WP2	14:30:05	54.469581	12.242270	26	
EMB311_15-5	TF0046	02/05	WP2	14:34:45	54.469593	12.242236	26	
EMB311_15-6	TF0046	02/05	CTD	14:41:48	54.469719	12.242125	26	
EMB311_15-7	TF0046	02/05	GLASSPHERE	14:47:41	54.469713	12.241874	26	
EMB311_15-8	TF0046	02/05	GLASSPHERE	14:53:40	54.469800	12.241383	26	
EMB311_16-1	TF0030	02/05	CTD	17:53:43	54.723356	12.781632	20	
EMB311_16-2	TF0030	02/05	PLA	17:54:43	54.723350	12.781717	20	
EMB311_16-3	TF0030	02/05	GLASSPHERE	18:07:43	54.723419	12.782692	20	
EMB311_16-4	TF0030	02/05	CTD	18:27:08	54.723280	12.783111	20	
EMB311_17-1	TF0083	02/05	CTD	21:34:25	54.549741	12.274926	23	
EMB311_18-1	TF0033	02/05	CTD	22:29:02	54.604555	12.331840	17	
EMB311_19-1	TF0002	02/05	CTD	23:27:19	54.649782	12.449686	15	
EMB311_20-1	TF0001	02/06	CTD	00:52:01	54.696129	12.699255	18	
EMB311_21-1	TF0115	02/06	CTD	02:50:16	54.794610	13.058080	28	
EMB311_22-1	TF0114	02/06	CTD	04:13:19	54.859440	13.276386	43	
EMB311_23-1	TF0113	02/06	GLASSPHERE	05:36:52	54.999828	13.299899	45	
EMB311_23-2	TF0113	02/06	CTD	05:37:34	54.999903	13.299854	45	

EMB311_24-1	TF0113	02/06	CTD	07:06:31	54.925048	13.499639	46	
EMB311_24-2	TF0113	02/06	PLA	07:07:01	54.925053	13.499671	46	
EMB311_24-3	TF0113	02/06	SD	07:09:01	54.925068	13.499789	45	
EMB311_24-4	TF0113	02/06	WP2	07:27:20	54.925165	13.499080	46	
EMB311_24-5	TF0113	02/06	WP2	07:35:55	54.925419	13.499638	46	
EMB311_24-6	TF0113	02/06	WP2	07:40:43	54.925474	13.499594	45	
EMB311_24-7	TF0113	02/06	GLASSPHERE	07:51:17	54.926067	13.499775	46	
EMB311_24-8	TF0113	02/06	CTD	08:11:12	54.925810	13.500871	46	
EMB311_25-1	TF0105	02/06	CTD	09:21:30	55.025325	13.606979	45	
EMB311_26-1	TF0104	02/06	CTD	10:35:03	55.068222	13.812784	44	
EMB311_27-1	TF0160	02/06	CTD	17:45:11	54.240124	14.068090	12	
EMB311_28-1	OBBoje	02/06	CTD	19:17:29	54.075392	14.155493	12	
EMB311_28-2	OBBoje	02/06	GLASSPHERE	19:22:49	54.075518	14.155711	12	
EMB311_29-1	TF0152	02/06	CTD	23:10:24	54.633691	14.283445	29	
EMB311_29-2	TF0152	02/06	GLASSPHERE	23:17:23	54.633428	14.283366	29	
EMB311_30-1	TF0112	02/07	CTD	01:08:22	54.803222	13.958744	38	
EMB311_30-2	TF0112	02/07	CTD	01:36:51	54.802782	13.957922	38	
EMB311_31-1	ABBoje	02/07	CTD	02:35:09	54.880536	13.861040	44	
EMB311_32-1	TF0103	02/07	CTD	04:35:24	55.063355	13.988538	45	
EMB311_33-1	TF0109	02/07	CTD	05:43:04	54.999986	14.083757	46	
EMB311_33-2	TF0109	02/07	PLA	05:45:06	55.000058	14.083658	46	
EMB311_33-3	TF0109	02/07	GLASSPHERE	05:54:47	54.999655	14.083262	46	
EMB311_33-4	TF0109	02/07	WP2	06:10:31	54.999700	14.083335	46	
EMB311_33-5	TF0109	02/07	WP2	06:15:26	54.999858	14.083027	46	
EMB311_34-1	TF0145	02/07	CTD	07:56:43	55.166572	14.250909	45	
EMB311_35-1	TF0144	02/07	CTD	09:56:27	55.256871	14.490437	42	
EMB311_36-1	TF0142	02/07	CTD	11:14:08	55.380044	14.586192	67	
EMB311_37-1	TF0140	02/07	CTD	12:21:06	55.466637	14.717940	68	
EMB311_38-1	TF0206	02/07	CTD	13:35:16	55.532991	14.916375	76	
EMB311_39-1	TF0207	02/07	CTD	14:48:18	55.495559	15.093698	85	
EMB311_40-1	TF0208	02/07	CTD	15:50:22	55.453048	15.234252	92	
EMB311_41-1	TF0200	02/07	CTD	17:15:25	55.383068	15.333719	91	
EMB311_42-1	TF0209	02/07	CTD	18:18:44	55.346381	15.466643	93	
EMB311_43-1	TF0211	02/07	CTD	19:26:05	55.330057	15.615525	95	
EMB311_44-1	TF0214	02/07	CTD	21:03:10	55.160281	15.660589	94	
EMB311_45-1	TF0212	02/07	CTD	22:33:22	55.301975	15.797243	94	
EMB311_46-1	TF0213	02/07	CTD	23:48:18	55.249879	15.983730	89	
EMB311_46-2	TF0213	02/08	GLASSPHERE	00:00:37	55.249724	15.983485	90	
EMB311_46-3	TF0213	02/08	GLASSPHERE	00:13:59	55.249760	15.983339	89	
EMB311_46-4	TF0213	02/08	WP2	00:27:36	55.249739	15.983388	89	
EMB311_46-5	TF0213	02/08	WP2	00:35:09	55.249706	15.983500	90	
EMB311_46-6	TF0213	02/08	WP2	00:42:41	55.249864	15.983089	89	
EMB311_46-7	TF0213	02/08	WP2	00:49:04	55.249762	15.983134	89	
EMB311_46-8	TF0213	02/08	CTD	01:06:23	55.249715	15.982911	89	
EMB311_46-9	TF0213	02/08	PLA	01:11:30	55.249833	15.983206	89	
EMB311_47-1	TF0221	02/08	CTD	02:13:24	55.221588	16.167730	82	
EMB311_48-1	TF0225	02/08	CTD	03:18:14	55.258600	16.321848	65	
EMB311_49-1	TF0226	02/08	CTD	04:16:33	55.296921	16.431917	56	
EMB311_50-1	TF0271	02/12	CTD	21:05:08	57.320323	20.050589	241	
EMB311_50-2	TF0271	02/12	PLA	21:08:24	57.320398	20.050312	243	
EMB311_50-3	TF0271	02/12	GLASSPHERE	21:20:49	57.320362	20.050105	243	
EMB311_50-4	TF0271	02/12	GLASSPHERE	21:44:40	57.320071	20.049990	243	
EMB311_50-5	TF0271	02/12	CTD	22:11:08	57.320211	20.049968	242	
EMB311_50-6	TF0271	02/12	CTD	22:58:59	57.320251	20.050353	243	
EMB311_50-7	TF0271	02/12	CTD	23:42:20	57.320217	20.049813	243	
EMB311_50-8	TF0271	02/13	CTD	00:18:51	57.320126	20.050172	241	
EMB311_50-9	TF0271	02/13	CTD	00:59:42	57.320076	20.050369	243	
EMB311_50-10	TF0271	02/13	CTD	01:21:15	57.320000	20.050188	243	
EMB311_51-1	GODESS	02/13	MOOR	07:06:17	57.317020	20.133188	246	Hydrophone release command
EMB311_51-1	GODESS	02/13	MOOR	07:56:14	57.318481	20.126026	246	Device on deck
EMB311_51-2	GODESS	02/13	MOOR	08:37:17	57.317789	20.121976	246	ARGO float deployed
EMB311_52-1	TF0272	02/13	CTD	10:51:27	57.071576	19.831278	210	

EMB311_53-1	TF0274	02/13	CTD	13:40:46	56.767804	19.752390	155	
EMB311_54-1	TF0261	02/13	CTD	16:32:46	56.491599	19.483055	144	
EMB311_55-1	TF0262	02/13	CTD	19:29:03	56.234259	19.301624	133	
EMB311_56-1	TF0265	02/13	CTD	22:17:50	55.958835	19.047431	112	
EMB311_57-1	TF0258	02/14	CTD	00:54:02	55.727040	18.766512	90	
EMB311_58-1	TF0259	02/14	CTD	03:11:33	55.549254	18.401018	90	
EMB311_58-2	TF0259	02/14	PLA	03:13:05	55.549404	18.400681	90	
EMB311_59-1	TF0256	02/14	CTD	05:16:09	55.326223	18.236383	79	
EMB311_60-1	TF0267	02/14	CTD	08:10:00	55.285543	17.593647	84	
EMB311_61-1	TF0222	02/14	CTD	10:49:39	55.216471	17.067327	91	
EMB311_62-1	TF0227	02/14	CTD	12:51:38	55.261325	16.639938	68	
EMB311_63-1	TF0226	02/14	CTD	14:03:50	55.296508	16.432684	57	
EMB311_64-1	TF0213	02/14	CTD	16:07:36	55.249940	15.983806	89	
EMB311_64-2	TF0213	02/14	PLA	16:09:34	55.250026	15.983887	89	
EMB311_64-3	TF0213	02/14	WP2	16:28:08	55.249932	15.983415	89	
EMB311_64-4	TF0213	02/14	WP2	16:36:24	55.250022	15.983296	89	
EMB311_64-5	TF0213	02/14	WP2	16:42:35	55.249496	15.983442	90	
EMB311_64-6	TF0213	02/14	WP2	16:49:28	55.248848	15.983287	89	
EMB311_65-1	TF0209	02/14	CTD	19:18:03	55.346985	15.466443	93	
EMB311_66-1	TF0206	02/14	CTD	22:36:28	55.533019	14.916055	75	
EMB311_67-1	TF0142	02/15	CTD	00:39:26	55.390910	14.567272	73	
EMB311_68-1	TF0145	02/15	CTD	03:00:31	55.166896	14.249805	45	
EMB311_69-1	TF0113	02/15	CTD	07:00:05	54.925225	13.501200	45	
EMB311_69-2	TF0113	02/15	PLA	07:00:26	54.925223	13.501217	45	
EMB311_69-3	TF0113	02/15	WP2	07:21:39	54.924826	13.500308	45	
EMB311_69-4	TF0113	02/15	WP2	07:26:58	54.924918	13.499995	45	
EMB311_70-1	TF0030	02/15	CTD	10:58:25	54.723478	12.782258	20	
EMB311_70-2	TF0030	02/15	PLA	10:59:33	54.723410	12.782305	20	
EMB311_70-3	TF0030	02/15	CTD	11:29:30	54.723330	12.783198	20	
EMB311_71-1	TF0002	02/15	CTD	13:13:21	54.650129	12.450125	15	
EMB311_72-1	TF0046	02/15	CTD	15:18:40	54.469816	12.240992	26	
EMB311_72-2	TF0046	02/15	PLA	15:21:18	54.469676	12.241539	26	
EMB311_73-1	TF0012	02/15	CTD	18:43:18	54.315094	11.550822	22	
EMB311_73-2	TF0012	02/15	PLA	18:45:43	54.315040	11.550510	22	
EMB311_74-1	TF0022	02/15	CTD	21:03:43	54.110439	11.175234	20	
EMB311_75-1	BOL2	02/15	CTD	22:08:22	54.029646	11.085286	10	
EMB311_76-1	BOL1	02/15	CTD	22:37:30	54.043000	11.084889	24	

Secchi disk (SD):	Defined white disk with bore holes to determine water transparency
WP-2 net (WP2):	Plankton net with closing mechanism and removable net bucket for zooplankton sampling
Plankton Net (PLA):	Small hand-thrown net for phytoplankton sampling in the Mixed Layer (ML)
CTD:	CTD rosette system with fluorometer, oxygen sensor, water sampler, and video camera
GLASSPHERE:	Glassphere used to sample contaminants

7 Data and Sample Storage and Availability

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

The access to the data will be restricted for three years after the data acquisition, to protect the research process, including scientific analysis and publication. After that time the data will become openly available to any person or any organization who requests them, under the international Creative Commons (CC) data license of type CC BY 4.0

(https://creativecommons.org/licenses/by/4.0/). For further details, refer to the IOW data policy document.

Table 7.1 Overview of data availability

Type	Database	Available	Free Access	Contact
Hydrographic data	ODIN	01.08.2023	01.08.2026	volker.mohrholz@io-warnemuende.de
Nutrient data	ODIN	01.08.2023	01.08.2026	joachim.kuss@io-warnemuende.de
Zooplankton	ODIN	01.08.2023	01.08.2026	joerg.dutz@io-warnemuende.de
Phytoplankton	ODIN	01.08.2023	01.08.2026	anke.kremp@io-warnemuende.de
Contaminants	ODIN	01.08.2023	01.08.2026	marion.kanwischer@io-warnemuende.de

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9 References

Grasshoff, K., Kremling, K., Ehrhardt, M., 1999. Methods of seawater analysis, 3rd edition. Wiley-VCH, Weinheim, Germany.

Prien, R. D., & Schulz-Bull, D. E. (2016). GODESS–a profiling mooring in the Gotland Basin. *Ocean Science*, *12*(4), 899-907.

Reissmann, J., H. Burchard, R. Feistel, E. Hagen, H.-U. Lass, V. Mohrholz, G. Nausch, L. Umlauf, and G. Wieczorek (2009), Vertical mixing in the Baltic Sea and consequences for eutrophication—A review, *Progr. Oceanogr.*, 82, 47– 80.

Winkler, L.W., 1888. Die Bestimmung des im Wasser gelösten Sauerstoffes. Berichte der deutschen chemischen Gesellschaft 21, 2843-2854.