

# Leibniz Institute for Baltic Sea Research Warnemünde

## Cruise Report

r/v "Elisabeth Mann Borgese"

Cruise-No. EMB 128

Monitoring Cruise  
10 May – 20 May 2016  
Kiel Bight to Northern Baltic Proper

This report is based on preliminary data

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1. **Cruise No.:** EMB 128
2. **Dates of the cruise:** from 10 May to 20 May 2016
3. **Particulars of the research vessel:**  
Name: "Elisabeth Mann Borgese"  
Nationality: Germany  
Operating Authority: Leibniz Institute for Baltic Sea Research (IOW)
4. **Geographical area in which ship has operated:**  
Kiel Bight to Northern Baltic Proper
5. **Dates and names of ports of call**  
No port of call
6. **Purpose of the cruise**  
Baltic monitoring in the frame of the COMBINE Programme of HELCOM
7. **Crew:**  
Name of master: Uwe Scholz  
Number of crew: 10
8. **Research staff:**  
Chief scientist: Dr. Norbert Wasmund  
  
Scientists: Dr. Beate Stawiarski  
Sabrina Erdmann  
  
Engineers: Jan Donath  
Ingo Schuffenhauer  
Mareike Floth-Peterson  
  
Technicians: Christian Burmeister  
Jenny Jeschek  
Lars Kreuzer  
  
Students: Ilona Steffen  
Paul Stroppe

9. **Co-operating institutions:**

All institutions dealing with HELCOM monitoring programmes.

10. **Scientific equipment**

CTD + Rosette water samplers "SBE 911plus", phytoplankton net (Apstein), zooplankton net (WP2), Secchi disk, nutrient analyser Evolution III from Alliance, oxygen analyser Titrino from Metrohm, thermosalinograph, profiling mooring GODESS ("Gotland Deep Environmental Sampling Station").

11. **General remarks and preliminary results**

This cruise is part of the German contribution to the HELCOM COMBINE program and contributes to IOW's long term data series in the central Baltic Sea. The area under investigation extended from Kiel Bight to the Northern Gotland Sea. Besides the regular station grid, additional stations were sampled in the Gotland Basin and the northern Baltic Proper to follow the further development of the past mayor salt water inflow (station map see Figs. 1-3). On the way back, selected HELCOM stations in the Bornholm Basin, Arkona

Basin and Mecklenburg Bight were sampled a second time for nutrient, phytoplankton and zooplankton data. The hydrographical, chemical and biological investigations were performed according to the Manual of the COMBINE Programme of HELCOM.

Additional samples on zooplankton distribution for research on population dynamics were taken in the Bornholm Basin. Molecular biological samples for the project ZOOM (project leader Dr. Oliver Schmale, IOW) were taken at stations TF0271, TF0286 and TF0284. Also samples of methane and carbon dioxide were taken in the frame of this project at several stations. Methods for determination of methane production by copepods for project ZOOM were tested (responsible scientist Dr. Beate Stawiarski). For the PhD theses of Sabrina Erdmann, the share of lignin components in the dissolved organic matter was investigated. The profiling mooring GODESS was recovered at station TF0271 on 14 May 2016 and deployed at that station on 17 May 2016 (responsible engineer Mareike Floth-Peterson). The results of this additional research are not presented in this report.

### **11.1 Weather conditions:**

Concerning the weather conditions, the cruise can roughly be divided into 4 periods:

- 1.) 10.-11.05.2016, while cruising through Mecklenburg Bight, Kiel Bight and Arkona Basin: high air pressure (>1012 hPa), easterly winds increasing from 5 to 18 m/s with a short peak of 23 m/s, air temperature during the day 10-16 °C; sunny.
- 2.) 12.-14.05.2016; from the Arkona Basin to the Eastern Gotland Basin (stat. TF0271): low air pressure (decreasing from 1011 to 997 hPa), Wind changes from easterly to northern direction and decreases from 12 to 2 m/s (at noon on 14.5.); air temperature 9-12 °C; sunny, but fog in the afternoon of 14.5.2016.
- 3.) 15.05.-17.05.2016; from the Eastern Gotland Basin (Station TF0271) via northern Baltic Proper, Landsort Deep, Western Gotland Basin back to the Eastern Gotland Basin: Air pressure increasing from 998 to 1007 hPa, Wind from northern to eastern directions; wind speed varied between 3 and 11 m/s with decreasing tendency; air temperature from 7-10 °C; cloudy, but it becomes sunny in the afternoon of the 17.5.2016.
- 4.) 18.05.-20.05.2016: Return from the Eastern Gotland Basin via Bornholm Basin, Arkona Basin and Mecklenburg Bay: Air pressure further increasing from 1008 to 1012 hPa. The wind turned to south-westerly directions on 18.5.2016 and further to south-east on 19.5.2016. Wind speed stays rather low (2-8 m/s). Mostly sunny. No rain during the whole cruise.

### **11.2 Hydrographical and hydrochemical conditions in the different sea areas:**

The hydrographical and hydrochemical characteristics during the cruise are summarized in the appendix (Tables 1 and 2 and Figs. 4 and 5).

The typical stratifications of the water column could be found in each of the Baltic basins. In the central Kiel Bight, a sharp pycnocline did not occur. The largest gradient of temperature and salinity was found at a depth of 12-15 m. The oxygen concentrations decreased to values lower than 6 ml/l below 15 m depth.

In Lübeck Bight (TF0022), the upper edge of the pycnocline was clearly found at 10 m depth, but in the central Bay of Mecklenburg Bight (TF0012) at only 5 m and in the Kadet Channel (TF0046) at 12 m depth, with a strong continuous salinity increase down to 17 m. The minimum oxygen concentration near the bottom was always higher than 3.5 ml/l in the western Baltic and exceeded even 5.5 ml/l in the central Kiel and Mecklenburg Bight. This was, however, 1.5-2 ml/l lower than in May 2015.

In the Arkona Basin, the salinity increase started frequently already at a depth of 15 m with the highest gradient mostly between 5 and 10 m above ground. The oxygen concentrations above bottom were very different even on shorter distances in the central part of the Arkona Basin. In the western part (TF0069, TF0113, TF0114), oxygen concentration above bottom

was only 1-3 ml/l, whereas it amounted to 4-6 ml/l in the eastern part of the Arkona Basin (TF0105, TF0104, AB Boje, TF0109, TF0103, TF0102) and even about 7 ml/l in the slightly shallower southern part (TF0111, TF0112, TF0121).

In the Bornholmgat (stat. TF0144, TF0142, TF0140) and in the western Bornholm Basin (stat. TF0200, TF0211, TF0212, TF0214), the thermocline started at a depth of 17 m, and the highest salinity gradient was found below 40 m depth. The lowest oxygen concentration in the Bornholm Basin was recorded above the ground (1-2 ml/l). In the Slupsk Furrow ("Stolpe Channel", stat. TF0222), a sharp salinity and temperature gradient occurred at 58-63 m depth, with increasing temperature (6°C) and decreasing oxygen concentrations (4.5 ml/l) below it.

In the southern part of the Eastern Gotland Basin (stat. TF0256), the halocline was even situated at 65-70 m depth, with increasing salinity (up to 13 g/kg), increasing temperature (up to 5.7 °C) and decreasing oxygen concentrations (4.9 ml/l) below it. The situation changed further to the north (stat. TF0259, TF0255, TF0253, TF0250); here a water body containing higher oxygen concentrations in comparison with the overlaying waters was found below 85 m depth, which had clearly higher salinity and slightly higher temperature than the overlaying water. Station TF0263 was the first station during this cruise where zero oxygen (but no H<sub>2</sub>S) was measured in a layer at 114-120 m depth; however the bottom water contained about 2 ml/l oxygen. The other stations in the Eastern Gotland Basin contained oxygen in all water layers except some very thin layers (1-2m), e.g. at stat. TF0271 at 88m, 111m and directly above bottom. Only the rather isolated stations at the north-western edge of the basin (GB\_B12) had "zero" oxygen in a broader layer (almost 50 m) above ground. A similar situation was found in regions north of the Eastern Gotland basin, like at station GB\_B21 and GB\_B20 with no oxygen below 80 m depth and station GB\_B19 and TF0286 with no oxygen below 115 m depth. All the deep basins north and west of the Eastern Gotland Basin (TF0285, TF0282, TF0283, TF0284, TF0240, TF0245) contained no oxygen below 75-85 m depth. Hydrogen sulphide was measured at these stations indicated as "negative oxygen" in Fig. 4,

The inflow of deep water has obviously reached station "Gotland NE" (=X\_0062) but hardly stations GB\_B15, TF0270 and GB\_B20, as on the latter stations only an insignificant oxygen signal was noticed near the bottom. Other stations (GB\_B16, GB\_B19, TF0286, GB\_B24) were still anoxic below 100m or 110 m depth.

### 11.3 Development in comparison with earlier cruises

After the mayor Baltic inflow from December 2014 (Mohrholz et al. 2015), some weak and moderate inflows were following in March 2015, November 2015 and February 2016. They affected the salinity, temperature, nutrient and oxygen conditions.

The situation in the deep basins of the northern Baltic Proper and the Western Gotland Basin (TF0285, TF0282, TF0283, TF0284, TF0240, TF0245) was rather stable, but temperature and salinity have increased in the bottom water.

The **salinity** in the bottom layer in comparison to the cruises from Mai 2014 and May 2015 is shown in the table below.

Salinity in the bottom layer

<u>Area:</u>	<u>May 2016</u>	<u>May 2015</u>	<u>May 2014</u>
Gotland Deep	13.77	13.54	12.21
Farö Deep	12.70	12.11	11.42
Landsort Deep	10.99	10.54	10.32
Karlsö Deep	9.87	9.60	9.48

The surface **water temperatures** of selected stations of this cruise are compared with early long-term mean values (1971-1990) collected during our May cruises in the 1970s and 1980s in the table below. Surface water temperatures in the first half of May of 2013 were much higher than long-term data from the beginning of the systematic monitoring programme, and they increased further in May 2015 and May 2016 (May 2014 not tested). The question is how far this trend will continue.

Temperature in the surface layer (°C)

Area:	May 2016	May 2015	May 2013	Mean 1971-1990
Mecklenburg Bight (TF0012)	11.3	9.7	8.2	2.6
Arkona Basin (TF0113)	9.8	8.2	6.2	2.1
Bornholm Basin (TF0213)	8.9	8.0	4.5	2.4
East.Gotland Basin (TF0271)	8.7	7.0	4.8	2.6
Farö Deep (TF0286)	7.9	4.3	5.3	2.3
Karlsö Deep (TF0245)	8.1	6.6	4.6	2.2

The long-term trend of increasing water temperature [°C] is representatively reflected in the deep water layers of the central deeps of the Baltic Proper. Only in the Bornholm Deep, the bottom-near water was slightly colder than in May 2015:

Temperature in the bottom layer (°C)

Area:	May 2016	May 2015	May 2014	May 2013	Mean 1971-1990
Bornholm Deep	6.24	7.00	5.60	5.12	6.12
Gotland Deep	7.53	6.88	6.62	6.41	5.62
Farö Deep	6.81	6.50	5.71	5.94	5.20
Landsort Deep	5.85	5.42	5.32	5.39	4.76
Karlsö Deep	5.21	5.01	4.99	5.33	4.18

After the mayor inflow and some smaller inflows into the Baltic Sea, the development of the **oxygen concentrations** in the deeper layers of the water column is most interesting. We paid special attention to the question whether a net consumption of the new oxygen has already occurred or whether the oxygenated deep water has spread further to the north.

The oxygen concentrations in the bottom water have decreased in the central Kiel and Mecklenburg Bight by 1.5-2 ml/l and were also lower in parts of the Arkona and Bornholm Basin in comparison with May 2015. For example, at the central station of the Arkona Basin (TF0113), oxygen concentrations above bottom were 5.67 ml/l in May 2015, 5.35 ml/l in March 2016 (Mohrholz 2016) and only 1.5 ml/l in May 2016. In the Bornholm Basin, the oxygen concentration near the ground was above 3 ml/l in May 2015, about 4 ml/l in March 2016, but only 1.56 ml/l in May 2016. Consequently, no new oxygen was introduced since the last measurements in March 2016, but a strong consumption occurred already.

The situation in the southern part of the Eastern Gotland Basin was rather similar to that of May 2015 with oxic water above the bottom. Already in May 2015, the central Gotland Deep (stat. TF0271) was filled with water of oxygen concentrations up to 2 ml/l below a depth of 130 m with only a narrow layer with zero oxygen at 120-130 m depth. Surprisingly, in March 2016 a larger depth range from 130-170 m was anoxic (Mohrholz 2016). Since then the oxygen situation in the Gotland Deep improved. Almost the complete water column at station TF0271 contained oxygen. The western station (GB\_B4) of an east-west transect has not been reached by the inflow events by May 2015 since the water was oxygen-free from 105 m

depth to the bottom (158 m), but a water body of up to 1.6 ml/l oxygen has intruded recently at 86-130 m depth by May 2016. Only the Station GB\_B12 in the north-western edge of the basin had still oxygen depletion below 110m. Obviously, the western part is reached much later by the inflow than the eastern part of the Eastern Gotland Basin. In contrast to May 2015, the inflow of deep water has reached also stations GB\_B15 and TF0270 as increased oxygen concentrations were measured near the bottom. No oxygen in the deeper layers was recorded at the shallower eastern stations of the northern transect (GB\_B21 to GB\_B19). The deeper station TF0286 (Farö Deep) was oxid near the bottom (see table below). At station TF0282, the “negative oxygen concentrations” above the bottom decreased from 0.89 ml/l in March 2016 to 0.11 ml/l in May 2016. Even in the Landsort Deep (TF0284), it decreased slightly from 1.35 ml/l to 1.05 ml/l in that period, but not at TF0240 and TF0245. Obviously, the deep oxid water proceeded from the Eastern Gotland Basin further to the north.

Oxygen concentrations in the bottom layer (ml/l)

Hydrogen sulphide was converted into negative oxygen equivalents.

Area:	May 2016	May 2015	May 2014	May 2013
Gotland Deep	0.08	2.09	-6.03	-7.59
Farö Deep	0.05	-1.18	-3.58	-3.57
Landsort Deep	-1,05	-0.73	-3.13	-0.78
Karlsö Deep	-1.13	-0.84	-0.74	-0.70

#### Nutrients

Due to the relative shortage of nitrogen in comparison with phosphorus in relation to the Redfield ratio, the combined nitrogen is almost exhausted in the surface water in the Baltic Proper after the spring bloom, whereas phosphorus is still available (Table 1 in Appendix). In the bottom-near layer, the situation changed strongly due to the inflow of oxygenated water: nitrate+nitrite concentrations increased in areas which were influenced by the Mayor Baltic Inflow in comparison with the situation before the inflow (see Tables below).

Area:	Phosphate May 2016	Phosphate May 2015	Phosphate May 2013
Gotland Deep	2.46	1.95	9.45
Farö Deep	2.59	3.30	7.45
Landsort Deep	3.23	3.70	4.95
Karlsö Deep	4.75	3.95	3.50

Area:	Nitrate+Nitrite May 2016	Nitrate+Nitrite May 2015	Nitrate+Nitrite May 2013
Gotland Deep	12.53	10.53	0.14
Farö Deep	4.89	0.25	0.52
Landsort Deep	0.00	0.35	0.18
Karlsö Deep	0.00	0.34	0.11

#### Biological Data

The biological data will be analysed and are not available yet.

**References:**

Mohrholz, V., Naumann, M., Nausch, G., Krüger, S., and Gräwe, U. (2015): Fresh oxygen for the Baltic Sea — An exceptional saline inflow after a decade of stagnation. *J. Mar. Sys.* 148, 152-166.

Mohrholz, V. (2016): Cruise report – EMB124. Leibniz Inst. for Baltic Sea Research. [http://www.io-warnemuende.de/tl\\_files/forschung/pdf/cruise-reports/cremb124.pdf](http://www.io-warnemuende.de/tl_files/forschung/pdf/cruise-reports/cremb124.pdf)

**Appendix**

Tables 1& 2: Preliminary results for selected parameters in the surface layer and the near-bottom layer (unvalidated results)

Figs. 1-3: Station grid (total grid and two sub-maps)

Fig. 4: Oxygen /hydrogen sulphide concentrations in the near-bottom layer for selected stations

Fig. 5: Transsect from the Kiel Bight to the Farö Deep for temperature, salinity and oxygen (unvalidated data)

Dr. Norbert Wasmund

Scientist in charge

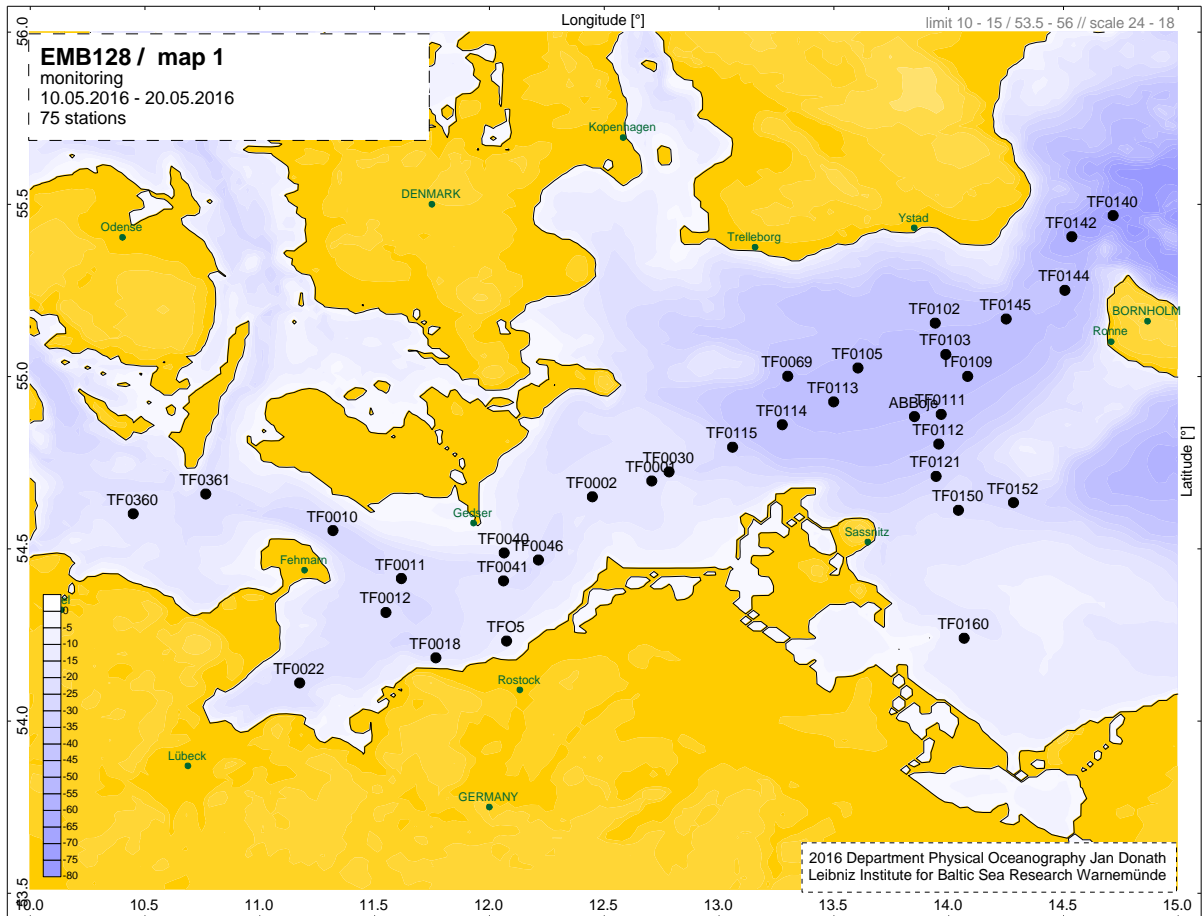
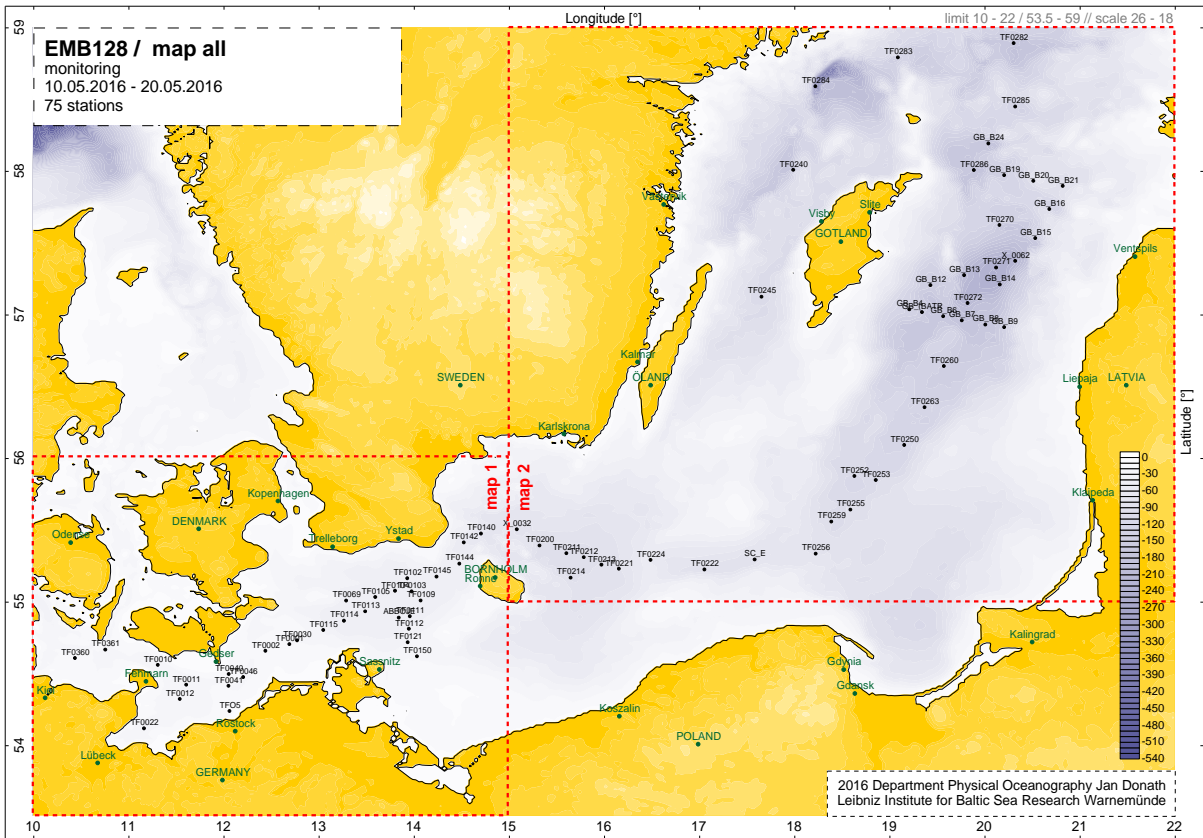


Fig1 and 2: Total station map and detailed map of the western Baltic Sea



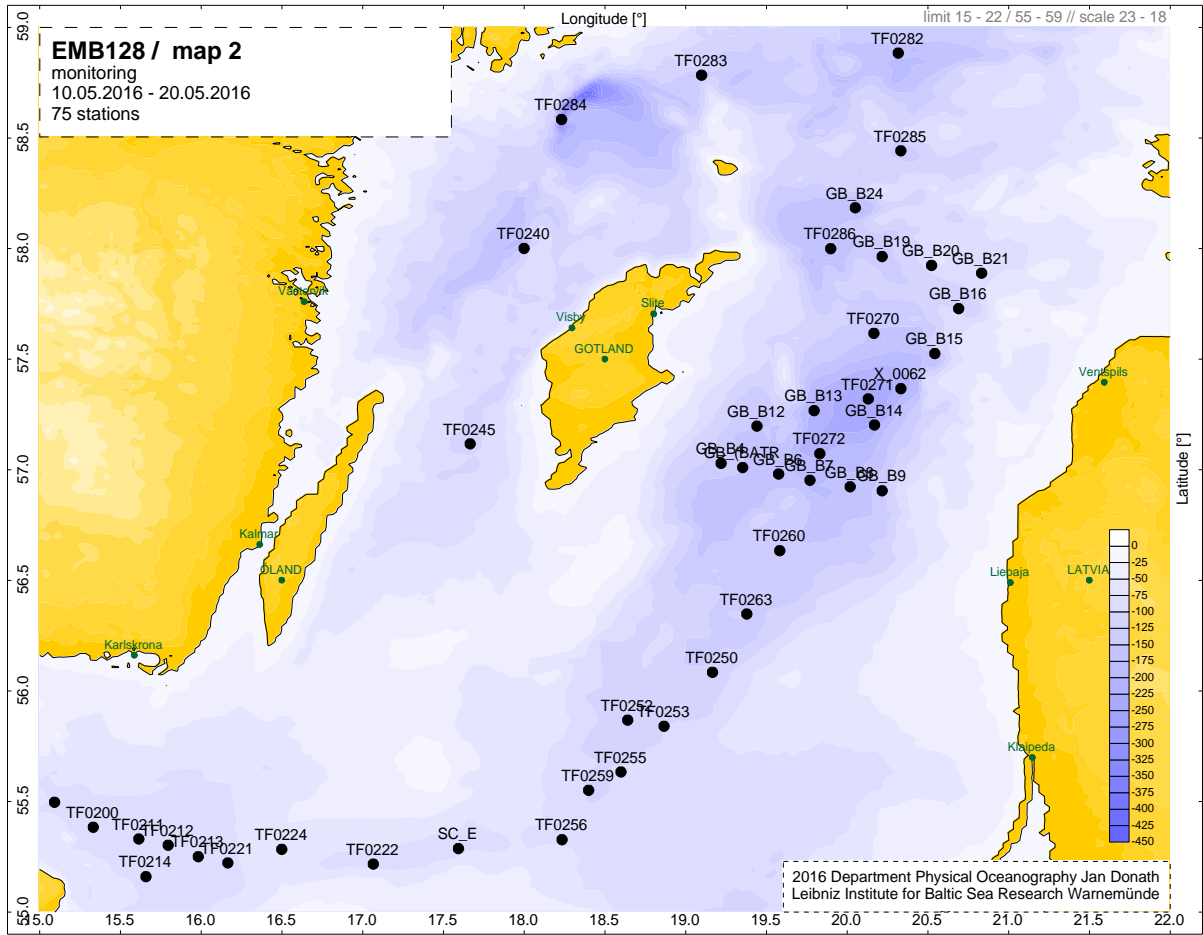


Fig. 3: Map of monitoring stations in the Baltic Proper.

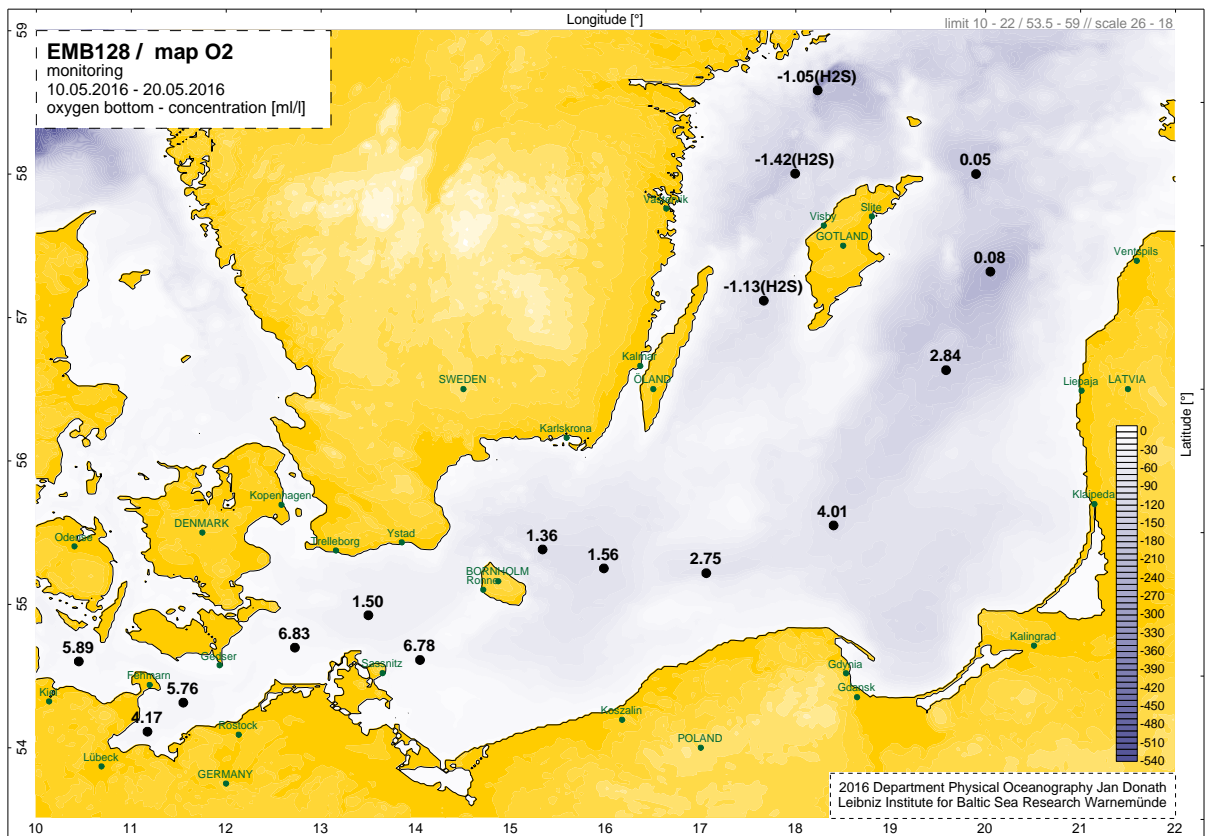


Fig. 4: Oxygen/hydrogen sulphide concentrations in the near-bottom layer (selected stations)

# EMB128 - Monitoring

Kiel Bight - Gotland Sea  
 10.05.2016 09:32 - 16.05.2016 03:35 UTC

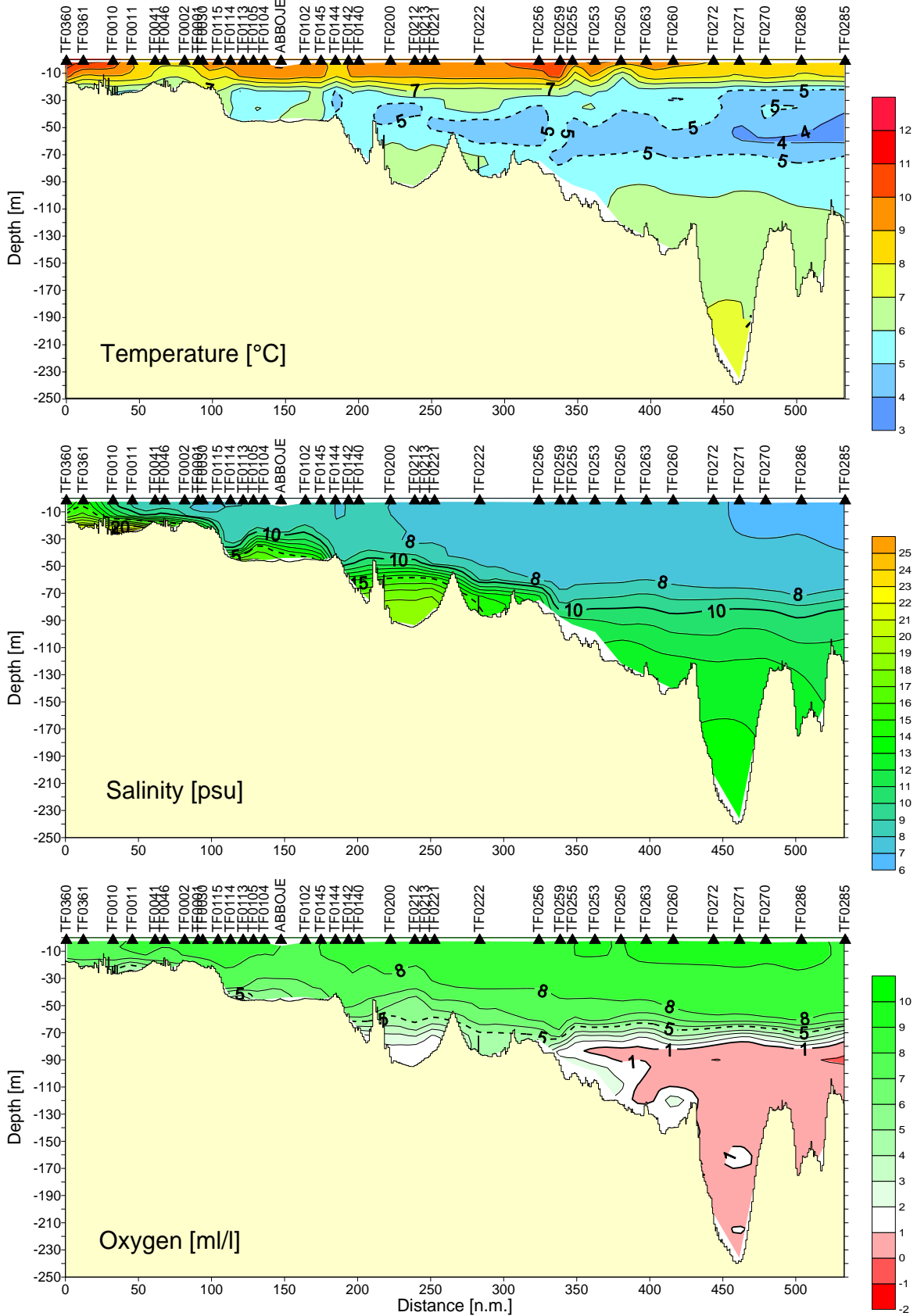


Fig. 5: Transect from the Kiel Bight to the Farø Deep for temperature, salinity and oxygen.

**Table 1: Surface layer**

Area	Station	Temperature	Salinity	PO <sub>4</sub> <sup>3-</sup>	NO <sub>23</sub> <sup>-*</sup>
Date	Name/ No. **	°C	PSU	µmol/dm <sup>3</sup>	µmol/dm <sup>3</sup>
Kiel Bight 10.5.2016	TF0360/ 005	11.10	12.11	0.06	0.77
Meckl. Bight 10.5.2016	TF0012/ 007	11.30	10.04	0.11	0.65
Lübeck Bight 10.5.2016	TF0022/ 006	11.84	12.91	0.00	0.93
Arkona Basin 11.5.2016	TF0113/ 017	9.80	7.96	0.30	0.46
Bornholm Deep 12.5.2016	TF0213/ 037	8.92	7.65	0.42	0.60
Stolpe Channel 13.5.2016	TF0222/ 040	9.57	7.57	0.20	0.51
SE Gotland Basin 13.5.2015	TF0259/ 043	10.84	7.47	0.09	0.50
Gotland Deep 14.5.2016	TF0271/ 052) <sup>a</sup>	8.72	7.11	0.05	0.02
Fårö Deep 15.5.2016	TF0286/ 070	7.90	6.91	0.22	0.02
Landsort Deep 16.5.2016	TF0284/ 075	7.71	6.43	0.20	0.39
Karlsö Deep 17.5.2016	TF0245/ 077	8.13	7.12	0.38	0.00

\*  $\Sigma \text{NO}_2^- + \text{NO}_3^-$ ; NO<sub>2</sub> was present only in traces in most areas under investigation

\*\* Station name see maps (Fig. 1 - 3)

)<sup>a</sup> This was the first surface cast at that station

**Table 2: Bottom-near water layer**

Area	Station	Sampl. depth	Temp.	Salinity	O <sub>2</sub>	PO <sub>4</sub> <sup>3-</sup>	NO <sub>23</sub> <sup>-*</sup>
Date	Name/ No. <sup>**</sup>	m	°C	PSU	cm <sup>3</sup> /dm <sup>3</sup>	µmol/dm <sup>3</sup>	µmol/dm <sup>3</sup>
Kiel Bight 10.5.2016	TF0360/ 005	17	5.55	21.27	5.89	0.35	3.71
Meckl. Bight 10.5.2016	TF0012/ 007	24	6.59	22.46	5.76	0.34	3.45
Lübeck Bight 10.5.2016	TF0022/ 006	22	4.82	21.39	4.17	0.70	4.57
Arkona Basin 11.5.2016	TF0113/ 017	46	5.21	19.31	1.50	1.42	6.45
Bornholm Deep 12.5.2016	TF0213/ 037	88	6.24	18.84	1.56	1.72	11.71
Stolpe Channel 13.5.2016	TF0222/ 040	88	5.96	15.20	2.75	1.34	6.87
SE Gotland Basin 13.5.2015	TF0259/ 043	87	5.71	13.00	4.01	1.57	5.95
Gotland Deep 14.5.2016	TF0271/ 052) <sup>a</sup>	233	7.53	13.77	0.08	2.46	12.53
Fårö Deep 15.5.2016	TF0286/ 070	189	6.81	12.70	0.05	2.59	4.89
Landsort Deep 16.5.2016	TF0284/ 075	438	5.85	10.99	-1.05	3.23	0.00
Karlsö Deep 17.5.2016	TF0245/ 077	107	5.21	9.87	-1.13	4.75	0.00

\*  $\Sigma \text{NO}_2^- + \text{NO}_3^-$ ; NO<sub>2</sub> was present only in traces in most areas under investigation

\*\* Station name see maps (Fig. 1 - 3)

)<sup>a</sup> This was the first cast at that station