Leibniz Institute for Baltic Sea Research Warnemünde

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C r u i s e R e p o r t

r/v "E. M. Borgese"

Cruise- No. EMB171

This report is based on preliminary data

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an der Universität Rostock
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1. **Cruise No.:** EMB 171

2. **Dates of the cruise:** from 14.11.2017 to 24.11.2017

3. **Particulars of the research vessel:**

Name: E.M. Borgese
Nationality: Germany
Operating Authority: Leibniz Institute of Baltic Sea Research Warnemünde (IOW)

4. **Geographical area in which ship has operated:**

5. **Dates and names of ports of call**

Sassnitz 17.11. – 17.11. 2017

6. **Purpose of the cruise**

Monitoring in the frame of the HELCOM COMBINE Programm, Long term data programm of IOW

7. **Crew:**

Name of master: Uwe Scholz
Number of crew: 11

8. **Research staff:**

Chief scientist:
Dr. Martin Schmidt, IOW
Scientific Crew:

Donath	Jan
Hand	Ines
Pötzsch	Michael
Sadkowiak	Birgit
Ruickoldt	Johann
Borges	Valeska
Jeschek	Jenny
Pohl	Frank
Hehl	Uwe
Westhoven	Charlotte

Observer:

Bartczak Thomasz

9. **Co-operating institutions:**

All institutions dealing with HELCOM monitoring programmes, University of Rostock

10. **Scientific equipment**

CTD SBE 911+ with doubled sensors, SBE oxygen sensor and
WETLABS ECO FLNTU Fluorometer/turbidity sensor
PAR/SPAR – sensor, SBE-35 thermometer
Rosette with water samplers
Plankton nets, WP2 net, filtration set
Van Veen grab, dredge

Autoanalyser *FlowSys (Allicance Instruments)*, Photometer, Titrino 716
Ships weather station (WERUM),Thermosalinograph

11. General remarks and preliminary result (ca. 2 pages)

Narrative and measurements

The cruise started Nov. 14th 2017 in Rostock-Marienehe. In the first leg of the cruise hydrographic, and biological and chemical measurements were carried out in the Western Baltic Sea between Kiel Bight and Bornholms Gatt and in the Odra Bight. At selected stations also macrozoobenthos was sampled. After a crew exchange in the evening of Nov. 17th, “E. M. Borgese” was heading through Bornholms Gatt to the Bornholm Sea. Station work was interrupted in the Stolpe Trench due to galeforce winds but could be resumed again in the morning of Nov. 19th. In the evening the central station, TF0271, in the Eastern Gotland Basin was worked. A surface sediment sample was taken with the Fram-lot. Next morning a mooring equipped with current meters, temperature, conductivity and oxygen sensor and a sediment trap could be recovered and laid out again. The northernmost station TF0282 was worked in the evening of Nov 20th, the Landsort Deep could be sampled Nov 21th. On the way back to the Bornholm See, the stations skipped earlier could be worked. Hence, the vertical sections, see Figure 10, are not fully synoptic.

Instrumentation and quality control

Station work started with a CTD-cast (SBE 911+ with sensors for temperature and conductivity, pressure, SBE oxygen sensor and WETLABS Fluoro/turbiditymeter) including water sampling for oxygen and nutrient measurements. Light conditions are determined with a PAR sensor, combined with a similar sensor on deck. The quality of the hydrographic measurements is controlled by the double sensor equipment of the CTD. As a measure of the overall stability of the CTD, the frequency of the central CTD quartz-generator is controlled. Additionally, the temperature sensors are compared regularly with a highly stable SBE-35 thermometer, for the control of salinity measurements water samples are taken to be measured later in the laboratory with an AUTOSAL 8400. The electrochemical Clark-cell based oxygen sensors are controlled and corrected with oxygen samples taken on every station at the surface and the bottom.

At selected stations phytoplankton samples are taken, Secci-depth is determined and 3 l water is filtered. The filters are frozen in liquid nitrogen for processing in the lab. Additionally zooplankton samples were taken with a WP2 net within the euphotic zone, and above and below the halocline. At some stations, TF0018, TF0012, TF0010, TF0360, TF0030, TF0109, TF0152, benthic samples are taken with a van Veen grab (three holes per station) and with a dredge.

Oxygen concentration in water samples is determined with a 716 DMS Titrino III, for H_2S determination the photometric Ethylen blue method is used. Nutrients (nitrate, nitrite, phosphate and silicate) are determined with an Autoanalyser *FlowSys (Allicance Instruments)*, for ammonium the photometric method is used. Quality is ensured by accreditation of the methods, for quality control during the cruise standard samples are processed together with the water samples.

At 8 stations macrozoobenthos samples (three samples at each station) were taken with a van-Veen-grab and with a dredge. One additional grab sample was taken for sediment analysis in the laboratory. Sampling was scheduled for daylight. Unfortunately, at station

TF0360, TF0012, and TF0030 sampling was possible at night time only. Following the HELCOM guidelines, species decomposition and abundance are analyzed three month after the cruise.

During the expedition, spectrophotometric pH-measurements comparing two pH-measuring systems were taken. The pH results of the well-established apparatus from the CO2 lab at the IOW, which measures discrete probes and uses a system developed by Carter et al. (2013), was compared to the pH measurements of two prototypes that were developed in the project EU BONUS PINBAL using the Contros HydroFIA pH® system. These measurement comparisons (occurring across a broad salinity spectrum) will help with the long-term goal of using the Contros HydroFIA pH® devices to monitor the acidification of the Baltic Sea.

Underway measurements are carried out with ships thermosalinograph and ships weather station. Data are stored in the DSHIP system. Thermolaninograph salinity was corrected by comparison with CTD based salinity in 3.5 m water depth.

As a pilot project for the determination of molecular weight and molecular size of dissolved organic phosphorus (DOP), different fractions of DOP in the surface water are separated with nano- and ultra filtration.

Preliminary results

Meteorological conditions

The cruise started after a period dominated by westerly winds of rapidly changing strength, overcast sky and little rainfall. The low pressure areas *Michael, Peter* and *Quintus* over Iceland and the high pressure zone *Yparak* and *Zoe* were extending eastward from the British islands and maintained winds of medium up to gale force strength from varying directions, overcast sky and intermittent rain.

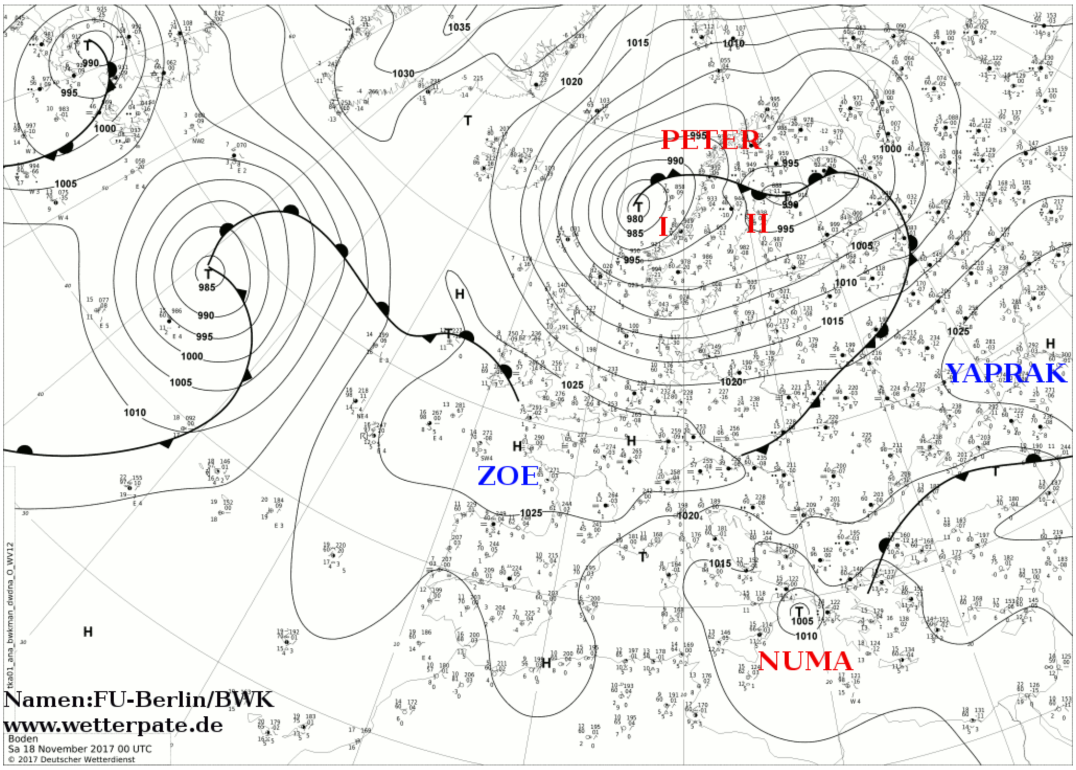


Fig. 1 Typical air pressure distribution during the first part of the cruise. (*The permission of the FU-Berlin to use the map in this report is kindly acknowledged.)*

In the evening of 18th of November, gale force wind from south west prohibited station work. The last three days of the cruise are governed by strong southerly wind from a frontal system related to low pressure area *Reinhard* trekking rapidly eastward over Scandinavia.

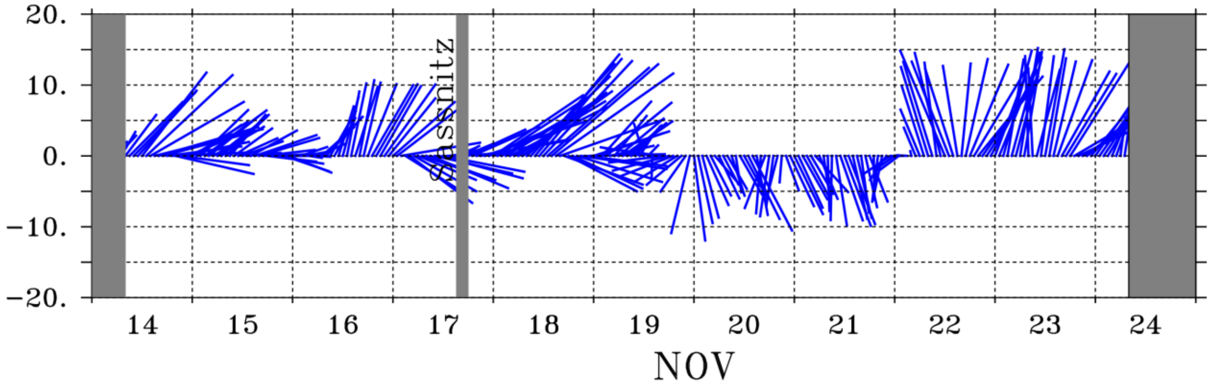


Fig. 2 Wind conditions during the cruise measured by ships weather station. Until Nov. 20th westerly winds are dominating later strong wind from the north and south are dominating.

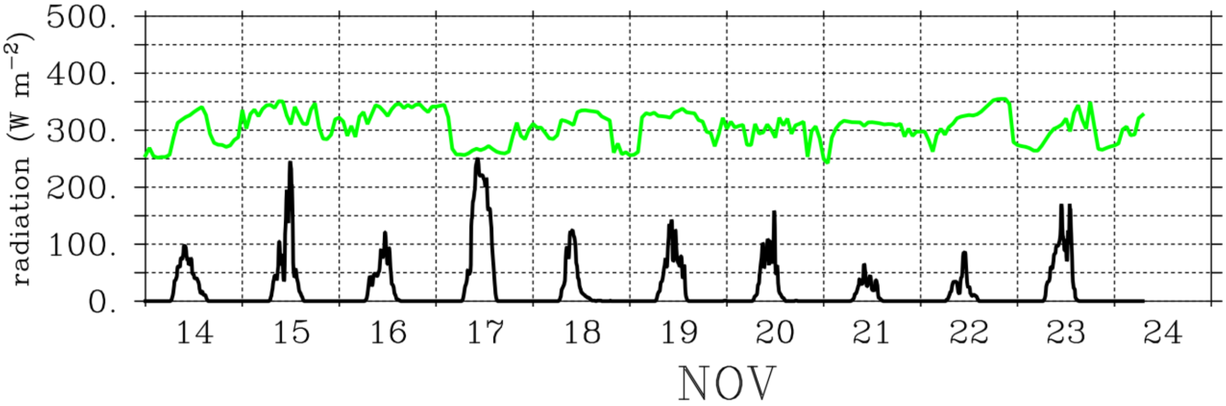


Fig. 3 Downwelling short wave (black) and long wave radiation (green) measured by ships weather station.

According to the season, downwelling short- and long wave radiation is small. Especially during the work in the Gotland basin the short day length and low sun angle results in

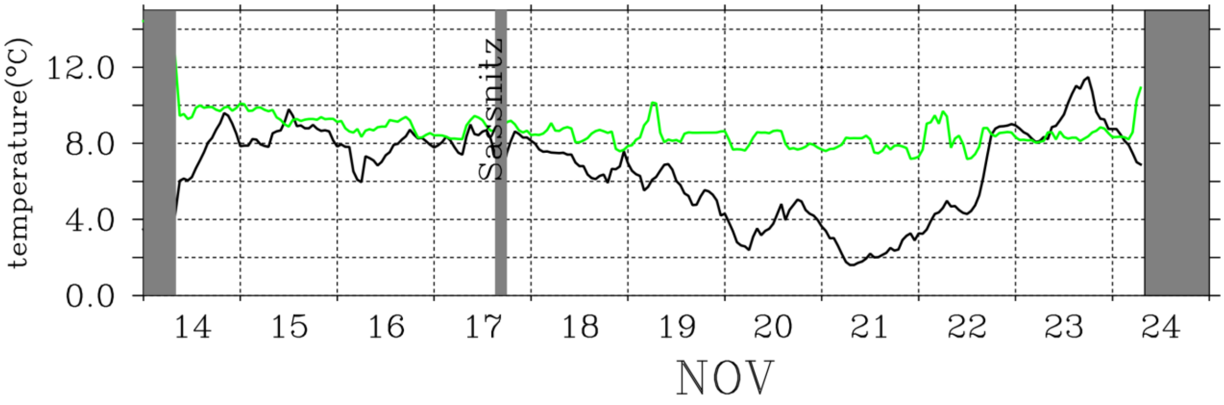
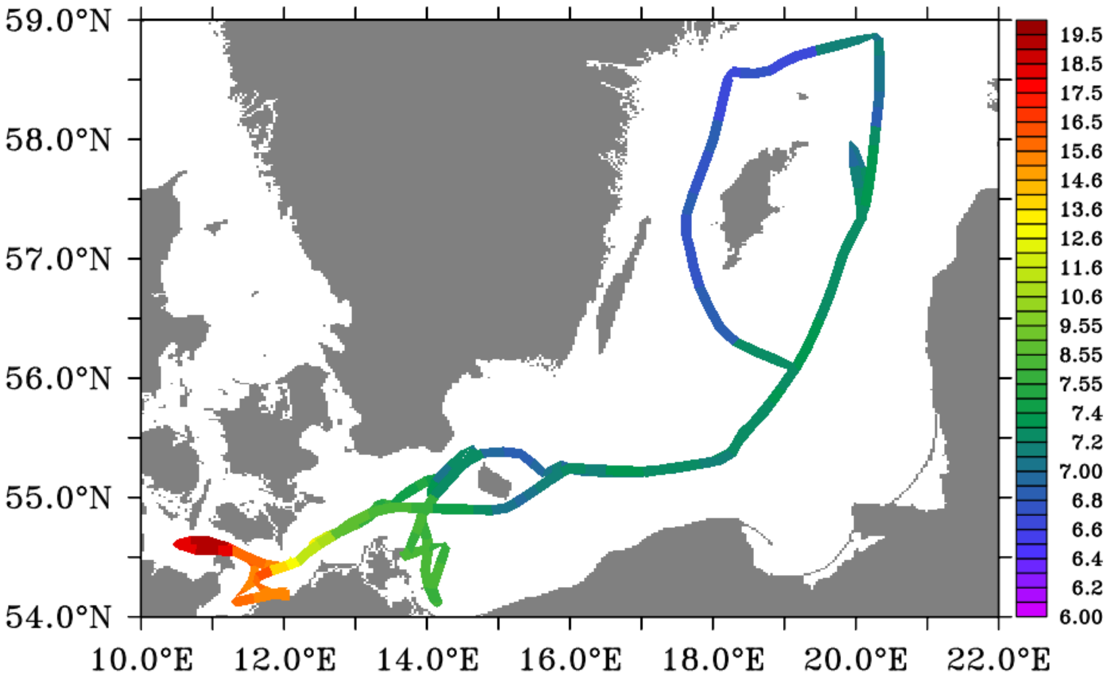


Fig. 4 Air temperature (black) and sea surface temperature [°C] measured by the thermosalinograph.

low radiation values. Air temperature is well below the sea surface temperature, which implies cooling of the water, instable surface layer and erosion of the remaining thermocline. Fig. 7 shows an example, where the surface boundary layer in the Gotland Sea is fully mixed and is eroding the halocline.

Underway measurements of surface conditions

Fig. 5 gives an overview over the variability of the sea surface salinity.



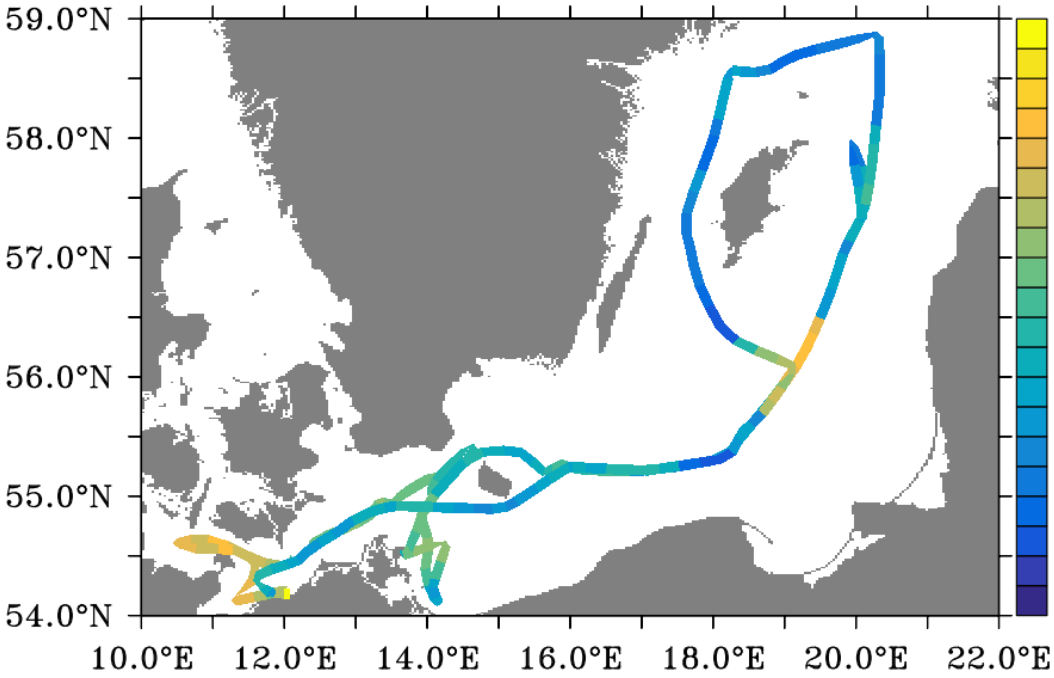


Fig. 5 Surface practical salinity (upper part) and surface temperature [°C] (lower part) measured with ships thermosalinograph.

Salinity in the entrance of Kiel Bight is below 20, which is typical for an outflow situation. In the Baltic it is decreasing north-eastward with a clear salinity gradient between the western and the eastern Gotland Basin. Generally, the plots reveal several horizontal fronts, note especially the huge patch of warmer water in the entrance of the Gotland Sea. The CTD data (see Fig. 1ß) show that it extends throughout the surface layer to the halocline. The western Gotland Basin reveals lower surface salinity than the eastern Gotland Basin.

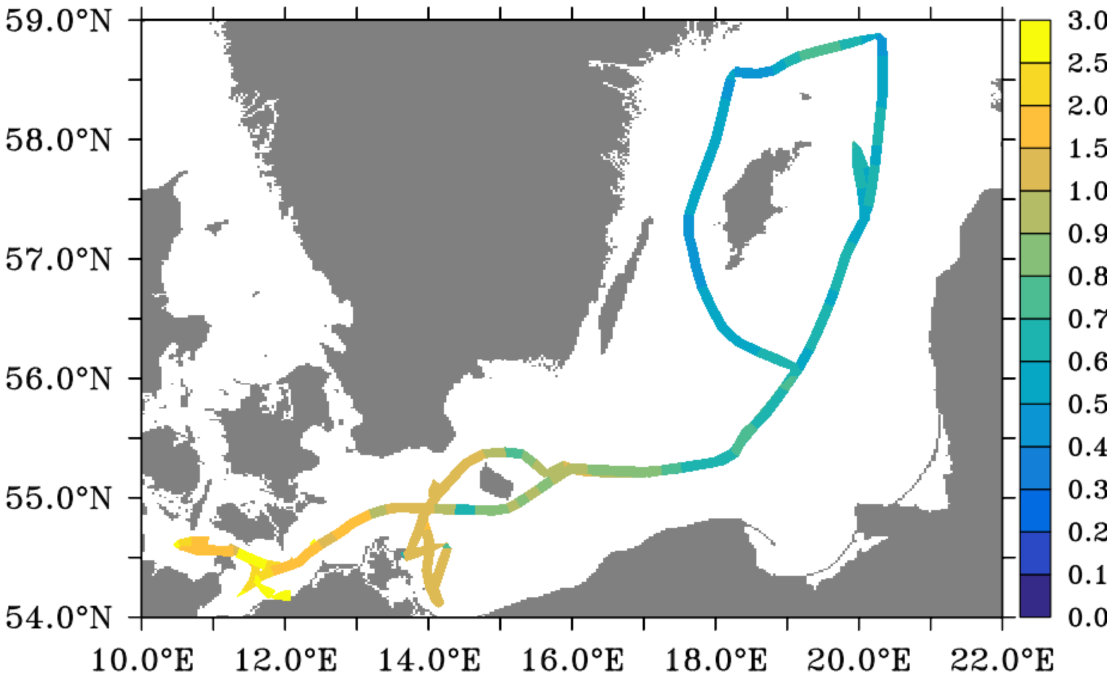


Fig. 6 Surface fluorescence in chlorophyll-a units, [mg dm^{-3}].

Fluorescence as a measure for chlorophyll-a concentration shows elevated values in the western Baltic Sea and is lower in the Gotland Basin. Especially in the western Baltic surface nutrients are depleted, which indicates some primary production takes place consuming the nutrients there.

Hydrographic conditions

The hydrographic conditions met **west of Darß Sill** are typical for the season. Colder but less saline water overlays warmer but more saline water. Surface salinity varies from about 18 in the Kiel Bight to 9 at Darß Sill. Surface temperature is uniform, about 12°C, in the beginning of the cruise, but amounts about 9°C 10 days later. Bottom salinity is about 19 in the Kiel Bight falls to 18 towards Darß sill. The bottom water is well oxygenated.

East of Darß Sill surface salinity is about 7.5 - 8 and amount 7.1 - 7.3 in the Eastern Gotland Basin but falls below 7 in the Western Gotland Basin. Oxygen concentration is only slightly depleted above the bottom in the Arkona Basin but oxygen is almost exhausted in the **Bornholm Basin,** see Fig. 10. A relatively warm (10°C) water mass stretches from the Arkona Basin into the Bornholm Basin, where it overlays stagnant colder bottom water. Fig. 7 shows the development of hydrographic conditions comparing conditions during a pre-inflow year (2014) and the previous year (2016) with the 2017 conditions. The bottom salinity has almost pre-inflow values, also the oxygen concentration is about zero again. The winter water layer that is completely missing in 2016 but was prominent at about 40 m depth in 2014 is almost re-established.

East of Stolpe Trench the profiles below the uniform surface layer are characterised by a fastly dropping oxygen concentration below 60 m depth. Occasionally the water is anoxic and a slight sulphidic smell was observed during sampling.

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In the **Central Gotland Basin,** the hydrographic conditions are determined by the major Baltic inflow event about two years ago which caused a partial ventilation of the deep Gotland Basin waters. We see a slow recovery of anoxic conditions in the bottom water. The thermocline is constantly at about 50 m depth. Compared with previous years the winter water is temperature is still enhanced by about 1 degree. The water temperature in the deeper water exceeds 6°C everywhere. The oxygen concentration is well below 1 cm³/dm³ below 170m depth the water is sulphidic. Hence, the typical anoxic conditions in the Eastern Gotland Basin are restoring after the inflow event. Compared with the previous year, salinity in the bottom water at station TF0271 is a decreasing, but all nutrient concentrations are increasing again, the inorganic nitrogen pool consists mostly of ammonium. Table 1 demonstrates the re-establishing anoxic conditions.

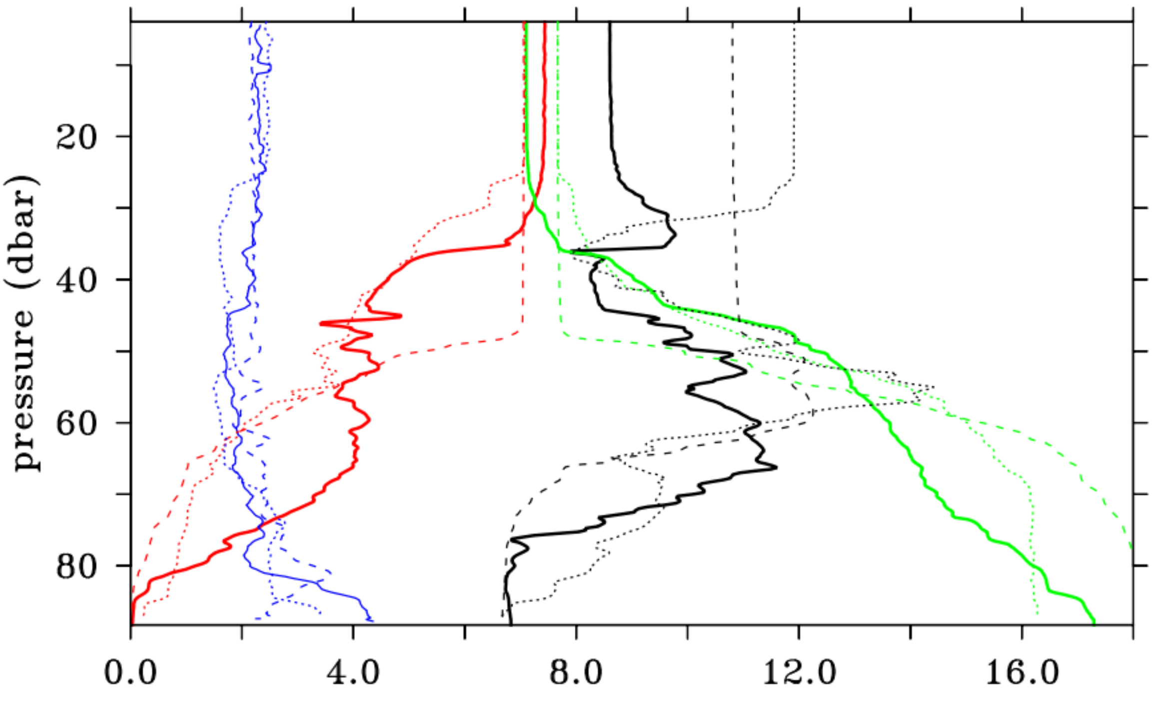


Fig. 7 Vertical profiles of temperature ([°C], black), salinity (green), oxygen concentration ([cm³/dm³] red) and turbidity (blue) for Nov. 2017 (thick line), Nov. 2016 (dashed line) and for the pre-inflow situation Nov. 2014 (dotted line) on station TF0213 in the Bornholm Basin.

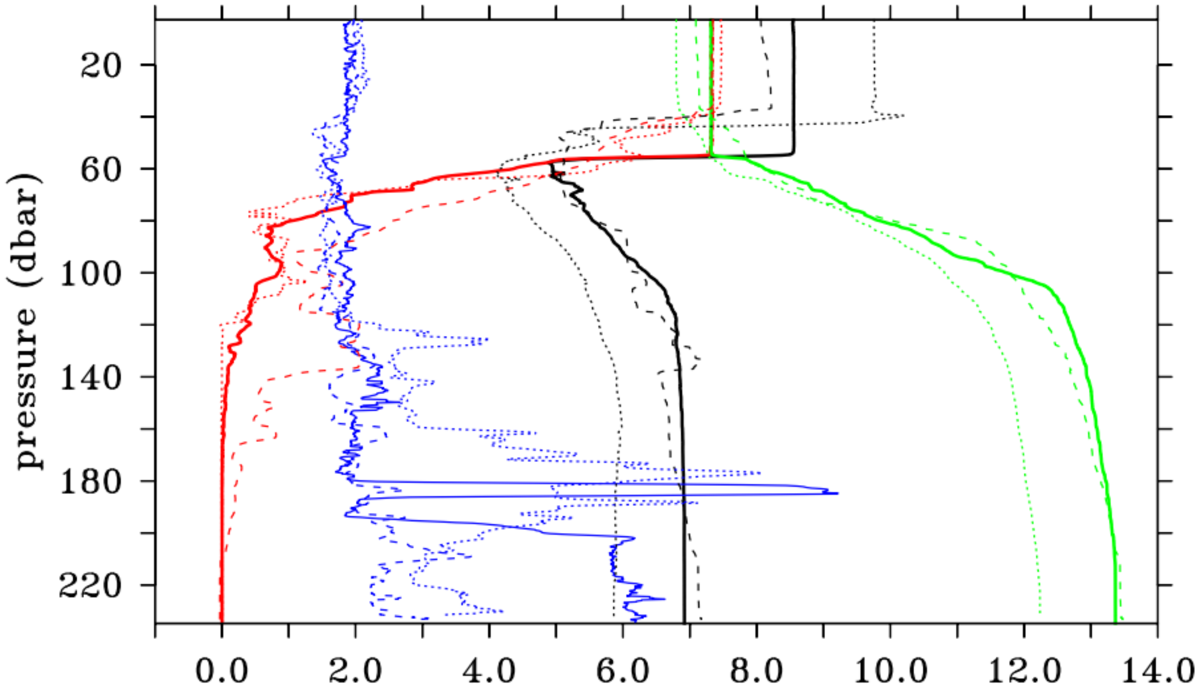


Fig. 8 Vertical profiles of temperature ([°C]black), salinity (green), oxygen concentration ([cm³/dm³], red) and turbidity (blue) for Nov. 2017 (thick line), Nov. 2016 (dashed line) and for the pre-inflow situation Nov. 2014 (dotted line) on station TF0271 in the Gotland Basin.

Fig. 8 shows the changes at station TF0271 in the Gotland Basin. The salinity in the layer below 100m depth is still enhanced compared with the conditions from 2014. The oxygen entrained during the last inflow that was still found in Nov. 2016 is already consumed. The pronounced turbidity maximum localised in the redoxcline becomes visible. Tab. 1 shows increasing nutrient concentration in the bottom water and hydrogen sulphide is forming again. Winter water depth is still at about 60m depth. Remarkably, the surface layer is fully mixed and the halocline that is found within the temperature minimum is eroding.

Appendix: Further maps and tables and plots

Table 1: Salinity, Temperature, oxygen and nutrient time development near bottom TF0271

Tables 2 - 3: Preliminary results for selected parameters in the surface layer and the near bottom layer

year	2001	2002	2003	2004	2005	2006	2007	2008*	2009*	2010	2011*	2012	2014	2015	2016	2017
S	12.03	12.15	12.78	12.92	12.71	12.65	12.79	12.56	12.45	12.39	12.23	12.17	12.07	13.38	13.44	13.36
T	6.25	6.53	4.92	6.26	5.95	5.94	6.65	6.32	6.31	6.42	6.43	6.42	6.38	6.86	7.13	6.92
O2/ $2H_2S$	-4.74	-7.43	1.77	-1.73	-3.75	0.16	-4.9	-5.20	-5.93	-7.01	-7.57	-7.44	-8.75	0.08	0.03	-0.86
PO_4	7.30	6.08	2.20	4.45	5.03	2.45	4.80	7.05	4.5	6.05	7.15	6.8	11.55	3.12	0.71	4.87
DIN			11.56		19.89	6.41	17.0			32.60		39.83	42.4	6.84	7.24	8.92
SIO_4	86.8		40.2	64.1				89.2	87.6	94.2	104.4	111.0	126.8	60.6	60.5	62.7

Table 1: Salinity, Temperature, oxygen and nutrient development near bottom TF0271

*: no autum data, data from Jan./Feb. cruise next year are shown.

Table 2: Surface layer (0 - 10m)

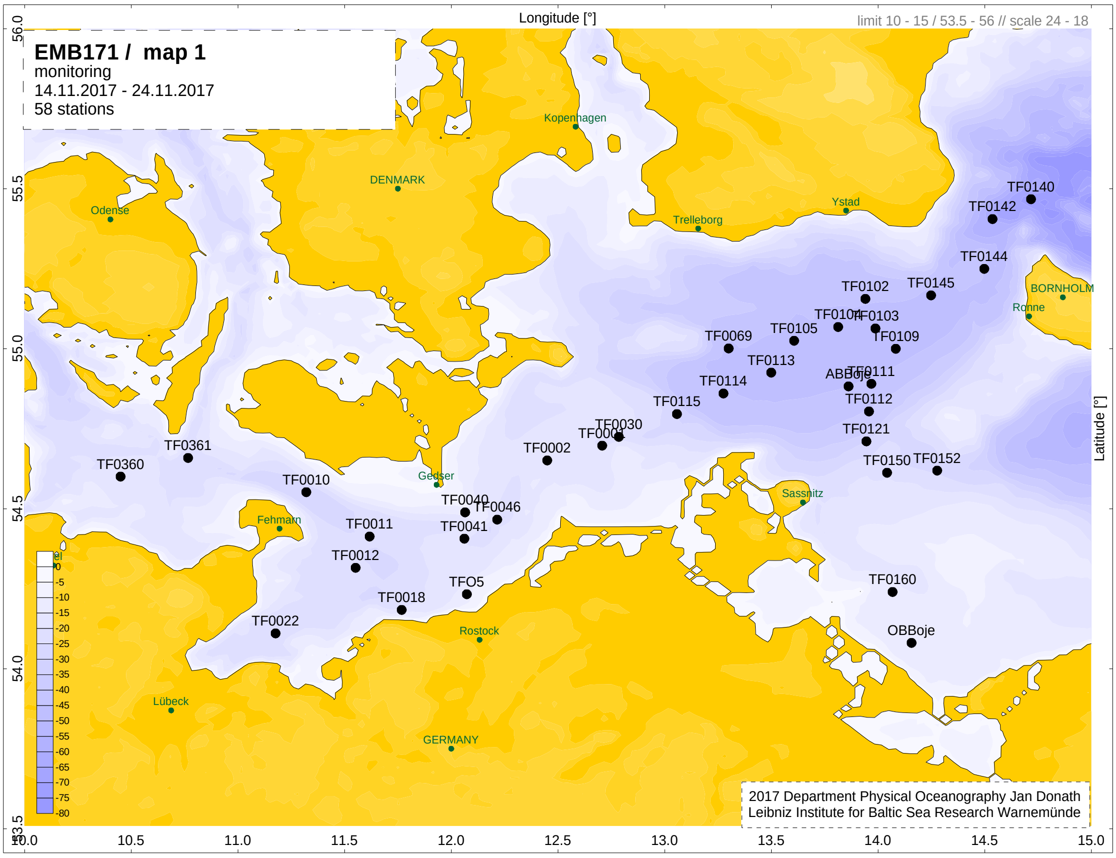
Area	Station	Tempera-ture	Salinity	PO_4^{3-}	NO_2^{3-} * DIN	SiO_4
Date	Name/ No. **	°C	PSU	µmol/dm^3	µmol/dm^3	µmol/dm^3
Kiel Bight	TF0360/08 14.11.2017	10.08	18.53	0.50	0.04 0.30	17.2
Meckl. Bight	TF0012/04 14.11.2017	9.89	15.48	0.26	0.06 0.14	11.3
Lübeck Bight	TF0022/03 15.11.2017	10.01	16.22	0.38	0.19	14.6
Arkona Basin	TF0113/18 15.11.2017	9.24	7.60	0.42	0.81 0.83	15.6
Pom. Bight	TF0160/34 17.11.2017	8.22	7.93	0.60	1.95	18.8
Bornholm Deep	TF0213/39 18.11.2017	8.60	7.10	0.38	0.57 0.61	15.3
Stolpe Channel	TF0222/58 22.11.2017	8.79	7.28	0.39	0.89	14.4
SE Gotland Basin	TF0259/42 22.11.2017	8.53	7.37	0.41	1.76	14.7
Gotland Deep	TF0271/44 19.11.2017	8.55	7.32	0.37	2.04 2.05	12.3
Fårö Deep	TF0286/46 20.11.2017	7.68	7.10	0.37	1.67	11.9
Landsort Deep	TF0284/50 21.11.2017	8.26	6.72	0.33	1.24 1.89	14.9
Karlsö Deep	TF0245/52 21.11.2017	7.89	6.76	0.32	1.33	14.1

* Σ NO_2^- + NO_3; NO_2 was present only in traces in most areas under investigation

** See maps

Table 3: Bottom-near water layer

Area	Station	Depth	Temp.	Salinity	O_2	PO_4^{3-}	NO_2^{3-} * DIN	SiO_4
Date	Name/ No. **	M	°C	PSU	cm³/dm³	μmol/dm³	μmol/dm³	μmol/dm³
Kiel Bight	TF0360/07 14.11.2017	17.5	10.13	18.66	6.77	0.57	1.54 1.61	11.0
Meckl. Bight	TF0012/04 14.11.2017	24.0	9.93	16.13	6.92	0.36	0.07 0.39	13.9
Lübeck Bight	TF0022/03 14.11.2017	22.0	11.90	17.89	4.86	1.45	5.55	29.7
Arkona Basin	TF0113/15 15.11.2017	46.0	11.41	18.60	5.15	0.89	4.32 5.62	20.0
Pom. Bight	TF0160/34 17.11.2017	14	8.40	8.37	7.47	0.61	1.98	18.9
Bornholm Deep	TF0213/39 18.11.2017	88.2	6.83	17.28	0.13	3.15	5.79 6.70	55.0
Stolpe Channel	TF0222/58 22.11.2017	90.0	8.47	12.46	2.76	1.39	7.03	34.3
SE Gotland Basin	TF0259/42 22.11.2017	88.2	6.36	11.49	0.67	2.31	6.6	45.6
Gotland Deep	TF0271/34 19.11.2017	235.0	6.92	13.36	-0.86	4.57	0.0 8.92	62.9
Fårö Deep	TF0286/46 20.11.2017	190	6.86	12.75	-0.12	3.27	0.0	56.5
Landsort Deep	TF0284/50 21.11.2017	438	6.30	11.47	-0.76	3.05	0.14 5.96	52.1
Karlsö Deep	TF0245/52 21.11.2017	108	5.65	10.51	-1.44	3.47	0.0	57.3



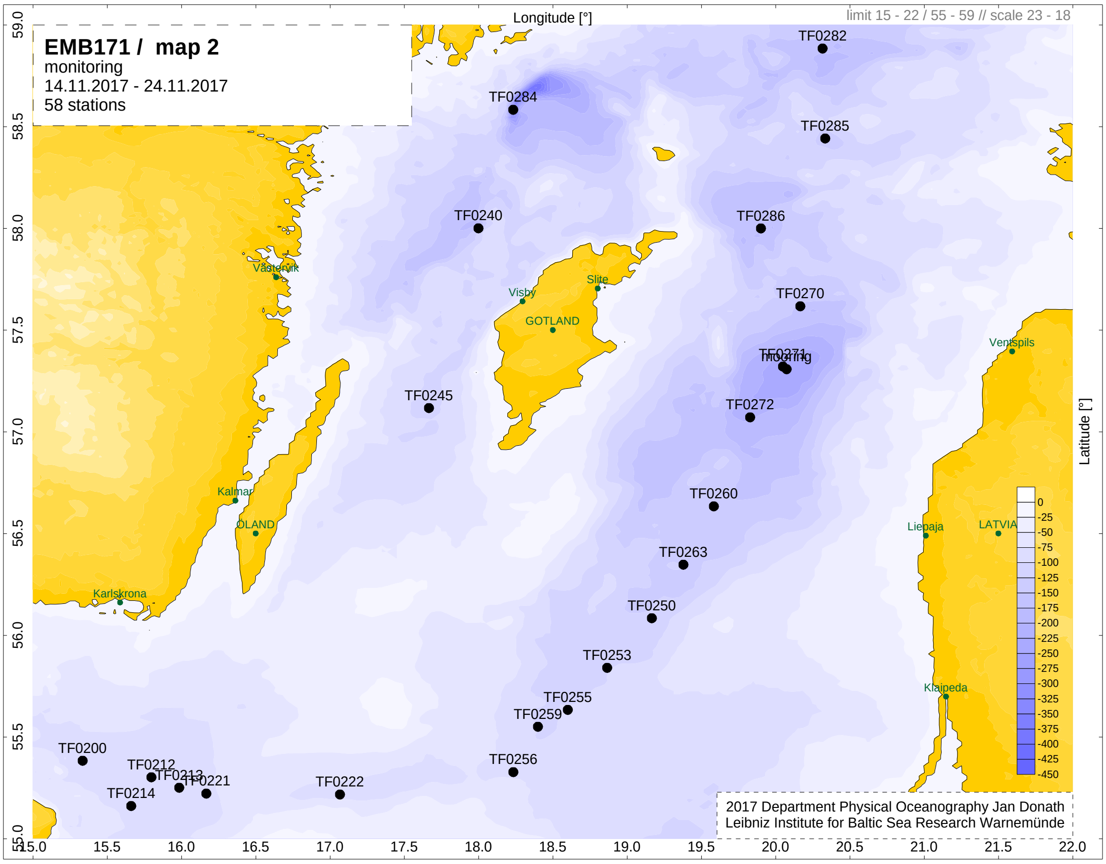


Fig. 9: Station map

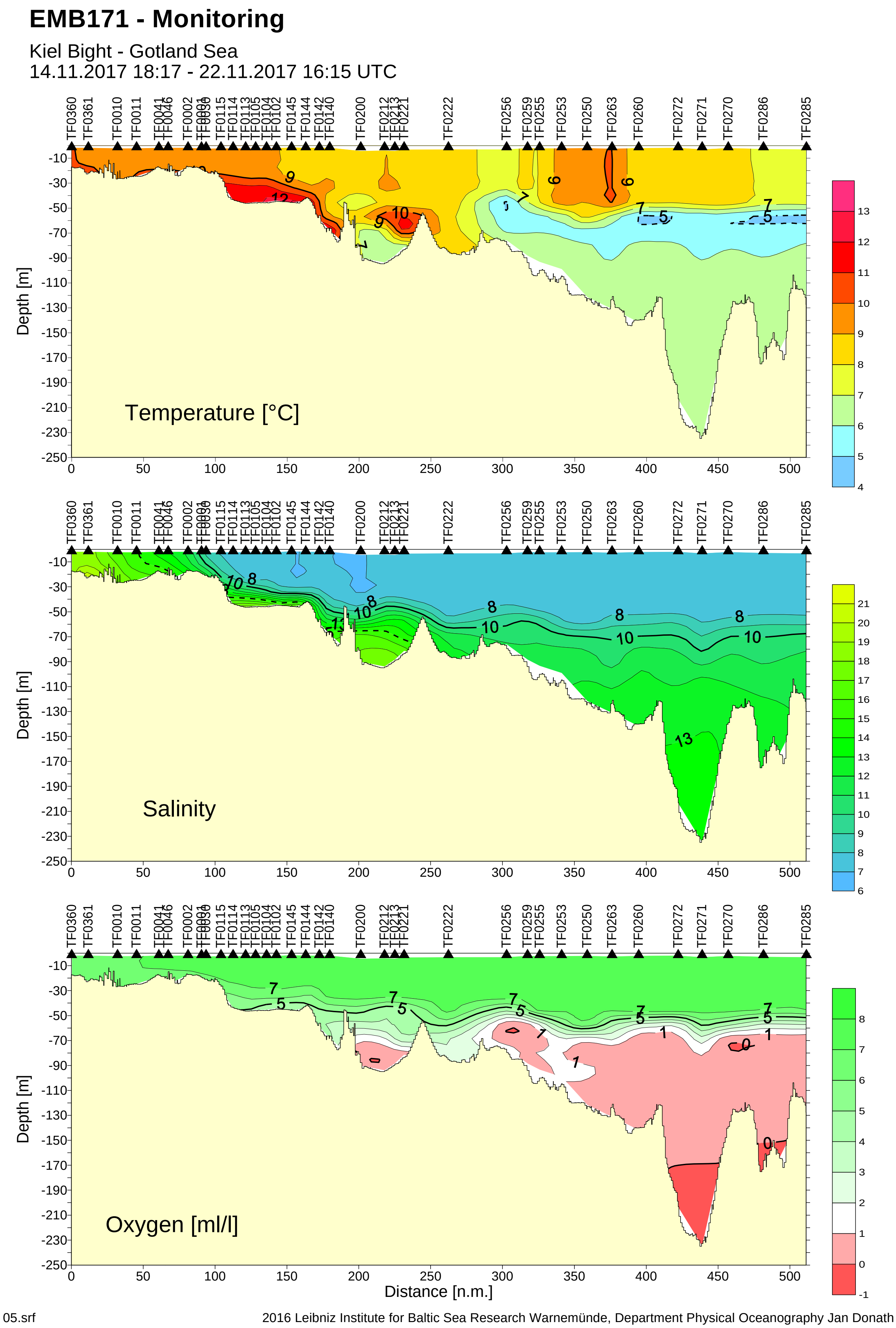


Fig. 10: Transect from the Kiel Bight to the Gotland Basin for temperature, salinity and oxygen

Station list

TFO5	Nov	14	2017	54	13.9559N	12	04.3834E
TF0018	Nov	14	2017	54	11.0187N	11	46.0881E
TF0022	Nov	14	2017	54	06.6166N	11	10.6116E
TF0012	Nov	14	2017	54	18.9121N	11	33.1041E
TF0011	Nov	14	2017	54	24.7776N	11	37.0520E
TF0361	Nov	14	2017	54	39.5073N	10	46.0076E
TF0360	Nov	14	2017	54	36.0056N	10	27.0189E
TF0010	Nov	15	2017	54	33.1004N	11	19.2572E
TF0041	Nov	15	2017	54	24.3833N	12	03.6993E
TF0040	Nov	15	2017	54	29.3023N	12	03.9032E
TF0046	Nov	15	2017	54	27.9444N	12	12.9238E
TF0002	Nov	15	2017	54	39.0463N	12	27.0048E
TF0001	Nov	15	2017	54	41.8171N	12	42.4472E
TF0030	Nov	15	2017	54	43.4634N	12	47.1335E
TF0115	Nov	15	2017	54	47.7403N	13	03.4835E
TF0114	Nov	15	2017	54	51.5882N	13	16.5500E
TF0069	Nov	15	2017	55	00.0289N	13	18.0138E
TF0113	Nov	15	2017	54	55.5083N	13	30.0057E
TF0105	Nov	15	2017	55	01.4872N	13	36.4288E
TF0104	Nov	15	2017	55	04.0624N	13	48.8184E
TF0102	Nov	16	2017	55	09.3218N	13	56.4860E
TF0145	Nov	16	2017	55	09.9908N	14	14.9439E
TF0144	Nov	16	2017	55	14.9680N	14	29.8912E
TF0140	Nov	16	2017	55	28.0142N	14	43.0571E
TF0142	Nov	16	2017	55	24.2943N	14	32.2327E
TF0103	Nov	16	2017	55	03.7853N	13	59.2832E
TF0109	Nov	16	2017	54	59.9842N	14	05.0140E
TF0111	Nov	16	2017	54	53.4113N	13	58.1385E
ABBoje	Nov	16	2017	54	52.9183N	13	51.7391E
TF0112	Nov	16	2017	54	48.2271N	13	57.4942E
TF0121	Nov	16	2017	54	42.6085N	13	56.7593E
TF0150	Nov	16	2017	54	36.7344N	14	02.5800E
OBBoje	Nov	16	2017	54	04.8352N	14	09.4452E
TF0160	Nov	17	2017	54	14.3725N	14	04.1370E
TF0152	Nov	17	2017	54	37.1438N	14	16.6480E
TF0200	Nov	18	2017	55	22.9738N	15	20.0686E
TF0214	Nov	18	2017	55	09.6429N	15	39.7002E
TF0212	Nov	18	2017	55	18.1060N	15	47.8628E
TF0213	Nov	18	2017	55	15.0398N	15	59.1018E
TF0221	Nov	18	2017	55	13.2911N	16	10.0541E
TF0263	Nov	19	2017	56	20.7847N	19	22.7436E
TF0260	Nov	19	2017	56	37.9968N	19	35.0425E
TF0272	Nov	19	2017	57	04.2392N	19	49.7192E
TF0271	Nov	19	2017	57	19.2181N	20	02.9914E
TF0270	Nov	20	2017	57	36.9844N	20	09.9817E
TF0286	Nov	20	2017	57	59.9520N	19	54.0890E
GONE	Nov	20	2017	57	18.4412N	20	04.4593E
TF0285	Nov	20	2017	58	26.4776N	20	20.0233E
TF0282	Nov	20	2017	58	52.9999N	20	18.9920E
TF0284	Nov	21	2017	58	34.9448N	18	14.0127E
TF0240	Nov	21	2017	57	59.9898N	17	59.9551E
TF0245	Nov	21	2017	57	06.9914N	17	39.9546E
TF0250	Nov	22	2017	56	05.0089N	19	09.9978E
TF0253	Nov	22	2017	55	50.4005N	18	51.9795E
TF0255	Nov	22	2017	55	37.9950N	18	36.0576E
TF0259	Nov	22	2017	55	33.0248N	18	24.0162E
TF0256	Nov	22	2017	55	19.6279N	18	14.0708E
TF0222	Nov	22	2017	55	13.0449N	17	04.0388E
TF0213	Nov	22	2017	55	15.0223N	15	58.9839E
TF0030	Nov	23	2017	54	43.4053N	12	47.0204E
TF0046	Nov	23	2017	54	27.9681N	12	13.0758E
TF0012	Nov	23	2017	54	18.9049N	11	33.0308E