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Leibniz Institute for Baltic Sea Research Warnemünde

FS „Meteor“

Monitoring cruise as part of

Cruise- No. M 117

23rd July – 16th August 2015

Kiel Bight to northern Gotland Sea

This report is based on preliminary data

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Monitoring cruise
Cruise No. M 117
FS "Meteor"

Warnemünde 17th August 2015

The fourth monitoring cruise of the Leibniz Institute for Baltic Sea Research Warnemünde in 2015 was carried out with rv "Meteor" between July 23rd and August 16th 2015 in combination with several research projects under the project title "Biochemical processes (nutrients dynamics, air-sea interactions, mercury speciation, zooplankton food quality) in upwelling zones and their horizontal gradients of the Baltic Sea" (BioChemUpwell).

The 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.

Scientific staff participating with respect to monitoring:

Günther Nausch (deputy cruise leader and scientist in charge)	23.07. – 17.08.2015
Jan Donath	23.07. – 17.08.2015
Martin Kolbe	23.07. – 17.08.2015
Lars Kreuzer	23.07. – 17.08.2015
Robert Mars	23.07. – 17.08.2015
Michael Poetzsch	23.07. – 17.08.2015
Susanne Schöne	23.07. – 17.08.2015
Ilona Steffen	23.07. – 17.08.2015
Sven Trinkler	23.07. – 17.08.2015
Peter Wlost	23.07. – 17.08.2015

The area under investigation covered the Baltic Sea between Kiel Bight and the northern Gotland Sea. Marine meteorological, hydrographical, hydrochemical and hydrobiological investigations were performed according to the COMBINE program of HELCOM. The station map is attached to this report.

The following hydrographical and hydrochemical characteristics have been observed during the cruise (cf. Tables 1 and 2 and Figs. 4 and 5):

- Surface temperatures varied between 15.6 °C (Bornholm Deep) and 18.3 °C (Mecklenburg Bight). Except the Mecklenburg Bight, temperatures in all investigated areas of the Baltic Sea are well below the long-term mean 1971-1900. They are clearly lying below the temperatures of the extreme warm summer 2014.

	2014	2015	**1971-1900**
Mecklenburg Bight	18.8°C	18.3°C	**17.7°C**
Arkona Basin	19.4°C	16.3°C	**17.0°C**
Bornholm Deep	19.4°C	15.6°C	**17.6°C**
Gotland Deep	19.4°C	16.2°C	**17.1°C**
Farö Deep	20.4°C	16.8°C	**17.0°C**
Landsort Deep	21.8°C	15.2 °C	**18.2°C**
Karlsö Deep	21.9°C	16.7 °C	**16.9°C**

Due to strong winds the surface layer was mixed down to around 25 m and a very sharp thermocline had developed.

- Deep water layer temperatures are higher as the long-term mean 1971-1990, increased further compared to July 2014, but are comparable in the Bornholm and Gotland Deeps to the observations of the previous monitoring cruise in May 2015. The warm temperatures are also reflecting the Major Baltic Inflow of December 2014 which was relatively warm.

	July 2014	May 2015	July 2015	**1971/90**
Bornholm Deep	5.9°C	7.00	7.01°C	**6.12 °C**
Gotland Deep	6.0°C	6.88	6.87°C	**5.62 °C**
Farö Deep	5.9°C	6.50	6.58°C	**5.20 °C**
Landsort Deep	5.2°C	5.42	5.68°C	**4.76 °C**
Karlsö Deep	5.2°C	4.99	5.02°C	**4.18 °C**

- The Major Baltic Inflow from December 2014 caused a strong increase in the bottom water salinity in the eastern Gotland Basin (Gotland Deep) already in March 2015. Salinity increased further until May, but showed a slight decrease until July 2015. Also in the more northern Farö Deep an increase in bottom water salinity could be observed. This could be the result of three earlier smaller inflows of November 2013 and spring 2014 which did not met the characteristics of a Major Baltic Inflow alone but could in sum traced until the central Baltic Sea.

	July 2014	March 2015	May 2015	July 2015
Gotland Deep	12.25	13.44	13.54	13.43
Farö Deep	11.58	11.86	12.11	12.23
Landsort Deep	10.41	not sampled	10.54	10.86
Karlsö Deep	9.58	9.57	9.60	9.65

- The effects of these different inflow events can be seen clearly in the oxygen situation of the deep water. Already in July 2014, the above mentioned smaller inflows could shortly ventilate the deep water of the Gotland Deep causing “good” preconditions for the Major Baltic Inflow of December 2014. Already in March 2015, the deep water was oxic there. However, an intermediate layer of uplifted anoxic water remained. In May 2015, the oxygen situation in the Gotland Deep improved further. Near to the bottom 2.09 ml/l were measured, the anoxic intermediate layer was found only

sporadically. During the present cruise, the whole water column was oxic, with lowest oxygen concentrations at 110 m water depth but already decreasing values near to the bottom.
In the Farö Deep, the hydrogen sulphide concentrations were reduced already in March 2015 compared to earlier investigations, but the situations has not improved further until the present cruise suggesting that these changes were more due to the smaller inflows earlier than the Major Baltic Inflow of December 2014.
The western Gotland Basin was so far not influenced by the different inflow activities since November 2013.

Oxygen concentrations (ml/l) in the near bottom layer of the deep basins of the central Baltic Sea. Hydrogen sulphide is given as negative oxygen equivalents:

	July 2014	March 2015	May 2015	July 2015
Gotland Deep	0.37	0.89	2.09	0.86
Farö Deep	-5.33	-1.14	-1.18	-1.54
Landsort Deep	-3.29	not sampled	-0.73	
Karlsö Deep	-2.44	-0.70	-0.84	

- The nutrient situation in the surface layer is typical for the season. Whereas the surface layer is completely exhausted from nitrate, measurable phosphate concentrations were found in the western Baltic Sea, the Arkona and Bornholm Basin (table 1). In contrast, in the eastern, northern and western Gotland Basin phosphate was nearly completely consumed, most probably due the blooming of cyanobacteria. In the vertical direction, nitrate was absent down to the halocline whereas phosphate concentrations increased to around 0.5 µmol/l directly below the thermocline. Thus, vertical mixing in autumn and winter will supply the surface layer with remarkable high phosphate concentrations but comparable low nitrate causing the N/P ratios in the winter surface layer well below the Redfield-ratio.

- In the deep waters of the central basins, the hydrographical situation is mirrored. The deep water of the Bornholm Basin was mainly oxic during the last years. The above mentioned three smaller inflows, but especially the Major Baltic Inflow of December 2014 caused good oxygen supply. Logically, phosphate concentrations are low due to precipitations and following sedimentation of the formed particles. On the other hand, high nitrate concentrations were found.
  In the Gotland Deep, nitrate concentrations increased further compared to May 2015. The good oxygen supply allowed nitrification. On the other hand, the increase in phosphate near to the bottom can be interpreted as beginning resolution from the sediment.
  The anoxic conditions in the Farö Deep prevent nitrification and nitrate is zero. Phosphate is decreasing slightly.
  As the inflow activities had not reached the western Gotland Basin, the nutrient situation in the deep water remained more or less unchanged.

  Phosphate concentrations (µmol/l) in the near bottom layer of the deep basins of the central Baltic Sea:

	July 2014	March 2015	May 2015	July 2015
Bornholm Deep	1.17	1.16	1.53	1.96

Gotland Deep	2.51	2.26	1.95	2.38
Farö Deep	4.30	3.42	3.30	2.98
Landsort Deep	3.25	not sampled	3.70	3.30
Karlsö Deep	3.05	3.95	3.95	3.60

Nitrate concentrations (µmol/l) in the near bottom layer of the deep basins of the central Baltic Sea:

	July 2014	March 2015	May 2015	July 2015
Bornholm Deep	11.24	9.48	11.25	13.76
Gotland Deep	0	8.98	10.53	12.30
Farö Deep	0	0	0	0
Landsort Deep	0	not sampled	0	0
Karlsö Deep	0	0	0	0

- In addition to the standard station net, a specific grid of stations was sampled (Fig. 3) to describe to evolution of the inflow more in detail. It could be shown that the inflowing water masses are moving on the eastern side of the Gotland Basin. Effects could be seen until station GB-B16 so far. For the same purpose, a scanfish transect was performed from station 286 (Farö Deep) to station 260 (Fig. 3, red line). Supplementing the different CTD casts, a higher resolution for the distribution of temperature, salinity and oxygen can be gathered from the still uninfluenced northern area to the already oxygenated area.

- During the cruise, samples for the determination of organic pollutants at 7 stations were taken. Samples for phyto- and zooplankton (14 stations), for methane distribution (12 stations) as well as for the carbonate system (1 station) were collected for later analysis in the laboratory.

- During the cruise, for the first an autoanalyzer system for the determination of nanomolar concentrations of phosphate and the sum of nitrite and nitrate was utilized. The colorimetric standard methods have a detection limit of 0.02 µM (phosphate and 0.05 – 0.1 µM (nitrite + nitrate). The Baltic Sea the concentrations of these nutrients are lying in summer at or below these detection limits. With the use of a so-called LWCC (Liquid Waveguide Capillary Cell), the sensitivity of the used methods could be increased significantly. Results allow new insights into the "real" nutrient limitation of phytoplankton growth.

Attachments

Tables 1 and 2: Preliminary results of selected parameters in the surface layer and the near bottom water layer - (unvalidated results)
Fig. 1: General station overview
Fig. 2: Sampled statin in the western Baltic Sea and the Arkona Basin
Fig. 3. Sampled stations in the central Baltic Sea including the special grid and the scanfish transect (redline) in the eastern Gotland Basin
Fig. 4: Oxygen/hydrogen sulphide in the bottom near layer for selected stations
Fig. 5: Transect from the Kiel Bight to the northern Gotland Basin for temperature, salinity and oxygen (unvalidated data)

Günther Nausch

Scientist in charge

Table 1: Surface water layer (about 1 m depth)

Area Date	Stat. Name/No.*	Temp. ºC	Sal. psu	O_2 ml/l	PO4 µM	NO3 µM	SiO4 µM
Meckl.Bight 24.07.2015	012/0005	18.29	10.36	6.59	0.14	0	10.8
Darss Sill 25.07.2015	030/0012	15.46	8.42	7.00	0.23	0	10.7
Arkona Basin 25.07.2015	113/0016	16.26	8.26	6.71	0.19	0	11.2
Bornholm Deep 27.07.2015	213/0036	15.64	7.62	6.51	0.28	0.08	13.3
Stolpe Channel 28.07.2015	222/0038	15.96	7.48	6.60	0.26	0.10	15.1
SE Gotland Basin 28.07.2015	259/0040	15.91	7.20	6.67	0.33	0.07	17.4
Gotland Deep 29.07.2015	271/0047	16.20	6.78	6.77	0.04	0.11	9.9
Farö Deep 31.07.2015	286/0049	16.81	6.29	6.88	0	0.09	8.3
Landsort Deep 05.08.2015	284/0058	15.22	5.68	7.40	0.02	0.14	8.8
Karlsö Deep 05.08.2015	245/0055	16.74	6.53	6.75	0	0	10.6

* see attached map

Table 2: Deep water layer (bottom near layer depths)

Area Date	Stat. Name/No.*	Depth m	Temp. °C	Sal. psu	O_2 ml/l	PO4 µM	NO3 µM	SiO4 µM
Meckl.Bight 24.07.2015	012/0005	24	10.75	18.86	1.63	1.08	3.47	51.0
Darss Sill 25.07.2015	030/0012	22	13.80	12.42	3.16	0.77	0	24.9
Arkona Basin 25.07.2015	113/0016	46	6.02	15.24	0.55	1.50	8.48	66.6
Bornholm Deep 27.07.2015	213/0036	87	7.01	19.14	1.24	1.96	13.76	53.2
Stolpe Channel 28.07.2015	222/0038	88	6.84	15.25	2.62	1.77	10.88	41.2
SE Gotland Basin 28.07.2015	259/0040	87	5.57	10.98	0.78	2.37	6.98	46.3
Gotland Deep 29.07.2015	271/0047	232	6.87	13.43	0.86	2.38	12.30	52.5
Farö Deep 31.07.2015	286/0049	189	6.58	12.23	-1.58**	2.98	0	63.0
Landsort Deep 05.08.2015	284/0058	434	5.68	10.86	-0.93**	3.30	0	63.2
Karlsö Deep 05.08.2015	245/0055	106	5.02	9.65	-1.28**	3.60	0	61.0

* see attached map
** hydrogen sulphide was converted into negative oxygen equivalents

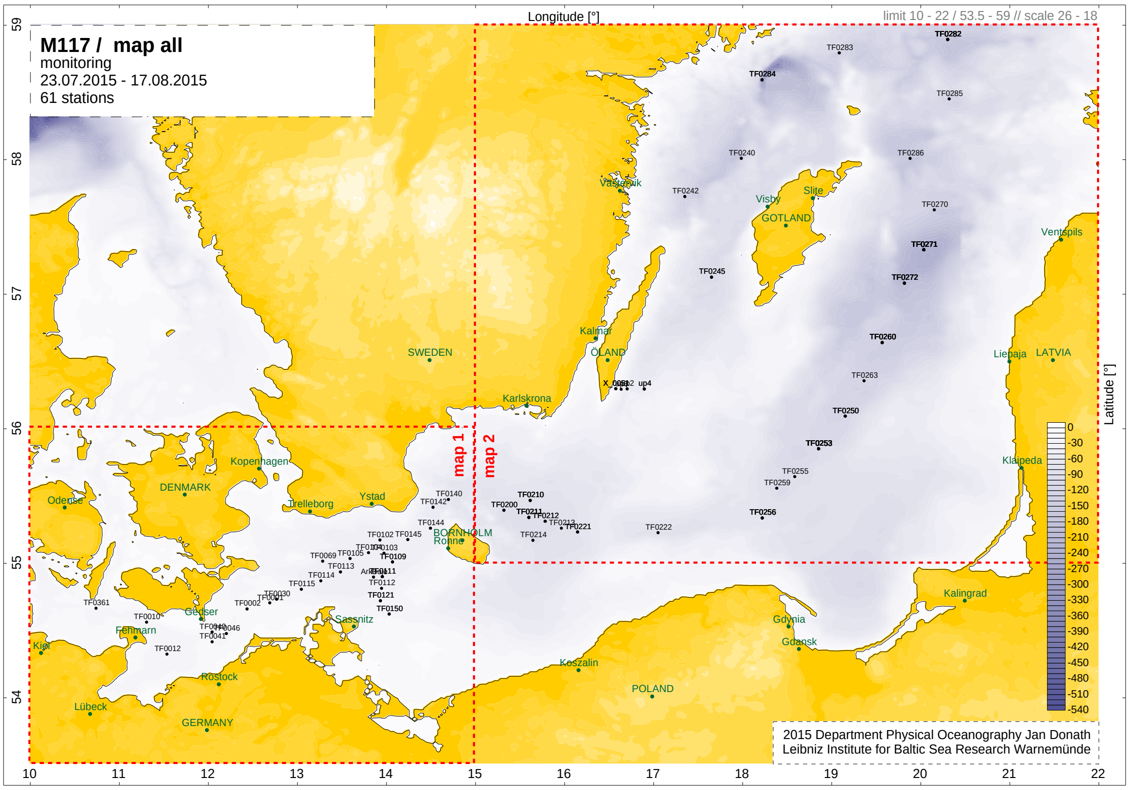


Figure 1

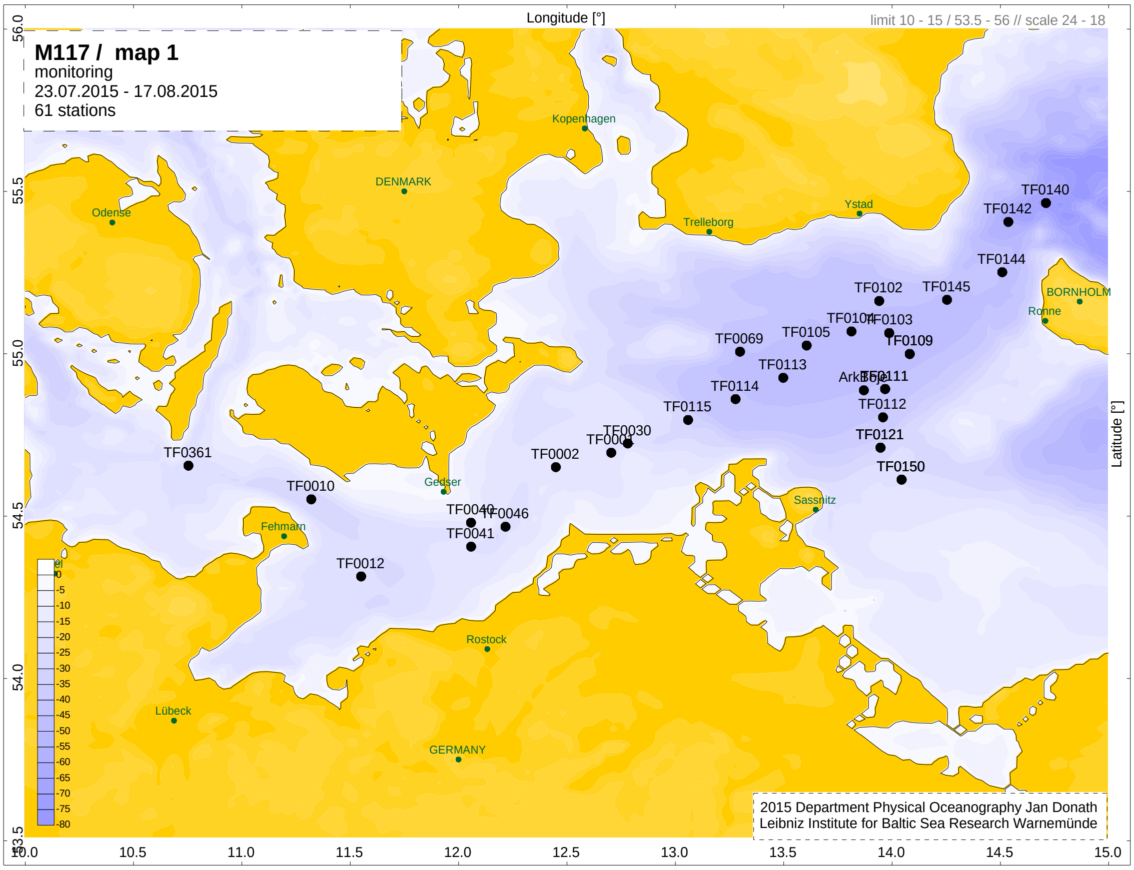


Figure 2

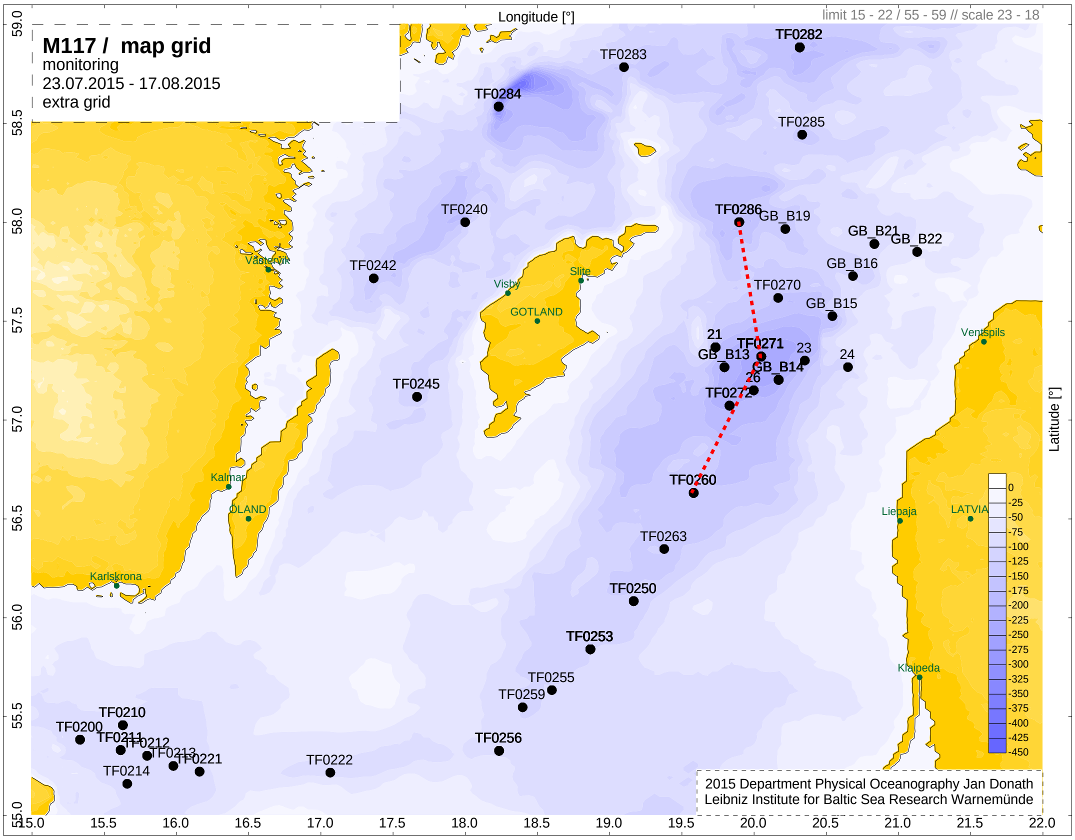


Figure 3

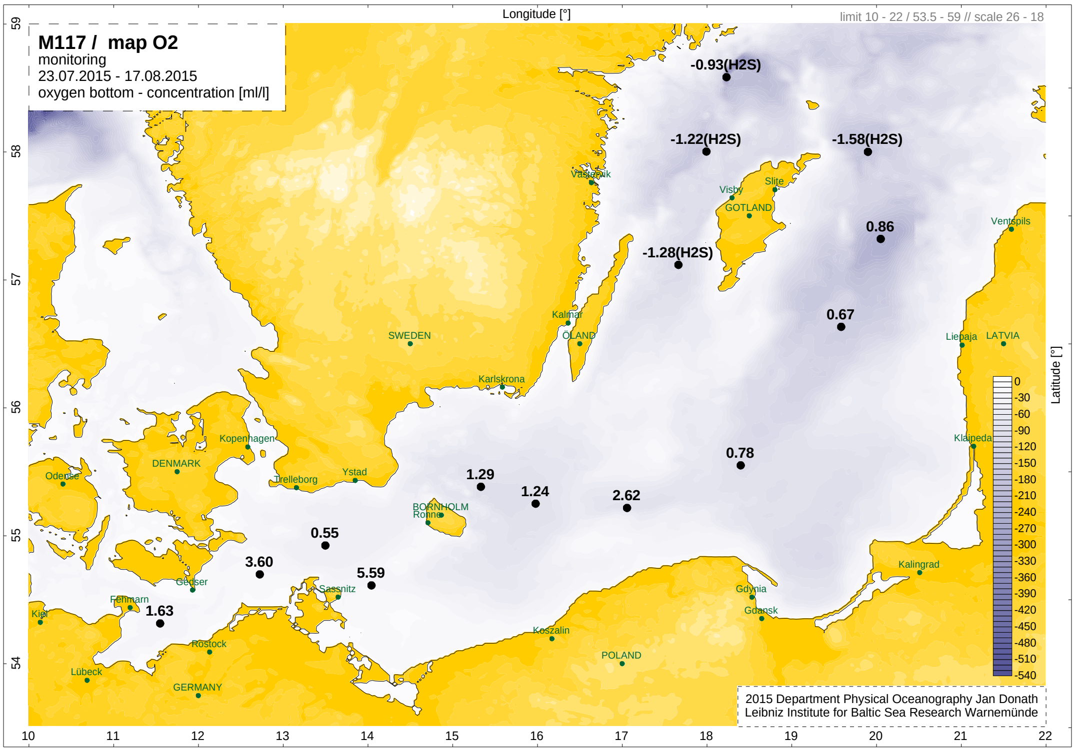
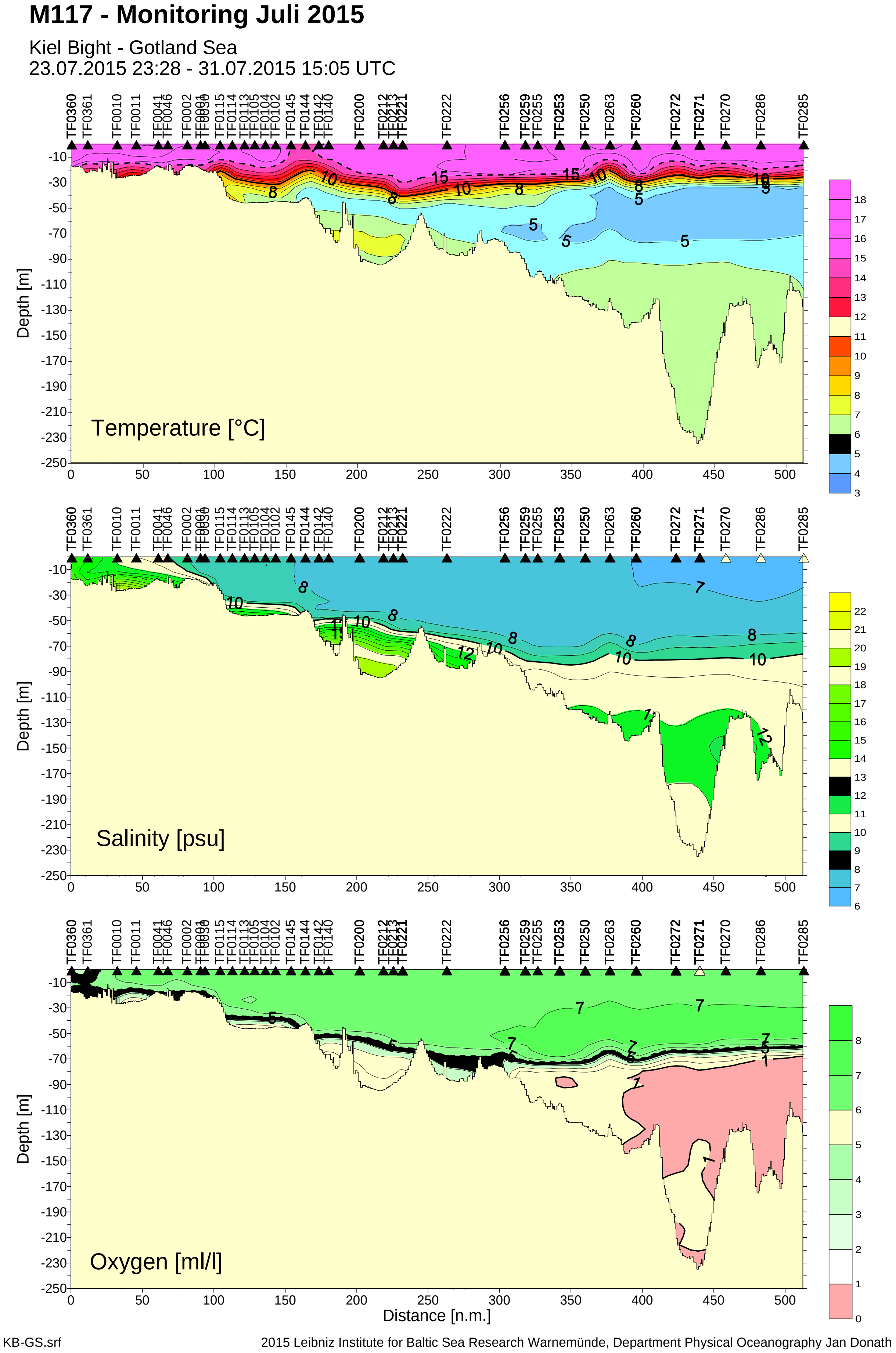


Figure 4



M117 - Monitoring Juli 2015
Kiel Bight - Gotland Sea
23.07.2015 23:28 - 31.07.2015 15:05 UTC
Temperature [°C]
Salinity [psu]
Oxygen [ml/l]
Depth [m]
Distance [n.m.]
KB-GS.srf
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Figure 5