# Leibniz Institute for Baltic Sea Research Warnemünde

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

r/v "E. M. Borgese"

Cruise- No. EMB060

This report is based on preliminary data

Leibniz-Institut für Ostseeforschung Warnemünde
an der Universität Rostock
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🗐 +49-381-5197 440

1. **Cruise No.:** EMB 060

2. **Dates of the cruise:** from 01.11.2013 to 12.11.2013

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 04.11. – 05.11. 2013

6. **Purpose of the cruise**
   Monitoring in the frame of the HELCOM COMBINE Programme and continuation of IOW's long-term measurements

7. Name of master: Volker Ziegner
   Number of crew: 11

8. **Research staff:**
   Chief scientist:
   Dr. Martin Schmidt, IOW
   Scientific Crew:

| | |
|---|---|
| Donath | Jan |
| Kreuzer | Lars |
| Hand | Ines |
| Pötzsch | Michael |
| Peterson | Mareike |
| Weinreben | Stefan |
| Glockzin | Ines |
| Langer | Simon |
| Meyer | David |
| Lehnert | Gerhard |
| Pohl | Frank |

   **Co-operating institutions:**
   All institutions dealing with HELCOM monitoring programmes

9. **Scientific equipment**

   CTD SBE 911+ with doubled sensors, SBE oxygen sensor and WETLABS Fluorometer, PAR - sensor
   Electronic Reversing Thermometer
   Autosal 8400
   Rosette with water samplers
   Plankton nets, WP2 net, filtration set
   Van Veen grab, dredge
   Autoanalyser, Photometer, Titrino 716
   Ships weather station (WERUM)

10. **General remarks and preliminary result** (ca. 2 pages)

The cruise started in Rostock-Marienehe under weather conditions normal for the season. Moderate westerly winds, cloud covered skies, bad visibility and occasionally little rain. Each station started with a CTD-cast (SBE 911+ with doubled sensors for temperature and conductivity, SBE oxygen sensor and WETLABS Fluorometer) including water sampling for oxygen and nutrient measurements. Light conditions were determined with a PAR sensor. At selected stations phytoplankton samples were taken, Secchi-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 a dredge. Benthos sampling at TF0160 had to be skipped because of high sea state.

Oxygen is determined with a 716 DMS Titrino III, for H2S determination the photometric methylen blue method is used. Nutrients (nitrate, nitrite, phosphate and silicate) are determined with an Autoanalyser Evolution III (Allicance Instruments), for ammonium the manual indophenol blue -method is used.

At 3$^{th}$ Nov. evening, station work was interrupted because of strong winds with high sea state but could be resumed in the Oder Bight next morning. After a crew exchange during the night from 4$^{th}$ to 5$^{th}$ Nov. in Saßnitz, station work was continued in the Arkona Sea, the Bornholm Gatt and the Bornhom Sea towards the Central Baltic Sea. Near station TF0271, the hydrographic mooring, GONE, equipped with an upward looking ADCP, thermistors, conductivity/temperature sensors, oxygen sensor, was maintained routinely. An experimental undulating mooring was laid (GODESS project) carrying several hydrographic and biochemical sensors. In addition, special samples for IOW's molecular-biological long term observation programme were taken.

When arriving at TF0271, the sea state allowed the maintenance of the aforementioned GONE mooring, several CTD casts and sampling with the plankton net. 7$^{th}$ Nov. evening wind speed was increasing again and only CTD work was possible. Hence, station work was continued northward. In the morning of 9$^{th}$ Nov. the ship returned to station TF0271 since wind speed was sufficiently low for laying out of the GODESS mooring. 9$^{th}$ Nov. evening station work was resumed in the Landsort Deep, TF0284, but was interrupted after two CTD casts by gale force winds and sea state up to 4m height. Hence, at this station surface nutrient samples are missing and the samples for the molecular-biological long term observation programme could not be taken. 10$^{th}$ Nov. afternoon station work was continued in the Karlsö Deep, TF0240.

*Preliminary results*

From the benthos sampling **west of Darß Sill** (TF00018, TF0012, TF0010, TF0360) muddy sediments were found, dominating species is the mussel *Arctica Islandica*. At station TF0360 the dredge samples contained many algae and serpent stars. **East of Darß Sill** (TF0030) the sediment consists of fine sand and dredged samples are dominated by ample of *Mytilus Edulis*. At station TF0109 oxygen in the bottom water is depleted and only a few individuals are found. The sediment at station TF0160 consists mainly of mussel shell dominated by mussels like *Mya Arenaria* and *Cerastoderma.* The spectrum of species is similar to that found in the previous years.

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 is about 14, in the Kiel Bight it reaches 16. Surface temperature is uniform about 11.8°C. Bottom salinity of about 23 is less than in the Arkona Basin west of Darß Sill.

**East of Darß Sill** surface salinity is about 8 and decreases to 6.3 in the Gotland Basin. In the Arkona Basin the thickness of the bottom layer with enhanced salinity (< 24) rarely exceeds 3 to 4 m thickness, temperature and salinity characteristics are similar to the Mecklenburg Bight. Oxygen concentration is slightly depleted above the bottom layer but not near the bottom indicating that possibly some minor overflow over Darß Sill happened recently refreshing the water in the bottom layer.

In the **Bornholm Basin** the often observed 4-layer structure is found. There is a homogeneous surface layer of 45 m thickness with a temperature of about 10.2°C and salinity of 7.2. Below the surface layer there is oxygen depleted winter water with a core temperature below 4°C followed by a warmer layer with temperature varying rapidly between 7°C and 8°C and oxygen concentration enhanced compared with the winter water. This layer can be understood as the main path of minor intermittent inflow of warmer and saline water. In turn, the bottom water is colder, more saline and contains almost no oxygen towards the bottom.

Through **Stolpe Channel** towards the **Central Gotland Basin** the thermocline depth is almost the same. The surface layer is not always vertically uniform, at TF0271 even a thermocline at 20m depth is found. Hence, deep mixing has not started yet and the Baltic winter water is still disclosed from surface contact. The core of the winter water is found at about 60 m depth. In the Stolpe Channel and in the Southern Gotland Basin the winter water has also a vertical structure. The upper part with a negative downward temperature gradient shows an enhanced oxygen concentration, a signature from the last contact with the atmosphere during winter time which this water mass has kept over spring and summer. Below the core of the winter water oxygen becomes rapidly depleted. In the Central Gotland Basin water is anoxic below 120m, at 130m depth the well know turbidity maximum is met and below this depth free $H_2S$ is found. There exists a well-mixed bottom layer of about 10m thickness with enhanced turbidity.

In the **Landsort Deep** the surface layer is still stratified. The core of the winter water is at 50 m depth, water is anoxic with $H_2S$ below 110 m depth. Also the Karlsö Deep is anoxic. Here the redoxcline is elevated to a depth of 60 m, below this depth $H_2S$ is found. Hence, west of Gotland in the Karlsö Deep $H_2S$ penetrates to the base of the winter water.

In the surface layer phosphate, nitrogen and silicate are present everywhere in the area of investigation. The fluorescence data show that some phytoplankton development is supported by this nutrient pool. Even in the oxic surface layers about 50% of the dissolved inorganic nitrogen (DIN) is found as ammonium, probably excreted by zooplankton. Near the bottom, most DIN is nitrified almost completely, when the bottom water is oxygenated, but when oxygen is exhausted and $H_2S$ is formed, no nitrate but high ammonium concentrations are found.

West of Darß Sill and in the Arkona Basin the surface water N/P ratio is less than 2 but reaches values of 7 in the Gotland Basin.  In the bottom water the N/P ratio is more constant and varies between 3.5 and 4.5.

Figure 1 shows profiles of hydrographic variables from the Central Gotland Basin, the Landsort Deep and the Karlsö Deep. Oxygen concentration decreases rapidly below the core of the winter water. A characteristic turbidity peak marks the boundary to sulphidic water masses. Note the onset of sulphidic water in the Karlsö Deep just below the winter water core.

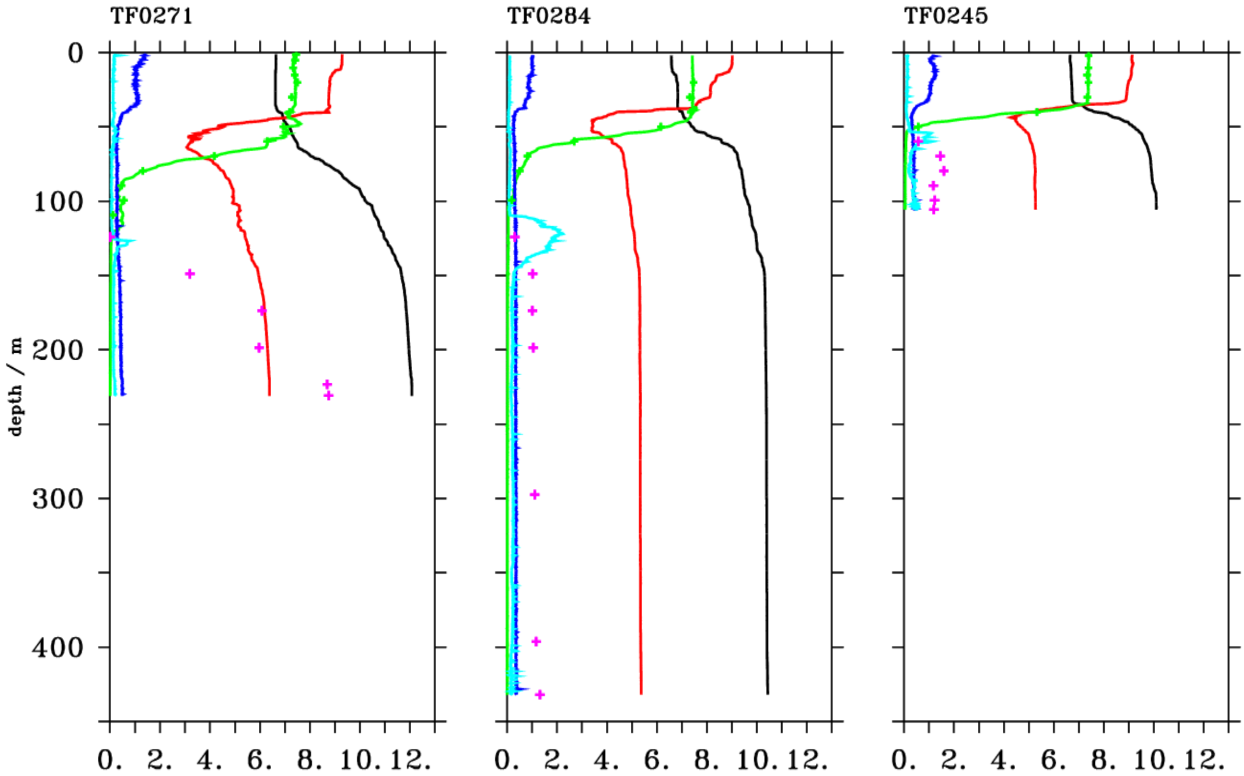



Figure 1: Examples for vertical profiles in the Central Gotland Basin (TF0271), Landsort Deep (TF0284), Karlsö Deep (TF0245). Black: salinity, red: temperature [°C], green: oxygen concentration [ml/l], blue: fluorescence, cyan: turbidity. Cyan crosses: $H_2S$ concentration [ml/l]. The numeric scale is the same for all quantities.

The maximum $H_2S$ concentrations but also maximum ammonium, phosphate and silicate concentrations are met as usually at station TF0271. The $H_2S$ concentration of -8.75 ml/l (oxygen equivalent) is the largest observed during previous autumn cruises since 2001 but also compared with the summer 2013. In turn salinity is the lowest (except 2001) and phosphate and DIN (mostly ammonium) concentrations are the largest observed since 2001, see table 1 and 3. The deep water in the Gotland Basin is still stagnant and only minor renewing inflows took place during 2013. Table 1 demonstrates the development of stagnant conditions since 2001. During major inflow 2003 and the minor inflow 2006 bottom water was replaced by more dense (more saline and colder) water that carries oxygen but less nutrients. After these events oxygen concentration ($H_2S$ counted as negative oxygen concentration) is decreasing and nutrients (phosphorus, silicate and nitrogen) are accumulated in the bottom water and form a growing nutrient pool.

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

| year | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008* | 2009* | 2010 | 2011* | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 |
| 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 |
| $O_2$ /$H_2S$ | -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 |
| $PO_4$ | 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 |
| DIN | | | 11.56 | | 19.89 | 6.41 | 17.0 | | | 32.60 | | 39.83 | 42.4 |
| $SIO_4$ | 86.8 | | 40.2 | 64.1 | | | | 89.2 | 87.6 | 94.2 | 104.4 | 111.0 | 126.8 |

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

**Appendix:** 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

Fig. 1: Examples for vertical profiles in the Central Gotland Basin (TF0271), Landsort Deep (TF0284), Karlsö Deep (TF0245).

Fig. 2: The station grid in the Western and Southern Baltic

Fig. 3: The station grid in the Central Baltic

Fig. 4: Oxygen concentrations in the near bottom layer for selected stations

Fig. 5: Transect from the Fehmarn Belt to the Bornholm Basin for temperature, salinity and oxygen

Fig. 6: Transect from the Kiel Bight to the Gotland Basin for temperature, salinity and oxygen

Fig. 7: Transect north of Gotland for temperature, salinity and oxygen

**Table 2: Surface layer (0 - 10m)**

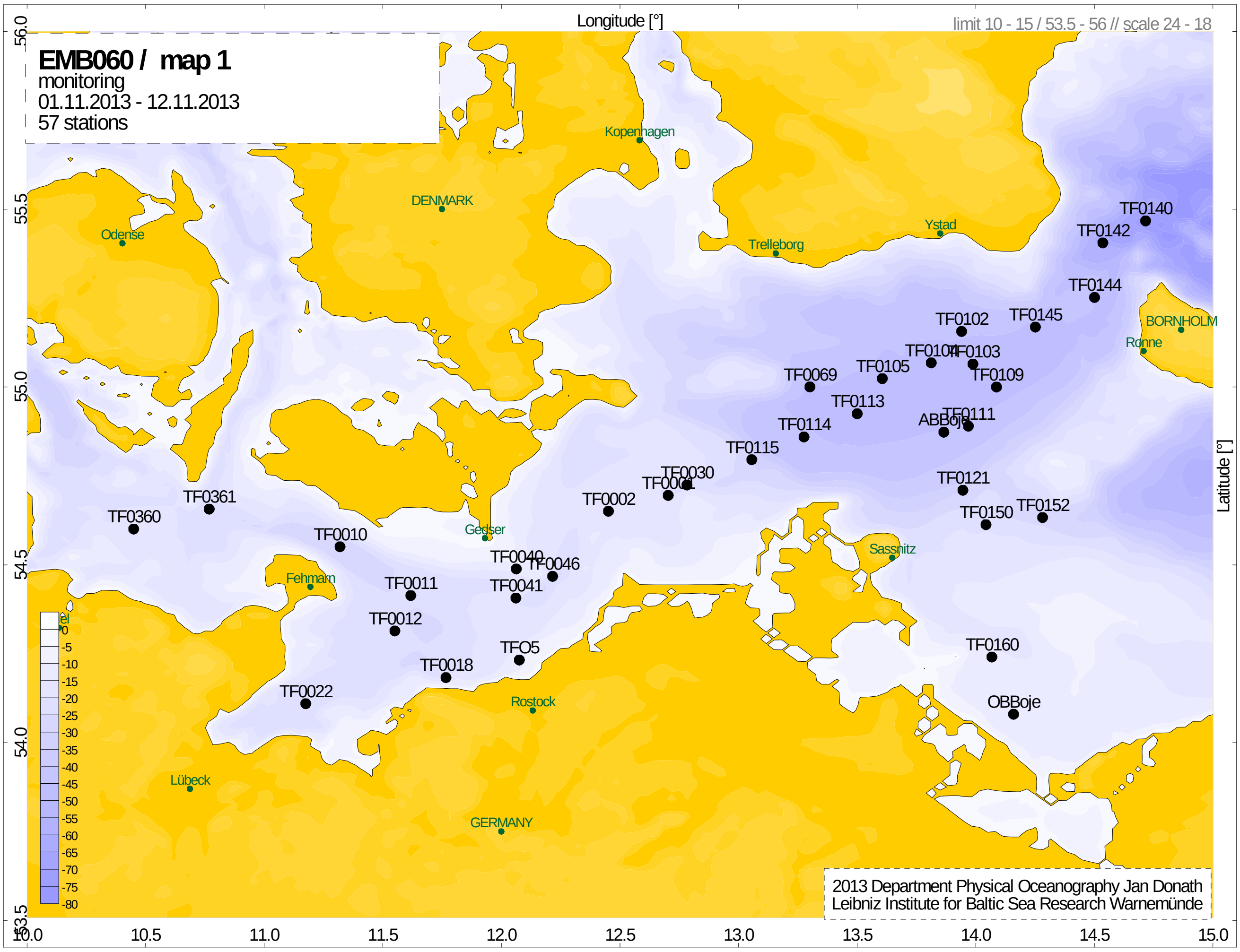
| Area | Station | Tempera-ture | Salinity | $PO_4^{3-}$ | $NO_2^{3-}$ * DIN | $SiO_4$ |
|---|---|---|---|---|---|---|
| Date | Name/ No. ** | °C | PSU | µmol/l | µmol/l | µmol/l |
| Kiel Bight | TF0360/08 02.11.2013 | 11.6 | 16.72 | 0.46 | 0.41 0.48 | 15.4 |
| Meckl. Bight | TF0012/03 01.11.2013 | 11.8 | 14.29 | 0.43 | 0.74 1.06 | 16.5 |
| Lübeck Bight | TF0022/06 01.11.2013 | 11.8 | 14.17 | 0.58 | 0.81 | 18.9 |
| Arkona Basin | TF0113/17 02.11.2013 | 11.29 | 7.72 | 0.16 | 0.14 0.29 | 5.5 |
| Pom. Bight | TF0160/27 04.11.2013 | 10.33 | 7.12 | 0.32 | 0.14 | 17.4 |
| Bornholm Deep | TF0213/41 06.11.2013 | 10.24 | 7.17 | 0.19 | 0.63 1.42 | 6.7 |
| Stolpe Channel | TF0222/43 06.11.2013 | 10.39 | 7.24 | 0.19 | 0.33 | 5.8 |
| SE Gotland Basin | TF0259/45 06.11.2013 | 10.25 | 7.18 | 0.23 | 0.77 1.43 | 7.4 |
| Gotland Deep | TF0271/52 07.11.2013 | 9.29 | 6.64 | 0.07 | 0.36 0.93 | 5.3 |
| Fårö Deep | TF0286/54 08.11.2013 | 9.38 | 6.37 | 0.1 | 0.34 0.77 | 6.5 |
| Landsort Deep | TF0284/56 09.11.2013 | 9.01 | 6.58 | | | |
| Karlsö Deep | TF0245/58 10.11.2013 | 9.13 | 6.65 | 0.25 | 0.64 1.18 | 8.5 |
| | | | | | | |

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

** See maps

**Table 3: Bottom-near water layer**

| Area | Station | Depth | Temp. | Salinity | $O_2$ | $PO_4^{3-}$ | $NO_{23}^{-}$ * DIN | $SiO_4$ |
|---|---|---|---|---|---|---|---|---|
| Date | Name/ No. ** | m | °C | PSU | ml/l | µmol/l | µmol/l | µmol/l |
| Kiel Bight | TF0360/08 02.11.2013 | 17.0 | 12.28 | 23.67 | 5.51 | 0.63 | 2.79 3.41 | 15.7 |
| Meckl. Bight | TF0012/03 01.11.2013 | 23.0 | 12.18 | 18.63 | 6.12 | 0.57 | 1.62 2.55 | 17.1 |
| Lübeck Bight | TF0022/06 01.11.2013 | 22.0 | 12.78 | 21.05 | 0.95 | 2.2 | 2.93 | 54,0 |
| Arkona Basin | TF0113/17 02.11.2013 | 44.5 | 11.96 | 23.87 | 4.77 | 0.95 | 3.99 4.92 | 23,0 |
| Pom. Bight | TF0160/27 04.11.2013 | 13.0 | 10.34 | 7.12 | 7.16 | 0.28 | 0.13 | 17,1 |
| Bornholm Deep | TF0213/41 06.11.2013 | 87.0 | 5.51 | 15.38 | 0.08 | 1.63 | 8.72 9.85 | 59.5 |
| Stolpe Channel | TF0222/43 06.11.2013 | 88.25 | 4.93 | 12.23 | 2.05 | 1.4 | 7.4 | 37.9 |
| SE Gotland Basin | TF0259/45 06.11.2013 | 86.5 | 4.55 | 10.29 | 0.89 | 2.15 | 6.39 6.98 | 46.0 |
| Gotland Deep | TF0271/52 07.11.2013 | 231.0 | 6.38 | 12.07 | -8.75 | 11.55 | 0.0 42.4 | 126.8 |
| Fårö Deep | TF0286/54 08.11.2013 | 187.0 | 5.86 | 11.43 | -7.74 | 5.55 | 0.0 22.3 | 90.0 |
| Landsort Deep | TF0284/56 09.11.2013 | 432.0 | 5.37 | 10.43 | -1.32 | 3.75 | 0.0 8.12 | 62.5 |
| Karlsö Deep | TF0245/58 10.11.2013 | 105.8 | 5.26 | 10.10 | -1.20 | 3.9 | 0.0 7.91 | 62.2 |
| | | | | | | | | |



EMB060 / map 1
monitoring
01.11.2013 - 12.11.2013
57 stations
Longitude [°]
limit 10 - 15 / 53.5 - 56 // scale 24 - 18
Latitude [°]
Kopenhagen
DENMARK
Odense
Trelleborg
Ystad
BORNHOLM
Rønne
Gedser
Fehmarn
Sassnitz
Rostock
Lübeck
GERMANY
TF0140
TF0142
TF0144
TF0145
TF0102
TF0104
TF0103
TF0105
TF0109
TF0069
TF0113
TF0114
ABBoje
TF0111
TF0115
TF0030
TF0001
TF0002
TF0121
TF0150
TF0152
TF0361
TF0360
TF0010
TF0040
TF0046
TF0041
TF0011
TF0012
TF05
TF0018
TF0022
TF0160
OBBoje
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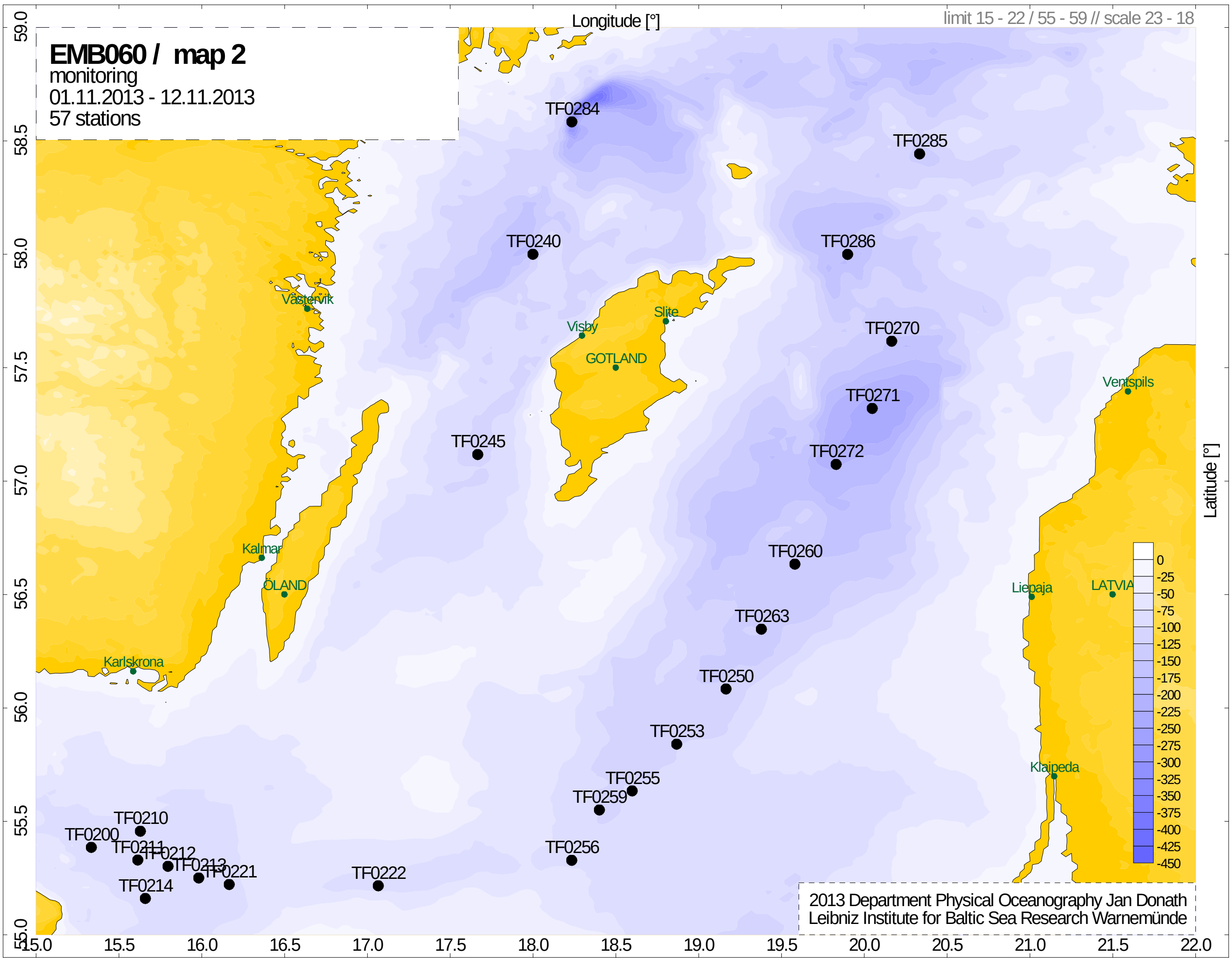
Figure 2



EMB060 / map 2
monitoring
01.11.2013 - 12.11.2013
57 stations
Longitude [°]
limit 15 - 22 / 55 - 59 // scale 23 - 18
Latitude [°]
TF0284
TF0285
TF0240
TF0286
TF0270
TF0271
TF0272
TF0245
TF0260
TF0263
TF0250
TF0253
TF0255
TF0259
TF0256
TF0210
TF0200
TF0211
TF0212
TF0213
TF0221
TF0214
TF0222
Västervik
Visby
Slite
GOTLAND
Ventspils
Kalmar
ÖLAND
Liepaja
LATVIA
Karlskrona
Klaipeda
0
-25
-50
-75
-100
-125
-150
-175
-200
-225
-250
-275
-300
-325
-350
-375
-400
-425
-450
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15.0
15.5
16.0
16.5
17.0
17.5
18.0
18.5
19.0
19.5
20.0
20.5
21.0
21.5
22.0
55.0
55.5
56.0
56.5
57.0
57.5
58.0
58.5
59.0


Figure 3

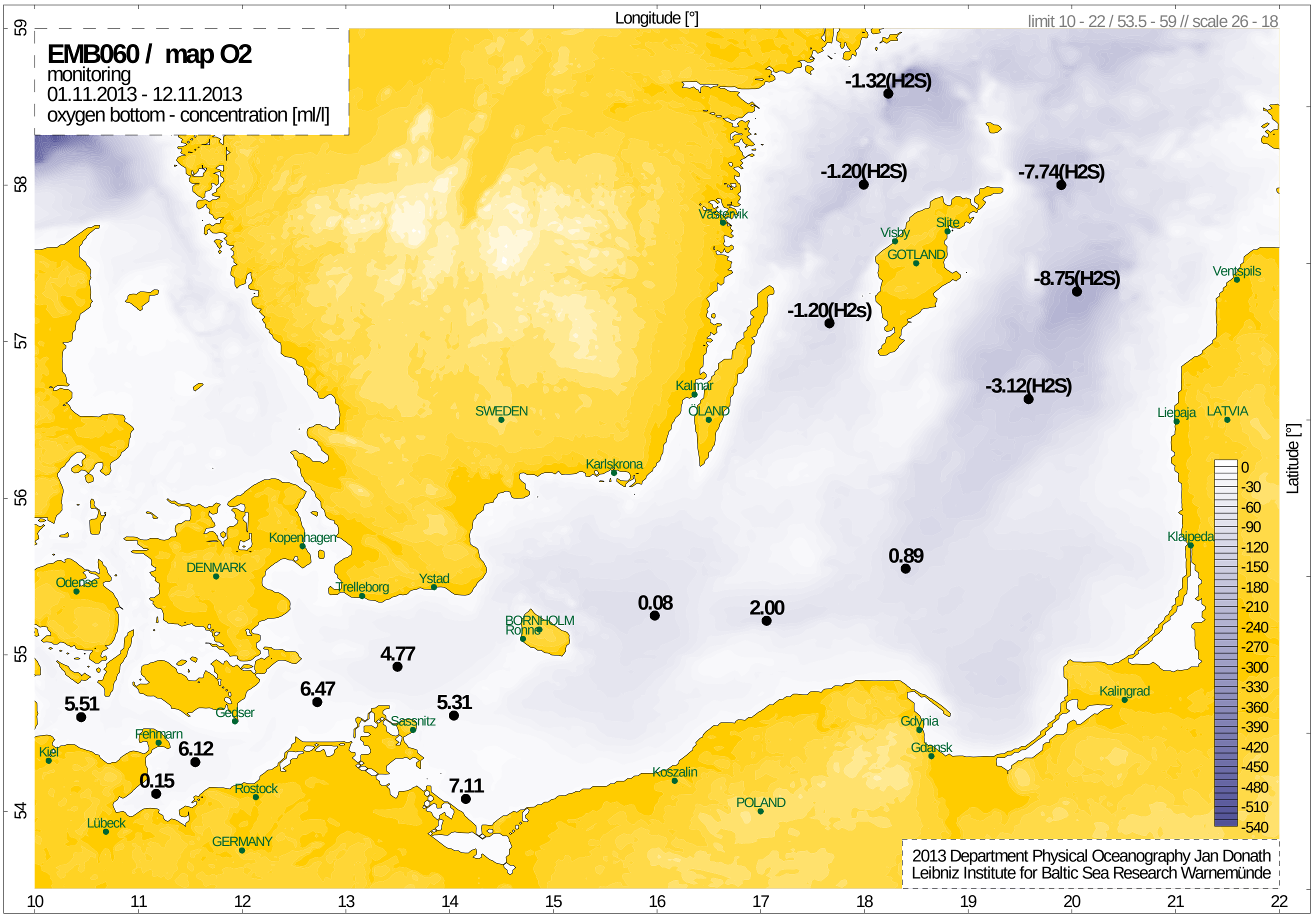
EMB060 / map O2
monitoring
01.11.2013 - 12.11.2013
oxygen bottom - concentration [ml/l]
Longitude [°]
limit 10 - 22 / 53.5 - 59 // scale 26 - 18
Latitude [°]
-1.32(H2S)
-1.20(H2S)
-7.74(H2S)
-8.75(H2S)
-1.20(H2s)
-3.12(H2S)
0.89
0.08
2.00
4.77
6.47
5.31
5.51
6.12
0.15
7.11
SWEDEN
DENMARK
GERMANY
POLAND
LATVIA
GOTLAND
ÖLAND
BORNHOLM
Västervik
Visby
Slite
Ventspils
Kalmar
Liepaja
Karlskrona
Klaipeda
Kopenhagen
Odense
Trelleborg
Ystad
Rønne
Kalingrad
Gdynia
Gdansk
Gedser
Sassnitz
Fehmarn
Kiel
Rostock
Koszalin
Lübeck
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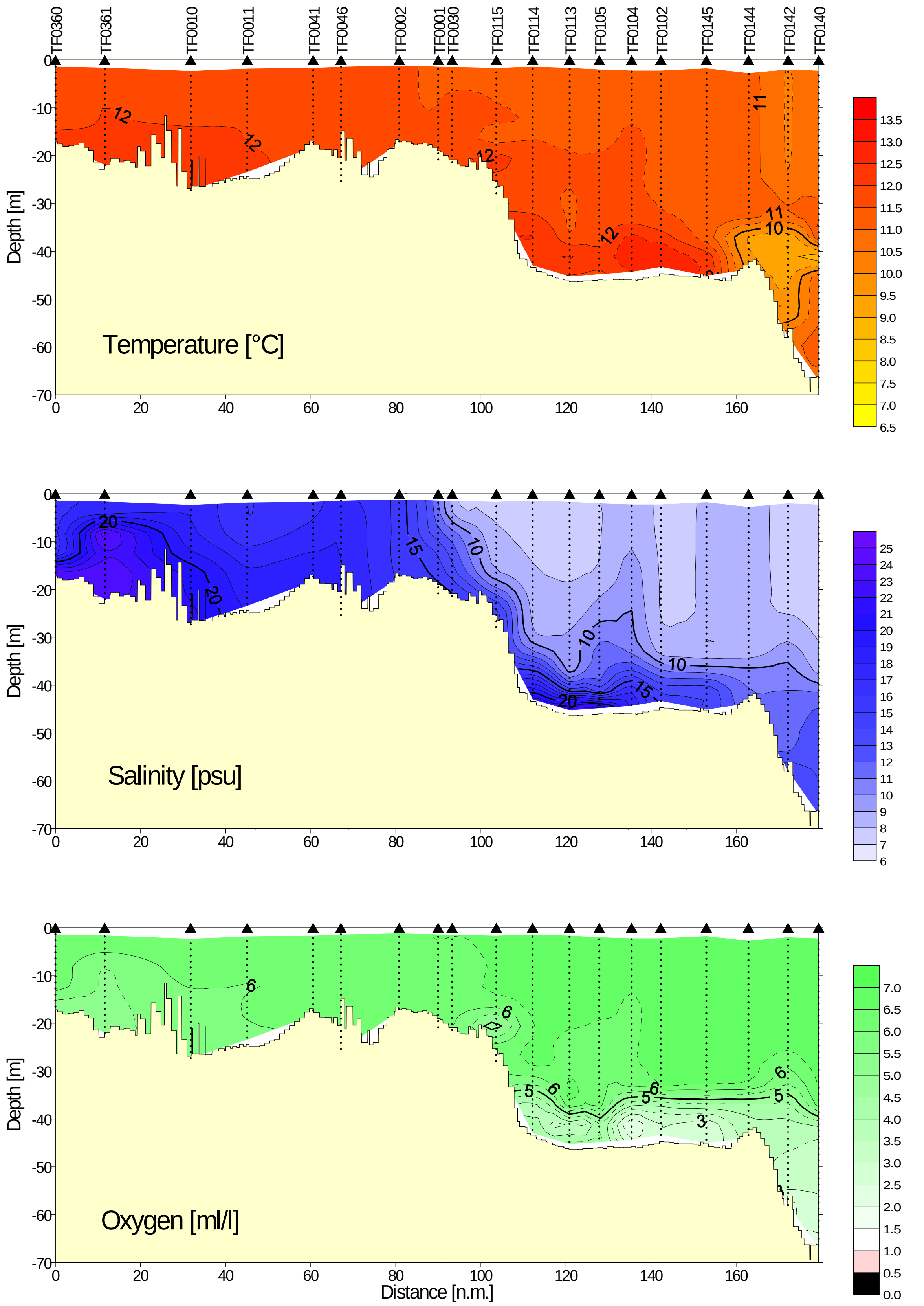
Figure 4

Fehmarnbelt-Bornholmbecken / none valid data
01.11.2013 14:08 - 05.11.2013 19:04 UTC

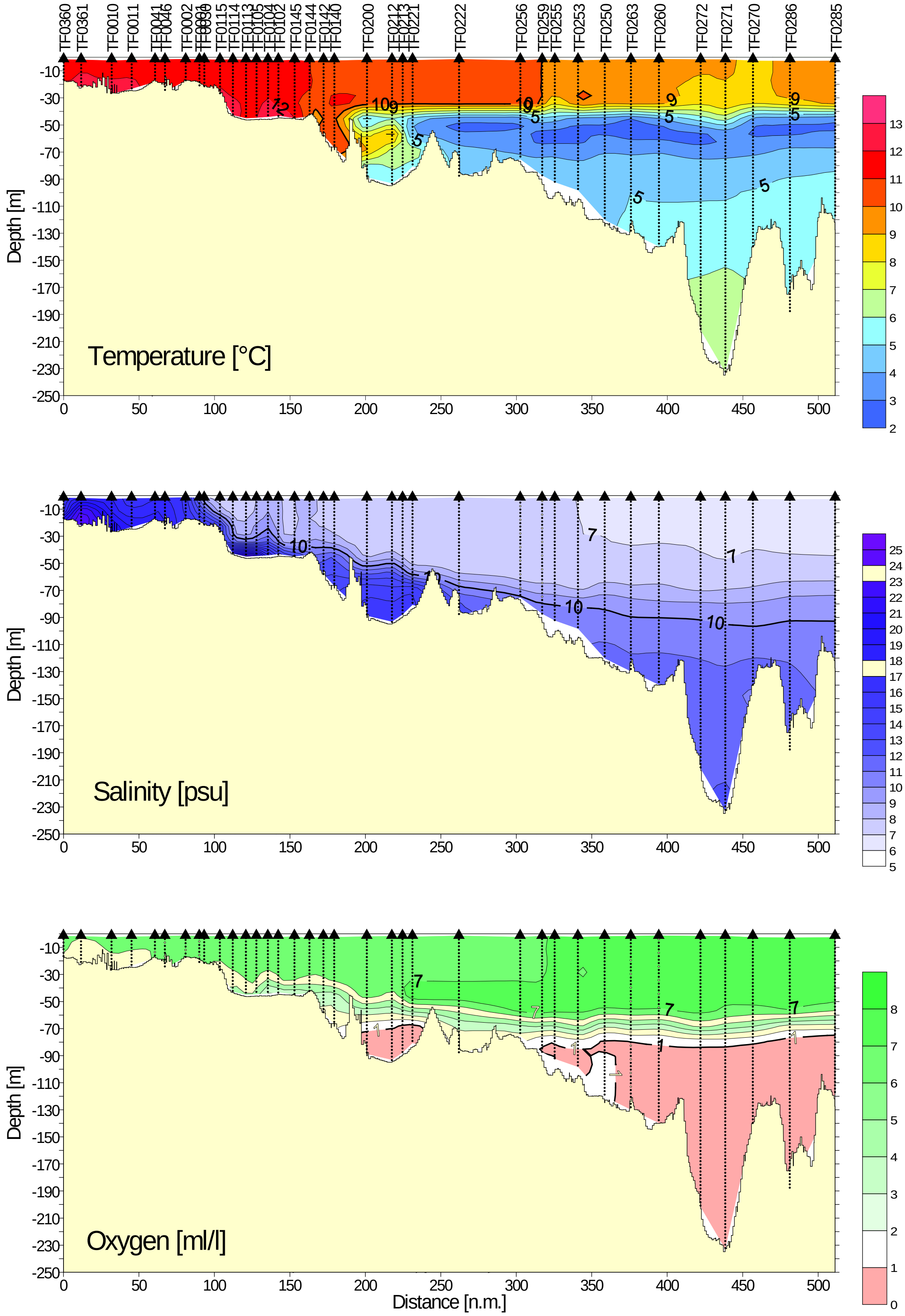



FB-BB.srf



Figure 5

Kiel Bight - Gotland Sea
01.11.2013 14:08 - 08.11.2013 18:40 UTC




KB-GS.srf

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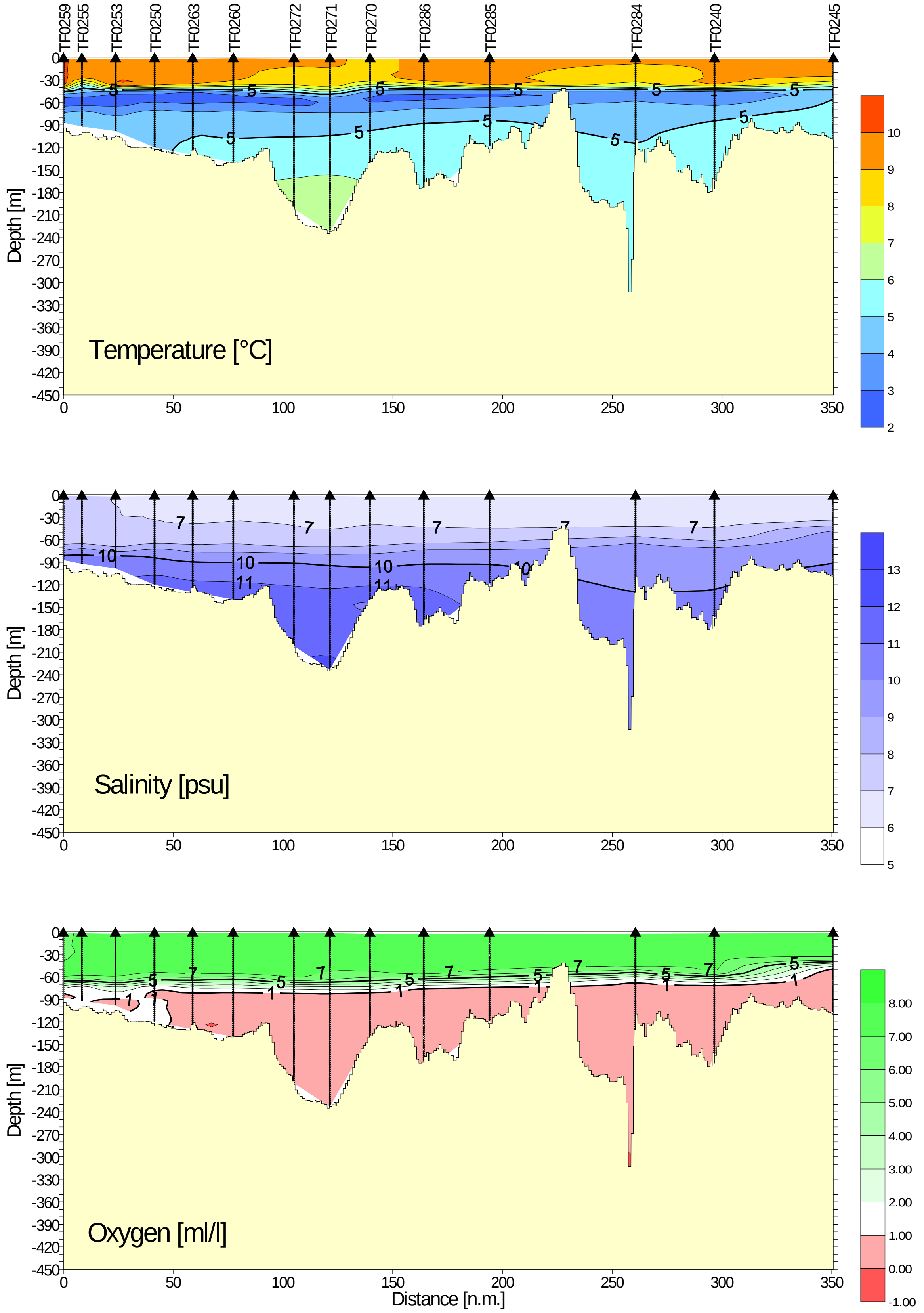
Figure 6

around Gotland Sea / none valid data
06.11.2013 16:52 - 10.11.2013 18:34 UTC




AGS.srf

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Figure 7