INSTITUT FÜR OSTSEEFORSCHUNG WARNEMÜNDE
an der Universität Rostock BALTIC SEA RESEARCH INSTITUTE

Baltic Sea Research Institute Warnemünde

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

r/v "Gauss"

Cruise- No. 11 / 05 / 09

Monitoring Cruise
25 October – 05 November 2005
Kiel Bight to northern Gotland Sea

This report is based on preliminary data

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1. **Cruise No.:** 11 / 05 / 09

2. **Dates of the cruise:** from 25 October to 05 November 2005

3. **Particulars of the research vessel:**
   Name: ”Gauss”
   Nationality: Germany
   Operating Authority: Federal Maritime and Hydrographic Agency (BSH)

4. **Geographical area in which ship has operated:**
   Kiel Bight to Northern Gotland Sea

5. **Dates and names of ports of call**
   28.10. – 29.10.2005, Saßnitz

6. **Purpose of the cruise**
   Baltic monitoring in the frame of the COMBINE Programme of HELCOM

7. **Crew:**
   Name of master: Ahrens
   Number of crew: 19

8. **Research staff:**
   Chief scientist: Dr. M. Schmidt

   Participants: Glockzin, Ines
   Grüttmüller, Annett
   Hand, Ines
   Heene, Toralf
   Hehl, Uwe
   Plüschke, Günter
   Dr. Röhner, Matthias
   Schuffenhauer, Ingo
   Sonntag, Nicole
   Simon, Heike
   Welz, Anne
   Weiel, Stefan

9. **Co-operating institutions:**
   All institutions dealing with HELCOM monitoring programmes.
   Forschungs- und Technologiezentrum Westküste, Büsum

10. **Scientific equipment**
    CTD 911+ with Dr. Haard Fluorometer
    Autosal 8400B, SIS reversing thermometers
    rosette with water samplers
    plankton nets WP2, filtration set
    van Veen grab, dredge, video camera,
    autoanalyser, 716 DMS Titrino
    ships weather station

11. **General remarks and preliminary results**

The area of investigation covers the Baltic Sea from Kiel Bight to northern Gotland Sea, (see the attached station maps). The meteorological, hydrographical, chemical and biological investigations were performed according to the COMBINE Programme of HELCOM. Quality control of the hydrographic data was guarantied by daily comparison measurements. 103 hydrographic stations were worked. Each station started with a CTD cast measuring depth, temperature, conductivity (salinity), oxygen concentration, fluorescense and turbidity, at some stations combined with water sampling for oxygen and nutrient determination.

At several stations plankton was sampled with WP2 nets, sample depth are chosen according to the measured temperature and salinity profiles. Chlorophyll-a samples are filtrated and frozen, other phytoplankton samples are conserved with Lugol.

Special zooplankton samples are taken for a reconsideration of biomass factors used for HELCOM. For a calibration of the size/carbon- relation of zooplankton species selected individuals are identified and measured and then frozen in liquid nitrogen for further analysis in the laboratory.

For long term observation of macrozoobenthos communities in selected representative areas between Fehmarn Belt and Bornholm Sea, benthos samples are taken at stations TF0010, TF0012, TF0018, TF0030, TF0109, TF0152 and TF0213 using a van Veen-grab and a dredge with 5mm net. Organisms are extracted from the samples with 1 mm sieves. Sampling is supplemented by video camera inspection. Detailed data analysis will be carried out in the laboratory. Similar to previous years, the bottom at all stations is populated with benthic organisms except station TF0213 where due to the anoxic conditions in the bottom water no living benthic organisms were found.

Seabird observations were carried out during daylight while the ship was steaming. In total, an area of 280 km² was surveyed and 813 individuals of 34 species could be observed. As expected the abundance of resting birds in the offshore areas of the Baltic Sea was very low. The most common species was the Hering gull *Larus agentatus* with 395 birds. Second common bird (102 Ind.) was the Common gull *Larus canus*, which was more abundant in the north-eastern parts of the trip. Auks dominated in the area east of Gotland, were 45 Razorbills *Alca torda* and some Guillemots *Uria aalge* were counted. Sea ducks, one of the characteristic groups of wintering birds in the Baltic Sea, were only seen in small densities, mostly because of the high water depth in the studied area. On some days high numbers of migrating passerine birds passed the ship, some even landing on board.

The cruise started after a long calm period. Stormy south westerly winds with wind speed of about 17 m/s (20 m/s in gusts) drove waves with strong white-capping. Heavy rain went down with lightning embedded while working stations in the Kiel Bight, Lübeck Bight and Mecklenburg Bight. Later, measuring at stations towards Darß Sill air pressure was rising and wind speed was decreasing to 10-12 m/s in connection with sunny or slightly cloudy conditions. In the Arkona Sea at October 27th and in the Bornholm Sea at October 28th calm sea with clear sky were met which turned later into rainy and foggy conditions.

Air temperature was slightly higher then sea surface temperature during station work west of Darß Sill but slightly below sea surface temperature during the work in Arkona and Bornholm Sea. Although surface cooling should be quite low under these conditions, the seasonal thermocline was already dissolved and the surface layer was well mixed down to the halocline. Surface salinity is about 15 in **Kiel Bight** and decreases from station TF0011 to station TF0115 east of Darß Sill from 15 to 7.8. Sea surface temperature (SST) is much less variable. In the west the underlying water mass is warm and

SST is about 13 °C, east of Darß Sill and in the Arkona Sea intrusions of cold water are embedded in the halocline, which is mixed partially upward, leading to a lower SST of about 12 °C.

West of Darß Sill the water mass below the halocline stems from the Belt Sea and is substantially warmer but more saline then the surface water. The stratification is quite strong here, so salinity at station TF0041 rises from 15 m to 16 m depth from 17 to more then 23 and reaches 26.8 in 17.5 m depth. However, the thickness of the saline bottom layer is small and only little saline bottom water can actually pass Darß Sill area. The bottom water is found as stagnant and has oxygen concentration below 1 cm^3/dm^3; at station TF0022 in the **Lübeck Bight** the deepest 6 m layer is anoxic, partially with H_2S. Phosphate concentration is high with 5.8-7.8 $\mu mol/dm^3$, but nitrate is almost zero. At November 4th this station was repeated. Hydrogen sulphide was reduced, but still present.

East of Darß Sill, in the **Arkona Sea** three main water bodies can be distinguished: i) well mixed and uniform surface water with temperature 12.5 °C and salinity of about 7.8, ii) warm more saline bottom water with temperature of 13.4 °C and salinity 16.3 and iii) intrusions of cold but less saline winter water from the Bornholm Sea between the surface and bottom water. The bottom water has low oxygen concentration decreasing to almost zero near the bottom, but does not become anoxic and carries more nitrate than 6 $\mu mol/dm^3$. The intermediate cold water is well ventilated. A meridional transect from Ystad to Odra Bight suggests an anticlockwise circulation of the cold intrusions and an eastward flow of the warmer bottom water at the southern slope of the Arkona Basin. A detailed geostrophic analysis has not been made yet.

After the stop in Saßnitz the **Pommeranian Bight** stations were worked. Wind was blowing with 6-5 Bft. from south-east and air temperature was about 9.5 °C which was well below sea surface temperature. The whole water column was mixed there by wind stirring and convection. Also nutrient distribution was vertically uniform. Exception is a very thin saline bottom boundary layer at station TF0131 in Saßnitz trench and a weak salinity gradient in the Odra Bight off Swinousce where a slight fresh water signal can be seen in surface salinity. Differently from all other stations, nitrate and phosphate are enhanced slightly in surface water indicating the river inflow as nutrient source.

In **Bornholm Sea** the typical main water bodies are found, i) a well mixed about 32 m thick surface layer with a temperature of 12.7 °C and salinity of 7.5, ii) a cold winter water layer with temperature of 4.5 °C and salinity of 8.2, iii) intrusions of warm saline water with the same temperature-salinity characteristic as Arkona sea bottom water and iv) a slightly colder bottom layer with maximum salinity of 16.2. The intrusions of warm water show pronounced horizontal temperature and salinity gradients indicating locally strong geostrophic currents. The bottom layer is stagnant and has significantly higher density then Arkona Sea bottom water. Hence, Bornholm Sea is characterised during the time of the cruise by weak inflow of warm saline water from the Arkona Sea in depth of about 60 m and outflow of colder winter water towards the Arkona Sea. Oxygen content of the bottom layer below 65 m is much lower then 1 cm^3/dm^3 and water in the deepest 20 m at stations TF0200, TF0210, TF0213, TF0220, TF0211, TF0212, TF0221 and TF0214 contain hydrogen sulfide. Salinity in 65 m depth is 14.6. Nitrate has disappeared by denitrification, instead a pool of ammonium, 7-21 $\mu mol/dm^3$, has been build up. Phosphate concentration is higher then 7 $\mu mol/dm^3$.

At November 3rd and 4th stations at the transect from TF0256 through Bornholm Sea to TF0113 were repeated. South-easterly and later southerly winds of 5-4 Bft. and sunny conditions allowed for undisturbed station work. Unusually for November, air temperature was higher then sea surface temperature. Hence vertical mixing was weak. Minor thermal stratification could develop again and the sharp thermocline met some days before was smoothed out. Possible consequences of this delayed cooling of the surface layer in the Bornholm Sea and the Arkona Sea cannot be foreseen.

Working Stolpe channel and Gotland Sea stations southerly winds of between 5 and 7 Bft are prevailing. Two moorings were recovered and laid out near station TF0271. Waves of about 2m hight made this work difficult. Air pressure was high corresponding to sunny days and cold nights. Later, working station Landsort Deep and stations west of Gotland wind decreased to 4 Bft. and turned to south-west. Air temperature was now more or less equal to sea surface temperature; sky was cloud covered with little rain and bad visibility conditions.

In **Stolpe Channel** the well mixed surface layer has salinity of 7.5. Winter water is colder then in Bornholm Basin which indicates its origin from the Gotland Sea. The warm intermediate layer does not continue through Stolpe channel but is replaced by a 10 m thick bottom layer with lower salinity of about 12.8 and temperature of 7.1 °C. Through **Stolpe Channel** and **Eastern Gotland Sea**, from station TF0224 to TF0253 the bottom water contains oxygen, which reveals some permanent but weak eastward near bottom transport through Stolpe Channel. Several pronounced elevations of isopycnals in the thermocline, but also in the halocline indicate sporadic and localised stronger currents and eddies.

In the central **Gotland Sea,** i.e**.** in the **Gotland Deep** and **Farö Deep** area**,** the surface water is well mixed down to the winter water layer, temperature and salinity are horizontally uniform. Surface salinity varies from 7.3 at TF0259 to 6.7 at Farö Deep. The winter water itself is less included in vertical mixing. Hence, surface nutrient concentration is still low; the N/P ratio varies around 1. At station TF0271 minimum temperature in the winter water is about 2.6 °C in 63 m depth, salinity is about 0.5-1 higher then in the surface water. In the winter water layer a pool with nitrite/nitrate of more than 2 $\mu mol/dm^3$ and phosphate of 1 $\mu mol/dm^3$ is found. Nitrate concentration is increasing downward to a maximum of 8.6 $\mu mol/dm^3$ in 110 m depth. Below, the water column is anoxic, nitrate/nitrite concentration is rapidly decreasing but more phosphate and ammonium is present. Below 150 m H_2S is found, nitrate concentration is zero and ammonium and phosphate are increasing to 20 $\mu mol/dm^3$ and 5 $\mu mol/dm^3$ respectively. Similar conditions are found also at the other stations in central Gotland Sea.

At **Landsort Deep** and **Karlsö Deep** surface temperature with 8.5-9 °C is lower than in the Gotland Deep, surface salinity varies from 6.3 to 6.7. The thermocline between surface water and winter water at about 30 m depth and much smoother and shallower than in the Gotland Sea. This indicates a more wind driven vertical mixing, whereas in the Gotland Deep convective mixing was prevailing, which leads to a sharp thermocline. The core of winter water is found at about 50 m depth with temperature of 3 °C. At depth below 80 m the water is anoxic; below 90-100 m H_2S is found. This water mass contains no nitrate but ammonium concentration up to 9 $\mu mol/dm^3$ and phosphate concentration of 3.5-4 $\mu mol/dm^3$.

Accordingly, the water mass below 90-110 m depth forms a large of pool of anoxic water with large nutrient content and high excess phosphate. Compared with the conditions met in October 2004 the total amount of anoxic water has increased. The bottom water appears slightly colder but less saline then 2004. The concentration of H_2S in the Gotland Deep has doubled; the phosphate concentration is enhanced by 0.6 $\mu mol/dm^3$.

Elevated phosphate values were also found in the surface waters at most stations. The only exceptions are the eastern Gotland Basin (TF0259 and TF0271) and the station TF0245 (Karslö Deep). Nitrate concentrations in the surface layer are normal for the season.

Attachments

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

Figs. 1-2: Station grid and cruise track

Fig. 3: Transect from the Kiel Bight to the northern Gotland Basin for temperature, salinity and oxygen (unvalidated data)

Fig. 4: Meridional transect from Ystad to Odra Bight for temperature, salinity and oxygen (unvalidated data)

Fig. 5: Warm water intrusions in the Bornholm Sea

Fig. 6: Transect around Gotland for temperature, salinity and oxygen (unvalidated data)

Fig. 7: Oxygen /hydrogen sulphide concentrations in the bottom near layer for selected stations

Dr. Martin Schmidt
Scientist in charge

Table 1: Surface layer (0 - 10m)

Area Date	Station Name/ No. **	Temp. °C	Salinity	NO_{23}^{-} * µmol/ dm^3	NH_4 µmol/ dm^3	PO_4^{3-} µmol/ dm^3	SiO_4 µmol/ dm^3
Kiel Bight 26.10.05	TF0360/ 005	13.05	14.66	0.1	0.26	0.51	14.0
Meckl. Bight 25.10.05	TF0012/ 003	12.05	11.28	0.07	0.32	0.6	17.4
Lübeck Bight 25.10.05	TF0022/ 004	12.75	12.50	0.33	NA	0.53	15.6
Arkona Basin 26.10.05	TF0113/ 019	12.30	7.82	0.24	0.2	0.56	14.7
Pom. Bight 29.10.05	TF0162/ 051	10.61	7.48	0.30	0.36	0.84	20.1
Bornholm Deep 28.10.05	TF0213/ 042	12.71	7.54	0.20	0.16	0.45	12.1
Stolpe Channel 30.10.05	TF0222/ 059	12.33	7.43	0.29	NA	0.34	10.7
SE Gotland Basin 30.10.05	TF0259/ 063	12.18	7.32	0.27	0.21	0.22	7.3
Gotland Deep 31.10.05	TF0271/ 070	10.09	6.90	0.49	0.2	0.19	8.5
Fårö Deep 01.11.05	TF0286/ 072	8.46	6.72	0.43	0.6	0.26	10.6
Landsort Deep 02.11.05	TF0284/ 074	8.74	6.39	0.28	0.17	0.66	12.3
Karlsö Deep 25.7.05	TF0245/ 076	9.05	6.74	0.21	0.18	0.25	11.

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

** Station name see maps (Fig. 1 und 2)

Table 2: Bottom-near water layer

Area	Station	Sample Depth	Temp.	Salin.	O_2	NO_{23}^{-} *	NH_4	PO_4^{3-}
Date	Name/ No. **	m	°C		cm³/ dm³	µmol/ dm^3	µmol/ dm^3	µmol/ dm^3
Kiel Bight 26.10.05	TF0360/ 005	17	13.72	16.56	4.85	0.3	1.08	0.8
Meckl. Bight 25.10.05	TF0012/ 003	23	13.39	21.92	0.56	5.80	6.82	2.68
Lübeck Bight 25.10.05	TF0022/ 004	22	12.81	21.56	-1.27	0.21	NA	7.75
Arkona Basin 26.10.05	TF0113/ 019	45	13.43	16.27	1.29	7.67	0.33	1.59
Pom. Bight 29.10.05	TF0162/ 051	14	10.63	7.49	7.28	0.3	0.42	0.83
Bornholm Deep 28.10.05	TF0213/ 042	87	7.03	16.20	-3.09	0.	21.34	7.6
Stolpe Channel 30.10.05	TF0222/ 059	89	7.10	12.88	2.06	6.93	NA	2.06
SE Gotland Basin 30.10.05	TF0259/ 063	87	6.06	11.64	2.54	7.0	0.25	2.0
Gotland Deep 31.10.05	TF0271/ 070	233	5.95	12.71	-3.75	0.	19.89	5.03
Fårö Deep 01.11.05	TF0286/ 072	189	6.06	12.15	-1.85	0.	9.4	4.0
Landsort Deep 02.11.05	TF0284/ 074	435	5.80	11.11	-0.57	0.	4.3	3.48
Karlsö Deep 02.11.05	TF0245/ 076	106	5.28	10.27	-1.09	0.	7.15	3.85

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

** Station name see maps (Fig. 1 und 2)

Monitoring

Station map TF110509
25.10.2005 - 05.11.2005
59 Station (Part1)

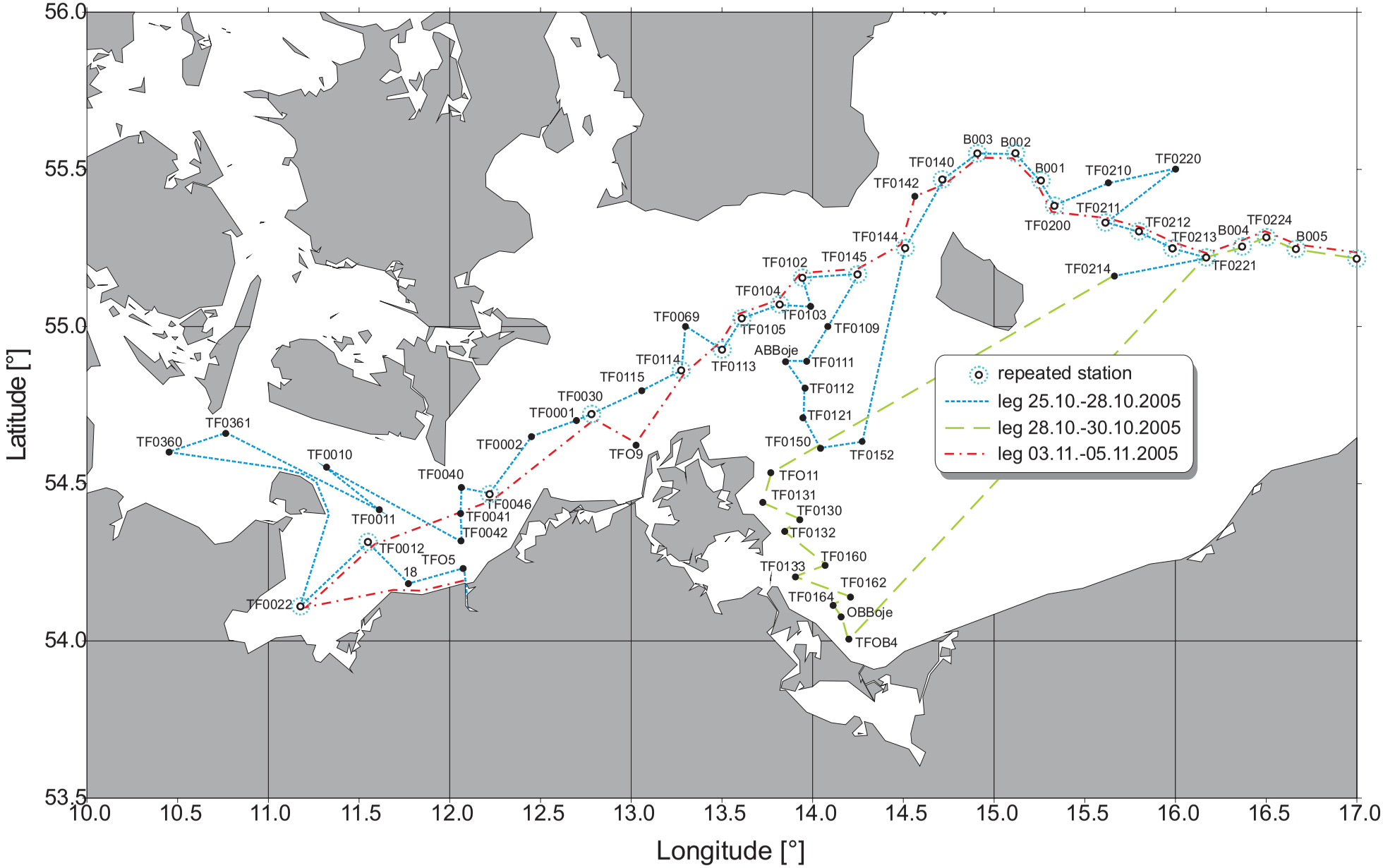

Figure 1

K1.srf

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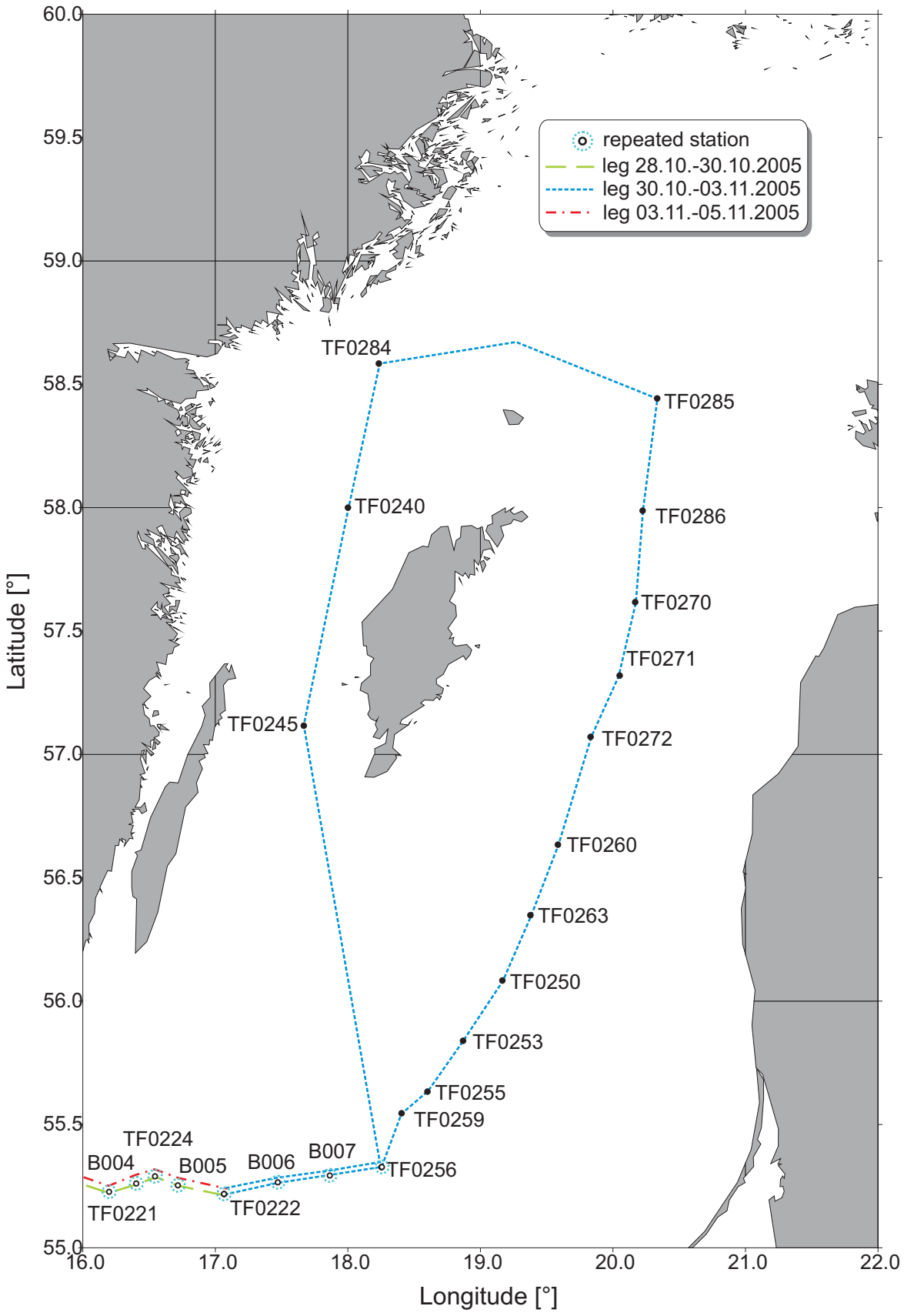
Monitoring

Station map TF110509
25.10.2005 - 05.11.2005
16 Station (Part2)

Figure 2



K2.srf

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Terminfahrt 11/05/09

gesamte Ostsee
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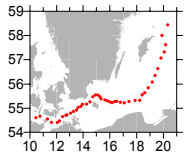
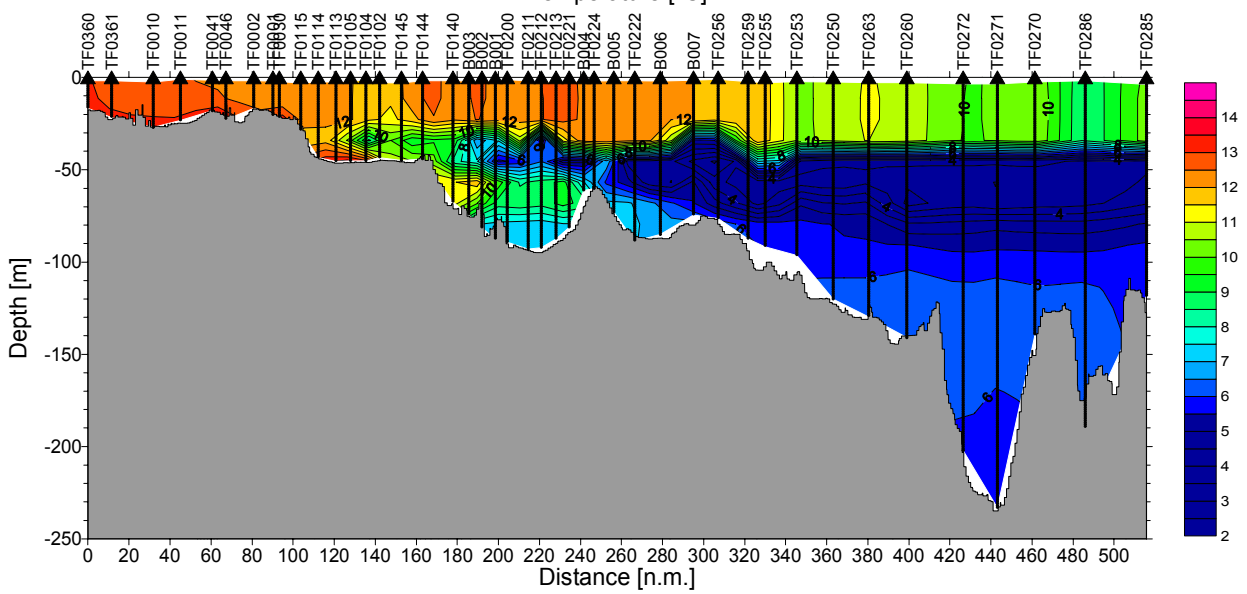


Temperature [°C]



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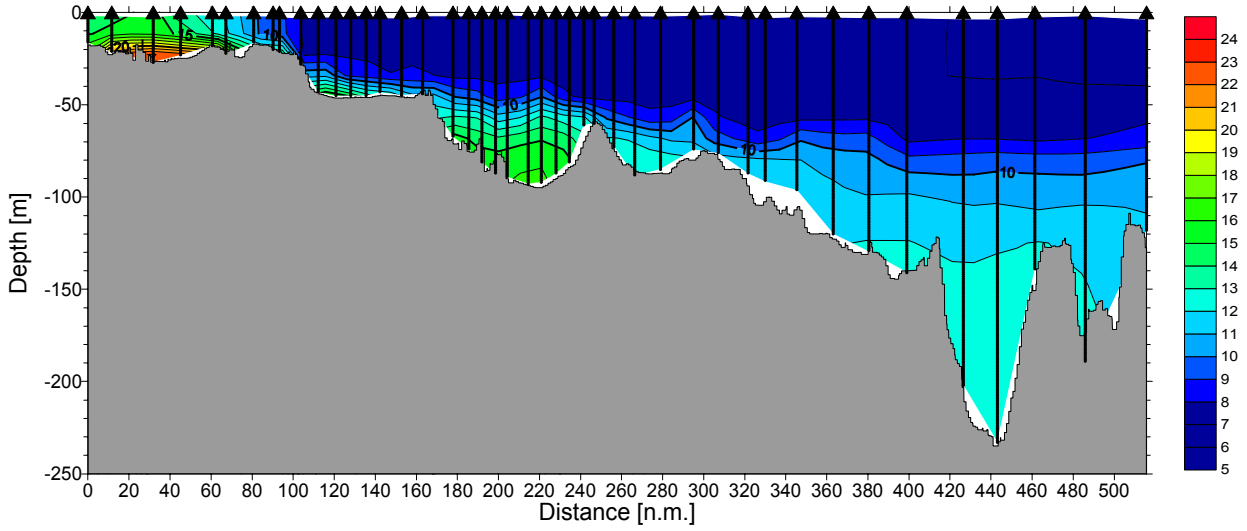
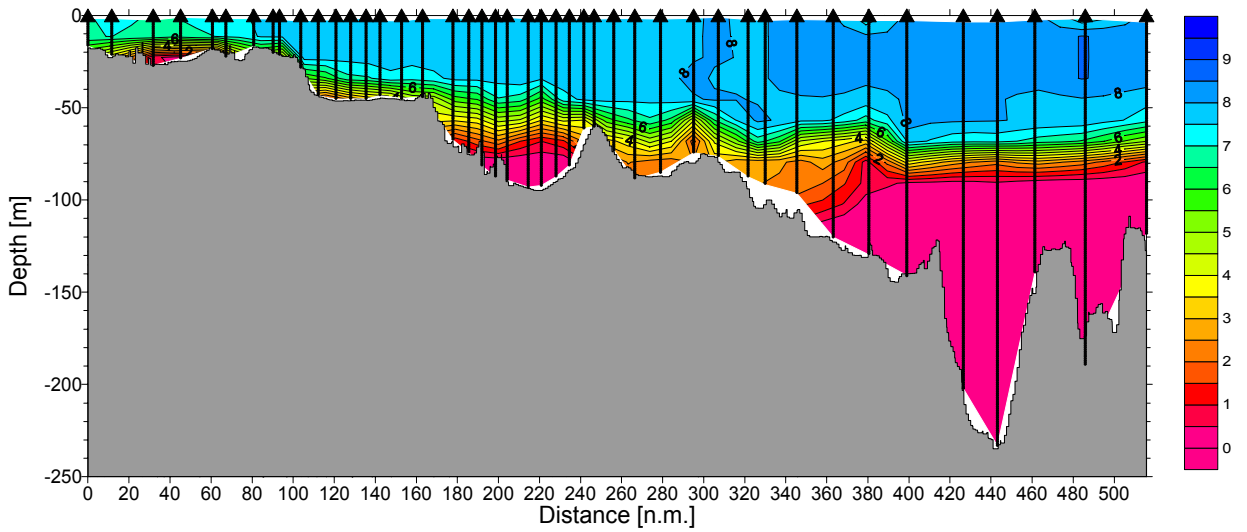


Oxygen [ml/l]



Terminfahrt 11/05/09

Ystadschnitt
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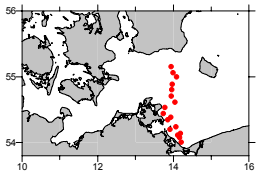
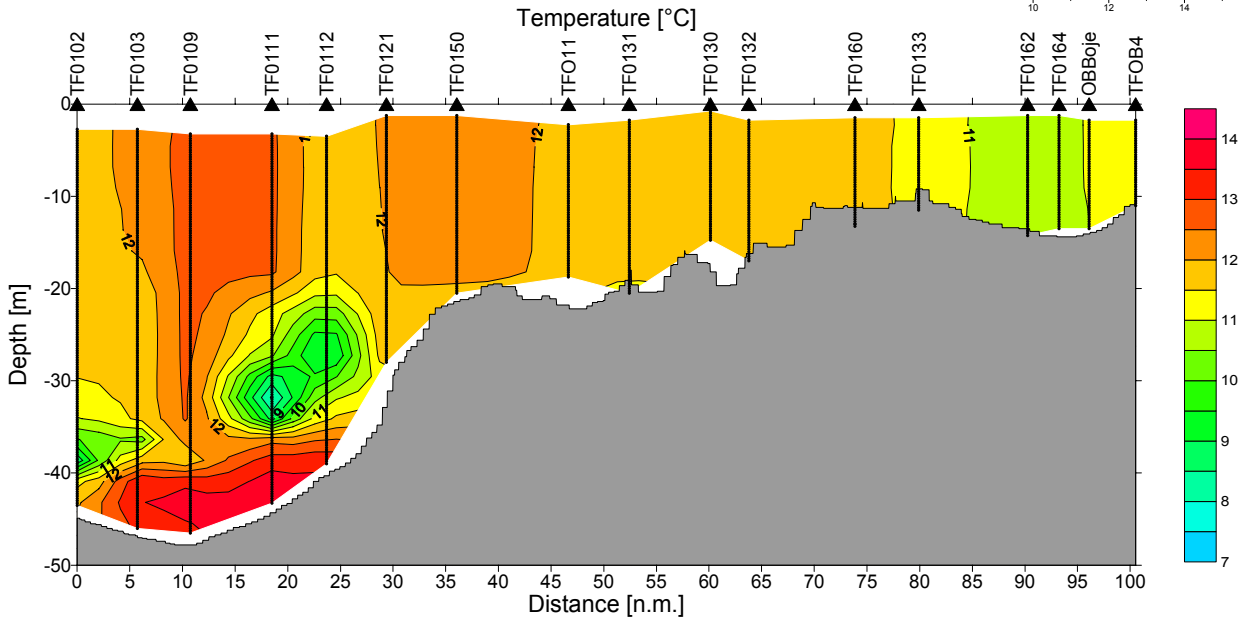


Temperature [°C]



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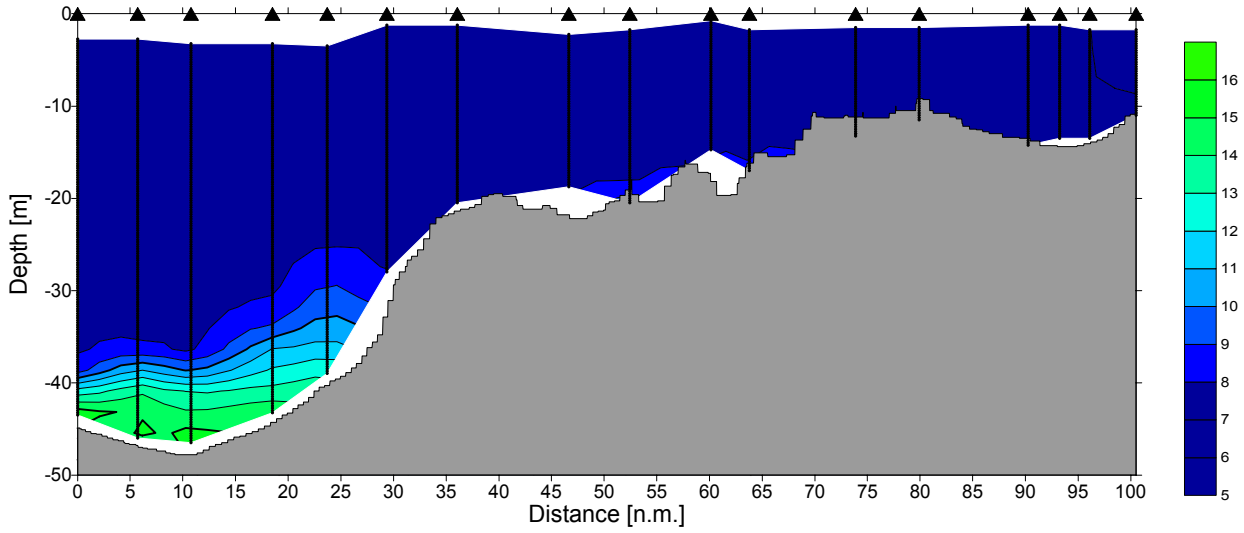
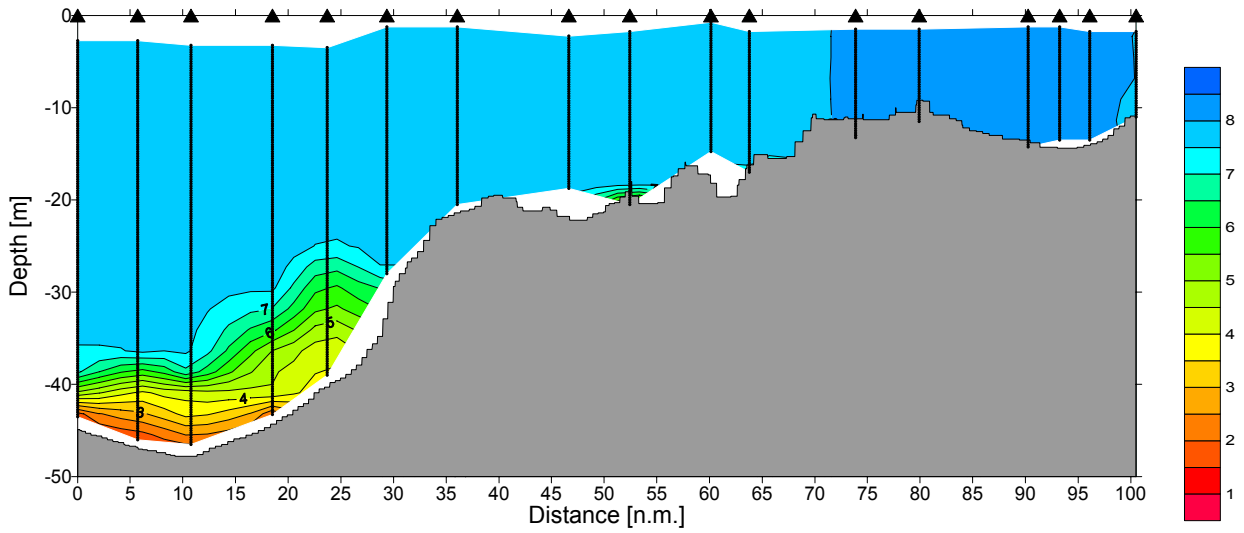


Oxygen [ml/l]



Terminfahrt 11/05/09

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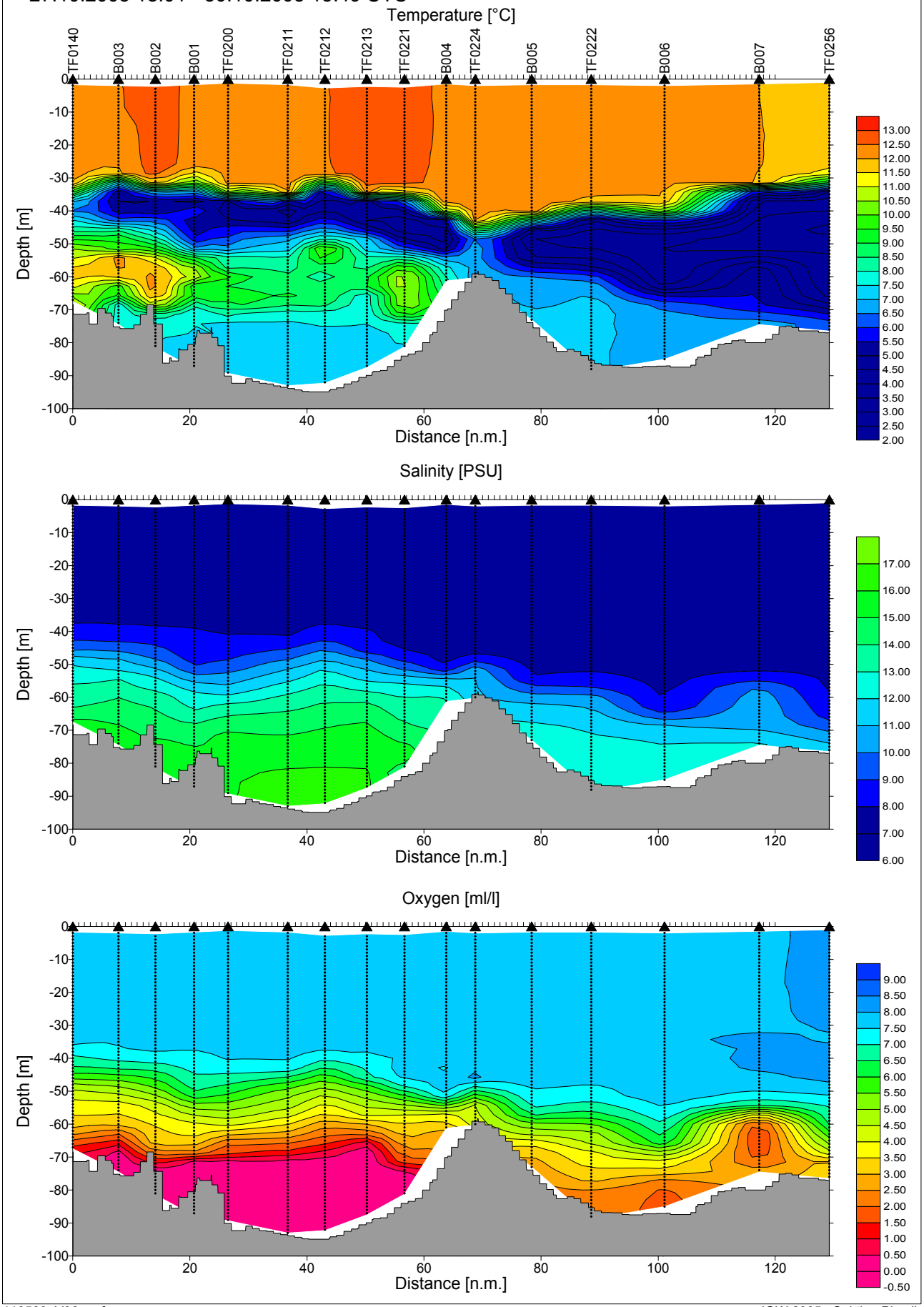

Terminfahrt 11/05/09

Um Gotland
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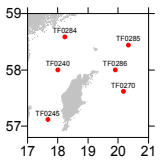

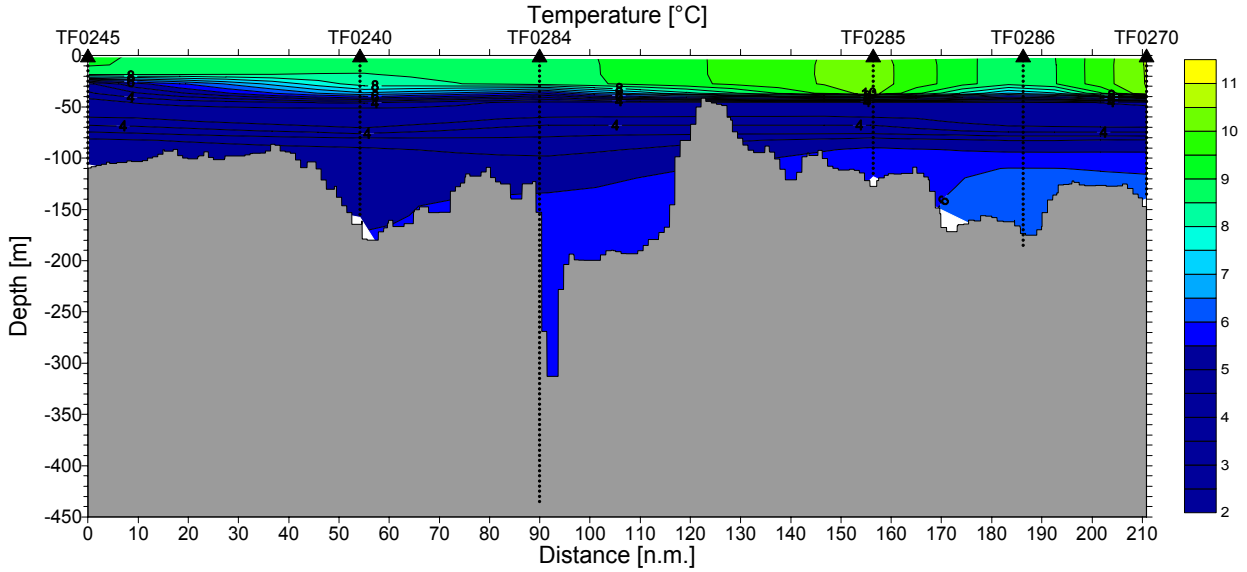

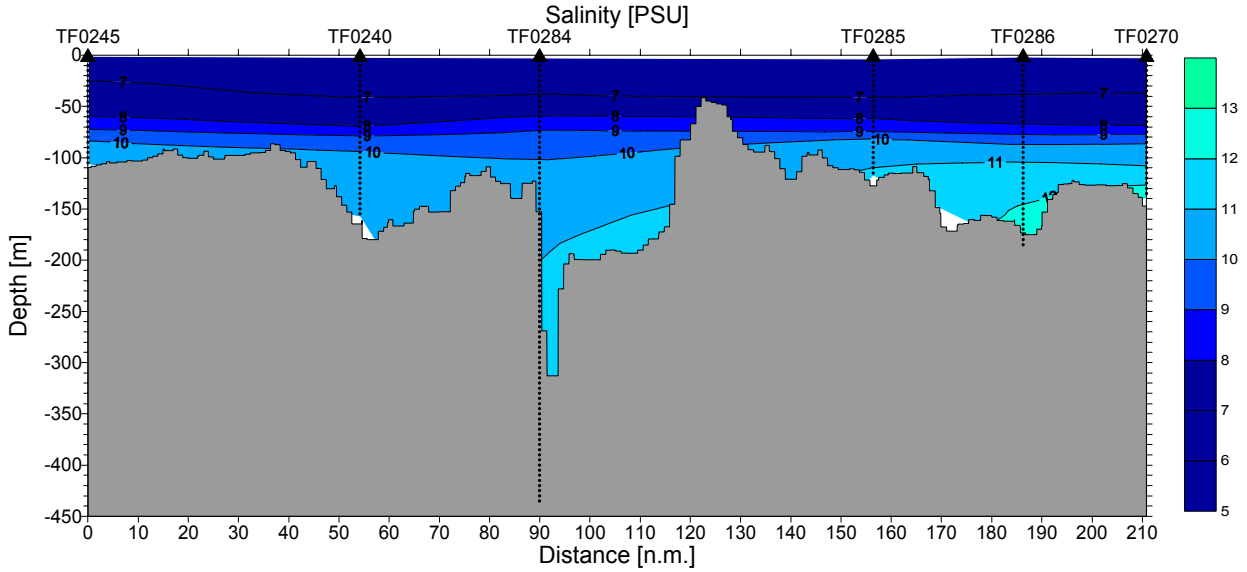

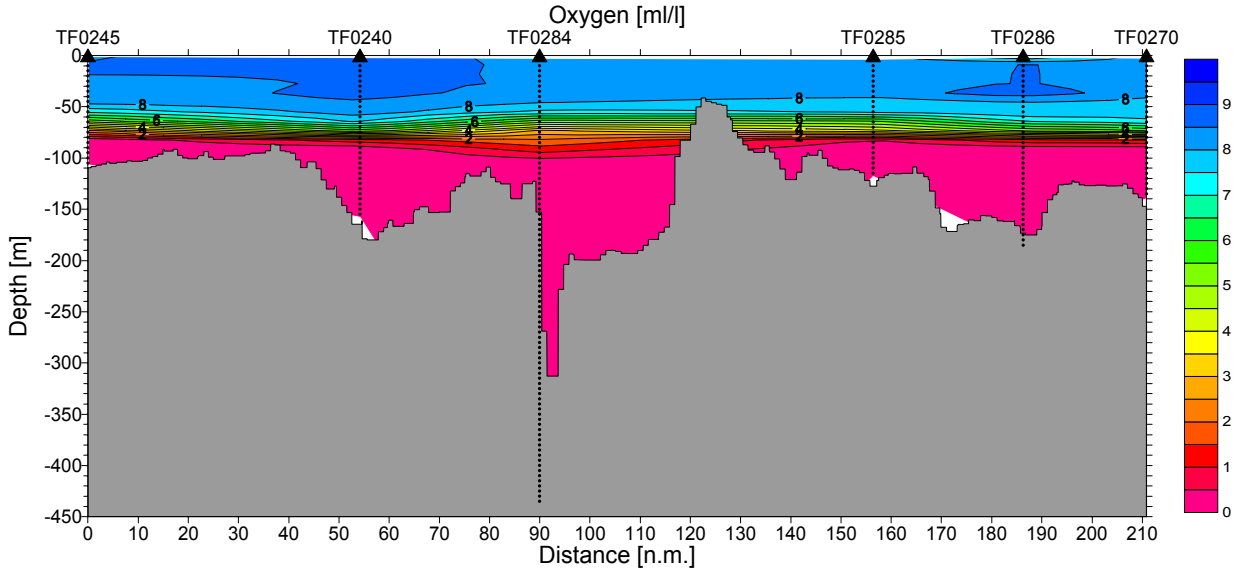

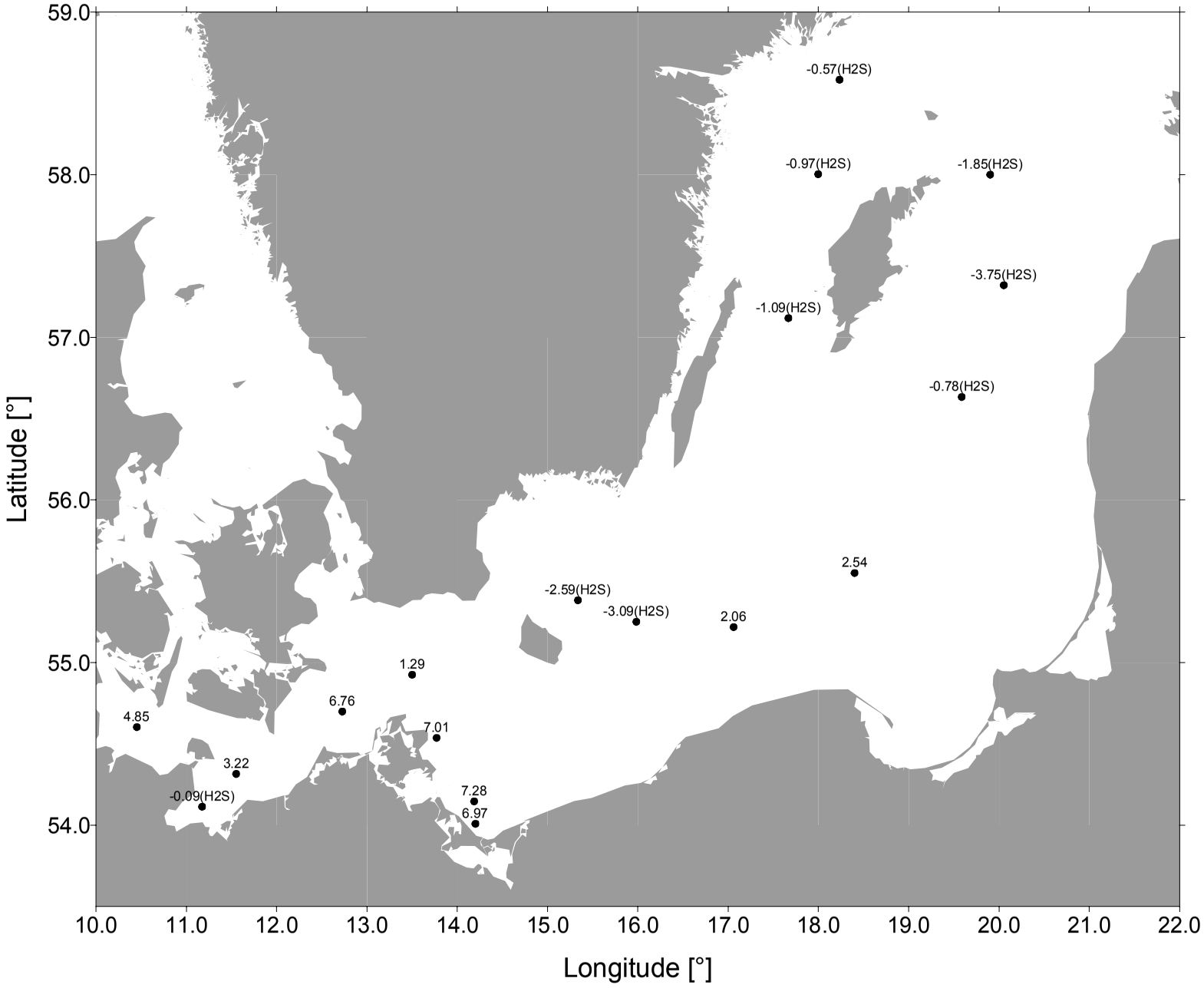

Monitoring

TF110509

01.11.2005 - 05.11.2005

Oxygen bottom concentration [ml/l]

O2.srf

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