

Baltic Sea Research Institute Warnemünde

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

r/v "Gauss"

Cruise- No. 11 / 06 / 07

Monitoring Cruise
07 November – 17 November 2006
Kiel Bight to northern Gotland Sea

This report is based on preliminary data

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1. **Cruise No.:** 11 / 06 / 07
2. **Dates of the cruise:** from 07 November to 17 November 2006
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**
10.11. – 11.11.2006, Saßnitz
6. **Purpose of the cruise**
Baltic monitoring in the frame of the COMBINE Programme of HELCOM
7. **Crew:**
 - Name of master: Langner
 - Number of crew: 19
8. **Research staff:**
 - Chief scientist: Dr. M. Schmidt

 - Participants:
 - Glockzin, Ines
 - Dr. Deutsch, Barbara
 - Grimm, Veronika
 - Heene, Toralf
 - Hehl, Uwe
 - Plüschke, Günter
 - Dr. Zettler, Michael
 - Dankert, Jutta
 - Weinreben, Stefan
 - Bahlo, Rainer
 - Welz, Anne
 - Dr. Kuß, Joachim
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, DMA 5000
 - 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 hydrographical, chemical, meteorological and biological investigations were performed according to the COMBINE Programme of HELCOM. Quality control of the hydrographic data was guaranteed by daily comparison measurements. 69 hydrographic stations were worked. Each station started with a CTD cast measuring depth, temperature, conductivity (salinity), oxygen concentration, fluorescence and turbidity, at some stations combined with water sampling for oxygen and nutrient determination.

At several stations plankton was sampled with WP2 nets, sample depths are chosen according to the measured temperature and salinity profiles. Chlorophyll-a samples are filtrated and frozen, other phytoplankton samples are conserved with Lugol. A first screening of phytoplankton net samples indicated a relatively high biomass in the western Baltic in comparison with the central Baltic Proper (Eastern Gotland Sea). An autumn bloom (*Ceratium tripos*, *C. fusus*, *Proboscia alata*, *Prorocentrum micans*) was recorded on 7/8 November 2006 in Mecklenburg Bight. The diversity was lower in the Arkona Sea, with *Ceratium tripos*, *C. fusus* and *Coscinodiscus granii* being the dominant species. *Ceratium* species disappeared farther east, and *Coscinodiscus granii* remained the dominant species in the southern Baltic Proper. In the Eastern Gotland Sea (13.11.06), *Coscinodiscus granii*, *Prorocentrum minimum* and *Aphanizomenon* sp. were most abundant.

For long term observation of macrozoobenthos communities in selected representative areas benthos samples are taken. During the monitoring survey in 2006 altogether 9 stations were sampled. All German Baltic off-shore water bodies (Kiel Bight, Mecklenburg Bight, Darss Rise, Arkona Basin and Pomeranian Bay) were considered. At each station first an overview about sediment structure and some epibenthic species was made visible by using a video imaging system. Second three van Veen grab samples were taken. The samples were sieved (1 mm) and afterwards fixed in formaldehyd (4 %). Additionally a grab sample for analysing sediment conditions (organic content, medium grain size) was used. Finally a dredge haul was carried out to catch the epibenthic and vagile fauna. Preliminary results showed that the hot summer conditions of 2006 had no (or only small) effects on the benthic community. The species diversity and the good population structure of the bivalves (*Arctica islandica*, *Macoma balthica*, *Mya arenaria*) implicate good living conditions during the last years. Echinodermes (*Asterias rubens* and *Ophiura albida*) indicate good oxygen supply at the westernmost stations (Kiel Bight, Fehmarnbelt). Even at the Darß rise *A. rubens* found favourable living conditions. It has to be checked if the species assemblages are similar to those of the previous years. Furthermore the abundance and the biomass will give us an instrument for assessing the macrozoobenthos development in comparison with the last decades.

To investigate the density anomaly of Baltic seawater, density was estimated at 6 stations with help of a density meter DMA 5000 to be compared with the density calculated from the UNESCO equation of state of seawater from salinity, measured with a salinometer AUTOSAL 8400 B. Samples were taken from the surface and from 50 m depth.

In order to calculate the Hg^0 air-sea flux in autumn, Hg^0 was measured in an hourly resolution in surface water (175 measurements) using an equilibrator coupled to a mercury analyzer (Tekran) and in air directly by the Tekran (2000 measurements). The water was taken from the ship's clean-seawater supply and for comparison from a cleaned pumping-system with a snorkel. The air was pumped from the upper deck to the lab via a tubing. In addition 19 samples for the determination of total mercury were taken.

Two moorings for deep current measurements in the Gotland Basin were maintained routinely. Near station TF0271 the moored sediment trap in combination with an oxygen sensor was recovered and deployed again. At a nearby position a McLane-Phytoplankton sampler (event triggered IOW-version) was deployed, which measures the near bottom transport of suspended matter.

The cruise started after a severe storm. After two days of moderate winds station work was interrupted by another storm in the morning of Nov. 9th and stations at transects could not be worked in synoptic order. Air temperature was below sea surface temperature favouring convective mixing. Accordingly, the seasonal thermocline is dissolved in the area of investigation.

West of Darß Sill the water column is well mixed, only in the **Lübeck Bight** (TF0022) and the **Kiel Bight** (TF0360) a weak halocline is found. Surface salinity is high and varies from 21 to 18 between Kiel Bight and Darß Sill. Bottom water is oxic with concentrations exceeding $6 \text{ cm}^3/\text{dm}^3$. The nutrient concentration is mostly vertically uniform and is already enhanced compared with summer values. Only in the Lübeck Bight oxygen concentration at the bottom is low, $2 \text{ cm}^3/\text{dm}^3$, and nitrate concentration exceeds $9 \text{ } \mu\text{mol}/\text{dm}^3$.

Repeated CTD casts at stations TF0046 and TF0012 on Nov. 16th reveals that water with salinity above 20 is still present west of Darß Sill, which has the potential to pass over Darß Sill.

East of Darß Sill surface salinity is rapidly decreasing. In the **Arkona Basin** a surface layer with salinity 7.5 was found with a layer thickness varying from 15 m at station TF0113 to 40 m at station TF0140. Bottom water is highly variable. From Station TF0113 towards the Bornholm Gatt bottom water salinity is decreasing from 18.5 to 16. Temperature of about $13 \text{ }^\circ\text{C}$ and low oxygen concentration of about $2 \text{ cm}^3/\text{dm}^3$ indicates that this water originates from warm summer inflow. Only at stations TF0113 and TF0069 a cold bottom layer was found with T/S characteristics corresponding to a weak new inflow over Darß Sill. At stations TF0144, TF0145 and TF0140 an intermediate layer of Bornholm Sea winter water is found with a temperature from $4.5 \text{ }^\circ\text{C}$ to $6.5 \text{ }^\circ\text{C}$. In the central Arkona Basin (TF0152, TF0150) the water body is uniform with salinity 8, temperature $10.5 \text{ }^\circ\text{C}$ and oxygen concentration 7 ml/l .

When stations TF0030 and TF0001 were repeated on Nov. 16th, bottom water salinity was enhanced to about 20, which indicates inflow of high saline water over Darß Sill into the Arkona Basin. Bottom salinity is decreasing eastward to 18.8 at TF0113, but there the bottom water is significantly warmer than at Darß Sill. Hence, during the time of the cruise, the inflow was only weak.

In **Bornholm Sea** the typical main water bodies are found, i) a well mixed about 35 m thick surface layer with a temperature of $9.8 \text{ }^\circ\text{C}$ and salinity of 7.5, ii) a cold winter water layer with temperature of $5.6 \text{ }^\circ\text{C}$ and salinity of 9, iii) intrusions of warm more saline water iv) a slightly colder bottom layer with maximum salinity of 16.9. Compared with the monitoring cruise from July 2006 bottom salinity is slightly increased. Oxygen content of the bottom layer below 80 m is lower than $1 \text{ cm}^3/\text{dm}^3$ but the hydrogen sulphide found there in July at station TF0213 has disappeared and the former anoxic bottom water was replaced by a slightly oxic layer. The large pool of ammonium was nitrified, nitrate concentration is high, $8.9 \text{ } \mu\text{mol}/\text{dm}^3$, and ammonium concentration is low. Also at TF0213 in the Bornholm Basin bottom water salinity is further elevated to 17.06.

In **Stolpe Channel** the well mixed surface layer has salinity of 7.5. Winter water is colder than in Bornholm Basin which indicates its origin from the Gotland Sea. Through **Stolpe Channel** and **Eastern Gotland Sea**, from station TF0258 to TF0253 the bottom water contains oxygen. The northward slope of isotherms and isohalines but also vertically intermittent oxygen profiles 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,. Surface salinity varies from 7.3 at TF0259 to 6.7 at Farö Deep. The winter water itself is less included in vertical mixing. Surface nutrient concentration is still low. At station TF0271 minimum temperature in the winter water is about 2.5 °C in 53 m depth. Compared with October 2005 the winter water layer is lifted upward by about 10 m. Within the winter water salinity is about 0.5-1 higher than in the surface water and a pool with nitrite/nitrate of more than 3.9 $\mu\text{mol}/\text{dm}^3$ and phosphate of 1.4 $\mu\text{mol}/\text{dm}^3$ is found there. This is about twice the amount found in the previous year. Nitrate concentration is increasing downward to a maximum of 6.75 $\mu\text{mol}/\text{dm}^3$ in 110 m depth. Below, the water column is anoxic, nitrate/nitrite concentration is rapidly decreasing but more phosphate and ammonium is present. Below about 150 m H_2S is found, nitrate concentration is zero and ammonium and phosphate are increasing to 9.45 $\mu\text{mol}/\text{dm}^3$ and 4.22 $\mu\text{mol}/\text{dm}^3$ respectively. This is less than in October 2005. The water body with oxygen concentration less than 1 cm^3/dm^3 is extended to a water depth of 70 – 80 m but intrusions of slightly oxic water in the anoxic water body and partially coexisting nitrate and H_2S indicate several recent but weak inflow events into the central Gotland Basin. Remarkably, also a thin bottom layer of about 6m is oxic. Ammonium is partially nitrified here and phosphate concentration is lower than in the layers above the oxic bottom layer. However, repeated CTD-casts about 1 n.m. away and one day later revealed an anoxic bottom layer again.

At Farö Deep similar conditions are met, but H_2S is already found below 80 m depth with some intrusions of water without H_2S below.

At **Landsort Deep** and **Karlsö Deep** surface temperature is lower than in the Gotland Deep, surface salinity varies from 6.3 to 6.7 and nitrate concentration is already elevated. The core of winter water is found at about 55 m depth with temperature of 3.7 °C and nitrate of 3.9 $\mu\text{mol}/\text{dm}^3$. At depth below 70 m the water is suboxic; below 90-100 m H_2S is found. This water mass contains no nitrate but ammonium concentration up to 5.5 $\mu\text{mol}/\text{dm}^3$ and phosphate concentration of about 3.5 $\mu\text{mol}/\text{dm}^3$.

Attachments

- Tables 1 and 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 eastward for temperature, salinity and oxygen (unvalidated data)
- Fig. 5: Transect around Gotland for temperature, salinity and oxygen (unvalidated data)
- Fig. 6: 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	Station	Temp.	Salinity	NO ₂₃ ⁻ *	NH ₄	PO ₄ ³⁻	SiO ₄
Date	Name/ No. **	°C		μmol/ dm ³	μmol/ dm ³	μmol/ dm ³	μmol/ dm ³
Kiel Bight 07.11.06	TF0360/ 004	11.6	20.0	1.55	1.15	0.52	18.1
Meckl. Bight 07.11.06	TF0012/ 003	12.1	19.4	2.52	0.97	0.69	21.0
Lübeck Bight 08.11.06	TF0022/ 006	11.3	18.6	0.39	NA	0.55	19.0
Arkona Basin 09.11.06	TF0113/ 020	10.7	8.5	1.02	0.15	0.21	9.8
Pom. Bight 09.11.06	TF0160/ 025	10.1	8.0	0.8	NA	0.26	10.8
Bornholm Deep 11.11.06	TF0213/ 039	9.8	7.5	0.15	0.15	0.24	4.1
Stolpe Channel 12.11.06	TF0222/ 041	9.2	7.5	0.7	NA	0.35	7.5
SE Gotland Basin 12.11.06	TF0259/ 043	8.9	7.3	0.62	0.20	0.22	4.4
Gotland Deep 13.11.06	TF0271/ 050	8.22	6.74	0.46	0.86	0.23	9.4
Fårö Deep 14.11.06	TF0286/ 052	7.87	6.78	0.72	0.49	0.22	7.7
Landsort Deep 15.11.06	TF0284/ 054	7.13	6.66	1.93	0.13	0.43	12.8
Karlsö Deep 15.11.06	TF0245/ 056	7.38	6.72	0.77	0.24	0.26	8.8

* $\Sigma \text{NO}_2^- + \text{NO}_3^-$; NO₂ 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		cm ³ / dm ³	µmol/ dm ³	µmol/ dm ³	µmol/ dm ³
Kiel Bight 07.11.06	TF0360/ 004	15	11.6	20.0	6.42	1.57	1.17	0.53
Meckl. Bight 07.11.06	TF0012/ 003	22	11.8	20.6	6.14	2.7	1.13	0.68
Lübeck Bight 08.11.06	TF0022/ 006	22	13.3	21.8	2.11	9.37	NA	2.06
Arkona Basin 09.11.06	TF0113/ 020	45	11.0	18.6	5.85	3.54	1.48	0.55
Pom. Bight 09.11.06	TF0160/ 025	12	10.1	8.0	7.36	0.79	NA	0.27
Bornholm Deep 11.11.06	TF0213/ 039	87	9.6	16.9	0.5	8.88	0.28	1.85
Stolpe Channel 12.11.06	TF0222/ 041	88	7.8	14.0	2.99	6.73	NA	1.44
SE Gotland Basin 12.11.06	TF0259/ 043	87	5.52	11.16	0.58	5.89	1.06	2.66
Gotland Deep 13.11.06	TF0271/ 050	233	5.94	12.65	0.16	2.79	3.62	2.45
Fårö Deep 14.11.06	TF0286/ 052	189	6.13	12.11	-0.22	0.25	11.77	4.43
Landsort Deep 15.11.06	TF0284/ 054	436	5.86	11.07	-0.87	0	5.48	3.62
Karlsö Deep 15.11.06	TF0245/ 056	107	5.22	10.27	-1.31	0.11	7.99	3.96

* $\Sigma \text{NO}_2^- + \text{NO}_3^-$; NO₂ was present only in traces in most areas under investigation

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

Monitoring
 Station map TF1100607
 07.11.2006 - 17.11.2006
 58 Station (Part1)

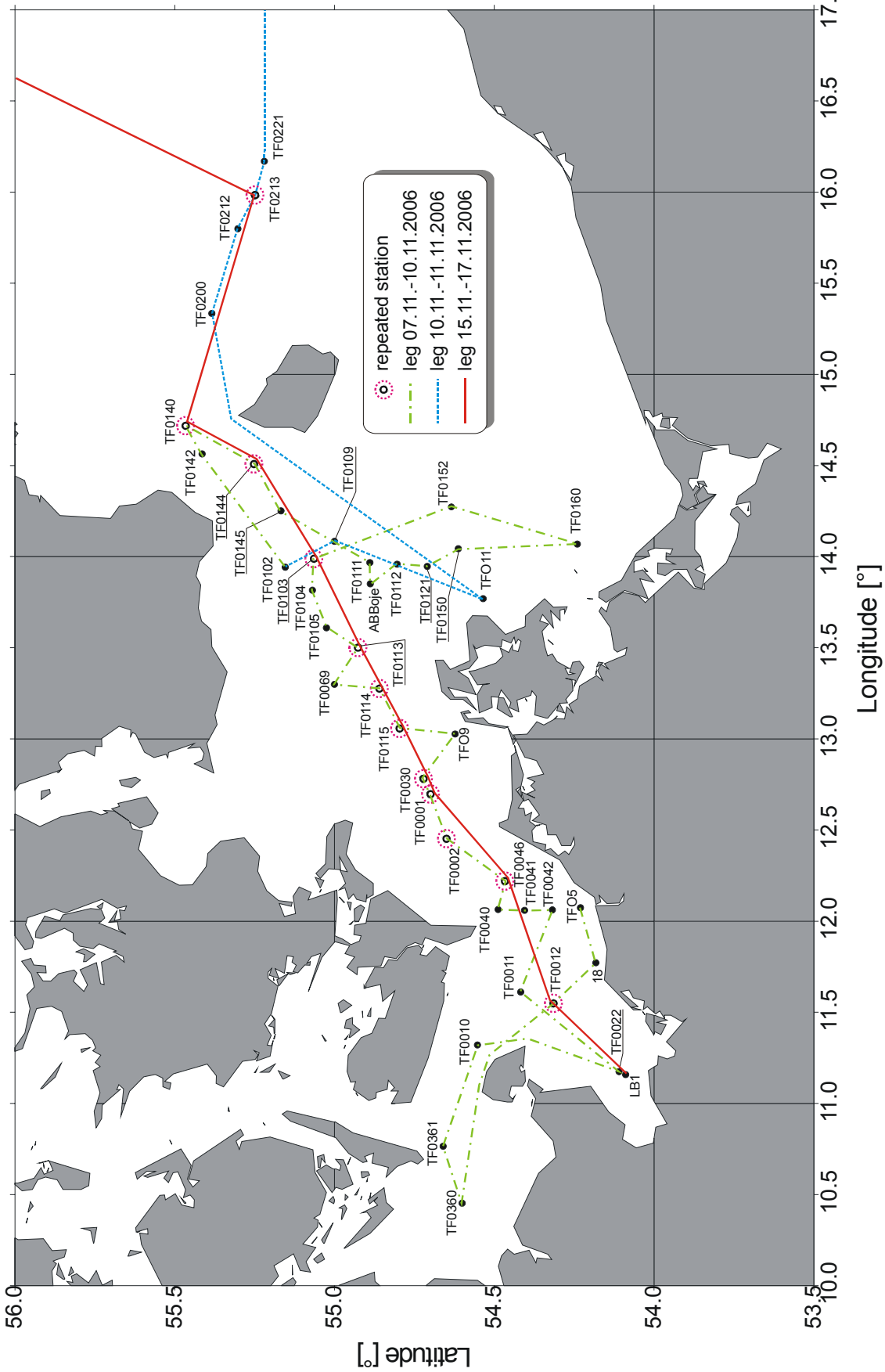
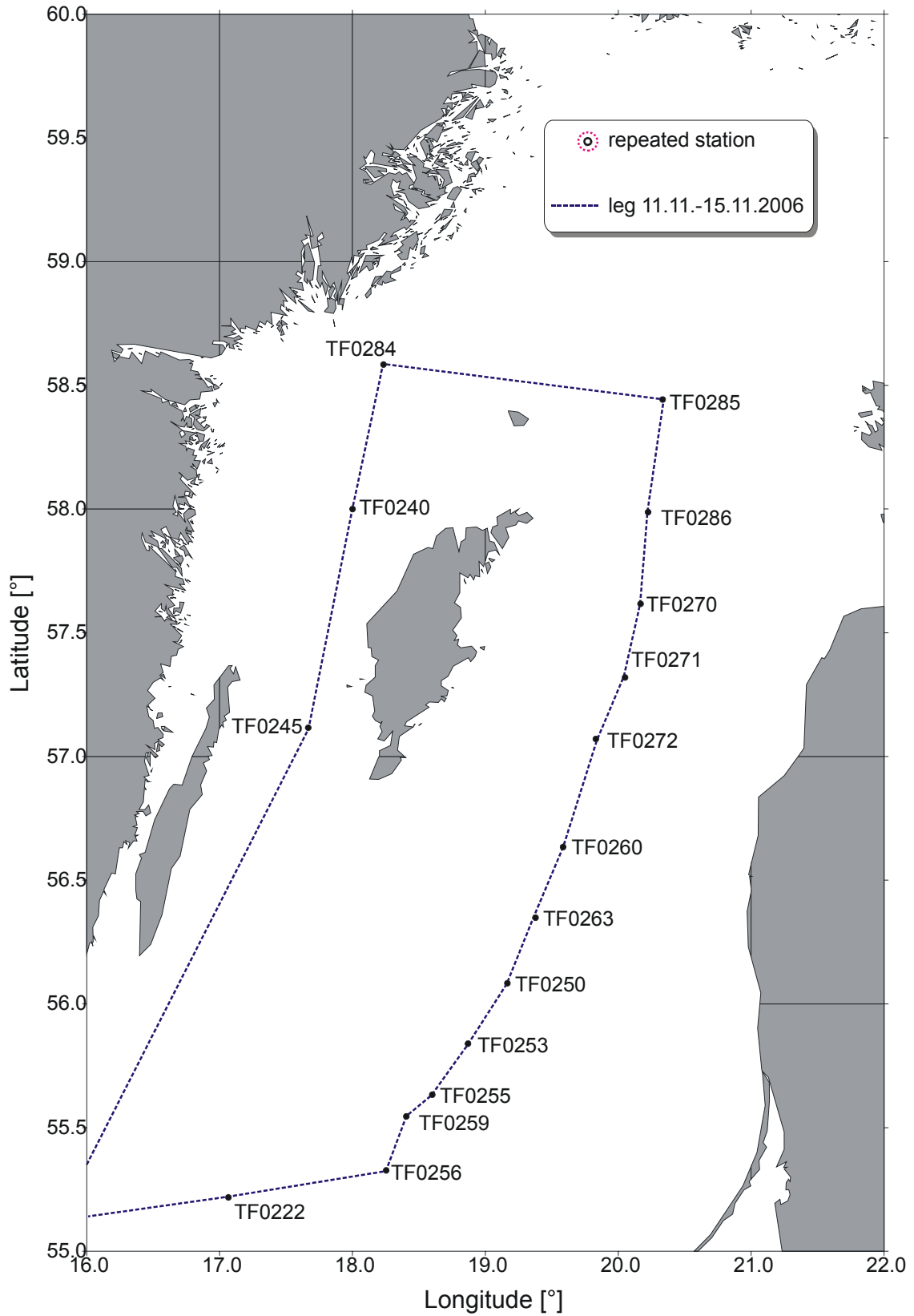


Figure 1

Monitoring

Station map Tf110607
07.11.2006 - 17.11.2006
16 Station (Part2)

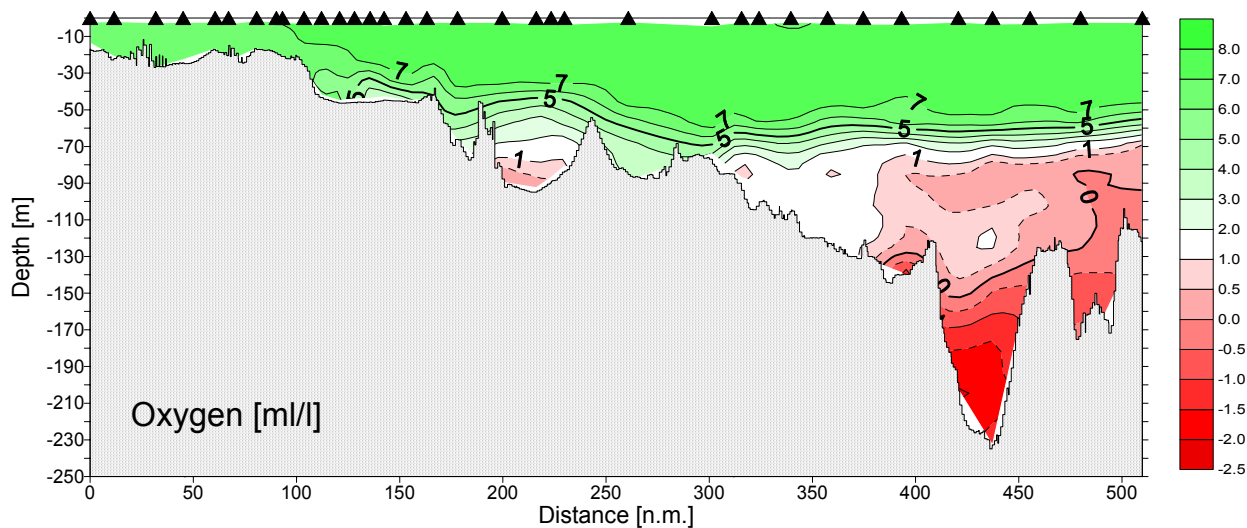
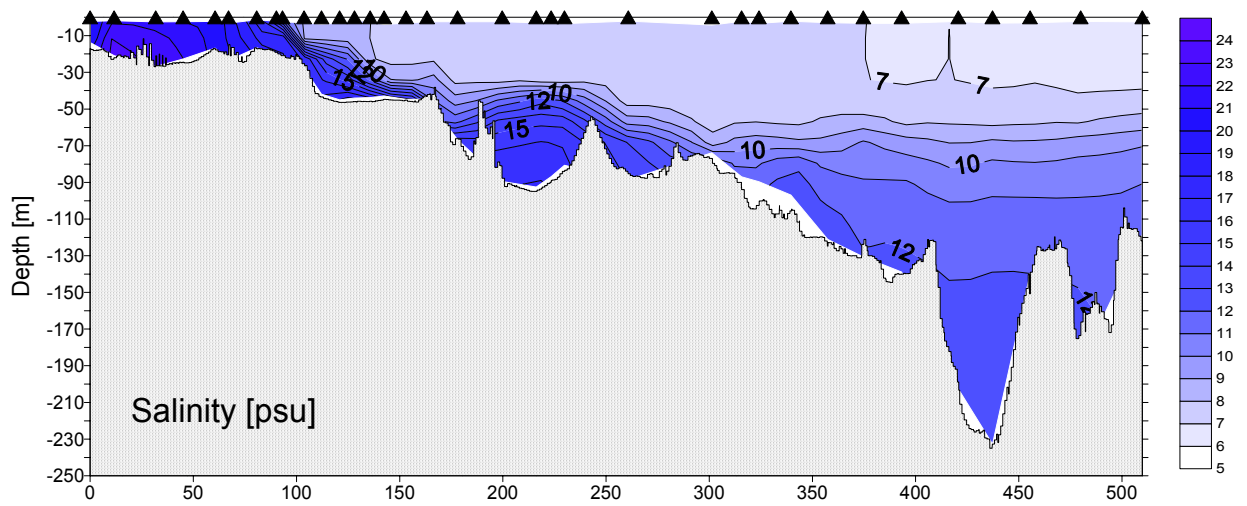
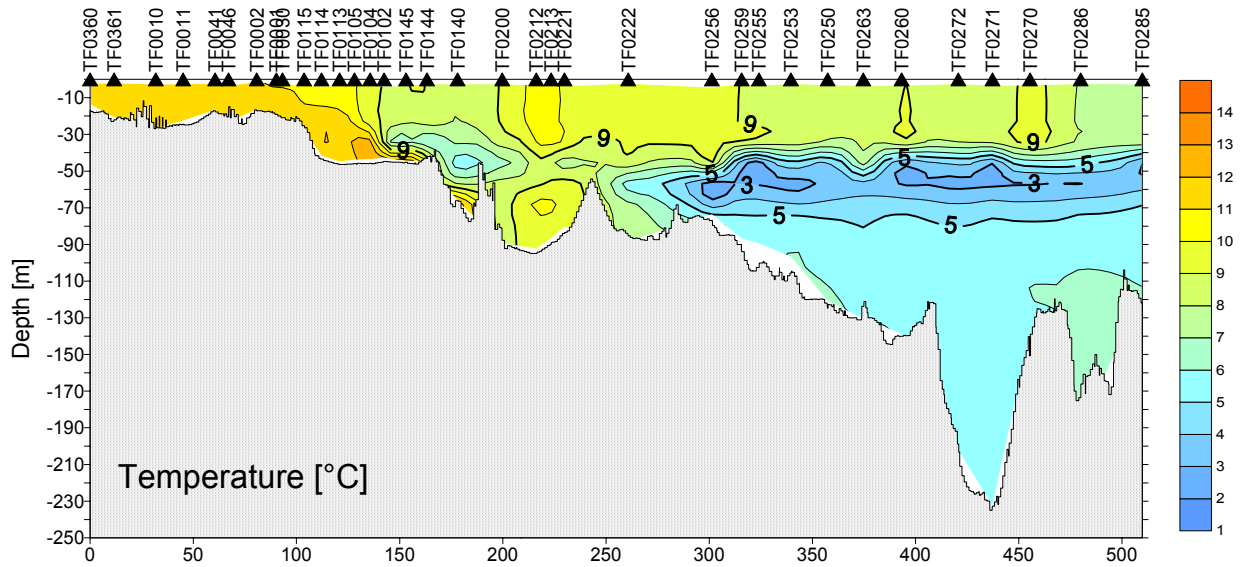
Figure 2



Monitoring 110607

Kiel Bight - Gotland Sea

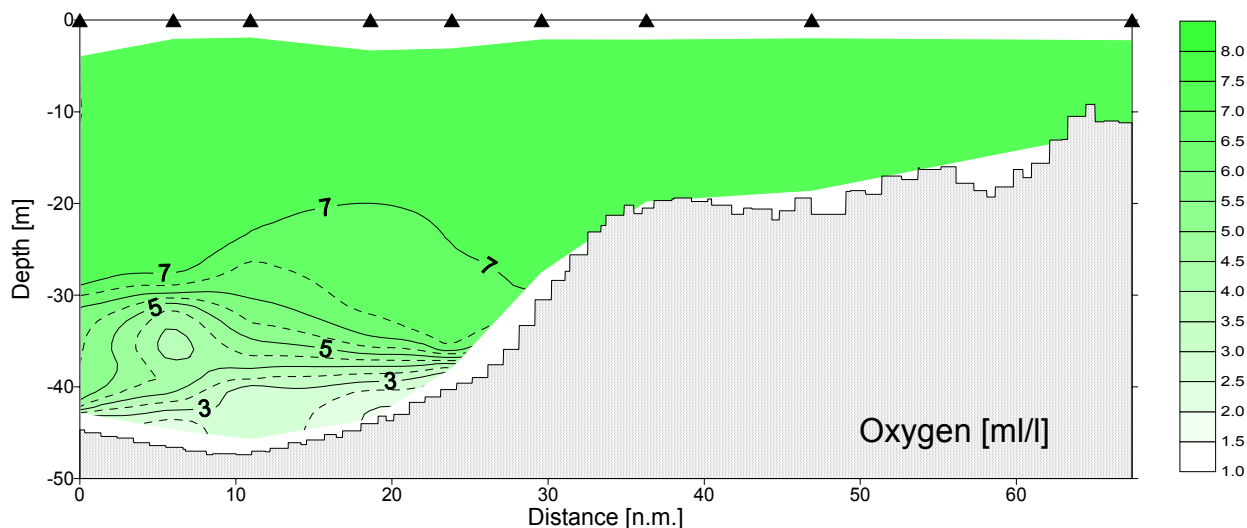
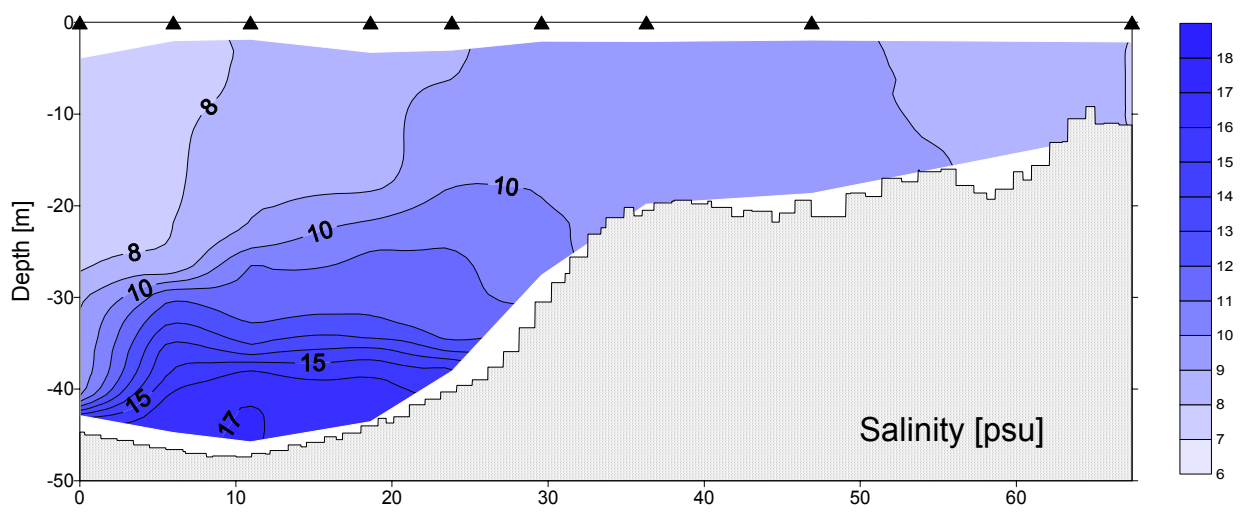
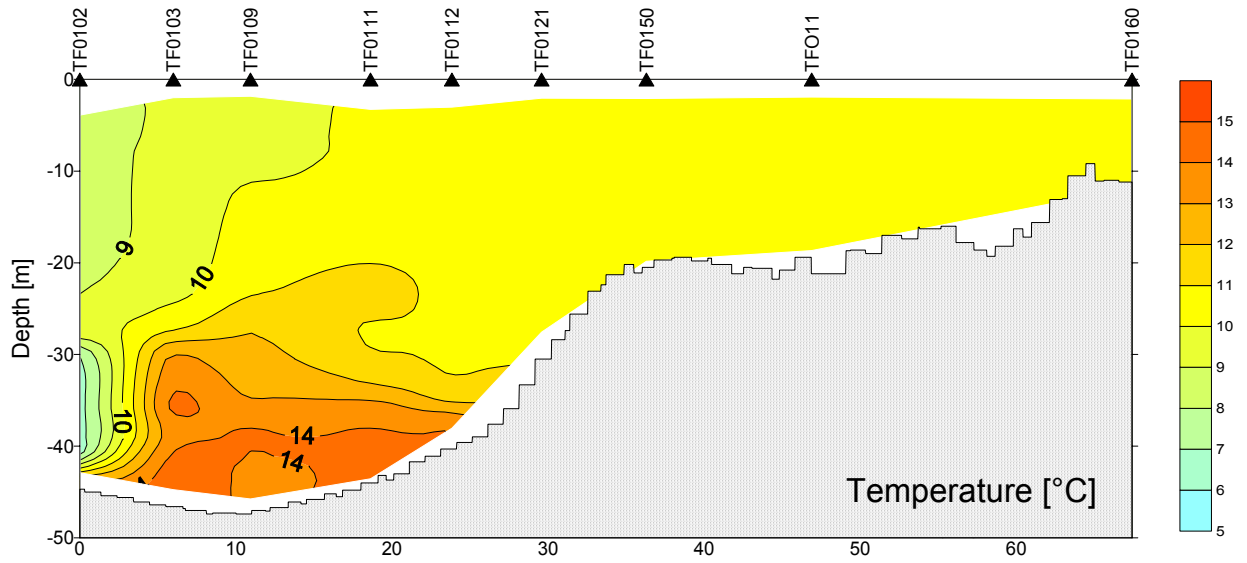
07.11.2006 20:20 - 14.11.2006 22:14 UTC



Monitoring 110607

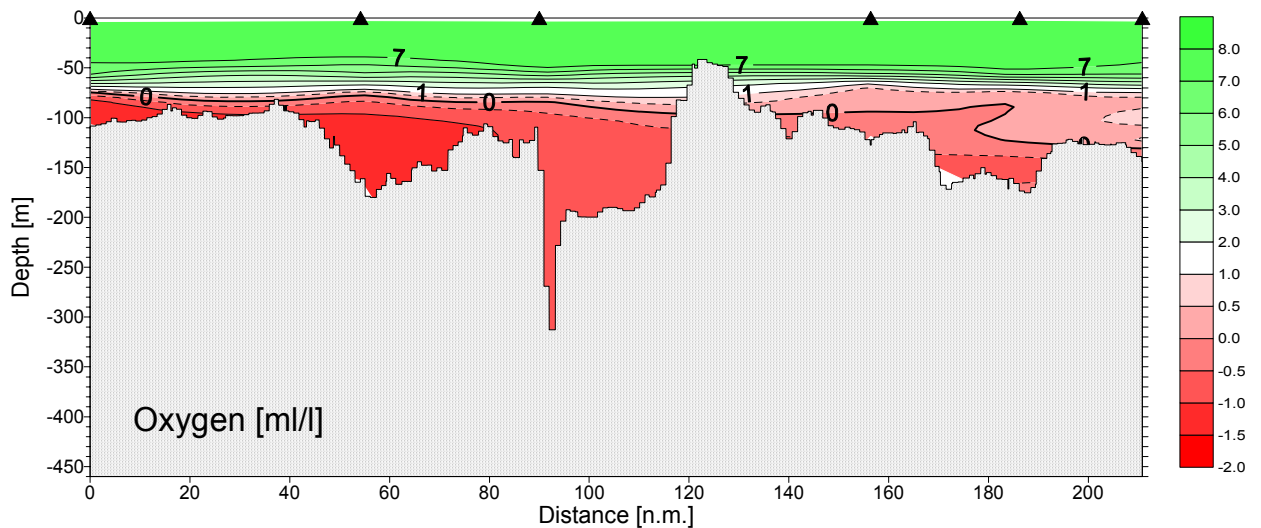
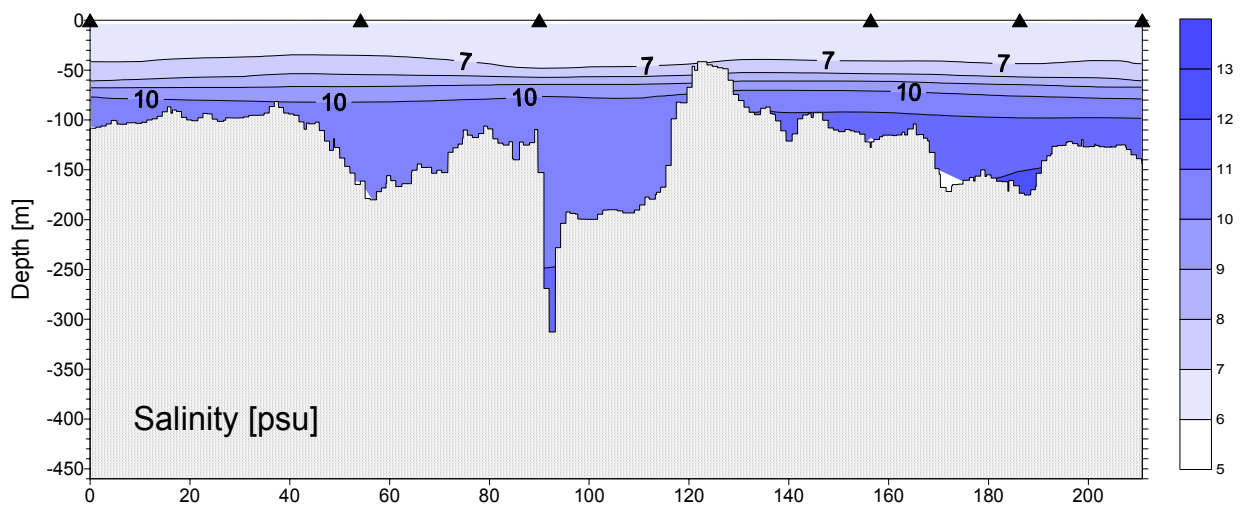
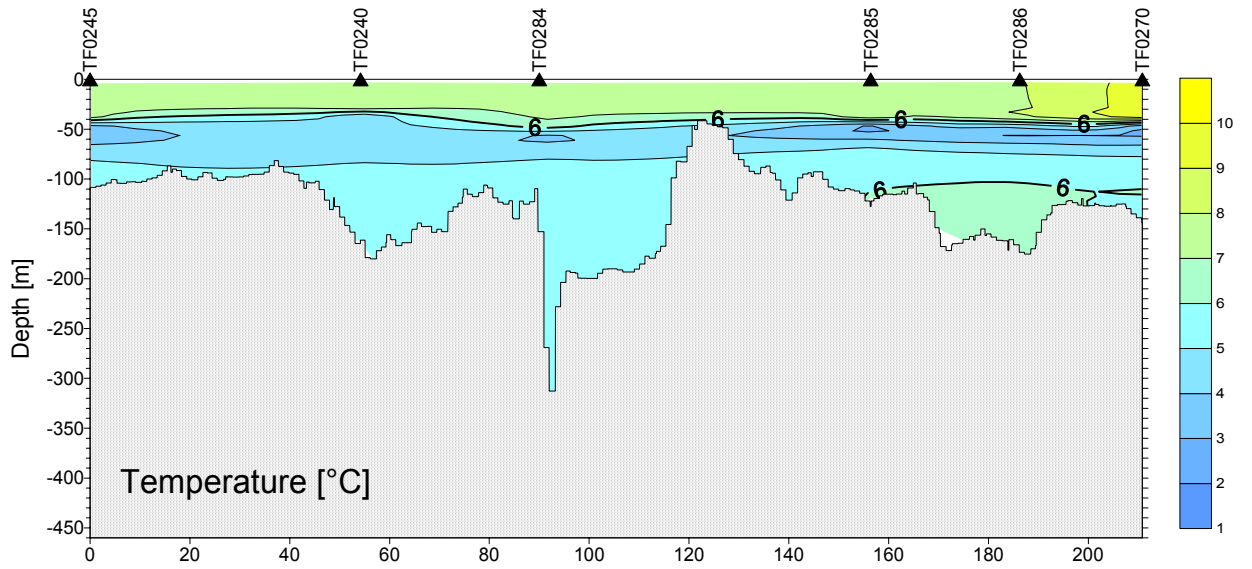
Ystad eastward

09.11.2006 06:00 - 10.11.2006 14:36 UTC



Monitoring 110607

around Gotland
14.11.2006 15:09 - 15.11.2006 19:08 UTC



Monitoring

TF1100607

07.11.2006 - 18.11.2006

Oxygen bottom concentration [m/l]

