ELISABETH MANN BORGESE – Berichte

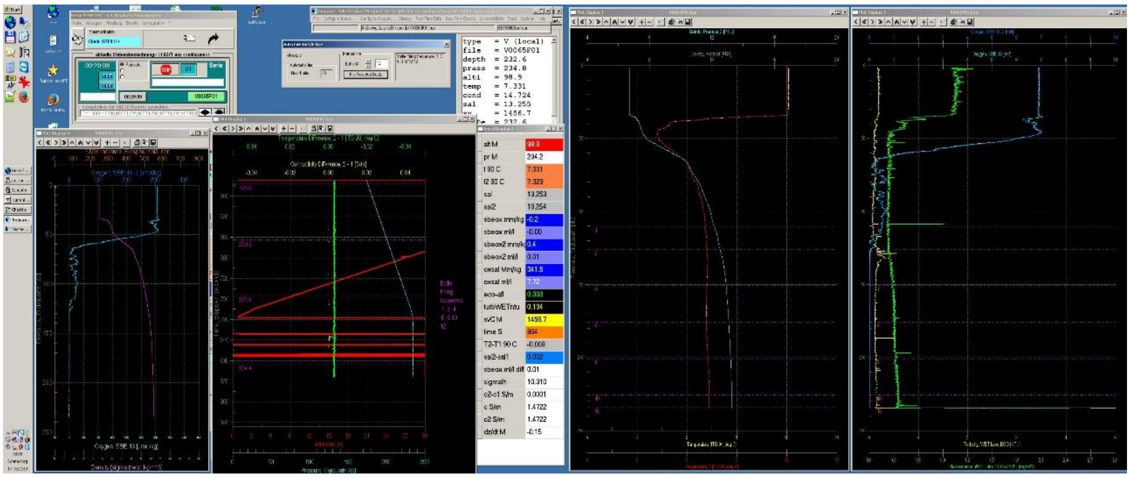
# *Baltic Monitoring Programme (BMP) of HELCOM and IOW's long-term observations, western Baltic to central Baltic Proper*

Cruise No. EMB224

2019-10-11 – 2019-10-23

Rostock-Marienehe to Rostock-Marienehe (Germany)

ACRONYM: HELCOM/long-term

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2019

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# 1 Cruise Summary

## 1.1 Summary

This campaign of measurements continues the regulary cruises to study the spatial and temporal variability of the Baltic Sea on annual and interannual time scale. It is conducted in the frame of the COMBINE Programme of the Helsinki Commission (HELCOM) as well as part of the IOW's long term data programme, performed since 1969. Some measurements during this cruise are related to an ongoing cooperation with the DTU. Moorings and autonomous platforms, used in key areas to get higher temporal resolution of data are maintained during this cruises. The data acquired are used for the regular national and international assessments of the state of the Baltic Sea, and provide the scientific basis for measures to be taken for the protection of the ecosystem Baltic Sea.

During this expedition hydrographic measurements were carried out in an area between the Kiel Bight and the central Baltic Sea. From water samples macro-nutrients and pollutants were determined, but also zooplankton and phytoplankton samples were taken. In the western Baltic sediment samples where taken to assess species decomposition and abundance of the macro-zoobenthos. Two mooring were maintained in the Gotland Basin, a profiling hydrographic and biochemical mooring at the Gotland Deep (GODESS) and the mooring “Gotland – central” equipped with sediment trap and hydrographic sensors were recovered and deployed.

At a few stations sediment cores as well as water samples were gained for the determination of uranium isotopes to investigate and reconstruct historical inflow events into the Baltic Sea.

## 1.2 Zusammenfassung

Die Messkampagne ist eine von fünf jährlichen Expeditionen zur Erfassung der räumlich-zeitlichen Variabilität des Ökosystems Ostsee mit einer Vielzahl hydrographischer, chemischer und biologischer Parameter. Die Arbeiten sind in das COMBINE Programme der Helsinki Kommission (HELCOM) zur Überwachung der Meeresumwelt eingebettet und setzen das IOW Langzeitdatenprogramm für Messungen außerhalb der deutschen Territorialgewässer fort, das seit 1969 fortlaufend durchgeführt wird. Während der Reise werden auch Verankerungen und autonome Messplattformen gewartet, die an Schlüsselstationen in den tiefen Ostseebecken eingesetzt werden, um die zeitliche Datenauflösung zu verbessern. Die gewonnenen Daten gehen in die regelmäßige nationale und internationale Bewertungen des Umweltzustandes der Ostsee ein und bilden die wissenschaftliche Basis für zu ergreifende Maßnahmen zum Schutz der Meeresumwelt.

Zur Aufnahme des aktuellen Zustandes im Gebiet der westlichen bis zentralen Ostsee wurden an 90 Stationen 129 CTD Einsätze gefahren. Für die Messung einer Vielzahl an Nährstoff- und Schadstoffparametern wurden dabei Wasserproben genommen. An Schlüsselstationen wurde außerdem das Zoo- und Phytoplankton beprobt. In der westlichen Ostsee wurde die jährlich Untersuchung des Makrozoobenthos vorgenommen. Zusätzlich wurden Sedimentkerne gezogen für eine Bestimmung der Uranisotopenverhältnisse gezogen. Die GODESS Verankerung wurde im Gotland- Tief geborgen. Obwohl der Messkörper beschädigt war, konnte mit Bordmittel eine Reparatur erfolgen, so dass die Verankerung erneut ausgebracht werden konnte. Auch die Verankerung Gotland Zentral (Sedimentfalle, hydrographische und Strömungsmessungen) konnte geborgen und trotz Beschädigung, wahrscheinlich durch ein Schlepptau, nach Reparatur erneut verankert werden (4.2.2019).

Die Expedition war von permanent windigen Witterungsverhältnissen geprägt, die Arbeiten mussten aber nur kurzzeitig unterbrochen werden, so dass alle geplanten Arbeiten durchgeführt werden konnten.

# 2 Participants

## 2.1 Principal Investigators

| Name | Institution |
|---|---|
| Schmidt, Martin, Dr. | IOW |

## 2.2 Scientific Party

| Name | Discipline | Institution |
|---|---|---|
| Schmidt, Martin, Dr. | Physical Oceanography/chief scientist | IOW |
| Ruickoldt, Johann | Physical Oceanography | IOW |
| Schöne, Susanne | Marine Chemistry | IOW |
| Sadkowiak, Birgit | Marine Chemistry | IOW |
| Hand, Ines | Marine Chemistry | IOW |
| Hehl, Uwe | Marine Biology | IOW |
| Pötzsch, Michael | Marine Geology | IOW |
| Lin, Mu | Marine Geology | DTU |
| Henschel, Tiffany (11.10.-15.10.2019) | Marine Biology | IOW |
| Floth-Peterson, Mareike (1.-11.2.2019) | Marine Chemistry | IOW |

## 2.3 Participating Institutions

| | |
|---|---|
| IOW | Leibniz Institute for Baltic Sea Research Warnemünde, Germany |
| DTU | Danish Technical University, Frederiksborgvej 399, Roskilde, Denmark |

## 2.4 Crew

| Name | Rank |
|---|---|
| Kaufmann, Tino | Kapitän / Master |

# 3 Research Program

## 3.1 Aims of the Cruise

The aim of the cuise is continuation of regular meteorological, hydrographic, hydrochemical and hydrobiological sampling in the Baltic Sea between Kiel Bight to the northern Gotland Basin.

These measurements are combined with a specific microbiological sampling in the Gotland Basin and Landsort Deep to investigate the specific microbial communities in view of the varying redox-conditions in the deep water of these areas. Another task is annual sampling of the macrozoobenthos in the German EEZ, carried out on behalf of the Federal Maritime and Hydrographic Agency (BSH) Hamburg und Rostock. Another task of the cuise is the maintainance of moorings in the Central Gotland Basin.

The acquired data are needed to detect and understand long-term variations and trends in the Baltic Sea ecosystem (IOW's long-term data programme 1969-2019). In addition, they will be used for regular national and international assessments of the state of the Baltic Sea (e.g. HELCOM 2018, NAUMANN et al. 2018) carried out in the frame of the COMBINE Programme of the Helsinki Commission (HELCOM) and for national monitoring demands. This data analysis provides a scientific basis for measures for the protection of the ecosystem Baltic Sea. The hydrographic and biochemical data are essential for modelling and understanding the variability of the Baltic Sea ecosystem on synoptic and climate time scales.

Additional program:
Sediment cores as well as water samples were gained for the determination of uranium isotopes to investigate and reconstruct historical inflow events.

## 3.2 Equipment and methods

Data acquisition was carried out using the following devices and measuring platforms.

At stations and transects:

- CTD SBE 911+ with rosette water sampler equipped with 13 free-flow bottles (5l)

  Double sensors packages
- In situ video camera attached to the CTD
- Oceanographic moorings (GODESS, Gotland central)
- Phytoplankton nets
- Zooplankton net (WP2)
- Secci desk
- Autoanalyser, Photometer, Titrino
- Frahmlot sediment corer, multicorer
- Van Veen grab, dredge

Each station work starts with a **CTD cast**. The sea state compensating winch allows a constant veering velocity of 0.3 m/s, which avoids "looping" of the CTD. Data are stored directly on a PC. Free flow bottles are closed automatically during the down-cast in predefined depth, at the bottom and at the sea surface. To sample additional specific depth, bottles are closed during up-cast after stopping the CTD winch.

To ensure high quality data, two conductivity, temperature and oxygen sensors are used in parallel. The common drift of all sensor values by a possibly drifting quartz normal of the CTD probes analog-digital transformers was excluded by observing the quartz oscillation frequency. In addition, at least once a day at selected stations inter-comparison measurements are carried out. Salinity samples are taken in homogeneous water bodies to be measure later with an AUTOSAL 5400 in the laboratory. In the same depth, temperature is controlled with a high precision thermometer SBE35. The zero point of the pressure sensor is controlled by means of a registration on deck, whereby the CTD probe was hanging in order to reduce the influence ship vibrations. The zero of the oxygen sensors was controlled prior the cruise by filling the sensor tube with dry pure dinitrogen gas. Measurements in anoxic and sulfidic deep waters in the Gotland Basin provide an additional control of the oxygen sensor stability.

**Macronutrients** (nitrate, nitrite, phosphate and silicate) are determined simultaneously from sea water samples using an autoanalyser CFA-Analyzer Evolution III.

**Nitrite** is measured by the reaction with Sulfanilamid in acid environment followed by coupling with N-(1-Naphthyl)ethylendiamindihydrochlorid.
Accuracy: ± 0.05 µmol/L

**Nitrate** is reduced to nitrite on copper covered cadmium granulate at pH-Bereich 7.5 bis 8.4. Subsequently the nitrite concentration measured as described above.
Accuracy: ± 0.5 µmol/L

**Phosphate** is determined via ist reaction with molybdate in strongly acid environment (pH<1) to a heteropolymolybdato-phosphoracid to be reduced by ascorbin acid to molybdanum blue.
Accuracy: ± 0.06 µmol/L

**Silicate** is detected via the reaction (pH 1.4 bis 1.6) with molybdate to yellow Heteropolymolybdato-silicate, to be reduced to molybdanum blue.
Accuracy: ± 0.23 µmol/L

**Ammonium** is determined by a colorimetric method based on the formation of blue indophenol from phenol and hypochlorite in the presence of ammonium. The accuracy is ± 0.5 µmol/kg. Samples are diverted from the nutrient samples, and are opened as short as possible to add reagents. A spectral photometer UV-mini 1240 is used for the optical determination of the ammonium concentration.

Almost every station **dissolved oxygen** is determined in selected homogeneous water bodies with the Winkler method. With a hose, calibrated oxygen bottles are filled bubble with seawater, fixed with potassium iodide, shaked at least 30 s and stored cool in the dark. Latest after 12 h, oxygen concentration is measured with a TITRINO with tiamo software. These measurements allow an accuracy of 0.2 ml/l and help to control the drift of the oxygen sensor.

**Hydrogen sulphide** samples are taken bubble free in glass bottles with help of a hose with an overflow of more than three times the bottle volume. The method is based on the transformation of p-aminodimethylanilin with hydrogen sulphide to methylenblue under the influence of iron(III)chloride in an acid environment. After shaking the bottle it is stored in the dark. At least after 24 h the hydrogen sulphide concentration is determined with a spectralphotometer UV-mini 1240. The accuracy is ± 3%.

For determination of the **phytoplankton** biomass on species level or on higher taxonomic rank, a representative water sample (250 ml) of the upper 10 m of the water column is prepared by mixing equal volumes taken from the rosette sampling bottles from surface, 2.5, 5, 7.5 and 10 m depth. In addition, a water sample (250 ml) from 20 m depth is taken at each sampling station. The samples are preserved with 1 ml acetic Lugol solution and stored until microscopic analyses in the institute's lab.

**Secci depth** is determined at stations representative for the major Baltic Sea stations for comparison with historical data.

For **zooplankton** assessment, net catches using a WP-2 net equipped with a TSK flowmeter and 100 µm mesh size were conducted at selected monitoring stations. To support the analysis of the long-term changes in the population dynamics of key copepod species in the Bornholm Basin, zooplankton nets (Apstein, mesh size 50 µm, WP-2 mesh size 100 µm) were deployed to quantitatively sample nauplii and copepodites (responsible scientist Dr. Jörg Dutz, IOW)

Organic and inorganic carbon determination:

For **macrozoobenthos** sampling, at 8 stations ranging from the Kiel Bay in the West to the Pomeranian Bay in the East in water depths between 20 and 50 m a van Veen grab was used for sampling. For quantitative analysis three replicates at each station and one grab for sediment analysis was deployed. Additionally a dredge was used for qualitative aspects. Following the HELCOM guidelines, after 3 month of waiting for weight stability, further processing of samples will be undertaken in the laboratory. After rinsing each haul, taxa will be sorted under a binocular microscope at 10-20 x magnification.

**Continuous measurements**:

- Underway measurements of surface water properties

  Conductivity, temperature, fluorescence and turbidity are gained continuously with ships thermosalinograph that was used in selfcleaning mode.

- Ships weather station

This data are compiled into a data set comprising the following data on hourly basis: time (UTC), latitude and longitude, depth, air pressure, air temperature, humidity, global radiation, infrared radiation, surface conductivity, surface salinity, surface water temperature, surface chlorophyll-a fluorescence, surface turbidity, wind direction, wind speed. Data are stored as netcdf files.

**The Gotland Deep Environmental Sampling Station (GODESS)** is a profiling mooring. See the Appendix. A profiling body with the sensor payload is ascending and descending through the water column at predefined times. GODESS consists of a bottom weight, holding the station in place, an acoustic releaser with recovery line, the underwater winch (NiGK, Japan) and the profiling instrumentation platform. The profiling instrumentation platform (PIP) is designed in IOW and consists of a Sea & Sun Technology CTD 90 M with sensors measuring the following quantities:

Conductivity, Temperature, Pressure, Oxygen, Turbidity, Chlorophyll a fluorescence, Oxidation-Reduction-Potential, pH.

In addition to the CTD data, we collect current velocity data (Aquadopp Current Profiler, Nortek), optical nitrate and HS- data (Opus, TriOS GmbH) and occasionally Micro Temperature and Micro Conductivity data (MicroRider, Rockland Scientific).

A typical deployment period lasts between 3 and 6 months. The repeated profiles cover mainly the redoxcline between the oxygenated surface layers and the anoxic deep layer.

## 3.3 Description of the Work Area

The area under investigation covered the western and central Baltic Sea from the Kiel Bight to the northern Gotland Basin (Fig. 3.1). Most stations are located along the so called thalweg transect of the Baltic Sea, describing the hydrographic conditions in all basins on the pathway of saltwater inflows from the North Atlantic. The deepest area of the Baltic Sea, the Landsort Deep is also included. A zonal section through the Gotland Basin allows for a more accurate determination of the anoxic areas and for observation of inflowing waters on the eastern slope of the Gotland Basin.

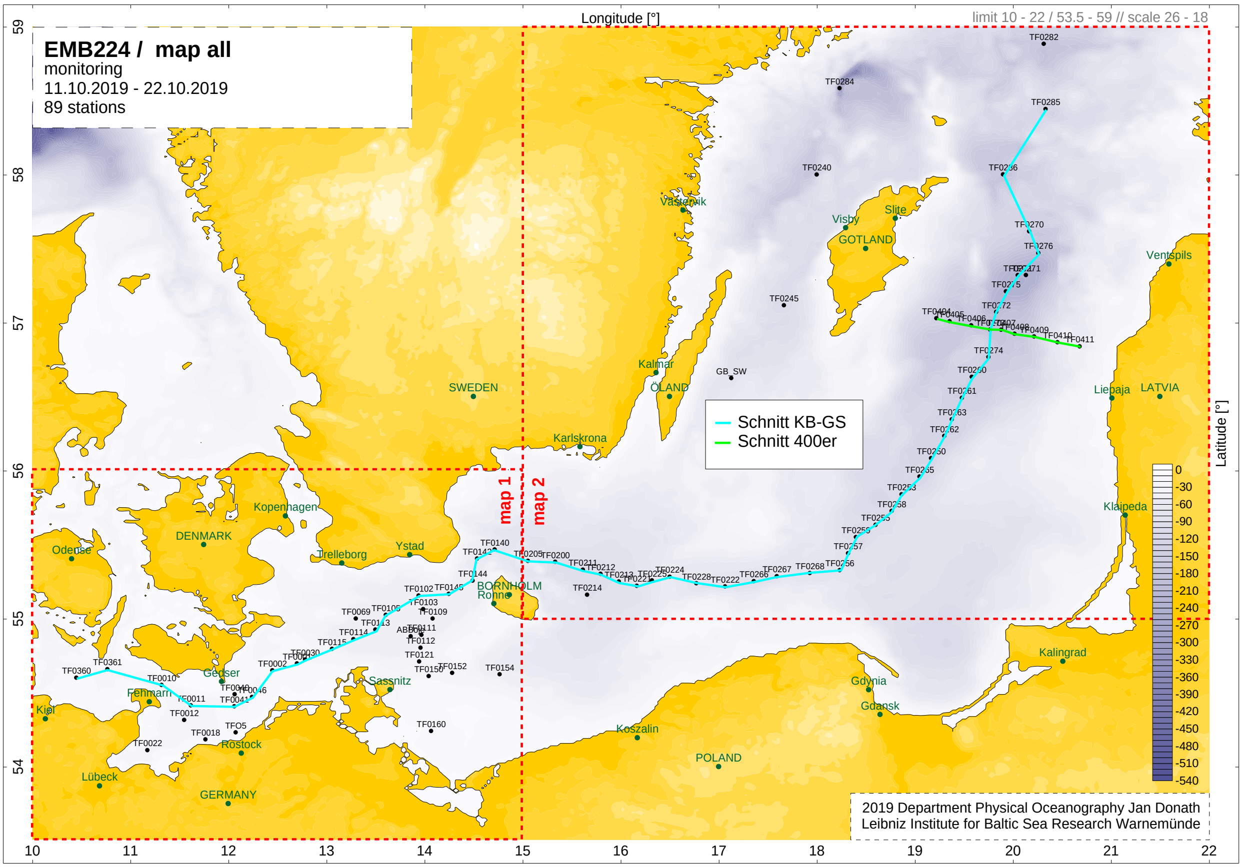



**Fig. 3.1** Track chart of R/V Elisabeth Mann Borgese of cruise EMB-224. “***K***iel ***B***ight- ***G***otland ***S***ea” marks the thalweg.

# 4 Narrative of the Cruise

| Date | Time [UTC] | Task |
|---|---|---|
| 2019-10-10 | 07:00 | loading of equipment, preparing devices for the cruise |
| 2019-10-11 | 06:30<br>07:30<br>08:00<br><br>09:00<br>10:00 - 24:00 | Embarking of scientific crew<br>Safety instructions<br>Departure from port Rostock-Marienehe, weather: sunny, moderate to strong wind SE<br>Start of station work in the Mecklenburg Bight, station TF005<br>Station work westward in the Mecklenburg Bight, Fehmarn Belt, Kiel Bight stations TF018 – TF361 |
| 2019-10-12 | 00:00 - 24:00 | Station work in Mecklenburg Bight, Darss Sill, stations TF360 – TF001 |
| 2019-10-13 | 00:00 – 24:00 | Station work in the Arkona Basin, stations TF069 - TF144 |
| 2019-10-14 | 00:00 - 10:40 | Station work in the Arkona Basin and Bornholms Gat, East of Rügen |
| 2019-10-15 | 00:08 - 10:00<br>19:00 – 24:00 | Crew exchange in Saßnitz. Tiffany Henschel, Mareike Floth-Peterson<br>Station work through Bornholms Gatt |
| 2019-10-16 | 02:00 - 05:00<br>06:00 – 24:00 | Station work on TF213<br>Station work through Slupsk furrow |
| 2019-10-17 | 00:00 - 18:00<br>18:00 - 00:00 | Station work on the thalweg into the Gotland Basin, TF255-271<br>CTD casts at TF271 for several projects |
| 2019-10-18 | 07:015 - 08:00<br>09:00 - 12:00<br>18:00 – 24:00 | Recovery of GODESS<br>Maintainence of sediment trap mooring in the eastern Gotland Basin,<br>Station work on the zonal section through eastern Gotland Basin. |
| 2019-10-19 | 00:00 - 24:00<br>06:00 – 11:00<br>12:00 – 24:00 | Station work on the zonal section through eastern Gotland Basin.<br>Deployment of GODESS<br>Station work in the northern Gotland Basin, TF276 - TF285 |
| 2019-10-20 | 00:00 – 23:00 | Station work in the western Gotland Basin, Landsort Deep, Karlsö Deep, station TF245, weather: strong wind SW |
| 2019-10-21 | 00:50 - 01:00<br><br>12:30 - 15:30<br>20:00 - 24:00 | Station work west of Gotland, stations TF0245<br>Transit to Bornholm Basin<br>Station work in the central Bornholm Basin, stations TF0213<br>Station work on TF0154, Multicorer, low winds calm sea |
| 2019-10-22 | 00:00 - 18:00 | Station work in the Arkona Basin, Darss Sill, Mecklenburg Bight, stations TF113 - TF012<br>Transit to port |
| 2019-10-23 | 08:00<br>08:00 - 11:00<br>11:00 | Arrival at port Rostock-Warnemünde<br>Deinstallation, unloading of scientific equipment, disembarking<br>Disembarking of scientific crew, end of cruise EMB-224 |

# 5 Preliminary Results

The results presented in the following section are preliminary and not comprehensive, since based in most cases on unevaluated raw data.

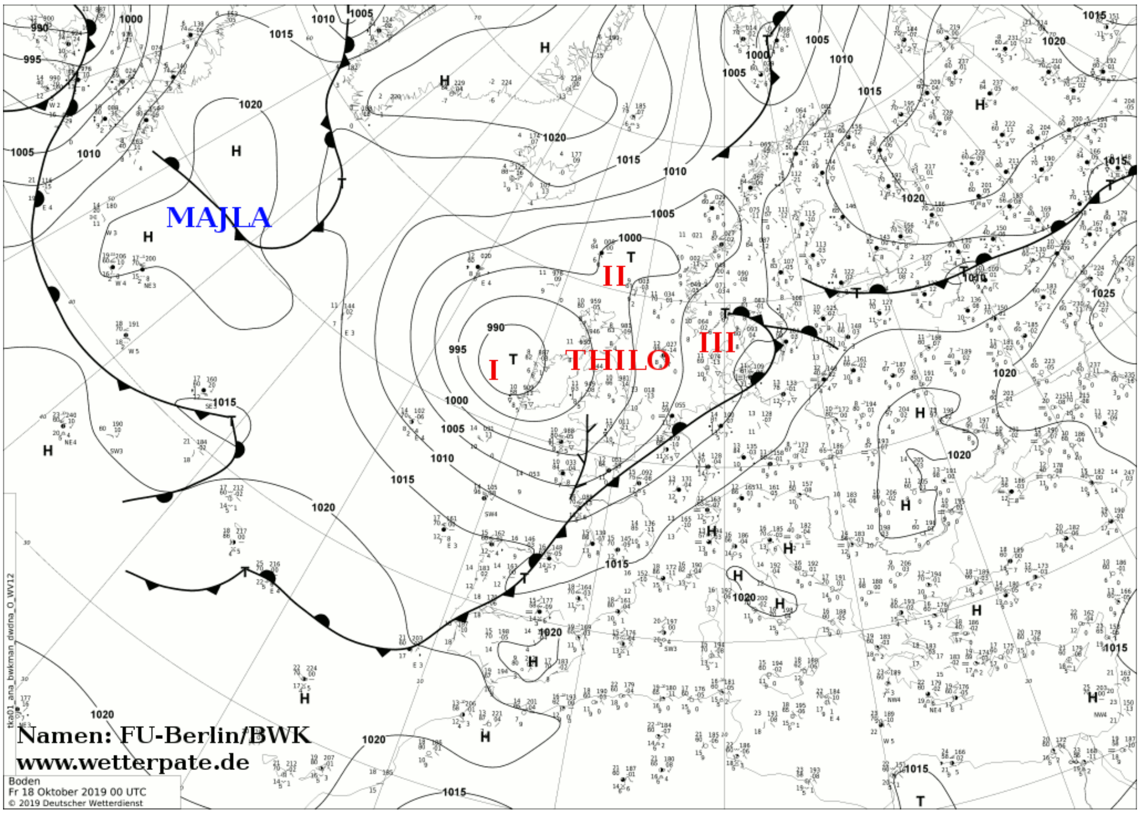



**Fig. 5.1** Typical bottom pressure distribution during the time of the cruise. (with kind permission from http://www.met.fu-berlin.de/de/wetter/bodenanalyse/)

## 5.1 Meteorological Conditions

The cruise took place in a period of mild autumn weather allowing for continuous station work and also for mooring maintenance in the Gotland Basin. Winds were mostly south to westerly with only little interruptions. Pressure gradients were moderate over Baltic Sea areas and wind strength varied from 3 and 6 Bft but crested with 7 Bft in the evening of Oct. 11$^{th}$ and Oct. 14$^{th}$. Air temperature varies around the sea surface temperature. Exception is the evening of Oct. 13$^{th}$, when the ship was within the area of cold upwelling water in the southern Hanö Bight that was caused by southerly winds stratifying significantly warmer air over colder water. Fig. 5.1 shows a typical air pressure distribution with low isobar density over the Baltic Sea area.

Figure 5.2 shows time series of the global and thermal radiation, air temperature and sea surface temperature and stick plots of hourly winds. At some days solar radiation is not exceeding 200 Wm$^{-2}$ at noon. Note, the prevailing south-westerly winds during the cruise causing upwelling favoring conditions along the Swedish coast.

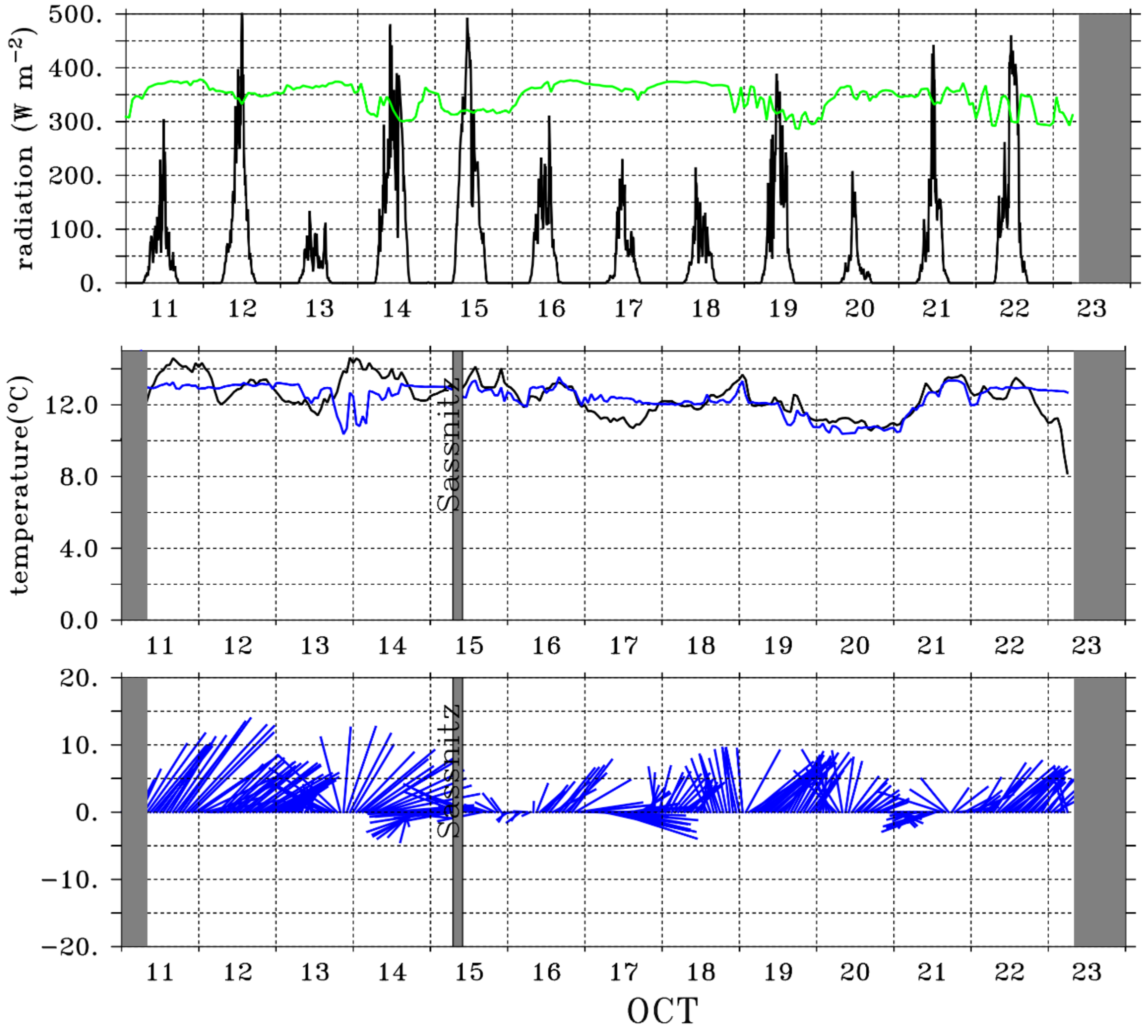



**Fig. 5.2** Solar (black) and thermal (green) radiation, air temperature (black) and sea surface temperature and stickplots of the wind speed measured by ships weather station during the cruise.

## 5.2 Surface conditions

Surface temperatures varied between 13°C and 11°C. Temperature and salinity profiles near the surface show autumn cooling. In the western Baltic, the saline bottom water is warmer than the surface water. The significant zonal gradient in the sea surface temperature is typical for autumn conditions.

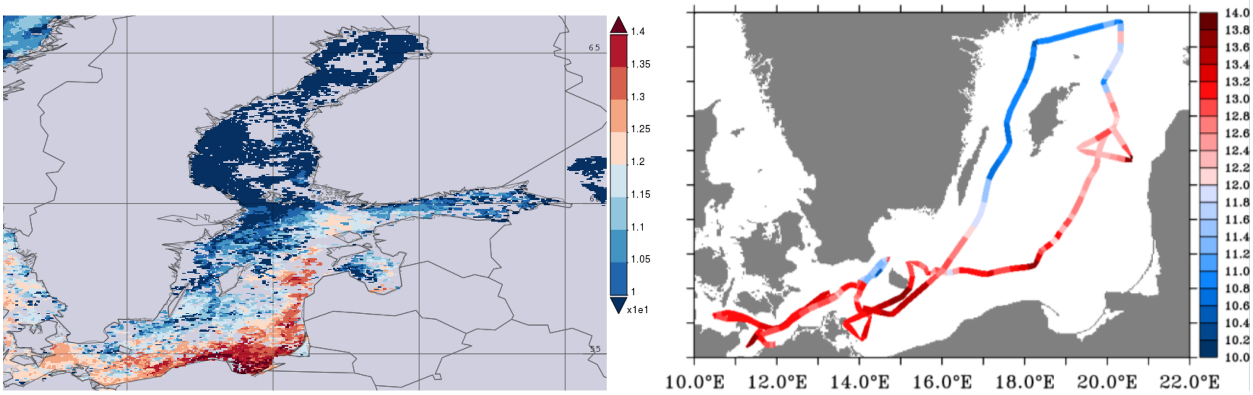



**Fig. 5.3** Sea surface temperature during the time of the cruise. Left figure: MODIS aqua 11µm nightly SST (https://giovanni.gsfc.nasa.gov/giovanni) averaged over the period of the cruise. Note, there is a factor of 10 in the temperature scale. Right figure: ships underway measures.

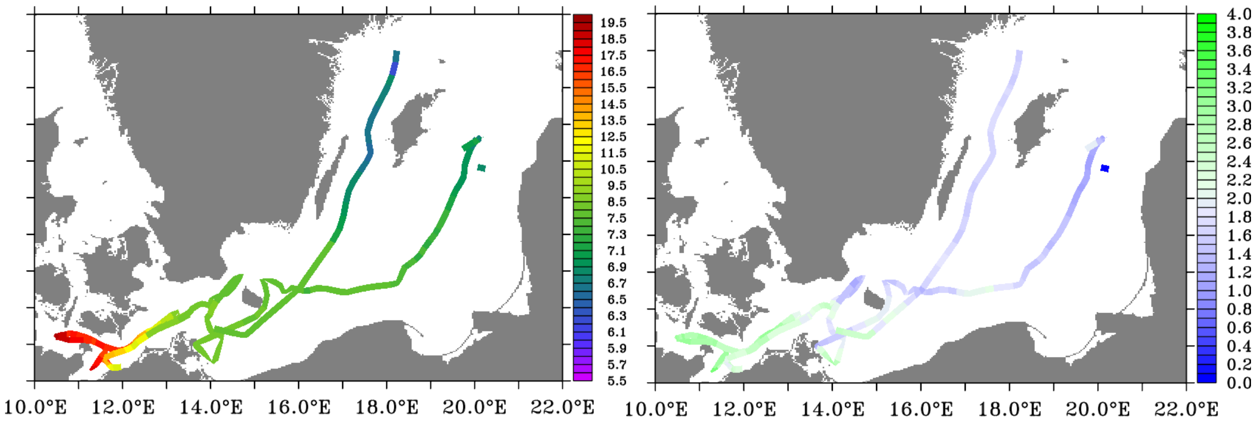



**Fig. 5.4** Practical salinity (left figure) and fluorescence (right figure) from ships underway measures. Fluorescence is given in chlorphyll-a units, mg $m^{-3}$. Data in the north are missing due to an instrument malfunction.

In the Baltic proper, chlorophyll-a represented by the fluorescence is generally small well below 2 mg $m^{-3}$, corresponding to a typical Secci depth of about 6 m. In the Arkona Basin and west of Darß Sill still some remaining fluorescence is met. At the surface, both the nutrients phosphorus and nitrogen are almost exhausted, but with the exception of the Kiel and Mecklenburg Bight the silicate concentration is well above 10µM. About half of the remaining nitrogen is available as ammonium. For a summary for key stations see Table 6.1.

## 5.3 Bottom oxygen concentration, specific situation in Mecklenburg Bight

The conditions in the Mecklenburg Bight deserve detailed attention. This area is an important fishery ground, is a touristic area but is also surrounded by land with intense agricultural activity and has two cities in its neighborhood. At stations TF0012 and TF0022 oxygen in the bottom water is almost exhausted (below 1 ml $l^{-1}$) and is also depleted at TF0011 and TF0010. A more detailed discussion is not possible from the sparse station grid but the fact should be noticed as stressor for plaice, one of the important targets of local fishery.

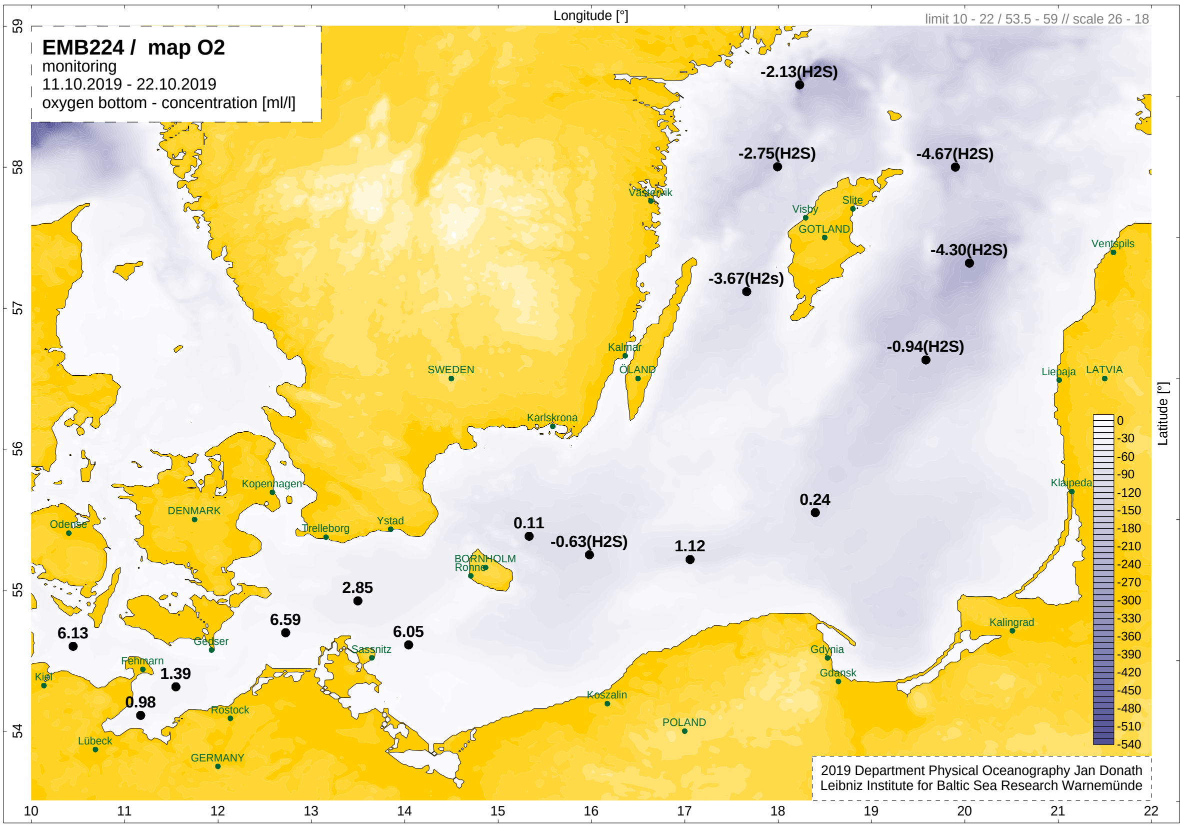



**Fig. 5.5** Oxygen/hydrogen sulphide conditions in the bottom near layer for selected key stations (hydrogen sulphide was converted into negative oxygen equivalents).

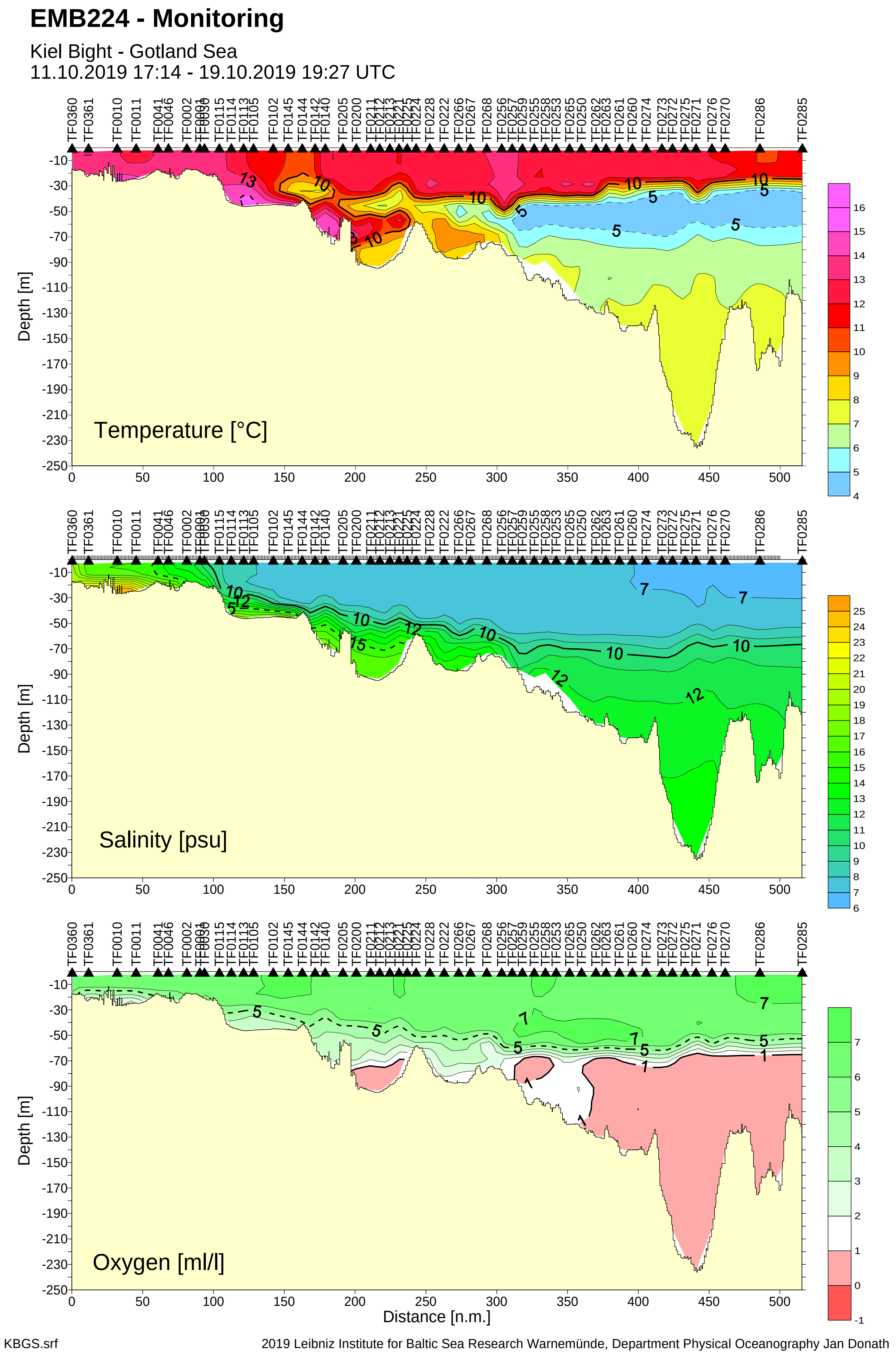



**Fig. 5.6** Cross section from Kiel Bight to eastern Gotland Basin showing the hydrographic parameters temperature, salinity and oxygen on the “thalweg” of Major Baltic Inflows (for location see map Fig. 3.1).

## 5.4 Hydrographic conditions along the Thalweg

Fig. 5.6 shows in situ temperature, salinity and oxygen concentration along the thalweg beween Kiel Bight and the Gotland Basin. The hydrographic conditions along this thalweg cover the transition from oceanic with high salinity and stratification governed mostly by potential temperature monotonically decreasing with depth to brackish waters, where stratification is strongly influenced by salinity. In the west, the seasonal thermocline is already dissolved by autumn cooling, the surface water is cooler than the more saline bottom water. A similar warm bottom water mass is also found in the Arkona Basin and in the Bornholm Gatt to station TF0140. A typical for the Bornholm Basin in the last decade, a warm surface layer overlays a remainder of cold winter water. Since the winter water is present all seasons, the warmer water below must have its origin in the Arkona Basin. It propagates also through Słupsk Furrow and is losing slowly its salinity-temperature characteristics when descending into the Gotland Basin. The Bornholm Sea bottom water is stagnant. It has lower temperature and higher salinity than the inflowing water and in anoxic.

Within the Gotland Basin the winter water layer becomes more pronounced. The temperature minimum is located at about 45m depth. The minimum temperature amounts to about 4°C. Below the winter water layer both, temperature and salinity are monotonically increasing. Bottom temperature at station TF0271 is 7.3°C practical salinity is 13.3.

Downward from the center of the winter water layer oxygen concentration is decreasing rapidly. In the Bornholm Basin the warmer water stratifying below the winter water causes some oxygenation. In Gotland Basin at the base of the winter water layer at 60m depth, oxygen concentration falls well below 1 ml $l^{-1}$. Between 60m and 120m depth oxygen concentration is varying indicating mixing by some ventilation from inflowing water stratifying into this depth horizon. Below 120m depth, the water becomes fully anoxic and hydrogen sulphide gives water samples its typical smell. At the redoxcline, a strong pronounced turbidity maximum is met.

## 5.5 Zonal cross section through the Eastern Gotland Basin

The zonal sections through the Eastern Gotland Basin towards the Latvian coast shows how the hydrographic conditions see on the thalweg section extend throughout the basin. There is a general doming structure of the isotherms. The thickness of the winter water layer has a maximum in the center of the Gotland Basin, but also the 7°C isotherm show a doming. Remarkably, there is an intrusion of a water mass with slightly enhanced oxygen concentration at the eastern coast that extends towards the center of the basin in 100m depth and corresponds to the hypoxic but oxygenated layer at the central station TF0271 in 100m depth.

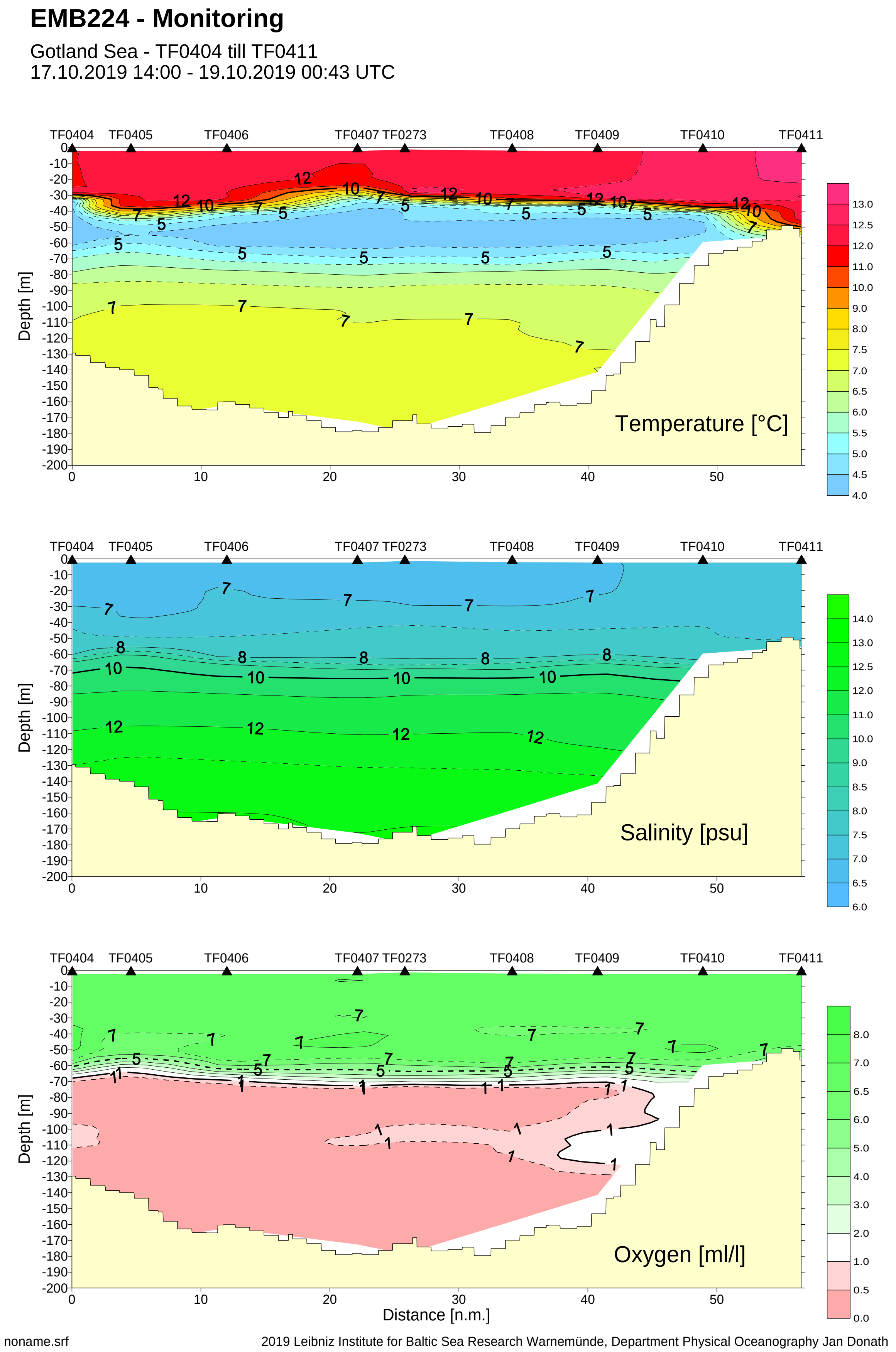
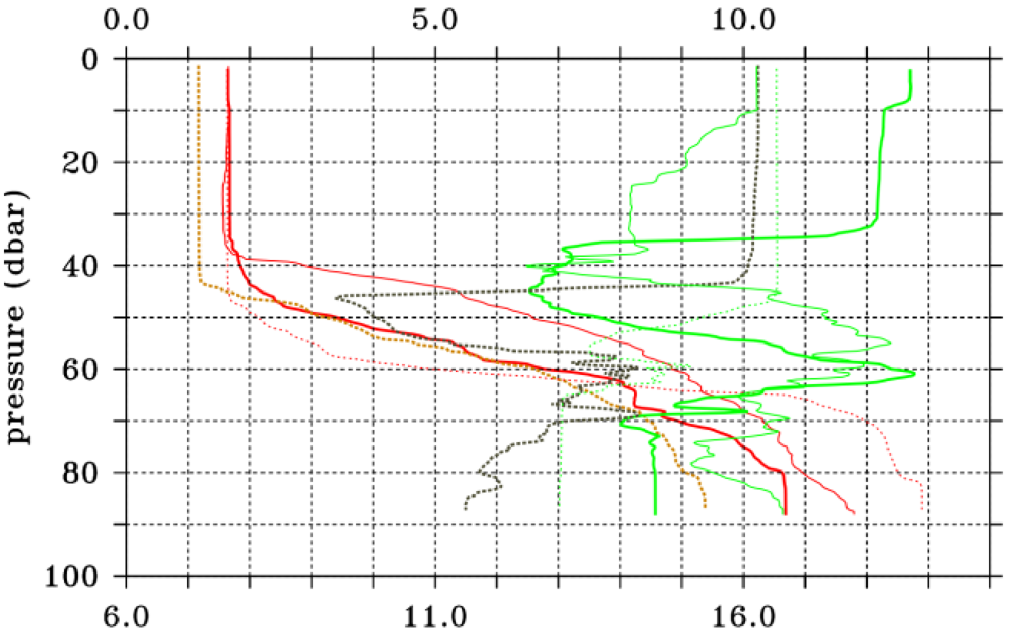



**Fig. 5.7** Zonal cross section through the central Gotland Basin, for location see map Fig. 3.1.

## 5.6 Hydrographic profiles in the Bornholm Basin and the Gotland Basin

Fig.s 5.8 and 5.9 show the development of the vertical structure of water bodies from conditions before (2013) and after the major inflow event (2015) and rapid reestablishing anoxic conditions in the years 2018 and 2019. The most significant difference between pre- and



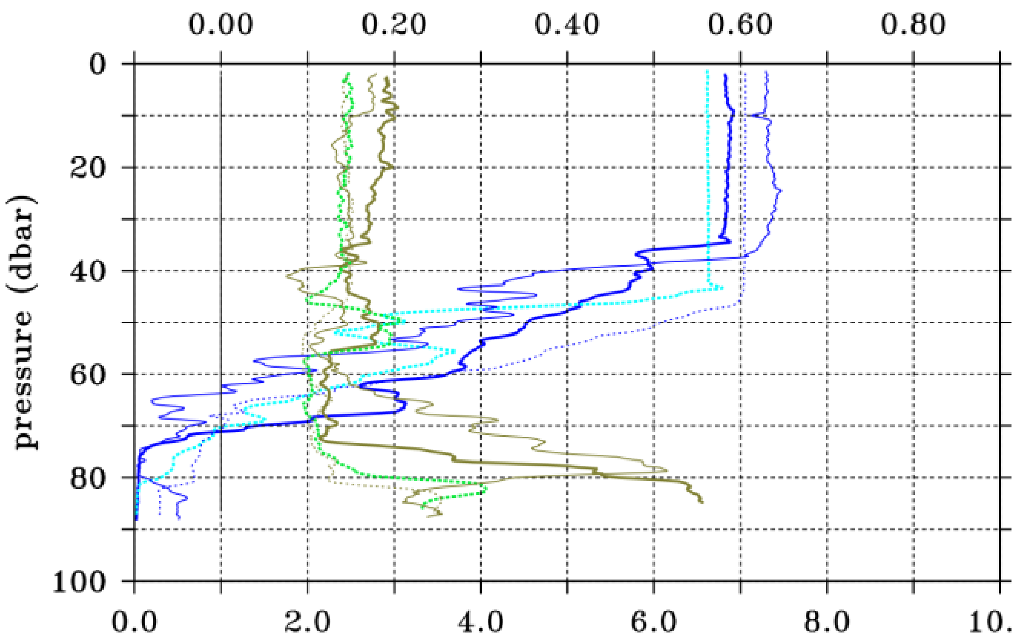




**Fig. 5.8** Upper Figure: temperature and salinity profiles at **TF0213** in the Bornholm Basin for stagnant conditions (2013, thick dotted lines), conditions after the major Baltic inflow (2015, thin dotted line) and during reestablishing anoxic conditions (2018, thin line). (2019 thick line). Brown and red denote practical salinity, (lower scale), grey and green denote temperature (upper scale). Lower Figure: Dissolved oxygen and turbidity profiles at **TF0213** in the Bornholm Basin for stagnant conditions (2013, thick dotted lines), conditions after the major Baltic inflow (2015, thin dotted line) and during reestablishing anoxic conditions (2018, thin line). (2019 thick line). Cyan and blue denote oxygen concentration (lower scale), green and brown denote turbidity (upper scale).

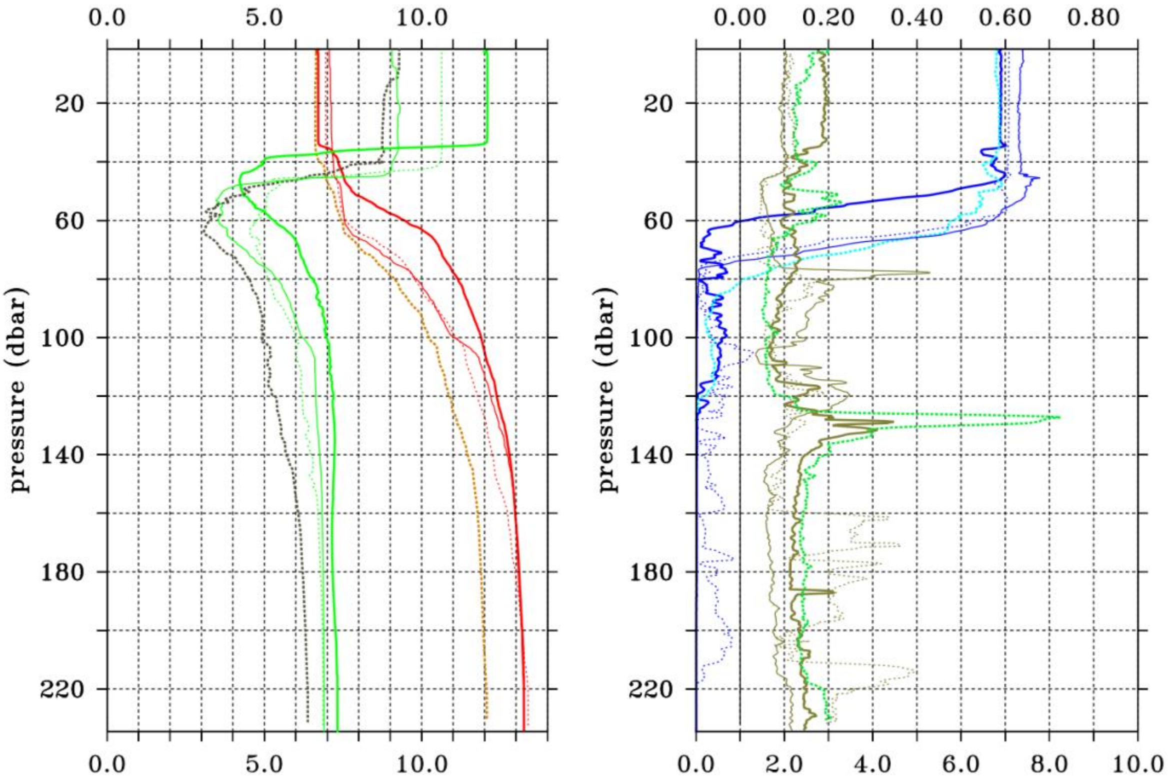



**Fig. 5.9** Left Figure: temperature and salinity profiles at **TF0271** in the Gotland Basin for stagnant conditions (2013, thick dotted lines), conditions after the major Baltic inflow (2015, thin dotted line) and during reestablishing anoxic conditions (2018, thin line). (2019 thick line). Brown and red denote practical salinity, (lower scale), grey and green denote temperature (upper scale). Right Figure: Dissolved oxygen and turbidity profiles at **TF0271** in the Gotland Basin for stagnant conditions (2013, thick dotted lines), conditions after the major Baltic inflow (2015, thin dotted line) and during reestablishing anoxic conditions (2018, thin line). (2019 thick line). Cyan and blue denote oxygen concentration (lower scale), green and brown denote turbidity (upper scale).

post-inflow conditions is that the winter water and the water body below is significantly warmer now. The center of the winter water is uplifted by about 15 m in the Gotland Basin and the winter water is about 1 deg warmer than before. Also the upper bound of the oxygen depleted layer is shifted upwards by about 20m, the redoxcline itself has reestablished at the same depth of about 130m depth. This is a remarkable loss of habitat for organisms depending on oxygenated waters. It may be speculated that this happened from the minor inflow seen in Fig. xxx for January 2019. Especially the salinity in the layer between 60m and 120m is enhanced compared with the situation in November 2018. During the Nov. 2018 cruise, this layer was sulphidic but is slightly oxic in October 2019. The turbidity maximum was at 80m depth before and is now found at 130m depth. Hence, the last warm inflow event has elevated the general oxygen content below the winter water layer, but due to the general uplift of the oxygen depleted layers the habitable zone in the central Gotland Basin is currently compressed.

## 5.7 Long term development in the Gotland Basin bottom water

The major Baltic inflow from December 2014 and the following minor inflow events up to 2018

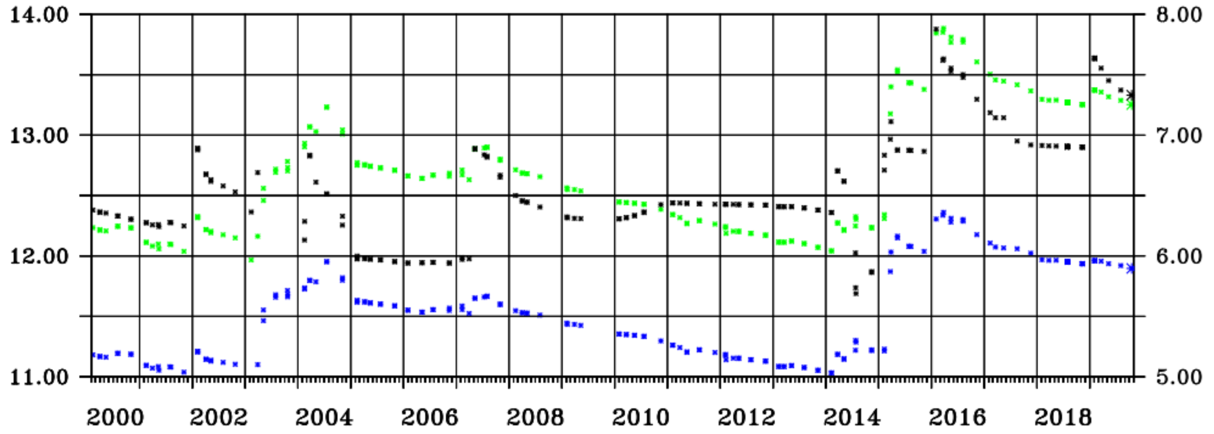



**Fig. 5.10** Time series of temperature (black, right axes) and practical salinity (green, left axes ) in the deep water of station **TF0271** in the Gotland Basin. The rightmost points are related to the cruise EMB-224. The blue dots mark in-situ density in kg $m^{-3}$ (subtracted 1000.5 kg $m^{-3}$ to fit to the left axes).

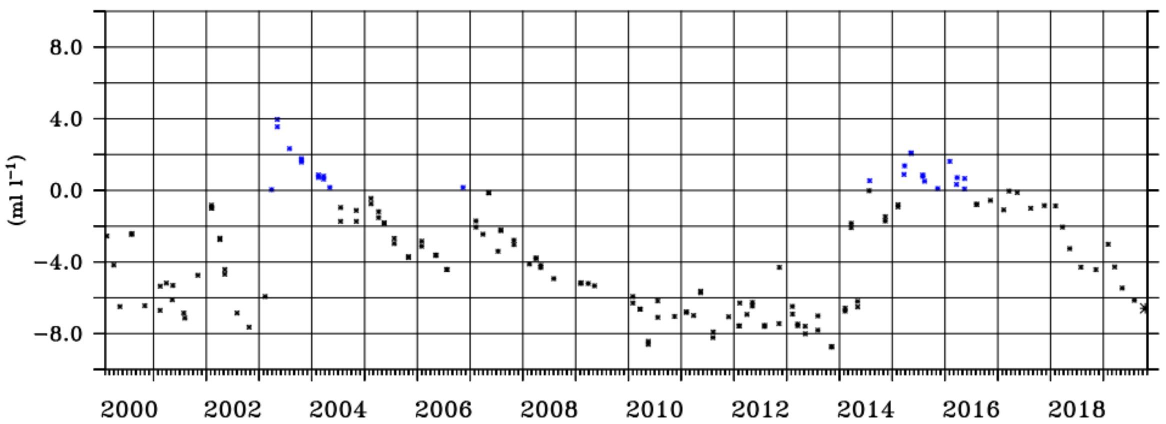



**Fig. 5.11** Time series of oxygen concentration (blue) and hydrogen sulphide concentration (black, negative oxygen equivalent) in the deep water of station **TF0271** in the Gotland Basin. The rightmost points are related to the cruise EMB-224.

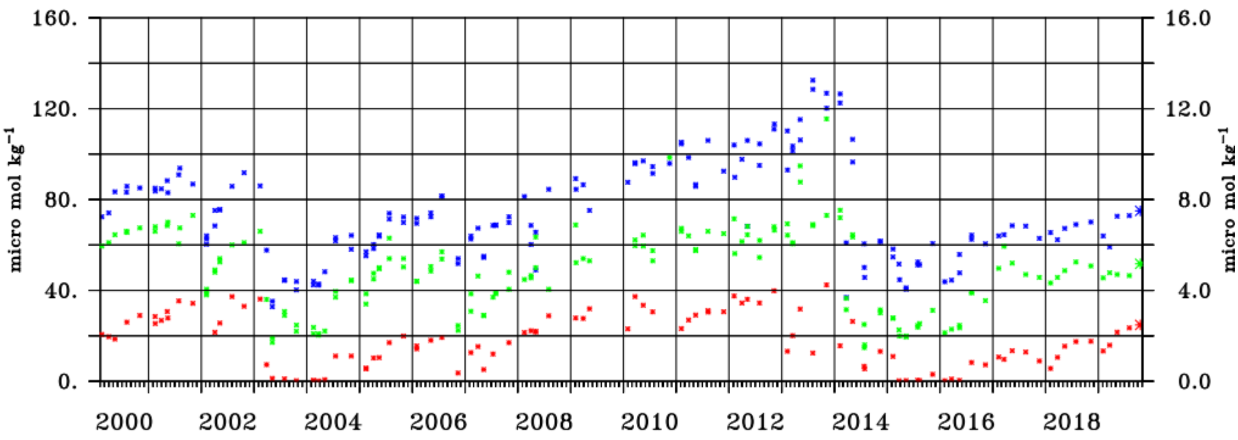



**Fig. 5.12** Time series of macronutrient in the deep water of station **TF0271** in the Gotland Basin. The rightmost points are related to the cruise EMB-224. Blue and left axes: silicate concentration, red and left axes: ammonium concentration, green and right axes: phosphate concentration.

rised the salinity in the bottom layer in the central Baltic Proper rapidly to a maximum of 13.84 at the Gotland Deep in February 2016. Afterwards, a decrease had started in the eastern Gotland Basin interrupted by a slight increase April 2017 and January 2019. The in-situ temperature shows a similar behavior, after a significant cooling from the major inflow and a step-wise warming from minor inflows, temperature relaxes towards some steady state. The last minor inflow happened in December 2018. Oxygen (negative hydrogen sulphide) concentration is almost on the same level than it was before the inflow. The nutrient pool in the Gotland Basin is continuously filling. As such, the current status of the Gotland Basin bottom water is differently than ever during the last two decades. The density is still elevated compared to pre-inflow conditions comparable to values after the inflow 2004. Replacement of this bottom water would require high density water. On the other hand hydrogen sulphide concentration is already elevated to typical pre-inflow conditions. This makes warm inflows into intermediate depth more likely, which in turn may sustain the uplift of the winter water layer and the compression of the ventilated layers in the Gotland Basin.

## 5.7 Uranium isotops in the surface water and the sediment

The concentration of uranium isotopes (U-238, U-236 and U-233) in sea water and sediment was determined successfully. First results for surface water uranium concentrations in relation to salinity allow improvement of the mixing line as baseline to determine uranium depletion in anoxic and sulphidic deep waters. Further analysis especially of sources and distribution of uranium isotopes in the Baltic Sea from the ratio of U-236/U-238 and U-233/U-236 will be done at DTU.

# 6 Tables and Station lists EMB224

## 6.1 Hydrographic conditions for surface and bottom waters at key stations

**Table 6.1** Surface water layer (about 3 m depth) - hydrographic and hydrochemical properties

| Area /Date | Station Name/No. | Temp. °C | Prac. Sal. | $O_2$ ml/l | $NH_4$ µM | $PO_4$ µM | $NO_{2+3}$ µM | $SiO_4$ µM |
|---|---|---|---|---|---|---|---|---|
| Kiel Bight /2019-10-12 | TF0360/07 | 12.91 | 18.84 | 6.34 | 0.15 | 0.39 | 0.13 | 6.5 |
| Meckl.Bight /2019-10-11 | TF0012/03 | 13.06 | 15.05 | 6.55 | 0.27 | 0.25 | 0.02 | 9.2 |
| Darss Sill /2019-10-13 | TF0030/17 | 13.08 | 9.74 | 6.80 | n.m. | 0.11 | 0.02 | 8.3 |
| Arkona Basin /2019-10-13 | TF0113/18 | 12.37 | 8.11 | 6.87 | 0.13 | 0.26 | 0.21 | 10.4 |
| Bornholm Deep /2019-10-16 | TF0213/40 | 12.70 | 7.64 | 6.86 | 0.11 | 0.26 | 0.15 | 11.3 |
| Stolpe Channel /2019-10-16 | TF0222/45 | 12.99 | 7.62 | 6.94 | 0.23 | 0.29 | 0.29 | 11.4 |
| SE Gotland Basin /2019.10.16 | TF0259/51 | 12.84 | 7.41 | 6.82 | 0.23 | 0.17 | 0.11 | 12.3 |
| Gotland Deep /2019-10-17 | TF0271/65 | 12.09 | 6.71 | 6.96 | 0.4 | 0.06 | 0.04 | 9.4 |
| Farö Deep /2019-10-19 | TF0286/77 | 10.90 | 6.51 | 7.21 | 0.14 | 0.14 | 0.12 | 13.8 |
| Landsort Deep /2019-10-20 | TF0284/80 | 10.38 | 5.99 | 7.34 | 0.18 | 0.18 | 0.18 | 16.3 |
| Karlsö Deep /2019-10-20 | TF0245/82 | 10.55 | 6.54 | 7.34 | 0.14 | 0.13 | 0.05 | 15.0 |

**Table 6.2** Deep water layer (bottom near depths) - hydrographic and hydrochemical properties

| Area /Date | Station Name /No.* | Temp. °C | Prac. Sal. | $O_2/2H_2S$ ml/l | $NH_4$ µM | $PO_4$ µM | $NO_{2+3}$ µM | $SiO_4$ µM |
|---|---|---|---|---|---|---|---|---|
| Kiel Bight /2019-10-12 | TF0360/07 | 13.22 | 19.80 | 6.08 | 0.21 | 0.55 | 0.05 | 8.9 |
| Meckl.Bight /2019-10-13 | TF0012/03 | 14.04 | 24.14 | 0.88 | 8.35 | 2.51 | 4.06 | 56.5 |
| Darss Sill /2019-10-13 | TF0030/17 | 13.68 | 15.4 | 5.24 | n.m. | 0.33 | 0.30 | 11.3 |
| Arkona Basin /2019-10-13 | TF0113/18 | 14.89 | 18.94 | 2.78 | 3.08 | 1.35 | 5.86 | 32.6 |
| Bornholm Deep /2019-10-16 | TF0213/40 | 8.58 | 16.68 | -0.63 | 9.63 | 8.73 | 0.02 | 85.0 |
| Stolpe Channel /2019-10-16 | TF0222/45 | 8.45 | 14.97 | 0.98 | 0.15 | 3.8 | 6.93 | 56.6 |
| SE Gotland Basin /03.02.16 | TF0259/51 | 6.84 | 11.68 | 0.39 | 3.79 | 2.8 | 1.85 | 49.0 |
| Gotland Deep /2019-10-17 | TF0271/65 | 7.33 | 13.25 | -6,59 | 24.8 | 5.17 | 0,0 | 75.0 |
| Farö Deep /2019-10-19 | TF0286/77 | 7.19 | 12.61 | -4.29 | 16.7 | 4.4 | 0,00 | 68.2 |
| Landsort Deep /2019-10-20 | TF0284/80 | 6.55 | 11.41 | -2.13 | 8.63 | 3.63 | 0,00 | 57.1 |
| Karlsö Deep /2019-10-20 | TF0245/82 | 5.73 | 10.54 | -3.66 | 14.71 | 3.75 | 0,00 | 64.0 |

* hydrogen sulphide was converted into negative oxygen equivalents

## 6.2 Station List – CTD measurements

| Number | Name | Begin | Date | Latitude | Longitude | Depth |
|---|---|---|---|---|---|---|
| 0001 | TFO5 | 07:31:30 | 11-OKT-19 | 54 13.8533N | 12 04.5351E | 12.73 |
| 0002 | TF0018 | 09:03:40 | 11-OKT-19 | 54 11.0181N | 11 46.0774E | 20.00 |
| 0003 | TF0012 | 11:36:58 | 11-OKT-19 | 54 18.9071N | 11 33.0508E | 24.18 |
| 0004 | TF0022 | 14:35:53 | 11-OKT-19 | 54 06.6380N | 11 10.5638E | 23.39 |
| 0005 | TF0011 | 17:08:09 | 11-OKT-19 | 54 24.8185N | 11 37.1329E | 24.45 |
| 0006 | TF0361 | 22:34:44 | 11-OKT-19 | 54 39.4903N | 10 46.0612E | 43.64 |
| 0007 | TF0360 | 04:42:55 | 12-OKT-19 | 54 36.0044N | 10 27.0351E | 18.01 |
| 0008 | TF0010 | 09:15:13 | 12-OKT-19 | 54 33.0670N | 11 19.2709E | 28.10 |
| 0009 | TF0041 | 13:15:41 | 12-OKT-19 | 54 24.4314N | 12 03.7020E | 19.43 |
| 0010 | TF0040 | 14:09:47 | 12-OKT-19 | 54 29.3091N | 12 03.9311E | 12.57 |
| 0011 | TF0046 | 15:12:13 | 12-OKT-19 | 54 28.2011N | 12 14.5437E | 28.82 |
| 0012 | TF0002 | 17:07:52 | 12-OKT-19 | 54 38.9814N | 12 26.9531E | 18.10 |
| 0013 | TF0001 | 18:20:16 | 12-OKT-19 | 54 41.7880N | 12 42.0804E | 21.20 |
| 0014 | TF0069 | 21:21:57 | 12-OKT-19 | 55 00.0014N | 13 18.0761E | 46.22 |
| 0015 | TF0114 | 22:51:35 | 12-OKT-19 | 54 51.6131N | 13 16.5918E | 44.77 |
| 0016 | TF0115 | 00:10:02 | 13-OKT-19 | 54 47.6955N | 13 03.4871E | 29.54 |
| 0017 | TF0030 | 04:45:57 | 13-OKT-19 | 54 43.3932N | 12 47.0429E | 23.06 |
| 0018 | TF0113 | 08:48:56 | 13-OKT-19 | 54 55.5091N | 13 30.0031E | 47.20 |
| 0019 | TF0105 | 10:52:22 | 13-OKT-19 | 55 01.5047N | 13 36.3910E | 46.48 |
| 0020 | TF0104 | 11:58:00 | 13-OKT-19 | 55 04.1033N | 13 48.7794E | 46.14 |
| 0021 | TF0109 | 15:58:15 | 13-OKT-19 | 55 00.0118N | 14 04.9975E | 48.49 |
| 0022 | TF0103 | 17:32:37 | 13-OKT-19 | 55 03.8139N | 13 59.2713E | 47.15 |
| 0023 | TF0102 | 18:26:28 | 13-OKT-19 | 55 09.3047N | 13 56.4520E | 45.47 |
| 0024 | TF0145 | 19:46:32 | 13-OKT-19 | 55 10.0167N | 14 14.8964E | 47.55 |
| 0025 | TF0144 | 21:08:09 | 13-OKT-19 | 55 15.3911N | 14 29.5255E | 45.13 |
| 0026 | TF0140 | 22:54:32 | 13-OKT-19 | 55 28.0144N | 14 43.0316E | 69.48 |
| 0027 | TF0142 | 01:30:12 | 14-OKT-19 | 55 24.2972N | 14 32.2315E | 60.68 |
| 0028 | TF0111 | 07:21:59 | 14-OKT-19 | 54 53.4117N | 13 58.2125E | 44.72 |
| 0029 | ABBoje | 08:29:51 | 14-OKT-19 | 54 52.8164N | 13 51.6236E | 46.62 |
| 0030 | TF0112 | 09:35:34 | 14-OKT-19 | 54 48.1924N | 13 57.6792E | 40.82 |
| 0031 | TF0121 | 10:37:53 | 14-OKT-19 | 54 42.5911N | 13 56.8320E | 30.15 |
| 0032 | TF0150 | 11:36:37 | 14-OKT-19 | 54 36.6890N | 14 02.6156E | 22.01 |
| 0033 | TF0152 | 12:41:47 | 14-OKT-19 | 54 37.9838N | 14 17.0292E | 30.78 |
| 0034 | TF0160 | 15:55:10 | 14-OKT-19 | 54 14.3915N | 14 04.1203E | 14.57 |
| 0035 | TF0205 | 17:25:21 | 15-OKT-19 | 55 23.4119N | 15 03.3383E | 75.65 |
| 0036 | TF0200 | 18:49:31 | 15-OKT-19 | 55 23.0094N | 15 19.9702E | 91.90 |
| 0037 | TF0211 | 20:19:52 | 15-OKT-19 | 55 19.8073N | 15 36.8950E | 95.86 |
| 0038 | TF0214 | 21:48:24 | 15-OKT-19 | 55 09.6675N | 15 39.5699E | 94.09 |
| 0039 | TF0212 | 23:15:25 | 15-OKT-19 | 55 18.1046N | 15 47.7669E | 95.75 |
| 0040 | TF0213 | 00:26:44 | 16-OKT-19 | 55 15.0043N | 15 58.9936E | 90.27 |
| 0041 | TF0221 | 04:38:09 | 16-OKT-19 | 55 13.2851N | 16 09.9850E | 83.38 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0042 | TF0225 | 05:56:44 | 16-OKT-19 | 55 15.4836N | 16 19.2652E | 66.47 |
| 0043 | TF0224 | 06:56:59 | 16-OKT-19 | 55 16.9744N | 16 30.0461E | 62.13 |
| 0044 | TF0228 | 08:28:48 | 16-OKT-19 | 55 14.2810N | 16 46.3613E | 77.83 |
| 0045 | TF0222 | 09:55:59 | 16-OKT-19 | 55 12.9961N | 17 03.9965E | 90.98 |
| 0046 | TF0266 | 11:55:03 | 16-OKT-19 | 55 15.1322N | 17 21.5945E | 89.57 |
| 0047 | TF0267 | 13:09:58 | 16-OKT-19 | 55 17.1309N | 17 35.6600E | 84.68 |
| 0048 | TF0268 | 14:43:07 | 16-OKT-19 | 55 18.4573N | 17 55.8263E | 74.57 |
| 0049 | TF0256 | 16:09:37 | 16-OKT-19 | 55 19.6077N | 18 14.1210E | 76.64 |
| 0050 | TF0257 | 17:40:46 | 16-OKT-19 | 55 26.4771N | 18 19.2595E | 87.63 |
| 0051 | TF0259 | 18:50:53 | 16-OKT-19 | 55 33.0347N | 18 24.0371E | 89.98 |
| 0052 | TF0255 | 22:10:02 | 16-OKT-19 | 55 37.9978N | 18 36.0386E | 95.22 |
| 0053 | TF0258 | 23:17:13 | 16-OKT-19 | 55 43.6203N | 18 45.9558E | 90.62 |
| 0054 | TF0253 | 00:28:35 | 17-OKT-19 | 55 50.3474N | 18 52.0198E | 99.80 |
| 0055 | TF0265 | 01:55:20 | 17-OKT-19 | 55 57.5572N | 19 02.9653E | 110.30 |
| 0056 | TF0250 | 03:09:11 | 17-OKT-19 | 56 05.0000N | 19 10.0883E | 123.44 |
| 0057 | TF0262 | 05:06:07 | 17-OKT-19 | 56 14.0447N | 19 18.1237E | 131.09 |
| 0058 | TF0263 | 06:21:13 | 17-OKT-19 | 56 20.7854N | 19 22.7024E | 133.54 |
| 0059 | TF0261 | 07:59:04 | 17-OKT-19 | 56 29.4943N | 19 28.8632E | 142.36 |
| 0060 | TF0260 | 09:39:26 | 17-OKT-19 | 56 37.9912N | 19 34.9094E | 142.98 |
| 0061 | TF0274 | 11:09:30 | 17-OKT-19 | 56 46.0230N | 19 45.1362E | 152.99 |
| 0062 | TF0273 | 12:47:55 | 17-OKT-19 | 56 57.0737N | 19 46.1660E | 181.71 |
| 0063 | TF0272 | 15:13:16 | 17-OKT-19 | 57 04.2706N | 19 49.8051E | 205.43 |
| 0064 | TF0275 | 16:36:09 | 17-OKT-19 | 57 12.5938N | 19 55.8143E | 226.80 |
| 0065 | TF0271 | 17:58:21 | 17-OKT-19 | 57 19.2178N | 20 03.0601E | 237.28 |
| 0066 | TF0404 | 16:15:59 | 18-OKT-19 | 57 01.7321N | 19 13.2626E | 160.94 |
| 0067 | TF0405 | 17:33:18 | 18-OKT-19 | 57 00.5106N | 19 21.3295E | 173.86 |
| 0068 | TF0406 | 18:42:45 | 18-OKT-19 | 56 58.8499N | 19 34.5814E | 165.92 |
| 0069 | TF0407 | 20:13:40 | 18-OKT-19 | 56 57.0579N | 19 52.8464E | 176.09 |
| 0070 | TF0408 | 21:10:09 | 18-OKT-19 | 56 55.4320N | 20 01.0648E | 164.17 |
| 0071 | TF0409 | 22:20:15 | 18-OKT-19 | 56 54.3302N | 20 13.0082E | 143.88 |
| 0072 | TF0410 | 23:35:19 | 18-OKT-19 | 56 52.0153N | 20 27.3170E | 61.02 |
| 0073 | TF0411 | 00:36:57 | 19-OKT-19 | 56 50.3408N | 20 40.9127E | 56.42 |
| 0074 | TF0271 | 05:53:36 | 19-OKT-19 | 57 19.2365N | 20 08.0299E | 242.61 |
| 0075 | TF0276 | 10:04:32 | 19-OKT-19 | 57 28.2008N | 20 15.6234E | 206.82 |
| 0076 | TF0270 | 11:47:57 | 19-OKT-19 | 57 36.9983N | 20 10.0274E | 142.95 |
| 0077 | TF0286 | 14:30:06 | 19-OKT-19 | 58 00.0140N | 19 54.0446E | 193.65 |
| 0078 | TF0285 | 19:20:05 | 19-OKT-19 | 58 26.5202N | 20 20.0780E | 123.21 |
| 0079 | TF0282 | 22:28:34 | 19-OKT-19 | 58 52.9661N | 20 19.0049E | 163.81 |
| 0080 | TF0284 | 07:59:07 | 20-OKT-19 | 58 34.9877N | 18 14.0159E | 440.29 |
| 0081 | TF0240 | 15:34:13 | 20-OKT-19 | 58 00.0100N | 18 00.0398E | 165.12 |
| 0082 | TF0245 | 22:21:31 | 20-OKT-19 | 57 06.9796N | 17 39.9952E | 109.96 |
| 0083 | GB_SW | 02:09:09 | 21-OKT-19 | 56 37.4437N | 17 07.7963E | 78.17 |
| 0084 | TF0213 | 10:50:13 | 21-OKT-19 | 55 15.0611N | 15 58.9990E | 89.03 |
| 0085 | TF0154 | 18:20:16 | 21-OKT-19 | 54 37.4353N | 14 46.0864E | 47.76 |
| 0086 | TF0113 | 00:21:44 | 22-OKT-19 | 54 55.4984N | 13 30.0368E | 47.18 |
| 0087 | TF0030 | 04:15:38 | 22-OKT-19 | 54 43.4293N | 12 47.0963E | 23.01 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 0088 | TF0046 | 07:14:32 | 22-OKT-19 | 54 28.1800N | 12 14.4780E | 28.17 |
| 0089 | TF0012 | 10:46:36 | 22-OKT-19 | 54 18.8974N | 11 33.0583E | 24.66 |

### 6.2 Station List – Radionuclide samples

| Number | Name | Begin | Date | Latitude | Longitude | method |
|---|---|---|---|---|---|---|
| 0021 | TF0109 | 15:58:15 | 13-OKT-19 | 55 00.0118N | 14 04.9975E | W |
| 0026 | TF0140 | 22:54:32 | 13-OKT-19 | 55 28.0144N | 14 43.0316E | W, MUC |
| 0040 | TF0213 | 00:26:44 | 16-OKT-19 | 55 15.0043N | 15 58.9936E | W, MUC |
| 0045 | TF0222 | 09:55:59 | 16-OKT-19 | 55 12.9961N | 17 03.9965E | W |
| 0051 | TF0259 | 18:50:53 | 16-OKT-19 | 55 33.0347N | 18 24.0371E | W, MUC |
| 0056 | TF0250 | 03:09:11 | 17-OKT-19 | 56 05.0000N | 19 10.0883E | W |
| 0062 | TF0273 | 12:47:55 | 17-OKT-19 | 56 57.0737N | 19 46.1660E | W |
| 0063 | TF0272 | 15:13:16 | 17-OKT-19 | 57 04.2706N | 19 49.8051E | W |
| 0064 | TF0275 | 16:36:09 | 17-OKT-19 | 57 12.5938N | 19 55.8143E | W |
| 0065 | TF0271 | 17:58:21 | 17-OKT-19 | 57 19.2178N | 20 03.0601E | W, MUC |
| 0077 | TF0286 | 14:30:06 | 19-OKT-19 | 58 00.0140N | 19 54.0446E | W |
| 0079 | TF0282 | 22:28:34 | 19-OKT-19 | 58 52.9661N | 20 19.0049E | W, MUC |
| 0080 | TF0284 | 07:59:07 | 20-OKT-19 | 58 34.9877N | 18 14.0159E | W |
| 0081 | TF0240 | 15:34:13 | 20-OKT-19 | 58 00.0100N | 18 00.0398E | W |
| 0083 | GB_SW | 02:09:09 | 21-OKT-19 | 56 37.4437N | 17 07.7963E | W |
| 0085 | TF0154 | 18:20:16 | 21-OKT-19 | 54 37.4353N | 14 46.0864E | W, MUC |
| 0086 | TF0113 | 00:21:44 | 22-OKT-19 | 54 55.4984N | 13 30.0368E | W, MUC |

### 6.3 Station List – Plankton Sampling

| Number | Name (IOW) | Begin | Date | Latitude | Longitude | Depth [dB] |
|---|---|---|---|---|---|---|
| 0007 | TF0360 | 04:42:55 | 12-OKT-19 | 54 36.0044N | 10 27.0351E | 18.47 |
| 0008 | TF0010 | 09:15:13 | 12-OKT-19 | 54 33.0670N | 11 19.2709E | 28.61 |
| 0011 | TF0046 | 15:12:13 | 12-OKT-19 | 54 28.2011N | 12 14.5437E | 28.35 |
| 0017 | TF0030 | 04:45:57 | 13-OKT-19 | 54 43.3932N | 12 47.0429E | 23.17 |
| 0021 | TF0109 | 15:58:15 | 13-OKT-19 | 55 00.0118N | 14 04.9975E | 48.05 |
| 0018 | TF0113 | 08:48:56 | 13-OKT-19 | 54 55.5091N | 13 30.0031E | 47.13 |
| 0040 | TF0213 | 00:26:44 | 16-OKT-19 | 55 15.0043N | 15 58.9936E | 89.87 |
| 0074 | TF0271 | 17:58:21 | 17-OKT-19 | 57 19.2178N | 20 03.0601E | 237.63 |
| 0084 | TF0213 | 10:50:13 | 21-OKT-19 | 55 15.0611N | 15 58.9990E | 89.03 |
| 0086 | TF0113 | 00:21:44 | 22-OKT-19 | 54 55.4984N | 13 30.0368E | 47.18 |
| 0087 | TF0030 | 04:15:38 | 22-OKT-19 | 54 43.4293N | 12 47.0963E | 22.51 |
| 0088 | TF0046 | 07:14:32 | 22-OKT-19 | 54 28.1800N | 12 14.4780E | 28.58 |

## 6.4 Station List – Benthos Sampling

Devices: van Veen Grab, dredge

| Number EMB-251- | Name (IOW) | Begin | Date | Latitude | Longitude | Depth [dB] |
|---|---|---|---|---|---|---|
| 0002 | TF0018 | 09:03:40 | 11-OKT-19 | 54 11.0181N | 11 46.0774E | 20.71 |
| 0003 | TF0012 | 11:36:58 | 11-OKT-19 | 54 18.9071N | 11 33.0508E | 25.03 |
| 0007 | TF0360 | 07:30:00 | 12-OKT-19 | 54 36.0044N | 10 27.0351E | 18.47 |
| 0008 | TF0010 | 07:30:00 | 12-OKT-19 | 54 36.0044N | 10 27.0351E | 28.61 |
| 0017 | TF0030 | 07:30:00 | 13-OKT-19 | 54 43.3932N | 12 47.0429E | 23.17 |
| 0021 | TF0109 | 15:58:15 | 13-OKT-19 | 55 00.0118N | 14 04.9975E | 48.05 |
| 0033 | TF0152 | 12:41:47 | 14-OKT-19 | 54 37.9838N | 14 17.0292E | 31.31 |
| 0034 | TF0160 | 15:55:10 | 14-OKT-19 | 54 14.3915N | 14 04.1203E | 14.72 |
| 0087 | TF0030 | 07:00:00 | 22-OKT-19 | 54 43.4293N | 12 47.0963E | 22.51 |

## 6.3 Water sample inventory – quantities and number of samples

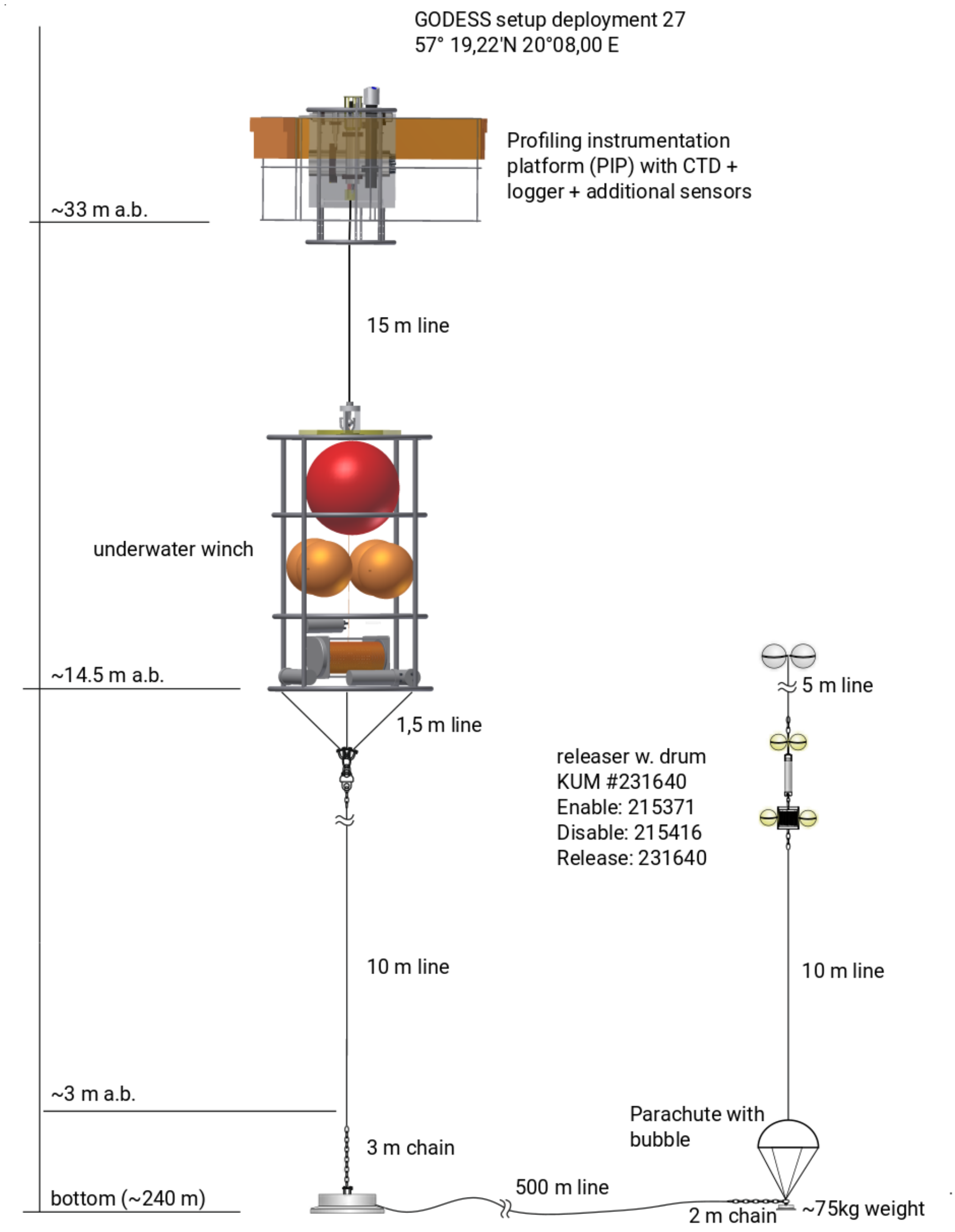
| Stationsnr. | Stationsbez. | CTD profile | Sauerstoff | PO4 | ** NO3 | ** NO2 | ** SIO4 | NH4 | P-Total | ** N-Gesamt | ** POM+DOM | Phyto-Netz | Chlorophyll | Phytoplankton | H2S-Best. | Sichttiefe (m) | DNA-Filter | CH4 | CO2 | Metalle | Radionuclide | Sediment | Fish-Filter | Zooplankton | P+G, Betain | SECCHI (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | TFO5 | x | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | | | | | 6,0 | | | | | | | | | | 6,0 |
| 2 | TF0018 | x | 2 | 2 | 2 | 2 | 2 | - | | - | - | | | | | | | | | | | | | | | |
| 3 | TF0012 | x | 2 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 1 | 6 | 2 | | 6,0 | | | | | | | | 1 | | 6,0 |
| 4 | TF0022 | x | 2 | 4 | 4 | 4 | 4 | - | | - | - | | | | | | | | | | | | | | | |
| 5 | TF0011 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 6 | TF0361 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 7 | TF0360 | x | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 5 | 3 | | 4,0 | | | | | | | | 1 | | 4,0 |
| 8 | TF0010 | x | 1 | 3 | 3 | 3 | 3 | - | | - | - | | | | | | | | | | | | | | | |
| 9 | TF0041 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 10 | TF0040 | x | 1 | 4 | 4 | 4 | 4 | - | | - | - | 1 | 5 | 2 | | 5,0 | | | | | | | | 1 | | 5,0 |
| 11 | TF0046 | x | 1 | 4 | 4 | 4 | 4 | - | | - | - | 1 | 5 | 2 | | 5,0 | | | | | | | | 1 | | 5,0 |
| 12 | TF0002 | x | 3 | 3 | 3 | 3 | 3 | - | | - | - | | | | | | | | | | | | | | | |
| 13 | TF0001 | x | 3 | 3 | 3 | 3 | 3 | - | | - | - | | | | | | | | | | | | | | | |
| 14 | TF0069 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 15 | TF0114 | x | 1 | 5 | 5 | 5 | 5 | - | | - | - | | | | | | | | | | | | | | | |
| 16 | TF0115 | x | 4 | 4 | 4 | 4 | 4 | - | | - | - | | | | | | | | | | | | | | | |
| 17 | TF0030 | x | 1 | 4 | 4 | 4 | 4 | - | | - | - | 1 | 6 | 2 | | | | | | | | | | | | 6,0 |
| 18 | TF0113 | x | 7 | 7 | 7 | 7 | 7 | 7 | 4 | 4 | 4 | 2 | 5 | 2 | | 6,0 | | 7 | 7 | | | | | 2 | | 6,0 |
| 19 | TF0105 | x | 1 | 5 | 5 | 5 | 5 | - | | - | - | | | | | | | | | | | | | | | |
| 20 | TF0104 | x | 1 | 5 | 5 | 5 | 5 | - | | - | - | | | | | | | | | | | | | | | |
| 21 | TF0109 | x | 1 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4 | 1 | 6 | 2 | | 4,0 | | | | | 4 | | | 2 | | 4,0 |
| 22 | TF0103 | x | 1 | 5 | 5 | 5 | 5 | - | | - | - | | | | | | | | | | | | | | | |
| 23 | TF0102 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 24 | TF0145 | x | 1 | 5 | 5 | 5 | 5 | - | | - | - | | | | | | | | | | | | | | | |
| 25 | TF0144 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 26 | TF0140 | x | 1 | 6 | 6 | 6 | 6 | - | | - | - | | | | | | | | | 6 | 4 | 1 | | | | |
| 27 | TF0142 | x | 1 | 5 | 5 | 5 | 5 | - | | - | - | | | | | | | | | | | | | | | |
| 28 | TF0111 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 29 | ABBoje | x | 2 | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 30 | TF0112 | x | 1 | 4 | 4 | 4 | 4 | - | | - | - | | | | | | | | | | | | | | | |
| 31 | TF0121 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 32 | TF0150 | x | 1 | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 33 | TF0152 | x | 4 | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 34 | TF0160 | x | 3 | 3 | 3 | 3 | 3 | - | | - | - | | | | | | | | | | | | | | | |
| 35 | TF0205 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 36 | TF0200 | x | 2 | 7 | 7 | 7 | 7 | - | | - | - | | | | | | | | | | | | | | | |
| 37 | TF0211 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 38 | TF0214 | x | 1 | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 | TF0212 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 40 | TF0213 | x | 8 | 10 | 10 | 10 | 10 | 10 | 6 | 6 | 6 | 1 | 5 | 10 | 2 | 6,0 | | 10 | 10 | 9 | 6 | 1 | | 8 | | |
| 41 | TF0221 | x | | | | | | - | | - | - | | | | | | | | | | | | | | | |
| 42 | TF0225 | x | | | | | | | | | | | | | | | | | | | | | | | | |
| 43 | TF0224 | x | | | | | | - | | - | - | | | | | | | | | | | | | | | |
| 44 | TF0228 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 45 | TF0222 | x | 2 | 7 | 7 | 7 | 7 | 7 | | - | - | | | | | | | | | | 5 | | | | | |
| 46 | TF0266 | x | | 2 | 2 | 2 | 2 | - | | - | - | | | | | | | | | | | | | | | |
| 47 | TF0267 | x | 2 | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 48 | TF0268 | x | | 2 | 2 | 2 | 2 | - | | - | - | | | | | | | | | | | | | | | |
| 49 | TF0256 | x | | 2 | 2 | 2 | 2 | - | | - | - | | | | | | | | | | | | | | | |
| 50 | TF0257 | x | | 2 | 2 | 2 | 2 | - | | - | - | | | | | | | | | | | | | | | |
| 51 | TF0259 | x | 6 | 7 | 7 | 7 | 7 | 7 | | - | - | 1 | 6 | 2 | 2 | | | | | 4 | 6 | 1 | | | | |
| 52 | TF0255 | x | | 2 | 2 | 2 | 2 | - | | - | - | | | | | | | | | | | | | | | |
| 53 | TF0258 | x | | 2 | 2 | 2 | 2 | - | | - | - | | | | | | | | | | | | | | | |
| 54 | TF0253 | x | | 2 | 2 | 2 | 2 | - | | - | - | | | | | | | | | | | | | | | |
| 55 | TF0265 | x | | 2 | 2 | 2 | 2 | - | | - | - | | | | | | | | | | | | | | | |
| 56 | TF0250 | x | | 2 | 2 | 2 | 2 | - | | - | - | | | | | | | | | | 6 | | | | | |
| 57 | TF0262 | x | | 2 | 2 | 2 | 2 | - | | - | - | | | | 1 | | | | | | | | | | | |
| 58 | TF0263 | x | | 4 | 4 | 4 | 4 | - | | - | - | | | | 1 | | | | | | | | | | | |
| 59 | TF0261 | x | | 4 | 4 | 4 | 4 | - | | - | - | | | | 2 | | | | | | | | | | | |
| 60 | TF0260 | x | 6 | 9 | 9 | 9 | 9 | 9 | | - | - | | | | 2 | | | | | | | | | | | |
| 61 | TF0274 | x | | | - | - | - | - | | - | - | | | | 2 | | | | | | | | | | | |
| 62 | TF0273 | x | | | - | - | - | - | | - | - | | | | | | | | | | 6 | | | | | |
| 63 | TF0272 | x | 1 | | - | - | - | - | | - | - | | | | 3 | | | | | | 2 | | | | | |
| 64 | TF0275 | x | | | - | - | - | - | | - | - | | | | | | | | | | 6 | | | | | |
| 65 | TF0271 | x | 16 | 21 | 21 | 21 | 21 | 21 | 12 | 12 | 12 | 2 | 5 | 2 | 17 | 5,5 | 52 | 24 | 21 | 17 | 1 | | 26 | | 52 | 6,0 |
| 66 | TF0404 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 67 | TF0405 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 68 | TF0406 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 69 | TF0407 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 70 | TF0408 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 71 | TF0409 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 72 | TF0410 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 73 | TF0411 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 74 | TF0271 | x | | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 75 | TF0276 | x | | | - | - | - | - | | - | - | | | | 4 | | | | | | | | | | | |
| 76 | TF0270 | x | 1 | | - | - | - | - | | - | - | | | | 1 | | | | | | | | | | | |
| 77 | TF0286 | x | 8 | 16 | 16 | 16 | 16 | 16 | 6 | 6 | 6 | | | | 8 | 5,5 | | 16 | 16 | | 10 | | | | | |
| 78 | TF0285 | x | 1 | | - | - | - | - | | - | - | | | | 3 | | | | | | | | | | | |
| 79 | TF0282 | x | | | - | - | - | - | | - | - | | | | 3 | | | | | | 6 | 1 | | | | |
| 80 | TF0284 | x | 10 | 16 | 16 | 16 | 16 | 16 | 10 | 10 | 10 | | | | 19 | 6,0 | 15 | | | 16 | 11 | | 26 | | 52 | 6,0 |
| 81 | TF0240 | x | 5 | 10 | 10 | 10 | 10 | 10 | | - | - | | | | 5 | | | | | | 6 | | | | | |
| 82 | TF0245 | x | 1 | 8 | 8 | 8 | 8 | 8 | | - | - | | | | 3 | | | | | | | | | | | |
| 83 | GB_SW | x | | | - | - | - | - | | - | - | | | | 1 | | | | | | 5 | | | | | |
| 84 | TF0213 | x | 6 | 7 | 7 | 7 | 7 | - | | - | - | | | | 1 | | | | | | | | | | | |

| | | CTD profile | Sauerstoff | PO4 | ** NO3 | ** NO2 | ** SIO4 | NH4 | P-Total | ** N-Gesamt | ** POM+DOM | Phyto-Netz | Chlorophyll | Phytoplankton | H2S-Best. | Sichttiefe (m) | DNA-Filter | DNA Filter | CO2 | Mu Metalle | Mu Radio | Mu Sediment | Fish-Filter | Zooplankton | P+G, Betain | SECCHI (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 85 | TF0154 | x | | | - | - | - | - | | - | - | | | | | | | | | | 4 | 1 | | | | |
| 86 | TF0113 | x | 1 | | - | - | - | - | | - | - | | | | | | | | | | 3 | 1 | | | | |
| 87 | TF0030 | x | 1 | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 88 | TF0046 | x | 1 | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| 89 | TF0012 | x | 1 | | - | - | - | - | | - | - | | | | | | | | | | | | | | | |
| | | | 129 | 242 | 242 | 242 | 242 | 125 | 50 | 50 | 50 | 12 | 54 | 29 | 80 | 11 | 67 | 57 | 54 | 52 | 91 | 6 | 52 | 16 | 104 | 10 |
| | | 89 | 46 | 46 | 46 | 46 | 46 | 14 | 9 | 9 | 9 | 10 | 10 | 10 | 19 | | 2 | 4 | 4 | 5 | 17 | 6 | 2 | 7 | 2 | |

## 6.5 Mooring work

| Date | Latitude [decimal] | Longitude [decimal] | Begin [UTC] | End [UTC] | Water Depth [m] | Action |
|---|---|---|---|---|---|---|
| 2019-10-18 | 57.30 | 20.08 | 8:15 | 11:30 | 241 | Mooring GODESS, recovery |
| 2019-10-18 | 57.32 | 20,13 | 11:00 | 13:30 | 240 | Mooring Gotland - central, recovery, maintenance, deployment |
| 2019-10-19 | 57.30 | 20.08 | 08:00 | 12:00 | 241 | Mooring GODESS deployment |



# 7 Data and Sample Storage and Availability

After validation data will be freely available in the IOW DB online via ODIN2 (https://odin2.io-warnemuende.de/#/). The data will be imported into national and international databases (MUDAB, HELCOM, ICES).

## 7.1 CTD sensors and handling

The CTD SBE911+ is equipped with pairs of temperature, conductivity and oxygen sensors. This allows to control the data quality during the cruise and to identify sensor malfunction.

| variable | Sensor type | Sensor ID | Date of calibration | |
|---|---|---|---|---|
| temperature | SBE-3 | 5491 | 2017-01-17 | Its-90 |
| | | 5492 | 2017-01-17 | |
| conductivity | SBE-4 | 4006 | 2017-01-17 | |
| | | 4007 | 2017-01-17 | |
| Oxygen conc. | SBE-43 | 1733 | 2019-08-08 | Sea-Bird equation |
| | SBE-43 | 1735 | 2019-08-08 | Sea-Bird equation |
| pressure | digiquarz | 100070 | 2006-05-16 | |
| fluorescence | WETlabs ECO Afl/fl | FL_22029_10V | 2010-09-28 | |
| turbidity | WETLAB ECO NTU | NTU_2029_10V | 2010-09-28 | |
| PAR | Biospherical Licor Chelsea | PAR_70256_10V | 12.08.2009 | |
| temperature | SBE-35 | | | |

To evaluate a possible drift of the CTD normal quartz, its frequency if observed during the cruise.

The deviation between the two sensor packages is monitored in homogeneous water layers. The deviation between the two SBE-3 thermometers was slowly growing during the cruise and amounts 3mK in the end. The deviation between the conductivity sensors did not exceed xxx

The quality of the temperature sensors is also monitored with a high precision thermometer SBE-35. ….Hannes

Prior the cruise the zero point of the oxygen sensors is verified by filling the sensors with oxygen free nitrogen gas. The sensor slope is calibrated during the cruise with oxygen samples taken in homogeneous water layers (3 bottles, 3 samples from each bottle).

To control the conductivity sensors, salt samples are taken in homogeneous layers to be measured later with an AUTOSAL in the laboratory against standard seawater.

## 7.2 Oxygen, nutrient and hydrogen sulphide measurements

After validation data are united with hydrographic and geographic references and are stored in IOW data base ODIN2 (https://odin2.io-warnemuende.de/#/).

## 7.2 Uranium water column and sediment data

The sediment and water column uranium isotop samples are processes successfully. Sediment samples are stored at DTU. Further data processing a publication will be done by Mu Lin at DTU.

# 8 References

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