

# **Cruise Report**

## **F.S. ALKOR Cruise No. 362**

**Dates of Cruise: 29. September to 02. October 2010**

**Projects:**  
**Student course in phys. oceanogr.**

Areas of Research: Physical oceanography

Port Call: Sassnitz (01. Oct. 2010)

Institute: IFM-GEOMAR Leibniz-Institut für Meereswissenschaften an der  
Universität Kiel

Chief Scientist: Dr. Johannes Karstensen

Number of Scientists: 7 & 6

Master: Norbert Hechler

# Chapter 1

## Scientific personal

Cruise code: AL 362

Cruise dates: 29.9. – 02.10.2010

Port call: Kiel – Sassnitz – Kiel

Table 1.1: Scientific personal AL 321: IFM-GEOMAR: Leibniz-Institut für Meereswissenschaften an der Universität Kiel, Kiel, Germany; CAU: Christian Albrechts Universität Kiel, Kiel, Germany

Name	Institute	Function	leg
Johannes Karstensen	IFM-GEOMAR	Chief scientist	1, 2
Andreas Pinck	IFM-GEOMAR	PO	1, 2
Nadine Mengis	CAU	Master student	1, 2
Johannes Hahn	IFM-GEOMAR	PO	1, 2
Jan Klaus Rieck	CAU	student	1
Thomas Doejen	CAU	student	1
Eva Nowatzki	CAU	student	1
Verena Rumpel	CAU	student	1
Sebastian Steinig	CAU	student	1
Ezra Eisbrenner	CAU	student	1
Tronje Kemena	CAU	student	1
Bendix Vogel	CAU	student	2
Lars Quer	CAU	student	2
Josephine Herrford	CAU	student	2
Sabrina Doerks	CAU	student	2
Marie Böttcher	CAU	student	2
Katharina Höflich	CAU	student	2
Michael Busack	Optimare, Bremerhaven		day 1
Franziska Badenschier	DLR-Wissen		day 1

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# Chapter 2

## Scientific Background

The main purpose of the ALKOR cruise AL362 was the training of students in observational methods for physical oceanographers. The scientific motivation of the cruise was to obtain a rather synoptic picture of the hydrography and water movement in the western Baltic, to service a mooring site at the southeastern opening of the Fehmarn Belt and to deploy and recover a pop-up test mooring off Booknis Eck.

Hydrographic and current sections from the Fehmarn Belt (section 'C') and along the deepest topography from about 10°40 E to 14°21 E (section 'L'). From the mooring site at the southeastern opening of the Fehmarn Belt the instruments (RADCP-600kHz with oxygen optode, T and C; self containing CTD Type MicoCat) have been serviced.

The main purpose of the cruise is educational. Undergraduate students are introduced into modern observational techniques of physical oceanography, basics in instrument calibration and interpretation of the observations. In addition the observations should give the students the opportunity to experience work and life at sea and to explore/investigate the Baltic Sea, the 'ocean' at their backyard.

# Chapter 3

## Cruise Narrative

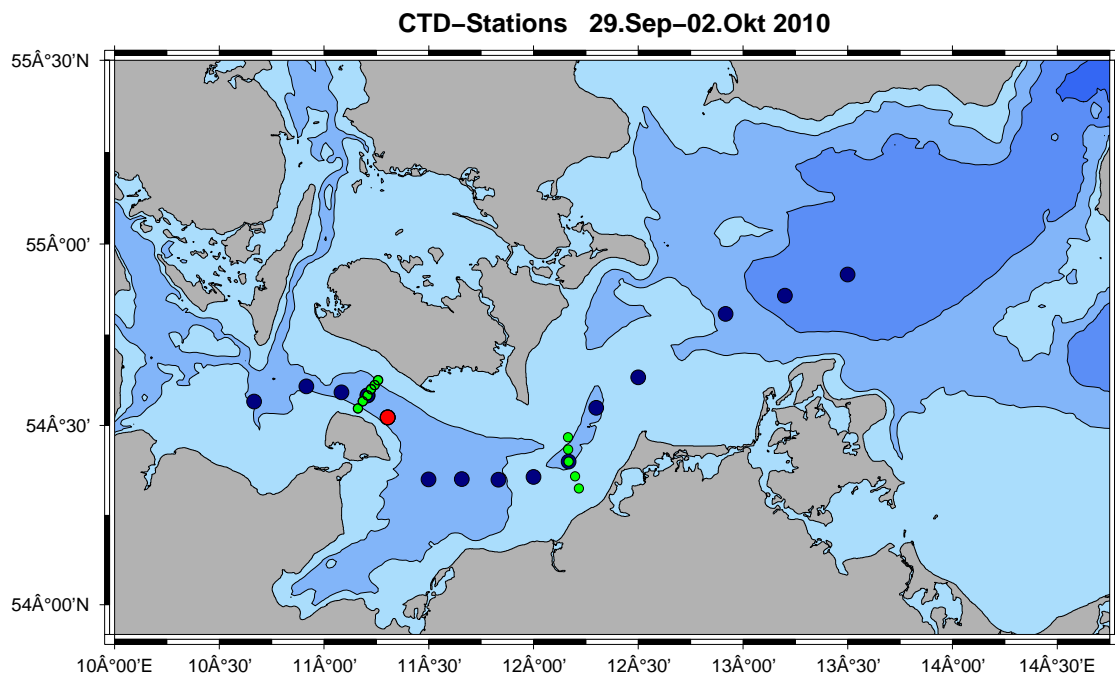


Figure 3.1: ALKOR 362 cruise stations. Black (LG section)/ Green (FB section) and Red dot are the CTD stations, red dot is also location of the V431 mooring.

### DAY 1:

Left Kiel at 07:50 (all times in Narrative are local time Kiel) heading for Booknis Eck. After Rainer Nausch, the first officer, did a safety instruction an introduction of the group and the planned program of the following days was given. In addition F. Badenschier from Deutschland Radio Wissen was on board to do some interviews with the students about "bachelor" studies. First the deployment of a pop-up buoy frame developed by Optimare/IFM-GEOMAR as part of the FP7 THOR project was prepared. The transit time to the site was used to prepare the electronics of the pop-up buoy frame as well as the instruments (1xSBE37IM, 1xSBE37SM,

1x300kHz RDI ADCP, 1xOptoden 3830 Logger).

One of the four pop-up's was programed to come to the surface at 12:30. A team of three divers joint us at Booknis Eck to film the release of the pop-up buoy. After deployment the divers went down and observed the mooring. Unfortunately the pop-up buoy was not released during the time interval the burnwire was programmed to be active (from 10:30 to 11:15 (UTC)). It was mentioned by Michael Busack that the low salinity may have prolonged the burnwire response. The divers reported that they did not observe LED activity in target buoy - which would have indicated that the burnwire current was on. An LED in a buoy to the right of target buoy was on (green).

The divers took the day passengers (M. Busack and F. Badenschier) on board of their motorboat and transported them back to shore. At about 13:30 we left Booknis Eck heading for Fehmarn Belt - too late for mooring V431 (Fehmarnbelt). The first station was a test to check the functioning of the CTD. In addition a rather large volume of water was sampled to be used as 'Substandard' for salinity calibration (see details below). Next the Fehmarnbelt section ('C') was sampled with a northward CTD section and a repeat section using the ADCP with 7 kn. The work was finished at 21:45 and we headed for a station at the Kadett Ridge to start CTD profile on day 2.

DAY 2 (Thursday, 30.09.2010):

Station work was started again at 07:00 while the first Praktikums station 15 was occupied at 07:30. We worked our way westward, towards the Fehmarn Belt. After occupation of 5 other stations we reached the position of the V431 mooring at 13:00. Recovery of the mooring went well. Some biofouling was visible on the transducer head of the RDCP600 but in general biofouling was moderate. We left the position going eastward, towards Praktikumsstation 19a, north of Rügen. We have to be in Rügen by tomorrow midday and before we will try to occupy two more stations in the early morning of the 01. Oct. 2010.

During the transit to st. 19 the TRBM frame and the instruments were cleaned and read out. To our disappointment the RDCP had only recorded from the 14. Sept. 2009 to the 30. Nov. 2009. Inspecting the battery voltage dropped to less than 6.8 Volts and this was very likely the reason why the instrument stopped recording. This is very surprising as the energy calculator determined a 385 days deployment duration. We did further tests measuring the current that was drained by the instrument during operation. They revealed no different numbers than the ones given by the manufacturer. What was surprising was that the battery was already at low level when deployed (7.0V).

DAY 3 (Friday, 01.10.2010):

After completing 2 Stations (Praktikums Station 19a & 19) Northeast off Rügen we steamed to Sassnitz and reached the pier around 12:00. After costumes clearing the students crew was exchanged (7 left, 6 entered) and we left Sassnitz at about 14:30 again. We heading towards completing the L-section CTD. The new students received a safety training from Rainer Nausch (1. officer) followed by an introduction into the program. The first station was occupied at 17:45 and three more on the L-Section followed. Next were 4 stations crossing the Kadett-Rinne.

DAY 4 (Saturday, 02.10.2010):

After a transit from Kadett Rinne we arrived at the V431 TRBM position at 07:45 where a CTD cast was performed. Cast continued over the Fehmarnbelt 2nd occupation followed by an ADCP section steaming with 7 knots. We headed for the recovery of the Pop-up test mooring off Booknis Eck and the system was recovered Saturday early afternoon without problems. No pop-up buoy was released. The problem with the system needs further investigation when back in Kiel. After the recovery we headed for the Westufer pier where we arrived at about 17:40 local time. All equipment was stowed away during the passage to allow for a quick unload of the equipment in Kiel.

# Chapter 4

## Preliminary results

### 4.1 Mooring

#### 4.1.1 V431 - TRBM Marienleuchte

The V431 was installed in the Speergebiet Marienleuchte in May 2002. During AL362 the 20th deployment was recovered and the 21th deployment started.

Table 4.1: V431: Summary of recovery of trawl resistant bottom mooring V431.

date; time (UTC)	latitude	longitude	depth	comment
14.09.2009; 12:02	54°31.32'N	011°18.28'E	28	20th deployment.
30.09.2010; 11:00				recovery (AL 362)
02.10.2010; 06:12	54°31.34'N	011°18.28'E	28	21th deployment.

The ADCP is placed in a shield frame at the bottom of Fehmarn Belt at a depth of 28 m (see table). It measures current speed and direction at 18 depths cells from bottom to surface with a depth interval of 1.5 m. Data below 4 m from sea surface has not been evaluated as it's corrupt due to surface reflections and side lobe effects. Due to instrument failure the measurement contains only data from September 14th to November 30th, 2009.

The current components  $u$  and  $v$  are rotated by  $46^\circ$  so that  $u$  points in the main current direction (along the topography), which is  $136^\circ$  (south east respectively north west), and  $v$  across the Fehmarn Belt. In depths below 15 m inflow into the Baltic dominates, above 15 m in- and outflow more or less equal each other. Maximum half day average current velocity is about 90 cm/s. Mean along topography current velocity during the measuring period is about 23.5 m/s.

Figure 4.2 shows temperature, conductivity and salinity (calculated from temperature, conductivity, pressure) for the period September 14th, 2009 to September 30th, 2010. The plot shows a bottom temperature range of  $0^\circ\text{C}$  to  $15^\circ\text{C}$  for Fehmarn Belt. Observations show a decreasing of temperature from  $14^\circ\text{C}$  to  $0^\circ\text{C}$  over a period of 4.5 months and an increasing of temperature from 0 to  $11^\circ\text{C}$  over a period of 8 months. MicroCAT and RDCP show in the overlapping period similar temperatures. The irregularity at the end of November might be due to RDCP failure (see

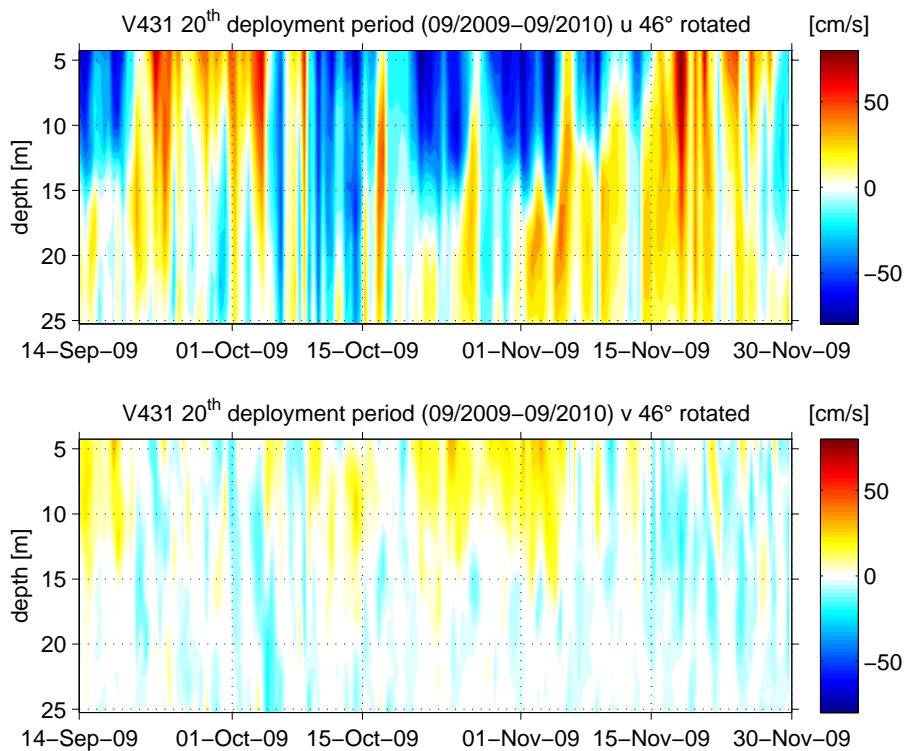


Figure 4.1: *Mooring V431, upward looking RDCP 600 (Aanderaa) 606kHz, velocities along and perpendicular to bathymetry (rotated clockwise by 46° from north). Values are averaged over half a day, upper three meters are cropped.*

above). Remarkable is the very low temperature (about 0°C) at the end of January at 28m depth. The winter 2009/2010 was very cold in Northern Germany and over the Baltic and influencing the whole water column.

The salinity time series show a range from 13 to 27. The minimum of salinity coincidences with the minimum of temperature in late January. The maximum is located in July/August. In late June observations show an increasing of both salinity and temperature. There is a drift between conductivity measurements from the RDCP and the MicroCAT (see later, technical, chapter).

Another interesting feature can be seen in the oxygen record from the RDCP600. In the first few weeks the oxygen content at the bottom (instrument location) was decreasing rapidly, probably due to high stratification and no advective renewal. A sudden increase of the oxygen (saturation) occurred in the week around the 1st October associated with a salinity decrease by about 3 and a warming by about 2K. This indicates that well ventilated surface waters were mixed down to the bottom, probably due to a strong wind mixing event.

Overall the oxygen observations are a very useful addition to the standard hydrographic parameters used before in the V431 mooring.

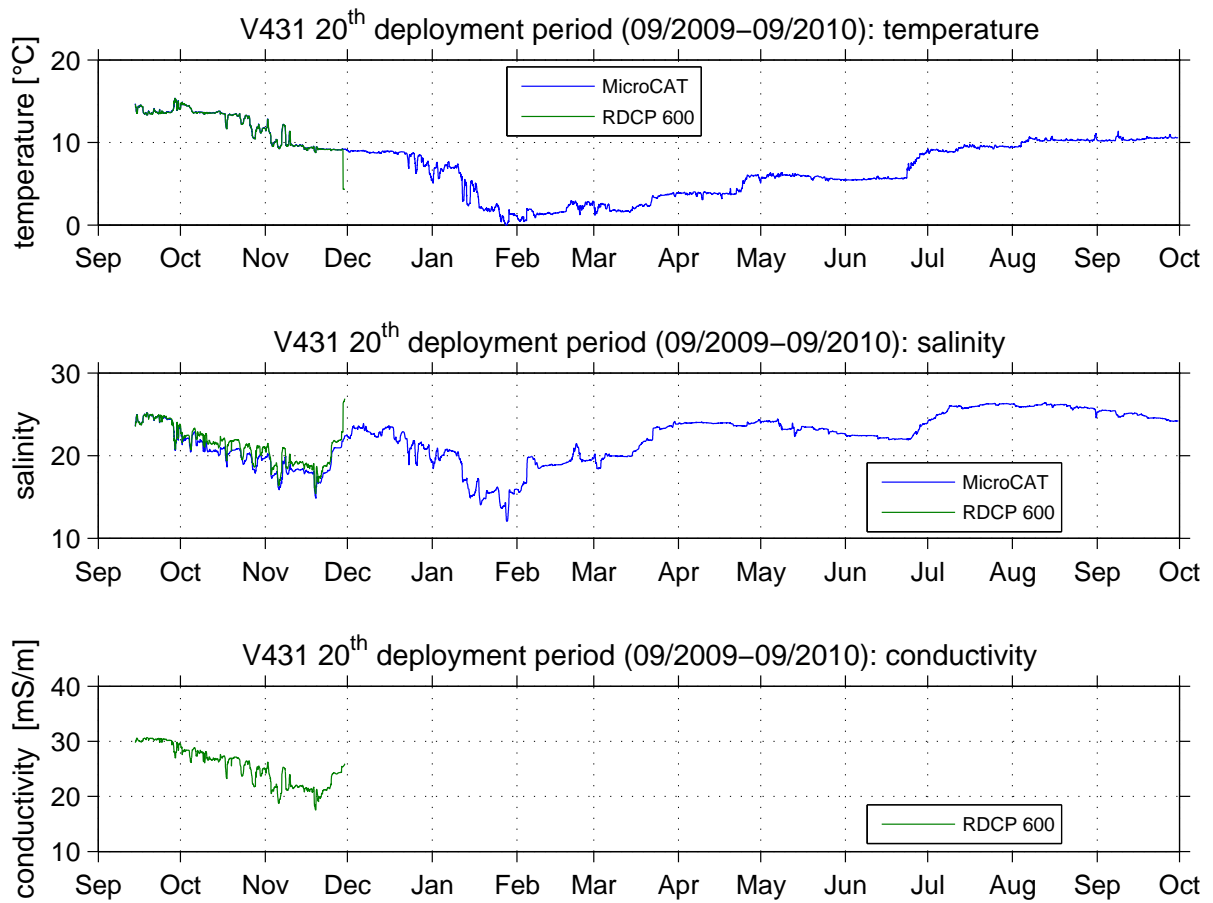


Figure 4.2: *Mooring V431, temperature and salinity observations by MicroCAT (SeaBird, SN: 2936) and RDCP 600 (Aanderaa).*

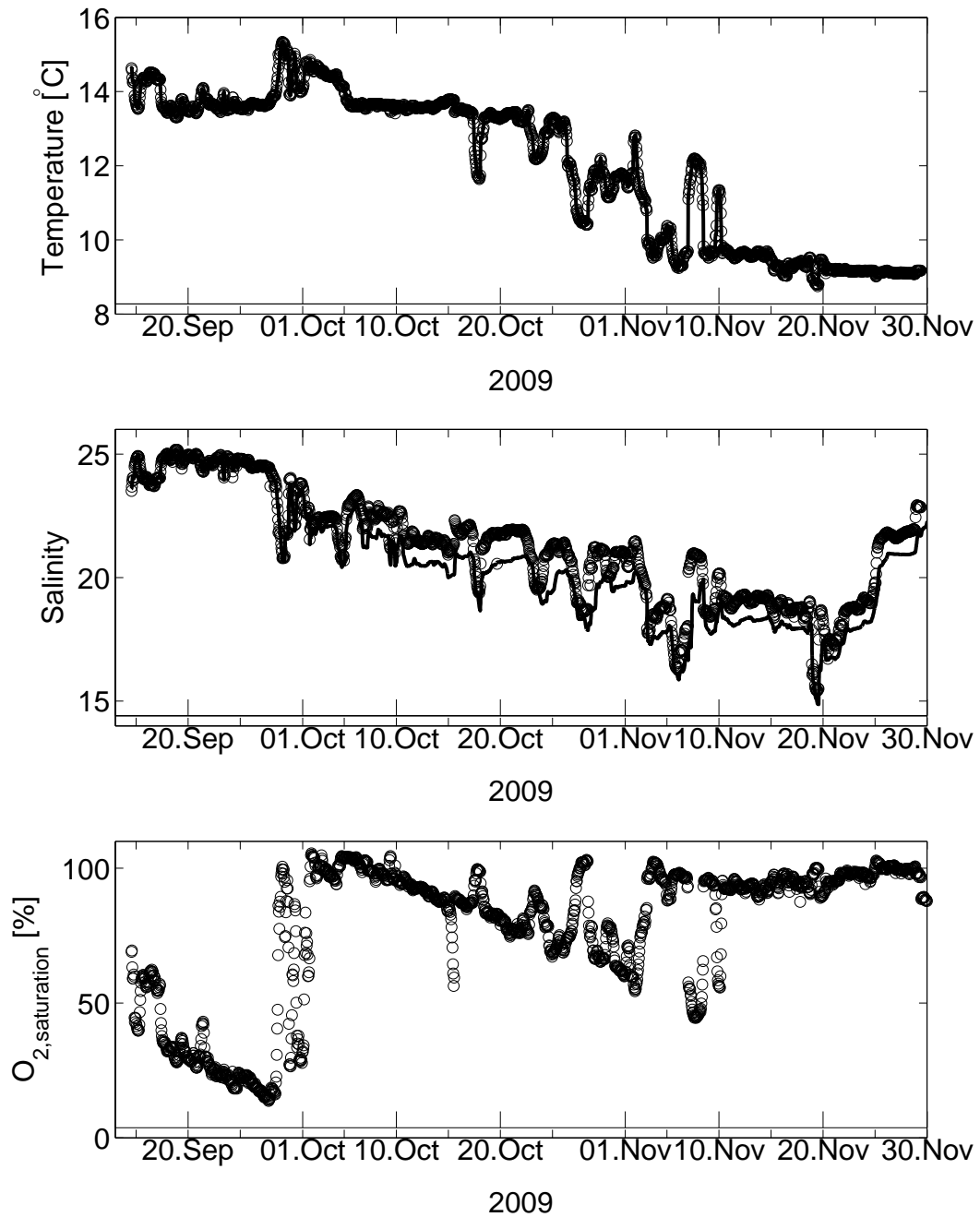


Figure 4.3: Timeseries temperature (upper) Aanderaa Temperature (o) and SBE37 (-); (middle) salinity; (lower) oxygen for the period were both instruments were operating in parallel (14.Sept. to 29.Oct. 2009).

### 4.1.2 Booknis Eck Pop-up Test mooring

A new developed pop-up buoy system was deployed at the beginning of AL362 off Booknis Eck north of the Eckernförder Bucht. Purpose was to test the data sampling system, the launch system of the pop-up buoys, and data telemetry system. The buoy frame was equipped with three serial connected devices (ADCP, Optode, SBE37SM) and one inductive device (SBE37 IM).

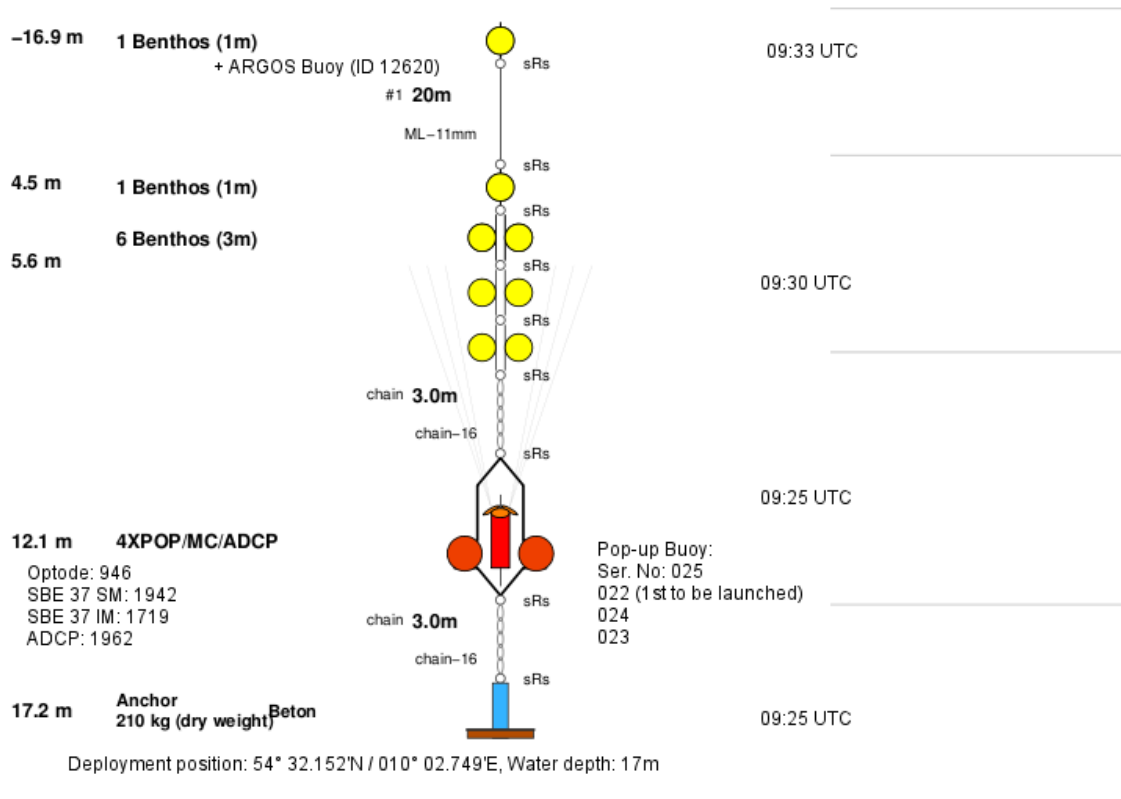


Figure 4.4: Configuration of Pop-up test mooring deployed at Speergebiet Booknis Eck (29.9.2010-02.10.2010).

To observe how the pop-up releases, one buoy (serial nr. 022) was programmed to come to start its burnwire at 12:30 with current lasting for 45 minutes (from 10:30 to 11:15 UTC). A team of three divers joined us (coming from Damp via at Booknis Eck to film the release of the pop-up buoy). After deployment the divers went down and observed the mooring. Unfortunately the pop-up buoy was not released during the time interval. One reason could be the low salinity of the water (Michael Busack) - nominal current is about 2A but may vary due to bad conductivity dependent on seawater salinity. The divers reported that they did not observe LED activity in target buoy - which would have indicated that the burnwire current was on. An LED in a buoy to the right of target buoy was on (green). The system was recovered the afternoon of Saturday the 02. Oct. 2010.

## 4.2 Meteorological observations

During the 4 days of the cruise, the large scale weather situation (Fig. 4.5) was determined by a high-pressure system ( $p=1027$  hPa) over the whole Baltic Sea moving eastwards very slowly.

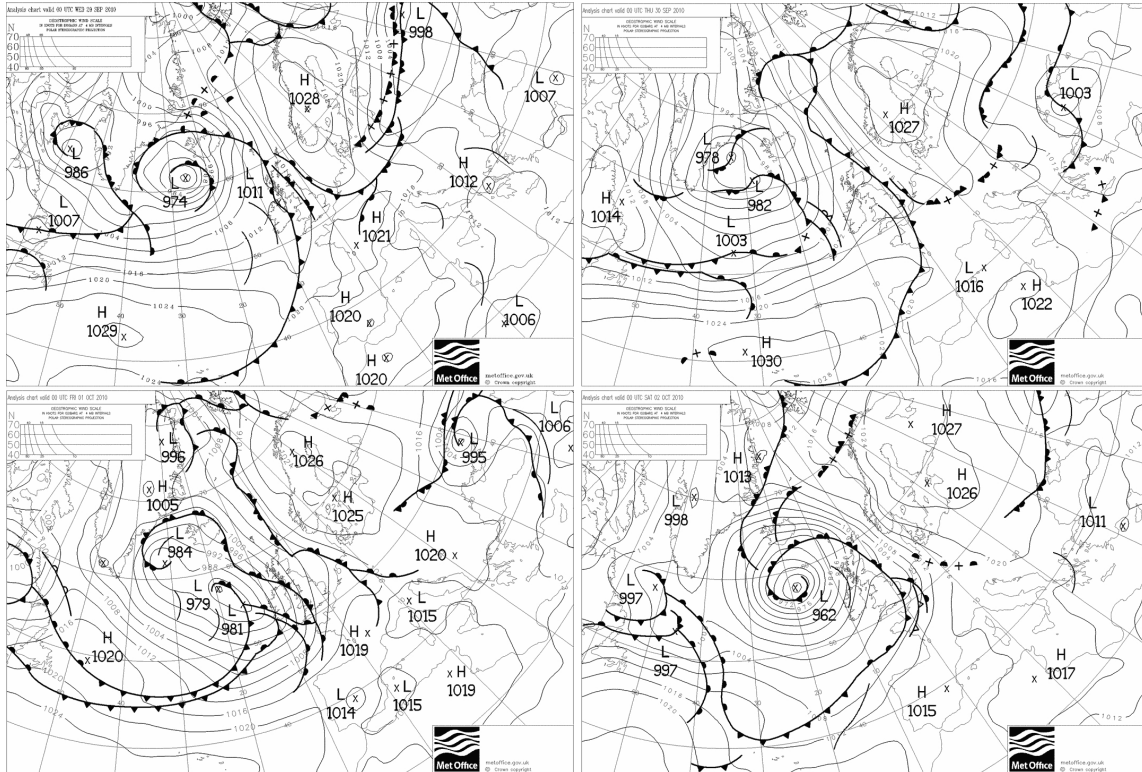


Figure 4.5: Weather charts from September, 29 to October, 2nd 2010 based on Bracknell-Data

About the four days of the trip a decrease of air pressure was observed. At the beginning the weather situation over Mid-Europe was mainly determined by high-pressure areas whereas low-pressure areas could be found over the North-Atlantic. At the end, a strong low ( $p=962$  hPa, Fig. 4.5, lower right) at the western side of Great Britain developed moving towards the North Sea. Therefore the pressure gradient between high and low increased for the last day of our expedition.

During the four days, the temperature ranged from 8.5°C - 13°C, whereas the dew point temperature increased from 4°C at the beginning to 12 °C at the end. The difference T-Td was relatively constant over time (Fig. 4.6), only during the night from 1st to 2nd of October, the difference sank to 0°C, resulting in rainfall and minimum values of temperature during this time. The mean temperature was relatively low for beginning of October due to the high-pressure area over the Baltic Sea.

The relative humidity seemed to be correlated with dew point temperature (Fig. 4.6), as both graphs show mostly the same lapse. Because of rainfall, maximum values of relative humidity were recorded in the night from 1st to 2nd of October. Generally, relative humidity was high due to the contiguousness to the ocean surface.

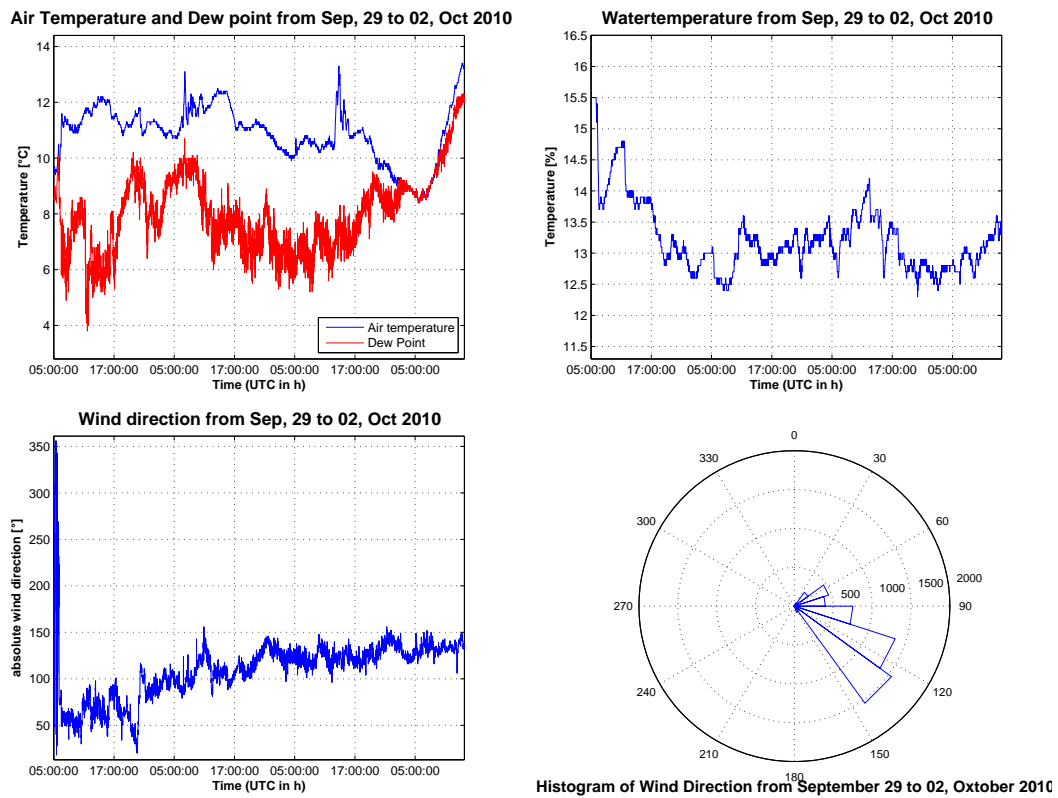


Figure 4.6: upper left: Temperature, Dew Point Temperature, b) Relative Humidity; upper right: Sea-surface temperature, lower left: Wind direction and Wind speed; lower right: frequency of wind direction.

Also shown in Fig. 4.6 are psychrometer data from students' measurements of dry and wet temperatures. Up to the late evening of October 1st the overall shape of the psychrometer data represents the DAVIS-SHIP data quite well. The latter shows a lot of short timescale variability. This is either due to short timescale fluctuations in humidity or due to imprecise measurements of humidity. No matter which of both is right, considering the quite noisy DAVIS-SHIP data and the many errors that could occur while reading the values at the psychrometer or calculating the dewpoint and humidity with tables that have a coarse resolution, the psychrometer data is quite accurate. Only during October 2nd the derived values are 5-10% too low.

Water temperature ranged from 12.3°C to 14°C, except three peaks during the trip which are due to dwell times of the ship in a harbor or during the time when testing the new mooring system on September, 29 from about 08:00 UTC to 12:00 UTC. These peaks result from warming of the surrounding water by the ship. The lapse of water temperature mainly follows a diurnal cycle with maximum values during the day (especially at noon) and minimum values by night and early in the morning.

The range of wind speed is from 3 m/s (2 Bft) to 15 m/s (7 Bft), increasing almost linearly over time (Fig. 4.6). Maximum values were recorded during the last night of the trip which can also be seen on the weather charts. The isobars of 1012 hPa and 1016 hPa got closer representing a stronger pressure gradient. A minimum was measured while laying in the harbor of Sassnitz on October, 1st. The two lowest minimum values were found during the first night, while crossing the Fehmarn Belt.

Generally, at the first day the wind came from north-east to east (Fig. 4.6) and then changed during the first night to wind from east south-east to south-east for the last three days of the cruise (Fig. 4.6). The first records with wind directions of 360 degrees are incorrect due to the impact of the Kieler Förde. The sudden decrease of wind direction to 10 degrees resulted from the influence of the land masses of Lolland.

There is a distinctive daily course to note inside the measurements of the short wave radiation (Fig. 4.7). During the night, it does not exist any incoming (short wave) radiation. Maximum values were recorded during the day, especially at noon without differences in characteristic of rising and falling edge. The range of the maxima is from 600 to 800 W/m<sup>2</sup>, depending on the cloudiness of each day. In Fig. 4.7 it can be seen that cloudiness seemed to increase during the cruise reducing the incoming solar radiation. The mean over this period is about 131 W/m<sup>2</sup> which is a little bit above the average for September for 50°N to 60°N of around 100 W/m<sup>2</sup> (NOC climatology) which shows the influence of the first two sunny days.

Net long wave radiation was calculated as the difference between an assumed outgoing long-wave radiation calculated from SST and the downward longwave radiation measured on board and ranged from 0 to -100 W/m<sup>2</sup> without any daily course. Its variability mainly depends on clouds which reflect the long wave radiation as the SST remains almost constant over time. That results in lower net transports of radiation. This can be seen in Fig. 4.7, for example in the afternoon of October, 1st. It has a mean of -42 W/m<sup>2</sup>.

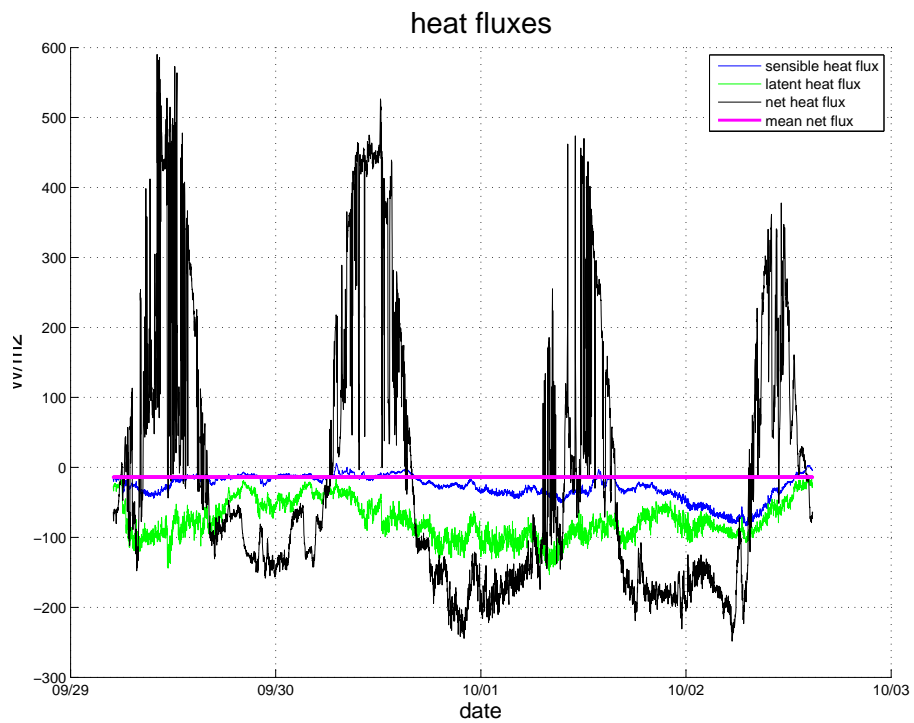
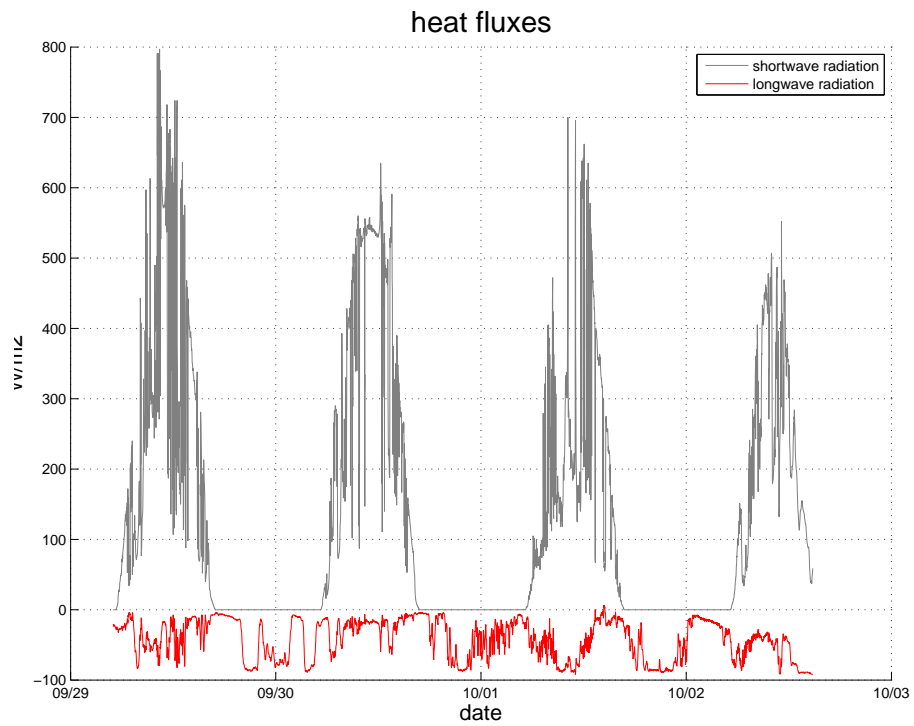


Figure 4.7: Upper: observed shortwave and longwave heat fluxes, lower: calculated sensible and latent heat fluxes, and derived net heat flux

The different heat fluxes, shown in Fig. 4.7 (lower), were calculated. The sensible heat flux is derived from a bulk formula with air temperature, sea surface temperature, wind speed and some coefficients and the latent heat flux is derived from relative humidity, sea surface temperature, wind speed and other coefficients (with matlab function hfbulktc).

The sensible heat flux has a mean of  $-28 \text{ W/m}^2$  during the cruise which is a lot less than the average of  $-3 \text{ W/m}^2$  (NOC climatology) but can be easily explained through the strong winds that were blowing specially during the last two days of the cruise. The mean latent heat flux during the cruise was  $-76 \text{ W/m}^2$  which is lower than the average of  $-48 \text{ W/m}^2$  (NOC climatology) and can also be explained through strong winds during the last two days and relatively dry air masses coming from the east during the first two days of the cruise.

The net heat flux varies strongly during the day. Only during the daytime it is positive around noon with maxima up to over  $600 \text{ W m}^{-2}$ . During the rest of the day the net heat flux is always negative with minima around  $-250 \text{ W m}^{-2}$  as there is no shortwave radiation. The mean net heat flux is around  $-14 \text{ W m}^{-2}$  which is lower than the September average of around  $0 \text{ W m}^{-2}$  but a lot higher than the October average of around  $-84 \text{ W m}^{-2}$ . It shows that the Baltic Sea lost heat during our cruise as can be expected in northern hemisphere autumn (all averages zonally for September over  $50^\circ\text{N}$  to  $60^\circ\text{N}$ ).

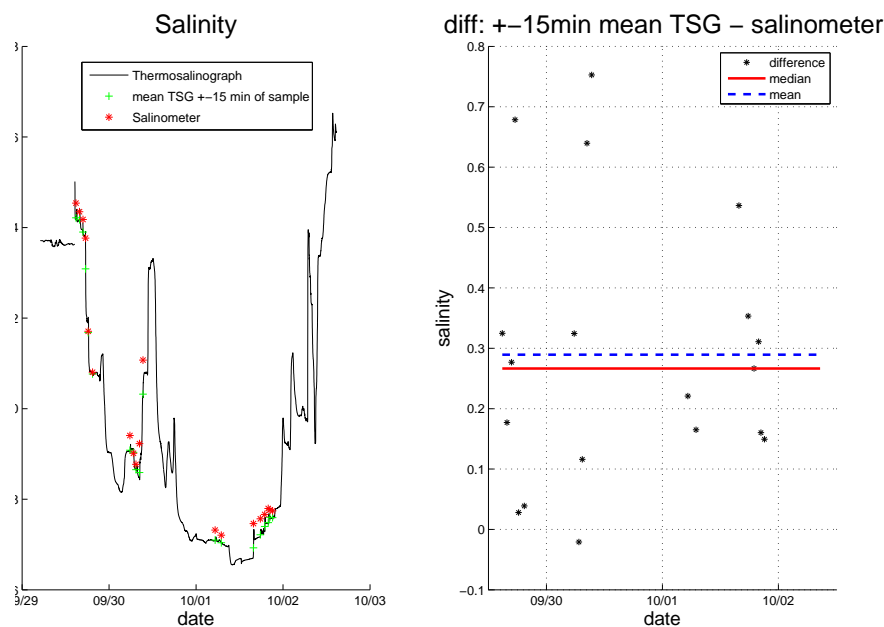


Figure 4.8: left: a) Salinity; b) difference of TSG and salinometer salinity

In Fig.4.8 the salinity values from the TSG are compared with all available water samples taken from the TSG at specific times and later validated through measurements with the Beckmann-Salinometer. The general shape of the salinity through time is quite the same in both methods but the Salinometer data is generally a bit higher. The difference was calculated by subtracting a mean of the TSG salinity over 15 minutes before to 15 minutes after the sample time from the measured salinities of the samples and ranges from -0.02 to 0.75 with a mean of 0.29 (Fig. 4.8). The median is 0.27. with the standard deviation of 0.22 This can also be seen in the frequency distribution (Fig. 8). Regarding the small amount of samples and the big problems in calculating this difference one could say the difference is almost normally distributed with an offset of around 0.3. So salinity measured with the salinometer was a bit higher then the TSG salinity.

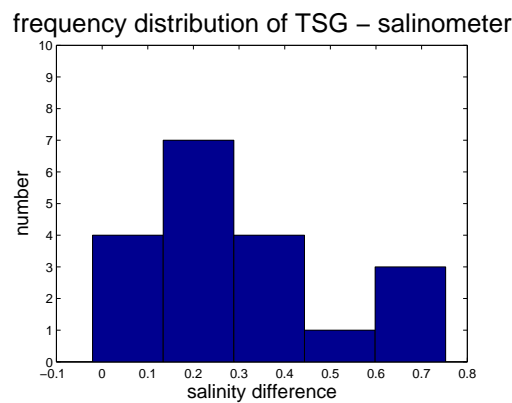


Figure 4.9: *Distribution of differences*

The problems mentioned above were the following. First there often are little peaks in salinity at the time at which the sample was taken which can also be seen in the temperature measured inside the TSG (not shown) as the temperature has a very important role in calculating salinity from conductivity. These peaks only consist of one value. As we have TSG salinity values every minute these peaks can not be due to the ship not moving during station time. Station time was always a lot longer than one minute. For the same reason it can not be due to hysteresis effects. One could imagine that while the ship is not moving the salinity sensor adjusts to the real salinity value while when the ship is moving there is always new water with different salinity flowing through and the sensors answer time is too slow. But then there should be longer periods of constant salinity during station time and not just peaks.

A more likely reason for the salinity peaks is that the taking of the sample, for which water is taken directly from the TSG, influences the sensors inside. Somehow the water inside the TSG gets warmer during this process and the calculated salinity is influenced by that.

Another problem might be that the time at which the sample was taken was not noted precisely enough. We did not note the time exactly when we took the samples but before or after when we were back in the lab. Especially if the ship was not at a station but still moving a noted time that is one or two minutes too late or too early can cause a big difference in salinity.

## 4.3 Hydrographic and currents along C and L section

### Fehmarnbelt (C section)

The temperature distribution within the upper 23 m of the Fehmarnbelt is nearly homogeneously with 13°C. With a very weak gradient the water gets warmer with 14°C in 10-15 m depth. Because of cold bottomwater with 10°C, the temperature gradient below 23 m depth is stronger.

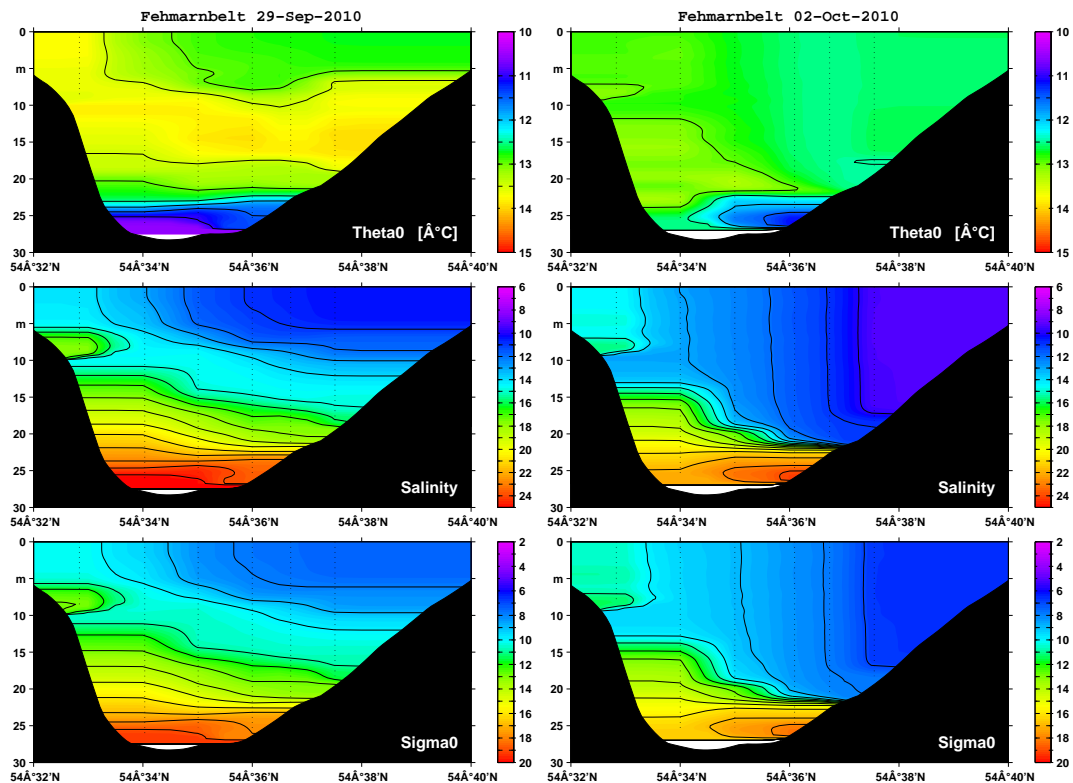


Figure 4.10: *Temperature, salinity, and density measured and already processed along the Fehmarn Belt. Left: 29. Sept. 2010; right: 02. Okt. 2010*

The salinity gradient increases with depth from low salinity water at the sea surface (around 10) to more saline waters at the bottom (around 24). In the northern part of this section salinity increases faster than in the southern part. But there can be noticed a higher salinity with 17, located between 54°32' and 54°34' in 5-7 m depth. The maximum in salinity at the bottom can be assigned to an inflow into the Baltic Sea coming from the North Sea.

Density shows high correlation with salinity. It is lower at the sea surface and gets higher with depth. The small maximum in salinity can also be found in density distribution near the southern continental slope in 5-7 m depth.

Three days later the temperature distribution within the upper 23 m is nearly homogeneous with about 13°C again. At the bottom there is a small area with cold water at 11°C.

Compared to the measurement three days before the lower part of the water column is not that

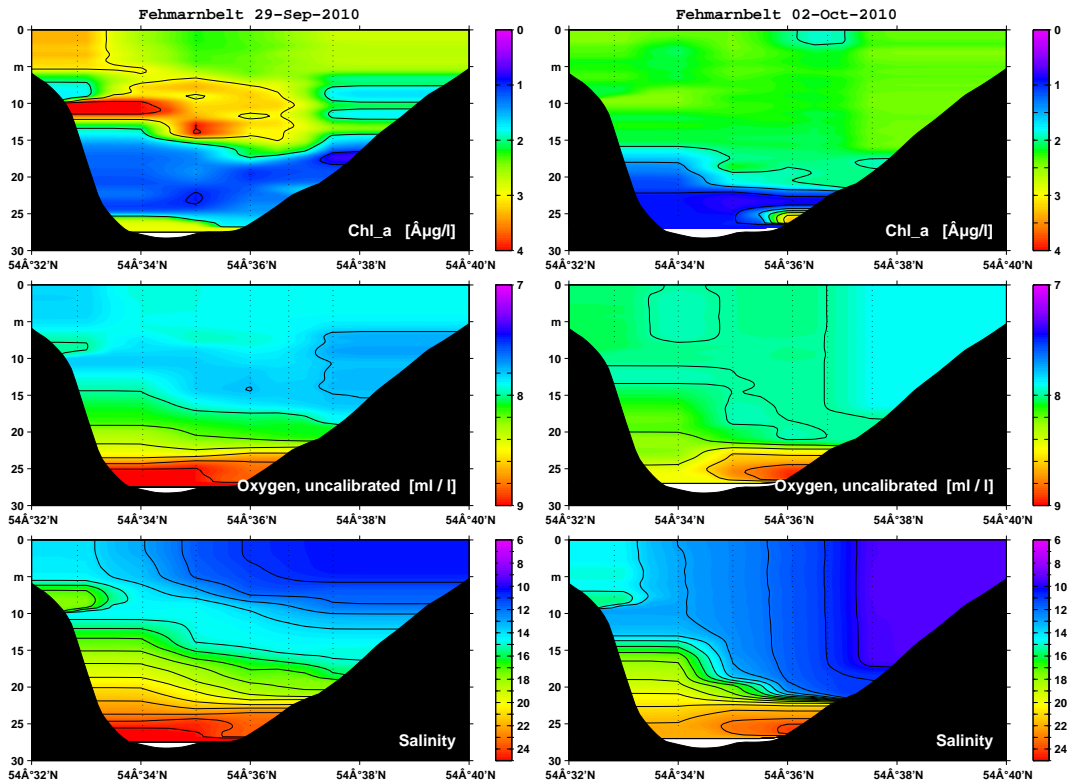


Figure 4.11: *Chlorophyll, oxygen and salinity measured along the Fehmarn Belt. Left: 29. Sept. 2010; right: 02. Okt. 2010*

salty anymore. The mass of fresh water reaches up to 20 m depth in the North and 14 m depth in the South of the section. The salinity gradient is stronger now, while the small maximum near the southern continental slope is weaker. All this can also be recognized in density distribution. As an result, this section of the Baltic Sea is strongly mixed by the interaction of ocean and atmosphere, e.g. by wind and the motion of waves. This correlates with the weather and is supported by the measurement of chlorophyll and oxygen. These show an oxygenation, which is a good indicator for wind-driven mixing.

### **Kadett Rinne (KD section)**

In this section the temperature distribution is relatively homogeneously, it reaches from 12.5°C at the bottom to 13.5°C in about 9m depth. Thus, there are only small variations in temperature within the whole water column.

All in all, salinity is lower than it is in C section, but shows a similarly strong gradient from sea surface to bottom. The inflow at the bottom, rich in salinity and coming from the North Sea, can still be identified in the KD section. Again, density correlates well with salinity.

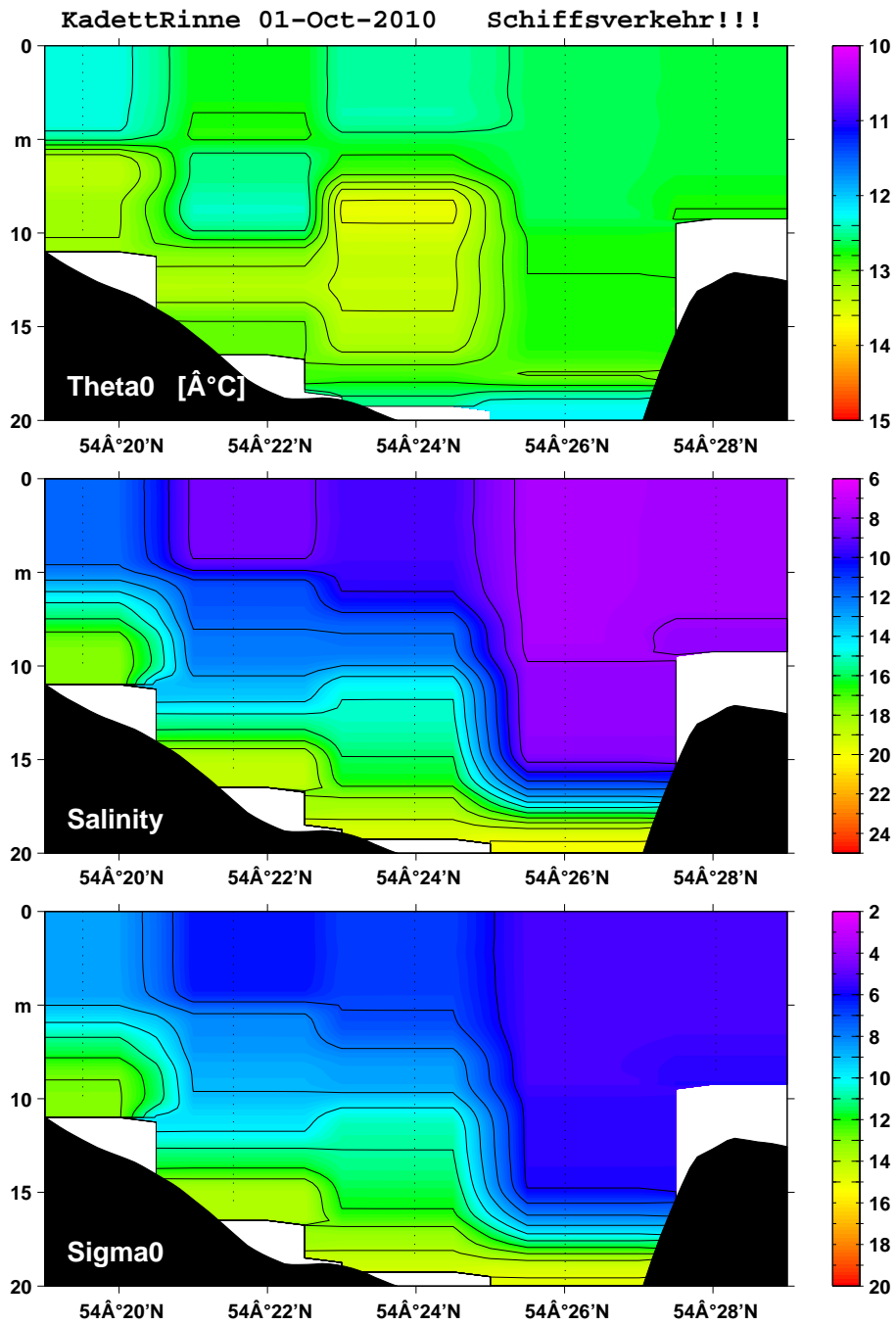


Figure 4.12: *Temperature, salinity, and density measured and already processed along the Kadett Rinne on 01. Oct. 2010*

## **Zonalsection (L section)**

Noticeable in the L section are three irregularities in the temperature distribution at about 11°20' in 27 m depth and at 13°20' to 14°20' in about 17-35 m depth. These are temperature minima with ca. 10.5-11.5°C while the rest of the basin is relatively homogeneously with 12.5-14°C, decreasing from west to east. There might be currents in the eastern part of the basin causing two of the anomalies.

Between 12°00' and 13°30' salinity is very low with 6-7 and shows a very weak gradient within the upper part of the water column, below 30 m depth it increases up to 18. In the western part of the basin a strong salinity gradient can be found. It is caused by a fresh water outflow at the sea surface beginning at 12°00'E and the salty inflow at the bottom reaching 12°00'E and rests of it even further eastwards. This inflow also has a big influence on density distribution and is the reason for high salinity at the bottom of C section.

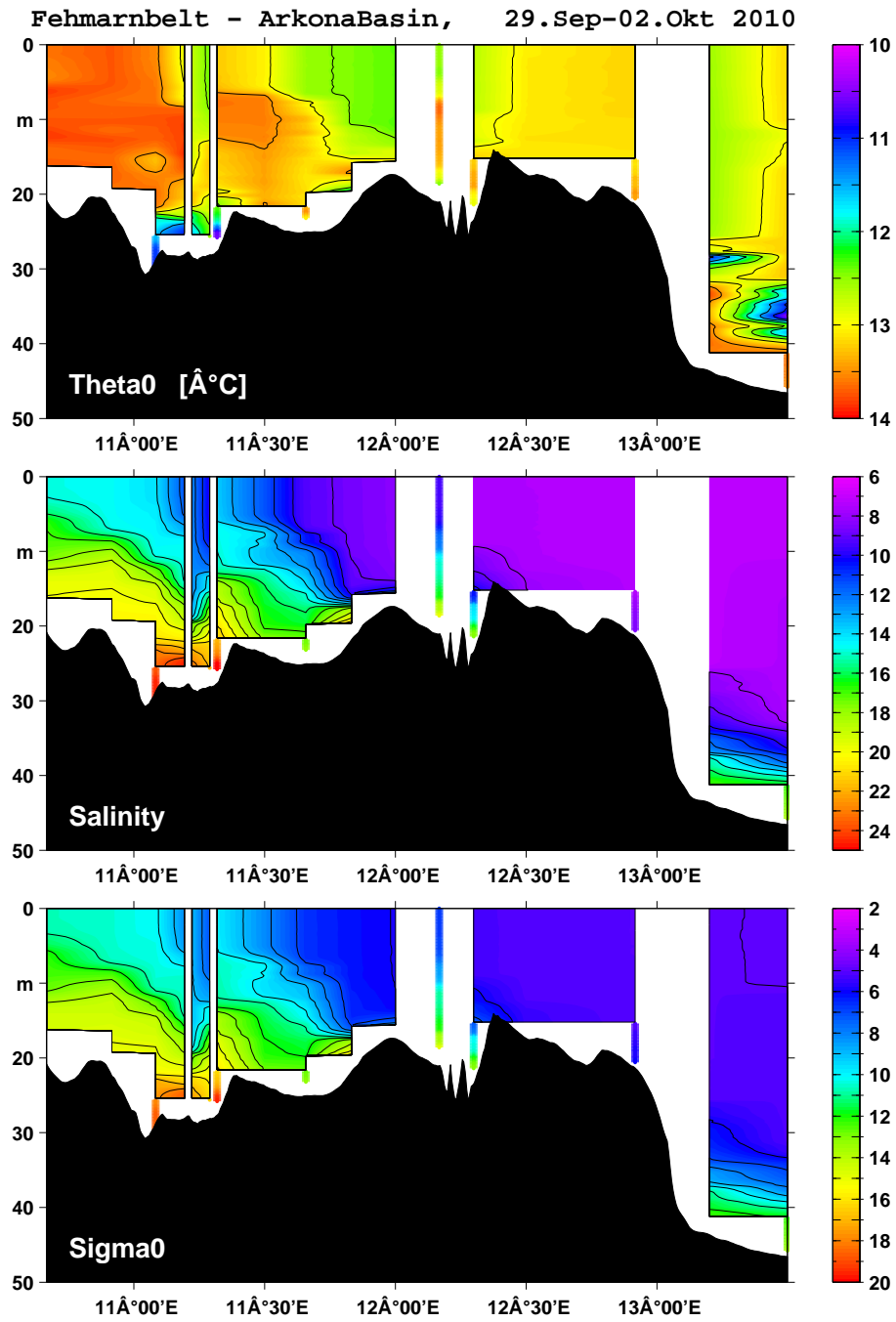


Figure 4.13: Temperature, salinity, and density as measured along the Zonalsection. 29. Sept. to 02. Oct. 2010

# Chapter 5

## Equipment/instruments

### 5.1 Technical: Mooring V431

Mooring deployment site V431 is located in the military zone of Marienleuchte at the south-eastern opening of the Fehmarnbelt. Water depth is about 28m. V431 consists of a Aanderaa RDCP600, serial 227 with temperature (serial 2639, type:3621), conductivity (serial 85, type: 4019A), oxygen optode (3830) and a self containing T/S recorder of type SBE-MicroCat (serial number 2936). The ADCP was programmed to record every hour, the MicroCat every 15 minutes. The MicroCat that worked without a problem (see Figure 4.1) is currently used as a backup for the T/C sensors that are in the RDCP600.

The Aanderaa RDCP600 is configured for current recordings in 1.5m depth cells covering the whole water column. So far no 100% successful deployment can be reported. First installation attempt was done in Sept. 2008 - but failed because of a flooded releaser. A few days later a new deployment was started but no data was recorded - probably due to a battery failure (self configuration). In June 2009 the next deployment started - with an original Aanderaa 35Ah battery which was recovered in September 2009 - only a few days of data were recorded for unknown reasons. In September 2009 another deployment started which was recovered during this cruise (AL362). During this deployment the RDCP600 was working for about 2.5 month - but finally stopped recording because of a low battery voltage (the battery was not replaced in June 2009 and had at that time already less than 7 V).

Comparing the T/S records from the RDCP600 and from the SBE37 (Figure 4.2 and 5.1) reveals obvious differences. In particular a strong deviation between the sanity (conductivity looks similar) measurement can be seen, reasons is known at this stage. The difference between the temperature sensors follows a linear drift, but it is unclear which sensor drifts or why a drift occurs.

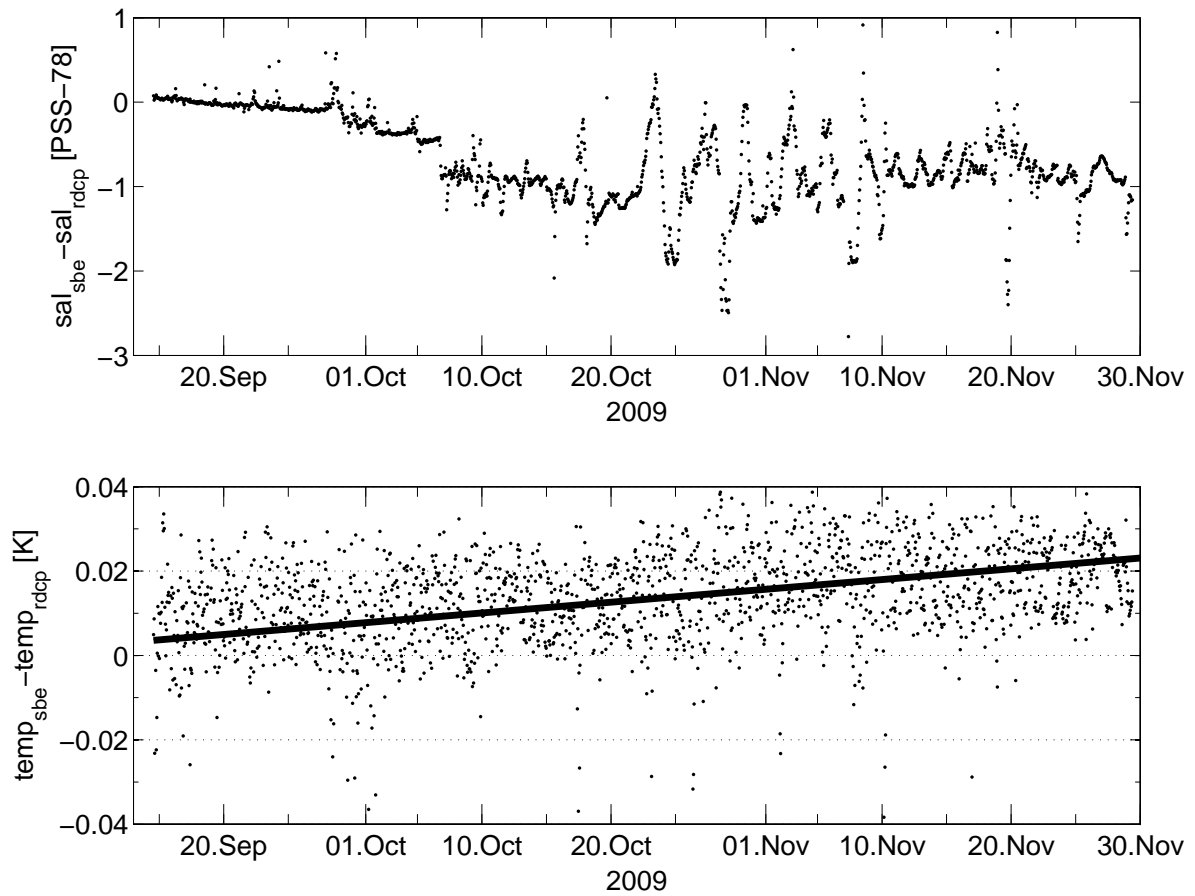


Figure 5.1: *Difference between SBE37 and RDCP600: (upper) salinity (Aanderaa Conductivity Type 85) and (lower) temperature (Aanderaa Type 3621).*

## 5.2 CTD/Rosette and Salinometer

### 5.2.1 CTD

A Hydro-Bios CTD was used during the cruise. For calibration of the conductivity sensor a Beckman Salinometer has been used.

### 5.2.2 Salinometer

For our salinity reference measurements we used a Beckman Salinometer on board of the Alkor. The Beckman Salinometer makes use of the inductive method to determine conductivity. Its main task lies in comparing the conductivity of standard water to that of a sample. For salinity measurements, the temperature effect is very important, because conductivity depends on both, temperature and salinity. As such the temperature of the sample has to be measured by the Beckman Salinometer too. Before measuring the collected samples, they have to stay in the laboratory for at least a day to adjust to the room temperature. Due to this procedure, large temperature deviations can be eliminated.

We can assume an accuracy of 0.003 if the temperature difference between sample and environment is less than 1K (according to manufacturer). We needed a repeat accuracy of 0.01 for at least 3 consecutive measurements of each sample during our salinity measurements on board of the Alkor. A calibration was required indeed before analysing the samples. For the calibration, we used Standard Water, which had a salinity of about 35. During our first CTD cast, we collected a larger amount of seawater, with an unknown, but constant salinity. We will refer to this as the “substandard”. To check whether there is a drift of the salinometer, we measured the substandard after every second sample. As long as a reference value existed, there is a proper operating mode of the salinometer. After every single sample measurement, the salinometer had to be expurgated and purged to get rid of the remnants of former samples. The CTD-samples were taken from depths with small temperature and salinity gradients. The accuracy of this measurement is 0.002 (according to manufacturer again).

First, we compiled a plot showing the measured substandard values with their variations over time (figure 5.2). The black line is the mean salinity value, while the blue crosses are the values of each single measurement of substandard (mean value of 2-4 measurements with discrepancies less than 0.01). The blue dotted lines represent the range of the standard deviation. The mean salinity is approximately 19.71, while the standard deviation is around 0.02 which means by comparing it with the accuracy of the salinometer (0.003), that we measured not properly or there was something wrong with the instrument. You can recognize a strong variation in the distribution of values from spot to spot. This can happen if the instrument was not properly purged and expurgated and so some rest of former samples may have altered the sample. Another reason could be that still some temperature fluctuations have not properly accounted for. If just the temperature difference between the substandard and the environment was more than 1K, the conductivity variations are great and so do the salinity. Last but not least there could be deviations since the vacuum pump was not permanently working properly. It had to get fixed in

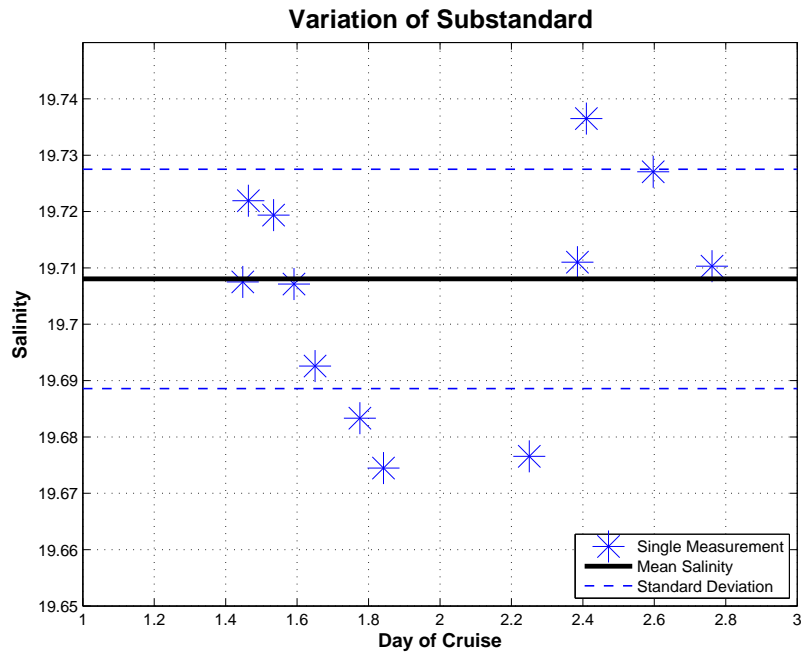


Figure 5.2: *Variation of substandard against time*

the beginning of the measurement and was not quite working bubble-free. A temporal drift of the salinometer could not be detected due to the large standard deviation of measurements.

In the next step we examined whether we could detect a drift of the CTD salinity measurements against time and pressure or not. Therefore we took the mean salinities for each sample bottle of the CTD profiles (measured with the salinometer) and subtracted the CTD measured salinity at the depth where the Niskin bottles were closed. We plotted the differences against time and pressure at the top of figure 5.3.

First of all there is no obvious drift of the CTD salinity data against time or pressure detectable. The scattering of the differences is once again very large (up to 2 in individual cases) but they are not significantly in- or decreasing with time and pressure. The accumulation of great deviations at low pressures for examples is due to less data in higher depths. One can also see rather large differences between CTD and salinometer salinities for some of the samples. Therefore we splitted the data in two separate ranges. Bearing in mind the standard deviation for substandard water of 0.02 (assumed accuracy of the salinometer) and uncertainty of the CTD measurements we marked every data point with an absolute difference greater than 0.1 with a red cross, smaller or equal than 0.1 with a blue cross.

The more precise distribution of the points with differences smaller or equal than 0.1 is shown in the bottom plots of figure 5.3 respectively their histogram in figure 5.4 . Considering the small amount of overall measurements the plot in figure 5.4 fits approximately the form of a Gaussian

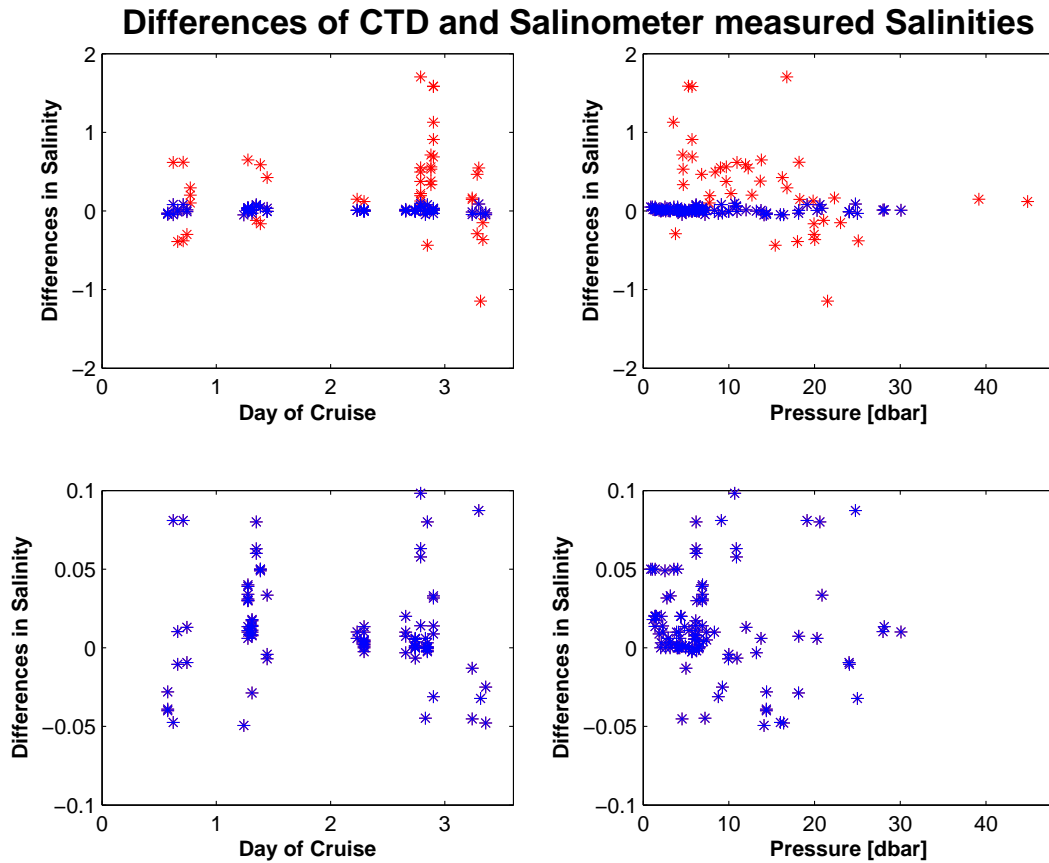


Figure 5.3: Differences between CTD and salinometer measured salinities against time (left) and pressure (right). Red crosses with absolute difference greater than 0.1.

distribution, it's normally distributed.

The differences greater than 0.1 (red crosses) are not explainable with measuring inaccuracy of the conductivity sensors alone, thus questioning the exactness of the extraction of the water samples. The Niskin bottles have a height of 85 cm each, which means that they store nearly 1 m of the water column inside when they get closed. Therefore the salinometer can only measure the mean salinity of this sample, leading to an unavoidable difference to the much smaller conductivity sensor of the CTD. In regions with small water depth associated with steep salinity gradients (like the Baltic Sea) this error gets even bigger.

The CTD-cast 024, with a very small water depth of 10 m, is used as an example. The data shows that bottle 2 of the rosette was closed between a depth of 5-6 m. In the vertical profile you can see, that this is the range of the steepest salinity raise of several psu per meter. With a bottle length of nearly 1 m water of several psu difference is mixed in the bottle. Compared with the CTD sensor there is a difference of about 1.6 (compare highest red cross in figure 5.3, top left plot).

Nevertheless, the Gaussian like distribution of differences for the samples with small devia-

tions give suggest a well calibrated CTD.

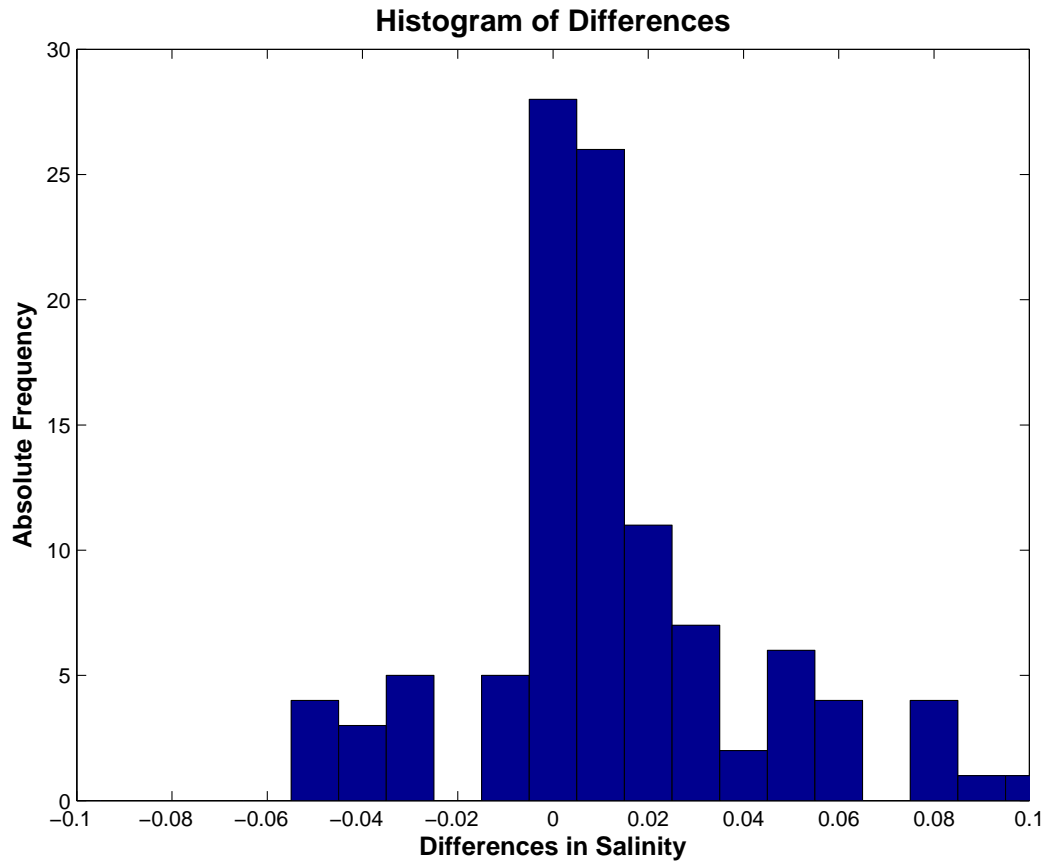


Figure 5.4: Histogram of CTD and salinometer absolute differences less than 0.1 (cf. blue crosses in figure 5.3)

## **5.3 Underway Measurements**

### **5.3.1 WERUM**

ALKOR has a new central data collection system from WERUM. The system worked perfect during the cruise and facilitated our work in providing on-line cruise map, a downloadable station book as well as export of relevant data. The WERUM is a substitute for the former 'DATADIS' system that caused a lot of trouble during the last years and we are very happy that this new WERUM system was installed on ALKOR.

### **5.3.2 Navigation**

ALKOR has a GPS navigational system as well as a gyro compass available and distributed via WERUM. The WERUM map viewer allowed to follow the cruise track online. A caveat so far is that the data is not easily accessible from any port. A THALES 3011 DGPS system was also installed which provided the navigational data (including ships heading) for the ADCP system.

### **5.3.3 Meteorological Data**

Since March 2006 ALKOR is equipped with a so called automatic weather station which should acquires the basic meteorological parameters (air temperature, wind speed and direction, wet-temperature, humidity, air-pressure). Shortwave radiation is also measured. Long wave radiation is recorded with an EPLAB (Eppley Laboratory, Inc.) Precision Infrared Radiometer (Model PIR).

### **5.3.4 Echo sounder**

The ER 60 SIMRAD echo sounder was activated during the cruise.

### **5.3.5 Thermosalinograph**

The thermosalinograph (TSG) on ALKOR is permanently installed at about 4m depth, takes up about one litre per second.

### **5.3.6 Vessel mounted ADCP**

A 600kHz workhorse ADCP from RD Instruments was mounted in the ships hull. The vmADCP is used with bottom tracking mode. Navigational data (including ships heading) is available via a THALES 3011 dGPS system.

# **Chapter 6**

## **Acknowledgement**

Thanks to Norbert Hechler (master), Rainer Nannen (1st) and Dierck Thüsam (2nd officer) and all the crew of ALKOR a successful and comfortable cruise could be performed.

# Chapter 7

## Appendix

### Station table

Station #, latitude, longitude, Depth, Year, Month, Day, Hour, Minute, position code

1	54.5663	10.6665	21	2010	09	29	13.82	1	0	0	0	0
2	54.6082	10.9160	23	2010	09	29	14.97	1	0	0	0	0
3	54.5917	11.0832	32	2010	09	29	15.90	1	0	0	0	0
4	54.5473	11.1625	11	2010	09	29	16.67	0	1	0	0	0
5	54.5672	11.1852	29	2010	09	29	17.05	0	1	0	0	0
6	54.5835	11.2083	28	2010	09	29	17.50	1	1	0	0	0
7	54.6000	11.2247	28	2010	09	29	17.83	0	1	0	0	0
8	54.6117	11.2410	24	2010	09	29	18.20	0	1	0	0	0
9	54.6252	11.2575	21	2010	09	29	18.53	0	1	0	0	0
10	54.3997	12.1673	21	2010	10	01	5.78	1	0	0	0	1
11	54.3570	12.0003	18	2010	09	30	6.67	1	0	0	0	0
12	54.3495	11.8323	22	2010	09	30	7.50	1	0	0	0	0
13	54.3510	11.6577	26	2010	09	30	8.40	1	0	0	0	0
14	54.3502	11.4987	24	2010	09	30	9.27	1	0	0	0	0
15	54.5225	11.3040	28	2010	09	30	10.67	1	0	1	0	0
16	54.8583	13.2000	44	2010	10	01	5.57	1	0	0	0	0
17	54.9165	13.4990	48	2010	10	01	7.05	1	0	0	0	0
18	54.8082	12.9165	22	2010	10	01	15.78	1	0	0	0	0
19	54.6333	12.4998	18	2010	10	01	17.82	1	0	0	0	0
20	54.5488	12.2992	24	2010	10	01	18.93	1	0	0	0	0
21	54.4673	12.1648	11	2010	10	01	19.93	0	0	0	0	1
22	54.4335	12.1655	26	2010	10	01	20.35	0	0	0	0	1
23	54.3590	12.1985	18	2010	10	01	21.10	0	0	0	0	1
24	54.3252	12.2163	13	2010	10	01	21.62	0	0	0	0	1
25	54.5223	11.3035	28	2010	10	02	5.75	1	0	1	0	0
26	54.5472	11.1618	10	2010	10	02	6.78	0	1	0	0	0
27	54.5667	11.1852	28	2010	10	02	7.13	0	1	0	0	0
28	54.5833	11.2070	28	2010	10	02	7.52	1	1	0	0	0
29	54.6015	11.2243	28	2010	10	02	7.98	0	1	0	0	0

30	54.6122	11.2423	24	2010	10	02	8.30	0	1	0	0	0
31	54.6258	11.2587	20	2010	10	02	8.60	0	1	0	0	0