Scientific cruise report – SUMMIX-MESO 2012

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Completed, 16.11.2012

Rendevouz on sea between the research vessels ELISABETH MANN BORGESE and METEOR in the Central Gotland Sea.

Contents

Basic information

Ship:	RV Elisabeth Mann Borgese
Cruise:	06EZ1212 (SUMMIX-MESO 2012)
Date:	July 06-19, 2012
Captain:	Volker Ziegner
Chief scientist:	Prof. Hans Burchard, Leibniz Institute for Baltic Sea Research Warnemünde

Objectives

It was intended to investigate the meso-scale and sub-meso-scale dynamics of the upper layers (upper 80 m) in the central Baltic Sea, using towed instruments and acoustic profilers, to better understand the physical conditions for cyanobacteria blooms. Under optimal weather conditions, we intended to carry out 10 one-day quasi-synoptic surveys by cruising in large meandering patterns (see fig. 1) covering areas of 15 X 15 nautical miles or 8 X 8 nautical miles, depending on the survey mode, see below. This cruise was the meso-scale component of the two-ship SUMMIX experiment together with RV Meteor (Physical and biochemical exchange-, mixing- and transformation processes in the central Baltic Sea during summer stratification and their controls on the cyanobacterial summer bloom) which was intended to be located at a fixed position nearby RV Elisabeth Mann Borgese in order to survey the water column in high vertical, spatial and parameter resolution, including biogeochemical experiments on board. In addition to the physical parameters, also vertical and horizontal zooplankton net tows as well as water samples taken by CTD bottles were planned.

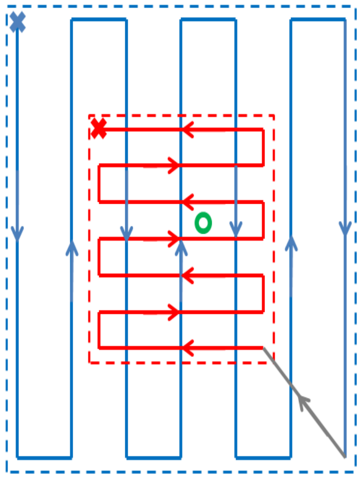


Fig.1: Typical meandering patterns which will be used for the three modes. Blue: 15 X 15 nm domain for the hydrography and the fine-structure modes; red: 8 X 8 nm domain for the micro-structure mode. These domains will be located inside the target area (19°20’E, 56°40’N & 20°50’E, 57°50’N) shown in the sea chart in fig. 2. The exact location will depend on the location of meso-scale eddies as identified by means of satellite images.

The work programme was planned to alternate between three different observational modes:

1. Hydrography mode (15 X 15 nm areas), using Scanfish, towed ADCP (300 – 1200 kHz), ship ADCP (600 KHz).

2. Fine-structure mode (15 X 15 nm), using towed CTD-chain, towed ADCP (300 – 1200 kHz), ship ADCP (600 KHz).

3. Micro-structure mode (8 X 8 nm), using towed horizontal micro-structure profiler, free-falling microstructure profiler (operated from the cruising ship using winches), towed ADCP (300 – 1200 kHz), ship ADCP (600 KHz).

During some of the surveys, a multi-beam echosounder (200-400 KHz) which is built into the hull of the ship, was used in hydrography mode to scan the hydrography and zooplankton signatures of the upper 80 m of the water column.

At the beginning and at the end of each survey, CTD-casts and plankton net casts were carried out within the target area (see figure 2).

The sequence and number of surveys within each of the three modes depends on the weather conditions. Under ideal conditions, we will carry out the following sequence of the modes: 1-2-3-1-2-3-1-2-3-1.

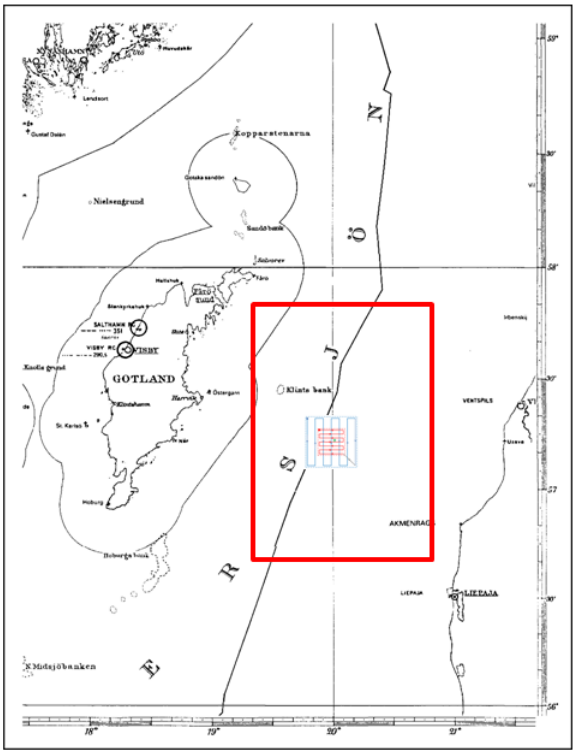


Fig. 2: Target area for the Summix-Meso cruise.

Staff of scientific crew

1. Hans Burchard	Chief Scientist, MSS-Profiler	IOW
2. Ulf Gräwe	MSS-Profiler, Scanfish, ADCP	IOW
3. Johannes Becherer	MSS-Profiler, Scanfish, ADCP	IOW
4. Toralf Heene	MSS-Profiler, Scanfish, ADCP	IOW
5. Kaveh Purkiani	MSS-Profiler, Scanfish, ADCP	IOW
6. Knut Klingbeil	MSS-Profiler, Scanfish, ADCP	IOW
7. Ulrich Bathmann (from 12.07.)	Zooplankton	IOW
8. Chistina Augustin (to 12.07.)	Zooplankton	IOW
9. Marcus Weinkauf	CO2/O2-Throughflow	IOW
10. Heinz-Volker Fiekas	CTD tow chain, TIMOSS	FWG
11. Michaela Knoll	CTD tow chain, TIMOSS	FWG
12. Jens Benecke	CTD tow chain, TIMOSS	FWG
13. Björn Ernst	CTD tow chain, TIMOSS	FWG
14. Jens Schneider v. Deimling	Day 1:: Multibeam echo sounder	GEOMAR

Towed equipment

Catamaran with ADCP (provided by FWG): Equipped with 2 ADCPs (1200 kHz & 300 kHz) which can be alternatedly switched on and off.Further equipment: Weatherstation, wave camera, thermosalinograph. The catamaran can only be used under fairly calm wave conditions, and was therefore only used during two days.

Free-falling micro-structure profilers (provided by IOW & FWG): The plan was to preliminary use the IOW profiler which however had been reported from the cruise before to show an increased noise level. Therefore, the FWG profiler was exclusively used during the cruise. IFWG provides a power block winch which allows profiling at up to 4 knots.

Horizontal microstructure profiler (provided by FWG): This profiler can only be deployed under calm conditions and was therefore not used during the cruise.

Towed CTD chain (provided by FWG): This chaoin has a length of 117 m which results at cruising at 4 knots about 80m profiling depth. It is equipped with 91 CTD fins of which 5 are additionally equipped with O2 sensors (30, 40, 50, 60, 70 m). Some of the conductivity sensors are defect such that interpolation from adjacent sensors will be carried out. The CTD chain will be uploaded before the cruise in Rostock-Marienehe and downloaded in Kiel at FWG.

Scanfish (provided by IOW): The Scanfish is IOWs standard tool to measure long and quasi-synoptic transects, but unfortunately got damaged during the first deployment (see narrative of the cruise).

Cruise track

The cruise track included long transits to and from the focal area in the Eastern Gotland Basin (including a harbor call in Roenne on the way out to let Lens Schneider von Deimling leave the ship) plus transits from the focal area to outside of Ventspils to exchange Christina Augustin with Ulrich Bathmann (see figure 3, upper panel).

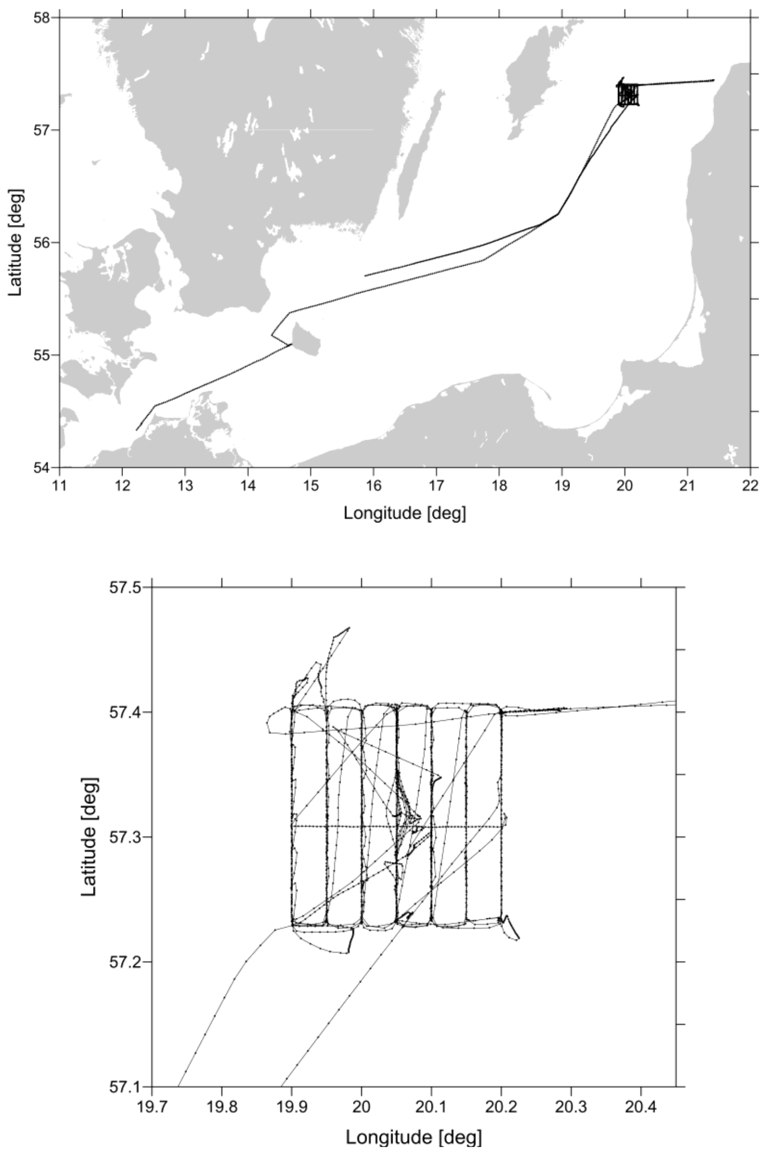


Fig. 3: Cruise track including transits to and from the focal area and to and from Ventspils (upper panel) and cruise track inside the focal area, where the meandering pattern is clearly visible (lower panel).

Weather conditions

The weather conditions during the cruise as observed from the weather station of the research vessel are shown in figure 5. Conditions were generally stormy with westerlies up to Bf. 9.

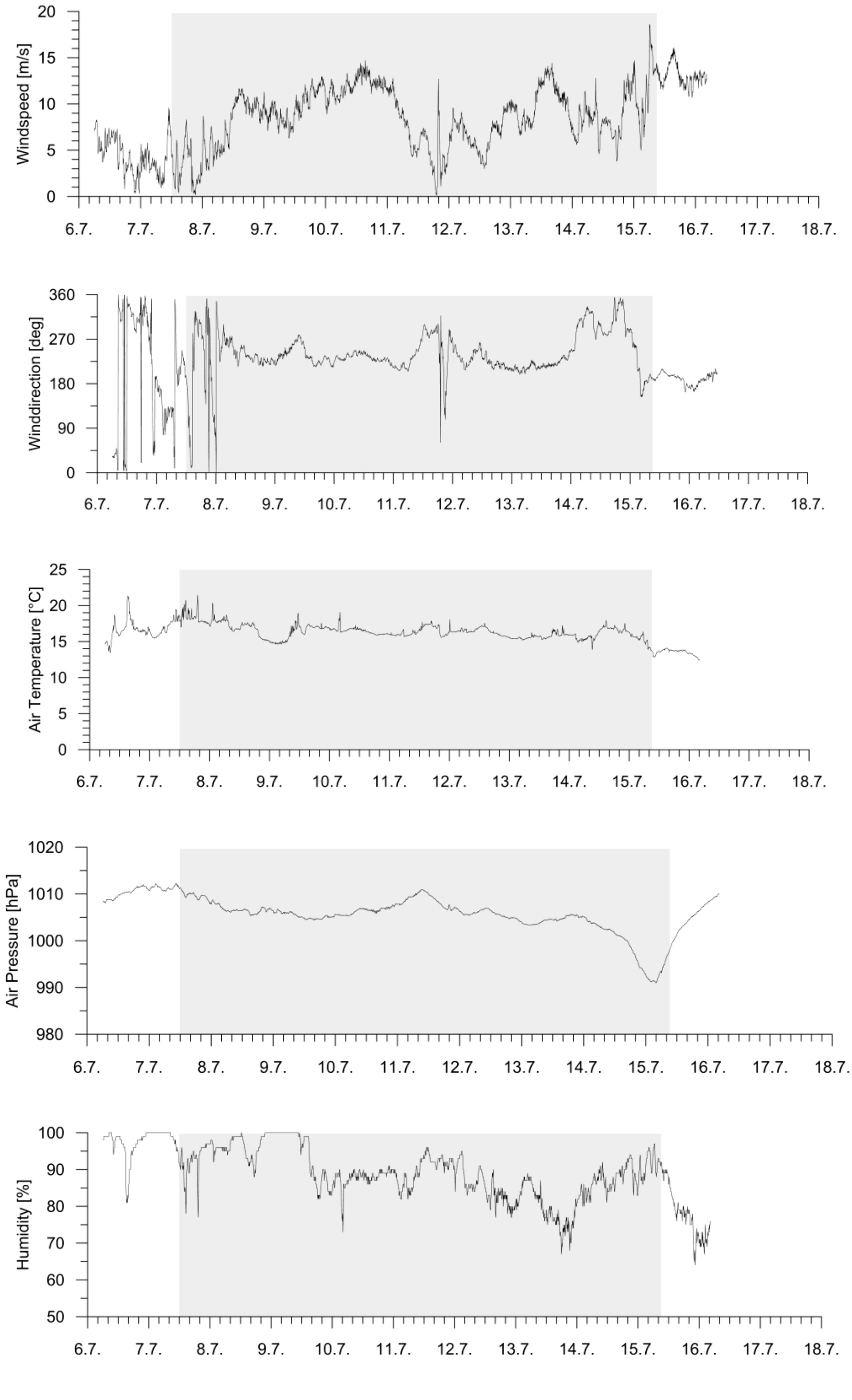


Fig. 4: Weather conditions during the cruise.

Narrative of the cruise

July 6 – July 7

6:30 h: Leaving Marienehe, delay because plankton net for Meteor had to be taken from IOW. Knut Klingbeil not on board because of sickness. Johannes Becherer on board instead during whole cruise (not only from Rønne onwards).

Rønne is reached around 17:00 h, Jens Schneider von Deimling leave the vessel to reach his plane from the airport. Around 18:00 h the vessel leaves Rønne heading for the target area around station TF 271 in the Central Gotland Sea.

TF 271 is reached around 16:00 h. Radio contact with the chief scientist of Meteor (Gregor Rehder) could be established. Gregor Rehder, Volker Mohrholz und Natalie Loick-Wilde (plus a chemistry technician) cameover to EMB by zodiac to receive two boxes with gear and to briefly discuss the coordination between the two vessels. Volker Mohrholz makes EMB scientists aware of a drifter buoy which had been deployed from the Meteor shortly before. This buoy sends ist position avery 20 mins. To Volker Mohrholz (Meteor) and Toralf Heene (EMB) via satellite phone.

The watches on EMB are organised as follows:

Watch I: 00-04, 12-16: Volker Fiekas, Kaveh Pukiani, (Toralf Heene)

Watch II: 04-08, 16-20: Michaela Knoll, Ulf Gräwe, (Jens Benecke)

Watch III: 08-12, 20-00: Björn Ernst, Johannes Becherer, (Hans Burchard)

(in brackets only for micro-structure mode). Note that all times in this narrative are in Middle European Summer Time.

As first observation from EMB a pure scanfish matrace is planned (07.07.-08.07.), see appendix for the track. It is attempted to drive the scanfish down to 90m, because otherwise it end inside the steep density gradient in 80m (see example CTD profiles in the appendix). Start of the scanfish matrace is July 7, 19:00 h at 10 nm X 10 nm size and station 271 (57°19' N, 20°03' E) in the centre.

July 8

The scanfish transect had to be aborted in the morning of July 8 at 57°19.0' N, 20°06.0' E: around 3:00 h (during transect 5), because it got entangled with a sediment trap mooring set out by Meteor. The scanfish and the mooring could be retrieved, but the scanfish cable was damaged in a way that the scanfish could not be further deployed during the entire cruise. Still, the zooplankton multi net could be towed with the cable since the smaller drag compared to the scanfish.

Afterwards, Volker Mohrholz came to EMB by zodiac to help reparing the sediment trap mooring. The mooring was then, after Volker had left EMB redeployed around ½ nm west of its original position (57°19,044'N; 20°04,841'E).

Afterwards (without taking zooplankton profiles), a towed CTD (plus catamaran) matrace was carried out, starting at the NW corner:

M2_01: 57°24.0' N, 19°54.0' E

M2_02: 57°14.0' N, 19°54.0' E

M2_03: 57°14.0' N, 19°57.0' E

M2_04: 57°24.0' N, 19°57.0' E

At the end of this second transect however the SW wind had become so strong that the catamaran was endangered due to waves and could have become damaged on the next southward transect. Therefore CTD chain and catamaran were retrieved without damage, despite the uncomfortable weather conditions.

July 9

Afterwards, a complete 10 X 10 nm matrace was carried out until July 9 (6:00 h) without any towed instruments (only with vessel-mounted ADCP (150 kHz, 4m bins), pCO2 system and multibeam echo sounder (with data recording only for the central transect).

After breakfast on July 9, the catamaran was moved to the portside oft he working deck to allow undisturbed operation of the plankton multi net using the scanfish winch. The multi net was then deployed at the southern end of the central transect.

Afterwards, the free-falling micro-structure profiler is tested for a sinking speed of 0.7m/s (which works fine) and then the central transect is profiled northwards (with tail wind) until a depth of 90m at a cruising sped of 2.5 knots. Afterwards the central transect is taken southwards against the wind at 1.5 knots with 40 m profiling depth (end of profiles in the winter water). Finally, a cross pattern is driven around station 271 with 10 nm transect length first from east to west, then, after a transit to the north, a central transect southwards:

Corner points:

M4_01: 57°24.0' N, 20°03.0' E (profiling depth 90 m)

M4_02: 57°14.0' N, 20°03.0' E

M4_03: 57°19.0' N, 20°12.0' E (profiling depth 40 m)

M4_04: 57°19.0' N, 19°54.0' E

M4_05: 57°24.0' N, 20°03.0' E (profiling depth 40 m)

M4_06: 57°14.0' N, 20°03.0' E

July 10

Around 2:30 h during the final southward transect, the cable oft he micro-structure profiler breaks due to reverse rotation of the winch. Luckily, the profiler is not lost, because the loose end of the cable is twisted into the winch. Toralf and Jens cut 30 m of the cable and reconnect the profiler. Afterwards, the southward transect is completed.

The wind has increased over night to about SW force 6-7. Therefore, the CTD chain will not be deployed, and instead a CTD grid along the matrace is carried out with 1.6 nm distance between stations (see appendix).

Over night, the chief scientist became seasick and was not seen on deck until the afternoon of July 11.

July 11

The CTD grid is aborted around 16:00 h on July 11 because of decrease of the wind speed (now force 3-4) which means favorable conditions for the towed CTD chain. A multi net tow is carried out at the SE corner of the matrace, then the CTD chain is deployed and calibrated by means of 3 CTD profiles. Around 19:00 h a reduced matrace is carried out (without trabsects 2 and 6 of the matrace) and with catamaran.

M6_01: 57°14.0'N, 20°12.0'E

M6_02: 57°24.0'N, 20°12.0'E

M6_03: 57°24.0'N, 20°06.0'E

M6_04: 57°14.0'N, 20°06.0'E

M6_05: 57°14.0'N, 20°03.0'E

M6_06: 57°24.0'N, 20°03.0'E
M6_07: 57°24.0'N, 20°00.0'E
M6_08: 57°14.0'N, 20°00.0'E
M6_09: 57°14.0'N, 19°54.0'E
M6_10: 57°24.0'N, 19°54.0'E

July 12

Towed CTD chain observations are finished around 10:00 h at the NW corner of the matrace. The CTD chain is retrieved and the vessel transits to the NE corner. There, a CTD profile is carried out and a horizontal multi net tow is made. Afterwards, EMB transits towards Ventspils where it reaches the approach buoy around 16:0 h.

The exchange of Christina Augustin with Uli Bathmann through a pilot boat works very smoothly, and EMB can transit directly back to the NE corner of the matrace. There short (1nm) micro-structure transects are carried out (first eastwards and then westwards along the track of the horizontal multi net tow) which is then repeated by Uli Bathmann. Afterwards a reduced micro-structure matrace is carried out (50 m profiling depth) at a speed of 3 knots, leaving out transects 2 and 6:

M7_01: 57°24.0'N, 20°12.0'E
M7_02: 57°14.0'N, 20°12.0'E
M7_03: 57°14.0'N, 20°06.0'E
M7_04: 57°24.0'N, 20°06.0'E
M7_05: 57°24.0'N, 20°03.0'E
M7_06: 57°14.0'N, 20°03.0'E
M7_07: 57°14.0'N, 20°00.0'E
M7_08: 57°24.0'N, 20°00.0'E
M7_09: 57°24.0'N, 19°54.0'E
M7_10: 57°14.0'N, 19°54.0'E

July 13

The matrace is continued during the night. In the morning wind is increasing, in the afternoon force 7 is reached. Matrace is completed at 19:00 h.

Until 22:15 h, no observations due to bad weather conditions. Afterwards a CTD cast and a horizontal multi net track are carried out against the wind (from SW).

Around 22:50 h transit to NE corner of target area and start of a matrace (starting southwards) without towed instruments (only ADCP, thermosalinigraph, pCO2, acoustics), omitting the westernmost transect:

M8_01: 57°24.0'N, 20°12.0'E
M8_02: 57°14.0'N, 20°12.0'E
M8_03: 57°14.0'N, 20°09.0'E
M8_04: 57°24.0'N, 20°09.0'E
M8_05: 57°24.0'N, 20°06.0'E
M8_06: 57°14.0'N, 20°06.0'E
M8_07: 57°14.0'N, 20°03.0'E
M8_08: 57°24.0'N, 20°03.0'E
M8_09: 57°24.0'N, 20°00.0'E

M8_10: 57°14.0'N, 20°00.0'E
M8_11: 57°14.0'N, 19°57.0'E
M8_12: 57°24.0'N, 19°57.0'E

Completed: July 14, around 9:00 h.

July 14

Afterwards, a towed CTD chain matrace is started from the NW corner of the target area, initiated with 3 CTD casts (140m). It rains and the wind has force 5 from SE.

M9_01: 57°24.0'N, 19°54.0'E
M9_02: 57°14.0'N, 19°54.0'E
M9_03: 57°14.0'N, 19°57.0'E
M9_04: 57°24.0'N, 19°57.0'E
M9_05: 57°24.0'N, 20°00.0'E
M9_06: 57°14.0'N, 20°00.0'E
M9_07: 57°14.0'N, 20°03.0'E (on this track the CTD is retrieved due to too much wind)
M9_08: 57°24.0'N, 20°03.0'E
M9_09: 57°24.0'N, 20°06.0'E
M9_10: 57°14.0'N, 20°06.0'E
M9_11: 57°14.0'N, 20°09.0'E
M9_12: 57°24.0'N, 20°09.0'E
M9_13: 57°24.0'N, 20°12.0'E (abortion half way through this transect)
M9_14: 57°14.0'N, 20°12.0'E

Around the evening of July 14 increasing wind is forecasted. Therefore CTD chain is retrieved around 22:00 h. Matrace is completed without CTD chain (only ADCP, thermosalinigraph, pCO2, acoustics). At location of CTD retrieval, one horizontal multi net cast is carried out.

July 15 – July 18

In the morning the wind has increased to force 8-9, the throughflow for the thermosalinograph has to be switched off. Around 10:00 h, it is decided to abort the cruise and transit back to Warnemünde, since the weather forecast is not promising.

On July 16 arrival in Warnemünde at 21:30 h, EMB is staying at Passagierkay during night.

The next morning (July 17) IOW dismounts ist gear from EMB. One truck load goes to IOW, one goes to Marienehe. The yellow scanfish winch went to Marienehe as well, but had to be taken back to EMB, because it was supposed to be repaired in Kiel. EMB leaves Warnemünde at around 9:30, with only the FWG staff plus the chief scientist from IOW. The harbor at Marinearsenal Kiel is reached at 18:00 h.

On July 18 around 8:00 h dismounting EMB from FWG gear starts and is finished at about 11:30 h.

Problems detected during cruise

The navigational echo sounder disturbs the signal of the vessel mounted 150 kHz ADCP and was switched off during ADCP operation in deep waters.

The internet connection was problematic, since during northward and southwards courses of the ship the signal was gone.

It would be nice to include the AIS signal into the vessels internal network to allow recognition of own systems (such as drifters).

The cooperation with the crew of EMB was very efficient and friendly and they tried to help as much as possible to make the cruise a success.

Preliminary results from the research groups

Measurements with the towed CTD-chain (M. Knoll)

Design

The towed CTD-chain enables to carry out high-resolution hydrographic measurements of the upper ocean underway. Fins equipped with temperature and conductivity, often pressure and sometimes oxygen sensors are inductively coupled to a simply coated steel wire that can be towed with up to 6 kn (Fig. 5). To reduce the towing resistance the wire is covered with fairings. The curvature of the wire while towing depends on the speed and on the kind of depressor attached to the end. The data is stored and displayed online onboard the ship. The vertical resolution is up to the distance of the sensor fins, the horizontal resolution is determined by the sampling rate that depends on the number of attached sensor fins. Both resolutions are also affected by the towing speed.

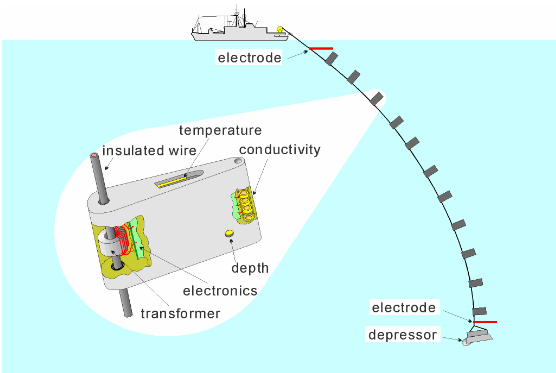


Fig. 5: Sensor fins and towing plan of the CTD-chain.

During the Summix experiment 91 sensor fins were attached to the wire with a distance of 1.3 m to each other. The sensors covered a depth range of approximately 6 – 95 m while 150 m of deployed wire were towed with 4 kn. This yields a vertical resolution of about 1 m. Since each sensor delivered data every 3 s the horizontal resolution along the transects was about 6 m. The CTD-chain was equipped with 5 oxygen sensor fins evenly distributed along the wire within a distance of 12.7 - 72.5 m to the depressor which corresponds to an approximate depth range of 36 to 84 m.

Measurements

During Summix the CTD-chain was operated three times (Fig. 6). The first deployment on July 8th was stopped after the two western meridional transects were completed. The second deployment on July 11th/12th started in the east and covered 5 meridional transects. The third deployment on July 14th starting in the west was stopped in the middle of the meridional transects due to bad weather conditions.

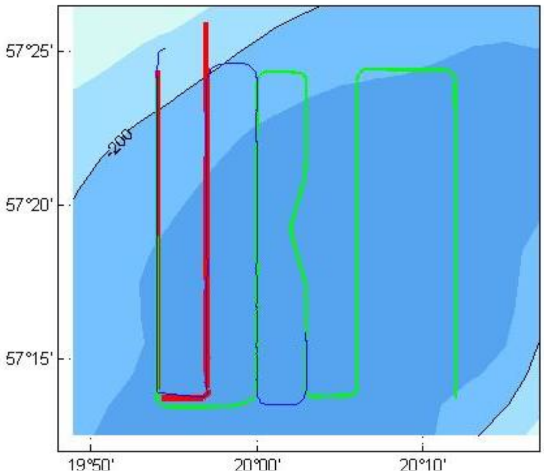


Fig. 6: CTD-chain tracks during the deployments on July 8th (red), 11th/12th (green) and 14th (blue).

A calibration of temperature and pressure sensors was carried out in the FWG laboratory in February 2012, while the last calibration of some conductivity sensors was conducted in August 2011, but most of them were calibrated earlier. Therefore, an in-situ calibration of the CTD-chain sensors was executed after each deployment. While the ship was drifting and the chain was hanging nearly straight down at the stern of the ship, several Seabird CTD-profiles were accomplished simultaneously for comparison at starboard side. The inhomogeneous hydrographic conditions in the water column made it difficult to adjust the CTD-chain data to the Seabird records. Nevertheless, the comparison between both instruments showed that the laboratory calibration of the temperature sensors is sufficient to achieve an accuracy of ±0.02°C. A final calibration of the conductivity and oxygen sensors of the CTD-chain still has to be carried out by assuming a mean stable stratification in the water column.

First Results

In general the surface temperature in the survey area was approximately 16°C and a strong thermocline was observed in 15 - 35 m depth (Fig. 7). The cold winter water with temperatures between 3 – 4°C covered the depth range of about 35 – 75 m, while the temperature below increased again up to 5°C in 90 m depth. The mean temperature profiles along the western meridional transect at 19° 54’ E during the three deployments showed a temporal change in stratification of the upper 15 m. Due to increased mixing caused by strong winds a well mixed surface layer appeared at the end of the cruise.

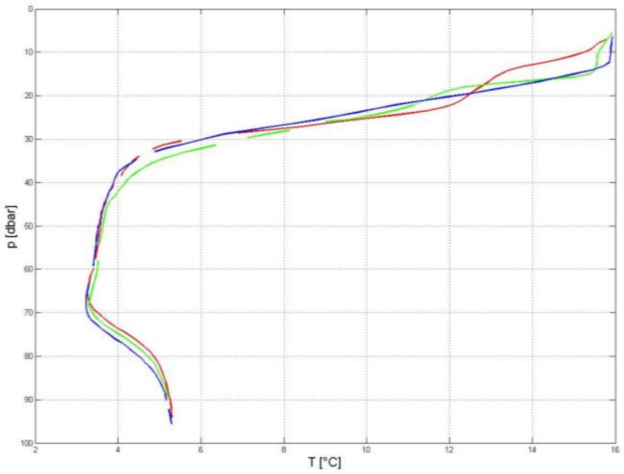


Fig. 7: Mean temperature profiles along the transects at 19° 54’ E during July 8th (red), 11th/12th (green) and 14th (blue).

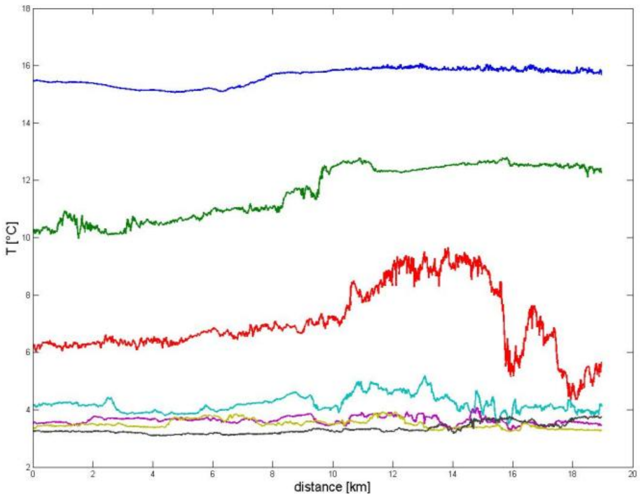


Fig. 8: Temperature along the transect from South to North at 19° 54’ E on July 12th on depth levels between 10 and 70 m every 10 m.

An example of the variability along the meridional transects is presented in fig. 8, showing the temperature on different depth levels versus the distance along the South to North transect at 19° 54’ E during the second deployment. Spatial variations were observed on all covered scales and in all depth levels. The highest variability occurred in the range of the thermocline. The spatial and temporal changes in the temperature stratification of all meridional transects obtained with the CTD-chain during the three different deployments are shown in fig. 9. A detailed analysis of the CTD-chain data will be carried out soon.

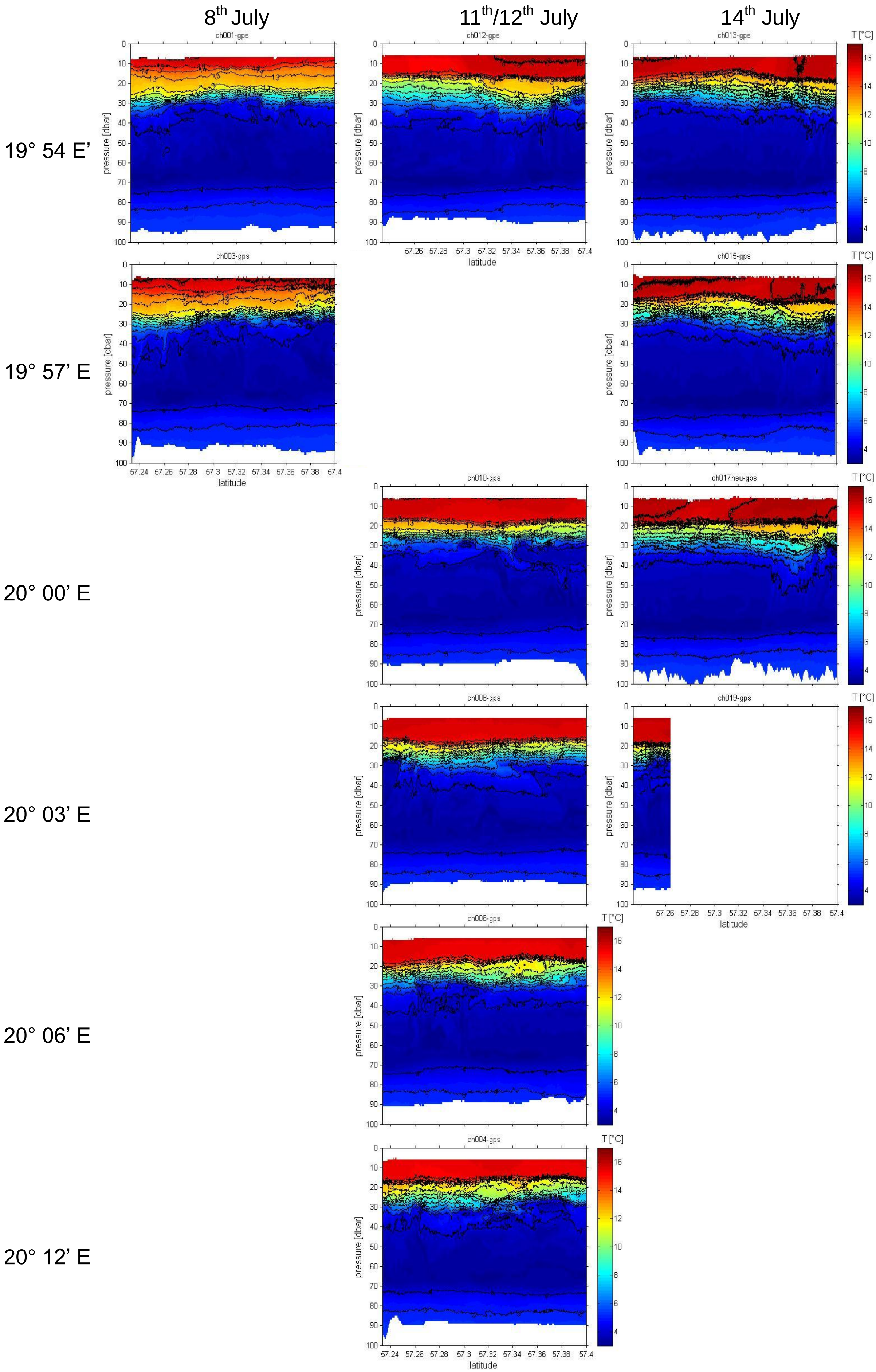


Fig. 9: Meridional temperature sections obtained with the CTD-chain during the 3 deployments.

Microstructure and turbulence measurements underway (V. Fiekas)

Instrumentation

It is state of the art to measure the vertical micro-scale stratification and turbulence using free-falling and highly resolving turbulence profilers from a ship on station. Tethered to a nearly neutral buoyancy cable, our profiler is usually balanced by additional weights for sinking velocities of approximately 0.7 m/s. To avoid cable-induced strumming effects contaminating the turbulence measurements, the cable should be released faster than the probe can sink.

The technical challenge is to perform undisturbed vertically profiling microstructure and turbulence measurements while the ship is sailing ahead with low speeds of 2 to 3 knots. For this reason, a special winch is equipped with a “power block” developed by ISW Wassermesstechnik Dr. Hartmut Prandke. The power block is able to launch the cable into the water faster than ship speed. Figure 10 shows the “power block” winch and the 1.3 m long microstructure and turbulence profiler (MSS) equipped with 2 highly sensitive airfoil shear probes to measure velocity fluctuations, a fast micro-thermistor to acquire thermal microstructures, standard precision CTD sensors and an acceleration sensor to record disturbing vibrations induced by the cable and housing. The sensor assembly is protected by a guard.

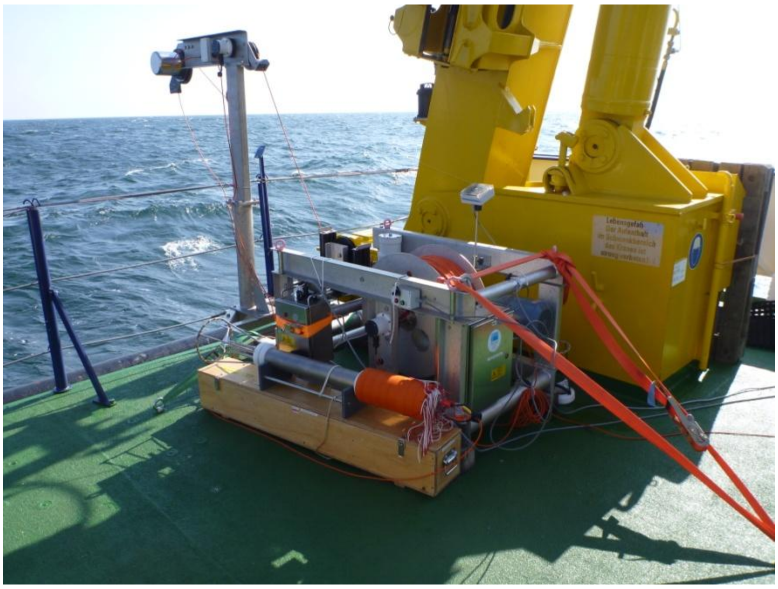


Fig. 10: Vertically free-falling microstructure profiler (MSS) on a wooden box in front of the special winch equipped with a „power block“ for turbulence measurements from a steaming ship.

Survey

During the submeso-scale survey of microstructure in the Central Gotland basin, the MSS profiler was deployed continuously from the steaming ship down to 50 and 100 m (for details see Table 1). A total of 661 profiles along 11 separate tracks were recorded during two survey periods from 9 to 10th and from 12 to 13th of June.

Track No.	Direction	Start				End				Depth	Profiles		#Profiles	Comments	
	[T°]	Date	Time (UTC)	Latitude	Longitude	Date	Time (UTC)	Latitude	Longitude	[m]	Begin	End			
1	360	09.07.2012	07:02:13	57°14.3493N	20°04.3334E	09.07.2012	11:53:03	57°23.8866N	20°03.0065E	100	1	48	48		Central section
2	180	09.07.2012	12:19:07	57°24.0098N	20°03.0284E	09.07.2012	19:58:25	57°14.0834N	20°03.0083E	50	49	205	157		Central section
3	270	09.07.2012	21:17:32	57°18.4819N	20°11.8594E	10.07.2012	03:31:32	57°18.5228N	19°54.1817E	50	206	302	97		
4	180	10.07.2012	04:31:59	57°23.9733N	20°03.0006E	10.07.2012	06:51:17	57°19.2687N	20°04.1493E	50	303	343	41		Central section
5	90	12.07.2012	17:37:55	57°24.0259N	20°11.9629E	12.07.2012	18:37:39	57°24.1787N	20°16.6894E	100	344	354	11		In advance of multinet track
6	270	12.07.2012	18:56:08	57°24.1712N	20°17.5595E	12.07.2012	19:28:12	57°24.1059N	20°16.3061E	100	355	361	7		In advance of multinet track
7	180	12.07.2012	21:18:21	57°23.9890N	20°11.9790E	13.07.2012	00:49:01	57°14.1183N	20°11.9964E	50	362	425	64		
8	360	13.07.2012	01:23:37	57°13.9272N	20°06.0569E	13.07.2012	04:46:34	57°23.9340N	20°06.0079E	50	426	480	55		
9	180	13.07.2012	05:11:42	57°24.0689N	20°02.9812E	13.07.2012	08:31:27	57°14.2137N	20°03.0073E	50	481	535	55		Central section
10	360	13.07.2012	09:01:37	57°14.2169N	19°59.9657E	13.07.2012	12:41:46	57°23.9281N	20°00.0110E	50	536	603	68	604 is missing	Strong Wind
11	180	13.07.2012	13:28:39	57°23.9568N	19°53.9966E	13.07.2012	16:51:59	57°14.1516N	19°54.0066E	50	605	661	58		

Table 1: Details of microstructure survey

Two different survey patterns were designed to acquire the spatial distribution of the oceanic microstructure and turbulence activities (Figure 11). Due to the bad weather conditions the horizontal microstructure profiler TIMOS was not used as initially planned.

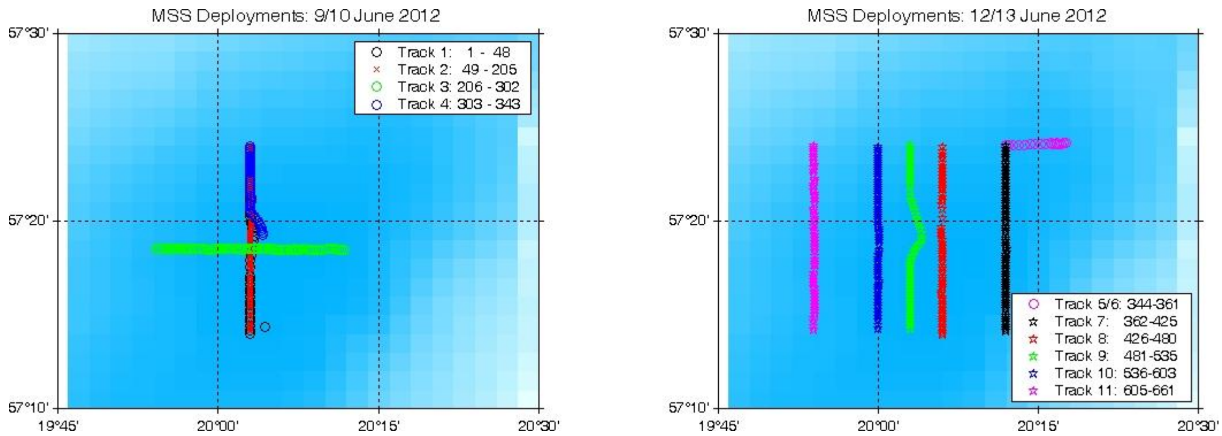


Fig. 11**:** Survey patterns during microstructure surveys taken June 9/10 and 12/13, 2012 in the central Gotland Basin. Each deployment is marked by a colored symbol. The different colors indicate the different tracks.

Preliminary results

Between the warm and fresh surface mixed layer above 12 m and the cooler but saltier Winter water below 40 m, an area was observed with a distinctive thermohaline fine structure (Figure 12a, b). This depth range was bounded above and below by strong pycnoclines (Figure 13a). The maxima of the Brunt-Väisälä frequency shown in Figure 13a expose the details of 3 clearly marked pycnoclines.

Figure 13b and c yield the vertical distributions of the turbulent kinetic energy dissipation rate ε and the thermal dissipation rate χ, presented as logarithm of ε and logarithm of χ. The depth range below the mixed layer was dominated by very low dissipation rates of 10^{-8} W/kg while the dissipation rate in the mixed layer was obviously higher than 10^{-8} W/kg. The penetration of higher dissipation rates from the surface corresponds to the increasing wind speed at 10:00 h. A slight deepening of the mixed layer of 2 to 3 m can be observed during that time (Figure 12 and 13a).

It has to be mentioned that the measured values of ε are close to the detection limit of 10^{-9} W/kg. Holtermann and Umlauf (2012) argued that the noise level of the current standard microstructure probes is at least more than a factor of 4 too high, in order to calculate the local mixing rate by means of ε. The thermal dissipation rate (Figure 13c) could be an alternative to describe the effect of turbulence.

Reference

Holtermann, P. and L. Umlauf (2012): The Baltic Sea Tracer Release Experiment: 2. Mixing Processes, J. Geophys. Res., 117,C01022, doi:10.1029/2011JC007445, 2012

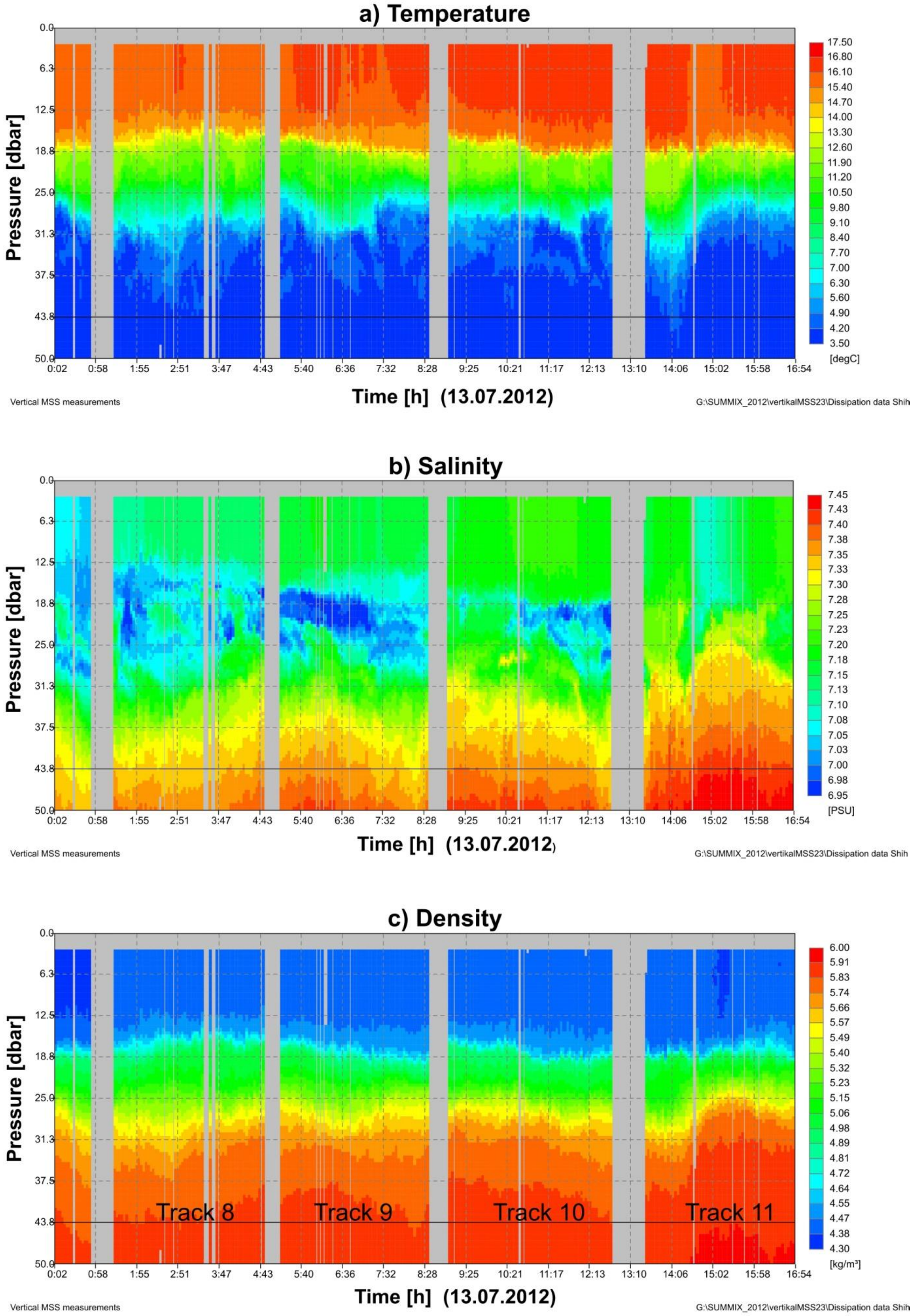


Fig. 12: Vertical sections of a) temperature T, b) salinity S, and c) density σ_t along the tracks 8 to 11 shown in Figure 2.

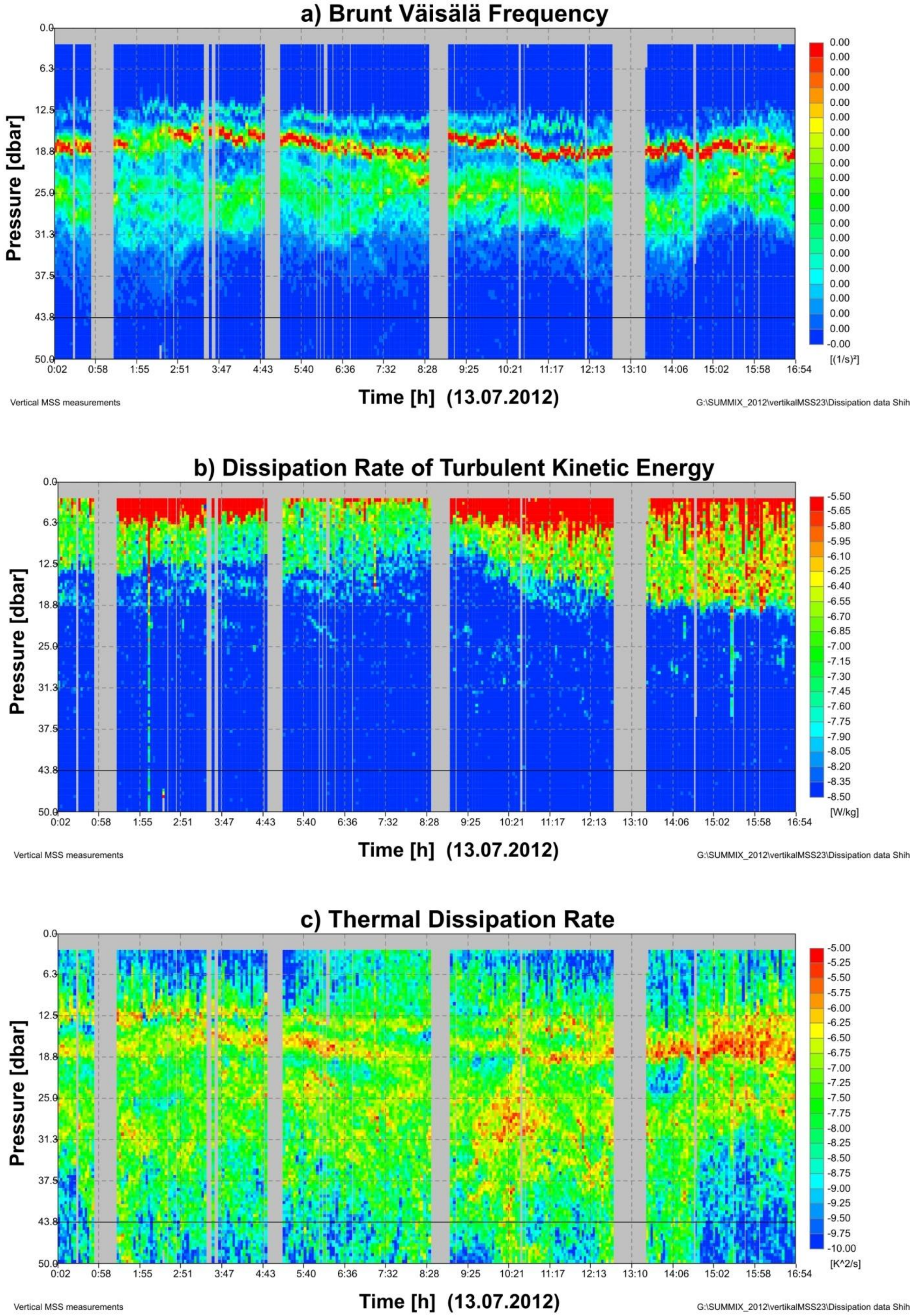


Fig. 13: Vertical sections of a) Brunt-Väisälä frequency N^2, b) logarithm of dissipation rate of turbulent kinetic energy $\log_{10}(\varepsilon)$, and c) logarithm of thermal dissipation rate $\log_{10}(\chi)$.

Biological sampling (C. Augustin, U. Bathmann, U. Gräwe, J. Schneider)

The aim of the study was the investigation on the spatial distribution of mesozooplankton in relation to high resulted horizontal and vertical hydrographical structures, which are mainly characterized by salinity and temperature. This investigation was mainly done by Ulrich Bathmann, Christina Augustin, Thorlaf Heene and Ulf Gräwe during this cruise and was in close cooperation with Nathalie Loick-Wilde on Bord of the RV Meteor, which was sampling in the Gotland Sea during the same time.

For each biological sampling a CTD was deployed in order to get samples from distinct water layers. This information about the actual salinity, temperature, oxygen and chlorophyll gradient was used to set the depth for the mesozooplankton sampling. For each of the biological stations, seawater from defined water layers was taken for determination of particle organic matter (carbon, nitrogen and partly phosphorus). After filtration, the samples were stored for later analysis in the laboratory at -20°C. We obtained 58 filters from 8 stations during the cruise.

Net samples were taken for the investigation of mesozooplankton distribution by means of a multiplanktonsampler (MPS) with 0.25 m^2 opening and 100 µm mesh size. The MPS was towed horizontally or vertically in 5 different water layers. During the SUMMIX cruise and due to the weather only 8 stations with 40 samples were accomplished. Each net sample was divided into two parts in order to estimate the zooplankton abundance and species composition as well as for measuring the phosphate content. For the zooplankton abundances samples were preserved in buffered formaldehyde (4%), while the other samples were frozen and stored at -80°C.

Mulitbeam measurements

The newly inbuilt multibeam sonar (R2 Sonic Control 2000) was used for the first time to record mesoscale hydrographical and biological structures of the water column with a frequency of 200-400 kHz. Since the system is quite new Jens Schneider v. Deimling (GEOMAR) joined the group during the first day (06.07.2012) to teach handling and the operation of the multibeam software. After arrival at the Gotland Sea at the destinated investigation area, the multibeam was started. Due to the high data output of the multibeam sonar, only selected transects were recorded. The multibeam data were additionally stored during the operations of the MPS. To have a continuous record of the sonar, only images were stored for the whole cruise. However, these images do not allow reconstructing the size spectra of mesozooplankton distributions.

First Results

The stratified water column in the Gotland Sea in July 2012 was sampled for zooplankton in 5 different layers due to temperature, salinity and oxygen gradients and the particle structure received from the multibeam (Figure 14). In the defined seawater layers we found specific zooplankton assemblages that will be analysed at home laboratory. The high resolutive records from the multibeam intensity indicated a close relation to zooplankton concentration. By comparing day and night time sampling data, we observed distinct vertical migration of copepods (Figure 15).

During the cruise a first qualitative observation of the composition of the zooplankton could be carried out. Young stages of calanoid copepods and rotifers inhabited the most upper layer. In this layer a peak of Chlorophyll a was detected, may be caused by cyanobacteria. In the cold winter water layer the calanoid copepods *Temora longicornis*, *Acartia longiremis* and *Centropages hamatus* were highly abundant. In the layer below 70 – 80 m, in the suboxic zone, only *Pseudocalanus* sp. and the dinoflagellate *Dinophysis* sp. were observed. The copepods in this area seemed to be very rich in oil indicating good feeding conditions. Below 90 m, in the anoxic zone, no copepods were sampled but there were phytoplankton organisms and organic particles (Figure 16). Further analysis will be conducted in the laboratories at the Leibniz Institute of Baltic Sea Research.

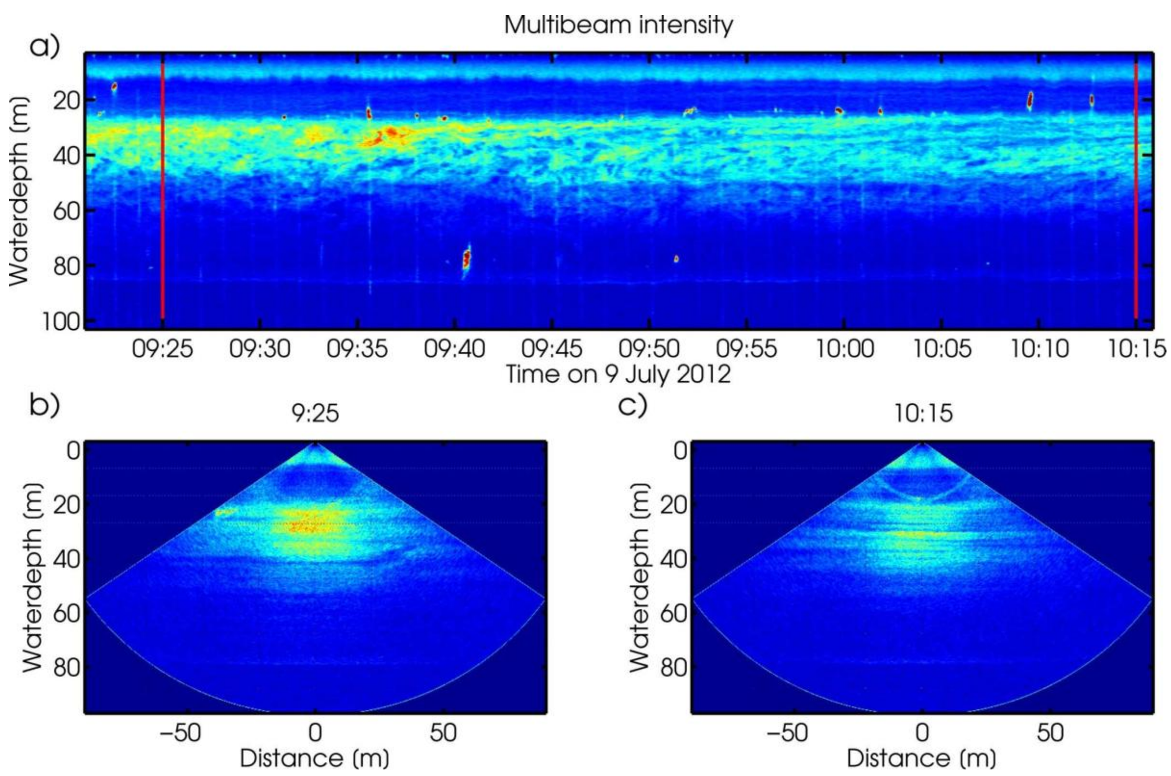


Fig. 14: Profiles of particle intensity detected by acoustic multibeam a) from 9:00 to 10:15 on the 9th of July between 0-100 m in the Gotland Sea. Particle distribution of a sector between 0-80 m is presented for 1b) 9:25 with high intensity and for 1b) 10:15 with lower intensity.

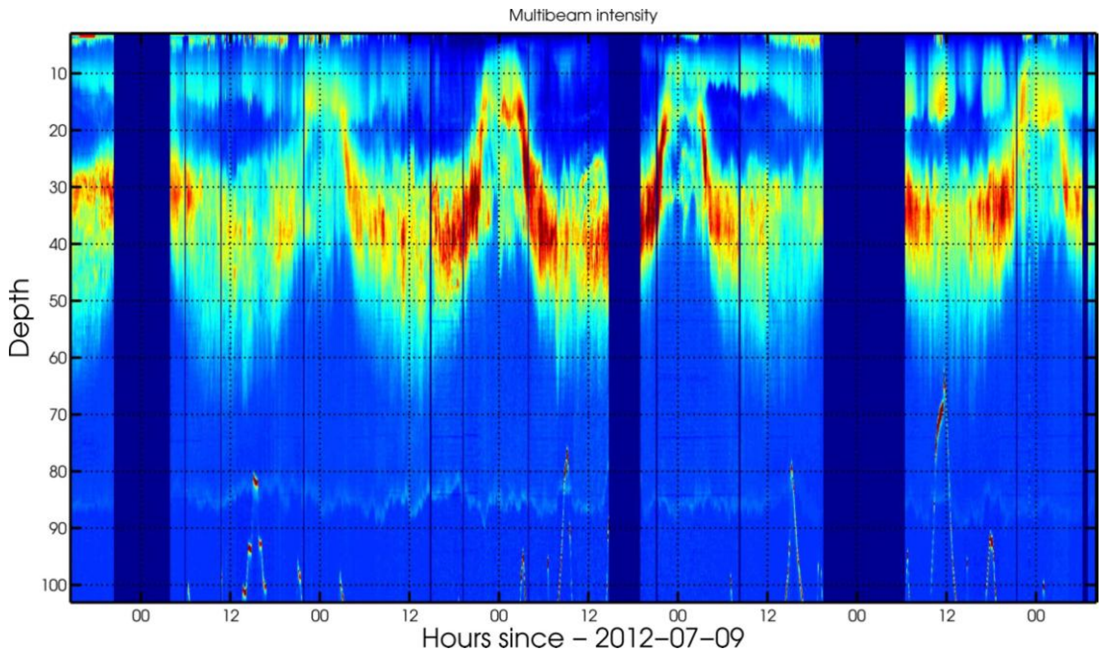


Fig. 15: Records of acoustic multibeam intensity from 09th - 13th of July between 0 - 100 m in the Gotland Sea.

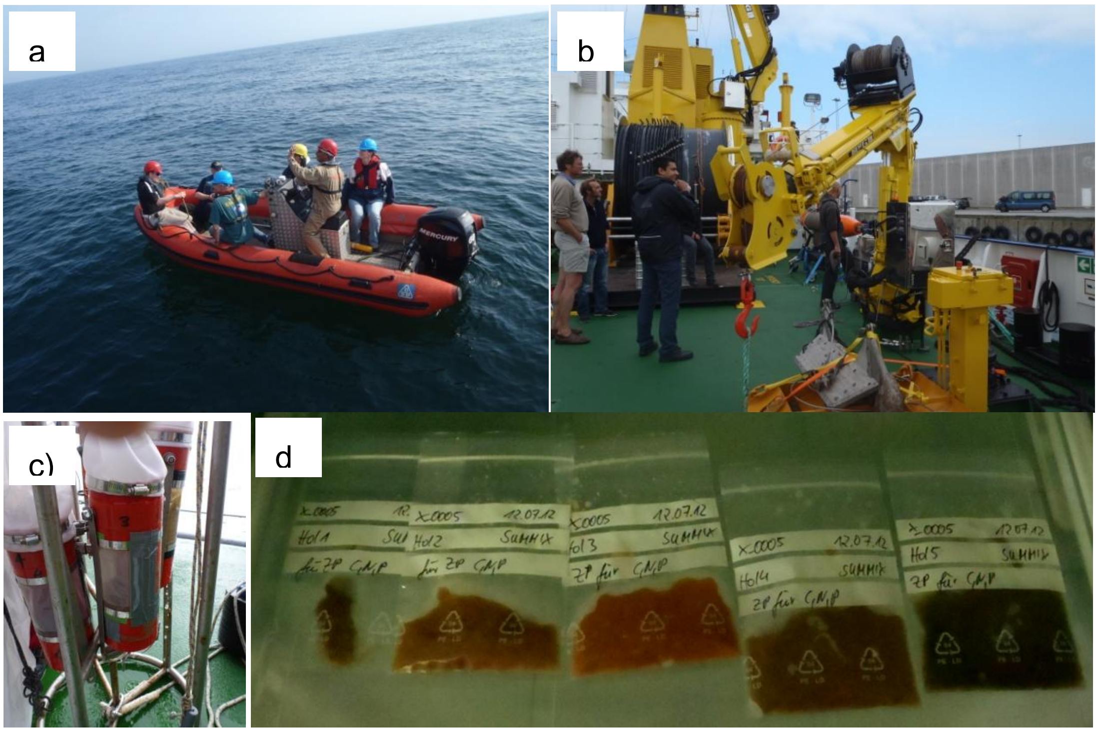


Fig. 16: Photos from the cruise a) Arrival of colleagues from RV Meteor b) Arrival in Bornholm to deliver Jens Schneider v. Deimling on 06.07.2012 c) Full cod ends after MPS sampling d) Frozen samples from one MPS sampling in 5 different depths.

Measurement of the CO2 partial pressure (M. Weinkauf, B. Schneider)

The surface water CO2 partial pressure, pCO2, was continuously recorded during the entire cruise. The purpose of the measurements was to support the concurrent carbon budget and nitrogen fixation studies on r/v Meteor (M87) at the central Gotland Sea station BY 15 and to contribute to the SUMMIX-MESO experiment by the identification of mixing events.

The variability of the pCO2 in the grid area was high with pCO2 values ranging from about 150 µatm to 190 µatm. A correlation with the surface temperature did not exist and a day-night cycle was also not observed. Both these observations indicate low biological activity. A distinct correlation existed between the pCO2 and salinity (Fig. xx) that reflects the different production history of the low and high salinity water in the east and west of the grid, respectively. Fig. 17 shows also that the pCO2 level increased by about 10 µatm during the duration of experiment. This can be explained by a deepening of the mixed layer depth due to the windy weather.

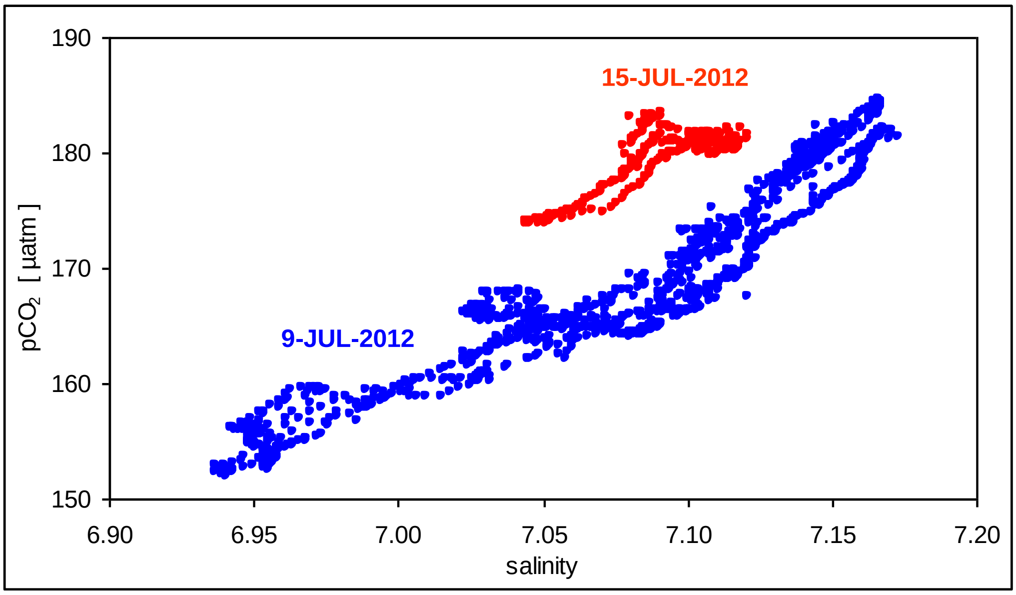


Fig. 17: The pCO2 as a function of salinity at the beginning and the end of the experiment.

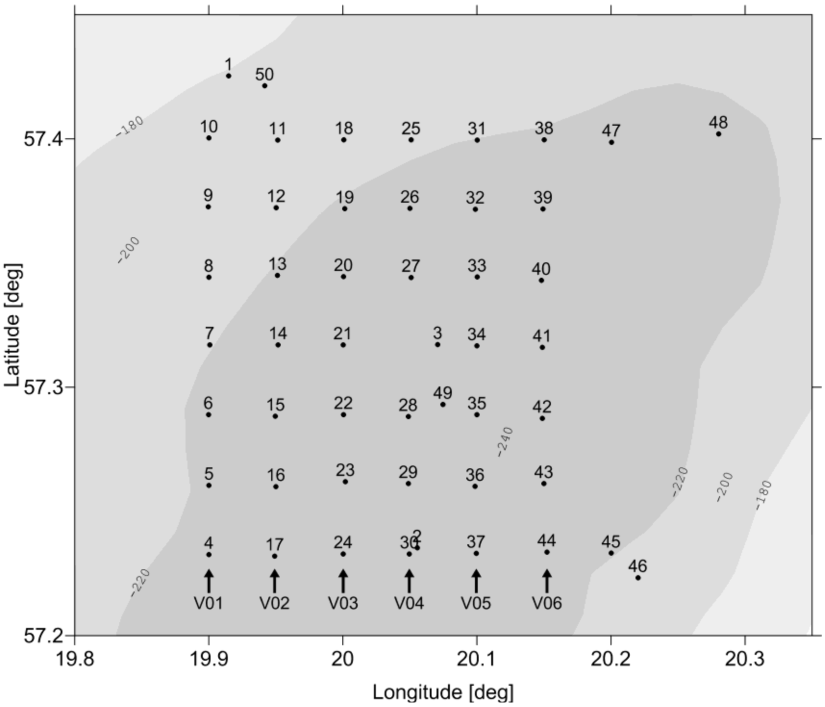
Appendix

List of CTD Stations

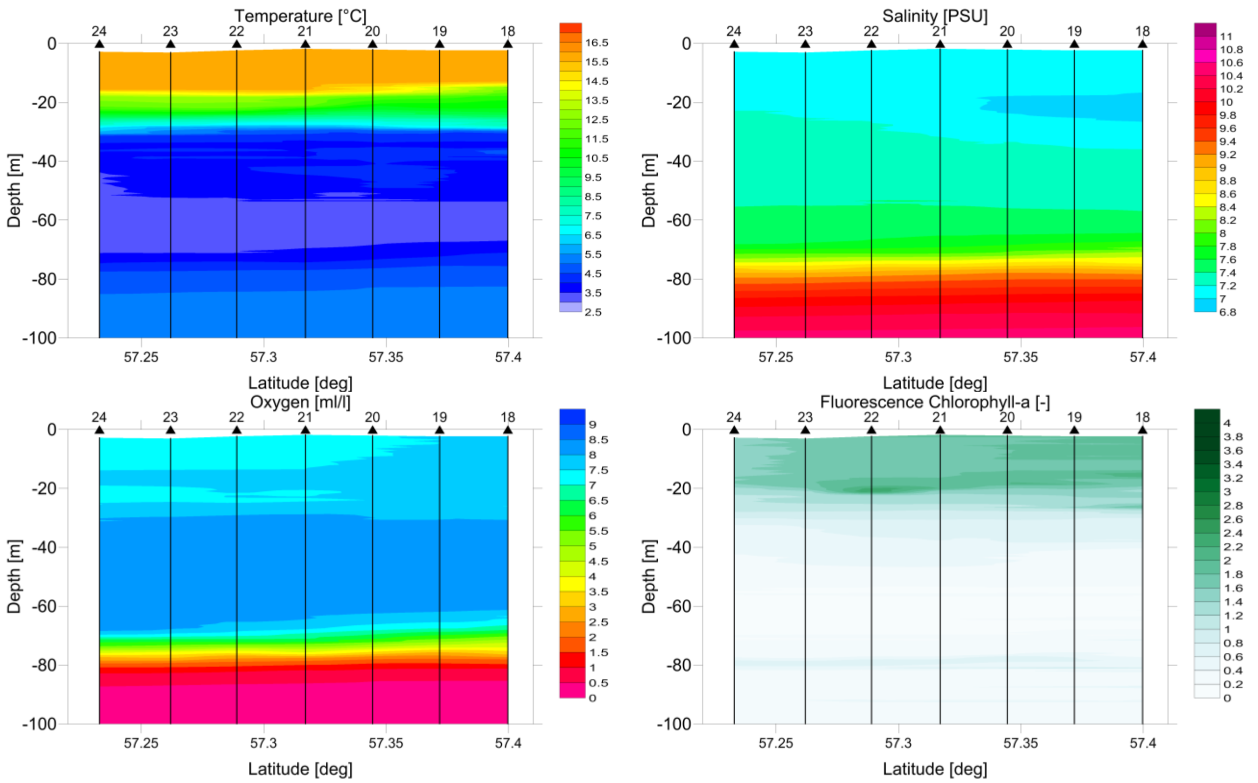
Station No.	Stat. Name	Date [UTC]	Time [UTC]	Latitude	Longitude	Waterdepth	CTD Filename
1	X_0001	08.07.2012	08:57	57° 25.53'N	019° 54.80'E	186	0001_01 0001_02
2	X_0002	09.07.2012	05:33	57° 14.09'N	020° 03.25'E		0002_01 0002F02
3	X_0003	10.07.2012	07:04	57° 19.03'N	020° 04.25'E		0003F01
4	CTD_0101	10.07.2012	09:10	57° 13.96'N	019° 54.00'E		0004_01
5	CTD_0102	10.07.2012	09:46	57° 15.63'N	019° 53.96'E		0005_01
6	CTD_0103	10.07.2012	10:30	57° 17.39'N	019° 54.01'E	224	0006_01
7	CTD_0104	10.07.2012	11:14	57° 19.06'N	019° 54.07'E	221	0007_01
8	CTD_0105	10.07.2012	11:52	57° 20.68'N	019° 54.01'E	215	0008_01
9	CTD_0106	10.07.2012	12:33	57° 22.37'N	019° 53.97'E	207	0009_01
10	CTD_0107	10.07.2012	13:13	57° 24.04'N	019° 54.01'E	196	0010_01
11	CTD_0207	10.07.2012	13:57	57° 23.99'N	019° 57.09'E	207	0011_01
12	CTD_0206	10.07.2012	14:34	57° 22.38'N	019° 57.03'E	214	0012_01
13	CTD_0205	10.07.2012	15:06	57° 20.72'N	019° 57.08'E	223	0013_01
14	CTD_0204	10.07.2012	15:40	57° 19.05'N	019° 57.11'E	229	0014_01
15	CTD_0203	10.07.2012	16:11	57° 17.33'N	019° 57.03'E	232	0015_01
16	CTD_0202	10.07.2012	16:47	57° 15.64'N	019° 57.00'E	232	0016_01
17	CTD_0201	10.07.2012	17:25	57° 13.95'N	019° 56.96'E	220	0017F01
18	CTD_0307	10.07.2012	19:13	57° 24.01'N	020° 00.02'E	213	0018F01
19	CTD_0306	10.07.2012	19:47	57° 22.33'N	020°0 0.07'E	223	0019_01
20	CTD_0305	10.07.2012	20:24	57° 20.69'N	020° 00.00'E	231	0020_01
21	CTD_0304	10.07.2012	20:58	57° 19.08'N	020° 00.02'E	232	0021_01
22	CTD_0303	10.07.2012	21:35	57° 17.37'N	020° 00.00'E	238	0022_01
23	CTD_0302	10.07.2012	22:22	57° 15.74'N	020° 00.13'E	238	0023_01
24	CTD_0301	10.07.2012	22:58	57° 14.07'N	020°0 0.02'E	235	0024_01
25	CTD_0407	11.07.2012	00:59	57° 24.05'N	020° 03.03'E	215	0025F01
26	CTD_0406	11.07.2012	01:40	57°	020° 03.02'E	225	0026_01

				22.37'N			0026K02
27	CTD_0405	11.07.2012	02:12	57° 20.68'N	020° 03.10'E	233	0027_01
28	CTD_0403	11.07.2012	03:10	57° 17.31'N	020° 02.98'E	240	0028_01
29	CTD_0402	11.07.2012	03:40	57° 15.71'N	020° 03.04'E	241	0029_01
30	CTD_0401	11.07.2012	04:10	57° 14.00'N	020° 03.03'E	237	0030_01
31	CTD_0507	11.07.2012	05:53	57° 24.01'N	020° 06.05'E	224	0031_01
32	CTD_0506	11.07.2012	06:25	57° 22.33'N	020° 06.03'E	232	0032_01
33	CTD_0505	11.07.2012	06:55	57° 20.68'N	020° 06.04'E	238	0033_01
34	CTD_0504	11.07.2012	07:26	57° 18.98'N	020° 05.93'E	241	0034_01
35	CTD_0503	11.07.2012	07:59	57° 17.33'N	020° 05.93'E	242	0035_01
36	CTD_0502	11.07.2012	08:31	57° 15.60'N	020° 05.87'E	240	0036F01
37	CTD_0501	11.07.2012	09:03	57° 13.98'N	020° 05.93'E	234	0037_01
38	CTD_0607	11.07.2012	10:18	57° 24.02'N	020° 08.99'E	225	0038_01
39	CTD_0606	11.07.2012	10:51	57° 22.32'N	020° 08.94'E	230	0039F01
40	CTD_0605	11.07.2012	11:24	57° 20.62'N	020° 08.90'E	236	0040F01
41	CTD_0604	11.07.2012	11:56	57° 18.98'N	020° 08.95'E	239	0041_01
42	CTD_0603	11.07.2012	12:30	57° 17.29'N	020° 08.95'E	240	0042F01
43	CTD_0602	11.07.2012	13:05	57° 15.67'N	020° 09.00'E	236	0043F01
44	CTD_0601	11.07.2012	13:40	57° 14.00'N	020° 09.01'E	238	0044F01
45	CTD_0701	11.07.2012	14:15	57° 14.02'N	020° 11.99'E	231	0045F01
46	X_0046	11.07.2012	16:06	57° 13.42'N	020° 13.18'E	228	0046_01 0046_02 0046F03 0046K04
47	CTD_0707	12.07.2012	08:32	57° 23.92'N	020° 11.98'E	225	0047F01 0047K02
48	X_0048	12.07.2012	19:47	57° 24.13'N	020° 16.73'E	225	0048F01
49	X_0049	13.07.2012	20:13	57° 17.61'N	020° 04.48'E	241	0049F01
50	X_0050	14.07.2012	08:45	57° 25.23'N	019° 56.56'E	188	0050_01 0050_02 0050F03 0050K04

Map of CTD Stations



Example CTD casts (V03)



List of Scanfish Tracks

Track No.		Date Time [UTC]	Latitude	Longitude	CTD Filename
SF01					Test, no data
SF02	Begin	07.07.2012 15:58	57° 13.78'N	19° 53.96'E	0001S02
	End	07.07.2012 17:40	57° 24.02'N	19° 54.00'E	
SF03	Begin	07.07.2012 17:40	57° 24.08'N	19° 54.04'E	0001S03
	End	07.07.2012 17:55	57° 24.10'N	19° 56.91'E	
SF04	Begin	07.07.2012 17:57	57° 23.83'N	19° 56.99'E	0001S04
	End	07.07.2012 19:33	57° 13.96'N	19° 57.01'E	
SF05	Begin	07.07.2012 19:34	57° 13.87'N	19° 57.04'E	0001S05
	End	07.07.2012 19:51	57° 14.02'N	20° 00.01'E	
SF06	Begin	07.07.2012 19:51	57° 14.08'N	20° 00.01'E	0001S06
	End	07.07.2012 21:26	57° 23.99'N	20° 00.00'E	
SF07	Begin	07.07.2012 21:27	57° 24.05'N	20° 00.01'E	0001S07
	End	07.07.2012 21:45	57° 23.99'N	20° 03.06'E	
SF08	Begin	07.07.2012 21:46	57° 23.94'N	20° 03.07'E	0001S08
	End	07.07.2012 23:26	57° 13.91'N	20° 03.02'E	
SF09	Begin	07.07.2012 23:27	57° 13.84'N	20° 03.11'E	0001S09
	End	07.07.2012 23:43	57° 14.02'N	20° 06.00'E	
SF10	Begin	07.07.2012 23:44	57° 14.06'N	20° 06.01'E	0001S10
	End	08.07.2012 01:10	57° 20.12'N	20° 06.05'E	

Map of Scanfish Tracks