



# Leibniz Institute for Baltic Sea Research Warnemünde



## Cruise Report

R/V Alkor

Cruise- No. AL400

This report is based on preliminary data

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1. **Cruise No.:** AL400
2. **Dates of the cruise:** from 04 to 20 September 2012
3. **Particulars of the research vessel:**
  - Name: Alkor
  - Nationality: Germany
  - Operating Authority: Leibniz-Institute for Baltic Sea Research Warnemünde, Germany
4. **Geographical area in which ship has operated:**  
Baltic Sea (Gotland Basin, Landsort Deep)
5. **Dates and names of ports of call**  
Visby (Sweden) from 13 to 15 September 2012
6. **Purpose of the cruise**  
This interdisciplinary cruise aimed at exploring the effects of lateral intrusions and turbulent mixing on the microbiology and biogeochemistry of the redoxcline in the deep basins of the Baltic Sea.
7. **Crew:**
  - Name of master: Nobert Hechler
  - Number of crew: 11
8. **Research staff:**
  - Chief scientist: Lars Umlauf
  - Scientists: Sabine Glaubitz
  - Engineers: Toralf Heene
  - Technicians: Sebastian Beier  
Katja Becker  
Stefanie Linsenbarth  
Jana Woelk  
Verena Merk  
Andreas Müller  
Robert Kemsies  
Jan-Torben Witte  
Christian Heene
9. **Co-operating institutions:**  
none
10. **Scientific equipment**  
CTD, ScanFish, microstructure profiler, vessel-mounted ADCP, moorings (CTD-chain, bottom-mounted ADCPs), equipment for nutrient analysis, scintillation counter, filtration devices for microbial sampling

## 11. General remarks and preliminary results

R/V Alkor started as scheduled on 04 September at 06:00 UTC from the old fisheries harbor in Rostock-Marienehe. First waypoint was the Arkona instrumentation buoy, close to which a bottom-mounted instrument frame with two current profilers was deployed around 14:00 UTC in 44 m depth (position was 54°53.0'N, 13°51.4'E). Purpose of this mooring was the testing of a new ADCP system for the observation of turbulence in the water column.

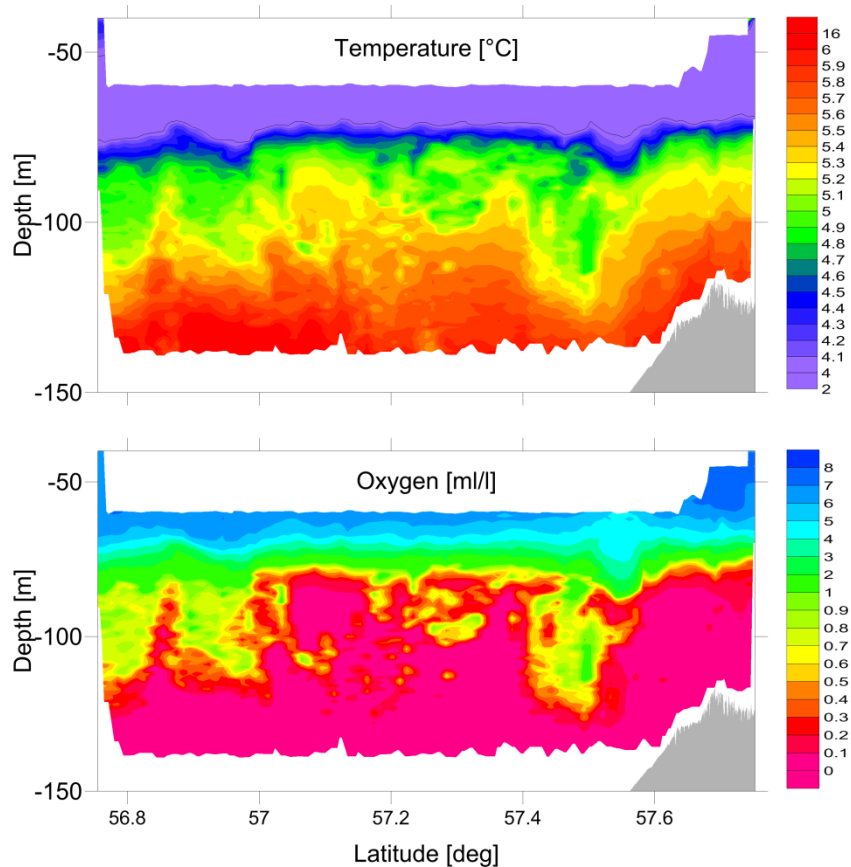
After this operation, the Alkor headed for the standard monitoring station TF271, located in the center of the Gotland Basin (see Fig. 3). After arrival on 05 September, the observational program started at 13:45 UTC with CTD measurements to obtain a first impression of the water column structure in the transition region between oxic and sulfidic waters that was the central theme of this cruise. Already these first observations revealed the presence of lateral intrusions with slightly lower temperature and substantially elevated oxygen concentrations compared to the ambient fluid. Also most of the following CTD profiles showed evidence of such intrusions throughout the Gotland Basin, suggesting ideal conditions for our planned investigations about the impact of these features on physical, chemical and microbial processes. With this idea in mind, water samples for chemical and microbial analyses were focused around the intrusion depths, or the redoxcline level if no intrusions were present. The following parameters were obtained: oxygen, nitrate, nitrite, ammonium, hydrogen sulfide, phosphate, heterotrophic and autotrophic production, samples for molecular analysis (e.g., CARD-FISH, DNA fingerprinting).

Around 16:15 UTC, after the end of the CTD measurements, turbulence profiling with the MSS90-L microstructure profiler started. Main goal of these first deployments of the MSS-profiler was to test the equipment and teach our students how to operate the system - but also to obtain a first picture of turbulence and mixing. Measurements were discontinued at 10:15 UTC, when the ship slowly started its way to the planned mooring position NE (see Fig. 3). In the morning of 06 September, a combined CTD/ADCP mooring from IOW's long-term monitoring program was recovered at position NE (57°22.0'N, 20°20.5'E) for maintenance, and re-deployed shortly after at the same position. At 11:15 UTC, following the exchange of the NE mooring, a quick ScanFish (towed CTD-system) survey was started in the vicinity of the Klints Bank in order to determine the optimal positions for the short-term moorings planned for this region (GTF1, see Tab. 2). Mooring work started around 14:30 UTC with the deployment of a 600 kHz ADCP on the western flank of the Klints Bank, followed by the deployment of a CTD chain and two nearby ADCPs (300 and 600 kHz) on the eastern flank. The most relevant information about these moorings is compiled in Tab. 1.

After mooring work was completed, an approximately 7 nm long transect across the Klints Bank was determined on which all measurements during the following days were performed (yellow line in Fig. 3). Microstructure profiles with the MSS90 profiler were taken at a rate of 5-10 minutes per profile, while the ship was slowly cruising along the transect, yielding a cross-sectional view of stratification, mixing parameters, and turbidity. Overall, 9 such transects were performed in the Klints Bank area as summarized in Tab. 4. In the periods between the microstructure measurements, CTD profiles were taken at selected stations (Tab. 3). Water samples were used to determine chemical and microbial parameters analogously to the measurements at station TF271 described above. On 09 September around 13:15 UTC, measurements on the transect were completed, and the next point of the observational program was started.

The basin-scale lateral structure of the redoxcline in the Gotland Basin was explored in the following with an approximately 52 nm long West-East ScanFish transect depicted in Fig. 3 (GTF2, see Tab. 2). This part of the program started on 09 September at 14:45 UTC, and continued until approximately 01:45 UTC on 10 September, when the eastern end of the transect near the Latvian coast was reached. Later on the same day, chemical and microbiological samples were taken along the GTF2 ScanFish transect, focusing on the neighborhood of a cold deep-water intrusion with elevated oxygen concentrations that was identified from the ScanFish data. The time between these CTD stations was usually filled with turbulence microstructure measurements (Tabs. 3 and 4).

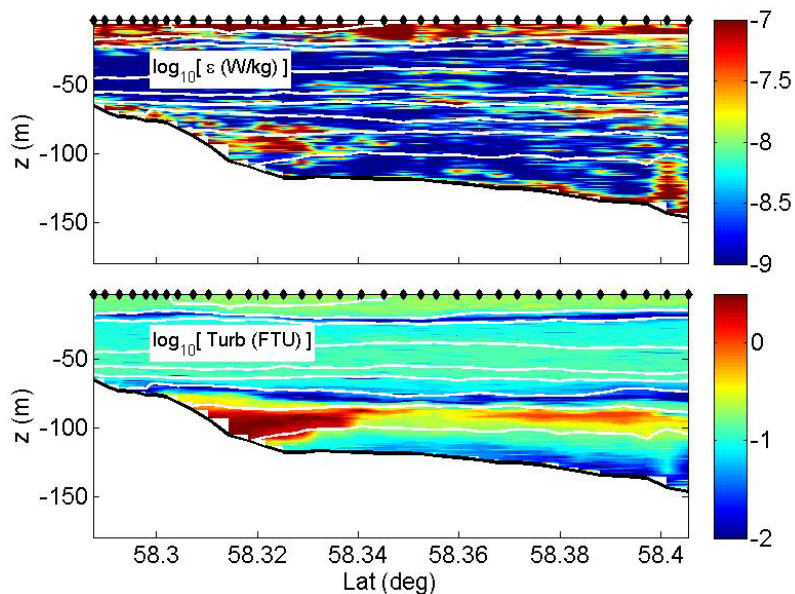
In the evening of 10 September, a new ScanFish transect was started (GTF3, see Tab. 2), this time from the southern to the northern rim of the basin as shown in Fig. 3. This new transect, finished around 06:45 UTC in the morning of 11 September, showed that intrusions of oxygen-rich cold waters were ubiquitous features inside and below the redoxcline (Fig. 1). A particularly strong intrusion of this type, located approximately at 47.5°N, could later be re-located and sampled with the CTD. After these measurements, the ship proceeded to the starting point of the final ScanFish transect (GTF4, see Tab. 4) in the Gotland Basin, which confirmed the ubiquitous nature of redoxcline intrusions. Long-term measurements with an autonomous profiling station in the center of the basin (performed independently of this cruise) suggest that such intrusions are the rule rather than the exception. The most important conclusion from this is that the classical picture of the redoxcline as a stable, vertically layered, and continuous transition region between oxic and sulfidic waters is of limited use for the description of the processes in the Gotland Basin.



**Fig. 1.** Temperature (upper panel) and oxygen from ScanFish transect GTF3 in the Gotland Basin (see Tab. 2 and Fig. 4).

The low-wind conditions in the morning of 12 September were used to recover the short-term moorings on the GT transect (Tab. 1), and begin, around 11:00 UTC, our way to the second study area located in the Landsort Deep. There, measurements started around 18:00 UTC with the basin-scale ScanFish transect shown in Fig. 4 (LTF1, Tab. 2). Different from the Gotland Basin, this and all following transects in this area did not show evidence for the presence of intrusions at our below the redoxcline level, suggesting a rather different hydrographic regime. The following day (13 September) was used for CTD and microstructure sampling at the central monitoring station TF284 (Fig. 4), and for the deployment of the short-term moorings LTM and LT-ADCP1 (Tab. 1) on the southern slope of the basin, adjacent to the LTF1 transect (Fig. 4). Weather predictions for the following night and the whole next day were bad with winds around force 8, disallowing further measurements. The stormy period had to be bridged in the nearby harbor of Visby (Sweden), where the Alkor arrived around 16:00 UTC.

On the morning of 15 September, the Alkor left the harbor of Visby again, heading for the station TF284, where CTD profiles were taken until 14:00 UTC (Tab. 3), followed by microstructure measurements in the vicinity of the station until 17:00 UTC (Tab. 4). The ship then approached the southern end of the transect, which was the starting point of the ScanFish measurements during the night (LTF1, see Tab. 2). A number of special features that became evident from these measurements, in particular the patches with strongly increased turbidity close to the topographic slopes of the basin, were sampled during the following day (16 September) with 4 high-resolution CTD profiles (LTC1-1 to LTC1-4, see Tab. 3). The following microstructure measurements conducted on three full transects (LTM1-LTM3, see Tab. 4) near a seamount in the southern part of the study area (orange line in Fig. 4) revealed that patches with high turbidity near topographic irregularities were associated with enhanced turbulence (one example is illustrated in Fig. 2 for transect LTM2). Water samples taken from these regions showed no evidence for sediment re-suspension but strongly enhanced microbial activities. This relation between mixing, turbidity, and microbial activity is one of the key results of this cruise.

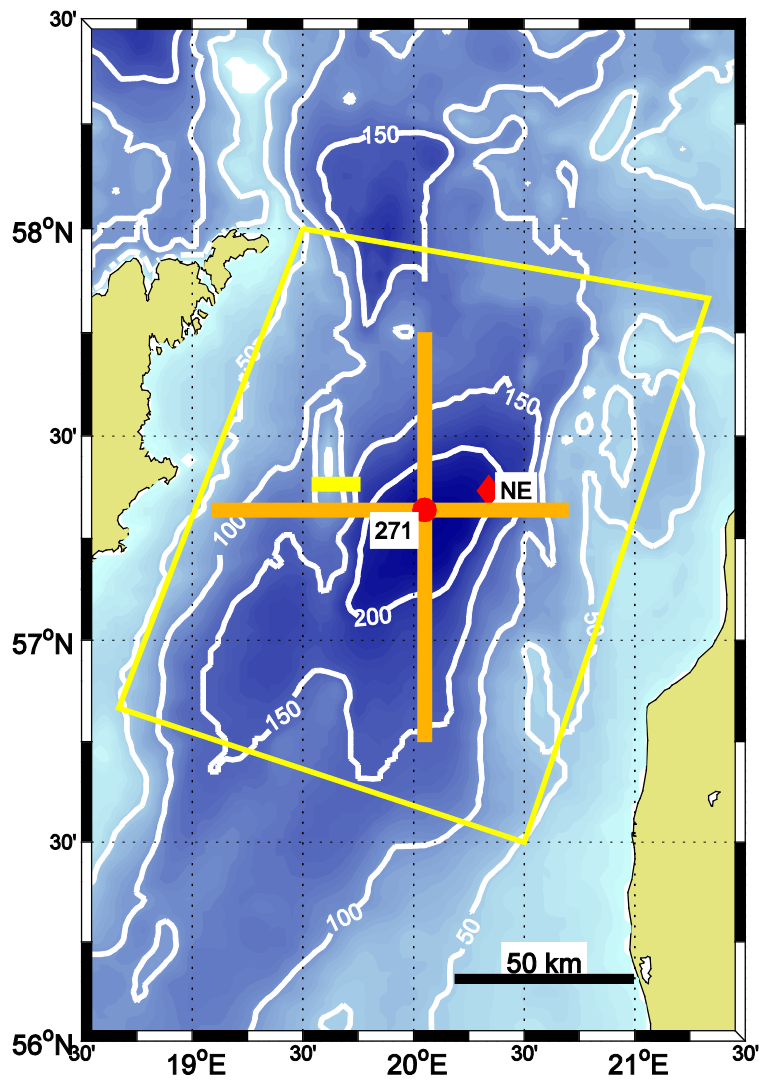


**Fig. 2.** Dissipation rate (upper panel) and turbidity for transect LTM2 south of the Landsort Deep (see Fig. 4 and Tab. 4). Note that both quantities are plotted on a logarithmic scale. Black markers at the top indicate spacing of microstructure casts.

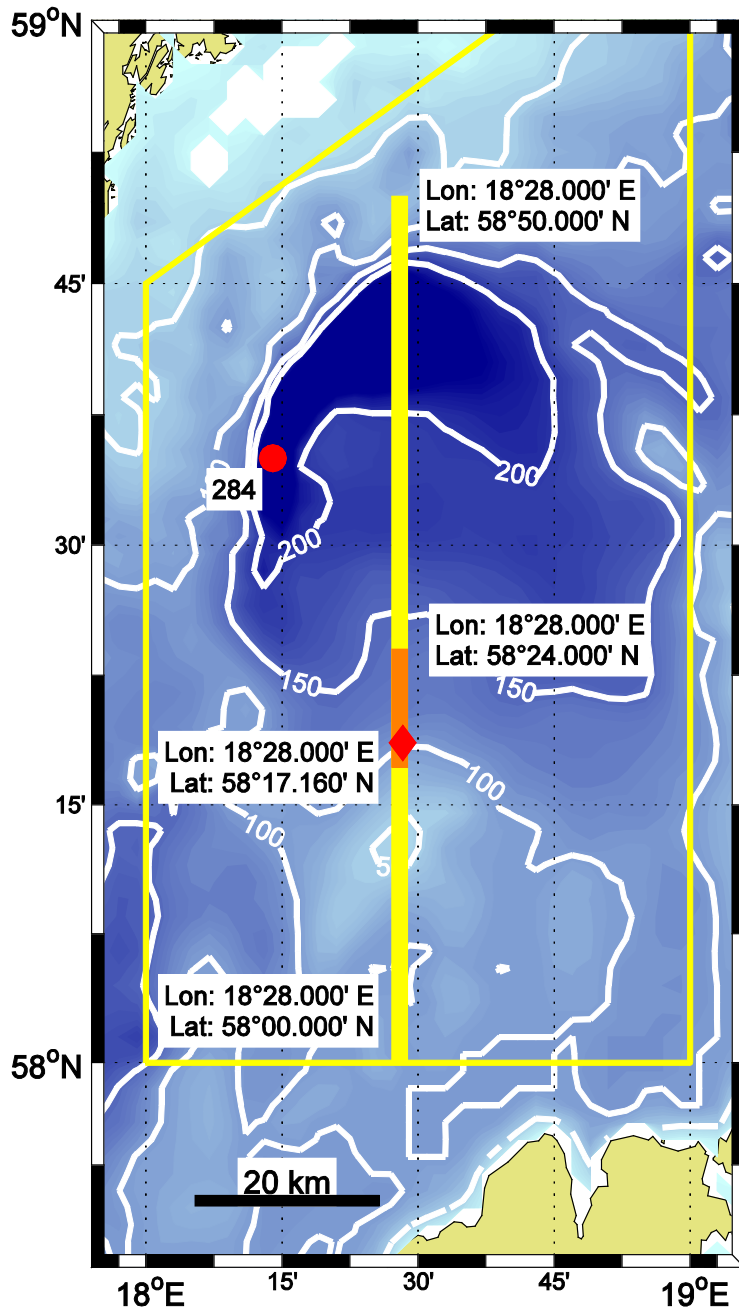
The rest of 17 September was used for one additional ScanFish transect (LTF3) until approximately 21:30 UTC, providing further evidence for strongly enhanced turbidity levels near the rough topography at both ends of the transect. The night was bridged with the final microstructure transect (LTM4) before moorings were recovered on the morning of 18 September. This was also the only time during this cruise when a substantial damage of equipment occurred: during recovery of one of the ADCPs the ground line became clamped to the hull of the ship (presumably due to corrugated or projecting underwater parts), and broke shortly after, resulting in the loss of parts of an ADCP protection device. After this mooring work, the ship headed back for the port of Warnemünde. Arrival and end of the cruise was 08:00 am on 20 September.

Overall, a unique data set could be obtained during this interdisciplinary cruise, showing, for the first time, direct evidence for the effect of mixing on chemical and microbial processes in a redoxcline. The observation that intrusions of oxic waters massively affected the structure of the redoxcline, often splitting it into several parts, points towards a revision of existing theories that view the redoxcline as a single, one-dimensional, and slowly evolving transition region between oxic and anoxic waters.

## Appendix: Maps and list of stations



**Fig. 3.** Area 1 in the Gotland Basin with topography at 50-m intervals. Indicated are: mooring position NE, standard monitoring station TF271, microstructure/CTD transect (thick yellow), and basin-scale ScanFish transects (orange). Yellow quadrilateral shows the notified research area.



**Fig. 4.** Area 2 in the Landsort Deep with topography at 50-m intervals. Indicated are: mooring position (red diamond), standard monitoring station TF284, basin-scale ScanFish transect (yellow), and microstructure transect (orange). Yellow quadrilateral shows the notified research area. Position labels mark the start and end of the transects, respectively.



**Tab. 1.** Description of short-term moorings

Name	Type	Deployment Recovery	Position	Depth
GT_ADCP2	TRBM-ADCP (600 kHz)	06-Sep-2012 14:37:00 12-Sep-2012 10:30:00	19°34.13'E 57°23.08'N	75.5 m
GT_ADCP1	TRBM-ADCP (300 kHz)	06-Sep-2012 16:04:00 12-Sep-2012 07:32:00	19°40.79'E 57°23.10'N	94.4 m
GT_CT	ADCP (600 kHz)	06-Sep-2012 16:38:00 12-Sep-2012 07:15:00	19°40.92'E 57°23.10'N	100 m
GT_CT	CTD chain	06-Sep-2012 16:38:00 12-Sep-2012 06:03:00	19°40.84'E 57°23.04'N	96 m
LT_ADCP1	TRBM-ADCP (300 kHz)	13-Sep-2012 11:03:00 18-Sep-2012 07:08:00	18°28.14'E 58°18.57'N	99.5 m
LT_CT	ADCP (600 kHz)	13-Sep-2012 11:17:00 18-Sep-2012 06:30:00	18°28.28'E 58°18.63'N	102.6 m
LT_CT	CTD chain	13-Sep-2012 11:34:00 18-Sep-2012 06:30:00	18°28.35'E 58°18.56'N	100.8 m

**Tab. 2.** Description of ScanFish transects

Name	UTC (start, end)	Position (start, end)
GTF1	06-Sep-2012 11:16:00 06-Sep-2012 14:00:00	19°50.0'E, 57°30.0'N 19°30.0'E, 57°30.0'N
GTF2	09-Sep-2012 14:45:00 10-Sep-2012 01:15:00	19°05.5'E, 57°19.2'N 20°42.0'E, 57°19.2'N
GTF3	10-Sep-2012 18:30:00 11-Sep-2012 06:45:00	20°03.0'E, 56°45.0'N 20°03.0'E, 57°45.0'N
GTF4	11-Sep-2012 17:15:00 12-Sep-2012 04:00:00	20°42.0'E, 57°19.2'N 19°05.5'E, 57°19.2'N
LTF1	12-Sep-2012 18:00:00 13-Sep-2012 04:00:00	18°28.0'E, 58°00.0'N 18°28.0'E, 58°50.0'N
LTF2	15-Sep-2012 18:50:00 15-Sep-2012 04:30:00	18°28.0'E, 58°50.0'N 18°28.0'E, 58°00.0'N
LTF3	17-Sep-2012 11:20:00 17-Sep-2012 21:20:00	18°28.0'E, 58°00.0'N 18°28.0'E, 58°50.0'N

**Tab. 3.** Description of CTD stations

<b>Number</b>	<b>Station Name</b>	<b>Start Time</b>	<b>Start Position</b>	<b>Depth</b>
1	TF0271	05-Sep-2012 05:47:55	020°03.0E, 57°19.2N	234
2	NE-23	06-Sep-2012 06:09:22	020°20.0E, 57°22.2N	214
3	GTC1-1	07-Sep-2012 07:25:57	019°40.0E, 57°23.0N	75
4	GTC1-2	07-Sep-2012 07:56:42	019°45.6E, 57°23.0N	168
5	GTC1-3	08-Sep-2012 08:52:47	019°33.1E, 57°23.1N	97
6	GTC1-4	08-Sep-2012 08:42:35	019°41.4E, 57°23.0N	107
7	GTC1-5	08-Sep-2012 08:36:33	019°42.4E, 57°23.1N	135
8	GTC1-5	09-Sep-2012 09:24:51	019°42.0E, 57°23.0N	128
9	GTC1-4	09-Sep-2012 09:05:27	019°41.3E, 57°23.0N	106
10	TF0271	10-Sep-2012 10:03:39	020°02.9E, 57°19.0N	234
11	GS1-1	10-Sep-2012 10:06:52	019°52.2E, 57°19.2N	207
12	GTC2-1	11-Sep-2012 11:40:05	020°03.0E, 57°28.5N	176
13	GTC2-2	11-Sep-2012 11:40:19	020°03.0E, 57°18.0N	230
14	TF0284	13-Sep-2012 13:00:23	018°14.0E, 58°35.0N	434
15	TF0284	15-Sep-2012 15:38:26	018°13.9E, 58°35.1N	439
16	LTC1-1	16-Sep-2012 16:14:08	018°27.7E, 58°05.9N	100
17	LTC1-2	16-Sep-2012 16:07:44	018°28.1E, 58°19.8N	113
18	LTC1-3	16-Sep-2012 16:56:16	018°28.1E, 58°33.0N	178
19	LTC1-4	16-Sep-2012 16:50:29	018°28.0E, 58°46.6N	156
20	LTC1-5	17-Sep-2012 17:12:19	018°28.1E, 58°23.4N	135
21	LTC1-6	17-Sep-2012 17:27:15	018°28.0E, 58°19.3N	109

**Tab. 4.** Description of microstructure stations and transects

<b>Name</b>	<b>Number</b>	<b>UTC (start, end)</b>	<b>Position (start, end)</b>
TF271 (test, NTC)	1-26	05-Sep-2012 16:24:50 05-Sep-2012 22:02:56	20.050E, 57.3200N
GTM01 (Klints Bank)	27-66	06-Sep-2012 17:48:55 06-Sep-2012 21:24:43	19.7681E, 57.3829N 19.5522E, 57.3834N
GTM02 (Klints Bank)	67-91	06-Sep-2012 22:40:29 07-Sep-2012 01:29:18	19.7696E, 57.3836N 19.6067E, 57.3839N
GTM03 (Klints Bank)	92-115	07-Sep-2012 06:52:25 07-Sep-2012 09:19:19	19.7649E, 57.3822N 19.6195E, 57.3832N
GTM04 (Klints Bank)	119-164	07-Sep-2012 13:53:04 07-Sep-2012 17:57:47	19.7544E, 57.3834N 19.5134E, 57.3830N
GTM05 (Klints Bank)	165-214	07-Sep-2012 20:22:31 08-Sep-2012 01:07:05	19.7701E, 57.3827N 19.5034E, 57.3834N
GTM06 (Klints Bank)	215-257	08-Sep-2012 02:49:34 08-Sep-2012 06:59:30	19.7613E, 57.3840N 19.5087E, 57.3835N
GTC_X2 (Klints Bank, NTC)	258-265	08-Sep-2012 08:54:10 08-Sep-2012 11:17:42	19.6397E, 57.3831N
GTM07 (Klints Bank)	266-309	08-Sep-2012 14:00:58 08-Sep-2012 18:14:46	19.7634E, 57.3829N 19.5079E, 57.3831N
GTM08 (Klints Bank)	310-326	08-Sep-2012 19:43:13 08-Sep-2012 21:54:56	19.7582E, 57.3826N 19.6416E, 57.3833N
GTM09 (Klints Bank)	331-372	09-Sep-2012 08:54:03 09-Sep-2012 13:02:58	19.7113E, 57.3836N 19.5027E, 57.3834N
TF271	373-378	10-Sep-2012 07:06:42 10-Sep-2012 07:44:03	20.0500E, 57.3200N
GS1/1	379-386	10-Sep-2012 09:18:05 10-Sep-2012 10:36:38	19.8735E, 57.3329N
GS1/2 (NTC)	387-392	10-Sep-2012 11:55:58 10-Sep-2012 14:27:47	19.8749E, 57.3357N
GTM10 (Gotland Eddy)	394-419	11-Sep-2012 08:09:28 11-Sep-2012 12:06:08	20.0504E, 57.5978N 20.0505E, 57.4592N
TF284	420-421	13-Sep-2012 08:06:25 13-Sep-2012 08:13:29	18.2333E, 58.5833N
TF284	422-435	15-Sep-2012 14:30:05 15-Sep-2012 16:55:57	18.2333E, 58.5833N

LTM01	436-471	16-Sep-2012 14:34:52 16-Sep-2012 18:26:42	18.4668E, 58.4029N 18.4672E, 58.2867N
LTM02	472-505	16-Sep-2012 19:23:53 16-Sep-2012 23:08:41	18.4682E, 58.4053N 18.4667E, 58.2875N
LTM03	506-540	17-Sep-2012 00:31:07 17-Sep-2012 04:18:07	18.4667E, 58.4007N 18.4665E, 58.2864N
LTM04	541-575	18-Sep-2012 00:20:05 18-Sep-2012 04:15:10	18.4670E, 58.3999N 18.4667E, 58.2855N