Leibniz-Institut für
Meereswissenschaften
an der Universität Kiel

Date: 07.01.08

Cruise Report

Compiled by: Dr. Joanna Waniek

F.S.Poseidon Cruise No.: 357

Dates of Cruise: from 05.09.2007 to 27.09.2007

Areas of Research: Physical & Chemical Oceanography

Port Calls: Rostock (Germany)

Institute: Institut für Ostseeforschung Warnemünde, Seestrasse 15, 18119 Rostock

Chief Scientist: Dr. habil. Joanna Waniek

Number of Scientists: 10

Project: BaTRE- Baltic Sea Tracer Release Experiment

Cruise Report

This cruise report consists of 23 pages including cover:

1. Scientific crew
2. Research programme
3. Narrative of cruise with technical details
4. Scientific report and first results
5. Moorings, scientific equipment and instruments
6. Additional remarks
7. Appendix
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   B. Station list

1. Scientific crew

Name	Function	Institute	Leg
Dr. Waniek, Joanna	Chief scientist	IOW	357/1-2
Dr. Umlauf, Lars	Scientist	IOW	357/1-2
Dr. Mohrholz, Volker	Scientist	IOW	357/1-2
Lehnert, Gerhard	Technician	IOW	357/1
Schuffenhauer, Ingo	Technician	IOW	357/1
Dr. Tanhua, Toste	Scientist	IFM-GEOMAR	357/1-2
Pinck, Andreas	Technician	IFM-GEOMAR	357/1
Müller, Mario	Technician	IFM-GEOMAR	357/1
Guest, Brian	Technician	WHOI	357/1
Dr. Sutherland, Stew	Technician	LDEO	357/1
Lage, Susanne	Technician	IOW	357/2
Dr. Schmale, Oliver	Scientist	IOW	357/2
Prof. Rehder, Gregor	Scientist	IOW	357/2
Schütt, Martina	Technician	IFM-GEOMAR	357/2
Fischer, Tim	Student	IFM-GEOMAR	357/2
Total : 10 (each leg)			

IFM-GEOMAR	Leibniz-Institut für Meereswissenschaften, Universität Kiel
IOW	Leibniz-Institut für Ostseeforschung Warnemünde
WHOI	Woods Hole Oceanographic Institution
LDEO	Lamont-Doherty Earth Observatory

Chief scientist:

Dr. habil. Joanna Waniek
Institut für Ostseeforschung Warnemünde
Seestrasse 15
18119 Rostock, Germany
Telefon: +49 (0) 381 5197 300
Telefax: +49 (0) 381 5197 302
e-mail: joanna.waniek@io-warnemuende.de

2. Research programme (J. Waniek)

The cruise P357/1-2 was the first cruise in the project BaTRE (DFG funded) that aims:

1) To quantify global vertical mixing parameters in the deep Eastern Gotland Basin of the Baltic Sea by means of a tracer release experiment
2) To identify the physical processes responsible for the observed integral mixing, in particular to distinguish between the contributions from local vertical mixing and boundary mixing processes
3) To determine the particle affinity of the tracers used.

Estimation of ocean diapycnal mixing and isopycnal spreading in the open ocean, marginal seas and near the ocean bottom boundary layers is often accomplished by purposeful long-lived tracer release. The technique has been successfully used and refined over the last decade. During P357 an ocean tracer injection system (OTIS), build by Woods Hole Oceanographic Institute (WHOI) in a close collaboration with a group of German scientist was used to inject an inert tracer in the eastern Gotland Basin. During this first OTIS deployment in the Baltic Sea, at a depth of about 200m a small amount of SF5CF3 was released in the Gotland Basin (P357-1) and firstly followed over the course of P357-2. This tracer release allows for the first time to directly observe integral diapycnal mixing, and to compare it to local diapycnal mixing estimates from microstructure profiling. A number of instruments chains were deployed in the vicinity of the tracer release and a intensive hydrographic survey (CTD and microstructure measurements) completed the research programme of P357/1-2.

3. Narrative of the cruise with technical details

Leg 1 After mobilisation and departure from Rostock RV Poseidon sailed to position A1 (56°N 41.98, 020°E 15.02) in the Eastern Gotland Basin, where a protected upward-looking ADCP and a short chain with MicroCat CTD-loggers was installed on the 9th of September. Following the deployment of the A1 mooring an initial survey of the Eastern Gotland Basin by means of CTD and Microstructure measurements was started to assess the hydrographical background parameters immediately before the tracer injection. The survey was interrupted to test the OTIS systems on the 10th of September, and to deploy 4 additional moorings (see section 5.4). All instrument chains except the A1 mooring will stay deployed at least for the duration of the tracer experiment. In the morning of the 11th of September the tracer was released between the positions 57.2993°N, 19.9530° E and 57.2955°N, 20.0082°E at ca. 200 m depth level (Fig. 1a). Immediately after the tracer release the work continued with the hydrographical survey e.g. combined CTD/MSS transects. The scientific work of the first leg finished on 14th of September and RV Poseidon returned to Rostock on the 16th of September few hours later then originally planned due to bad weather conditions on the way back.

a) b)

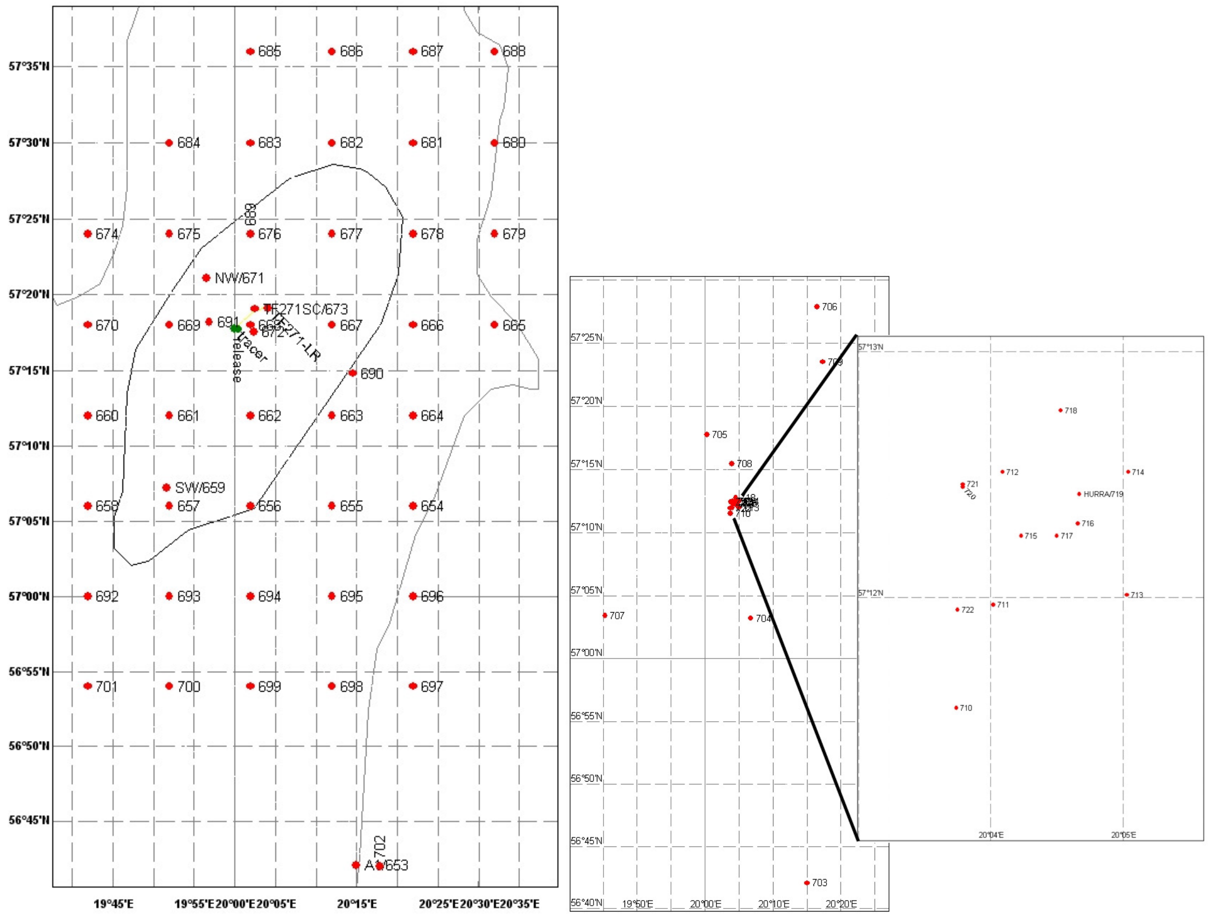


Fig 1. Working area a) of P357/1 with CTD/MSS stations indicated by number, locations of the moorings A1, SW, NW, TF271-LR and TF271-SC respectively and the tracer release marked by the green circles, and b) of P357/2.

3.2. Leg 2 The second leg of the cruise started with a 3 days period of setting up the instrumentation for the tracer measurements (GC-MS), in the harbour of Rostock. Following the initial preparation time, RV Poseidon sailed to the A1 station and started the search for the tracer on 21st of September. A transect across the Gotland Basin (e.g. region deeper than 200 m) was conducted using the CTD and P-CTD devises and the samples were obtained on regular basis. Initially the samples were taken from the injection density level with the P-CTD. After the system failed vertically resolving CTD profiles were carried out and water samples were obtained from the rosette. At several positions microstructure profiles were also carried out. The tracer concentration was evaluated from the continuous samples of the P-CTD via GC-MS and from discrete samples obtained at each CTD position. The tracer was detected for the first time at station Hurra (57°N 12.42, 020°E 04.67, station number 719) on the 24th of September and on two another locations next to station Hurra (Fig. 1b). The scientific work finished in the evening of 24th of September. RV Poseidon returned to Rostock on 27th of September where the cruise terminated.

4. Scientific report and first results
4.1 Leg 1

Microstructure measurements In order to relate the basin scale mixing indicated by the spreading of the tracer cloud during this cruise also extensive shear microstructure measurements have been obtained. The microstructure profiler was operated in free-falling mode, sampling the whole water column at several stations (see Fig. 2). At each station a burst of profiles (typically 4-5) was obtained to increase the statistical significance of the dissipation rate estimates. Fig. 2 illustrates stratification measurements obtained from the profiler's fine-structure CTD probes for a cross-basin transect. The potential density surface of approximately 9.90 kg/m^3 at which the tracer was injected is seen to be highly variably in depth, with a relatively weak surrounding stratification (Fig. 2).

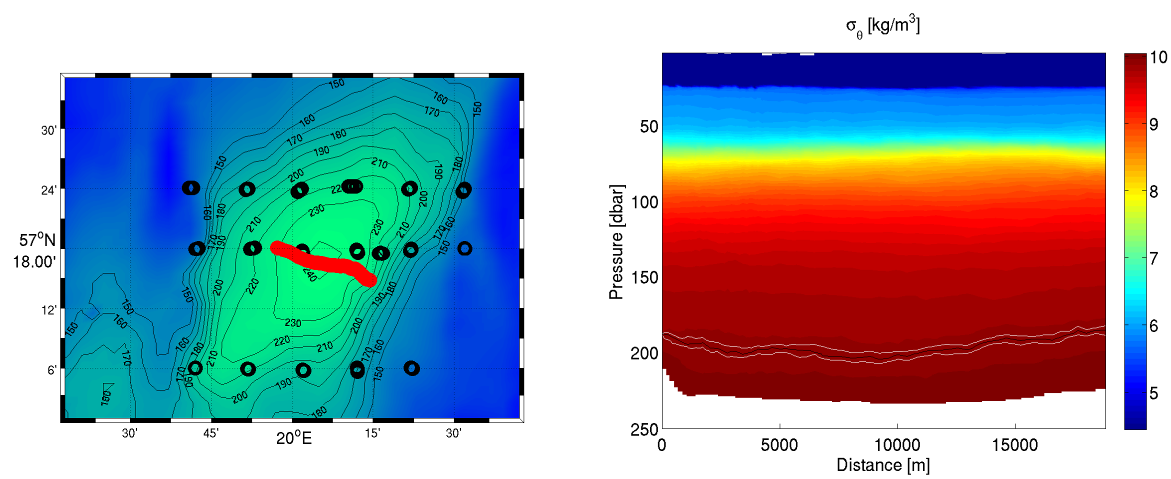


Fig. 2. Left panel. Topography of the Eastern Gotland Basin with all MSS-stations marked as circles (leg 1 only).Cross-basin microstructure transect is marked red. Right panel: Potential density on cross-basin transect with injection density marked as black contour. White lines indicate variations of ± 0.01 kg/m^3 around the injection level.

The data from the two shear-microstructure sensors of the profiler have been used to obtain estimates of the dissipation rate of the turbulent kinetic energy. This parameter is directly related to other relevant mixing parameters like the turbulent diffusivity and the vertical buoyancy flux. The results for a few selected stations are displayed in Fig. 3 illustrating very low mixing levels away from the boundary layers, only occasionally interrupted by mixing "events". Enhanced mixing is observed only in the surface layer (hence irrelevant for the tracer transport), and in a turbulent bottom boundary layer of a few meters thickness.

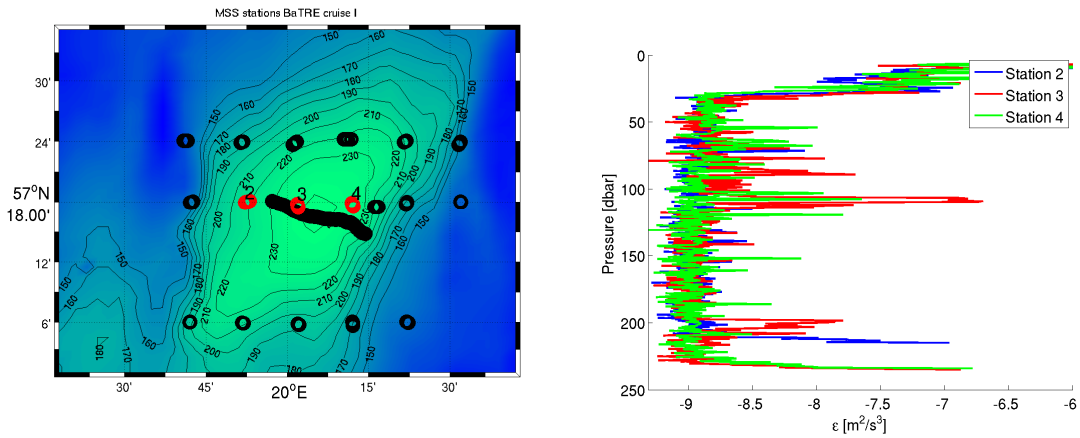


Fig. 3. Left panel: As in previous figure with selected station marked red. Right panel: Averaged profiles of dissipation rate at the stations marked in left panel.

Hydrography (CTD)

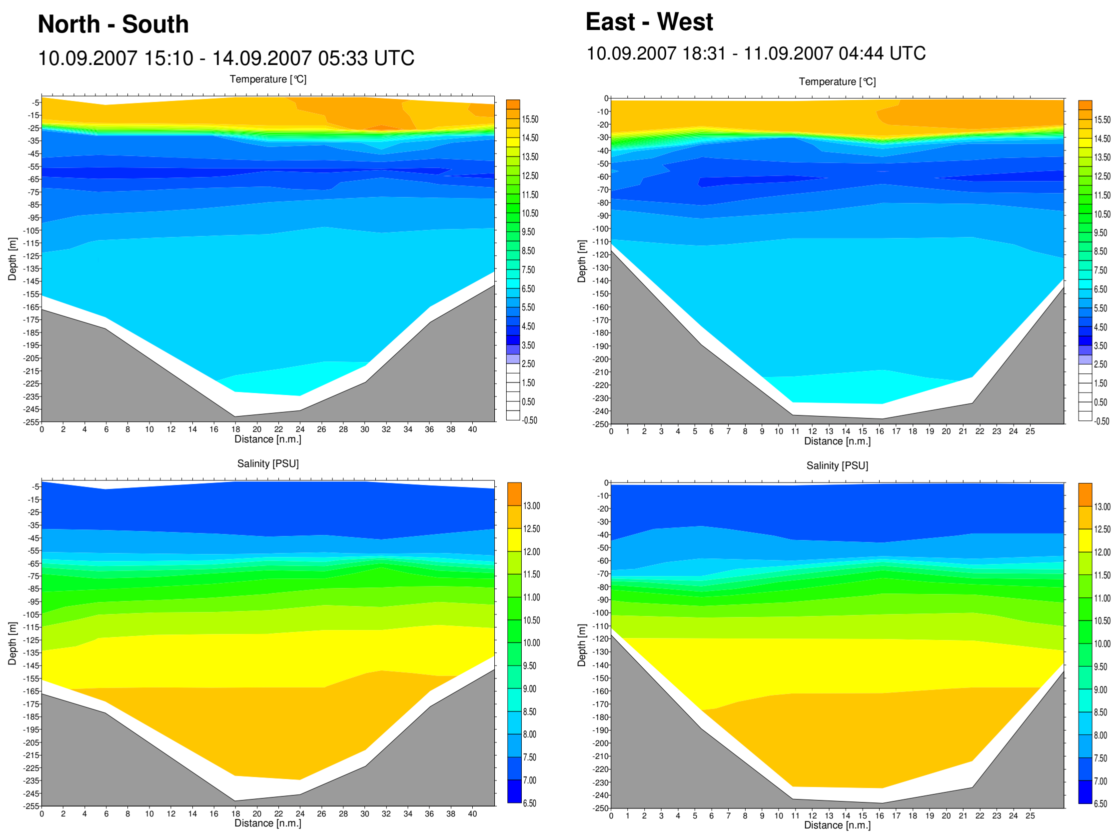


Fig. 4 Temperature and salinity distribution along two transects through the Eastern Gotland Basin.

The CTD measurements revealed the expected three layer stratification in the Eastern Gotland basin (Fig. 4). The seasonal thermocline was found between 25 and 30m, separating the warm brackish surface waters from the cool intermediate winter water (IWW). The core of the IWW covers the depth range from 45 to 70m, with minimum temperatures of about 4°C. The strongest salinity gradients in the halocline were found between 65 and 90 m. The slight doming of the isotherms and isohalines near the halocline and below point towards a basin scale cyclonic circulation in the sub-halocline layers.

Tracer release The tracer injection took place on September 11th between positions 57.2993°N, 19.9530° E and 57.2955°N, 20.0082°E (Fig. 1b). The density (sigma theta) of the injection was 9.90 kg/m^3, which was located at approximately 200 meter depth, i.e. ~30 meters above the bottom of the Gotland Basin. The density layer show considerable amount of variability in its position at depth as demonstrated by the P-CTD measurements during the second cruise leg (Fig. 5). A quantity of 0.9 kg of SF_5CF_3 was injected during the tracer release.

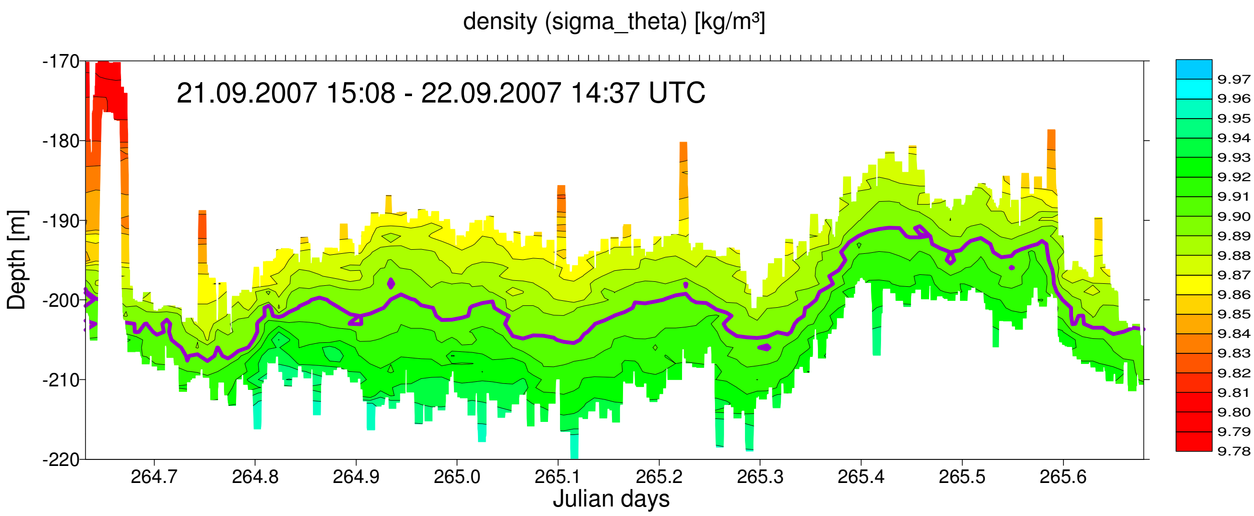


Fig. 5 Vertical position (violet line) of the 9.9 kg/m³ density interface along the PCTD Transect 1 through the Eastern Gotland Basin.

4.1. Leg 2

Tracer analysis During the cruise, 115 and 293 discrete samples from the Niskin bottles were analysed by the IFM-GEOMAR and IOW group, respectively. In addition, roughly 500 samples were analysed (equally divided between the IFM-GEOMAR and IOW groups) as discrete samples drawn from the continuous flow from the pump-CTD. Further more, an excess of 500 chromatograms from the equilibrator system were analysed.

The tracer distribution was, as expected, found to be very inhomogeneous (patchy) during this initial survey, only 2 weeks after the tracer release. It proved to be very difficult to find the tracer, and it has to be emphasized that the success of the mission can be attributed to the high sampling frequency, which was a result of the use of 3 analytical systems, and the availability of the towed pump-CTD. We were able to hit the tracer 3 times. During the first tracer finding at what was later named “Station Hurra”, we were able to get a detailed vertical profile by profiling with the pump CTD in place. Unfortunately, the CTD-unit of the pump CTD was not functioning at that time correctly. Thus, the profile can only be related to the rope length of the pump CTD (Fig 6). Unfortunately, it was not possible to hit the patch again on the CTD/Rosette cast immediately after the recovery of the pump CTD system at “Station Hurra”. Successful casts at a later stage of the cruise obviously only hit very thin strikes of the tracer, with maxima apparently shifted to slightly higher density levels. However, we have a positive proof that the tracer injection was successful and that the tracer was injected to the desired density level. This will be very valuable information for the evaluation of the spreading and distribution of the tracer during the upcoming BaTRE cruises.

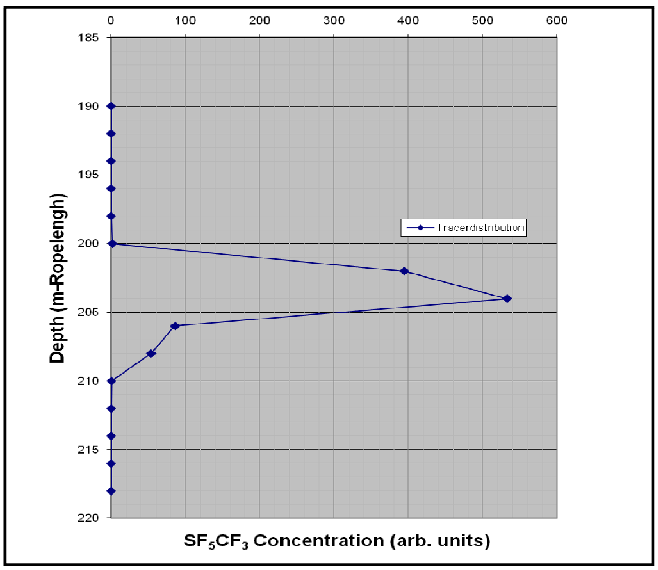


Fig. 6. Distribution of the tracer at station Hurra (station number 719, 57°N 12.42, 020°E 04.67) measured on the IOW analytical system.

5. Scientific equipment: moorings and instruments

5.1. CTD During both cruise legs a SeaBird 911+ CTD was employed to measure the distribution of temperature, salinity and oxygen. All casts cover the water column from the surface down to the bottom. Intercomparison measurements were carried out to keep the absolute accuracy of data within the following ranges: temperature ±0.005K, salinity ±0.005 and oxygen concentration ±10µmol l-1. The CTD data set of the first cruise leg consists of 40 CTD casts, which cover the central Eastern Gotland Basin at a regular grid. During the second leg 19 CTD casts were carried out to obtain hydrographic data at key stations along the PCTD transects and in the vicinity of the tracer plume.

5.2 MSS A modified version (extended housing) of an MSS90 shear microstructure profiler from ISW was used during P357. The sensor package consisted of two microstructure shear probes, a set of fine-structure CTD sensors from SST, and an FP07 micro-temperature sensor from PME. During leg 1 226 microstructure cast were carried out whereas during leg 2, only very few microstructure profiles were obtained, mainly for sensor inter-calibration with other CTD systems.

5.3 Ocean Tracer Injection System (OTIS). The new Ocean Tracer Injection System (OTIS) was used for the first time ever during this cruise. Brian Guest primarily constructed the instrument at WHOI under the supervision of Dr. Jim Ledwell. Stew Sutherland designed the software. Both Brian and Stew were part of the scientific crew of leg 1 to ensure efficient technology transfer and the operation of the OTIS.

The OTIS (Fig. 7.) performed extremely well during the operation. A few days of the cruise before the OTIS was used for injection was used to deal with minor problems with the sled and the software. A buoyancy test of the OTIS was performed on September the 10^{th}, which showed that the OTIS appeared to be slightly too heavy. To overcome this problem, two benthos balls were added to the OTIS. A new buoyancy test was performed with satisfactory result. The OTIS was launched and recovered from the stern with help of the A-frame during these tests. This worked well, and we were confident that we could safely launch and recover the OTIS from the stern also for future operation (the OTIS is normally launched and recovered from the side). The tracer injection was performed on September 11 (between 10:50 and 11:05 UTC) under ideal weather conditions. The OTIS was connected to winch W6 with a conducting cable. Since it is imperative to the tracer injection that the OTIS remain on a specified density (a CTD provides information to the lab of the actual depth, temperature and salinity of the surroundings of the OTIS), we were learning to "fly" the OTIS for about 1 hour before the actual injection, During this time, a primer fluid was pumped out of the sled at low speed to assure that the fine orifices did not become clogged. The crewmember that was operating the winch got indication via a manual indicator from the lab to whether the sled was to shallow or to deep. The sensitivity of this indicator can be determined from the lab. Since this was a new operation for all people involved, we used more than hour to get used to this, and to get the optimal sensitivity on the indicator.

When we were confident on the operation of the OTIS, we lowered the instrument to the target density and started the release. In 15 minutes of injection at the target density, we managed to inject 0.9 kg of the tracer (SF_5CF_3). Based on the record from the OTIS, we could determine that the tracer was injected at a very narrow band, within +/- 1 meter from our target density. This has to be judged as a great success, particularly considering that this was a brand new and unproved instrument, and this was the first time that pure SF_5CF_3 was ever used for an injection of this sort. Particularly impressive was the fact that none of the 8 orifices became clogged during the operation, a fact that might be attributed to the choice of primer fluid (Vertrel XF). It is fair to say that during this cruise, the German team (T. Tanhua, A. Pinck, M. Müller and I. Shuffenhauer) gained a lot of experience in operating the OTIS, and the OTIS proved to be a well working system

Fig. 7 The OTIS on deck prior to deployment. Photo by Mario Müller.

5.4 Moorings During the first leg of the P357 cruise a series of mooring with acoustical and mechanical current meters and MicroCats for measurements of temperature and conductivity was deployed in the eastern Gotland Basin. The positions of the moorings are listed in Tab. 1 and the technical details of each of the moorings can be found in the Appendix A.

Table. 1. List of moorings installed during P357-1.

Mooring	Date of deployment	Latitude	Longitude	Water depth / m
A1	09 September 2007	56°N 41,97'	020°E 14,97'	128
SW	10 September 2007	57°N 07,20'	019°E 51,57'	230
NW	11 September 2007	57°N 20,8'	019°E 57,3'	235
TF271-SC	11 September 2007	57°N 19,01'	020°E 03,08'	244
TF271-LR	11 September 2007	57°N 19,26'	020°E 04,24'	244

5.5. **P-CTD System description:** The IOW-Pump-CTD-System is an integrated measurement devise for profiling CTD-, Oxygen-, Fluorescence-, Turbidity- and LADCP- measurements in combination with sophisticated online water sampling down to 400 m of water depth. The system developed in close co-operation between IOW instrumentation department and the MPI nutrient group in Bremen following the ideas of G. Friedrich et al. from MBARI California.

In combination with electronic CTD- and other standard parameter measurements rosette water sampling can be carried out with up to 12 preprogrammable 5 l FreeFlow bottles as usual. In addition to that the CTD-rosette is equipped with an extra high pressure pump and produces a continuous water stream of 2 to 3 litres per minute from the CTD through cable and winch to the lab. The CTD- and Pump rosette system can be used in different configurations according to different requirements e.g. with an under water camera, an LADCP and or other sensors. The entire system contains additionally a special hose cable, a computer controlled winch with an electrical and fluid slip ring system, a special isolating high power electrical supply unit, the CTD-Deck unit, a digital flow meter for the water stream and several PCs for CTD-, Rosette-, Camera-, ADCP- and winch control (Fig. 8.). The specifications of the system are summarised in

Table. 2. Tab. 2. PCTD Specifications:

CTD-Probe	***SEABIRD SBE 911plus***	***S/N 0603***
Pressure Sensor	DIGIQUARTZ	S/N 78962
Temperature Sensor	SBE 3plus	S/N 2883
Conductivity Sensor	SBE 4	S/N 1150
Oxygen Sensor	SBE 43	S/N 0411
Submersible Pump	SBE 5T	S/N 0975
Altimeter	BENTHOS	S/N 1151
Fluorometer	Dr. Haardt; µ-Backscatter / ChlA	S/N 12100

High press. Submers. Pump Unit	***IOW***	***S/N 0003***
Pump motor	Franklin po-mo 10c-0,5 kVA	S/N 0003
PROCON vane pump Ser. 3	103A060F11XX	S/N 0003

The water flow through the cable is dependent on the individual cable and cable length, the individual pump and pump motor (submersible deep well pump motor). It differs from 1.5 l/min up to 2.5 l/min in the actual configuration with about 300 m of FALMAT®-cable, a PROCON® Series 3 vane pump and a 0.5 kVA Franklin® motor. The pump cable consists of a nylon hose in the centre (inner/outer diameter: 6/8 mm), a strengthening Kevlar layer, 9 electrical wires for pump power supply, 4 twisted pairs for data transmission and an outer PUR mantle (over all diameter: 18 mm, breaking strength: 3.5 t). The individual pump functions stable for a long time and the flow rate is usually constant in the range of +/- 0.1 l/min. The actual flow rate is monitored by a PC controlled digital flow meter. So the actual travel time from the inlet to the outlet can be estimated with an accuracy of +/- 1 second, using the flow rate measured by the flow meter.

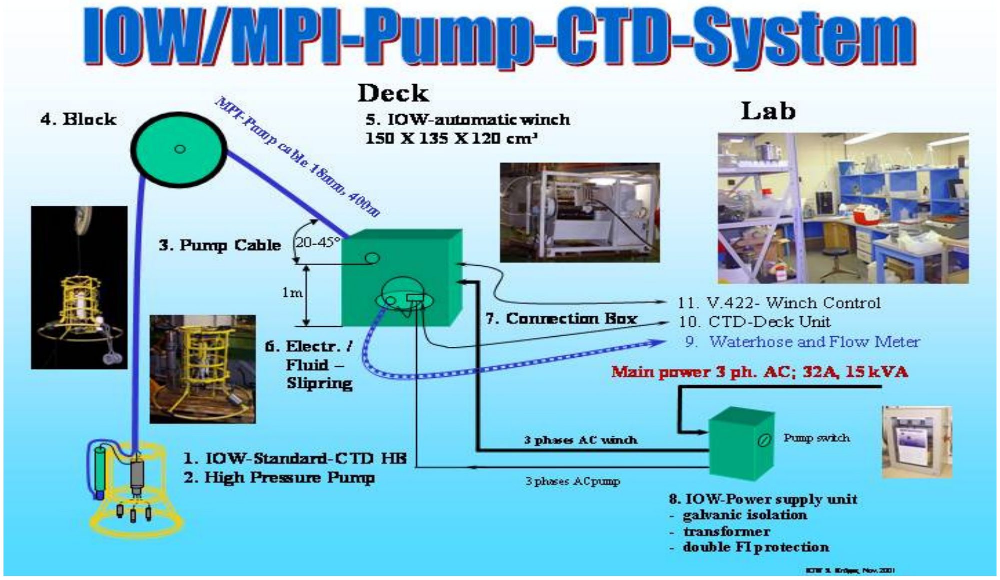


Fig. 8 The IOW P-CTD System including the deck, the laboratory and the in-situ unit.

For the BaTRE Tracer search the PCTD-Rosette was chopped as much as possible: assembly and protection parts as well as all FreeFlow Bottles were removed. Extra lead and later steel weights of at least 180 kg were attached to the CTD guard cage to make it heavy and fit for towing with low speed at a given depth. The system own winch was especially modified for the 18 mm pump cable and got an integrated electrical/fluid slip ring system. The winch was positioned on the aft working deck of R/V POSEIDON facing to the A-frame at the stern.

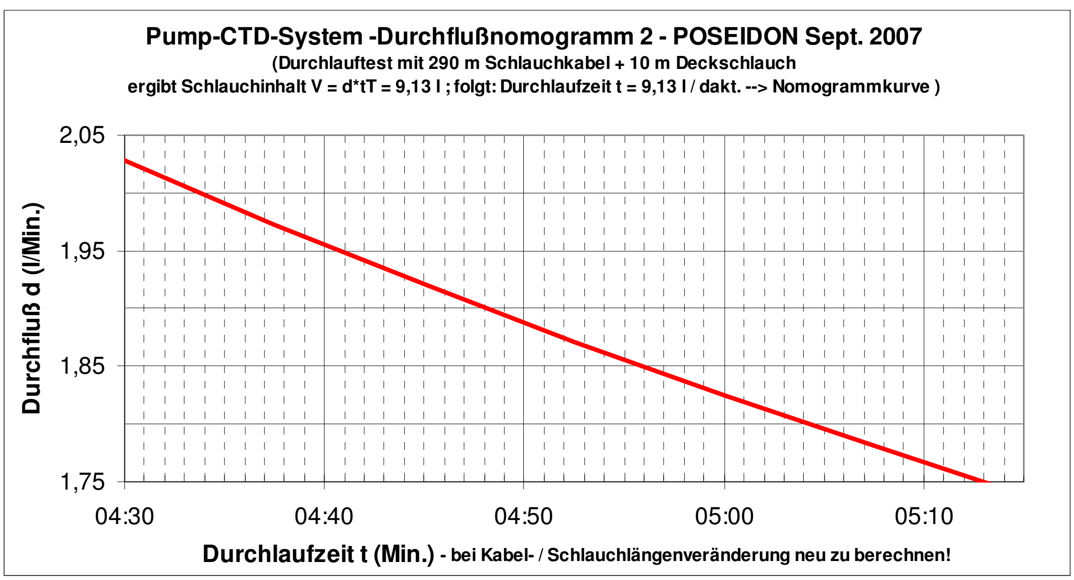


Fig. 9. For a cable length of 300 m and a flow rate of 1.75 l/min the travel time at the BaTRE experiment was estimated to 5 min 13 s.

The intention was to tow the probe slowly by the vessel and controlling the depth by the PCTD winch to keep the probe in the constant density layer where the still patchy tracer should be expected. Applying the water stream to an equilibrator connected to a continuous sampling GC and taking discrete samples manually for another GC every several minutes should enable an immediate tracer finding. Because the actual PCTD, even in a chopped form is not designed as a towed body it was difficult to find the right method and the right towing speed to keep the probe stable in a constant density layer of about 200 m where the tracer was expected. At least it functioned, sailing with the wind with 1 to 1.5 kn and about 280 m of pump cable out. To improve the probability to find the tracer the probe was undulated by the PC controlled winch about 5 m up and down from the tracer target density layer. For the P357-2 cruise the travel time of water was estimated to be 5 min 13 s (Fig.9).
With this “towed undulating method” the first tracer patch was found at station Hurra (719, 57°N 12.42, 020°E 04.67). At least the stress to the inner wires of the cable was too much. Especially the thin twisted pairs were broken. But by changing to spare twisted pairs and later to thicker wires the system could be kept in operation and at least 6 tracks with 3 tracer findings could be carried out (see PCTD diaries and data).

5.6. Analytical systems A total of three GC/Purge and trap systems, one from IOW and two from IFM-GEOMAR was used for the analytical detection of the tracer during the cruise. The two systems from IFM-GEOMAR are established since a long time and have so far normally been used for the analysis of CFCs (Bullister, J.L. & Weiss, R.F., 1988: Determination of CCl3F and CCl2F2 in seawater and air. Deep-Sea Research, 35(5): 839-853.). These systems were modified to optimize for the analysis of CF_5CF_3.
At IOW, a complete new system was build up, based on the knowledge and constructed in close collaboration with IFM-GEOMAR, using the same extraction procedure and analytical components (Fig.10). This system worked without any flaws during this first campaign. The IOW-instrument and one of the IFM-GEOMAR samples were dedicated to measurements on discrete water samples, taken either from the CTD/Rosette system or from the pump CTD of IOW using gas-tight 100 ml syringes.
Sub-samples of approximately 20 ml were transferred into the purge-vial. The dissolved gases were stripped with nitrogen for 4.5 min. and subsequently concentrated on a 12 cm HaySep D (60/80 mesh) column installed into a cryo-cooled Peltier Trap run at -30°C. The Peltier Trap was subsequently heated to 120°C and the gases were transferred to a custom modified gas chromatograph (GC Shimadzu 2014 or Shimadzu GC 14, respectively). The preparation line consists of, in series, a 15 cm Porasil C packed 1/8" column used as a pre-column and a 180 cm Carbograph packed 1/8" column plus a 20 cm Molesieve (5A) 1/8" packed column as main columns. The SF_5CF_3 and CFC-12 peaks were isolated by backflushing the slower eluting

components from the pre-column. Detection was performed using an Electron Capture Detector. This set-up thus allowed to effectively analyze SF_5CF_3 and CFC-12 (that elutes only slightly after the SF5CF3).

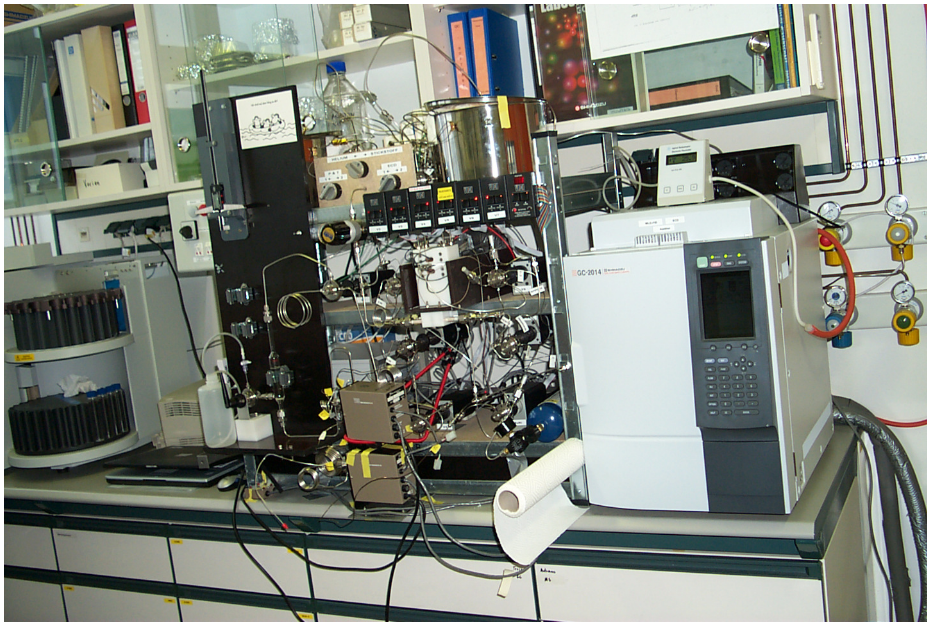


Fig. 10 Newly-developed Purge and Trap system of IOW (Marine Chemistry Department) build for the BaTRE project.

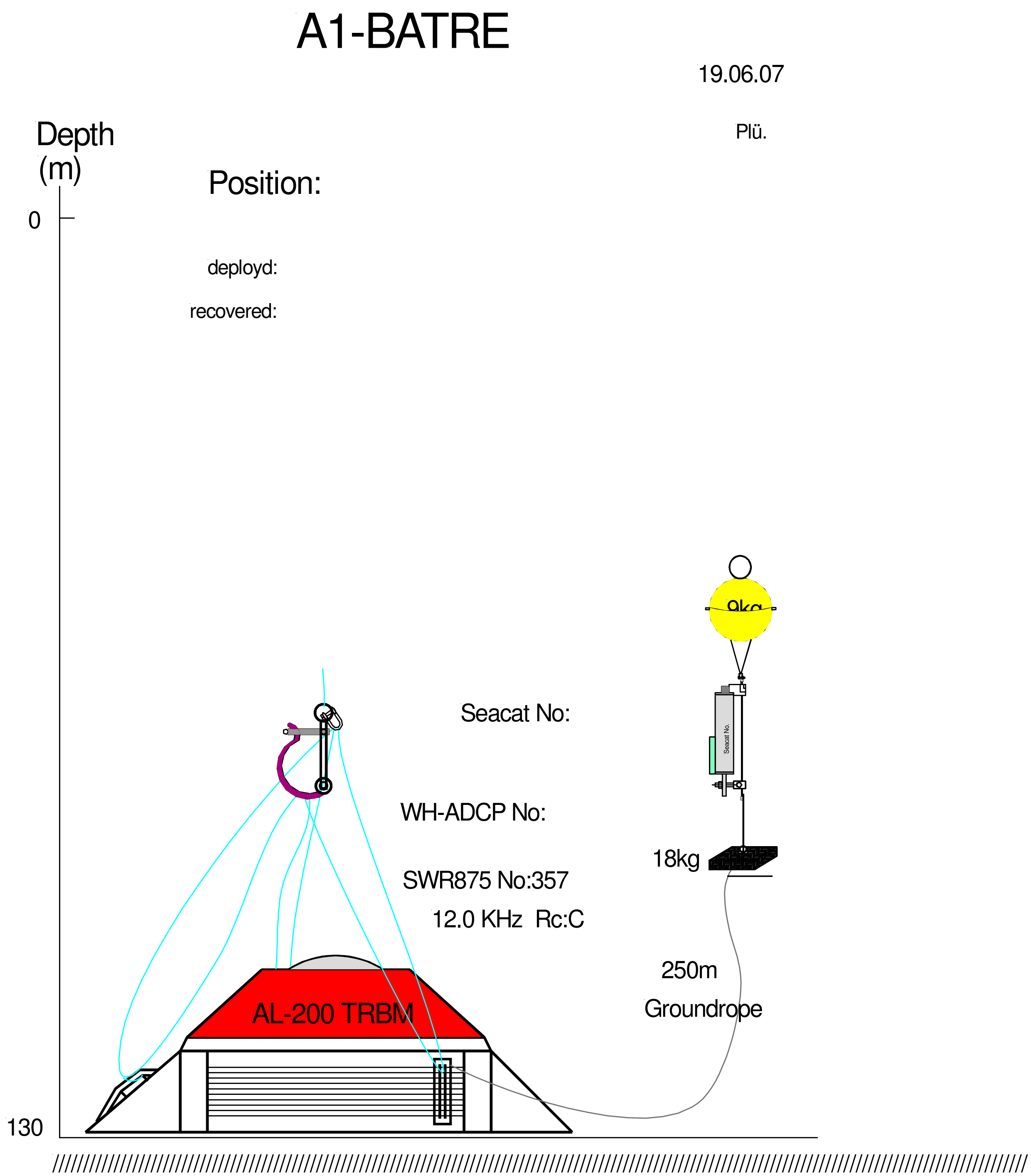
The second instrument of IFM-GEOMAR was used in-line with an equilibrator connected to the continuous flow from the pump-CTD. A flow rate of approximately 2 Liter/min was maintained through the equilibrator. A 12 ml sample of the circulating air was sampled automatically approximately every 6 minutes. This volume of air was trapped, desorbed and analysed, following the routine usually used for standard-measurements. The experience from this set-up was very positive. The water from the pump-CTD partly equilibrated with the headspace in the equilibrator, and proved to be an excellent indicator for the presence of tracer along the cruise-track. Due to the large carry over effect of the equilibrator, even a small signal from a narrow streak of the tracer gave a strong signal on the GC. However, the same carry over effect made the set-up a very poor indicator of when we left the tracer patch. This was however not critical, and though not allowing quantitative measurement of the tracer in the water, these disadvantages were well compensated by the advantages of the “watch-dog” system to locate the tracer patch.
Standardization on all instruments was performed relative to two working standards (BaTRE 1 and BaTRE2) containing SF_5CF_3, CFC-12 and CFC-11. The absolute concentration of these two standards will be determined later in 2007, awaiting the preparation of a primary standard by Deuste-Steiniger.

5.7. PC-Log & Acoustic Doppler Current Meter A PC-Based programme package consecutively logged the data streams from the ship's navigational units, as well as from the thermosalinograph and from the DWD (Deutscher Wetterdienst) sensors. The currents along the cruise track were continuously monitored using the Vessel mounted Acoustic Doppler Current Meter (VMADCP) of the ship. Due to low scattering particle concentrations in the anoxic deep layers reliable data were gathered only in the upper 200m. The basin scale currents were dominated by the inertial oscillations with a vertical phase shift and a magnitude of about 5 to 10 cm/s.

6. Acknowledgements
We would like to thank Captain Michael Schneider and his crew for their cooperation and help during this cruise.

7. Appendices

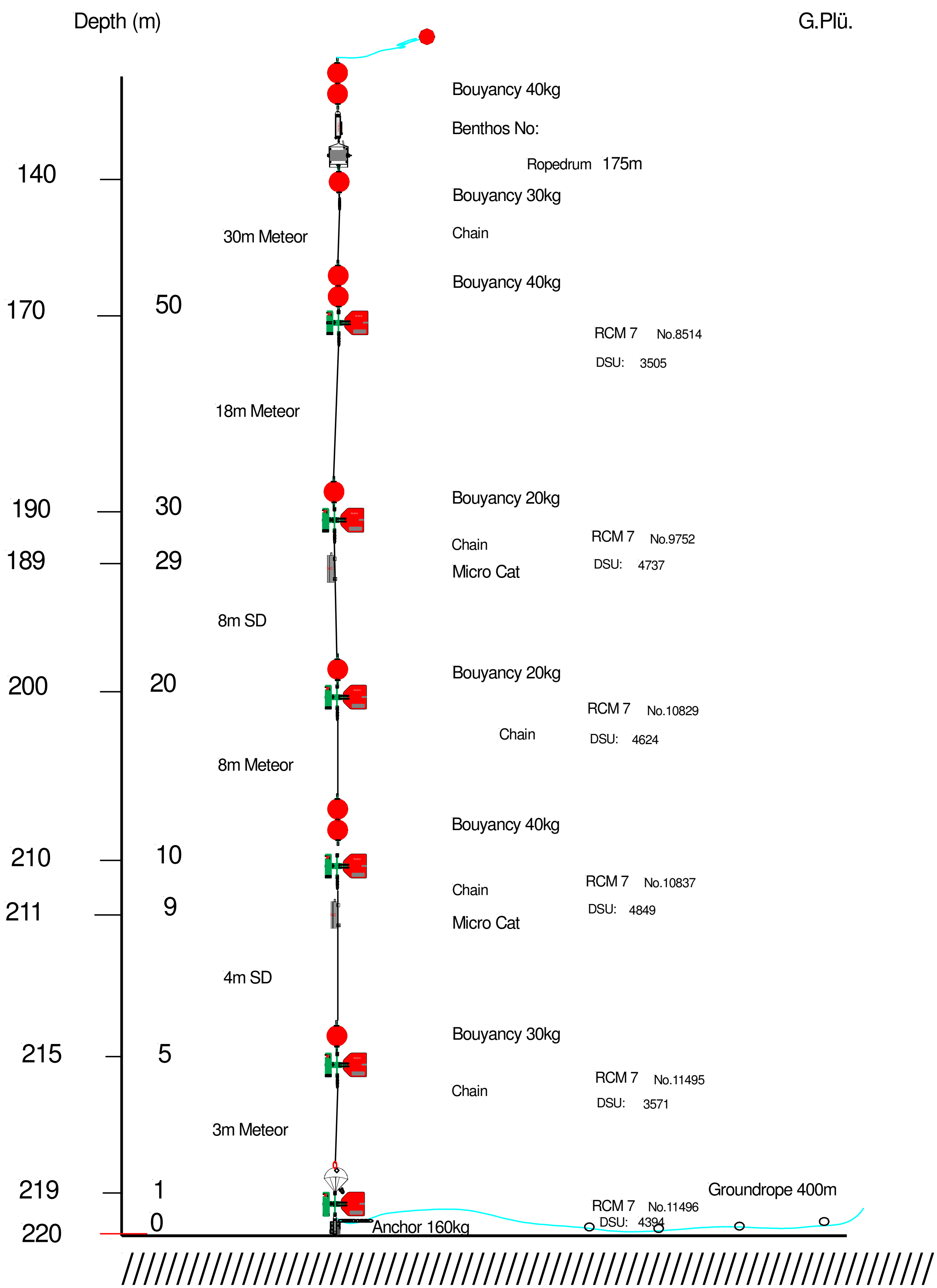
A. Moorings diagrams



NW-BATRE

20.06.2007

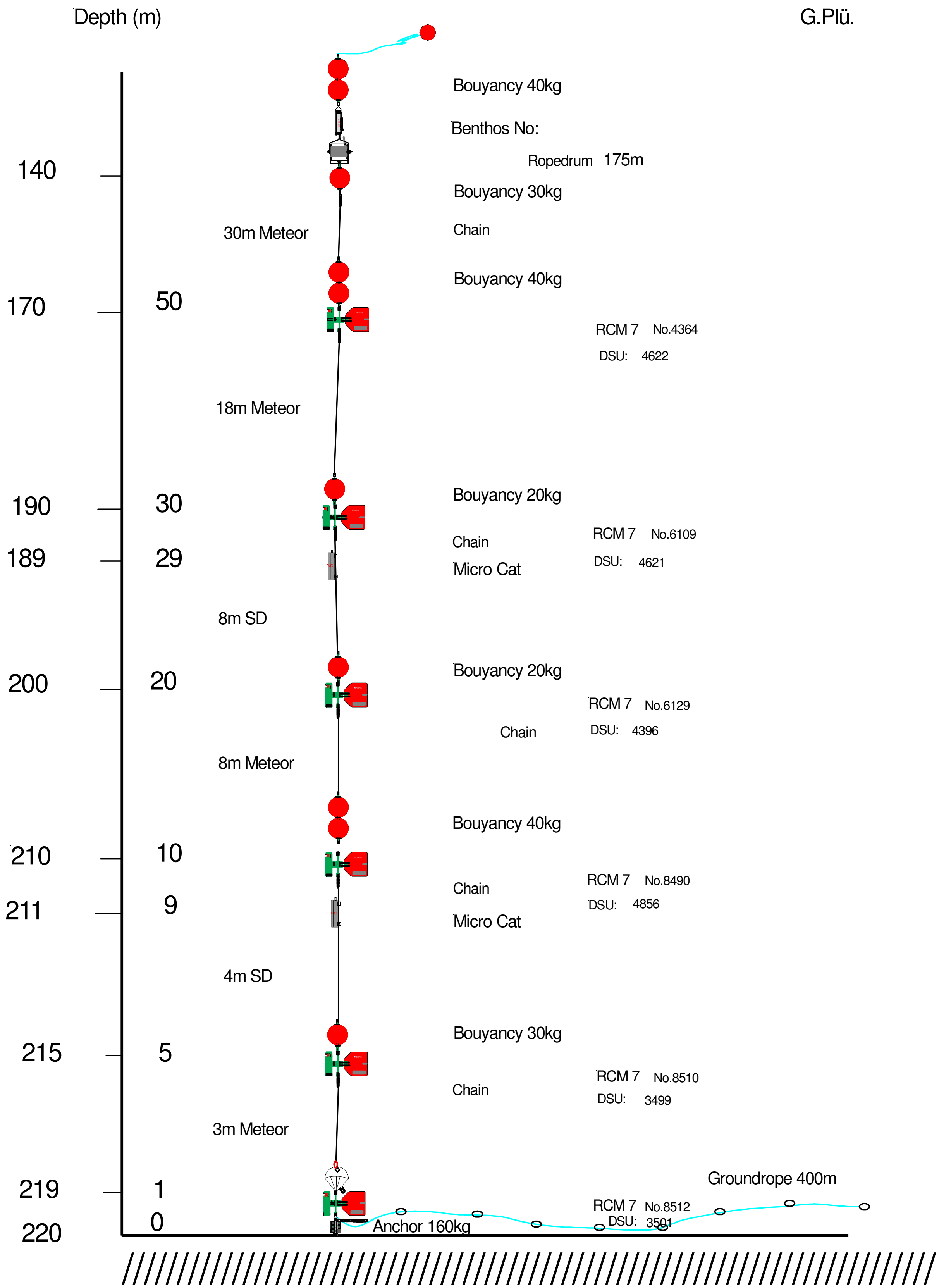
G.Plü.



SW_BATRE

20.06.2007

G.Plü.



TF271-LR

19.06.2007

Plü.

Depth(m)

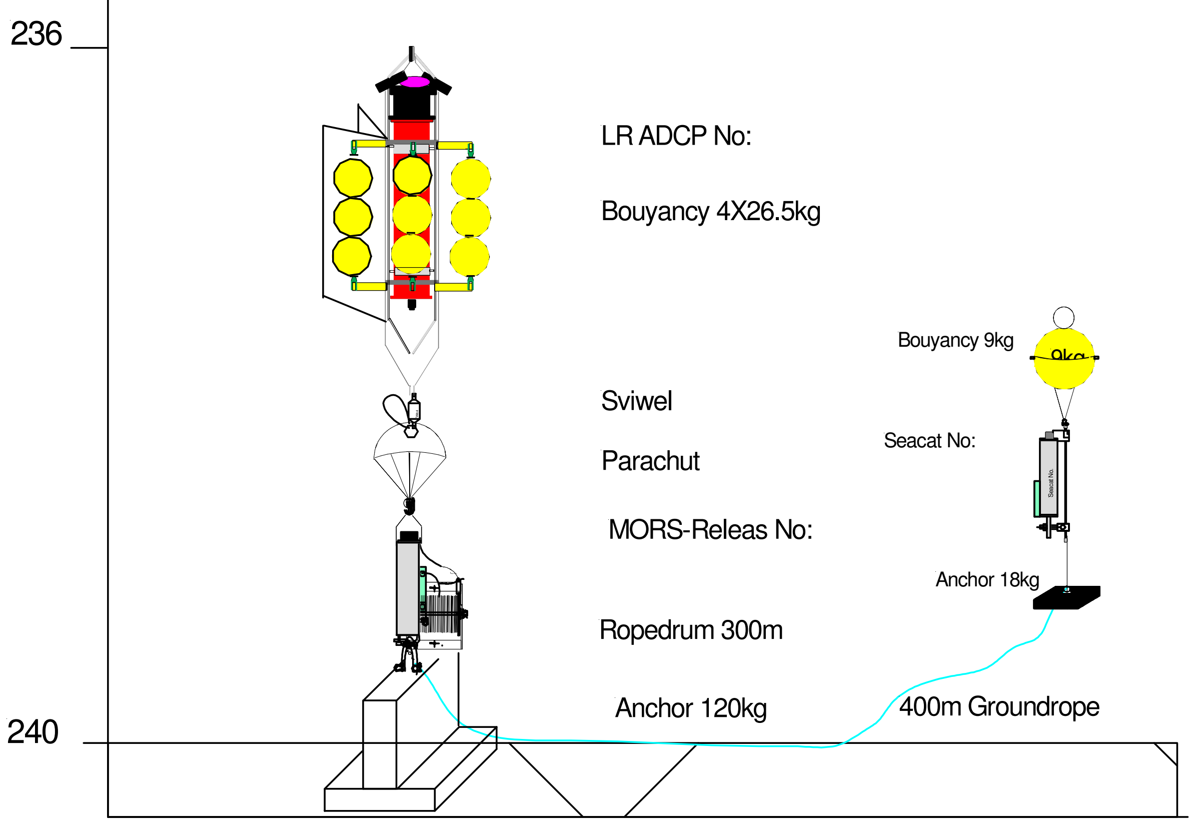
Position:

0

Deployment:

Stückliste:

1. T-Anker
2. Drift anchor
3. ADCP whis framework
4. 1Yoke swirl
5. Bouyancy 40kg
6. Bouyancy 4X26,5kg
7. Rope Box 300m
8. MORS Relaes No:
9. 400m Goundrope
10. Bouyancy 9kg
11. Seacat No:
12. Anchor 18kg
13. Rope 2.5m

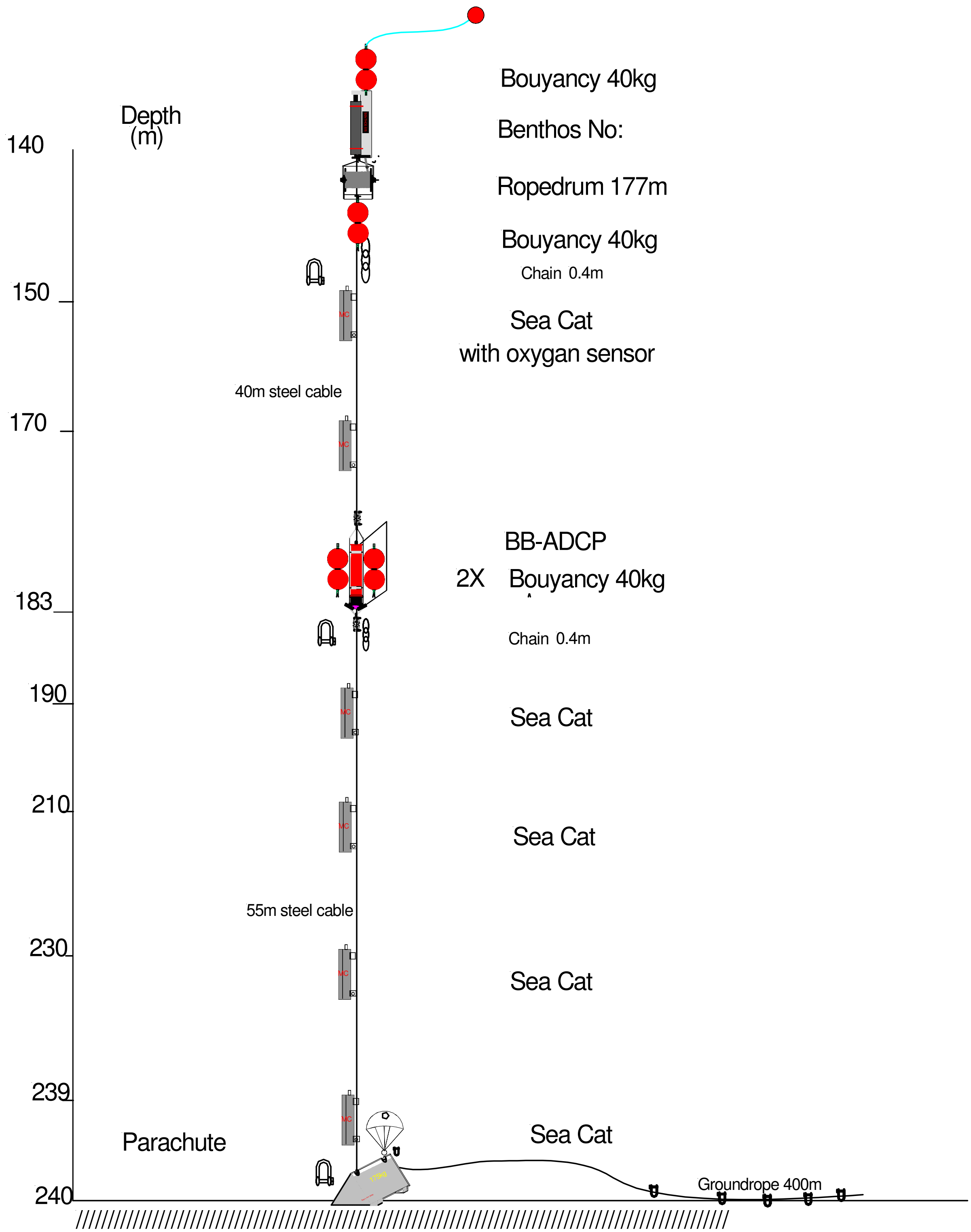


TF271-SC

11.07.07

Plü.

Position:



B. Station list

Stat. No	Date	Time /UTC	Description	Latitude	Longitude
			P357/1		
653	09/09/2007	16:32	A1 mooring	56°41.97'N	020°14.97'E
653-2	09/09/2007	17:30	CTD	56°41.95'N	020° 15.27'E
653-3	09/09/2007	17:51	MSS	56°41.98'N	020° 15.55'E
654	10/09/2007	22:43	MSS	57°06.04'N	020°21.94'E
655	10/09/2007	00:19	MSS	57°06.06'N	020°12.02'E
656	10/09/2007	02:20	MSS	57°05.89'N	020°02.01'E
657	10/09/2007	04:15	MSS	57°05.86'N	019°51.92'E
658	10/09/2007	06:14	MSS	57°06.03'N	019°42.07'E
658-2	10/09/2007	07:15	OTIS buoyancy test	57°05.99'N	019°41.93'E
659	10/09/2007	08:26	CTD	57°07.22'N	019°51.63'E
659-2	10/09/2007	10:34	SW mooring	57°07.31'N	019°51.96'E
660	10/09/2007	12:45	CTD	57°12.06'N	019°41.95'E
661	10/09/2007	13:58	CTD	57°12.10'N	019°52.00'E
662	10/09/2007	15:02	CTD	57°11.95'N	020°02.00'E
663	10/09/2007	16:05	CTD	57°12.02'N	020°12.11'E
664	10/09/2007	17:09	CTD	57°11.93'N	020°21.94'E
665	10/09/2007	18:24	CTD	57°18.02'N	020°31.90'E
665-2	10/09/2007	18:40	MSS	57°18.06'N	020°31.93'E
666	10/09/2007	19:57	CTD	57°18.02'N	020°21.99'E
666-2	10/09/2007	20:12	MSS	57°18.03'N	020°21.95'E
667	10/09/2007	21:49	CTD	57°18.00'N	020°11.95'E
667-2	10/09/2007	22:10	MSS	57°17.89'N	020°11.92'E
668	11/09/2007	00:01	CTD	57°18.03'N	020°02.03'E
668-2	11/09/2007	00:19	MSS	57°17.97'N	020°01.88'E
669	11/09/2007	02:20	CTD	57°17.93'N	020°02.07'E
669-2	11/09/2007	02:43	MSS	57°17.94'N	019°52.22'E
670	11/09/2007	04:38	CTD	57°17.96'N	019°41.99'E
670-2	11/09/2007	04:55	MSS	57°17.94'N	019°42.07'E
671	11/09/2007	06:34	NW mooring	57°21.11'N	019°56.56'E
672	11/09/2007	07:47	CTD	57°17.54'N	020°02.37'E
672-2	11/09/2007	08:43	OTIS tracer release	57°18.01'N	019°55.96'E
673	11/09/2007	13:18	TF271-SC mooring	57°19.06'N	020°02.54'E
673-2	11/09/2007	14:11	TF271-LR mooring	57°19.11'N	020°04.11'E
674	11/09/2007	17:20	CTD	57°24.03'N	019°41.91'E
674-2	11/09/2007	17:39	MSS	57°24.10'N	019°41.61'E
675	11/09/2007	19:04	CTD	57°23.98'N	019°51.92'E
675-2	11/09/2007	19:21	MSS	57°23.98'N	019°51.84'E
676	11/09/2007	21:13	CTD	57°24.02'N	020°02.04'E
676-2	11/09/2007	21:33	MSS	57°23.97'N	020°01.79'E
677	11/09/2007	23:45	CTD	57°24.02'N	020°12.04'E
677-2	12/09/2007	00:03	MSS	57°24.21'N	020°11.85'E
678	12/09/2007	02:18	CTD	57°24.01'N	020°21.99'E

Stat. No	Date	Time /UTC	Description	Latitude	Longitude
P357/1					
678-2	12/09/2007	02:40	MSS	57°24.09'N	020°22.06'E
679	12/09/2007	04:46	CTD	57°23.92'N	020°32.04'E
679-2	12/09/2007	05:01	MSS	57°23.93'N	020°31.93'E
680	12/09/2007	06:57	CTD	57°30.05'N	020°32.07'E
681	12/09/2007	08:05	CTD	57°30.00'N	020°21.98'E
682	12/09/2007	09:05	CTD	57°30.00'N	020°12.02'E
683	12/09/2007	10:09	CTD	57°29.99'N	020°02.05'E
684	12/09/2007	11:15	CTD	57°29.97'N	019°52.04'E
685	12/09/2007	12:38	CTD	57°35.97'N	020°02.04'E
686	12/09/2007	12:38	CTD	57°35.98'N	020°12.00'E
687	12/09/2007	14:47	CTD	57°35.96'N	020°22.03'E
688	12/09/2007	15:48	CTD	57°35.98'N	020°31.95'E
689	12/09/2007	18:28	CTD	57°24.00'N	020°01.90'E
689-2	12/09/2007	19:12	CTD	57°24.01'N	020°02.09'E
689-3	12/09/2007	20:02	CTD	57°23.99'N	020°02.05'E
690	12/09/2007	23:43	MSS	57°14.80'N	020°14.59'E
691	13/09/2007	13:15	CTD	57°18.18'N	019°56.91'E
692	13/09/2007	16:23	CTD	57°00.03'N	019°41.93'E
692-2	13/09/2007	16:43	MSS	57°00.13'N	019°41.93'E
693	13/09/2007	18:24	CTD	57°00.02'N	019°51.98'E
693-2	13/09/2007	18:40	MSS	57°00.03'N	019°52.07'E
694	13/09/2007	20:13	CTD	56°59.96'N	020°02.01'E
694-2	13/09/2007	20:30	MSS	57°00.01'N	020°02.15'E
695	13/09/2007	22:23	CTD	57°00.01'N	020°11.90'E
695-2	13/09/2007	22:42	MSS	57°00.17'N	020°11.90'E
696	14/09/2007	00:23	CTD	56°59.98'N	020°21.99'E
696-2	14/09/2007	00:38	MSS	57°00.06'N	020°21.78'E
697	14/09/2007	02:20	CTD	56°53.98'N	020°21.95'E
697-2	14/09/2007	02:36	MSS	56°54.06'N	020°21.85'E
698	14/09/2007	03:38	CTD	56°53.98'N	020°11.86'E
698-2	14/09/2007	03:59	MSS	56°54.22'N	020°11.78'E
699	14/09/2007	05:23	CTD	56°54.02'N	020°02.07'E
699-2	14/09/2007	05:44	MSS	56°54.10'N	020°02.09'E
700	14/09/2007	07:04	CTD	56°54.00'N	019°51.95'E
700-2	14/09/2007	07:24	MSS	56°54.01'N	019°52.04'E
701	14/09/2007	08:55	CTD	56°54.01'N	019°41.98'E
701-2	14/09/2007	09:11	MSS	56°54.06'N	019°41.93'E
702	14/09/2007	12:15	MSS	56°41.94'N	020°17.91'E

Stat. No	Date	Time /UTC	Description	Latitude	Longitude
P357/2					
703	21/09/2007	01:42	CTD	56°42.05'N	020°15.07'E
704	21/09/2007	06:16	MSS	57°03.21'N	020°06.75'E
704-2	21/09/2007	06:50	CTD	57°02.96'N	020°06.44'E
704-3	21/09/2007	07:10	P-CTD	57°02.90'N	020°06.65'E
705	21/09/2007	11:38	CTD	57°17.79'N	020°00.28'E
705-2	21/09/2007	12:19	MSS	57°17.76'N	019°59.81'E
706	21/09/2007	14:21	CTD	57°27.86'N	020°16.54'E
706-2	21/09/2007	14:57	P-CTD	57°27.93'N	020°16.67'E
707	22/09/2007	17:15	CTD	57°03.40'N	019°45.29'E
708	22/09/2007	19:32	CTD	57°15.48'N	020°03.95'E
709	22/09/2007	21:26	CTD	57°23.52'N	020°17.33'E
709-2	22/09/2007	22:05	P-CTD	57°23.58'N	020°17.36'E
709-3	23/09/2007	12:00	P-CTD	57°12.42'N	020°04.68'E
709-4	23/09/2007	16:19	CTD	57°12.42'N	020°04.71'E
709-5	23/09/2007	17:06	MSS	57°12.39'N	020°04.63'E
709-6	23/09/2007	18:06	CTD	57°12.41'N	020°04.68'E
710	23/09/2007	19:05	CTD	57°11.55'N	020°03.74'E
711	23/09/2007	20:35	CTD	57°11.97'N	020°04.02'E
712	23/09/2007	21:52	CTD	57°12.51'N	020°04.09'E
713	23/09/2007	23:19	CTD	57°12.01'N	020°05.03'E
714	24/09/2007	00:41	CTD	57°12.51'N	020°05.04'E
715	24/09/2007	02:10	CTD	57°12.25'N	020°04.23'E
716	24/09/2007	03:37	CTD	57°12.30'N	020°04.66'E
717	24/09/2007	04:51	CTD	57°12.25'N	020°04.50'E
718	24/09/2007	06:16	CTD	57°12.76'N	020°04.53'E
719	24/09/2007	07:22	P-CTD	57°12.42'N	020°04.67'E
720	24/09/2007	11:58	CTD	57°12.45'N	020°03.79'E
721	24/09/2007	13:08	P-CTD	57°12.46'N	020°03.79'E
722	24/09/2007	14:43	P-CTD	57°11.95'N	020°03.75'E
722-2	24/09/2007	16:43	P-CTD	57°11.88'N	020°03.78'E