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Cruise Report

of the

METROL **cruise** to the **Skagerrak**

12.06. - 22.06. 2003,

F.S. Heincke cruise **HE 191**

A research project supported by the **European Commission**
under the Fifth Framework Programme and contributing
to the implementation of the Key Action "Sustainable marine ecosystems"
within the Energy, Environment and Sustainable
Development

Contract no: **EVK3-CT-2002-00080**

Report F.S. Heincke – cruise no HE 191

RV Heincke call sign: DBCK
Cruise number: HE 191
Dates of Cruise: 12.06.-22.06.2003
General subject of research: Geology/geochemistry, EU Project METROL (Methane fluxes in ocean margin sediments: microbiological and geochemical control)

Port Calls: Bremerhaven: 12.06.2003; 22.06.2003
Institute: Alfred Wegener Institute for Polar and Marine Research

Chief Scientist: Dr. Christian Borowski, MPI-Bremen, Celsiusstr. 1, D-28359 Bremen, Germany Tel. +49 421 2028 649, Fax +49 421 2028 580, e-mail cborowsk@mpi-bremen.de

1. Cruise objectives

This cruise and the scientific work is part of the collaborative project METROL sponsored by the EU (METROL: METhane fluxes in ocean margin sediments: microbiological and geochemical contROL) lead by the MPI-Bremen. Project partners are Germany, Norway, Denmark, UK, The Netherlands, Romania, and Ukraine. In the framework of this project the question is addressed how the methane turnover is regulated in shallow gassy sediments of the European continental margin.

Objectives of this cruise were shallow hydro acoustic mapping of subsurface gas plumes and sediment sampling for (*i*) the quantification of the microbial turnover of methane in gassy sediments as well as the characterisation of the geochemical conditions for the anaerobic methane oxidation; (*ii*) the characterisation and identification of microorganisms involved in the methane oxidation in aerobic and anaerobic sediment layers. As part of these investigations, characteristic organic molecules are to be identified which can be used as biomarkers for the anaerobic methane oxidising microorganisms. At sites with active methane seepage, additional water samples should give information on the aerobic oxidation of methane in the water column.

Target working area was the Skagerrak Trench, stretching from shallow areas on the southern slope in the Danish EEZ to the deepest parts of the trench in the Norwegian EEZ. The purpose of the cruise was primarily to collect the samples which will be analyzed in the home laboratories during subsequent months.

2. Participants / participating institutions

1. Christian Borowski (chief scientist) MPI
1. Tomas Wilkop (technician) AWI
2. Regina Usbeck (scientist) AWI/Fielax
3. Nina Knab (scientist) MPI
4. Jens Kallmeyer (scientist) MPI
5. Maren Nickel (scientist) MPI
6. Fabian Jacobi (student) MPI
7. Barry Cragg (scientist) Univ. Bristol
8. Fiona Brock (scientist) Univ. Bristol
9. Dan Secrieru (scientist) GeoEcoMar
10. Christian Hübscher (scientist) Univ. Hamburg
11. Sofie Gradmann (student) Univ. Hamburg

AWI = Alfred Wegener Inst. for Polar and Marine Research, Columbusstr., 27568 Bremerhaven, Germany
MPI = Max Planck Institute for Marine Microbiology, Celsiusstr. 1, Bremen, Germany
Univ. Bristol = University of Bristol, Dep. Earth Sciences, Queens Road, Bristol BS8 1RJ, Great Britain.
GeoEcoMar = National Institute for Marine Geology and GeoEcology, 23-25 Dimitrie Onciul St, 70318 Bucharest, Romania
Univ. Hamburg = Geophysical Institute, University of Hamburg, Bundesstr. 55, Hamburg, Germany

3. Scientific equipment

Seismic equipment

The seismic survey was performed with two instruments, a water gun and a boomer:

- Water gun: S15.02 water gun (Seismic Systems/Sodera, USA) – a pneumatic seismic source using compressed air as air guns do. Compressed air stored in the firing chamber (0.16 l per "shot") is used to propel a water jet that creates vacuum cavities. These emit a strong bubble-free high-frequency acoustic pulse when they implode due to surrounding hydrostatic pressure. The pulse has a broad spectrum and a middle frequency of around 1.2 kHz. Penetration depth of the signal is maximum 200 m.
- Boomer: 230-1 Uniboom (EG&G, USA). The boomer is towed behind the ship at the water surface. Reflected sound frequencies of 0.6-2.5 kHz are recorded by the streamer hydrophones.

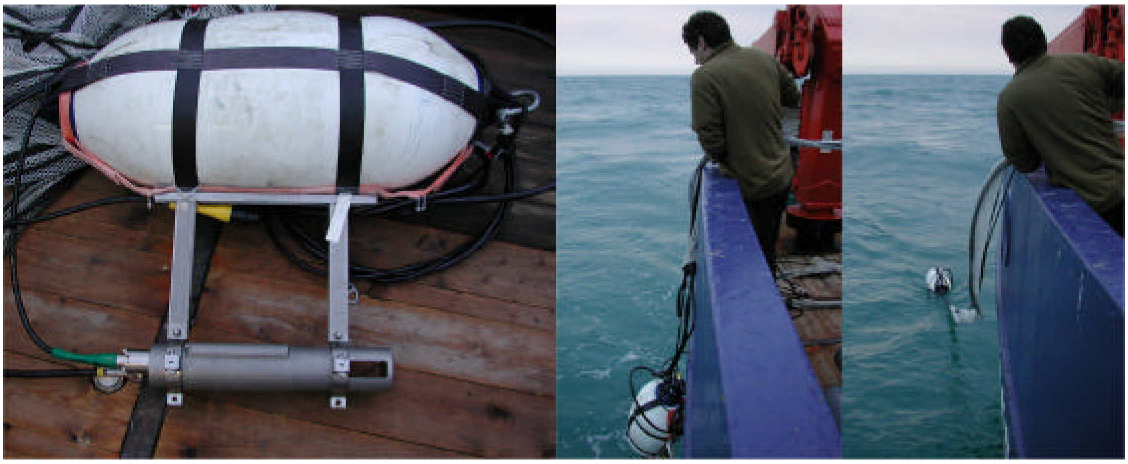

Figure 1. Left: S15.02 water gun mounted under a boy. Middle and right: The water gun was launched by hand over the side of the ship.

Echosounders

The navigation echosounder of RV Heincke was used for the determination of the water depth. A "fish finder" and an Atlas DESO25 sediment echosounder (33 kHz; Seatronics, USA) were used for the detection of pockmarks in water depths down to 550m.

Sediment sampling

- Gravity corer (GC): A large gravity corer equipped with a top weight of approx. 700 kg recovered sediment cores of maximum 5.5 m length. The cores were sub-sampled for the analyses of various geochemical and micobiological parameters (see below).
- Rumohr lot (RL): A small gravity corer that samples the top 50-100 cm of sediment. This corer is used to sample surface sediments which are usually incompletely recovered by the gravity corer. The RL consists of a top frame, loaded with weights (~40 kg) and a plexy-glass core liner of variable length. A lid at the top end closes during bottom contact and seals the core on top during sample recovery. We used 1-m long core liners and the core lengths obtained from the various stations ranged from 50 – 95 cm. These cores served for calibration of the biogeochemical gradients found in the long GC cores.
- Multiple corer (MUC): A multiple corer (type of Barnett et al. 1985) was equipped with five coring tubes of 9.5 cm inner diameter and 60 cm length.
- Van Veen grab: A 1/10-m^{-2} Van Veen Grab was used for quickly "probing" the sediment for seep outlets.

Water sampling

- CTD/rosette. The CTD was a OTS124 (ME Grisard). The Rosette was equipped with 9 Niskin-bottles.

Figure 2. Sampling gear. A: Recovery of the gravity corer. B: Rumohr lot with sediment core visible through the wall of the plexy-glass liner. C: Multi corer filled with 30 cm long cores. D. 0.2 m² Van Veen grab. E. The CTD/Rosette just below the water surface on the way down. F: After recovery, the gravity corer is laid down horizontally.

4. Narrative

12-June-03

12:00 Middle European Standard Time (MEST) We are leaving the port of Bremerhaven, heading to "Roter Sand" off Bremerhaven in the German Bight.

13:06 MEST Start of scientific work with a CTD-rosette station at „Roter Sand". Ship station 762

13:20 MEST Continue the cruise with heading to the Skagerrak. During the transit, installation of laboratories and scientific equipment (Gravity corer, Multi corer, Rumohr lot)

13-June-03

14:40 UTC Arrival in working area 1. Ship station 763: Test of Multi corer

15:15 UTC Test of seismic equipment at Pos. 57°47`N, 9°43`E

16:39 UTC Ship stations 764, 765: seismic profiles 1 and 2 with Water gun.

14-June-03

08:00 UTC End of seismic profile

11:06-17:10 UTC station work, ship stations 766-774: gravity corer and Rumohr lot, wind W 5.

17:10 UTC Seismic profile 3 with Water gun, ship station 775.

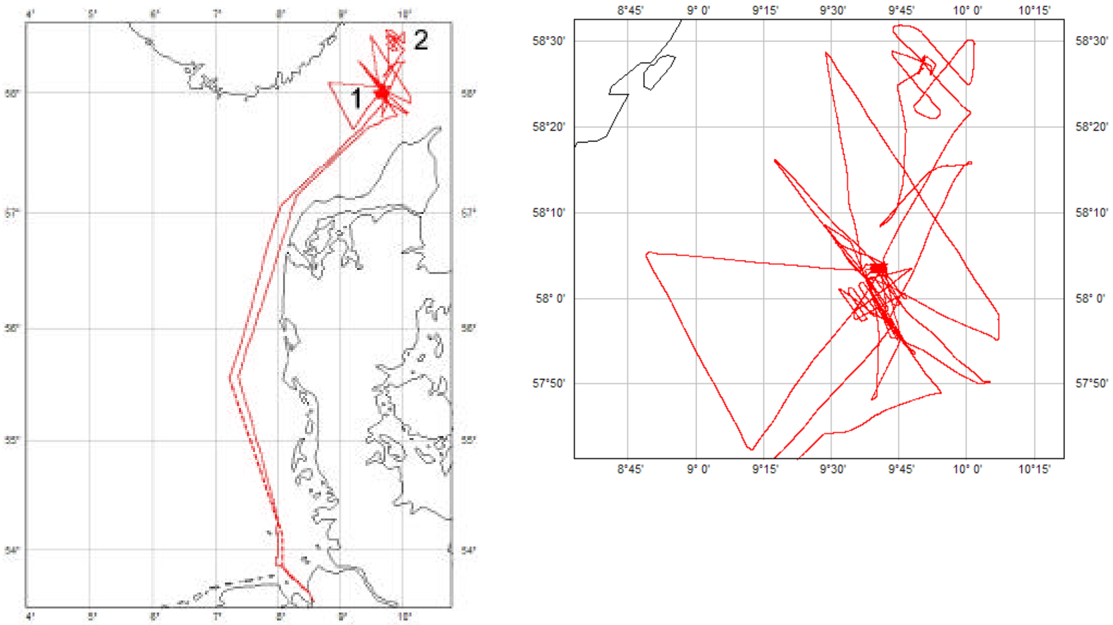

Figure 3. Cruise Track HE 191, with working areas 1 and 2.

15-June-03

04:00 UTC End of profile, Pos. 58°19,3`N, 9°30,0`E

07:00 UTC Station work with Rumohr lot and Gravity corer, ship stations 776-781.
Wind calms down to N 3

10:50-14:20 UTC profile with echosounder DESO25, ship station 78215:06 UTC Station work at 58° 02,7`N, 9° 37,7`E, Gravity corer and CTD. Ship stations 783, 784
moving to starting point of seismic profile 4

20:40 UTC Seismic profile 4 with Water gun, ship station 785

Figure 4. Launching of the streamer

16-June-03

02:19 UTC	End of seismic profile 4, Pos. 58°05,3`N, 8°49,5`E
06:03 UTC	Start of station work at pos. 58°03,3`N, 9°36,5`E alternating deployments of CTD/rosette, Multi corer, Rumohr lot, Gravity corer, and Van Veen grab. Ship stations 786-810. Moving to starting point of seismic profile 5 at pos. 57°54,0`N, 9°46,9`E.
19:18 UTC	Seismic profile 5 with Boomer, ship station 810-a

Figure 5. Recovery of the gravity corer and start of core processing.

17-Jun-03

02:18 UTC	End if profile 5, Pos. 58°08,5`N, 9°28,5`E
04:32 UTC	Start with station work at Pos. 57°55,2`N, 9°45,3`E, alternating deployments of Rumohr lot, Gravity corer, CTD/rosette at various positions, ship stations 811-823 Moving to starting point of seismic profile 6 at pos. 58°03,5`N, 9°48`E
18:36 UTC	Start with seismic profiles 6-16 with Water gun. Ship stations 824-834

18-June-03

06:28 UTC End of profile 16 at pos. 58°01,0`N, 9°31,8`E, moving to next position.
07:42 UTC Start with station work at pos. 57° 57,1`N, 9° 42,4`E.
Alternating deployments of Gravity corer, Rumohr lot, Van Veen grab, ship stations 835-847.
15:55-16:15 UTC working-boat maneuver at 57° 57,1`N, 9° 42,4`E
16:45 UTC Transit to working area 2
18:54 UTC Pos. 58° 22,0`N, 10° 00,0`E
Start with seismic profiles 17-20 with water gun, ship stations 848-852

Figure 6. Working-boat maneuver

19-June-03

05:51 UTC End of Seismic profile 20, 58° 28,0`N, 9°43,9`E
moving to pos. 58° 27,7`N, 9°50,6`E
08:21 UTC Start with echosounder profiles with DESO25, ship stations 852-856
12:10 UTC Start with station work at pos. 58° 26,5`N, 9°49,0`E.
Alternating deployments of Gravity corer, Rumohr lot. Ship stations 857-861.
16:25 UTC Wind picks up to WSW 7/8. End of station work.
17:00 UTC Moving to position 58°16´N, 10°00`E.

20-June-03

04:00 UTC On pos. 58°16´N, 10°00`E. Wind has not calmed (W 7/8), station work impossible
07:00 UTC Secure and tie down scientific equipment
08:45 UTC Pos. 57° 56.6`N, 9°43.4`E, Wind continuously speeds up. End of scientific work. Disassemble scientific equipment on deck. Return to Bremerhaven.

21-June-03

Transit to Bremerhaven. Disassemble laboratory equipment.

22-June-03

00:54 MEST Arrival in Bremerhaven

5. Overall sampling program

Seismics

MCS profiles 1 and 2 (ship stations 764, 765) served for an overview on the shallow seismic reflection patterns across the depth gradient of the southern Skagerrak Trench slope. The chosen way points of profiles of 1 and 2 led across the area that was investigated for methane seepage by earlier studies (Dando et al, 1994, Zimmermann et al 1997). Profiles 3 an 4 (ship stations 775, 784) were performed parallel to profile 1 and extended the observations in working area 1 to the west and the east. Profile 5 (ship station 810-a) was the only boomer profile of the cruise, which served for a comparison with the MCS data and was performed on the same track as profile 1. A detailed survey of the core area of working area 1 was done with profiles 6-16 (ship stations 824-834). 17-20 were performed in working area 2.

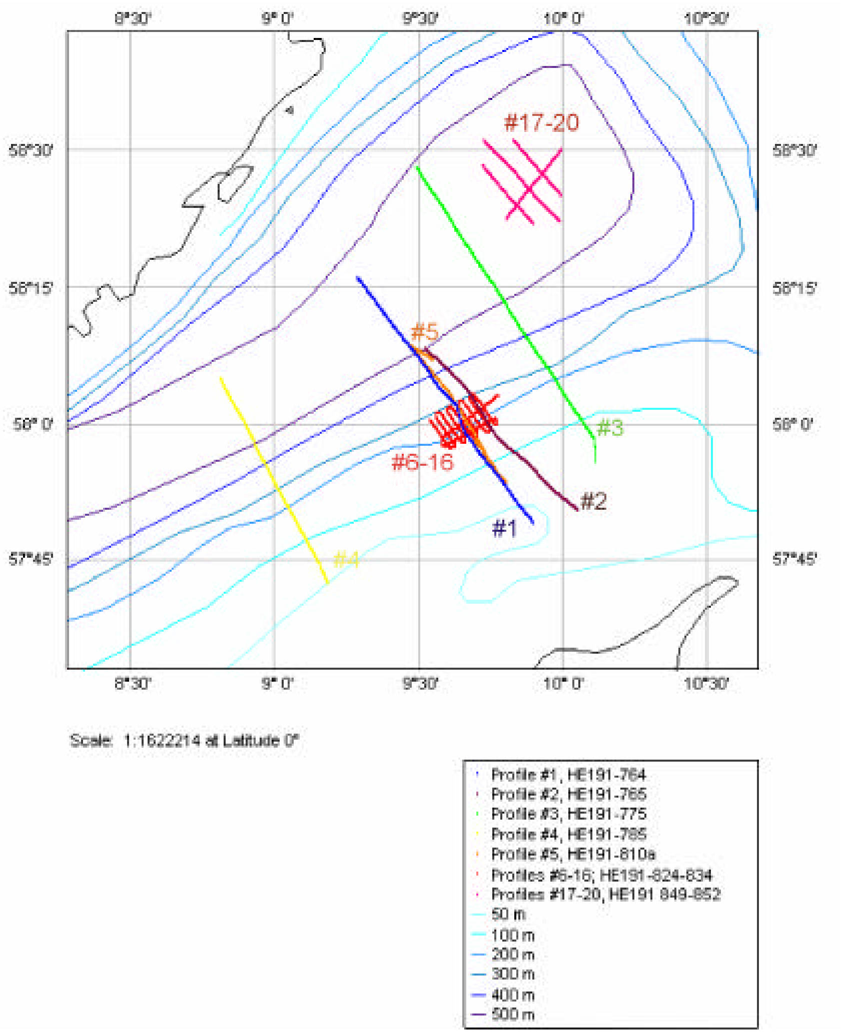

Figure 7. Overview on the seismic profiles in working area 1 (profiles 1-16) and working area 2 (Profiles 17-20).

Sediments

The sediment sampling program in working area one had two objectives.
1. Sampling across the depth gradient of the southern trench slope was entirely done along seismic profile 1. The water depths in which the sediment cores were collected along this transect ranged between 86 and 496 m.
2. A transect of 5 gravity cores and the accompanying Rumohr lot samples was sampled across a pockmark on the upper trench slope.
Additionally to the intensive sampling program in working area 1, two gravity cores and three Rumohr lot cores were sampled in working area 2.

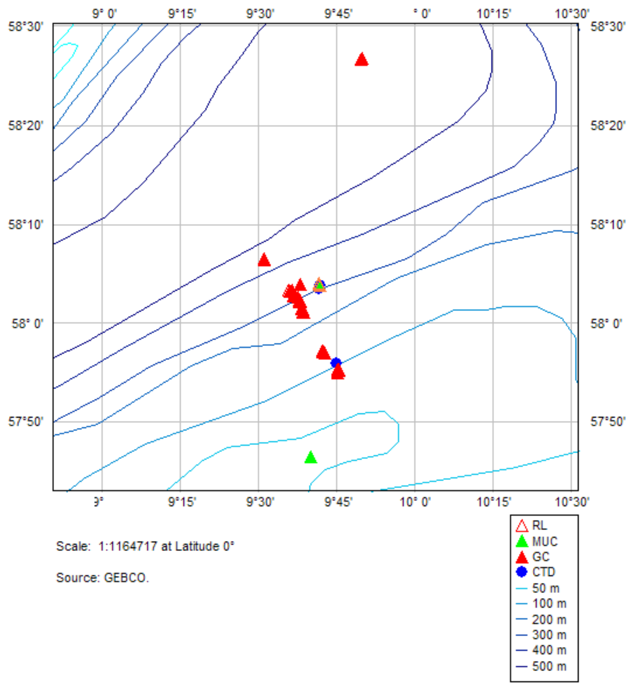

Figure 8. Overview on the sediment sampling locations during HE 191. The aligned sampling stations in working area 1 were positioned along seismic profile 1. Two gravity cores and three Rumohr lots samples were obtained from the working area 2 in the north.

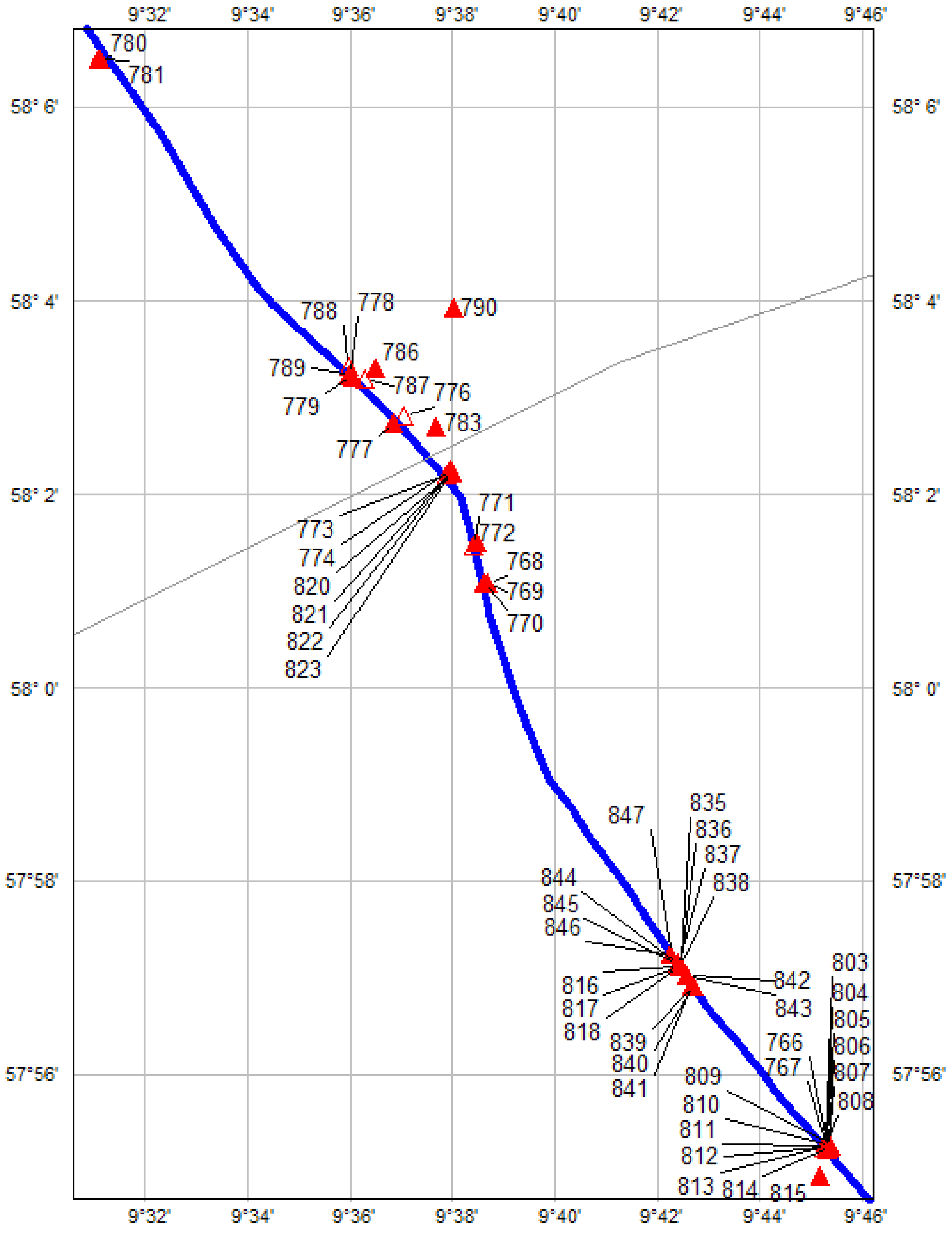

Figure 9: Sediment sampling locations along the transect following seismic profile 1. For position details see Table 1.

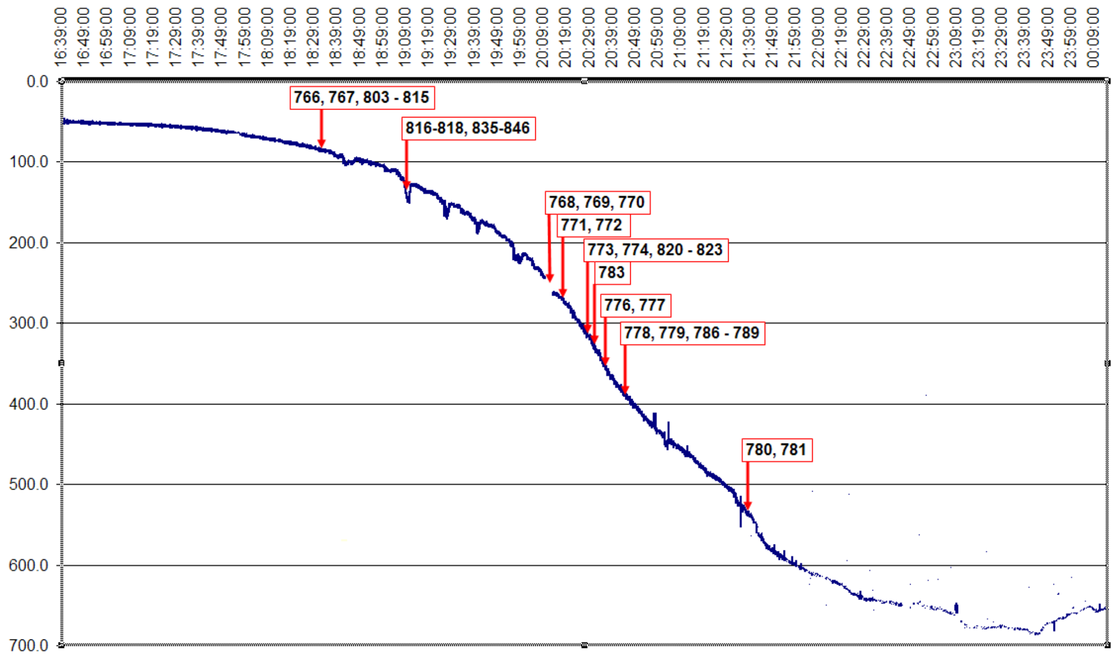

Figure 10: Bathymetric profile of seismic profile 1 and sediment stations. A pockmark on the upper slope was sampled with a serious of 5 gravity cores and accompanying Rumohr lot samples.

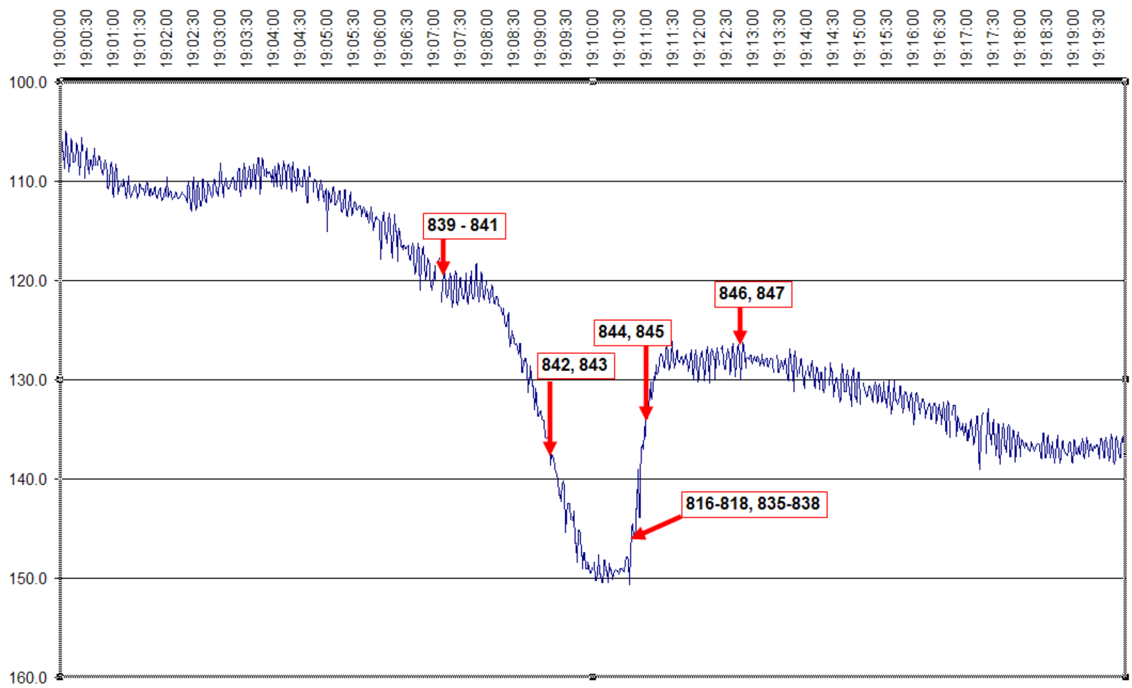

Figure 11. Bathymteric profile and sampling transect across the pockmar on the upper trench slope.

Active seepage

The DESO 25 echosounder was used to search for gas flares in the water column as an indication for active seepage. Observations were performed on a small scale grid, that was positioned in the core area of working area 1 according the coordinates of reported seeps and according to conspicuous cloudy signals observed in the 35-kHh echosoundings during the seismic profiling which had been interpreted as potential gas flares. Positions of the most conspicuous signals were selected for sampling with the Multi corer and Van Veen grab.

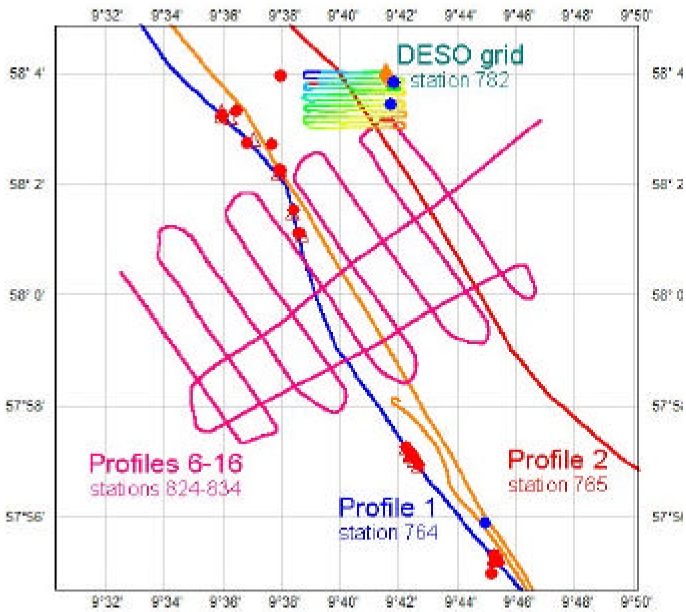

Figure 12. Overview on the location of seismic profiles, gravity coring stations (red dots) and the DESO25 survey in the central region of working area 1. CTD stations are indicated as blue circles. Multiple Van Veen grab deployments were performed at the location marked with the orange diamond.

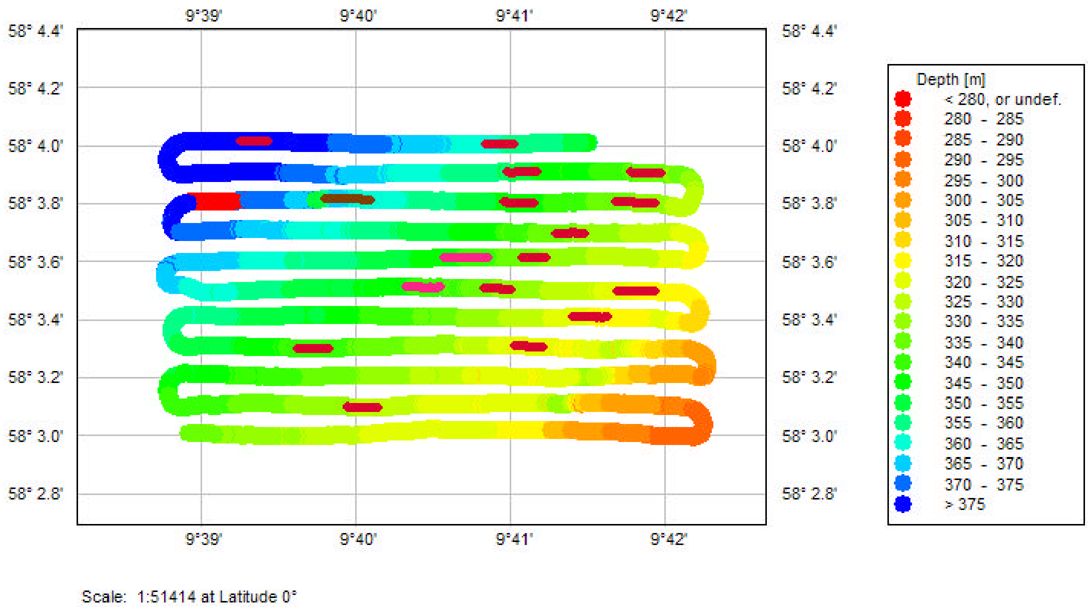

Figure 13. Detailed view of the DESO 25 survey grid. The coloring of the track indicates water depths of the sea floor. Red marks on the track indicate the locations in which the echogram showed cloudy signals. The most conspicuous signal was seen at the position in the upper right corner of the grid. This position served as the starting point for a sequence of multiple Van Veen grab deployments, which was performed while the ship was drifting slowly to the south west. One of these samples retrieved black sulfidic surface sediment, which is believed to origin from a seep outlet.

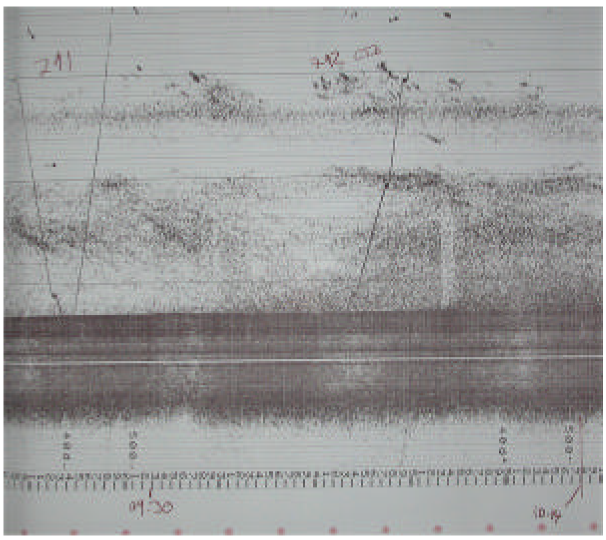

Figure 14. DESO25 echogram showing cloudy signal in the near-bottom water and reflections of the down and up-gowing CTD at ship stations 791 and 792. Note that the ship is standing still and that potential flares are depicted as more or less evenly distributed shading instead of columns.

6. Treatment of gravity cores: geochemical parameters, process rates and microbiology

The sediment cores obtained with the gravity corer were up to 575 cm long. Immediately after retrieval, the cores were cut into 1-m long sections (4-6, depending on the entire core length). Before the sectioned core liner was capped,

1) sediment was sampled from the top of the sediment for *in situ* CH_4 concentrations
2) temperature was measured
3) pH was measured

The capped sections were stored upright until further treatment.

Based on the “rough” *in situ* CH_4-profile (i.e. 1-m interval) it was decided in which of the 4-6 sections the SMTZ was to be expected, and an appropriate sub-sampling scheme for detailed methane and sulfate profiling was developed for each individual core. Two strategies were followed:

1. A first serious of cores served for the determination of the SMTZ at different locations along the transects across the trench slope and across the pockmark. In these cores, the wall of the pvc-liner was opened at distance intervals of 10 to 20 cm, and samples for the analysis of methane and sulfate concentrations were taken.
2. A total of four sample sites were selected for detailed analyses of geochemical, microbiological and molecular ecological parameters and for rate measurements of anaerobic oxidation of methane (AOM), sulfate reduction (SRR) and methanogenesis. Three of these sites were distributed at different depths across the trench slope (i.e.86 m, 307 m, 390 m) and one was located on the bottom of the pockmark (120 m). Each of these locations was sampled with two gravity cores and a Rumohr lot core.
   Sections subject to detailed sub-sampling were placed horizontally in a cutting rag and the necessary number of 20-cm long Plexiglas core liners were pressed 10 cm into the sediment (Fig. 16). Samples for AOM were taken as triplicates in 5-cm intervals. The sediment was extruded from the GC-core liner using a piston until the bottom of the inserted core liners were in line with the rim of the GC core liner and the extruded “lump” of mud was cut of. The subcores were closed with rubber stoppers, gently washed and stored at *in situ* temperature until further treatment. As the number of target parameters was too large, two groups were formed which were always sampled from the same of the two duplicates.

Figure 15. Example for the detailed sub-sampling schemes in the two duplicate gravity cores 816GC and 834 GC from the bottom of the pockmark. The grey shaded squares indicate the sediment depths in which the sub-samples for the various parameters were taken. Note that the parameters listed in the headers of the schemes were always sampled together from the same cores.

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Core identity:	816 GC	Date core collected	#
Length of core:	cm	Date core sampled:	#

Section 4: 5cm shrinkage
Section 1: 10cm shrinkage

Core sec.	Subc. No.	Depth interval in core section	Depth interval from top of core	Discharged	CH4	AOM	SRR	14C rates	density/porosity	porewater	VFA	Sulphate	CH4 isotopes	H2O isotopes	AODC & FISH	16S (MPI)	16S (Bristol)	pH
5	-	0 - 11	0 - 11															
	1	11 - 21	11 - 21															7.33
	-	21 - 25.5	21 - 25.5															
4	-	0 - 5	25.5 - 30.5															
	2	5 - 15	30.5 - 40.5			2	2											7.38
	3	15 - 25	40.5 - 50.5			2	2											7.39
	4	25 - 35	50.5 - 60.5															7.31
	5	35 - 45	60.5 - 70.5															7.36
	6	45 - 55	70.5 - 80.5															7.27
	7	55 - 65	80.5 - 90.5															7.25
	8	65 - 75	90.5 - 100.5															7.26
	9	75 - 85	100.5 - 110.5															7.26
	10	85 - 90	110.5 - 115.5															7.31
	-	90 - 97	115.5 - 122.5															
3	-	0 - 5	122.5 - 127.5															
	11	5 - 15	127.5 - 137.5															7.28
	12	15 - 25	137.5 - 147.5															
	13	25 - 35	147.5 - 157.5															7.29
	14	35 - 45	157.5 - 167.5															
	15	45 - 55	167.5 - 177.5															7.36
	16	55 - 65	177.5 - 187.5															
	17	65 - 75	187.5 - 197.5		2	2	2											7.57
	18	75 - 85	197.5 - 207.5		2	2	2											7.55
	19	85 - 95	207.5 - 217.5		2	2	2											7.63
	-	95 - 99	217.5 - 221.5															
2	-	0 - 5	221.5 - 226.5															
	20	5 - 15	226.5 - 236.5		2	2	2											7.53
	21	15 - 25	236.5 - 246.5		2	2	2											
	22	25 - 35	246.5 - 256.5		2	2	2											7.45
	23	35 - 45	256.5 - 266.5															
	24	45 - 55	266.5 - 276.5															7.30
	-	55 - 65	276.5 - 286.5															
	25	65 - 75	286.5 - 296.5															7.36
	-	75 - 85	296.5 - 306.5															
2	26	85 - 95	306.5 - 316.5															7.41
	-	95 - 100	316.5 - 321.5															
1	-	0 - 5	321.5 - 326.5															
	27	5 - 15	326.5 - 336.5															7.62
	-	15 - 30	336.5 - 351.5															
	28	30 - 40	351.5 - 361.5															7.66
	-	40 - 50	361.5 - 371.5															
	29	50 - 60	371.5 - 381.5															7.66
	-	60 - 70	381.5 - 391.5															
	30	70 - 80	391.5 - 401.5															7.62
	-	90 - 100	401.5 - 421.5															

Figure 15, continued

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Core identity:	**836 GC**	**Date core collected**	
Length of core:	cm	**Date core sampled:**	

Section 4: 23cm shrinkage
Section 1: 7 cm shrinkage

Core sec.	Subc. No.	Depth interval in core section			Depth interval from top of core			Discharged	16S (MPI)	16S (Bristol)	Biomarkers	CH4 diffusion	Fe / Si
4	-	0	-	7	0	-	7						
	1	7	-	17	7	-	17						
	-	17	-	27	17	-	27						
	2	27	-	37	27	-	37						
	-	37	-	47	37	-	47						
	3	47	-	57	47	-	57						
	-	57	-	67	57	-	67						
	4	67	-	77	67	-	77						
	-	77	-	79	77	-	79						
3	-	0	-	5	79	-	84						
	5	5	-	15	84	-	94						
	-	15	-	30	94	-	109						
	6	30	-	40	109	-	119						
	-	40	-	55	119	-	134						
	7	55	-	65	134	-	144						
	-	65	-	80	144	-	159						
	8	80	-	90	159	-	169						
	-	90	-	100	169	-	179						
2	-	0	-	5	179	-	184						
	9	5	-	15	184	-	194						
	-	15	-	40	194	-	219						
	10	40	-	50	219	-	229						
	-	50	-	75	229	-	254						
	11	75	-	85	254	-	264						
	-	85	-	100	264	-	279						
1	-	0	-	8	279	-	287						
	12	8	-	18	287	-	297						
	-	18	-	38	297	-	317						
	13	38	-	48	317	-	327						
	-	48	-	68	327	-	347						
	14	68	-	78	347	-	357						
	-	78	-	100	357	-	379						

Figure 16. Sub-sampling of the 1-m sections of a gravity core for detailed analyses of geochemical and microbiological parameters and process rate measurements. Core liners of various diameters were pushed from the top into the sediment.

Samples obtained with the Rumor Lot and the Multi corer were used to analyze pore water gradients of sulfate and determinations of sedimentation rate in the upper sediment layers, which are usually washed out in gravity cores.

7. Preliminary results

Seismics

The high-resolution multi-channel seismic (MCS) data illustrate the correlation of fluid escape structures (e.g., pockmarks) on the seafloor with reflection pattern from both Quaternary and Mesozoic successions, which are typical of gas charged strata. Signal attenuation and acoustic whitening within the Quaternary succession of the upper slope indicate the presence of gas as already described by other authors (Bøe et al. 1998, Rise et al. 1999). The alignments of elongate depressions correlate with the location of bright reflections within Cretaceous strata which subcrop at the erosional unconformity beneath the Quaternary succession. The observations support the thesis that thermogenic gas from Cretaceous strata contributed to the seepage at the elongate depressions. MCS data reveal acoustic turbulence at and beneath the unconformity downslope of the edge of gas front in water depths of more than 400 m, which indicates the presence of gas. We suggest that gas accumulates beneath the unconformity beneath a Quaternary capping sequence. In the central Norwegian Trench pockmark lineaments lie above subcropping bright reflections within the Jurassic bedrock. Some pockmark lineaments lie above elongated near vertical faults in the overburden.

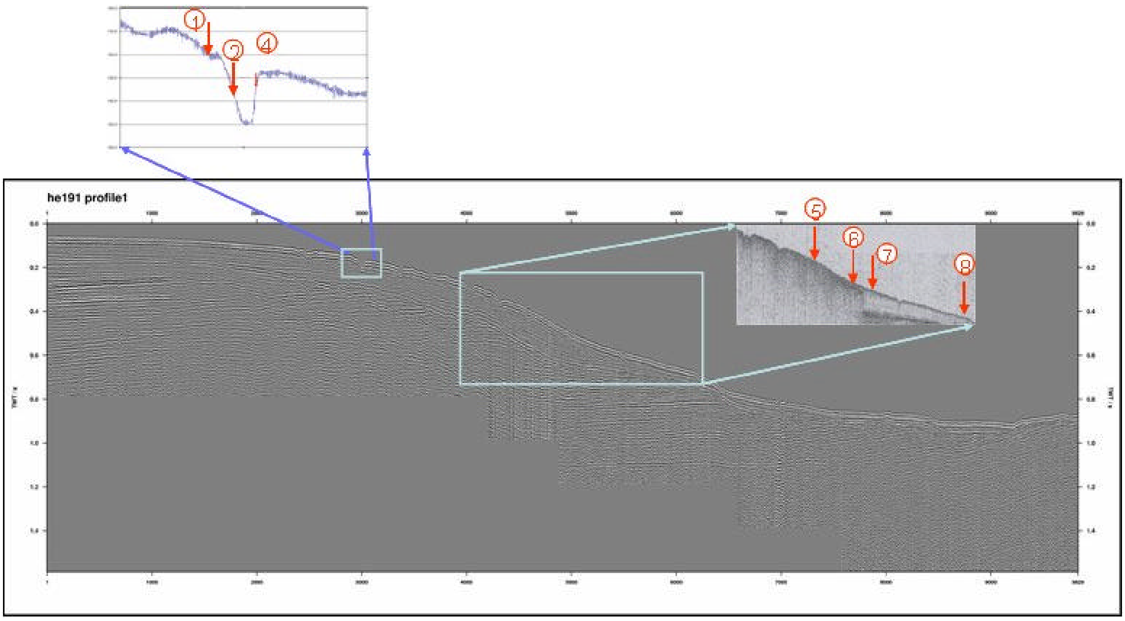

Figure 17. Seismic profile 1 and selected coring locations in the pockmark and around the gas front drop (see insert).

Sediments

The sediment sampling program primarily focused on cores along the depth gradient of the southern slope of the Skagerrak trench. Most of the cores were obtained along the seismic profile 1 (working area 1, see figs 1, 3 and 4, tabs 1 and 2) in water depths between 85 m and 540 m, while two gravity cores plus the accompanying Rumohr lot cores were sampled around 58°26.70’ N and 9°50’ E in approx 500 m water depth (working area 2). On board analyses concentrated on the determination of methane concentrations in the porewaters of the gravity cores, while all other biogechemical and microbiological parameters will be analyzed during the subsequent months in the home laboratories. One major target on board was to identify the sediment depth of the sulfate methane transition zone (SMTZ) - the sediment layer in which the anaerobic oxidation of methane takes place, which is an important process for cycling of methane in marine sediments.

Area 1:

On the southern slope of the Skagerrak Trench, porewater methane was present in sediments between 85 m and 400 m water depth, while no methane occurred in the cores sampled at 540 m. In the shallower parts, methane was found below 2 m sediment depth, while at some deeper stations the SMTZ reached the top end of the cores. A transect through a pockmark showed an asymmetrical pattern of the methane distribution. Detailed analyses of the SMTZ will reveal the associated geochemical and microbiological processes at the various sampling locations. Active methane seepage was explored at locations where such phenomena have been reported before (Dando et al. 1994, Zimmermann et al. 1999), but signals from profiles with the DESO25 echosounder could not be unequivocally interpreted and multi corer deployments remained unsuccessful. However, black gassy surface sediment was once recovered from a non-pockmark location with a Van Veen grab at 58°0.4’ N and 9°31.64’ E.

Area 2:

Pockmarks described by Rise et al. (1999) were the targets in area 2. Gravity core #857 was positioned in an area of suspected pockmark accumulation according to the multi channel seismics, while the apart positioned core #860 served as a control. Both cores did not contain dissolved methane, and it was decided not to further concentrate on this area.

Literature:

Barnett PRO, Watsen J, Conelly D 1984. A multiple corer for taking virtually undisturbed samples from shelf, bathyal, and abyssal sediments. Oceanologica Acta, 399-408.

Bøe R, Rise L, Ottesen D 1998. Elongate depressions on the southern slope of the Norwegian Trench (Skagerrak): morphology and evolution. Marine Geology 146, 191-203.

Dando PR, Bussmann I, Niven SJ, O'Hara SCM, Schmaljohann R, Taylor L. J. 1994. A methane seep area in the Skagerrak, the habitat of the pogonophore *Siboglinum poseidoni* and the bivalve mollusc *Thyasira sarsi*. Marine Ecology Progress Series107, 137-167.

Rise L, Sættem J, Fanavoll S, Thorsnes T, Ottesen D, Bøe R 1999. Sea-bed pockmarks related to fluid migration from Mesozoic bedrock strata in the Skagerrak offshore Norway. Marine and Petroleum Geology 16, 619-631.

Zimmermann S, Hughes RG, Flügel HJ 1997. The effect of methane seepage on the spatial distribution of oxygen and dissolved sulphide within a muddy sediment. Marine Geology 137, 149-157.

6. Station lists

Gear abbreviations:

Seis multi channel seismics or boomer (only profile 5, station # 810)
DESO DESO25 echosounder
GC Gravity corer
RL Rumor lot
MUC Multi corer
VV Van Veen grab
CTD CTD/rosette

Tab 1: List of profiles

Station #	PI	Gear	Profile #	Begin	UTC	Lat. (N)	Long. (E)	End	UTC	Lat. (N)	Long. (E)
764	Hübscher	Seis	1	13/06/2003	16:39:00	57°48.94764	9°54.22752	14/06/2003	0:15:00	58°16.0098	9°17.54076
765	Hübscher	Seis	2	14/06/2003	2:20:00	58°8.23944	9°31.55394	14/06/2003	7:43:48	57°50.41272	10°3.30498
775	Hübscher	Seis	3	00/01/1900	0:00:00	°	°	15/06/2003	3:44:00	58°28.0893	9°29.86722
782	Usbeck	DESO	-	15/06/2003	10:50:00	58°4.01076	9°41.50974	15/06/2003	14:20:20	58°3.00702	9°38.92692
785	Hübscher	Seis	4	15/06/2003	20:42:00	57°42.43182	9°0.191902	04/01/1900	2:19:00	58°5.01246	8°48.97194
810-a	Hübscher	Seis	5	16/06/2003	19:18:00	57°0.968322	9°42.03702	17/06/2003	2:18:00	58°7.02462	9°33.18606
824-834	Hübscher	Seis	6-16	17/06/2003	18:36:00	58°3.1305	9°46.86636	18/06/2003	6:28:00	58°0.39828	9°32.5626
848	Borowski	VV	-	18/06/2003	13:37:25	58°4.04207	9°41.63519	18/06/2003	15:08:20	58°4.12856	9°41.63505
849	Hübscher	Seis	17	18/06/2003	18:54:00	58°22.1865	9°59.6532	18/06/2003	21:20:00	58°31.00842	9°43.87656
850	Hübscher	Seis	18	18/06/2003	22:12:00	58°30.98808	9°50.01708	18/06/2003	23:50:00	58°25.00902	10°0.00582
851	Hübscher	Seis	19	19/06/2003	1:07:00	58°30.00756	9°0.02898	19/06/2003	3:15:00	58°22.48596	9°48.45492
852	Hübscher	Seis	20	19/06/2003	4:09:00	58°21.98964	9°54.0219	19/06/2003	5:51:00	58°28.35912	9°0.727512
853	Borowski	DESO	-	19/06/2003	8:21:40	58°28.10497	9°50.83552	00/01/1900	0:00:00	°	°
854	Borowski	DESO	-	19/06/2003	0:00:00	°	°	00/01/1900	0:00:00	°	°
855	Borowski	DESO	-	19/06/2003	0:00:00	°	°	00/01/1900	0:00:00	°	°
856	Borowski	DESO	-	19/06/2003	0:00:00	°	°	19/06/2003	10:53:00	58°28.14378	9°50.59796

Tab. 2. Sediment stations.

Date	Station #	PI	Gear	Gear on Bottom			
				UTC	Lat. (N)	Long. (E)	Depth (m)
12/06/2003	762	Usbeck	CTD	13:06:30	53°50.69869	8°5.42066	13.3
13/06/2003	763	Borowski	MUC	14:42:00	57°46.36137	9°40.11117	0.0
14/06/2003	766	Borowski	RL	11:06:00	57°55.22302	9°45.319	85.9
14/06/2003	767	Borowski	GC	11:31:00	57°55.23984	9°45.31077	87.2
14/06/2003	768	Borowski	RL	12:51:01	58°1.08049	9°38.68776	265.2
14/06/2003	769	Borowski	GC	13:14:45	58°1.09333	9°38.682	266.6
14/06/2003	770	Borowski	GC	14:31:53	58°1.09535	9°38.62538	265.8
14/06/2003	771	Borowski	RL	15:19:20	58°1.47436	9°38.41335	269.4
14/06/2003	772	Borowski	GC	15:42:50	58°1.51573	9°38.45988	269.0
14/06/2003	773	Borowski	RL	16:38:54	58°2.2054	9°37.89611	309.0
14/06/2003	774	Borowski	GC	17:04:03	58°2.25072	9°37.97088	311.0
15/06/2003	776	Borowski	RL	6:51:58	58°2.80978	9°37.06143	354.9
15/06/2003	777	Borowski	GC	7:15:37	58°2.74319	9°36.85114	354.2
15/06/2003	778	Borowski	RL	7:59:29	58°3.23319	9°35.9924	391.7
15/06/2003	779	Borowski	GC	8:18:00	58°3.2183	9°36.03015	389.6
15/06/2003	780	Borowski	RL	9:21:40	58°6.4997	9°31.12237	537.4
15/06/2003	781	Borowski	GC	9:46:30	58°6.4911	9°31.08305	534.5
15/06/2003	783	Borowski	GC	15:06:50	58°2.70912	9°37.6833	339.2
15/06/2003	783	Usbeck	CTD	16:49:00	58°3.82266	9°41.87286	335.1
16/06/2003	786	Borowski	GC	6:03:35	58°3.3159	9°36.48907	386.4
16/06/2003	787	Borowski	RL	6:35:14	58°3.20124	9°36.2886	384.3
16/06/2003	788	Borowski	RL	7:01:00	58°3.31896	9°35.96484	393.4
16/06/2003	789	Borowski	GC	7:31:00	58°3.25332	9°36.00546	391.1
16/06/2003	790	Borowski	GC	8:31:00	58°3.93756	9°38.01942	394.4
16/06/2003	791	Usbeck	CTD	9:21:00	58°3.82776	9°41.86404	335.1
16/06/2003	792	Usbeck	CTD	9:48:40	58°3.82404	9°41.81622	335.1
16/06/2003	793	Borowski	MUC	10:14:00	58°3.81826	9°41.82409	335.5
16/06/2003	794	Borowski	MUC	10:56:00	58°3.8373	9°41.81444	335.4
16/06/2003	795	Usbeck	CTD	11:26:00	58°3.42601	9°41.75476	331.9
16/06/2003	796	Borowski	VV	???	°	°	334.8
16/06/2003	797	Borowski	VV	13:09:00	58°3.83406	9°41.86957	335.2
16/06/2003	798	Borowski	VV	13:25:04	58°3.86769	9°41.81056	337.4
16/06/2003	799	Borowski	VV	13:38:27	58°3.93611	9°41.71885	342.5
16/06/2003	800	Borowski	VV	???	°	°	0.0
16/06/2003	801	Borowski	VV	13:50:19	58°4.00206	9°41.64537	348.6
16/06/2003	802	Borowski	VV	14:01:30	58°4.06065	9°41.59228	350.9
16/06/2003	803	Borowski	RL	15:15:08	57°55.24644	9°45.2558	86.3
16/06/2003	804	Borowski	RL	15:21:20	57°55.2488	9°45.29531	86.2
16/06/2003	805	Borowski	RL	15:30:50	57°55.2731	9°45.28932	86.4
16/06/2003	806	Borowski	RL	15:40:00	57°55.25169	9°45.33377	86.2
16/06/2003	807	Borowski	GC	16:12:53	57°55.24532	9°45.33555	86.3
16/06/2003	808	Borowski	GC	16:51:17	57°55.27971	9°45.29464	86.3
16/06/2003	809	Borowski	RL	17:10:52	57°55.28502	9°45.34019	86.1
16/06/2003	810	Borowski	RL	17:23:50	57°55.26749	9°45.38729	86.9
17/06/2003	811	Borowski	GC	4:23:30	57°55.25827	9°45.29846	86.2
17/06/2003	812	Borowski	GC	4:51:19	57°55.24457	9°45.29993	86.1
17/06/2003	813	Borowski	GC	5:13:20	57°55.26239	9°45.31632	86.4
17/06/2003	814	Borowski	GC	7:04:50	57°55.23757	9°45.35759	85.7
17/06/2003	815	Borowski	GC	7:39:45	57°54.95166	9°45.17638	82.7
17/06/2003	816	Borowski	GC	10:35:15	57°57.12172	9°42.43051	146.8
17/06/2003	817	Borowski	RL	10:59:00	57°57.11617	9°42.42274	148.4
17/06/2003	818	Borowski	RL	11:09:30	57°57.11809	9°42.42783	148.1
17/06/2003	819	Usbeck	CTD	11:44:50	57°55.87234	9°44.94803	104.2
17/06/2003	820	Borowski	GC	16:01:00	58°2.22593	9°37.99144	307.7
17/06/2003	821	Borowski	GC	16:54:06	58°2.24558	9°37.98319	308.7
17/06/2003	822	Borowski	RL	17:15:20	58°2.25507	9°37.96951	309.0
17/06/2003	823	Borowski	RL	17:30:12	58°2.23817	9°37.96622	308.4
18/06/2003	835	Borowski	GC	7:42:08	57°57.12268	9°42.4473	149.2
18/06/2003	836	Borowski	GC	8:42:33	57°57.12532	9°42.45235	148.9
18/06/2003	837	Borowski	RL	9:03:28	57°57.12415	9°42.41944	147.9
18/06/2003	838	Borowski	RL	9:12:10	57°57.12071	9°42.44422	149.2
18/06/2003	839	Borowski	GC	10:15:00	57°56.91281	9°42.70767	120.2
18/06/2003	840	Borowski	RL	10:34:31	57°56.91388	9°42.68695	120.6
18/06/2003	841	Borowski	RL	10:46:56	57°56.92716	9°42.69726	121.0
18/06/2003	842	Borowski	GC	11:05:08	57°57.03626	9°42.56353	138.2
18/06/2003	843	Borowski	RL	11:18:12	57°57.02876	9°42.55548	137.9
18/06/2003	844	Borowski	GC	11:42:08	57°57.14379	9°42.39673	134.1
18/06/2003	845	Borowski	RL	11:53:30	57°57.15448	9°42.40029	132.0
18/06/2003	846	Borowski	GC	12:14:00	57°57.24911	9°42.2689	128.0
18/06/2003	847	Borowski	RL	12:23:20	57°57.24787	9°42.26087	128.0
19/06/2003	857	Borowski	GC	12:10:30	58°26.67075	9°49.65427	496.0
19/06/2003	858	Borowski	RL	14:25:07	58°26.69154	9°49.698	506.0
19/06/2003	859	Borowski	RL	14:49:24	58°26.68697	9°49.67996	504.0
19/06/2003	860	Borowski	GC	15:21:55	58°26.79149	9°50.03202	499.0
19/06/2003	861	Borowski	RL	16:25:00	58°26.76712	9°49.97556	493.0