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Helmholtz-Zentrum für Ozeanforschung Kiel

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Fahrtbericht / Cruise Report
POS427

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23.02. – 19.03.2012
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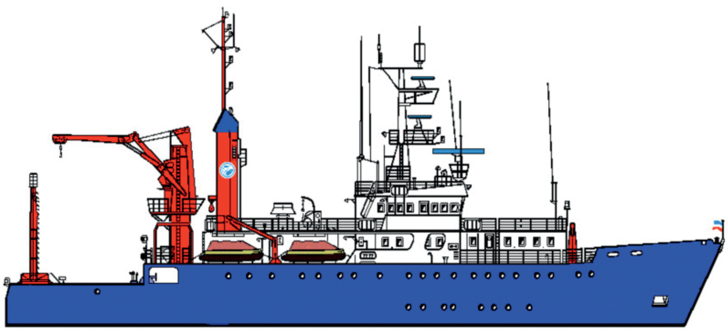

Berichte aus dem Helmholtz-Zentrum für Ozeanforschung Kiel (GEOMAR)

Nr. 3 (N. Ser.)

June 2012

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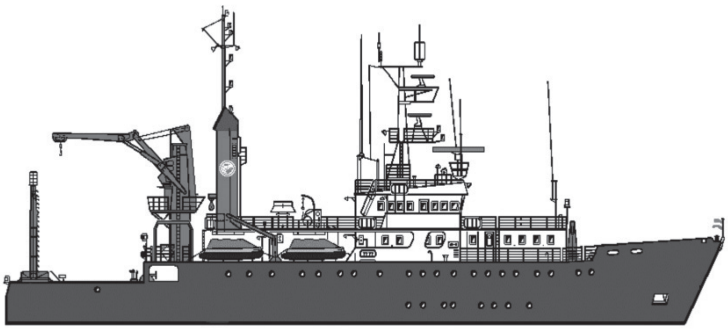

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Content

1. Abstract

Cruise P427 DokuGas with R/V POSEIDON aimed to acquire high-resolution 3D multichannel seismic data of the Kerch Flare. Kerch Flare is an active seep site identified within the Don-Kuban fan at a water depth of 900 m, well below the top of the gas hydrate stability zone (700 m). Investigations of the Kerch Flare were further supported by deep towed sidescan sonar mapping.

In addition a deep towed multichannel seismic profile was recorded along the Eastern Sorokin Trough crossing a recently detected mound feature and the long known Egorov seep site.

On all profiles the water column was scanned for indications of gas flares by the use of the water column imaging provided through the hull mounted ELAC multibeam. Dedicated surveys were undertaken to complete mapping of shallow seeps (above the top of the hydrate stability zone) along the upper slope. Additional sidescan sonar investigations will provide information about possible seafloor alterations caused by the seep activity.

2. Introduction

The Black Sea is todays largest anoxic basin and offers ideal conditions for the preservation of organic matter (Reeburgh et al., 1991). Decomposition of the organic matter by bacteria or thermal cracking produces large amounts of methane gas within the Black Sea sediments. The Black Sea consequently constitutes a natural laboratory for the study of gas emissions and methane cycling in the marine environment as well as possible interactions with climate changes. With ongoing discussions about gas hydrate exploitation or the use of gas hydrate reservoirs for CO2 sequestration, a good understanding of fluid and methane circulation within continental margin sediments becomes a necessity. The large number of different types of fluid-venting systems in the Black Sea (both in shallow and in deep water) makes it an ideal target for investigations with mid-size research vessels such as RV Poseidon.

Project DokuGas sets out to use innovative geoacoustic and 3D-seismic investigations of the northern Black Sea margin in the area of the Kerch peninsula (Crimea, Black Sea) for the characterisation of near-surface and deep fluid circulation. The margin south of Kerch peninsula is part of the Don-Kuban deep-sea fan and is characterised by numerous emissions of biogenic methane gas, while the peninsula itself is known for the presence of several mud volcanoes. The mud volcanoes are believed to be sourced from the 5-8 km deep Maikop formation as they expel methane of thermogenic origin. The Don-Kuban fan is under compression similar to the Sorokin Trough and unlike the Palaeo-Dnepr fan. Shallow methane emissions have been well identified on the upper slope. Despite detailed bathymetric mapping mud volcanoes, which are pronounced morphologic features in the Sorokin Trough (Bohrmann et al., 2003), were not identified. Nevertheless a singular active seep site, the Kerch Flare, has been identified at a water depth of 900 m, within the hydrate stability zone (top GHSZ 700 m; Römer et al., submitted). The aim of our combined WCI multibeam, sidescan sonar and 3D-seismic investigation is imaging the fluid expulsion system of the Kerch Flare and deducing how this site of focused fluid flow functions. In addition, WCI and sidescan profiles will provide additional records of shallow seeps sites above the hydrate stability zone. Herewith activity and spatial distribution of previously reported active seep sites and corresponding seafloor alterations could be confirmed.

3. Cruise Narrative

Due to mechanical problems with the main propulsion R/V POSEIDON was unable to complete the previous cruise in time. The arrival at port of Burgas was delayed by three days.

Nine scientists from GEOMAR arrived on Feb. 20, 2012 in Burgas, Bulgaria, awaiting the arrival of R/V POSEIDON on Feb. 23. In the morning of Feb. 23, heavy fog caused port authorities in Burgas to close the harbour for all traffic. Therefore the scientific crew could board the vessel not earlier than in the afternoon at 16:00 hrs local time. Three trucks with scientific equipment were already waiting to be unloaded. In the early evening at 18:30 all equipment was loaded on board. Installation of major equipment needed to be postponed until the next day. Expected delivery of food supply for the vessel, bunkering, on-deck installation of scientific equipment caused further delay of departure time from Burgas until 15:00 hrs local time on Feb. 25, 2012.

After completion of the major cruise preparations a safety instruction for all new crew members and scientists was given on Feb. 25. R/V POSEIDON left the port of Burgas on 15:00 hrs as scheduled, starting a 400 nm eastward transit towards the research area of the Don-Kuban fan.

At 07:00 hrs on Feb. 27 scientific work began with deployment of a CTD to acquire a velocity depth profile for the multibeam bathymetry system. Prior to the start of the 3D seismic survey in the area of the Kerch flare an OBS was deployed to serve for long offset records of the airgun shots, with the capability to develop a velocity depth profile. At late morning the 3D seismic system was deployed with 14 parallel streamer sections. The desired area of investigation was reached at 16:55 hrs. Despite wind forces of 6 – 8 Bft. the wave height stayed moderate and still allowing operation of the trawl doors of the streamer system. A strong southwest directed current of 1.2 kn, however, influenced the survey speed. As the wind blew continuously from northerly directions the Kerch peninsula provided enough shelter to keep the wave state calm enough to continue the survey.

Until Mar. 3, 08:00 hrs 58 profiles were completed when the port trawl wire broke and the system needed to be recovered. Upon redeployment at 14:00 hrs the recording unit could no longer initialize the streamer system. This failure could not be located immediately and the operation needed to be postponed. During night hours a multibeam survey with water column imaging in shallow waters (above 700 m water depth) was undertaken. Seep sites that were identified by our colleagues from MARUM (Bremen) and IBSS (Sevastopol) by operation of single beam sounders should be checked if they are still active. The swath of the multibeam should be used to map additional seep sites at greater lateral offset, which might not have been covered by the single beam surveys.

In the morning of Mar. 4 the OBS was recovered to enable a time comparison of the internal clock before the batteries went down. As preparation for the scheduled sidescan survey the OBS was redeployed in 700 m water depth, in order to serve for the calibration of the POSDIONIA ultra short baseline navigation system. Unfortunately the electronics cabinet failed after 20 minutes of measurement and the calibration could not be completed. Later tests and discussion with the manufacturer iXSea concluded for a major failure that could not be repaired at sea. Consequently the deep towed sidescan sonar was deployed for a survey covering the Kerch Flare site without navigation aids. A set of eight profiles was completed covering the slope from about 600 to 1200 m water depth. During the survey it became apparent that the analogue instruments for winch speed and rope length did not work properly.

On Mar. 6 at 17:00 hrs the sidescan sonar was recovered and the night hours were used for additional bathymetry in shallow waters. As on some profiles artificial anomalies were observed in the bathymetry recordings, a short calibration run could be used to check the correction values applied to the motion sensor of the multibeam system. As a result slightly modified values for pitch and roll correction were calculated and proved to enhance the bathymetry processing.

At 08:00 hrs in the morning of Mar. 7 the P-Cable 3D seismic system was deployed again. Unfortunately, two of the four compressors failed and needed to be repaired before the active seismic profiling could start. At 13:00 hrs the compressors were ready again, when the streamer showed a major failure and could no longer be activated. After recovery of the system it turned out that the control device and the spare unit of the streamer system were severely damaged due to a short circuit. As the streamer system was no longer available the time needed to investigate repair options was used to undertake a time-laps observation of the Kerch flare and flares above the 720 m stability depth of gas hydrates with the WCI option of the multibeam system. During continued repair attempts of the P-Cable system the afternoon of Mar. 8 was used to complete the bathymetric map along the shelf-break towards 36° 36’ E, where the first clusters of active seepage had been found during the 2003/2004 CRIMEA cruises. Multibeam tracks with the WCI option were used to test the ongoing activity of the known flares and to investigate additional seeps that may not have been recognized during the previous single beam surveys. At 23:00 hrs we began a time-laps recording sequence of the Kerch Flare and another seep cluster that is slightly shallower than 720 m water depth. The observations will be used to investigate time variations in strength of activity and a possible tide dependency.

During Mar. 8 it turned out that the P-Cable recording devices were heavily damaged and only one system could be made ready for operation. Prior to redeployment a careful inspection of all connectors was undertaken. In the meantime a bathymetric survey was used to extend the existing bathymetric map. Mapping the shelf-break should reveal the characteristic of the upper termination of the canyon systems cutting into the slope of the margin. The bathymetric survey was continued with a grid of profiles across the seep locations known in the area around 36° E. Some of them had already been identified during the CRIMEA cruises in 2003/2004.

In the morning of Mar. 9 a P-Cable with 9 streamers was assembled and tested on deck. Therefore the bathymetric survey was postponed and POSEIDON headed for the 3D area. At 14:30 hrs the P-Cable was deployed and tested in the water. After final positioning of the trawl doors the remaining streamer control unit failed. Obviously a DC/DC converter failed and caused other components to fail as well. Attempts were undertaken to replace visually identified broken parts from the second unit, but the Ethernet connection, which is required for communication, could not be established again. At 20:00 hrs the bathymetric survey from last night was continued.

During the morning hours of Mar. 10 the deep towed multichannel streamer could be set up with 33 hydrophone nodes. Operating its own recording devices, the system could be used to investigate the 2000 m deep Sorokin Trough with 2D seismic profiling. The available cable length of 2500 m was not sufficient for a sidescan survey in such water depth. At 18:30 hrs the deep towed streamer was deployed in the Sorokin Trough. The system required restarting several times but recording could be continued. In the morning hours of Mar. 11 node #4 failed and the survey had to be continued with three nodes only. After completion of the active seismic line the system was recovered. Dismounting of node 4 succeeded on deck with 32 available hydrophones. After redeployment the system did not start again. The control PC in the tow fish could not re-establish the connection to the streamer. As similar instabilities already occurred during the night before, while the streamer worked on deck the system was recovered and the survey was continued with flare imaging only.

Along the two DeepTow profiles some active flares were observed. The strongest one at 44°27.5’ N 35°28’ E was used to test several beam configurations of the ELAC multibeam. During the night the survey was continued with multibeam mapping. The remaining night hours were used to complete the bathymetric survey in this region.

In the afternoon of Mar. 12 POSEIDON returned to the shelf region at 36° E. We deployed the sidescan sonar in order to map the slope between 400 m and 800 m water depth. A large number of seeps had already been identified by our colleagues of MARUM and IBSS using a single beam echo sounder. Our survey should test the activity and look for possible additional seeps. The survey was completed at 14:00 hrs on Mar. 13.

As the research permit ended on Mar. 13 24:00 hrs we left the area at 15:00 hrs local time. The remaining working hours were dedicated to a final inspection along long known mud volcanoes in the Sorokin Trough. The multibeam should allow to identify ongoing activity by a single run across these structures.

The field work was terminated in time and POSEIDON set course towards the port of Heraklion, Greece, where the cruise should end on Mar. 18.

Throughout the cruise weather conditions were mediocre. Cold temperatures usually around zero degrees and lower (down -4°C) were not favourable for outside works. Wind speeds varied between force three and increased up to force nine. As wind directions were all the time from northern directions Kerch peninsula provided good shelter and ship operations could be continued at all times.

4. Crew

a) Ships crew

No.	Rank	Name	First Name
1	Captain	Günther	Matthias
2	1. Off.	Griese	Theo
3	Naut. WO	Gerlach	Stefan
4	I. techn. Off.	Stange	Hans-Otto
5	II. techn. Off	Hagedorn	Günther
6	boatswain	Schrage	Frank
7	A/B	Kuhn	Ronald
8	A/B	Meiling	Ralf
9	A/B	Rauf	Bernd
10	A/B	Hänel	Bernd-Michael
11	A/B	Heyne	Roland
12	Motorman	Engel	Rüdiger
13	Electrician	Klare	Oliver
14	Cook	Wolff	Thomas
15	Steward	Gerischewski	Bernd

b) Scientifc crew

No.	Name & Given name	Function onboard
1.	Bialas, Joerg	Chief scientist
2.	Papenberg, Cord	Multibeam
3.	Klaeschen, Dirk	Seismic
4.	Dumke, Ines	Sidescan
5.	Koch, Stephanie	Seismic
6.	Matthiessen, Torge	Technician
7.	Wetzel, Gero	Electronics
8.	Mansdorf, Steffen	Compressor
9.	Zander, Timo	Seismic
10.	Artemov, Yuriy	Observer, Ukraine

5. Equipment used

Due to the size of R/V POSEIDON the working deck provides only limited space for storage of equipment (Fig. 5.1). A 10" compressor container is placed on the port side aft end of the working deck. Two winches for streamer and P-Cable operation are required on the aft working deck. Sidescan sonar and depressor weight were located between the A-frame. The dry-lab was used as acoustic lab with all acquisition control devices. The chemistry-lab was used for seismic processing, while the geology-lab was used for mechanical and electronic repairs.

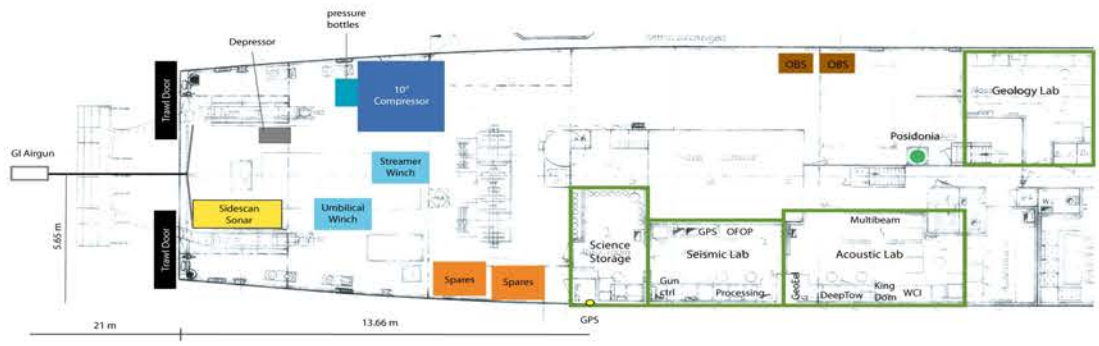

Figure 5.1: Usage of the deck and lab space of R/V POSEIDON

a) L3-ELAC Nautik SBE 3050 Multibeam

In the course of the SUGAR project a new multibeam system was developed with the capability to record and visualize full swath water column data (WCI-data) in order to detect and map gas flares rising from the seafloor into the water column.

The SeaBeam SBE 3050 multibeam system by ELAC Nautik was recently built into the hull of RV POSEIDON. For this purpose a gondola was fixed underneath the hull of POSEIDON, which gave space for the transducers and provides best protection against bubble disturbances. Due to size limitations the transducer arrays were chosen in a 1.5° by 2° dimension. The SeaBeam 3050 is the latest generation of mid and shallow water multibeam bathymetric sonar systems from L-3 Communications ELAC Nautik GmbH. The new multi-ping technology of the SeaBeam 3050 allows a higher maximum survey speed without loosing 100% bottom coverage by creating two swaths per ping cycle.

The system operates in the 50 kHz frequency band in water depths ranging from 3 m below the transducers to approx. 3,000 m.

Fig.5.a.1: Gondola with Multibeam transducers

The system can be used at survey speeds of up to 14 knots (N.B. ship speed of R/V Poseidon is limited to 11 knots, however). It has an across-ship swath wide of up to 140 degrees. A maximum of 386 reception beams is provided for each multi-ping. The SeaBeam 3050 uses a transmit technique, which fully compensates for vessel pitch and yaw motion, recorded by the CodaOctopus motion sensor F180 (see below) and which is integrated into the system's network. The compensation is achieved by splitting the transmit fan in several sectors which can be steered individually. This technique achieves full motion compensation and guarantees a stable straight coverage under the vessel. The SeaBeam 3050 generates sonar data for wide-swath contour charts, backscatter data for seabed sediment classification, raw data for water column imaging (WCI) and sidescan data for side-scan images.

The F180 inertial attitude and positioning system from CodaOctopus is integrated into the sonar system network, making precision measurements of vessel attitude (including heading), dynamics and geographical position for use in compensating the vessel motion for hydrographic surveying. The system is a multi-sensor system consisting of an inertial measurement unit (IMU), built up of three solid-state gyros and three inertial grade accelerometers, and two survey grade GPS receivers.

a) Multichannel 3D seismic P-Cable system

GEOMAR is holding an academic license of the P-Cable (VBPR patent of 2003) system covering development and application. The development of a modular version at IFM-GEOMAR was completed 2009 [*Bialas and Brückmann*, 2009].

Compared to standard reflection seismic applications in 2-D and 3-D the basic difference is that the P-Cable is build by a cross cable towed perpendicular to the ships heading. Instead of a few single streamers the P-Cable uses a large number of short streamer sections towed parallel from the cross cable. Drawback is the limited depth penetration due to the short offsets, which do not allow the removal of the multiple energy. This is well compensated by the reduced costs of the system and the ability to operate it even from small multi purpose vessels, the usual academic platform for marine research.

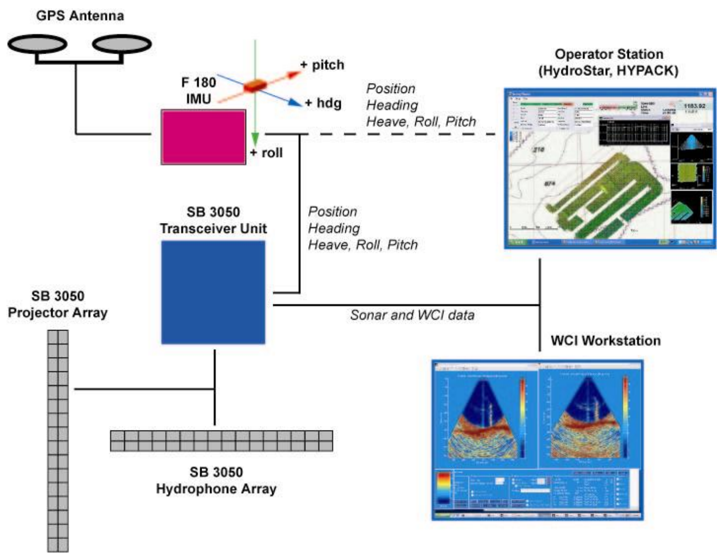

Figure 5a.2: Data flow of the sonar system, motion sensor and operating PC.

Figure 5.b.1 shows the basic principle of the P-Cable design. The advantages of the GEOMAR development are twofold. The cross cable is based on a strength member, a Dynema rope (Fig. 5.b.2), which takes the stretch forces of the trawl doors (Fig. 5.b.3). Attached to this rope is the data cable with the streamer connections. GEOMAR developed a modular cross cable, which allows exchange of each single streamer connector (node) with data cable and strength member section in case of a malfunction. This allows easy service and reduced service costs. Other systems were build by a data cable moulded in one piece, which need to be replaced as whole part if one node fails.

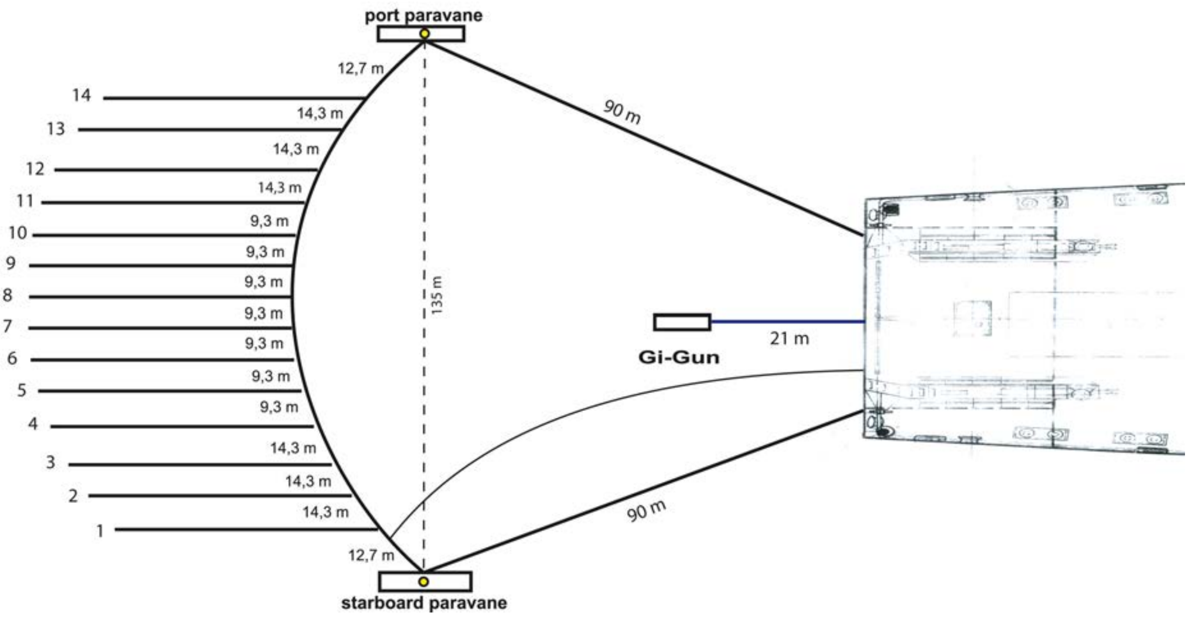

Figure 5.b.1: Drawing of the P-Cable design as it was installed on R/V POSEIDON

As well the modular design allows inserting connecting cables of different length between the node. Consequently modifications for different resolutions of the P-Cable and SwathSeis application is possible. The current evolution of the system provides 14 active nodes connected by 15 m and 10 m long data cables. On both sides the closest node is located 11.7 m off the triple point. The 182 m long cross cable is stretched by two trawl doors, floating at the sea surface. Floats attached to each break out and on the four centre-most 10 m cable sections help to keep the streamers at 2 m depth. Each of the trawl doors provides a lifting force of 2 tons. Although the doors are designed to provide maximum lift at 4 kn sailing speed the cross cable was stretched to about 135 m width at 3 kn already.

Onboard R/V POSEIDON the trawl doors were located outside the aft working deck, hold by the trawl wires (Fig. 5.b.3). Upon deployment the door next to the umbilical is released from its resting position while the ship sails at 1 kn through water against wind and waves. The door is lowered into the water while a 10 m long lead cable between door and connection point of cross cable is kept on board. Then the data cable from the recording device to the door is hooked to the connection between lead wire and cross cable. Now trawl wire, data cable and cross cable are paid out simultaneously. At the same time streamer sections are connected to the nodes of the cross cable. Floats are fixed to each node in order to keep the cross cable at even depth. When the entire cross cable is deployed it is connected to the lead wire of the second trawl door. Now both trawl wires are given out until the final length with sufficient stretch of the trawl doors is reached.

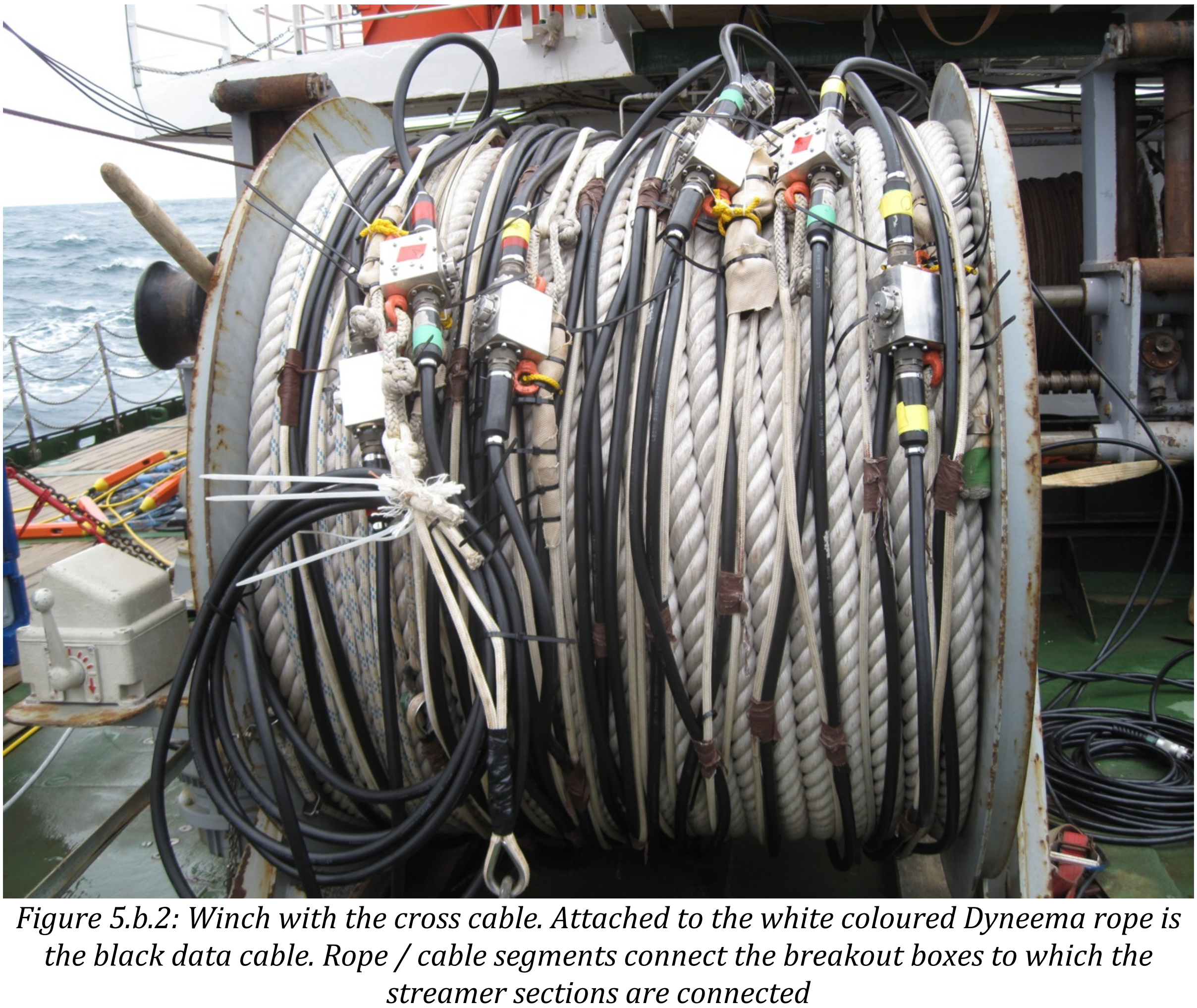

Figure 5.b.2: Winch with the cross cable. Attached to the white coloured Dyneema rope is the black data cable. Rope / cable segments connect the breakout boxes to which the streamer sections are connected

Positions of the trawl doors with real coordinates, relative distance to the vessel and offset between the doors are provided within an online navigation package. Autonomous GPS receivers were mounted on each trawl door together with a serial radio link to the vessel (Fig. 5.b.4). GPS positions from the vessel, trawl doors and the airgun are recorded via a serial multiport on a laptop. Output via TCP/IP protocol provides the NMEA strings for other computers in the local network. The program OFOP is used to display ship and trawl door positions online on top of a bathymetric map. Scheduled track lines can be displayed as well. Moreover the offsets between trawl doors as well as between doors and vessel are calculated. A connection line between the two trawl doors can be drawn in selectable time intervals. The length of the line can be adjusted to the expected CDP coverage. Hence a coverage map is build up on the screen and allows identifying possible gaps in the 3-D coverage immediately. Shell scripts were prepared to provide an online repositioning of the streamer positions. Based on the database update a computed coverage map is modified every 15 minutes. Therefore modifications on the track planning due to gaps remaining after the ship passed by can be carried out at short notice.

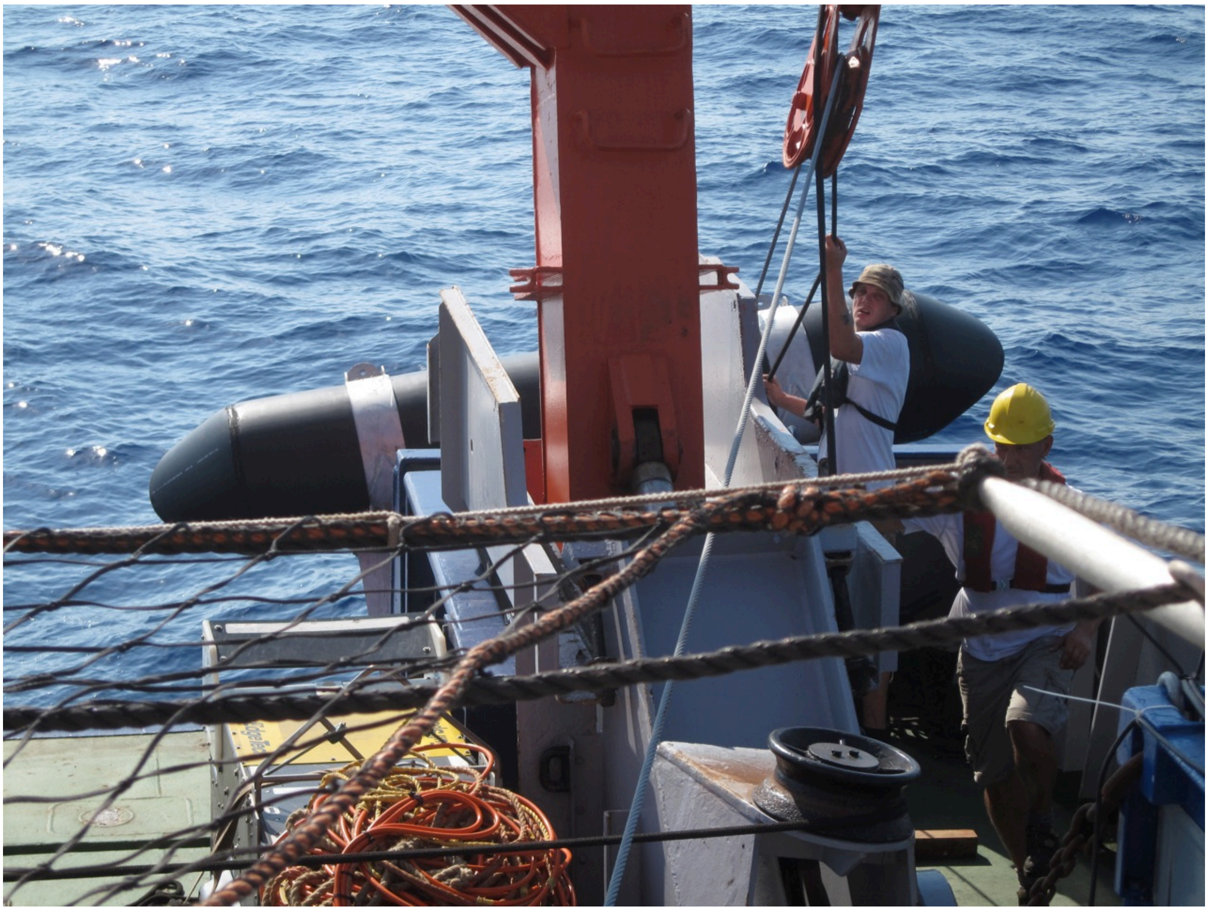

Figure 5.b.3: Port side trawl door at its rest position at the aft of R/V POSEIDON

a) GI Airgun and compressor

Active seismic signals were generated by the use of a 210 cubic-inch GI Airgun (Fig. 5.b.4). In order to achieve the desired shot interval of 7s a compressor with delivery of about 8 m^3 compressed air per minute is required. Due to the limited space on the working deck this unit may not be larger than a 10” container. These limitations are met by a C4 Junkers compressor container only, which was chartered for the cruise (Fig. 5.c.1).

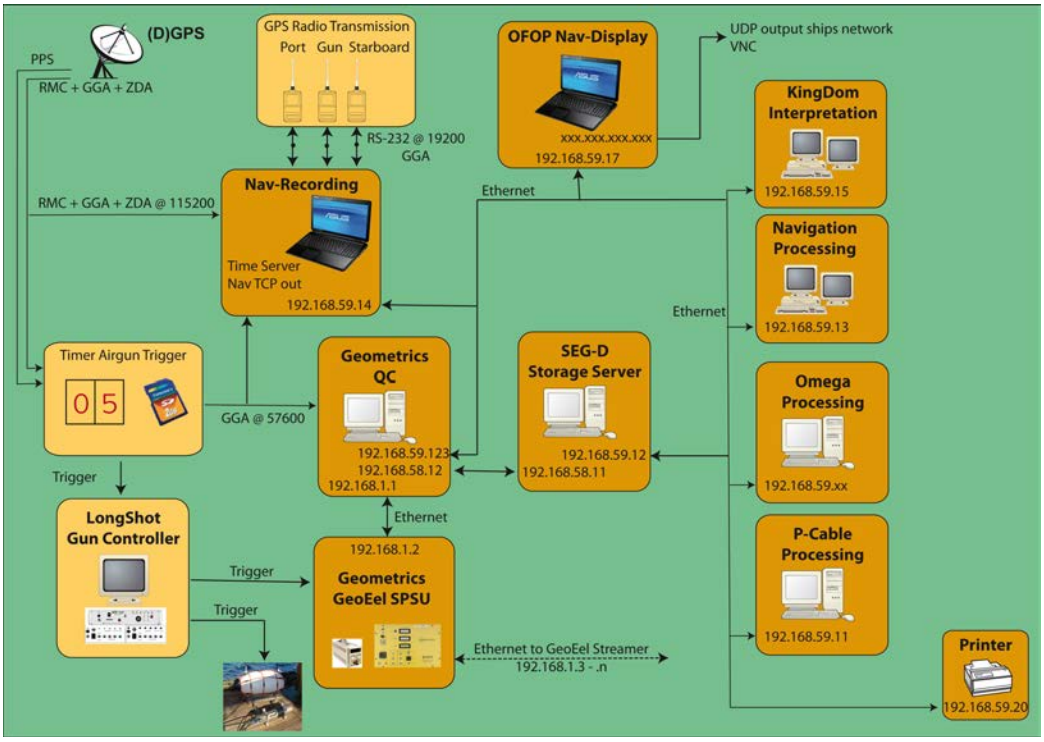

Figure 5.b.4: Network and computing devices on board. Navigation and data recording and processing are realized within a multifold local area network.

Fuel, oil and cooling water were supplied by the vessel. Cooling water from the vessel is supplied through a C-size fire hose. Limited space between ships rail and the backside of the compressor caused strong bending of the fire hose, which limited the water through-flow. The internal diameter of the cooling circuit inside the compressor is of larger B-size. Both facts caused limited cooling. Therefore only three of the four compressors could be operated at one time. The amount of compressed air was sufficient to serve for a shot rate of 7 seconds at 150 bar.

Figure 5.c.1: C4 Junkers compressor with air buffer installed onboard R/V POSEIDON

b) DeepTow Sidescan Sonar

High-resolution backscatter information of the seafloor was to be obtained using the DTS-1 sidescan sonar system (Fig. 5.d.1) operated by GEOMAR. The DTS-1 sidescan sonar is a dual-frequency, chirp sidescan sonar (EdgeTech Full-Spectrum) working with 75 and 410 kHz centre frequencies. The 410 kHz sidescan sonar emits a pulse of 40 kHz bandwidth and 2.4 ms duration (giving a range resolution of 1.8 cm), and the 75 kHz sidescan sonar provides a choice between two pulses of 7.5 and 2 kHz bandwidth and 14 and 50 ms pulse length, respectively. They provide a maximum across-track resolution of 10 cm. With typical towing speeds of 2.5 to 3.0 kn and a range of 750 m for the 75 kHz sidescan sonar, maximum along-track resolution is on the order of 1.3 metres. In addition to the sidescan sonar sensors, the DTS-1 contains a 2-16 kHz chirp subbottom profiler providing a choice of three different pulses of 20 ms pulse length each. The 2-10 kHz, 2-12 kHz or 2-15 kHz pulse gives a nominal vertical resolution between 6 and 10 cm. The sidescan sonar and the subbottom profiler can be run with different trigger modes, internal, external, coupled and gated triggers. Coupled and gated trigger modes also allow specifying trigger delays. The sonar electronics provide four serial ports (RS232) to attach up to four additional sensors. One of these ports is used for a Honeywell attitude sensor providing information on heading, roll and pitch and a second port is used for a Sea&Sun pressure sensor. Finally, there is the possibility of recording data directly in the underwater unit through a mass-storage option with a total storage capacity of 80 GByte (plus 80 Gbyte emergency backup).

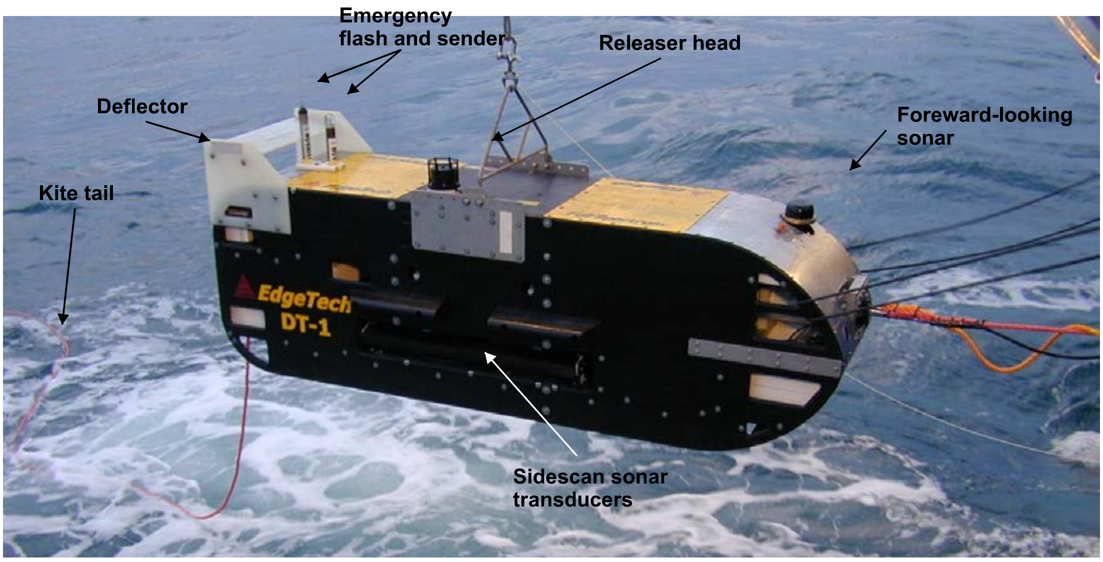

Figure 5.d.1: A picture of the DTS-1 sidescan sonar towfish. The forward-looking sonar is no longer mounted.

The sonar electronic is housed in a titanium pressure vessel mounted on a towfish of 2.8 m x 0.8 m x 0.9 m in dimension (Fig. 5.d.1). The towfish houses a second titanium pressure vessel containing the underwater part of the telemetry system (SEND DSC-Link). In addition, a releaser capable to work with the USBL positioning system POSIDONIA (IXSEA-OCEANO) with separate receiver head, and an emergency flash and radio beacon (NOVATECH) are included in the towfish. The towfish is also equipped with a deflector at the rear in order to reduce negative pitch of the towfish due to the weight of the depressor and buoyancy of the towfish.

The towfish is connected to the sea cable via the depressor through a 45-m long umbilical cable (Fig. 5.d.2). The umbilical cable is tied to a buoyant rope that takes up the actual towing forces. An additional rope has been taped to the buoyant rope and serves to pull in the instrument during recovery.

The main operations of the DTS-1 sidescan sonar are run using HydroStar Online, the multibeam bathymetry software developed by ELAC Nautik GmbH and adapted to the acquisition of EdgeTech sidescan sonar data. This software package allows onscreen presentation of the data, of the tow fish's attitude, and the tow fish's navigation when connected to the POSIDONIA USBL positioning system. It also allows setting the main parameters of the sonar electronics, such as selected pulse, range, power output, gain, ping rate, and range of registered data. HydroStar Online also allows activating data storage either in XSE-format on the HydroStar Online PC or in JSF-format underwater on the full-spectrum deep-water unit FS-DW. Simultaneous storage in both XSE and JSF-formats is also possible. Accessing the underwater electronics directly via the surface full-spectrum interface-unit FS-IU and modifying the sonar.ini file of the FS-DW allows changing additional settings such as trigger mode. The FS-IU also runs JStar, a diagnostic software tool that also allows running some basic data acquisition and data display functions. HydroStar Online creates a new XSE-file when a file size of 25 MB is reached, while a new JSF-file is created every 40 MB. How fast this file size is reached depends on the amount of data generated, which depends on the use or not use of the high-frequency (410 kHz) sidescan sonar. The amount of data generated is also a function of the sidescan sonar and subbottom pulses and of the data window that is specified in the initialisation file (sonar.ini) on the FS-DW. The data window specifies the range over which data are sampled.

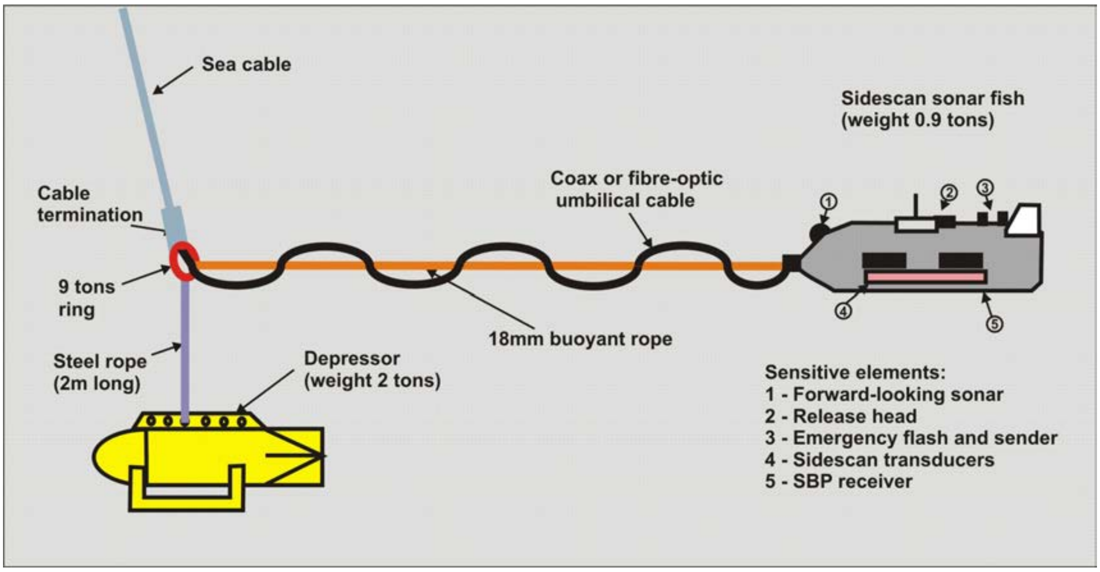

Figure 5.d.2: The DTS-1 towing configuration.

The subbottom profiler data have to be corrected for varying water depths in which the towfish is flying. These corrections are based on depth information provided by the pressure sensor mounted on the towfish and have been carried out with in-house processing scripts based on GMT and Seismic Unix software packages.

The sidescan sonar serves as attachment point for a deep-towed seismic streamer (see Chapter 5.e) that can be used simultaneously with the sidescan sonar (Fig. 5.e.1).

c) DeepTow Multichannel Streamer

With standard surface streamers the lateral resolution is reduced with increasing water depth. Using a deep-towed streamer could provide a constant and improved resolution as the receiver array is towed about 100 meters above the seafloor (Fig. 5.e.1). Due to the drag of the deep sea cable in the water the tow fish is expected to be 2 to 2.5 times the water depth offset behind the vessel. Operating a standard GI airgun as sound source this allows the undershooting of high reflective seafloor elements (e.g. carbonate crusts). Consequently the DeepTow provides the opportunity to resolve reflection interfaces in regions where standard surface streamers provide blanking areas only. With the source still at the sea surface and the receiver deployed at depth the raypath for the sound emission is no longer symmetric and hence the concept of CDP stacking does not hold true any more. Therefore full waveform migration needs to be applied to integrate all streamer channels into one seismic section.

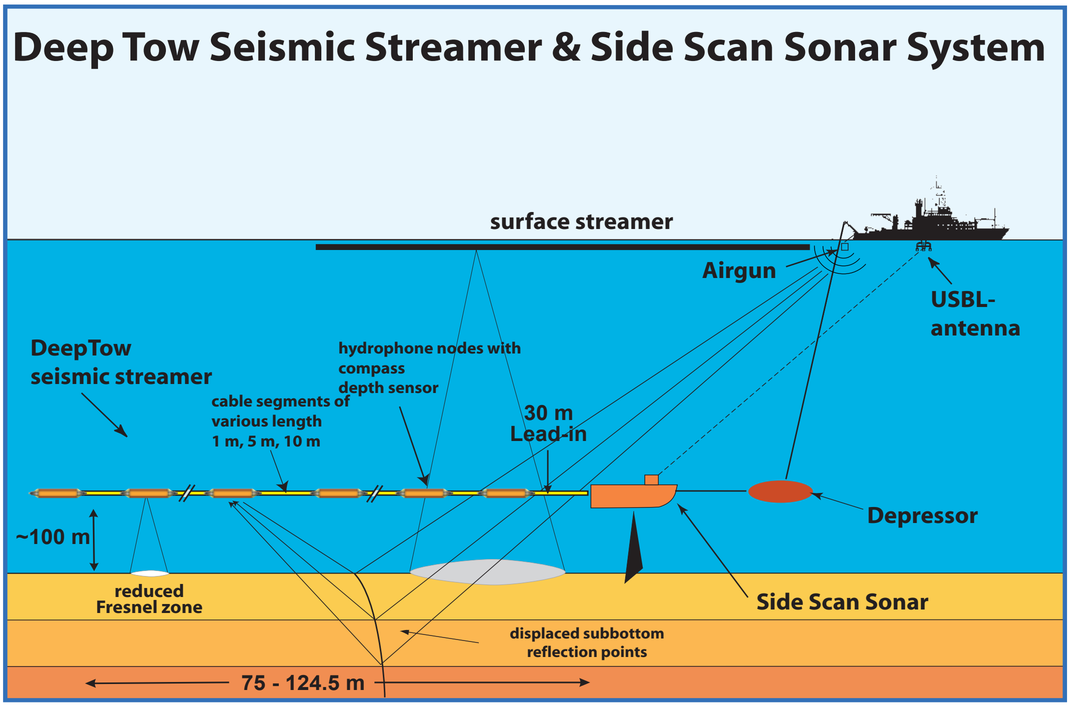

Figure 5.e.1: Scetch of the DeepTow system with multichannel streamer and Sidescan

The deep towed multichannel streamer is a new custom-made development, designed by companies SEND Off-shore, Hamburg, and KUM, Kiel. It comprises of single hydrophone modules and modular cable connections (Fig. 5.e.2). From a so-called Top-PC (TPC) Ethernet connections to the Bottom-PC (BPC) in the tow fish and the GeoEel seismic quality-control recording system from Geometrics are connected. In addition, the sidescan sonar PCs in the tow fish and on board the vessel are connected via the TPC, BPC and the modems of the telemetry system (Fig. 5.e.3). The TPC runs a control program for the deep towed streamer. Here all parameters (shot interval, record length, etc.) are specified and submitted to the streamer and the recording system. Moreover the control program displays heading and depth distribution of the hydrophones and other statistical system information.

Figure 5b.2: Photgraph of the streamer hydrophones and cable segments during setup of the multichannel chain.

During profiling a GPS-based time-code is interpreted to generate the wanted shot interval and to distribute the trigger signal to all external systems and the streamer at depth. Depending on the bandwidth of the towing cable a certain number of hydrophone data can be transmitted onboard in real-time via the towing cable. The hydrophone nodes are equipped with a compass and a depth sensor. During operation the USBL system POSIDONIA is used to track the position of the towfish. From this database exact positions for each hydrophone at each shot time can be calculated.

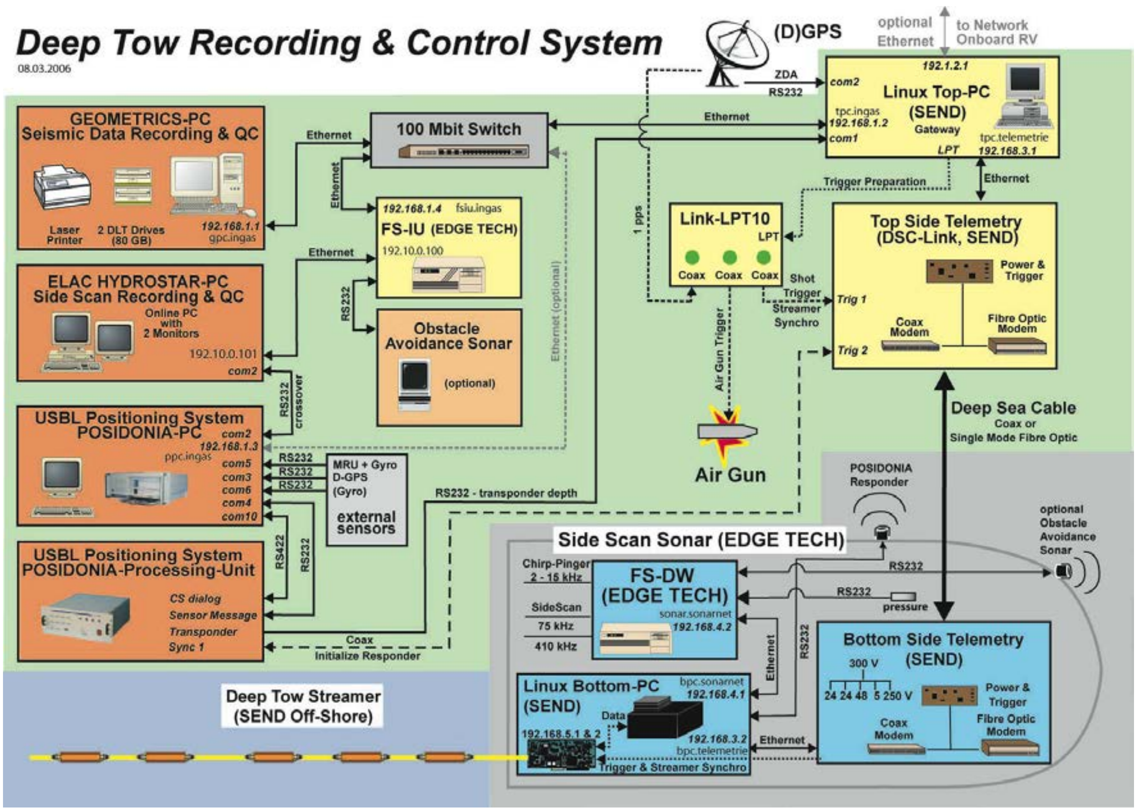

Figure 5c.3: Overview of the data connections within the DeepTow control system

During the cruise the main processing cabinet of the POSIDONIA system failed due to unknown reasons after 10 minutes of operation. Therefore coordinates of the twofish were not available. Moreover the readings of cable length and cable speed were not available from the winch during the time of deep towed streamer operation.

6. Work performed and results

Within the course of the cruise P-427 DokuGas 3D and 2D multichannel seismic data have been acquired. Two Sidescan sonar surveys were completed mapping seafloor backscatter at both deep and shallow seep sites. Multibeam data were acquired continuously with WCI data recording switched on at almost all tracks. Figure 6.1 shows an overview of the working areas and the applied techniques.

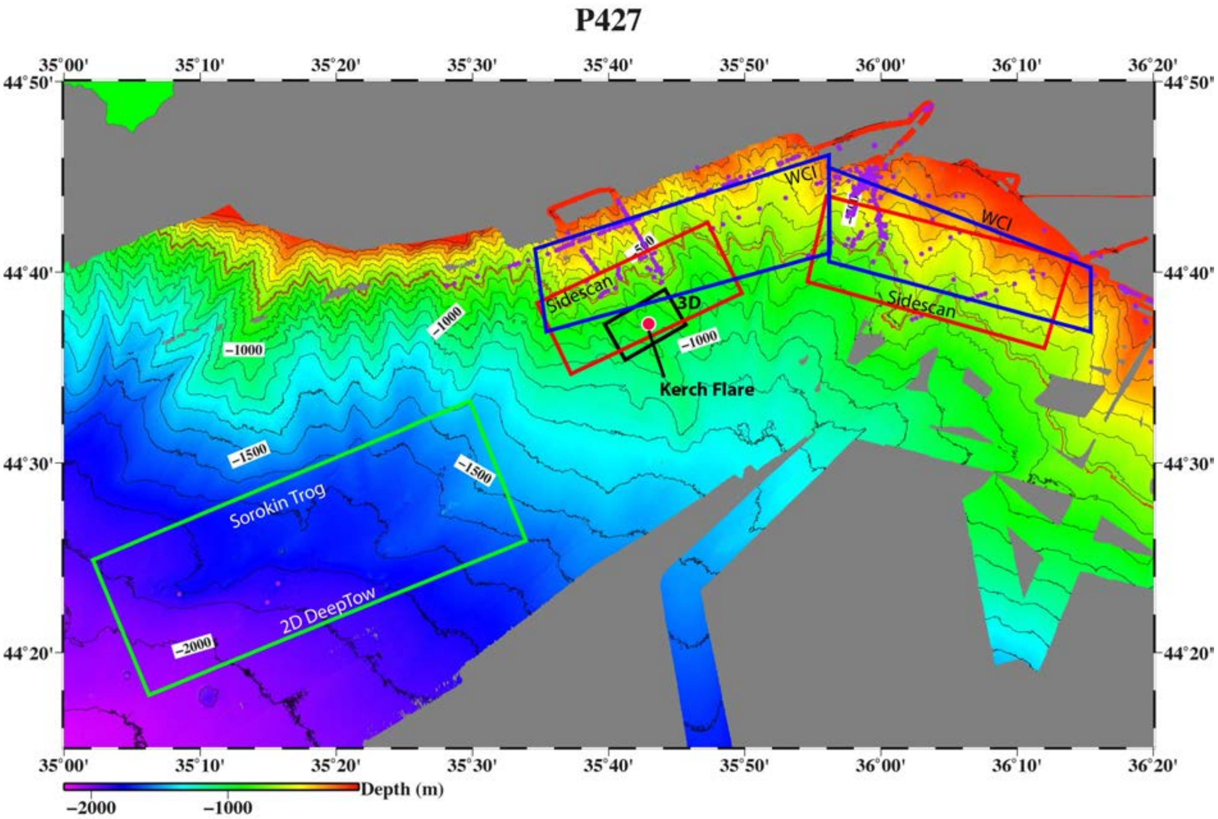

Figure 6.1: Overview of the survey areas.
Major applied equipment is noted at the bounding boxes. Purple dots mark active seep sites mapped by scientists from IBSS.

a) L3-ELAC Nautik SBE 3050 Multibeam

One pre-requisite of multibeam bathymetry surveys is the exact knowledge of the water sound velocity. Therefore we deployed a CDT at 35° 40’ E / 44° 25’ N in a water depth of 1500 m (Fig. 6.a.1), which covers the foreseen survey depth.

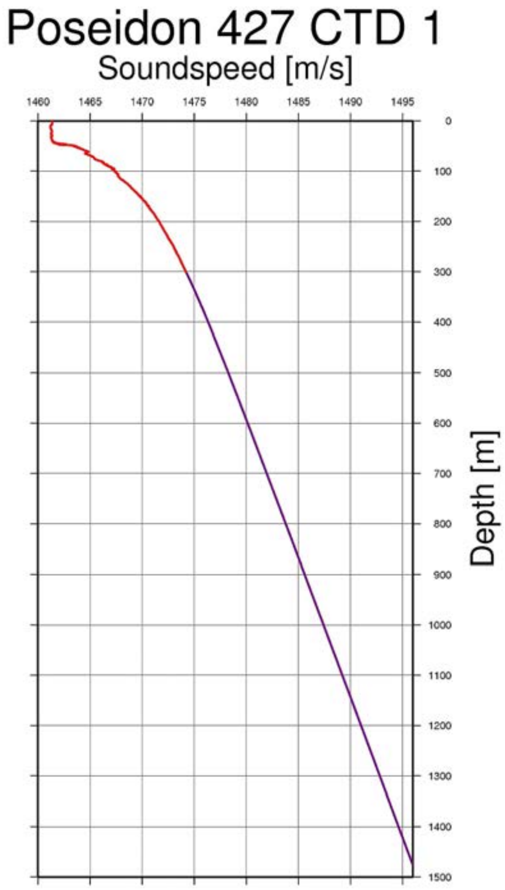

Figure 6.a.1: Sound velocity profile calculated from CTD cast CTD measurements reached 1500 m water depth.

The multibeam system was operated on all courses during the cruise. Due to the high rate of data accumulation the WCI option was switched off on a few tracks, when areas were revisited after short time interval or previous profiles confirmed no gas flare activities. Nevertheless about 8 TB of WCI data had been collected at the end of the cruise.

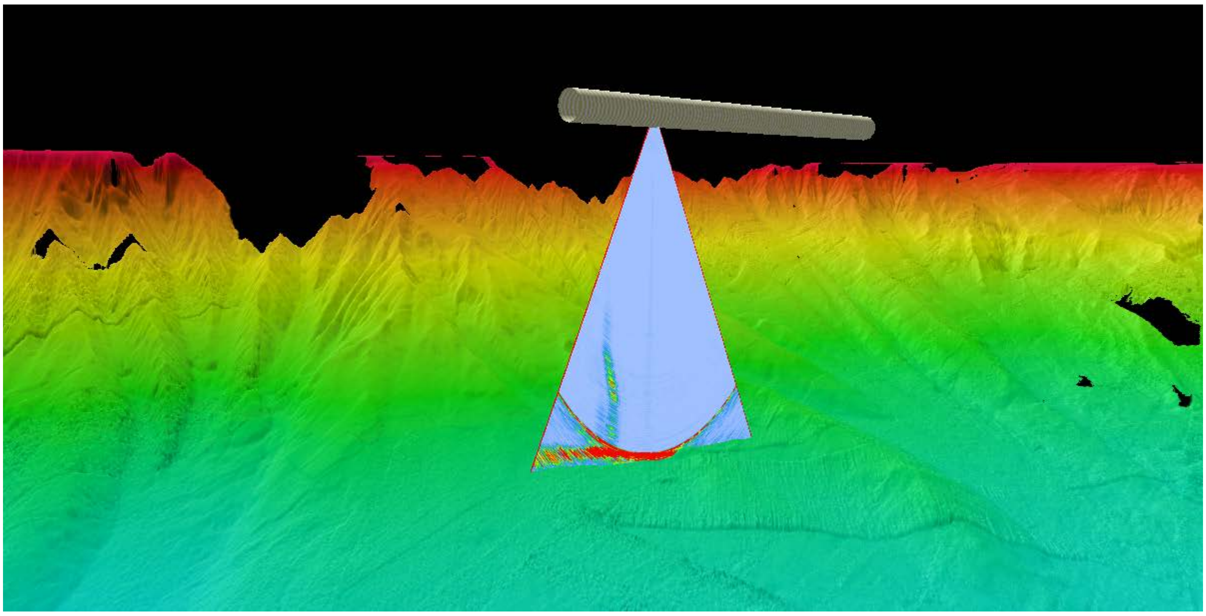

Figure 6.a.1: Water Column Image (WCI) of the Kerch Flare. The 3D viewer Fledermaus has been used to superimpose the WCI swath above the bathymetry. Left of the centre two flares from the Kerch site of different height are visible.

One major target was the Kerch Flare, which was covered several times during the 3D seismic survey (see chapter 6.b, Fig. 6.a.2). At least 58 crossings were acquired over a time span of about four days. During these crossings three major flares were observed in the online display of the WCI-Viewer. Following the seismic profile coverage with a horizontal line spacing of 50 m the opening angle for the multibeam could be reduced to 90° degrees. Chosen length of the pulse was variable (1 ms, 3 ms and 10 ms) in order to provide high resolution for the water column image processing. The time interval between successive pings was chosen on automatic depending on the water depth.

Due to the width of the 3D seismic data volume of about four kilometers observations of the gas flares were done at varying offsets. Therefore the flares are not only detected within the centre beams but also by the outer beams. Hence a comparison of the detection quality and amplitude appearance for observations across the beam fan will ultimately be possible.

Due to the requirement to sail along parallel lines observations with variable azimuth were not possible. Therefore a time window of 13 hours was dedicated to a time-laps experiment. Two orthogonal tracks crossing the Kerch flare and additional tracks crossing nearby flares above 700 m water depth were sailed in repetition. Total time for one turn was about one hour and therefore the whole experiment enabled multiple azimuth observations of a deep (within the GHSZ) and a shallow (out off the GHSZ) site were completed. Also observation of the online viewer did not reveal remarkable differences, which may be caused by tides or other time dependent influences. Detailed analyses and comparison of the single records are required.

During the 3D survey small offsets between overlapping and reversed bathymetric records were observed. As weather conditions did not change much during this time a possible explanation might be found in some less precise values for the offset calibration of the motion sensor. A multibeam survey in shallow waters above the shelf brake was used to select short profiles, which were used to run a calibration for the system. As a result correction values of –1.9 for pitch and –0.2 for roll were found. These values were now set in the system for further mapping and previously acquired multibeam data was corrected accordingly.

Two surveys were dedicated to flare imaging along the upper slope of the shelf (Fig. 6.1, WCI). A large number of flares were already mapped by Ukrainian scientists from the Institute of Biology of the Southern Seas (IBSS, Fig. 6.1 purple dots) through the use of single beam echo sounders only. A much denser seep site distribution is provided by [*Römer et al.*, submitted], which is based on Parasound images. Roemer et al. divide the observed flares in strong and weak occurrences. Using the WCI capability of the hull mounted multibeam enables to confirm the activity of the seeps and to check if additional sites could be identified. Moreover provides the observation of the same seeps with different sounding tools an opportunity to compare the signal strength during detection of the flares and possibly decide whether strong and weak flares of the Parasound survey are real or just the result of different offset from the site of gas emission on the seafloor.

The tracks of R/V POSEIDON were chosen to cross morphologic structures known as mud volcanoes from previous cruises in order to provide an additional snapshot observation of their ongoing activity.

b) Multichannel 3D seismic acquisition at the Kerch Flare

The first target for the investigations was the dedicated 3D area around the Kerch Flare (Fig. 6.b.1). The Kerch Flare is an active flare in about 900 m water depth and was first mapped during cruise M72/3b in 2007 and studied in more detail during cruise MSM15/2 [*Bohrmann et al.*, 2011]. A high resolution bathymetric survey with the Bremen AUV [*Römer et al.*, submitted] revealed two slightly elevated regions from where active gas expulsion is observed.

The Don-Kuban slope is located between the Sorokin Trough and the Kerch peninsula. From both areas fluid expulsion from mud volcanoes are known. In addition the upper slope along the Kerch peninsula is known to host numerous shallow seeps sites, which are generally found above the 720 m deep top of the gas hydrate stability zone. Therefore it was expected to find features of both, the mud volcano system and the shallow seep system. Bathymetry mapping should be used to identify additional mud volcanoes at the base of the slope and possibly up-slope when getting closer to the on-shore extension of the mud volcano chain.

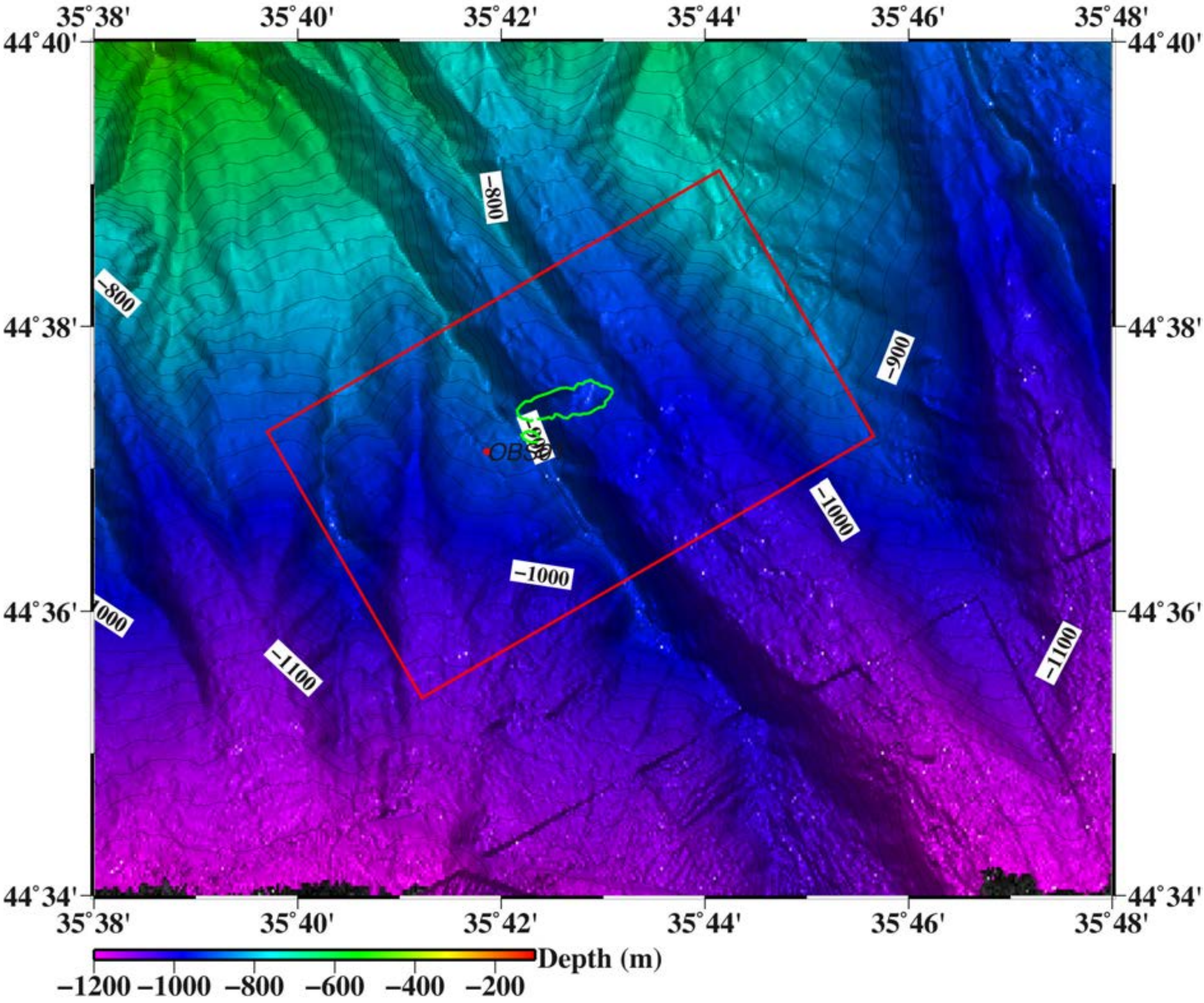

Figure 6.b.1: Location of the 3D seismic survey area at the Kerch Flare
The base region of the active flare has been mapped in great detail through an AUV survey by the University of Bremen [Römer et al., submitted]. Active flares were reported from two elevated regions (marked in green), which are interpreted as mound structures.

From the regional bathymetric map acquired during the MSM15/2 cruise with R/V MERIAN, however, no indications for additional mud volcanoes were found. The only active site in water depth below the 720 m limit of the gas hydrate stability field is the Kerch Flare. Acquisition of a high resolution 3D seismic survey should reveal the major structures in the upper sediment column at the site and provide a three dimensional image of the feeder channel.

58 seismic profiles were acquired between Feb. 27, 2012 and Mar.3, 2012 (Fig. 6.b.2). Due to limitations of the compressor (see 5.c) a shot rate of 7 sec. was chosen with recording length of 4 sec at 0.5 ms sampling interval. The active length of 12.5 m of the streamer sections required a sailing speed of 3 kn through water. Strong surface currents of up to more than 1.2 kn resulted in variable speed over ground within survey direction. Unfortunately both available streamer control units broke down after recovery of the 3D system due to broken tow wires.

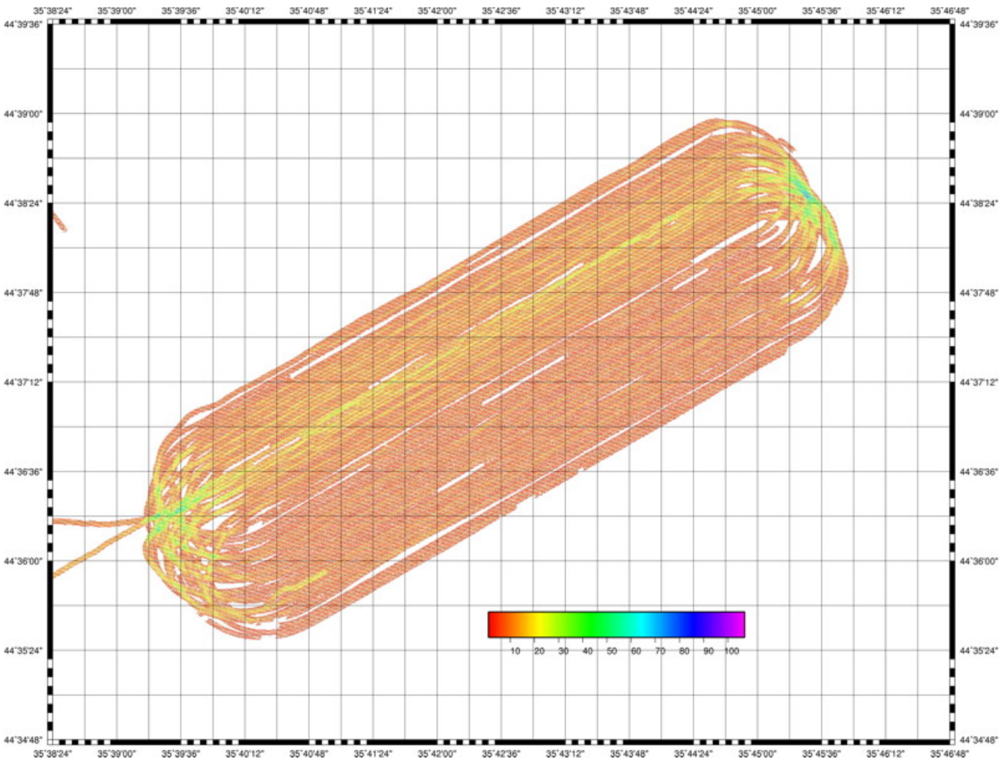

Figure 6.b.2: Coverage map of the seismic 3D area after completion of 58 airgun profiles. Color code is due to trace fold in each bin filed.

Despite a missing GPS position of the starboard door the navigation processing could be completed in good time. The remaining gaps were small enough to be closed by sophisticated interpolation algorithms in space and time.

The resulting 3D data cube could be processed on a 3.25 m * 3.25 m grid. A 2D section from the centre of the cube highlights the major characteristics of the data set (Fig. 6.b.3). Bathymetric ridges, possibly formed by downslope currents draining the shelf, are the major topographic features. At Kerch Flare the sediments change their reflectivity. Between 1.4 sTWT and 1.6 sTWT areas with chaotic reflections or blanking possibly indicate high gas content. To the East three sediment interfaces enclose a stack with almost no reflectivity between 1.6 sTWT and 1.8 sTWT. These blanking areas terminate in an upward direction underneath the Kerch Flare. Further to the West the blanking is less pronounced and thinner. It terminates again in an upward bending underneath the Kerch Flare.

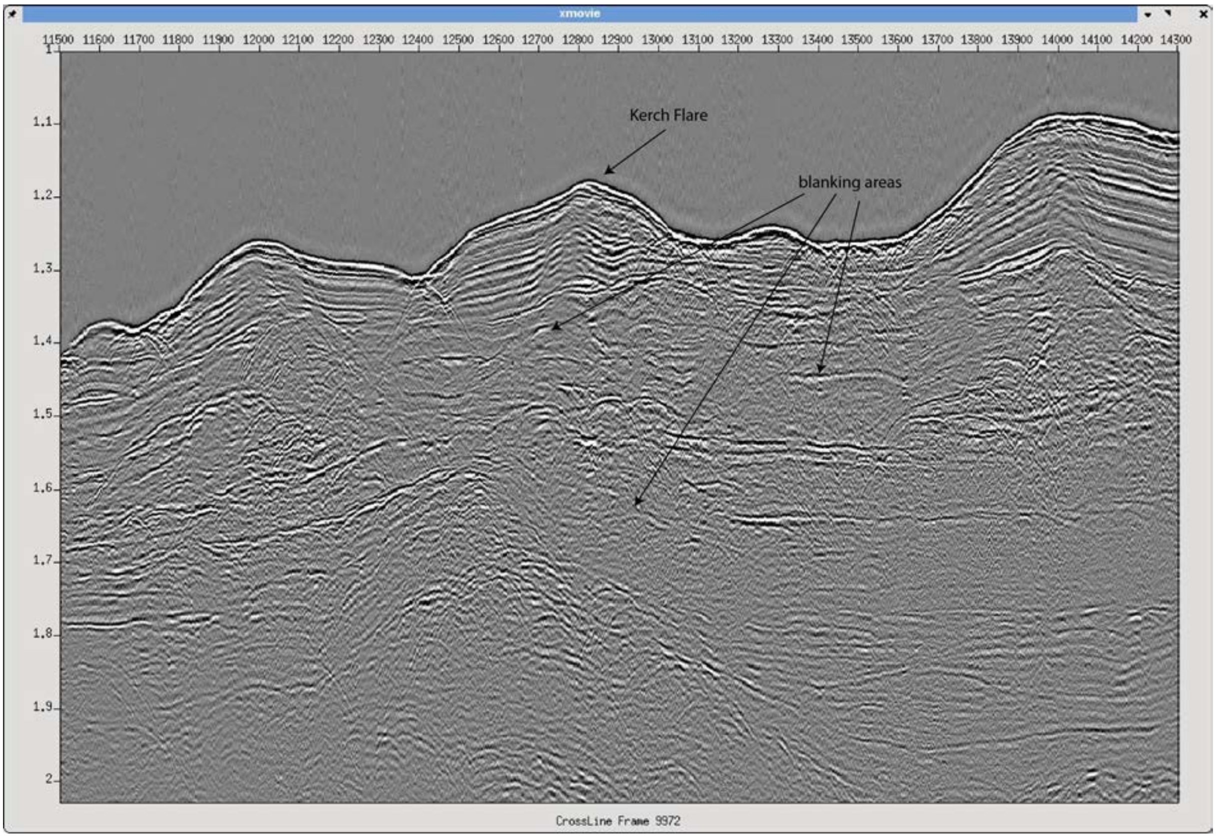

Figure 6.b.3: Cross section through the 3D data cube. The bathymetric ridges, underlying the Kerch Flare are nicely seen. Underlying sediments change their reflectivity underneath the Kerch flare site. Between 1.4 sTWT and 1.6 sTWT areas with chaotic reflections or blanking indicate high gas content.

c) DeepTow Multichannel Streamer

In the Eastern Sorokin Trough several active flares were known to rise from mud volcanoes and other seep sites (e.g. Egorov Flare) since the CRIMEA and M52 cruises. During the MSM15/2 cruise an additional mound structure with a weak flare (M16 in [*Bohrmann et al.*, 2011]) was found. Multibeam bathymetry with WCI recording and 2D seismic with the deep towed multichannel streamer should be applied to confirm the ongoing activity of the flares and the structure of the feeder channels in the sediment. As the Sorokin Trough reaches water depth of 1600 m down to 2100 m (Fig. 6.1) it was out of reach for the deployment of the Sidescan. The deep sea winch of POSEIDON could provide 2500 m of cable only, which would be sufficient to tow the Sidescan in about 1200 m water depth. Therefore the deep towed streamer was operated only as seismic signals could be record even if the streamer was towed a few hundred meters above the seafloor. Activity at the recently found flare M16 could be confirmed. At the Egorov site no flares were detected online.

During deployment of the deep towed streamer the winch displays of cable length and cable speed were out of order as well did the USBL system POSIDONIA not work. Consequently the true positions for the hydrophones of the streamer need to be recalculated during post processing steps at a later time and single trace plots are available on board only. Fig. 6.c.1 shows a blow up of the mound structure at site M16.

Even in the single trace section the interruption of the sediment interfaces underneath the mound structure becomes visible. There seems to be energy down to a sediment depth of about 0.6 sTWT. The full data quality will be available after migration of the complete 33 hydrophones operated in the streamer.

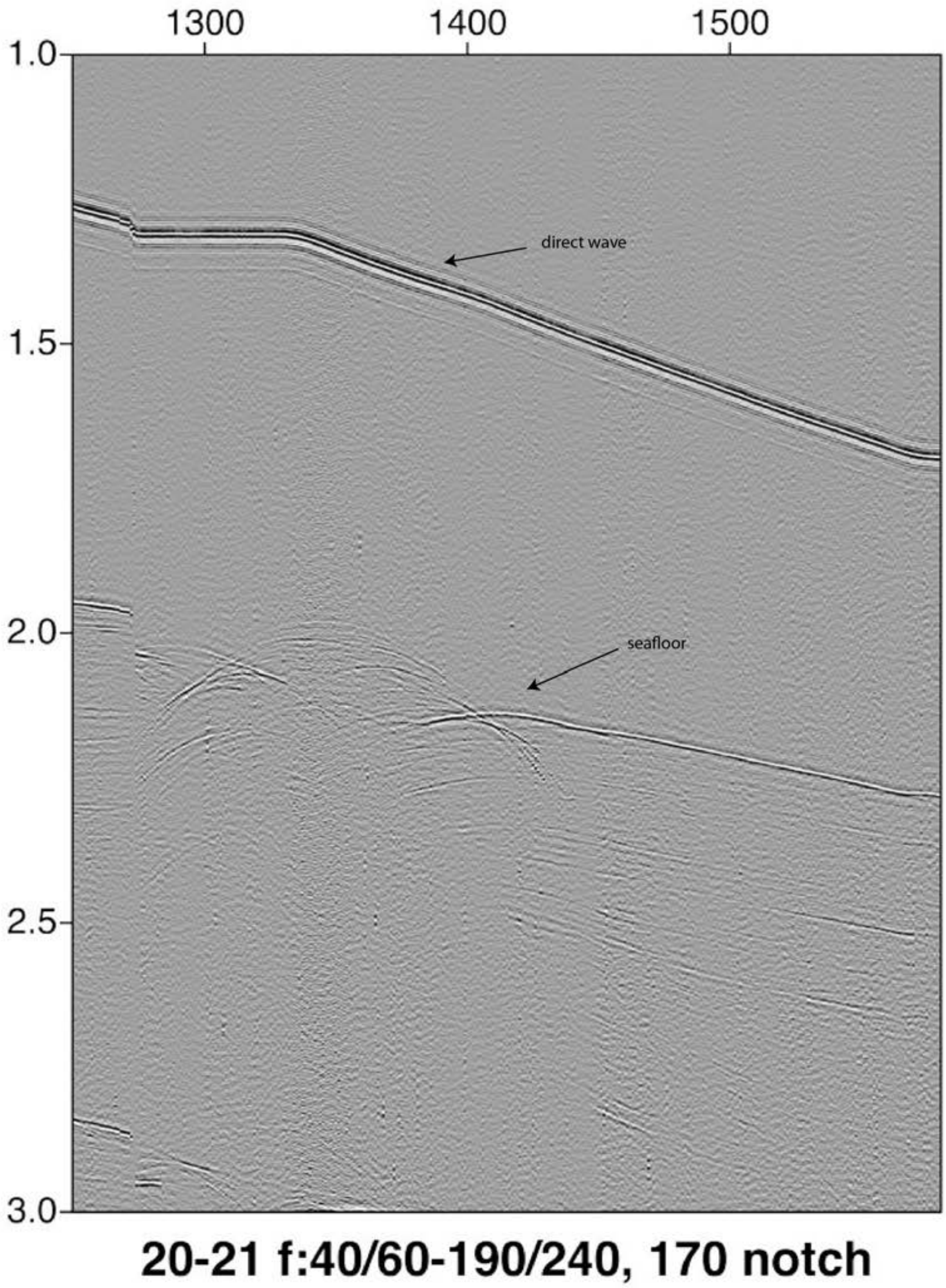

Fig. 6.b.5: Single channel section (#20) of the deep towed streamer Distance between direct wave arrival and seafloor is variable due to continuous pay out of the deep sea cable. Winch operations are visible from the continuity of the direct wave arrival. Data processing will correct for this at a later stage.

d) Sidescan Sonar

Two sidescan sonar surveys were conducted in the greater area of the Kerch Flares (Fig. 6.1). Their objectives were the detection of gas bubbles escaping from the seafloor, the investigation of the presence of authigenic carbonates indicating long-lasting fluid seepage, as well as mapping of seafloor structures.

The first deployment started on Mar. 4 at 15:30 UTC and ended on Mar. 6 at 14:30 UTC. The survey comprised eight parallel profiles of 10 nm length extending in a SW-NE direction across the area of the Kerch Flares as well as the survey area of the 3D seismic survey. Profile separation was 1.3 km (0.756 nm) to ensure some overlap of the outer sidescan beams. During acquisition the 75 kHz mode was used with a ping rate of 1 Hz which led to a constant range of 750 m. With a ship's speed of 3 kn, the DTS-1 system was towed at an average altitude of 100 m above the seafloor.

Unfortunately, the true towfish position could not be obtained. The Posidonia USBL system did not respond, in which case the towfish position is normally approximated by using a layback method which takes into account the ship's position and the length of the winch cable. However, the cable length display of the winch did not work properly at the time and hence it could not be used to calculate the true towfish position. Positioning will therefore have to be attempted during post-processing by taking into account the seafloor morphology from the subbottom profiler data and the bathymetry.

The unprocessed sidescan sonar data showed the presence of gas bubbles marked by a so-called flare in the water column next to another possible flare within the area of the Kerch Flares (Fig. 6.d.1).

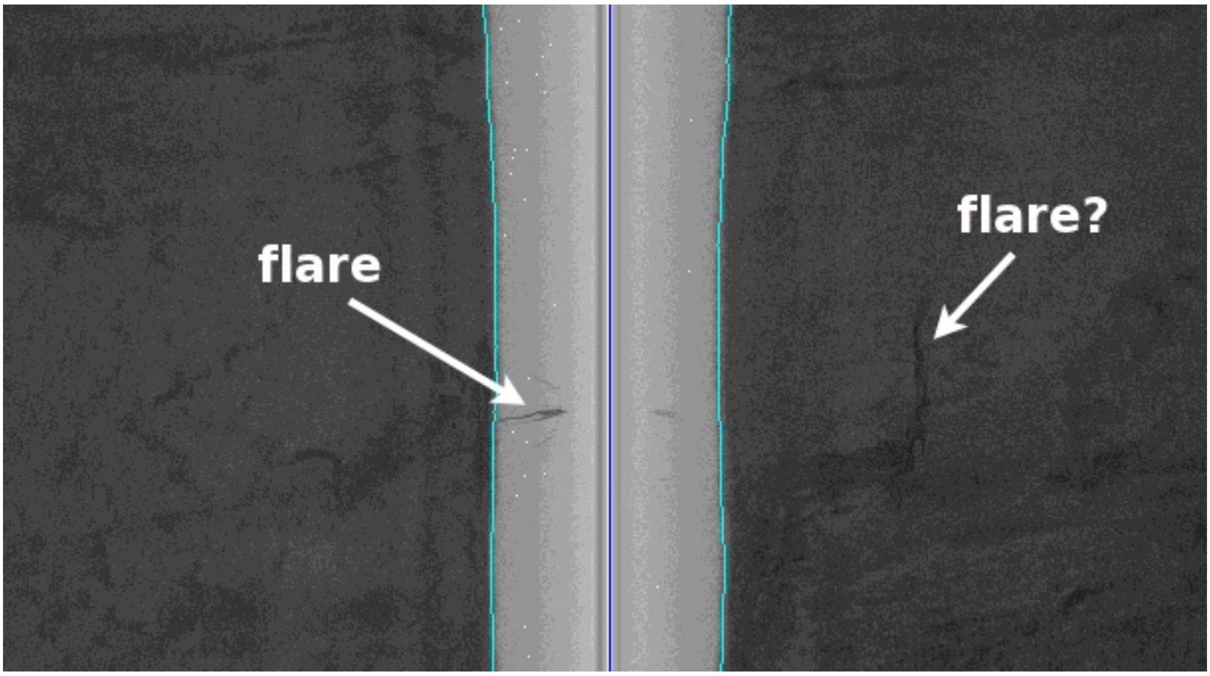

Fig. 6.d.1: Raw sidescan sonar data of the Kerch Flare area showing two possible flares.

In the shallow subsurface of the Kerch Flare area, the 2-10 kHz subbottom profiler shows two sections of acoustic blanking which indicates the presence of gas within sediments (Fig. 6.d.2).

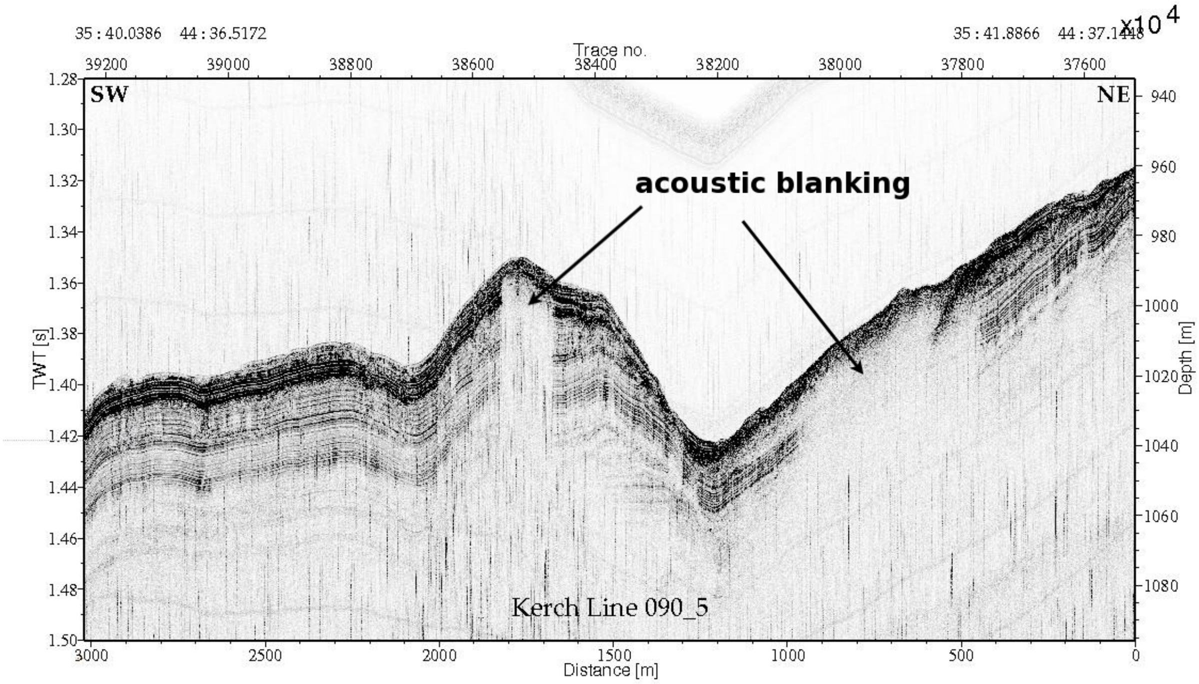

Fig. 6.d.2: Subbottom section of the Kerch Flare area. Acoustic blanking patches mark the presence of gas within the shallow subsurface.

Throughout most of the survey area, penetration of the chirp signal is as deep as 30-50 m, showing clearly stratified sediments. Along the four northern profiles (profiles 5-8), multiple flares indicate further sites of active seepage (Fig. 6.d.3 A). Some of these flares appear much stronger than those observed in the Kerch Flare area.

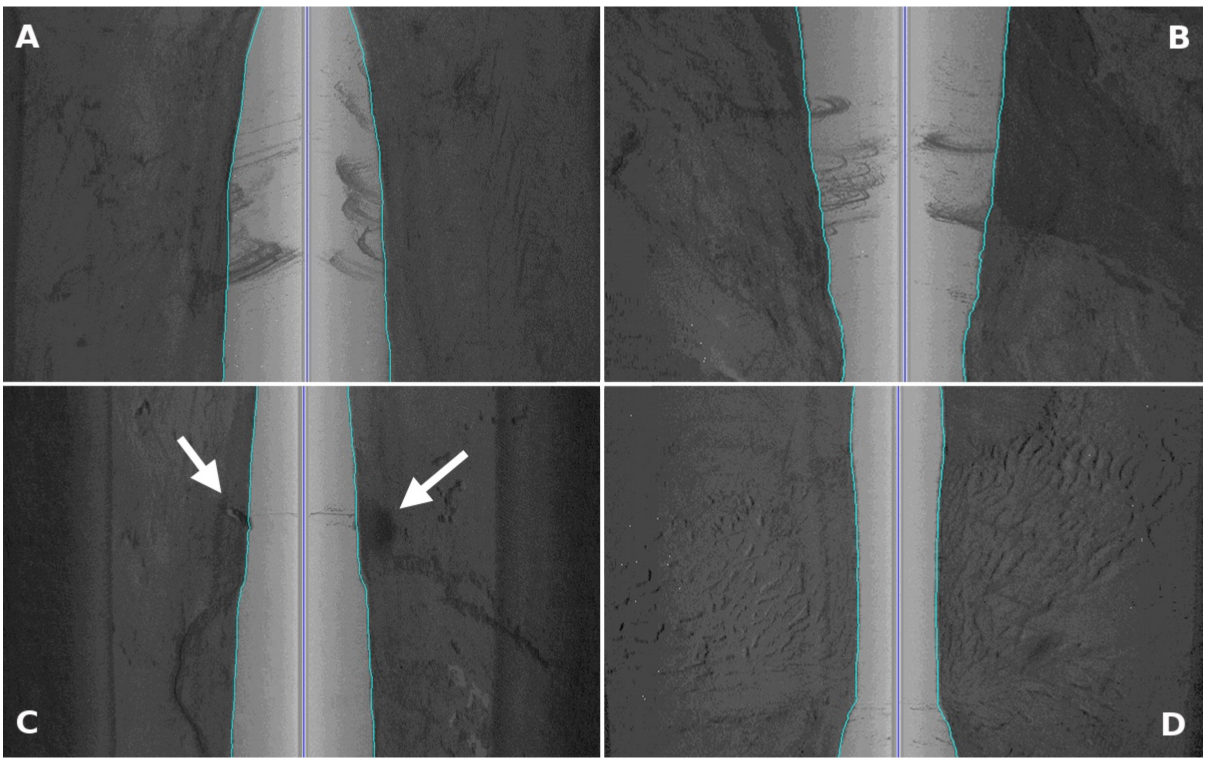

Fig. 6.d.3: Unprocessed sidescan sonar data showing multiple large flares in the watercolumn on P6 (A) and P9 (B). On P10 a flare is visible next to a high-backscatter patch (C), (D) shows sediment waves on P11.

A second deployment was carried out between Mar. 12 17:30 UTC and Mar. 13 13:00 UTC in the northeastern survey area to further investigate the flare sites that had been mapped by the multibeam survey. Sidescan and subbottom profiler data were acquired with the 75 kHz mode on five parallel profiles trending in approximate W-E direction. Profiles 9-12 had lengths of 11 nm whereas profile 13 was abandoned after about two hours. Again the distance between the profiles was 1.3 km to ensure overlap of the outer beams. The survey speed was 3 kn except on profile 11 where it amounted to 4 kn. As the rope length display of the winch was functioning again, towfish positioning could be done using the layback method. Georeferenced images of this profiles show irregular patches of high backscatter intensity (Fig. 6.d.4) that correlate with extensive flares in the water column. Other areas of increased backscatter intensity aligned in a downslope direction are, however, interpreted as sediment pathways or gullies.

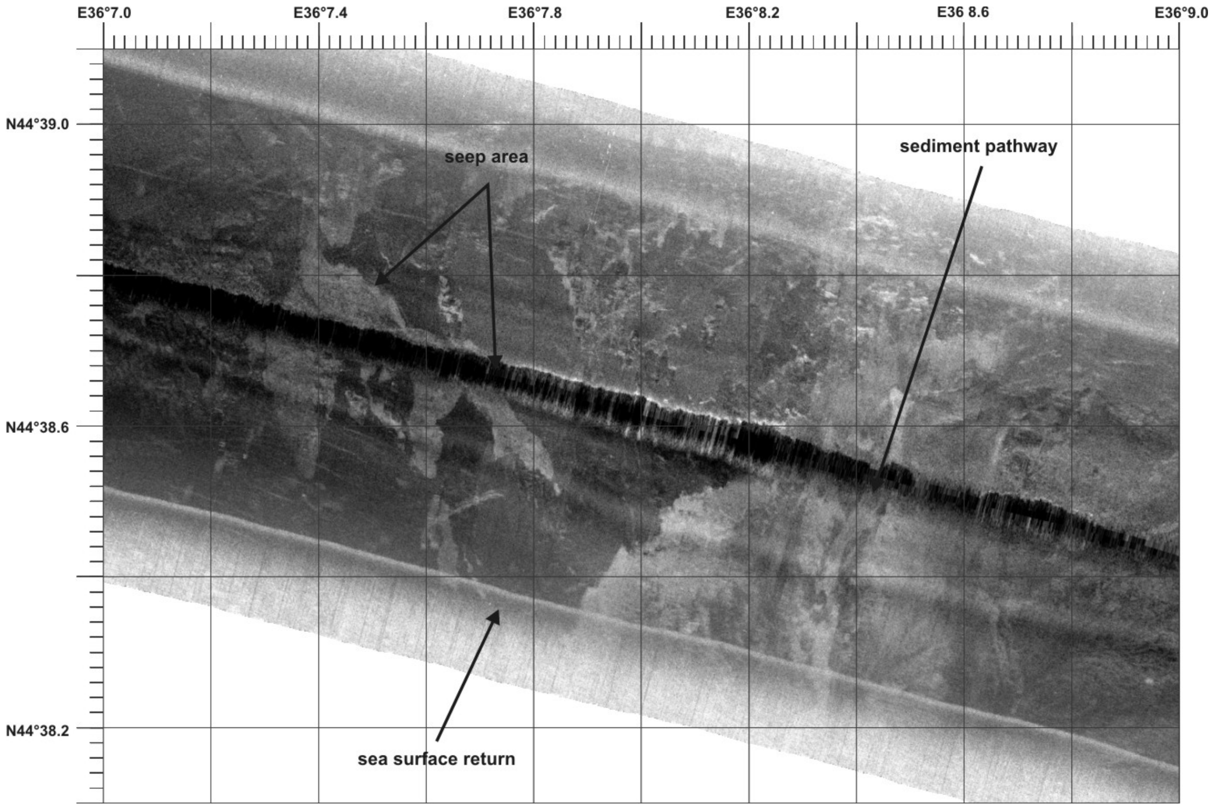

Fig. 6.d.4: Processed sidescan sonar profile along the upper slope showing several areas of high backscatter intensity interpreted as either seeps or sediment pathways.

The raw sidescan sonar data showed multiple small and larger flare-shaped anomalies in the water column which are associated with rising gas bubbles (Fig. 6.d.3 B). At least one flare is located close to a high-backscatter patch which may possibly be associated with authigenic carbonate, thus indicating long-lasting seepage (Fig. 6.d.3 C). Also, the data displays numerous linear and sub-linear features that may be attributed to seafloor morphology. Profile 11 shows an area of small sediment waves (Fig. 6.d.3 D). The subbottom profiler data of the second survey could not be analyzed onboard.

7. Acknowledgements

Our thanks go to the captain and crew of R/V POSEIDON. The outstanding support of the crew was a major contribution to the successful operation. Cruise P-427 was granted through DFG project DOKUGAS (KL1846/3-1).

8. Appendix

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No.	Title
1	FS POSEIDON Fahrtbericht / Cruise Report POS421, 08. – 18.11.2011, Kiel - Las Palmas, Ed.: T.J. Müller, 26 pp, DOI: 10.3289/GEOMAR_REP_NS_1_2012
2	Nitrous Oxide Time Series Measurements off Peru – A Collaboration between SFB 754 and IMARPE –, Annual Report 2011, Eds.: Baustian, T., M. Graco, H.W. Bange, G. Flores, J. Ledesma, M. Sarmiento, V. Leon, C. Robles, O. Moron, 20 pp, DOI: 10.3289/GEOMAR_REP_NS_2_2012
3	FS POSEIDON Fahrtbericht / Cruise Report POS427 – Fluid emissions from mud volcanoes, cold seeps and fluid circulation at the Don-_Kuban deep sea fan (Kerch peninsula, Crimea, Black Sea) – 23.02. – 19.03.2012, Burgas, Bulgaria - Heraklion, Greece, Ed.: J. Bialas, 32 pp, DOI: 10.3289/GEOMAR_REP_NS_3_2012

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