LEIBNIZ INSTITUTE FOR BALTIC SEA RESEARCH WARNEMÜNDE

Date: 30.07.14

Cruise Report

Compiled by: Dr. Joanna Waniek

R.V. Poseidon Cruise No.: 470

Dates of Cruise: from 25.05.2014 to 15.06.2014

Areas of Research: Biogeochemistry, Physical Oceanography, Maritime Technology

Port Calls: Malaga (Spain), Funchal (Portugal)

Institute: Leibniz Institut für Ostseeforschung Warnemünde, Seestraße 15, 18119 Rostock

Chief Scientist: PD. Dr. habil. Joanna Waniek

Number of Scientists: 10

Project: DFG: WA2157/5-1, BMWI: 03SX276 A/B

Cruise Report

This cruise report consists of 31 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
   A. Station list

1. Scientific crew:

Name	Function	Institute	Cruise/Leg
Dr. Waniek, Joanna	Chief scientist	IOW	470
Dr. Kaiser, David	Scientist	IOW	470
Jeschek, Jenny	Technician	IOW	470
Mars, Robert	Technician	IOW	470
Kurowski, Martin	Scientist	URO	470
DewitzDetlef	Technician	URO	470
Körner, Gerhard	Scientist	Enitech	470
Kebkal, Oleksiy	Technician	Evologics	470
Golz, Matthias	Scientist	TUB	470
Neumann, Sergej	Scientist	KIT	470
Total : 10			

IOW Leibniz Institut für Ostseeforschung Warnemünde

Evologics EvoLogics GmbH, FuE Bionik, Berlin

Enitech Enitech GmbH, Rostock

TUB Technische Universität Berlin

URO Universität Rostock

KIT Karlsruhe Institut für Technolgie

Chief scientist:

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2. Research program (J. Waniek, IOW)

The research program and the aims of the cruise mirror the plans of both involved projects (DECADE & SMIS) and are depicted in the working plan of the expedition: By means of hydrographic work the physical and biogeochemical conditions in the upper 2000 m of the water column in the catchment area of Kiel276 will be registered. Those CTD registrations are used to locate the Azores Front relative to the position of the deep sea mooring Kiel 276 along three meridians (23°W, 22°W and 21°W) between 30°N and 37°N allowing for a 3-D mapping of the front. Additionally, extensive tests of the SMIS fleet composed of surface vehicle and bottom unit will be carried out. The work is completed by trials of several AUV components and test of acoustic systems in various configurations.

3. Narrative of the cruise with technical details (J. Waniek, IOW)

24.05.2014- In the morning the cruise participants embark the ship and after uploading the containers started setting up the laboratories and testing the gear.

25.05.2014 - At 6:30 UTC after safety instruction Poseidon left the port of Malaga and started the transit to our first working area at 16.30°W, 37°N. Wind 5-6 Bft, expected arrival time morning of 28th May 2014.

26.05.2014 - We are still on transit to the first working area, wind 6 Bft, sea 5-6. The surface registration started (Thermosalinograph, surface Fluorometer, and water pumping from the ship internal system for determination of organic pollutants).

27.05.2014 - Transit continues same weather conditions as on previous days.

28.05.2014 - Poseidon arrived in our first working area. Here the CTD is tested; ROV and the surface drifter are tested regarding acoustic communication and general functionality as well. After successful first trial we continue our transit until the morning of 29th of May.

29.05.2014 - At 36°52.9N, 19°17.4W ROV and the drifter are deployed for an extensive communication test again. After completion we continue our transit to the main working area at 37°N, 22°W.

30.05.2014 - At 6:00 UTC we start with the hydrographic section at 37°N, 22°W, which will combine CTD casts down to the bottom (time permitting) and diverse trials of the SMIS vehicles or their components. The hydrographic section will continue southwards to 30°N.

31.05.2014 - 35.5°N, 22°W: Here beside the CTD cast the TMS and the drifter are deployed for first communication range test. After reaching 5 km distance between the drifter and the ship (and/or TMS at depths) the communication breaks down and we have to recover both systems. The CTD has some problems with transmitting data at depth greater 4000 m, similar to those reported from P459 last year (Fig. 1).

01.06.-03.06.2014- Our work continues with CTD's and trials of the SMIS vehicles. The front has different structure this time comparing to previous surveys. The weather conditions are getting continuously better, and the forecast promises further improvement.

04.06.2014- Our work goes well favored by good weather conditions and almost entirely calms sea. Today we deployed the surface vehicle MESSIN for the first time and sailed with it parallel to the ship movement for a short distance.

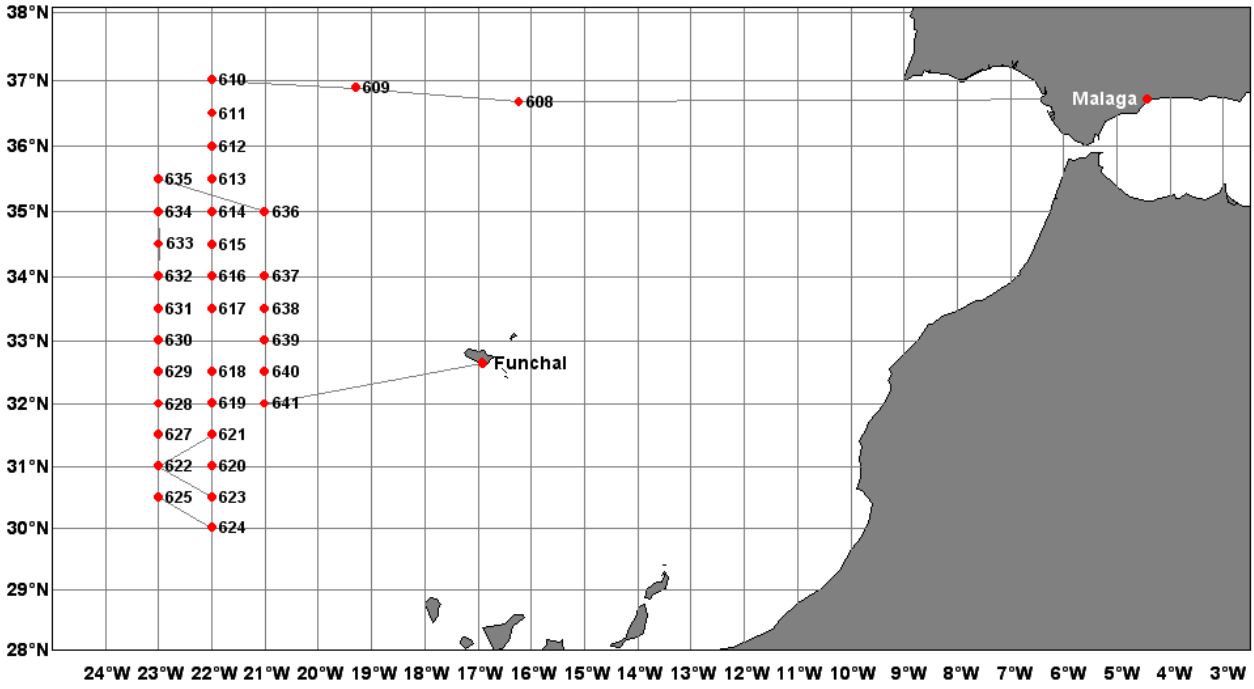


Fig. 1: Cruise track of POS470 in Mai/June 2014 from Malaga (Spain) to Funchal (Portugal). Numbers indicate the positions of hydrographic stations (CTDs).

05.06.-08.06.2014- We continue our work along 23°W with CTD's (down to the bottom) and extensive trials of the SMIS vehicles. The weather is good and the sea apart from a relatively high swell is calm. TMS in combination with the bottom station and the drifter were successfully deployed. Tonight we had a barbeque on board and will enjoy the break until 9th of June at 4:00 UTC.

09.06.2014- We continue the section towards North along 23°W, however until now we have not detected the Azores Front (Fig. 1).

10.06.2014- The hydrographic work continues by means of CTD. Today we have crosses the Azores Front for the second time. The temperature gradients here (23°W) are steep in comparison with 22°W. Calm weather (2 Bft) and sea is predicted for the rest of the cruise.

11-13.06.2014- The CTD deployments continue, we are working along 21°W hopping to cross the front for the third time during the cruise. At 8 pm the scientific work terminates and we are heading to Funchal.

14.06.2014- We are on transit to Funchal where the cruise terminates, data archiving, packing of the gear and securing our samples fills the day.

15.06.2014- In the morning RV Poseidon arrives in Funchal, at 6:00 UTC. The scientific gear is loaded into 2 containers and send back home. All cruise participants disembark in the early afternoon and transfer to a hotel before flying home next day.

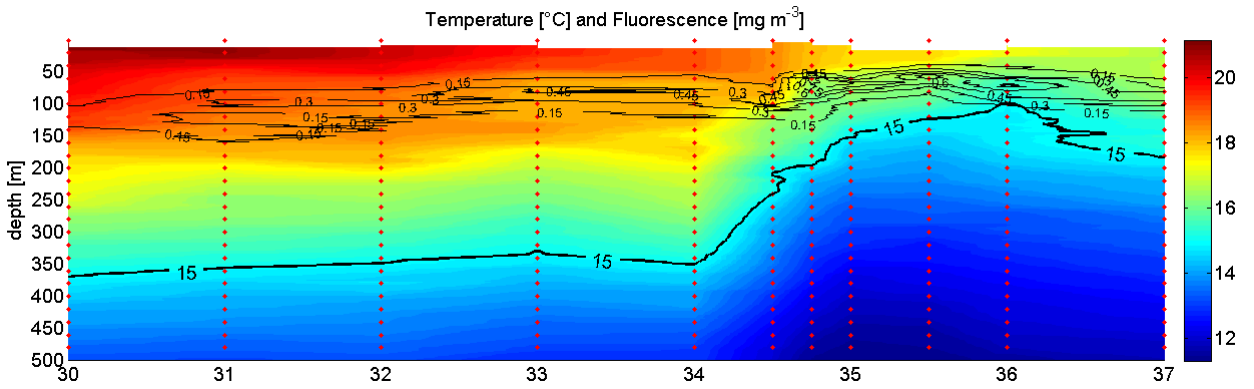
4. Scientific report and first results

4.1 Hydrographic sections (J. Waniek, R. Mars, D. Kaiser, J. Jeschek, IOW)

One of the objectives of the cruise POS470 was to investigate the water column properties along three meridians (23°W, 22°W and 21°W) between 30°N to 37°N in order to localize the Azores Front and to understand the changes in the biogeochemical properties corresponding to the frontal area (Fig. 1). For this purpose, CTD measurements were done at 14 stations every 30 nm along the 22°W. Most of the CTD casts were performed down to the bottom (~5000 m) and at selected depth samples for a number of parameters were taken (Chlorophyll a, suspended particulate matter, nutrients, particulate organic carbon, dissolved organic carbon, raster electron microscopy). Additionally, oxygen and fluorescence data were recorded at all stations.

To detect the Azores Front, in-situ measurements of at least temperature and salinity are necessary because the front does not have any surface indication and therefore cannot be detected via remote sensing. The position of the frontal system is typically defined through the 15°C isotherm upward movement from 300 m to above 200 m depth. Figure 2 shows the vertical temperature in the upper 500 m of the water column along 22°W for POS452 and the upper 300 m for POS470 between 30°N and 37°N, respectively.

a) POS452 Mai 2013



a) POS470 Mai 2014

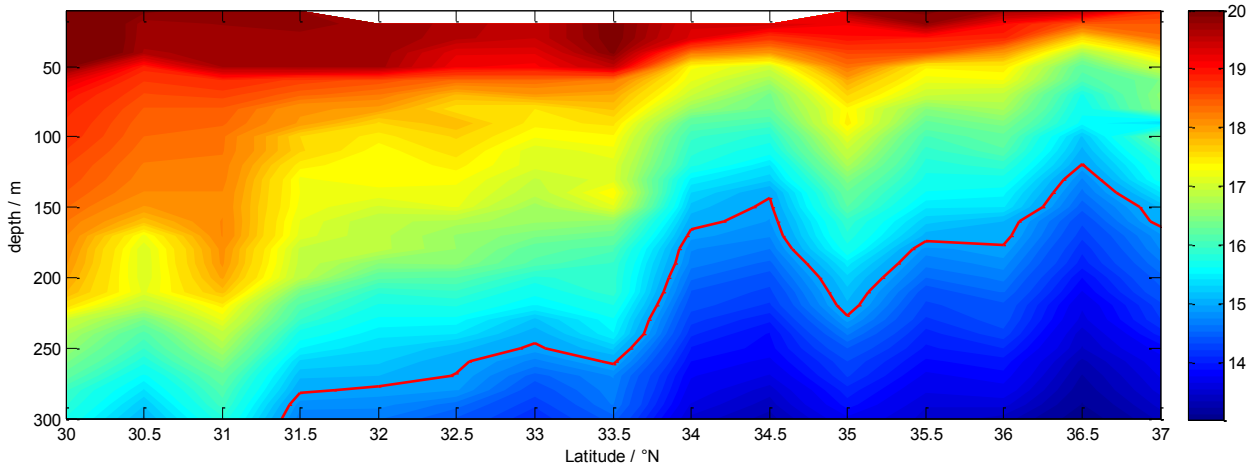


Fig. 2: Vertical temperature distribution in the upper 500 m depth during the POS452 cruise in Mai 2013 (a) with chlorophyll a line overlaid, (b) vertical temperature structure during Mai/June 2014 along 22°W (POS470). The 15°C isotherm is marked black/red in all three graphs.

During POS470 cruise the front look different compared to the previous year, especially to the structure observed in Mai 2013 and September 2013 (not shown). In Mai 2013 (POS452) the front was located between 34.5°N and 35°N, and the isotherms lifted up to 200 m over a distance of roughly 45 nm. Few month later, in September 2013 (POS459) the Azores Front had almost similar structure and unchanged location as well (not shown), however at 35°N the 15° isotherm seems to deepen again. In Mai 2013 the deepening of the isotherm was seen one degree further North at 36°N. In contrast during POS470 the front stretched over remarkably long distance (Fig. 2b) and had different structure. The 15°C isotherm started lifting up initially quite slowly just south of 31.5°N from 300 m to reach 200 m at 34°N before going up and down between 120 m and 180 m almost to the end of the transect at 37°N (Fig. 2b).

Further analyses of the hydrographic section, especially those along 23°N and , 21°N will give insight into the 3-D Structure of the front and together with the results of the laboratory analyses of the collected samples will allow to assess the impact of the frontal system on the particles collected with the deep sea mooring Kiel276.

4.2 Experimental trials with USV *MESSIN* (M. Kurowski, D. Dewitz, URO)

Motivation The superior focus of the experimental trials was collecting oceanographic data at the water surface using an Unmanned Surface Vehicle (USV). Specifically, the aim was to survey a restricted area with the CTD sensor MicroCat Seabird 37-SM to test the vehicle characteristics and measurement capabilities of the USV. Parallel to these tests, a bidirectional communication test between two surface acoustic nodes has been carried out. At the water surface, sea waves create noise which directly affects the acoustic communication. Additionally, surface vehicles create noise itself, mainly with their propulsion. The aim was to determine and to compare these effects, in order to draw conclusions about structural engineering needs during the development phase of USVs used as acoustic nodes.

Method The tests have been performed using the autonomous catamaran *MESSIN* of the Institute of Automation of the University of Rostock. The vehicle provides the ability to install additional equipment easily. In that way the CTD sensor has been installed between the hulls of the catamaran. In order to carry out the acoustic tests, an USBL modem has been installed at the *MESSIN* too. To establish the bidirectional acoustic link, another USBL modem has been installed in the vertical shaft of the R/V Poseidon. The installation of the CTD sensor and the acoustic modem between the hulls of the catamaran *MESSIN* is shown in figure 3.

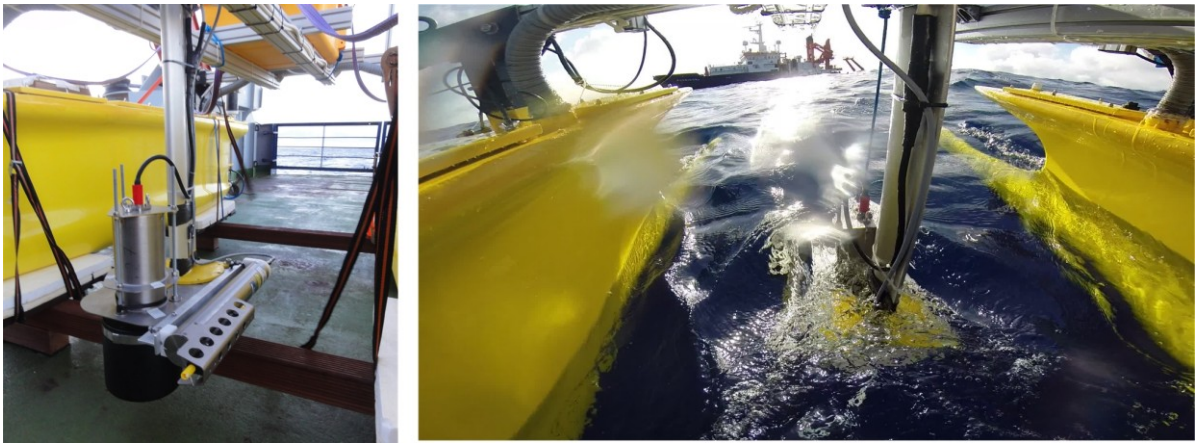


Fig. 3: Installation of the CTD and the USBL modem between the hulls of USV *MESSIN.*

For analyzing and comparing the CTD and acoustic data, the USV MESSIN is equipped with different navigation and motion sensors; see section 5 for more information about the installed equipment.

Experimental trial procedures:

- Launching *MESSIN*, *MESSIN* is maneuvered portside of the R/V Poseidon and kept in a distance of about 50-100 m;
- R/V Poseidon starts to move with 2 kn through water; *MESSIN* runs parallel in about 50-100 m abeam to perform acoustic measurements and recording CTD data; distance covered on 04.06.2014: 1 nm and on 09.06.2014: 2.5 nm;
- R/V Poseidon stops and *MESSIN* performs comparative acoustic measurements with and without active propulsion of the *MESSIN*; acoustic message tests with different packet lengths (8, 32, 64 bytes, varying) with the acoustic modems for the same vehicle constellation; comparative acoustic measurements at higher travel speeds of *MESSIN;* parallel: permanent CTD measurements;
- End of surface to surface communication tests and CTD measurements;
- Recovery of *MESSIN*

First results: The experimental trails using the USV *MESSIN* moving parallel to the R/V Poseidon were carried out successfully. In addition, CTD data were recorded by *MESSIN* in a limited area. Figure 4 shows the position of USV *MESSIN* and R/V Poseidon and corresponding near surface salinity measurements, as an example of the measurement capabilities of the USV.

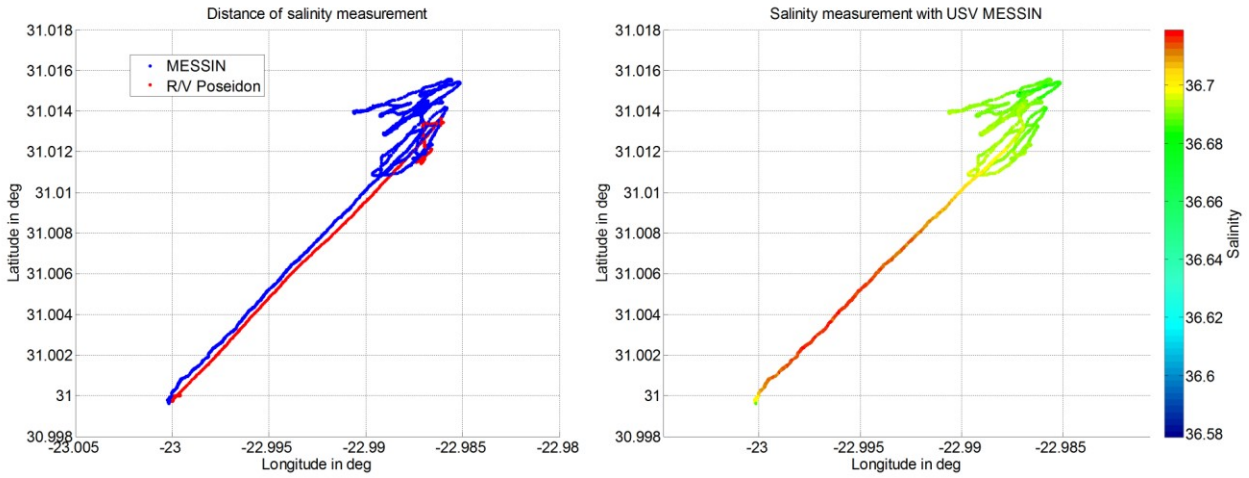


Fig. 4: Position of MESSIN and R/V Poseidon (left) and near surface salinity data (right) at 04.06.2014.

First results concerning the acoustic communications have been determined by the test procedures:

- Experimental tests of the bidirectional data communication from surface (*MESSIN* modem) to surface (R/V Poseidon modem) has been completed successfully;
- Experimental tests of the bidirectional positioning functionality using the USBL acoustic modem from surface (*MESSIN* modem) to surface (R/V Poseidon modem) has been completed successfully;
- The acoustic noise measurements with and without *MESSIN* propulsion have shown that the noise level rises by 10 to 15 dB depending on the propulsion speed;

The acoustic communication data show promising results, despite the low depth of the MESSIN modem and the surface to surface communication. Detailed test results concerning the acoustic communication characteristics can be found in the partial report of KIT (section 4.5).

4.3 Experimental trials with acoustic surface drifter *Emmi* (M. Kurowski, D. Dewitz, URO)

Motivation In order to ensure a reliable communication between the various autonomous underwater and surface vehicles within the SMIS project, the properties and the quality of the deep sea acoustic communication link have to be determined. For this reason, the aim of the experimental trials was the investigation of the positioning characteristics of the acoustic communication link using very low frequency USBL modems (S2C 7/17). The experiments should show which acoustic distance could be reached between a deep sea device and a special autonomous low noise surface device. For this purpose, a surface drifter was used to increase the distance between the deep sea modem and the drifter modem until a communication break is noticed. It was planned to reach an acoustic distance of 6.000 m to 8.000 m. In addition, changes of the acoustic communication quality should be examined in cases where the surface modem is lowered to a depth of at most 29m below the surface buoy.

Method In order to achieve the aims, the low noise acoustic drifter *Emmi* was designed. *Emmi* allows performing widely weather independent acoustic communication tests. In that way, the drifter communicates with a deep sea modem, which is lowered to full depths using the single-conductor cable of the R/V Poseidon. Therefore the deep sea modem has been installed on the *TMS*. Additionally, a USBL S2C 7/17 has been installed in the vertical shaft of the R/V Poseidon

to measure and compare noise differences between *Emmi*, *TMS*, and R/V Poseidon. The involved partners of the acoustic communication trials are shown with figure 5.

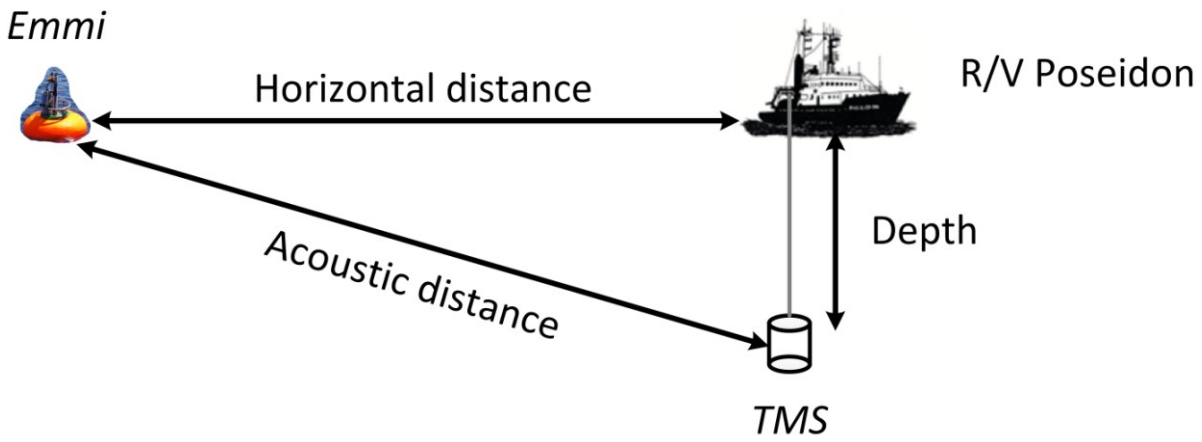


Fig. 5: Communication partners during the acoustic trials.

Emmi itself consists of a surface marker buoy also used as a lifting body and an underwater acoustic part. The lifting body has a weight of about 120 kg, a diameter of 1200 mm, a height of 600 mm, and a buoyancy of about 250 kg. The buoy is equipped with a motion sensor including GPS and WiFi. In addition, a flag, a flashlight and a radio beacon have been installed. The underwater acoustic part consists of an aluminum frame with the acoustic modem (USBL S2C 7/17), and a 2 kWh battery to power the modem and the buoy electronics. The overall dimensions are L750 mm x H500 mm x B500 mm. The total weight is about 77 kg. The mechanical connection between the surface and the underwater devices is realized by different chains and ropes, which may be variably connected. That allows different lengths between the surface and the underwater part, see section 5 for more detailed information.

First results: During the experimental trials, a total of six long distance tests have been done using the acoustic surface drifter *Emmi* in various configurations. The main results can be summarized as follows:

Trial number	***Emmi* configuration**	**Date**	**Wind condition**	***TMS* depth**	**Horizontal distance**	**Calculated acoustic distance**
4	short	05.06.2014	Bft 3-4	4.800 m	7.066 m	8.542 m
5	short with baffle	06.06.2014	Bft 4	5.000 m	7.656 m	9.144 m
6	long with baffle	09.06.2014	Bft 2	5.000 m	8.305 m	9.694 m

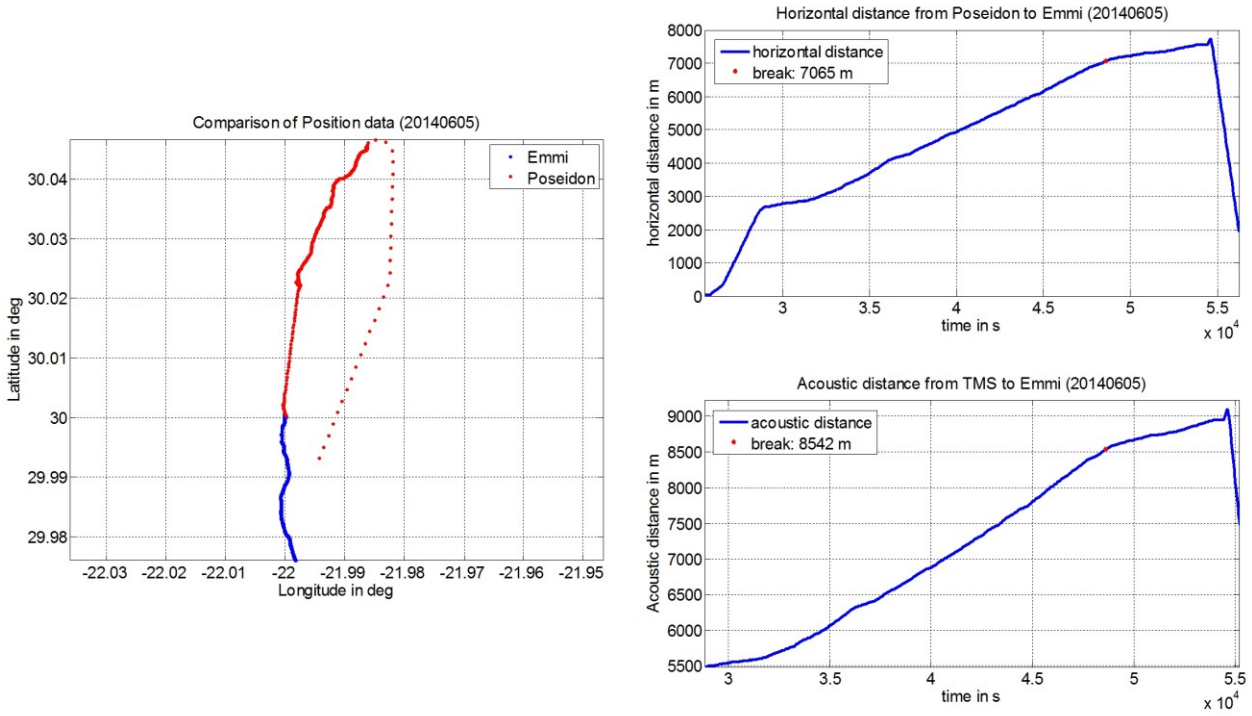


Fig. 6: First results with the acoustic drifter *Emmi* (trial 4).

The final results have exceeded the expectations. One reason is the moderate weather situation with maximum winds around Bft4 during the acoustic trials. On the other hand, the induced background noise due to the drifter itself was on a minimum level. Figure 6 shows the results of the fourth acoustic trial to measure the maximum acoustic communication distance. Detailed test results concerning the acoustic communication characteristics can be found in section 4.5.

4.4 „SMIS" work packages (G. Körner, ENITECH GmbH)

Main aims of the cruise were the tests of the SMIS power supply modules, the testing of the winch drive the deep-sea station, the testing of the acoustic network with range test and testing of the test platform ground station with the help of the testing platform ERNO 2 TMS. Another focus was to test the optical modems in open waters. In order to test the acoustic network, the ERNO 2 TMS was equipped with a USBL modem and controlled and monitored by the DSL communication over the single coax cable. With this arrangement a vehicle near the ground (about 5.000 m depth) was simulated. For the test the platform ground station the ERNO 2 ROV telemetry was integrated into the test platform. The platform was docked to the TMS and

operated at the ERNO 2 TMS over the ROV cable. For this purpose, a new, more powerful ROV cable winch was installed in the TMS and tested (Fig. 7).

Methods

Pressure-tolerant power supply modules: The pressure-tolerant power supply modules were tested on a drifter (from surface to 25 m water depth) and in the test platform *deep-sea station* (up to 5300 m water depth). They consist in each case of the following modules:

- Buffer battery 24 V, 2 kWh, BG 153
- Emergency battery 24 V, 2 kWh, BG 153
- 24 V main and emergency power distribution BG 156 with 5 power switch assemblies
- Optical On-Off Switch BG 157

The power supply modules were used in *Emmi* mainly to supply the acoustic modems during testing of the acoustic network and the range tests. In addition to the acoustic modem additional cared communication modules and a flash light was used on the drifter. In sunlight and strong light reflections in the water the system has been turned off during a range test. As a reason for the malfunction a not properly locked rocker of the on - off switch was determined. As a precaution, the rocker has been enlarged for safe closure of the switch ports for the following tests.

In the test platform *deep-sea station*, the power supply modules have been repeatedly and successfully tested in water depths of around 5.000 m. The complete testing platform was supplied through the pressure-tolerant power supply modules. Main consumer was next to the headlights the pressure-tolerant winch drive in the deep-sea station. In the tests a failure of one of the five power switches was detected after the second dive in about 5.000 m water depth. As an error source an early failure of a DC / DC converter is assumed. The tests were successfully continued without repair.

Winch drive *deep-sea station:* After initial problems with the winch motor assembly as well as a position detection error the winch drive ran reliably. The test was carried out on board with a weight of 150 kg and in water with 75 kg. The winch drive run bad at depths (around 4.000 m). The gear oil cured at 400 bar and 2.5°C water temperature. Test with better performing gear oil was arranged with help of pendulum test (indirect viscosity measurements).

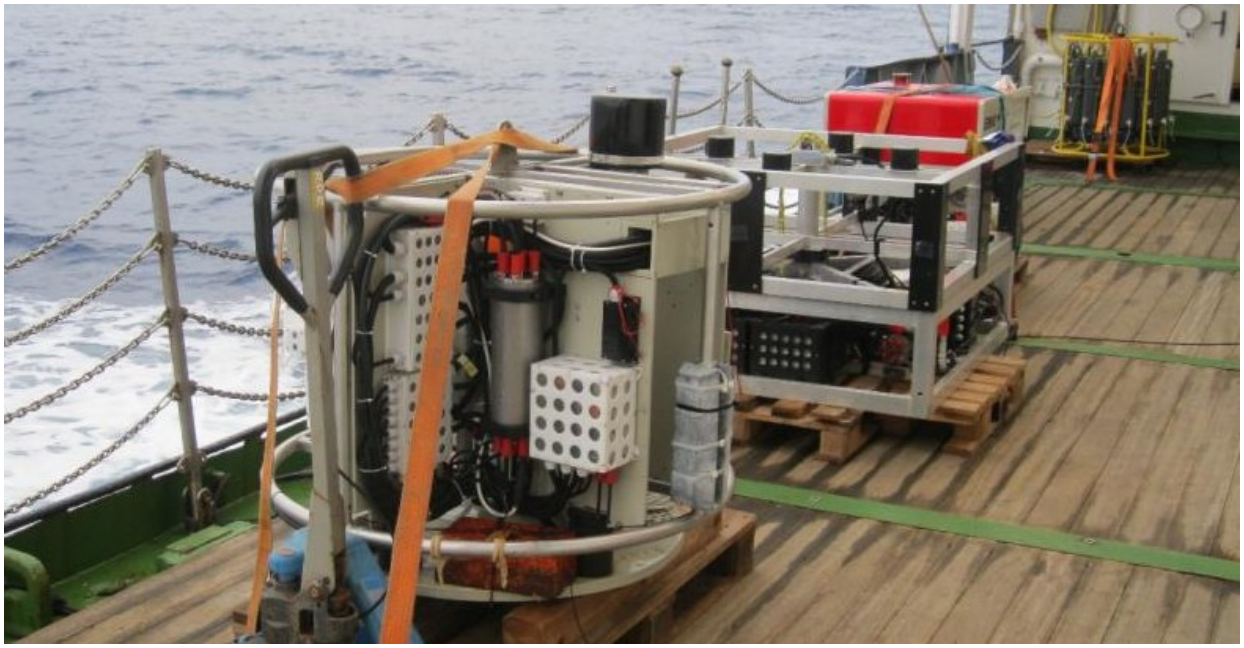


Fig 7: ERNO TMS, ground station ERNO2 ROV on deck.

ERNO 2 TMS, test platform *ground station:* To test the *ground station* a new, more powerful ROV cable winch was installed with gearless torque motor and tested in the ERNO 2 TMS. After the first deep sea dive, the winch was very difficult to move. A ball bearing had set itself evident by the deep-sea burden so that the engine mounting and the water gap had to be readjusted. Furthermore, the winch controller has failed after two dives and had to be repaired. Than in the deep sea, the winch engine worked reliably. In the following tests the winch was driven and without problems decoupled and coupled with a test weight of 30 kg. The maximum tensile force could be detected with a test weight between 45 and 50 kg. In the longer term the winch actuator should be increased (tensile forces up to 75 kg). In addition, the ball bearing must be redesigned to resist to seawater. The telemetry of ERNO 2 ROV's was installed into the testing platform *ground station*. The testing platform *deep-sea station* has been docked and operated on the ERNO 2 TMS over the ROV cable.

Optical modem: With an older optical modem (carrier frequency 1 MHz) range tests were carried out in sea water and compared with previous range test in the Baltic Sea. With a new optical modem (carrier frequency around 5 MHz frequency shift keyed) were carried out new range tests and tests in the deep sea at the CTD probe. Transmitter and receiver were mounted on rods and measured alongside the vessel at defined distances with respect to the reception level. Subsequent measurements were carried out:

- Transmitter and receiver on deck at day sunlight
- Transmitter and receiver on deck at night
- Transmitter and receiver in the water at day
- Transmitter and receiver in the water at night

Fig. 8: Test set-up for optical modem tests.

Pressure-tolerant power supply modules: Despite the failed power switch all tests with the power system in the test platform *ground station* were conducted without repair safely and reliably at depths of around 5000 m. After the repair of the switching port cover at the optical on-off-switch all tests with the drifter were successful. The power supply runs over a long period with high reliability. The charging in both systems was also successful.

Winch drive *deep-sea station:* The necessary tensile forces were safely reached. Suitable gear oil was found to operate the winch safely.

ERNO 2 TMS, test platform *ground station:* By using the ERNO 2 system as a testing platform, the *ground station* was tested safely, controlled and monitored on single conductor cable. 12 deployments were performed with the ERNO 2 TMS for the acoustic network and TUB test platform *ground station.* The unlimited period of use through easy power charging via the single core cable was also of a great benefit.

Optical modem: The measurements in day light and at night brought same results. The measurement results “in water” compared to “in air” were unexpectedly better. The development of optical modems for the deep sea with distances of 100 m and carrier frequencies around 10 MHz in the sea water seems to be feasible and realistic (Fig. 8).

4.5 Acoustic communication and localization (S. Neumann, KIT)

Objectives of cruise: Nowadays the acoustic communication is an important part of every distributed underwater system that spreads over a large area. Especially for mobile multi robot systems like the SMIS project there is no alternative to acoustic in order to communicate over long distances. The experiments described in this section try to identify certain aspects of acoustic communication and the surrounding environmental conditions in the middle Atlantic Ocean. Furthermore the acoustic localization technology called Ultra Short Baseline (USBL) will be investigated. All experiments in this section used the S2CR 7/17 USBL modem from Evologics GmbH for communication, localization and acoustic noise measurements. Goals of the experiments are:

- range test of acoustic communication
- package error rate in different conditions
- observation of communication quality in different conditions
- test of acoustic multi-hop communication with SUNSET
- range test of acoustic localization
- empirical analysis of acoustic localization precision
- acoustic noise analysis of the communication conditions in the open ocean

Methods: In order to conduct the experiments, the acoustic USBL modems where mounted on four different vehicles and test apparatus. The first modem was mounted to a plate that could be lowered beneath the research vessels (RV) bow. Another one was attached to a tethered management system (TMS) from Enitech GmbH. TMS can be connected to the research vessel via a single conductor cable on a winch and this way it can be lowered to the sea bottom. A third modem was mounted beneath a drifter buoy (Emmi) or the unmanned surface vehicle MESSIN, both from University of Rostock. Three different setups were chosen for experiments:

1) *RV + TMS:* This configuration was used to observe a point-to-point communication from the surface to slow moving or static underwater devices like ROVs, AUVs or seabed stations. Thereby the TMS was lowered to a depth of approximately 5000 meters where communication parameters can change according to temperature, salinity, pressure as well as noise sources like the research vessels propulsion or waves.

2) *RV + MESSIN:* As another point-to-point setup, the unmanned surface vehicle was utilizes for communication tests of surface to surface scenarios. The acoustic channel here is characterized by reflections of the acoustic signal at the surface and higher noise which is induced by waves. Also the noise effect of Messins propulsion was measured.

3) *RV + TMS + DRIFFTER:* For long range tests the drifter was launched in combination with TMS. As the drifter got carried away by ocean streams, TMS was lowered to the sea bottom. While the drifter was constantly moving away from RV and TMS, communication among all three modems was tested. At a certain distance between RV and drifter a direct communication was not possible anymore. However TMS could communicate to the drifter due to better channel properties in the depth. In this case a multi-hop communication between RV and drifter was tested with TMS as intermediate node.

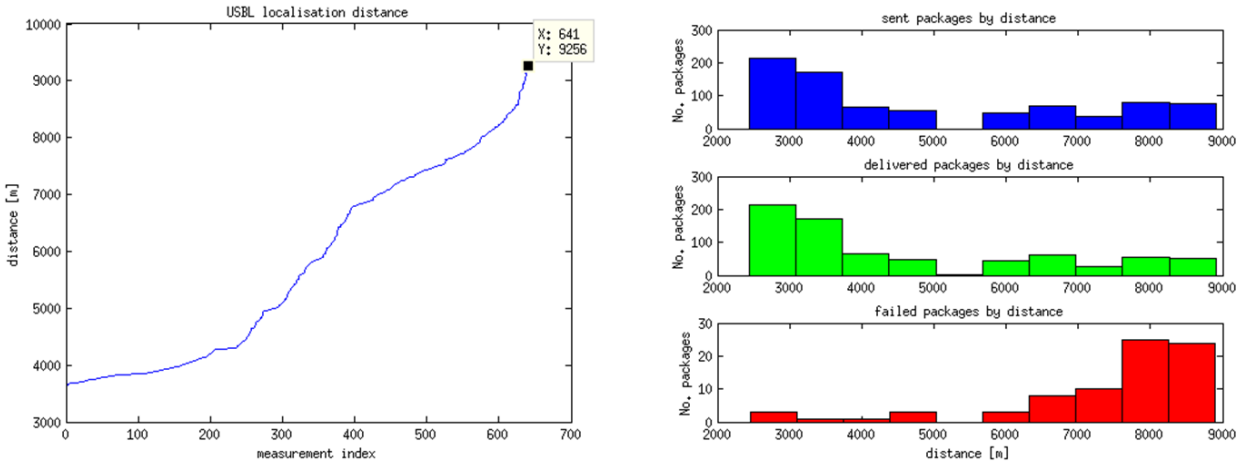


Fig. 9: USBL localization distance (left) and communication package statistics by distance (right).

First results: Multiple long range experiments were conducted to find out the communication range of the USBL modems. Under good weather conditions (very light swell, wind speed 2 at the Beaufort scale) communication between TMS at 5000 m depth and the drifter on the surface was still possible at a slant range of over 10 km. Although a total communication breakdown could not be observed, more packages got lost with a higher distance (see fig. 9).

The received signal strength indicator (RSSI) and the signals integrity level in figure 10 show how the signal quality decreases with higher distances and depths.

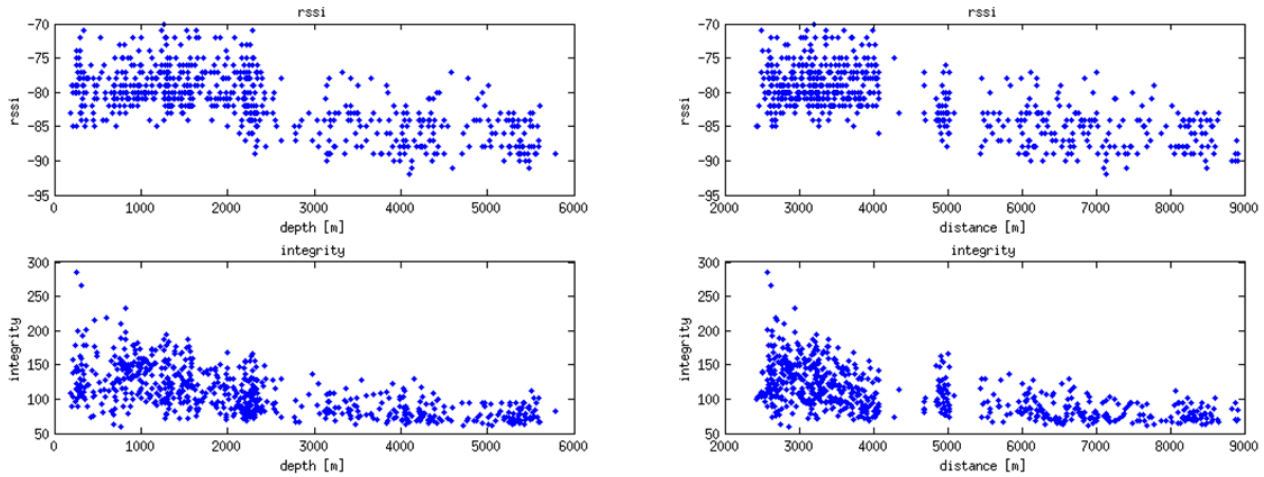


Fig. 10: Signal strength and integrity level for different depths and distances

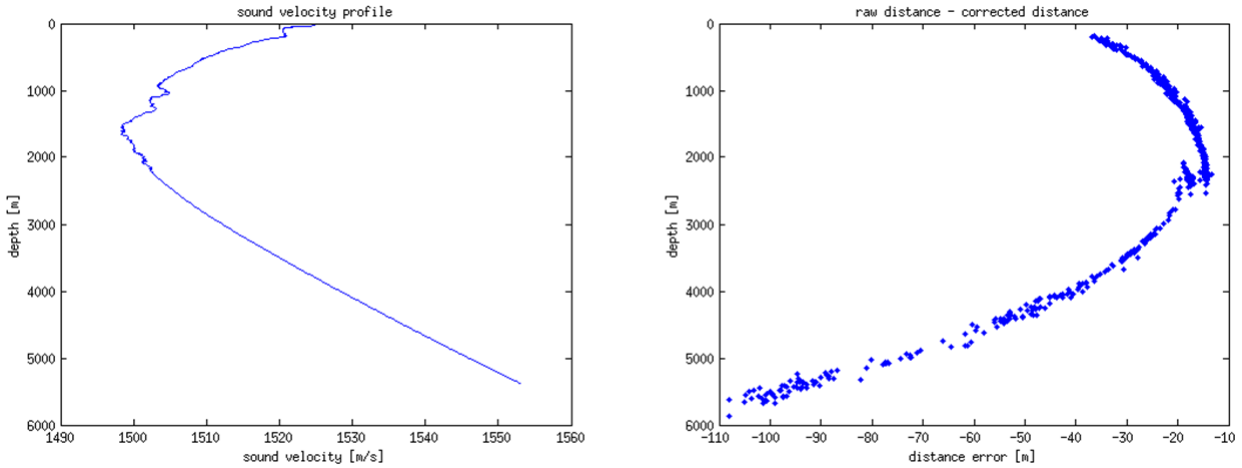


Fig. 11: sound velocity profile recorded with a CTD (left) and distance error of USBL localization by assuming a constant sound velocity.

Localization was observed until a maximal distance of around 9250 m slant range where this denotes the raw measurement value. The USBL device calculates the distance by time of arrival of the sound signal. While the device assumes a constant sound velocity of 1500 m/s in reality the sound velocity is a function of water density which changes with the depth. This introduces an error in the measurement that can be corrected if one knows the sound velocity over depth and the depths of sender and receiver. Figure 11 shows a sound velocity profile and the error that is produced by assuming a constant sound velocity.

Acoustic noise can corrupt communication and localization. While the subsea is very quiet, at the surface there is a lot of acoustic noise pollution induced by waves and also the research vessel (see fig. 12 left). Also relatively small propellers like the ones at the surface vehicle Messin can have a big impact on acoustic communication which is seen in figure 12.

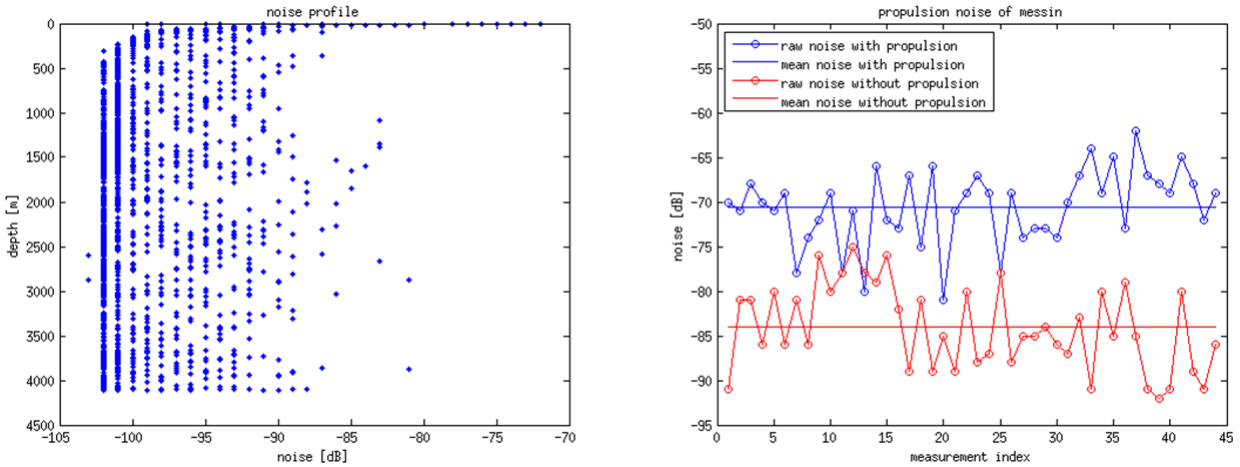


Fig. 12: Noise profile recorded with TMS (left) and noise measurement of MESSINS with propellers turned on and off

This information can be taken into consideration when designing a surface vehicle which main purpose is to establish an acoustic communication to underwater vehicles, like the one in the SMIS project.

4.5. TUB test carrier - VT (M. Golz, TU Berlin)

The test arrangement consist of the tether management system (TMS) from Enitech GmbH, which provides the data link via the umbilical from the ship to the topside unit on deck, and the test carrier (VT) of the Technical University of Berlin (see Fig. 15). The application of a compact test carrier was necessary due to the limited deck opening and limited winch capacity of RV Poseidon. The VT is equipped with the following sensors and devices:

- Xsense AHRS (heading, roll, pitch, acceleration, velocity)
- TUB in-house developed gyro and compass (heading, roll, pitch, acceleration, velocity)
- Keller pressure transmitter (water pressure, temperature)
- Benthos altimeter (altitude measurements)
- 3 video cameras, 4 LED-lights (visualization of the trials)
- AXIS video grabber (video encoder – to Ethernet)
- MOXA serial adapter (serial to Ethernet)
- magnetic coupling device for ballast weight (supports the ballast weight fixture)
- VT-winch with planetary gear and motor (lifting ballast weight for landing procedure)

The trials are used to determine the pressure resistance and the adequate functionality of the equipment and sensors during deep-sea operations, below 5000 m depth. All tests are performed to utilize the gathered information for the prospected prototype of a seabed station. Especially the behavior of the deep-sea VT-winch, the syntactic foam and the landing procedure should be investigated. In order to fulfill the set goals, the following test campaigns were conducted:

1. Trial (30.05.2014, UTC 13:06, 36°30.03'N | 22°00.09'W, 1500 m)

This was the first deep-sea dive of the coupled system VT-TMS. Experiences should be gained for the handling on deck, launch and recovery procedure and the operational functionality of the system. Despite some network problems due to interfering firewall settings, the trial could be executed without any system failure. The handling on deck and the launch procedure turned out to be feasible. All components worked without problems down to 1500 m depth. During the recovery procedure, connection losses were noticed which effected the ballast weight holding function. For that reason the recovery of the VT was affected by one to two meters long hanging ballast weight.

Some mechanically improvements of the VT-winch were implemented to ensure a safe recovery procedure for the upcoming second deep-sea trial.

2. Trial (06.06.2014, UTC 07:39, 31°00.00'N | 23°00.00'W, 5300 m)

All network troubles could be fixed. This trial offered the possibility to bring the system to full ocean depth. Again, the functionality of all mechanical and electrical systems was tested under the harsh conditions of the deep-sea. All systems worked down to 3000 m depth. With the increasing pressure and sinking water temperature the gearbox oil of the VT-winch got more and more viscous which has led to a jammed winch. Furthermore, water penetration caused a short circuit in the electric motor from Enitech. Nevertheless all other components have functioned as requested down to 5300 m depth. Only the altimeter doesn't provide an accurate measurement of altitude/range data.

This time the launch and recovery of the system worked without any problems.

During the recovery process of the VT-TMS an external damage of the umbilical was detected. The crew of RV Poseidon suspected a twisted wire, caused by the large volume and big cross sectional area of the syntactic foam in combination with the ocean currents. Consequently the buoyancy blocks needed to be removed from the VT structure. Thus, the landing procedure could not be realised in further trials.

The electric motor has been repaired and a gearbox oil change was applied.

3. Trial (10.06.2014, UTC 08:14, 34°02.50'N | 22°50.19'W, 2000 m)

Despite the absent buoyancy, another sea trial was necessary to determine a reliable functionality of the VT-winch in the deep-sea. Unfortunately a total failure occurred at 2000 m depth. For that reason the trial was terminated. Diagnostics: failure of a power circuit breaker inside the Enitech main distribution board.

4. Trial (11.06.2014, UTC 08:28, 35°29.99'N | 23°00.01'W, 4250 m)

At this time the VT-TMS system was ideally prepared for a final deep-sea test. All components worked without any issues. With the new gearbox oil the winch lifted the ballast weight of 72 kg in every water depth without significant influence of the water pressure or temperature. The magnetic coupling device operated reliable, as before. At UTC 10:30, touchdown of the ballast weight in 4250 m depth (see Fig. 15). Under these circumstances, the landing maneuver could have been realized if the buoyancy blocks were mounted.

Reason for the twisted umbilical Figure 14 shows the comparison of the twist behavior between the VT with and without the mounted syntactic foam. The red dotted boxes indicate stages were the VT-TMS system was not lowered or hauled by the ship winch, also visible by the constant pressure values. In this situation the VT-TMS system tends to rotate, what can be seen by the magnitude of the heading angle. An even severe behavior can be observed during the approach of the seabed (red lined boxes), which was carried out at very low ship-winch speed (0.1 – 0.2 m/s). The VT-TMS system turns around its own axis several times. During the hauling out (blue lined boxes) it turns to the other side. The initial twist occurs in the deep-sea environment where practically no significant currents are present (approx. 0 - 0.1 m/s). Accordingly, an excitation from underwater currents is highly unlikely.

Interesting: In both cases the VT-TMS system turns exactly 9 times in the same direction at a very long umbilical and turns the same amount of rotations back before surfacing. Thus it can be assumed that the VT-TMS system (no matter if with or without syntactic foam) does not cause the rotation. Probably internal stresses of the umbilical cause the twist.

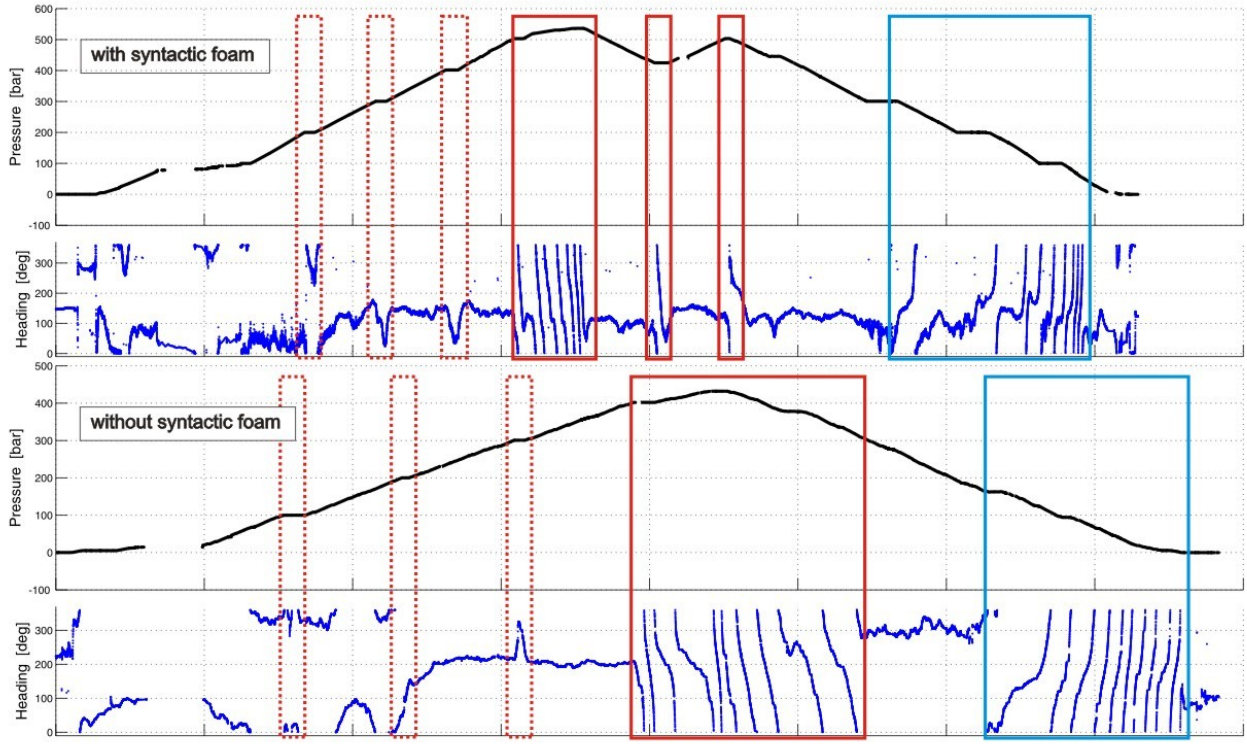


Fig. 14: Comparison of the twist behavior between VT w/ and w/o syntactic foam. Top: trial from 06.06.2014 (5300 m), bottom: trial from 11.06.2014 (4250 m)

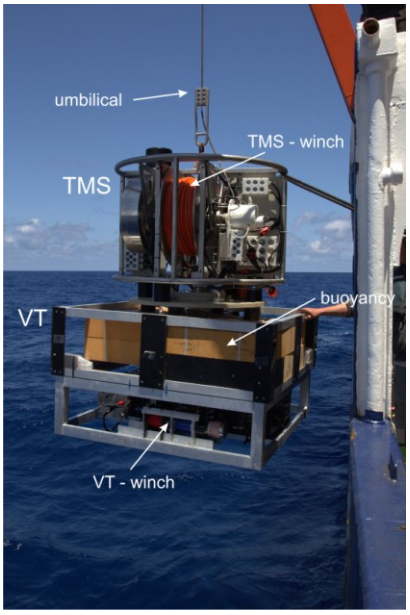


Fig. 15: Test arrangement of the TU Berlin.

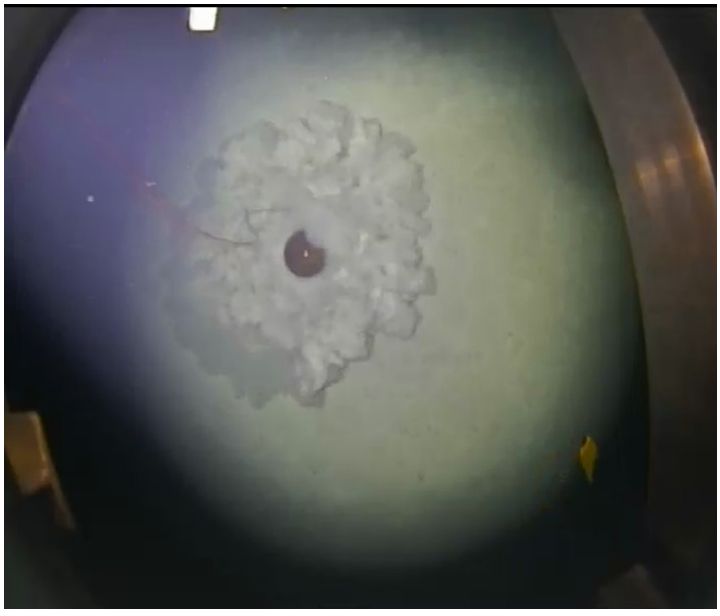


Fig. 161: Touch down on the seabed in 4250 m depth.

Conclusion A lot of new experience could be gained from the expedition P470. Starting from a better positioning of screws and ending with suitable gearbox oil. Furthermore a working deep-sea winch with magnetic coupling device, water proof junction boxes for the electronic connections and reliable data acquisition software could be proven in the deep-sea environment.

Unfortunately the landing maneuver couldn't be realized due to the restrictions on the ship side. These tests need to be investigated within an upcoming expedition.

5. Scientific equipment, moorings and instruments

5.1. CTD/ Water Sampling (J. Waniek, R. Mars, D. Kaiser, J. Jeschek, IOW)

During the cruise a CTD system composed of SBE9plus and a 14 Hydrobios free flow bottles of 5L each was used. The CTD had additionally a second temperature sensor and sensors for dissolved oxygen, turbidity and chlorophyll a as well mounted and an altimeter devise to detect the bottom. Almost all cast were carried out over the full water depth. After initial problems with some of the connecting cables, the entire system runs smoothly. In total 41 CTD profiles of 5000m or more were obtained during the cruise.

5.2. USV *MESSIN* (M. Kurowski, D. Dewitz, URO)

MESSIN Pilot card:

- Length: 3.3 m; breadth: 1.8 m; displacement: 350 kg; maximum payload: 100 kg (with additional buoyancy 200 kg); max. speed: 4kn; operational duration (battery): 6-8 h

MESSIN payload installations:

- PNI SeaTrax Magnetometer, Crossbow AHRS440-200, Septentrio AsteRx3 DGNSS, Airmar WX100 Weather Station; EvoLogics S2C7/17 USBL Modem and Seabird MicroCat 37-SM.

5.3. Acoustic surface drifter *Emmi* (M. Kurowski, D. Dewitz, URO)

As already mentioned, the mechanical connection between the surface lifting body and the underwater acoustic device is variable and consists of various chains and ropes, which can be variably connected. Because of the variable structure, different spacing configurations can be realized (Fig. 17).

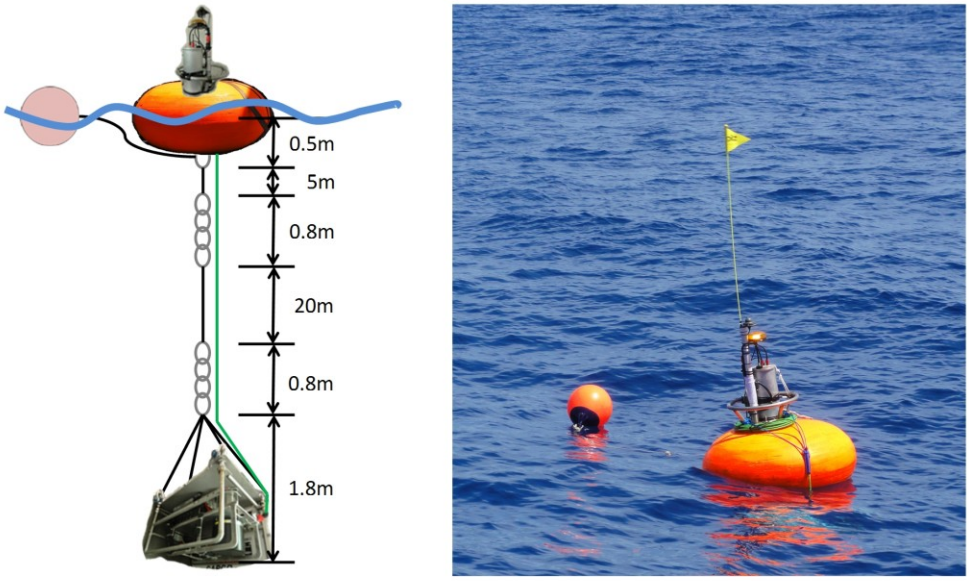


Fig. 17: Experimental set-up of the acoustic drifter *Emmi*.

The following configurations are provided (not exclusively).

Configuration	**Elements**	**Length (o.a.)**
short	Buoy, connection ropes and acoustic part	2.3 m
middle	Buoy, 5 m rope, connection ropes and acoustic part	7.3 m
long	Buoy, 5 m rope, 20 m rope, connection ropes and acoustic part	27.3 m
long_C	Buoy, 5 m rope, chain, 20 m rope, chain, connection ropes and acoustic part	28.9 m

The electrical connection between the two parts is realized with a hybrid cable with integrated power supply and Ethernet. Figure 18 shows the individual components of the one part and on the other hand the connection cable and the cable between the two elements.

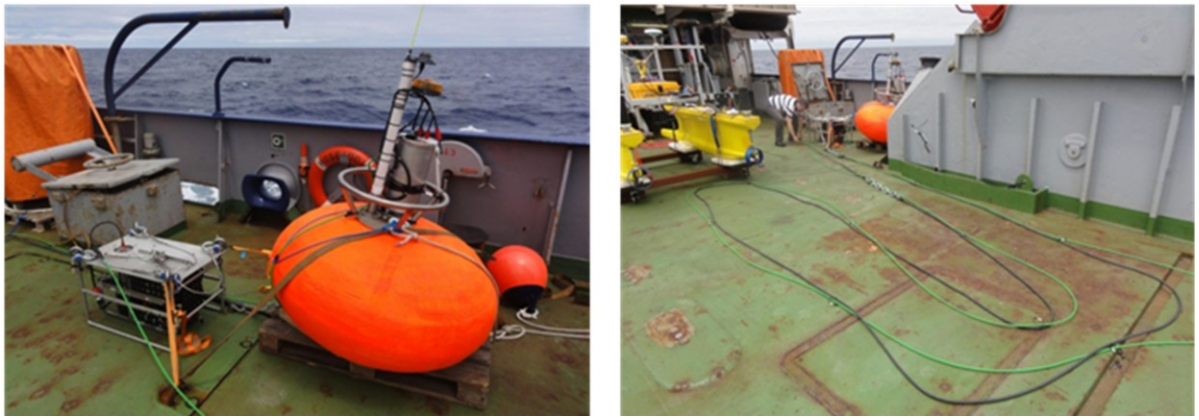


Fig. 18: Buoy with electronics and acoustic part (left), connection cable and rope (right).

6. Acknowledgements

We thank Captain Klaus Ricke and the crew of R/V Poseidon for their support and help during this cruise.

7. Appendices

Appendix A: List of stations

Cruise/Station	Date	Time UTC	Latitude	Longitude	Water depth m	Wind. m/s	Corse degree	Speed kn	Action
POS470/608-1	28.05.14	07:04	36° 40,24' N	16° 13,90' W	4276,3	NNW 7	322,6	1,1	Acoustic Modem zu Wasser im Lotschacht
POS470/608-2	28.05.14	07:46	36° 41,04' N	16° 14,13' W	4176,4	N 7	4,5	0,4	ERNO ROV / TMS zu Wasser
POS470/608-3	28.05.14	10:04	36° 41,04' N	16° 14,07' W	4181,2	N 6	151,0	0,5	Drifter TD zu Wasser
POS470/608-2	28.05.14	11:44	36° 41,03' N	16° 14,07' W	4182,0	N 7	142,0	0,6	ERNO ROV / TMS an Deck max=3800m
POS470/608-1	28.05.14	11:46	36° 41,03' N	16° 14,07' W	4184,3	N 6	333,0	0,4	Acoustic Modem AM an Deck
POS470/608-3	28.05.14	12:20	36° 40,30' N	16° 13,88' W	4234,2	NNW 7	186,4	0,8	Drifter TD an Deck
POS470/608-5	28.05.14	12:27	36° 40,28' N	16° 13,99' W	4238,0	NNW 8	263,8	0,5	CTD/rosette water sampler
POS470/608-5	28.05.14	12:44	36° 40,26' N	16° 14,02' W	4256,2	NNW 8	130,8	0,3	CTD/rosette water sample, auf Tiefe
POS470/608-5	28.05.14	12:46	36° 40,27' N	16° 14,02' W	4239,4	NNW 7	358,5	0,9	CTD/rosette water sampler, an Deck
POS470/609-1	29.05.14	07:08	36° 52,93' N	19° 17,46' W	5000,6	N 3	335,4	1,0	Acoustic Modem zu Wasser im Lotschacht
POS470/609-2	29.05.14	07:30	36° 53,02' N	19° 17,45' W	4999,9	NW 3	232,4	0,5	Remote operated vehicle ROV zu Wasser
POS470/609-2	29.05.14	07:42	36° 53,03' N	19° 17,44' W	4999,6	WNW 4	59,5	0,5	Remote operated vehicle ROV an Deck
POS470/609-3	29.05.14	08:07	36° 53,03' N	19° 17,45' W	4999,6	NW 4	50,7	0,4	ERNO ROV / TMS zu Wasser
POS470/609-3	29.05.14	08:16	36° 53,04' N	19° 17,45' W	4999,7	WNW 3	27,5	0,4	ERNO ROV / TMS an Deck max= 50 m
POS470/609-4	29.05.14	08:29	36° 53,03' N	19° 17,45' W	4999,3	NW 4	207,9	0,6	ERNO ROV / TMS zu Wasser, Test SL 50 m
POS470/609-4	29.05.14	08:34	36° 53,02' N	19° 17,45' W	5001,6	NW 3	243,3	0,3	ERNO ROV / TMS an Deck
POS470/609-5	29.05.14	08:54	36° 53,03' N	19° 17,43' W	4999,5	WNW 3	53,3	0,4	ERNO ROV / TMS zu Wasser
POS470/609-6	29.05.14	10:45	36° 53,03' N	19° 17,42' W	5000,2	NW 4	75,9	0,4	Drifter TD zu Wasser
POS470/609-1	29.05.14	13:02	36° 52,89' N	19° 17,42' W	5000,0	NW 4	161,7	0,3	Acoustic Modem AM an Deck
POS470/609-5	29.05.14	14:12	36° 52,90' N	19° 17,41' W	5000,0	WNW 4	84,8	0,6	ERNO ROV / TMS an Deck SL max 5048m
POS470/609-6	29.05.14	15:00	36° 53,45' N	19° 14,02' W	5000,0	WNW 5	104,5	0,8	Drifter TD an Deck
POS470/610-1	30.05.14	06:02	36° 59,99' N	22° 0,01' W	4080,1	N 4	45,0	0,6	CTD/rosette water sampler zu Wasser
POS470/610-1	30.05.14	07:20	37° 0,00' N	22° 0,00' W	4080,0	N 5	340,6	0,5	CTD/rosette water sampler auf Tiefe. 3900m
POS470/610-1	30.05.14	08:47	37° 0,00' N	22° 0,00' W	4110,2	N 6	158,8	0,3	CTD/rosette water sampler an Deck
POS470/611-1	30.05.14	12:45	36° 30,01' N	22° 0,00' W	4029,8	NE 6	314,6	0,4	Acoustic Modem AM zu Wasser
POS470/611-2	30.05.14	13:06	36° 30,03' N	22° 0,09' W	4027,7	NE 6	310,2	1,0	Bottom Unit BU / TMS zu Wasser
POS470/611-2	30.05.14	15:34	36° 30,04' N	22° 0,27' W	4019,2	NNE 6	308,3	1,1	Bottom Unit BU / TMS an Deck, 1500m

Cruise/Station	Date	Time UTC	Latitude	Longitude	Water depth m	Wind. m/s	Corse degree	Speed kn	Action
POS470/611-1	30.05.14	15:43	36° 30,15' N	22° 0,42' W	4013,8	NNE 6	311,8	1,1	Acoustic Modem an Deck
POS470/611-3	30.05.14	15:59	36° 30,00' N	22° 0,02' W	4031,2	NNE 6	79,0	0,8	CTD/rosette water sampler zu Wasser
POS470/611-3	30.05.14	17:24	36° 29,99' N	21° 59,99' W	4031,8	NNE 6	149,2	0,2	CTD/rosette water sampler auf Tiefe , 4087m
POS470/611-3	30.05.14	18:51	36° 30,00' N	22° 0,00' W	4030,3	NNE 6	56,4	0,3	CTD/rosette water sampler Deck
POS470/612-1	30.05.14	23:11	35° 59,99' N	21° 59,99' W	4213,5	NE 9	197,0	0,6	CTD/rosette water sampler zu Wasser
POS470/612-1	31.05.14	00:34	36° 0,01' N	22° 0,00' W	4210,5	NE 9	242,2	0,6	CTD/rosette water sampler auf Tiefe, 4274m
POS470/612-1	31.05.14	01:59	36° 0,00' N	22° 0,00' W	4211,1	NE 8	204,2	0,8	CTD/rosette water sampler an Deck
POS470/613-1	31.05.14	06:08	35° 30,01' N	22° 0,02' W	4937,0	NNE 9	183,5	0,4	Acoustic Modem zu Wasser im Lotschacht
POS470/613-2	31.05.14	07:45	35° 30,07' N	21° 59,92' W	4940,4	ENE 8	348,8	0,8	Drifter zu Wasser
POS470/613-3	31.05.14	07:52	35° 30,23' N	21° 59,99' W	4969,9	NE 9	34,7	0,6	Bottom Unit BU / TMS zu Wasser
POS470/613-3	31.05.14	12:47	35° 32,06' N	21° 57,49' W	4969,1	NE 8	26,2	0,7	Bottom Unit BU / TMS an Deck, 4800m
POS470/613-1	31.05.14	13:30	35° 31,72' N	22° 0,02' W	4955,6	NE 9	286,7	1,8	Acoustic Modem an Deck
POS470/613-2	31.05.14	13:52	35° 32,08' N	22° 1,15' W	4933,7	ENE 8	314,5	1,3	Drifter an Deck
POS470/613-4	31.05.14	14:23	35° 32,19' N	22° 1,20' W	4934,0	NE 6	83,9	0,7	CTD/rosette water sampler zu Wasser
POS470/613-4	31.05.14	15:53	35° 32,23' N	22° 1,15' W	4934,5	NE 8	15,1	0,5	CTD/rosette water sampler auf Tiefe, 5018m
POS470/613-4	31.05.14	17:39	35° 32,20' N	22° 0,97' W	4936,1	NE 6	133,2	0,5	CTD/rosette water sampler an Deck
POS470/614-1	31.05.14	21:39	35° 0,02' N	22° 0,00' W	5013,4	NNE 8	317,4	0,7	CTD/rosette water sampler zu Wasser
POS470/614-1	31.05.14	23:19	35° 0,00' N	22° 0,04' W	5013,3	NNE 9	12,5	0,3	CTD/rosette water sampler auf Tiefe, 5105m
POS470/614-1	01.06.14	01:06	35° 0,01' N	22° 0,02' W	5013,7	NNE 10	82,1	0,5	CTD/rosette water sampler an Deck
POS470/615-1	01.06.14	05:00	34° 29,99' N	22° 0,03' W	5157,7	NE 9	76,8	1,0	CTD/rosette water sampler zu Wasser
POS470/615-1	01.06.14	06:43	34° 30,01' N	21° 59,99' W	5165,8	NE 10	245,8	0,9	CTD/rosette water sampler auf Tiefe, 5263m
POS470/615-1	01.06.14	08:28	34° 30,01' N	22° 0,01' W	0,0	ENE 10	51,9	0,5	CTD/rosette water sampler an Deck
POS470/616-1	01.06.14	12:22	33° 59,98' N	21° 59,91' W	5290,4	NE 11	228,6	0,9	CTD/rosette water sampler zu Wasser
POS470/616-1	01.06.14	14:00	34° 0,01' N	22° 0,03' W	5294,7	NE 11	241,9	0,4	CTD/rosette water sampler auf Tiefe, 5384 m
POS470/616-1	01.06.14	15:34	34° 0,03' N	22° 0,01' W	5299,9	ENE 10	45,9	0,6	CTD/rosette water sampler an Deck
POS470/617-1	01.06.14	19:59	33° 30,00' N	22° 0,01' W	5276,7	NE 10	209,8	0,4	CTD/rosette water sampler zu Wasser
POS470/617-1	01.06.14	21:48	33° 30,02' N	22° 0,00' W	5275,5	NE 12	157,1	0,6	CTD/rosette water sampler auf Tiefe, 5373,0
POS470/617-1	01.06.14	23:24	33° 30,00' N	22° 0,01' W	5301,2	NE 13	252,9	0,8	CTD/rosette water sampler an Deck
POS470/618-1	02.06.14	07:47	32° 30,00' N	22° 0,02' W	5171,6	ENE 10	16,5	1,1	Acoustic Modem zu Wasser

Cruise/Station	Date	Time UTC	Latitude	Longitude	Water depth m	Wind. m/s	Corse degree	Speed kn	Action
POS470/618-2	02.06.14	07:55	32° 30,00' N	22° 0,01' W	5172,3	NE 10	286,0	0,5	Thether Management System Messbeginn
POS470/618-2	02.06.14	11:40	32° 30,01' N	22° 0,02' W	5136,6	ENE 11	321,3	0,8	Thether Management System TMS, 5000 m
POS470/618-3	02.06.14	11:58	32° 30,00' N	22° 0,02' W	5155,5	ENE 11	274,3	0,8	CTD/rosette water sampler zu Wasser
POS470/618-3	02.06.14	13:26	32° 29,98' N	21° 59,99' W	5170,7	NE 10	130,3	0,4	CTD/rosette water sampler auf Tiefe, 5265m
POS470/618-1	02.06.14	14:53	32° 30,00' N	22° 0,02' W	5172,7	ENE 9	216,2	1,0	Acoustic Modem an Deck
POS470/618-3	02.06.14	14:59	32° 30,00' N	22° 0,01' W	5197,8	ENE 10	57,9	0,9	CTD/rosette water sampler an Deck
POS470/619-1	02.06.14	19:02	31° 59,99' N	21° 59,99' W	5053,4	ENE 11	259,3	0,5	CTD/rosette water sampler zu Wasser
POS470/619-1	02.06.14	20:36	32° 0,00' N	21° 59,98' W	5052,9	ENE 9	72,1	0,8	CTD/rosette water sampler auf Tiefe,5074m
POS470/619-1	02.06.14	22:05	32° 0,00' N	21° 59,99' W	5076,1	ENE 12	326,9	0,4	CTD/rosette water sampler an Deck
POS470/620-1	03.06.14	07:10	31° 0,03' N	22° 0,02' W	5008,4	NE 8	119,0	0,9	CTD/rosette water sampler zu Wasser
POS470/620-1	03.06.14	08:46	31° 0,02' N	22° 0,02' W	5033,5	ENE 10	78,7	0,5	CTD/rosette water sampler auf Tiefe, 5100m
POS470/620-1	03.06.14	10:15	31° 0,00' N	22° 0,00' W	5008,7	ENE 9	300,1	0,8	CTD/rosette water sampler an Deck
POS470/621-1	03.06.14	14:52	31° 30,00' N	22° 0,03' W	5035,8	ENE 8	9,3	0,9	CTD/rosette water sampler zu Wasser
POS470/621-1	03.06.14	16:24	31° 29,99' N	22° 0,00' W	5042,4	NE 9	210,6	0,6	CTD/rosette water sampler auf Tiefe, 5130m
POS470/621-1	03.06.14	17:57	31° 30,01' N	21° 59,99' W	5039,7	NE 8	59,1	0,3	CTD/rosette water sampler an Deck
POS470/622-1	04.06.14	03:00	30° 59,98' N	22° 59,96' W	5204,3	ENE 8	321,3	0,5	CTD/rosette water sampler zu Wasser
POS470/622-1	04.06.14	04:36	31° 0,00' N	23° 0,00' W	5203,4	NE 6	25,0	0,6	CTD/rosette water sampler auf Tiefe, 5284m
POS470/622-1	04.06.14	06:10	31° 0,00' N	23° 0,00' W	5223,7	NNE 9	174,8	0,5	CTD/rosette water sampler an Deck
POS470/622-2	04.06.14	07:15	31° 0,01' N	23° 0,01' W	5208,5	ENE 7	326,4	0,5	Acoustic Modem zu Wasser im Lotschacht
POS470/622-3	04.06.14	07:41	30° 59,98' N	23° 0,00' W	5207,0	NE 7	87,2	0,6	MESSIN zu Wasser
POS470/622-3	04.06.14	09:59	31° 0,72' N	22° 59,20' W	5214,0	NE 6	24,5	0,4	MESSIN an Deck
POS470/622-2	04.06.14	10:14	31° 0,74' N	22° 59,19' W	5204,7	NE 5	217,6	0,6	Acoustic Modem an Deck
POS470/623-1	04.06.14	17:39	30° 29,97' N	22° 0,02' W	5003,6	NE 7	70,9	0,7	CTD/rosette water sampler zu Wasser
POS470/623-1	04.06.14	19:15	30° 30,01' N	21° 59,98' W	4998,7	NE 7	205,7	0,4	CTD/rosette water sampler auf Tiefe, 5091 m
POS470/623-1	04.06.14	20:50	30° 30,01' N	22° 0,00' W	4997,2	NNE 6	201,9	0,5	CTD/rosette water sampler an Deck
POS470/624-1	05.06.14	02:03	30° 0,01' N	22° 0,01' W	4994,3	NNE 6	308,4	0,4	CTD/rosette water sampler zu Wasser
POS470/624-1	05.06.14	03:28	30° 0,01' N	22° 0,03' W	4993,6	NE 6	251,0	0,3	CTD/rosette water sampler auf Tiefe, 5085m
POS470/624-1	05.06.14	04:48	30° 0,02' N	21° 59,98' W	4995,4	NNE 3	211,0	0,4	CTD/rosette water sampler an Deck
POS470/624-2	05.06.14	07:11	30° 0,06' N	22° 0,01' W	5011,3	N 5	342,7	0,5	Drifter zu Wasser

Cruise/Station	Date	Time UTC	Latitude	Longitude	Water depth m	Wind. m/s	Corse degree	Speed kn	Action
POS470/624-3	05.06.14	07:16	30° 0,11' N	22° 0,02' W	4993,5	N 5	343,5	0,4	Acoustic Modem zu Wasser
POS470/624-4	05.06.14	08:06	30° 1,34' N	21° 59,86' W	4992,4	NNE 6	258,1	0,4	TMS Messbeginn
POS470/624-4	05.06.14	14:58	30° 2,75' N	21° 59,17' W	4988,5	NNW 3	18,6	0,4	TMS Messende, 4800 m
POS470/624-3	05.06.14	15:06	30° 2,73' N	21° 59,18' W	4989,2	NNW 3	207,0	0,6	Acoustic Modem an Deck
POS470/624-2	05.06.14	16:00	29° 58,51' N	21° 59,84' W	4994,8	NNW 4	185,6	0,4	Drifter an Deck
POS470/625-1	06.06.14	00:08	30° 29,96' N	22° 59,96' W	5196,9	WNW 7	272,9	0,7	CTD/rosette water sampler zu Wasser
POS470/625-1	06.06.14	01:34	30° 30,02' N	22° 59,98' W	5203,6	WNW 6	280,9	0,3	CTD/rosette water sampler auf Tiefe, 5294m
POS470/625-1	06.06.14	03:00	30° 30,05' N	22° 59,99' W	5194,6	W 6	308,4	0,3	CTD/rosette water sampler an Deck
POS470/626-1	06.06.14	07:18	30° 59,99' N	23° 0,01' W	5206,6	W 6	316,6	0,5	Acoustic Modem zu Wasser
POS470/626-2	06.06.14	07:39	31° 0,00' N	23° 0,00' W	5203,4	W 8	12,5	0,4	Bottom Unit BU / TMS zu Wasser
POS470/626-2	06.06.14	15:45	31° 0,00' N	23° 0,00' W	5212,6	NNW 5	341,6	0,6	Bottom Unit BU / TMS an Deck, 5325m
POS470/626-3	06.06.14	16:07	31° 0,00' N	23° 0,03' W	5212,0	NW 6	334,0	1,0	Drifter zu Wasser
POS470/626-4	06.06.14	16:58	30° 59,11' N	22° 59,77' W	5198,0	NW 6	227,7	0,8	Bottom Unit BU / TMS zu Wasser ohne BU
POS470/626-4	06.06.14	17:14	30° 59,11' N	22° 59,78' W	5205,3	NW 6	179,3	0,6	Bottom Unit BU / TMS an Deck,165m
POS470/626-5	06.06.14	17:39	30° 59,95' N	23° 0,10' W	5210,8	NW 5	334,1	0,4	Bottom Unit BU / TMS zu Wasser ohne BU
POS470/626-5	07.06.14	00:26	30° 59,93' N	23° 0,07' W	5210,7	NNW 5	168,7	0,9	Bottom Unit BU / TMS an Deck,5000m
POS470/626-1	07.06.14	00:34	30° 59,93' N	23° 0,07' W	5203,4	NNW 6	143,9	0,9	Acoustic Modem AM an Deck
POS470/626-3	07.06.14	07:16	30° 51,64' N	22° 59,10' W	5187,2	WNW 3	27,8	0,4	Drifter an Deck
POS470/627-1	07.06.14	12:34	31° 29,97' N	22° 59,99' W	5252,3	WNW 4	343,5	1,0	CTD/rosette water sampler zu Wasser
POS470/627-1	07.06.14	14:00	31° 29,98' N	23° 0,02' W	5257,3	W 4	325,8	0,7	CTD/rosette water sampler auf Tiefe, 5353m
POS470/627-1	07.06.14	15:25	31° 29,98' N	23° 0,04' W	5254,5	WNW 5	8,6	0,5	CTD/rosette water sampler an Deck
POS470/628-1	07.06.14	19:50	32° 0,00' N	22° 59,95' W	5263,1	WNW 6	3,6	0,8	CTD/rosette water sampler zu Wasser
POS470/628-1	07.06.14	22:53	32° 0,00' N	23° 0,01' W	5264,8	WNW 4	358,6	0,5	CTD/rosette water sampler an Deck
POS470/629-1	08.06.14	03:06	32° 29,99' N	22° 59,94' W	5301,5	W 3	338,1	0,9	CTD/rosette water sampler zu Wasser
POS470/629-1	08.06.14	04:41	32° 30,01' N	22° 59,99' W	5301,7	NW 7	120,5	1,1	CTD/rosette water sampler auf Tiefe, 5407m
POS470/629-1	08.06.14	06:10	32° 30,06' N	22° 59,96' W	5341,6	SW 5	144,3	0,9	CTD/rosette water sampler an Deck
POS470/630-1	08.06.14	10:13	33° 0,01' N	23° 0,00' W	5320,4	WSW 6	359,2	1,2	CTD/rosette water sampler zu Wasser
POS470/630-1	08.06.14	11:11	32° 59,99' N	22° 59,98' W	5324,2	W 6	338,7	1,0	CTD/rosette water sampler auf 3133m Abbruch
POS470/630-1	08.06.14	11:58	33° 0,13' N	22° 59,71' W	5331,3	W 5	0,8	0,8	CTD/rosette water sampler an Deck

Cruise/Station	Date	Time UTC	Latitude	Longitude	Water depth m	Wind. m/s	Corse degree	Speed kn	Action
POS470/631-1	09.06.14	05:00	33° 30,00' N	22° 59,97' W	5339,0	WSW 7	284,5	1,3	CTD/rosette water sampler zu Wasser
POS470/631-1	09.06.14	06:40	33° 30,01' N	22° 59,98' W	5357,3	WSW 8	83,6	0,9	CTD/rosette water sampler auf Tiefe, 5445m
POS470/631-1	09.06.14	08:18	33° 30,63' N	22° 59,38' W	5343,0	WSW 7	37,2	0,8	CTD/rosette water sampler an Deck
POS470/631-2	09.06.14	08:30	33° 30,76' N	22° 59,23' W	0,0	WSW 7	41,3	1,2	Acoustic Modem zu Wasser
POS470/631-3	09.06.14	08:41	33° 30,88' N	22° 59,11' W	5355,9	WSW 7	31,6	1,1	MESSIN SVzu Wasser
POS470/631-3	09.06.14	10:05	33° 33,10' N	22° 58,91' W	5340,6	WSW 7	3,9	1,7	MESSIN SVan Deck
POS470/631-2	09.06.14	10:20	33° 33,37' N	22° 58,75' W	5340,3	WSW 7	34,4	1,6	Acoustic Modem an Deck
POS470/632-1	09.06.14	13:54	34° 0,02' N	22° 59,97' W	5301,5	W 2	43,0	1,2	Drifter zu Wasser
POS470/632-2	09.06.14	15:12	34° 2,12' N	22° 59,66' W	5293,1	NW 2	100,5	0,9	Acoustic Modem zu Wasser im Lotschacht
POS470/632-3	09.06.14	15:15	34° 2,13' N	22° 59,64' W	5292,8	NW 2	64,7	0,9	Bottom Unit BU / TMS zu Wasser ohne BU
POS470/632-3	09.06.14	15:37	34° 2,26' N	22° 59,47' W	5294,7	NW 2	27,7	1,0	Bottom Unit BU / TMS auf Tief, 1000m
POS470/632-3	09.06.14	15:59	34° 2,40' N	22° 59,22' W	5294,9	NNW 2	43,5	1,1	Bottom Unit BU / TMS an Deck
POS470/632-4	09.06.14	17:25	34° 2,68' N	22° 58,81' W	5294,5	N 3	32,2	0,5	Bottom Unit BU / TMS zu Wasser ohne BU
POS470/632-4	09.06.14	19:58	34° 3,64' N	22° 57,85' W	5295,8	NW 4	56,8	0,5	Bottom Unit BU / TMS auf Tiefe
POS470/632-4	10.06.14	00:38	34° 5,25' N	22° 56,25' W	5292,7	NW 3	26,8	0,9	Bottom Unit BU / TMS an Deck
POS470/632-2	10.06.14	00:46	34° 5,30' N	22° 56,19' W	5286,6	NW 3	31,6	0,6	Acoustic Modem AM an Deck
POS470/632-5	10.06.14	01:47	34° 1,19' N	22° 53,66' W	5304,1	NW 2	9,7	0,6	CTD/rosette water sampler zu Wasser
POS470/632-5	10.06.14	03:06	34° 1,48' N	22° 53,12' W	5291,9	NW 2	6,7	0,6	CTD/rosette water sampler auf Tiefe, 5323m
POS470/632-5	10.06.14	04:23	34° 1,82' N	22° 52,82' W	5289,6	WNW 2	9,0	0,9	CTD/rosette water sampler an Deck
POS470/632-1	10.06.14	07:10	34° 1,72' N	22° 50,69' W	5300,5	W 3	45,3	1,8	Drifter an Deck
POS470/632-6	10.06.14	08:09	34° 2,46' N	22° 50,24' W	5295,6	W 2	47,7	0,7	Acoustic Modem zu Wasser
POS470/632-7	10.06.14	08:14	34° 2,50' N	22° 50,19' W	5300,3	W 3	38,2	1,0	Bottom Unit BU / TMS zu Wasser, 2000 m
POS470/632-7	10.06.14	09:58	34° 3,22' N	22° 49,04' W	5299,8	WNW 3	74,4	0,8	Bottom Unit BU / TMS auf Tiefe, 2000 m
POS470/632-6	10.06.14	10:20	34° 3,33' N	22° 48,73' W	5305,1	W 3	41,4	1,1	Acoustic Modem an Deck
POS470/632-7	10.06.14	10:29	34° 3,41' N	22° 48,61' W	5305,1	WNW 3	51,2	0,9	Bottom Unit BU / TMS an Deck
POS470/633-1	10.06.14	15:17	34° 30,25' N	22° 59,83' W	5163,3	WNW 3	331,2	0,6	CTD/rosette water sampler zu Wasser
POS470/633-1	10.06.14	16:48	34° 30,51' N	22° 59,77' W	5163,8	WNW 3	48,3	0,5	CTD/rosette water sampler auf Tiefe, 5263m
POS470/633-1	10.06.14	18:03	34° 30,86' N	22° 59,52' W	5169,6	WNW 4	0,1	0,4	CTD/rosette water sampler an Deck
POS470/634-1	10.06.14	21:59	34° 59,99' N	23° 0,00' W	4890,8	W 3	352,7	0,5	CTD/rosette water sampler zu Wasser

Cruise/Station	Date	Time UTC	Latitude	Longitude	Water depth m	Wind. m/s	Corse degree	Speed kn	Action
POS470/634-1	10.06.14	23:26	35° 0,01' N	23° 0,01' W	4921,3	W 2	292,7	0,3	CTD/rosette water sampler auf Tiefe,4940m
POS470/634-1	11.06.14	00:45	35° 0,01' N	23° 0,00' W	4923,4	WNW 3	121,4	0,5	CTD/rosette water sampler an Deck
POS470/635-1	11.06.14	05:00	35° 29,98' N	22° 59,98' W	4208,4	WNW 3	276,0	0,7	CTD/rosette water sampler zu Wasser
POS470/635-1	11.06.14	06:20	35° 30,02' N	23° 0,02' W	4204,0	WSW 2	289,1	0,4	CTD/rosette water sampler auf Tiefe, 4275m
POS470/635-1	11.06.14	07:53	35° 30,01' N	22° 59,99' W	4204,8	W 2	316,8	0,4	CTD/rosette water sampler an Deck
POS470/635-2	11.06.14	08:00	35° 30,02' N	22° 59,99' W	4203,8	WSW 3	26,1	0,5	Acoustic Modem zu Wasser
POS470/635-3	11.06.14	08:28	35° 29,99' N	23° 0,01' W	4205,4	WSW 3	116,2	0,6	Bottom Unit BU / TMS zu Wasser
POS470/635-3	11.06.14	10:25	35° 29,99' N	22° 59,99' W	4207,9	WSW 3	96,5	0,4	Bottom Unit BU / TMS auf Tiefe, 4299 m
POS470/635-3	11.06.14	12:05	35° 29,96' N	23° 0,01' W	4205,9	W 2	143,9	0,6	Bottom Unit BU / TMS an Deck
POS470/635-2	11.06.14	12:18	35° 29,98' N	23° 0,00' W	4208,2	WSW 2	66,4	1,0	Acoustic Modem an Deck
POS470/636-1	12.06.14	00:06	35° 0,04' N	20° 59,98' W	5134,1	NNE 3	30,4	0,6	CTD/rosette water sampler zu Wasser
POS470/636-1	12.06.14	00:10	35° 0,07' N	20° 59,95' W	5137,1	NE 3	23,7	0,6	CTD/rosette water sampler an Deck no data
POS470/636-2	12.06.14	00:18	35° 0,13' N	20° 59,95' W	5135,7	NE 4	326,1	0,6	CTD/rosette water sampler zu Wasser
POS470/636-2	12.06.14	01:47	35° 0,27' N	20° 59,91' W	5142,1	N 2	31,4	0,9	CTD/rosette water sampler auf Tiefe, 5232m
POS470/636-2	12.06.14	03:22	35° 0,43' N	20° 59,90' W	5140,0	NNE 2	17,7	1,4	CTD/rosette water sampler an Deck
POS470/637-1	12.06.14	10:27	34° 0,00' N	20° 59,99' W	5176,0	NNE 6	16,0	0,6	CTD/rosette water sampler zu Wasser
POS470/637-1	12.06.14	11:15	34° 0,02' N	21° 0,01' W	5178,3	NNE 7	197,2	0,8	CTD/rosette water sampler auf Tiefe, 1800
POS470/637-1	12.06.14	11:47	34° 0,04' N	21° 0,01' W	5175,5	NNE 5	8,8	0,4	CTD/rosette water sampler an Deck Defekt
POS470/637-2	12.06.14	12:39	34° 0,02' N	20° 59,99' W	5233,4	NNE 5	6,0	0,5	CTD/rosette water sampler zu Wasser
POS470/637-2	12.06.14	12:44	34° 0,02' N	20° 59,99' W	5175,8	NNE 5	351,5	0,6	CTD/rosette water sampler an Deck Defekt
POS470/637-3	12.06.14	12:55	34° 0,06' N	20° 59,99' W	5175,6	NNE 6	184,6	0,9	CTD/rosette water sampler zu Wasser
POS470/637-3	12.06.14	14:25	34° 0,06' N	21° 0,02' W	5175,2	NE 7	246,9	1,0	CTD/rosette water sampler zu Wasser, 5274m
POS470/637-3	12.06.14	15:59	34° 0,04' N	21° 0,01' W	5174,3	NE 6	29,0	0,9	CTD/rosette water sampler an Deck
POS470/638-1	12.06.14	19:44	33° 30,00' N	21° 0,02' W	5214,6	NE 7	48,6	1,2	CTD/rosette water sampler zu Wasser
POS470/638-1	12.06.14	21:23	33° 30,01' N	21° 0,00' W	5220,4	NE 8	207,3	0,3	CTD/rosette water sampler auf Tiefe, 5317 m
POS470/638-1	12.06.14	23:15	33° 30,06' N	20° 59,99' W	5215,6	NE 8	79,3	0,7	CTD/rosette water sampler an Deck
POS470/639-1	13.06.14	03:10	33° 0,03' N	21° 0,02' W	5158,4	NE 10	132,9	0,6	CTD/rosette water sampler zu Wasser
POS470/639-1	13.06.14	04:35	33° 0,02' N	21° 0,00' W	5147,2	NE 8	279,2	0,6	CTD/rosette water sampler auf Tiefe, 5183m
POS470/639-1	13.06.14	06:20	32° 59,98' N	21° 0,01' W	5150,5	NE 9	210,5	0,8	CTD/rosette water sampler an Deck

Cruise/Station	Date	Time UTC	Latitude	Longitude	Water depth m	Wind. m/s	Corse degree	Speed kn	Action	
POS470/640-1	13.06.14	09:59	32° 30,00' N	20° 59,99' W	4964,6	NE 9	32,3	0,5	CTD/rosette water sampler	zu Wasser
POS470/640-1	13.06.14	11:32	32° 30,00' N	20° 59,97' W	4962,8	NE 9	186,7	0,8	CTD/rosette water sampler	auf Tiefe, 5062m
POS470/640-1	13.06.14	13:06	32° 30,01' N	20° 59,99' W	4967,8	NE 7	213,4	0,4	CTD/rosette water sampler	an Deck
POS470/641-1	13.06.14	16:33	31° 59,92' N	21° 0,01' W	4851,9	NE 9	36,2	1,1	CTD/rosette water sampler	zu Wasser
POS470/641-1	13.06.14	18:20	32° 0,00' N	20° 59,99' W	4855,2	NNE 8	169,8	0,6	CTD/rosette water sampler	auf Tiefe, 4941m
POS470/641-1	13.06.14	20:22	31° 59,99' N	21° 0,00' W	4849,9	NE 8	15,9	0,5	CTD/rosette water sampler	an Deck