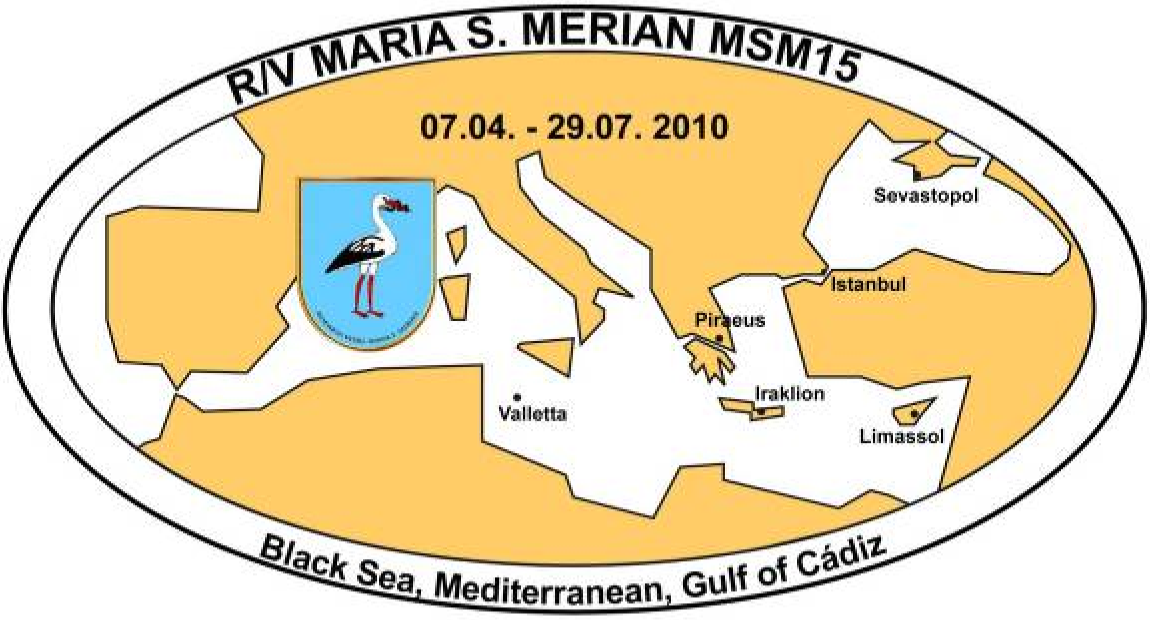
MARIA S. MERIAN-Berichte 11-5

"HYPOX"

Cruise No. 15, Leg 1

April 12 – May 08, 2010
Istanbul (Turkey) – Eregli (Turkey) – Sevastopol (Ukraine) – Istanbul (Turkey)



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2011

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1 Summary

Hypoxic conditions in aquatic ecosystems will increase in dimension and frequency as a consequence of global change. Ocean warming decreases oxygen concentrations, increases the stratification of water bodies and decreases the deep-water circulation. In combination with eutrophication, strong feed-back mechanisms are observed, leading to a further decrease in oxygen availability, to a decline of the water quality and the health of aquatic ecosystems, and to an increased production of greenhouse gases. The research cruise MSM 15/1 was a major activity of the Project HYPOX "In situ monitoring of oxygen depletion in hypoxic ecosystems of coastal and open seas, and land-locked water bodies" of the EU 7th framework program "ENV.2008.4.1.2.1. Monitoring and observing oxygen depletion throughout the different Earth system components". HYPOX investigates the effect of oxygen depletion on biogeochemical processes in aquatic ecosystems. Hence, the research cruise HYPOX (MSM 15/1) aimed to quantify the concentration and uptake of oxygen at the anoxic boundaries in the water column and at the sediment water interface of the Black Sea, in parallel with the measurement of nitrogen, carbon, sulfur and iron fluxes. The Black Sea is an ideal study system for this purpose: The high productivity and export of organic matter has lead to the formation of the largest anoxic basin on earth. The limited exchange of water between the Black Sea and the Mediterranean through the Istanbul Strait and the strong freshwater input by the rivers of the Black Sea catchment area cause a strong pycnocline and chemocline in 50-100 m water depth. Climate change in combination with increasing nutrient input causes strong regional effects. The warm, saline and oxygen-rich Mediterranean water flows from Istanbul Strait below the less dense water masses in the Black Sea. Oxygen-rich filaments reach beneath the pycnocline and strongly influence biogeochemistry. Climate change is expected to affect the transport of Mediterranean water into the Black Sea with important consequences for the ecosystems and their functioning. Off the Crimean peninsula, strong variations in oxygen and sulphide concentrations were observed in 130-165 m depth, caused by regional circulation patterns. Internal waves cause the temporary aeration of anoxic areas of the shelf or transport poisonous sulfide into suboxic and hypoxic depths, thus affecting the benthic community. In addition to the aims of the HYPOX project, the expedition contributed to the Global Earth Observation System of Systems (GEOSS) and to the network programs ESONET and EMSO, by using newly developed underwater technology for long-term measurements of oxygen and other elements. During the research cruise MSM 15/1 we successfully used new in situ observatories and new research methods to investigate the temporal and spatial dynamics of transport and turnover rates of oxygen and sulphide, and their effects on the biogeochemistry and the diversity of the pelagic and benthic communities.

Zusammenfassung

Im Zuge der Klimaveränderung werden aquatische Ökosysteme in zunehmender Zahl und zunehmend häufig hypoxischen (sauerstoffarmen) Bedingungen ausgesetzt. Die Erwärmung reduziert den Sauerstoffgehalt, verstärkt die Schichtung und verringert die Tiefenzirkulation der

Wasserkörper. In Verbindung mit der Überdüngung der Gewässer führt dies zu einer drastischen Verringerung von Sauerstoffverfügbarkeit und Wasserqualität und zu einem dramatischen Rückgang der Tierpopulationen und Artenvielfalt. Zusätzlich verstärkt sich das Problem selbst, da hypoxische Systeme vermehrt Treibhausgase freisetzen. Die Expedition MSM 15/1 stellt eine Hauptaktivität des Projektes HYPOX ("In situ monitoring of oxygen depletion in hypoxic ecosystems of coastal and open seas, and land-locked water bodies") dar, ein EU projekt des 7. Rahmenprogramms im Bereich "ENV.2008.4.1.2.1. Monitoring and observing oxygen depletion throughout the different Earth system components". HYPOX untersucht den Einfluss von Sauerstoffmangel auf bio-geochemische Prozesse in aquatischen Ökosystemen. In diesem Sinne diente die Projekt-Expedition MSM 15/1 dazu, die Sauerstoffkonzentrationen und Aufnahmeraten an oxisch/anoxischen Übergängen innerhalb der Wassersäule und an der Sediment-Wassergrenze zu bestimmen und mit den Flüssen von Stickstoff, Kohlenstoff, Schwefel und Eisen in Beziehung zu setzen. Das Schwarze Meer stellt ein ideales System dar um diese Zusammenhänge zu untersuchen. Die hohe Produktivität und der starke Export organischen Materials hat zur Bildung des weltweit größten anoxischen Beckens geführt. Der geringe Wasseraustausch zwischen dem Schwarzen Meer und dem Mittelmeer durch die Straße von Istanbul und der starke Süßwassereintrag aus dem Schwarzmeer-Wassereinzugsgebiet führen zur Ausbildung einer starken Dichtesprungschicht und einer sprunghaften Veränderung der chemischen Bedingungen in einer Wassertiefe von 50-100 m. Die Klimaveränderung in Kombination mit zunehmendem Nährstoffeintrag führt lokal zu dramatischen Veränderungen. Das über die Strasse von Istanbul zufließende warme und salzreiche Mittelmeerwasser schichtet sich in der Wassersäule des Schwarzen Meeres in größerer Tiefe ein. In den anoxischen Wassermassen unterhalb der Dichtesprungschicht üben die sauerstoffreichen Filamente einen starken Einfluss auf die Biogeochemie aus. Es wird erwartet, dass die Klimaveränderung den Transport von Mittelmeerwasser in das Schwarze Meer beeinflussen wird – mit erheblichen Konsequenzen für die Ökosysteme und ihre Funktion. Vor der Krim-Halbinsel wurden in 130-165 m Wassertiefe starke Fluktuationen in den Konzentrationen von Sauerstoff und Sulfid beobachtet, die von regionalen Mustern in der Wasserzirkulation herrühren. Interne Wellen führen zu einer vorübergehenden Belüftung anoxischer Bereiche des Schelfs während auch giftiges Sulfid in suboxische oder hypoxische Bereiche transportiert wird und dort die benthischen Lebensgemeinschaften beeinflusst. Zusätzlich zu den Zielen des HYPOX Projektes trug die Expedition mit dem Einsatz neuartiger Unterwassertechnologien für die Messungen von Sauerstoff und anderen Parametern außerdem zum "Global Earth Observation System of Systems" (GEOSS) und zu den Netzwerk Programmen ESONET and EMSO bei. Während der Expedition MSM 15/1 kamen neue in situ Observatorien und Forschungsmethoden zum Einsatz um zeitliche und räumliche Änderungen im Transport und in den Umsatzraten von Sauerstoff und Sulfid zu erfassen und den Einfluss dieser Änderungen auf die Biogeochemie und die Diversität der pelagischen und benthischen Lebensgemeinschaften zu untersuchen.

2 Participants

Name	Discipline	Institution
Boetius, Antje, Prof. Dr.	Marine Microbiology / Chief Scientist	AWI
Acar, Dursun	Palaeoproxies	ITU
Albrecht, Sebastian	CTD, PARASOUND	FIELAX
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Erdem, Zeynep	Palaeoproxies	ITU
Fischer, Jan, Dr.	O_2 Sensor Technology	MPI
Gulin, Maksim, Dr.	Biology	IBSS
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Ishan, Yudi Nurul	Nutrients	MPI
Janssen, Felix, Dr.	In Situ Biogeochemistry	MPI
Jessen, Gerdhard	Microbiology	MPI
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Le Reste, Serge	Argo Float Profiling	IFREMER
Lichtschlag, Anna, Dr.	In Situ Biogeochemistry	MPI
Nordhausen, Axel	In situ Instrument Technology	MPI
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Mazlumyan, Sofia, Dr.	Biology	IBSS
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Stiens, Rafael	Microbiology	MPI
Weiz, Erika	Microbiology	MPI
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Exchange scientific/technical crew , Port Eregli, 19.04.

Name	Discipline	Institution
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Lo Bue, Nadia	MEDUSA profiling	INGV
Marinario, Giuditta	MEDUSA profiling	INGV

Exchange scientific/technical crew , Sevastopol, 23.04.

Name	Discipline	Institution
Bussack, Michael	MOVE	OPTIMARE
Düssman, Ralf	MOVE	MARUM
Hissmann, Karen	JAGO	IFM-GEOMAR
Klagge, Torben	JAGO	IFM-GEOMAR
Meyer, Jörn Patrick	In Situ Instruments Technology	MPI
Schauer, Jürgen	JAGO	IFM-GEOMAR
Waldmann, Christoph, Dr.	MOVE	MARUM
Wenzhöfer, Frank, Dr.	In Situ Biogeochemistry	AWI

AWI	Alfred-Wegener-Institut für Polar- und Meeresforschung
IBSS	A.O. Kovalevsky Institute of Biology of the Southern Seas, Ukrainian Academy of Sciences
EAWAG	Eidgenössische Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz
FIELAX	Gesellschaft für wissenschaftliche Datenverarbeitung mbh
IFM-GEOMAR	Leibniz-Institut für Meereswissenschaften an der Universität Kiel
IFREMER	French Research Institute for Exploitation of the Sea
ITU	Istanbul Technical University, Ayazaga Campus
INGV	Istituto Nazionale di Geofisica e Vulcanologia
MARUM	Zentrum für marine Umweltwissenschaften, Universität Bremen
MPI	Max-Planck-Institut für Marine Mikrobiologie
OPTIMARE	OPTIMARE Analytik GmbH & Co. KG
TECNOMARE	Engineering Company for Oil Upstream

3 Research Program

Main objectives of the research program were in situ measurements of hydrographic and biogeochemical processes in hypoxic to anoxic zones in the Black Sea within the EU project HYPOX. The high productivity and export of organic matter has lead to the formation of this largest anoxic basin on earth. Two areas with different types of variations in oxygen supply were selected. 1) The limited exchange of water between the Black Sea and the Mediterranean through the Istanbul Strait and the strong freshwater input by the rivers of the Black Sea catchment area cause a strong pycnocline and chemocline in 50-100 m water depth. The warm, saline and oxygen-rich Mediterranean water flows from Istanbul Strait below the less dense water masses in the Black Sea. Oxygen rich filaments reach beneath the pycnocline and strongly influence biogeochemistry 2) Off the Crimean peninsula, strong variations in oxygen and sulphide concentrations can be found in 130-165 m depth, caused by regional circulation patterns. Internal waves cause the temporary aeration of anoxic areas of the shelf or transport poisonous sulfide into suboxic and hypoxic depths, thus affecting the benthic community.

During the research cruise MSM 15/1 it was planned to use new in situ observatories and new research methods to investigate the temporal and spatial dynamics of transport and turnover rates of oxygen and sulphide, and their effects on the biogeochemistry and the diversity of the pelagic and benthic communities. In the area of the inflow of Mediterranean water to the Black Sea, multicorer, box corer and gravity corer stations (70-300 m, every 20-100 m) were selected along a transect, combined with CTD-Rosettes, in situ pumps and bottom water gears. IFREMER deployed an autonomous profiler for oceanographic studies of the area. The work program in the Western Black Sea was planned for 6 days, followed by an exchanged of parts of the scientific crew before the transit to the Crimean working area. In the Crimean area, surveys using MEDUSA tows were to be conducted to map the hydrographical conditions, the distribution of oxygen and sulfide and the habitat structure of the continental shelf and slope sediments. Additional CTD profiles and multicorer deployments were planned to provide 3D resolution data in the hypoxic areas that constitute the basis for the deployment of the observatories. A further exchange of scientific crew was needed to switch to work with MOVE and JAGO for the biogeochemical, geological and biological sampling of the Crimean slope. Along different transects the dynamics of the oxygenated, hypoxic and anoxic water masses were to be investigated in parallel to the composition and distribution of the benthic community and the sediment biogeochemistry. By applying “free fall lander” and MOVE operated measurements, and by deploying observatories and experiments with JAGO and by high resolution sampling across the chemocline in water column and sediment, the interaction between oxygen availability and the composition and functioning of benthic communities was investigated. This program was planned for 12 days.

Nearly all objectives of the research program were completed in both areas, despite some problems with unforeseen military exercises in the working area.

4 Narrative of the Cruise

The scientific crew of expedition MSM15/1 embarked the MARIA S. MERIAN in the port of “Haydarpasa” on 10th of April. The scientific team comprised 23 scientists, students, technicians, and engineers from seven institutions and 8 countries. We left the port of Haydarpasa on 12th of April in the afternoon, as we had to wait for a convoy of ships moving north towards the Black

Sea. The first measurements started on 12th of April, 4 hours after leaving port. The main focus for the first week was to investigate the inflow of oxic water bodies from the Marmara Sea into the anoxic Black Sea at high resolution. Already the first CTD casts along the main canyon northeast of the Bosporus inflow showed that intrusions of warm and salty oxic waters were virtually absent. Consequently, we planned a Marmara plume search strategy in the canyons and on the shelf edge for the next days, with repeated CTD-Rosette casts at water depths from 60 to 1200 m on the continental margin. In the night of 13th of April we started a coring transect from 300 m to 75 m water depth up the crest between the two main canyons. The canyons are characterized by thick layers of extremely fine, fluidic sediments, which were sampled with different types of gravity cores. The coring program continued throughout the nights of April 14th-18th, to investigate traces of hypoxia in the geological record, noble gases, isotope geochemistry and biomarkers. At the same sites, we collected samples for the analysis of macro-, meio- and microfauna, to identify benthic communities and key species specific for different concentrations of oxygen, using the TV guided multiple corer and the box corer. On the 16th of April we completed the survey for evidence of recent Maramara water inflow on the shelf and in the main canyons, finding only one site at 600 m water depth with a density profile indicative of a Mediterranean water mass. The fine scale distribution of water column chemical parameters was investigated here with a new "Pump CTD". Close by, the "PROVOR" float equipped with an autonomous CTD and an oxygen sensor was deployed for continuous profiling of the water column. On 17th of April we carried out a long TV-guided MUC transect across the entire biogeochemical sampling area from 300 m water depth onto the shelf. At 300 m water depths we observed gas bubbling from the seafloor during sampling, in 220-200 m water depths we found large mats of sulfide oxidizing bacteria as a first sign of minimal supplies of oxygen and at 180 m we could see the first larger animals such as polychaete worms and starfish. After having finished our work in the Bosporus area, we returned to Port Eregli in the morning of 19th of April, for an exchange of scientific crew. Unfortunately, due to the Europe-wide cancellation of flights due to volcanic ash clouds, only three of the eight new scientists arrived in time for our departure from Port Eregli in the afternoon of the 19th of April.

Reaching the Crimean shelf in the morning of the 20th of April, we started immediately with the first MEDUSA transect. This system monitored the seafloor with a video-camera towed by the ship, carrying several sensors to characterize the properties of the surrounding water, including oxygen, salinity, temperature, methane, and turbidity. The seafloor between 100-140 m water depth showed a complex microstructure of ripples and cracks alternating with outcrops of carbonates. This indicates temporarily strong currents and could be related to the high density of canyons and channels visible in the bathymetry of the region. Below 200 m water depth in permanent anoxia, we found soft, muddy sediments covered by layers of sedimented fluff. On 21st of April we continued with long MEDUSA transects at the depths of 160m, 140m and 120m, to monitor the spatial variability of oxygen. Close by, at about 240 m water depth are two large fields of gas seeps, which we also explored with MEDUSA, to test the hypothesis that the gas ebullition influences the position of the chemocline. A first analysis of the data from all sensors indicated that the boundary between hypoxia and anoxia is found at 175 m. Alternating with MEDUSA we carried out box core sampling for IBSS, and seafloor mapping with the high-resolution multibeam sonar EM1002 of MERIAN, to fill gaps in our bathymetry map. Just before finishing the monitoring work on 22nd of April, we deployed three moorings with hydrographical and oxygen sensors, to record temporal variation in the hypoxic region of the shelf edge between 160 and 120 m water depth. When we were just about done with the last MEDUSA transect, the captain informed us of a navy exercise covering our entire working area for an unknown period of time. However, for another exchange of crew, we had to anyway enter the port of Sevastopol on 23rd of April. After some consideration with different authorities, we steamed to a new site west off Sevastopol in the evening of 24th of April, as the military exercises were announced to continue till 29th of April.

We started with the first JAGO dive already in the morning of 25th of April, after a night of CTD sampling and bathymetric mapping of the new working area off Crimea. The first dive was dedicated to exploring the 10-25 µM oxygen zone at 160-150 m water depth. This was followed by some sensor calibrations and another JAGO dive to the <10 µM oxygen zone. In the evening of 25th of April, MOVE was deployed with many different payloads, including a benthic chamber, a seafloor scanner, oxygen optodes and sediment profilers as well as a high resolution camera ("Megacam"). The third week of the cruise MSM15/1 started with rough seas, prohibiting the planned JAGO and MOVE dives. As an alternative program, we deployed four autonomous in situ instruments, which measure oxygen concentrations and consumption together with a variety of environmental parameters. In addition to the Multifiber Optode (MUFO) and the Benthic Boundary Layer (BBL) profiler mentioned earlier, we use the eddy correlation system "EDDY" for integrated measurements of oxygen consumption at scales of 10-100 square meters of seafloor, and a "Lander" system with a benthic chamber and a microprofiler for high-resolution measurements of benthic processes. The weather improved already in the afternoon of the 27th of April, and we were able to dive with JAGO to the anoxic zone of the Crimean Shelf, followed by a MOVE deployment. The next MOVE and JAGO dives showed that oxygen conditions changed strongly during a phase of stronger currents probably associated with the wind force. The zone between 160-140 m turned from a hypoxic area (5-25 µM oxygen) to an anoxic zone. At the same time, we recorded a few µM of oxygen at the deep, usually anoxic site. This high temporal variability in oxygen supply was also confirmed by the four autonomous instruments, which we deployed a few times in the area. On 29th of April we continue the exploration work with JAGO with dives to the 125 and 150 m zone. The 150 m dive investigated the patchy bacterial mats of the hypoxic zone, which were associated with thick accumulations of sedimented organic matter of 4-6 cm in diameter.

On 29th of April we could steam to the first working area, to recover our moorings after the ending of the military exercise in the morning of the 30th of April. We finished sampling of this area with TV-guided multiple coring. In the night of the 30th of April we returned to this area to deploy two of the three long term moorings at depths of 150 and 135m, together with the four in situ tools. On May 1st and 2nd we place our third mooring and carry out several dives to retrieve samples, and to compare the rates of biogeochemical processes with or without benthic fauna at our reference site at 100m closer to the Crimean coast. Unfortunately, more military exercises were announced in the southwestern deeper section of our sampling area, hence we finalized sampling of the 200m zone with the TV-MUC and the EAWAG gravity core. Till 5th of May we had to stay in the shallower section and repeated some previous measurements, to get a better record of the temporal variations of oxygen.

The fourth and last week of the expedition HYPOX was dedicated to closing the gaps in the sampling scheme of our two working areas on the Ukrainian shelf before returning to Istanbul.

On Monday May 3rd we dedicated the first dive to a rendezvous of the two mobile underwater instruments MOVE (the benthic crawler) and the manned submersible JAGO. During 4th and 5th of May we deployed moorings, MOVE and JAGO at the intermediate depth zones. On May 6th we carried out two last short dives of JAGO in the morning, to sample a permanently anoxic zone at 400m depth as another reference site, and to record the vertical distribution of mega- and macroplankton associated with the chemocline. In the evening of the 6th of May, the last MOVE deployment was scheduled as a revisit of the 100m station with the main mission of taking photographs of active benthic fauna at the permanently oxic reference site. The last task of this mission was the retrieval of the three oceanographic moorings, starting at the break of the new day May 7th. The very last station of the mission MSM15/1 was the deployment of "NEMO" floats to monitor temperature, salinity and oxygen for a period of 2-3 years.
We arrived early in the morning of the 8th of May in Istanbul. All scientists of MSM15/1 embarked the same day and returned to their home institutions after a highly successful expedition.

5 Preliminary Results

5.1 Multibeam Swathmapping, PARASOUND

(S. Albrecht, Z. Erdem)

Multibeam Swathmapping

Multibeam swathmapping surveys were performed with the onboard multibeam echo sounder system Kongsberg EM1002. This is a shallow to medium water echo sounding system developed for ranges between 2 and 1000 meters. It operates at a frequency of 95 kHz.

A single sounding ping results in 111 water depth measurements (beams) along a profile perpendicular to the ship's long axis. The width of this depth profile is approx. 7.5 times the water depth at the system's maximum coverage angle of 150 degrees. By pinging continuously a swath of depth profiles is recorded at a ping rate of 0.5-10 Hz depending on the water depth.
The across track spacing between two beams is either equiangle (1.3 degrees per beam) or equidistant depending on the selected mode. The along track spacing depends on the ship's speed over ground and the ping rate.

To assign a geographic position to a depth measurement, navigation data of MARIA S. MERIAN is provided by a Seapath intertial navigation system (INS). This data is based on a differential GPS signal from a Trimble SPS461 DGPS system. Ship's motion data is needed to correct the depth measurements concerning pitch, roll and heave of the vessel. This data is supplied by the Seapath INS, too. To correct the refraction of the sonar signal between the echo sounder's transducer and the nearby water a sound velocity sensor is installed at the ship's keel. To correct the refraction of the sonar signal on its way through the water column, sound velocity profiles calculated from CTD (conductivity, temperature, depth) measurements were provided to the EM1002 system for each survey. On board MARIA S. MERIAN the EM1002 multibeam system is not hull-mounted; instead it has to be deployed in the moon pool for surveying and recovered for transits.

On this cruise 14 multibeam surveys were performed with an overall time of 72 hours. During most of these surveys the EM1002 and the Atlas PARASOUND sub-bottom profiler were operated simultaneously. All surveys were run at a speed of 5 knots over ground. To improve the data quality and data resolution a coverage angle of 120 degrees or less was applied.

In the Bosporus area only one profile was surveyed during a TV-MUC transect. In the Crimea I area several surveys extended an area already surveyed on Meteor cruise M72/2. In the Crimea II area several surveys were required to retrieve reliable information on the seafloor for planning deployments of scientific devices. The exact survey profiles, times and areas are listed in APPENDIX Section A.4.

Besides operating the multibeam sonar system, the processing of data was also part of the work on board. Using the software Kongsberg Neptune the raw data files .ALL (Kongsberg format) of each survey have been added to projects each covering a whole survey area. Turns and bends in the ship's navigation data were rejected because they lead to low quality depth information. Noise and standard deviation filters were applied to the data to remove erroneous depth measurements caused by hydro-acoustic disturbances i.e. because of waves or interferences with other sounding systems. After closing a survey area the project has been exported as .XYZ files containing all measured soundings as single coordinates (longitude, latitude, depth). Further data processing included the calculation of digital terrain models and bathymetric raster sets from .XYZ files and the visualization in maps.

Throughout all surveys the EM1002 system worked very reliable. A problem not solvable during this cruise was a systematic error in the outer starboard beams (approx. from beam 88 to 111). These were lowered about 1 m compared to the other beams in the fan. Therefore all these beams had to be deleted for every profile. The resulting profile width decreased to 80 % and the line spacing between the profiles had to be decreased significantly, too.

PARASOUND

The Atlas PARASOUND DS P-70 is a parametric sediment echo sounder or sub-bottom profiler. This is a seismic system which can be used to detect the internal structures of sedimentary cover along the ship track. To penetrate the sedimentary layers at the sea floor, a low frequency signal is required. To combine a reasonably small transducer with a very narrow beam the system takes advantage of the parametric effect, which results from the non-linear hydro-acoustic behavior of water for high energy signals. The transmission of two high energy signals of slightly different frequencies (i.e. 18 kHz and 22 kHz) creates harmonics at the

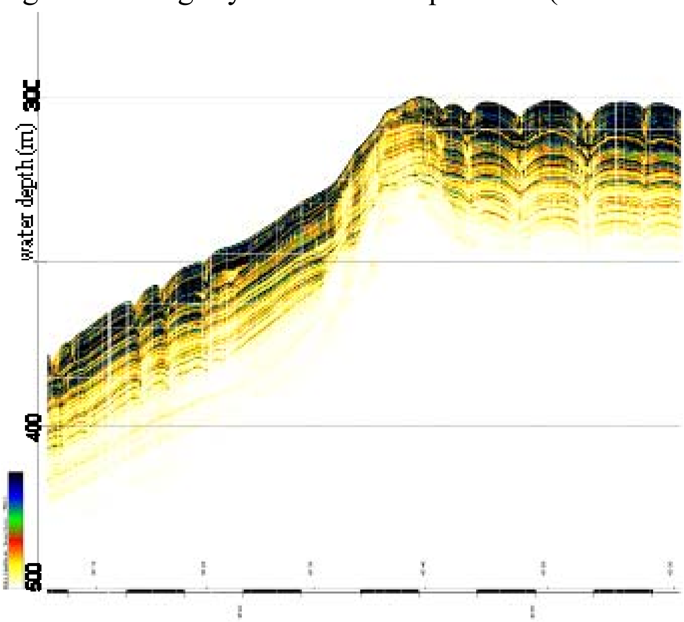

Fig. 5.1
Echogram plot of a low frequency (4 kHz) Atlas PARASOUND profile.

difference frequency (i.e. 4 kHz) and the frequency sum (i.e. 40 kHz). With variable frequencies from 0.5 kHz to 6 kHz and an opening angle of approx. 4 degrees the system provides high resolution information of the sedimentary layers up to a depth of 200 m below sea floor.

On this cruise the Atlas PARASOUND system was utilized to record the sedimentary cover as well as to ect gas flares in the working areas. During most of the surveys the Atlas PARASOUND and the multibeam echo sounder Kongsberg EM1002 were operated simultaneously. The exact survey profiles, times and areas are listed in APPENDIX Section A.4. All surveys were run at a speed of 5 knots over ground. The PARASOUND system was operated in single pulse mode with a pulse length of 0.5 ms, a primary high frequency (PHF) of 20 kHz and a secondary low frequency (SLF) of 4 kHz.

In the post-processing all raw data files (ASD, PS3 and SGY format) have been sorted to .TAR archives for each survey and echogram plots have been created using the seismic data processing software SeNT (cf. Fig. 5.1).

Bathymetry of the study area (Bosporus region)

The Istanbul Strait (Bosporus) outlet area of the Black Sea is located north of the Istanbul Strait, creating the only connection of the anoxic Black Sea basin to the worlds oceans. The outlet area includes the shelf and upper slope areas.

The multibeam bathymetry mapping (Fig. 5.2 and Fig. 5.3) of the different parts of the Istanbul Strait's outlet area were carried out by NATO R/V ALLIANCE (Di Iorio and Yüce, 1998) and R/V KOCA PIRI REIS (Flood et al., 2009). Fig. 5.2 and Fig. 5.3 show the submarine extension of the Bosporus channel from the coast towards NE. About 10 km from the coast there is a bend that makes the channel turn towards NW. At this coastal part before the bend, the channel extends up to 35 m below the seafloor with a rough topography due to the Upper Cretaceous volcanic bedrock. After the bend the channel spreads out to become <10 m deep and forms a fan delta on the mid and outer shelf areas with anastomosed distributary channels, 5-8 m high levées, in channel stream lined bars, crevasse sprays, and NW-SE oriented linear to wavy sedimentary structures in between the channel- levée complexes (Fig. 5.3; Di Iorio and Yüce, 1998; Flood et al., 2009).

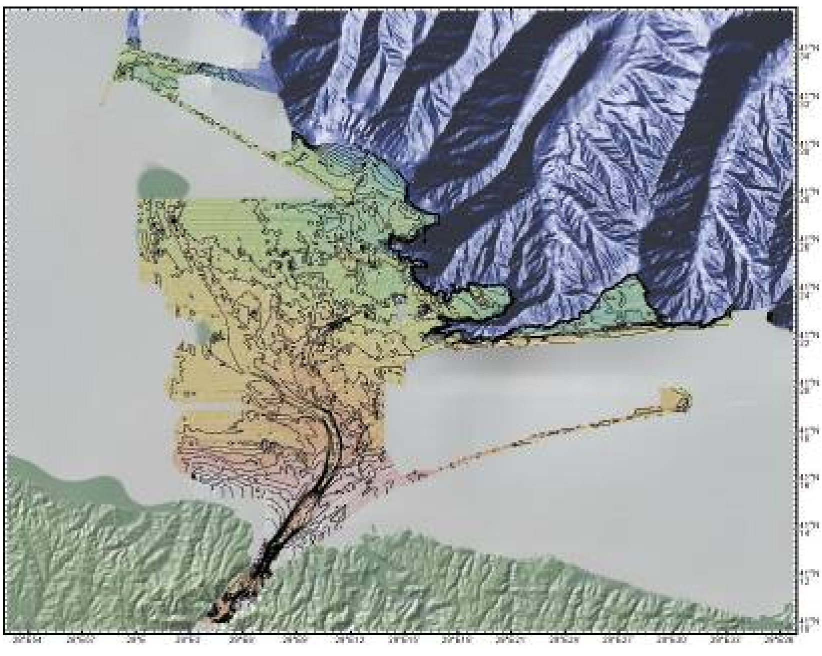

Fig. 5.2
Multibeam bathymetric map of the Istanbul Strait (Bosporus) outlet area (Di Irio and Yüce, 1998; Flood et al., 2009).

Towards the shelf edge at -105m, the channels become broad and the degree of channel bifurcation increases. The continental slope is characterized by NE-trending submarine canyons, the most conspicuous of which is located directly north of the main strait's channel (Fig. 5.2). NW-SE trending asymmetric ridges in between the channel-levée complexes are 1-2 m high (Fig. 5.3). These ridges have been interpreted by Aksu et al. (2002) to be coastal sand bars that were drowned with sea level rise.

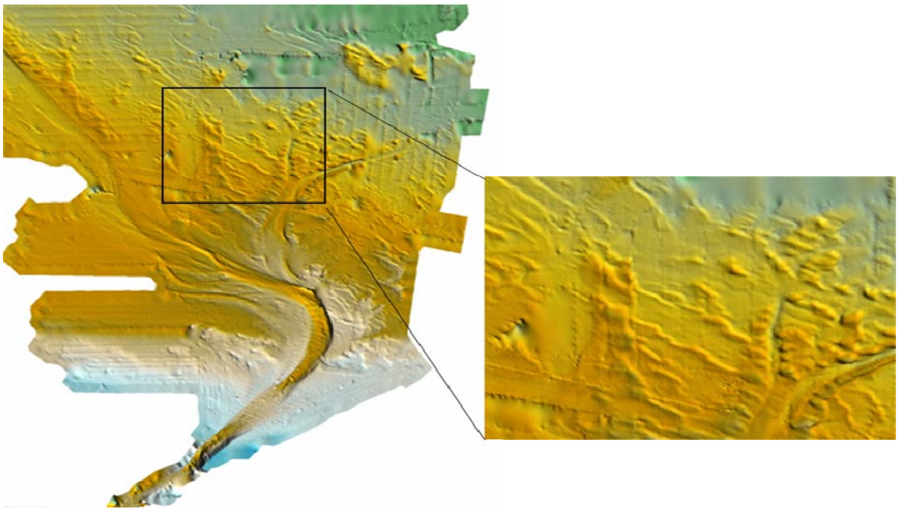

Fig. 5.3 Sun-illuminated image of the Istanbul Strait (Bosporus) Shelf area showing the submarine extension of the Bosporus channel, its submarine fan delta and distributory channels.

Geophysical sub-bottom profiling and sediment sampling was carried out with the R/V ARAR (November 2009) along depth transects from -75 m to -300 m on the shelf and upper slope areas. The sub-bottom profiling and previous multibeam bathymetric mapping confirmed the presence of a channel-levée complex developed by the inflow of Mediterranean water that started sometime in the early Holocene. During the R/V MARIA S. MERIAN cruise the seismic lines SL1 and SL8 were used for further studies (Fig. 5.4). In the Bosporus region during the cruise only one multibeam profile was surveyed during a TV-MUC transect (SL1).

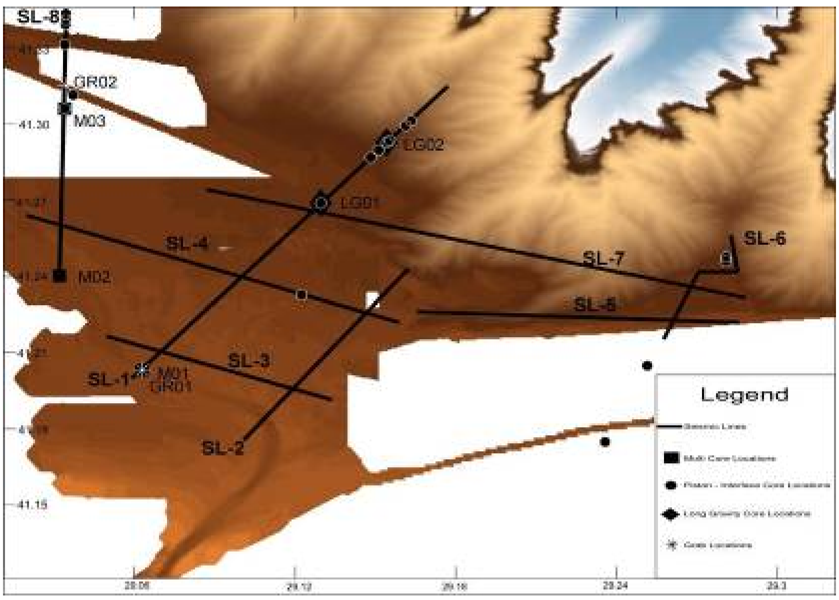

Fig. 5.4 Bathymetric map of the Istanbul Strait's outlet area in the Black Sea, showing the location of the seismic lines and cores which, were carried out by R/V ARAR (Nov. 2009).

5.2 Oxygen monitoring in the Bosporus inflow area

5.2.1 Argo floats

(S. Le Reste, J.-F. Rolin)

Long-term monitoring of oxygen and associated parameters is a key aspect of the HYPOX project (FP7). The working proposal of IFREMER in the Bosporus area during HYPOX was the determination of the feasibility of long-term monitoring using profiling floats with oxygen sensors. For this purpose, the MARIA S. MERIAN cruise 15/1 was an excellent opportunity to implement this in context with a full physical survey of the area by the scientific crew.

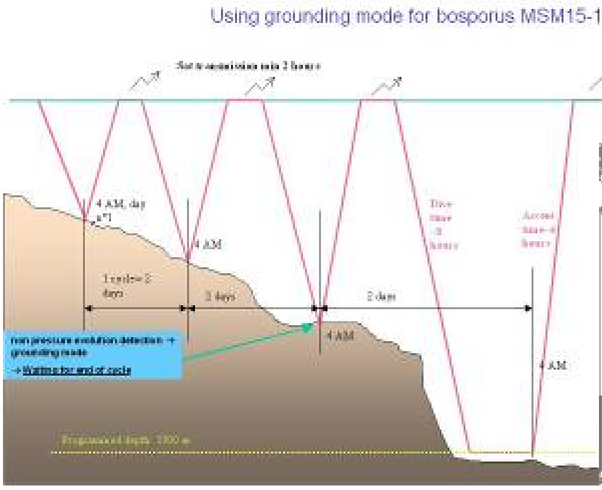

Fig. 5.5
PROVOR DO profiler programming for the HYPOX Black Sea experiment.

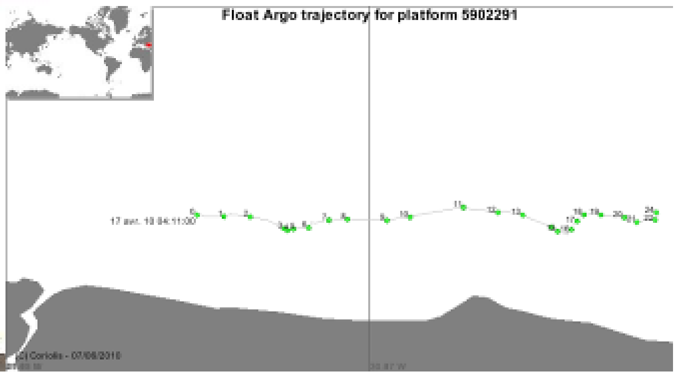

Fig. 5.6
Float trajectory HYPOX Black Sea experiment.

One PROVOR float was built (PROVOR HYPOX DO-02) and another refitted (PROVOR HYPOX DO-01) with the recent Aanderaa (AADI) optodes 4330 and standard Seabird CTD by nke for IFREMER. This was done according to the validation procedure with a set of Argo floats with DO measurement by the Argo-Coriolis team in March 2010.

The second float (n°1) was sent in a container from Bremen to Istanbul. After opening the container, we recognized that the cylinder, which protects the optode, was broken due to a manufacturing defect in the wooden and foam parts that support the floats during transportation. Hence only one float was available and this led to a deployment strategy, which intended to check most of the monitoring feasibility issues in this area, focusing on the determination of the oxygen bottom layer by the hydrology specialists on board.

Thus, a special grounding mode was used for programming (Fig. 5.5). The time at the sea surface was reduced due to an optimisation of the Argos transmission (several satellite addresses and use of the time slot of the visibility of the latest satellite “Argos3”).

During the deployment of the float, the ship started its propulsion, while the float was a few tens of centimetres from the ship hull and thus the float was blown away and immersed. Hereupon, the float entered a "grounded" mode at the surface. This led to a surface drift during the first cycle and to wrong functioning of the salinity sensor during 20 out of 24 cycles.

Profiles are available on the Argo/Coriolis web site (*float reference* 5902291).

The float drifted during profiling, following the east direction of the Black Sea rim current (*see* Fig. 5.6). There is no evidence of drift during the waiting phase on the seafloor (from 100 to 1220 dbar) and the limit of 1300 dbar was never reached. The float visited during one cycle or more all the canyons from 29°19’ to Eregli bay. The temperature and oxygen profiles of the first cycles are consistent with the CTD profiles of the cruise performed in the days before the deployment. No evidence of an oxygenated bottom layer was found.

The PROVOR DO float cycled every two days from 17th April to 6th June 2010. A technical parameter analysis is underway to determine the reason for this early stop.

The results of this experiment will be used for the preparation of the deployment of the second float, repaired and modified as a “Probio” with Iridium transmission capabilities.

5.2.2 CTD

(S. Albrecht, D. Donis, G. Jessen)

Objective

The main focus in the Bosporus area was the investigation of the inflow of oxic water bodies from the Marmara Sea into the anoxic water of the Black Sea. The vertical stratification of the Black Sea is determined by low-salinity surface waters of riverin origin overlying high-salinity deep waters of Mediterranean origin, resulting in a sharp permanent pycnocline that inhibits exchange between surface and deep waters (Latif et al., 1991).

The mixture of Bosporus outflow water with the overlying cold intermediate layer (CIL) water forms the Bosporus plume, which ventilates the deep layers of the Black Sea. The occurrence of these circumstances is variable in response to changing climate.

The hydrochemical structure of the Black Sea is determined by the peculiarities of the hydrophysical regime. Thus, variability in seasonal mixing and Mediterranean inflow and outflow through the Bosporus Strait can play a crucial role in the salinity, water budget, and chemical composition of the Black Sea water column (Neretin et al., 2001; Özsoy and Ünlüata, 1997).

CTD casts

Conductivity-temperature-depth (CTD) casts were carried out using a Sea-Bird Electronics, Inc. SBE 911plus system. The unit was equipped with sensors for temperature (SBE03+), conductivity (SBE04C) and pressure (Digiquartz 410K-105) along with additional sensors for oxygen (SBE43) and fluorescence/turbidity (Wetlab ECO-AFL/FL). Temperature, conductivity and oxygen were measured redundantly by a sensor pair. The underwater unit was attached to a SBE 32 carousel water sampler with room for 24 NISKIN 10 L-bottles. The collected data from each cast has been processed using IOW’s Reiseassistent and Sea-Bird’s SBEDataProc software. It has been provided as an EXCEL file containing data and diagrams for each sensor as well as a bottle file containing averaged sensor values for each water sample taken.

The complete system worked properly throughout most times of the cruise. Due to a malfunctioning altimeter the CTD could not be lowered down to the desired heights above seafloor. A system breakdown could be repaired by re-terminating the sea wire connection at the CTD.

In total 54 CTD casts were carried out in the Bosporus area. The data was also used for calculating sound velocity profiles needed for the echosounder systems and the POSIDONIA underwater positioning system.

The casts started on 12.04.2010 at St. 178 and ended on 18.04.2010 at St. 336 (Fig. 5.7).

Discrete water samples for analyses of dissolved inorganic nutrients, oxygen and sulfide were taken from rosette-CTD casts and samples for $18O_2$, 13C, suspended organic matter and organic geochemistry were stored (for detailed usage of samples, *see* APPENDIX Section A.2, water column sampling list).

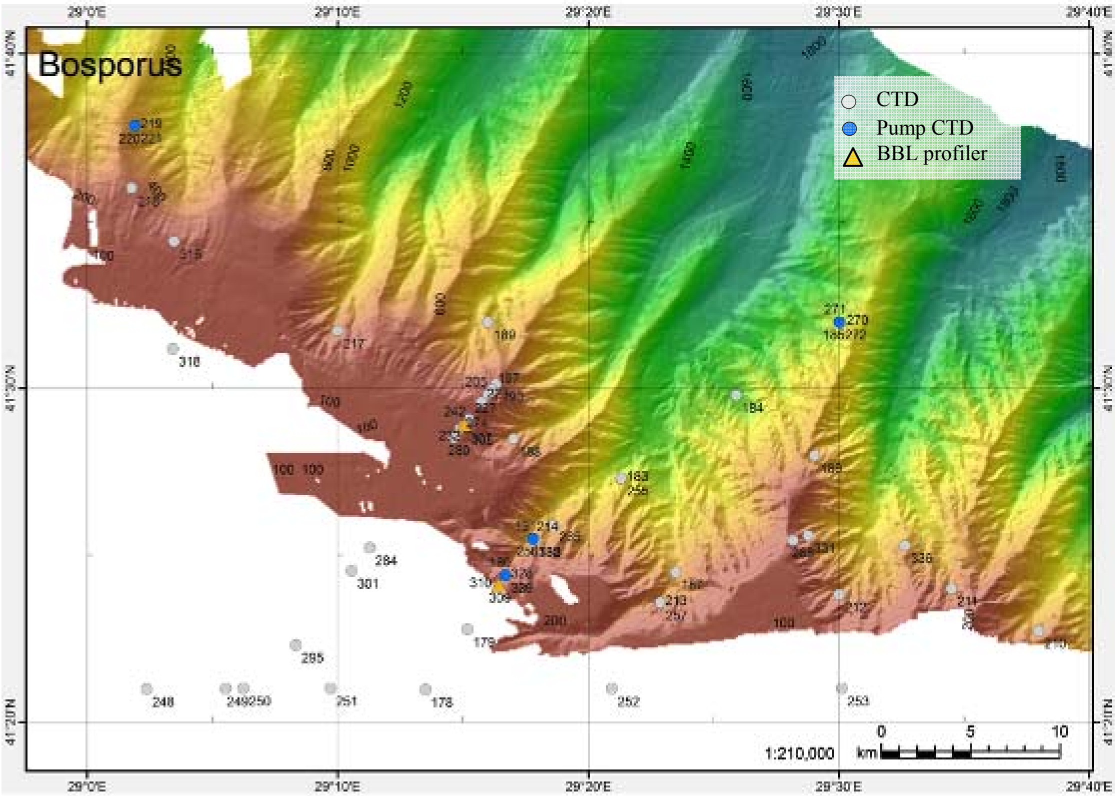

Fig. 5.7 Map of the CTD casts for the Bosporus area.

The first set of CTD profiles showed that there were no intrusions of warm and salty oxic waters that are considered as typical for this area, so the next casts were planned on the canyon and on the shelf edge. This was done because bottom contours can affect fingering, and the multiple channeling of the plume crossing the shelf can result in various entry points into the water column after the shelf break (Glazer et al., 2006). The oxygen profiles for this area are plotted in Fig. 5.8.

The data obtained from the oxygen sensors of the CTD (Fig. 5.8) was corrected with the values obtained from the corresponding depths from Winkler analyses on board.

The absence of evidence of recent Bosporus inflow for all the casts carried out between the 12th and the 18th of April can be due to previous weather conditions. The strong northerly winds that prevailed before the cruise probably piled up surface waters, which blocked the deep outflow of the Bosporus. This is confirmed by the tens of CTD casts in all parts of the working area that showed only traces of older filaments of Marmara Sea waters, which have already lost their oxygen.

Only the last CTD cast at St. 328 finally detected a strong filament of Marmara waters (Fig. 5.9).

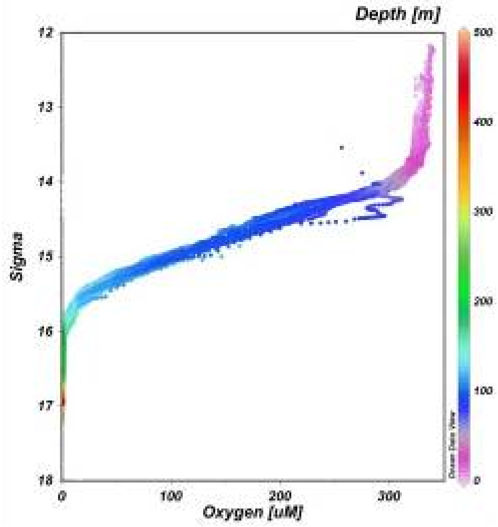

Fig. 5.8
Oxygen concentration profiles for all CTD casts in the Bosporus area.

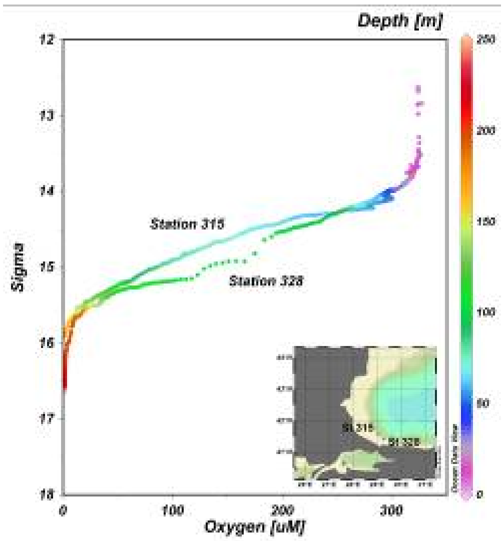

Fig. 5.9
Oxygen concentration profiles, where the Bosporus plume was detected.

5.2.3 Watercolum sampling (Pump-CTD)

(G. Lavik, M. Holtappels, Y. N. Ishan, A. Lichtschlag, G. Klockgether)

The Black Sea is the world's largest anoxic basin and has been considered a model system for anoxic systems in general. The stable succession of stratification is oxic-suboxic-anoxic with restricted vertical mixing. Lately the importance of lateral intrusions of Mediterranean waters into the anoxic layers has received increased attention. The warm and saline Mediterranean surface waters overflowing the Bosporus Strait are denser than the low saline surface water in the Black Sea and is laterally injected into the anoxic parts of the water column, with important implications for the element cycling (Konovalov et al. 2003, Schippers et al. 2005) and nutrient balance (Lam et al. 2007) throughout a large part of the Black Sea. The overflow of this saline Mediterranean water is at the same time the basis for the strong density structure preventing ventilation of the deep Black Sea basin. However, both the physical dynamic of the inflow events (*see* 5.2.1 Argo floats) as well as the direct effect of the Bosporus overflow water on the microbial structure and biogeochemical processes is poorly known.

The Bosporus water is carried eastward by the coriolis driven rim current, and to study the effect of the inflow waters we sampled the water column east and west of the Bosporus, as well as where the deepest channels across the shelf is entering the deep Black Sea basin from the Bosporus channel (Fig. 5.10). The immediate effect of the oxygenated water in the anoxic/sulfidic water column could lead to blooms of sulphide oxidizing bacteria which might also use nitrate as an electron donor (i.e. Lavik et al. 2009). However, the effect of oxygen is not necessarily gone when no free oxygen is measurable in the water column, but part of the oxygen can be stored in form of i.e. nitrate/nitrite, manganese oxides, iron oxides, upon ammonium, manganese and iron oxidation. Probably due to enhanced microbial activity as well as all of these oxidized elements (except nitrate) are particles, these warm and saline Bosporus intrusions can be tracer way into the Black Sea in form of enhance turbidity. During MSM 15/1 we could not find any fresh intrusions with oxic water layers underlying sulfidic waters, but at station MSM15-272 we could find a massive warm intrusion at ~300m water depth (16.8 sigmaθ, Fig. 5.10).

We used a combination of nutrient measurements, various $^{15}N/^{13}C/^{18}O$-incubation experiments with additions of manganese oxide an sulfide to stimulate particular microbial activities, as well as DNA/RNA based techniques to investigate the processes responsible for nitrate/nitrite reduction, ammonium oxidation and oxygen consumption from the oxic to anoxic part of the Bosporus inlet area. A normal CTD-Rosette system was used for the sampling of nutrients, incubations water and molecular work. Additionally, we tested out a newly developed free falling pump-CTD system for continuous water sampling independent of ship movement at the four main stations for water column work (*see* 6. station list). The Pump-CTD system was additionally equipped with fast responding oxygen microsensors to detect minor oxygen intrusions.

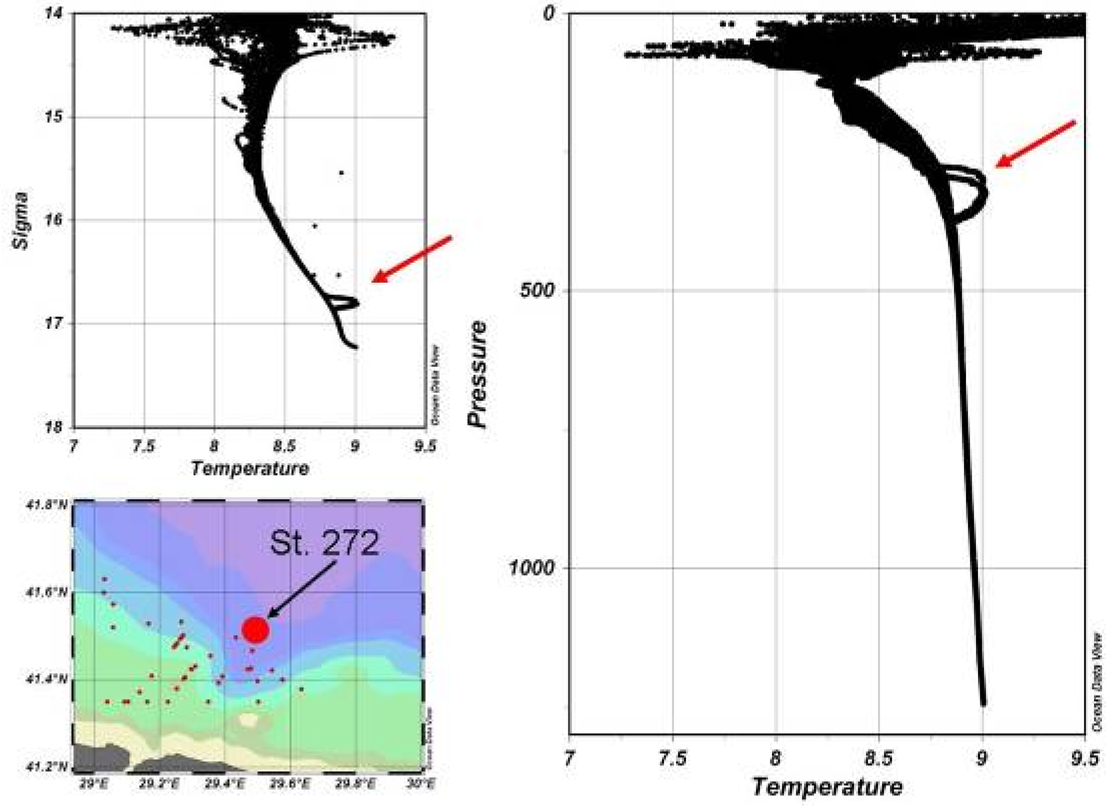

Fig. 5.10 Overview of the CTD stations during MSM 15/1. The only major intrusion of warm and saline Bosporus overflow water that was detected at station 270/272 is marked by an red arrow.

5.2.4 Benthic Boundary Layer

(M. Holtappels)

The inflow of Mediterranean water through the Bosporus Strait is the only source of saline water into the Black Sea. This inflow establishes a permanent halocline in the Black Sea, which reduces the mixing and thus the transport of oxygen to deep waters. Despite the importance of the inflow for the overall Black Sea budget, the transport of inflowing water masses along the shelf and slope topography is still poorly described. To identify inflowing water masses by their salinity, temperature and oxygen anomalies in the bottom water we used an automated sampling device called "BBL-Profiler".

The BBL-Profiler (Fig. 5.11) is deployed to the seafloor. It is equipped with CTD, Acoustic Doppler Velocimeter (ADV), oxygen optode and turbidity sensor, which are mounted to a sled to measure salinity, temperature, current velocity, oxygen concentration and turbidity in a high vertical resolution.

In the Bosporus region, the BBL-Profiler was deployed at two stations (~150m depth). During each deployment, one complete profile was measured over a time period of 30 minutes. Preliminary results show no significant differences in temperature, salinity and oxygen compared to the above water column suggesting that the bottom water hydrography was not influenced by the Bosporus inflow. This agrees well with the disappointing fact that hardly no inflow event was detected by the CTD survey during our stay in the Bosporus region.

Fig. 5.11
The BBL-Profiler.

5.2.5 Geological coring

(Z. Erdem, U. Ülgen)

Geological coring was done in the Bosporus area by ITU, EAWAG, MPI and IBSS (Fig. 5.12). Coring sites were selected using the seismic profiles obtained during the R/V ARAR-09 cruise. Coring for different purposes was done with 5 different devices: ITU gravity corer, EAWAG gravity corer, MARUM long gravity corer, TV-MUC and box corer (for detailed usage of samples *see* APPENDIX Section A.2, sediment sampling list).

In the Bosporus area 17 TV-MUC deployments were done, each with 8 transparent pipes (9 cm diameter and 60 cm length). In total 77 cores were recovered from TV-MUC deployments-30 for IBSS, 46 for MPI and 1 for ITU (for detailed core description *see* APPENDIX Section A.3 TV-MUC Core descriptions).

For short coring ITU and EAWAG corers were used. Altogether 36 cores were taken with the ITU corer (7 cm diameter PVC pipes with lengths of 1.2-1.5 meter) for chemical and physical analysis. 5 of these cores were used by IBSS for sampling of benthic organisms. With the EAWAG corer (6.3 cm diameter transparent PVC pipes with lengths of 1-1.5 meter) 8 cores were recovered.

Long coring was done with the MARUM long gravity corer and the EAWAG corer. On two stations (St. 234 and St. 291) 12m-long pipes were used and two cores with 7.6 and 2.2 meters were recovered. On St. 291 the corer was bended, therefore coring continued with 6 meter pipes and 2 cores with lengths of 4 and 4.6 meters were recovered (St. 320 and St. 325). With the EAWAG corer two long cores with 3 meter long pipes were used. One long core was taken by ITU and the second one was sampled for noble gases.

For benthic sampling 13 box cores were recovered from 8 different locations. The samples were processes by the scientists of IBSS board.

ITU-EMCOL is going to analyze the sediment cores collected in the Istanbul Strait's outlet area of the Black Sea during the 15/1 cruise, using Multi-Sensor Core Logger (MSCL) for physical properties, total organic (TOC) and inorganic (TIC) contents and Itrax XRF Core Scanner for inorganic (elemental) geochemical analysis. The analyzed proxies will be used to reconstruct the changes in the past redox and climate conditions at high resolution. The processing of the other sediment cores will be described in the following sections.

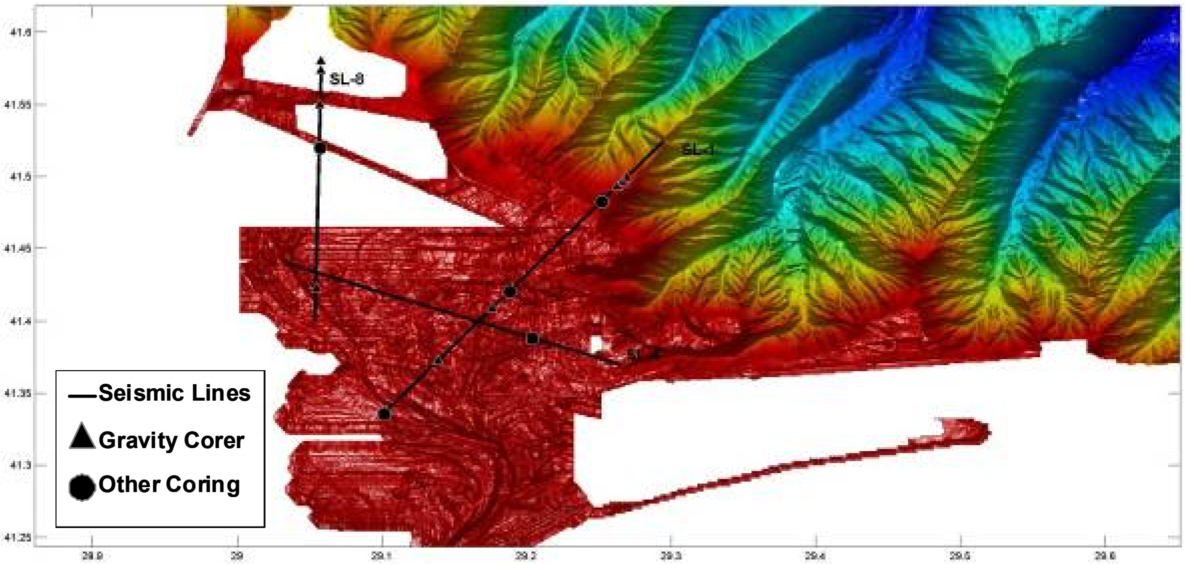

Fig. 5.12 Bathymetrical map of the study area (Bosporus outlet area). Black lines are seismic lines (SL1, SL2 and SL8) analyzed for selecting geological coring locations. Black dots are locations with long gravity coring and triangles are other coring locations.

5.2.6 Nobel gases

(R. North)

Black Sea sediment samples were collected in order to measure noble gas concentrations of the pore water. Dissolved atmospheric (noble) gas concentrations depend on, and thus reflect the physical conditions of the surface water during the last air-water partitioning (Aeschbach-Hertig et al., 1999). As a result, noble gas concentrations of the pore water are useful as tracers to determine past oxygen and salinity concentrations of the water body. The method has been proven as an effective tracer of environmental change in the sediment pore waters of freshwater (Brennwald et al., 2004) and saline (Tomonaga, 2010, Tomonaga et al., in review) systems.

For a complete description of the noble gas sampling methods used, and the theory behind the method, the reader is referred to Brennwald et al. (2003), Brennwald et al. (2004), Tomonaga (2010) and Tomonaga et al. (in review). Sediment cores were taken using a light gravity corer (providing approx. 1-2m long cores), and "squeezed" to transfer samples into copper tube sample containers (spaced along the length of the core). The method ensures the samples are not exposed to the atmosphere or other potential contamination sources.

Noble gas samples were taken at three locations in the Bosporus inflow area. The first sample taken at a depth of 300 m produced a lot of free gas when brought on board. As a result, these samples are not expected to produce significant results due to the stripping of noble gases from the pore water by the gas bubbles. Cores taken at 159 m and 96.4 m, successfully obtained six samples each, with 20 cm spacing between each sample. At each site a second core was taken for dating purposes.

The core sites were chosen to represent oxic (96.4 m), hypoxic (159 m) and anoxic (300 m) zones, as well as attempting to obtain samples above and below past anoxic boundaries, and hypothesized freshwater shorelines. The noble gas content could give insight into salinity and oxygen conditions before and after the Mediterranean-Bosporus connection. It is still unclear whether or not the cores reached these boundaries and will require dating of the samples.

Presently the samples are being processed. The sediment is separated from the pore water and the noble gas contents of the latter are measured using a mass spectrometer.

5.2.7 Biogeochemistry and microbiology

(D. Donis, G. Jessen, A. Lichtschlag)

The Bosporus outlet area is characterized by the lateral intrusions of oxygenated Mediterranean waters into the anoxic water column of the Black Sea. The variability of the seasonal mixing of the two water masses can play a crucial role in the salinity, water budget, and chemical composition of the Black Sea water column, however, the effect on the sediment biogeochemistry and the benthic microbial composition is largely unknown. To investigate biogeochemical processes and adaptation of benthic microorganism in this area subject to variable oxygen concentration, sediment and pore water from TV-MUC cores were analyzes on board and additionally preserved for various geochemical and microbial analyses in the home laboratories.

Biogeochemistry

Pore water was sampled at in a cold room set to in situ temperature (8°C) directly from sediment using Rhizon soil moisture samplers. The samplers were connected to standard syringes using luer-lock fittings and PVC tubing. Evacuating the syringe by drawing the piston was sufficient to withdraw filtered pore water from the sediments. 5 mL syringes were used to sample pore water every cm for the first 10 cm and 10 mL syringes were used to sample every 2 cm until 30 cm (2 arrays for each core) (Fig. 5.13).

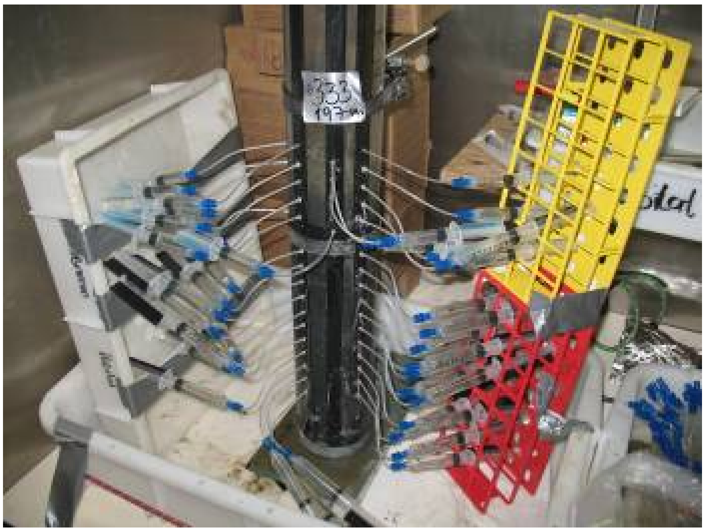

Fig. 5.13
Rhizon array on a sediment core.

After pore water extraction nitrite, hydrogen sulphide, alkalinity and ammonia (Table 5.1) were analyzed directly on board with spectrophotometerical methods according to protocols kindly provided by IFM-GEOMAR. Care was taken to analyze pore water samples immediately after extraction, especially for sulphide due to its high volatility. Total Alkalinity was measured by titration with 0.02M HCl. Ammonium was measured by adding Phenol solution to 1 cm^3 sample; after 2 minutes 0.1 cm^3 citrate buffer and 0.2 cm^3 DTT reagent were added. After mixing, the samples were kept protected from sunlight for about 10 hours under room temperature, before the absorbance was measured at 630 nm. For hydrogen sulfide measurement 1 cm^3 sample was added to 50 µl of the zinc acetate gelatine solution into an Eppendorf tube. The ZnS was kept in colloidal solution. Afterwards, 10 µl of the colour reagent (400 mg N,N-Dimethyl-1,4-phenylenediamine-dihydrochloride dissolved in 100 cm^3 HCl (6N)) and 10 µl of the catalyst (1.6 g $FeCl_3$ * 6 H_2O dissolved in 100 cm^3 HCl (6N)) were added. Absorbance was measured after 1 hour at 670 nm. For nitrite measurement 0.1 cm^3 sulphanilamide-solution and 0.1 cm^3 NED-solution were added to 5cm^3 sample. The absorbance of the red azo dye was read after 30 minutes at 540nm.

Table 5.1 Sediment and pore water analyzes in the Bosporus area. SRR: sulfate reduction rates; AODC: acridine orange direct counts; DIC: dissolved inorganic carbon, TA: total alkalinity.

Station	Latitude	Longitude	depth (m)	sediment sampled for	pore water fixed	pore water analyzed on board
224	41° 29.59' N	29° 15.74' E	196	SRR, AODC/FISH, DNA, RNA, porosity, methane, ARISA, Corg, C/N, organic + inorganic geochemistry	sulfate, sulfide, nutrients, DIC, TA, DICisotopes, dissolved Mn/Fe	nitrite, ammonium, sulfide, TA
243/264	41° 28.92' N	29° 15.06' E	153	SRR, AODC/FISH, DNA, RNA, porosity, methane, ARISA, Corg, C/N, organic + inorganic geochemistry	sulfate, sulfide, nutrients, DIC, TA, DICisotopes, dissolved Mn/Fe	nitrite, ammonium, sulfide, TA
285	41° 25.21' N	29° 11.29' E	97	SRR, AODC/FISH, DNA, RNA, porosity, methane, ARISA, Corg, C/N, organic + inorganic geochemistry	sulfate, sulfide, nutrients, DIC, TA, DICisotopes, dissolved Mn/Fe	nitrite, ammonium, sulfide, TA
332	41° 29.94' N	29° 16.11' E	253	SRR, AODC/FISH, DNA, RNA, porosity, methane, ARISA, Corg, C/N, organic + inorganic geochemistry	sulfate, sulfide, nutrients, DIC, TA, DICisotopes, dissolved Mn/Fe	nitrite, ammonium, sulfide, TA
333	41° 29.66' N	29° 15.82' E	200	ARISA	sulfate, sulfide, nutrients, DIC, TA, DICisotopes, dissolved Mn/Fe	nitrite, ammonium, sulfide, TA

In addition, pore water was extracted with the same procedure and preserved for further laboratory analyses (Table 5.1). For sulfate/sulfide concentration measurements 1mL pore water was fixed Eppendorf tubes with 500µL ZnAc and stored at 4°C. For nutrient analyzes about 10 mL pore water were frozen without fixation in 15 mL plastic vials at -20°C. For DIC/alkalinity analyzes 2mL pore water were stored headspace-free in glass vial at 4°C; 2mL pore water for DIC isotopes measurements were stored headspace-free in glass vial at 4°C. Finally, 0.8-1.3mL pore water was fixed in Eppendorf tubes with 200µL HCl for dissolved Mn/Fe determination and stored at 4°C.

For sediment sampling cores were sliced every centimetre for the first 10 cm and every 2 cm until 30 cm at in situ temperature (8°C), sampled were preserved for the following analyses. For porosity, sediment was sampled stored at 4°C in 5mL cut syringes. For methane concentration analyzes 5 mL of sediment was added to 10 mL NaOH (2.5%), in 20 mL gas tight Crimpvials and stored at 4°C. For sulfate reduction rate measurements 2 subcores from each sampled station were injected with 10µL of tracer (2010-1-1), incubated, sliced and stored in ZnAc. In addition, sediment was frozen for further geochemical analyzes (solid phase iron and manganese, elemental sulfur, Corg, C/N, d13C and d15N (MPI, Senckenberg Institute) and determination of organic components (EAWAG, MPI).

Microbiology

In order to evaluate the influence of oxygen levels on microbial community diversity and composition at the sediment/water interface, TV-MUC samples were retrieved (*see* Table 5.1). At every site, 3 different cores were taken and sliced every cm for the first 10 cm and every 2 cm until 30 cm at in situ temperature (8°C), sampled and preserved according to the different molecular approaches and analyses. Samples were taken for analyzes of general microbial diversity, acridine orange direct counts (AODC), fluorescence in situ hybridization (FISH), DNA, RNA and community fingerprinting methods. For AODC, 2mL sediment was added to 9mL formaline sea water, preserved in a scintivial at 4°C. A subsample of 0.5 mL of the sediment was taken and fixed in 2 mL Et-OH in a cryovial and preserved at -20 °C for FISH. DNA samples were stored in 15 mL tubes at -20°C, and RNA samples at -80°C. In order to evaluate the dynamics of microbial community structure associated with dynamics in oxygen depletion at the sediment/water interface, a quantitative version of ARISA, called qARISA will be performed according to the methodology proposed by Ramette (2009) (Fig. 5.14) with the purpose of a detailed quantitative description of specific operational taxonomic units (OTUs) within the microbial community inhabiting the sediment in the Black Sea. These will finally be combined with the geochemical parameters measured on parallel samples.

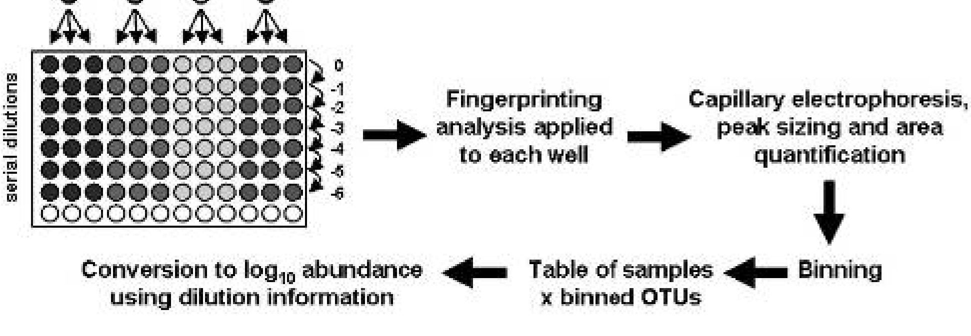

Fig. 5.14 qfingerprinting strategy (from Ramette 2009).

5.2.8 Biology

(N. Sergeeva, M. Gulin., S. Mazlumyan)

The main task of the scientific team of the Institute of Biology of the Southern Seas (IBSS) during the MARIA S. MERIAN 15/1 cruise was the investigation of benthic organisms in accordance with the work proposed in the HYPOX project (WP3, 4 and 6). For the Bosporus inflow area this includes (i) comparison of benthic fauna diversity, density and biomass, (ii) analyses of benthic community structures and adaptation (community structure as potential indicator for oxygen depletion) (iii) taxonomic investigation of meiobenthos as redox indicator in oxic/anoxic interfaces of the Black Sea, (iv) studies of the boundary of the habitat of the mollusk *Modiolula phaseolina* (Philippi, 1844) in the Black Sea and (v) studies of benthos distribution in connection with depth fluctuations of the oxygen/sulfide-chemocline.

One specific task was the search for living fauna in the zone where hydrogen sulfide is permanently present in the bottom water. Investigations were based on earlier published data, where living metazoa was discovered under permanent anoxic conditions of the Black Sea for the first time (Sergeeva 2004, Korovchinskiy and Sergeeva, 2008).

In the Bosporus inflow area seafloor sediment sampling was done along one transect with a sediment sampling depth ranging between 83-294 m water depth. Important material for the investigation of the modern structure of macrobenthos and meiobenthos communities along a depth gradient crossing the oxic/anoxic interface was obtained. The sediment cores (gravity cores and TV-MUC cores) were sectioned into the following horizontal layers: 0-1, 1-2, 2-3, 3-4, 4-5cm. In these sections the depth distribution of benthic fauna in the sediment and the vertical fauna distribution patterns at small spatial scales were analyzed. Furthermore, meiobenthos structure was studied and microscopic observations of living fauna were done. The examination of the sediments sampled during coring was done in the laboratories of the R/V MARIA S. MERIAN. Stations investigated by IBSS are listed in the sediment sampling list in APPENDIX section A.2.

Preliminary Results

In the home laboratories (IBSS) preparative work (sorting of fauna to high taxonomic level, numerical determination of organisms, species identification, etc.) for further detailed analyses and estimation of biological diversity, abundance, biomass and boundaries of distribution of the benthic species was done.

Preliminary results showed that in the Bosporus inflow area meiobenthos was present in all studied depths (83-294m). The taxonomical structure of meiobenthos was diverse. We were able to record a specific benthos community along the oxic/anoxic interface in Bosporus inflow area. This specific community includes representatives similar to those found in some communities along the oxic/anoxic interface of the NW part of the Black Sea (Sergeeva and Zaika 2008, Zaika, 1999; Zaika et al. 1999).

Additionally, during the R/V MARIA S. MERIAN cruise for the first time sediments in the Bosporus region underlying a permanently hydrogen sulfide containing water column (250-300 m water depth) was searched for living fauna. Using light microscopy actively moving protozoans (large ciliates) and metazoans (free-living nematodes) were observed in these sediments. These observations were recorded on video. We assume that these living organisms are no contaminations from the water column. This is an unique scientific result providing clear evidence that benthic eukaryotes can live under hypoxic/sulphidic conditions in the Black Sea.

In addition, macrobenthos was found at a water depths range between 83-252m in TV-MUC cores and at a water depths range between 96-153m in box cores. Among macrobenthos we found representatives of Hydrozoa, Porifera, Polychaeta, Oligochaeta, Turbellaria, Bivalvia, Gastropoda, Malacostraca, Echinodermata, Anthozoa and Tunicata. Between 200-252m depth only Hydrozoa, Polychaeta, Oligochaeta, Malacostraca and Tunicata were detected.

5.3 Oxygen monitoring at the Crimean Shelf edge

5.3.1 Nemo floats

(F. Janssen, M. Bussack)

The NEMO float is an ARGO-type floating oceanographic observatory that is manufactured by OPTIMARE (Bremerhaven, Germany). Following a pre-programmed measurement cycle these floats produce subsequent vertical profiles of physical properties of the water column. In line with the goals of the HYPOX project and following the white paper on the addition of oxygen sensors to the global ARGO array (Gruber et al., 2007) an oxygen sensor was added to the NEMO floats in addition to the standard ARGO float sensors for conductivity, temperature and pressure. Returning to the surface after the measurement profile the instrument transmits date, time and geographic position together with the collected data via Iridium telemetry in Short Burst Data (SBD) packages. After data transmission the system sinks to a preprogrammed parking depth where it drifts for a defined period of time until it is time for the next upward profiling.

Two floats (Serial number 144 and 145, purchased by the AWI HGF-MPG Bridge Group on Deep Sea Ecology and Technology and the GKSS Institute for Coastal Research, respectively) were deployed off the Crimean Shelf on 7. May 2010, the last day of station work during leg MSM 15/1 (Fig. 5.15). The missions of both instruments followed a similar scheme with a measurement cycle of five days, a profile depth of 500, and a parking depth of 450 meters. However, in order to investigate the suitability of different oxygen monitoring strategies the measurement routines of the two floats differed in some details: the mission of AWI/MPG float 144 was focusing on the upper, potentially oxic water layer with a coarser vertical resolution in the presumable oxic water column below 240 m water depth. The reduction in the amount of data that have to be collected and transmitted (116 of instead of 256 data points per profile for the GKSS float) was expected to extend the battery life and the total number of profiles during the float lifetime without loosing information on the oxygen distribution.

A preliminary analysis of data from the first 4 months shows that the floats so far remained in relatively close vicinity of the deployment position (Fig. 5.16). This is a surprise as the systems were expected to immediately drift westward with the rim current, a strong large scale current that flows counterclockwise in parallel to the coastline in the entire Black Sea.

Fig. 5.15
NEMO float 144 upon deployment. Close to the water surface the rope that was wrapped around the instrument body was released.

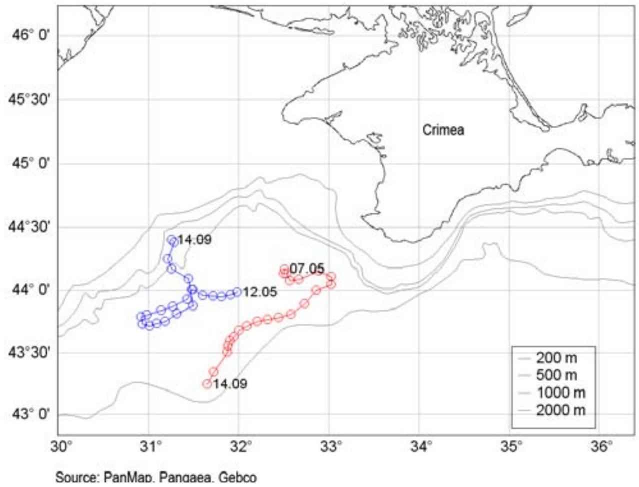

Fig. 5.16
The drifting tracks of AWI-MPG float 144 and GKSS float 145. Each circle depicts the location of one surfacing and data transmission event.

An example profile (Fig. 5.17a) shows the close connection between oxygen content and water column physical properties with a characteristic co-occurrence of the pycnocline (where salinity (and density) increase) and the oxycline (where dissolved oxygen concentration drops). However, the position of the oxycline shows a large variability (Fig. 5.17b). As a consequence, the oxygen concentration at a given depth strongly varies as a function of time with potentially substantial consequences for the ecosystem (Fig. 5.17c). It cannot be ruled out that the observed changes are in part due to spatial variability. However, they are most likely also the result of temporal oscillations as they were also observed in Crimean Shelf bottom waters throughout the cruise leg.

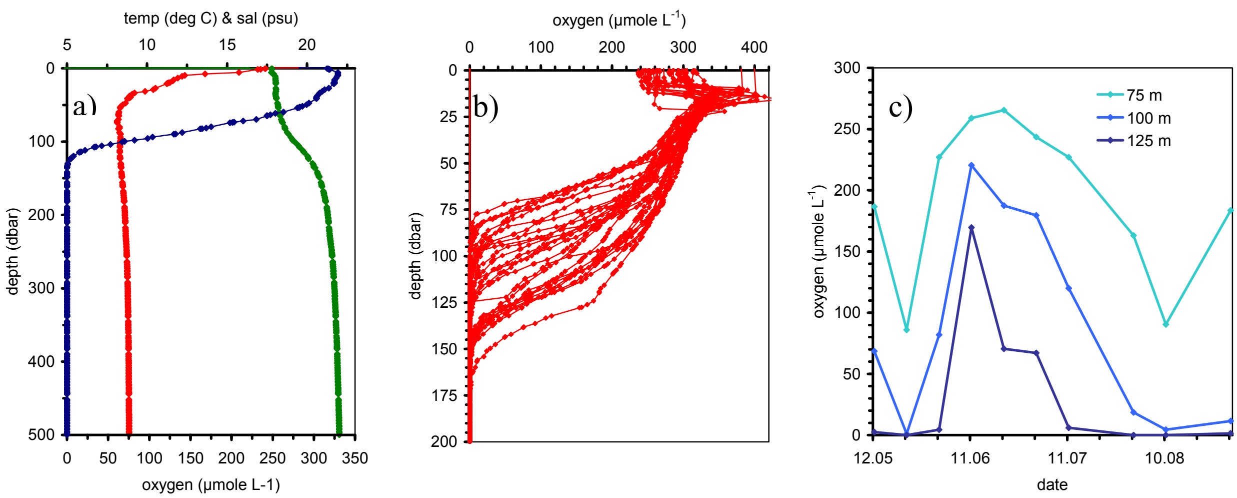

Fig. 5.17 Example data: (a) the first profile of float 145 showing temperature (red), conductivity (green) and dissolved oxygen concentration (blue); (b) all oxygen profiles measured by float 145; (c) time series of dissolved oxygen concentrations for depths of 75, 100, and 125 m.

5.3.2 CTD

(S. Albrecht, D. Donis, G. Jessen)

Objective

In the Crimea area the CTD casts were carried out to investigate the chemocline depth. Two areas were investigated: Crimea I defined by 31° 54´E – 32° 2´E and 44° 46´N- 44° 50´N and Crimea II defined by 32° 40´ E - 33° 15`E and 44° 30` N - 44° 50´N.

In the Crimean areas (I and II), the sampling has focused on the shelf edge between the bathymetries of 100 and 200 m. The deployments were planned in order to have transects of oxygen concentration across the slope.

CTD casts

Conductivity-temperature-depth (CTD) casts were carried out using the same Sea-Bird Electronics, Inc. SBE 911plus system as described in chapter 5.2.2. In total 39 CTD casts were carried out in the Crimean area (Fig. 5.18 and Fig. 5.19 , for details *see* APPENDIX, section A. 2, water column sampling list).

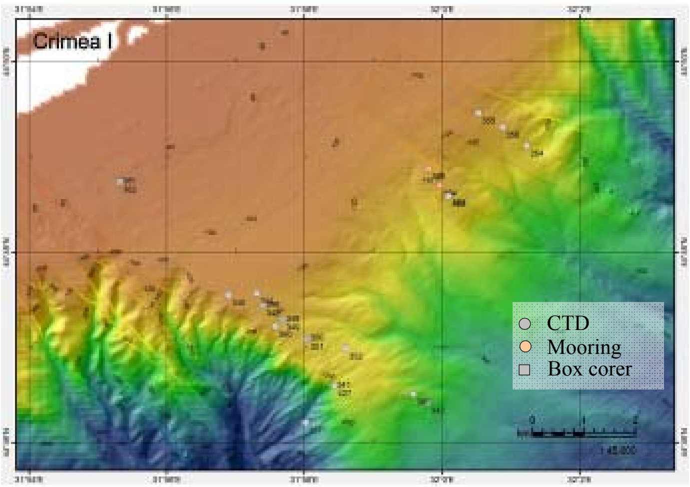

Fig. 5.18
Map of CTD casts, mooring sites and locations of sediment sampling by box corers in the Crimean area I.

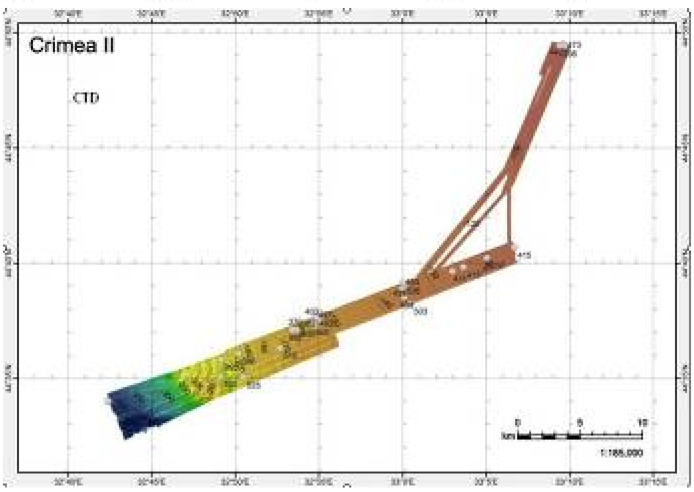

Fig. 5.19
Map of CTD casts for Crimean area II.

From the CTD profiles we can see how the near shore mesoscale dynamics have their influence on chemocline processes and transversal exchange between shore and open water (Fig. 5.18, Fig. 5.19).

The isolines pattern that we see in Fig. 5.19 occurs when water from the shore is flowing downwards the shelf.

As for the previous area, samples were collected from the Rosette to carry out chemical measurements, and the data from the CTD´s oxygen sensor was corrected with the values obtained for the corresponding depths with Winkler analysis on board.

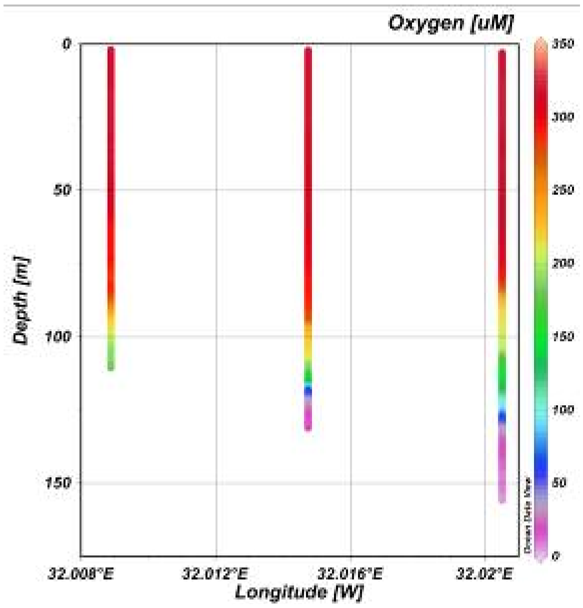

Fig. 5.18
Oxygen concentrations for St. 354, 355, 358 (Crimea I).

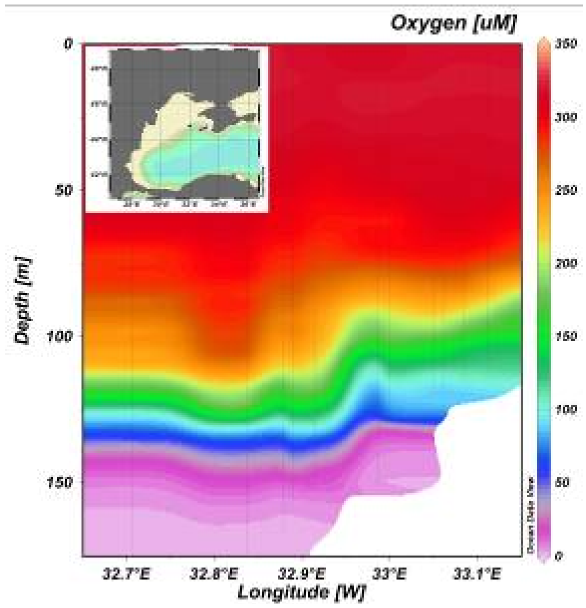

Fig. 5.19
Oxygen concentrations for transect from St. 368 - 415 (Crimea II).

5.3.3 MEDUSA surveys

(N. LoBue, G. Marinaro, F. Furlan)

The objective of the MEDUSA surveys in the Black Sea was to perform an instrumental and visual exploration, including oxygen, methane and CTD measurements, in selected hypoxic-anoxic areas and in correspondence with gas seeps on the Crimea Shelf. The MEDUSA team embarked on MARIA S. MERIAN on April 19th in Port Eregli.

During the survey MEDUSA transmitted in real-time to its Surface Control Unit all data collected by the scientific payload (Table 5. 2), acquired at 1 Hz sampling rate.

A POSIDONIA transponder was added to MEDUSA in order to provide a precise positioning at sea. MEDUSA (Fig. 5.20, 5.21) was completely assembled on 19th April and the surface control unit was installed in the ship hangar. The surveys started on April 20th. Before each Medusa dive, CTD casts were performed in order to provide a water column reference and water samples were collected to perform analytical analysis of oxygen (Winkler Titration) to be compared with the optode measurements.

In total 6 transects were carried out, which included data recording along vertical profiles (cast) and horizontal survey (towing) (Fig. 5.22). For detailed description of the MEDUSA transects, *see* APPENDIX, Section A.6.

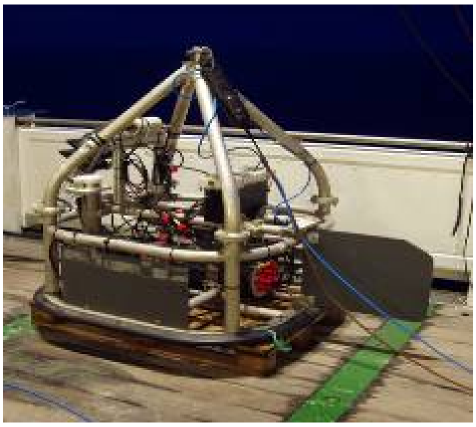

Fig. 5.20:
MEDUSA system.

Fig. 5.21
Chimneys of seep found at St. 367.

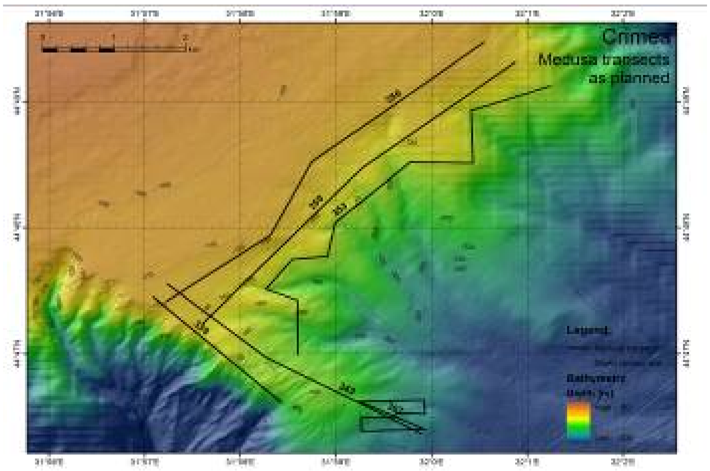

Fig.5.22
Map of the six transects surveyed by MEDUSA.

Table 5.2 MEDUSA deployments.

DESCRIPTION	MODEL-MANUFACTURER	RANGE	RESOLUT.	RESPONSE TIME
CH_4 sensor (1)	K-METS – Franateci	0.01-10 µM	2 nM	~ 2 min
CH_4 sensor (2)	HydroC – CONTROS	0.1-100 µM	10 nM	~2 min
O_2 sensor	Optode 3830 – AANDERAA	0-500 µM	<1 µM	< 25 s
TV camera + light	Multi SeaCam 1060 – DEEPSEA POWER&LIGHT			
CTD	SBE-19plus	0-9 S/m -5;35 °C 7000 dbar	0.00007 S/m 0.0001°C 0.002% f.s.	
Turbidimeter	Wet labs ECO-NTU, controlled by CTD	0.0024-5 m^{-1}		

5.3.4 JAGO dives

(K. Hissmann, J. Schauer, T. Klagge and science team)

The manned submersible „JAGO“ (Fig. 5.23), operated by IFM-GEOMAR in Kiel, was used during MSM 15/1 for in situ documentation of the habitat, oxygen monitoring along transects close to the sea floor, and for sampling near-bottom water and sediments with push cores. The submersible has a maximum operating depth of 400 m and is therefore an ideal tool for a working area like the Crimean Shelf. JAGO can accommodate two persons, the pilot and a scientist/observer. The highly manoeuvrable vehicle has two large acrylic dome ports, one at the front (diameter 70 cm) and one at the top (45 cm). It is electrically driven and moves autonomously within the reach of the navigation and communication systems on board the support vessel. JAGO is equipped with USBL underwater positioning system, fluxgate compass, vertical and horizontal sonar, underwater telephone, digital video (HDV) and digital still cameras, CTD and a manipulator arm for collecting and handling sampling devices.

The compact size of JAGO (3 x 2 x 2.5 m LWH) and its relatively small weight of 3 tons allow a launch and recovery from a wide variety of ships with sufficient crane capacity (min. 5 tons SWL). The submersible operates worldwide and is regularly used from on board the German research vessels among which R/V MARIA S. MERIAN is one of the most suitable for JAGO. The vessel is an extremely stable platform, has a large working deck, and possesses three deck cranes with sufficient lifting capacity and outreach for save handling. Very helpful for the submersible operation is the "follow target mode" in the vessel's dynamic positioning system. It enables the vessel to automatically follow a moving target.

During MSM 15/1 JAGO was launched and recovered with deck crane #3 at the starboard aft deck. Both crane operators (N. Bosselmann, N. Kreft) knew JAGO from previous cruises, were familiar with the handling procedure and therefore assured safe launching and recovery. A recently purchased work boat (6 m DSB inflatable with aluminium hull and 60 HP Yamaha outboard engine) was used to tow JAGO away from the ship's side after deployment and back under crane position for recovery. While submerged, JAGO was tracked by POSIDONIA 6000 (USBL underwater positioning system from IXSEA), part of the ship's equipment (including Mini-transponder MT 861S-HD-R mounted on JAGO). The position data (ship and sub) were integrated into MIMOSA navigational software to display and follow both JAGO and MERIAN tracks upon GIS based bathymetric map layers in real time. The ship automatically followed JAGO in "follow target" mode. Communication between JAGO and MERIAN were maintained by acoustic underwater telephone ORCATRON and the ET/RT8x1 transponder (IXSEA) that is permanently installed on an extendable pole inside the vessel's bow.

Oxygen concentrations were measured with an Aanderaa oxygen optode (AADI 3830 S/N848) that was attached to JAGO's bow, approximately 40 cm above its lower side. The optode was connected via RS232/USB serial adapter to a Laptop for continuous data display and logging inside the submersible. Measurements were taken during the entire dive, during de- and ascent and while flying close over the seafloor along transects of various lengths (*see* Tab. 5.3). The habitat was continuously video-documented with a SONY HDV Camcorder HVR-V1E mounted in the centre of JAGO's large front viewport. After each dive, post-processing of the original HDV video footages provided digitized copies of the video material with overlaid UTC time code for evaluation by the science party. During each dive, video still images were captured by video-grabber from the running camera. These images were integrated into the ALAMER dive protocol (detailed dive protocols are available in the APPENDIX, Section A.1), which was used by the observer inside JAGO to log observations and activities. Near-bottom water samples were taken with a 5 L NISKIN bottle attached to the port bow of the submersible. Sediment, sediment in-fauna and microbial mats were collected with push cores of 255 mm inner length and 72 mm diameter, max. 6 per dive. The push cores were stored in the sampling basket at the lower front of the submersible. The sampling site was marked with site markers. A CTD (SAIV A/S SD204 Norway) at the stern of the submersible continuously recorded depth, temperature, salinity and density during each dive.

Dive sites were selected based on the multibeam charts, which were produced during the cruise. During MSM 15/1, JAGO performed a total of 19 dives to bottom depths of 100 to 376 m, with usually two dives per day (Tab. 5.3). The total dive time was 45 hrs 25 min, the total distance travelled along the seafloor was 22 km. Eighteen different scientists and technicians participated in the dives. Most of them entered a human-occupied submersible for the first time and therefore gained an extraordinary personal experience. Most dives focussed on the hypoxic - anoxic transition zone (120-170 m depth) with measurements of the oxygen concentrations close to the bottom along long transects, push coring mainly of or in close vicinity to bacterial mats, and documentation of the sparsely benthic community. Dive 1110(5) was dedicated to the inspection of the four free falling instruments deployed at 150 to 153 m depth. JAGO detected all four instruments by horizontal sonar from a distance of about 150 m. Particularly the legs of the "Chamber lander" were found to penetrate too deep into the soft sediment and had to be adjusted for the next deployment of the lander. Dive 1117(12) was an "underwater-rendezvous" at 101 m depth between JAGO and the remotely operated benthic crawler MOVE (MARUM) (Fig. 5.24). JAGO documented in close communication with the vehicle control unit on board the MERIAN the in-situ measurements and movements of the moving lander system on the sea floor. Dive 1123(18) was a deeper dive for push coring in the permanently anoxic zone. The vertical distribution of the mega- and macro plankton within the water column above and below the chemocline was documented during Dive 1124(19), a free water dive and the last one of the cruise. During most of the dives, bottom currents were moderate. They helped to clear visibility after steering up sediment by settling on the soft bottom for sampling. At times, marine snow was found to be dense close to the sea floor.

Handling of the submersible from on board the MERIAN went extremely smooth thanks to the professional support from the entire ships crew on deck, bridge and work boat and due to mostly very calm sea conditions.

Fig. 5.23
MOVE under water, documented by JAGO.

Fig. 5.24
JAGO and MERIAN.

Table 5. 3 Short JAGO dive table (for a more detailed version *see* APPENDIX Section A.1).

JAGO Dive #	Project Dive /St.	Date	Location	UTC Time submerged	Time surfacing	Total dive time (min)	Distance (m)	Touch down position	Lift off position	Min-Max Depth (m)
1106	1 (372)	25/04/10	Crimea Shelf	8:50	12:37	227	2803	N 44°37.074 E 32°53.545	N 44°37.618 E 32°55.007	152-160
1107	2 (374)	25/04/10	Crimea Shelf	17:38	20:01	143	1695	N 44°37.180 E 32°54.449	N 44°37.078 E 32°53.486	154-161
1108	3 (394)	27/04/10	Crimea Shelf	13:36	16:56	200	1976	N 44°36.037 E 32°50.197	N 44°35.833 E 32°49.025	191-204
1109	4 (398)	28/04/10	Crimea Shelf	5:32	7:37	125	755	N 44°38.080 E 32°57.644	N 44°37.910 E 32°57.214	142-145
1110	5 (405)	28/04/10	Crimea Shelf	14:22	17:44	202	2034	N 44°37.219 E 32°54.792	N 44°37.298 E 32°55.089	150-153
1111	6 (412)	29/04/10	Crimea Shelf	5:26	8:05	159	1424	N 44°39.682 E 33°02.857	N 44°39.742 E 33°02.660	122-125
1112	7 (416)	29/04/10	Crimea Shelf	11:34	13:37	123	288	N 44°37.242 E 32°54.856	no USBL	150-153
1113	8 (440)	01/05/10	Crimea Shelf	6:25	8:17	112	1474	N 44°40.781 E 33.06.366	N 44°40.493 E 33°05.532	115-118
1114	9 (444)	01/05/10	Crimea Shelf	12:10	14:46	156	862	N 44°49.326 E 33°09.451	N 44°48.314 E 33°09.384	100-102
1115	10 (456)	02/05/10	Crimea Shelf	8:35	10:03	88	551	N 44°38.902 E 32°59.937	N 44°38.995 E 32°59.759	135
1116	11 (460)	02/05/10	Crimea Shelf	14:26	16:34	128	1623	N 44°38.898 E 32°59.977	N 33°00.259 E 33°00.126	131-134
1117	12 (477)	03/05/10	Crimea Shelf	5:58	8:31	153	567	N 44°49.203 E 33°09.339	N 44°49.273 E 33°09.339	101
1118	13 (482)	03/05/10	Crimea Shelf	12:16	14:54	158	625	N 44°49.077 E 33°09.401	N 44°49.979 E 33°09.349	101-102
1119	14 (486)	04/05/10	Crimea Shelf	7:00	9:07	127	1515	N 44°38.956 E 33°00.888	N 44°39.125 E 33°01.776	128-132
1120	15 (492)	04/05/10	Crimea Shelf	12:58	15:22	144	639	N 44°37.616 E 32°54.631	N 44°37.647 E 32°54.757	152
1121	16 (507)	05/05/10	Crimea Shelf	6:00	8:08	128	754	N 44°36.341 E 35°52.713	N 44°36.422 E 32°53.057	166-168
1122	17 (512)	05/05/10	Crimea Shelf	12:37	14:39	122	898	N 44°37.392 E 32°56.208	N 44°37.510 E 32°56.452	147
1123	18 (527)	06/05/10	Crimea Shelf	5:54	7:53	119	796	N 44°33.527 E 32°44.224	N 44°33.447 E 32°56.065	363-376
1124	19 (529)	06/05/10	Crimea shelf	9:47	11:38	111	855	N 44°35.281 E 32°49.480	N 44°35.048 E 32°49.156	40-135
Total	**19 dives**				**45h 25min**	**2725**	22134	**22 km**		

5.3.5 MOVE & payloads

(C. Waldmann, R. Düssmann, M. Bussack, F. Janssen, F. Wenzhöfer, A. Lichtschlag)

The underwater vehicle CMOVE (Fig. 5.25) has been developed and is now operated by the University of Bremen/MARUM since 2005. It has undergone several test and first science missions. It has now reached a degree of maturity that allows for using it in a versatile way. For the MERIAN MSM 15/1 cruise a number of biochemical sensors and instruments have been integrated into the vehicle frame. Due to its construction the vehicle is very flexible in regard to the integration of scientific payload. The frame can be extended by inserting separate modules or attaching instruments from outside.

Fig. 5.25
The underwater crawler CMOVE during deployment. All four scientific payload instruments can be seen. Starting from the left between the front wheels the elevator for the microelectrodes is shown. In the background with the red stripe the incubation chamber can be seen. The big green pressure housing is the MEGACAM and behind it the laser scanner Lance-A-Lot is mounted.

The electrical adaption is done by connecting the instruments to the power source of the vehicle and allowing the interfaces to be fed through the data link, which is realized by a fibre optic cable. For the MSM 15/1 cruise the following instruments have been integrated:

- Microelectrodes on elevator (microprofiling unit)
- Stirred incubation chamber with precision oxygen sensor
- High resolution camera MEGACAM
- Laser Scanning System Lance-A-Lot

Deployment and Recovery

Before the deployment the vehicle was fully charged (3 KWh) and the communication link was checked. All payload instruments are interrogated to assure a proper operation.

The deployment configuration as shown in Fig. 5.26 has been chosen as the fibre optic cable that is connected from the ship to the vehicle allows for a high speed connection that is an important prerequisite to be able to observe the seafloor with video cameras in real time. The depressor weight is necessary to keep the ship wire under tension. Due to the high drag of the vehicle lowering speeds of 0.2 m/s have to be chosen. For deep sea applications one could raise the lowering speed by attaching an additional dead weight that can be dropped before touching the seafloor. With this configuration only a limited lateral operating range of the order of 20 m can be realized. As the R/V MARIA S. MERIAN possesses a dynamic positioning system this is not a big issue as the transponders on the vehicle and the depressor weight can be used to let the ship follow the movement of CMOVE. The grey tube shown in the graph is a protection for the cable. The fibre optic cable had to be attached to the ship wire for every deployment. With deployment depths of 100-250 m this is not a big issue. However, for deeper deployments the fibre optic cable that is available on the research vessel would be used.

With this deployment procedure the optical link to the vehicle has to be disconnected until the system comes close to the seafloor. For the final 20 m the vehicle is lowered while the video camera is on. This allows for an excellent control of the landing procedure.

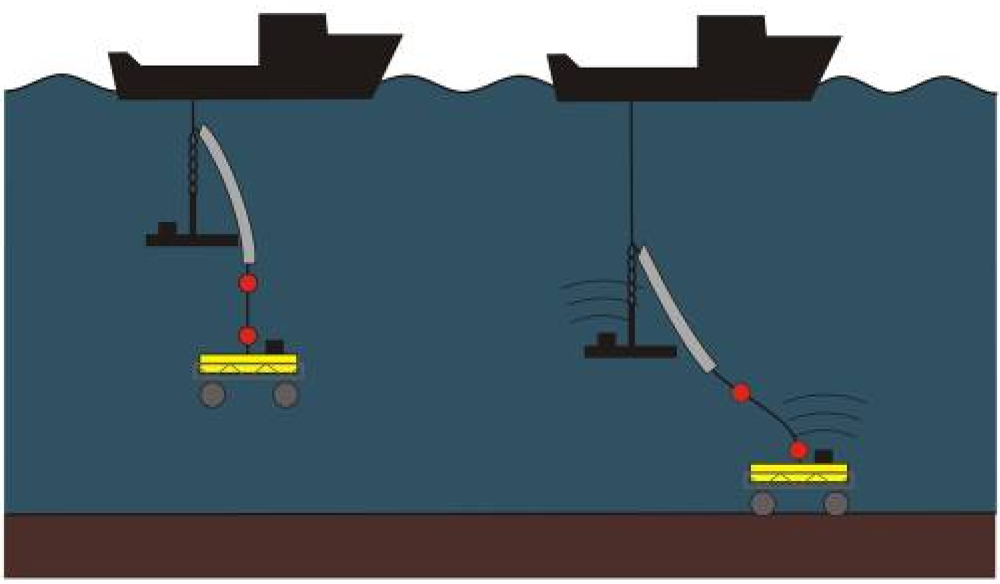

Fig. 5.26 Deployment scenario of the CMOVE vehicle. Left- lowering; right- operation on the seafloor.

The recovery is not posing any particular issues to the operators. The vehicle can literally be pulled out the mud. Again the lifting speed is limited to 0.2-0.3 m/s to not put the frame under too much mechanical stress due to the drag. During the lifting the mechanical parts that have been in contact with the seafloor are cleaned by the water flow.

The vehicle also would allow for free fall deployment and unaided surfacing. This is not suitable for this configuration.

Operation on the seafloor

The weight in water of the crawler has been adjusted to 600N. The weight is defined by the stiffness of the sediment. Typically the wheels should sink by 10 cm into the seafloor to reach optimal traction. Also the overall weight should be equally distributed on all four wheels. The vehicle is highly manoeuvrable as the system is built symmetrical. There is no front and back side and the vehicle can also be operated sideways. It is very important to be able to place the sensors exactly into the right spot. This can be carried out with the help of the video camera. The steering itself is done manually. An automatic control would only be reasonable if the sediment properties are known in advance as this would have an influence on the steering behaviour. With the experience collected up to now an autonomous control would be possible to a certain degree. However, a complete control, for instance just by pointing on the video screen on the object of interest, is not feasible up to now.

The CMOVE crawler reaches a maximum speed of 10 cm/s. During this cruise the system was moving forward at 6 cm/s. The slow speed is advantageous not just in saving energy but also preventing to entrench the system.

For the navigation of the system both the sonar transponder and the Doppler velocity log could be used. The DVL is well suited for determining the position locally while the USBL system allows for tracing the vehicle over larger distances. With the DVL an accuracy of 1%

referred to the path travelled can be reached. This seems low but has to do with the basic physical principle of the method.

Summary

All components of the system worked satisfactorily. No major fault occurred and accordingly a great amount of information could be collected. The deployment method proofed to work reliably but has to be changed for greater depths. Ideally the system should be operated with no direct connection to the ship. This would make a different type of communication link necessary which actually has been proven to be feasible for the NEREUS vehicle of WHOI. Altogether 10 dives were carried out during MSM 15/1 (Table 5.4).

Table 5. 4 CMOVE dives during the cruise.

Station	DIVE	Date	Latitude	Longitude	Depth (m)
375	1	25.04.2010	44° 37.46' N	32° 54.90' E	156.4
386	2	26.04.2010	44° 37.58' N	32° 54.97' E	155.5
397	3	27.04.2010	44° 37.55' N	32° 55.10' E	154.1
406	4	28.04.2010	44° 37.19' N	32° 54.72' E	157
455	5	02.05.2010	44° 38.92' N	32° 59.97' E	137.4
476	6	03.05.2010	44° 49.26' N	33° 9.32' E	104.7
484	7	03.05.2010	44° 49.49' N	33° 9.32' E	106.9
498	8	04.05.2010	44° 37.43' N	32° 54.83' E	155.1
521	9	05.05.2010	44° 35.74' N	32° 49.25' E	205.9
535	10	06.05.2010	44° 49.43' N	33° 9.43' E	103.9

High resolution photography and sediment su rface micro-topography measurements using the benthic crawler platform CMOVE during leg 15/1 of R/V MARIA S. MERIAN

In order to investigate small scale structures and traces of life at the sediment surface a high resolution camera „MEGACAM“ and a laser scanning device („LS“) were attached to CMOVE. MEGACAM (Table 5.5), a high resolution digital camera was oriented vertically, looking straight down at the sediment surface. Different oxygen levels along the Crimean Shelf were expected to result in different populations and abundances of higher life. The aim of the high resolution photography was to document the organisms themselves and their traces of life („Lebensspuren“) to be able to link that to the ambient oxygen availability at the respective sites (Fig. 5.27, Fig. 5.28). While direct oxygen measurements represent a snapshot at the time of sampling, the presence, abundance, and behavior of organisms provides information on environmental conditions over longer periods of time. In addition to high resolution images, image time series at a lower resolution were also recorded to document movements of the fauna at the sediment surface. The laser scanning device („LS“) was used to determine the sediment micro-topography at the respective sites - thereby extending the two dimensional MEGACAM images to the third dimension (sediment height). The LS consisted of a linear drive that moves a downward looking line laser together with a monochrome digital camera horizontally over the seafloor. In view of the inclined camera elevations and depressions of the sediment surface translate into different positions of the laser line in the images. From series of laser line images recorded while camera and laser were moved along a 700 mm long stretch the sediment micro-topography of a 700 mm x 200 mm large area can be determined at sub-mm accuracy. In the majority of the deployments, also MEGACAM was attached to the horizontal drive in order to get visual and 3D information of the same sediment stretch and to facilitate imagery of larger sediment stretches by image-mosaicing.

Table 5. 5 The CMOVE deployments that included MEGACAM imagery and LS measurements with information on water depth and the data obtained.

basic information		MegaCam image time series		MegaCam high resolution shots		Surface scanner	
water depth	deployments	series	frames	mosaics	images	scancs	scan-mosaic combinations
105	3	7	781	2	63	6	2
135	1	0	0	0	2	0	0
155	4 (5)	3	215	5	302	8	7
205	1	1	130	2	51	4	2

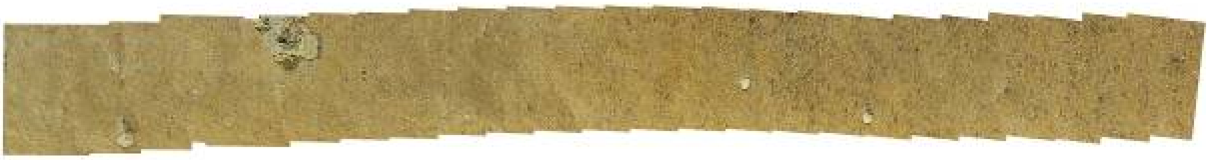

Fig. 5.27 An example of a mosaic consisting of 24 individual high resolution MEGACAM images.

Fig. 5.28 A high resolution image of the Crimean Shelf seafloor recorded with MEGACAM. The insert shows the remarkable resolution of the images that allows identification of small macrofauna specimen.

Biogeochemical investigations

In order to investigate the oxygen consumption and sulfide release at different spatial scales a microprofiler and benthic chamber unit was attached to CMOVE. Using the capability of CMOVE to navigate at the seafloor investigations could be performed at a water depth range between 104-200 meter at selected spots targeted with the cameras of CMOVE.

The **microprofiler module** hosted 3 oxygen and 2 sulfide sensors. The array of microelectrodes was lowered towards the sediment-water interface until the sensors recorded a signal change due to the fact that the sensors penetrated from the water column into the sediment, where after the sensor array was lowered in increments of 100 µm to a depth of several centimetres. At each depth the dataset of the sensors were recorded and thereby a number of vertical concentration profiles were obtained.

The **benthic chamber module** is a modified version of the free-falling chamber lander used to study benthic processes at the seafloor. This small benthic module consists of a circular chamber, an electronic cylinder, and a water sampling system. The chamber encloses an area of ca. 285 cm^2 together with 10-15 cm of overlying bottom water. Two O_2 sensors mounted in the chamber lid monitor the concentration change in the enclosed water body, which is gently stirred by a stirrer mounted in the lid. During the incubation 5 water samples (each 50 mL) were retrieved, operated online through the CMOVE-electronics, for later analyses of DIC, nutrients (e.g. NO_3^-, NH_4^+) and other elements. After positioning MOVE at the targeted area the chamber was lowered into the sediment, controlled by the video camera of MOVE. The duration of the measuring cycles varied between 2 and 4 hours.

During the cruise 8 deployments with chamber and/or profiler measurements at different spatial scales, reaching from mm to hundred of meters, have been performed (Table 5.6.). Preliminary benthic oxygen consumption rates show a relative invariant flux between 5.7 and 9.5 mmol m^{-2} d^{-1} at the different sites, water depth and bottom water oxygen concentrations. However, from further analysis of DIC and nutrient samples as well as high-resolution oxygen and sulphide microprofiles we might be able to distinguish differences in benthic biogeochemical processes underlying these oxygen uptake rates.

Table 5.6 Summary of CMOVE dives with benthic chamber and /or microprofiler as payload.

station	dive	water depth (m)	instruments
386	MOVE-2	155.5	benthic chamber and microprofiler
397	MOVE-3	154.1	benthic chamber and microprofiler
406	MOVE-4	157	microprofiler
455	MOVE-5	137.4	benthic chamber and microprofiler
484	MOVE-7	106.9	benthic chamber and microprofiler
498	MOVE-8	155	benthic chamber
521	MOVE-9	205.9	benthic chamber and microprofiler
535	MOVE-10	103.9	benthic chamber

5.3.6 Benthic boundary layer measurements (Profiler-Chamber-Lander, Eddy, MuFO, BBL, BWS)

(F. Wenzhöfer, A. Lichtschlag, A. Nordhausen, J. Fischer, F. Janssen, M. Holtappels)

Profiler-Chamber-Lander

A benthic lander system (Fig. 5.29) was used to study the significance of benthic fluxes for oxygen changes in the lowermost water column and how benthic fluxes react to the observed changes in oxygen availability. The moored lander was equipped with different instruments to investigate the oxygen penetration and distribution as well as the oxygen uptake of the sediment: (1) **Microprofiler**: The microprofiler was equipped with 3-4O_2, 2H_2S, 2pH, and 1 redox microsensors and a temperature macrosensors (PT 1000) covering an area of 180 cm^2. Microprofiles across the sediment-water interface were performed with a vertical resolution of 100 µm on a total length of 18 cm. During the deployment the microsensor array performed up to 3 vertical profiles along a horizontal transect of 26 cm.

(2) **Benthic chamber**: Benthic chamber incubations were used to measure the total oxygen consumption and nutrient exchange of the sediment. This measurement integrates all relevant solute transport processes (diffusion, advection and fauna-mediated transport) over an area of 400 cm^2.

A total of 6 lander deployments (APPENDIX, Section A.2, Table A.2.3) with 12 benthic chamber incubations were obtained along a depth transect from the oxygenated shallow to the deeper anoxic sites. Very few data have been evaluated so far. First preliminary results reveal oxygen consumptions rates of 16 and 9 mmol m^{-2} d^{-1} at the 104 and 140m study site, respectively. Vertical microprofiles show an oxygen penetration between 0.4 and 10.7 mm, while sulfide was not detected in the upper centimeter of the sediments.

Fig. 5.29
Deployment of MPI lander system with microprofiler and benthic chambers as payload.

EDDY

Vertical transport of O_2 in the water column results exclusively from turbulent motions. The typical pattern of these turbulent motions, that the O_2 concentration on average is higher when the vertical velocity is pointing toward the sediment and lower when the velocity is pointing upward, gives over time a net transport of O_2 toward the sediment. Eddy correlation (Fig. 5.30) relies on measuring the vertical velocity and the oxygen concentration fast enough to calculate the momentary advective flux due to turbulent motions. Integrated over time for a period long enough to get a statistically sound average, it gives a net O_2 transport directed towards the sediment (Berg et al. 2003). For further details on the functioning of EDDY refer to APPENDIX, Section A.6. During this cruise Eddy was deployed 5 times (APPENDIX, Section A.2, Table A.2.3). Due to technical problems with the programming software the first two deployments failed but the remaining stations provided 44 hours of oxygen flux data. Preliminary results revealed an oxygen flux of - 6 and 1.14 mmol m^{-2} d^{-1} at the 140 and 104 m site, respectively.

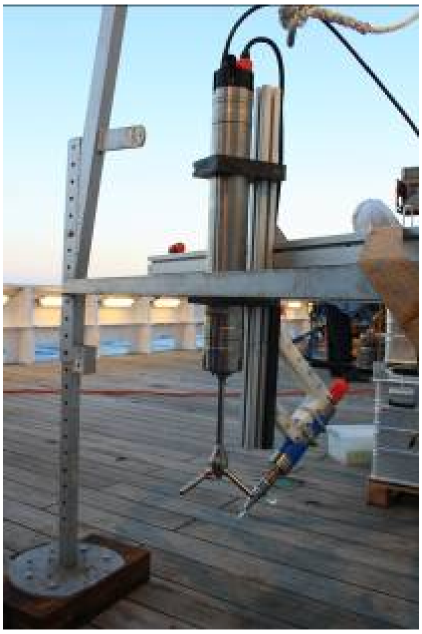

Fig. 5.30
Eddy correlation device Clark-type micro-electrode and the flow velocity with an acoustic Doppler velocimeter.

Multi Fiber Optode (MuFO)

Especially at water depths where the oxycline is close to the sediment surface, strong oxygen gradients within the water column could be expected. To measure these gradients in high spatial and temporal resolution on the Crimean Shelf, the prototype of a multi-sensor optode was applied for the first time. The Multi Fiber Optode (MuFO) consists of a vertical string of 100 oxygen optodes with a sensor diameter of 2 mm which are read out simultaneously by an opto-electronic system that was deployed on the seafloor (Fig. 5.31 left). The sensors were distributed along 0-8 m above the sediment surface. The bottom 3m were supported by a pole; spacing between the sensors varied from 10 mm for the first 20 sensors to 1m for the top 3 m. Two calibration of the system were performed by submerging it for ~20 min close to the water surface and in anoxic waters (water depth >200m).

All 5 deployments (APPENDIX, Section A.2, Table A.2.3) of the system were successful. The measured average gradients are in good agreement with the results from the BWS and the BBL Profiler.

In one case (St. 381), strong fluctuations of the oxygen gradient with a period of ~2 min could be observed (Fig. 5.31, right). These oscillations coincided with a change in wind speed and direction and could be explained by internal waves.

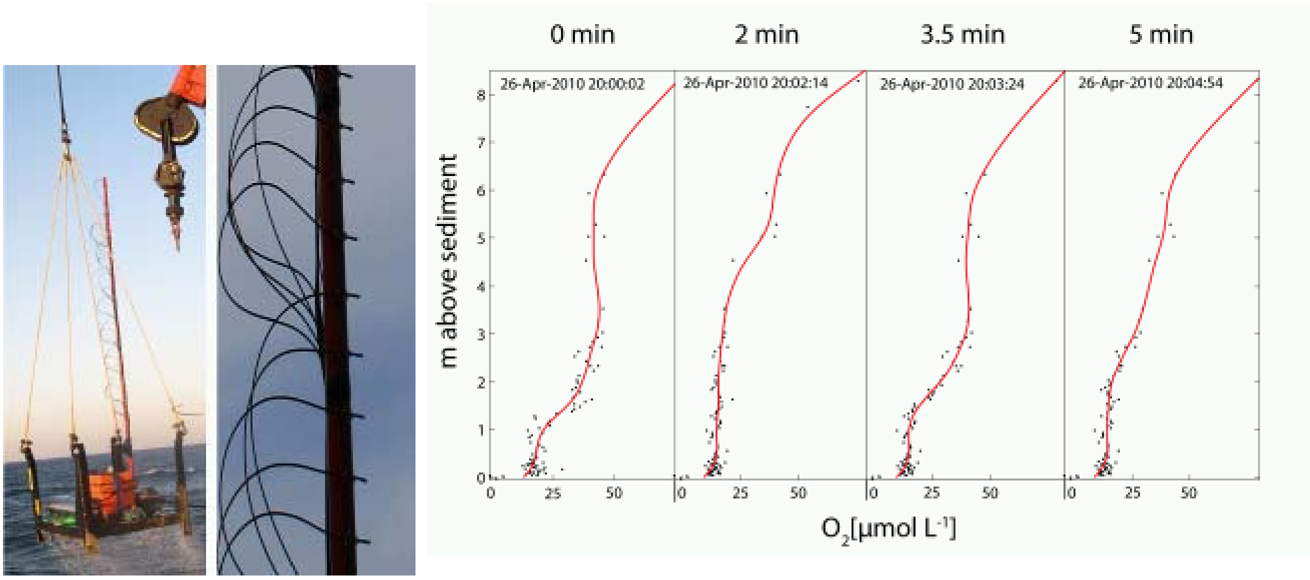

Fig. 5.31 Multi Fiber Optode (MuFO) setup with 100 single sensors to measure changes in oxygen concentration in high spatial and temporal resolution close to the seafloor (left). Strong oscillations with a period of ~2min could be observed at station 381 (right).

BBL-Profiler and Bottom Water Sampler (BWS)

In the Black Sea, sediments that insect with the pycnocline of the water column are exposed to highly variable oxygen concentrations. The availability of oxygen depends on the vertical displacement of the chemocline as well as on the concentration gradient caused by benthic consumption and reduced turbulent transport in the stratified BBL. To disentangle the drivers for varying oxygen concentrations in the bottom water, vertical oxygen and density gradients have to be measured in the BBL over a longer time period. This was done with the BBL-Profiler, described in part 5.2.4.

On the Crimean Shelf the BBL-profiler was deployed 6 times at depths varying between 100m and 200m. At each deployment, 4-9 complete profiles were measured over a time period of 7-10 hours. Preliminary results (Fig. 5.32) show that the high accuracy of the oxygen measurement allowed to resolve gradients of much less than 1µM per meter. Furthermore, salinity and temperature gradients were observed. The spatial (vertical) and temporal variability of oxygen could be related to the change of salinity and temperature suggesting that the oxygen variability in the BBL is mainly driven by the vertical displacement of the chemocline. Although turbulent mixing in the BBL was reduced due to the density stratification, the benthic oxygen consumption was probably too low to create steep oxygen gradients.

In addition, 7 deployments of the bottom water sampler (described in detail by Sauter et al. 2005) were carried out to retrieve ~ 6liters of bottom water from 35, 72, 118, 166 and 213 cm above the sea floor. Next to Winkler titration for the determination of oxygen concentrations, the water samples were used for incubation experiments with ^{15}N labeled nitrogen compounds to investigate the N-cycling in the hypoxic bottom water. The analysis of these experiments is in progress.

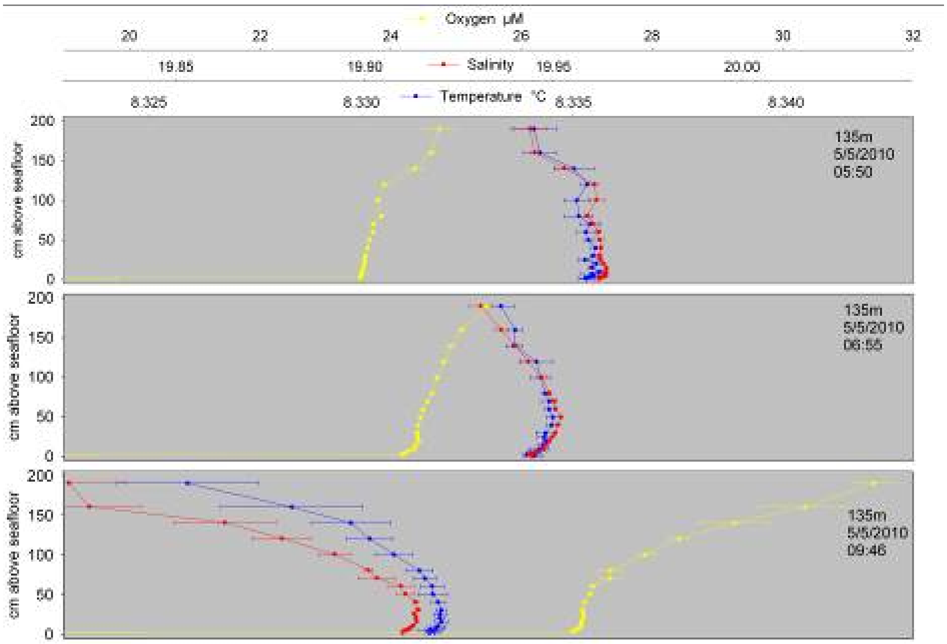

Fig. 5.32 Temporal and spatial variability of oxygen, salinity and temperature in the bottom water.

5.3.7 Nobel gases

(R. North)

The methods for noble gas measurement described in Section 5.2.6 were repeated at three sites on the Crimean Shelf edge. Sediment cores at St. 468 (105.4m), St. 497 (156.4m), and St. 519 (205.9m), (APPENDIX, Section A.2, sediment sampling list) provided nine, seven and ten samples, respectively. Samples were taken every 10 cm, as cores shorter than those obtained at the Bosporus sites were available. A second core was taken at each site and will be used for dating purposes.

The many highly resolved and accurate oxygen measurements taken on the research cruise allowed the three core sites to be accurately chosen for oxic (103.9 m), hypoxic (156.4 m), and anoxic (205.9 m) conditions. Additionally, these measurements showed a large temporal variation in oxygen concentration at the hypoxic site. It is anticipated that because of the ability to select these sites, the noble gas measurements could provide very interesting insight into past variations in oxygen and salinity along the shelf. Combined with samples taken at the Bosporus and on the Romanian Shelf (Mare Nigrum, May 2010), spatial and temporal variation of salinity and oxygen will be investigated.

Presently the samples are being processed and measurements are expected to commence soon.

5.3.8 Biogeochemistry and microbiology

(D. Donis, G. Jessen, A. Lichtschlag)

The research focus on the Crimean Shelf was on the oxygen dynamics and the spatial and temporal variability in oxygen availability in the bottom waters and in sediments. One important task was the effect of these dynamics on biogeochemical processes and diversity of microbial communities. In order to understand in detail how sediment processes react to changes in oxygen availability, geochemical and molecular parameters were investigated. Oxygen depletion in the water column or the first mm of the sediment leads to a variety of alternative pathways for microbial organic matter degradation and a distinct geochemical zonation of redox-sensitive species in the sediment.

Biogeochemistry

To analyze the biogeochemical processes in the upper part of the sediment, pore water was extracted from sediment cores retrieved by a TV-guided multicorer (methods described in 5.2.7) along a transect stretching from the permanently oxic (104 m water depth) to the permanently anoxic zone (207 m water depth) at Crimea II (Table 5.7). Sulfide, nitrite, alkalinity, and ammonium were measured in resolution of 1 to 2 cm depth intervals on board of the ship. Pore water samples were fixed for later measurements of nutrients, sulfate, methane, and dissolved iron and manganese. Furthermore, sediments collected from the Crimean Shelf will be analyzed for sulfate reduction rates, methane, organic matter content, C/N ratios, and the abundance of further electron-acceptors for microbial degradation of organic matter (methods described in 5.2.7).

Microbiology

In total 14 stations were sampled (13 TV-MUC stations and 1 push core JAGO station, *see* Table 5.7) at the Crimean Shelf area and the sample methods were applied as described in 5.2.7. In addition, push core samples obtained with the help of the submersible JAGO were used to investigate the microbial mats, found at 150 m depth in the hypoxic zone of the Crimean Shelf. At this site, 6 samples were taken, at the microbial mat spot and outside the microbial mat, where large white microbial filaments, resembling filamentous giant sulfur oxidizers, were found (Fig. 5.33). The filaments were variable in size and diameter and the white color might be due to sulfur inclusions, commonly found in giant sulfur bacteria. High resolution sampling (0.5 cm horizon) were carried out for future general microbial diversity analyses. Additionally, ex-situ microsensor measurements of H_2S were conducted on retrieved cores in the laboratory and showed that the giant bacteria were clearly associated with the sulfide, originating in the upper few centimeters of the sediment (Fig. 5.34).

Fig. 5.33

Push cores from the microbial mat (right) and the reference site (left) obtained from the JAGO dive 1120 (St. 492) in the Black Sea. One optical unit is equivalent to ca. 25 µm.

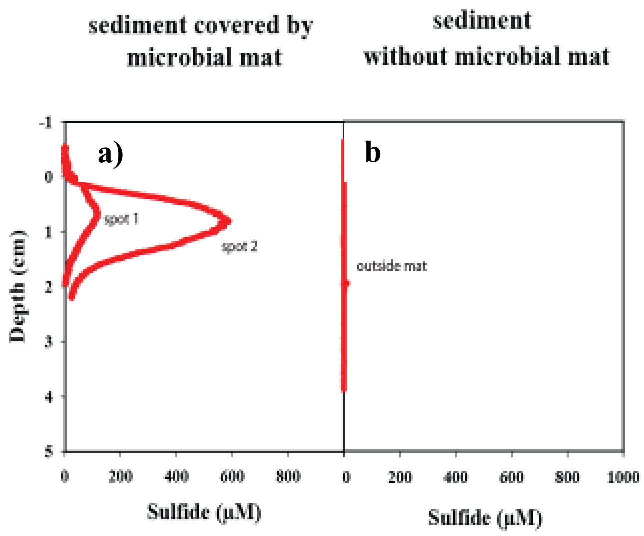

Fig. 5.34
Sulfide profiles measured with microsensors a) in the sediment covered by microbial mat and b) in adjacent sediments without microbial mat.

Table 5.7 Sediment and pore water analyzes in the Crimean Shelf area. SRR: sulfate reduction rates; AODC: acridine orange direct counts; DIC: dissolved inorganic carbon, TA: total alkalinity.

Station	Latitude	Longitude	depth (m)	sediment sampled for	pore water fixed	pore water analyzed on board
377	44° 37.54' N	32° 54.97' E	156	SRR, AODC/FISH, DNA, RNA, porosity, methane, ARISA, Corg, C/N, organic + inorganic geochemistry	sulfate, sulfide, nutrients, DIC, TA, DICisotopes, dissolved Mn/Fe	nitrite, ammonium, sulfide, TA
393	44° 37.12' N	32° 53.40' E	165	SRR, AODC/FISH, DNA, RNA, porosity, methane, ARISA, Corg, C/N, organic + inorganic geochemistry	sulfate, sulfide, nutrients, DIC, TA, DICisotopes, dissolved Mn/Fe	nitrite, ammonium, sulfide, TA
421	44° 48.73' N	31° 55.31' E	83	ARISA	nutrients	-
422	44° 47.45' N	31° 57.38' E	124	ARISA	nutrients	-
424	44° 47.29' N	31° 57.70' E	148	ARISA	nutrients	sulfide, TA
425	44° 47.09' N	31° 58.05' E	163	ARISA	-	sulfide, TA
426	44° 46.87' N	31° 58.50' E	175	ARISA	nutrients	sulfide, TA
428	44° 46.60' N	31° 58.44' E	212	ARISA	nutrients	sulfide, TA
448	44° 35.84' N	32° 49.03' E	204	SRR, AODC/FISH, DNA, RNA, porosity, methane, ARISA, Corg, C/N, organic + inorganic geochemistry	sulfate, sulfide, nutrients, DIC, TA, DICisotopes, dissolved Mn/Fe	nitrite, ammonium, sulfide, TA
459	44° 40.48' N	33° 5.53' E	120	ARISA	-	sulfide, alk
462	44° 49.45' N	33° 9.27' E	104	SRR, AODC/FISH, DNA, RNA, porosity, methane, ARISA, Corg, C/N, organic + inorganic geochemistry	sulfate, sulfide, nutrients, DIC, TA, DICisotopes, dissolved Mn/Fe	nitrite, ammonium, sulfide, TA
487	44° 38.80' N	33° 0.26' E	136	SRR, AODC/FISH, DNA, RNA, porosity, methane, ARISA, Corg, C/N, organic + inorganic geochemistry	sulfate, sulfide, nutrients, DIC, TA, DICisotopes, dissolved Mn/Fe	nitrite, ammonium, sulfide, TA
506	44° 36.38' N	32° 52.72' E	171	ARISA	-	sulfide, TA
513	44° 37.87' N	32° 57.22' E	146	-	-	sulfide, TA

5.3.9 Biology

(N. Sergeeva, M. Gulin., S. Mazlumyan)

Methods and Material

Samples for studying meiobenthos were collected using TV-MUCs and push cores obtained by the submersible JAGO; for studying macrobenthos samples were collected using the box corer. Objectives and methods correspond to those described for the Bosporus area (5.2.9). Bottom sediment sampling was done along a transect at the north-western shelf of Crimea (Crimea-I) and along one transect at the western region of the Crimea peninsula (Crimea-II) with sampling depth ranging from 83-212 m at Crimea-I and 118-363 m at Crimea-II. In total 31 stations were sampled for benthos; meiobenthos and macrobenthos will be studied at 21 stations (38 replicates) and 10 station (10 replicates), respectively. For the studies of modern macrobenthos fauna and distribution of the deep water mollusk *Modiolula phaseolina* box corer samples and additional 8 TV-MUC stations were sampled.

Study of alive/dead ratio of *M. phaseolina* will be made on the base of benthic sampling with the box corer (8 samples) and the TV-MUC (8 samples). The seafloor samples were washed with sea water through two benthic sieves, the upper one with a mesh diameter of 3mm, the lower one of 1mm. For further analysis in the IBSS laboratories living mollusks were photographed and fixed with alcohol on board the research vessel. Shells of dead animals were dried at temperatures from +50 to +60 °C, and weighed with a electronic balance Sartorius PT600 (Germany). In the IBSS laboratories the morphometry of the fixed mollusks and the shells of the dead mollusks will be analyzed.

To determine the properties of different habitats formed by the structure of meiobenthos we used the technical capabilities of the submarine JAGO. With underwater observations, local differences of the seafloor surface of each station could be visually assessed. One main task was the selection of sediment covered by a well-developed bacterial mat and a control, without such bacterial mats visible. In addition, it was possible to obtain material of spots characterized by the accumulation of living mollusks, their dead shells, spots without mollusks, and sites with different color of the surface layer, which might be due to differences of the Eh potential and methane seeping from below.

It is expected that the final analysis of the taxonomic structure and the abundance of meiobenthos will asses the impact of the bacterial mats, local oxygen depletion in the environment and the role of mollusks (alive and dead) in thevsformation of the meiobenthos communities.

Measurements of redox-potential (Eh, mV) in the near-bottom water were conducted with a standard ionometer PH150M (Belasus) in a set with platinum measuring electrode Corning (USA) and silver electrode of comparison. Eh-electrode was calibrated according to pattern HI7021 (Hungary).

Preliminary Results

The study of the seafloor sediments showed that on the Crimean Shelf meiobenthic fauna was found at all studied depths (100-363m). The taxonomical structure of the meiobenthos was diverse. The number of taxa varied from 3 to 11 groups of high level, depending on water depth. Nematodes were most abundant among the meiobenthos taxa. Gromida, Ciliophora, Hydrozoa, Foraminifera and Harpacticoida were subdominant among the benthic fauna of the oxic/anoxic interface, depending on water depth and characteristics of the biotopes.

We already discovered a specific benthic community along the oxic/anoxic interface in the Crimean Shelf at a water depths ranging between 154 and 174 m. Polychaetes were represented by *Vigtorniella zaikai* and *Protodrilus* sp., which are specific species found only at such depths of the studied NW part of the Black Sea.

Using light microscopy we observed active and living Hydrozoa at 155 and 163m water depths and living Foraminifera were observed at 163m water depth. Furthermore, during two days we observed active and living Nematodes at 120m water depth and kept them alive in the refrigerator.

Macrobenthic fauna was also found at a water depths range from 83 to 154m in TV-MUC cores and from 83 to 140m in box core samples.

At a depths of 170m (St. 507) and 174m (St. 426) we found in the surface horizon of bottom sediments obtained with the TV-MUC unusual benthic hydrobionts, which have similarities with young specimens of *Oikopleura dioica* (Appendicularia).

Macrobenthos fauna contained representatives of Polychaeta, Oligochaeta, Malacostraca, Mollusca and Echinodermata. At the depths 136 and 147m we found fields of iron-manganese nodules, with shells of the mollusk *Modiolula phaseolina* as kernel of these nodules. However, in general the benthos structure of these fields was characterized by low diversity and abundance. The samples of macrofauna and meiofauna of the Crimean Shelf edge are in process.

The redox-potential of the bottom layer water column measured on board R/V MARIA S.MERIAN showed the spatial-temporal dynamic of the near-bottom water mass of the studied regions. It suggests that sulfide starts to accumulate in the near-bottom horizon at approximately 161m depth, as measured at the transect of Crimea-II. Obviously, the water mass intrusion containing hydrogen sulfite, could rise 15 meters to about 146 m isobath. In contrast, the suboxic zone of the overlying water could decrease to 10 feet below its normal position. Such variations (but with somewhat smaller amplitude) may last only for very short periods of time. For example, at May 4th, the redox potential in the bottom water at a depth of 152 m was +211 mV. However, the day after we recorded a negative Eh (- 91 mV) at the bottom at 147-meter depth. This indicates a sharp rise of the chemocline. At the time of observation in the Bosporus area the upper limit of the hydrogen sulfide zone near the bottom of the slope was found at a depths of 180-186 m, i.e. at 20 meters and deeper than in the Crimea-II area.

To understand the current state and possible changes in the structure and vertical distribution of benthic fauna of the studied area, the scientists from IBSS will use further information on oxygen and hydrogen sulfide concentrations in the bottom layers of water masses and sedimentary pore water obtained by other members of the cruise. To assess the impact of oxygen deficiency on the biota, we are thus looking forward for scientific cooperation with interested experts / participants of the cruise.

These interim data will be included in the relevant periodic reports, publications and presentations at conferences. The final results of the study of benthos will be included in the final report and database project "HYPOX". The biological results will also be deposited in the National Database of Ukraine, IBSS NANU and MHI NANU and can be used to justify future projects. Collection materials of benthic fauna will be stored in the Department of Ecology benthic Institute of Biology of Southern Seas.

6 Station List MSM15/1

6.1 Station List

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/178-2	12.04.2010	17:00	41° 20.97' N	29° 13.50' E	82.2	264.8	0.1	CTD/RO	RL max. 80m	MSM15-1_178-2
MSM15/179-1	12.04.2010	18:04	41° 22.78' N	29° 15.18' E	93.1	306	0.2	CTD/RO	RL max. 84m	MSM15-1_179-1
MSM15/180-1	12.04.2010	19:18	41° 24.38' N	29° 16.67' E	264.7	188.8	0.4	CTD/RO	RL max. 263m	MSM15-1_180-1
MSM15/181-1	12.04.2010	21:03	41° 25.48' N	29° 17.79' E	541.6	192.9	0.1	CTD/RO	RL max. 530m	MSM15-1_181-1
MSM15/182-1	12.04.2010	22:20	41° 25.48' N	29° 17.79' E	540	221.9	0.4	FFP CTD	RL max. 300m	MSM15-1_182-1
MSM15/183-1	13.04.2010	01:35	41° 27.30' N	29° 21.29' E	992.4	33.2	0.1	CTD/RO	RL max. 981m	MSM15-1_183-1
MSM15/184-1	13.04.2010	03:15	41° 29.80' N	29° 25.89' E	1257.9	77.7	0.2	CTD/RO	RL max. 1243m	MSM15-1_184-1
MSM15/185-1	13.04.2010	04:46	41° 31.99' N	29° 30.00' E	1091.5	204.4	0.2	CTD/RO	RL max. 1060m	MSM15-1_185-1
MSM15/186-1	13.04.2010	06:27	41° 27.99' N	29° 29.02' E	585.2	227.2	0.1	CTD/RO	RL max. 580 m	MSM15-1_186-1
MSM15/187-1	13.04.2010	08:15	41° 24.49' N	29° 23.48' E	646.4	279.5	0.1	CTD/RO	RL max. 638 m	MSM15-1_187-1
MSM15/188-1	13.04.2010	10:25	41° 28.49' N	29° 17.02' E	529.3	213.2	0.2	CTD/RO	RL max. 505m	MSM15-1_188-1
MSM15/189-1	13.04.2010	11:55	41° 31.99' N	29° 16.00' E	748.1	32.2	0.2	CTD/RO	RL max. 740m	MSM15-1_189-1
MSM15/190-1	13.04.2010	13:06	41° 30.13' N	29° 16.32' E	300.7	159.9	0.2	CTD/RO	RL max. 288m	MSM15-1_190-1
MSM15/191-1	13.04.2010	13:46	41° 30.15' N	29° 16.34' E	307.3	54.9	0.1	TVMUC		MSM15-1_191-1
MSM15/192-1	13.04.2010	14:26	41° 30.14' N	29° 16.34' E	306.1	56.8	0.2	ITUC	RL max. 319m	MSM15-1_192-1
MSM15/193-1	13.04.2010	14:48	41° 30.14' N	29° 16.34' E	310.2	329.1	0.4	ITUC	RL max. 311m	MSM15-1_193-1
MSM15/194-1	13.04.2010	15:05	41° 30.14' N	29° 16.34' E	309.1	116.3	0.1	EAWAGC	RL max. 315m	MSM15-1_194-1
MSM15/195-1	13.04.2010	15:31	41° 30.14' N	29° 16.34' E	306.1	304.1	0.1	EAWAGC	RL max. 315 m	MSM15-1_195-1
MSM15/196-1	13.04.2010	16:17	41° 30.16' N	29° 16.37' E	311.1	330.2	0.2	TVMUC		MSM15-1_196-1
MSM15/197-1	13.04.2010	17:21	41° 29.97' N	29° 16.16' E	259.9	354.3	0.2	CTD/RO	RL max. 250 m	MSM15-1_197-1
MSM15/198-1	13.04.2010	17:58	41° 29.98' N	29° 16.17' E	261.7	70	0.2	TVMUC		MSM15-1_198-1
MSM15/199-1	13.04.2010	18:22	41° 29.98' N	29° 16.17' E	263.7	273.3	0.2	ITUC	RL max. 275 m	MSM15-1_199-1
MSM15/200-1	13.04.2010	18:38	41° 29.98' N	29° 16.17' E	261.5	293.2	0.2	ITUC	RL max. 274 m	MSM15-1_200-1
MSM15/201-1	13.04.2010	18:51	41° 29.98' N	29° 16.17' E	262.6	177.1	0.4	ITUC	RL max. 265 m	MSM15-1_201-1
MSM15/202-1	13.04.2010	19:48	41° 29.94' N	29° 16.13' E	252.8	26.2	0.2	TVMUC		MSM15-1_202-1
MSM15/203-1	13.04.2010	20:10	41° 29.94' N	29° 16.13' E	252.4	134.8	0.1	ITUC	RL max. 256 m	MSM15-1_203-1
MSM15/204-1	13.04.2010	20:24	41° 29.94' N	29° 16.13' E	252.4	125.2	0.2	ITUC	RL max. 250 m	MSM15-1_204-1
MSM15/205-1	13.04.2010	21:26	41° 29.81' N	29° 15.99' E	220.7	222.7	0.2	CTD/RO	RL max. 206m	MSM15-1_205-1
MSM15/206-1	13.04.2010	21:49	41° 29.81' N	29° 15.99' E	222.7	198.2	0.1	ITUC	RL max. 219m	MSM15-1_206-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/207-1	13.04.2010	22:10	41° 29.81' N	29° 15.99' E	220.6	202.7	0.4	ITUC	RL max. 217m	MSM15-1_207-1
MSM15/208-1	13.04.2010	22:28	41° 29.81' N	29° 15.99' E	221	243.9	0.4	ITUC	RL max. 216m	MSM15-1_208-1
MSM15/209-1	13.04.2010	22:46	41° 29.82' N	29° 15.99' E	223	209.1	0.2	ITUC	RL max. 216m	MSM15-1_209-1
MSM15/210-1	14.04.2010	01:40	41° 22.74' N	29° 37.97' E	550.8	95.8	0.4	CTD/RO	RL max. 523m	MSM15-1_210-1
MSM15/211-1	14.04.2010	02:54	41° 24.00' N	29° 34.49' E	482.5	255.1	0.3	CTD/RO	RL max. 440m	MSM15-1_211-1
MSM15/212-1	14.04.2010	04:14	41° 23.82' N	29° 30.00' E	475.8	208.2	0.4	CTD/RO	RL max. 476m	MSM15-1_212-1
MSM15/213-1	14.04.2010	05:52	41° 23.58' N	29° 22.83' E	509.9	298.9	0.1	CTD/RO	RL max. 493 m	MSM15-1_213-1
MSM15/214-1	14.04.2010	07:24	41° 25.46' N	29° 17.91' E	523.4	312.9	0.4	CTD/RO	RL max. 514 m	MSM15-1_214-1
MSM15/215-1	14.04.2010	08:39	41° 30.14' N	29° 16.33' E	297	278.3	0	TVMUC		MSM15-1_215-1
MSM15/216-1	14.04.2010	09:16	41° 30.14' N	29° 16.33' E	299.9	82.3	0.1	TVMUC		MSM15-1_216-1
MSM15/217-1	14.04.2010	10:49	41° 31.73' N	29° 9.99' E	479.1	36.8	0	CTD/RO	RL max. 481m	MSM15-1_217-1
MSM15/218-1	14.04.2010	12:20	41° 35.99' N	29° 1.77' E	373.2	294	0.2	CTD/RO	RL max. 317m	MSM15-1_218-1
MSM15/219-1	14.04.2010	13:37	41° 37.84' N	29° 1.90' E	645.3	85.3	0.2	CTD/RO	RL max. 642m	MSM15-1_219-1
MSM15/220-1	14.04.2010	16:28	41° 37.84' N	29° 1.90' E	649.1	83.1	0.1	FFP CTD		MSM15-1_220-1
MSM15/221-1	14.04.2010	17:52	41° 37.85' N	29° 1.90' E	646.9	9.2	0.2	CTD/RO	RL max. 402 m	MSM15-1_221-1
MSM15/222-1	14.04.2010	18:54	41° 35.69' N	29° 1.02' E	296.9	187.6	7.2	MB		MSM15-1_222-1
MSM15/223-1	14.04.2010	21:37	41° 29.59' N	29° 15.74' E	196.8	243.8	0.2	CTD/RO	RL max. 191m	MSM15-1_223-1
MSM15/224-1	14.04.2010	22:10	41° 29.59' N	29° 15.74' E	199.9	121.6	0.2	TVMUC	RL max. 205m	MSM15-1_224-1
MSM15/225-1	14.04.2010	22:37	41° 29.59' N	29° 15.74' E	199.7	144.7	0.2	ITUC	RL max. 194m	MSM15-1_225-1
MSM15/226-1	14.04.2010	22:53	41° 29.59' N	29° 15.74' E	197.9	232.1	0.2	ITUC	RL max. 192m	MSM15-1_226-1
MSM15/227-1	14.04.2010	23:42	41° 29.08' N	29° 15.23' E	171.8	330.3	0.2	CTD/RO	RL max. 161m	MSM15-1_227-1
MSM15/228-1	15.04.2010	00:04	41° 29.08' N	29° 15.23' E	173.9	135.5	0.2	TVMUC		MSM15-1_228-1
MSM15/229-1	15.04.2010	00:54	41° 29.08' N	29° 15.24' E	172.6	65.6	0.1	ITUC	RL max. 172m	MSM15-1_229-1
MSM15/230-1	15.04.2010	01:07	41° 29.08' N	29° 15.24' E	172.4	16.3	0.2	ITUC	RL max. 172m	MSM15-1_230-1
MSM15/231-1	15.04.2010	01:27	41° 29.08' N	29° 15.24' E	171.7	306.1	0.1	BC	RL max. 181m	MSM15-1_231-1
MSM15/232-1	15.04.2010	02:02	41° 28.97' N	29° 15.12' E	159	52.3	0.2	CTD/RO	RL max. 146m	MSM15-1_232-1
MSM15/233-1	15.04.2010	02:17	41° 28.97' N	29° 15.12' E	159.7	353.8	0.2	BC	RL max. 168m	MSM15-1_233-1
MSM15/234-1	15.04.2010	02:39	41° 28.97' N	29° 15.12' E	159	265.8	0.2	GC	RL max. 169m	MSM15-1_234-1
MSM15/235-1	15.04.2010	03:40	41° 28.97' N	29° 15.12' E	159	82.8	0.3	TVMUC		MSM15-1_235-1
MSM15/236-1	15.04.2010	03:59	41° 28.97' N	29° 15.13' E	159.7	147.6	0.2	ITUC	RL max. 157m	MSM15-1_236-1
MSM15/237-1	15.04.2010	04:12	41° 28.97' N	29° 15.13' E	159	155.1	0.2	EAWAGC	RL max. 158m	MSM15-1_237-1
MSM15/238-1	15.04.2010	04:24	41° 28.97' N	29° 15.13' E	160.4	322.2	0.1	EAWAGC	RL max. 158m	MSM15-1_238-1
MSM15/239-1	15.04.2010	04:36	41° 28.97' N	29° 15.13' E	159.7	207.2	0.2	EAWAGC	RL max. 158m	MSM15-1_239-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/240-1	15.04.2010	04:54	41° 28.97' N	29° 15.13' E	159.7	252.9	0	ITUC		MSM15-1_240-1
MSM15/241-1	15.04.2010	05:20	41° 28.97' N	29° 15.13' E	159.1	240.9	0.2	EAWAGC	RL max. 162 m	MSM15-1_241-1
MSM15/242-1	15.04.2010	06:37	41° 28.92' N	29° 15.06' E	152.2	238.6	0.1	CTD/RO	RL max. 146 m	MSM15-1_242-1
MSM15/243-1	15.04.2010	06:54	41° 28.92' N	29° 15.06' E	152.1	58.2	0.1	TVMUC		MSM15-1_243-1
MSM15/244-1	15.04.2010	07:12	41° 28.92' N	29° 15.06' E	152.2	172.7	0.2	ITUC	RL max. 151 m	MSM15-1_244-1
MSM15/245-1	15.04.2010	07:20	41° 28.92' N	29° 15.06' E	152.9	261.1	0.1	ITUC	RL max. 150 m	MSM15-1_245-1
MSM15/246-1	15.04.2010	07:48	41° 28.92' N	29° 15.06' E	152.2	211.6	0.1	BC	RL max. 161 m	MSM15-1_246-1
MSM15/247-1	15.04.2010	08:19	41° 28.92' N	29° 15.06' E	153	349.5	0	BC	RL max. 158 m	MSM15-1_247-1
MSM15/248-1	15.04.2010	11:15	41° 20.99' N	29° 2.37' E	80.9	186.7	0.1	CTD/RO	RL max. 72m	MSM15-1_248-1
MSM15/249-1	15.04.2010	12:34	41° 21.00' N	29° 5.53' E	81.6	26.8	0.2	CTD/RO	RL max. 79m	MSM15-1_249-1
MSM15/250-1	15.04.2010	13:07	41° 21.01' N	29° 6.23' E	81.9	245.1	0	CTD/RO	RL max. 75m	MSM15-1_250-1
MSM15/251-1	15.04.2010	13:54	41° 21.01' N	29° 9.71' E	76.3	8.3	0.2	CTD/RO	RL max. 71m	MSM15-1_251-1
MSM15/252-1	15.04.2010	15:37	41° 21.00' N	29° 20.93' E	89.8	276.3	0.2	CTD/RO	RL max. 85m	MSM15-1_252-1
MSM15/253-1	15.04.2010	17:06	41° 21.01' N	29° 30.11' E	93.5	43.5	0.2	CTD/RO	RL max. 88m	MSM15-1_253-1
MSM15/254-1	15.04.2010	17:11	41° 21.01' N	29° 30.11' E	94	132.9	0.1	MB		MSM15-1_254-1
MSM15/255-1	15.04.2010	19:40	41° 27.31' N	29° 21.30' E	976.7	312.8	0.2	CTD/RO	RL max. 976 m	MSM15-1_255-1
MSM15/256-1	15.04.2010	21:18	41° 25.50' N	29° 17.78' E	549.1	136	0.1	CTD/RO	RL max. 543m	MSM15-1_256-1
MSM15/257-1	15.04.2010	22:44	41° 23.58' N	29° 22.85' E	488.1	215.5	0.1	CTD/RO	RL max. 483m	MSM15-1_257-1
MSM15/258-1	15.04.2010	22:56	41° 23.58' N	29° 22.85' E	488.9	211	0.2	MB		MSM15-1_258-1
MSM15/259-1	16.04.2010	00:26	41° 29.08' N	29° 15.24' E	172.4	76.7	0.3	BC	RL max. 175m	MSM15-1_259-1
MSM15/260-1	16.04.2010	00:53	41° 28.96' N	29° 15.13' E	158.9	291.5	0.3	BC	RL max. 160m	MSM15-1_260-1
MSM15/261-1	16.04.2010	01:50	41° 30.12' N	29° 16.33' E	294.2	208.8	0.1	TVMUC		MSM15-1_261-1
MSM15/262-1	16.04.2010	02:29	41° 30.13' N	29° 16.34' E	295.7	34.2	0.3	TVMUC		MSM15-1_262-1
MSM15/263-1	16.04.2010	03:09	41° 29.92' N	29° 16.12' E	248.4	114.7	0.3	TVMUC		MSM15-1_263-1
MSM15/264-1	16.04.2010	04:22	41° 28.91' N	29° 15.07' E	149.9	225.5	0.3	TVMUC		MSM15-1_264-1
MSM15/265-1	16.04.2010	05:58	41° 25.89' N	29° 18.60' E	661	310	-0.3	CTD/RO	RL max. 652 m	MSM15-1_265-1
MSM15/266-1	16.04.2010	06:31	41° 25.88' N	29° 18.63' E	640.8	106.1	0.4	PF		MSM15-1_266-1
MSM15/267-1	16.04.2010	07:35	41° 25.81' N	29° 19.05' E	542.4	88.2	0.1	MB		MSM15-1_267-1
MSM15/268-1	16.04.2010	09:07	41° 25.45' N	29° 28.17' E	243.1	276.3	0.2	CTD/RO	RL max. 230m	MSM15-1_268-1
MSM15/269-1	16.04.2010	10:06	41° 28.33' N	29° 28.94' E	0	12.7	7	MB		MSM15-1_269-1
MSM15/270-1	16.04.2010	11:30	41° 31.97' N	29° 30.07' E	1063.1	77.6	0.2	CTD/RO	RL max. 1062m	MSM15-1_270-1
MSM15/271-1	16.04.2010	12:28	41° 31.98' N	29° 30.01' E	1068.4	116.8	0.2	FFP CTD	RL max. 395m	MSM15-1_271-1
MSM15/272-1	16.04.2010	15:19	41° 31.99' N	29° 30.01' E	1066.7	204.3	-0.6	CTD/RO	RL max. 401 m	MSM15-1_272-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/273-1	16.04.2010	17:18	41° 29.66' N	29° 19.13' E	845.2	254.8	7.4	MB		MSM15-1_273-1
MSM15/274-1	16.04.2010	18:23	41° 28.79' N	29° 14.89' E	135.6	119.1	0.3	CTD/RO	RL max. 127 m	MSM15-1_274-1
MSM15/275-1	16.04.2010	18:53	41° 28.78' N	29° 14.91' E	134.2	97.3	0.1	TVMUC		MSM15-1_275-1
MSM15/276-1	16.04.2010	19:08	41° 28.77' N	29° 14.90' E	135.6	210.8	0.3	ITUC	RL max. 136 m	MSM15-1_276-1
MSM15/277-1	16.04.2010	19:16	41° 28.77' N	29° 14.90' E	134.8	222.9	0.3	ITUC	RL max. 136 m	MSM15-1_277-1
MSM15/278-1	16.04.2010	19:50	41° 28.77' N	29° 14.90' E	131.6	257.1	0.5	BC	RL max. 137 m	MSM15-1_278-1
MSM15/279-1	16.04.2010	20:11	41° 28.77' N	29° 14.90' E	130.9	86.6	0.1	BC	RL max. 136 m	MSM15-1_279-1
MSM15/280-1	16.04.2010	20:55	41° 28.53' N	29° 14.62' E	115.9	75.1	0.2	CTD/RO	RL max. 112 m	MSM15-1_280-1
MSM15/281-1	16.04.2010	21:13	41° 28.53' N	29° 14.62' E	116	72.9	0.1	BC	RL max. 114m	MSM15-1_281-1
MSM15/282-1	16.04.2010	21:35	41° 28.54' N	29° 14.62' E	116.6	238.9	0.3	BC	RL max. 116	MSM15-1_282-1
MSM15/283-1	16.04.2010	22:29	41° 28.54' N	29° 14.63' E	117.4	83.2	0.1	TVMUC		MSM15-1_283-1
MSM15/284-1	16.04.2010	23:49	41° 25.22' N	29° 11.28' E	96.5	110.5	0.2	CTD/RO	RL max. 85m	MSM15-1_284-1
MSM15/285-1	17.04.2010	00:05	41° 25.21' N	29° 11.29' E	97.2	63.1	0.1	TVMUC	RL max. 99m	MSM15-1_285-1
MSM15/286-1	17.04.2010	00:47	41° 25.22' N	29° 11.29' E	96.4	246	0.5	TVMUC	RL max. 96m	MSM15-1_286-1
MSM15/287-1	17.04.2010	01:02	41° 25.23' N	29° 11.30' E	96.2	15.4	0.2	ITUC	RL max. 98m	MSM15-1_287-1
MSM15/288-1	17.04.2010	01:13	41° 25.23' N	29° 11.30' E	96.4	176.5	0	EAWAGC	RL max. 105m	MSM15-1_288-1
MSM15/289-1	17.04.2010	01:23	41° 25.22' N	29° 11.29' E	97.2	352.8	0.3	EAWAGC	RL max. 105m	MSM15-1_289-1
MSM15/290-1	17.04.2010	01:34	41° 25.22' N	29° 11.29' E	97.3	197.9	0.2	EAWAGC	RL max. 106m	MSM15-1_290-1
MSM15/291-1	17.04.2010	02:06	41° 25.22' N	29° 11.29' E	96.5	324.2	0.3	GC	RL max. 107m	MSM15-1_291-1
MSM15/292-1	17.04.2010	02:32	41° 25.22' N	29° 11.29' E	96.4	278.1	0	EAWAGC	RL max. 109m	MSM15-1_292-1
MSM15/293-1	17.04.2010	02:48	41° 25.22' N	29° 11.29' E	96.5	75.9	0.1	BC	RL max. 102m	MSM15-1_293-1
MSM15/294-1	17.04.2010	03:11	41° 25.22' N	29° 11.29' E	96.4	266.8	0.2	BC	RL max. 102m	MSM15-1_294-1
MSM15/295-1	17.04.2010	04:12	41° 22.31' N	29° 8.33' E	81.9	76.6	0.1	CTD/RO	RL max. 74m	MSM15-1_295-1
MSM15/296-1	17.04.2010	04:21	41° 22.31' N	29° 8.32' E	82.8	270.8	0.1	BC	RL max. 84m	MSM15-1_296-1
MSM15/297-1	17.04.2010	04:40	41° 22.31' N	29° 8.32' E	81.7	243.5	0.1	BC	RL max. 86m	MSM15-1_297-1
MSM15/298-1	17.04.2010	05:23	41° 22.31' N	29° 8.32' E	81.8	95.3	0.2	TVMUC		MSM15-1_298-1
MSM15/299-1	17.04.2010	05:36	41° 22.31' N	29° 8.32' E	82.1	159.8	0.1	ITUC	RL max. 84 m	MSM15-1_299-1
MSM15/300-1	17.04.2010	05:42	41° 22.31' N	29° 8.32' E	82.2	326.9	0.1	ITUC	RL max. 86 m	MSM15-1_300-1
MSM15/301-1	17.04.2010	06:36	41° 24.53' N	29° 10.56' E	92.6	203.6	0.2	CTD/RO	RL max. 86 m	MSM15-1_301-1
MSM15/302-1	17.04.2010	06:49	41° 24.53' N	29° 10.56' E	92.6	266	0.2	TVMUC		MSM15-1_302-1
MSM15/303-1	17.04.2010	07:02	41° 24.53' N	29° 10.56' E	91.2	289	0.2	ITUC	RL max. 94 m	MSM15-1_303-1
MSM15/304-1	17.04.2010	07:09	41° 24.53' N	29° 10.56' E	92	88.1	0.2	ITUC	RL max. 95 m	MSM15-1_304-1
MSM15/305-1	17.04.2010	09:31	41° 30.25' N	29° 16.44' E	334.4	51.5	0	TVMUC	RL 325m	MSM15-1_305-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/306-1	17.04.2010	17:15	41° 28.90' N	29° 15.12' E	155.8	106.4	0.2	PS		MSM15-1_306-1
MSM15/307-1	17.04.2010	17:42	41° 28.91' N	29° 15.06' E	152.8	153.5	0.1	CTD/RO	RL max. 146 m	MSM15-1_307-1
MSM15/308-1	17.04.2010	18:22	41° 28.91' N	29° 15.06' E	150.6	104	0.2	BBL PROFILER	RL max. 151 m	MSM15-1_308-1
MSM15/309-1	17.04.2010	21:20	41° 24.11' N	29° 16.43' E	145.8	271.2	0.1	CTD/RO	RL max. 150m	MSM15-1_309-1
MSM15/310-1	17.04.2010	21:52	41° 24.11' N	29° 16.43' E	147.1	76.8	0.2	BBL PROFILER	RL max. 167m	MSM15-1_310-1
MSM15/311-1	18.04.2010	01:54	41° 34.78' N	29° 3.45' E	307.1	149.9	0	ITUC	RL max. 315m	MSM15-1_311-1
MSM15/312-1	18.04.2010	02:07	41° 34.78' N	29° 3.45' E	307.1	117.2	0.1	ITUC	RL max. 316m	MSM15-1_312-1
MSM15/313-1	18.04.2010	02:43	41° 32.97' N	29° 3.41' E	116.9	248.3	0.3	ITUC	RL max. 117m	MSM15-1_313-1
MSM15/314-1	18.04.2010	02:53	41° 32.97' N	29° 3.41' E	116.9	356	0.1	ITUC	RL max. 120m	MSM15-1_314-1
MSM15/315-1	18.04.2010	03:37	41° 34.40' N	29° 3.46' E	188.3	288	0.1	CTD/RO	RL max. 174m	MSM15-1_315-1
MSM15/316-1	18.04.2010	03:51	41° 34.40' N	29° 3.46' E	188.3	141.7	0.1	ITUC	RL max. 186m	MSM15-1_316-1
MSM15/317-1	18.04.2010	04:13	41° 34.40' N	29° 3.46' E	187.5	200.4	0.2	ITUC	RL max. 191m	MSM15-1_317-1
MSM15/318-1	18.04.2010	05:13	41° 31.19' N	29° 3.42' E	97.3	80	0.4	CTD/RO	RL max. 85 m	MSM15-1_318-1
MSM15/319-1	18.04.2010	05:26	41° 31.20' N	29° 3.42' E	101.8	91.5	0.1	ITUC	RL max. 97 m	MSM15-1_319-1
MSM15/320-1	18.04.2010	05:42	41° 31.20' N	29° 3.42' E	98.8	103.5	0.1	GC	RL max. 96 m	MSM15-1_320-1
MSM15/321-1	18.04.2010	06:47	41° 25.36' N	29° 3.27' E	83	174.9	0.2	ITUC	RL max. 85 m	MSM15-1_321-1
MSM15/322-1	18.04.2010	06:53	41° 25.36' N	29° 3.27' E	81.6	164.4	0.1	ITUC	RL max. 83 m	MSM15-1_322-1
MSM15/323-1	18.04.2010	07:59	41° 23.28' N	29° 12.26' E	87.7	57	0.2	ITUC	RL max. 86 m	MSM15-1_323-1
MSM15/324-1	18.04.2010	08:10	41° 23.28' N	29° 12.26' E	87.6	37.7	0.2	GC	RL max. 80 m	MSM15-1_324-1
MSM15/325-1	18.04.2010	08:31	41° 23.28' N	29° 12.26' E	87.2	233	0.1	GC	RL max. 83 m	MSM15-1_325-1
MSM15/326-1	18.04.2010	08:41	41° 23.28' N	29° 12.26' E	87.5	141.1	0.1	MB		MSM15-1_326-1
MSM15/327-1	18.04.2010	10:00	41° 24.40' N	29° 16.70' E	210.1	352.2	0.2	MB		MSM15-1_327-1
MSM15/328-1	18.04.2010	10:17	41° 24.40' N	29° 16.69' E	258.2	359.7	0	CTD/RO	RL max. 245m	MSM15-1_328-1
MSM15/329-1	18.04.2010	11:42	41° 24.40' N	29° 16.69' E	262.8	131.2	0.1	FFP CTD	RL max. 240m	MSM15-1_329-1
MSM15/330-1	18.04.2010	12:48	41° 24.40' N	29° 16.69' E	234.1	131.8	0.1	CTD/RO	RL max. 245m	MSM15-1_330-1
MSM15/331-2	18.04.2010	16:05	41° 25.59' N	29° 28.77' E	443.2	328.4	0.1	CTD/RO	RL max. 363m	MSM15-1_331-2
MSM15/332-1	18.04.2010	17:47	41° 29.94' N	29° 16.11' E	253.2	76.8	0.1	TVMUC		MSM15-1_332-1
MSM15/333-1	18.04.2010	18:51	41° 29.63' N	29° 15.80' E	200.2	4.3	0.1	TVMUC		MSM15-1_333-1
MSM15/334-1	18.04.2010	19:17	41° 27.26' N	29° 16.99' E	152.7	166.3	12.9	MB		MSM15-1_334-1
MSM15/335-1	18.04.2010	19:56	41° 25.49' N	29° 17.79' E	602.6	271.1	0.1	CTD/RO	RL max. 587 m	MSM15-1_335-1
MSM15/336-1	18.04.2010	21:36	41° 25.29' N	29° 32.63' E	624.4	245.5	0.1	CTD/RO	RL max. 608m	MSM15-1_336-1
MSM15/337-1	20.04.2010	07:39	44° 46.21' N	31° 58.02' E	363.6	106.6	0.3	CTD/RO	RL max. 347 m	MSM15-1_337-1
MSM15/338-1	20.04.2010	08:31	44° 46.21' N	31° 58.02' E	363.8	122.8	1	MB		MSM15-1_338-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/339-1	20.04.2010	09:50	44° 46.61' N	31° 58.43' E	207.4	3.3	0.1	MEDUSA		MSM15-1_339-1
MSM15/340-1	20.04.2010	14:07	44° 47.55' N	31° 56.90' E	112.2	160.8	0.1	CTD/RO	RL max. 99 m	MSM15-1_340-1
MSM15/341-1	20.04.2010	15:04	44° 46.60' N	31° 58.43' E	207.9	273.7	0.7	CTD/RO	RL max. 201m	MSM15-1_341-1
MSM15/342-1	20.04.2010	15:59	44° 46.42' N	31° 59.79' E	255.9	297.4	0.6	CTD/RO	RL max. 241m	MSM15-1_342-1
MSM15/343-1	20.04.2010	16:48	44° 46.42' N	31° 59.79' E	257.1	172.6	0.2	MEDUSA		MSM15-1_343-1
MSM15/344-1	20.04.2010	20:40	44° 47.57' N	31° 57.31' E	117.2	359.5	0.2	CTD/RO	RL max. 101 m	MSM15-1_344-1
MSM15/345-1	20.04.2010	21:10	44° 47.37' N	31° 56.18' E	154.7	313.8	5	MB+PS		MSM15-1_345-1
MSM15/346-1	21.04.2010	05:15	44° 47.44' N	31° 57.40' E	124	279.7	0.2	BC	RL max. 133 m	MSM15-1_346-1
MSM15/347-1	21.04.2010	05:37	44° 47.44' N	31° 57.40' E	124.1	317	0.2	BC	RL max. 135 m	MSM15-1_347-1
MSM15/348-1	21.04.2010	06:02	44° 47.29' N	31° 57.69' E	145.6	349.5	0.4	BC	RL max. 160 m	MSM15-1_348-1
MSM15/349-1	21.04.2010	06:21	44° 47.29' N	31° 57.69' E	144.8	105	0.6	BC	RL max. 161 m	MSM15-1_349-1
MSM15/350-1	21.04.2010	06:54	44° 47.09' N	31° 58.04' E	161.3	172.1	0.2	BC	RL max. 176 m	MSM15-1_350-1
MSM15/351-1	21.04.2010	07:13	44° 47.09' N	31° 58.04' E	160.9	304.9	0.4	BC	RL max. 173 m	MSM15-1_351-1
MSM15/352-1	21.04.2010	08:09	44° 46.99' N	31° 58.60' E	182.1	133	0.4	CTD/RO	RL max. 174 m	MSM15-1_352-1
MSM15/353-1	21.04.2010	08:52	44° 46.99' N	31° 58.60' E	181.3	321.1	0.1	MEDUSA		MSM15-1_353-1
MSM15/354-1	21.04.2010	15:19	44° 49.12' N	32° 1.23' E	169.1	54.2	0.1	CTD/RO	RL max. 155 m	MSM15-1_354-1
MSM15/355-1	21.04.2010	15:59	44° 49.46' N	32° 0.53' E	120.4	338.5	0.3	CTD/RO	RL max. 98m	MSM15-1_355-1
MSM15/356-1	21.04.2010	16:28	44° 49.47' N	32° 0.53' E	121.2	181.6	0.2	MEDUSA		MSM15-1_356-1
MSM15/357-1	21.04.2010	21:42	44° 48.62' N	31° 59.74' E	300.5	135.9	3.9	MB+PS		MSM15-1_357-1
MSM15/358-1	22.04.2010	06:26	44° 49.31' N	32° 0.88' E	138.4	11.9	0.1	CTD/RO	RL max. 131 m	MSM15-1_358-1
MSM15/359-1	22.04.2010	07:02	44° 49.31' N	32° 0.88' E	138.4	274.5	0.1	MEDUSA		MSM15-1_359-1
MSM15/360-1	22.04.2010	11:45	44° 47.22' N	31° 57.58' E	142.2	331.4	0.1	CTD/RO	RL max. 131m	MSM15-1_360-1
MSM15/361-1	22.04.2010	12:28	44° 48.74' N	31° 55.32' E	82.9	30.5	0.2	BC	RL max. 81m	MSM15-1_361-1
MSM15/362-1	22.04.2010	12:44	44° 48.74' N	31° 55.32' E	83	292.3	0.1	BC	RL max. 81m	MSM15-1_362-1
MSM15/363-1	22.04.2010	14:04	44° 48.60' N	32° 0.10' E	149.7	243	0.1	MOORST	Ankerstein zu Wasser	MSM15-1_363-1
MSM15/364-1	22.04.2010	15:02	44° 48.70' N	31° 59.97' E	142.1	7.5	0.2	MOORST	Ankerstein zu Wasser	MSM15-1_364-1
MSM15/365-1	22.04.2010	15:44	44° 48.88' N	31° 59.80' E	133.9	100.2	0.1	MOORST	Ankerstein zu Wasser	MSM15-1_365-1
MSM15/366-1	22.04.2010	17:02	44° 46.51' N	31° 59.58' E	224.8	353.2	0.2	CTD/RO	RL max. 215 m	MSM15-1_366-1
MSM15/367-2	22.04.2010	20:01	44° 46.51' N	31° 59.36' E	213.5	96	0.2	MEDUSA		MSM15-1_367-2
MSM15/368-1	24.04.2010	20:35	44° 34.01' N	32° 42.40' E	395.5	204.5	0.5	CTD/RO	RL max. 385 m	MSM15-1_368-1
MSM15/369-1	24.04.2010	21:02	44° 34.01' N	32° 42.40' E	395.5	43	0.3	MB+PS		MSM15-1_369-1
MSM15/370-1	24.04.2010	23:06	44° 37.12' N	32° 53.68' E	161.7	23.5	-0.2	CTD/RO	RL max. 150 m	MSM15-1_370-1
MSM15/371-1	25.04.2010	06:20	44° 37.12' N	32° 53.67' E	161.6	178.4	-0.2	JAGO		MSM15-1_371-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/372-1	25.04.2010	08:53	44° 37.14' N	32° 53.49' E	0	78.7	0.1	JAGO		MSM15-1_372-1
MSM15/373-1	25.04.2010	15:19	44° 33.99' N	32° 42.39' E	397.6	196.4	-0.6	MUFO	RL 250m for calibration	MSM15-1_373-1
MSM15/374-1	25.04.2010	17:42	44° 37.27' N	32° 54.31' E	0	272.4	0.3	JAGO		MSM15-1_374-1
MSM15/375-1	25.04.2010	21:30	44° 37.46' N	32° 54.90' E	155.6	207.4	0.2	MOVE		MSM15-1_375-1
MSM15/376-1	26.04.2010	00:47	44° 36.87' N	32° 53.46' E	164.4	62.5	5.3	MB+PS		MSM15-1_376-1
MSM15/377-1	26.04.2010	10:34	44° 37.55' N	32° 54.98' E	156.1	344.5	0.4	TVMUC	RL max. 159m	MSM15-1_377-1
MSM15/378-1	26.04.2010	11:28	44° 37.53' N	32° 54.98' E	155.4	182.5	0.1	TVMUC	RL max. 159m	MSM15-1_378-1
MSM15/379-1	26.04.2010	12:33	44° 37.55' N	32° 54.97' E	154.7	297.5	0.2	TVMUC	RL max. 156m	MSM15-1_379-1
MSM15/380-1	26.04.2010	14:00	44° 37.65' N	32° 54.51' E	155.5	303.6	0.1	BBL MOR		MSM15-1_380-1
MSM15/381-1	26.04.2010	14:49	44° 37.62' N	32° 54.72' E	155.5	324.9	0.2	MUFO MOR		MSM15-1_381-1
MSM15/382-1	26.04.2010	15:58	44° 37.73' N	32° 54.91' E	157	73	0.1	CTD/RO	RL max. 147m	MSM15-1_382-1
MSM15/383-1	26.04.2010	17:13	44° 37.74' N	32° 54.92' E	153.9	320.7	0.2	KL MOR		MSM15-1_383-1
MSM15/384-1	26.04.2010	17:37	44° 37.77' N	32° 55.19' E	153.3	117.5	0	EDDY MOR		MSM15-1_384-1
MSM15/385-1	26.04.2010	18:52	44° 37.65' N	32° 55.08' E	153.9	258.8	0.1	BWS	RL max. 158 m	MSM15-1_385-1
MSM15/386-1	26.04.2010	20:22	44° 37.58' N	32° 54.97' E	155.5	279	0.1	MOVE	RL max. 157 m	MSM15-1_386-1
MSM15/387-1	27.04.2010	02:33	44° 37.61' N	32° 54.50' E	0	96.4	0.3	BBL MOR	Recovering	MSM15-1_387-1
MSM15/388-1	27.04.2010	03:11	44° 37.58' N	32° 54.72' E	154.9	121.3	0.1	MUFO MOR	Recovering	MSM15-1_388-1
MSM15/389-1	27.04.2010	03:59	44° 37.73' N	32° 55.19' E	154	146.3	0.1	EDDY MOR	Recovering	MSM15-1_389-1
MSM15/390-1	27.04.2010	04:40	44° 37.72' N	32° 54.92' E	154.7	339.2	0	KL MOR	Recovering	MSM15-1_390-1
MSM15/391-1	27.04.2010	05:08	44° 36.78' N	32° 53.42' E	165.9	62	4	MB+PS		MSM15-1_391-1
MSM15/392-1	27.04.2010	11:03	44° 37.12' N	32° 53.40' E	165.8	68.3	0.5	CTD/RO	RL max. 158m	MSM15-1_392-1
MSM15/393-1	27.04.2010	12:01	44° 37.08' N	32° 53.48' E	163.9	116.7	0.2	TVMUC	RL max. 166m	MSM15-1_393-1
MSM15/394-1	27.04.2010	13:37	44° 36.00' N	32° 50.19' E	193.9	37.1	0.2	JAGO		MSM15-1_394-1
MSM15/395-1	27.04.2010	17:49	44° 35.82' N	32° 49.15' E	205.9	296.5	0.4	CTD/RO	RL max. 194 m	MSM15-1_395-1
MSM15/396-1	27.04.2010	18:35	44° 36.09' N	32° 50.19' E	193.9	67.1	0.2	CTD/RO	RL max. 185 m	MSM15-1_396-1
MSM15/397-1	27.04.2010	19:55	44° 37.55' N	32° 55.11' E	155.3	316.4	0.1	MOVE	RL max. 159 m	MSM15-1_397-1
MSM15/398-1	28.04.2010	05:26	44° 38.25' N	32° 57.61' E	144.9	121.2	0.2	JAGO		MSM15-1_398-1
MSM15/399-1	28.04.2010	09:55	44° 37.34' N	32° 54.72' E	155.5	296.4	0.2	KL MOR	Freifall	MSM15-1_399-1
MSM15/400-1	28.04.2010	10:34	44° 37.31' N	32° 55.07' E	156.2	252.1	0.3	MUFO MOR	Freifall	MSM15-1_400-1
MSM15/401-1	28.04.2010	11:24	44° 37.45' N	32° 55.29' E	154.7	6.2	0.3	BBL MOR	Freifall	MSM15-1_401-1
MSM15/402-1	28.04.2010	11:59	44° 37.46' N	32° 55.05' E	154.7	356.8	0.2	EDDY MOR	Freifall	MSM15-1_402-1
MSM15/403-1	28.04.2010	12:47	44° 37.57' N	32° 55.00' E	154.7	65.8	0.2	CTD/RO	RL max. 145m	MSM15-1_403-1
MSM15/404-1	28.04.2010	13:15	44° 37.57' N	32° 55.00' E	155.5	161.4	0.1	BWS	RL max. 157m	MSM15-1_404-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/405-1	28.04.2010	14:24	44° 37.23' N	32° 54.59' E	157	190.6	0.1	JAGO		MSM15-1_405-1
MSM15/406-1	28.04.2010	19:15	44° 37.19' N	32° 54.72' E	156.1	149.6	0.1	MOVE	RL max. 155 m	MSM15-1_406-1
MSM15/407-1	28.04.2010	23:58	44° 37.29' N	32° 55.06' E	155.5	62.5	0.2	MUFO MOR	Recovering	MSM15-1_407-1
MSM15/408-1	29.04.2010	00:35	44° 37.42' N	32° 55.28' E	154.7	146	0.1	BBL MOR	Recovering	MSM15-1_408-1
MSM15/409-1	29.04.2010	01:00	44° 37.44' N	32° 55.05' E	154.7	68.8	0.1	EDDY MOR	Recovering	MSM15-1_409-1
MSM15/410-1	29.04.2010	01:53	44° 37.35' N	32° 54.72' E	155.5	40.3	0.1	KL MOR	Recovering	MSM15-1_410-1
MSM15/411-1	29.04.2010	04:20	44° 39.66' N	33° 2.97' E	127.7	267.2	0.1	CTD/RO	RL max. 120m	MSM15-1_411-1
MSM15/412-1	29.04.2010	05:25	44° 39.72' N	33° 2.99' E	127.6	156.4	0.1	JAGO		MSM15-1_412-1
MSM15/413-1	29.04.2010	08:46	44° 39.84' N	33° 3.63' E	126.1	206.2	0.1	CTD/RO	RL max. 121 m	MSM15-1_413-1
MSM15/414-1	29.04.2010	09:25	44° 40.24' N	33° 5.02' E	123.1	251.2	0.1	CTD/RO	RL max. 118m	MSM15-1_414-1
MSM15/415-1	29.04.2010	10:07	44° 40.70' N	33° 6.68' E	117.8	128.2	0.2	CTD/RO	RL max. 111m	MSM15-1_415-1
MSM15/416-1	29.04.2010	11:35	44° 37.25' N	32° 54.74' E	155.4	25.2	0.1	JAGO		MSM15-1_416-1
MSM15/417-1	30.04.2010	05:09	44° 32.60' N	32° 43.22' E	569	247.3	5.5	MB+PS		MSM15-1_417-1
MSM15/418-1	30.04.2010	09:40	44° 48.54' N	32° 0.09' E	155.1	253.4	0.1	MOORST	Recovering	MSM15-1_418-1
MSM15/419-1	30.04.2010	10:14	44° 48.68' N	31° 59.96' E	142.3	199.9	0.1	MOORST	Recovering	MSM15-1_419-1
MSM15/420-1	30.04.2010	10:47	44° 48.86' N	31° 59.78' E	131.8	161.6	0.1	MOORST	Recovering	MSM15-1_420-1
MSM15/421-1	30.04.2010	11:37	44° 48.73' N	31° 55.31' E	83.5	167.4	0.1	TVMUC	RL max. 80m	MSM15-1_421-1
MSM15/422-1	30.04.2010	12:30	44° 47.45' N	31° 57.38' E	124.2	193.3	0.2	TVMUC		MSM15-1_422-1
MSM15/423-1	30.04.2010	13:03	44° 47.45' N	31° 57.38' E	124.2	185	0.1	TVMUC	RL max. 122m	MSM15-1_423-1
MSM15/424-1	30.04.2010	13:35	44° 47.29' N	31° 57.70' E	147.7	183.8	0.4	TVMUC	RL max. 148m	MSM15-1_424-1
MSM15/425-1	30.04.2010	14:03	44° 47.09' N	31° 58.05' E	163.2	268.1	0.3	TVMUC	RL max. 163m	MSM15-1_425-1
MSM15/426-1	30.04.2010	14:49	44° 46.87' N	31° 58.50' E	174.9	262.8	0.2	TVMUC	RL max. 173m	MSM15-1_426-1
MSM15/427-1	30.04.2010	15:26	44° 46.60' N	31° 58.44' E	213.4	282.1	0.3	CTD/RO	RL max. 207 m	MSM15-1_427-1
MSM15/428-1	30.04.2010	15:51	44° 46.60' N	31° 58.44' E	212.6	10.4	0.1	TVMUC		MSM15-1_428-1
MSM15/429-1	30.04.2010	16:43	44° 48.59' N	32° 0.09' E	149.4	51.8	0	CTD/RO	RL max. 142 m	MSM15-1_429-1
MSM15/430-1	30.04.2010	21:33	44° 37.30' N	32° 54.75' E	156.2	205.8	0.1	CTD/RO	RL max. 149m	MSM15-1_430-1
MSM15/431-1	30.04.2010	22:28	44° 37.30' N	32° 54.75' E	155.4	77	0.1	MOORST	Ankerstein und Seaguard	MSM15-1_431-1
MSM15/432-1	30.04.2010	23:41	44° 39.04' N	33° 0.14' E	136.6	54.7	0.2	CTD/RO	RL max. 128m	MSM15-1_432-1
MSM15/433-1	30.04.2010	23:53	44° 39.04' N	33° 0.15' E	137.4	95.4	0.1	MOORST	Ankerstein und Seaguard	MSM15-1_433-1
MSM15/434-1	01.05.2010	00:51	44° 38.93' N	32° 59.98' E	137.4	170.5	0.1	KL MOR		MSM15-1_434-1
MSM15/435-1	01.05.2010	01:36	44° 38.84' N	33° 0.18' E	140.4	197.7	0	EDDY MOR		MSM15-1_435-1
MSM15/436-1	01.05.2010	02:09	44° 38.72' N	33° 0.06' E	138.1	272.9	0.2	BBL MOR		MSM15-1_436-1
MSM15/437-1	01.05.2010	02:55	44° 38.68' N	33° 0.26' E	136.6	253.3	0.1	MUFO MOR		MSM15-1_437-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/438-1	01.05.2010	03:45	44° 38.53' N	33° 0.08' E	138.1	124.8	0.1	CTD/RO	RL max. 128m	MSM15-1_438-1
MSM15/439-1	01.05.2010	04:08	44° 38.53' N	33° 0.08' E	138.9	252.9	0.1	BWS	RL max. 138m	MSM15-1_439-1
MSM15/439-2	01.05.2010	04:52	44° 38.53' N	33° 0.08' E	137.4	69	0.2	BWS	RL max. 140m	MSM15-1_439-2
MSM15/440-1	01.05.2010	06:26	44° 40.82' N	33° 6.43' E	118.6	73.7	0.1	JAGO		MSM15-1_440-1
MSM15/441-1	01.05.2010	08:44	44° 40.53' N	33° 5.68' E	0	78.9	3	MB+PS		MSM15-1_441-1
MSM15/442-1	01.05.2010	10:59	44° 49.50' N	33° 9.59' E	105	152.1	0.1	CTD/RO	RL max. 100m, BoKo	MSM15-1_442-1
MSM15/443-1	01.05.2010	11:07	44° 49.50' N	33° 9.59' E	105.8	197.5	0.1	MOORST	Ankerstein und Seacat	MSM15-1_443-1
MSM15/444-1	01.05.2010	12:09	44° 49.32' N	33° 9.46' E	104.2	343.3	0.1	JAGO		MSM15-1_444-1
MSM15/445-1	01.05.2010	15:03	44° 48.90' N	33° 9.23' E	105	169.8	0	MB+PS		MSM15-1_445-1
MSM15/446-1	01.05.2010	17:44	44° 38.72' N	33° 0.23' E	138.9	319.2	0.2	MUFO MOR	Recovering	MSM15-1_446-1
MSM15/447-1	01.05.2010	19:18	44° 35.84' N	32° 49.02' E	206.6	22.9	0.1	TVMUC		MSM15-1_447-1
MSM15/448-1	01.05.2010	19:50	44° 35.84' N	32° 49.03' E	207.4	199.7	0.3	TVMUC		MSM15-1_448-1
MSM15/449-1	01.05.2010	20:19	44° 35.85' N	32° 49.03' E	207.4	346.5	0.2	TVMUC		MSM15-1_449-1
MSM15/450-1	01.05.2010	22:22	44° 38.77' N	33° 0.06' E	137.4	136.4	0.1	BBL MOR	Recovering	MSM15-1_450-1
MSM15/451-1	01.05.2010	23:03	44° 38.89' N	33° 0.17' E	137.4	189.2	0.1	EDDY MOR	Recovering	MSM15-1_451-1
MSM15/452-1	01.05.2010	23:50	44° 38.93' N	32° 59.98' E	138.1	73.3	0.1	KL MOR	Recovering	MSM15-1_452-1
MSM15/453-1	02.05.2010	00:22	44° 38.91' N	32° 59.97' E	138.1	342.5	0	CTD/RO	RL max. 129m	MSM15-1_453-1
MSM15/454-1	02.05.2010	00:52	44° 38.91' N	32° 59.97' E	138.9	214	0	BWS	RL max. 142m	MSM15-1_454-1
MSM15/455-1	02.05.2010	02:05	44° 38.92' N	32° 59.97' E	137.4	27.2	0	MOVE	RL max. 119m	MSM15-1_455-1
MSM15/456-1	02.05.2010	08:35	44° 38.92' N	32° 59.97' E	138.1	271.7	0	JAGO		MSM15-1_456-1
MSM15/457-1	02.05.2010	11:43	44° 37.53' N	32° 54.79' E	154.2	117.2	0	CTD/RO	RL max. 148m	MSM15-1_457-1
MSM15/458-1	02.05.2010	13:06	44° 40.49' N	33° 5.53' E	120.4	99.5	0.1	TVMUC		MSM15-1_458-1
MSM15/459-1	02.05.2010	13:24	44° 40.48' N	33° 5.53' E	120.4	179.9	0.1	TVMUC		MSM15-1_459-1
MSM15/460-1	02.05.2010	14:26	44° 38.87' N	32° 59.94' E	138.4	66	0.1	JAGO		MSM15-1_460-1
MSM15/461-1	02.05.2010	19:07	44° 49.56' N	33° 9.34' E	103.9	23.3	5	MB+PS		MSM15-1_461-1
MSM15/462-1	02.05.2010	19:29	44° 49.45' N	33° 9.26' E	104.7	290.4	0.2	TVMUC		MSM15-1_462-1
MSM15/463-1	02.05.2010	19:55	44° 49.45' N	33° 9.26' E	103.9	345.3	0.1	TVMUC		MSM15-1_463-1
MSM15/464-1	02.05.2010	20:24	44° 49.45' N	33° 9.26' E	103.9	343.6	0.1	TVMUC		MSM15-1_464-1
MSM15/465-1	02.05.2010	20:42	44° 49.43' N	33° 9.25' E	103.9	130.4	0.1	EAWAGC	RL max. 108 m	MSM15-1_465-1
MSM15/466-1	02.05.2010	20:53	44° 49.43' N	33° 9.25' E	105.4	46	0.1	EAWAGC	RL max. 107 m	MSM15-1_466-1
MSM15/467-1	02.05.2010	21:03	44° 49.43' N	33° 9.25' E	106.2	192.1	0.1	EAWAGC	RL max. 107m	MSM15-1_467-1
MSM15/468-1	02.05.2010	21:15	44° 49.43' N	33° 9.25' E	105.4	191.9	0.1	EAWAGC	RL max. 106m	MSM15-1_468-1
MSM15/469-1	02.05.2010	21:42	44° 49.46' N	33° 9.67' E	105.5	53.5	0.1	KL MOR		MSM15-1_469-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/470-1	02.05.2010	22:15	44° 49.49' N	33° 9.31' E	104	144.6	0.1	EDDY MOR		MSM15-1_470-1
MSM15/471-1	02.05.2010	22:49	44° 49.37' N	33° 9.16' E	105.5	170.5	0.2	BBL MOR		MSM15-1_471-1
MSM15/472-1	02.05.2010	23:29	44° 49.25' N	33° 9.64' E	106.2	162.8	0.1	MUFO MOR		MSM15-1_472-1
MSM15/473-1	03.05.2010	00:16	44° 49.43' N	33° 9.66' E	103.2	153.9	0.1	CTD/RO	RL max. 96m	MSM15-1_473-1
MSM15/474-1	03.05.2010	00:38	44° 49.43' N	33° 9.66' E	103.2	183.5	0.4	BWS	RL max. 106m	MSM15-1_474-1
MSM15/475-1	03.05.2010	03:58	44° 49.44' N	33° 9.84' E	103.9	22.1	5	MB+PS		MSM15-1_475-1
MSM15/476-1	03.05.2010	06:36	44° 49.26' N	33° 9.32' E	106.9	19.8	0.2	MOVE	RL max. 105 m	MSM15-1_476-1
MSM15/477-1	03.05.2010	05:59	44° 49.26' N	33° 9.32' E	105.4	316.2	0.2	JAGO		MSM15-1_477-1
MSM15/478-1	03.05.2010	09:41	44° 49.24' N	33° 9.63' E	917.8	187.6	0.1	MUFO MOR	Recovering	MSM15-1_478-1
MSM15/479-1	03.05.2010	10:14	44° 49.48' N	33° 9.29' E	0	204.2	0.1	EDDY MOR	Recovering	MSM15-1_479-1
MSM15/480-1	03.05.2010	10:50	44° 49.37' N	33° 9.14' E	0	23.2	0.2	BBL MOR	Recovering	MSM15-1_480-1
MSM15/481-1	03.05.2010	11:29	44° 49.34' N	33° 9.46' E	0	194.9	0	KL MOR	Recovering	MSM15-1_481-1
MSM15/482-1	03.05.2010	12:16	44° 49.07' N	33° 9.53' E	0	267.2	0	JAGO		MSM15-1_482-1
MSM15/483-1	03.05.2010	17:13	44° 49.42' N	33° 9.70' E	103.9	23.2	5.1	MB+PS		MSM15-1_483-1
MSM15/484-1	03.05.2010	17:53	44° 49.49' N	33° 9.32' E	103.9	7.9	0.2	MOVE	RL max. 102 m	MSM15-1_484-1
MSM15/485-1	04.05.2010	03:00	44° 49.49' N	33° 9.25' E	106.9	58.5	0.2	MB+PS		MSM15-1_485-1
MSM15/486-1	04.05.2010	06:59	44° 39.00' N	33° 0.96' E	134	202.6	0	JAGO		MSM15-1_486-1
MSM15/487-1	04.05.2010	09:51	44° 38.78' N	33° 0.25' E	136.2	43.7	0.1	TVMUC	RL max. 141m	MSM15-1_487-1
MSM15/488-1	04.05.2010	10:15	44° 38.79' N	33° 0.26' E	136.2	35.7	0	TVMUC	RL max. 144m	MSM15-1_488-1
MSM15/489-1	04.05.2010	10:40	44° 38.79' N	33° 0.25' E	137.7	336.3	0.1	TVMUC	RL max. 141m	MSM15-1_489-1
MSM15/490-1	04.05.2010	11:27	44° 38.79' N	33° 0.27' E	137.7	337.1	0.1	BC	RL max. 144	MSM15-1_490-1
MSM15/491-1	04.05.2010	12:29	44° 37.49' N	32° 54.75' E	154.9	168.9	0.1	BC	RL max. 157m	MSM15-1_491-1
MSM15/492-1	04.05.2010	12:58	44° 37.49' N	32° 54.75' E	985.3	143.3	0.2	JAGO		MSM15-1_492-1
MSM15/493-1	04.05.2010	15:59	44° 37.66' N	32° 54.85' E	154.2	106.7	0.1	CTD/RO	RL max. 149m	MSM15-1_493-1
MSM15/494-1	04.05.2010	16:37	44° 37.41' N	32° 55.02' E	155.8	62.8	0.1	EAWAGC	RL max. 159m	MSM15-1_494-1
MSM15/495-1	04.05.2010	16:48	44° 37.41' N	32° 55.01' E	155.7	148.1	0.3	EAWAGC	RL max. 158m	MSM15-1_495-1
MSM15/496-1	04.05.2010	16:59	44° 37.41' N	32° 55.01' E	156.5	255.9	0.4	EAWAGC	RL max. 159m	MSM15-1_496-1
MSM15/497-1	04.05.2010	17:09	44° 37.41' N	32° 55.02' E	156.4	204.7	0.4	EAWAGC	RL amx. 158m	MSM15-1_497-1
MSM15/498-1	04.05.2010	18:08	44° 37.43' N	32° 54.84' E	155	71	0.2	MOVE	RL max. 160 m	MSM15-1_498-1
MSM15/499-1	05.05.2010	00:11	44° 38.80' N	33° 0.26' E	139.9	263.6	0.1	KL MOR		MSM15-1_499-1
MSM15/500-1	05.05.2010	00:41	44° 38.67' N	33° 0.10' E	136.9	108.4	0.1	EDDY MOR		MSM15-1_500-1
MSM15/501-1	05.05.2010	01:10	44° 38.51' N	33° 0.21' E	137.7	187.7	0.1	BBL MOR		MSM15-1_501-1
MSM15/502-1	05.05.2010	01:46	44° 38.33' N	33° 0.14' E	138.4	45.8	0.2	MUFO MOR		MSM15-1_502-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/503-1	05.05.2010	02:31	44° 38.26' N	33° 0.46' E	136.9	117.2	0.1	CTD/RO	RL max. 131m	MSM15-1_503-1
MSM15/504-1	05.05.2010	02:56	44° 38.26' N	33° 0.46' E	136.9	146.1	0.1	BWS	RL max. 143m	MSM15-1_504-1
MSM15/505-1	05.05.2010	04:36	44° 36.38' N	32° 52.72' E	170.7	34.7	0.1	BC	RL max. 171m	MSM15-1_505-1
MSM15/506-1	05.05.2010	05:28	44° 36.38' N	32° 52.72' E	170.7	127.2	0.2	TVMUC		MSM15-1_506-1
MSM15/507-1	05.05.2010	05:59	44° 36.38' N	32° 52.72' E	169.9	129.4	0.2	JAGO		MSM15-1_507-1
MSM15/508-1	05.05.2010	09:57	44° 38.35' N	33° 0.12' E	137.6	50.7	0.1	MUFO MOR	Recovering	MSM15-1_508-1
MSM15/509-1	05.05.2010	10:28	44° 38.52' N	33° 0.18' E	136.9	163.3	0.1	BBL MOR	Recovering	MSM15-1_509-1
MSM15/510-1	05.05.2010	11:02	44° 38.72' N	32° 59.99' E	136.9	298.7	0.6	EDDY MOR	Recovering	MSM15-1_510-1
MSM15/511-1	05.05.2010	11:37	44° 38.81' N	33° 0.26' E	136.2	15.7	0.1	KL MOR	Recovering	MSM15-1_511-1
MSM15/512-1	05.05.2010	12:38	44° 37.39' N	32° 56.21' E	149.7	154.5	0	JAGO		MSM15-1_512-1
MSM15/513-1	05.05.2010	15:20	44° 37.87' N	32° 57.22' E	146.7	331.4	0.1	TVMUC		MSM15-1_513-1
MSM15/514-1	05.05.2010	15:57	44° 37.87' N	32° 57.22' E	147.4	21.4	0.1	BC	RL max. 158m	MSM15-1_514-1
MSM15/515-1	05.05.2010	17:02	44° 36.33' N	32° 52.68' E	172.2	15.4	0.1	CTD/RO	RL max. 166m	MSM15-1_515-1
MSM15/516-1	05.05.2010	17:47	44° 35.74' N	32° 49.25' E	205.9	266.2	0.2	BC	RL max. 210 m	MSM15-1_516-1
MSM15/517-1	05.05.2010	18:04	44° 35.74' N	32° 49.25' E	205.9	342.7	0.1	EAWAGC	RL max. 210 m	MSM15-1_517-1
MSM15/518-1	05.05.2010	18:14	44° 35.74' N	32° 49.25' E	205.9	340	0	EAWAGC	RL max. 207 m	MSM15-1_518-1
MSM15/519-1	05.05.2010	18:25	44° 35.74' N	32° 49.25' E	205.9	21	0.1	EAWAGC	RL max. 207 m	MSM15-1_519-1
MSM15/520-1	05.05.2010	18:35	44° 35.74' N	32° 49.25' E	205.9	315.7	0	EAWAGC	RL max. 206 m	MSM15-1_520-1
MSM15/521-1	05.05.2010	20:03	44° 35.74' N	32° 49.25' E	205.9	68	0	MOVE	RL max. 204 m	MSM15-1_521-1
MSM15/522-1	06.05.2010	00:47	44° 35.92' N	32° 49.89' E	199.2	18.7	0.1	KL MOR		MSM15-1_522-1
MSM15/523-1	06.05.2010	01:18	44° 35.60' N	32° 49.92' E	200.7	342.5	0.2	BBL MOR		MSM15-1_523-1
MSM15/524-1	06.05.2010	02:25	44° 35.39' N	32° 50.18' E	196.2	87.2	0.1	MUFO	auf RL 180m, Messung in der Wassersäule	MSM15-1_524-1
MSM15/525-1	06.05.2010	03:31	44° 35.04' N	32° 50.49' E	194.7	254	0.2	CTD/RO	RL max. 187m	MSM15-1_525-1
MSM15/526-1	06.05.2010	04:14	44° 35.04' N	32° 50.49' E	195.4	231.9	0.3	BWS	RL max. 198m	MSM15-1_526-1
MSM15/527-1	06.05.2010	05:50	44° 33.56' N	32° 44.24' E	362.7	56.2	0.1	JAGO		MSM15-1_527-1
MSM15/528-1	06.05.2010	09:01	44° 35.73' N	32° 49.23' E	205.9	146	0.2	TVMUC	RL max. 208m	MSM15-1_528-1
MSM15/529-1	06.05.2010	09:55	44° 35.29' N	32° 49.48' E	211.2	305.7	0	JAGO		MSM15-1_529-1
MSM15/530-1	06.05.2010	12:11	44° 35.09' N	32° 49.10' E	208.2	171.9	0	CTD/RO	RL max. 198m	MSM15-1_530-1
MSM15/531-1	06.05.2010	13:10	44° 35.62' N	32° 49.92' E	200.7	218.7	0.1	BBL MOR	Recovering	MSM15-1_531-1
MSM15/532-1	06.05.2010	14:11	44° 35.93' N	32° 49.91' E	200.7	330.7	0.1	KL MOR	Recovering	MSM15-1_532-1
MSM15/533-1	06.05.2010	15:40	44° 38.56' N	33° 0.07' E	136.9	359.8	0.1	BC	RL max. 147m	MSM15-1_533-1
MSM15/534-1	06.05.2010	18:21	44° 49.43' N	33° 9.46' E	103.9	90.2	0.1	BC	RL max. 108 m	MSM15-1_534-1

Station	Date UTC	Time UTC	Position Latitude	Position Longitude	Depth [m]	Head. [deg]	Speed [kn]	Gear	Comment	Pangaea ID
MSM15/535-1	06.05.2010	19:21	44° 49.43' N	33° 9.43' E	103.9	360	0.1	MOVE	RL max. 103 m	MSM15-1_535-1
MSM15/536-1	07.05.2010	01:18	44° 49.42' N	33° 9.42' E	106.2	8.3	0.1	CTD/RO	RL max. 96m	MSM15-1_536-1
MSM15/537-1	07.05.2010	01:48	44° 49.46' N	33° 9.59' E	103.2	87.9	0.2	MOORST	Recovering	MSM15-1_537-1
MSM15/538-1	07.05.2010	03:11	44° 39.14' N	33° 0.03' E	136.9	34.3	0.1	CTD/RO	RL max. 129m	MSM15-1_538-1
MSM15/539-1	07.05.2010	03:55	44° 39.22' N	32° 59.98' E	136.1	329.2	1.4	MOORST	Recovering	MSM15-1_539-1
MSM15/540-1	07.05.2010	04:46	44° 37.35' N	32° 54.60' E	154.9	324.6	0.1	CTD/RO	RL max. 151m	MSM15-1_540-1
MSM15/541-1	07.05.2010	05:33	44° 37.47' N	32° 54.12' E	157.2	287.7	1.4	MOORST	Recovering	MSM15-1_541-1
MSM15/542-1	07.05.2010	08:17	44° 10.00' N	32° 30.01' E	0	106.9	0.2	ARGOFL		MSM15-1_542-1
MSM15/543-1	07.05.2010	09:54	44° 0.02' N	32° 4.92' E	0	246.7	1.5	ARGOFL		MSM15-1_543-1

Gear List RV MARIA S. MERIAN on MSM 15/1

Ship based tools

BBL PROFILER	MES	Benthic Boundary Layer Profiler
BC	SAM	Box corer
BWS	SAM	Bottom water sampler
CTD	MES	CTD
EAWAGC	SAM	EAWAG Corer
EM1002	MES	Shallow Water Multibeam Echosounder
EM120	MES	Deep Water Multibeam Echosounder
FFP CTD	MES	Free Fall Pump CTD
GC	SAM	Gravity corer
ITUC	SAM	ITU Corer
MB	MES	Multibeam Echosounder, on MSM15-1 default EM1002
MEDUSA	MES	Video and CTD RLeigh
MUFO MOR	MOOR	Multi Fibre Optics Sensor Mooring
PS	MES	Atlas Parasound Sub-Bottom Echosounder
RO	SAM	Rosette water sampler
TV-MUC	SAM	TV-Multicorer

Submersible based tools

MRK	POS	Passive Marker
NIS_5L	SAM	Niskin bottle 5 litre volume (Water) on the lift
OPTODE	MES	Oxygen Optode
PUC	SAM	Pushcore (Geochemistry)

Lander

ARGOFL	MOOR	ARGO Float
BBL MOR	MOOR	Benthic Boundary Layer Profiler Mooring
KL MOR	MOOR	Chamber Lander Mooring
MOORST	MOOR	Mooring (short time)
MUFO MOR	MOOR	Multi Fibre Optics Sensor Mooring
EDDY MOR	MOOR	Eddy Mooring
HYPOX	MOOR	Hypox lander
PF	MOOR	Provor Float

7 Data and Sample Storage and Availability

Post-cruise data archival will be hosted by the information system PANGAEA at the World Data Center for Marine Environmental Sciences (WDC-MARE), which is operated on a long-term base by the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven (AWI) and the MARUM, Bremen. The ship's station list and all metadata from sampling and observations are stored in the WDC MARE data base PANGAEA , including ship tracks, (http://www.pangaea.de/search?q=msm15*) and have been submitted as CSR to the DOD (BSH). Further scientific data retrieved from observations, measurements and home-based data analyses will also be submitted to PANGAEA either upon publication, or with password protection by the individual P.I.s as soon as the data are available and quality-assessed. This includes oceanographic, physical, geological, chemical and biological data, for most of which parameters are already defined in PANGAEA. Molecular data will be deposited in globally accessible databases such as GenBank. As many of the retrieved data will be needed for modeling and budgeting, we expect a very good flow of data between the multidisciplinary participants. For benthic images a photo and video database is under construction at the research center MARUM (Bremen), which in the future will be accessible to taxonomic specialists. All zoological samples are stored at IBSS (Macro and Meiofauna), and all microbiological samples are stored deep frozen or fixed at the MPI in Bremen. They have already been made available upon request to several German institutes and museums, and will be provided if needed upon definition of scientific collaborations.

8 Acknowledgements

R/V MARIA S. MERIAN Cruise MSM15-1 "HYPOX" was an interdisciplinary and international project hosting scientists from a network of partners of the 7th FP EU project HYPOX. We thank all of the related institutions and funding agencies for their support. The cruise and research program were planned, coordinated, and carried out by MPI. The shipboard crew of the MARIA S. MERIAN provided excellent technical support for the large variety of instruments required for the complex operations at sea. Hence we would especially like to thank the Master of the research vessel MARIA S. MERIAN, Kapitän Friedhelm von Staa and his crew for their excellent support with work at sea. Also, we thank the JAGO, MOVE and MEDUSA teams for the excellent dives essential for fulfilling the goals of the cruise. The MERIAN ship time was provided by the Deutsche Forschungsgemeinschaft. Financial support for the HYPOX project was provided though the EU 7th FP. For the complex diplomatic and logistic operations we cordially thank the METEOR/MERIAN Leitstelle Hamburg for their help.

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