MARIA S. MERIAN-BERICHTE

LOOME

Cruise No. 16, Leg 2

September 24 – October 10, 2010, Tromsø – Tromsø (Norway)

A. Boetius, D. De Beer, S. Albrecht, V. Asendorf, A. Billings, R. Camilli, K De Rycker, A. Duester, L. Dussud, G. Eickert-Groetschel, J. Felden, B. Ferre, C. German, F. Harmegnies, J. Kinsey, J. Maloney, R. Stiens, J. Van Campenhout, J. Vercruysse, W. Versteeg, M. Viehweger, E. Weiz, G. Wetzel, D. Yoerger

Editorial Assistance:

Senatskommission für Ozeanographie der Deutschen Forschungsgemeinschaft
MARUM – Zentrum für Marine Umweltwissenschaften der Universität Bremen

Leitstelle Deutsche Forschungsschiffe
Institut für Meereskunde der Universität Hamburg

2013

The MARIA S. MERIAN-Berichte are published at irregular intervals. They are working papers for people who are occupied with the respective expedition and are intended as reports for the funding institutions. The opinions expressed in the MARIA S. MERIAN-Berichte are only those of the authors.

The MARIA S. MERIAN expeditions are funded by the *Deutsche Forschungsgemeinschaft (DFG)* and the *Bundesministerium für Bildung und Forschung (BMBF)*.

The reports are available in PDF format from http://www.dfg-ozean.de/.

Editor:
DFG Senatskommission für Ozeanographie
c/o MARUM – Zentrum für Marine Umweltwissenschaften
Universität Bremen
Leobener Strasse
28359 Bremen

Author:
Prof. Dr. Antje Boetius
HGF MPG Brückengruppe für
Tiefseeökologie und -technologie
Alfred-Wegener-Institut für
Polar- und Meeresforschung
Am Handelshafen 12
D-27570 Bremerhaven / Germany

Telefon: +49 (0)421 2028 860
Telefax: +49 (0)421 2028 690
e-mail: aboetius@mpi-bremen.de

Citation: Antje Boetius, RV MARIA S. MERIAN, Cruise Report MSM16/L2, LOOME 2010, 47 pp., DFG Senatskommission für Ozeanographie

ISSN 2195-8483

Table of Content

1 Summary

The leg MSM16-2 started on the 24.09.10 in Tromsø (Norway) and ended on the 08.10.10 also in Tromsø. It carried out multidisciplinary research at the long-term deep water observatory Håkon Mosby Mud Volcano (72°N, 14° 43'E) for the EU-Projects ESONET "European Seas Observatory Network" (Demonstration Mission LOOME "Long term observations on mud volcano eruptions"), HERMIONE "Hotspot Ecosystem Research and Man's Impact on European Seas" (Workpackage 5 "Chemosynthetic Ecosystems") and the GDRE DIWOOD, a partner of the ESF EUROCORES EuroDeep project CHEMECO "Colonization processes in chemosynthetic ecosystems". Specific objectives included the recovery of the LOOME observatory components deployed in 2009, and the completion of geological, physical and biogeochemical measurements for the analysis of ecosystem changes related to mud and gas eruptions. All components were successfully retrieved with the help of the ROV GENESIS and the excellent maneuverability of MARIA S. MERIAN. In addition, the use of the AUV Sentry equipped with a multibeam, subbottom profiler, CTD and photographic unit as well as with a mass spectrometer provided a systematic overview on changes associated with mud volcanism.

Zusammenfassung

Der Fahrtabschnitt MSM16-2 begann am 24.09.2010 in Tromsø (Norwegen) und endete am 24.09.2010 ebenfalls in Tromsø. Die Expedition hatte zum Ziel multidisziplinäre Tiefseeforschung durchzuführen für verschieden Projekte wie ESONET "European Seas Observatory Network" (Demonstration Mission LOOME "Long term observations on mud volcano eruptions"), HERMIONE "Hotspot Ecosystem Research and Man's Impact on European Seas" (Workpackage 5 "Chemosynthetic Ecosystems") und GDRE DIWOOD, ein Partner im ESF EUROCORES EuroDeep Projekt CHEMECO "Colonization processes in chemosynthetic ecosystems". Die wichtigste Aufgabe der Ausfahrt war die Bergung des 2009 ausgebrachten LOOME Schlammvulkan-Observatoriums, sowie die Durchführung von geologischen, physikalischen und biochemischen Messungen, um zeitliche Veränderungen des Ökosystems in Zusammenhang mit Schlammeruptionen zu untersuchen. Mit Hilfe des ROV GENESIS sowie der exzellenten Manövrierfähigkeit der MARIA S. MERIAN konnten alle Komponenten des Observatoriums geborgen werden. Zusätzlich ermöglichte der Einsatz des AUV Sentry, unter anderen ausgestattet mit Multibeam-, CTD-, Profiler- und Fotoeinheiten sowie einem Massenspektrometer, eine systematischen Überblick über die Veränderungen des Ökosystems durch Schlammvulkanismus zu erhalten.

2 Participants

Name	Discipline	Institution
Boetius, A. Prof. Dr.	Chief Scientist	AWI
De Beer, D. Dr.	Coordinator LOOME	MPI
Felden, J. Dr.	In situ Biogeochemistry	MPI
Viehweger, M.	LOOME recovery	MPI
Asendorf, V.	Lift, Lander	MPI
Weiz, E.	Biogeochemistry	MPI
Stiens, R.	Biogeochemistry	MPI

Van Campenhout, J.	Biology	Ugent
Wetzel, G.	Heat flux	IfM GEOMAR
Harmegnies, F.	T lance	IFREMER
Dussud, L.	LOOME recovery	IFREMER
Ferre, B. Dr.	OBS	TROMSO
Eickert-Groetschel, G.	Microsensor	MPI
Albrecht, S.	Mapping, Data management	Fielax
German, C. Dr.	AUV team leader	WHOI
Camilli, C. Dr.	In situ mass spectrometry	WHOI
Billings, A. Dr.	AUV	WHOI
Kinsey, J. Dr	AUV	WHOI
Duester, A. Dr.	AUV	WHOI
Yoerger, D.	AUV	WHOI
Maloney, J.	AUV	WHOI
Versteeg, W. Dr.	ROV team	Gent
Vercruysse, J.	ROV team	Gent
De Rycker, K.	ROV team	Gent

MPI	Max-Planck-Institute for Marine Microbiology
AWI	Alfred Wegener Institute for Polar and Marine Research
UGent	University Gent
WHOI	Woods Hole Oceanographic Institution
IFREMER	French Research Institute for Exploitation of the Sea
IFM GEOMAR	Leibniz-Institute for Marine Research at the University Kiel

3 Research Program

The Håkon Mosby is located at a water depth of 1250 m on the SW Barents Sea slope. At this site, liquefied mud, gas, and geofluids rising from a subseafloor depth of at least 3 kilometers, form a highly active mud volcano with a diameter of 1.5 kilometer, characterized by permanent gas emission. It is the priority target site of the ESONET project and also a key site of the EU projects HERMES, HERMIONE, MARBEF and the ESF EuroDeep program CHEMECO. Earlier investigations showed that fluid flow rates control the distribution of chemosynthetic communities, the stability of the hydrate system and gas emission. The first long-term observation of sediment temperatures from September 2005 to June 2006 yielded evidence of several eruptive events, indicated by abrupt temperature increases of several °C within a few days. High-resolution bathymetric maps and video observations of the seafloor also showed changes in the morphology of HMMV at that time.

A year before the MSM16/2 mission, on 24th July 2009 the LOOME observatory was deployed with the research vessel POLARSTERN and the ROV QUEST (MARUM). The MSM16/2 mission was planned to recover all LOOME observatory components, and to complete a detailed investigation of the temporal variability of the activity at HMMV, to compare events before, during, and after an eruption, and to analyze their effects on gas hydrate stability and the distribution of benthic communities.

The seafloor observatory LOOME consisted of numerous autonomous instruments that were integrated in an autonomous cabled network. In order to minimize the effect of potential failures, all instruments were autonomous in terms of data storage and power supply. We were prepared for a safe and efficient recovery procedure via ROV in combination with a hook lowered by the ship's winch, and as back up plan we were also prepared for an autonomous release of the main observatory frame. Chemical sensors measuring at the seafloor and in the water column were to be recovered with the frame of the observatory. The OBS was planned to be recovered autonomously; the temperature lance and camera were also recovered by the ship's cable hooked to the components at the seafloor by the ROV.

Furthermore, we performed physical, geological and biogeochemical measurements at the main HMMV habitats. These investigations included sediment sampling by using TV-guided multicorer device, benthic lander deployments equipped with benthic chambers and a profiler unit, and T-Lance transect in order to compare results to previous measurements in 2009. A detailed assessment of the inventory of microbes, meiofauna and macrofauna before, during and after the observation period will provide insights into the effects of seepage variability on the distribution of habitats. ROV and AUV based video mosaicking of the seafloor together with AUV-based high-resolution mapping provided highly interesting results of recent mud volcanism, and changes in the habitat distribution at the HMMV. The AUV measured also methane emission via in situ mass spectrometry. All these approaches were used to investigated interannual changes connected to eruption events and mud displacement recorded by the LOOME observatory at the HMMV.

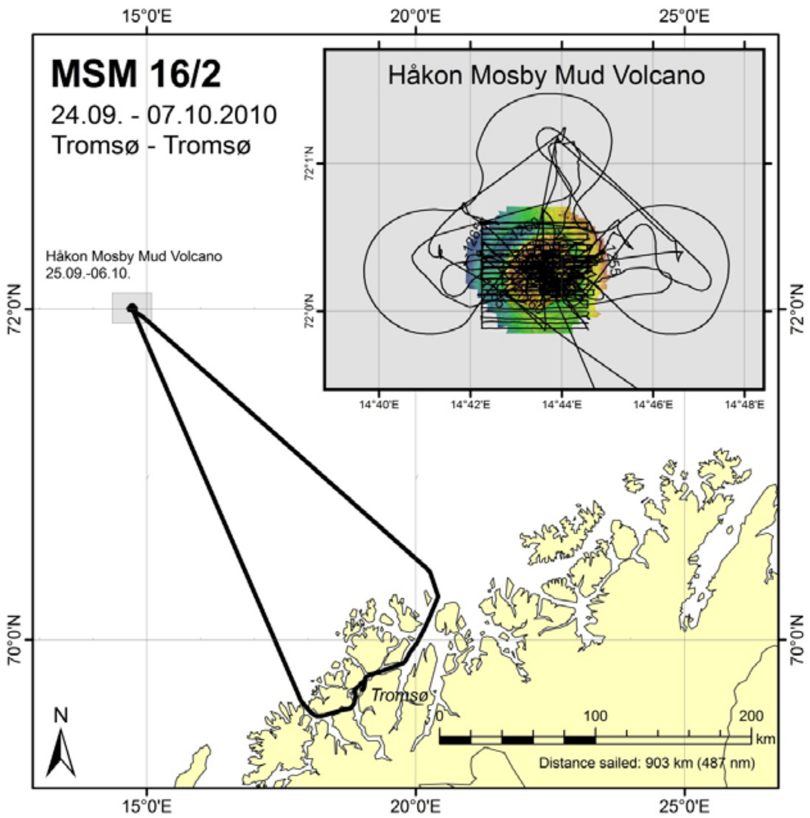


Figure 3.1: Track chart of R/V MERIAN Cruise MSM16/2

4 Narrative of the Cruise

The LOOME mission MSM16-2 started on the 24th September 2010 heading from Tromsø to the HMMV, and work started late 25th September 2010 in stormy seas using the video-guided multicorer. Thanks to the precise positioning of the MERIAN, we were able to visually relocate most observatory components, the LOOME central frame on the gashydrate-bearing rim, and the sensors in the mud flow 50-100 m southwards of the LOOME frame. We were astonished to see the sensor cables of LOOME under tension, indicating some movement of the muds. Winds were too strong in the morning of the 26th September to launch the ROV and AUV. Hence, we deployed navigation transponders for the AUV Sentry, and calibrated the navigation tools of the ROV Genesis, AUV Sentry and the mobile Posidonia and Gaps Transponders. The wave height decreased during the day, and we were able to launch AUV Sentry in the evening. The first goal was to produce a complete microbathymetry of the HMMV along with a subsurface sonar survey. The AUV is able to run for up to 30 h independent of the ship allowing parallel work with other scientific instruments. Hence, we were able to launch the ROV Genesis of University Gent for a first Reconnaissance-dive immediately after the AUV.

Next was the deployment of the benthic lander to carry out measurements of the total benthic oxygen and methane fluxes, as well as profiles of pH, sulfide and other pore water species. Unfortunately, the program of the 26.09.2010 had to be changed, as the fiber optics cable of the ship was damaged and we were not able to continue the TV-guided multicorer program or the online temperature measurements in the seabed.

As the previous surveys with the TV-MUC were not successful in locating the IFREMER T-lance moored in 2009, nor the OBS of the University Tromsø, we planned further ROV Genesis dives, to first recover the AIM camera observatory of IFREMER and the LOOME frame, and to locate and recover the T-lance and OBS. On 27.9.2010 we started the first recovery dive for the camera. This operation is highly challenging for the ship and the ROV, as we have to work with two cables in the water – that of the ROV, and the ship's cable with a hook to pick up and haul in the observatory components, to be coordinated at a depth of 1250 m. Due to the very good weather conditions and the excellent maneuverability of the ship, we were able to retrieve in one dive both the camera and the LOOME frame. A first look at the data downloads showed that most components had worked and recorded data for a year.

On the 28.09.2010 we continued with the mapping of the mud volcano especially in the north, which showed significant changes in the seafloor topography. The high-resolution images obtained with the AUV Sentry allowed us to get a better insight into the shape of the mud flows and the distribution of chemosynthetic communities. On the 29.9.2010, we sampled the new, fresh mudflow identified both by AUV and ROV with the multicorer and the benthic lander. A large Parasound survey showed abundant gas flares in the water column across the entire mud volcano center as well as associated with the Northern rim containing gas hydrates. The 30th September was dedicated to a further search of the missing T-lance: we finally found it after a day of searching in circles 160 m south of its original mooring position. The T-lance reaches 17 m into the seabed, and hence at least the top 20 m of the central mud flow must have migrated this large distance south – parallel to the slope. Accordingly, the data showed a decrease of the surface temperature gradient with increasing distance from the hot spot. This fits the observation of larger bacterial mats and higher abundances if Zoarces fish and rays in the former barren center. In the afternoon of 30.9.2010 we had a transfer of scientists at sea, to be able to run the in situ mass spectrometer for a quantification of methane and carbon dioxide in the water column. Finally, also the fiber optics cable was repaired in the evening of the 30.9.2010, and we started the real-time in situ temperature transects during the night.

On 1.10.2010 we launched AUV Sentry again for a 30 h dive, for the parallel high resolution recording of the fresh mudflows in the North as well as the methane concentrations at different water depths. In parallel we deployed the chamber lander, TV-guided multicorer, heat flow lance, and on the 2.10.2010 also the ROV. This dive was dedicated to retrieving samples from the long term DIWOOD experiments on sunken wood in the deep sea - after 3 years, the wood-boring bivalves had almost completely consumed the wood and only few organisms were retrieved together with the wood samples. On 3.10.2010, we have recovered the OBS and continued with high-resolution measurements in the water column and above the seafloor to better quantify gas emission, and to map the surface temperature of the central mud flow. At night, the map of subsurface temperatures was completed with the online heat probe. On the 4th October, after more than a week of great weather, wind and waves picked up again, so that we continued with TV-multicorer stations and gas flare mapping with the ship's Parasound system. In the morning of the 5.10.2010, we had a window in the weather situation and deployed the AUV for a last dive crossing the mud volcano and completing a few circles in the water column to see how high we can detect the gas. But we had to retrieve it later that day, as the winds are were picking up again. We completed our sampling of sediments with the TV-guided multicorer as well as the gas flare maps, and set out for the last station of this mission in the morning of the 6th October. This time the in situ mass spectrometer was tied to the TV-guided multicorer to check its response close to the gas emission sites previously observed. However, the three main sites of free gas and hydrate chip emission were now quiescent, keeping their secret if they could be detected with mass spectrometer surveys. At midday of the 6th October we steamed back to Tromsø, where we ended the mission MSM16/2 with the debarking of the scientists.

5 Preliminary Results

5.1 Shipboard Hyroacoustic and Water sampling

5.1.1 Gas flare mapping

(S. Albrecht, B. Ferre)

Gas flares result from tiny bubbles ascending from sources of the sea floor. The high density difference between gas bubble and surrounding sea water provides a good reflector for hydroacoustic waves, so that echo sounders operated at adequate frequencies and settings may determine a "visible" plume (Figure. 5.1.1). The HMMV is known to be an active producer of gas flares and one objective of this cruise was the temporal observation of gas flares and location of probable sources. Preliminary results were directly used for station planning of AUV, ROV and TV-MUC.

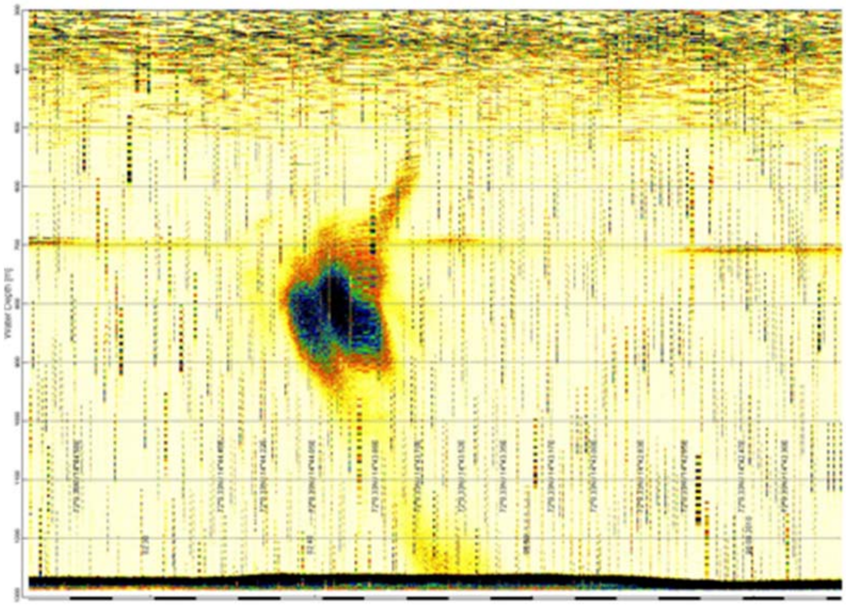


Figure 5.1.1: Echogram plot of a gas flare observed during the cruise at Håkon Mosby Mud Volcano (echogram y-axis: 300-1300 m depth, lines in 100 m interval, x-axis: ~1000 m, each bar 50 m)

The echo sounder used for gas flare mapping was the Atlas Parasound P-70 parametric sub-bottom profiler. This system is actually developed for detecting internal structures of sedimentary coverage along the ship track. To penetrate the sedimentary layers at the sea floor, a low frequency signal is required. It is achieved by the transmission of two high energy signals of slightly different frequencies (e. g. 16 kHz and 20 kHz) which creates harmonics at the difference frequency (4 kHz) and the frequency sum (36 kHz).

At the HMMV (water depth approx. 1250 m) the primary high frequency of 20 kHz was found to be adequate for gas flare detection. In 1250 m water depth the echo sounder's acoustic footprint on the seafloor is approximately 90 m, which results from the opening angle of the beam of 4 degrees across ship and 4.5 degrees along ship.

On this cruise 20 east-west survey lines across the mud volcano were planned, based on the same lines that were used for gas flare mapping during POLARSTERN cruise ARK-XXIV/2 (2009). To achieve a full coverage of the sea floor, the spacing of the profiles had been chosen to be 70 m. This considers the acoustic footprint of 90 m in 1250 m water depth and an overlapping of 20 m for adjacent profiles.

After a general mapping survey of all 20 lines, distinct lines with observed gas flares were repeated continuously during several days. In total 54 profiles were surveyed during the cruise. The survey speed was approximately 1 knot. The Parasound system was operated in single pulse mode with a pulse length of 0.5 ms at a primary high frequency (PHF) of approximately 20 kHz, a secondary low frequency (SLF) of approximately 4 kHz and a mean sound velocity of 1480 m/s. Due to the weather conditions all profiles were performed sideways with a heading towards south. The effects on the data's quality were tolerable. The recorded and processed data sets include the ASD, PS3 and SGY formats as well as echogram plots (PNG) for each of both frequencies.

All resulting echogram data sets were analyzed for visible gas flares and their location in the water column. To locate probable sources of the gas flares all positions with gas flare reflections right above the sea floor were picked and plotted in figure 5.1.2.

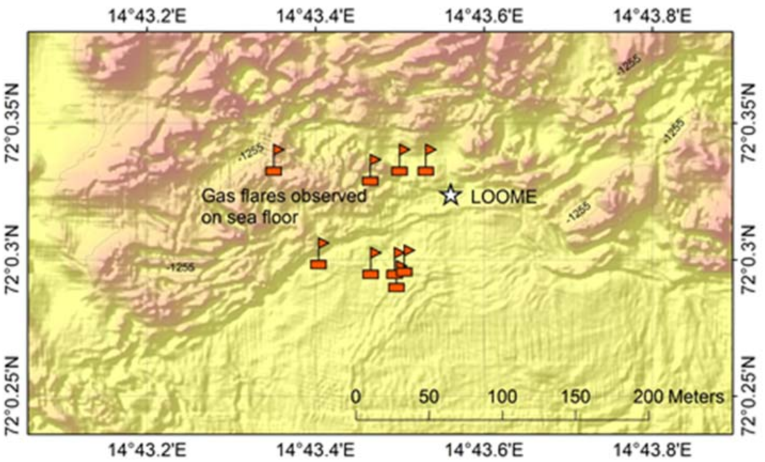


Figure 5.1.2: Map of gas flare detections found in the Håkon Mosby Mud Volcano area that are located right above the sea floor as an indication for probable gas sources.

5.1.2 Sound velocity profiles and calibration of mass spectrometer

(S.Albrecht)

In total two CTD casts were carried out. The data was needed for calculating sound velocity profiles for several echo sounder and underwater navigation systems. Water samples were taken for a calibration of the mass spectrometer. The CTD casts were carried out using the shipboard Sea-Bird Electronics, Inc. SBE 911plus system maintained by the IOW (Leibniz-Institut für Ostseeforschung Warnemünde). 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 10L-bottles. The collected data from each cast was processed using IOW's Reiseassistent and Sea-Bird's SBEDataProc software. It has been provided as an Excel file containing data and charts for each sensor as well as a bottle file containing averaged sensor values for each water sample taken.

5.2 AUV Dives

(C. German, Rich Camilli, Dana Yoerger)

5.2.1 System Overview and Dive Table/Maps

The autonomous underwater vehicle (AUV) *Sentry* (Figure 5.2.1.1) is the newest member of the National Deep Submergence Facility operated by Woods Hole Oceanographic Institution. It formally joined the NDSF in Summer 2010, replacing its predecessor *ABE*. Initially designed for operations down to 4,500 meters depth, *Sentry's* capability will be extended to 6500m in 2011. *Sentry* also builds on *ABE*'s successes with improved speed, range, maneuverability and, with its more hydrodynamic shape, faster ascent and descent rates. *Sentry* can be mobilized readily for use as a stand alone vehicle on a wide range of research vessels, as in the MSM 16-2 cruise, but can also be used very effectively in tandem with *Alvin* or an ROV such as the NDSF's *Jason* or the MARUM ROV *Quest* to improve the efficiency of deep submergence investigations. It carries an extensive scientific sensor suite as standard but can also accommodate additional user-provided science payloads enabling it to be used for a variety of oceanographic (mid-water) as well as near-seabed (imaging, geophysical survey) investigations. *Sentry* produces bathymetric and magnetic maps of the seafloor and is capable of taking high quality digital color photographs in a variety of deep-sea terrains including along mid-ocean ridges and at ocean margins and in complex settings such as hydrothermal vent and cold seep ecosystems. Its navigation system uses a doppler velocity log and inertial navigation system, aided by acoustic navigation systems (USBL or LBL). The USBL system also provides acoustic communications, which can be used to obtain the vehicle state and sensor status as well as to retask the vehicle in mid-deployment.

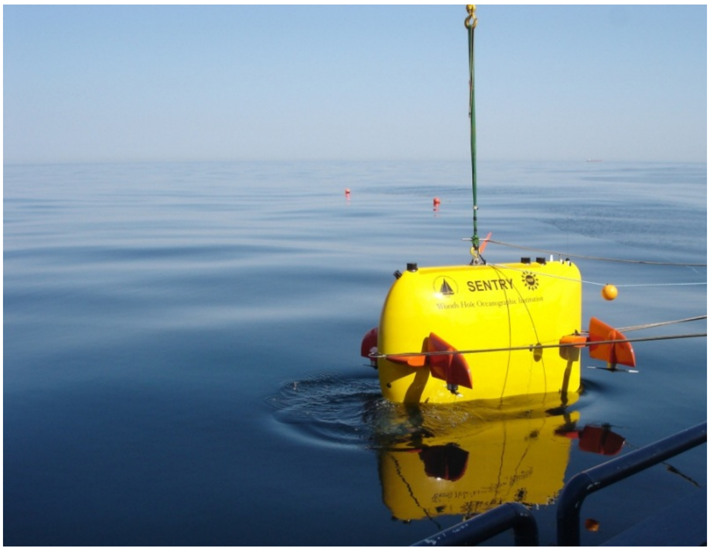


Figure. 5.2.1.1: The *Sentry* Autonomous Underwater Vehicle (AUV)

As well as traditional uses established by *ABE* (seafloor mapping, bottom photography, hydrothermal plume detection and investigation) *Sentry* is increasingly being utilized for a much wider range of oceanographic applications. In June 2010, for example, it was used on an NSF RAPID cruise working almost exclusively in mid-water to detect and trace hydrocarbon plumes dispersing through the Gulf of Mexico. Over the course of the MSM 16-2 cruise, the following sensors were deployed from Sentry:

1. Reson 7125 400 khz multibeam sonar (dives 073-076)
2. Edgetech subbottom profiler, SBP (dives 073-075)
3. GCTD: fast response CT sensor
4. Seapoint optical backscatter sensor
5. Anderaa optode
6. Tethys mass spectrometer (dives 076-078)

In total, a series of 6 dives were undertaken (Table 5.2.1.1):

• **Sentry 073** (Figure. 5.2.1.2a) had a main priority of making a detailed multibeam map of the entire HMMV study area. The vehicle flew at 20 m altitude with a spacing of 50 m between survey lines. The vehicle was localized by combining the real-time DVL and INS track with postprocessed LBL from all three transponders.

• **Sentry 074** used the multibeam data from dive 073 to run a near-bottom survey at 5 m altitude for seabed photography in and around the LOOME area, concurrent with ROV-based LOOME recovery operations. One block of the survey was shifted West, mid-mission, to avoid collision with the ROV (Figure. 5.2.1.2b)

• **Sentry 075** (Figure. 5.2.1.2c) completed the (3.5 m height/5 m line-spacing) photo-survey begun on dive 074, then expanded upward and outward to survey over the same area at increasing height using the SBP to prospect for active gas-bubble plumes.

• **Sentry 076** used TETHYS together with photography to survey over two areas (Figure. 5.2.1.2d) then ran flux-study tracks around the north block at 3.5, 5 and 10m height.

• **Sentry 077** completed a final photo-survey block (3.5 m alt/5 m line-spacing) then commenced surveys around the entire HMMV for flux studies at 1250, 1225, 1200 & 1175m depths. The dive ended early due to concerns over deteriorating weather.

• **Sentry 078** aimed to complete the survey begun on dive 077. Unfortunately the drive for the forward control surface failed after ~30 minutes into the mission and this last dive had to be aborted with insufficient time for repair before cruise end.

Table 5.2.1.1: Dive Details for the Sentry AUV Missions 073-078

Dive No.	Start (Y/M/D; GMT)	End (Y/M/D; GMT)	Mission Priorities	Track (km)
073	2010/09/26; 18:33	2010/09/27; 15:56	Mapping, SBP, plume search	68.8
074	2010/09/28; 11:31	2010/09/29; 09:43	Photos, SBP, plume search	27.1
075	2010/09/29; 18:31	2010/09/30; 16:58	Photos, SBP, plume search	41.9
076	2010/10/01; 20:49	2010/10/03; 06:03	TETHYS, photos, flux study	42.4
077	2010/10/03; 16:31	2010/10/04; 03:06	Photos, TETHYS flux study	21.2
078	2010/10/05; 08:29	2010/10/05; 13:18	TETHYS flux study	12.1

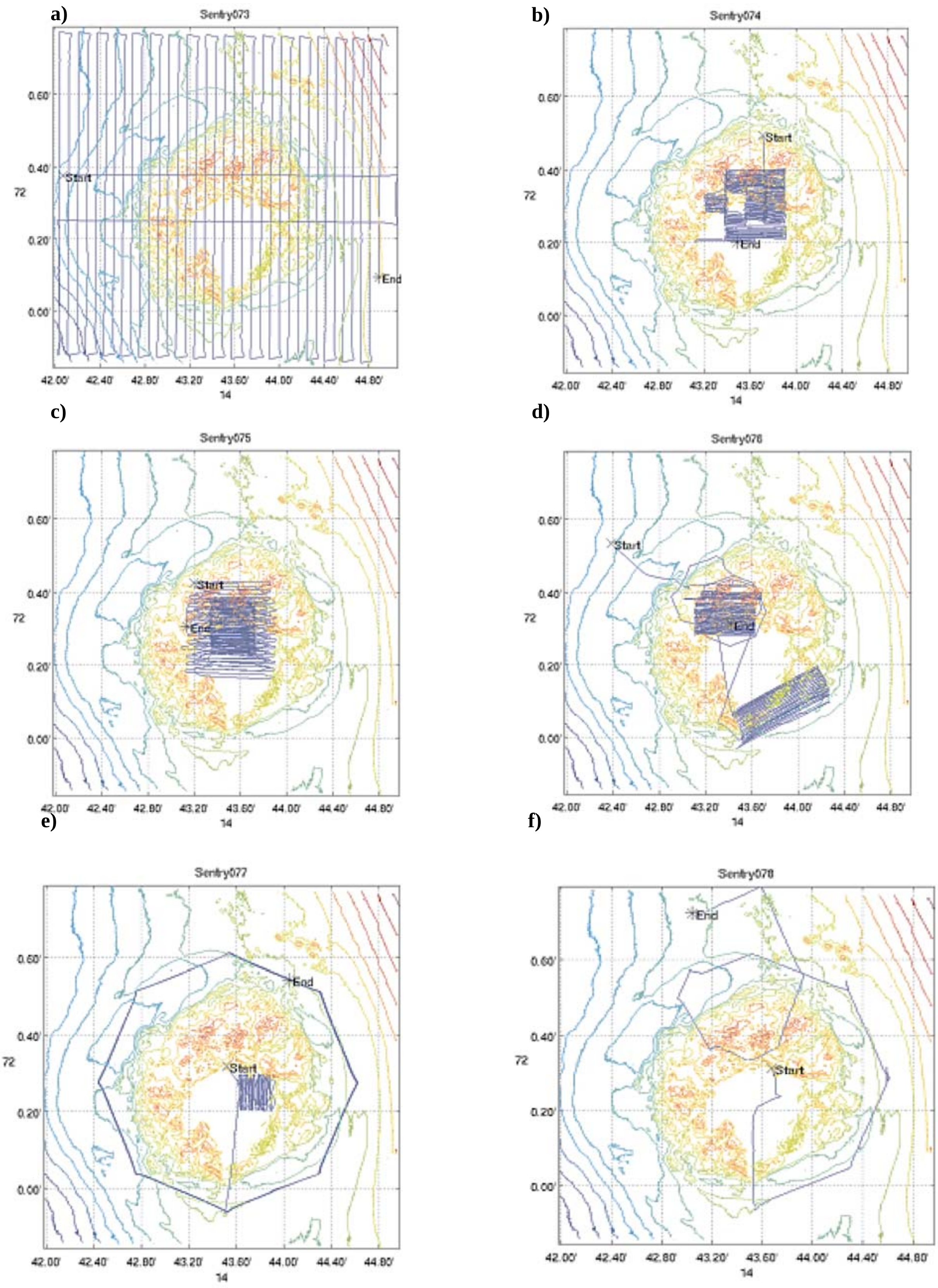


Figure. 5.2.1.2: Dive Tracks for Sentry dives 073-078

5.2.2 CTD

The CTD data acquired for *Sentry* on this cruise used a combination of a pressure (depth) sensor from Paroscientific (8B7000-I) and a novel Conductivity and Temperature sensor designed for low-power fast-response use on AUVs and Gliders developed by Neil Brown Ocean Sensors Inc. Early in the cruise (Dive 073) it appeared that, in addition to some sensor drift upon first deployment of the vehicle, there were deep-water temperature anomalies to the north of the HMMV study area that were not related to any other in situ water column and/or underlying geophysical signals reported from the same dive (Figure. 5.2.2.1).

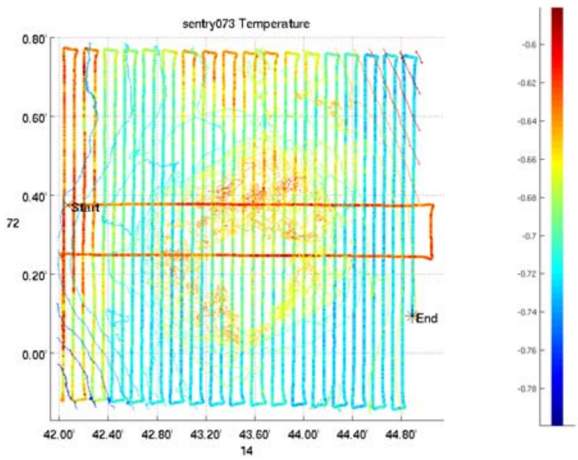


Figure 5.2.2.1: This plot shows the temperature measured during dive 073. The sensor appears to drift early in the dive – i.e. the relatively high temperatures during the crossing lines and first few tracks are likely an artifact. The elevated temperatures to the north of the HMMV do not correspond to depth changes

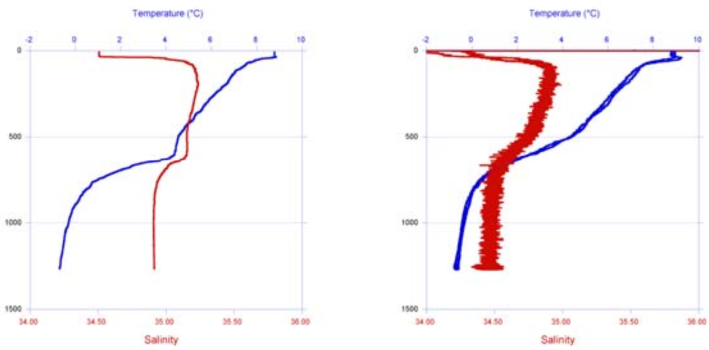


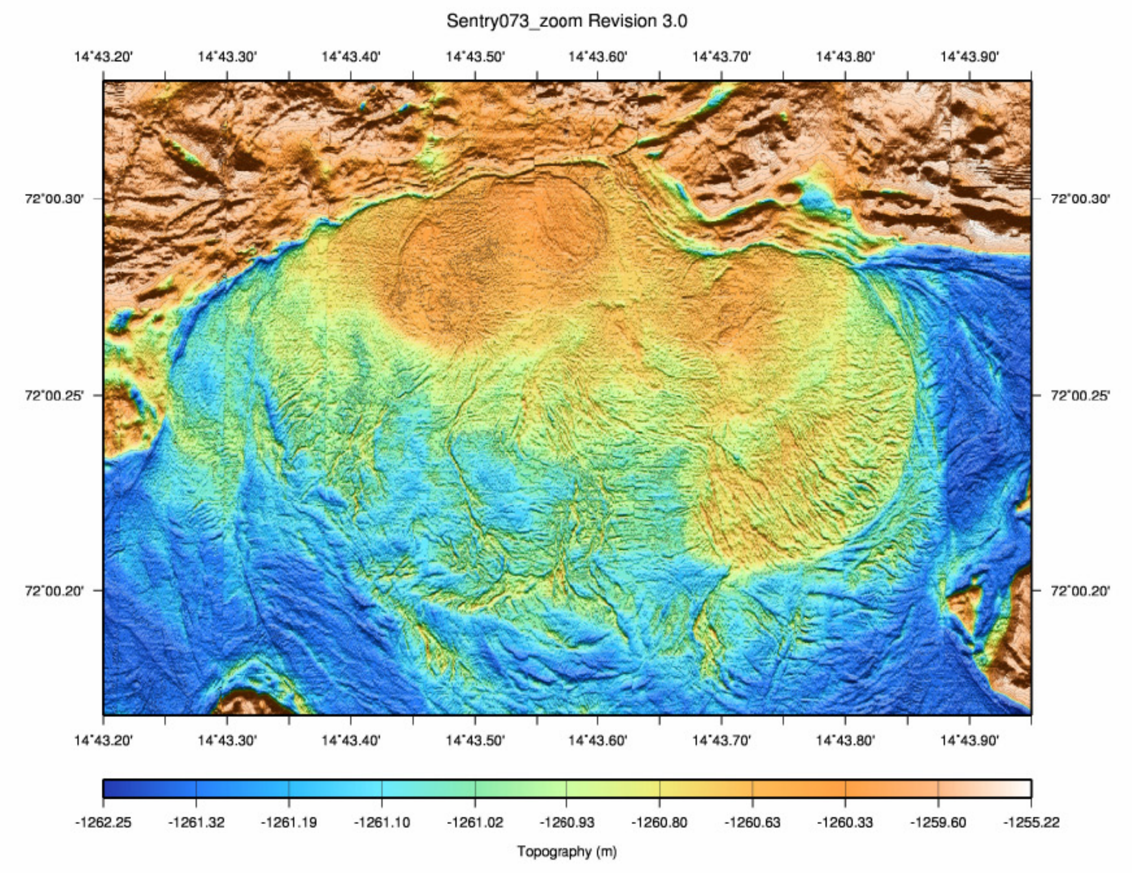
Figure 5.2.2.2: Vertical profiles of Temperature and Salinity measured directly above the HMMV. Left panel = shipboard CTD profile and righ panel = data collected from Sentry dive 073. Note the increased noise: signal ratio in the Sentry data, for the salinity profile in particular.

Upon closer inspection of the data, and communication with colleagues ashore, including those involved in the development and manufacture of the instrument it was confirmed that both the temperature and, especially, the salinity traces from the instrument were noisier than should typically be expected – e.g. in comparison with the SBE 9/11+ instrument on the ship's CTD-rosette. Post-cruise inspection of the sensor found water in the oil filled cable section that was spliced in to connect the sensor to the Sentry data acquisition and logging system which likely accounts for how this problem arose.

5.2.3 Multibeam

The Reson 7125 multibeam instrument was run on all of *Sentry* dives 073-076 but the primary data-set acquired was collected on the first dive (073) while surveying in bottom-following mode at a fixed target altitude of 20m along survey lines spaced at 50m off-set intervals (Figure 5.2.1.2a). The entire relief over the whole survey area was significantly less than 50 m making even the smallest errors in processing the data readily apparent. As such, this data set provided an excellent test for the newly implemented Sentry/Reson data pipeline and Figure 5.2.3.1 (left panel) shows the results of post-dive processing at sea using entirely automated scripts.

Figure 5.2.3.1: Detail of the LOOME area revealing evidence for a new (since July 2009) ~100m x 200m x 1m thick mud-flow.



While the initial results from this work (above) revealed bathymetry very similar to the previous data-set collected by the ROV Victor in 2007, a detailed examination of the LOOME region toward the center of the HMMV (Figure. 5.2.3.1) revealed important differences and, in particular, evidence for a ~100 m wide (E-W) and 200 m long (N-S) but only ~1 m thick mud-flow that must have been emplaced between the time of this cruise and the LOOME emplacement in July 2009. Shipboard processing of the data revealed small timing errors in the LBL processing for these data and we have also subsequently identified mechanisms to correct for tides (apparent as offsets in adjacent N-S strips of data in the shipboard data). Post-cruise processing of water column data from the Reson has also revealed a potential to detect/image water-column/bubble plumes in concert with seafloor mapping (Figure 5.2.3.2).

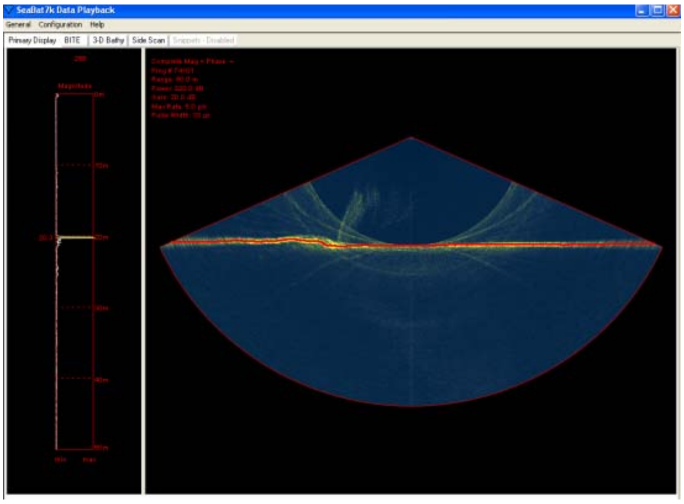


Figure 5.2.3.2: Evidence from Reson multi-beam (water column data) for the potential to map water column (gas bubble) plumes in situ, in parallel with seafloor imaging efforts.

5.2.4 Sediment sonar

This was the first *Sentry* cruise to make dedicated use of the new Edgetech sub-bottom profiler and the results were very encouraging. Although the system was not deployed on all *Sentry* dives (weight, size and power consumption dictate that only either the Edgetech system or the TETHYS mass spectrometer can be deployed on any given Sentry dive) we were able to demonstrate two separate and equally valuable uses for the instrument over the course of the cruise.

First, the system was used to investigate structures beneath the seafloor (Figure 5.2.4.1). A complete survey of this type was conducted across the entire HMMV study area during Sentry 073 (68.8km of 50m-spaced track lines: Figures 5.2.1.2, 5.2.3.1) co-registered with our multibeam bathymetry mapping and complementary *in situ* water column sensor data.

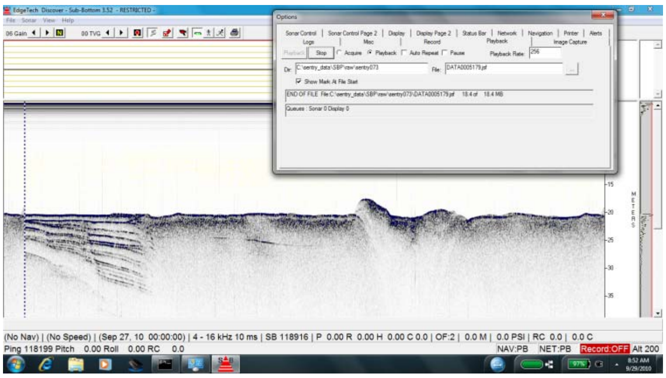


Figure 5.2.4.1: An example of Sentry Edgetech data showing regular layering of sediments (dipping from left to right at left of panel) truncated by a more homogeneous section with, toward its center, clear evidence for a mud “upflow” pipe.

Second, during a subsequent dive (Sentry 075) we took the opportunity to survey over known areas of active gas-rich fluid-flow toward the centre of the HMMV (above the LOOME observatory site) to investigate how easily we could use the Edgetech system to image and locate bubble plumes emitted from the seafloor at various altitudes (Figure 5.2.4.1). Our results suggest that the Edgetech has great potential as a system that can be used in future in the systematic exploration for further cold seep sites along previously uninvestigated ocean margins.

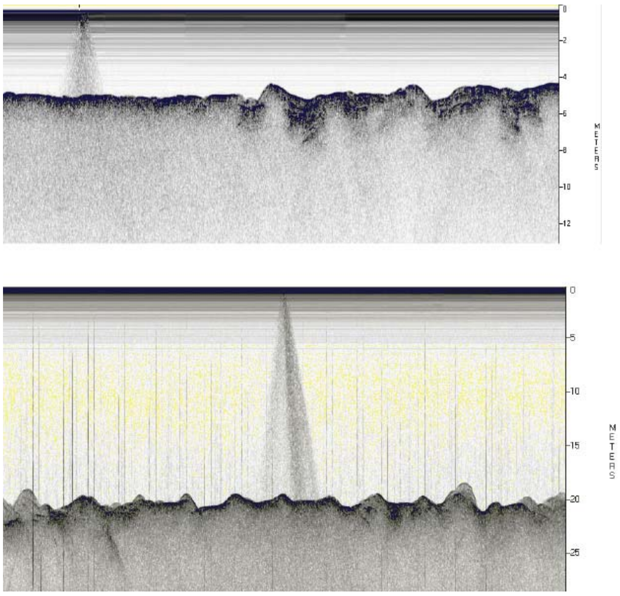


Figure 5.2.4.2: Example of *Sentry* Edgetech data that intercepted gas-rich bubble plumes rising from the seabed (apparent as inverted cones ascending from the seabed to the top of the data section) as imaged on Sentry dive 075 above the LOOME observatory site at survey altitudes of 5m (top panel) and 20m (bottom) above the seafloor.

5.2.5 Bottom photography

Photographs of the seafloor were collected routinely from *Sentry* during the majority of dives. These were initially taken at altitudes of 5 m off bottom (sentry 074 & 075) but, later in the cruise this was changed to 3.5 m off bottom to coincide with the use of the TETHYS in situ mass spectrometer in near-bottom mode (Sentry 076 & 077). While it was generally the case that this was feasible because of the extremely low relief of the HMMV as a whole, the Sentry vehicle did impact the soft seafloor early during Sentry dive 076 and, upon recovery of the vehicle, it was found that fouling of the camera housing by extremely sticky mud that never washed off meant that no clear seabed images were collected throughout the majority of that dive. Happily, however, almost all of dive 076 was devoted to a re-survey with THETHYS of areas that had already been imaged during joint EdgeTech and camera surveys (Sentry 074, 075) during which extremely clear and high quality digital still images had been collected from across the entire LOOME study area. Our final photo-survey work during dive 077 (together with TETHYS) was conducted across the more eastern section of the central flat zone of the HMMV where shipboard processing of our multibeam data revealed evidence for the 100 m x 200 m x 1 m thick mud-flow (Figure 5.2.3.1).

All photographs were collected along parallel survey lines spaced at 5m intervals and yielded fields of view that, at 5m off bottom, extended over an area of ~6m across track by ~4m along track. For this cruise a replacement strobe was in use that had a recharge time of 7 seconds. By adjusting Sentry to fly at a reduced speed of 0.35m/s along track this ensured reasonable overlap of ~33% between adjacent photographs that can be mosaicked together into strips of images along axis, post-cruise. Due to limitations of both coverage and accuracy in our vehicle navigation, however, it has not routinely proved feasible to mosaic adjacent strips of Sentry (or predecessor ABE) photographs together.

One of the particular advantages of using *Sentry* during this cruise was that we were able to photo-document the locations of multiple components of the LOOME observatory - and even one of the MPI Lander deployments conducted in parallel - *in situ* at the seabed prior to their recovery (Figure 5.2.5.1). Not only was this useful in placing the LOOME data in context (e.g. the IFREMER time-series camera) but it also helped us understand natural processes that had occurred during the time of the LOOME Observatory mission. For example, the scar marks observed "downstream" from LOOME temperature sensor 4 (Figure 5.5.5.1; bottom left panel) do not derive from the sensors being dragged from right to left across the seafloor but, rather, from the surface layers of mud at the HMMV flowing from left to right past the deployed time-series instrument! Of at least equal importance, however, was that our saturation coverage, with down-looking photographs of the entire LOOME study area - as well as the fresh mud-flow surfaces - means that we will now be able to complete comprehensive mapping of the underlying seabed in terms of both geological features and the various different biological habitats arranged concentrically across the surface of the HMMV (Figure 5.2.5.2).

Figure 5.2.5.1: Examples of LOOME instruments deployed on the seafloor at the HMMV. Clockwise from top left: IFREMER time-lapse camera; MPI-Bremen Lander (3m tall, hence, photographed while Sentry flew just 2 m above the instrument at ~1260 m depth); LOOME T-sensor 1 (bottom left) with cabling for 4 additional sensors extending across image from left to right (~N-S); LOOME T-sensor 4 with cabling for LOOME T-sensor 5 continuing, left to right (N-S) across image. (Note the "scour" marks left behind by active mud flow toward the south in the "wake" of the T sensor).

Figure 5.2.5.2: Examples of biological fauna and geological features from the HMMV. Clockwise from top left: 1) fields of pogonophorans from the "highlands" to the North of the LOOME study area; 2) extensive microbial mats covering the outer portions of the central flat HMMV interior with (to left) evidence for a swarm of (pink) amphipods; 3) heavily pock-marked seafloor from closer to the center of the HMMV with less extensive mats and (overlying strip of microbial mat) "blobs" that may derive from either free gas bubbles or chips of gas hydrate that are predicted to be buoyant at depths ≥1000 m at HMMV; 4) transition between bacterial mat and the center habitat.

5.2.6 Mass spectrometry

For dives 076-078, *Sentry* was equipped with a TETHYS mass spectrometer. TETHYS (TETHered Yearlong Spectrometer) is a self-contained in situ membrane inlet mass spectrometer optimized for deployment on AUVs, towed platforms, ROVs, and human occupied submersibles. The instrument's double focusing analyzer provides high abundance sensitivity, stability and mass resolution while its low power consumption enables remote operation with battery power. Minimum detection limits are typically on the order of parts-per-billion with an overall instrument response time of less than 10 seconds for concentration quantification at 95% confidence interval (Camilli & Duryea, 2009). This enables high spatial and temporal resolution mapping of dissolved hydrocarbon fractions on spatial scales of ≤1 meter. Since 2006, TETHYS instruments have been deployed on over two dozen expeditions and are in routine use aboard submersible vehicles for offshore oil spill cleanup (e.g. Camilli et al., 2010) and investigation of deep ocean hydrates and cold seeps.

Figure 5.2.6.1: Top, photograph of the TETHYS mass spectrometer. Bottom: photograph of the TETHYS mass spectrometer integrated into the Sentry AUV's portside payload bay.

The *Sentry*-mounted TETHYS mass spectrometer performed without fault on all three Sentry dives at the HMMV site, recording over 4,100 discrete sample measurements. Each sample analysis consisted of six ion peak indicators (m/z = 15, 17, 32, 34, 40 & 44; corresponding to methane, water vapor, oxygen, hydrogen sulfide, argon, and carbon dioxide, respectively). Data from each dive was geo-referenced with Sentry navigation records, enabling 3D reconstructions of water-column chemical data to be overlain onto underlying seafloor bathymetric data.

In addition a shipboard TETHYS mass spectrometric analysis was conducted on gases evolved from sediment samples collected near the vicinity of active methane expulsion sites. The results (Figure 5.2.6.2) show indicator ion peaks for C_1-C_5 hydrocarbons as well as major atmospheric gases. In comparison to negative controls of ambient air, methane, carbon dioxide, and sulfide levels are elevated, but C_2-C_5 levels also appear at approximately the same levels, indicating that these trace levels of higher hydrocarbons are probably artefacts from the sample handling process. Overall, these data suggest that the mud volcano's evolved gases are biogenic in origin.

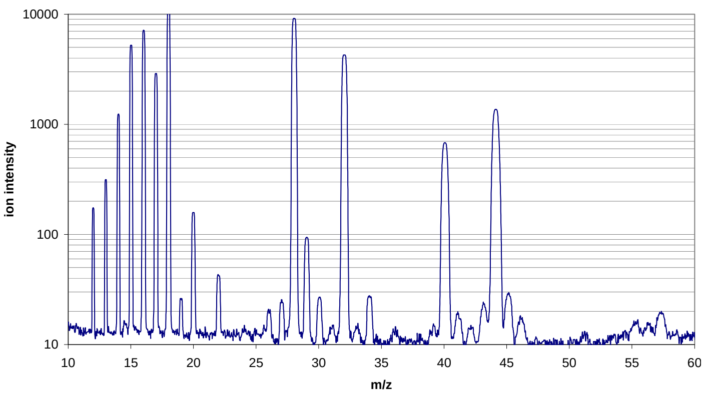


Figure 5.2.6.2: Mass spectrum of a gas sample (10-60 amu) collected from a MUC sediment core. This sample contains a mixture of gases from the sediment core and the ship's ambient air.

In-situ data recorded during *Sentry* dive operations indicate highly localized methane emission sites with coincident carbon dioxide anomalies. These emission sites appear to be located in areas of exposed hydrate, but not in the smooth mud flow areas, or the peripheral'moat' of the HMMV. Vertical profile data collected as the AUV ascended indicate methane concentration anomalies at depths of ~950 m, 700 m, and 350 m, perhaps indicative of neutrally buoyant plumes forming at these depths.

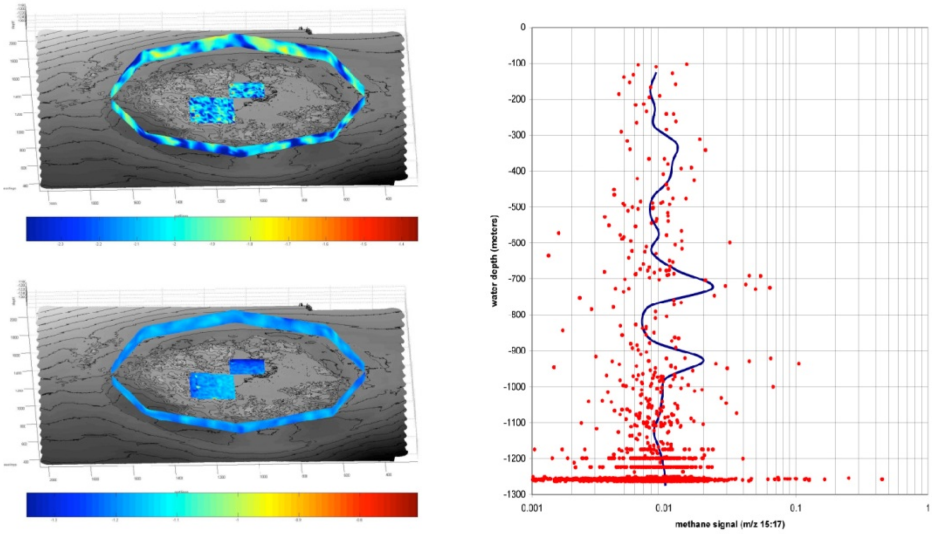


Figure 5.2.6.3: Left: 3D projections of Sentry 077 methane (top) and carbon dioxide (bottom) relative distributions (color indicating log-scale intensity) superimposed on HMMV microbathymetry (gray scale); Right: Vertical profile of Tethys data collected during ascent from the seafloor revealing evidence for multiple layers of methane enrichment in mid-water at ~950 m, ~750 m and ~350 m in addition to near-bottom enrichments close to the seafloor at ≥1200m.

5.2.7 In Situ Eh, Optical Back-scatter, and Dissolved Oxygen sensors

Three further in situ sensors were deployed on all Sentry dives. The first of these was an Eh sensor developed by Dr Ko-ichi Nakamura, a non-sailing Co-PI of the Sentry team for this cruise, based at AIST in Japan. Alongside this Eh electrode, we also deployed a SeaPoint optical back scatter sensor (OBS) and an Optode dissolved oxygen sensor (DO). Together, these data aided in the localization of sites of active fluid flow both during both near bottom (photography ± TETHYS) surveys and at greater heights off-bottom (e.g. during mapping and SBP surveys – dives 073 & 075 - and in the later stages of our TETHYS-led investigations – dives 077 & 078). Routinely, these sensor data are logged to a single flat Sentry sensor data file that is time stamped, lending itself to rapid preliminary post-dive analysis (Figure 5.2.7.1).

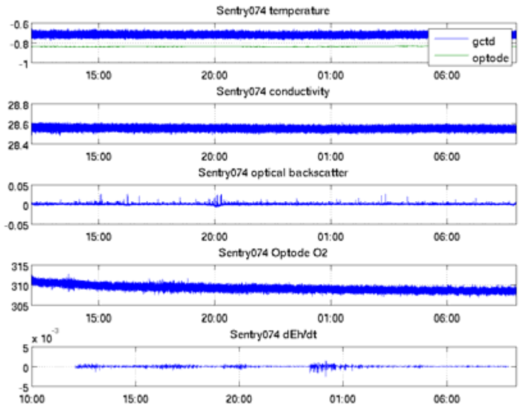


Figure 5.2.7.1: Time-series plots of (from top to bottom): Temperature, Conductivity, Optical Backscatter, Dissolved Oxygen and –dEh/dt sensor values throughout the near-bottom survey portion of Sentry dive 078.

Subsequently, once all the navigation data for a dive have been processed, the same sensor data can be re-plotted as two dimensional spatially-coordinated color-intensity plots superimposed upon the underlying bathymetry (Figure 5.2.7.2). At the HMMV, -dEh/dt and OBS values typically showed close correlations revealing sites of active flow (similar to our prior experience at hydrothermal vents) to reveal potential target sites for active fluid flow (Figure 5.2.7.2) that could be ground-truthed either from co-registered Sentry photographs or from dedicated follow-on ROV dives. Sadly, our DO sensor showed no similar efficacy at detecting active fluid flow.

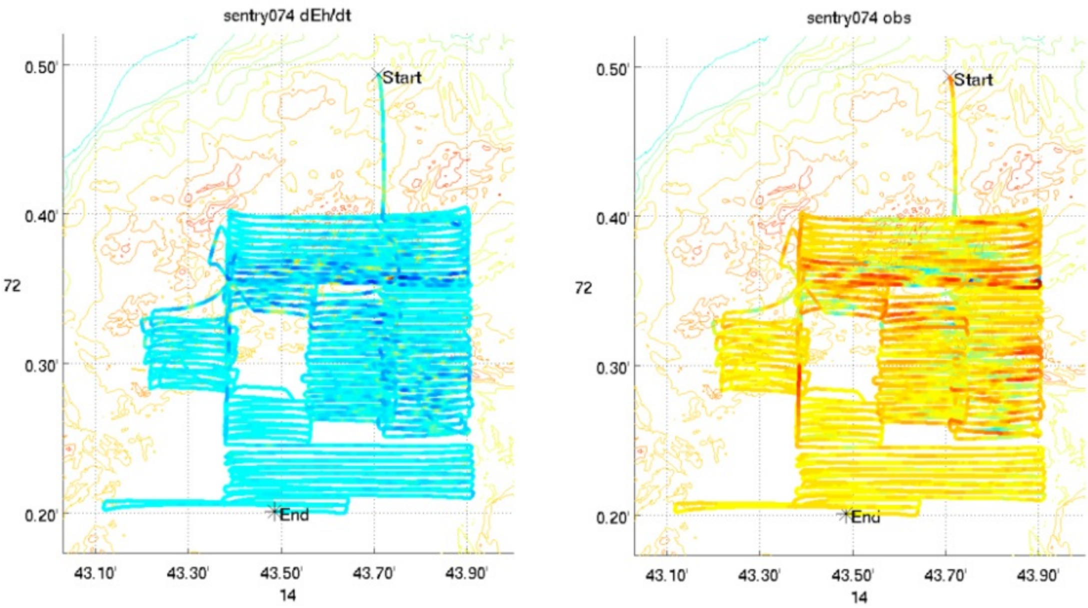


Figure 5.2.7.2: Plots of *in situ* -dEh/dt (left) and optical back scatter (right) sensor data from *Sentry* dive 078 over the LOOME study area of the HMMV. Deepest colors reveal greatest intensity in both sensors' data which are closely correlated, spatially and indicate areas of most active fluid flow.

5.3 ROV "Genesis" dives

One of the main objectives during this survey was the recovery of a seafloor observatory called "LOOME". Before the start of this cruise a safe and efficient recovery procedure via the ROV "Genesis" was prepared. A temperature lance and camera was hooked to a ship's cable by the ROV for recovery. Also video surveying and sampling of some wooden blocks for a colonization experiment were foreseen.

5.3.1 System overview and Dive Table

(W. Versteeg)

The RCMG was acquired in 2006, thanks to an “Impulsfinanciering” (a research fund of Ghent University), a Sub-Atlantic Cherokee-type ROV “Genesis” with TMS (garage-system) and shipboard winch (Figure 5.3.1.1). This winch hosts a reinforced cable of 1600 m which can bring the TMS and ROV to a safe depth, normally around 20-40 m above the seafloor, prior to the ROV launch (with a maximum tether of 200 m). The winch cable is connected to a pilot control interface which was installed in the ROV container. This encompasses the physical control of the ROV and its instruments, including the ROV cameras. 5 cameras and 1 still camera were active: one on the TMS (ROV launch & re-entry control), a backward looking within the ROV (for TMS re-entry and tether inspection), a camera in the front of the ROV looking at the arm and tray, and the two forward-looking black & white and color cameras. An overlay on the screen with navigation control information could be put on an arbitrary camera display. The main sampling tool on the ROV is the controlled grab arm and a deployable tray in which samples can be stored. During ROV survey, the control is performed by the pilot and the PI scientist (scientist, co-pilot/navigator), assisted by 1 or 2 shipboard scientists for stills capture, logging of operations and communication to the bridge. The ROV also contains a depth control, an altimeter and forward-looking sonar for detection of seabed objects.

Figure 5.3.1.1: ROV in TMS (photo: B. Ferre)

Positioning of the TMS and ROV was done through the GAPS positioning system (IXSEA) and a DGPS-system from Simrad. This Global Acoustic Positioning System, GAPS, is a portable Ultra Short Base Line (USBL) with integrated Inertial Navigation System (INS) and Global Positioning System (GPS). The GAPS was installed in one of the two moon pools of the RV Maria S. Merian and a transponder fixed on the TMS and on the ROV, resulting in the position of the TMS and ROV. Navigation from the GAPS software is stored in raw format. During the deployments, the ship’s, TMS and ROV navigation was also recorded through the OFOP software (J. Greinert, Royal NIOZ, The Netherlands). A CTD was run during the dives, but not further used for scientific assessments due to the technical nature of the dives.

The ship could easily brought (and remain) in position with its (marvellous) Dynamic Position system during the different dives. One of the ROV-cameras was displayed on a screen at the Bridge for better interaction between Bridge and ROV-control room. A total of 6 dives were taken during this survey. A short overview of the dives is given in the table below (Table 5.3.1.1)

Table 5.3.1.1: Overview of the dives during this survey

Dive814-01 MSM16/814-1 26/09/2010			
20:25	72° 0.32' N	14° 43.56' E	ROV at surface
21:17	72° 0.32' N	14° 43.57' E	Communication problem TMS at 1000m; return to deck!
21:55	72° 0.32' N	14° 43.57' E	ROV on deck
Dive820-02 MSM16/820-1 27/09/2010			
16:54	72° 0.31' N	14° 43.70' E	ROV at surface
17:43	72° 0.31' N	14° 43.79' E	start reconnaissance LOOME
22:20	72° 0.09' N	14° 43.90' E	Start returning to the surface
23:18	72° 0.09' N	14° 44.44' E	ROV on deck
Dive825-03 MSM16/825-1 28/09/2010			
14:17	72° 0.31' N	14° 43.64' E	ROV at surface
15:16	72° 0.31' N	14° 43.64' E	Start of Camera recovery
15:39	72° 0.31' N	14° 43.64' E	Camera within sight
17:01	72° 0.30' N	14° 43.60' E	Camera on the hook
17:09	72° 0.30' N	14° 43.60' E	ROV back in TMS
17:33	72° 0.30' N	14° 43.60' E	Camera on deck
17:41	72° 0.32' N	14° 43.57' E	Transit to LOOME-station
18:40	72° 0.32' N	14° 43.57' E	LOOME within sight
20:12	72° 0.31' N	14° 43.59' E	LOOME-station on hook and ROV returning to TMS
21:09	72° 0.31' N	14° 43.59' E	ROV on deck
22:01	72° 0.21' N	14° 43.91' E	LOOME-station on deck
Dive835-04 MSM16/835-1 30/09/2010			
06:22	72° 0.25' N	14° 43.63' E	ROV at surface
07:25	72° 0.25' N	14° 43.58' E	Start of T-Lance recovery
14:01	72° 0.14' N	14° 43.65' E	T-Lance fixed on cable and ROV returning to TMS
14:57	72° 0.14' N	14° 43.65' E	ROV on deck
Dive844-05 MSM16/844-1 02/10/2010			
06:08	72° 0.39' N	14° 43.64' E	ROV at surface
06:56	72° 0.39' N	14° 43.61' E	Start of wood collection at site 1
07:07	72° 0.39' N	14° 43.65' E	Found the wood at site 1
07:57	72° 0.39' N	14° 43.65' E	Wood piece 1 in middle box
08:25	72° 0.39' N	14° 43.65' E	Wood piece 2 in left box
09:02	72° 0.39' N	14° 43.65' E	Wood piece 3 in right box and ROV returning to TMS
12:00	72° 0.13' N	14° 43.59' E	ROV at surface
Dive851-06 MSM16/851-1 03/10/2010			
12:00	72° 0.13' N	14° 43.59' E	ROV at surface
12:50	72° 0.13' N	14° 43.60' E	Start of T-stick measurements at stations 1 -> 13
16:09	72° 0.24' N	14° 43.65' E	ROV in TMS and waiting for AUV
17:44	72° 0.26' N	14° 43.41' E	ROV out of TMS and restarting measurements at WP13
18:45	72° 0.23' N	14° 43.61' E	Last T-stick measurement at WP10; start video-surveying for Lander weights
19:56	72° 0.29' N	14° 43.58' E	ROV back in TMS
20:45	72° 0.29' N	14° 43.59' E	ROV on deck

5.4 Profiler-Chamber-Lander

(J.Felden, D. de Beer, V. Asendorf, M. Viehweger, G. Eickert)

Mud volcanoes, cold seeps and anoxic environments are shaped by a complex interplay of biological, geochemical, and geological processes (e.g. Jørgensen & Boetius, 2007; Levin, 2005; Niemann et al., 2006; Treude et al., 2003). Thereby biogeochemical and physicochemical gradients are extremely steep and variable at these ecosystems. However, still little is known about the spatial and temporal distribution of fluid and gas flow in sediments around seep structures and their effect on related biogeochemical processes, and factors controlling fluid and gas flow. The expulsion and venting of hydrocarbon-rich fluids fuel a variety of geomicrobial processes such as carbonate precipitation and the growth of chemosynthetic communities. At active sites, bio-/geochemical reactions take place along sharp gradients (often on cm to mm-scale) below the sediment surface. Constraining these reactions and the related chemical gradients thus require in situ technologies. So far, only few geochemical and microbiological investigations have been carried out based on in situ studies of methane seeping sediments and microbial habitats. However, at the HMMV in situ quantification of oxygen and methane flux were performed since 2003 (de Beer et al., 2006), and thus it is one of the best studied submarine mud volcanoes worldwide in this respect. Previous studies showed that methane efflux and oxygen uptake varies between the different habitats in the order of magnitudes (Felden et al., 2010) but also temporal variation seems to occur. Therefore, in situ measurements were also performed in the framework of the LOOME expeditions in 2009 and 2010. The aim was to relate in situ measured geochemical fluxes and gradients to mud volcano eruption events recorded by the LOOME observatory. During the MSM16-2, a benthic lander system (Figure 5.4.1) was used to deploy the instruments again on the same locations like 2009.

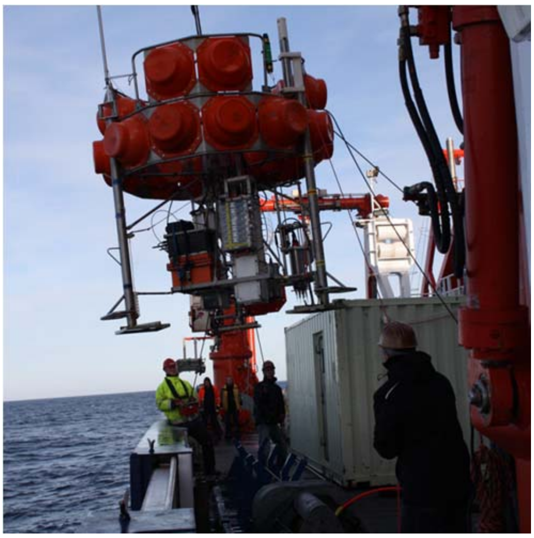


Figure 5.4.1: Deployment of the benthic lander system, which was equipped with two benthic chambers and one microprofiler module.

The lander was equipped with different instruments to investigate benthic fluxes and the vertical distribution of different geochemical compounds:

(1) Microprofiler: The microprofiler was equipped with 3O_2, 2H_2S, 2 pH, 1 redox and 1 N_2O microsensors and a temperature macrosensor (PT 1000) covering an area of 180 cm^2. Microprofiles across the sediment-water interface were performed with a vertical resolution of 200 µm on a total length of 12 cm.

(2) Benthic chamber: Benthic chamber incubations were used to measure total oxygen consumption, nutrient and methane fluxes between the sediment and the water column. This measurement integrates all relevant solute transport processes (diffusion, advection and fauna-mediated transport) over an area of 400 cm^2. The oxygen concentration of the enclosed water is followed continuously by oxygen optode while other compounds (DIC, methane, H_2S, nutrients) will be analyzed back in the home laboratory on retrieved water samples taken at pre-programmed time intervals during the incubation.

During the MSM16-2, the lander system war deployed successfully five times (Table 5.4.1) including additional measurements at fresh mud flows at the HMMV center and a reference non-seep site outside of the seep structure (Figure 5.4.2).

Table 5.4.1: Overview of Benthic Lander deployments during the MSM16-2.

PANGAEA Event	Date (2010)	Lat. (N°)	Long. (E°)	water depth (m)	site description
MSM16/2_806-1	26.09.	72.00233	14.73083	-1255	failed
MSM16/2_815-1	27.09.	72.00267	14.73260	-1262	failed
MSM16/2_821-1	28.09.	72.00307	14.73150	-1262	Beggiatoa mat
MSM16/2_833-1	29.09.	72.00501	14.72645	-1260	hot center
MSM16/2_840-1	01.10.	72.00408	14.72701	-1259	geographical center
MSM16/2_848-1	02.10.	72.00532	14.72650	-1259	center
MSM16/2_853-1	03.10.	72.00654	14.74703	-1257	reference

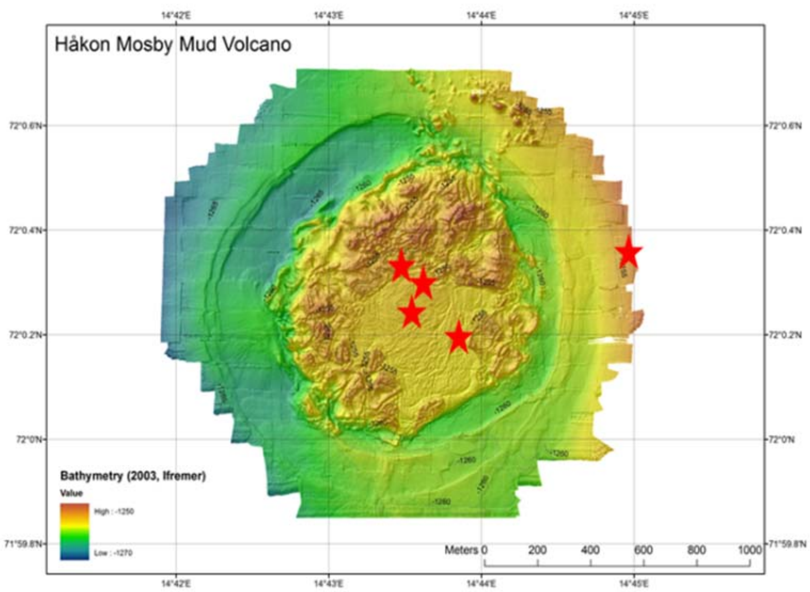


Figure 5.4.2: The benthic lander was deployed at four different HMMV habitats and once outside of the mud volcano during the MSM16-2 cruise (map copyright WHOI, created during the MSM 16-2 by the *Sentry*-AUV team).

The first analyses of the high resolution vertical microsensor profiles measured at HMMV center, HMMV Beggiatoa mat, and reference site indicate that the steepest temperature gradient was found at the HMMV center, decreasing towards the MV rim. These results are also in good agreement to previous studies (de Beer et al., 2006; Felden et al., 2010; Lichtschlag et al., 2010). Oxygen penetration in HMMV seep sediments is always limited to a few µm in contrast to the non-seep influenced sediment at the reference site. Outside of the HMMV, oxygen penetrated up to 3.6 cm into the sediment, and thus diffusive oxygen uptake (< 1 mmol m^{-2} d^{-1}) was also low, typical for oligotrophic polar deep-sea sediments. After we have evaluated all measurements, we will compare the results to those gained in 2009 during the LOOME deployment expedition and to the other biogeochemical parameters measured before and after the most recent eruptions events at the HMMV.

During this cruise, we have gained data from a total of eight benthic chamber incubations. The first preliminary results show that total oxygen uptake rates at the HMMV are in the same range than previous measurements, and higher than at the reference site (3 mmol m^{-2} d^{-1}; Figure 5.4.3). Water and gas samples retrieved during the incubation are going to be analyzed in the home laboratory. Especially, we are highly interested in the methane fluxes in order to explore whether the most recent mud displacement at the HMMV is reflected in the benthic chamber measurements or not.

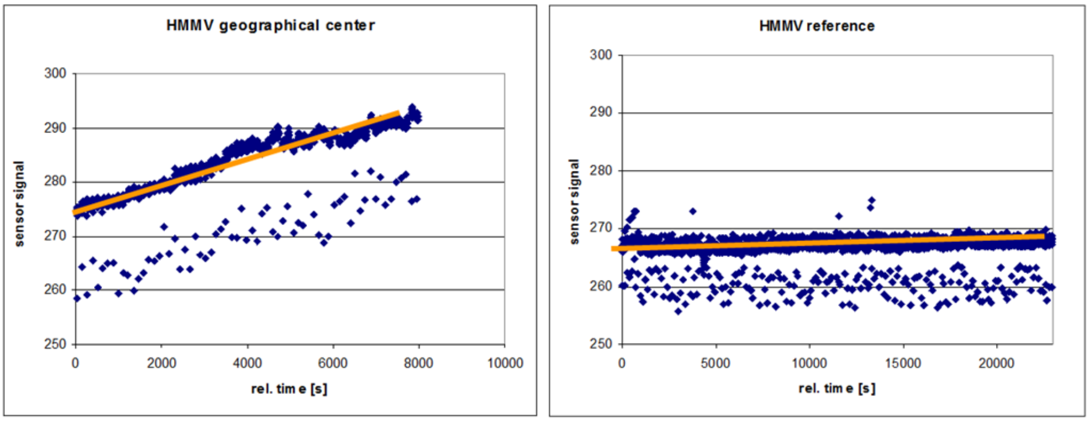


Figure 5.4.3: Raw data diagrams from two benthic chamber incubations at the HMMV geographical center and the reference site. The optode sensor signal intensity is increasing by decreasing oxygen concentration and thus indicates oxygen consumption over time during in situ benthic chamber incubations. The total oxygen consumption of the geographical HMMV center (left panel) is higher compared to the non- seep reference site as indicated by the steeper gradient over time.

5.5 TV-MUC

5.5.1 System Overview and Deployment Table

(R. Stiens)

The main sediment sampling tool in this investigation was a TV guided multiple corer equipped with both, a black and white and a color video camera (MARUM telemetry).

The black and white video signal, which is conveyed by a coaxial cable was recorded on tape. The color video signal is conveyed by a glass fiber and was meant to be recorded digitally, but unfortunately the glass fiber was unavailable for several days during the cruise.

5.5.2 Biogeochemistry

(R. Stiens, E. Weiz)

The main biogeochemical investigations focused on 5 habitats with different geobiological characteristics, the sites with Beggiatoa mat coverage (split up into northern, eastern, and western Beggiatoa mats), the hot center which was defined by temperature lance measurements, the geological center of the HMMV structure, the area with recently expelled mud (referred to as new mud flow), and a reference site outside HMMV. Samples were also taken at the Pogonophora fields to complete earlier sampling transects.

Sampling for the determination of biogeochemical parameters included sulfate reduction rates (SR), rates of anaerobic oxidation of methane (AOM), total number of prokaryotes (AODC), sediments porosity (POR), concentrations of pore water constituents like ammonia, phosphate, nitrate, nitrite and silicate (NUTR), dissolved inorganic carbon concentrations (DIC). For the application of molecular ecological methods in the home laboratory, we sampled sediment for 16S rDNA clone libraries (DNA), fluorescence in situ hybridization (FISH), and ARISA (Automated Ribosomal Intergenic Spacer Analysis) at 5 sampling sites: reference site outside HMMV, eastern Beggiatoa site, hot center, geographical center and on a new central mud flow. To carry out isotope-labeled carbon dioxide assimilation experiments, samples from the hot center, the eastern Beggiatoa site and the reference site were taken (^{13}C-DIC).

All three Beggiatoa sites were also sampled for further investigation of large sulfur bacterial diversity by ARISA and 16S rDNA clone libraries (S-DIV). To study nematodes and to determine specific habitat parameters samples were taken at all Beggiatoa sites and the hot center (N-DIV), for further information see 5.5.3.

Table 5.5.2.1: List of multiple corer stations

Gear	Date (2010)	Station (MSM 16/2)	Site Description	Latitude (72° N)	Longitude (14° E)	applied methods
TV-MUC	25.09	801	center (above Loome sensor strings)	0.322'	43.580'	
TV-MUC	25.09	802	eastern Beggiatoa mats	0.172'	43.882'	^{13}C-DIC, N-DIV
MUC	26.09	809	reference site outside HMMV	0.160'	43.940'	^{13}C-DIC, SR, AODC, FISH, DNA, ARISA, POR, NUTR, DIC
MUC	26.09	810	hot center	0.297'	43.573'	N-DIV, ^{13}C-DIC
MUC	27.09	817	eastern Beggiatoa mats	0.185'	43.885'	^{13}C-DIC
MUC	27.09	818	eastern Beggiatoa mats	0.179'	43.882'	^{13}C-DIC
MUC	27.09	819	eastern Beggiatoa mats	0.155'	43.961'	^{13}C-DIC, N-DIV
MUC	28.09	822	eastern Beggiatoa mats	0.157'	43.942'	N-DIV
MUC	28.09	823	eastern Beggiatoa mats	0.162'	43.947'	AOM, SR, AODC, FISH, DNA, ARISA, POR
MUC	29.09	826	eastern Beggiatoa mats	0.187'	43.881'	AOM, SR, NUTR, DIC
MUC	29.09	827	eastern Beggiatoa mats	0.186'	43.877'	AOM, SR, NUTR, DIC
MUC	29.09	829	eastern Beggiatoa mats	0.165'	43.947'	N-DIV
MUC	29.09	830	eastern	0.152'	43.947'	N-DIV

Gear	Date (2010)	Station (MSM 16/2)	Site Description	Latitude (72° N)	Longitude (14° E)	applied methods
			Beggiatoa mats			
MUC	29.09	831	eastern Beggiatoa mats	0.151'	43.938'	N-DIV, AOM, SR, S-DIV
MUC	01.10	838	hot center	0.288'	43.568'	AOM, SR, AODC, FISH, DNA, ARISA, POR, NUTR, DIC
TV-MUC	01.10	839	northern Beggiatoa mats	0.312'	43.583'	N-DIV, S-DIV
TV-MUC	01.10	841	northern Beggiatoa mats	0.312'	43.609'	N-DIV, S-DIV
MUC	02.10	846	eastern Beggiatoa mats	0.162'	43.950'	N-DIV
MUC	02.10	847	geographical center	0.251'	43.617'	AOM, SR, AODC, FISH, DNA, ARISA, POR, NUTR, DIC
TV-MUC	04.10	855	new mud flow (geographical center)	0.242'	43.784'	AOM, SR, AODC, FISH, DNA, ARISA, POR, NUTR, DIC
TV-MUC	04.10	856	northern Beggiatoa mats	0.312'	43.563'	N-DIV, S-DIV
TV-MUC	04.10	857	western Beggiato mats	0.179'	43.218'	N-DIV, S-DIV
TV-MUC	04.10	858	western Beggiato mats	0.168'	43.206'	N-DIV, S-DIV
TV-MUC	05.10	862	western Beggiato mats	0.168'	43.202'	N-DIV, S-DIV
TV-MUC	05.10	863	eastern Beggiatoa mats	0.157'	43.952'	S-DIV
TV-MUC	05.10	864	Pogonophora site	0.285'	43.194'	Completion of earlier sampling transect
TV-MUC (Mass-spectrometer)	06.10	866	transect over HMMV area	0.27	43.60	

5.5.3 Biology

(J. Van Campenhout)

19 cores will be used to pick out 10.000 *Halomonhystera disjuncta* (*H. disjuncta)* nematodes in order to extract mRNA for gene expression analysis. Transcriptomes of this nematode, but from different locations, will be compared, which will lead to insights in adaptation and flexibility. These transcriptome databases will be linked to environmental parameters (3 cores) and fatty acid composition (5 cores).

Meiofaunal communities from the North, West and South-East *Beggiatoa* mats will be compared (5 cores). In addition, a population genetic approach (7 cores) will give more insights in cryptic speciation as well as evolution and phylogeny.

Meiofaunal communities from 11 cores, from 2 benthic lander chamber incubations, will be analyzed in addition to the lander measurement.

Table 5.5.3.1: Sample list Ghent University. Samples were taking with (TV)-Muc. c = core(s).

Purposes	# cores	Stations (MSM16-2)	Storage
Transcriptomics	19	802 (5c), 822 (2c), 829 (3c), 830 (5c), 831 (4c)	-80°
Environmental parameters	3	802 (1c), 822 (1c), 831 (1c)	-20°
Community analysis	2 3 11	841 (1c), 858 (1c) 856 (1c), 857 (1c), 862 (1c) 840 (3c), 848 (4c), 853 (4c)	Formaldehyde (4%) -20° Formaldehyde (4%)
Population genetics	7	810 (1c), 819 (1c), 839 (1c), 841 (1c), 856 (1c), 857 (1c), 858 (1c), 862 (1c)	-20°
Back up samples	2 3	802 (1c), 822 (1c) 829 (1c), 830 (1c), 831 (1c)	Formaldehyde 4%, Ethanol 80 %
Fatty acid analysis	5	846 (1c), 857 (3c), 862 (1c)	-20°

5.5.4 Microbiology

(A. Boetius, S. Grünke und J. Felden)

In previous years two types of thiotrophic microbial mats have been observed at the HMMV, including giant white mats that can cover up to several hundreds of square meters on the seafloor and smaller gray mats of 1-5 m in diameter. As indicated by microscopy, the white mats are formed by only two types of giant *Beggiatoa* filaments, while the gray mats were found to harbor a high diversity of known and unknown types of (potential) sulfide-oxidizing bacteria.

During the MSM16-2 cruise, 8 TV-MUC deployments on white mats in the northern, south-eastern, and western parts of the HMMV (Table 5.5.4.1) were conducted. The sediment samples were sectioned into 1-cm intervals (up to 10 cm depth) and preserved at -20°C. The upper layers (0-2 cm) will be subjected to an ARISA-based approach containing samples from previous HMMV cruises in 2006, 2007 and 2009). ARISA (Automated Ribosomal Intergenic Spacer Analysis) is a high-throughput fingerprinting technique used for comparing microbial diversity patterns. This approach will help us to reveal whether there are consistent differences in overall bacterial diversity patterns between white and gray mats. Finally, these data will be combined with 16S rRNA gene analyses and biogeochemical measurements (Felden et al., 2010; Lichtschlag et al., 2010) to achieve a comprehensive picture on thiotrophic mat diversity and niche differentiation at the HMMV (including a comparison with mats from the Nyegga and Storegga area) (Grünke et al., in prep.).

Table 5.5.4.1: MUC samples (MSM16-2) for investigating bacterial diversity of white mats

HMMV area	Stations (MSM16-2)	Sediment horizon/Analysis
North	839, 841, 856	0-2cm/ARISA
South-East	831, 863	0-2 cm/ARISA
West	857, 858, 862	0-2 cm/ARISA

5.6 Heat flux measurements

(G.Wetzel, T. Feseker)

5.6.1 System Overview and Deployment Table

In-situ measurements of sediment temperature and thermal conductivity were obtained using a standard violin-bow type heat flow probe, manufactured by FIELAX GmbH, Bremerhaven. The instrument is equipped with 22 temperature sensors distributed equally over an active length of 5.46 m. Measuring at a resolution of 0.0006 °C the sensors were calibrated to a precision of 0.002 °C. Additional sensors for acceleration, tilt, and water temperature help to control the measurements. All data can be transmitted from the probe to the winch control room in real time when using the ship's coax cable. Alternatively, the probe can also be operated in an autonomous mode when using a standard wire. At each station, the sediment temperature profile was measured during the first 7 minutes after penetration. The equilibrium temperatures were obtained by extrapolation from the recorded time series. At selected stations, the thermal conductivity of the sediments was determined by measuring the decay of a heat pulse emitted from a heater wire along the entire active length of the probe following the initial temperature measurement. The sensor string was calibrated at between 1100 and 1200 m water depth at the beginning of stations MSM16/2-837, MSM16/2-843, and MSM16/2-854.

In addition to the winch-operated heat flow probe, a short temperature probe was used during dive 851 of the ROV. The "T-Stick" consists of a lance with 8 temperature sensors distributed equally over a length of 0.315 m and a data logger, which is attached to the upper part of the lance. Resolution and precision of the temperature sensors are the same as for the heat flow probe. For each measurement, the T-Stick is lowered into the sediment using the manipulator arm of the ROV and left in position for at least 7 minutes. Equilibrium temperatures are obtained by extrapolation from the recorded data.

Table 5.6.1.1: List of heat flow probe stations

Station	Pangaea-Event	Date	Time	Latitude	Longitude
MSM16/836-1	MSM16/2_836-1	30/09/2010	15:04	72°0.14'	14°43.627'
MSM16/837-1	MSM16/2_837-1	30/09/2010	20:16	72°0.448'	14°43.388'
MSM16/837-2	MSM16/2_837-2	30/09/2010	20:49	72°0.397'	14°43.378'
MSM16/837-3	MSM16/2_837-3	30/09/2010	21:31	72°0.342'	14°43.502'
MSM16/837-4	MSM16/2_837-4	30/09/2010	21:58	72°0.331'	14°43.568'
MSM16/837-5	MSM16/2_837-5	30/09/2010	22:26	72°0.316'	14°43.59'
MSM16/837-6	MSM16/2_837-6	30/09/2010	22:49	72°0.302'	14°43.574'

Station	Pangaea-Event	Date	Time	Latitude	Longitude
MSM16/837-7	MSM16/2_837-7	30/09/2010	23:22	72°0.283'	14°43.598'
MSM16/837-8	MSM16/2_837-8	30/09/2010	23:48	72°0.278'	14°43.661'
MSM16/837-9	MSM16/2_837-9	01/10/2010	00:22	72°0.238'	14°43.78'
MSM16/837-10	MSM16/2_837-10	01/10/2010	00:54	72°0.196'	14°43.896'
MSM16/837-11	MSM16/2_837-11	01/10/2010	01:29	72°0.148'	14°44.015'
MSM16/837-12	MSM16/2_837-12	01/10/2010	02:30	72°0.302'	14°44.202'
MSM16/837-13	MSM16/2_837-13	01/10/2010	03:01	72°0.279'	14°44.014'
MSM16/837-14	MSM16/2_837-14	01/10/2010	03:23	72°0.275'	14°43.901'
MSM16/837-15	MSM16/2_837-15	01/10/2010	03:46	72°0.269'	14°43.734'
MSM16/837-16	MSM16/2_837-16	01/10/2010	04:03	72°0.289'	14°43.664'
MSM16/837-17	MSM16/2_837-17	01/10/2010	04:26	72°0.282'	14°43.476'
MSM16/837-18	MSM16/2_837-18	01/10/2010	04:49	72°0.241'	14°43.409'
MSM16/843-1	MSM16/2_843-1	01/10/2010	23:41	72°0.183'	14°42.673'
MSM16/843-2	MSM16/2_843-2	02/10/2010	00:22	72°0.196'	14°42.911'
MSM16/843-3	MSM16/2_843-3	02/10/2010	00:55	72°0.216'	14°43.102'
MSM16/843-4	MSM16/2_843-4	02/10/2010	01:28	72°0.223'	14°43.28'
MSM16/843-5	MSM16/2_843-5	02/10/2010	01:53	72°0.214'	14°43.41'
MSM16/843-6	MSM16/2_843-6	02/10/2010	02:16	72°0.228'	14°43.574'
MSM16/843-7	MSM16/2_843-7	02/10/2010	02:41	72°0.192'	14°43.33'
MSM16/843-8	MSM16/2_843-8	02/10/2010	03:04	72°0.17'	14°43.302'
MSM16/843-9	MSM16/2_843-9	02/10/2010	03:28	72°0.169'	14°43.244'
MSM16/843-10	MSM16/2_843-10	02/10/2010	03:48	72°0.134'	14°43.206'
MSM16/849-1	MSM16/2_849-1	02/10/2010	22:01	72°0.272'	14°43.574'
MSM16/849-2	MSM16/2_849-2	02/10/2010	22:27	72°0.254'	14°43.518'
MSM16/849-3	MSM16/2_849-3	02/10/2010	22:49	72°0.254'	14°43.616'
MSM16/849-4	MSM16/2_849-4	02/10/2010	23:11	72°0.238'	14°43.676'
MSM16/849-5	MSM16/2_849-5	02/10/2010	23:32	72°0.235'	14°43.62'
MSM16/849-6	MSM16/2_849-6	02/10/2010	23:55	72°0.226'	14°43.504'
MSM16/849-7	MSM16/2_849-7	03/10/2010	00:18	72°0.213'	14°43.607'
MSM16/849-8	MSM16/2_849-8	03/10/2010	00:42	72°0.204'	14°43.727'
MSM16/849-9	MSM16/2_849-9	03/10/2010	01:06	72°0.187'	14°43.612'
MSM16/849-10	MSM16/2_849-10	03/10/2010	01:29	72°0.18'	14°43.502'
MSM16/849-11	MSM16/2_849-11	03/10/2010	01:54	72°0.16'	14°43.613'
MSM16/849-12	MSM16/2_849-12	03/10/2010	02:19	72°0.171'	14°43.808'
MSM16/849-13	MSM16/2_849-13	03/10/2010	02:41	72°0.144'	14°43.861'
MSM16/849-14	MSM16/2_849-14	03/10/2010	03:07	72°0.105'	14°43.928'
MSM16/849-15	MSM16/2_849-15	03/10/2010	03:32	72°0.094'	14°43.633'
MSM16/849-16	MSM16/2_849-16	03/10/2010	03:53	72°0.069'	14°43.502'
MSM16/849-17	MSM16/2_849-17	03/10/2010	04:16	72°0.129'	14°43.615'
MSM16/849-18	MSM16/2_849-18	03/10/2010	04:36	72°0.133'	14°43.501'
MSM16/854-1	MSM16/2_854-1	04/10/2010	00:58	72°0.043'	14°43.491'
MSM16/854-2	MSM16/2_854-2	04/10/2010	01:34	72°0.104'	14°43.568'
MSM16/854-3	MSM16/2_854-3	04/10/2010	04:11	72°0.152'	14°43.597'
MSM16/854-4	MSM16/2_854-4	04/10/2010	04:32	72°0.162'	14°43.412'

Station	Pangaea-Event	Date	Time	Latitude	Longitude
MSM16/854-5	MSM16/2_854-5	04/10/2010	05:00	72°0.196'	14°43.215'
MSM16/854-6	MSM16/2_854-6	04/10/2010	05:22	72°0.252'	14°43.256'
MSM16/854-7	MSM16/2_854-7	04/10/2010	05:40	72°0.278'	14°43.349'
MSM16/854-8	MSM16/2_854-8	04/10/2010	06:11	72°0.305'	14°43.47'
MSM16/854-9	MSM16/2_854-9	04/10/2010	06:42	72°0.313'	14°43.589'
MSM16/854-10	MSM16/2_854-10	04/10/2010	07:28	72°0.28'	14°43.78'
MSM16/854-11	MSM16/2_854-11	04/10/2010	07:54	72°0.264'	14°43.824'
MSM16/854-12	MSM16/2_854-12	04/10/2010	08:18	72°0.243'	14°43.888'
MSM16/854-13	MSM16/2_854-13	04/10/2010	08:36	72°0.242'	14°43.797'
MSM16/854-14	MSM16/2_854-14	04/10/2010	09:12	72°0.358'	14°43.621'
MSM16/854-15	MSM16/2_854-15	04/10/2010	09:42	72°0.396'	14°43.878'
MSM16/854-16	MSM16/2_854-16	04/10/2010	10:12	72°0.458'	14°44.009'
MSM16/854-17	MSM16/2_854-17	04/10/2010	11:13	72°0.313'	14°43.583'
MSM16/854-18	MSM16/2_854-18	04/10/2010	07:10	72°0.296'	14°43.763'

Table 5.6.1.2: List of T-Stick measurements during dive 851

Dive station	Pangaea-Event	Date	Time	Latitude	Longitude
851-TS1	MSM16/2_851_TST1	03/10/2010	13:04	72° 0.148	14° 43.613
851-TS2	MSM16/2_851_TST2	03/10/2010	13:24	72° 0.202	14° 43.674
851-TS3	MSM16/2_851_TST3	03/10/2010	13:40	72° 0.215	14° 43.754
851-TS4	MSM16/2_851_TST4	03/10/2010	13:56	72° 0.242	14° 43.773
851-TS5	MSM16/2_851_TST5	03/10/2010	14:10	72° 0.259	14° 43.787
851-TS6	MSM16/2_851_TST6a	03/10/2010	14:30	72° 0.273	14° 43.785
851-TS6b	MSM16/2_851_TST6b	03/10/2010	14:42	72° 0.274	14° 43.786
851-TS7	MSM16/2_851_TST7	03/10/2010	15:02	72° 0.296	14° 43.760
851-TS8	MSM16/2_851_TST8a	03/10/2010	15:17	72° 0.276	14° 43.686
851-TS8b	MSM16/2_851_TST8b	03/10/2010	15:32	72° 0.284	14° 43.694
851-TS9	MSM16/2_851_TST9	03/10/2010	15:49	72° 0.261	14° 43.659
851-TS10	MSM16/2_851_TST10	03/10/2010	18:35	72° 0.240	14° 43.605
851-TS11	MSM16/2_851_TST11	03/10/2010	18:22	72° 0.265	14° 43.607
851-TS12	MSM16/2_851_TST12	03/10/2010	18:08	72° 0.275	14° 43.514
851-TS13	MSM16/2_851_TST13	03/10/2010	17:48	72° 0.278	14° 43.427

5.6.2 Heat flux

The ascent of warm mud and fluids at mud volcanoes creates temperature anomalies in shallow sediments. Quantification and mapping of these anomalies in turn provides information about the recent activity of the mud volcano and helps to identify patterns of fluid flow and mud eruptions.

At several stations, movement of the probe in the mud or movement of mud around the probe during the measurements caused unusual temperature fluctuations at individual sensors and made the processing of the data difficult. Preliminary evaluation of the measurements reveals extremely high temperatures of up to 45°C at less than 5 m below the seafloor in the central area and very heterogeneous profiles throughout the central flat area, which is indicative of recent activity.

5.7 LOOME recovery

5.7.1 System Overview and Deployment Table

(D. De Beer)

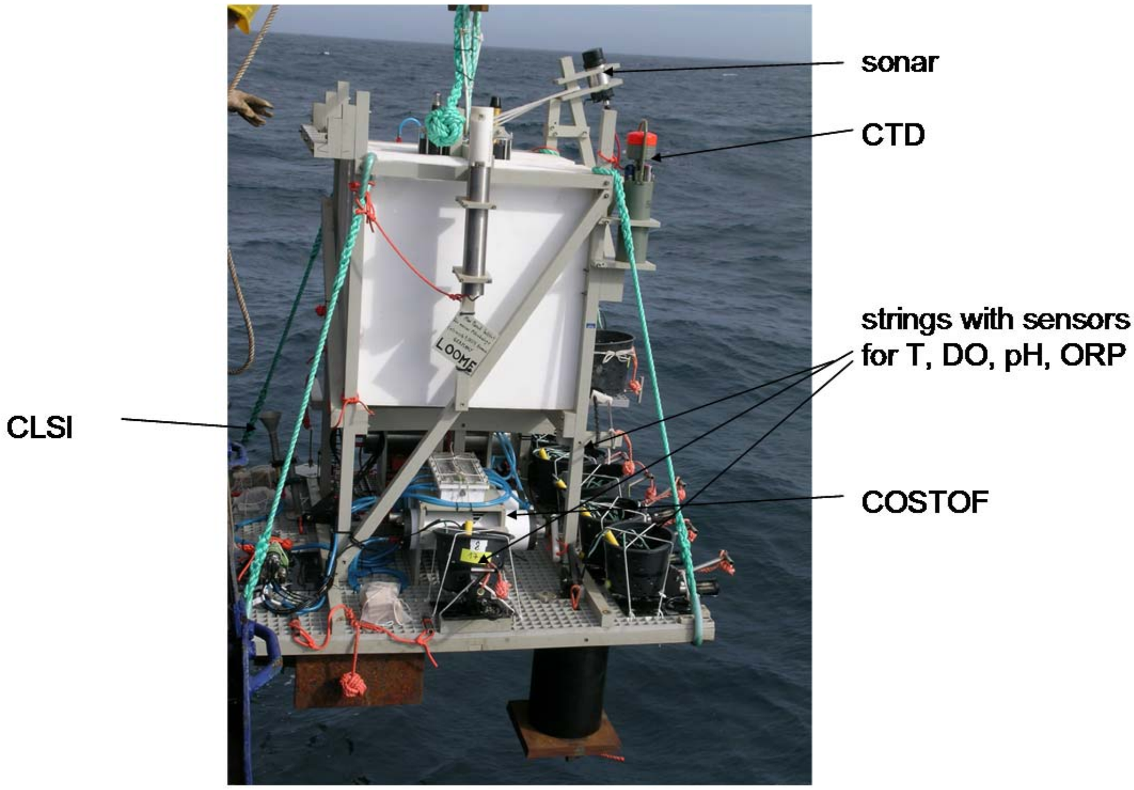


Figure 5.7.1.1: Deployment of the LOOME main frame in 2009.

LOOME (Long-term Observatory On Mud volcano Eruptions) is a demonstration mission from the ESONET EU network of excellence. The aim of LOOME is to detect the events leading to, during and after a mudvolcano eruption. The observatory is an array of instruments, aimed to measure downwards (geo-acoustics, deep T measurements), surface phenomena (T-strings and sensors measuring DO, pH and ORP), and sensors for the water column (turbidity, pressure, T, salinity, DO, and gasflares by scanning sonar). Additionally, a camera is positioned to register dynamics in faunal behavior and abundance, as well to visualize gas bubbles. With exception of the OBS, the camera and the 15 m T-lance, the sensors are connected to the frame of LOOME, where all data are collected.

The deployment of LOOME was performed by lowering the frame by winch (Figure 5.7.1.1), followed by positioning of the surface sensors across the most active site by ROV. The frame was placed on an inactive slab of hydrates, eastwards and adjacent to the hot spot. The camera was placed near the frame by the ROV, on the very border of the hydrates and warm mud. The

T-lance was deployed by winch at the western border of the active site (Table 5.7.1.1). The positioning of the frame and sensors was done by ROV.

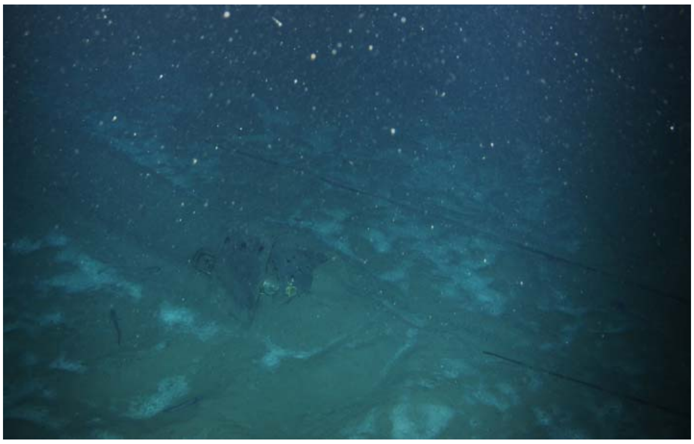


Figure 5.7.1.2: During the one year of deployment, chemosensors connected via cables to the LOOME main frame were pulled away by mud movement and made trails on the seafloor.

In 2010 the frame with sensors was recovered. A first reconnaissance learned that the frame remained at position, and that all sensors were visible. The T-strings and chemical sensors were pulled away from the frame by moving mud, but remained connected. All cables were pulled in south-eastern direction and the sensors made trails in the mud (Figure 5.7.1.2). The T-lance, of 15 m length and 1500 kg, was found after a long search about 160 m south of the deployment position. Thus sediment has flowed at least 160 m. The camera was placed on the edge of the hydrates and had stayed in position. The OBS was located approximately by pinging, but not observed by the ROV.

The camera, LOOME frame, and T-lance were recovered by the ship winch and using the ROV to connect the hook to the equipment. The strings and loggers remained connected, were very entangled but intact, and were after surfacing pulled on deck by hand. All recoveries were without problems and first view on the temperature and chemosensor data indicate that several eruptive events occurred.

Table 5.7.1.1: Time and Positions of the LOOME compartments deployed in 2009 and recovered in 2010

Compartments	N	E	deployment/ recovery date (UTC)	deployment mode	recovery mode
LOOME frame (MPI)	72 00.3240	014 43.5607	24.7.2009/ 28.9.2010	ROV/winch	ROV/winch
T-String 100m (Ifm-Geomar)	72 00.2715	014 43.6079	25.7.2009/ 28.9.2010	ROV	ROV/winch
Microsensor string (MPI)	72 00.2700	014 43.6109	25.7.2009/ 28.9.2010	ROV	ROV/winch
Microsensor string (MPI)	72 00.2760	014 43.5895	25.7.2009/ 28.9.2010	ROV	ROV/winch
T-Stick Loome (Ifm-Geomar)	72 00.2989	014 43.5900	25.7.2009/ 28.9.2010	ROV	ROV/winch

Compartments	N	E	deployment/ recovery date (UTC)	deployment mode	recovery mode
Microsensor string (MPI)	72 00.2880	014 43.5970	25.7.2009/ 28.9.2010	ROV	ROV/winch
Microsensor string (MPI)	72 00.2940	014 43.5900	25.7.2009/ 28.9.2010	ROV	ROV/winch
Microsensor string (MPI)	72 00.3038	014 43.5840	25.7.2009/ 28.9.2010	ROV	ROV/winch
Microsensor string (MPI)	72 00.3116	014 43.5576	25.7.2009/ 28.9.2010	ROV	ROV/winch
Camera AIM (Ifremer)	72 00.3120	014 43.6260	26.7.2009/ 28.9.2010	ROV	ROV/winch
T-Lance Loome (Ifremer)	72 00.2460	014 43.6080	27.7.2009/ 30.9.2010	Winch	ROV/winch
OBS (UIT)	72 00.27*	014 44.24*	Sept. 2009/ 5.10.2010	As lander	self releasing

**approximated by pinging*

5.7.2 CTD

(M.Schlüter, D. De Beer)

As part of the long term LOOME deployment we contributed the Sun & Sea multi parameter probe CTD 60M. The device is rated to 2000 m water depth. The housing and connector is made of titanium. As energy supply we decided for a DeepSea Power & Light SeaBattery™ (12V), which allows a run time of the CTD 60M of more than a year. The memory capacity of the probe is sufficient to allow data storage for more than a year as well, applying a time resolution of better than one measurement per minute. The probe was configured to start running when the energy supply is connected and a magnetic switch is closed. An LED on top of CTD is indicating the current state of the probe.

Our major aim was to record the temperature and pressure regime in the bottom water at the Håkon Mosby Mud Volcano. For example, previous investigations suggested that tidal variations as well as changes in current direction might be able to affect the release of gases from the seafloor as well as the direction of gas flares (e.g. Sauter et al., 2006).

We received the CTD 60M back in the laboratory at AWI in begin of October 2010. Essentially the CTD looked like new. For download of the data we opened the device. No water or corrosion was visible to us. The download started as expected. Unfortunately, after a 70% complete, the download was interrupted and a “WriteBuffer Overflow” message was thrown. Retries showed the same result.

We contacted the manufacturer and submitted the error report as well as the CTD. Since application of refined software for the read out of the FLASH memory were unsuccessful, the CTD was completely dismounted. This showed that a tiny amount of seawater entered the pressure housing causing corrosion of some essential electronically parts. The corrupted data retrieved from the FLASH memory suggests that the malfunction of the device occurred after a few days only. It was surprising that a small amount of water entered the pressure housing since we would had expected a complete flushing of the housing in case of a leakage.

Although speculative, it could be that a tiny amount of water entered the housing during the initial state of the deployment (within the upper tens of meters) when the hydrostatic pressure on the lid or connectors is low and change of ambient temperature is large; whereas under enhanced pressure the lid etc. are "self-sealing". We honestly regret this malfunction and would like to thank the LOOME Team aboard RV M.S.MERIAN for their support.

5.7.3 Sonar

(C. Waldmann)

A scanning sonar system (TRITECH SUPER SeaKing DST) has been deployed from July 2009 to October 2010 as part of the LOOME observatory to measure gas fluxes from the seafloor that are expected to occur during outburst events of the Håkon Mosby Mud volcano. The transducer of the scanning sonar has been mounted as high as possible on the LOOME frame to allow for a larger scanning range. Also, as can be seen on the Figure 5.7.3.1 it was tilted which allows an even further range at the cost of a limited circumferential observing range. Due to a failure before deployment the electronic system had to be revised and no longer allowed an event triggered operation. However, a fixed operation schedule had been programmed to be able to take observations during the entire deployment period. The sonar was at that stage completely autonomous meaning that it had its own power supply and data storage system.

The idea of using this type of acoustic method is related to the fact that acoustic radiation is scattered from gas bubbles due to the difference in impedance of the two media. The sonar had to be calibrated in the lab to correlate gas fluxes with acoustic signals. The sonar survived the one year deployment without any visible outside damage.

The data that hopefully can be retrieved will be converted from a proprietary binary format to a text format and then investigated using a MATLAB routine. If everything had worked properly about 20 MB of acoustic data will be recovered and made available through the ESONET project data website.

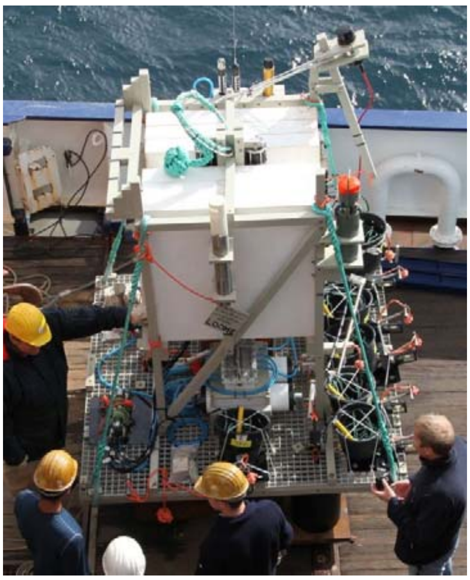


Figure 5.7.3.1: The figure shows the LOOME observatory frame right before deployment. The scanning sonar head can be seen on the upper right part of the picture characterized by the black rubber structure with the red cable attached.

5.7.4 Chemical Sensors

(D. De Beer)

Six sensor units each having a pH, DO and ORP sensor, plus a central logger, and connection cables were purchased from RBR (Ottawa). The sensing loggers were placed at a transect across the hot spot. Unfortunately, 5 of the 7 loggers were drowned. Only the central logger, that collected the data from the 6 sensor loggers, and one of the sensor loggers remained dry and functional. The sensor was positioned at 50 m south of the frame, in the center of the hot spot. The ORP did not show interpretable signals. The DO and pH signals showed good correlation (Figure 5.7.4.1). At the end of October 2009 both signals decreased, the pH became as low as 4, possibly indicating increased seepage, or burial in expelled sediments. In December both sensors regained seawater values and then decreased again until the end of May 2010. A pH of 4 can only be reached by very high CO_2 levels of 20 mM or more. The dynamics of the signals indicate eruptions and sediment movements from October 2009 till the end of the deployment.

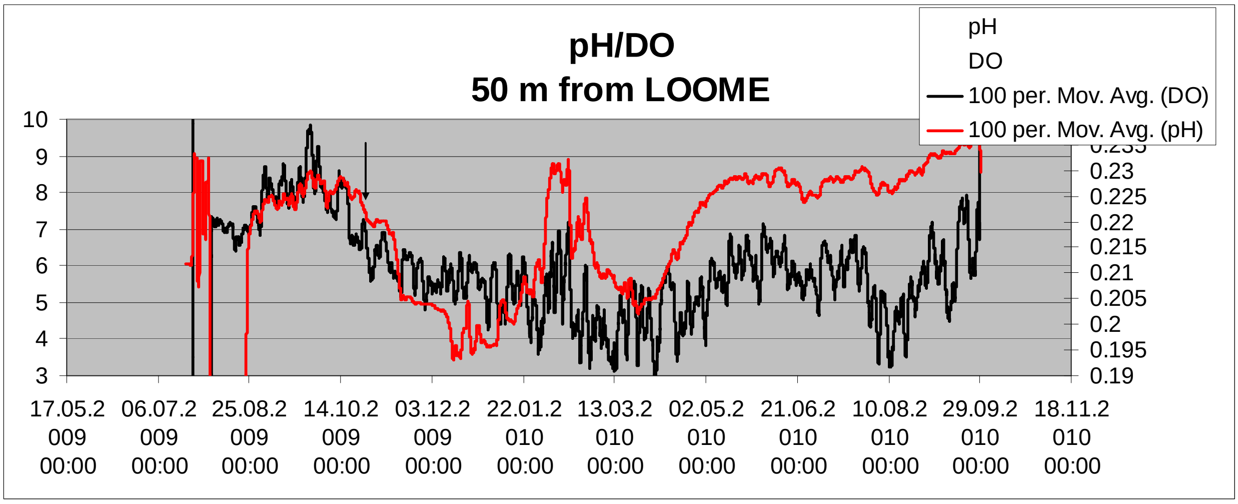


Figure 5.7.4.1: The DO and pH signal correlate nicely and both signal decreased in October 2010 (see arrow).

5.7.5 T-String and T-Stick

(G. Wetzel, T. Feseker)

Both the seabed thermistor string and the short sediment temperature probe were recovered with the LOOME observatory. In addition to temperature, the loggers also recorded bottom water pressure at a sampling interval of 20 minutes. All 24 channels of the seabed thermistor string worked without failure during the entire observation. The data shows numerous small events recorded by individual sensors as well as a few larger scale events detected by several neighboring sensors. Even though the data obtained from the short temperature probe was strongly disturbed by leakage through a corroded connector, the data shows clearly that the probe was pulled out of the sediment on October 26, 2009, presumably by advancing mud flows.

5.7.6 T-Lance

(F. Harmegnies, JP Foucher)

The Ifremer T-lance comprises of a coring pipe (outer diameter of 0.115 m) on which in total of 7 temperature sensors (NKE-THP; Figure 5.7.6.1) had been attached (Table 5.7.6.1). Please note, a complementary upper probe was attached above the weight of the corer (275 kg, outer diameter of 0.365 m) and was intended for bottom water temperature monitoring during the duration of the experiment. However, it was actually driven into the sediment down to an estimated sub-bottom depth of 6.7 m due to over-penetration into soft crater mud. The coring pipe had a plug at its lower end, preventing mud penetration into the pipe. After the recovery of the T-lance, it was checked that there was no mud in the pipe. The T-Lance was deployed at the seafloor at the 26.07.2009 (N72°00.246'; E014°43.610') and recovered at the 30/09/2010 (N72°00.159'; E014°43.606'). The difference between the two positions is approximately 160 m and the instrument had been moved towards south by mud flows. The temperature probes measured and recorded data every 30 minutes over a time period of 430 days 21 hours 30 minutes, resulting into a total number of 20684 single measurements. All of the probes have worked correctly and the quality of the data is excellent. Further analyzes will provide us with more detailed information about the eruption events recorded by other compounds of the LOOME observatory and resulted in the displacement of the T-Lance during the deployment.

Table 5.7.6.1: In total 8 temperature probes were mounted to the T-Lance.

Probe no	Probe distance from lower end of pipe (m)	Probe sensor no
1	0,5	THP22012
2	1,9	THP25001
3	3,3	THP25002
4	4,71	THP25006
5	6,1	THP25009
6	7,52	THP26003
7	8,92	THP26004
Lest	11,16	THP26005

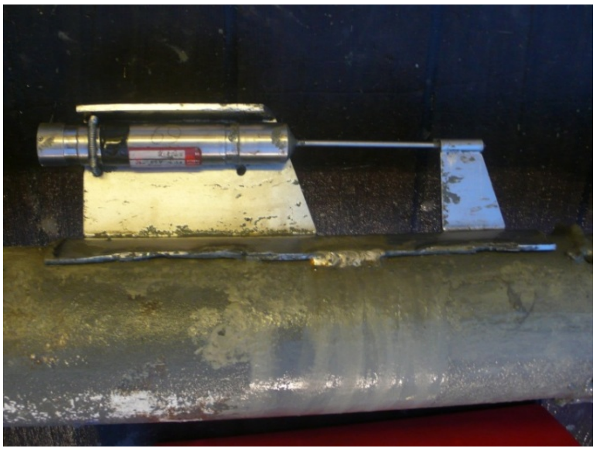


Figure 5.7.6.1: Each of the temperature probes was separately mounted to the T-Lance.

5.7.7 Autonomous Imaging Module (AIM) deployment on HMMV

(J. Blandin, J. Legrand, S. Dentrecolas, K. Olu)

The Autonomous Imaging Module (AIM) is a Time-lapse Video camera that can be deployed for several months on the seafloor. During ROV deployment, image control is possible by CLSI link. The Autonomous Imaging Module (AIM) was developed by Ifremer during the ExocetD FP7 European project. A first prototype was deployed in August 2006 on an hydrothermal vent site. A second prototype has been built for cold seeps in the framework of the HERMES

European program. The technical team involved in this technical development was composed of engineers from the Underwater System Department at Ifremer Toulon and for the last system, engineers from Ifremer Brest for the lights. The system includes the underwater autonomous module and the surface unit needed for configuration, check and data copy.

For the LOOME observatory, the AIM was deployed for one year, with a frequency of 2 video sequences of 2 min per day. The scientific objectives were to observe Zoarcidae fish behavior on and next to microbial mats, and to explore the temporal dynamics of microbial mat habitat (extend or decrease of the colonized area). Furthermore, the observed biological changes should be linked to the environmental parameters recorded by the observatory chemical or physical sensors

The AIM has been deployed with the ROV Quest during the Polarstern ARK-XXIV/2 cruise, on the 26th of July, 2009. During the deployment, the configuration (zoom, iris, focus) were successfully controlled with the use of the contact-less link, the module being connected to the ROV. The camera was put in Autonomous mode until the Recovery during the MERIAN MSM16 cruise (3 hours of recovery). After the recovery of the mooring, video sequences were downloaded at Ifremer Toulon.

The initial autonomy of the batteries (1 yr) was reduced to 5.5 months, because of water entry in the camera bottle, that have reduced data recording. The last video record was therefore the 12/12/2009. Between the deployment and the recovery, the AIM was slightly buried in the sediment due to a close-by gas eruption. Consequently, the camera record during the last month was not usable. There is therefore 4.5 months of data. 274 video files representing 2 min sequences are available (e.g. Figure 5.7.7.1). The position during recovery was N 72° 0.3110’- E 14° 43.5848.

Figure 5.7.7.1: left: Video module on microbial mats before its recovery (recorded by the AUV-Sentry). right: image digitized from a AIM video sequence.

5.7.8 OBS

(B. Ferret, j. Mienert)

A multi-component Ocean Bottom Seismometer (OBS) was deployed to record seismic recordable events from July 2009 to October 2010. The multi-component OBS was initially deployed in approx. 1257 m water depth at the northern area inside the HMMV, but ended up in the southern area, about 300m from the initial position. The OBS system used during this survey of the HMMV is a KUM design and was purchased by the Department of Geology of the University of Tromsø (Figure 5.7.8.1). It is an autonomous sea floor recording platform, designed to record both compressional and shear waves reflected and refracted through the sediments. It consists of a titanium frame with buoyancy made of syntactic foam, a KUMQUAT acoustic release system, and a digital data recorder in a separate pressure case. A hydrophone and a 3-component geophone are used to record the seismic wave field. The Tromsø OBS has a 4.5 Hz geophone attached. While the hydrophone is fixed to the frame of the OBS, the geophone is detached from it. This design insures that the geophone is mechanically decoupled from the frame, to avoid noise generated by the frame being recorded by the geophone. The whole system is rated for a water depth of up to 6000 m. The OBS is attached to a ground weight via the acoustic release system, to make it sink to the sea floor after deployment. When the seismic experiment is completed, the OBS is released from its ground weight by sending an acoustic code, and it rises to the sea surface by its buoyancy.

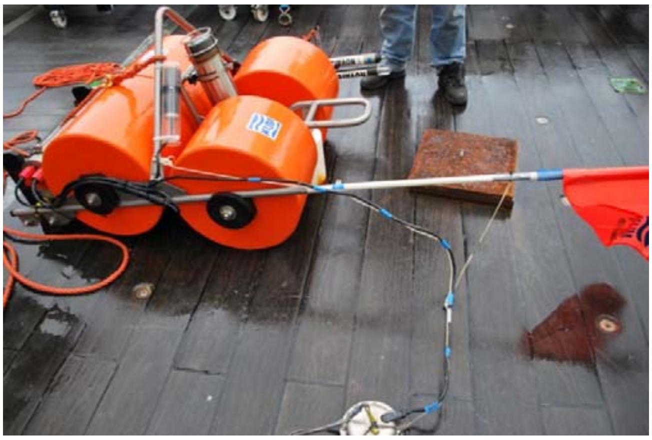


Figure 5.7.8.1: OBS after the recovery on deck of the MSM Merian.

5.8 Wood colonization experiments

(P. Pop Ristova)

The organic carbon from wood falls represents time and spatially limited energy source to the deep sea. Degradation processes can lead to oxygen depletion, followed by anaerobic degradation and finally to development of reducing conditions with high concentrations of sulphide. Such conditions promote establishment of highly productive and rich chemosynthetic communities. It was proposed that wood and other large organic falls could act as stepping stones in the dispersal of chemosynthetic organisms among cold seeps and hydrothermal vents (Smith et al., 2008). To elucidate the role of large organic falls into the deep sea, two wood experiments (wood-1 and wood-2) consisting of one large log (200 cm length and 30 cm diameter) and 10 smaller logs (25 x 30 cm x 10 - 15 cm) of Douglas fir, were deployed at HMMV during the ARKXXII/1b cruise in 2007 (N72°00.3917'; E014° 43.6320). The sunken woods were for the first time sampled during the ARKXXIV/2 cruise in 2009. During the MSM 16-2 cruise and after 3-year of deployment, we had a chance once more to recover samples from this wood. Three small wood logs were detached from the wood experiment with the help of the ROV. Once on board, the samples were stored in seawater at 0 °C and subsampled at in situ temperature of 4 °C. From each wood log, 6 subsamples were taken, 3 from the surface (0 – 2 cm) and 3 from the inside wood (2 - 4 cm). The wood subsamples were fixed for different molecular analyses (e.g. DNA, Fluoresence In Situ Hybridization (FISH), prokaryotic abundances by Acridine Orange Direct Counts, that will be performed in the home laboratory.

First visual inspection with the ROV revealed that the surrounding sediment of the wood was highly populated by Pogonophora –indicator organisms of reduced conditions (Figure 5.8.1). The degradation of the wood has progressed since 2009. The bark of the wood was almost intact whilst the whole inner part was heavily degraded and crowded with siphon shells of wood-boring bivalves.

To understand better the different stages of degradation of wood, as well as to identify the key degrading organisms and the importance of their larvae stages, three wood parcels were attached to the LOOME observatory and deployed in 2009. All three wood parcels, comprised of wood cubicles placed in nets with different mash sizes, were recovered during this cruise. First examination of the wood parcels on board revealed that only the wood cubicles placed in the net with the largest mesh size showed indications of degradation. Living wood-boring bivalve specimens, most probably the same ones found at the large wood experiment, were found in the partly degraded wood cubicles (Figure 5.8.2).

This specific research is part of the ESF EUROCORES EuroDEEP Project "Colonization processes in chemosynthetic ecosystems – CHEMECO" and the MPG-CNRS GDRE „Diversity, establishment and function of organisms associated with marine wood falls – DIWOOD"

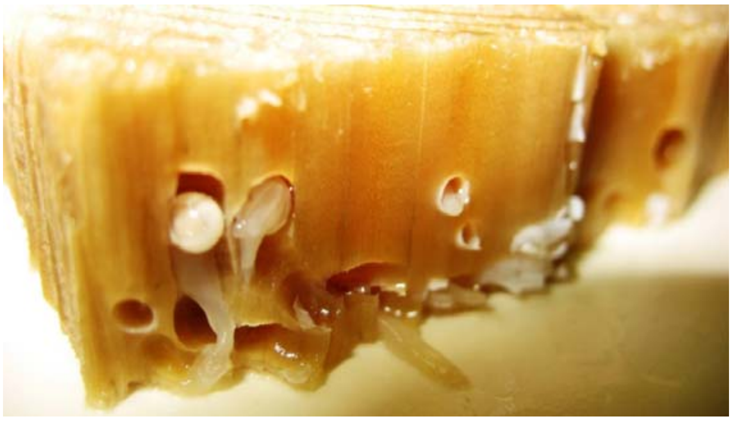


Figure 5.8.1: Partly degraded LOOME wood-cubicle with wood-boring bivalves.

Figure 5.8.2: Wood-1 experiment surrounded by sediment populated with Pogonophora.

6 Station List MSM16-2

Station No./ Event Label	Date 2010	Time [UTC]	Gear	Latitude [°N]	Longitude [°E]	WaterDepth [m]	Remarks/ Recovery
MSM16/2_800-1	25.09.	11:43	CTD/Rosette	72.0047	14.7272	-1273	at max. depth
MSM16/2_801-2	25.09.	15:57	TV-MUC	72.0043	14.7263	-1260	
MSM16/2_802-1	25.09.	18:44	TV-MUC	72.0029	14.7314	-1353	put down
MSM16/2_803-1	25.09.	20:04	Mooring	72.0042	14.6833	-1285	surface
MSM16/2_804-1	25.09.	20:45	Mooring	72.0175	14.7268	-1256	surface
MSM16/2_805-1	25.09.	21:31	Mooring	72.0042	14.7703	-1242	surface
MSM16/2_806-1	26.09.	0:54	Bottom lander	72.0023	14.7308	-1255	Information
MSM16/2_808-1	26.09.	5:27	Heat-Flow probe	72.0048	14.7370		start heaving
MSM16/2_809-1	26.09.	8:23	MUC	72.0067	14.7477	-1257	at sea bottom
MSM16/2_810-1	26.09.	9:42	MUC	72.0050	14.7263	-1258	at sea bottom
MSM16/2_813-1	26.09.	18:33	AUV	72.0053	14.6980	-1272	AUV in water
MSM16/2_814-1	26.09.	20:25	ROV	72.0053	14.7260	-1258	surface
MSM16/2_815-1	27.09.	1:15	Bottom lander	72.0027	14.7326	-1262	at sea floor
MSM16/2_816-1	27.09.	2:40	ParaSound	72.0098	14.7058	-1272	
MSM16/2_817-1	27.09.	8:33	MUC	72.0031	14.7315	-1261	at sea bottom
MSM16/2_818-1	27.09.	9:56	MUC	72.0030	14.7314	-1262	at sea bottom
MSM16/2_819-1	27.09.	11:27	MUC	72.0026	14.7327	-1262	at sea bottom
MSM16/2_821-1	28.09.	1:43	Bottom lander	72.0031	14.7315	-1262	at sea floor
MSM16/2_816-2	28.09.	2:30	ParaSound	72.0055	14.7427	-1264	
MSM16/2_822-1	28.09.	8:15	MUC	72.0026	14.7324	-1260	at sea bottom
MSM16/2_823-1	28.09.	9:54	MUC	72.0027	14.7325	-1262	at sea bottom
MSM16/2_824-1	28.09.	11:32	AUV	72.0075	14.7253	-1258	AUV in water
MSM16/2_816-3	29.09.	0:10	Parasound	72.0018	14.7427	-1265	
MSM16/2_826-1	29.09.	6:15	MUC	72.0031	14.7313	-1260	at sea bottom
MSM16/2_827-1	29.09.	7:29	MUC	72.0031	14.7314	-1259	at sea bottom
MSM16/2_828-1	29.09.	10:45	OBS	72.0045	14.7373	-1260	hydrophone into water
MSM16/2_829-1	29.09.	13:05	MUC	72.0028	14.7325	-1260	at sea bottom
MSM16/2_830-1	29.09.	15:43	MUC	72.0026	14.7325	-1260	at sea bottom
MSM16/2_831-1	29.09.	17:05	MUC	72.0025	14.7323	-1210	at sea bottom
MSM16/2_832-1	29.09.	18:32	AUV	72.0062	14.7172	-1199	AUV in water
MSM16/2_833-1	29.09.	21:48	Bottom lander	72.0050	14.7265	-1260	at sea floor
MSM16/2_816-4	29.09.	23:00	ParaSound	71.9980	14.7430	-1264	
MSM16/2_834-1	30.09.	1:13	ParaSound	72.0100	14.7062	-1272	
MSM16/2_836-1	30.09.	15:58	Heat-Flow probe	72.0023	14.7275	-1260	on deck
MSM16/2_837-1	30.09.	20:16	Heat-Flow probe	72.0075	14.7231	-1257	at the bottom
MSM16/2_837-2	30.09.	20:49	Heat-Flow probe	72.0066	14.7230	-1253	at the bottom
MSM16/2_837-3	30.09.	21:31	Heat-Flow probe	72.0057	14.7250	-1257	at the bottom
MSM16/2_837-4	30.09.	21:58	Heat-Flow probe	72.0055	14.7261	-1257	at the bottom
MSM16/2_837-5	30.09.	22:26	Heat-Flow probe	72.0053	14.7265	-1258	at the bottom
MSM16/2_837-6	30.09.	22:49	Heat-Flow probe	72.0050	14.7262	-1258	at the bottom
MSM16/2_837-7	30.09.	23:22	Heat-Flow probe	72.0047	14.7266	-1259	at the bottom
MSM16/2_837-8	30.09.	23:48	Heat-Flow probe	72.0046	14.7277	-1260	at the bottom

Station No./ Event Label	**Date 2010**	**Time [UTC]**	**Gear**	**Latitude [°N]**	**Longitude [°E]**	**WaterDepth [m]**	**Remarks/ Recovery**
MSM16/2_837-9	01.10.	0:22	Heat-Flow probe	72.0040	14.7297	-1259	at the bottom
MSM16/2_837-10	01.10.	0:54	Heat-Flow probe	72.0033	14.7316	-1258	at the bottom
MSM16/2_837-11	01.10.	1:29	Heat-Flow probe	72.0025	14.7336	-1260	at the bottom
MSM16/2_837-12	01.10.	2:30	Heat-Flow probe	72.0050	14.7367	-1258	at the bottom
MSM16/2_837-13	01.10.	3:01	Heat-Flow probe	72.0047	14.7336	-1259	at the bottom
MSM16/2_837-14	01.10.	3:23	Heat-Flow probe	72.0046	14.7317	-1259	at the bottom
MSM16/2_837-15	01.10.	3:46	Heat-Flow probe	72.0045	14.7289	-1259	at the bottom
MSM16/2_837-16	01.10.	4:03	Heat-Flow probe	72.0048	14.7277	-1259	at the bottom
MSM16/2_837-17	01.10.	4:26	Heat-Flow probe	72.0047	14.7246	-1259	at the bottom
MSM16/2_837-18	01.10.	4:49	Heat-Flow probe	72.0040	14.7235	-1259	at the bottom
MSM16/2_838-1	01.10.	9:13	MUC	72.0048	14.7262	-1258	at sea bottom
MSM16/2_839-1	01.10.	11:44	TV-MUC	72.0052	14.7263	-1260	put down
MSM16/2_840-1	01.10.	14:58	Bottom lander	72.0041	14.7270	-1259	slipped
MSM16/2_841-1	01.10.	17:17	TV-MUC	72.0052	14.7269	-1261	put down
MSM16/2_842-1	01.10.	20:49	AUV	72.0067	14.7078	-1269	AUV in water
MSM16/2_843-1	01.10.	23:41	Heat-Flow probe	72.0031	14.7112	-1264	at the bottom
MSM16/2_843-2	02.10.	0:22	Heat-Flow probe	72.0033	14.7152		at the bottom
MSM16/2_843-3	02.10.	0:55	Heat-Flow probe	72.0036	14.7184	-1256	at the bottom
MSM16/2_843-4	02.10.	1:28	Heat-Flow probe	72.0037	14.7213	-1259	at the bottom
MSM16/2_843-5	02.10.	1:53	Heat-Flow probe	72.0036	14.7235	-1259	at the bottom
MSM16/2_843-6	02.10.	2:16	Heat-Flow probe	72.0038	14.7262	-1259	at the bottom
MSM16/2_843-7	02.10.	2:41	Heat-Flow probe	72.0032	14.7222	-1258	at the bottom
MSM16/2_843-8	02.10.	3:04	Heat-Flow probe	72.0028	14.7217	-1256	at the bottom
MSM16/2_843-9	02.10.	3:28	Heat-Flow probe	72.0028	14.7207		at the bottom
MSM16/2_843-10	02.10.	3:48	Heat-Flow probe	72.0022	14.7201	-1256	at the bottom
MSM16/2_844_ WOOD1	02.10.	7:55	Wood substrat	72.0066	14.7277	-1255	
MSM16/2_844_ WOOD2	02.10.	8:25	Wood substrat	72.0066	14.7277	-1255	
MSM16/2_844_ WOOD3	02.10.	9:02	Wood substrat	72.0066	14.7277	-1255	
MSM16/2_845-1	02.10.	12:26	TV-MUC	72.0040	14.7210	-1259	
MSM16/2_846-1	02.10.	14:37	MUC	72.0027	14.7325	-1260	at sea bottom
MSM16/2_847-1	02.10.	16:29	MUC	72.0042	14.7270	-1260	at sea bottom
MSM16/2_848-1	02.10.	20:45	Bottom lander	72.0053	14.7265	-1259	slipped
MSM16/2_849-1	02.10.	22:01	Heat-Flow probe	72.0045	14.7262	-1260	at the bottom
MSM16/2_849-2	02.10.	22:27	Heat-Flow probe	72.0042	14.7253	-1260	at the bottom
MSM16/2_849-3	02.10.	22:49	Heat-Flow probe	72.0042	14.7269	-1260	at the bottom
MSM16/2_849-4	02.10.	23:11	Heat-Flow probe	72.0040	14.7279	-1255	at the bottom
MSM16/2_849-5	02.10.	23:32	Heat-Flow probe	72.0039	14.7270	-1259	at the bottom
MSM16/2_849-6	02.10.	23:55	Heat-Flow probe	72.0038	14.7251	-1260	at the bottom
MSM16/2_849-7	03.10.	0:18	Heat-Flow probe	72.0036	14.7268	-1260	at the bottom
MSM16/2_849-8	03.10.	0:42	Heat-Flow probe	72.0034	14.7288	-1260	at the bottom
MSM16/2_849-9	03.10.	1:06	Heat-Flow probe	72.0031	14.7269	-1260	at the bottom
MSM16/2_849-10	03.10.	1:29	Heat-Flow probe	72.0030	14.7250	-1256	at the bottom
MSM16/2_849-11	03.10.	1:54	Heat-Flow probe	72.0027	14.7269	-1260	at the bottom
MSM16/2_849-12	03.10.	2:19	Heat-Flow probe	72.0029	14.7301	-1255	at the bottom
MSM16/2_849-13	03.10.	2:41	Heat-Flow probe	72.0024	14.7310	-1255	at the bottom

Station No./ Event Label	Date 2010	Time [UTC]	Gear	Latitude [°N]	Longitude [°E]	WaterDepth [m]	Remarks/ Recovery
MSM16/2_849-14	03.10.	3:07	Heat-Flow probe	72.0018	14.7321	-1260	at the bottom
MSM16/2_849-15	03.10.	3:32	Heat-Flow probe	72.0016	14.7272	-1260	at the bottom
MSM16/2_849-16	03.10.	3:53	Heat-Flow probe	72.0012	14.7250	-1255	at the bottom
MSM16/2_849-17	03.10.	4:16	Heat-Flow probe	72.0022	14.7269	-1255	at the bottom
MSM16/2_849-18	03.10.	4:36	Heat-Flow probe	72.0022	14.7250	-1263	at the bottom
MSM16/2_850-1	03.10.	7:02	OBS	72.0023	14.7408	-1263	released
MSM16/2_851_TST1	03.10.	13:12	T-Stick	72.0025	14.7270	-1259	
MSM16/2_851_TST2	03.10.	13:36	T-Stick	72.0034	14.7282	-1259	
MSM16/2_851_TST3	03.10.	13:50	T-Stick	72.0036	14.7292	-1258	
MSM16/2_851_TST4	03.10.	14:06	T-Stick	72.0041	14.7295	-1258	
MSM16/2_851_TST5	03.10.	14:25	T-Stick	72.0043	14.7298	-1259	
MSM16/2_851_TST6a	03.10.	14:39	T-Stick	72.0046	14.7296	-1259	
MSM16/2_851_TST6b	03.10.	14:52	T-Stick	72.0046	14.7297	-1259	
MSM16/2_851_TST7	03.10.	15:11	T-Stick	72.0049	14.7293	-1259	
MSM16/2_851_TST8a	03.10.	15:27	T-Stick	72.0046	14.7280	-1259	
MSM16/2_851_TST8b	03.10.	15:41	T-Stick	72.0048	14.7282	-1257	
MSM16/2_851_TST9	03.10.	16:00	T-Stick	72.0044	14.7276	-1256	
MSM16/2_851_TST13	03.10.	18:00	T-Stick	72.0046	14.7237	-1258	
MSM16/2_851_TST12	03.10.	18:17	T-Stick	72.0046	14.7252	-1259	
MSM16/2_851_TST11	03.10.	18:31	T-Stick	72.0044	14.7268	-1259	
MSM16/2_851_TST10	03.10.	18:45	T-Stick	72.0040	14.7268	-1259	
MSM16/2_852-1	03.10.	16:31	AUV	72.0040	14.7280	-1260	AUV in water
MSM16/2_853-1	03.10.	23:04	Bottom lander	72.0065	14.7470	-1257	slipped
MSM16/2_854-1	04.10.	0:58	Heat-Flow probe	72.0007	14.7249	-1255	at the bottom
MSM16/2_854-2	04.10.	1:34	Heat-Flow probe	72.0017	14.7261	-1255	at the bottom
MSM16/2_854-3	04.10.	4:11	Heat-Flow probe	72.0025	14.7266	-1260	at the bottom
MSM16/2_854-4	04.10.	4:32	Heat-Flow probe	72.0027	14.7235	-1257	at the bottom
MSM16/2_854-5	04.10.	5:00	Heat-Flow probe	72.0033	14.7203	-1261	at the bottom
MSM16/2_854-6	04.10.	5:22	Heat-Flow probe	72.0042	14.7209	-1260	at the bottom
MSM16/2_854-7	04.10.	5:40	Heat-Flow probe	72.0046	14.7225	-1260	at the bottom
MSM16/2_854-8	04.10.	6:11	Heat-Flow probe	72.0051	14.7245	-1260	at the bottom
MSM16/2_854-9	04.10.	6:42	Heat-Flow probe	72.0052	14.7265	-1259	at the bottom
MSM16/2_854-10	04.10.	7:28	Heat-Flow probe	72.0047	14.7297	-1260	at the bottom
MSM16/2_854-11	04.10.	7:54	Heat-Flow probe	72.0044	14.7304	-1261	at the bottom
MSM16/2_854-12	04.10.	8:18	Heat-Flow probe	72.0041	14.7315	-1257	at the bottom
MSM16/2_854-13	04.10.	8:36	Heat-Flow probe	72.0040	14.7299	-1261	at the bottom
MSM16/2_854-14	04.10.	9:12	Heat-Flow probe	72.0060	14.7270	-1260	at the bottom
MSM16/2_854-15	04.10.	9:42	Heat-Flow probe	72.0066	14.7313	-1259	at the bottom
MSM16/2_854-16	04.10.	10:12	Heat-Flow probe	72.0076	14.7335	-1262	at the bottom
MSM16/2_854-17	04.10.	11:13	Heat-Flow probe	72.0052	14.7264	-1260	at the bottom
MSM16/2_855-1	04.10.	13:01	TV-MUC	72.0040	14.7298	-1261	put down
MSM16/2_856-1	04.10.	14:59	TV-MUC	72.0052	14.7260	-1282	put down
MSM16/2_857-1	04.10.	16:52	TV-MUC	72.0030	14.7203	-1271	put down
MSM16/2_858-1	04.10.	18:11	TV-MUC	72.0028	14.7201	-1267	put down
MSM16/2_859-1	05.10.	0:31	Parasound	72.0050	14.7427	-1283	

Station No./ Event Label	Date 2010	Time [UTC]	Gear	Latitude [°N]	Longitude [°E]	WaterDepth [m]	Remarks/ Recovery
MSM16/2_860-1	05.10.	8:35	AUV	72.0023	14.7277	-1268	AUV in water
MSM16/2_861-1	05.10.	11:29	CTD/Rosette	72.0043	14.7267	-1267	at depth
MSM16/2_862-1	05.10.	17:36	TV-MUC	72.0028	14.7200	-1272	put down
MSM16/2_863-1	05.10.	18:53	TV-MUC	72.0026	14.7325	-1271	put down
MSM16/2_864-1	05.10.	20:13	TV-MUC	72.0048	14.7198	-1266	put down
MSM16/2_865-1	06.10.	0:44	Parasound	72.0063	14.7427	-1270	

7 Data and Sample Storage and Availability

Metadata and post-cruise data are hosted by the information system PANGAEA (http://www.pangaea.de/) 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 all stored in the WDC MARE data base PANGAEA (http://www.pangaea.de/search?count=10&minlat=&minlon=&maxlat=&maxlon=&mindate=&maxdate=&env=All&q=loome+), including ship tracks doi:10.1594/PANGAEA.753242), and including all Parasound data (doi:10.1594/PANGAEA.753248). Video and photographic data are archived in the MARUM Videodata base. 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 will include geophysical, geochemical, and biological data gained during the MSM 16-2 cruise as well as data gained from each of the LOOME components (Figure 7.1). As many of the retrieved data will be needed for modelling and budgeting, we expect a very good flow of data between the multidisciplinary participants. Samples for meiofauna biodiversity are stored at Gent University, and all microbiological samples (frozen sediments for DNA analyses) are stored at MPI. Molecular data will be deposited in globally accessible databases such as GenBank. Samples and data will be made available upon request and specification of scientific collaborations.

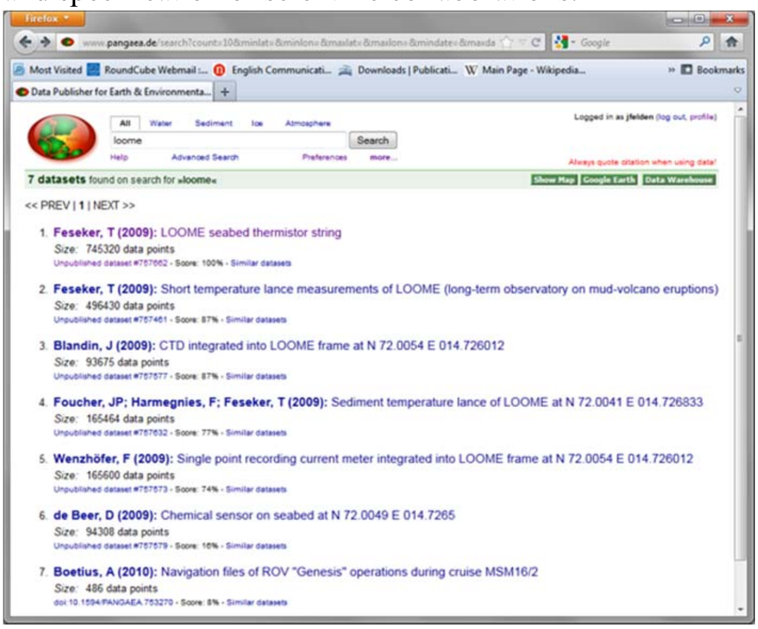


Figure 7.1: First data gained in the framework of the LOOME deployment are already submitted to PANGAEA

8 Acknowledgements

We thank Captain and crew of the MERIAN expedition MSM16/2 for their excellent support of our work at sea. Also, we thank the ROV GENESIS team for the excellent recovery dives, and the AUV Sentry team of WHOI for the outstanding support with work at sea. The shiptime was provided by the Deutsche Forschungsgemeinschaft. Financial support for the different tasks completed during the cruise came from the EU Projects ESONET and HERMIONE, the GDRE DIWOOD, as well as from the research institutes involved. We gratefully acknowledge this support.

9 References

Camilli R, Duryea AN (2009) Characterizing Spatial and Temporal Variability of Dissolved Gases in Aquatic Environments with in situ Mass Spectrometry. *Environ. Sci. Technol.,* **43**, 5014-5021.

Camilli R, Reddy CM, Yoerger DR, Van Mooy BaS, Jakuba MV, Kinsey JC, Mcintyre CP, Sylva SP, Maloney JV (2010) Tracking Hydrocarbon Plume Transport and Biodegradation at Deepwater Horizon. *Science,* **330**, 201-204.

De Beer D, Sauter E, Niemann H, Kaul N, Foucher JP, Witte U, Schlüter M, Boetius A (2006) In situ fluxes and zonation of microbial activity in surface sediments of the Håkon Mosby mud volcano. *Limnol. Oceanogr.,* **51**, 1315-1331.

Felden J, Wenzhöfer F, Feseker T, Boetius A (2010) Transport and consumption of oxygen and methane in different habitats of the Håkon Mosby Mud Volcano (HMMV). *Limnol. Oceanogr.,* **55**, 2366-2380.

Grünke S, Lichtschlag A, De Beer D, Felden J, Boetius A (in prep.) Diversity of mat-forming sulfide oxidizers in deep-sea thiotrophic bacterial mats associated with cold seeps of the Norwegian continental margin.

Jørgensen BB, Boetius A (2007) Feast and famine - microbial life in the deep-sea bed. *Nat. Rev. Microbiol.,* **5**, 770-781.

Levin LA (2005) Ecology of cold seep sediments: Interactions of fauna with flow, chemistry and microbes. *Oceanography and Marine Biology - an Annual Review, Vol. 43,* **43**, 1-46.

Lichtschlag A, Felden J, Brüchert V, Boetius A, De Beer D (2010) Geochemical processes and chemosynthetic primary production in different thiotrophic mats of the Håkon Mosby Mud Volcano (Barents Sea). *Limnol. Oceanogr.,* **55**, 931-949.

Niemann H, Lösekann T, De Beer D, Elvert M, Nadalig T, Knittel K, Amann R, Sauter EJ, Schluter M, Klages M, Foucher JP, Boetius A (2006) Novel microbial communities of the Håkon Mosby mud volcano and their role as a methane sink. *Nature,* **443**, 854-858.

Sauter EJ, Muyakshin SI, Charlou JL, Schluter M, Boetius A, Jerosch K, Damm E, Foucher JP, Klages M (2006) Methane discharge from a deep-sea submarine mud volcano into the upper water column by gas hydrate-coated methane bubbles. *Earth Planet. Sci. Lett.,* **243**, 354-365.

Smith KL, Ruhl HA, Kaufmann RS, Kahru M (2008) Tracing abyssal food supply back to upper-ocean processes over a 17-year time series in the northeast Pacific. *Limnol. Oceanogr.,* **53**, 2655-2667.

Treude T, Boetius A, Knittel K, Wallmann K, Jørgensen BB (2003) Anaerobic oxidation of methane above gas hydrates at Hydrate Ridge, NE Pacific Ocean. *Marine Ecology-Progress Series,* **264**, 1-14.