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Short Cruise Report

MERIAN MSM16-2

"LOOME"- Long Term Observatory of Mud Volcano Eruptions

Tromsø - Tromsø

24.09.2010 – 08.10.2010

Chief Scientist: Antje Boetius

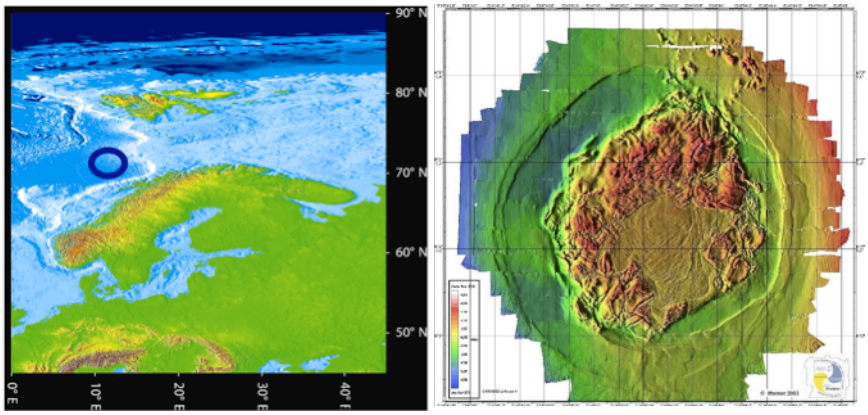
Captain: Matthias Günther

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 Haakon 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 interannual temporal changes related to eruptions. All components were successfully retrieved with the help of the ROV GENESIS and all comparative analyses were completed. 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 complete overview on changes associated with mud volcanism.

Narrative:

The LOOME mission MSM16-2 started on the 24 September 2010 heading to the Håkon Mosby mud volcano (HMMV), 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. 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.



The Haakon Mosby mud volcano on the Norwegian margin. Right: The microbathymetry map completed in 2003 (VICTOR6000; IFREMER)

A year before the MSM16/2 mission, on 24. 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.

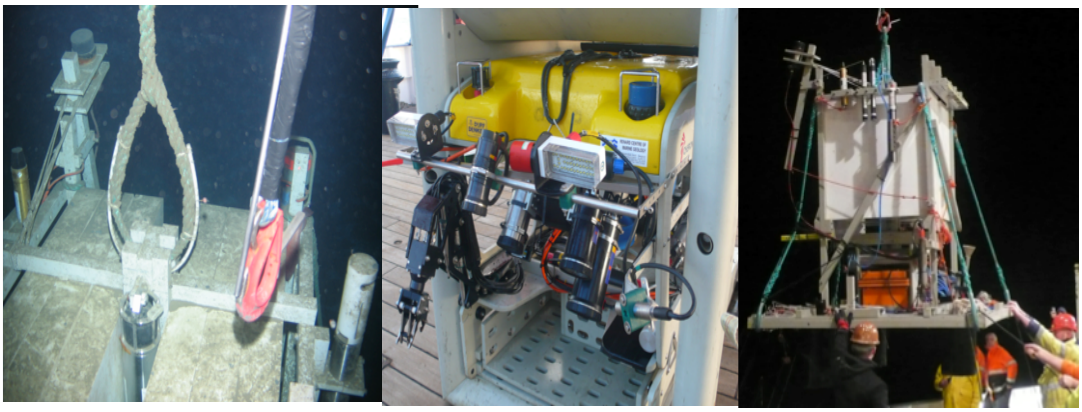
On site work started late 25 September 2010 in stormy seas using the video-guided multicorer. Thanks to the precise positioning of the MERIAN we were able to visually relocate most observatory components, the LOOME central frame on the gashydrate-bearing rim, and the sensors in the mud flow 50-100 m 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 26 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.

AUV Sentry (WHOI) close to its launch. Source: F. Harmegnies

Next was the deployment of the benthic chamber lander to carry out measurements of the total benthic oxygen and methane fluxes, as well as profiles of pH, sulfide and other porewater species. Unfortunately, the program of the 26.09.10 had to be changed, as the fibre 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 Tromso, we planned further ROV Genesis dives, to recover the AIM camera observatory of IFREMER and the LOOME frame, and to locate and recover the T-lance and OBS. On 27.9. 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 September we continued with the mapping of the mud volcano especially in the north, which showed significant changes in the seafloor



Recovery of the LOOME frame with ROV GENESIS. Left: The hook tied to the ship's cable is picked up by the ROV to be clamped to the loop of the recovery rope. Middle: ROV Genesis with its small manipulator arm. Right: LOOME is recovered on board. Source F. Harmegnies

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. 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 30 September was dedicated to a further search of the missing T lance: we finally found it after a day of searching in circles 160m 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. 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 fibre optics cable was repaired in the evening of the 30.9., and we started the realtime in situ temperature transects during the night.

On 1.10. 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 concentations at different water depths. In parallel we deployed the chamber lander, TV-guided multicorer, heat flow lance, and on the 2.10. also the ROV. This dive is dedicated to retrieving samples from the long term DIWOOD experiments on sunken wood in the deep sea - after 3 years, the wood-boring bivalves have almost completely consumed the wood and only few organisms are retrieved together with the wood samples. On 3.10, 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 is completed with the online heat probe. On the 4 October, after more than a week of great weather, wind and waves pick up again, so that we continue with TV multicorer stations and gas flare mapping with the ship's parasound system. In the morning of the 5.10. we have a window in the weather situation and deploy 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 have to retrieve it late that day, as the winds are picking up again. We complete our sampling of sediments with the TV MUC 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 MUC 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 Tromso where we ended the mission MSM16/2 with the debarking of the scientists. In conclusion, most of our program is successfully completed. The use of temperature probes and geo-phones will allow an early identification of changes in fluid flow and mud movement. Lances with temperature sensors deployed at selected locations in the central area have recorded changes in porewater flow several meters below the seafloor. Additional sensors measuring temperature, redox potential, oxygen, pH, sulfide, and methane were positioned directly at the seafloor to study changes in the chemical com-position of the pore fluids and to investigate the spatial extent of eruptive events. Sonar systems in combination with current profilers and flow meters will help to detect and quantify the release of gas bubbles. 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. The additional high-resolution mapping of HMMV by AUV Sentry will reveal morphostructural changes caused by eruptive events.

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. 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.

Station list

Station	Date (UTC)	Time (UTC)	PositionLat N	PositionLon E	Depth [m]	Gear
MSM16/800-1	25.09.2010	11:43	72° 0.28'	14° 43.63'	1273	CTD/rosette
MSM16/801-2	25.09.2010	15:57	72° 0.26'	14° 43.58'	1260	TV-Multicorer
MSM16/802-1	25.09.2010	18:44	72° 0.17'	14° 43.84'	1258	TV-Multicorer
MSM16/803-1	25.09.2010	20:04	72° 0.25'	14° 41.00'	1285	Transponder
MSM16/804-1	25.09.2010	20:45	72° 1.05'	14° 43.61'	1256	Transponder
MSM16/805-1	25.09.2010	21:31	72° 0.25'	14° 46.22'	1242	Transponder
MSM16/806-1	26.09.2010	01:17	72° 0.12'	14° 43.62'	1255	Bottom lander
MSM16/807-1	26.09.2010	01:53	72° 0.40' N	14° 43.07' E		Posidonia
MSM16/808-1	26.09.2010	05:02	72° 0.29' N	14° 44.22' E		Heat Flow
MSM16/809-1	26.09.2010	08:23	72°0.323'	14°43.561'	1257	Multicorer
MSM16/810-1	26.09.2010	09:36	72°0.289'	14°43.583'	1258	Multicorer
MSM16/811-1	26.09.2010	10:38	72° 0.14' N	14° 43.62' E	1260	Transponder
MSM16/813-1	27.09.2010	14:27	71°59.654'	14°42.825'	1266	AUV
MSM16/814-1	27.09.2010	20:25	72° 0.32' N	14° 43.56' E	1258	ROV
MSM16/815-1	27.09.2010	01:15	72°0.160'	14°43.956'	1262	Bottom lander
MSM16/816-1	27.09.2010	02:40	72° 0.59'	14° 42.35'	1271	Parasound
MSM16/816-2	28.09.2010	02:29	72° 0.33'	14° 44.57'	1264	Parasound
MSM16/816-3	29.09.2010	05:25	71° 59.92'	14° 44.55'	1265	Parasound
MSM16/816-4	29.09.2010	22:57	71° 59.88'	14° 44.56'	1261	Parasound
MSM16/817-1	27.09.2010	08:33	72°0.184'	14°43.889'	1261	Multicorer
MSM16/818-1	27.09.2010	09:56	72°0.179'	14°43.881'	1262	Multicorer
MSM16/819-1	27.09.2010	11:27	72°0.155'	14°43.961'	1262	Multicorer
MSM16/820-1	27.09.2010	16:54	72° 0.31'	14° 43.70'	1259.9	ROV
MSM16/821-1	28.09.2010	01:43	72°0.184'	14°43.890'	1262	Bottom lander
MSM16/822-1	28.09.2010	08:15	72°0.157'	14°43.941'	1260	Multicorer
MSM16/823-1	28.09.2010	09:54	72°0.162'	14°43.948'	1262	Multicorer
MSM16/824-1	28.09.2010	11:33	72° 0.45'	14° 43.52'	1258	AUV
MSM16/825-1	28.09.2010	14:17	72° 0.31'	14° 43.64'	1260	ROV
MSM16/826-1	29.09.2010	06:15	72°0.187'	14°43.88'	1260	Multicorer
MSM16/827-1	29.09.2010	07:29	72°0.187'	14°43.881'	1259	Multicorer
MSM16/829-1	29.09.2010	13:05	72°0.165'	14°43.947'	1260	Multicorer
MSM16/830-1	29.09.2010	15:43	72°0.153'	14°43.947'	1260	Multicorer
MSM16/831-1	29.09.2010	17:05	72°0.151'	14°43.939'	1211	Multicorer
MSM16/832-1	29.09.2010	18:32	72° 0.37'	14° 43.03'	1199	AUV
MSM16/833-1	29.09.2010	21:48	72°0.299'	14°43.593'	1260	Bottom lander
MSM16/834-1	30.09.2010	01:12	72° 0.59'	14° 42.32'	1270	Parasound
MSM16/835-1	30.09.2010	06:22	72° 0.25'	14° 43.63'	1259	ROV
MSM16/836-1	30.09.2010	15:04	72°0.14'	14°43.627'	1260	T-Lance
MSM16/837-1	30.09.2010	20:16	72°0.448'	14°43.388'	1257	Heat Flow
MSM16/837-2	30.09.2010	20:49	72°0.397'	14°43.378'	1253	Heat Flow
MSM16/837-3	30.09.2010	21:31	72°0.342'	14°43.502'	1257	Heat Flow
MSM16/837-4	30.09.2010	21:58	72°0.331'	14°43.568'	1257	Heat Flow
MSM16/837-5	30.09.2010	22:26	72°0.316'	14°43.59'	1258	Heat Flow
MSM16/837-6	30.09.2010	22:49	72°0.302'	14°43.574'	1258	Heat Flow
MSM16/837-7	30.09.2010	23:22	72°0.283'	14°43.598'	1259	Heat Flow
MSM16/837-8	30.09.2010	23:48	72°0.278'	14°43.661'	1261	Heat Flow
MSM16/837-9	01.10.2010	00:22	72°0.238'	14°43.78'	1259	Heat Flow
MSM16/837-10	01.10.2010	00:54	72°0.196'	14°43.896'	1258	Heat Flow
MSM16/837-11	01.10.2010	01:29	72°0.148'	14°44.015'	1260	Heat Flow
MSM16/837-12	01.10.2010	02:30	72°0.302'	14°44.202'	1258	Heat Flow
MSM16/837-13	01.10.2010	03:01	72°0.279'	14°44.014'	1259	Heat Flow
MSM16/837-14	01.10.2010	03:23	72°0.275'	14°43.901'	1259	Heat Flow
MSM16/837-15	01.10.2010	03:46	72°0.269'	14°43.734'	1259	Heat Flow
MSM16/837-16	01.10.2010	04:03	72°0.289'	14°43.664'	1259	Heat Flow
MSM16/837-17	01.10.2010	04:26	72°0.282'	14°43.476'	1259	Heat Flow
MSM16/837-18	01.10.2010	04:49	72°0.241'	14°43.409'	1259	Heat Flow
MSM16/838-1	01.10.2010	09:13	72°0.288'	14°43.569'	1259	Multicorer
MSM16/839-1	01.10.2010	11:44	72°0.313'	14°43.579'	1260	TV-Multicorer
MSM16/840-1	01.10.2010	14:58	72°0.244'	14°43.620'	1259	Bottom lander
MSM16/841-1	01.10.2010	17:17	72°0.313'	14°43.611'	1261	TV-Multicorer

Station	Date (UTC)	Time (UTC)	PositionLat N	PositionLon E	Depth [m]	Gear
MSM16/842-1	01.10.2010	20:49	72° 0.40'	14° 42.47'	1269	AUV
MSM16/843-1	01.10.2010	23:41	72°0.183'	14°42.673'	1264	Heat Flow
MSM16/843-2	02.10.2010	00:22	72°0.196'	14°42.911'		Heat Flow
MSM16/843-3	02.10.2010	00:55	72°0.216'	14°43.102'	1256	Heat Flow
MSM16/843-4	02.10.2010	01:28	72°0.223'	14°43.28'	1259	Heat Flow
MSM16/843-5	02.10.2010	01:53	72°0.214'	14°43.41'	1259	Heat Flow
MSM16/843-6	02.10.2010	02:16	72°0.228'	14°43.574'	1259	Heat Flow
MSM16/843-7	02.10.2010	02:41	72°0.192'	14°43.33'	1258	Heat Flow
MSM16/843-8	02.10.2010	03:04	72°0.17'	14°43.302'	1256	Heat Flow
MSM16/843-9	02.10.2010	03:28	72°0.169'	14°43.244'		Heat Flow
MSM16/843-10	02.10.2010	03:48	72°0.134'	14°43.206'	1256	Heat Flow
MSM16/844-1	02.10.2010	06:08	72° 0.39'	14° 43.64'	1257	ROV
MSM16/845-1	02.10.2010	12:02	72° 0.24'	14° 43.25'	1258	Multicorer
MSM16/846-1	02.10.2010	14:37	72°0.163'	14°43.951'	1260	Multicorer
MSM16/847-1	02.10.2010	16:29	72°0.25'	14°43.621'	1260	Multicorer
MSM16/848-1	02.10.2010	20:45	72°0.316'	14°43.588'	1259	Bottom lander
MSM16/849-1	02.10.2010	22:01	72°0.272'	14°43.574'	1260	Heat Flow
MSM16/849-2	02.10.2010	22:27	72°0.254'	14°43.518'	1260	Heat Flow
MSM16/849-3	02.10.2010	22:49	72°0.254'	14°43.616'	1260	Heat Flow
MSM16/849-4	02.10.2010	23:11	72°0.238'	14°43.676'	1255	Heat Flow
MSM16/849-5	02.10.2010	23:32	72°0.235'	14°43.62'	1259	Heat Flow
MSM16/849-6	02.10.2010	23:55	72°0.226'	14°43.504'	1260	Heat Flow
MSM16/849-7	03.10.2010	00:18	72°0.213'	14°43.607'	1260	Heat Flow
MSM16/849-8	03.10.2010	00:42	72°0.204'	14°43.727'	1260	Heat Flow
MSM16/849-9	03.10.2010	01:06	72°0.187'	14°43.612'	1260	Heat Flow
MSM16/849-10	03.10.2010	01:29	72°0.18'	14°43.502'	1256	Heat Flow
MSM16/849-11	03.10.2010	01:54	72°0.16'	14°43.613'	1260	Heat Flow
MSM16/849-12	03.10.2010	02:19	72°0.171'	14°43.808'	1255	Heat Flow
MSM16/849-13	03.10.2010	02:41	72°0.144'	14°43.861'	1255	Heat Flow
MSM16/849-14	03.10.2010	03:07	72°0.105'	14°43.928'	1260	Heat Flow
MSM16/849-15	03.10.2010	03:32	72°0.094'	14°43.633'	1260	Heat Flow
MSM16/849-16	03.10.2010	03:53	72°0.069'	14°43.502'	1255	Heat Flow
MSM16/849-17	03.10.2010	04:16	72°0.129'	14°43.615'	1255	Heat Flow
MSM16/849-18	03.10.2010	04:36	72°0.133'	14°43.501'	1263	Heat Flow
MSM16/850-1	03.10.2010	07:59			1263	OBS
MSM16/851-1	03.10.2010	12:00	72° 0.13' N	14° 43.59' E	1260	ROV
MSM16/852-1	03.10.2010	16:31	72° 0.24'	14° 43.68'	1260	AUV
MSM16/853-1	03.10.2010	23:04	72°0.393'	14°44.824'	1257	Bottom lander
MSM16/854-1	04.10.2010	00:58	72°0.043'	14°43.491'	1255	Heat Flow
MSM16/854-2	04.10.2010	01:34	72°0.104'	14°43.568'	1255	Heat Flow
MSM16/854-3	04.10.2010	04:11	72°0.152'	14°43.597'	1261	Heat Flow
MSM16/854-4	04.10.2010	04:32	72°0.162'	14°43.412'	1257	Heat Flow
MSM16/854-5	04.10.2010	05:00	72°0.196'	14°43.215'	1261	Heat Flow
MSM16/854-6	04.10.2010	05:22	72°0.252'	14°43.256'	1260	Heat Flow
MSM16/854-7	04.10.2010	05:40	72°0.278'	14°43.349'	1260	Heat Flow
MSM16/854-8	04.10.2010	06:11	72°0.305'	14°43.47'	1260	Heat Flow
MSM16/854-9	04.10.2010	06:42	72°0.313'	14°43.589'	1259	Heat Flow
MSM16/854-10	04.10.2010	07:28	72°0.28'	14°43.78'	1260	Heat Flow
MSM16/854-11	04.10.2010	07:54	72°0.264'	14°43.824'	1261	Heat Flow
MSM16/854-12	04.10.2010	08:18	72°0.243'	14°43.888'	1257	Heat Flow
MSM16/854-13	04.10.2010	08:36	72°0.242'	14°43.797'	1261	Heat Flow
MSM16/854-14	04.10.2010	09:12	72°0.358'	14°43.621'	1260	Heat Flow
MSM16/854-15	04.10.2010	09:42	72°0.396'	14°43.878'	1259	Heat Flow
MSM16/854-16	04.10.2010	10:12	72°0.458'	14°44.009'	1262	Heat Flow
MSM16/854-17	04.10.2010	11:13	72°0.313'	14°43.583'	1260	Heat Flow
MSM16/854-18	05.10.2010	07:10	72°0.296'N	14°43.763'E	1260	Head Flow
MSM16/855-1	04.10.2010	13:01	72°0.242'	14°43.788'	1261	TV-Multicorer
MSM16/856-1	04.10.2010	14:59	72°0.31'	14°43.561'	1263	TV-Multicorer
MSM16/857-1	04.10.2010	16:52	72°0.179'	14°43.217'	1271	TV-Multicorer
MSM16/858-1	04.10.2010	18:11	72°0.168'	14°43.205'	1267	TV-Multicorer
MSM16/859-1	04.10.2010	14:09	72° 0.32'	14° 43.61'	1273	Parasound
MSM16/860-1	05.10.2010	08:37	72° 0.13'	14° 43.71'	1266	AUV

Station	Date (UTC)	Time (UTC)	PositionLat N	PositionLon E	Depth [m]	Gear
MSM16/861-1	05.10.2010	11:29	72° 0.26'	14° 43.60'	1267	CTD/rosette
MSM16/862-1	05.10.2010	17:36	72°0.167'	14°43.202'	1272	TV-Multicorer
MSM16/863-1	05.10.2010	18:53	72°0.157'	14°43.952'	1271	TV-Multicorer
MSM16/864-1	05.10.2010	20:13	72°0.285'	14°43.188'	1267	TV-Multicorer
MSM16/865-1	05.10.2010	20:42	72° 0.27'	14° 43.21'	1268	Parasound
MSM16/866-1	06.10.2010	07:48	72° 0.27'	14° 43.60'	1264	TV-Multicorer

Institutes

AWI
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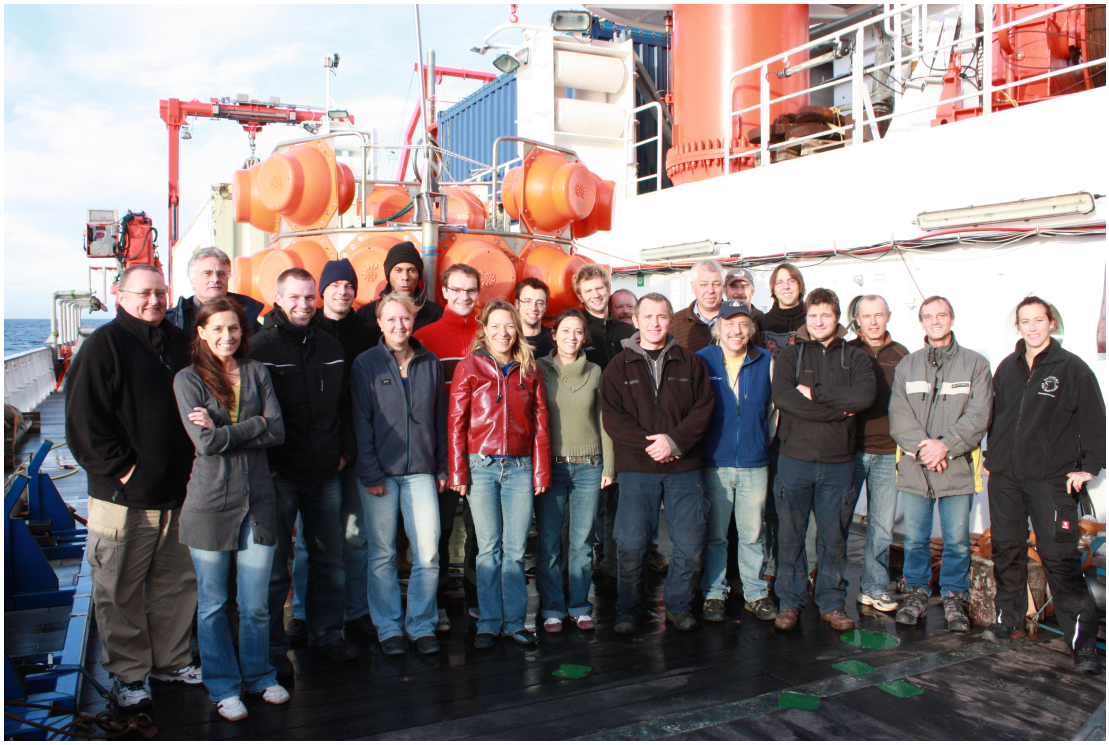
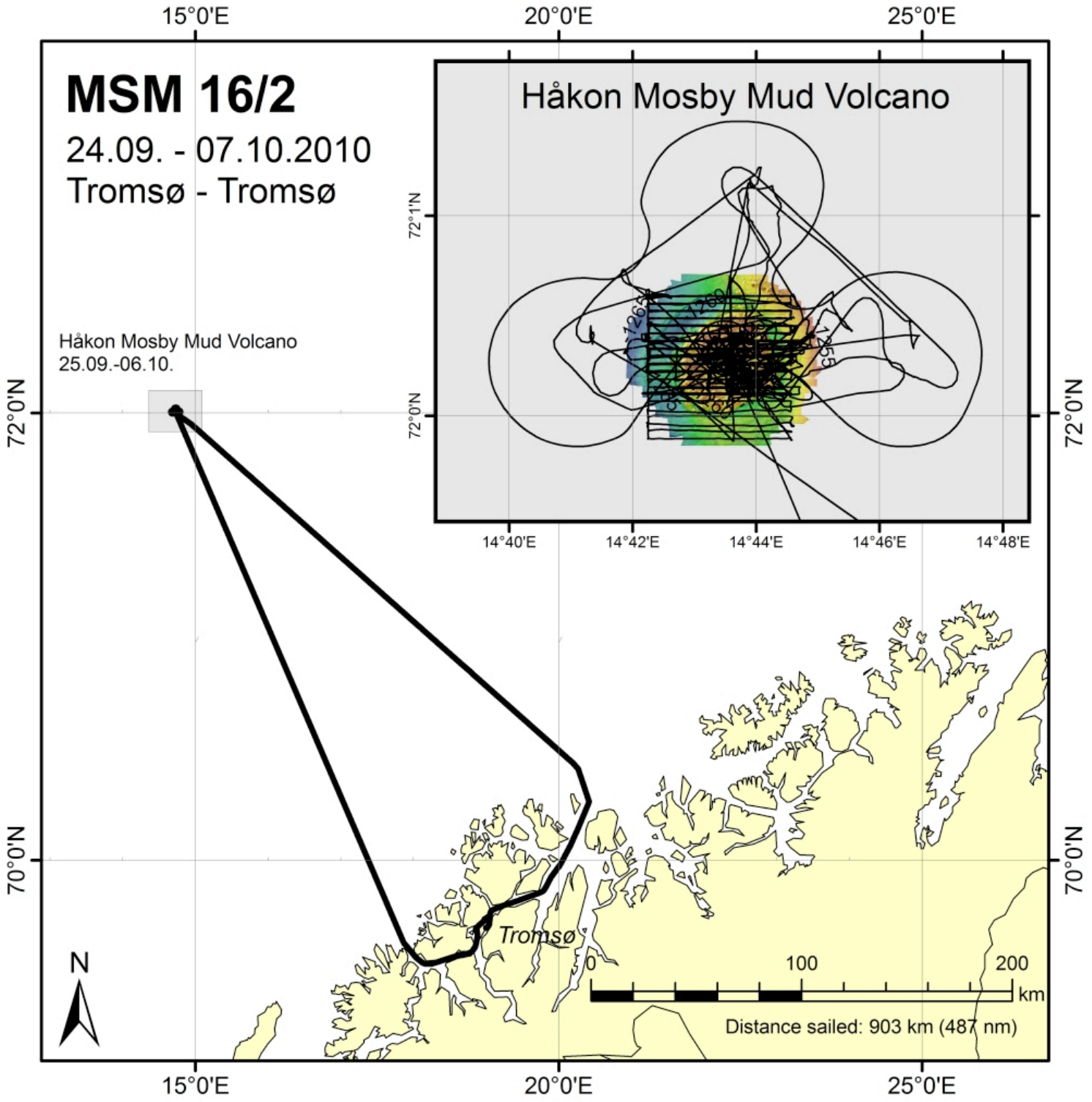
List of participants

1.	Antje Boetius	Chief Scientist	AWI
2.	Dirk De Beer	In situ biogeochemistry	MPI
3.	Janine Felden	In situ biogeochemistry	MPI
4.	Marc Viehweger	LOOME recovery	MPI
5.	Volker Asendorf	Lift, Coring	MPI
6.	Erika Weiz	Biogeochemistry	MPI
7.	Rafael Stiens	Biogeochemistry	MPI
8.	Gabriele Eicken	Biogeochemistry/Microsensors	MPI
9.	Gero Wetzel	Heat flux	IfM GEOMAR
10.	Francois Harmegnies	T lance recovery	IFREMER
11.	Loic Dussud	Camera recovery	IFREMER
12.	Benedicte Ferré	OBS	UTromsø
13.	Jelle Van Campenhout	Benthos biology	UGhent
14.	Sebastian Albrecht	Mapping, Data management	Fielax
15.	Chris German	AUV Sentry team leader	WHOI
16.	Rich Camilli	In situ mass spectrometry	WHOI
17.	Andy Billings	AUV Mechanical engineer	WHOI
18.	James Kinsey	AUV Programming	WHOI
19.	Al Duester	AUV Electrical engineer	WHOI
20.	Dana Yoerger	AUV Mission planning	WHOI
21.	Wim Versteeg	ROV team	UGent
22.	Jeroen Vercruysse	ROV team	UGent
23.	Koen De Rycker	ROV team	UGent

The MSM16/2 team




MSM 16/2
24.09. - 07.10.2010
Tromsø - Tromsø
Håkon Mosby Mud Volcano
25.09.-06.10.
Håkon Mosby Mud Volcano
72°1'N
72°0'N
14°40'E
14°42'E
14°44'E
14°46'E
14°48'E
15°0'E
20°0'E
25°0'E
72°0'N
70°0'N
Tromsø
N
0
100
200
km
Distance sailed: 903 km (487 nm)