Short Report POSEIDON Cruise 434

4D- observation of hydro-dynamical, chemical, and biological properties and its influence on cold-water coral growth in the Stjernsund, Norway

Bergen – Tromsø - Kiel
25. May – 14 . June 2012

Cruise lead
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I. Objectives

POSEIDON cruise 434 lead to one of the northernmost European cold-water coral reefs to investigate the environmental boundary conditions of recent cold-water coral ecosystem functioning (growth and distribution pattern). Our work was directed to the Stjernsund, a passage in south of Hammerfest, Norway.
Overarching objective was to investigate for the first time potential reef effects and feedbacks of cold-water coral reefs and the ambient water masses in a 4D-observation mode employing a novel long-term observatory for meso-scale (~5 km x 3 km) investigations. Thus, this study will add complete new and important aspects to the understanding of factors controlling cold-water coral growth and occurrences in N- Atlantic waters.

Key questions to be addressed are:

- Which boundary conditions: hydro-dynamical (internal waves, tides), biochemical (nutrient pulses, respiration gradients, daily O_2-regime)and geo-morphological led to the emplacement of the reef in relation to the regional oceanographic and biochemical settings. How are these conditions mirrored by the recent facies distribution on the meso-scale?
- Can we deduce hydro-dynamical, and –biochemical conditions which would lead to an active migration and/or expansion of coral reefs to the North in relation to global change?
  How is the small scale hydro-dynamical and biochemical regime influenced by the reef ecosystem and vice versa?
- How is the biological activity of the ecosystem related to changes in the abiotic and biogeochemical environment, such as diurnal and spatial activity pattern of reef megafauna, nekton, and community oxygen consumption?
- What is the impact of tidally influenced mixing processes on the distribution of nutrients, dissolved oxygen, and how are these processes translated into carbonate skeleton of the corals?
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The study area is an ideal test bed to address these objectives since the Stjernsund reef is characterized by healthy living corals and rich associated fauna while the oceanographic setting is limited to a NW-SE trending passage with dominating flow from the NW. Additionally, the reef displays all structures/zones which are known for this type of ecosystem such as normal sund/fjord trough sediments, coral rubble, as well as living and dead corals. The MoLab observatory array measures physical, biogeochemical, and hydro-chemical parameters in 4D resolution.
So far our current knowledge of cold water coral ecology was mainly based on single point measurements at the sediment-water interface whereas the MoLab approach provides an enormously improved resolution of the associated dynamics of the ecosystem in time and space.
During cruise POSEIDON 434 we deployed the MoLab observatory which measures timely synchronized physical, chemical, and biogeochemical parameters for a period of 105 days. Afterwards the MoLab observatory array will be retrieved in September 2012 (POSEIDON Cruise 438). MoLab will enable us for the very first time to investigate interconnected processes on various scales in a true 4D approach. This technology is new to the German oceanographic research community and was used, for the first time, on this cruise.

The comprehensive data set will then be used as the basis for various types of numerical models which improve our understanding of oceanographic-biological interaction. The combination of high quality data sets and numerical models will further facilitate our knowledge of future coral reef development under prognosticated global change in Arctic environments.

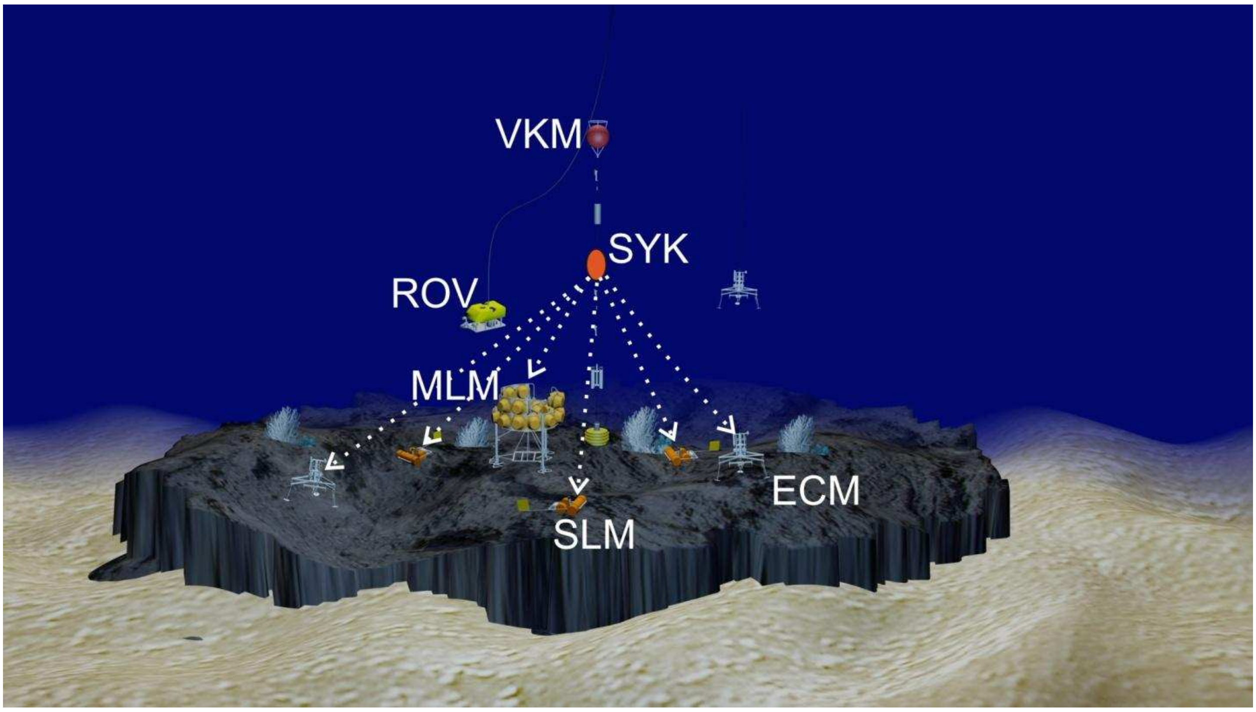

Figure 1: Schematic view of the MoLab Observatory deployed on an idealized carbonate mound. The basis configuration of MoLab array contains: a Master Lander (MLM), three smaller Satellite Landers (SLM), three Eddy Correlation Modules (ECM) and two oceanographic moorings of 500 m length (VKM). The dotted lines indicate the acoustic linkages to the master clock (time synchronization of sensors).

The MoLab observatory comprises of the following components and sensors:

<u>2x Moorings (VKM and VKM+SYK) equipped with:</u>

- temperature/salinity logger
- dissolved oxygen sensor
- ADCP
- optical turbidity logger
- chlorophyll

One VKM is equipped with a synchronization HAM-knot (SYK) which allows timely synchronized measurements.

<u>1x Master Lander (MLM) equipped with:</u>

- ADCP (300 kHz)
- ADCP (1200 kHz)
- CTD
- 4 dissolved oxygen sensor
- sediment trap
- digital time lapse camera system
- pH sensor

- chlorophyll
- turbidity

3x Satellite Lander (SLM) equipped with:

- ADCP
- CTD
- fluorometer
- optical turbidity logger
- dissolved oxygen sensor
- pH sensor
- chlorophyll
- turbidity

3x Eddy Correlation Module (ECM):

- eddy flux sensor

The new work-class ROV "PHOCA" was employed for site surveys (habitat and facies mapping), sampling and deployment/re-arrangement of instruments and modules (Fig. 2).

Figure 2: ROV "PHOCA" carrying an Eddy Correlation Module on the front porch ready for deployment.

II. Area of investigation

The study site was located in the Stjernsund in the Finmark Region (North Norway, Fig. 3).

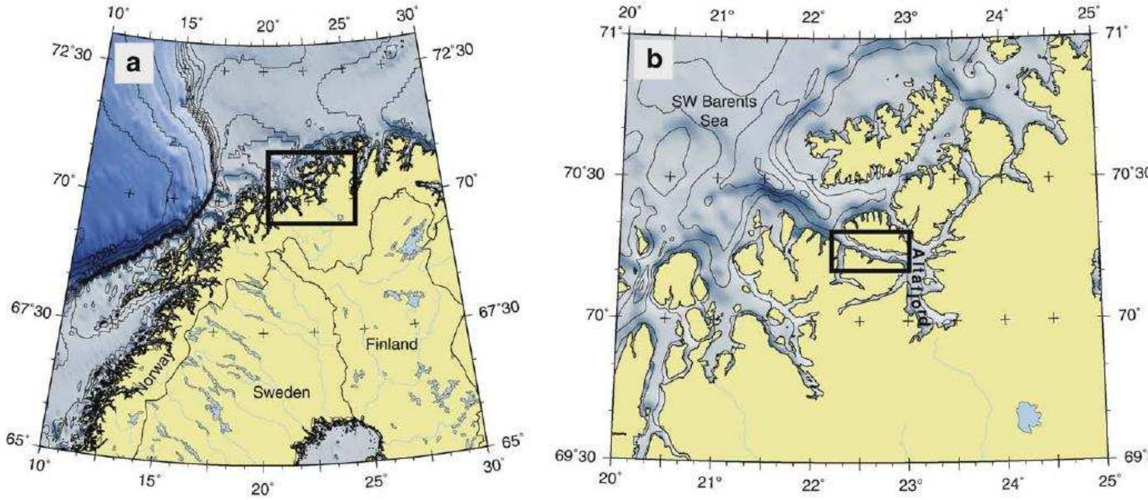

Figure 3: a) The Finmark district of northern Norway with b) the study site of the Stjernsund (box).

The Stjernsund is a NW-SE trending passage between the Norwegian Sea (Lopphavet) and the Altafjord. The passage is limited to the North by the island Stjernøya and the Norwegian mainland to the South. The working area is arranged by a rectangle following the shape of the Stjernsund (Fig. 4). The length of the sund is approximately 10 nm which implied only short steaming distances between individual stations. The center of activity was located in the middle of the passage at the reef structure which divides the sund into two basins. Maximum depths of the basins are 500 m. The deployment area of the MoLab observatory w stretched about 3 nm x 2 nm with the sill/reef in the center. The main reef is NNE-SSW oriented and located about 25 m below the sill crest at about 225 m water depth.

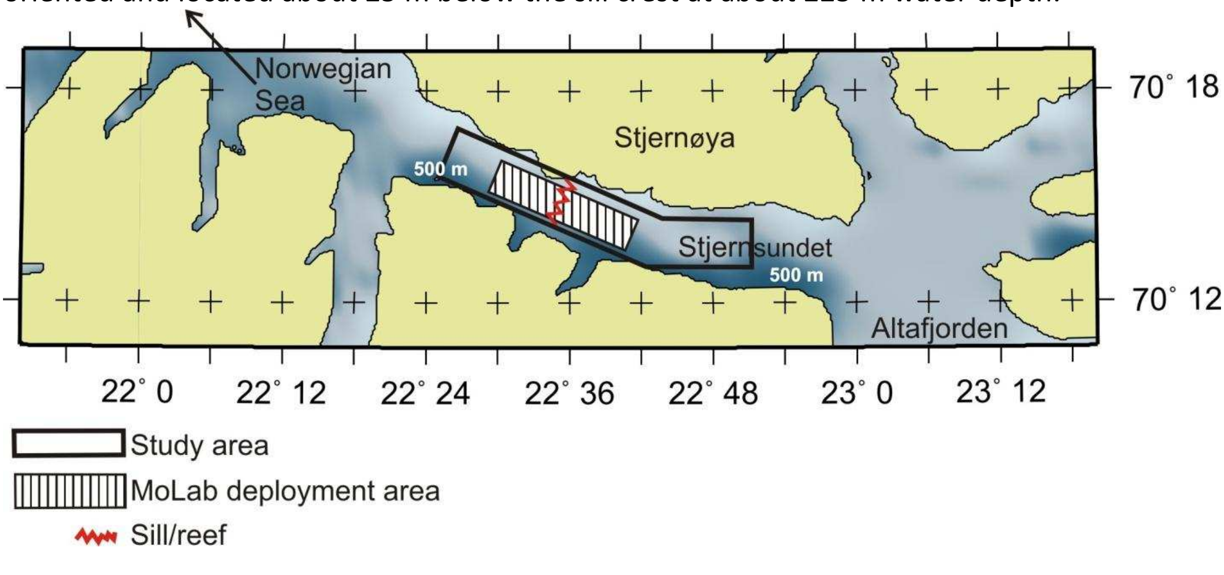

Figure 4: The Stjernsund with the study area.

III. Participants

Name	First Name	Task	Institution
Pfannkuche	Olaf	Chief Scientist	GEOMAR
Cherednichenko	Sergiy	Engineer (Electr.)	GEOMAR
Cuno	Patrick	Technician (ROV)	GEOMAR
Flögel	Sascha	Scientist	GEOMAR
Hennke	Jan	Technician (ROV)	GEOMAR
Meier	Arne	Technician (ROV)	GEOMAR
Linke	Peter	Scientist	GEOMAR
Petersen	Asmus	Technician	GEOMAR
Pieper	Martin	Engineer (ROV)	GEOMAR
Schott	Thorsten	Technician	Oktopus
Vega	Maria	Engineer (Electr.)	Develogic

IV. Participating Institutions

Devologic: develogic GmbH, Eiffestrasse 598, 20537 Hamburg, Germany.

GEOMAR: Helmholtz-Zentrum für Meeresforschung, Wischhofstr. 1-3, 24148 Kiel, Germany.

Oktopus: OKTOPUS GmbH, Wischhofstraße 1-3, 24148 Kiel, Germany.

V. Narrative of the cruise

Friday, 25.05.2012: The scientific party embarked R/V POSEIDON in the morning at Bergen Norway. Due to the disembarkation/re-embarkation of a ferry on the same wharf the loading of the scientific equipment and the installation of the ROV PHOCA system was delayed and could only start in the afternoon. While most of the equipment was unloaded from the trucks on the pier, we started with the installation of the PHOCA winch with the help of a mobile crane- Two metal plates were mounted on the after deck and the winch was placed on the plates to measure the right angle to pay out the wire through a special block on the a-frame. Before final installation four container locks were welded on the bottom plate to fasten the winch in the right angle position. With the help of the crane the launch and recovery system (LARS) was attached to the A-Frame and finally the ROV control container was placed on the deck.

Saturday, 26.05.2012: In the course of the day we completed the loading of the equipment from the pier and started to assemble the MoLab master Lander and other MoLab modules. The ROV team prepared the ROV, winch and control container.

Sunday, 27.05.2012: During the morning we performed a harbor test of the ROV PHOCA in the water. At 13:00h POSEIDON left Bergen and started the transit to our working station in the Stjernsund at 70°16'30''N / 22°26'00''E.

Monday, 28.05.2012: We continued our transit along the Norwegian coast to the working area.

Tuesday, 29.05.2012: We continued our track along the Norwegian coast to the working area.

Wednesday, 30.05.2012: We continued our journey along the Norwegian coast to the working area.

Thursday, 31.05.2012: In the evening we reached our working area in the Stjernsund a passage in between an island and the mainland near Hammerfest. The Stjernsund consists of two basins divided by a morainic sill which is colonized in the crest region by a flourishing cold-water reef ecosystem. Our study area stretched over ca. 3 nm with the sill at its center. We started station work at 20:00h with a CTD/RO cast by 380m NW of the central sill (Stat. 143).

Friday, 01.06.2012: In the course of the morning we deployed a mooring (VKM) with mircro-cats, optodes and a 125 kHz ADCP NW of the central sill by 350m (Stat. 144). A CTD/RO cast followed in two cables distance (Stat. 145). Afterwards we moved to a position SE of the sill where we deployed the second mooring with the same instrumentation as in the first by 350m (Stat. 146). Another CTD/RO cast adjacent to the mooring site followed (Stat. 147).

Saturday, 02.06.2012: Station work started in the morning with a ROV-transect from the outer slope of the sill to the top region (Stat. 148) for photographic and video inspection of potential lander deployment sites. The dive had to be canceled after two hours because of technical problems. We then changed to CTD/RO casting on top of the sill by 223m (Stat. 149). After a short inspection of the sea floor with a video system mounted on our deployment frame for the landers (Stat. 150) we deployed the POZ lander video controlled and geo-referenced by 362m on the NW slope of the sill (Stat. 151).

Sunday, 03.06.2012: The morning was again dedicated to ROV-transecting from the NW-slope basis to the top of the sill (Stat. 152). In the early afternoon we deployed the first SLM-Lander with the video frame on the SE-slope of the sill by 332m (Stat. 153). In the late afternoon and evening another ROV-Transect on the crest of the sill followed (Stat. 154). This dive had to be shortened again because of technical problems with the ROV positioning.

Monday, 04.06.2012: The second SLM lander was deployed on the top region of the sill by 234m in a sponge community (Stat. 155). The rest of the day was spent with the preparation of the large MLM-Lander. The lander was deployed in the evening on the top of the sill inhabited by a mixed coral gorgonarian community (Stat. 156).

Tuesday, 05.06.2012: Our first activity was the deployment of the third SLM-Lander on the SE slope of the sill by 275m (Stat. 157). Afterwards we changed position to the MLM deployment site (Stat. 156) and contacted the lander via an acoustic modem to transfer a picture of the landing site from the time lapse camera integrated into the MLM. The acoustic data transfer could be established and by receiving a color picture depicting a mixed community of white Lophelia corals and large gorgonarians. Later we performed a ROV transect (Stat. 158) from the SLM#1 deployment site to the MLM deployment site and could verify the good positioning both of the SLM and MLM standing about 250m apart. During the evening we made another ROV dive (Stat. 159) to deploy the first of the three ECM. The ECM was successfully placed with the help of the ROV manipulators close to the MLM.

Wednesday, 06.06.2012: In the morning we placed the second ECM with the ROV on the NW slope of the sill (Stat. 160) by 360m adjacent to a SLM-Lander (Stat. 151). In the afternoon the third ECM was successfully placed on a coral community with the ROV (Stat. 161). The ECM site was in ca. 150m distance to the deployment site of the SLM#3 which was also planned to land in a coral community but proofed to stand on coral rubble after the inspection with the ROV. In consequence we picked up the SLM with the ROV manipulators and drove the lander to a suitable position close to the ECM. The ROV dive ended at the MLM deployment site. Afterwards we tried again to establish acoustic modem contact with the MLM but the data strings were crippled so that we could not receive another sea floor photo of the time lapse camera. At 19: 10h we finished scientific research activities and left the Stjernsund steaming towards Tromsö.

Thursday, 07.06.2012: We arrived at the oil pier in Tromsö harbor at 09:00h to take over bunker. Afterwards we hauled to the passenger terminal for provisioning and to stay overnight.
Friday, 08.06.2012: At 09:00 we cast off at Tromsö and started our journey home to Kiel. We steamed through the inner fjord passage and entered the open sea at the mouth of the Vestfjord (Lofot Islands).
Saturday, 09.06.2012: We continued our home passage through the Norwegian Sea.
Sunday, 10.06.2012: We continued our home passage through the Norwegian Sea.
Monday, 11.06.2012: We continued our home transit along the Norwegian West coast
Tuesday, 12.06.2012: We continued our home passage through the Skagerrak
Wednesday, 13.06.2012: We continued our home journey through the Kattegat and Great Belt.
Thursday, 14.06.2012: R/V POSEIDON was moored at the GEOMAR Pier at 09:00h, thus ending its 434th voyage.

VI. Equipment used and gear abbreviations

CTD/RO: CTD/Rosette water sampler
ECM#1: Eddy Correlation Module 1
ECM#2: Eddy Correlation Module 2
ECM#3: Eddy Correlation Module 3
MLM: Master Lander
POZ: POZ Satellite Lander
ROV: Remotely Operated Vehicle
SLM#1: Satellite Lander 1
SLM#2: Satellite Lander 2
SLM#3: Satellite Lander 3
VKM#1-HAM: Oceanographic Mooring with HAM-Node (350m length).
VKM#2: Oceanographic Mooring (350m length)

VII. List of sampling Stations

See over leaf in Table 1.

Table 1: Station List POSEIDON 434

Station	Gear	Date	Time	Coordi	nates 1	Depth	Coordi	nates 2	Depth	Time
POS434		2012	(UTC)	Lat. °N	Long. °E	(m)	Lat. °N	Long. °E	(m)	(UTC)
143	CTD/RO	31.05.	18:41	70° 16,303	22° 25,928	380				
144	VKM#2	01.06.	07:35	70° 16,141	22° 27,290	350				
145	CTD/RO	01.06.	08:26	70° 16,190	22° 26,711	368				
146	VKM#1	01.06.	10:30	70° 15,768	22° 30,081	350				
147	CTD/RO	01.06.	13:56	70° 15,832	22° 29,550	311				
148	ROV-1	02.06.	09:11	70° 16,385	22° 25,980	355	70° 16,321	22° 27,550	355	10:56
149	CTD/RO	02.06.	10:50	70° 16,149	22° 28,518	223				
150	VFR (Test)	02.06.	13:55	70° 16,223	22° 28,570	245				
151	POZ	02.06.	16:57	70° 16,214	22° 26,875	362				
152	ROV-2	03.06.	09:02	70° 16,314	22° 27,734	348	70° 16,062	22° 29,048	247	11:42
153	SLM#3	03.06.	12:38	70° 15,888	22° 29,947	330				
154	ROV-3	03.06.	15:22	70° 15,892	22° 28,338	229	70° 16,144	22° 28,695	213	17;20
155	SLM#2	04.06.	09:45	70° 15,485	22° 28,338	235				
156	MLM	04.06.	16:20	70° 16,086	22° 28,498	215				
157	SLM#1	05.06.	09:01	70° 16,216	22° 28,705	211				
158	ROV-4	05.06.	12:11	70° 15,940	22° 28,543	238	70° 16,510	22° 28,510	13:23	212
159	ECM#1 / ROV-5	05.06,	16:39	70° 16,070	22° 28,515	214				
160	ECM#2 / ROV-6	06.06.	08:34	70° 16,220	22° 26,893	359				
161	ECM#3 / ROV-7	06.06,	13:16	70° 16,222	22° 28,702	211				