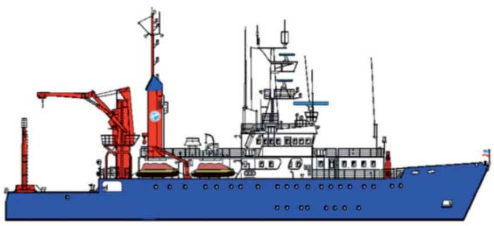
GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

RV POSEIDON

Cruise Report POS455

L O R E L E I



LOphelia **RE**ef **L**ander **E**xpedition and **I**nvestigation

Bremerhaven–(Kristiansund) – Kiel

24.06. – (12.07.) – 17.07.2013

Content

Citation: Form, A. U., Büscher, J., Hissmann, K., Flögel, S., Wisshak, M., Rüggeberg, A., Hennige, S., Bennecke, S., Bannister, R., Schauer, J., and Fenske, M. (2014) RV POSEIDON Cruise Report POS455 LORELEI Lophelia Reef Lander Expedition and Investigation, 29 pp.

1. Scientific crew

Tab. 1 Cruise participants during RV POSEIDON cruise POS455.

Name	Participation	Function	Institute / Affiliation
Form, Armin	24.06. – 17.07.	Chief Scientist	GEOMAR
Büscher, Janina	24.06. – 17.07.	Coral cultivation	GEOMAR
Hissmann, Karen	24.06. – 16.07.	JAGO-team	GEOMAR
Schauer, Jürgen	24.06. – 16.07.	JAGO-team	GEOMAR
Fenske, Martin	24.06. – 16.07.	JAGO-team	GEOMAR
Flögel, Sascha	28.06. – 03.07.	Lander study	GEOMAR
Rüggeberg, Andres	28.06. – 03.07.	Lander study	GEOMAR
Bennecke, Swaantje	03.07. – 16.07.	CTD	GEOMAR
Wisshak, Max	28.06. – 12.07.	Bioerosion studies	Senckenberg am Meer
Hennige, Sebastian	28.06. – 12.07.	Resp. & growth exp.	HWU
Bannister, Raymond	28.06. – 12.07.	Sponge studies	IMR
Hutzler, Aaron	24.06. – 03.07.	Visual observation	Fraunhofer IIS

Chief scientist and contact:

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2. Research Programme

2.1 Short introduction – Research Background

(Form, A.)

As a result of the raising CO_2-emissions and the resultant ocean acidification (decreasing pH and carbonate ion concentration), the impact on marine organism that build their skeletons and protective shells with calcium carbonate (e.g., mollusks, sea urchins, coccolithophorids, and stony corals) becomes more and more detrimental. In the last few years, many experiments with tropical reef building corals have shown, that a lowering of the carbonate ion concentration significantly reduces calcification rates and therefore growth (e.g., Gattuso *et al.* 1999; Langdon *et al.* 2000, 2003; Marubini *et al.* 2001, 2002). In the middle of this century, many tropical coral reefs may well erode faster than they can rebuild.

Cold-water corals are living in an environment (high geographical latitude, cold and deep waters) already close to a critical carbonate ion concentration below calcium carbonate dissolves. Actual projections indicate that about 70% of the currently known *Lophelia* reef structures will be in serious danger until the end of the century (Guinotte *et al.* 2006). Therefore *L. pertusa* was cultured at GEOMAR to determine its long-term response to ocean acidification. Our work has revealed that – unexpectedly and controversially to the majority of warm-water corals – this species is potentially able to cope with elevated concentrations of CO_2. Whereas short-term (1 week) high CO_2 exposure resulted in a decline of calcification by 26-29 % for a pH decrease of 0.1 units and net dissolution of calcium carbonate, *L. pertusa* was capable to acclimate to acidified conditions in long-term (6 months) incubations, leading to slightly enhanced rates of calcification (Form & Riebesell, 2012).But all these studies were carried out in the laboratory under controlled conditions without considering natural variability and ecosystem interactions with the associated fauna. Moreover, only very little is known about the nutrition (food sources and quantity) of cold-water corals in their natural habitat. In a multifactorial laboratory study during BIOACID phase II we could show that food availability is one of the key drivers that promote the capability of these organisms to withstand environmental pressures such as alterations in the carbonate chemistry and temperature (Büscher, Form & Riebesell, in prep.). To take into account the influences of natural fluctuations and interactions (e.g. bioerosion), we aim to merge *in-situ* results with laboratory experimental studies for a comprehensive understanding of likely ecosystem responses under past, present and future environmental conditions.

2.2 Major cruise objectives

The scientific main objectives and methods of the POS455 cruise were:

- Deployment of three mini-landers in close proximity to cold-water coral bioherms (2 x Nordleksa, 1 x Sula Reef) and deployment of artificial substrata and previously weighed and labeled cold-water corals (*Lophelia pertusa*) and associated fauna next to the landers. This was done in order to correlate natural reef bioerosion and growth rates with the geo-physical and hydrodynamic characteristics (e.g. temperature, pH, conductivity, turbidity, etc.) from the three development sites after one year *in-situ* incubation.

- The collection of water samples to characterise the ambient water masses of cold-water coral reef sites with respect to multiple biogeochemical parameters (oxygen, total alkalinity, dissolved inorganic carbonate, nutrients, trace elements and isotopes).

- The sampling of living and dead specimens of *Lophelia pertusa* and associated organisms with the manned submersible JAGO for ongoing laboratory experiments concerning the effects of climate change (ocean acidification and ocean warming) on ecophysiological parameters of the corals (e.g. growth, routine metabolism, fitness) in the framework of the BMBF funded project BIOACID at GEOMAR in Kiel.

3. Narrative of the cruise

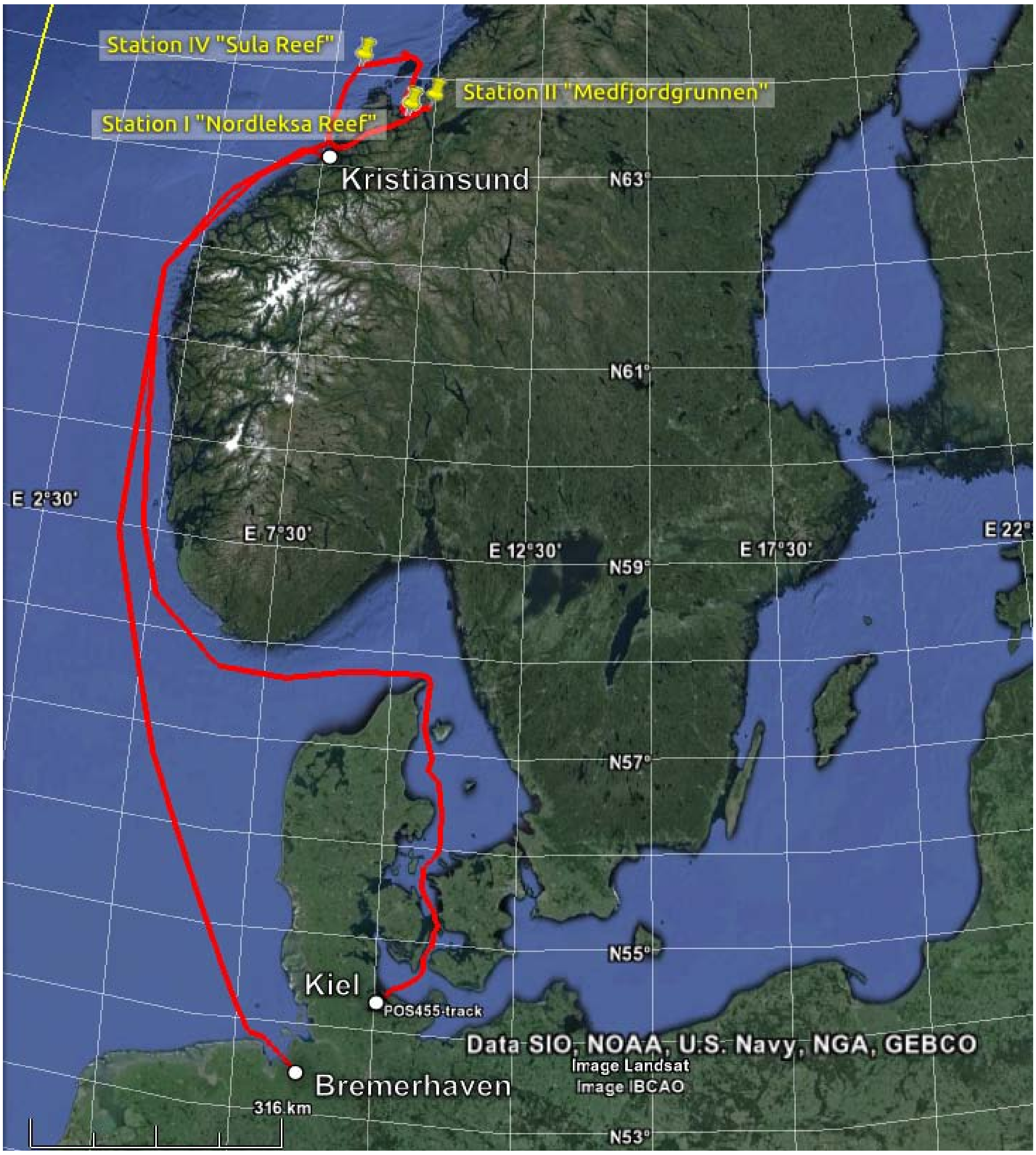

Fig. 1 Cruise track of RV POSEIDON cruise POS455 (red line) and visited stations during scientific work (yellow markers). Station III "Bjugnfjorden" (not shown) was cancelled due to time constraints. Map: Google earth (Version 7.1.2.2041, Mountain View, CA: Google Inc. 2014). High resolution cruise track data as well as complete station list (incl. sub-stations, see Appendix) can be directly accessed with Google earth by importing the following resource file: https://portal.geomar.de/metadata/leg/kmlexport/318842

Note: in the following cruise narrative, station numbers with Roman numerals (I-IV) refer to the main research areas, as requested by the diplomatic application whereas Latin numerals (835-865) refer to the internal continuous station numbering of RV POSEIDON (see Appendix; 1. Stationlist).

24th June 2013

At 1:00 p.m. RV POSEIDON has left port Bremerhaven and headed towards Station I (Nordleksa). Set up scientific equipment for cultivation of *Lophelia pertusa* and associated fauna and for on-board experiments during the transit.

29th June 2013

Arrived at Station I (Nordleksa) at 2:30 a.m.. Three hours seawater pumping with a water pump attached to the CTD frame followed (station 835/1). At 8:00 a.m., embarkation of a Norwegian, Scottish and another German cruise participant (see Tab. 1 for details). After a handling training with the submersible JAGO (station 836/1) the first scientific dive was performed (dive #1, station 836/2). Afterwards, a few CTD casts were conducted.

30th June 2013

At 8:00 a.m. a CTD cast was performed with water sampling through the water column (station 837/2). Afterwards, a JAGO dive was initiated (dive #2, station 837/1) for coral sampling and seeking a suitable reef-site position for the lander deployments. Another JAGO dive for the same objective was conducted in the afternoon at 15:40 p.m. (dive #3, station 838/1).

01st July 2013

At 7:00 a.m. three people from the German TV channel ZDF came aboard for filming purposes. From Brekstad the RV POSEIDON headed towards Station II (Medfjordgrunnen/ Stjørnfjorden; 63°43.10’N, 09°54.30’E). At 8:30 a.m. a JAGO dive was conducted (dive #4, station 839/1). At 13:00 p.m. a rendezvous with partners from the OZEANEUM (Stralsund, Germany) took place for organisms transfer and filming purposes. Afterwards, a CTD cast with bottom water sampling was performed to characterise the water column and for pH sensor calibration of the landers (63°43.133’N, 09°54.287’E; station 840/1). In the afternoon, a JAGO dive (dive #5, station 841/1) was performed together with the divers from the OZEANEUM. In the evening the RV POSEIDON headed back towards Station I (Nordleksa).

02nd July 2013

One Lander and one bioerosion pyramid (see chapter 4.3, *In-situ* experiments) was deployed (63°36.479’N, 09°22.972’E; station 842/1+2). At 10:30 a.m. a JAGO dive (dive #6, station 843/1) was conducted in order to set the released lander and the bioerosion pyramid to their predefined positions in the middle area of the reef saddle. Afterwards, the second lander and bioerosion pyramid was deployed at a position more distant to the reef site (63°36.544’N, 09°22.939’E, station 844/1+2). At 16:00 p.m. divers from the OZEANEUM joint the RV POSEIDON again. A second JAGO dive was conducted together with the OZEANEUM diver team at 16:30 p.m. for photo and video documentation purposes in shallow waters (dive #7, station 845/1). Afterwards at 20:30 p.m., water pumping for three hours was performed to exchange the water in the cultivation tanks and for filling four 1000 L watertanks with fresh seawater from approx. 50 m water depth (station 846/1).

03rd July 2013

At 8:30 a.m. a JAGO dive was conducted to revisit the second lander and bioerosion pyramid deployment position (dive #8, station 847/1). Afterwards, two CTD casts were done at the two different lander deployment positions to sample bottom water (stations 848/1 and 849/1; first lander position 2 and then lander position 1, respectively). In the afternoon (15.00 p.m.) the RV POSEIDON headed towards Brekstad for a partial crew exchange (via Zodiac). At 17.30 p.m. the vessel left the Trondheimsfjorden and headed towards Station IV (Sula Reef).

04th July 2013

At 6:00 a.m. the third bioerosion pyramid and afterwards the third lander was released at 64°06.039'N and 08°07.039'E in the Sula Ridge approximately 50 – 75 m away from living coral areas (stations 850/1 and 850/2). The first dive with JAGO at Station IV was conducted at 8:20 a.m. for coral sampling activities (dive #9, station 850/3). During the dive the deep-water pump (attached to the CTD frame) was downcasted to approx. 50-60 m water depth in order fill four 1000 L water tanks with fresh seawater and to exchange the water in the cultivation tanks onboard (station 850/4). After lunch, again water was pumped for two hours to continue the water exchange and to start filling the vessels seawater tanks. Inbetween the filling, another JAGO dive for sampling (dive #10, station 851/1) was conducted.

05th July 2013

At 8:00 a.m. the CTD was downcasted at the lander deployment position at the Sula Ridge in order to characterise the water column and to take water samples (station 852/1). After the CTD, station work was canceled due to bad weather conditions and the RV POSEIDON headed back to Station I (Nordleksa) in the Trondheimsfjord.

06th July 2013

At 8:40 a.m. a JAGO dive was conducted for limited sampling of living corals and dead erect coral framework (dive #11, station 853/1). The next dive was performed at 14:40 p.m. in order to collect sponges for on-board measurements (dive #12, station 854/1).

07th July 2013

The first JAGO dive at this day started at 8:35 a.m. (dive #13, station 855/1). *In-situ* experiments were deployed at the seafloor next to the first lander position and limited sampling of living coral branches and associated organisms was conducted during the dive. As the weather conditions developed too rough for a second JAGO dive in the afternoon, one CTD cast for water sampling at each of the two lander positions was performed instead (stations 856/1 and 857/1).

08th July 2013

At 8:35 a.m a JAGO dive was conducted to deploy *in-situ* experiments at the second lander position in Nordleksa (dive #14, station 858/1). In the afternoon (15:20 p.m.) another JAGO dive was performed for filming purposes and to deploy an *in-situ* coral behaviour monitoring set up (dive #15, station859/1).

09th July 2013

Due to rough weather conditions, only one JAGO dive was conducted at 16:15 p.m. (dive #16, station 860/1).

10th July 2013

At 8:30 a.m. a JAGO dive was conducted in order to collect sponges for further onboard experiments (dive #17, station 861/1). In the afternoon (15:30 p.m.) another JAGO dive was conducted (dive #18, station 862/1). During the night, the RV POSEIDON headed towards Station IV (Sula Reef).

11th July 2013

The vessel arrived at station during the early morning. Ongoing rough weather conditions prevented a JAGO dive in the morning. Instead, deep water pumping from approximately 80 m water depth to fill the ship's internal aquaria tanks and four 1000 L tanks was done until 15:00 p.m. (station 863/1). At 15:30 p.m. a JAGO dive was performed to sample corals for laboratory experiments (dive #19, station 864/1). Afterwards, a CTD was downcasted (station 865/1) close to the third lander position. At ~ 22:00 p.m. scientific work was finished and the RV POSEIDON headed towards Kristiansund.

12th July 2013

At ~8:00 a.m. the RV POSEIDON docked at the pier in Kristiansund. After customs clearing and declaration of sampled cold-water corals according to CITES regulations, three scientists left the RV POSEIDON (see chapter 1., Tab. 1 for details). At 13:00 p.m. the vessel started heading towards Kiel, Germany.

12th – 17th July 2013

On the 15th July at 20:00 p.m. the RV POSEIDON arrived at the pier at GEOMAR (east shore). After customs clearance on the 16th July, JAGO and scientific equipment was unloaded. On the 17th July, the sampled animals were transferred to the laboratory aquaria at GEOMAR. End of scientific cruise POS455 / LORELEI.

4. Measurements and sampling

4.1 Submersible JAGO activities

(Hissmann, K., Schauer, J., Fenske, M.)

One of the main research equipment used during P455 was the manned submersible JAGO that can take two persons, a pilot and a scientific observer, to water depths of maximum 400 m. The submersible has a compact size and a low weight of 3 tons that enables deployment also from smaller and middle-sized vessels like the FS POSEIDON and a logistically simple transport in a single 20’ ISO container. The vehicle is equipped with USBL navigation and positioning system, fluxgate compass, vertical and horizontal sonar, underwater telephone for communication, digital video (HDV) and still cameras, CTD and a manipulator arm for collecting and handling various sampling devices and instruments.

The submersible has been frequently used for research on cold-water corals during previous cruises (e.g. with RV POSEIDON, RV ALKOR and RV POLARSTERN: POS228/1997, POS253/1999, POS325/2005, AL275/2006, AL290/2008 and PS ARK 22/1a/2007). During POS455 the submersible was mainly used to collect live and dead (neo-fossil) corals for laboratory long-term experiments and for assisting in positioning bottom landers and *in-situ* experiments, and for video documentation.

The submersible container left Kiel on the 06/21/2013 and was transported by truck to Bremerhaven. It was loaded on board the POSEIDON on 06/24/2013. The mobilization of the submersible on board the vessel took place in Bremerhaven while the ship was still in port (installation and testing of the USBL underwater navigation and positioning system, UT-communication, etc). After arrival in the Trondheim Fjord, the usual handling training for launching and recovering JAGO by the ship’s crew were performed on 06/29/2013 in the main working area of Station I ("Nordleksa"). The first scientific dive took place straight after these exercises. Diving operations ended on 07/11/2013 with a final dive at Station IV (“Sula Reef”) offshore of the Trondheim Fjord (see above).

The submersible team consisted of three people: Karen Hissmann (scientific and operational coordination of dives, technical assistance), Jürgen Schauer (submersible pilot and technician) and Martin Fenske (technical support, assistance as swimmer during launching and recovering the submersible (“hookman”)).

Like POS420 in September 2011, the POSEIDON cruise POS455 focussed on the cold-water coral mound “Nordleksa” within the Trondheimfjord and on the Sula Ridge about 80 nm offshore north-west of the fjord entrance. A total of 19 dives were conducted, of which 17 took place within the fjord and two at the Sula Reef where adverse weather conditions prevented further dives. The first dive was used to collect cold-water corals for *in-situ* experiments on natural coral growth to be deployed during the course of the cruise. Also the next two dives at Nordleksa Reef had this purpose. They also served to explore suitable locations for placing bottom landers that were equipped with numerous oceanographic sensors (see next chapter, 4.2).

The Nordleksa Reef, which is growing on a mound that rises from the fjord bottom at 200 m to a depth of 150 m depth was documented during the dives on video and still images. Beside the usual survey cameras inside the submersible, Mini-HD cameras (GoPro Hero 3) were used by the JAGO-Team for the underwater and on deck documentation of the cruise.

Like in 2011, strong tidal bottom currents that were sometimes difficult to predict aggravated some of the submersible dives around the Nordleksa Reef. Currents were much less problematic at the vast Sula Reef offshore at the shelf slope.

All scientific cruise members participated in the submersible dives. Dives took place at bottom depths between 12 and 307 m and lasted for a total of 53 hours (Tab. 2).

Tab. 2 Detailed dive log of JAGO dives during research cruise POS455. JAGO pilot: J. Schauer; All times in UTC.

Dive # / Station #	**Date**	**Location**	**Time** submerged	**Time** surfacing	**Total dive time** (min)	**Touch down position (N/E)**	**Lift off position (N/E)**	**Min-Max Depth** (m)	**Observer**
1	06/29/2013	Trondheimfjord	11:09	13:23	134	N 63°36.46'	N 63°36.46'	157-189	A. Hutzler
836/2		Nordleksa-Reef				E 09°22.76'	E 09°22.76'		
2	06/30/2013	Trondheimfjord	7:38	10:20	162	N 63°36.43'	N 63°36.42'	140-227	S. Flögel
837/1		Nordleksa-Reef				E 09°22.30'	E 09°22.62'		
3	06/30/2013	Trondheimfjord	13:42	16:26	164	N 63°36.49'	N 63°36.50'	154-160	A. Rüggeberg
838/1		Nordleksa-Reef				E 09°22.95'	E 09°23.08'		
4	07/01/2013	Trondheimfjord	7:06	9:05	119	N 63°43.37'	N 63°43.17'	12-178	A. Form
839/1		Medfjordgrunnen				E 09°55.20'	E 09°55.64'		
5	07/01/2013	Trondheimfjord	16:05	17:36	91	N 63°43.23'	N 63°43.23'	20-25	K. Hissmann
841/1		Medfjordgrunnen				E 09°55.62'	E 09°55.63'		
6	07/02/2013	Trondheimfjord	8:39	12:46	247	N 63°36.48'	N 63°36.49'	145-180	M. Wisshak
843/1		Nordleksa-Reef				E 09°22.87'	E 09°23.02'		
7	07/02/2013	Trondheimfjord	15:51	16:40	49	N 63°37.78'	N 63°37.78'	24-28	K. Hissmann
845/1		Seamount north NL				E 09°21.68'	E 09°21.68'		
8	07/03/2013	Trondheimfjord	6:39	9:14	155	N 63°36.54'	N 63°36.54'	205-220	S. Flögel
847/1		Nordleksa-Reef				E 09°22.87'	E 09°22.93'		
9	07/04/2013	Sula-Reef	6:17	8:48	151	N 64°06.62'	N 64°06.60'	285-307	M. Wisshak
850/3		northern part				E 08°07.13'	E 08°07.17'		
10	07/04/2013	Sula-Reef	12:15	15:40	205	N 64°06.65'	N 64°06.69'	283-302	J. Büscher

851/1		northern part				E 08°07.19'	E 08°07.50'		
11	07/06/2013	Trondheimfjord	6:50	9:42	172	N 63°36.67'	N 63°36.79'	220-236	S. Henninge
853/1		Nordleksa northeast				E 09°23.99'	E 09°24.01'		
12	07/06/2013	Trondheimfjord	12:45	15:40	175	N 63°36.34'	N 63°36.44'	140-198	R. Bannister
854/1		Nordleksa-Reef				E 09°22.67'	E 09°22.51'		
13	07/07/2013	Trondheimfjord	6:38	10:05	207	N 63°36.48'	N 63°36.46'	175-200	M. Fenske
855/1		Nordleksa-Reef				E 09°23.09'	E 09°22.88'		
14	07/08/2013	Trondheimfjord	6:41	10:13	212	N 63°36.57'	N 63°36.50'	150-207	S. Bennecke
858/1		Nordleksa-Reef				E 09°23.09'	E 09°23.01'		
15	07/08/2013	Trondheimfjord	13:21	16:48	207	N 63°36.44'	N 63°36.49'	156-186	A. Form
859/1		Nordleksa-Reef				E 09°22.67'	E 09°22.95'		
16	07/09/2013	Trondheimfjord	14:12	17:36	204	N 63°36.34'	N 63°36.48'	183-210	S. Henninge
860/1		Nordleksa-Reef				E 09°22.54'	E 09°22.93'		
17	07/10/2013	Trondheimfjord	6:41	10:36	235	N 63°36.85'	N 63°36.45'	217	R. Bannister
861/1		ridge north NL Reef				E 09°22.75'	E 09°22.66'		
18	07/10/2013	Trondheimfjord	13:41	15:38	117	N 63°36.48'	N 63°36.44'	167-216	S. Bennecke
862/1		Nordleksa-Reef				E 09°22.55'	E 09°22.54'		
19	07/11/2013	Sula-Reef	13:42	16:55	193	N 64°06.61'	N 64°06.58'	284-307	J. Büscher
864/1		northern part				E 08°07.05'	E 08°07.07'		
19 in total		3 sites			3199 (53h)			12 - 307	

4.2 Benthic lander deployments

(Flögel, S., Rüggeberg, A., Wisshak, M.)

Three benthic lander systems were deployed in cold-water coral reefs (Tab. 3) to investigate the environmental boundary conditions of recent cold-water coral ecosystem functioning (growth and distribution pattern). By using these lander systems we can investigate the interconnection of biotic and abiotic processes on various scales in 3D approach for the time span of more than one year. Thus, the major focus point is to significantly advance our current understanding of the feedback mechanisms and processes of this important marine ecosystem to the hydrodynamical, biochemical, geomorphological boundary conditions which led to the settlement of the Nordleksa and Sula reef and to extrapolate conditions which would lead to an active expansion of coral reefs in general. Other goals are to analyze the effect of the reef structure on the local hydrographic and biogeochemical settings and to study the pattern of the ecosystem in relation to diurnal and small sale spatial changes in the hydrodynamic, physical, chemical and biogeochemical environmental parameters**.** A comprehensive multidisciplinary dataset will be produced.

Tab. 3 Overview of the three landers deployed during RV POSEIDON cruise POS455.

Lander	Laying	Recovery	Reef	Lat. (N)	Long. (E)	Depth(m)
1	07/02/2013	08/21-25/2014	Nordleksa, reef sadle	63°36.479'	9°22.972'	175
2	07/02/2013	08/21-25/2014	Nordleksa, off-reef	63°36.544'	9°22.939'	215
3	07/04/2013	08/17-19/2014	Sula Reef	64°06.039'	8°07.039'	300

Station I / Nord-Leksa reef:

We have deployed two Satellite Lander Modules (SLMs) after a sorrow survey with the manned submersible JAGO. One of the SLMs was deployed in the living part of the reef while the other module was deployed in an off-reef setting (Fig. 2) to better distinguish potential prerequisites for cold-water coral growth within the working area. Each module is equipped with a cluster of sensors and programmed to log :

- current speed
- current direction
- CTD (conductivity, temperature, pressure)
- turbidity
- dissolved oxygen
- pH
- chlorophyll fluorescence

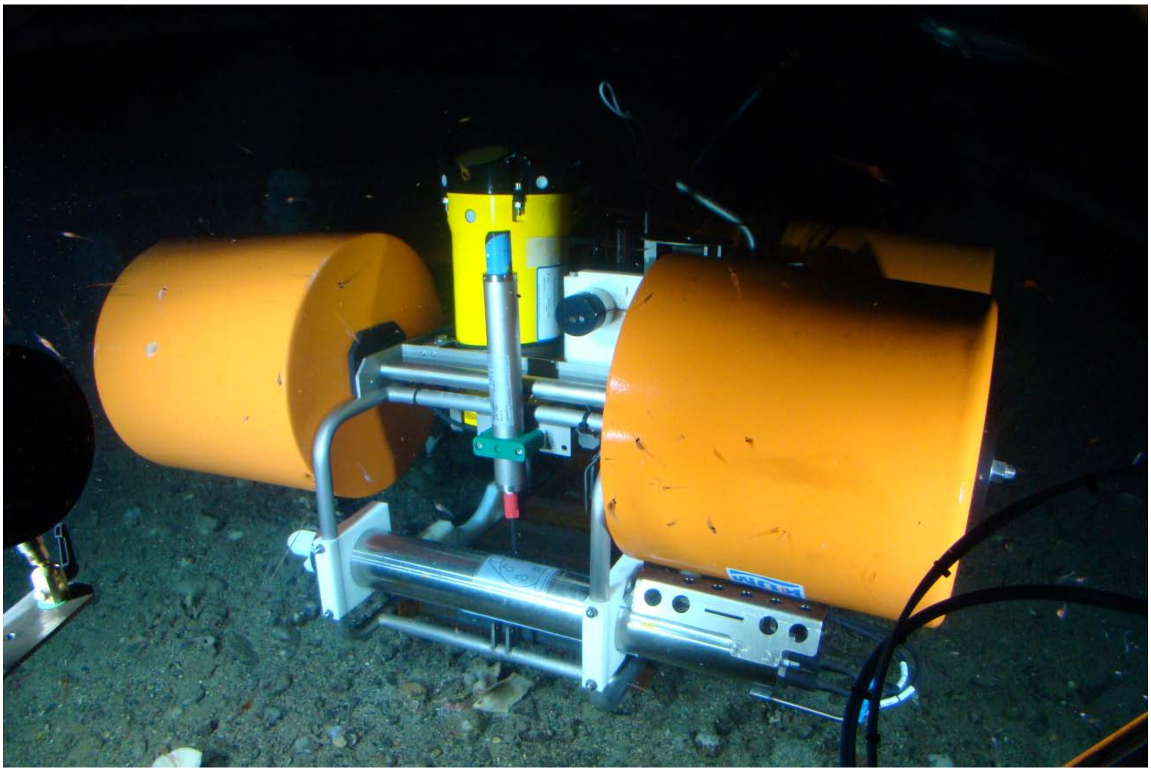

Fig. 2 SLM after deployment in the dead part of the reef, Station I (Nordleksa). The photo was taken from within the manned submersible JAGO (Photo: Sascha Flögel).

Station IV / Sula reef:

The lander at the Sula Reef site is a SENCKENBERG Aanderaa Seaguard RCM mounted in a pyramid-shaped POM frame (Fig. 3) and its sensors are programmed to log:

- current speed
- current direction
- CTD (conductivity, temperature, pressure)

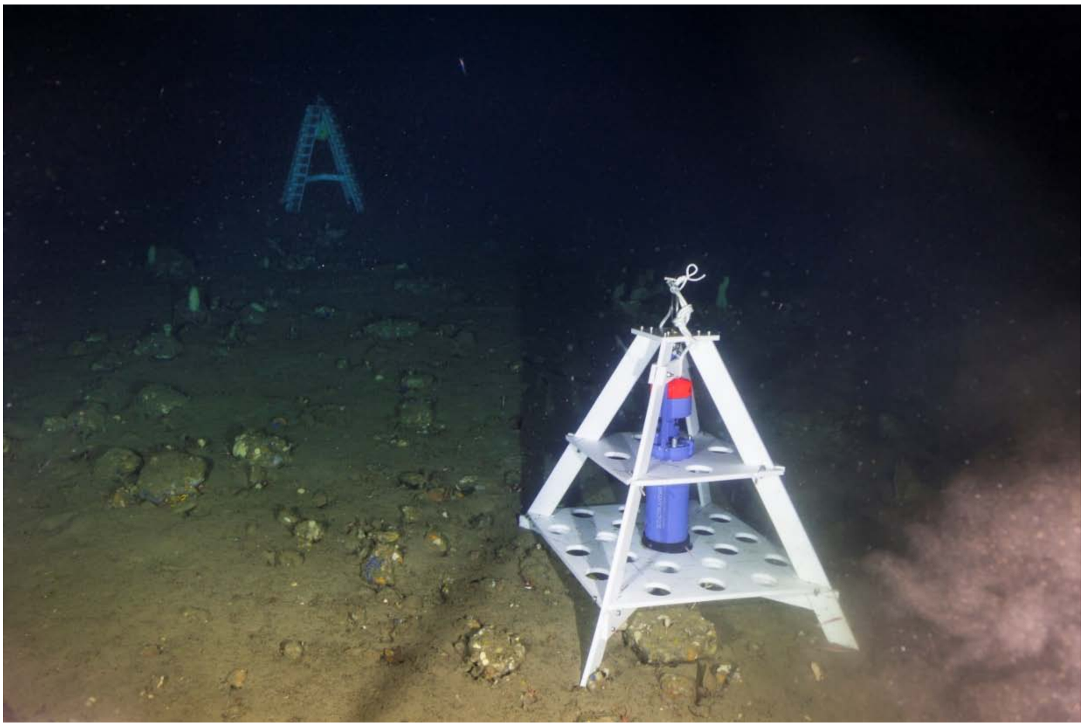

Fig. 3 The Seaguard RCM in a POM frame sitting in 305 m water depth surrounded in few tens of metres by extensive live *Lophelia* reef framework and only few metres from the corresponding *in-situ* settlement experiment visible in the background (Photo: Max Wisshak).

All three benthic landers are intend to recover after more than 12 months in the summer of 2014.

4.3 In-situ *experiments*

Assessment of coral and bivalve growth, substrat colonisation and bioerosionin the field
(Form, A., Wisshak, M., Büscher, J.)

Alongside the three lander positions (see above, Tab.3), small *in-situ* incubation baskets have been deployed (Fig. 5) equipped with few coral (*L. pertusa*) and bivalve (*Acesta excavata*) samples that were collected from the different reef sites and live stained (Fig. 4) prior to the deployment.

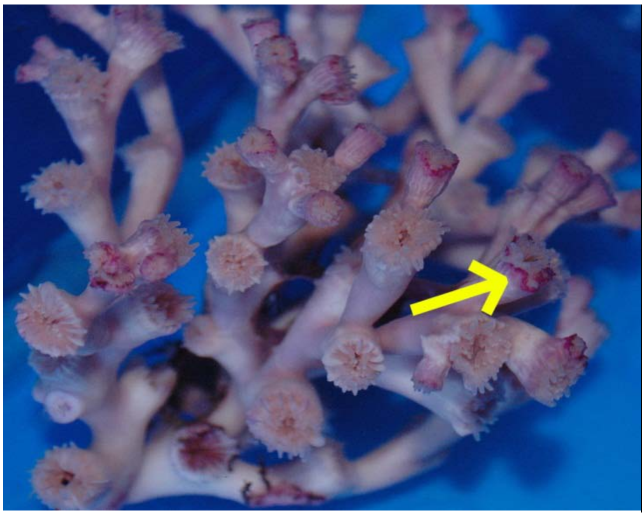

Fig. 4 Branch of a white *L. pertusa* colony after live staining with Alizarin Red S (yellow arrow) (Photo: JAGO team).

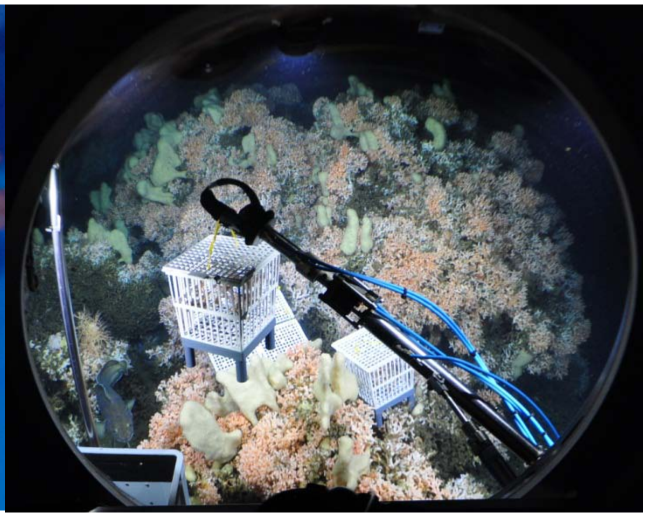

Fig. 5 Deployment of *in-situ* cultivation baskets with the sensitive manipulater arm of the submersible JAGO (Photo: JAGO team).

After recovery of the landers and the *in-situ* experiments during the planned RV POSEIDON cruise POS473 in summer 2014, biological parameters of the samples will be analysed with respect to growth, bioerosion, metabolic activity, and fitness under the different conditions.

Additionally, settlement experiments were deployed at the same three sites in order to investigate the dependency of settlement by calcareous encrusting fauna and the degree of bioerosion of calcareous substrates in relation to current speed and main current direction. The experiments comprise pyramid-shaped POM frames one metre in height, with the four legs being plastered by 7 x 7 cm sized PVC settlement plates and bivalve bioerosion blocks (Fig. 6). The epi-and endolithic fauna to be recorded on the experimental substrates will contribute to the SENCKENBERG database of associated fauna of cold-water corals reefs and will be analysed with respect to similarity among the two different reef sites and among the on and off-mound locations within the Nordleksa Reef structure.

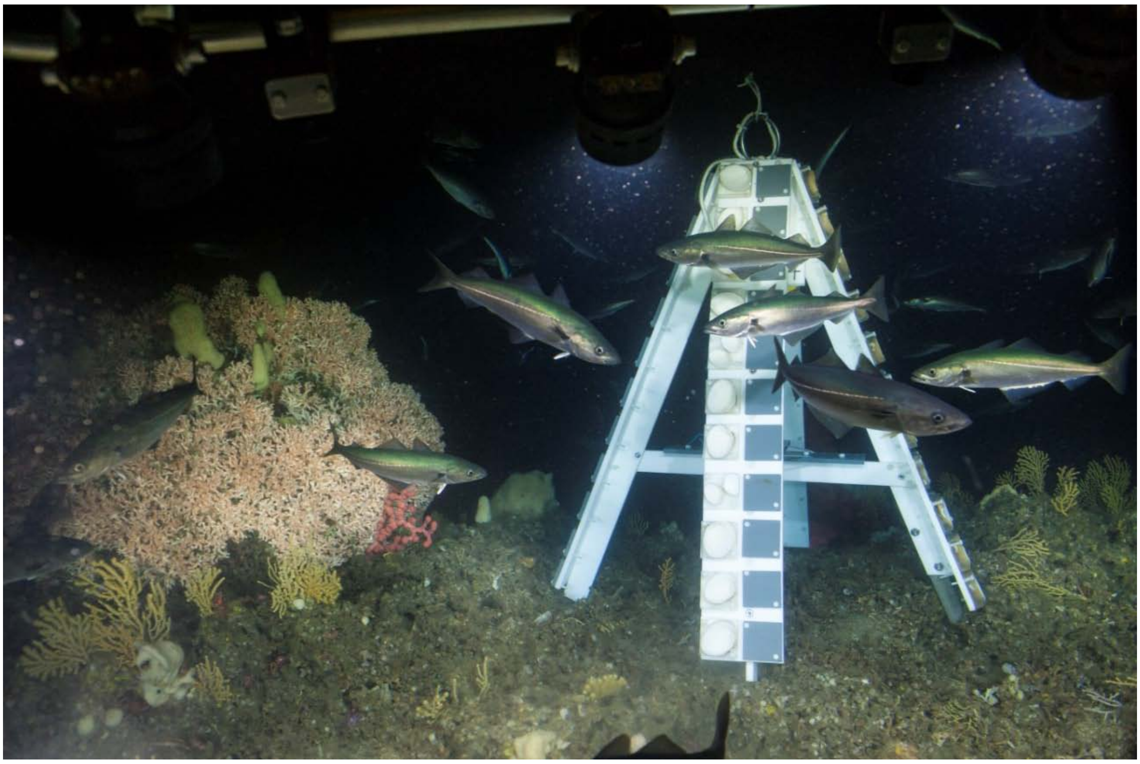

Fig. 6 Settlement experiment, sitting right next to live *Lophelia* framework near the saddle between the two coral reef mounds at the Nordleksa reef site (Station 843/1) in 180 m water depth (Photo: Max Wisshak).

Coral polyp behaviour study in their natural habitat
(Form, A., Schauer, J., Fenske, M.)

Polyp behaviour is an important factor with respect to the polyp's health. The polyps react to changes in water quality or other disturbances immediately and long before complex or time-consuming analysis may point out the possible causes. In scientific studies expansion/contraction behaviour patterns have been extensively examined on tropical shallow-water corals (Kawaguti 1954; Abel 1963; Lewis & Price 1975; Lasker 1979; Brown *et al.* 1994; Levy *et al.* 2001; Levy *et al.* 2006) and sea anemones (Gladfelter 1975; Sebens & Deriemer 1977). Depending on the question and habitat of the examined corals, most of these studies attributed their polyp behaviour patterns to diel cycles of food availability, tidal water currents or solar irradiance. Due to the relatively high technical efforts needed to investigate cold-water corals to date only a few descriptions of their behaviour under laboratory conditions exists (Shelton 1980; Mortensen 2001; Roberts & Anderson 2002).

To investigate the retraction/extension behaviour of cold-water coral *Lophelia pertusa* in their natural habitat, an autonomous video setup (GoPro Hero 3 in a watertight housing) was deployed in front of a living coral colony (Fig. 7) with the submersible JAGO.

Fig. 7 Underwater video camera placed in front of a single *L. pertusa* colony for natural polyp behaviour monitoring in the bottom region of the Nordleksa Reef structures (Photo: JAGO team).

4.4 CTD Measurements and water sampling

(Rüggeberg, A., Flögel, S., Bennecke, S.)

CTD measurements during RV POSEIDON cruise POS455 were performed to determine general water mass characteristics and the influence of physical parameters of water masses bathing living cold-water coral reefs, to control the pumping of deep-water for on-board tank experiments and to keep collected cold-water corals alive for the transit to Kiel, and to calibrate pH-sensors of the lander modules.

The CTD system used is a SeaBird Electronics, model 911 plus type built into a rosette housing capable of holding 12 10-litre water sampler bottles (Niskin-type). Pre-cruise laboratory calibrations of conductivity, temperature and pressure sensors were performed. All parameters yielded coefficients for a linear fit. Additionally, a detector for the fluorescence of Chlorophyll-a and sensors for dissolved oxygen and turbidity were mounted. The CTD system was equipped with two SBE units resulting in double measurements of conductivity, temperature, pressure, and sound velocity for additional control of the quality of measurements.

The overall impression of CTD performance was very positive. The up- and downcast profiles showed virtually no offset. Further processing of the data was performed using software SBE Data Processing©which is part of Seasoft V2 software suite (ftp://ftp.halcyon.com/pub/seabird/out) and Ocean Data View Version 4.5.5

(http://www.odv.awi.de) for visualisation. Table 4 summarizes the manually written log sheets for the individual CTD casts.

Bottom water samples were taken to determine stable isotope characteristics ($\delta^{18}O$, $\delta^{13}C_{DIC}$, δD) and the seawater carbonate chemistry of the waters bathing the coral reefs as well as in predefined intervals within the water column. All samples collected are listed in table 5.

Tab. 4 CTD station details. RV POSEIDON cruise POS455.

CTD	Station	Date	UTC	Lat. (N)	Long. (E)	Depth(m)
01	835/1	06/29/2013	00:33	63°36.85’	9°20.78’	~ 54
02	837/2	06/30/2013	06:35	63°36.57’	9°22.49’	236
03	840/1	07/01/2013	13:08	63°43.13’	9°54.29’	236
04	846/1	07/02/2013	18:52	63°36.41’	9°20.51’	n/a
05	848/1	07/03/2013	10:35	63°36.55’	9°22.96’	216
06	849/1	07/03/2013	11:18	63°36.49’	9°22.96’	175
07	852/1	07/05/2013	04:00	64°06.67’	8°07.25’	300
08	856/1	07/07/2013	14:29	63°36.53’	9°23.02’	194,end 213
09	857/1	07/07/2013	15:15	63°36.44’	9°22.95’	216.6
10	863/1	07/11/2013	08:58	64°06.67’	8°07.13’	n/a
11	865/1	07/11/2013	17:40	64°06.71’	8°06.99’	302

Tab. 5 Water samples collected during RV POSEIDON cruise POS455.

Station	Bottle #	Depth (m)	Temp. (°C)	Sal. (PSU)
837/2	1-2	232	7.82	35.13
	3-4	197	7.79	35.05
	5-6	158	7.77	34.97
	7-8	118	7.70	34.77
	9-10	79	7.63	34.50
	11	59	7.65	34.23
	12	25	8.01	33.27
848/1	1-4	211	7.82	35.13
849/1	1-4	172	7.80	35.07
852/1	1-3	290	7.16	35.10
	4-6	260	7.30	35.20
856/1	1-3	205	7.79	35.03
	4-6	175	7.78	35.01
857/1	1-3	200	7.78	35.02
	4-6	170	7.77	35.00
865/1	1-3	290	7.79	35.26
	4-6	260	7.83	35.27

4.5 Onboard cultivations and experiments

Maintaining the corals on board (Form, A., Büscher, J.)

In a first step all coral branches were carefully transferred from the collecting basket of the JAGO submersible into large buckets filled with fresh and clean seawater. After a period of acclimation the living coral fragments and their accompanying fauna were transferred from the buckets into four 500 litres PVC transportation tanks in the wet laboratory of RV POSEIDON.

Each of the four transportation tanks was equipped with a glass fibre lattice (5 * 5 cm grid size) on the bottom for sample fixation. Small coral fragments were secured with special coral glue on a prepared PVC socket board. Furthermore internal water pumps (equipped with mechanical filters) were installed for water movement. For maintaining a constant water temperature (7.5 ± 1 °C), a closed recirculation between the PVC tanks and cooling aggregates (Aqua Medic, Titan 4000) was established.

Due to biological processes the water was renewed at regular intervals with fresh seawater.

Short-term respiration & hypoxia measurements (Büscher, J., Hennige, S.)

Oxygen consumption rates of freshly collected *Lophelia pertusa* fragments from the Nordleksa reef complex were measured in ten respiration chambers (800 mL volume) using an optode based oxygen analyser (Oxy-10 mini, PreSens GmbH). Each respiration chamber (RC) was implemented in a small plastic aquarium that was filled with natural seawater from ~ 50 m depth. For acclimatisation purposes for the corals and to regulate the temperature in the RCs, all aquaria containing the RCs were connected via tubings with each other (Fig. 8). After closure of the RCs, all coral fragments were measured independently for 12 hours in order to follow the respiration activity in terms of oxygen reduction in a closed system. After measuring the respiration of freshly collected coral fragments under ambient conditions (8°C), temperature was increased quickly (overnight) to 12°C, which represents nearly the upper limit of temperatures where this species still can be found. Afterwards, respiration rates were measured again to gain insight into shock-response mechanisms of *L. pertusa*. Moreover, at the high temperature respiration was not only recorded for the first 12 hours but allowed to decrease from 100 % oxygen saturation to zero. This was done to be able to make assumptions about the respiratory regulation ability of *L. pertusa* for which the entire physiological respiration curve over the complete range of oxygen concentrations needs to be assessed. Every hour during the measurements photographs were taken of all coral replicates in order to record the polyp behaviour (expansion and retraction) over time.

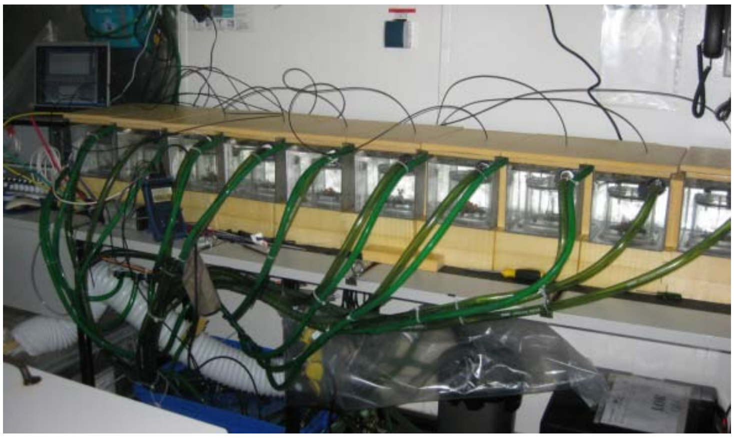

Fig. 8 Experimental setup of short-term oxygen consumption measurements within closed respiration chambers in the wet laboratory of RV POSEIDON (Photo: Janina Büscher).

Coral tissue fusion experiment (Hennige, S., Büscher, J.)

During the last cold-water coral expedition with RV POSEIDON in 2011 (POS420) a naturally fused *Lophelia pertusa* coral of a white and an orange colony was found and collected in the Sula Ridge (Fig. 9). This raised the question if genetically different coral colonies (especially in case of different colour morphs) would fuse and therewith stabilise the reef system further or if they compete for space and hard substratum. Therefore, particular attention was given to the collection of naturally occurring red/white fused samples from different reef locations to confirm the natural incidence and to be sure that it was not just coincidence. Furthermore, artificial fusion experiments were initiated. For this, little *L. pertusa* fragments were glued with special coral glue to prepared bases and positioned so that two different fragments touch each other. By this means, coral fragments of the same colony (autogenic fusion; white-white or orange-orange) as well as coral fragments of different colonies from different reef locations (allogenic fusion; white-white, white-orange) were put together (Fig. 10). Moreover, the same was done with few *Madrepora oculata* fragments. Additional, inter-species fusion samples between *L. pertusa* and *M. oculata* was generated (xenogenic fusion). All samples were prepared on board the ship and were transferred to the aquarium systems at GEOMAR in Kiel to monitor over the subsequent months (up to 1 year planned), if fusion occurs and to what extent tissue or even skeleton might melt together.

Fig. 9 Naturally fused white and orange coral colonies (Photo: Solvin Zankl).

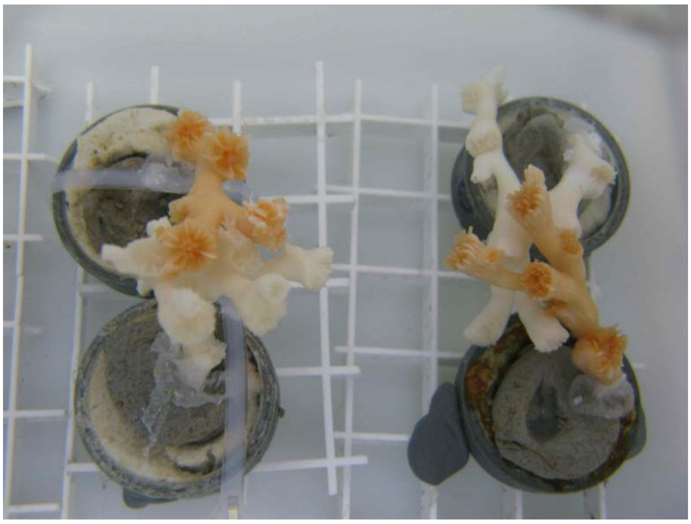

Fig. 10 Fusion experiment (Photo: Sebastian Hennige).

Sponge experiments (Bannister, R.)

We collected 2 main sponge species from cold-water coral reefs at Station I (Nordleksa). These species comprised of *Mycale lingue* and an unknown species. Whilst onboard the vessel experiments to collect feeding samples from both of these species as well as measurements on the pumping activity were conducted. In addition, tissue samples for analysis of length width and height measurements together with volume, wet weight and dry weight were performed. These values will allow for analysis of video data to estimate the biomass and abundance of these species within the coral reef systems. This information will be used for comparisons with Sula reef sponges on next years cruise.

5. Preliminary results

20.12.2012, 24.6-17.7.13, Jnr 12/17918

5.1 Submersible JAGO survey dives in the Trondheim Fjord

(Hissmann, K., Schauer, J., Fenske, M.)

As in 2011 most of the submersible dives during P455 took place at the Nordleksa Reef which rises from about 210 to 145 m water depth. The coral mound has a dimension of about 1700 m in west-to-east and about 600 m in north-to-south direction, with a saddle like depression between the two main reef tops. *Lophelia pertusa* is the most dominant species on the mound, present in both white and orange morphotypes. Large specimens of gorgonians like *Paragorgia* *arborea* and *Primnoa resedaeformis*, as found frequently at other locations within the fjord but also at other reefs along the Norwegian coast, seemed to be less abundant at Nordleksa.

A second elevation in a distance of about 1300 m north-east of the main reef, which has been the target of one dive in 2011, was re-visited once during P455. It is less colonized by living corals. A lot of the coral specimens found at the flanks and on the top of this smaller mound were either dead or appeared less “healthy”. They were covered more frequently with detritus or soft sediment and the single colonies have shorter branches, giving the appearance of a kind of “bonsai” growth pattern, probably caused by suffering from less ideal environmental conditions. The deep living bivalve, *Acesta excavata* or giant file clam is very abundant at the lower parts of this mound, where the bivalve is forming dense aggregations, colonizing almost every niche.

During another dive, a third elevation ca. 1600 m north of the main Nordleksa reef was explored. Also here, the bivalve *Acesta excavata*was present in dense aggregations, and the corals appeared to be in the same less flourishing condition as on the second elevation. Numerous different sponges were collected at this reef.

The Mareano.no map of coral occurrences along the Norwegian coast and in the fjords indicates an isolated coral record within a side branch of the Trondheimsfjord (called Stjørnfjorden) at the base of a ridge named Medfjordgrunnen (63°43.1’N, 09°54.3’E). A single dive at this location, starting at 180 m depth and moving upslope, revealed a soft bottom in the lower part that changed into a gravel slope with some rocky areas at the top of the ridge between 30 and 12 m water depth. No stony corals were found.

One short dive was dedicated to explore the top of a “sea mount” southeast of the small island Kommersoya at 63°37.78’N, 09°21.68’E. The summit was found to be almost bare of life, probably because of the strong tidal currents passing by.

5.2 CTD and other oceanographic data

No profiles compiled yet. A comprehensive description of hydrodynamic characteristics of the examined stations will follow after recovery and data analysis of the lander data incombination with short-term CTD cast data. The whole datasets will be published after cruise 2014 and made publicly accessible.

Continously recorded data from the ship’s onboard measurements systems (thermosalinograph, weather conditions,single beam, etc.) can be already downloaded from Werum’s DSHIP measurement data management system hosted at GEOMAR:
http://dship.geomar.de/poseidon/index.htm

6. Acknowledgements

The scientific party of RV POSEIDON cruise POS455 gratefully acknowledge the very good cooperation and technical assistance of the captain and his crew who substantially contributed to the overall success of this expedition.

We deeply acknowledge work permissions granted by the coastal state Norway.

Additionally, we appreciate the MAREANO project for the access to detailed bathymetric maps, which were very helpful to plan and conduct the dives with the manned submersible JAGO.

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Appendix

1. Stationlist

Tab. A1 RV POSEIDON logbook entries of main events during research cruise POS455.

Station POS455	**Date**	**Time (UTC)**	**Gear**	**Logbook entry / action**	**Latitude (N)**	**Longitude (E)**	**Depth (m)**
835/1	06/29/2013	1:04	Water pump	surface	63.61250	9.32983	256
835/1		1:22		at depth, 36m	63.61217	9.32967	259
835/1		1:58		at depth, 54m	63.61050	9.33183	281
835/1		3:07		on deck	63.61267	9.32750	249
836/1		10:10	JAGO	to water	63.61333	9.38500	222
836/1		10:22		on deck	63.61383	9.38300	223
836/2		11:06	JAGO	to water	63.60683	9.38000	200
836/2		13:33		on deck	63.60850	9.37967	170
837/2	06/30/2013	6:21	CTD / rosette	surface	63.60883	9.37500	234
837/2		6:37		at depth, 236m	63.60950	9.37467	238
837/2		6:54		on deck	63.60917	9.37367	242
837/1		7:33	JAGO	to water	63.60733	9.37717	142
837/1		10:29		on deck	63.60683	9.37100	241
838/1		13:38	JAGO	to water	63.60717	9.37900	175
838/1		16:38		on deck	63.60850	9.38000	178
839/1	07/01/2013	7:01	JAGO	to water	63.72183	9.91950	140
839/1		9:16		on deck	63.71900	9.92950	59
840/1		12:57	CTD / rosette	surface	63.71883	9.90483	236
840/1		13:07		at depth, 231m	63.71883	9.90467	234
840/1		13:14		on deck	63.71867	9.90517	236
841/1		16:04	JAGO	to water	63.72183	9.92367	111
841/1		17:51		on deck	63.72150	9.92467	97
842/1	07/02/2013	6:30	Lander 1	surface	63.60800	9.38200	181
842/1		7:12		released, 175m	63.60800	9.38267	185
842/2		7:48	*In-situ* exp. platform	surface	63.60800	9.38300	166
842/2		8:07		released, 175m	63.60800	9.38283	x
843/1		8:35	JAGO	to water	63.60733	9.38300	220
843/1		12:56		on deck	63.60733	9.38233	218
844/1		13:20	Lander 2	surface	63.60900	9.38217	214
844/1		13:35		released, 210m	63.60900	9.38217	216
844/2		13:39	*In-situ* exp. platform	surface	63.60900	9.38217	215
844/2		14:06		released, 210m	63.60900	9.38233	215

845/1		15:28	JAGO	to water	63.62933	9.36067	57
845/1		17:49		on deck	63.62750	9.35567	143
846/1		18:38	Water pump	surface	63.60767	9.34033	339
846/1		18:58		at depth, 39m	63.60683	9.34167	351
846/1		19:46		at depth, 57m	63.60600	9.34150	350
846/1		21:24		on deck	63.60167	9.33567	353
847/1	07/03/2013	6:32	JAGO	to water	63.60867	9.38217	190
847/1		9:14		on deck	63.60800	9.38267	170
848/1		10:24	CTD / rosette	surface	63.60900	9.38183	214
848/1		10:34		at depth, 214m	63.60900	9.38167	216
848/1		10:42		on deck	63.60917	9.38183	215
849/1		11:08	CTD / rosette	surface	63.60817	9.38233	176
849/1		11:18		at depth, 173m	63.60817	9.38250	178
849/1		11:25		on deck	63.60817	9.38217	175
850/1	07/04/2013	4:03	*In-situ* exp. platform	surface	64.11067	8.11767	300
850/1		4:34		released, 295m	64.11083	8.11733	300
850/2		4:44	Lander 3	surface	64.11083	8.11750	299
850/2		5:05		released, 290m	64.11083	8.11767	300
850/3		6:18	JAGO	to water	64.11067	8.11783	301
850/4		6:39	Water pump	surface	64.11083	8.11850	300
850/4		6:47		at depth, 37m	64.11067	8.11833	299
850/4		7:18		at depth, 58m	64.11067	8.11800	300
850/4		8:35		on deck	64.11083	8.11833	300
850/3		8:56	JAGO	on deck	64.11117	8.11833	300
850/5		10:25	Water pump	surface	64.11050	8.11867	300
850/5		10:33		at depth, 56m	64.11033	8.11867	300
850/5		11:11		at depth, 80m	64.11067	8.11917	299
850/5		11:59		on deck	64.11050	8.11900	299
851/1		12:11	JAGO	to water	64.11067	8.11883	299
851/2		12:21	Water pump	surface	64.11083	8.11900	299
851/2		12:30		at depth, 77m	64.11117	8.11983	299
851/2		14:57		on deck	64.11083	8.11983	299
851/1		15:57	JAGO	on deck	64.11033	8.12633	296
852/1	07/05/2013	4:07	CTD / rosette	surface	64.11083	8.12033	299
852/1		4:24		at depth, 285m	64.11083	8.12050	298
852/1		4:25		at depth, 290m	64.11083	8.12050	298
852/1		4:28		at depth, 260m	64.11100	8.12000	298
852/1		4:38		on deck	64.11083	8.11983	298

853/1	07/06/2013	6:45	JAGO	to water	63.61067	9.39567	219
853/1		9:55		on deck	63.61217	9.39967	200
854/1		12:43	JAGO	to water	63.60683	9.38217	221
854/1		15:49		on deck	63.60650	9.37683	x
855/1	07/07/2013	6:37	JAGO	to water	63.60767	9.38283	197
855/1		10:16		on deck	63.60783	9.38083	150
856/1		14:29	CTD / rosette	surface	63.60883	9.38383	187
856/1		14:43		at depth, 205m	63.60900	9.38267	214
856/1		14:51		on deck	63.60900	9.38150	206
857/1		15:17	CTD / rosette	surface	63.60717	9.38283	219
857/1		15:33		at depth, 195m	63.60700	9.38217	210
857/1		15:41		on deck	63.60717	9.38333	221
858/1	07/08/2013	6:37	JAGO	to water	63.60950	9.38183	218
858/1		10:19		on deck	63.60883	9.38717	164
859/1		13:21	JAGO	to water	63.60783	9.38100	161
859/1		16:55		on deck	63.60800	9.38417	170
860/1	07/09/2013	14:07	JAGO	to water	63.60833	9.38667	169
860/1		17:44		on deck	63.60733	9.38750	221
861/1	07/10/2013	6:40	JAGO	to water	63.61467	9.37917	242
861/1		10:16		on deck	63.61583	9.38750	219
862/1		13:43	JAGO	to water	63.60767	9.38100	188
862/1		15:47		on deck	63.60733	9.37400	225
863/1	07/11/2013	8:58	Water pump	surface	64.11117	8.11883	299
863/1		9:12		at depth, 78m	64.11167	8.12050	300
863/1		12:24		at depth, 67m	64.11100	8.12167	298
863/1		13:00		on deck	64.10950	8.11583	297
864/1		13:40	JAGO	to water	64.11033	8.11683	302
864/1		17:12		on deck	64.11250	8.10900	305
865/1		17:38	CTD / rosette	surface	64.11167	8.11700	299
865/1		17:38		at depth, 290m	64.11167	8.11700	299
865/1		18:00		on deck	64.11217	8.11567	302

The complete ship's logbook (including all sub-stations, e.g. use of rubber boat, hydrophone for JAGO communications, etc.) as well as logged data from the board instruments can be downloaded from the Data Management Portal for Kiel Marine Sciences hosted at GEOMAR: https://portal.geomar.de/metadata/leg/show/318842

2. Scleractinian cold-water coral samples (CITES reg.)

Tab. A2 Stony cold-water coral samples (*Lophelia pertusa* and *Madrepora oculata*) collected during the RV POSEIDON cruise POS455 with the aid of the manned submarine JAGO.

Species	**Station(s)**	**JAGO Dive #**	**Sample description**	**Estimated size of samples (kg)**
Lophelia pertusa	I (Nordleksa) IV (Sula Reef)	1, 2, 3, 8, 9, 10,11, 13, 16, 19	small branches and colonies of red and white colour variants	34 kg
Madrepora oculata	IV (Sula Reef)	9, 10, 19	small fragments	0.2 kg
				34.2 kg *

* Note: The actual amount of living *L. pertusa*and *M. oculata* was much less because many of the collected fragments consisted of large parts ofneo-fossil dead erect coral framework.