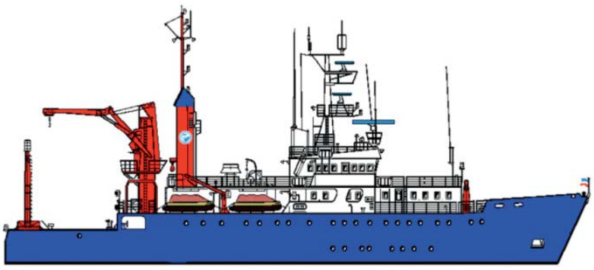
GEOMAR
Helmholtz-Zentrum für Ozeanforschung Kiel

RV POSEIDON

Cruise Report POS473

L O R E L E I II



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

Tromsø – Bergen – Esbjerg

15.08. – 31.08. – 04.09.2014

Content

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1. Scientific crew

Name	Participation	Function	Institute / Affiliation
Form, Armin	15.08. – 04.09.	Chief Scientist	GEOMAR
Büscher, Janina	15.08. – 04.09.	Co-Chief Scientist	GEOMAR
Hissmann, Karen	15.08. – 04.09.	JAGO-Team	GEOMAR
Schauer, Jürgen	15.08. – 04.09.	JAGO-Team	GEOMAR
Fenske, Martin	15.08. – 04.09.	JAGO-Team	GEOMAR
Flögel, Sascha	20.08. – 22.08.	Lander study	GEOMAR
Rüggeberg, Andres	15.08. – 22.08.	Lander study	GEOMAR
Pfannkuche, Olaf	22.08. – 24.08.	Observation	GEOMAR
Bannister, Raymond	22.08. – 31.08.	Sponge study	IMR
Kutti, Tina	22.08. – 31.08.	Sponge study	IMR
Wisshak, Max	15.08. – 31.08.	Bioerosion study	Senckenberg am Meer
Stapp, Laura	15.08. – 04.09.	Physiology	Alfred Wegener Institute
Bennecke, Swaantje	25.08. – 31.08.	CTD	GEOMAR
Küter, Marie	15.08. – 04.09.	Cultivation	GEOMAR
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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 from the two research cruises POS455 and POS473 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 POS473 cruise were:

- Recovery of three mini-landers which were deployed in June 2014 during the RV POSEIDON cruise POS455 in close proximity to cold-water coral bioherms (2 x Nordleksa, 1 x Sula Reef) and recovery of artificial substrata and previously weighed and labeled cold-water corals (*Lophelia pertusa*) next to the landers. With this study we aim 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

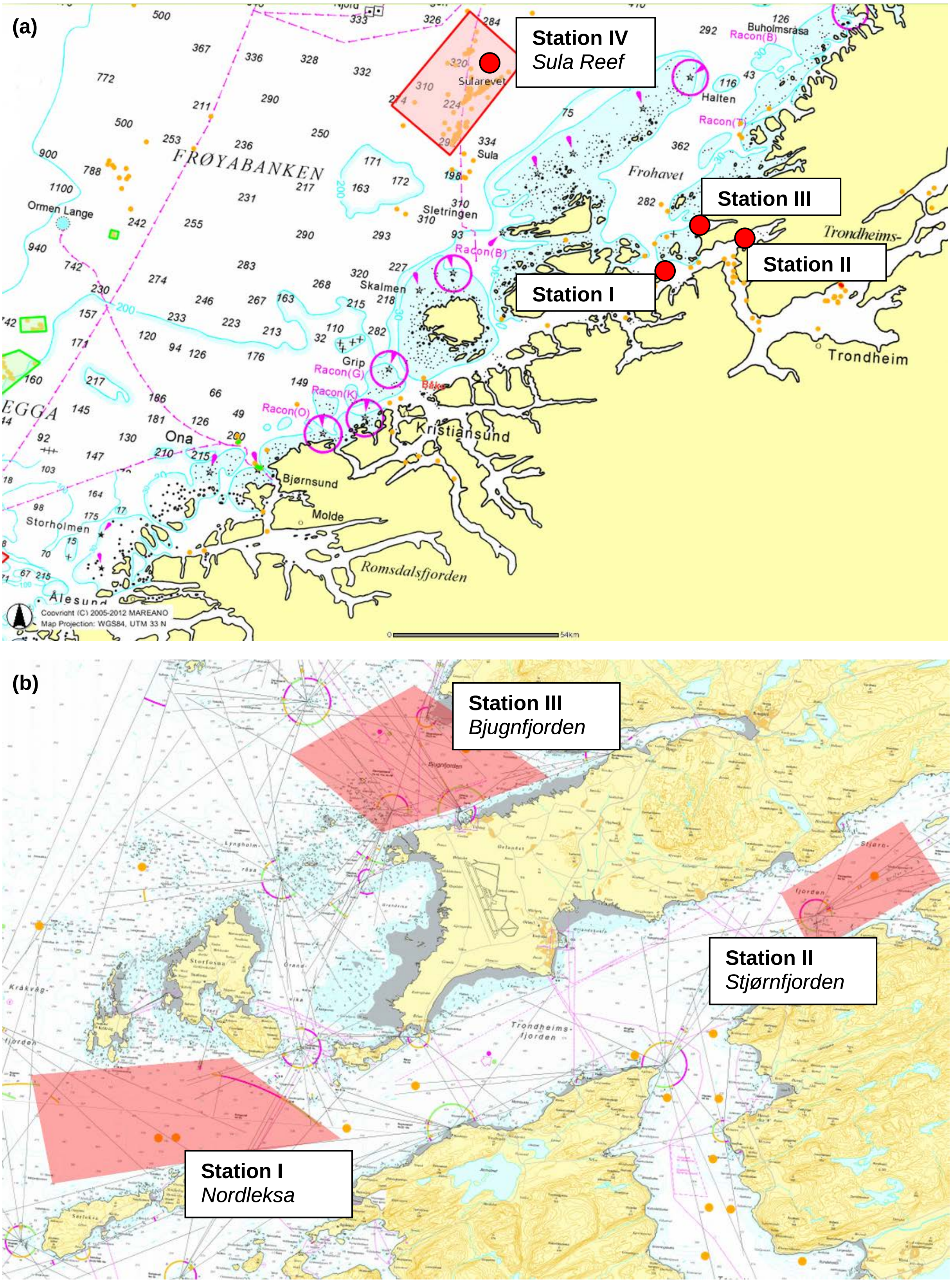

Figure 1 (a) Overview of the stations applied for POS473 including offshore study area (Station IV) and detailed map **(b)** of coastal study areas (Station I-III). Only Station I (Nordleksa Reef) and Station IV (Sula Reef) were visited during the research cruise POS473 with RV POSEIDON in summer 2014.

High resolution cruise track data as well as complete station list (incl. sub-stations, see Appendix) can be directly downloaded from:

https://portal.geomar.de/metadata/cruise/kmlexport/324813

Note: in the following cruise narrative, station numbers with Roman numerals (I, IV) refer to the main study areas (stations, see Fig. 1), as requested by the diplomatic application whereas Latin numerals (885-921) refer to the internal continuous station numbering of RV POSEIDON (see Appendix; 1. Stationlist). All times in local time.

14th August 2014

Loading of scientific equipment and embarkation of the scientific crew (see 1. for details).

15th August 2014

At 9:00 a.m. RV POSEIDON has left port Tromsø and headed towards Station IV (Sula Reef). Set up scientific equipment for cultivation of *Lophelia pertusa* and associated fauna and for on-board experiments.

16th August 2014

Transit to Sula Reef cancelled due to bad weather conditions. Instead, RV POSEIDON headed towards Station I (Nordleksa / 63° 36.48' N, 9° 22.97' E). Continuation of lab preparations.

17th August 2014

Arrived at Station I (Nordleksa) at the early afternoon. At 15:30 p.m. a handling and training manoeuvre with the manned submersible JAGO was performed. Afterwards, seawater was pumped for four hours with a deep-water pump (attached on CTD) in order to fill the cultivation tanks and experimental aquaria onboard the vessel (885-1,-2).

18th August 2014

Nordleksa / 63° 36.48' N, 9° 22.97' E. At 8:00 a.m. a CTD (886-1) for characterising the water column and water sampling was conducted. At around 7:00 a.m. the first JAGO dive (887-1) was performed. During the dive, the *in-situ* experiments (baskets with stained *Lophelia pertusa*) were partly recovered. After a second CTD (888-1) in the early afternoon a second JAGO dive (888-2) took place to further recover the *in-situ* experiments. In the evening, RV POSEIDON headed towards sheltered waters inside the fjord to allow the scientists precise weighing measurements of the recovered samples.

19th August 2014

Nordleksa / 63° 36.54' N, 9° 22.94' E. At 8:00 a.m. a CTD (889-1) was downcasted. Afterwards, JAGO was applied (890-1) to continue the recovery of the *in-situ* experiments. A second CTD was conducted at 14.00 p.m. (891-1) followed by another JAGO dive (892-1) at around 16:00 p.m.. Seawater was pumped (892-2) to refresh the water in the cultivation tanks while JAGO was submerged. After JAGO was back on board, RV POSEIDON headed towards Brekstad.

20th August 2014

Brekstad, 8:00 a.m.. Partial crew exchange via POSEIDON rescue boat (see 1. for details). Afterwards, heading back to Station I / 63° 36.54' N, 9° 22.94' E. At around 11:00 a.m. three people (GEOMAR media team) came aboard for filming purposes as daily visitors via motor boat. After lunch, a JAGO dive (893-1) was conducted to visually search for the small bottom lander (see 4.1, Submersible JAGO). After JAGO was back on board the first bottom lander was recovered (894-1) by RV POSEIDON after it was acoustically released from the bottom. In the evening, RV POSEIDON headed inwards the fjord for another weighing session of the recovered *in-situ* experiments in sheltered waters.

21st August 2014

Nordleksa / 63° 36.54' N, 9° 22.94' E. At 8:00 a.m. the GEOMAR media team came aboard as daily visitors (see above). At 8:30 a.m. a JAGO dive was conducted (895-1) to visually search for the second bottom lander and to collect live and dead corals and associated organisms. After JAGO was back on board the second bottom lander was recovered (896-1) by RV POSEIDON after it was acoustically released from the bottom. In the afternoon, two JAGO dives were performed to document JAGO activities (897-1) in the field and to further collect coral samples and to record a video transect over the reef top (898-1).

22nd August 2014

Brekstad, 8:00 a.m.. Partial crew exchange via POSEIDON rescue boat (see 1. for details). Afterwards, heading back to Nordleksa / 63°36.54'N, 9°22.94'E. At around 10:00 a.m. the GEOMAR media team came aboard as daily visitors (see above). At 10:30 a.m. a JAGO dive was conducted (899-1) for the collection of live *Lophelia* corals for genetic analyses and in order to record a video transect along the reef. Another JAGO dive in the afternoon was applied (900-1) in order to collect live sponges for our Norwegian colleagues and their studies.

23rd August 2014

At 8:00 a.m. the GEOMAR media team came aboard as daily visitors (see above). At 8:30 a.m. a JAGO dive was conducted (901-1) in order to collect live sponges for our Norwegian colleagues and their studies. A second JAGO dive was conducted at 16:00 p.m. (902-1) to collect live *Lophelia* corals for genetic analyses and live sponges for our Norwegian colleagues.

24th August 2014

At 9:00 a.m. the GEOMAR media team came aboard as daily visitors (see above). At 10:30 a.m. a JAGO dive was conducted (903-1) in order to record a video transect along the top of the reef and to further collect live sponges. After JAGO was back on board, RV POSEIDON headed to Brekstad for a partial crew exchange (see 1. for details) via POSEIDON rescue boat. Afterwards, RV POSEIDON headed back to Nordleksa / 63° 36.49' N, 9° 22.93' E for another JAGO dive (904-1). During this dive, live *Lophelia* corals for genetic and physiological analyses were sampled and a time lapse camera was recoverd, which was placed in front of a coral colony three days before. Seawater was pumped (905-1) to refresh the water in the cultivation tanks while JAGO was submerged.

25th August 2014

Nordleksa / 63° 36.54' N, 9° 22.94' E. At around 8:00 a.m. it was continued to pump seawater (906-1) into the cultivation and water storage tanks for about two hours. Meanwhile, at 9:00 a.m. the GEOMAR media team came aboard as daily visitors (see above). At 11:00 a.m. a JAGO dive was conducted (907-1) for final sampling of live corals, sponges and other associated organisms at the Nordleksa reef site. In the afternoon, at 16:00 p.m., a short surface dive of JAGO took place (908-1) for media purposes. After JAGO was back on board the GEOMAR media team finally leaves the RV POSEIDON and the vessel headed towards station IV (Sula Reef).

26th August 2014

Sula Reef / 64° 06.63' N, 8° 07.05' E. At 8:30 a.m. a first JAGO dive (909-1) at the new location was conducted for the deployment of the time lapse camera and the recovery of the *in-situ* experiments deployed in 2013. Afterwards, a CTD (910-1) for characterising the water column and water sampling was conducted. At 16:30 p.m. a second JAGO dive (911-1) took place in order to collect live *Lophelia* corals and bivalves for laboratory experiments and genetic analyses.

27th August 2014

At 9:00 a.m. a JAGO dive (912-1) was conducted for the recovery of the time lapse camera and the recovery of the third bottom lander deployed in 2013. In the afternoon at 16:00 p.m. another JAGO dive was performed (913-1) for the sampling of live *Lophelia* corals for laboratory experiments and genetic analyses. Seawater was pumped (914-1) to refresh the water in the cultivation tanks while JAGO was submerged.

28th August 2014

Sula Reef / 64° 04.95' N, 8° 01.95' E. At 8:00 a.m. a CTD (915-1) for characterising the water column above the top of the reef and water sampling was conducted. At 9:00 a.m. a JAGO dive (916-1) was conducted in order to collect live sponges for our Norwegian colleagues and their studies. For the same reason another JAGO dive was conducted at 16:00 p.m. (918-1) after a CTD downcast in the early afternoon (917-1). In the evening, seawater was pumped with the deep-water pump in order to renew the water in all cultivation and storage tanks completely (919-1).

29th August 2014

At 9:00 a.m. the final JAGO dive (920-1) was conducted. During this dive, a video transect along the top of the reef structures was recorded and live coral colonies were collected for laboratory experiments. At 14:00 p.m. a CTD was downcasted. Afterwards, the scientific part of the cruise was finished and the RV POSEIDON started heading towards Bergen.

30th August 2014

During the transit, some onboard measurements continued.

31st August – 2nd September 2014

At 9:06 a.m. the RV POSEIDON docked at the pier in Bergen. Our two Norwegian colleagues and two other scientists left the vessel (see 1. for details) after customs clearance. Declaration of sampled cold-water corals with the customs according to CITES regulations. Leaving Bergen on 2nd of September at 9:00 a.m. and heading towards Esbjerg.

2nd – 4th September 2014

Transfer towards Esbjerg / DK and packing. End of scientific cruise POS473 / LORELEI II after docking at the pier in Esbjerk / DK on 4th September at 9:30 a.m. and customs clearance / declaration of cold-water coral samples according to CITES.

4. Measurements and sampling

4.1 Submersible JAGO

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

One of the main research equipment used during POS473 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 (HD) and still cameras, CTD and a manipulator arm for collecting and handling various sampling devices, *in-situ* experiments 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, POS391/2009, POS420/2011, POS455/2013, AL275/2006, AL290/2008 and PS ARK 22/1a/2007). During POS473 the submersible was mainly used for recovering *in-situ* experiments that were placed into the reef a year before, for video documentation and for collecting live and fossil corals, bivalves and sponges for long-term experiments in the laboratory.

The submersible container left Kiel on the 25th of July 2014 and was shipped to Tromsø, North Norway, where it was transferred on board the RV POSEIDON on the 14th of August 2014. The mobilization of the submersible on board the vessel took place while the vessel was still in port in Tromsø (installation and testing of the USBL underwater navigation and positioning system, UT-communication, etc).
After the transit to mid Norway and arrival in the Trondheim Fjord, the usual handling training for launching and recovering JAGO by the ship’s crew were performed on the 17th of August in the main working area "Nordleksa". The first scientific dive took place the day after. Diving operations ended on 29th of August with a final dive at the Sula Reef offshore of the Trondheim Fjord. The submersible container was offloaded from FS POSEIDON on the 4th of September in the port of Esbjerg / Denmark and was trucked back to Kiel on the same day.

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 and POS455 in 2013, the POSEIDON cruise POS473 mainly focussed on the cold-water coral mound “Nordleksa” within the Trondheim fjord and on the larger Sula Reef about 80 nm offshore north-west of the fjord entrance. A total of 23 dives were conducted, of which 16 took place within the fjord and 7 at Sula. The relatively high number of dives for a total of only 12 working days on site reflects the overall very favourable weather conditions in both working areas during the operation period. To avoid difficulties for manoeuvring the submersible in strong bottom currents caused by the tides, the dives were timed with the periods of daily tidal low and high stands.

The first dives at Nordleksa Reef were used to re-locate and recover *in-situ* experiments that were placed into the reef a year before during POS455. The plastic baskets contained either live colour-stained *Lophelia* corals, dead coral rubble or live reef-associated bivalves of the species *Acesta excavata.* The experiments should provide information on growth rates of corals and clams in their natural environment and on bioerosion rates. With one exception, all baskets were found, re-collected and brought back on board. Surprisingly, non of the baskets were found at the same spot where they had been placed one year before. This shows that the bottom currents steered by the tides must be very strong at times.

The two bottom landers that were stationed next to the bioerosion experiments at the Nordleksa Reef could not be re-located by JAGO. Within one year, they were obviously moved by the bottom current for at least 100-200 m, as their surfacing position indicated after they were acoustically released from the bottom.

Also the coral and *Acesta* baskets, the bioerosion experiments and the lander that were placed a year before offshore at the Sula Reef were relocated and recovered with JAGO. They were found at the same location where they had been deployed one year before. Bottom currents are much weaker outside of the fjord.

After all experiments were recovered, the submersible was again used to selectively collect live specimens of stony and soft corals and *Acesta* bivalves for further laboratory experiments. Numerous sponges of different species were collected for the Norwegian cruise participants. It was a challenge to collect the extremely fragile reef-associated sponges with as little damages as possible so that they could be used for laboratory experiments on their filtration rates. The sensitive claw of the submersible’s manipulator arm once again proved to be an excellent tool for this task.

To record the 24 hrs activities of individual polyps within a single colony *in-situ*, a autonomous camera especially designed for this experiment by the JAGO-Team was placed with JAGO in front of a *Lophelia* colony. The camera was recovered after one day. The images provided an excellent sequence for analysing activity patterns.

The Nordleksa Reef, which is growing on a mound that rises from the fjord bottomat 200 m to a depth of 150 m depth, and the Sula reef were again video- and still-documented for biodiversity and ecosystem studies.

All scientific cruise members participated in the submersible dives. Dives took place at bottom depths between 140 and 306 m and lasted for a total of 66 hours (see Table 1). The scientific objectives of the dives were achieved at 100 %. All corals that were collected with JAGO were still in very good condition at the end of the cruise and transferred alive to aquaria in Kiel.

The cooperation between the captain of the vessel, its crew and the JAGO-Team during launching and recovery of the submersible from on board the POSEIDON was as excellent and professional as usual. In average it took less than 10 minutes from surfacing, recovering and securing the submersible on deck.

Table 1 Detailed dive log of JAGO dives during RV POSEIDON cruise POS473. JAGO pilot: Jürgen 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 / 887	8/18/2014	Trondheimfjord Nordleksa-Reef	07:02	10:53	231	no USBL	no USBL	143-221	Max Wisshak
2 / 889	8/18/2014	Trondheimfjord Nordleksa-Reef	13:42	16:19	157	N 63°36.47' E 09°23.03'	N 63°36.43' E 09°22.91'	172-221	Andres Rüggeberg
3 / 890	8/19/2014	Trondheimfjord Nordleksa-Reef	06:41	10:36	235	N 63°36.56' E 09°22.84'	N 63°36.54' E 09°22.95'	212-222	Laura Stapp
4 / 892	8/19/2014	Trondheimfjord Nordleksa-Reef	14:13	16:52	159	N 63°36.52' E 09°23.04'	N 63°36.58' E 09°23.00'	160-220	Janina Büscher
5 / 893	8/20/2014	Trondheimfjord Nordleksa-Reef	10:51	14:29	218	N 63°36.48' E 09°22.98'	N 63°36.41' E 09°22.95'	158-222	Sascha Flögel
6 / 895	8/21/2014	Trondheimfjord Nordleksa-Reef	06:37	09:04	147	N 63°36.46' E 09°23.06'	N 63°36.44' E 09°22.98'	200-225	Andres Rüggeberg
7 / 897	8/21/2014	Trondheimfjord Nordleksa-Reef	11:40	12:20	40	no USBL	no USBL	10	Karen Hissmann
8 / 898	8/21/2014	Trondheimfjord Nordleksa-Reef	14:17	17:38	201	N 63°36.43' E 09°22.98'	N 63°36.46' E 09°22.87'	170-222	Sascha Flögel
9 / 899	8/22/2014	Trondheimfjord Nordleksa-Reef	07:43	10:59	196	N 63°36.54' E 09°22.78'	N 63°36.48' E 09°22.81'	141-210	Olaf Pfannkuche
10 / 900	8/22/2014	Trondheimfjord Nordleksa-Reef	13:37	16:56	199	N 63°36.39' E 09°22.55'	N 63°36.35' E 09°22.66'	142-208	Tina Kutti
11 / 901	8/23/2014	Trondheimfjord Nordleksa-Reef	06:38	10:15	217	N 63°36.52' E 09°23.06'	N 63°36.49' E 09°23.12'	149-187	Raymond Bannister

12 / 902	8/23/2014	Trondheimfjord Nordleksa-Reef	14:12	16:50	158	N 63°36.43' E 09°22.72'	N 63°36.42' E 09°22.69'	150-174	Marie Küter
13 / 903	8/24/2014	Trondheimfjord Nordleksa-Reef	08:40	11:47	187	N 63°36.57' E 09°23.09'	N 63°36.42' E 09°22.55'	140-206	Swaantje Bennecke
14 / 904	8/24/2014	Trondheimfjord Nordleksa-Reef	15:25	17:35	130	N 63°36.41' E 09°22.69'	N 63°36.49' E 09°22.91'	154-180	Armin Form
15 / 907	8/25/2014	Trondheimfjord Nordleksa-Reef	09:10	11:52	162	N 63°36.44' E 09°22.67'	N 63°36.49' E 09°22.95'	162-220	Laura Stapp
16 / 908	8/25/2014	Trondheimfjord Nordleksa-Reef	15:52	16:35	43	no USBL	no USBL	25	Karen Hissmann
17 / 909	8/26/2014	Sula-Reef	06:36	09:01	145	N 64°06.64' E 08°07.06'	N 64°06.64' E 08°07.06'	303-304	Max Wisshak
18 / 911	8/26/2014	Sula-Reef	14:33	17:24	171	N 64°06.54' E 08°07.06'	N 64°06.54' E 08°07.11'	268-306	Janina Büscher
19 / 912	8/27/2014	Sula-Reef	07:13	10:24	191	N 64°06.57' E 08°07.24'	N 64°06.65' E 08°07.07'	267-305	Armin Form
20 / 913	8/27/2014	Sula-Reef	14:09	17:07	178	N 64°06.51' E 08°17.12'	N 64°06.53' E 08°17.12'	264-288	Marie Küter
21 / 916	8/28/2014	Sula-Reef	07:05	10:25	200	N 64°04.95' E 08°02.08'	N 64°04.89' E 08°22.15'	258-285	Raymond Bannister
22 / 918	8/28/2014	Sula-Reef	14:03	17:15	192	N 64°04.90' E 08°01.83'	N 64°04.92' E 08°02.06'	269-286	Tina Kutti
23 / 921	8/29/2014	Sula-Reef	07:07	10:30	203	N 64°04.92' E 08°01.99'	N 64°04.82' E 08°01.81'	245-263	Karen Hissmann
23 in total		2 sites			3960 (66h)			10 - 306	12 observers

4.2 Benthic lander recovery

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

All three benthic landers were successfully recovered after more than 12 months of deployment.

<u>Scientific background (cf. POS455 cruise report):</u>

Three benthic lander systems were deployed in a northern cold-water coral reef 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 Nord-Leksa 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.

For further details please see POS455 cruise report.

4.3 In-situ *experiments*

Assessment of coral and bivalve growth, substrat colonisation and bioerosion in the field

(Form, A., Büscher, J., Wisshak, M.)

All *in-situ* experiments (except 1 incubation basket) were successfully recovered after more than 12 months of deployment. For further details please see paragraph 4.1 (Submersible JAGO) or POS455 cruise report.

Coral polyp behaviour study in their natural habitat

(Form, A., Schauer, J. Fenske, M.)

<u>Scientific background (cf. POS455 cruise report):</u>

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 further investigate the retraction/extension behaviour of cold-water coral *Lophelia pertusa* in their natural habitat, an advanced version of the autonomous video setup from the 2013 cruise (cf. POS455 cruise report) was deployed in front of a living coral colony with the submersible JAGO.

Figure 2 Underwater video camera system (version 2.0) placed in front of a whole *L. pertusa* colony. Nordleksa reef. (Photo: JAGO team).

4.4 CTD Measurements and water sampling

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

Like during POS455, CTD measurements during this cruise were also 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 again 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 2 summarizes the CTD casts performed during the research cruise.

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 predifined intervals within the water column. All samples (including JAGO) collected are listed in Table 3.

Table 2 CTD station details. RV POSEIDON cruise POS473.

CTD	Station	Date	UTC	Latitude	Longitude	Depth(m)
01	886-1	8/18/2014	06:12	63° 36.46' N	9° 22.93' E	182
02	888-1	8/18/2014	11:39	63° 36.47' N	9° 23.03' E	180
03	889-1	8/19/2014	06:10	63° 36.55' N	9° 22.89' E	208
04	891-1	8/19/2014	12:12	63° 36.53' N	9° 22.96' E	203
05	910-1	8/26/2014	12:25	64° 6.66' N	8° 7.12' E	292
06	915-1	8/28/2014	06:19	64° 4.91' N	8° 1.97' E	270
07	917-1	8/28/2014	12:17	64° 4.95' N	8° 1.97' E	267
08	921-1	8/29/2014	12:11	64° 4.94' N	8° 1.96' E	266

Table 3 Water samples collected during RV POSEIDON cruise POS473.

Station	Location	Date	Gear	Depth

886-1	Nordleksa	8/18/2014	CTD	182
886-1	Nordleksa	8/18/2014	CTD	170
886-1	Nordleksa	8/18/2014	CTD	20
887-1	Nordleksa	8/18/2014	JAGO	180
889-1	Nordleksa	8/19/2014	CTD	208
889-1	Nordleksa	8/19/2014	CTD	198
889-1	Nordleksa	8/19/2014	CTD	20
895-1	Nordleksa	8/21/2014	JAGO	?
899-1	Nordleksa	8/22/2014	JAGO	163
906-1	Nordleksa	8/25/2014	JAGO	?
909-1	Sula Landerpos.	8/26/2014	JAGO	?
910-1	Sula Landerpos.	8/26/2014	CTD	290
910-1	Sula Landerpos.	8/26/2014	CTD	280
910-1	Sula Landerpos.	8/26/2014	CTD	20
911-1	Sula Reef	8/26/2014	JAGO	?
915-1	Sula Reef Top	8/28/2014	CTD	270
915-1	Sula Reef Top	8/28/2014	CTD	260
915-1	Sula Reef Top	8/28/2014	CTD	20

4.5 Maintaining the corals on board and onboard experiments

(Form, A., Büscher, J.)

Cultivation and onboard experiments were performed according to the procedures conducted during RV POSEIDON cruise POS455 (for further details please see cruise report POS455).

5. Preliminary results

4.2.2014, 15.-31.8.2014, Jnr 14/1781

5.1 CTD and other oceanographic data

No profiles compiled yet. A comprehensive description of hydrodynamic characteristics of the examined stations will follow after data analysis of the lander data in combination with short-term CTD cast data (measurements in progress). **The whole datasets will be published 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

5.2 In-situ and onboard experiments

Analyses of the *in-situ* experiments are still in progress and will be published together with the results from the onboard experiments. **The whole datasets will be published and made publicly accessible.**

6. Acknowledgements

The scientific party of RV POSEIDON cruise POS473 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.

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7. References (cf. POS455 cruise report)

Abel, E. (1963) Rhythmik bei Anthozoen. Neptun 12, 331-333.

Brown, B. E., Letissier, M. D. A. & Dunne, R. P. (1994) Tissue retraction in the scleractinian coral *Coeloseris mayeri*, its effect upon coral pigmentation, and preliminary implications for heat balance. Marine Ecology Progress Series 105(3), 209-218.

Dullo, W.-C., Flögel, S., Rüggeberg, A. (2008) Cold-water coral growth in relation to the hydrography of the Celtic and Nordic European continental margin. Marine Ecology Progress Series, 371, 165-176.

Form, A. U. and Riebesell, U. (2012) Acclimation to ocean acidification during long-term CO_2 exposure in the cold-water coral *Lophelia pertusa*. Global Change Biology, 18(3), 843-853, DOI: 10.1111/j.1365-2486.2011.02583.x.

Form, A., Büscher, J., Hissmann, K., Schauer, J., López Correa, M., Müller, C., Hennige, S., Roberts, M., Riebesell, U. (2012) Biological observation and sampling of cold-water corals to investigate impacts on climate change. RV POSEIDON Cruise Report POS420, COWACSS, Trondheim - Kiel, 8-30 September 2011, 29 pp.

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

Gattuso, J.-P., Allemand, D. & Frankignoulle, M. (1999) Photosynthesis and calcification at cellular, organismal and community levels in coral reefs: a review on interactions and control by carbonate chemistry. American Zoologist, 39, 160–83.

Gladfelter, W. B. (1975) Sea anemone with zooxanthellae: Simultaneous contraction and expansion in response to changing light intensity. Science 189(4202), 570-571.

Guinotte, J.M., Orr, J., Cairns, S., Freiwald, A., Morgan, L. & George, R. (2006) Will human-induced changes in seawater chemistry alter the distribution of deep-sea scleractinian corals? Frontiers in Ecology and the Environment, 4(3), 141–146.

Kawaguti, S. (1954) Effects of light and ammonium on the expansion of polyps in the reef corals. Biological journal of Okayama University 2, 45-50.

Langdon, C., Broecker, W., Hammond, D., Glenn, E., Fitzsimmons, K., Nelson, S.G., Peng, T.-H., Hajdas, I., & Bonani, G. (2003) Effect of elevated CO_2 on the community metabolism of an experimental coral reef. Global Biogeochemical Cycles, 17(1), 1-14.

Langdon, C., Takahashi, T., Sweeney, C., Chipman, D., Goddard, J., Marubini, F., Aceves, H., Barnett, H. & Atkinson, M.J. (2000) Effect of calcium carbonate saturation state on the calcification rate of an experimental coral reef. Global Biogeochemical Cycles, 14, 639-654.

Lasker, H. R. (1979) Light dependent activity patterns among reef corals: *Montastrea cavernosa*. The Biological Bulletin 156(2), 196-211.

Levy, O., Dubinsky, Z., Achituv, Y. & Erez, J. (2006) Diurnal polyp expansion behavior in stony corals may enhance carbon availability for symbionts photosynthesis. Journal of Experimental Marine Biology and Ecology 333(1), 1-11.

Levy, O., Mizrahi, L., Chadwick-Furman, N. E. & Achituv, Y. (2001) Factors controlling the expansion behavior of *Favia favus* (Cnidaria: Scleractinia): Effects of light, flow, and planktonic prey. The Biological Bulletin 200(2), 118-126.

Lewis, J. B. & Price, W. S. (1975) Feeding strategies of Atlantic reef corals. Journal of Zoology 176, 527-544.

Marubini, F., Barnett, H., Langdon, C. & Atkinson, M.J. (2001) Dependence of calcification on light and carbonate ion concentration for the hermatypic coral *Porites compressa*. Marine Ecology Progress Series, 220, 153-162.

Marubini, F., Ferrier-Pages, C. & Cuif, J.-P. (2002) Suppression of growth in scleractinian corals by decreasing ambient carbonate ion concentration: a cross-family comparison. Proceedings of The Royal Society B – Biological Sciences, 270, 179-184.

Mortensen, P. B. (2001) Aquarium observations on the deep-water coral *Lophelia pertusa* (L., 1758) (Scleractinia) and selected associated invertebrates. Ophelia 54(2), 83-104.

Roberts, J. M. & Anderson, R. M. (2002) A new laboratory method for monitoring deep-water coral polyp behaviour. Hydrobiologia 471, 143-148.

Sebens, K. P. & Deriemer, K. (1977) Diel cycles of expansion and contraction in coral reef anthozoans. Marine Biology 43, 247-256.

Shelton, G. (1980) *Lophelia pertusa* (L.): electrical conduction and behaviour in a deep-water coral. Journal of the Marine Biological Association of the United Kingdom 60(2), 517-528.

Appendix

1. Stationlist

Station	Date	Time (UTC)	Gear	Logbook entry / action	Latitude	Longitude	Depth (m)
884-1	8/17/2014	13:30	JAGO submarine	to water	63° 36.48' N	9° 23.04' E	156.9
884-1		14:00	JAGO submarine	on deck	63° 36.56' N	9° 23.28' E	210.1
885-1		15:05	CTD / deep-water pump	to water	63° 36.48' N	9° 22.96' E	179.7
885-1		15:06	CTD / deep-water pump	at depth, 37 m, malfunction	63° 36.48' N	9° 22.97' E	180.5
885-1		15:29	CTD / deep-water pump	on deck	63° 36.47' N	9° 22.95' E	182.9
885-2		16:08	CTD / deep-water pump	to water	63° 36.49' N	9° 23.02' E	161.3
885-2		16:17	CTD / deep-water pump	at depth, 58 m, water pumping	63° 36.48' N	9° 23.01' E	161.5
885-2		18:58	CTD / deep-water pump	on deck	63° 36.41' N	9° 23.02' E	221.9
886-1	8/18/2014	06:01	CTD / rosette	to water	63° 36.48' N	9° 22.96' E	0
886-1		06:12	CTD / rosette	at depth, 182 m	63° 36.46' N	9° 22.93' E	0
886-1		06:23	CTD / rosette	on deck	63° 36.45' N	9° 22.98' E	244.7
887-1		06:57	JAGO submarine	to water	63° 36.46' N	9° 23.04' E	0
887-1		11:05	JAGO submarine	on deck	63° 36.50' N	9° 23.12' E	0
888-1		11:25	CTD / rosette	to water	63° 36.48' N	9° 22.98' E	0
888-1		11:39	CTD / rosette	at depth, 180 m	63° 36.47' N	9° 23.03' E	0
888-1		11:43	CTD / rosette	on deck	63° 36.46' N	9° 23.05' E	0
888-2		13:38	JAGO submarine	to water	63° 36.47' N	9° 23.03' E	0
888-2		16:47	JAGO submarine	on deck	63° 36.27' N	9° 22.47' E	209.7
889-1	8/19/2014	06:00	CTD / rosette	to water	63° 36.56' N	9° 22.89' E	0
889-1		06:10	CTD / rosette	at depth, 208 m	63° 36.55' N	9° 22.89' E	0
889-1		06:20	CTD / rosette	on deck	63° 36.55' N	9° 22.90' E	0
890-1		06:35	JAGO submarine	to water	63° 36.52' N	9° 22.90' E	0
890-1		10:50	JAGO submarine	on deck	63° 36.49' N	9° 22.90' E	0
891-1		12:02	CTD / rosette	to water	63° 36.54' N	9° 22.95' E	0
891-1		12:12	CTD / rosette	at depth, 203 m	63° 36.53' N	9° 22.96' E	0
891-1		12:21	CTD / rosette	on deck	63° 36.54' N	9° 22.95' E	0
892-1		14:07	JAGO submarine	to water	63° 36.54' N	9° 22.98' E	0
892-2		14:23	CTD / deep-water pump	to water	63° 36.54' N	9° 23.03' E	0
892-2		14:33	CTD / deep-water pump	at depth, 55 m, water pumping	63° 36.55' N	9° 23.02' E	0
892-2		16:33	CTD / deep-water pump	on deck	63° 36.53' N	9° 22.97' E	0
892-1		17:04	JAGO submarine	on deck	63° 36.61' N	9° 23.12' E	0
893-1	8/20/2014	10:48	JAGO submarine	to water	63° 36.50' N	9° 22.95' E	0
893-1		14:39	JAGO submarine	on deck	63° 36.43' N	9° 22.95' E	0
894-1		14:53	Bottom lander	hydrophone to water	63° 36.51' N	9° 22.94' E	0

894-1		15:00	Bottom lander	released	63° 36.53' N	9° 23.05' E	0
894-1		15:02	Bottom lander	lander surfaced	63° 36.53' N	9° 23.09' E	0
894-1		15:04	Bottom lander	hydrophone on deck	63° 36.54' N	9° 23.13' E	0
894-1		15:13	Bottom lander	on deck	63° 36.56' N	9° 23.02' E	0
895-1	8/21/2014	06:31	JAGO submarine	to water	63° 36.56' N	9° 22.97' E	0
895-1		09:11	JAGO submarine	on deck	63° 36.44' N	9° 22.88' E	0
896-1		09:12	Bottom lander	hydrophone to water	63° 36.44' N	9° 22.88' E	0
896-1		09:16	Bottom lander	released	63° 36.45' N	9° 22.91' E	0
896-1		09:19	Bottom lander	lander surfaced	63° 36.46' N	9° 22.93' E	0
896-1		09:20	Bottom lander	hydrophone on deck	63° 36.46' N	9° 22.94' E	0
896-1		09:26	Bottom lander	on deck	63° 36.53' N	9° 22.93' E	0
897-1		11:30	JAGO submarine	to water	63° 36.50' N	9° 22.99' E	0
897-1		12:42	JAGO submarine	on deck	63° 36.45' N	9° 23.38' E	0
898-1		13:45	JAGO submarine	to water	63° 36.50' N	9° 22.98' E	0
898-1		17:46	JAGO submarine	on deck	63° 36.49' N	9° 23.01' E	0
899-1	8/22/2014	08:38	JAGO submarine	to water	63° 36.51' N	9° 22.89' E	0
899-1		11:09	JAGO submarine	on deck	63° 36.52' N	9° 22.69' E	0
900-1		13:31	JAGO submarine	to water	63° 36.47' N	9° 22.71' E	0
900-1		17:07	JAGO submarine	on deck	63° 36.37' N	9° 22.83' E	0
901-1	8/23/2014	06:34	JAGO submarine	to water	63° 36.49' N	9° 22.83' E	0
901-1		10:22	JAGO submarine	on deck	63° 36.50' N	9° 23.03' E	0
902-1		14:08	JAGO submarine	to water	63° 36.54' N	9° 22.94' E	0
902-1		16:58	JAGO submarine	on deck	63° 36.43' N	9° 22.83' E	0
903-1	8/24/2014	08:35	JAGO submarine	to water	63° 36.54' N	9° 22.93' E	0
903-1		11:55	JAGO submarine	on deck	63° 36.39' N	9° 22.43' E	0
904-1		15:20	JAGO submarine	to water	63° 36.47' N	9° 22.94' E	0
905-1		16:03	CTD / deep-water pump	to water	63° 36.45' N	9° 22.90' E	0
905-1		16:11	CTD / deep-water pump	at depth, 55 m, water pumping	63° 36.47' N	9° 22.93' E	0
905-1		17:32	CTD / deep-water pump	on deck	63° 36.51' N	9° 22.91' E	0
904-1		17:45	JAGO submarine	on deck	63° 36.50' N	9° 23.19' E	0
906-1	8/25/2014	06:12	CTD / deep-water pump	to water	63° 36.48' N	9° 23.13' E	0
906-1		06:21	CTD / deep-water pump	at depth, 54 m, water pumping	63° 36.48' N	9° 23.13' E	0
906-1		08:31	CTD / deep-water pump	on deck	63° 36.48' N	9° 23.10' E	0
907-1		09:07	JAGO submarine	to water	63° 36.52' N	9° 22.61' E	0
907-1		12:01	JAGO submarine	on deck	63° 36.43' N	9° 22.50' E	0
908-1		13:46	JAGO submarine	to water	63° 36.48' N	9° 22.54' E	0
908-1		15:12	JAGO submarine	on deck	63° 36.27' N	9° 21.90' E	0
909-1	8/26/2014	06:33	JAGO submarine	to water	64° 6.63' N	8° 7.07' E	299.4

909-1		09:11	JAGO submarine	on deck	64° 6.65' N	8° 7.41' E	297.5
910-1		12:01	CTD / rosette	to water	64° 6.65' N	8° 7.08' E	300
910-1		12:25	CTD / rosette	at depth, 292 m	64° 6.66' N	8° 7.12' E	301
910-1		12:58	CTD / rosette	on deck	64° 6.64' N	8° 7.09' E	299.4
911-1		14:29	JAGO submarine	to water	64° 6.63' N	8° 7.09' E	298.5
911-1		17:31	JAGO submarine	on deck	64° 6.48' N	8° 7.08' E	290.4
912-1	8/27/2014	07:08	JAGO submarine	to water	64° 6.65' N	8° 7.14' E	299.7
912-1		10:38	JAGO submarine	on deck	64° 6.60' N	8° 7.28' E	298.8
913-1		14:06	JAGO submarine	to water	64° 6.61' N	8° 7.13' E	299.4
914-1		14:25	CTD / deep-water pump	to water	64° 6.57' N	8° 7.29' E	339.4
914-1		14:33	CTD / deep-water pump	at depth, 55 m, water pumping	64° 6.54' N	8° 7.25' E	270
914-1		16:45	CTD / deep-water pump	on deck	64° 6.52' N	8° 7.14' E	291
913-1		17:16	JAGO submarine	on deck	64° 6.46' N	8° 6.87' E	291
915-1	8/28/2014	06:05	CTD / rosette	to water	64° 4.94' N	8° 1.92' E	279.7
915-1		06:19	CTD / rosette	at depth, 270 m	64° 4.91' N	8° 1.97' E	279.7
915-1		06:38	CTD / rosette	on deck	64° 4.88' N	8° 2.06' E	252.2
916-1		07:03	JAGO submarine	to water	64° 4.96' N	8° 1.99' E	280.7
916-1		10:33	JAGO submarine	on deck	64° 4.86' N	8° 2.55' E	291
917-1		12:05	CTD / rosette	to water	64° 4.95' N	8° 1.95' E	283.2
917-1		12:17	CTD / rosette	at depth, 267 m	64° 4.95' N	8° 1.97' E	282.9
917-1		12:28	CTD / rosette	on deck	64° 4.95' N	8° 1.99' E	282.2
918-1		14:00	JAGO submarine	to water	64° 4.95' N	8° 1.92' E	279.7
918-1		17:22	JAGO submarine	on deck	64° 4.82' N	8° 2.06' E	0
919-1		17:50	CTD / deep-water pump	to water	64° 4.91' N	8° 2.01' E	6.6
919-1		17:55	CTD / deep-water pump	at depth, 55 m, water pumping	64° 4.90' N	8° 2.03' E	264.1
919-1		20:37	CTD / deep-water pump	on deck	64° 4.95' N	8° 2.12' E	280.4
920-1	8/29/2014	07:04	JAGO submarine	to water	64° 4.92' N	8° 1.96' E	0
920-1		10:44	JAGO submarine	on deck	64° 4.90' N	8° 2.27' E	0
921-1		12:00	CTD / rosette	to water	64° 4.95' N	8° 1.96' E	0
921-1		12:11	CTD / rosette	at depth, 266 m	64° 4.94' N	8° 1.96' E	281
921-1		12:22	CTD / rosette	on deck	64° 4.94' N	8° 1.99' E	281.3

The complete ship's logbook (including all sub-stations, e.g. use of rubber boat, 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/cruise/show/324813

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

Station #	Location	Species	Sample description	estimated size of samples (kg)
887-1, 888-2, 890-1, 892-1, 895-1, 898-1, 899-1, 902-1, 904-1, 907-1, 909-1, 911-1, 913-1, 920-1	Nordleksa Reef and Sula Reef	*Lophelia pertusa*	small branches and single colonies of living *L. pertusa* of both colour variants (white & red)	25 kg*

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