IFM-GEOMAR

Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

FS ALKOR
Fahrtbericht / Cruise Report AL 316

Geobiological investigations and sampling of Norwegian aphotic coral reef ecosystems

Kiel - Kiel

06.03. - 22.03.2008

Content

1. Scientific crew

Name	Function	Institute
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Holtmann, Wiebke	Student	IFM-GEOMAR, FB 2
Margreth, Stephan	Scientist	Uni Fribourg
Meyerhöfer, Michael	Scientist	IFM-GEOMAR, FB 2
Pratschko, Margit	Journalist	
Rüggeberg, Andres	Scientist	IFM-GEOMAR, FB 1
Schauer, Jürgen	Technician	IFM-GEOMAR FB 1, Jago-Team
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2. Research Programme (Armin Form, Andres Rüggeberg)

2.1 Short introduction

As a result of the 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., molluscs, sea urchins, pteropods, foraminifera, coccolithophorids and stony corals) becomes more and more detrimental. In the last few years, many experiments with tropical reef building (hermatypic) corals have shown, that a lowering of the carbonate ion concentration reduces calcification rates and therefore growth significantly (e.g., Gattuso et al. 1999; Langdon et al. 2000, 2003; Marubini et al. 2001, 2002). By the middle of this century, many tropical coral reefs may well erode faster than they can rebuild. However, nothing is known about the effects of ocean acidification on cold-water corals. This gap of information has to be closed urgently, because 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 solves. 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). Hermatypic cold-water corals, such as *Lophelia pertusa* are forming complex three dimensional structures in a more or less plain deep sea area and therefore are hosting communities of associated species and sometimes reveal a high level of endemism. In particular they form the breeding grounds for many deep-sea animals including fish of high commercial importance. Nevertheless, knowledge about the biology and ecological importance of the cold-water corals is still in its infancy and future research will be urgently needed.

In order to start filling this actual gap of knowledge an interdisciplinary research project with cold-water corals was prefaced at the IFM-GEOMAR, Kiel. For a series of future laboratory experiments, living fragments of the hermatypic cold-water coral Lophelia pertusa will be needed and therefore have to be collected during cruise AL316.

2.2 Deep-water Coral Reefs and Scientific Objectives

Deep-water coral ecosystems are widely distributed along the continental margins of the NE-Atlantic, where the colonial azooxanthellate Lophelia pertusa (Scleractinia) is the major reef constructing coral. This coral species (Figure 1) has the potential to build substantial reefs in the aphotic zone. The corals live in aphotic deeper environments under the absence of light. The transfer of food and nutrients from the fertile surface to the deeper waters nourishes the coral ecosystem. Local environmental conditions measured in and near coral ecosystems show some common features along the European continental margin:

(1) the availability of hard substrate to settle on (drop stone boulders, exhumed carbonate hardgrounds, larger calcareous skeletons, and outcropping rock exposures),

(2) the preferred location on pre-existing topographic highs (moraine ridges, iceberg plough mark levees, flutes, carbonate mounds, submerged oceanic banks, and seamount flanks),

(3) the existence of periodic vigorous currents driven by tidal rectification to prevent sedimentation of particles,

(4) an ambient water temperature window between 3° and 14°C,

(5) fully aerobic to slightly oxygen-depleted conditions.

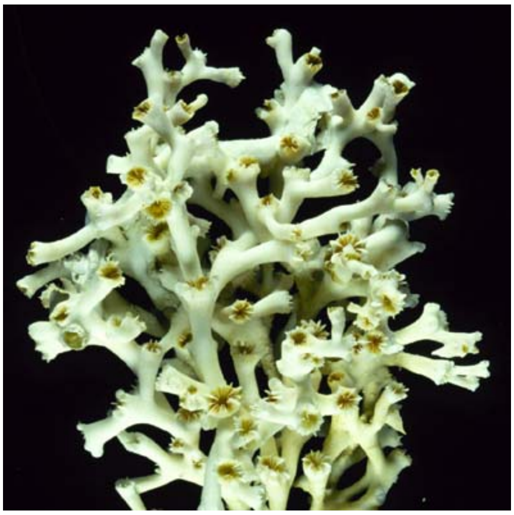

Figure 1: *The cold-water, reef-building scleractinian Lophelia pertusa (Photo: A. Freiwald).*

2.3 Major cruise objectives

The scientific objectives and methods of the ALK-316 cruise were:

- To collect live cold-water coral Lophelia pertusa and associated reef fauna.
- To analyse the physical and chemical water mass properties (temperature, salinity, oxygen, light transmission, chlorophyll fluorescence, DIC; nitrate, nitrite, silicate and phosphate) bathing the cold-water coral reefs.

References

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Pfannkuche, O. & Cruise Participants (2004) Geobiological investigations of aphotic coral reef ecosystems in the NE- Skagerrak, unpubl. Cruise Report RV ALKOR cruise AL232, Kiel – Strömstad (Sweden) – Kiel, 30.10. –

3. Narrative of the cruise

March 6th, 2008

After loading the scientific equipment and the manned submersible JAGO, RV ALKOR departed from Kiel at 9:25 PM. Six scientists, one technician and one student boarded the vessel (see Scientific Crew). The vessel left the Kiel Fjord and headed for Alesund in Norway.

March 10th, 2008

Arrival in Alesund harbour at 1:30 PM. Staying there overnight.

March 11th, 2008

Leaving Alesund port at 8:15 AM and performing two dives with the manned submersible JAGO in the Grytafjord. Coming back to Alesund port at 5:45 PM. Two scientists left the ship till March 13th, leaving space for two Norwegian pilots, who stood on board during the next two days.

In the same evening arrived the director of IFM-GEOMAR and the Secretary of State of the Ministry of Science and Economy of the German State Schleswig – Holstein. One journalist and one technician for film documentation embarked in addition.

March 12th, 2008

Leaving Alesund port at 1:45 AM and performing three dives with the manned submersible JAGO in the Julsundet. Staying at sea overnight.

March 13th, 2008

Performing three dives with the manned submersible JAGO in the Storegga Eiagrunnen. Arriving Alesund port at 6:00 PM.

March 14th, 2008

Due to repair of the radar system ALKOR could leave Alesund port only late in the afternoon at 4:00 PM.

March 15th, 2008

Reaching Sula Ridge at 8:00 AM and performing two dives with the manned submersible JAGO.

March 16th, 2008

Interruption of the scientific work because of bad weather. Seeking shelter in Frohavet.

March 18th, 2008

Leaving Frohavet at 4:00 AM with direction Oslofjord.

March 20th, 2008

Arriving Oslofjord at 1:30 PM and performing one dive with the manned submersible JAGO. Interrupting work at 4:00 PM due to weather conditions ad heading for Kiel

March 22nd, 2008

Arriving in Kiel at 8:00 AM and finishing expedition.

4. Technical details

4.1 Research Submersible "JAGO" *(JAGO Team Jürgen Schauer & Karen Hissmann)*

The main working tool during AL316 for the investigation, in situ documentation and sampling of cold water corals off Norway was the manned submersible "JAGO" of IFM-GEOMAR.

JAGO is certified to a maximum operating depth of 400 m and can accommodate two persons, the pilot and a scientist/observer, at atmospheric pressure. The autonomous underwater vehicle has two large acrylic dome ports that allow excellent visibility on the seafloor. The craft is electrically driven and able to move underwater autonomously within the reach of the navigation and communication systems stationed on board the support vessel. The submersible is equipped with fluxgate compass, USBL navigation and positioning system, underwater telephone, horizontal and vertical scanning sonar, digital video and still cameras, oceanographic sensors and 8 function manipulator arm for handling various sampling devices. Typical applications are benthic and/or mid-water observations and surveys, video/photo documentation, underwater sampling, environmental studies, search and location of objects, salvage work and support in emergency cases. JAGO has made more than 1050 dives throughout the World's Oceans and in deep lakes. The craft is stationed at the Leibniz Institute of Marine Sciences IFM-GEOMAR in Kiel since January 2006.

Because of its compact construction and small weight of 3 tons JAGO can be launched and recovered from nearly any larger boat and vessel with sufficient crane capacity. The most important requirements for handling of the submersible are a deck crane or stern gantry with sufficient lifting capacity (minimum 5 tons) at an outreach of at least 3 metres from the ship's side, and sufficient deck space for save handling during deployment and recovery.

The submersible is operated regularly from on board the German research vessels. AL316 was the third cruise with JAGO on RV ALKOR. The ship has a low working deck with a free board of less than 2 metres which is advantageous for deployment and recovery of the submersible. JAGO was deployed over the ship's starboard side. The deck crane of the ship, manufactured by NMF Hamburg, has a SWL of 5 tons at its inner boom (outreach 2.4-7.5 m), and a SWL of 2.5 tons at the outer boom (outreach 2.4-12.5 m). Since JAGO handling requires a SWL of minimum 5 tons, the submersible was lifted with the crane cable running through a sheave at the end of the inner boom. The outreach of the crane at that position is just sufficient for out- and in-boarding of the submersible, however, only at calm sea conditions (max 5 Beaufort). The inner boom had to be lifted quite high up in order to lift JAGO off the deck. In this position the length of the crane cable between the crane sheave and the lifting strop of the submersible is about 8-9 m. At such a long cable any heavy load starts swinging when lifted off a pitching platform. Two side lines, attached to the port side of the submersible and kept tight while the submersible was lifted, reduced but could not prevent swinging. Already a slight swell affected handling and increased the risk of damaging JAGO by hitting against the ship's side or the superstructure beside the main deck. Despite of these restrictions and thanks to the support of a cautious team (assistants on JAGO ["hookmen"] Andres Rüggeberg and Armin Form, crane operator Bosun Hardy Schwieger, and the workboat-team René Papke and Uli Hampel), JAGO was deployed and recovered during this cruise for 11 dives at 5 different locations (see appendix 1 and 2).

General Specifications

Dimensions	Length 3.2 m, Beam 2.0 m, Height 2.5 m
Weight in air	3000 kg
Operation depth	400 m
Cruising speed	1 knot
Crew	1 pilot, 1 observer
Life Support	96 man hours
Pressure hull	steel, 15 – 18 mm
Viewports	bow-window (ø 700 mm), top dome / hatch (ø 450 mm), providing 360-degree view, both acrylic
Power supply	lead acid batteries, total capacity 540 AH – 24 Volt DC
Propulsion	4 reversible horizontal thrusters at stern, 2 rotational thrusters on starboard and port side, 1 bow and 1 aft thruster
General systems	720 l floatation tanks for buoyancy at surface 40 l ballast tank for buoyancy control underwater 2 oxygen high pressure cylinders 3 pressure air cylinders Filters for air regeneration (carbon dioxide absorbent)
Rescue systems	Emergency drop weight Dead Man Safety-System Generation of >500 kg positive buoyancy Emergency buoy with rescue device
Equipment	Underwater navigation and positioning system, fluxgate compass, depth gauges, vertical and horizontal scanning sonar, underwater acoustic telephone communication, digital video- and still cameras, hydraulic manipulator arm with 8 functions and exchangeable claws, CTD, sampling devices for organisms, gas, water, fluids, sediments, rocks
Certified by	Germanischer Lloyd Hamburg
Built	1989, Germany

4.2 CTD / Rosette

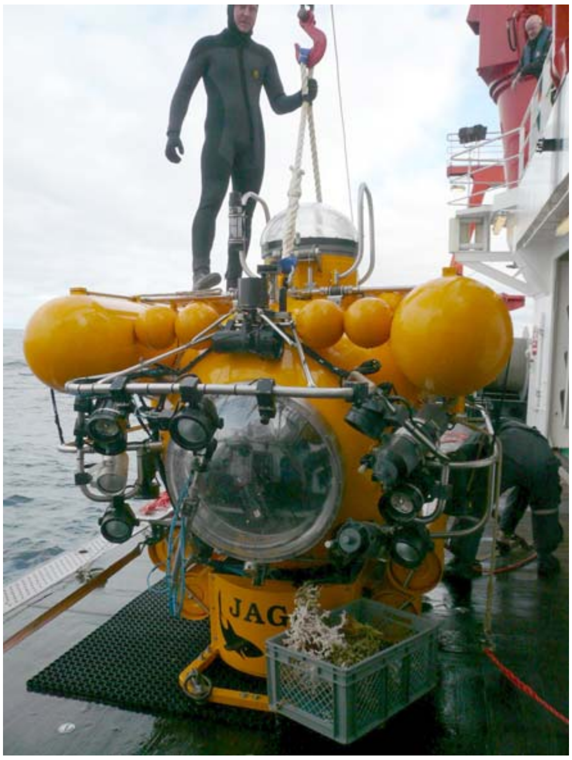
The CTD system used is a Hydro-Bios Kiel multi-parameter sensor built into a rosette housing capable of holding 12 10-litre water sampler bottles (Niskin-type). Pre-cruise laboratory calibrations of conductivity, temperature and pressure sensors were performed. All parameters yielded coefficients for a linear fit. Technical details of the sensors are summarized in table 1. Additionally, a detector for the fluorescence of Chlorophyll-a and sensors for dissolved oxygen and sound velocity were attached.

Table 1: *Technical details of multi-parameter sensor of the CTD system Hydro-Bios Kiel.*

Standard sensor	Pressure	Temperature	Conductivity
Measurement range	0 – 3000 dbar	-2 … +32°C	0 … 65 mS/cm
Resolution	0.05 dbar	0.0005°C	0.001 mS/cm
Precision	±0.1 %	0.0005°C	0.01 mS/cm
AD-transformation	16 bit, 16 µs		
EC conformity (CE)	EN 50081-1, EN 50082-1		

5. Measurements and sampling

5.1 JAGO



Training of the ship's crew in handling JAGO and the first two dives took place in the Grytafjord, northeast of Alesund. The next three dives were performed at one location in the Julsundet (also northeast of Alesund) where cold water corals were sighted and documented but not sampled (no sampling permission within the fjords). The dive site was chosen according to information provided by André Freiwald (University of Erlangen) who maintains a data bank on cold water coral occurrences along the European coast. Lophelia corals were found in 140-150 m water depth, and large gorgonians, which were growing on a vertical cliff of a giant drop-stone, in 80-140 m. Dives at Storegga / Eiagrunnen off Alesund revealed no coral sightings. The dive site was selected according to information provided by local fishermen. Eiagrunnen is a more or less plain area covered with cobbles, pebbles and boulders which are mainly inhabited by sponges. The next two dives took place at the Sula-Ridge. The Sula reef complex has been explored with JAGO before during expeditions with RV POSEIDON in 1997 and 1999. The reef is located in 270-300 m and has a large extension. The visibility at this water depth is usually very good and almost no bottom current made dives very comfortable. Living Lophelia and Madrepora corals of both colour variations and a Primnoa gorgonian were carefully collected with JAGO's manipulator arm. Water samples were taken close to the reef with two 5 ltr NISKIN bottles. After the second sampling dive deteriorating weather unfortunately prevented any further submersible dives in this area. A final single dive was performed in the Oslofjord at a shallow coral reef mound located east of the Soester Islands. Tidal currents are usually strong in this area and were also faced during this last dive. No sampling basket was attached to the submersible since no sampling permission was given for this area by the Norwegian authorities. The visibility during this dive was relatively bad due to a lot of particles within the water column. Living corals were documented between 90 and 100 m. The same coral mound was also inspected in 2006. A second documentation dive at this location could not be realized due to rapidly deteriorating weather conditions.

Figure 2: *Selective sampling of orange Lophelia corals at Sula Ridge with the manipulator arm of research submersible JAGO at 285 m depth. Removing collected coral colonies from JAGO's sampling basket on board the RV ALKOR*

Figure 3: *Lophelia coral mound east of Soester Islands, Oslofjord, at 90 m water depth, JAGO dive # 1052*

5.2 CTD and Water Sampling

One CTD Profiles was carried out in the Oslo fjord area. Water samples were taken for geochemical investigations ($d^{18}O$, $d^{13}C_{DIC}$, Th, and element ratios) at 5 m, 20 m, 40 m, 80 m, and 100 m (Table 2).

Table 2: *Water samples taken at Søndere Søster Reef, Oslo fjord.*

CTD Station 2 Date: 20.03.2008 Time: 13:52

Water depth: 112 m Lat.: 59°05.678'N Long.: 010°47.998'E

Bottle #	**Water depth (m)**	**Temperature (°C)**	**Salinity**
1 – 2	100	6.73	34.94
3 – 4	80	6.35	34.75
5 – 6	40	6.16	34.35
7 – 8	20	5.94	33.12
9 – 11	5	5.10	31.70

An additional benthic water sample close to the living corals at Sula Reef was taken by two five litres Niskin bottles attached to the submersible JAGO for analyses of alkalinity, dissolved inorganic carbon (DIC), nutrients, and stable isotopes ($d^{18}O$, $d^{13}C_{DIC}$).

5.3 Genetic sampling (Wiebke Holtmann, Armin Form)

For later research of possible interactions between Lophelia pertusa and associated microbial fauna samples were taken from branches of the Sula ridge following a preparation protocol for the further analyse FISH. First 16 separated polyps were transferred in 4% formaldehyde/seawater solution, then in 1x PBS and after all they were stored in PBS/EtOH (1:1) in -20°C.

Beside this, samples for DNA/RNA analyses were taken: 43 separated polyps of Lophelia pertusa and Madrepora oculata (samples from Sula ridge) were frozen in -20°C and will be stored in -80°C in Kiel.

Figure 4: *Genetic sampling*

5.4 Seabed Sampling (Stephan Margreth and Andres Rüggeberg)

We used a small Van Veen grab for sedimentological and micropalaeontological sampling at Sula Reef. This grab was used especially in areas rich in live corals in order to minimize damage to the benthic habitat. Due to restricted sampling in Norwegian fjords, only two grab stations were carried out in the pebbly sand and coral rubble facies at the foot of the Sula Reef (see grab protocols).

First, the recovered sediment and fauna was described including photographic documentation of each grab. Surface sediment was sampled for grain-size and benthic foraminiferal studies. One samples was stained with a solution of 2 g of rose bengal in 1 l ethanol to identify living benthic foraminiferal species. Another sample was taken to perform grain-size analyses (sortable silt as current proxy) while a third sample remained in seawater for further investigation at IFM-GEOMAR. The remaining sediment was sampled in plastic bags for further investigation at University of Fribourg, Switzerland.

5.5 Maintaining the Corals on Board *(Armin Form)*

In a first step all samples were carefully transferred from the collecting basket on the JAGO submerse into large buckets filled with fresh and clean seawater. After a period of acclimatisation the living Lophelia fragments and their associated fauna were transferred from the buckets into prepared large transportation tanks in the wet laboratory of RV ALKOR.

Each of the three 750 litres tanks was equipped with a powerful dive-pump for strong water current, an air-stone which was supported with fresh air through an air-pump and with a fibre glass lattice (5 * 5cm grid size) on the bottom for sample fixation. The water in the transportation tanks was fresh seawater from the previously filled aquaria tanks of RV ALKOR. Due to biological processes and warming-up the water were renewed at regular intervals.

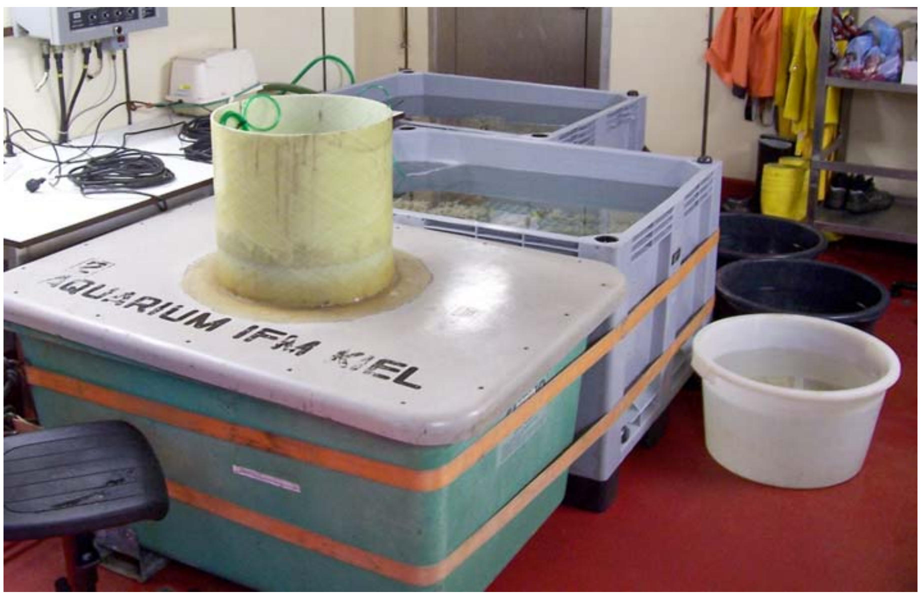


Figure5: *Transportation tanks in the wet laboratory of RV ALKOR. Photo: M. Gruber*

6. Preliminary Results

6.1 Physical Oceanography *(Michael Meyerhöfer, Andres Rüggeberg, Stephan Margreth)*

Physical parameters of the water column and the physical environmental conditions over the coral reefs at the Søndere Søster Reef (Oslofjord) indicate a well-stratified water column. Low temperatures occur at the surface down to 45 m (5–6.3°C, respectively). Salinity is strongly influenced by fresh water discharge and varies between ~31 and 34.5 within the uppermost 45 m. Between 45 m and 90 m water depth, uniform temperatures and salinities of ~ 6.3°C and ~ 34.6 still indicate Baltic outflow waters (Figure 6).

Increasing temperature and salinity values show an influence of Atlantic Waters below 90 m water depth, where the cold-water coral and sponge reefs occur. The Lophelia reefs East of the Søndere Søster island thrive in Atlantic waters with seasonal changes in winter and summer temperatures of ~ 7°C and 8.5°C and winter and summer salinities of 36 and 35 (Pfannkuche & Cruise Participants 2004).

Chlorophyll fluorescence profile indicates low values with hardly any variability. No well-defined subsurface maximum as during RV ALKOR cruise AL275 in March 2006 was observed (Rüggeberg and Form 2007) indicating that the phytoplankton spring bloom was already finished in this area.

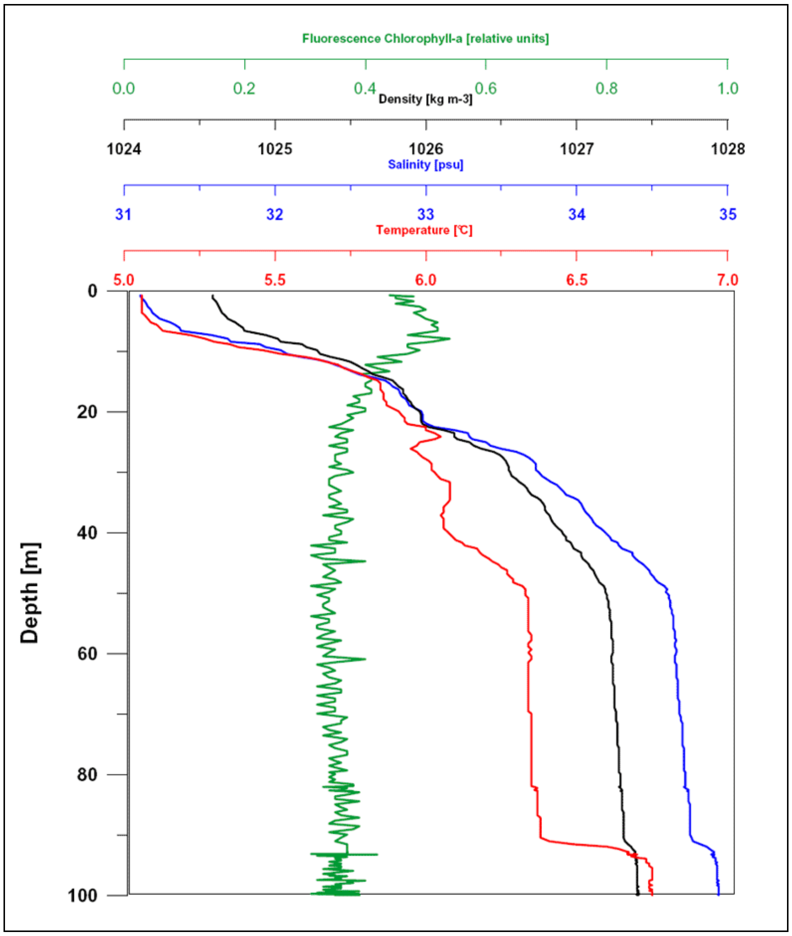


Figure 6: *CTD and fluorescence profiles*

References

Andres Rüggeberg, Armin Form, Eds., (2007) IFM-GEOMAR Report No. 10: RV ALKOR Fahrtbericht / Cruise Report AL 275 - Geobiological investigations and sampling of aphotic coral reef ecosystems in the NE- Skagerrak, 24.03–30.03.2006: 39 pp.

Olaf Pfannkuche, Cruise Participants (2004) RV ALKOR Fahrtbericht / Cruise Report AL 232 - Geobiological investigations of aphotic coral reef ecosystems in the NE- Skagerrak, 30.10.–11.11.2003: 35 pp.

6.2 Seabed Sampling - Preliminary Results *(Stephan Margreth and Andres Rüggeberg)*

Surface sediment was sieved using a 63 µm sieve. Fraction >63 µm of both grab stations was analyzed with a digital camera connected to a binocular. Species of Rotaliina show highest abundance of the foraminiferal assemblage followed by Textulariina and Miliolina (Table 3, Plate 1).

Table 3. *Dominant benthic foraminifera, their suborders and life style of grab samples AL316-320 and 321.*

Species	Suborder	Live habitat
Sigmoilopsis schlumbergeri	Textulariina	epibenthic
Textularia sp.	Textulariina	epibenthic attached
Quinqueloculina seminulum	Miliolina	epibenthic
Pyrgo rotalaria	Miliolina	epibenthic
Hyrrokkin sarcophaga	Rotaliina	epibenthic attached
Hyalinea balthica	Rotaliina	epibenthic
Cibicides lobatulus	Rotaliina	epibenthic attached
Cibicides refulgens	Rotaliina	epibenthic attached
Uvigerina mediterranea	Rotaliina	endobenthic
Trifarina angulosa	Rotaliina	endobenthic
Planulina wuellerstorfi	Rotaliina	epibenthic attached
Discanomalina coronata	Rotaliina	epibenthic attached

All species have an epifaunal life style except for Uvigerina mediterranea and Trifarina angulosa. An attached epifaunal life style dominates with species clinging on elevated substrates like dropstones or dead coral fragments (Table X, Plate 2). Only Hyrrokkin sarcophaga was observed on the calyx of a living Lophelia pertusa (Plate 2) from the coral reef facies. This species bores through the coral skeleton and feeds on the coral polyp (Cedhagen, 1994). Also from the surface sediment of grab AL316-321, where fossil coral fragments were observed, a fossil H. sarcophaga was identified indicating that this species can be used as an indicator for (formerly) living corals. In comparison to other cold-water coral habitats (e.g., Porcupine Seabight, Rockall Bank, Skagerrak), a similar benthic foraminiferal assemblage was described for dead coral rubble facies and areas below the coral reefs (Rüggeberg et al. 2007).

Lat. (N)	**64°06.30’**	**Date**	**16.03.2008**
Long. (E)	**008°04.80’**	**Time (UTC)**	**16:39**
Depth (m)	**296**	**Operator**	**AR / SM**

Photo of Sample

Sample description:

General aspects:
NW off Sula Reef within pebbly sand facies (Freiwald et al. 1997)

Dominating feature:
Silty sand with pebbles and drop stones, below 5 cm dark-greyish layer of muddy silt (anoxic?)

Sediment colour: olive grey

Corals: no

Fauna: bryozoans, sponges, brachiopods, ascidians, hydroid

Sedimentological Surface Sampling

- Surface bulk samples for planktonic and benthic foraminiferal analyses, phosphor measurements (Margreth – University of Fribourg, Swiss)
- Surface bulk sample (stained with rose bengal) for live benthic foraminiferal analysis (Rüggeberg – IFM-GEOMAR)
- Surface bulk sample for grain size analysis (Rüggeberg – IFM-GEOMAR)

Preliminary Interpretation:

External (distal) reef facies of coarse-grained sediment indicates a strong hydrodynamic regime with low sedimentation rate during the Holocene (drop stones on sediment surface). The benthic foraminiferal assemblage of surface sediment supports the interpretation of a high-energy environment with available elevated substrates (drop stones).

Dominant benthic foraminifers: see Plate 1.

Station: AL 316 – 321   Location: Sula Reef

Lat. (N)	**64°05.88'**	**Date**	**16.03.2008**
Long. (E)	**008°05.35'**	**Time (UTC)**	**17:20**
Depth (m)	**278**	**Operator**	**AR / SM**

Photo of Sample

Sample description:

General aspects:
E off Sula Reef at the foot of the reef

Dominating feature:
Coral fragments of different preservation stages in a silty-sandy sediment matrix and small drop stones (2–5 cm), below 2-3 cm finer sediment matrix (silt)

Sediment colour: greyish-brown

Corals: fossil to subrecent

Fauna: bryozoans, brachiopods, molluscs

Sedimentological Surface Sampling

- Surface bulk samples for planktonic and benthic foraminiferal analyses, phosphor measurements (Margreth – University of Fribourg, Swiss)
- Surface bulk sample (stained with rose bengal) for live benthic foraminiferal analysis (Rüggeberg – IFM-GEOMAR)
- Surface bulk sample for grain size analysis (Rüggeberg – IFM-GEOMAR)

Preliminary Interpretation:

External reef facies of coarse-grained sediment indicates a strong hydrodynamic regime with low sedimentation rate during the Holocene (drop stones on sediment surface). Fossil to subrecent coral fragments of *Lophelia pertusa* demonstrate the proximity to the living coral reef. The benthic foraminiferal assemblage of surface sediment supports the interpretation of a high-energy environment with available elevated substrates of drop stones and coral fragments.

Dominant benthic foraminifers: see Plate 1 and 2.

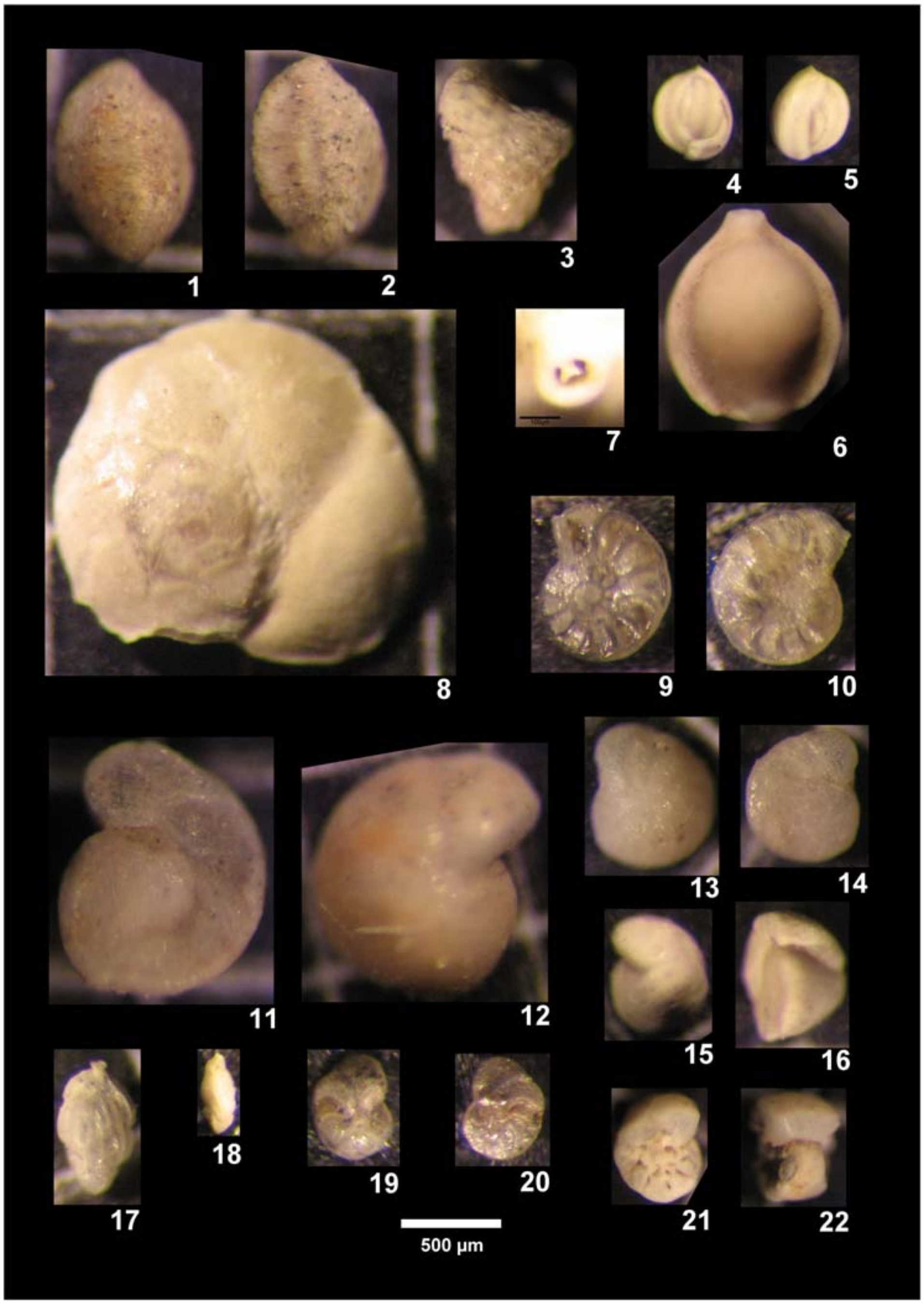


Plate 1. 1-2 *Sigmoilopsis schlumbergeri* (SILVESTRI, 1904), **3** *Textularia* sp., **4-5** *Quinqueloculina seminulum* (LINNÉ, 1758), **6-7** *Pyrgo rotalaria* LOEBLICH & TAPPAN, 1953, **8** *Hyrrokkin sarcophaga* CEDHAGEN, 1994, **9-10** *Hyalinea balthica* (SCHRÖTER, 1783), **11-14** *Cibicides lobatulus* (WALKER & JACOBS, 1798),**15-16** *Cibicides refulgens* MONTFORT, 1808, **17** *Uvigerina mediterranea* HOFKER, 1932, **18** *Trifarina angulosa* CUSHMAN, 1923, **19-20** *Planulina wuellerstorfi* (SCHWAGER, 1866), **21-22** *Discanomalina coronata* (PARKER and JONES, 1857).

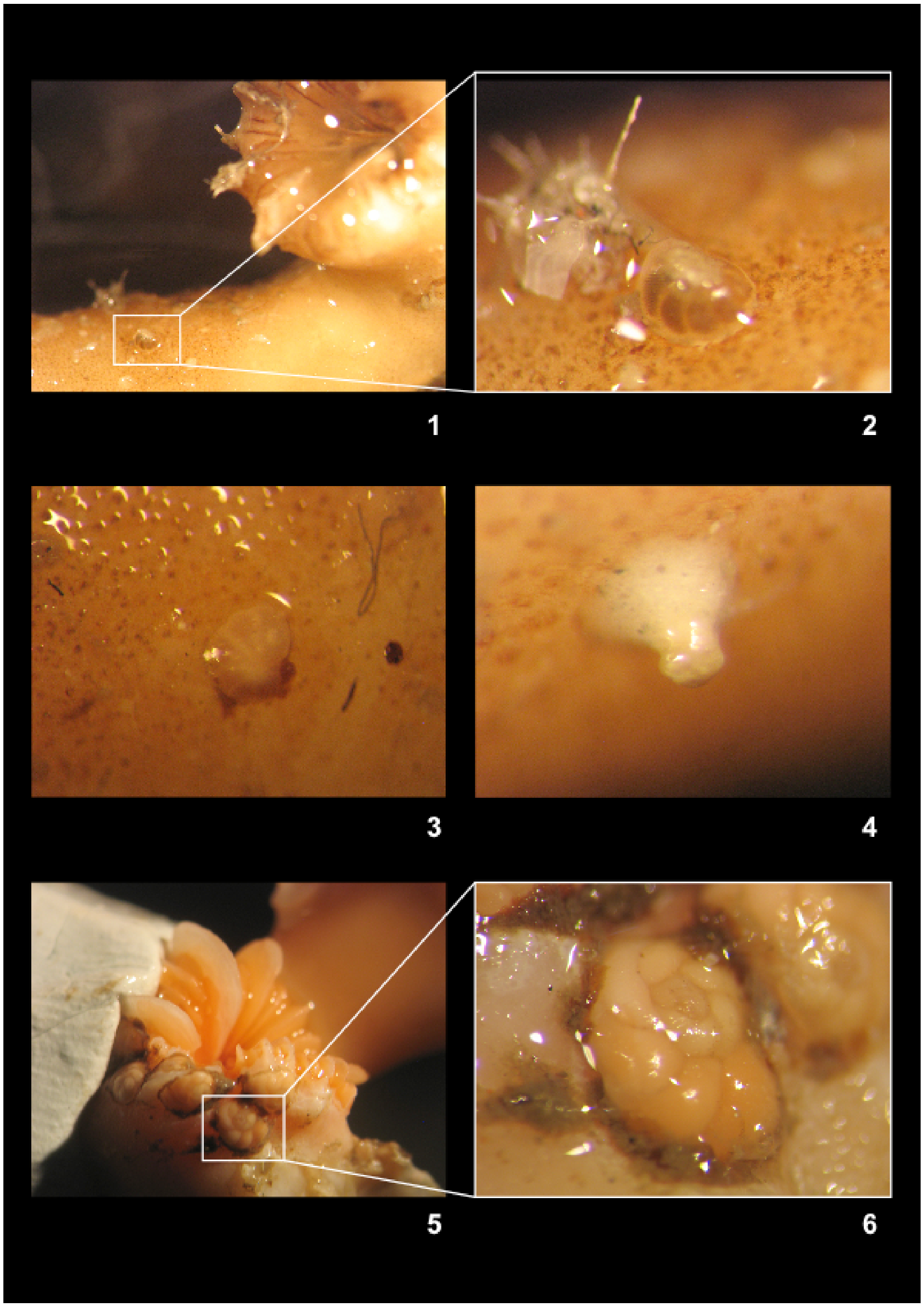


Plate 2. 1-2 Living benthic foraminiferal species on a dead coral fragment of *Lophelia pertusa* from the sediment surface: **1-2** *Discanomalina coronata*, **3** *Cibicides lobatulus*, **4** agglutinated foraminiferal species. **5-6** Parasitic *Hyrrokkin sarcophaga* on a living polyp of *Lophelia pertusa*.

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Cibicides lobatulus (WALKER & JACOB) = *Nautilus lobatulus* WALKER & JACOB, 1798. Feyling-Hanssen *et al.* (1971, pl. 9, figs. 9-14), Thies (1991, pl. 17, fig. 4, pl. 18, figs. 1-20), Struck (1992, pl. 5, fig. 1), Schönfeld (2002b, pl.1, figs. 2-3).

Cibicides refulgens MONTFORT = *C. refulgens* MONTFORT, 1808. Schönfeld (2002b, pl.1, figs. 11-12), Weston (1985, pl. 2, fig. 8).

Discanomalina coronata (PARKER and JONES) = *Anomalina coronata* PARKER and JONES, 1857. Schönfeld (2002b, pl.1, fig. 14).

Hyalinea balthica (SCHRÖTER) = *Nautilus balthicus* SCHRÖTER, 1783. Oki (1989, pl. 17, fig. 6).

Hyrrokkin sarcophaga CEDHAGEN = *H. sarcophaga* CEDHAGEN, 1994. Freiwald and Schönfeld (1996, p. 202, fig. 2a; p. 205, fig. 5a).

Planulina wuellerstorfi (SCHWAGER) = *Anomalina wuellerstorfi* SCHWAGER, 1866. Holbourn and Henderson (2002, pl. 5, figs. 6-8, following the generic assignation of van Morkhoven et al. (1986)).

Pyrgo rotalaria LOEBLICH & TAPPAN = *P. rotalaria* LOEBLICH & TAPPAN, 1953. Thies (1991, pl. 14, fig. 4; pl. 15, figs. 1-21), Struck (1992, pl. 3, fig. 1).

Quinqueloculina seminulum (LINNÉ) = *Serpula seminulum* LINNÉ, 1758. Feyling-Hanssen et al. (1971, pl. 1, figs. 18-20), Jennings and Helgadottir (1994, pl. 1, fig. 14).

Sigmoilopsis schlumbergeri (SILVESTRI) = *Sigmoilina schlumbergeri* SILVESTRI, 1904. Oki (1989, pl. 5, figs. 7a-b), Feyling-Hanssen et al. (1971, pl. 2, figs. 17, 18).

Trifarina bradyi CUSHMAN = *T. bradyi* CUSHMAN, 1923. Weston (1985, pl. 1, fig. 5), Heß (1998, pl. 10, fig. 14).

Uvigerina mediterranea HOFKER = *U. mediterranea* HOFKER, 1932. Thies (1991, pl. 17, fig. 3), Schiebel (1992, pl. 3, fig. 7).

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7. Acknowledgements

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Appendix 1: JAGO Dive list – ALKOR 316 Norway 2008

JAGO Dive #	Project Dive #	Date	Location	Time submerged	Time surfacing	Total dive time (min)	Touch down position	Lift off position	Min-Max Depth (m)	Pilot	Observer	Video tapes #
1042	1	11.03.08	Grytafjord	11:20	12:56	96	N 62°31.54	-	150-184	J.Schauer	W. Holtmann	-
			near Alesund				E 06°16.26	-				
1043	2	11.03.08	Grytafjord	14:54	16:08	74	N 62°31.03	N 62°31.02	115-150	J.Schauer	S. Magreth	-
							E 06°13.15	E 06°13.39				
1044	3	12.03.08	Julsundet	09:50	11:06	76	N 62°46.14	N 62°46.01	140-160	J.Schauer	J. de Jager	-
			near Alesund				E 06°55.91	E 06°56.08				
1045	4	12.03.08	Julsundet	13:47	15:02	75	N 62°46.21	N 62°46.14	146-150	J.Schauer	P. Herzig	1
							E 06°55.58	E 06°55.80				
1046	5	12.03.08	Julsundet	15:51	17:28	97	N 62°46.34	N 62°46.32	78-160	J.Schauer	M. Pratschko	1, 2
							E 06°55.94	E 06°56.02				
1047	6	13.03.08	Storegga	09:30	10:32	62	N 62°48.99	N 62°48.84	100-108	J.Schauer	J. de Jager	3
			Eiagrunnen				E 05°56.64	E 05°56.54				
1048	7	13.03.08	Storegga	13:34	14:53	79	N 62°49.55	N 62°49.42	95-105	J.Schauer	A. Form	3
			Eiagrunnen				E 05°57.75	E 05°57.48				
1049	8	13.03.08	Storegga	15:10	15:45	35	MiniROV	MiniROV	22	J.Schauer	A. Form	4
			Eiagrunnen				VideoRay	VideoRay				
1050	9	15.03.08	Sula Ridge	08:31	10:27	116	N 64°06.00	N 64°05.96	275-298	J.Schauer	U. Riebesell	4
							E 08°05.41	E 08°05.39				
1051	10	15.03.08	Sula Ridge	12:46	14:32	106	N 64°05.88	N 64°05.90	280-290	J.Schauer	A. Rüggeberg	5, 6
							E 08°05.41	E 08°05.47				
1052	11	20.03.08	Oslofjord	13:39	15:13	94	N 59°05.74	N 59°05.66	90-108	J.Schauer	A. Form	7
							E 10°47.87	E 10°47.89				

Appendix 2: JAGO Dive tracks – ALKOR 316 Norway 2008

JAGO Dive 1042 (1) 11.03.08			J.Schauer, Wiebke Holtmann		Grytafjord
					northeast of Alesund
Deployment training and test dive for underwater tracking + communication system					
Time (LT)	Depth (m)	North	East	Comments	
11:20	0	62°31.54	06°16.261	submerged	
11:35	150	-	-	at steep wall	
11:45	155	-	-	no USBL tracking, transducer failure	
12:17	178	-	-	move sw parallel to slope, *Acesta* bivalves, sponges,	
				stones with black coating, sediment	
12:30	183	-	-	start ascent	
12:56	0	-	-	surfaced	

JAGO Dive 1043 (2) 11.03.08			J.Schauer, Stefan Margreth (Fribourg)		Grytafjord
					northeast of Alesund
Fjord dive, too much swell offshore					
Time (LT)	Depth (m)	North	East	Comments	
14:54	0	62°31.034	06°13.153	submerged	
15:04	132	62°31.025	06°13.152	at bottom, strong current from 80°	
15:14		62°31.022	06°13.26		
15:19		62°31.023	06°13.334		
15:24	150	62°31.022	06°13.345	up and down profile, substrate changing from rocky	
				bottom to soft sediment, sea stars	
15:31	144	62°31.022	06°13.395	single rock (drop stone), sea anemones, bryozoan,	
				sponges, no coral rubble	
15:39				more soft sediment, sea cucamber, cod	
15:49	115	62°31.020	06°13.392	start ascent	
16:08	0	-	-	surfaced	

JAGO Dive 1044 (3) 12.03.08			J.Schauer, Jost de Jager (Staatssekr.)		Julsundet
					northeast of Alesund
Fjord dive, too much swell offshore					
Time (LT)	Depth (m)	North	East	Comments	
09:50	0	62°46.166	06°55.835	submerged	
10:04	148	62°46.137	06°55.908	at bottom, gravel, sea anemones, sponges, sea stars	
10:12	148	62°46.122	06°55.942	first corals	
10:28	140	62°46.092	06°55.973	coral aggregation, caulifower growth form	
				exclusively white *Lophelia* corals, no *Madrepora*,	
				coral rubble, dense coral aggregation upslope	
10:34	145	62°46.059	06°56.033	no corals	
10:39		62°46.032	06°56.061		
10:42	152	62°46.024	06°56.078	strong current from north, stationary	
10:50	160	62°46.014	06°56.081	strong current, dive abandoned, start ascent	
11:06	0	-	-	surfaced	

JAGO Dive 1045 (4) 12.03.08			J.Schauer, Peter Herzig		Julsundet
					northeast of Alesund
Fjord dive, too much swell offshore					Video tape 1
Time (LT)	Depth (m)	North	East	Comments	
13:47	0	62°46.253	06°55.539	submerged	
14:04	146	62°46.210	06°55.575	at bottom	
14:08		62°46.191	06°55.609		
14:14		62°46.177	06°55.712		
14:18		62°46.162	06°55.770	slight current	
14:23		62°46.138	06°55.838	first coral reef	
14:45	150	62°46.142	06°55.797	nice reef, start ascent	
15:02	0	-	-	surfaced	

JAGO Dive 1046 (5) 12.03.08			J.Schauer, Margit Pratschko (FOCUS)		Julsundet
					northeast of Alesund
Fjord dive, too much swell offshore					Tape 1+2
Time (LT)	Depth (m)	North	East	Comments	
15:51	0	62°46.35	06°55.692	submerged	
16:08	160	62°46.344	06°55.935	rocky bottom, large drop strones, no current	
16:13	156	62°46.329	06°55.952	a lot of coral rubble, move upslope	
16:23	137	62°46.309	06°55.944	in front of large bolder with vertical wall,	
				overgrown with gorgonians	
16:41	110	62°46.324	96°55.945	giant gorgonians, move upwards along steep wall	
16:51	90	62°46.319	96°55.982	still moving upslope	
17:00	78	62°46.319	06°56.017	on top of bolder, polished rock, yellow gorgonians	
17:18	80	62°46.319	06°56.017	start ascent	
17:28	0	-	-	surfaced	

<u>JAGO Dive 1047 (6) 13.03.08</u>			J.Schauer, Jost de Jager (Staatssekr)		Storegga / Eiagrunnen
					northeast of Alesund
coral location from fishermen (Fossa 2002)					Tape 3
<u>Time (LT)</u>	<u>Depth (m)</u>	<u>North</u>	<u>East</u>	<u>Comments</u>	
09:30	0	-	-	submerged	
09:40	100	62°48.988	05°56.638	at bottom, gravel, cobbles + pebbles, slight current	
09:46	100	62°48.968	05°56.591		
09:51		62°48.932	05°56.581		
09:54		62°48.912	05°56.533		
09:58	108	62°48.92	05°56.43		
10:04		62°48.899	05°56.459		
10:07		62°48.899	05°56.483		
10:10		62°48.884	05°56.549	rocks, gravel, 2 *Bromse bromse* fish, no corals	
10:14		62°48.866	05°56.528		
10:16		62°48.843	05°56.563		
10:18				getting shallower, sandy, scattered rocks, sponges	
10:20		62°48.840	05°56.543	start ascent	
10:32	0	-	-	surfaced	

JAGO Dive 1048 (7) 13.03.08			J.Schauer, Armin Form		Storegga / Eiagrunnen
					northeast of Alesund
					Tape 3
Time (LT)	Depth (m)	North	East	Comments	
13:34	0	-	-	submerged	
13:44	95	62°49.551	05°57.750	at bottom, gravel plain, single rocks	
14:01		62°49.526	05°57.673		
14:03	100	62°49.500	05°57.669	relatively strong current, gravel + sand, no structure	
14:10		62°49.476	05°57.600		
14:12		62°49.461	05°57.578	current increasing, no structure	
14:17		62°49.435	05°57.563		
14:21		62°49.428	05°57.541		
14:22		62°49.412	05°57.519		
14:27		62°49.401	05°57.479	sand desert	
14:33		62°49.413	05°57.461	investigating gravel	
14:44	105	62°49.415	05°57.483		
14:53	0	-	-	surfaced	

JAGO Dive 1049 (8) 13.03.08			J.Schauer, Armin Form		Storegga / Eiagrunnen
					northeast of Alesund
short dive for mini ROV demonstration and JAGO shots underwater					Tape 4
Time (LT)	Depth (m)	North	East	Comments	
15:10	0	-	-	submerged	
	22	-	-	in water column, filmed by VideoRay miniROV	
15:45		-	-	surfaced	

JAGO Dive 1050 (9) 15.03.08			J.Schauer, Ulf Riebesell		Sula-Ridge
					Tape 4
coral reef dive					
Time (LT)	Depth (m)	North	East	Comments	
08:31	0	64°06.045	08°05.493	submerged	
08:54	298	64°05.998	08°05.406	at bottom, coral rubble + first single corals	
08:59		64°05.972	08°05.436		
09:09		64°05.962	08°05.381		
09:15		64°05.967	08°05.325		
09:23		64°05.982	08°05.410	collecting corals	
09:58	275	64°05.960	08°05.391		
10:03	275	64°05.964	08°05.392	sampling busket full, start ascent	
10:27	0	-	-	surfaced	

JAGO Dive 1051 (10) 15.03.08			J.Schauer, Andres Rüggeberg		Sula-Ridge
					Tape 5+6
coral reef dive					
Time (LT)	Depth (m)	North	East	Comments	
12:46	0	64°05.879	08°05.423	submerged	
13:05	290	64°05.871	08°05.407	at bottom, gravel and sponges	
13:10		64°05.879	08°05.419	at base of coral reef	
13:14	285	64°05.893	08°05.419		
13:17		64°05.899	08°05.438		
13:26		64°05.907	08°05.447		
13:29	285	64°05.893	08°05.419	collecting corals, Lophelia white + red, Madrepora	
13:40	285	64°05.882	08°05.479	moved a short distance	
13:53		64°05.896	08°05.467		
14:03		64°05.900	08°05.461		
14:10	285	64°05.907	08°05.463	sampling busket full of corals	
14:13	280	64°05.898	08°05.467	2 m above ground, start ascent	
14:32	0	-	-	surfaced	
JAGO Dive 1052 (11) 20.03.08			J.Schauer, Armin Form		Oslofjord
					Tape 7

coral reef dive					
Time (LT)	Depth (m)	North	East	Comments	
13:39	0	-	-	submerged	
13:50	108	59°05.738	10°47.867	at bottom, very murky water, current from south	
13:55		59°05.726	10°47.863		
13:58		59°05.710	10°47.868		
14:02		59°05.705	10°47.87	first coral rubble, still low visibility, counter-current	
14:07		59°05.685	10°47.859		
14:10		59°05.670	10°47.869		
14:14		59°05.652	10°47.884	first living corals	
14:18		59°05.694	10°47.875	surrounded by corals	
14:40		59°05.652	10°47.864	move around in narrow area, same pos. like 2006	
14:47	90	59°05.648	10°47.877	on top of coral reef	
15:05	90	59°05.659	10°47.888	start ascent	
15:13	0	-	-	surfaced	

Appendix 3: Overview work areas Sula Ridge and Oslofjord