METEOR-Berichte

ANNA
Cold-Water Coral Ecosystems off Angola and Namibia

Cruise No. M122

December 30, 2015 – January 31, 2016
Walvis Bay (Namibia) – Walvis Bay (Namibia)

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1 Summary

R/V METEOR expedition M122 focused on the investigation of cold-water coral (CWC) occurrences in the Southeast Atlantic Ocean off the coasts of Namibia and Angola, a region characterised by a distinct oxygen minimum zone. Special emphasis was on the distribution, the appearance, the faunal assemblage and the vitality of these ecosystems under present and past (glacial) conditions. Based on detailed mapping (multibeam echosounder, PARASOUND and multichannel seismic) in the two working areas off Namibia and Angola, a total of 16 dives with the MARUM ROV SQUID were conducted to allow for a detailed characterisation of the existing facies and fauna. These observations were complemented by studies on the structure (CTD and water samples) and variability (lander systems) of the water column and by extensive seabed sampling including long sediment cores that will enable to study the development of CWC ecosystems in the Southeast Atlantic under changing environmental conditions, e.g., over glacial-interglacial cycles.

The most remarkable result of the expedition was the observation of living CWC within the oxygen minimum zone off Angola. Thriving CWC under dissolved oxygen concentrations of <1 ml L^{-1}, as found off Angola, have never been observed before, neither in nature nor in laboratory experiments. In contrast, off Namibia, where dissolved oxygen concentrations are even lower with <0.5 ml L^{-1}, only fossil CWC were encountered. However, their presence is a clear indicator for the existence of better living conditions for the CWC in the past. With the framework-building CWC acting as ecosystem engineers, their vitality is decisive for the local biodiversity in the investigated upper continental slope settings.

Zusammenfassung

Im Mittelpunkt der FS METEOR Expedition M122 stand die Untersuchung von Kaltwasserkorallen (KWK)-Vorkommen im Südost-Atlantik vor den Küsten Namibias und Angolas, einer Region, die durch eine ausprägte Sauerstoffminimumzone gekennzeichnet ist. Dabei lag das Hauptaugenmerk auf der Erfassung der Verteilung, dem Erscheinungsbild, der Faunenvergesellschaftung und dem Zustand dieser Ökosysteme unter heutigen und vergangenen (glazialen) Bedingungen. Nach eingehenden Vermessungen (Fächerecholot, PARASOUND und Mehrkanal-Seismik) wurden in den beiden Arbeitsgebieten vor Namibia und Angola im Zuge von 16 Tauchgängen mit dem MARUM ROV SQUID detaillierte Fazies- und Faunen-Charakterisierungen durchgeführt. Diese wurden durch Untersuchungen zum Aufbau (CTD und Wasserproben) und zur Variabilität (Landersysteme) der Wassersäule und durch zahlreiche Bodenproben und Sedimentkerne ergänzt, wobei gerade Letztere dazu dienen werden, die Entwicklung der südost-atlantischen KWK-Vorkommen über den letzten Glazial-Interglazial-Zyklus zu rekonstruieren und mit Klima-gesteuerten Veränderungen der Umweltbedingungen zu korrelieren.

Das herausstechende Ergebnis der Expedition war das Auffinden lebender KWK im Bereich der Sauerstoffminimumzone vor Angola. Weder in der Natur noch in Laborexperimenten sind jemals lebende KWK bei Sauerstoffgehalten von <1 ml L^{-1} beobachtet worden. Im Gegensatz dazu wurden vor Namibia bei noch geringeren Sauerstoffgehalten von <0,5 ml L^{-1} nur noch fossile KWK angetroffen, die allerdings auf bessere Lebensbedingungen für die KWK auch in dieser Region in der Vergangenheit hinweisen. Die Vitalität der als Ökosystemingenieure fungierenden gerüstbildenden KWK ist ein entscheidender Faktor für die Biodiversität in den untersuchten Bereichen entlang der oberen Kontinentalhänge.

2 Participants

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Fig. 2.1 *Scientific crew of expedition M122 "ANNA" on-board R/V METEOR.*

Participating Institutions

MARUM	Zentrum für Marine Umweltwissenschaften, Universität Bremen
MTU-GeoB	Meerestechnik-Umweltforschung, FB Geowissenschaften, Universität Bremen
IWES	Fraunhofer-Institut für Windenergie und Energiesystemtechnik, Bremen
SAM	Senckenberg am Meer, Wilhelmshaven
GEOMAR	Helmholtz-Zentrum für Ozeanforschung, Kiel
IUPH	Institut für Umweltphysik, Universität Heidelberg
NIOZ	Royal Netherlands Institute for Sea Research, Texel, The Netherlands
IEO	Centro Oceanográfico de Baleares, Span. Institute of Oceanography, Palma de Mallorca, Spain
UB	Institute of Marine Sciences, CSIC, University of Barcelona, Spain
INIP	Instituto Nacional de Investigacao Pesqueira, Luanda, Angola
DWD	Deutscher Wetterdienst, Geschäftsfeld Seeschifffahrt, Hamburg

3 Research Programme

The research programme of R/V METEOR cruise M122 focussed on a detailed study of cold-water corals (CWC) along the Namibian and Angolan continental margins. CWC are the architects of important bioconstructions and are the nuclei of unique biodiversity hotspots in the deep sea. Present knowledge about the distribution and ecology of CWC as well as their sensitivity to environmental change derived mainly from studies on coral sites in the North Atlantic Ocean. For other regions in the Atlantic, in particular in the low latitudes, only few scattered reports of CWC exist. Except for one site along the Angolan margin (at 7°S; see Le Guilloux et al. 2009), the knowledge about the occurrence of CWC along the Namibian and Angolan margins was rather sparse prior to M122. However, recent hydroacoustic campaigns (M76-3, MSM20-1) revealed extended areas showing numerous seabed structures which resemble coral mounds known from the NE Atlantic. Although this region is characterised by an extensive oxygen minimum zone, the few reports about the occurrence of CWC demonstrated the great potential to discover extensive and large occurrences along the Angolan and Namibian margins. R/V METEOR cruise M122 intended to conduct an intense survey and sampling programme (**i**) to validate if the hydroacoustically detected mound-like seabed structures along the Namibian and Angolan margins are indeed formed by CWC, (**ii**) to investigate the spatial distribution and vitality of the CWC as well as the prevailing environmental setting steering their occurrence, and (**iii**) to reconstruct their temporal development across glacial-interglacial timescales.

CWC are of special interest for marine scientists because of (**i**) their capacity to act as ecosystem engineers and habitat providers creating highly diverse bathyal ecosystems, (**ii**) their intrinsic link to the regional hydrographic setting, and (**iii**) their ability to create 3-dimensional geological structures at the seafloor (coral mounds) that can serve as important palaeo-archives (incl. the CWC themselves). However, only recently the significance of CWC (also on a global scale) has been revealed triggered by the progress in deep-sea technologies. Beyond the exploration of hotspots along the European and North American Atlantic margins, our knowledge about CWC is still rather limited, if not absent at all. One example for a rather underexplored region was the SE Atlantic, for which our knowledge about CWC prior to the cruise can be summarised as:

- CWC (mainly *Lophelia pertusa* and possibly *Madrepora oculata*), forming substantial geological structures, exist off northern Angola (~7.3°S) at 350 - 450 m water depth, and probably off central Angola (~9.7°S) at 260 - 550 m water depth,

- geological structures most likely formed by CWC exist off northern Namibia (~20.8°S) at 160 - 260 m water depth, and
- CWC fragments (mostly alive) were found in dredge samples from the Valdivia seamount on Walvis Ridge and from the Congo Canyon (6.5°S).

With respect to this limited knowledge and to the high potential for the existence of extensive low latitude CWC ecosystems in the SE Atlantic in a peculiar setting (e.g., regarding the low dissolved oxygen (O_2) concentrations along the Namibian and Angolan margins, M122 working areas A & B indicated in Fig. 4.1), this region was a prime target for CWC research. Especially, as these sites could be compared with a CWC site existing in well oxygenated waters on Valdivia seamount (Walvis Ridge; working area C), which allowed to compare the impact of varying ambient oxygen conditions on the CWC. Thus, the main hypotheses to be tested during the expedition were as follows:

Hypothesis I: The most prominent CWC species *Lophelia pertusa* can withstand very low O_2 concentrations, lower as shown before in any field or laboratory studies.
Hypothesis II: Although vivid, the low-oxygen adopted SE Atlantic CWC ecosystems display a reduced diversity and population density with a different species composition compared to their NE Atlantic counterparts.
Hypothesis III: The prosperity of SE Atlantic CWC ecosystems varied on decadal to orbital timescales and this variability was directly controlled by changes in productivity and/or O_2 concentration.
Hypothesis IV: CWC skeletons act as palaeo-archives which provide detailed information about past water mass characteristics.
Hypothesis V: While the initiation of the coral mounds in the SE Atlantic is favoured by an active tectonic regime, their long-term development is related to the changes in the oceanographic setting.

Deviations from the original cruise proposal: Originally, three working areas were planned for cruise M122. In addition to the two areas visited, one off Namibia and one off Angola, a third target region was the Valdivia Seamount on the Walvis Ridge (Fig. 4.1). However, due to the 6-days-delay in leaving the first working area off Namibia, caused by the need to wait for the ROV spare parts (see chapter 4), there was not enough time left to visit the Valdivia Seamount without seriously compromising the work off Angola. However, there was hardly any loss in station time, as the loss due to the return trip to Walvis Bay to collect the spare parts was balanced by the gain of time due to skipping the long transit (~2x 500 nm) to the Walvis Ridge. Thus, the available station time was equally allocated to the two working areas off Namibia and Angola, with providing more station time to these as originally planned, thereby increasing the amount of data and samples that could be collected there.

4 Narrative of the Cruise

Wednesday, December 30, 2015 ◊ After one busy day of unloading containers, installing sampling gears and preparing laboratories, R/V METEOR left the harbour of Walvis Bay (Namibia) at 9:00h in the morning. On-board were 30 scientists from institutions located in Bremen, Wilhelmshaven, Kiel, Heidelberg, Hamburg, Texel (The Netherlands), Barcelona (Spain), Palma de Mallorca (Spain), and Luanda (Angola). After leaving the harbour, R/V METEOR set course to the first working area off northern Namibia (Fig. 4.1). Low wind speeds and only a weak swell (<2 m) made the acclimation on-board easy to all participants.

Thursday, Dec 31, 2015 ◊ Soon after midnight, R/V METEOR reached the first working area. It was planned to start the station work with the application of a video-guided CTD, which allows a targeted water sampling at sites, where living cold-water corals (CWC) can be observed. The selected site for the first Video-CTD operation was situated close to those seabed structures located in ~230 m water depth, that were identified by multibeam echosounder (MBES) and PARASOUND (PS) sub-bottom profiler data obtained during cruise MSM20-1, and that were preliminary interpreted as CWC mounds. Unfortunately, this Video-CTD station had to be aborted (GeoB20501) due to technical problems. During the night, a reconnaissance MBES/PS survey (GeoB20502) was conducted to detect potential CWC mound structures in deeper waters down to 700 m, however, without finding any structures. At 10:30h, the 120-m-long multichannel seismic streamer was deployed (GeoB20503) and a first survey to investigate the sub-seabed in the mound region (at ~250 m water depth) started. In the evening, the scientific and nautical crews jointly celebrated the beginning of the New Year!

Friday, Jan 1, 2016 ◊ After finishing the seismic survey, a second attempt for a Video-CTD cast (GeoB20504) was conducted, but it failed again due to technical problems. Afterwards, good weather conditions, with weak winds and a long swell of ~1.5 m, allowed for the maiden dive of the newly-acquired MARUM ROV SQUID (GeoB20505). This first ROV dive was overall very successful and absolutely impressive as for the first time the presence of CWC mounds off Namibia could be confirmed! This coral mound area was called the **Sylvester Mounds**. In this dysoxic environment only fossil remnants of the CWC species *Lophelia pertusa* were found covering the numerous small-sized mounds. Nevertheless, despite these harsh environmental conditions, live benthic fauna was observed at the seafloor comprising sponges, actinians, crustaceans, and bryozoans. The dive lasted until 19:00h, and immediately afterwards, the GEOMAR satellite mini lander (SML; GeoB20506) and two NIOZ ALBEX landers (GeoB20507/08) were deployed to collect time-series data of various environmental data for some days. The night was spend with another MBES/PS survey (GeoB20509) to extend the mapped area further north.

Saturday, Jan 2, 2016 ◊ In the morning, two of the CWC mounds that belong to the **Sylvester Mounds** and that have been observed during the ROV dive the day before, were sampled with a giant box corer (GeoB20510/11), with both cores yielding a mixture of coral rubble, other bioclasts, hemipelagic sediments and various living organisms. Two more ROV dives, one continuing the survey on the **Sylvester Mounds** (GeoB20512) and one exploring the **New Year Mounds** (GeoB20513), a mound cluster being situated further to the south, revealed a consistent pattern with common coral rubble on the mounds and strongly bioturbated sediments in between the mounds. During the night, a multichannel seismic survey (GeoB20514) focussing on a small-scale analysis of the various sub-seafloor structures in the working area was conducted.

Sunday, Jan 3, 2016 ◊ During the two ROV dives the day before, some of the propellers showed serious problems with some shaft seals. As these problems required careful analysis, the ROV could not be deployed for the following two days. Instead, several coral mounds belonging to the **New Year and Sylvester Mounds** were sampled by the giant box corer (GeoB20515/16) and the gravity corer (GeoB 20516-18), all yielding a mixture of CWC fragments, other bioclasts and hemipelagic sediments. Additionally, a series of grab samples (GeoB20520-24) was collected in order to calibrate the backscatter dataset derived from the MBES surveys. One of these samples revealed the presence of fossil coral fragments in a water depth as shallow as 163 m. Another attempt to apply the Video-CTD failed again due to technical problems (GeoB20519). Instead, the ship's CTD was applied which finally recovered water samples and data of the water mass properties (GeoB20525). To conclude station work for this day, a reconnaissance MBES/PS survey (GeoB20526) as far north as 20°20'S was conducted that revealed (1) additional coral mounds in this northernmost area and (2) that the escarpment showing a straight south-north trend across the working area suddenly vanishes in the north.

Monday, Jan 4, 2016 ◊ Most of the day was spent with an extensive geological sampling programme with the gravity corer and the grab sampler. Two sediment cores (GeoB20527/28) were collected east of the escarpment from specific large-scale seabed structures with the aim to get some information about those lithologies underlying the thin sediment veneer that have been identified during the seismic surveys. Although this aim could not be accomplished, gravity core GeoB20528 interestingly yielded a 2.5-m-thick layer of large bivalve and gastropod shells overlain by only a few tens of centimetres of hemipelagic sediments. Two off-mound sites for palaeoceanographic reconstructions, one collected from the western slope of the escarpment (GeoB20529) and one collected north of the Sylvester Mounds region (GeoB20530) yielded records of 1.6 and 2.3 m. Finally, a ~10-m-long coral-bearing sediment core (GeoB20531) was retrieved from a coral mound of the **Sylvester Mounds** area (same position as GeoB20518) that apparently penetrated the entire mound structure. Afterwards, the programme was continued with four grab samples (GeoB20532-35) in the east that finally recovered some hardrocks from the underlying lithologies. Following a CTD cast (GeoB20536) in the south-western part of the study area, a seismic survey to study the fate of the escarpment in the north was started. Moreover, despite the problems with two propellers, it has been decided to continue the ROV dive operations within the following days. Nevertheless, as similar problems have been expected to show up with the remaining propellers, some spare parts were meanwhile ordered. These were expected to arrive in Walvis Bay within the next 4 days.

Tuesday, Jan 5, 2016 ◊ Also this day was largely spent with geological sampling. The first two stations targeted the steep escarpment with a box corer (GeoB20539) and an escarpment mound with a gravity corer (GeoB20540). The box corer recovered a big slab of rock with some coral fragments. Unfortunately, the box corer got damaged, but could be repaired and was ready again in the afternoon. The gravity corer revealed a short sequence (24 cm) of coral rubble from a site in only ~160 m water depth. On the way to the Squid Mounds in the north, two white spots identified in the backscatter map were sampled for ground truth purposes with the grab sampler. Whereas the first circular white spot (GeoB20541) revealed the common hemipelagic sediment already sampled at other sites, which provided no new clues to the origin of this spot, the second target obviously was a rock outcrop (GeoB20542) as revealed by the recovered stone. At the **Squid Mounds** (~220 m), a CTD cast (GeoB20543), a box (GeoB20545) and a gravity core (GeoB20543) were taken. The latter revealed a ~5-m-long record composed of coral rubble and sediments covered by a layer with bivalve shells. A much shorter record with similar material was recovered by the grab sampler and the gravity corer from the more northerly **Pickel Mound** (GeoB20544). And even at this site, in only 160 m water depth, abundant coral fragments were found.

Wednesday, Jan 6, 2016 ◊ The steep escarpment and the **Escarpment Mounds** on its top were the target for the next ROV dive (GeoB20547). Along the E-W transect from the deep towards the top of the escarpment, the facies changed from heavily bioturbated hemipelagic sediments to a coral rubble facies, and finally, to outcropping rocks surrounded by the coral rubble facies. Especially the rocks were covered by a high number of bryozoans, ophiuroids, sponges and actinians. Again, living CWC were absent. On top of the escarpment, where the MBES data revealed small, only 2-3-m-high mound-like structures, the facies again changed to a coral rubble facies without any outcropping rocks. After the dive, grab samples were collected along the dive track. One sample was retrieved from the top (GeoB20548) and one from the slope (GeoB20549) of the escarpment with both revealing a coral and bryozoan rubble facies. Seaward of a zone lacking any sediment cover, a gravity corer (GeoB20550) was taken in 370 m water depth to obtain a palaeoceanographic record from slightly deeper waters. In the evening, a transect of 7 CTD stations (GeoB20551-57) from deep (400 m) to shallow (150 m) water depths started that lasted until the next morning. All station work still benefitted from the good weather conditions with winds usually below 4 Bft and a long swell of <2 m.

Thursday, Jan 7, 2016 ◊ During the night, another MBES/PS survey (GeoB20558) was started to explore potential mound settings further south. At 20°54'S, a promising site was found, which was selected as a target for the next ROV dive (GeoB20559). Due to the large amount of fish (*Merluccius* sp.) encountered when reaching the seafloor, these mounds were called **Merluza Mounds**. The observations revealed large areas covered with coral rubble overgrown by sponges, bryozoans and many other benthic organisms. Boulder areas on the slopes gave a hint to the most likely initial settling ground of the corals. On the mounds, a CTD cast (GeoB20560) was conducted to analyse the water column structure and to take water samples directly from the seafloor. Two grab samplers collected from the **Merluza Mounds** revealed hemipelagic sediments with few corals fragments (GeoB20560) and hemipelagic sediments with abundant worm tubes (GeoB20561), with the latter grab sampler obviously having missed the main mound structure. Afterwards, mapping with MBES/PS (GeoB 20562) was continued further southward. In the evening, the wind picked up.

Friday, Jan 8, 2016 ◊ An increase in wind strength and wave height (>3 m) prevented this day a safe deployment of the ROV. Instead, a geological sampling programme was conducted, starting at the **Priska Mounds**, which were discovered during the MBES/PS survey the night before. Being located at 20°59'S, the Priska Mounds seem to be the southernmost mounds along this part of the Namibian margin. Three grab samples (GeoB20563-65) were collected from these mounds all revealing abundant coral rubble. At the third grab sampling site, an additional CTD cast was conducted. Afterwards, we returned to the **Merluza Mounds** and continued station work with box coring. While the first box core (GeoB20566) revealed a mixture of hemipelagic sediments with coral rubble, at the second site (GeoB20567) the box corer toppled over two times without yielding any sample material. Going back to the **Priska Mounds**, a gravity core (GeoB20568, same position as grab sample GeoB20564) was collected providing a 3-m-long record of coral-bearing sediments. The sampling programme was concluded with a grab sample (GeoB20569) collected from the deepest mound structure of the **Priska Mounds** yielding again abundant coral rubble. For the night programme, we headed north to complete the MBES/PS mapping over there (GeoB20570). As we got the notification that the ordered ROV spare parts were not expected to arrive in Walvis Bay before the following week, we decided to extend the station work in the Namibian working area.

Saturday, Jan 9, 2016 ◊ This day, the weather conditions still did not allow a safe deployment of the ROV. Thus, the bottom and water sampling programme was continued. The sampling started with a box and a gravity corer collected from the **Squid Mounds** at the same site (GeoB20571) yielding abundant coral rubble and a 5.5-m-long record of coral-bearing sediments. During the MBES/PS survey the night before, a rather large mound structure was detected 6 nm further to the south. At this site, a CTD cast (GeoB20572) was conducted, followed by the recovery of a 6-m-long coral-bearing gravity core. As this core overpenetrated, a second coring attempt with a 12-m-long steel pipe was done that resulted in a 10-m-long sediment core. The final box corer was characterised by abundant sea stars that finally gave the name for this structure, the **Sea Star Mound**. In the afternoon, we recovered both ALBEX landers (GeoB20507/08), which had been deployed in the area of the Sylvester Mounds on Jan 1 (see above). Interestingly, the meat put on one of them as a bait still was largely intact indicating the absence of large predators at the seafloor. As we were still puzzled with the underlying geological structure of the area, another seismic survey (GeoB20575) was done during the night.

Sunday, Jan 10, 2016 ◊ Luckily, the swell went down and the ROV could be deployed. Dive target were the **Squid Mounds** in the north (GeoB20576). This dive confirmed the impression of a north-south gradient in biodiversity at the seafloor. Some of the common species (some fish and bryozoans) found further south could not be observed here. Instead, a clear facies pattern ranging from strongly bioturbated hemipelagic sediments to a sea star facies, and finally, a coral rubble facies was detected across all the mounds. With three grab samples and a CTD cast obtained for the Squid Mounds (GeoB20577-79), the sampling programme on these mounds was continued. Again, the night was spent with MBES/PS mapping (GeoB20580).

Monday, Jan 11, 2016 ◊ This morning started with an ROV dive (GeoB20581) targeting the **Priska Mounds**, which were the southernmost mounds having been discovered so far during M122. Already when reaching the seafloor, a tremendous difference to the dive conducted at the northernmost Squid Mounds the day before, became obvious. At the Priska Mounds, the ROV encountered many fishes at the seafloor close to the first mound, and bryozoans and sponges being abundant on the coral mounds also reflected a higher diversity in the south compared to the north. After the dive, another gravity core

(GeoB20582) was collected from a small mound belonging to the Priska Mounds, which might have even penetrated the entire mound structure. Further south, another off-mound gravity core (GeoB20583) and one grab sample (GeoB20584) from two of the very small Priska Mounds with an elevation of just 1-2 were collected. After finishing station work, R/V METEOR headed westwards to conduct a "deep" CTD cast at a water depth of 1000 m (GeoB20585).

Tuesday, Jan 12, and Wednesday, Jan 13, 2016 ◊ These two days were spent with picking up the ROV spare parts and some other material in Walvis Bay.

Thursday, Jan 14, 2016 ◊ Upon returning to our working area off Namibia, we recovered the SML lander from the Sylvester Mounds (GeoB20506) which was deployed on Jan 1 (see above). Finally, a gravity core (GeoB20588) was collected from an off-mound site in 240 m water depth which yielded a 4.8-m-long record being composed of an 80-cm-thick layer of large mollusc shells overlying hemipelagic sediments. With this activity the station work in the Namibia working area was completed and R/V METEOR started the transit to the working area off Angola, which was used for additional *en route* MBES mapping. The transit route was planned to mainly cover the depth window of interest (200 m to 500 m; Fig. 4.1), where additional, so far unknown CWC mounds have been expected. Already on leaving the Namibian working area, it became clear that the Northern Namibian Mound province extends even further north than mapped so far.

Friday, Jan 15, 2016 ◊ Soon after passing the Walvis Ridge and entering Angolan waters, the first Angolan mound structures were discovered in the MBES data at around 17°S, again in water depths between 200 m and 300 m. Around noon, we stopped at a 1000-m-deep station to conduct a CTD cast (GeoB20901) aiming to gain information about the upper water mass structure in the Angola Basin and to obtain a sound velocity profile urgently needed to calibrate the MBES data for this basin.

Saturday, Jan 16, 2016 ◊ On continuing the transit, we did a further CTD cast (GeoB20902) at 600 m water depth during the morning. In the evening, the mid-cruise barbeque was celebrated.

Sunday, Jan 17, 2016 ◊ After arriving in the Angolan working area, we started station work with an MBES survey (GeoB20903). The following first ROV dive (GeoB20904) conducted in this region revealed for the first time during this cruise living framework-forming scleractinian CWC between 500 and 470 m. The two common species *L. pertusa* and *Madrepora oculata* were observed to colonise the steep slopes of coral mounds, which we named the **Valentine Mounds.** Beside living CWC, also a much more diverse benthic community was detected off Angola compared to the Namibian coral sites. Living specimens of *L. pertusa* and *M. oculata* were successfully sampled with the ROV, which was in particular important for starting the ecophysiological aquaria experiments of our Spanish colleagues (see chapter 5.7). Unfortunately, the ship-based POSIDONIA underwater positioning system failed during the ROV dive. Before starting another MBES/PS survey (GeoB20904), the CTD (GeoB20905) was deployed to obtain water samples to aid further analyses/experiments on the live material sampled by the ROV.

Monday, Jan 18, 2016 ◊ Various tests revealed that the POSIDONIA system was entirely out of service. Therefore, we started to install our GAPS system in the ship's moon pool, while the ADCP 35 kHz had to be switched-off and dismantled. The sampling programme during the day comprised a series of grab samples and gravity cores, which were collected from various mound sites (**Valentine Mounds**: GeoB20907-09, **Twin Mounds**: GeoB20910, **Anna Ridge**: GeoB20912-13) in ~50 m depth intervals covering a water depth range of 500 to 250 m. In addition, a gravity core was retrieved from an off-mound site in 380 m water depth (GeoB20911). At the last station, another test with the Video-CTD failed. Subsequently, a water column profile and the water samples needed for the experiments were again obtained with the ship's CTD (GeoB20913). The night was spent with tracing this coral mound area further south by an MBES/PS survey (GeoB20914).

Tuesday, Jan 19, 2016 ◊ In the morning the GAPS system could be successfully tested during a CTD cast. The SML lander was deployed (GeoB20915) west of the **Valentine Mounds**, while one ALBEX lander was deployed west of the mound cluster in slightly deeper waters (GeoB20916). The following ROV dive (GeoB20917), a continuation of the previous dive along the **Valentine Mounds**, revealed a highly diverse ecosystem with abundant living CWC including white and red colour morphs of *L. pertusa* and also *M. oculata*, despite dissolved oxygen (O_2) concentrations of partly below 0.8 ml L^{-1}. The terrain along the dive track was very rugged, excluding the planned deployment of another lander. Upon finishing the dive, the next multichannel seismic survey for the night was prepared (GeoB20918).

Wednesday, Jan 20, 2016 ◊ A CTD station (GeoB20919) at approximately 900 m water depth served the further characterisation of the water column and the needs of the ecophysiology group to continuously supply the CWC, held alive in the aquaria, with "fresh" water. Focusing on the shallower mound structures along the **Anna Ridge**, the next ROV dive (GeoB20920) offered some spectacular observations: (1) living CWC were rather rare although the seafloor was densely covered with coral rubble; (2) one living specimen of *L. pertusa* was sampled from waters with temperatures of >14°C; (3) abundant deep-sea oysters (*Neopycnodonte* sp.) were observed; and (4) the top of the ridge was covered by rocks. After the deployment of the second ALBEX lander (GeoB20921) close to the Anna Ridge, three grab samples (GeoB20922-24) were taken from sites, where the PS data indicated outcropping old strata. In two of the samples, high concentrations of phosphoritic sands were found.

Thursday, Jan 21, 2016 ◊ Again, the morning started with a CTD cast (GeoB20926) to sample water for the aquaria experiments. The following ROV dive (GeoB20927) targeted the **Buffalo Mounds**, which surprised us with a very abundant and diverse underwater scenery right in the middle of the regional oxygen minimum zone with O_2 concentrations of below 0.8 ml L^{-1}. A high number of samples were collected during the dive comprising living *L. pertusa* and *M. oculata*, octocorals, antipatharians, anemones and sponges. A highlight was the successful sampling of a live specimen of the bivalve *Acesta* sp., which is at the same time the southernmost documented finding (9°42'S) of this species in the Atlantic Ocean. As soon as the ROV was back on deck, we sailed 2 nm back to the **Valentine Mounds** where a 7.5-m-long coral-bearing sediment core was retrieved (GeoB20928). For the night, another multichannel seismic survey had been prepared (GeoB20929).

Friday, Jan 22, 2016 ◊ Station work for this day focussed on the **Scary Mounds**, a strange morphological setting with very narrow ridges enclosing deep depressions being located in the southernmost mapped area off Angola (9°49'S). However, ROV dive GeoB20930 revealed that these structures are also built-up by CWC showing a very dense coverage of living corals along the tops of the narrow ridges and of the wider central ridge. The depressions were filled with a mixture of coral rubble and soft sediments. Again, a high number of samples were collected during the dive (e.g., living *L. pertusa* and *M. oculata*, octocorals, actinians, sponges and gastropods). In order to supply also the geologists with additional material, a series of gravity cores (GeoB20931-33) and grab samples (GeoB20933-35) were collected from the **Scary Mounds**. After another CTD cast (GeoB20936), the night was used to fill the gaps in the northern part of the MBES map (GeoB20937).

Saturday, Jan 23, 2016 ◊ Close after sunrise, we arrived at one of the ALBEX lander sites (GeoB20921), which was deployed on Jan 20 close to the Anna Ridge, and recovered the lander successfully. The **Snake Mounds** were the target for the next ROV dive (GeoB20938). These mounds are located in similar depths as the Anna Ridge (up to 250 m). Also here, only few living CWC were observed. In contrast to the Anna Ridge, no rocks/crusts were discovered on the Snake Mounds. In the afternoon, the NIOZ ALBEX Lander was re-deployed at a slightly deeper site west of the **Valentine Mounds** (GeoB20940). The night was spent with a N-S trending CTD transect consisting of 9 stations (GeoB20942-50).

Sunday, Jan 24, 2016 ◊ To obtain a broader overview on the coral structures (e.g., size, distribution) at the seafloor, the video-mosaicking capabilities of the ROV SQUID were tested during dive GeoB20951. For this reason, a site on the **Buffalo Mounds** was re-visited (see dive GeoB20927, Jan 21). While the handling of the ROV (including station keep etc.) worked pretty well, the camera settings still might need some improvement. Nevertheless, after processing the collected video footage, we expect to get a nice video-mosaic. After the recovery of the ROV, we collected a gravity corer from a contourite body (GeoB20952) and a box corer from the **Snake Mounds** (GeoB20953), which, however, needed two attempts to be successful as it toppled over on the steep slope in the first try. Four grab samplers (GeoB20954/55) were taken from the **Anna Ridge** in order to enhance the statistical significance of a species analyses (mainly molluscs) in the sediments and to trace the origin of authigenic crusts formed at the seafloor.

Monday, Jan 25, 2016 ◊ The **Castle Mounds** were the target of ROV dive GeoB20957, which are the northernmost coral mounds visited by the ROV during M122. Shells of chemosynthetic bivalves and microbial mats were detected at the base of one of the mounds (~450 m water depth), indicating fluid/gas seeping in the region. When climbing up a steep slope, the density of living CWC increased to finally culminate at the top of the structure in a very dense coverage of large live colonies. After the ROV dive, a grab sampler (GeoB20958) was taken at the site with the microbial mats. Two more gravity cores from the **Snake Mounds** (GeoB20959/60) and a final box core from an off-mound area east of the **Anna Ridge** concluded the seabed sampling programme of this cruise, before the last CTD transect (GeoB20963-68) started.

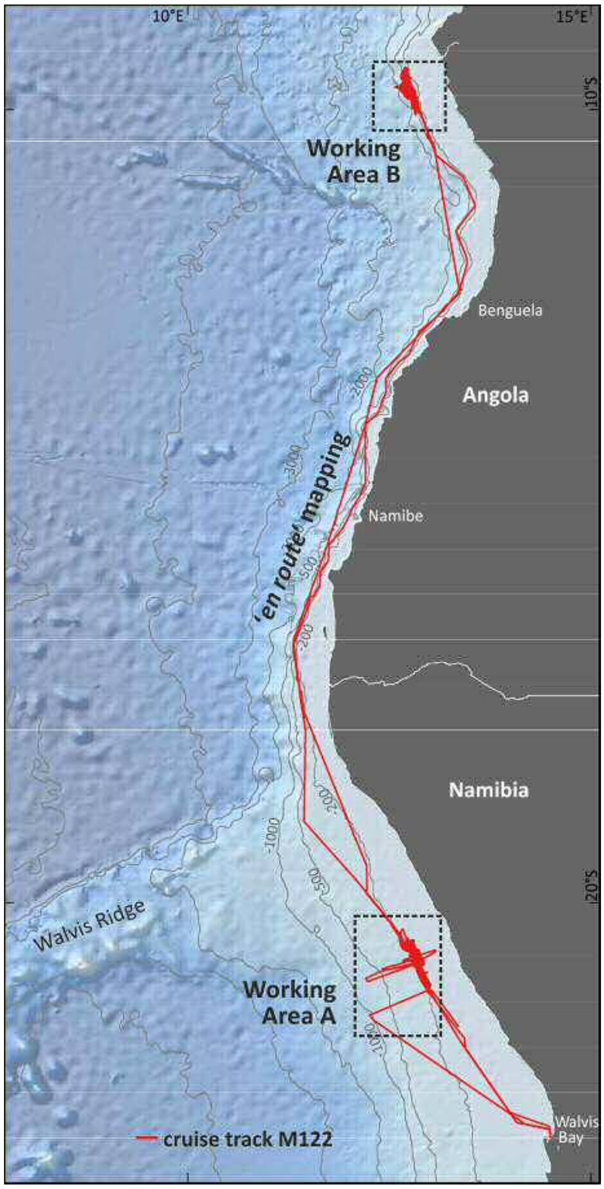


***Fig. 4.1** Track chart of expedition M122 with R/V METEOR starting in Walvis Bay (Namibia) on Dec 30, 2015, and ending again in Walvis Bay on Jan 31, 2016.*

Tuesday, Jan 26, 2016 ◊ This morning saw the successful recovery of the 3 lander systems within just two hours, which had been placed in close vicinity to the Valentine Mounds. The SML (GeoB20915) and one ALBEX lander (GeoB20916) were deployed for 7 days, while the second ALBEX lander was deployed for 2.5 days (GeoB20940). Afterwards, R/V METEOR started to sail south towards Walvis Bay, however, with some *en route* programme. A gap in the Angolan MBES map was completed (GeoB20969), and later on, a short MBES survey (GeoB20970) was conducted on one of the conspicuous settings detected on the northbound transit almost two weeks ago, which are likely also coral mounds.

Wednesday, Jan 27, 2016 ◊ On reaching a 2000-m-deep station, the ROV was prepared to send it down to its maximum operational depth. This instrument testing was successful, despite some problems with the hydraulics. The final station work of M122 commenced with a CTD station (GeoB20971).

Thursday, Jan 28, to Sunday, Jan 31, 2016 ◊ On the transit back to Walvis Bay the remaining time was used to make some small MBES maps over areas of possible coral mounds found on the northbound transit (GeoB20972/73). Furthermore, some still existing gaps in the MBES map of the first working area off Namibia were completed (GeoB20974). On-board, the scientific crew started to de-install the equipment from the laboratories and to pack the boxes. On Sunday morning, R/V METEOR arrived in Walvis Bay, where immediately the loading of the containers started.

5 Methodology and Instrumentation

5.1 Underwater Hydroacoustics

P. Wintersteller & J. Titschack; watch-support: M. Bender, R. Eichstädter, A. Gori, C. Orejas, F. João, I. Moçambique, A.-M. Wefing; processing support: M. Bender & A.-M. Wefing

All surveys with the Multibeam Echosounders (MBES), PARASOUND sub-Bottom Profiler (PS-SBP) and Acoustic Doppler Current Profiler (ADCP) were guided by watches. For detailed information, a hydroacoustic protocol is available (pwintersteller@marum.de). Besides the malfunctions of MBES EM710 and POSIDONIA, all systems run very stable during cruise M122.

5.1.1 Attributed Sensors (Navigation, Motion Data, Sound Velocity)

The ship's position was calculated by the KONGSBERG SEAPATH 320 Inertial Navigation System (INS). Motion data (roll, pitch, heave) as well as heading and Differential Global Positioning System (DGPS) information was generated by the SEAPATH 320 in combination with the motion reference unit (KONGSBERG MRU 5+), and delivered to all hydroacoustic devices applied during M122. When using a SEAPATH 320 INS, the internal coordinate system refers to the approximate centre of gravity (COG) of the vessel (on R/V METEOR a fixed point in the engine room/workshop area). This implies that lever arms and offsets to the DGPS antenna (CNAV3050-1) as well as the MRU are considered when referencing to an ideal plane at the COG. Every acoustic device on-board has its own lever arms or offsets between the given COG-plane and their own transceiver/receiver arrays, which are set by the different acquisition software packages. Surface sound velocity (SSV) is recorded in real-time (1/sec) by SV&P SMART probes, mounted starboard and redundant portside, near the transducer of the two MBES. Sound velocity profiles (SVP) were calculated from several CTD down-casts (n=28) or directly acquired with expendable sound velocity probes (XSV; n=2). SVPs were updated almost daily due to the high variability of the sound velocity in both working areas over the entire water column (Figs. 5.1.1 and 5.1.2).

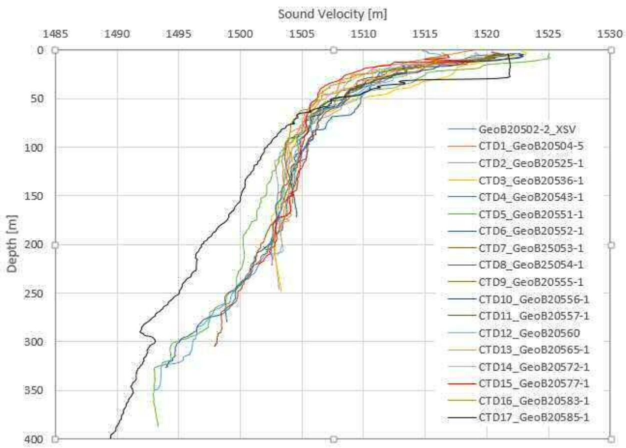


Fig. 5.1.1 *SVPs measured offshore Namibia showing a high variability of about 10m/s down to 40 m water depth between Dec 31, 2015 and Jan 14, 2016. The CTD17 SVP was conducted in 1000 m water depth.*

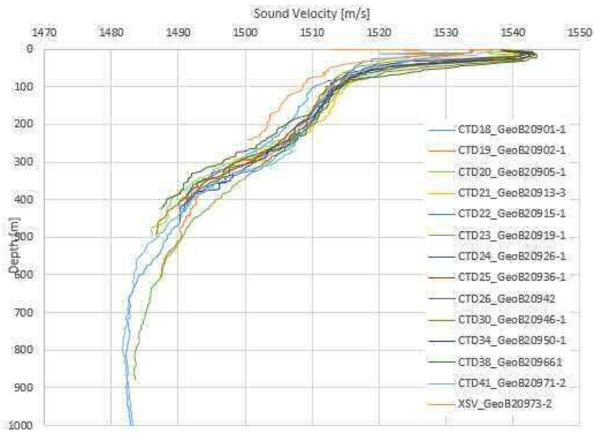


Fig. 5.1.2 *SVPs measured offshore Angola with very high sound velocities near sea surface and at least two well established water masses down to 500 m water depth. CTD18 SVP and CTD41 SVP were conducted in 1000 and 2000 m water depth, respectively.*

5.1.2 Ultra-short Baseline (USBL) POSIDONIA

IXSEA's POSIDONIA 6000 is a hull-mounted ultra-short baseline (USBL) underwater navigation system and maintained by the scientific-technical service (WTD) on-board R/V METEOR. The latest calibration of POSIDONIA has been conducted in Oct, 2015. Configurations used during M122 are provided in Appendix 1. During the cruise, the system was used to supply navigation to the INS of ROV SQUID until dive 8 (GeoB

20904; Jan 15, 2016). A transmission failure prohibited its application afterwards. To assure a proper refraction through the water column the SVP was updated for every area of investigation in the acquisition software ABYSS. During ROV dives 1 to 5 (GeoB20505, -12, -13, -47 and -59) the raw-signal was logged, while for dives 6 to 8 (GeoB 20576, -81, and GeoB20904) the POSIDONIA spike-rejection filter was applied. It clearly enhances the calculations and navigation/depth output of the Kalman-filter, integrated in the ROVs INS (MiniPOS).

5.1.3. Multibeam Echosounder (MBES)

(a) Data Acquisition

MBES surveys were conducted in parallel with KONGSBERG EM710 and EM122, both hull-mounted MBES with linearly arrayed transducers in a Mills cross configuration. Wherever applicable the orientation of the surveys was planned according to the weather conditions, avoiding aeration and motion-artefacts due to wind and crosscutting waves. SVPs were measured and applied to the raw data during acquisition using the SIS software from KONGSBERG. The **EM122 MBES** is a deep-sea system operating with 11.5 to 12.5 kHz. On-board R/V METEOR, a beam width configuration of 1° (TX) and 2° (RX) is installed. A swath angle of up to 150 degrees and a maximum coverage of 5.5 times the water depth can be reached. During cruise M122, the maximum swath width was set to 120 degrees to improve data quality, reduce the amount of noisy data at the outer beams, and increase the ping rate. The **EM710 MBES** is a shallow- to medium-water system operating with 70 to 100 kHz. A swath angle of up 150 degrees with a maximum coverage of 6 times the water depth down to about 800 m water depth can be reached. On-board R/V METEOR, a beam width configuration of 1° by 2° allowed a high density "soft-beam-forming" of 400 beams per ping. During cruise M122, the EM710 was set to a swath width of 120 degrees. A first malfunction of one of the EM710's signal processing boards (BSP) occurred on Jan 21, 2016. One board was changed by a spare part but the same error appeared on another BSP just the next day. For one day a complete shutdown and restart helped reactivating the system every 3-4 hours. When the periods shortened to 1-2 hours on Jan 23, 2016, the system was switched off. Further runtime parameters for both systems are provided in Appendix A.

(b) Post-Processing

The free and open source software package MB-System (vers. 5.4.2213; see Caress and Chayes 1995) was used for bathymetric post-processing. The large amount of data impeded processing the whole dataset. The EM122 dataset recorded off Namibia remained untouched while for the EM710 data the following steps were conducted to about 60% of the entire M122 surveys:

- Converting the data to editable MB-format.
- Applying correct SVP if needed.
- Applying tide correction (see Fig. 5.1.3).
- Manual editing of the dataset.
- Correcting amplitude (aka backscatter) and sidescan (time series) values based on a function of grazing angle with respect to the seafloor (slope).
- Applying the changes to the raw files, creating processed files
- Grid the data, using netCDF (GMT) file format.

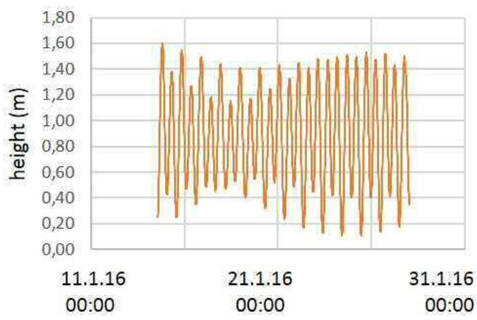


Fig. 5.1.3 *Tide curve at Porto Amboin, Angola, used for the tide correction of the MBES datasets off Angola.*

The generated bathymetry maps are presented in chapters 6.1.1 and 6.2.1. ESRI ArcGIS vers. 10.3.1 was used to create maps and a sustainable spatial data management of the data obtained during the cruise. First detailed processing revealed a small roll-calibration error, which will be corrected later on.

5.1.4 ATLAS PARASOUND Sub-Bottom Profiler (SBP)

The hull-mounted ATLAS PARASOUND P70 is a deep-sea parametric sub-bottom profiler (SBP) which utilizes the parametric effect based on non-linear relation of pressure and density during sonar propagation. Two high intensity waves with frequencies of ~18-20 kHz (aka primary high frequency, PHF) and a 22-24 kHz wave were used to create a so-called secondary high (about 40-42 kHz) and a secondary low frequency (SLF) of about 4 kHz. While the SLF is used for the sub-bottom profiling, the PHF signal can be recorded synchronously to image potential gas bubbles, plankton, fishes or nepheloid layers in the water column. The opening angle of the transducer array is 4° by 5°, which corresponds to a footprint size of about 7% of the water depth. The data acquisition was performed with the real-time values of SSV measured close to the Tx/Rx-array (System C-Keel) and a static SVP of 1500 m/s (C-Mean). The program ATLAS PARASTORE is used for storing and displaying echograms, while the program ATLAS Hydromap Control (AHC) is used to set proper hydroacoustic settings during acquisition (shown in Appendix A). During PARASOUND operations, data of the entire water column and sub-bottom are recorded and stored as vendor-specified *.asd files. The obtained data can be replayed in PARASTORE. Along with this raw files so-called *.ps3 and auxiliary data files were recorded for a certain given depth window. The ps3-file format is used to further process and convert the data to SegY format or used to directly plot (on-the-fly processed) profiles with the SeNT software (developed by V. Spiess & H. Keil, MTU-GeoB, University of Bremen, Germany).

5.1.5 Acoustic Doppler Current Profiler (ADCP)

Data were recorded from the two shipboard Acoustic Doppler Current Profiler (ADCP), the RDI Ocean Surveyor 38 and 75 kHz, both phased array. The systems are fully operational and require minimal operator interference. Data were acquired using the RDI software VMDAS (Vessel-Mount Data Acquisition). Operating parameters used during M122 are provided in Appendix A. To avoid interference with the MBES signal, ADCPs were turned off during most MBES/PS surveys but turned on during station work or on transits. Detailed information can be found in the hydroacoustic protocol (pwintersteller@marum.de). Due to the malfunction of POSIDONIA, the ADCP 38 kHz was removed from the moon pool Jan 15, 2016, in order to install the GAPS USBL system for the ROV SQUID.

5.1.6 Hydroacoustic Data Acquisition

The weather during the cruise was ideal for the hydroacoustic data acquisition. Low wind (usually below 5 Bft) and waves below 2 m created optimal conditions for the MBES and PARASOUND-SBP surveys (conducted at an average speed of 8-9 knots). The PARASOUND-SBP reached penetrations of up to 170 m off Namibia (in very well layered sediment packages) and of up to 120 m off Angola. A last 24-hour survey was conducted during the transit from Angola to Walvis Bay. Note, since EM710 had a malfunction and was not applicable after Jan 22, 2016, the data was partly recorded with EM122. Therefore, the given statistic provided in Appendix A is largely a combination of EM710 and EM122 data.

5.2 Multichannel Seismics

J. Haberkern, C. Ramos, F. Bergmann

During cruise M122, seismic equipment of the working group Marine Technology/Environmental Research at the Department of Geosciences (MTU-GeoB), University of Bremen, was combined with equipment of the Fraunhofer IWES. High-resolution multichannel seismic data (list of seismic profiles recorded during M122 is provided in Appendix B) were acquired to image the sedimentary structures on a meter-scale, which can usually not be resolved by conventional seismic systems. Main components of the system were the seismic source, the streamer, the acquisition system, the trigger unit and the GPS/Navigation system from the ship. (Fig. 5.2.1).

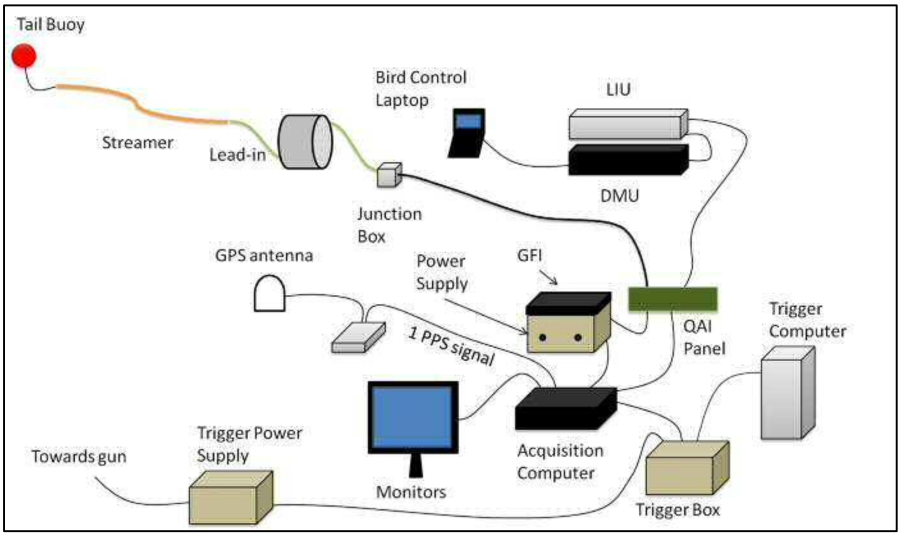
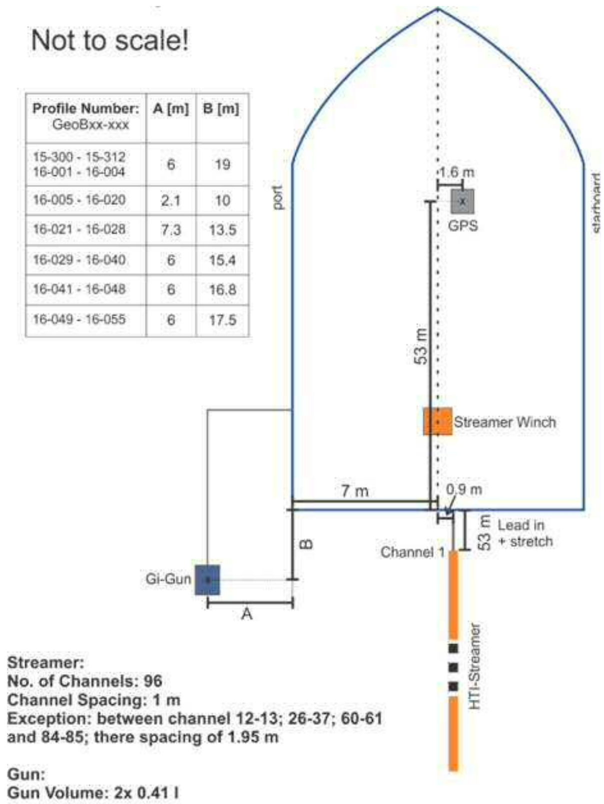


Fig. 5.2.1 *Schematic drawing of all components of the seismic acquisition systems used during cruise M122.*

5.2.1 Wet End (In Water Equipment)

Recording: A Hydroscience Technologies Inc. (HTI) 96 Channel digital streamer of 120 m length was used comprising 5 sections, the first and the last sections having 12 channels, and the three central sections having 24 channels each. The first and the last sections included 12.5 m of stretch. All channels within the sections were spaced by 1 m and between sections by 1.95 m. The data was digitized on the streamer previous to transmission by four HTI SeaMUX A/D converters, which were built-in between the sections. The streamer was towed with a Lead-In of ~30.5 m, which together with the stretch of 12.5 m amounted for 53 m distance between the first channel and the ships stern (Fig. 5.2.2).

Streamer depth control: Four ION 5010 DigiBird units were used for depth control. Each allowed an adjustable depth control and provided depth information through pressure sensors. The streamer depth varied between 1.5 – 2 m, adjusted depending on weather conditions. Three birds were attached in the centre of the first three streamer sections. For the first survey, the fourth bird was situated in the last section. Since the fourth section surfaced multiple times, the bird was moved to the fourth section and the tail was trimmed with lead instead.



Profile Number: GeoBxx-xxx	A [m]	B [m]
15-300 - 15-312 16-001 - 16-004	6	19
16-005 - 16-020	2.1	10
16-021 - 16-028	7.3	13.5
16-029 - 16-040	6	15.4
16-041 - 16-048	6	16.8
16-049 - 16-055	6	17.5

Fig. 5.2.2 *Towing geometry during cruise M122.*

Source: A Sercel MiniGI gun was operated without volume reducers for a total of 0.49 lt. (30 cu.in.) in both generator and injector chambers. This type of source injected a secondary pulse on the primary bubble to control bubble oscillation and source signature. The injector was triggered with a delay of 15 ms to the generator signal. High-pressurized air was provided by the compressor container manufactured by Sauer Company. The gun was shot at an air pressure of 150 bar. Shooting rates where adapted depending on water depth to ensure optimal coverage as well as recording of maximum signal penetration. With an average speed of ~4.5 knots during seismic profiling the shot point distance amounted to approx. 7-10 m. The gun was towed at port side with varying distances (Fig. 5.2.2).

5.2.2 Dry End (Shipboard Equipment)

Power supply: A Glassman High Voltage power source supplied power to the streamer. During normal operation, the streamer was supplied with a constant current of approximately 750 mA and used approximately 8-10 V per active section. Power was controlled by a Ground Interrupt Unit (GFI) to prevent damage to personnel and equipment.

Recording: HTI NTRS (New Technology Acquisition System) comprised computer and acquisition software. It was interfaced with the streamer through a Quad-Array Interface Panel (QA), ~ 50 m decks cable and a deck Junction Box. The acquisition software provided nearly continuous recording of the 96 channels in an HTI internal SEG-D format (*.s1) to hard disk. Maximum sampling rate provided was 250 µs. For online quality control, shot gathers were displayed. Additionally, the monitoring of A/D-converter parameters such as voltage, temperature, pressure, and calculated parity errors was possible.

Depth Control: The "depth control computer" and "ION System 3" bird control software was applied and was interfaced through the streamer using magnetic communication coils. Two additional units were necessary for communication, the Data Management Unit (DMU) and the Line Interface Unit (LIU). Both acted as physical interfaces between the shipboard computer and the sensors on the cables. Bird depth and additional parameters could be manually checked and modified. As this produced an interference signal it was only performed occasionally.

Triggering system: A custom trigger system was used. The unit was set up on an IBM compatible PC with a Windows NT 4.0 operating system and included a real-time controller interface card (SORCUS) with 16I/O channels, synchronized by an internal clock. The unit was connected to an amplifier unit and a gun amplifier unit. The PC ran custom software, which allowed defining arbitrary combinations of trigger signals, which were used to optimize the available recording time for the seismic source and to minimize shot distance. The amplifier unit converted the controller output to positive TTL levels. The gun amplifier unit, which generates a 60V/ 8A trigger level, controlled the magnetic valve of the gun.

On-board data processing included the conversion of the HTI internal SEG-D format to SEG-Y format (IBM) using the custom made software ps32sgy. The SEG-Y data were then loaded into the Vista Processing suite. To geo-reference the data, shot times were exported for each shot - receiver couple. In combination with the ships navigation data, exact coordinates for the gun and all receivers were calculated for each shot in the custom-made software WinGeoApp. The coordinates were re-imported into Vista where the data were binned into CMP bins of 1 m along track distance. Furthermore, a gun delay of 13 ms was corrected as well as normal moveout (NMO) assuming an overall constant velocity of 1500 m/s. For a first profile view, data were ormsby filtered (20/40, 1000/2000), scaled and stacked. First on-board interpretation was performed with the Software "Kingdom". Data examples are presented in chapters 6.1.3 and 6.2.3.

5.3 Hydrography with CTD and Water Sampler

C. Dullo, F. Mienis, R. Eichstädter, S. Flöter, A. Gori, C. Orejas, D. Saturov, A.-M. Wefing

5.3.1 Objectives

The major objective for the Conductivity-Temperature-Depth (CTD) measurements during cruise M122 was to determine general water mass characteristics, i.e. the physical parameters of water masses as well as the geochemical composition, to determine the presently dominant water masses influencing the cold-water coral (CWC) ecosystems investigated off Namibia and Angola. Therefore, in addition to physical properties, water samples were collected for stable isotope (C and O) analysis, suspended particulate matter (SPM) as well as for nutrients. Additionally, large volume thermocline waters were collected for analysis of the radiogenic Nd isotope composition as well as the rare earth element (REE) contents, proxies for provenance and chemical cycling. The scope beyond the available hydrographic and geochemical data was clearly to resolve the local to regional variability of water masses in the close vicinity of CWC habitats including variability in space (transects) and time (tidal cycles).

5.3.2 Sampling and Methods

The CTD profiler applied during M122 was a Seabird "SBE 9 plus" underwater unit and a Seabird "SBE 11plus V2" deck unit. The SBE 9 plus was additionally equipped with two dissolved oxygen (O_2) sensors, a chlorophyll-a sensor, a combined fluorescence and turbidity sensor (Wetlabs), and a Seabird bottle release unit including a rosette water sampler for 24 10L Niskin® water sampling bottles, that were electronically triggered to close at given depths on the up-cast of the CTD profiles. For the analysis and interpretation of the measurements, the downcast raw data were processed with “SBE Data Processing” software. The CTD system provided by the ship operated very reliable. To visualize the data, we used "Ocean Data View" software (mp-Vers. 4.5.7; www.odv.de).

In total, 41 CTD casts were performed. From each station, bottom water was sampled to study hydrochemical (geochemical) variabilities. For suspended particulate matter analysis, 10L of bottom water were sampled from most of the stations, as well as the same amount from the chlorophyll maximum in the surface water. The water was filtered over pre-weighed GFF filters and filters were stored at -20°C. These filters will be later analysed for stable carbon and nitrogen isotopes and pigments at NIOZ. In addition, a nutrient sample was collected from bottom and surface waters. For the study of water mass characteristics and their relation to palaeo-water masses, another 10L of water were sampled 20 m above the bottom from intermediate depths and from the level of the chlorophyll maximum. Furthermore, the ecophysiology and macrobenthos working groups (IEO/UB and SAM) were supplied with bottom water for cultivating living biota, which were sampled during the ROV dives. Large volume water samples for further geochemical studies of radiogenic isotopes and REE were acidified according to the GEOTRACES guideline (www.geotraces.org) and were stored for shipping to IUPH where the chemical extraction of REE will be conducted as well as the isotopic analyses.

5.4 Sediment Sampling Gears and Sample Treatment

C. Wienberg, A. Freiwald, M. Bender, K. Dehning, R. Eichstädter, L. Hoffmann, F. João, M. Lavaleye, K. Matsuyama, B. Meyer-Schack, F. Mienis, I. Moçambique, A.-M. Wefing, M. Wilsenack

5.4.1 Grab Sampler (GS)

For qualitative samples of surface sediments and benthic fauna, a Van-Veen-type grab sampler was deployed at a total of 25 stations off Namibia and at a total of 19 stations off Angola, of which 24/17 deployments (93%) were successful (a brief sediment and fauna description of each grab sample is provided in Appendix C). The grab samples were photographed, the sediments and living and dead faunal composition described. Living fauna was fixed in 95% ethanol.

One sub-sample of each grab was collected for future grain size analyses at the laboratories of MARUM for the purpose to calibrate ("ground truth") MBES-derived backscatter data. For some grab samples (see Table 5.4.1), samples were also collected for further metabarcoding analyses (see chapter 5.4.3).

The remaining sample was washed through sieves of 5 mm, 2 mm, 1 mm, and 0.5 mm mesh sizes and dried. The sieving residue meta data were documented on-board within the "SAM-Archive" data base. The sieving residue itself will be stored at SAM in Wilhelmshaven, and provided on demand for further taxonomical analyses.

5.4.2 Giant Box Corer (GBC)

A giant box corer was the main sampling tool for undisturbed surface sediments during R/V METEOR cruise M122. The box corer had a diameter of 50x50 cm and a height of 55 cm. It was deployed at a total of 12 stations off Namibia and three times off Angola, of which 10/2 deployments were successful (80%; a brief sediment-fauna description of each box core is provided in Appendix C), three times the corer was empty. The low number of box cores collected off Angola was attributed the rather steep flanks of the Angolan CWC mounds, which largely avoided a secure deployment of the box corer. The following standard sub-sampling scheme was conducted on each successfully recovered box core (see also Fig. 5.4.1; for list of sub-samples see Appendix C):

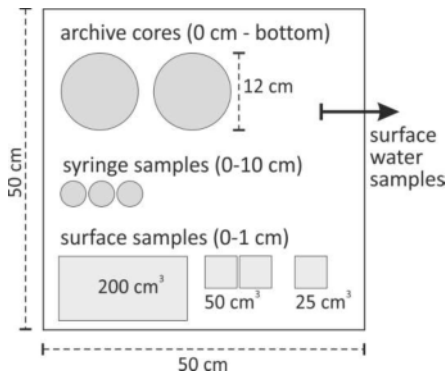


Fig. 5.4.1 *Standard sampling scheme applied for giant box cores (incl. water samples, surface sediment samples, and archives cores) collected during cruise M122.*

a) Water sampling. (GEOMAR, NIOZ, IEO)
b) Rinsing of the remaining super-standing water to sample living fauna. (SAM)
c) Collecting of living fauna from the sediment surface and fixation in 95% ethanol. (SAM)
d) Surface sediment sampling (0-1 cm) for further grain size analyses (25 cm^3). (MARUM)
   Surface sediment sampling for further foraminifera analyses (50 cm^3, 200 cm^3). (SAM, MARUM)
e) 3x syringes (3x 50 ml) from the upper 5 cm plus 3x 1cm^3 for further metabarcoding analyses. (NIOZ)
f) Sampling of the sediment column by 2 archive cores (12 cm in diameter). (MARUM, SAM)
g) Sieving of the remaining sediment column over 4 sieves (5 mm, 2 mm, 1 mm and 0.5 mm) to collect bioclasts. Fossil fragments were dried, living organisms fixed in 95% ethanol. (SAM)
   Selected fossil cold-water coral fragments will be used for dating analyses. (MARUM, IUPH)
h) Documentation of the sieving residue meta data within the "SAM-Archive" data base. The sieving residue itself will be stored at SAM in Wilhelmshaven, and provided on demand for further taxonomical analyses. (SAM)

5.4.3 Assessing Macro-, Meio-, and Microbenthic Diversity by Metabarcoding

<u>M. Lavaleye</u>, F. Mienis

Marine benthic ecosystems are often characterized by high biodiversity and are of global importance to climate, nutrient cycling and primary and secondary productivity. In general, a loss of biodiversity is believed to have a negative effect on the stability of the ecosystem, meaning e.g. a higher vulnerability to diseases and invasions. For this reasons measuring and monitoring biodiversity is thought to be important. Collecting data on the biodiversity of marine benthos in the traditional way by looking at morphological differences is a time-consuming and costly process as it requires taxonomic expertise, which is scarce, particularly for invertebrates. The identification of species based on morphological characteristics in marine benthic samples is often restricted to larger and distinguishable metazoans, often neglecting cryptic species and immature specimens. Moreover, meiofauna species are often omitted although these smaller species are often referred to as sensitive indicators for changing habitats. Identifying species with DNA techniques is quickly evolving and is becoming faster and cheaper. Metabarcoding has the potential to allow us to assess biodiversity in a new, i.e. consistent and replicable way across different ecosystems. Metabarcoding is by now a commonly used term in microbiology for the study of the complete genetic material obtained from environmental community samples. However, up to now this technique has been rarely used to analyse the metazoan species of all taxonomic groups in bulk sediment samples.

During cruise M122, three syringe samples (50 ml, 0-5 cm) were taken from box corers (n=10) and grab samplers (n=6) to extract DNA and to identify the metazoan species with the metabarcoding technique, with the purpose of eventually getting a detailed biodiversity assessment of the different stations. For the analyses of the microbiota, three small surface sediment samples (1 cm^3) from the same samples were taken. If the box cores still contained overstanding bottom water, 6 L were filtered to extract suspended microbiota for the same purpose (a list of sub-samples is provided in Appendix C).

5.4.4 Gravity Corer (GC)

C. Wienberg, M. Bender, K. Dehning, B. Meyer-Schack, F. Mienis, A.-M. Wefing, M. Wilsenack

A gravity corer with a pipe length of 6 or 12 m and a weight of 2 tons was applied to recover long sediment sequences. Imprints of the manufacturer along the plastic liners were used to retain the orientation of the core. Once on-board, the sediment core was cut into 1-m-sections, closed with caps on both ends and labelled according to a standard scheme (Fig. 5.4.2).

Off Namibia, the gravity corer was used at 19 stations (17x equipped with 6-m-long and 2x with a 12-m-long core barrel), thereby collecting twelve coral-bearing (on-mound) cores and seven coral-barren (off-mound) cores. Eighteen coring attempts were successful, only once the core pipe was slightly bent, but the core material could be recovered. Sediment recoveries ranged between 0.24 m and 10.21 m resulting in a total recovery of ~82 m. Off Angola, the gravity corer was deployed at 11 stations (1x 6-m and 10x with a 12-m core barrel), collecting nine on-mound and two off-mound cores. All coring attempts off Angola were successful and sediment recoveries ranged between 4.51 m and 10.44 m resulting in a total recovery of ~76 m. Overall, ~158 core metres were recovered during the entire cruise M122.

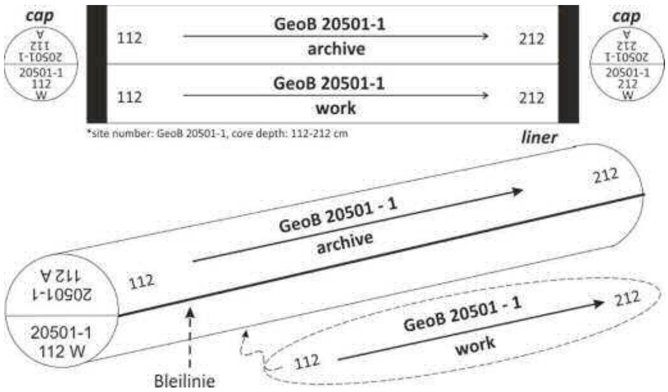


Fig. 5.4.2 *The 1-m-long core sections are closed with caps on both ends and labelled according to a standard scheme for GeoB cores of the MARUM (Bremen).*

Seven off-mound cores were opened on-board and visually described. On the archive halves, line- and colour-scans were performed (see Appendix D). Two series of syringes (10 ccm) were sampled in 5-cm-intervals from the work halves for e.g., stable isotope, radiocarbon, grain size analyses at the home laboratories. All coral-bearing on-mound sediment cores (n=21; 120 core metres) and two (Namibian) off-mound cores, the two latter containing large bivalve and gastropod shells, remained unopened, as they will be scanned by computer tomography before opening. The coral-bearing on-mound cores will be used for coral quantification, coral dating and calculation of mound aggradation rates as a cooperation between MARUM and IUPH. All sediment cores collected during cruise M122 are stored in the MARUM core repository at the University of Bremen.

5.5 MARUM SQUID ROV

N. Nowald, T. Leymann, C. Seiter, V. Vittori

The remotely operated vehicle ROV SQUID is a 2000 m depth-rated, light work-class ROV manufactured by SAAB Seaeye, UK. The ROV was adapted at MARUM for scientific use. The concept of ROV SQUID is to provide a powerful tool for the scientific community, realized on a small footprint at a considerably low weight that can be shipped within one 20" ISO container. The system was put into service in July 2015 and was deployed for the first time during M122. Overall, 16 dives were conducted with a total bottom time of 70 hours (for detailed dive statistics see Appendix E). The system consists of three major components: the vehicle, the winch and the topside equipment (Figs. 5.5.1 & 5.5.2).

Fig. 5.5.1 *(a) MARUM ROV SQUID (photo: D. Hebbeln). (b) The ROV vehicle and its winch installed on deck R/V METEOR (photo: C. Rohleder). (c) The sampling box incl. nets and a Niskin bottle for water sampling (photo: K. Matsuyama).*

5.5.1 Vehicle description

Dimensions and power: Vehicle dimensions are 2.1 x 1.2 x 1.9 m (LxWxH) with a total weight of the ROV of 1.3t. The topside power supply provides 3000 VAC at 800 Hz, which is converted by the transformer on the ROV to 500 V for the thrusters and hydraulics and 24 V for the low power devices such as cameras, the Pan and Tilt unit or LEDs. Overall power of the ROV is 45 KW. The vehicle is equipped with 11 thrusters, 8 horizontals and 3 verticals, providing a forward bollard pull of ~500 kg. The thruster power allows operations in areas with up to 3 knots current velocities.

Navigation: The ROV SQUID is equipped with a standard navigation sensor package (comprising the Valeport MiniPS depth sensor and the Tritech PA200 altimeter), which measures the height of the ROV above the seafloor. These sensors are used for auto-altitude and auto-depth hold manoeuvres. The CP16 navigation pod comprises an integrated 3D magnetometer (3D compass) with an embedded processor capable of calculating roll, pitch and yaw in real-time. Using the CP16 navigation pod, auto-heading as well as pitch/roll hold are possible with the ROV. The ROV SQUID is equipped with a CDL MiniPOS/NAV3 navigation unit, which is a fully self-contained Attitude Heading and Reference System (AHRS). It comprises a gyrocompass based around a Monolithic Ring Laser Gyrocompass (MRLG). Together with the MRLG, three axis accelerometers make the MiniPOS a full inertial system. The MiniPOS is coupled to a RDI Workhorse Doppler Velocity Log (DVL) for precise navigation above the seafloor. The unit can also be used as primary navigation unit as it provides the same functionality as the CP16 navigation pod. The MiniPOS also calculates its own position, using the on-board sensors and a USBL input (see "Positioning"). A Tritech Seaking sonar is a dual frequency forward looking sonar operating at 325/675 kHz. The device is installed on the upper porch for full 360° obstacle detection/avoidance.

Cameras/Optics: The SQUID is equipped with 5 cameras. Two DSPL MultiseaCams serve as forward looking and rear cameras to monitor the orientation of the ROV umbilical. A vertically, on the front porched mounted DSPL Wide-I is giving a full overview of the area in front of the vehicle. An Imenco Tigershark stills acquires images at a resolution of 12 megapixels and is mounted on the Pan and Tilt unit of the vehicle. The external flashgun of the stills is installed at a 45° angle on the upper porch of the ROV. Main working camera is the Insite Pacific MiniZEUS MKII, likewise mounted on the ROVs Pan and Tilt unit. The MiniZEUS is a full HD camera with a resolution of 2.38 megapixel. The MiniZEUS has a hemispherical dome port and a fully corrected optical lens with a 10 x optical zoom. The optical lens corrects for chromatic, geometric and radial distortion that occur when using optical systems underwater. While diving, a live video stream of the MiniZEUS was streamed via the ship´s network allowing the entire scientific party to follow the video observations outside the ROV´s control lab. Two Imenco Dusky Shark line lasers are installed on the Pan and Tilt of SQUID. They project two parallel laser beams (lines) at a distance of 30 cm and can be used for size measurements of objects on the seafloor (Fig. 5.5.2).

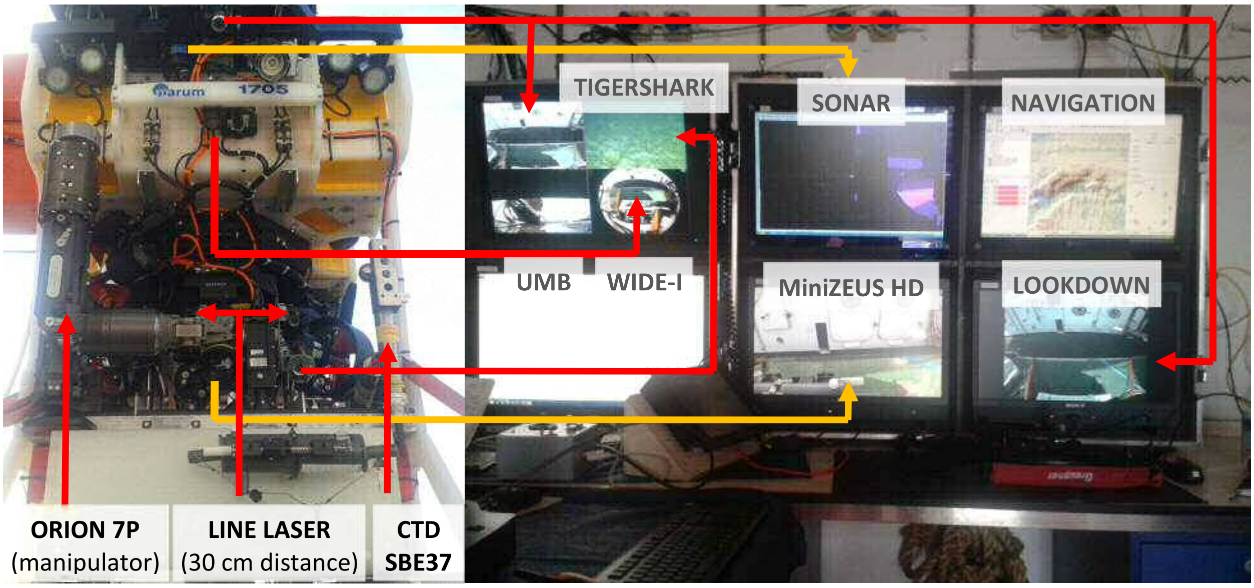


Fig. 5.5.2 *Front of ROV SQUID with its major components and video/navigation displays in the laboratory.*

Lighting: The SQUID comes with 6 x 24V dimmable LEDs at 3520 lumens. One pair is installed on the starboard side and the second pair on the port side of the ROV. The other two LEDs are placed on the Pan and Tilt unit and on the upper porch facing backwards towards the ROV umbilical.

Hydraulics: On-board, the SQUID is a hydraulic pump (iHPU) providing a maximum operating pressure of 210 bar. The pump supplies the vehicle´s manipulator and the drawer box of the tool skid with hydraulic power. The Orion 7P manipulator, manufactured by Schilling Robotics, is installed on the starboard side of the vehicle (Fig. 5.5.2). It is a fully proportional, hydraulical manipulator with 7 degrees of freedom. The reach of the arm is 1.5 m and has a lifting capacity 68 kg. The Orion is remotely controlled via a Master Controller, which is a miniature of the Slave Arm installed on the vehicle. The movement of the Master Controller directly translates into proportional movements of the Slave Arm, allowing precise operations beyond the centimetre range. The tool skid is mounted underneath the vehicle´s main frame. It carries the MiniPOS device and also a sample box that can be opened and closed hydraulically. The sample box is used to place scientific gear (e.g. nets) and also to store samples taken during the dive in several compartments.

Vehicle telemetry: The ROV uses a single mode fibre optic telemetry in combination with a Coarse Wave Division Multiplexer (CWDM). The CWDM increases the telemetry capabilities as it splits the light in several wavelength ranges that serve as individual channels for a variety of telemetry boards which provide i.e. video, serial or Ethernet links. All vehicle controls, videos, etc. run on a single fibre. Solely the MiniZEUS requires a dedicated fibre, due to the large bandwidth of the HD video signal. In addition, the SQUID has a Small Survey Pod inside the vehicle´s frame, for the integration of additional scientific sensors. 6 ports for serial communication, a 1Gigabit Ethernet link for sensors that require a high bandwidth and 2 additional PAL video channels.

Positioning: During M122, ROV SQUID used the acoustic POSIDONIA USBL positioning system installed on the R/V METEOR (dives 1-8). After the dropout of the POSIDONIA system, the portable USBL system GAPS (IXBlue) with an accuracy of 0.2% of the slant range was mobilized with the antenna being installed inside the moon pool of the vessel (dives 9-16). In addition to the position provided by the USBL systems, the MiniPOS of the SQUID calculates its own position by using all vehicle sensors and the USBL input. Once the inertial system of the MiniPOS is calibrated, the Aided Navigation mode becomes active. When available, the MiniPOS sends precise position updates at a much higher frequency (1 sec) compared to USBL systems. Furthermore, the Aided Navigation allows the vehicle to go into the station keep mode, that holds the ROV on position without being displaced in X or Y direction. While station keeping, the vehicle can be shifted in any X and/or Y direction at given distances with an accuracy of 10 cm. For instance, for the video-mosaicking carried out during dive #14 (GeoB 20951), the vehicle was displaced very precisely along several parallel lines between 5 and 10 m length at a line spacing of 1 m.

Video and Data: All navigation data from the ROV and the vessel are stored in a separate navigation file. The videos and still images contain a timestamp for georeferencing using the navigation file. The videos of the MiniZEUS and forward looking MultiseaCam were stored on hard disk in an MP4 video format. The ROV SQUID´s navigation software is a plug-in called POSIVIEW coded for the open source ArcGis software QGis. A georeferenced TIFF navigation map is used to display the position and heading of the vessel and the ROV on top of the map during the dives.

Scientific tools: As standard tools, three nets were installed inside the sample box (Fig. 5.5.1). A 1L Niskin water bottle was mounted on the front part of the box and was closed on demand by the manipulator. A SBE 37 CTD recorded oceanographical parameters such as oxygen and temperature, and the data were displayed in real-time in the ROV lab. A separate Bio-Box inside the main sample box served as a storage container for living (and light) organisms collected during the dives (a list of ROV samples collected during M122 supplemented by a brief description is provided in Appendix E).

5.5.2 Winch and Cable

The winch was designed and constructed by Mac-Gregor Hatlapa and has a weight of 4.7 t including the cable (Fig. 5.5.1). Overall dimensions are 2.1 x 1.9 x 1.9m (LxWxH). Maximum Line-Pull is 2.5 t on the lower layer and maximum spooling velocity is 30 m/min. The 19 mm soft umbilical was manufactured by Norddeutsche Seekabelwerke and has a total length of 2400 m. The inner part consists of three Aramid layers, resulting in a breaking strain of 120 kN and safe working load of 20 kN. Three 4^2 copper conductors supply the ROV with electrical power and 7 drain wires serve as protective earth. A total of 6 single mode fibres are available in pairs stored inside three individual metal tubes. During expedition M122, the winch was installed on the loading hatch of the R/V METEOR, which also served as the parking position for the ROV (Fig. 5.5.1).

5.5.2 Topside Equipment

The topside equipment consists of the 3kV transformer (described in chapter 5.51) and the control racks and video monitors, which were installed in one of the vessel's laboratories ("Grob-Nasslabor"). The control racks encompass two control cases, one for the vehicle control running e.g. the ROV control software ICON, and a second 19" case mainly used for navigation and video distribution/recording. In addition, two cases with monitors (Fig. 5.5.2) were placed on the tables of the vessel´s laboratory, which displayed the live videos and navigation software POSIVIEW for the pilot and co-pilot.

5.6 Lander Systems

5.6.1 NIOZ ALBEX Lander

F. Mienis, M. Lavaleye

During M122, two NIOZ ALBEX landers (Fig. 5.6.1) were deployed for short durations (2.5-8 days) in the coral mound areas off Namibia and Angola. During the deployments, the ALBEX landers consisted of an aluminium tripod equipped with 13 glass Benthos™ floats, two IXSEA acoustic releasers and a single 260 kg ballast weight necessary for deployment and recovery. A satellite buoy, radio beacon, flash light and large orange flag were attached to the frame to locate it after surfacing. Landers were equipped with an Aquadopp profiler current meter, a combined OBS and Fluorometer (Wetlabs) connected to a NIOZ-built datalogger, a combined temperature and dissolved oxygen sensor (RINCO) and a Technicap PPS4/3 sediment trap with a rotating carrousel with 12 bottles. The sediment trap was programmed to sample at a daily interval. On the ALBEX-TROL lander a HighDef video camera (Sony) with infra-red illumination (LED) was installed, directed at bait which was attached to the lander frame before deployment. The other ALBEX lander was additionally equipped with a McLane particle pump, fitted with 24 filter units over which 7.5L of seawater was filtered at two hour intervals. Suspended matter samples collected with the sediment trap and particle pump will be stored frozen and will be analysed for stable nitrogen and carbon isotopes at NIOZ.

5.6.2 GEOMAR SML Lander

C. Dullo, D. Saturov

One benthic lander system (satellite minilander = SML; Fig. 5.6.2) was deployed in both working areas (Namibia: 14 days, Angola: 8 days) to investigate the environmental boundary conditions of the CWC settings there. By using this lander system, the daily dynamics of biotic and abiotic processes can be investigated. Thus, the major focus was to improve the current understanding of the hydrodynamic boundary conditions, which control the development of CWC mounds off Namibia and Angola. The lander data are stored in the instruments and will be retrieved at home in the hydrophysical laboratory of GEOMAR. The SML Lander is equipped with (1) a 600 kHz ADCP Workhorse Sentinel 600 from RDI, (2) a CTD (conductivity, temperature, pressure) from SBE SBE16V2, (3) a fluorometer, (4) an optical turbidity logger from Wetlabs, (5) a dissolved oxygen sensor from SBE, and (6) a pH sensor from SBE. The sampling rate of each sensor was set to 5 minutes. The SML was deployed applying a video guided launcher system, which allowed the video controlled inspection of the seafloor, before the lander was released. As soon as the site was selected, the lander was acoustically released from the launcher about 1 m above the seafloor. Its final settlement on the seafloor was observed video controlled as well.

Fig. 5.6.1 *One of the ALBEX landers (NIOZ) during deployment (photo: D. Hebbeln).*

Fig. 5.6.2 *SML lander (GEOMAR) and launch system before deployment (photo: M. Lavaleye).*

5.7 Benthic Ecology and Ecophysiology

C. Orejas, A. Gori

5.7.1 Aquaria Experiments

Aquaria set-up: The aquaria set-up on-board comprised two tanks (50 litres capacity each): one for acclimation and maintenance and the other for the experiments. Tanks were connected to chiller units (Hailea chiller) in order to maintain controlled water temperature (Fig. 5.7.1). In the experimental tank a

Tele shake plate (Thermo Fisher Scientific) was installed in order to keep the water moving inside the jars used for the experimental incubations, which were conducted with specimens of *Lophelia pertusa* from the Angolan coral mounds, which were carefully collected by the ROV SQUID.

Experimental design: Incubation measurements of metabolic activity (respiration and ammonium excretion) and growth rates (calcification) were conducted under two treatments: (1) natural dissolved oxygen (O_2) concentration of ~2 ml L^{-1} (using the water sampled by the CTD-rosette at the same location and depth as the corals), and (2) reduced O_2 concentrations.

Lophelia pertusa specimens were collected on Jan 17, 2016, during ROV dive GeoB 20904 (Valentine Mounds, Angolan margin) at around 480 m water depth. Corals were immediately transferred to the cool room. Coral nubbins (~3-6 cm) were prepared using the best preserved branches from three different colonies. Eight nubbins were maintained in the acclimation tank (filled with water collected with the CTD-rosette close to the seafloor at ~500 m water depth) to allow the recovery of the polyps after manipulation. After some hours, each coral nubbin was transferred to the incubation chambers (~400 ml volume), which were filled with water from the CTD-rosette (also collected close to the seafloor). Each experimental chamber included a stirrer to keep the water in movement; once filled, chambers were closed with a lead and sealed with parafilm to avoid any gas exchange. During the entire experiment water renewal was manually carried out every six hours in order to provide the corals with fresh water, food and to avoid an ammonium increase in the chambers. Water was always collected by means of the CTD-rosette, and temperature and O_2 concentration were carefully controlled. Temperature and O_2 concentration was controlled in every single chamber before each water renewal. After three days under natural low O_2 concentrations, the first physiological measurement was carried out.

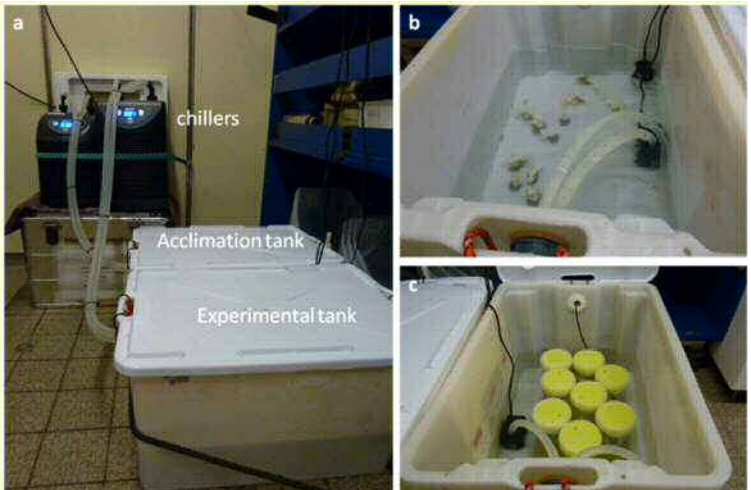


***Fig. 5.7.1** a) Aquaria experimental set up, chillers and the two tanks are displayed; b) acclimation tank with some nubbins of* Lophelia pertusa*; c) experimental tank with jars containing corals nubbins above the Tele shake plate.*

First physiological measurement: Coral growth and metabolism at T_0: The eight nubbins and four control chambers were incubated for 8 h in water collected from the coral's natural environment, which has a low O_2 concentration (~2- 2.5 ml L^{-1}). At the beginning and end of the incubation, temperature and O_2 concentration were measured, and water samples for ammonium and total alkalinity (TA) determination were collected. After this first incubation, four corals were further maintained under low O_2 concentrations, whereas for the other four corals, O_2 concentration was increased up to saturation levels. Corals were maintained under these two different O_2 concentrations for three more days, and water was renewed every six hours. After that time, a second physiological measurement was carried out.

Second physiological measurement: Coral growth and metabolism at $T_{3\ days}$: Four nubbins and two control chambers were incubated like in the 1st measurement, whereas the remaining four corals and two additional controls were incubated under high O_2 concentration. As in the previous incubation, at the beginning and end of the incubation temperature and O_2 concentration were measured, and water samples for ammonium and TA determination were collected. After the second incubation, corals were maintained four more days under the respective low and high O_2 concentrations. Water was renewed every six hours. After this period, the last physiological measurement was carried out.

Third physiological measurement: Coral growth and metabolism at $T_{1\,week}$: As for the second incubation, four nubbins and two control chambers were incubated with natural water with low O_2 concentration, whereas the remaining four corals and two additional controls were incubated under high O_2 concentration. At the beginning and end of the incubation, temperature and O_2 concenration were measured, and water samples for ammonium and TA determination were collected.

5.7.2 Benthic Trophic Levels in the Angolan Cold-water Coral Communities

Five specimens of the most abundant epibenthic megafauna organisms, representing different trophic guilds in the cold-water coral (CWC) communities of the Angolan mounds, were collected. Organisms were sampled with the ROV SQUID, the grab sampler and the giant box corer. Specimens (or fragments of the specimens for large organisms) were carefully cleaned in seawater, put in zip bags and/or vials and frozen at -80°C until stable isotope (^{13}C, ^{15}N) analyses will be performed in the home lab. These analyses will be combined with the same kind of stable isotope analyses, which will be conducted on the particulate suspended matter in water samples from the same location.

6. Preliminary Results by Region

6.1 The Northern Namibian Margin

6.1.1 Overview

During the time of planning the expedition M122, the only available site information for the northern Namibian margin were some hydroacoustic data obtained during R/V MARIA S. MERIAN cruise MSM20-1, when the newly installed EM1002 MBES has been tested. MBES/PS data revealed some conspicuous mound-like features in ~230 m water depth, which resembled cold-water coral (CWC) mounds from other Atlantic sites. However, ground truth information was not available at that time and World Ocean Atlas data indicated rather high temperatures and rather low dissolved oxygen (O_2) concentrations, at first glance disqualifying this area as a suitable CWC habitat.

The observations obtained during cruise M122 revealed that the temperatures (12°C-13.3°C) prevailing in those water depths occupied by the coral mounds (160-240 m water depth; see Fig. 6.1.1), probably still fit the thermal requirements of CWC such as *Lophelia pertusa*. However, O_2 concentrations of mostly below 0.5 ml L^{-1} are likely too low for *L. pertusa*, with respect to their (preliminary) defined oxygen thresholds ranging from ~3-7.2 ml L^{-1} (e.g., Davies & Guinotte 2011). Nevertheless, the ROV observations and the geological sampling clearly proofed these seafloor structures to be coral mounds, although these mounds show nowadays no active aggradation and living CWC are completely absent. Today, the mounds are covered with fossil coral rubble exclusively made up by *L. pertusa* overgrown by a sparse living benthic fauna that is probably also limited by the low O_2 concentrations. Interestingly, a distinct north to south trend towards a higher biodiversity was observed during the ROV-observations extending over an area of 30 nm.

Obviously, environmental conditions for the CWC must have been more favourable in the past. Strongly corroded coral fragments at the sediment surface, while well-preserved fragments prevail within the sediment column as revealed by the on-mound gravity cores, point to a long-lasting exposure time of the coral fragments at the seabed surface. Interestingly, since the demise of the CWC, no significant sediment cover has been deposited on the mounds. Up to 10-m long-sedimentary records obtained from these mounds, consisting of a mix of coral rubble, other bioclasts and hemipelagic sediments, will allow to define the period of active coral growth and active mound aggradation off northern Namibia. Speculations resulting from on-board discussion considering environmental and sea level changes in the past favour an Early Holocene period, but these need to be verified by radiocarbon or U-series dating of coral fragments collected from the cores. Layers of sandy sediments embedded in thick layers composed of large bivalve and gastropod shells and shell hash observed in some of the recovered off-mound cores might correspond to periods of coral growth and mound formation, with the latter also being dependent on the supply of sediments.

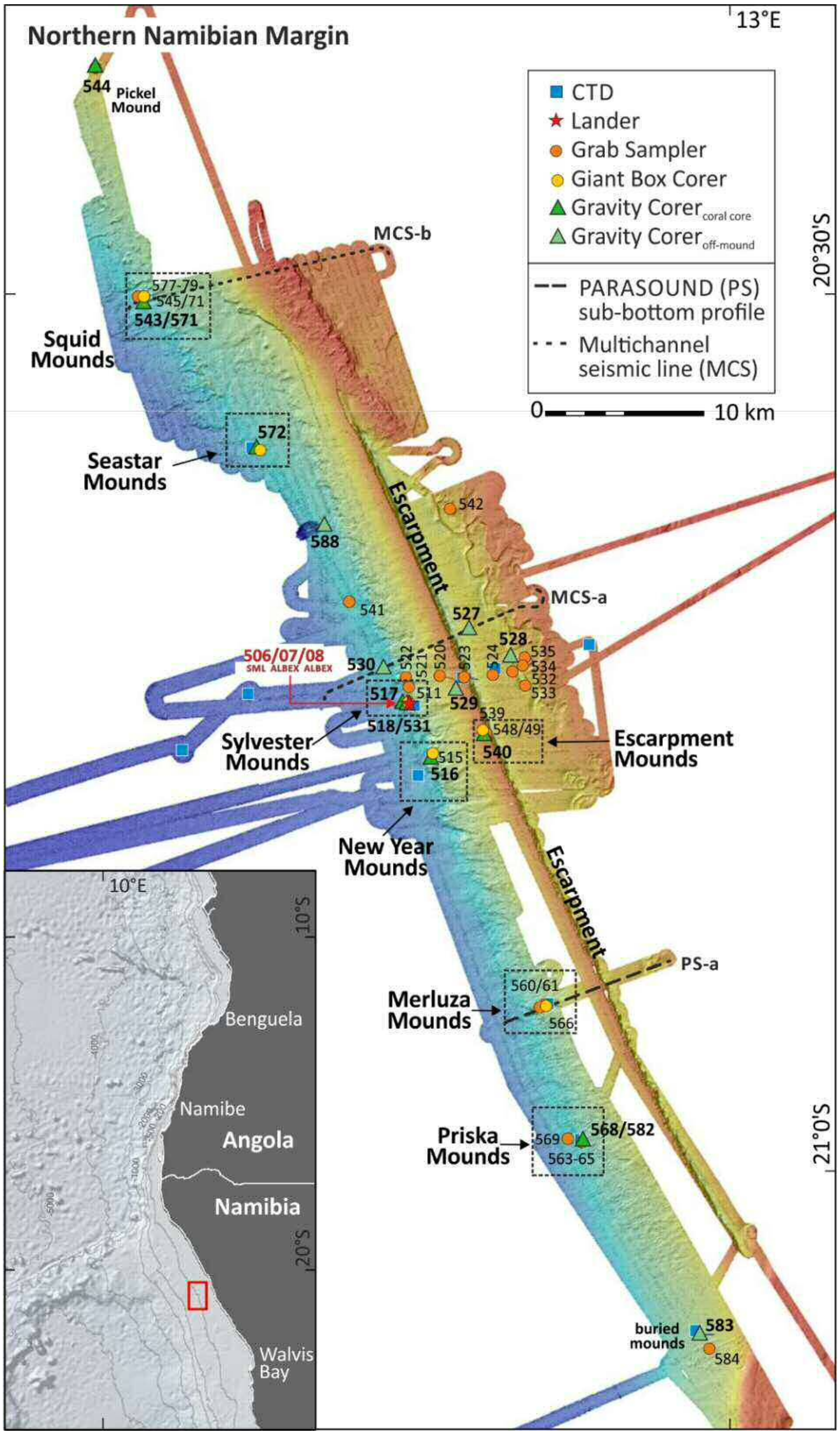


Fig. 6.1.1 *Multibeam bathymetry overview map of the Northern Namibian cold-water coral mound area mapped during M122.Indicated are sampling positions (GeoB 20xxx; see legend for gear symbols). Only those PARASOUND/multichannel seismic lines (PS/MCS; bold dashed lines) that are shown below are indicated. Cold-water coral mound/ridge sites investigated during M122 are marked by dashed squares.*

The coral mounds are part of a larger geomorphologic setting, which in the Namibian working area is dominated by a NNW-SSE stretching escarpment and various other erosive features (Figs. 6.1.1 and 6.1.2). A prominent almost horizontal reflector in the multichannel seismic data, found throughout the entire working area, excludes any tectonic imprint on the regional geomorphology. Many of the coral mound settings seem to be related to outcrops of older strata, which probably form hardgrounds that once enabled the settling of coral larvae under suited environmental conditions. The subsurface studies using PARASOUND and multichannel seismic data, further revealed that the observed mounds have their base more or less at the same level as the surrounding seafloor, and thus, are probably rather "young". No indication for any older or buried coral mounds has been found in the subsurface record.

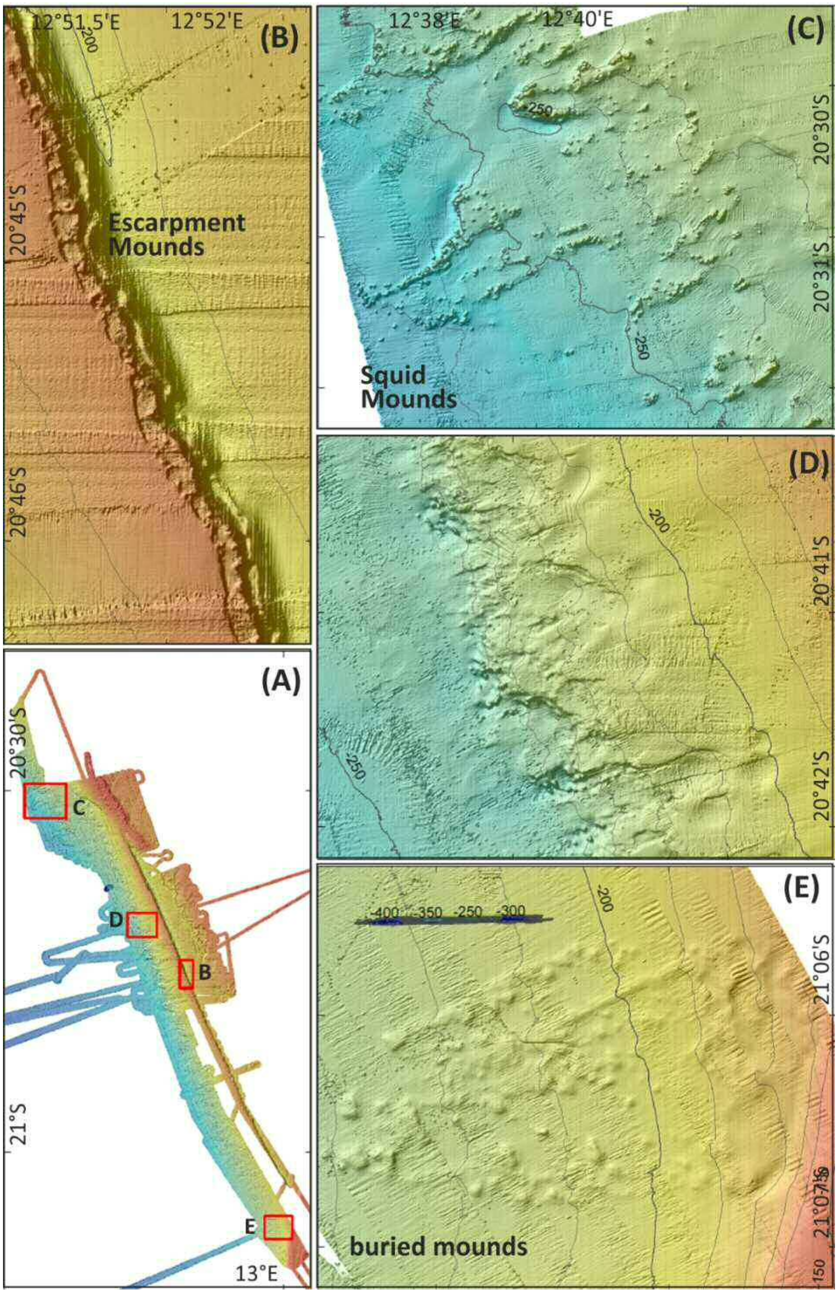


Fig. 6.1.2 *Close-ups of the various coral mound settings along the Namibian margin. (**A**) Overview map. (**B**) Escarpment Mounds in the center of the study area. (**C**) The Squid Mounds located on a subsurface height. (**D**) Coral mounds on the base of the westward facing slope west of the escarpment located on slump scars. (**E**) The southern, almost buried mounds.*

With respect to the hypotheses (H) formulated in chapter 3, the results from the Namibian coral mounds do not contribute to H#1 (oxygen tolerance) and H#2 (biodiversity), as we did not find any living *L. pertusa* in this region, where the O_2 concentrations in the depths of the coral mounds usually were below 0.5 ml L^{-1}. Obviously, H#3 (temporal variability) can be confirmed, as we did find widespread remains of a formerly vivid CWC ecosystem. However, regarding the environmental condition which triggered the coral growth of Namibia during the past only the future analyses in the home labs will provide some clues. The same also applies to H#4 (coral palaeo-archive). Finally, H#5 (tectonic forcing) has been disproved for the Namibian mounds as the position of the mounds is not linked to tectonics but to rather strong erosive settings that exhumed older and harder strata most likely serving as ideal settling grounds for the initial coral population.

6.1.2 The Water Column Structure

The water masses in the investigated area off Namibia derive from different sources, mainly from the western South Atlantic and from the Indian Ocean forming the South Atlantic Subtropical Surface Water (SASSW) and the South Atlantic Central Water (SACW). The SACW is characterized by pronounced linear trend in any given temperature salinity plot (TS plot) ranging from 16°C/35.5 PSU to 6°C/34.6 PSU. Both, SASSW and SACW comprise the wind driven Benguela Current (BC) flowing equatorward with average speeds of 10 – 30 cm s^{-1} (Shannon 2001). North of 30° this current spreads into its warmer oceanic (BOC) and cooler but nutrient-rich coastal branch (BCC; Shannon & Nelson 1996), which forms the water mass flowing over the Namibian shelf where the CWC mounds were encountered. Below the SACW, the less saline and cooler Antarctic Intermediate Water (AAIW) occurs, exhibiting a core temperature of 4-5°C and a salinity of ~34.5 PSU in a water depth around 700 – 800 m. The AAIW off Namibia also contributes to the NNW and NW transport of the BC, which is in the order of 15 – 25 Sv (Shannon 2001). Below the AAIW at around 1000 m, the North Atlantic Deep Water (NADW) is present indicated by increasing salinity.

Seventeen CTD casts were performed arranged parallel and perpendicular to the shelf including one deeper station down to 1000 m (GeoB20585-1). All casts exhibit SASSW and SACW, while AAIW and traces of NADW were encountered only in the deep station (Fig. 6.1.3). At the surface, SASSW shows 19.8°C potential temperature and a salinity of 35.22 PSU. SASSW stretches down to 85 m water depth, where salinity reaches 35.39 PSU at 14°C potential temperature. Further down, salinity and potential temperature decreases rapidly to reach 7.25°C and 34.6 PSU at 479 m comprising the SACW. Below 479 m water depth, the line in the TS plot is modified by an increased reduction in potential temperature and a lower decrease in salinity reflecting the first slight influence of the deeper AAIW. How-ever, we still ascribe the entire water mass between 85 and 600 m water depth to the SACW. In 600 m, potential temperature plots around 6.0°C and salinity reads 34.66 PSU, which marks the onset of the AAIW. The salinity minimum of the AAIW was observed at 783 m water depth with a potential temperature of 4.6°C and a salinity of 34.47 PSU. Traces of NADW were encountered below 1000 m. At 1030 m, the potential temperature and salinity recorded 3.83°C and 34.53 PSU, respectively. The deep (1000 m) station GeoB20585 (Fig. 6.1.3) exhibits little less saline SACW down to 291 m, which seems to be advected from the more central parts of the South Atlantic. Similar shifts were observed during some

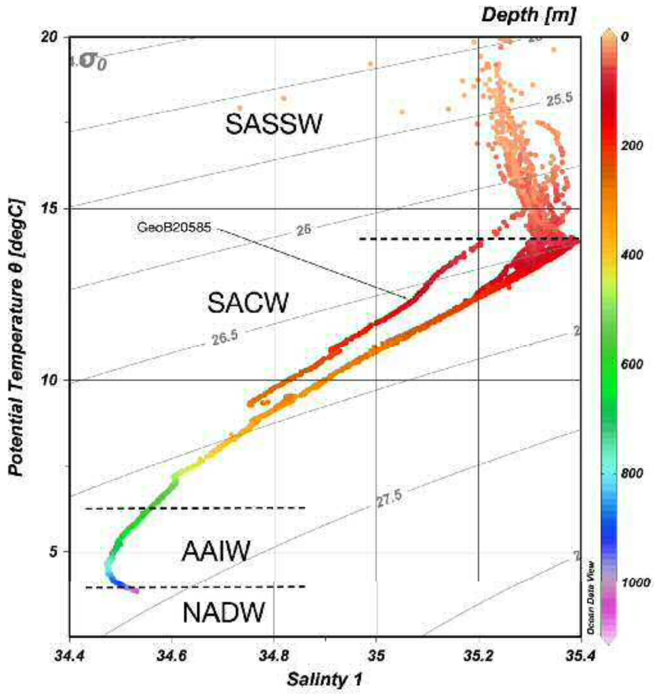


Fig. 6.1.3 *TS-plot of all 17 CTD casts in the working area off Namibia. SASSW = South Atlantic Subtropical Surface Water; SACW = South Atlantic Central Water; AAIW = Antarctic Intermediate Water; NADW = North Atlantic Deep Water.*

further offshore casts of the previous R/V METEOR cruise M120 and R/V MARIA S. MERIAN cruise MSM19 (pers. comm. G. Krahman, GEOMAR).

For all CTD casts, a pronounced oxygen minimum with minimum values of 0.14 ml L^{-1} was observed. Oxygen depletion commenced around 50 m water depth, still exhibiting values around 4 ml L^{-1} (Fig. 6.1.4a), while around 85 m, corresponding to the boundary between SASSW and SACW, values already plot between 1 and 1.5 ml L^{-1}. Below 150 m, oxygen concentrations exhibit values below 0.5 ml L^{-1} that get even down to below 0.1 ml L^{-1} close to the dead/fossil coral at the seafloor. Only sites GeoB20583-1 and GeoB20572-1 showed values slightly above 0.2 ml L^{-1} (Fig. 6.1.4b). Wind speeds were higher during casts of the stations GeoB20543-1, 72-1 and 83-1, which may have caused more upwelling. In stations off the shelf, we observed an increase in oxygen concentrations >1.0 ml L^{-1} below 347 m water depth. In the transition to the AAIW the concentration reached almost 2.0 ml L^{-1} and stays well above 3.2 ml L^{-1} throughout the whole water column down to the onset of NADW.

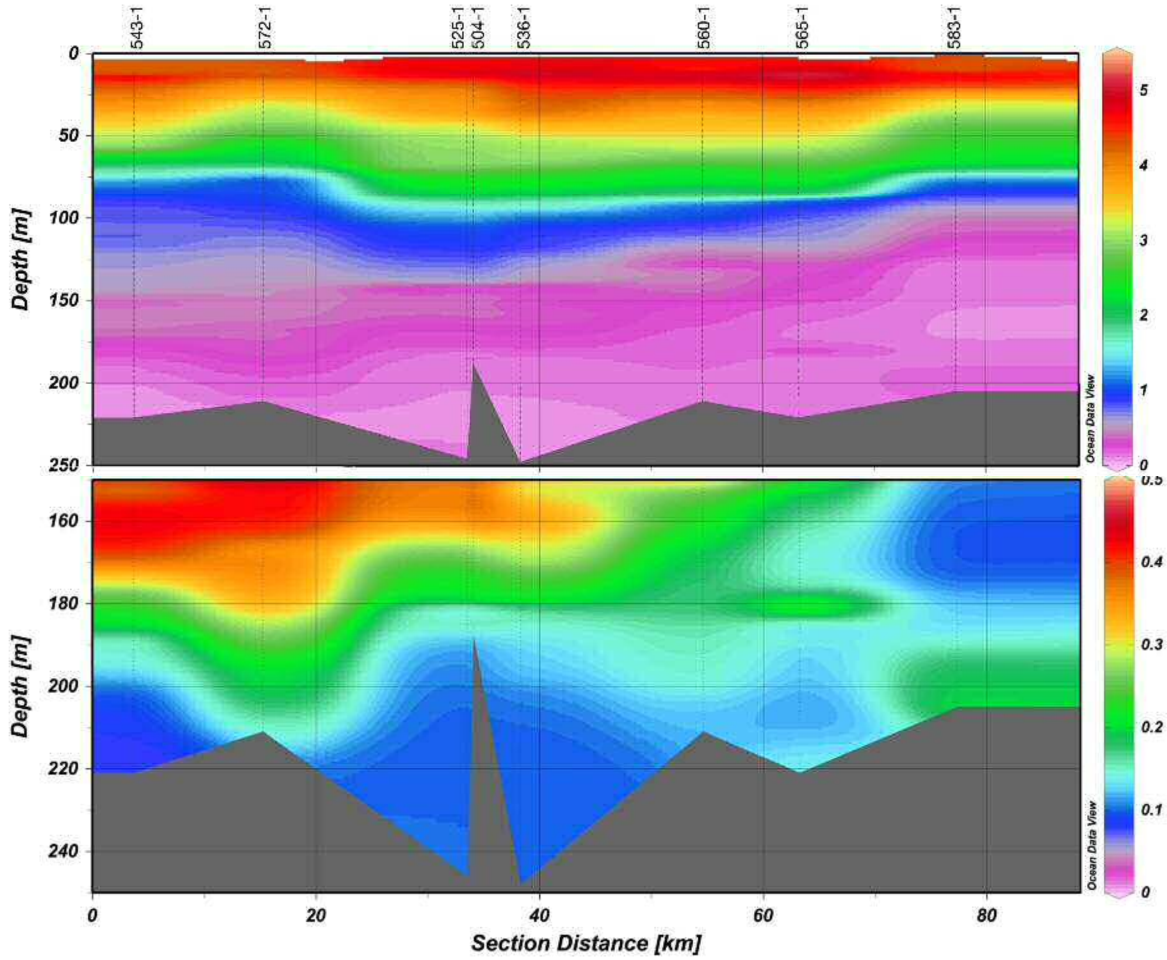


Fig. 6.1.4 *(**a**) Oxygen concentration in ml L^{-1} for the section parallel to the shelf along the Northern Namibian margin. Abbreviated station numbers indicate the CTD stations: only the last four digits of the full GeoB station number are given, thus, 543-1 corresponds to GeoB20543-1. (**b**) Oxygen concentration for the depth interval between 150 m and the bottom. The distance is similar in both sections.*

6.1.3 Bathymetry and Sub-Seafloor Structures

Off Namibia, an 1179-km^2–large area on the outer shelf west of the Namibian Skeleton Coast was mapped. It extends nearly 100 km in NW-SE direction and up to 17 km in SW-NE direction. Water depths within the area range between ~140 m and 400 m. The most prominent feature within the mapping area is represented by a straight, at least 63-km-long escarpment with heights of up to 45 m (Figs. 6.1.1 & 6.1.2B). The escarpment has a predominant strike direction towards 158°. Only the southern 15 km exhibit a slightly different strike direction of 153°. Its eastern margin is steep and exhibits slope angles of up to 40°. While the eastern slope is presumably erosive, the upper western slope, as well as an about 3.5-km-wide area east of the escarpment, show a smooth morphology, which might suggest sedimentation in these areas. About 3.5 km west of the escarpment the morphology changes abruptly. Shoal channels and a series of small headwalls are developed in a water depth of ~240 m. The crescent-shaped headwalls exhibit a secular strike direction more or less parallel to the escarpment. The area west of the headwalls changes laterally from a slightly hilly morphology towards a gentle westward dipping plain.

In the north-eastern part of the mapping area a submarine high, occurs at water depths < 160 m and a relative elevation of up to 40 m. Its north-eastern steep margin is about 12.5 km long, dips with up to 20° and strikes to the SE with an angle of about 150°. The south-eastern margin of the high dips more gentle with angles of only 1-2° and exhibits a wavy morphology. The northward striking headwalls, described from the western central part, ends in this area and merges morphologically with the outcrop of older strata further north.

Coral mounds in the mapping area occur in the various morphological settings described above. (i) Coral mounds with heights of 4-6 m are located directly on top of the central escarpment in water depths of about 170 m (Fig. 6.1.2B); (ii) in the NW (20.44°S - 20.60°S), the coral mounds occur between 270 and 230 m water depth, are up to 10-17 m high, and are rooted on small highs within the slightly westward dipping plain (Fig. 6.1.2C); (iii) between 20.71 and 21.00°S small clusters of coral mounds with heights of 3-12 m occur along small ridges and channel walls and appear in the vicinity of the crescent-shaped headwalls in water depths ranging from 230 to 255 m (Fig. 6.1.2D); and (iv) in the south, between 21.09°S and 21.12°S, potential small (< 4 m in height) coral mounds occur in water depths ranging from 230 to 180 m close to a north-south oriented escarpment (Fig. 6.1.2). Some of the mounds in the south seem buried by sub-recent sediments (Fig. 6.1.2E).

In general, all coral mounds exhibit a rather circular shape and their heights increase from the south to the north within the mapped area. Furthermore, multiple coral mounds were detected on the transit to Angola between 20°16'S and 20°26'S and in water depths ranging from 215 to 260 m.

The multichannel seismic profile MCS-a (GeoB15-306; Fig. 6.1.5), allows to identify several seismic units. In the lower part (below 350-400 ms TWT, secular unit 1) several stacked wedge shaped units occur. Internal reflectors dip westwards and are bounded either by high amplitude reflectors or by geometry changes. One exception is a unit that is onlapping on the unit below and thins out towards the east. Overall, internal seismic structure is subparallel and divergent with highly continuous reflectors. Reflector amplitudes vary strongly. Except for one unit in the east of the profile between 450 and 500 ms TWT, which displays less continuous to chaotic reflectors.

A significant change of seismic facies is marked by a high amplitude reflector starting at 400 ms TWT in the west of the profile and shallowing to the east of the profile. This unconformity is overlain by a setting of highly diverse reflections, which is grouped in two subunits. The lower subunit is approximately 50 ms TWT thick and displays lateral amplitude changes along contorted but generally seaward dipping reflectors. The boundary to the upper subunit is diffuse and transparent. The upper subunit is contorted in the east of the profile but displays subparallel, fairly continuous reflectors in the middle of the profile. Those are dipping towards the west of the profile and truncate at the seafloor. The seafloor topography in general follows the westward dipping trend but is modulated significantly by a channel and a ridge like escarpment with a height of 60 ms TWT.

Insight into sub-seafloor structures in the northern part of the study area is provided by the multichannel seismic profile MCS-b (GeoB16-013; Fig. 6.1.6). The lower seismic units are very similar to the units in MCS-a, except that they seem to be draping some pre-existing topography. This is visible in a bulge throughout all reflectors at ~13000 m distance along profile. The top of those lower units is indicated by the same high amplitude reflection already described for profile MCS-a, visible at around 35-

37 ms TWT. Again, this reflector marks a notable change in reflection patterns and its contact with the overlying units is discordant. However, the overlying units differ remarkably from profile MCS-a. Three subunits can be differentiated:

1. Directly above the high amplitude reflection, in the central and eastern parts of the profile, a thick (10-15 ms TWT), semi-transparent package appears. Internal reflectors within this subunit have very poor continuity. In the central part of the profile, the subunit extends to the seafloor and forms the escarpment. Here, reflectors near the seafloor are more continuous and have higher amplitudes. It is clearly visible that they truncate at the escarpment, indicating that it formed by erosion and/or mass wasting.
2. The second subunit is situated west and on top of the escarpment. It consists of high amplitude, seaward dipping and contorted reflections. Towards the western part, coral mounds have been identified at the seafloor, due to their pronounced morphology and the occurrence of diffraction hyperbola in the unmigrated seismic section. They are in contact with both, the high amplitude reflection and the previously described semi-transparent unit. Both contacts are discordant.
3. The third subunit occurs east of the escarpment. It is thin and of variable morphology. It shapes the seafloor on the eastern part of the profile, in the form of plateau shaped features separated by troughs.

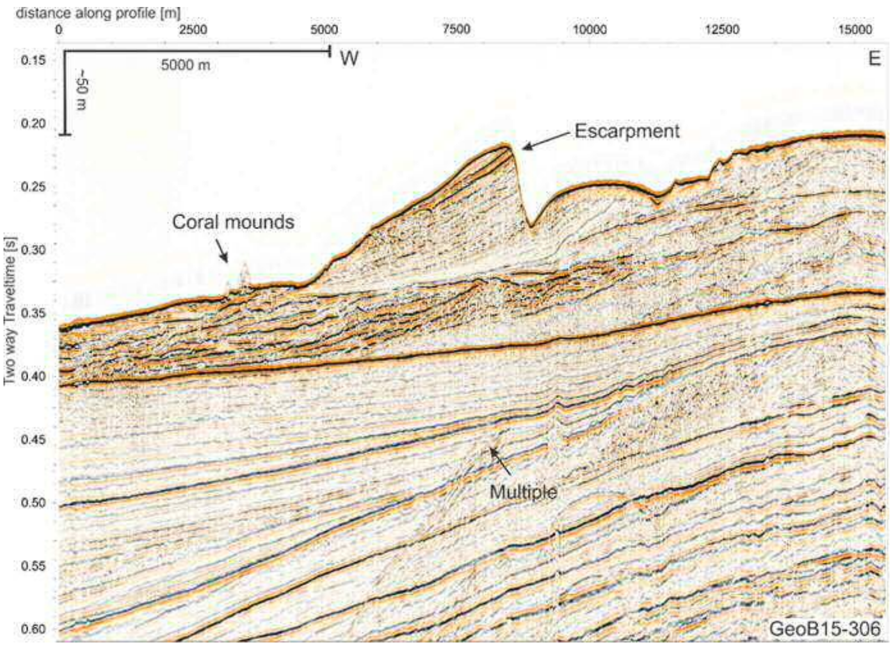


Fig. 6.1.5 *The multichannel seismic line MCS-a (GeoB15-306) has a W-E orientation and crosses the Escarpment and some coral mounds in the central part of the working area (for position of line see Fig. 6.1.1).*

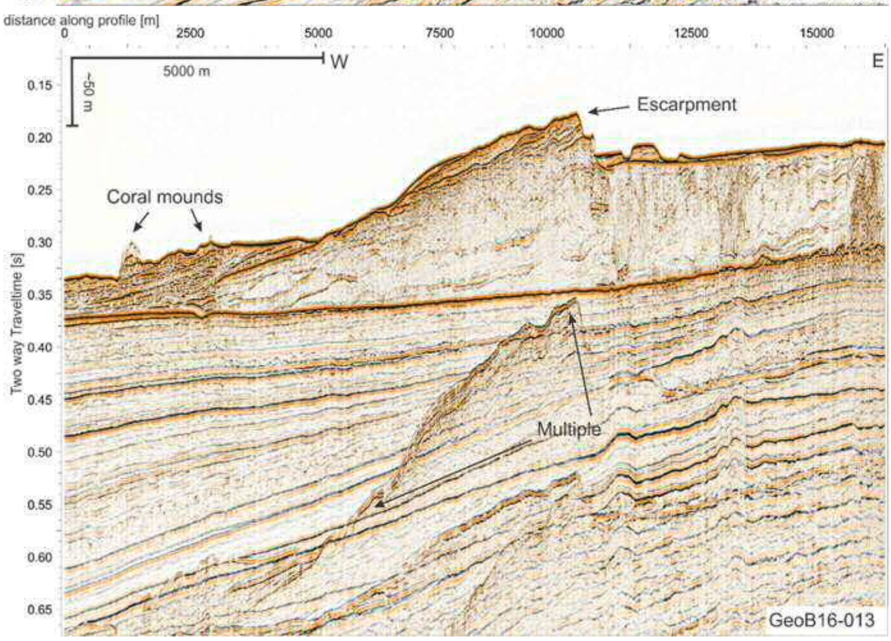


Fig. 6.1.6 *The multichannel seismic line MCS-b (GeoB16-013) has a W-E orientation and crosses the Escarpment and the Squid Mounds in the northern part of the working area (for position of line see Fig. 6.1.1). The lower seismic units are very similar to the units in MCS-a (GeoB15-306) shown above.*

PARASOUND data from the southern centre of the mapped area (PS-a, MBPS 20160107 1649-1732; see Fig 6.1.1 for position) show much more variability in near seafloor structures (Fig. 6.1.7). Although signal penetration along the profile does not everywhere reach the most dominant reflection identified in the MCS, (see dashed line in Fig. 6.1.7) the contorted but generally seaward dipping nature of the overlaying unit is clearly visible. Coral mounds (Merluza Mounds) appear as diffraction hyperbolas with vertical blanking zones beneath. Furthermore, it shows transparent fill units in the channel east of the escarpment and a most likely sub-recent sediment cover that drapes the unconform boundary to the prograding unit in the whole area only excluding the vicinity of the mounds. These sediments exhibit maximum thicknesses of 2-6 m and show partly an internal contouritic structure.

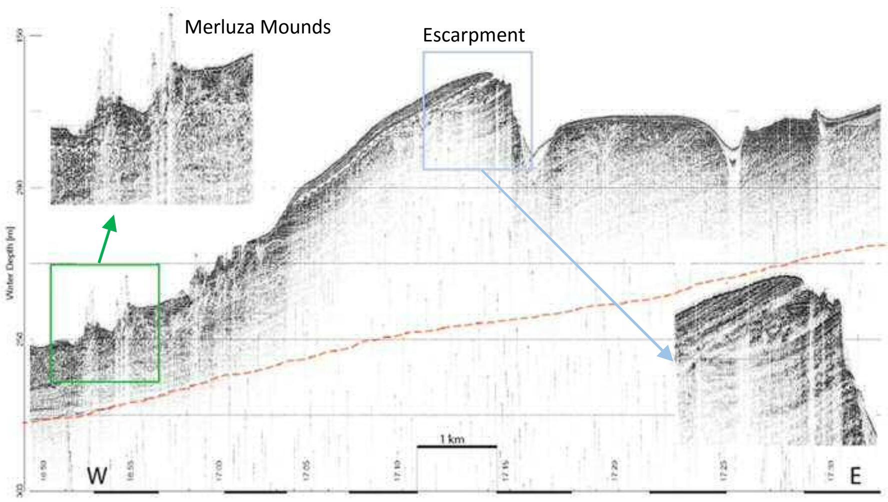


Fig. 6.1.7 *W-E oriented PARASOUND sub-bottom profile PS-a (MBPS 20160107 1649-1732; for position of profile see Fig. 6.1.1) with close-ups of the escarpment area (blue box) and the Merluza Mounds (green box) around the outcrops towards the west. The dashed red line represents the seismic reflector separating the secular units 1 and 2.*

From the multichannel seismic and PARASOUND data it becomes obvious that the sub seafloor can be sorted into three secular units. The first (oldest) unit is represented by the wedge-shaped facies below the dominant boundary reflector (Figs. 6.1.5 & 6.1.6). The dominant reflector marks the surface on which the sedimentation switches from a retrogradational to a progradational system. The second unit occurs directly above this reflector, has a progradational trend, and is represented by at least four subunits. These are characterised by lateral amplitude changes along differently contorted, but generally seaward dipping reflectors (Figs. 6.1.5, 6.1.6 & 6.1.7). Since few of the units are continuous throughout the whole area, it is expected that more subunits exist. The third unit is comprised of the sub-recent drape which is only resolved in PARASOUND data together with the coral mounds.

The absence of faults clearly suggests that the complex morphology is not related to tectonic processes. Consequently, the modern seafloor morphology within the mapped area off Namibia predominantly presents the result of former intense erosion, expressed in the erosional unconformity on top of the second unit. Erosion, in the most extreme case, builds up topography with height changes of 45 m, clearly illustrated by the outcropping of strata along the escarpment (see close-up Fig. 6.1.7). The occurrence of coral mounds is distributed on the erosional areas throughout the working area.

6.1.4 ROV Observations

The first ROV SQUID mission had the task to provide ground truth information about the geological origin and faunal composition of selected groups of conical to elongated seabed structures occurring on the gently seaward dipping Namibian slope (see chapter 6.1.3). Both, the morphological expression of the mounded structures mapped with MBES and the internal hydroacoustic signature shown on the seismic records revealed all aspects of cold-water coral (CWC) mounds. In total, seven ROV dives were carried out in six locations within an about 30-nm-long sector of the NNW-SSE striking northern Namibian slope defined by 20°30'S to 21°S and 12°37.5'E and 12°54'E. From north to south, the mound clusters were informally named as follows: Squid Mounds, Sylvester Mounds, Escarpment Mounds, New Year Mounds, Merluza Mounds and Priska Mounds (Fig. 6.1.8). The CWC mound clusters west of the escarpment occur at an apparently narrow water depth interval ranging from 240 to 215 m, whereas conical structures on the top of the escarpment are located at 160-170 m depth (Table 6.1.1). Interestingly, the depth ranges (expressed as Δ value in Table 6.1.1) of mound occurrences within the area studied narrows from NW to SE, respectively from 18–27 m to 8–9 m. Individual mound heights vary from 1-10 m.

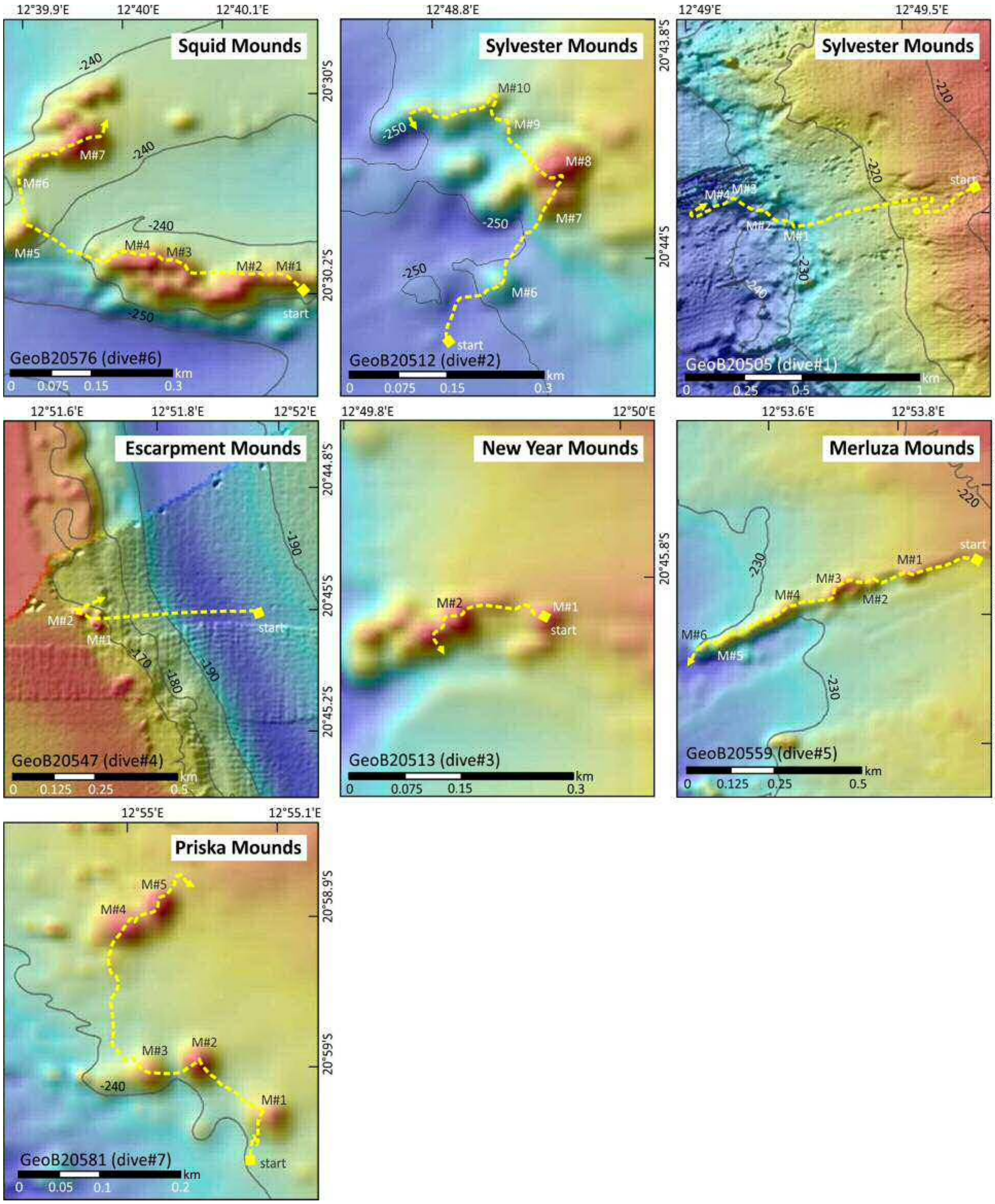


Fig. 6.1.8 *Bathymetry maps showing the seven dive tracks (indicated by dashed yellow lines) conducted in six cold-water coral mound sites along the Namibian margin (M: coral mound). From north to south these are: Squid, Sylvester, Escarpment, New Year, Merluza and Priska Mounds (for location of coral mound sites see Fig. 6.1.1).*

Location	ROV SQUID dive No.	Station No. (GeoB)	Depth interval of mounds (m)	Δ Mound occurrences
Squid Mounds	#06	20576-1	239-221	18 m
Sylvester Mounds	#01	20505-1	246-219	27 m
	#02	20512-1		
Escarpment Mounds	#04	20547-1	168-160	8 m
New Year Mounds	#03	20513-1	234-226	8 m
Merluza Mounds	#05	20559-1	223-214	9 m
Priska Mounds	#07	20581-1	234-226	8 m

***Table 6.1.1** Overview of mound depth intervals and the corresponding depth limits (expressed as Δ value) of the ROV-surveyed Namibian mounds from north to south (see Fig. 6.1.1 for mound location).*

Geological observations of the mound structures and the adjacent seabed with characteristic benthic communities

Fossil coral mounds: All mound-like structures surveyed during M122, turned out to represent fossil CWC mounds built entirely by *Lophelia pertusa* frameworks and trapped fine-grained deposits. The surface expression of the coral mounds is patchily variable, from pure coral rubble, exposed meshwork of *Lophelia* framework, to sediment-clogged *Lophelia* framework. Interspersed are areas of fine sand allowing a characteristic soft substrate community to establish next to a hard substrate community. The megafauna shows a low diverse (taxonomical and functional) assemblage of five commonly occurring sponge species in the area which we informally describe according to their distinguishable morphology. Two sponge species are locally abundant and have grown up to 30-cm-height: warty multi-towered sponge that we called the "cathedral" sponge (Fig. 6.1.9 A), and a slender, ramose yellow sponge (Fig. 6.1.9 D, F). Most conspicuous, however, are masses of yellow patches that have overgrown the coral skeletons, exposed shells and even sponges and ascidians. This organism is a cheilostome bryozoan belonging to the genus *Metroperiella* and has shown to be highly fluorescent under UV light in the lab (Fig. 6.1.9 B). *Metroperiella* is considered having high growth rates in the area as even short-lived egg capsules of nassariid gastropods have been completely overgrown and forced the eggs to die next to uninfested egg capsules. This dominant bryozoan is also capable to repel settling of detritus from its colony surface efficiently. Some coral mounds have larger aggregations of an erect-flexible and weakly calcified flustrellid bryozoan, probably *Sarsiflustra* or *Klugeflustra*. Other commonly found sessile organism groups are at least five species of actiniarians (at least temporaily sessile), zoanthids, several hydroid species, some thin encrusting sponges, serpulid and sabellid polychaetes. The abundance pattern of the above-mentioned groups varies between the mound locations (see Appendix F). The mobile fauna shows asteroids (one species) and ophiuroids (1-2 species with *Amphiura* as the most abundant). The latter often forms very dense populations on top the mounds and rock ledges (see below). Other mobile organisms are *Bathynectes* (likely *B. piperitus*), the stomatopod *Pterygosquilla armatus*, two shrimp species, pycnogonids (two species, mostly on bryozoans), amphipods (likely 3 species), cumaceans (1 species) and holothurians (2-3 species; resting in the calyxes of fossil Lophelia). The most common gastropods are *Nassarius* and *Murex* followed by nudibranchs. The soft substrate patches within the coral mounds yield cerianthids and tube-forming onuphid and terebellid polychaetes. The dominant and most conspicuous organisms (the cathedral sponge and the flustrellid bryozoans), belong to the active suspension feeders, which seems to be one of the dominant functional groups together with the detritivores.

A very interesting feature is the locally great abundance of an about 5-10-cm-long gobiid fish (most likely *Sufflogobius bibarbatus*) that lives and hides underneath coral framework in great numbers. Other fish encountered in the coral mounds are some *Lophius* and some *Merluccius*. Occasionally swarms of carangid fishes (probably *Trachurus*) were observed.

Rock outcrops: In all mound locations, a belt of rocky outcrops pierces through the seabed that became rapidly draped by coral rubble and sediment-clogged coral framework upslope. Many rocks are tilted (25-30°) and create up to 1-m-high hard substrates for the present benthic communities (see below) and most likely represent individual lithified former sedimentary sequences. In other cases, platy rock outcrops are flat lying on the seabed, partly buried by recent deposits.

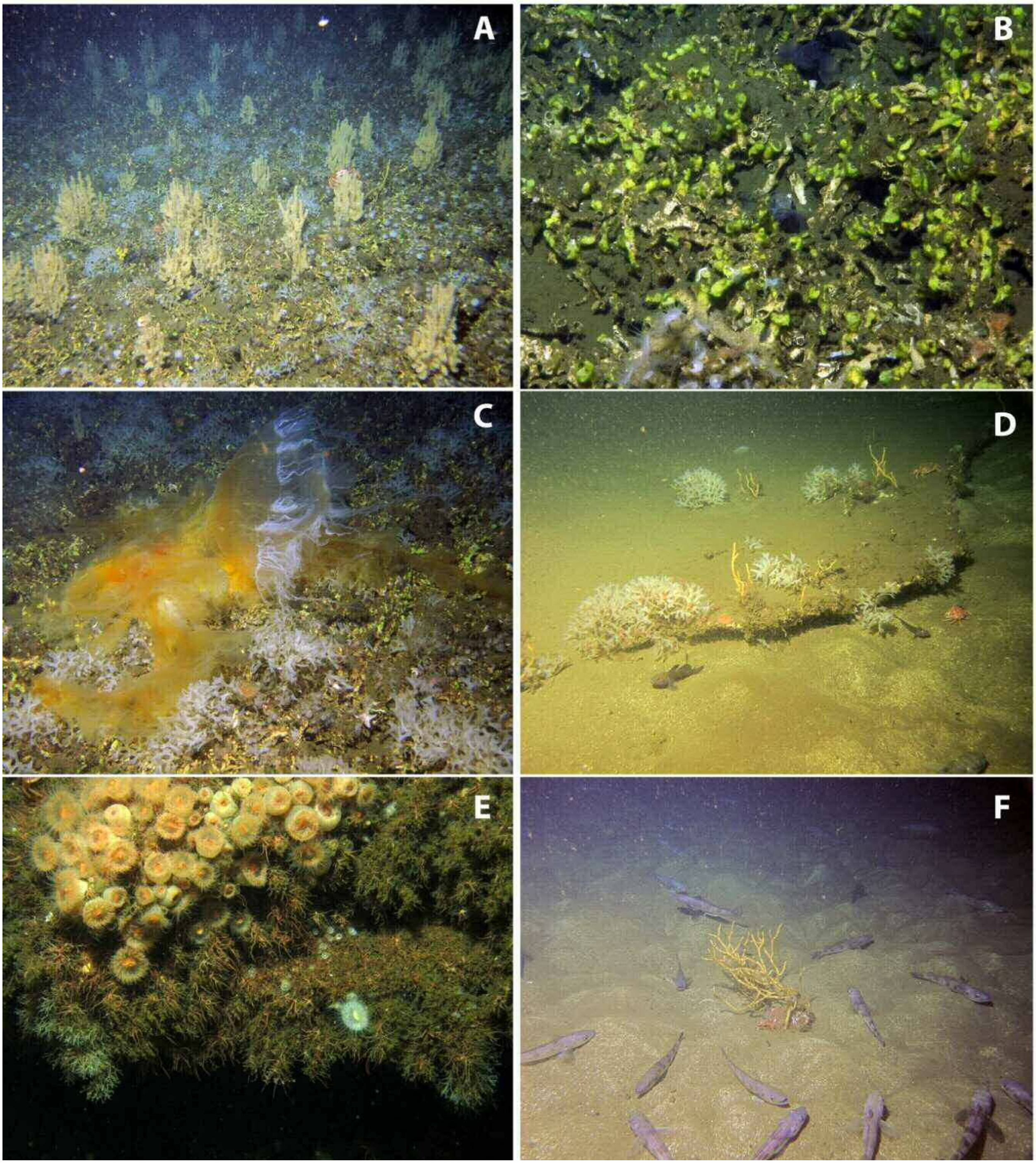


Fig. 6.1.9 *Habitats of the fossil coral mounds and adjacent seabed off Namibia.* ***A*** *Near top of Merluza Mound (214 m) with fossil dead coral framework colonized by 'cathedral' sponges and flustrellid bryozoan colonies.* ***B*** *Close-up from the Sylvester Mound top (222 m) with fossil coral rubble intensely populated by rapid growing, fluorescent bryozoans (*Metroperiella *sp.), a common phenomenon encountered on all Namibian mounds.* ***C*** *Top of Merluza Mound with a stranded and decaying jellyfish. Note the masses of flustrellid and* Metroperiella *bryozoans covering fossil coral rubble (219 m).* ***D*** *Platy rock outcrop near Priska Mound with bioturbated sand around. Note the gobiid fishes (*Sufflogobius *sp.) living underneath the rock ledge. Rock flanks are populated with bryozoans and sponges (235 m).* ***E*** *Rock outcrop near the Escarpment Mounds (163 m) with masses of Cellaria bryozoan colonies and actiniarian aggregations.* ***F*** *Bioturbated muddy sand with abundant* Merluccius *(Hake) near the base of the Merluza Mound (221 m). The small rock is colonized with the common finger-stick sponge.*

Rocks sampled with the ROV (as well as those sampled with grab sampler and box corer) yielded dark grey sandstones. The texture is well-sorted silt to fine sand, followed by less competent but stiff black clay layers. Both the sandstones and clay layers show a genuinely preserved trace fossil assemblage of various burrowing – and probably boring - organisms. The rock outcrops at the mound bases encountered show shell haloes either consisting of formerly epibenthic *Pycnodonte* oysters, or almost entirely of fossil infaunal bivalves. The live rock fauna shows the same composition as on the coral framework, however, with highly variable abundance patterns from rock to rock. On large rocks, dense aggregations of *Cellaria* bryozoans are growing upside down underneath rock ledges (Fig. 6.1.9 E). The tilted and plane-lying rocks are undermined by *Sufflogobius bibarbatus* (Fig. 6.1.9 D). The dominant functional group was the active suspension feeder group mostly represented by ascidians, bryozoans and sponges.

Bioturbated sand: The surrounding sediment is silty fine sand strongly bioturbated by organisms. Most evident are up to 10-cm-high and up to 15-cm-wide excavation mounds of callianassid crustaceans. Therefore, we termed the off-mound facies as bioturbated sand (BTS). The upwarped deposits of these callianassid mounds show the presence of coarser bioclastic sediment underneath the present silty sand, a stratification that has been proven with the box corer and grab samples. In the depressions, a greenish organic fluffy layer is present. This layer easily gets blown off when the ROV comes close to bottom. No clear current ripples were seen, except in the BTS pathways between two neighbouring mounds, where funneling of currents may occasionally move the surface sediment. Otherwise, existing ripple structures might quickly get destroyed by bioturbation.

Common inhabitants of the BTS and visible with the ROV are cerianthids (2-3 species) and tubes from onuphid and terebellid polychaetes. The mobile benthic assemblage shows *Bathynectes* (common), shrimps and especially near coral mounds, the stomatopod *Pterygosquilla armatus*. The sandy soft bottom locations were dominated by active suspension feeders.

The most common fish is *Merluccius*, up to 30 cm in length and mostly lying on the ground with the head facing against the main current. Great numbers of *Merluccius* were encountered with the ROV approaching the Merluza Mounds (Fig. 6.1.9 F). *Sufflogobius bibarbatus* is common and becomes more abundant when approaching rocks or coral mounds. Rare fishes seen are *Lophius* (always close to a mound), a sole and a triglid fish.

Main conclusions: The mound-like seabed structures identified in the hydroacoustics are indeed cold-water coral mounds, however fossil. The only former mound-constructing coral was *Lophelia pertusa*. The present community represents an impoverished fauna with few but locally very abundant species and high biomass. *Sufflogobius bibarbatus* is the most abundant fish in the coral mounds were it finds food and shelter in this topographically complex habitat. This gobiid is known for its adaptation to thrive under hypoxic conditions. Major mega- and macrofaunal functional groups are lacking. We did not encounter any echinoids, crinoids, octocorals, brachiopods and many other common associates of the upper bathyal environment. Depletion of oxygen seems to be the driving element allowing only opportunistic species to survive and to reproduce.

The contribution of bryozoans, especially of the pest-like yellow *Metroperiella* is a hitherto unreported phenomenon. At some locations carcasses of shrimps and fish were observed lying on the seabed next of presumed scavengers but these carcasses do not have raised the interest of the latter to consume the food. This observation goes in line with the surprising result of the baited trap from the ALBEX Lander (see chapter 6.1.6).

Visible human impact on the coral mound habitat seems to be low. We encountered one lost net with a corresponding trawl mark and one lost glass jar. All objects became populated by *Metroperiella* and other organisms.

6.1.5 Sediment Sampling

Surface samples

A total of 24 grab samples and ten box cores were collected from various sites along the Namibian margin to obtain information about the surface sediments and the benthic macrofaunal composition. In addition, biogenic and rock samples were collected from the seabed surface by the ROV SQUID during video observation. A detailed description of all surface samples is provided in Appendices C and E.

Sediment cores

For the working area off the Northern Namibian Margin, twelve so-called "on-mound" gravity cores were collected from the various cold-water coral (CWC) mounds examined during M122, including the Squid, Sea Star, Sylvester, New Year, Escarpment and Priska Mounds (Table 6.1.2; for coring location see Fig. 6.1.1). These coral-bearing cores were not opened on-board as this requires special treatment (freezing for 24 hours, opening with a special stone saw) to avoid any disturbance of the coral-sediment (hard-soft) sedimentary record. In addition, it is planned to scan these cores by computer tomography before opening to get information about coral fragments size and orientation, and thus, in combination with dating, to get important information about the depositional history of the coral mounds.

Table 6.1.2 *Metadata of coral-bearing gravity cores collected during M122 from various Namibian coral mounds.*

Mound area	GeoB		Lat (S)	Lon (E)	WD	REC	Remark
Pickel Mound	20544-1	GC6	20°22.267'	12°38.468'	162m	0.76m	core pipe bent, hit probably a hard-ground, one core section was saved
Squid Mounds	20543-2	GC6	20°30.187'	12°40.066'	224 m	4.85 m	oysters on top, corals throughout
Squid Mounds	20571-2	GC6	20°30.193'	12°40.122'	225 m	5.48 m	corals throughout
Sea Star Mounds	20572-2	GC6	20°35.248'	12°43.966'	218 m	5.87 m	overpenetration; corals throughout, strong H_2S smell
Sea Star Mounds	20572-3	GC12	20°35.248'	12°43.969'	219 m	9.87 m	corals throughout, strong H_2S smell, degassing
Sylvester Mounds	20517-1	GC6	20°43.980'	12°49.076'	235 m	0.52 m	corals on top; M#4
Sylvester Mounds	20518-1	GC6	20°43.930'	12°48.916'	232 m	5.78 m	slight overpenetration; corals throughout; M#8
Sylvester Mounds	20531-1	GC12	20°43.933'	12°48.919'	232 m	10.21 m	corals in the upper 8m, below shell hash and soft sediment; M#8
New Year Mounds	20516-3	GC6	20°45.834'	12°49.887'	225 m	5.74 m	corals throughout
Escarpment slope	20540-1	GC6	20°45.024'	12°51.704'	159 m	0.24 m	few coral fragments and shells
Priska Mounds	20568-1	GC6	20°59.006'	12°55.044'	236 m	2.90 m	corals throughout
Priska Mounds	20582-1	GC6	20°58.896'	12°55.031'	231 m	3.04 m	corals throughout

Nevertheless, during cutting the plastic liner into 1-m-sections, it was observed that all these cores contain coral fragments throughout the entire record. The only exception is the ~10-m-long core GeoB 20531-1 collected from the Sylvester Mounds (Table 6.1.2), which contained just in the upper 8 core metres coral fragments embedded in hemipelagic sediments, whereas below 8 m core depth no more coral remains were present. This might indicate that the respective (rather small-sized) coral mound was fully penetrated, which might provide information about the time of initial coral settlement and subsequent aggradation history of the mound. In addition, coral fragments which were partly lost during the cutting procedure revealed solely *Lophelia* fragments. These *Lophelia* skeletons had mostly a very "fresh" or pristine appearance, which is in complete contrast to the strongly corroded coral fragments observed on the surface of the Namibian coral mounds during the ROV video surveys (see chapter 6.1.4).

Beside the on-mound cores, seven off-mound cores (barren of any coral fragments) were collected from the Namibian margin (Table 6.1.3; for coring location see Fig. 6.1.1). Five cores were opened on-board and visually described (see Appendix D). Two off-mound cores, one collected south of the Sea Star

Mounds (GeoB20588-1) and one collected south of the southern Priska Mounds (GeoB20583-2), both contained an upper layer (0.8-m and 1.5-m-thick) with large bivalve and gastropod shells, while below this shell layer, a silty sedimentary facies with few mm-sized shell hash was deposited. Gastropods belonging to the families Nassaridae and Volutidae (*Athleta lutosa*), and bivalves belonging to the families Verrinidae, Tellinidae (*Tellina* spp.) and Lucinidae (*Lucinoma* sp.) were identified, with the two latter being indicative for oxygen reduced conditions and/or comprising chemosynthetic species. In core GeoB20583-2, even a clear transition from *Pycnodonte* sp. (oysters; 0-14 cm core depth), to Verrinidae (14-53 cm) and finally to Tellinidae (53-83 cm) species were observed (see Appendix D).

Two off-mound cores collected east of the large Escarpment also contained layers with large mollusc shells. Core GeoB 20528-1 revealed an interval with large shells between 115 cm and 376 cm core depth, while above and below this layer very dark sandy to silty sediments are deposited.Again species of the families (Gastropoda) Nassaridae (*Nassarius* sp.), Turritellidae, Turridae (*Turris* sp.), Buccinidae, Volutidae (*Athleta lutosa)*, (Bivalvia) Veneridae, Lucinidae (*Lucinoma* sp.), Tellinidae (*Tellina* sp.), and Nuculidae (*Nucula* sp.) were identified. An interesting (although very preliminary) observation is that between 115 cm and 295 cm core depth the mollusc assemblage is dominated by species that indicate a sandy facies and well-ventilated conditions, while between 295 cm and 376 cm core depth solely tellinid species were found which indicate a muddy facies and oxygen reduced conditions. Core GeoB20527-1 (Fig. 6.1.10) shows a sequence of shell hash (0-14 cm core depth), large mollusc shells (14-117 cm), and again shell hash (117-130 cm). Molluscs of the shell layer comprise (Gastropoda) Naticidae (*Natica* sp.), Marginellidae, Buccinidae, Nassaridae (*Nassarius* sp.), (Bivalvia) Veneridae, Nuculidae, Lucinidae (*Lucinoma* sp.), and Tellinidae (*Tellina* sp.).

However, an even more interesting finding for this core is a large (15 cm x 9 cm), dark and heavy rock which was found below the shell/shell hash layer (Fig. 6.1.10). This rock was preliminary interpreted as a phosphorite (!). Probably a more widespread occurrence of such rocks might have served as a settling ground for the CWC in the area. Below the rock, the sediment changed to a stiff clayey silt without any larger components.

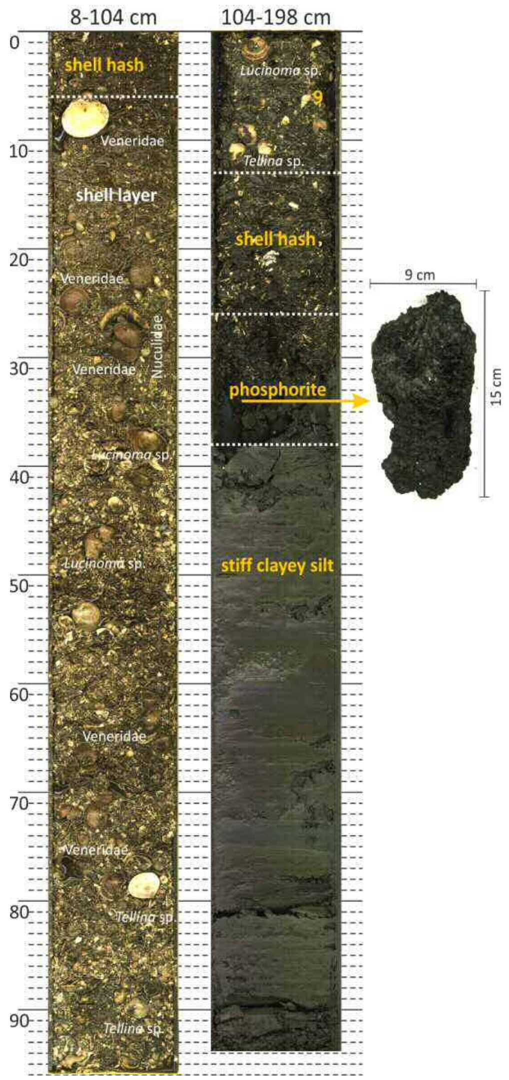


Fig. 6.1.10 *Linescan showing the off-mound core GeoB20527-1. The sedimentary record comprises an upper shell layer (14-117 cm) composed of large bivalves and gastropods, shell hash (117-130 cm), a 15x9 cm large rock (phosphorite?; 130-142 cm) and stiff clayey silt.*

Finally, off-mound core GeoB20550-1 showed a recovery of >5 m and is entirely composed of dark olive grey to olive grey silty sand to sand with very few small-sized shell fragments. This core was collected for the purpose to calibrate seismic information obtained for the area.

Table 6.1.3 *Metadata of off-mound gravity cores collected during M122 from the Namibian margin.*

Area	GeoB	Lat (S)	Lon (E)	WD	REC	Remark	
S of Sea star Mounds	20588-1 GC6	20°37.868'	12°46.244'	238 m	4.79 m	0-83cm: large mollusc shells	opened
E of Escarpment	20527-1 GC6	20°41.410'	12°51.194'	182 m	1.98 m	0-130 cm: large mollusc shells, below phosphoritic rock & stiff clayey silt	opened
E of Escarpment	20528-1 GC6	20°42.330'	12°52.610'	187 m	5.09 m	115-376 cm: interval with large mollusc shells, above and below soft sediment	opened
W of Escarpment	20529-1 GC6	20°43.467'	12°50.736'	165 m	2.61 m	large shells, few sediment	closed
N of Sylvester M.	20530-1 GC6	20°42.733'	12°48.269'	242 m	1.30 m	shell hash	closed
for seismic	20550-1 GC6	20°51.029'	12°28.103'	367 m	5.43 m	soft sediments	opened
S of Priska Mounds	20583-2 GC6	21°05.563'	12°59.082'	211 m	5.59 m	0-149cm: large mollusc shells	opened

6.1.6 Time-Series Lander Data

Both ALBEX landers were deployed in the Sylvester Mounds area (see Fig. 6.1.1). One was deployed on a small mound (~210 m water depth), while the ALBEX-TROL lander was deployed in an off-mound area for comparison (~220 m water depth), both sides belong the Sylvester Mound area. Data recorded with both landers showed similar trends. A clear semi-diurnal tidal cycle was present as shown by daily fluctuations in temperature (min. 11.8°C, max. 13.1°C; Fig. 6.1.11) and current speed. Average near bottom temperatures were 12.6°C and average current speed was 0.09 m s^{-1} at both lander sites. Oxygen levels at both sites were particularly low and fluctuated within the tidal cycle between 0-0.54 mg L^{-1} at the ALBEX-TROL site and 0-0.39 mg L^{-1} at the ALBEX site. Colder water contained more oxygen compared to water with higher temperatures (Fig. 6.1.11).

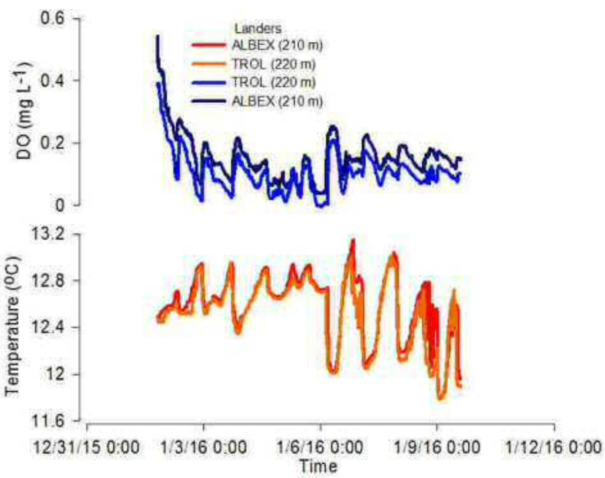


Fig. 6.1.11 *Daily fluctuations of temperature and dissolved oxygen concentrations (DO) at the lander sites (GeoB 20507, 20508; Sylvester Mounds).*

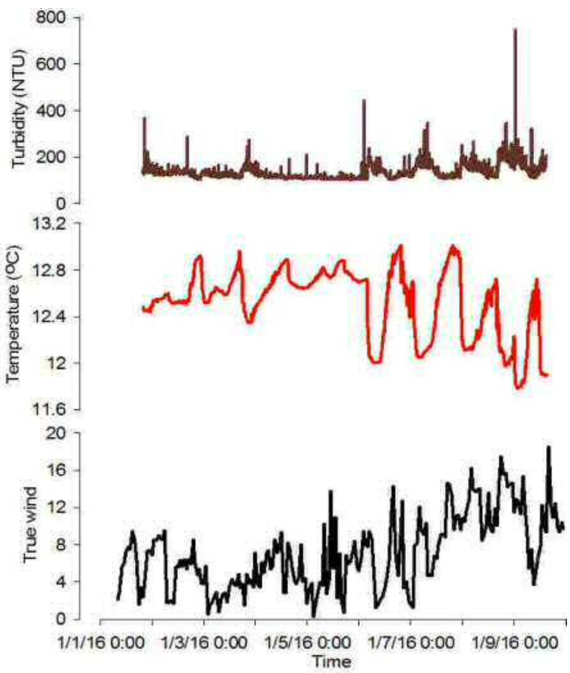


Fig. 6.1.12 *Increased wind speed during the second part of the deployment is related to increased amplitudes of daily fluctuations in temperature and turbidity.*

Current speeds varied between 0 and 0.28 m s^{-1} at the ALBEX-TROL site and 0-0.31 m s^{-1} at the ALBEX site. Peaks in current speed and temperature were positively correlated, while current speed and oxygen concentrations were negatively correlated. Acoustic and optical backscatter data showed the same trend, with peak values after a decrease in current speed. The amplitude of daily fluctuations increased during the last days of the deployment period, which was likely related to an increase in wind speed during this time period (Fig. 6.1.12). From the sediment trap three samples were retrieved as well as 24 samples for suspended particulate matter which were collected with the particle pump.

The ALBEX-TROL lander was additionally equipped with a camera filming bait that was attached to the frame. First swimming crabs (*Bathynectes* sp.) arrived at the bait 5 minutes after the deployment. First analysis of the video showed that only crabs and shrimps were feeding on the bait. Peculiar was the fact that still most of the bait was present on the lander after the recovery, which to our opinion indicates that large predators avoid the oxygen minimum zone, as normally bait is gone within hours.

6.2 The Angolan Margin

6.2.1 Overview

As for the Namibian margin, also for the Angolan working area, the only available site survey information prior to expedition M122 comprised some seismic and hydroacoustic data obtained during R/V METEOR cruise M76-3 (data courtesy: V. Spiess, MTU-GeoB, University of Bremen, Germany). These data indicated mound structures along the Angolan margin resembling cold-water coral (CWC) mounds, however, without any available ground truthing (samples, videos). Similar as for the Namibian working area, also for Angola, environmental data available from the World Ocean Atlas revealed low dissolved oxygen (O_2) concentrations, which are below the thresholds allowing for a sustained CWC population according to the literature (Davies & Guinotte 2011).

Surprisingly, we encountered thriving CWC reefs dominated by *Lophelia pertusa* on the top of mounds which reach water depths between 470 and 330 m. These reefs are marked by a much higher biodiversity compared to Namibia, but still, many faunal groups commonly found on better ventilated coral mounds are missing here. However, on shallower mound tops and ridges only sparse live coral settlement and a rather low biodiversity could be observed. Off Angola, oxygen concentrations of >0.5 ml L^{-1} are higher than of Namibia, however, still way below of any other reported live occurrence of *L. pertusa*. Interestingly, in the shallower regions, where only few living corals were found, oxygen concentrations were higher, thus, pointing either to temperature or to a combination of both forcing factors in controlling the vitality of *L. pertusa*. Nevertheless, as also these mounds are largely made up by coral rubble embedded in hemipelagic sediments, it is most likely that the corals found better living conditions in the past also on top of these shallow structures.

Within the mapped area, coral mounds could be followed over a distance of >30 nm. These mounds consist of the typical coral mound facies comprising a mixture of hemipelagic sediments and coral fragments. With heights of >100 m the Angolan Mounds are much higher than their Namibian cousins and, thus, might have a longer aggradation history. However, this needs to be proofed with the analysis (e.g., dating) of the coral-bearing sediment cores collected from the mounds, which have recoveries of up to 10 m. The coral mounds range in structure from individual, conical mounds to complex mound structures and eventually to long ridges (Figs. 6.2.1 & 6.2.2). Especially the latter appear to be partly routed on tectonic faults whereas in other places slump scars seem to underlie some mound structures. Thus, in contrast to Namibia, the Angolan Mound province or at least the onset of mound growth obviously is controlled by an active tectonic setting, thus supporting hypothesis H#5 formulated in chapter 3. Probably related to such tectonic activities are the occurrences of pock marks (Fig. 6.2.2) and seep structures observed with the ROV (see chapter 6.2.4).

Moreover, H#1 stating that *L. pertusa* can withstand much lower oxygen concentration than described so far in the literature, can now be confirmed by the obtained data/observations. H#2 postulating a low biodiversity for such low oxygen CWC settings is to some extent true, as some important faunal groups being common for many other Atlantic CWC sites, are missing off Angola. Nevertheless, despite the very low O_2 concentrations, the observed biodiversity was still surprisingly high.

Also for the Angolan region, H#3 (temporal variability) can be confirmed as the high abundance of coral rubble and dead coral framework observed on the shallow mounds is in clear contrast to the limited life found there presently. But, as for Namibia, from the on-board studies nothing can yet be concluded regarding the timing of coral colonisation and mound aggradation, and about possible forcing factors. Combining both CWC regions, some of the general hypotheses formulated before M122 could already successfully be tested by the shipboard data. The remaining ones most likely can be finally tested once the further analyses in the home laboratories will be completed.

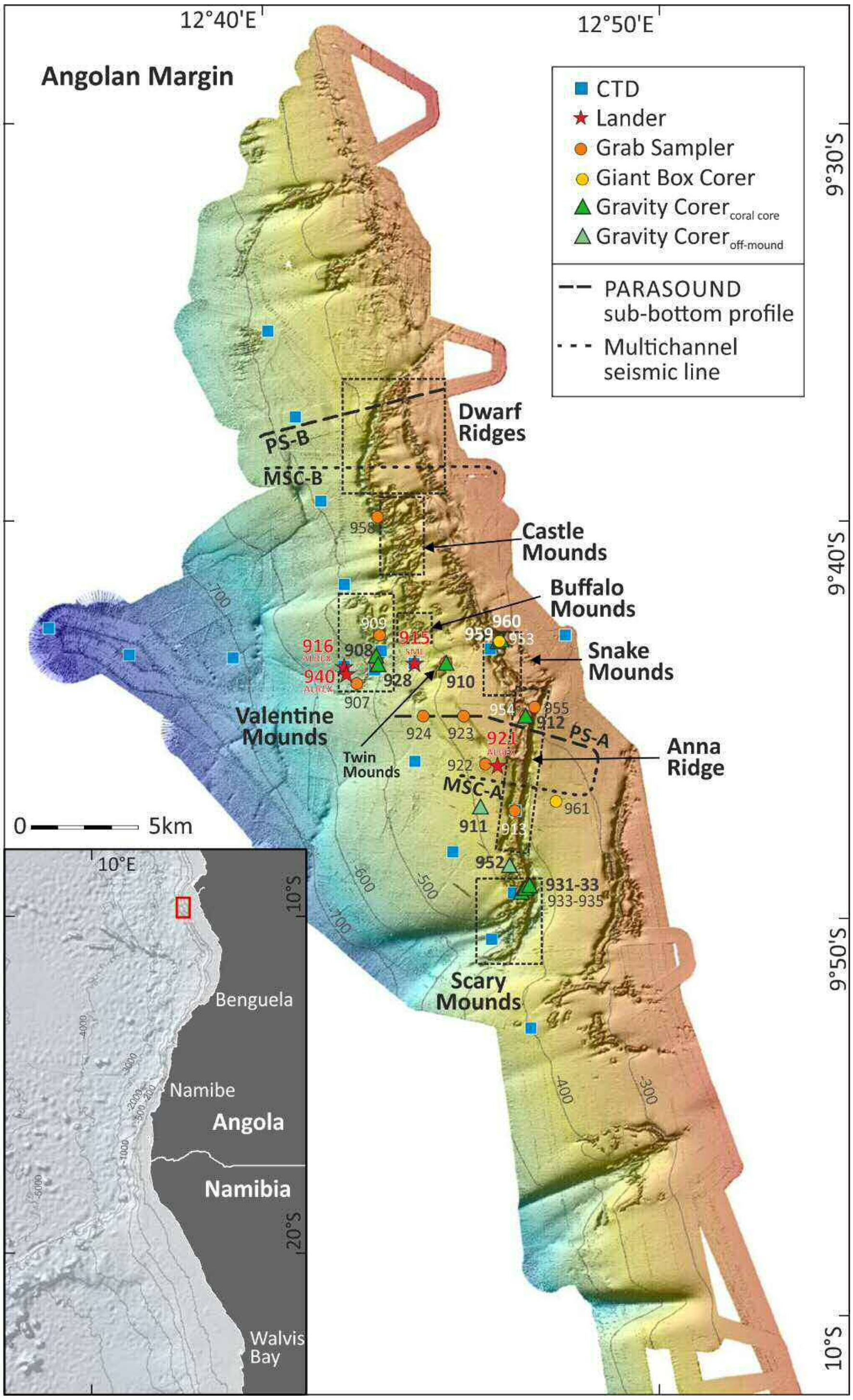


__Fig. 6.2.1__ Multibeam bathymetry overview map of the Angolan cold-water coral mound area mapped during M122. Indicated are sampling positions (GeoB 20xxx; see legend for gear symbols). Only those PARASOUND and multichannel seismic lines (PS/MCS; bold dashed lines) that are shown below are indicated. Cold-water coral mound/ridge sites investigated during M122 are marked by dashed squares.

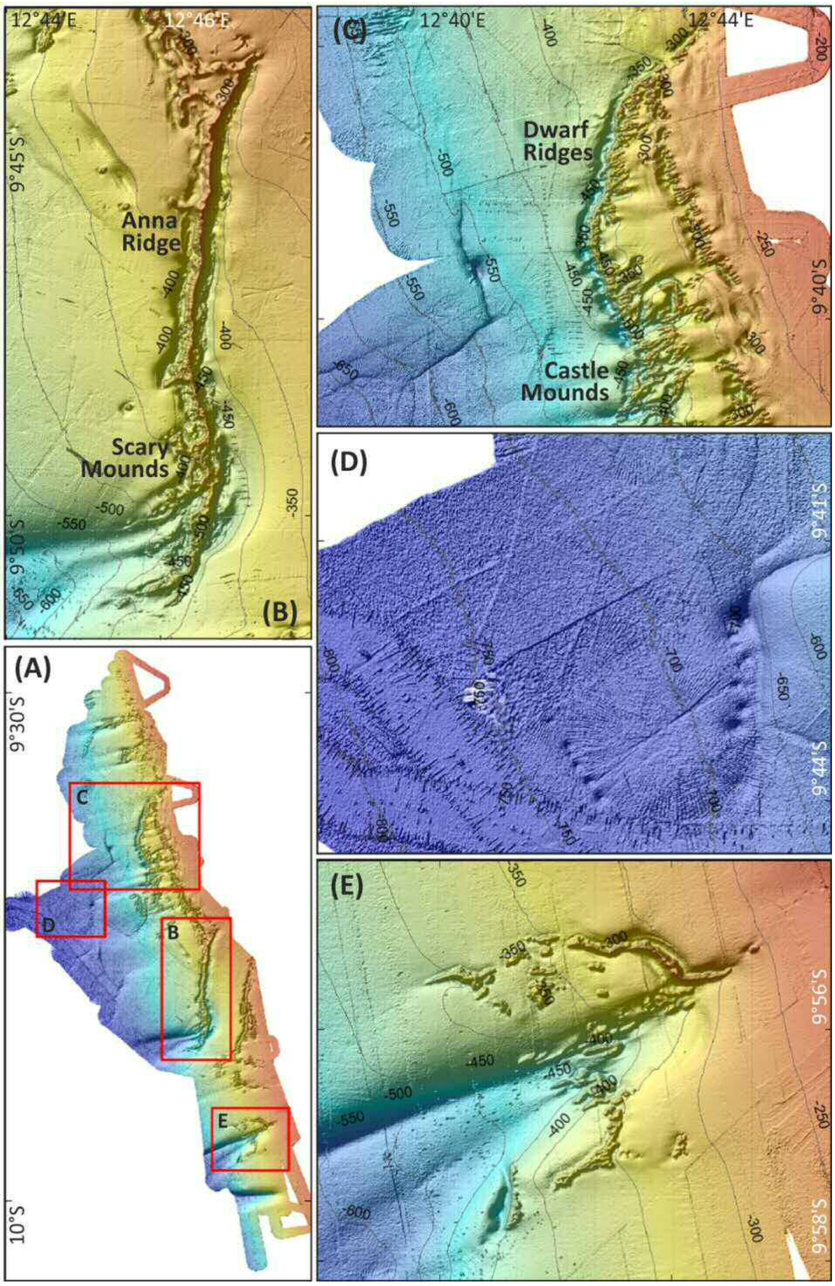


*Fig. 6.2.2 Close-ups of the various coral mound settings in the Angolan margin cold-water coral mound region. (**A**) Overview map. (**B**) Anna Ridge and Scary Mounds. (**C**) Dwarf Ridges. (**D**) One of the pockmark regions. (**E**) Coral mounds flanking one of the canyons in the southern part of the area.*

6.2.2 The Water Column Structure

The predominant water masses in the investigated area off Angola show the equivalent sources of origin like those off Namibia, since the water masses below ~35-40 m water depth show the same signatures as seen off Namibia. These water masses comprise South Atlantic Subtropical Surface Water (SASSW) and the South Atlantic Central Water (SACW), which are characterized by a pronounced linear trend in all temperature-salinity (TS) plots ranging from 17.5°C/35.7 PSU to 6.8°C/34.6 PSU. Both, SASSW and SACW still belong to the equatorward-flowing Benguela Current (BC) and interact at around 14°S-16°S with the southward-flowing warmer Angola Current (AC) resulting in the Angola-Benguela Front (ABF; see e.g., Mohrholz et al. 2001). Although there is some debate whether the BC extends up to the ABF or even up to the Angola Front (AF) at ~5°S, we may argue that the Benguela systems extends to the AF since all our TS-plots, both off Namibia and off Angola, do not show any significant differences except for the most shallowest parts down to 40 m. Below the SACW, the less saline and cooler Antarctic Intermediate Water (AAIW) occurs, exhibiting a core temperature of 4-5°C and a salinity of 34.5 PSU in a water depth of around

700 – 800 m. Below the AAIW at around 1200 m, the North Atlantic Deep Water (NADW) occurs, indicated by a strong increase in salinity reaching values of >34.9 PSU at around 2000 m.

Off Angola, we performed 2 CTD casts on our transit between both working areas and one deep station (2000 m) on our way back to Walvis Bay. In the working area we performed another 21 casts arranged parallel and perpendicular to the shelf. All casts exhibit SASSW and SACW, while AAIW was encountered only in stations reaching deeper than 750 m. Traces of NADW where observed in the stations *en route* and showed up clearly only in the last 2000-m-cast (GeoB20971-2; Fig. 6.2.3). The surface waters in the area exhibited very high potential temperatures of around 30°C and extremely reduced salinities of around 28.2 PSU, due to the discharge of the Cuvo, the Cuanza, and the Congo rivers, also indicated by frequent remains of land plants and civil trash. The majority of freshwater input may derive from the Congo, since its strongest discharge occurs from November till January. Below the less saline surface waters reaching down to 10 m, we observed surface waters with high salinities of up to 36.08 PSU and potential temperatures of 27.58°C between 19 m and 24 m water depth. This saline surface water derives from water masses of the South Equatorial Counter Current (SECC) being advected by the eastern branch of the AC as part of the cyclonic current system of the Angola Dome (AD), indicating a southward transport of these waters. SASSW stretches from between 40 m (closer to the coast) and 32 m (further off the coast) down to 70 m water depth showing potential temperatures between 22-23°C and salinities between 35.6-35.8 PSU. Between 70 m and 512 m water depth, salinity decreases rapidly from 35.7 PSU to 34.62 PSU, whereas potential temperature decreases from 17.37°C to 6.8°C. These waters belong to the SACW. Below 500 m, the line in the TS plot is modified by an increased reduction in potential temperature and a less decrease in salinity, exhibiting already some influence of the deeper AAIW. However, we still ascribe this water mass to the SACW down to 600 m. There, potential temperature plots around 6.2°C and salinity reads 34.58 PSU, which indicate the presence of the AAIW. The salinity minimum of the AAIW was observed at 775 m water depth having a potential temperature of 4.67°C and a salinity of 34.49 PSU. Traces of NADW were encountered below 1000 m and in the deepest station (GeoB20971-2), where we observed the salinity maximum in 2016 m water depth reaching 34.93 PSU and 3.12°C potential temperature.

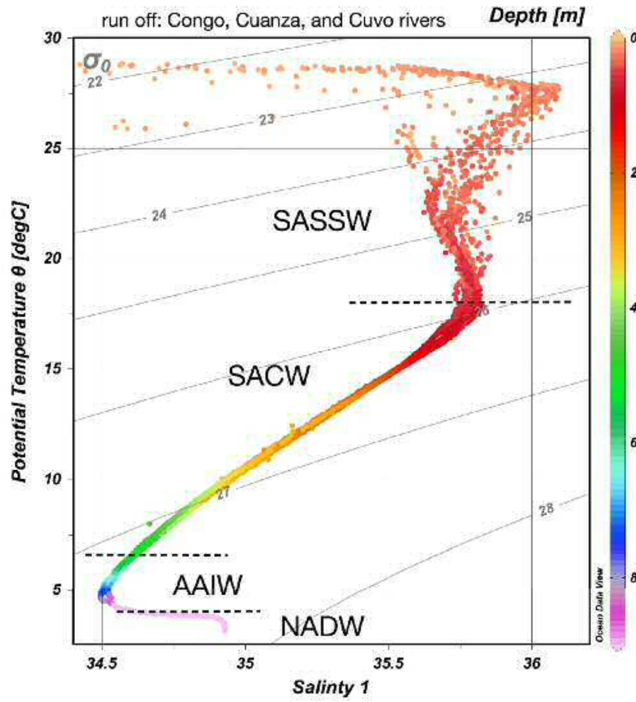


Fig. 6.2.3 *TS-plot of all 24 CTD casts taken in the Angola working area and en route. SASSW = South Atlantic Subtropical Surface Water; SACW = South Atlantic Central Water; AAIW = Antarctic Intermediate Water; NADW = North Atlantic Deep Water. Note the strong influence of river discharge in the topmost water levels.*

Stretching between 9°S and 12°E, the Angola working area aligns latitudinally with the AD located between 5°S and 15°S, however, in a more easterly position closer to the continent. Here, in the vicinity of the AD the main oxygen minimum layer of the South Atlantic is being formed. Organic carbon (OC) rich waters are advected from the Namibian upwelling region to the N and NW and the OC remineralisation creates the oxygen minimum at around 400 m water depth. This oxygen depleted water (1 ml L^{-1} and even less) flows to the south in water depths between 230 m and 500 m bathing the observed CWC reefs. We observed contrasting current directions in the ship's ADCP data. The uppermost layer of the surface water, characterized by reduced salinities and the SASSW below, exhibited a south component (180°), while the still oxygenated layer of the SACW below showed a northwestward direction (345°) and the oxygen depleted part of the SACW again flowed south. However, this general pattern (Fig. 6.2.4) was not persistent as indicated by short-term changes recorded in the ship's ADCP data, possibly as a result of tides or internal waves. These short-term changes were also empirically observed by the ROV pilots during ROV operation. A detailed analysis of the ADCP lander data is necessary to unravel the complex interaction.

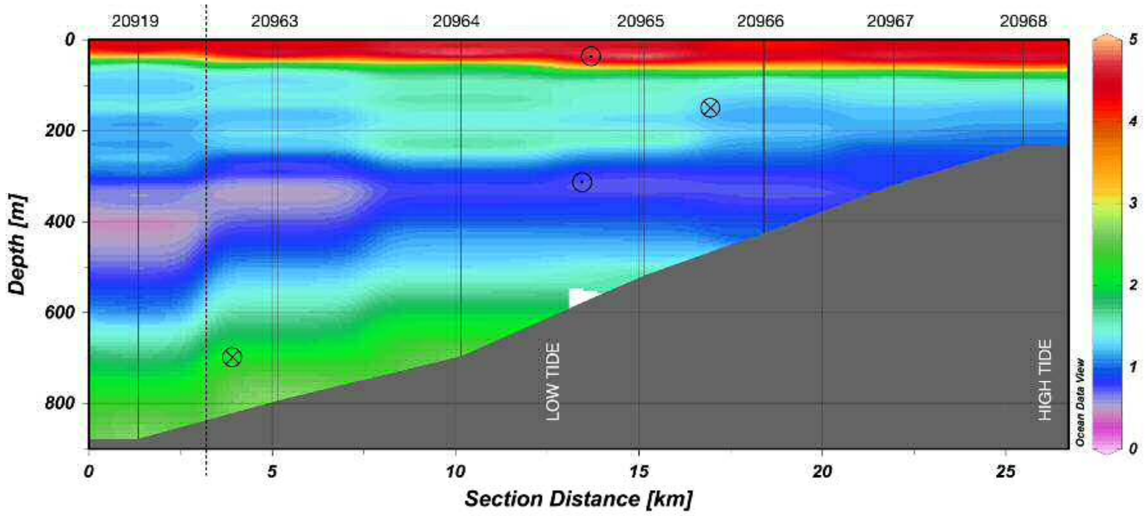


Fig. 6.2.4 *Oxygen concentrations in ml L^{-1} in the Angola working area. Note the core of the oxygen minimum zone in the west. Observed (but probably not continuous) current directions are indicated in the different bathymetric levels. The numbers indicate GeoB stations. GeoB20919 was measured on Jan 20, 2016, 7:20 UTC, while stations GeoB 20963 (Jan 25, 2016, 19:05 UTC) to GeoB20968 (Jan 26, 2016, 03:04 UTC) were measured consecutively*

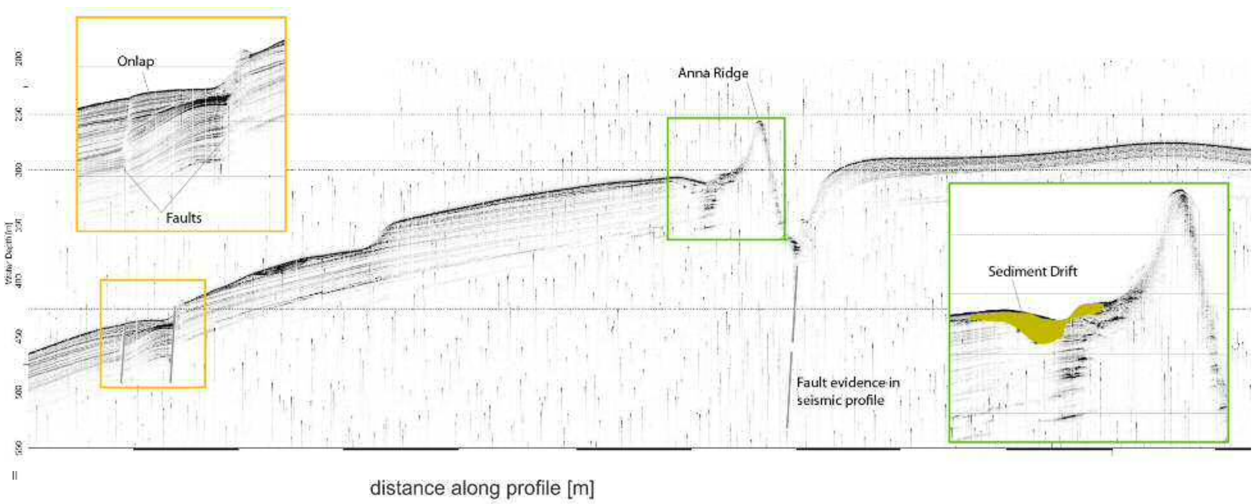
6.2.3 Bathymetry and Sub-Seafloor Structures

Along the Angolan margin, an area of 835-km^2 was mapped west of the Angolan province Bengo in water depths ranging between 170 m and 910 m. The area extends over 69 km in N-S and 22 km in E-W direction. The seafloor topography is highly structured by three small canyons, multiple elongated depressions and steep, well pronounced ridges with various morphologies (Fig. 6.2.1). Three small canyons are located in the southern part of the mapped area. They appear as headless canyons, end in about 300 m water depth and therefore do not reach the shelf. The northern canyon seems to originate in the eastern moat of the Anna Ridge and the ridge itself partly dissects the canyon (Fig. 6.2.2 B). In the canyon further south, coral mounds occur within the uppermost part of the canyon (Fig. 6.2.2 E). Multiple straight and listric- to J-shaped faults occur as bathymetric depressions along the slope with a dominant strike direction of N-NNE (~0°-25°) and a subordinate strike direction of ENE (~30°-75°). Several faults in the northern area are accompanied by small pockmarks along their downslope flanks (Fig. 6.2.2 D).

The ridges seem to be built up by coral mounds and occur in water depths ranging from about 250 m to 500 m. They are up to 100 m high and exhibit steep slopes with angles of up to 45°. Their shape is chain-like elongated with a total length of up to 18 km (e.g., Anna Ridge, Fig. 6.2.2 B). These ridges also follow the major strike directions already observed in the elongated depressions. The Scary Mounds (Fig. 6.2.2 B) with their comb-like morphology including their internal depression indicate that the observed ridges developed from the amalgamation of single coral mounds. The NNE striking Anna Ridge is about 13 km long and is accompanied by a shallower subparallel ridge in the SE. Both ridges follow a chute, which is potentially related to the Cuanza river run-out. The chute is about 4-km-wide, has a smooth seafloor morphology and reveals a different acoustic backscatter, which indicates sub-recent sedimentation. The

Dwarf Ridges in the north exhibit two ridge that are fused in the north and open to the south (Fig. 6.2.2 C). Besides the predominating ridges, smaller coral mound clusters occur in the area, partly also organized in chains or developed as small-sized ridges. Overall, it seems that the upslope ridge flanks, especially of the shallower ridges, are draped by sediments.

The observed sub-seafloor stratigraphy is exemplarily illustrated in two sub-bottom profiles (PARASOUND) and two multichannel seismic lines (Figs. 6.2.5 & 6.2.6). Both seismic profiles have vertical signal penetration down to more than 500 ms TWT (~325 mbsf). However, in the current processing state, interpretation of deeper reflectors is obstructed by the multiple seafloor reflections (compare Fig. 6.2.5, ~1100 s TWT).



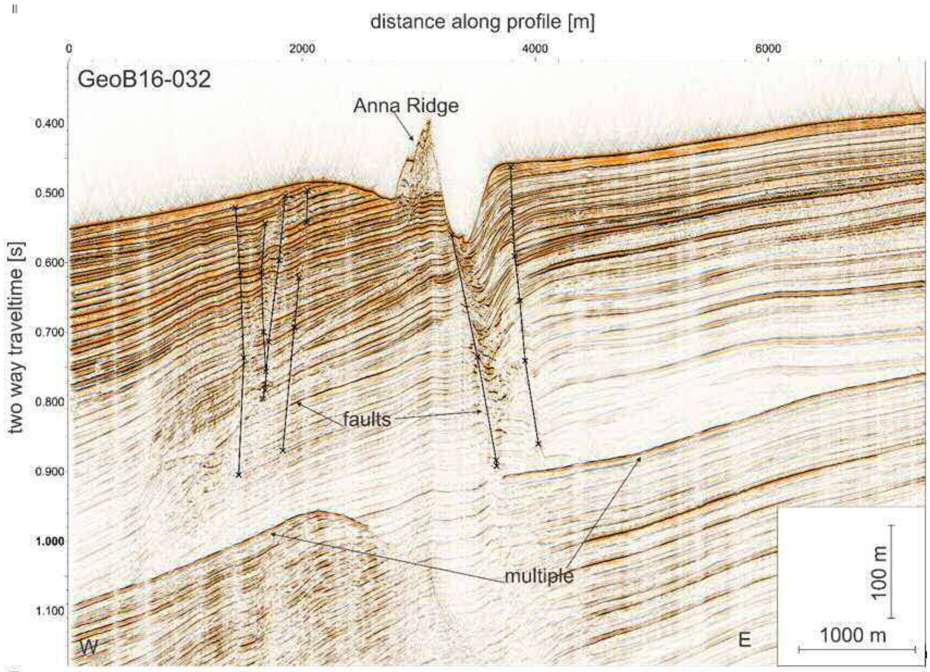


Fig. 6.2.5
*(**above**) PARASOUND sub-bottom profile PS-A (20160117_2300-0023) showing the Anna Ridge including close-ups, about 2 km north of the seismic profile MCS-A.*
*(**left**) Multichannel seismic line MCS-A (GeoB16-032) across the Anna Ridge (for position of profile/line see Fig. 6.2.1).*

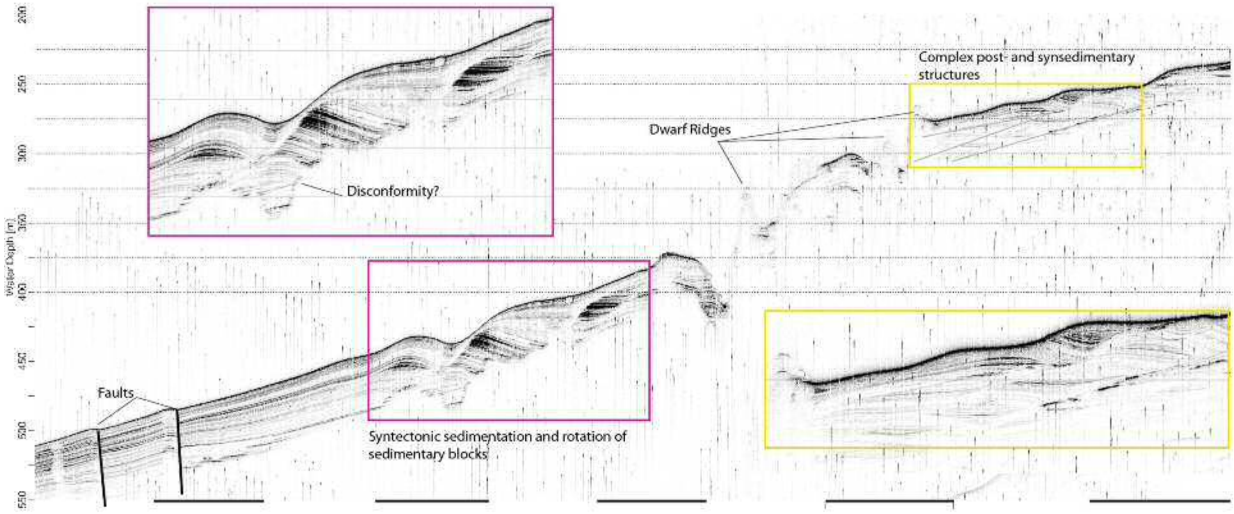
Insight into the sub-seafloor structures in the area of the Anna Ridge is provided by a W-E-oriented PARASOUND profile (PS-A: 20160117_2300-0023) and by a parallel but about 2 km south lying and 7-km-long multichannel seismic profile (MCS-A: GeoB16-032; see Fig. 6.2.5). The seafloor within this region shows a general westward dipping trend just interrupted by the ~100 ms TWT high Anna Ridge and an eastward lying, ~300 m wide and ~ 100 ms TWT deep depression. The same general dipping direction as for the seafloor is observed for deeper lying reflections. The PARASOUND profile reveals three faults that reach the surface and sub-recent sedimentary layers, respectively. A recent drape of contourite deposits is visible in the western vicinity of the Anna Ridge. In the seismic profile, the sediment column can be vertically separated into an upper package of high amplitude reflectors on top of a package of low amplitude reflectors. Horizontally, the profile is divided into two parts, separated by two prominent faults (3200 m and 3800 m distance along profile) truncating sub-bottom reflections. Both faults can be traced from the seafloor down to the depth of the multiple, which disguises a potential further extent.

East of the faults, reflectors are mostly subparallel with very rare and only singular toplap reflector truncations (see Fig. 6.2.5, 4200 m distance along profile, 550 ms TWT). The reflectors slightly diverge towards the west until they are cut by the eastern fault (see Fig. 6.2.5, 3800 m distance along profile). Between the two faults, reflector geometry changes tremendously. Dipping angles increase, the dip direction reverses locally and reflector truncations occur frequently, switching from down- to toplaps from the lower to the upper boundaries of the dip reversed units. This irregular unit coincides with the seafloor depression east of the Anna Ridge. The internal sedimentary pattern, especially the divergence and the distinct topographic low indicate bottom current activity. These current influenced deposits are clearly bounded by the fault at 3200 m distance along profile. Thus suggesting that faulting of the sediment column resulted in a seafloor irregularity where current interaction was initiated.

The Anna Ridge shows faint and contorted internal reflectors that dip westwards. The whole structure has a clear basis on the high amplitude reflectors truncating on the depression flank, which indicates a formation unrelated to faulting. Additionally, the ridge itself, as being a seafloor obstacle, has potential to perturb bottom currents further. West of the seafloor depression, a unit of high amplitude reflectors is visible. They are mostly parallel to subparallel with just some internal irregularities, such as an erosional discontinuity and some internal faulting. Since these faults only show small offsets, reflector geometries are sustained throughout. Toplaps at the seafloor indicate reflector erosion as those are situated above the base of the Anna Ridge they might be related to a bottom current core generated by the presence of the ridge.

The second example reveals the internal structure of the two roughly N-S striking Dwarf Ridges by a W-E-oriented ~11-km-long multichannel seismic line (MCS-B: GeoB16-050) and a 10-km-long PARASOUND profile (PS-B: 20160121_1916-2023), which was recorded almost 3 km to the north (see Fig. 6.2.6 for position). In addition to the morphologic expression of these ridges, their internal chaotic seismic reflections and the transparency in the 4 kHz SLF are characteristic for the internal structure of coral mounds/ridges. Similar to the Anna Ridge area, the sub-seafloor stratigraphy below the Dwarf Ridges is horizontally separated by two deep reaching faults (4400 m and 4800 m along profile; Fig 6.2.6). The fault offset cannot be determined without doubt since reflector geometries change remarkably. The faults coincide with the deeper, western Dwarf Ridge and a ~50 ms TWT deep topographic depression west of the ridge. The seafloor shows an overall westwards dipping trend. At the deeper Dwarf Ridge the seafloor depth changes abruptly forming a step of ~80 – 100 ms TWT (~60 – 74 m). This indicates a significant change in the depositional regime and might suggest a sediment input from the east and that the coral ridge acts as a barrier hindering a further down-slope sediment transport. The upper ~150 ms TWT of the deposits east of the Dwarf Ridges show a complex internal architecture (Fig. 6.2.6). Overall amplitudes are low with few singular medium amplitude reflectors, which always mark changes in the divergence pattern, thus, indicating changes in the current regime impacting sedimentation. The reflectors onlap onto the two ridges. Directly east of the deeper Dwarf Ridge and west of the shallower Dwarf Ridge, seafloor depressions occur. There, internal architecture and overall morphology suggest bottom current activity. Below 150 ms TWT reflections are mostly parallel. Here, the lowermost reflectors have medium to rather low amplitudes, overlain by a unit of high amplitude reflectors which are all parallel. Those two units are cut by three more faults producing minor offsets. The surface of the high amplitude reflectors is incised by a few shallow depressions.

To the west of the deeper Dwarf Ridge, an undisturbed block extends for ~2.5 km until the sub-bottom shows prominent, deep reaching faults (~1000 m distance along profile; Fig. 6.2.6). Here, the sediment column is separated vertically into two major seismic units marked by changes in reflection pattern as well as amplitude. The lowermost one (from ~750 ms TWT downwards) consists of slightly bent but parallel low amplitude reflectors while the upper one (from ~750 ms TWT upwards) has mostly high amplitude reflectors. At the top of the lower unit an erosional truncation (4 km distance along profile, ~750 ms TWT) forms an initial, U-shaped depression which proceeds also in the overburden deposits and even up to the seafloor. The divergent behaviour and changes between draping and erosion of the depression as well as the internal reflector geometry of the surrounding deposits indicate a direct current influence as already observed within the Anna Ridge area. Again, this coincides with sub-bottom faulting and a mound ridge forming an obstacle at the seafloor suggesting a similar formation mechanism of initial faulting, subsequent bottom current perturbation and at some point mound aggradation, leading to further bottom current perturbation.



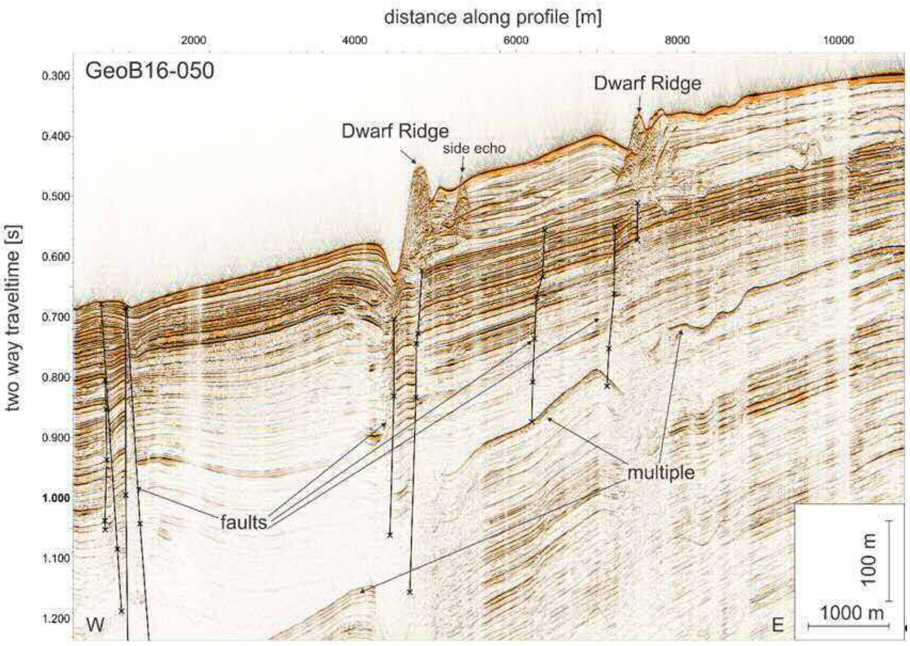


Fig. 6.2.6
*(**above**) PARASOUND sub-bottom profile PS-B (20160121_1916-2023) showing the Dwarf Ridges including close-ups (coloured boxes).*
*(**left**) Nearby parallel multi-channel seismic line MCS-B (GeoB16-050) across the Dwarf Ridges (for position of profile/line see Fig. 6.2.1).*

Overall, the working area off Angola is characterised by coral ridges and coral mounds that are predominantly organised in chains. Major features, such as the Anna Ridge and the Dwarf Ridges are related to fault structures. The related sediment patterns suggest syn-sedimentary faulting long before the formation of the coral mounds. Within the entire mapping area many faults which reach the seafloor, locally even related to pockmarks (Fig. 6.2.2 D), are observed. Not all of the faults are associated to coral mounds. A number of coral mounds/ridges without underlying faults are observed.

A more distinct relation exists with the occurrence of mounds and water depth, as they all fall into a depth window of 250 to 500 m. This might suggest that oceanographic parameters in concert with an active fault system, provides suitable conditions for coral settlement and mound formation. Furthermore, the distribution of thick contouritic deposits, as well as erosive structures in the vicinity of the coral mounds show the interaction of coral ridges with the local current regime.

6.2.4 ROV Observations

The main task of the ROV dives was to provide ground truth information on the presence, ecological status and composition of CWC off Angola. Within our study area, seven explorative ROV dives have been carried out on one CWC ridge and on five mound clusters detected within the MBES data (Fig. 6.2.7). Two dives were conducted on rather shallow CWC structures comprising the Anna Ridge and the Snake Mounds with their summits being situated at 250-260 m water depth. Mound structures with summits at 330-340 m depth belong to the Castle, Scary and Buffalo Mounds. Two dives were spent on the "deep" Valentine Mounds, with their summits at ~413 m water depth (Fig. 6.2.7). For information on the fully covered depths and the individual heights of the targets, we refer to Table 6.2.1.

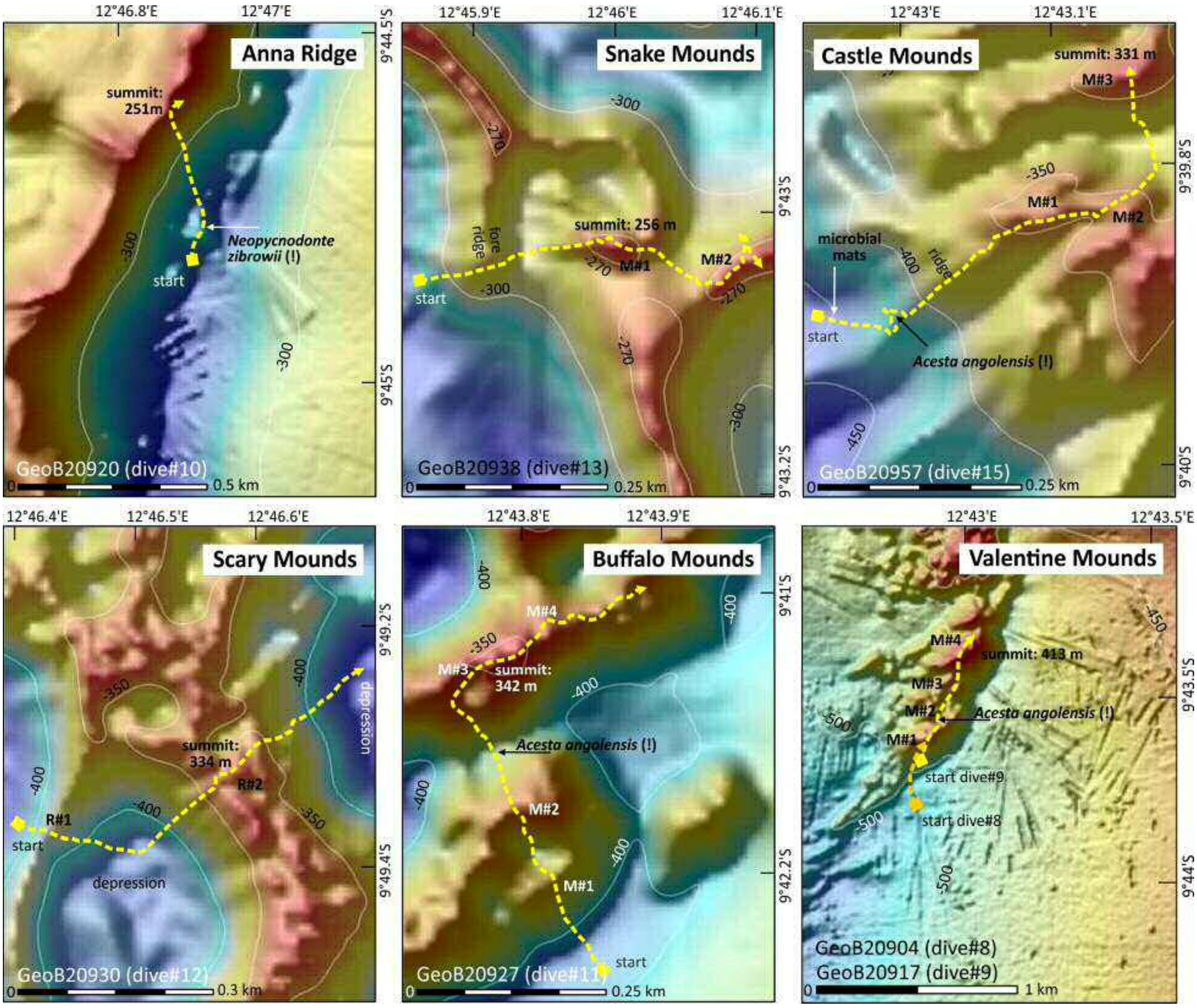


__Fig. 6.2.7__ Bathymetry maps showing the seven dive tracks (indicated by dashed yellow lines) conducted in six cold-water coral sites along the Angolan margin (M: coral mound, R: coral ridge). From shallow to deep water depths (regarding the position of the summit) these are: Anna Ridge, Snake, Castle, Scary, Buffalo and Valentine Mounds (for location of coral mound/ridge sites see Fig. 6.2.1).

Table 6.2.1 *Overview on the mound and ridge structures surveyed with ROV SQUID off Angola (see Fig. 6.2.1 for mound location) grouped from shallow to deep (different colour codes used for shallow (green), middle group (blue) and deep (darker blue)). Overview of dissolved oxygen (O_2) concentrations and ambient seawater temperatures at the reef sites and shallow tops measured with the ROV-mounted CTD.*

Location	ROV SQUID dive No.	Station No. (GeoB)	Depth (m)	HoS (m)	Reef DR (m)	Δ (m)	DoL (m)	Reef O_2 (ml L^{-1})	T (°C)
Anna Ridge	#10	20920-1	336-251	85	-	-*	335	0.7-0.9	11.1-14.1
Snake Mounds	#13	20938-1	291-256	34	-	-*	289	0.7-0.8	11.7-12.0
Castle Mounds	#15	20957-1	447-331	116	360-331	29	418	0.6-0.7	9.0-9.3
Scary Mounds	#12	20930-1	414-334	80	375-334	41	412	0.6-0.7	9.0-9.3
Buffalo Mounds	#11	20927-1	404-342	55	362-349	13	394	0.7-0.8	9.5-11.1
Valentine Mounds	#08	20904-1	503-413	90	473-413	60	503	0.8-1.1	7.8-8.5
	#09	20917-1							

DR: Depth Range of CWC reefs; DoL: Deepest occurrence of *Lophelia*; HoS: Height of underlying seabed structure; Δ: Bathymetric expression of reef habitat; *: Only single and very small *Lophelia* colonies encountered.

<u>Presence and distribution pattern of CWC</u>: Live scleractinian CWC were encountered on all dives of Angola. Highest abundance has *Lophelia pertusa* (estimated 99%), followed by *Madrepora oculata* and some solitary corals. The bathymetric range of live *Lophelia* colonies is from 503 m to 251 m water depth. On the shallow mound/ridge group (250-260 m), live corals occurred widely scattered as small colonies, whereas all the summits of the deep mounds are covered by flourishing *Lophelia* reef habitat covering a depth range from 473 to 331 m, which coincides with the oxygen minimum zone (Table 6.2.1). *Lophelia* colonies display different morphotypes, thereby the fanshape-like morphotype was dominant in those areas where the corals were growing as hedges (“belts”); however, some cauliflower-like colonies as well as colonies with undetermined growth pattern were observed as well.

Other cnidarian groups recorded are hydroids, octocorals with Stolonifera (*Clavularia*) and gorgonians (Acanthogorgiidae are Plexauridae most abundant, Pennatulacea (one species present on soft substrates), Actiniaria (several species, some of them in high abundance on coral rubble or as symbionts on hexactinellid sponges) and two Antipatharia species (the bottle brush-like is probably *Parantipathes* and is locally common).

Overall, passive suspension feeders (mostly cnidarians) were the most dominant and conspicuous benthic group observed in almost all dives. In contrast, shallow areas between the coral mounds, characterized by soft bottom or soft bottom with coral rubble, were dominated by sponges (active suspension feeders). Locally other filter feeders presented high abundance as it was the case of the active filter feeder oysters. Predators were represented mostly by crustaceans and starfish. Ophiuroids (mostly detritus feeders) were present in the soft bottom areas as well as in the rocky boulders present in the shallower mounds explored.

Characteristic features of the deep coral mound structures (>330 m depth)

The main framework-constructor is *Lophelia pertusa* with white tissue as the prevailing colourmorph. Occasionally red-tissued *Lophelia* morphs were present amongst the white colonies (Fig. 6.2.8 A), in some cases only visible in the summits of the mounds. We found all growth stages developed on the reefs; recently settled colonies with few polyps, next to 50 cm high colonies. Individual colony branches are often straight and follow a strict zig-zag pattern. The live polyp zone is up to 30 cm thick and consists of 20 to 25 polyp generations. Underneath, the tissue-barren dead framework is developed. This dead coral framework (dCRF) can attain 1 m in length and lies aside on the seabed, thus indicating a change in growth direction and position of the coral colony along with time. The most conspicuous growth pattern are up to 1-m-high and 2-3-m-wide coral hedges with a straight or arcuate outline (Fig. 6.2.8 B). These hedges form the core of the CWC reefs off Angola and are irregularly distributed near the tops of the mounds.

The bathymetric expression of reef habitat from the mound tops down-slope varies from mound to mound and between the flanks of individual mounds – probably controlled by the local hydrodynamic flow field. On the deep Valentine Mound, coral hedges were recorded from the summit at 413 m depth about 60 m downslope, corresponding to 473 m depth (see Table 6.2.1). Behind the coral hedges, pools of muddy sand either pure or speckled with coral rubble, are developed and provide habitat for soft substrate dwellers. The existence of fine-grained deposition at the current-rich summit of coral mounds is probably caused by framework trapping and baffling of detritus out of particle-laden bottom water, especially in lee situations behind the hedges and facilitated at times of low-speed tidal-driven currents.

Madrepora oculata is the second framework constructor but it seems to be far less abundant than *Lophelia*. Having said this, *Madrepora* often builds hedges of its own species, sometimes 1 m high and 2.50 m wide (Fig. 6.2.8 C). Post mortem, *Madrepora* easily disintegrates into saltstick-like fragments.

<u>Faunistic observations and interactions</u>: Only squat lobsters (Munididae, Galatheidae), shrimps and a corallivore echinoid (probably *Gracilechinus*) were found within the live zone (Fig. 6.2.8 F; the gut content of some sampled specimens showed pieces of coral skeleton). A small (12-cm-long) fish (probably a, or similar to *Benthocometes*) seems to live between the corals of the live zone. The symbiotic *Eunice* sp. is present but mostly in the basal sections of the colonies. Associated to the encalcified parchment tubes of *Eunice* is a polynoid scale worm. An aspect to point out is that zooplanktonic organisms were not observed within the coral branches in the close-up views, this is in contrast to observations made for *Lophelia* reefs from other Atlantic areas.

The colonization of the dead coral rubble facies (dCRF) is complex. A fluffy turf layer comprising of dendroid, flexible foraminifers and hydroids covers vast portions of the exposed skeleton. The skeleton itself shows faint Fe-Mn coatings. Other elements are several octocorals, large hydroids, serpulids, actiniarians, antipatharians, *Clavularia* and bryozoans (Fig. 6.2.8 D). Very prominent are large (up to 10 cm) erect rigid *Turritigera* colonies. A yellow *Metroperiella* is present, but in low numbers, and it is probably another species as found off Namibia (see also chapter 6.1.4). Grey zoarcids, *Helicolenus dactylopterus* (common), *Trachyscorpia* (rare), *Laemonema* and eel-like fishes (very common scavenger, see chapter 6.2.6) are present in the dCRF. Swarms of *Gephyroberyx darwinii*, pairs of *Zenopsis conchifer* and at least three macrourid species were recorded preferably in or above the reef habitat. Sponges form another important group of the dCRF. Most conspicuous are up to 25-cm-high *Aphrocallistes*, often standing in groups and with a yellow actiniarian as symbiont (Fig. 6.2.8 E). Other common large sponges are *Sympagella* and a lobate pachastrellid species. Numerous encrusting or small sponges add to this phylum.

The muddy sand pools behind the hedges attract pennatulaceans, foraminifers and tube-forming polychaetes (Onuphidae) and serves as ambush sites for *Lophius* anglerfishes (two species present). The mobile benthic assemblage shows ophiuroids (mostly seen on some sponges and in between the dCRF; a big *Asteroschema*-like brittle star shows preference for clinging in *Callogorgia* colonies), big *Chaceon maritae* (often half buried in soft sediment), *Eumunida bella* and other squat lobsters (no specific habitat preference noted) and *Bathynectes pirperitus*. Asteroids are common with at least 4 different species. Occasionally gastropods were spotted (*Sveltia*, *Ranella*, *Nassarius*).

<u>Fate of coral hedges and the creation of allochthonous coral rubble flanks</u>: The live corals in the reef habitat are attached to dCRF lying around free on the seabed (except in rocky areas). As the coral colonies in a hedge grow upward and outward with their branches oriented preferably against the residual current direction, the increase in surface resistance (fanshape-like morphotype) and weight causes capsizing of the entire hedge or parts of it. In other words, anchoring and stable positioning of old colonies on an unstable ground must be a limiting factor for more prolific growth. What happens are gravity-driven coral debris flows down the slope. This coral sliding zone is the next prominent feature of mounds with actively growing reefs on top. Underneath the upper hedge zone, graveyards of transported coral colonies (partly still alive) and broken branches form a sedimentary facies of its own entity - the allochthonous (transported) coral rubble (Fig. 6.2.8 F). Surviving displaced colonies respond with re-orientated growth direction of the coral branches.

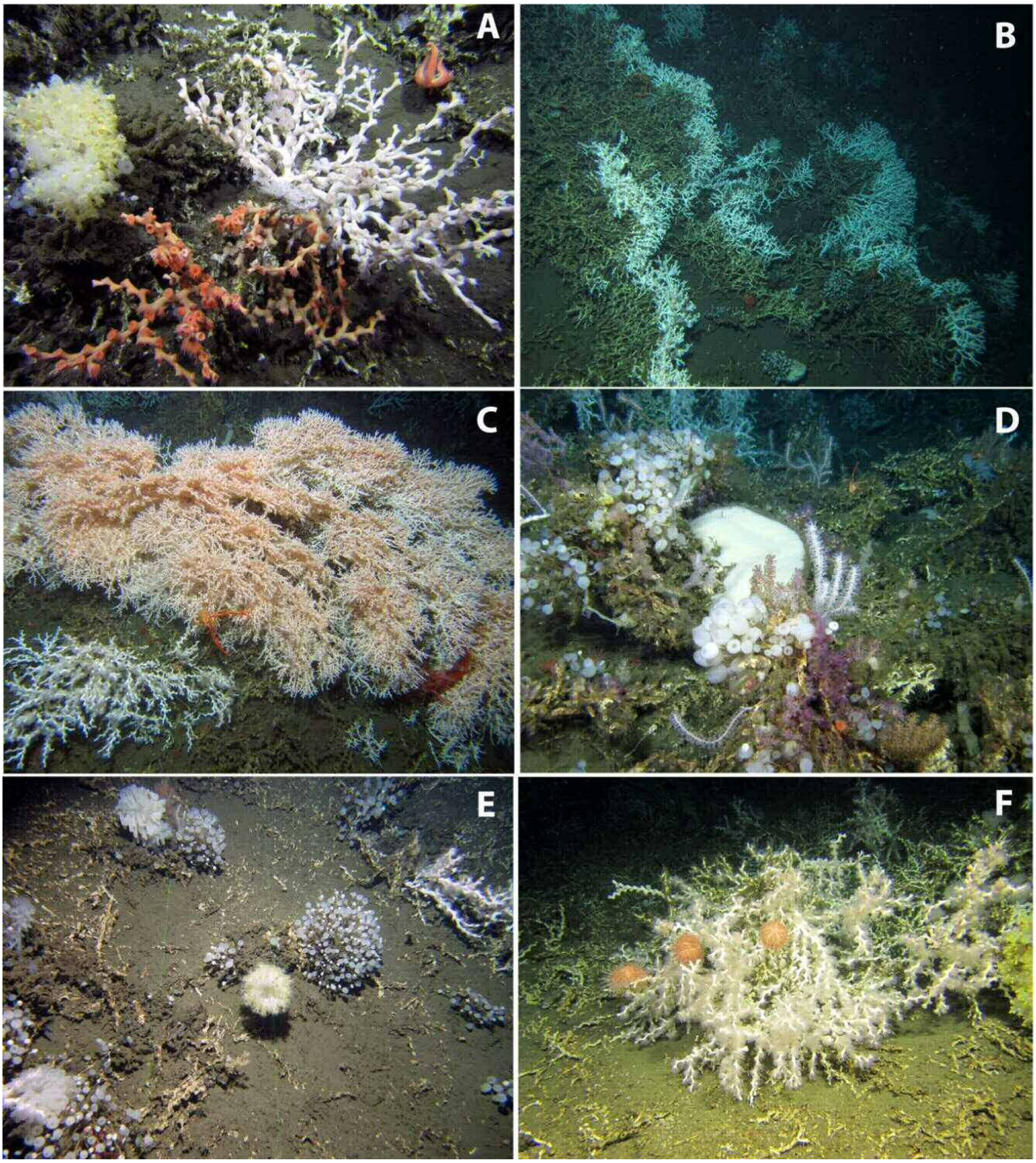


Fig. 6.2.8 *Features of vivid CWC reefs from the Angolan Margin.* ***A*** *A red and white colourmorph of Lophelia pertusa with characteristic zig-zag growth pattern of individual coral branches (Valentine Mounds, 445 m).* ***B*** *Downward view from the top of one of the Buffalo Mounds on a coral hedge (347 m).* ***C*** *Large Madrepora oculata colony measuring 2.50 m across and 1 m in height (Scary Mounds, 336 m).* ***D*** *Species-rich assemblage behind the coral hedges with sponges, octocorals, solitary corals and actiniarians (Buffalo Mounds, 353 m).* ***E*** *Dead coral framework colonized by the two sponge species Sympagella and Aphrocallistes. Note the top view into an Aphrocallistes specimen with its symbiontic yellowish actiniarian (Valentine Mounds, 433 m).* ***F*** *Displaced Lophelia colony on coral rubble being grazed by echinoids, the main corallivore predator (Valentine Mounds, 461 m).*

Basically, the same species composition as described above is found in the dCRF and coral rubble facies. Most prominent are larger aggregations of hexactinellid sponges (*Aphrocallistes*, *Sympagella* and another big yet not determined species) and gorgonians. The crustacean assemblage shows the same species but the big *Chaceon* crabs are more easily visible. Hermit crabs are locally very common together with shrimps. In such a habitat, all four *Acesta angolensis* specimens were documented (two of them sampled) at depths between 470 m (Valentine Mounds) and 385 m (Buffalo Mounds). *Acesta angolensis* is an 8-13 cm large file clam that was always encountered as a single specimen lying byssally attached to coral rubble or to a small rock outcrop (on Castle Mound near the seepage area at 415 m depth).Deep downslope coral rubble becomes the prominent coarse fraction and is embedded in muddy sand. At the mound bases, we observed an abrupt change from coral rubble muddy sand to muddy sand, often bioturbated by burrowing crustaceans, polychaetes, echiurids amongst others. Morphological elements are current-generated moats around the mounds, often 1-4 m deep. In this environment, most specimens of *Chaunax pictus* were observed.

The moat in front of the Castle Mounds shows some evidence of active seepage. Grey spots with small (dm-sized) depressions filled with black matter in the centre and surrounded by (probably) whitish microbial mats, and frequent findings of dead but still double-valved Vesicomyidae support this line of thought (see also chapter 6.2.3).

The shallow coral mound and ridge structures (250-340 m)

Two seabed structures surveyed with the ROV SQUID show no flourishing CWC activity. Only very few and small *Lophelia* colonies were spotted at these sites. However, the seabed of the Anna Ridge and the Snake Mounds is covered with fossil coral rubble all way up, indicating former suitable environmental conditions for CWC growth. On both structures, nearly no hexactinellid sponges were recorded, which were so prominent elements along the flanks and summits of the deeper mounds.

Anna Ridge bears a lot of peculiarities not seen on the other dive sites. At the base of Anna Ridge isolated pinnacle rocks, about 2.5 m high and with a round circumference, pierce through the flat coral rubble ground at 336 m depth. No smaller rocks around thus indicating a spotlike distribution. A sampled piece of rock showed a sandstone rich in burrows and/or borings, externally cemented *Lophelia* and both the sandstone and the corals are overcoated with 1-3-mm-thick Fe-Mn crust. The corals are largely dissolved and only voids remain. The vertical flanks of the pinnacles are plastered with 13-18-cm-large *Neopycnodonte* oysters, probably the first finding and sampling of live giant deep-sea oysters on the southern hemisphere (Fig. 6.4.9 A)! The shallowest oysters were recorded at 291 m depth. While the oysters concentrate mostly along the lower flanks of the rocks, numerous parchment tubes made by Eunice stick out perpendicular from the rock surfaces on the upper parts of the structure. The tubes are heavily surrounded by a consortium of hydroids and bryozoans which themselves are populated by Caprellidae, Acari, amphipods and benthic foraminifers (mostly *Discanomalina*). Near the pinnacle rocks we recorded many sharks (probably *Scyliorhinus cervigoni*) and one *Paromola cuvieri*, carrying a gorgonian octocoral.

From 331 m upslope, the coral rubble becomes increasingly overcrusted by authigenic, most likely phosphoritic crusts and from 318 m more platy crusts, few centimetres thick appeared. These crusts measure up to 15 cm across. *Lophelia* fragments are larger and concentrated in a form of rubble piles with partly exhumed crusts underneath. From 296 m upslope, the seabed is covered by authigenic crusts and platy rocks to the top of the ridge (Fig. 6.2.9 B). Here, we found one small *Lophelia* colony that thrived at a temperature of 14.1°C, the highest temperature record ever measured in nature for this coral (although we do not know for how long the high temperatures persist on Anna Ridge). The appearance of the crusts and rocks is different from the isolated pinnacle rocks further down. Rock samples from all areas will solve the origin and composition of these formations. Such crusts were also spotted at the base of the Snake

Mounds at 324 m depth, but not seen upslope any more. The Snake Mounds harbour a diverse gorgonian, hydroid and demosponge assemblage. *Lophelia* was seen only as small scattered colonies. In a trough between two mounds with prevailing bioturbated muddy sand, we documented several pink *Acanthocarpus brevispina* crabs, not seen anywhere else.

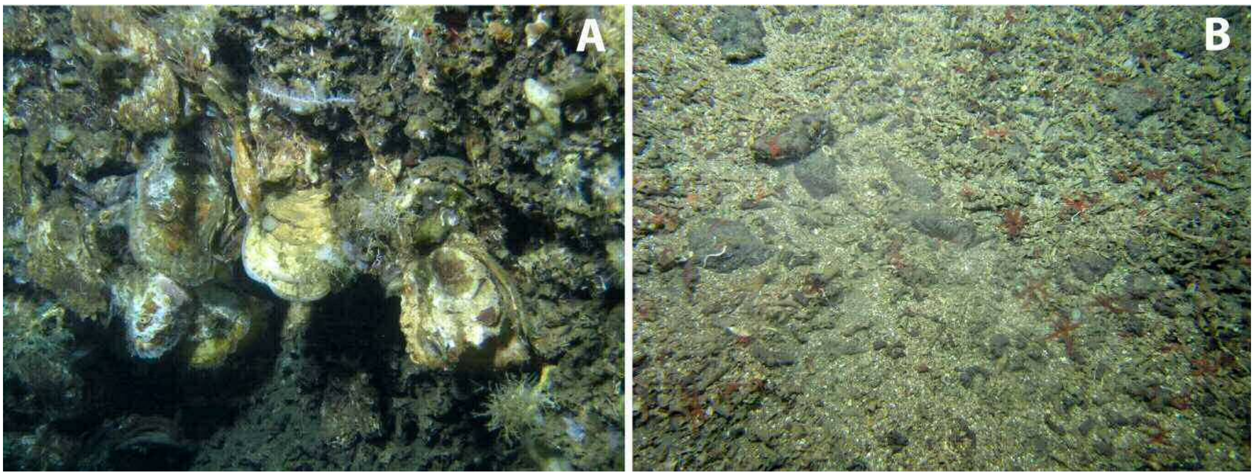


Fig. 6.2.9 A *Plasters of the giant deep-sea oyster, Neopycnodonte, on a pinnacle rock (Anna Ridge, -307 m).* ***B*** *Phosphoritic concretions (?) and coated coral rubble on the upper flanks of Anna Ridge (-296 m).*

CWC reef formation and the oxygen minimum zone: The thriving CWC reefs off Angola form under the lowest dissolved oxygen (O_2) concentrations ever observed for CWC. During our surveys, the ROV-mounted CTD continuously measured temperature, salinity and O_2 concentration. In terms of temperature, the CWC reefs were found at temperature ranges from 7.8 to 14.1°C (Table 6.2.1). Coldest temperatures of this range were encountered on the deep Valentine Mounds, whereas toward the shallower mounds and the ridge, temperatures climb up to 14.1°C as seen on top of Anna Ridge where we spotted only one small *Lophelia* colony – the highest (at least short term) value ever documented for *Lophelia pertusa*. The range of O_2 concentration obtained from the reef areas are very low with 1.1 to 0.6 ml L^{-1} and document the presence of the oxygen minimum zone. The deep (500 – 400 m) Valentine Mounds show highest values reaching a O_2 concentration of 1.1 ml L^{-1} in the bottom water. The range of measured O_2 concentrations decreased to 0.6 and 0.8 ml L^{-1} around the middle deep (400 – 300 m) mounds. This indicates that the deeper mounds receive slightly higher oxygenated waters compared to those above. The range of O_2 concentrations on the two reef-less shallow stations (Anna Ridge and Snake Mounds) yielded values between 0.7 and 0.9 ml L^{-1} accompanied by the highest temperatures along this transect.

Signs of human impact: Visible human impact on the seabed was very low. Solely for Anna Ridge, we observed one lost long line, but we did not encounter any sign of trawl marks, cables or garbage on the seafloor. However, we noticed large amounts of floating macroplastic stuff at the sea surface, especially at the shallow stations (Snake Mounds, Anna Ridge).

Main conclusions: The presence of live CWC on mounded structures off Angola is known from other sources but was never main subject of a cruise to unravel a more complete picture of the distribution, ecological status, biodiversity and environmental controls. To conclude, the reefs off Angola are mainly constructed by *Lophelia pertusa* and to small amounts by *Madrepora oculata*. The framework constructing role of large hexactinellids should not be underestimated in this region. Reef growth was documented at depths between 473 m and 331 m. On shallower structures only isolated and small coral colonies were seen.

Overall, we found the lowest O_2 concentration ever documented for living occurrences of *Lophelia* and *Madrepora* in nature – with 1.1 to 0.6 ml L^{-1} respectively. The lack of shallower reefs cannot be explained by the reduced oxygen conditions in combination with higher temperatures of up to 14.1°C, that may create stressful conditions for the CWC. A lack of sufficient larval supply at shallower depths may be another factor to consider. At former times, thriving CWC reefs were present on these shallower structures as well. We are fully aware that our results represent a snapshot only and not much is known on seasonal variation of the various environmental parameters over an annual cycle. For some of the shallower CWC sites phosphoritic (?) crusts were observed (Anna Ridge and Snake Mounds). We saw many fossil *Lophelia* fragments serving as nuclei for authigenic concretions. Analyses in the home labs will try to solve the composition and the time constraints of raise and decline of the shallow CWC reefs and subsequent formation of concretions and crusts.

The first finding of live deep-sea oysters, *Neopycnodonte*, in the southern hemisphere was another highlight of the cruise. We could also provide first ecological and environmental information on the ecology of the large file clam *Acesta angolensis*.

6.2.5 Sediment Sampling

Surface samples

A total of 17 grab samples and two box cores were collected from various sites along the Angolan margin to obtain information about surface sediments and the benthic macrofaunal composition. In addition, biogenic and rock samples were collected from the seafloor by the ROV SQUID during video observation. A detailed description of all surface samples is provided in Appendix C and E.

Sediment cores

For the working area on the Angolan margin, nine "on-mound" gravity cores were collected from the various cold-water coral (CWC) mounds examined during M122, including the Valentine, Scary, Snake and Twin Mounds, and the Anna Ridge (Table 6.2.2; for coring location see Fig. 6.2.1). These coral-bearing cores remained unopened (see chapter 6.1.5). However, as for the on-mound cores collected off Namibia, all cores retrieved from the different Angolan coral mounds, having recoveries between 4.5 m and 10.5 m, are entirely composed of coral fragments embedded in hemipelagic sediments (Table 6.2.2). In addition, two off-mound cores were collected from the Angolan margin, one west of the pronounced Anna Ridge (GeoB20911-1) and one west of the Scary Mounds (GeoB20952-1), being the southern extension of the Anna Ridge (Table 6.2.2; for coring location see Fig. 6.2.1). Both cores were opened on-board and visually described. The cores have recoveries of > 5 m and are composed of very dark silty sand to silt occasionally containing mm-sized shell hash (see Appendix D for detailed description).

Table 6.2.2 *Metadata of coral-bearing (on-mound) gravity cores collected during M122 from various Angolan coral mounds and of two off-mound cores.*

Mound area	GeoB		Lat (S)	Lon (E)	WD	REC	Remark
Valentine Mounds	20908-2	GC6	9°43.605'	12°42.893'	439 m	4.51 m	corals throughout
Valentine Mounds	20928-2	GC12	9°43.388'	12°42.899'	457 m	7.57 m	corals throughout
Twin Mounds	20910-2	GC12	9°43.573'	12°44.665'	334 m	6.75 m	corals throughout
Anna Ridge	20912-1	GC12	9°44.903'	12°46.663'	247 m	4.88 m	corals throughout
Scary Mounds	20931-1	GC12	9°49.239'	12°46.669'	424 m	5.67 m	corals throughout
Scary Mounds	20932-1	GC12	9°49.277'	12°46.624'	369 m	7.32 m	corals throughout
Scary Mounds	20933-1	GC12	9°49.331'	12°46.565'	338 m	9.83 m	corals throughout
Snake Mounds	20959-1	GC12	9°43.027'	12°45.961'	279 m	7.55 m	corals throughout; mound flank
Snake Mounds	20960-1	GC12	9°43.017'	12°45.997'	264 m	10.44 m	corals throughout; mound top
off-mound	20911-1	GC12	9°47.238'	12°45.533'	386 m	5.59 m	west of Anna Ridge; opened
off-mound	20952-1	GC12	9°48.663'	12°46.266'	389 m	5.39 m	west of Scary Mounds; opened

6.2.6 Time-Series Lander Data

On the Angolan margin, the ALBEX-TROL lander with a baited experiment was deployed at 550 m water depth in the vicinity of the Valentine Mounds (GeoB20916) for the duration of the working period (~7 days) in the area. The ALBEX lander equipped with the particle pump was first deployed near the relatively shallow Anna Ridge at 340 m water depth (GeoB20921). After two and a half days, this lander was recovered and deployed for another short deployment (GeoB20940) in the deeper part of the mound area near the ALBEX-TROL lander (west of Valentine Mounds). Main aim of the multiple deployments with the lander equipped with the particle pump was to define, if samples of particulate matter and their geochemical composition differ at different water depths.

Preliminary analysis of the lander data shows a distinct semi-diurnal tidal cycle, causing daily fluctuations in temperature, oxygen and current speed. A general decreasing trend in temperature was observed during the deployment period at all lander sites. Temperature at the shallow ALBEX location (west of the Anna Ridge) fluctuated between 9.1 and 12.6 °C (average 10.02 °C) and oxygen levels varied between 0.86 - 1.39 mg L^{-1} (Fig. 6.2.10a). At the ALBEX-TROL site (GeoB 20916) near-bed temperature fluctuated between 6.4 - 8 °C (average 7.1 °C) (Fig. 6.2.10b). Oxygen levels at this depth were higher and varied between 1.35 - 2.34 mg L^{-1}. At both depths oxygen levels were significantly higher compared to oxygen levels as measured on the Namibian margin. Current speeds as measured at the ALBEX-TROL site were similar to current speeds measured on the Namibian margin. Peak current speeds were 0.27 ms^{-1} and average current speed was 0.1 ms^{-1} over the deployment period.

The ALBEX-TROL lander was again equipped with a baited camera experiment. First species to arrive at the bait were eels (arrival time 5.43 minutes), which were followed by numerous large crabs (*Chaecon sp.*) (arrival time 27.36 minutes). During the deployment bait was completely consumed after 5 days. This is in sharp contrast with the Namibian site where bait was hardly touched.

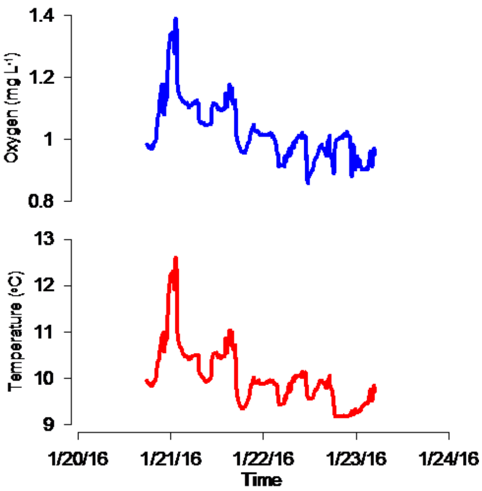


Fig. 6.2.10a *Daily fluctuations of temperature and oxygen concentrations at the shallow ALBEX lander site (GeoB 20921; west of Anna Ridge).*

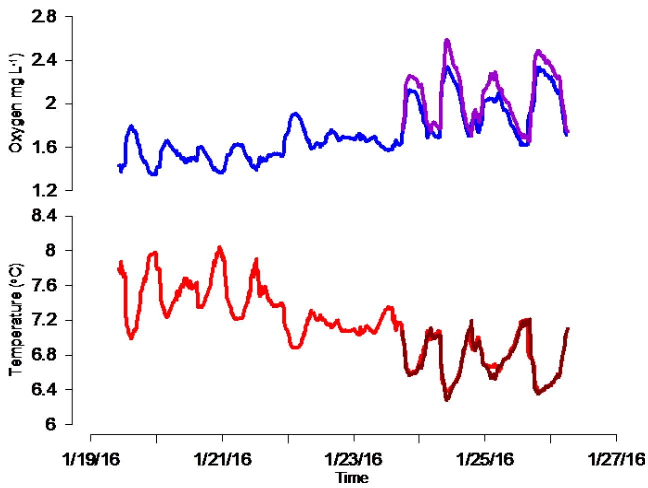


Fig. 6.2.10b *Daily fluctuations of temperature and oxygen concentrations at the TROL lander site (GeoB 20916; Valentine Mounds).*

7 Weather conditions during M122

C. Rohleder (DWD)

On Dec 30, 09:05 local time, R/V METEOR left the harbour of Walvis Bay (Namibia) to expedition M122. At this time, the centre of the subtropical high was far to the west over the subtropical Atlantic. A shallow continental trough of low pressure expanded from Namibia to the coastal waters, and hence, to the first working area off Namibia. Associated rain shower activities were only ashore. Away from the coast, fog patches were repeatedly encountered, therefore the first days of the expedition were marked by poor visibility and fog.

Over New Year's Eve, a high-pressure centre developed near 29°S/0°E, which shifted south-eastward and weakened in the following days. This caused a mostly southern flow and pushed spacious fog patches and low stratus fields into the working area. This flow was only occasionally disrupted by the development of small-scale low pressure systems in the coastal area, where rain showers and thunderstorms were formed ashore, so that lightning could be observed in the east on the evening of Jan 04. In the research area itself, these low pressure systems became noticeable primarily through changes in the direction of the mostly weak wind. Only on Jan 06, R/V METEOR was affected by a rain shower.

During the second week of the expedition, a constant fresh to strong southern flow and a strong swell on its eastern flank developed as a result of the strengthening of the largely stationary subtropical high (1033hPa). On Jan 8, swell and wind sea reached heights of over 3.5 m but weakened in the course of the next day again. However, due to the sea conditions, the planned dives with the ROV SQUID had to be postponed until Jan 10.

In the beginning of the third week of the expedition, the extended high above the South Atlantic slightly weakened. On Jan 12, R/V METEOR reached the harbour of Walvis Bay (to pick up spare parts for the ROV) with little wind and swell. With Bft 2 and barely existing swell, the regularly necessary test of the lifeboats easily could be carried out on this occasion. On Jan 13, the cruise was continued. The weather conditions remained stable. Some small-scale low-pressure areas near the Namibian coast caused weak wind from different directions. When R/V METEOR reached the second working area off Angola, being situated slightly south to Luanda, the area was mainly characterized by weak air pressure differences. Near the coast, orographic effects became evident. Regularly right-handed and slightly increasing wind in the afternoons, that turned back and decreased only in the course of the night, were observed. Small-scale low-pressure areas across the coast repeatedly caused short-term disturbances of the otherwise stable weather conditions. These resulted in some heavy showers over the ship and its surroundings from Jan 19 to Jan 21. On Jan 19, even a waterspout was observed. However, the rain showers and the associated increase of wind and wind sea were always short and did not disrupt the research essentially.

On Jan 26, the research in the working area on the Angolan margin was completed and R/V METEOR started its way back to Walvis Bay. On the way south, the air pressure differences increased slightly as mainly reflected by freshening winds. The significant wave height reached values of ~3.5 m on Jan 28. During the last weekend of the expedition, the sea calmed down. On Jan 31, R/V METEOR reached Walvis Bay in good weather conditions.

8 Station List M122

Station-N°	Meteor	Gear	Latitude (S)		Longit. (E)		Date	Time	WD	REMARKS	Site
(GeoB)	(M1220)		°	min	°	min	ddmmyy	(UTC)	(m)		
Northern Namibian Margin											
20501-1	1347-1	V-CTD	20	47.190	12	47.390	30.12.15	23:00	271	failed	
20502-1	1348-1	MBES/PS	20	47.290	12	47.160	30.12.15	23:46	260	*start survey*	
			20	47.280	12	45.900	31.12.15	08:35	290	*end survey*	
20502-2	1349-1	XSV	20	53.360	12	20.780	31.12.15	05:26	512	sound velocity profile	
20503-1	1350-1	MCS	20	47.300	12	50.080	31.12.15	10:08	246	*start survey*	
			20	46.870	12	49.220	01.01.16	06:06	249	*end survey*	
20504-1	001-1	V-CTD	20	44.067	12	49.330	01.01.16	07:58	220	failed	Sylvester M.
20505-1	001-3	ROV	20	43.899	12	49.703	01.01.16	11:37	205	*start dive #1*	Sylvester M.
			20	43.991	12	49.041	01.01.16	16:54	233	*end of dive*	
20505-2	001-3	ROV	20	43.995	12	49.055	01.01.16	16:08	238	ROV S #1: hardground	
20505-3	001-3	ROV	20	43.989	12	49.041	01.01.16	16:50	232	ROV S #2: coral rubble, water sample	
20506-1	001-4	SML	20	43.929	12	49.107	01.01.16	18:07	222	*deployment*	Sylvester M.
			20	48.858	12	48.807	14.01.16	06:37	240	*recovery*	
20507-1	002-1	ALBEX	20	44.030	12	49.230	01.01.16	19:22	210	*deployment*	Sylvester M. (particle pump)
			20	44.030	12	49.230	09.01.16	14:14	210	*recovery*	
20508-1	003-1	ALBEX TROL	20	44.030	12	49.140	01.01.16	19:53	220	*deployment*	Sylvester M. (baited experiment)
			20	44.030	12	49.140	09.01.16	14:46	220	*recovery*	
20509-1	004-1	MBES/PS	20	40.810	12	50.270	01.01.16	20:47	222	*start survey*	
			20	36.230	12	51.720	02.01.16	05:35	153	*end survey*	
20510-1	005-1	GBC	20	43.962	12	49.119	02.01.16	06:44	230	REC: ~15cm; coral rubble	Sylvester M.
20511-1	006-1	GBC	20	43.981	12	49.069	02.01.16	07:23	232	REC: ~20cm; coral rubble	Sylvester M.
20512-1	007-1	ROV	20	44.071	12	48.841	02.01.16	09:18	246	*start dive #2*	Sylvester M.
			20	43.882	12	48.782	02.01.16	12:13	241	*end of dive*	
20512-2	007-1	ROV	20	43.981	12	48.876	02.01.16	10:22	242	ROV S #1: hardground, sponges	
20512-3	007-1	ROV	20	43.865	12	48.850	02.01.16	11:40	231	ROV S #2: sponge, coral rubble	
20513-1	008-1	ROV	20	45.829	12	49.944	02.01.16	14:35	221	*start dive #3* (aborted)	New Year M.
			20	45.847	12	49.868	02.01.16	15:45	226	*end of dive*	
20513-2	008-1	ROV	20	45.828	12	49.880	02.01.16	15:26	220	ROV S #1: bryozoan, coral rubble	
20513-3	008-1	ROV	20	45.847	12	49.868	02.01.16	15:53	226	ROV S #2: water sample	
20514-1	009-1	MCS	20	45.720	12	50.140	02.01.16	16:29	162	*start survey*	
			20	44.350	12	50.830	03.01.16	05:36	175	*end survey*	
20515-1	010-1	GBC	20	45.828	12	49.976	03.01.16	06:33	226	REC: 23-25cm; sediment, worm tubes	New Year M.
20516-1	011-1	GBC	20	45.818	12	49.880	03.01.16	07:31	219	REC: 30-32cm; sediment, worm tubes	New Year M.
20516-2	011-2	GBC	20	45.834	12	49.887	03.01.16	08:10	223	REC: 40cm; coral rubble	New Year M.
20516-3	011-3	GC	20	45.834	12	49.887	03.01.16	08:54	225	REC: 5.74m; corals	New Year M.
20517-1	012-1	GC	20	43.980	12	49.076	03.01.16	10:05	235	REC: 0.52m; corals	Sylvester M. M#4
20518-1	013-1	GC	20	43.930	12	48.916	03.01.16	10:48	232	REC: 5.78m; corals, overpenetration	Sylvester M. M#8
20519-1	014-1	V-CTD	20	43.990	12	48.840	03.01.16	11:58	248	failed	Sylvester M.
20520-1	015-1	GS	20	43.476	12	49.866	03.01.16	12:51	234	coral and Pycnodonte rubble, sandy sediment	backscatter calibration
20521-1	016-1	GS	20	43.436	12	49.146	03.01.16	13:44	223	sand, shell hash, tubes	backscatter calibration
20522-1	017-1	GS	20	43.113	12	49.045	03.01.16	14:23	219	sand, shell hash, tubes	backscatter calibration
20523-1	018-1	GS	20	43.052	12	50.193	03.01.16	14:58	182	sand, shell hash, tubes	backscatter calibration
20524-1	019-1	GS	20	43.104	12	51.031	03.01.16	15:33	189	failed, not released	backscatter calibration
20524-2	019-2	GS	20	43.104	12	51.030	03.01.16	15:44	167	few sediment, corals, shell hash, hard rocks	backscatter calibration

Station-N°	Meteor	Gear	Latitude (S)		Longit. (E)		Date	Time	WD	REMARKS	Site
(GeoB)	(M1220)		°	min	°	min	ddmmyy	(UTC)	(m)		
20525-1	020-1	CTD+RO	20	43.990	12	48.830	03.01.16	17:31	247	water sampling	Sylvester M.
20526-1	021-1	MBES/PS	20	43.990	12	48.830	03.01.16	17:59	210	*start survey*	
			20	41.820	12	48.150	04.01.16	05:47	242	*end survey*	
20527-1	022-1	GC	20	41.410	12	51.194	04.01.16	06:39	182	REC: 1.98m; shell hash	E of Escarpment
20528-1	023-1	GC	20	42.330	12	52.610	04.01.16	07:45	187	REC: 5.06m; shell hash	E of Escarpment
20529-1	024-1	GC	20	43.467	12	50.736	04.01.16	08:56	165	REC: 2.26m; shell hash	W of Escarpment
20530-1	025-1	GC	20	42.733	12	48.269	04.01.16	10:20	242	REC: 1.30m; sediment, shell hash	N of Sylvester M.
20531-1	026-1	GC	20	43.933	12	48.919	04.01.16	11:22	232	REC: 10.21m; 0-8m: corals; below: shell hash & sediment	Sylvester M. M#8
20532-1	027-1	GS	20	43.024	12	52.009	04.01.16	12:18	178	sand, shell hash	backscatter calibration
20533-1	028-1	GS	20	43.390	12	53.107	04.01.16	13:04	183	silty sediment	backscatter calibration
20534-1	029-1	GS	20	42.706	12	53.036	04.01.16	13:55	176	hardground	backscatter calibration
20535-1	030-1	GS	20	42.432	12	53.090	04.01.16	14:28	168	clayey rocks, bivalves	backscatter calibration
20536-1	031-1	CTD+RO	20	46.470	12	49.450	04.01.16	15:32	250	water sampling	New Year M.
20537-1	032-1	MBES/PS	20	38.050	12	49.010	04.01.16	16:37	204	*start survey*	
			20	32.720	12	46.630	04.01.16	17:16	154	*end survey*	
20538-1	033-1	MCS	20	32.290	12	47.630	04.01.16	17:49	166	*start survey*	
			20	41.820	12	49.430	05.01.16	05:03	191	*end survey*	
20539-1	034-1	GBC	20	45.018	12	51.733	05.01.16	06:03	166	large hardground boulder; box damaged	Escarpment M.
20540-1	035-1	GC	20	45.024	12	51.704	05.01.16	07:15	159	REC: 0.24m; few coral fragments and shells	Escarpment M.
20541-1	036-1	GS	20	40.521	12	47.106	05.01.16	08:55	242	sand, shell hash, tubes	backscatter calibration
20542-1	037-1	GS	20	37.349	12	50.544	05.01.16	10:15	165	hardground	backscatter calibration
20543-1	038-1	CTD+RO	20	30.180	12	40.060	05.01.16	12:03	224	water sampling	Squid M.
20543-2	038-2	GC	20	30.187	12	40.066	05.01.16	12:33	224	REC: 4.85m; top: corals, oysters, fine sediment	Squid M.
20544-1	039-1	GC	20	22.267	12	38.468	05.01.16	13:59	162	REC: 0.76m; pipe bent, corals	Pickel Mound
20544-2	039-2	GS	20	22.265	12	38.468	05.01.16	14:38	160	coral rubble	Pickel Mound
20545-1	040-1	GBC	20	30.184	12	40.067	05.01.16	16:07	224	REC: 22-32cm; *Pycno-donte*-coral rubble	Squid M.
20546-1	041-1	MBES/PS	20	29.880	12	39.460	05.01.16	16:41	256	*start survey*	
			20	41.660	12	50.950	06.01.16	05:48	187	*end survey*	
20547-1	042-1	ROV	20	45.006	12	51.964	06.01.16	08:18	192	*start dive #4*	Escarpment M.
			20	45.004	12	51.659	06.01.16	12:23	162	*end of dive*	
20547-2	042-1	ROV	20	45.011	12	51.757	06.01.16	10:49	178	ROV S #1: sponge	
20547-3	042-1	ROV	20	45.015	12	51.757	06.01.16	11:12	168	ROV S #2: bryozoan	
20547-4	042-1	ROV	20	45.005	12	51.676	06.01.16	11:53	160	ROV S #3: water sample	
20547-5	042-1	ROV	20	45.003	12	51.667	06.01.16	12:11	163	ROV S #4: *Cellaria* (bryozoan)	
20547-6	042-1	ROV	20	45.003	12	51.667	06.01.16	12:15	163	ROV S #5: *Cellaria* (bryozoan)	
20547-7	042-1	ROV	20	45.003	12	51.667	06.01.16	12:17	163	ROV S #6: *Cellaria* (bryozoan)	
20548-1	043-1	GS	20	45.025	12	51.715	06.01.16	13:10	162	coral rubble, shell hash	Escarpment M.
20549-1	044-1	GS	20	45.014	12	51.778	06.01.16	13:44	175	coral rubble, bivalves	Escarpment M.
20550-1	045-1	GC	20	51.029	12	28.103	06.01.16	16:27	367	REC: 5.43m	deep off-mound site
20551-1	046-1	CTD+RO	20	50.000	12	25.000	06.01.16	17:51	391	water sampling	CTD transect
20552-1	047-1	CTD+RO	20	47.792	12	33.110	06.01.16	19:25	333	water sampling	CTD transect
20553-1	048-1	CTD+RO	20	45.588	12	41.383	06.01.16	20:55	310	water sampling	CTD transect
20554-1	049-1	CTD+RO	20	43.681	12	43.639	06.01.16	21:55	286	water sampling	CTD transect
20555-1	050-1	CTD+RO	20	43.118	12	50.985	06.01.16	23:10	163	water sampling	CTD transect

Station-N°	Meteor	Gear	Latitude (S)		Longit. (E)		Date	Time	WD	REMARKS	Site
(GeoB)	(M1220)		°	min	°	min	ddmmyy	(UTC)	(m)		
20556-1	051-1	CTD+RO	20	42.802	12	52.079	06.01.16	23:55	178	water sampling	CTD transect
20557-1	052-1	CTD+RO	20	41.979	12	55.303	07.01.16	00:51	150	water sampling	CTD transect
20558-1	053-1	MBES/PS	20	41.980	12	55.300	07.01.16	01:05	149	*start survey*	
			20	54.110	12	53.860	07.01.16	07:11	214	*end survey*	
20559-1	054-1	ROV	20	54.318	12	53.922	07.01.16	08:44	221	*start dive#5*	Merluza M.
			20	54.473	12	53.475	07.01.16	13:57	235	*end of dive*	
20559-2	054-1	ROV	20	54.335	12	53.838	07.01.16	10:27	220	ROV S #1: sponge	
20559-3	054-1	ROV	20	54.336	12	53.812	07.01.16	10:41	219	ROV S #2: white bryozoan	
20559-4	054-1	ROV	20	54.336	12	53.813	07.01.16	10:47	218	ROV S #3: water sample	
20559-5	054-1	ROV	20	54.345	12	53.755	07.01.16	11:15	220	ROV S #4a-d: 4 white bryozoans (partly lost)	
20560-1	055-1	CTD+RO	20	54.341	12	53.818	07.01.16	15:12	217	water sampling	Merluza M.
20560-2	055-2	GS	20	54.337	12	53.819	07.01.16	15:43	217	off-mound: sediment, worm tubes	Merluza M.
20561-1	056-1	GS	20	54.417	12	53.538	07.01.16	16:12	224	off-mound: sediment, worm tubes	Merluza M.
20562-1	057-1	MBES/PS	20	55.060	12	51.970	07.01.16	16:46	252.5	*start survey*	
			20	57.590	12	55.260	08.01.16	08:08	218.7	*end survey*	
20563-1	058-1	GS	20	59.040	12	55.096	08.01.16	09:01	232	coral rubble	Priska M.
20564-1	059-1	GS	20	59.006	12	55.045	08.01.16	09:30	234	coral rubble	Priska M.
20565-1	060-1	CTD+RO	20	58.913	12	55.002	08.01.16	11:05	233	water sampling	Priska M.
20565-2	060-2	GS	20	58.918	12	55.003	08.01.16	11:40	232	coral rubble	Priska M.
20566-1	061-1	GBC	20	54.346	12	53.829	08.01.16	12:57	223	REC: 12cm; coral rubble, bivalves	Merluza M.
20567-1	062-1	GBC	20	54.412	12	53.609	08.01.16	13:44	225	failed, toppled over	Merluza M.
20567-2	062-2	GBC	20	54.412	12	53.609	08.01.16	14:09	226	failed, toppled over	Merluza M.
20568-1	063-1	GC	20	59.006	12	55.044	08.01.16	15:21	236	REC: 2.90m; corals, strong H_2S smell	Priska M.
20569-1	064-1	GS	20	58.892	12	54.586	08.01.16	16:10	243	coral rubble	Priska M.
20570-1	065-1	MBES/PS	20	59.09	12	53.92	08.01.16	16:29	247.7	*start survey*	
			20	28.260	12	40.120	09.01.16	06:17	221.4	*end survey*	
20571-1	066-1	GBC	20	30.194	12	40.122	09.01.16	06:55	225	REC: 30cm; coral rubble	Squid M.
20571-2	066-2	GC	20	30.193	12	40.122	09.01.16	07:55	225	REC: 5.48m; corals	Squid M.
20572-1	067-1	CTD+RO	20	35.249	12	43.97	09.01.16	09:04	233	water sampling	Sea Star M.
20572-2	067-2	GC	20	35.248	12	43.966	09.01.16	09:26	218	REC: 5.87m; overpenetration, corals	Sea Star M.
20572-3	067-3	GC	20	35.248	12	43.969	09.01.16	10:48	218.7	REC: 9.87m; corals	Sea Star M.
20572-4	067-4	GBC	20	35.249	12	43.968	09.01.16	12:05	221	REC: 30cm; coral rubble	Sea Star M.
20575-1	070-1	MCS	20	28.020	12	43.760	09.01.16	17:20	138.7	*start survey*	
			20	28.630	12	39.340	10.01.16	05:22	235.9	*end survey*	
20576-1	071-1	ROV	20	30.196	12	40.180	10.01.16	09:23	235	*start dive#6*	Squid M.
			20	30.034	12	39.983	10.01.16	13:03	230	*end of dive*	
20576-2	071-1	ROV	20	30.143	12	39.926	10.01.16	11:23	238	ROV S #1: yellow sponge	
20576-3	071-1	ROV	20	30.131	12	39.903	10.01.16	11:43	225	ROV S #2: bryozoans	
20576-4	071-1	ROV	20	30.034	12	39.981	10.01.16	12:49	230	ROV S #3: water (lost during recovery)	
20577-1	072-1	CTD+RO	20	30.049	12	39.948	10.01.16	14:21	221	water sampling	Squid M.
20577-2	072-2	GS	20	30.048	12	39.947	10.01.16	14:50	221	coral rubble	Squid M.
20578-1	073-1	GS	20	30.080	12	39.894	10.01.16	15:21	230	coral rubble	Squid M.
20579-1	074-1	GS	20	30.128	12	39.901	10.01.16	15:48	223	coral rubble	Squid M.
20580-1	075-1	MBES/PS	20	30.190	12	43.350	10.01.16	16:35	194.1	*start survey*	
			20	58.940	12	55.250	11.01.16	05:45	225.1	*end survey*	
20581-1	076-1	ROV	20	59.063	12	55.082	11.01.16	07:47	235	*start dive#7*	Priska M.
			20	58.878	12	55.032	11.01.16	12:07	233	*end of dive*	

Station-N°	Meteor	Gear	Latitude (S)		Longit. (E)		Date	Time	WD	REMARKS	Site
(GeoB)	(M1220)		°	min	°	min	ddmmyy	(UTC)	(m)		
20581-2	076-1	ROV	20	59.033	12	55.088	11.01.16	08:17	230	ROV S #1: sponge, coral rubble	
20581-3	076-1	ROV	20	59.033	12	55.088	11.01.16	08:27	230	ROV S #2: white bryozoan	
20581-4	076-1	ROV	20	59.000	12	55.061	11.01.16	09:06	235	ROV S #3: yellow sponge	
20581-5	076-1	ROV	20	59.010	12	55.061	11.01.16	09:10	235	ROV S #4: yellow tree-like sponge	
20581-6	076-1	ROV	20	58.994	12	55.004	11.01.16	10:06	232	ROV S #5: white bryozoan	
20581-7	076-1	ROV	20	58.886	12	55.022	11.01.16	11:07	225	ROV S #6: water sample	
20582-1	077-1	GC	20	58.896	12	55.081	11.01.16	12:03	231	REC: 3.04m; corals	Priska M.
20583-1	078-1	CTD+RO	21	5.565	12	59.083	11.01.16	14:08	212	water sampling	S of Priska M.
20583-2	078-2	GC	21	5.563	12	59.082	11.01.16	14:32	211	REC: 5.59m	S of Priska M.
20584-1	079-1	GS	21	6.112	12	59.415	11.01.16	15:21	206	sand, shell hash, tubes	backscatter calibration
20585-1	080-1	CTD+RO	21	25.371	12	15.291	11.01.16	20:44	1042	water sampling	deep station
20586-1	081-1	MBES/PS	21	9.840	13	0.930	13.01.16	22:42	147	*start survey*	
			20	43.970	12	49.160	14.01.16	05:46	228	*end survey*	
20588-1	083-1	GC	20	37.868	12	46.244	14.01.16	07:59	238	REC: 4.79m	S of Sea Star M.
Angolan Margin											
20901-1	084-1	CTD+RO	16	8.938	11	30.786	15.01.16	11:33	1053	water sampling	1000 m
20902-1	085-1	CTD+RO	12	47.374	12	52.433	16.01.16	07:42	611	water sampling	600 m
20903-1	086-1	MBES/PS	9	52.770	12	49.810	17.01.16	02:54	252	*start survey*	
			9	44.190	12	42.450	17.01.16	08:10	527	*end survey*	
20904-1	087-1	ROV	9	43.769	12	42.851	17.01.16	10:36	502	*start dive#8*	Valentin Mounds
			9	43.661	12	42.887	17.01.16	15:25	483	*end of dive*	
20904-2	087-1	ROV	9	43.700	12	42.876	17.01.16	12:37	501	ROV S #1: live *Lophelia*	
20904-3	087-1	ROV	9	43.700	12	42.876	17.01.16	13:30	501	ROV S #2: live *Madrepora*	
20904-4	087-1	ROV	9	43.688	12	42.881	17.01.16	14:09	486	ROV S #3: water sample	
20904-5	087-1	ROV	9	43.688	12	42.881	17.01.16	14:25	486	ROV S #4: live *Lophelia* (thick theca)	
20904-6	087-1	ROV	9	43.661	12	42.887	17.01.16	14:56	483	ROV S #5: sea urchins, live & dead *Lophelia*	
20904-7	087-1	ROV	9	43.661	12	42.887	17.01.16	15:18	483	ROV S #6: *Aphrocallistes*, yellow anemones	
20905-1	088-1	CTD+RO	9	43.747	12	42.875	17.01.16	17:01	501	water sampling	
20906-1	089-1	MCS	9	39.460	12	44.690	17.01.16	18:43	293	*start survey*	
			9	39.900	12	39.830	18.01.16	8:00	553	*end survey*	
20907-1	090-1	GS	9	44.092	12	42.410	18.01.16	9:46	517	coral rubble	Valentine M.
20908-1	091-1	GS	9	43.601	12	42.896	18.01.16	10:49	442	coral rubble	Valentine M.
20908-2	091-2	GC	9	43.605	12	42.893	18.01.16	11:22	439	REC: 4.51m; corals	Valentine M.
20909-1	092-1	GS	9	42.871	12	42.997	18.01.16	12:40	396	coral rubble	Valentine M.
20910-1	093-1	GS	9	43.573	12	44.664	18.01.16	13:36	334	coral framework	Twin M.
20910-2	093-2	GC	9	43.573	12	44.665	18.01.16	14:01	334	REC: 6.75m, corals	Twin M.
20911-1	094-1	GC	9	47.238	12	45.533	18.01.16	15:11	386	REC: 5.59m	off-mound
20912-1	095-1	GC	9	44.903	12	46.663	18.01.16	16:04	247	REC: 4.88m, corals	Anna Ridge
20912-2	095-2	GS	9	44.903	12	46.663	18.01.16	16:30	247	coral rubble	Anna Ridge
20913-1	096-1	GS	9	47.296	12	46.401	18.01.16	17:20	307	coral rubble	Anna Ridge
20913-2	096-2	V-CTD	9	47.296	12	46.403	18.01.16	18:10	304	failed	Anna Ridge
20913-3	096-3	CTD+RO	9	47.296	12	46.403	18.01.16	18:39	303	water sampling	Anna Ridge
20914-1	097-1	MBES/PS	9	47.220	12	46.570	18.01.16	10:00	413	*start survey*	
			9	43.800	12	46.880	19.01.16	05:26	254	*end survey*	
20915-1	098-1	CTD+RO	9	43.572	12	43.863	19.01.16	06:28	433	water sampling	Valentine M
20915-2	098-1	SML	9	43.574	12	43.868	19.01.16	08:28	430	*deployment*	Valentine M.
			9	43.574	12	43.868	26.01.16	05:05	430	*recovery*	
20916-1	099-1	ALBEX TROL	9	43.660	12	42.090	19.01.16	09:54	526	*deployment*	Valentine M. (baited experiment)
			9	43.660	12	42.09	26.01.16	05:49	526	*recovery*	

Station-N°	Meteor	Gear	Latitude (S)		Longit. (E)		Date	Time	WD	REMARKS	Site
(GeoB)	(M1220)		°	min	°	min	ddmmyy	(UTC)	(m)		
20917-1	100-1	ROV	9	43.665	12	42.891	19.01.16	11:46	473	*start dive #9*	Valentine M.
			9	43.009	12	43.009	19.01.16	16:21	426	*end of dive*	
20917-2	100-1	ROV	9	43.664	12	42.889	19.01.16	12:22	473	ROV S #1: *Sympagella* sponges on rubble	
20917-3	100-1	ROV	9	43.626	12	42.898	19.01.16	13:13	446	ROV S #2: live *Lophelia* (white & red)	
20917-4	100-1	ROV	9	43.626	12	42.898	19.01.16	13:56	446	ROV S #3: water sample	
20918-1	101-1	MCS	9	42.990	12	46.670	19.01.16	18:05	254	*start survey*	
			9	50.610	12	44.160	20.01.16	05:18	624	*end survey*	
20919-1	102-1	CTD+RO	9	42.709	12	34.651	20.01.16	07:20	886	water sampling	
20920-1	103-1	ROV	9	44.763	12	46.929	20.01.16	10:51	336	*start dive#10*	Anna Ridge
			9	44.606	12	46.882	20.01.16	15:42	251	*end of dive*	
20920-2	103-1	ROV	9	44.756	12	46.922	20.01.16	11:16	336	ROV S #1: *Neopgynodonte* oysters (6x)	
20920-3	103-1	ROV	9	44.753	12	46.921	20.01.16	11:59	336	ROV S #2: white sponge, *Eunice* tube	
20920-4	103-1	ROV	9	44.753	12	46.920	20.01.16	12:21	336	ROV S #3: sea urchin	
20920-5	103-1	ROV	9	44.686	12	46.900	20.01.16	13:15	307	ROV S #4: sea urchin	
20920-6	103-1	ROV	9	44.686	12	46.900	20.01.16	13:27	307	ROV S #5: *Neopgynodonte* oyster (2x)	
20920-7	103-1	ROV	9	44.663	12	46.894	20.01.16	14:01	296	ROV S #6: rock	
20920-8	103-1	ROV	9	44.659	12	46.893	20.01.16	14:20	294	ROV S #7: sea urchin	
20920-9	103-1	ROV	9	44.615	12	46.876	20.01.16	15:04	252	ROV S #8: sponge	
20920-10	103-1	ROV	9	44.615	12	46.876	20.01.16	15:10	252	ROV S #9: water sample	
20920-11	103-1	ROV	9	44.606	12	46.881	20.01.16	15:38	251	ROV S #10: live *Lophelia*	
20921-1	104-1	ALBEX	9	46.160	12	45.960	20.01.16	16:52	342	*deployment*	W of Anna Ridge (particle pump)
			9	46.160	12	45.96	23.01.16	05:44	342	*recovery*	
20922-1	105-1	GS	9	46.123	12	45.650	20.01.16	17:23	357	sand (phosphoritic)	
20923-1	106-1	GS	9	44.907	12	45.105	20.01.16	18:07	359	sand (phosphoritic), clay	
20924-1	107-1	GS	9	44.913	12	44.092	20.01.16	19:07	431	sand (phosphoritic)	
20925-1	108-1	MBES/PS	9	44.430	12	39.330	20.01.16	19:40	499	*start survey*	
			9	39.330	12	45.300	21.01.16	04:53	239	*end survey*	
20926-1	109-1	CTD+RO	9	43.268	12	43.034	21.01.16	05:48	432	water sampling	
20927-1	110-1	ROV	9	42.270	12	43.858	21.01.16	08:14	402	*start dive#11*	Buffalo Mounds
			9	41.998	12	43.883	21.01.16	13:31	356	*end of dive*	
20927-2	110-1	ROV	9	42.239	12	43.838	21.01.16	08:40	387	ROV S #1: live *Madrepora*, live *Lophelia*	
20927-3	110-1	ROV	9	42.239	12	43.838	21.01.16	08:59	379	ROV S #2: water sample	
20927-4	110-1	ROV	9	42.228	12	43.829	21.01.16	09:30	371	ROV S #3: live *Lophelia* (one branch)	
20927-5	110-1	ROV	9	42.171	12	43.803	21.01.16	10:11	359	ROV S #4: octocorals & antipatharians	
20927-6	110-1	ROV	9	42.116	12	43.781	21.01.16	11:25	385	ROV S #5: live *Acesta* (!)	
20927-7	110-1	ROV	9	42.102	12	43.774	21.01.16	11:42	372	ROV S #6: white sponge, bryozoans	
20927-8	110-1	ROV	9	42.019	12	43.820	21.01.16	12:56	349	ROV S #7: live *Aphrocallistes* & anemones	
20927-9	110-1	ROV	9	42.019	12	43.820	21.01.16	13:02	349	ROV S #8: live *Lophelia*	
20927-10	110-1	ROV	9	41.998	12	43.883	21.01.16	13:50	356	ROV S #9: dead coral framework, sea star, live *Lophelia*	
20928-1	111-1	GC	9	43.388	12	42.899	21.01.16	15:34	457	REC: 7.57m, corals	Valentine M.
20929-1	112-1	MCS	9	42.780	12	43.550	21.01.16	16:23	422	*start survey*	
			9	46.710	12	42.920	22.01.16	04:58	504	*end survey*	
20930-1	113-1	ROV	9	49.364	12	46.405	22.01.16	07:22	412	*start dive#12*	Scary M.
			9	49.239	12	46.685	22.01.16	12:10	425	*end of dive*	
20930-2	113-1	ROV	9	49.372	12	46.429	22.01.16	07:51	374	ROV S #1: live *Lophelia* with yellow bryozoan	
20930-3	113-1	ROV	9	49.372	12	46.429	22.01.16	07:54	374	ROV S #2: water sample	
20930-4	113-1	ROV	9	49.372	12	46.436	22.01.16	08:08	374	ROV S #3: octocorals, *Aphrocallistes*, yellow anemones	
20930-5	113-1	ROV	9	49.381	12	46.514	22.01.16	09:03	412	ROV S #4: live gastropod	

Station-N°	Meteor	Gear	Latitude (S)		Longit. (E)		Date	Time	WD	REMARKS	Site
(GeoB)	(M1220)		°	min	°	min	ddmmyy	(UTC)	(m)		
20930-6	113-1	ROV	9	49.354	12	46.540	22.01.16	09:35	361	ROV S #5: coral rubble, red actinians (net)	
20930-7	113-1	ROV	9	49.318	12	46.582	22.01.16	10:19	335	ROV S #6: live *Madrepora* (2x net)	
20930-8	113-1	ROV	9	49.250	12	46.669	22.01.16	11:59	425	ROV S #7: anemone	
20931-1	114-1	GC	9	49.239	12	46.669	22.01.16	13:37	424	REC: 5.67m, corals	Scary M.
20932-1	115-1	GC	9	49.277	12	46.624	22.01.16	14:29	369	REC: 7.32m, corals	Scary M.
20933-1	116-1	GC	9	49.331	12	46.565	22.01.16	15:23	338	REC: 9.83m, corals	Scary M.
20933-2	116-2	GS	9	49.336	12	46.565	22.01.16	16:16	345	failed, not closed	Scary M.
20933-3	116-3	GS	9	49.337	12	46.564	22.01.16	16:33	346	coral rubble	Scary M.
20934-1	117-1	GS	9	49.362	12	46.544	22.01.16	17:03	384	not closed, few corals	Scary M.
20934-2	117-2	GS	9	49.362	12	46.543	22.01.16	17:25	382	coral rubble	Scary M.
20935-1	118-1	GS	9	49.384	12	46.514	22.01.16	17:54	412	fine coral rubble	Scary M.
20936-1	119-1	CTD+RO	9	49.358	12	46.366	22.01.16	18:47	424	water sampling	Scary M.
20937-1	120-1	MBES/PS	9	44.300	12	45.820	22.01.16	19:45	306	*start survey*	
			9	43.510	12	46.110	23.01.16	05:20	177	*end survey*	
20938-1	122-1	ROV	9	43.049	12	45.862	23.01.16	09:17	320	*start dive#13*	Snake M.
			9	43.033	12	46.100	23.01.16	11:57	256	*end of dive*	
20938-2	122-1	ROV	9	43.032	12	46.033	23.01.16	10:35	271	ROV S #1: long piece of wood, overgrown	
20938-3	122-1	ROV	9	43.033	12	46.100	23.01.16	11:56	256	ROV S #2: water sample	
20939-1	123-1	MBES/PS	9	43.080	12	46.050	23.01.16	13:58	267	*start survey*	
			9	44.950	12	42.430	23.01.16	14:49	532	*end survey*	
20940-1	124-1	ALBEX	9	43.840	12	42.150	23.01.16	15:05	532	*deployment*	W of Valentine M. (particle pump)
			9	43.840	12	42.150	26.01.16	06:22	532	*recovery*	
20941-1	125-1	MBES/PS	9	43.960	12	42.120	23.01.16	15:20	538	*start survey*	
			9	36.520	12	40.710	23.01.16	17:24	459	*end survey*	
20942-1	126-1	CTD+RO	9	35.223	12	40.172	23.01.16	17:52	463	water sampling	CTD transect
20943-1	127-1	CTD+RO	9	37.378	12	40.874	23.01.16	18:59	465	water sampling	CTD transect
20944-1	128-1	CTD+RO	9	39.505	12	41.522	23.01.16	20:13	489	water sampling	CTD transect
20945-1	129-1	CTD+RO	9	41.667	12	42.110	23.01.16	22:41	490	water sampling	CTD transect
20946-1	130-1	CTD+RO	9	43.812	12	42.885	23.01.16	23:39	500	water sampling	CTD transect
20947-1	131-1	CTD+RO	9	46.045	12	43.868	24.01.16	01:12	459	water sampling	CTD transect
20948-1	132-1	CTD+RO	9	48.330	12	44.844	24.01.16	02:13	430	water sampling	CTD transect
20949-1	133-1	CTD+RO	9	50.522	12	45.818	24.01.16	03:26	544	water sampling	CTD transect
20950-1	134-1	CTD+RO	9	52.758	12	46.792	24.01.16	04:44	391	water sampling	CTD transect
20951-1	135-1	ROV	9	42.096	12	43.746	24.01.16	08:22	357	*start dive#14*	Buffalo M.
			9	42.086	12	43.758	24.01.16	10:41	348	*end of dive*	
20951-2	135-1	ROV	9	42.090	12	43.762	24.01.16	08:54	351	start mosaicking (4m x 10m)	
			9	42.085	12	43.761	24.01.16	09:50	351	end mosaicking	
20952-1	136-1	GC12	9	48.663	12	46.266	24.01.16	14:05	389	REC: 5.39m	off-mound
20953-1	137-1	GBC	9	43.022	12	45.996	24.01.16	14:48	259	empty, toppled over	Snake M.
20953-2	137-2	GBC	9	43.026	12	46.005	24.01.16	15:48	259	REC: 20cm, coral rubble	Snake M.
20954-1	138-1	GS	9	44.901	12	46.663	24.01.16	16:41	248	coral rubble	Anna Ridge
20954-2	138-2	GS	9	44.901	12	46.661	24.01.16	16:58	248	coral rubble	Anna Ridge
20954-3	138-3	GS	9	44.901	12	46.661	24.01.16	17:17	248	coral rubble	Anna Ridge
20955-1	139-1	GS	9	44.680	12	46.896	24.01.16	17:45	299	coral rubble	Anna Ridge
20956-1	140-1	MBES/PS	9	46.520	12	48.380	24.01.16	18:18	288	*start survey*	
			9	40.140	12	40.200	25.01.16	05:23	551	*end survey*	
20957-1	141-1	ROV	9	39.901	12	42.945	25.01.16	07:05	447	*start dive#15*	Castle Mounds
			9	39.742	12	43.152	25.01.16	12:00	331	*end of dive*	
20957-2	141-1	ROV	9	39.902	12	42.945	25.01.16	07:12	447	ROV S #1: bivalve shells	
20957-3	141-1	ROV	9	39.913	12	42.993	25.01.16	08:09	414	ROV S #2: live *Lophelia/Acesta*, rock, gorgonian	

Station-N°	Meteor	Gear	Latitude (S)		Longit. (E)		Date	Time	WD	REMARKS	Site
(GeoB)	(M1220)		°	min	°	min	ddmmyy	(UTC)	(m)		
20957-4	141-1	ROV	9	39.910	12	43.006	25.01.16	09:06	399	ROV S #3: white gorgonian, ophiuroid	
20957-5	141-1	ROV	9	39.879	12	43.031	25.01.16	09:36	363	ROV S #4: sea stars, yellow sponge	
20957-6	141-1	ROV	9	39.858	12	43.058	25.01.16	10:12	348	ROV S #5: water sample	
20957-7	141-1	ROV	9	39.858	12	43.058	25.01.16	10:18	348	ROV S #6: red live *Lophelia* (?)	
20957-8	141-1	ROV	9	39.774	12	43.162	25.01.16	11:45	362	ROV S #7: dead coral framework, bryozoan	
20958-1	142-1	GS	9	39.898	12	42.937	25.01.16	13:18	453	sand	Castle M.
20959-1	143-1	GC12	9	43.027	12	45.961	25.01.16	14:24	279	REC: 7.55m, corals	Snake M. (flank)
20960-1	144-1	GC12	9	43.017	12	45.997	25.01.16	15:16	264	REC: 10.44m, corals	Snake M.(top)
20961-1	145-1	GBC	9	47.062	12	47.428	25.01.16	16:27	332	REC: 55cm, biot. silt	off-mound
20962-1	146-1	MBES/PS	9	47.060	12	47.430	25.01.16	16:48	332	*start survey (continued between CTD casts)*	
			9	42.870	12	47.670	26.01.16	03:03	332	*end survey*	
20963-1	147-1	CTD+RO	9	43.379	12	36.673	25.01.16	19:05	803	water sampling	CTD transect
20964-1	148-1	CTD+RO	9	43.445	12	39.300	25.01.16	20:44	703	water sampling	CTD transect
20965-1	149-1	CTD+RO	9	43.674	12	42.093	25.01.16	22:39	527	water sampling	CTD transect
20966-1	150-1	CTD+RO	9	43.570	12	43.852	26.01.16	00:27	431	water sampling	CTD transect
20967-1	151-1	CTD+RO	9	43.225	12	45.765	26.01.16	01:53	323	water sampling	CTD transect
20968-1	152-1	CTD+RO	9	42.872	12	47.665	26.01.16	03:12	236	water sampling	CTD transect
20969-1	153-1	MBES/PS	9	44.640	12	47.900	26.01.16	07:38	259	*start survey*	
			12	15.380	13	23.020	27.01.16	00:54	298	*end survey*	
20970-1	154-1	MBES/PS	12	15.620	13	23.230	27.01.16	00:56	236	*start survey*	
			12	19.220	13	21.890	27.01.16	01:37	353	*end survey*	
20971-1	155-1	ROV	13	22.842	12	20.745	27.01.16	12:26	1997	*start dive#16*	2000-m-site
			13	22.848	12	20.745	27.01.16	13:35	1997	*end dive*	
20971-3	155-2	CTD+RO	13	22.863	12	20.758	27.01.16	16:41	2005	water sampling	2000-m-site
20972-1	156-1	MBES/PS	17	7.890	11	11.940	28.01.16	15:07	233	*start survey*	
			17	11.940	11	22.580	28.01.16	16:33	238	*end survey*	
20973-1	157-1	MBES/PS	17	20.990	11	23.700	28.01.16	17:25	270	*start survey*	
			17	25.290	11	25.070	28.01.16	19:04	235	*end survey*	
20973-2	158-1	XSV	17	22.110	11	24.220	28.01.16	18:19	262	sound velocity profile	
20974-1	159-1	MBES/PS	19	53.250	12	13.220	29.01.16	10:10	237	*start survey*	
			21	7.080	13	2.150	30.01.16	12:21	135	*end survey*	

Abbreviations:
WD, water depth; REC, recovery; ROV S: ROV sample, M: Mounds
V-CTD: video-guided CTD, CTD+RO; CTD plus water sampler, SML: satellite mini lander (GEOMAR), ALBEX: Lander (NIOZ), MCS: multichannel seismic, MBES/PS: surveys with Multibeam Echosounder and PARASOUND sub-bottom profiler, XSV: eXpendable Sound Velocity probes, GC: gravity core, GBC: giant box corer, GS: grab sampler

9 Data and Sample Storage and Availability

A Short Cruise Report was already compiled on-board at the end of the cruise. A final station list was submitted to PANGAEA. The cruise was performed within the Exclusive Economic Zones of Angola and Namibia. No formal request for data was made by the respective authorities.

All shipboard data will be transferred to the PANGAEA database as soon as they are available and quality checked. Depending on data type and progress of sample analysis, this will be done generally within 2-3 years, but at latest in January 2019. The compilation listed below names the scientists who are responsible for access to the different data and sample sets. Cooperation on the obtained data and samples is always welcome and interested scientists may contact the responsible persons indicated in the list below.

Type	Remark	Contact
Hydro-acoustics	MBES (EM 122, EM 710), PARASOUND and ADCP data are held at MARUM (Bremen). The MBES data were forwarded to the BSH.	Prof. Dr. D. Hebbeln (dhebbeln@marum.de) P. Wintersteller (pwintersteller@marum.de)
Seismic	All multichannel seismic data are held at the Dept. of Geosciences, University of Bremen (MTU-GeoB).	Prof. Dr. V. Spieß (vspiess@uni-bremen.de)
Hydrography	CTD data are held and will be analysed at the GEOMAR (Kiel).	Prof. Dr. C. Dullo (cdullo@geomar.de)
Lander	The ALBEX lander data are held at the NIOZ (Texel). The SML data are held at the GEOMAR (Kiel).	Dr. F. Mienis (fmienis@nioz.nl) Prof. Dr. C. Dullo (cdullo@geomar.de)
Sediments	All sediment cores and samples are stored at the MARUM GeoB core repository (Bremen).	Prof. Dr. D. Hebbeln (dhebbeln@marum.de) Dr. C. Wienberg (cwberg@marum.de)
Zoobenthos	Samples and metadata are held at Senckenberg am Meer (Wilhelmshaven) and will be analysed in cooperation with the DZMB (Wilhelmshaven).	Prof. Dr. A. Freiwald (andre.freiwald@senckenberg.de)
Seafloor imaging	Photo and video footage obtained by the ROV are held at the MARUM (Bremen) and at Senckenberg am Meer (Wilhelmshaven).	Dr. C. Wienberg (cwberg@marum.de) Prof. Dr. A. Freiwald (andre.freiwald@senckenberg.de)

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