RV METEOR – M182

31.05. - 10.07.2022, Mindelo - Pt. Delgada

3rd Weekly Report

13. - 19.06.2022

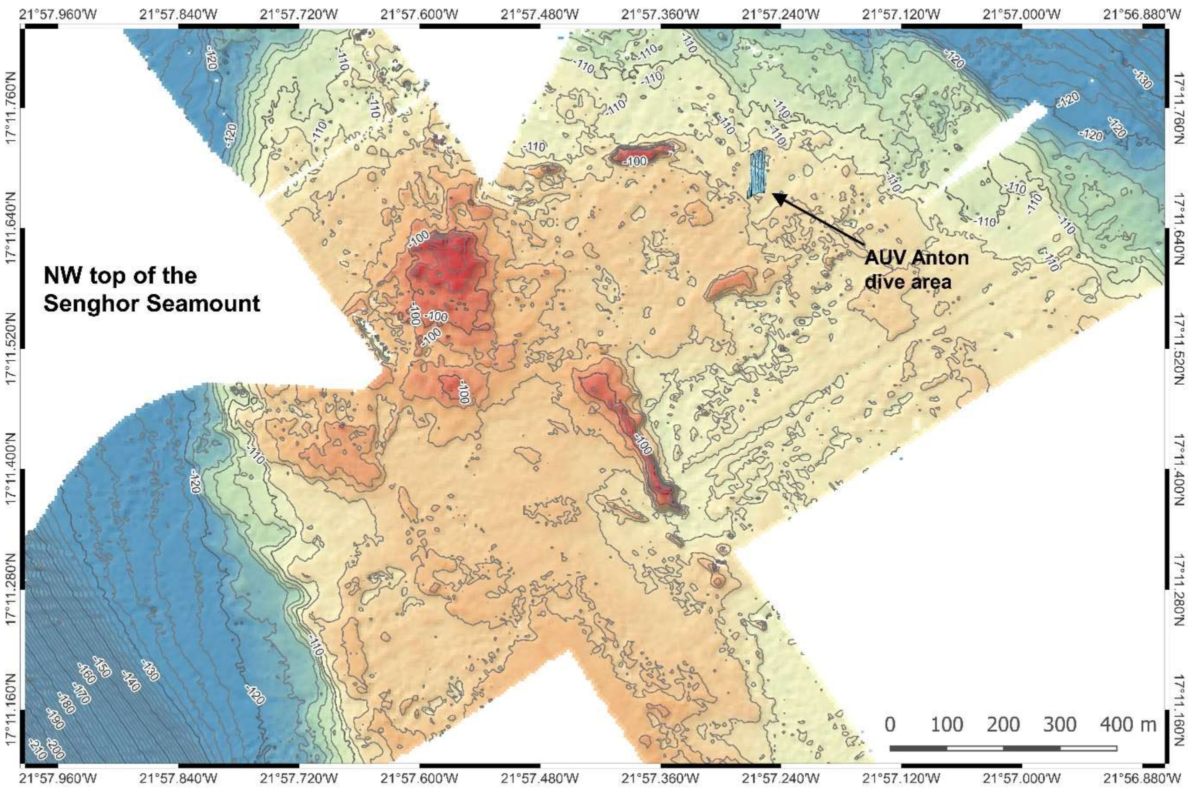
Almost 3 weeks have passed and it is almost half time. We are also spatially halfway through our work area and are about to leave the Cape Verdean and reach Mauritanian waters. Within the last week we sampled an eddy and let our AUVs dive for the first time. A highlight for the benthic working groups was the Senghor Seamount. An underwater mountain that rises from the sefloor (ca. 3000 m) to 100 m water depth. Its plateau and slopes provide a habitat for a diverse fauna amidst the surrounding and rather barren deep sea. In addition to corals, sponges and large schools of fish, we were able to observe hammerhead sharks and even a moonfish. The shallow water also gave us the opportunity to use one of our small AUVs (Anton) to do a photo mission, its first dive in the “real” ocean.

Work of the last week

During the last week the CTD team surveyed the eddy structure with two cross-sectional transects. This allowed us to narrow down the vortex center which could be confirmed by a final S-N ADCP based current profile. Our colleagues from Kiel in the physical oceanography department receive the current data directly from the ship and are able to support us in the analysis and confirm our estimation of the eddy center position. The center can be recognized by the abrupt change of the flow direction as described in the previous weekly report.

Once it was clear that it was indeed a vortex, it was a matter of developing a detailed sampling plan. Ideally, we would like to study the eddy synoptically, but its large extent of about 70 x 90 nm meant that we needed at least 7 hours from the western to the eastern edge; plus the station time for CTD sampling. Of course, we have to accept that eddies are dynamic features, and their structure change during the time of the sampling (it moves westward ~4km a day).

Since at first glance the eddy core does not turn out to be as productive as we had hoped, we concentrated our work on 13th June on the eddy edge, which coincides with our planned study area E2. In the XOFOS video footage from the water column, we saw significantly more biological activity on the seafloor than at the previous station in the eddy center. To verify the impression, the BIGO lander and Panta Rhei (Deep Sea Rover) will be deployed at this position to measure the benthic total oxygen uptake (TOU). Afterwards we will move back to the eddy core and investigate the pelagic diversity deploying the XOFOS and pelagic Multinet. Using the CTD, water samples have been taken at different positions in the eddy, but sample processing is laborious and takes about 5 hours for each station. We needed to take this into account in the station plan and thus had time for further MUC stations and a short detour to the Senghor seamount just south of one of our CTD stations. The seamount rises to 100 m below the surface and offers good conditions for a first test dive of our hover-capable shallow water AUV Anton. To ensure that Anton will not encounter any obstacles on his mission (e.g. ghost fishing gear), we mapped the area beforehand with 5 m resolution using the multibeam echo sounder. The map revealed morphological changes of up to 12 m height, which would create problems for the AUV. Using XOFOS observations we could define a relatively flat area that was well suited for the AUV mission.



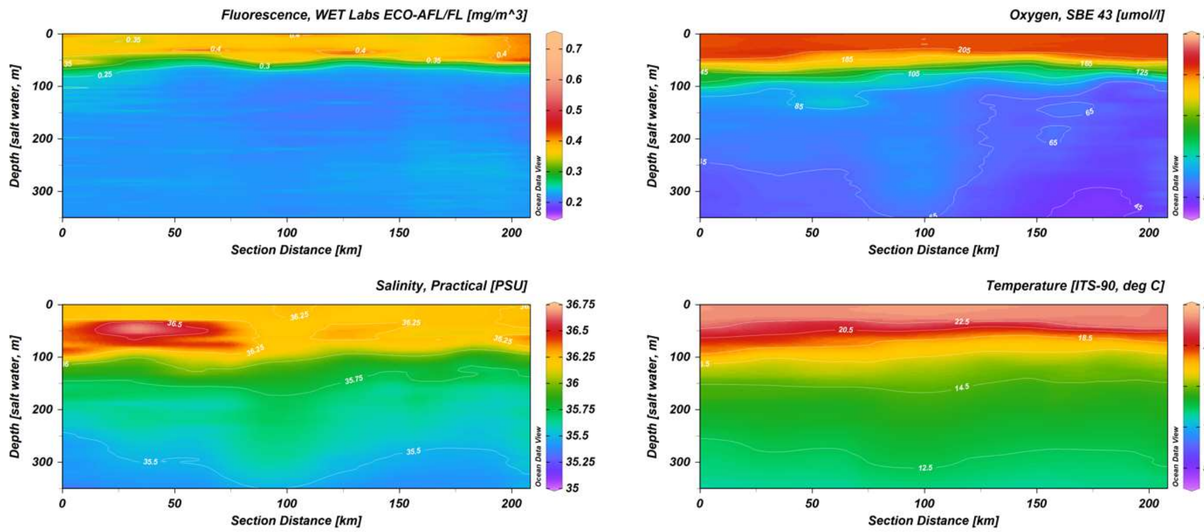
Senghor Seamount and dive position of AUV Anton.

During the XOFOS dive we were impressed by the diversity of corals, sponges and fishes on the seafloor, typically associated with hard bottoms. With increasing depth and sediment cover on the seafloor, the fauna quickly changed below 150 m water depth. It again resembled more the deep sea that we have observed so far during the cruise. Continuing after the seamount with eddy sampling CTDs and sailing back to E2, the large AUV Tiffy was deployed for a number of dives.

Further results from the scientists

CTDs

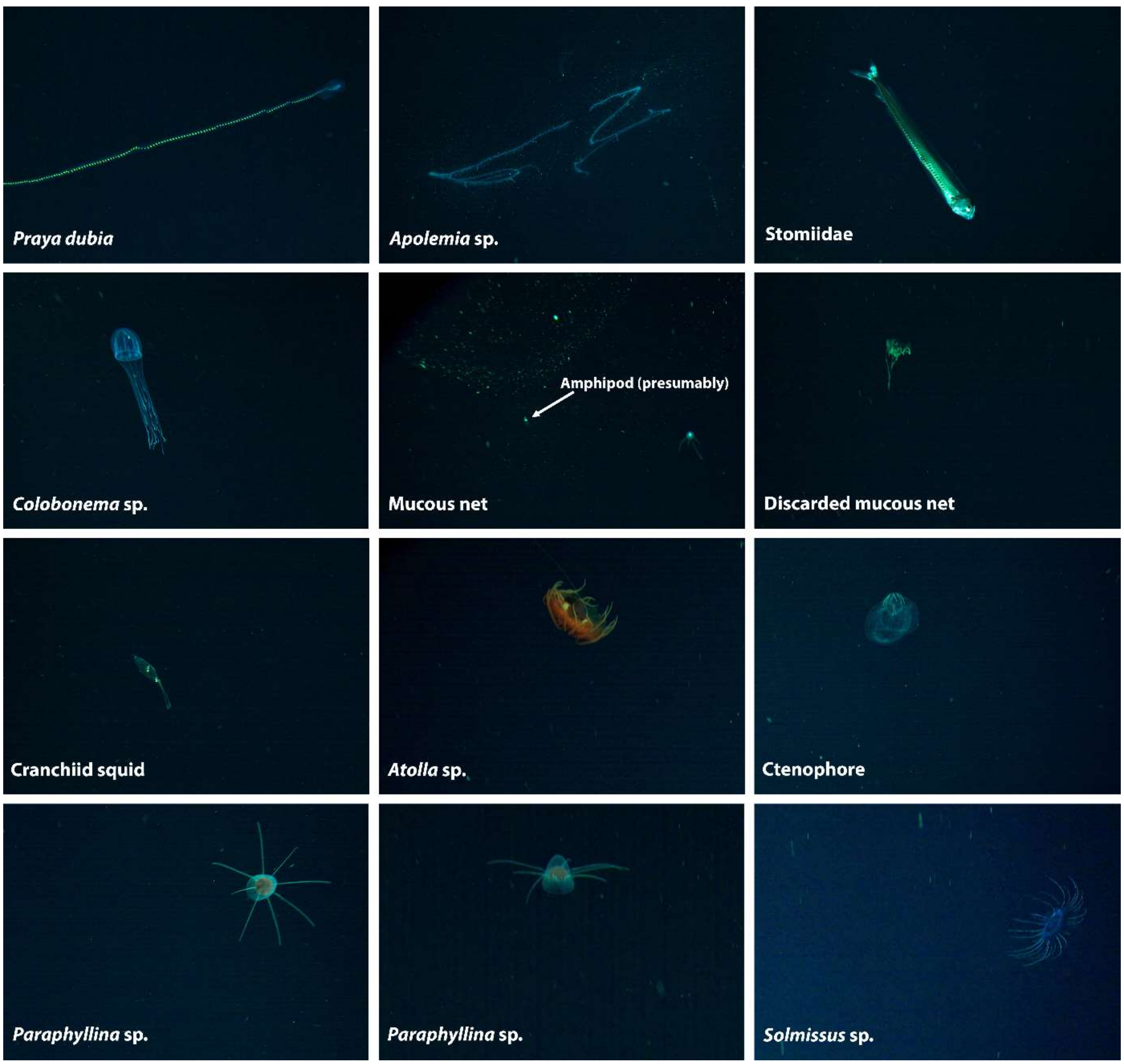
The final S-N CTD section from 17°N to 18.5°N included 8 CTD profiles (without water sampling) with a distance of about 8 nm between stations and continuous ADCP current measurements. Preliminary analysis of these data confirmed a counterclockwise rotating eddy structure (cyclonic eddy). Contrary to our expectations, the phytoplankton biomass in the eddy core seemed to be rather low. However, we did detect slight changes in chlorophyll-a fluorescence between the marginal areas and the core. Since the core is located at ~22°W and this structure migrates westward from Cape Verde at about 4 km per day, it is possible that this is an eddy structure in the process of dissolution. After further analysis of the inorganic and organic nutrient distribution, we will ultimately be able to answer this question. The largest differences between the edge and core areas were noted in the oxygen distribution. There was a tendency for the oxygen minimum zone to increase from 400 m depth to as low as 80 m in the marginal areas (40-60 µmol kg-1). The salinity gradient decreased slightly from SW toward NE, however, a salinity anomaly was evident in the core region of the eddy structure that extended up to 300 m into the water column. During the next week we will proceed with the sampling of the eddy and then continue our planned sampling of the W-E transect towards Mauritania.



S-N CTD section through the eddy structure. From top left to bottom right, fluorescence, salinity, oxygen concentration, and temperature. Data are shown down to a depth of 350 m (data were collected down to 1500 m).

More biology in the water column

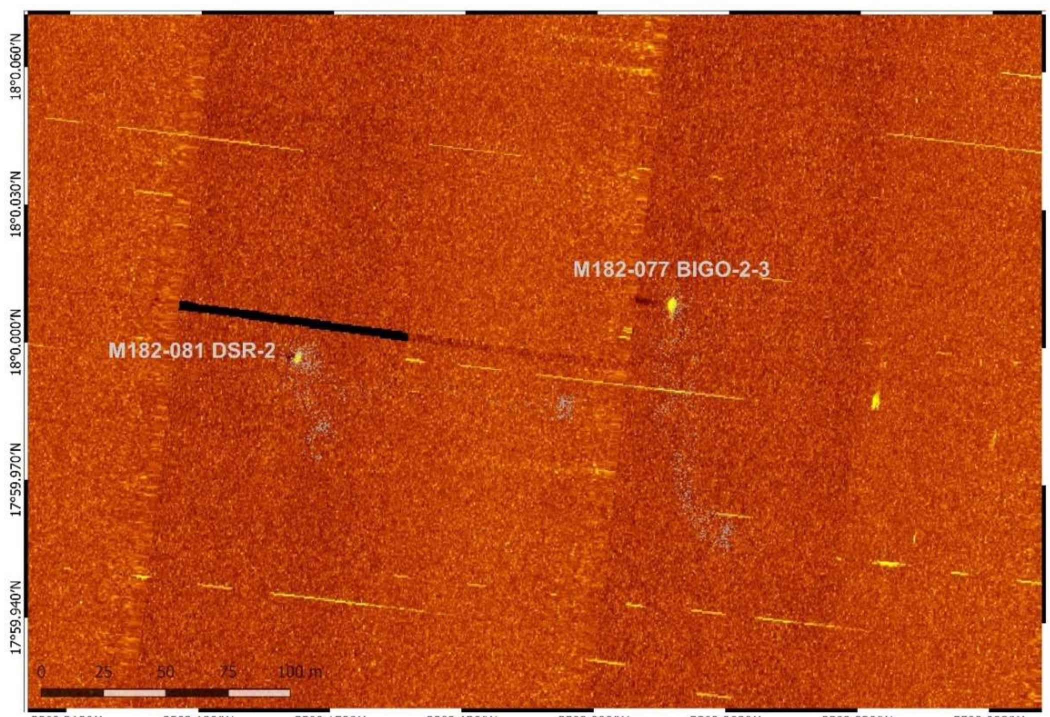
This week we deployed the 9th multinet, and we continued to perform day and night video transects with the XOFOS system in pelagic mode. The target stations included the eddy core and the eddy periphery. Surprisingly, the eddy core did not reveal any strikingly different fauna from the background ocean communities. The eddy periphery, on the other hand, had seemingly higher abundances and more diverse communities than the eddy core. In particular gelatinous fauna were more prevalent in the periphery where we observed ctenophores, siphonophores and hydromedusae. Some of these taxa are among the giants of the ocean. *Praya dubia* and *Apolemia* are siphonophores that can reach similar lengths as whales, and these colonial organisms that are related to jellyfish and corals (cnidarians) can grow more than 30 m long. They increase their surface even more by extending their long tentacles, which are equipped with stinging cells, fishing the deep sea for prey. Other organisms enhance the chance of capturing prey by having large mouth-openings or long teeth to ensure that once a prey is captured it cannot escape. An example is the dragonfish (Stomiidae) which teeth extend far from the lower jaw. As a result of the arms race between predator and prey in the deep sea, prey organisms have also evolved tactics to startle or escape from predators. Similar to a lizard dropping its tale, *Colobonema* jellyfish have the ability to drop their tentacles as decoy when chased by a predator. We have repeatedly observed this hydromedusa during the pelagic video transects. But not all food has to be hunted. In the deep sea there is a continuous rain of organic matter, also known as marine snow. Video transects consistently provided evidence of this. This marine snow consists of dead and decaying material such as algal cells, zooplankton corpses, moults and mucus. Animal-build mucus structures are one of the contributors to the vertical flux of marine snow. These mucus structures may be built by organisms such as filter-feeding larvaceans or flux-feeding pteropods (pelagic snails), and sometimes can be rather big. The discarded mucus structures start sinking to the deeper layers and as a result of hydrostatic pressure become denser and compact packages of organic matter, which is eaten by detritus feeding organisms. When still intact the large mucus structures may form a habitat for microorganisms and crustaceans. The role and magnitude of the flux of big particles are not well studied in ocean biogeochemistry, partly since they are hard to quantify. The pelagic video transects contribute to resolving their distribution and abundance. The stereo camera on the XOFOS will also allow us to measure the size of the particles.



Creatures of the Abyss, … ok, not sooo deep but rarely seen by humans nonetheless.

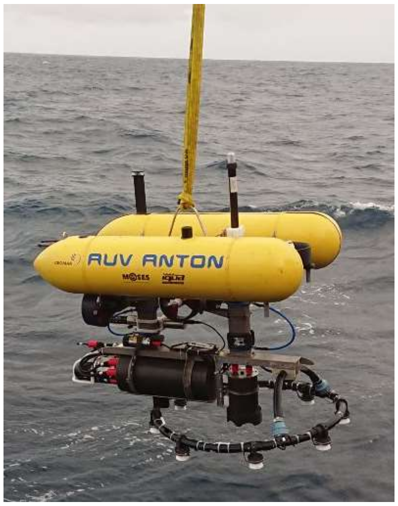
AUV Deployments

Tiffy is back in business, although some issues still remain, which we will deal with during the remaining cruise (we still have half way to go). On 13th June, Tiffy had her first dive for some time. The test was more designed as test after the O-ring had finally arrived from Cape Verde and was fixed in the 'Inertial Navigation Sensor' (INS, a very very precise motion sensor) of the AUV. The first dive was a water column dive in an up and down "zigzag" course to investigate the top 250m in a square of about 3 by 3 km. As the AUV did not have bottom lock with the DVL, she was not so good on track and surfaced about 2km from the supposed position, after some acoustic triangulation she could be recovered safely. The second dive was aimed at surveying the area around the deployed BIGO lander and Panta Rhei Rover in 3300m water depth. Unfortunately, some wrong settings prevented the AUV from maintaining the mission on the seafloor and she decided to surface again, where she was picked up rather quickly. Finally, the third survey successfully recorded sides scan data of the Rover and the BIGO lander. During the dive we also planned a camera survey which could not be executed. The DSLR camera inside the system of the AUV (the DeepSeaCam, developed at GEOMAR) failed to take any images. Luckily, Tim Weiß, our software developer, immediately did some bug-fixing and adjustments at GEOMAR and the new software has already been installed on the system. Tiffy will be deployed again tomorrow morning to repeat the photo mission and this time we are confident that everything will work out. As mentioned earlier, Tiffy has been out of service for 2.5 years and the draw backs we are experiencing are normal steps for prototypical technology of this complexity when it is used for the first time in the open ocean.

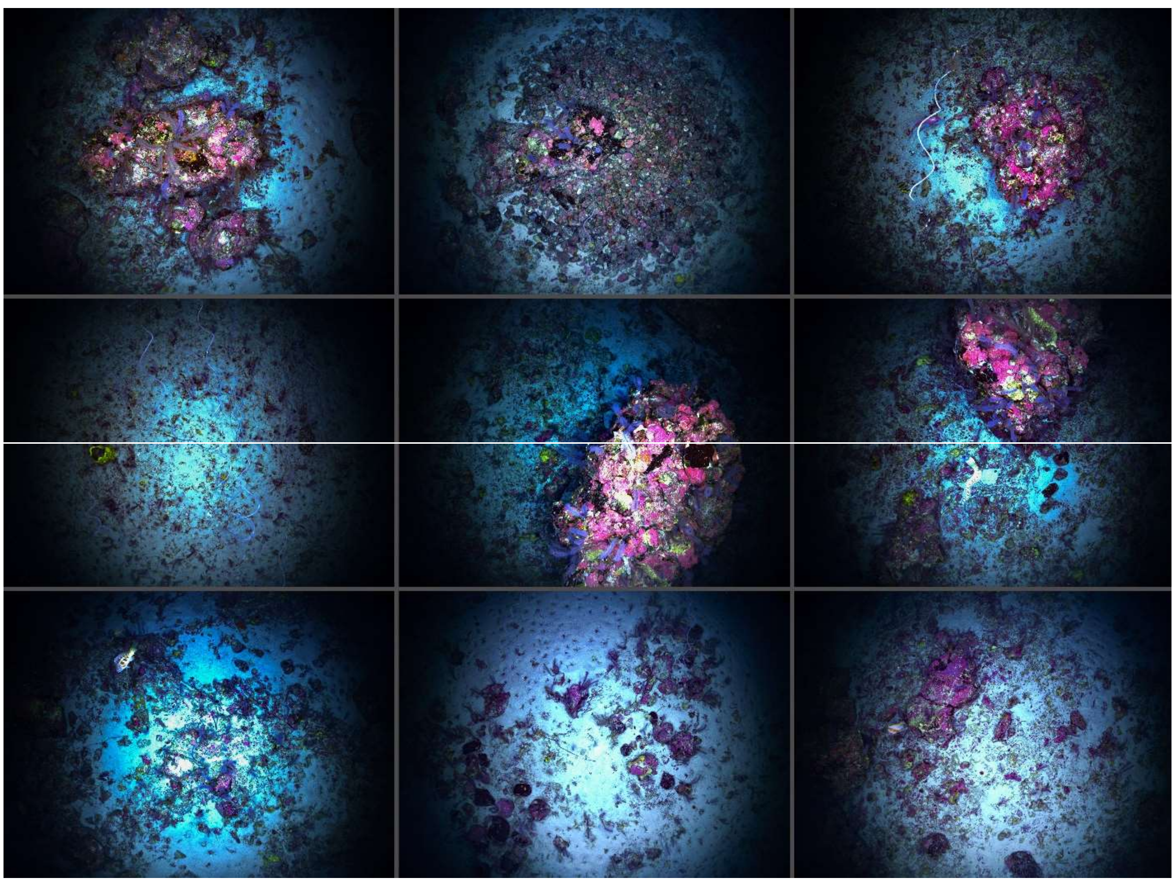


Sidescan image of the E2 area with two bright yellow dots caused by the lander BIGO and the rover Panta Rhei. Apart from these two artificial features, the seafloor is very homogeneous, as already seen on the XOFOS video transects. The next sidescan mission with the AUV will use the 400 kHz system instead of the 120 kHz system for this dive (M182_100-1).

Also, AUV ANTON got his first dive in the open ocean. ANTON is well experienced in the Baltic Sea where he surveys munition for a few years now, but has never dived in the Atlantic. ANTON is a GIRONA 500 AUV made to dive down to 500m only.



AUV Anton just before being released in the Atlantic.



Fish-Eye lens pictures from AUV Anton. The illumination is ideal as we kept a safe distance to the seafloor of 2.7m. The outer parts are quite dark but the inner parts show old coral structures overgrown by red-algae and the seafloor is covered with little pits from worms long spiral corals.

Thus, we needed a shallow area for a first dive where the DVL bottom lock can be gained rather quickly. Fortunately, the CTD Eddy Hunt brought us close to the Senghor Seamount, an almost 3km high seamount that reaches up to 90m below the ocean surface. The ecosystem here is completely different compared to the deep sea, different types of corals, lots of fish, sea stars and sea urchins live here. After an XOFOS dive, ANTON was deployed on the very flat top of the seamount to run a photomosaic mission using the GEOMAR developed CORAMO Camera System. This worked out very well although the orientation of the eight flash LEDs need adjustment for the next dive. But a first photomosaic has been produced (see above). In summary, we are very pleased with the AUV's work so far, especially after the delay due to the O-ring; it was worth getting the spares.

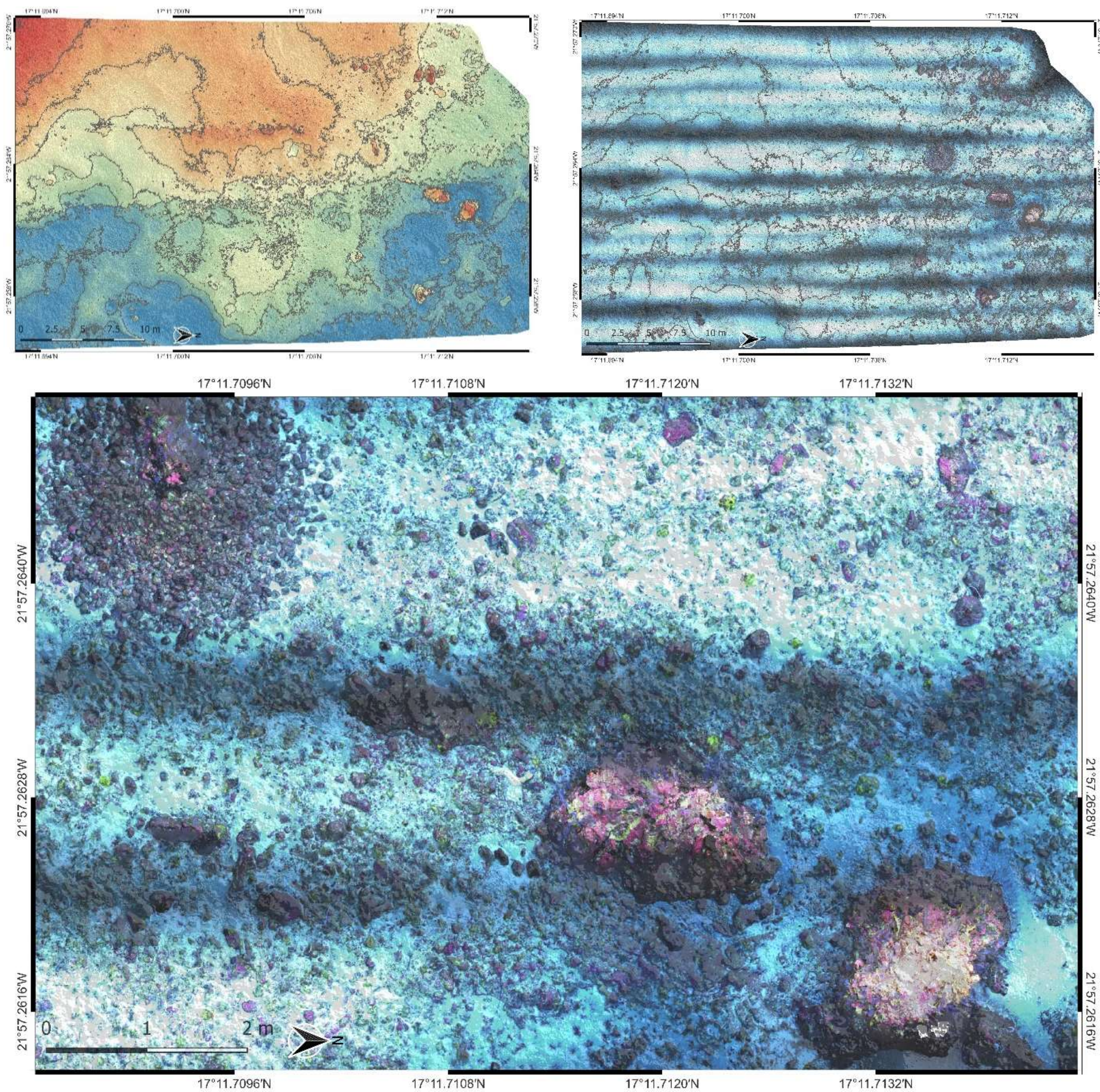
Photo mapping

During M182 a lot of different photo and video data are recorded by the different systems. Particularly the 4K videos from XOFOS are stored on the specially installed media server. Using software developed at GEOMAR (the Tomato Tool = Tolles Master Tool), individual images (about one per second) are extracted from the video and using the time stamp, a preliminary position and orientation can be determined for each image based on the available navigation data. Depending on the camera platform (AUV Anton/Luise, AUV Tiffy, XOFOS or lander platform) and the sensors this navigation is “more or less” accurate.

For each survey a project is created in a photomosaic software called Metashape and images are added. Features within pairs of images (e.g. a certain corner of a rock or coral) are matched and if there is a sufficient overlap with enough unique features, a relative orientation between the images is determined. In aggregate and in combination with the navigation data, a precise navigation solution and a point cloud of the seafloor can be created. If necessary, markers can be placed manually if the algorithm is not able to close larger gaps automatically. The resulting point cloud is then “densified” with additional image data and from this dense point cloud, 3D models, digital terrain models (DEMs) and orthomosaics can be calculated. Such a photomosaic has the advantage that it can be merged with the bathymetric data in a GIS (geo-information) software and morphological derivatives can be calculated. In addition, precise annotation of seafloor features is possible and data sets can be explored in 3D, see below.

Digital Earth Viewer

For most of the instruments on this cruise we have dedicated software to view and analyze the data. But it is not easily possible to display several of these in 4D data simultaneously (spatially and temporally). The Digital Earth Viewer offers exactly this possibility. We use the bathymetry acquired with the EM122 in combination with data from previous missions and GEBCO as a morphological basis. On top of this, the ship ADCP current data are plotted as vectors and CTD stations can be plotted as point clouds with different sizes and colors representing e.g. the oxygen concentration or temperature. Also, the camera derived digital terrain models can be plotted and explored like in “Google-Earth”. However, this will be presented the next time.



Photogrammetric reconstructions of Antons camera data showing the digital terrain model on the top left, the photomosaic on the top right and a zoom in of the photomosaic with hillshade illumination at the bottom.

With half of the cruise almost done, everyone involved, crew and science team alike, is well and we are confident that the second half of the cruise will be as successful as the first.

With best regards from all on board,

Mareike Kampmeier & Jens Greinert

GEOMAR Helmholtz Centre for Ocean Research Kiel