MARIA S. MERIAN-Berichte

Intra-annual variability of biological, chemical and physical parameters at the Senghor seamount

Cruise No. MSM61

18.02.2017 – 27.02.2017,
Mindelo (Cabo Verde) – Las Palmas (Spain)

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1 Cruise Summary

1.1 Summary in English

The main goal of cruise MSM61 was to install an autonomous multidisciplinary observatory at the summit of Senghor Seamount off the Cape Verdean archipelago. A suite of different mobile and moored instrument platforms equipped with physical, biological and biogeochemical instruments was deployed during the cruise in order to investigate spatio-temporal variability of physical and biogeochemical conditions and how these affect the local ecosystem at this open-ocean seamount. The research program further included hydrographic work, biological and biogeochemical sampling as well as video transects in the meso- and bathypelagic zones both at Senghor Seamount and at the Cape Verde Ocean Observatory (CVOO).

1.2 Zusammenfassung

Das Hauptziel der Expedition MSM61 war die Installation eines autonomen, multidisziplinären Observatoriums auf dem Gipfel des Senghor Unterwasserberges vor dem Kapverdischen Archipel. Verschiedenste mobile und verankerte Systeme ausgestattet mit physikalischen, biologischen und biogeochemischen Instrumenten wurden während der Fahrt ausgebracht, um die räumliche und zeitliche Variabilität von physikalischen und biogeochemischen Parametern und deren Einfluss auf das lokale Ökosystem zu untersuchen. Das Forschungsprogramm beinhaltete darüber hinaus hydrographische Arbeiten, biologische sowie biogeochemische Probennahmen, als auch Videotransekte in der meso- und bathypelagischen Zone des Ozeans. Die Arbeiten wurden zum einen beim kapverdischen Ozeanobservatorium CVOO als auch beim Senghor Unterwasserberg durchgeführt.

2 Participants

2.1 Principal Investigators

Name	Institution
Fiedler, Björn, Dr.	GEOMAR
Hoving, Henk-Jan, Dr.	GEOMAR
Karstensen, Johannes, Dr. (not on board)	GEOMAR
Waldmann, Christoph, Dr. (not on board)	MARUM
Fock, Heino, Dr. (not on board)	THÜNEN
Cunha, Marina, Dr. (not on board)	Uni-Aveiro

2.2 Scientific Party

Name	Discipline	Institution
Fiedler, Björn, Dr.	Chemistry, Chief Scientist	GEOMAR
Hoving, Henk-Jan, Dr.	Scientist, Ecology	GEOMAR
Gross, Henrik	Technician, Ecology	GEOMAR
Liu, Hongbo	Ph.D. Student, Deep-Sea Monitoring	GEOMAR
Pinck, Andreas	Technician, Physics	GEOMAR
Witt, René	Technician, Physics	GEOMAR
Schott, Thorsten	Technician Deep-Sea Monitoring	GEOMAR
Stechert, Robin	Student Helper, Physics	GEOMAR
Schütte, Florian, Dr.	Scientist, Physics	GEOMAR
Zenk, Cordula	Helper, Chemistry	GEOMAR
Silva, Pericles	Scientist, Chemistry	UNI-CV/INDP, CV
Vieira, Nuno	Technician, Chemistry	INDP, CV
Leibold, Patrick	Technician, Informatics	GEOMAR
Meckel, Sebastian	Technician, Ocean Technology	MARUM
Barrera, Carlos	Scientist, Ocean Technology	PLOCAN
Kieft, Brian	Technician, Informatics	MBARI
Genio, Luciana, Dr.	Scientist, Ecology	Uni-Aveiro
Czudaj, Stephanie	Scientist, Ecology	THÜNEN
Kaehlert, Sarah	Guest, Media	GEOMAR
Ode, Lisa-Marie	Guest, School Program	GEOMAR
Liebender, Anna-Sophie	Guest, Marine Economy	OECD

2.3 Participating Institutions

GEOMAR	GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
UNI-CV	Universidade de Cabo Verde, Mindelo, Cabo Verde
INDP	Instituto Nacional de Desenvolvimento das Pescas, Mindelo, Cabo Verde
MARUM	MARUM Zentrum für Marine Umweltwissenschaften der Universität Bremen, Germany
PLOCAN	Plataforma Oceanica de Canarias, Spain

MBARI	Monterey Bay Aquarium Research Institute, Monterey Bay, USA
Uni-Aveiro	Universidade de Aveiro, Aveiro, Portugal
THÜNEN	Thünen Institut für Seefischerei, Hamburg, Germany
OECD	Organisation for Economic Co-operation and Development, Paris, France

3 Research Program

3.1 Description of the Work Area

The Senghor seamount is located 17°12′N 021°57′W (Figure 3.1) in the Northeast Atlantic trade wind regime. Denda et al. (2017) provide a detailed description of the Senghor Seamount. The seamount has a nearly circular shape with a small summit plateau with a minimum depth of about 90 m and a base at about 3300m depth. The summit itself as well as the edges of the summit (down to several hundred meter depth) show a heterogeneous surface structure covered with sediment in most parts but also shows rocky areas in the centre. Along the slopes down to the deep sea floor soft bottom alternates with rocky areas.

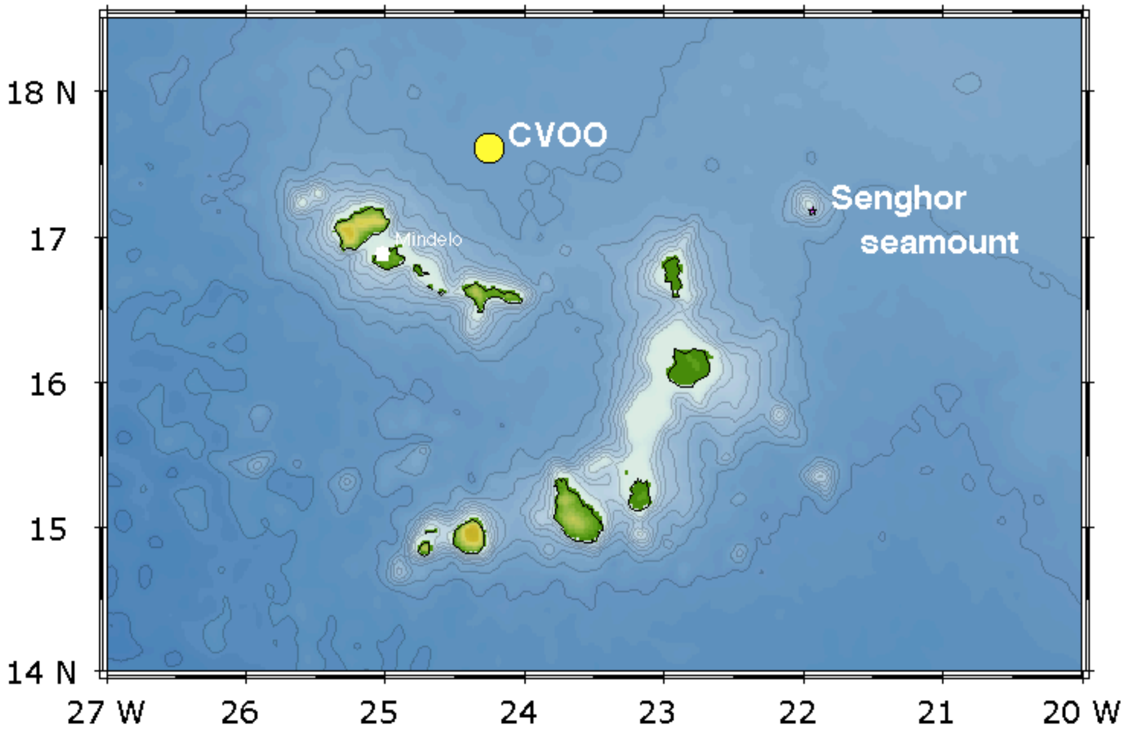

Fig. 3.1 Overview map of the working areas CVOO and Sneghor Seamount in Cabo Verdean waters.

The mean upper layer flow field in the region shows weak zonal currents (Brandt et al. 2015). The steady trade wind creates primarily Ekman and near inertial currents. The interaction of the seamount with tidal currents may be responsible for ripple marks at a water depth of about 100 m. Denda et al. (2017) reported on a high retention potential of Senghor seamount based on observations of high abundances of meroplanktonic larvae and high standing stocks of microzooplankton. Although Senghor Seamount has been subject to various sampling efforts, in particular micro-and mesozooplankton (Denda and Christiansen, 2014, Denda et al., 2017), fish larvae (Hanel et al 2010) and benthopelagic fish (e.g., Menezes et al. 2004) and more recently during MSM49 (Christiansen, Hoving, Möllmann) the medium-sized nekton and macrozooplankton communities, there is no information on the role of Senghor seamount in the ecology of oceanic predators. Studies on Senghor Seamount have been cruise-based and continuous longer term observations on the ecosystem dynamics including biogeochemical and biophysical interactions are absent.

The Senghor seamount is located in an "eddy corridor" of the eastern tropical Atlantic (Schütte et al. 2016). Mesoscale eddies, created in the Mauritanian upwelling region in boreal summer propagate westward, in the latitudinal range from 17°N of 18°N. Some of the eddies (cyclonic, anticyclonic Modewater eddies) can support the creation of a low oxygen core that is found just below the mixed layer, at very shallow depth of several tenth of meters (Karstensen et al. 2015). The eddies have been frequently observed at the CVOO mooring and these observations typically take place in February which is related to the creating of the eddies in June by instability of the coastal undercurrent (Schütte at al 2016). In situ observations of macrozooplankton inside the eddies in the ETNA show a unique faunal composition compared to the surrounding ocean environment.

3.2 Aims of the Cruise

The expedition MSM61 operated off West Africa at the Cape Verde Ocean Observatory (CVOO) time series station as well as at the Senghor Seamount, northeast of Cape Verde islands. Scientific objectives were:

- Investigating temporal variability and long-term changes of physical and biogeochemical parameters off West Africa by contributing and extending the CVOO time series data set.
- Determining variability of diversity and abundance of predators and prey (micronekton and zooplankton) and their linkage to biogeochemical and hydrographic/currents variability at the seamount crest and flanks?
- How does the seamount topography affect near-field biogeochemistry of the surface ocean and upper water column and how does it relate to net community production (e.g., induced by local upwelling or eddies)?
- Is the Senghor Seamount interacting with the tidal currents and which types of circulation pattern occur (incl. retention)?

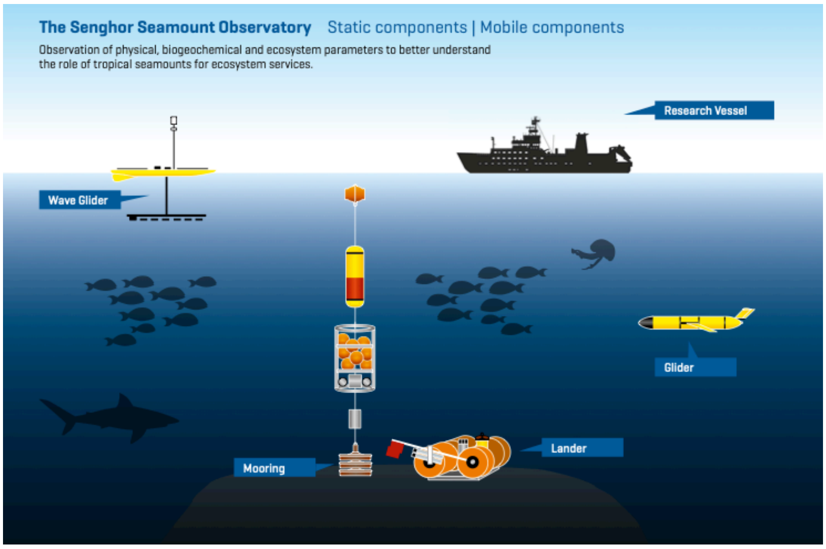

Fig. 3.2 The schematic illustrates the different components of the Senghor Seamount Observatory that was deployed during MSM61.

3.3 Agenda of the Cruise

The work program was divided into 3 components:

- A full-depth biogeochemical sampling at the CVOO time series site,
- Deployment of an autonomous and modular ecosystem observatory at Senghor seamount,
- Ship-borne hydrographic and video sections across the seamount.

At the CVOO time series station a CTD rosette sampler survey including a biogeochemical sampling was carried out – further extending the time series data set. Moreover, horizontal camera transects were acquired at different depth to estimate the mesozooplankton distribution at the site. At the Sengor Seamount, mobile and moored observatories have been installed that will acquire physical, biogeochemical and ecosystem relevant data even beyond MSM61. The data will be used for investigations on basic physical, biogeochemical, and ecosystem processes at tropical seamounts and in particular their role in shaping the local biodiversity.

The observatory consists of a stationary bottom lander at the edge of the summit for long term recordings. Furthermore, a coordinated swarm of two Wave Gliders (surface incl. acoustic profiling, 0 – 100 m) and an electric glider (water column, 0 1000 m) were operated at Senghor Seamount.

CTD rosette measurements and ship-ADCP surveys were conducted in order to resolve hydrography, biogeochemistry and circulation around the seamount. Video transects were done in order to record the mesozooplankton distribution at different areas of the seamount and multinets were deployed for taxonomic studies.

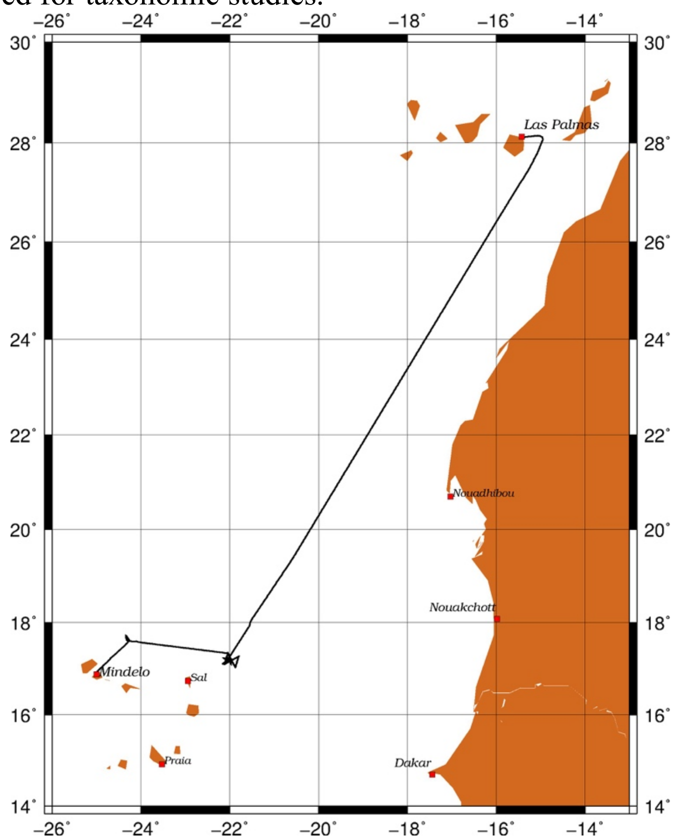

Fig. 3.3 Track chart of RV MARIA S. MERIAN Cruise MSM61.

4 Narrative of the Cruise

Expedition MSM61 started on Feb 18th in the morning from the port of Mindelo, Sao Vicente, Cape Verde. The first working area (CVOO) was located 60 nautical miles northeast of Mindelo. Approx. half way a test station was conducted which included a 1000 m hydrocast with the CTD, incl. biogeochemical sampling and a releaser test. A test dive with the towed camera system PELAGIOS had to be aborted due to a technical malfunction.

At CVOO hydrocast station we spent about 23 hours of intense station work which consisted of day- and nighttime Multinet hauls down to 800 m water depth, day- and nighttime PELAGIOS surveys down to 1000 m and a full-depth (3609 m) CTD hydrocast including sampling for biogeochemical parameters (dissolved inorganic carbon, total alkalinity, dissolved oxygen, nutrients). The last task before the transit to the next working area (Senghor Seamount) was the recovery of a small surface telemetry buoy which was attached to the CVOO mooring 2 nautical miles north of the CVOO hydrocast station. The buoy failed just 2 days earlier and therefore a replacement with a dummy buoy became necessary.

After 12 hours of transit we reached the Senghor Seamount and an instrument test was performed with the PELAGIOS (spectral camera test) which was repeated a few times during the next 4.5 days at the seamount. Afterwards we recorded two current sections with the hull-mounted Acoustic Doppler Current Profiler (ADCP, 75 & 38.5 kHz) in order to obtain a first picture of the current flow field during our stay at the seamount.

One of the main objectives of this cruise was to install an autonomous observatory at the summit of the seamount that consists of a short mooring incl. a moored profiler, a bottom lander and two autonomous surface vehicles (so-called wave Glider). Thus, we began with installations of these systems already on the first day at the seamount in order to monitor and ensure the functionality of these components during our stay at the seamount. On the first day (February 20th) the mooring as well as the lander were deployed. Furthermore, an underwater glider which was deployed from Sao Vicente Island 4 weeks ahead of our cruise was recovered at the flank of the seamount. Harsh wind conditions didn't allow using the zodiac for this operation. Instead, a rescue net was used to recovery the glider safely. The glider got refurbished on board and was redeployed after 2 days again for continuation of its mission at the seamount.

During the following night and day we extensively used PELAGIOS and the Multinet for day- and nighttime observations and we also deployed two Wave Gliders and send them on cross-sections across the seamount for autonomous measurements of biogeochemical parameters and hydroacoustic measurements of biomass and currents.

We also conducted a hydrographic northwest-southeast CTD section across the summit including water sampling again for carbon parameters, oxygen and nutrients. For logistical reasons we interrupted the section work with a PELAGIOS deployment. We also had to recover the mooring and one Wave Glider in between as malfunctions of these systems occurred.

The following 24 hour ADCP section was conducted in order to look at tidal influences on the flow field around the summit. We also used that time to fix issues with the moored profiler and the Wave Glider.

Just before the last ADCP section on day 4 (February 23rd) we redeployed the Wave Glider and after the final ADCP section the moored profiler was redeployed as well. During the last night at the Seamount we conducted final PELAGIOS and Multinet deployments. Meanwhile, it turned out that again technical problems with the mooring and the Wave Glider occurred, which made a spontaneous recovery necessary once again. After that we left the working area at Senghor Seamount and started our transit to Las Palmas.

5 Preliminary Results

5.1 Hydrography

5.1.1 CTD measurements

(F. Schütte, J. Karstensen [not on board], G. Krahmann [not on board])

Introduction

During MSM61 a total of 13 CTD-profiles were collected, two near the Cape Verde Ocean Observatory (CVOO) and eleven as a hydrographic section across the Senghor Seamount. Nearly all casts were done to full ocean depth (see station list). During the cruise the GEOMAR SBE#3 with a Seabird SBE 9 CTD rosette system has been used. The CTD system was equipped with one Digiquartz pressure sensor (s/n 75760) and double sensor packages (temperature 1 = s/n 4831, temperature 2 = s/n 4823, conductivity 1 = s/n 2452, conductivity 2 = s/n 3381, oxygen 1 (sbe 43) = s/n 631, oxygen 2 (sbe 43) = s/n 2592. Data acquisition was done using Seabird Seasave software version 7.21k. The CTD was mounted on the GO4 rosette frame with a 24 bottle rosette sampling system with 10 liter bottles. During the whole cruise MSM61 only 21 bottles were attached to the rosette due to the mounted lADCP on the CTD frame.

Methods

The calibration of the conductivity and oxygen sensors of the CTD followed the usual approach by taking water samples from the CTD rosette system and analyzing them for high accuracy conductivity and oxygen values on board. For conductivity 263 samples were taken and analyzed on one of GEOMAR's Guildline Autosal salinometers operated by Nuno Vieira (see section 5.1.2). For oxygen 167 samples were taken and analyzed using the Winkler titration method operated by Pericles Silva (see section 5.1.2). For the downcast part of the profiles this resulted in correction terms (added to the values measured by the CTD) of 0.00082715+8.3028e-08*P+5.8793e-05*T-0.00037419*C for conductivity and 0.55885+0.0034357*P-7.7918e-08*P*P+0.097484*T+0.070734*O for oxygen. The remaining rms differences between the corrected CTD values and the on-board measurements were 0.003 PSU and 1.04 µmol/kg, respectively. The downcast part of the profile was used as it consists of measurements that during the descent of the CTD are not perturbed by the rosette frame's wake. For the final data the second of the two parallel sets of sensors present in the CTD was used as it was slightly less noisy.

However, due to questionable results from oxygen titrations (section 5.1.2), the oxygen sensor calibration was done based on the calibration from MSM60. This was justified by having used exactly the same CTD system and at the same time having a much larger number of CTD profiles and a higher quality of water samples available. This has led to a more robust result than the described calibration based on MSM61 data only.

Preliminary results and outlook

One CTD section from northwest to southeast over the Senghor seamount was done to investigate the hydrographic and oxygen structures occurring over and around the seamount. A first impression of different parameter distributions (temperature, salinity, potential density and oxygen) are shown in figure 5.1. The CTD data will be further processed and analyzed ashore.

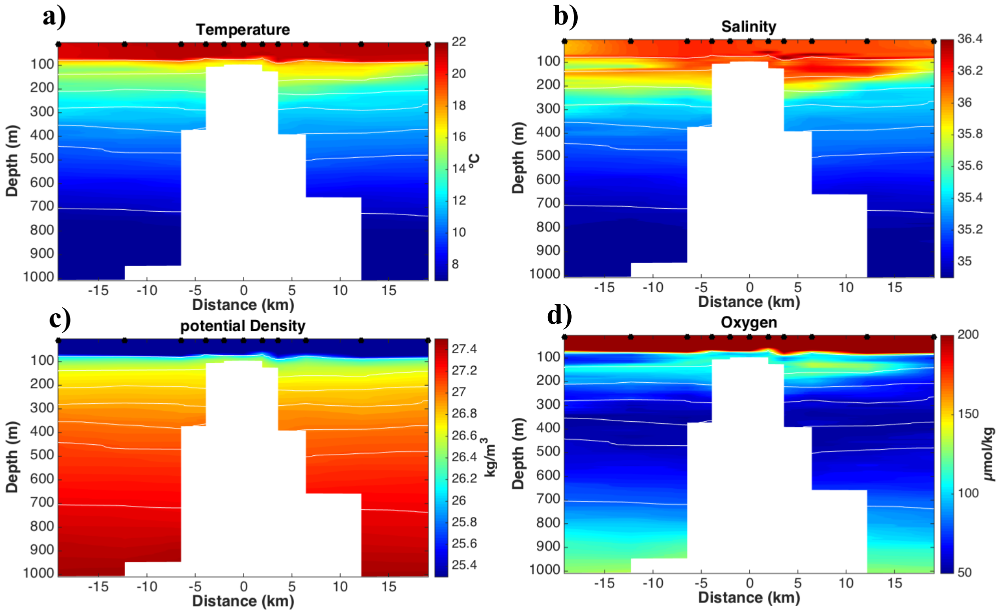

Fig. 5.1 CTD section consist out of eleven CTD profiles (black stars) over the Senghor Seamount in a a) temperature, b) salinity c) potential density and c) oxygen.

5.1.2 Water sampling (biogeochemistry)

(P. Silva, N. Vieira, B. Fiedler)

Introduction

We performed a discrete sampling programme for nutrients (nitrate, nitrite, phosphate and silicate), dissolved oxygen, and inorganic carbon parameters, e.g. DIC (dissolved organic carbon) and TA (total alkalinity) at all 13 CTD stations. Only dissolved oxygen samples were analysed on board, all other parameters were preserved for shore-based analysed in the home lab at GEOMAR, Kiel.

Methods

Oxygen samples

The sampling was done in 100 mL glass bottles with glass stoppers. After the bottles were carefully rinsed they were filled to the top and 1 mL $MgCl_2$ and 1 mL KI/KOH solution were added. The bottles were closed and then shaken for approximately one minute and immediately measured once all the samples were taken. Oxygen samples were analysed according to a standard Winkler titration. Using triplicate samples, the precision was estimated to be 0.38 µmol L^{-1}.

Nutrient samples

The water for the nutrient analyses was sampled in PE-vials. Vials were rinsed three times, then filled and immediately frozen after sampling in -20°C freezer. Samples were measured within 8 months after sampling using a Seal Quaatro (Seal Analytical, Norderstedt, Germany) autoanalyzer. Using triplicate samples the precision was estimated to be 0.26 µmol L^{-1} (nitrate), 0.04 µmol L^{-1} (phosphate), 0.07 µmol L^{-1} (nitrite), 0.12 µmol L^{-1} (silicate).

DIC/TA

Samples for CO_2 measurements were collected in 500 mL glass bottles with glass stoppers. The sampling and preservation procedure followed the recommendations from (Dickson, Sabine, & Christian, 2007). All samples were stored dark. DIC analyses were made using a coulometric titration method using the SOMMA (single operator multi-parameter metabolic analyzer) system. The SOMMA collects and dispenses an accurately known volume of seawater to a stripping chamber, acidifies it, purges the CO_2 from the solution, dries the gas, and delivers it to a coulometer cell, where the CO_2 reacts with the solution and builds an acid that is titrated with in-situ produced OH^- ions. TA was determined by titration of seawater with a strong acid, following the EMF of a proton sensitive electrode. The titration curve shows two inflection points, characterizing the protonation of carbonate and bicarbonate, respectively. The acid consumption up to the second point is equal to the titration alkalinity. Alkalinity was determined by a semi-automatic analyzer, the VINDTA instrument (Versatile Instrument for the Determination of Titration Alkalinity).

Preliminary results and outlook

In general, replicate measurements for all parameters indicate a poorer precision when compared to other cruises. This most likely resulted from less experienced personnel that collected and processed the samples on board. Furthermore, it turned out that dissolved oxygen values derived from winkler titrations show a systematic offset when compared to deep water historical data from CVOO. This most likely resulted from expired reagents that were used for sample analysis on board. Discrete sample data for DIC/TA and for nutrients provided a valuable extension of the CVOO time-series data set which dates back to 2006. Due to the unavailability of the local research vessel Islandia in Cabo Verde, samplings of opportunity such as this one are highly valuable for the continuation of the time-series. Nutrient and DIC/TA data collected at Senghor seamount reflects the oxygen distribution around the summit that was observed with the CTD-mounted oxygen sensor (Figure 5.1). Lower nutrient and DIC concentrations were found southeast of the summit at subsurface depth (100-200 m). This corresponds with elevated oxygen concentrations found at this depth and might result from subducted water masses from upper layers around the seamount. Biogeochemical data obtained from Senghor seamount during MSM61 will be used as a baseline for future surveys as such data was not collected before at this seamount.

5.1.3 Underway hydroacoustics

(F. Schütte, J. Karstensen [not on board])

Introduction

Underway-current measurements were performed continuously throughout the whole cruise, using two vessel-mounted Acoustic Doppler Current Profilers (VMADCP): a 75 kHz RDI Ocean Surveyor (OS75) mounted in the ship's hull, and a 38 kHz RDI Ocean Surveyor (OS38) placed in the moon pool. The OS38 was aligned to zero degrees (relative to the ship's center line) in order to reduce interference with the OS75 that is aligned to 45 degrees. First both instruments worked well and produced good data. After the additional installation of a high precision Echosounder (needed for the deployment of the lander) in the moon pool, the range of the OS38 was drastically reduced. Part of our explanation was the missing ice protection cap of the moon pool, which needed to be deinstalled during the use of the high precision Echosounder. After two days the high precision Echosounder was deinstalled and the ice protection cap installed again and the OS38 produce good data for the rest of the cruise.

Methods

Both instruments were run in the more precise but less robust broadband (BB) mode. The configurations of the two instruments are: OS38 using 16m bins, pinging at 25 per minute and OS75 using 4 m bins, pinging at 35 per minute. Depending on the region and sea state, the ranges covered by the instruments are around 500 m for the OS75 and around 1000 m for the OS38. During the entire cruise the SEAPATH navigation data was of high quality. Most shipboard acoustic devises were switched of during the cruise to avoid acoustic interference. Otherwise especially the Doppler Log and the multibeam echosounder would have produced significant interferences with the VMADCP's. One strong source of noise was the pump jet (bow thruster) during the station, which rendered especially the OS75 data useless. VMDAS software was used to configure the VMADCPs and to record the VMADCP data as well as the ships navigational data. The data were processed on board and a preliminary data set was used for a number of near real time velocity products.

Preliminary results and outlook

Several VMADCP transects (perpendicular to each other) over the Senghor seamount were done to investigate the currents and tidal structure around the seamount. The first view on the preliminary processed VMADCP data shows highly variable currents (in terms of velocities and directions) around the seamount on different depths (Figure 5.2). It indicates to an area of high turbulence and mixing. The ADCP data will be further processed and analyzed ashore. In addition backscatter data will be used to identify zooplankton diurnal vertical migration patterns around Senghor Seamount, complementary to data from an earlier cruise over the Senghor Seamount (e.g. MSM49).

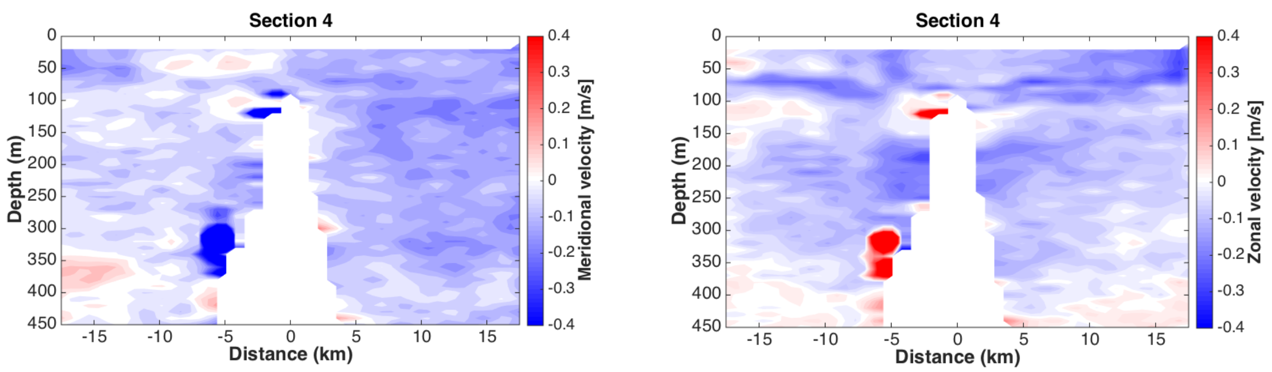

Fig. 5.2 Meridional (left) and zonal (right) currents across Senghor seamount during one single crossing, based on underway ADCP measurements.

5.2 Marine Ecology

5.2.1 Pelagic video surveys

(H.J. Hoving, H. Gross, H. Liu, T. Schoening [not on board])

Introduction

The cruise on RV MARIA S. MERIAN targeted several regions that are of ecological interest. The first was the Cape Verde Ocean Observatory. In addition to the biogeochemical measurements and zooplankton collections taken at this time series station, recent efforts have added biological observations of larger pelagic fauna as part of the project 'in situ observations of Cape Verdean pelagic fauna in a changing ocean'. This project aims to establish baseline data of pelagic fauna distribution, diversity and abundance, and determine how organisms are distributed in relation to environmental parameters including oxygen. Oxygen minimum zones have a profound impact on the vertical distribution of pelagic organisms, and are expanding as a result of global change. Therefore, we aim to investigate the vertical distribution of gelatinous zooplankton, crustaceans, cephalopods and fishes to predict the effect of an expanding oxygen minimum zone on the ecosystem of the eastern Atlantic.

Many pelagic organisms, in particular gelatinous fauna, are delicate and cannot be quantified and identified properly by net catches. Optical observation systems are better capable to quantify these organisms. In addition, the benefit of in situ observations is that information on behavior and fine scale distribution is collected. During MSM61 we used a novel ocean observation device, PELAGIOS, which can be used to collect pelagic video transect data in the open ocean.

While oxygen minimum zones are situated in the mesopelagic zone, which ranges from 200-1000 m, one of the largest but least explored environments in the ocean is the bathypelagic zone, the volume of water between 1000-3000 m. Biological surveys of this habitat are extremely rare, and we know very little how faunal patterns compare to the overlying ocean layers. From other areas (Monterey Bay) it is known that the bathypelagic zone is the habitat for a variety of organisms in particular gelatinous organisms. Therefore during MSM61 we aimed to perform the first bathypelagic video surveys in Cape Verde waters.

Besides oceanographic features, topographic features such as seamounts may also impact the distribution and abundance of organisms. While seamounts have been shown to be hotspots for larger fauna such as turtles, large pelagic fishes and sharks, the role of seamounts in Cape Verdean waters for these organisms remains unstudied. Previous cruise efforts by German scientists investigated micro and meso- and macrozooplankton at Senghor seamount mostly using net sampling. Here we use combination of tools to investigate the biological communities of Senghor Seamount summit including pelagic surveys.

Methods

To obtain video transect data we deployed the pelagic in situ observation system PELAGIOS. This instrument consists of a HD camera, LED light arrays, a depth sensor and a battery for powering the lights and the camera. All these components are integrated in an aluminum frame. The instrument is towed at 1 knot by the ship and by doing so video transect data is collected from the water column. By identifying and quantifying organisms on the collected video it is possible to reconstruct diversity and abundance patterns. We performed video transects at different depths in order to reconstruct vertical distributions of organisms. To understand the daily vertical migration we deployed PELAGIOS during the day and during the night.

Besides the conventional video survey with a "white" light source and an RGB camera, we also tested a prototype of a spectral camera to explore the potential applicability of in situ observation by using multispectral imaging technology underwater. The so called underwater multispectral imaging system (as shown in Figure 5.3) synchronizes a monochrome camera with 16 coloured LEDs, assembled in two arrays (8 pairs) at different wavelengths to provide 2D spatial light intensity distribution of the scene in 8 spectral channels (while an RGB camera provides only 3 channels, i.e., red, green and blue) in one second. During the cruise, 9 dives (30 minutes each) were deployed with different multispectral camera settings, LED array layouts and towing depths (as shown in Figure 5.3). 129,600 images were obtained in total. Analysis of the spectral data will be conducted post-cruise.

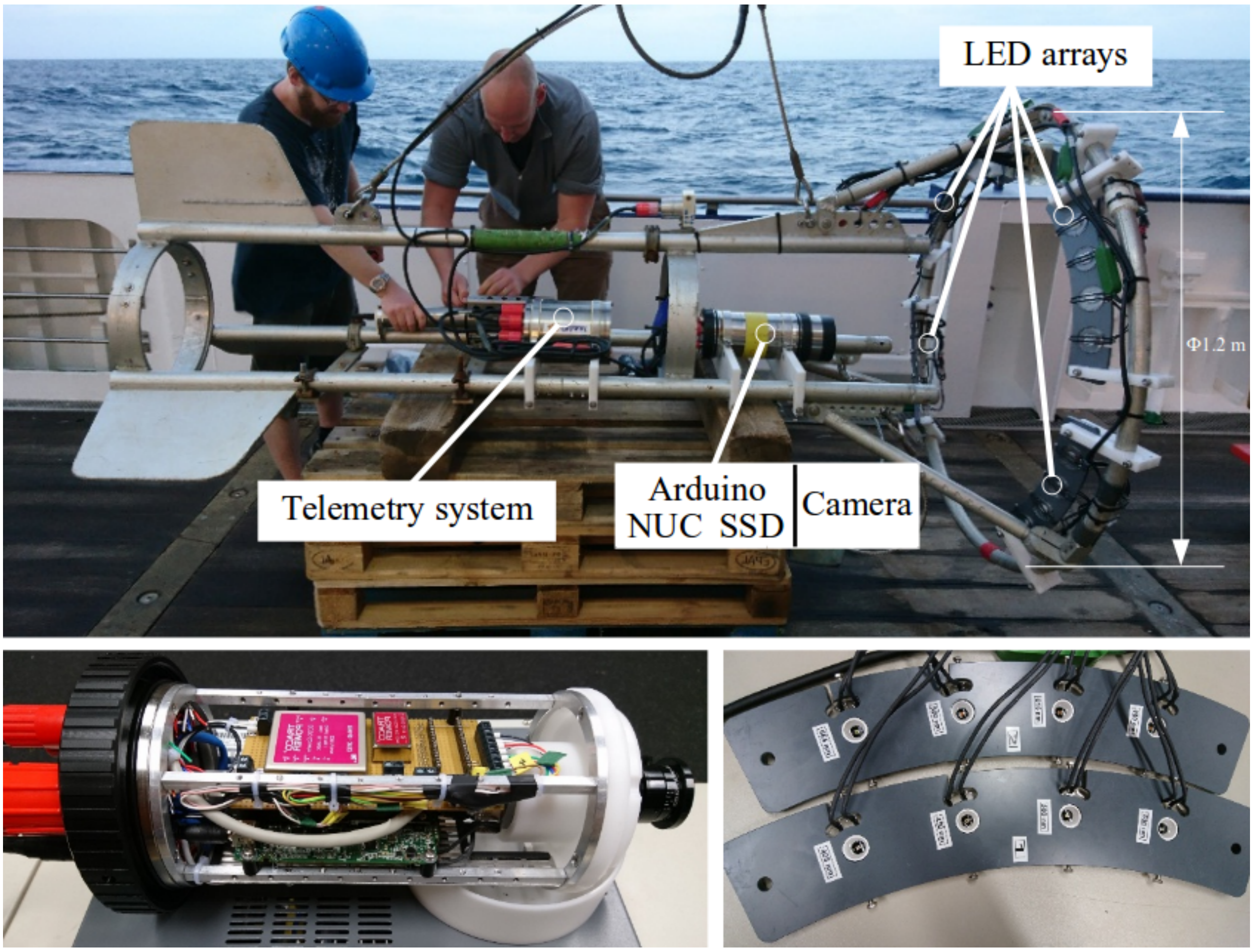

Fig. 5.3 Overall setup of the towed camera system PELAGIOS (upper), the camera unit (lower left) and the LED array (lower right).

A clip on the deployment of PELAGIOS and observations of the Cape Verdean pelagic ecosystem can be found on the website: https://www.wissenschaftsjahr.de/2016-17/das-wissenschaftsjahr/die-forschungsflotte/forschungsschiff-blogs/unerforschte-meeresgebiete.html.

Table 5.1 Summary of PELAGIOS deployments during MSM61.

Date	Station	Longitude	Latitude	Max. depth (m)	Duration
18/2/2017	CVOO test	17° 34.97	24° 17.1	316	51m
19/2/2017	CVOO_night	17° 34.99	24° 17.02	1005	5h35m
19/2/2017	CVOO_day	17° 37	24° 18.23	865	1h1m
20/2/2017	Spectral camera	17° 20.44	22° 15.41	80	23m
20/2/2017	Spectral camera	17° 9.93	21° 58.56	106	3h50m
21/2/2017	Deep Tow I night	17° 12.38	22° 0.91	609	6h18m
21/2/2017	Deep Tow I Day	17° 14.44	22° 2.43	953	4h8m
22/2/2017	Spectral	17° 20.46	22° 2.52	100	4h10m
23/2/2017	Senghor summit	17° 10.43	21° 56.74	90	1h2m
23/2/2017	Senghor summit	17° 10.94	21° 56.89	99	1h13m
24/2/2017	Deep Tow II	17° 10.88	22° 3.13	1204	6h12m

Preliminary results and outlook

We are currently analyzing the collected transect video. The video data are annotated and organisms are identified and quantified and correlated with their environment (depth, CTD, oxygen) resulting in a database of organisms in their physical and chemical environment.

The video surveys at CVOO will contribute to repeat observations (M119, MSM49) at this station, which, together with observations collected during POS520 in February 2018 will be combined into a publication on baseline data on the vertical distribution and abundance of pelagic fauna at the oceanic time series station. First insights from the video transects in the bathypelagic zone reveal interesting patterns that require further investigation. While with increasing depth organisms become less dense, they are of larger size than in shallower waters. Snipe eels were seen in the deeper tows. A deep-sea squid of the family Mastigoteuthidae and a bright red physonect siphonophore were also encountered as well as various ctenophores. Giant radiolarians were also a very abundant component of the deep community as well as deep red crustaceans. Preliminary analysis of the collected video suggests that the fauna in the lower mesopelagic and bathypelagic zone is profoundly different from the overlying epi and mesopelagic zone. These observations will be coupled with bathypelagic observations that were obtained during POS532 to provide the first baseline information on bathypelagic communities in Cape Verde waters. Preliminary analysis of the two night deployments at Senghor seamount summit showed that gelatinous fauna including doliolids, polychaetes, siphonophores and ctenophores are the very abundant. While small fishes and squids were observed at 95 m, no large aggregations of fishes were observed as in previous deployments on MSM49. The PELAGIOS observations of Senghor Summit will be coupled with the observations obtained by the lander and the Wave Glider, and the observations done by PELAGIOS during MSM49.

As for the field test of the spectral camera, two issues emerge during the preliminary image processing. One the one hand, the images are quite dark. On the other hand, the position of the target changes among different images because of the relative movement with camera. Figure 5.4 shows four individuals in the respective 8 channels and a color image by fusing the eight monochrome images into an RGB format image.

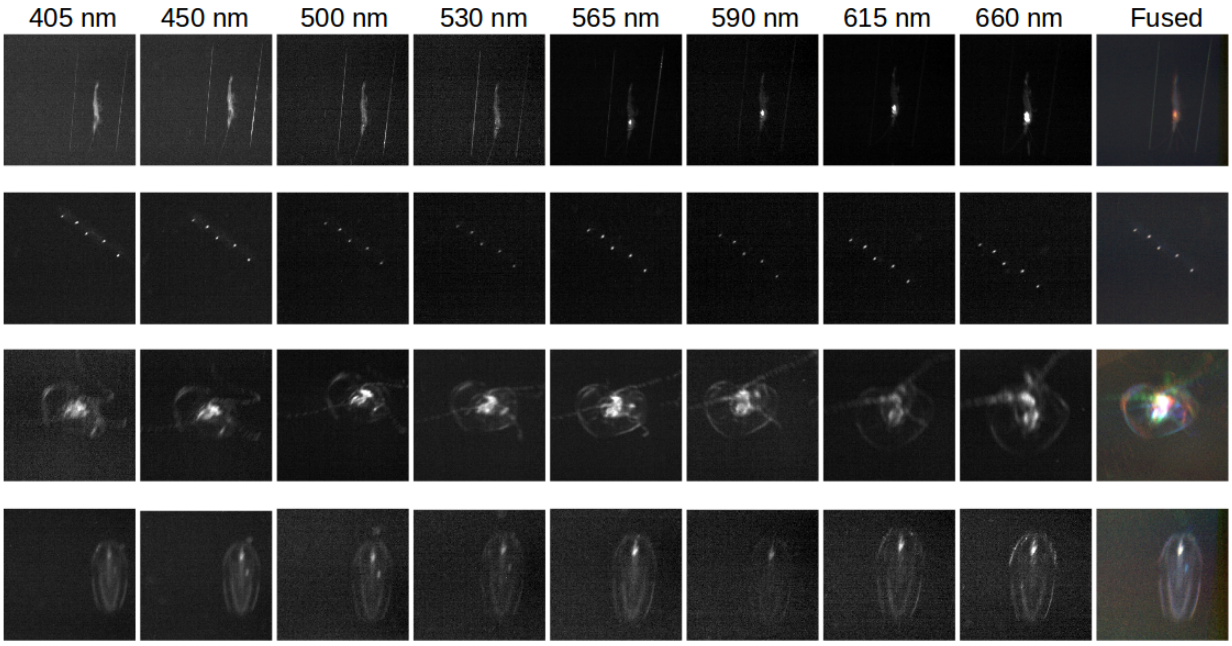

Fig. 5.4 Examples of pictures taken from the spectral camera mounted on PELAGIOS.

5.2.2 Zooplankton multinet sampling

(S. Czudaj, L. Genio, H. Fock [not on board])

Introduction

As singular topographic anomalies in an otherwise rather uniform environment, seamounts offer unique places of enhanced nutrient supply to the pelagic community. At the same time, they serve as important opportunities for settlement, enabling the dispersal of many species. Their stableness even allows the evolution of endemic species. Mesozooplankton communities are a critical component of tropical food-webs, transferring surface productivity to higher trophic consumers that inhabit deeper pelagic waters. They are characterized by ubiquitous, mostly nocturnal, diel vertical migrations to the epipelagic layers, followed tightly by their micronectonic predators. Seamounts disrupt this behavioral pattern. We are interested in community changes in this ecosystem relative to pelagic ocean parts and how this affects the food-web structure.

Methods

We sampled mesozooplankton by oblique depth-stratified tows using a Hydrobios MultiNet Maxi (0.5 m^2 net opening, 9 nets). One net was damaged, therefore, eight strata were sampled at CVOO and at Senghor seamount during one day and one night tow each: 800 – 600 m, 600 – 500 m, 500 – 375 m, 375 – 300 m, 300 – 200 m, 200 – 100 m, 100 – 50 m, 50 – 0 m. These depths were chosen to enable comparison with previously conducted MultiNet tows in the OMZ core region in the area. Care was taken to avoid vertical migration by sampling earlier/later than two hours prior/posterior to sunset/sunrise. At Senghor seamount additionally one night tow was conducted at the summit sampling five depths: 90 – 80 m, 80 – 60 m, 60 – 40 m, 40 – 20 m, 20 – 0 m. Due to cruise logistics a previsioned day cast had to be cancelled. Samples were split between University of Aveiro, Portugal and Thuenen Institute of Sea Fisheries, Hamburg and preserved in either 4 % formaldehyde – seawater – solution, 20 % Dimethylsulfoxide (DMSO) or frozen at -20°C as bulk samples or separated by species groups.

Preliminary results and outlook

As a first analysis, we analysed stable nitrogen isotopes of appendicularian samples to investigate whether a preservation effect exists between samples stored at -20°C and those preserved in buffered 4%-formaldehyde –seawater solution. The results give confidence that nitrogen isotope values do not change significantly during 2-month storage in the common method buffered 4%-formaldehyde –seawater solution and that appendicularians hence provide a suitable baseline for bulk nitrogen isotope analysis.

Planned analysis that is still to be done includes a community analysis of the vertical zooplankton distribution using a ZOOSCAN to investigate the pelagic food web structure in the area. In addition, invertebrate larvae will be sorted and identified to the lowest taxonomic level. MultiNet samples will provide ground-truthing data for ADCP records and will also serve as baseline for comparisons with long-term samples obtained from larval traps and colonization experiments being carried out at the CVOO time-series station, as well as at Senghor seamount.

5.2.3 Larvae trap and settlement experiments

(L. Genio, M. Cunha)

Introduction

Understanding the extent to which marine populations are connected by larval dispersal is vital to comprehend past impacts and future prospects for sustaining biodiversity and preserving deep-sea ecosystems. Previous studies of mesoscale flow processes near seamounts have demonstrated their potential to retain larvae of benthic invertebrates, to accumulate larvae near source populations, and to advect larvae as concentrated patches in discrete eddies to distant habitats, separated hundreds to thousands of kilometres apart (Mullineaux, 1994).

A new modular device, consisting of a colonization frame that hosts three experimental substrates (wood, bones and oyster shells) attached to a cross array of four passive larval tube traps (Figure 5.5), has been developed under a transnational access project to Fixed-point Open Ocean Observatories ($FixO^3$-TNA), to determine **l**arval **o**ccurrences in **o**pen **o**cean: connectivity studies in the **At**lantic and M**ed**iterranean (LO^3CAted). Deployment of these devices at Senghor seamount aim to test their capability to collect larvae and early settler invertebrates at shallower depths (~100 m), and at the same time provide new insights into larval distributions near seamounts, as well as comparing these results with bathyal and abyssal samples obtained from CVOO and three other observatories of the FixO3 network.

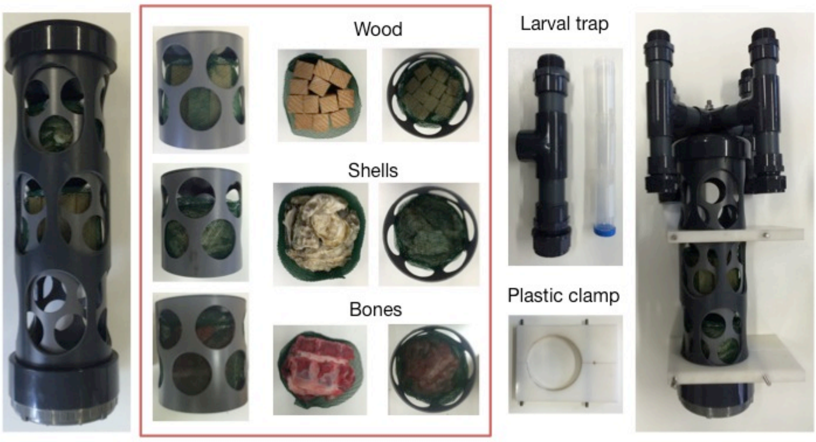

Fig. 5.5 LO³CAted modular sampling device. From left to right: settlement frame [14 cm Ø; 55 cm height] enclosing containers [12.5 cm Ø; 13 cm height] with experimental biogenic substrates; larval traps consisting of three stacked 50 ml Falcon tubes, which are inserted inside a PVC tube and can be attached on top of the settlement frame in a cross arrangement. The complete device can be fixed to the mooring line with plastic clamps.

Methods

During MSM61 cruise, three sets of LO³CAted devices were deployed at the summit of Senghor seamount, using the profiler mooring array and bottom lander (Figure 5.6, refer to section 5.3.1).

Larval traps were filled with 20% Dimethyl sulfoxide saturated with NaCl (~40 g per liter). The fixative solution was prepared onboard using Milli-Q water (stir for ~1 h and let to settle overnight) and kept refrigerated until deployment. The funnel-shaped stack of Falcon tubes form internal baffles that prevent larval escape and wash out. Falcon tube columns were washed with Milli-Q water (3x) and dried overnight before being filled with fixative solution.

Fig. 5.6 LO³CAted sampling devices attached to mooring cable (left) and lander (right) for deployment at Senghor seamount.

The tube traps were covered with parafilm to prevent the fixative release during mooring/lander descent (Figure 5.7). The parafilm was secured with rubber bands attached to a magnesium fusible link that dissolves after two days in seawater. When the link dissolves, a rubber band pulls off the plastic film, opening the trap. One set of four tube traps was attached to the top colonization frame on the mooring array and another set of four tubes was attached on top of the lander frame (same level as the ADCP).

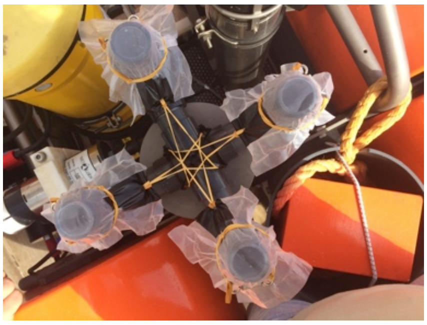

Fig. 5.7 Larval traps covered with parafilm secured with rubber bands and magnesium links.

The experimental substrates were enclosed in a 2mm mesh net inside PVC containers with holes for water flowing. Wood (12 pieces of 2 x 2.5 x 8.5 cm natural pine wood per basket) and oyster shells (~20 valves per basket) were previously prepared in the laboratory at Aveiro University (Portugal). Wood had a heat shock treatment (56°C for 30 min), and shells were brushed and washed with tap water, and dried at 60°C. Cow bones were bought in Mindelo and placed inside identical 2 mm mesh net baskets (~550 – 650 g per basket), and then frozen at the Instituto Nacional para o Desenvolvimento das Pescas (INDP) before taken onboard. Experimental substrates (wood, bones and shells) were randomly ordered in each colonization frame. Final arrangement of substrates is shown in Table 1:

Table 5.2 Experimental substrates order in each LO^{3}CAted settlement frame

System	Frame	Top	Middle	Bottom
Mooring	Upper	Shell	Wood	Bones
	Lower	Bone	Wood	Shell
Lander	Upper	Shell	Bone	Wood

Due to technical issues, the mooring had to be recovered and therefore only one set of LO^{3}CAted devices was left at the seamount summit.

Preliminary results and outlook

Recovery of the lander is planned for September 2017. Once the LO^{3}CAted device is retrieved, larval trap samples will be transferred to collection vials and sorted under a stereomicroscope. Individual substrate containers will be immediately transferred to 5L plastic buckets and placed in the cold room at ~5°C. The following procedure will be performed for each substrate: 1) net basket is removed from the PVC container; 2) line securing the top of the net basket is cut and top net cover is lifted; 3) substrate top view is photographed; 4) subsamples are preserved into different fixatives (95% Ethanol, 4% Formol and -80 °C) for future processing in the laboratory. Ethanol-cleaned forceps will be used to transfer substrate samples. In the laboratory, molecular and morphological tools will be applied to taxonomically identify larval and early settler metazoans as well as the microbial biofilms.

The results obtained from Senghor seamount will be compared with data collected from FixO3 sites (PAP, ESTOC, CVOO and PYLOS), and the Nazaré Canyon mooring (MONICAN01). These results will provide new insights into spatial and temporal patterns of larval assemblages across geographic and depth gradients, advancing the existing knowledge of biogeographic distributions and connectivity of deep-sea metapopulations.

5.3 Autonomous Systems

5.3.1 Moored profiler and bottom lander

(B. Fiedler, J. Karstensen [not on board], S. Flögel [not on board])

Introduction

Migratory oceanic fauna show increased abundances around oceanic features such as mesoscale eddies, fronts and seamounts (Morato et al. 2010, Arur et al. 2014, Rowden et al. 2010). Because seamounts have fixed positions in space they provide an ideal test-bed to study ecosystem processes that drive the aggregation of pelagic predators. Seamount studies based on single cruises provide only very limited temporal coverage on seamount habitat use by pelagic predators. Moreover, ocean dynamics of seamount systems are complex and migration patterns of predatory fishes, sharks and their prey observed during single research expeditions are difficult to interpret because of space/time aliasing and potential data gaps in habitat use of oceanic predators.

Biophysical and biogeochemical interactions at seamounts and mesoscale eddies generate mesoscale and submesoscale variability that is not easy to be observed during classical shiü-based surveys. Variability of these interactions may occur on timescales from minutes to weeks. Autonomous assets equipped with physical, biogeochemical and biological sensors can overcome such an observation gap. During MSM61 an experimental moored winch-profiler was tested at Senghor seamount with the aim to obtain daily vertical profiles at the summit of weeks and months. An additional mini-lander was installed in order to also resolved taxonomy of local fauna (see also section 5.2.3).

Methods

The moored winch-profiler was developed at GEOMAR and already tested during several short-term deployments before. It consists of a NGK (Japan) winch as the core component. Then winch got significantly modified by several components in order to carry a biogeochemical profiler developed by the company Develogic (Germany). Winch and profiler were communicated over the wire (inductive link) and the profiler was equipped with a Seabird (US) SBE52MP, a Wetlabs (US) FLNTURT fluorometer, a Seabird SBE63 oxygen sensor and a CONTROS (Germany) Hydro-CO_2 sensor. Above the profiler a satellite beacon was installed to send a subset of profile data over an Iridium satellite link. The winch was moored at approx. 130m water depth at the summit and tested. The lander (MoLab SLM lander) was installed at a water depth of 119 m at the southern edge of the summit. The lander was equipped with a Seabird SBE19 CTD, an AADI (Norway) oxygen optode 4330, a Wetlabs FLNTURT fluorometer, a Teledyne (US) 300 kHz workhorse ADCP sensor and a self-made time-laps camera incl. LED lights.

Fig. 5.8 Underwater winch during deployment at Senghor Seamount.

Preliminary results and outlook

The underwater winch incl. profiler was deployed twice during the cruise due to technical problems during operation. After the first profile and data telemetry the winch stopped and did not conduct the next profile anymore. Further, the acoustic link between the ship and the winch via acoustic modems also stopped working. Due to these circumstances the mooring was recovered for troubleshooting purposes. It turned out that a software bug from the manufacturer (Develogic) has caused the termination of profiling and the acoustic communication. After a configuration update at least the profiling bug could be fixed and a second deployment was carried out (still without acoustic link). Unfortunately, after deployment a problem occurred with wire-spooling during the first downcast which caused the profiler to remain at the surface. Thus, testing of the underwater winch had to be aborted and the equipment was recovered again.

The lander deployed during MSM61 remained at the summit for 7 months after MSM61 and got recovered by MV YERSIN during the Monaco Explorations campaign in Cabo Verde in Sept./Oct. 2017. All data was successfully recovered and already used for scientific analysis. The time-lapse camera unfortunately only worked during the first 24 h of the deployment due to battery problems. However, even during this short time frame a fish species was revealed (Figure 5.9) which for the first time was documented in Cabo Verdean waters (Freitas et al., 2018).

Fig. 5.9 Picture taken from the time-lapse camera mounted on the lander at Senghor Seamount at 119 m depth. First-time report of *serranus cabrilla* in Cabo Verdeans waters (Freitas et al., 2018).

5.3.2 Surface glider

(S. Meckel, B. Fiedler, C. Waldmann [not on board])

Introduction

As part of a cooperation between GEOMAR, MARUM and PLOCAN within the ROBEX project, the MARUM Wave Glider SV3 (Liquid Robotics, Inc.) was used as an autonomous, mobile and multiple sensor platform. The vehicle has supported research activities in the area of the Senghor seamount by collecting various data (current, particle density, chlorophyll fluorescence, turbidity, dissolved oxygen, pH, conductivity and temperature).

After the deployment the vehicle performed transects crossing the Senghor seamount for about one month. The Wave Glider was supposed to keep surveying Senghor seamount for a few more days after RV MARIA S. MERIAN has left the operation area and then sending it north to Gran Canary for its recovery.

The vehicle has been deployed 11:14 UTC on February 21st, 2017 at near Senghor seamount summit and has been sent on a closed loop track crossing the Senghor Seamount summit. Several crossings of the summit were performed as shown in Fig. 5.10.

Another Wave Glider, a SV2 version, has been deployed shortly after the MARUM SV3 Wave Glider. However, this glider was only able to achieve one cross-section as it had to be recovered already 1 day after deployment due to technical malfunctions.

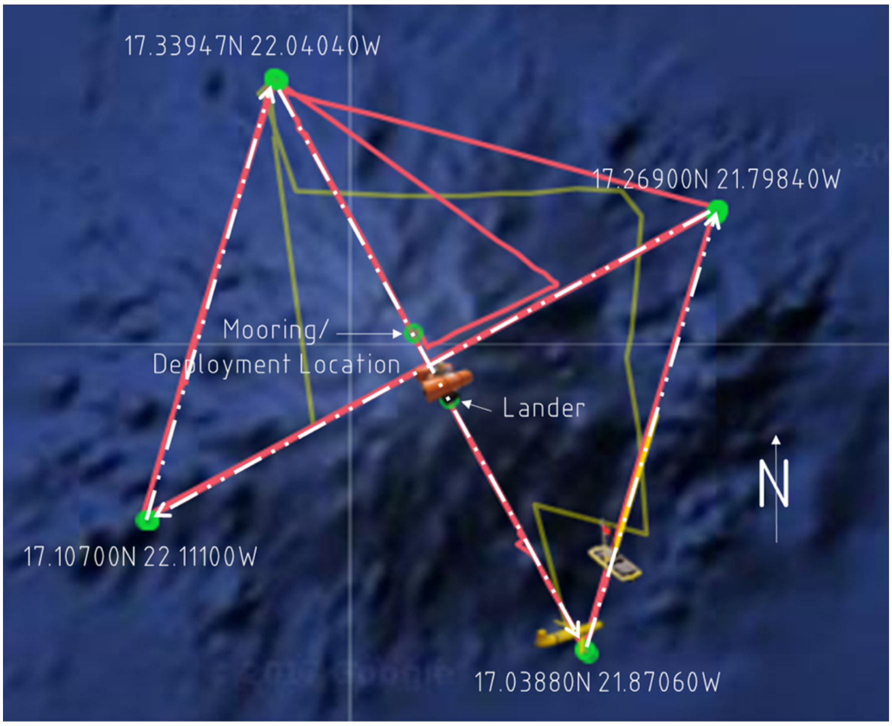

Fig. 5.10 MARUM Wave Glider SV3 track over Senghor Seamount until RV MARIA S. MERIAN has left the operation area on February 24th, 2017. Furthermore, the figure shows the deployment position of the mooring, the Wave Glider deployment location, the lander site and the position of the underwater glider.

Methods

The SV3 Wave Glider was equipped with an RDI Workhorse Monitor 300 kHz (2min sampling rate - current/-direction and particle density down to 150m depth), a Turner C3 submersible Fluorometer (1h sampling rate - chlorophyll fluorescence, turbidity), a Seabird GPCTD (1h sampling rate – conductivity, temperature, depth), a Seabird SBE43F (1h sampling rate – dissolved oxygen), a Sensorlab SP200H-SM (1h sampling rate – pH) and Airmar Weather Station PB200 (10min sampling rate – wind speed, wind gust speed, wind direction, temperature, humidity).

The SV2 Wave Glider was equipped with a biogeochemical sensor package consisting of a pCO_2 Sensor (HydroC®, Contros, Kiel, Germany, SN CO2-0412-012), an oxygen sensor (SBE63, Sea Bird Electronics, Bellevue, USA, SN 63-0492), a two channel fluorometer (FLNTURT, Sea Bird Electronics, Bellevue, USA, SN 2768) measuring turbidity and fluorescence and a sensor to measure the total gas pressure of all dissolved gases (HGTD, Pro-Oceanus Systems Inc., Halifax, Canada, SN 3316916). Additionally, the SV2 Wave Glider was equipped with a single-beam and single frequency (200 kHz) echo sounder (Simrad EK 15, Kongsberg Maritime, Kongsberg, Norway).

Preliminary results and outlook

The Senghor Seamount Mission has ended on March 14th, 2017. While its presence at the Senghor Seamount 10 full transects were performed. After a duration of 10 days the SV3 vehicle water speed has decreased from 2.3kn to 0.3kn due to unexpected barnacle growth. To avoid non-manoeuvrability the vehicle was sent to Cabo Verde for visual inspection and cleaning by divers. Visual inspection has shown a complete loss of Seabird GPCTD, Seabird SBE43F and Sensorlab SP200H-SM sensors due to a mechanical malfunction of its attachment points.

The vehicle has been recovered after 45 days at sea and 1656nm distance at 14:55 UTC on April 8th, 2017 by RV POLARSTERN. Current and backscatter data have been continuously recorded by the RDI Workhorse Monitor (300 kHz, Fig. 5.11). However, due to mentioned loss of the sensors attached to the sub no data could be recovered from the other sensors.

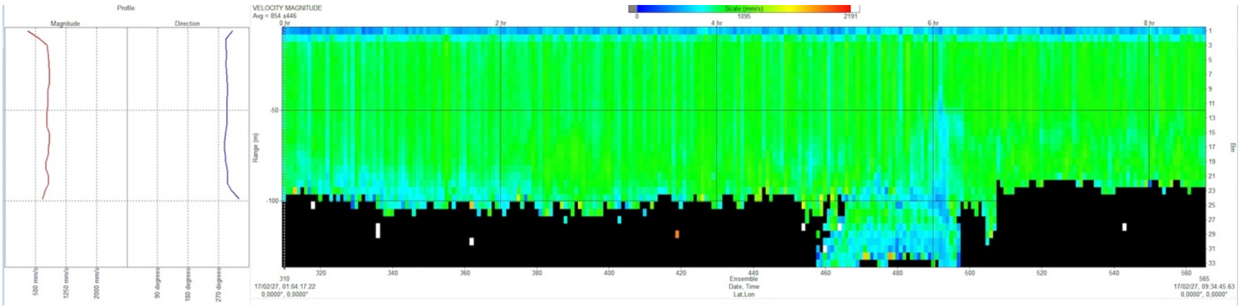

Fig. 5.11 Excerpt of raw data displayed with the software of TELEDYNE RDI WinADCP covering a time interval of 8.5 hours on February 27, 2017. While the platform is moving over the area of Senghor Seamount it encounters different depths ranges.

5.3.3 Underwater glider

(F. Schütte, J. Karstensen [not on board])

Introduction

In January 2017 (one and a half month before the cruise MSM61) one autonomous glider system (ifm14) manufactured by Teledyne Webb Research was deployed from Mindelo (Sao Vicente / Cabo Verde) by Florian Schütte and Christian Begler. The glider investigated the water mass distribution due to mesoscale variability in area between the archipelago and the territories of Senegal and Mauretania. During MSM61 the glider was recovered, maintained (e.g. new batteries) and deployed again. It was planned that the glider will be in the water for more than two months after its deployment from the RV MARIA S. MERIAN (MSM61) investigating the hydrographical structures around the Senghor Seamount. After the mission it was expected to recover the Glider near the islands. Unfortunately, due to technical problems the glider needed to be recovered after 25 days in the waters near the Senghor seamount.

Methods

The glider (ifm14) was encompassed with a set of build-in sensors; a CTD, an Aanderaa optode to measure dissolved oxygen and a Wetlabs combined CHL-a fluorescence and turbidity sensor. The glider was equipped with enough battery power to run for about three months. Normally all deployment, service and recovery operations were done with inflatable boats. Unfortunately, the weather conditions during the recovery and deployment with the RV MARIA S. MERIAN (MSM61) do not allow operations with inflatable boats (strong winds and high waves). We decided to recover the glider with a rescue net, which was never done before. Due to the high performance of the RV MARIA S. MERIAN and its crew to navigate very close and precise to the glider, the glider was successfully and easily recovered. This is an option for future glider recoveries under bad weather conditions. The glider ifm14 was recovered on the 19/02/2017 on the position 17° 11'N and 21° 58'W at 8:00 UTC. After the successful recovery using the net we decided to deploy the glider ifm14 on the 23/02/2017 on the position 17° 20'N and 22° 02'W at 13:00 UTC with the net as well. During the deployment it was planned to traverse with the RV MARIA S. MERIAN away from the glider. Unfortunately, the glider was sucked in from the backdraft and several contacts between the glider and the ship occur. It turns out that the deployment with the rescue net lowered from the starboard side is not an option for future glider deployments under bad weather conditions. A way to improve the deployment under bad weather conditions is maybe to lower the net with the glider at the aft of the ship under very slow forward movement of the ship itself. However, after the deployment all science sensors delivered excellent data, only some warnings associated to the fin occurred, but the control of the glider was not influenced so it was decided that the glider stays in the water. But after 25 days of successful data delivery the problem with the fin was getting serious and the glider needed to be recovered from the RV RON BROWN on the 11/03/2017 on the position 16° 30'N and 21° 59'W at 10:00 UTC.

Preliminary results and outlook

The glider conducted four high-resolution sections over the Senghor Seamount within seven days to investigate the variability of temperature, salinity, oxygen, chlorophyll and turbidity (Figure 5.12). Glider sections confirmed the asymmetrical distribution of water masses around the summit but with a much higher spatial resolution. The data need to be further processed and analyzed ashore.

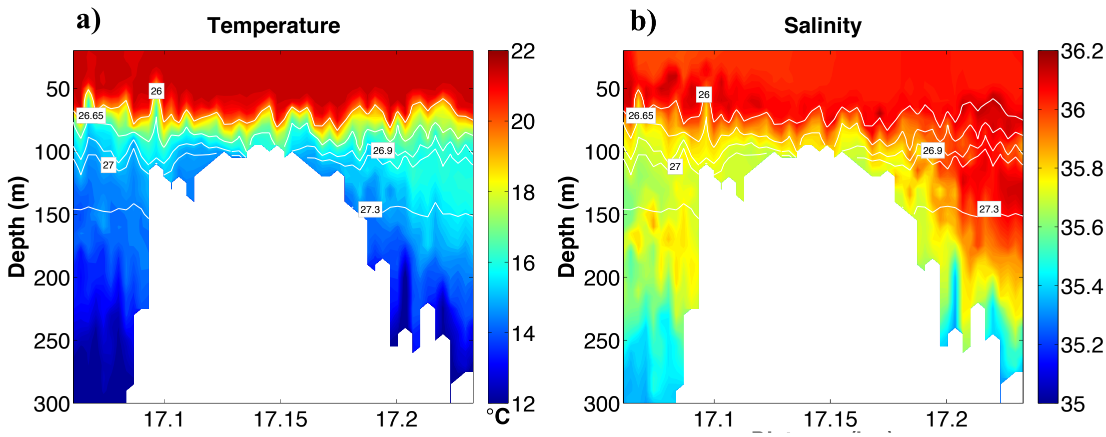

Fig. 5.12 One Glider section over the Senghor Seamount in **a)** temperature and **b)** salinity. The white contour lines represent isopycnals of potential density.

6 Station List MSM61

6.1 Overall Station List

Station No.	Date	Gear	Time	Latitude	Longitude	Water Depth
			[UTC]	[°N]	[°W]	[m]
MSM61/470-1	18.02.2017	CTD/RO/LADCP	12:11	17° 12.66'	24° 41.64'	2910.3
MSM61/471-1	18.02.2017	MN	16:53	17° 35.02'	24° 17.04'	3595
MSM61/471-2	18.02.2017	CTD/RO/LADCP	18:41	17° 34.97'	24° 17.01'	3594.1
MSM61/471-3	18.02.2017	PGS	21:38	17° 35.01'	24° 17.07'	3593.4
MSM61/471-4	18.02.2017	PGS	23:23	17° 34.99'	24° 17.02'	3593.7
MSM61/471-5	19.02.2017	MN	05:51	17° 34.99'	24° 17.00'	3594
MSM61/471-6	19.02.2017	PGS	07:20	17° 37.15'	24° 18.23'	3606.8
MSM61/472-1	19.02.2017	MOR	14:33	17° 36.25'	24° 15.28'	3600.9
MSM61/473-1	20.02.2017	PGS	03:30	17° 20.44'	22° 2.54'	3210.7
MSM61/473-2	20.02.2017	ADCP	04:06	17° 20.53'	22° 2.53'	3212.5
MSM61/473-3	20.02.2017	XSV	09:16	17° 7.96'	22° 3.86'	2604.1
MSM61/473-2	20.02.2017	ADCP	09:39	17° 6.50'	22° 6.78'	2724.2
MSM61/474-1	20.02.2017	MOR	13:00	17° 12.38'	21° 57.70'	-
MSM61/475-1	20.02.2017	GL	15:55	17° 6.33'	22° 9.88'	3211.6
MSM61/476-1	20.02.2017	LANDER	18:05	17° 10.44'	21° 56.83'	0
MSM61/476-2	20.02.2017	PGS	19:31	17° 9.93'	21° 58.56'	647.6
MSM61/476-3	20.02.2017	PGS	20:51	17° 10.29'	21° 58.77'	619.9
MSM61/476-4	20.02.2017	PGS	22:00	17° 10.59'	21° 58.92'	610.4
MSM61/476-5	20.02.2017	PGS	22:48	17° 10.91'	21° 59.02'	672.7
MSM61/477-1	21.02.2017	MN	00:13	17° 8.22'	21° 58.95'	1047.3
MSM61/477-2	21.02.2017	PGS	02:23	17° 12.38'	22° 0.91'	1090.2
MSM61/477-3	21.02.2017	PGS	03:42	17° 12.65'	22° 1.12'	1193.8
MSM61/477-4	21.02.2017	PGS	04:49	17° 12.84'	22° 1.26'	1288.3
MSM61/477-5	21.02.2017	PGS	06:28	17° 13.11'	22° 1.45'	1280.6
MSM61/477-6	21.02.2017	PGS	07:31	17° 13.52'	22° 1.75'	1447.9
MSM61/478-1	21.02.2017	MOR	10:04	17° 12.39'	21° 57.72'	140
MSM61/478-2	21.02.2017	WAVGL	11:15	17° 12.40'	21° 57.73'	140
MSM61/478-3	21.02.2017	WAVGL	11:22	17° 12.40'	21° 57.73'	-
MSM61/479-1	21.02.2017	MN	12:39	17° 6.52'	21° 58.27'	1937.7
MSM61/479-2	21.02.2017	PGS	14:41	17° 10.32'	22° 0.82'	1272.2
MSM61/480-1	21.02.2017	MOR	20:38	17° 12.36'	21° 57.66'	139
MSM61/480-2	21.02.2017	CTD/RO/LADCP	21:03	17° 12.38'	21° 57.60'	140.3
MSM61/481-1	21.02.2017	CTD/RO/LADCP	22:05	17° 13.05'	21° 58.32'	409
MSM61/482-1	21.02.2017	CTD/RO/LADCP	23:25	17° 14.41'	21° 59.10'	676.3
MSM61/483-1	22.02.2017	CTD/RO/LADCP	01:00	17° 17.14'	22° 0.65'	2261.5
MSM61/484-1	22.02.2017	CTD/RO/LADCP	02:25	17° 20.44'	22° 2.52'	3215.8
MSM61/484-2	22.02.2017	PGS	03:15	17° 20.46'	22° 2.52'	3220.9
MSM61/484-3	22.02.2017	PGS	04:32	17° 21.04'	22° 2.54'	3237.6
MSM61/484-4	22.02.2017	PGS	05:46	17° 21.36'	22° 2.60'	3248.4
MSM61/484-5	22.02.2017	PGS	06:47	17° 21.67'	22° 2.65'	3253.8
MSM61/485-1	22.02.2017	CTD/RO/LADCP	08:53	17° 11.38'	21° 57.32'	-
MSM61/486-1	22.02.2017	CTD/RO/LADCP	09:48	17° 10.42'	21° 56.77'	119.7
MSM61/487-1	22.02.2017	MOR	10:34	17° 12.23'	21° 57.85'	140.8
MSM61/488-1	22.02.2017	WAVGL	11:50	17° 9.88'	22° 0.13'	822.2
MSM61/489-1	22.02.2017	CTD/RO/LADCP	12:40	17° 9.83'	21° 57.63'	518.6
MSM61/490-1	22.02.2017	CTD/RO/LADCP	13:59	17° 8.28'	21° 55.65'	965.9
MSM61/491-1	22.02.2017	CTD/RO/LADCP	15:22	17° 5.53'	21° 54.03'	2429.2
MSM61/492-1	22.02.2017	CTD/RO/LADCP	16:39	17° 2.25'	21° 52.15'	3274.7
MSM61/493-1	22.02.2017	ADCP	17:32	17° 2.25'	21° 52.16'	3278.5
MSM61/493-1	23.02.2017	ADCP	11:55	17° 19.68'	22° 2.74'	3110.1
MSM61/494-1	23.02.2017	GL	12:27	17° 20.26'	22° 2.51'	3216.6
MSM61/493-1	23.02.2017	ADCP	13:11	17° 20.25'	22° 2.78'	3167.4
MSM61/494-1	23.02.2017	GL	13:12	17° 20.29'	22° 2.76'	3171.9
MSM61/493-1	23.02.2017	ADCP	15:18	17° 3.02'	21° 52.59'	3219.2
MSM61/495-1	23.02.2017	WAVGL	16:53	17° 16.24'	21° 47.84'	3273.9

MSM61/493-1	23.02.2017	ADCP	17:08	17° 16.25'	21° 47.84'	3276.2
MSM61/496-1	23.02.2017	MOR	18:28	17° 12.35'	21° 57.73'	140.1
MSM61/497-1	23.02.2017	PGS	20:03	17° 10.43'	21° 56.74'	120.8
MSM61/497-2	23.02.2017	PGS	21:43	17° 10.94'	21° 56.83'	108.8
MSM61/498-1	23.02.2017	MN	23:21	17° 11.37'	21° 57.28'	108.8
MSM61/499-1	24.02.2017	MOR	00:40	17° 12.21'	21° 58.20'	226.6
MSM61/500-1	24.02.2017	PGS	02:18	17° 10.88'	22° 3.13'	2052.1
MSM61/499-1	24.02.2017	MOR	09:30	17° 12.37'	21° 57.79'	139.6
MSM61/501-1	24.02.2017	WAVGL	11:04	17° 7.85'	22° 4.85'	2680.1

Gear Coding:

CTD/RO/LADCP:	CTD/rosette sampler/lowered Acoustic Doppler Current Profiler
MN:	Multinet
PGS:	PELAGIOS towed camera
MOR:	Mooring operations (deployment/recovery)
ADCP:	Acoustic Doppler Current Profiler sections
XSV:	Expandable Sound Velocity Profiler
GL:	autonomous underwater glider
WAVGL:	autonomous surface glider (Wave Glider)
LANDER:	Bottom Lander

7 Data and Sample Storage and Availability

In Kiel, a joint data management team is set up to store the data from various projects and cruises in a web-based multi-user-system. Data gathered during MSM61 were stored at the Kiel data portal (OSIS) and ProxSys (Video), respectively, and remained proprietary for the PIs and participants of this cruise. Each station was logged as an event file. All data are being submitted to PANGAEA within approx. 3.5 years after the cruise, i.e. by spring/summer 2020. Preliminary CTD data were submitted to CORIOLIS during the cruise for real time oceanographic analysis and Argo calibration. Contact persons for the different datasets are listed in Table 7.1.

Table 7.1 Overview of data availability

Type	**Database**	**Available**	**Free Access**	**Contact**
CTD data	PANGAEA (subm.)	July 2017	May 2020	gkrahmann@geomar.de
VM- and L-ADCP data	PANGAEA (subm.)	July 2017	May 2020	gkrahmann@geomar.de
Thermosalinograph data	PANGAEA (subm.)	July 2017	May 2020	gkrahmann@geomar.de
Bottle data	OSIS → PANGAEA	May 2020	June 2020	bfiedler@geomar.de
Video data (PELAGIOS)	ProxSys → PANGAEA	July 2017	June 2020	hhoving@geomar.de
Zooplankton data	OSIS → PANGAEA	April 2020	June 2020	heino.fock@thuenen.de
Lander data	OSIS → PANGAEA	May 2020	June 2020	bfiedler@geomar.de
Waveglider data	OSIS → PANGAEA	May 2020	June 2020	bfiedler@geomar.de
Bathymetry	PANGAEA	Sept. 2018	Sept. 2018	awoelfl@geomar.de
Larvae trap data	Uni-Aveiro → PANGAEA	May 2019	June 2020	marina.cunha@ua.pt

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10 Abbreviations

ADCP	= Acoustic Doppler Current Profiler
CHL-a	= Chlorophyll-a
CTD	= CTD Rosette
CVOO	= Cape Verde Ocean Observatory
DIC	= Dissolved Inorganic Carbon
ETNA	= Eastern Tropical North Atlantic
ESTOC	= European Station for Time series in the Ocean Canary Islands
GD	= underwater glider
HD	= high definition
LED	= light-emitting diode
LO^{3}CAted	= larval occurrences in open ocean: connectivity studies in the Atlantic and Mediterranean
MEO	= modular ecosystem observatory
MOR	= Mooring operations
MN	= Multiple Opening/Closing Net (Multi Net)
OMZ	= oxygen minimum zone
PAP	= The Porcupine Abyssal Plain Sustained Observatory
PGS	= PELAGIOS towed camera
PYLOS	= Multidisciplinary observatory mooring located in the cross road of Adriatic and Eastern Mediterranean basins
RGB	= red, green, blue color model
ROBEX	= Robotic Exploration of Extreme Environments
SOMMA	= single operator multi-parameter metabolic analyzer
TA	= Total Alkalinity
TNA	= trans-national access
VMADCP	= Vessel-mounted Acoustic Doppler Current Profiler
VINDTA	= Versatile Instrument for the Determination of Titration Alkalinity
WAVGL	= Wave Glider
XSV	= expandable sound velocity profiler