MARIA S. MERIAN-Berichte

SEAMOX: The Influence of Seamounts and Oxygen Minimum Zones on Pelagic Fauna in the Eastern Tropical Atlantic

Cruise No. MSM49

November 28 - December 21, 2015
Las Palmas de Gran Canaria (Spain) - Mindelo (Republic of Cape Verde)

B. Christiansen, C. Buchholz, F. Buchholz, X. Chi, S. Christiansen, A. Denda, E. Fabrizius, H. Hauss, H.J.T. Hoving, S. Janßen, M. Kaufmann, A. Kronschnabel, A. Lischka, F. Lüskow, B. Martin, V. Merten, P. Silva, N. Pinheiro, B. Springer, S. Zankl, T. Zeimet

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Editor:
DFG-Senatskommission für Ozeanographie
c/o MARUM – Zentrum für Marine Umweltwissenschaften
Universität Bremen
Leobener Strasse
28359 Bremen

Author:
Dr. Bernd Christiansen
Universität Hamburg
Institut für Hydrobiologie und Fischereiwissenschaft
Große Elbstraße 133
22767 Hamburg

Telefon:+49-40-42838-6670
Telefax:+49-40-42838-6678
E-Mail: bchristiansen@uni-hamburg.de

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1 Summary

Cruise MSM49 focused on the impact of the oxygen minimum zone (OMZ) and of a shallow topographic feature, Senghor Seamount, on the abundance, distribution, diversity and trophic structure of the medium-sized pelagic fauna (macrozooplankton, micronekton, and squids). Using a combination of optical and multiple net systems, the ecological zonation of these oceanographic features in the Cape Verde area was investigated and collections for detailed foodweb studies were performed. A total of 10 stations to the north, east and south of the Cape Verde archipelago were sampled, including the Cape Verde Ocean Observatory (CVOO), Senghor Seamount summit and middle slopes, a cyclonic eddy, and oceanic stations with differing intensities of the OMZ. Preliminary results show that organisms were abundant in the oxygen-poor layers; the communities there were apparently dominated by gelatinous zooplankton. Pelagic communities differing from the surrounding ocean were observed at Senghor Seamount and in the core of the cyclonic eddy.

Zusammenfassung

Gegenstand der Reise MSM49 war der Einfluss von Sauerstoffminimumschichten (OMZ) und eines flachen Seebergs, Senghor Seamount, auf die Abundanz, Verteilung, Diversität und trophische Struktur der mittelgroßen pelagischen Fauna (Makrozooplankton, Mikronekton und Kalmare). Mit einer Kombination aus optischen Systemen und Mehrfachnetzen wurde die ökologische Zonierung der ozeanographischen und topographischen Strukturen im Bereich der Kapverdischen Inseln untersucht, und es wurden Proben für detaillierte Nahrungsnetzuntersuchungen genommen. Insgesamt konnten 10 Stationen im Norden, Osten und Süden der Kapverdischen Inseln beprobt werden. Dazu gehörten Stationen am Cape Verde Ocean Observatory (CVOO), an den mittleren Hängen und dem Gipfel des Senghor Seamount, in einem zyklonischen Eddy sowie ozeanische Stationen mit unterschiedlicher Intensität der OMZ. Vorläufige Ergebnisse zeigen, dass auch in den sauerstoffarmen Schichten Organismen häufig waren und die pelagischen Gemeinschaften dort von gelatinösem Zooplankton dominiert wurden. Am Senghor Seamount und im Kern des zyklonischen Eddys wurden pelagische Gemeinschaften beobachtet, die sich von denen des um-gebenden Ozeans unterschieden.

2 Participants

Name	Discipline	Institution
Christiansen, Bernd, Dr.	chief scientist	UHH-IHF
Buchholz, Cornelia, Dr.	krill/MOCNESS	AWI
Buchholz, Friedrich, Prof.	krill/MOCNESS	AWI
Chi, Xupeng	gelatinous zooplankton	GEOMAR
Christiansen, Svenja	zooplankton/UVP, PELAGIOS	GEOMAR
Denda, Anneke, Dr.	zooplankton, micronekton/MOCNESS	UHH-IHF
Fabrizius, Eduard	technics	GEOMAR
Hoving, Hendrik J.T., Dr.	macrozooplankton/PELAGIOS	GEOMAR
Janßen, Silke	technics/MOCNESS	UHH-IHF
Kaufmann, Manfred, Prof.	phytoplankton	UMA and CIIMAR
Kronschnabel, Alessandra	zooplankton/MOCNESS	UHH-IHF
Lischka, Alexandra	cephalopods	GEOMAR
Lüskow, Florian	gelatinous zooplankton	GEOMAR
Martin, Bettina, Dr.	zooplankton/MOCNESS	UHH-IHF
Merten, Veronique	cephalopods	GEOMAR
Pinheiro, Neusa	oxygen	UniCV
Silva, Pericles	oxygen	INDP
Springer, Barbara, Dr.	CTD, ADCP	UHH-IHF
Zankl, Solvin	photography	
Zeimet, Timo	zooplankton/MOCNESS	UHH-IHF

AWI	Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
CIIMAR	CIIMAR-Madeira, Funchal, Portugal
GEOMAR	Helmholtz-Zentrum für Ozeanforschung Kiel, Germany
INDP	Instituto Nacional de Desenvolvimento das Pescas, Mindelo, Sao Vicente, Republic of Cape Verde
UHH-IHF	Universität Hamburg, Institut für Hydrobiologie und Fischereiwissenschaft, Hamburg, Germany
UMA	Universidade da Madeira, Estação de Biologia Marinha do Funchal, Funchal, Portugal
UniCV	Universidade de Cabo Verde, Mindelo, Sao Vicente, Republic of Cape Verde

3 Research Programme

(B. Christiansen, H.J.T. Hoving)

The overarching aim of cruise MSM49 was to assess the medium-sized pelagic fauna, such as gelatinous macrozooplankton, mesopelagic fishes, shrimps, krill and squids, and their role within the pelagic community in relation to 1) water mass properties, with special emphasis on oxygen minimum zones (OMZ) of different intensity, and 2) the influence of a shallow seamount reaching into the realm of the fauna which performs extensive diel vertical migrations. The study area in the waters around the Cape Verde islands in the eastern tropical Atlantic (ETA), offers both, OMZs of different intensity and an isolated shallow seamount (Senghor Seamount) with well-known bathymetry and ecology of smaller-sized plankton. In order to reach the goals, the following main objectives were addressed:

1. Description of water mass properties (oxygen, salinity, temperature, fluorescence, POC)
2. Mapping of the standing stocks, abundance, biodiversity, vertical distribution and diel vertical migrations of medium-sized pelagic fauna in the epi- and mesopelagic zones around the Cape Verde Islands within different hydrographic and bathymetric settings (strong OMZ vs. weak OMZ, seamount vs. deep-sea plain, seamount summit vs. slopes)
3. Analysis of the trophic structure of the medium-sized pelagic fauna

While optical methods are superior at surveying fragile gelatinous zooplankton, fast swimming fauna is typically better assessed using nets. Combining advanced optical samplers with modern multiple net systems and traditional trawls made depth-stratified, quantitative sampling possible for a wide taxonomical range of the ecologically important medium-sized pelagic fauna, which has rarely been considered in open-ocean studies so far. The resulting data will be used to

- identify the influence of OMZs of different intensities on the composition, distribution and diel vertical migration behaviour of small nekton and macrozooplankton
- establish a baseline of faunal patterns in relation to OMZs of different intensity by correlating fauna to the ecological zonation associated with OMZs (mixed layer, pycnocline, upper oxygen limited zone, OMZ core, lower oxygen limited zone)
- determine the ecological effect of the intrusion of a shallow seamount into the OMZ
- evaluate the influence of shallow topography and its associated hydrodynamic characteristics on the distribution and abundance of small nekton and macrozooplankton
- identify the role of gelatinous plankton and of (micro)nekton in the pelagic food web in different hydrographic, hydrodynamic and topographic settings
- determine the role of the squid *Sthenoteuthis pteropus* in the pelagic food web of the ETA
- contribute to repeat hydrographic and biological measurements (e.g., CVOO, Senghor Smt.)

The information gained from this cruise will advance our understanding of the ecology of medium-sized pelagic fauna in the ETA under different forcings, and will help to predict the possible consequences of expanding oxygen minimum zones. In addition, it will complement previous and ongoing studies on the smaller components of the pelagic communities in the area (phytoplankton, micro-, meso- and macrozooplankton), leading to a comprehensive picture of the pelagic ecosystem in the region.

No bottom-touching gear was used on the cruise. A complete abandonment of invasive methods in the water column was not possible in order to achieve the scientific goals, but the impact on the pelagic communities was minimal, since only relatively small nets in a small number of hauls were used in addition to the non-invasive optical methods.

4 Narrative of the Cruise

(B. Christiansen)

MARIA S. MERIAN left the port of Las Palmas on 28 November, 2015, at 09:00. The transit to the study area was used for assembling and testing the instruments and for setting up the laboratories. The sampling programme included different nets and optical systems in order to assess a wide variety of pelagic fauna. The PELAGIOS, a newly developed towed video camera system, aimed especially at gelatinous macrozooplankton. The Underwater Vision Profiler (UVP) is an optical recorder for smaller-sized plankton and particles; it was used in combination with the PELAGIOS and the CTD-rosette. The MOCNESS is a multiple net system with a series of nets which can be opened and closed sequentially. Two types were used; the 10m^2-MOCNESS (MOC-10) has a 10 m^2 net opening and was equipped with five nets of 1.5 mm mesh size targeting micronekton. The 1m^2-MOCNESS (MOC-1) with a 1 m^2 opening carried three nets of 2 mm mesh size specifically for krill plus six nets of 335 µm for macrozooplankton and larger mesozooplankton. The WP3 is a simple conical net which was used for gently sampling gelatinous organisms, and the Apstein net with a mesh aperture of 55 µm was employed to sample larger phytoplankton. A non-closing Isaac Kidd Midwater Trawl (IKMT) was used for fishing micronekton at some stations. Water samples for different chemical and biological analyses were taken with a 24 bottle CTD-rosette. Squids were fished by hook-and line.

On 30 November we reached the Cape Verdian EEZ and performed a short test station with two shallow CTD hauls before steaming to our first study site, CVOO (Cape Verde Ocean Observatory), see Figure 4.1. The general sampling scheme for all stations comprised two CTD-rosette casts, one day and one night haul each with PELAGIOS and MOC-10, two day and two night MOC-1 hauls, two WP3 and one Apstein net hauls. Hook-and-line fishing for squids was done during night times when station work allowed. MOCNESS and PELAGIOS were fished down to 1000 m, WP3 and IKMT to 500 m, and the Apstein net to 150 m.

The CVOO is a monitoring site mainly for hydrographic and biogeochemical parameters and is jointly operated by GEOMAR and INDP. We started work there in the morning of 1 December with a CTD-rosette cast, followed by MOCNESS and PELAGIOS. Winds at CVOO were moderate, the sky was overcast with Saharan dust. Sargassum was abundant on the sea surface, and during the night large pyrosome colonies were frequently observed. The CTD casts at CVOO showed a shallow OMZ at 100 m, above the permanent OMZ, which points to the influence of a cyclonic eddy. Net samples and PELAGIOS videos indicated that organisms were abundant in the OMZ; large ctenophores seemed to be particularly linked with the low oxygen zone.

Station work at CVOO was finished on 3 December, and we proceeded to station CV-N. Here, in order to save some time for the eddy search (see below), only a shortened sampling programme with one haul each of CTD-rosette, MOCNESS (1m^2 and 10m^2) and PELAGIOS was performed, before we steamed to station Senghor Ref, about 55 NM north of Senghor Seamount. This station, which is not influenced by elevated topography, served as an oceanic reference station for Senghor Seamount and had also been sampled during previous cruises to the seamount on R/Vs METEOR and POSEIDON. The oxygen distribution at Senghor Ref showed the expected profile with the minimum at 400 m. We left this station after finishing the full sampling programme on 5 December and arrived at Senghor Seamount on 6 December. The weather had improved meanwhile, with clear sky and gentle breeze.

Senghor Seamount is a nearly conical seamount which rises from 3300 m to a small summit

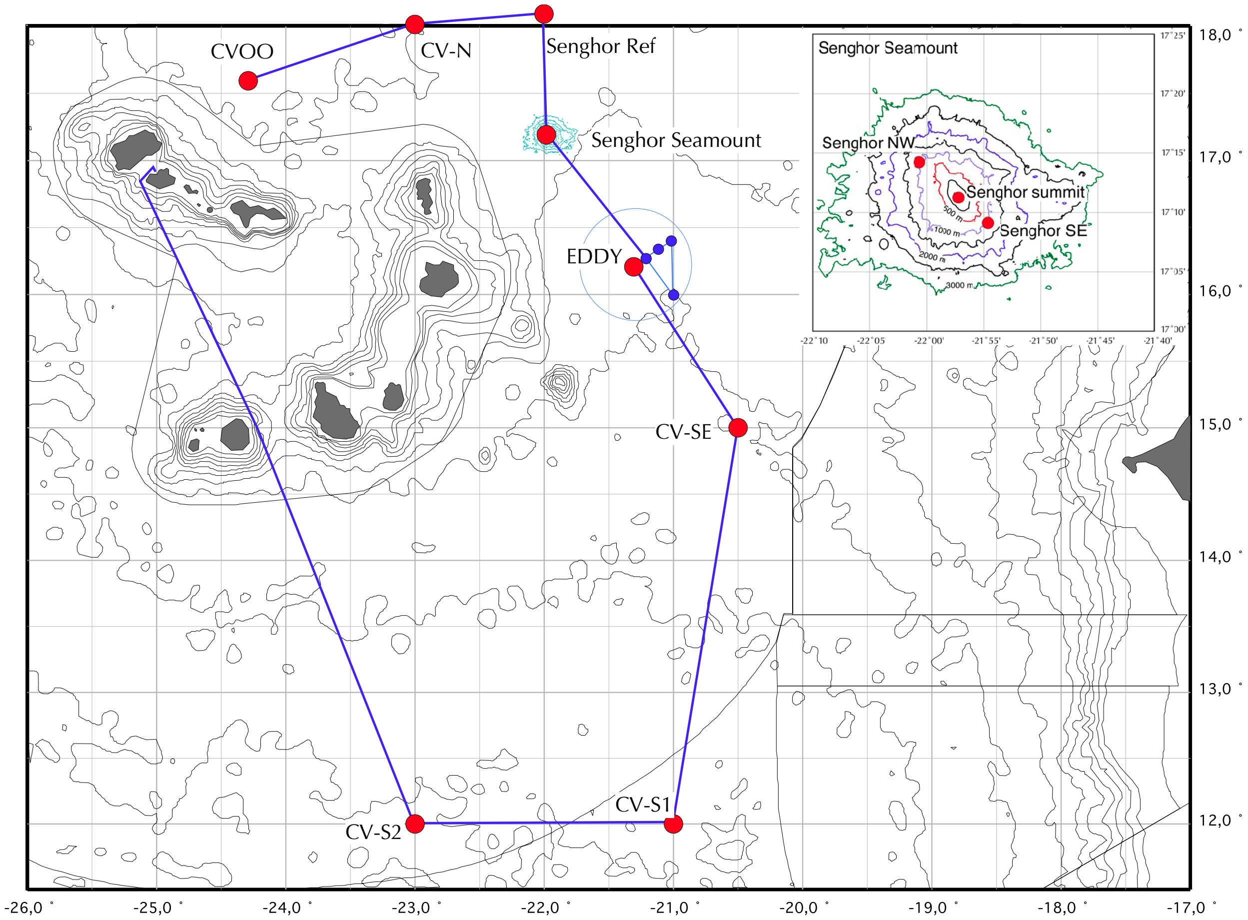

Fig. 4.1 MSM 49 study sites and cruise track. Inset: Senghor Seamount stations.

plateau with a minimum depth of 100 m. Our work on this cruise focused on three locations: the northwestern slope above the 1000 m contour, the southwestern slope above the 1000 m contour, and the summit. We started at the northwestern slope, but since the distance between the three locations was very short, we could optimize shiptime usage by changing between stations, when appropriate. Above the slopes, our routine sampling programme with full profiles down to 1000 m and including all sampling gear was employed. On the summit, the MOC-10 was not used; instead we fished the IKMT from the surface to 80 m, which was the maximum sampling depth also for the other nets. With the PELAGIOS we were able to sample down to within 1 m above the bottom by mounting an additional, downward looking camera. During the PELAGIOS night haul, high abundances of fishes were observed in the near-bottom layer. The work at Senghor was finished on 10 December.

Initially, the next station (CV-E) was planned at 16°N - 020°W. However, we had information that a cyclonic eddy was slowly proceeding westwards close to our supposed cruise track, and we decided to sample this eddy if we were able to locate its core. Using two orthogonal ADCP transects guided by information from satellite data, and a series of CTD casts, we found the core of the eddy at 16°12.4'N - 021°18.4'W on 11 December and employed the full sampling programme there, starting with the small MOCNESS followed by PELAGIOS. As expected, very low oxygen values of <40 µmol L^{-1} were observed in a shallow lens at 100 m. The deep OMZ showed minimum O_2 concentrations of ca. 45 µmol L^{-1} between 200 and 300 m. Organisms were frequently observed in the layers of low oxygen concentrations and were also abundant in net samples of the same depths. Preliminary observations of the net samples indicate that the eddy featured a species composition which differed markedly from the other stations. For example, an indicator species for coastal upwelling, the copepod *Calanoides carinatus*, showed up regularly in the eddy samples, but was rare at the other stations.

On 13 December in the afternoon we finished sampling in the eddy with the PELAGIOS daytime cast and steamed to our next station, CV-SE, which had initially been planned for 14°N, but was shifted to 15°N now to serve as a reference station for the eddy. We arrived there shortly before midnight on 13 December and started station work with the deployment of the PELAGIOS. After finishing the routine sampling programme there on 15 December at 16:00, we proceeded to the first of our two southernmost stations, CV-S1, at 12°N in the area of the expected most intense OMZ of the Cape Verde region, where we arrived in the morning of 16 December and started sampling with a first CTD. MOCNESS, PELAGIOS and the smaller nets followed, and on 18 December at 00:00 we finished station work here and steamed to station CV-S2, where the lowest O_2 concentrations outside the eddy were observed with 41.4 µmol L^{-1} at 400 m. The routine sampling programme was performed without problems, and on 20 December we left station CV-S2 for the transit to Mindelo.

MARIA S. MERIAN docked in the port of Mindelo on 21 December at 08:30.

Deviation from the original workplan

Thanks to favourable weather conditions during the whole cruise, most of the scientific programme could be implemented as planned. However, two of the originally planned stations were shifted because we took the opportunity to sample the centre of a cyclonic eddy which moved from the African shelf westwards close to our supposed cruise track. As these eddies feature a core with very low oxygen concentrations, sampling the eddy complemented our studies on the influence of oxygen minimum zones on the pelagic ecosystem well. As a result, our initial station CV-E was omitted and station CV-SE was shifted about 60 NM to the north in order to serve as a reference station for the eddy.

The IKMT was used only at stations CVOO and Senghor Ref and at the seamount summit because the samples indicated that the 10m^2-MOCNESS collected the same faunal spectrum, but quantitatively, depth-stratified and in better condition. However, some of the MOC-10 samples are not quantitative due to technical problems with the release mechanism.

5 Preliminary Results

5.1 Water Column Characteristics

5.1.1 Profiles of Temperature, Salinity, Oxygen, Fluorescence and Biogeochemistry

(M. Kaufmann, N. Pinheiro, P. Silva, B. Springer)

Introduction

The study area was located around the Cape Verde Islands between 12°–18°N and 20°–24°W respectively. The sampling was focussed on four major sites/features: stations north of the Cape Verde archipelago, Senghor Seamount, a cyclonic eddy to the east of Cape Verde islands and further stations to the south (Fig. 4.1). The area is influenced hydrographically by large-scale interactions between the Canary Current (CC), the North Equatorial Current (NEC) and the North

Equatorial Counter Current (NECC) (Fernandes et al., 2004), separated by the Cape Verde Frontal Zone (CVFZ). This feature extends, with some seasonal variability, from Cape Blanc to the SW close to the north-western islands of the archipelago (Pérez-Rodriguez et al., 2001; Vangriesheim et al., 2003).

Regarding dissolved oxygen saturation the study area lies within a marked oxygen minimum zone (OMZ) due to very productive zones off northwest Africa, which is strongest to the south and east of the archipelago and weaker to the north (Löscher et al., 2015). The current structure revealed also the passage of mesoscale eddies in this area with formation of a low O_2-core. During the cruise a cyclonic eddy was located and sampled.

Water depth in the area is in general between 3000 and 5000 m, interrupted by a few, usually deep, seamounts. The only shallow offshore seamount in the area is Senghor Seamount, which is located NE of Sal island and rises from 3300 m to 100 m below the surface.

Methods

CTD-profiles were recorded with the ship's CTD/Rosette system consisting of a SBE 911 plus CTD (SEA-BIRD ELECTRONICS, INC.) incorporating double conductivity, temperature and dissolved oxygen sensors (all SEA-BIRD ELECTRONICS), as well as a combined Fluorescence/ Turbidity sensor (WET LABS, ECO-FL-NTU) and a PAR-sensor (BIOSPHERICAL INSTRUMENTS INC., QSP2350). All sensors were calibrated a few months before the cruise.

The CTD was mounted to a SBE32 carousel equipped with 24 Niskin bottles (OCEANTEST EQUIPMENT INC.) with 10 L volume each. At each station the CTD was deployed and lowered initially to a depth of 23 m due to the need of activation of the Underwater Vision Profiler (UVP), which was fixed to the CTD/Rosette system for underwater visual profiles (see Chapter 5.3.2). After a short period of approximately 30 s the system was heaved to the surface and then lowered to the desired depth (usually around 1000 m). During the upcast, water samples were taken at pre-established depths for dissolved oxygen (DO), nutrients, particulate organic matter (POM), fatty acids, seston, phytopigments and phytoplankton. All sensor data were acquired at 24-Hz resolution by the CTD's decks unit and stored as raw data.

During the cruise a first data assessment was performed using the manufacturers processing software (SEASOFT V2 software suite) and following procedures described by McTaggart et al. (2010). The pre-processing steps include conversion from raw binary data to engineering units in ASCII format, separation of the downcast from the upcast profiles, low pass filtering of the pressure channel to reduce high frequency noise, correction from pressure inversion caused by ship motion, derivation of correct salinity and bin averaging of the downcast profile into 1 dbar pressure intervals. The pre-processed data was imported for data quality control (DQC) using the OceanDataView software (Schlitzer, 2015).

During cruise MSM49 a total of 26 CTD/Rosette casts were completed ranging from depths between 80 and 3584 m with most casts around 900-1200 m. At 12 stations water samples were drawn from the CTD/Rosette for DO determination by Winkler titration following Langdon (2010), with modifications and using the visual starch endpoint method. Samples were taken from depths ranging between 10 and 3500 m (mostly down to 800-1200 m), with 6 to 18 discrete depths (average 14) per station. In total, 173 determinations were performed (excluding triplicate determinations at some stations and some depths in order to check for method/reagents bias).

Cruise MSM49 was also used to contribute to the increasing CVOO time-series data set by collecting biogeochemical water samples (dissolved inorganic carbon (DIC), total alkalinity (TA), oxygen and nutrients) between 3600 m and the surface. These samples will be analyzed at GEOMAR in early 2016 and quality controlled results will be included into the CVOO data set.

Preliminary results and outlook

Stations north of the Cape Verde islands (CVOO, CV-N, Senghor Ref; Fig. 5.1). The temperature curves at the northern stations decreased in a more or less exponential shape (except for the thermocline down to about 50 m) from 25 °C at the surface down to 3 °C in 1750 m depth. Salinity decreased nearly linearly from the surface down to about 750 m with corresponding values from 36.5 to 34.5. Below 800 m there was a slight increase to 1200 m to 35. This value did not change substantially down to 1750 m. Density increased from the thermocline at 50 m from 1024 to 1026 kg m^{-3} with a slight variation between casts and stations. Below 100 m the variations between stations were smaller and values increased to 1027 kg m^{-3}. The fluorescence maximum was at about 50 m which correlated with the pycnocline.

DO surface values were around 200 µmol kg^{-1} and decreased strongly below the thermocline to around 50 µmol kg^{-1}. The oxygen minimum zone was at around 250-350 m water depth. At greater depths DO increased again linearly to 200 µmol kg^{-1} in 1750 m depth.

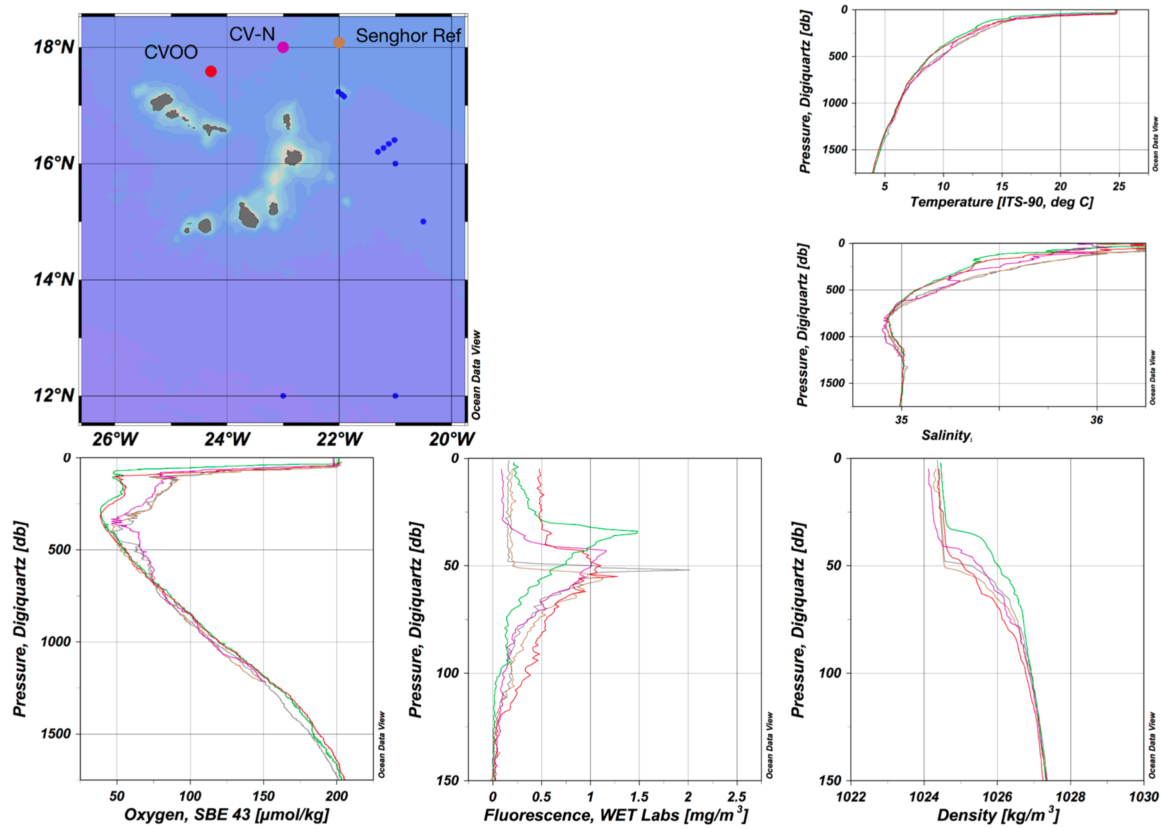

Fig. 5.1 Vertical profiles of temperature, salinity, density, DO (CTD-sensor) within the first 1750 m in the northern stations of the Cape Verde islands. The location of plotted stations is indicated in the map.

Senghor Seamount (Fig. 5.2). The thermocline at Senghor seamount was between 35 and 60 m with 25 °C at the surface. Below the thermocline temperature decreased also exponentially to 6 °C in 1000 m depth. Salinity decreased nearly linearly from the surface down to about 1000 m with corresponding values from 36.5 to 34.5. Below 800 m the values did not change substantially.

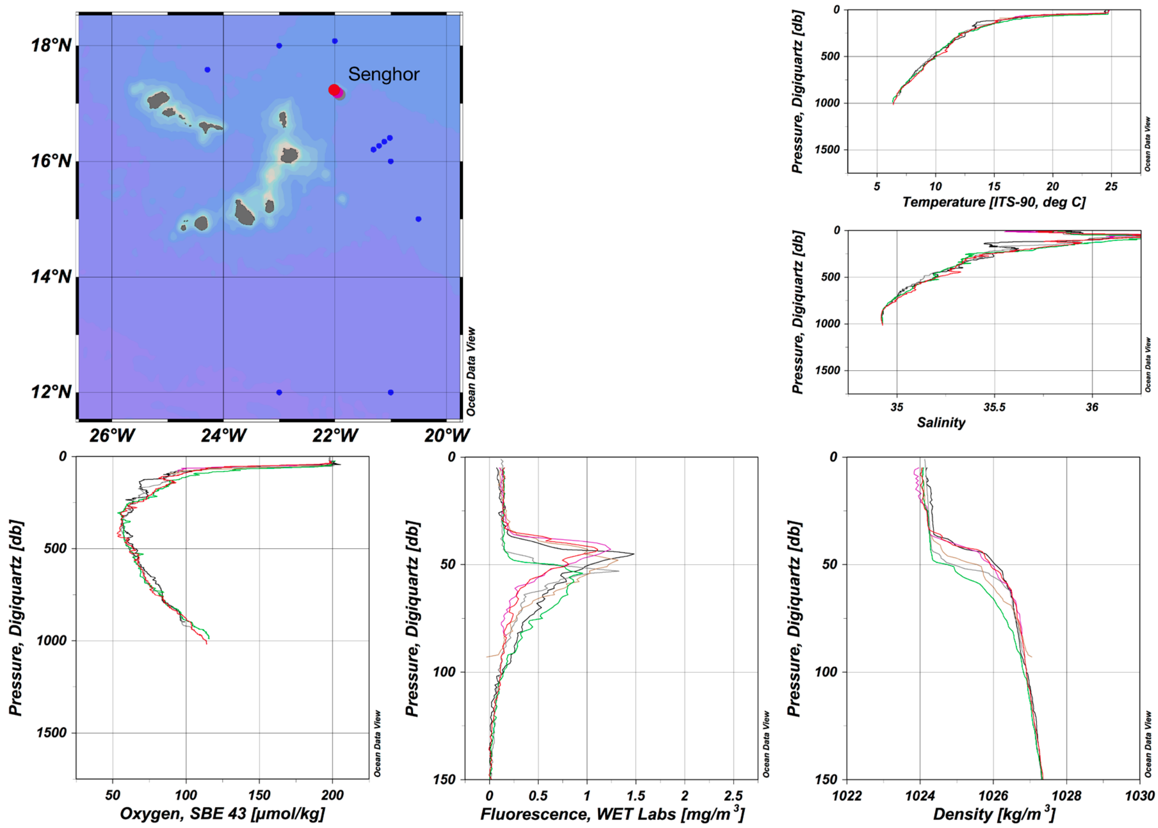

Fig. 5.2 Vertical profiles of temperature, salinity, density, DO (CTD-sensor) within the first 1750 m at Senghor Seamount. The location of plotted stations is indicated in the map.

Density increased from the thermocline between 35 and 60 m from 1024 (above) to 1027 kg m^{-3} (below) with a slight variation between casts and stations. The fluorescence maximum varied between stations around the seamount and was observed between 35 and 60 m.

DO values at the surface were around 200 µmol kg^{-1} and decreased strongly below the thermocline to around 60 µmol kg^{-1}. The oxygen minimum zone was around 250-350 m. At greater depths DO increased linearly to 120 µmol kg^{-1} in 1000 m depth.

Eddy transect east of the Cape Verde islands (EDDY, Fig. 5.3). The temperature at the eddy stations decreased steeply from 25 °C at the surface to 10 °C in 250 m depth and further to 6 °C in 1000 m. Salinity increased from the surface (35.5) towards the thermocline in about 50 m depth to 35.8 and decreased slightly to 34.7 in 750 m. Below there was another decrease at about 800 m. Density increased from the thermocline at 50 m from 1024 to 1027 kg m^{-3} with a slight variation between casts and stations. Below 100 m the variations between stations became smaller. The fluorescence maximum varied between stations between 35 and 60 m.

DO values at the surface were around 200 µmol kg^{-1} and decreased strongly below the thermocline to around 40 µmol kg^{-1}. Between 100 and 250 m there was an inversion with increasing values of up to 50 µmol kg^{-1}. At greater depths DO increased linearly to 125 µmol kg^{-1} again in 1000 m depth.

Stations south-east of the Cape Verde islands (CV-SE, CV-S1, CV-S2; Fig. 5.4). The temperature at the southeastern stations decreased more or less exponentially (except for the thermocline down to about 40 m) from 27 °C at the surface to 4 °C in 1500 m depth. Salinity decreased from surface

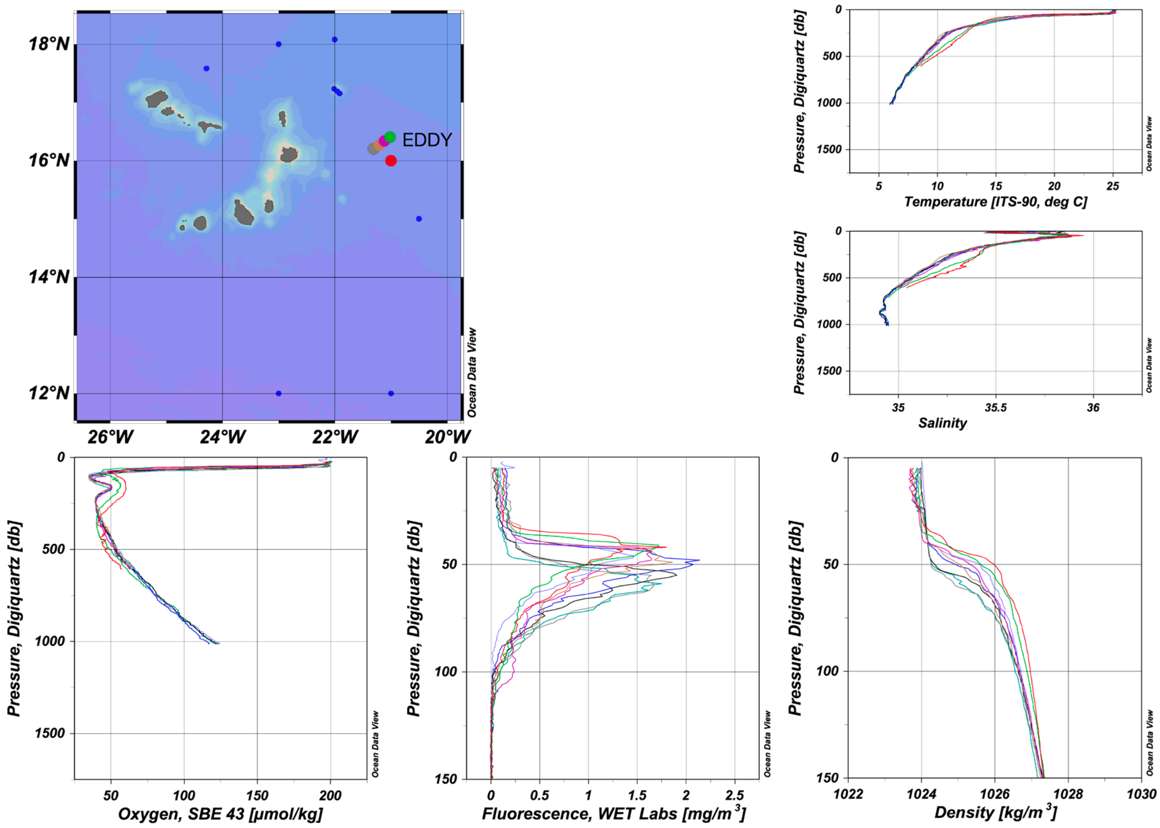

Fig. 5.3 Vertical profiles of temperature, salinity, density, DO (CTD-sensor) within the first 1750 m of the eddy east of Cape Verde. The location of plotted stations is indicated in the map.

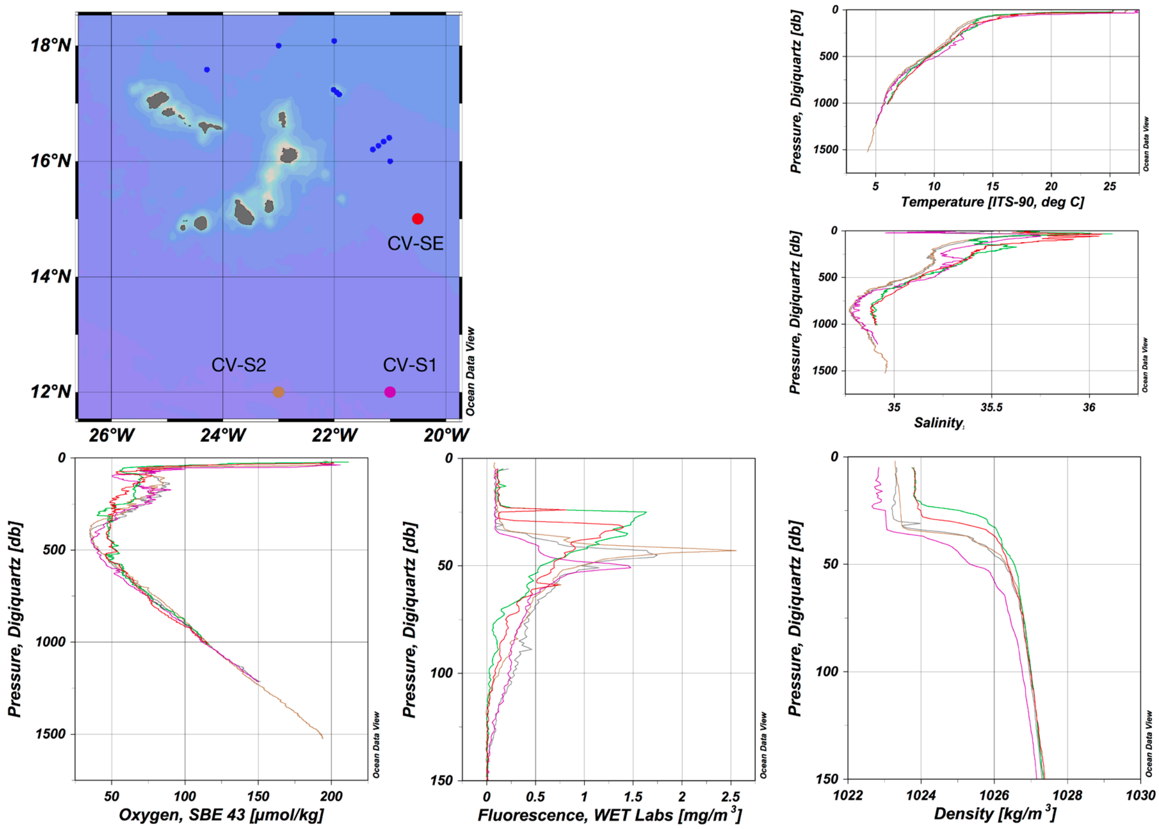

Fig. 5.4 Vertical profiles of temperature, salinity, density, DO (CTD-sensor) within the first 1750 m at stations SE of Cape Verde. The location of plotted stations is indicated in the map.

down to about 750 m with values from 36 to 34.5. Below 800 m there was a slight increase towards 1500 m with 34.8. Density increased from the thermocline at 40 m from 1023 to 1026 kg m^{-3} with some variations between casts and stations. Below 50 m the variations between stations were less pronounced and density increased to 1027.3 kg m^{-3} in 150 m. The fluorescence maximum was observed between 25 and 50 m.

DO values at the surface were around 200 µmol kg^{-1} and decreased considerably below the thermocline to around 50 µmol kg^{-1}. The oxygen minimum zone was situated around 300-400 m. At greater depths DO increased linearly to 190 µmol kg^{-1} again in 1500 m depth.

Comparison of oxygen profiles (Fig. 5.5). The DO profiles of all stations reveal a moderate oxygen minimum zone around 400 m with corresponding values as low as 40 µmol kg^{-1}. At some stations (Eddy and CV-SE) there was an additional, shallower minimum around 100 m with 40 µmol kg^{-1}. A highly significant correlation was obtained between DO values measured by the CTD-sensor and values obtained by Winkler titration (Spearman correlation $r_s = 0.9817$, $p<0.001$), showing that the measurements of the oxygen seensor on the CTD can be considered as reliable.

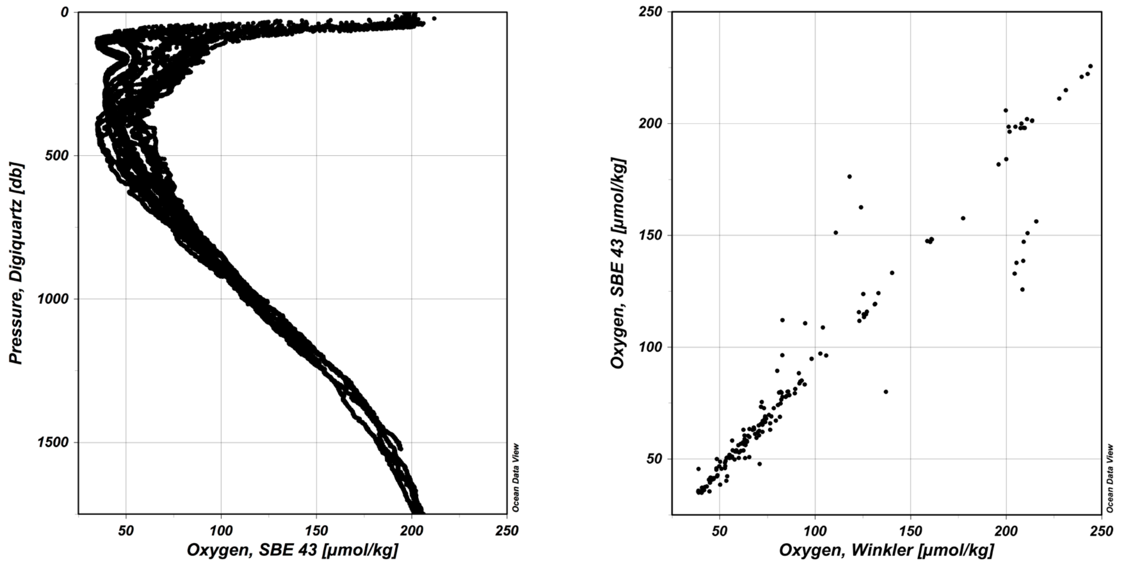

Fig. 5.5 DO content of all 26 CTD stations (left). Correlation between DO measured by the CTD-sensor vs. Winkler determination (right).

Water masses (Fig. 5.6). With help of a temperature-salinity plot (TS-plot) the following water masses could be preliminarily identified: Between 200 and around 700 m North Atlantic Central Water (NACW) was observed at the northern and eastern stations; at the two stations south of Cape Verde we found South Atlantic Central Water (SACW) at these depths. At intermediate layers, from 700 to 1500 m, Antarctic Intermediate Water (AAIW) could be detected, whereas at layers deeper than 1500 m North Atlantic Deep Water (NADW) was found.

Perspectives. The hydrographic data will be processed in detail and made available to other working groups as well as in a database for later access. Hydrographic data will be used in correlation with biological data to help explaining observed ecological patterns of pelagic flora and faunal communities.

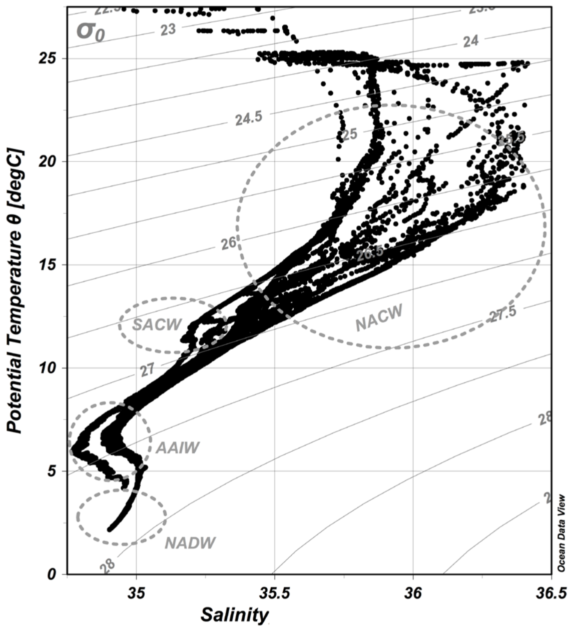

Fig. 5.6 TS-Plot of all 26 CTD stations with indications of different water masses.

5.1.2 Underway Measurements with Vessel Mounted ADCP

(S. Christiansen, B. Springer)

Introduction

Underway current and backscatter measurements were performed continuously throughout the whole cruise using two vessel mounted Acoustic Doppler Current Profilers (VMADCP). At Senghor Seamount repeated ADCP measurements were conducted along 4 daytime and 2 night-time transects over the summit from the southwest to the northeast inside the 1000 m isobath. The main aim of this ADCP survey was to confirm interesting zooplankton vertical migration patterns in the acoustic backscatter, which were observed at an earlier cruise (P446).

Methods

The METEOR 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 were used. VMDAS software Version 1.46 was employed for collecting the data. Both ADCPs were turned on on 30th November, 2015. Both instruments worked well and produced good data for the duration of the cruise except between 9th December, 13:00 and 10th December, 20:50 when the 75 kHz ADCP did not record any velocity data for – so far – unknown reasons. It was noticed only after some time that both instruments were aligned to 45 degrees and therefore were interfering with each other, which has to be considered in the analysis.

Both the OS38 and the OS75 were set up first with the initialisation file from MSM46 (11:50-19:44 on 30th November). At 19:45 the setups (ini-files) were exchanged. There were some problems with the initialisation of the baud rate in the OS38 since the predefined baud rates did not work. At 12:46 on 1st of December the OS38 was started with the default baud rate and recorded permanently from then on. Both ADCPs were run in the more precise but less robust broadband (BB) mode. The configurations of the two instruments were: OS38 using 80 bins of 16 m with the default baud rate and OS75 using 128 bins of 5 m with a baud rate of 115200 bps. Both instruments transducer depths were set to 7 m and single-ping bottom track was disabled.

Depending on the region, sea state and ship velocity, the vertical ranges covered by the instruments were between 500 m and 600 m for the OS75, and between 800 m and 1000 m for the OS38. During the entire cruise the SEAPATH navigation data was of high quality. VMDAS software was used to configure the VMADCPs and to record the VMADCP data as well as the ships navigational data. Part of the data were processed on board and a preliminary data set was used for locating the cyclonic eddy. Data recording was stopped and immediately restarted a few times in order to produce smaller data sets and facilitate first analyses.

Preliminary results and outlook

ADCP preliminary data processing shows variable current velocities and directions in the study area, indicating a turbulent surface flow (Fig 5.7). A cyclonic eddy was located by performing two perpendicular transects through the estimated core (from geostrophic currents detected by satellite) of the eddy and identification of the lowest current velocities as centre point (see velocity map in Fig. 5.7). The ADCP data will be further processed and analysed ashore. Backscatter data will be used to identify zooplankton diel vertical migration patterns around Senghor Seamount, complementary to data from an earlier cruise (P446). Furthermore, the data will be added to the existing data set of eddies in the ETA and will be used to characterise the current velocity properties of the sampled cyclonic eddy.

5.2 Particulate Organic Matter and Phytoplankton

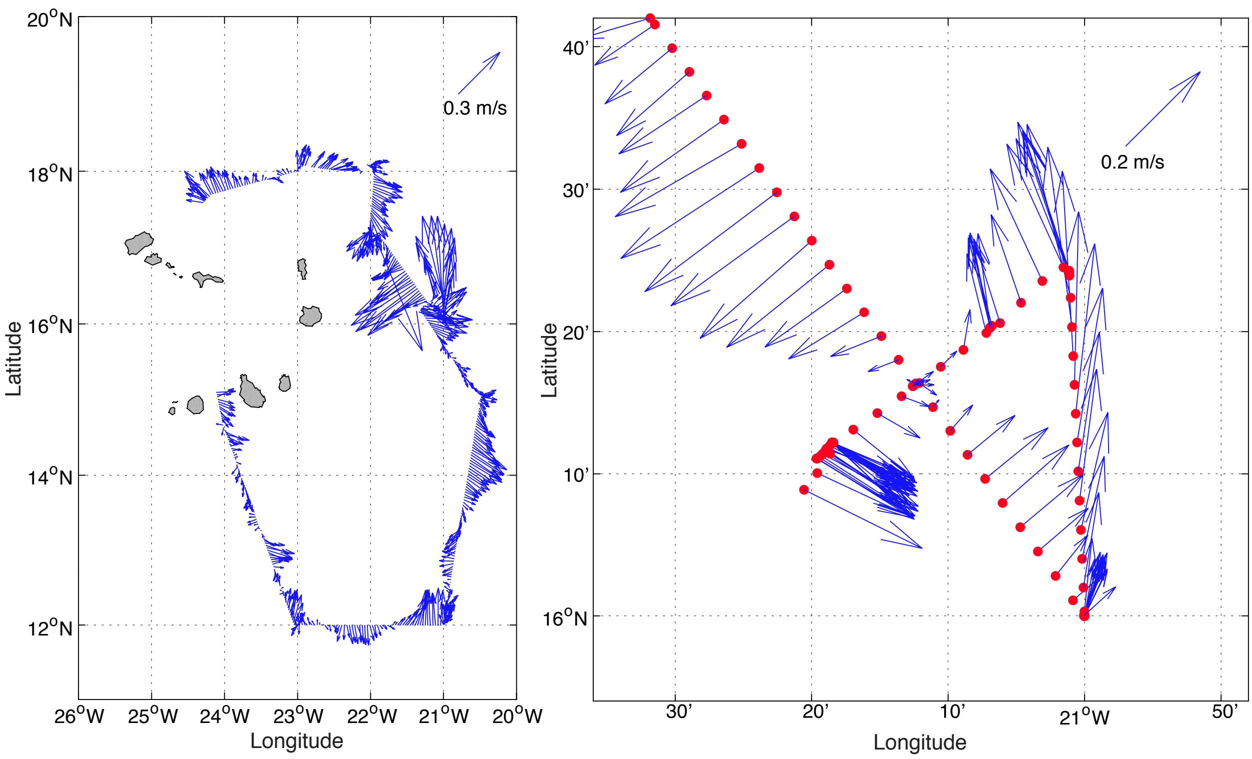

Fig. 5.7 Horizontal velocity from 38 kHz ADCP averaged between 100-200 m depth for the whole cruise track (left) and for the cyclonic eddy (right).

5.2.1 POM and Nutrients

(X. Chi)

Introduction

Particulate organic matter (POM) can provide a trophic connection between microbial assemblages and macro consumers (Kondratieff and Simmons, 1985). Understanding the composition and stoichiometry of POM is highly important for studying pelagic food webs in certain aquatic systems. Nutrient limitation of growth rates is important for both the stoichiometry of phytoplankton biomass and the determination of phytoplankton community structure (Rhee, 1973, Flynn et al. 2010). Thus, understanding the biochemical composition of POM and nutrients distribution in water layers is important for investigating energy and matters cycle in food web.

Methods

During MSM49, water samples for POM and nutrients measurements were collected by a CTD with a 24 bottle rosette (see 5.1.1). Stations where POM was collected included Senghor Ref, Senghor Seamount, Eddy and CV-SE (Eddy Ref), and CV-S1. The aimed depth for water and POM collection is 1000, 400, 200 and 25 m in deep sea stations, and 50, 25 m at Senghor Seamount station. After collection of the water with the CTD, water samples for POM measurements were filtered on GF/F filters. For each sample, three litres was filtered, and three replicates were prepared. Water samples for nutrient measurements were filtered through cellulose acetate filter (0.8 µm) and collected in 20 mL plastic vials. All samples were kept frozen (POM samples for fatty acid analysis were kept at -80 °C, POM samples for stable isotopes analysis and nutrients samples were kept at -20 °C) until further analysis.

Preliminary results and outlook

Results are not yet available. Before further analysis of the POM samples, the samples will be dried. For stable isotopes analysis, the dried POM samples will be combusted in an elemental analyser system connected to a temperature controlled gas chromatography oven, which is connected to an isotope ratio mass spectrometer (Hansen et al., 2009). For fatty acids analysis, we will use the method modified after Christie (1989). Nutrients will be measured by autoanalyzer from SKALAR (SAN PLUS).

5.2.2 Phytoplankton

(M. Kaufmann)

Introduction

The area around Cape Verde Islands is not well studied regarding phytoplankton community dynamics and taxonomy. However, investigations exist with respect to integral ecological aspects related to, for example, the Cape Verde Frontal Zone (Zenk et al., 1991), upwelling filaments forming off the NW African Coast (Meunier et al., 2012), impacts of Saharan dust reaching the area (Baker et al., 2007; Marañón et al., 2010). The eastern subtropical North Atlantic is an oligotrophic to mesotrophic region, bordered to the west and north by the oligotrophic subtropical gyre, to the east by the NW African coast with frequent formation of eddies and filaments transporting upwelled, nutrient-rich water from the coast offshore and to the south by the equatorial convergence also often transporting upwelled waters towards Cape Verde. Given this situation the main objective of investigations on phytoplankton during the cruise was to evaluate the phytoplankton community covering the whole dimensional range between 0.2-2, 2-20 and 20-200 µm respectively pico-, nanno- and microphytoplankton.

Methods

From the total of 26 CTD stations, water samples were taken at 10 of them. Using CTD and fluorescence profiles the sampling depths were determined individually for each station during downcast. Typically, 8 distinctive depths were sampled for different purposes: phytopigment determination by HPLC, identification and enumeration of coccolithophores (nannophytoplankton), identification and enumeration of picophytoplankton by flow cytometry and identification and enumeration of microphytoplankton by Utermöhl method (Tab. 5.1).

Tab.5.1 Number of samples and volumes filtered for each phytoplankton group

	HPLC	Coccolithophores	Picoplankton	Utermöhl enumeration	Apstein-net	total
No. samples	83	79	79	10	9	260
Volume filtered (L)	299	364	-	-	-	663

At 8 stations vertical casts with an Apstein-net with a mesh size of 55 µm were made between 0 and ±150 m. This will allow for a better qualitative analysis of the microphytoplankton community by light microscopy. The concentrated net sample was transferred into brown PE bottles and fixed with about 2-3 mL Lugol solution.

For Utermöhl enumeration a volume of about 200 mL was sampled directly from the Niskin bottles immediately after each cast and fixed with Lugol solution (about 2-3 mL). The remaining volume was transferred to 10 l folding cans and transferred to the lab for filtering. For picophytoplankton determination 3.2 mL of water sample from each depth were transferred into cryovials and fixed with 0.2 ml of a 20 % paraformaldehyde solution. After 15 min fixation in a refrigerator, the samples were shock frozen in liquid nitrogen and stored at -80 ºC until further analysis onshore. For phytopigment analysis by HPLC, between 1.75-4 L of water sample from each depth was filtered with low vacuum suction (~200 mbar) onto glass fibre filters (GF/F, 25 mm diameter, ~0.7 µm nominal pore size), the filters folded into half and dry blotted with paper towel, folded into 1/8, transferred to 1.5 mL reaction vials with a punctured lid, immediately frozen in liquid nitrogen and stored at -80 ºC. For nannophytoplankton analysis, between 2.3-5 L of water sample from each depth was filtered with low vacuum suction (~200 mbar) onto polycarbonate membranes (Nuclepore, 47 mm diameter, 0.4 µm nominal pore size), washed with a few mL of mineral water to get rid of excess salt (mineral water was preferred over Milli-Q due to its pH about 7; Milli-Q water usually has a pH of around 6 due to contaminations and mainly dissolution of CO_2 from the air causing a decrease of the pH which could be problematic for calcareous nannoplankton like coccolithophorids), dried at 37 ºC in plastic Petri dishes and sealed thereafter with Parafilm™.

Preliminary results and outlook

During filtration for phytopigment analysis first impressions confirmed the presence of a Deep Chlorophyll Maximum (DCM), as observed in the CTD-profiles by fluorescence. The filters from around the DCM presented a visible green coloration (Fig. 5.8).

A first look at some of the Apstein-net samples with a dissecting microscope at low magnification showed the presence of a number of dinoflagellate species and some diatoms, as well as the presence of the cyanophyte Trichodesmium, which is typically found in subtropical-tropical open ocean waters (Tab. 5.2).

Phytopigments, coccolithophores and microplankton will be analysed at the University of Madeira / Ocean Observatory of Madeira (UMa/OOM), whereas the analysis of the picoplankton samples will be performed at a lab still to be defined, for example, at the University of Las Palmas de Gran Canaria, Spain.

The processed and analysed data will give an overview of the basic trophic level in terms of community composition and biomass available for subsequent trophic levels which were sampled and studied in great detail by other working groups during the cruise. This should allow for a more comprehensive understanding of the ecology of pelagic fauna in the area of the Cape Verde islands in general and with respect to oxygen minimum zones in particular.

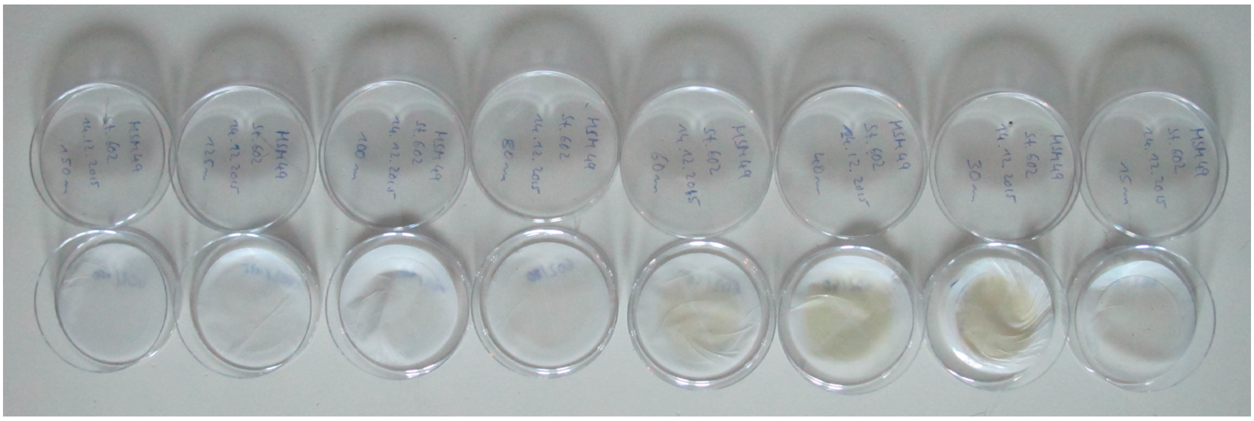

Fig. 5.8 Visible green colouration observed at filters for coccolithophore analysis around the DCM (30-60 m).

Tab. 5.2 Taxon list of phytoplankton identified on-board.

Class	*Taxon*
Cyanophyceae	*Trichodesmium*
Dinophyceae	*Ceratium* spp.
Dinophyceae	*Ceratium breve*
Dinophyceae	*Ceratium tripos*
Dinophyceae	*Ceratocorys horrida*
Dinophyceae	*Protoperidinium*
Dinophyceae	*Pyrocystis pseudonoctiluca*
Dinophyceae	*Pyrocystis lunula*
Dinophyceae	*Ornithocercus*
Bacillariophyceae	*Asterolampra*
Bacillariophyceae	*Planktoniella*
Bacillariophyceae	*Rhizosolenia* sp.
Bacillariophyceae	unidentified centric diatom

5.3 Zooplankton and Micronekton

5.3.1 Standing Stocks, Distribution, Composition and Size Structure of Zooplankton and Micronekton from Net Hauls

(A. Denda, S. Janßen, A. Lischka, B. Martin)

Introduction

The pelagic community in the waters around the Cape Verde islands in the eastern tropical Atlantic is exposed to different hydrographic, hydrodynamic and topographic features. Water masses of varying properties, especially oxygen minimum zones (OMZ) might influence the ecological zonation of zooplankton and micronekton. Whereas to the north of Cape Verde a moderate oxygen zone is present, the core of the OMZ is expanding south of the islands at ~12° N. East (~60 NM) of the Cape Verde islands the shallow topography of Senghor Seamount interferes with the ocean currents and might affect local circulation patterns by the formation of seamount-associated flows (see Genin & Boehlert, 1985; Dower et al., 1992; Lavelle & Mohn, 2010) or isopycnal doming and increased vertical mixing (Eriksen 1998). These hydrodynamic features generate advection, upwelling or local retention of water masses, including particles, phytoplankton and zooplankton (Genin & Boehlert, 1985; Roden, 1994), which may attract smaller and larger nekton to the seamount surrounding waters. Westward propagating eddies are another hydrodynamic feature affecting the waters around the Cape Verde including the faunal zonation and composition; arising from the Mauritanian coast they transport water masses and organisms of the upwelling system to the open ocean.

The aim of the zooplankton and micronekton research during the MSM49 expedition was to investigate the distribution, composition and size structure of the pelagic community in relation to (1) the influence of the shallow Senghor Seamount reaching into the depth of diel vertical migration, (2) the water mass properties within the cyclonic eddy and (3) the oxygen minimum zones (OMZ) of different intensity. The following questions are addressed:

(a) Are there differences in zooplankton and micronekton distribution and composition between the seamount, the eddy core, the OMZs and the unaffected open ocean reference sites in terms of biomass, abundance and taxonomic composition?

(b) Are there differences between day and night distributions of zooplankton and micronekton, indicating diel vertical migrations? Are these migrations affected by the bottom topography of the seamount and by OMZs of different intensities, i.e. do they differ from the unaffected open ocean sites?

The study on the medium-sized pelagic fauna will fill a gap in the past work at Senghor Seamount, which focused on micro- and mesozooplankton and benthopelagic fish communities (see Denda & Christiansen, 2014; Denda, 2015; Denda et al., 2016), and will therefore complement the knowledge about the functioning of the Senghor Seamount ecosystem. Furthermore the study aims at understanding the impact of an expanding OMZ on distribution and restriction of the pelagic fauna in the Cape Verde region.

Methods

Zooplankton and micronekton were caught by oblique hauls with a 1m²-MOCNESS (Multiple Opening and Closing Net and Environmental Sensing System; Wiebe et al., 1985), a 10m²-MOCNESS and an IKMT (Isaac Kidd midwater trawl). The 1m²-MOCNESS (MOC-1) was equipped with three nets of 2000 µm mesh size (especially for krill) and six nets of 335 µm mesh size (for meso- and macrozooplankton). The five nets of the 10m²-MOCNESS (MOC-10) had a mesh of 1500 µm (for macrozooplankton and micronekton). Both net systems were equipped with a pressure sensor, an inclinometer, a flowmeter and probes for temperature and conductivity. Environmental data (temperature, salinity, pressure) were recorded simultaneously during sampling. The towing speed was 2 knots. The whole water column was subdivided into smaller sampling intervals, depending on the OMZ, and was sampled from the surface to a maximum of 1000 m depth and back. In total 37 oblique hauls were taken with the 1m²-MOCNESS, two day and two night deployments per location, except at CV-N due to the revised cruise plan (see Chapter 4). A total of 16 hauls were performed with the 10m²-MOCNESS, one day and one night haul at each location (Fig. 4.1). The Senghor summit station was not sampled with the 10m²-MOCNESS due to the shallow water depth, and a technical failure hampered sampling at locations CVOO and CV-N. The IKMT (for small and medium sized nekton) has a mouth opening of ~7 m². The overall length of the coarse-meshed net was 10 m, ending in a cod end of 500 µm mesh size. The IKMT was deployed in oblique hauls to a maximum depth of 500 m only four times during the night, because the samples indicated that the 10m²-MOCNESS sampled the same faunal spectrum, but quantitatively, depth-stratified and in better condition.

All samples collected with the MOCNESS were split into two halves, one of which was preserved in a 4 % formaldehyde seawater solution for further biomass determination and taxonomic identification. The other half was sorted on board for gelatinous macrozooplankton (see chapter 5.3.3), krill (see chapter 5.3.4) and cephalopods. Samples of the IKMT were sorted directly for gelatinous macrozooplankton, cephalopods, shrimps and mesopelagic fishes. Samples were preserved in 4 % formaldehyde for further taxonomic identification.

Preliminary results and outlook

Biomass standing stocks. Standing stocks of total biomass (wet weight) of macrozooplankton and micronekton from the 10m²-MOCNESS were integrated over the full sampling depth of 1000 m and include macrozooplankton (2-20 mm) and micronekton (20-200 mm) as well as gelatinous organisms and salps larger 20 mm and fishes larger 120 mm. The lowest mean standing stock of day and night catches was measured at station CV-S1 with 14.7 g m^{-2} and the highest of 18.3 g m^{-2} inside the eddy (Fig. 5.9). In general, biomass standing stocks at the northern stations, the seamount and the reference site, where oxygen concentrations are moderate, were higher than at the southern sites CV-SE, CV-S1 and CV-S2 within the OMZ. However, differences were statistically not significant (pooled day and night data; ANOVA: $F = 0.223$, $p > 0.05$). The size composition was similar at the seamount, the reference site and the CV-SE station. Macrozooplankton (2-20 mm) made up 23-35 % of the total biomass and micronekton 27-35 % (Fig. 5.9). Jellies contributed 2-13 %, salps up to 23 % and the amount of larger fishes ranged between 8 and 37 %. Inside the eddy gelatinous zooplankton contributed a large amount to the biomass (37 %), whereas larger fishes made up only 1 %. At the southernmost stations salps were completely missing, and larger fishes were absent at station CV-S2.

Vertical biomass distribution. The biomass concentrations (wet weight) of macrozooplankton and micronekton, without larger gelatinous zooplankton, salps and fishes, indicate slight differences in the vertical profiles during day and night distributions (Fig. 5.10). The lowest biomass

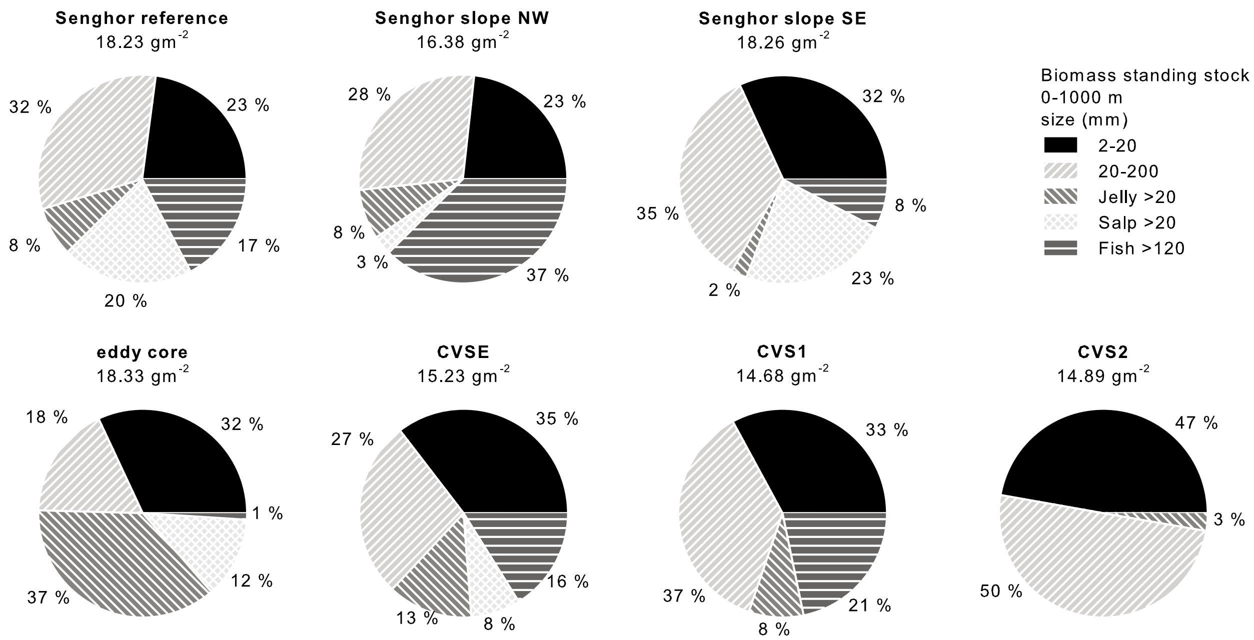

Fig. 5.9 Biomass standing stocks (wet weight, g m^{-2}) in the upper 1000 m with size composition (%) from the 10m²-MOCNESS (mean values of day and night catches).

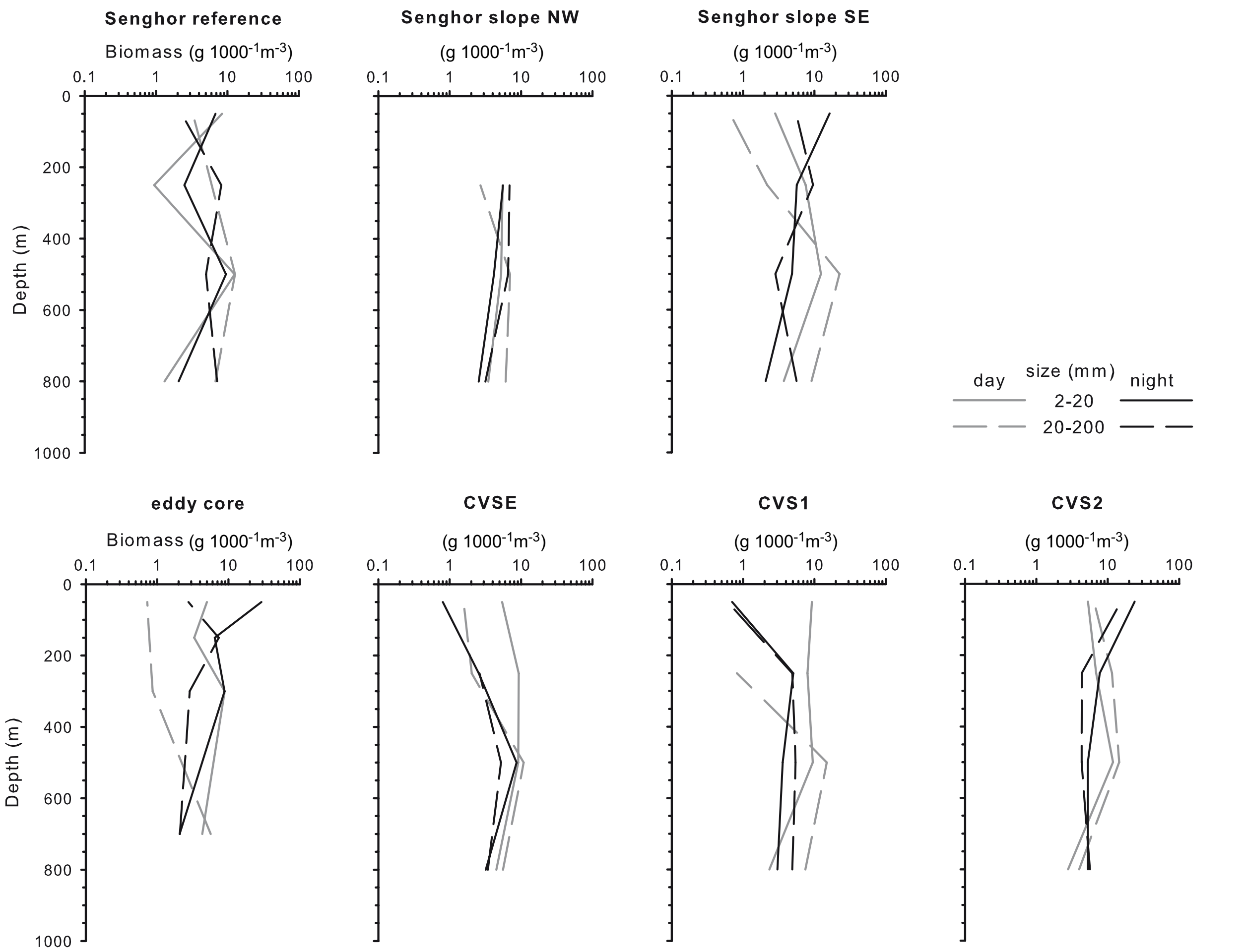

Fig. 5.10 Vertical biomass (wet weight, g 1000^{-1} m^{-3}) distribution of macrozooplankton (2-20 mm) and micronekton (20-200 mm) during day and night from the 10m²-MOCNESS.

concentration of macrozooplankton was measured at night in the upper 100 m at CV-S1 with 0.70 g 1000^{-1} m^{-3}. Inside the upper water layers of the eddy the biomass concentration was highest with 29.0 g 1000^{-1} m^{-3} at night. No micronekton was caught in the surface waters of CV-SE and CV-S1 during night and day. A maximum biomass of 16.6 g 1000^{-1} m^{-3} was measured in the mid waters at Senghor slope SE during the day. At Senghor slope SE, the eddy and CV-S2 the vertical distribution of macrozooplankton biomass indicates some diel vertical migration, whereas at the other stations no such pattern could be found, which points to a generally high amount of non-migrating zooplankton in the Cape Verde waters as observed in a previous study at Senghor Seamount (Denda and Christiansen, 2014). Patterns of diel vertical migration were more pronounced within the micronekton distribution. In relation to the oxygen concentration, macrozooplankton biomass, for example, was reduced at the core of the oxygen minimum inside the eddy at about 100 m depth. Preliminary taxonomic observations indicate that the eddy features a species composition which differs markedly from the other stations. For example, an indicator species for coastal upwelling, the copepod *Calanoides carinatus*, showed up much more frequently in the mid water samples of the eddy than at the other stations.

Taxonomic composition of cephalopods. A total of 429 cephalopods were collected by four different gears. The 1m²-MOCNESS caught 154 specimens, 242 individuals were collected with the 10m²-MOCNESS, 29 specimens were caught with the IKMT and 4 additional individuals with the WP3 (see chapter 5.3.3 for explanations). A total of 28 species belonging to 18 families were identified (Tab. 5.3). The majority were early life stages of cephalopods with the most abundant cranchid species *Liocranchia reinhardti* (25 % of MOC-1, 35 % of MOC-10 and 41 % of IKMT catches).

Tab. 5.3 Cephalopods collected by different gear.

	MOC-1			MOC-10			IKMT			WP3		
Taxon	n	%	size range (mm)	n	%	size range (mm)	n	%	size range (mm)	n	%	size range (mm)
Teuthoidea Oegopsida												
Bathyteuthidae												
Bathyteuthis abyssicola	1	0.65	13	5	2.07	9-12						
Chiroteuthidae												
Chiroteuthis veranyi	1	0.65	13	1	0.41	23						
Grimalditeuthis sp.	1	0.65	40									
Chtenopterygidae												
Chtenopteryx sicula	4	2.60	2-8	1	0.41	8	1	3.45	13			
Cranchiidae												
Bathothauma lyromma	1	0.65	40									
Cranchia scabra	9	5.84	9-60	13	5.37	4-21	5	17.4	9-17			
Cranchiidae indet	5	3.25	3-10	3	1.24	5-7						
Galiteuthis armata	1	0.65	12.2	1	0.41	20						
Helicocranchia sp.	5	3.25	6-22	4	1.65	13-26						
Leachia atlantica	4	2.60	7-22	10	4.13	6-54	2	6.90	46-55			
Liocranchia reinhardti	39	25.3	2-57	85	35.2	2-50	12	41.4	9-62			
Megalocranchia oceanica	1	0.65	34	4	1.65	4-11						
Teuthowenia maculata	1	0.65	13	2	0.83	6-7						
Teuthowenia sp.	4	2.60	3-10	8	3.31	3-22						

Tab. 5.3 continued

	MOC-1			MOC-10			IKMT			WP3		
Taxon	n	%	size range (mm)	n	%	size range (mm)	n	%	size range (mm)	n	%	size range (mm)
Enoploteuthidae												
Abraliopsis pfefferi				1	0.41	5	1	3.45	22			
Abraliopsis sp.	3	1.95	4-7.5	9	3.72	5-15						
Enoploteuthidae indet.	6	3.90	2.5-15	1	0.41	3						
Enoploteuthis sp.	1	0.65	10	2	0.83	4-12	1	3.45	20			
Histioteuthidae												
Histioteuthidae indet.	2	1.30	3-10	3	1.24	4-7						
Lepidoteuthidae												
Lepidoteuthidae indet.	1	0.65	13	4	1.65	12-16						
Lycoteuthidae												
Lycoteuthidae indet.	2	1.30	4									
Mastigoteuthidae												
Mastigoteuthis sp.	10	6.49	4-50	20	8.26	6-86						
Ommastrephidae												
Ommastrephidae indet.	4	2.60	3-5	1	0.41	6						
Sthenoteuthis pteropus	1	0.65	6									
Onychoteuthidae												
Onychoteuthidae indet.	4	2.60	3-10	4	1.65	5-10						
Onychoteuthis banksii	1	0.65	9	8	3.31	6-20	2	6.90	10-15			
Onykia carriboea	1	0.65	5									
Pyroteuthidae												
Pterygioteuthis sp.	3	1.95	3-7	2	0.83	3-4						
Pyroteuthidae indet.	6	3.90	6-29	2	0.83	7	2	6.90	17-22			
Pyroteuthis margaritifera				5	2.07	9-12						
Thysanoteuthidae												
Thysanoteuthis rhombus	1	0.65	5									
Teuthoidea indet.	13	8.44	2-6	4	1.65	3-11						
Vampyromorpha												
Vampyroteuthis infernalis	4	2.60	13-65	8	3.31	12-75	1	3.45	25			
Octopoda												
Argonautidae												
Argonauta argo	1	0.65	8	1	0.41	7						
Bolitaenidae												
Bolitaenidae indet.	8	5.19	9-30	16	6.61	5-52				3	75	4-9
Japetella diaphana	1	0.65	18									
Vitreledonellidae												
Vitreledonella richardi	2	1.30	20-84	9	3.72	4-45	1	3.45	42	1	25	14
Octopodidae indet.				1	0.41	8	1	3.45	13			
Octopus defilippi	1	0.65	5	3	1.24	4-7						
Octopus sp.	1	0.65	3									
Sum	154			242			29			4		
Sum (all)	429											

Perspectives. With the results of this cruise we can detect possible effects induced on the pelagic community by (1) the interaction between a seamount topography and the current regime, (2) a cyclonic eddy and (3) different OMZ intensities. The further analysis of biomass, abundance and taxonomic composition of meso- and macrozooplankton and micronekton will give information about the importance of diel vertical migration and will identify the position of micronekton within the pelagic fauna. Furthermore, measurements of stable isotopes ratios and stomach content analysis will give information about trophic interactions in the pelagic food chain and the food sources at the different sampling locations (see chapter 5.4). In addition the contribution of zooplankton and micronekton to the total carbon flux will be estimated by community- and size-specific respiration rates in the different hydrographic settings.

5.3.2 *Distribution, Composition and Size Structure of Meso- and Macrozooplankton from Optical Samplers (PELAGIOS and UVP)*

(H.J.T. Hoving, S. Christiansen, E. Fabrizius, H. Hauss)

Introduction

While nets are able to capture organisms, they also underestimate fragile gelatinous organisms since these organisms tend to get damaged, or not sampled in nets. Optical samplers therefore are good tools to substantiate net collections in determining faunal distribution and abundance patterns. Underwater surveys with optical techniques (e.g. ROVs, plankton recorders) have revealed fauna that are not sampled by nets, and show a diverse fauna of gelatinous organisms in the meso- and bathypelagic zones (Robison, 2004). During MSM49 we used a recently developed optical method, the pelagic *in situ* observation system (Hoving et al., 2014) or PELAGIOS (Fig. 5.11), to investigate the impact of different oceanographic features on the vertical distribution, abundance and diversity of macrozooplankton and (micro)nekton. The PELAGIOS is a towed ocean

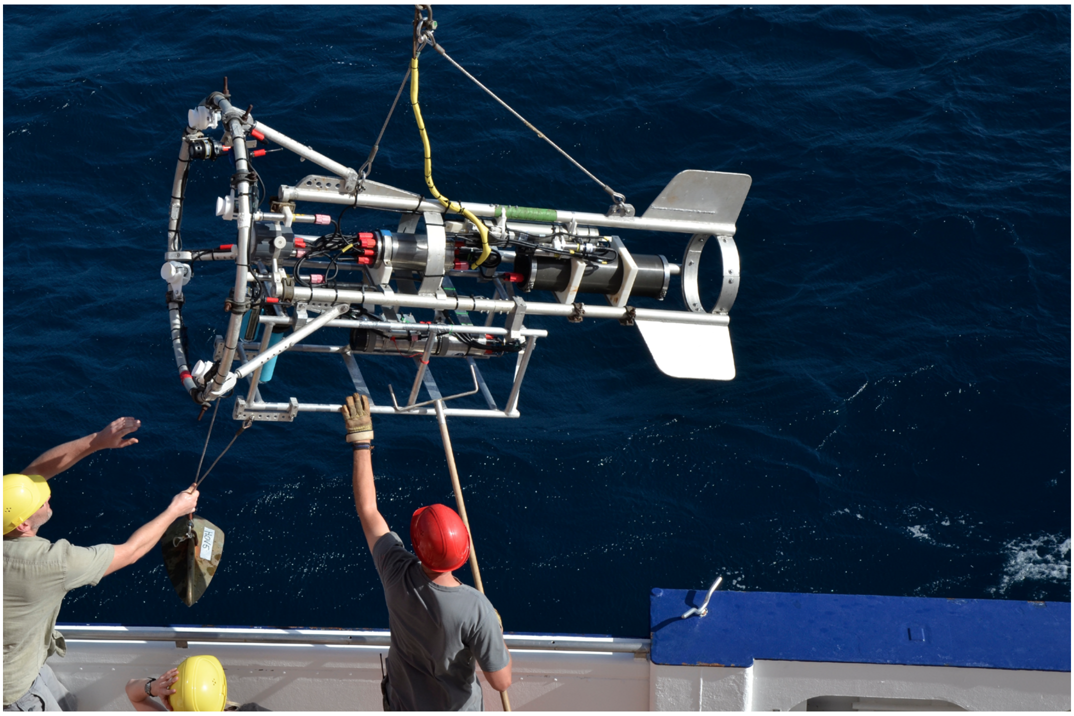

Fig. 5.11 The PELAGIOS with UVP mounted underneath being retrieved after a transecting cast (Photo: B. Christiansen).

observation instrument that consists of an aluminium frame with a forward looking HD video camera and LED lights, a CTD and oxygen sensor and batteries. Additionally, an underwater vision profiler (UVP5) was attached underneath the PELAGIOS and on the CTD rosette for quantification of mesozooplankton and particles. The UVP consists of a HD camera in a pressure-proof case, a light array and two red LEDs, which illuminate a defined water volume (0.93 L). The combination of the PELAGIOS with the UVP5 will enable the correlation of abundances of macrozooplankton and micronekton with particle and mesozooplankton data.

Material and methods

On 10 different stations we performed a total of 24 PELAGIOS deployments, deploying the system from the side crane of the ship, and towing it at 1 knot. The transect depth ranged from 20-1000 m, and the tow duration at each depth ranged from 11-33 min, with a total duration of up to 6.5 h per deployment. Each station consisted of a day and a night tow. A telemetry (SEA AND SUN TECHNOLOGY) transmitted a reduced resolution version of the recorded HD video back to the ship via the CTD conducting cable allowing a preview of faunal HD observations. The CTD data showed the depth and oxygen concentrations of the sampled depth, and enabled steering the instrument to the desired depth. The total recorded HD video is >80 hours.

The Underwater Vision Profiler 5 (UVP5), was mounted interchangeably on the CTD-rosette and on the PELAGIOS. During the downcast of a CTD deployment or PELAGIOS deployment, the UVP5 takes 3 to 11 pictures per second of the illuminated field. For each picture, particles larger than 60 µm are sized and counted. Furthermore, images of particles with a size > 500 µm are saved as separate “vignettes” - small cut-outs of the original picture – which allow for later, computer assisted identification of these particles and, for example, their grouping into different particle, phyto- and zooplankton classes.

In total, 22 CTD-mounted UVP5 profiles were taken during MSM49; four to a depth of 1200 dbar, seven casts went to a depth of 1000 dbar, six between 600 dbar and 900 dbar, two deeper than 1500 dbar and three casts to 200 dbar or shallower. The UVP5 was run autonomously and a specific depth routine was carried out to start it: The CTD was lowered first to 22 dbar to enable the power up of the UVP5 and to start image acquisition, then it was hauled to the surface before the actual downcast began.

A total of 22 UVP5 profiles combined with the PELAGIOS towed camera system were achieved during the cruise. During the first six casts, the UVP5 was started manually on deck and recorded the complete downcast. After that, the UVP5 could not be started manually any more due to unknown problems, so the following casts were started with the autonomous pressure routine similar to the CTD-mounted casts, except that the gear was not hoisted to the surface after power up. Data are thus lacking from the first 20 m of the water column. All measurements were taken with the same configuration settings of the UVP5, and a well-defined distance between the camera and the lights of 36 cm.

Preliminary results and outlook

A first insight into the video shows a large variety of gelatinous zooplankton; ctenophores, medusae siphonophores, salps, doliolids and appendicularians (Fig. 5.12), but other organisms that were observed with PELAGIOS include cephalopods, fishes, crustaceans, radiolarians, chaetognaths.

A few of the observed species were captured by the MOCNESS nets but many species were not. This further supports the notion that characterization of communities should be performed by a combination of different instruments.

While the live preview observations during the deployments cruise already suggested substantial differences between communities of the different sampled ocean features, the collected video will be analysed in detail and organisms will be annotated and identified to the lowest possible taxon. This analysis will result in quantitative and qualitative information on abundance, distribution and diversity data and will allow a reconstruction of the vertical ecological zonation of Senghor Seamount, a mesoscale eddy and oxygen minimum zones of various intensity in the eastern tropical Atlantic.

Results from the UVP are not yet available. The data will be analysed at GEOMAR in the framework of master theses under supervision of H.J.T Hoving and H. Hauss.

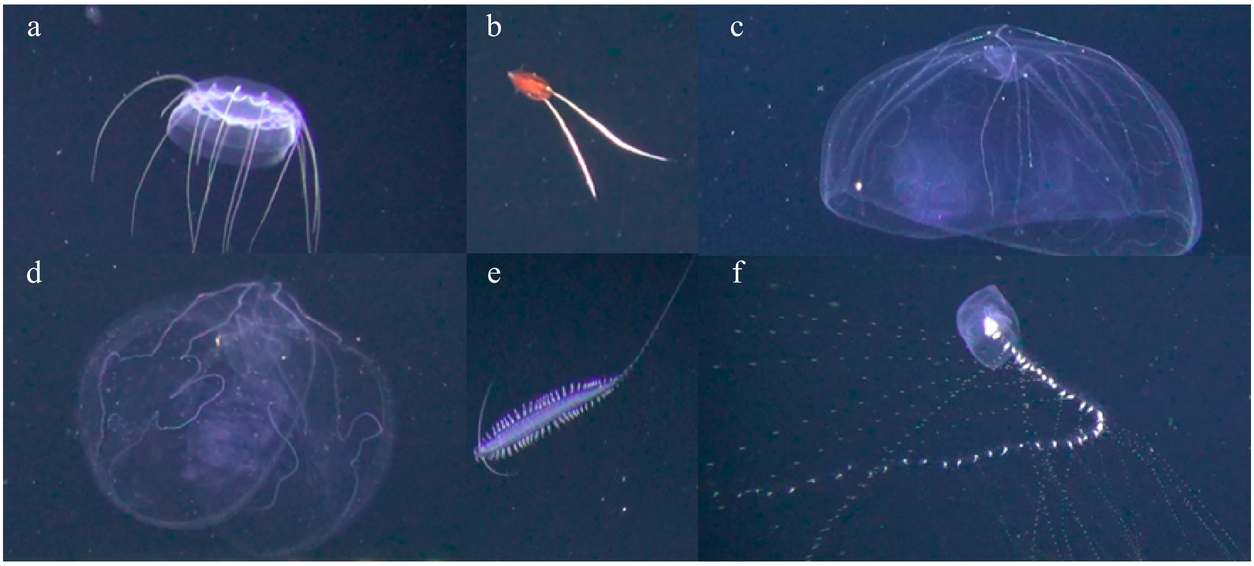

Fig. 5.12 Examples of pelagic organisms observed by PELAGIOS a) *Solmissus* sp. (Hydromedusa b) 'red tortuga' (cydippid ctenophore) c) lobate ctenophore d) 'Bathyceroe' (ctenophore) e) tomopterid polychaete f) 'Rosacea' (siphonophore)

5.3.3 Gelatinous Meso- and Macrozooplankton Around the Cape Verde Islands

(F. Lüskow, H.J.T. Hoving)

Introduction

Gelatinous zooplankton (e.g. medusae, siphonophores, doliolids, appendicularians, ctenophores, and salps) is a highly heterogenic taxonomic and ecological group of holo- and meroplanktonic animals (Hamner et al. 1975) that evolutionary appeared more than 550 million years ago (Parsons 1979). Members of this group play important roles in a variety of food webs (Robison 2004, Cardona et al. 2012, Kellnreitner et al. 2013, D’Ambra et al. 2014, McNamara et al. 2014) and inhabit all marine ecosystems around the globe from the poles to the equator and from lagoons to the deepest parts of the world’s oceans (Hosia et al. 2008, Youngbluth et al. 2008, Richardson et al. 2009).

During MSM49 we targeted this animal group with various net hauls (1 and 10m^2-MOCNESS, and WP3) to investigate the abundance, diversity and spatial (horizontal and vertical) distribution of gelatinous meso- and macrozooplankton (0.2-200 mm and 2-20 cm, respectively, Sieburth et al. 1978). By performing day and night tows diurnal migrations were studied. The station trajectory was planned in such way that it allowed an investigation of the impact of a topographical feature (Senghor seamount) and of oceanographic features (oxygen minimum zone (OMZ) and mesoscale eddy) on the diversity, distribution, and abundance of gelatinous zooplankton in the eastern tropical Atlantic (ETA) Ocean. The impact of the OMZ on pelagic fauna distribution and abundance is relevant since these zones have been reported to expand as a result of climate change Stramma et al. 2008). By studying the distribution patterns of gelatinous organisms in relation to differing abiotic factors, especially in relation to an OMZ, the goal is to predict which groups might profit from a changing ocean in the future.

Methods

A study area ranging from north of the Cape Verde Islands to the south of the archipelago (see details in chapter 4) was quantitatively sampled for gelatinous zooplankton using a 1m^2-MOCNESS (n = 37), a 10m^2-MOCNESS (n = 16), and qualitatively with a WP3 (n = 20). Within an hour after collection, MOCNESS samples were split into halves, one half being directly preserved and the other half sorted alive on a light table for gelatinous zooplankton identification down to the lowest possible taxonomic level. Life species identification on-board is going to be confirmed by external specialists (A. Hosia, G. Jarms, and O. Tendal) based on borax-buffered 4% formalin preserved individuals (n = 37 samples), as well as molecular techniques (n = 137 samples). Photographs of living gelatinous organisms further substantiated the examination and record for species identification.

Preliminary results and outlook

Thus far 17 species of gelatinous zooplankton organisms have been identified (Tab. 5.4) including 4 ctenophores, 3 scyphozoan medusae, 3 hydrozoan medusae, 1 pyrosome, 4 physonect siphonophore, 1 acorn worm larva, and 1 anthozoan larva. A variety of pelagic polychaetes were collected on the last 6 stations of the cruise (see Fig. 4.1) and these were partly preserved in ethanol and formalin. Several other species identifications are still in progress (mainly salps and hydromedusae). DNA barcoding of some collected specimens will confirm or aid in species identifications.

The most frequently observed taxa of gelatinous zooplankton were relatively small (1 to 10 cm in body length or umbrella diameter) as earlier described from the Mid-Atlantic Ridge (Hosia et al. 2008, Youngbluth et al. 2008). From the preliminary analysis of data it appears that 3 scyphozoan jellyfish and 1 atentaculate ctenophore (*Beroe* sp., most probable *B. cucumis*), *Periphylla periphylla*, and *Atolla* spp. (*A. parva* and *A. wyvillei*) are cosmopolitan members of the mesopelagic zone in the ETA (Fig. 5.13). The vertical distribution of *Beroe* sp. is more regular than the others and this species contributes most to the total gelatinous fauna abundance (up to 12 ind. 1000^{-1} m^{-3} on stations Senghor NW and Eddy, Fig. 5.14). The shallower stations on the NW and SE flanks of the Senghor seamount and on top of the summit showed a different pelagic community with higher proportions of polychaetes, anthozoan larvae, and acorn worm larvae compared to the oceanic reference station. The pulsing ctenophore *Ocyropsis crystallina* was only collected with the WP3 on station CVOO and Eddy (n = 2), whereas it was abundant on video recordings using the

PELAGIOS at most stations (see Chapter 5.3.2). The bigger nets ($1m^{2}$- and $10m^{2}$-MOCNESS) that were towed at higher speeds (around 2 knots) did not catch any specimens of this species. A first data evaluation suggests that the abundance of pyrosomes (most probable *Pyrostremma agassizi*) increased drastically at stations south of the seamount (*i.e.* Eddy, CV-SE, CV-S1, CV-S2), characterised by a more pronounced OMZ. *P. agassizi* mainly occurred in the upper 200 m.

Table. 5.4 Medusae, ctenophores, pyrosomes, siphonophores, and meroplanktonic specimens collected with $1m^{2}$- and 10-m^{2} MOCNESS, and WP3.

Species	Station								
	CVOO	CV-N	Senghor Ref	Senghor NW	Senghor Summit	Senghor SE	Eddy	CV-SE	CV-S1
Ctenophora									
Beroe sp.	x	x	x	x		x	x	x	x
Hormiphora sp.	x			x	x				x
Ocyropsis crystallina	x						x		
Velamen parallelum								x	
Cnidaria									
Scyphozoa									
Periphylla periphylla	x	x	x	x			x		x
Atolla wyvillei		x	x	x		x	x	x	x
Atolla parva	x	x	x	x		x	x	x	x
Hydrozoa									
Leptothecata									
Zygocanna vagans							x		
Aequorea sp.	x	x	x	x	x	x	x	x	x
Trachymedusa									
Liriope tetraphylla					x	x	x	x	x
Siphonophora									
Physophora hydrostatica									x
Resomia dunni			x	x	x		x		x
Praya dubia			x	x		x	x	x	x
Hippopodius hippopus								x	x
Thaliacea									
Pyrostremma agassizi	x	x	x	x	x	x	x	x	x
Acorn worm larva				x	x	x		x	
Anthozoan larva							x		

Fig. 5.13 Dominant species at most stations during MSM49: From left to right: *Atolla* sp., *Periphylla periphylla*, and *Beroe* sp. Photos: S. Zankl.

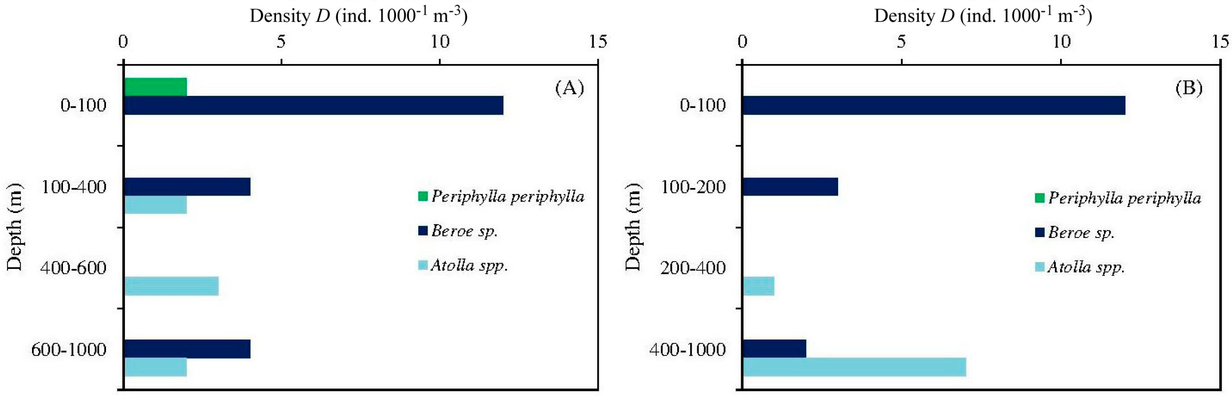

Fig. 5.14 The vertical distributions and abundances (D, ind. 1000^{-3} m^{-3}) of the three dominant gelatinous zooplankton genera; data is from two example stations: (A) Eddy 5 (MOC-10 (10), 19:25) and (B) Senghor NW (MOC-10 (5), 19:45).

5.3.4 *Krill, an Indicator: Distribution and Trophic Position of Euphausiids in Relation to Oxygen Depletion and Topography*

(F. Buchholz, C. Buchholz)

Introduction

Although there are only 86 species of euphausiids, they are distributed worldwide and are pivotal components of ecosystems at all latitudes. Most species are truly pelagic and are consumers of phyto- and zooplankton, building strong links within food chains reaching from primary producers, other meso-zooplankton, squid, fish, seals, birds and up to whales. Accordingly, krill are suitable indicators of seasonal and long-term changes in food web composition from the bottom-up as well as top-down perspective. In spite of their key role in the ecosystem, there is a lack of knowledge regarding krill distribution, population dynamics and functional biology in the North Atlantic regions. This type of baseline knowledge is needed to be used in various ecosystem models and may generally contribute to a better understanding of ecosystem dynamics in the open ocean.

The cruise data on physical and trophic environment gave an ideal background to estimate krill performance in the NE-Atlantic and to compare it with, for example, the Sargasso Sea environment (ref. MSM41, April 2015) and in view of global change.

Methods

The major part of the sampling relied on the "krill-nets", i.e., a set of three single nets mounted in a MOCNESS (Multi Opening and Closing Net with Environmental Sensing System), optimized for catch of fast swimming macro-zooplankton which avoid smaller nets. The krill-nets (1 m^2 mouth) were of soft fabric and with large mesh-size (2 mm) equipped with soft cod ends for gentle catch. The three nets were opened and closed on the downward run of the MOCNESS from 0-200 m, 200-600 m, 600-1000 m, lowered at increasing speeds of 0.2, 0.3 and 0.5 m s^{-1} to allow for an adequate volume fished. The larger part of samples were analysed for species composition and numbers on live specimens on board. All samples were preserved to be further analysed back home.

Preliminary results and outlook

Preliminary results showed that 22 species were found, accountable to the generally high tropical diversity. Abundance increased from north to south. Highest abundances were found at the Senghor Seamount summit station and in the eddy core station indicating concentration effects within the seamount area and the eddy. The seamount was dominated by shallow water species but a deeper species appeared also to have been washed to the top plateau by local currents. The eddy showed an outstandingly high diversity of krill species. Regional species distribution will be related to latitude, hydrography and topography.

Exemplarily, the vertical distribution, abundance and species composition between day and night are shown for station 595, the Senghor SE-slope (Fig. 5.15). The first net fished the euphotic zone between 0 and 200 m depth. Net 2 covered the mesopelagic layer comprising the OMZ, i.e. the oxygen minimum zone between 200 and 600 m. The third, deep net entered the bathypelagic

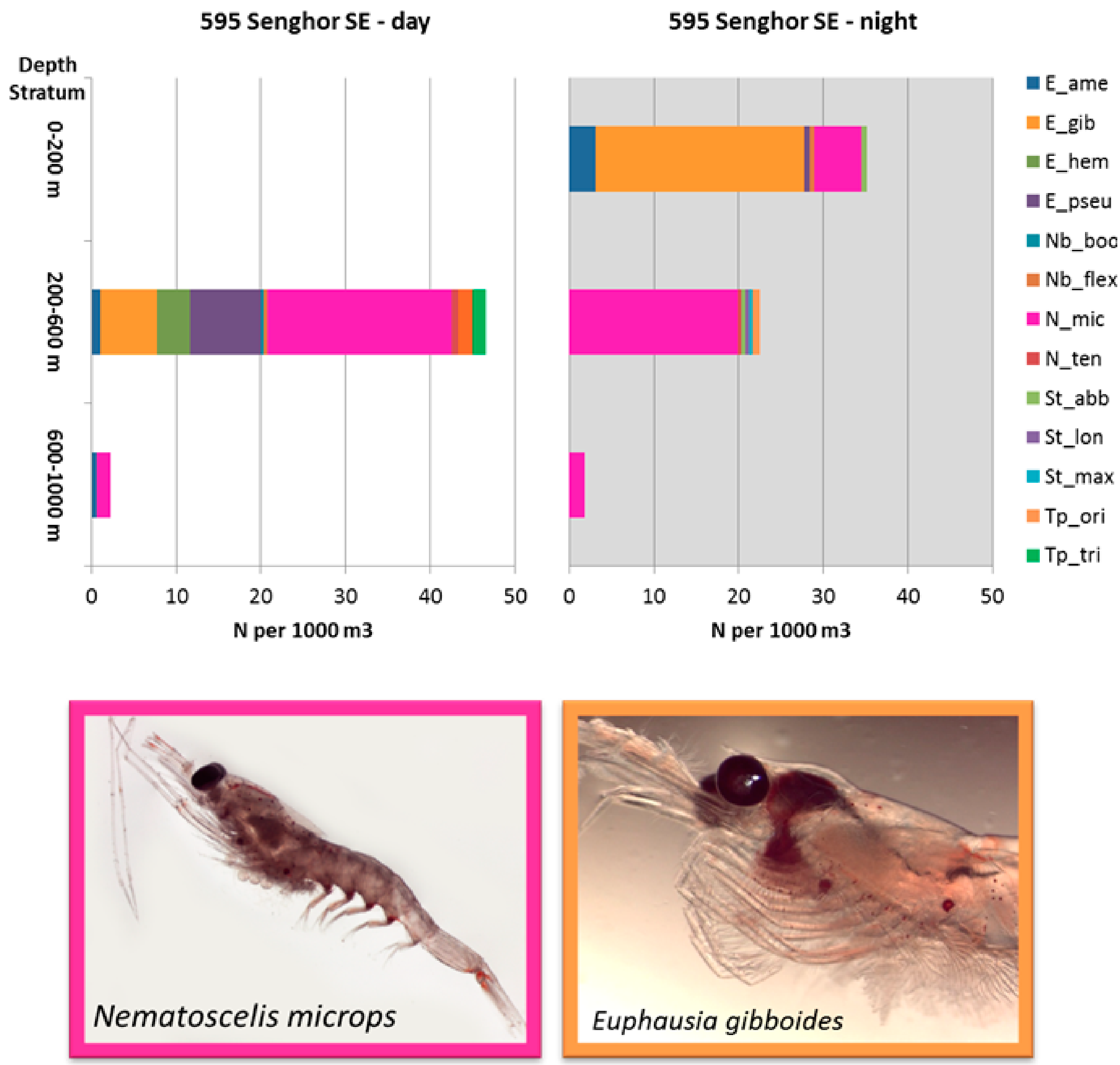

Fig. 5.15 Number of krill specimens per 1000m³ fished by three nets of the MOCNESS at 0-200 m, 200-600 m and 600-1000 m. Species identified on board were: E_ame – *Euphausia americana*; E_gib – *Euphausia gibboides*; E_hem – *Euphausia hemigibba*; E_pseu – *Euphausia pseudogibba;* N-boo – *Nematobrachion boopsis*; Nb_flex – *Nematobrachion flexipes*; N_mic – *Nematoscelis microps*; N_ten – *Nematoscelis tenella*; St_abb – *Stylocheiron abbreviatum*; St_lon – *Stylocheiron longipes*; St_max – *Stylocheiron maximum*; Tp_ori – *Thysanopoda orientalis*; Tp_tri – *Thysanopoda tricuspidata*. Bottom left: *Nematoscelis microps*; bottom right: *Euphausia gibboides.* Photos: F. and C. Buchholz

zone. During the night, active vertical migrators appeared in the upper layer which was void of krill during day-time. The middle layer was most densely populated during the day by ten species. Apparently, the lower limit of vertical migration is reached somewhere below 600 m. The most abundant species at this station were, by far, *Euphausia gibboides* and *Nematoscelis microps.* The latter species is conspicuously carnivorous, characterized by its long raptorial thoracopods, equipped with sharp dagger-like bristles (upper left, Fig. 5.15 – bottom left). Known from congeners, *N. microps* appears to remain all day within the OMZ, catching zooplankton. The OMZ presumably serves as a niche sheltering the krill from fish predation. In contrast, the herbivorous *E. gibboides* (Fig. 5.15 - bottom right) is equipped with a wide and fine filtering basket and rises to the surface to feed on phytoplankton, sheltered from visual predators in the dark. The behaviour and physiology of the other species will be compared and related to hydrography, oxygen distribution and regional trophic environment. We are particularly looking forward to relate our net catches to particles and organisms determined by the optical counters.

5.3.5 Diversity, Standing Stocks and Distribution of Mesopelagic Fishes

(A. Denda, B. Christiansen)

Introduction

The cruise MSM49 studied the impact of shallow seamount topography and oxygen minimum zones (OMZs) on the mesopelagic communities in the eastern tropical Atlantic around the Cape Verde islands. The mesopelagic fauna probably contributes the highest amount to the oceanic biomass and plays a key role in marine food webs. Mesopelagic organisms, such as fishes, squids and crustaceans, often show strong diel vertical migrating behaviour. They stay at depth of 200-1000 m during the day, ascend to surface waters at night for feeding and descent back to deeper waters at dawn to avoid visual predators.

Current-topography interactions at Senghor Seamount could generate special hydrographic conditions in the surrounding waters, such as upwelling, closed recirculation cells or seamount trapped waves. These local hydrodynamic features would affect the biogeochemical and biological processes by uplift of nutrient-rich waters and trapping of particles and smaller plankton. Therefore Senghor Seamount might be an important food source for higher trophic levels, where the mesopelagic fish fauna may represent the link between zooplankton and predators such as seabirds, squids, piscivorous fishes and marine mammals (Porteiro & Sutton, 2007).

OMZs typically develop in the mesopelagic layer in waters where the surface productivity is high combined with high remineralisation rates and low circulation. The zones of the reduced oxygen concentrations have a strong impact on the mesopelagic community and often feature reduced biomass and diversity. While krill, gelatinous organisms and squids are well adapted to low oxygen concentrations, mesopelagic fishes probably avoid these zones (Koslow et al. 2011).

On cruise MSM49 we addressed specifically the following questions:

(a) What are the main components of the mesopelagic fish fauna in the Cape Verde waters?

(b) How is the vertical migration and distribution of the mesopelagic fishes influenced by the seamount and the OMZs?

(c) Which trophic position do the mesopelagic fishes adopt within the food web and do they play a key role in linking zooplankton with higher level predators?

Methods

Mesopelagic fishes were caught by oblique hauls with a 10m^2-MOCNESS (Wiebe et al., 1985) and an IKMT; for detailed catch information see chapter 5.3.1. The MOCNESS hauls were subdivided into smaller sampling intervals (1000-600-400-100-0 m) and performed during day and night to detect patterns of diel vertical migration in the mesopelagic fauna. All samples collected with the MOCNESS were split into two halves, one of which was preserved in a 4 % formaldehyde sea-water solution. From the other half mesopelagic fishes were withdrawn directly after recovery of the net and dorsal muscle tissue was taken for stable isotope analyses. Tissue samples were frozen at -20 °C until further analyses. The fishes were fixed in formaldehyde then for further length and weight measurement, taxonomic identification and stomach content analyses in the home lab.

Table 5.5 Preliminary list of mesopelagic fishes collected on cruise MSM49.

Species	Order	Family	Depth (m)	Size TL (mm)
Searsia koefoedi	Clupeiformes	Searsiidae	600-1000	140
Cyclothone spec.	Clupeiformes	Gonostomatidae	0-1000	20-60
Gonostoma elongatum	Clupeiformes	Gonostomatidae	600-1000	195
Gonostoma spec.	Clupeiformes	Gonostomatidae	0-1000	20-60
Argyropelecus aculeatus	Clupeiformes	Sternoptychidae	0-200	20
Argyropelecus hemigymnus	Clupeiformes	Sternoptychidae	100-600	10-25
Argyropelecus olfersi	Clupeiformes	Sternoptychidae	100-400	20
Polypinus polli	Clupeiformes	Sternoptychidae	100-600	25-50
Sternoptyx diaphana	Clupeiformes	Sternoptychidae	400-1000	15-20
Sternoptyx pseudobscura	Clupeiformes	Sternoptychidae	400-1000	10-40
Vinciguerria nimbaria	Clupeiformes	Photichthyidae	0-600	15-45
Vinciguerria poweriae	Clupeiformes	Photichthyidae	0-400	15
Astronesthidae unid.	Clupeiformes	Astronesthidae	200-1000	125-190
Chauliodus danae	Clupeiformes	Chauliodontidae	600-1000	180
Chauliodus sloani	Clupeiformes	Chauliodontidae	600-1000	195-205
Flagellostomias boureei	Clupeiformes	Melanostomiidae	600-1000	220-235
Melanostomias bartonbeani	Clupeiformes	Melanostomiidae	100-400	260
Melanostomias spec.	Clupeiformes	Melanostomiidae	600-1000	220
Melanostomiidae unid.	Clupeiformes	Melanostomiidae	0-1000	45-270
Nansenia oblita	Clupeiformes	Argentinidae	600-1000	90
Myctophidae unid.	Scopeliformes	Myctophidae	0-1000	10-100
Paralepididae unid.	Scopeliformes	Paralepididae	400-600	25-70
Serrivomer beani	Anguilliformes	Serrivomeridae	200-1000	285-480
Nemichthys curvirostris	Anguilliformes	Nemichthyidae	0-600	315-450
Nemichthyidae unid.	Anguilliformes	Nemichthyidae	100-600	300-510
Stylephorus chordatus	Lampidiformes	Stylephoridae	100-600	120-250
Poromitra megalops	Beryciformes	Melamphaidae	400-600	25-40
Scopelogadus beanii	Beryciformes	Melamphaidae	400-1000	25-70
Antigonia capros	Zeiformes	Caproidae	100-400	50
Elagatus bipinnulata	Perciformes	Carangidae	0-200	110
Protogrammus souasi	Perciformes	Callionymidae	0-200	30
Melanocoetus johnsonii	Lophiiformes	Melanocetidae	400-1000	25
Dolopichthys allector	Lophiiformes	Oneirodidae	400-1000	20
Cryptosaras couesi	Lophiiformes	Ceratiidae	400-1000	20-115

Preliminary results and outlook

A total of 26 species of mesopelagic fishes belonging to 20 families could be identified on board (Tab. 5.5, Fig. 5.16). Numbers of individuals have not been counted yet, but visual inspection of the samples shows that gonostomatids and myctophids were the most abundant fishes covering the full depth range of the mesopelagic layer. Further analyses on taxonomy and abundance of the fixed samples will be performed at UHH-IHF in the next months.

We expect to find evidence for effects induced on the mesopelagic fish community by the shallow seamount topography and by low oxygen concentrations. The contribution of the mesopelagic fishes to the total carbon flux will be estimated by community and size-specific respiration rates and will give information about the importance of diel vertical migration for active biomass transport and food supply from productive surface waters into deeper layers. Measurements of stable isotopes ratios and stomach content analyses will elucidate the role of the mesopelagic fish fauna in the pelagic food chain and the nutritional links to the zooplankton community as well as to higher trophic level predators.

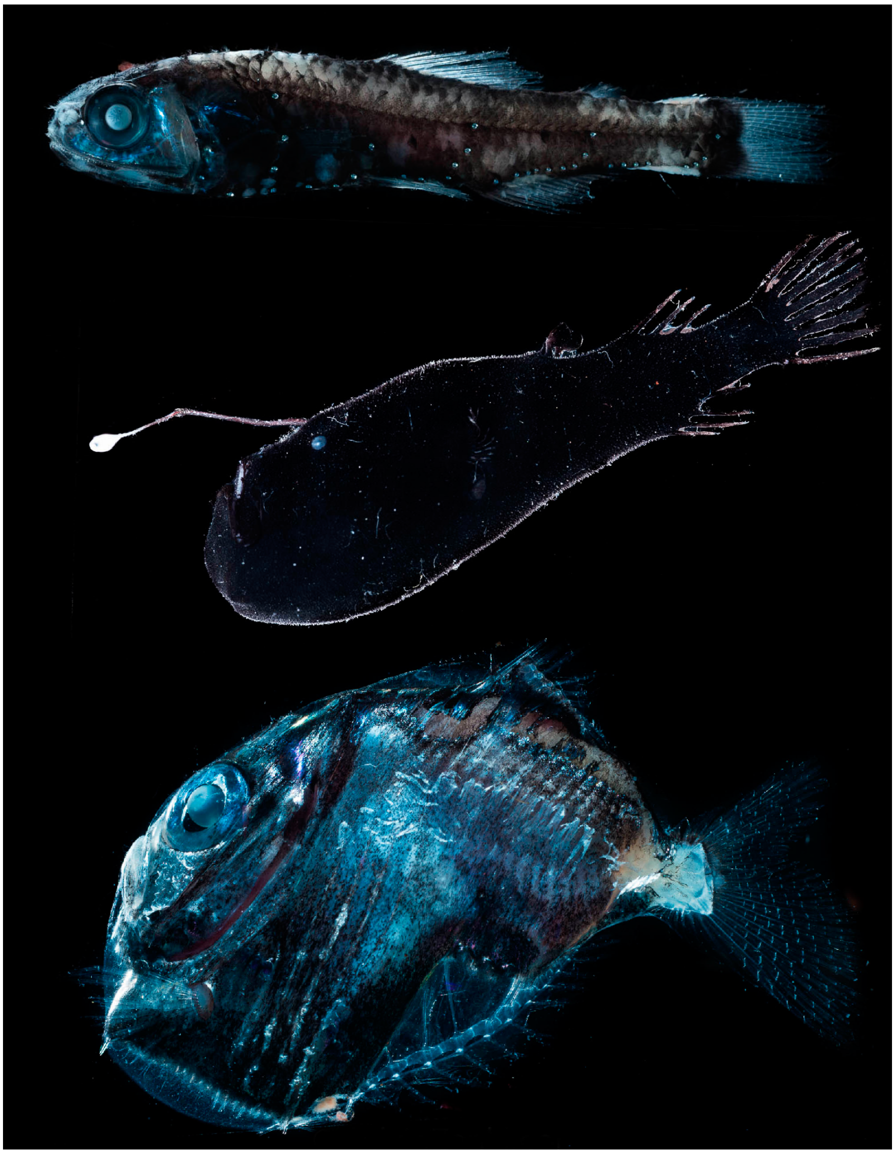

Fig. 5.16 Examples of mesopelagic fishes caught on MSM49: Myctophidae indet. (top), *Cryptopsaras couesi* (middle), *Sternoptyx diaphana* (bottom). Photos: S. Zankl.

5.4 Trophic Ecology of Pelagic Communities and Seabirds

(A. Denda, X. Chi, B. Christiansen, S. Christiansen, H. Hauss, V. Merten)

Introduction

One focus of cruise MSM49 to the Cape Verde area is to assess the impact of the OMZ and of a shallow topographic feature, Senghor Seamount, on the trophic structure of the medium-sized pelagic fauna, including macrozooplankton, micronekton and squids. Senghor Seamount is located ~60 NM east of the Cape Verde islands with a summit depth of 90 m below the surface and interferes with the ocean currents. Enhanced horizontal flux of pelagic organisms past the shallow seamount as well as the uplift of deeper nutrient-rich water and enhanced primary production correlated with aggregations of zooplankton, micronekton and fish (Genin & Boehlert 1985; Dower et al. 1992; Genin 2004) might cause changes in food sources and trophic interactions as compared with open ocean sites. Within the OMZ, metabolic processes of the organisms might be restricted featuring specially adapted feeding habits or avoiding behaviour.

For the identification of food sources and trophic relationships the combination of stomach contents and biochemical markers, such as stable isotopes and fatty acids, is an effective and common method. A stomach content of recently ingested prey provides information on consumers' feeding behaviour and the preferred prey type. Stable isotope ratios of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) change from prey to predator during metabolism and are a measure of already digested and assimilated diet. This isotopic fractionation during feeding, assimilation and respiration processes allows for estimation of the diet carbon source as well as of the trophic level of an organism and the food web structure (e.g. Minagawa & Wada 1984; Peterson & Fry 1987; Post 2002). Fatty acid analysis is useful to find out the food source that contributes most significantly to growth of a particular gelatinous zooplankton species.

Since recent studies on the trophic structure of Eastern Atlantic Seamounts indicate a central role of the mesopelagic micronekton in the pelagic-benthopelagic food web (see Denda, 2015), the medium-sized pelagic fauna is of special interest for the present study and will contribute to a better understanding of the trophic ecology of Senghor Seamount. Furthermore, we aim to detect possible impacts by the changing OMZ on the pelagic food web in the Eastern tropical Atlantic, and in this regard to elucidate the ecological role of mesopelagic fishes, squids and jellies. One very abundant species in the eastern tropical Atlantic is the orange back squid *Sthenoteuthis pteropus* (Fig. 5.17). Since pelagic squids are voracious predators, important prey for other animals and constitute a large pelagic biomass, they often play a key role in the oceanic food web. In particular the following questions are addressed:

(a) Which trophic interactions do exist within the pelagic communities? Do they change between the different hydrographic, hydrodynamic and topographic settings?
(b) Which position do the micronekton adopt within the trophic structure?
(c) Which role does the orange back squid *Sthenoteuthis pteropus* play in the pelagic food web of the eastern tropical Atlantic?

In addition, opportunistic sampling of seabirds and their presumed zooplankton prey were done in order to detect foraging patterns and the influence of OMZs on the distribution and food ecology of storm petrels in the tropical North Atlantic. This data will complement the existing information from earlier cruises (M116 and M097).

Fig. 5.17 The orange back squid *Sthenoteuthis pteropus.* Photo: S. Zankl.

Methods

For the analyses of stable carbon, nitrogen and sulphur isotope ratios as well as fatty acid signatures of the pelagic communities, samples of suspended particulate organic matter (POM), zooplankton and micronekton were collected at the Senghor reference site, Senghor Seamount, the eddy and CV-S1. The stable isotope (SI) values of epipelagic POM will be used as baseline for the trophic connections through the whole water column and for estimation of consumer levels.

Water samples for POM were taken in 25 m, 200 m, 400 m and 1000 m, using Niskin bottles mounted on a Seabird CTD-Rosette. After recovery of the CTD-Rosette, water samples were vacuum filtered at low pressure on pre-combusted (500 °C; 0.5 h) and pre-weighed fibre glass filters (Whatman GF/F, ø 2.5 cm, pore size 0.7 µm), rinsed with Milli-Q water and frozen at -20 °C until further analyses. Three parallels were run per sampling depth using a sample volume of 5 l per filter.

Zooplankton and micronekton were caught by oblique hauls with a 1m^2-MOCNESS and a 10m^2-MOCNESS (see chapter 5.3.1). All samples were split into two halves, one of which was preserved in a 4 % formaldehyde seawater solution for further biomass determination and taxonomic identification. From the other half specimens of meso- and macrozooplankton, gelatinous zooplankton, squids and fishes were sorted directly on board for stable isotope samples. Those zooplankton and micronekton taxa were selected which were supposed to be abundant over the whole sampling depth, include different feeding types and cover a wide range of trophic levels. Samples were rinsed with Milli-Q water and, depending on the size of the meso- and macrozooplankton specimens, 1-100 individuals were pooled per sample. From fishes, a small sample of dorsal muscle tissue was taken; the remaining fish was fixed in formaldehyde for further length and weight measurement, taxonomic identification and stomach content analyses. All isotope samples were frozen at -20 °C until further analyses.

Squids and larger nekton were caught by hook-and-line at each station. Length and weight were measured directly after recovery of the catch, and stomachs were dissected and fixed in formaldehyde for content analyses. A sample of dorsal muscle tissue was taken from the fishes for stable isotope analyses. From the squid *Sthenoteuthis pteropus*, DNA samples were taken of the arms and stable isotope samples from the mantle. The gladius was also sampled for many individuals. The gladius grows with the individual, and samples of different parts of the gladii will be analyzed for stable isotopes. This should result in a chronological record of the individual's stable isotope signatures and may reveal the ontogenetic change in diet and habitat.

Feather samples were obtained from storm petrels that landed on deck at night. They were caught, and in the morning, they were weighed and their beak and wing length measured. Then two feather samples were taken for the SI analysis, one from the hind part of the head and one from the breast of the bird. After this treatment the birds were released by giving starting aid. In order to provide local stable isotope signatures of zooplankton prey of oceanic seabirds, epipelagic copepods from the genus *Pontella* and chaetognaths from the genus *Sagitta* were picked out of the zooplankton samples from net hauls on each station, either from a drifting WP2-net, (lowered by hand to the surface alongside the ship during the CTD stations for 10 minutes) or from the surface net (net 9) of the 1m^2-MOCNESS, or from the WP3-net. A total of 3-5 individuals of the calanoid copepod genus *Pontella* and 1-2 (depending on their size) chaetognaths were picked out with a pasteur pipette. These samples were put into pre-weighed tin cups and dried at 55 °C for later stable isotope analysis in the lab in Kiel (PI: S. Ismar) and will be compared with the isotopic signatures of the seabird feather samples taken during the cruise.

Preliminary results and Outlook

In total, 569 samples of zooplankton and micronekton for stable isotope analyses were taken from the net hauls. In addition, a total of 703 samples of gelatinous zooplankton and 233 samples of POM were frozen. Hook-and-line fishing yielded 65 individuals of the pelagic squid *Sthenoteuthis pteropus* and additionally one escolar (Gempylidae) as well as five individuals of the common dolphinfish *Coryphaena hippurus*, a common top predator in subtropical and tropical waters.

The principal goal of this study is to investigate trophic interactions within the pelagic community in the eastern tropical Atlantic. We expect to identify dietary sources within the zooplankton and micronekton communities as well as primary food sources of the pelagic squids and dolphinfishes to understand the role of key taxa in a complex food web in different hydrographic, hydrodynamic and topographic settings. Furthermore, the fished *Sthenoteuthis pteropus* will be used for toxicology studies. We aim to analyse the contamination of heavy metals in this species.

A total of 22 seabirds were captured and sampled. The most abundant species was the storm petrel *Oceanodroma leucorhoea* with 18 individuals. The remaining birds included two *Oceanodroma jabejabe*, one *Pelagodroma marina* and one bulwer‘s petrel (*Bulweria bulwerii*). A total of 23 samples from 11 net hauls will be used to analyse the zooplankton SI composition. With these data, together with data from M116 and M97, preferred feeding habitats of storm petrels and potential impacts of the OMZ will be analysed in the working group of S. Ismar, GEOMAR.

7 Station List MSM49

All times and positions refer to beginning of station.

Gear abbreviations:

CTD/RO	Seabird CTD with 24 bottle rosette
PGS	PELAGIOS
MOC-1	$1m^2$-MOCNESS
MOC-10	$10m^2$-MOCNESS
WP3	WP3 net
IKMT	Isaac Kidd Midwater Trawl
APSN	Apstein net
UVP	Underwater Vision Profiler

Station No	Date	Time (UTC)	Latitude	Longitude	Depth (m)	Gear
MSM49_583-1	01.12.2015	08:24	17° 35.00' N	24° 17.04' W	3611.5	CTD/RO+UVP
MSM49_583-3	01.12.2015	10:04	17° 35.37' N	24° 17.11' W	3613.2	MOC-1
MSM49_583-4	01.12.2015	14:14	17° 35.00' N	24° 17.01' W	3613.9	PGS+UVP
MSM49_583-5	01.12.2015	15:56	17° 35.38' N	24° 17.33' W	3614.1	PGS+UVP
MSM49_583-6	01.12.2015	16:53	17° 35.43' N	24° 17.38' W	3614.1	PGS+UVP
MSM49_583-7	01.12.2015	19:15	17° 35.09' N	24° 16.92' W	3612.2	MOC-10
MSM49_583-8	01.12.2015	23:03	17° 35.13' N	24° 16.87' W	3612.0	MOC-1
MSM49_583-9	02.12.2015	02:15	17° 39.67' N	24° 13.58' W	3614.6	PGS+UVP
MSM49_583-10	02.12.2015	08:14	17° 37.10' N	24° 16.23' W	3615.2	MOC-1
MSM49_583-11	02.12.2015	12:36	17° 35.06' N	24° 17.07' W	3608.4	PGS+UVP
MSM49_583-12	02.12.2015	16:26	17° 35.01' N	24° 17.05' W	3613.4	CTD/RO
MSM49_583-13	02.12.2015	19:16	17° 35.79' N	24° 17.34' W	3615.5	WP3
MSM49_583-14	02.12.2015	21:03	17° 37.26' N	24° 17.06' W	3617.3	IKMT
MSM49_583-15	02.12.2015	23:59	17° 37.06' N	24° 17.29' W	3619.5	MOC-1
MSM49_584-1	03.12.2015	09:26	17° 59.98' N	23° 00.02' W	3504.5	CTD/RO+UVP
MSM49_584-2	03.12.2015	10:51	18° 00.01' N	22° 59.99' W	3504.7	MOC-1
MSM49_584-2	03.12.2015	12:21	18° 02.26' N	22° 57.91' W	3496.9	MOC-1
MSM49_584-3	03.12.2015	14:24	17° 59.99' N	23° 00.02' W	3504.3	PGS+UVP
MSM49_584-4	03.12.2015	19:22	18° 02.86' N	23° 04.36' W	3542.6	MOC-10
MSM49_585-1	04.12.2015	02:34	18° 00.21' N	22° 04.31' W	3311.1	MOC-1
MSM49_585-2	04.12.2015	05:47	18° 04.99' N	22° 00.02' W	3307.4	CTD/RO
MSM49_585-3	04.12.2015	08:30	18° 05.04' N	21° 59.96' W	3306.8	MOC-1
MSM49_585-4	04.12.2015	12:37	18° 05.01' N	22° 00.00' W	3306.6	PGS+UVP
MSM49_585-5	04.12.2015	18:00	18° 04.97' N	22° 00.02' W	3307.5	APSN
MSM49_585-6	04.12.2015	20:10	18° 05.06' N	21° 59.92' W	3307.4	IKMT
MSM49_585-7	04.12.2015	22:57	18° 05.05' N	21° 59.89' W	3306.9	MOC-1
MSM49_585-8	05.12.2015	02:55	18° 04.98' N	22° 00.02' W	3307.0	PGS+UVP
MSM49_585-9	05.12.2015	08:40	18° 04.99' N	22° 00.02' W	3306.6	CTD/RO+UVP
MSM49_585-10	05.12.2015	09:55	18° 05.03' N	21° 59.97' W	3306.3	MOC-1
MSM49_585-11	05.12.2015	14:00	18° 05.32' N	21° 59.52' W	3305.6	MOC-10
MSM49_585-12	05.12.2015	17:12	18° 04.99' N	22° 00.02' W	3306.6	WP3
MSM49_585-13	05.12.2015	18:17	18° 05.01' N	22° 00.04' W	3308.2	APSN
MSM49_585-14	05.12.2015	19:12	18° 05.23' N	21° 59.72' W	3305.8	MOC-10
MSM49_586-1	06.12.2015	02:55	17° 14.18' N	22° 00.62' W	946.1	IKMT
MSM49_586-2	06.12.2015	07:02	17° 14.23' N	22° 00.72' W	1004.2	CTD/RO+UVP
MSM49_586-3	06.12.2015	09:00	17° 10.92' N	22° 02.54' W	1900.0	MOC-1
MSM49_586-4	06.12.2015	13:23	17° 14.18' N	22° 00.66' W	987.2	PGS+UVP
MSM49_586-4	06.12.2015	13:39	17° 14.19' N	22° 00.66' W	987.1	PGS+UVP
MSM49_586-5	06.12.2015	18:45	17° 14.22' N	22° 00.72' W	1005.6	APSN

Station list continued

Station No	Date	Time (UTC)	Latitude	Longitude	Depth (m)	Gear
MSM49_586-6	06.12.2015	19:45	17° 10.95' N	22° 02.52' W	1894.6	MOC-10
MSM49_586-7	06.12.2015	23:01	17° 14.22' N	22° 00.73' W	1007.2	PGS+UVP
MSM49_586-8	07.12.2015	07:01	17° 14.22' N	22° 00.71' W	1004.4	CTD/RO
MSM49_586-9	07.12.2015	08:58	17° 10.99' N	22° 02.51' W	1889.3	MOC-10
MSM49_587-1	07.12.2015	12:25	17° 09.91' N	21° 57.62' W	487.7	MOC-1
MSM49_587-2	07.12.2015	14:09	17° 10.33' N	21° 57.47' W	273.4	MOC-1
MSM49_587-3	07.12.2015	14:54	17° 11.26' N	21° 57.27' W	108.5	PGS+UVP
MSM49_587-4	07.12.2015	16:41	17° 10.33' N	21° 57.48' W	277.4	IKMT
MSM49_587-5	07.12.2015	17:27	17° 11.26' N	21° 57.27' W	107.9	CTD/RO+UVP
MSM49_587-6	07.12.2015	17:56	17° 11.26' N	21° 57.27' W	109.4	WP3
MSM49_587-7	07.12.2015	18:42	17° 11.26' N	21° 57.27' W	109.3	APSN
MSM49_587-8	07.12.2015	19:05	17° 11.27' N	21° 57.27' W	109.9	CTD/RO+UVP
MSM49_587-9	07.12.2015	22:17	17° 10.36' N	21° 57.46' W	255.2	MOC-1
MSM49_587-10	07.12.2015	23:15	17° 11.26' N	21° 57.27' W	218.4	PGS+UVP
MSM49_588-1	08.12.2015	01:28	17° 10.94' N	22° 02.53' W	1894.7	MOC-1
MSM49_588-2	08.12.2015	05:29	17° 14.22' N	22° 00.72' W	1004.8	WP3
MSM49_588-2	08.12.2015	06:22	17° 14.22' N	22° 00.72' W	1005.3	WP3
MSM49_588-3	08.12.2015	07:59	17° 10.88' N	22° 02.56' W	1905.0	MOC-1
MSM49_590-1	08.12.2015	17:40	17° 11.26' N	21° 57.29' W	109.1	PGS
MSM49_591-1	08.12.2015	20:15	17° 10.89' N	22° 02.56' W	1890.0	MOC-1
MSM49_592-1	09.12.2015	00:15	17° 11.26' N	21° 57.29' W	108.5	PGS
MSM49_593-1	09.12.2015	02:01	17° 10.44' N	21° 57.68' W	305.5	MOC-1
MSM49_593-2	09.12.2015	03:03	17° 10.79' N	21° 57.36' W	117.5	IKMT
MSM49_595-1	09.12.2015	06:39	17° 09.13' N	21° 54.70' W	921.0	WP3
MSM49_595-2	09.12.2015	07:45	17° 09.15' N	21° 54.71' W	947.0	CTD/RO
MSM49_595-3	09.12.2015	09:36	17° 04.57' N	21° 54.45' W	2643.0	MOC-10
MSM49_595-4	09.12.2015	13:02	17° 09.16' N	21° 54.68' W	976.3	PGS+UVP
MSM49_595-5	09.12.2015	19:09	17° 07.40' N	21° 54.81' W	1699.6	MOC-10
MSM49_595-6	09.12.2015	23:00	17° 05.00' N	21° 55.73' W	2631.6	MOC-1
MSM49_595-7	10.12.2015	02:40	17° 09.72' N	21° 55.31' W	542.7	PGS+UVP
MSM49_595-8	10.12.2015	03:15	17° 09.72' N	21° 55.31' W	540.1	PGS+UVP
MSM49_595-9	10.12.2015	07:58	17° 05.08' N	21° 55.69' W	2648	MOC-1
MSM49_595-10	10.12.2015	11:40	17° 09.12' N	21° 54.74' W	932.5	APSN
MSM49_595-11	10.12.2015	12:46	17° 05.03' N	21° 55.72' W	2654.8	MOC-1
MSM49_595-12	10.12.2015	16:26	17° 09.69' N	21° 52.45' W	1728.3	PGS+UVP
MSM49_595-13	10.12.2015	17:31	17° 09.51' N	21° 53.10' W	1676.1	PGS+UVP
MSM49_595-14	10.12.2015	18:45	17° 09.13' N	21° 54.69' W	959.8	CTD/RO+UVP
MSM49_595-15	10.12.2015	20:46	17° 04.56' N	21° 56.97' W	2763	MOC-1
MSM49_596-1	11.12.2015	07:24	15° 59.99' N	21° 00.01' W	3870.2	CTD/RO+UVP
MSM49_597-1	11.12.2015	11:56	16° 24.10' N	21° 01.13' W	3759.6	CTD/RO+UVP
MSM49_598-1	11.12.2015	13:24	16° 20.28' N	21° 06.92' W	3795.0	CTD/RO+UVP
MSM49_599-1	11.12.2015	14:52	16° 16.16' N	21° 12.60' W	3819.5	CTD/RO+UVP
MSM49_600-1	11.12.2015	16:19	16° 12.17' N	21° 18.51' W	3840.2	CTD/RO+UVP
MSM49_601-1	11.12.2015	20:19	16° 12.19' N	21° 18.51' W	3839.8	CTD/RO+UVP
MSM49_601-2	11.12.2015	22:13	16° 08.78' N	21° 20.54' W	3854.1	MOC-1
MSM49_601-3	12.12.2015	01:46	16° 10.41' N	21° 16.36' W	3842.9	PGS+UVP
MSM49_601-4	12.12.2015	06:57	16° 12.19' N	21° 18.52' W	3838.8	CTD/RO
MSM49_601-5	12.12.2015	08:25	16° 10.48' N	21° 19.34' W	3846.4	MOC-10
MSM49_601-6	12.12.2015	11:13	16° 12.24' N	21° 18.52' W	3837.9	APSN
MSM49_601-7	12.12.2015	12:17	16° 09.93' N	21° 20.49' W	3848.7	MOC-1
MSM49_601-8	12.12.2015	15:36	16° 12.19' N	21° 18.52' W	3837.7	CTD/RO+UVP

Station list continued

Station No	Date	Time (UTC)	Latitude	Longitude	Depth (m)	Gear
MSM49_601-9	12.12.2015	16:59	16° 12.20' N	21° 18.53' W	3838.1	WP3
MSM49_601-9	12.12.2015	17:25	16° 12.23' N	21° 18.55' W	3838.6	WP3
MSM49_601-9	12.12.2015	17:51	16° 12.26' N	21° 18.60' W	3838.1	WP3
MSM49_601-10	12.12.2015	19:30	16° 10.55' N	21° 19.50' W	3846.6	MOC-10
MSM49_601-11	12.12.2015	23:05	16° 08.71' N	21° 20.56' W	3853.5	MOC-1
MSM49_601-12	13.12.2015	02:08	16° 12.18' N	21° 18.50' W	3839.8	CTD/RO+UVP
MSM49_601-13	13.12.2015	03:09	16° 12.18' N	21° 18.50' W	3838.7	WP3
MSM49_601-13	13.12.2015	03:44	16° 12.18' N	21° 18.50' W	3840.4	WP3
MSM49_601-13	13.12.2015	04:20	16° 12.18' N	21° 18.50' W	3839.6	WP3
MSM49_601-14	13.12.2015	07:54	16° 08.28' N	21° 19.23' W	3853.8	MOC-1
MSM49_601-15	13.12.2015	11:12	16° 13.43' N	21° 16.24' W	3833.4	PGS+UVP
MSM49_602-1	13.12.2015	23:28	15° 01.59' N	20° 28.05' W	4055.0	PGS+UVP
MSM49_602-2	14.12.2015	04:49	14° 59.99' N	20° 30.01' W	4071.9	WP3
MSM49_602-2	14.12.2015	06:21	14° 59.99' N	20° 30.01' W	4071.0	WP3
MSM49_602-3	14.12.2015	08:11	14° 59.99' N	20° 30.01' W	4072.4	CTD/RO+UVP
MSM49_602-4	14.12.2015	09:56	14° 56.52' N	20° 32.09' W	4088.2	MOC-1
MSM49_602-5	14.12.2015	13:18	14° 59.08' N	20° 27.56' W	4062.0	PGS+UVP
MSM49_602-6	14.12.2015	19:05	15° 00.18' N	20° 29.94' W	4071.0	MOC-10
MSM49_602-7	14.12.2015	22:13	14° 59.99' N	20° 30.01' W	4071.4	MOC-1
MSM49_602-8	15.12.2015	02:06	15° 00.09' N	20° 29.97' W	4069.2	MOC-1
MSM49_602-9	15.12.2015	05:45	14° 59.99' N	20° 30.01' W	4070.4	CTD/RO+UVP
MSM49_602-10	15.12.2015	07:56	15° 00.05' N	20° 29.99' W	4068.3	MOC-1
MSM49_602-11	15.12.2015	11:46	15° 00.11' N	20° 29.96' W	4073.3	MOC-10
MSM49_602-12	15.12.2015	14:11	15° 04.27' N	20° 27.95' W	4050.4	APSN
MSM49_603-1	16.12.2015	07:43	11° 59.99' N	21° 00.01' W	4924.4	CTD/RO+UVP
MSM49_603-2	16.12.2015	09:13	12° 00.10' N	20° 59.96' W	4926.1	MOC-10
MSM49_603-4	16.12.2015	12:02	12° 01.21' N	20° 57.24' W	4918.2	PGS+UVP
MSM49_603-5	16.12.2015	19:03	12° 00.19' N	20° 59.94' W	4920.0	MOC-10
MSM49_603-6	16.12.2015	22:04	12° 00.09' N	20° 59.98' W	4922.6	MOC-1
MSM49_603-7	17.12.2015	01:34	12° 00.08' N	20° 59.96' W	4920.4	MOC-1
MSM49_603-8	17.12.2015	04:51	11° 59.99' N	21° 00.01' W	4921.5	WP3
MSM49_603-8	17.12.2015	06:22	11° 59.99' N	21° 00.01' W	4924.0	WP3
MSM49_603-9	17.12.2015	08:07	11° 59.99' N	21° 00.01' W	4922.6	APSN
MSM49_603-10	17.12.2015	08:34	11° 59.99' N	21° 00.01' W	4920.2	CTD/RO+UVP
MSM49_603-11	17.12.2015	09:34	12° 00.06' N	20° 59.97' W	4921.9	MOC-1
MSM49_603-12	17.12.2015	13:29	12° 00.05' N	20° 59.94' W	4922.1	MOC-1
MSM49_603-13	17.12.2015	16:54	11° 59.99' N	21° 00.01' W	4921.7	WP3
MSM49_603-14	17.12.2015	19:56	12° 00.85' N	20° 57.61' W	4917.6	PGS+UVP
MSM49_604-1	18.12.2015	10:49	11° 58.62' N	23° 01.44' W	5059.6	MOC-1
MSM49_604-2	18.12.2015	14:14	11° 58.65' N	23° 01.39' W	5057.6	MOC-1
MSM49_604-3	18.12.2015	19:02	11° 58.69' N	23° 01.35' W	5056.8	MOC-10
MSM49_604-4	18.12.2015	22:13	11° 58.62' N	23° 01.42' W	5057.6	MOC-1
MSM49_604-5	19.12.2015	01:55	11° 58.61' N	23° 01.42' W	5059.2	MOC-1
MSM49_604-6	19.12.2015	05:23	11° 59.99' N	23° 00.01' W	5053.1	CTD/RO+UVP
MSM49_604-7	19.12.2015	07:16	11° 59.99' N	23° 00.01' W	5052.1	APSN
MSM49_604-8	19.12.2015	08:07	11° 58.57' N	23° 01.24' W	5056.7	MOC-10
MSM49_604-9	19.12.2015	11:05	12° 00.85' N	22° 57.63' W	5045.3	PGS+UVP
MSM49_604-10	19.12.2015	17:24	11° 59.99' N	23° 00.01' W	5052.4	CTD/RO
MSM49_604-11	19.12.2015	18:33	11° 59.99' N	23° 00.01' W	5054.2	WP3
MSM49_604-12	19.12.2015	21:01	12° 00.85' N	22° 57.63' W	5044.9	PGS+UVP

8 Data and Sample Storage and Availability

A Cruise Summary Report (CSR) was compiled and submitted to DOD (Deutsches Ozeanographisches Datenzentrum), BSH, Hamburg, on 4 January, 2016. On the same day, the station list was submitted to PANGAEA. The cruise was performed within waters of Cape Verdian jurisdiction and in international waters. No particular obligations were requested by Cape Verdian authorities.

After finishing the processing of the samples, all biological material will be sent to the appropriate scientific collections and museums, as indicated in the directives of the DFG. For example, fish and cephalopods will go to Zoologisches Institut und Museum Hamburg, decapod crustaceans will go to Senckenberg.

All general cruise information will be made freely available from the Kiel Ocean Science Information System (OSIS). The raw data acquired during the cruise will be made publicly visible and stored as georeferenced data sets within OSIS. This system stores metadata supplied by the researchers directly along with scientific data. Most metadata and part of the raw data (CTD, ADCP, UVP, EM122) are already available in OSIS. The predefined process of cruise program publication with the ability to reference data files by sampling events enables merging of scientific raw and primary data collections. This first level data will be synchronized subsequently with the GEOMAR data base system allowing for an immediate exchange of the data within the project group. Subsequent results may be added in the same context, as well as print publications related to the cruise or scientific measurements derived from this cruise. The GEOMAR library connects the publication repository with OSIS for overarching cruise output reporting. The direct publication of the metadata promotes communication with scientists outside the project and institutes without endangering the safety of the scientific data. The metadata will be made publicly accessible immediately. The associated scientific data will be made freely available upon publication, but latest three years after the cruise. These data will be transferred to PANGAEA in order to ensure the long-term public data availability worldwide.

Tab. 8.1 Data storage and availability. Availabilities show the latest anticipated date.

Type	database	available	free access	responsible contact
Hydrography				
CTD, ADCP raw data	OSIS/PANGAEA	5/2016	12/2018	B. Christiansen (bchristiansen@uni-hamburg.de)
CTD proc. data	OSIS/PANGAEA	12/2016	12/2018	B. Christiansen (bchristiansen@uni-hamburg.de)
ADCP proc. data	OSIS/PANGAEA	12/2016	12/2018	F. Schütte (fschuette@geomar.de) H. Hauss (hhauss@geomar.de) C. Mohn (chmo@bios.au.dk)
Nutrients, POM	OSIS/PANGAEA	12/2016	12/2018	J. Javid (jjavid@geomar.de)
Phytoplankton	OSIS/PANGAEA	12/2017	12/2018	M. Kaufmann (mkbiomar@staff.uma.pt)
Zooplankton/ micronekton				
Net samples	OSIS/PANGAEA	7/2017	12/2018	B. Christiansen (bchristiansen@uni-hamburg.de)
UVP	OSIS, SVN	7/2017	12/2018	H. Hauss ((hhauss@geomar.de)
PELAGIOS	OSIS/PANGAEA	7/2017	12/2018	H.J.T. Hoving (hhoving@geomar.de)
Gelatinous fauna	OSIS/PANGAEA	7/2017	12/2018	F. Lüskow (florian.lueskow@web.de)
Krill	OSIS/PANGAEA	12/2016	12/2018	F. Buchholz (friedrich.buchholz@awi.de)
Mesopelagic fishes	OSIS/PANGAEA	7/2017	12/2018	B. Christiansen (bchristiansen@uni-hamburg.de)
Stable isotopes	OSIS/PANGAEA	12/2016	12/2018	B. Christiansen (bchristiansen@uni-hamburg.de) J. Javid (jjavid@geomar.de) S. Ismar (sismar@geomar.de)

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