MARIA S. MERIAN-BERICHTE

Productivity and Life Cycles of Plankton and Nekton in the Coastal Upwelling Area of the Benguela Shelf – Trophic and Physical-Chemical Control Mechanisms

Pela-Gimber

Cruise No.07, Leg 2 - 3

February 11 – April 17, 2008
Las Palmas (Spain) - Walvis Bay (Namibia)

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Abstract

The RV MARIA S. MERIAN -cruise MSM07 was part of the German IMBER-Initiative (GIMBER: German IMBER[1]) and concentrated on analysing the interrelationships between pelagic (PELA-GIMBER) ecosystem components, biogeochemical and physical processes as well as human impact. The investigations performed during the three cruise legs were focusing on the analysis of physical-chemical drivers on the primary production level up to interrelationships between and within higher trophic levels in the ecosystem.

- On transit between Las Palmas de Canaria and Walvis Bay the effect of different biogeochemical environments on the production/decomposition-processes at the lower ecosystem levels was studied. On a multi-station transect across the equator the physical processes in the equatorial current system and the resulting chemical and biological structures were observed. On the SE-African shelf off the Kunene river mouth benthic colonization patterns were compared with the distribution of functional properties such as the exchange dynamics between sediment and water.
- During leg MSM07/2b the pelagic communities in the northern Benguela upwelling were sampled along three transects perpendicular to the coast with 5 stations each at 17.5°S, 20°S and 23°S. Information on distribution, abundance and biomass of different pelagic species was collected to detect different nutritional preferences. The hydrographical conditions in the study area were recorded by means of a CTDO-probe equipped with a lowered ADCP (LADCP). Nutrient analyses, study of the N:P ratio and permanent recordings of VMADCP and thermosalinograph were performed in parallel.
- Leg MSM7/3 was dedicated especially to the implementation of physiological experiments on board of the ship. Based on the more large scale hydrographical and planktological station work especially of cruise leg 2b as well as on real-time satellite images of sea surface temperature and chlorophyll-a distribution, live organisms in good condition were caught for the experiments on board. In selected areas between Kunene River (17°15'S) and Palgrave Point (20°S), short transects perpendicular to the coast have been performed, and a number of different nets with different mesh sizes were used to sample the complete size spectrum of the plankton community. Different taxonomical groups of plankton were in the focus of these works: copepods, euphausiids, fish larvae and young fish.

Zusammenfassung

Die Reise MSM07 war Teil der deutschen IMBER-Initiative (GIMBER: German IMBER[2]) und konzentrierte sich auf die Untersuchung von Wechselwirkungen zwischen pelagischen (PELA-GIMBER) Ökosystemkomponenten, biogeochemischen und physikalischen Prozessen und menschlichen Einflüssen. In diesem Rahmen fanden auf den drei Fahrtabschnitten Untersuchungen statt, die durchgängig von der Wirkung physikalisch-chemischer Antriebe auf die primären Funktionsebenen bis zu den Wechselbeziehungen in den höheren trophischen Ebenen des marinen Ökosystems reichten.

- Auf der Transitreise zwischen den Kanaren und Namibia wurde die Wirkung unterschiedlicher physiko-chemischer Grundbedingungen auf die Produktions-/Dekompositions-Abläufe auf den unteren Ebenen des Ökosystems untersucht. Auf einem Nord-Süd Schnitt über den Äquator konnte die physikalisch-dynamischen Prozesse des Stromsytems am Äquator und die resultierenden chemischen und

[1,2] IMBER – Integrated Marine Biogeochemistry and Ecosystem Research (http://www.imber.info)

biologischen Strukturen beobachtet werden. Auf dem Schelfgebiet vor dem Kunene-Fluss wurden benthische Besiedlungsmuster mit den funktionalen Gegebenheiten, in diesem Falle die Austauschdynamik zwischen Sediment und Wassersäule, untersucht.

- Während des zweiten Fahrtabschnitts MSM07/2b wurde die pelagische Lebensgemeinschaft im nördlichen Benguela Auftriebsgebiet auf drei küstennormalen Schnitten mit je 5 Stationen beprobt (auf 17,5°S, 20°S und 23°S), um Informationen über Verbreitung, Häufigkeit und Biomasse einiger Zieltaxa zu sammeln und unterschiedliche Nahrungspräferenzen zu erfassen. Die hydrographischen Bedingungen im Untersuchungsgebiet wurden mit Hilfe von CTDO und LADCP erfasst. Parallel dazu wurden Nährstoffanalysen durchgeführt, um das N:P Verhältnis zu bestimmen, und Temperatur, Salzgehalt und Strömung mit VMADCP und Thermosalinograph kontinuierlich aufgezeichnet.
- Der dritte Fahrtabschnitt war speziell für die Durchführung von physiologischen Experimenten an Bord konzipiert. Basierend auf den eher großräumigen hydrographischen und planktologischen Aufnahmen während des vorangegangenen Abschnitts und zeitnahen Satellitenaufnahmen der Oberflächentemperatur und Chlorophyllverteilung sollten hier vor allem lebende Organismen für die geplanten Experimente an Bord gefangen werden. In ausgesuchten Gebieten wurden kurze küstennormale Schnitte durchgeführt, auf denen dann unterschiedlichste Netze mit verschiedenen Maschenweiten eingesetzt wurden, um das gesamte Größenspektrum des Planktons zu erfassen. Der Hauptaugenmerk lag auf Copepoden, Euphausiiden und Fischlarven und –juvenilen.

Research Objectives

The cruise was divided into 3 research legs with different areas of investigation and also different research objectives.

Leg MSM 07/1

Transit Rostock - Las Palmas.

Leg MSM 07/2a

On transit between Las Palmas de Gran Canaria and Walvis Bay the effect of different biogeochemical environments on the production/decomposition-processes at the primary levels of the ecosystem was studied. On a transect across the equator the physical processes in the equatorial current system were in focus. Off the Kunene river mouth benthic colonization patterns were compared with the distribution of functional properties, in this case the exchange dynamics between sediment and water.

Leg MSM 07/2b

The German IMBER-initiative (GIMBER) concentrates on the study of interactions between biological system components, biogeochemical and physical processes and human impacts on marine ecosystems. In the region of the Benguela upwelling it was studied how effects of structural differences in the communities of primary producers (flagellates vs. diatoms) do further propagate through the foodweb and regulate throphic interactions on higher levels. Data of abundance, vertical distribution, food spectra, trophodynamics and physiological rates were recorded for important pelagic target groups such as copepods, euphhausiids, gelatinous zooplankton, fish larvae and mesopelagic nekton employing state of the art methodology. These data serve as a base for trophic and biogeochemical modelling in the frame of the planned GIMBER-programme and are supposed to provide information on the expected results of a regime shift in other areas.

Leg MSM 07/3

The third cruise leg was dedicated especially to the implementation of physiological experiments on board of the ship. Based on the more large scale hydrographical and planktological station work of the cruise legs 2a and 2b as well as on real-time satellite images of sea surface temperature and chlorophyll-a distribution, live organisms in good condition were caught for the experiments on board. In selected areas between Kunene River (17°15’S) and Palgrave Point (20°S), short transects perpendicular to the coast have been performed, and a number of different nets with different mesh sizes were used.

Different taxonomical groups of plankton were investigated: copepods, euphausiids, and fish larvae were in the focus of these works. An undulating video plankton recorder (LOKI) was used to investigate the in-situ small-scale distribution of plankton organisms.
In continuation of the hydrographical and planktological work done in the area since many years, a South-North transect at 11°30'E has been worked up at the end of the station work, reaching from 19 to 14°S. The passage from the investigation area to Mindelo, Cape Verde, was used intensively to continue the physiological experiments.

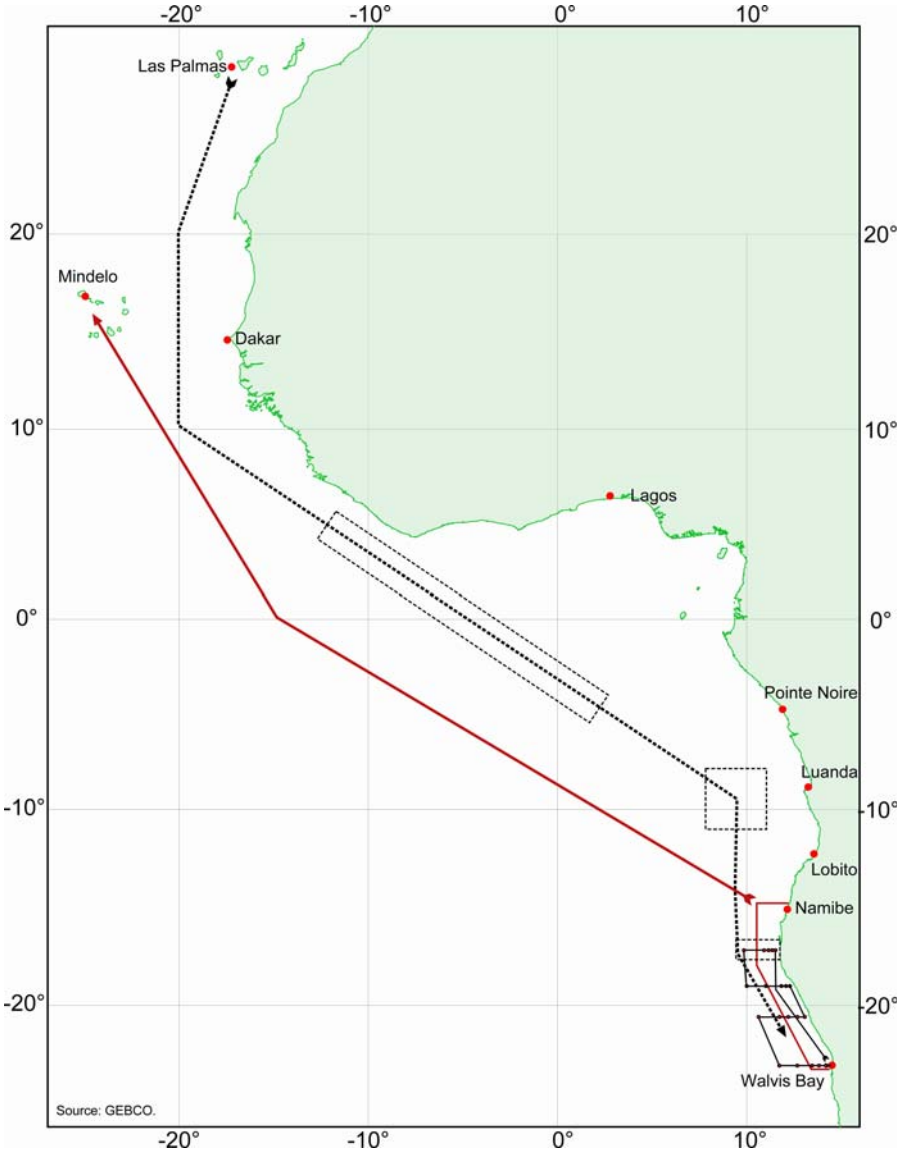

Figure 1 Cruise tracks and working areas of RV MARIA S. MERIAN cruise MSM07, cruise legs 2a (Dotted rectangular areas), 2b (Solid line cruise track from/to Walvis Bay) and 3 (Red coastal box between Walvis Bay and Namibe). For enlarged view of leg 2b and 3 cruise legs see chapter 2.2 and 3.2.

Acknowledgement

We are grateful to the master of RV MARIA S. MERIAN, Kapitän Friedhelm von Staa, and his crew. In a friendly and highly efficient way they guaranteed the success of our work at sea. Our thanks go to Kapitän Berkenheger and his group at the Control Station METEOR/MERIAN for their administrative support. Thanks to the Deutsche Forschungsgemeinschaft DFG for funding RV MARIA S. MERIAN ship time and logistics.

MARIA S. MERIAN-BERICHTE

Productivity and Life Cycles of Plankton and Nekton in the Coastal Upwelling Area of the Benguela Shelf – Trophic and Physical-Chemical Control Mechanisms

Pela-Gimber

PART 1

Cruise No. 07, Leg 2a

February 19th – March 8th, 2008
Las Palmas - Walvis Bay

F.Pollehne, C. Berg, , A. Hagenmeier U. Hehl, H. Johannsen, G.Jost, R. Kay, S. Krüger, M. Labrenz, V. Mohrholz, M. Römer, D. Rüß, M. Schmidt, R. Schmidt, S. Schmitz, U. Struck, N. Wasmund, S. Weinreben, P. Wlost , M. Zettler

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1.1 Participants MSM07/2a

	Name	Discipline	Institution
1	Pollehne, Falk Dr.	chief scientist , nutrient chemistry	IOW
2	Mohrholz, Volker, Dr.	Hydrography	IOW
3	Schmidt, Martin, Dr.	Hydrography	IOW
4	Weinreben, Stefan	Hydrography	IOW
5	Krüger, Siegfried	Instrumentation, pump-CTD/ scanfish	IOW
6	Rüß, Dietmar	Instrumentation ADCP/LADCP/TADC P	IOW
7	Wlost, Peter	Instrumentation pump-CTD/ scanfish	IOW
8	Kay, Reinhard	Instrumentation TADCP/deck systems	IOW
9	Schmidt, Robert	Ghemistry, gas chemistry , CO^2 /O^2	IOW
10	Hagenmeier, Anna	Chemistry, nutrient chemistry	IOW
11	Labrenz, Matthias, Dr.	Molecular biology	IOW
12	Jost, Günter, Dr.	Microbiology	IOW
13	Wassmund, Norbert, Dr.	Biology, phytoplankton, N-fixation	IOW
14	Johansen, Henning	Biology, phytoplankton, molecular biology	IOW
15	Berg, Carlo	Microbiology , bacteriochlorophyll	IOW
16	Struck, Ulrich , Dr.	Chemistry,nat.isotopes, bulk variables	HU Berlin
17	Schmitz, Sandra	Chemistry, nat.isotopes, filtration	HU Berlin
18	Zettler, Michael, Dr.	Biology, benthos	IOW
19	Hehl, Uwe	Biology, benthos	IOW
20	Röhmer, Miriam	Chemistry, dissolved organic carbon, oxygen	Uni-HH

IOW: Institut für Ostseeforschung Warnemünde, Seestrasse 15, 18119 Warnemünde

HU Berlin: Museum für Naturkunde der Humboldt-Universität zu Berlin, Invalidenstrasse 43, 10115 Berlin

Uni-HH: Institut für Biogeochemie und Meereschemie, Universität Hamburg Bundesstraße 55, D-20146 Hamburg

1.2 Research Program

On a transit leg between Las Palmas de Canaria and Walvis Bay the effect of different biogeochemical base settings on the production/decomposition-equilibria within the primary levels of the ecosystem was studied. The question, how far basic biogeochemical signals and those, which result from activitiess of higher trophic levels can extend into the ecosytem and regulate structural and functional properties in other parts, touches an intensely discussed problem in recent research of marine systems. The assessment of either longterm climatic effects or shortterm direct anthropogenic action on changes in ecosystems is closely coupled to this topic. In this frame, studies of primary biological processes in marine pelagic systems with different basic settings on the transect along the African coast on leg 7/2a were linked to intense studies of trophic interactions in the Benguela region on the following legs of cruise 7.

The dynamic physical processes in the equatorial current system were studied by means of towed CTD and ADCP-systems. The physical and chemical variables in the northwest African upwelling, the Kongo- plume, the Angola-gyre and in the northern Benguela-region were recorded by CTDO-profiles and by nutrient-analyses in watersamples which serve the characterzation of source watermasses of the production systems and the hydrographical regime. The survey of structure and performance of microbial and microalgal communities and the interconnection of production– and decomposition-processes in the different areas on the track is supposed to resolve the question for the efficiency of biochemical drivers on primary processes in the food web. The quantitative balance between production and decomposition in the mixed layer was surveyed on the whole track by measuring partial pressure of CO_2.
An important driver for export production in nitrogen limited waters is the fixation of atmospheric nitrogen by cyanobacteria. On the cruise measurements of nitrogen fixation rates of these organisms were performed in order to compared them with basic settings of light and nutritive environment and the resulting patterns of isotopic composition in the produced organic substance. These studies are supposed to increase our knowledge on the influence of basic biogeochemical drivers on the function of the biological communities.
On the last part of this leg this question was reverted. Here the influence of different organismal distribution patterns on the composition and strenght of the exchange of elements between sediment and water were studied. Off the Kunene estuary in the Angolan/Namibian border region the abundance and diversity of the benthic community will be linked to the benthopelagic fluxes of oxygen and inorganic species of N,P and Si.

1.3 Narrative of the Cruise

The RV MARIA S. MERIAN left Las Palmas de Gran Canaria on Feb.19th at 1.30 a.m. and reached the first station in the upwelling region off Mauretania on Feb. 20th at 4.00 p.m. Water samples within the first 200 m of the water column were obtained with a CTD-rosette-sampler system, analyses of oxygen and inorganic plant nutrients were performed immediately and particulate material was filtrated for later analysis. Rate measurements for biological element turnover of microalgae and bacteria were performed within the surface mixed layer. Samples were taken for

molecular biological characterization of the microbial communities and the distribution of bacterio-chlorophyll was measured, the role of which in the production cycle is

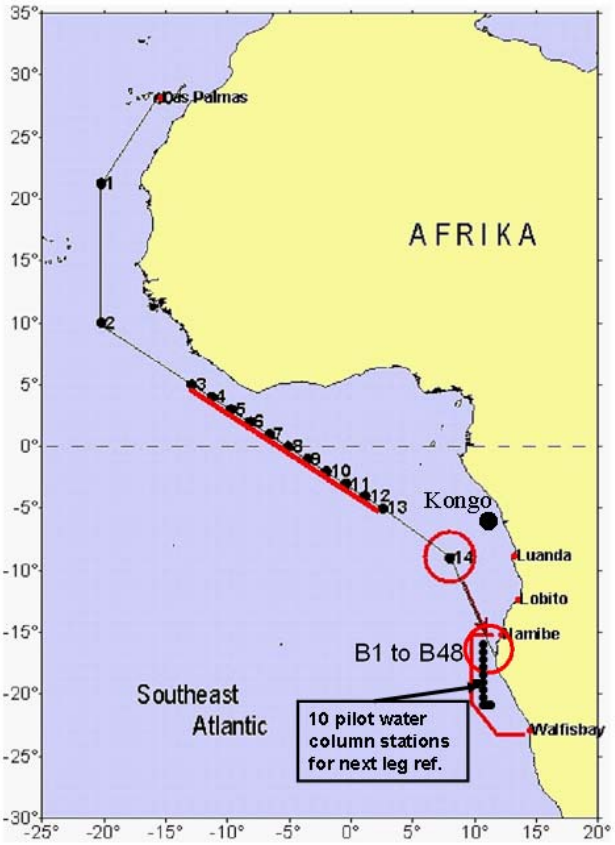

Figure 1.1: Cruise tracks and working areas of MSM 07 leg 2a within the PELA-GIMBER programme. The map shows the transect with stations in the NW-African upwelling (1), the equatorial current-system (3-13), the station in the Angola Gyre (14), the benthos-transect off the mouth of river Kunene (B1-B48) and pilot stations within the Benguela upwelling.

quite unclear. By means of a LADCP (Lowered Acoustic Doppler Current Profiler), attached to the CTD , current speed and direction in the top 500 m of the Water column was estimated.
This standard programme was repeated at a station within the Mauretanian EEZ at 19 °N, 19 ° W on the 21st and at a station at 10° N, 20° W on the 22nd of February. Temperature, salinity and partial pressure of CO_2 were estimated continuously in surface waters, provided research permits from national authorities were granted, when the cruise track touched territorial waters of African states.
From Feb. 24th until the 1st of March a transect through the equatorial current system was performed , employing towed instruments (ADCP and Scanfish) and discrete water stations down to 500 m depth every 0.5 degree. At these stations the full set of biological and chemical measurements was caried out as described above, so that a well resolved description of the aequatorial system in terms of physical and biogeochemical variables is expected.
After the equatorial transect a single station in the central Angola Gyre at 9° S, 8° E was studied with a hydrocast down to 1500 m depth on the 2nd of March.
On the 4th of March benthic work started at the northern part of the Namibian coast southwards of the Kunene rivermouth. Here, on a coast-near grid of 20 stations between 17° 16’ S and 17° 25’ S biological samples were obtained with grab sampler , multicorer and dredge. At every station the watercolumn was sampled for dissolved and particulate constituents as well. At two stations single cores from the multicorer were incubated in a temperature-adapted room for 12

hours and the exchange between water and sediments in terms of oxygen, nitrate, phosphate and silica was examined. This part of the program was terminated at the 6th of March and the ship headed towards Walvis Bay.
On the track along the coast on the 200 m isobath hydrographical measurements were performed very 20 miles in order to characterize the regional water mass distribution at this time of the year and provide these data for the next leg, which was concerned with the local biogeochemical processes in the Benguela region. The ship reached Walvis Bay on the 8th of March after a successful cruise with an accomplished programme according to plan and no problems at all.

1.4 Preliminary Results

1.4.1 Hydrography

(M. Schmidt, V.Mohrholz, T.Heene)

The Equatorial Transect:
The LADCP measurements reveal the typical equatorial current system. The Equatorial Undercurrent with an NEE-ward core velocity of 1ms^{-1} in 50 m depth. A westward surface current was not found at the equator but displaced southward at 2°S. At the equator in 450 m depth there is another westward current with about 0.3ms^{-1} current velocity. At about 2°N and 2°S westward the Equatorial Counter currents become visible (Fig. 1.2).

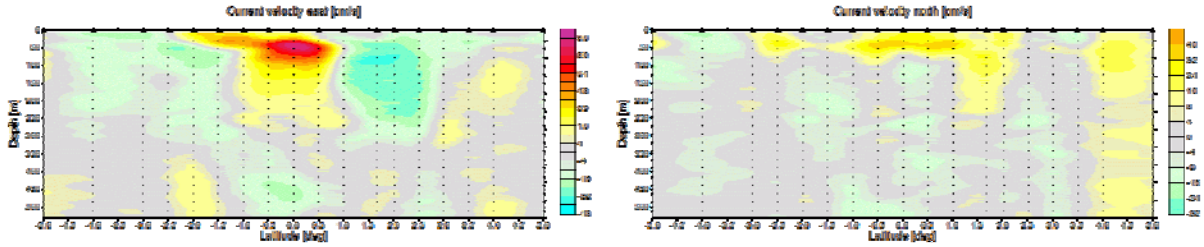

Figure 1.2: (left) and north components (right) of equatorial subsurface currents measured with the LADCP. off the mouth of river Kunene (B1-B48) and pilot stations within the Benguela upwelling.

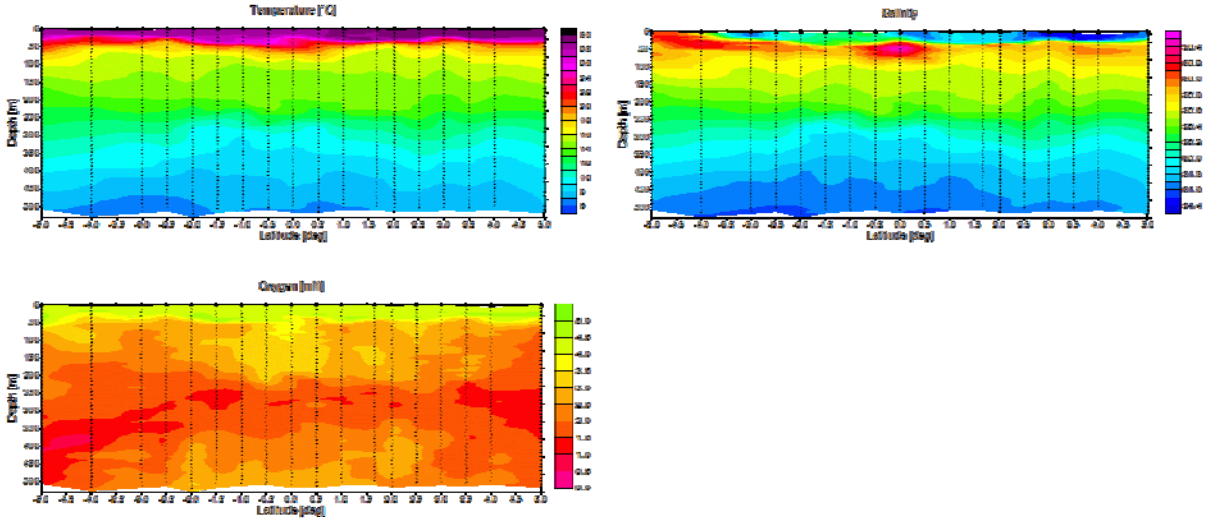

Figure 1.3: Temperature, salinity and oxygen at the equatorial transect measured with the CTD.

Temperature and salinity distribution show a strong stratification (Fig. 1.3). The surface layer is about 25 m thick and carries warm (29-30 °C) but less saline water. Surface salinity varies from

34.4 to 35.2. Below the surface layer at about 50 m - 100 m depth salinity is elevated, the maximum value is observed in the core of the Equatorial Undercurrent. At 4°S the saline layer reaches the surface. Below the saline layer salinity is slowly decreasing and reaches 34.5 in 500 m depth, which is typical for Antarctic Intermediate Water. Below 300 m depth the isotherms and isohalines show a doming, whereby minimum depth is found at about 1°S. At 5°N and 5°S water with the same salinity is found about 80 m deeper. The surface water is nearly saturated with oxygen, but oxygen concentration decreases rapidly below 50 m depth. Maximum concentrations are found in about 35 m depth where the deep chlorophyll maximum is located (Fig. 1.4). The minimum concentration of less then 2ml l^{-1} occurs in 250 m depth. At 4°S and 5°S the minimum concentration is less then 1ml l^{-1}. This water masss constitutes the oxygen minimum zone in the Angola Gyre.

The Angola Dome Area:
In the Angola Dome only one hydrographic station was sampled. Measurements were extended to 1500 m to get also samples for oxygen, nutrient and density measurements from the Antarctic Intermediate Water and North Atlantic Deep Water. The profiles for temperature, salinity and oxygen concentration down to 1500 m depth and for the surface 150 m of fluorescence and the related oxygen saturation are shown in Figure 1.4. a and b

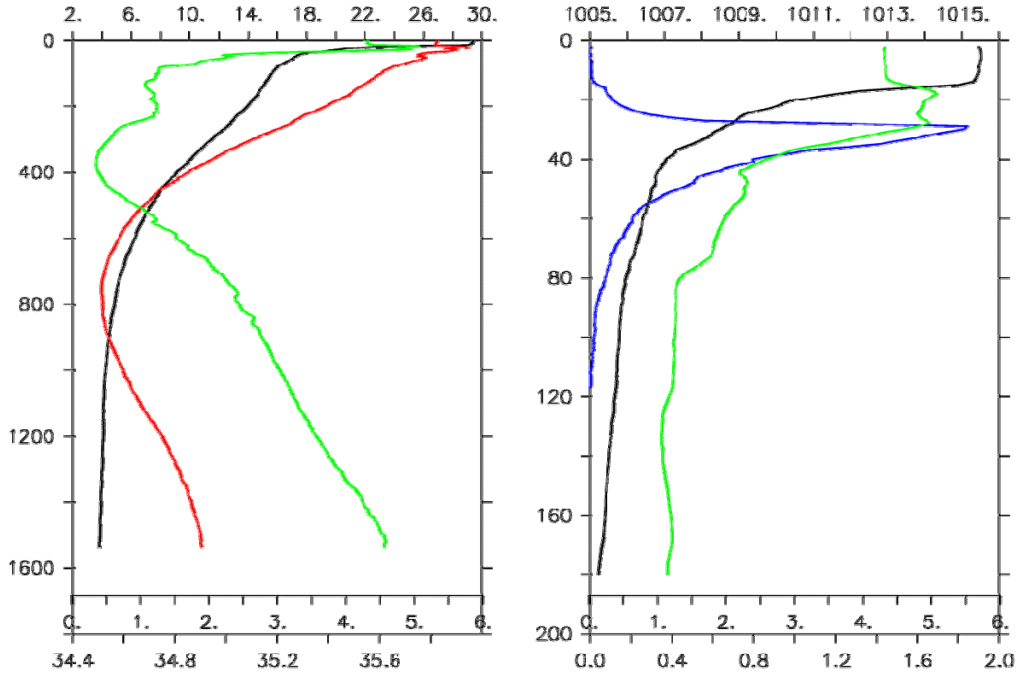

Figure 1.4: Vertical profiles of temperature (black), salinity (red), oxygen concentration (green) in the upper 1500 m (left figure) and density (black), fluorescence (blue) and oxygen concentration (green) (right figure) in the surface 150 m of the Angola Dome area.

The vertical profile shows the salinity maximum at the surface, kept stable by the high sea surface temperature and the typical salinity minimum in the Antarctic Intermediate Water. The oxygen concentration is high in the surface water but decreases rapidly below the thermocline towards a minimum concentration in about 390 m depth. Resolving the upper layer reveals a strong pynocline at 18 m depth generated by strong solar surface heating. Fluorescence is minor in the surface layer but has a deep maximum at about 40 m depth well below the pycnocline. There is a maximum of oxygen oversaturation below the basis of the pycnocline which seems to correspond to the upper part of the fluorescence peak. In the fluorescence peak itself oxygen is not saturated (not shown) and is decreasing rapidly with depth below the fluorescence maximum. Hence, immediately after sunset respiration or mineralisation processes outweight oxygen

release from primary production below the fluorescence maximum. Similar profiles are found at other near equatorial stations.

The Angola-Benguela Frontal Zone:
Temperature and salinity distribution show a strong stratification. The surface layer is about 25 m thick and carries warm (21-24 °C) water. Surface salinity varies from 35.3 in the south to 35.9 in the north, where patches of more saline water are met. Between 50 m and 100 m depth several salinity maxima and minima show the ventilation of the shelf with different water bodies. At 18°S in 120 m depth less saline, colder and oxygenized water seems to ventilate the shelf area.

1.4.2 . Chemical Oceanography

(F.Pollehne, R.Schmidt, A.Hagenmeier, G.Jost)

Nutrients and oxygen :
Concentrations of oxygen and inorganic dissolved nutrients (PO_4, NH_3, NO_2,NO_3, SiO_4) were measured photometrically at all stations. During the whole expedition titrated oxygen concentration corresponded well with the CTD-oxygen-sensors, so that a highly resolved dataset on lateral and vertical distribution of oxygen is available.

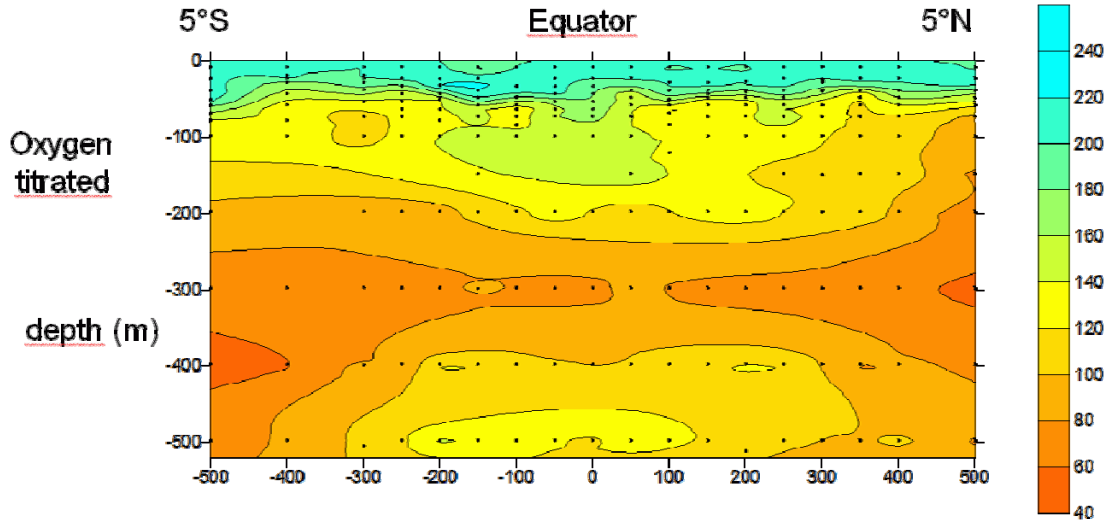

Figure 1.5: Oxygen concentrations (µmol) vs. depth (m) on the equatorial transect (+500 = 5°N, -500 = 5°S)

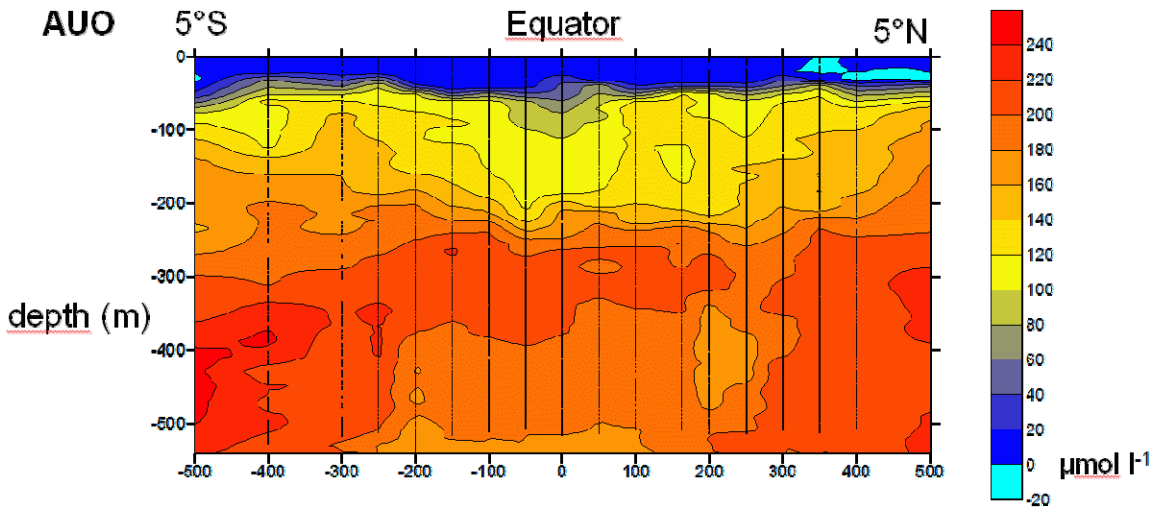

Figure 1.6: Apparent oxygen utilisation over the equatorial transect. (+500 = 5°N, -500 = 5°S)

Calculated AOU shows the highest gradient below the chlorophyll maximum layer at about 50 m, which is most probably due to the continuous input of fresh degradable organic matter, and the highest oxygen deficit at 300 -500 m , which is rather an effect of the age (time without contact to atmosphere) of the water mass.

In all measured chemical variables the physical structure of the equatorial current system with Equatorial Undercurrent, the Equatorial Countercurrents and a deeper westward undercurrent at 450 m depth beneath the equator becomes visible. Ratios of nitrogen to phosphorus (Fig. 1.7) in the tropical east atlantic top 500m are, with about 13.9 lower than "Redfield " beneath the deep chlorophyll maximum and decrease to < 10 in the surface mixed layer with still detectable amounts of free PO_4 at the surface.

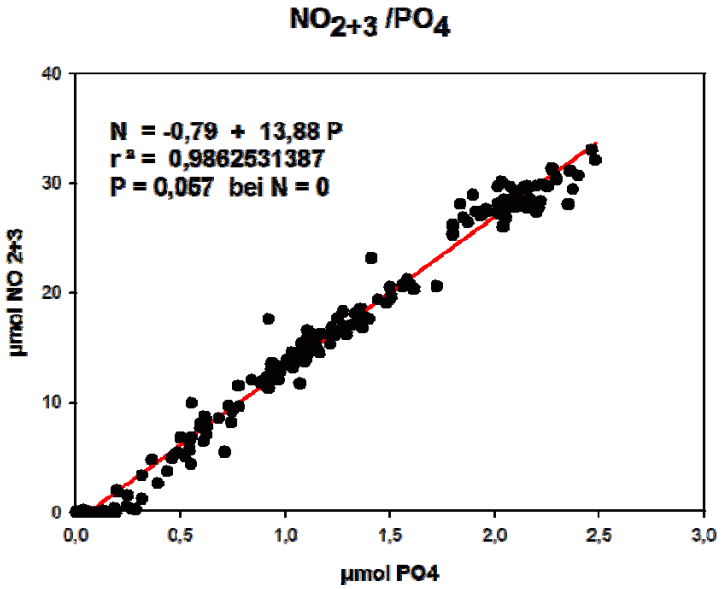

Figure 1.7: N/P relationship in inorganic dissolved species on all oceanic stations of the cruise (NH4 was always at the detection limit).

The linear slope of the N/P relationship throughout the oxygen minimum zone in the oceanic waters indicates, that nitrate is not used for the oxidation of organic matter. So the major source

of the high excess phosphate on the continental shelf off Namibia seem to be the sulfidic areas on the shelf and particularly the sediments.

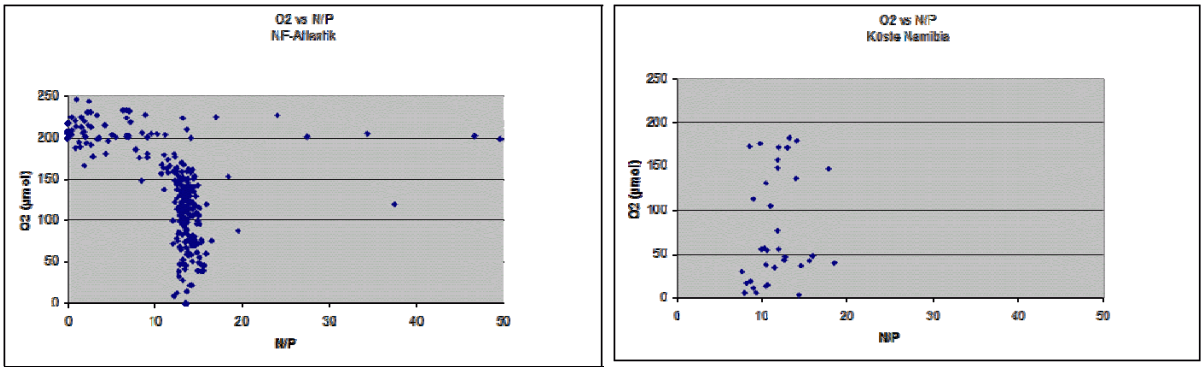

Figure 1.8: Plot of N/P in inorganic nutrients (NO3,NO2, NH4) agains oxygen in the open atlantic stations (left) and on the Namibian shelf (right). The large scatter at the ocean surface samples is due to the fact, that at some stations both N and P were at detection limit.

This becomes evident, when the N/P ratio of inorganic nutrients (NO_3,NO_2, NH_4) is plotted against oxygen concentrations in the water column. Whereas at the saturation level of oxygen in the surface waters of the open Atlantik the ratio tends to decrease because of a slight P accumulation, and remains stable at ~ 13.9 in the deeper water even at low oxygen, at the shelf stations the N/P ratio decreases from already low values of about 10 to ratios below 10 in the bottom water. Whereas NH_4-concentrations in the oceanic regions remained in the range below 1% of dissolved inorganic nitrogen, it contributed up to 10 % in the bottomwater of the shelf stations and therefore had to be considered in the comparison. A comparison between calculated AUO (apparent oxygen utilisation) and CO_2 is in progress.

CO_2-partial pressure:
Continuous measurements of the partial pressure of CO_2 and O_2 were used to calculate temporal changes of the dissolved inorganic carbon (DIC) and of the O_2 concentrations in the surface water. A budget for both CO2 and O_2 is established for time intervals of days to weeks resulting in two independent mass balance equations. These allow the determination of the mean transfer velocity, since at stable surface water stratification the major sink/source terms for CO2 and O2 are the air-sea flux and the biological production.
The pCO_2 measurements were performed by equilibration of surface water with air and detection of the equilibrium CO_2 concentration in air by a LI-7000 CO_2/H_2O analyzer (Licor Biosciences). The pO_2 was measured directly in the water phase in the equilibrator using the fiber-optic oxygen meter Fibox3 (PreSens). The water flux through the equilibrator was continuously supplied by the ships pure sea water centrifugal pump. Air measurements have been conducted once or twice per day.
Furthermore, 32 measurements of deep water (up to 340m) pCO_2 and pO_2 were performed. In these cases the water was supplied by the IOW pump-CTD system.
Additionally, 159 sub-surface water samples have been analyzed for DIC. The determination was performed on board as soon as possible, usually within a few hours, after sampling. The coulometric SOMMA system (Johnson et al., 1993) was used and calibrated with certified DIC reference material (CRM, Dr.A. Dickson, University of California, San Diego).
Last but not least an intercalibration experiment has been done to test the accuracy of the used optode. The measured oxygen concentrations of samples taken from 12 depths of a CTD cast were compared to Winkler measurements.

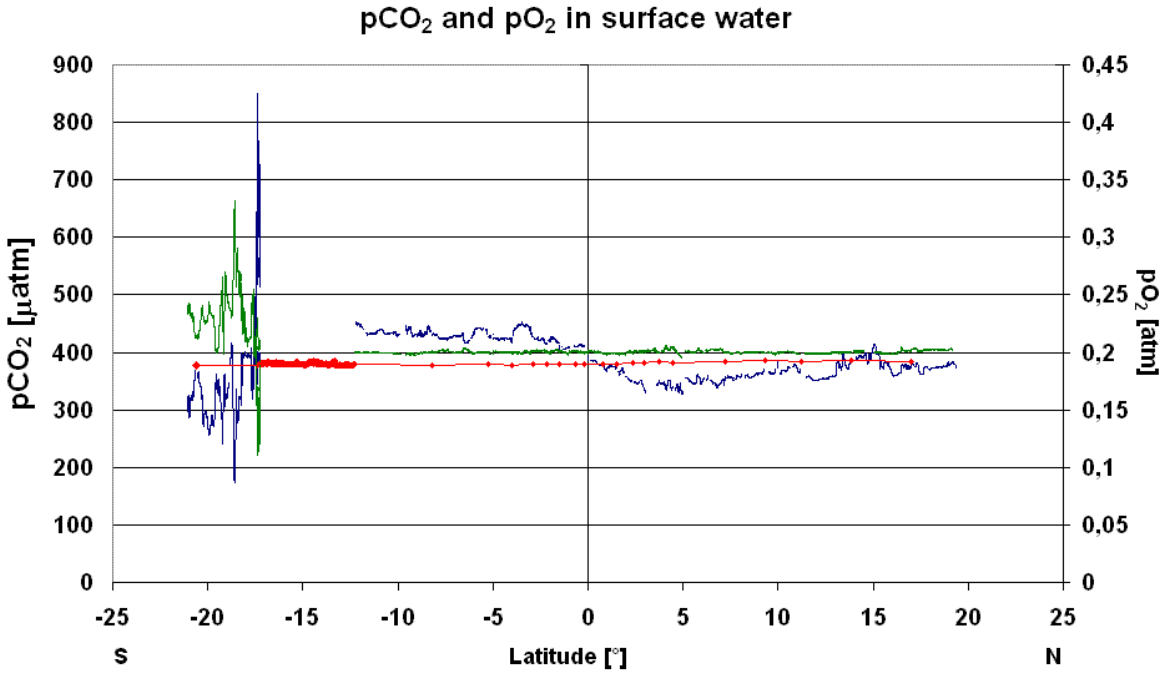

Figure 1.9: Continuous surface recordings of partial pressure of oxygen (green) and carbon dioxide (blue).Atmospheric saturation values are shown in red. Explanations see text.

The surface water in the northern hemiphere was undersaturated with CO_2 (blue) with regard to the atmosphere (red), while south of the equator it is supersaturated. Almost on the whole transect the surface water was equilibrated with oxygen (green). In the upwelling area off Namibia pCO_2 values of up to 850 µatm have been observed.
At approx. 20° south there was a typical bloom situation characterized by supersaturation of oxygen and a deficit in carbon dioxide. In the oxygen minimumzone sub-surface partial pressures of CO_2 of up to 1000 µatm could be measured.

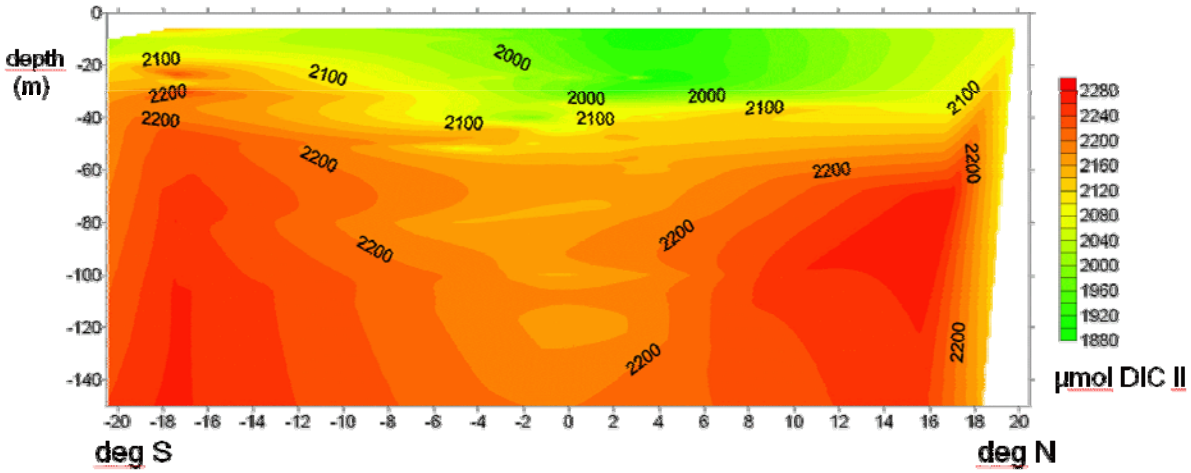

Figure 1.1: Concentrations of dissolved inorganic carbon (DIC) on a transect from 20°N (+20) to 20°S (-20).

The concentrations of DIC in surface water are lower in the northern hemisphere. In the upwelling region they are as high as in sub-surface water. Deeper water masses near the equator had lower concentrations of DIC than those of higher latitudes and corresponded well with AOU and oxygen measurements. Measurements of dissolved organic carbon (DOC) are in progress.

1.4.3. Primary production and nitrogen fixation

(N.Wasmund, U.Struck)

Altough the complete set of in-situ samples and experiments is not yet analyzed (about 20 % are still to be processed), a rather unexpected picture starts to emerge. In spite of excess orthophosphate in the mixed layer of all stations in the oligotrophic SE-Atlantik and particularly in the upwelling zone off Namibia, the measured nitrogen fixation rates remained at the detection limit. The isotopic signature (delta N-15) in particulate organic matter of the top 500 metres including the mixed layer was always in the range of normal food chain fractionation between 5 and 6 permill and therefore showed no indication of relevant N-fixation activities. Numerous experiments were performed in bulk samples, in fractions above and below 10 µm, in daylight and night experiments, but no relevant rates were encountered. The calculated fraction of organic nitrogen provided by N-fixation (calculated from PON-stock measurements and N-fix-rates) did not exceed fractions of a permill of the PON. Microscopic observations on board showed only occasional occurrences of *Trichodesmium spec.*, the prominent oceanic nitrogen fixing organisms, which, however, displayed morphological irregularities probably related to the missing ability to fix N at that time. Molecular biological analyses of NIF-genes in the different fractions are not yet available and will show, if there is at least a certain potential for nitrogen fixation. The initial hypothesis, that excess phosphate in surface waters close to a continent is necessarily generating nitrogen fixation could not be proven up to now. In the light of our results it seems, that excess phosphate is rather an indicator for the lack of nitrogen fixation, as it would otherwise be biologically "titrated" out of the surface water. The final assessment of this problem has to be suspended until the availability of all data.

Chlorophyll values of CTD-fluorescence probes corresponded quite well with laboratory measurements of extracted samples (Fig. 1.11) and showed the same general pattern over the transect.

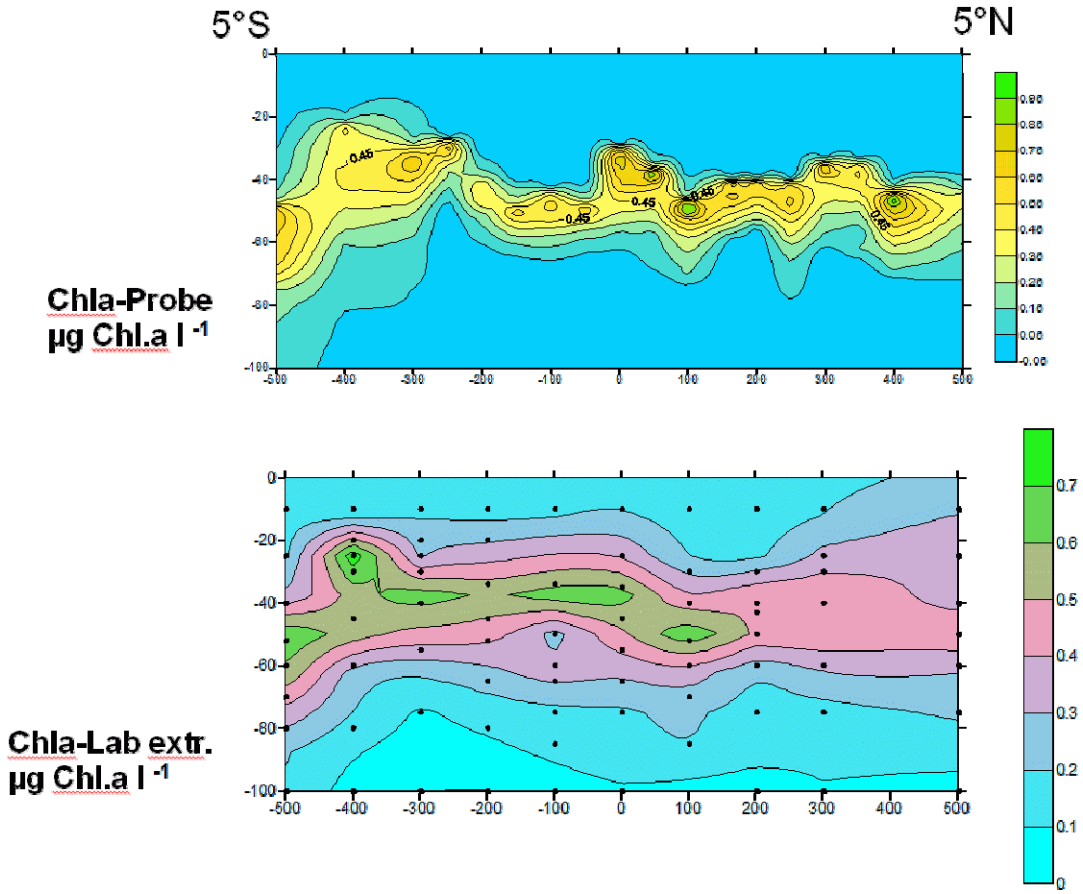

Figure 1.2: Comparison between Chl.a results of CTD-fluorescence probe and laboratory extraction method.

1.4.4. Bacteria , community respiration and bacterial production

(G.Jost)

During the cruise we measured community respiration by Winkler titration of 24 to 48 hours incubated dark bottles. An example shows the community respiration in the upper 100m along a transect across the equator (Fig. 1.12).

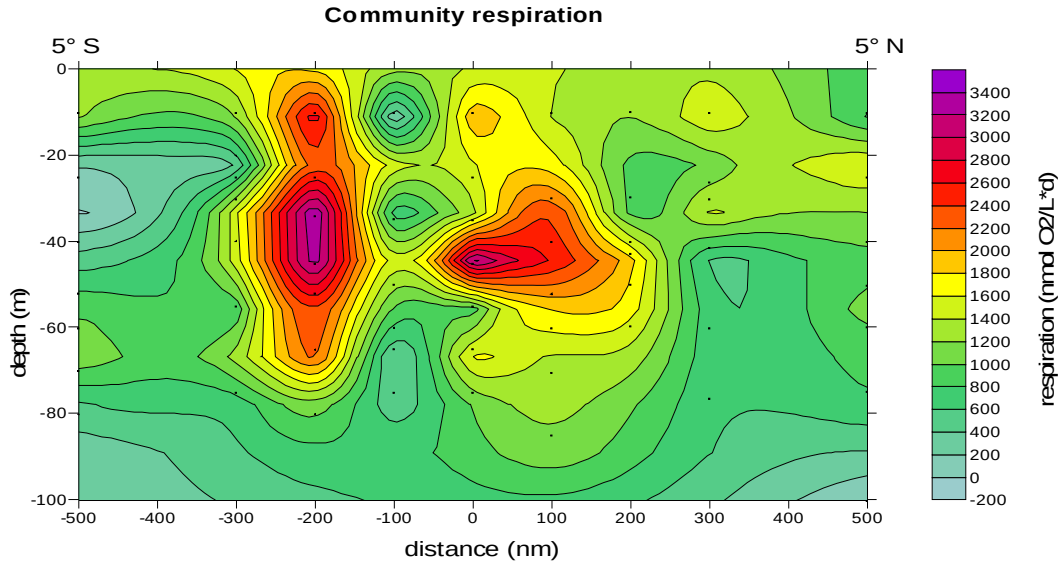

Figure 1.3: Community respiration at the equatorial transect

Higher values were either measured at the surface (10m) or between 30 and 50m. The highest oxygen consumption rate was 3.4 µM oxygen per day. The asymmetric picture with lower respiration at the northern part of this transect is also shown by other parameters. Oxygen consumption in deeper water layers was not detectable by this method.
Bacterial production measured by leucine incubation was in the range of less than 1 nM C per day in water depths between 100 and 200 m (not shown). At the equatorial transect highest values were measured with 20 nM C per day at 35m depth (Fig.1.13).

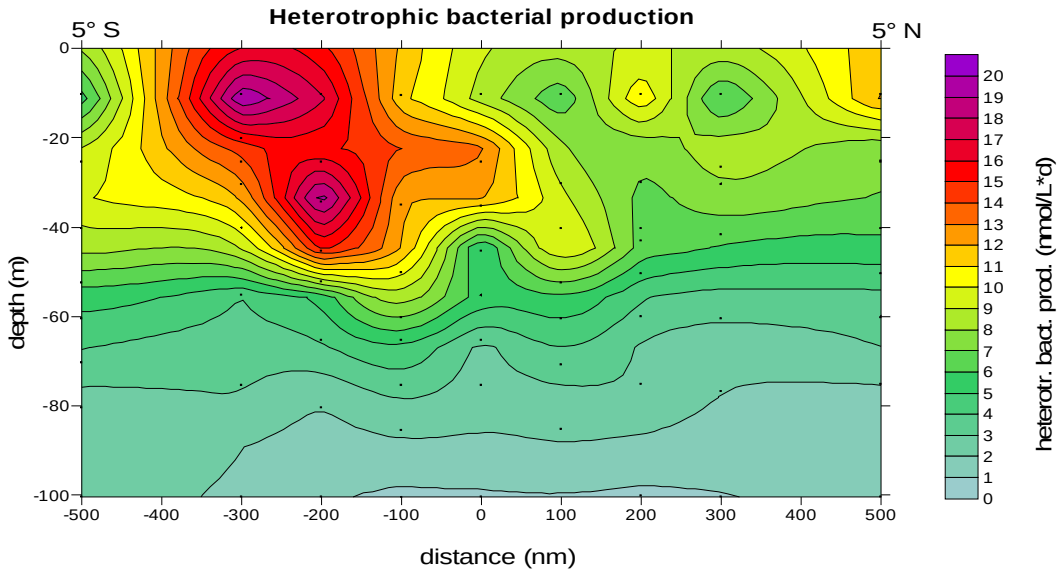

Figure 1.4: Production of heterotrophic bacteria at the equatorial transect based on leucine incorporation.

Higher bacterial production was generally restricted to the upper 50m of the water column. As already stated for community respiration, also bacterial production was higher at the southern part of the transect.Measurements of bacterial production at a shelf station in front of the Kunene river (not shown) were about 8 to 10 times higher as at the transect.
Based on bacterial counting by flow cytometry and bacterial production, bacterial turnover times were calculated. The shortest turnover times on the transect were in the very high range of about one month. Even at the shelf, this time was in the range of several days. Bacterial numbers and activity parameters did not always match.

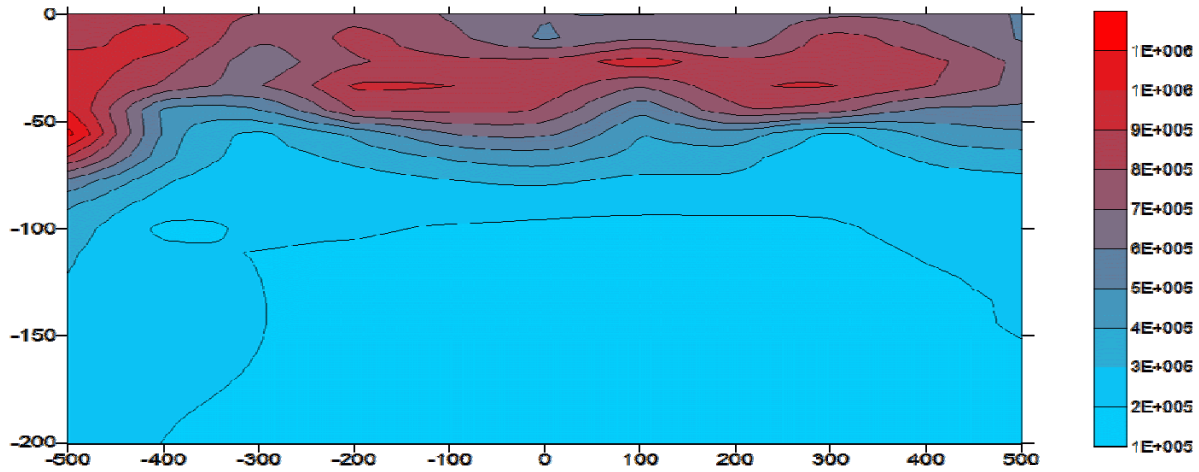

Figure 1.5: Bacterial numbers on the equatorial transect (+500 = 5°N, -500 = 5°S)

1.4.5. Bacteriochlorophyll *a* concentrations in the South Atlantic

(M.Labrenz, C.Berg, H.Johansen)

Aerobic anoxygenic phototrophic bacteria (AAP) exhibit the ability of both living under aerobic conditions and using light for driving energy-consuming processes via ATP production. During the cruise the distribution of bacteriochlorophyll *a* (Bchl *a*) referring to the abundance of AAPs in the South Atlantic with emphasis on an equatorial transect was studied. The goal was to both investigate the day/night regeneration characteristics and the vertical distribution of Bchl *a* in the water column.Along the cruise route samples for Bchl *a* analysis were taken at 20 stations for the vertical profile including 11 stations within the equatorial transect from 4°59'N 12°54'W to 4°59'S 02°35'E. Samples from the surface water (depth 5 m) were taken daily every 6 hours throughout the cruise at 5 a.m., 11 a.m., 5 p.m. and 11 p.m. Overall Bchl *a* concentrations were measured directly by a fluorometer at 830 nm against a blank from 300 m depth. In order to inhibit absorption by phytoplankton 15 µl DCMU were added to 150 ml sample volume prior to measurement.
Phytoplankton chlorophyll concentrations were separately measured with a PhytoPAM Analyzer.For analysis of the microbial diversity 1 litre of sample water was filtrated through 0.2 µm filters. These were quick-frozen at -196° C and afterwards stored at -20° C for molecular analysis.In addition 4 ml were fixated with 0.5 ml paraformaldehyde and glutaraldehyde (P+G) for total cell number quantification via flow cytometry. 100 ml of formaldehyde fixated samples were filtered through 0.2 µm filters for fluorescence in situ hybridisation (FISH). 10 ml volume was fixated with 0.5 ml formaldehyde for cell number quantification of Bchl *a* containing cells.
Along the equatorial transect samples were taken with a station density of 01° latitude from 05° N to 05° S by a CTD with attached water bottles. The depths that have been sampled for Bchl *a* investigation ranged from 10 to 200 m. Each depth was examined with the methods described above.
In order to study the regeneration or degradation of Bchl *a* a volume of 2 litres untreated water sample was incubated in closed glass bottles swimming in boxes filled with surface water. Environmental temperature was maintained by a pump system letting circulate ocean water through the box. The box was covered with transparent foil. Sub samples were taken to measure Bchl *a* concentrations during incubation time.

Concentrations of Bchl *a* in the surface water along the equatorial transect varied during daytime. Higher concentrations were measured at 5 and 11 a.m. whereas in the second half of the day Bchl *a* concentrations decreased to average values of 5 ng/l (Fig. 1.15). This suggests a regeneration phase of Bchl *a* in the late night/early morning.

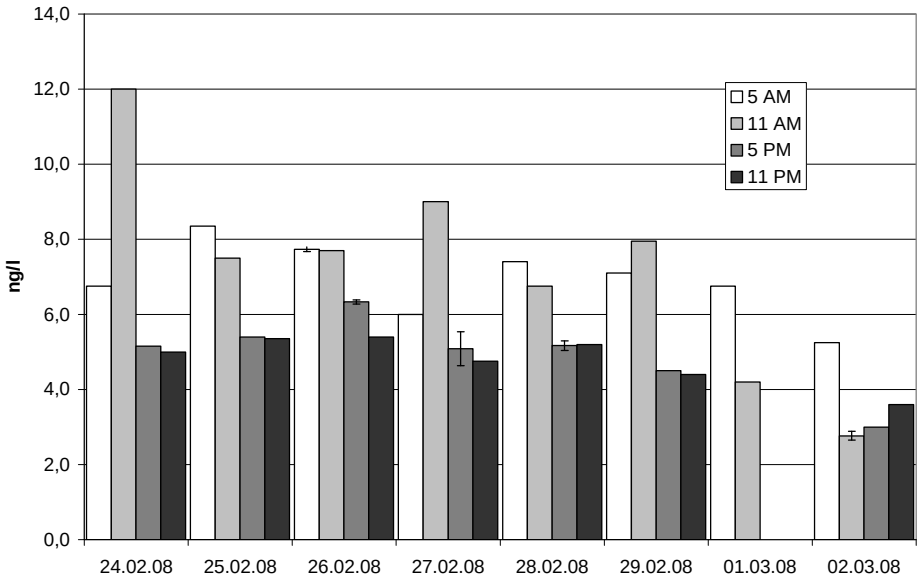

Figure 1.6: Bchl a concentrations in the surface water along the equatorial transect over time.

The Bchl *a* maximum was located slightly above the zone in which the Chl concentration of phytoplankton reaches its maximum.
Highest concentrations were measured between 30 and 40 metres of depth at 2° N (Fig. 1.16). Another maximum was located between 40 and 50 metres in the south equatorial current (SEC) at 1° S and in 50 m at 5° S.

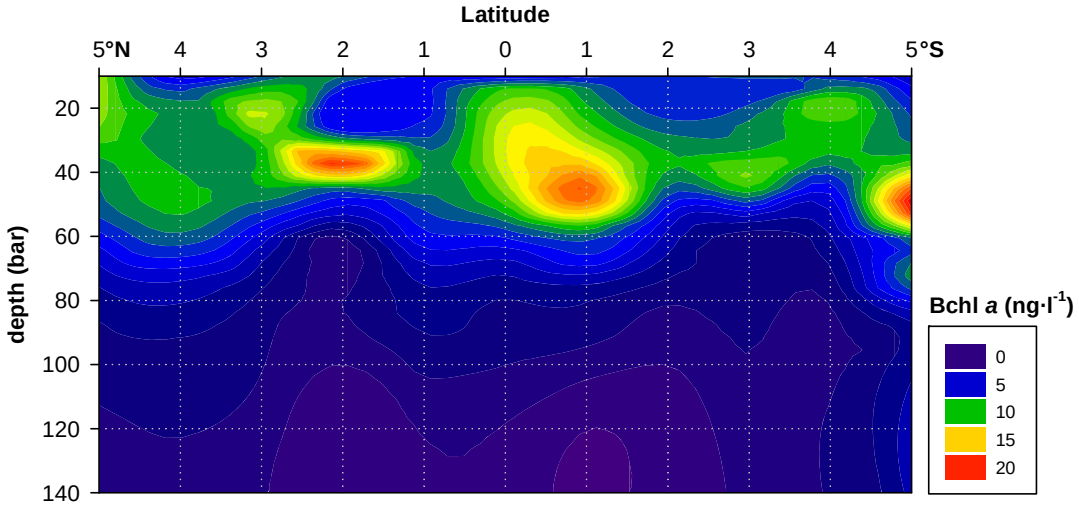

Figure 1.7: Bchl a concentrations within the water column along the equatorial transect in february/ march 2008. The resolution of the sampling stations is 1° latitude. Vertically 9 depths have been sampled with focus on the upper 100 m.

1.4.6.Benthic surveys in coastal waters off Namibia

(M. Zettler, U.Hehl, F.Pollehne)

Until now the analysis of 76 replicates and the 19 dredge samples is not completed. Both subarctic and subtropic taxonomical groups are to be expected in the waters off Namibia. Most of the sampled station were situated within the mud belt off Namibia. Only two stations (shallower 30 m) had more diverse substrates. Whereas the mud stations were characterised by a typically low diverse species community (dominated by *Nuculana bicuspidata* and *Nassarius*

sp.) the near coastal shallow stations showed benthic assemblages with a much higher diversity. Typical species were the lamp shell (Brachiopoda) *Discinisca tenuis* which built thick layers of living and empty shells. This shell layer serves as substrate for a high amount of other epi- and endobenthic species like brittle stars (*Amphiura* sp. and *Ophiura* sp.), amphipods and polychaetes.

Figure 1.8: The macrozoobenthos was sampled by a 0.1 m² van Veen grab (left) and by using a dredge (right).

Figure 1.9: left: Dominant members of the benthic community in the muddy sediments off Namibia in water depths between 30 and 120 m are the bivalve Nuculana bicuspidata and the gastropod *Nassarius cf. incrassatus*). right: Contrary to the deeper muddy stations the near coastal shallow stations (<30 m water depth) were mainly colonised by the lamp shell *Discinisca tenuis*. This substrate were used by a lot of other epibenthic species like ophiurids and gastropods.

Experiments

By using a multicorer at two stations sediment cores were sampled. At each three replicates were stored in a cooling room (15°C) for measurements of oxygen consumption and nutrient fluxes. At the beginning and after 12 h of exposition these parameters were analysed. The sediments were extremely muddy and rich in organic matter even at coastal stations, which were exposed to wave action. This led to anoxic conditions with free hydrogen sulfide just below the sediment surface. Nevertheless a large amount of clams and snails with a restricted diversity inhabit this area, which obviously can cope with the reduced oxygen concentrations in the bottom water. Here a clear decrease of the nitrate values towards the sediment could be observed, which indicates high sedimentary denitrification rates. The role of the macrofauna in this process is not yet clear but the very high exchange rates between sediment and water in the incubation experiments indicate a dominant role of these organisms in the transport of interstitial water.

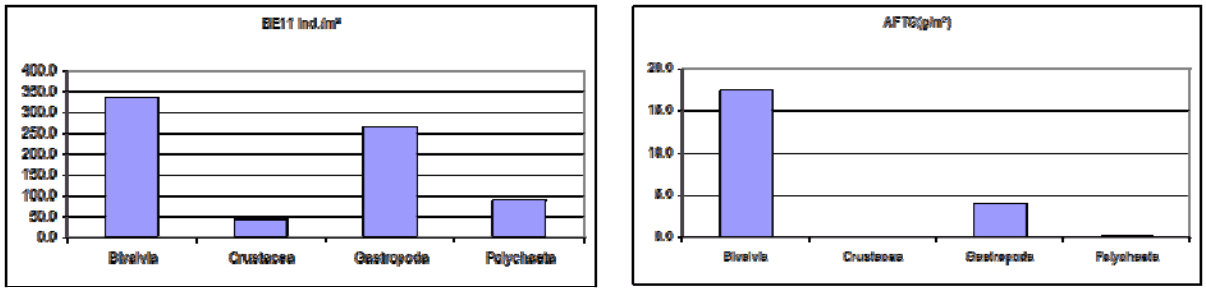

Figure 1.10: Macrofauna abundance (left) and biomass (right) at one station (St. B11, 75 m water depth) in the mudbelt off northern Namibia.

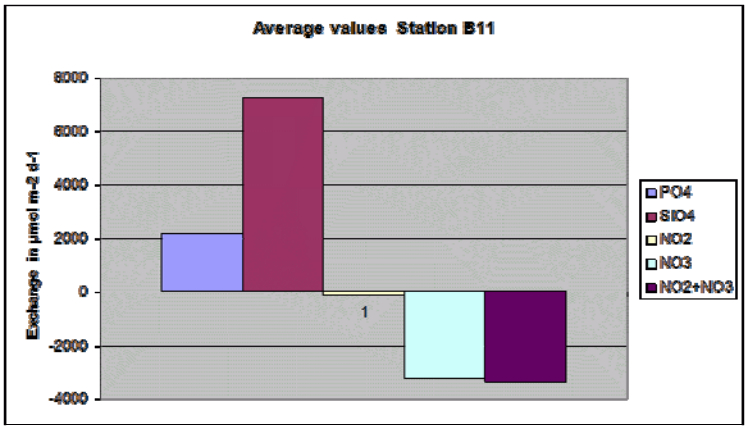

Figure 1.11: Sediment /water exchange of plant nutrients at station B11. Loss of nitrate amounted to about 3 mmol m-2 d-1, whereas sedimentary output of Si and P came up to 7 and 2.1 mmol m-2 d-1 respectively.

State of the evaluation

Analysis of collected samples are nearly finished. After completion we will be able to construct carbon budgets for north- and southequatorial waters and relate differences in stocks of bulk variables to disequilibria in production/decomposition dynamics of pelagic auto- and heterotrophs.

1.5 Station List MSM 07/2a

Station No.	Date	Time [UTC]	Position Lat	Position Lon	Depth [m]	Windstrength [m/s]	Course [°]	Speed [kn]	Gear
MSM7/001-1	20.02.2008	16:43	19° 56,87' N	18° 45,10' W	2824.8	ENE 6	311.7	-0.1	CTD/rosette water sampler
MSM7/001-1	20.02.2008	17:03	19° 56,87' N	18° 45,10' W	2824.1	ENE 5	314.9	0.7	CTD/rosette water sampler
MSM7/001-1	20.02.2008	17:13	19° 56,87' N	18° 45,10' W	2824.6	ENE 5	330	0.2	CTD/rosette water sampler
MSM7/001-2	20.02.2008	17:55	19° 56,87' N	18° 45,10' W	2824.8	ENE 5	172.8	0.8	CTD/rosette water sampler
MSM7/001-2	20.02.2008	18:13	19° 56,87' N	18° 45,10' W	2823.9	ENE 5	194.6	0.2	CTD/rosette water sampler
MSM7/001-2	20.02.2008	18:22	19° 56,87' N	18° 45,10' W	2824.9	NE 6	86.7	0.6	CTD/rosette water sampler
MSM7/002-1	21.02.2008	08:14	16° 59,62' N	19° 7,85' W	3345.3	NE 7	2.3	0.5	CTD/rosette water sampler
MSM7/002-1	21.02.2008	08:39	16° 59,62' N	19° 7,85' W	3346.7	NE 6	143.3	0.3	CTD/rosette water sampler
MSM7/002-1	21.02.2008	08:59	16° 59,62' N	19° 7,85' W	3346.6	NE 7	132.3	0.4	CTD/rosette water sampler
MSM7/002-2	21.02.2008	09:23	16° 59,62' N	19° 7,85' W	3345.8	ENE 6	327.6	0.4	CTD/rosette water sampler
MSM7/002-2	21.02.2008	09:44	16° 59,62' N	19° 7,85' W	3345.7	ENE 7	106.8	0.4	CTD/rosette water sampler
MSM7/002-2	21.02.2008	09:51	16° 59,62' N	19° 7,85' W	3345.8	ENE 7	338.6	0.3	CTD/rosette water sampler
MSM7/003-1	22.02.2008	16:45	9° 59,80' N	19° 59,94' W	4460.1	N 7	210.1	0.9	IOW Pump-CTD/Rosette
MSM7/003-2	22.02.2008	16:56	9° 59,64' N	19° 59,98' W	4471.3	NNW 8	205.2	1.2	CTD/rosette water sampler
MSM7/003-2	22.02.2008	17:25	9° 59,18' N	20° 0,10' W	4408	N 7	185.9	1.2	CTD/rosette water sampler
MSM7/003-2	22.02.2008	17:44	9° 58,96' N	20° 0,16' W	4409	NNW 7	199.8	0.6	CTD/rosette water sampler
MSM7/003-3	22.02.2008	18:01	9° 58,69' N	20° 0,20' W	4419.7	NNW 6	196.6	1.3	CTD/rosette water sampler
MSM7/003-3	22.02.2008	18:16	9° 58,45' N	20° 0,28' W	4427.4	NNW 6	191.2	1.4	CTD/rosette water sampler
MSM7/003-3	22.02.2008	18:23	9° 58,36' N	20° 0,30' W	4428.5	NNW 5	183.5	1.1	CTD/rosette water sampler
MSM7/003-1	22.02.2008	18:31	9° 58,24' N	20° 0,32' W	4433.6	NNW 6	181.2	1.2	IOW Pump-CTD/Rosette
MSM7/003-1	22.02.2008	19:08	9° 57,75' N	20° 0,20' W	4413.4	NNW 5	172.6	0.7	IOW Pump-CTD/Rosette
MSM7/004-1	24.02.2008	08:19	5° 0,09' N	12° 54,97' W	4109	W 5	119.5	0.8	IOW Pump-CTD/Rosette
MSM7/004-1	24.02.2008	08:42	5° 0,00' N	12° 54,68' W	4506.5	WNW 5	131.4	1.1	IOW Pump-CTD/Rosette
MSM7/004-2	24.02.2008	09:05	4° 59,81' N	12° 54,38' W	4477.7	W 4	117.8	0.9	CTD/rosette water sampler
MSM7/004-2	24.02.2008	09:29	4° 59,76' N	12° 54,23' W	4476.8	WNW 4	117.4	0.9	CTD/rosette water sampler
MSM7/004-2	24.02.2008	09:43	4° 59,75' N	12° 54,13' W	4474.8	WNW 4	104	0.9	CTD/rosette water sampler
MSM7/004-1	24.02.2008	09:46	4° 59,74' N	12° 54,11' W	4474.5	WNW 4	95.3	0.2	IOW Pump-CTD/Rosette
MSM7/005-1	24.02.2008	18:36	4° 0,07' N	11° 16,07' W	4030.7	W 4	194.5	0.4	CTD/rosette water sampler
MSM7/005-1	24.02.2008	18:54	4° 0,07' N	11° 16,07' W	4030.9	WNW 5	351.1	0.3	CTD/rosette water sampler
MSM7/005-1	24.02.2008	19:06	4° 0,07' N	11° 16,07' W	4030.7	WNW 5	105.3	0.4	CTD/rosette water sampler
MSM7/005-2	24.02.2008	19:10	4° 0,08' N	11° 16,07' W	4030.4	W 5	329.5	0.5	Plankton net
MSM7/005-2	24.02.2008	19:13	4° 0,08' N	11° 16,06' W	4030.6	W 4	109.8	0.8	Plankton net
MSM7/005-3	24.02.2008	19:20	4° 0,10' N	11° 16,01' W	4031.1	W 5	73.3	0.6	ADCP Katamaran
MSM7/005-4	24.02.2008	19:33	3° 59,66' N	11° 15,53' W	4036.8	W 6	122.3	4.8	Scan-Fish
MSM7/005-3	24.02.2008	19:43	3° 59,19' N	11° 14,81' W	4029.4	WSW 6	125.7	6	ADCP Katamaran
MSM7/005-4	24.02.2008	19:57	3° 58,21' N	11° 13,32' W	4037.6	WSW 5	122	8.8	Scan-Fish
MSM7/005-4	24.02.2008	20:46	3° 54,61' N	11° 7,77' W	4014	SW 6	123.8	8	Scan-Fish
MSM7/005-4	24.02.2008	21:13	3° 52,82' N	11° 5,01' W	4017.5	WSW 5	118.6	4.2	Scan-Fish
MSM7/005-3	25.02.2008	02:43	3° 29,80' N	10° 29,58' W	4556	SW 6	82.5	0.5	ADCP Katamaran
MSM7/005-5	25.02.2008	02:54	3° 29,82' N	10° 29,55' W	4593.9	SW 6	110.2	0.7	CTD/rosette water sampler
MSM7/005-5	25.02.2008	03:10	3° 29,82' N	10° 29,55' W	4553.3	SW 5	334.6	0.7	CTD/rosette water sampler
MSM7/005-5	25.02.2008	03:21	3° 29,82' N	10° 29,55' W	4553.1	SW 5	357.6	0.8	CTD/rosette water sampler
MSM7/005-6	25.02.2008	03:33	3° 29,75' N	10° 29,41' W	4512.6	WSW 6	122.7	3.3	ADCP Katamaran
MSM7/005-6	25.02.2008	03:39	3° 29,35' N	10° 28,76' W	4535.1	WSW 6	121.9	8.6	ADCP Katamaran
MSM7/005-6	25.02.2008	10:44	3° 0,01' N	9° 43,40' W	4728.6	SW 6	95.3	0.8	ADCP Katamaran
MSM7/006-1	25.02.2008	10:54	3° 0,01' N	9° 43,39' W	4729.7	SW 6	59.6	0.3	CTD/rosette water sampler
MSM7/006-1	25.02.2008	11:14	3° 0,12' N	9° 43,24' W	4726.2	SW 6	2.7	0.6	CTD/rosette water sampler
MSM7/006-1	25.02.2008	11:29	3° 0,23' N	9° 43,24' W	4726.6	SW 7	10.4	1.1	CTD/rosette water sampler
MSM7/006-2	25.02.2008	11:51	3° 0,42' N	9° 43,04' W	4729.6	SW 6	33.2	0.5	CTD/rosette water sampler
MSM7/006-2	25.02.2008	12:08	3° 0,55' N	9° 42,97' W	4728.8	WSW 5	17.6	0.4	CTD/rosette water sampler
MSM7/006-2	25.02.2008	12:33	3° 0,72' N	9° 42,85' W	4727	SW 6	49.5	1	CTD/rosette water sampler
MSM7/006-3	25.02.2008	12:46	3° 0,69' N	9° 42,73' W	4728.5	SW 5	162.2	1.2	ADCP Katamaran
MSM7/006-3	25.02.2008	13:01	2° 59,33' N	9° 42,62' W	4731.5	SW 6	136.3	6.3	ADCP Katamaran
MSM7/006-3	25.02.2008	20:02	2° 30,21' N	8° 57,38' W	4814.6	SW 5	129	1.5	ADCP Katamaran
MSM7/006-4	25.02.2008	20:06	2° 30,14' N	8° 57,30' W	4814.7	SW 6	113.5	1.8	CTD/rosette water sampler
MSM7/006-5	25.02.2008	20:07	2° 30,13' N	8° 57,27' W	4815	SW 6	108.1	1.8	Plankton net
MSM7/006-5	25.02.2008	20:10	2° 30,13' N	8° 57,22' W	4814.7	SW 6	30.2	0.5	Plankton net
MSM7/006-6	25.02.2008	20:11	2° 30,15' N	8° 57,21' W	4814.9	SW 6	24.3	0.9	Plankton net
MSM7/006-6	25.02.2008	20:13	2° 30,17' N	8° 57,20' W	4814.7	SW 5	18.1	1.3	Plankton net
MSM7/006-4	25.02.2008	20:32	2° 30,41' N	8° 57,09' W	4814.6	SSW 7	329.3	0.7	CTD/rosette water sampler
MSM7/006-4	25.02.2008	20:43	2° 30,53' N	8° 57,17' W	4813.2	SSW 6	332.7	0.8	CTD/rosette water sampler
MSM7/006-7	25.02.2008	20:50	2° 30,63' N	8° 57,18' W	4812.3	SSW 6	17.8	0.3	ADCP Katamaran
MSM7/006-7	25.02.2008	20:54	2° 30,63' N	8° 57,07' W	4813.2	S 5	123.1	3.9	ADCP Katamaran

MSM7/006-7	26.02.2008	04:04	2° 0,20' N	8° 10,76' W	5107.5	SSW 5	35.2	2.3	ADCP Katamaran
MSM7/007-1	26.02.2008	04:13	2° 0,39' N	8° 10,67' W	5102.8	SSW 6	343.9	0.9	IOW Pump-CTD/Rosette
MSM7/007-1	26.02.2008	04:31	2° 0,54' N	8° 10,68' W	5100	SW 6	264	0.2	IOW Pump-CTD/Rosette
MSM7/007-1	26.02.2008	04:39	2° 0,58' N	8° 10,73' W	5101.7	SW 6	336.8	0.4	IOW Pump-CTD/Rosette
MSM7/007-2	26.02.2008	04:46	2° 0,64' N	8° 10,75' W	5094	SSW 7	351.6	0.7	IOW Pump-CTD/Rosette
MSM7/007-2	26.02.2008	04:57	2° 0,72' N	8° 10,75' W	5102.2	SSW 6	316	0.7	IOW Pump-CTD/Rosette
MSM7/007-3	26.02.2008	05:14	2° 0,90' N	8° 10,79' W	5088.7	SSW 6	358	0.9	CTD/rosette water sampler
MSM7/007-3	26.02.2008	05:36	2° 1,25' N	8° 10,81' W	5098.8	SSW 6	350.7	1	CTD/rosette water sampler
MSM7/007-3	26.02.2008	05:47	2° 1,36' N	8° 10,87' W	5097.9	SW 6	334.9	0.4	CTD/rosette water sampler
MSM7/007-2	26.02.2008	05:58	2° 1,47' N	8° 10,91' W	5097.2	SW 6	343.3	0.5	IOW Pump-CTD/Rosette
MSM7/007-4	26.02.2008	06:05	2° 1,54' N	8° 10,82' W	5097.1	SW 6	127.4	0.9	ADCP Katamaran
MSM7/007-4	26.02.2008	06:14	2° 0,96' N	8° 10,60' W	5098.4	SW 7	151.6	7.9	ADCP Katamaran
MSM7/007-4	26.02.2008	11:13	1° 40,23' N	7° 39,29' W	3563.6	SW 4	118.3	1.1	ADCP Katamaran
MSM7/007-4	26.02.2008	11:16	1° 40,21' N	7° 39,25' W	4924.7	SSW 4	122.9	0.3	ADCP Katamaran
MSM7/007-5	26.02.2008	11:21	1° 40,20' N	7° 39,21' W	4875.8	SSW 4	61.7	0.4	CTD/rosette water sampler
MSM7/007-5	26.02.2008	11:41	1° 40,37' N	7° 39,13' W	4870.7	SSW 4	331	0.5	CTD/rosette water sampler
MSM7/007-5	26.02.2008	11:53	1° 40,45' N	7° 39,13' W	4823.6	SW 4	21.8	1.1	CTD/rosette water sampler
MSM7/008-1	26.02.2008	17:50	1° 0,02' N	6° 35,16' W	5134.8	SSW 5	73.7	0.5	IOW Pump-CTD/Rosette
MSM7/008-1	26.02.2008	18:14	1° 0,16' N	6° 35,23' W	5136.6	SSW 5	222.4	0.2	IOW Pump-CTD/Rosette
MSM7/008-2	26.02.2008	18:38	1° 0,23' N	6° 35,25' W	5134.1	SW 5	348.8	0.5	CTD/rosette water sampler
MSM7/008-2	26.02.2008	18:56	1° 0,38' N	6° 35,36' W	5134	SSW 5	329.3	0.6	CTD/rosette water sampler
MSM7/008-2	26.02.2008	19:12	1° 0,44' N	6° 35,38' W	5134.7	SSW 5	346.1	0.6	CTD/rosette water sampler
MSM7/008-1	26.02.2008	19:18	1° 0,48' N	6° 35,37' W	5134.2	SSW 5	352.1	0.5	IOW Pump-CTD/Rosette
MSM7/008-3	26.02.2008	19:26	1° 0,57' N	6° 35,35' W	5134.2	SSW 5	26	1.7	ADCP Katamaran
MSM7/008-3	26.02.2008	19:33	1° 0,28' N	6° 34,88' W	5133.8	SW 6	131.4	8.3	ADCP Katamaran
MSM7/008-3	27.02.2008	02:29	0° 30,08' N	5° 50,35' W	5112.2	S 2	120.9	1	ADCP Katamaran
MSM7/008-4	27.02.2008	02:35	0° 30,06' N	5° 50,32' W	5111.8	SSW 2	41.9	0.1	CTD/rosette water sampler
MSM7/008-4	27.02.2008	02:53	0° 30,14' N	5° 50,32' W	5112.6	S 2	348	0.3	CTD/rosette water sampler
MSM7/008-4	27.02.2008	03:03	0° 30,21' N	5° 50,25' W	5107.2	S 3	42.3	0.9	CTD/rosette water sampler
MSM7/008-5	27.02.2008	03:09	0° 30,21' N	5° 50,13' W	5042.5	S 2	118.3	1.4	ADCP Katamaran
MSM7/008-5	27.02.2008	03:15	0° 29,95' N	5° 49,83' W	5087	S 2	132.2	7.2	ADCP Katamaran
MSM7/008-5	27.02.2008	10:07	0° 0,14' N	5° 5,58' W	5123.6	SSW 4	159	2.4	ADCP Katamaran
MSM7/009-1	27.02.2008	10:21	0° 0,06' N	5° 5,38' W	5123.5	SSW 4	31.2	0.6	IOW Pump-CTD/Rosette
MSM7/009-1	27.02.2008	10:26	0° 0,11' N	5° 5,34' W	5123.5	SSW 4	74.6	0.5	IOW Pump-CTD/Rosette
MSM7/009-2	27.02.2008	10:28	0° 0,12' N	5° 5,33' W	5123.6	SSW 4	36.3	0.6	CTD/rosette water sampler
MSM7/009-2	27.02.2008	10:44	0° 0,25' N	5° 5,30' W	5123.7	SSW 3	14.6	0.7	CTD/rosette water sampler
MSM7/009-2	27.02.2008	10:47	0° 0,29' N	5° 5,28' W	5123.4	SSW 4	27.9	1.1	CTD/rosette water sampler
MSM7/009-2	27.02.2008	11:07	0° 0,50' N	5° 5,10' W	5123.6	SSW 3	49.7	0.2	CTD/rosette water sampler
MSM7/009-3	27.02.2008	11:11	0° 0,53' N	5° 5,08' W	5123.7	SSW 3	50.6	0.3	IOW Pump-CTD/Rosette
MSM7/009-3	27.02.2008	11:17	0° 0,57' N	5° 5,04' W	5123.9	SSW 3	63.4	0.7	IOW Pump-CTD/Rosette
MSM7/009-2	27.02.2008	11:17	0° 0,57' N	5° 5,04' W	5123.9	SSW 3	63.4	0.7	CTD/rosette water sampler
MSM7/009-3	27.02.2008	11:59	0° 0,58' N	5° 4,77' W	5124	SSE 3	183.9	0.5	IOW Pump-CTD/Rosette
MSM7/009-4	27.02.2008	12:06	0° 0,53' N	5° 4,82' W	5124	S 3	235.7	1	ADCP Katamaran
MSM7/009-4	27.02.2008	12:15	0° 0,12' N	5° 4,99' W	5123.5	S 3	175.4	6.3	ADCP Katamaran
MSM7/009-4	27.02.2008	19:15	0° 29,35' S	4° 19,97' W	5117.9	SSW 4	116.1	2.7	ADCP Katamaran
MSM7/009-5	27.02.2008	19:29	0° 29,88' S	4° 19,29' W	5118.4	S 4	353.7	0.3	CTD/rosette water sampler
MSM7/009-5	27.02.2008	19:51	0° 29,68' S	4° 19,27' W	5119.5	S 5	17.2	1	CTD/rosette water sampler
MSM7/009-5	27.02.2008	20:06	0° 29,47' S	4° 19,25' W	5116.7	S 5	11.4	1.6	CTD/rosette water sampler
MSM7/009-6	27.02.2008	20:15	0° 29,36' S	4° 19,10' W	5117.5	S 5	101.9	2.7	ADCP Katamaran
MSM7/009-6	27.02.2008	20:20	0° 29,52' S	4° 18,81' W	5116.9	S 5	124.3	6.8	ADCP Katamaran
MSM7/009-6	28.02.2008	03:19	0° 59,91' S	3° 32,91' W	5090.9	SSE 4	128.5	1.5	ADCP Katamaran
MSM7/010-1	28.02.2008	03:26	0° 59,94' S	3° 32,81' W	5098.9	SSE 4	66.2	0.7	IOW Pump-CTD/Rosette
MSM7/010-1	28.02.2008	03:40	0° 59,90' S	3° 32,75' W	5095.2	SSE 4	40	0.4	IOW Pump-CTD/Rosette
MSM7/010-2	28.02.2008	04:00	0° 59,89' S	3° 32,71' W	5099.1	SSE 4	7.1	0.5	CTD/rosette water sampler
MSM7/010-2	28.02.2008	04:19	0° 59,85' S	3° 32,70' W	5099.5	S 4	356.6	0.7	CTD/rosette water sampler
MSM7/010-2	28.02.2008	04:29	0° 59,80' S	3° 32,73' W	5096.7	SSE 4	19	0.5	CTD/rosette water sampler
MSM7/010-1	28.02.2008	04:34	0° 59,75' S	3° 32,71' W	5098.8	S 4	354.2	1.1	IOW Pump-CTD/Rosette
MSM7/010-3	28.02.2008	04:40	0° 59,71' S	3° 32,68' W	5098.9	SSE 4	87.1	1.2	ADCP Katamaran
MSM7/010-3	28.02.2008	04:47	0° 59,95' S	3° 32,24' W	5100.8	S 5	121.1	6.7	ADCP Katamaran
MSM7/010-3	28.02.2008	12:13	1° 30,01' S	2° 46,12' W	4960.8	SE 3	109.9	0.5	ADCP Katamaran
MSM7/010-4	28.02.2008	12:21	1° 29,99' S	2° 46,04' W	4954.8	SSE 4	48.5	0.5	CTD/rosette water sampler
MSM7/010-4	28.02.2008	12:41	1° 29,80' S	2° 45,97' W	4947.6	SSE 4	26.2	0.7	CTD/rosette water sampler
MSM7/010-4	28.02.2008	12:52	1° 29,75' S	2° 45,91' W	4944	SSE 3	24.8	0.6	CTD/rosette water sampler
MSM7/010-5	28.02.2008	12:58	1° 29,79' S	2° 45,86' W	4941.4	SE 4	142.4	2.1	ADCP Katamaran
MSM7/010-5	28.02.2008	13:05	1° 30,33' S	2° 45,54' W	4938	SSE 4	132.2	7.4	ADCP Katamaran
MSM7/010-5	28.02.2008	20:04	1° 59,52' S	2° 0,29' W	4971.2	S 3	122	1.8	ADCP Katamaran
MSM7/011-1	28.02.2008	20:17	1° 59,94' S	1° 59,57' W	4963.8	SSW 3	126.4	0.2	IOW Pump-CTD/Rosette

MSM7/011-1	28.02.2008	20:32	1° 59,85' S	1° 59,57' W	4964.6	SSW 3	14.1	0.2	IOW Pump-CTD/Rosette
MSM7/011-2	28.02.2008	20:36	1° 59,84' S	1° 59,57' W	4963.7	S 4	335	0.3	CTD/rosette water sampler
MSM7/011-2	28.02.2008	20:48	1° 59,76' S	1° 59,58' W	4961.9	S 4	16.2	0.6	CTD/rosette water sampler
MSM7/011-2	28.02.2008	20:52	1° 59,75' S	1° 59,57' W	4963.3	S 4	14.9	0.6	CTD/rosette water sampler
MSM7/011-3	28.02.2008	20:59	1° 59,70' S	1° 59,58' W	4962.1	SSE 3	15.1	0.5	CTD/rosette water sampler
MSM7/011-3	28.02.2008	21:18	1° 59,59' S	1° 59,58' W	4929.7	SSE 3	51.8	0.8	CTD/rosette water sampler
MSM7/011-1	28.02.2008	21:20	1° 59,58' S	1° 59,57' W	4955.9	SSE 3	37	0.9	IOW Pump-CTD/Rosette
MSM7/011-3	28.02.2008	21:31	1° 59,55' S	1° 59,57' W	4956.8	S 3	5.4	0.5	CTD/rosette water sampler
MSM7/011-4	28.02.2008	21:37	1° 59,54' S	1° 59,53' W	4939	S 3	112.8	1.9	ADCP Katamaran
MSM7/011-4	28.02.2008	21:47	2° 0,10' S	1° 58,90' W	4974.6	S 3	127.4	7.9	ADCP Katamaran
MSM7/011-4	29.02.2008	04:59	2° 29,59' S	1° 12,64' W	4420.7	S 3	119.4	2.8	ADCP Katamaran
MSM7/011-5	29.02.2008	05:08	2° 29,82' S	1° 12,44' W	4388.3	S 3	212.1	0.5	CTD/rosette water sampler
MSM7/011-5	29.02.2008	05:27	2° 29,79' S	1° 12,45' W	4370.6	SSE 3	112.5	0.4	CTD/rosette water sampler
MSM7/011-5	29.02.2008	05:38	2° 29,76' S	1° 12,45' W	4408.1	SSE 3	0.4	0.4	CTD/rosette water sampler
MSM7/011-6	29.02.2008	05:47	2° 29,77' S	1° 12,40' W	4376.3	S 3	119.8	1.5	ADCP Katamaran
MSM7/011-6	29.02.2008	05:55	2° 30,14' S	1° 11,81' W	4278.9	S 3	119.1	7.6	ADCP Katamaran
MSM7/011-6	29.02.2008	13:35	3° 0,06' S	0° 24,52' W	4684	S 3	232	0.2	ADCP Katamaran
MSM7/012-1	29.02.2008	13:41	3° 0,03' S	0° 24,58' W	4678.9	SSE 3	315.2	1.1	CTD/rosette water sampler
MSM7/012-2	29.02.2008	13:53	2° 59,92' S	0° 24,76' W	4678.9	SSW 2	300.6	0.7	IOW Pump-CTD/Rosette
MSM7/012-3	29.02.2008	13:56	2° 59,93' S	0° 24,77' W	4678.5	SSW 3	223.6	0.4	Plankton net
MSM7/012-3	29.02.2008	13:59	2° 59,94' S	0° 24,78' W	4675.5	SSW 2	207.2	0.6	Plankton net
MSM7/012-2	29.02.2008	14:50	3° 0,05' S	0° 25,09' W	4697.6	SSW 3	259.4	0.4	IOW Pump-CTD/Rosette
MSM7/012-1	29.02.2008	14:58	3° 0,07' S	0° 25,13' W	4681.7	S 3	340.6	1	CTD/rosette water sampler
MSM7/012-1	29.02.2008	15:12	3° 0,17' S	0° 25,24' W	4664.6	S 2	262.8	0.9	CTD/rosette water sampler
MSM7/012-2	29.02.2008	15:17	3° 0,20' S	0° 25,29' W	4668.9	SSW 3	223.4	0.7	IOW Pump-CTD/Rosette
MSM7/013-1	01.03.2008	00:23	4° 0,08' S	1° 8,71' E	4865.9	S 4	72.4	0.7	CTD/rosette water sampler
MSM7/013-2	01.03.2008	00:32	4° 0,10' S	1° 8,73' E	4868.3	S 4	183.6	1.1	IOW Pump-CTD/Rosette
MSM7/013-1	01.03.2008	00:50	4° 0,13' S	1° 8,70' E	4869.3	S 4	298.5	0.7	CTD/rosette water sampler
MSM7/013-1	01.03.2008	01:03	4° 0,13' S	1° 8,71' E	4869.2	S 4	140.4	0.8	CTD/rosette water sampler
MSM7/013-2	01.03.2008	01:19	4° 0,08' S	1° 8,70' E	4867.9	SSW 5	24.8	1.4	IOW Pump-CTD/Rosette
MSM7/013-2	01.03.2008	01:48	4° 0,05' S	1° 8,75' E	4865.9	S 5	155.2	0.4	IOW Pump-CTD/Rosette
MSM7/014-1	01.03.2008	09:51	4° 59,92' S	2° 35,46' E	5236.5	SE 3	349	0.5	CTD/rosette water sampler
MSM7/014-2	01.03.2008	10:01	4° 59,88' S	2° 35,40' E	5235.7	SE 4	316	0.6	IOW Pump-CTD/Rosette
MSM7/014-1	01.03.2008	10:52	4° 59,75' S	2° 35,08' E	5230.8	SE 5	296.1	0.4	CTD/rosette water sampler
MSM7/014-2	01.03.2008	10:54	4° 59,75' S	2° 35,07' E	5223.4	SE 4	298.1	0.7	IOW Pump-CTD/Rosette
MSM7/014-2	01.03.2008	11:02	4° 59,73' S	2° 35,03' E	5230.7	SE 4	238.8	0.4	IOW Pump-CTD/Rosette
MSM7/014-1	01.03.2008	11:05	4° 59,73' S	2° 35,01' E	5229.6	SE 4	297.9	0.8	CTD/rosette water sampler
MSM7/014-3	01.03.2008	11:17	4° 59,63' S	2° 34,93' E	5227.2	SE 4	326	1	IOW Pump-CTD/Rosette
MSM7/014-3	01.03.2008	11:18	4° 59,61' S	2° 34,92' E	5212.3	SE 4	331.6	1.3	IOW Pump-CTD/Rosette
MSM7/014-3	01.03.2008	11:28	4° 59,50' S	2° 34,81' E	5011.2	SE 4	325.3	0.9	IOW Pump-CTD/Rosette
MSM7/015-1	02.03.2008	18:33	9° 0,01' S	7° 59,91' E	4690.3	S 4	320.8	1	CTD/rosette water sampler
MSM7/015-2	02.03.2008	18:50	8° 59,95' S	7° 59,78' E	4691.3	S 5	299	0.8	IOW Pump-CTD/Rosette
MSM7/015-1	02.03.2008	19:09	8° 59,90' S	7° 59,61' E	4691.2	SSE 5	230.7	0.5	CTD/rosette water sampler
MSM7/015-1	02.03.2008	19:41	8° 59,84' S	7° 59,41' E	4691.2	SSE 5	288.1	0.8	CTD/rosette water sampler
MSM7/015-1	02.03.2008	19:46	8° 59,79' S	7° 59,34' E	4688.1	SSE 5	284.9	0.9	CTD/rosette water sampler
MSM7/015-1	02.03.2008	19:52	8° 59,76' S	7° 59,26' E	4691.8	SSE 4	300.3	1.3	CTD/rosette water sampler
MSM7/015-2	02.03.2008	20:07	8° 59,66' S	7° 59,07' E	4691.8	SSE 5	246.6	0.6	IOW Pump-CTD/Rosette
MSM7/015-2	02.03.2008	20:42	8° 59,61' S	7° 58,94' E	4692	S 5	333.2	0.4	IOW Pump-CTD/Rosette
MSM7/016-1	04.03.2008	13:38	17° 16,05' S	11° 36,22' E	105.8	S 9	29.4	0.1	CTD/rosette water sampler
MSM7/016-2	04.03.2008	13:41	17° 16,06' S	11° 36,22' E	106.1	S 9	181.5	0.6	Plankton net
MSM7/016-2	04.03.2008	13:43	17° 16,07' S	11° 36,21' E	106.1	S 9	27.8	0.1	Plankton net
MSM7/016-1	04.03.2008	13:47	17° 16,07' S	11° 36,20' E	106.2	S 9	234.3	0.8	CTD/rosette water sampler
MSM7/016-1	04.03.2008	13:52	17° 16,05' S	11° 36,18' E	106.1	S 10	252.5	0.9	CTD/rosette water sampler
MSM7/016-3	04.03.2008	13:58	17° 16,04' S	11° 36,17' E	106.1	S 10	106	0.6	van Veen grab
MSM7/016-3	04.03.2008	15:04	17° 16,08' S	11° 36,17' E	106.3	SSW 9	197.4	0.6	van Veen grab
MSM7/016-4	04.03.2008	15:12	17° 16,07' S	11° 36,17' E	106.3	SSW 8	20	0.5	Multi corer
MSM7/016-4	04.03.2008	15:15	17° 16,08' S	11° 36,17' E	106.3	SSW 8	192.2	0.8	Multi corer
MSM7/016-4	04.03.2008	15:17	17° 16,07' S	11° 36,17' E	106.1	SSW 8	222.7	0.4	Multi corer
MSM7/016-4	04.03.2008	15:21	17° 16,07' S	11° 36,17' E	106.4	SSW 8	359.2	0.7	Multi corer
MSM7/016-4	04.03.2008	15:26	17° 16,07' S	11° 36,17' E	106.1	SSW 8	337.2	0.6	Multi corer
MSM7/016-5	04.03.2008	15:34	17° 16,08' S	11° 36,17' E	106.3	SSW 8	185.9	0.5	Dredge
MSM7/016-5	04.03.2008	15:45	17° 16,05' S	11° 36,28' E	105.1	SSW 9	127.6	1	Dredge
MSM7/016-5	04.03.2008	15:47	17° 16,04' S	11° 36,32' E	104.8	SSW 9	122	0.4	Dredge
MSM7/016-5	04.03.2008	16:04	17° 16,04' S	11° 36,52' E	103	SSW 8	85.3	1	Dredge
MSM7/017-1	04.03.2008	17:04	17° 16,05' S	11° 41,23' E	63.4	SSW 7	235.8	1.1	CTD/rosette water sampler
MSM7/017-1	04.03.2008	17:14	17° 16,05' S	11° 41,23' E	63.3	SSW 8	50.3	0.9	CTD/rosette water sampler
MSM7/017-2	04.03.2008	17:21	17° 16,05' S	11° 41,23' E	63.2	SSW 7	1.1	0.2	van Veen grab

MSM7/017-1	04.03.2008	17:21	17° 16,05' S	11° 41,23' E	63.2	SSW 7	1.1	0.2	CTD/rosette water sampler
MSM7/017-2	04.03.2008	17:36	17° 16,05' S	11° 41,23' E	63.2	SSW 7	9.6	0.6	van Veen grab
MSM7/017-3	04.03.2008	17:39	17° 16,05' S	11° 41,23' E	63.1	SSW 7	48.7	0.4	van Veen grab
MSM7/017-3	04.03.2008	18:03	17° 16,05' S	11° 41,23' E	63.1	SSW 8	214.1	0.5	van Veen grab
MSM7/017-4	04.03.2008	18:10	17° 16,05' S	11° 41,23' E	63	SSW 8	30	0.3	Multi corer
MSM7/017-4	04.03.2008	18:14	17° 16,05' S	11° 41,24' E	63.1	SSW 8	23.1	0.3	Multi corer
MSM7/017-4	04.03.2008	18:19	17° 16,05' S	11° 41,23' E	62.1	SSW 7	202.5	0.7	Multi corer
MSM7/017-5	04.03.2008	18:29	17° 16,05' S	11° 41,29' E	62.5	SSW 8	75.9	1	Dredge
MSM7/017-5	04.03.2008	18:33	17° 16,06' S	11° 41,33' E	61.9	SSW 8	99.7	0.5	Dredge
MSM7/017-5	04.03.2008	18:33	17° 16,06' S	11° 41,33' E	61.9	SSW 8	99.7	0.5	Dredge
MSM7/017-5	04.03.2008	18:38	17° 16,06' S	11° 41,38' E	61.2	SSW 8	57.5	1.2	Dredge
MSM7/018-1	04.03.2008	19:05	17° 16,05' S	11° 43,44' E	31.1	SSW 10	257	0.4	CTD/rosette water sampler
MSM7/018-1	04.03.2008	19:14	17° 16,05' S	11° 43,44' E	31.1	SSW 9	235.7	0.6	CTD/rosette water sampler
MSM7/018-1	04.03.2008	19:16	17° 16,05' S	11° 43,44' E	31.3	SSW 9	160.7	1.1	CTD/rosette water sampler
MSM7/018-2	04.03.2008	19:19	17° 16,05' S	11° 43,44' E	31.1	SSW 9	173.8	0.9	van Veen grab
MSM7/018-2	04.03.2008	19:35	17° 16,05' S	11° 43,44' E	31.3	SSW 9	39.6	1.4	van Veen grab
MSM7/018-3	04.03.2008	19:39	17° 16,05' S	11° 43,44' E	31.1	SSW 9	68.2	0.9	Multi corer
MSM7/018-3	04.03.2008	19:40	17° 16,05' S	11° 43,44' E	31.2	SSW 9	12.9	0.6	Multi corer
MSM7/018-3	04.03.2008	19:44	17° 16,05' S	11° 43,44' E	31.4	SSW 9	301.2	0.8	Multi corer
MSM7/018-4	04.03.2008	19:49	17° 16,04' S	11° 43,45' E	31.1	SSW 10	54	1	Dredge
MSM7/018-4	04.03.2008	19:51	17° 16,05' S	11° 43,46' E	31	SSW 9	179.9	0.9	Dredge
MSM7/018-4	04.03.2008	19:51	17° 16,05' S	11° 43,46' E	31	SSW 9	179.9	0.9	Dredge
MSM7/018-4	04.03.2008	19:56	17° 16,08' S	11° 43,47' E	30.9	SSW 9	61.7	0.4	Dredge
MSM7/019-1	04.03.2008	20:22	17° 17,35' S	11° 42,62' E	48.5	S 10	198.4	0.4	CTD/rosette water sampler
MSM7/019-1	04.03.2008	20:31	17° 17,35' S	11° 42,62' E	48.5	S 9	36.3	0.2	CTD/rosette water sampler
MSM7/019-1	04.03.2008	20:34	17° 17,35' S	11° 42,62' E	48.5	SSW 9	205.3	1.7	CTD/rosette water sampler
MSM7/019-2	04.03.2008	20:36	17° 17,35' S	11° 42,62' E	48.7	SSW 9	244.9	0.4	van Veen grab
MSM7/019-2	04.03.2008	20:54	17° 17,35' S	11° 42,62' E	48.8	SSW 8	221.9	0.6	van Veen grab
MSM7/019-3	04.03.2008	20:57	17° 17,35' S	11° 42,62' E	48.7	SSW 9	196.2	0.4	Multi corer
MSM7/019-3	04.03.2008	20:59	17° 17,35' S	11° 42,62' E	48.5	SSW 9	215.4	0.7	Multi corer
MSM7/019-3	04.03.2008	21:03	17° 17,35' S	11° 42,62' E	48.6	SSW 9	231.1	0.3	Multi corer
MSM7/019-4	04.03.2008	21:08	17° 17,35' S	11° 42,65' E	48.2	SSW 8	101.4	0.9	Dredge
MSM7/019-4	04.03.2008	21:10	17° 17,35' S	11° 42,68' E	47.7	SSW 8	85.1	0.5	Dredge
MSM7/019-4	04.03.2008	21:10	17° 17,35' S	11° 42,68' E	47.7	SSW 8	85.1	0.5	Dredge
MSM7/019-4	04.03.2008	21:16	17° 17,37' S	11° 42,76' E	46.5	SSW 9	108.4	0.6	Dredge
MSM7/020-1	04.03.2008	21:46	17° 17,38' S	11° 39,49' E	81.5	S 8	22.9	0.5	CTD/rosette water sampler
MSM7/020-1	04.03.2008	21:57	17° 17,38' S	11° 39,49' E	81.5	S 10	194.8	0.3	CTD/rosette water sampler
MSM7/020-1	04.03.2008	22:00	17° 17,38' S	11° 39,49' E	81.2	S 11	211.3	0.7	CTD/rosette water sampler
MSM7/020-2	04.03.2008	22:01	17° 17,38' S	11° 39,49' E	81.5	S 11	13.6	0.8	van Veen grab
MSM7/020-2	04.03.2008	22:28	17° 17,38' S	11° 39,49' E	81.5	SSW 9	353.8	0.4	van Veen grab
MSM7/020-3	04.03.2008	22:32	17° 17,38' S	11° 39,49' E	81.9	SSW 9	228	0.6	Multi corer
MSM7/020-3	04.03.2008	22:35	17° 17,38' S	11° 39,49' E	81.7	SSW 9	5	0.5	Multi corer
MSM7/020-3	04.03.2008	22:39	17° 17,38' S	11° 39,49' E	82	SSW 9	10.4	0.7	Multi corer
MSM7/020-4	04.03.2008	22:43	17° 17,38' S	11° 39,49' E	81.7	SSW 9	92.1	0.4	Dredge
MSM7/020-4	04.03.2008	22:46	17° 17,39' S	11° 39,51' E	81.7	SSW 8	157.7	0.6	Dredge
MSM7/020-4	04.03.2008	22:47	17° 17,39' S	11° 39,51' E	81.3	SSW 8	149.9	0.8	Dredge
MSM7/020-4	04.03.2008	22:52	17° 17,40' S	11° 39,55' E	81	SSW 9	91.2	0.9	Dredge
MSM7/021-1	04.03.2008	23:30	17° 17,38' S	11° 36,15' E	107.9	S 9	222.5	0.5	CTD/rosette water sampler
MSM7/021-1	04.03.2008	23:40	17° 17,38' S	11° 36,15' E	107.8	S 8	47.2	0.3	CTD/rosette water sampler
MSM7/021-1	04.03.2008	23:45	17° 17,39' S	11° 36,15' E	107.8	SSW 8	219.3	0.4	CTD/rosette water sampler
MSM7/021-2	04.03.2008	23:46	17° 17,38' S	11° 36,15' E	107.7	S 8	239.8	0.2	van Veen grab
MSM7/021-2	05.03.2008	00:30	17° 17,39' S	11° 36,15' E	107.9	SSW 7	205.8	0.4	van Veen grab
MSM7/021-3	05.03.2008	00:35	17° 17,38' S	11° 36,15' E	108.1	SSW 7	19.7	0.2	Dredge
MSM7/021-3	05.03.2008	00:40	17° 17,39' S	11° 36,17' E	109.4	SSW 8	160.8	1	Dredge
MSM7/021-3	05.03.2008	00:42	17° 17,42' S	11° 36,18' E	108	SSW 9	173.3	0.7	Dredge
MSM7/021-3	05.03.2008	00:47	17° 17,47' S	11° 36,21' E	107.8	SSW 8	131.3	0.6	Dredge
MSM7/022-1	05.03.2008	01:15	17° 19,00' S	11° 36,11' E	110.8	S 7	218.4	0.5	CTD/rosette water sampler
MSM7/022-1	05.03.2008	01:30	17° 18,91' S	11° 36,09' E	111	S 9	19.6	1.2	CTD/rosette water sampler
MSM7/022-1	05.03.2008	01:34	17° 18,85' S	11° 36,13' E	110.2	S 6	58.5	1.2	CTD/rosette water sampler
MSM7/022-2	05.03.2008	01:40	17° 18,88' S	11° 36,19' E	110	SW 7	176.6	0.4	van Veen grab
MSM7/022-2	05.03.2008	02:21	17° 18,88' S	11° 36,19' E	110.2	SSW 7	331	0.5	van Veen grab
MSM7/022-3	05.03.2008	02:24	17° 18,88' S	11° 36,19' E	110.1	S 7	28.2	0.5	Dredge
MSM7/022-3	05.03.2008	02:30	17° 18,88' S	11° 36,20' E	109.8	SSW 7	48.1	1.4	Dredge
MSM7/022-3	05.03.2008	02:32	17° 18,88' S	11° 36,21' E	109.6	SSW 7	90.3	0.9	Dredge
MSM7/022-3	05.03.2008	02:39	17° 18,90' S	11° 36,25' E	109.5	SSW 6	141.3	0.4	Dredge
MSM7/023-1	05.03.2008	03:13	17° 18,95' S	11° 39,54' E	82.8	SSW 7	18.8	1	CTD/rosette water sampler
MSM7/023-1	05.03.2008	03:22	17° 18,94' S	11° 39,54' E	82.5	S 6	185.6	0.3	CTD/rosette water sampler

MSM7/023-1	05.03.2008	03:26	17° 18,94' S	11° 39,54' E	82.4	S 7	176.9	0.6	CTD/rosette water sampler
MSM7/023-2	05.03.2008	03:28	17° 18,94' S	11° 39,54' E	82.4	S 7	3.5	0.5	van Veen grab
MSM7/023-2	05.03.2008	03:49	17° 18,94' S	11° 39,54' E	82.4	SSW 6	320.8	0.4	van Veen grab
MSM7/023-3	05.03.2008	03:53	17° 18,94' S	11° 39,54' E	82.4	SSW 5	69.1	0.4	Dredge
MSM7/023-3	05.03.2008	03:56	17° 18,94' S	11° 39,55' E	82.2	SSW 4	165.3	0.8	Dredge
MSM7/023-3	05.03.2008	03:56	17° 18,94' S	11° 39,55' E	82.2	SSW 4	165.3	0.8	Dredge
MSM7/023-3	05.03.2008	04:03	17° 18,93' S	11° 39,57' E	81.9	SW 5	132	0.5	Dredge
MSM7/024-1	05.03.2008	04:54	17° 18,96' S	11° 43,39' E	26	S 3	189.1	0.3	CTD/rosette water sampler
MSM7/024-1	05.03.2008	05:02	17° 18,96' S	11° 43,39' E	25.6	SSE 3	223.3	0.4	CTD/rosette water sampler
MSM7/024-1	05.03.2008	05:05	17° 18,96' S	11° 43,39' E	25.4	SE 2	34.9	0.9	CTD/rosette water sampler
MSM7/024-2	05.03.2008	05:07	17° 18,96' S	11° 43,39' E	25.3	SE 3	44.2	0.9	van Veen grab
MSM7/024-2	05.03.2008	05:14	17° 18,96' S	11° 43,39' E	25.4	E 2	58.1	0.5	van Veen grab
MSM7/024-3	05.03.2008	05:15	17° 18,96' S	11° 43,39' E	25.4	E 2	217.5	0.4	van Veen grab
MSM7/024-3	05.03.2008	05:39	17° 18,96' S	11° 43,39' E	25.8	E 3	65.8	0.6	van Veen grab
MSM7/024-4	05.03.2008	05:47	17° 18,97' S	11° 43,39' E	26	ENE 3	47.8	1.1	Multi corer
MSM7/024-4	05.03.2008	05:50	17° 18,96' S	11° 43,39' E	25.8	ENE 2	228	0.6	Multi corer
MSM7/024-4	05.03.2008	05:54	17° 18,97' S	11° 43,39' E	26.2	NNE 2	31.6	1.8	Multi corer
MSM7/024-5	05.03.2008	06:02	17° 18,96' S	11° 43,39' E	25.9	NW 0	358.8	1.1	Multi corer
MSM7/024-5	05.03.2008	06:05	17° 18,97' S	11° 43,39' E	25.9	N 2	222.2	1	Multi corer
MSM7/024-5	05.03.2008	06:07	17° 18,97' S	11° 43,39' E	25.9	NNW 2	39	0.4	Multi corer
MSM7/024-6	05.03.2008	06:10	17° 18,97' S	11° 43,39' E	25.8	N 2	354.1	0.4	Multi corer
MSM7/024-6	05.03.2008	06:12	17° 18,97' S	11° 43,39' E	26	NW 2	241.5	0.4	Multi corer
MSM7/024-6	05.03.2008	06:17	17° 18,97' S	11° 43,39' E	25.9	NNW 2	209.5	1.3	Multi corer
MSM7/024-7	05.03.2008	06:22	17° 18,96' S	11° 43,40' E	25.4	NE 1	155.8	0.4	Dredge
MSM7/024-7	05.03.2008	06:27	17° 18,96' S	11° 43,42' E	23.5	SW 0	116.7	0.3	Dredge
MSM7/024-7	05.03.2008	06:27	17° 18,96' S	11° 43,42' E	23.5	SW 0	116.7	0.3	Dredge
MSM7/024-7	05.03.2008	06:31	17° 18,96' S	11° 43,44' E	22.2	SSE 0	82	0.5	Dredge
MSM7/025-1	05.03.2008	07:00	17° 20,33' S	11° 42,21' E	56.2	SSW 3	169.4	0.5	CTD/rosette water sampler
MSM7/025-1	05.03.2008	07:12	17° 20,33' S	11° 42,21' E	55.5	SSW 4	216	0.8	CTD/rosette water sampler
MSM7/025-1	05.03.2008	07:15	17° 20,33' S	11° 42,21' E	55.4	SSW 3	19.8	0.2	CTD/rosette water sampler
MSM7/025-2	05.03.2008	07:18	17° 20,33' S	11° 42,21' E	55.5	SSW 4	228.7	0.6	van Veen grab
MSM7/025-2	05.03.2008	07:44	17° 20,33' S	11° 42,21' E	55.5	S 4	163.5	1.3	van Veen grab
MSM7/025-3	05.03.2008	07:50	17° 20,33' S	11° 42,21' E	55.6	S 5	140.9	0.4	Dredge
MSM7/025-3	05.03.2008	07:56	17° 20,35' S	11° 42,24' E	55.2	S 5	138.8	0.4	Dredge
MSM7/025-3	05.03.2008	07:56	17° 20,35' S	11° 42,24' E	55.2	S 5	138.8	0.4	Dredge
MSM7/025-3	05.03.2008	08:01	17° 20,34' S	11° 42,27' E	54.8	S 5	94.6	0.4	Dredge
MSM7/026-1	05.03.2008	08:32	17° 20,34' S	11° 39,53' E	83.8	SSW 7	31	1.4	CTD/rosette water sampler
MSM7/026-1	05.03.2008	08:43	17° 20,34' S	11° 39,53' E	83.5	S 6	22.8	0.5	CTD/rosette water sampler
MSM7/026-1	05.03.2008	08:48	17° 20,35' S	11° 39,53' E	83.5	S 6	267.1	0.2	CTD/rosette water sampler
MSM7/026-2	05.03.2008	08:50	17° 20,34' S	11° 39,53' E	83.9	S 6	27.7	0.4	van Veen grab
MSM7/026-2	05.03.2008	09:24	17° 20,34' S	11° 39,53' E	83.7	SSW 4	46.2	0.9	van Veen grab
MSM7/026-3	05.03.2008	09:29	17° 20,34' S	11° 39,55' E	83.7	SSW 4	101.2	0.6	Dredge
MSM7/026-3	05.03.2008	09:33	17° 20,35' S	11° 39,58' E	83.2	SW 4	102.6	0.5	Dredge
MSM7/026-3	05.03.2008	09:34	17° 20,35' S	11° 39,59' E	83.3	SW 4	82.3	0.4	Dredge
MSM7/026-3	05.03.2008	09:40	17° 20,34' S	11° 39,64' E	82.5	SW 5	108.6	0.5	Dredge
MSM7/027-1	05.03.2008	10:18	17° 20,38' S	11° 36,13' E	112.2	SSW 5	63.8	0.1	CTD/rosette water sampler
MSM7/027-1	05.03.2008	10:29	17° 20,38' S	11° 36,12' E	112.3	SSW 5	198	0.9	CTD/rosette water sampler
MSM7/027-1	05.03.2008	10:36	17° 20,38' S	11° 36,12' E	112.3	SW 5	178.6	0.6	CTD/rosette water sampler
MSM7/027-2	05.03.2008	10:37	17° 20,38' S	11° 36,13' E	112.3	SW 5	190.8	0.5	van Veen grab
MSM7/027-2	05.03.2008	11:23	17° 20,38' S	11° 36,12' E	112.5	SSW 5	1.6	0.5	van Veen grab
MSM7/027-3	05.03.2008	11:28	17° 20,38' S	11° 36,13' E	112.4	SSW 5	63.8	0.4	Dredge
MSM7/027-3	05.03.2008	11:32	17° 20,38' S	11° 36,16' E	112.2	SSW 5	87.6	0.7	Dredge
MSM7/027-3	05.03.2008	11:33	17° 20,38' S	11° 36,16' E	112.1	SSW 5	104.8	0.4	Dredge
MSM7/027-3	05.03.2008	11:41	17° 20,40' S	11° 36,22' E	111.8	SSW 6	117.2	0.5	Dredge
MSM7/028-1	05.03.2008	12:23	17° 22,09' S	11° 39,54' E	85.6	SSW 8	33.9	0.6	CTD/rosette water sampler
MSM7/028-1	05.03.2008	12:34	17° 22,09' S	11° 39,57' E	85.4	SSW 8	6.5	0.4	CTD/rosette water sampler
MSM7/028-1	05.03.2008	12:37	17° 22,09' S	11° 39,57' E	85.4	SSW 7	207.5	0.6	CTD/rosette water sampler
MSM7/028-2	05.03.2008	12:39	17° 22,09' S	11° 39,56' E	85.4	SSW 8	4.9	0.2	van Veen grab
MSM7/028-2	05.03.2008	13:17	17° 22,09' S	11° 39,57' E	85.4	SSW 8	316.4	0.6	van Veen grab
MSM7/028-3	05.03.2008	13:22	17° 22,10' S	11° 39,57' E	86	SSW 7	107.7	0.3	Dredge
MSM7/028-3	05.03.2008	13:27	17° 22,10' S	11° 39,61' E	85.5	SW 8	70.9	1.3	Dredge
MSM7/028-3	05.03.2008	13:27	17° 22,10' S	11° 39,61' E	85.5	SW 8	70.9	1.3	Dredge
MSM7/028-3	05.03.2008	13:36	17° 22,11' S	11° 39,69' E	84.4	SSW 7	76.5	0.7	Dredge
MSM7/029-1	05.03.2008	14:12	17° 22,05' S	11° 42,23' E	56.9	SSW 7	322.1	0.2	CTD/rosette water sampler
MSM7/029-1	05.03.2008	14:20	17° 22,05' S	11° 42,23' E	56.8	SSW 6	31.5	0.4	CTD/rosette water sampler
MSM7/029-1	05.03.2008	14:23	17° 22,05' S	11° 42,23' E	56.9	SSW 6	202.7	0.3	CTD/rosette water sampler
MSM7/029-2	05.03.2008	14:26	17° 22,05' S	11° 42,23' E	57.1	SSW 7	32.7	0.9	van Veen grab
MSM7/029-2	05.03.2008	14:55	17° 22,05' S	11° 42,23' E	57	SSW 8	278.7	0.4	van Veen grab

MSM7/029-3	05.03.2008	15:00	17° 22,05' S	11° 42,24' E	57.2	SSW 7	73.4	0.9	Dredge
MSM7/029-3	05.03.2008	15:04	17° 22,05' S	11° 42,29' E	56.3	SSW 8	76.2	0.9	Dredge
MSM7/029-3	05.03.2008	15:04	17° 22,05' S	11° 42,29' E	56.3	SSW 8	76.2	0.9	Dredge
MSM7/029-3	05.03.2008	15:13	17° 22,04' S	11° 42,38' E	54.9	SSW 8	156.7	1.3	Dredge
MSM7/029-4	05.03.2008	15:21	17° 22,22' S	11° 42,44' E	53.9	SSW 9	214.5	0.4	CTD/rosette water sampler
MSM7/029-4	05.03.2008	15:24	17° 22,22' S	11° 42,44' E	54	SSW 9	312.6	0.4	CTD/rosette water sampler
MSM7/029-4	05.03.2008	15:32	17° 22,22' S	11° 42,44' E	53.8	SSW 9	357.6	0.3	CTD/rosette water sampler
MSM7/030-1	05.03.2008	15:57	17° 23,42' S	11° 43,43' E	29.6	SSW 10	4.2	0.3	CTD/rosette water sampler
MSM7/030-1	05.03.2008	16:04	17° 23,41' S	11° 43,43' E	29.6	SSW 9	294.6	1.1	CTD/rosette water sampler
MSM7/030-1	05.03.2008	16:08	17° 23,41' S	11° 43,43' E	29.8	SSW 9	66.2	0.9	CTD/rosette water sampler
MSM7/030-2	05.03.2008	16:10	17° 23,41' S	11° 43,43' E	29.5	SSW 9	17.2	0.6	van Veen grab
MSM7/030-2	05.03.2008	16:13	17° 23,42' S	11° 43,43' E	29.9	SSW 9	230.5	0.6	van Veen grab
MSM7/030-3	05.03.2008	16:15	17° 23,41' S	11° 43,43' E	29.5	SSW 9	97.2	0.8	van Veen grab
MSM7/030-3	05.03.2008	16:27	17° 23,43' S	11° 43,43' E	30	SSW 9	163	0.8	van Veen grab
MSM7/030-4	05.03.2008	16:33	17° 23,50' S	11° 43,44' E	29.7	SSW 9	212.4	0.7	van Veen grab
MSM7/030-4	05.03.2008	16:40	17° 23,50' S	11° 43,43' E	29.9	SSW 9	224.3	0.6	van Veen grab
MSM7/030-5	05.03.2008	16:53	17° 23,50' S	11° 43,43' E	29.8	SSW 8	38	0.9	Dredge
MSM7/030-5	05.03.2008	16:55	17° 23,50' S	11° 43,44' E	29.6	SSW 8	143.3	0.9	Dredge
MSM7/030-5	05.03.2008	16:56	17° 23,50' S	11° 43,45' E	29.1	SSW 8	130.1	0.9	Dredge
MSM7/030-5	05.03.2008	16:58	17° 23,51' S	11° 43,47' E	26.4	SSW 8	69	1	Dredge
MSM7/031-1	05.03.2008	17:22	17° 23,41' S	11° 42,22' E	57.2	SSW 8	344.4	0.9	CTD/rosette water sampler
MSM7/031-1	05.03.2008	17:34	17° 23,41' S	11° 42,22' E	57.1	SSW 8	197.6	0.3	CTD/rosette water sampler
MSM7/031-1	05.03.2008	17:37	17° 23,41' S	11° 42,22' E	57.2	SSW 8	194.6	0.3	CTD/rosette water sampler
MSM7/031-2	05.03.2008	17:39	17° 23,41' S	11° 42,22' E	57.1	SSW 8	31.8	0.8	van Veen grab
MSM7/031-2	05.03.2008	18:08	17° 23,41' S	11° 42,22' E	57	SSW 8	25.8	0.9	van Veen grab
MSM7/031-3	05.03.2008	18:10	17° 23,41' S	11° 42,22' E	57.7	SSW 8	208.2	0.4	Dredge
MSM7/031-3	05.03.2008	18:16	17° 23,41' S	11° 42,24' E	56.9	S 8	60.3	0.5	Dredge
MSM7/031-3	05.03.2008	18:16	17° 23,41' S	11° 42,24' E	56.9	S 8	60.3	0.5	Dredge
MSM7/031-3	05.03.2008	18:19	17° 23,40' S	11° 42,27' E	56.5	SSW 9	75	0.3	Dredge
MSM7/032-1	05.03.2008	19:03	17° 23,42' S	11° 36,12' E	115.7	SSW 5	194.9	0.4	CTD/rosette water sampler
MSM7/032-1	05.03.2008	19:15	17° 23,42' S	11° 36,12' E	115.5	S 6	225.5	0.4	CTD/rosette water sampler
MSM7/032-1	05.03.2008	19:20	17° 23,41' S	11° 36,13' E	115.5	S 6	33.6	0.8	CTD/rosette water sampler
MSM7/032-2	05.03.2008	19:21	17° 23,42' S	11° 36,12' E	115.5	S 6	249.5	0.4	van Veen grab
MSM7/032-2	05.03.2008	19:57	17° 23,41' S	11° 36,12' E	115.9	SSW 5	9.2	0.8	van Veen grab
MSM7/032-3	05.03.2008	20:01	17° 23,41' S	11° 36,12' E	115.6	S 6	54.3	0.4	Dredge
MSM7/032-3	05.03.2008	20:10	17° 23,41' S	11° 36,19' E	115.2	SSW 6	147.8	0.7	Dredge
MSM7/032-3	05.03.2008	20:11	17° 23,41' S	11° 36,19' E	115.8	SSW 6	49.8	1.4	Dredge
MSM7/032-3	05.03.2008	20:17	17° 23,40' S	11° 36,24' E	114.8	SSW 6	112.3	0.2	Dredge
MSM7/033-1	05.03.2008	20:43	17° 25,25' S	11° 36,14' E	115.5	S 7	195.8	0.5	CTD/rosette water sampler
MSM7/033-1	05.03.2008	21:00	17° 25,25' S	11° 36,14' E	116.3	SSW 7	252.9	0.4	CTD/rosette water sampler
MSM7/033-1	05.03.2008	21:04	17° 25,25' S	11° 36,14' E	115.7	SSW 7	14.8	0.7	CTD/rosette water sampler
MSM7/033-2	05.03.2008	21:05	17° 25,25' S	11° 36,14' E	115.8	SSW 7	291.7	0.5	van Veen grab
MSM7/033-2	05.03.2008	21:39	17° 25,25' S	11° 36,14' E	115.8	S 6	294.4	0.6	van Veen grab
MSM7/033-3	05.03.2008	21:44	17° 25,25' S	11° 36,15' E	115.8	S 6	84.3	0.3	Dredge
MSM7/033-3	05.03.2008	21:49	17° 25,25' S	11° 36,18' E	116	S 6	106.4	0.8	Dredge
MSM7/033-3	05.03.2008	21:50	17° 25,24' S	11° 36,19' E	115.9	S 6	69.3	0.5	Dredge
MSM7/033-3	05.03.2008	21:56	17° 25,23' S	11° 36,24' E	116.1	SSW 5	58.8	0.8	Dredge
MSM7/034-1	05.03.2008	22:30	17° 25,23' S	11° 39,14' E	91.8	S 7	16.7	0.6	CTD/rosette water sampler
MSM7/034-1	05.03.2008	22:43	17° 25,23' S	11° 39,14' E	92.2	SSW 6	18.8	0.7	CTD/rosette water sampler
MSM7/034-1	05.03.2008	22:47	17° 25,23' S	11° 39,14' E	92	SSW 5	50.8	0.3	CTD/rosette water sampler
MSM7/034-2	05.03.2008	22:50	17° 25,23' S	11° 39,14' E	92	SSW 6	14.8	0.6	van Veen grab
MSM7/034-2	05.03.2008	23:25	17° 25,23' S	11° 39,14' E	92.2	SSW 5	290.5	0	van Veen grab
MSM7/034-3	05.03.2008	23:28	17° 25,23' S	11° 39,14' E	92.1	S 5	203	0.8	Dredge
MSM7/034-3	05.03.2008	23:34	17° 25,23' S	11° 39,16' E	91.9	S 5	66	0.4	Dredge
MSM7/034-3	05.03.2008	23:34	17° 25,23' S	11° 39,16' E	91.9	S 5	66	0.4	Dredge
MSM7/034-3	05.03.2008	23:40	17° 25,26' S	11° 39,19' E	91.5	S 5	156.4	0.6	Dredge
MSM7/035-1	06.03.2008	00:33	17° 25,36' S	11° 32,11' E	148.6	S 3	26.8	0.3	CTD/rosette water sampler
MSM7/035-1	06.03.2008	01:28	17° 25,36' S	11° 32,13' E	148.6	NNE 2	97.9	0.2	CTD/rosette water sampler
MSM7/036-1	06.03.2008	04:04	17° 25,26' S	11° 1,88' E	1516.8	NNE 4	208.1	0.5	CTD/rosette water sampler
MSM7/036-1	06.03.2008	04:36	17° 25,26' S	11° 1,88' E	1515.9	ENE 7	250.3	0.8	CTD/rosette water sampler
MSM7/036-1	06.03.2008	05:08	17° 25,26' S	11° 1,88' E	1515.9	NE 8	11.2	0.3	CTD/rosette water sampler
MSM7/037-1	06.03.2008	06:21	17° 15,71' S	11° 10,71' E	945.1	N 5	209.9	0.9	CTD/rosette water sampler
MSM7/037-1	06.03.2008	06:40	17° 15,71' S	11° 10,71' E	946	W 4	11.7	0.4	CTD/rosette water sampler
MSM7/037-1	06.03.2008	06:46	17° 15,71' S	11° 10,71' E	944.9	W 2	194.6	1.2	CTD/rosette water sampler
MSM7/037-1	06.03.2008	06:59	17° 15,71' S	11° 10,71' E	944.9	WNW 3	183.3	0.9	CTD/rosette water sampler
MSM7/037-1	06.03.2008	07:18	17° 15,71' S	11° 10,71' E	945	NNW 5	196.3	0.1	CTD/rosette water sampler
MSM7/037-2	06.03.2008	07:50	17° 15,71' S	11° 10,70' E	945.5	NNE 5	207.2	1.1	IOW Pump-CTD/Rosette
MSM7/037-2	06.03.2008	08:11	17° 15,70' S	11° 10,65' E	949.9	NNE 5	241.3	0.4	IOW Pump-CTD/Rosette

MSM7/037-2	06.03.2008	08:46	17° 15,72' S	11° 10,49' E	964.1	NNE 7	16.8	0.6	IOW Pump-CTD/Rosette
MSM7/037-3	06.03.2008	09:07	17° 15,73' S	11° 10,41' E	972.1	NE 6	242.8	0.5	IOW Pump-CTD/Rosette
MSM7/037-3	06.03.2008	09:09	17° 15,73' S	11° 10,40' E	972.5	NE 6	258.2	0.7	IOW Pump-CTD/Rosette
MSM7/037-3	06.03.2008	09:18	17° 15,72' S	11° 10,39' E	974.3	NNE 6	212.7	1.4	IOW Pump-CTD/Rosette
MSM7/038-1	06.03.2008	11:10	17° 34,57' S	11° 17,17' E	724.9	N 6	165.3	0.3	CTD/rosette water sampler
MSM7/038-1	06.03.2008	11:27	17° 34,57' S	11° 17,17' E	725.4	N 7	18.8	0.2	CTD/rosette water sampler
MSM7/038-1	06.03.2008	11:43	17° 34,57' S	11° 17,17' E	725.7	N 7	174.3	0.4	CTD/rosette water sampler
MSM7/039-1	06.03.2008	13:49	17° 53,50' S	11° 29,52' E	223.1	NW 6	222.6	0.2	CTD/rosette water sampler
MSM7/039-1	06.03.2008	14:03	17° 53,50' S	11° 29,52' E	223	WNW 5	23.3	0.8	CTD/rosette water sampler
MSM7/039-1	06.03.2008	14:08	17° 53,50' S	11° 29,52' E	222.7	WNW 5	195.6	0.6	CTD/rosette water sampler
MSM7/040-1	06.03.2008	16:15	18° 12,67' S	11° 33,60' E	219.4	SSW 6	201.4	0.6	CTD/rosette water sampler
MSM7/040-1	06.03.2008	16:28	18° 12,67' S	11° 33,60' E	219.4	S 5	22.5	1.1	CTD/rosette water sampler
MSM7/040-1	06.03.2008	16:35	18° 12,67' S	11° 33,60' E	219.5	S 5	346.6	0.3	CTD/rosette water sampler
MSM7/041-1	06.03.2008	19:16	18° 30,94' S	11° 42,55' E	182.9	ESE 7	187.4	0.5	CTD/rosette water sampler
MSM7/041-1	06.03.2008	19:34	18° 30,94' S	11° 42,55' E	183.2	ESE 5	209.8	0.7	CTD/rosette water sampler
MSM7/041-1	06.03.2008	19:40	18° 30,94' S	11° 42,55' E	183	ESE 4	341.7	0.8	CTD/rosette water sampler
MSM7/042-1	06.03.2008	21:44	18° 49,02' S	11° 51,49' E	222	E 4	194.6	0.6	CTD/rosette water sampler
MSM7/042-1	06.03.2008	22:00	18° 49,02' S	11° 51,49' E	222.1	E 3	21.5	0.5	CTD/rosette water sampler
MSM7/042-1	06.03.2008	22:09	18° 49,02' S	11° 51,49' E	222.2	E 3	184.1	0.6	CTD/rosette water sampler
MSM7/043-1	07.03.2008	00:04	19° 7,36' S	12° 0,67' E	234.7	E 4	209.6	1.3	CTD/rosette water sampler
MSM7/043-1	07.03.2008	00:16	19° 7,36' S	12° 0,67' E	234.8	ESE 4	210	0.1	CTD/rosette water sampler
MSM7/043-1	07.03.2008	00:23	19° 7,36' S	12° 0,67' E	234.8	ESE 4	242	1.1	CTD/rosette water sampler
MSM7/044-1	07.03.2008	07:35	20° 30,02' S	12° 41,99' E	221.5	S 1	185.6	0.3	CTD/rosette water sampler
MSM7/044-1	07.03.2008	07:46	20° 30,00' S	12° 41,95' E	221.8	SSW 1	300	0.7	CTD/rosette water sampler
MSM7/044-1	07.03.2008	07:53	20° 29,99' S	12° 41,89' E	222.2	S 2	263.2	1.2	CTD/rosette water sampler
MSM7/044-1	07.03.2008	08:00	20° 29,98' S	12° 41,84' E	222.4	S 2	306.5	0.2	CTD/rosette water sampler
MSM7/044-1	07.03.2008	08:07	20° 29,98' S	12° 41,79' E	222.7	SSE 3	231.7	0.3	CTD/rosette water sampler
MSM7/044-2	07.03.2008	08:17	20° 29,97' S	12° 41,67' E	223.8	S 3	303.7	0.7	IOW Pump-CTD/Rosette
MSM7/044-2	07.03.2008	08:31	20° 29,91' S	12° 41,52' E	224.5	S 2	281.2	0.8	IOW Pump-CTD/Rosette
MSM7/044-2	07.03.2008	08:33	20° 29,90' S	12° 41,49' E	224.5	S 2	316.6	0.2	IOW Pump-CTD/Rosette
MSM7/044-2	07.03.2008	08:58	20° 29,84' S	12° 41,26' E	223.8	SW 1	306	1.4	IOW Pump-CTD/Rosette
MSM7/045-1	07.03.2008	11:06	20° 46,49' S	12° 54,39' E	182.3	SSW 5	37.2	0.3	CTD/rosette water sampler
MSM7/045-1	07.03.2008	11:18	20° 46,42' S	12° 54,36' E	185.1	SSW 4	357.6	0.7	CTD/rosette water sampler
MSM7/045-1	07.03.2008	11:31	20° 46,32' S	12° 54,33' E	180.9	SSW 5	320.6	0.5	CTD/rosette water sampler
MSM7/046-1	07.03.2008	13:12	21° 2,68' S	13° 6,47' E	128.4	SW 5	223.8	1	CTD/rosette water sampler
MSM7/046-1	07.03.2008	13:23	21° 2,66' S	13° 6,44' E	127.9	SW 5	352.3	0.8	CTD/rosette water sampler
MSM7/046-1	07.03.2008	13:37	21° 2,65' S	13° 6,40' E	127.6	SW 6	189.6	1.5	CTD/rosette water sampler
MSM7/047-1	07.03.2008	15:23	21° 19,56' S	13° 19,26' E	122.5	ESE 1	156.5	0.5	CTD/rosette water sampler
MSM7/047-1	07.03.2008	15:36	21° 19,57' S	13° 19,25' E	122.4	E 2	190.6	1.2	CTD/rosette water sampler
MSM7/047-1	07.03.2008	15:44	21° 19,70' S	13° 19,27' E	122.2	E 2	153.9	4.1	CTD/rosette water sampler
MSM7/048-1	07.03.2008	17:14	21° 35,89' S	13° 31,38' E	112	ENE 1	56.4	0.6	CTD/rosette water sampler
MSM7/048-1	07.03.2008	17:24	21° 35,90' S	13° 31,43' E	111.8	S 1	107.6	0.5	CTD/rosette water sampler
MSM7/048-1	07.03.2008	17:28	21° 35,91' S	13° 31,45' E	111.7	SW 1	144.3	0.5	CTD/rosette water sampler

1.6 Acknowledgements

We acknowledge the friendly and professional assistance of captain and crew of the RV MARIA S. MERIAN, who contributed significantly to the success of the expedition. We thank all the efficient colleagues, who run the logistics on land. We are grateful to the DFG (German Science Foundation) for funding the cruise.

1.7 Attachments: Statements concerning the disposition of biological material/collected species and oceanographic data

Biological taxa: diverse, Makrozoobenthos
Dr. Michael L. Zettler

According to the rules on transfer of zoological material collected on expeditions with RV Maria S. Merian DZMB (Senckenberg) has been informed on the collection of material in the area of Angola and Namibia.
Analysis of samples will take at least three years. Type material has been deposited in different museums (see publications), other material is stored in IOW and will be further analysed. After that it should be archived in DZMB.
Publications of IOW-working group „Ökologie benthischer Organismen“ based on material from this cruise:

Bochert, R. Zettler, M.L. 2009: A new species of Heterospio (Polychaeta, Longosomatidae) from offshore Angola. Zoological Science 26: 735-737
Bochert, R. Zettler, M.L. 2010: Grandidierella (Amphipoda: Aoridae) from Angola with description of a new species. Crustaceana 83: 1209-1219
Bochert, R., Zettler, M.L. (in press): Nebalia deborahae a new species of Leptostraca (Crustacea: Phyllocarida) from South West Africa. Crustaceana
Bochert, R., Zettler, M.L. (subm.): First record of Trochochaeta (Polychaeta) in southern hemisphere with description of a new species. Journal of the Marine Biological Association of the United Kingdom
Bochert, R., Zettler, M.L. 2011: Cumacea from the continental shelf of Angola and Namibia with descriptions of new species. Zootaxa 2978: 1-33
Glück, F., Stöhr, S., Bochert, R., Zettler, M.L. (in prep.): Brittle stars (Echinodermata: Ophiuroida) from the continental shelf of Angola and Namibia. Zootaxa
Massier, W., Zettler, M.L. 2009: Marginella himburgae nov. sp. (Gastropoda: Marginellidae: Marginella). Description of a new Marginellidae species from Namibia. Malacologia Mostra Mondiale 65: 3-4
Rolán, E., Zettler, M.L. 2010: A new species of Gibbula (Mollusca, Archaegastopoda) from Namibia. Iberus 28: 73-78
Thandar, A.S., Zettler, M.L., Arumugam, P. 2010: Additions to the sea cucumber fauna of Namibia and Angola, with descriptions of new taxa (Echinodermata: Holothuroidea). Zootaxa 2655: 1-24
Zettler, M.L., Bochert, R., Pollehne, F. 2009: Macrozoobenthos diversity in an oxygen minimum zone off northern Namibia. Marine Biology 156: 1949-1961

2. Data Policy

The data inventory of this cruise is accessible at DOD (Deutsches Ozeanograhisches Datenzentrum) under DOD-Ref-No.20080065
Current profiler data are listed in DOD.
Oceanographic data of all stations are stored in the central ODIN- database of the Leibniz-Institute for Baltic Sea Research Warnemuende and accessible upon request

MARIA S. MERIAN-BERICHTE

Productivity and Life Cycles of Plankton and Nekton in the Coastal Upwelling Area of the Benguela Shelf – Trophic and Physical-Chemical Control Mechanisms

Pela-Gimber

PART 2

Cruise No. 07, Leg 2b

March 9th – March 20th, 2008
Walvis Bay - Walvis Bay

V. Mohrholz, T. Heene, M. Schmidt, S. Schmitz, U. Struck, R. Hanel, T. Joschko, R. Koppelmann, A. Kreiner, B. Martin, S. Klimpel, T. Rixen, M. Schaber, H. Auel, S. Bröhl, C. Buchholz, A. Denda, S. Oesterle, L. Lehnhoff, L. Franceschinis, F. Mwapopi

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2.1 Participants

1	Volker Mohrholz	Chief Scientist	IOW, Warnemünde
2	Toralf Heene	Hydrography	IOW, Warnemünde
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5	Ulrich Struck	N-fixation	Humboldt-University Berlin
6	Reinhold Hanel	Fish	IfM-Geomar, Kiel
7	Tanja Joschko	Zooplankton	AWI, Bremerhaven
8	Rolf Koppelmann	Zooplankton	IHF, Hamburg
9	Anja Kreiner	Zooplankton	NatMIRC, Swakopmund
10	Bettina Martin	Zooplankton	IHF, Hamburg
11	Sven Klimpel	Fish	University Düsseldorf
12	Tim Rixen	Biochemistry	ZMT, Bremen
13	Matthias Schaber	Fish	IfM-Geomar, Kiel
14	Holger Auel	Zooplankton	University Bremen
15	Steffanie Bröhl	Zooplankton	ZMT, Bremen
16	Cornelia Buchholz	Euphausids	AWI, Bremerhaven
17	Annecke Denda	Zooplankton	IHF, Hamburg
18	Steffen Oesterle	Hydrography	NatMIRC, Swakopmund
19	Laura Lehnhoff	Biochemistry	ZMT, Bremen
20	Lorenzo Franceschinis	Zooplankton	ZMT, Bremen
21	Ferdinand Mwapopi	Zooplankton	NatMIRC, Swakopmund

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2.2 Research Program

Zooplankton organisms are important producers and consumers of organic material in marine ecosystems. They transfer carbon to higher trophic levels via the food chain and contribute to the transport of carbon into greater depths. On the other hand, they play an important role for the re-mineralization of organic matter. The main goal of this project is to identify the influences of lateral and vertical fluxes of material on the zooplankton community and to assess possible feedback mechanisms in the Namibian Upwelling region. Zooplankton will be sampled on two cruises and will be analyzed for biomass and abundance. These results will be synthesized in the proposed project GENUS and will provide data for modeling.
During the cruise MSM07/2b the pelagic communities in the northern Benguela upwelling were sampled on three cross shelf transects with 5 stations each at 17.5°S, 20°S and 23°S to derive regional information on distribution , abundance and biomass of target taxa and to recognise different nutritional preferences. The hydrographical conditions in the study area were recorded using CTDO/LADCP technique. Nutrient analyses, study of the N:P ratio and permanent recordings of VMADCP and thermosalinograph were performed in parallel. A map of the ship track and worked stations is given in Figure 2.1.

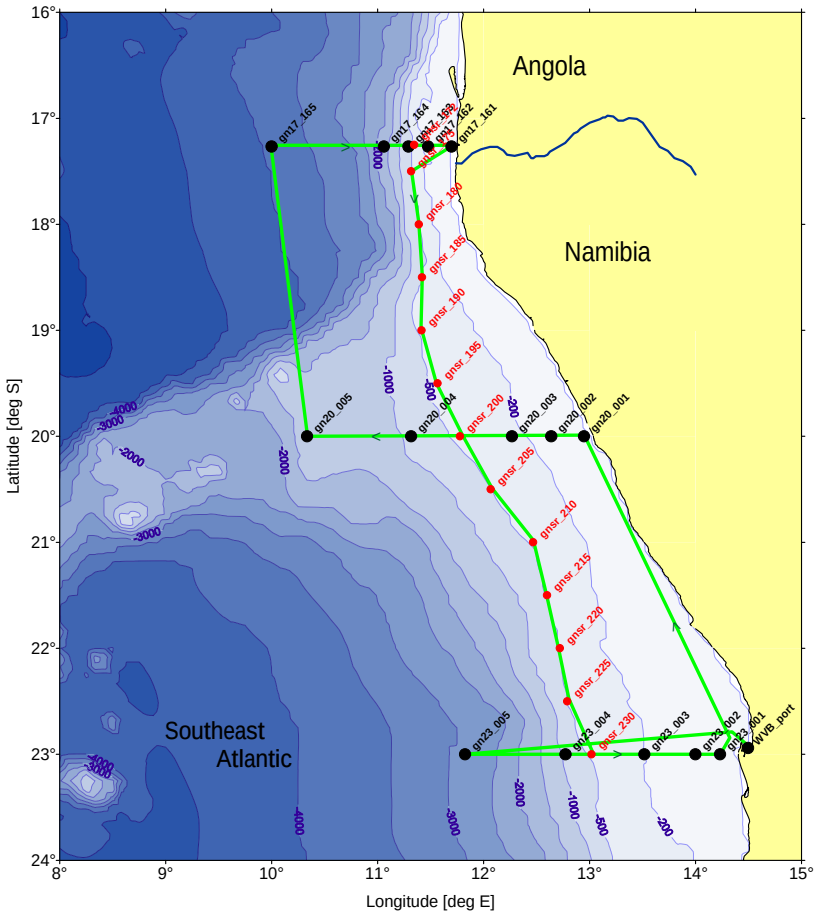

Figure 2.1: Cruise track of MSM07/2b. Regular stations at the transects are indicated by black dots. The red dots denote stations were only the CTD was deployed.

2.3 Narrative of the Cruise

09. March: All scientists on board. Although the personal luggage of six scientists is still missing, we decided to start with the work in order to save measuring time. The ship left the port of Walvis Bay towards the first transect at 23°S.

10. March: Start of measurements at the first station in the early morning (03:30). A CTD and a PumpCTD cast were performed. The work was continued with Multinet, Apstein Net, and MOCness casts (1m² and 10m²). Due to technical problems with the 1m² MOCness, only the Double MOCness 1m² was used.

11. March: Continuation of station work at the 23°S transect. The technical problems with the 1m² MOCness could be fixed.

12. March: Work at 23°S transect finished. Departure to road Walvis Bay were missing luggage was picked up from a pilot vessel. At 09:00 departure to the second transect at 20°S above the Walvis Ridge. The transect was reached at 23:30. The measurements at stations started.

13. March: Continuation of station work at the Walvis Ridge transect. The casts with the 10m² MOCness were partly replaced by IKMT net hauls.

14. March: Continuation of station work at the 20°S transect. Work at transect was finished at 20:00. Departure to the third transect off the Kunene mouth (17.5°S).

15. March: Start of measurements at the third transect at 11:00.

16. March: Continuation of station work at the Kunene transect.

17. March: Continuation of station work at the 17.5°S transect. Measurements at the transect were finished at 15:00. Start with the CTD transect at the shelf edge (500m isobath).

18. March: Continuation of CTD transect along the shelf edge on the way to Walvis Bay. Packing the equipment that will be not used at the next cruise leg.

19. March: Arrival at Walvis Bay at 09:00. Disembarking of the scientific crew.

20. March: Reception on board with the German ambassador in Namibia, local authorities and scientists from the NatMIRC institute in Swakopmund.

2.4 Preliminary Results

2.4.1 Hydrography

(M. Schmidt, V.Mohrholz, T.Heene)

At the Walvis Bay transect (23°S) temperature and salinity near the coastline indicate upwelling, but there is a remaining thermal stratification at the easternmost station. The separation of the more saline water mass at the coast from the water body at about 13°E could have been established by some along-shore transport. The more saline water met off-shore in about 50m depth is a typical phenomenon related to an Ekman compensation current below the surface mixing layer. The downward sloping isolines of temperature and salinity between 200m and 600m indicate a southward directed transport of Central Water at the shelf edge.
Off the coastal upwelling region the surface water is nearly saturated with oxygen, but some oxygen depleted water is brought to the surface near the coast. Above the shelf and the continental margin oxygen concentration decreases rapidly below 50m depth. The minimum concentration of less then 0.5ml/l was found at 150m depth above the shelf and the shelf edge. With respect to the southward transport of Central Water this water body may belong to the oxygen minimum zone in the Angola Gyre but with more reduced oxygen content from respiration and mineralisation in the bottom water and the sediment belt at the shelf north of this transect.

Similarly to observations along the Walvis Bay transect at 23°S the isotherms at the Walvis Ridge transect (20°S) are inclined upward above 100m depth and are sloping downward towards the coast below. This can be understood as upwelling near the surface driven by local wind and downwelling below caused by coastal trapped waves in connection with a southward directed undercurrent, which transports Central Water at the shelf edge pole-ward. Reduced surface salinity near the coast indicates a north-ward coastal jet. There are two main regions with oxygen depleted water. Bottom water at the shelf is suboxic between 100m and 150m depth. This zone merges into the off-shore oxygen minimum layer at about 350m depth. A third patch of low oxygen water at 12.3°S in about 50m depth corresponds to a salinity maximum, which suggests, that SACW is propagating south-ward here.

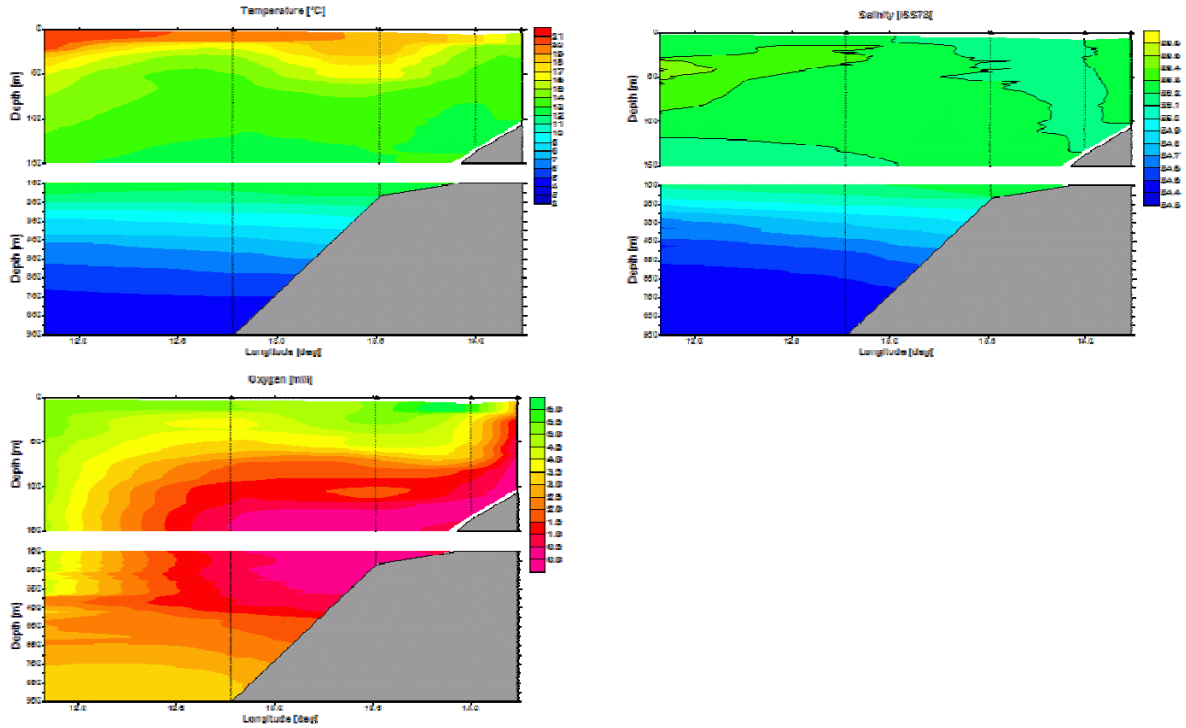

Figure 2.2: Distribution of temperature (left) and salinity (right) and dissolved oxygen (bottom) at the Walvis Bay transect (23°S).

Maximum sea surface temperature at the Kunene transect (17.5°S) is about 26°C. The surface layer is about 25m thick and vertically uniform. There is a significant zonal temperature gradient, which originates most probably from previous upwelling events near the coast. However, the basis of the mixing layer is not elevated. Isotherms and isohalines show a downward slope between 100m and 300m depth but no elevation below. However, the horizontal station distance is too large for a detailed analysis. Below the mixed surface layer oxygen is depleted. Near the coast the oxygen depleted zone starts immediately below the mixed layer, off-shore oxygenated water extends to about 100m depth. The typical Angola Gyre oxygen minimum is found here at about 350m depth.

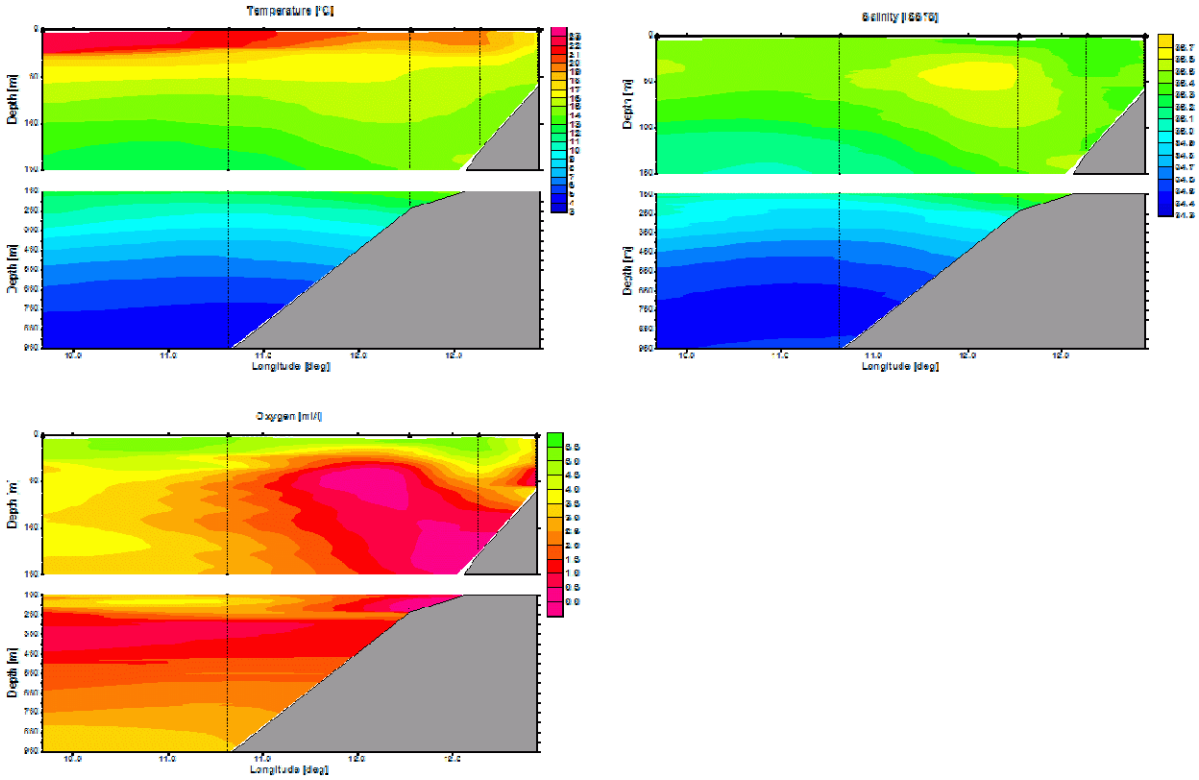

Figure 2.3: Distribution of temperature (left) and salinity (right) and dissolved oxygen (bottom) at the Walvis Ridge transect (20°S).

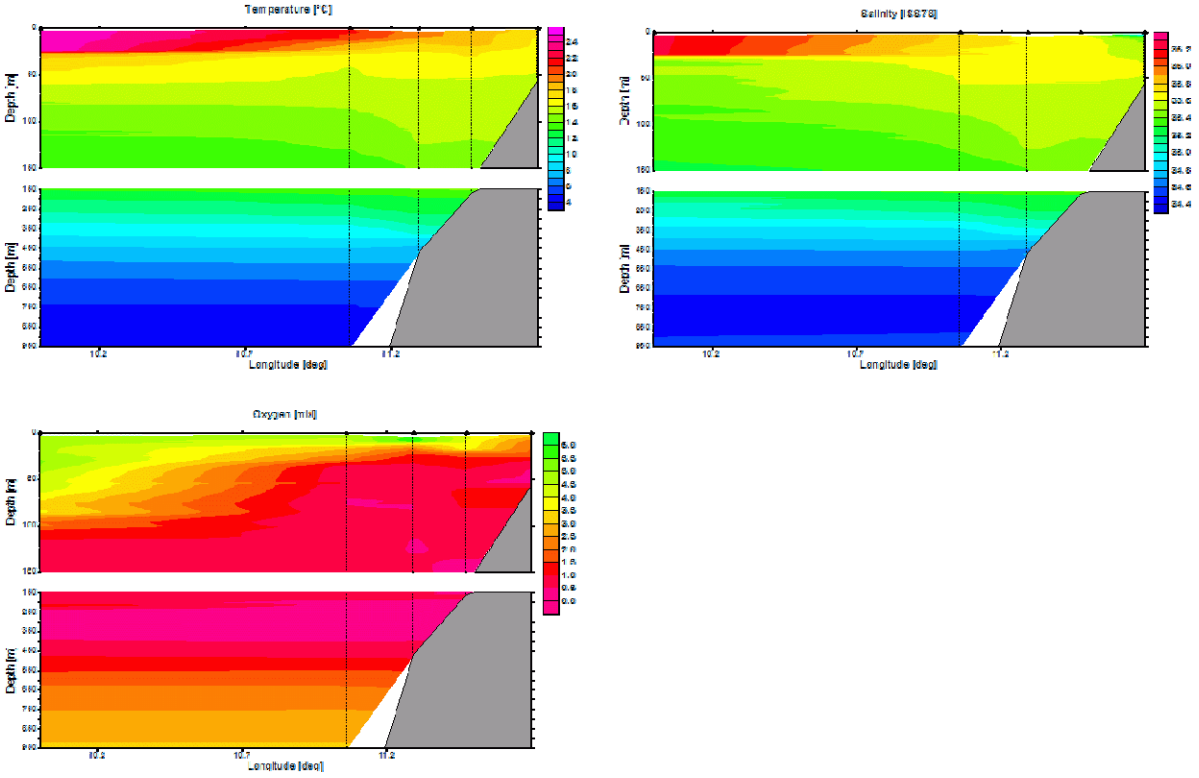

Figure 2.4: Distribution of temperature (left) and salinity (right) and dissolved oxygen (bottom) at the Kunene transect (17°S).

2.4.2 Nutrients, carbon and plankton

(Tim Rixen, Laura Lehnhoff, Anja Kreiner and Steffen Oesterle)

Coastal upwelling systems produce horizontal gradients along which factors controlling shifts in the planktonic community structure and the associated biologically mediated CO_2 uptake referred to as the biological pump can be studied. Therefore plankton and water samples were collected along transects perpendicular and parallel to the Namibian coast. In addition to water samples, pCO_2 was measured continuously by using an underway system. At the stations the pCO_2 underway system was connected to a pump CTD in order to obtain pCO_2 depth profiles down to a water-depth of up to 360 m. The obtained samples and data were complemented by various meteorological and oceanographic parameters which were also measured continuously by underway systems installed on board RV MARIA S. MERIAN (see cruise track Figure 2.1). The meteorological and oceanographic data were provided by M. Schmidt.

Methods

- pCO_2 were measured continuously by a newly developed surface underway carbon dioxide analyzer (SUNDANS, MARIANDA),
- total alkalinity (TA) will be determined potentiometrically using VINDTA 2 S system (MARIANDA),
- water samples for nutrients analysis were stored in a deep freeze and will be measured by a SKALAR autoanalyzer during the following leg,
- oxygen concentrations were measured in > 120 water samples by applying the Winkler method in order the validate the data collected by the CTD,
- plankton samples down to water-depth of 100 m were collected by using the Apstain net. The obtained samples were stored in 250ml-PE bottles and preserved with 4% formaldehyde buffered to a pH-value of 8.2 with hexamethylentetramine. Samples were stored at 4°C until further analysis.

Overall approximately 400 nutrient, 120 TA, 100 methane and 18 plankton samples were collected during the cruises.

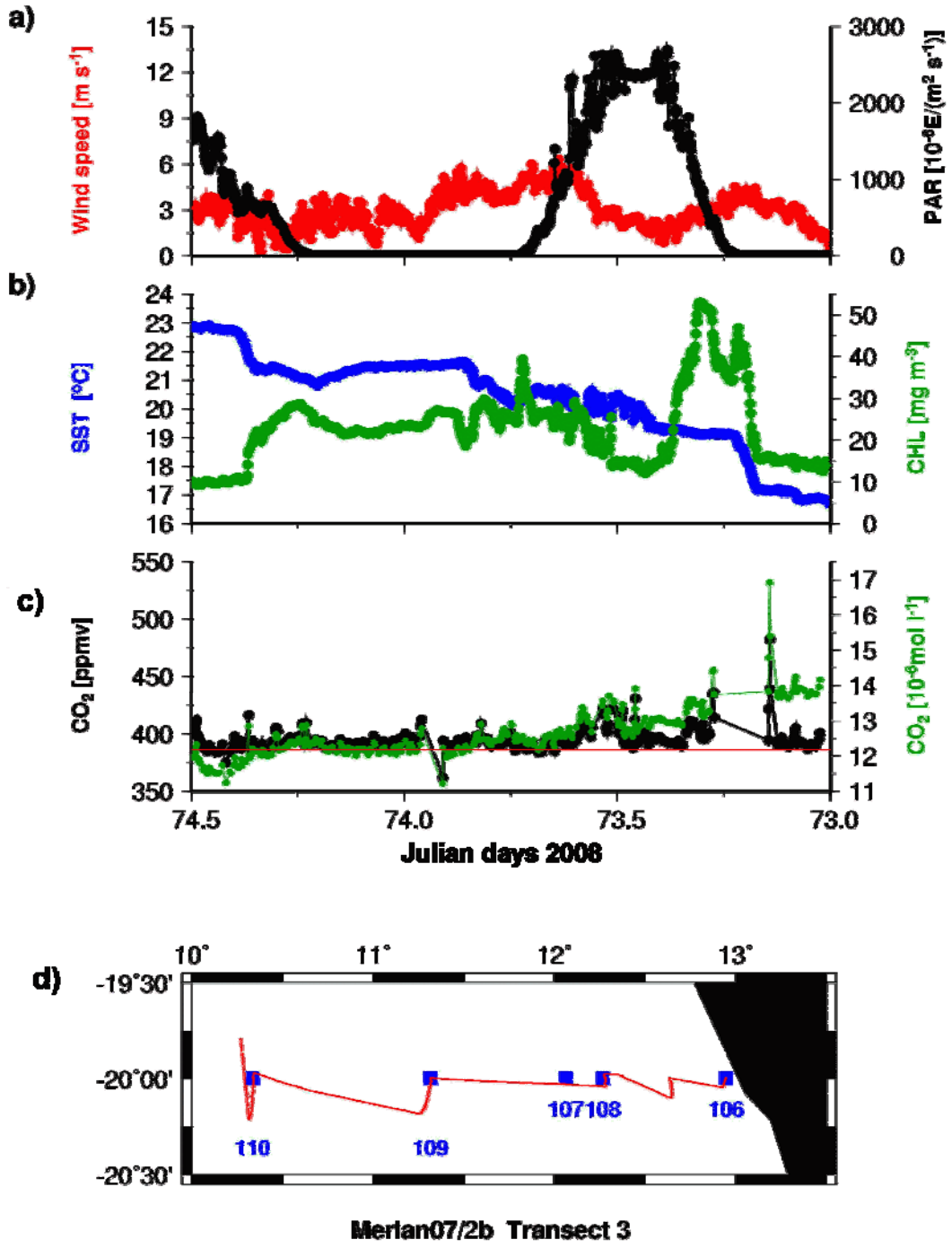

Figure 2.5: (a) Wind speed, photosynthetic active radiation (PAR), (b) sea surface temperature, surface chlorophyll concentration, (c) pCO2 in the surface water (black) and the atmosphere (red) as well as CO2 concentrations (green) versus the time during which we sailed from station 106 to 110.

Upwelling appeared to be strongest within a narrow belt extending parallel to the coast up to approximately 70 km offshore. While advecting offshore, the SSTs increased from ~16 to ~23 °C (Fig. 2.5). During the first steep SST increase from 16 to 19°C diatom blooms were observed as indicated by the enhanced chlorophyll concentrations and seen by the preliminary evaluation of the plankton samples. These bloom declined and were followed by another bloom at higher

SSTs ~130 km offshore. This offshore bloom still has to be characterized as well as the reason for the decline of the diatom which could for example caused by the lack of silicate in combination with an enhanced grazing pressure. However, this will be evaluated in much more detail after the water and plankton samples are analyzed.

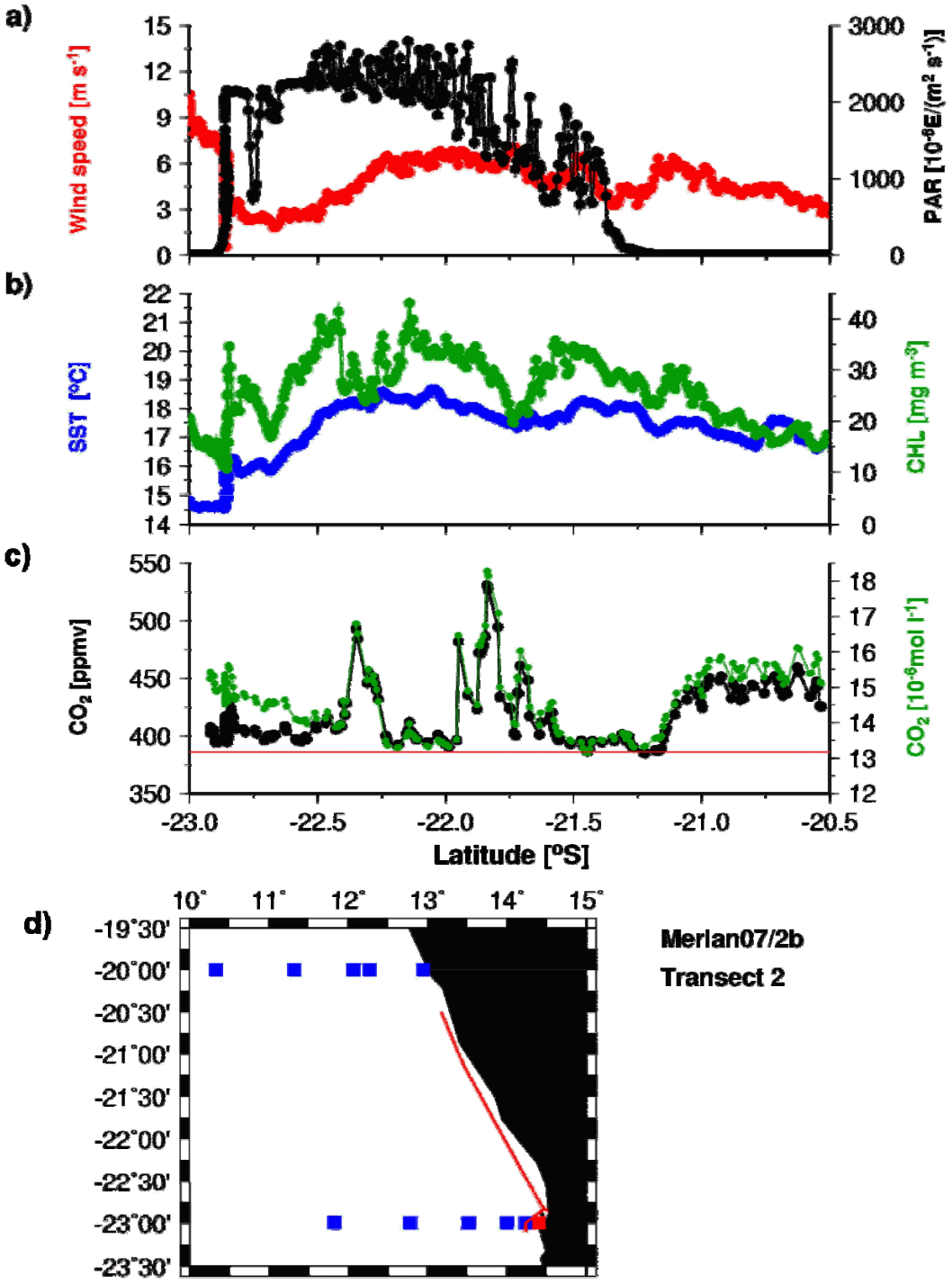

Figure 2.6: The same as previous figure but along a transect parallel to the coast as illustrated by the map

The chlorophyll concentrations and the SST showed that the diatom dominated narrow belt along the coast was not a uniform unit. Although SST and chlorophyll generally followed the

solar irradiation and showed low values during night and high values during day, there were also unexpected excursions towards lower chlorophyll concentrations during the day. Low chlorophyll concentrations which are generally associated with enhanced CO_2 concentrations suggest in turn that photosynthesis could reduce pCO_2 by ~140 ppmv.
Along the transects from the coast towards the more open ocean sites the pCO_2 values were close to the atmospheric pCO_2 suggesting a relatively low net flux of CO_2 across the air water interface (Fig. 2.6). This seems to be caused by the biologically mediated uptake of CO_2, which reduced the pCO_2 increase, caused by the warming of the offshore advecting upwelled water. Although there were a few locations further offshore at which the pCO_2 in the water dropped below the atmospheric concentrations, probably the entire study area acted as source for atmospheric CO_2 during the expedition.

2.4.3 Mesozooplankton sampling by Multinet

(Holger Auel, Tanja Joschko)

Mesozooplankton was sampled at each station by stratified vertical hauls with a multiple opening/closing net system (Hydrobios Multinet Midi) with a mouth opening of 0.25 m^2 and equipped with five nets of 150 µm mesh size.
The net was lowered to a maximum sampling depth of 1000 m or – at shallower stations – shortly above the seafloor and heaved vertically at a speed of 0.5 m s^{-1}. Sampled depth intervals were chosen according to hydrographic profiles of water temperature, chlorophyll content and oxygen concentration determined by CTD casts immediately before the Multinet deployment and, hence, varied between the different stations.

The Multinet was deployed over the starboard side using the large "Schiebebalken" over the working deck and one of the 11 mm mono-conductor cables. This set-up proved very efficient and operated exceedingly well. Only once, at stn. 104, probably because of the heavy swell, the security lever of the Multinet changed position and prohibited the regular closure of the nets. This problem could be solved quickly with the skilful help of the deck crew and the haul was repeated successfully.

Samples were transferred into a temperature-controlled room (15°C) immediately after the catch and screened in photo dishes for a preliminary assessment of abundance and species composition. Certain species including large copepods, some other crustaceans, pteropods, and fish larvae were sorted out from the catch and either used for respiration measurements on board or deep-frozen at -80°C for later molecular genetic and/or biochemical analyses (fatty acid trophic biomarkers, stable isotope signatures). The remains of the samples were preserved in a 4% formaldehyde/seawater solution for quantitative analyses of abundance, biomass and species composition at the home institute.

2.4.4. Mesozooplankton and micronekton sampling by MOCNESS

(Rolf Koppelmann, Cornelia Buchholz, Anneke Denda, Reinhold Hanel, Sven Klimpel, Bettina Martin, Matthias Schaber)

Mesozooplankton and micronekton was sampled to gain insights into the vertical and horizontal distribution of these faunal elements in the Namibian upwelling area. Furthermore, the samples will be used for biochemical and gut content analyses and for the determination of physiological rates. Five stations were sampled on three transects from the coast to open waters.

Mesozooplankton samples were taken by oblique hauls (towing speed 2 knots) with the use of a 1m^2-Double-MOCNESS (Multiple Opening and Closing Net and Environmental Sensing

System). The system is equipped with 2 * 10 nets of 333-µm mesh aperture side by side with a one square meter opening each. The nets can be opened and closed sequentially. Parallel sampling was performed and the sampling intervals were 25 m in the top 50 m, 50 m between 50 m and 200 m, and 200 m at greater depths. The filtered volume was calculated by a flowmeter. Veering and heaving speed of the winch was up to 0.5 m s^{-1}, heaving speed was reduced to 0.1-0.3 m s^{-1} for sampling in shallow waters. The ascent rates were between 9 and 16 m min^{-1}. The device carried CTD-probes to collect environmental data.

Upon recovery of the 1m^2-Double-MOCNESS, the left nets were rinsed with seawater and the plankton was preserved immediately in a 4% formaldehyde-seawater solution buffered with sodiumtetraborate. Prior to the preservation of the material, subsamples were taken for the determination of CN, stable isotopes ($\delta^{15}N$, $\delta^{13}C$), metabolic activity (ETSA), and for gut content analyses and frozen at -80° C. The right nets were used by other groups to pick living animals for experiments. The remaining zooplankton in these nets was also preserved in buffered formaldehyde.

Depending on the instant analysis of the 1m^2-Double-MOCNESS, an open ring trawl with an opening of 1.8 m^2 and a mesh aperture of 2000 µm was deployed in the appropriate depth for fish larvae. A ten minute tow and gentle heaving at 0.1 m s^{-1} assured high quality living animals for physiological experiments.

A single 1m^2-MOCNESS with 9 nets, mesh aperture 2000 µm, was used by the AWI-BAH working group to collect euphausiids and fish larvae (ZMT) for respirations experiments. The gear was only used at the deep stations on the northern transect.

The 10m^2-MOCNESS is similar in construction to the 1m^2-MOCNESS, but equipped with 5 nets of 1600 µm mesh aperture and a mouth opening of ten square meters. The system is designed to catch mainly micronektonic animals. Sampling intervals were similar to the one square meter system at the shallow stations but coarser at the deeper stations due to the limited amount of nets available. Either this system or the IKMT of the Kiel working group was used at the stations. Some animals were sorted out of the catches for biochemical analyses. The remaining catch was preserved in a 4% formaldehyde-seawater solution buffered with sodiumtetraborate.

2.4.5. Ichthyoplankton sampling

(Anja Kreiner, Stefanie Bröhl)

In order to describe the horizontal and vertical distribution of fish larvae, ichthyoplankton was sampled with the Multiple Opening and Closing Net and Environmental Sensing System (MOCNESS). Upon recovery of the 1m^2-Double-MOCNESS, the right nets were rinsed with seawater and samples were scrutinized on board and all fish larvae were removed. Samples of the 10m^2 MOCNESS, the ring trawl and the single MOCNESS were also scrutinized for fish larvae. Fish larvae were preserved in 4% formalin for species determination and length measurements. Some clupeoid and *Trachurus* larvae were frozen at -80°C in order to extract the otoliths for age determination at a later stage. All samples from the right nets of the double MOCNESS were preserved in 4% formalin for determining the wet weight of the zooplankton.
Fish larvae were also collected from the 10m^2 MOCNESS (section), the ringtrawl (section) and the IKMT (section). Larvae were roughly identified and preserved in 4% formalin for later analysis.

The double MOCNESS caught fish larvae on all stations except for stations five and seven (Fig. 2.7). Most larvae found throughout the survey area were of the mesopelagic group, followed by *Engraulis, Trachurus* and Myctophidae (Fig. 2.8). Other larvae caught during the survey included pipefish, Gobidae, Blennidae, *Leptocephalus, Sardinella* etc.

Larvae of mesopelagic fish were mainly caught in deoths of more than 400m, while *Trachurus* and *Engraulis* larvae were mainly found in depths of less than 150m. Myctophidae larvae were found at almost all depths.

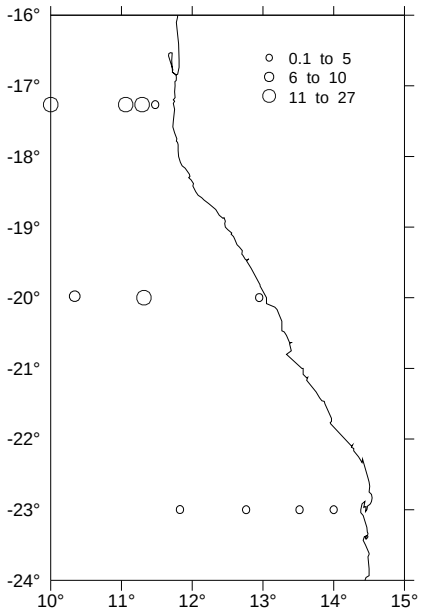

Figure 2.7: Map of all fish larvae (number per square meter surface water) caught in the double MOCNESS during the survey

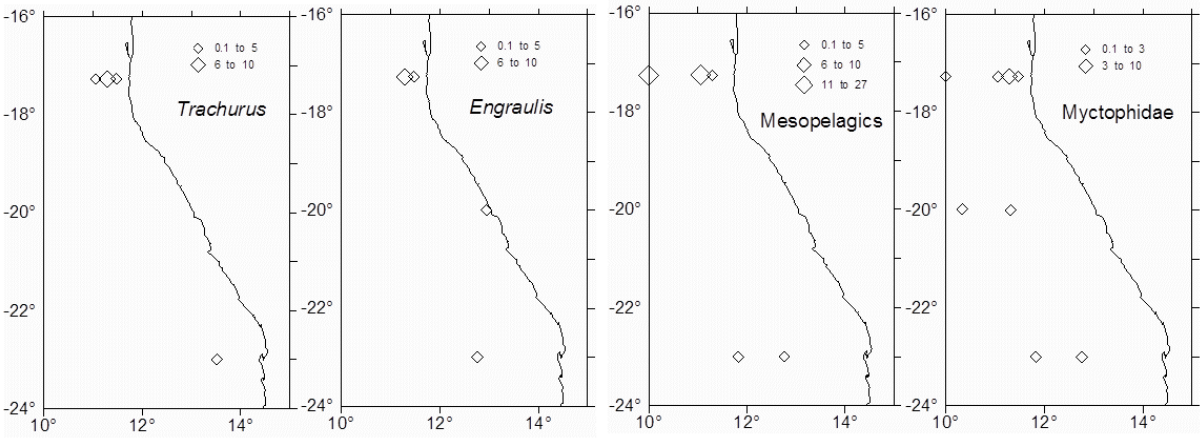

Figure 2.8: Map of all fish larvae (number per square meter surface water) of different groups (Myctophidae, mesopelagics) and species (*Engraulis, Trachurus*) caught in the double MOCNESS during the survey.

The 10m^2 MOCNESS caught a large number of fish larvae on station 12 between 200m and 1000m depth. A significant number of *Engraulis* larvae were caught on station 13 with the 10m^2 MOCNESS.

On station 6 (20°00'S/12°58'E), 122 *Engraulis* larvae were in the ringtrawl between 0 and 30m. On station 3 (23°00'S/13°31'E), 64 *Trachurus* larvae were caught in the IKMT between 100m and the surface.

2.4.6. Fish

(Reinhold Hanel)

Coastal upwelling regions like the area off Namibia are generally characterised by short trophical cascades and high abundances of small pelagic schooling fish species mainly of the families Clupeidae and Engraulidae. Further offshore, outside the shelf edge, these communities are replaced by mesopelagic fish communities, dominated in biomass mostly by diurnally vertically migrating lanternfishes (Myctophidae). Despite their small body size, sardines and anchovies as well as lanternfishes play a crucial role in the food-web of the Benguela region. They are the major predators on crustacean plankton and at the same time important prey for top predators like seabirds and seals. Due to climatic and fisheries impacts the size of these stocks can highly fluctuate.

Research goals of MSM07/2b and subsequent surveys regarding nekton ecology include:

- Provision of an inventory of species and communities of the shelf and mesopelagic fish and cephalopod fauna.
- Definition of phylogeographic boundaries and population structure of some key species
- Indication of key bentho-pelagic tropho-dynamic processes for the nekton
- Indication of probable exchange processes between shelf and shelf-edge / continental slope

Micronecton organisms, when present, were collected from IKMT, 10 m^2 MOCNESS and Double-MOCNESS catches, identified to the lowest possible taxonomic level and preserved by freezing at -20°C for subsequent analyses. Final species identification, morphometry, maturity stage and gut content analyses as well as parasitological and phylogeographic investigations will be performed at the Leibniz Institute of Marine Sciences Kiel and the University of Düsseldorf.

IKMT and 10 m^2 MOCNESS catches at the three outermost stations of each transect revealed a representative overview of the mesopelagic fish fauna of the outer Benguela current system. Different species of lanternfishes (Myctophidae), bristlemouths (Gonostomatidae), hatchetfish (Sternoptychidae), deepsea smelts (Bathylagidae), dragonfishes (Stomiidae), loosejaws (Malacosteidae), pearleyes (Scopelarchidae), deepsea anglers (Ceratiidae, Melanocetidae), bigscale fishes (Melamphaidae) and lanternbellies (Acropomatidae) were found and preserved for subsequent stomach content analyses as well as for parasitological and/or phylogeographic investigations. Due to a lack of time, a diurnal sampling design with day- and night-catches at least at single stations could not be applied. This will be one essential task for future investigations within this program to assess the importance of vertical feeding migrations for the transfer of nutrients from the epipelagial to deeper layers outside the shelf.
The picture changed tremendously for the two southern transects when reaching shallower shelf regions. Micronecton catches were limited to a few horse mackerel (*Trachurus capensis*) juveniles, although the overall revealed biomass per catch unit effort significantly increased due to large numbers of medium to large sized jellyfish. From our catches we cannot confirm the recently reported outburst of pelagic gobies in the coastal upwelling areas, since not a single individual could be documented. More detailed surveys targeting fish assemblages in the vicinity of oxygen minimum zones would be needed to test the hypothesis whether pelagic gobies are

able to outcompete clupeoid fishes at medium to low oxygen concentrations in the upwelling areas.
The northernmost transect was characterised by an obvious shift in fish community composition towards more warm-adapted species and a slight increase in biodiversity. At the two outermost stations, subtropical midwater species like the snipe eel *Nemichthys curvirostris*, the bristlemouth *Triplophos hemingi* and scaleless dragonfishes of the genus *Odontostomias* appeared for the first time or significantly increased in abundance. Jellyfish abundance significantly decreased on the 3 shelf stations compared to the two more southern transects.

Figure 2.9: Mesopelagic fishes sampled during MSM07/2b. Upper left*:* *Anoplogaster cornuta*; upper right: *Caristius sp.*; lower left: *Melanocetus johnsoni*, lower left: *Nemichthys curvirostris*.

Scientific deep water catches of fish from Benguela current region are rather scarce. Detailed taxonomic work will help to identify community structures and ocean boundaries. Gut content analyses and parasite infestation will provide information on the structure of food webs at higher trophic levels. Tissue samples will be used for DNA barcoding purposes, interspecific phylogenetic as well as intraspecific phylogeographic comparisons.

2.4.7. Euphausiids

(Cornelia Buchholz)

The reproductive status of organisms is not only important for physiological experiments but also for an assessment of their energy budget. In the Namibian upwelling region euphausiids, a

substantial factor in the food web and regular vertical migrators, have to cope with steep gradients of the temperature, oxygen and trophic environment. Moreover, their reproductive and growth activities have to be finely tuned. With the shedding of the shell at moulting they would otherwise loose their eggs or, if the eggs are directly released into the water column, loose energy needed for egg maturation.

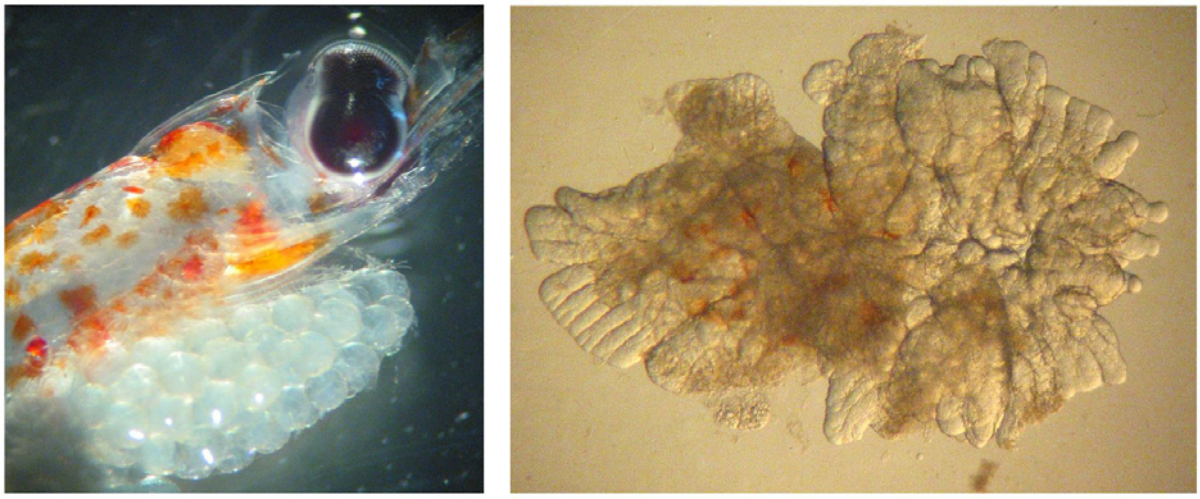

Figure 2.10: *Nematoscelis* spec. (left) *Euphausia hanseni*, Ovary (right)

During leg 2b the analysis of the reproductive status of *Euphausia hanseni* was started comparing in situ appearance of the ovary in living krill with the size and later the histological appearance of the isolated ovaries (Figure 2.10). The laboratory conditions and limited ship movements of RV MARIA S. MERIAN allow the preparation of very delicate tissues under the dissecting scope even at windy weather.

A preliminary analysis of still living euphausiids we caught at different stations, suggests a horizontally differing distribution of species with *Nyctiphanes capensis* in the south (lat.23°). Many of those were carrying eggs already developed to the nauplius stage (Fig. 2.11) but not yet released. The bulk of the krill in the 20°S transect and many, depending on depth, in the northern 17° transect were *Nematoscelis megalops* (species to be confirmed), while *Euphausia hanseni* dominated in a deeper layer at Station gn17_164.

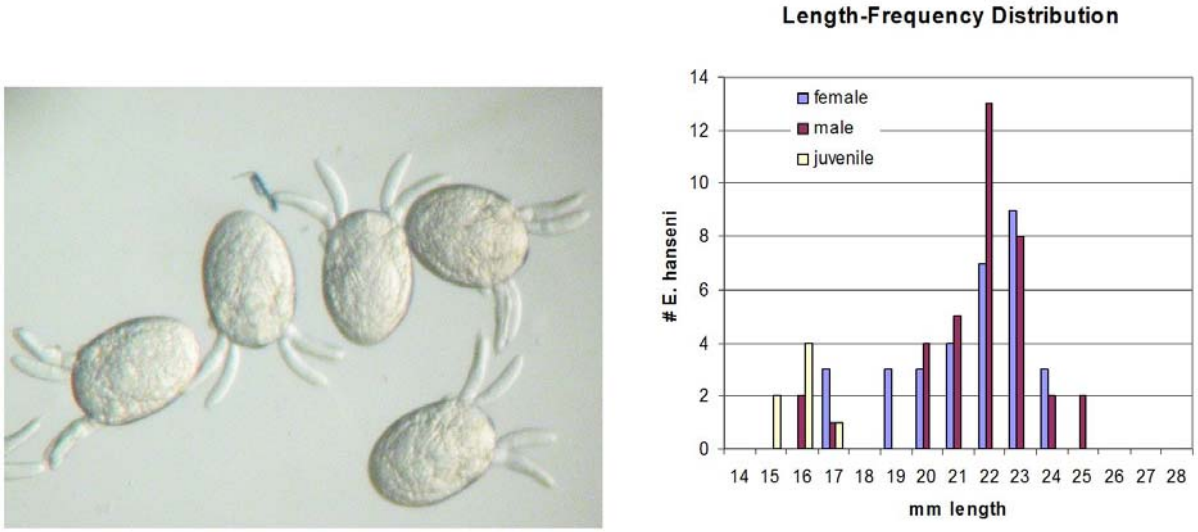

Figure 2.11: *Nyctiphanes capensis*, Nauplii (left), length distribution of *Euphausia hanseni* (right).

Random sample: *E.hanseni* 296; *N. megalops 100*
The gender ratio (female/male) of *E. hanseni* was 0.86. The size distribution in a sample of 76 individually identified and sexed krill is shown in the diagram.

The MOC1 with an opening of 1 m^2 and a mesh size of 2000 µm rendered clean samples of euphausiids in good condition , so that in the following leg 3, physiological experiments will be possible.

2.4.8. Suspended matter sampling and nitrogen fixation experiments

(Sandra Schmitz, Ulrich Struck)

During MSM cruise 7/2b at 15 stations suspended matter sampling was performed. We used a multi-port filtering device to sample the water for 5 different parameters >0.8micron: Chlorophyll a, particulate Phophorus, particulate Silicate, particulate organic carbon and particulate nitrogen, as well as total SPM. Samples are stored frozen or dried for later processing at onshore laboratories. The overall number of samples retrieved amounts to about 600.
On six selected stations day-light incubations for nitrogen fixation rates estimates were performed. On the three sampled transects one station close to the coast and one off shore station was selected for the incubations. We used two different water types for the incubation from two different water depth (>10micron prefiltered and bulk water) and incubated them under 4 different radiation conditions (100%, 75%, 30%, and 15% of incoming irradiance) on deck.
The water samples were kept cool in a permanent flow of sea water pumped into the incubator. The samples were treated with 2ml of 100 Atom% pure $15N_2$ per litre before the start of the experiment. Incubation time was typically 4 hour during day time. After the incubation the water was filtered on precombusted (4hours at 450°C) Whatmann GF glass fibre filters and dried in an oven at 40 °. The nitrogen isotope measurement of the samples will be performed in the stable isotope laboratories at the Natural History Museum in Berlin, Germany.

2.4.9. Underway measurements of temperature, salinity and fluorescence

(Martin Schmidt)

The saline surface water penetrates south to 18°S and is replaced by less saline water there. There is a cross-shore salinity gradient with lower salinity near the coast and patches of more saline water off-shore.

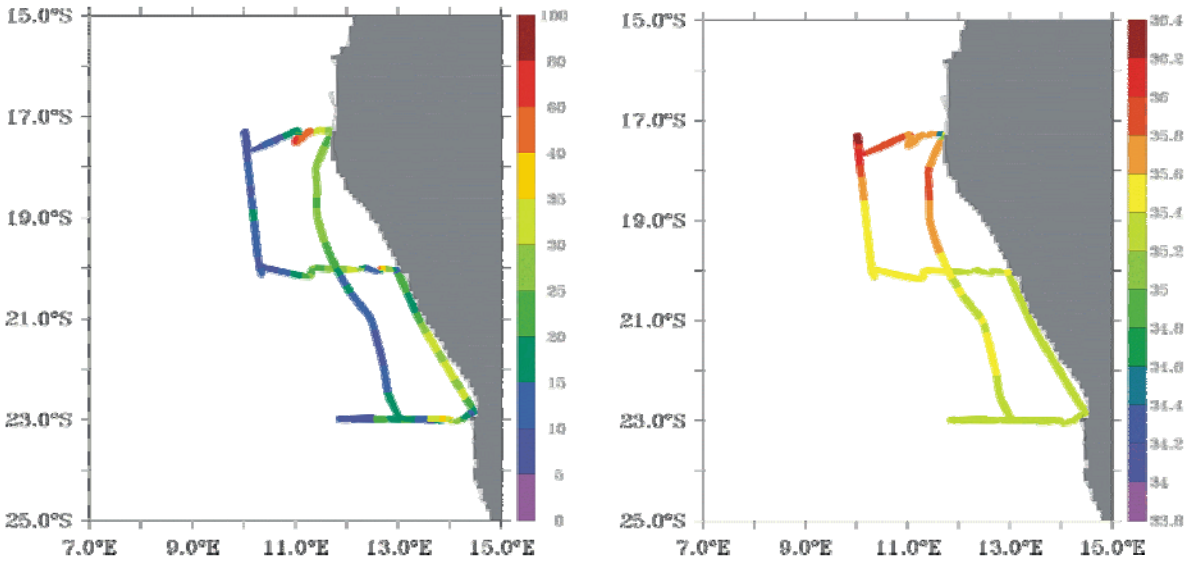

Figure 2.12: Fluorescence in chlorophyll-A units (µg l^{-1}, nonlinear scale) (left) and salinity (right) in the surface water. (09. March - 19.March 2008)

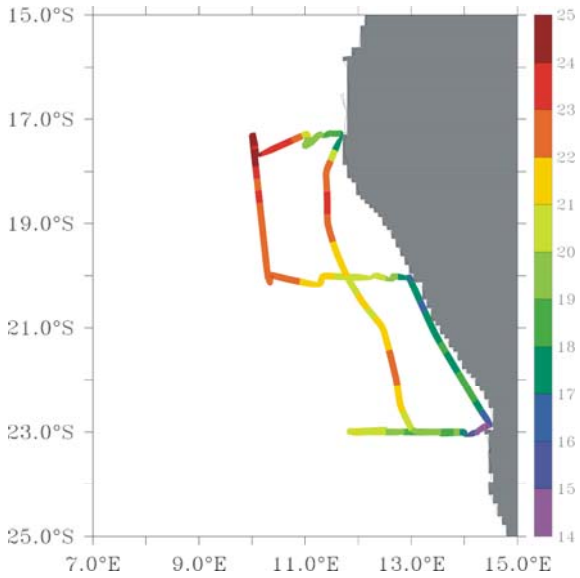

Figure 2.13: Surface temperature in the upwelling area. (09. March - 19.March 2008)

Surface temperature is lowest near the coast due to upwelling. There is a remarkable variability between legs 2a and 2b, especially at 17°S and off Walvis Bay, but also along the Namibian coast between 17°S and 23°S. Comparing both legs, the area of colder water at 17°S is more extended at leg 2b. This corresponds to a considerable amount of phytoplankton, which was visible during leg 2b as thick flocks in surface water and in net samples, but also to be seen as enhanced fluorescence. The patch of high chlorophyll-a fluorescence at 22°S (Fig. 2.12)

corresponds to a bloom, which caused a red tide in Swakopmund at 8th and 9th of March and several lobster walkouts at following days.

The upwelling of cold water seen off Walvis Bay started 11th of March and went along with turquoise water colour and smell of H_2S.

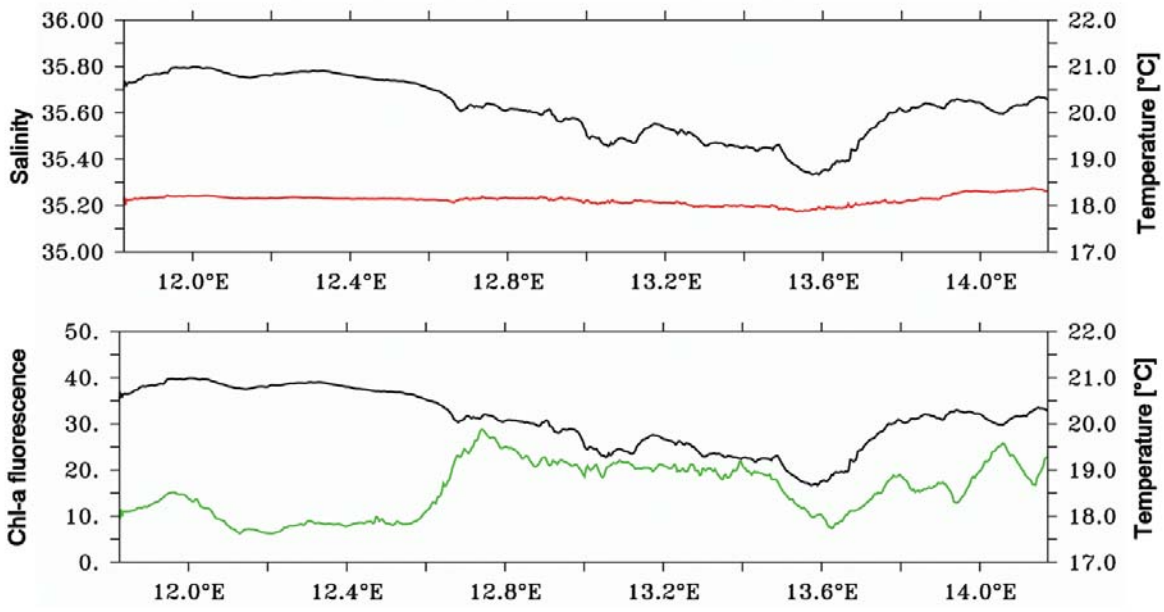

Figure 2.14: Surface temperature, salinity and fluorescence at the 23° S transect, sampled from 9th March to 10th of March. black line: temperature [°C], red line: salinity, green line: fluorescence [µg l^{-1}].

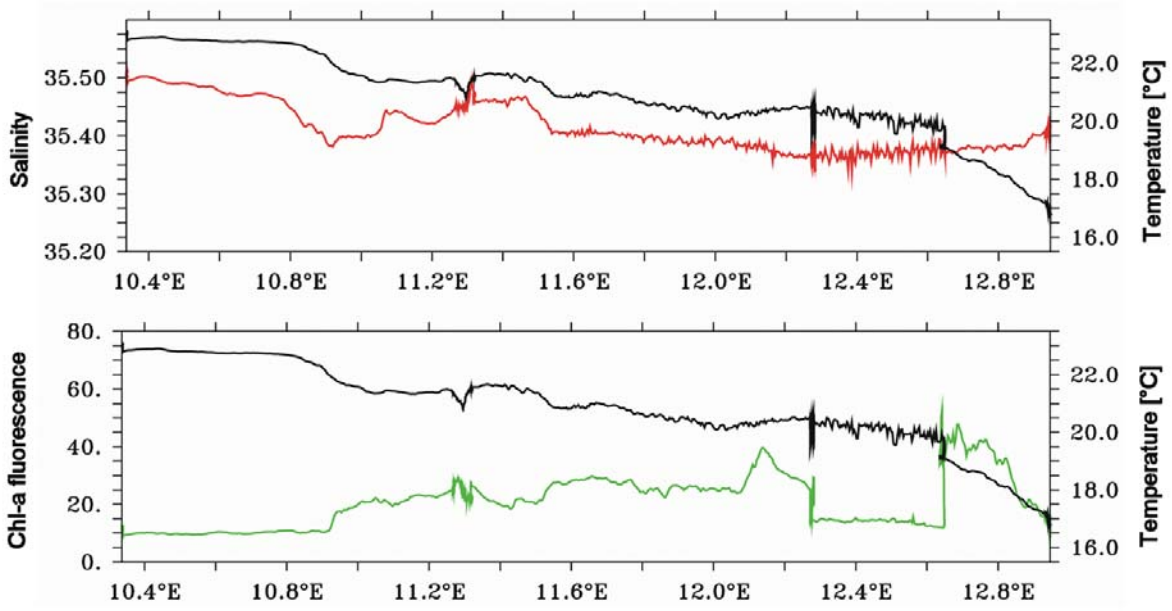

Figure 2.15: Surface temperature, salinity and fluorescence at the 20° S transect. Black line: temperature [°C], red line: salinity, green line: fluorescence [µg l^{-1}].

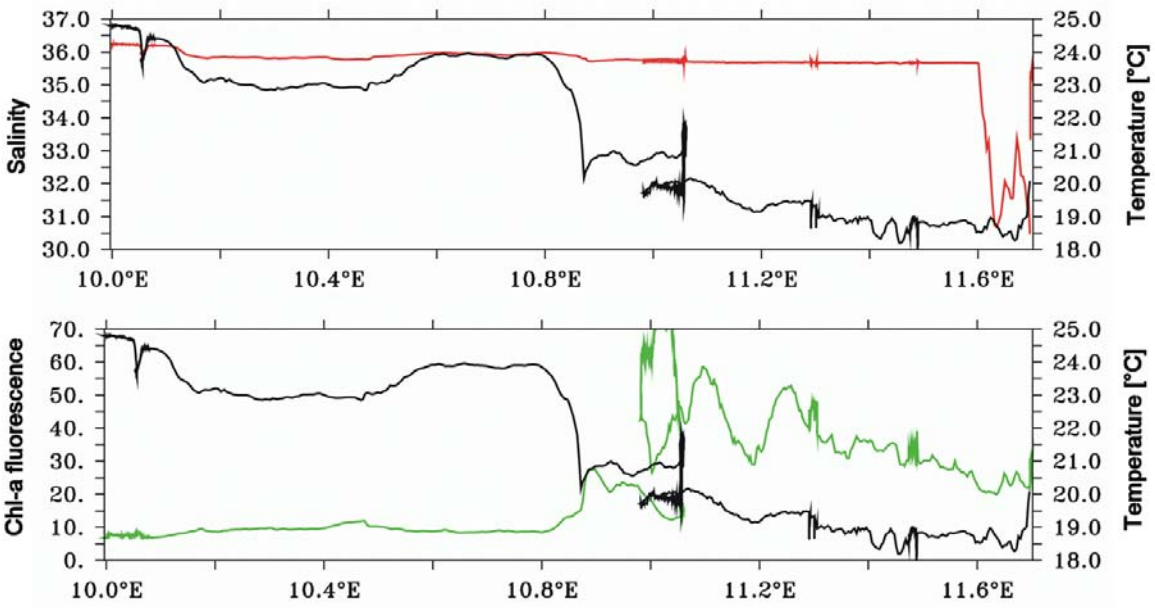

Figure 2.16: Surface temperature, salinity and fluorescence at the 17° S transect. Black line: temperature [°C], red line: salinity, green line: fluorescence [µg l^{-1}].

Figure 2.14 to Figure 2.16 show surface temperature, salinity and fluorescence at cross shore transects. Note, that the upwelling off Walvis Bay started later at 11th of March and is not to be seen in Figure 2.14. At all transects surface salinity is rather uniform with a minor increase towards the open ocean. The low salinity values at 17°S are from nearby the Kunene mouth. Temperature has an overall cross shore gradient with lowest temperature near the coast. Fluorescence reveals a zonal but patchy structure, maximum values are found in colder water bodies and the warmer water far off-shore shows generally low fluorescence.

2.4.10 Ship's meteorological station

(Martin Schmidt)

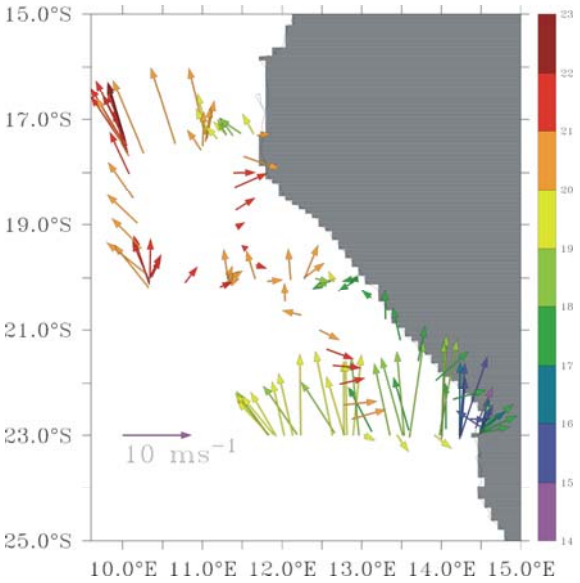

Figure 2.17: Wind speed and air temperature at leg 2b. Colours stand for air temperature [°C].

Figure 2.17 shows wind speed (as arrows) and air temperature (colour coded). The arrows orient in geographical co-ordinates, hence the angle depends on the aspect ratio of the figures. The

wind speed and air temperature are given at sensor height (29.5~m or 20~m above ships gravity center). The onset of strong southerly winds at 10th of March favours upwelling and low sea surface temperature as well as air temperature is observed off Walvis Bay and along the Namibian coast. During leg 2b winds are moderate to strong from southerly direction but are diminishing at 17th of March.

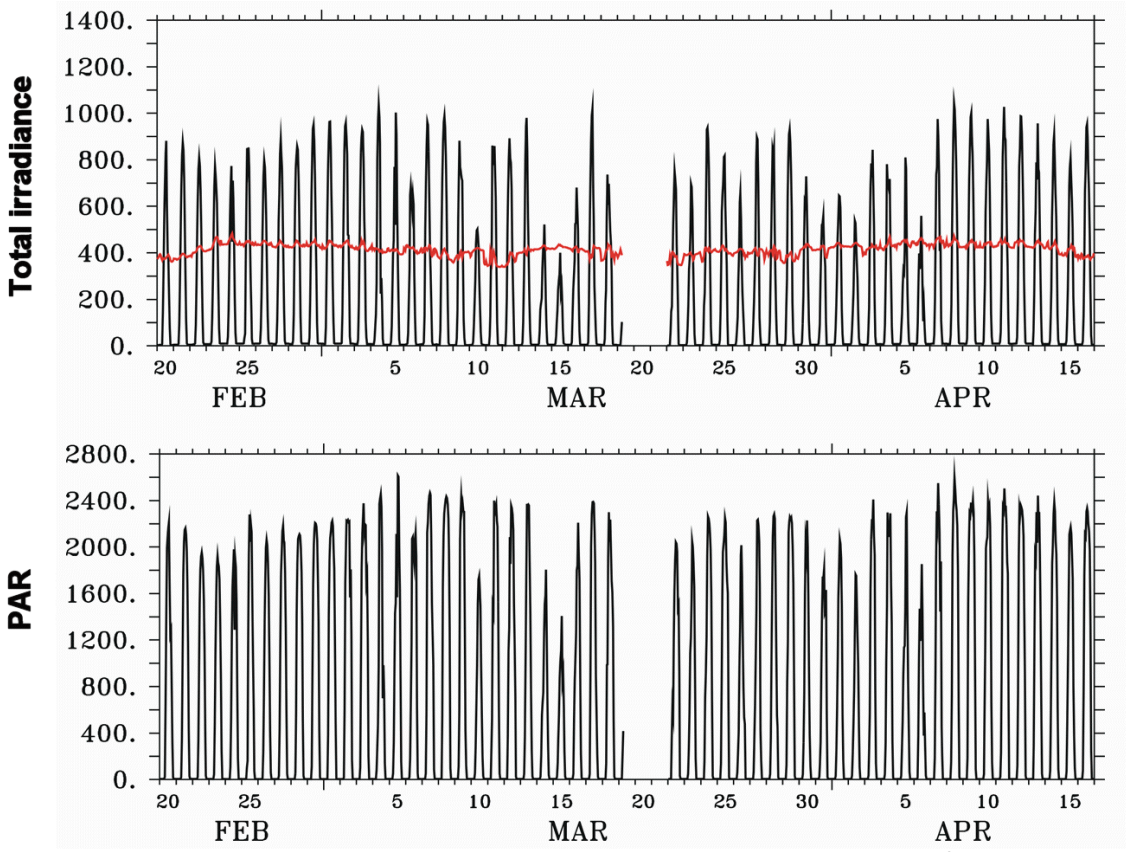

Figure 2.18: Shortwave (black line) and longwave (red line) incoming radiation in Wm^{-2} (upper panel) and photosynthetic active radiation in μEm^{-2} (lower panel).

Solar short wave radiation shows a daily cycle with maximum values above 800 Wm^{-2} except 10th, 14th and 15th of March, where sky was overclouded. The incident long wave radiation shows neither a daily cycle nor a meridional variability but has a nearly constant value of about 400 Wm^{-2}. At cloudy days it is slightly enhanced. The photosynthetic active radiation (PAR) shows the same pattern like the solar short wave radiation. The daily maximum value is above 2000 μEm^{-2}.

2.5 Station List MSM 07/2 b

Table 2.1: List of Stations

Stat. Nr.	Name	Time	Latitude	Longitude	Depth	CTD	PCTD/ Nets
0101	gn23_005	10.03.2008 03:12:38	22°59.8586'S	011°49.6091'E	12.5	0101	01
0102	gn23_004	10.03.2008 20:05:24	22°59.9705'S	012°45.7434'E	993.9	0102	02
0103	gn23_003	11.03.2008 08:27:00	22°59.9783'S	013°31.0236'E	219.7	0103	03
0104	gn23_002	11.03.2008 15:31:41	22°59.9632'S	013°59.9812'E	138.7	0104	04
0105	gn23_001	11.03.2008 21:30:12	23°00.0430'S	014°14.0263'E	107.4	0105	05
0106	gn20_001	12.03.2008 23:42:59	19°59.8689'S	012°56.7641'E	59.5	0106	06
0107	gn20_002	13.03.2008 05:31:38	19°59.9801'S	012°38.2899'E	129.2	0107	07
0108	gn20_003	13.03.2008 12:25:38	19°59.2242'S	012°16.3456'E	238.7	0108	08
0109	gn20_004	13.03.2008 21:05:53	19°59.9548'S	011°19.0575'E	967.4	0109	09
0110	gn20_005	14.03.2008 11:40:37	19°58.7529'S	010°20.2924'E	1387.0	0110	10
0111	gn17_165	15.03.2008 10:58:25	17°15.8607'S	010°00.0361'E	3924.2	0111	11
0112	gn17_164	16.03.2008 07:40:27	17°16.0034'S	011°03.6256'E	1600.3	0112	12
0113	gn17_163	16.03.2008 22:16:58	17°15.8686'S	011°17.5307'E		0113	13
0114	gn17_162	17.03.2008 04:02:30	17°15.9737'S	011°28.4536'E	164.9	0114	14
0115	gn17_161	17.03.2008 07:53:12	17°16.0921'S	011°41.8406'E	56.6	0115	15
0116	gnsr_180	17.03.2008 13:09:11	18°00.0587'S	011°23.3260'E	438.3	0116	-
0117	gnsr_190	17.03.2008 18:56:55	18°59.9114'S	011°24.9703'E	449.7	0117	-
0118	gnsr_195	17.03.2008 21:42:43	19°29.8402'S	011°33.9248'E	461.4	0118	-
0119	gnsr_200	18.03.2008 00:43:25	20°00.0314'S	011°46.6643'E	454.5	0119	-
0120	gnsr_205	18.03.2008 03:49:58	20°29.8499'S	012°03.9493'E	482.9	0120	-
0121	gnsr_210	18.03.2008 07:07:43	20°59.9468'S	012°28.1066'E	456.6	0121	-
0122	gnsr_215	18.03.2008 10:20:21	21°30.0022'S	012°36.0382'E	448.8	0122	-
0123	gnsr_220	18.03.2008 13:08:14	21°59.9983'S	012°43.2045'E	409.1	0123	-
0124	gnsr_225	18.03.2008 15:54:18	22°30.3750'S	012°47.4471'E	470.0	0124	-
0125	gnsr_230	18.03.2008 19:04:07	22°59.6211'S	013°01.1222'E	460.3	0125	-
0126	<DRIFT>	19.03.2008 00:13:50	22°59.6822'S	014°03.0552'E	132.0	0126	-

Zooplankton stations

Fifteen 1-m^2-Double-MOCNESS hauls and seven 10-m^2- MOCNESS hauls were taken on the three transects (Tables 2 and 3). The systems worked very reliable except for one malfunction of the 10-m^2- MOCNESS during haul 2. In total, 196 samples were taken with the 1-m^2-Double-MOCNESS and 24 samples with the 10-m^2-MOCNESS at discrete depths intervals and large amounts of water were filtered through the nets (Tables 4-7) to integrate over small scale patchiness. Directly upon recovery of the systems, the nets were rinsed with seawater and the samples were treated as stated in section "Mesozooplankton and micronekton sampling".

Acknowledgement

Although time was a limiting factor during the cruise, we were able to conduct a sufficient data set for further analyses which will be evaluated in the course of the GENUS project in the home laboratories. We wish to thank the crew of the RV MARIA S. MERIAN for the professional handling of the equipment. They contributed significantly to the success of the cruise.

Table 2.2: 1-m^2-Double-MOCNESS haul data. See Fig. 2.1. for the location of the stations.

Haul	Station	Date	Sampling time		max. water depth (m)	Max depth sampled (m)
			Start	End		
MOC-D-01	gn23_005	10.03.08	07:20	09:45	2933	1000

MOC-D-02	gn23_004	11.03.08	02:28	04:40	920	800
MOC-D-03	gn23_003	11.03.08	10:55	11:40	216	150
MOC-D-04	gn23_002	11.03.08	18:03	18:20	137	100
MOC-D-05	gn23_001	11.03.08	23:22	23:43	105	75
MOC-D-06	gn20_001	13.03.08	02:53	03:07	70	50
MOC-D-07	gn20_002	13.03.08	07:36	08:01	127	100
MOC-D-08	gn20_003	13.03.08	15:40	16:24	245	200
MOC-D-09	gn20_004	14.03.08	01:10	03:40	1016	900
MOC-D-10	gn20_005	14.03.08	15:05	17:19	1387	1000
MOC-D-11	gn17_165	15.03.08	23:30	02:14	3980	1000
MOC-D-12	gn17_164	16.03.08	11:40	14:17	1465	1000
MOC-D-13	gn17_163	17.03.08	02:21	03:05	412	150
MOC-D-14	gn17_162	17.03.08	06:09	06:31	155	100
MOC-D-15	gn17_161	17.03.08	09:16	09:23	55	40

Table 2.3: 10-m^2- MOCNESS haul data. See Fig. 2.1. for the location of the stations.

Haul	Station	Date	Time = UTC Sampling time		max. Water depth (m)	Max depth sampled (m)	Remarks
			Start	End			
MOC-10-01	gn20_001	13.03.08	01:50	02:10	65	50	
MOC-10-02	gn20_002	13.03.08	08:44	09:11	126	100	Net release failed
MOC-10-03	gn20_003	13.03.08	14:48	15:09	239	100	
MOC-10-04	gn20_004	14.03.08	04:16	06:30	1075	900	
MOC-10-05	gn17_165	15.03.08	19:52	21:10	3900	1000	
MOC-10-06	gn17_164	16.03.08	16:55	19:34	1946	1000	
MOC-10-07	gn17_163	17.03.08	00:48	01:17	433	100	

Table 2.4: Sampled depths intervals 1-m^2-Double-MOCNESS

Nets / **Haul**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
D-01	0-1000	1000-800	800-600	600-400	400-200	200-150	150-100	100-50	50-25	25-0
D-02	0-800	800-600	600-400	400-200	200-150	150-100	100-50	50-25	25-0	
D-03	0-150	150-100	100-50	50-25	25-0					
D-04	0-100	100-75	75-50	50-25	25-0					
D-05	0-75	75-50	50-25	25-0						
D-06	0-50	50-25	25-0							
D-07			0-100	100-75	75-50	50-25	25-0			
D-08					0-200	200-150	150-100	100-50	50-25	25-0
D-09	0-900	900-800	800-600	600-400	400-200	200-150	150-100	100-50	50-25	25-0
D-10	0-1000	1000-800	800-600	600-400	400-200	200-150	150-100	100-50	50-25	25-0
D-11	0-1000	1000-800	800-600	600-400	400-200	200-150	150-100	100-50	50-25	25-0
D-12	0-1000	1000-800	800-600	600-400	400-200	200-150	150-100	100-50	50-25	25-0
D-13	0-150	150-100	100-50	50-25	25-0					
D-14					0-100	100-50	50-25	25-0		
D-15								0-40	40-20	20-0

Table 2.5: 1-m2-Double-MOCNESS filtered volumes in m^3

Nets / **Haul**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
D-01	1737	588	711	739	1054	157	189	234	136	90
D-02	2481	716	728	1009	238	293	257	152	182	
D-03	1650	89	133	52	130					
D-04	260	70	22	34	56					
D-05	762	69	60	58						
D-06	254	134	90							
D-07			611	133	65	85	100			
D-08					1222	131	135	131	88	144
D-09	2544	442	1062	862	847	152	115	100	75	88
D-10	2894	548	536	348	518	211	165	146	50	78
D-11	2845	720	974	1223	1133	247	104	110	49	78
D-12	2924	753	685	1386	1416	210	217	181	77	65
D-13	997	178	117	52	129					
D-14					703	255	68	93		
D-15								208	78	62

Table 2.6: Sampled depths intervals 10-m^2- MOCNESS

	Haul MOC-10-						
Net	**01**	**02**	**03**	**04**	**05**	**06**	**07**
1	0-50	0-100	0-100	0-900	0-1000	0-1000	0-100
2	50-25	100-75	100-50	900-500	1000-500	1000-500	100-50
3	25-0	75-50	50-25	500-250	500-250	500-250	50-25
4		50-25	25-0	250-0	250-0	250-0	25-0
5		25-0					

Table 2.7: 10-m^2- MOCNESS: filtered volumes in m^3

	Haul MOC-10-						
Net	**01**	**02**	**03**	**04**	**05**	**06**	**07**
1	6163	4319	5503	22858	31253	28252	8471
2	1307	851	2470	13993	16695	15126	4689
3	2508	807	1580	6225	8586	7406	1256
4		1261	1023	8790	9540	7550	1858
5		1572					

2.6 Acknowledgements

The expedition was funded by the DFG (German Science Foundation). The professional assistance of captain Friedhelm von Staa and the crew of the R.V. Maria S. Merian, who contributed significantly to the success of the expedition, is greatly acknowledged. We thank all other colleagues, who have contributed to the cruise by instrument maintenance, technical assistance and logistics.

2.7 Attachments: Statements concerning the disposition of biological material/collected species and oceanographic data

The data inventory of this cruise is accessible at DOD (Deutsches Ozeanograhisches Datenzentrum) under DOD-Ref-No.20080065. Current profiler data are listed in DOD. Oceanographic data of all stations are validated and stored in the central ODIN- database of the Leibniz-Institute for Baltic Sea Research Warnemuende and accessible upon request. The hydrographic data were also stored in the reagional data base of the Southern African Data Centre for Oceanography (SADCO).
Biological material collected during the cruise consists of plankton organisms and is stored in Bremen (BreMare, ZMT), Bremerhaven (AWI) and Hamburg (IHF). Results on composition and abundance will be transferred into PANGAEA data bank.

MARIA S. MERIAN-BERICHTE

Productivity and Life Cycles of Plankton and Nekton in the Coastal Upwelling Area of the Benguela Shelf – Trophic and Physical-Chemical Control Mechanisms

Pela-Gimber

PART 3

The Northern Namibian Benguela Upwelling System

Cruise No. 07, Leg 3
March 22 – April 17, 2008
Walvis Bay - Mindelo

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Table of Contents Part 3 (MSM 07/3) Page

3.1 Participants

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10	Jessica Frost	Gelatinous Plankton	IHF, Hamburg
11	Wilhelm Hagen	Zooplankton	MarZoo, Bremen
12	Andreas Kunzmann	Respiration	ZMT, Bremen
13	Laura Lehnhoff	Biochemistry	ZMT, Bremen
14	André Miggel	Hydrography	MCM, Cape Town
15	Franz-Joseph Sartoris	Zooplankton. Diversity	AWI, Bremerhaven
16	Sigrid Schiel	Zooplankton, Diversity	AWI, Bremerhaven
17	Ingo Schuffenhauer	Hydrography	IOW, Warnemünde
18	Jan Schulz	Plankton-Video	AWI, Bremerhaven
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3.2 Research Program

The third cruise leg was dedicated especially to the implementation of physiological experiments on board of the ship. Based on the more large scale hydrographical and planktological station work especially of cruise leg 2b as well as on real-time satellite images of sea surface temperature and chlorophyll-a distribution, live organisms in good condition were caught for the experiments on board. In selected areas, short transects perpendicular to the coast have been performed, and a number of different nets with different mesh sizes were used to sample the complete size spectrum of the plankton community. Different taxonomical groups of plankton were investigated: copepods, euphausiids, and fish larvae and young fish were in the focus of these works. An undulating video plankton recorder (LOKI) has been used to investigate the in-situ small-scale distribution of planktonic organisms.
Several transects perpendicular to the coast could be worke up, e.g. the Walvis Bay line as a routine sampling transect of the NatMIRC institute in Swakopmund, trasnects off Terrace Bay, Möwe Bay, Rocky Point and Cunene River, and off Namibe as the routine transect of INIP, Luanda. A South-North transect at 11°30'E reaching from 19 to 14°S, worked up during former cruises in 2002, 2004 and 2007, was revisited and sampled for hydrographic and plankton profiles at the end of the station work.
The passage from the investigation area to Mindelo, Cape Verde Islands, was used to continue the physiological experiments as long as possible.
The survey grid is shown in Figure 3.1. Details of the stations are listed in the Appendix.

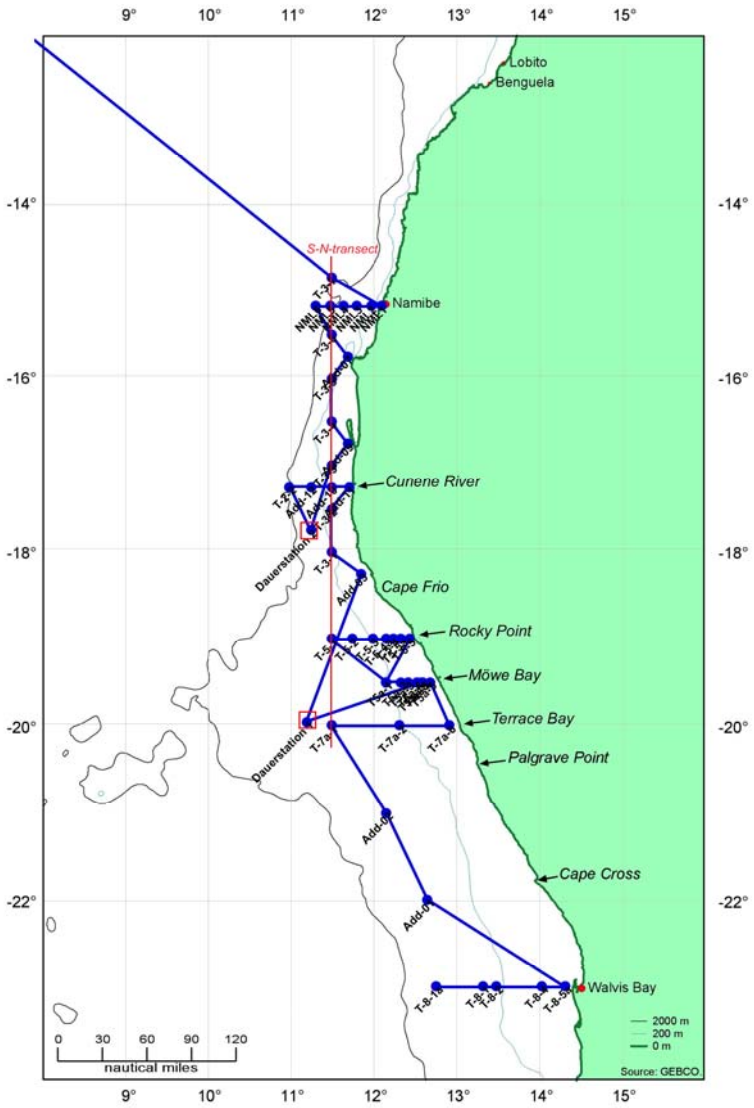


Figure 3.1: Station work of RV MARIA S. MERIAN during MSM07/3 starting from Walvis Bay and ending in Mindelo, Cape Verde Islands.

3.3 Narrative of the Cruise

22 - 29 March 2008: Transects T8 (Walvis Bay at 23° S) to T5 (19° S):

RV MARIA S. MERIAN left Walvis Bay at 10h00 (ships time) on 22nd March 2008. The ship proceeded immediately to the outer station on the Walvis Bay monitoring line, about 100nm from the port, interrupted only by a short shakedown station to test and calibrate the routinely used CTD. The Walvis Bay monitoring line was the first transect normal to the coast that was planned to analyse the coast-offshore development of upwelling waters. CTD, vertical Multinet with 200µm meshes and Apstein net were chosen as routine gears for the transect. In addition a Double MOCNESS with 300µm mesh size was used in this area to get stratified catches of the Macrozooplankton.

However, plankton abundance was very low and hence it was decided to move more northwards to look for other upwelling cells for sampling. Based on satellite images, cooler surface water could be detected along the coast between Cape Cross (22°S) and Rocky Point (19°S). This cool coastal water was used as starting point for another two transects normal to the coast at 20°S, 19°30'S and 19°S. Routine equipment at these stations was the CTD, Apstein net and a vertical

and towed (500µm mesh size) Multinet. A lightframe video camera was deployed at some stations to observe small scale plankton distribution. Experience after a few hauls showed that the ringtrawl (2000µm mesh size) and the Tucker trawl revealed good live material for the onboard experiments, for which preparations had been started immediately after leaving Walvis Bay.

29/30 March 2008

In the planning phase three positions had been foreseen to realise continuous 24h stations (Dauerstation): south of the Angola-Benguela Front, in the ABF and north of the ABF. For the first 24h station we were looking for an area influenced by Benguela current waters. Based on satellite image a position at 20°S 11°10'E was selected for this purpose and a routine sampling with an initial CTD followed by several vertical Multnet, Single MOCNESS, Double MOCNESS and LOKI casts was performed. The station work was concluded with a CTD cast. The station was well selected to investigate the diurnal migration pattern of euphausiids.

30 March – 1 April 2008

The vessel moved north towards the coast to again supply the experimentally working groups with more live material. South and around of Cape Frio it was known from former cruises to encounter early life stages of fish, which would be suitable for the oxygen consumption and tolerance experiments in the climatised labs and containers. The area between Cape Frio and the Cunene river mouth is known to serve as spawning ground for many species due to the nearly permanent upwelling and high primary production. During the cruise leg 2a upwelling was observed off the Cunene river, and this time the mature upwelling waters could be found.

1/2 April 2008

Different to former cruises the Angola-Benguela Front was this time arranged in a North-South direction and not West-East. The 2nd continuous station was thus placed more southerly then during the last cruises at 17°45'S 11°18'E. Mainly Single MOCNESS, Double MOCNESS and LOKI were used to take up the diurnal pattern in the plankton community.

2 - 3 April 2008

Leaving the position of the 24h station, RV MARIA S. MERIAN moved northward and took up the sampling on the north-south Transect at 11°30'E with some side-work at two inshore stations for catching live material. This transect has been a standard transect during the last cruises in the area and the intention was to continue the sampling on its stations for a time series that covers nine years now. CTD, vertical and towed Multinet were deployed, Ring trawl was used at the two nearshore stations for live material. This was the last occasion to fill the aquaria with organisms for experiments during the long steaming time on the way to Mindelo.

3 – 4 April 2008

As a courtesy for our Angolan colleagues a set of stations has been worked up on the so called Namibe monitoring line at 15° 09' S. We started at 11°19'E working up 6 stations until the entrance of the port of Namibe. A CTD down to 1000m and a vertical multinet down to 200m was the routine gear used at these stations. The vessel then went back to 11°30'E to work up the northernmost station of Transect 3 and with this concluded station work of the cruise in the late afternoon on 4 April 2008. RV MARIA S. MERIAN at 1600 UTC took new course and headed towards Mindelo, Cape Verdes. After four hours steaming, one engine broke down so that the vessel had to continue its travel with only one propulsion.

14 April 2008.

At about 5 o'clock RV MARIA S. MERIAN reached the position to take up an automated hydrographic measuring system ("glider"), that had been deployed about 6 weeks before. As it had run out of battery power there was the risk to loose the equipment and the originally foreseen recovery during MSM08/1 had to be brought forward. As the glider was frequently transmitting his GPS position, the recovery could be realised until 8 o'clock and RV MARIA S. MERIAN continued its way to Mindelo.

17 April 2008.

The ship called in Mindelo/Cape Verde Islands on 17 April 2008 in the afternoon, finishing the 3rd leg of the cruise.

3.4 Preliminary results

3.4.1 Physical Oceanography

(I. Schuffenhauer, A. Miggel, W. Ekau)

The CTD system used was a Seabird SBE9plus. It was equipped with double sensors for temperature, salinity and oxygen. This system had also a precision pressure sensor for the depth, a 3 channel Haardt-Fluorometer with channels for Chlorophyll a, phycoerythrin and a backscattering turbidity sensor. Additional to that we used a PAR/Irradiance Licor Sensor, a rosette sampler with 24 free-flow bottles of 10 l and an altimeter. Because of the double sensors no calibration measurements for temperature were necessary. Calibrations were made for oxygen and salinity (for CTD and Thermosal). A mean error of 0.003 PSU has been found for salinity measurements of the CTD.

CTD casts were made routinely to 1000 m or just above the bottom, and occasionally to 2000 m to coincide with deep Multinet hauls. A total of 46 casts were made during leg 3. At routine stations, discrete water samples were collected at the surface and the depth of maximum fluorescence (F-max), the depth of minimum oxygen concentration, and at varying depths for copepod incubation experiments. Winkler titrations were conducted to measure the oxygen concentration at the surface and O_2-minimum in order to calibrate the SBE sensors. Chlorophyll analyses from the surface and F-max were used to calibrate the *in situ* water column fluorescence profiles. Chl a concentration was measured fluorometrically using a Trios fluorometer.

Real-time mapping of Sea Surface Temperature (SST) was obtained from NOAA satellite images prepared and provided by colleagues from the Oceanography Department, University of Cape Town. The images covered 14°S to 27°S and showed a pronounced upwelling plume off Lüderitz and a consistent narrow band of cool water along the coast between Cape Cross and Cape Frio. These images were used for short-term station positioning.

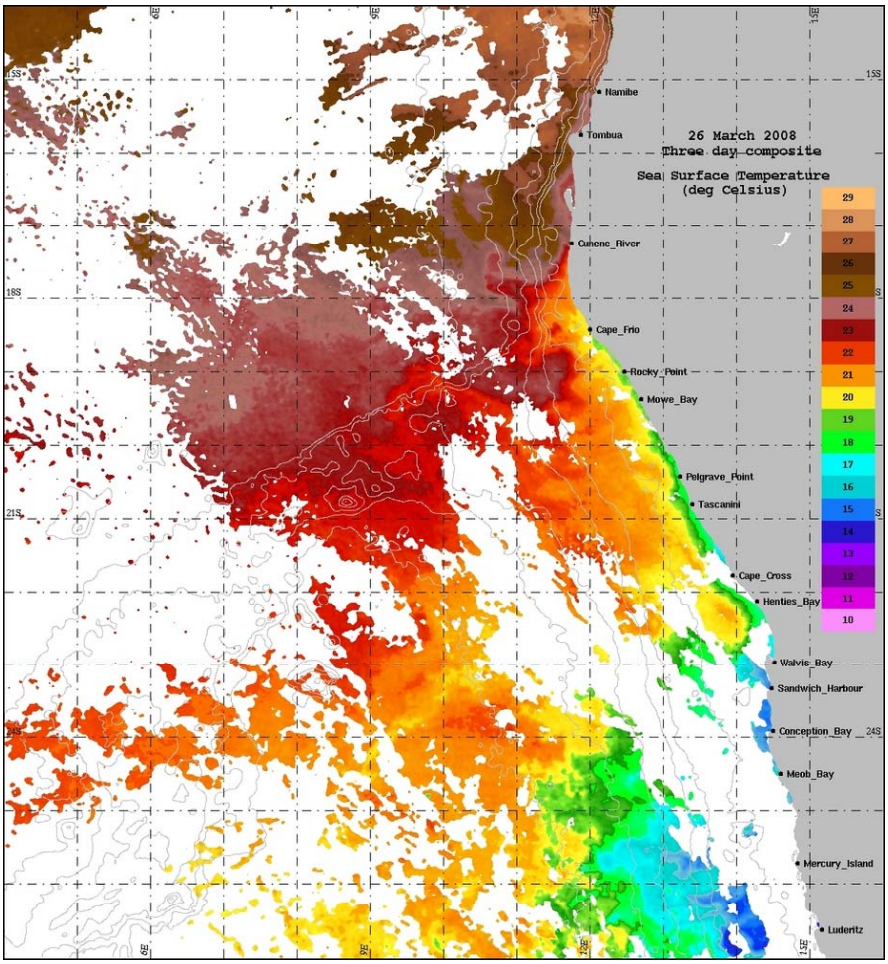


Figure 3.2: SST from NOAA satellite imagery for 26 March 2008.

En route information on the *in situ* SST and surface salinity was obtained from the hull-mounted thermo-salinograph. Parameters are recorded at intervals of one minute. Figure 3.3 shows the interpolated SSTs along the cruise track between 14 and 23°S. Cool water was found off Walvis Bay and along the coast between 20° and 18°S. These patches of cool water coincide with the SSTs derived from the CTD casts.

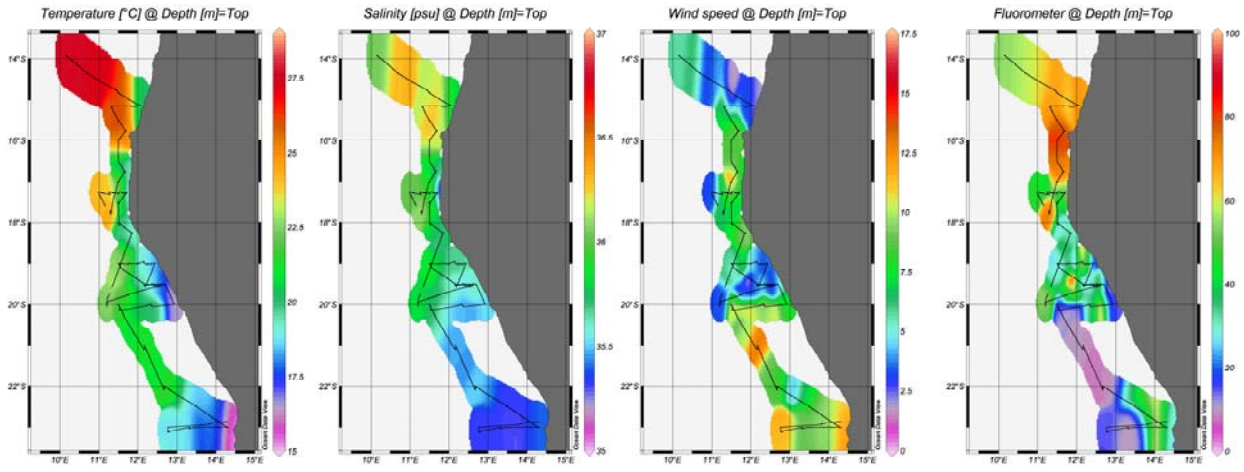


Figure 3.3: Surface temperature, salinity and fluorescence from the hull-mounted thermo-salinograph as well as wind speed during the cruise MSM07/3.

Cool water of <17°C (minimum 15.0°C) was found near the coast off Walvis Bay, stretching up to about 20°S. The whole transect off Walvis Bay showed SSTs <19°C. This surface water seemed to be distributed up to Cape Frio at 18°30'S, forming a narrow band of cool water along the northern Namibian coast. Another small cell of cooler water was found off the Cunene River mouth, indicating the presence of recently upwelled water.
High SSTs (maximum 26.15°C) were measured at the northern offshore stations. The satellite images depict warm Angolan and oceanic waters penetrating far southward, surrounding the northward flowing Benguela current water and squeezing it into a relatively narrow band against the coast; this picture is reflected also in the temperature distribution based on CTD and thermosalinograph data. This situation leads to a north-south orientation of the Angola-Benguela Front that is represented by the 22°C isotherm. The nearshore part of the front is located at about 16°30'S, but about 40 nm offshore it sharply turns southward and follows the 11°30' meridian. This picture is different from previous cruises in the region, where the front was at the same latitude, but oriented perpendicular to the coast.
Unusually cool surface water was found at the inner stations of the Namibe monitoring line, indicating offshore transport of surface water and upwelling of water from shallow depths.

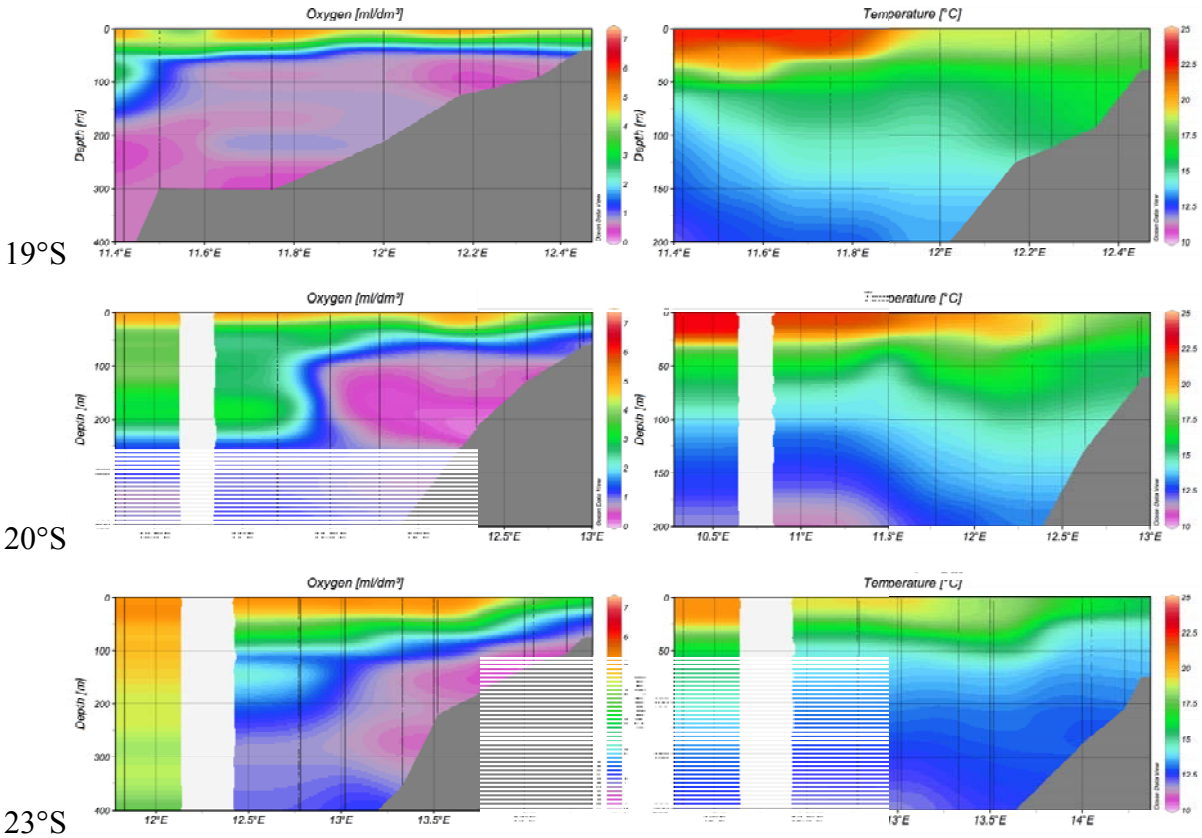


Figure 3.4: Temperature and oxygen profiles at 19, 20 and 23 °S.

The temperature and oxygen profiles shown in Figure 3.4 indicate only weak upwelling during the time of the cruise.

3.4.2 Chemical Oceanography

(M. Birkicht, L. Lehnhoff, J. Schulz)

Water sampling was performed with a rosette water sampler equipped with 24 free flow bottles (10 liter volume each). One CTD cast was conducted at each station during leg 3 of MSM07. CTD was lowered to the sea bottom at shallow stations and the entire water column sampled at several depths [m] (5, 15, 20, 30, 40, 50, 70, 90, 100, 110, 130, 150, 200, 250, 300, 400, 500, 600, 800, 1000, 1200, 1500).
The obtained water samples were divided for methane, hydrogen sulphide and dissolved oxygen measurement. Samples from free flow bottles were taken with a silicon tube into prepared plastic tubes, glass bottles, glass tubes and 60.00 mL Winkler-bottles.
Samples for hydrogen sulphide, dissolved oxygen, alkalinity and nutrients were analysed directly on board. Aliquots of 20 milliliters water samples which were taken for methane analysis were poisoned with 100 µL of saturated $HgCl_2$ solution in tight stoppered glass bottles and stored at 4°C until analysis.
250 mL of the water were taken to analyse the alkalinity of the seawater with an automated device using one half cell pH-electrode (Orion), one half cell reference electrode Ag/AgCl (Mettler) and a third platinum helping-electrode. The titration was done using a Mettler-Toledo titration device adjusted with 0.1N HCl seawater density, which was connected to VINDTA (Marianda) including PC-software control (LabView).
A volume of 100 mL water was filtered through disposable syringe filters (0.45 µm) into two wide neck PE-bottles (one as backup) to determine dissolved nutrient content (ammonium, nitrate, nitrite, o-phosphate and silica) in the water. These water samples were frozen at -20°C until analysis by automated flow injection analysis (FIAS) with a SKALAR instrument according to the methods of Grasshoff (1999).
Oxygen was analysed using a Titration device from Schott. The Platinum electrode and Ag/AgCl reference electrode and starch solution indicated the end point of titration according to WOCE-standard methods.
The hydrogen sulphide analysis was performed by using an Ag/AgS Ion Sensitive Electrode from Ingold to determine out brakes of H_2S close to the Namibian coastal shelf area. The samples were put directly into *SAOB-reagent for sulfide electrode* to form Sulphide and prevent oxidizing.
The thermodynamic driving force of CO_2 gas exchange between the ocean and atmosphere is often expressed as the difference in partial pressure of CO_2 (pCO_2) in seawater and overlaying marine air ($DpCO_2$). The flux is expressed as: $F = ksDpCO_2$, where the gas transfer velocity (k) is a function of wind speed and solubility (s) is a function of seawater temperature and salinity. Accurate measurements of pCO_2 with adequate spatial and temporal resolution is of essential importance in order to better constrain the seasonal and geographical variations of F. Therefore an online system was installed during leg 3. The instrument is called SUNDANS (Surface UNderway carbon Dioxide partial pressure ANalySer, Marianda).

Preliminary results
Sulphide was not detected at any station (detecting limit = $1*10^{-6}$ µM S^{2-}) neither in the oxygen minimum zone nor at the bottom.
The alkalinity varied horizontally and vertically around the oceanic level of 2200 µM.
In general high nitrate concentration in combination with low temperatures are characteristics of deep sea water masses and if found in the upper water layer indicate upwelling. Nitrate concentrations found during the cruise indicate weak upwelling, which is supported by the results of silica measurements. However, the distribution of silica indicates a different source of

the water mass from below 800m down to 1200m. These results have to be confirmed by distribution pattern of silica containing algae and cyanobacteria.
A linear discrimination function analysis (LDA) (Fig. 3.5), as well as a multivariate discrimination technique (Sammon mapping based on Manhattan distance) (Fig. 3.6) of the nutrient data shows 4-5 different water masses which is in good correlation to the sigma-t plots and the environmental scatter plot (Fig. 3.7) binned to the respective water layers (0-100m, 100m-200m, 200-400m, 400-800m, 800-1200m). It seems to be an older aged water body in the upper layer, because the NO_3 values are not always the same like in the depth of 800-1200m which is a nutrient rich water body.

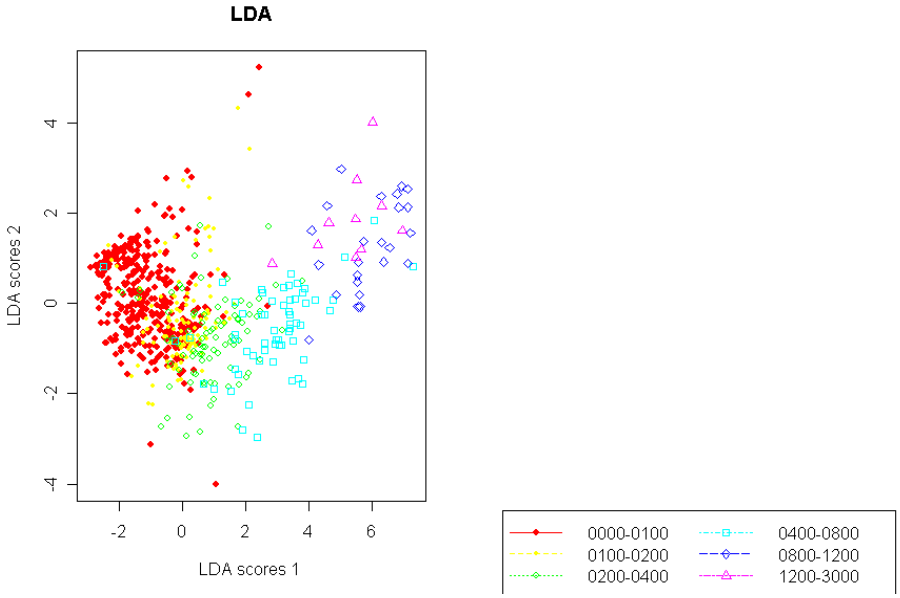


Figure 3.5: Linear discrimination function analysis based on nutrient data (NO_2, NO_3, PO_4, Si)

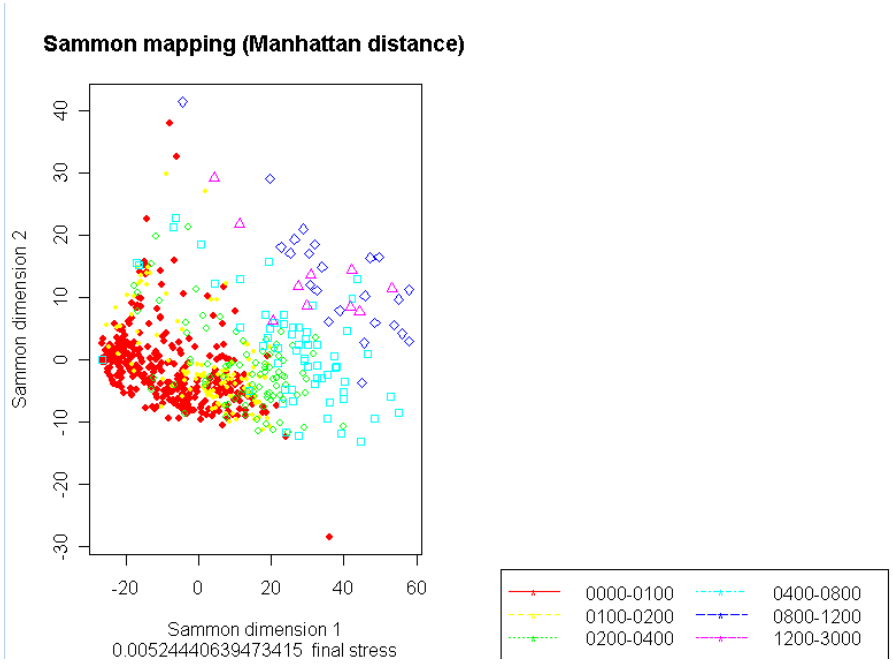


Figure 3.6: Sammon mapping based on a Manhattan metric of the nutrient data (NO_2, NO_3, PO_4, Si)

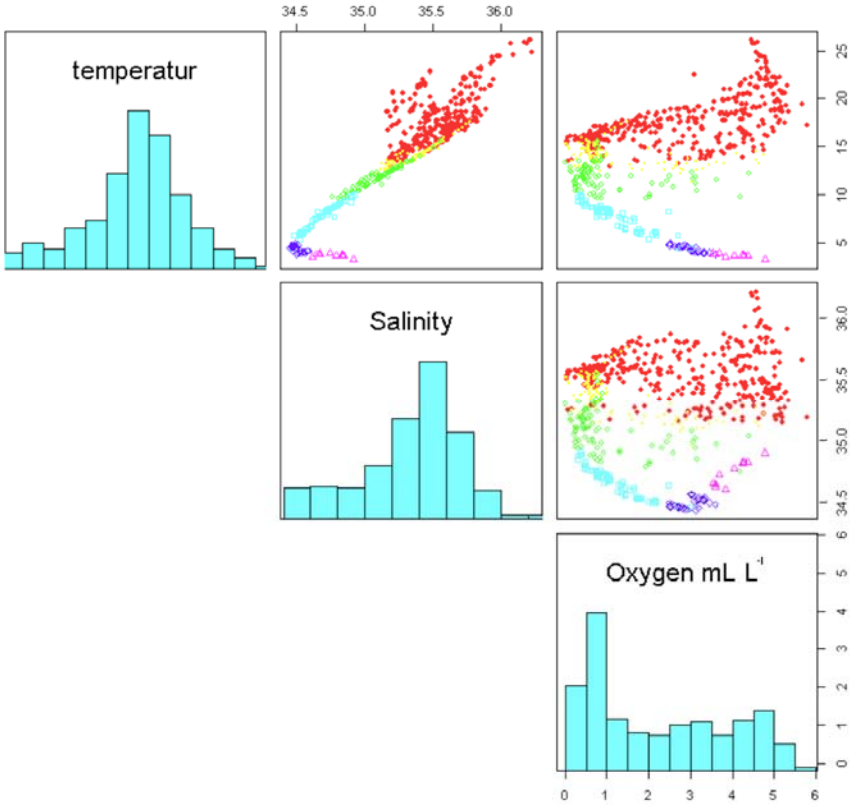


Figure 3.7: Environmental plot of physicochemical parameters. Lower triangular matrix shows unclassified scatter plots, while the upper matrix is coloured according to the respective depth layers. The colour code of this analysis is the same as for the two multivariate analyses (Figs 3.5 and 3.6).

Mostly the N/P ratio lays at 17 which is close to the theoretical value of 16. This indicates no nitrate reduction in the water column in the offshore region at greater depth (Fig. 3.8)

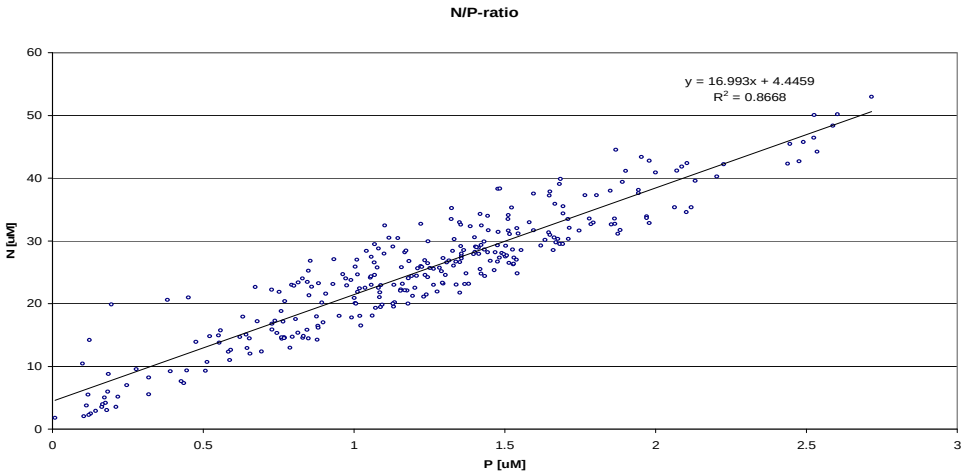


Figure 3.8: N/P-ratio during MSM07

3.4.3 Phytoplankton

(H. Auel, S. Schiel)

The concentration of chlorophyll *a* in the surface layer was measured continuously along the cruise track with a fluorometer connected to the thermosalinograph of the vessel (Fig. 3.9). Highest chlorophyll *a* concentrations were detected at 16°S associated with the strongest gradient in sea surface temperature of the Angola-Benguela Front. The lowest chlorophyll values were recorded offshore between 20° and 22°S. Thus, surprisingly, chlorophyll concentrations appeared to be generally higher in the tropically warm waters north of 17°S than in the southern part of the study area, which was more strongly affected by colder waters of the Benguela Current.

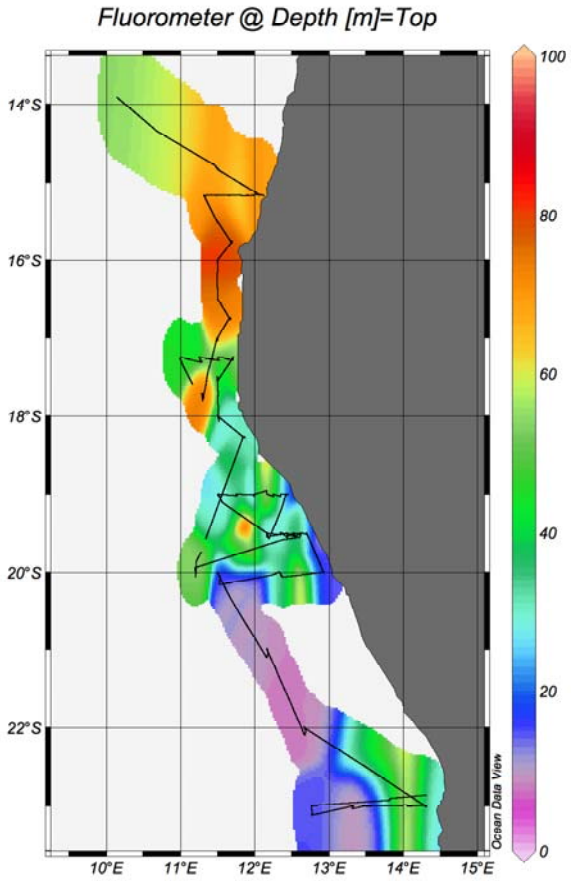


Figure 3.9: Chlorophyll a [µg L^{-1}] concentration from fluorometric measurements of the hull-mounted sensor.

Along the transects perpendicular to the coast at 19°S, 20°S and in particular 23°S, chlorophyll *a* concentration followed a general pattern with low to medium concentrations at the inshore stations, elevated levels on the shelf at some distance from the coast, and again lower values over the continental rise and further offshore (Fig. 3.10).

However, fluorometric measurements of chlorophyll by the sensor mounted on the CTD only partly confirmed the general distribution pattern described above (Fig. 3.9). Based on the surface data at the limited number of sampling stations, chlorophyll *a* concentration decreased from higher values at inshore stations to generally lower levels offshore. This decline was more pronounced along the 15°S transect off Namibe with maximum values inshore and a stronger gradient as compared to the more gentle decrease in chlorophyll *a* concentration along the Walvis Bay line at 23°S. According to the CTD data, chlorophyll *a* values were generally higher in the south-eastern part of the study area influenced by the Benguela Current, while chlorophyll

a levels in the area north-west of a line from 21°S 11°30'E to 18°30'S 12°E were very low, with the exception of the inshore stations on the Namibe line.

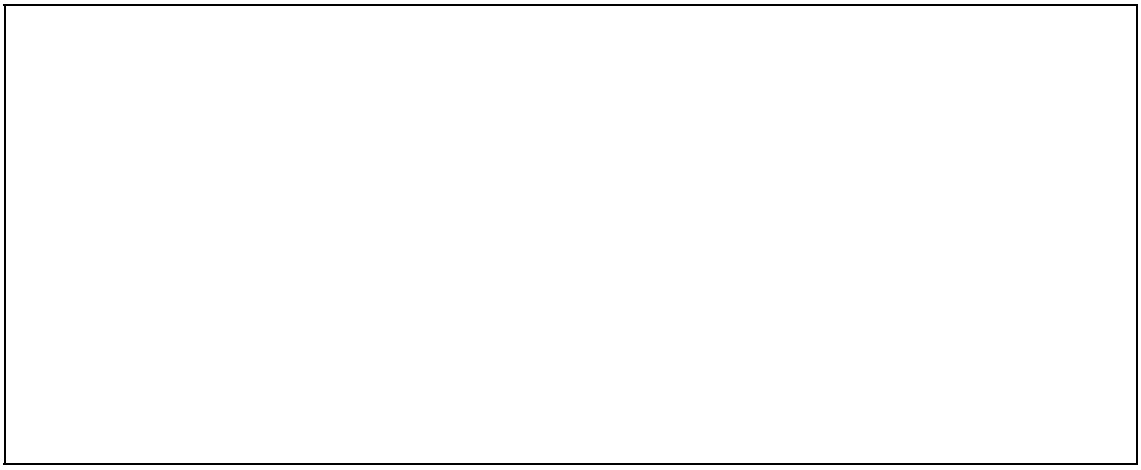


Figure 3.10: Chlorophyll profiles perpendicular to the coast at 15, 19, 20 and 23°S.

In addition to differences in the general distribution trend of chlorophyll *a*, the actual data of the two fluorometers deviated substantially from one another. Whereas the ship-based fluorometer measured values in the range of 6 to 200 µg chl *a* L^{-1}, the CTD-mounted device gave data between 0 and 4 µg L^{-1}, stressing the urgent need for a cross-calibration of the different sensors and a reassessment of both data sets after the cruise.
Water samples were taken routinely by a rosette-bottle sampler attached to the CTD frame.
Sub-samples of 1 to 2 L volume from the surface layer and from 20, 40, 60, and 100 m depth were filtered on GF/F filters. One set of samples was filtered on pre-combusted filters and dried at 40°C before freezing at -80°C for the determination of C/N ratios and stable isotope signatures ($\delta^{13}C$, $\delta^{15}N$), while the other samples were immediately deep-frozen at -80°C for assessment of phytoplankton composition by HPLC pigment analysis.

3.4.4 Mesozooplankton

(H. Auel, S. Schiel, A. da Silva, H. Verheye)

Field studies

The aim of the water column studies was analyses of zooplankton communities in the northern Benguela upwelling region. Our research focussed on species composition, abundance, population structure, vertical distribution, maturity of gonads and gut content studies.

Work at sea
A multiple opening-closing net with an opening of 0.25 m^2 equipped with 5 nets of 150 µm mesh size was used as a standard device for the quantitative sampling of mesozooplankton. The multinet was towed vertically, and the depth ranges were defined according to the temperature profiles at the respective station. On the shelf and slope stations the hauls covered the entire water column between the surface and the sea floor, while at oceanic stations, the net was deployed down to 1000 m.
At a time station zooplankton hauls were carried out approximately all 4 hours to get informations about the diel vertical migration pattern of the dominant species and stages. All samples were preserved in borax-buffered 4% formaldehyde/sea water solution.

First results
In general, mesozooplankton concentrations and species occurrence varied greatly between sampling sites. Typically, the upwelling copepod species *Calanoides carinatus* at copepodite stage V was found at greater depth (mainly between 400 an 600 m) at more offshore stations in a restting phase, while at more inshore stations the population was active and consisted mainly of adults.
A thorough investigation of the samples will elucidate the regional and vertical distribution of the zooplankton community, and the data will be discussed with respect to the life strategies of the dominant species and relationships to hydrography and phytoplankton.

3.4.5 Interactions between gelatinous zooplankton and discontinuities and the resulting influences on pelagic food webs

(J. Frost)

Objective

Gelatinous zooplankton, herein referred to as jellies, deserve their reputation as the most enigmatic of plankton because they are difficult to capture, preserve and quantify, yet they often constitute a predatory biomass large enough to exert strong top-down influences on productivity and survival of zooplankton and ichthyoplankton. Furthermore, jellies can exert bottom-up influences on energy transfer to fish and higher predators by altering fluxes of particles, carbon and nutrients, creating an ever-growing concern that in many seas these carnivorous jellies expand at the expense of fish. Such influences remain poorly quantified due to a lack of reliable data. This cruise should provide information on the detailed function and role of jellies with regard to discontinuities in facilitating high plankton species diversity and their impact on the sustainability of plankton communities that currently remains cryptic. Examining the trophic links of jellies will contribute to understanding carbon transfer and associated effects on fisheries production. Coupling hydrography with the biotic structure of jellies will contribute to answering the overall question, under which conditions can jellies influence pelagic food webs?

Sampling
In addition to sampling with the 1 m^2 MOCNESS (see zooplankton section), jellies were collected using a closing WP2 net (Hydrobios, Kiel, 57 cm diameter, 300 µm mesh) that was pulled through the water column. Physical damage to medusae and ctenophora was mitigated by hauling the net slowly and attaching a large (~ 50 L) plastic bag at the cod end. Samples were collected for abundance, distribution, carbon and nitrogen content as well as stable isotopic measurements.

Sample processing
Immediately after each haul, contents were carefully emptied into a large bucket and jellies were handpicked using wide-mouth suction pipettes and jars. Jellies were individually separated by Genera, enumerated and either stored at –80°C for subsequent isotopic analysis or preserved with 4% borax-buffered formaldehyde-seawater solution.

Preliminary results

Among the medusae sampled, frequently occurring offshore deep-water species included *Atolla russeli* and *Periphylla periphylla*, while dominant inshore shallow-water species included *Chrysaora hysoscella*, *Aequorea forskalea* and *Clytia spp. Beroe sp.* was the most dominant ctenophora sampled without a preferential depth. One notable event was the shallow-water occurrence of the ctenophore *Pleurobrachia pileus* north of (17°15'S, 11°43'E) among a bloom of *Coscinodiscus sp*., formerly not known from the northern Benguela Current. Gibbons et al. (2003, Afr. J. mar. Sci. 25: 253–261) reported *P. pileus* occurring only in deeper waters and off the west coast of South Africa.

3.4.6 Macrozooplankton

(F. Buchholz, C. Buchholz, A. Denda, J. Frost)

Additionally to the net-routine on zooplankton using the multi-nets, a suite of larger nets were employed for the catch of micronekton, including euphausiids, fish larvae, juvenile fish and larger zooplankton. These were the Double-MOCNESS (D-MOC, 2x 1m2, 333 µm), where Anneke Denda was responsible and the following nets by Fritz Buchholz, AWI-BAH, namely a single MOCNESS (MOC-1, 1 m2, 2000µm), a Ring trawl (RT, 2 m2, 2000 µm) and a Tucker trawl (TT, 1 m2, 1000 µm).

Multiple Opening and Closing Net with Environmental Sensing System, MOCNESS (Single and Double version)

1. D-MOC: Mesozooplankton and micronekton was sampled to gain insights into the vertical and horizontal distribution of these faunal elements in the Namibian upwelling area. Furthermore, the samples will be used for biochemical and gut content analyses and for the determination of physiological rates.

Mesozooplankton samples were taken by oblique hauls (towing speed 2 knots) with the use of a 1m²-Double-MOCNESS (Multiple Opening and Closing Net and Environmental Sensing System). The system is equipped with 2 x 10 nets of 333 µm mesh aperture side by side with a one square meter opening each. The nets can be opened and closed sequentially. Parallel sampling was performed and the sampling intervals were 25 m in the top 50 m, 50 m between 50 m and 200 m, and 200 m at greater depths. The filtered volume was calculated by a flowmeter. Veering and heaving speed of the winch was up to 0.3-0.5 m s^{-1}. The ascent rates were between 9 and 16 m min^{-1}. The device carried CTD-probes to collect environmental data.

Upon recovery of the 1m²-Double-MOCNESS, the left nets were rinsed with seawater and the plankton was preserved immediately in a 4% formaldehyde-seawater solution buffered with sodiumtetraborate. Prior to the preservation of the material, subsamples were taken to pick abundant animals for the determination of CN, stable isotopes ($\delta^{15}N$, $\delta^{13}C$), metabolic activity (ETSA), and for gut content analyses and frozen at −80 °C and -20 °C. The following animals were picked: *Calanoides carinatus*, *Eucalanus* spp. and *Euchaeta* spp. (Copepoda), Euphausiacea, Decapoda, Pteropoda, Siphonophora, different Medusa and different fish species. The right nets were used by other groups to pick living animals for experiments. The remaining zooplankton in these nets was also preserved in buffered formaldehyde.

D-MOC sampling data

Zooplankton was sampled on two cruise legs, MSM_7_2b and _3, and will be analysed for biomass, abundance and carbon budget. Below, an overview is given on the samples taken during leg 3 of the RV MARIA S. MERIAN cruise 07.

Eight 1 m²-Double-MOCNESS hauls were taken on four transects and two 24-h-stations (Table 1).The system worked reliable except for failed communication to the underwater-unit during haul 19 and 20, indicating no sampling at the first 24-h-station. In total, 116 samples were taken with the 1 m²-Double-MOCNESS at discrete depths intervals (Table 2). Large amounts of water were filtered with the nets (Table 3) to integrate over small scale patchiness.

Table 3.1: 1m²-Double-MOCNESS haul data.

Haul	Station	Date	Start	End Time UTC	Water depth (m)	Max depth sampled (m)
MOC-D-16	MSM07/03-75 T-8-1a	22.03.08	21:31	00:01	992	900
MOC-D-17	MSM07/03-76 T-8-1	23.03.08	04:25	05:25	356	300
MOC-D-18	MSM07/03-82 T-7a-1	25.03.08	04:58	06:50	789	700
MOC-D-19	MSM07/03-97 T-5-1	28.03.08	02:12	02:54	288	200
MOC-D-20	MSM07/03-102 24-h-Station 1	29.03.08	12:04	12:56	1109	communication to UW-unit failed
MOC-D-21	MSM07/03-110 24-h-Station 2	02.04.08	00:18	02:35	801	750
MOC-D-22	MSM07/03-110 24-h-Station 2	02.04.08	12:00	14:10	760	700
MOC-D-23	MSM07/03-123 T-3-7	04.04.08	13:49	15:39	2551	700

Table 3.2: 1m²-Double-MOCNESS: sampled depths intervals in m.

Nets L and R	MOC-D-16	MOC-D-17	MOC-D-18	MOC-D-19	MOC-D-20	MOC-D-21	MOC-D-22	MOC-D-23
1	0-900	0-300	0-700	0-200	0-248	0-750	0-700	0-700
2	900-800	300-200	700-600	200-100	248-0	750-600	700-600	700-600
3	800-600	200-150	600-400	100-50		600-400	600-400	600-400
4	600-400	150-100	400-200	50-25		400-200	400-200	400-200
5	400-200	100-50	200-150	25-0		200-150	200-150	200-150

6	200-150	50-25	150-100			150-100	150-100	150-100
7	150-100	25-0	100-50			100-50	100-50	100-50
8	100-50		50-25			50-25	50-25	50-25
9	50-25		25-0			25-0	25-0	25-0
10	25-0							

Table 3.3: m²-Double-MOCNESS: filtered volumes in m³.

Nets L and R	MOC-D-16	MOC-D-17	MOC-D-18	MOC-D-19	MOC-D-20	MOC-D-21	MOC-D-22	MOC-D-23
1	976	663	1220	521		1210	1678	580
2	252	384	232	476		317	398	489
3	936	148	714	174		927	1233	814
4	975	151	831	129		1247	1566	841
5	1162	199	160	100		189	218	267
6	81	61	179			164	196	319
7	125	67	116			211	246	329
8	250		62			102	140	147
9	75		163			145	360	130
10	100							

2. MOC-1: The single MOCNESS was equipped with 9 nets with 2000µm mesh, where Net 0 was the integrative sample from 0 to 600m. Subsequently. nets were opened and closed at the following depth steps: 600-400m, 400-300m, 300-200m, 200-150m, 150-100m, 100-50m, 50-25m, 25-0m. Locations and times see station list, volumes filtered per net: on request (friedrich.buchholz@awi.de).
The MOC-1 was employed 13 times at depths from 200 to over 2000 (maximal fishing depth 600m). The station selection followed the general station grid, duplicating stations from previous cruises for comparison. At one 24h station 3 hauls were taken at midnight, dawn and noon and at a 36 hour station samples were taken five times at cardinal times of the diurnal cycle with a dusk repeat. Here, vertical migration of krill was studied in particular with respect to the oxygen minimum zone (location and times: see station list).
The large mesh size was taken to firstly minimize net avoidance by reducing the net pressure front wave. Secondly, cleaner samples with respect to gentle preservation of larger specimens, particularly euphausiid species were obtained, both for the sake of sexual and moult stage determination in freshly caught adult krill. The large mesh size is also advantageous to obtain un-damaged specimens for experimentation (see report below).The same holds for fish larvae and larger zooplankton as well as juvenile fish, decapod shrimp and gelatinous zooplankton taken from the nets by the other working groups or physiological and other study.

3. Tucker Trawl and Ring Trawl: The Tucker Trawl served as a back-up of the MOC-1 as it has a similar geometry and net opening of 1 m² as the MOC-1 albeit with a single net. However, it was predominantly employed for the catch of fish larvae, as was the Ring trawl (see report Kunzmann, below). The Ring-Trawl was used twice to take integrative samples in a double-oblique haul aiming at krill in shallower depths.

The two MOCs were flown generally successfully. However, initially, a few hauls could not be realized as connection problems occurred, being caused, as it was detected in the end, by

intermittent connection failures between the winch and the outlet of the mono-conductor cable at the ship's side.

3.4.7 Ichthyoplankton

(S. Bröhl and W. Ekau)

For the ichthyoplankton (mainly Clupeidae, Engraulidae, Gobiidae), and the mesopelagic nekton (especially lantern fishes Myctophidae), the spatial distribution (vertical and horizontal), abundance, biomass, food composition and energy demand was intended to be quantified with different methods in order to produce a comprehensive picture of the productivity and trophodynamics of the Benguela upwelling system. To achieve this goal, samples were collected on the different transects and stations mainly by means of a towed Multinet (MN), but also from the single and double MOCNESS (details see last chapter). The Multinet was equipped with 5 nets of 500µm-mesh size and a mouth area of 0.25 m^2. It was towed obliquely in 5 different depth strata. A total of 35 hauls was taken. The net was equipped with an electronic flowmeter to measure the filtered volume of each net. A temperature, salinity and oxygen probe were mounted and gave real time measurements of these parameters supporting the decision of the sampling depth stratification. Samples were screened immediately after the haul for live larvae to transfer them into aquaria for physiological experiments. Species of interest (see above) were sorted out as quick as possible and deep frozen at -80°C for further processing in the home laboratory: extracting otoliths for aging and growth estimation, food and lipid analysis. The remaining samples were preserved in buffered formalin (4% in seawater) for community studies. All samples were analysed roughly for their content of fish larvae. These preliminary results were standardised to individuals /m^2 in terms of the volume of water filtered by each net and the depth of the stratum.

Total abundance of fish larvae was low. Fish eggs were hardly found. Onboard a total of 980 larvae could be sorted from the nets, 360 coming from the Multinet, 340 from the Double MOCNESS and about 280 from the Single MOCNESS. Catchability of the MOCNESS nets was highest in myctophids and mesopelagics, due to the sampling depth of 600 to 1000 m. All other taxonomic groups were mainly caught with the Hydrobios Multinet.

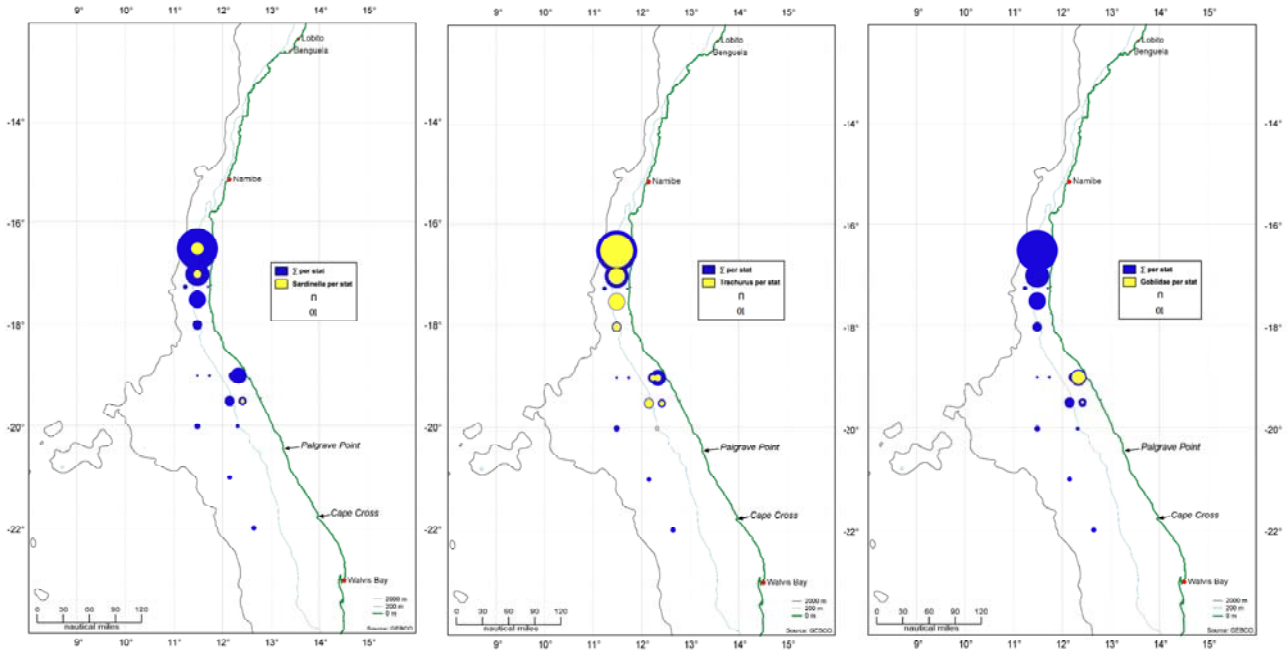


Figure 3.11: Horizontal distribution of abundance of fish larvae as analysed on board. Dark blue represents total number of larvae, yellow stands for Sardinella aurita (left), Trachurus trachurus (middle), and Gobiids (right).

The focus of larval distribution in the Hydrobios multinet catches during this cruise was on the shelf off Rocky Point (≈ 19°S) and around and north of the Cunene river (17°30' - 16°30'S) (Fig. 3.11). The most abundant species was *Trachurus trachurus* representing nearly 50% of the extracted larvae and thus dominating the distribution pattern. No *Sardinops sagax* larvae could be detected, but *Sardinella aurita* distribution reached down to 19°30'S, while during former cruises the border between the distribution areas of these two species was in the ABF area (≈ 17°S). The second abundant taxonomic group were the gobiids with their distribution center again off Rocky Point.
The MOCNESS were used mainly in deeper waters beyond the shelf edge, the Single-MOCNESS being routinely deployed down to 600 m and the Double-MOCNESS reaching down to 900m. The main fish catches of these nets consisted of myctophids and other mesopelagic species.
The vertical distribution showed differences between the nets. While the Hydrobios multinet caught fish larvae mainly in the upper 100 m, the two MOCNESS' had the main catches in 300 to 600 m, where they caught the myctophids and mesopelagics. Interestingly the ranges of abundance of the three nets do not differ too much, even if the mesh sizes were extremely different: 300µm for D-MOC, 500µm for MN and 2000µm for S-MOC.

3.4.8 Physiological studies

(H. Auel, F. Buchholz, W. Hagen, F-J. Sartoris, S. Schiel)

Ecophysiological studies on dominant zooplankton taxa were conducted by the Marine Zoology team from the University of Bremen in close cooperation with the staff of AWI/BAH and MCM in the region of the northern Benguela upwelling system.
Specimens of various important zooplankton taxa (Cnidaria, Copepoda, Decapoda, Mysidacea, Amphipoda, Euphausiacea and Chaetognatha) were sampled from different regions (transects) and depth strata in order to investigate their biochemical and eco-physiological adaptations to abiotic and biotic environmental factors and to elucidate feeding relationships. Altogether more than 1.200 samples were collected and deep-frozen at –80°C.
Special attention was given to the herbivorous copepod *Calanoides carinatus*, a key species in upwelling regions representing a major link between primary production and higher trophic levels such as pelagic fish. Copepodite stages CV of this species occurred in high abundances in deeper water layers offshore, where they survived in a resting stage (diapause), until upwelling and thus favourable feeding conditions triggered further development. Coupled with an ontogenetic vertical migration, diapausing provides an advantageous strategy to cope with an unpredictable and strongly pulsed food supply caused by short-termed upwelling events. This adaptation ensures that one part of the population is retained in the upwelling area and newly upwelled water masses can be re-colonised rapidly. In contrast, actively feeding adult females and males were present only in epipelagic strata at shallower stations. Earlier developmental stages of *C. carinatus* occurred very rarely at scattered positions.
Additional more detailed investigations focused on the krill species *Euphausia hanseni*, a dominant component of upwelling communities in the Benguela System. In close cooperation with the krill working group, specimens were dissected, the moulting and sexual developmental stage determined and the hepatopancreas, ovaries, and the remaining body separately deep-frozen for further lipid analysis in the home labs.
The lipid biochemistry of all these specimens and components will be analysed by state of the art technology (densitometry, gas chromatography etc.) to determine lipid content, lipid class composition as well as fatty acid and alcohol compositions. On the one hand, these data will be evaluated for physiological condition and energetic adaptations, e.g. by comparing active and

resting stages of *C. carinatus*. On the other hand, trophic marker fatty acids will be used to reveal dietary preferences of various species, integrated over several weeks.
In order to provide quantitative data on basic metabolic activity and energy demand of dominant copepods, respiration measurements were conducted on board. Specimens were sorted from the catch and immediately transferred into a cold laboratory at simulated in situ temperatures. After at least one day of acclimatisation, one to seven individuals were incubated in gas-tight bottles filled with ca 250 ml of bacteria-free filtered seawater for 24 to 36 hours. After the termination of the experiments, the oxygen concentration in the incubation bottles was measured by Winkler titration (precision 0.05 ml/l) and oxygen consumption calculated in relation to animal-free controls.
For grazing experiments copepod specimens were sorted according to species and developmental stages from different depth layers gained by the multinet and the double MOCNESS. The experiments were run at 16°C and 5°C in the cooled laboratories of the ship and lasted for 24 hours. The food offered was the natural phytoplankton suspension from the rosette samples of the chlorophyll maximum layer. For measuring the concentration of the food supply at the beginning and end of the experiments, samples were taken for the HPLC pigment analysis. For obtaining information on preferential feeding on different size classes, additional, subsamples for microscopic counting were also taken.
Haemolymph samples of various copepod species have been taken in order to investigate whether ontogenetic migration is related to and/or relays on ammonia aided buoyancy. The ammonia levels of copepod species with and without an ontogenetic migration pattern will be measured by ion chromatography at the AWI. In addition, *Calanoides carinatus* from offshore where they are diapausing will be compared with active feeding adults from shallow water sampling sites. This will help us to answer the question whether ammonia buoyancy is only used during diapause or throughout the whole life cycle of ontogenetic migrating copepods.

Secondary production: copepod egg production rates (H. Verheye, MCM, Cape Town)

Marine secondary production is defined as the conversion by heterotrophs of assimilated energy derived from primary producers into body tissue, or the amount of tissue (= biomass) accumulated by zooplankton (and zoobenthos) per unit time and per unit area, regardless of its fate. It includes production lost to predators and other loss sources as well as reproductive products (viz. eggs). Copepods are very suitable for estimating zooplankton production because of their abundance and life history features. Calculation of copepod production requires data on both their biomass (obtained from net tows) and their growth rate. The latter comprises somatic growth (weight gain) of larval (nauplii N1-N6) and juvenile (copepodids C1-C5) stages plus reproductive growth (fecundity or egg production) of adult females (the contribution by adult males is negligible).
Secondary production work in the northern Benguela Current and Angola-Benguela Front region has been conducted during cruises in 1997, 1999, 2000, 2002, 2004 and 2007, and focused on the measurement of both reproductive growth of several dominant calanoid copepods and occasionally on somatic growth of the diapausal 5th copepodite stage (C5) of a single species, *Calanoides carinatus*. This copepod is known to enter into a state of developmental arrest (dormancy, diapause) at its pre-adult copepodite stage C5. When environmental conditions are unfavourable for its reproduction and scope for population growth, the animals delay their final moult to adulthood and assume a temporary state of dormancy (varying from a few days to several months depending on latitudinal distribution and oceanography); they descend to great depths in offshore waters where they adopt very reduced metabolic rates, surviving on energy reserves stored in the form of lipids (see papers by Auel *et al*. 2005 and Verheye *et al*. 2005 in *Afr. J. mar. Sci.*, Vol. 27, and by Auel and Verheye 2007 in *J. Exp. Mar. Biol. Ecol*.).

The focus during this cruise was on the measurement of egg production by females of dominant calanoid copepod species. Lively, undamaged specimens were sorted from collections made using a variety of plankton nets (vertical and oblique Multinets, MOC-1, MOC-D, Ring Trawl and WP-2) usually between 14h00 and 02h00. Daily egg production rate (EPR) was measured from bottle incubations. Typically, adult female copepods were placed singly or in pairs or triplets (depending on species and body size) into opaque 1-litre incubation bottles, filled with ambient surface water filtered through a 63-µm mesh in order to exclude possible contamination with eggs present therein. The bottles were maintained at a fairly constant temperature of 16-17ºC in a cooled, re-circulating on-deck incubator. After 24 hours (and occasionally after up to 44 hours), the incubations were terminated, the condition of the female(s) was assessed and the eggs spawned (as well as the nauplii that had hatched) during the incubation period were enumerated under a microscope. The number of eggs (and nauplii) per female produced during a 24-h period is a measure of their fecundity or daily egg production rate.

In total, 142 EPR experiments were conducted during the cruise, and daily EPRs were obtained using a total of 415 females of 14 identified and some 6-8 as yet unidentified copepod species (see Table 3.4). Although more rigorous analysis of the data is required, production rates at the time of sampling appeared to be generally lower than during February 2007, except for *Calanoides carinatus* and *Centropages brachiatus*, two typical members of the coastal upwelling community, which showed similar to greater EPRs during 2008 than 2007 (see Table X).

Active reproduction of *C. brachiatus* was observed at all stations, an observation not uncommon for this species in the region. Fairly good EPRs of >30 eggs spawned female^{-1} day^{-1} were measured at stations 218 and 220 (on the nearshore sector of transect T5 at 18ºS), and a maximum of 107 eggs female^{-1} day^{-1} at the latter station. For *C. carinatus*, rates in excess of 30 eggs female^{-1} day^{-1} were also recorded at the same two stations, but elsewhere rates were generally below 20 eggs female^{-1} day^{-1} with a few instances of zero or near-zero EPRs (at stations 209, 223, 230 and 231 (at or beyond the shelf edge between 17º30'S and 20ºS). A maximum EPR of 37 eggs female^{-1} day^{-1} was seen at nearshore station 249 on the Namibe Monitoring Line. Both maximum rates of daily egg production given above are, however, well below the maximum rates known for these copepods from field and laboratory observations, reinforcing the apparent, generally low copepod production in the area of investigation at the time. This may be somewhat surprising given that there were usually a large number of faecal pellets produced during the incubation period, suggesting that the females had been grazing actively prior to their capture and/or on the numerous dinoflagellates that were often present in the 63-µm pre-screened incubation water.

As for most other copepods species for which an appreciable dataset was gathered during the cruise (such as *Metridia lucens*, *Eucalanus hyalinus*, *Pleuromamma quadrangulata* and *Rhincalanus nasutus*), mean and maximum daily egg production rates were well below the known values published in the literature (see Richardson *et al*. 2001). One exception is the large, blue pontellid *Labidocera acutifrons* (colloquially referred to as 'Smurfs'), which produced eggs at a mean daily rate of 13.6 eggs female^{-1} day^{-1} (max. 143.0 eggs female^{-1} day^{-1}). Although lower than in 2007, these rates are still substantially higher than previous estimates of 10.1 eggs female^{-1} day^{-1} (max. 23.7 eggs female^{-1} day^{-1}) for this species in the region, as well as for other species elsewhere (e.g. *L. aestiva* off Oregon).

Table 3.4: Summary of daily egg production rates (eggs female^{-1} day^{-1}) measured during cruise MSM 07/3 in March-April 2008, and comparison with results obtained during a cruise in February 2007 (RV Dr Fridtjof Nansen) in the same region. n = the number of EPR experiments for each species.

	Merian: March-April 2008				**Nansen: February 2007**			
Species	***n***	**min.**	**max.**	**mean**	***n***	**min.**	**max.**	**mean**
Acartia sp. *(Paracartia africana ?)*	2	0.0	0.5	0.2				
Aetideopsis carinata	1	0.0	0.0	0.0				
Calanoides carinatus	35	0.0	37.6	10.0	30	0.0	40.0	3.3
Centropages brachiatus	5	36.2	107.4	59.5	5	35.0	71.0	54.2
Centropages sp.?	8	3.1	34.1	15.8				
Eucalanus hyalinus	14	0.0	39.5	6.0	22	0.0	270.0	24.3
Euchirella messinensis	2	0.0	0.0	0.0	10	0.0	270.0	75.4
Labidocera acutifrons	16	0.0	143.0	13.6	35	0.0	158.6	39.7
Metridia lucens	18	0.0	4.5	0.6	13	0.0	74.0	6.6
Megacalanus sp.	1	0.0	0.0	0.0				
Nannocalanus minor					6	0.0	3.8	1.3
Neocalanus gracilis					2	0.0	4.0	2.0
Neocalanus robustior					12	0.0	26.7	5.1
Pareucalanus sewelli					32	0.0	13.0	2.3
Pleuromamma quadrangulata	11	0.0	1.6	0.4	6	0.0	13.0	6.0
Pleuromamma xiphias					2	40.2	59.8	50.0
Pontella securifer	3	0.0	0.0	0.0	3	1.9	59.8	34.0
Pontellid (small sp.)	3	15.8	55.9	38.9				
Rhincalanus cornutus					1	0.0	0.0	
Rhincalanus nasutus	8	0.0	0.6	0.1	1	0.0	0.0	
Scolecithrix danae					2	0.0	1.0	0.5
Subeucalanus subtenuis					1	13.0	0.0	
Temora sp.					1	0.0	0.0	
Undinula vulgaris					3	0.0	13.0	8.0
unidentified	14	0.0	55.2		4	0.0	4.9	--

3.4.9 Respiration physiology (Fish larvae and juveniles, crustaceans)

(A. Kunzmann and L. Franceschinis)

Studies on metabolism of fish reveal energy requirements and activity levels. The common method to estimate metabolism is to measure or calculate a Standard or Routine Oxygen Consumption (SOC or ROC). Estimating a species-specific SOC can help defining distribution ranges depending on environmental factors such as temperature and oxygen saturation. Areas with variable oxygen concentrations, such as the Benguela Current System, present a challenge for fish and crustacean zooplankton. Numerous experimental studies have demonstrated that pelagic fish larvae respond negatively to low oxygen concentrations in terms of their behaviour and/or survival. On the other hand, it has been demonstrated that both krill and benthic fish occur in low-oxygen areas of 1 ml/l and less. Little is known about the oxygen tolerance of fish larvae of different species and at which levels oxygen becomes critical for their survival. Several

strategies adopted to cope with oxygen minimum layers are likely to include anaerobic pathways as well as short recovery times.
During this cruise leg about 75 oxygen consumption experiments with fish larvae and juveniles of flatfish, horse mackerel and needlefish, as well as some simple first-trials on a few others (megalopas, cephalopods, krill) have been performed. The following equipment was used:

- Intermittent flow respirometer (about 25 experiments), with circular, flat-bottom acrylic respiration chambers of different volumes (65 ml to 500 ml, according to size of animal). Oxygen content and temperature were automatically measured using a computer-controlled oxygen probe (WTW) and customised software based on Measure Foundry (Data Translations). When O_2 saturation dropped below a given value, the water was exchanged with oxygenated seawater from a separate tank. For more details see Kunzmann et al. (2007 Crustaceana 80:77-95) and Zimmermann & Kunzmann (2001, MEPS 219, 229-239).
- Closed chamber respirometer (about 50 experiments), with glass vials/chambers of different volumes (10 ml to 250 ml, according to size of animal). Oxygen content and temperature were automatically determined using a PreSens Optode system (Microx and Fibox). Oxygen saturation was regulated manually, and monitoring and recording was done with PreSens software (TX3 and PST3-V532).

All systems were filled with sterile-filtered (Sartobran 0.2 µm), natural seawater. All measurements were performed at ambient temperatures of 16-17 °C (during this cruise no larvae of the northern part of the expedition area with temperatures up to 21 °C were used). Individual experiments lasted between a few hours and two days and were repeated with gradually lowered O_2 concentrations, in some cases down to 0% oxygen.
As on the previous cruise in 2007 (NanOxy07), experimental work fully depended on the successful catch of live animals in good condition. Fish larvae showed to be the most delicate organisms among those caught in the nets. Most larvae were already dead by the time the nets were inspected. The cause seemed to be related to the trawling speed, quick decompression and time of trawling. Another problem was the constant presence of jellyfish in the catches, which causes massive death of fish upon contact with nematocysts.
Multinet (vertical/towed) and MOC (single/double) were used as indicator to set the fishing depth for live material. Catches made with a Ring trawl (RT, 2 m^2, 2000 µm) and a Tucker trawl (TT, 1 m^2, 1000 µm) at depths between 40 and 80 m at coastal stations (80-120 m bottom depth) were most promising. In areas of high jellyfish abundance killings by jellyfish could be successfully reduced through the closure of the net of the TT before reaching the surface. In general, the RT was more successful, due to the larger fishing volume and fast operating times (constant ship speed 2 knots, down with 0.2-0.4 m/s; up 0.2 m/s, in final phase reduce ship speed to 1 knot). Of the survivors most clupeid, blennid and flatfish larvae died within two hours after the catch. Particularly at the stations 226 – 229 flatfish and horse mackerel larvae survived in larger numbers. The most successful stations in general were shallow coastal stations (mainly No. 226 and 227; corresponding to No. 100 and 101 of the ships protocol).
Because identification of life fish larvae is difficult, only broad taxonomic groups are considered here. Oxygen consumption rates of flat fish larvae (Soleidae), horse mackerel (Carangidae), needlefish (Syngnathidae) and a few megalopa/juveniles of decapod crabs were measured. After the experiments the animals were frozen at -80 °C for subsequent taxonomic identification afterwards and for biochemical analysis.
Preliminary results indicate that needlefish and flatfish larvae tolerate low oxygen levels down to 40% saturation and horse mackerel larvae down to 30% saturation. Below 40% flatfish and needlefish die, whereas below 30% horse mackerel seem to be able to regulate oxygen

consumption. In flatfish and needlefish the oxygen consumption seems stable, independent of oxygen concentration.
Megalopa larvae of decapod crabs survived several hours of exposure to oxygen levels as low as 10% saturation, and exposure to 0% oxygen up to 3-5 hours seems to be the final limit. An anaerobic pathway seems to allow a motionless "hibernating" mode. In particular below 10% their oxygen consumption depends strongly on the oxygen concentration. When oxygen is offered again, the oxygen consumption increases dramatically and fast recovery is achieved. So far no difference between individuals with long (> 12 h) and short (< 1 h) resting intervals could be observed. Also, repeated exposure to low and very low oxygen levels does not change consumption.
Horse mackerel (Carangidae) larvae accounted for a major part of oxygen consumption experiments carried out during this cruise. About 20 larvae and juveniles of the genus *Trachurus (T. capensis)* were recovered from net catches in an excellent condition, their size ranging from 25 to 70 mm. This allowed us to perform about 24 respiration experiments on this species, and the larvae could be maintained alive in aquaria for the whole duration of the cruise.
Preliminary results indicate that *T. capensis* has its optimal oxygen saturation level above 40%. Experiments showed that below this value the animal deliberately lowered its metabolic rate and oxygen consumption, sometimes down to 50% of the ROC. Once fully oxygenated water was re-supplied, oxygen consumption reached a peak as high as 200% of the original ROC. This recovery state never lasted longer than 30 min., suggesting that metabolites, such as lactate, may have accumulated during the time spent at oxygen saturation levels below 40%.
Several replicates proved that *T. capensis* is able to tolerate oxygen saturation as low as 10%, at which extreme hyperventilation and uneasiness observed in the animals prompted us not to proceed any further so as to avoid valuable sample loss.
Other parameters monitored during respiration measurements included the counting of the gill beats per minute, in an attempt to determine the critical oxygen level. These data, however, proved to be a misleading clue, as the fish increased the volume of water passing through the gills by adjusting the amplitude of the gill movements rather then the rate. Although we did not have any means to measure the amplitude of gill movements, visual observation confirmed that below an oxygen saturation of 40% *T. capensis* responded by gradually initiating hyperventilation.
It is intended to analyse the physiological adaptation mechanisms of *T. capensis* at critical oxygen levels by measuring citrate synthetase activity. For this purpose individuals will be opposed to an increasing exposure time at saturation levels as low as 20% and 10%, then larvae will be frozen at -80°C immediately without allowing recovery time.
Different developmental stages of *T. capensis,* with different oxygen requirements, may be involved in the distribution of this species throughout the Benguela system. The project therefore aims to find a relation between mass-specific oxygen consumption and age of the fish from analysis of the otoliths. Finally, these data will be compared with the temperature and oxygen profiles at the sampling sites. A strict correlation between the presence of *T. spec* and oxygen saturation levels above a specific threshold might indicate a distribution governed by factors such as oxygen and temperature. However, larger individuals may have better chances to evade anoxic layers than larvae and smaller juveniles. It might be even argued that larger individuals are much more tolerant to physiological stress. Final conclusions cannot be drawn until further processing of data.

3.4.10 Euphausiids in upwelling areas of the Benguela-Angola current system

(C. and F. Buchholz)

The work on krill complements the study of the ecological role of ichthyo- and zooplankton under food web aspects as well as in eco-physiology. Equally, data on nutrients and primary

production are essential to assess krill physiology. The described krill approach relates to three linked topics: functional biodiversity, life cycle strategies and physiological-/biochemical adaptation:

Functional biodiversity:
8 major species found in MOCNESS- and multi-net catches are related to neritic and oceanic water masses. Such zoo-geographical considerations will be evaluated under adaptive and food web aspects. It was confirmed that the largest euphausiid, *Euphausia hanseni* dominated the species but showed considerably lower population densities than in February 2004. In contrast, a second larger species, *Nematoscelis megalops* appeared in larger numbers in the samples, probably indicating a persisting influx of waters from farther South.

Life cycle strategies:
Krill generally closely relate the egg maturation/spawning cycle to the moult cycle. Both cycles may be synchronized by external factors, and as new results show, by nutritional pulses, like plankton blooms. A close coordination of growth and reproductive processes may be considered a specific adaptation to the seasonal upwelling regime. How this in turn relates to the specific trophic environment of the area is again valuable to study under food web aspects. A large sample set for histology and biochemical analysis, partly on lipids in coop. with W. Hagen, was accumulated on moult and reproductive phase staged specimens (400 specimens staged, 40 dissected and preserved). From moult stages, current growth rate can be derived.

Physiological/biochemical adaptation:
The current results confirm previous detailed data on the typical diurnal vertical migration pattern with a focus on *E. hanseni*. The summer range was determined at 400m reaching to the very surface. In this way krill stays in the oxygen depleted layer of ca. 500m and experiences a temperature differential of up to 10°C. How this behaviour is related to respiration capacity and thermal tolerance will be studied. Respiration measurements indicated a high oxygen depletion tolerance and will be flanked by determination of key aerobic and an-aerobic metabolic enzymes, and their adaptive capacity, according to Buchholz (2003, Marine and freshwater behaviour and physiology, 36, 229-247). The comparison to temperate and polar krill species will be helpful, because these are considered extremely oxygen dependent species. A further food web relationship may be added by determining the specific induction of various digestive enzymes in conjunction with stable isotope measurements. Physiological data will be used for parameterization of an ECOPATH model.

3.4.11 Zooplankton distribution in relation to hydrographic parameters with the Light frame On-sight Key species Investigation device (LOKI)

(J. Schulz, K. Barz)

Objective
Little is known about physico-chemical parameters controlling the distribution of planktonic species. When assessing their vertical distribution by means of plankton nets depth integration is a limiting factor intrinsic to the method. The precise assessment of zooplankton species in different layers is more difficult. Predicting shifts in species distributions requires detailed knowledge on physiological and behavioural constraints. In addition, both direction and velocity of advection depend on vertical distribution pattern which may change on a diel and seasonal scale. Therefore high resolution sampling is required to describe the vertical distribution of

zooplankton in relation to the environmental parameters. To solve this problem, a new device for optical *in-situ* detection of micro plankton species was deployed on this cruise leg.

Gear

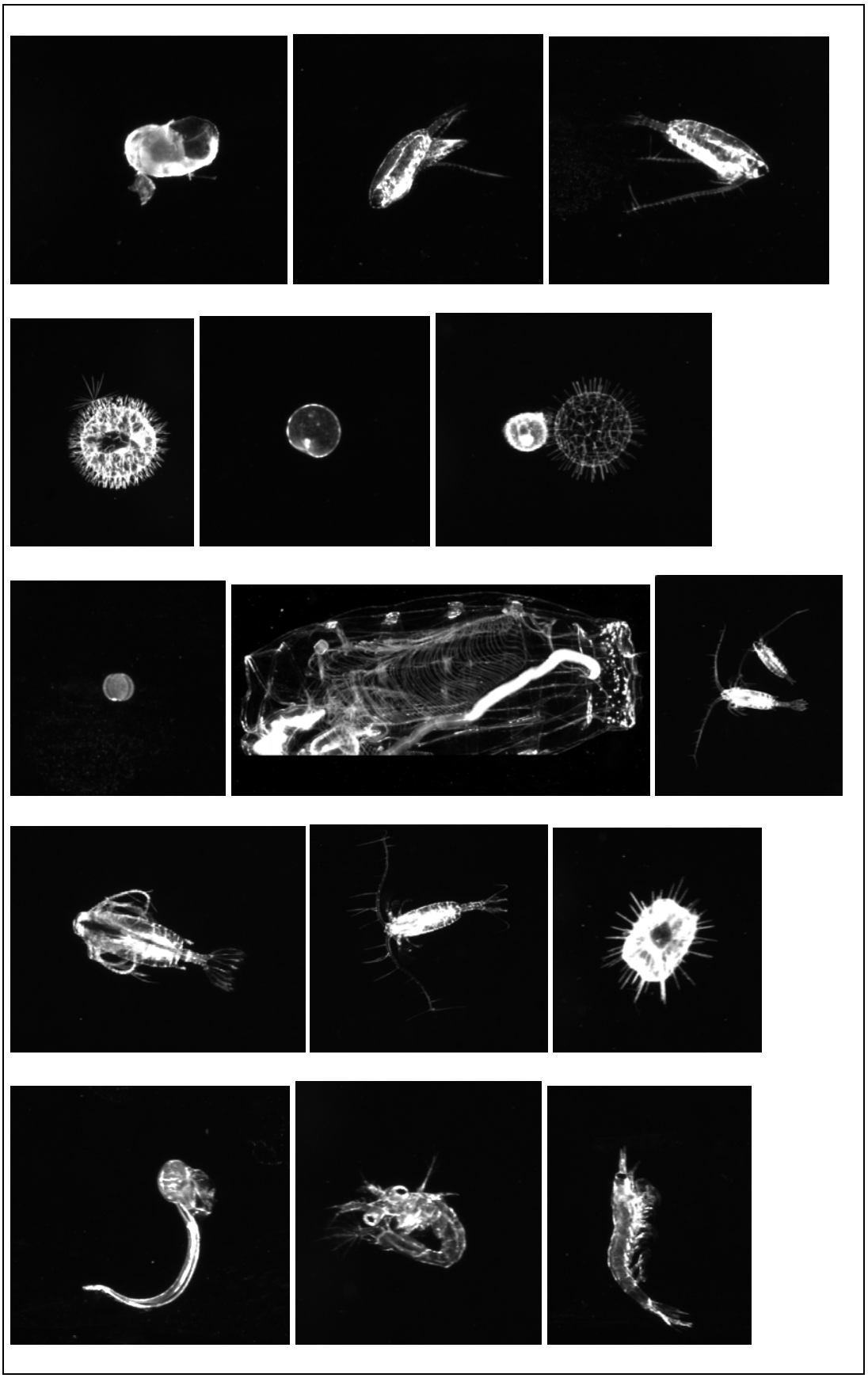
The LOKI system is a newly developed towed optical gear. The abbreviation stands for **L**ightframe **O**n-sight **K**eyspecies **I**nvestigation. It can be used to study the vertical and horizontal variability of mesoplankton distributions on small scales down to the decimeter level. An adopted setup of camera and an especially designed illumination unit allows LOKI to take up to 25 frames per second with shutter times below 50 µs at good signal to noise ratios (see Panel 1). From the underwater unit, objects are cut out from the taken frames in real time and stored with a time-stamp. This time-stamp is coupled with the assignment of environmental parameters and metadata of each object during the data processing procedure. The parameters and metadata include the geographic information, date, time, temperature, salinity, depth, fluorescence and oxygen. The data processing setup is done in a browser frontend, connected with a SQL based database.

Preliminary results

During the cruise, the LOKI system was deployed 20 times at 11 stations (see Table 2). Nine of these hauls were taken in a horizontal, towed modus, while 11 were operated vertically on the two 24h stations. Due to initial problems the first haul was terminated. Whenever bottom depths allowed, the system was deployed down to its temporary maximum operation depth of 440 m.

The image quality is sufficient to distinguish clearly between large taxonomic groups. In most cases identification is possible to the species level by distinct characters, when individuals were not imaged sagittaly.

Low abundances were found at all stations, which was congruent to the multinet catches. It was further seen that the majority of the zooplankton community was connected to steep gradients or fronts, while the water masses between these fronts is sparsely utilised. By oceanographic CTD deployments previously identified layers of high fluorescence could be identified as densely occurring diatoms, such as *Coscinodiscus* sp. Zooplankton species were located on both sides of these bands, while only few where found within.



Panel 3.1: Examples set of typical plankton organisms recorded around hydrographic fronts during the cruise. Images are not the same scale.

Table 3.5: Overview of LOKI hauls during cruise MSM07, leg 3

Station	Haul	Operation mode	Objects imaged
0209_MSM07-03_083	2	Horizontal	8975
0214_MSM07-03_088	3	Horizontal	5205
0216_MSM07-03_090	4	Horizontal	3947
0221_MSM07-03_095	5	Horizontal	9940
0228_MSM07-03_102	6	Vertical	347
0228_MSM07-03_102	7	Vertical	365
0228_MSM07-03_102	8	Vertical	504
0228_MSM07-03_102	9	Vertical	757
0228_MSM07-03_102	10	Vertical	1482
0228_MSM07-03_102	11	Vertical	8050
0231_MSM07-03_105	12	Horizontal	7978
0232_MSM07-03_106	13	Horizontal	3681
0234_MSM07-03_108	14	Horizontal	509
0236_MSM07-03_110	15	Vertical	1222
0236_MSM07-03_110	16	Vertical	2317
0236_MSM07-03_110	17	Vertical	2704
0236_MSM07-03_110	18	Vertical	2114
0236_MSM07-03_110	19	Vertical	1908
0237_MSM07-03_111	20	Horizontal	6627
Total	19		68632

3.5 Station list MSM 07/3

Ship Stat. No.	CTD-no.	old stat no.	Lat	Long	Water Depth	CTD	MSNV	MNo	APSN	MOC-1	MOC-D	RT	TT	WP2	LOKI
						45	49	35	30	12	8	13	5	9	20
CTD calibration station at 22.3.08 14:00 h															
22.03.2008															
MSM07/3-75	201	T-8-1a	23°00'	12°46'	986	1	1		1		1				
23.03.2008															
MSM07/3-76	202	T-8-1	23°00'	13°20'	353	1	1		1		1				
MSM07/3-77	203	T-8-2	23°00'	13°30'	237	1	1		1						
MSM07/3-78	204	T-8-4	23°00'	14°03'	132	1	1		1						
MSM07/3-79	205	T-8-5a	23°00'	14°20'	73	1		1	1						
24.03.2008															
MSM07/3-80	206	Add-01	22°00'	12°40'	512	1	1	1	1	1					
MSM07/3-81	207	Add-02	21°00'	12°10'	808	1	1	1	1	1					
25.03.2008															
MSM07/3-82	208	T-7a-1	20°00'	11°30'	777	1		1	1		1				1
MSM07/3-83	209	T-7a-2	20°00'	12°20'	213	1		1	1			1			1
MSM07/3-84	210	T-7a-6	20°00'	12°56'	68	1		1	1					1	
MSM07/3-85	211	T5a-5	19°30'	12°42'	62	1	1	1	1						
26.03.2008															
MSM07/3-86	212	T5a-4a	19°30'	12°36'	89	1	1	1	1					1	
MSM07/3-87	213	T5a-4	19°30'	12°32'	117	1	1	1	1			1			
MSM07/3-88	214	T5a-3	19°30'	12°26'	134	1	1	1	1			1			1
MSM07/3-89	215	T5a-2	19°30'	12°21'	143	1	1	1	1						
MSM07/3-90	216	T5a-1	19°30'	12°10'	234	1	1	1	1			1			1
MSM07/3-91	217	T-5-5	19°00'	12°27'	39	1	1	1	1						
27.03.2008															
MSM07/3-92	218	T5-5a	19°00'	12°21'	92	1	1	1	1						
MSM07/3-93	219	T-5-4	19°00'	12°15'	111	1	1	1	1			1			
MSM07/3-94	220	T-5-4a	19°00'	12°10'	125	1	1	1	1					1	1
MSM07/3-95	221	T-5-3	19°00'	12°00'	211	1	1	1	1						
MSM07/3-96	222	T-5-2	19°00'	11°45'	302	1	1	1	1					1	
MSM07/3-97	223	T-5-1	19°00'	11°30'	297	1	1	1	1	1	1				
28.03.2008															
MSM07/3-98	224	T5a-1	19°30'	12°10'	240			1				1			
MSM07/3-99	225	T5a-3	19°30'	12°26'	135			1				1			
MSM07/3-100	226	T5a-4	19°30'	12°32'	117			1				1	1		
MSM07/3-101	227	T5a-5	19°30'	12°37'	91							1	1		
29.03.2008															
MSM07/3-102	228a,b	Dauerstation 1	19°57'	11°12'	1100	2	14		1	3	1			1	6
30.03.2008															
MSM07/3-103	229	Add-03	18°15'	11°52'	42	1		1	1				2	1	
31.03.2008															
MSM07/3-104	230	T-3-1	18°00'	11°30'	242	1	1	1	1	1					
MSM07/3-105	231	T-3-2	17°30'	11°30'	163	1	1	1	1						1
MSM07/3-106	232	Add-11	17°15'	11°43'	39	1	1	1					1	1	1
MSM07/3-	233	Add-10	17°15'	11°30'	140	1		1	1			1			

107															
MSM07/3-108	234	Add-12	17°15'	11°15'	597	1	1	1							1
01.04.2008															
MSM07/3-109	235	T-2-2	17°15'	11°00'	2117	1	1	1	1						
MSM07/3-110	236a,b	Dauerstation 2	17°45'	11°15'	790	2		2		5	2				5
02.04.2008															
MSM07/3-111	237	T-3-3	17°00'	11°30'	106	1	1	1	1					1	1
03.04.2008															
MSM07/3-112		Add-09	16°45'	11°42'	31							1			
MSM07/3-113	240	T-3-4	16°30'	11°30'	103	1	1	1							
MSM07/3-114	242	T-3-5	16°00'	11°30'	1246	1	1	1							
MSM07/3-115		Add-07	15°45'	11°42'	180							1		1	
MSM07/3-116	243	T-3-6	15°30'	11°30'	1719	1	1								
MSM07/3-117	244	NML6	15°10'	11°19'	2430	1	1								
MSM07/3-118	246	NML5	15°10'	11°29'	2342	1	1								
MSM07/3-119	247	NML4	15°10'	11°39'	1745	1	1								
04.04.2008															
MSM07/3-120	248	NML3	15°10'	11°49'	1115	1	1								
MSM07/3-121	249	NML2	15°10'	11°59'	421	1	1								
MSM07/3-122	250	NML1	15°10'	12°07'	227	1	1					1			
MSM07/3-123	251	T-3-7	14°50'	11°30'	2577	1	1	1			1				

3.6 Acknowledgements

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3.7 Attachments: Statements concerning the disposition of biological material/collected species and oceanographic data

The data inventory of this cruise is accessible at DOD (Deutsches Ozeanograhisches Datenzentrum) under DOD-Ref-No.20080065. Current profiler data are listed in DOD.
Oceanographic data of all stations are validated and stored in the central ODIN- database of the Leibniz-Institute for Baltic Sea Research Warnemuende and accessible upon request. The hydrographic data were also stored in the reagional data base of the Southern African Data Centre for Oceanography (SADCO).

Biological material collected during the cruise consists of plankton organisms and is stored in Bremen (BreMare, ZMT), Bremerhaven (AWI) and Hamburg (IHF). Results on composition and abundance will be transferred into PANGAEA data bank.