Report of cruise D356 RRS Discovery 10 September (Walvis Bay) – 13 October 2010 (Cape Town)

Collated by Friedrich Buchholz

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Description of project

***ClimShelf:* Ecology and Biogeochemistry of the Upwelling System of the Southwest African *Shelf* under conditions of *Clim*atic Change within Project GENUS**

High productivity and fast turnover rates of nutrients and organic and inorganic matter characterize the shelf seas. Both, high fishery effort as well as other anthropogenic influences – including the elevated CO_2 input – affect the regions significantly. Climatic change with altered gas budgets, shift of ocean currents, and the considerable warming of sea water visibly and rapidly impact the conditions of life and production in the shelf seas, as well as the adjoining coasts. To assess the effects of global change, it is necessary to record the regional *status quo* situation and to develop and apply adequate means for prognosis. The ClimShelf project will investigate the dynamics of material flux in the shelf sea area of the poly-pulsed Benguela Upwelling system, including the exchange with the open ocean. Combined with existing data from local long-term series and previous cruises, modelling approaches will be developed to forecast the ecological effects of climate change. The expedition is planned as the third field phase of the running RTD-project GENUS (Geochemistry and Ecology of the Namibian Upwelling System) of the German Ministry of Education and Research (BMBF) under the international umbrella of IMBER (Integrated Marine Biogeochemistry and Ecosystems Research).

Nature of objectives of the project:

Marine Ecology, Biological Oceanography, Biogeochemistry, Marine Eco-physiology, Climatic research

Relevant previous or future research cruises:

Within Project GENUS the following cruises to the same area off Namibia are relevant:
Previous: MSM07/2 und 3 (20.2.-12.4.08) with German RVs MARIA S. MERIAN und M76/2 (14.5.-1.6.08) RV METEOR, and South African FRV AFRICANA (01.11.-15.12.2009)
Future: RV MARIA S. MERIAN (Jan.-Feb., May-June 2011)

Narrative of cruise

The cruise was split into two legs in order to accommodate as many as possible project participants including capacity building and partners from Namibia and S. Africa. The timing of the cruise was intended to cover the spring phase being known as the maximum of upwelling activity in the area. The first Leg was oriented at continuing regular synopses of the Northern Benguela current system in terms of geochemistry and ecology. The second Leg repeated interesting stations met during the first Leg focused on longer term studies of processes. In particular, the formation and succession of filaments was studied. In fact, strong upwelling activity, reaching from the Luederitz- cell to North of the Namibian border, was encountered and recorded by satellite imagery as SST and CHl_a visualizations (kindly provided by PML, Univ. of Cape Town and US microwave data collation).

The first Leg began at the Walvis line at 23 grd S, where a mooring was recovered with 1 year of data. These and further cruise data were useful in a long term context at this interesting area. From the previous synopsis transect, the Kunene transect at 17 grd 18' S was worked along, next. The cruise track was kept near shore to take samples of fish larvae on the way. At the slope station of the Kunene Transect, the winch system failed and the ship had to return to Walvis Bay roads to pick up a technician who was able to repair the system during the following days. During that time, a subsidiary programme was run, to complete the Walvis Bay Transect using Bongo, Ringtrawl and WP2 nets as well as Microstructure sonde, which could be run independently of the main winch circuit. The outermost deep sea station could then be worked upon with the main system back in operation. On the way back along the transect, further stations were done. Twelve scientists were exchanged at Walvis Bay on 24 September while the ship was at the Pier.

Leg 2 started at noon, parallel to the coast with Ring Trawl stations and pick up of the short term mooring. From there, we steamed to the West to start a survey through potential filament heads between 21 grd and 19 grd S with Scanfish and Katamaran. When the Rocky Point Transect on the 19 grd S latitude was reached this was begun with a deep station, then worked towards the coast. The ship went W again so that on the 11 grd 00' meridian a further survey with Scanfish and Katamaran due North was done, oriented at Satellite imagery which showed an extensive filament. On the way back to the SSW, Microstructure sonde and CTD were combined with deployments of the full set of nets available. At the end of this transect, the ship moved W to reach the outer margin of the filament under study. CTD, MSS and nets were deployed again to record the hydrography and biotic environment. The survey of the filament was successful and expected to yield valuable data. From the 19th parallel the ship sailed back South towards the position of the third mooring at the Walvis Bay transect (23 grd S). Here a 36h process study with hydrography measurements and net deployments was done. The vertical migration of zooplankton was recorded in parallel with the ship's 150 kHz ADCP. The mooring was released in the end but not recovered.

Six scientists were taken ashore at Walvis Bay on 10 October, among those two Namibian and one S. African colleague to attend this year's Benguela Current Commission Congress at Swakopmund where GENUS was presented. With this, the scientific programme was ended and RRS Discovery

steamed to Cape Town, arriving in the evening of 13 October. Containers were off-loaded in the morning of 14 October 2010.

For reference, see Fig. 2, Cruise Map and Participants List in the addendum.

Acknowledgements

In spite of technical problems, particularly the winch failure, but generally, the support of captain, officers and crew was extraordinary. This also applies to the on-shore support in solving problems.
The cruise was characterized by a "we are in one boat" attitude towards fulfilling our science objectives within an international project. We congratulate to the whole crew's performance and are looking forward to again sail on British ships and to pay back ship-time and support to our colleagues from UK.

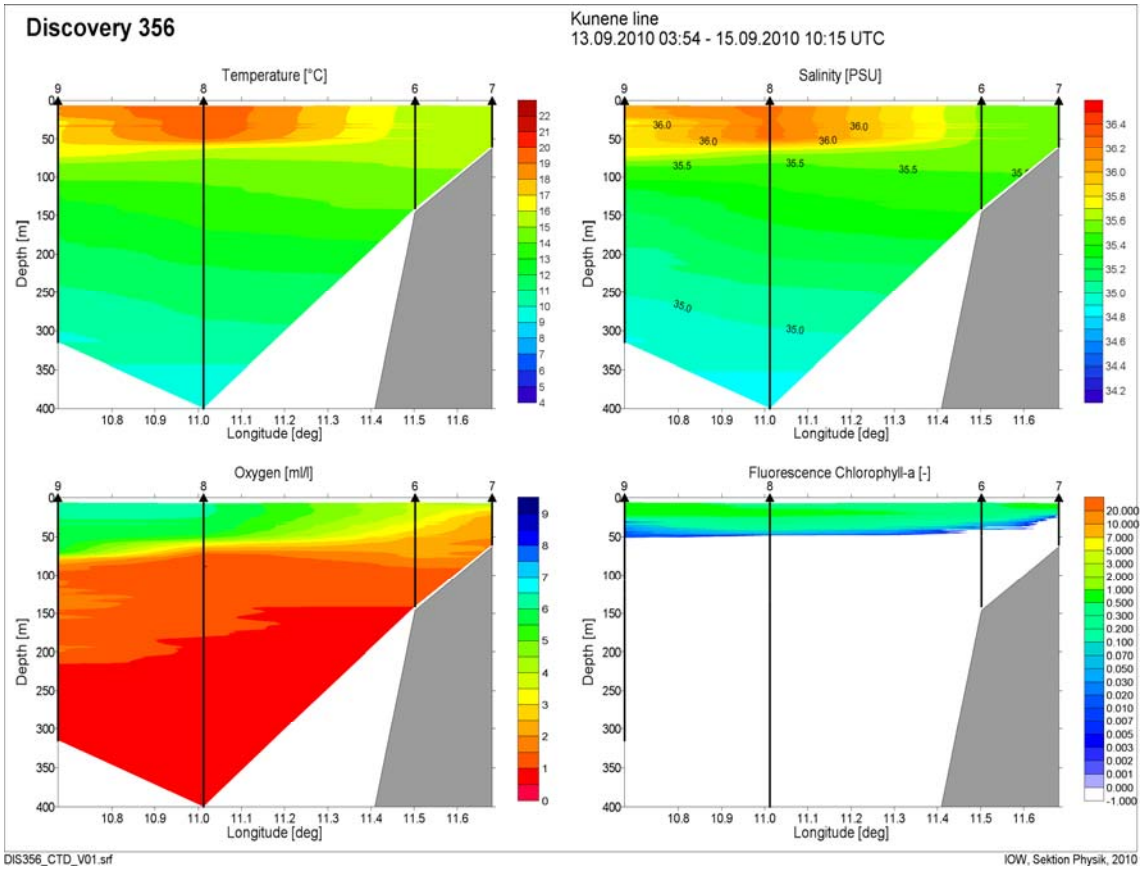
Reports
Leg 1: 10 September (Walvis Bay) – 24 September (Walvis Bay) and Leg 2: 24 September – 13 October 2010 (Cape Town)

Sub-Project 2 Hydrographic measurements

Volker Mohrholz, Toralf Heene, Martin Schmidt Institute for Baltic Sea Research, Warnemünde

The hydrographic investigations during the first leg of Dis356 covered two transects in the northern Benguela, one off the Kunene river mouth at 17° 30' S and one off Walvis Bay at 23°S. A CTD (SeaBird

911+) was used at each station to measure vertical profiles of temperature, salinity, oxygen and fluorescence. At selected depth water samples were taken for nutrient and phytoplankton measurements. Due to a winch failure the depth of CTD casts at the Kunene transect was limited to



the upper 400 m. For CO_2- determination the CTD was equipped with a pump system, that delivers a continuous water flow through a hose into the chemical lab. Additionally, a free falling micro-structure probe (MSS) was used to obtain shear profiles that were used to quantify the dissipation of turbulent kinetic energy and vertical fluxes of dissolved substances in dependence on the ocean stratification. he cruise started during strong winds favoring coastal upwelling followed by a rather calm period when the Kunene transect was worked. Synoptic figures of the Kunene transect show cold and less saline upwelled water near the coast and warm saline waters of tropical origin more off-shore.

The CTD casts reach the core of the oxygen minimum zone, which extends to sub-surface waters at the in-shore station. The horizontal gradient in the surface water reflects the reduced saturation concentration with increasing temperature.

At the transect off Walvis Bay the winch problems could be fixed. Thus CTD casts down to 3000 m could were carried out (not shown).

The microstructure profiles at the shelf revealed the usual enhanced dissipation rates near the surface and low dissipation below the thermocline. The corresponding estimates for the mass eddy diffusion coefficient confirm commonly accepted values that were however not well supported by direct dissipation measurements until now. The enhanced dissipation in the bottom layer of the shelf edge is a strong hint for mixing due to breaking internal waves and swell.

The station work was supplemented with underway navigation, meteorological and surface hydrographic measurements for later use for the carbon cycle measurements. Two ship borne RD-Instruments ADCPs (75 kHz long range, 150 kHz Broad band) delivered current data to a depth of 400 m or 150 m respectively.

During the first leg of the cruise a short term mooring was deployed at 21°S. A second long term mooring 20nm off Walvis Bay was successfully recovered.

Working group „Phytoplankton“

Norbert Wasmund, Anja Hansen, Institute for Baltic Sea Research, Warnemünde

The work on phytoplankton comprised
(1) analyses of biomass parameters including species composition in the station grid/transects,
(2) experiments on phytoplankton succession, primary production and nitrogen fixation.

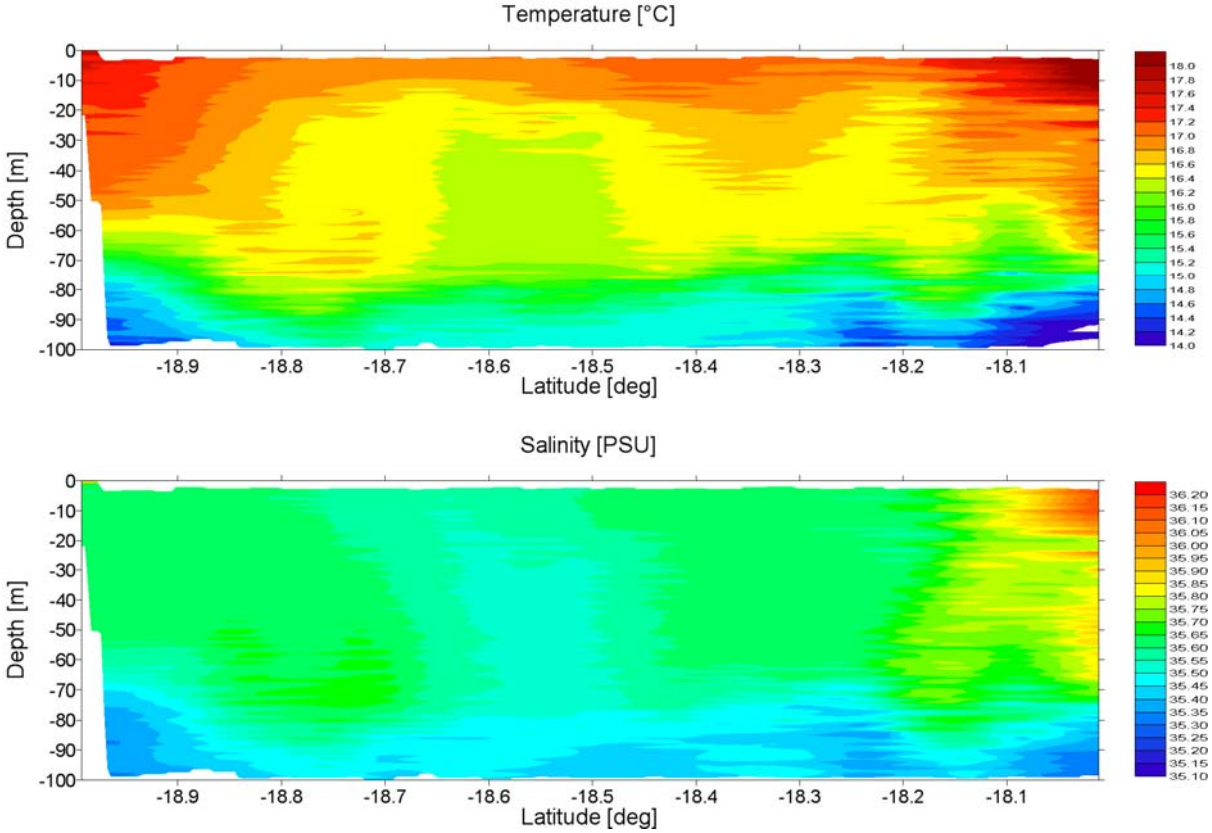
To (1):
13 stations were sampled, each with several samples from different depths, for microscopic analyses and measurements of chlorophyll a concentrations. The microscopy will deliver information on taxonomic composition and corresponding biomass. In order to get rough information on the composition of ultraplankton < 5 µm, samples for flow-cytometric analyses were collected from 11 stations. These analyses were not possible on board but have to performed at the IOW.

To (2):
At three stations (D356_6, D356_8 and D356_11), 4 barrels were filled with surface water and installed on deck for mesocosm experiments. Each series was treated with nutrients, addition of Trichodesmium and heating in order to create optimum growth conditions for diazotrophic cyanobacteria. The experiment was especially designed to answer the question if there is a potential for cyanobacteria growth in the upwelling area. As the analyses will be performed after the cruise only, currently no results can be presented. The results will be assessed together with data of nutrient concentrations and dissolved inorganic carbon, which will be delivered from TP4 (Tim Rixen).

Contribution of WP2 to the cruise report D356, leg 2:

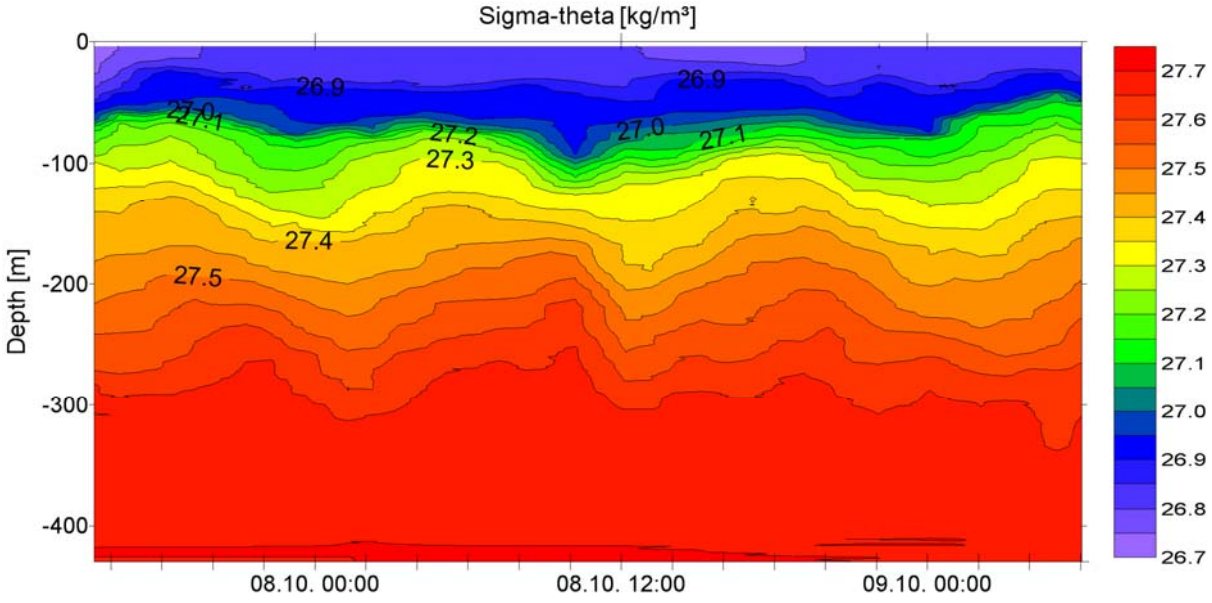
A) Hydrography (V.Mohrholz, M. Schmidt, T. Heene, A. Muller)
The hydrographic investigations during the second half of Dis356 were focussed on the mesoscale dynamics of upwelling filaments and on the action of internal tidal waves at the shelf break at 23°S.
Off Cape Frio an upwelling filament, suitable for the planned investigations, was detected in TMI satellite SST data. The observations of this filament were carried out along two cross-filament transects at 11°E and 9.6°E. Each transect was worked twice. First it was covered with towed instruments in order to gain information on the general filament structure. For this purpose a towed undulating CTD (ScanFish) and a towed ADCP catamaran were used. Than the filament was worked again using a vertical CTD and a microstructure profiler (MSS).

The data of the towed instruments (ScanFish and ADCP catamaran) revealed a hydrographic data set with a horizontal resolution of 1500m in the upper water layer from 3 to 100m depth.



In the towed CTD data the filament visible as a water body with lower temperature and salinity than the ambient water in the upper layer (see figure). Due to a series of calm days a thin surface layer was heated and thus the filament is hidden in satellite SST data. The data from the vertical CTD points to a filament depth of about 100 to 110m. The Chl-a fluorescence showed maxima both edges of the filament were mixing between filament waters and ambient oceanic waters occur.

To obtain the internal tidal wave at the shelf edge a 36h time series station was performed on the 23°S transect at 400m water depth. Every second hour two MSS profiles were taken. Additionally a CTD cast was carried out at begin and end of the time series. The preliminary analysis showed a clear indication for the presence of internal tidal waves at this position. In the bottom layer the vertical structure changed between well mixed and stratified conditions in the time scale of the M2 tide. During well mixed phases the mixed bottom layer had an vertical extent up to 100m. Also the turbidity was enhanced in the bottom layer, which points to breaking events of internal waves.



B) Phytoplankton (N. Wasmund, A. Hansen), summary of legs 1 and 2:

The aim of the small phytoplankton working group within TP2 was

A) contribution of phytoplankton basis data for the use in other working groups of GENUS (e.g. for food chain investigations by zooplanktologists or for validation of the biological parts of the models)

B) investigations on the influence of the maturation of upwelled water („filaments“) on the composition, biomass and production of the phytoplankton

C) specific investigations on the occurrence of nitrogen fixation in the Benguela region.

The topics A and B were covered by phytoplankton samplings in the station grid, performed by a rosette sampler (combined with CTD). A sampling statistics is given in Table 1. Samples were taken from different depths in order to get representative data from the euphotic zone. They were preserved for qualitative and quantitative microscopic analyses and for chlorophyll *a* analyses, which have, however, only to be performed at the institute. In order to get rough information on the composition of ultraplankton < 5 µm, samples for flow-cytometric analyses were collected. Also phytoplankton net samples will be analysed later in order to support the species identification. Only Secchi depth readings were immediately available, but not from the nights (data see Table 1). Especially at the stations 30-35 and 37-41, covering the two transects across the investigated filament, intensive measurements of primary production and nitrogen fixation were carried through. They will answer the question whether the water in the filament is still highly productive in comparison with the surrounding water, where nitrogen fixation was expected. The low N/P ratios (<16) should stimulate the nitrogen-fixing cyanobacteria, but only few *Trichodesmium* were found in samples from the surface drift net.

The Topic C aimed at checking the reasons for the low cyanobacteria abundance in the waters investigated. Twelve tanks of 90 litres were filled with surface water, Nr. 1-4 in front of the Kunene mouth (station D356_6), Nr. 5-8 in the oceanic part of the Kunene transect (station D356_8) and Nr.

9-12 in front of Walvisbay (station D356_11). Each series was treated with nutrients, addition of *Trichodesmium* (from cultures) and heating (up to 20-24 °C) in order to create optimum growth conditions for diazotrophic cyanobacteria. The tanks were sampled every third day over a period of 3 weeks. The samples will be analysed for phytoplankton composition and biomass, chlorophyll a concentrations and rates of primary production and nitrogen fixation. Also samples for analyses of nutrients and dissolved inorganic carbon were taken and analysed on board by colleagues of the TP4 (Tim Rixen and co-workers). It turned out that nitrate was quickly consumed but not the phosphate. It will be of interest whether the algae took up the nitrate (this will show up on the filters) or if high denitrification occurred. The constantly high phosphate concentration and the strongly reduced nitrate concentrations in the tanks suggest that no nitrogen fixation may have occurred.

Table 1: Sample statistics of the phytoplankton investigations and data of the Secchi depth readings.

STATION	DATE [yyyymmdd]	TIME [hh:mm:ss]	Number of Chl.a-samples	Number of Phytopl. samples	Number of Phytopl.net samples	Number of samples for N-fix. and prim. prod.	Secchi depth (m)
02	20100911	20:08:46	1	1	1		
03	20100911	23:22:51	1	2			
06	20100913	04:52:05	6	2	1	19	
07	20100913	14:21:43	5	2	1		
08	20100914	15:06:14	7	5	1	22	10
09	20100915	10:13:27	1	2			7
11	20100917	10:43:00	1	1	1	18	
12	20100918	13:05:28	-	3			
14	20100919	07:58:43	1	3	1		10
15	20100920	04:33:28	6	2	1		10
16	20100920	16:47:09	5	2	1		13
17	20100922	04:19:00	5	3	1		6
18	20100923	01:19:22	5	3	1		
19	20100924	16:59:40	5	2	1		
20	20100925	11:36:56	6	2	1		5
21	20100925	18:18:56	5	1	1		
22	20100926	06:48:57	5	2	1		6
23	20100927	08:24:36	5	2	1		13
24	20100928	07:33:01	5	2	1		11
25	20100928	16:11:07	6	2	1		
26	20100929	11:11:00	-	-	1		12
27	20100929	20:00:00	1	-	1		5
28	20100930	08:10:00	-	-	1		8
30	20100930	21:15:13	6	2	1	10	
31	20101002	05:01:57	7	5	1	10	
32	20101002	11:28:21	6	4	1	10	7
33	20101002	21:06:17	6	5	1	10	
34	20101003	04:29:20	6	5	1	10	
35	20101003	08:19:48	5	4	1	10	11
37	20101004	23:15:47	6	4	1	10	
38	20101005	02:22:15	6	4	1	10	
39	20101005	15:55:48	6	4	1	10	9
40	20101005	17:21:43	5	1			
41	20101005	20:05:51	6	4	1	10	
43	20101007	14:33:43	6	3	1		9
Sum of station samplings:			**153**	**89**	**31**	**159**	
Sum of samples from experiments:			**68**	**68**		**460**	

Subproject 3: Nutrient Fluxes - Geochemical and Isotopic Tracers

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Institute for Biogeochemistry and Marine Chemistry, University of Hamburg, Germany
GKSS Research Institute, Geesthacht, Germany

Major contributions of the working group *Nutrient fluxes - Geochemical and Isotopic Tracers* to the GENUS project and specifically during the *RRS Discovery Voyage* are to measure and decipher the biogeochemical cycling of nutrient elements between the atmosphere, water column, biota and sediments. These results are prerequisites to understand the trophic interactions and energy flows within the biotic system and to validate and improve existing models, which are part of other sub-projects within the GENUS frame work. In particular we focussed our work on two subjects:

(1) Automatic detection of physical variables, nutrients and gas components in the surface water throughout the entire cruise (Ferrybox and *Systea* autoanalyzer)
(2) Sampling and filtration of particulate matter (*seston)* and dissolved components (nutrients and other organic and inorganic substances for stable isotopes)

(1) Ferrybox and *Systea* autoanalyzer

The Ferrybox including the autoanalyzer *Systea Micromac 1000* was attached to a continuous flow (5 litres per minute) of surface seawater and measured every minute (every 30 minutes for nutrients) the following variables: conductivity, temperature, salinity, oxygen (content and saturation), fluorescence, turbidity, chlorophyll, phycoerythrin, CDOM, NO_2, NO_3, PO_4 and SiO_2. Precision of nutrient measurements was checked against fresh calibration standards on a daily basis. In addition, samples for re-calibration in our home laboratories were taken every day. Thus, we state that some of the results shown in the figures below should be treated as preliminary and have to be validated after the cruise. Particularly, results of nitrogen components (NO_2, NO_3) are so far questionable as the *Systea Micromac 1000* has been used for the first time ever (it was sent to the ship directly from the manufacturer) and produced unusually low values throughout the voyage.

First results show major changes in the northern most part of the study area compared to the rest of the Namibian coastline. Temperature and salinity were elevated on the Kunene transect, oxygen and chlorophyll concentration, in contrast, severely depleted. Nutrient results were somehow ambiguous. Phosphate concentrations were moderately elevated between 17° and 19° S but drop to almost zero concentrations in the southern part and on the Walvis transect. Silicate concentrations were also slightly elevated in the northernmost part; however, concentrations spiked at the inward part of the Walvis transect to values close to 40 µmol per liter. Chlorophyll distribution revealed the small scale (and short-term?) patchiness of the study area where no clear trend was found during the first part of D-356. Nitrogen bearing nutrients most likely reveal a systematic error as we measured positive nitrite values but negative nitrate values. In addition, as we observed the existence of phosphate at almost every station there should have been significant nitrate concentrations as well.

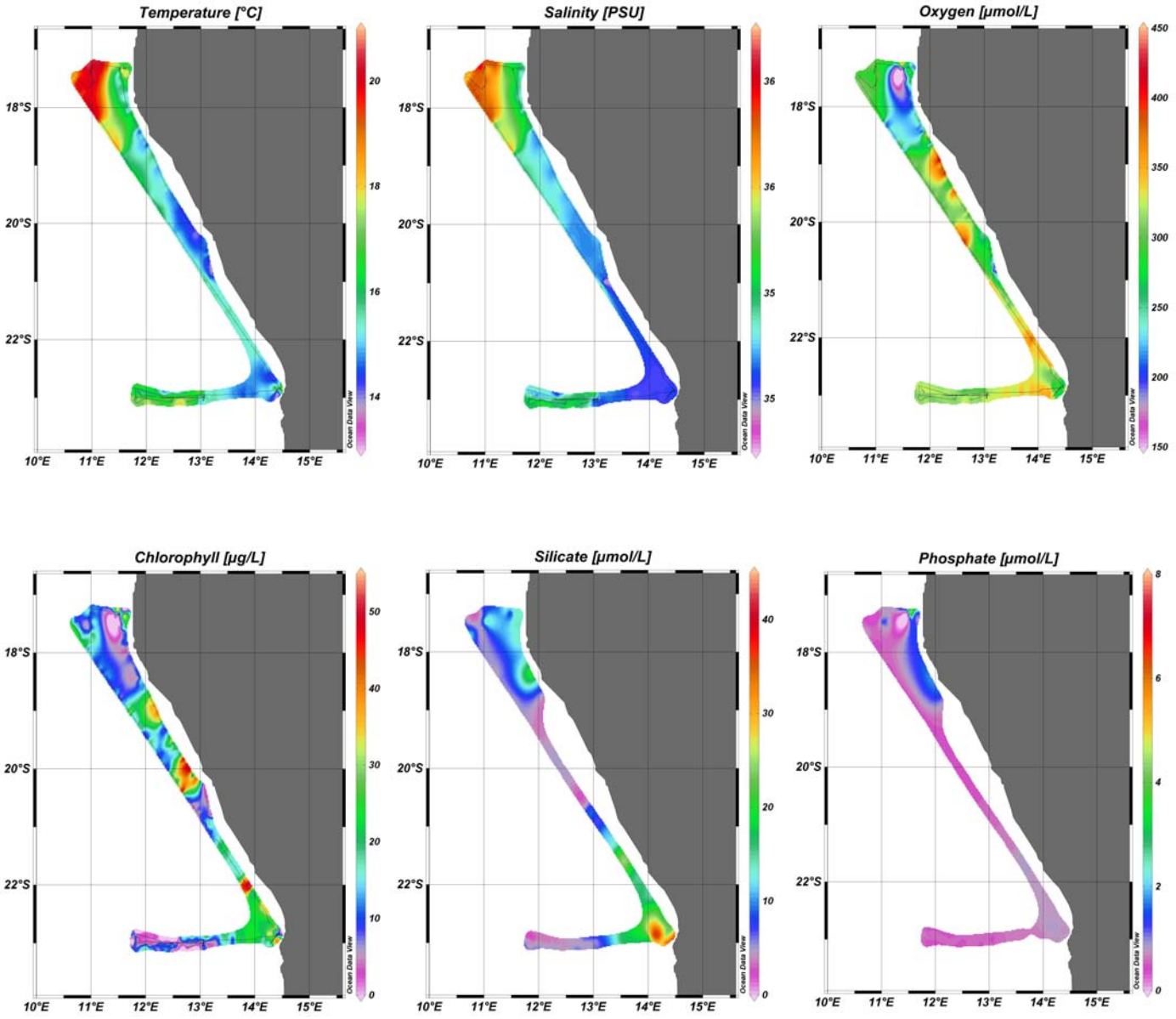

Fig. 1: Physical and chemical properties of the Benguela upwelling area in September 2010 obtained from continuous measurements (>12,000 data points) of a Ferrybox and *Systea* autoanalyzer installed on RRS Discovery.

(2) Water Sampling

Water samples were taken from almost every CTD cast from various depths (see Table below). The particulate matter fraction was filtered on pre-combusted GF/F filters. Further analytical investigations of this particulate fraction will be carried out for the bulk geochemical content, isotopic composition (^{13}C and ^{15}N) and biogeochemical proxies such as, for example, amino acid spectra. Filtrated water will be analysed on the isotopic composition of nutrients (^{15}N and ^{18}O) of NO_3, NO_2 and DON. These results are a prerequisite for understanding nutrient cycling and biotic interactions. Moreover, one major aim is to establish empirical fractionation factors of dissolved

inorganic nitrogen and diagenetic alteration by paired analyses of □^{15}N in dissolved components compared to chlorophyll, bulk particulate mater, and surface sediments. Analogous analyses at higher trophic levels will be done by other sub-projects. In addition to the filtration campaign incubation experiments with labelled nitrogen gas ($^{15}N_2$) will be carried out at selected stations during the second part of D-356 (similar to SP-2, which already performed incubation experiments during the first part of this cruise) in order to detect and to describe potential nitrogen fixation in the Benguela upwelling system (see Montoya et al. 1996, Environmental Microbiology 62, 986-993 and Wasmund et al. 2001, Marine Ecology Progress Series, 214, 1-14 for further details on the analytical method).

Tab. 1: Water samples taken from CTD casts. N-Fix = nitrogen fixation experiments carried out with labelled $^{15}N_2$ gas in an incubation box installed on deck (planned for D-356, leg 2). PM = particulate matter on GF/F filters.

Station No.	Position [Lat/Lon]	Water Depth [m]	Bottle Depth [m]	Nutrients	$^{15}NO_3$	N-Fix	PM [Liter]	Remarks
D-356 #6	17° 20.166' S	146	0	X	X		6	Chl-Max
	11° 29.636' E		10	X	X		9	Chl-Max
			20	X	X		9	Chl-Max
			30	X	X		7	
			50	X	X		9	
			75	X	X		9	
			100	X	X		8.5	
			125	X	X		8	
D-356 #7	17° 18.130' S	63	0	X	X		6	
	11° 40.873' E		10	X	X		8	Chl-Max
			20	X	X		9	
			30	X	X		9	
			50	X	X		8	
			60	X	X		5	
D-358 #8	17° 20.450 'S	1470	0	X	X		9	Chl-Max
	10° 59.960 'E		10	X	X		9	Chl-Max
			20	X	X		8	Chl-Max
			30	X	X		9	
			50	X	X		9	
			75	X	X		9	
			100	X	X		9	
			125	X	X		8	
			150	X	X		9	
			200	X	X		13	
			500	X	X		15	
			700	X	X		15	
			1000	X	X		15	
			1450	X	X		16	
D-359 #9		>2400	0	X	X		7	
			10	X	X		9	Chl-Max
			30	X	X		7	
			100	X	X		8	
			210	X	X		6	
			270	X	X		6	O_2-Minimum
D-356 #12	23° 03.07' S	ca. 3000	0	X	X		11, 11	1x reg, 1x Cop
	11° 46.69' E		10	X	X		5	
			30	X	X		11	Chl-Max
			50	X	X		8	
			100	X	X		9	

			200	X	X		9	
Station No.	**Position [Lat/Lon]**	**Water Depth [m]**	**Bottle Depth [m]**	**Nutrients**	**$^{15}NO_3$**	**N-Fix**	**PM [Liter]**	**Remarks**
D-356 #14	23° 03.538' S	ca. 1000	0	X	X		11	
	12° 49.960' E		10	X	X		5	
			30	X	X		6	Chl-Max
			50	X	X		5	
			100	X	X		9	
			200	X	X		5	
D-356 #15	23° 03.10' S	470	0	X	X		10	
	13° 02.03' N		10	X	X		11	
			20	X	X		8	
			30	X	X		8	
			50	X	X		9	Chl-Max
			75	X	X		7	
			100	X	X		6.5	
			125	X	X		6	
			150	X	X		9	
			200	X	X		15	low Oxygen
			460	X	X		15	low Oxygen
D-356 #16	22° 50.00’ S	>3000	0	X	X		10	
	11° 48.00’ E		10	X	X		8	
			20				6	
			75	X	X		6	
			125	X	X		8	
			150	X	X		6	
			500	X	X		15	
			700	X	X		13	
			1000	X	X		11	
			2000	X	X		17	
			3000	X	X		18	
D-356 #17	23° 02.770’ S	240	0	X	X		5	
	13° 30.201’ E		10	X	X		6	
			20	X	X		9	
			30	X	X		7	Chl-Max
			50	X	X		6	
			75	X	X		9	
			100	X	X		9	
			125	X	X		9	
			150	X	X		9	
			225	X	X		6	
D-358 #18	23° 00.829’ S	132	0	X	X		7	
	13° 59.823’ E		10	X	X		7	
			20	X	X		7	
			30	X	X		7	
			50	X	X		6	
			75	X	X		7	
			100	X	X		9	
			125	X	X		9	
D-358 #19	21° 57.91’ S	56	0	X	X		5	
	13° 55.91’ E		10	X	X		-	
			20	X	X		5	
			30	X	X		5	
			50	X	X		3	

Station No.	Position [Lat/Lon]	Water Depth [m]	Bottle Depth [m]	Nutrients	$^{15}NO_3$	N-Fix	PM [Liter]	Remarks
D-358 #21	20° 59.55’ S	795	0	X	X		6	Chl-Max <50m
	12° 10.93’ E		10	X	X		5,5	
			20	X	X		5,5	
			30	X	X		6	
			50	X	X		6	
			75	X	X		9	
			100	X	X		7,5	
			500	X	X		17,5	
			700	X	X		13	
			795	X	X		14	
D-358 #22	20° 59.871’ S	2151	0	X	X		6	
	11° 24.107’ E		10	X	X		6	
			20	X	X		6	
			30	X	X		6	
			50	X	X		6	
			75	X	X		8,5	
			100	X	X		8,5	
			500	X	X		18	
			700	X	X		13,5	
			1000	X	X		14	
D-358 #23	18° 59.590’ S	2750	0	X	X		8	
	10° 19.839’ E		10	X	X		8	
			20	X	X		10	
			30	X	X		12	
			50	X	X		11	
			75	X	X		10	
			100	X	X		13,5	
			350	X	X		15,5	O2-Minimum
			500	X	X		16,5	
			700	X	X		18	
			1000	X	X		13	
			2000	X	X		18	
			2757	X	X		10	
D-358 #24	19° 02.826’ S	1094	0	X	X		8	
	11° 04.941’ E		10	X	X		8	
			20	X	X		8	
			30	X	X		8	
			50	X	X		6	
			75	X	X		8	
			100	X	X		15	
			350	X	X		13	O2-Minimum
			500	X	X		16.5	
			700	X	X		17	
			1089	X	X		10	
D-358 #25	18° 59.326’ S	277	0	X	X		9	Chl-Max <20m
	11° 30.459’ E		10	X	X		10	
			20	X	X		10	
			30	X	X		10	
			50	X	X		12	
			75	X	X		11	
			100	X	X		13	
			275	X	X		14	
D-358 #27	18° 59.425’ S	120	0	X	X		6	
	12° 11.320’ E							
D-358 #28	18° 59.09’ S	56	0	X	X		6	

	12° 23.478’ E							
Station No.	**Position [Lat/Lon]**	**Water Depth [m]**	**Bottle Depth [m]**	**Nutrients**	**$^{15}NO_3$**	**N-Fix**	**PM [Liter]**	**Remarks**
D-356 #30	17° 36.789’ S	2257.0	0	X	X	X	8	Chl-Max
	11° 00.000’ E		10	X	X		8	
			20	X	X		8	
			30	X	X		9	
			50	X	X		11	Chl-Max
			75	X	X		11.5	
			100	X	X		15	
			200	X	X		15.5	
D-356 #31	17° 55.017’ S	2579.0	0	X	X		4	Chl-Max <30m
	10° 55.296’ E		10	X	X		6	
			20	X	X		6	
			30	X	X		6	
			50	X	X		9	
			70	X	X		12	Chl-Max
			100	X	X		12	
			200	X	X		15	
D-356 #32	18° 14.921’ S	3175.0	0	X	X	X	8	Chl-Max
	10° 50.097’ E		10	X	X		8	
			20	X	X		8	
			30	X	X		9	Chl-Max
			50	X	X		11	Chl-Max
			75	X	X		11.5	
			100	X	X		15	
			200	X	X		15.5	
D-356 #33	18° 34.8824’ S	3162.0	0	X	X		3	Chl-Max <15m
	10° 45.537’ E		10	X	X		4	
			20	X	X		6	
			30	X	X		8	
			50	X	X		10	
			75	X	X		14	
			100	X	X		16.5	
			200	X	X		20	
D-356 #34	18° 54.970’ S	1780.0	0	X	X	X	6	Chl-Max <35m
	10° 41.262’ E		10	X	X		14	
			20	X	X		16	
			30	X	X		14	
			50	X	X		13	
			75	X	X		15.5	
			100	X	X		14	
			200	X	X		19	
D-356 #35	19° 02.736’ S	1635.0	0	X	X		8	Chl-Max <20m
	10° 39.576’ E		10	X	X		7	
			20	X	X		14	
			30	X	X		7	
			40	X	X		10	Chl-Max
			75	X	X		15.5	
D-356 #37	18° 00.057’ S	4275.0	0	X	X		8	Chl-Max <30m
	9° 41.768’ E		10	X	X		7	
			30	X	X		14	
			50	X	X		7	
			100	X	X		10	

Station No.	Position [Lat/Lon]	Water Depth [m]	Bottle Depth [m]	Nutrients	$^{15}NO_3$	N-Fix	PM [Liter]	Remarks
D-356 #38	18° 17.929' S	4279.0	0	X	X		10	Chl-Max <15m
	9° 39.845' E		10	X	X		10	
			30	X	X		13	
			50	X	X		7	
			100	X	X		17,5	
D-356 #39	18° 41.048' S	4382.0	0	X	X	X	8	Chl-Max <20m
	9° 39.325' E		10	X	X		6	
			20	X	X		8	
			30	X	X		14	
			50	X	X		15	
			75	X	X		15.5	
			100	X	X		11	
			200	X	X		17	
D-356 #41	18° 59.612' S	4439.0	0	X	X	X	8	Chl-Max <20m
	9° 40.417' E		10	X	X		8	
			30	X	X		12	
			50	X	X		5.5	
			100	X	X		18	
D-356 #43	23° 00.100' S	395.0	0				6	Chl-Max <50m
	13° 03.304' E		10				6.5	
			20				5	
			30				7	
			50				10	
			100				16	
			395				18	

SP4 Geo: Carbon - Biogeochemistry

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Introduction

GENUS is a multidisciplinary program aiming to improve our understanding of the complex interaction between biological, biogeochemical and physical processes within the Benguela Upwelling System and their response to environmental changes. Within this framework the subproject TP4-Biogeochmistry aims at studying the functioning of the biological pump which is referred to as the uptake of carbon through the photosynthesis of organic matter, the precipitation of calcium carbonate and the subsequent transport of carbon from the surface ocean into the sediments. The biological pump strongly influences CO_2 fluxes across the air-water interface and the distribution of dissolved oxygen in the water column. Furthermore it plays an important role for the

long-term sequestration of atmospheric CO_2 by linking the three major carbon reservoirs; atmosphere, ocean and lithosphere.

Aims

The cruise 'D356' was the third GENUS cruise in which we participated. The cruise 'D356' was of crucial importance for us, as it covered the main upwelling season off Namibia. The data we collected will complement our picture which so far based on data collected during the boreal winter (December) and spring (March, Fig.1).

Our aim during the cruise 'D356' was

1. to quantify CO_2 fluxes across the air-water interface,
2. to determine aragonite saturation states in surface waters by measuring total alkalinity TA and pCO_2,
3. to measure TA and dissolved inorganic carbon concentrations (DIC) in water samples collected along vertical profiles,
4. to collect samples for the determination nutrients (PO_4, NO_3, NO_2, Si), and
5. to measure the stabile carbon isotope ratios of the DIC ($\delta^{13}C$ – DIC).

Methods:

The mole fraction of CO_2 (xCO_2) was continuously measured in the ocean and the atmosphere by using a „*underway carbon dioxide analyzer*" SUNDANS. Sea water temperatures, salinity, wind seeds and the atmospheric pressure was continuously recorded by the RRS Discovery. The collected data were evaluated and used to convert xCO_2 into the fugacity of CO_2 (fCO_2) which is required to calculate the CO_2 flux across the sea water interface. Between stations water samples were collected from the underway system in order to analyze TA and to calculate aragonite saturation states. High resolution vertical profiles were obtained by using the pump-ctd which was directly connected to SUNDANS. Additionally each three minutes discrete water samples were taken in order to obtain a vertical resolution of ~ 20m.

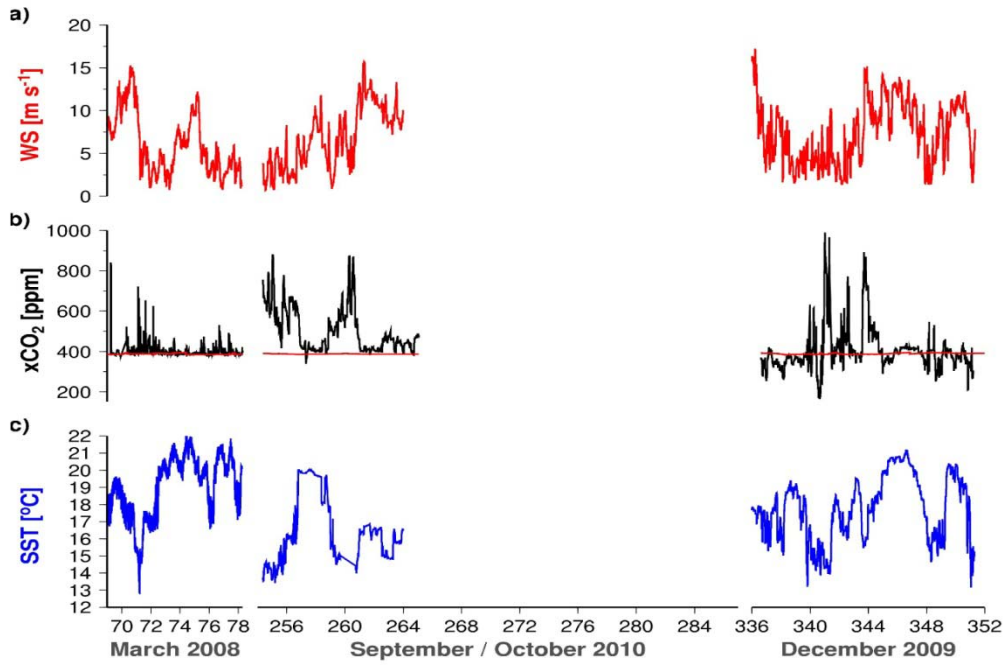

Fig. 1: Winds speed, xCO_2, and sea water temperatures (SST) measured during the three GENUS cruises versus time (day of the year).

Preliminary results and discussion

Contrary to March and similar to December, the xCO_2 in the surface water revealed an extreme spatial variability (Fig.1) caused by the complex interplay of upwelling of CO_2 enriched deep water, the biological uptake and the CO_2 emission. However, based on the data collected during the three cruises the mean fCO2 was approximately 450 µatm (Fig.2) suggesting a CO_2 flux of 0.25 Tg C yr^{-1} into the atmosphere from the continental shelf of the northern Benguela Upwelling System between Walvis Bay and the Kunene river. Contrary to the northern Benguela Upwelling System the ocean is taken up carbon in the southern Benguela Upwelling System between Walvis Bay and Cape Town. This results base so far only on data collected in December 2009 and has, however, to be updated by data which will be collected during the second leg of the cruise D356.

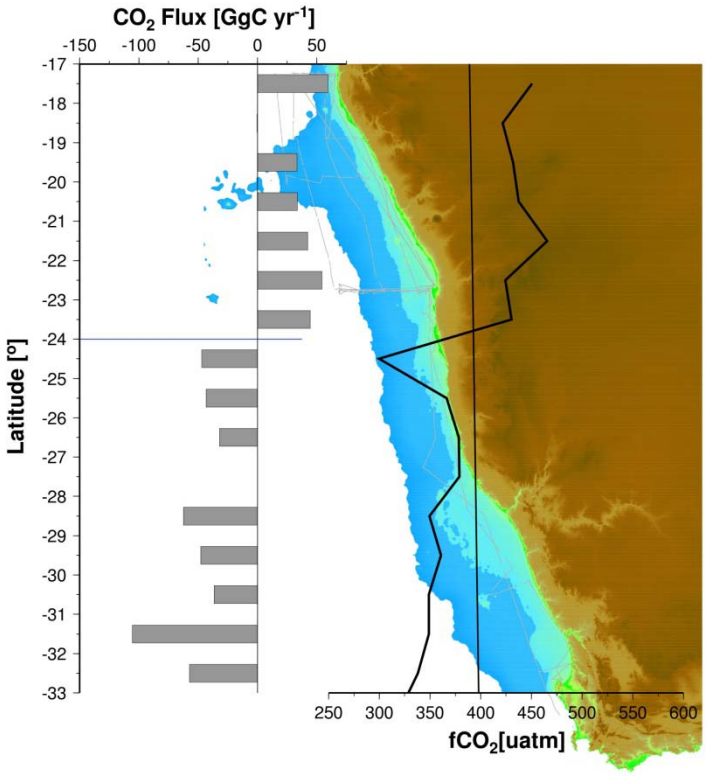

Fig. 2: Mean latitudinal CO_2 fluxes from the continental margin (marked in the blue) along the African coast and the mean fCO_2 in the water (bold line) and atmosphere (thin line). Thin grey lines indicate the cruise tracks.

SP4 Bio: Ichthyoplankton and fish studies

Leg 1 Werner Ekau, Andreas Kunzmann, Simon Geist, Stefanie Bröhl - ZMT

A central aim of the work within GENUS is to understand the trophic interrelationships between the different components of the Northern Benguela upwelling system and their reaction under the influence of climatic and anthropogenous induced changes. For the identification of key processes/species and analysis of key rates of biological ecosystem components a number of seagoing campaigns are organised to collect the respective data and samples. The first sampling campaign of ichthyplankton was carried out in 2008 with the German RV Maria S. Merian, a second in December 2009 on FRS Africana. Besides a general investigation on the distribution of fish larvae the focus of the work on this cruise was put on experiments to estimate oxygen consumption of early stages of species such as sardine, horse mackerel, flatfish and others, and to validate daily increment deposition in otoliths by marking the fish with tetracycline and calcein.

The original sampling scheme for Ichthyoplankton of three transects perpendicular to the coast could not be followed because of technical reasons. Depending on the technical conditions, three different nets were used to catch eggs and larvae: an obliquely towed Multinet (MN_{obl}), a Bongo net and a Ring Trawl. The Multinet was equipped with 5 nets of 500µm-mesh size and a mouth

area of 0.25 m^2. It was towed over the stern obliquely in 5 different depth strata. A total of 5 hauls was taken. The Multinet is equipped with two flowmeters, one inside and another one outside the net, to measure the nets' trajectory through the water and calculate the filtered volume. The Bongo net consisted of two nets of 60 cm diameter each, equipped with one 300 and one 500 µm net. The Bongo was towed at 4 stations over the stern in a double oblique manner. Flowmeter and GPS positions at times "net in the water" and "net out of water" are used to calculate the trajectory of the net through the water. Depth was recorded with an rbr-depth recorder. The Ring Trawl had a diameter of 1.6 m and a mesh size of 1000µm. A total of 15 hauls were performed, either vertically over the side and towed horizontally over the stern. Ring Trawls were not considered to catch quantitatively but rather used to catch live material for the experiments.

Temperature controlled fish keeping tanks were installed and respiratory equipment for batch and flow through systems was set up in a specially equipped 20' Lab-Container owned by ZMT. Due to technical problems with the internal power supply the container could not been used in the first days. Pretrials were run with every system, but only one respiration experiment of a flatfish larvae could be conducted during leg1, due to the very poor supply with live material.

All samples were analysed roughly for their content of fish larvae. Samples were preserved in buffered formalin (4% in seawater) for community studies, alcohol for genetic studies or frozen for age determination and stomach, fatty acid and isotope studies.

During leg 1 in total 415 fish larvae were caught and immediately frozen to -80°C after their standard length was measured. Most were members of mesopelagic species. The key species of our studies were clearly underrepresented: 3 clupeid, 20 *Trachurus trachurus capensis*, 20 Goby, 19 Hake and 40 flatfish larvae were caught. Only three of the flatfish larvae were alive and in a good condition when they came on board.

At 11°40' S around 200 Sardine and Anchovy eggs and 10 Fish eggs were caught and kept until hatching, which occurred after two to three days , but survival of the hatchlings was very poor in comparison to the Africana cruise.

Larvae were sorted out directly after the catch and immediately frozen to -80°C to permit subsequent trophic analysis in Germany.

Leg 2 Ichthyoplankton and fish studies (Werner Ekau, Andreas Kunzmann, Simon Geist, Stefanie Bröhl - ZMT)

The planned sampling scheme for Ichthyoplankton was to sample coastal stations (<200 m depth, preferably < 50 m depth) with special "physiologist hauls" in order to get as much life material as possible. In addition fish sampling during the filament study should reveal, whether coastal larvae and juveniles are also found offshore in coastal water masses.

Two different nets were used to catch eggs and larvae: an obliquely towed Multinet (MN_{obl}) and a Ring Trawl. The Multinet was equipped with 5 nets of 500µm-mesh size and a mouth area of 0.25 m^2. It was towed over the stern obliquely in 5 different depth strata. The Multinet is equipped with two flow meters, one inside and another one outside the net, to measure the nets' trajectory through the water and calculate the filtered volume. The Ring Trawl had a diameter of 1.6 m and a mesh size

of 1000µm and was towed horizontally over the stern. Ring Trawls were not considered to catch quantitatively but rather used to catch live material for the experiments.

A total of 56 towed Ringtrawl and 5 oblique Multinet casts were done during leg 2 (see Tab. 1).

Temperature controlled fish keeping tanks (2x 200 l, Saeplast Iceland) were installed and respiratory equipment for batch and intermittent-flow systems was set up in a specially equipped 20' Lab-Container owned by ZMT, which was set to constant temperature at 16° C.

Significant amounts of Trachurus larvae (HMC) were caught at the innermost stations of Rocky Point line (more than 300 larvae). Additionally a few Goby and Scorpaenid larvae occurred as well.

During the first filament study some Clupeid and Anchovy larvae (ca 50) were caught together with fewer HMC (ca. 20) and single flatfish and scorpaenid specimens. At the last station of the filament study larvae of Snoek (30 individuals, identification to be confirmed) and another species not yet identified were caught. Mesopelagic larvae were abundant at many stations.

Live specimens could only be caught in very little numbers: 3 horsemackerel, 10 Scorpaenid, 4 needlefish and 5 flatfish. Most of them were kept alive for several weeks onboard the vessel. Although the supply with live material was poor, some 20 metabolism experiments could be performed, lasting from 6 to 48 hours, each. But in the life material, the key species of our studies were clearly underrepresented

All Multinet samples and some selected Mocness samples were analysed roughly for their content of fish larvae. Samples were preserved in buffered formalin (4% in seawater) for community studies, alcohol for genetic studies or frozen for age determination and stomach, fatty acid and isotope studies.

During leg 2 in more than 600 fish larvae were caught and standard length was measured. Larvae were sorted out directly after the catch and immediately frozen to -80°C to permit subsequent trophic analysis in Germany.

Station	South	East	Depth	RTo	MNo	Time (min)	No. Fish larvae	comments
19	21° 57	13° 56	50	6		105		2nd depth= 100m
20								
21				1		30	22 mesopel	
22							8 mesopel	
23								
24	19° 06	11° 05	105 0	1	1	90	6	
25			287	2	1	100	6xHMC, Lophius, Goby, 11x ANC	
26			200	2	1	100	8x hmc, mesopel	incl. 60 min repair of net
27	19° 00	12° 11	112	4	1	120	9xhmc, 2xgoby, 84x mesopel	
28			63	2	1	70	9xhmc, lophius	
27-II	18° 59	12° 10	116	3		60		
26-II	19° 01	11° 59	208	6		120	34xhmc, goby, mesopel	

	19°	11°					many hmc !!, goby, blenni, mesopel, ANC,
25-II	04	30	319	3		60	20x Scorp
29							
	17°	11°	220				Scorp, HMC,
30	37	00	9	3		60	Clupeid
	17°	10°	269				20x HMC, Clupeid, ANC,
31	56	57	0	3		60	plattfische
			317				
32			3				
	18°	10°	162				17xClupeid, 8xANC, div
33	45	46	6	3		60	mesopel
							30x snoek, 15x
	18°	10°	170				panzerknacker, wenige
34	59	40	4	3		60	mesopel
							11x scorp aus D-
35							Moc
36							
37							
38							
	18°	9°3	437				6x snoek, goby, mesopel,
39	39	9	8	3		60	panzerknacker
40							
41							
	18°	12°					240xHMC,
42	59	10	250	5		120	3xGoby
	23°	13°					
43	00	02	422	6		120	31x mesopel
44						60	
45							
Sum				56	5	1455	
						24.25	h Station time

SP 5 Mesozooplankton and micronekton investigations

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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; and they also play an important role for the re-mineralization of organic matter. The GENUS project 5 (Meso- and macrozooplankton dynamics in the southwest African upwelling region: shelf sea - open ocean interactions) will investigate different groups of zooplankton and micronekton and transfer - rates between these groups. Leg 1 of Discovery cruise 356 was designed to conduct samples to qualify and quantify zooplankton main groups. Material was sampled with a $1m^2$- Double MOCNESS (Multiple Opening and Closing Net and Environmental Sensing System) and a WP2 net.

The MOCNESS is equipped with 18 nets of 333 µm mesh size which can be opened and closed sequentially. The water column was sampled in fine-stratified intervals by oblique towing at a speed of 2 knots (Table 1). The filtered volume is calculated by a flowmeter. The device carries CTD-probes to collect environmental data. Upon recovery of the MOCNESS, the nets were rinsed with seawater. The WP-2 net is a ring net with a mesh size of 300 µm which was towed vertically. The plankton sampled by both nets was preserved immediately in a 4% formaldehyde-seawater solution buffered with sodium-tetraborate or was frozen at -20 °C for stable isotope analyses.

The initially planned day and night sampling at four stations (2 x onshore, shelf-break, offshore) on three transects failed due to winch problems. On the northern transect (Kunene) 5 hauls (locations) were performed. One haul failed due to technical problems with the gear, one haul had to be interrupted due to winch problems. Sampling on the Rocky Point transect was canceled. The Walvis Bay transect was sampled with the MOCNESS (Table 1) and the WP2 net (Table 2). The detailed analyses and data interpretation will be done later in the home-laboratory.

Table 1: Sampling data of MOCNESS hauls.

Haul	Station	Date	Time UTC	Water Depth (m)	Sample intervals (m depth)
01	6	13.9.	01:43	145	100-50-25-0
02	6	13.9.	09:35	147	100-50-25-0
03	8	13.9.	20:10	1563	350-300-250-200-150-100-50-25-0
04	8	14.9.	connection	with	gear failed
05	8	14.9.	16:23	1795	1000-800-600-400-200 (interrupted)
06	15	19.9.	22:20	437	350-300-250-200-150-100-50-25-0
07	15	20.9.	05:20	462	350-300-250-200-150-100-50-25-0
08	16	20.9.	17:16	2998	2620-2500-2250-2000-1750-1500-1250-1000-800-600-400-200-100-50-25-0
09	16	21.9.	07:16	2889	1000-800-600-400-200-100-50-25-0
10	17	22.9.	00:02	231	150-100-50-25-0
11	17	22.9.	07:34	271	150-100-50-25-0
12	18	22.9.	21:43	130	100-50-25-0

Table 2: Sampling data of WP2 hauls.

Haul	Station	Date	Time UTC	Water Depth (m)	Sampling depth (m)
01	9	15.9.	14:20	2471	50-0
02	11	17.9.	08:27	84	50-0
03	12	18.9.	11:16	2941	5 * 200-0
04	13	18.9.	22:38	1716	5 * 200-0
05	14	19.9.	07:25	1041	5 * 200-0
06	17	22.9.	01:03	227	5 * 200-0
07					
08					
09					
10					
11					

SP 5 Mesozooplankton and micronekton investigations, Leg 2

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On the second leg of Discovery 356 catches of Zooplankton with the Double-MOCNESS were continued successfully. The planned stations at the Rocky Point transect that could not be sampled on the first transect were completed. At the station above 285 m WD Decapoda were caught at night in great numbers. Above 200 and 100 m WD diatoms and green algae were found in the nets as well as a high abundance of copepods.
Furthermore a filament, that had been detected by the oceanographers north of Rocky Point, was fished three times with the Double-MOCNESS, in two vertical and one horizontal haul. In the horizontal haul at night in 30-50 m high abundances of Krill were sampled.
Finally, a night as well as a day haul were conducted at the 36 hour station off Walvis Bay.
Additionally to the 16 Double-MOCNESS- and the 16 WP2-hauls (see table 1 and 2) a drift net and an Apstein net were deployed, the former to catch living chaetognaths for respiration experiments, the latter for future investigations of Microzooplankton (table 3). Due to the fragile condition of the chaetognaths, the experiments with living animals failed.
The detailed studies (biomass, taxonomy and biochemical analyses) and data interpretation will be done later in the home-laboratory.

Table 1: Sampling data of MOCNESS hauls.

Haul	Station	Date	Time UTC	Water Depth (m)	Sample intervals (m depth)
10	17	22.9.	00:02	231	150-100-50-25-0
11	17	22.9.	07:34	206	150-100-50-25-0
12	18	22.9.	21:43	130	100-50-25-0
13	23	27.9.	09:40	2613	2000-1750-1500-1250-1000-800-600-400-200-100-50-25-0
14	23	27.9.	21:40	2442	1000-800-600-400-200-100-50-25-0
15	25	28.9.	15:06	285	250-200-150-100-50-25-0
16	25	29.9.	00:26	278	250-200-150-100-50-25-0
17	26	29.9.	12:04	198	150-100-50-25-0
18	27	29.9.	22:14	114	100-50-25-0
19	28	30.9.	01:02	200	150-100-50-25-0
20	29	30.9.	11:13	112	100-50-25-0
21	32	2.10.	14:20	3173	1000-800-600-400-200-100-50-25-0
22	35	3.10.	17:11	3102	36-66-61-51-53-47-41-44-45-40-36-34-0
23	39	5.10.	08:11	4363	350-300-250-200-150-100-50-25-0
24	43	7.10.	20:36	391	300-250-200-150-100-50-25-0
25	43	8.10.	08:47	403	350-300-250-200-150-100-50-25-0

Table 2: Sampling data of WP2 hauls.

Haul	Station	Date	Time UTC	Water Depth (m)	Sampling depth (m)
06	17	22.9.	01:03	227	5 x 200-0
07	19	24.9.	16:40	56	40-0
08	20	25.9.	04:30	116	40-0
09	20	25.9.	04:48	116	40-0

10	20	25.9.	08:47	116	40-0
11	20	25.9.	08:55	116	40-0
12	21	25.9.	21:27	772	5 x 200-0
13	21	25.9.	22:28	772	3 x 200-0
15	25	27.9.	22:10	272	50-0
16	25	27.9.	22:15	272	50-0
17	26	28.9.	13:32	198	50-0
18	30	1.10.	22:00	2194	50-0
19	31	2.10.	06:11	2579	50-0
20	32	2.10.	13:20	3193	50-0
21	33	2.10.	22:13	3162	50-0
22	34	3.10.	5:55	1908	50-0

Table 3: Sampling data of Apstein hauls.

Haul	Station	Date	Time UTC	Water Depth (m)	Sampling depth (m)
02	20	25.9.	04:35	116	25-0
03	21	25.9.	22:50	772	25-0
04	30	1.10.	22:00	2194	25-0
05	31	2.10.	03:10	2580	25-0
06	32	2.10.	13:20	3193	25-0
07	33	2.10.	21:40	3160	25-0
08	34	3.10.	4:45	1908	25-0
09	37	4.10.	20:40	4282	25-0
10	39	5.10.	06:05	4355	25-0
11	40	5.10.	16:55	4421	25-0
12	41	5.10.	19:35	4440	25-0
13	42	6.10.	13:05	220	25-0
14	43	8.10.	18:59	386	25-0

SP 6 Trophodynamics and respiration of copepods and decapods

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Leg 1

Mesozooplankton was collected by stratified vertical hauls with a MultiNet Midi (HydroBios, Kiel, Germany; mouth opening: 0.25 m^2: mesh size: 300 µm) at 5 stations in the northern Benguela upwelling system. Maximum sampling depth was either bottom depth or 2,000 m at the offshore station. Depending on water depth, either a set of five discrete depth layers was sampled in one haul, or two successive hauls were conducted immediately one after the other to combine deep sampling down to 2,000 m with a higher vertical resolution of the upper layers. Additional material for respiration experiments was taken from drift nets, ring trawls, oblique MultiNet hauls, double-MOCNESS trawls and MOCNESS-1 trawls operated by other GENUS teams.

MultiNet samples were analysed under a dissecting microscope and specimens of different copepod

and decapod species selected for respiration measurements on board. The remains of the samples were preserved in a 4% formaldehyde in seawater solution or ethanol for later analyses of mesozooplankton abundance, biomass, vertical distribution and species composition.

Respiration rates of different mesozooplankton species were measured by optode respirometry with two 1-channel- and one 10-channel optode respirometers (PreSens Precision Sensing Fibox 3 and Oxy-10 Mini, Regensburg, Germany) under simulated in situ conditions in two fridges on board. Depth profiles of temperature derived from the CTD sensor were used to set the fridges to the ambient temperature at sampling depth. Experiments were run in gas-tight glass bottles filled with sterilised and filtered seawater to avoid bias by microbial respiration. For each set of experiments, two animal-free controls were measured under exactly the same conditions to compensate potential errors. More than 200 individual respiration measurements were conducted at different temperatures between 6.5¡C for deep-sea species and 19¡C for surface-dwelling animals.

After the experiments, all specimens were deep-frozen at -80¡C for later dry-mass determination in the home lab in order to convert the experimental results to mass-specific respiration rates. Some of the specimens will also be used for analyses of stable isotope ratios ($\delta^{13}C$, $\delta^{15}N$) or lipid content and composition.

In addition and in close cooperation with TP7, specimens of the dominant krill species *Euphausia hanseni* were sampled to elucidate the relationship between gonad development and lipid content and composition. Males were deep-frozen entirely after determination of size and moulting stage, while females were dissected under a stereo microscope to also classify their sexual maturity and to deep-freeze hepatopancreas, ovaries and the rest of the body separately for higher resolution.

Leg 2 Distribution, vertical migration and respiration of mesozooplankton

Anna Schukat[1], Rainer Kiko[2], Francois Sequin[1] ([1]Dept. of Marine Zoology, University of Bremen (FB 2), [2] IFM-GEOMAR, Kiel, Germany)

Mesozooplankton was collected by stratified vertical hauls with a MultiNet Midi (HydroBios, Kiel, Germany; mouth opening: 0.25 m^2: mesh size: 300 µm) at 17 stations in the northern Benguela upwelling system. Maximum sampling depth was either bottom depth or in case of the filament study 200 m. A set of five discrete depth layers was sampled in one haul. The filament was sampled twice (5 stations each, north start-point, north-margin, mid, south-margin and south end-point of filament) with also five depth layers (200-150 m, 150-100 m, 100-50 m, 50-30 m and 30-0 m) to investigate the distribution of mesozooplankton in the different structures of the filament. The vertical migration of mesozooplankton was analysed by several vertical hauls over 36 hours.
Material for respiration experiments was taken from the MultiNet and additional from drift nets, ring trawls, double-MOCNESS trawls and MOCNESS-1 trawls operated by other GENUS teams.

MultiNet samples were analysed under a dissecting microscope and specimens of different copepod

and decapod species selected for respiration measurements on board. The remains of the samples were preserved in a 4% formaldehyde in seawater solution or ethanol for later analyses of mesozooplankton abundance, biomass, vertical distribution and species composition.

Respiration rates of different copepod species were measured by optode respirometry with two 1-channel- and one 10-channel optode respirometers (PreSens Precision Sensing Fibox 3 and Oxy-10 Mini, Regensburg, Germany) under simulated in situ conditions or under a chosen standard temperature of 18°C in two fridges on board. For each set of experiments, two animal-free controls were measured under exactly the same conditions to compensate potential errors. More than 200 individual respiration measurements were conducted. After the experiments, all specimens were deep-frozen at -80°C for later dry-mass determination in the home lab. Some of the specimens will also be used for analyses of stable isotope ratios ($\delta^{13}C$, $\delta^{15}N$) or lipid content and composition.

***In situ* fixation of mesozooplankton**

Rainer Kiko[2], Anna Schukat[1], Francois Sequin[1] ([1]Dept. of Marine Zoology, University of Bremen (FB 2), [2] IFM-GEOMAR, Kiel, Germany)

An instrument which allows for the *in situ* fixation of mesozooplankton was developed within a "Cluster of excellence - Future Ocean" project at the IFM-GEOMAR. The instrument consists of an insulated cod end and a pump, which contains a highly concentrated ammoniumsulfate-solution as fixative. After sampling a certain depth layer, the insulated cod end is closed and the fixative injected into the cod end, leading to the *in situ* fixation of the catch. This instrument was successfully deployed three times during the second leg of D356. Sampling targeted the oxygen minimum layer and zooplankton could be fixed at oxygen concentrations of about 1 ml/l. In parallel, surface catches were performed with a WP 2-net or a driftnet and fixed immediately after recovery. The samples will be used for analysis of the transcriptome of the species sampled, in order to identify adaptations to low oxygen concentrations within the respective species. Species isolated from the samples are *Rhincalanus cornutus*, *Eucalanus hyalinus*, *Nannocalanus minor*, *Calanoides carinatus* and *Pleuromamma robusta*. The samples will also be available for the gut content analysis of the organisms, using genetic or optical methods.

TP 6 associated: Secondary production: copepod egg production rates (Discovery D356: Leg2)

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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 also includes production lost to predators and other loss sources in addition to 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. Poor buggers!).

Secondary production work in the northern Benguela Current region off Namibia has been conducted during several cruises in 1997, 1999, 2000, 2002, 2004, 2007 and 2008, by measuring daily egg production rates of several dominant calanoid copepods, with a focus on *Calanoides carinatus*, a member of the coastal upwelling community. 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 Vol. 27 of *Afr. J. mar. Sci.*, and by Auel and Verheye 2007 in *J. Exp. Mar. Biol. Ecol*.).

The focus during Leg 2 of the GENUS cruise onboard RRS *Discovery* (D356) was on the measurement of reproductive growth by females of dominant broadcast-spawning calanoid copepod species. Usually, lively, undamaged specimens were gently sorted from 10-minute collections, made in the upper 10 m using a Driftnet, within 15 minutes after collection in order to ensure that the animals are in a pristine condition when incubated. On a few occasions, when Driftnet collections yielded limited catches of copepods, specimens were sorted from the obliquely towed Multinet and Ring Trawl. However, although these females may appear to be undamaged morphologically speaking, they are likely to have undergone severe physiological stresses during towing and due to the crowding effect in the cod-end buckets of these nets. Such unnatural conditions may account for the sub-normal (zero to near-zero) egg production rates commonly observed in females recovered from towed net systems.

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 ambient sea surface temperature in a dark on-deck incubator with continuous flow-through of surface seawater. After 24 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. Experiments where females were found dead or moribund are not considered for further analysis.

In total, 119 EPR experiments were conducted during Leg 2 of the cruise; the data obtained during Leg 1 are currently not available for inclusion in this report. Daily EPRs were obtained at 17 station positions using a total of 165 females of six identified and nine as yet unidentified copepod species. The minimum, maximum and mean EPR for each of the 15 taxa are summarized in the Summary Table below.

Taxonomic identification of a number of taxa remains to be verified and more rigorous analysis of the data is required, so that the EPRs reported here should be viewed as preliminary and their interpretation treated with caution. Nevertheless, EPRs observed at the time of sampling appear to be generally lower than during two recent austral late-summer/early-spring cruises in the same region (in February 2007 on RV *Dr Fridtjof Nansen* and in March-April 2008 on RV *Maria S. Merian*) as well as during earlier cruises there (as reported by Richardson et al. 2001 – S. Afr. J. Sci., Vol 97).

Two exceptions are *Calanoides carinatus* and *Centropages brachiatus*, whose rates of egg production were on average appreciably greater during this cruise (late-spring/early-summer 2010) than ever measured before in the northern Benguela. Active egg production of these two typical coastal upwelling copepods was measured at all stations, an observation not uncommon for this species in the coastal upwelling system of the Benguela Current, unlike most other species where zero EPRs often occur.

For *C. carinatus*, a mean EPR of 34.0 eggs spawned female^{-1} day^{-1} was measured during cruise Leg 2, with a maximum of 75.9 eggs female^{-1} day^{-1} at station 28. These values are much higher compared with those measured during both 2007 (0.0-40.0 eggs female^{-1} day^{-1}, mean = 3.3 eggs female^{-1} day^{-1}) and 2008 (0.0-37.6 eggs female^{-1} day^{-1}, mean = 10.0 eggs female^{-1} day^{-1}), as well as during the late-1990s (0.0-68.0 eggs female^{-1} day^{-1}, mean = 11.1 eggs female^{-1} day^{-1}, Richardson et al. 2001). A maximum rate of 143.0 eggs female^{-1} day^{-1} (mean = 24.0 eggs female^{-1} day^{-1}) has been reported for this species in the southern Benguela off South Africa, where egg production rates have been measured since 1988 (Richardson et al. 2001).

During Leg 2 of the 2010 cruise, females of *C. brachiatus* produced on average 86.7 eggs female^{-1} day^{-1}, ranging between 21.0 and 231.2 eggs female^{-1} day^{-1}, considerably higher than during 2007 (range: 35.0-71.0 eggs female^{-1} day^{-1}; mean = 54.2 eggs female^{-1} day^{-1}) and 2008 (range: 36.0-107.4 eggs female^{-1} day^{-1}; mean = 59.5 eggs female^{-1} day^{-1}), while during cruises in the late-1990s this copepod has been observed to produce eggs at a rate of up to 224 (mean: 62) eggs female^{-1} day^{-1} in the northern Benguela (Richardson et al. 2001). The maximum rate of 231.2 eggs female^{-1} day^{-1} for *C. brachiatus* was, as for *C. carinatus*, also observed at station 28. It represents the highest record of daily egg production for this species observed to date in the northern Benguela region off Namibia. However, it is still well below the maximum rate of 279 eggs female^{-1} day^{-1} known for this copepod from field and laboratory observations in the southern Benguela off South Africa (Richardson et al. 2001).

Also noteworthy are the EPRs of the large calanoid copepod, *Pareucalanus sewelli*, observed during this cruise, ranging between 0.0 and 117 eggs female^{-1} day^{-1}, with a mean of 28.5 eggs female^{-1} day^{-1}, the maximum rate being recorded at station 24. These rates are much higher than previous observations of 0.0-13.0 (mean: 2.3) eggs female^{-1} day^{-1} (2007) and up to 63 (mean: 22) eggs female^{-1} day^{-1} (late 1990s) in the region.

Despite the new 'Guinness-Book-of-Records'-type record egg production rates of a few species mentioned above, and notwithstanding seasonal and interannual variability, there appears to be a general decline in copepod production in the area of investigation over the past decade or so, when *in situ* measurements have been made. A decline in secondary production may be a response to a

decline in primary production in the region, provided the latter decline is in line with the global long-term decline in phytoplankton biomass and production observed in the world's oceans over the past century, based on *in situ* chlorophyll and ocean transparency measurements in the upper ocean (see Boyce et al. 2010 – *Nature* Vol. 466, pp. 591-596). While this (wild) speculation requires further data and analysis to support it, a decline in production does not, however, seem to apply to copepods such as *Calanoides carinatus* and *Centropages brachiatus*. On the contrary, they seem to persistently thrive in the local coastal upwelling community. This may be because of their unique life-history characteristics and/or their trophic plasticity, enabling them to take advantage of the dynamic and highly variable nature of coastal upwelling and the associated sequential succession of phytoplankton populations.

Summary Table: Minimum, maximum and mean daily Egg Production Rate (EPR) measured during GENUS cruise D356 on RRS *Discovery*, Leg 2 (24 Sept.-9 Oct. 2010); n is the number of incubation experiments per species.

Daily EPR (eggs female^{-1} day^{-1})				
Species	**n**	**Min.**	**Max.**	**Mean**
Calanoides carinatus	20	0.9	75.9	34.0
Centropages brachiatus	19	21.0	231.2	86.7
Centropages sp.	1	37.9	37.9	37.9
Eucalanus hyalinus	2	0.0	29.0	10.1
Eucalanus sp.	1	49.4	49.4	49.4
Nannocalanus-like *?*	3	39.2	45.0	42.4
Nannocalanus minor	8	0.0	3.8	1.4
Pareucalanus sewelli	16	0.0	117.0	28.5
Pleuromamma sp.	5	0.0	2.1	1.4
Rhincalanus nasutus	17	0.0	19.9	3.4
unidentified sp.1	11	0	11.5	1.5
unidentified sp.2	1	50	50.0	50.0
unidentified sp.3	3	0	0.0	0.0
unidentified sp.4	1	28.9	28.9	28.9
unidentified sp.5	1	0	0.0	0.0

SP 7 Krill as pivotal component of the plankton of the northern Benguela current system

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Distribution and abundance of euphausiids will be assessed from depth related catches with a MOCNESS-1 multinet (2mm mesh). Among the four target species of the northern Benguela current area, *Euphausia hanseni*, *Nematoscelis megalops* and *Nyctiphanes capensis* were found. Particularly the latter species appeared in very high abundances in neritic waters.

Respiration measurements under ambient temperature of three euphausiid species were used to estimate standard metabolic rates (SMR). A 4-channel optode respirometer (PreSens, Germany) and special respiration chambers, optimized for krill, were employed. Reproductive and moulting states of *E. hanseni* were determined after the respiration measurement using microscopic morphometric methodology to analyse possible effects on metabolic rates. Results will be compared with those from the previous FRV Africana cruise to clarify seasonal effects. Starvation experiments were conducted on board to assess effects on respiration rate, excretion rate (NH_4) and the moulting frequency. Furthermore, growth rates were determined for all three species by incubation experiments with the IGR (Instantaneous Growth Rate) method and related to the size/gender relationship in the field. Krill samples stored at -80°C will be analysed for metabolites produced under different conditions (ambient and both normoxic and hypoxic conditions in captivity). Stable isotope analysis together with C/N ratio and the lipid content will be done for all euphausiid species.

Leg 2

During the filament study the MOCNESS was used to catch krill in order to refer these catches to different water masses. Five stations with different hydrographic conditions were sampled. The net catches mostly showed large numbers of krill, and had been preserved in formalin.

At the 36-hour station the MOCNESS was deployed every six hours to 400m depth to determine the range of the diel vertical migration (DVM) of *E. hanseni* and *N. megalops.* in relation to the trophic environment. Parallel recordings of the ship board 150 kHz ADCP will be related to krill and zooplankton diurnal vertical distribution.

Some preliminary results

During the D 356 cruise we measured significant differences in the respiration rate of *E. hanseni* at several stations (Fig. 1). Krill at station 10 were relatively small and unproductive in terms of moulting and reproductivity. This may indicate an unfavourable food supply induced by a non-upwelling situation. In contrast, specimens at Station 26 and 30 were highly productive and the oceanographic data indicated a clear upwelling situation with high food supply for krill.

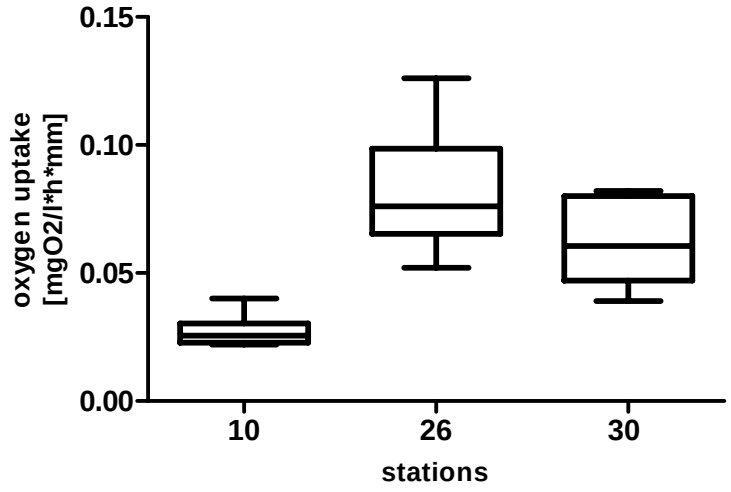

Fig. 1: Respiration rates of *E. hanseni* at different stations

Upwelling may initiate favourable conditions to which *E. hanseni* can react fast with an increase in metabolism, moulting and reproductive state. These effects were pronounced and may overlay seasonal differences.

Fig.2: *Euphausia hanseni*, female, cephalothorax and first abdominal segment. The ovary displays an orange tint in large oocytes (to be confirmed by histology) indicating impending spawning. A spermatophore can be distinguished attached to the red thelycum between thoracopods and gills.

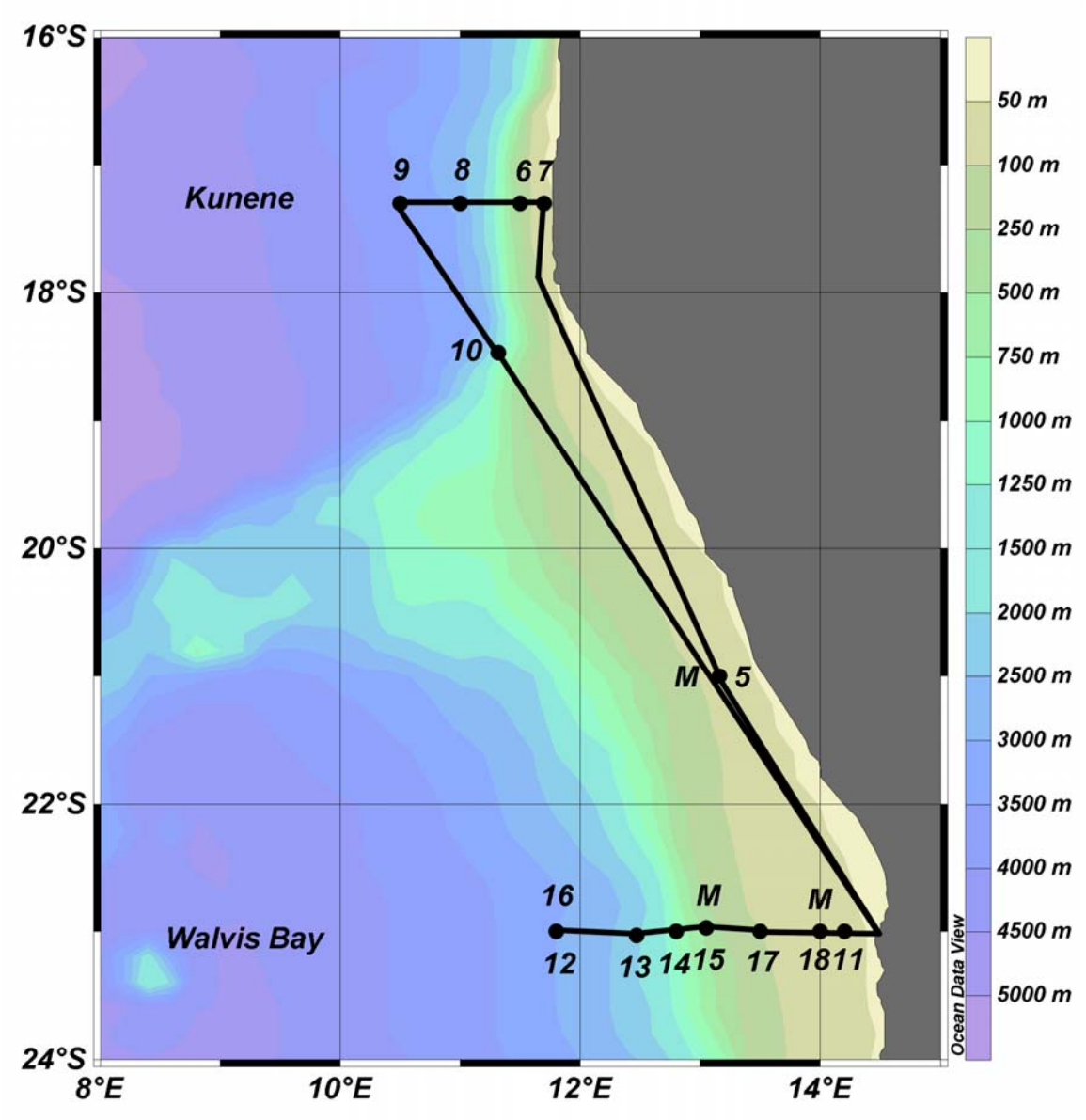

Fig. 1 Cruise Map D356 – Leg 1. Numbering indicates positions of stations. M designates position of moorings worked upon.

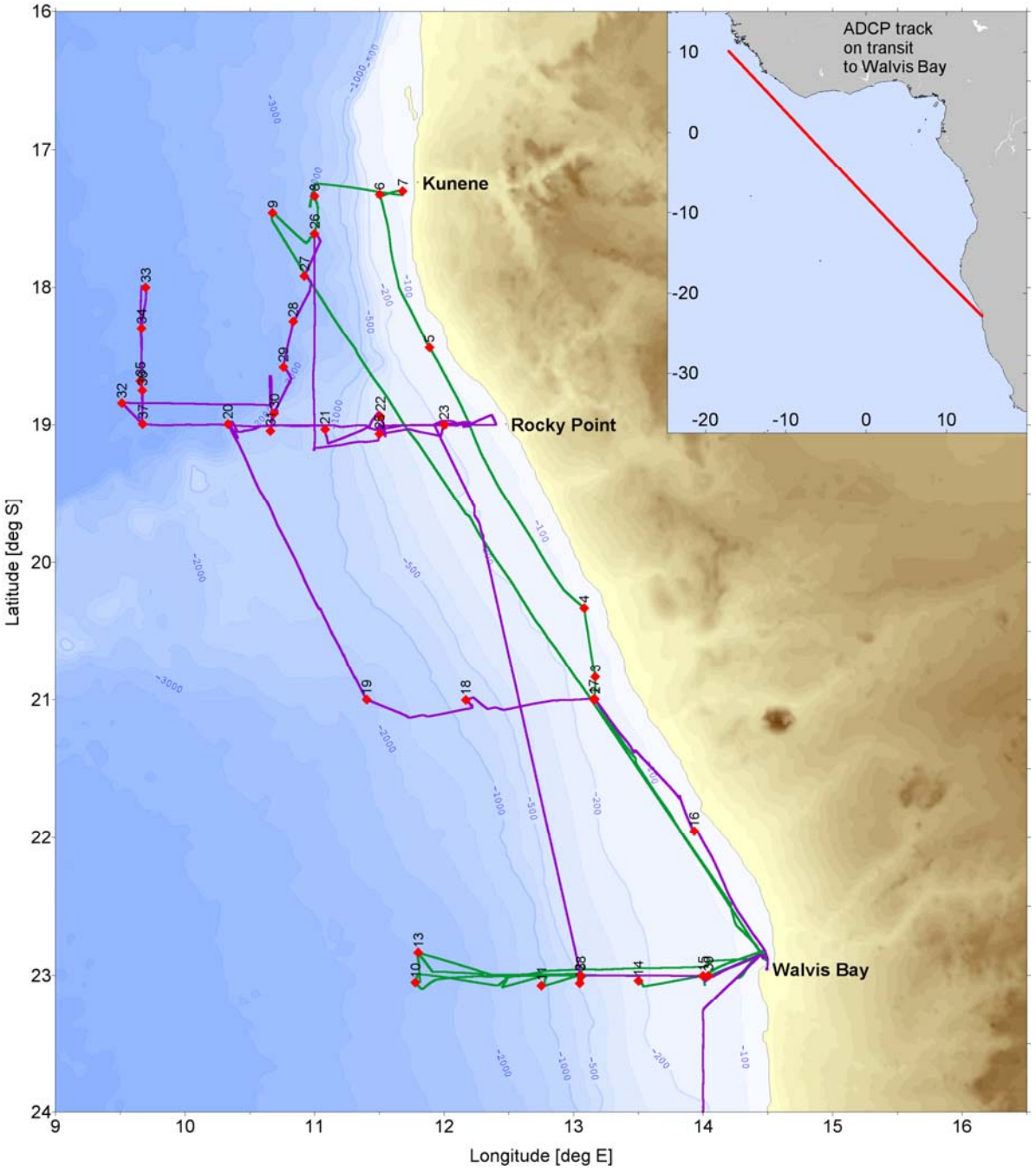

Fig. 2 Cruise Map D356 – Leg 1 & 2. Numbering indicates positions of CTD stations. Lines in green: Leg 1; magenta: Leg 2

Table of Stations (CTD at begin of other deployments at our near location)

No.	*Station No. Stat. Name*		Date	*Time [UTC]*	*Latitude*	*Longitude*	*CTD cast(s)*	*LADCP cast*	*MSS casts*
1	0001 WVB_Port	Begin	10.09.2010	07:54	22° 53.35'S	14° 28.98'E	0001xnn		
		End	10.09.2010	09:31	22° 51.86'S	14° 28.34'E			
2	0002 D356_02	Begin	11.09.2010	19:54	20° 59.81'S	13° 09.86'E	0002xnn	001	
		End	11.09.2010	20:25	20° 59.74'S	13° 09.81'E			
3	0003 D356_03	Begin	11.09.2010	23:10	20° 49.94'S	13° 09.99'E	0003xnn	002	
		End	12.09.2010	00:01	20° 50.06'S	13° 10.19'E			
4	0004 D356_04	Begin	12.09.2010	04:05	20° 19.97'S	13° 04.85'E	0004xnn	003	
		End	12.09.2010	04:22	20° 19.85'S	13° 04.77'E			
5	0005 D356_05	Begin	12.09.2010	17:23	18° 26.43'S	11° 53.19'E	0005xnn		
		End	12.09.2010	17:43	18° 26.55'S	11° 53.20'E			
6	0006 D356_06	Begin	13.09.2010	03:38	17° 19.68'S	11° 30.29'E	0006xnn	004	0005 - 0008
		End	13.09.2010	12:53	17° 19.73'S	11° 32.91'E			
7	0007 D356_07	Begin	13.09.2010	14:12	17° 18.15'S	11° 40.87'E	0007xnn	005	0009 - 0012
		End	13.09.2010	15:59	17° 18.39'S	11° 40.82'E			
8	0008 D356_08	Begin	14.09.2010	06:33	17° 20.42'S	10° 59.94'E	0008xnn	006	0013 - 0016
		End	14.09.2010	15:38	17° 25.29'S	11° 01.45'E			
9	0009 D356_09	Begin	15.09.2010	10:13	17° 27.62'S	10° 40.52'E	0009xnn		
		End	15.09.2010	12:51	17° 28.04'S	10° 40.15'E			
10	0010 D356_10	Begin	15.09.2010	21:00	18° 27.03'S	11° 19.50'E	Only Ringtrawl done at station, no CTD, MMS or LADCP		
		End	15.09.2010	21:53	18° 28.06'S	11° 19.60'E			
11	0011 D356_11	Begin	17.09.2010	8:57	23° 00.93'S	14° 16.73'E			0017 - 0020
		End	17.09.2010	9:11	23° 01.05'S	14° 16.54'E			
12	0012 D356_12	Begin	18.09.2010	09:12	23° 03.05'S	11° 46.73'E	0010xnn		0021 - 0024
		End	18.09.2010	15:25	23° 03.18'S	11° 46.79'E			
13	0013 D356_13	Begin	19.09.2010	00:15	23° 04.40'S	12° 27.76'E			0025 - 0028
		End	19.09.2010	00:55	23° 04.95'S	12° 26.97'E			
14	0014 D356_14	Begin	19.09.2010	07:56	23° 04.35'S	12° 45.12'E	0011xnn		0029 - 0032
		End	19.09.2010	11:07	23° 04.09'S	12° 44.66'E			
15	0015 D356_15	Begin	19.09.2010	23:27	23° 03.38'S	13° 02.90'E	0012xnn	007	0033 - 0036
		End	20.09.2010	05:37	23° 01.90'S	13° 02.12'E			
16	0016 D356_16	Begin	20.09.2010	13:43	22° 50.00'S	11° 48.02'E	0013xnn	008	
		End	20.09.2010	16:46	22° 50.02'S	11° 47.52'E			
17	0017 D356_17	Begin	22.09.2010	02:36	23° 02.24'S	13° 29.97'E	0014xnn	009	0037 - 0040
		End	22.09.2010	07:24	23° 03.07'S	13° 31.53'E			
18	0018 D356_18	Begin	22.09.2010	23:08	23° 00.09'S	13° 59.95'E	0015xnn	010	0041 - 0044
		End	23.09.2010	02:04	23° 00.18'S	14° 00.25'E			
19	0019 D356_19	Begin	24.09.2010	16:59	21° 57.26'S	13° 55.91'E	0016xnn		0045 - 0048
		End	24.09.2010	17:34	21° 57.12'S	13° 55.84'E			
20	0020 D356_20	Begin	25.09.2010	07:18	20° 59.74'S	13° 09.28'E	0017xnn		0049 - 0057
		End	25.09.2010	12:03	20° 59.51'S	13° 09.24'E			
21	0021 D356_21	Begin	25.09.2010	18:18	21° 00.07'S	12° 10.04'E	0018xnn	011	
		End	25.09.2010	19:42	21° 00.01'S	12° 10.62'E			
22	0022 D356_22	Begin	26.09.2010	06:48	20° 59.87'S	11° 24.11'E	0019xnn	012	0058 - 0061
		End	26.09.2010	14:36	20° 59.59'S	11° 24.70'E			
23	0023 D356_23	Begin	27.09.2010	05:44	18° 59.59'S	10° 19.84'E	0020xnn	013	0062 - 0065
		End	27.09.2010	17.11	18° 58.77'S	10° 20.04'E			
24	0024	Begin	28.09.2010	05:50	19° 02.01'S	11° 04.86'E	0021xnn	014	0066 -

	D356_24	End	28.09.2010	08:36	19° 03.08'S	11° 04.99'E			0069
25	0025	Begin	28.09.2010	16:11	18° 56.33'S	11° 30.46'E	0022xnn	015	0070 -
	D356_25	End	28.09.2010	19:49	18° 56.32'S	11° 30.60'E			0083
26	0026	Begin	29.09.2010	09:46	18° 59.95'S	12° 00.01'E	0023xnn	016	0084 -
	D356_26	End	29.09.2010	11:12	18° 59.45'S	12° 00.33'E			0087
27	0027	Begin	29.09.2010	19:59	18° 59.84'S	12° 10.32'E	0024xnn		0088 -
	D356_27	End	30.09.2010	18:55	19° 02.99'S	11° 48.40'E			0095
28	0028	Begin	30.09.2010	20:14	19° 04.00'S	11° 30.05'E	0025xnn		
	D356_25	End	30.09.2010	20:28	19° 04.02'S	11° 30.05'E			
29	0029	Begin	01.10.2010	19:45	17° 36.79'S	11° 00.00'E	0026xnn		0096 -
	D356_29	End	01.10.2010	20:54	17° 36.65'S	11° 00.09'E			0099
30	0030	Begin	01.10.2010	21:15	17° 37.05'S	11° 00.47'E	0026xnn		
	D356_30	End	01.10.2010	21:29	17° 36.95'S	11° 00.50'E			
31	0031	Begin	02.10.2010	03:33	17° 55.02'S	10° 55.30'E	0027xnn		0100 -
	D356_31	End	02.10.2010	05:13	17° 55.26'S	10° 56.07'E			0103
32	0032	Begin	02.10.2010	11:18	18° 14.92'S	10° 50.10'E	0028xnn	017	0104 -
	D356_32	End	02.10.2010	12:59	18° 15.99'S	10° 49.66'E			0107
33	0033	Begin	02.10.2010	19:35	18° 34.88'S	10° 45.54'E	0029xnn		0108 -
	D356_33	End	02.10.2010	21:18	18° 35.58'S	10° 46.17'E			0111
34	0034	Begin	03.10.2010	02:58	18° 55.03'S	10° 41.17'E	0030xnn	018	0112 -
	D356_34	End	03.10.2010	04:47	18° 54.45'S	10° 42.32'E			0115
35	0035	Begin	03.10.2010	08:20	19° 02.74'S	10° 39.58'E	0031xnn	019	
	D356_35	End	03.10.2010	08:51	19° 02.47'S	10° 39.84'E			
36	0036	Begin	04.10.2010	06:08	18° 50.58'S	09° 30.66'E	0032xnn		0116 -
	D356_36	End	04.10.2010	07:23	18° 50.88'S	09° 30.94'E			0119
37	0037	Begin	04.10.2010	23:15	18° 00.06'S	09° 41.77'E	0033xnn	020	
	D356_37	End	04.10.2010	23:40	18° 00.05'S	09° 42.07'E			
38	0038	Begin	05.10.2010	02:22	18° 17.93'S	09° 39.85'E	0034xnn	021	0120 -
	D356_38	End	05.10.2010	07:25	18° 17.86'S	09° 39.80'E			0123
39	0039	Begin	05.10.2010	15:07	18° 41.06'S	09° 39.33'E	0035xnn	022	
	D356_39	End	05.10.2010	16:01	18° 41.01'S	09° 39.25'E			
40	0040	Begin	05.10.2010	17:21	18° 45.15'S	09° 40.23'E	0036xnn	023	
	D356_40	End	05.10.2010	17:51	18° 45.25'S	09° 40.47'E			
41	0041	Begin	05.10.2010	20:05	18° 59.61'S	09° 40.42'E	0037xnn	024	
	D356_41	End	05.10.2010	20:30	18° 59.55'S	09° 40.58'E			
42	0041	Begin					Only Ringtrawl done at station,		
	D356_41	End					no CTD, MMS or LADCP		
43	0043	Begin					0038xnn	025	
	D356_43	End							
34	0044	Begin					0039xnn		
	D356_44	End							

Participants Discovery 356

	9.9. - 24.9.2010				24.9. - 13.10.2010			
#	**Name**	**First Name**	**Institute/ Subproj.**	**Cab. No.**	**Name**	**First Name**	**Institute/ Subproject**	**Cab. No.**
1	Buchholz	Friedrich	Chief Sci. TP 7	1	Buchholz	Friedrich	Chief Sci. TP 7	1
2	Buchholz	Cornelia	TP7	13	Buchholz	Cornelia	TP7	13
3	Werner	Thorsten	TP7	28	Werner	Thorsten	TP7	28
4	Mohrholz	Volker	TP2	2	Mohrholz	Volker	TP2 to 10.10.	2
5	Wasmund	Norbert	TP2	15	Wasmund	Norbert	TP2	15
6	Heene	Toralf	TP2	29	Heene	Toralf	TP2	29
7	Schmidt	Martin	TP2	16	Schmidt	Martin	TP2 to 10.10.	16
8	Lahajnar	Niko	TP3	7	Langenberg	Frauke	TP3	7
9	Stöber	Annette	Media, Uni HH	18	Christoff	Suzie	TP4 NatMirc to 10.10.	9
10	Peters	Patrick	Media, Uni HH	23	Muller	Annethea	TP2 NatMirc	11
11	Ankele	Markus	TP3 (Ferry Box)	24	Ankele	Markus	TP3 (Ferry Box)	30
12	Ekau	Werner	TP4 Bio	10	Kunzmann	Andreas	TP4 Bio to 10.10.	17
13	Bröhl	Steffi	TP4 Bio	19	Staschok	Christina	TP4 Geo TA	14
14	Geist	Simon	TP4 Bio	27	Geist	Simon	TP4 Bio	27
15	Rixen	Tim	TP4 Geo	17	Birkicht	Matthias	TP4 Geo	18
16	Lehnhoff	Laura	TP4 Geo	21	Lehnhoff	Laura	TP4 Geo	37 10
17	Flohr	Anita	TP4 Geo	26	Flohr	Anita	TP4 Geo	~~26~~
18	Koppelmann	Rolf	TP5	6	Bohata	Karolina	TP5	23
19	Martin	Bettina	TP5	20	Martin	Bettina	TP5	20
20	Denda	Anneke	TP5	22	Denda	Anneke	TP5	19
21	Kesselring	Tina	TP5	12	Kesselring	Tina	TP5	12
22	Hagen	Willy	TP6	8	Kiko	Rainer	TP6 IfM	24
23	Auel	Holger	TP6	9	Seguin	Francois	TP6 Stud	21
24	Schukat	Anna	TP6	25	Schukat	Anna	TP6	25
25	Teuber	Lena	TP6	14	Horaeb	Richard	TP6 NatMirc to 10.10.	22
26	Hansen	Anja	TP2	11	Jones	Susan	MCM S. Afrika	8
27	Worship	Marco	MCM, S. Afrika	30	Verheye	Hans	MCM , S. Afrika to 10.10.	6
28	Duncan	Paul	SysOp, UK	3	Duncan	Paul	SysOp, UK	3

Participants Transit Glasgow – Walvis, 13.8. – 9.9. 2010:

Auel, Holger (TP6)
Teuber, Lena (TP6)
Muller, Annethea (TP2)

Exchange Walvis Bay 24.9. out / in
Disembark Walvis Bay 10.10. out