Maria S. Merian - Cruise MSM 07/2b

Walvis Bay - Walvis Bay
9. – 19. March 2008

by Dr. Volker Mohrholz, Chief Scientist
Leibniz-Institut für Ostseeforschung Warnemünde

Scientific Background

The German IMBER-initiative 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 will be studied how effects of structural differences in the communities of primary producers (flagellates vs. diatoms) will further propagate through the food web and regulate trophic interactions on higher levels. Data of abundance, vertical distribution, food spectra, trophodynamics and physiological rates were recorded for important pelagic target groups like copepods, euphausids, 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 GENUS programme and are supposed to provide information on the expected results of a regime shift in domestic waters.

The N:P ratios in the surface waters off Namibia and Angola are by far lower than the Redfield-ratio and therefore a substantial N-limitation for primary producers has to be assumed. Under these conditions it is important to find out, whether there are really no diazotrophic cyanobacteria like Trichodesmium present. Is their absence already a proof, that no nitrogen fixation is performed or is this process taken over by unicellular diazotrophic cyanobacteria which have been already found in the subtropical Pacific? These organisms can be identified by either flow cytometry of by molecular biological methods. The latter can be applied to determine the diversity of cyanobacteria or their nif-genes (DNA –analysis) or to assess the potential of nitrogen-fixation (nig-geneexpression of mRNA). These analyses will be performed by molecular biologists. The rates of N-fixation were recorded simultaneously with primary production in incubation experiments. Samples were size fractionated. Parallel to rate measurements nutrient and plant pigments will be analyzed and samples for microscopical analysis of phytoplankton biomass were taken.

In upwelling areas a distinct gradient in the mesozooplankton structure can be observed between the centre of the upwelling and the open ocean. During this leg the following questions will have to be answered by means of incubation experiments: What is the predation influence of different guilds of mesozooplankton (Euphausids, calanoid copepods, gelatinous zooplankton) on different functional groups of the microbial food web (bacteria, picoalgae, heterotrophic and mixotrophic flagellates, Ciliates) Are there direct or indirect

effects emanating from the mesozooplankton (via ciliates) on the diversity , phenotypic specification of the bacterioplankton and its activity patterns? The vertical distribution of zooplankton was observed with different net gear (Multinetz, Midi, Maxi, MOCNESS, IKMT).

Participants and Institutions

1	Volker Mohrholz	Chief Scientist	IOW, Warnemünde
2	Toralf Heene	Hydrography	IOW, Warnemünde
3	Martin Schmidt	Hydrography	IOW, Warnemünde
4	Sandra Schmitz	N-fixation	Humboldt-University Berlin
5	Ulrich Struck	N-fixation	Humboldt-University Berlin
6	Reinhold Hanel	Fish	IfM-Geomar, Kiel
7	Tanja Joschko	Zooplankton	AWI, Bremerhaven
8	Rolf Koppelmann	Ichtioplankton	IHF, Hamburg
9	Anja Kreiner	Zooplankton	NatMIRC, Swakopmund
10	Bettina Martin	Ichtioplankton	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	Ichtioplankton	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

Baltic Sea Research Institute Warnemünde (IOW)
Dept. for Physical Oceanography and Instrumentation
P.O.Box 301161, 18112 Rostock, Germany

Zentrum für Marine Tropenökologie (ZMT)
(Center for Tropical Marine Ecology)
Fahrenheitstr. 6, 28359 Bremen, Germany

Marine Animal Ecology
Alfred Wegener Institute for Polar and Marine Research (AWI)
Columbusstrasse , 27568 Bremerhaven, Germany

National Marine Information & Research Centre (NatMIRC)
Ministry of Fisheries & Marine Resources
PO Box 912, Swakopmund, Namibia

Institute of Zoomorphology, Cell Biology and Parasitology
Heinrich-Heine-University
Universitätsstr. 1, 40225 Düsseldorf, Germany

Leibniz-Institut für Meereswissenschaften IFM-GEOMAR
FB 3, Marine Ökologie, Fischereibiologie
Düsternbrooker Weg 20, 24105 Kiel, Germany

Universität Hamburg
Institut für Hydrobiologie und Fischereiwissenschaft
Große Elbstr.133, D-22767 Hamburg, Germany

Humboldt-Universität zu Berlin
Museum für Naturkunde, 10099 Berlin, Germany

Research Program

During the cruise MSM07/2b the pelagic communities in the northern Benguela upwelling were sampled on three coast normal 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 1.

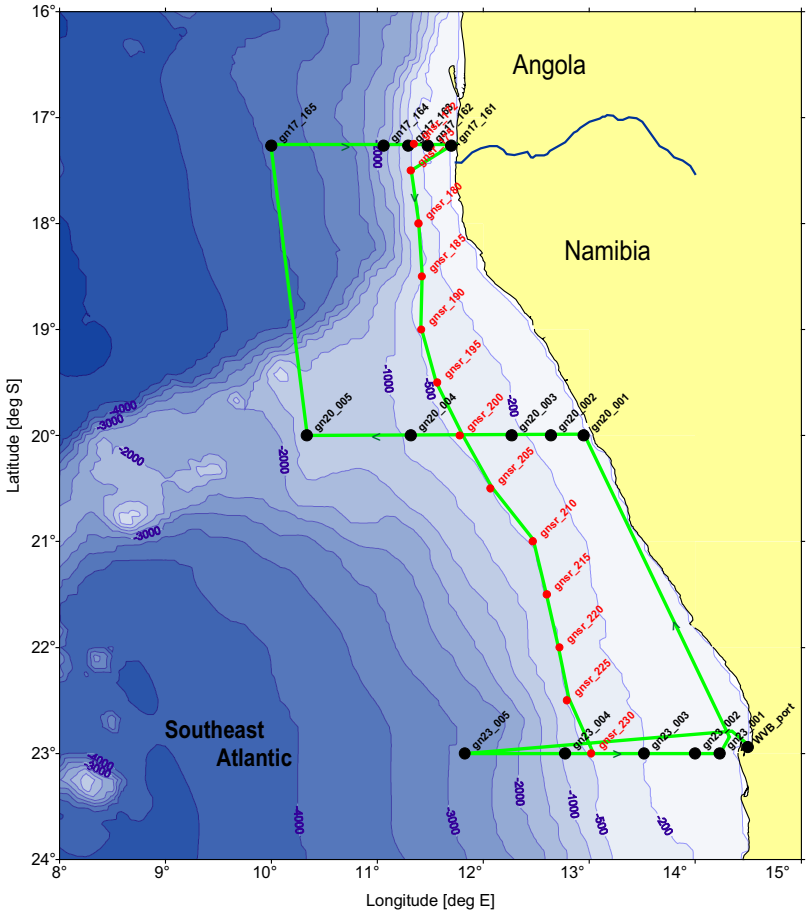

Figure 1: Cruise track of MSM07/2b. Regular stations at the transects are indicated by black dots. The red dots denote stations were only the CTD was deployed.

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 departure 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 rede 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 the 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 embassador in Namibia, local authorities and scientists from the NatMIRC institute in Swakopmund.

First Preliminary Results

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 contend from respiration and mineralisation in the bottom water and the sediment belt at the shelf north of this transect.

Similarly to finding for 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.

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 oxygenized water extends to about 100m depth. The typical Angola Gyre oxygen minimum is found here at about 350m depth.

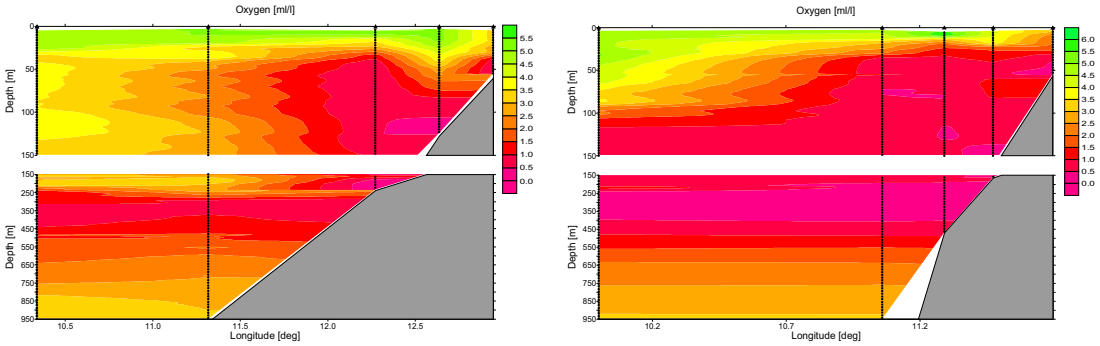

Figure 2: Oxygen distribution at the Walvis Bay (left) and the Kunene transect (right).

Nutrients, carbon and plankton *(T. Rixen, L. Lehnhoff, A. Kreiner and S. Oesterle)*

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 (Figure 3). During the first steep SST increase from 16 to 19°C diatom blooms were established as indicated by the enhanced chlorophyll concentrations and seen by the

preliminary evaluation of the plankton samples. These blooms declined and were followed by second blooms at higher SSTs ~130 km offshore. The seconds bloom still has to be characterized as well as the reason for the decline of the diatom which could for example be caused 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 were analyzed.

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 and high values during night and day, respectively there were also unexpected excursions towards lower chlorophyll concentrations during the day. Low chlorophyll concentrations which are generally associated with enhanced CO2 concentrations suggest in turn that photosynthesis could reduce pCO2 by ~140 ppmv. Along the transects from the coast towards the more open ocean sites the pCO2 were close to the atmospheric pCO2 suggesting a relatively low net flux of CO2 across the air water interface (Figure 3). This seems to be caused by the biologically mediated uptake of CO2 which reduced the pCO2 increase caused by the warming of the offshore advecting upwelled water. Although especially further offshore were a few locations at which the pCO2 in the water dropped below those of the atmosphere the entire study area probably acted as source for atmospheric CO2 during the expedition.

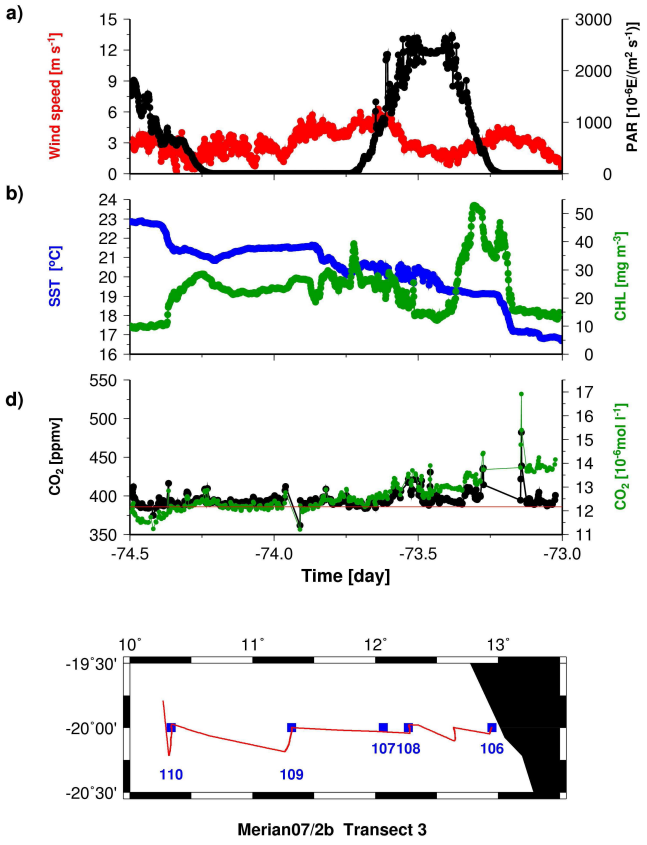

Figure 3: Wind speed, photosynthetic active radiation (PAR), (b) sea surface temperature, surface chlorophyll concentration, (c) pCO2 in the surface water (black) and the atmosphere (red) as well as CO2 concentrations versus the time during which we sailed from station 106 to 110.

Ichthyoplankton sampling *(A. Kreiner and S. Bröhl)*

The double MOCNESS caught fish larvae on all stations except for stations five and seven (Fig.1). Most larvae found throughout the survey area were of the mesopelagic group, followed by Engraulis, Trachurus and Myctophidae. 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. The 10m2 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 by with the 10m2 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.

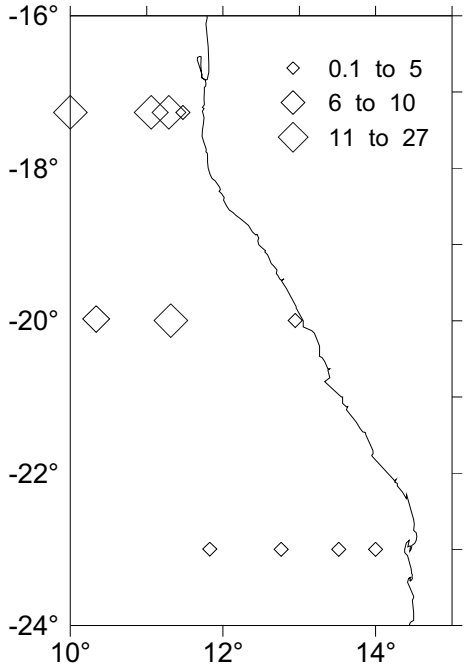

Figure 4: Map of all fish larvae (number per square meter surface water) caught in the double MOCNESS during the survey.

Fish *(R.Hanel, S. Klimpel and M. Schaber)*

IKMT and 10 m2 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), dragon fishes (Stomiidae), loosejaws (Malacosteidae), pearleyes (Scopelarchidae), deep sea 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 achieved. 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, subtropial 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 5: Mesopelagic fishes sampled during MSM07/2b. Upper left: *Anoplogaster cornuta*; upper right: *Caristius sp.*; lower left: *Melanocetus johnsoni*, lower left: *Nemichthys curvirostris*.

Mesozooplankton sampling by Multinet *(H. Auel and T. 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 m2 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. Table X provides an overview about the Multinet deployments during the cruise led MSM 07/2b.
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.

Mesozooplankton and micronekton sampling *(R. Koppelmann, C. Buchholz, A. Denda, R. Hanel, S. Klimpel, B. Martin, M. 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.

Suspended matter sampling and nitrogen fixation experiments *(S. Schmitz and U. Struck)*

At 15 stations suspended matter sampling was performed. A multi-port filtering device was used 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 Seston. 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 samples transect one station close to the coast and one off shore stations 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%) on deck.
The nitrogen isotope measurement of the samples will be performed in the stable isotope laboratories at the Natural History Museum in Berlin, Germany.

Station Tables

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	-