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The Expedition of the Research Vessel "Polarstern" to the Antarctic in 2007 (ANT-XXIV/1)

Edited by
Sigrid Schiel
with contributions of the participants

HELMHOLTZ GEMEINSCHAFT

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* Anschrift / Address
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www.awi.de

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ANT-XXIV/1

26 October – 26 November 2007
Bremerhaven – Cape Town

Fahrtleiter / Chief Scientist

Sigrid Schiel

Koordinator / Coordinator

Eberhard Fahrbach

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1. FAHRTVERLAUF UND ZUSAMMENFASSUNG

Sigrid Schiel
Alfred-Wegener-Institut, Bremerhaven

Am 26. Oktober 2007 trat das Forschungsschiff *Polarstern* mit 43 wissenschaftlichen Fahrtteilnehmern seine 24. Antarktisreise von Bremerhaven nach Kapstadt an (Fig.1.1). Während des ersten Fahrtabschnittes (ANT-XXIV/1) wurden verschiedene wissenschaftliche Programme durchgeführt, außerdem fanden in der Biskaya ein erfolgreicher Test des Tiefsee-Sediment-Echolots PARASOUND und die Kalibrierung des Unterwassernavigationssystems POSIDONIA statt. Die PARASOUND/POSIDONIA-Testmannschaft wurde am 4. November in Las Palmas/Gran Canaria ausgeschifft, gleichzeitig wurden 2 weitere Wissenschaftler und 1 Fotograf eingeschifft.

Der Schwerpunkt des wissenschaftlichen Programms des ersten Fahrtabschnittes (ANT-XXIV/1) lag auf den Untersuchungen zur Biodiversität des Zooplanktons innerhalb des internationalen Projektes „Census of Marine Zooplankton“ (CMarZ), einem Feldprojekt des “Census of Marine Life” (CoML). CoML ist ein globales Netz-werk, das im Rahmen eines zehnjährigen Projekts die Diversität, die Verteilung und das Vorkommen mariner Lebewesen in der Vergangenheit, Gegenwart und Zukunft untersucht. CMarZ hat sich zum Ziel gesetzt, präzise und vollständige Informationen zur Artendiversität, Biomasse, biogeographischen Verteilung, genetischen Diversität und Gemeinschaftsstrukturen weltweit zu produzieren und zu ergänzen.

26 Zooplanktologen aus 11 Nationen nahmen an der Fahrt teil. Die Zooplanktonfänge wurden mit drei verschiedenen Planktonnetzen (1-m^2 MOCNESS, 10-m^2 MOCNESS, Multinetz) auf insgesamt neun Stationen zwischen 24°41’N und 27°S durchgeführt und schließen vier Tiefseefänge ein, die bis in eine Tiefe von 5110 m gingen. Ein Teil der gewonnenen Proben wurden an Bord direkt bearbeitet. Insgesamt wurden über 60.000 Tiere aussortiert und in 473 Arten bestimmt. 122 DNA Sequenzen wurden von 66 Arten an Bord durchgeführt. Weitere 2043 Individuen wurden für die spätere molekulargenetische Analyse fixiert. Einige neue Arten wurden entdeckt und für die Erstbeschreibung, die erst in den heimatlichen Instituten stattfindet, konserviert.

Folgende weitere wissenschaftliche Programme wurden während der Fahrt ausgeführt:

- Die AWI - Universität Bremen – Helmholtz - Nachwuchsgruppe „Bio-Optics“ führte optische und biologische Messungen als Vergleichsmessungen für Satelliten-beobachtungen durch und hat kontinuierlich die Phytoplanktondichte im Ober-flächenwasser des Brunnenschachts und auf einigen Stationen in den oberen 100 m der Wassersäule gemessen.

- Die Luftchemiker von der Universität Lancaster und der GKSS haben den Gehalt an POPs (persistente organische Schadstoffe) in der Luft und im Wasser untersucht, um Informationen zur Verteilung und zum Verbleib dieser Substanzen zu erhalten.

- Meteorologen vom Kieler Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR) ermittelten den Zustand der bewölkten Atmosphäre und deren Einfluss auf die Nettostrahlungsbilanz an der Meeresoberfläche.

- Das Heidelberger Institut für Umweltphysik untersuchte die Verteilungen von Spurengasen in der Atmosphäre mit Hilfe der “Multi Axis - Differentiellen Optischen Absorptions -Spektroskopie“ (MAX-DOAS).

Der Fahrtabschnitt endete am 26. November 2007 in Kapstadt.

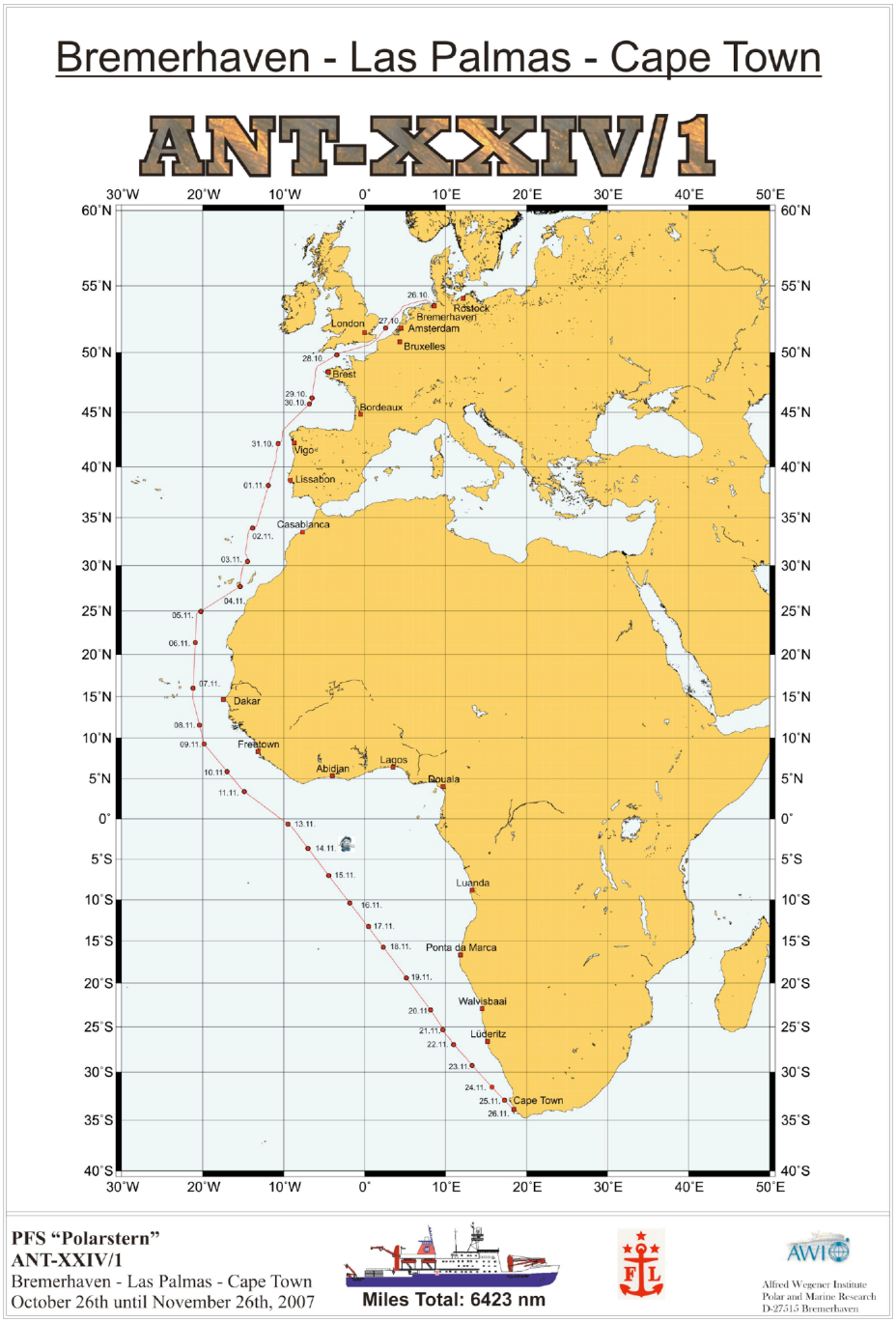


Abb. 1.1: Fahrtverlauf der Polarstern während des Abschnitts ANT-XXIV/1
Fig. 1.1: Cruise track of Polarstern during leg ANT-XXIV/1

SUMMARY AND ITINERARY

On 26 October 2007 *Polarstern* set sail for her 24th Antarctic expedition from Bremerhaven to Cape Town (Fig. 1.1) with 43 scientists on board. During the first leg of the cruise (ANT-XXIV/1) different scientific programmes were performed. Among the first tasks were a test of the deep-sea sediment echosounder PARASOUND in the Bay of Biscay and the calibration of the underwater navigation system POSIDONIA. On 4 November, the six PARASOUND/ POSIDONIA persons left the ship in Las Palmas/ Gran Canaria and three "new" participants (2 zooplanktologists and 1 photographer) embarked.

The first leg's (ANT-XXIV/1) main mission was the investigation of the biodiversity of Zooplankton embedded in the international project „Census of marine Zooplankton" (CMarZ), a field project of the "Census of Marine Life" (CoML). CoML is a global network of researchers engaged in a ten-year initiative to assess and explain the diversity, distribution and abundance of marine life in the oceans – past, present and future. CMarZ is working towards a taxonomically comprehensive assessment of biodiversity of animal plankton throughout the world oceans. The overriding project goal is to produce accurate and complete information on zooplankton species diversity, biomass, biogeographic distribution, genetic diversity, and community structure.

26 zooplanktologists from 11 nations joined the cruise. For the zooplankton catches three different plankton nets (1-m^2 MOCNESS, 10-m^2 MOCNESS, Multinet) were deployed at nine stations including 4 deep sea hauls to a maximum depth of 5110 m. The samples were evaluated partly directly on board. 60000 Animals were sorted and 473 species determined. 2043 further individuals were fixed for subsequent molecular genetic analysis. Some new species were discovered and conserved for their first description which has to take place in the home laboratories.

The following additional scientific programmes were carried out during the complete cruise:

- The bio-optical team of the AWI – University of Bremen – Helmholtz University Young Investigators Groups carried out optical and biological measurements in the surface water as ground truthing for satellite observations as well as at some stations in the upper 100 m of the water column.

- The group of the University of Lancaster collected air and water samples for the analysis of persistent organic pollutants (POPs) along the cruise journey to clarify their distribution and fate in seawater and atmosphere.

- Meteorologists of the Leibniz Institute of Marine Research Kiel (IFM-GEOMAR) determined the state of the atmosphere and its effect on the net radiation budget at the sea surface.

- The Heidelberg Institute of Environmental Physics carried out “Multi-Axis-Differential Optical Absorption Spectroscopy” (MAX-DOAS) measurements to determine the distribution and amount of different atmospheric trace gases in the atmosphere.

ANT-XXIV/1 finished on 26 November 2007 in Cape Town.

2. WEATHER CONDITIONS

Mathias Zöllner
Alfred-Wegener-Institut, Bremerhaven

Mathias Zöllner, a meteorologist from AWI Bremerhaven, joined the cruise at 24 hours notice due to the unforseen illness of the DWD colleague. This short notice lead to a change of programme and his work was focused on:

- visual meteorological observations,
- radio-soundings,
- control of meteorological measurements, computing and data acquisition, in particular after stronger system changes in the shipyard, and
- support for remote meteorological advice from DWD Hamburg for nautical and scientific purpose.

With light wind from easterly direction *Polarstern* left the harbor of Bremerhaven as scheduled on 26 October 2007 at 1 pm. Due to the influence of a strong low pressure system west of Scotland which was moving rapidly north-eastward, the wind increased soon after reaching the mouth of river Weser and the German Bight to wind force 5 Beaufort and turned to a southerly direction. However, wave height of about 1 meter was still relatively low for this situation.

When RV *Polarstern* reached the English Channel there was decreasing visibility, light rain and light showers due to the frontal system of this strong low. The maximum wind speed was measured from the southwest with a force of 7 to 8. The wind force decreased to Beaufort 5 towards the end of the English Channel but stronger swell wave height of about 3 meters was observed.

While crossing the Bay of Biscay visibility was good and with a wind force of 4 to 7 Beaufort and a wave height of 3.5 meters typical conditions for this area. Cape Finisterre was passed in the early morning of 31 October under wind force 7 Beaufort coming from the Southeast.

On the way south to Grand Canaria trade wind set in relatively early. It was just slightly influenced by a flat low over Mauretania.

Shortly before approaching Las Palmas on 4 November, the wind decreased close to calm. In combination with low wave height transfer of scientists and technicians via boat was not a problem. Wind and temperature (about 21°C) did not change

markedly until reaching 25°N. Here wind increased to Beaufort 5 and turned from an easterly to a north-easterly direction.

After *Polarstern* entered the area of Cape Verde a strong dust loaded airmass from the African continent reached the ship. Decreased visibility lower than 5 nautical miles and deposition of desert sands as well as a great number of insects from Africa was seen on deck. 6-day-backtrajectories of this event have shown a North-African airmass origin. The highest air temperature observed on board was also measured during this event on 8 November at 9 pm at position 11.4°N and 20.3°W and shows 29.1°C. The highest observed water temperature was measured one day later at 3 pm at position 8.8°N and 19.4°W read 29.4°C.

First light showers terminated the presence of dust and the stronger turbidity of the atmosphere after reaching the Intertropical Convergence Zone (ITCZ) at about 8°N shortly before airmass actually changed. Low amounts of precipitation and the absence of thunderstorms were indicators for a light ITCZ. At about 3°N last light showers and decreasing cloud amount marked the end of the ITCZ-passage.

Under the influence of the South Equatorial-Current water and air temperatures were decreasing constantly by one degree per day.

South of 7°S south-easterly trade winds with forces 4 to 7 Beaufort were observed as expected for the area. The cold Benguela Current lead to a further decrease in temperature. An air temperature of only 19°C was recorded during the passage of the solar zenith position on 20 November at about 19°S.

The weather situation for the last part of the cruise down to Cape Town was relatively constant. It was mainly determined by winds with forces 5 to 7 Beaufort from southerly direction. The combination with swell of 3 to 4 meters high from southerly directions resulted in a typical and not too comfortable pitching of *Polarstern*.

In the morning hours on 26 November Cape Town was reached under similar wind and wave conditions.

3. CENSUS OF MARINE ZOOPLANKTON

S. Schiel[1)], A. Bucklin[2)], P. Wiebe[3)]

[1)]Alfred-Wegener-Institut, Bremerhaven
[2)]Department of Marine Sciences, University of Connecticut
[3)]Woods Hole Oceanographic Institution

Our current understanding of global patterns of pelagic biodiversity results from decades of work by biological oceanographers, marine ecologists, and taxonomists. But despite more than a century of sampling the oceans, comprehensive understanding of zooplankton biodiversity has eluded researchers because of the fragility, rarity, small size, and/or systematic complexity of many taxa. For many zooplankton groups, there are longstanding and unresolved questions of species identification, systematic relationships, genetic diversity and structure, and biogeography. Molecular systematic analysis has revealed cryptic species within oceanic and coastal species, and has called into question previous interpretations of biogeographic patterns and evolutionary relationships.

There are distinctive latitudinal gradients in marine zooplankton species richness. An equatorial maximum in species richness is typical for marine benthos. In contrast, zooplankton species richness is highest in climatically-stable subtropical open ocean gyres and shows local minima along the equator. However, recent studies of species numbers of calanoid copepods in the upper 300 m along a transit from Bremerhaven to Cape Town with *Polarstern* in 2002 also demonstrated an equatorial maximum. Such exceptional diversity patterns indicate that more detailed studies are needed to elucidate the underlying mechanisms driving zooplankton diversity.

Less-studied areas - where the number of unknown species is probably very high (”biodiversity hotspots“) - include:

- Southern hemisphere: Oceans of the southern hemisphere are poorly studied relative to the northern hemisphere in both coastal and oceanic regions (except parts of the Antarctic).
- Open ocean waters: Oceanic waters are generally under-sampled relative to coastal regions.
- Deep sea: This widely unexplored part of the ocean is inhabited by a multitude of undiscovered species, emphasizing the need for its continued intensive study.

The main task of the CMarZ research during ANT-XXIV/1 was therefore the investigation of zooplankton throughout the entire water column of oceanic stations in the subtropical and tropical Atlantic, with a particular focus on the poorly-known meso- and bathypelagic realms, and to determine DNA sequences (i.e., DNA barcodes) for identified zooplankton specimens at sea. Thus, the research concentrated on the joint analysis of the samples; and the scientific team included CMarZ researchers, taxonomic experts, molecular specialists and students.

3.1 MOCNESS sampling for zooplankton

P. Wiebe, D. Allison
Woods Hole Oceanographic Institution (WHOI)

Zooplankton and micronekton were quantitatively sampled throughout the water column using a 1-m^2 and a 10-m^2 MOCNESS (Multiple Opening/Closing Net and Environmental Sensing System; Wiebe et al. 1985).

The MOCNESS is an electronically controlled system with communication between the net and the surface through conducting trawl wire. The MOCNESS Serial Asciii Interface Loop was used to telemeter data continuously to the ship, including pressure, temperature, conductivity, flow counts, and net angle. From these data, salinity, horizontal speed, vertical velocity, and volume filtered were computed and displaced. In addition, a GPS input from the ship provided information on the ships position and distance a net traveled while open. This allowed on-the-fly adjustment of sampling depths or times, and completion of a continuous series of stratified hauls in a relatively short time. All data were recorded electronically for subsequent analysis.

The 10-m^2 MOCNESS (MOC10) carried 5 separate nets; the mesh size of the nets was a combination of 3 mm and 335 μm mesh. Net 0 had 3 mm mesh and nets 1 to 4 had 335 μm mesh nets of special design that were fabricated for CMarZ cruises. In addition, at the beginning of the cruise, deflector side flaps and net bar flaps were constructed to prevent contamination of the deep samples from plankton in other strata, especially those closer to the surface (Fig. 3.1.1). The MOC10 was launched, towed, and recovered through a stern A-frame with the ship maintaining a speed of 1.5 to 2.5 knots. The trawl was deployed with the first net open (3 mm mesh) down to the deepest depth desired, nominally 5,000 m (Fig. 3.1.2). It was closed at that point and subsequent nets (335 μm) were opened at desired depths as the trawl was hauled obliquely toward the surface. Thus, one MOC10 net sampled from the surface to the bottom and the other nets normally sampled ~1,000 m intervals from the bottom up to a depth of 1,000 m. Above 1,000 m, vertically stratified sampling was done using a 1-m^2 MOCNESS (MOC1) equipped with 9 nets with 335 μm mesh also deployed from the stern (Fig. 3.1.2). This system sampled 200 m depth intervals from

1,000 to 200 m, 100 m from 200 to 100 m, 50 m from 100 to 50 m, and 25 m intervals from 50 to the surface.

A flow meter calibration station was conducted south of the Canary Islands with sampling to 100 m by both systems (Fig. 3.1.3, Appendix A.4 and A.5). Two of the deep station locations along the eastern Atlantic transit line were north of the equator (one south of the Cape Verde Islands and one just north of the equator) and two were in the south Atlantic (one in the Angola Basin and one south of the Walvis Ridge). The tows with the 10-m system generally took 10 to 12 hours and those taken with the 1-m system took about 3.5 hours.

Fig. 3.1.1: Deployment of the 10-m^2 (A) and 1-m^2 (B) MOCNESS from the stern of the Polarstern. Note the net bar and deflector flaps on the MOC10 to prevent contamination of the samples from great depths with animals living at shallower depths.

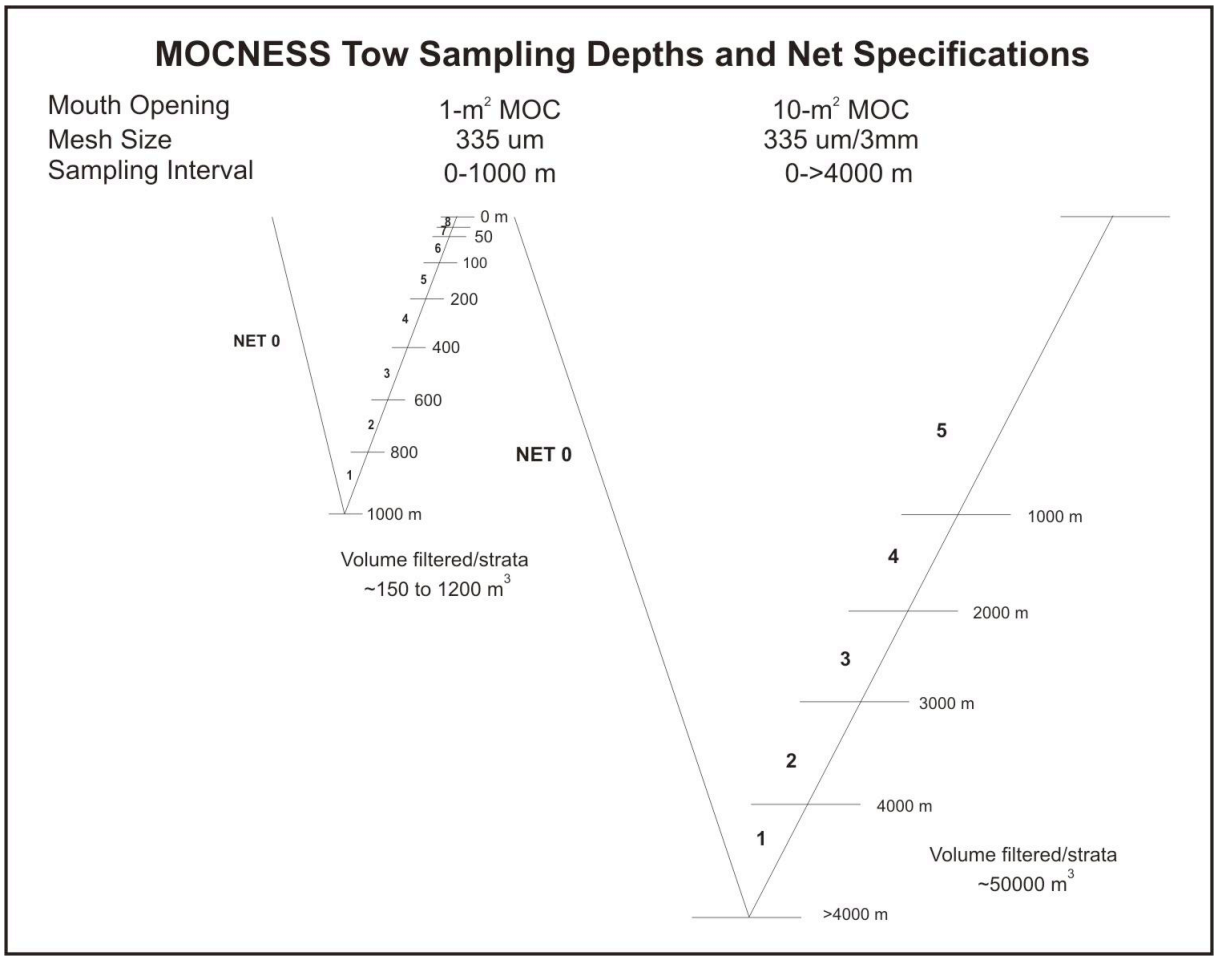


Fig. 3.1.2: The general towing and sampling strategies used for the MOCNESS's

The use of the large trawl below 1,000 m enabled large volumes of water to be sampled (tens of thousands of cubic meters) to compensate for the very low abundance of species that occur at bathy- and abyssopelagic depths (Fig. 3.1.4). The smaller MOC1 provided adequate sample sizes in the upper 1,000 m.

An example of the process of deep towing is illustrated with the tow made in the Angola Basin at station 6 (13°09.103'S; 0°18.650' E). The MOC10, which was deployed at 06:00, took 4.5 hours to descend to 5,110 meters where the bottom depth was 5,540 m. To get to that depth the maximum amount of wire (8,363 m) on the winch drum was paid out (down to the last wrap). The depth strata intended to be sampled by the four fine mesh trawl nets were 5,110 to 4,000 m, 4,000 to 3,000 m, 3,000 to 2,000 m, and 2,000 to 1,000 m. However, while the second net was hauled slowly back towards the surface between 4,000 and 3,000 m, the cable holding the net bar to the toggle release mechanism parted at 3885 m depth, closing net 2 and opening net 3 prematurely. The other nets opened and closed as planned. Thus, net 1 filtered about 70,000 m^3, net 2 only filtered about 6,000 m^3, while net 3 filtered more than 100,000 m^3 and net 4 filtered nearly 70,000 m^3. The net system arrived back at the surface at 18:00, 12 hours after the start.

3.1 MOCNESS Sampling for zooplankton

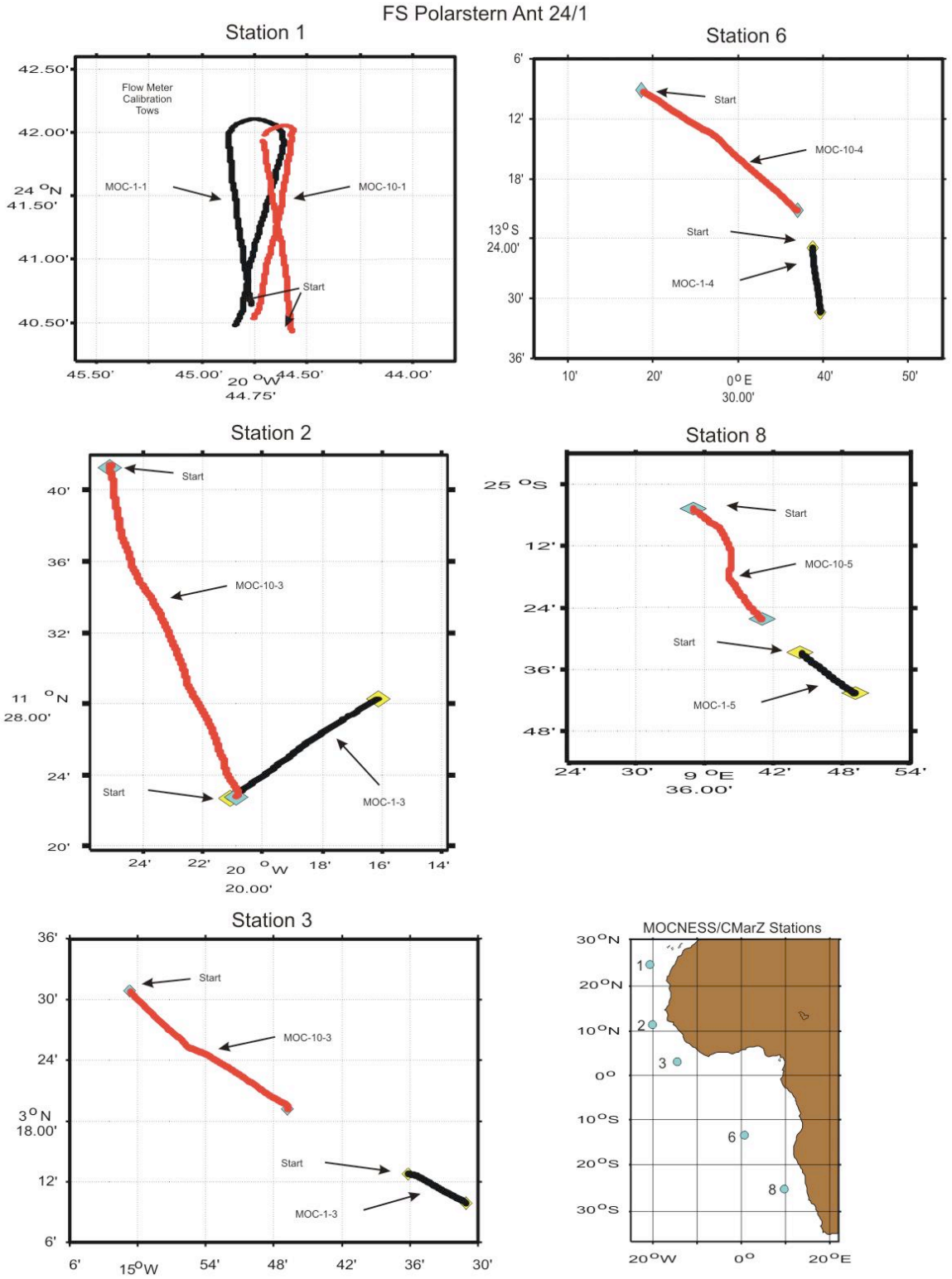


Fig. 3.1.3: Position of the MOCNESS tows along the trackline of the Polarstern

The catches were spectacular for a variety of reasons, especially in nets 3 and 4. Species of fish rarely seen were present in several nets, including a female angler fish with an attached male. Very large copepods (*Megacalanus* with antennae about 4 cm in width), some of the largest known, were present in substantial numbers. A large eyeless chaetognath was caught. A number of species of deep-sea squid and pteropods were in very good condition. The excitement was palpable in the dry lab as the taxonomists worked to identify species while they were still fresh, and some still alive. One scientist was heard to exclaim that "it was the best set of samples of deep-sea animals that he had every seen".'

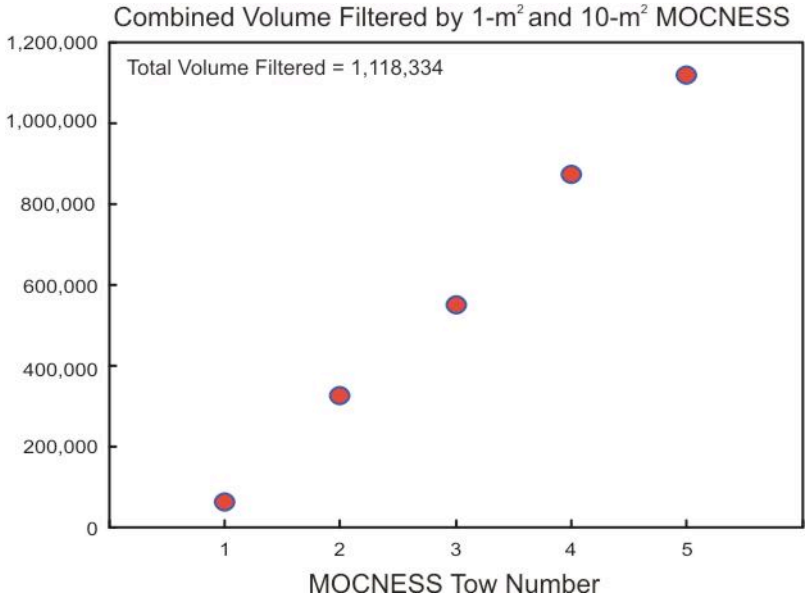


Fig. 3.1.4: Cumulative volume filtered by the 10-m^2 and 1-m^2 MOCNESS. The 1-m^2 system filtered a total of ~52,000 m^3 and the 10-m^2 system filtered a total of ~1,066,000 m^3

Reference

Wiebe P.H., Morton A.W., Bradley A.M., Backus R.H., Craddock J.E., Cowles T.J., Barber V.A., Flierl G.R. (1985). New developments in the MOCNESS, an apparatus for sampling zooplankton and micronekton. Mar. Biol. 87: 313-323.

Water column structure at the stations

The series of five MOCNESS sampling stations provided contrasting physical settings for the zooplankton collections. North of the equator surface water were quite warm, between 24° and 29° C in a relatively shallow mixed layer (Fig. 3.1.5). There was a rapid monotonic decrease in temperature in the main thermocline that occurred between ~70 and 1,000 m and then a more gradual decline in temperature to a minimum of <3°C below 4,000 m. The salinity was >37 PSU in the upper 100 m at station 1. Closer to the equator at stations 2 and 3, upper water column T/S properties were distinctly different with lower salinity water at the surface increasing to a maximum within the upper 100 m. Below 100 m, there was a steady decrease in salinity to a minimum between 800 to 900 m and then an increase down to about

1,500 m before gradually decreasing down to the bottom (4,000 to 5,000 m). South of the equator at the Angola Basin and Walvis Ridge stations, similar patterns in the temperature and salinity profiles occurred throughout the water column except that both salinity and temperature were maximal at the surface.

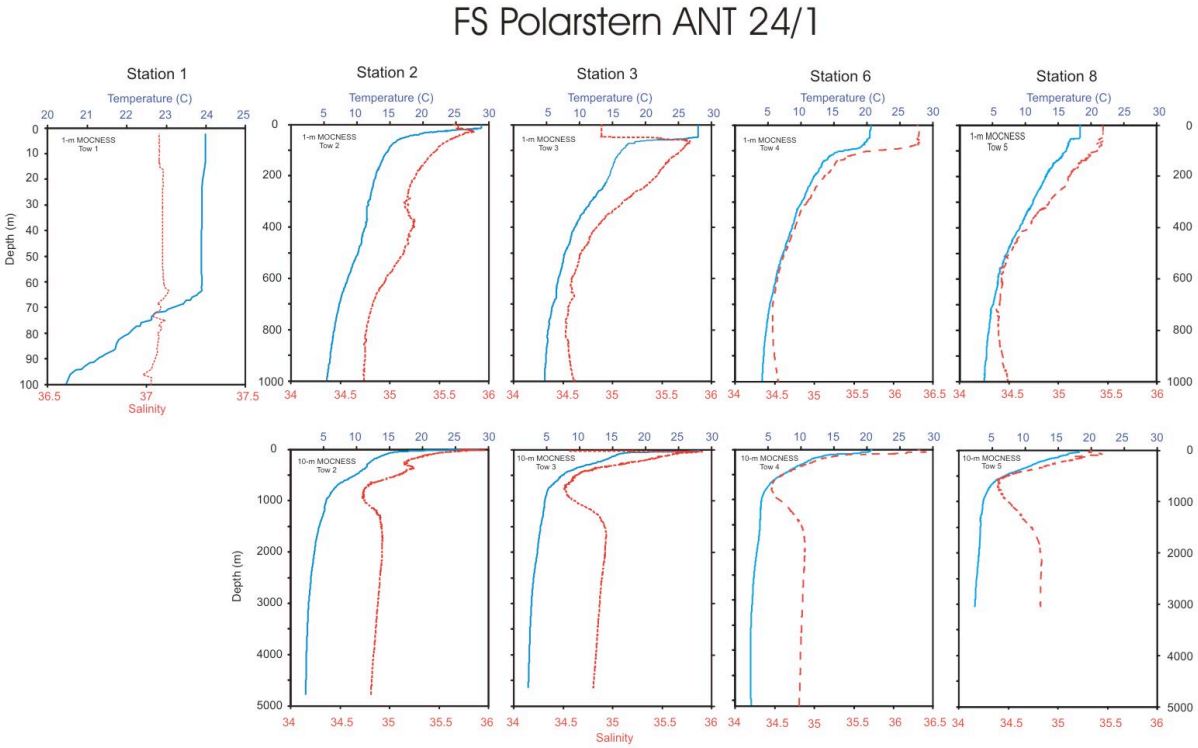


Fig. 3.1.5: Vertical temperature and salinity profiles in the upper 1,000 m and entire water column sampled (~5,000 m) for each CMarZ station

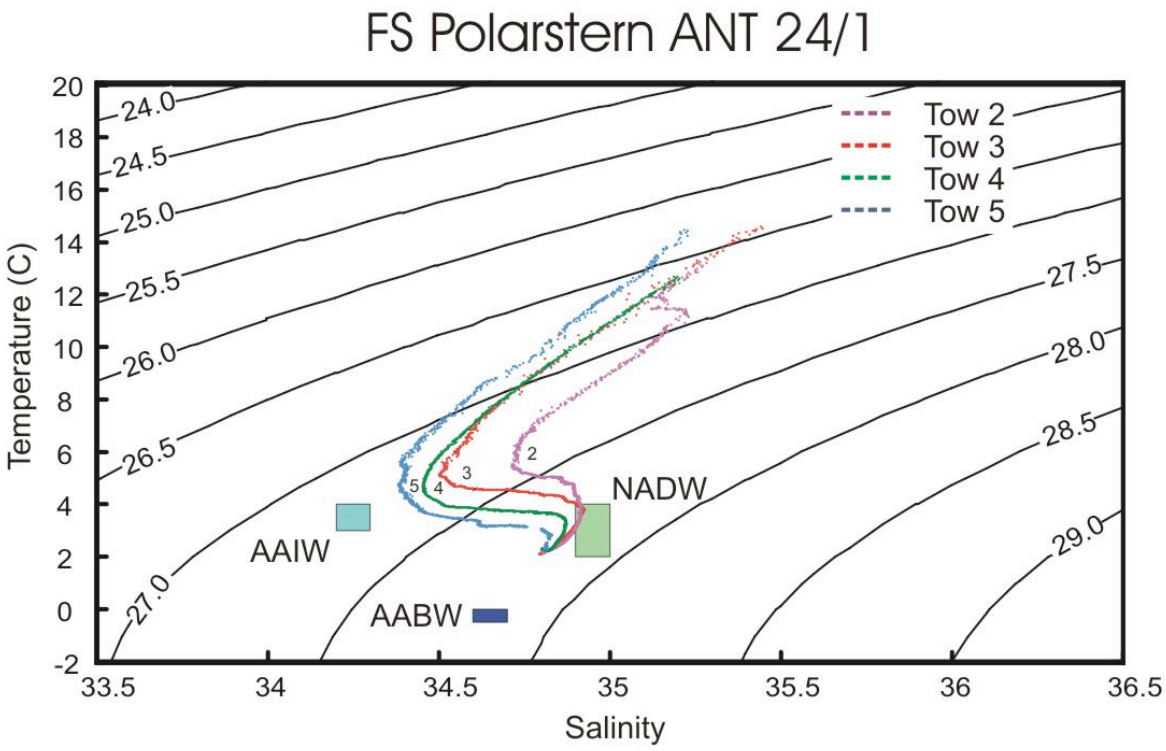


Fig. 3.1.6: Temperature versus salinity plot showing the change in deep-sea water properties at the four locations where sampling was conducted to the close to the sea floor.

The source regions for subsurface water sampled (North Atlantic Deep Water, Antarctic Bottom Water, and Antarctic Intermediate Water) during this cruise are defined by a narrow range of temperature and salinity as illustrated in Fig. 3.1.6. The TS plots for each of the four deep stations begin at 150 m below the surface.

The subsurface salinity minimum is associated with the Antarctic Intermediate Water (AAIW) and the stations (6 and 8) with salinity and temperature values closest to the source water box indicate more AAIW is present at those locations. The AAIW is coming from the south, as part of the thermohaline circulation. Below 3,000 m, the influence of mixing between NADW and AABW is evident. Unfortunately, the presence of AABW at the most southern station (8) could not be determined because the temperature probe failed during the first portion of the tow and good data were obtained only down to 3,200 m. The influence of AABW was clearly evident in the zooplankton species caught at this station, which had a strong Antarctic affinity.

3.2 Multinet sampling

H. Auel[1)], S. Kruse[2)], S. Schiel[2)]

[1)]Marine Zoologie, Universität Bremen
[2)]Alfred-Wegner Institut, Bremerhaven

Stratified mesozooplankton samples were collected at five stations with multiple opening/closing net systems (Multinet, Hydro-Bios Kiel). At the first four stations, the Multinet type Maxi with a mouth opening of 0.5 m^2, nine nets and a mesh size of 150 μm was used (Fig. 3.2.1). Due to strong winds and a high swell, the last station was sampled with the smaller Multinet type Midi with a mouth opening of 0.25 m^2 and five nets equipped with 100 μm meshes. The standard sampling intervals of the vertical hauls with Multinet Maxi were 1000-800-600-500-400-300-200-100-50-0 m, while at the last station the depth profile consisted of the intervals 1005-500-300-100-50-0 m.

Fig. 3.2.1: Night sampling with the Maxi Multinet (Photo P. Wiebe)

In general, the deployment of the Multinet was very successful without technical problems. Nevertheless, at the first station there was a considerable offset between the depth readings of the Multinet's pressure sensor and the actual cable length (1,000 vs. 1,194 m). Fortunately, the winch technician was able to fix the biased cable length measurements before the second station. After that, pressure-derived depth measurements and cable length agreed very well and were cross-checked with data from the echosounder, which at some stations nicely showed the descent and ascent of the Multinet.

In general, copepods dominated all depth strata of the Multinet hauls in terms of both, abundance and biomass. However, in the surface layer over the top of Ewing Seamount (stn. 9, 23°14.3'S 8°14.3'E) juveniles of the pteropod *Limacina bulimoides* occurred in very high abundance together with some individuals of *L. inflata*, while the sub-surface layer (50-100 m) at the last station (stn. 11, 26°59.3'S 10°58.8'E) was strongly dominated by small pyrosomid colonies.

3.3 Mollusks

H. Ossenbrügger, U. Piatkowski
Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR)

Objectives

In the phylum of the Mollusca holoplanktonic species are found in two different classes, the Cephalopoda and the Gastropoda. In the Cephalopoda the early life stages of squid and many octopods are typically planktonic, while their adult forms belong to the nekton. Within the Gastropoda only few species are holoplanktonic. Most of these belong to the pteropods and the heteropods. Although holoplanktonic mollusks are an important and often quite abundant component of the oceanic plankton communities, little is known about their ecology and biogeography; especially from meso- and bathypelagic waters.

Macroplankton and micronekton sampling was performed with the MOCNESS system (see chapter 3.1). Here we report on the pelagic mollusks which have been collected during five MOCNESS stations along a transect from the subtropical waters near the Canary Islands through the tropical Eastern Atlantic Ocean to the temperate waters off southern Africa. All pelagic mollusks in the samples were identified on board to the lowest possible taxon and first results on their geographical distribution are provided below. Additionally, tissue samples or whole specimens were provided for DNA-barcoding for accurate species identification, to reveal possible cryptic species and to investigate the phylogeny of major groups (see chapter 3.9, page 48, on barcoding). Studies on the vertical distribution of pelagic mollusks and possible affinities to water masses will follow at a later stage.

Work at sea

The samples of four 10-m^2 MOCNESS stations between 0 - 5,000 m (16 discrete-depth and 5 oblique tows) plus the 10-m^2 MOCNESS trial station were analyzed completely regarding pelagic mollusks, as well as all samples of the four 1-m^2 MOCNESS between 0-1,000 m (32 discrete-depth and 5 oblique tows) plus the 1-m^2 MOCNESS trial station.

Immediately after the nets were recovered, samples were taken from the cod-end buckets and maintained in cooled seawater before being processed in the ship's laboratory. The processing was carried out at 4°C. It included photographing and

presorting of large animals of each sample. Afterwards the catch was splitted: one half was preserved in 98 % ethanol, one quarter in formalin and the other quarter was used for live observation and on board identification of the species composition.

Preliminary results

Pteropods

A total of about 1,000 specimens of 34 species of Thecosomata and four species of Gymnosomata were collected from the samples. Of these 249 specimens of 32 species were supplied for barcoding. The highest diversity of pteropods (21 species) was found in the MOC1 catch of the upper 1,000 m at 03°13'N (Fig. 3.3.1a). In the upper 1,000 m of the water column a trend to a higher species number was observed in tropical waters (Fig. 3.3.1a). This trend was not found in the deeper tows of the MOC10 (Fig. 3.3.1b).

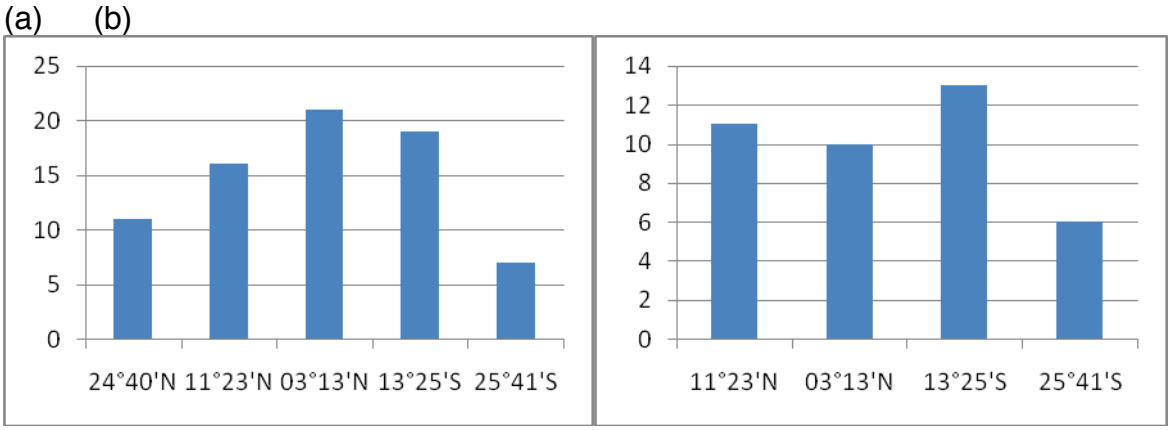


Fig. 3.3.1: Numbers of pteropod species found in MOC1 (a) and MOC10 (b)

Due to time constraints at the end of the station transect it was not possible to sort the catches of tow 5 (25°41'S) in the same detailed fashion as the other tows; therefore species numbers of this tow were probably too low. At all stations highest specimen numbers were observed in the family Limacinidae, except tow 5 at 25°41'S, which was dominated by the pseudothecosomate pteropod *Cymbulia peroni*. We found four known species of *Clio* in our samples (see Table 3.3.1) plus a fifth species, which we believe is new to science. It was caught at 13°25'S in 2,000 to 4,000 m depth (tow 4) as well as at 25°41'S in 4,000 to 4,400 m depth (tow 5). Tissue samples of one of these specimens and from the other four *Clio* species were given for barcoding to investigate the phylogenetic status of the *Clio* species and the validity of the possibly new species.

Tab. 3.3.1: Pteropods collected during ANT-XXIV/1

Family	Species	24°40‘ N	11°23’N	03°13’N	13°25’S	25°41’S
Cavoliniidae	*Cavolinia inflexa* f. *imitans*	+	+	+	+	+
Cavoliniidae	*Cavolinia uncinata uncinata* f. *uncinata*		+		+	
Cavoliniidae	*Clio chaptali*		+	+	+	
Cavoliniidae	*Clio cuspidata*				+	
Cavoliniidae	*Clio pyramidata* f. *lanceolata*		+	+	+	+
Cavoliniidae	*Clio recurva*		+	+	+	+
Cavoliniidae	*Clio* sp. nov.				+	+
Cavoliniidae	*Creseis acicula* f. *acicula*	+	+	+	0	
Cavoliniidae	*Creseis acicula* f. *clava*			+	0	
Cavoliniidae	*Creseis virgula* f. *conica*		+	+	+	
Cavoliniidae	*Creseis virgula* f. *virgula*		+		0	
Cavoliniidae	*Cuvierina columnella* f. *atlantica*		+	+	0	
Cavoliniidae	*Diacavolinia* cf. *deshayesi*				+	
Cavoliniidae	*Diacavolinia* cf. *limbata*		+		0	
Cavoliniidae	*Diacavolinia* sp.		+	+	0	
Cavoliniidae	*Diacria* cf *rampali*				0	+
Cavoliniidae	*Diacria* cf. *trispinosa*				+	
Cavoliniidae	*Diacria danae*	+	+	+	+	
Cavoliniidae	*Diacria rampali*			+	+	
Cavoliniidae	*Diacria trispinosa*	+	+	+	+	+
Cavoliniidae	*Hyalocylis striata*	+		+	+	
Cavoliniidae	*Styliola subula*	+	+	+	0	
Clionidae	*Thliptodon antarcticus*				+	
Cliopsidae	*Cliopsis krohni*			+	0	
Cymbuliidae	*Corolla* sp.		+		0	
Cymbuliidae	*Cymbulia sibogae*		+	+	0	
Cymbuliidae	*Cymbulia peroni*				0	+
Desmopteridae	*Desmopterus papilio*	+	+	+	+	
Limacinidae	*Limacina (Munthea) bulimoides*	+	+	+	+	+
Limacinidae	*Limacina (Thilea)*		+	+	0	

Family	Species	24°40‘ N	11°23’N	03°13’N	13°25’S	25°41’S
	helicoides					
Limacinidae	*Limacina (Thilea) inflata*	+	+	+	+	
Limacinidae	*Limacina (Thilea) lesueurii*	+	+	+	+	
Limacinidae	*Limacina (Munthea) trochiformis*				+	
Peraclidae	*Peraclis apicifulva*			+	0	
Peraclidae	*Peraclis bispinosa*		+	+	0	
Peraclidae	*Peraclis moluccensis*		+	+	+	
Peraclidae	*Peraclis reticulata*	+	+		+	
Peraclidae	*Peraclis valdiviae*				+	
Pneumodermatidae	*Pneumoderma* cf. *atlanticum*		+	+	+	
Pneumodermatidae	*Schizobrachium polycotylum*			+	0	

Heteropods

A total of 168 specimens of 14 species were collected from the samples (Tab. 3.3.2). Of these 52 specimens of 8 species were supplied for barcoding. Highest diversity of heteropods (ten species) occurred at 13°25’S (MOC1 and MOC10 combined). The species numbers along the transect did not show any clear trend. Heteropods did not occur at 25°41’S (tow 5), but a more detailed sorting of the samples of this tow may alter this preliminary observation.

Tab. 3.3.2: Heteropods collected during ANT-XXIV/1

Family	Species	24°40‘N	11°23‘N	03°13‘N	13°25‘S	25°41‘S
Atlantidae	*Atlanta fragilis*				+	
Atlantidae	*Atlanta fusca*	+			+	
Atlantidae	*Atlanta helicinoides*	+			0	
Atlantidae	*Atlanta inclinata*	+	+	+	+	
Atlantidae	*Atlanta inflata*				+	
Atlantidae	*Atlanta lesueuri*			+	+	
Atlantidae	*Atlanta oligogyra*				+	
Atlantidae	*Atlanta peroni*	+		+	+	
Atlantidae	*Atlanta tokiokai*	+	+		0	
Atlantidae	*Oxygyrus keraudreni*			+	+	
Atlantidae	*Protatlanta souleyeti*				+	
Carinariidae	*Cardiopoda richardi*				+	
Pterotracheidae	*Firoloida desmaresti*		+		0	
Pterotracheidae	*Pterotrachea coronata*	+		+	0	

Nudibranchs

One species, *Phylloroe bucephala*, of holoplanktonic Nudibranchia was found. It occurred with three specimens in tow 3 (03°13'N), of which two were supplied for barcoding.

Cephalopods

Within the cephalopod group only 67 specimens were caught. A compilation of the tentatively identified species/taxa at the five MOCNESS stations is shown in Table 3.3.3. They represented at least 23 taxonomic groups, which underlines the high species diversity of cephalopods and which makes this collection very valuable for the studies on oceanic cephalopods from tropical and subtropical Atlantic waters. Two additional specimens belonging to the species *Sthenoteuthis pteropus* and *Bolitaena pygmaea* were caught in the surface layers during two Multinet hauls. All specimens were early life stages, no adult forms were caught. The three stations closer to the equator showed the highest cephalopod species diversity and abundance (see Table 3.3.3).

The catches revealed a typical tropical/subtropical cephalopod fauna. Cephalopods were most abundant in the surface layers (100 - 0 m), which were sampled at night. The most abundant cephalopod was the squid *Pterygioteuthis giardi giardi* (9 specimens) which occurred at three stations, followed by the pelagic octopod *Vitreleledonella richardi* (6 specimens) occurring at two stations, and the early life stages of the hooked squid *Onychoteuthis banksi* (5 specimens) which was caught at three stations. Many of the specimens caught were in superb condition, especially when they were taken in the surface layers where many animals were still alive after capture. Identification is still tentatively for many of the specimens. Tissue samples for barcoding were taken from nineteen specimens, and genetic studies are planned to achieve a more precise identification.

The capture of *Magnapinna atlantica* was an important highlight of the cephalopod sampling. The specimen was in an excellent condition and there are only a very few samples of this species reported todate. A number of photographs of many species as well as drawings of the rhynchoteuthion larvae of the ommastrephids *Hyaloteuthis pelagica* and *Sthenoteuthis pteropus* will help to shed more light into the abundance and distribution patterns of tropical and subtropical cephalopods from the oceanic regions of the Atlantic Ocean.

Tab. 3.3.3: Summary of cephalopods caught at the five MOCNESS stations along the transect of the cruise. Numbers represent the sum of all specimens caught with the various nets at each station. Stations are listed in columns according to the approximate position at the beginning of the hauls.

Taxon	24°40'N	11°23'N	03°13'N	13°25'S	25°41'S
Abraliopsis morisii				3	
Bathyteuthis abyssicola		1	1	1	
Bolitaena pygmaea			1		
Chiroteuthis veranyi				1	
Chtenopteryx sicula		1		1	
Egea inermis		1			
Enoploteuthis leptura			1	1	
Enoploteuthidae indet.	2		2		
Grimalditeuthis bonplandi				1	
Helicocranchia pfefferi			2		1
Hyaloteuthis pelagica		3			
Leachia atlantica	4				
Liguriella podolphtalma		1			
Lycoteuthis diadema		1			
Magnapinna atlantica			1		
Mastigoteuthis psychrophila					1
Mastigoteuthis sp.		2			
Octopus defilippi		1			
Octopus sp.		1		1	
Onychoteuthis banksi		2	2	1	
Pterygioteuthis giardi giardi			5	3	1
Sthenoteuthis pteropus		2			
Teuthoidea indet.		2	2	1	
Teuthowenia pellucida		1			
Vampyroteuthis infernalis			1	1	
Vitreleledonella richardi		1		5	
Total species	**2**	**14**	**10**	**12**	**3**
Total specimens	**6**	**20**	**18**	**20**	**3**

3.4 Ostracods

M. V. Angel[1)], K. Blachowiak-Samolyk[2)]

[1)] National Oceanography Centre, Southampton

[2)]Institute of Oceanology, Polish Academy of Sciences

Objectives

Our objectives on the cruise were:-

1. To sort and identify as many species of planktonic ostracods from the MOC 1 and MOC10 samples as possible.
2. To find novel species and extend information on the zoogeographical range of the species particularly those occurring at abyssopelagic depths in the context of the 2006 CMarZ cruise to the Sargasso Sea onboard *Ron Brown.*
3. To provide as many samples of accurately identified species as possible to extend the bar-coding coverage initiated on the earlier CMarZ cruise to the Sargasso Sea.

Work at sea

Many of the ethanol and formalin preserved samples were totally sorted for ostracods.

Preliminary results

Unfortunately there was not enough time to sort all the samples collected at the final station. Even so, there were indications that the Walvis Ridge, which was a physical barrier separating the deep-water communities at the fourth and the fifth stations, does have a strong influence on the deep-living ostracod communities. For example the Southern Ocean endemic species *Conchoecilla chuni* occurred at the fifth final station but not further north. Overall more than 22,500 specimens were sorted at sea, but it was not possible to identify all these specimens, as several species cannot be reliably identified at sea. Even so, 98 putative species were identified (53 from MOC1 samples, 61 from MOC10 samples, and 36 being common to both), of which at least six are either novel or undescribed. Comparative data for the ‚Ron Brown' cruise are: 88 putative species identified, 52 from MOC1 samples and 76 from MOC10 samples (note there was a problem of shallow water contamination in some of the MOC10 samples). Some of the novel species were caught on both cruises, for example a species provisionally named *Fellia 'abyssopelagica'* was caught not only from the ‚Ron Brown', but also in deep samples collected by RRS ‚Discovery' in 1979. This large and conspicuous species occurred at each of the ‚*Polarstern*' MOC10 stations at depths > 3,000 m (Fig. 3.4.1). It clearly has a widespread distribution throughout much of the tropical and subtropical Atlantic. Another abyssopelagic species that was regularly caught was *Archiconchoecissa pljusnini.* Thus the abyssopelagic fauna may include many species that are ubiquitous in the deep ocean.

Another unexpected observation was that some specimens of a *Halocypris* species appeared to be brooding embryos. Whereas brooding is the rule in the myodocopid

ostracods, such as *Gigantocypris*, previously the only halocyprid species known to brood was *Euconchoecia* spp. *Halocypris* species are normally epipelagic/ mesopelagic, so the presence of one in very deep samples was totally unexpected. Its abundance in the deep samples was sufficient to rule out the possibility that their presence was the result of contamination.

Comparing the species composition at each station, showed there were some large latitudinal changes. In the MOC1 samples, i.e. at depths < 1,000 m, these changes were probably related either to changes in the water masses, or to latitudinal shifts in the seasonality of organic fluxes. At the greater depths sampled by the MOC10, the factors influencing the presence or absence of species can only be guessed at. Some species appear to be ubiquitous whereas others are more localised. On this cruise we collected specimens of 21 species including *Paramollicia rhynchena, Paramollicia major, Paraconchoecia dentata* and *Paraconchoecia cophopyga,* which were not collected during the ‚Ron Brown' cruise in the Western Atlantic. Whereas 11 species including *Paraconchoecia dorsotuberculata, Vityazoecia lunata, Muelleroecia glandulosa and Euconchoecia chierchiae* collected in the Sargasso Sea were missing from the ‚*Polarstern*' Eastern Atlantic samples.

Before the start of the ‚Ron Brown' cruise, 140 ostracod species had been recorded from the Atlantic Ocean. Together these two cruises have shown that many of the species formerly considered to be rare, are widespread and relatively abundant at depths > 2,000- 3,000 m (Appendix A.6). The *Ron Brown* cruise added a further 10 putative to the overall list, although none of them has yet been described. On ANT-XXIV/1 the number of probably new species so far stands at 6, and doubtless several more will be found when the samples can be critically evaluated.

Fig. 3.4.1: Photograph of 'Fellia abyssopelagica' one of the novel species caught during ANT-XXIV/1 that occurred regularly at abyssopelgic depths (Photo C. Clarke-Hopcroft).

The live fractions of most MOCNESS samples were examined for specimens suitable for barcoding. Special attention was paid to the deep MOC10 tows, which as expected contained many rarer and poorly-known, and even novel, species. A total of 540 fresh specimens representing 77 species were picked out for sequencing.

The majority of the species that remain to be collected for barcoding are either high latitude species or are members of the almost unstudied community inhabiting the benthopelagic. The latter includes many species of the genus *Bathyconchoecia.* Five species of *Bathyconchoecia* were collected on *Polarstern* ANT-XXIV/1, but 15 novel species await description from epibenthic samples collected in the North Atlantic, and a further 12 from samples collected during earlier *Polarstern* cruises in the Southern Ocean. This novel fauna needs to be specifically targeted in future sampling.

In addition several of the more photogenic species were picked out for the photographers, who between them photographed 15 species.

3.5 Copepods

Pelagic copepods have not been extensively sampled in the South Atlantic, particularly in the deep parts of the central and southeastern oceanic regions and certainly not to bathypelagic depths (Bradford-Grieve et al. 1999). Thus the samples collected by the MOC1 and MOC10 nets were expected to contain new records and

new species. During the relatively short duration of this research voyage we could not expect to authoritatively document new records and undescribed species.

In general, we observed that the deep samples contained a diverse fauna, although strongly dominated in biomass by a few families (*Augaptilidae* and *Lucicutiidae*) with lower numbers of rarer taxa that often prove difficult to identify on board. We have also observed the bimodal vertical distributions of *Onceidae* copepods, with two peaks in most upper layer (0 – 50 m) and mesopelagic layer (300 – 400 m). In contrast, single modal vertical distributions in upper layers were observed for *Oithona* species. All ethanol preserved samples will be housed at the Alfred Wegener Institute, Bremerhaven as well as the formalin preserved multinet samples. The formalin preseved MOCNESS samples will be housed at Woods Hole Oceanographic Institute. Both these samples will be a rich source of material for the documentation of the pelagic copepod fauna of the eastern South Atlantic.

Several projects motivated researchers on this voyage. First, comparative studies of the phylogeography of pelagic copepods including studies of the calanoid family *Scolecitrichidae*, and the cyclopoid families *Onceaidae* and *Oithonidae*, described below. Second, researchers aimed to add to the general numbers of pelagic copepods that have been barcoded. In order to fulfill a third aim (understanding the deep phylogeny of the calanoid copepod families) a deliberate choice was made to sort identified examples of a broad range of families from these samples.

References

Bradford-Grieve J., Markhaseva E.L., Rocha C.E.F. & Abiahy B. (1999). Copepoda. In: South Atlantic Zooplankton. Vol.2 (ed. Boltovskoy D.), Backhuys Publishers, Leiden, pp. 869-1098.

3.5.1 Comparative Phylogeography of pelagic copepods

M. Kuriyama, R. Machida, Y. Nishibe
Ocean Research Institute
University of Tokyo
Not on board: Shushei Nishida (ORI)

Objectives

The species diversity of the oceanic zooplankton is characterized by a high local diversity, in contrast to low global diversity. Moreover, in the mesopelagic assemblages, the highest diversity was observed in many taxa and regions. However, the possible mechanism generating the local diversity is poorly known. In the mean time, recent advancement of molecular biological techniques are progressively revealing cryptic species within zooplankton species that have been referred to as cosmopolitans or known to have ocean-wide distributions. Most studies have focused on the epipelagic species, thus little is known of the gene flow of

populations in the meso- and/or bathypelagic zooplankton. We aim to analyze the phylogeography of the families Scolecitrichidae and Oncaeaidae and the genus *Oithona*. The family Scolecitrichidae is among the most species-rich families of the calanoid copepods, and is widely distributed throughout the world oceans. Many species of this family are found to exhibit the partitioning of vertical habitats through the water column. Species of the family Oncaeidae are pelagic microcopepods of major importance to the marine ecosystems. Their habitats range from low to high latitudes and from epipelagic to bathypelagic depth zones. Species of the genus *Oithona* are among the most common and numerous zooplankters and are found in various aquatic habitats including epipelagic and mesopelagic zones of the open ocean and coastal waters. Using these copepods as model zooplankter, population genetic structure along the transect line will be analyzed, and the speciation mechanism in the open oceans discussed.

Work at sea

Copepods were collected by various kinds of plankton nets including the MOC1, MOC10, and Multinet. After sampling, copepods were sorted out from fresh or ethanol preserved samples, and kept in vials filled with 95 % ethanol. Further analysis, including species identification and genetic analysis, will be continued.

Preliminary results

Following is the list of specimens collected during the cruise.

Oithona spp.
Oncaea venusta
O. mediterranea
O. media
O. scottodiacarloi
O. wardemari
O. brodskii
O. englishii
O. prolata
Triconia conifera
T. derivata
T. dentipes
Conaea rapax
Epicalymma

Scolecitrichida

3.5.2 Genetic identification of species and calanoid phylogeny

J. Grieve[1)], R. Escribano[2)], L. Blanco Bercial[3)]

[1)]National Institute of Water and Atmospheric Research
[2)]Estacion de Biologia Marina-Dichato Universidad de Concepcion
[3)]Departamento de Biología de Organismos y Sistemas, Universidad de Oviedo

Objectives

As we work in more detail over the global oceans, questions have arisen about the limits to species, as defined morphologically, and their distributions. It is already known that several closely related, but not yet described, species exist in families such as the Acartiidae, Paracalanidae, Lucicutiidae, Calanidae, Clausocalanidae and Eucalanidae. Also, an apparently large amount of morphological variability hampers the analysis of the augaptilid genus *Euaugaptilus*.

Our specific aim was to identify species from a wide range of calanoid families to submit for barcoding and DNA extraction.

Work at sea

Using stereo and compound microscopes and available literature we identified species from epipelagic, mesopelagic and bathypelagic depths from ethanol preserved samples and submitted them to the genetics laboratory. Specimens that were photographed were also identified.

Specific attention was paid to *Calanoides* in an attempt to examine population continuity along the eastern North and South Atlantic borders to confirm the distinctness of *C. carinatus* s.s. found in the Western South Atlantic from the eastern populations.

Attention was also given to the bathypelagic family Megacalanidae which occupies a key place in the phylogeny of the Calanoida. Twenty six lots that include species of *Megacalanus, Bathycalanus* and *Bradycalanus* were selected for further morphological and genetic analysis.

Rare bathypelagic species of *Temorites* in the Bathypontiidae, a family that has an ambiguous position in current views of calanoid phylogeny, were also selected for further morphological and genetic analysis.

Preliminary results

In conjunction with the DNA team, and specifically Ann Bucklin and Rob Jennings, we selected 144 taxa made up of 467 specimens across 22 families for barcoding and DNA extraction for later analyses that would go towards a phylogenetic study of the

Calanoida. The current effort aboard *Polarstern*, in conjunction with previous work, has now resulted in examples of 26 out of 41 calanoid families being available for the phylogenetic analysis.

For the details of the material submitted and preliminary results see the section on DNA - Barcoding (3.9, page 48).

3.5.3 Biodiversity and ecology of deep-sea copepods

H. Auel
Marine Zoologie, Universität Bremen

Objectives

The two copepod families Euchaetidae and Aetideidae are important components of zooplankton communities throughout the World Ocean, especially in deep oceanic waters. Most of these species inhabit meso- and bathypelagic depths, while some are epi- or benthopelagic. The genus *Paraeuchaeta* is carnivorous and includes major predators on other mesozooplankton. Aetideid copepods are generally referred to as omnivorous. Species of both families can be responsible for one to two thirds of the total energy flow through the carnivorous trophic level, and may consume nearly half of the vertical carbon flux. Thus, these meso- and bathypelagic copepods substantially affect pelagic-benthic coupling processes and, hence, may have a significant impact on carbon and energy fluxes in marine ecosystems.

A characteristic, but still enigmatic feature of Euchaetidae and Aetideidae is the co-occurrence of several to many closely related species in pelagic deep-sea habitats. For instance, 14 species of the genus *Paraeuchaeta* coexist in the Southern Ocean off South Georgia and also in the North Atlantic Rockall Trough. Since the pelagic deep-sea is an almost homogeneous environment without physical barriers, the sympatric co-occurrences of such closely related species raises the questions how the biodiversity of these deep-sea species evolved and what mechanisms effectively minimize inter-specific competition. Most deep-sea ecosystems depend on primary production in the thin euphotic surface layer of the ocean and the sinking of organic matter to deeper strata. Thus, resource limitation presumably represents an important factor in the evolution of meso- and bathypelagic species.

Therefore, the project focuses on differences in vertical distribution, life-cycle strategies, diet spectra and feeding behaviour of different co-occurring deep-sea copepods in order to characterise their distinct ecological niches in the deep-sea pelagic realm. The project contributes to an improved understanding of deep-sea biodiversity and evolutionary

patterns in general and, in particular, of the reasons and mechanisms sustaining a relatively rich meso- and bathypelagic fauna with a comparatively high biodiversity despite the limited food supply and in the absence of physical barriers. With these objectives, our project covers central issues of international marine biodiversity initiatives, such as Census of Marine Zooplankton (CMarZ) and Census of Marine Life (CoML).

Work at sea

While the primary focus of our DFG-funded project lies on Polar Regions, the Atlantic meridional transect during ANT-XXIV/1 provided an ideal opportunity for sampling deep-sea copepods throughout the Atlantic Ocean, effectively linking the two major study areas in the Arctic Greenland Sea and in the Atlantic sector of the Southern Ocean.

During ANT-XXIV/1 deep-sea copepods were sampled by MOCNESS and Multinet hauls at ten stations and sorted alive immediately after the catch in a cold container. About 1,200 specimens from at least 57 different species were collected and deep-frozen at -80°C for later molecular genetic and biochemical analyses in the home laboratory. Sampling concentrated on the two families Euchaetidae and Aetideidae, but additional species of deep-sea copepods including *Megacalanus princeps*, *Bradycalanus* spp., *Gaussia princeps*, *Pleuromamma* spp. and *Lucicutia* spp. were also collected. In particular, we were lucky to find individuals of some of those species also sampled in Polar Regions, e.g. *Gaetanus brevispinus*, *G. tenuispinus* and *Paraeuchaeta barbata*, for comparative molecular genetic analyses. The preliminary results indicate that several species of deep-sea copepods so far considered bi-polar or anti-tropical in their distribution are in fact cosmopolites, which inhabit greater depths in tropical and sub-tropical latitudes (tropical submergence). Because of the very limited sampling effort for pelagic deep-sea species in lower latitudes, their occurrence there may have been underestimated or overlooked so far.

Species of Euchaetidae and Aetideidae sampled during ANT-XXIV/1 will help to complete the phylogenetic tree of these families. A total of 485 frozen samples were collected and will be used for stable isotope and fatty acid biomarker analyses to study trophic level and dietary composition of deep-sea copepods from different latitudes.

3.6 Euphausiids

N. Copley, P. Wiebe
Woods Hole Oceanographic Institution

Objectives

Our objective on this cruise regarding euphausiids was to collect and identify as many different species from those that were to be found in the plankton tows in order to increase the number of euphausiid species that have been barcoded.

Work at sea

Some euphausiids were examined from all three fractions: formalin, ethanol, and live. The formalin split was not used for DNA analysis, so early in the cruise they provided a good source of euphausiids that could be examined at length in order to establish the species present. Once we became familiar with the species, we mainly sorted from the ethanol samples. These were most useful for submission to the on-board DNA barcoding effort because the live fractions could be looked at only briefly in order to keep their genetic material intact. Many of the specimens were photographed using the dissecting microscope and camera equipment provided by Cheryl Clark-Hopcroft.

Preliminary results

Euphausiids were identified from the first four MOCNESS stations with a total of 172 euphausiid specimens representing 23 species, more than 1/4 of all known species worldwide. Most of the euphausiids were found in the 1-m^2 MOCNESS samples, which collected in the top 1,000 m. Only three species were collected in the 10-m^2 MOCNESS and they were found in the shallowest net (1,000- 2,000 m) although not all nets were examined from the tows. Photographs of the specimens will be used as identification checks, for the web photo gallery and as material for the CMarZ species pages (see www.cmarz.org).

Measurements of eye and carapace lengths are the primary method of distinguishing *N. atlantica* from *N. microps*, two very similar species with overlapping distributions. This relationship was originally established using formalin preserved specimens and may not hold for animals in 95 % ethanol, in which they shrink significantly. The photos of *Nematoscelis atlantica* (Fig. 3.6.1) were used to record eye and carapace lengths of the ethanol specimens and will be used to compare with formalin data. The genetic analysis will be essential for validating this method of identification.

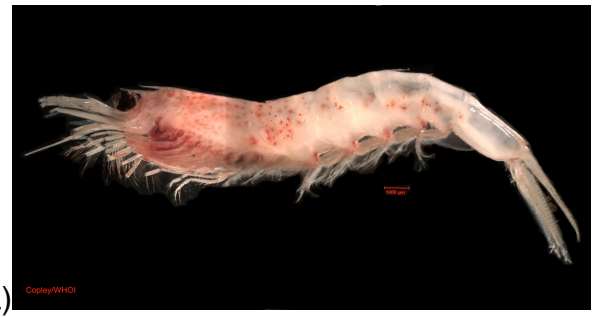
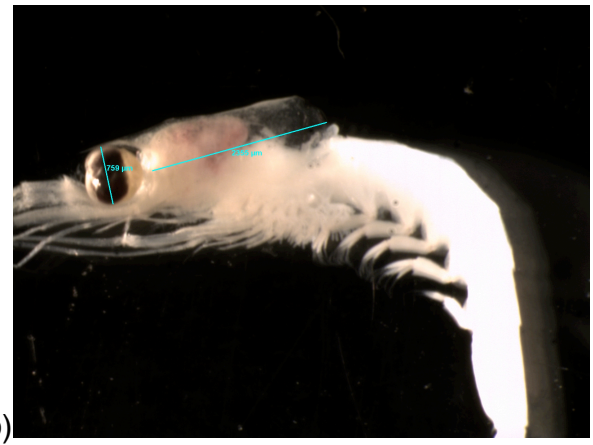
(a)  (b) 

Fig. 3.6.1: Thysanopoda tricuspidata (a) and Nematoscellis atlantica (b)

Tab. 3.6.1: List of the euphausiid species collected and identified, by station

Euphausiids	**station**							
species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Bentheuphausia amblyops		x				x		
Euphausia americana	x		x			x		
Euphausia gibboides			x			x		x
Euphausia hanseni	x		x					
Euphausia hemigibba/pseudogibba juv.	x							
Euphausia krohni	x							
Euphausia pseudogibba			x					
Euphausia tenera			x					
Nematobrachion boöpis		x	x			x		
Nematobrachion flexipes			x					
Nematoscelis atlantica		x	x			x		
Nematoscelis atlantica/microps	x		x					
Nematoscelis microps	x		x					
Nematoscelis tenella	x		x					
Stylocheiron abbreviatum	x	x	x					
Stylocheiron carinatum						x		
Stylocheiron elongatum	x							
Stylocheiron longicorne		x	x					
Stylocheiron microphthalma	x							
Stylocheiron suhmi			x					
Thysanopoda microphthalma		x						
Thysanopoda monocatha		x				x		
Thysanopoda obtusifrons						x		
Thysanopoda pectinata			x					
Thysanopoda tricuspidata			x			x		

Notes: Multinet station samples 4,5,7 were not examined
Station 8: Euphausiids not identified, sex/molt stage only (Buchholz)

3.6.1 Comparative studies of distribution, growth and reproductive status in euphasiids

F. Buchholz
Biologische Anstalt Helgoland in der Stiftung Alfred-Wegener-Institut

Objectives

In previous extensive ecological investigations of the West-African upwelling systems euphausiids, commonly known as krill, have been considered as important components of the zooplankton communities. In fact, krill – species can dominate the plankton by up to 60 % in biomass and consist of at least 8 principal species. Accordingly, their importance in specific neritic and pelagic food webs is high. Euphausiids have also served as water mass indicators. Consequently, horizontal distribution and some vertical distribution patterns have been recorded.

However, these previous investigations usually stopped short at a certain distance from the African coast or shelf. Nevertheless, due to the complicated current situation in the area there is a regular offshore export into the open Atlantic. The distribution patterns of the krill species will be evaluated with respect to this export along the planned transect. At the same time these patterns serve for a comparison with ongoing reseach in the shelf situation. Species distribution studies were flanked by detailed analysis of growth and reproduction by moult and reproductive staging of fresh specimens on board and of some adaptive traits in biochemical composition. Trophic relationships will also be considered on a comparative basis.

Work at sea

The major commitment was the deployment and maximisation of the $1m^2$ MOCNESS (MOC1) for the entire plankton group. The nine nets (330 μm) were used to differentiate vertical distribution of plankton down to 1,000 m as a composite of the depth steps of the MOC10 from 1,000 to 4,500 m. Research was focused on the horizontal and vertical distribution of the Euphausiacea and their physiological status in terms of growth and reproductive processes.

Preliminary results

In the four catches, euphausiid species were numerous, reflecting the high diversity of the sub-tropical and tropical situation (Fig. 3.6.1.1). MOC1 was deployed at night, in order to make use of the concentrating effect of vertically migrating krill. For the same reason, the larger species were predominantly studied as they are fast swimmers, able to hold their horizontal position against currents, and may thus be characteristic of specific regions. In fact, these were found in relatively larger numbers between 200 and 50 m at max. concentrations of 10 specimens per 1,000 m^3. *Euphausia gibboides,* with a mean body length of 23 mm (min. – max.: 16 - 26 mm), dominated at the Cap Verde station (002), the Equatorial station (003), the Angola Basin station (004) and the Benguela Basin station (005). Other larger euphausiids, considered tropical, were *Thysanopoda tricuspidata* at Station 003,

(body length 15 - 25 mm) and *T. monocantha* (body length 25 - 32 mm) co-occurred with *E. gibboides* at Station 004. At Station 005 *E. gibboides* dominated and was found alone close to the surface.

Euphausia hanseni (max. body length 27 mm) is considered as the species of reference with respect to the coastal upwelling systems, both North and South of the equator, from 25° N to 35° S and is thought to occur as far as 500 nm offshore. However, this species was not found in the four stations, possibly indicating that we met the open oceanic situation not having been influenced by offshore transports from the coast towards West. Conversely, it may be taken as a confirmation that *E. hanseni* is a coastal (but not neritic) species or a “continental slope species”. The latter attribute may be also true for other species e.g. *Meganyctiphanes norvegica,* which is also widely distributed but restricted to the shelf and fringe seas of the North Atlantic.

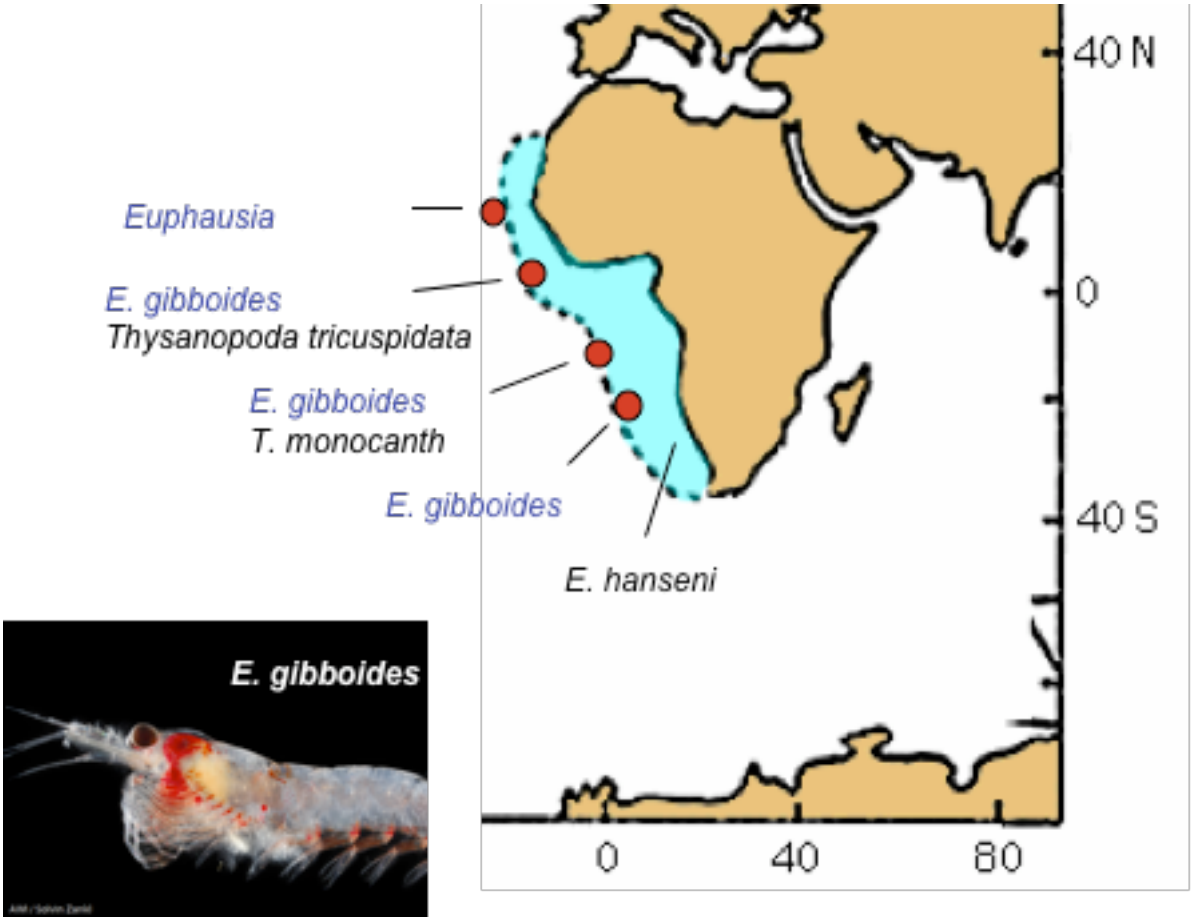


Fig. 3.6.1.1: Main occurrence of large eupahusiid species during ANT-XXIV/1

Physiology/Experiments

Euphausiids tend to moult synchronously. Furthermore, reproduction in terms of the ovarian cycle of egg production is timed with the moult cycle, where e.g. in *M. norvegica* two moult cycles accommodate one complete cycle of vitellogenesis and three consecutive spawning events. Specimens caught were kept live until staged for moult and reproductive phases. *E. gibboides* at the Equatorial station 003 showed clear moult synchronicity having just undergone an ecdysis. Ovarian stages indicated low reproductive activity. At the same location, *T. tricuspidata* females were all in immediate pre-spawn condition and were in intermediate moult stages indicating the usual timing of the two cycles.

It may be concluded that the trophic situation was apparently such that it supported both growth and reproductive activity in the two species. Conversely, moult and ovarian processes are coordinated as in the models *E. superba* and *M. norvegica* studied so far. Furthermore, moult synchronicity in a swarm has been confirmed in a tropical species for the first time.

3.7 Chaetognaths and Amphipods

A. C. Pierrot-Bults[1)], S. Kruse[2)], H. Miyamoto[3)]

[1)]Zoological Museum Amsterdam,University of Amsterdam
[2)]Alfred-Wegener-Institute, Bremerhaven
[3)]Ocean Research Institute, University of Tokyo

Introduction

The phylum Chaetognatha comprises about 80 pelagic species. In this paper we still use the genus *Sagitta* s.l. instead of the newly erected ones. The Atlantic fauna is less rich than the Indo-Pacific fauna and the cruise track (see Fig. 1.1) only covered oceanic waters. According to the literature we expected to find about 20 species. Amphipods comprise about 400 pelagic species, according to the literature about 150 occur in the South-east Atlantic.

Chaetognaths and amphipods were collected by various kinds of plankton nets including, MOC1, MOC10, and Multinet (see capter 3.1 and 3.2). Especially the sampling with MOC10 between near bottom and 1,000 m was expected to bring new insights as these bathypelagic layers are very seldom sampled.

Objectives

One of the main objectives was to sample live specimens for molecular and biochemical analyses.

The investigations of Svenja Kruse during this cruise included the Atlantic amphipod and chaetognath species taken from the surface down to 5,000 m water depth. As the focus of these studies lies on the carnivores of the Southern Ocean and their role in mesopelagic food webs, this cruise will give the opportunity to compare the

Antarctic data of different seasons with data of the Atlantic, as an extension of the Antarctic studies to the north. This sampling along a north-south transect in the Atlantic will reveal spatial distribution and composition of species especially of the chaetognath community. Additional biochemical analysis (e.g. fatty acid analysis) will give information on the investigated species' food composition. This information will contribute to the understanding of their role in the food webs in different parts of the Atlantic Ocean.

The main aim of Hiroomi Miyamoto during this cruise is to investigate molecular phylogeny and population genetic studies of pelagic Chaetognatha. Chaetognatha exclusively inhabit oceanic environments ranging from polar region to tropics and they are also known to occur in different vertical layers from the surface to the bathypelagic. They are one of the most abundant carnivorous zooplankton and play an important role in terms of organic matter and energy transfer in the ocean ecosystems. However, very little is known about the phylogenetic relationship of pelagic Chaetognatha. On the other hand, recent advancement of molecular biological techniques enables us to analyze the phylogenetic relationships based on the sequence variation of either mitochondrial or nuclear genomes. Among those genomes, the mitochondrial genome hold several favorable characteristics, including a high copy number of genomes in the cell, small genome size, maternal inheritance, lack of the intermolecular recombination, and, among others, a faster rate of evolution than is found in single-copy nuclear DNA which is the most important reason for its wide use in systematic studies. Recently, two complete mitochondrial DNA sequences of Chaetognatha have been reported independently (Papillon et al. 2004, Helfenbein et al. 2004). From their results, some unique characteristics have been revealed, those include extremely small size, lack of several genes, and frequent occurrence of gene rearrangement. Here, we are going to study the molecular phylogenetic relationship of pelagic Chaetognatha using the complete mitochondrial DNA sequences as a genetic marker.

The investigations of Annelies Pierrot-Bults were to study quantatively the horizontal and vertical distribution of Chaetognatha between the surface and > 4,000 m and included the identification and the fixation of live specimens for barcoding and for population genetic studies. Barcoding all known plankton species is one of the objectives of the CmarZ studies. Population genetic studies are carried out to illuminate the relationships of the different populations of the same species in different parts of their distribution area. A specific question is the true nature of so-called bi-antitropical or bipolar species e.g. *Sagitta maxima, Sagitta zetesios* and *Sagitta tasmanica*.

Hopefully barcoding will solve some questions of species validity in the genus Eukrohnia. For example whether *Eukrohnia bathyantarctica* which is reported from the North-Atlantic is the same species as the one found in the (sub)Antarctic or whether *E. bathypelagica* is a valid species.

Preliminary results

During this cruise 23 chaetognath species (Tab. 3.7.2) and about 35 amphipod species (Tab. 3.7.1) could be preliminary identified on board ship. In total 11084 specimens of chaetognaths and 380 specimens of amphipods were preliminary identified.

Svenja Kruse

The samples of the southernmost MOCNESS station (25°S 9°E) comprised typical Antarctic species such as the amphipod *Primno macropa*. Few amphipod species have unfortunately been found in sufficient number for biochemical analysis. Among those the species of the genera *Phronima*, *Lanceola* and *Scina* for instance were most frequently caught alive and in a good condition.

Among the chaetognaths the deep living species such as *Eukrohnia bathyantarctica*, *E. fowleri* and *Sagitta macrocephala* were sorted and immediately stored at -80°C. Other abundant epipelagic species e.g. *Sagitta hexaptera* or *Pterosagitta draco* have been additionally selected. Altogether eleven different chaetognath species were caught in sufficient numbers for biochemical analyses. The chaetognaths *E. bathyantarcica* and *E. hamata*, as well as the amphipod *Lanceola sayana* may be of special interest, as they also occur in the Southern Ocean. All samples taken during this cruise will be analysed in the home laboratories.

Hiroomi Miyamoto

In total, five genera with 23 species have been collected.

Chaetognatha individuals for molecular phylogeny and population genetic studies were identified under the light microscope without fixation. Then a small part of body tissue was cut out and fixed in 95 % ethanol. The rest of the body parts were preserved in formalin for further morphological analysis. Further analysis will be continued in the home institutions.

Tab. 3.7.1: Amphipod species identified during ANT-XXIV/1

Hyperiidea
Cranocephalus scleroticus
Cystisoma magna
Hyperietta sp.
Amphipods of the family Hyperiidae
Lanceola clausi
Lanceola sayana
Lanceola serrata
Lanceola pacifica
Lanceola sp.
Microphasma agassizi
Oxycephalus clausi
Oxycephalus piscator
Paraphronima gracilis
Parapronoe crustulum
Parapronoe sp.
Phronima atlantica
Phronima sedentaria
Phronima solitaria
Prhonima sp.
Phronimella elongata
Platyscelus sp.
Primno brevidens
Primno latreillei
Primno macropa
Scina crassicornis
Scina sp.
Streetsia mindanaonis
Streetsia steenstrupi
Streetsia sp.
Vibilia armata
Vibilia sp.

Gammaridea:
Cyphocaris anaonyx
Cyphocaris richardi
Eurythenes gryllus
Eurythenes obesus
Stenopleura atlantica
Amphipods of the family Eusiridae

Tab. 3.7.2: Chaetognath species identified during ANT-XXIV/1

Eukrohnia bathyantarctica
Eukrohnia bathypelagica (still debated)
Eukrohnia hamata
Eukrohnia fowleri
Eukrohnia macroneura
Heterokrohnia sp
Heterokohnia mirabilis
Krohnitta subtilis
Krohnitta pacifica
Sagitta enflata
Sagitta decipiens
Sagitta gazellae
Sagitta hexaptera
Sagitta lyra
Sagitta serratodentata
Sagitta minima
Sagitta sibogae
Sagitta maxima
Sagitta macrocephala
Sagitta planctonis
Sagitta zetesios
Sagitta bipunctata
Sagitta tasmanica
Pterosagitta draco

Annelies C. Pierrot-Bults

Chaetognath individuals were identified from live specimens and preserved in ethanol for barcoding, in aceton for population genetic studies, and in formaldehyde 4 % for further morphological studies. Three of the species e.g. *Sagitta maxima, Sagitta tasmanica* and *Sagitta zetesios* for the bi-antitropical studies were found. Unfortunately there were only enough specimens of *Sagitta zetesios* to carry out these studies. Fourteen abundant species were fixed for general population genetic studies and eighteen species were preserved for barcoding.

Heterokrohnia spec. might be new to science. Further analysis in the home laboratory has to be carried out to confirm the species.

In the southernmost station a few specimens of *Sagitta tasmanica* and *Sagitta gazellae* pointed to subantarctic influence.

In tow 3 net 1 there are significant more specimens per 1,000 m^3 water as in the deep layers of the other three tows.

Eukrohnia fowleri was not found in the two southern tows 4 and 5.

Heterokrohnia is mainly found below 2,000 m.

In the superficial layers tow 2 net 7 (50-25 m) was the most abundant of all samples with a number of 16,678 specimens per 1,000 m^3. However in the same tow net 6 (100-50 m) showed a much lower concentration than in the other tows.

The vertical distribution of the species was as expected, with a great concentration between 100 and 0 m because of the night sampling. The number of species in the MOC10 nets is low.

The preliminary results are shown in Appendix A.7 for the MOC10 and in Appendix A.8 for the MOC1.

Twelve chaetognath species were photogrphed for later reference.

References

Helfenbein K.G., Fourcade H.M., Vanjani R.G., Boore J.L. (2004). The mitochondrial genome of Paraspadella gotoi is highly reduced and reveals that chaetognaths are a sister group to protostomes. PNAS 101: 10639-10643.

Papillon D., Perez Y., Caubit X., LeParco Y. (2004). Identification of Chaetognaths as Protostomes Is Supported by the Analysis of Their Mitochondrial Genome. MBE 21: 2122-2129.

3.8 Pelagic fishes

T. Sutton
Harbor Branch Oceanograohic Institution (HBOI)

Objectives

- To quantitatively census the meso- and bathypelagic fish assemblages captured during midwater trawling in the eastern Atlantic from 11°N - 25°S.
- To provide accurate species identification of fish specimens for CMarZ barcoding.
- To obtain fresh fish specimens for the development of a molecular technique for the identification of rapidly digested gut contents, emphasizing the role of gelatinous zooplankton as prey for deep-pelagic fishes.
- To obtain fish specimens for five ancillary projects:
    - The vision of the stoplight dragonfish, *Malacosteus niger* (with Hans-Joachem Wagner, Uni. Tübingen, and Julian Partridge, Uni. Bristol) – fresh eyes needed for retinal histology studies.
    - Body size determination of deep-pelagic fishes as a function of muscle cell physiology (with Stephen Kinsey, UNC Wilmington) – frozen muscle needed for NMR spectroscopy.
    - Interrelationships of the whalefishes (Cetomimidae) (with John Paxton, Australian Museum) – specimens needed to confirm taxonomic revision.
    - Tissue Bank donation (with Ed Wiley, Uni. Kansas Center for Biodiversity).
    - Species resolution of the pearlside genus *Maurolicus* (Sternoptychidae) (with David Rees, Bergen Museum).

Work at sea

- 16 discrete-depth and 5 oblique tows with the 10-m^2 MOCNESS between 0-5000 m were analyzed completely – all fishes identified, measured, and converted to wet weight biomass (g).
- 32 discrete-depth and 5 oblique tows with the 1-m^2 MOCNESS between 0-1,000 m were analyzed completely – all fishes identified, measured, and converted to wet weight biomass (g).
- Target fishes for process studies were immediately removed, identified, and flash frozen or stored in 95 % EtOH for later analysis. All other fishes were preserved in 10 % buffered formalin for gut content analysis and/or museum deposition (Museum of Comparative Zoology, Harvard).
- 151 samples were flash frozen and 85 samples were preserved in 95 % EtOH for later molecular analyses (representing 57 species). Additionally, 2 sets of eyes from *Malacosteus*, two whalefishes, and one *Maurolicus* specimen were collected for ancillary projects.

Preliminary results

A total of 118 species were collected (1,778 specimens; 642.7 g wet weight biomass). Diversity was extremely high, as 16 orders, 36 families, and 78 genera were represented by these 118 species. As is the norm for bathypelagic sampling,

the bristelmouths (Gonostomatidae) of the genus *Cyclothone* dominated fish numbers, with *C. pallida, C. acclinidens, C. alba, C. pseudopallida*, and *C. obscura* representing 27.7 % , 13.4 % , 11.1 % , 6.4 % and 4.6 % of total numbers, respectively. No other fish taxon contributed more than 3 % In terms of biodiversity, the lantern-fishes (Myctophidae) contributed the most species (31), followed by the dragonfishes (Stomiidae, 14 spp.). Total numbers of both families would have been much higher if the top 1,000 m had been sampled with the 10-m^2 MOCNESS at night, as these fishes can easily avoid the 1-m^2 MOCNESS (based on a test sample during the CMarZ Sargasso Sea R/V Ron Brown cruise). Some of the remarkable catches include:

- The first known transforming female of the whalefish species *Cetostoma regani*. This specimen is eagerly awaited in Australia and the U.S., as it will be the key to unlocking the "Cetomimid/Miripinnid/Eutaeniophorid" mystery. This specimen proves that these three fish families are actually a single species (♀, ♂, and larva, respectively).
- Several species were taken that are only known from ten or fewer specimens worldwide: these include the slickheads *Leptochilichthys agassizii* and *L. pinguis*, the pearlfish *Maurolicus breviculus* (previously known only from the eastern tropical Pacific) and a female anglerfish *Neoceratias spinifer* with an attached male (Solvin may have the first live photo ever taken of this union.
- There were four putatively undescribed adults and one undescribed larval fish form.
- A total fish list in presented in Appendix A.9.

A clear reduction (an order of magnitude) in fish abundance/biomass was observed as the cruise track proceeded south (Fig. 3.8.1). These data will be correlated with physical oceanographic and plankton biomass/production observations.

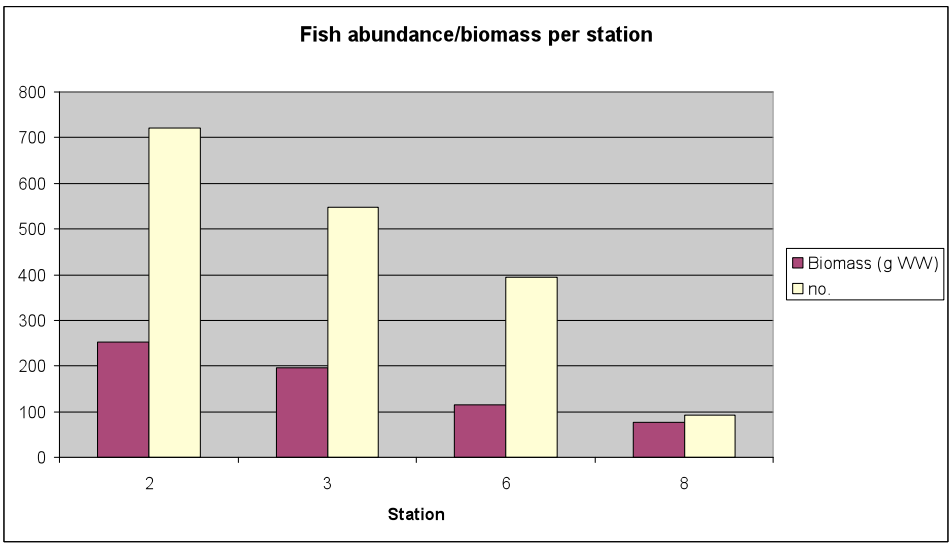


Fig. 3.8.1: Deep-pelagic fish catch totals by CMarZ station number

3.9 DNA barcoding-at-sea

A. Bucklin[1)], R. Jennings[1)], L. Nigro, P. Batta Lona[1)], L. Blanco Bercial[2)], C. J. Sweetman[3)], C. Folker*[4)]

[1)]University of Connecticut – Avery Point
[2)]Departamento de Biología de Organismos y Sistemas,Universidad de Oviedo
[3)]Harbor Branch Oceanograohic Institution
[4)]Deutsches Zentrum für Marine Biodiversitätsforschung

(*received barcoding training in the lab)

Objectives

1) to obtain and catalogue identified alcohol-preserved specimens of holo-zooplankton species;
2) to extract DNA from some specimens of all species obtained;
3) to determine DNA barcodes in the at-sea DNA sequencing laboratory; and
4) to return identified specimens in alcohol and extracted DNA in liquid nitrogen to UConn for continued analysis

Work at sea

Specimens submitted for DNA barcoding:
In all, 2,043 individual specimens were submitted for barcoding during the cruise. We catalogued specimens of 338 definitively-identified species of zooplankton (Table 3.9.1). Also included were specimens that were tentatively identified to another 51 species; additional specimens of each of these species were retained by the taxonomist for careful examination and later definitive identification.

Tab. 3.9.1: Summary of numbers of species for the major groups of zooplankton obtained for DNA barcoding during the CMarZ Polarstern Transit (October – November, 2007) and CMarZ cruise to the Sargasso Sea (April 2006).

Phylum	**Group**	***Polarstern Transit***	***Sargasso Sea***	***Both Regions***
Arthropoda	Amphipoda	14	11	2
	Cladocera	1	1	1
	Copepoda	139	148	60
	Decapoda	1	16	1
	Euphausiidae	23	20	11
	Mysidacea	0	6	0
	Ostracoda	74	60	35
	Chaetognatha	17	10	6
Cnidaria	Hydrozoa	0	17	0
	Scyphozoa	0	6	0
	Siphonophora	0	58	0

Phylum	Group	*Polarstern Transit*	*Sargasso Sea*	*Both Regions*
	Ctenophora	0	11	0
Mollusca	Cephalopoda	13	5	2
	Gastropoda	41	48	19
Urochordata	Larvacea	0	12	0
	Thaliacea	15	11	5
TOTALS		**338**	**440**	**142**

Identified specimens for DNA analysis were preserved in undenatured 95 % ethanol. Species were identified using a dissecting or compound microscope, as necessary. The taxonomists took special care to minimize heat and light during microscopic examination of the specimens to preserve DNA quality for analysis. For species smaller than ~25 mm, the entire specimen was consumed for DNA sequencing, with one or more additional intact individuals retained as specimen vouchers. For larger organisms, small portions of specimens were excised and used for analysis.

DNA extraction: During the cruise, DNA was extracted and purified for a total of 1,018 individual specimens. A Qiagen DNeasy Kit was used to extract DNA following standard protocols. Tissue is dissected under sterile conditions and digested with proteinase K until no solid pieces of tissue were visible. Purified genomic DNA is eluted in Buffer AE (supplied in the DNeasy Kit) with two elutions of 75 uL each.

PCR amplification: A total of 190s PCRs were successfully carried out during the cruise. A 708 base-pair region of the mitochondrial cytochrome oxidase C subunit I (COI) gene was amplified using “universal” reaction parameters and consensus PCR primers from Folmer et al. (1994). The PCR reactions were carried out in one of three thermal cycler machines: an Applied Biosystems, Inc. ABI 9600 and two Perkin-Elmer 480 machines. PCR templates were checked for quality by electrophoresis and the results were visualized under UV light to detect and diagnose the PCR results.

DNA sequencing-at-sea: Successful PCR products were purified prior to sequencing using a Qiagen PCR Cleanup Kit and manufacturer’s protocols. The purified template DNA was eluted in Buffer EB (10mM Tris). The reaction cocktail used ABI BigDye 3.1 Terminator sequencing chemistry. The reactions were one-half standard volume (1/2X) for the PE-480 or one-quarter volume for the ABI 9600 thermal cycler. The sequences were read by a 4-capillary ABI 3130 DNA Sequencer, using a 50 cm capillary array and standard operating conditions. A one-hour electrophoresis time was sufficient to determine a 500 - 700 base-pair sequence. Sequencing was done from each end of the DNA template for bi-directional coverage of the COI gene fragment.

Preliminary data analysis: DNA sequences were checked for accuracy by importing into the Molecular Evolutionary Genetic Analysis (MEGA) programme (Ver. 4.0). Text files were exported for alignment in CLUSTAL-X and preliminary examination for

artifact and error by cluster analysis in MEGA. The definitive quality control check and analysis will be done at UConn using the Abi Sequencer software package protocols. The DNA barcode for a given species is the DNA sequence for one individual, selected among the sequences for at least three individuals per species. Each DNA barcode must be supported by a bi-directional sequence read for at least one specimen.

Return shipping of specimens and DNA: The DNA samples and identified specimens in small vials of alcohol are being shipped by air to the University of Connecticut for further analysis and determination of additional barcodes.

Preliminary results

The DNA barcoding lab determined 122 DNA sequences of the targeted barcode region for 66 species. The barcodes are displayed in a cluster diagram, which clearly resolves the diverse taxonomic groups of zooplankton (Fig. 3.9.1).

The barcode results will be summarized for publication and including in manuscripts in preparation on target groups. Target dates for completion of barcode data set, submission of the sequence data to GenBank, publication and public release of the data will be discussed with all cruise participants. Authorship of planned collaborative publications will be discussed with the taxonomists who submitted specimens for barcoding as desired.

The *Polarstern* transit cruise was an excellent opportunity for CMarZ to complete a comprehensive biodiversity assessment of the eastern Atlantic – the first dedicated CMarZ survey cruise in the Southern Hemisphere. The cruise allowed us to make significant progress toward a primary CMarZ goal of a comprehensive DNA barcode database for zooplankton species throughout the world oceans. The total numbers of species and the balance among the major groups of holozooplankton reflects both the diversity of the pelagic community and the expertise and interest of the taxonomists onboard. The numbers of species collected and submitted for barcoding during the *Polarstern* transit were similar to a previous CMarZ cruise to the Sargasso Sea (Northwestern Atlantic) during April 2006, although the balance across taxonomic groups differed somewhat.

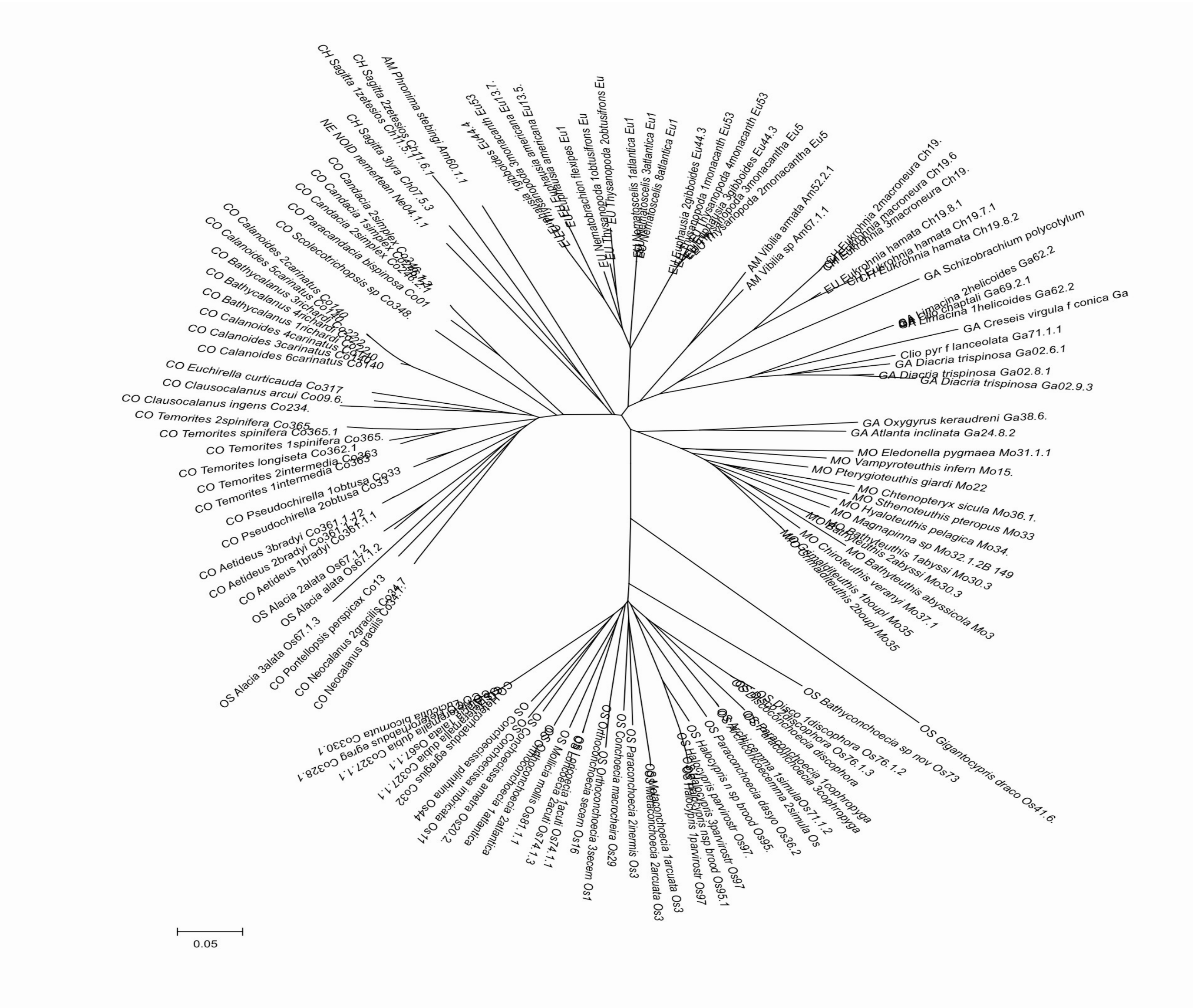


Fig. 3.9.1: Cluster analysis of 122 DNA barcodes for 66 species of holozooplankton collected during the Polarstern transit. This preliminary analysis is used for barcode evaluation and validation, and for identification of artefactual sequences. The barcode cluster resolved the major taxonomic groups of zooplankton. The several sequences that cluster with different taxa will be examined for accuracy and validity.

The DNA barcodes for zooplankton determined on this and other CMarZ cruises will be used for: 1) rapid and accurate identification of known species, 2) recognition of cryptic species and taxonomically-significant geographic variation, 3) discovery of new species, 4) identification of larval and adult life stages of a given species, and 5) identification of prey species in the gut contents of predators.

References

Folmer O., Black M., Hoeh W., Lutz R., Vrijenhoek R. (1994). DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. Mol. Mar. Biol. Biotechnol. 3(5): 294-249.

3.10 Zooplankton metagenomics

R. Machida
Ocean Research Institute, University of Tokyo (ORI)

Objectives

Among the biological components of the ocean ecosystem, zooplankton plays critical roles in energy and matter transfer through the system. However, our understanding of zooplankton biodiversity is very limited because of the fragility, rarity, small size, and systematic complexity of many taxa. Here we present the analysis of zooplankton metagenomics, which exhaustively determines the mitochondrial COI gene sequences from bulk zooplankton samples. This approach will enable us to compare the species richness of zooplankton communities. Advantage of this analysis is that we can acquire almost all metazoan mitochondrial COI gene sequences. However, we do not have the species information of those sequences because the starting template of the analysis will be extracted from bulk zooplankton sample. Therefore, we will further compare the zooplankton metagenomic sequences and DNA barcoding sequence, and try to estimate the species information of those sequences. From the zooplankton metagenomic analysis, we will also obtain sequences of those DNA barcoding have not finished. We are now constructing the database to open those sequences to public.

Work at sea

Samples for zooplankton metagenomic analysis have been collected using MOC1, Net0. After the sample collection, seawater was removed and the sample transferred to RNALater (Ambion). Further analysis will be continued on land.

Preliminary results

In total, four samples from all MOC1 sampling stations were collected.

Station (position)	Collection date, time	Volume of the sample
4 (11 22N; 20 21W)	08 Nov. 2007, 19:20	about 120ml
5 (03 12N: 14 36W)	11 Nov. 2007, 19:39	about 100ml
8 (13° 24S: 00 38E)	17 Nov. 2007, 19:13	about 150ml
10 (25° 32S: 09 44E)	21 Nov. 2007, 19:00	about 80ml

3.11 Media outreach programme

C. Clarke-Hopcroft
Institute of Marine Science
University of Alaska

Photographic documentations of approximately 90 indvidual animals from a variety of different groups including copepods, amphipods, pteropods, cephalopods, decapods, euphausids and salps were made during this CMarZ cruise. Large numbers of ostracod and chaetognath specimens were photographed and several new species were documented. We even have some photographs of “castaway” barnacles that were found floating in rafts. These photographs will add to the growing CMarZ library of zooplankton photographs and many will be included on the CMarZ webpage and species pages (see www.cmarz.org/gallery).

4. BIO-OPTICAL MEASUREMENTS: GROUND-TRUTHING FOR SATELLITE OBSERVATIONS

B. Schmitt, L. Bentama[1)], S. Gehnke[2)]
[1)]Alfred-Wegener-Institut, Bremerhaven
[2)]GKSS Forschungszentrum Geesthacht
Not on board: A. Bracher (AWI), R. Röttgers (GKSS)

Objectives

It has been estimated that marine phytoplankton contributes 30 to 60 % to the global primary production. The large uncertainty range is a result of the lack of global information on phytoplankton absorption and light penetration depth, which cannot be supplied by the current ocean colour satellite sensors. The spectral resolution of these sensors is not sufficient to extract the relevant information. The variation of phytoplankton absorption in ocean waters also affects the retrieval of chlorophyll *a* concentrations (a measure of phytoplankton biomass) derived from satellite data, which are important input data used in primary production models. Results by Bracher et al. (2006) show that specific phytoplankton absorption spectra as well as information on the light penetration depth can be derived by combining information from measurements of the two satellite instruments, MERIS with high spatial, and SCIAMACHY with high spectral resolution (both operating on board of the European environmental satellite ENVISAT).

Field measurements in the open ocean of phytoplankton pigment composition, optical characteristics of phytoplankton and other water constituents, reflectance and underwater light measurements are highly precise input parameters for the validation of results from the analyses of satellite data and modelling.

The aim of this research project is to improve estimates of global marine primary production and the distribution of major phytoplankton functional groups by using remote sensing data in combination with *in-situ* measurements of ocean optics, phytoplankton productivity and composition and particulate organic carbon (POC). In particular, data will be collected during this cruise to improve our understanding of the oceans variability in optical properties and to improve/develop remote sensing algorithms for the investigated research area. Algorithms to retrieve POC from space are still very basic, but are of great importance for studies concerning biogeochemical cycles and the biological pump within the world's oceans because carbon and not chlorophyll are the bases for those studies. Through a better knowledge of the sinks and sources of CO_2 in the ocean a contribution will be made to a better understanding of changes in the world's climate as well as to the understanding of the marine food web.

Work at sea

1. Water samples

Water samples were taken frequently (approximately every 6 hours, two dark and two light samples) from beneath the ship (moon pool). Sampling times were closely coordinated with the group from Lancaster to allow analysis of possible correlations between our data in the future.

Water samples were processed for various analyses:

- Filtered onto GF/F filters for analysis of pigments, total suspended matter, POC and particulate absorption measurements.
- Preserved for flow cytometry measurements later in the laboratory in Bremerhaven.
- Particulate absorption in suspension and absorption of Gelbstoff were measured during the cruise using the point-source integrating-cavity absorption meter (PSICAM) (Röttgers et al. 2005).

2. Online and *In-situ* Optical Measurements

- A FASTtracka Fast Repetition Rate Fluorimeter (FRRF) was used in a flow-through system with water continuously pumped from the moon pool to provide online data of chlorophyll fluorescence during the cruise. A second FRRF was deployed at the stations to 100 or 150 m to measure fluorescence in the water column.
- Remote sensing reflectance was measured firstly from onboard the ship with a set of three radiometers for a few hours per day, when the conditions were not cloudy and secondly in the water column (0 - 100 m) at the stations.

Preliminary results

Data from FRRF and PSICAM

At the start of the cruise we measured higher chlorophyll concentrations when crossing the English Channel, then concentrations rapidly sank to near detection limit of our equipment (Fig. 4.1). On 06.11.07 a sandstorm reached the ship and fluorescence of particles peaked for a few hours. After crossing the equator on 13.11.07 chlorophyll concentrations (Chl) started to rise probably due to upwelling systems in the region and – besides a small depression for a few days – did not diminish until the end of the sampling on board.

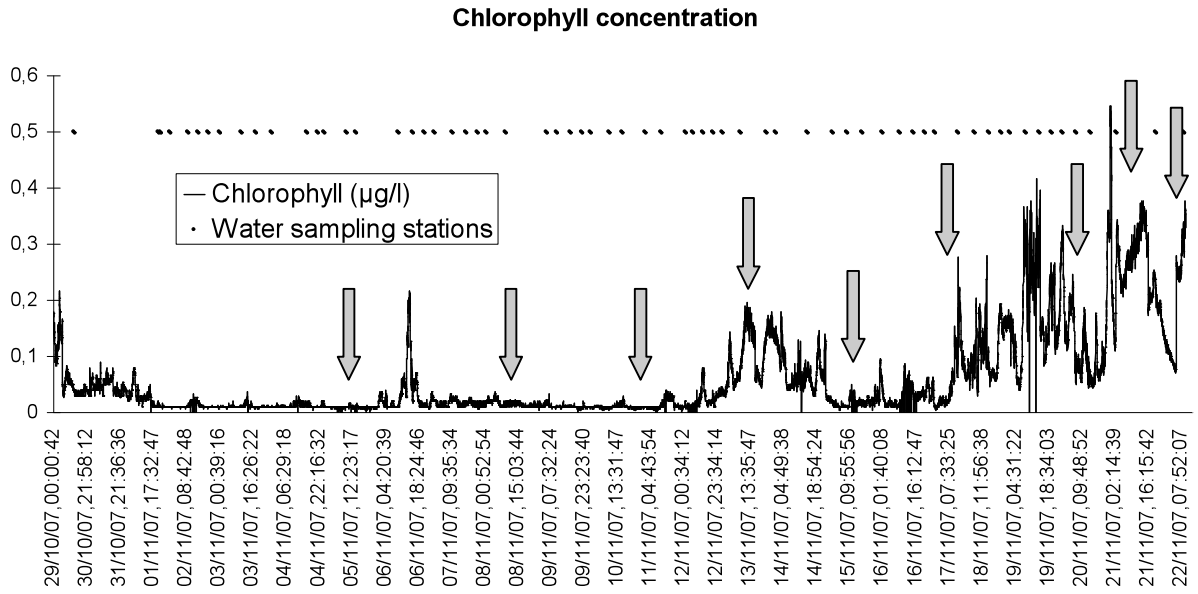


Fig. 4.1: Chlorophyll concentration during the Polarstern cruise ANT-XXIV/1 measured by Fast Repetition Rate Fluorimeter (FRRF), preliminary uncorrected data, arrows indicate stations 1-9

The absorption measurements with the PSICAM corroborate generally with the FRRF data. Fig. 4.2 shows the Chl absorption for the two absorption peaks of Chl *a* in the Atlantic south of Las Palmas. These results still have to be corrected for instrument settings and calibrations.

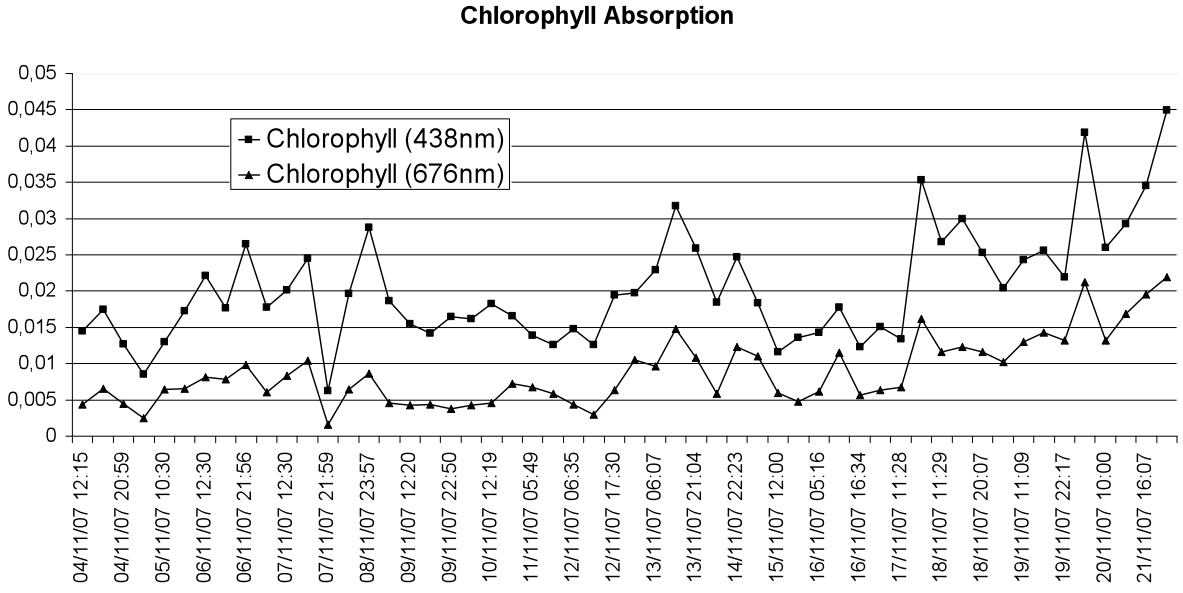


Fig. 4.2: Chlorophyll a absorption in water samples measured by Point-source Integrating-cavity Absorption Meter (PSICAM) during Polarstern cruise ANT-XXIV/1

Additionally, water samples were filtered and the frozen or dried filters will be transported to the home laboratories for further analyses of pigments by high-performance liquid chromatography (HPLC) and fluorometry, particulate absorption, total suspended matter (TSM) and particulate organic carbon (POC). Water samples were also preserved for analysis by flow-cytometry.

Combined with satellite pictures of the sampling sites, this range of analyses and *in-situ* measurements will hopefully give a detailed picture of the surface phytoplankton community in the Northern and Southern Atlantic.

References

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Röttgers R., Schönfeld W., Kipp P.-R., Doerffer R. (2005). Practical test of a point-source integrating cavity absorption meter: the performance of different collector assemblies. Applied Optics 44(26): 5549-5560.

5. PERSISTENT ORGANIC POLLUTANTS (POPS) IN AIR AND WATER

J. Barber[1)], C. Benskin[1)], C. Moeckel[1)]I, J. Schuster[1)], S. Gehnke[2)]

[1)]University Lancaster

[2)]GKSS Forschungszentrum Geesthacht

Objectives

Building on results obtained during a previous *Polarstern* Bremerhaven to Cape Town transfer cruise in 2005, scientists from Lancaster University and GKSS carried out air and water sampling during ANT-XXIV/1, to allow further investigation of the roles of proximity to land masses and oceanic properties, on the global distribution of persistent organic pollutants (POPs). An exciting observation on the 2005 cruise was the discovery of a possible link between diurnal cycling of POPs in air over parts of the open ocean, and biological processes in the sea, which could be controlling these phenomena. Another important finding was the unexpected presence of high levels of POPs around the Mauritania area of Western Africa. The hypothesis of the biological pump influencing the atmospheric and seawater concentrations has been investigated further by collecting air and water samples in parallel with biological measurements, such as oceanic chlorophyll pigment concentrations and fluorescence levels, being recorded by another research group onboard. Intensive air and water sampling was carried out in regions of the ocean in the North Atlantic (8-0°N) and in the South Atlantic (0-20°S). New sampling equipment was being used for the first time to take shorter duration, and thus more temporally resolved, air and water samples which will allow better observation of diurnal cycles in air and water pollutant concentrations. Also on the ANT-XXIV/1 cruise we collected air and water samples to be analysed for perfluorinated compounds (PFCs), a newly emerging class of chemical contaminants, whose global distribution is currently poorly understood.

Work at sea

Air and water samples were collected onboard the *Polarstern* for analysis back in the labs at Lancaster University and GKSS. Different methods were employed for sampling of POPs and PFCs. Air samples for analysis of POPs were collected using four high-volume air samplers, including two new machines with improved air sampling capacity. Air samples were collected by aspirating air through a glass fibre filter and polyurethane foam plugs to collect chemicals in the particulate and gas phases, respectively. Samples were collecting over 12-h and 6-h intervals. Air samples for analysis of PFCs were collected using two high volume air samplers, in a similar method to that described above, except that an additional layer of sampling

material, consisting of 25 g of XAD-2 resin, was employed to help trap the more volatile chemicals from the gaseous phase. Additionally, air sampling modules were spiked with recovery standard prior to deployment. Samples were collected over 24-h and 72-h intervals for analysis of high and low abundance PFCs.

Water samples for analysis of POPs were collected from the ship's Teflon line which draws from the sea at a depth of 3 m. Samples were collected by drawing water through an *in-situ* pump containing a large glass fibre filter and a glass column containing PAD resin, to collect chemicals in the particulate and dissolved phases, respectively. Water was sampled at around 1-1.4 l/min, in order to achieve a sample volume of around 700 l in the desired 12 h sampling period. Samples were taken using two sampling devices, with one running throughout the whole sampling campaign, and the other used occasionally for duplicate or offset (by 6 h) sampling. Additionally, water was sampled passively using semi-permeable membrane devices (SPMDs) deployed in a system of two flow-through water tanks. 4 SPMDs were deployed simultaneously to ensure enough sampling material was present to collect all the dissolved POPs. Samples were collected over 5 day periods. Water samples for analysis of PFCs were collected from the ships stainless steel line which samples from the sea at a depth of 11 m. 2 l of water was drawn from the line into a glass bottle and filtered through a small glass fibre filter to collect particulate phase PFCs. The filtrate was collected, spiked with recovery standard, and then passed through a solid phase extraction (SPE) cartridge to collect dissolved phase PFCs. Cartridges were then cleaned by eluting with 5ml of formic acid solution, and dried. These were then sealed in aluminium foil packets, for extraction at a later date. Air and water samples were stored in the onboard cold room at -20 ºC and 4 ºC respectively, and will be extracted and analysed by gas chromatography and liquid chromatography mass spectrometry (GC-MS and LC-MS) after they have been shipped to Lancaster University and GKSS.

Samples for analysis of dissolved organic carbon (DOC) content were drawn from the moon pool, which draws water from beneath the ship. 15 ml samples were gently pushed with a pre-cleaned syringe (rinsed with hydrochloric acid, sodium hydroxide, Milli-Q water and seawater) through a pre-rinsed filter (rinsed with Milli-Q water and seawater), in order to remove particulate organic carbon (POC) including cells, and collected in a specially pre-treated glass ampule. Concentrated hydrochloric acid was added to the filtered sample to preserve its state, and the ampule was sealed by melting with a Bunsen burner. Samples were frozen at an angle of 45 º and then stored at -20ºC until analysis. Analysis of these samples will be carried out at AWI.

Preliminary results

For analysis of POPs, a total of 33 paired 6h air samples and 26 paired 12-h air samples were collected between 26 ºN and 25 ºS, in order to investigate the the location of sources of pollutants on the African mainland and diurnal cycling of POPs. Approximately 400 m^3 of air were collected over 6 h per 'new' sampler compared with 200 m^3 of air over 12 h per 'old' sampler. The increased sampling frequency from

every 12 h to every 6 h compared with previous studies should lead to a better understanding of the cycling of POPs between air and water over the open ocean. Interestingly, Saharan dust was found on the air filters over a 4 day period between 22 ºN and 8 ºN. Prior to the main sampling campaign, 12-h air samples were collected six times with the 4 samplers positioned at different locations on the ship, in order to verify that the ship was not acting as a source of pollutants. 6 passive air samplers were deployed at different locations around the ship for the duration of the cruise also with this aim in mind.

A total of 36 12-h water samples were collected for analysis of POPs. 12-h samples were collected once per day from 26 ºN to 8 ºN, after which two consecutive 12h (day/night) samples were collected each day from 8 ºN to 25 ºS. This diurnally split water sampling will enable us to determine whether the diurnal POP concentration cycling previously observed in air also occurs in the sea. During this second sampling period, 3 duplicate samples and 5 samples offset by 6 h (i.e. sampling a different but overlapping 12-h time interval to the other sampler) were taken with the 2nd sampler. Additionally, a total of 6 integrated 5 day passive water samples were collected with SPMDs between 45 ºN and 26 ºS. A total of 64 DOC samples were collected between 30 ºN and 26 ºS, at 6-h intervals. These samples will enable us to tell whether any diurnal cycle in water concentrations can be related to changes in DOC concentration.

For analysis of PFCs, a total of 31 24-h and 12 72-h air samples were collected in parallel between 50 ºN and 15 ºS. Approximately 400 m^3 and 1,200 m^3 of air were collected in a 24-h and 72-h sample, respectively. A total of 42 water samples were collected for analysis of PFCs from between 46 ºN and 26 ºS. Sampling effort was greatest in the source areas of the Northern Hemisphere, and lowest in the more pristine Southern hemisphere, i.e. 3 samples were collected per day north of Las Palmas, 2 samples were collected per day between Las Palmas and the Equator, and one sample per day was collected south of the Equator. Air and water concentrations of PFCs determined along the latitudinal transect during this cruise will be the first spatially resolved data for the Atlantic Ocean.

6. THE ATMOSPHERE/OCEAN INTERSECTION

A. Wassmann, Y. Zoll
Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR)
Not on board: Andreas Macke (IFM-GEOMAR)

Abbreviations

AOT – Aerosol Optical Thickness
IASI – Infrared Atmospheric Sounding Interferometer
IWV – Integrated Water Vapor
ITCZ – Inter Tropical Convergence Zone
LWP – Liquid Water Path
MORE – Meridional Ocean Radiation Experiment
IASI – Infrared Atmospheric Sounding Interferometer

Objectives

Clouds remain one of the biggest obstacles in our understanding of the coupled ocean-atmosphere climate system. Even under realistic forcing from observed wind, humidity and pressure fields climate models have difficulties to reproduce the correct spatial and temporal climatology of cloud cover. Because of the strong inhomogeneity of cloud pattern on those scales that are relevant for the radiative transfer processes it is obvious that subgrid-scale processes must be accounted for in radiative transfer parameterizations. Combined observations of cloud physical and radiative properties are a key to adjust or to validate such parameterizations.

In 2003 the Meridional Ocean Radiation Experiment (MORE) was initiated by S. Gulev and A. Macke as a joint initiative of the P. Shirshov Institute of Oceanology (IORAS) and the Leibniz-Institute for Marine Sciences IFM-GEOMAR. The research goal is to conduct long-term measurements of surface energy fluxes above the ocean at mid-latitude, subtropical and tropical conditions with an emphasis on the role of the cloudy atmosphere on the short wave (SW) and long wave (LW) radiation fluxes. A further objective is to provide validation data for temperature and humidity profiles from the new infrared sounding interferometer IASI onboard the first European polar orbiting operational weather satellite MetOp.

Work at sea

The *Polarstern* cruise ANT-XXIV/1 from Bremerhaven to Cape Town in November 2007 was utilized for the 7th MORE cruise, for a validation project POLARSTERN/IASI in collaboration with EUMETSAT and as preparation for a new project OCEANET starting in January 2008.

In addition to meteorological standard equipment (including a pyranometer) on board *Polarstern* a set of a pyrano- a pygeogeometer was installed to overcome shadowing effects of the mast in the shortwave and to receive thermal downwelling radiation. To automatically obtain the cloud coverage and cloud type a whole sky imager, manufactured at IFM-GEOMAR, took pictures of the sky every 15 seconds. This enables a detailed analysis of the impact of clouds on the radiation budget at the sea surface as well as an allocation of liquid water path (LWP) to different cloud types or in clear sky cases a determination of a possible LWP-bias of the corresponding LWP algorithm (see below).

As initiated during the previous transect ANT-XXIII/10 in April 2007, a multi-channel microwave radiometer (HATPRO, Radiometer Physics), has been installed for continuous measurements of atmospheric temperature and humidity profiles as well as LWP and water vapour integrated over a column in the atmosphere (IWV).

Together with sun photometer measurements of aerosol optical thickness the data from the microwave radiometer provide a unique information set for interpretation of the amount of downwelling solar and thermal radiation at the sea surface.

In addition to the continuous profiling by means of the HATPRO microwave radiometer, radiosondes have been launched whenever *Polarstern* was in the field of view of the IASI instrument onboard the polar orbiting meteorological satellite MetOp.

Preliminary results

Figures 6.1 and 6.2 show the overall time series of the temperature and relative humidity profiles as retrieved from the microwave radiometer, starting on October 27, 2007 at the entrance of the English Channel and ending on November 23, 2007 off the cost of South Africa.

During the cruise climatologically and synoptically different regimes have been crossed: while leaving the English Channel in the mid latitudes around October 28 a low pressure system passed by with heavy winds and rain. The corresponding parts of the profiles show the disturbance of the microwave measurements due to precipitating clouds that are not accounted for in the retrieval, this is particularly true for the humidity profile.

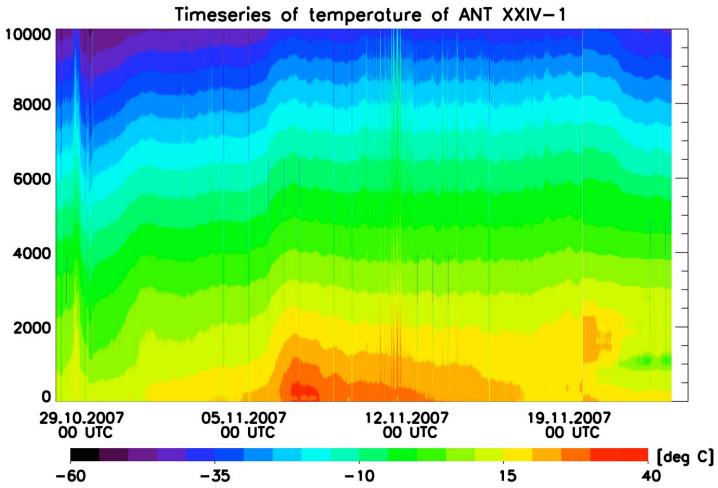

Fig. 6.1: Time series of temperature profiles during ANT-XXIV/1

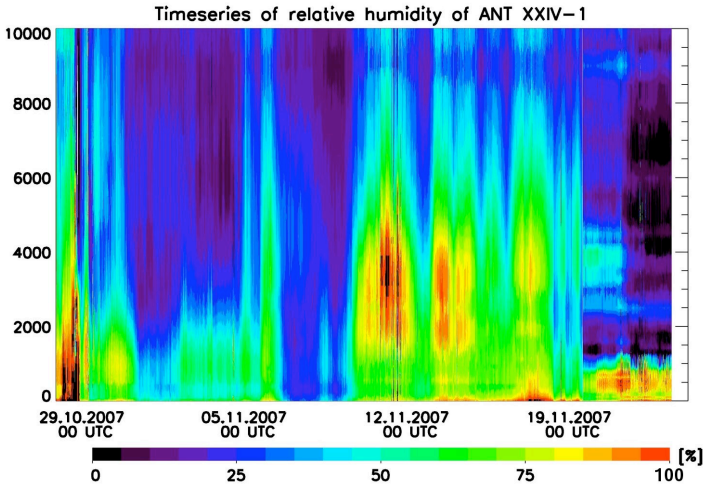

Fig. 6.2: Time series of relative humidity profiles during ANT-XXIV/1

Steaming along the coast of West Africa Saharan dry air packed with dust and insects (Fig. 6.3) completely changed the properties of the atmosphere.

Fig. 6.3: Red-brown dust and dragonfly brought by dust event

As shown in the profiles from November 6 to November 8 the relative humidity dropped to around 25 % throughout the entire atmospheric column and the temperature increased significantly. The dust carried in the atmosphere is best seen by regarding the aerosol optical thickness (AOT) at visible wavelengths in Fig. 6.4. Occasional spikes in the AOT time series result from cirrus clouds or partial cloudiness in the instruments field of view.

The AOT starts increasing with the beginning of the dust event on November 7 and remains at a high level until the end on November 9, where the AOT decreases.

Approaching the ITCZ around November 11 the atmosphere becomes more humid due to the deep convection. Travelling further south the temperature and humidity decreases again caused by subsiding air masses typical for subtropical regions. Crossing the different climatic regions can also be seen in Fig. 6.5 where the IWV increases towards the tropics due to the warmer air that carries more water vapor.

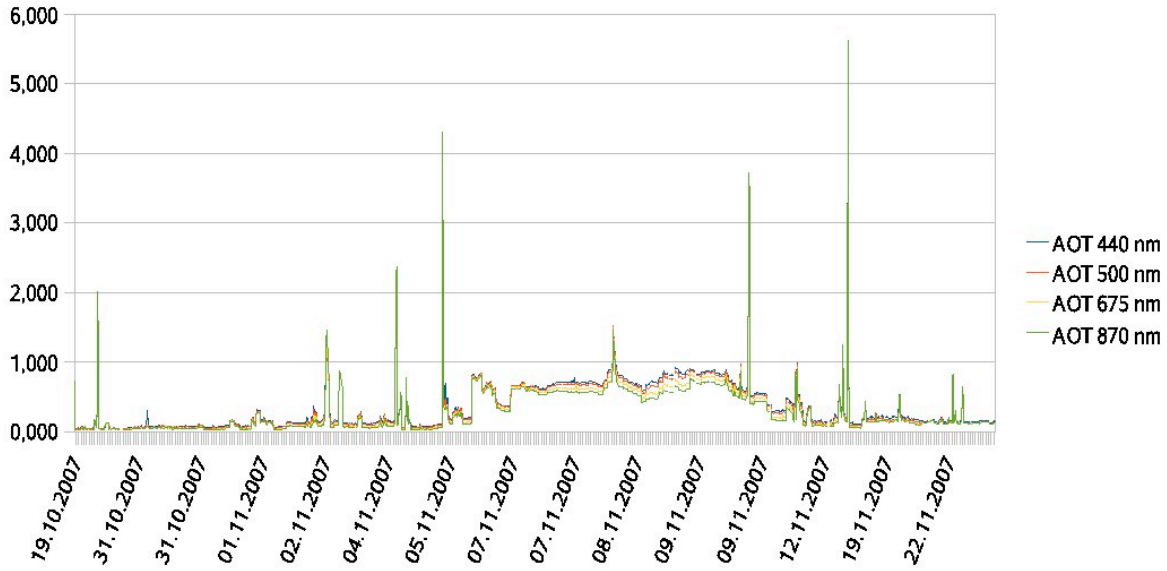

Fig. 6.4: Aerosol optical thickness during ANT-XXIV/1

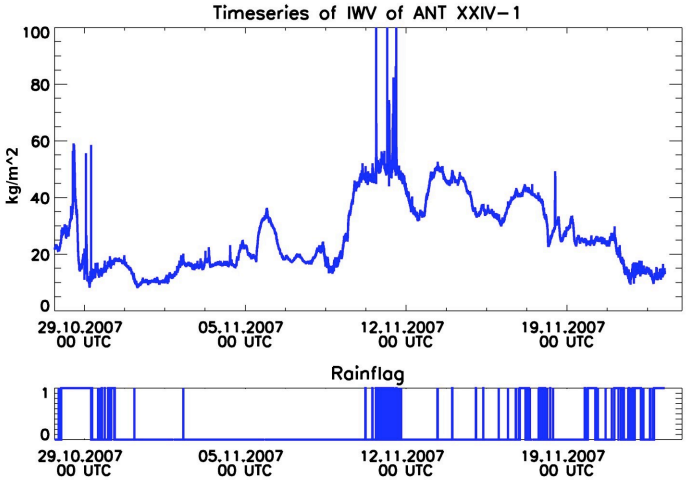

Fig. 6.5: Time series of integrated water vapor during ANT-XXIV/1

The cruise has been used to further improve the retrievals for temperature, humidity, IWV, and LWP. The old retrievals delivered with the radiometer are optimized for a mid-latitude coastal station. Thus new maritime retrievals for on board operation are necessary and latitudinal dependency considering the climatologically different regimes has to be included. To this end, a 25 year climatology of radiosonde data from *Polarstern* and from island stations have been utilized to train microwave retrieval algorithm that are more specialized to marine tropical, subtropical, and mid latitude conditions. In Fig. 6.6 the improvement by the new temperature and humidity retrievals (green) is shown compared to the original retrieval (blue). The resulting values of temperature, relative humidity, and absolute humidity are plotted against the corresponding values from the radiosonde ascend, which is used as truth.

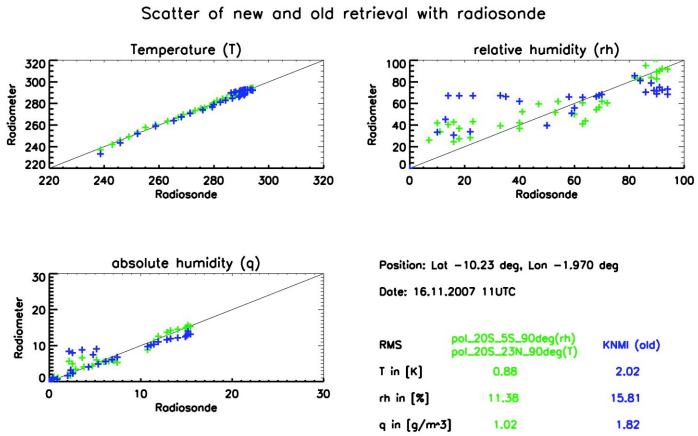

Fig. 6.6: Improvement of the temperature and humidity retrievals

Finally, radiosonde profiles of temperature and relative humidity have been compared to co-located satellite based atmospheric soundings from the IASI radiometer on board MetOp which is exemplified in Fig. 6.7 for November 17. The IASI profiles (blue) fit well to the radiosonde profiles (red) with decreasing height in case of temperature to approximately 800 hPa. As can be seen in Fig. 6.7 the black horizontal line denotes the height of a backscatter signal of a device for detecting cloud bottom heights (derived from the onboard ceilometer) which shows the presence of clouds. Due to the fact that clouds are opaque in the infrared spectrum, in opposite contrast to the microwave spectrum, the radiosonde profile is well reproduced by IASI above the cloud top. In case of the relative humidity profile the IASI profiles overestimate the radiosonde data.

Fig. 6.7 also shows a good accordance between the radiometer and the radiosonde in case of the temperature profile. For relative humidity the radiometer profile fits the shape of the radiosonde despite discrepancies close to the ground and in approximately 800hPa.

Two IASI profiles exist for both temperature and relative humidity due to the fact that IASI provides four profiles for each. The criteria for the number of chosen profiles is that the position of the IASI profiles is close that of the radiosonde release and a certain number of dummy values is not to be exceeded.

In summary, the atmospheric profiling during ANT-XXIV/1 has been very successful. For the first time, to our knowledge, a complete time series of humidity and temperature profile has been taken during a ship based meridional transect.

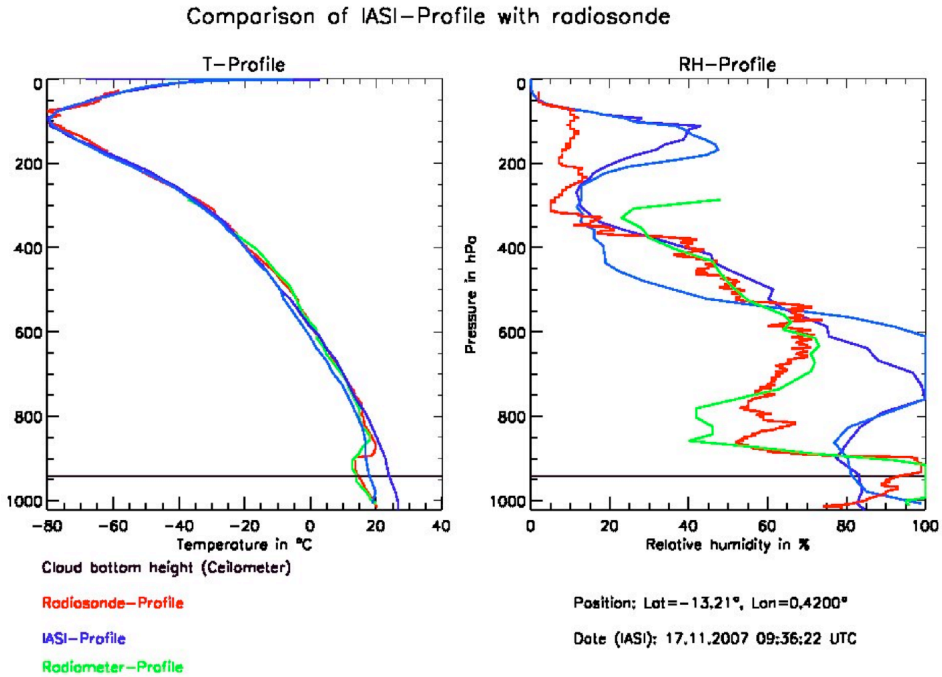

Fig. 6.7: Comparison of temperature and relative humidity profiles of IASI (blue), radiosonde (red) and radiometer (green)

7. MAX-DOAS-MEASUREMENTS

J. Helmschmidt
Institut für Umweltphysik, Universität Heidelberg (IUP)
Not on board: Roman Sinreich (IUP)

Objectives

A Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) device was installed onboard *Polarstern* by the Intitute of Environmental Physics, University of Heidelberg. The DOAS method identifies and measures the amount of atmospheric trace gases due to their characteristic absorption of light passing through the atmosphere. By looking into different elevation angles (Multi-Axis) it is additionally possible to estimate height profiles of these trace gases. Lower elevation angles lead to measurements with more horizontal scattered light. Thus tropospheric gases are mainly absorbed in the longer light path. Measurements in direction of the zenith show mainly absorptions of stratospheric gases. These ship borne measurements allow a validation of DOAS measurements of the satellite instrument SCIAMACHY onboard ENVISAT.

Work at sea

Since all calibration and maintenance work was accomplished two days before departure, the scattered sunlight measurements could start from the beginning of this cruise. A quartz fiber bundle feeds the light from the telescope to a spectrometer with a wavelength range from about 290 to 430 nm. During the day the telescope pointed to a 3° angle and was manually moved to the zenith position around noon, since problems with the automatic motor-controlling occurred. At night offset and dark current measurements were performed. To reduce the effect of the ship's movements the telescope is mounted on a cardan suspension.

The DOAS analysis and evaluation will be performed at the Institute of Environmental Physics and focus on the trace gases NO_2, O_3, BrO and HCHO. Due to earlier measurements we expect higher concentrations of NO_2 in the English Channel region and around Cape Town as well as BrO abundance near the Cape Verdi Islands. The data results will finally be integrated with a worldwide net of atmospheric research.

The MAX-DOAS measurements will be performed during the entire cruise ANT-XXIV.

8. SEA TRIAL AND TESTING OF THE NEW UPGRADED DEEP SEA SEDIMENT ECHO SOUNDER "PARASOUND DS III-P70" DURING ANT-XXIV/1

F. Niessen[1)], S. El-Naggar[1)], T. Liebe[2)], J. Rogenhagen[3)], J. Reuter[4)]

[1)]Alfred-Wegener-Institut, Bremerhaven
[2)]Reederei F. Laeisz Bremerhaven GmbH
[3)]FIELAX Gesellschaft für wissenschaftliche Datenverarbeitung mbH
[4)]Atlas Hydrographie

Objectives

The Deep Sea Sediment Echo Sounder "PARASOUND DS III-P70" (ATLAS HYDROGRAPHIC, Bremen, Germany) was upgraded from DS II to DS III-P70 during the shipyard stay of *Polarstern* in Bremerhaven between 04.05.07 and 29.05.07.

New hardware and software were installed and tested under harbor conditions in Bremerhaven prior to sailing. The first operational test under real conditions at sea was carried out during the first part of the cruise ARK-XXII/1 between Bremerhaven and Tromsø between 29.05.07 and 06.06.07 (Klages & Thiede, in prep.).

This report is about the final sea trial carried out during the cruise ANT-XXIV/1 on route from Bremerhaven to Las Palmas. The actual testing area including data-storage is located in the Bay of Biscay at the former test locations Location 1 and Location 1a (Fig. 8.1) where deep-sea conditions allow a broader range of operational settings. Water depths of more than 4,000 m are necessary for such tests.

Location 1 and Location 1a have been surveyed by *Polarstern* in the past as test and calibration areas for Hydrosweep and previous system versions of Parasound. Reference data from previous cruises are available from these locations and are used for comparison between data of the previous and the upgraded Parasound systems.

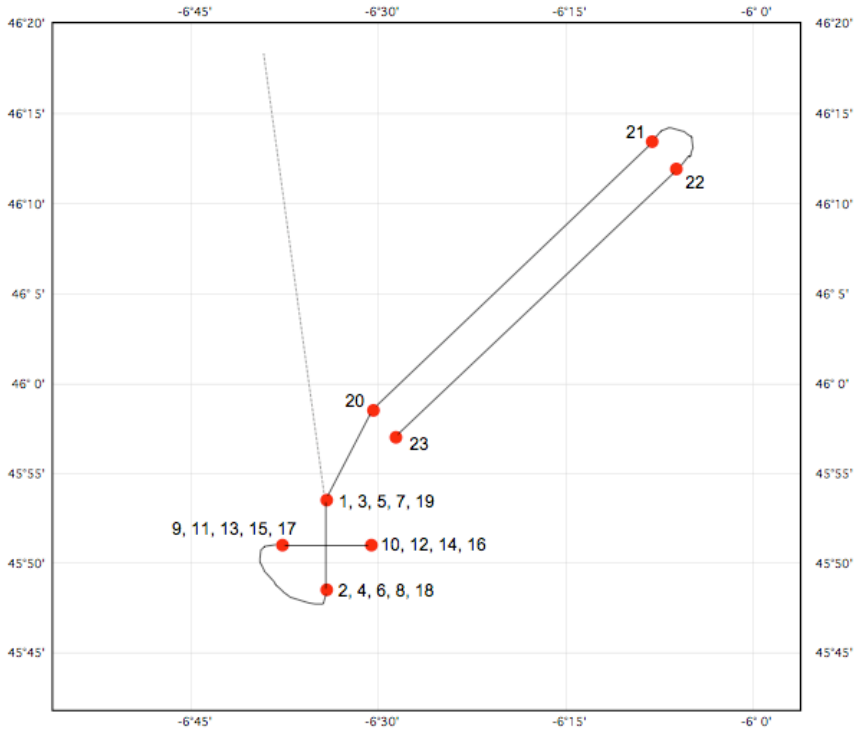

Fig. 8.1: Area of test and survey profiles and waypoints in the Bay of Biscay (location 1: waypoints 1 to 19 and location 1a: waypoints 20 to 23)

The work at sea had several goals:

- Complete and tune the final installation according to the list of system faults and missing options formulated during the first sea trial tests on ARK XXII/1.
- Operational checks using different transmission parameters (frequencies, power, sea states, water depth, etc).
- Sea Trial and acceptance tests at Loc. 1 and Loc. 1a (up to 24 hours in the Bay of Biscay) including data analysis and validations.
- On route operation for further testing, de-bugging and system improvement between the test locations and Las Palmas.

Brief description of additional options offered by DS III-P70

Despite the total setup of the new Parasound system DS III-P70 currently installed on *Polarstern* offering a whole range of new surveying possibilities, the basic principle of the system remained essentially the same as the previous version DS II. The system generates two primary frequencies between 18 and 33 kHz (formerly 18 and 23.5 kHz) transmitting in a narrow beam of 4° at high power. As a result of the non-linear acoustic interaction of the primary frequencies within the water column, a secondary frequency is created based on the parametric effect. The parametric frequency is the difference frequency of the two primary waves transmitted. As a

result of the longer wavelength, the parametric frequency allows sub-bottom penetration up to 150 m (depending on sediment composition) with a vertical resolution of ca. 40 cm. The use and basic principles of the parametric system Parasound are first described in detail by Spiess (1992). Numerous brief descriptions followed in several reports of *Polarstern* cruises. Upgrades and operations were described in Stein (2005), Budeus (2007), El Naggar (2007), van der Loeff (2007) and Klages & Thiede (in prep.). The latter includes a schematic diagram of the system components of the new system and a summary of the frequency range applicable by DS III-P70 including their advantages compared to the old system.

ATLAS PARASOUND D III-P70 is controlled by means of the ATLAS HYDROMAP CONTROL software via Operator PC. ATLAS PARASTORE-3 provides a user-friendly graphical interface and has been designed to acquire, visualize, process, store, convert, quality control, replay and print data from Parasound profiles via Operator PC. In general terms, both software packages were already available for controlling the previous Parasound system DS II. However, with the replacement of the entire electronic unit (except the hull-mounted transducers) by highly sophisticated units of modern standards a lot more functional options became available leading to major upgrades of both ATLAS HYDROMAP CONTROL and ATLAS PARASTORE-3 software.

The new system DS III-P70 offers a wide range of different adjustments to run the system (Table 8.1). One of several major advantages of the new system is the individual or combined use of different frequencies. These include:

- PHF: The Primary High Frequency signal is applied for normal MBES or SBES operation and for the creation of a parametric signal in the parametric basic operation modes.
- SLF: The Secondary Low Frequency signal is the parametric difference signal. This signal is used for sub-bottom profiling.
- SHF: In contrast to the Secondary Low Frequency (SLF), the Secondary High Frequency signal is the parametric sum signal of an ATLAS PARASOUND with a frequency of approx. 40 kHz. In addition to the PHF signal, the SHF signal can be applied for bottom detection.
- PLF: The Primary Low Frequency (PLF) signal is a primary signal of an ATLAS PARASOUND in the range of 6 kHz – 10 kHz. This signal is used for sub-bottom profiling when an ATLAS PARASOUND is applied as a conventional nonparametric sub-bottom profiler.

Tab. 8.1: Options and selectable ranges of various settings of the new Parasound DS III P70 system.

Variable Settings	**Options**	**Selectable Ranges**
Mode of Operation	P-SBP/SBES P-SBP/MBES C-SBP/SBES SBES Area SBES WWM	PHF, SHF, SLF PHF, SHF, SLF PLF PHF PHF, Side Scan PHF, PLF
Frequency	PHF SHF SLF PLF	18-33 kHz 36.5-40 kHz 0.5-6 kHz 6-10 kHz
Pulselength	No. of Periods	1 period - 25ms
Transmission Source Level	Transmission Power Source Level Reduction Transmission Voltage	0.4-100 % 0-24 dB 10-160 V
Beam Steering	by distance across by distance along by angle across by angle along	+/- 0.27 * mean depth +/- 0.46 * mean depth' -10° - +10° -15° - +15°'
Mode of Transmisson	Single Pulse Quasi-Equidistant Pulse Train	 Interval >/= 50ms 1-16 pulses, Interval >/= 200ms
Pulse Type	Continuous Wave Frequency Modulated (Chirp) Barker Coded	 Frequency Shift 0-6 kHz
Pulse Shape	Rectangular Triangular Hamming Hann Gaussian Deconvolution	

By means of the different physical characteristics of frequencies in terms of resolution in the water column and potential for sub-bottom penetration in combination with capabilities of pulse transmission originally designed for both Parasound and Hydrosweep, the new DS III-P70 Parasound can be run in 6 different modes of

operation. These modes require specific or optionally available frequencies as listed above and summarized in Table 8.1:

1. P-SBP/SBES: Parametric Sub-Bottom Profiling / Single-Beam Echo Sounder Operation
2. P-SBP/MBES: Across-Ship Parametric Sub-Bottom Profiling / Multi-Beam Echo Sounder Operation
3. C-SBP/SBES: Conventional Sub-Bottom Profiling / Single-Beam Echo Sounder Operation
4. SBES: Single-Beam Echo Sounder Operation
5. Area MBES: Area-Related Multi-Beam Echo Sounder Operation
6. WWM: Whale Warning Mode (basic operation mode intended to scare away marine mammals before normal survey operation is started)

Similar to the previous system, DS III-P70 can be run as „simple“ parametric sub-bottom profiler (P-SBS/SBES). New options, which may particularly be interesting under the aspect of marine mammal protection, are modes like WWM and C-SBP/SBES. The former has been designed to scare away marine mammals, which may be in the neighborhood of the ATLAS PARASOUND operating vessel. In the WWM, a predefined sequence of pulses with different harmless transmission source levels, different beam widths, different pulse lengths and/or different frequencies are sent out automatically. The WWM pulse sequence can be configured by the user via an XML file. In case, for the same reason as given above, an acoustic source level reduction is required while sub-bottom profiling may need to be continued, the system can be operated in C-SBP/SBES mode. This, however, will result in reduction of data quality compared to the P-SBS/SBES mode as the lateral resolution is conventional and not as high as recorded in the narrow beam of 4° opening angle of the parametric mode (see below).

Table 8.1 summarizes the settings, which can be chosen by the user of the new DS III-P70 system within the new ATLAS HYDROMAP CONTROL software. For a given mode of operation’ and ‚frequency’ different pulse lengths, transmission source levels, beam transmission angles, modes of transmission, pulse types and pulse shapes can be selected (Table 8.1). Each of these settings offers a different choice out of several options. The latter are further sub-selectable in wide ranges of adjustments. Thus, Table 8.1 should be read as a matrix in which a large number of different possibilities of combination of settings, options and ranges are selectable to run the system. The user may be referred to the manual of ATLAS HYDROMAP CONTROL software.

The upgraded ATLAS PARASTORE Software also offers a lot more possibility for data visualization, processing, storage and printing. Improved visualization includes the option to flatten the sea floor in order to remove sea-floor topography in echogram windows and thus better visualize lateral variability of layer thicknesses in sediment packages. The new version also provides an auxiliary data plot, which

enables the user to plot, for example, ship motion data into the echogram window together with sea floor topography in order to analyze effects or quality of ship-motion compensation. New processing tools allow deconvolution, correlation and stacking. In addition to the previous version, storage of processed data and storage of a readable SEG-Y data format are possible. In addition to direct printing of graphical profiles on paper the new option of printing into PDF-files is available. The operator can now choose to run the echogram window delay manually or automatically. In the latter mode with variable bathymetry, the system recognizes the sea floor and sub-bottom echoes getting to the edge of the window and will shift the delay accordingly.

Work at sea

The cruise time from Bremerhaven to Las Palmas was used to run the system along the entire track and perform certain tests of two different types:

- specific tests over largely unknown or not previously ‚Parasound-surveyed' areas
- test-profiling and surveying including data storage in the Bay of Biscay where data have been measured using Parasound during previous cruises.

On-route to Las Palmas we have tested:

- general system stability
- automatic echogram window shift
- operation in shallow water
- operation with stronger vessel motion and sufficient motion compensation
- data storage, replay and general readability/faultiness of data
- beam steering in single and multi-beam modes
- different options of printing
- visualization options including flatten sea floor and track plot

In the test area in the Bay of Biscay we repeated profiling in previously surveyed areas Loc. 1 and 1a (Fig. 8.1), which are described in van der Loeff (2007). In total 14 different settings, modes and selected ranges were tested according to Table 8.1 and are summarized in Table 8.2. Table 8.2 also includes navigation data and times of arrival at waypoints. After waypoint 16 we have chosen the optimal settings from the tests between waypoints 1 and 15, and then performed a survey along lines previously surveyed in Loc. 1 and Loc. 1a (Fig. 8.1, Table 8.1). Along the test and survey profiles the settings, options and ranges were kept stable and only unprocessed raw data were stored.

Data Comparison

Sub-bottom structures and penetration potential do not differ much along N-S and W-E profiles at Loc. 1. For both profile orientations a largely flat sea floor and well stratified sediments are predominant. At this location we have tested 14 different settings of the system as outlined in Table 8.1. In terms of functioning of the system only the profile from waypoint 3 to 4 (Pulse Train) did not produce meaningful data

due to settings of the PARASTORE echogram window, which the system did not tolerate. Later during the cruise the problem was analyzed and understood. It can be avoided by setting the window size to >/= 200 m. An improvement of the software has to be implemented in order to rule out settings not suitable for operation. Along the 14 profiles we could only select a relatively small amount of optional settings possible. Limited time between the lines and lack of experience using the system at sea, may not have allowed for optimal tuning of different settings for a given profile. It was the first time that such a sea test was carried out using Parasound DS III-P70 at in deep water. It was noted that a proportion of ship motion remained in the data. Insufficient motion correction resulted in decrease of sub-bottom reflector resolution at locations 1 and 1a. Motion compensation was improved later during the cruise.

By comparing the profiles from location 1 to each other, it turns out that settings subjectively revealed the best result, which were similar to those mostly used for previous Parasound versions (e.g. DS II: 4 kHz parametric frequency, 2 cycles from a continuous wave transmitted with a rectangular shape; DS III-P70: profile waypoint 2 to 3, Table 8.2, Fig. 8.2a). This profile functions as a reference to the comparisons described below. It was interesting to note, that for the same settings, but reducing transmission power to 50 % , nearly the same penetration was gained (Fig. 8.2b), whereas a further reduction to 25 % (not shown) resulted in significant lost of sub-bottom information. Frequency modulated pulses (chirped), tuned for higher resolution, (waypoint 6 to 7, Table 8.2, Fig. 8.2c), have gained resolution in the upper 20m sub-bottom but lost penetration in deeper strata.

Tab. 8.2: Navigation data and Parasound settings of test and survey profiles recorded at Location 1 and 1a (see Fig. 8.1 for profiles and waypoints).

WP (no.)	Latitude N	Longitude W	Dist. (nm)	Month_ Day_Time (UTC)	Profile Job/Direction	Mode of Operation	SLF PLF (kHz)	Cycles (no.)	Transm. Power (%)	Mode of Transmission	Pulse Type	Pulse Shape
1	45° 53.5	6° 34.15	5	10291431	Test Loc.1 N-S	P-SBP/SBES	4	4	100	Single Pulse	Cont. Wave	Gaussian
2	45° 48.5	6° 34.15	5	10291511	Test Loc.1 S-N	P-SBP/SBES	4	2	100	Equidistance	Cont. Wave	Rectangular
3	45° 53.5	6° 34.15	5	10291550	Test Loc.1 N-S	P-SBP/SBES	4	4	100	Pulse Train	Cont. Wave	Rectangular
4	45° 48.5	6° 34.15	5	10291630	Test Loc.1 S-N	P-SBP/SBES	4	2	50	Equidistance	Cont. Wave	Rectangular
5	45° 53.5	6° 34.15	5	10291705	Test Loc.1 N-S	P-SBP/SBES	4	8	100	Equidistance	Barker Coded	Rectangular
6	45° 48.5	6° 34.15	5	10291750	Test Loc.1 S-N	P-SBP/SBES	3.0-4.2	8	100	Equidistance	Chirp high res.	Rectangular
7	45° 53.5	6° 34.15	5	10291830	Test Loc.1 N-S	P-SBP/SBES	2.7-4.2	24	100	Equidistance	Chirp deep pen.	Rectangular
8	45° 48.5	6° 34.15	3.5	10291858	Transit							
9	45° 51	6° 37.7	5	10291933	Test Loc.1 W-E	P-SBP/SBES	4	40	100	Equidistance	Cont. Wave	Gaussian
10	45° 51	6° 30.55	5	10292010	Test Loc.1E-W	P-SBP/SBES	4	16	100	Equidistance	Cont. Wave	Rectangular
11	45° 51	6° 37.7	5	10292047	Test Loc.1 W-E	P-SBP/SBES	4	20	100	Equidistance	Cont. Wave	Deconvolution
12	45° 51	6° 30.55	5	10292125	Test Loc.1 E-W	P-SBP/SBES	4	8	25	Equidistance	Cont. Wave	Rectangular
13	45° 51	6° 37.7	5	10292204	Test Loc.1 W-E	C-SBP/SBES	6	2	100	Equidistance	Cont. Wave	Rectangular
14	45° 51	6° 30.55	5	10292240	Test Loc.1 E-W	P-SBP/SBES	4	8	25	Equidistance	Cont. Wave	Rectangular
15	45° 51	6° 37.7	5	10292318	Test Loc.1 W-E	P-SBP/SBES	4	4	100	Equidistance	Cont. Wave	Deconvolution
16	45° 51	6° 30.55	5	10292357	Survey Loc.1 E-W	P-SBP/SBES	4	2	100	Equidistance	Cont. Wave	Rectangular
17	45° 51	6° 37.7	3.5	10300027	Transit							
18	45° 48.5	6° 34.15	5	10300056	Survey Loc.1 S-N	P-SBP/SBES	4	2	100	Equidistance	Cont. Wave	Rectangular

WP (no.)	Latitude N	Longitude W	Dist. (nm)	Month_ Day_Time (UTC)	Profile Job/Direction	Mode of Operation	SLF PLF (kHz)	Cycles (no.)	Transm. Power (%)	Mode of Transmission	Pulse Type	Pulse Shape
18	45° 48.5	6° 34.15	5	10300056	Survey Loc.1 S-N	P-SBP/SBES	4	2	100	Equidistance	Cont. Wave	Rectangular
19	45° 53.5	6° 34.15	5.64	10300127	Transit Survey Loc.1a SW-NE	P-SBP/SBES	4	2	100	Equidistance	Cont. Wave	Rectangular
20	45° 58.5	6° 30.4	21.5	10300159								
21	46° 13.44	6° 08.06	2	10300403	Transit Survey Loc.1a NE-SW	P-SBP/SBES	4	2	100	Equidistance	Cont. Wave	Rectangular
22	46° 11.92	6° 06.12	21.6	10300414	End of Survey		4	2	100	Equidistance	Cont. Wave	Rectangular
23	45°57	6° 28.6		10300515								

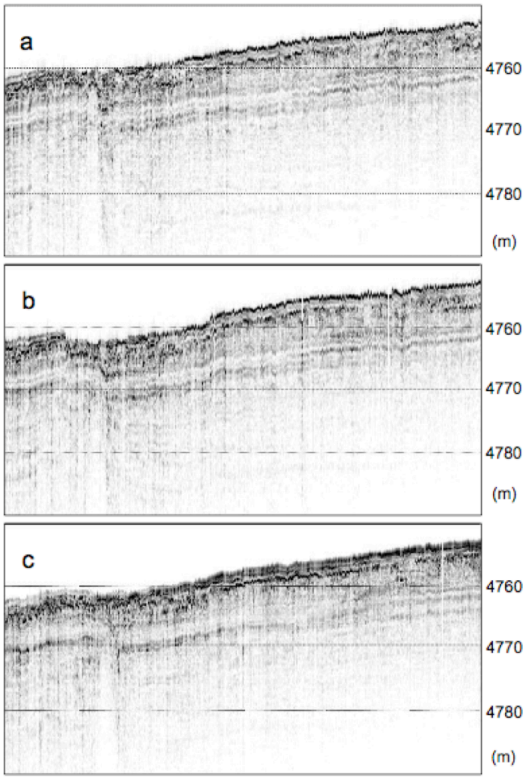

Fig. 8.2: Examples of Parasound profiles recorded at Location 1. (a) waypoints 2 to 3, (b) waypoints 4 to 5, (c) waypoints 6 to 7 (see Table 8.2 for navigation and Parasound details). Profile length 5 nm.

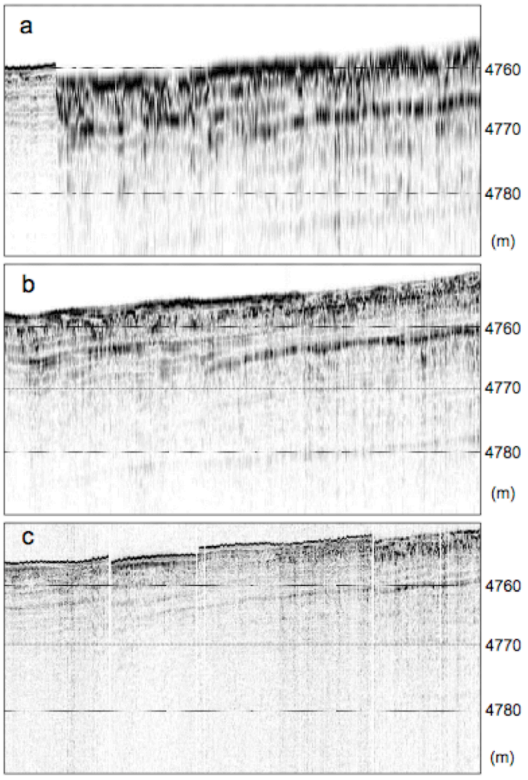

Fig. 8.3: Examples of Parasound profiles recorded at Location 1. (a) waypoints 9 to 10, (b) waypoints 11 to 12, (c) waypoints 13 to 14 (see Table 8.2 for navigation and Parasound details). Profile length 5 nm.

In contrast, a Gaussian pulse transmitted with 40 cycles (waypoint 9 to 10, Table 8.2, Fig. 8.3a) resulted in insufficient resolution and did not gain a significant increase in penetration. By using a deconvolution pulse shape with 20 cycles as a continuous wave (waypoint 11 to 12, Table 8.2, Fig. 8.3b), some resolution is lost and penetration is similar to the reference profile.

The contrast between stronger and weaker reflectors in the profile seems to be increased. Finally, a PLF pulse of 6 kHz transmitted with 2 cycles as continuous wave (waypoint 13 to 14, Table 8.2, Fig. 8.3c) exhibit a reasonable resolution but insufficient penetration below 20 m sub-bottom.

After the test described above we surveyed Loc. 1 and part of 1a (from waypoints 16 to 23, Fig. 8.1) using the following settings: 4 kHz parametric frequency, 2 cycles from a continuous wave transmitted with a rectangular shape at 100 % energy in Quasi-Equidistance mode (such as between waypoints 2 and 3 (Table 8.2). A 5 to 6 km long section recorded between waypoints 22 and 23 (Fig. 8.4a) is compared with

data recorded by Parasound DS II on the same line (Fig. 8.4b) during cruise ANT-XXIII/1 between waypoints 3c and 3d (van der Loeff, 2007). The DS-II system was run with the following settings: 4 kHz parametric frequency, 2 cycles from a continuous wave transmitted with a rectangular shape in Pilot-tone mode switched to a water-depth range of 10,000 m.

It is obvious that the profile recorded by the new system in 2007 exhibits a significantly better resolution and penetration compared to 2005 (Fig. 8.4). The geological situation is such that a large slide (likely derived from the European continental slope) moved downslope and covers and/or reworked the pelagic type of sedimentary sequence along the upper end of profile. The remaining part of the pelagic sequence was subjected to lateral stress by slide motion, which resulted in stair-case rotational faulting of formerly undisturbed and probably weakly consolidated sediments (e.g. Whittington & Niessen, 1997). Steeply downslope dipping faults subdivide the sediments into lateral packages where stratification remained largely intact. Downslope of the slide, faulting affected the entire upper and acoustically more transparent sediment package. Only a few faults proximal to the slide continue into the lower strata, which appear to be more massive as indicated by increased acoustic backscatter. In the Parasound data of 2005 the faults are hardly visible. Lateral resolution as well as insufficient penetration of the profile (Fig. 8.4b) would not have allowed the geological interpretation given above from 2007 data. Apart from the difference in penetration it appears that the Quasi-Equidistance mode used in 2007 allows a lot better resolution of the fault planes compared to the Pulse-Trains transmitted in 2005.

Conclusions

The new Parasound system offers a wide range of possibilities for sophisticated acoustic analyses of bottom and sub-bottom structures of the sea floor. However, basic settings like P-SBP/SBES (as we have used in our survey above) will be likely to dominate routine profiling during geoscience expeditions for some while. Nonetheless, running the system even with basic operation, Parasound has become a lot more complex due to variable options of settings available and adjustable ranges.

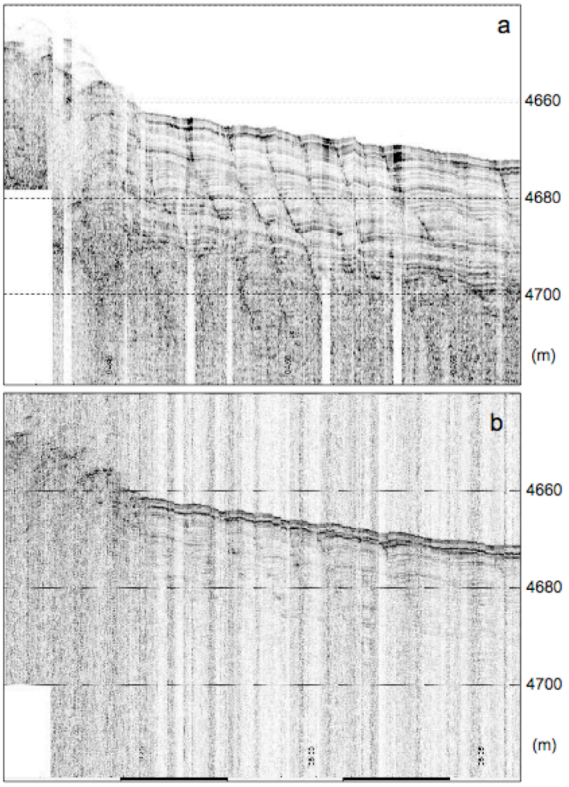

Fig. 8.4: Examples of Parasound profiles recorded at Location 1a. (a) section between waypoints 22 and 23 (see Table 8.2 for navigation and Parasound details), (b) same section as (a) recorded in 2005 (van der Loeff 2007). Distance bar (white or black) is 1 km.

Operators and watch keepers can easily get lost in the large variety of different windows open on the screen when searching for settings subjected to change if applicable. Therefore, profiling and data acquisition requires good physical and operational knowledge and/or specific user training, which need to be different and more time consuming compared to the previous practice of using the system DS II.

During the entire cruise and for all modes of operation, the stability of the new system has demonstrated significant improvement. Minor problems were listed, and, if not resolved before the end of the cruise, should be observed during forthcoming cruises for final elimination. From our preliminary experience it is not recommended to use Single-Pulse mode of transmission in shallow water up to 100 m depths, because too many pulses are transmitted and frequent self-configuration of the system may cause small time slots with lost of data. Instead, using the Semi-Equidistance mode is more convenient as it allows the reduction of pulses and subsequently eliminates problems of system stability. Also, Semi-Equidistance mode of transmission appears to result in significantly better sub-bottom data quality if used in deep water (> 4,000 m) unless

specific reasons (e.g. ice breaking causes high-amplitude background noise) require a maximum of pulses to be transmitted. In such a case the Pulse Train may offer data improvement compared to Semi-Equidistance mode. However, it appeared to us that data recorded from operation in Semi-Equidistance mode have faulty navigation information (likely distance) in the trace headers resulting in significant incorrect lateral profile scaling if plotted according to distance.

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9. SEA TRIALS AND CALIBRATION OF POSIDONIA AT ANT-XXIV/1 ON 31.10.07

S. El-Naggar[1)], T. Liebe[2)], J. Rogenhagen[3)], H. Muhle[3)]

[1)]Alfred-Wegener-Institut, Bremerhaven
[2)]Reederei F. Laeisz Bremerhaven GmbH
[3)]FIELAX Gesellschaft für wissenschaftliche Datenverarbeitung mbH

The Antenna of the Under Water Navigation System (POSIDONIA) of *Polarstern* was damaged during the cruise ARK-XXII/1 in summer 2007. The completely repaired system was tested and calibrated during the cruise ANT-XXIV/1 on 31.10.07 at 42°09.5' N; 10° 39.95' W.

A mooring system was prepared for the calibration using the POSIDONIA Transponder Nr. 35 (Fig. 9.1). The calibration was carried out according to the specification of the producer (IXSEA). The old calibration parameter set was changed to zero and a new set was measured and determined using the following procedure:

The final position of the transponder at the sea floor was measured and used as a reference point for the calibration. The measured water depth was about 2,730 m and this defines the diameter of the ship track surrounding the transponder (shapes like a figure of 8 with a diameter of 1 mile, Fig. 9.2). The calibration was carried out with a ship speed of 5 knots. After data processing a new calibration parameter set was calculated and used for the next step of calibration. The first calibration measurement was repeated under using the new calibration parameter set (Fig. 9.3). A second calibration parameter set was calculated by using the data of the second measurements.

Comparison of both data sets led to an equivalent positioning result without any deviation (Fig. 9.4). Finally the first calibration parameter set was accepted and used to operate the system.

The POSIDONIA system is now fully operational and can be used in the future without any limitation.

General data and conditions during the test:

Date:	31.10.2007
Location:	42° 09.5’ N; 10° 39.95’ W
Water depth:	2730 m
Wind speed:	13.2 m/s
Wind direction:	58°
Air temperature:	15.4° C
Water temperature:	17.1° C
Sea state:	3 m

Used Transponder and Releaser: Nr. 35

Start of test:	09:30 hour UTC
End of test:	14:08 hour UTC

Calibration parameter set:	Heading:	- 0.79
	Roll:	+ 0.169
	Pitch:	+ 0.41

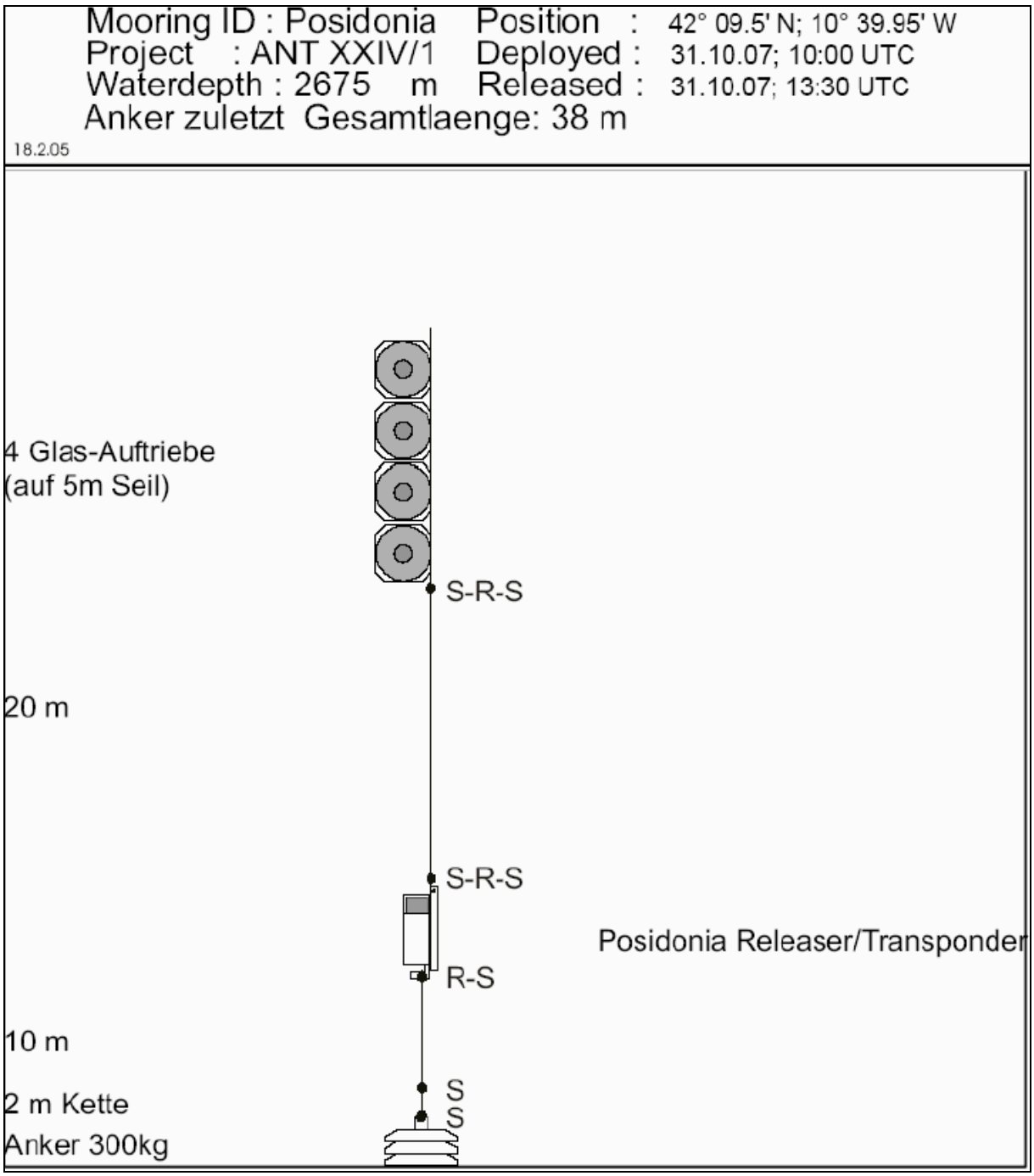

Fig. 9.1: Schemata of the mooring on 31.10.07

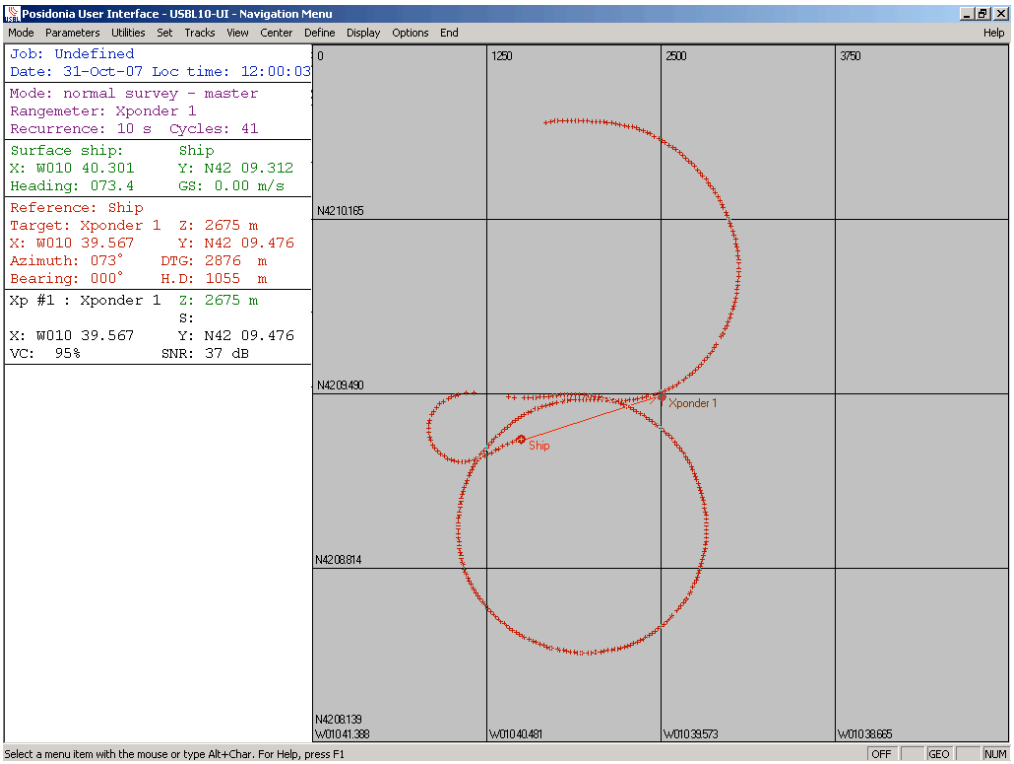

Fig. 9.2: First calibration circle, about. 1,950 m in diameter, ship speed about 5 knots

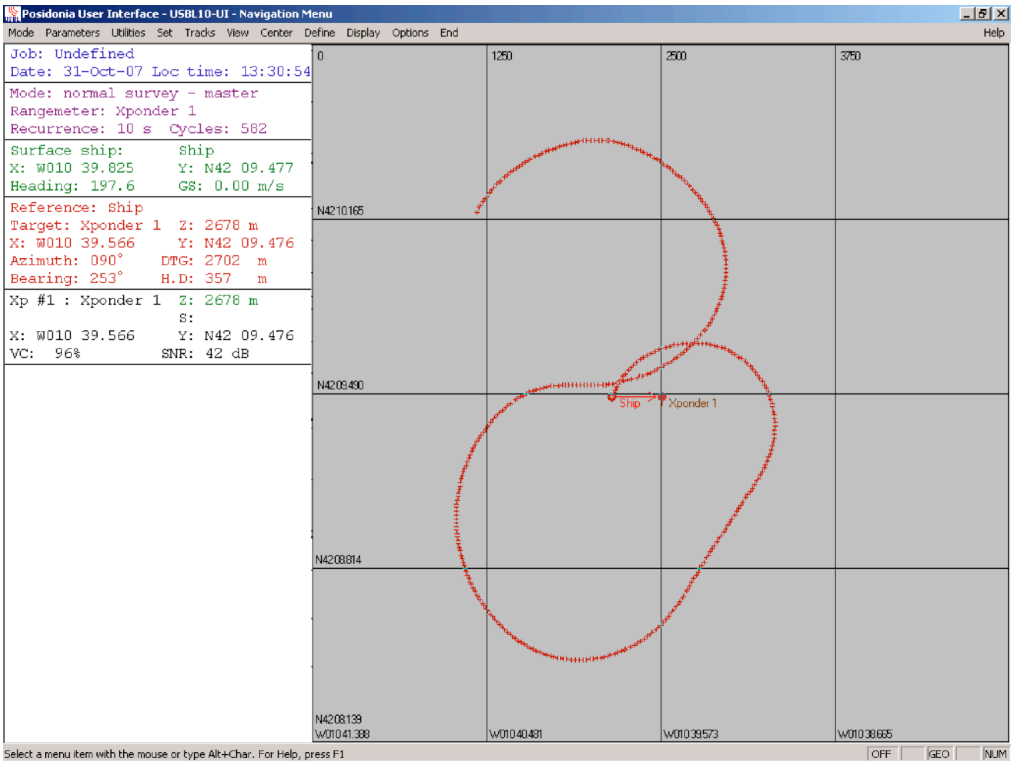

Fig. 9.3: The second calibration circle

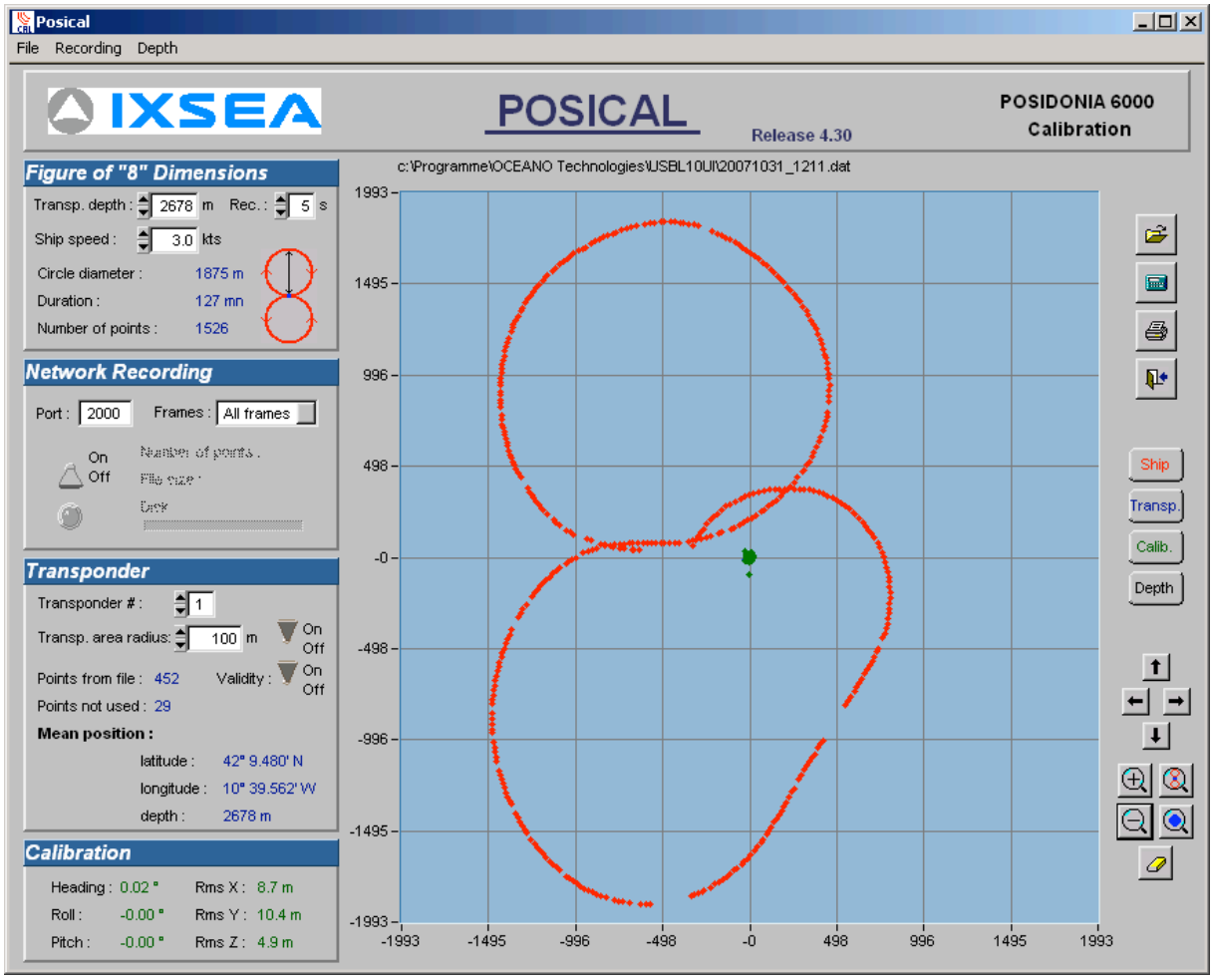

Fig. 9.4: Comparison of both calibration results

APPENDIX

A.1 PARTICIPATING INSTITUTIONS

A.2 CRUISE PARTICIPANTS

A.3 SHIP'S CREW

A.4 SUMMARY OF 1-M^2 MOCNESS TOWS

A.5 SUMMARY OF 10-M^2 MOCNESS TOWS

A.6 OSTRACOD SPECIES FROM THE ATLANTIC

A.7 CHAETOGNATHS FROM MOC10

A.8 CHAETOGNATHS FROM MOC1

A.9 DEEP-PELAGIC FISHES

A.10 STATION LIST

A.1 BETEILIGTE INSTITUTE/ PARTICIPATING INSTITUTIONS

	Adresse **Address**
Atlas Hydrographie	Atlas Hydrographie Kürfürstenallee 130 28211 Bremen/ Germany
AWI	Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft Am Handelshafen 12 27570 Bremerhaven/ Germany
BAH-AWI	Biologische Anstalt Helgoland in der Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung Postfach 180 27483 Helgoland/ Germany
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg/Germany
DZMB	Deutsches Zentrum für Marine Biodiversitätsforschung Schleusenstraße 1 26383 Wilhelmshaven/ Germany
FIELAX	FIELAX Gesellschaft für wissenschaftliche Datenverarbeitung mbH Schifferstraße 10-14 27568 Bremerhaven/Germany
GKSS	GKSS Forschungszentrum Geesthacht, Institut für Küstenforschung, Max Planck- Str. 1, 21502 Geesthacht/Germany
HB-MarZoo	Marine Zoologie (FB2) Universität Bremen (NW2A) Postfach 330440 28334 Bremen/ Germany

	Adresse Address
HBOI	Harbor Branch Oceanograohic Institution 5600 US. 1 North Fort Pierce, FL 34949/ USA
IFM-GEOMAR	Leibniz-Institut für Meereswissenschaften Düsternbrooker Weg 20 24105 Kiel/ Germany
IMS	Institute of Marine Science University of Alaska Fairbanks, Alaska 99775/ USA
IOPAS	Institute of Oceanology Polish Academy of Sciences 55 Powst. Warszawy St. 81-712 Sopot/ Poland
IUP	Institut für Umweltphysik Universität Heidelberg Im Neuenheimer Feld 229 69120 Heidelberg/ Germany
LAEISZ	Reederei F. Laeisz Bremerhaven GmbH Brückenstraße 25 27568 Bremerhaven/ Germany
NIWA	National Institute of Water and Atmospheric Research 301 Evans Bay Parode Private Bay 14901 Kilbirnie, Wellington/ New Zealand
NOCS	National Oceanography Centre, Southampton University of Southampton Waterfront Campus Southampton SO14 3ZH/ UK
ORI	Ocean Research Institute University of Tokyo 1-15-1 Minamidai, Nakano-ku Tokyo 164-8639/ Japan
UConn	Department of Marine Sciences University of Connecticut – Avery Point 1080 Shennecossett Road Groton CT 06340/ USA

	Adresse **Address**
UdeC	Estacion de Biologia Marina-Dichato Universidad de Concepcion Casilla 160-C Concepcion/ Chile
UniOvi BOS	Departamento de Biología de Organismos y Sistemas Universidad de Oviedo C/ Catedrático Rodrigo Uria s/n Oviedo 33071/ Spain
University Lancaster	Centre for Chemicals Management, and Environmental Science Department, Lancaster Environment Centre Lancaster University Lancaster, LA1 4YQ/ UK
WHOI	Department of Biology (MS-33) Woods Hole Oceanographic Institution 10 School St. Woods Hole, MA 02543/ USA
ZMA	Zoological Museum Amsterdam University of Amsterdam P.O. Box 94766 1090 GT Amsterdam/ The Netherlands

A.2 FAHRTTEILNEHMER/PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute
Allison	Dicky	WHOI
Angel	Martin	NOCS
Auel	Holger	HB-MarZoo
Barber	Jonathan	University Lancaster
Batta Lona	Paola	UConn
Benskin	Clare	University Lancaster
Bentama	Laila	AWI
Blanco Bercial	Leocadio	UniOvi BOS
Blachowiak-Samolyk	Katarzyna	IO PAS
Buchholz	Friedrich	BAH-AWI
Bucklin	Ann	UConn
Clarke-Hopcroft **	Cheryl	IMS
Copley	Nancy	WHOI
El-Naggar *	Saad	AWI
Escribano	Rubén	UdeC
Folkers	Christina	DZMB
Gehnke	Steffen	GKSS
Grieve	Janet	NIWA
Helmschmidt	Jessica	IUP
Jennings	Rob	UConn
Kruse	Svenja	AWI
Kuriyama	Mikiko	ORI
Liebe *	Thomas	Laeisz
Machida	Ryuji	ORI
Milhahn	Kirstin	Journalist
Miyamoto	Hiroomi	ORI
Moeckel	Claudia	University Lancaster
Niessen	Frank*	AWI
Nigro	Lisa	UConn
Nishibe	Yuichiro	ORI
Ossenbrügge	Holger	IfM-GEOMAR
Piatkowski	Uwe	IfM-GEOMAR

Name/ Last name	Vorname/ First name	Institut/ Institute
Pierrot-Bults	Annelies**	ZMA
Reuter	Joachim*	Atlas Hydrographie
Rogenhagen	Johannes*	FIELAX
Schiel	Sigrid	AWI
Schmitt	Bettina	AWI
Schuster	Jasmin	University Lancaster
Sutton	Tracey	HBOI
Sweetman	Christopher	HBOI
Wassmann	Andreas	IFM-GEOMAR
Wiebe	Peter	WHOI
Zankl	Solvin**	Photographer
Zoll	Yann	IFM-GEOMAR

*disembarking in Las Palmas
**embarking in Las Palmas

A.3 SCHIFFSBESATZUNG/SHIP'S CREW

	Name	Rank
1.	Jacobi, Nils	Master
2.	Grundmann, Uwe	1. Offic.
3.	Ziemann, Olaf	Ch. Eng.
4.	Bratz, Herbert	2. Offc.
5.	Peine, Lutz	2. Offc.
6.	Türke, Helmut	Doctor
7.	Koch, George	R.Offc.
8.	Kotnik, Herbert	2. Eng.
9.	Schnürch, Helmut	2. Eng.
10.	Westphal, Henning	3. Eng.
11.	Holtz, Hartmut	Elec.Tech.
12.	Rehe, Lars	Electron.
13.	Fröb, Martin	Electron.
14.	Feiertag, Thomas	Electron.
15.	Clasen, Burkhard	Boatsw.
16.	Neisner, Winfried	Carpenter
17.	Kreis, Reinhard	A.B.
18.	Schultz, Ottomar	A.B.
19.	Burzan, G.-Ekkehard	A.B.
20.	Schröder, Norbert	A.B.
21.	Moser, Siegfried	A.B.
22.	Pousada Martinez, S.	A.B.
23.	Hartwig-L., Andreas	A.B.
24.	Kretzschmar, Uwe	A.B.
25.	Beth, Detlef	Storekeep.
26.	Kliem, Peter	Mot-man
27.	Fritz, Günter	Mot-man
28.	Krösche, Horst	Mot-man
29.	Dinse, Horst	Mot-man
30.	Watzel, Bernhard	Mot-man
31.	Fischer, Matthias	Cook
32.	Tupy, Mario	Cooksmate
33.	Völske, Thomas	Cooksmate
34.	Dinse, Petra	1.Stwdess
35.	Stelzmann, Sandra	Stwdss/KS
36.	Streit, Christina	2.Stwdess
37.	Schmidt, Maria	2.Stwdess
38.	Deuß, Stefanie	2.Stwdess
39.	Hu Guo, Yong	2.Steward
40.	Sun, YongSheng	2.Steward
41.	Yu, ChunLeung	Laundrym.

A.4 SUMMARY OF 1-M^2 MOCNESS TOWS

Tow #	Stat. #	Date 2007	Time (local) Start/End	Latitude Start/End	Longitude Start/End	Depths sampled (m)	Volume filtered (m^3)	Comments
1-m MOCNESS Tows								
1	1	05.11.	1828 s 2015 e	24° 40.727 24° 40.478	-20° 44.770 -20° 44.842	Net 0: 0-100	4603.2	Calibration station*
2	2	08.11.	1920 s 2248 e	11° 22.754 11° 28.270	-20° 21.022 -20° 16.122	Net 0: 0-1000 Net 1: 1003-797 Net 2: 797-599 Net 3: 599-399 Net 4: 399-191 Net 5: 191-101 Net 6: 101-49 Net 7: 49-24 Net 8: 24-0	3886 1538 1380 1965 1403 1156 586 326 455	All nets worked fine and net response received for all of them.
3	3	11.11.	1939 s 2258 e	03° 12.807 03° 09.943	-14° 36.094 -14° 31.048	Net 0: 0-1003 Net 1: 1000-792 Net 2: 792-600 Net 3: 600-398 Net 4: 398-200 Net 5: 200-100 Net 6: 100-49 Net 7: 49-23 Net 8: 23-0	2124 1432 987 1661 1839 1447 682 243 200	All nets worked fine and net response received for all of them.
4	4	17.11.	1913 s 2240 e	-13° 24.960 -13° 121.419	0° 38.800 0° 39.737	Net 0: 0-1000 Net 1: 996-794 Net 2: 794-599 Net 3: 599-398 Net 4: 398-199 Net 5: 198-98 Net 6: 98-49 Net 7: 49-0 Net 8: 0-0	2411 1087 1313 1716 1624 1297 907 645 198	All nets worked fine and net response received for all of them. Net 8 opened/ closed at the surface on purpose.

Tow #	Stat. #	Date 2007	Time (local) Start/End	Latitude Start/End	Longitude Start/End	Depths sampled (m)	Volume filtered (m^3)	Comments
5	8	21.11.	1900 s	-25° 40.550	09° 44.330	Net 0: 0-1003	3942	All nets worked fine
			2254 e	-25° 32.60	09° 49.174	Net 1: 1015-799	1637	and net response
						Net 2:799-599	1618	received for all of
						Net 3: 599-399	1239	them.
						Net 4: 399-201	1632	
						Net 5: 201-98	1447	
						Net 6: 98-48	863	
						Net 7: 48-25	166	
						Net 8: 25-0	142	

*Flow meter calibration tow with net sent to 100 m for 1 nm run in one direction and after 180 turn, a second 1 nm run in opposite direction. Only net 0 had a bucket. Other nets on the frame had no buckets and were not used. Net 0 closed at the surface. Volume filtered based in old flow meter calibration.

A.5 SUMMARY OF 10-M^2 MOCNESS TOWS

Net bar containment flaps and side deflector flags were installed on the 10–m^2 MOCNESS at the start of the cruise.

Tow #	Stat. #	Date 2007	Time (local) Start/End	Latitude Start/End	Longitude Start/End	Depths Sampled (m)	Volume filtered (m3)
10 - MOCNESS Tows							
1	3	05.11.	1628 s 1813 e	24° 40.39 24° 40.536	-20° 44.574 -20° 44.757	Net 0: 0-100	~55843.8
2	3	08.11.	0832 s 1850 e	11° 41.00 11° 22.766	20° 25.128 20° 20.910	Net 0: 0000-4795 Net 1: 4795-4000 Net 2: 4000-3000 Net 3: 3000-2000 Net 4: 2000-1000	54166 52253 59461 47092 37795
3	4	11.11.	0600 s 1643 e	03° 30.605 03° 19.238	-15° 00.497 -14° 46.767	Net 0: 0000-4650 Net 1: 4650-3999 Net 2: 3999-2993 Net 3: 2993-1957 Net 4: 1957-0998	10970 45244 59113 48446 50693
4	8	21.11	0600 s 1813 e	-13° 09.298 -13° 21.225	0° 18.965 0° 37.068	Net 0: 0000-5038 Net 1: 5110-3993 Net 2: 3993-3886 Net 3: 3886-1987 Net 4: 1985-0998	65876 70623 5744 102410 67615
5	10	21.11.	0603 s 1750 e	-25° 04.919 -25° 26.17	09° 35.011 09° 40.81	Net 0: 0000-4390 Net 1: 4390-3992 Net 2: 3992-2990 Net 3: 2990-2062 Net 4: 2062-0984	47906 37054 56173 45233 46826

Comments

Tow 1: Flow meter calibration tow with net sent to 100 m for a 1 nm run in one direction and after 180 turn, a second 1 nm run in opposite direction. Only net 0 with 3 mm mesh used. No other nets on the frame. Volume filtered based on new flow meter calibration value of 5.73 m/flow counts.

Tow 2: First deep tow on cruise and all worked very well.

Tow 3: All worked very well.

Tow 4: This was a good tow, except that the tab broke on the net bar holding top of net 2 and bottom of net 3. Thus net 2 closed and net 3 opened prematurely.

Tow 5: This was a good tow, except that the nico press sleeve holding the cable to the net bar tab failed at 2062 m prematurily closing net 3 and opening net 4.

A.6 OSTRACOD SPECIES FROM THE ATLANTIC

Ostracod species recorded from the Atlantic, showing those identified during the two CMarZ cruises in the Atlantic. ● indicates presence, + indicates the species picked out for sequencing during *Polarstern* XXIV/1.

Genus	*Species*	Authority, date	Polarstern XXIV		Ron Brown 0603	
			MOC 1	MOC10	MOC 1	MOC 10
Subfamily Conchoecinae						
Alacia	*alata alata*	(Müller, G.W., 1906)	+			
	leptothrix	(Müller, G.W., 1906)				
	valdiviae	(Müller, G.W., 1906)		+		●
Boroecia	*borealis*	(Sars, G.O., 1866)				
	maxima	(Brady & Norman, 1896)				
*Clausoecia**	*pusilla*	(Müller, G.W., 1906)		+		●
Conchoecetta	*acuminata*	Claus, 1890	+		●	
	giesbrechti	(Müller, G.W., 1906)	+			
Conchoecia	*hyalophyllum*	Claus, 1890	●	●	●	●
	lophura	Müller, G.W., 1906	●	●	●	●
	macrocheira	Müller, G.W., 1906	●	●	●	●
	magna	Claus, 1874	+		●	●
	parvidentata	Müller, G.W., 1906				
	subarcuata	Claus, 1890	●			●
Conchoecilla	*chuni*	Müller, G.W., 1906	+	●		
	daphnoides	Claus, 1890	+	●	●	●
	d.minor	(Müller, G.W., 1906)				
Conchoecissa	*ametra*	(Müller, G.W., 1906)	●	+	●	●
	imbricata	(Brady, 1880)	+	●	●	●
	plinthina	(Müller, G.W., 1906)		+		●
	symmetrica	(Müller, G.W., 1906)				
*Deeveyoecia**	*arcuata*	(Deevey, 1978)		+		●
Discoconchoecia	*elegans*	(Sars, G.O., 1866)	+	●	●	●
	discophora ss	(Müller, G.W., 1906)	+	●		
Gaussicia	*edentata*	(Müller, G.W., 1906)	●			
	gaussi	(Müller, G.W., 1908)		●		●
	aff. gaussi			●		
	incisa	(Müller, G.W., 1906)		+		●
	subedentata	(Gooday, 1976)				
*Juryoecia**	D'	new species				●
*Kyrtoecia**	*kyrtophora*	(Müller, G.W., 1906)	+		●	
Loricoecia	*acutimarginata*	Chavtur, 1977		+		●
	ctenophora	(Müller, G.W., 1906)			●	
	loricata	(Claus, 1894)	●		●	●
Macroconchoecia	*caudata*	(Müller, G.W., 1906)				
	macroreticulata	(Ellis, 1984)		+		●
	reticulata	(Müller, G.W., 1906)		●		●
	spinireticulata	(Ellis, 1984)		+	●	●
Metaconchoecia	*fowleri*	(Gooday, 1981)	●	+	●	●
	acuta	(Gooday, 1981)	●		●	●
	discoveryi	(Gooday, 1981)	●	●	●	●
	inflata	(Gooday, 1981)	+		●	

Genus	*Species*	Authority, date	Polarstern XXIV		Ron Brown 0603	
			MOC 1	MOC10	MOC 1	MOC 10
	obtusa	(Gooday, 1981)	●		●	●
	rotundata	(Müller, G.W., 1890)	+		●	●
	skogsbergi	(Iles. 1953)		+		●
	aff. skogsbergi	sensu Angel, 1968				
	subinflata	(Gooday, 1981)	+		●	
	wolferi	(Gooday, 1981)	●			
Mikroconchoecia	*acuticosta*	(Müller, G.W., 1906)				
	curta	(Lubbock, 1860)	+		●	●
	echinulata	Claus, 1891	+		●	●
	stigmatica	(Müller, G.W., 1906)		+	●	●
Mollicia	*eltaninae*	(Deevey, 1978)				
	kampta	(Müller, G.W., 1906)	●	+		
	mollis	(Müller, G.W., 1906)		+		
	tyloda	(Müller, G.W., 1906)		+		●
*Muelleroecia**	*glandulosa*	(Müller, G.W., 1906)		●		●
	macromma	(Müller, G.W., 1906)		●		
	aff. macromma					●
*Nasoecia**	*nasotuberculata*	(Müller, G.W., 1906)	+		●	
Obtusoecia	*obtusata*	(Sars, G.O., 1866)				
Orthoconchoecia	*atlantica*	(Lubbock, 1856)	+	●	●	●
	bispinosa	(Claus, 1890)	+		●	●
	haddoni	(Brady & Norman, 1896)				
	haddoni 'southern'	(Müller, G.W., 1906)	+			
	secernenda	(Vavra, 1906)	+	●	●	●
Paraconchoecia	*aequiseta*	(Müller, G.W., 1906)	●	+	●	●
	allotherium	(Müller, G.W., 1906)	+			
	cophopyga	(Müller, G.W., 1906)		+		●
	dasyophthalma	(Müller, G.W., 1906)		+		●
	dentata	(Müller, G.W., 1906)		+		●
	dorsotuberculata	(Müller, G.W., 1906)		+	●	●
	echinata	(Müller, G.W., 1906)	+			
	hirsuta	(Müller, G.W., 1906)			●	●
	inermis	Claus, 1890	●			●
	mamillata	(Müller, G.W., 1906)		+		●
	mesadenia	(Ellis, 1985)				
	nanomamillata	(Deevey & Brooks, 1980)	●		●	●
	oblonga	Claus, 1890	●		●	●
	spinifera	Claus, 1891	●		●	●
Paramollicia	*dichotoma*	(Müller, G.W., 1906)				●
	major	(Müller, G.W., 1906)		●		
	plactolycos	(Müller, G.W., 1906)		●		●
	rhynchena	(Müller, G.W., 1906)	●			
Platyconchoecia	*prosadene*	(Müller, G.W., 1906)				
Porroecia	*hystrix*	(Angel & Ellis, 1987)				
	parthenoda	(Müller, G.W., 1906)	+		●	●
	porrecta	(Claus, 1890)	+		●	●
	pseudoparthenoda	(Angel, 1972)	+		●	●
	spinirostris	(Claus, 1874)	+		●	●
Proceroecia	*brachyaskos*	(Müller, G.W., 1906)	+		●	●
	convexa	(Deevey, 1977)			●	●
	macroprocera	(Angel, 1971)			●	
	microprocera	(Angel, 1971)	+		●	●

Genus	*Species*	Authority, date	Polarstern XXIV		Ron Brown 0603	
			MOC 1	MOC10	MOC 1	MOC 10
	procera	(Müller, G.W., 1894)	+		●	
	vitjazi	(Rudjakov, 1962)				
Pseudoconchoecia	*concentrica*	(Müller, G.W., 1906)				
Rotundoecia	*teretivalvata*	(Iles. 1953)	●		●	
*Vityazoecia**	*lunata*	(Deevey, 1978)		●		?
* These genera are currently classified as Metaconchoecia, which is under revision						
Subfamily Halocypridinae						
Halocypria	*globosa*	Claus, 1874		●	●	●
Halocypris	*inflata*	Dana, 1849	+		●	●
	brooding'	?n.sp		+		
	pelagica	Claus, 1890			●	
	striata	Müller, G.W., 1806		●		
Fellia	*bicornis*	(Müller, G.W., 1906)				●
	cornuta	(Müller, G.W., 1906)		+		
	abyssopelagica'			+		●
Subfamily Archiconchoecinae						
Archiconchoecia	*striata*	Müller, G.W., 1894	+		●	●
Archiconchoecilla	*versicula*	Deevey, 1978	+			●
Archiconchoecinna	*cuneata*	(Muller , 1908)				●
Archiconchoecissa	*pljusnini*	Chavtur & Stovbun, 2003		+		●
	aff. *pljusnini*	Angel unpublished				
	cucullata	(Brady 1902)		●		●
	aff. *cucullata*	Angel, 1983	+		●	●
	bradyi'	Angel unpublished		●		
Archiconchoecemma	*simula*	(Deevey, 1982)		+		●
Archiconchoecerra	*longiseta*	Deevey, 1978		●		
Archiconchoecetta	*bifurcata*	Deevey, 1978a				
	bimucronata	Deevey, 1978a		+		
	bispicula	Deevey, 1978a		+	●	●
	fabiformis	Deevey, 1978b				
	falcata	Deevey, 1978a				
	gastrodes	Deevey, 1978a				
	pilosa	Deevey, 1978a				
	ventricosa	Müller, G.W., 1906				
	Novel species			●		
Subfamily Euconchoecinae						
Bathyconchoecia	*caini*	Ellis 1989				
	crosnieri	Poulsen, 1969				
	darcythompsoni	(Scott, 1909)				
	deeveyae	Kornicker, 1970				
	diacantha	Deevey, 1975				
	foveolata	Deevey, 1968				
	galerita	Deevey, 1968				
	hardingae	Deevey, 1975				
	kornickeri	Deevey, 1968		●		●
	laqueata	Deevey 1968				
	latirostris	Poulsen, 1972				
	longispinata	Ellis, 1987		●		
	nodosa	Poulsen 1972				

Genus	*Species*	Authority, date	Polarstern XXIV		Ron Brown 0603	
			MOC 1	MOC10	MOC 1	MOC 10
	omega	Kornicker & Rudjakov, 2004				
	paulula	Deevey, 1968				
	septemspinosa	Angel, 1970		●		
	sagittarius	Deevey, 1968		●		
	subrufa	Angel, 1970				
	sp a	Kornicker, 1991				
	sp b	Kornicker, 1991				
	RB#1	n.sp		●		●
	RB#2	n.sp				●
	RB#3	n.sp				●
	striatissima'	n.sp				●
Euconchoecia	*aculeata*	(Scott, 1894)				
	chierchiae	Müller, 1890			●	
ORDER MYODOCOPIDA						
Family Cypridinidae						
Macrocypridina	*castanea*	(Brady, 1897)		●	●	
	poulseni	Martens, 1979				
Gigantocypris	*dracontovalis*	Cannon, 1940		+		●
	**muelleri*	Skogsberg, 1920		+		●
Total Species			**53**	**61**	**52**	**76**

A.7 CHAETOGNATHS FROM MOC10

Nov 08 tow 2 MOC10

species	net 1	net 2	net 3	net 4
Heterokrohnia sp.	8	32		
Eukrohnia bathyantarctica		60	198	100
Sagitta macrocephala		152	403	648
Eukrohnia fowleri		10	72	76
Eukrohnia spp	4		124	620
Sagitta zetesios			7	16
damaged	12	148	100	136
TOTAL	24	402	904	1596
volume filtered/1000	52.253	59.461	47.092	37.795
n/ 1,000m^3	**0.5**	**6.8**	**19.2**	**42.2**

Nov 11 tow 3 MOC10

species	net 1	net 2	net 3	net 4
Heterokrohnia sp.	12	3		
Eukrohnia bathyantarctica	38	77	110	104
Sagitta macrocephala	144	100	132	418
Eukrohnia fowleri	31	106	1	32
Eukrohnia spp			392	392
Sagitta zetesios		12		2
Sagitta maxima				4
damaged		141	112	184
TOTAL	225	439	747	1136
volume filtered/ 1,000	45.244	59.113	48.446	50.639
n/ 1,000m^3	**5.0**	**7.4**	**15.4**	**22.4**

Nov 16 tow 4 MOC10

species	net 1	net 2	net 3	net 4
Heterokrohnia sp.	25			
Heterokrohnia mirabilis			49	
Eukrohnia bathyantarctica			308	282
Sagitta macrocephala			257	904
Eukrohnia fowleri				
Eukrohnia spp	4		36	428
Sagitta zetesios				35
damaged	12		372	1208
TOTAL	41		1022	2857
volume filtered	70.623		102.410	67.615
n/ 1,000m^3	**0.6**		**10.0**	**42.3**

Nov 16 tow 5 MOC10

species	net 1	net 2	net 3	net 4
Heterokrohnia sp.	15	25	24	8
Heterokrohnia mirabilis	1	1	1	

Nov 16 tow 5 MOC10

species	net 1	net 2	net 3	net 4
Eukrohnia bathyantarctica	1	27	113	233
Sagitta macrocephala	8	24	180	469
Eukrohnia fowleri				
Eukrohnia spp	4		16	2186
Sagitta zetesios			5	113
Sagitta maxima	4		4	
Sagitta gazellae				48
damaged	24	24	112	136
TOTAL	24	402	904	1596
volume filtered	37.054	56.173	45.233	46.826
n/ 1,000m^3	**0.6**	**7.2**	**20.0**	**34.1**

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A.8 CHAETOGNATHS FROM MOC1

7 Nov tow 2 MOC1								
species	net 1	net 2	net 3	net 4	net 5	net 6	net 7	net 8
Heterokrohnia sp. ?	4							
Sagitta macrocephala	36							
Eukrohnia fowleri	32	56						
Sagitta zetesios	4	4						
Sagitta planctonis cf	4							
S. zetesios/planctonis juv			28	4	8	4	16	
Sagitta maxima cf		4						
Sagitta lyra		8	56	160		80		
Eukrohnia spp.	12		56	20	76			
Krohnitta subtilis				56	68	112	232	12
Sagitta serratodentata				4	4	120	160	444
Sagitta sibogae				20	48			
Sagitta hexaptera					8		120	216
Pterosagitta draco					4	60	1904	764
Sagitta enflata						236	400	940
Sagitta minima						12	328	
Sagitta bipunctata								148
Krohnitta pacifica						4		4
damaged/unidentified		28	24	76	72	232	2280	1024
TOTAL	92	100	164	340	288	860	5440	3552
volume filtered/ 1,000	1.538	1.380	1.965	1.403	1.156	0.586	0.326	0.445
N/ 1,000m^3	**59.8**	**72.5**	**83.5**	**242.3**	**249.1**	**1467.6**	**16687.1**	**7982.0**

11 Nov tow 3 MOC1

species	net 1	net 2	net 3	net 4	net 5	net 6	net 7	net 8
Heterokrohnia sp.								
Sagitta macrocephala	16	4						
Eukrohnia fowleri	26	47						
Sagitta zetesios	2	2						
Sagitta planctonis cf		3						
S. zetesios/planctonis juv			8			56		
Sagitta maxima cf	1							
Sagitta lyra			24	76	36	152		
Eukrohnia spp.	24	16	68	28				
Krohnitta subtilis				8	140	952		
Sagitta serratodentata						64		340
Sagitta sibogae				56	48			
Sagitta hexaptera					8	40		7
Pterosagitta draco					24	528		
Sagitta enflata			4		216	2632		936
Sagitta minima						144		
Krohnitta pacifica						80		88
Sagitta bipunctata								8
damaged/unidentified		12	24	96	408	1832	1496	164
TOTAL	69	84	128	264	880	6480	1496	1379
volume filtered/ 1,000	1.432	0.987	1.661	1.839	1.447	0.682	0.243	0.200
N/ 1,000m^3	**48.2**	**85.1**	**77.1**	**143.6**	**608.2**	**9501.5**	**6156.4**	**6895.0**

17 Nov tow 4 MOC1

species	net 1	net 2	net 3	net 4	net 5	net 6	net 7	net 8
Heterokrohnia sp.								
Sagitta macrocephala	8	4						
Eukrohnia fowleri	7	47						
Eukrohnia spp	48	72	24	104				
Sagitta zetesios		2						
Sagitta planctonis cf		3	12	16	20			
S. zetesios/planctonis juv		4						
Sagitta maxima cf								
Sagitta lyra		8	12	64	168			
Krohnitta subtilis			4	12	84	144	48	
Sagitta serratodentata					484	320	896	1232
Sagitta sibogae								
Sagitta hexaptera					76	952	144	40
Pterosagitta draco					72	2880	816	64
Sagitta enflata					116	952	320	48
Sagitta minima					4			
Krohnitta pacifica								
Sagitta bipunctata							16	8
damaged/unidentified		12	12	80	588	528	336	328
TOTAL	63	152	64	276	1612	5776	2576	1720
volume filtered/ 1,000	1.087	1.313	1.716	1.624	1.297	0.907	0.645	0.198
N/ 1,000m^3	**58.0**	**115.8**	**37.3**	**170.0**	**1242.9**	**6368.2**	**3993.8**	**8686.9**

A.9 DEEP-PELAGIC FISHES

Order	Family	Species	no.	% total
Anguilliformes	Congridae	Leptocephalus-*Ariosomma* type	1	0.1
Anguilliformes	Congridae	Leptocephalus - congrid type	48	2.7
Anguilliformes	Nemichthyidae	*Avocettina cuticeps*	1	0.1
Anguilliformes	Nemichthyidae	Leptocephalus - Nemichthyidae	2	0.1
Anguilliformes	Synaphobranchidae	Leptocephalus - synaphobranchid type	1	0.1
Argentiformes	Alepocephalidae	alepocephalid juvenile	1	0.1
Argentiformes	Leptochilichthyidae	*Leptochilichthys agassizii*	1	0.1
Argentiformes	Leptochilichthyidae	*Leptochilichthys pinguis*	1	0.1
Argentiformes	Microstomatidae	*Bathylagichthys greyae*	1	0.1
Argentiformes	Microstomatidae	*Bathylagus antarcticus*	2	0.1
Argentiformes	Microstomatidae	*Bathylagus* sp.	5	0.3
Argentiformes	Microstomatidae	*Dolicholagus longirostris*	3	0.2
Argentiformes	Opisthoproctidae	*Dolichopteryx* (damaged)	1	0.1
Argentiformes		fish larvae - argentinoid	1	0.1
Aulopiformes	Notosudidae	*Ahliesaurus berryi*	1	0.1
Aulopiformes	Paralepididae	*Lestidiops affinis*	2	0.1
Aulopiformes	Paralepididae	*Lestidiops* juvenile	1	0.1
Aulopiformes	Paralepididae	Paralepidid juvenile	2	0.1
Aulopiformes	Paralepididae	*Paralepis* cf. *atlanticus*	1	0.1
Aulopiformes	Scopelarchidae	scopelarchid juvenile	2	0.1
Aulopiformes	Scopelarchidae	*Scopelarchus analis*	1	0.1
Beryciformes	Berycidae	*Beryx splendens*	1	0.1
Cetomimiformes	Cetomimidae	*Cetomimus* sp. A	1	0.1
Cetomimiformes	Cetomimidae	*Cetostoma regani*	1	0.1
Gadiformes	Bregmacerotidae	*Bregmaceros* ASH sp. 5	5	0.3
Gadiformes	Macrouridae	Macrourid juvenile	1	0.1
Gadiformes	Macrouridae	*Trachonurus villosus*	1	0.1
Lampridiformes	Stylephoridae	*Stylephorus chordatus*	2	0.1
Lophiiformes	Ceratiidae	*Cryptopsaras couesii*	2	0.1
Lophiiformes	Gigantactinidae	*Gigantactis* Male Group II	1	0.1
Lophiiformes	Himantolophidae	Himantolophid male	2	0.1
Lophiiformes	Linophrynidae	*Linophryne* sp. male	3	0.2
Lophiiformes	Melanocetidae	*Melanocetus murrayi*	1	0.1
Lophiiformes	Neoceratiidae	*Neoceratias spinifer* with male	2	0.1
Lophiiformes	Oneirodidae	*Chirophryne xenolophus*	1	0.1
Lophiiformes		Ceratioid larva	2	0.1
Myctophiformes	Myctophidae	*Benthosema suborbitale*	9	0.5
Myctophiformes	Myctophidae	*Bolinichthys indicus*	1	0.1
Myctophiformes	Myctophidae	*Bolinichthys photothorax*	2	0.1
Myctophiformes	Myctophidae	*Ceratoscopelus warmingii*	8	0.4
Myctophiformes	Myctophidae	*Diaphus dumerilii*	8	0.4
Myctophiformes	Myctophidae	*Diaphus holti*	1	0.1

Order	Family	Species	no.	% total
Myctophiformes	Myctophidae	*Diaphus* juv.	1	0.1
Myctophiformes	Myctophidae	*Diaphus mollis*	1	0.1
Myctophiformes	Myctophidae	*Diaphus* sp. A	2	0.1
Myctophiformes	Myctophidae	*Diaphus splendidus*	19	1.1
Myctophiformes	Myctophidae	*Diogenichthys atlanticus*	10	0.6
Myctophiformes	Myctophidae	*Diogenichthys panguris*	1	0.1
Myctophiformes	Myctophidae	*Gonichthys cocco*	2	0.1
Myctophiformes	Myctophidae	*Hygophum macrochir*	25	1.4
Myctophiformes	Myctophidae	*Hygophum reinhardtii*	5	0.3
Myctophiformes	Myctophidae	*Hygophum taaningi*	1	0.1
Myctophiformes	Myctophidae	*Lampanyctus alatus*	21	1.2
Myctophiformes	Myctophidae	*Lampanyctus crocodilus*	1	0.1
Myctophiformes	Myctophidae	*Lampanyctus* juvenile	3	0.2
Myctophiformes	Myctophidae	*Lampanyctus photonotus*	3	0.2
Myctophiformes	Myctophidae	*Lampanyctus pontifex*	1	0.1
Myctophiformes	Myctophidae	*Lampanyctus pusillus*	1	0.1
Myctophiformes	Myctophidae	*Lepidophanes guentheri*	11	0.6
Myctophiformes	Myctophidae	*Loweina rara*	1	0.1
Myctophiformes	Myctophidae	Myctophid larvae	41	2.3
Myctophiformes	Myctophidae	*Myctophum affine*	1	0.1
Myctophiformes	Myctophidae	*Myctophum nitidulum*	1	0.1
Myctophiformes	Myctophidae	*Nannobrachium* (damaged)	5	0.3
Myctophiformes	Myctophidae	*Nannobrachium achirus*	4	0.2
Myctophiformes	Myctophidae	*Nannobrachium atrum*	1	0.1
Myctophiformes	Myctophidae	*Nannobrachium isaacsi*	4	0.2
Myctophiformes	Myctophidae	*Notolychnus valdiviae*	13	0.7
Myctophiformes	Myctophidae	*Notoscopelus resplendens*	1	0.1
Myctophiformes	Myctophidae	*Symbolophorus rufinis*	1	0.1
Myctophiformes	Myctophidae	*Taaningichthys bathyphilus*	1	0.1
Ophidiiformes	Ophidiidae	*Laemonema* juvenile	1	0.1
Osmeriformes	Platytroctidae	*Pellisolus facilis*	1	0.1
Osmeriformes	Platytroctidae	platytroctoid larva	3	0.2
Perciformes	Chiasmodontidae	*Chiasmodon* juvenile	1	0.1
Perciformes	Chiasmodontidae	*Kali normani*	1	0.1
Perciformes	Gempylidae	*Diplospinus multistriatus*	8	0.4
Perciformes	Gempylidae	gempylid larva	3	0.2
Perciformes	Howellidae	*Howella brodiei*	1	0.1
Perciformes	Scombridae	Scombroid larva	2	0.1
Perciformes		Perciform larva	7	0.4
Pleuronectiformes	Bothidae	Bothid larva	2	0.1
Stephanoberyciformes	Melamphaidae	*Melamphaes eulepis*	4	0.2
Stephanoberyciformes	Melamphaidae	*Melamphaes microps*	1	0.1
Stephanoberyciformes	Melamphaidae	*Melamphaes polylepis*	1	0.1
Stephanoberyciformes	Melamphaidae	*Melamphaes simus*	14	0.8
Stephanoberyciformes	Melamphaidae	*Melamphaes* TBD	9	0.5
Stephanoberyciformes	Melamphaidae	*Melamphaes typhlops*	1	0.1
Stephanoberyciformes	Melamphaidae	Melamphaid juvenile	2	0.1

Order	Family	Species	no.	% total
Stephanoberyciformes	Melamphaidae	*Poromitra crassiceps*	1	0.1
Stephanoberyciformes	Melamphaidae	*Poromitra megalops*	1	0.1
Stephanoberyciformes	Melamphaidae	*Scopeloberyx robustus*	2	0.1
Stephanoberyciformes	Melamphaidae	*Scopelogadus mizolepis mizolepis*	15	0.8
Stomiiformes	Diplophidae	*Diplophos taenia*	2	0.1
Stomiiformes	Gonostomatidae	*Bonapartia pedaliota*	4	0.2
Stomiiformes	Gonostomatidae	*Cyclothone "pallida"* light form	3	0.2
Stomiiformes	Gonostomatidae	*Cyclothone* (damaged)	22	1.2
Stomiiformes	Gonostomatidae	*Cyclothone acclinidens*	239	13.4
Stomiiformes	Gonostomatidae	*Cyclothone alba*	197	11.1
Stomiiformes	Gonostomatidae	*Cyclothone microdon*	3	0.2
Stomiiformes	Gonostomatidae	*Cyclothone obscura*	85	4.8
Stomiiformes	Gonostomatidae	*Cyclothone pallida*	492	27.7
Stomiiformes	Gonostomatidae	*Cyclothone pseudopallida*	114	6.4
Stomiiformes	Phosichthyidae	*Vinciguerria nimbaria*	26	1.5
Stomiiformes	Phosichthyidae	*Vinciguerria poweriae*	4	0.2
Stomiiformes	Sternoptychidae	*Argyropelecus affinis*	8	0.4
Stomiiformes	Sternoptychidae	*Argyropelecus gigas*	1	0.1
Stomiiformes	Sternoptychidae	*Argyropelecus hemigymnus*	14	0.8
Stomiiformes	Sternoptychidae	*Argyropelecus* larva	5	0.3
Stomiiformes	Sternoptychidae	*Argyropelecus olfersi*	17	1.0
Stomiiformes	Sternoptychidae	*Maurolicus breviculus*	1	0.1
Stomiiformes	Sternoptychidae	*Polyipnus* juvenile	1	0.1
Stomiiformes	Sternoptychidae	*Polyipnus polli*	1	0.1
Stomiiformes	Sternoptychidae	*Sternoptyx diaphana*	28	1.6
Stomiiformes	Sternoptychidae	*Sternoptyx* juvenile	9	0.5
Stomiiformes	Sternoptychidae	*Sternoptyx pseudobscura*	19	1.1
Stomiiformes	Sternoptychidae	*Valencienellus tripunctulatus*	7	0.4
Stomiiformes	Stomiidae	*Aristostomias xenostoma*	2	0.1
Stomiiformes	Stomiidae	*Astronesthes* juvenile	1	0.1
Stomiiformes	Stomiidae	*Bathophilus* sp. A	1	0.1
Stomiiformes	Stomiidae	*Borostomias elucens*	2	0.1
Stomiiformes	Stomiidae	*Borostomias* juvenile	2	0.1
Stomiiformes	Stomiidae	*Borostomias mononema*	1	0.1
Stomiiformes	Stomiidae	*Chauliodus sloani*	6	0.3
Stomiiformes	Stomiidae	*Eustomias* (damaged)	1	0.1
Stomiiformes	Stomiidae	*Idiacanthus fasciola*	1	0.1
Stomiiformes	Stomiidae	*Malacosteus niger*	4	0.2
Stomiiformes	Stomiidae	*Melanostomias biseriatus*	1	0.1
Stomiiformes	Stomiidae	*Photostomias atrox*	1	0.1
Stomiiformes	Stomiidae	*Photostomias guernei*	1	0.1
Stomiiformes	Stomiidae	*Rhadinesthes decimus*	1	0.1
Stomiiformes	Stomiidae	*Stomias boa*	4	0.2
Stomiiformes	Stomiidae	*Stomias* juvenile	1	0.1
Stomiiformes	Stomiidae	stomiid larvae	1	0.1
Stomiiformes		stomiiform larvae	19	1.1
		Fish larva - unidentified - sp. A	2	0.1

Order	Family	Species	no.	% total
		fish larvae - TBD	27	1.5
Taxonomic totals				
orders	**16**			
families	**36**			
genera	**78**			

A.10 STATIONSLISTE/STATION LIST

Station	Date	Time	Position		Depth	Gear	Comment
PS71	2007		Latitude	Longitude	[m]		
001	29./30.10.	14:30	45°’53,66’N	06°34,18’W	4754	HS_PS	Start
		07:12	45°50,88’N	06°37,51’W			End
	30.10	07:29	45°50,96’N	06°38,06’W	4753	REL	Start
		09:31	45°50,85’N	06°38,27’W			End
002	31.10.	09:23	42°09,58’N	10°38,92’W	2732	POS	Start
		14:25	42°09,46’N	10°39,67’W			End
003	05.11.	14:42	24°39,99’N	20°44,39’W	4156	PAR	Start
		15:30	24°40,44’N	20°44,58’W			End
		15:32	24°40,51’N	20°44,58’W	4163	MOC 10	Start
		17:02	24°40,80’N	20°44,71’W			End
		17:27	24°40,55’N	20°44,75’W	4164	MOC 1	Start
		19:15	24°40,48’N	20°44,84’W			End
		19:35	24°40,57’N	20°44,85’W	4163	MN	Start
		21:11	24°40,32’N	20°45.45’W			End
004	08.11.	08:30	11°41.21’N	20°25,13’W	4898	MOC 10	Start
		19:03	11°22,71’N	20°21,08’W			End
		19:20	11°22,75’N	20°21,03’W	4874	MOC 1	Start
		22:49	11°28,29’N	20°16,10°W			End
005	11.11.	05:57	03°30.71’N	15°00,60’W	4757	MOC 10	Start
		16:59	03°19,22’N	14°47,01’W			End
		19:36	03°12,83’N	14°36,18’W	4722	MOC 1	Start
		22:53	03°10,03’N	14°31,17°W			End
006	13.11.	15:39	01°00,00’S	09°00,01’W	4709	PAR	Start
		16:05	01°00,06’S	09°00,02’W			End
		16:05	00°59,99’S	09°00,16’W	4704	MN	Start
		17.22	01°00,00’S	09°00,01’W			End
		16:22	01°00,03’S	09°00,08’W	4102	FLUORS	Start
		16:41	01°00,06’S	09°00,11’W			End
007	15.11.	15:00	07°26,21’S	04°07,71’W	4423	PAR	Start
		15:29	07°26,13’S	04°08,00’W			End
		15:37	07°26,15’S	04°08,17’W	4417	MN	Start
		17.22	07°26,28’S	04°08,78’W			End
		15:44	07°26,15’S	04°08,26’W	4424	FLUORS	Start
		16:05	07°26,16’S	04°08,38’W			End
008	17.11.	04:59	13°09.22’S	00°18,83’E	5485	MOC 10	Start
		17:25	13°21,16’S	00°37,06’E			End
		18:09	13°24.76’S	00°38,74’E	5501	MOC 1	Start
		21:40	13°31,41’S	00°39,74’E			End
009	20.11.	13:12	23°14,71’S	08°14,82’E	908	PAR	Start
		13:37	23°14,57’S	08°14,58’E			End
		13:17	23°14,66’S	08°14,76’E	925	HN	Start
		13.38	23°14,56’S	08°14,67’E			End
		13:56	23°14,38’S	08°14,33’E	948	MN	Start
		15.13	23°14,66’S	08°14,25’E			End
		14:05	23°14,31’S	08°14,30’E	960	FLUORS	Start
		14.27	23°14,36’S	08°14,26’E			End
010	21.11.	04:00	25°04.67’S	09°34,84’E	4471	MOC 10	Start
		15:56	25°26.17’S	09°40,81’E			End
		17:00	25°32.60’S	09°44,33’E	4460	MOC 1	Start

Station	Date	Time	Position		Depth	Gear	Comment
		21:00	25°40.67'S	09°49,31'E			End
011	22.11.	11:57	26°59.91'S	10°59,93'E	4613	PAR	Start
		12:22	26°59.71'S	10°59,62'E			End
		12:23	26°59.70'S	10°59,61'E	4613	FLUORS	Start
		12:47	26°59.45'S	10°59,19'E			End
		12:49	26°59.42'S	10°59,15'E	4613	MN	Start
		14:00	26°59.25'S	10°58,34'E			End

Abkürzungen/Abbreviations

FLUORS Fluorimeter
HN Hand net
HS_PS HydroSweep/ParaSound profile
MN Multinet
MOC1 MOCNESS 1m^2
MOC10 MOCNESS 10 m^2
PAR Radiation-meter
POS Posedonia Test
REL Releaser Test

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