



EXPEDITION PROGRAMME No. 54

RV "POLARSTERN"

ANTARCTIC XVII/3
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ALFRED WEGENER INSTITUTE
FOR POLAR AND MARINE RESEARCH
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RV "POLARSTERN"

ANTARCTIC XVII/3

Ecology of the Antarctic Sea Ice Zone (EASIZ III)

Cape Town - Punta Arenas

17.03. - 11.05.2000

Coordinator: D.K. Fütterer

Chief Scientist: W.E. Arntz

**ALFRED WEGENER INSTITUTE
FOR POLAR AND MARINE RESEARCH**

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1 Summary and itinerary

As during the two preceding cruises EASIZ I (1996) and EASIZ II (1998), the third "Polarstern" cruise of SCAR's international EASIZ programme will concentrate on limited areas to be studied and a small number of joint projects ("box concept"). Among the 7 nations participating in the cruise, Spain follows the host country in number of participants. The principal projects to be realized include:

(i) Benthic-pelagic coupling in the high Antarctic ecosystem and the role of suspension feeders. Food analyses of benthic suspension feeders (mostly cnidarians) revealed limited connection between the rain of larger particles sinking to the seafloor during the short Antarctic summer and the food of these organisms, and incubation experiments presented evidence for the use of the fine seston fraction by certain suspension feeders. Both the food analyses and the experiments will be continued and refined, putting major emphasis on the quality of the food offer and the processes that make the food available to the benthos. A multidisciplinary approach will be undertaken including microbial ecology, seston quality analysis, flow measurements, sediment dynamics, and the study of other variables and processes above and at the seafloor. Investigations on shallow areas which present specific environmental conditions and a special fauna of suspension feeders will be intensified by means of visual methods and a large TV grab.

(ii) Effect of iceberg scour on macro- and meiobenthic, and demersal fish, communities. As on the preceding cruises, the task is to identify recurrent successional stages during the process of recolonisation after iceberg scour, and to assess the temporal and spatial scales of the processes involved. The final goal is to determine the capacity of recovery (resilience) of Antarctic benthic communities in comparison with other marine ecosystems. One of the major difficulties to be overcome is age and growth determination of those organisms that have no hard structures, and where alternative modern methods have to be applied. The combination of fish and invertebrate approaches in joint studies has proved to be scientifically rewarding. Improved video techniques on the multibox corer are expected to be helpful in distinguishing between disturbed sites and "virgin" areas which did not suffer iceberg scour for a long time.

(iii) Biodiversity and evolutionary links of the high Antarctic Weddell Sea with the Antarctic Peninsula and other regions.

Latitudinal diversity gradients are far from clear due to worldwide continuous changes in sampling gear and enormous difficulties in taxonomic identification. The baseline material for genuine comparisons will be complemented by the use of gear such as multibox corer, multicorer and epibenthic sledge. Representative samples will be taken, and the material will be worked up at a single institution, to determine total per haul, or per sample, invertebrate diversity for areas in the eastern Weddell Sea and off the Antarctic Peninsula. Genetic variability will be studied in copepods and peracarid crustaceans. Other specific taxa to be studied within the biodiversity context include cnidarians, bryozoans, amphipods, molluscs, crinoids, asteroids, and cephalopods. Light and electron microscopic studies will be performed on the occurrence of parasites in Antarctic invertebrates and fish.

(iv) Adaptive strategies on the population and community level.

This project addresses physiological, ecological and behavioural adaptations to the Antarctic environment in meio/macrofauna and fish populations and communities. Due to the late time of the cruise in the Antarctic season, special emphasis will be laid on processes and strategies in populations under autumn conditions, and on spatio-temporal distribution of demersal and pelagic fish communities in relation to environmental conditions. Taxa under specific consideration will be decapod crustaceans, polychaetes, asteroids, eelpouts (Zoarcidae) and the scallop *Adamussium colbecki*.

(v) Structure and function of marine natural products in Antarctic invertebrates.

Proceeding on the assumption that the Antarctic benthic system is a fairly old one, and that the manifold interactions observed between its faunal elements reflect the frequent use of secondary metabolites and other natural substances, an attempt will be made to explore the biochemical and ecological significance of marine natural products in the field. Taxa to be studied include pterobranchs, priapulids, brachiopods, bryozoans, gastropods and cnidarians.

In addition to these core projects, studies will be undertaken, among others, on persistent organic pollutants in the Southern Ocean ecosystem, and novel drifting buoys will be deployed in the marginal ice zone to improve understanding of the mechanisms of Antarctic sea ice formation in winter.

"Polarstern" will leave Cape Town on March 17, 2000 heading for Atka Bay where the GB group will install some land-based equipment for their drifting buoys. Moorings will be deployed off Kapp Norvegia at an early stage to account for environmental data during the major part of the expedition, while the vessel works between Atka Bay and the Drescher Inlet.

Around 20 April, "Polarstern" will leave the eastern Weddell Sea and head for the South Shetland Islands, where (if the weather allows it) some equipment, samples and live material will be picked up at the Dallmann Laboratory (Jubany Base). The vessel will then continue to Rothera Base to deliver some fuel, and return to the Bransfield Strait to do some work in the Antarctic Peninsula area. Around 07 May, personnel (and, if necessary, materials) will be picked up from the Dallmann Laboratory, and "Polarstern" will head for South America to arrive on schedule in Punta Arenas, on 11 May 2000.

1 Zusammenfassende Übersicht und Fahrtverlauf

Wie schon bei den vorausgegangenen Expeditionen EASIZ I (1996) und EASIZ II (1998) wird sich auch die dritte Reise der "Polarstern" im Rahmen des internationalen SCAR-EASIZ-Programms auf begrenzte Untersuchungsgebiete und eine kleine Zahl gemeinsamer Projekte konzentrieren ("Boxkonzept"). Unter den sieben Nationen, die sich an der Reise beteiligen, stellt Spanien nach dem Gastgeberland die höchste Zahl der Teilnehmer. Geplant sind vor allem die folgenden Arbeiten:

(i) Benthopelagische Kopplung im hochantarktischen Ökosystem und die Rolle der Suspensionsfresser.

Nahrungsanalysen an benthischen Suspensionsfressern (v.a. Nesseltiere) haben gezeigt, daß nur eine eingeschränkte Beziehung zwischen dem Regen größerer Partikel, die zum Meeresboden sinken, und der Nahrung dieser Organismen besteht. Inkubationsexperimente belegten darüberhinaus die Nutzung der feinen Sestonfraktion durch bestimmte Suspensionsfresser. Nahrungsanalysen und Experimente sollen mit verfeinerten Methoden fortgesetzt werden. Dabei wird ein noch größeres Gewicht auf die Qualität des Nahrungsangebots und die Prozesse gelegt, welche die Nahrung für das Benthos verfügbar machen. Mikrobielle Ökologie, Qualitätsanalysen des Seston, Messungen des Energieflusses, Sedimentdynamik sowie andere Variable und Prozesse am und über dem Meeresboden sollen in einem multidisziplinären Ansatz kombiniert werden. Flache Areale mit ihren spezifischen Umweltbedingungen und einer besonderen Suspensionsfresserfauna werden auf dieser Reise mit Hilfe visueller Methoden und eines großen TV-Greifers intensiver untersucht.

(ii) Auswirkungen von Eisbergstrandungen auf Makro- und Meiobenthos sowie auf Bodenfischgemeinschaften.

Wie auf den vorangegangenen EASIZ-Reisen sollen die einzelnen Sukzessionsstadien, die während der Wiederbesiedlung nach Eisbergstrandungen aufeinanderfolgen, identifiziert und die Raum- und Zeitskalen der dabei ablaufenden Prozesse bestimmt werden. Endziel ist eine Abschätzung der Erholungsfähigkeit (Resilienz) antarktischer Benthosgemeinschaften im Vergleich zu anderen marinen Ökosystemen. Eine erhebliche Schwierigkeit dabei ist die Bestimmung von Alter und Wachstum von Organismen, die nicht über Hartstrukturen verfügen; hier müssen moderne alternative Methoden angewendet werden. Eine Verknüpfung von Fisch- und Wirbellosenansätzen in gemeinsamen Projekten hat sich als wissenschaftlich ergiebig erwiesen. Die verbesserte Videotechnik am Mehrfachgreifer sollte bei der Unterscheidung von gestörten und

"jungfräulichen" Arealen, die lange Zeit keine Störung durch Eisberge erfahren haben, hilfreich sein.

(iii) Biodiversität und evolutionäre Beziehungen des hochantarktischen Weddellmeeres mit der Antarktischen Halbinsel und anderen Regionen.

Latitudinale Diversitätsgradienten sind aufgrund ständiger weltweiter Veränderungen an den Sammelgeräten und enormer Probleme bei der taxonomischen Bestimmung weiterhin alles andere als klar. Unsere Datenbasis für gültige Vergleiche über einen weiten Breitengradienten soll durch den Einsatz von Mehrfachgreifer, Multicorer und Epibenthoschlitzen vervollständigt werden. Repräsentative Proben werden genommen und von einer einzigen Institution aufgearbeitet, um die gesamte Wirbellosendiversität pro Hol oder Probe im östlichen Weddellmeer und vor der Antarktischen Halbinsel zu erfassen. Die genetische Variabilität soll an Copepoden und peracariden Krebsen bestimmt werden. Andere Untersuchungsobjekte im Rahmen der Biodiversität sind Nesseltiere, Moostierchen, Amphipoden, Mollusken, Haarsterne, Seesterne und Tintenfische. Das Vorkommen von Parasiten in antarktischen Wirbellosen und Fischen soll licht- und elektronenmikroskopisch untersucht werden.

(iv) Anpassungsstrategien auf dem Populations- und Gemeinschaftsniveau.

In diesem Projekt werden physiologische, ökologische und verhaltensmäßige Anpassungen an die antarktischen Umweltbedingungen bei Populationen und Gemeinschaften der Meio- und Makrofauna sowie der Fische studiert. Aufgrund der späten Jahreszeit, in der die Expedition stattfindet, soll ein besonderes Gewicht auf Populationsprozesse und -strategien unter Herbstbedingungen sowie auf die Analyse der Raum-Zeit-Verteilung demersaler und pelagischer Fischgemeinschaften in Abhängigkeit von den Umweltbedingungen gelegt werden. Unter diesen Aspekten werden dekapode Krebse, Polychäten, Seesterne, Aalmuttern (Zoarcidae) und die Jakobsmuschel *Adamussium colbecki* die Hauptuntersuchungsobjekte sein.

(v) Struktur und Funktion von marinen Naturstoffen in antarktischen Wirbellosen.

Unter der Annahme, daß das antarktische Ökosystem recht alt ist, und daß die vielfältigen Interaktionen, die zwischen verschiedenen Faunenelementen beobachtet wurden, häufigen Gebrauch von Sekundärmetaboliten und anderen Naturstoffen anzeigen, soll die biochemische und ökologische Bedeutung dieser Substanzen im Freiland aufgeklärt werden. Dabei werden insbesondere Pterobranchier ,

Priapuliden, Brachiopoden, Bryozoen, Schnecken und Nesseltiere berücksichtigt.

Zusätzlich zu diesen Kernprojekten werden u.a. persistente organische Schadstoffe im Ökosystem des Südpolarmeeres gemessen und neuartige Driftbojen in der Eisrandzone ausgebracht, um die Mechanismen der antarktischen Meereisbildung im Winter besser verstehen zu lernen.

Die "Polarstern" wird am 17. März 2000 aus Kapstadt in Richtung Atka-Bucht auslaufen, wo die britische Arbeitsgruppe Meßgeräte für ihre Driftbojen an der Neumayer-Station installieren möchte. Anschließend sollen schnellstmöglich Verankerungen vor Kapp Norvegia ausgebracht werden, um während der Hauptphase der Expedition, wenn das Schiff zwischen der Atka-Bucht und dem Drescher-Inlet arbeitet, über Umweltdaten zu verfügen.

Um den 18. April verläßt "Polarstern" das östliche Weddellmeer in Richtung auf die Südshetland-Inseln, wo (unter günstigen Wetterbedingungen) bereits Gerät, Proben und Lebendmaterial vom Dallmann-Labor an der Jubany-Station übernommen werden sollen. Das Schiff fährt dann weiter zur englischen Base Rothera, um dort Brennstoff abzuliefern, und kehrt in die Bransfield-Straße zurück, um die Arbeiten an der Antarktischen Halbinsel zu erledigen. Um den 07. Mai wird Personal sowie - falls noch nötig - Material vom Dallmann-Labor übernommen, und "Polarstern" dampft nach Südamerika, wo sie am 11. Mai in Punta Arenas eintreffen wird.

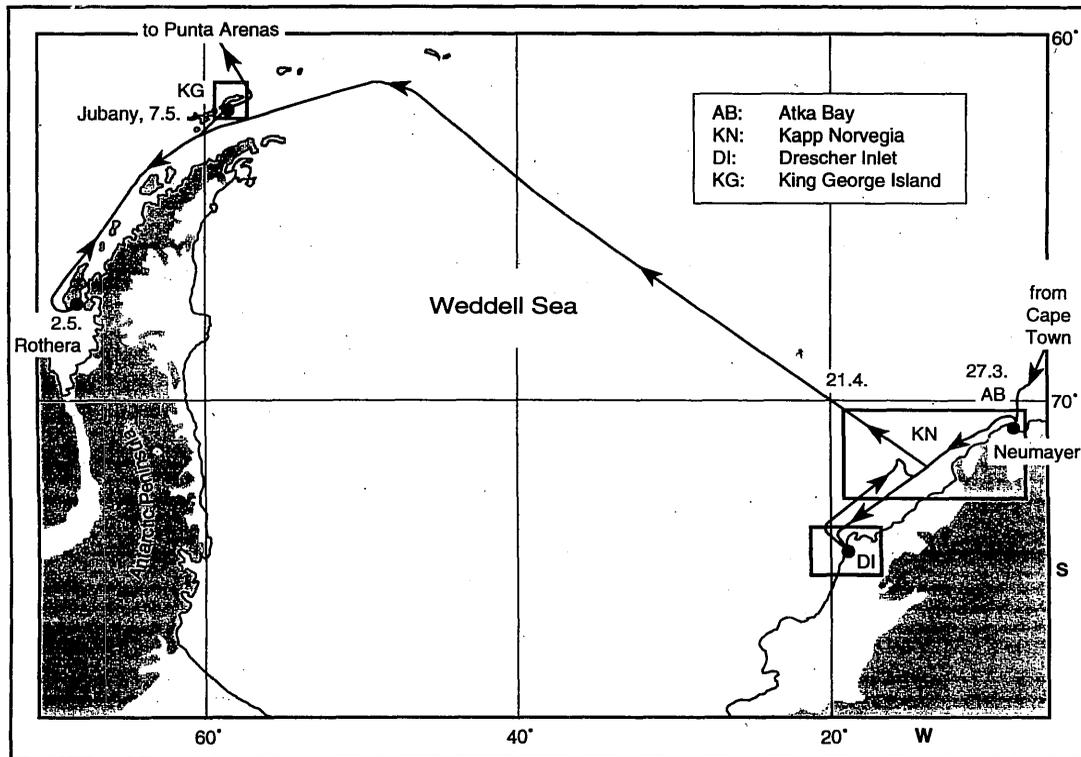


Fig. 1: Areas of investigation. Overview.

2 Scientific projects

2.1 Pelagobenthic/benthopelagic coupling

2.1.1 Multidisciplinary approach to understand the ecological role of benthic suspension feeder communities in the Antarctic ecosystem (ICM, AWI, UBC, USE)

Rationale

Benthic communities dwell in the interface zone between sea floor and water column. From the viewpoint of pelagic ecology, the benthos is often regarded as a sink only where the remainders of the production in the water column come to rest. However, in littoral and shelf systems, taking suspension feeder communities as an example, the benthos is an extremely active part of the system, receiving food particles settling out of, as well as actively exploiting production in, the water column. Consequently, communities of suspension feeders make up a highly active boundary system relatively distant from the concept of discontinuities or ecotones between communities.

A generally accepted paradigm was that Antarctic benthic communities should have a long period of inactivity during austral winter. Recent studies on certain littoral benthic suspension feeders suggest, however, that this period of inactivity may last only a few weeks, at least in shallow water. These results also indicate special adaptations to low food levels and to the use of locally higher food concentrations (patch feeding).

Efficient food assimilation, the use of alternative resources such as the fine fraction of seston, and continuous food supply by resuspension and advection processes also during winter might help to understand the development of suspension-feeder dominated, very diversified, high biomass and tridimensionally structured communities even under conditions of low food availability.

The studies to be carried out under this project will serve to check the following hypotheses, part of which are derived from work in other marine ecosystems:

-- Food availability in the water column and at the Antarctic seafloor may not be as limited as considered hitherto, taking into account the small food fraction and the role of processes such as lateral advection and resuspension.

- Sessile suspension feeders should respond significantly to fluctuations in food availability. Capture should increase at high current speeds and high food quality, and result in an increase of abundance and diversity of these suspension feeders.
- Suspension feeders depend upon the food items that come in contact with their organs of prey capture. They should therefore be able to feed on a wide range of prey items, and they should not select but rather concentrate on the most abundant items.
- The energetical dependence of suspension feeders upon the pelagic system and its fluctuations should be manifest in all energy acquisition processes. For example, reproduction should be subject to low predictability and strong variations in food availability, which should lead to a high variability of reproductive strategies.
- As well-developed communities of suspension feeders may exert an important impact on plankton populations and the abundance of suspended organic matter in the water mass adjacent to the bottom, their activity should enhance the processes related with organic matter transformation and recycling.
- Since suspension feeders are extremely efficient organisms in terms of energy transfer from the pelagial to the benthic system, they should build heterogenous and spatially patchy communities dependent on hydrodynamics and food availability.

Investigation programme

The following studies are to be carried out on the high Antarctic Weddell Sea shelf and slope, at single shallow sites, on the shelf of the Antarctic Peninsula, and in the cool containers aboard "Polarstern":

- Flow measurements and sediment dynamics near the bottom: identification of the processes that cause resuspension and/or transport events and the variability of particle fluxes, as well as their transfer offshore and the formation of near-bottom nepheloid layers (in collaboration with the team of D. Gerdes)
- Water column seston analysis including pico-, nano, micro and zooplankton (in collaboration with the teams of S. Schiel and C. Pedrós)
- High resolution experiments: small-scale studies at three stations selected in function of the high or low density of benthic suspension feeder communities
- Biological and chemical processes near the bottom: particle concentration, microbial activity and organic nutrient concentration (in collaboration with the team of C. Pedrós)
- Study of natural diet: incubations with the sponge *Stylocordyla borealis* and gut content analysis of the hydroid *Tubularia ralphii*

- Stoichiometric analysis (lipids, proteins and carbohydrates) of several species of gorgonians in relation to the composition of these substances in the sediments and the water column
- Reproductive strategies and quantification of gonad production and larval release in several species of gorgonians and pennatulaceans. Abundance and spatial heterogeneity of the more abundant species of these groups on the continental shelf of the Weddell Sea (in collaboration with the team of J. Gutt).
- Relationship between zooplankton vertical migration, their abundance close to the bottom, and suspension feeder prey capture (in collaboration with the team of S. Schiel):

2.1.2 Horizontal sampling of zooplankton (AWI, ICM, UOB)

Rationale

During the last EASIZ cruise, benthic sampling and ROV observations showed the existence of large communities of benthic suspension feeders dominated by hydrozoans and anthozoans. One of the objectives of this cruise, besides evaluating the type of prey and feeding rates of these communities, is to estimate the trophic impact on the nearby zooplankton populations.

Investigation programme

Horizontal sampling of the zooplankton populations inhabiting the column near the seafloor will be undertaken in order to estimate their composition and abundance. On the other hand, horizontal hauls will be carried out at depths where echosounding shows the existence of zooplankton aggregations, with the objective of identifying their specific composition and to estimate density.

2.2 Iceberg disturbance

2.2.1 Iceberg effects on benthic and fish communities (AWI, UBC, UMAG)

Rationale

The knowledge of community resilience (its capacity of recovery after a disturbance) is of essential importance for ecosystem conservation and will be of increasing relevance in the Antarctic since new international rules of nature conservation have been established under the "Madrid Protocol". There are obvious differences in the resistance of a community to environmental stress. Some strongly fluctuating marine ecosystems may withstand quite a lot of impact whereas other highly

persistent systems such as Antarctic benthic communities are supposed to be sensitive or even fragile. However, the data on which this paradigm is based are still poor.

In situ videos recorded during the EASIZ I and II cruises demonstrate that part of the benthos inhabiting the high Antarctic shelf is regularly affected by iceberg scouring. Iceberg grounding causes considerable damage to benthic communities. Sessile organisms are eradicated and pioneer species begin to grow in high abundances. Recent analyses indicate that the assemblages recover along highly complex pathways of succession, suggesting it may take decades or even centuries for a patch to return to its original appearance. Scour marks are found in all different stages of recolonization, thus providing an insight in the whole process of recolonization. On larger spatial scales, the co-existence of different recolonisation stages seems to enhance rather than reduce species diversity.

The goal of our studies is to provide an improved data base which may finally enable us to quantify recolonisation and succession processes in high Antarctic benthos and demersal fish assemblages both spatially and temporally.

Investigation programme

The synoptical approach of our studies basically comprises the following aspects:

- Quantification of scour mark density and extension on the shelf off Kapp Norvegia to estimate the role of this effect on benthic and fish assemblages.
- Species composition, diversity, organism biomass and density in disturbed and undisturbed areas nearby will be compared in order to describe recolonization and succession in formerly devastated areas. The comparison of benthic community structures inside and outside disturbed areas will allow to age the disturbance and to estimate the time required to re-establish the initial benthic structure.
- A detailed study of the demersal fish fauna and their potential prey in scour marks and in undisturbed areas will be carried out to evaluate the role of fish as predators on macrobenthic communities in early successional stages, and to estimate the impact of iceberg scours on the fish communities.

Gears to be applied in these synoptical studies are ROV, photo sledge, UW-video guided multibox corer, epibenthos sledge, otter trawl, Agassiz trawl, and CTD.

2.2.2 Stability and resilience of the meiobenthos in relation to iceberg scouring activity (UGZ, UOG)

Rationale

In connection with studies on species diversity and on the community structure of harpacticoid and nematode associations the influence of physical disturbances on the habitat is of particular interest.

The intention is to compare harpacticoid species composition and diversity between areas of the sea floor which are severely disturbed by icebergs and those that are undisturbed. Differences in community structure and diversity patterns will be studied on the family, genus, and species level. It is hoped that sampling of many replicates will allow to determine whether possible differences are due to the disturbing effects of icebergs.

To answer these questions replicates of multicorer samples from the eastern Weddell Sea will be analyzed quantitatively and compared with each other. This requires that during ANT XVII/3 multicorer samples are taken in undisturbed areas of the seafloor and in immediately adjacent ones disturbed by iceberg action. It is important to know the date of the disturbance in order to evaluate processes of recolonization. This requires cooperation of different disciplines.

Investigation programme

As the sublittoral zone along Kapp Norvegia is regularly abraded by calving icebergs from the ice shelf, disruption of sediment and associated depauperation of the macrofauna was thought to be a major factor structuring the meiofauna living there. During the past EASIZ cruises meiofauna has been successfully sampled in order to study depauperation, (re)distribution and (re)colonisation. The first results show that there is indeed a profound iceberg impact on meiobenthic higher taxon level and on nematode genus diversity.

In contrast to our low subtidal studies meiobenthic recolonisation and resilience could, however, not be adequately interpreted, leaving us with many unsolved hypotheses. A similar sampling design (e.g. weekly sampling) as in shallow waters is not possible, due to practical constraints of working along the deep continental shelf. Therefore, if the occasion arises, we would like to start a preliminary experiment with settlement panels in order to follow recolonisation of meiofauna during a short time interval. The basic idea is that, due to their very short generation times, meiofauna will recolonise the sediments within a few days or weeks.

2.3 Biodiversity

2.3.1 ZOOPLANKTON (AWI, ICM)

Rationale

In the Antarctic Ocean the zooplankton community is dominated by species of the genera *Calanus*, *Metridia*, *Micocalanus*, *Ctenocalanus* and *Oithona* (Metz 1996, Schiel 1998). These species represent a major component in the trophic web closing the gap between phytoplankton and ichthyoplankton (Hubold & Hagen 1997). Despite their ecological importance and their broad geographic distribution, uncertainty still exists as to their phylogenetic relationships (Bradford, 1988).

Molecular-genetic analyses on copepods

Within the framework of this project, phylogenetic relationships on species or population level among selected copepod taxa will be analysed using molecular genetic methods. Species of the genus *Calanus* might provide ample grounds for comparison, as they differ in their geographic distribution and inhabit different water masses, e.g. *C. propinquus*, which occur in the Coastal Current (Weddell Sea, Lazarev Sea) (Schnack-Schiel et al. in press), and *C. simillimus*, which predominate in the Antarctic Circumpolar Current (Mackintosh 1934). Another aim of this study is to be able to distinguish between sympatric species of similar morphology, e.g., *Microcalanus pygmaeus* and *M. pusillus*, whose correct identification is made even more difficult by a high degree of intraspecific variability and the frequent occurrence of hybrids. A combination of methods customarily applied in planktology and molecular biological methods might provide means for distinguishing ecological types, genetically different types of a given species, and facilitate the reliable identification of new species. For example the molecular genetic results will be compared with detailed morphological examinations at different stages of copepods caught in the field as well as individuals of crossing experiments.

Investigation programme

Individuals of the target taxa will be collected using a Multinet. Special attention is paid to sampling a variety of ocean regions (Circumpolar Current, Weddell Sea) and different depth ranges to obtain data on the vertical distribution and structure of the copepod community.

After retrieval of the gear, copepods will immediately be sorted, identified and preserved in liquid nitrogen for molecular genetic analysis. In addition, female copepods of different species will be selected for in-vitro respiration experiments and karyological examinations on board.

At the end of the cruise live female copepods will be transported under constant conditions back to the laboratory at the AWI Bremerhaven, where they will be used for crossing experiments.

Gelatinous zooplankton

Emphasis will be devoted to the collection of particular species of gelatinous carnivores in order to complete the quite advanced fauna of planktonic cnidarians (hydromedusae and siphonophores) of the Southern Ocean.

2.3.2 Biodiversity of Peracarida (Crustacea, Malacostraca) (ZIZM)

Rationale

Selected taxa of the peracarid fauna of the Weddell Sea will be compared with regard to their genetic variability along a) vertical gradients (shelf - slope - deep sea), b) in the context of longitudinal gradients (Subantarctic Islands- SE-Weddell Sea - Antarctic Peninsula), and latitudinal gradients (Angola basin (Meteor cruise no. 48) - Subantarctic Islands - Antarctica).

A collection of suitably preserved amphipod and cumacean material shall be built up for later studies on genetic inter- and intraspecific variability of Antarctic species of Amphipoda and Cumacea.

Investigation programme

Peracarids will be sampled from the shelf to the deep sea in the two working areas (SE-Weddell Sea, Antarctic Peninsula). Material from the shelf and slope will be collected out of AGT, EBS, Rauschert dredge, and TV grab. 3-4 deep-sea stations (> 1000 m) are to be taken by EBS. For the investigations on certain species of Amphipoda and Cumacea with molecular genetic techniques, it is necessary to freeze material on board and to continue with the final analyses in the laboratory at home. Prior to fixation, animals will have to be kept in aquaria on board for some time.

2.3.3 Zoogeography of amphipods and their association with other zoobenthos (AWI)

Rationale

a) & b) Collections of small amphipods below the catching flat of the epibenthos sledge by use of a special dredge. This amphipod material is required for the Monography "The Amphipod Fauna of the South

Shetland Islands with Zoogeographical Comparisons to the Magellanic Region and the High Antarctic " (in prep.).

- c) Primary colonisation by amphipod species and the influence of species immigrating later.
- d) Examination of associations (commensalism and parasitism).
- e) Completion of the determination list containing more than 100 species.

Investigation programme

- a) Continued recording of the amphipod fauna in the Weddell Sea for the study of reproduction and seasonal rhythms. Comparison with the amphipod fauna of the West Antarctic and the Magellan region.
- b) Special consideration of shallow water areas with rocky bottom.
- c) Observations about changes of the amphipod species spectrum in areas with iceberg scours.
- d) Continued investigations on associations of amphipods with Porifera, Cnidaria (Hydrozoa, Gorgonaria), and Tunicata (Ascidiae).
- e) Increase the collection of zoobenthos photos for AWI's determination list.

2.3.4 Biodiversity, phylogeny and ontogeny of Antarctic molluscs and crinoids (UM, ZIZM, ZSM)

Rationale

The biodiversity of Antarctic molluscs and crinoids will be studied during the EASIZ III cruise in the southeastern Weddell Sea and off the Antarctic Peninsula. It should be possible to collect material from different habitats in sufficient quantities for multiple uses (live observations, special fixations, etc.). The ultrastructure, ontogeny and phylogeny of selected groups are also a focus of our interest.

Work hypotheses

-- Biodiversity

Which molluscs and crinoids inhabit the Weddell Sea? Research on taxonomy and community structure are the basis for any ecological comparisons on species level (e.g. disturbed vs. non-disturbed areas) and also for biogeographical comparisons with the mollusc and crinoid fauna of adjacent areas (i.e. Antarctica, Magellan region and south Atlantic Ocean). Comprehensive databases have already been developed in our workgroup (e.g. molluscs of the Magellan region).

-- Ultrastructure of selected groups

More material and data on important groups (e.g. Monoplacophora, basal Opisthobranchia, and larvae of Crinoidea) are badly needed for functional and phylogenetic analyses.

-- Ontogeny of Monoplacophora and Crinoidea

Many Antarctic monoplacophorans and crinoids are brooders. Thus obtaining adults will make it easy to get different ontogenetic stages for, e.g., ultrastructural study. This information is essential to the understanding of their poorly known ecology and evolutionary history.

-- Phylogeny

What is the origin and evolution of Antarctic molluscs and crinoids? Many basal or enigmatic Mollusca and Crinoidea inhabit the Antarctic region and adjacent deep waters (e.g. *Tomthompsonia*, Hyocrinida). Several groups show a significant radiation in Antarctic waters (e.g. Isometrinae, Heliometrinae, Notocrinidae). Modern methods, i.e. histological, ultrastructural, immunocytochemical, molecular and biochemical approaches, are appropriate tools to answer these fascinating questions.

2.3.5 Analysis of bryozoan communities in the Weddell Sea (GPI)

Rationale

Contrary to systematic work on bryozoans, the knowledge of this group as part of the ecosystems of polar shelves is widely unknown. In many areas of Antarctica bryozoans are an important part of the benthos. More than 4300 species are known world-wide, and most of them belong to the Cheilostomida. However, there is little knowledge on polar cheilostome bryozoans and some of the Antarctic and Subantarctic bryozoans are only known from earlier expeditions. Few analyses of small-scale colonisation strategies of bryozoans and their epifauna in polar seas have been made. Studies on bryozoan communities in Antarctica are restricted to the littoral and sublittoral of Signy Island.

Investigation programme

- interpretation of underwater photographs with regard to distribution, density and structure of bryozoan communities;

- faunistic revision of bryozoans and their biogeographic distribution with regard to the influence of water masses;
- analysis of the structural potential of bryozoan communities in forming different habitats; to what extent do bryozoans build substrate or produce new habitats with their skeletal sediment components;
- studies on special settlement strategies and succession of bryozoans in bryozoan dominated benthos communities to evaluate the structure and history of the communities;
- study of growth bands in bryozoan skeletons with regard to seasonality and the interpretation of life cycles;
- analysis of growth forms and their adaption to the environment.

2.3.6 Investigations on the diversity of macrozoobenthos communities in the eastern Weddell Sea and at the Antarctic Peninsula (ZISP, AWI)

Rationale

Calculating diversity from the species rich hauls in Antarctic waters has hitherto been little successful due to the fact that a large part of the fauna from these catches could not be determined to species level. Distribution among specialists, who are scattered all over the world and are mostly occupied with other samples, has yielded very variable returns which were restricted to a few taxa; calculating diversity for total catches has not been possible.

On cruise EASIZ I in 1996 benthic invertebrate species numbers per haul, as estimated on board, were between 69 and 235 for the Agassiz trawl and between 90 and 244 for the bottom trawl. As some species cannot be separated even with the joint expertise of the experts aboard, these figures should represent minimum estimates.

Investigation programme

To calculate diversity it is not sufficient to use species numbers; the number of specimens per species has to be counted as well from representative subsamples. This cannot be done on the vessel. For this reason, representative, unbiased subsamples are to be taken from a number of catches in the Weddell Sea and off the Antarctic Peninsula. They will be preserved and analyzed in the ZISP, which offers the necessary taxonomic expertise of about 20 specialists for different taxa. Target communities are areas with and without iceberg scour (to be previously identified by visual methods), various successional stages of recolonisation, and assemblages from different water depths. A TV grab or giant box corer will take samples from shallow areas heavily covered

with stones or sponges. Additionally, as on EASIZ I, total invertebrate species numbers per catch will be estimated with the assistance of all experts on board.

Cooperation is sought above all with the "visual methods" group, for the identification of suitable stations and to compare diversity between the two approaches, as well as with other benthos groups and the fish group. Furthermore, the diversity group is interested in all hydrographic and sedimentological information with reference to the sampling sites.

2.3.7 Comparative studies on shallow-water epibenthic communities of Marguerite Bay (Antarctic Peninsula) and in the Weddell Sea

Rationale

In general the faunas of the Antarctic Peninsula and the high Antarctic Weddell Sea are considered to belong to different zoogeographical regions. Apart from a strong seasonality with ice coverage and primary production, relative constancy of physical conditions characterize both regions. Otherwise, however, there are some striking differences in the physical factors between both regions. About 95 % of the coastline and nearshore region of the high Antarctic is covered by floating or grounded glacier ice, so very shallow areas are extremely scarce. Conversely, the Antarctic Peninsula has a true coast and, thus, true littoral areas are common.

Investigation programme

In the Weddell Sea two sites with water depth of only 60 m are known: the inner parts of Atka Bay and a recently discovered shallow bank off Four Seasons Inlet (NE of Kapp Norvegia).

A detailed study of the communities that live in these shallow waters will be carried out, in order to compare these assemblages with studies of the shallow water of Marguerite Bay, Antarctic Peninsula. If no apparent differences at community level are discernible, it can be assumed that benthic communities that live in the shallow water of Antarctica have a circumpolar distribution, provided that suitable habitats exist.

If differences between communities exist, the question arises, what are the reasons. Do particular physical processes determine the benthic fauna at the shallow sites in the Weddell Sea, or are the differences just a result of limited larval dispersal because extreme shallow areas are very scarce?

The studies will be carried out with a remotely operated vehicle, photo sledge, and TV-grab.

2.3.8 Density, distribution and diversity of Harpacticoida, Nematoda and other meiobenthos (UGZ,UOB)

Rationale

One of the main topics of our research is the study of the distribution and diversity of Harpacticoida, Nematoda and other meiobenthos in Antarctic and adjacent waters. Benthos samples shall be taken with the multicorer at the Antarctic Peninsula. They are needed for a more thorough comparison of associations of Harpacticoida and Nematoda between South America and the high Antarctic. Statistical analysis in this case (similarity and diversity analysis) does not require that several replicate samples are taken with the multicorer.

Meiobenthos under autumn conditions:

Ecological research in the Weddell Sea to date shows that the meiofaunal communities at Kapp Norvegia are characterised by high densities and biomasses, reaching 5.106 organisms m^{-2} of sediment surface and a standing stock dry weight of 1 g m^{-2} . In addition nematode diversity is high as well. Features such as very high, but patchy primary production, with subsequent variable fluxes to the seabed were reflected in the meiobenthic distribution patterns of abundance, biomass and diversity. It was suggested that the meiobenthos responds rapidly and efficiently to this episodic food supply. Yet the controlling factor of food as a limiting factor is not yet studied.

Investigation programme

During this campaign we will sample meiofauna under autumn conditions which we have reason to believe differ considerably in the quantity and nature of organic matter supplied to the benthos during the summer.

2.3.9 Light and electron microscopic studies on the occurrence of parasites in invertebrates and fish of Antarctic waters

Rationale

During previous expeditions several groups of parasites were described especially from Antarctic fish and seals. However, the knowledge on protozoan parasitic species is very scarce and mainly limited to those species in fish, whereas invertebrates are rather neglected in this field,

although among the phyla Microsporidia and Myxozoa numerous species should be of high pathogenicity. Furthermore such protozoan parasites might be introduced into Antarctic hosts via vectors such as whales. Thus fish and invertebrates will be investigated for their role as final and intermediate hosts of parasites that might have an important impact on the food chains in this region.

Investigation programme

Small invertebrates will be investigated *in toto*, whereas larger specimens and fish will be dissected in order to study portions of skin, gills, muscle, kidney and intestine. The observed parasite stages will be investigated and photographed by light microscopy, recorded on video tapes and then prepared for the different methods of transmission and scanning electron microscopy and for use in the PCR technique (to be done at home).

Portions of the collected material will be transferred to different German and international laboratories for further investigations. Detailed studies (involving several diploma and PhD students) will be done at home using methods that cannot be carried out on board.

2.4 Adaptive strategies

2.4.1 Respiration of meiofauna under varying food and temperature conditions (UGZ, UOB)

Rationale

Many of the characteristic features of the biology of Antarctic marine organisms have been ascribed directly to the effects of the prevailing low temperatures. However, the relationship is more complex than originally envisaged and it is now becoming clear that the seasonal nature of food supply is of major importance to the biology of many Antarctic marine organisms. The importance of seasonality in the availability of food for Antarctic meiobenthos has been documented for the low subtidal communities at Signy Island, and the impact has been inferred from meiofauna studies in the Weddell Sea. However, the differential effect of the two dominant ecological factors in the Southern Ocean (low temperatures and the markedly seasonal primary production) could hardly be interpreted. Our attempt is therefore to follow the importance of temperature and food in metabolic rates of the meiobenthos from the Weddell Sea by measuring individual respiration of certain meiofauna taxa under different circumstances of both factors.

Investigation programme

Meiofaunal respiration will be measured using the Strathkelvin polarographic electrode method for oxygen consumption and a less temperature sensitive method based on CO₂ respiration. This involves the use of a few tens to a few hundred individuals per measurement, depending on the size and the respiratory activity of the animals. A parallel study will be performed on (preferably) the same taxa but from temperate sediments. This is to test whether evolution has produced compensation in the physiology of polar marine meiobenthos (that is, a reduced cost of maintenance metabolism).

2.4.2 Reproductive biology of polychaetes on the Weddell Sea shelf during autumn (SZI)

Rationale

In order to evaluate the role and interplay between phylogenetic and ecological factors in the life history traits of marine benthic invertebrates, polychaetes represent a useful group since they show a large variety of strategies. However, especially when studying polar regions, it is important to compare taxa belonging to the same, or closely related, groups, since many polychaete families show morpho-functional constraints linked to the size (e.g., brooding in Sabellidae), and mainly regarding egg size (e.g., Polynoidae) and the type of development.

Material collected during the cruises EASIZ I and EASIZ II revealed the presence of some interesting features as regards the reproduction of some polychetes. At least four species of Polynoidae (*Harmothoe spinosa*, *H. cf. magellanica*, *Harmothoe* sp., *Hermadion* sp.) showed brooding of eggs under the elitre (Gambi 1997 and 1999), a feature that was rarely reported in polynoids and found for the first time in the Antarctic representatives of this family. Brooding was also observed in the large tubicolous sabellid *Myxicola cf. sulcata* which incubated the embryos within the branchial crown. The two sympatric species of Perkinsiana, *P. littoralis* and *P. borsibrunoi* (Giangrande and Gambi, 1997), showed a different maturation of the gametes. In *P. littoralis* mature sperms were observed, as well as a modal class of relatively large eggs ranging from 150 µm to 200 µm, while in *P. borsibrunoi* only spermatids and a lower egg size (modal class 100-150 µm) occurred. This pattern may indicate a certain delay in maturation, and therefore a reproductive isolation, between these two closely related species.

Investigation programme

Due to the above discussed results, the programme proposed for the EASIZ III cruise, that will be conducted in autumn 2000 in the Weddell Sea, should focus on collecting polychaetes in a different season of the year to check their reproductive status in comparison to the summer season. In particular the attention will be concentrated on testifying the occurrence and extent of brooding in some of the species already identified as brooders, as well as in the other ones.

Samples should be taken on the continental shelf and slope of the Weddell Sea both in the areas of Kapp Norvegia and Vestkapp. Samples should be collected with the Agassiz and bottom trawls and also with the TV grab. A limited space for the rearing of some polychaetes (2-3 aquaria) in one of the cool rooms is required. A limited space (1 litre) in the - 80 °C freezer is also required for the preservation of samples for DNA analysis.

2.4.3 Comparative studies on the juvenile development of decapod crustaceans from the Magellan Region and the Weddell Sea (UMAG, AWI)

Rationale

The dominant group of decapod crustaceans in the Subantarctic waters of the Magellan Region are anomuran crabs whereas in the Weddell Sea only a few caridean shrimps, such as *Chorismus antarcticus* (Hippolytidae), *Notocrangon antarcticus* (Crangonidae) and *Nematocarcinus lanceopes* (Nematocarcinidae) represent the Decapoda. Intensive investigations carried out in the past have demonstrated that larval development, reproductive cycles and growth of decapod species follow the seasonal variation of primary and secondary production. However, little is known on the juvenile development. On the one hand, the mesh sizes of the bottom gear normally restricts sampling size to the adults, and on the other hand, rearing in tanks was focused on the larval stages exclusively.

Investigation programme

We plan tank experiments to study the impact of the substrate type and of the food availability on the development of juvenile shrimps and crabs. Since spawning of the eggs occurs at the end of austral summer, aboard RV "Polarstern" egg bearing female shrimps will be picked from Agassiz trawl hauls, and will be kept alive during the expedition. Additional adult specimens will be fixed aboard for comparative studies on the lipid metabolism and reproductive biology. All material will be shipped to the laboratories of the UMAG in Punta Arenas, Chile. Based

on former studies, we expect that larval development will be finished in the beginning of 2001, allowing us to start the main experiments with the juveniles. The planned study is part of an ongoing Chilean - German cooperation between the AWI and the UMAG.

2.4.4 Trophic structure and energy flow of the Weddell Sea shelf ecosystem (AWI)

Rationale

Communities of shelf and slope areas play a significant role in Antarctic carbon cycling. In order to understand this role, we have to identify the major pathways of carbon through the shelf communities. Our long-term effort in the analysis of trophic relations and population dynamics aims at a balanced carbon flow model for the Weddell Sea shelf and slope ecosystem.

Investigation programme

- Trophic links between species of the benthic community

Stable isotope ratios ($^{14}/^{15}\text{N}$, $^{12}/^{13}\text{C}$) in organic matter change with the transfer of N and C through the food web, owing to selectivity of enzymes for one of the isotopes. Hence, stable isotope ratios can be used to determine the relative trophic position of the members of a community. On board "Polarstern", samples will be collected and prepared for analysis of stable isotope ratios (N, C).

- Position of asteroids in the Weddell Sea benthic communities

In terms of abundance and biomass, asteroids are one of the most prominent taxa in the Antarctic shelf and slope benthos. Little is known, however, about their trophic role and their contribution to overall energy flow. We are not able to determine individual age and growth in asteroids. Therefore mass specific respiration rates of abundant species will be measured onboard. These data are subsequently used to estimate consumption and production via empirical relations. Further samples will be collected for stomach content analysis and measurement of stable isotope ratios (see above).

- Metabolic activity of important benthic taxa

Onboard "Polarstern" respiration rates of a range of benthic taxa, especially molluscs and sponges, will be determined in order to obtain basic information on the metabolism of these taxa and to compare metabolic activity during austral autumn with activity during austral summer.

2.4.5 Ecology and reproductive biology of Antarctic Cephalopoda (NN-Allcock, AWI)

Rationale

One of the primary conclusions of the recent EASIZ workshop on biodiversity was that there is an enormous need to expand the current time window for sampling. The opportunity to sample in April/May is therefore invaluable.

Investigation programme

The primary objective during this cruise is to collect reproductive data. This will extend the temporal scale of an already large data set to a period of almost 6 months and is likely to yield valuable information on the life history strategies of Antarctic octopuses. As on previous cruises, all specimens from each catch would be identified to species, measured, sexed, and assigned a maturity stage. Additionally we shall collect parasites at the request of Harry Palm, Institut für Meereskunde der Universität Kiel. The animals in best conditions will be kept in aquaria and transported to the AWI for physiological experiments. Dissection of species will provide data on octopus feeding strategies, insight in the age profile will be provided by incorporation experiments with the fluorescent compound Alizarin. Collection of additional tissue samples will act as a catalyst for further molecular work.

2.4.6 Adaptation potential of growth and ecology of Antarctic eelpouts (Zoarcidae) (AWI)

Rationale

Antarctic eelpouts (Zoarcidae) are one of the few Antarctic fish families that are not endemic to this region. Zoarcids are widely distributed and are very abundant as well in Antarctic as in boreal and Arctic waters. Antarctic animals are constantly exposed to temperatures close to freezing whereas boreal species only seasonally encounter similar environmental conditions. Thus adaptation to the temperature regime requires different strategies. Boreal species may reduce their metabolism during cold seasons to maintenance level and limit growth and reproduction to warmer periods. Antarctic species must be able to maintain growth rates and reproduction despite permanent low temperatures.

Investigation programme

Ageing, maturity and production of Antarctic Zoarcidae will be investigated on the basis of material from bottom trawls and traps in

the eastern Weddell Sea and off the Antarctic Peninsula. Samples will be analysed in comparison with samples from the North, Baltic, and White Seas. The planned research will be carried out in close cooperation with the ecophysiology group.

2.4.7 Temperature physiology of Antarctic invertebrates and fish (AWI, NN-Allcock)

Rationale

Temperature is considered to be one of the most important abiotic factors shaping marine ecosystems due to its major impact on all biological processes. Focusing on life in cold oceans, our research addresses the question of how boundary conditions are defined from a physiological point of view and which physiological or biochemical characteristics or processes are responsible for limiting survival. Those key processes may comprise oxygen uptake and transportation, energy provision or maintenance of ionic and acid-base balance.

Since the inward diffusion of ions along the osmotic gradient is only slightly altered by temperature, the metabolic costs for the elimination of surplus ions are maintained at low temperatures. Marine fish are, in contrast to marine invertebrates, hypoosmotic to the ambient water which requires an upregulation of ion transport mechanisms which are strongly inhibited in the cold. The eurythermal North Sea eelpout *Zoarces viviparus* maintain oxygen consumption below 3 °C owing to high costs of ion regulation in the cold.

Investigation programme

For comparative analyses of the temperature dependence of ion regulatory capacities and acid-base regulation Antarctic eelpout *Pachycara brachycephalum* will be collected using suitable traps and transported to the AWI for further physiological investigations.

Recently we have proposed that the biogeography of marine crustaceans in cold oceans is related to the combined effects of $[Mg^{2+}]_e$ and low temperature. Activity levels in decapod crustaceans are related to $[Mg^{2+}]_e$ while $[Mg^{2+}]_e$ increases with falling temperatures in most crustaceans and, in addition, available evidence suggests that the anaesthetic potency of magnesium increases with decreasing temperature. Up to now little is known about magnesium regulation in Antarctic crustacea. We will therefore collect available crustacean species and determine the extracellular magnesium concentration. The capability to regulate $[Mg^{2+}]_e$ will be investigated

and in addition the influence of different magnesium concentrations on activity and oxygen consumption.

2.4.8 Demersal fish communities - ecological adaptive strategies (AWI, COC, IEAB)

Rationale

Fish fauna composition, relative biomass and size structure are strongly dependent on several environmental factors including e.g. temperature, depth and geographical area. To estimate the influence of the various factors, high Antarctic (Weddell Sea) and Antarctic Peninsula fish fauna will be compared and analysed in combination with ecological parameters. The data from the current cruise will be combined with data from previous cruises to analyse the spatio-temporal distribution of demersal fish.

Investigation programme

One main focus will be on ecological adaptations and growth strategies in several species of the genus *Trematomus*. Information on habitat preferences, food composition, age structure, maturity, fecundity and growth parameters of the different species will be analysed to determine adaptive strategies to different environmental conditions. These investigations will be carried out in close cooperation with the Iceberg-Disturbance working group and CTD profiles.

2.4.9 Role of Nototheniidae in the fish assemblages of the eastern Weddell Sea and off the Antarctic Peninsula (COC, IEAB)

Rationale

Species belonging to the genus *Trematomus* are the most abundant Nototheniidae fish in the Eastern Weddell Sea. They seem to play an important role in the ecosystem being characteristic of different biocenosis within the continental shelf. That is apparently the case, for example, of species such as *Trematomus pennellii* and *Trematomus nicolai* that could be considered indicators of highly disturbed environments, or *Trematomus scotti* and *Trematomus lepidorhinus* which are almost exclusively associated to very stable and structured benthic communities. In Subantarctic areas the genus *Trematomus* is scarcer, both in number of species represented and in abundance. They are replaced by other Nototheniidae species among which the most important ones are *Gobionotothen gibberifrons*, *Notothenia coriiceps*, *Notothenia rossii* and *Lepidonotothen kempii*.

Investigation programme

The general objective of the project would be to carry out a comparative analysis between fish assemblages occurring on the shelf in the eastern Weddell Sea and off the Antarctic Peninsula area to try to define the ecological function of Nototheniidae species in the respective ecosystems.

Tasks to be conducted to achieve the proposed general objective would be the following:

- _ Determination of key benthic Nototheniidae species in both regions and identification of major biocenosis they belong to. This will be done by sampling using a standard commercial bottom trawl in selected areas of the Weddell Sea and the Antarctic Peninsula and by applying traditional statistics and multivariate analysis techniques to the collected data.
- _ Determination of the life history of key species from both regions. This includes studies on reproduction looking at maturation processes and fecundity; age determination and growth using direct methods; and feeding ecology by applying traditional methods of stomach content analyses.

In order to extend the amount of data available for the studies, the information gathered in the course of the cruise would be complemented with those obtained in previous cruises conducted in the study regions.

Apart from the work directly related to the tasks of this proposal, all type of data and biological material related to the taxonomy, the abundance and the biology of every fish species caught during the cruise will also be collected to increase the current database on Antarctic fish and to facilitate subsequent investigations.

The research will be conducted in cooperation with the AWI Ichthyologists team, being the responsibility of the Spanish team the age and growth studies and the sex and fecundity analyses. The community analysis will be carried out jointly .

To conduct the proposed research time should be dedicated for bottom trawl fishing in both study areas: the eastern Weddell Sea and the Antarctic Peninsula.

2.4.10 Vertical migration and distribution patterns of the pelagic fish community in the Drescher Inlet (AWI)

Rationale

Studies on the diving and feeding behaviour of seals in the Drescher Inlet showed that feeding activities were most intense within the pycnocline in the upper 130 to 210m of the water column. Above the pycnocline and down to the sea floor at a depth of 420m feeding activities were significantly lower (see Mammals Working Group, AWI). Species composition, distribution, densities and size spectra of possible prey have been initiated during the cruise ANT XV/3.

Investigation programme

These studies will be continued to determine diel vertical migration behaviour, distribution, relative abundance and species composition of the pelagic fish community near the ice shelf of the Drescher Inlet and to estimate the biomass of possible prey for seals. Population studies (age structure, growth, diet, maturity) will be carried out on dominant species such as *Pleuragramma antarcticum* and *Anotopterus pharao* in relation to the available food in the water column in order to complement information on the pelagic food web.

Relative abundance, migration patterns and spatial distribution will be determined by means of electronic echosounding in combination with demersal and pelagic fish catches. The spatial distribution will be related to abiotic factors like water temperature and stratification.

The proposed research will be carried out in close cooperation with the zooplankton and CTD profile working groups.

2.5 Marine natural products

2.5.1 Chemical ecology in Antarctic waters (AWI, NN-Allcock)

Rationale

Marine organisms, especially invertebrates such as sponges, soft corals, and molluscs, produce many secondary metabolites which are unprecedented within the terrestrial habitat. Secondary metabolites are not required for primary metabolic processes like respiration, energy turnover or photosynthesis. They evolved for specific purposes such as attraction of members of the same species as well as toxins to repel predators. In the field of natural product research marine organisms in tropical waters have received much more attention than Antarctic

organisms. However, the Antarctic seafloor is covered with a dynamic community of corals, snails, tunicates, sponges and molluscs. Many of these organisms are immobile and use chemical defense mechanisms for antifouling or against predators. In our work we will look specifically at chemical relations between these Antarctic organisms.

Investigation programme

During this cruise we will collect animals from many phyla to allow for the screening of potentially interesting natural products on a broad base. On board we will concentrate on the interaction between predators and their prey. We will keep potential predators and their potential prey in aquaria exposing them to each other to monitor behavioural reactions and physiological parameters like oxygen consumption and heart rate. In addition we will use raw extracts as a first step to identify biologically active substances and determine threshold concentrations.

2.5.2 Structure and function of marine natural products in Antarctic invertebrates (AWI)

Rationale

Low molecular weight natural products from marine organisms have been considered as sources for interesting new chemical structures since 30 years. In organic chemistry new synthetic methods were developed from biomimetic considerations; in physiology and medicine marine natural products were used as tools and leads for drug development. The principal goal of our investigation is to explore the biochemical and ecological significance of marine natural products in the field. Our results will contribute to the understanding of evolution and biodiversity in the Antarctic benthos.

Not all animal taxa produce fossil records which exhibit descent and evolution. Sometimes phylogenetic relationships can be derived from living organisms and are preserved in biosynthetic pathways during geological times. We will try to find out whether halogenated natural products biosynthesized by Enteropneusta, also occur in Pterobranchia from Antarctica, both of which belong to Hemichordata. Priapulids and brachiopods, known since Cambrian times and early representatives of the main protostome groups, will be sampled and analyzed for comparison. In gorgonians, which are diverse and abundant in the eastern Weddell Sea, we will search for terpenes to look for molecular markers in species radiation. Chemotaxonomic clustering of Antarctic sponges will be tried with membrane constituents such as sterols and long chain fatty acids.

Indications for ecological functions of natural products are derived from product levels in different organs and body parts of solitary animals as well as in morphologically different organisms of colonies. We will continue our investigation on sources of defensive chemicals in Antarctic nudibranchs and extend it to further gastropod species. Chemical analyses of skin, gills, alimentary canal and reproductive organs will be given preference. In some bryozoans from temperate zones, like the North Sea, halogenated alkaloids can be detected, but nothing is known about the ecological function of these compounds. Although diversity and abundance of bryozoans is high, there are only few investigations on natural products. Since bryozoans are key organisms of the epibenthic community in the eastern Weddell Sea, they will be included in our chemical screening. Interesting and biologically active natural products have also been found in non-Antarctic relatives of colonial *Clavularia frankliniana* and other Octocorallia, therefore, these organisms will be analysed as well.

The occurrence of dense populations of epibenthic suspension feeders on the eastern Weddell Sea Shelf is poorly understood. Feeding on nutrient rich bottom currents and low metabolic activity of animals during winter time are suggested as possible explanations for this population density. We will characterize the trophic potential of this habitat by analyzing biogenic compounds of different chemical persistence in bottom water and surface sediments. In necrophagous amphipods and isopods, which accumulate food without further digestion for extensive periods of time, the alimentary canal will be analyzed for intermediates in lipid metabolism and natural antibiotics.

Investigation programme

Animals for general work will be sampled using dredges and Agassiz trawls. Additionally uninjured and less disturbed specimens as well as entire colonies will be collected from Video grabs. For control of sampling, chemical screening will be performed onboard. After homogenization and dehydration of the biological material natural products will be extracted using supercritical carbondioxide. Product mixtures will be chromatographically separated and individual compounds mass spectrometrically characterized and quantified. Based upon these preliminary results additional samples will be collected, frozen in liquid nitrogen and taken to Bremerhaven at -80°C for further analyses in the home laboratory. There, research work will be continued by analyzing microsamples from frozen tissues, testing natural product extracts for biological activity, and isolating as well as identifying unknown compounds using additional spectroscopic methods.

2.6 Other investigations

2.6.1 Study of the winter Antarctic marginal ice zone using innovative ice buoys (SPI, DMRL)

Rationale

Our experiment seeks to improve our understanding of the mechanisms of Antarctic sea ice formation and deformation in winter, using a novel drifting buoy. An array of buoys, especially designed for deployment in the highly mobile ice formation zone, will be used to clarify the processes involved in the deformation, seasonal variability and dynamics of sea ice in this region. The array will map the dynamics of first year ice, from its formation in early winter to its decay the following summer.

Antarctic sea ice first forms as small 'pancakes', up to 3-5m in diameter, due to the high turbulence levels of the Southern Ocean which prevent the initial frazil ice crystals consolidating into a coherent young ice sheet. The small size and constantly changing aggregations of these pancakes makes study of their detailed motion very difficult and precludes the use of satellite feature-tracking methods.

Ice buoys are usually designed to be deployed on solid pack ice, and conventional Argos drifters cannot resolve short time-scales due to long gaps between position fixes. The new buoy design mimics pancakes in their size, freeboard and draft, and has sloping sides to allow the buoy to rise up under ice pressure and avoid crushing. It incorporates Global Positioning System (GPS) and Low Earth Orbit satellite technology (LEO) allowing location and environmental data to be provided at the frequency required to resolve many of these processes for the first time.

Major scientific aims of the project are listed below:

I. Large scale motion

- a) Determine the relative importance of advection and *in situ* ice production to the winter advance of the Antarctic ice edge. Similarly, determine the rate of meltback - offset by advection - of the ice edge in spring. Buoy data provide an accurate measure of advection, while satellite images give the overall position and character of the ice cover.
- b) Determine the appropriate dynamics and rheology choice for modelling the motion of the evolving winter first-year ice cover. Wind-driven motion is of particular interest, since the turning angle and drag coefficient for pancakes is presently poorly known and ice models currently use values inappropriate to this region.

II. Mesoscale motion

- a) Examine the characteristics and energy of absolute and relative ice motion variability at time scales which are resolvable by GPS but unresolvable by Argos, i.e. 20 minutes to 4 hours.
- b) Determine the role played by these scales of motion in contributing to the ocean-atmosphere heat flux and net ice growth rate through the cyclic creation of new open water area by divergence and subsequent evolution of young ice into ridging by convergence.

III. Effect of waves on the ice cover

- a) Analyse the role of penetrating wave energy and its implications for ice dynamics and thermodynamics, using the wave spectral parameters generated by vertical accelerometers in the buoys.
- b) Use synergy of accelerometer and sea surface temperature measurements to test for the predicted effect of storm passages past the ice edge. These events may induce upwelling near the ice edge, with accompanying ice melt, in addition to breaking up the consolidated cover (McPhee, 1994).
- c) Apply wave spectra to the inversion analysis of SAR-derived wave dispersion data for estimating pancake ice thickness, using the method described in Wadhams and Holt (1991).

Investigation programme

We will deploy an array of six buoys at the ice edge in the eastern Weddell Sea, during *Polarstern's* transect from Neumayer base to the Antarctic Peninsula. The planned shape of the array has been found most useful for mesoscale ice dynamics experiments in other MIZs (e.g. the MIZEX experiments in the Arctic, 1983-9), and consists of a group of 5 buoys on a 150 km baseline, with a further buoy displaced some 400 km along the ice edge. The two outermost buoys will be emplaced within 50 km of the outer ice edge, in loose pancake. The two innermost buoys will also probably be in pancake ice at the time of deployment, but as winter progresses and the ice edge advances faster than the buoys, each buoy in turn will become embedded in a consolidated first-year ice cover.

During the deployment of each buoy, we will carry out a programme of ice physics measurements. These data will provide a baseline characterisation of pancake and consolidated zones that can be related to the parameters obtained from later array measurements. Measurements will include profiling of temperature, salinity and fabric from ice cores. Oxygen-18 concentrations will be taken to determine the meteoric ice content (Eicken *et al.*, 1994) through the ice and overlying snow layer. In the pancake zone, larger pancakes will be examined in the same way where safe, while smaller pancakes will be lifted on board and analysed on deck. A shallow (200m) CTD cast will be taken at each

deployment location. Helicopter aerial photography transects will also be flown to determine the size distribution of floes from the ice edge to the consolidated pack.

2.6.2 Persistent, bioaccumulative, toxic chemicals in the Antarctic ecosystem (AWI)

Rationale

Global distribution of persistent organic pollutants (POPs) is now well documented. Years after emission within industrialized zones POPs arrive in remote areas, at high mountains and in deep oceans. Impact in polar areas is of special concern and more critical than at lower latitudes since polar ecosystems are sensitive and detrimental effects last longer. Risks have already been assessed for the Arctic ecosystem. Surprisingly little is known about human impact in the southern hemisphere. Our objective is to measure and evaluate contamination originating from long range transport, cold condensation and marine bioaccumulation of POPs in the Antarctic ecosystem. Results are of importance for nature conservation on a global scale.

In previous work we investigated key POPs in air breathing animals of the Weddell Sea and Bransfield Strait, such as Adelie penguins and Weddell seals that are high up in the food chain. Compared to levels in animals of the northern hemisphere, POPs in Antarctica were one to two orders of magnitudes lower; but some were even equal because of preferred atmospheric transport. As early as 1987 we analyzed residues in fish caught around Elephant Island. Repeated analyses in 1996 exhibited a doubling of levels within one decade upon average. However, individual burdens and changes of POPs were also dependent on the biological species investigated which possibly reflects different feeding habits and/or metabolic capacities.

Investigation programme

During Ant XVII/3 our investigations will be extended. We will collect fish with known biology in the eastern Weddell Sea. Active pelagic and sluggish demersal species as well as generalistic and specific feeders will be compared. Deep-water fish will be given special preference. Fish livers and intestinal lipid deposits are scheduled for chemical analysis. For the first time, benthic and pelagic invertebrates will be included. In polar areas biomass from primary production flourishes in spring which supplies plenty of food as well as POPs to the sea floor. Since the Antarctic benthos exhibits low metabolic activity and high longevity, it may act as a buffer for the accumulation of POPs. 'Giant' invertebrate species representing links in benthopelagic coupling will be sampled,

including necrophagous amphipods, isopods with different modes of life and caridean shrimps. Better evaluation of residue levels will be attempted by normalizing data to results from stable isotope analysis. All samples will be deep frozen on board immediately after sampling. Preparation of animal parts for trace organic analysis as well as chromatographic separation and mass spectrometric identification of individual POPs will be performed in the home laboratory.

Fahrtteilnehmer/Participants**ANT XVII/3****Cape Town – Punta Arenas**

Alfonso, Ma Isabel	USE
Allcock, Louise	NMS
Arntz, Wolf	AWI
Artigues, Bernat	UIB
Bader, Beate	UfG
Baumgartner, Martha	AWI
Bohn, Jens Michael	ZI/LMU
Brey, Thomas	AWI
Coon, Max	TUD
Cornils, Astrid	AWI
Dewicke, Ann	UGZ
Dinkeldein, Wolfgang	HSW
Doble, Martin	SPRI
Drebing, Wolfgang	AWI
Gasol, Joseph-M.	ICM
Gerdes, Dieter	AWI
Gili, Josep Maria	ICM
Goerke , Helmut	AWI
Gonzales Jiménez, José	IEO
Grabbert, Sabine	UOB
Heilmayer, Olaf	AWI
Hohmann, Constanze	AWI
Janssens, Thiery	UGZ
Klein , Boris	AWI
Knust, Rainer	AWI
Köhler, Herbert	DWD
Krüger, Oliver	AWI
Lahrmann, Uwe	HSW
León, Roxana	UMAG
Lörz, Anne-Nina	ZIM
López, Pablo	USE
Marquard, Lucie	AWI
Mehlhorn , Birgit	UD
Mehlhorn , Heinz	UD
Mintenbeck, Katja	AWI
Montiel, Americo	UMAG
Müller, Annegret	AWI
Orejas, Covadonga	AWI

Pagès, Francesc	ICM
Palanques, Albert	ICM
Pedrós-Alió, Carlos	ICM
Peppe, Oliver	DML
Piraino, Stefano	IST
Ragua-Gil	AWI
Rauschert, Martin	AWI
Rossi, Sergi	ICM
Sabater, Francesc	UBE
Sartoris, Franz-Joseph	AWI
Schröder, Alexander	AWI
Schrödl, Michael	ZSM
Sirenko, Boris	ZISP
Smirnov, Igor	ZISP
Starmans, Andreas	AWI
Stüfing, Reinhard	DWD
Suck , Inken	AWI
Teixido, Nuria	AWI
Weber, Kurt	AWI
Zepick, Burkhard	HSW
Ziemers, Ole	ZSM

Beteiligte Institute/ Participating Institutes

AWI	Alfred-Wegener-Institut Für Polar- und Meeresforschung Columbusstrasse D-27568 Bremerhaven, Germany
UIB	Institut Mediterrani D`Estudis Avancats Campus Universitari 07071 Palma de Mallorca, Spain
IST	Instituto Sperimentale Talassografico Via Roma 3 74100 Taranto, Italy
DWD	Deutscher Wetterdienst Geschäftsfeld Seeschifffahrt Bernhard-Nocht-Strasse 76 D-20359 Hamburg, Germany
DML	Dunstaffnage Marine Laboratory P.O. Box 3, Oban Argyll, PA34 4AD, United Kingdom
ICM	Institut de Ciències del Mar Plaça del Mar s/n 08039 Barcelona, Spain
IEO	Instituto Español de Oceanografía Carretera San Andrés s/n 38120 Santa Cruz de Tenerife, Spain
IfG	Institut für Geowissenschaften Olshausenstrasse 40-60 D-24118 Kiel, Germany
LAEISZ	Reederei F. Laeisz Barkhausenstrasse 37 D-27568 Bremerhaven, Germany
NMS	National Museums of Scotland Chambers Street Edinburgh EH1 1JF, United Kingdom

SPRI	Scott Polar Research Institute Lensfield Rd. Cambridge CB21HZ, United Kingdom
UBE	University of Barcelona Department of Ecology Diagonal 645 08028 Barcelona, Spain
TUD	Technical University of Denmark Department of Electromagnetic Systems DK-2800 Lyngby, Denmark
DU	Zellbiologie und Parasitologie der Universität Düsseldorf Universitätsstrasse 1 D-40225 Düsseldorf, Germany
UGZ	University of Gent Marine Biology Section K.L. Ledeganckstraat 35 B-9000 Gent, Belgium
UMAG	Universidad de Magallanes Instituto de la Patzgonia AV. Bulnes 61890, Chile
UOB	Universität Oldenburg FB7 AG Zoosystematik und Morphologie Postfach 25 03 D-26111 Oldenburg, Germany
USE	Universidad de Sevilla Laboratorio de Biologica Marina Avd. Reina Mercedes no 6 31012 Sevilla, Spain
HSW	Helicopter Service Wasserthal GmbH Kätnerweg 43 D-22393 Hamburg, Germany

ZIM	Zoologisches Institut und Museum Martin-Luther-King-Platz 3 D-20146 Hamburg, Germany
ZI/LMU	Zoologisches Institut der LMU, München Karlstrasse 25 D-80333 München, Germany
ZISP	Zoological Institute Russian Academy of Sciences Universitetskaya Emb. 1 St. Petersburg 199034, Russia
ZSM	Zoologische Staatssammlung München Münchhausenstrasse 21 D-81245 München, Germany

Schiffsbesatzung/Ship's Crew ANT XVII/3

Master	Keil, Jürgen
1. Offic.	Grundmann, Uwe
1. Offic.	Rodewald, Martin
Ch. Eng.	Schulz, Volker
2. Offic.	Peine, Lutz
2. Offic.	Boche, Martin
Doctor	Evers, Fridtjof
R. Offic.	Hecht Andreas
2. Eng.	Delff, Wolfgang
2. Eng.	Folta, Henryk
2. Eng.	Simon, Wolfgang
Electron.	Piskorzynski, Andreas
Electron.	Fröb, Martin
Electron.	Baier, Ulrich
Electron.	Bretfeld, Holger
Electr.	Holz, Hartmut
Boatsw.	Loidl, Reiner
Carpenter	Neisner, Winfried
A. B.	Bäcker, Andreas
A. B.	Hagemann, Manfred
A. B.	Schmidt, Uwe
A. B.	Winkler, Michael
A. B.	Bastigkeit, Kai
A. B.	Bohne, Jens
A. B.	Hartwig, Andreas
Storekeep.	Beth, Detlef
Mot-man	Arias Iglesias, Bnr.
Mot-man	Giermann, Frank
Mot-man	Fritz, Günter
Mot-man	Krösche, Eckard
Mot-man	Dinse, Horst
Cook	Fischer, Matthias
Cooksmate	Tupy, Mario
Cooksmate	Müller-H., Ralf
1. Stwdess	Dinse, Petra
Stwdess/KS	Brendel, Christina
2. Stwdess	Streit, Christina
2. Stwdess	Schmidt, Maria
2. Stwdess	Silinski, Carmen
2. Stwdess	Huang, Wu-Mei
Stwdess/KM	Möller, Wolfgang
Laundrym.	Yu, Kwnok Yuen

