The Expedition ANTARKTIS XIV/2 of RV "Polarstern" in 1996/97

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Ber. Polarforsch. 274 (1998)
ISSN 0176 - 5027

Content

Cruise Leg ANT XIV/2 (Punta Quilla - Punta Arenas)
November 12, 1996 to January 1, 1997

1 INTRODUCTION

1.1 Summary

During the second leg of the RV "Polarstern" cruise ANT XIV the major research have been focused on the region around the Antarctic Peninsula (Figs. 1 and 2). Around Elephant and King George Island, intensive investigations were conducted on fish and krill biology under the umbrella of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLAR). Beside these studies other special topics have been investigated: The physiological adaptation of Antarctic animals to the cold environment; samples of fish eggs were collected for electron microscopical investigations; and the distribution and abundance of parasites in fishes were determined. Another major part of the programme were studies on the ecology and life strategies of cephalopods. The biological research also included ecological and taxonomic studies on Cumacea, Amphipoda and Isopoda. Biochemical investigations on the lipid biosynthesis and accumulation were performed on the dominant copepod species. The abundance and distribution of whales was monitored by observations and by acoustic methods using hydrophones. The investigation on the influence of UV-B radiation on phytoplankton and primary production was another main topic of the biological studies. The programmes of the physical oceanography included the hydrography of this region and the use of a new developed LIDAR system to measure dissolved organic material and "gelbstoff" as well as fluorescent pigments in algae in the upper layer of the water column.

1.2 Itinerary

On November 12, shortly before midnight, the cruise started. The departure was delayed by half a day due to heavy storm and since "Polarstern" could only leave the harbour at high tide. We sailed directly towards the Antarctic Peninsula (Elephant Island), where the first main fishery programme was planned. During the next day the area south of the South American continent was reached. The wind forces were around 8 Bft, sometimes gusting even higher. Due to the rough sea, the first station was delayed. However, in the early morning of November 15 a bottom trawl, the Agassiz trawl, was launched to get first samples from a depth of about 3300 m. At the next station the equipment was tested. Then we went further south directly towards Elephant Island where in the early afternoon the net was launched and the fishery started. The weather was quite good, with sunshine and temperatures already below 0°C. The trawling time on the bottom net was about half an hour and then the trawl came back on board. The two first hauls were successful. The catches were transferred directly to the fish lab, where the species were determined, sorted, measured and weighed. Next morning fishing continued. During the fourth haul the net snagged somewhere on the bottom. It took some time before the net was recovered, and a new net had to be attached to the warps. Unfortunately the weather worsened again with wind forces around 8 Bft, snow and rain, making further work impossible. Thus, all work was re-scheduled to the next morning of November 18.

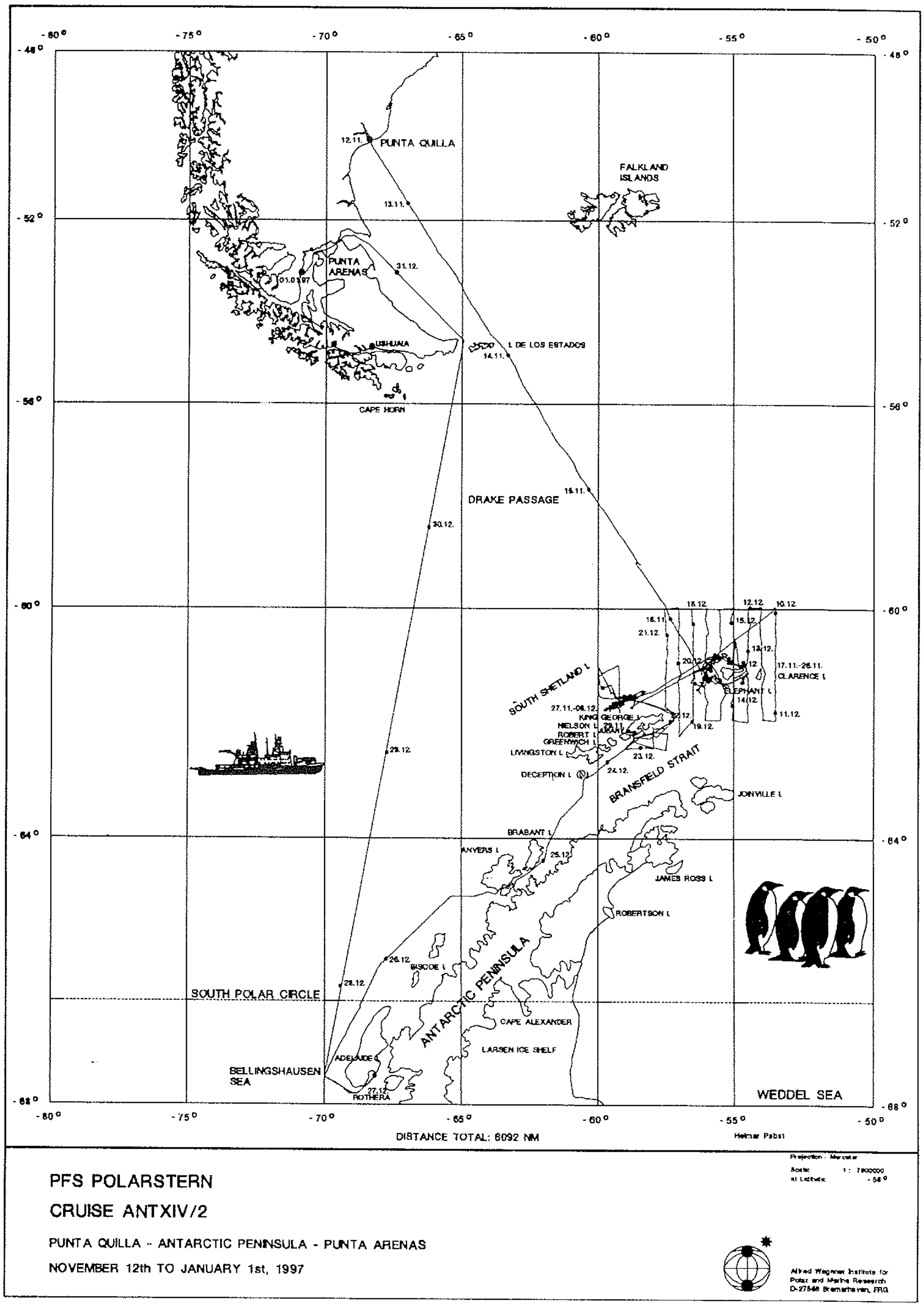

Fig. 1.1. Cruise track of ANT XIV/2

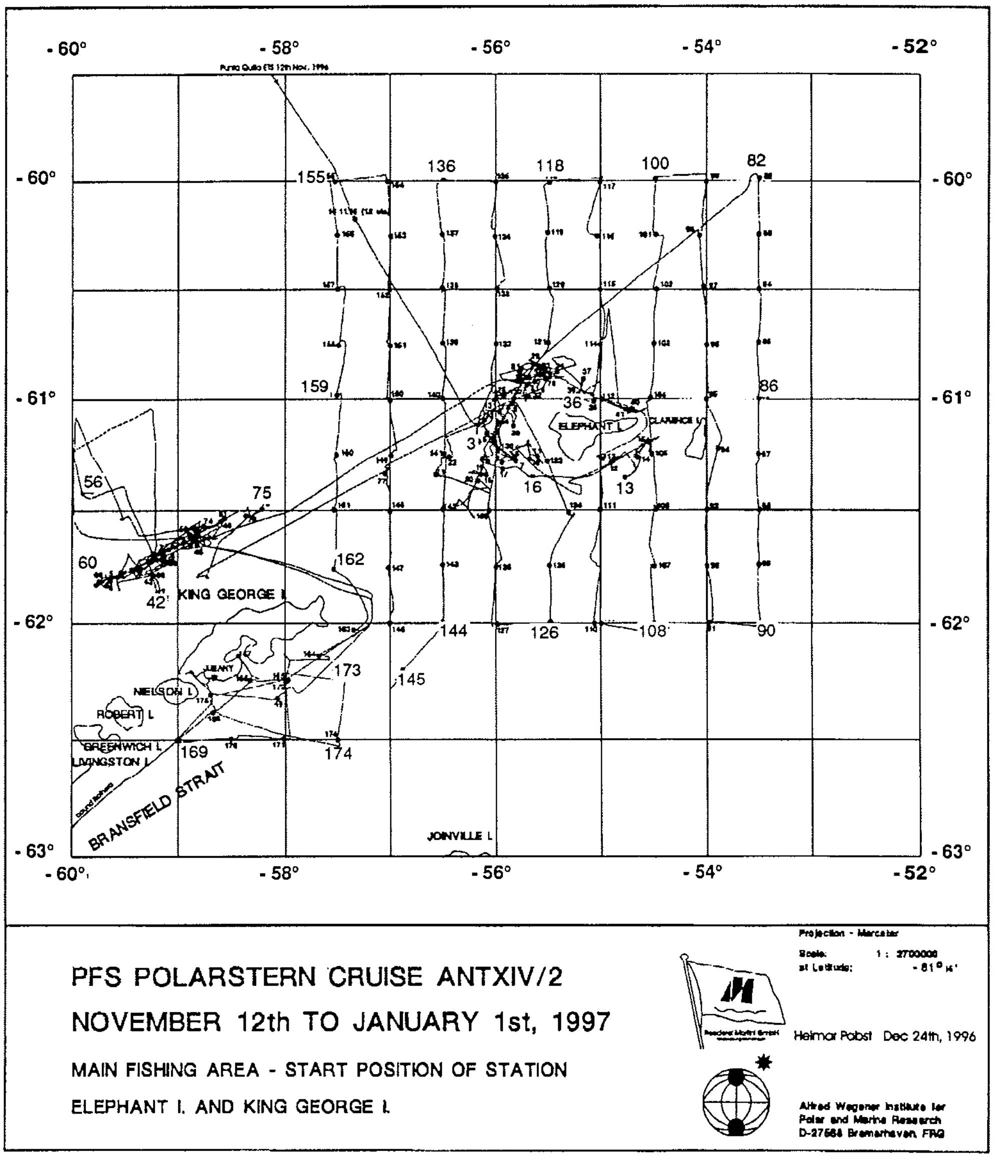

Fig. 1.2. Detailed research area and stations around Elephant and King George Island

The programme was continued with the bottom trawl sampling on the leeward side of Elephant Island, out of the wind. This proved to be most opportune because the wind was still gusting strongly. During the next night we could manage two Agassiz hauls. This net supplied the physiologists with samples for their investigations and experiments. The next day, November 20, the trawl unfortunately snagged again the bottom and a partially torn net was retrieved on deck. Another net had to be rigged. During night the jigging machine was tried out for the first time to catch squid. The machine itself worked well, but neither the squid nor fish could be caught. On Friday, November 22, the wind had abated, and it remained calm until the next day. The fishery followed suite and there were no problems. In the evening, we recovered two of the fish traps that had been set the previous day. Unfortunately, no fishes were caught, only isopods and amphipods were attracted by the bait.

On Sunday, November 24, we had again strong winds and snowfalls. Despite this, the work could be followed according to plan. By Tuesday, we had completed the first part of the programme: The bottom trawl survey around Elephant Island was very successful, 35 hauls had been conducted with catches varying considerably with fishing depth. The predominant species in the catches were Antarctic rockcod and some icefish species. Because of again bad weather, two remaining fishing stations, which were to be occupied on the way to King George Island, had to abandoned. Winds were gusting to Force 9 with snow storms and a sea with waves up to 10 m.

By the next morning, November 27, the programme was continued north of King George Island. The low pressure cell had passed and the wind had dropped. The whale watchers were able to make a first observation flight. Eight fin whales were sighted. On board, we started to fish the slope to catch cephalopods at different depth horizons off King George Island. The bottom trawl was used to fish the 400, 600 and 800 m depth horizons, while running CTD casts, light measurement experiments and Bongo net hauls between the fishing stations. The fishery was successful and in total about 2300 cephalopods were caught. This was the richest collection both in numbers of specimens and numbers of species, that has been made in the Antarctic Peninsula region. Among the ca. 15 different species were a large number of new ones.

During the night of November 28, we made our way to Jubany, the Argentinean station and the German Dallmann Laboratory. At 8 o'clock the next morning the ship hoved to opposite the small island of Ardley, which is quite close to the station and from which the remains of an old, disused observation post were removed. While this was going on, the helicopters were airlifting scientific equipment and supplies to the Dallmann Lab. Everyone could visit the station.

Benthopelagic fishing commenced again the next morning and two fish traps were deployed. A longer transect for whale observations were carried out. Unfortunately, stormy weather was again predicted, making meaningful observation considerably more difficult. By the afternoon we were once more at our fishing position. But fishing could not be started because the wind was gusting to Force 9. We had to wait for the wind to abate. The weather had changed by the next morning and one fishing station was occupied. The fish traps, which we couldn't recover because of the bad weather, were now recovered. This time it was very successful, and there were about 50 fishes, called eel pouts, in the trap. The second trap also contained about 25 specimens. They were precisely the species that the physiologists wanted to investigate.

On the evening of December 3, the night schedule of fishing was started because during night certain organisms do migrate up from the sea floor into the water column. The giant benthopelagic net was used for catching three times each night. In total 9 night hauls and 7 daylight hauls were conducted. These hauls, which fished to depths of 800 m and just above the sea floor, yielded a rich catch of pelagic fishes. Unfortunately during the last night haul, the net snagged with the bottom. The belly of the net was badly ripped and fishing with the pelagic gear had to be finished.

On December 10, the research on krill begun which started again in the Elephant Island region. Krill was caught with a small net, the RMT (Rectangular Midwater Trawl), which was towed behind the ship for about half an hour. The net went into the water about every 3-4 hours; the stations are 15 nautical miles apart. With exception of the last two days the weather of this week was mainly misty. For whale observations the region was probed with a hydrophone, in an attempt to record the sounds of whales. The hydrophone, which was connected to a 400 m length of cable, was deployed when the ship was underway. Between krill hauls, the Agassiz trawl was used to collect specimens on the sea floor in order to provide other groups with samples and material for their work. Isopods and amphipods were sampled and even smaller crustaceans were collected with a special small dredge, which was dragged behind the Agassiz trawl. Several animals were new species, while other known species were found in our sampling area for the first time.

Bad weather overtook us once more north of King George Island on December 21. Therefore work was continued on the south side of King George Island where the weather had calmed down, and, after discussions with US scientists, a few additional stations were occupied close to the coast and in Admiralty Bay. These stations were aimed at providing information on the composition of krill in a localised area. They supplement the research on penguin diets being undertaken by the US scientists, who were working there at the same time. A direct comparison will be made with the plankton samples collected by the "Polarstern". The comparison will be used to determine whether penguins select distinct sizes, age classes or stages of maturity of krill, or whether their diet is undifferentiated.

On December 23 during the course of station work, three scientists were picked up from the Dallmann Laboratory by helicopter. The krill programme was concluded in the early morning of December 24. Christmas Eve was spent off Deception Island and on Christmas Day we had reached the entrance to the Gerlache Strait. On December 27 we anchored in the morning just off the Rothera jetty in order to supply the base with aviation fuel. In the evening we had finished our visit and started with our direct return course to Punta Arenas where we arrived on the morning of January 1, 1997.

2 WEATHER CONDITIONS (M. Gebauer and H. Sonnabend)

Leaving Punta Quilla was rather late, because loading RV "Polarstern" had to be interrupted due to heavy storm. In the night, the ship could leave the harbour, accompanied by stormy westerly winds. The course was south-east in direction of Elephant Island and the weather conditions were not difficult with sometimes gusty winds. On the 15th of November we arrived in an area with weak differences of air pressure, but after a quiet short calm a low system was arriving. The wave-height reached 3 to 4 m. After a very short intermediate high pressure influence the frontal zone intensified again, and due to the forecasted north-westerly winds with 8 to 9 Bft the "Polarstern" sought shelter south-east of Elephant Island. Despite continuous strong to stormy winds scientific work could be accomplished without having a break.

The quick changing, sometimes very windy westerly weather conditions, lasted until the 23th of November. This day Evangelistas on the south-west Chilean coast was influenced by a hurricane in the afternoon. The direction of wind in the area of the RV "Polarstern" changed gradually to north-east, but the center of the hurricane did not influence the ship severely. Only a secondary low passed "Polarstern" with wind force 6 to 7 Bft, mostly accompanied by poor visibility.

Up to the 25th of November weak differences of pressure remained around Elephant Island. The prevailing weather conditions were fog or mist. Next day a low had developed to a storm while its center passed rather near south of our ship. For a short time, wind speed increased to force 8 to 9, before later the wind blew from west with 5 to 6 Bft. During a short intermediate high pressure influence on the following day, the visibility was good enough to observe wales from helicopter.

At the end of November the Antarctic research station "Jubany" was visited. While the center of a low crossed the Antarctic Peninsula just in this region, the weather conditions changed quickly between patches of low clouds and sunny moments, due to special orographic conditions. The helicopter flights had just been finished, when a short, but heavy snow shower occurred.

During the first week of December there was a quick change of strong north-westerly winds and short periods of high pressure influence. In this southern early summer time, the wind blew often from north-west to north-east, prevailingly connected to poor visibility (Figs. 2.1 and 2.2). Due to the advection of relatively warm and moist air, quite often fog or low stratus clouds developed above water temperature near 0°C. After the first ten days of December, a rather intense low transpassed with strong easterly winds and high swell coming from west caused braking waves from various directions. In the middle of December there followed a period of high pressure influence with weak winds and often good visibility, lasting until the 20th of the month. In the last ten days of the cruise weather conditions changed from short periods of sunshine and weak wind to sometimes gusty winds or poor visibility, a short visit to the Antarctic base Rothera was influenced by an increasing amount of clouds.

The distribution of wind speed corresponded generally to the climatological data for the area of this cruise (Figs. 2.1 and 2.2). The mean wind speed during this cruise was 19±8 knots, nearly in accordance with the climatological value of 15 kt during November to December known for the area around Elephant Island. The whole cruise consisted completely of a quickly changing sequence of different weather conditions, without long periods with either weak wind and sunshine or bad and windy weather, as it should be during this period in this area due to the normal climatological conditions.

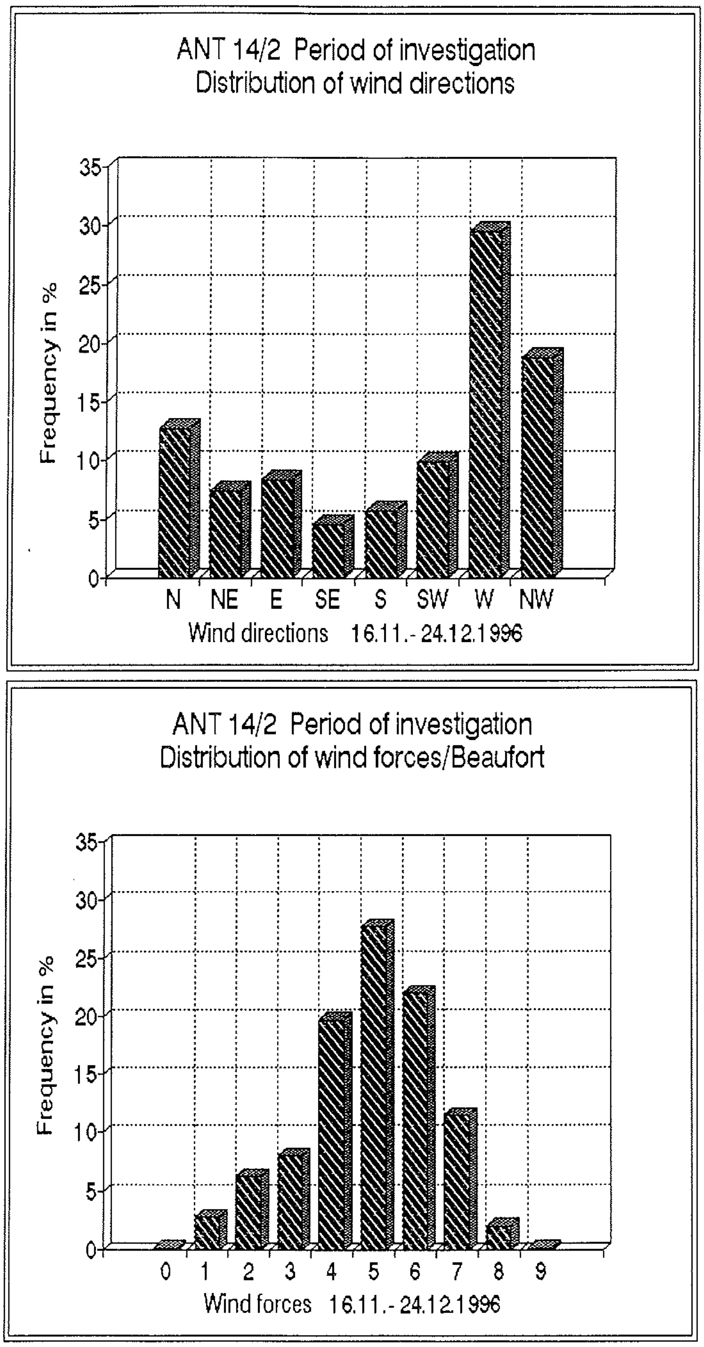

Fig. 2.1. Frequency of wind directions and wind forces

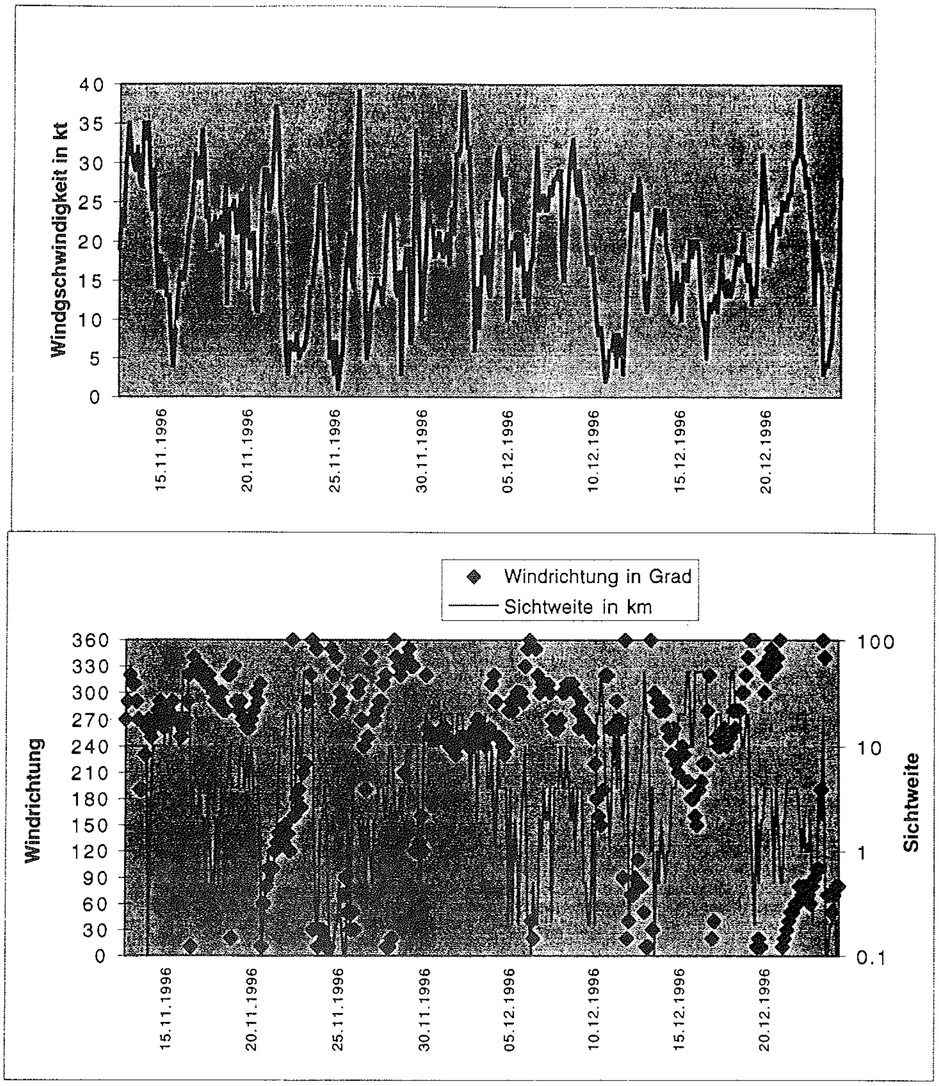

Fig. 2.2. Daily observations of wind forces, wind direction and visibility

3 INVESTIGATIONS ON ANTARCTIC FISH (K.-H. Kock)

Antarctic fish studies during ANT XIV-2 comprised three main parts:

Investigations on the composition and the abundance of the demersal fish fauna on the shelf of Elephant Island (South Shetland Islands).

The composition of the fish fauna on the northern slope of King George Island (South Shetland Islands).

The composition of the mesopelagic fish fauna in a localised area on the slope of King George Island and their significance in the trophic system of this region.

In addition, fishes taken in Agassiz trawls during sampling for benthic crustaceans (see Coleman, this volume; Held, this volume), and fish larvae obtained from RMT1+8 catches (see Siegel et al., this volume), were studied. Otoliths were collected from 34 species representing 11 families of Antarctic fish in order to assist in the identification of fish remains from squid and fish stomachs. Tissue samples from a number of species were frozen for molecular genetic studies.

The following nets were used:

- A 140' commercially-sized bottom trawl with a small-meshed liner of 20 mm mesh size in the codend. This trawl has been the standard gear on previous demersal fish surveys in this region;
- a 1088# pelagic net with a height of 11-12 m with a small-meshed liner of 12 mm in the codend. The net was equipped with a netsonde and was towed in midwater and in the near-bottom layer;
- an Agassiz Trawl with a mouth opening of 3 x 1 m;
- a RMT 1+8 (see Siegel et al., this volume).

3.1 The composition and abundance of the demersal fish fauna around Elephant Island (K.-H. Kock, L. Döllefeld, P.A. Hulley, H.-P. Jährig, W. Petzel, C. Pusch, V. Siegel, M.G. White)

Introduction

The Lesser Antarctic and the High Antarctic demersal fish faunas overlap in the region of the southern islands of the Scotia Arc. About 50 fish species have been found in the vicinity of Elephant Island, with Lesser Antarctic species predominating both in terms of species and biomass. The most abundant species on the island shelf were mackerel icefish (*Champsocephalus gunnari*), marbled notothenia (*Notothenia rossii*), green notothenia (*Gobionotothen gibberifrons*) and Scotia Sea icefish (*Chaenocephalus aceratus*). A commercial fishery was conducted in this region at the end of the 1970's/early 1980's by fishing fleets from former Eastern Bloc countries targeting mackerel icefish and marbled notothenia. The other abundant species formed a regular by-catch in these fisheries. After 1982/83, fishing occurred only irregularly. Results of surveys carried out by the Federal Research Centre for Fisheries in Hamburg between 1985 and 1987 demonstrated that stocks of mackerel icefish and marbled notothenia were by then heavily depleted. At the end of the 1980's, commercial harvesting of finfish was prohibited in the Antarctic Peninsula region by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) until evidence could be provided that stocks might have recovered from over-exploitation.

No information has become available to CCAMLR on fish stocks in the area since 1987. Consequently, we conducted the bottom trawl survey in November/December 1996 in order to provide CCAMLR with more recent data on the development of fish stocks in this region.

Material and Methods

Sampling was based on the same stratified random survey design utilised during previous surveys. All sampling stations were selected randomly, but were restricted to areas where trawling grounds were known to be suitable. A total of 37 hauls (of 40 planned hauls) was carried out between 65 and 500 m depth on 16 - 26 November and 9 December, 1996. The location of fishing stations is shown in Fig. 3.1. Fishing was conducted only during daylight hours. With a few exceptions, when rough bottom conditions necessitated earlier hauling, towing time was 30 min at a speed of 3.4 - 4.0 knots. A CTD profile was available for most fishing stations.

Catch composition of each tow was recorded in terms of weight and number of individuals. In addition to the catch composition, length and maturity were determined in subsamples of the most abundant species. Stomach content analysis was carried out in mackerel icefish. Samples of *Gobionotothen gibberifrons*, *Champsocephalus gunnari* and *Lepidonotothen larseni* were frozen for subsequent analyses of the diet, growth and condition factor in Hamburg.

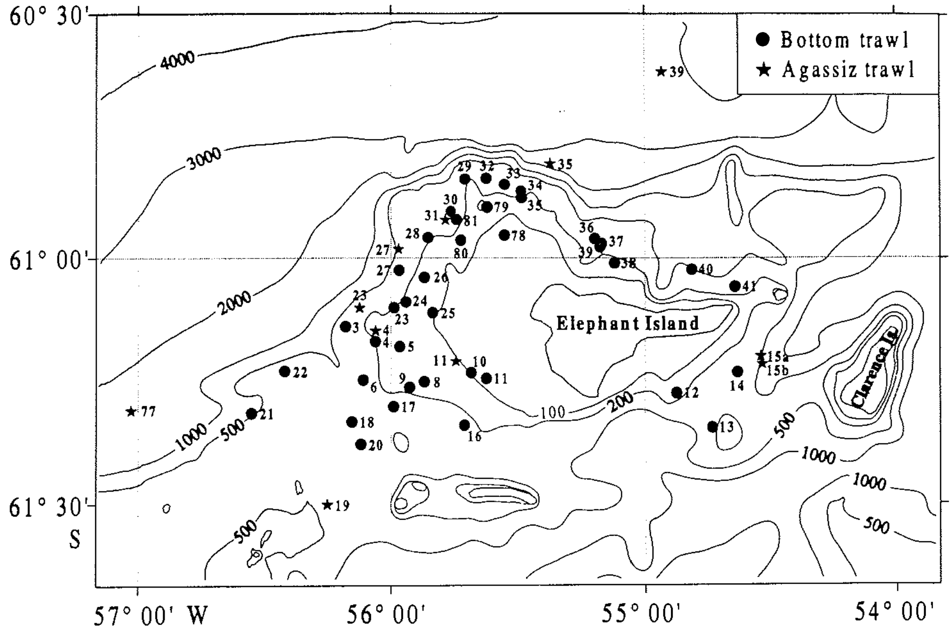

Fig. 3.1. Location of fishing stations (from Piatkowski et al., this volume)

Preliminary results

A total of 39 species was found in our catches (Table 3.1). With the exception of *Trematomus scotti* (Nototheniidae) and *Nansenia antarctica* (Microstomatidae), all other species were observed during previous cruises.

Table 3.1. List of species caught in the course of the bottom trawl survey in the vicinity of Elephant Island

Family	Species	Occurrence 1)
Nototheniidae	*Notothenia rossii*	regular
	N. coriiceps	common
	Gobionotothen gibberifrons	common
	Lepidonotothen larseni	common
	L. squamifrons	common deeper than 250m
	L. nudifrons	common shallower than200m
	Trematomus eulepidotus	regular
	T. bernacchii	rare
	T. hansoni	rare
	T. newnesi	rare
	T. scotti	rare
	Dissostichus mawsoni	regular
	Pleuragramma antarcticum	rare
Harpagiferidae	*Harpagifer antarcticus*	rare
Artedidraconidae	*Artedidraco skottsbergi*	rare
Bathydraconidae	*Gerlachea australis*	rare
	Parachaenichthys charcoti	regular
	Racovitzia glacialis	regular
Channichthyidae	*Champsocephalus gunnari*	common
	Chaenocephalus aceratus	common
	Chionodraco rastrospinosus	common
	Pseudochaenichthys georgianus	common
	Cryodraco antarcticus	regular
	Chaenodraco wilsoni	regular
	Pagetopsis macropterus	rare
Rajidae	*Bathyraja* species 2	common
	B. maccaini	regular
	B. eatonii	rare
Zoarcidae	*Lycodichthys antarcticus*	rare
	Ophthalmolycus amberensis	regular
Muraenolepidae	*Muraenolepis microps*	regular
Myctophidae	*Electrona antarctica*	regular deeper than 200m
	Gymnoscopelus nicholsi	common deeper than 200m
	G. braueri	regular
	G. opisthopterus	rare
Notosudidae	*Scopelosaurus hamiltoni*	rare
Paralepididae	*Notolepis coatsi*	regular
Gempylidae	*Paradiplospinus gracilis*	rare
Microstomatidae	*Nansenia antarctica*	rare

1) common: present in more than 30% of the hauls; regular: present in 5 - 30% of the hauls; rare: present in less than 5% of the hauls

The rare occurrence of many species in our catches does not necessarily indicate that they are rare in the area, because the depth range of a number of demersal and mesopelagic species, such a *Harpagifer antarcticus* or myctophids, was not adequately covered by our survey.

The total catch of finfish during the survey was 5.39 tonnes with a by-catch of 9.76 tonnes of benthic invertebrates. The total catch of finfish was less than one third of the catch taken during the survey in 1987. The most common species in the catches in terms of weight were *Gobionotothen gibberifrons*, *Chaenocephalus aceratus*, *Champsocephalus gunnari* and *Notothenia coriiceps.* They accounted for a similar proportion of the catch as in 1987 (Table 3.2). The second most abundant species in terms of numbers was *Lepidonotothen larseni.* In contrast to surveys in the 1980's, no aggregations of *Notothenia rossii* were encountered during the survey.

Table 3.2. The percentage composition of the most abundant species in the total catch in the surveys in November/December 1987 and November/December 1996

Species	Percentage composition in 1987	Percentage composition in 1996
Gobionotothen gibberifrons	57.7	60.2
Chaenocephalus aceratus	17.1	21.0
Champsocephalus gunnari	5.2	6.5
Notothenia coriiceps	8.8	4.0
N. rossii	5.4	0.3

Biomass estimates have not been carried out yet. However, the comparatively low catch levels suggest that standing stock biomass of species previously exploited has not increased since 1987. Preliminary analyses of length compositions of the most abundant species also indicate little changes when compared to 1987. Given the scarcity of *Notothenia rossii* in our catches, no information could be obtained on the development of this stock.

Stomach content analysis of *Champsocephalus gunnari* revealed that krill (*Euphausia superba*) was the predominant food item. Other euphausids, such as *Thysanoessa* sp., hyperiids and fish were only of minor importance as diet.

3.2 The composition of the fish fauna on the northern slope of King George Island (K.-H. Kock, L. Döllefeld, P.A. Hulley, H.-P. Jährig, W. Petzel, C. Pusch, V. Siegel, M.G. White)

Introduction

Information on the fish fauna on the continental slope of the Antarctic is limited as most trawling has been carried out in the shallower waters of the shelf down to about 500 m where fish concentrations of commercial value are more likely to be encountered. In order to obtain a better insight into the composition of both the pelagic and demersal fish fauna and their trophic interactions, we conducted a trawling programme in a localised area on the northern slope of King George

Island. This programme was carried out in close collaboration with a programme on cephalopod distribution and ecology (see Piatkowski et al., this volume).

Material and Methods

A total of 21 hauls (of 27 planned hauls) was carried out by means of the 140' bottom trawl and the 1088# pelagic trawl between 250 and 860 m depth on 27 - 28 November and 30 November to 6 December 1996. The location of fishing stations is provided in Fig. 3.2. Pelagic trawling was carried out at three different depth strata: 200-300 m, 300-400 m and 20-5 m above the bottom over 400, 600, and 800m bottom depth. The bottom trawl was deployed during daylight hours only while pelagic trawling was conducted also during the night. Towing time was 30 min on the bottom and 30 to 60 min in midwater at a speed of 3.0 to 3.8 knots. A CTD profile was available for most fishing stations. Rugged bottom conditions and steep slopes often made trawling very difficult. The programme had to be abandoned before completion when within a day, a pelagic and a bottom trawl snagged the bottom which resulted in considerable damage to both nets.

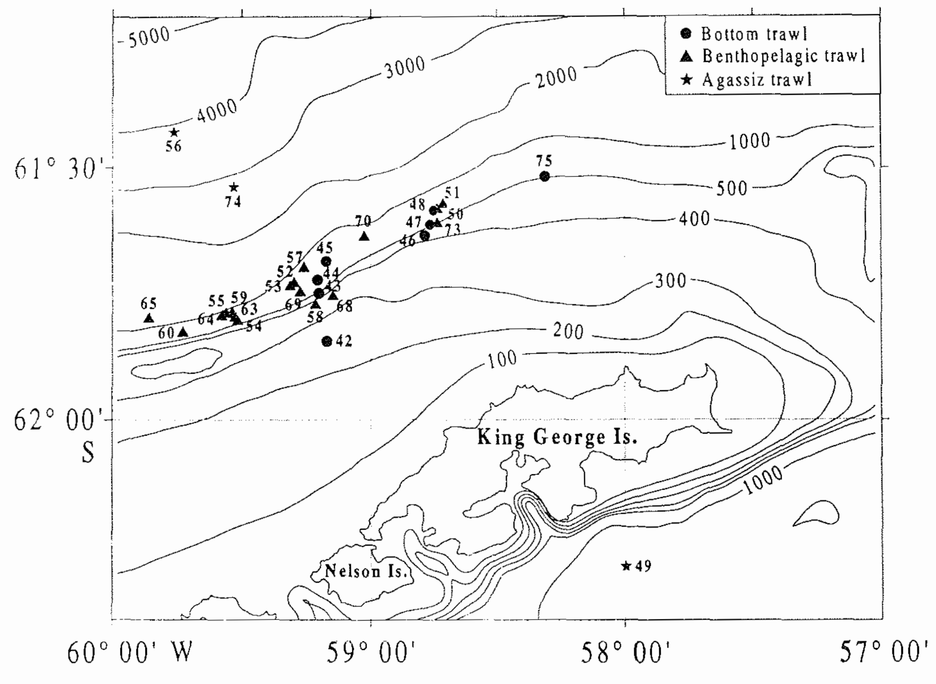

Fig. 3.2. Location of fishing stations (from Piatkowski et al., this volume)

Preliminary results

A total of 59 species was found in our catches (Table 3.3). This number is likely to increase after members of the families Liparididae, Zoarcidae and Macrouridae have been studied in more detail by specialists.

Table 3.3. List of species caught in bottom and pelagic hauls off the northern coast of King George Island

Family	Species	Occurrence
Nototheniidae	*Aethotaxis mitopteryx*	bottom
	Dissostichus mawsoni	bottom and pelagic juveniles
	Gobionotothen gibberifrons	bottom
	Notothenia coriiceps	bottom
	N. rossii	bottom
	Lepidonotothen larseni	bottom
	L. squamifrons	bottom, near-bottom
	Pleuragramma antarcticum	bottom, near-bottom
	Trematomus hansoni	bottom
	T. loennbergii	bottom, near-bottom
Artedidraconidae	*Dolloidraco longedorsalis*	bottom
	Pogonophryne species	bottom
Bathydraconidae	*Bathydraco marri*	bottom
	Gymnodraco acuticeps	bottom
	Vomeridens infuscipinnis	bottom
Channichthyidae	*Champsocephalus guunnari*	bottom
	Chaenocephaus aceratus	bottom
	Chaenodraco wilsoni	bottom
	Chionobathyscus dewitti	bottom
	Chionodraco rastrospinosus	bottom
	Cryodraco antarcticus	bottom
	Neopagetopsis ionah	bottom, juveniles midwater
Muraenolepidae	*Muraenolepis microps*	bottom
Macrouridae	*Macrourus holotrachys*	bottom, near-bottom
	Coelorinchus species	bottom
Rajidae	*Bathyraja maccaini*	bottom
	Bathyraja species 2	bottom
	Raja georgiana	juveniles, egg capsules; bottom
Zoarcidae	*Ophthalmolycus amberensis*	bottom
	Lycodichthys antarcticus	bottom
	Zoarcidae sp. 1	bottom
	Zoarcidae sp. 2	bottom
	Zoarcidae sp. 3	bottom
	Lycodapus species	near-bottom
Liparididae	*Paraliparis* species	bottom,
	Careproctus species	bottom

Table 3.3. Continued

Family	*Species*	Occurrence
Moridae	*Antimora rostrata*	bottom
Centrolophidae	*Icichthys australis*	near-bottom
Gempylidae	*Paradiplospinus gracilis*	near-bottom
Notosudidae	*Scopelosaurus hamiltoni*	near-bottom
Melamphaidae	*Poromitra crassiceps*	mid-water
Paralepididae	*Notolepis coatsi*	mid-water, near-bottom
Bathylagidae	*Bathylagus antarcticus*	mid-water
Stomiidae	*Borostomias antarcticus*	mid-water
Microstomatidae	*Nansenia antarctica*	mid-water
Gonostomatidae	*Cyclothone* species	mid-water
Scopelarchidae	*Benthalbella elongata*	mid-water
	B. macropinna	mid-water
Chiasmodontidae	*Chiasmodon niger*	mid-water
Myctophidae	*Electrona antarctica*	mid-water, near-bottom
	Krefftichthys anderssoni	mid-water
	Protomyctophum bolini	mid-water
	P. choriodon	mid-water
	Gymnoscopelus braueri	mid-water, near bottom
	G. fraseri	mid-water
	G. hintonoides	mid-water
	G. nicholsi	mid-water, near-bottom
	G. opisthopterus	mid-water, near bottom

The bottom fish fauna on the slope from 550 to 860 m was predominated by High-Antarctic notothenioids, such as *Trematomus loennbergii* and *Chionobathyscus dewitti*. Only few individuals of *Lepidonotothen squamifrons*, *T. loennbergii* and *Pleuragramma antarcticum* were found in the near-bottom layer. A more detailed account of the mesopelagic fishes is provided by Hulley et al., this volume. Subsamples of all species were collected for subsequent taxonomic studies and stomach content analyses.

3.3 Mesopelagic fishes (P. A. Hulley, K-H. Kock, C. Pusch, M.G. White)

Introduction

The role of mesopelagic fishes in the Southern Ocean ecosystem, more particularly their trophic effect on the standing stocks of krill, copepods and fish larvae, is at present obscure.

Lantern fishes (Myctophidae) are the most abundant and the most species diverse family of all oceanic marine teleosts. Globally, there are about 250 species. They are distributed from Arctic to Antarctic waters, and from the surface of the sea at night, to depths exceeding 4000 m. Many species undertake diurnal vertical migration, thereby cycling energy from the upper to the deeper water layers. Where existing commercial stocks are fully- or over-exploited, myctophids represent a potential for the development of alternative fisheries.

More than 30 myctophid species are known to occur in Antarctic waters and their *alpha*-taxonomy is now well-established. Acoustic estimates for lantern fishes (mainly *Electrona carlsbergi*) between 48°S and 56°S and 8°W and 48°W indicate a biomass of about 2 million tonnes. The total biomass of Antarctic myctophids has been estimated at 70 to 200 million tonnes.

The mesopelagic fish component of leg ANT XIV/2 was focused on improving the knowledge of the fine-scale distribution and abundance of species in the Elephant Island / King George Island region, and on gaining new insight into their trophic significance (see also Piatkowski et al., this volume). The use of a variety of sampling gears was therefore a pre-requisite for a more rigorous study of the interaction between the benthic, epibenthic (10-20 m above the bottom) and pelagic communities.

Material and Methods

During leg ANT XIV/2, more than 170 stations were occupied with a variety of nets. Station data are given in this volume. Catch data for the mesopelagic fish specimens emanating from the BT-140', PT-1088, RMT-8, Bongo and Agassiz hauls are given in Table 3.4. A total of 17 020 specimens were taken by these nets. The PT-1088 hauls yielded some 15 522 specimens, while 467, 20, 3, and 8 specimens were taken by the BT-140', RMT-8, Bongo and Agassiz hauls, respectively (Table 3.4). The fresh material from the BT-140' and PT-1088 hauls was identified to species, weighed and counted. Standard lengths were made either on the entire sample or a subsample of each species from each station. More than 2 500 specimens have been stored at -30°C for more detailed taxonomic studies and for subsequent investigations of their stomach contents. Material from the Bongo and Agassiz hauls was handled in a similar manner, but the material was fixed in 4% formalin for later investigation.

Midway through the PT-1088 sampling programme the net snagged the bottom and was damaged. The remainder of the programme could not be completed.

Some preliminary analyses of the BT-140' and PT-1088 catches were made using a suite of multivariate statistical programmes (PRIMER Version 4.0). These included cluster analyses (Bray-Curtis index), multidimensional scaling ordination and percentage similarity analyses (SIMPER). Raw data scores were standardized to reflect the number of specimens/hour of the trawling time at depth, and the resulting data in the 35 stations by 20 species matrix was root-root transformed prior to analysis, in order to accommodate high density values in some species. Detailed results are not presented in this report.

Table 3.4. Catch statistics for mesopelagic fishes from various gears.

FAMILY	GENUS	SPECIES	BT-140	PT-1088	RMT-8	Bongo	Agassiz	TOTAL
Astronesthidae	*Borostomias*	*antarcticus*	1	1	0	0	1	3
Bathylagidae	*Bathylagus*	*antarcticus*	0	4	0	0	0	4
Chiasmodontidae	*Chiasmodon*	*niger*	0	1	0	0	0	1
Gempylidae	*Paradiplospinus*	*gracilis*	57	182	0	0	0	239
Gonostomatidae	*Cyclothone*	sp	0	2	0	0	0	2
Melamphaidae	*Poromitra*	*crassiceps*	0	2	0	0	0	2
Microstomatidae	*Nansenia*	*antarctica*	1	3	0	0	0	4
Myctophidae	*Electrona*	*antarctica*	244	10090	2	1	2	10339
	Electrona	*subaspera*	0	0	0	1	0	1
	Gymnoscopelus (G)	*braueri*	22	2253	0	0	4	2279
	Gymnoscopelus (G)	*nicholsi*	125	662	1	0	0	788
	Gymnoscopelus (G)	*opisthopterus*	9	27	0	0	0	36
	Gymnoscopelus (N)	*fraseri*	0	2	0	0	0	2
	Gymnoscopelus (N)	*hintonoides*	0	15	0	0	0	15
	Krefftichthys	*anderssoni*	0	23	1	1	0	25
	Lampanyctus	*achirus*	0	0	0	0	1	1
	Protomyctophum (P)	*bolini*	0	3217	5	0	0	3222
	Protomyctophum (P)	*choriodon*	0	1	0	0	0	1
Notosudidae	*Scopelosaurus*	*hamiltoni*	1	3	0	0	0	4
Paralepididae	*Notolepis*	*coatsi*	2	34	11	0	0	47
Scopelarchidae	*Benthalbella*	*elongata*	1	0	0	0	0	1
	Benthalbella	*macropinna*	4	0	0	0	0	4
TOTAL			467	16522	20	3	8	17020

Results

The family Myctophidae (11 species in 5 genera) was the most species diverse. Other families were represented by single species, except for the Scopelarchidae. Here, both Southern Ocean species (*Benthalbella elongata*, *B. macropinna*) were caught. Four species of lantern fishes, *Electrona antarctica* (60.8% of total by number), *Protomyctophum (P) bolini* (18.9%), *Gymnoscopelus (G) braueri* (13.4%) and *Gymnoscopelus (G) nicholsi* (4.6%), made up the bulk of the catches, and were present in catches made by the other gears. One specimen of *Lampanyctus achirus* was taken in a deep Agassiz trawl (Station 02: 3 723 m) and a single specimen of *Protomyctophum (P) choriodon* in a PT-1088 haul in 400 m off Elephant Island. The latter represents a new record for the region. *Gymnoscopelus (N) fraseri* and *Gymnoscopelus (N) hintonoides* represent additional new records for the family Myctophidae in this region, as do the records for *Borostomias antarcticus* (Astronesthidae), *Nansenia antarctica* (Microstomatidae), *Chiasmodon niger* (Chiasmodontidae) and *Poromitra crassiceps* (Melamphaeidae). The two specimens of *Cyclothone* (Gonostomatidae) were badly damaged and could not be identified to species.

No mesopelagic fishes were caught in depths shallower than 198 m, suggesting an inshore distributional limit at the continental shelf break. This is in line with similar findings elsewhere. Generally speaking, species abundance was higher in pelagic hauls than in benthic hauls, and species diversity increased with increasing fishing depth.

Cluster analysis (Fig. 3.3) of the complete data set indicated two major groups of stations: those occupied with the BT-140, and those with the PT-1088. Two PT-1088 hauls (Station 050 and Station 073) appeared to be more closely associated with the BT-140 station group. However, the data from Station 050 should be treated with reservation because the haul was aborted during the trawling period. During Station 073, the net was fished for several minutes on the bottom, where it eventually snagged and was damaged. Station 048 (BT-140) appeared to be completely different to all other stations (Bray-Curtis index = 0.0%). It has not been included in Figure 3.3. Due to the large quantity of mud contained in the cod-end, the catch from this station was landed on deck and worked off with water hoses. Further discussion of the above stations is beyond the scope of this preliminary report.

Similar analyses for the lantern fish data from the PT-1088 stations (Figs 3.4) revealed two major groups of stations: a shallow (295 to 450 m) group of stations, and a deeper group (440 to 825 m). These suggest a transition in relative abundances in the 440 m to 450 m depth horizon and could well be associated with the presence of warmer deep water at and below these depths. For the Mytophidae, *Protomyctophum (P) bolini* appeared to be a good indicator species for the shallower group of stations. *Electrona antarctica* and *Gymnoscopelus (G) braueri* appeared to be indicator species for the deeper group of stations (Table 3.5). Size-frequency distributions for *P. bolini* revealed that only small specimens were taken during the sampling programme, and that there may be some size-depth correlation, with larger specimens being taken at greater depths.

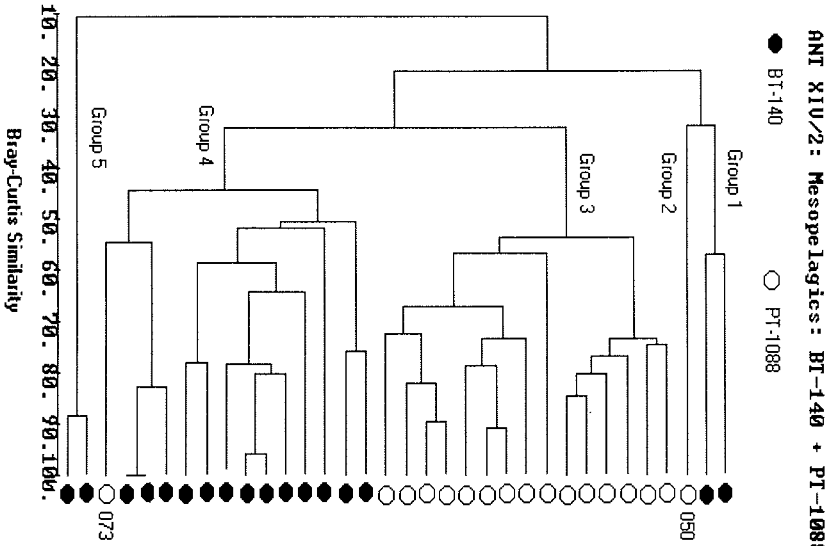

Fig. 3.3. Dendrogram of station affinities based on root-root transformed densities (specimens/hour) of mesopelagic fishes caught with the BT-140' and PT-1088 nets, using the Bray-Curtis similarity index and group-average clustering. St. 048 not included (see text).

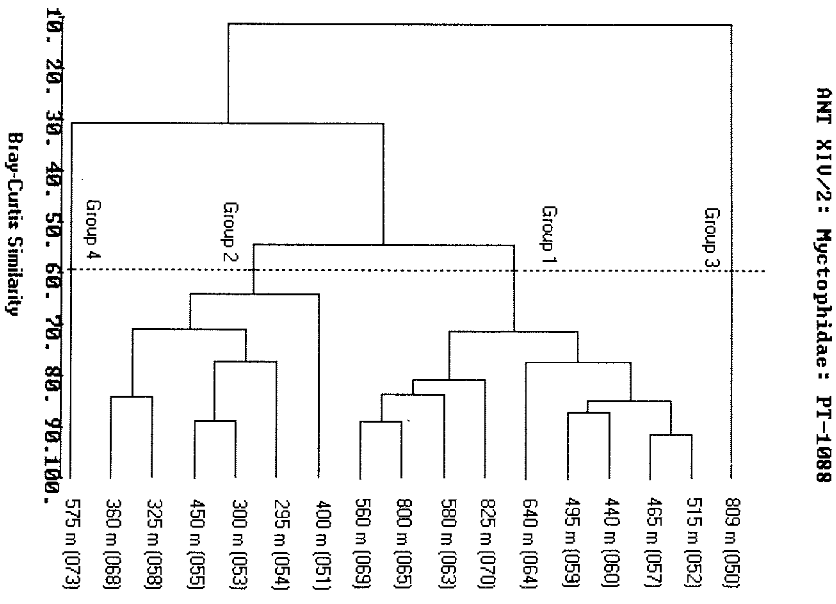

Fig. 3.4. Dendrogram of station affinities based on root-root transformed densities (specimens/hour) of Myctophidae caught with the PT-1088 net, using the Bray-Curtis similarity index and group-average clustering. Fishing depth (metres); station numbers in paratheses.

Initial spot-check studies of the stomach contents from a few specimens of *Electrona antarctica*, *Gymnoscopelus (G) nicholsi* and *Protomyctophum (P) bolini* revealed that the small *P. bolini* specimens had been feeding on copepods, while krill (*Euphausia superba*) was the major component of the diet in the larger *E. antarctica* and *G. nicholsi* specimens. This suggests some degree of niche differentiation based on the size spectrum of the prey organisms.

Conclusions

The results discussed above are of a preliminary nature only. Much work still has to be done. Incompletion of the epibenthic sampling programme may limit the investigation of fine-scale patterning by mesopelagic fishes in the Elephant Island region. However, the large collection of frozen material, from which stomach content data will be derived, should provide the necessary information to shed new light on the trophic significance of mesopelagic fishes in the Antarctic ecosystem.

Table 3.5. Analysis of similarity (SIMPER) based on groups formed from cluster analysis of Myctophidae from PT-1088 net (Fig. 3.4).
* = non-Myctophidae.

Species	Group 2 av abun	Group 1 av abun	av term	ratio	percent	cum %
E. antarctica	33.33	1678.22	13.60	2.68	28.62	28.62
G. braueri	.00	494.89	7.92	1.57	16.67	45.29
P. bolini	626.33	143.11	5.38	1.66	11.32	56.61
* *P. gracilis*	2.50	29.00	3.74	1.77	7.88	64.49
G. nicholsi	72.67	68.33	3.04	.86	6.41	70.90
* *N. coatsi*	.33	6.11	2.99	1.38	6.30	77.19
K. anderssoni	.00	4.78	2.56	1.08	5.39	82.58
G. hintonoides	.00	3.00	2.20	1.08	4.62	87.20
G. opisthopterus	.00	5.89	1.01	.48	2.13	89.33
* *N. antarcticus*	.00	.44	.99	.69	2.09	91.43
* *B. antarcticus*	.00	.89	.72	.52	1.52	92.95
* *S. hamiltoni*	.00	.56	.71	.53	1.49	94.44
G. fraseri	.00	.33	.66	.53	1.39	95.83
P. choriodon	.17	.00	.53	.43	1.12	96.95
* *B. macropinna*	.00	.11	.39	.35	.82	97.77
* *P. crassiceps*	.00	.44	.38	.35	.79	98.56
* *Cyclothone* sp.	.00	.44	.37	.35	.77	99.33
* *C. niger*	.00	.22	.32	.35	.67	100.00

3.4 Fishes from Agassiz trawl catches (K.-H. Kock, P.A. Hulley)

Information on the composition of the Antarctic deep-sea fish fauna is sparse. Agassiz trawl catches which were conducted at various depths from 313 to 3723 m in order to catch benthic amphipods and isopods (see Coleman this volume; Held, this volume), provided an opportunity to augment our knowledge of Antarctic deep-sea fishes. Most specimens from hauls deeper than 1500 m were members of the families Macrouridae, Zoarcidae and Liparididae (*Paraliparis* ssp., *Careproctus* ssp.) which could not be identified to species level onboard. They will be studied by specialists in the course of 1997. The only notothenioids caught in deeper water were *Bathydraco macrolepis* (Bathydraconidae) and *Chionobathyscus dewitti* (Channichthyidae) in 1514 m at 62°14.7'S, 56°57.0'W. *Trematomus tokarevi* was found the first time west of the Antarctic Peninsula (66°36.1'S, 68°42'W) in 630 m.

3.5 Larval and juvenile fish collected during December 1996 in the Elephant Island region (M.G. White, K.-H. Kock, V. Siegel)

Introduction

One of the main objectives during "Polarstern" cruise ANT XIV/2 was to undertake a study of the biology, distribution and abundance of the krill stocks in the Elephant Island area. In addition, the zooplankton community composition was to be evaluated to provide baseline information about species diversity and abundance, so this can be used for comparison with former and future results in research to study the natural variability within the Antarctic marine ecosystem.

Few species of Antarctic fish are pelagic but many of the demersal species have an extended pelagic larval phase of development and so a diverse ichthyoplankton is a consistent component of the zooplankton community. As a contribution of a description of the spring zooplankton community in the Elephant Island area, the ichthyoplankton was to be identified to the species level.

Methods

Larval and young fish were extracted from the zooplankton catches made with a Rectangular Midwater Trawl with mouth area of 8 m^2 and 1 m^2 (RMT8+1). This net was deployed as a double oblique haul 0 - 200 m at a 15 x 15 nm grid of established stations around Elephant Island and the eastern end of King George Island. The details of the stations occupied and the methods employed are given in Siegel et al. (this volume). In addition some larval and young fish were found in catches made with a benthopelagic trawl during an earlier phase of ANT XIV/2. See Piatkowski et al. (this volume) and Kock et al. (this volume) for details of the methods used.

Zooplankton from the RMT1 and RMT8 nets were inspected directly after capture and processed to determine *Euphausia superba* biomass, abundance and size structure. Salps were processed in a similar manner. All larval/postlarval fish that were visible to the eye were extracted from the remaining zooplankton, identified to species level and the length of each individual measured as soon as possible after capture. Kellermann (1989) was used as a reference for confirming the identity of larval fish. Standard length (sl) was recorded and rounded to the nearest millimeter below. Total length (tl) was measured when the caudal fin was undamaged. After initial inspection the fish were straightened and left to relax in a petri dish, then partly fixed in this posture before being fixed and stored in a buffered 90:10 seawater:formaldehyde. RMT1 zooplankton samples were preserved entire without further processing unless the volume required these to be subsampled.

The newly hatched stages of some species of Antarctic fish are less than 5 mm long and so may not have been observed during the initial zooplankton sorting on RV "Polarstern". These will probably be revealed when the RMT1 samples are processed in Germany.

Preliminary results

Most of the sample grid was over deep water. In common with former studies at the South Shetland Islands (White & North 1987; Kellermann 1986) and other Antarctic localities, such as at South Georgia (North 1988; Loeb et al. 1993; White et al. 1996), Kerguelen (Koubbi et al. 1990) and the Weddell Sea (White & Piatkowski 1993), zooplankton samples collected in oceanic water have relatively few larval fish while samples from neritic waters contain greater numbers and more species. Just over half of the stations yielded fish larvae, usually in small numbers.

Forty nine of the 92 RMT stations yielded larval or postlarval fish. In addition, postlarval fish occurred in 6 benthopelagic trawl hauls. A total of 194 larval or postlarval specimens were collected from the 55 stations in which the young stages of fish were observed. Eight juvenile or adult myctophids were also captured in RMT 8 catches.

Table 3.6 gives a summary of the larval fish captured, the number of stations at which they occurred and their size range. The specimens of larval fish were preserved and have been returned to the Institut für Seefischerei, Hamburg for further systematic and ecological studies.

Table 3.6. Postlarval fish species, number of individual larval and size range.

Species	Station No.	No. specimens	size range (sl mm)
Chionodraco rastrospinosus	16	32	25 - 48
Lepidonotothen larseni	15	62	8 - 13
Notolepis coatsi	14	16	10 - 164
Neopagetopsis ionah	13	18	42 - 52
Trematomus newnesi	12	17	16 - 27
Chaenodraco wilsoni	8	12	33 - 49
Cryodraco antarcticus	5	6	46 - 58
Myctophid larvae	4	5	3 - 9
Notothenia coriiceps	3	3	12 - 17
Protomyctophum bolini (adult)	3	5	41 - 45
Pseudochaenichthys georgianus	2	2	12 - 24
Champsocephalus gunnari	2	4	19 - 28
Gobionotothen gibberifrons	2	11	7 - 9
Dissostichus mawsoni	2	2	71 - 77
Artedidraco skottsbergi	1	3	13 - 15
Lepidonotothen nudifrons	1	1	13
Krefftichthys anderssoni (adult)	1	1	59
Gymnoscopelus nicholsi (adult)	1	1	144

Species diversity and abundance values for individual catches were low with an average of 1.8 species and 3.6 specimens captured during each RMT 8 deployment (Table 3.7). Nevertheless, the zooplankton sampling programme for the Elephant Island area collected the larval/postlarval stages of 16 species, 13 genera and 5 families.

Table 3.7. Rectangular Midwater Trawl stations: summary of physical and biological data

Station	Depth (m)	Vol filtered (m^3)	Total volume (ml)	Fish (n)	Fish (sp)	Total vol (ml/m^3)	Fish (n/m^6)	Fish (sp/m^6)
Mean	1918	18602	5008	3.65	1.83	0.30	0.21	0.10
Median	1664	19340	3400	2.00	1.00	0.20	0.13	0.08
sd	1328	4826	5684	3.89	1.12	0.35	0.23	0.06
min	61	4812	200	1.00	1.00	0.01	0.04	0.04
max	4914	31286	32250	18.00	6.00	2.02	1.17	0.27

The nototheniid *Lepidonotothen larseni* was the most numerous individual species and was the second dominant species at Stations (Table 3.6). Channichthyid (Icefish) larvae occurred most frequently in catches and among these *Chionodraco rastrospinosus* occurred at the greatest number of stations. The second most frequent icefish species (13 stations, 18 specimens) occurred as a larval stage resembling species from the genera *Pagetopsis* or *Pseudochaenichthys*. After examination, the meristic characteristics, pigment distribution of individuals and the provenance indicated that these larvae had the characteristics of the genus *Neopagetopsis*. The specimens were tentatively identified as *Neopagetopsis ionah*. This species is recorded as demersal adults at the South Shetland Islands and was caught during the ANT XIV/2 ground-fish survey. A description of the larval stages of *N. ionah* has not yet been published.

Figures 3.5 illustrate the distribution for each species captured during ANT XIV/2. The distribution patterns of species collected in oceanic water imply that their occurrence may be water-mass related but analysis of this is dependent upon interpretation of the oceanographic data. In common with observations of the distribution of notothenioid larvae at other locations in the Southern Ocean, greater abundance values and species diversity occurred near to land masses and over the continental shelf. In general there was an inverse relationship between species per haul and water depth as well as specimen numbers per haul and the water depth (correlation [Pearson] = -0.39 and -0.38 respectively).

Examination of the distribution patterns of the larval and postlarval fish revealed that the majority of species were found in the southern part of the survey grid, south of 61°S. Five of the six species of icefish occurred south of this latitude and only *C. wilsoni* had a distribution that extended to the north. The larvae of the more widely distributed nototheniids, *L. larseni* and *T. newnesi* and the myctophid larvae also occurred south of 61°S. Some species exhibited a distinct neritic distribution pattern. The larvae of *Gobionotothen gibberifrons, Champsocephalus gunnari, Pseudochaenichthys georgianus, and Lepidonotothen nudifrons* occurred in coastal waters near King George Island.

By contrast, the larvae of the oceanic paralepidid, *Notolepis coatsi* was distributed in both the southern and northern sectors of the survey area and the adult myctophids, *Krefftichthys anderssoni* and *Protomyctophum bolini,* were only found near the northern edge of the survey area.

Adult *Notothenia coriiceps* were a common component of the bottom trawl catches during the ground-fish survey at Elephant Island. This species spawns in May-June and the eggs hatch in the austral spring after a prolonged incubation. The eggs and larval stages of *N. coriiceps* are often found dispersed away from the shelf where the adults spawn (White et al. 1982). During the zooplankton survey, larval *N. coriiceps* were found near the northern shelf of King George Island and at stations to the north and south of 61°S. Of note was that these specimens of *N. coriiceps* larvae occurred as a near-hatching egg at the beginning of the study period (6 December), then as a newly hatched larvae extracted from the stomach of a larval *Chionodraco rastrospinosus* (17 December), and a third specimen as a free swimming larva near the end of the cruise (20 December).

A more detailed examination occurrence and distribution of the taxa will occur once the RMT catch composition and oceanographic data are available.

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Chionodraco rastrospinosus | *Chaenodraco wilsoni*

Neopagetopsis ionah | *Cryodraco antarcticus*

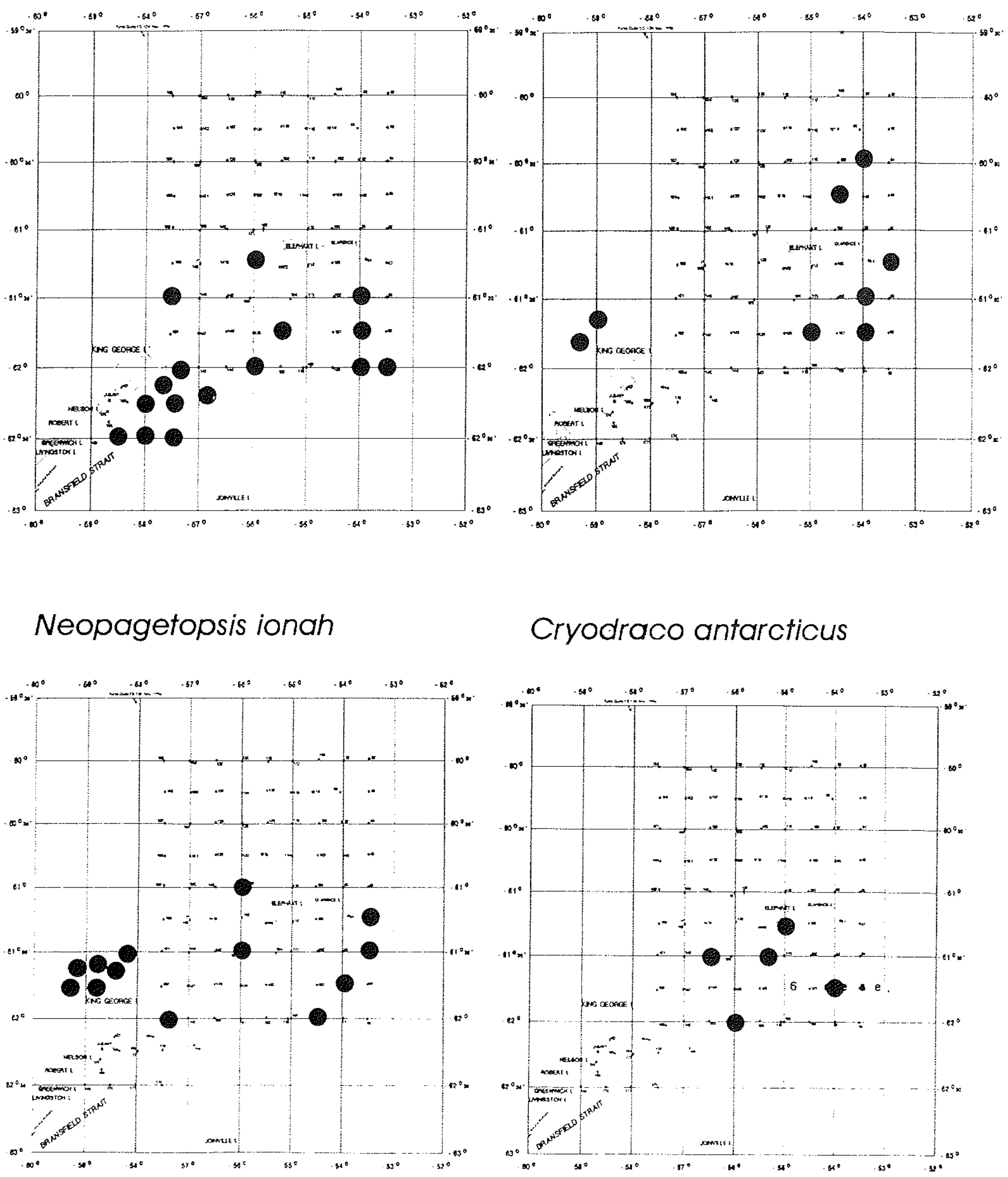


Fig. 3.5. Distribution of larval and juvenile fish species

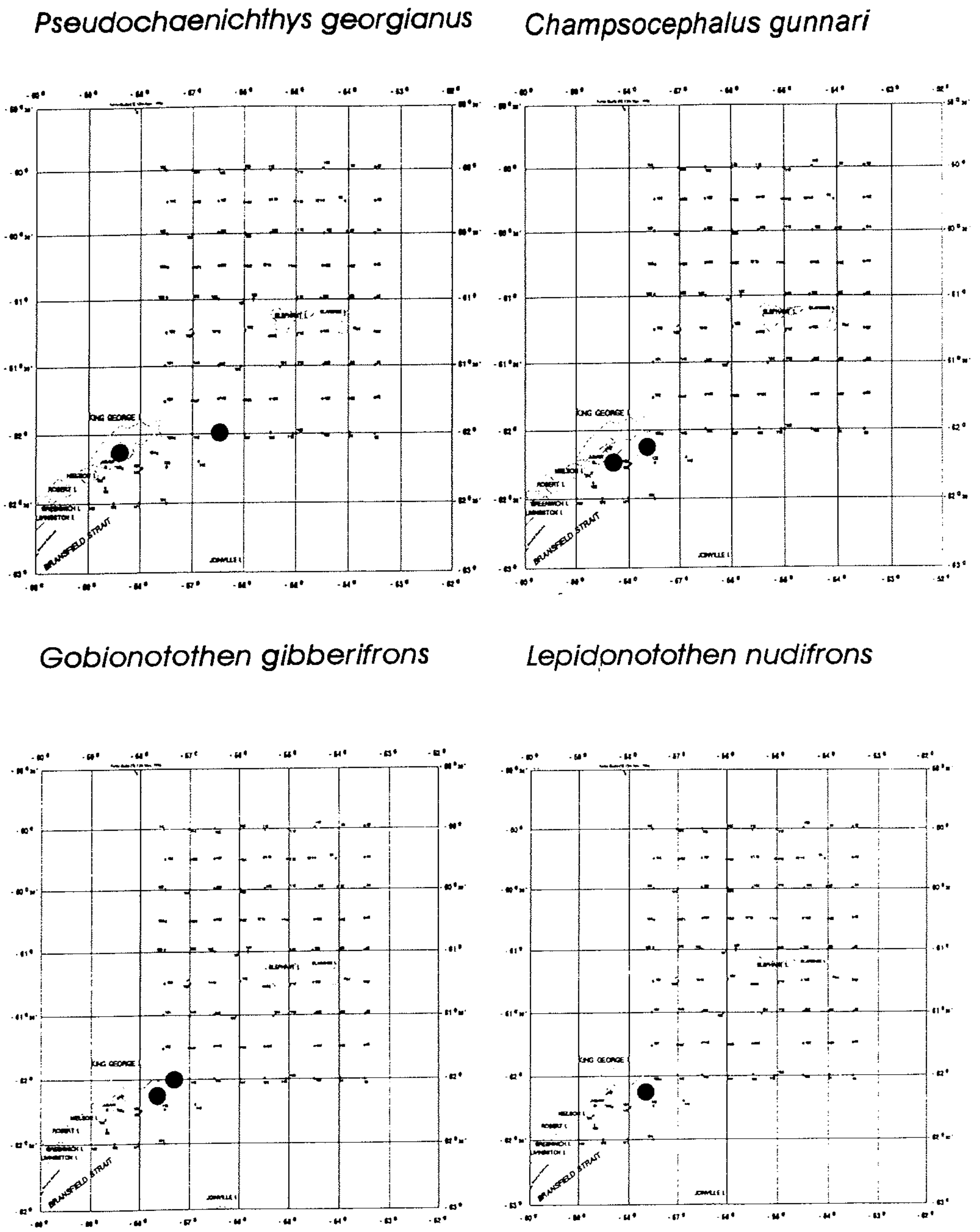


Fig. 3.5. Continued

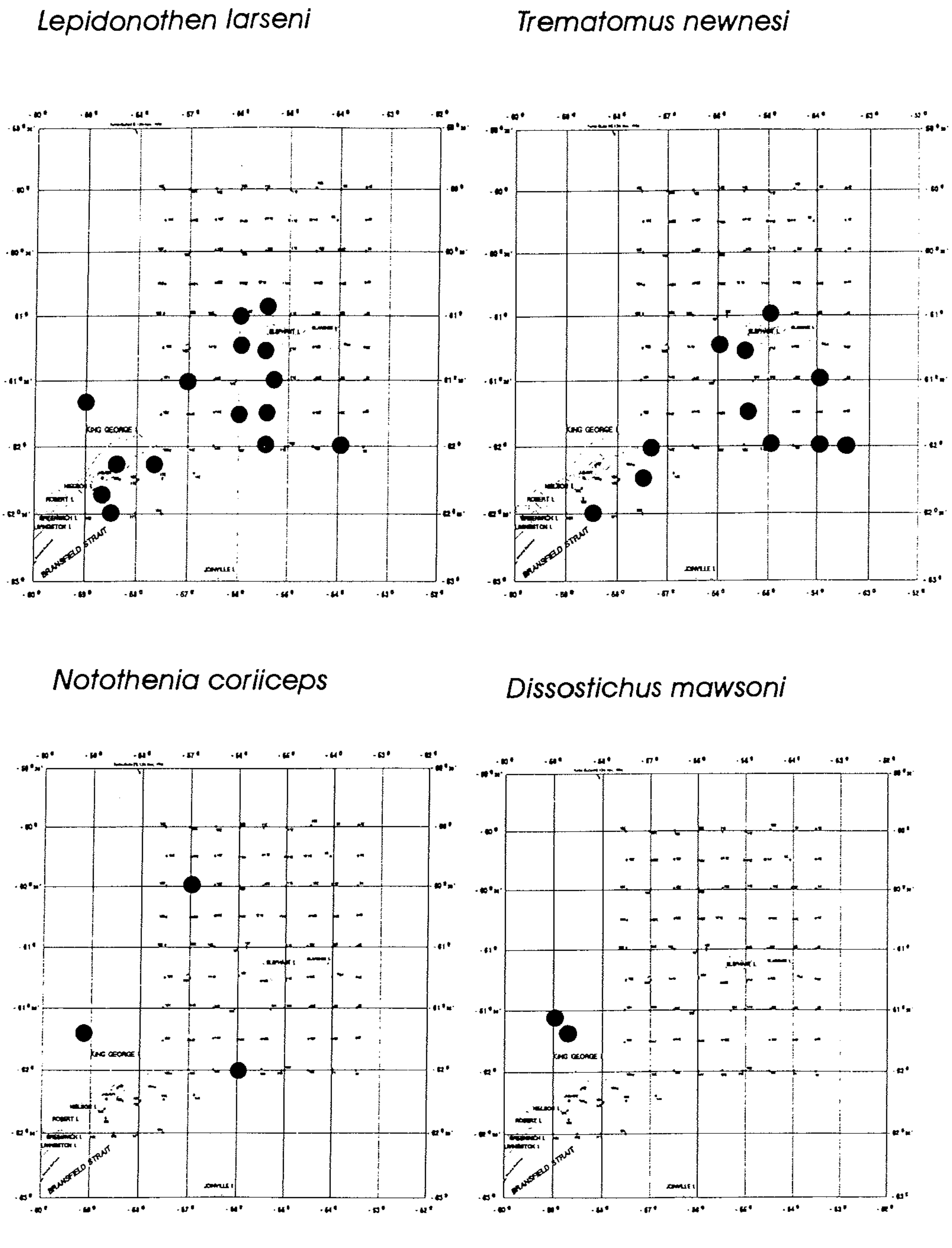
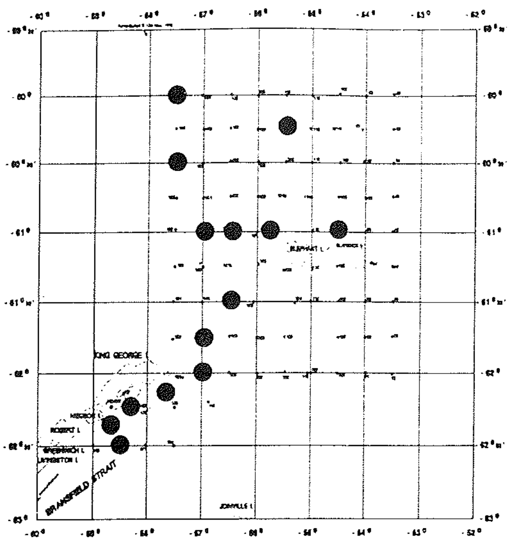
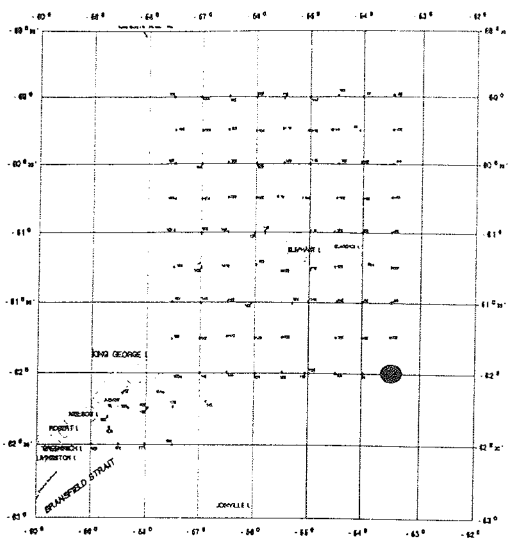


Fig. 3.5. Continued

Notolepis coatsi



Artedidraco skottsbergi

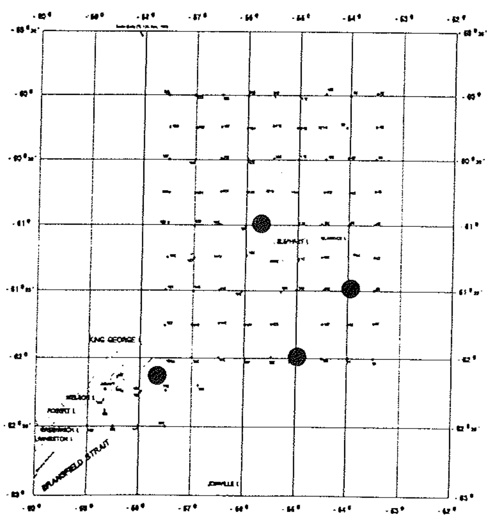


● *Protomyctophum bolini*

○ *Krefftichthys anderssoni*

■ *Gymnoscopelus nicholsi*

Myctophid larvae



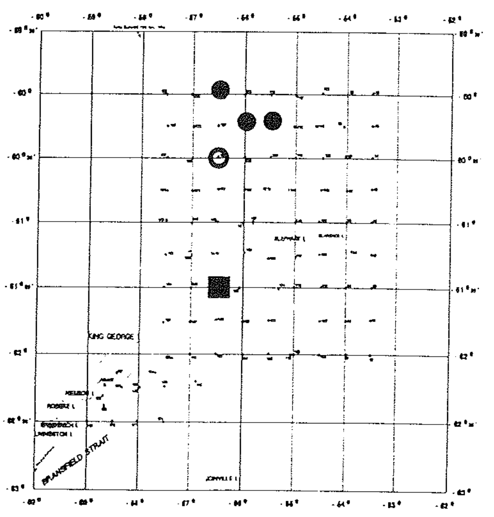


Fig. 3.5. Continued

3.6 Studies on the population genetics of Antarctic notothenioids
(L. Döllefeld, K.-H. Kock)

Samples of muscle, liver and spleen tissue were collected for DNA/RNA studies of a number of notothenioid species (Table 3.8). This work is conducted in close collaboration with the University of Padova, Italy.

Table 3.8. Number of tissue samples by species collected for DNA/RNA studies

Species	No. of samples DNA studies	No. of samples RNA studies
Gobionotothen gibberifrons	101	4
Notothenia coriiceps	79	4
N. rossii	25	4
Trematomus bernacchii	5	4
T. newnesi	1	0
Pleuragramma antarcticum	20	6
Champsocephalus gunnari	110	4
Chionodraco rastrospinosus	103	4

3.7 Studies on reproductive characteristics of Antarctic fish (R. Riehl)

Introduction

Descriptions of Antarctic fish eggs are sparse on electron microscopical level (Riehl & Kock 1989; Riehl & Ekau 1990; White et al. 1996). The egg diameter, colour, absence or presence of oil droplets are features which often do not permit an unequivocal identification. As a consequence, our ability to identify fish eggs from the Southern Ocean to species is limited. Scanning electron microscopy (SEM) was found to be a powerful means which could assist in the identification of fish eggs on genus and species level. On SEM level, there are four main features which were found to be species-specific: The surface pattern of the zona radiata, the distance between the pores (= interpore distance), the diameter of pores and the morphology of the micropyle. At present, a catalogue of Antarctic fish eggs is in preparation (Riehl & Kock, in prep.) which, among others, will describe these features for a large number of Antarctic fish species. One of the main aims of this cruise was to augment the number of species to be dealt with in the catalogue.

Only in a few Antarctic fish species oogenetical and spermatogenetical events are studied on light microscopical level. In most Antarctic fish species oogenesis and spermatogenesis are unknown on electron microscopical level. Therefore another aim of this cruise was to collect samples for transmission electron microscopical (TEM) and cytochemical studies.

Investigations carried out

Mature oocytes of seven Antarctic fish species were collected during ANT XIV/2 (Table 3.9). Among them were oocytes of the eelpout *Ophthalmolycus amberensis* which have never been studied before. The material was preserved in buffered glutaraldehyde for SEM purposes.

Ovarian and testis tissues were collected from 17 species (Table 3.9) in order to study their oogenesis and spermatogenesis. Tissues were preserved in glutaraldehyde for TEM and treated with special solutions to detect some enzymes (acid and alkaline phosphatase, Na^+,K^+-activated ATPase). SEM, TEM and cytochemical studies will be conducted at Düsseldorf University in the course of 1997.

Literature

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White, M.G., Veit, R.R., North, A.W. & Robinson, K. (1996). Egg-shell morphology of the Antarctic fish *Notothenia rossi* Richardson, and the distribution and abundance of pelagic eggs at South Georgia. Antarctic Science 8: 267-271.

Table 3.9. List of species collected

Species for SEM study
Chaenocephalus aceratus
Chaenodraco wilsoni
Champsocephalus gunnari
Chionodraco rastrospinosus
Gobionotothen gibberifronsr
Lepidonotothen squamifrons
Ophthalmolycus amberensisf

Species for studies on oogenesis and spermatogenesis
Chaenocephalus aceratus
Chionodraco rastrospinosus
eelpout (still undetermined)
Electrona antarctica
Gobionotothen gibberifrons
Gymnoscopelius opisthopterus
Krefftichthys anderssoni
Lepidonotothen nudifrons
Lepidonotothen squamifrons
Muraenolepis microps
Nansenia antarctica
Notothenia coriiceps
Ophthalmolycus amberensis
Paradiplospinus gracilis
Pseudochaenichthys georgianus
Racovitzia glacialis
Trematomus bernacchii

3.8 The nematode fauna in fish around the Antarctic Peninsula
(T. Walter)

Introduction

Today investigations on the parasitic fauna in Antarctic waters are restricted to a few observations. A limited number of studies, mainly on single parasite species exist. Only a few quantitative data concerning infestion with parasitic nematodes from the Antarctic are available (Klöser et al. 1992; Reimer 1987; Palm et al. 1994). The main topic of this study during ANT XIV/2 was to investigate a diversity of different fish species out of different families for the occurrence of parasitic nematodes with special interest on the species *Contracaecum osculatum* (Rudolphi 1802) and *Pseudoterranova decipiens* (Krabbe 1878) which use mainly benthic intermediate hosts within their life cycle and *Contracaecum radiatum* (Linstow 1907), an endemic species with a pelagic life cycle. All three species belong to the family Anisakidae but their taxonomical positions are still not absolutely clarified. These data will be confirmed with previously obtained data from the eastern Weddell sea coast and at Jubany (Antarctic Peninsula). Thus, the infestion rates of fish with parasitic nematodes in relation to different High-Antarctic coastal zones can be compared. Another aim during this leg was to collect other parasite groups from fish and other hosts.

Methods

Fishes of 18 species from the area around Elephant Island and King George Island were collected by different hauls by the Agassiz trawl, the benthopelagic net and the bottom trawl, and deep frozen (-30°C) immediately after the catch. Specimens of several parasite species from fishes and cephalopods were collected and preserved. Furthermore 3 different nematode species (*Contracaecum osculatum, C. radiatum* and *Pseudoterranova decipiens*) were collected, frozen in liquid nitrogen and stored at -125°C or preserved in alcohol for further molecular biological investigations. Thus, it might be possible to get more information about basic taxonomical questions within this group which are not yet solved. Length, weight and sex of 126 fishes (out of 8 species) was determined and the body cavity, organs and musculature examined for *Pseudoterranova decipiens.* The prevalences and intensities for each species were taken.

Preliminary results

Third stage larvae of *P. decipiens*, *C. osculatum* and *C. radiatum* were found in different Antarctic fish species. Most of the parasites were found in the liver, or in the liver surface, or free in the body cavity. No nematodes were found in the musculature of any fish. The prevalence and intensity of parasitic nematodes in the teleosts *Chaenocephalus aceratus*, *Chionodraco rastrospinosus, Lepidonotothen larseni, Notothenia coriiceps* and *Pseudochanichthys georgianus* were very high (prevalence: 25-100 %). More then 100 nematodes (*Pseudoterranova decipiens*) were found in the liver of a single fish (*C. acerastus*). This represents a significant difference to the low prevalences and intensities published from the eastern Weddell sea coast (Palm 1994). Now for the first time, together with further investigations on 280 frozen fish, collected during this study, a comparison of the infestion rates in relation to different high Antarctic coastal zones will be possible.

The occurrence of the leeches *Notobdella nototheniae*, *Platybdella levigata* and *Trachelobdella lubrica* were also high on some fish. Parasitic copepods were found to infest the gills of the octopod *Megaleledone senoi*. Other, not yet identified, parasites were detected in the gastrointestine of the cephalopoda *Benthoctopus* sp.

Two unknown parasitic copepods were detected to infest the rat tail *Macrourus holotrachys* and another unknown Macrouridae. The prevalence and intensity were taken for each species. A similar but undescribed species is known from the Weddell sea (Palm, pers. com.). Investigations for further identification of the different parasites will be carried out at the Institut of Marine Research, Kiel.

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3.9 Physiological ecology of pelagic fish (R.F.Robertson)

Abstract

Some striking adaptions are found in Antarctic teleosts, generally including the loss of a swimbladder, the presense of anti freeze glyco-peptides in the blood, the development of aglomerular kidneys, and in the icefishes enlarged hearts (cardiomegaly) and absence of respiratory pigments. Recently an unusual, possible unique vertebrate stress response has been documented in sluggish inshore species, where circulating catecholamines (the classic "flight or fight" hormones) are apparently not involved (Egginton & Davison 1996). It is, however, possible that these findings are biased by the type of species available for study, and are not representative of the broader Antarctic fish fauna. Various sized specimens from different ecological niches were collected from bottom ground trawls (Grundschleppnetz) and bentho-pelagic trawls around King George Island (62°S58°W) and Elephant Island (61°S55°W).These fish will be transported frozen (-30°C) back to the UK, where the adaptions for active locomotion, including the effects of body morphometrics and the capacity to synthesis stress hormones will be studied. In addition these specimens from more open water habitats will help to answer the question wither or not the unusual stress response found in sluggish inshore fish can be applied in general to the wider fish fauna in Antarctica.

Introduction

The unique fish fauna around Antarctica is dominated by a single perciform suborder, the Notothenoidei, whose phylogeny has been well defined by traditional and molecular techniques. They have undergone a remarkable adaptive radiation (into a variety of forms from small, sculpin-like to large, hake-like species, using predominantly labriform locomotion) that is possibly unique in the marine environment, and which molecular evidence suggests is a relatively recent event

(Clarke & Johnston 1996). The last few decades has seen the development of extensive scientific and commercial fishing in the area that has provided much data on the growth and reproduction of a wide range of species. In contrast, financial constraints and logistical difficulties have meant that studies into the physiological mechanisms that allow these fishes to sucessfully exploit this extremely cold, and highly seasonal environment have mainly concentrated on a few inshore species, predominately from the Nototheniididae and Channichthyidae (Kock 1992; Eastman 1993). Antarctic pelagic fishes are diverse in their origins, coming from bathypelagic, mesopelagic and, of most interest for our purpose, from coastal fish families that have become secondarily adapted to midwater life. However, most species (about 75% of those so far recorded) inhabit benthic or demersal niches, which is thought to reflect the benthic lifestyle of the parent taxa, and helps explain the lack of a functional swimbladder (Kock 1992). Those species that are now able to exploit the water column have therefore had to evolve means of adjusting buoyancy, including reduced skeletal ossification and extensive lipid deposits, e.g., the Antarctic silverfish, *Pleurogramma antarticum* (Eastman 1993).

Current data indicate a range of adjustments at the molecular level has maintained function in cold water, although the rates of physiological systems are lower than found in temperature species, and maximal power output of fast muscle in Antarctic fish at 0°C is only a third that of tropical species at 25°C. While the factorial scope (the difference between resting and maximal acitivity) is similiar for Antarctic fish and tropical species, the absolute metabolic flux is siginificantly less in the former (Clarke & Johnston 1996), which severely limits the power available for locomotion and therefore may explain the relative paucity of truly pelagic species in Antarctica. What is unclear is the degree to which different species from different niches are restricted in their swimming capacity.

Despite the expanding literature on the strategies Antarctic fishes have evolved to cope so successfully with life in the cold, many questions remain unresolved. This placement on the RV "Polarstern", ANT XIV/2 cruise has provided a unique opportunity to address two key problems of physiological ecology of pelagic species:

1) to determine whether the recently described unusual stress response of sluggish fish (extreme down regulation of the normal adrenergic cardiovascular control) is representative of the wider fish fauna.
2) to determine the proportional growth (allometric relationship) of heart and skeletal muscles as index of the effort required to maintain an active lifestyle, compared to related benthic species.

Material and Methods

The species list for the proposed sampling stations numbered about 50. The two species for which some data (Egginton, unpublished) already exist will be of value in providing a reference and allowing the size range to be extended. Fish were either caught in half hour bottom ground trawls or one hour bentho-pelagic trawls. Based on the outcome of the first 5 trawls it was decided to concentrate sampling on only those species that were frequently caught and had a good size range because of the time constraints extracting fresh blood samples and dissecting whole animals between trawls. Four key species were selected from different niches: *Notothenia gibberifrons* (sluggish, truly benthic), *Champsocephalus gunneri* (active, pelagic channicthyid), *Notothenia rossii* (relatively active, bentho-pelagic) and *Dissostichus* *mawsoni* (active, pelagic notothenid). Table 3.10 shows the list of samples and specimens collected for analysis back in the UK.

Blood samples and head kidney samples were only taken from post catch fish that showed signs of life and were frozen immediately at -125°C for shipment back to the UK. Blood was extracted via the caudual artery into heparinised syringes and centrifuged (13 000 g, 3 min) to obtain plasma. An antioxidant chelating medium (10 %v/v) was added to the plasma samples prior to freezing (10 mM reduced glutathione, 100 mM EDTA). Blunt dissection on fresh fish were performed to remove the ventricle, auricle, spleen, gonad and the six swimming (pectoral) muscles. These were stored frozen (-30°C) in preweighed tubes and will be acurately weighed on return to the UK. Analysis for stress hormones will be performed by HPLC with electrochemical detection (Egginton 1994). The stress of capture has been shown to produce the highest levels of circulating catecholamines, and these data therefore may be used as an index of the capacity for catecholamine production. Head kidney samples will also be sampled, and assayed for the enzymes of catecholamine metabolism (monoamine oxidase and catechol-O-methyltransferase; Randall & Perry 1992) and synthesis (Phenylthanolamine-N-methyltransferase; Reid et al., 1996).

Muscle mass relative to total or lean (gonad free) body mass, to avoid complication due to different stages of sexual maturity, will be examined in an allometric analysis and compared to previous data from inshore epibenthic or benthic Antarctic and temperate marine species. An explanation for the apparent discrepancy in scaling between cardiac and locomotory muscle (Fig. 3.6) will be sought. Water and lipid content (chloroform/methanol extraction) will be determined to assess the contribution of reduced muscle density to buoyancy. Together these data will help to define the extent of energy saving adaptions required by pelagic fish. The opportunity will also be used to address the unressolved question of whether the well developed hypobranchial arterial system found in channichthyids (Rankin et al. 1987) is functional in other notothenoids (Eastman 1993). Albumin-conjugated Evans blue dye, or india ink-gelatin, will be injected into the efferent branchial artery and the architecture of the vascular network supplying the locomotory (pectoral) muscles mapped. These data will indicate whether oxygen or nutrient supply to swimming muscles is also limiting in those species that posses respiratory pigments, thus requiring a supplementary supply.

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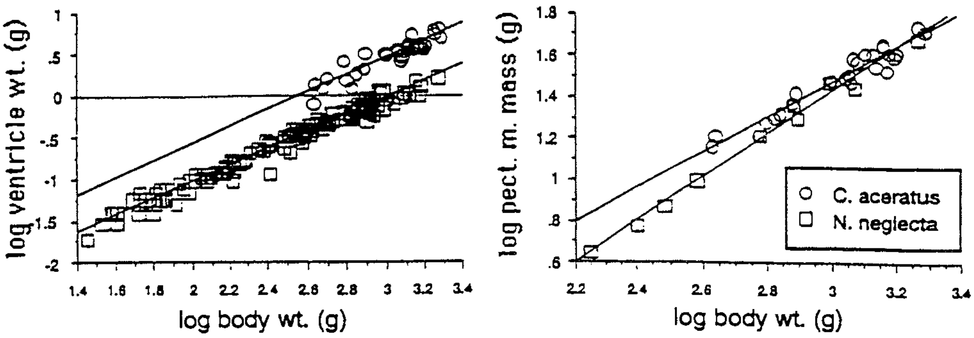

Fig. 3.6. Log ventricle (g) and log pectoral muscle mass (g) against log weight (g) in *C.aceratus* and *N.coriiceps (neglecta)*, unpublished data, S. Egginton, Birmingham University, UK)

Table 3.10. Samples and species collected to be studied on return to the UK

Species	Full dissection	Fish Frozen Whole	Plasma Samples	Kidney Samples
C. guunnari	18	7	17	15
C. rastrospinous			13	16
C. aceratus	6	35	3	6
N. rossii	12		14	11
G. gibberifrons	14	32	18	16
D. mawsoni	13		13	12
T. euplepidotus				10
L. squamifrons			10	
L. arseni		70		
G. braueri		25		

Acknowledgements: The Officers and crew of the PFS 'POLARSTERN' and the following people for their expertise in fish identification; Karl-Hermann Kock, Volker Siegel, P.A."Butch" Hulley and Martin White.

4 PHYSIOLOGICAL ADAPTATION TO COLD ENVIRONMENT IN ANTARCTIC ANIMALS (I. Hardewig, C. Tesch, B. Klein and G. Frank)

Introduction

Species inhabiting the Antarctic environment must be able to cope permanently with water temperatures near the freezing point of sea water. Survival under those extreme environmental conditions requires special physiological adaptations. It has been proposed that Antarctic species developed a powerful metabolic machinery that can function at high (cold adapted) levels despite subzero temperatures. This phenomenon of metabolic cold adaptation should be manifested in high metabolic rates of the Antarctic species compared to that of animals from temperate zones. The adaptation to subzero temperatures goes along with a reduced tolerance towards an elevation of the body temperature. In Antarctic fish upper lethal temperatures about 6°C are common. It is not clear, however, which metabolic processes are impaired by high temperatures and are responsible for limited survival.

We intended to investigate physiological adaptations to extreme cold in Antarctic vertebrates (fish) and in highly developed invertebrates (cephalopods). Our research on fish focused on Antarctic eelpout (Zoarcidae) because this family is widely distributed not only on the Southern but also on the Northern hemisphere and occurs in polar as well as boreal waters. Comparative investigations on related species from Antarctic and temperate regions allow to identify the physiological adaptations to the temperature regime of the distribution area of each species. The data we obtained on board will be compared to results of previous experiments on the eelpout *Zoarces viviparus* from the North Sea.

Material and Methods

During the cruise quite a few specimen of different species of eelpout were caught by bottom trawling, but those animals were in poor condition and not suitable for physiological experiments. We deployed specially designed traps as this is the most gentle way of catching fish in deeper waters. After several unsuccessful attempts, where we only caught one single specimen, we finally pulled up two traps from 500 m depth (61°43,3'S; 59°12,5'W) containing about 40 eelpout (*Ophtalmolycus amberensis*) each! Obviously, these animals appear in clusters and several traps have to be deployed to have a good chance to get a fair number of animals.

After the fish were allowed to recover for a week in our aquarium container at 0°C, we determined the oxygen consumption rates of 5 specimen in an intermittent flow respirometer. The experimental temperature was raised about 1°C per day from 0°C up to 9°C to investigate the effect of increasing body temperatures on the uptake of oxygen. High blank rates of oxygen consumption were caused by microbial action and could not be avoided by filtering the sea water or thoroughly cleaning the experimental set up. Therefore, we had to use antibiotics (Cotrimoxazol) at a concentration of 13 mg/l to keep the blanks at a reasonably low level (below 10% of the signal).

Preliminary results

Figure 4.1 shows the respiration rates of *O. amberensis* at different temperatures compared to respiration data of *Zoarces viviparus* from the North Sea. *Z. viviparus* was caught during the winter at 3°C water temperature, while *O. amberensis* occurs at water temperatures of 0°C. Both curves match between 3 and 6°C indicating that Antarctic eelpout display comparable metabolic rates as their relatives from temperate water, and thus do not show metabolic cold adaptation. It is striking that above 6°C oxygen consumption rates of the Antarctic species increase far more steeply than those of *Z. vivparus*. This may indicate that *O. amberensis* is approaching its upper lethal temperature, which we expect to be at about 10°C, while *Z.viviparus* survives temperatures up to 26°C. The effect of an increase in body temperature on the metabolic status of *O. amberensis* was investigated in a parallel experiment where animals were incubated at 0, 3, 6 and 9° C for 24h. Analysis of muscle and blood samples will show which metabolic processes are impaired by high temperatures: ion distribution (as indicated by plasma ion composition), acid-base balance (determined by measurement of intracellular pH) and aerobic energy provision (mirrored by cellular creatine, ATP and phosphocreatine concentration and by levels of anaerobic end products such as lactate). The analytical work will be carried out at our home institute.

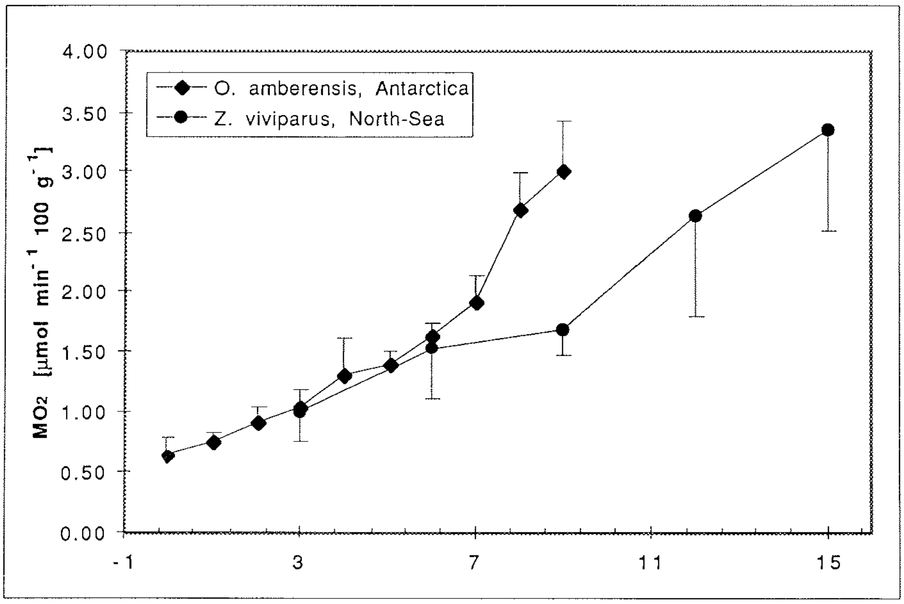

Fig. 4.1. Respiration rates of fish (Zoarcidae) originating from the South Shetlands (Antarctica) and the German Bight (North Sea).

Generally, a correlation exists between the basal metabolic rate of an organism and its capacity for aerobic activity. The low metabolic rate of *O. amberensis* compared to temperate species (see Fig. 4.1) may hint at a low aerobic scope for activity. We forced the animals to swim vigorously for about 3 minutes until exhaustion, conditions under which temperate fish species produce large amounts of lactate which accumulate in the blood. In the investigated Antarctic fish species (all members of the family Notothenoidae), however, lactate production is negligable during activity. We did not find significant amounts of lactate in the plasma of exhausted *O. amberensis*, although white muscle tissue show high activities of lactate dehydrogenase (1.99 U/mg protein at 10°C @ 400 U/g FW). Further analysis of tissue samples from control, exhausted and recovered fish will reveal why no lactate is produced and which energy source the animals use instead.

A similar series of experiments was carried out with the benthic octopod *Pareledone charcoti*. These experiments may show if the absence of anaerobic end products is a general phenomenon in polar species or if this is restricted to Antarctic fish.

It was striking that *P. charcoti* showed a remarkable tolerance towards an increase in body temperature. While notothenoid species show an upper lethal temperature between 4 and 6°C, Antarctic eelpouts are less sensitive to thermal stress and survived 9°C for 24h. At this temperature the animals lost balance and seemed to be unconscious. *P. charcoti*, however, could be kept for 8 days at 8°C, without showing stress symptoms. The determination of the specific activities of aerobic (malate dehydrogenase) and anaerobic (argenine kinase and octopine dehydrogenase) enzymes show that the ratios of the enzyme activities tend to shift in favour of the anaerobic enzymes after short term incubations (Fig. 4.2 represents data for arm tissue, similar effects were observed in mantle and gill tissue as well).

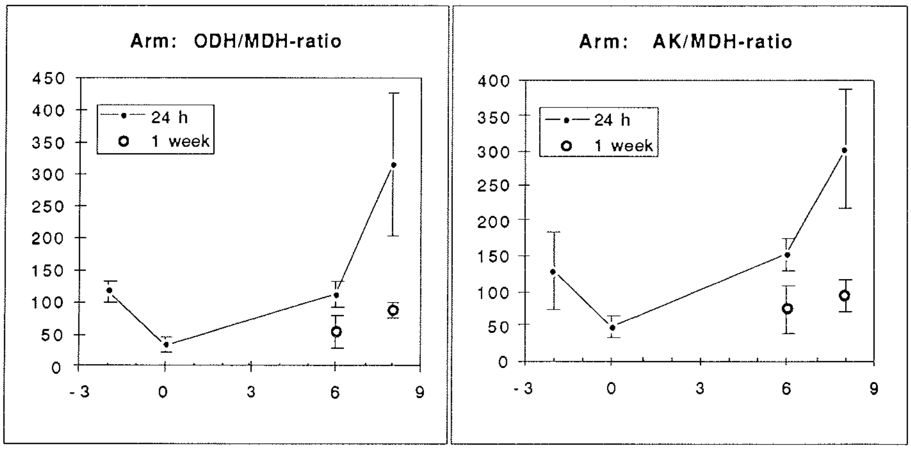

Fig. 4.2. Ratios of anaerobic and aerobic enzyme activities in the arm tissue of *P. charcoti* after short term and long term incubations at different temeratures. ODH = octopine dehydrogenase; MDH = malate dehydrogenase; AK = argenine kinase.

The observed shift is due to a decrease of MDH activity perhaps induced by an accelerated break down of the enzyme at higher temperatures. After long term incubation, however, this effect is reversed indicating that these animals are able to recover and to acclimate to the new thermal conditions. The effects of high temperature on the metabolic status of the tissue will be determined at the Alfred Wegener Institute.

The experiments we were able to perform on board will provide insight in the special features of the physiology of Antarctic animals. Investigations on vertebrate as well as invertebrate species will show, whether these two groups use different strategies to adapt to the same environment, or if there are general physiological mechanisms enabling life under these extreme conditions.

5 CEPHALOPOD ECOLOGY (U. Piatkowski, L. Allcock, M. Hevia, S. Steimer, M. Vecchione)

Introduction

Research on Antarctic cephalopods is still in a very early stage, although the ecological importance of this faunal group within the Antarctic marine food chain is widely acknowledged. Cephalopods are key prey organisms of top predators such as penguins, seals and toothed whales. Squid, in turn, are very efficient in preying upon Antarctic krill; and octopods are active bottom dwellers though their prey are not well known. Sufficient data to quantitatively elaborate cephalopods' roles as prey and predator within the Antarctic marine ecosystem are still lacking. Even information on species composition, abundance, life cycle and general biology are fragmentary. Moreover, the taxonomy of Antarctic cephalopods, particularly of the octopods, is in a particularly unsettled state. There is a critical need for systematic revision in the octopods and for description of squid development.

The ANT XIV/2 cruise provided a unique possibility to sample cephalopods with different fishery gear in various regions of the Atlantic sector of the Southern Ocean in order to address a variety of questions concerning Antarctic cephalopod ecology. Our work during the cruise focused on distribution and abundance studies, taxonomy, ageing, diet studies and investigations on the early life stages of cephalopods. In the following we will present preliminary results of our work on board and a brief outline of further planned studies on the cephalopod collection.

Material and Methods

On this cruise we have collected 2640 cephalopod specimens, comprising 6 squid species and approximately 22 octopod species, from bottom trawls (BT-140'), benthopelagic trawls (PT-1088'), Agassiz trawls, RMT 8 hauls and Bongo hauls (Tab. 5.1). The study concentrated on the area around Elephant Island and the continental slope region north of King George Island (Figs. 5.1 and 5.2). Additionally, seven Agassiz trawl stations were performed in the Bransfield Strait and west of the Antarctic Peninsula near the South Polar Circle. For descriptions of the various gears and information on station data see Kock et al. (this volume) and Siegel et al. (this volume).

All cephalopods were sorted from the catches, counted and identified to the lowest possible taxon. Dorsal mantle length, total length, sex and maturity stage were recorded for all specimens. Morphometric measurements were taken for all cephalopod species (where possible from 20 mature males and 20 mature females) and tissue samples have been taken for subsequent biochemical analysis.

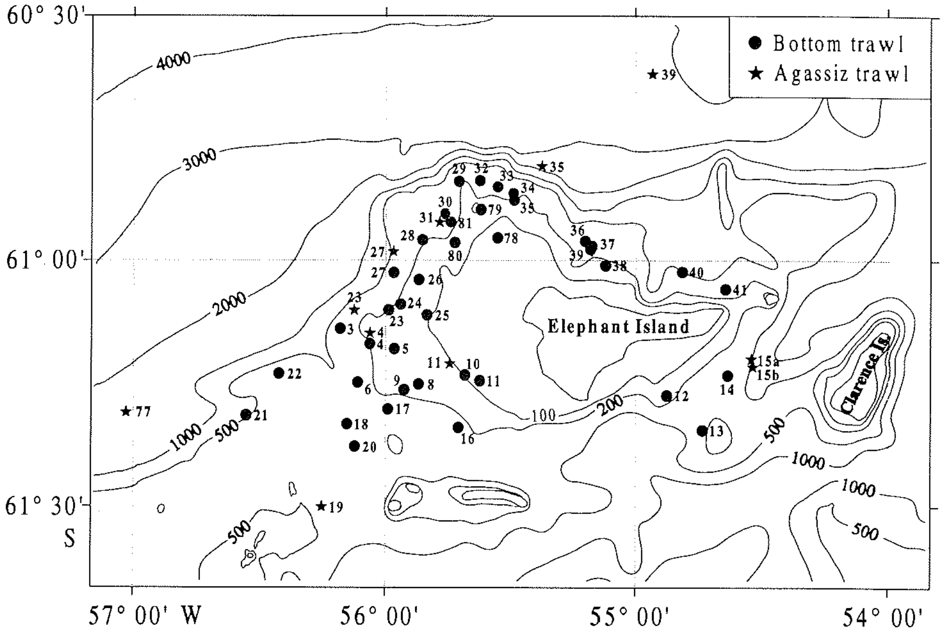

Fig. 5.1. Sampling site in the study area around Elephant Island

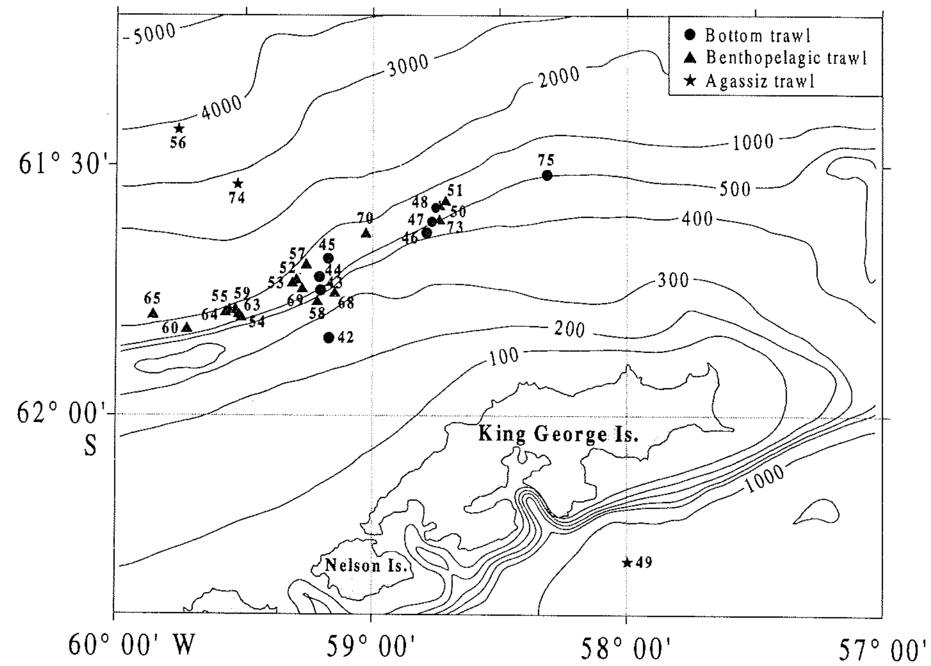

Fig. 5.2. Sampling sites in the study area north of King George Island.

Results

Squids were represented by six species with an undescribed species of *Brachioteuthis* being the most abundant (Table 5.1). The number of squid captured was comparatively low due to an early damage of the benthopelagic trawl midway through the sampling programme north of King George Island. Nevertheless, the collection of nearly 100 specimens will contribute important studies on the taxonomy and life cycle of Antarctic squid, particularly of the glacier squid, *Psychroteuthis glacialis* and of *Brachioteuthis* sp.. Initial analysis of the distribution pattern of *P. glacialis* indicates that it was more abundant in the deeper stations (>400 m). Diet analyses revealed that the species preys upon myctophids. Otoliths found in the digestive tract of several specimens showed that *P. glacialis* had fed upon *Electrona antarctica* and *Protomyctophum bolini* shortly before it was captured (White et al. this volume). Statoliths were taken from 87 specimens (*P. glacialis*, *Brachioteuthis* sp., *Galiteuthis glacialis*) for further ageing studies.

Eight juvenile squids were collected by the RMT 8, several of them in very good condition. The specimens will be used for the description of *Alluroteuthis antarcticus* and *Psychroteuthis glacialis* development.

Next to fishes, octopods were one of the dominant groups in the bottom trawl samples. We collected 2543 specimens, representing the most comprehensive collection of Antarctic octopods so far. The most abundant octopods in the Antarctic belong to the endemic genus *Pareledone*. There is much confusion surrounding this genus. Its validity has been questioned previously on the basis that *Pareledone* species have been united by characteristics that separate them from most other genera, but not from what has been constructed as the common ancestor of all octopods. There is no evidence to suggest members of *Pareledone* share a unique evolutionary history. Currently 7 species of *Pareledone* are considered to be valid. Tissue samples will be analysed using starch gel electrophoresis. This will allow calculation of genetic diversity between groups of samples, using established indices. Electrophoresis has been widely used to settle taxonomic debates about many marine invertebrates, including other cephalopods. When genetic distances among the species have been established it should be possible to assess, in part, which morphological characters are important for octopod phylogeny. Many of the descriptions of the species encountered during this cruise are either inaccurate or incomplete and the morphometric characters will be used to help rectify this problem. Furthermore, they will be used in the description of new species.

On this cruise the three *Pareledone* species previously reported from this area (*P. charcoti*, *P. turqueti*, and *P. polymorpha*) were found in large numbers, together with 9 putative new species of this genus (Tab. 5.1). Of these, 3 have papillated skin and closely resemble *P. charcoti* (*Pareledone cf. charcoti* type 1, 2, 3), 3 have smooth skin and closely resemble *P. turqueti* (*Pareledone cf. turqueti* type 1, 2, 3), 2 species resemble *P. polymorpha* (*Pareledone cf. polymorpha* type 1, 2), and one species resembles none of the above (*Pareledone* sp. 1); the status of several specimens (*Pareledone* sp. 2 and sp. 3) remains unclear. It has previously been suggested that *P. polymorpha*, together with *P. adeliana* (and now *Pareledone cf. polymorpha* types 1 and 2), should be removed from the genus *Pareledone* and placed in a new genus. The taxonomic data collected during this cruise support this suggestion. The possible species status of all morphotypes collected will be verified using enzyme electrophoresis and a reappraisal of the genus will be undertaken.

Table 5.1. Cephalopod species and number of specimens

Species	Number	Species	Number
Squid		Octopods continued	
Moroteuthis knipovitchi	2	*Pareledone polymorpha s.s.*	225
Psychroteuthis glacialis	19	*Pareledone cf. polymorpha* type 1	47
Alluroteuthis antarcticus	2	*Pareledone cf. polymorpha* type 2	2
Brachioteuthis sp.	61	*Pareledone* sp. 1	263
Galiteuthis glacialis	14	*Pareledone* sp. 2	3
Bathyteuthis abyssicola	1	*Pareledone* sp. 3	2
		Graneledone antarcticus	1
Octopods		*Graneledone* sp.	25
Pareledone charcoti s.s.	726	*Megaleledone senoi*	60
Pareledone cf. charcoti type 1	47	*Thaumeledone brevis*	9
Pareledone cf. charcoti type 2	375	*Bentheledone cf. levis*	6
Pareledone cf. charcoti type 3	397	Bentheledoninae sp. 1	1
Pareledone turqueti s.s.	68	*Benthoctopus cf. levis*	39
Pareledone cf. turqueti type 1	143	*Grimpoteuthis glacialis*	52
Pareledone cf. turqueti type 2	49		
Pareledone cf. turqueti type 3	1	Total number	2640

In addition to further taxonomic studies, detailed descriptions of abundance and distribution of Antarctic octopods sampled during the cruise will follow. Preliminary results on the geographical distribution and relative abundance (per 30 minutes of bottom trawling) and of *Pareledone charcoti* and *P. turqueti* in the Elephant Island region are shown in Figs. 5.3 and 5.4. They demonstrate that *P. turqueti* preferred the more shallow stations whereas *P. charcoti* was evenly distributed over a wide depth range with slight preferences along the 200 m depth contour. The ranges of the mean depth distributions for the major species calculated from all bottom and Agassiz trawls are shown in Figs. 5.5 and 5.6. Depth distributions vary considerably among species, even between closely related forms. The biggest octopod, a 9 kg specimen of *Megaleledone senoi*, was sampled in the northeast of Elephant Island in a 500 m depth bottom trawl.

Among the many octopods collected during the trawling survey were several species that are not members of the common Antarctic subfamily Pareledoninae. All are either poorly known or new to science, so we will describe their morphology and anatomy. We will also use protein electrophoresis to investigate relationships among them. Thirty-nine specimens of a *Benthoctopus* species are similar to *B. levis*, but differ from it in arm length, web depth, and details of the hectocotylus. A single *Graneledone antarctica* is unusual because it is the largest reported specimen (104 mm dorsal mantle length, DML) and the first mature female. The 9 *Thaumeledone brevis* include mature males and females and will allow us to redescribe the species and to discuss variability within it. 6 *Bentheledone* from a single deep (3213 m) sample may be *B. albida*, until now known only from the holotype. They are characterized by a small calamus and tiny anterior salivary glands. A very small (23 mm DML) mature female of a fragile dark purple species without an ink sac has suckers in a single series and proportionally huge salivary glands. We will describe it as a new genus and species in the subfamily Bentheledoninae.

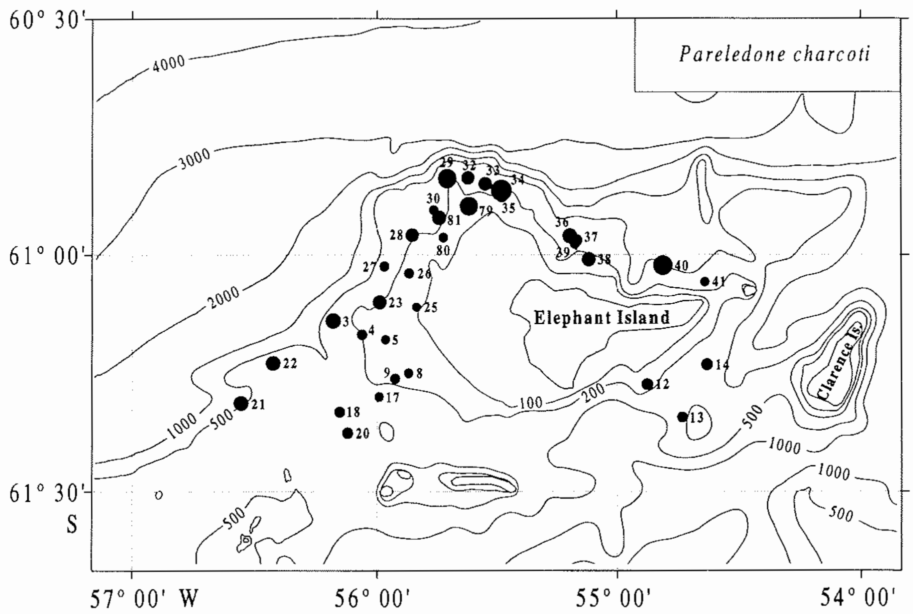

Fig. 5.3. Distribution and relative abundance of *Pareledone charcoti* near Elephant Island during ANT XIV/2. Symbols give relative abundance per 30 minutes of bottom trawling. Biggest symbol equals 61 specimens, smallest symbol 1 specimen. Only positive stations are shown.

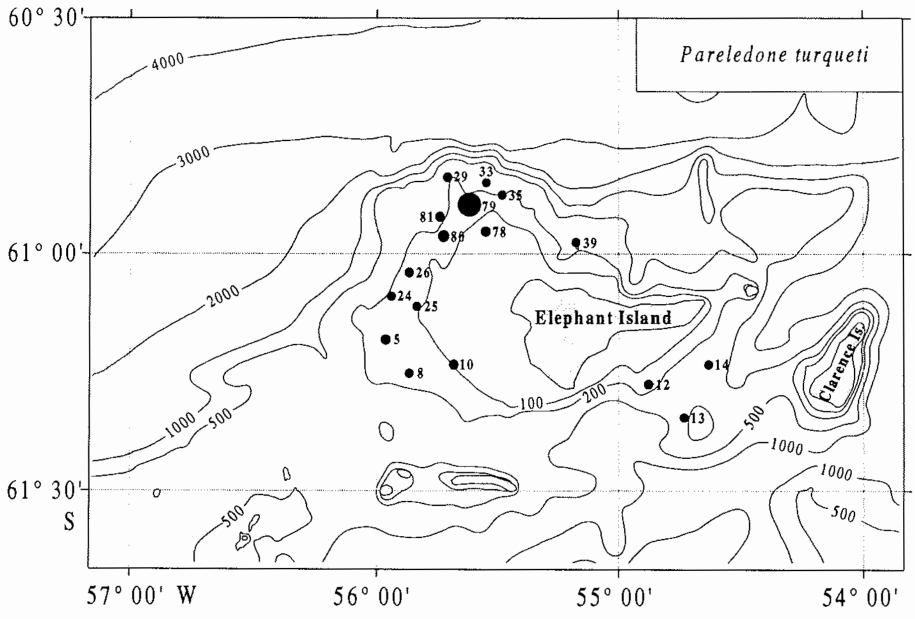

Fig. 5.4. Distribution and relative abundance of *Pareledone turqueti* near Elephant Island during ANT XIV/2. Symbols give relative abundance per 30 minutes of bottom trawling. Biggest symbol equals 14 specimens, smallest symbol 1 specimen. Only positive stations are shown.

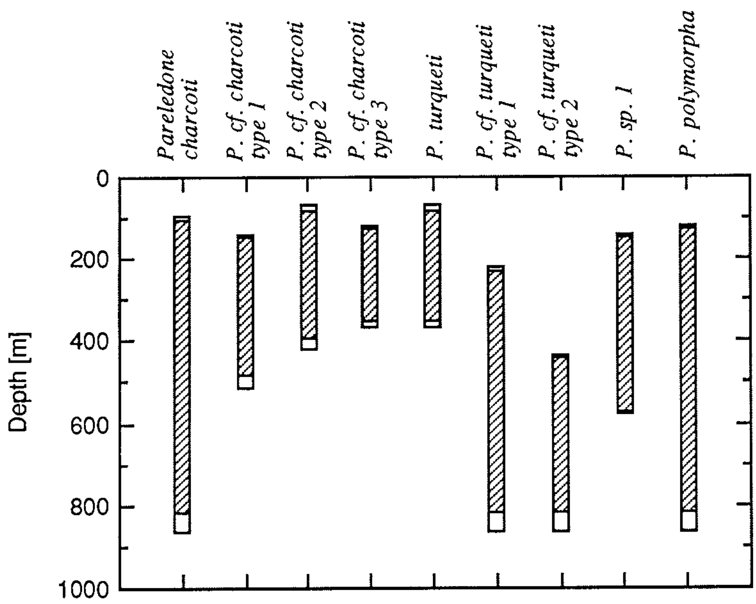

Fig. 5.5. Ranges of depth distribution of *Pareledone* species captured during ANT XIV/2.

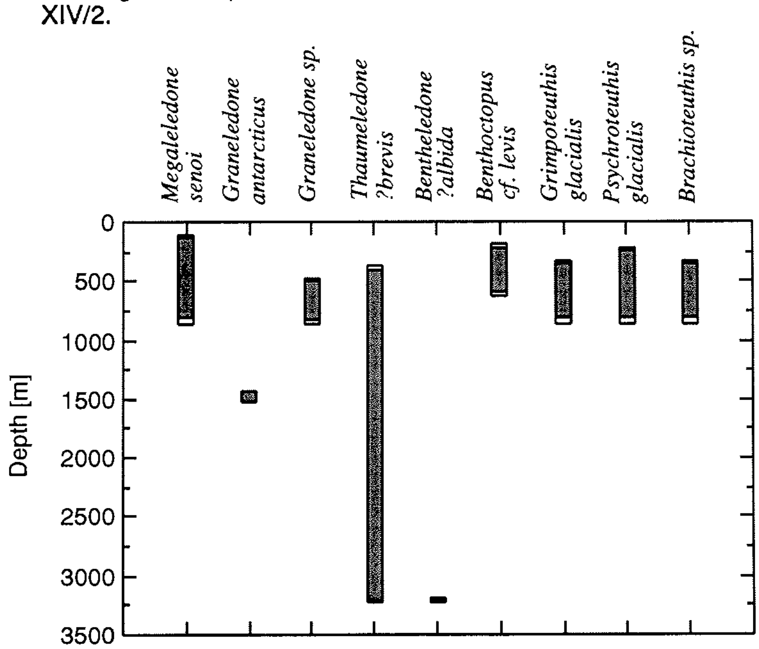

Fig. 5.6. Ranges of depth distribution of selected cephalopod species captured during ANT XIV/2.

The capture of 52 specimens of the cirrate octopod *"Grimpoteuthis" glacialis*, 20-165 mm dorsal mantle length, will allow us to examine the basic biology of this species. Their presence in bottom trawls at depths of 330-879 m, but absence from benthopelagic trawls, is consistent with habits that are primarily benthic. The largest sample, 40 specimens, came from a soft mud bottom and indicates the patchy nature of the distribution. Males tended to have greater total length and weight than females of similar mantle length. The males, however, were mature at a smaller size. Mature males have tiny sperm packets, rather than typical cephalopod spermatophores, in their lower reproductive tract. Mature females have large, smooth eggs in the proximal oviduct, in the huge oviducal gland, and in the distal oviduct. The latter eggs have a thick, sticky coating. Ovarian eggs vary greatly in size, possibly indicating protracted egg laying. Observations on live animals directly after capture indicate that this species swims primarily by fin action, rather than by jetting or medusoid pulses with the arm/web complex. It may be capable of limited changes in color pattern, especially on the oral surface of the web. Three pairs of surface structures, that appear superficially to be white spots anterior to the eyes and near the bases of the fins, are actually transparent patches in the skin. When considered in association with the transparent subdermal layer and the anatomy of the eyes, optic nerves, and optic lobes, these clear patches seem to function in detecting unfocused light on the horizontal plane of the benthic animal.

Tissue samples were collected from 13 cephalopod genera. These will be used by Ph.D. student David Carlini at the College of William and Mary (USA). He is examining higher-level phylogeny in the Cephalopoda based on DNA sequence analysis. A tissue sample from *Moroteuthis knipovitchi* will also be sent to Laure Bonnand at the Museum of Natural History in Paris in support of her review of the squid family Onychoteuthidae.

Conclusions

The results are still preliminary and further analyses still have to be done. Investigation of squid distribution pattern may be of limited character due to the damage of the benthopelagic trawl during the pelagic sampling programme. Nevertheless, the present collection of cephalopods is extremely valuable for Southern Ocean ecosystem research and in particular for further progress in Antarctic cephalopod science.

5.1 Cephalopod studies: Identification of fish in the diet of squid by use of residual structures (M.G. White, U. Piatkowski)

Introduction

In studies of the Antarctic marine food-web Antarctic krill (*Euphausia superba*) is considered to be the key organism upon which most predators feed. However, squid also comprise a significant component of the diet of toothed whales, elephant seals, several species of albatross and some penguins and fish (cf. Clarke 1996). Cephalopods triturate their food and so the components of their diet are difficult to identify. Early studies on the diet of Antarctic squid using electrophoretic methods indicated that these consume quantities of Antarctic krill (Kear 1992). More recent studies on the food-web in ice-free regions of the Southern Ocean have demonstrated that squid also consume large quantities of fish - particularly myctophids (Rodhouse et al. 1992) and imply an alternative food-chain to that dependent upon krill in this part of the Southern Ocean (Rodhouse & White 1995).

Studies planned during "Polarstern" cruise ANT XIV/2 included the opportunity to deploy large pelagic nets in a manner likely to capture squid (Piatkowski et al. this volume; Kock et al. this volume) and were targeted at the ice squid, *Psychroteuthis antarcticus*.

The objective of this study was to collect samples of otoliths from a representative size range of fish captured within the foraging range of benthopelagic and oceanic squid and conserve them in a manner that would enable the species and size range of fish in the diet of squid to be identified and quantified. The otoliths of the majority of fish can be used to identify them to species level and so these residual structures are of value when examining fish in the diet of predators.

Methods

Sagittal otoliths were dissected from the cranium of recently dead fish collected in the bottom trawl and bentho-pelagic trawl catches. The extracted otoliths were washed in freshwater, dried, and stored in glass vials or paper envelopes. A size range of each species of fish was selected to enable the size of fish in relation to size of otolith to be calculated. Attention was paid to the smaller size range of fish and the smaller species because these were likely to be those most often to be predated by squid.

It was not possible to make detailed drawings or weigh the otoliths during the cruise and so this work will be undertaken later at the British Antarctic Survey (BAS) laboratories in Cambridge.

Preliminary results

Otoliths were collected from 34 species representing 11 families of Antarctic fish (Table 5.2). Not all the species of fish captured during the cruise were sampled nor all the size ranges obtained, however, all accessible material was sampled. Further material to complete the inventory and size range may become available in future at the host Institutions in Germany from among samples that have been frozen for other studies.

Among the squid captured during ANT XIV/2, the gut contents of four *Psychroteuthis antarcticus* included residues from fish such as muscle, bones, scales, eye-lens's and otoliths. Most of these remains were not identifiable but the otoliths had a morphology typical of the Myctophidae. The otoliths were tentatively identified and appeared to have been the result of consuming two species of myctophid, *Protomyctophum bolini* and *Electrona antarctica.* An estimation of fish size and weight will follow a more detailed examination and comparison with reference material at BAS.

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Rodhouse P. G. White M. G. & Jones M. R. R. (1992). Trophic relations of the cephalopod *Martialia hyadesi* (Teuthoidea: Ommastrephidae) at the Antarctic Polar Front. Mar. Biol. 114: 415-421.
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Table 5.2. Species and specimen size-range of fish from which otoliths were collected during ANT XIV/2

Species	Range SL(mm)	Species	Range SL(mm)
Notothenia rossii	364 - 420	*Electrona antarctica (m)*	61 - 84
Notothenia coriiceps	337 - 467	*Electrona antarctica (f)*	63 - 99
Lepidonotothen squamifrons	75 - 385	*Gymnoscopelus nicholsi*	132 - 162
Lepidonotothen larseni	89 - 209	*Gymnoscopelus braueri*	71 - 112
Lepidonotothen nudifrons	49 - 166	*Gymnoscopelus hintonoides*	54 - 72
Gobionotothen gibberifrons	243 - 365	*Gymnoscopelus opisthopterus*	102 - 170
Trematomus scotti	108	*Protomyctophum bolini*	34 - 57
Trematomus eulepidotus	101 - 287	*Krefftichthys anderssoni*	54 - 72
Dissostichus mawsoni	380 - 460	*Nansenia antarctica*	75 - 85
Chaenodraco wilsoni	146 - 244	*Notolepis coatsi*	111 - 288
Chionodraco rastrospinosus	320 - 372	*Paradiplospinus gracilis*	307 - 406
Chionobathyscus dewitti	250 - 364	*Borostomias antarctica*	138
Champsocephalus gunnari	174 - 181	*Macrourus holotrachys*	190 - 400
Chaenocephalus aceratus	189 - 530	*Antimora rostrata*	176 - 258
Cryodraco antarctica	45	*Pogonophryne ?permitini*	113
Parachaenichthys charcoti	98 - 147	*Pleuragramma antarcticum*	158
Racovitzia glacialis	207 - 279		
Gerlachea australis	223		

6 INVESTIGATIONS ON THE KRILL STOCK AND THE EPIPELAGIC ZOOPLANKTON COMMUNITY IN THE ELEPHANT ISLAND REGION

(V. Siegel, K.-H. Kock, W. Petzel, P.A. Hulley, C. Pusch, L. Döllefeld, M. White)

Introduction

Since the season 1977/78 biological investigations have been carried out in the Elephant Island region on the distribution, abundance and population dynamics of Antarctic krill. These national research activities were followed by the international BIOMASS programme (Biological Investigations On Marine Antarctic Systems and Stocks) starting with the first expedition (FIBEX) in 1981. In the post-BIOMASS period since 1986 the German research activities concentrated in the Elephant Island region as a monitoring site for the krill stocks in the Southwest Atlantic. This research was later joined by the US scientific AMLR programme and the long-term activity is now carried out on an annual basis.

During the early years krill research was conducted in the light of potential and new fisheries resources. However, scientific results of the BIOMASS period have shown that krill does in fact occur in large swarms and quantities, but it was also recognized that krill has a long lifespan, slow growth rate, long juvenile phase and relatively late sexual maturation. These factors strongly affect the productivity of the stocks and this is obviously much lower than expected earlier, despite the large biomass. Meanwhile the research activities concentrate on the detection of possible effects of the established krill fishery on the stocks. Furthermore it is intended to support basic data on the status and the fluctuation of the krill stocks to enable a modelling process of the krill system as well as to allow a sound management of this fishery resource under the umbrella of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) to which the Federal Republic of Germany is a signatory member.

This unique longterm data set for the Antarctic krill made evident that krill abundance is highly variable. On the one hand we can observe regular, predictable seasonal fluctuations with a winter minimum and a summer maximum in krill abundance along the Antarctic Peninsula. On the other hand irregular or less predictable fluctuations occur between years. It was found out that these interannual variations are not due to a breakdown or increased mortality in the krill stock, but to the occurrence of weak year classes and poor recruitment during some years. Primarily at least two major factors seem to regulate the krill recruitment, one environmental parameter, i.e. the extention and duration of the winter sea-ice cover, and one biological parameter, i.e. the density of salps during the pre-spawning and spawning period of krill.

The objectives of our work are to verify these biological and environmental relationships to krill spawning and recruitment success and to develop this conceptual model further into a quantitative model which may in future allow us to make at least short-term predictions about the development of the krill stock on an annual basis. Necessary data to describe the status of the stock include the age composition of the stock, the growth and maturation rate, the variability of the recruitment rate and the development and variability of the spawning period. Furthermore oceanographic and climatic data (especially sea-ice) are essential to describe the dynamics and variability of these environmental processes which strongly influence the krill stock in its seasonal and annual development.

Material and Methods

During 10 to 24 December 1996 a station grid was surveyed consisting of 97 standard stations around Elephant and King George Islands (Fig. 6.1). 89 of these stations were sampled successfully, another 3 nearshore stations were included south of King George Island to support additional small scale information for synoptic penguin diet investigations in Admiralty Bay of King George Island. 8 stations north of King George Island had to be cancelled due to bad weather conditions and time constrains.

Krill and zooplankton sampling was conducted with the standard gear RMT 1+8 (Rectangular Midwater Trawl). Routine net tows ranged from the surface down to 200 m depth or as close as 10 m to the bottom at shallower stations. The net was equipped with flowmeter and on-line depth recorder to allow the calculation of the filtered water volume and the standardization of net catches. Towing speed ranged from 2 to 2.5 knots, mesh sizes for the large 8 m^2 net was 4 mm and is primarily used for the analysis of krill and salps. The small RMT1 net has a mesh size of 0.320 mm and is used to obtain data for the smaller zooplankton fraction and early life stages of fish.

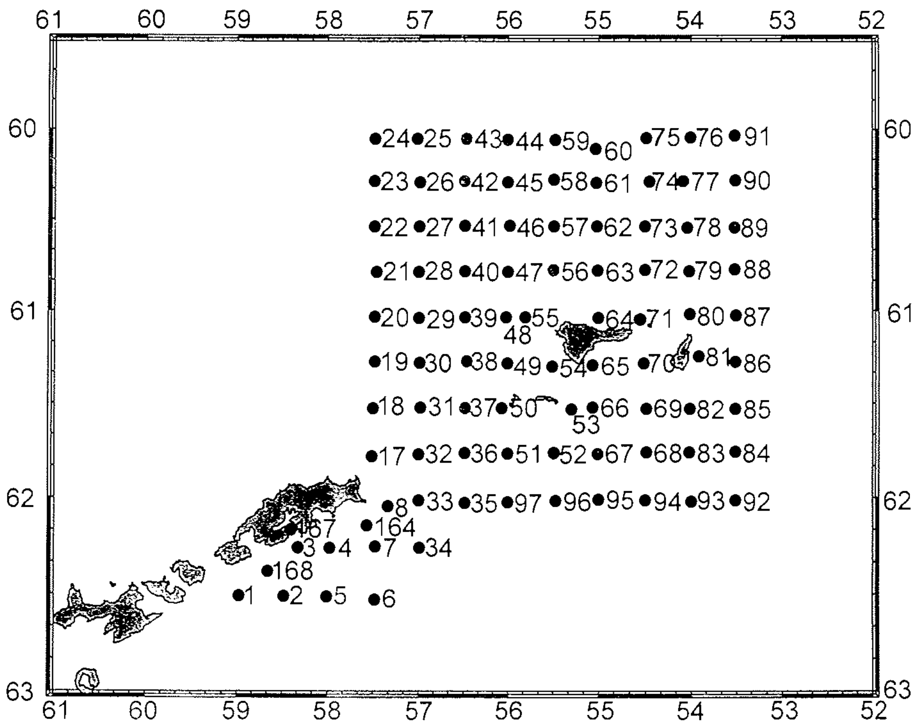


Fig. 6.1. Standard station grid for the krill RMT-net sampling survey around Elephant and King George Island.

Immediately after the tow, krill and salps were removed from the plankton catch and counted. In case of larger catches the number of krill and salps were counted from quantitative subsamples. Krill was preserved in 4% formalin seawater solution before length measurements were undertaken and sex and maturity stages were determined. Salps were measured from the fresh samples. Krill length measurements were carried out to the millimeter below from the anterior margin of the eye to the tip of the telson (total length). Maturity stages were determined according to the classification of Makarov and Denys (1981, BIOMASS Handbooks). Salps were measured to the millimeter below as body length (see Foxton 1956, Discovery Reports). The rest of the zooplankton was preserved in 4% formalin solution for later landbased sorting and analysis. All station data and the biological counts and measurements were entered into the database of the Seafisheries Research Institute (dBASE format).

Preliminary results

Krill and salps occurred in almost all of the catches. Krill was absent from only 3 while salps were missing in 2 samples. The rest of the epipelagic zooplankton was relatively scarce. Other euphausiid species like *Thysanoessa macrura* were rare compared to other years. Hyperiid amphipods, chaetognaths, polychaetes, copepods and pteropods only occurred in very low numbers. The present investigations took place in the early phase of the summer season, so that the high mid summer concentrations (generally expected during January and February) were probably not reached during this survey. However, high densities of krill were already found in the eastern part of the station grid around Clarence Island, south of King George Island and north west of Elephant Island (Fig. 6.2). The maximum catch yielded 30 kg of krill, the second largest 27 kg, both in the eastern part of the area. Maximum krill density exceeded 7350 specimens per 1000 m^3. This catch in the eastern Bransfield Strait consisted exclusively of juvenile stages. Mean salp density was generally higher than krill density, however, the maximum salp density reached only 1040 salps per 1000 m^3. This observation indicated that salps were more uniformely distributed while krill occurrence is more patchy. This conclusion is supported by the standard deviations given for the mean densities in Table 6.1.

The single high catches strongly influence the mean calculated for the average number of krill in the entire survey area. This again can be seen from the extremely high standard deviation in Table 6.1. A more realistic value of krill abundance is given by the median in Table 6.1. The comparison for different years shows that even the median value for krill density was much higher than in previous years. Obviously the krill stock is recovering from the very low abundance in the early 1990ies, when krill recruitment had been very low for a couple of years.

Preliminary analyses of the length frequency distribution show that the krill stock is dominated by length classes around 35 mm (Fig. 6.3). This modal size represents age group 2, i.e. the krill year-class 1994/95. The high abundance of these size classes indicate that this year-class experienced a very successful recruitment. We also see indications for a substantial number of one year old juveniles, but the calculation of the recruitment index and the interpretation of a successful recruitment of this 1995/96 year-class will have to wait until all samples have been analysed. The juvenile age group 1 is represented by size classes between 20 and 30 mm. In principal it does not seem to repeat the very successful recruitment of the 1994/95 year-class.

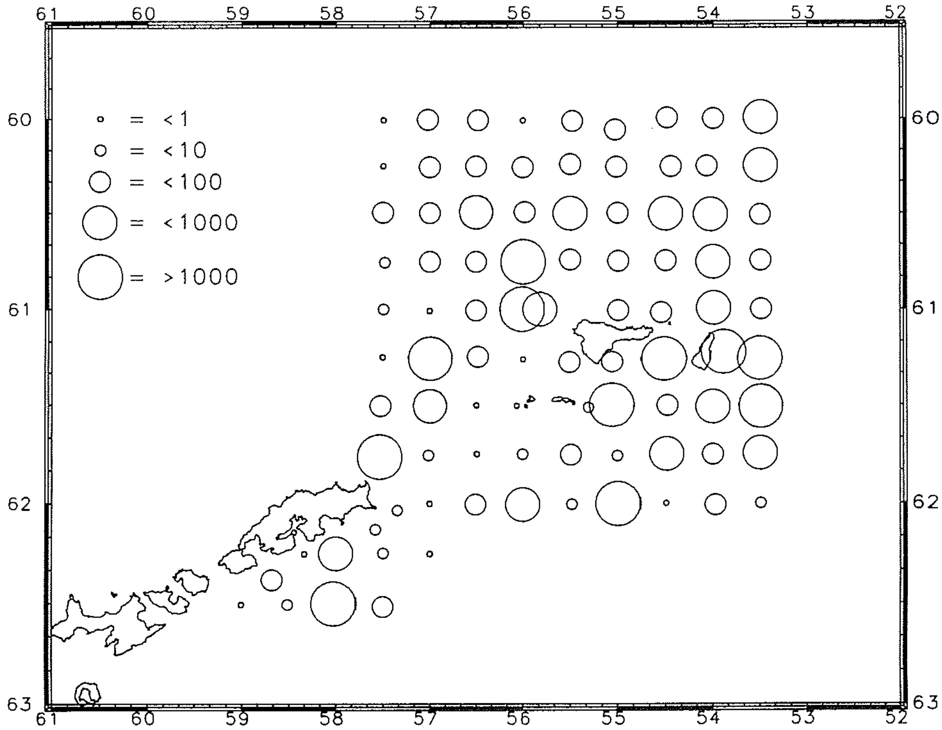


Fig. 6.2. Krill density in numbers per 1000 m^3 in the Elephant Island region during December 1996

Table 6.1. Krill and salp densities (numbers per 1000 m^3 in the Elephant Island area during past years

	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97 Elephant	1996/97 Total Grid
Krill							
No stations	63	70	63	77	72	82	92
median density	5.7	8.2	3.1	1.3	11.4	30.6	27.4
mean	23.7	28.8	34.5	127.1	82.1	287.8	346.7
st. dev.	78.0	64.4	94.2	882.5	245.1	583.1	926.7
min	0.0	0.0	0.0	0.0	0.0	0.0	0.0
max	594.1	438.9	495.9	7739.4	1500.8	2528.1	7353.7
Salps							
no. stations	63	70	63	77	72	82	92
median density	14.0	245.8	582.3	0.6	4.1	43.9	43.9
mean	94.3	1213.4	931.9	3.7	133.2	119.4	111.3
st. dev.	192.3	2537.7	950.2	8.6	867.7	165.9	158.9
min	0.0	6.9	9.5	0.0	0.0	0.0	0.0
max	1231.1	16078.8	4781.7	43.2	7385.4	1041.4	1041.4

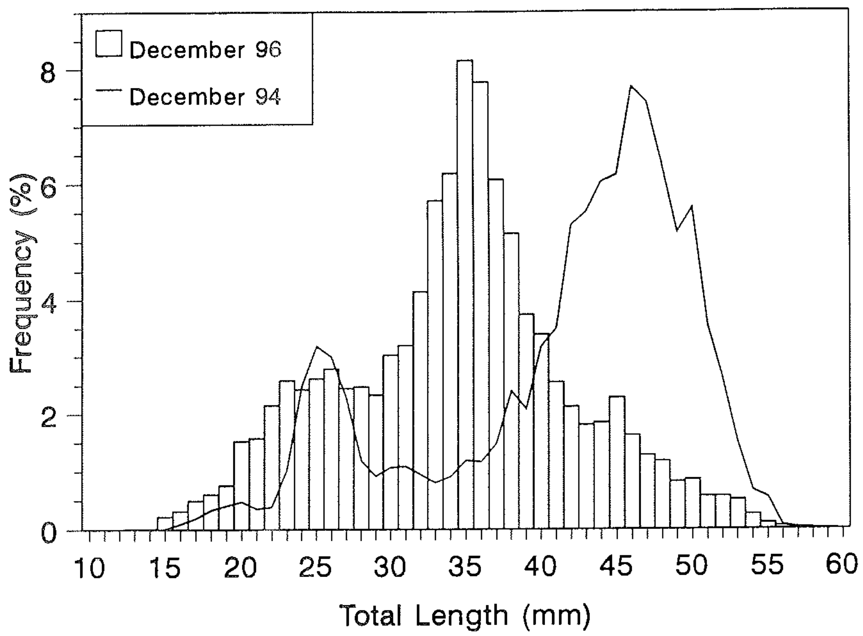
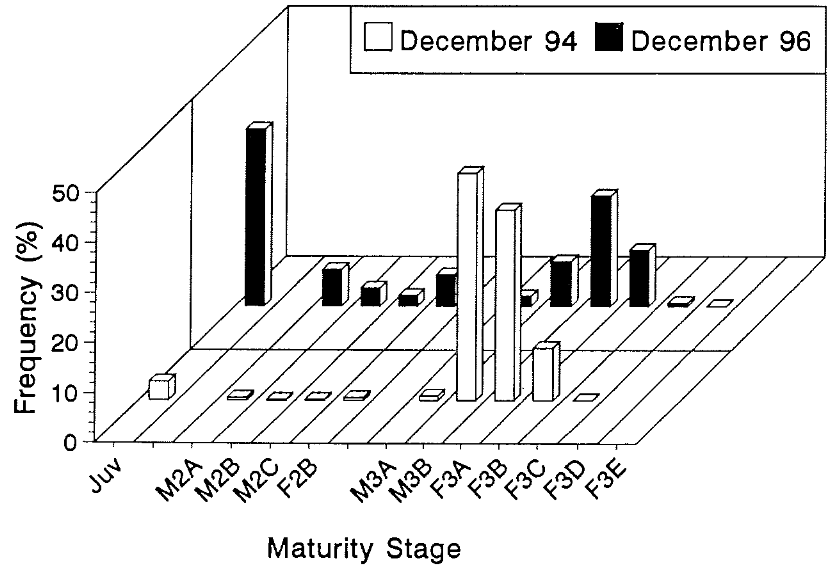


Fig. 6.3. Krill length frequency distributions for the survey area during "Polarstern" cruises in December 1994 and December 1996.

The two year old 1994/95 year-class is partly entering the adult stage during the present spawning season, while the 1995/96 year-class will not finish its maturation before two years time. During the surveys of the past years hardly any juvenile or immature krill were found in the Elephant Island area. The stock consisted almost completely of large, old, mature krill. At the same time krill abundance was low (see Table 6.1). However, the two incoming age groups with above average recruitment success will certainly increase the stock abundance over the next years compared to the period of the early 1990ies.

During the present survey adult krill was mostly found to be in pre-spawning (stage 3A) and early spawning (stages 3B) condition (Fig. 6.4a). However, the first gravid stages (3C and 3D) were already observed since mid December. 33 % of all adult females were carrying spermatophore (Fig. 6.4b). This proportion is slightly higher than the one observed in December 1994. This indicates that the spawning season will probably have its peak in January. From the existing long-term data set this would be classified as a normal to relatively early year for krill reproduction for this area. Early spawning favours the success of krill reproduction, but is not the only parameter that determines the later recruitment success. The timing of the ongoing spawning season, salp abundance during that critical period and winter sea-ice conditions during the winter following the spawning event regulate the strength of the krill year-class. It will be of great interest to watch the development of the spawning stock, if the early onset of spawning continues during the current season. Data will be available from the US cruise studying the same standard station grid during January 1997.



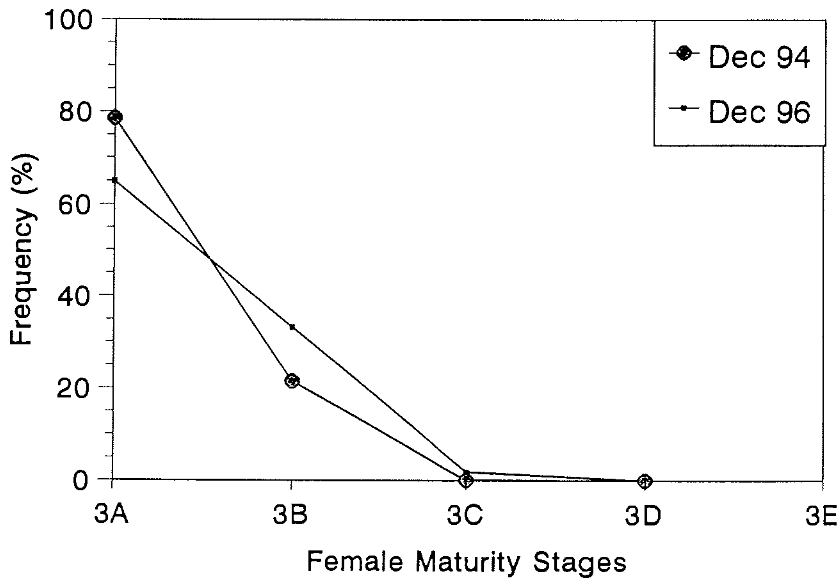


Fig. 6.4. Krill maturity stage composition in the Elephant Island region during December 1994 and December 1996. a) overall stock maturity stage composition (stage 1 = juvenile, stage 2 = various immature stages, stage 3 = various adult stages, M = males, F = females)
b) proportion of adult female maturity stages (3A = prespawning phase, 3B = carrying spermatophores, 3C = developing maturity, 3D = gravid, 3E = spent females).

The second factor influencing krill recruitment is the occurrence of salp abundance. High salp densities strongly reduce the spawning success of krill or the survival of early krill larvae. The abundance of salps was higher than during the last "Polarstern" cruise in 1994/95, but still one order of magnitude lower than in the years 1992/93 and 1993/94 (see Table 6.1), when massive salp blooms were found in the survey area. Highest densities were generally observed in the eastern part of the survey area with a maximum extending 1040 salps per 1000 m^3. During years of mass occurrence of salps these may negatively influence the reproductive success of krill, because both species are competing for the same food resource. Since salps were not present in extremely high densities, the proceeding krill spawning season and the survival of the developing krill larvae will probably not be strongly affected by salps.

7 SYSTEMATICS AND BIOGEOGRAPHY OF CUMACEA AND AMPHIPODA (CRUSTACEA) (C. O. Coleman)

The aim of this project was to collect material for systematic work including biogeography, functional morphology and anatomy of Cumacea and Amphipoda.

Close to Elephant Island and King George Island samples were taken at 86 stations. Material was sorted out from 44 stations of the fishery bottom trawl and 19 stations of the Agassiz-trawl. Numerous crustaceans were collected with a very small dredge that was towed behind the Agassiz trawl. Many scavengers (amphipods and isopods) were taken out of 4 baited traps, that were left on the sea bottom overnight. Interesting pelagic amphipods were also found in the rectangular midwater trawl, bongo net and bentho-pelagic net. One of the main points of interest were 9 deep-sea samples, that were taken with the Agassiz trawl and the small dredge at 1400 to 3700 m depth. These trawls were not always successful. Some samples yielded very little fauna although the substrate looked promising. This was especially true for stations in several deep-sea basins of the Bransfield Strait. In some other samples, taken west of the South Shetland Islands, there were many crustaceans.

Beside crustaceans various other groups of animals were collected for other working groups: Bivalves, which occurred in almost all benthos samples, were collected for a systematic study carried out at the Zoological Institute and Museum in Hamburg. Unsorted subsamples from the benthos were frozen to sort out mites (Acari) from the substrate (for the Taxonomic working group, Biological Institute; Helgoland). Tanaidacean crustaceans were collected for a project of the University of Lodz (Poland).

The animals were sorted on board into the different systematic groups. Part of the material was fixed in formaldehyde solution for future histological examinations. Most of the material was preserved in ethanol, which beside classical taxonomic work allows studies of molecular genetics.

The scientific value of the collected material can only be estimated after intensive study, but already on board several new species of amphipods were identified. Several amphipod species were recorded for the first time in this region. Especially interesting were 11 different amphipod species, that occurred inside sponges. They seem to be well adapted to this environment. Gut content examinations, which were carried out on board, showed that several specimens of an undetermined stegocephalid species had morsels that looked like eggs of sponges in their fore-gut.

8 GENETIC ISOLATION AND SPECIATION EVENTS IN ANTARCTIC BENTHIC ISOPODS (C. Held)

Introduction

Previous work has shown that several isopod species in the Antarctic differ morphologically between populations whereas the variability within the population is typically low, thus forming local races within a species. It is unknown whether genetic isolation of population or epigenetic environmental effects are responsible for the formation of races. A deeper knowledge of this question could help understanding why the extant Antarctic benthic fauna can be so diverse even though its environment has been remarkably stable during the past 20 million years or more.

The major aim of this study was to collect and suitably preserve benthic isopods so that this material can further be analysed in the lab for a detailed genetic analysis. Populations around King George Island and Elephant Island will be compared with material collected earlier this year in the Weddell Sea (ANT XIII/3).

Material and Methods

Sample preservation and DNA extraction: Since most of the collections in the past have been preserved in formalin for morphological studies these rich collections cannot be used in a genetic context. But even preservation of marine isopods in 70% ethanol has proved to be problematic in our hands since this procedure led to a high percentage of cases in which no DNA extraction was possible.

Preservation of specimens in cold (-30°C) ethanol, however, yielded suitable DNA in routine work using a modified DTAB/CTAB extraction protocol. It is assumed that highly active or large amounts of DNAses are hereby prevented from digesting DNA during the early phase of preservation while the alcohol has not totally penetrated the tissue.

Work on board: Isopod material was sorted out by hand and sieved mainly from Agassiz trawl (AGT; 22 stations) and bottom trawl (GSN; 37 stations), but occasionally also from Minidredge (MD; 1 station), Bongo net (BN; 4 stations), baited traps (TRP; 2 stations), Benthopelagic net (BPN; 3 stations) and rectangular midwater trawl (RMT; 2 stations).

DNA and tissue samples have been extracted on board from 292 specimens, 254 of which belonging to the four most common species: *Ceratoserolis trilobitoides, C. meridionalis, Serolella bouvieri* and *Glyptonotus antarcticus.*

Outlook

Since DNA sequencing is not possible on board no further results can be shown at present. Preliminary genetic data of material from King George Island kindly provided by J. Kowalke (AWI), however, indicate that local populations are indeed genetically distinct from conspecific populations from the Eastern Weddell Sea collected earlier this year (ANT XIII/3).

9 LIPIDS IN ANTARCTIC COPEPODS (C. Albers, E. Mizdalski, G. Kattner)

Introduction

Lipids are of major importance for the survival of zooplankton organisms in polar regions. Polar copepods accumulate large lipid depots to cope with the pronounced seasonality of food availability as well as constant low temperatures. Extensive lipid storage acts as an energy reserve for overwintering and reproduction. Especially herbivorous species depend on lipid reserves to survive long starvation periods, when the darkness of polar winter or ice coverage prevent primary production. In addition, lipids are the structural components of biomembranes. Due to the extensive lipid storage copepods transfer via lipids energy to higher trophic levels. Of special interest is the $^{13}C/^{12}C$ ratio of the animals, of their food and of their predators, in order to characterise the carbon flux of lipids between the different trophic levels.

Rhincalanus gigas, *Calanoides acutus* and *Metridia gerlachei* are key species in the Antarctic food web. They are the link between the primary producers (phytoplankton) and higher trophic species. Unfortunately, planned experiments with these copepods on their lipid biosynthesis using ^{13}C labelled phytoplankton could not be performed due to the very low abundance of specimens during the entire cruise.

Research has almost focused on larger zooplankters, like *Calanus* and *Calanoides* species, which dominate the zooplankton biomass. Nothing is known on the lipid biochemistry of small size copepods. Therefore the abundant smaller species *Oncaea curvata*, *Oncaea antarctica*, *Oithona similis* and *Ctenocalanus citer* were collected to obtain first information on their lipid storage modes and compositions.

Material and Methods

Bongo-net hauls (mesh size 200 and 310 µm) and Apstein-net hauls were performed at 67 stations to collect the copepod specimens. In order to study the $^{13}C/^{12}C$ ratio and lipid composition, individuals were sorted on board according to species, ontogenetic stage and sex. Along with every zooplankton net, phytoplankton samples were collected and deep frozen to study the $^{13}C/^{12}C$ ratio of the food. For lipid analyses in total 500 samples of the larger copepod species were frozen in dichloromethane /methanol at -30°C. Additionally 30 samples of small size copepods were collected and deep-frozen for further lipid analyses. The stable isotope ratios and the composition of fatty acids and fatty alcohols will be analysed at the Alfred Wegener Institute because the analytical methods are too complex to be conducted on board the ship.

10 PHYTOPLANKTON STUDIES

10.1 Investigation of the under water light regime (R. Röttgers, N. Dijkman, L. Hinrichs, G. Pollmeyer)

Introduction

The under water light regime (PAR, UV-A and UV-B) is of great importance for primary production. Phytoplankton growth is often limited by light availability, whereas UV-A and UV-B radiation can inhibit photosynthesis. Depletion of atmospheric ozone increases UV-B radiation relative to UV-A and photosynthetic active radiation (PAR) and can therefore decrease primary productivity. Both the light intensity and the light quality change with depth due to the optical properties of seawater and absorption by suspended particles (e.g. phytoplankton).

The aim of this study was to describe the penetration of PAR, UV-A and UV-B in the waters around the South Shetland Islands. Combined with similar measurements on deck, the under water light regime over the day can be estimated.

Material and Methods

During the cruise photosynthetic active radiation was continuously measured on deck with a 2pi Sensor (LiCor) connected to a LI-1000 Datalogger and a QSR-240 (2pi collector, Biospherical Instruments). Additionally, the on deck sensor of a Biospherical MER-2040 Underwater Profiler recorded the spectral composition of the incident radiation. UV-B radiation was continuously measured with a UV-B Spectroradiometer (Dr. Tüg, AWI).

Depth profiles of the underwater light field were measured at 21 stations with the MER 2040 (0-100 m), at 340, 380, 412, 443, 465, 490, 510, 520, 560, 615, 633, 665 and 683 nm, an UV-B Spectroradiometer (0-50 m; 280-320 nm) and a PAR Spectroradiometer (0-50 m; 400-800 nm), both instruments are provided by Dr. Tüg.

10.2 Distribution, species composition and bio-optical properties of the phytoplankton around the South Shetland Islands (R. Röttgers, N. Dijkman, L. Hinrichs, G. Pollmeyer)

Introduction

The purpose of this study was to characterise the phytoplankton community around the South Shetland Islands. This included the determination of the phytoplankton species composition, spatial distribution and biomass, pigmentation and bio-optical properties.

Material and Methods

Water from 0-200 m were taken with a rosette sampler connected to a CTD probe. Samples of 1-2 L were filtered onto Whatman GF/F glass fiber filters. The samples were flash frozen in liquid nitrogen and stored at -80°C for later analysis of pigment composition, MAA content, POC/PON content and particulate absorption. Chlorophyll *a* content was measured directly using a Turner design fluorometer previously calibrated with a chlorophyll *a* standard. Samples for species composition were taken and conserved with formaldehyde. At some stations phytoplankton samples were taken with a 20 µm mesh Apstein net from 40-0 m depth and also preserved with formaldehyde.

10.3 Impact of enhanced UV-B radiation on primary production of Antarctic phytoplankton (R. Röttgers)

Introduction

UV-B as well as UV-A radiation is known to inhibit photosynthesis and decrease primary production of Antarctic phytoplankton. Changes in atmospheric ozone content would alter this inhibitory effect by changing the incident UV-B. The sensitivity of phytoplankton for UV-B radiation, time scales for observable effects and rates of recovery are strongly influenced by photosynthetic rates, driven by energy of the visible light. The main topic was to examine changes in the photosynthesis-light-response curves of natural phytoplankton under normal and enhanced UV-B fluxes.

Material and Methods

During this study newly developed on deck incubators were used to examine the response of natural phytoplankton to different UV-B fluxes under simulated irradiances. These incubators provide a complete light spectrum (280-800 nm) comparable to natural sunlight of different atmospheric ozone contents.

At 28 stations around Elephant Island photosynthesis light curves of two different UV-B fluxes relative to visible light were measured. For this purpose water from 10 m depth was incubated for 4h in two on deck incubators at light intensities from 5 to 700 µmol photons PAR m^{-2} s^{-1} and the ^{14}C uptake was measured. Whenever possible measurements were performed several times during a day, including the night, to examine daily variations of UV-B sensitivity.

10.4 Regulation of photosynthesis in Antarctic phytoplankton (N. Dijkman)

Introduction

In their natural environment algae almost continuously experience changes in light regime. Several processes, e.g. regulating the dissipation of absorbed energy as heat, can be used to optimise photosynthesis and avoid damage to the photosynthetic apparatus. The fluorescence signal can be used to monitor these processes. Part of the light absorbed by the light harvesting complex of the photosynthetic apparatus is returned as fluorescence and changes in other energy dissipating processes in the light harvesting complex are reflected in the fluorescence signal.

The aim of this study was to monitor changes in the hierarchical cascade of photosynthetic processes over depth and in time by measuring the fluorescence signal and relate these changes to the physical structure of waters around the South Shetland Islands.

Material and Methods

Fluorescence measurements were performed on water samples from 0-200 m at 80 stations during the cruise. Fluorescence was measured with a pulse amplitude modulated fluorometer (PAM fluorometer; Heinz Walz, Effeltrich). Measurements included determination of the operational quantum yield with saturating pulses of light and induction curves with and without a blocker of electron transport. Depth profiles were made several times during the day to monitor daily variations. Changes in photosynthetic parameters will be compared to depth profiles of the underwater light regime and on deck measurements of light intensity. In addition to the depth profiles water samples were exposed to increasing light intensities and the changes in the fluorescence signal monitored.

Preliminary results

At most stations *Corethron criophyllum* was the dominant phytoplankton species. Chlorophyll *a* values were generally between 0.1 and 2.5 µg/l and differed considerably between stations. Fig. 10.1 is an example of a chlorophyll depth profile. Chlorophyll concentrations decreased with depth. The operational quantum yield shows an increase in the upper 50 m. These low values are most likely the result of increased heat dissipation and thus lower photosynthetic efficiency as a protection against high light intensities. The figures 10.2 and 10.3 show respectively the on deck light intensity during the same day and the UV-B radiation at different depths of this station.

Most instruments require calibration at home before final results are available. Also, determination of species composition, POC/PON, pigments and particulate absorption will be performed in the laboratory at the AWI.

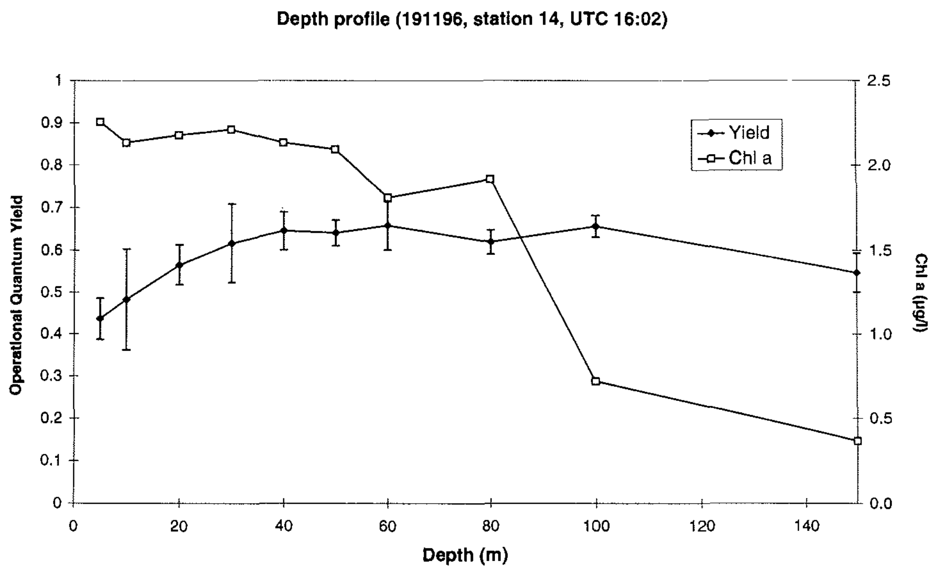


Fig. 10.1. Depth profile of the operational quantum yield and chlorophyll concentrations (µg/l).

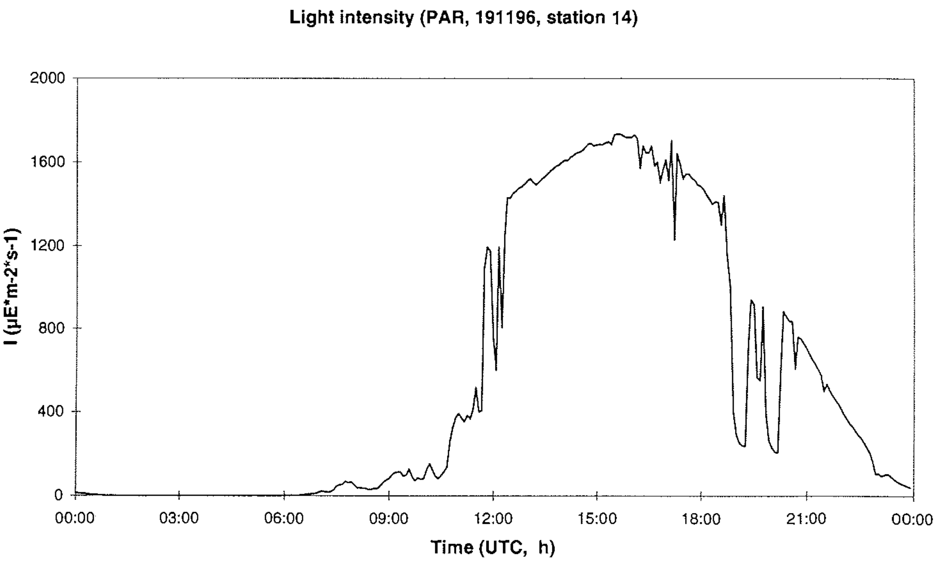


Fig. 10.2. On deck light intensity (µE m^{-2} s^{-1}) during a day.

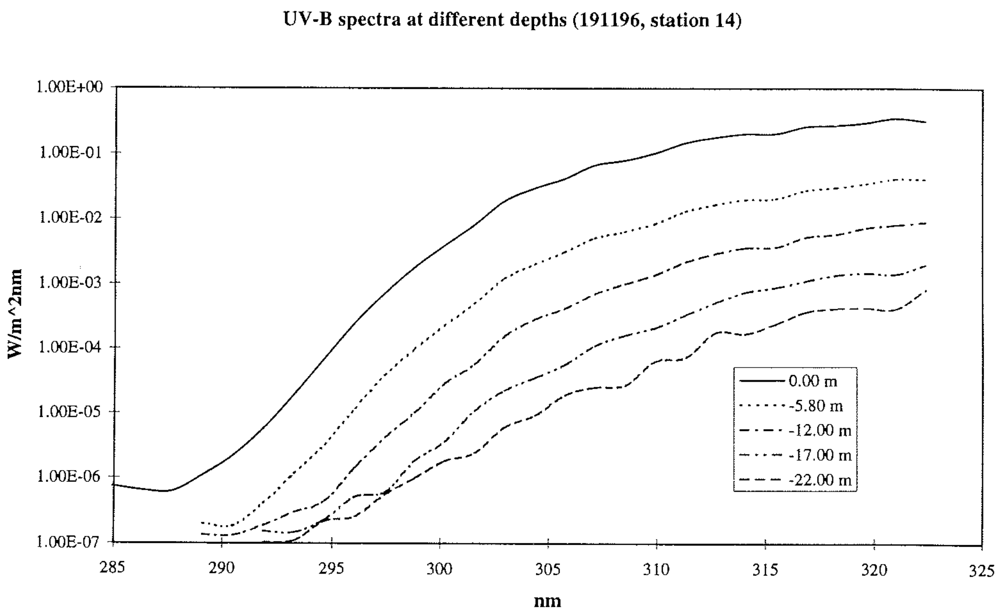


Fig. 10.3. Depth profile of UV-B radiation.

11 ABUNDANCE, DISTRIBUTION AND BEHAVIOUR OF CETACEANS IN THE REGION OF THE SOUTH SHETLAND ISLANDS WITH REGARD TO ABIOTIC AND ECOLOGICAL FACTORS (H. Pankow, G. Prochnow, M. Scheidat, B. Wurche)

Introduction

Since the south polar oceans have been declared to a whale sanctuary by the IWC (International Whaling Commission) in 1994, research efforts increased in order to obtain a more extensive picture of cetacean stocks in this region. Antarctic waters represent - especially because of the high abundance of krill - one of the main feeding grounds for the great whales. So far, only little is known about cetaceans in the area that will be covered by the research cruise ANT XIV/2. Futhermore, the area has never been included in IWC surveys.

During this cruise we conducted systematic whale observations to identify species and record abundance and behaviour of animals sighted. Possible interactions and relationships to other marine mammals and/or birds will also be noted. As far as possible, photographic documentation is made. In co-operation with other working groups we will try to find out possible ecological correlations. For example, parallel to the BFA krill survey we conducted a modified line transect survey for whales.

This research cruise was not designed as a special cetacean survey, but mainly as a fishery research program. Due to the fact that we had no influence on ship operation and time the RV "Polarstern" was used as a so called "platform of opportunity".

Material and methods

The methods of "distance sampling" we used on this trip are based on the assumptions that it is not possible to determine the amount of all individuals in a given area. This is especially true for marine mammals, which are spending most of their life submerged and often occur in offshore waters that are difficult to survey. The two methods applied on this cruise, 'line transect' and 'point transect', use the distances of the sightings to the transect line or point to estimate the density of populations. A large proportion of the animals may go undetected, but the theory allows accurate estimates of density, using the concept of a detection function which takes into account that the number of sightings decreases with increasing distance from the line or point.

In general it has to be considered that both methods are adversely influenced by meteorological phenomena, like rain, strong wind and glare, so that the detectability of objects is reduced or even impossible.

On "Polarstern" observations took place from November 15 to December 29, 1996, as far as weather conditions permitted. Depending on ship operations, line or point transect surveys were carried out. Observation platforms were the crows nest at a height of 27 m, the "Peildeck" and the bridge. Main observation platform was the crows nest, being occupied between 6:00 and19:00 (during the krill survey between 3:00 and 22:00) so that the whole daylight period was covered. During line transect two observers were on duty, whereas only one person conducted point transect survey.

Additional to the ship based survey an aerial survey by helicopter was carried out. Most of the flights took place during the krill survey when weather conditions were suitable. Flights were conducted at an altitude of 1000 resp. 500 ft (depending on ceiling and visibility) and at a speed of 100 kn. The transect had the shape of a square with leg lengths of approximate 25 nm each. The positions of the waypoints were taken from the GPS. At a sighting the helicopter approached the whales for species identification and in some cases for aerial photography.

During ANT XIV/2 all identified and unidentified whales were registered. If the results were not achieved by the methods mentioned above they were qualified as "incidental sightings".

Results

The results of this project will be analyzed in qualitative and quantitative ways. Tables 11.1 and 11.2 show a first qualitative presentation of our sightings. All whales seen from the helicopter could be identified whereas from the ship for 60% of all animals seen the species could not be determined.

Table 11.1. Number of whales

Number of animals	ship	helicopter
identified animals	97	85
unidentied animals	147	0
total	244	85

Table 11.2. Identified species

Species	Number of animals in: ship based sightings	Aerial sightings
Fin Whale (*Balaenoptera physalus*)	24	66
Humpback Whale (*Megaptera novaeangliae*)	23	10
Minke Whale (*Balaenoptera acutorostrata*)	4	0
Ziphiids (Ziphiidae)	6	8
Pilotwhale (*Globicephala melas*)	35	0
Spermwhale (*Physeter macrocephalus*)	0	1
Hourglass Dolphin (*Lagonorhynchus cruciger*)	5	0

Discussion

Whale surveys can be conducted as a dedicated survey or by using a vessel as a platform of opportunity. In contrast to a dedicated survey were the transects can be planned beforehand by the observers, on a platform of opportunity the survey design has to be adapted to the ship activity. Although this has obviously an influence on the quality of the data collected by a set method (as for example line transect), the use of a vessel like the RV "Polarstern" supplies us with the possibility of correlating our results with the biotic and abiotic data collected by the various working groups. A definite practical advantage of using a platform of opportunity is the relatively low cost of conducting a survey, especially in remote areas as the Antarctic.

The use of helicopters from the ship turned out to be an excellent addition to the ship based survey. The flight transects were designed according to line transect methodology and thereby covering an area that could not be reached by the vessel. Another advantage was the fact that all whales could be identified from the helicopter which has not been possible from the ship. The data collected will be analyzed in a diploma thesis.

11.1 Cetacean Acoustic Survey (R. Leaper, M. Scheidat)

Introduction

The Southern Ocean was declared as a whale sanctuary by the International Whaling Commission in 1994. An important aspect of this decision was the need to monitor populations of whales that had been substantially reduced by whaling. The assessment of cetacean populations is not an easy task due to the difficulty of detecting these animals and measuring the way in which the probability of detection is affected by range and environmental conditions. Most cetacean surveys are based on visual observations from ships or aircraft using line-transect methods. Cetaceans are however highly vocal animals and sound propagates well in the sea, enabling passive acoustics to be used to detect many species. Acoustic survey methods have a number of advantages over visual observations because they can be carried out 24 hours a day and are much less affected by meteorological conditions such as fog and strong winds, which frequently make visual observations impossible. In addition, acoustic techniques have much greater scope for automation. Automated systems can be operated by a single person, reducing the need for large teams of visual observers and eliminating biases caused by inter-observer variation.

The system used aboard the "Polarstern" was based on techniques developed for surveying sperm whale (*Physeter macrocephalus*) populations from much smaller vessels (Leaper et al. 1992). These methods have been successfully applied during a survey from the 95 m *Aurora Australis* (Gillespie 1996), but the "Polarstern" is the largest vessel from which such equipment has been deployed. Sperm whales are a particularly suitable species for acoustic study because they make loud distinctive clicks throughout long deep dives and spend relatively little time at the surface.

Ship noise is the key limiting factor for an acoustic survey from large vessels. This meant that it was not possible to monitor the lower frequencies (< 200Hz) which include the vocalisations of mysticetes. Hence the acoustic survey was aimed at odontocetes, in particular sperm whales, but also other species such as the southern bottlenose whale (*Hyperoodon planifrons*) for which it may be possible to develop effective acoustic survey methods.

Equipment

The equipment used consisted of a hydrophone array towed behind the ship and an automated recording system. The array was towed on a 400 m kevlar reinforced cable and consisted of a 10 m long, oil-filled, polyurethane tube containing two Benthos AQ-4 elements, 3 m apart, and an HS150 ball hydrophone. Each element had a separate pre-amplifier, with a bandwidth of 200 Hz to 40 kHz on the AQ-4 elements and up to 145 kHz on the HS150.

The recording system was divided into three parts; an 'audible range' system recording sounds in the 200 Hz to 22 kHz range, a 'wider bandwidth' system sensitive to the 200 Hz to 40 kHz range, and a high frequency click detector sensitive to narrow bands around 30, 75 and 120 kHz. Both audible and wider bandwidth signals were amplified using a differential amplifier and filtered using high-pass filters set at 200 Hz. The high pass filters were set to minimise the effects of ship noise. The audible range system used a standard SONY TCD-D10 Pro Digital Audio Tape (DAT) recorder controlled by a personal computer (PC) to make 30 second recordings every two minutes. For the wider bandwidth recordings, signals were digitised directly to a PC at a sample rate of 96 kHz to make 20 second samples every 80 seconds. These samples were then replayed to DAT from the hard disk at the normal DAT sample rate of 48 kHz. This effectively doubled the bandwidth of the recording system. All recordings were made in stereo and the time between signals arriving at each element was used to calculate bearings relative to the axis of the array.

The high frequency click detector was developed for surveys of small cetaceans and allows a PC to continuously monitor the signal for short click type sounds. The system used aboard the "Polarstern" is a modified version of the equipment described in Chappell et al. (1996), with the lower frequency band set to 30 kHz instead of 50. The intention was that this system would provide an immediate indication of sections of interest on the DAT recordings and also monitor any high frequency clicks detected during the idle part of the recording cycle.

Deployment of hydrophone from "Polarstern"

The hydrophone was deployed from the stern of the "Polarstern" and recovered using a capstan winch. A 20 m length of nylon rope was used to act as a shock absorber between the cable and the ship. The hydrophone was deployed whenever the vessel was steaming between stations and during passages. Recovery of the 400 m cable took about 30 minutes. The system was designed to be deployed and operated by a single person. However, due to the large number of stations on the cruise (176) for which the hydrophone needed to be brought on deck, it was necessary to have two operators working shifts.

Results

The hydrophone was deployed for a total of about 260 hours, covering over 2000 miles of trackline. The survey transects for which the hydrophone was deployed in the South Shetlands area are shown in Fig. 11.1. These resulted in 65 hours of audible range and 130 hours of wider bandwidth recordings. Due to the intense survey programme at the end of the cruise, only the first 80 hours of deployment were listened to aboard the ship.

Noise levels from the "Polarstern" varied considerably depending on the ship's speed, weather conditions and the pitch settings of the two controllable pitch propellers. Noise levels were generally lowest at higher cruising speeds of around 14 knots when the ship was running using four engines and both propellers set to around 22 degrees of pitch. Noise levels increased significantly if only three engines were used at speeds of around 10 knots, with one propeller set to a finer

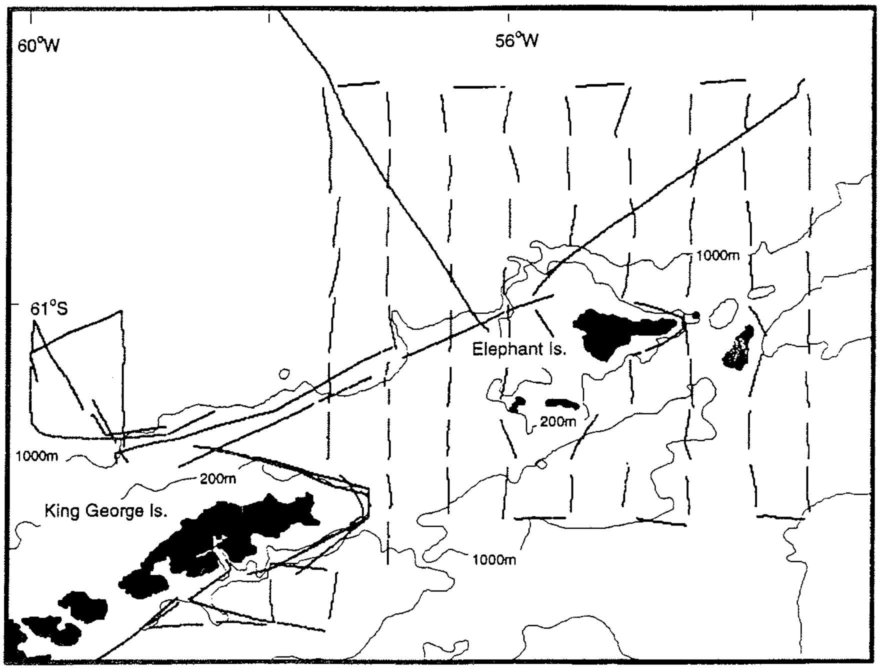


Fig. 11.1. Transects during which hydrophone was deployed around South Shetland Islands

pitch. Below 8 knots, cavitation noise from the propellers made acoustic survey work impossible. The ship also operated a continuous 12 kHz sonar which was audible on all recordings but should not interfere with the analysis.

Of the tapes that had been listened to by the end of the cruise, there were four detections of sperm whales and one detection of several click trains of higher frequency clicks from an unknown species. These clicks had their main energy around 20 kHz and a repetition rate of 200 Hz.

Discussion

Initial analysis shows that noise levels from the "Polarstern" are relatively high and will limit the range at which cetaceans can be detected acoustically to rather less than previous surveys. Nevertheless, sperm whales were detected acoustically on four separate occasions and there were no sightings from the vessel, demonstrating the effectiveness of acoustic techniques. Further analysis will be carried out to determine the bearings to all acoustic detections wherever possible. These bearings will then be used to estimate an effective range of detection provided that there are sufficient acoustic encounters. It is hoped to be able to estimate the density of sperm whales around the South Shetland Islands from these data.

Acoustic detections of other species will be described and compared to what is known of vocal behaviour of the species likely to be present in the study area. If sufficient data are available these will be used as the first stage in designing acoustic survey methods for these species.

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12 LIDAR-MEASUREMENTS OF OPTICAL PARAMETERS IN THE UPPER OCEAN LAYER (H. Harms, K. Ohm, M. Stolze, R. Willkomm)

Objectives

During ANT XIV/2 of RV "Polarstern" our aim was the final test of an underwater LIDAR which had been developed by the University of Oldenburg and the Alfred Wegener Institute within the EU project Euromar. Measurements of the downward looking LIDAR result in vertical profiles of beam attenuation, fluorescence of yellow substances and chlorophyll in the upper ocean layer. Calibration and validation of the LIDAR profiles are performed by comparisons with profiles obtained from optical *in situ* probes and with water samples from different depths. The samples are analysed by means of a spectrofluorometer with different excitation wavelengths in the UV and the visible range. In addition CTD casts are performed to characterise the hydrographic properties of the region as support for other working groups.

Methods

The LIDAR is installed in the ship's keel 11 m below the waterline close to the hydrographic well so that daylight is efficiently suppressed by the ship's hull. A quartz window serves as the LIDAR's interface with the water, resulting in a well defined surface for the passing radiation. The Nd:YAG-laser excitates fluorescence of substances by means of short pulses (duration 1 ns, energy 100 mJ) with the wavelengths of 355 or 532 nm. The emitted fluorescent radiation is received in different discrete channels at wavelengths of 405, 440, 532, 650, and 685 nm and is registered with a time resolution of 0.2 m. The wavelengths are chosen to correspond to Stokes-Raman scattering and to the maximum of yellow substances and chlorophyll fluorescence. From the time dependency of the Raman signal one can derive the beam attenuation coefficient which is an important inherent property of water and which controls the penetration depth. The fluorescence signals allow to calculate depth resolved concentrations of matter, by normalising them with the corresponding Raman signals. The laser is operated with a repetition rate of 10 Hz. 128 signals are averaged so that a mean profile is obtained every 15 seconds. A ship's speed of 10 kn results in a profile representing 80 m of the ship's path.

The spectrofluorometer for the analysis of water samples *in vitro* was a Perkin-Elmer type LS-50. In order to calibrate the fluorescence data of the LIDAR, excitation wavelengths of 270, 344, and 420 nm are used. Straylight suppression in the instrument has been improved by additional optical filters. Therefore the yellow substances fluorescence could be measured reliably without deteriorating the signal by straylight from scattering particles despite use of a single monochromator.

The CTD work was done with a Seabird SB911 plus combined with a turbidity sensor and two single wavelength fluorometers for yellow substances and chlorophyll. These sensors (BackScat, Dr. Haardt) are assembled together with the CTD in a rosette water sampler.

Experiments

The LIDAR has been installed in Bremerhaven before the beginning of the ANT XIV-expeditions. The telescope was optimised for a penetration depth of 40 m by adequate focusing. With a penetration depth of 38 m, the range was almost reached for Raman scattering excitated with a wavelength of 355 nm. This wavelength was preferred instead of 532 nm because of its greater penetration depth. The LIDAR system worked faultlessly, so that vertical profiles of beam attenuation, chlorophyll, and yellow substances fluorescence could be measured throughout the entire cruise leg. Every 5 minutes a burst sample of 128 laser pulses has been averaged to one profile.

160 station casts serve as a basis for calibration and performance evaluation. 1550 water samples have been analysed with the fluorometer in the laboratory. The majority of samples has been taken in the depth range between 10 and 100 m. These data have to be processed later at the University of Oldenburg. Therefore a final calibration of the LIDAR data was not possible during the cruise. Additional water samples have been taken from the sea water tap while steaming and have been analysed in the same way. Thus, numerous surface data points are available to complete the transects. The maximum depth of all CTD casts was 1000 m.

In addition, comparisons with data from other working groups (Dijkman, Röttgers, this volume) are possible. Of special interest is the relation between chlorophyll concentration and fluorescence signals, varying with stress on the photo system.

The overall performance of the system allowed us to prepare a manual how to start and operate the LIDAR on board and to instruct one of the technicians of the ship's crew to start the system in Capetown when RV "Polarstern" headed for Bremerhaven. Thus we got additional LIDAR data of a meridian Atlantic transect.

13 THE MODERN APPROACH TO SATELLITE REMOTE SENSING OF SEA ICE
(C. Garrity, W. Dimmler, U. Lembke and H. Pabst)

Introduction

Each year the RV "Polarstern" travels in the harsh polar regions conducting scientific work and logistic support. This ice strengthened research vessel requires sea ice information for both navigation and scientific planning while encountering sea ice. Prior to this cruise, sea ice products were often provided to the ship in the form of passive microwave sea ice concentration products from the Microwave Group-Ottawa River, Inc., Canada in coordination with the Canadian Atmospheric Environment Service as well as from the Bundesamt für Seeschiffahrt und Hydrographie (BSH), Deutscher Eisdienst (German Ice Service). For polar areas, BSH requests sea ice products from the US National Ice Center, based on both passive and visible satellite information. These products are sent to the ship at a considerable expense using communication satellites such as INMARSAT. Since the advent of "real time" reception of satellite data, communication links to remote agencies providing ice information, can be cut. Data received directly from a satellite to a ship allows for the mapping of various geophysical parameters within minutes after a satellite overpass. Real time data from the NOAA series of satellites which operate in the visible and infra-red region provide only a limited operational sea ice product. Cloud cover can considerably hinder, to the point of obscuring, the underlying sea ice, when using the NOAA satellite data. An all weather, day and night sensor, operating in the microwave region can qualify as an operational tool to map sea ice. Using the Special Sensor Microwave Imager (SSM/I), the cloud cover is virtually transparent, and the sea ice conditions can be derived, regardless of the weather and available daylight.

For the first time, the RV "Polarstern" is equipped with a Polar Satellite Tracking Antenna to receive the US Defense Meteorological Satellite Program (DMSP) F-series data. The same antenna is used to receive the NOAA Advanced Very High Resolution Radiometric data (AVHRR). The two telemetry's can be attached to a receiver, using one down-converter. The TeraScan system was developed and installed on the ship by SeaSpace Corporation, San Diego, California. This cruise provided the necessary conditions for testing of the upgraded TeraScan system deployed on the RV "Polarstern". Currently, the DMSP reception is generally only available at US military sites where decryption devices exist, or over the Antarctic region, where the data is transmitted in an un-encrypted format due to the International Antarctic Treaty.

The objectives during this cruise were:
a) testing of the upgraded TeraScan system to receive DMSP satellite data
b) upgrade the XVU software to a windows version, TeraVision
c) introduction of the DMSP data products to the various users.

Principle for Operation of the SeaSpace Receiving Station

Reception
Both the US NOAA meteorological and DMSP satellite data can now be received directly from the satellite on the RV "Polarstern". These satellites are in a near-polar sunsynchronous orbit at a height of about 850 km. Each of the NOAA and DMSP satellite data are received several times a day, providing visible to infra-red for the former, plus microwave data for the later. In the NOAA AVHRR series, channels 1

and 2 are of interest for observing sea ice during cloud free conditions, since these channels operate with visible wavelengths, 0.62 mm and 0.91 mm, respectively. The other three channels are of greater interest for meteorology, and they operate at the infra-red wavelengths: 3.7 mm, 10.8 mm and 12.0 mm. The field of view for the visible channels are 1.1 km at nadir. The US Air Force operates the DMSP satellites, denoted by a "f" number, such as f-10, f-11 and f-13. Of particular interest for mapping sea ice, are the SSM/I and Operational Linescan System (OLS) frequencies on the f-satellites. The SSM/I measures both horizontal and vertical polarization's at 19.36, 37.0 and 85Ghz, and vertically at 22.235 Ghz. The OLS is a two-channel imager, operating in the visible and infra-red spectrum. It differs from the AVHRR in that it has a very high spatial resolution at nadir of 600 m, with a variable scan, thus the distance between pixels are the same at nadir as at the end of the scan line. The OLS visible channel covers roughly the same spectral region as the AVHRR channels 1 and 2 combined. The OLS visible channel bandwidth provides useful images even when collected at night since the reflected moonlight can provide enough illumination on the earth's surface. The resolution of the SSM/I channels will be addressed when discussing sea ice products in the next section.

Reception of the satellite overpasses can be manually or automatically scheduled by tracking the satellite, framing the data and writing the data to the "passdisk" on the dedicated Sun Sparc20 workstation. Each orbital coverage can be viewed in order to optimize the data collection based on area(s) of interest. A total of eight satellite overpasses can be stored on the "passdisk" before overwriting a stored orbit. Once a satellite pass is processed off the "passdisk", it can be archived for future use.

Data Processing and Algorithms

The software for providing a sea ice concentration map using the passive microwave data from the SSM/I sensor is included with the TeraScan system. This software provides two algorithms for mapping sea ice from space. The NASA Team algorithm provides sea ice products with a grid spacing of 25 km, whereas the new 85 Ghz algorithm developed at SCRIPPS, University of California, provides a grid spacing of 12.5 km. The 85 Ghz algorithm is under evaluation for the Arctic (Lubin et al., 1996) and to date has not been evaluated for the Antarctic. Thus, the 85 Ghz derived sea ice product is not operational at the present time, and should be presented to a user with caution. Under clear sky conditions the AVHRR and OLS visible channel images can be used to verify the derived sea ice products.

Results according to objectives

Testing of the upgraded TeraScan system

This component of the objectives took approximately 75% of the cruise time. While in Punta Quilla, Argentina, SSM/I data was received with many missing data lines and samples. Once at sea, the problem remained until December 23. Great efforts were spent in "trouble shooting" the various components of the TeraScan system in order to find the reason for the poor reception of SSM/I data. The AVHRR data was received with no data gaps, except for the masking of the ship's structure, such as the chimney, which depended on the orbit and heading of the ship.

Continuous contact with SeaSpace by e-mail guided us to the issue of re-aligning the antenna. It was thought that the antenna alignment may not be accurate enough for the DMSP reception, due to the narrower transmitting bandwidth as compared to that for the NOAA satellites. Precise alignment of the antenna could only be achieved under calm seas. After a couple of weeks, the alignment was completed, but the problem remained. All cables were checked for noise interference and various computer components for proper contacts. No noise and grounding problems were observed. Spares for the Antenna Control Unit were tried, but the problem remained or worsened.

Knowing that there were other TeraScan systems located in the Antarctic, McMurdo and Palmer stations were contacted to see if they were also having a problem with DMSP reception. There were no problems at these sites, plus the fact that the TeraScan System on the RV "Polarstern" was receiving all f-satellites poorly, indicated that it was a problem specific to the system onboard.

An upgraded version of the software to ingest the DMSP satellite data into TeraScan format was received via "ftp" from SeaSpace-AWI-Polarstern. This new software did not solve the problem of the data dropouts in the SSM/I images. However, SSM/I derived sea ice concentration maps could be provided on the ship for general interest. The data dropouts were a hindrance, however by capturing all possible DMSP satellite overpasses for the Antarctic Peninsula, a useable pass was eventually obtained. This was time consuming, however timeliness was not important during this cruise since the ship was not operating in areas with substantial sea ice. The only area of potential sea ice for the ship to encounter was near the British Research Station, Rothera. This area had sea ice concentrations up to 85% during the first couple of weeks of the cruise, but depleted rapidly to 0% by the end of December, due to the opening up of a polynya south of Adelaide Island.

The data dropout problem became worse with time. On December 23, a loose connection was found linking the receiver to the down-converter. This connection was not checked previously due to the fact that the same cable connection was used for the reception of AVHRR data. Thus, it was the wrong assumption that the cable connection was secure because the AVHRR data reception was working correctly. Detailed reports on the "trouble shooting" aspects of the TeraScan system have been written by the technicians on board. As of December 23, all available DMSP and NOAA satellite data have been received properly.

Upgrade from XVU to TeraVision

The new "windows" software version of XVU was installed on the dedicated Sparc20 TeraScan computer the first week on the RV "Polarstern". There were no problems encountered with the new TeraVision software, however a list of recommendations and upgrades to the software will be provided to SeaSpace as a result of using the package during this cruise.

Introduction of the DMSP products to the various users

The most successful demonstration of the DMSP derived SSM/I products was for the Meteorological Office. The product of most interest to the Met Office was the windspeed over the open ocean colour map. The windspeed maps compared well with that observed from the ship as well as areas of stronger winds based on weather information. Products such as total liquid water and vapour in the atmosphere were not as interesting due to the detailed radiosonde data available daily on the ship. Rain over the open ocean sparked some interest as a product. The AVHRR visible and infra-red images received using the TeraScan antenna provide a resolution of 1.1 km compared to 10 km from the Met Office. However, the higher resolution is more important for observing sea ice, as compared to cloud structure.

The most disappointing aspect of the demonstration objectives was that for sea ice information. It is very difficult to introduce a new technique to map sea ice to users such as a Captain and Nautical Officers when the ship is no where near sea ice. From passed experiences on the RV "Polarstern" and other ships of different nationalities, it is crucial that the SSM/I sea ice products are used for navigation before one can become confident and comfortable with the product. Mid-way during this cruise, a couple of sea ice maps were shown for the Adelaide Island area, in anticipation that there might be some sea ice encountered while visiting Rothera station. Since there was no sea ice, except some small areas of brash ice, to be encountered by the ship, sea ice maps were not provided to the bridge as a hard-copy, but rather sea ice maps were displayed daily on the computer screen of the TeraScan system located near the bridge. The resolution and information on the computer screen far excels that of a hard-copy. Hard-copies were posted for interest to the scientists outside the computer room.

It is difficult to provide an example of a SSM/I sea ice product for this cruise report since the final product is in colour. In future, it will be recommended to provide a product with a sea ice concentration number represented as a percent of sea ice for each pixel and/or a contour product that can be printed in black and white with no loss of information.

Three technicians on board during this cruise learned to operate and trouble shoot the TeraScan System. However, training in the full use of the sea ice products could not be achieved due to not being in the sea ice.

Preliminary Results

This cruise provided an opportunity to compare satellite passive microwave data with satellite images in the visible wavelengths. Regions of the Weddell Sea containing sea ice under cloud free conditions as well as south of Deception Island where a polynya was forming during December provided excellent tools for the merging of the two data sets. A visual comparison of the derived sea ice concentrations using each of the NASA Team and the 85 Ghz algorithms revealed the potential of the higher frequency channels for mapping sea ice. For example, the NASA Team algorithm uses the 37 and 19 Ghz channels, and did not locate the polynya south of Adelaide Island. The over estimation in sea ice concentration was as high as 30% for this polynya while using the coarser resolution provided by the NASA Team algorithm. The 85 Ghz sea ice products showed the polynya development which corresponded to the polynya shape and size seen in the visible AVHRR images.

The analysis was achieved by overlaying the SSM/I sea ice coloured maps on an visible satellite image within a few hours of eachother. The images could be imported from the TeraVision software to Photoshop providing the overlay products.

Recommendations

The last objective for the cruise was not achieved, mainly due to spending many hours trouble shooting the system, and even more due to the fact that we were not in sea ice. It is recommended that the NASA Team sea ice products for mapping total sea ice concentration be provided to the bridge as a navigation tool and to the chief scientist for planning purposes while in sea ice. The NASA Team sea ice type concentration maps should be provided to show areas of old ice only during the winter/cold seasons, that is, when the snow cover is dry. The 85 Ghz SSM/I high resolution sea ice product should not be used operationally in the Antarctic at the present time. The evaluation of this algorithm is required in the Antarctic in the near future. Cloud free visible channel AVHRR and OLS images, can show the lead structure in the ice, and areas of old ice based on the shape of an ice floe. If the ice floes have rounded edges, the user can expect the floes to be old ice, for example.

It is recommended that a remote sensing sea ice specialist works with the captains and nautical officers while working in sea ice as an introduction to the SSM/I products. These SSM/I products do not need any interpretation by the final user, since the algorithms provide a quantitative display of the sea ice conditions, however confidence in a new product needs to be acquired with usage. There is no need for the RV "Polarstern" to request sea ice maps from the US National Ice Center, which occurred during this cruise for the Rothera area. The US sea ice products that are provided consists of information from the DMSP and NOAA satellites that have been averaged over about a three day period. These near-weekly sea ice maps are derived using the same data and algorithm (NASA Team) that is used on the RV "Polarstern". The major difference is the US operational sea ice product produced at shore is not as good as that on the ship. This is because the US National Ice Center uses orbital information that are averaged over a few days. Numerous sea ice maps from each of the satellite orbits can be produced in a day on the ship, and within minutes of a satellite reception of SSM/I data.

It is important to try and receive a decryption device from the US Air Force for the SSM/I data in the Arctic since the RV "Polarstern" operates at least half of her time in this region. The full operational use of the TeraScan system could then be achieved on the RV "Polarstern".

Acknowledgments. The main author would like to thank Udo Lembke and Werner Dimmler for their long efforts in trouble shooting of the upgraded TeraScan system. The prompt support provided by SeaSpace Corporation was appreciated.

Reference

Lubin, D., Garrity, C., Ramseier, R.O., B. Whritner, Evaluation of the Special Sensor Microwave Imager 85.5 Ghz channels for Total Sea Ice Concentration Retrieval during the Arctic Summer, submitted to: Remote Sensing of Environment, 12 July, 1996 (revisions being made).

14 STATION LIST

Station No.	Date 1996	Time (UTC)	Lat. S	Long. W	Depth (m)	Gear
001	15.11.	06.45	57°30'	60°36'	3298	AGT
		10.05	57°27'	60°39'	3299	
002	15.11.	21.22	59°10'	58°30'	3709	CTD, MER, UV-B, BN, AGT
	16.11.	04.40	59°09'	58°38'	3734	
003	16.11.	18.35	61°12'	56°10'	284	CTD, GSN
		21.07	61°05'	56°08'	357	
004	16.11.	22.35	61°12'	56°01'	148	GSN, CTD, BN, Trap I and II depl., AGT
	17.11.	03.22	61°09'	56°03'	156	
005	17.11.	08.39	61°13'	55°57'	99	CTD, GSN
		10.48	61°07'	55°57'	130	
006	17.11.	12.20	61°17'	55°10'	251	CTD, GSN
		16.39	61°13'	56°05'	184	
007	17.11.	18.00	61°17'	55°49'	167	CTD, BN, Trap I recov., loss of Trap II
		23.09	61°09'	56°05'	177	
008	18.11.	09.27	61°16'	55°50'	158	GSN
		10.43	61°14'	55°57'	142	
009	18.11.	12.13	61°17'	55°56'	227	CTD, GSN
		14.22	61°15'	55°51'	138	
010	18.11.	15.45	61°16'	55°41'	110	CTD, MER, UV-B, BN, GSN
		18.39	61°11'	55°41'	78	
011	18.11.	20.10	61°16'	55°36'	77	GSN, CTD, BN, AGT
		23.23	61°13'	55°47'	109	
012	19.11.	08.41	61°17'	54°54'	219	CTD, GSN
		11.15	61°14'	55°45'	248	
013	19.11.	12.25	61°21'	54°46'	293	CTD, GSN
		14.20	61°18'	54°39'	284	
014	19.11.	16.16	61°17'	54°39'	357	CTD, MER, UV-B, BN, GSN
		20.09	61°11'	54°34'	582	
015	19.11.	22.23	61°11'	54°33'	587	BN, CTD, AGT, AGT
	20.11.	03.12	61°12'	54°32'	582	
016	20.11.	09.48	61°21'	55°39'	176	CTD, GSN
		11.40	61°18'	55°49'	234	
017	20.11.	12.16	61°19'	55°56'	288	CTD, GSN
		14.35	61°17'	56°07'	307	
018	20.11.	15.10	61°20'	56°05'	337	CTD, MER, UV-B, BN, GSN
		18.55	61°20'	56°16'	345	
019	20.11.	19.53	61°20'	56°09'	314	CTD, BN, AGT, Jigging
	21.11.	03.23	61°29'	56°22'	519	
020	21.11.	08.33	61°22'	56°11'	244	CTD, GSN
		11.05	61°25'	56°03'	280	
021	21.11.	13.32	61°20'	56°34'	450	CTD, GSN
		15.50	61°16'	56°31'	412	
022	21.11.	15.32	61°17'	56°26'	421	CTD, BN, GSN
		18.45	61°10'	56°28'	462	
023	21.11.	19.53	61°06'	56°06'	384	GSN, CTD, BN, Trap I and II depl., AGT
	22.11.	02.58	61°06'	56°07'	470	
024	22.11.	08.38	61°06'	56°00'	154	CTD, GSN
		10.56	61°02'	55°53'	168	

Station No.	Date 1996	Time (UTC)	Lat. S	Long. W	Depth (m)	Gear
025	22.11.	11.40	61°07'	55°50'	102	CTD, GSN
		13.19	61°05'	55°51'	116	
026	22.11.	14.15	61°01'	55°51'	137	CTD, MER, UV-B, BN, GSN
		17.22	61°05'	55°55'	153	
027	22.11.	17.40	61°03'	55°58'	271	GSN, CTD, BN, Trap I and II recov., AGT,
	23.11.	04.00	60°59'	55°57'	300	Jigging
028	23.11.	08.31	60°59'	55°55'	214	CTD, GSN
		10.45	60°57'	55°45'	219	
029	23.11.	12.15	60°51'	55°38'	281	CTD, GSN
		14.00	60°51'	55°46'	250	
030	23.11.	15.06	60°55'	55°45'	261	CTD, MER, UV-B, BN, GSN
		21.41	60°53'	55°45'	245	
031	23.11.	22.53	60°53'	55°47'	443	BN, Trap I and II depl., AGT, Jigging
	24.11.	04.20	60°54'	55°57'	734	
032	24.11.	08.48	60°50'	55°41'	349	CTD, GSN
		10.42	60°51'	55°32'	318	
033	24.11.	11.46	60°51'	55°36'	248	CTD, GSN
		13.35	60°52'	55°29'	271	
034	24.11.	14.00	60°53'	55°25'	281	CTD, BN, GSN
		16.41	60°50'	55°36'	302	
035	24.11.	17.05	60°53'	55°32'	201	GSN, CTD, Trap I and II recov.,BN, AGT
	25.11.	07.12	60°49'	55°27'	2072	
036	25.11.	09.15	60°59'	55°14'	303	CTD, GSN
		11.30	60°56'	55°10'	386	
037	25.11.	11.40	60°54'	55°10'	873	CTD, GSN
		14.55	60°58'	55°07'	296	
038	25.11.	15.23	61°01'	55°04'	229	CTD, MER, UV-B, BN, GSN
		18.25	61°00'	55°13'	159	
039	25.11.	19.12	60°59'	55°14'	372	GSN, CTD
		20.34	60°57'	55°05'	466	
	26.11.	00.45	60°44'	54°59'	3211	BN, AGT
		05.12	60°35'	54°56'	3228	
040	26.11.	08.30	61°03'	54°42'	509	GSN, CTD
		10.58	61°01'	54°55'	565	
041	26.11.	11.45	61°03'	54°45'	370	CTD, GSN
		14.30	61°04'	54°42'	384	
042	27.11.	08.34	61°52'	59°12'	235	CTD, GSN
		10.42	61°49'	59°12'	324	
043	27.11.	11.30	61°47'	59°14'	390	GSN
		12.45	61°44'	59°09'	393	
044	27.11.	13.15	61°42'	59°07'	628	GSN, CTD, MER, UV-B, BN
		17.47	61°46'	59°22'	733	
045	27.11.	18.35	61°45'	59°23'	751	GSN, CTD, BN
	28.11.	01.28	61°37'	58°49'	810	
046	28.11.	09.02	61°39'	58°49'	401	CTD, GSN
		11.36	61°36'	58°40'	386	
047	28.11.	12.40	61°38'	58°52'	700	GSN
		15.19	61°34'	58°35'	598	
048	28.11.	16.00	61°33'	58°36'	792	CTD, BN, GSN
		21.32	61°38'	58°47'	390	

Station No.	Date 1996	Time (UTC)	Lat. S	Long. W	Depth (m)	Gear
049	30.11.	00.30	62°20'	58°04'	1880	AGT
		03.41	62°18'	57°53'	1920	
050	30.11.	11.45	61°36'	58°48'	791	CTD, BPN, AGT
		15.58	61°32'	58°35'	815	
051	30.11.	16.14	61°32'	58°34'	823	CTD, MER, UV-B, BN, BPN, BN,
	01.12.	04.15	61°37'	58°48'	697	Jigging
052	01.12.	08.47	61°41'	59°08'	797	CTD, BPN
		12.15	61°45'	59°21'	725	
053	01.12.	13.20	61°43'	59°13'	720	BPN
		15.07	61°46'	59°21'	483	
054	01.12.	15.21	61°46'	59°21'	655	CTD, BN, BPN
		18.56	61°48'	59°37'	512	
055	01.12.	19.16	61°49'	59°38'	477	BPN, CTD, BN, Trap I and II deployed
	02.12.	01.48	61°44'	59°13'	567	
056	02.12.	11.05	61°27'	59°54'	3430	AGT
		16.04	61°23'	59°31'	3721	
057	03.12.	10.13	61°41'	59°05'	801	BPN, CTD, BN, MER, UV-B, Trap I and II
		17.42	61°44'	59°13'	534	recov.
058	03.12.	21.18	61°41'	59°07'	396	CTD, BN, BPN
	04.12.	01.00	61°47'	59°20'	390	
059	04.12.	01.30	61°46'	59°26'	740	BPN
		04.01	61°49'	59°44'	965	
060	04.12.	04.24	61°49'	59°45'	1341	BPN
		06.54	61°48'	59°34'	580	
061	04.12.	11.05	61°47'	59°32'	900	CTD, BN
		12.33	61°47'	59°32'	961	
062	04.12.	15.10	61°47'	59°32'	966	CTD, BN
		12.33	61°47'	59°32'	961	
063	04.12.	21.06	61°46'	59°21'	454	CTD, BN, BPN
	05.12.	01.05	61°48'	59°37'	608	
064	05.12.	03.00	61°50'	59°40'	440	BPN
		05.41	61°47'	59°31'	981	
065	05.12.	06.21	61°47'	59°32'	849	BPN
		08.58	61°50'	59°47'	1046	
066	05.12.	11.03	61°47'	59°32'	1191	CTD, BN
		12.34	61°47'	59°33'	1216	
067	05.12.	15.10	61°48'	59°34'	591	CTD, BN
		16.25	61°48'	59°34'	554	
068	05.12.	21.35	61°48'	59°14'	367	CTD, BN, BPN
	06.12.	00.41	61°44'	59°05'	360	
069	06.12.	02.57	61°43'	59°09'	430	BPN
		05.29	61°46'	59°24'	756	
070	06.12.	06.28	61°41'	59°10'	796	BPN
		09.24	61°37'	58°54'	850	
071	06.12.	11.05	61°37'	58°53'	788	CTD, BN, RMT-Test
		15.03	61°33'	58°48'	1284	
072	06.12.	18.00	61°46'	59°24'	743	CTD, BN
		19.27	61°45'	59°24'	742	
073	06.12.	21.26	61°39'	58°53'	490	CTD, BN, BPN
	07.12.	01.30	61°36'	58°43'	575	

Station No.	Date 1996	Time (UTC)	Lat. S	Long. W	Depth (m)	Gear
074	07.12.	14.15	61°32'	59°29'	2979	AGT, BN
		19.56	61°32'	59°32'	3028	
075	08.12.	08.37	61°30'	58°13'	671	CTD, GSN
		12.15	61°31'	58°19'	637	
076	08.12.	12.56	61°31'	58°22'	698	CTD, MER, UV-B, BN
		15.20	61°32'	58°22'	534	
077	09.12.	02.00	61°20'	57°03'	1440	AGT
		05.00	61°18'	57°03'	1555	
078	09.12.	09.38	60°55'	55°32'	110	CTD, GSN
		11.30	60°56'	55°32'	113	
079	09.12.	12.34	60°53'	55°32'	178	CTD, GSN
		14.03	60°54'	55°37'	120	
080	09.12.	15.44	60°56'	55°41'	131	CTD, MER, UV-B, BN, GSN
		19.06	61°01'	55°43'	76	
081	09.12.	20.30	60°56'	55°42'	136	GSN, CTD,BN
		23.24	60°54'	55°48'	412	
082	10.12.	09.23	59°59'	53°30'	3233	RMT, CTD,BN
		11.32	60°00'	53°30'	3237	
083	10.12.	13.22	60°15'	53°30'	2360	RMT, CTD
		14.48	60°16'	53°30'	2327	
084	10.12.	16.35	60°30'	53°30'	2441	RMT, CTD, BN
		18.44	60°31'	53°29'	2367	
085	10.12.	20.25	60°45'	53°30'	556	RMT, CTD
		21.39	60°45'	53°31'	552	
086	10.12.	23.41	61°00'	53°30'	1887	RMT, CTD
	11.12.	01.12	61°01'	53°31'	2006	
087	11.12.	03.10	61°15'	53°30'	1058	RMT, CTD
		04.43	61°17'	53°31'	891	
088	11.12.	06.14	61°30'	53°30'	697	RMT, CTD
		07.26	61°31'	53°29'	684	
089	11.12.	09.10	61°45'	53°30'	531	RMT, CTD, BN
		11.10	61°45'	53°30'	524	
090	11.12.	13.20	62°00'	53°30'	1359	RMT, CTD
		14.25	62°01'	53°30'	1370	
091	11.12.	16.13	62°00'	53°59'	508	RMT, CTD, MER, UV-B, BN
		18.51	61°59'	53°57'	524	
092	11.12.	20.27	61°45'	54°00'	331	RMT, CTD
		21.25	61°43'	54°00'	374	
093	11.12.	22.53	61°30'	54°00'	730	RMT, CTD
	12.12.	00.28	61°28'	53°59'	773	
094	12.12.	02.15	61°13'	53°54'	1284	RMT, CTD
		03.56	61°11'	53°52'	1381	
095	12.12.	05.22	60°59'	54°00'	1054	RMT, CTD
		06.56	60°58'	53°59'	1206	
096	12.12.	08.41	60°45'	54°00'	1726	RMT, CTD, BN
		10.49	60°45'	53°59'	2225	
097	12.12.	12.55	60°30'	54°02'	2992	RMT, CTD
		14.13	60°29'	54°03'	3009	
098	12.12.	16.10	60°15'	54°04'	2750	RMT, CTD, MER, UV-B, BN
		19.18	60°14'	54°03'	2685	
099	12.12.	20.56	60°00'	54°00'	3093	RMT, CTD

Station No.	Date 1996	Time (UTC)	Lat. S	Long. W	Depth (m)	Gear
		22.27	59°58'	54°00'	3017	
100	13.12.	00.21	60°00'	54°29'	1146	RMT, CTD
		01.50	60°00'	54°28'	1970	
101	13.12.	03.58	60°15'	54°29'	3065	RMT, CTD
		05.30	60°15'	54°25'	3031	
102	13.12.	07.42	60°30'	54°30'	3249	RMT, CTD
		09.13	60°30'	54°28'	3232	
103	13.12.	11.19	60°45'	54°22'	3013	RMT, CTD, BN
		13.33	60°46'	54°30'	2672	
104	13.12.	15.11	61°00'	54°32'	593	RMT, CTD, BN, MER, UV-B
		18.07	61°01'	54°34'	583	
105	13.12.	19.49	61°15'	54°31'	555	RMT, CTD
		20.56	61°14'	54°30'	681	
106	13.12.	22.47	61°30'	54°29'	1577	RMT, CTD
	14.12.	00.15	61°29'	54°30'	1520	
107	14.12.	02.12	61°45'	54°30'	711	RMT, CTD
		03.12	61°45'	54°31'	650	
108	14.12.	04.53	62°00'	54°30'	606	RMT, CTD
		06.24	62°02'	54°29'	808	
109	14.12.	08.08	62°00'	55°00'	1367	RMT, CTD
		09.38	62°00'	55°03'	1351	
110	14.12.	11.15	61°45'	55°04'	2045	RMT, CTD, BN, AGT
		17.49	61°40'	55°03'	2232	
111	14.12.	19.00	61°30'	55°00'	667	RMT, CTD, BN
		20.39	61°30'	54°59'	879	
112	14.12.	22.29	61°16'	55°00'	246	RMT, CTD
		23.14	61°15'	55°02'	173	
113	15.12.	02.33	61°00'	55°00'	503	RMT, CTD
		03.42	61°00'	55°04'	276	
114	15.12.	05.17	60°45'	55°00'	3272	RMT, CTD
		06.45	60°44'	54°58'	3277	
115	15.12.	08.09	60°30'	55°00'	3436	RMT, CTD
		09.42	60°28'	54°59'	3510	
116	15.12.	11.10	60°15'	55°02'	3400	RMT, CTD
		12.43	60°15'	55°06'	3435	
117	15.12.	14.20	60°00'	55°00'	3605	RMT, CTD, MER, UV-B, BN, AGT
		19.00	59°59'	54°59'	3597	
118	15.12.	20.46	60°01'	55°29'	3564	RMT, CTD
		22.22	60°01'	55°32'	3584	
119	15.12.	23.30	60°14'	55°30'	3554	RMT, CTD
	16.12.	01.15	60°16'	55°31'	3557	
120	16.12.	02.50	60°30'	55°30'	3465	RMT, CTD
		04.21	60°32'	55°27'	3520	
121	16.12.	05.42	60°45'	55°30'	3390	RMT, CTD
		07.06	60°47'	55°31'	3106	
122	16.12.	08.50	61°00'	55°49'	144	RMT, CTD
		09.41	61°01'	55°49'	127	
123	16.12.	11.41	61°17'	55°31'	61	RMT, CTD
		12.15	61°17'	55°30'	62	
124	16.12.	13.55	61°31'	55°19'	454	RMT, CTD, MER, BN, UV-B
		16.45	61°31'	55°15'	500	

Station No.	Date 1996	Time (UTC)	Lat. S	Long. W	Depth (m)	Gear
125	16.12.	18.24	61°45'	55°29'	1865	RMT, CTD
		19.55	61°46'	55°29'	2742	
126	16.12.	21.28	62°00'	55°29'	1126	RMT, CTD, BN, CTD
	17.12.	00.30	62°00'	55°31'	1101	
127	17.12.	01.59	62°00'	55°59'	2143	RMT, CTD
		03.20	62°01'	56°02'	2098	
128	17.12.	04.58	61°45'	56°00'	794	RMT, CTD, BN
		06.57	61°44'	55°58'	795	
129	17.12.	08.40	61°30'	56°04'	347	RMT, CTD, BN
		09.47	61°28'	56°04'	293	
130	17.12.	11.13	61°16'	56°00'	?	RMT, CTD
		12.55	61°14'	55°58'	146	
131	17.12.	14.28	61°00'	56°01'	454	RMT, CTD, MER, UV-B, BN
		17.48	60°58'	56°01'	953	
132	17.12.	19.13	60°45'	56°00'	2871	RMT, CTD
		20.42	60°43'	55°59'	3842	
133	17.12.	22.18	60°30'	55°59'	3814	RMT, CTD, BN
	18.12.	00.32	60°28'	56°00'	3879	
134	18.12.	01.53	60°15'	56°00'	3755	RMT, CTD
		03.25	60°13'	56°02'	3832	
135	18.12.	04.52	60°00'	56°00'	3709	RMT, CTD
		06.20	60°00'	56°00'	3712	
136	18.12.	07.56	60°00'	56°30'	3601	RMT, CTD
		09.36	60°01'	56°34'	3603	
137	18.12.	11.05	60°15'	56°30'	3726	RMT, CTD, BN
		13.30	60°17'	56°29'	3763	
138	18.12.	14.46	60°29'	56°30'	3908	RMT, CTD, MER, UV-B, BN
		18.09	60°30'	56°28'	3834	
139	18.12.	19.47	60°45'	56°30'	2971	RMT, CTD
		21.18	60°46'	56°28'	2546	
140	18.12.	22.51	61°00'	56°30'	2118	RMT, CTD
	19.12.	00.20	61°01'	56°29'	2075	
141	19.12.	01.47	61°15'	56°29'	355	RMT, CTD
		02.49	61°16'	56°28'	402	
142	19.12.	04.14	61°30'	56°30'	496	RMT, CTD
		05.28	61°31'	56°29'	525	
143	19.12.	06.52	61°45'	56°30'	536	RMT, CTD
		08.07	61°45'	56°30'	530	
144	19.12.	09.40	62°00'	56°30'	1714	RMT, CTD, BN
		11.56	62°02'	56°31'	1350	
145	19.12.	13.30	62°12'	56°53'	1405	AGT, CTD, MER, UV-B, RMT
		21.29	62°15'	57°00'	1536	
146	19.12.	22.59	62°00'	57°00'	643	RMT, CTD
		23.56	61°58'	57°00'	492	
147	20.12.	01.54	61°45'	57°01'	395	RMT, CTD
		02.48	61°45'	57°00'	403	
148	20.12.	04.46	61°30'	57°00'	478	RMT, CTD
		06.00	61°29'	57°00'	483	
149	20.12.	07.31	61°15'	57°00'	1612	RMT, CTD
		09.01	61°14'	57°00'	1708	

Station No.	Date 1996	Time (UTC)	Lat. S	Long. W	Depth (m)	Gear
150	20.12.	10.32	61°00'	57°00'	2822	RMT, CTD, BN
		12.45	61°00'	57°02'	2795	
151	20.12.	14.26	60°45'	57°00'	3656	RMT, CTD, MER, UV-B, BN
		17.45	60°44'	57°01'	3810	
152	20.12.	19.36	60°30'	57°00'	1990	RMT, CTD
		20.59	60°29'	57°01'	1761	
153	20.12.	22.36	60°15'	57°00'	4106	RMT, CTD
		23.56	60°14'	57°01'	4105	
154	21.12.	01.34	60°00'	57°02'	3319	RMT, CTD
		03.06	59°59'	57°03'	3525	
155	21.12.	04.45	60°00'	57°30'	1868	RMT, CTD
		06.11	60°00'	57°34'	1934	
156	21.12.	07.52	60°15'	57°30'	2539	RMT, CTD
		09.14	60°13'	57°30'	3286	
157	21.12.	11.03	60°30'	57°30'	3678	RMT, CTD, BN
		13.18	60°29'	57°26'	3530	
158	21.12.	15.05	60°45'	57°29'	4600	RMT, CTD, MER, UV-B, BN
		17.56	60°44'	57°26'	4439	
159	21.12.	19.40	60°59'	57°30'	4006	RMT, CTD
		21.03	60°59'	57°29'	3886	
160	21.12.	22.48	61°15'	57°30'	2025	RMT, CTD
	22.12.	00.45	61°16'	57°32'	2546	
161	22.12.	02.20	61°30'	57°32'	636	RMT, CTD
		03.40	61°30'	57°30'	605	
162	22.12.	05.19	61°46'	57°32'	343	RMT, CTD, AGT
		08.37	61°47'	57°29'	312	
163	22.12.	10.55	62°02'	57°21'	184	CTD, BN, RMT
		12.23	62°02'	57°19'	252	
164	22.12.	13.51	62°08'	57°40'	555	RMT, CTD, BN, AGT
		19.20	62°09'	57°59'	454	
165	22.12.	20.18	62°15'	57°58'	1608	CTD
		21.03	62°15'	57°58'	1574	
166	22.12.	22.19	62°15'	58°20'	551	RMT, CTD
		23.37	62°14'	58°15'	510	
167	23.12.	00.55	62°09'	58°26'	419	RMT, CTD
		02.15	62°10'	58°23'	500	
168	23.12.	04.11	62°23'	58°41'	1100	RMT, CTD
		05.47	62°24'	58°44'	1210	
169	23.12.	07.03	62°30'	59°00'	1480	RMT, CTD
		08.41	62°31'	59°01'	1499	
170	23.12.	10.11	62°30'	58°31'	1636	RMT, CTD, BN
		12.30	62°29'	58°27'	1569	
171	23.12.	13.50	62°30'	58°01'	1789	RMT, CTD, BN
		15.51	62°30'	57°58'	1787	
172	23.12.	17.34	62°15'	58°00'	1655	RMT, CTD
		19.00	62°13'	58°00'	1215	
173	23.12.	20.28	62°15'	57°30'	1922	RMT, CTD
		22.31	62°15'	57°26'	1771	
174	24.12.	00.11	62°30'	57°30'	1455	RMT, CTD
		01.30	62°32'	57°29'	1425	

Station No.	Date 1996	Time (UTC)	Lat. S	Long. W	Depth (m)	Gear
175	24.12.	06.09	62°19'	58°42'	496	AGT
		07.39	62°20'	58°41'	505	
176	26.12.	11.04	65°54'	67°45'	484	CTD, MER, BN, AGT
		14.31	65°55'	67°49'	438	
177	26.12.	19.52	66°35'	68°42'	593	CTD, MER, BN, AGT
		22.53	66°36'	68°42'	630	

Abbreviations

AGT	Agassiz Trawl
BN	Bongo Net
BPN	Bentho-pelagisches Netz (1088# pelagic net)
CTD	CTD probe
GSN	Grundschleppnetz (140' commercially-sized bottom trawl)
MER	Biospherical MER-2040 Underwater Profiler
PAR	Photosynthetic Active Radiation Spectroradiometer
RMT	Rectangular Midwater Trawl
UV-B	UV-B Spectroradiometer

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Peine	Lutz	Naut. Offc.
Thoenies	Rainer	Doctor
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Folta	Henryk	Eng.
Simon	Wolfgang	Eng.
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Fröb	Martin	Electronician
Dimmler	Werner	Electronician
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Holtz	Hartmut	Electrician
Loidl	Reiner	Boatswain
Neisner	Winfried	Carpenter
Moser	Siegfried	Decks Crew
Hartwig	Andreas	Decks Crew
Bäcker	Andreas	Decks Crew
Bohne	Jens	Decks Crew
Hagemann	Manfred	Decks Crew
Schmidt	Uwe	Decks Crew
Winkler	Michael	Decks Crew
Bindernagel	Knuth	Decks Crew
Renner	Norbert	Store Keeper
Arias Iglesias	Enrice	Motormen
Giermann	Frank	Motormen
Fritz	Günter	Motormen
Krösche	Eckard	Motormen
Dinse	Horst	Motormen
Silinski	Frank	Cook
Tupy	Mario	Cook Mate
Hünecke	Heino	Cook Mate
Dinse	Petra	Stewardess
Lehmbecker	Claudia	Stewardess/KS
Klemet	Regine	Stewardess
Schmidt	Maria	Stewardess
Silinski	Carmen	Stewardess
Huang	Wu-Mei	Steward
Wu	Chi Lung	Steward
Yu	Kwok Yuen	Laundry

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