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NEW RESULTS ON THE FISH AND SHRIMP FAUNA OF THE WEDDELL SEA AND LAZAREV SEA (ANTARCTIC)

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Abstract: A total of 151 demersal fishes and 555 shrimps were recorded on 1785 photographs which represent 1607 m^2 sea floor of the shelf and upper slope of the Weddell Sea (Halley Bay near-shore area) and of the Lazarev Sea. The Lazarev Sea showed a high number of species (24) and an average abundance of 7.24 n/100 m^2. In the Halley Bay near-shore area only 11 species were found, however the abundance was high with 15.66 n/100 m^2. The species composition of these areas was compared using cluster analysis with previous results from adjacent areas. The Lazarev Sea was combined with the Halley Bay near-shore and the Kapp Norvegia areas to an area-cluster "north" which was different from an area-cluster "south" which comprised the Gould/Vahsel Bay, Vestkapp and Halley Bay off-shore areas. The most abundant species were *Trematomus lepidorhinus* in the Lazarev Sea and *T. scotti* in the Halley Bay near-shore area. The shrimp fauna was dominated in the Halley Bay near-shore area by *Chorismus antarcticus* with an abundance of 33.45 n/100 m^2 whereas in the Lazarev Sea the three generally most abundant Antarctic shrimps *C. antarcticus, Notocrangon antarcticus* and *Nematocarcinus lanceopes* showed values between 1.25 and 3.42 n/100 m^2. Between the two shelf-inhabiting species *C. antarcticus* and *N. antarcticus* no difference in depth zonation was found. A small scale analysis of the occurrence of *N. antarcticus* and *N. lanceopes* indicated random dispersion patterns at most investigated stations.

1. Introduction

The major objective of this investigation was a faunistic classification of the fish and shrimp fauna in the zone of permanent pack-ice on the shelf and upper slope of the high Antarctic. The investigation carried out by means of underwater photography will complete former results from the southeastern Weddell Sea and was extended into the easterly adjacent Lazarev Sea.

The results from the Lazarev Sea obtained by two different methods, trawling (WÖHRMANN and ZIMMERMANN, 1992; GORNY and ARNTZ, 1992) and underwater photography (GUTT, 1992) were the first from this area. The main interest was a description of the fish and shrimp fauna and a comparison with results from the Weddell Sea on the basis of the underwater photographs. This method yields qualitative and quantitative information on the zoogeography and vertical zonation in terms of abundance and species composition. Some of these parameters can only be obtained by the imaging method which therefore complements traditional trawl catches.

The Halley Bay area in the Weddell Sea had been sampled in the past mainly off-shore so that the additional near-shore stations fill a gap in our knowledge of the benthic communities. Studies using imaging methods have been carried out in the southeastern Weddell Sea since 1985 so that on the basis of more than 3000 m^2 observed area the fish and shrimp fauna is fairly well known (EKAU and GUTT, 1991; GUTT *et al.*, 1991). Information from approximately 40 trawl catches is available from SCHWARZBACH (1988), EKAU (1990), ARNTZ and GORNY (1991), and HUBOLD (1992). Faunistic investigations on the benthos (VOß, 1988; GUTT, 1991; BARTHEL and GUTT, 1992) showed that in this area different adjacent assemblages can be present even at a small spatial scale and lead to a complex image of life communities on or close to the sea floor with sometimes even contradictionary results.

The increase in more detailed research in the Weddell Sea and its extension into the Lazarev Sea is of special interest to zoogeographical classification of the fauna. According to ANDRIASHEV (1965), DEWITT (1971) and EKAU (1988) the fish fauna of this area belongs to the East-Antarctic zoogeographical province, very close to the border to the West-Antarctic province. Among the demersal fish fauna within the Weddell Sea a certain zoogeographical structure is known which is dominated in most areas by the Nototheniidae, only in one area by the Channichthyidae (EKAU, 1990; HUBOLD, 1992). In general the distribution is partly influenced by a depth zonation, partly by a zoogeographical pattern in terms of species composition and abundance. HUBOLD (1992) found three different communities of demersal fish in the southeastern Weddell Sea, of which one association combines most catches with a broad depth range (203–695 m) on the shelf, the two other associations are situated at the upper shelf edge in the Halley Bay area and in the Filchner Depression. The latter one in the southernmost part of the Weddell Sea differs most from all other areas due to its unique species composition and its low abundance (EKAU and GUTT, 1991; HUBOLD, 1992).

The shrimp fauna of the southeastern Weddell Sea is known to be dominated by the three species *Chorismus antarcticus, Notocrangon antarcticus* and *Nematocarcinus lanceopes* with a clear vertical zonation and regional differences in both, species composition and abundance (ARNTZ and GORNY, 1991; GUTT *et al.*, 1991).

2. Material and Methods

The new material presented here was collected during the expedition ANT IX/3 with RV POLARSTERN in 1991. For cruise report and station list see and BATHMANN *et al.* (1992). On 24 stations (=transects) a total of 1785 photographs were taken which represent 1607 m^2 of seafloor (Fig. 1). Results from the expeditions ANT III, ANT VI, and ANT VII published by EKAU and GUTT

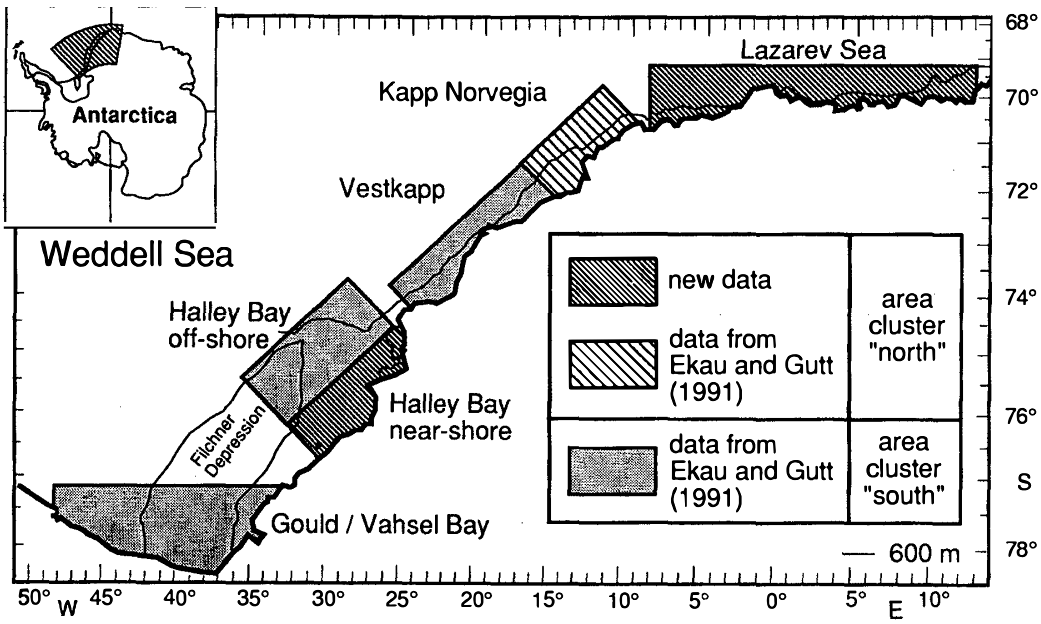

Fig. 1. Areas of investigation.

(1991) were used for comparison; all separate stations are listed by HEMPEL (1985), FÜTTERER (1988), and ARNTZ *et al.* (1990) respectively. The equipment consisted of a 70 mm underwater camera (GUTT, 1988) pointing vertically downward, which was triggered by a bottom contact switch at a constant distance from the sea floor. At the first station the trigger weight was visible on the photographs so that a direct calculation of the size of the photographed area (0.90 m^2) from the known size of the trigger weight was possible. On the basis of 53 pictures the methodological error of this parameter was estimated to be less than 10%. Each photo station from the drifting ship comprised between 63 and 81 pictures, which were taken without control of the sampling site at intervals of approximately 20 s. The distance between the first and last photograph varied between 0.02 km and 2.08 km depending upon the drift speed of the ship.

The fish data were analysed by a cluster analysis using the Jaccard-Index (JACCARD, 1902), Bray-Curtis-Index (BRAY and CURTIS, 1957), and the Canberra Metric (LANCE and WILLIAMS, 1967). Only taxa with presence in at least two regions were considered to minimise the possible methodological error that single co-ocurrences which are due to chance will mislead to combine such stations to a true cluster. The group of unidentified fishes was omitted because it contributes no additional information.

Small scale dispersion patterns of shrimps within one transect were calculated by the measure of patchiness $m'/m=1+V/m^2-1/m$ (LLOYD, 1967) where m=sample mean, V=sample variance, m'=index of mean crowding=$m+V/m-1$. A two-tailed chi-square statistic was used to test the significance of departure from randomness ($m'/m=1$). An aggregated dispersion is indicated by $m'/m>1$, a uniform one by $m'/m<1$. The measure of patchiness is statistically independent of the mean and therefore more useful than the more popular variance-mean-ratio when comparing samples of different abundances (ELLIOTT, 1971).

3. Results

3.1. Fishes

The new results (ANT IX) are presented in combination with those from EKAU and GUTT (1991) (ANT III, VI, VII) to enable a direct comparison of all data available, obtained by means of underwater photography (Table 1).

A total of 151 fishes were photographed in the Lazarev Sea and Halley Bay near-shore area during ANT IX/3 while 269 specimens were from the previous expeditions to other areas. In total, an average abundance of 9.35 n/100 m^2 was calculated. The most abundant species, with more than 0.50 n/100 m^2, were *Trematomus lepidorhinus* and *Prionodraco evansii* in the Lazarev Sea and *T. scotti, P. evansii, T. lepidorhinus, Dollloidraco longedorsalis,* and *T. loennbergii* in the Halley Bay near-shore area.

For statistical analysis the fish data from the single stations within each geographic area, Halley Bay near-shore (ANT IX), Halley Bay off-shore (ANT III, VI, VII), Lazarev Sea (ANT IX), Kapp Norvegia, Gould/Vahsel Bay, and Vestkapp (all ANT III, VI, VII) were summed up to compare with and to classify the two new sets of data from Halley Bay near-shore area and Lazarev Sea. The results of the cluster-analysis based on all three similarity or distance coefficients (Jaccard, Canberra, Bray-Curtis) indicate a close relationship between the Lazarev Sea and the Kapp Norvegia area which together with the Halley Bay near-shore area formed the area-cluster "north". The Gould/Vahsel Bay, the Vestkapp, and the Halley Bay off-shore areas were combined to form the area-cluster "south". The separation between the clusters was made at the 15% and 45% similarity level for the species and areas respectively. A representative result is shown in Table 1, a community table based on cluster analyses using the Jaccard-Index (complete linkage) for both, the species and the areas. The community table shows, that the area cluster "south" is only dominated by representatives of the species cluster "B", whereas the cluster "north" exhibits high presences in both species clusters, "A", such as *Cygnodraco mawsoni* and *Pogonophryne* sp. and "B". Although the classification of the species by cluster analysis does not reflect any systematic grouping at the family level, the area-cluster "north" is clearly dominated by the Nototheniidae, whereas within the area-cluster "south" the species were more uniformly distributed among the four dominant families, Nototheniidae, Channichthyidae, Artedidraconidae and Bathydraconidae. The mean abundances within the cluster "north" with 7.24 to 18.14 n/100 m^2 was high compared with the cluster "south" with only 2.84 to 10.80 n/100 m^2.

Differences within the area-clusters are visible mainly in the cluster "north". In the Kapp Norvegia area more of the abundant species, which were considered in the cluster analysis were present which lead to the highest abundance of fish in general. The highest species richness occurred in the Lazarev Sea partly due to the rare species which were not included in the cluster analysis, such as *Trematomus bernacchii* or *Muraenolepis microps*, whereas in the Halley Bay near-shore area only half of the species of the other two areas were found.

Table 1. Fishes and shrimps recorded photographically in the Lazarev and Weddell Sea. Abundances for fish and shrimps are given as n/100m². For calculation of shrimp biomass see "Results". Abundances of fishes partly classified according to cluster analysis (Jaccard-Index, complete linkage) for areas and species.

	Taxon	Kapp Norvegia*	Lazarev Sea**	Halley Bay near shore**	Gould/ Vahsel Bay*	Vestkapp*	Halley Bay off shore*	
	area photographed (qm)	931.4	1197.9	408.6	949.4	435.0	567.4	
	no. of fish taxa ("indet."excl.)	22	24	11	12	11	14	
	no. of fish specimens	169	87	64	27	47	26	
	total fish (n/100 qm)	18.14	7.24	15.66	2.84	10.80	4.58	
	Nototeniidae	14.61	4.33	9.55	0.97	4.34	1.42	
	Artedidraconidae	1.40	0.49	1.46	0.92	1.61	0.36	
	Channichthyidae	0.43	0.59	0.48	0.22	1.15	0.53	
	Bathydraconidae	0.96	1.33	3.42	0.75	2.76	1.78	
		"north"			"south"			Cluster
A	*Artedidraco orianae*	0.32	0.25	-	-	-	-	
A	*Histiodraco veliver*	0.11	0.08	-	-	-	-	
N	*Notothenia* spp.	0.11	0.25	-	-	-	-	
N	*rematomus penellii*	0.32	0.17	-	-	-	-	
L	Liparidae spp.	0.11	0.17	-	-	-	-	
N	*Lepidonotothen nudifrons*	0.54	0.08	0.49	-	-	-	
A	*Pogonophryne* spp.	0.43	0.08	0.24	0.21	-	-	
B	*Cygnodraco mawsoni*	0.32	0.17	0.24	0.11	-	-	
N	*Trematomus loennbergii*	0.11	0.42	0.98	0.53	-	0.18	A
CH	Channichthyidae spp.	0.11	-	0.24	-	-	0.18	
B	*Racovitzia glacialis*	0.21	-	-	-	-	0.18	
N	*Dissostichus mawsoni*	0.11	-	-	-	-	0.18	
A	*Dolloidraco longedorsalis*	0.43	-	1.22	-	1.15	0.18	
B	*Bathydraco* spp.	0.43	0.17	-	-	0.46	0.18	
CH	*Cryodraco antarciticus*	0.11	0.17	-	-	-	-	
N	*Trematomus eulepidotus*	0.11	-	-	0.11	0.20	-	
Z	Zoarcidae spp.	0.21	-	-	-	0.46	-	
CH	*Chionodraco myersi*	0.21	0.25	-	0.11	1.15	0.35	
N	*Trematomus* spp.	0.21	0.08	-	0.11	0.23	0.18	
A	*Artedidraco* spp.	-	0.08	-	0.21	0.46	0.18	
N	*Trematomus lepidorhinus*	12.24	2.83	2.45	0.11	1.38	0.35	
N	*Trematomus scotti*	0.86	0.25	5.63	0.11	2.53	0.53	B
B	*Prionodraco evansii*	-	0.58	2.69	0.53	2.07	1.06	
B	Bathydraconidae spp.	-	0.25	-	-	-	0.18	
B	*Gerlachea australis*	-	0.08	0.49	-	-	0.18	
B	*Gymnodraco acuticeps*	-	0.08	-	-	0.23	-	
A	*Pogonophryne scotti*	0.11	-	-	-	-	-	
B	*Akrotaxis nudiceps*	-	-	-	0.11	-	-	
CH	*Pagetopsis macropterus*	-	-	-	0.11	-	-	not
CH	*Pagetopsis maculatus*	-	-	0.24	-	-	-	consid-
N	*Trematomus bernacchii*	-	0.17	-	-	-	-	ered
N	*Pleuragramma antarcticus*	-	0.25	-	-	-	-	in
P	*Notolepis coatsi*	-	0.08	-	-	-	-	cluster
P	*Muraenolepis microps*	-	0.08	-	-	-	-	analysis
	fish indetermined	0.43	0.17	0.73	0.53	0.69	0.53	

Table 1. (Continued).

Taxon	Kapp Norvegia*	Lazarev Sea**	Halley Bay near shore**	Gould/ Vahsel Bay*	Vestkapp	*Halley Boy off shore
	"north"			"south"		
Chorismus antarcticus (n);	2.36	1.42	0.49	0.21	0.46	2.06
presence	50	28	17	7	10	25
(wet weight/	5.35/	3.22	1.11/	0.48/	1.04	4.67/
dry weight)	0.93	0.56	0.19	0.08	0.18	0.82
Notocrangon antarcticus (n)	6.76	1.25	33.45	7.06	4.83	7.57
presence	35	28	83	33	30	33
(wet weight/	27.90/	5.16/	138.05/	29.14/	19.93	31.24/
dry weight)	5.60	1.04	27.70	5.85	4.00	6.27
Nematocarcinus lanceopes (n)	9.56	3.42	-	0.74	2.30	2.24
presence	10	17	-	20	20	17
(wet weight/	47.87/	17.12/	-	3.71/	11.52	11.22/
dry weight)	10.16	3.64	-	0.79	2.44	2.38
no. of specimens	76	73	139	174	33	60

A: Artedidraconidae; B: Bathydraconidae; CH: Channichthyidae; N: Nototheniidae; P: Paralepididiae; L: Liparidae; Z: Zoarcidae

M: Muraenolepididae (Gadiformes)

* data from ANT III, VI, VII

** data from ANT IX

One remarkable result of the cluster analysis showed a high degree of dissimilarity between both Halley Bay areas based on the characteristics described above and shown in Table 1.

3.2. *Shrimps*

Abundance of shrimp according to the geographical areas is listed in Table 1. The three species investigated were observed on photographs from nearly all areas with abundances between 0.21 n/100 m^2 (*Chorismus antarcticus* in the Gould/Vahsel Bay) and 33.45 n/100 m^2 (*Notocrangon antarcticus* in the Halley Bay near-shore area) with presences ranging from 7 to 83% of the investigated stations. Only in one area (Halley Bay near-shore) one species (*Nematocarcinus lanceopes*) was totally absent. These results show a clear difference in the shrimp fauna between the two newly investigated areas: the Lazarev Sea with low abundance and presence for all three species, and the Halley Bay near-shore area with highest abundance and presence of only one species, *C. antarcticus.*

The abundance according to depth for the single stations is shown in Fig. 2. In the near-shore Halley Bay area *Notocrangon antarcticus* was present at all depths with abundance between 11.53 and 78.95 n/100 m^2. *Chorismus antarcticus* was observed only at one shallow station with low density. In the Lazarev Sea *C. antarcticus* and *N. antarcticus* covered nearly the full depth range on the shelf down to 500 m with maximum abundance of 11.97 and 13.47 n/100 m^2 respectively. However, the presences for both species were below 50%. *N. lanceopes*

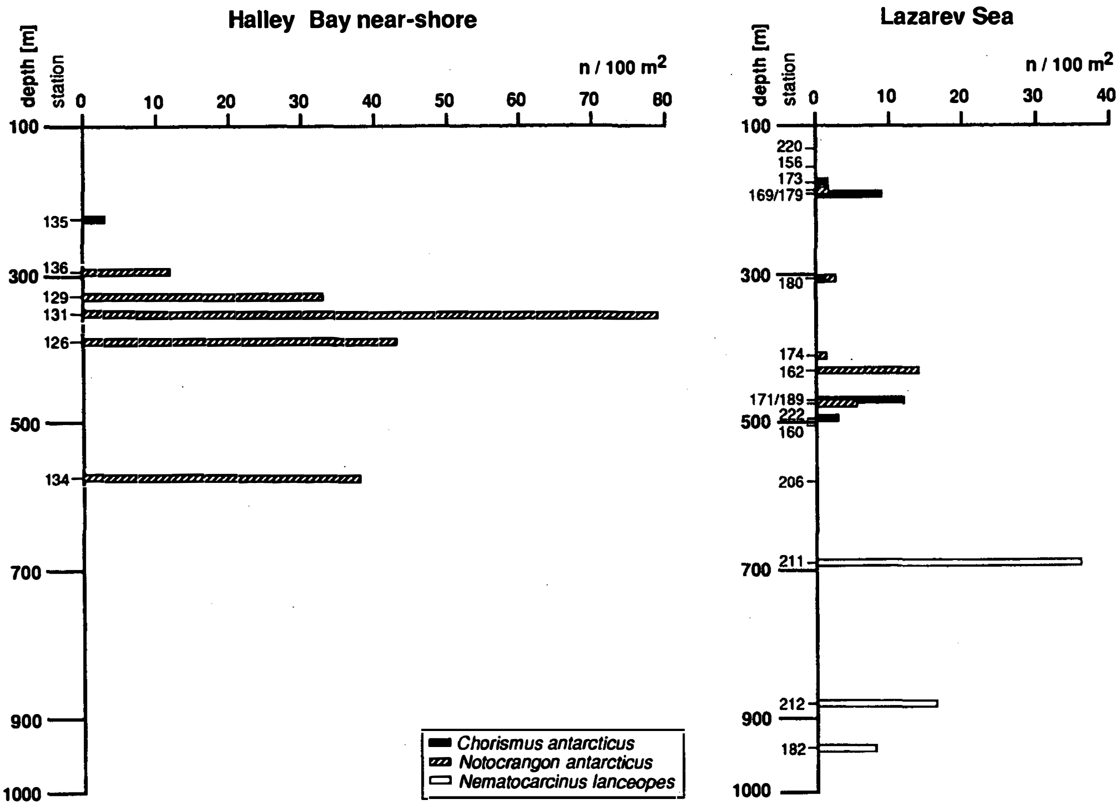

Fig. 2. Abundances of shrimps according to depth.

was photographed only at the three stations that were deeper than 600 m with abundance between 7.51 and 35.61 n/100 m^2. The biomass values were calculated by the use of mean individual weights and conversion factors from wet weight to dry weight obtained from trawl catches for each of the species separately (Gorny, 1992).

The small scale spatial dispersion patterns within each station were statistically analysed for those with an abundance of more than 24 specimens per species (Fig. 3). The patterns were random for *Notocrangon antarcticus* at stns 126, 134, and for *Nematocarcinus lanceopes* at stn. 211, whereas it was patchy for *N. antarcticus* at stn. 131.

4. Discussion

4.1. Fishes

The fish fauna of Antarctic waters was separated by Andriashev (1965) into two faunistic regions: A West Antarctic province with relatively high abundance and low diversity, and an East Antarctic province with a relatively high species richness but low abundance (Hubold, 1992). The provinces also differ in species composition. Off the Antarctic Peninsula the *Notothenia*-species are dominant whereas in the Weddell and Ross Sea *Trematomus, Chionodraco* and *Pleuragramma* are more abundant. However, the continental shelf waters of the East Antarctic are not homogeneous in terms of environmental factors. The Weddell

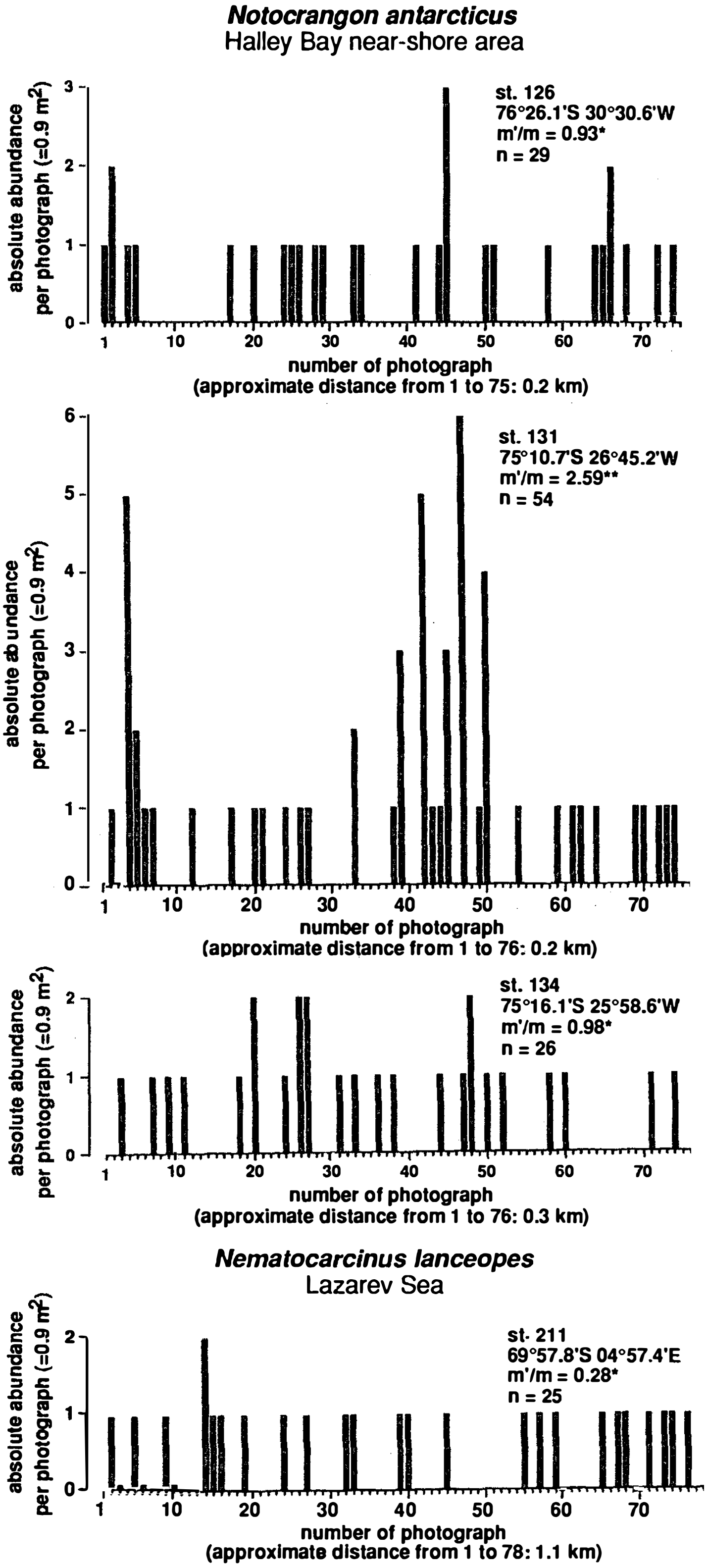

Fig. 3. *Dispersion patterns of shrimps.*
**denotes no significant departure from randomness ($p<0.05$).*
***denotes departure from randomness ($p<0.05$)=patchy dispersion pattern, because $m'/m>1$.*

as well as the Ross Sea are large areas with specific oceanographic regimes and for the most part have a much broader shelf than the rest of the Antarctic coast. This must influence the local fauna directly or indirectly. Within the Weddell Sea the fish fauna is less diverse and lower in biomass in the south (Gould/Vahsel Bay) than on the southeastern shelf between the Atka Bay and the Halley Bay area. The results show that the faunal composition of the Weddell Sea is similar to the newly investigated Lazarev Sea. Thus, the inclusion of the Weddell Sea in the East Antarctic Province established by ANDRIASHEV (1965), DEWITT (1970), SCHWARZBACH (1988) and EKAU (1990) is confirmed by the results based on underwater-photography. However, all areas investigated within the East Antarctic province show a patchy species composition, whereas the Lazarev Sea is most similar to the northern Weddell Sea and very different from the southern Weddell Sea. The latter forms a special kind of a subprovince within the Greater Antarctic District (KOCK, 1985).

The difference in species composition within the Halley Bay area coincides with faunistic results for the benthos. Different communities abut each other in this area (VOß, 1988; GUTT, 1991). Because most of the fish species feed on benthic or hyperbenthic organisms (SCHWARZBACH, 1988), the diversity within this area can be explained partly by the different food sources. The more pelagic feeding Channichthyidae are more dominant in the Halley Bay off-shore area where the epibenthos is known to be relatively poor in abundance and species diversity on the very broad shelf with low near bottom current. These fishes were observed to swim some decimeters to a few meters above the bottom in a more open habitat than that found in the sponge communities. In the same environment, species like *Pogonophryne* sp., *Trematomus loennbergii* and *Chionodraco myersi* use the sea floor, where it is not covered by the epifauna, to rest on or even to move across using their pelvic fins (*Pogonophryne*). Most of the Nototheniids are more dominant in the near-shore Halley Bay area, where they make use of the rich epibenthic community as their habitat (EKAU and GUTT, 1991). However, in this area open habitat species are also present, which indicates that this area is a transitional faunistic region with a small scale, highly varying species composition in terms of the benthic and hyperbenthic communities and as a consequence a high β-biodiversity (between habitats) for the twhole area. The same holds true for the Lazarev Sea with a highly patchy distribution of the benthic assemblages (GUTT, 1992). As a consequence a high number of fish species appear that are closely linked to the benthic communities. A similar result of a higher percentage of non-notothenioid species in the Lazarev than in the Weddell Sea was also obtained by trawl catches (WÖHRMANN and ZIMMERMANN, 1992). However, the macrourid *Macrourus holothrachys* which dominated the deeper catches was totally absent on the photographs. This might be due to this species swimming further above the bottom than most other demersal fishes.

4.2. Shrimps

For the shrimps a similar link between the three dominant species and their environment is known. *Chorismus antarcticus* was generally found in the Weddell

Sea on the shallower shelf in the "Eastern Shelf Community" sensu Voß (1988), usually resting on sponges when observed using underwater photographic methods. This habitat to which the Halley Bay near-shore area belongs was also found to be preferred by the notothenioid fishes. *Notocrangon antarcticus* is most abundant on the deeper shelf where it was often observed partly buried in the sediment in areas without a rich epifauna (GUTT *et al.*, 1991). Here among the fishes the Channichthyidae are known to be dominant. The high abundance and presence of *N. antarcticus* in the Halley Bay near-shore and the low values for the off-shore area are in contrast to the results on benthic assemblages and on the above presented results on the fish fauna. The low abundance of *C. antarcticus* in the Halley Bay near-shore area, however, might be due to the lack of the large sponges in this area on which they are usually observed, here the epifauna mostly consists of masses of the small *Rossella racovitzae*, budding type (BARTHEL and GUTT, 1991), and different compound ascidians (own unpubl. results). These taxa are apparently not the preferred substratum of *C. antarcticus.* The high abundance of *N. antarcticus* can only be explained by the relatively high presence of small patches without epifauna similar to the Halley Bay off-shore area, within the benthic assemblage generally dominated by the near-shore epifauna. The complete lack of *Nematocarcinus lanceopes* near-shore is due to the water depths which lie in this area above the distribution range of this species.

In the Lazarev Sea *Notocrangon antarcticus* was rare and *Chorismus antarcticus* and *Nematocarcinus lanceopes* showed an intermediate abundance relative to the other areas of investigation. The presences are lower than for the adjacent Kapp Norvegia area. This indicates that the degree of patchiness in benthic assemblages within the Lazarev Sea is higher than in other areas and that therefore the Lazarev Sea harbours a broader variety of different habitats. A similar result of high β-diversity among fishes is described above. No difference in depth preference for *C. antarcticus* and *N. antarcticus* as described by ARNTZ and GORNY (1991) and GUTT *et al.* (1991) for the Weddell Sea was found. This result leads to the conclusion that the preference of different depth ranges is due to the environment, *e.g.* substratum, which can change with depth and therefore influences only indirectly the composition of the shrimp fauna. In this case no true vertical zonation for both species exists.

This medium-scale, patchy distribution between stations was generally not found for a smaller spatial scale within stations with high abundance, which represent a transect length of 0.20 to 1.06 km. Only at one station of the three in the Halley Bay near-shore area a slightly patchy dispersion was found for *Notocrangon antarcticus*, at the other two stations the pattern was random for this species. At another station the dispersion pattern for *Nematocarcinus lanceopes* was also at random. The comparison of the distribution patterns on different spatial scales (between areas, within one area and within one station) indicate that the size in a one dimensional extension of significant shrimp patches lies between a few hundred meters and a few kilometers. Similar results were obtained by GUTT *et al.* (1991) for the same species in the Gould Bay, Halley

Bay off-shore, and Kapp Norvegia area.

5. Ecological Conclusion

The results on the fishes as well as those on the shrimps show that within the East Antarctic faunal province a certain degree of patchiness occurs in both taxa and that there is a general overlap with results of the benthos. Thus, it can be concluded that a coupling exists in terms of energy flow between the sessile life on the sea floor (in- and epifauna), the motile benthos (shrimps and others), the hyperbenthos (crustaceans and other components of the diet of demersal fishes)—for hyperbenthic krill in that area see GUTT and SIEGEL (1993)—and the pelagic environment (euphausiaceans and copepods).

Acknowledgments

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