TROPHIC ECOLOGY OF DEMERSAL FISH COMMUNITY NORTH OF THE SOUTH SHETLAND ISLANDS, WITH NOTES ON THE ECOLOGICAL ROLE OF THE KRILL

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Abstract: Bottom trawls at 8 stations and at depths from about 200 to 400 m were carried out to the north of the South Shetland Islands. Thirty-six species of fish belonging to 9 families were caught. *Notothenia gibberifrons, Chionodraco rastrospinosus, Gymnoscopelus nicholsi* and 2 Rajidae made up about 80% of the number of fish caught. The dominant species was *N. gibberifrons* accounting for 51.9% of the total number of individuals and 44.7% of the total weight. It is shown that the krill (*Euphausia superba,* DANA) is an important food item in the diet of these demersal fish and that while many nototheniid species supplement their diet with benthic organisms, channichthyid species supplement their diets with other fish. The significance of these results is discussed in relation to the distribution of the krill and to the ecological role of the krill in the Antarctic food chain.

1. Introduction

In view of the recent commercial exploitation of the Antarctic krill (*Euphausia superba*, DANA) it has become important to study the role of the krill in the trophic ecology of Antarctic ecosystem. The importance of the krill in the trophic ecology of Antarctic fish has been the subject of several studies (PERMITIN, 1970; PERMITIN and TARVERDIYEVA, 1972, 1978; KAWAMURA, 1976; ROWEDDER, 1979; TARGETT, 1981). Although these studies have made a valuable contribution to the trophic ecology of Antarctic fish, more information was required and in 1981 as part of the Japanese contribution to BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) a bottom trawling survey was carried out by the Japan Marine Fishery Resource Research Center at 8 stations to the north of the South Shetland Islands. The taxonomic information on this collection has already been published (IWAMI and ABE, 1982) and in this paper the food and feeding of the dominant species are described.

2. Materials and Methods

The material was collected during an exploratory krill fishery cruise of the 96-m research vessel YOSHINO MARU to the Antarctic in 1980/81. The locations of the stations fished are shown in Fig. 1 and full details of the stations are given in Table 1. The net used was a commercial bottom trawl with the headline length, the width between the wings and the headline height of 68.6, 23 and 8 m, respectively. The trawl was towed at a speed of 4 knots. To stop digestion of the stomach contents the fish were frozen by

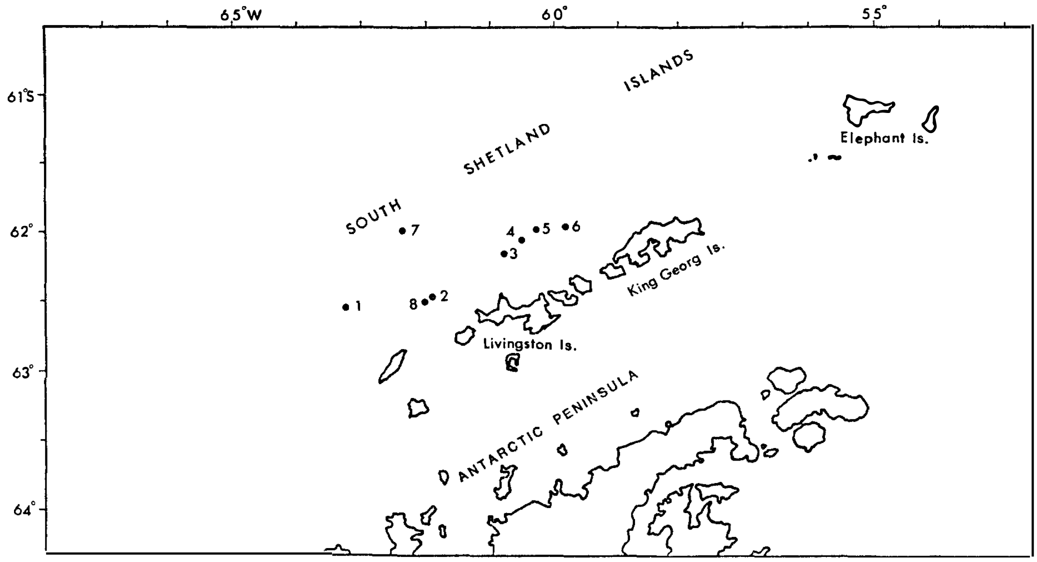

Fig. 1. Scotia Sea around the South Shetland Islands showing the stations where the bottom trawl was operated.

Table 1. The bottom trawling stations to the north of the South Shetland Islands.

Station number	Latitude	Longitude	Depth range (m)	Bottom water temperature (°C)	Date	Times
1	62°34′S	63°11′W	225–258	—	Jan. 8, 1981	1315–1330
2	62°29′S	61°52′W	189–189	−0.8	Jan. 8, 1981	1500–1530
3	62°10′S	60°47′W	406–420	−0.7	Jan. 8, 1981	2005–2035
4	62°06′S	60°32′W	284–305	−0.6	Jan. 8, 1981	2305–2325
5	62°02′S	60°17′W	360–370	−0.5	Jan. 9, 1981	0115–0145
6	61°59′S	59°48′W	250–258	−0.5	Jan. 9, 1981	0405–0425
7	62°02′S	62°21′W	350–429	−0.2	Jan. 9, 1981	0755–0835
8	62°31′S	62°06′W	295–300	−0.6	Jan. 9, 1981	1530–1550

a contact freezer at −40°C as soon as possible after capture. Later, in the laboratory the fish were identified, measured (standard length in mm) and weighed (g). Representative samples (up to 320) of stomach contents were removed from each of the main species, weighed and the prey items were identified. The results were expressed as the frequency of occurrence (the number of stomachs containing a particular prey item expressed as a percentage of the total number of stomachs containing food) and as the proportion by weight of each prey type.

3. Results and Discussion

The collection comprised 36 species of fish belonging to 9 families and the number of individuals and their weight for all stations combined are given in Table 2. The detailed species composition of each station has already been published (IWAMI and ABE, 1982). Five species, *Notothenia gibberifrons*, *Chionodraco rastrospinosus*, *Gymnoscopelus nicholsi* and 2 species of Rajidae accounted for 78.8% of the total number

Table 2. Weight and number of fish species caught by bottom trawl to the north of the South Shetland Islands.

Fish species	Weight caught	Percent by weight	Number caught	Percent by number
Nototheniidae:				
Notothenia gibberifrons	394.9 kg	44.7%	1892	51.9%
Pleuragramma antarcticum	5.7	0.6	147	4.0
Notothenia nybelini	5.0	0.6	99	2.7
N. kempi	3.6	0.4	13	0.4
Trematomus eulepidotus	2.3	0.3	16	0.4
Others (7 sepecies)*	4.7	0.5	23	0.6
Channichthyidae:				
Chionodraco rastrospinosus	131.3	14.9	314	8.6
Pseudochaenichthys georgianus	59.3	6.7	57	1.6
Champsocephalus gunnari	38.1	4.3	139	3.8
Chaenocephalus aceratus	37.9	4.3	81	2.2
Cryodraco antarcticus	16.5	1.9	118	3.2
Others (4 species)**	1.3	0.1	10	0.3
Bathydraconidae:				
Gymnodraco acuticeps	2.8	0.3	25	0.7
Others (2 species)***	0.6	0.1	13	0.4
Harpagiferidae:				
Pogonophryne scotti	0.9	0.1	2	0.1
P. spp.	0.4	0.1	1	0.1
Myctophidae:				
Gymnoscopelus nicholsi	13.9	1.6	385	10.6
Myctophidae sp.	0.2	0.1	14	0.4
Liparidae:				
Paraliparis somovi	0.1	0.1	1	0.1
P. sp.	0.1	0.1	1	0.1
Gadidae:				
Micromesistius australis	0.8	0.1	1	0.1
Zoarcidae				
Austrolycichthys spp.	1.0	0.1	11	0.3
Rajidae:				
Rajidae spp.	161.4	18.3	279	7.7
Total	882.8		3642	

* *Notothenia rossii, Thremátomus tokarevi, T. hansoni, T. scotti, Pagothenia brachysoma, Dissostichus mawsoni* and *Aethotaxis mitoptrys.*
** *Chionodraco myersi, Neopagetopsis ionah, Chaenodraco wilsoni* and *Pagetopsis macropterus.*
*** *Gerlachea australis* and *Racovitzia glacialis.*

of individuals caught. The dominant species was *Notothenia gibberifrons* accounting for 51.9% of the number of individuals and 44.7% of the total weight. The next most important species was *Chionodraco rastrospinosus* which accounted for 8.6 and 14.9% of the number of individuals and the weight of the total catch respectively. Although numerically important at 10.6% of the number of individuals, *Gymnoscopelus nicholsi* accounted only for 1.6% of the weight of the total catch because of its small size.

Table 3. Frequency of occurrence of food items in each of the main fish species caught by bottom trawl to the north of the South Shetland Islands.

Fish species \ Food item	Channichthyids	Notothenids	Myctophids	*E. superba*	Isopods	Amphipods	Copepods	Polychaetes	Zygophiurae	Bivalves	Ave. of others	No. of empty	No. of specimens examined
	%	%	%	%	%	%	%	%	%	%	%		
Cryodraco antarcticus	7.1	50.0		50.0								19	33
Pseudochaenichthys georgianus	10.3	10.3	3.4	96.6							3.4	18	47
Rajidae spp.		9.9	1.4	93.0	7.0	8.5					1.4	14	85
Chionodraco rastrospinosus	1.2	3.5	1.2	94.1		1.2					1.2	104	185
Chaenocephalus aceratus		4.5		100.0								23	45
Notothenia kempi			33.3	100.0								1	10
Champsocephalus gunnari			1.4	100.0								18	89
Notothenia gibberifrons				73.8	10.6	21.6		24.7	34.4	21.6	0.9	4	320
Trematomus eulepidotus				90.0	9.1	9.1		9.1				3	14
Notothenia nybelini				93.2		9.1		2.3			2.7	7	51
Gymnodraco acuticeps				100.0								6	10
Gerlachea australis				100.0								0	3
Racovitzia glacialis				100.0								1	2
Pleuragramma antarcticum				100.0								5	18
Gymnoscopelus nicholsi			3.1	93.8			78.1					7	39

The frequency of occurrence of the food items of the most important species is given in Table 3. It is evident that the krill is an important component of the diet of these Antarctic fish. Several species, *Pleuragramma antarcticum*, *Racovitzia glacialis*, *Gerlachea australis* and *Gymnodraco acuticeps* only had the krill in their stomachs but the number of fish examined was small. The dominant species *Notothenia gibberifrons* fed on a wide range of benthic and benthopelagic organisms such as isopods, amphipods, polychaetes, zygophiurae and bivalve molluscus in addition to the krill (Fig. 2). PERMITIN (1970) also showed that this species fed on a wide variety of benthic organisms. Amphipods, isopods and polychaetes were also present in the diet of the nototheniid *Trematomus eulepidotus*. While most species of the family Nototheniidae fed on a diet of the krill supplemented with benthic organisms, species of the family Channichthyidae supplemented their diet with fish of the families Channichthyidae, Nototheniidae and Myctophidae. The most common fish in the diet of the species *Cryodraco antarcticus* and *Pseudochaenichthys georgianus* were channichthyids and nototheniids (Figs. 3 and 4). PERMITIN (1970) also reported that *P. georgianus* feed on the fish and the krill and commented on the adaptations which enable this species to exploit both the demersal

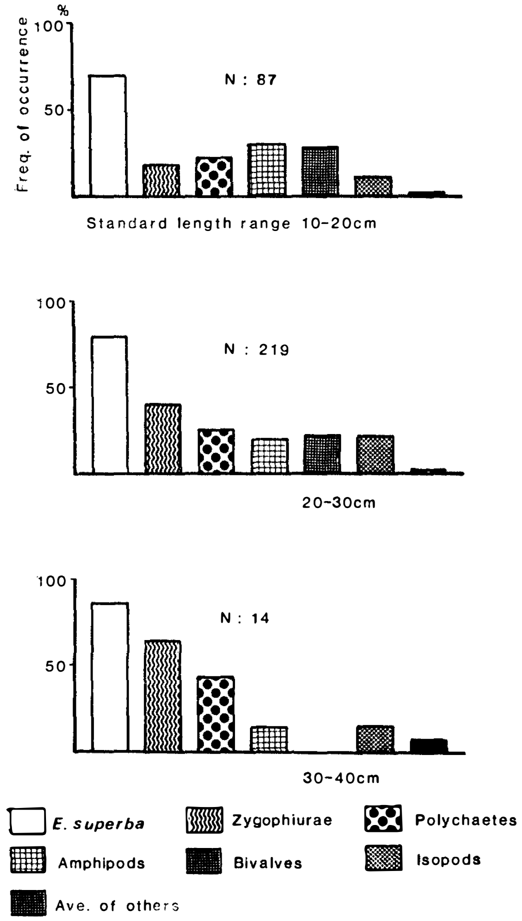

Fig. 2. Frequency of occurrence of food items in various length groups of Notothenia gibberifrons.

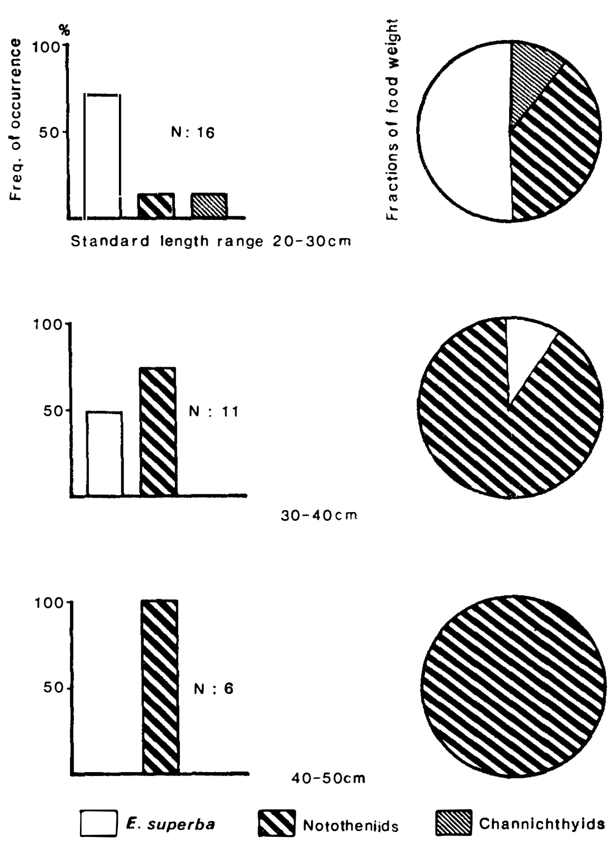

Fig. 3. Frequency of occurrence and proportional weight of food items in various length groups of Cryodraco antarcticus.

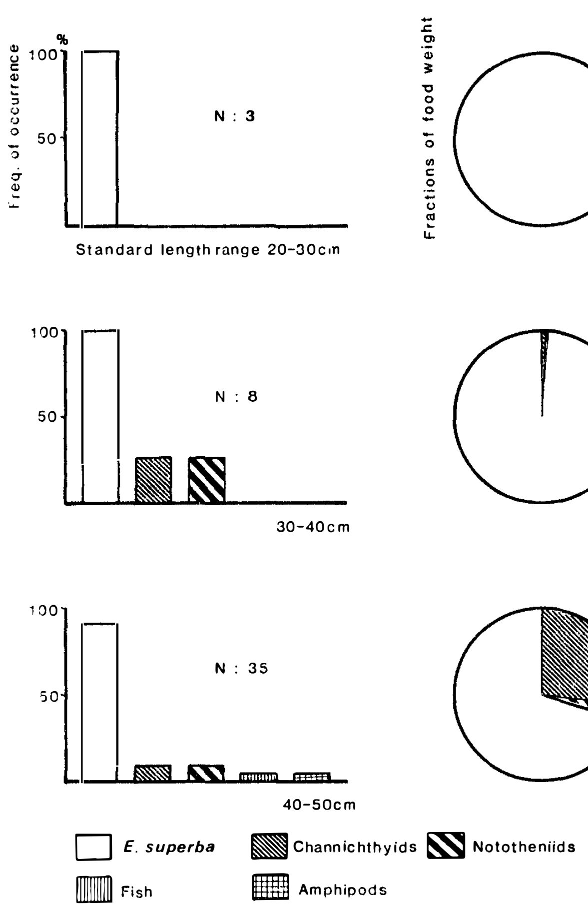

Fig. 4. Frequency of occurence and proportional weight of food items in various length groups of Pseudochaenichthys georgianus.

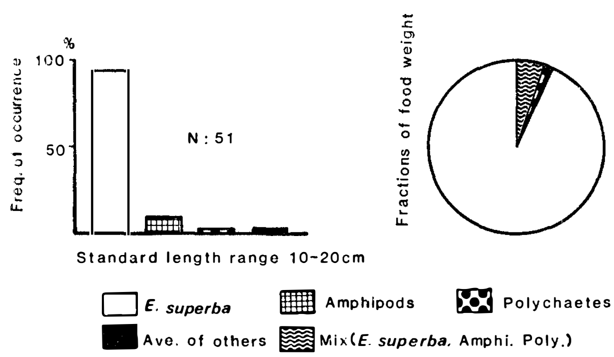

Fig. 5. Frequency of occurrence and proportional weight of food items in Notothenia nybelini.

and pelagic environments. Myctophids were of lesser importance in the diet of channichthyid fish but were important in the diet of the nototheniid *Notothenia kempi*, although only a few fish were examined.

Figures 2, 3 and 4 also show how the diet of *N. gibberifrons*, *P. georgianus* and *C. antarcticus* changes with increasing size of the fish and for the latter two species the relative importance of the krill and the fish in terms of weight. Further examples for the

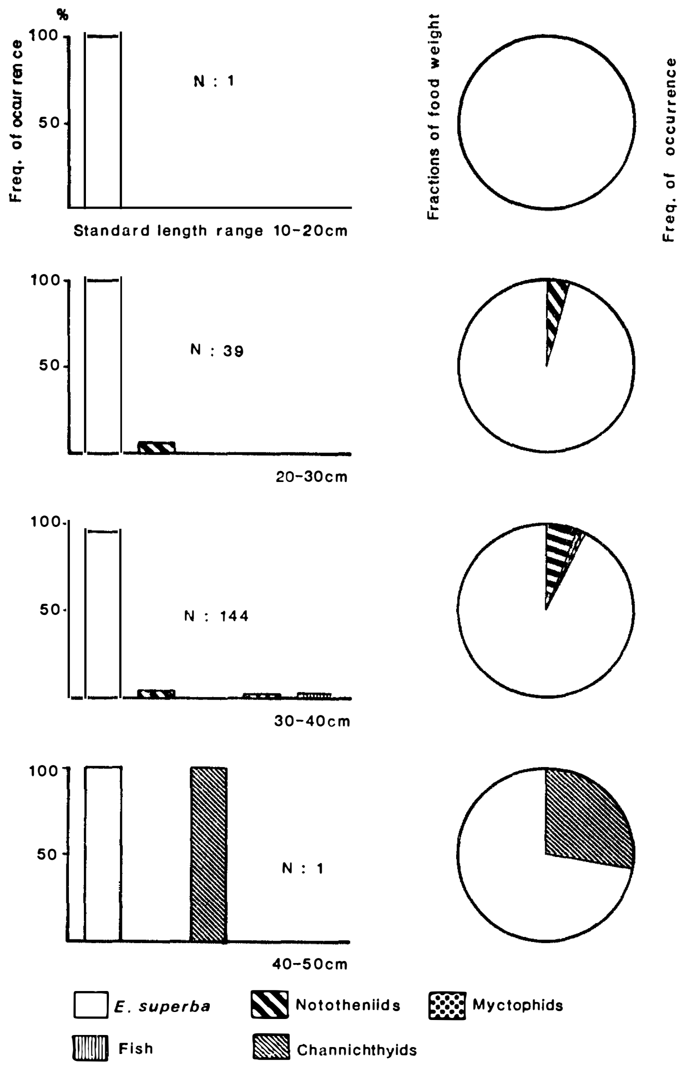

Fig. 6. Frequency of occurrence and proportional weight of food items in various length groups of Chionodraco rastrospinosus.

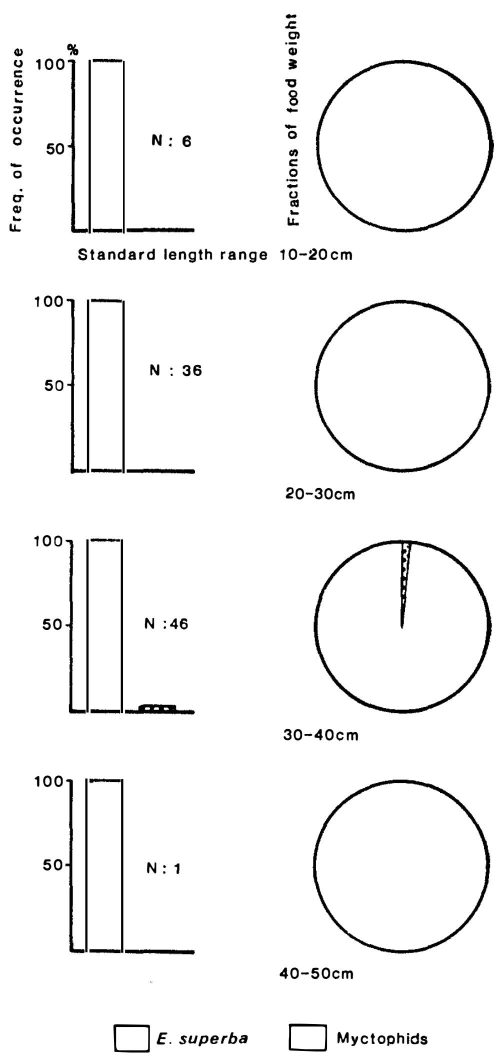

Fig. 7. Frequency of occurrence and proportional weight of food items in various length groups of Champsocephalus gunnari.

nototheniid *Notothenia nybelini* and the channichthyids *Chionodraco rastrospinosus* and *Champsocephalus gunnari* are shown in Figs. 5, 6 and 7 respectively, and in addition to showing an increase in importance of the fish in the diet with increasing size also demonstrate the importance of the krill in terms of weight. The greater importance of the krill in the diet of smaller channichthyid fish may be related to the observation by NYBELIN (1947) that juvenile channichthyids feed in the pelagic zone.

The krill from the stomachs of several species were measured and their body length frequency distributions are shown in Fig. 8. The body length greater than 40 mm was dominant. It suggests that the fish either actively select this size group or that only adult krill were available at the location or the time of sampling. An analysis of the consumption of the krill at each of the stations (Table 4) shows that there was no evidence to suggest a dial variation in feeding and this together with the fact that they had

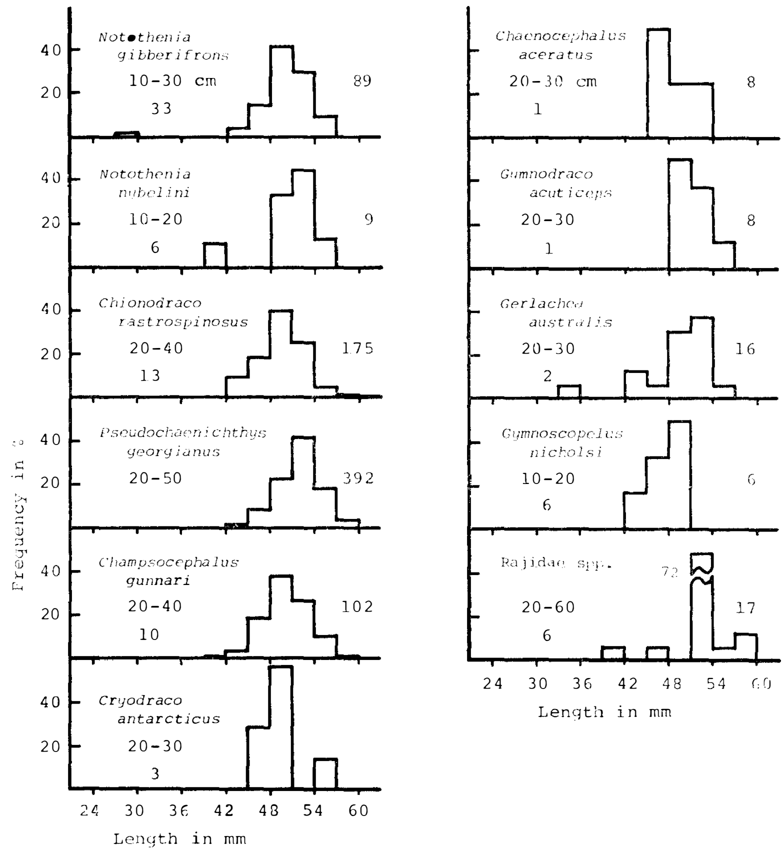

Fig. 8. Body length frequency of E. superba *found in stomachs of each fish species. Left: standard length range and number of each fish species examined. Right: number of krill measured.*

Table 4. The frequency of occurrence of E. superba *found in stomachs of each fish species at different times of the day.*

Species \ Net number	1	2	8	3	4	5	6	7
Towing time	1315–1330	1500–1530	1530–1550	2005–2035	2305–2325	0115–0145	0405–0425	0775–0835
Depth range (m)	225–258	189	295–300	406–420	284–305	360–370	250–258	350–429
Notothenia gibberifrons	52.2%	70.2%	73.9%	92.6%	95.0%	98.0%	43.3%	83.3%
N. nybelini	90.9	—	100.0	100.0	100.0	100.0	88.2	100.0
N. rossii	—	100.0	—	—	—	—	—	—
Trematomus eulepidotus	100.0	—	100.0	0.0	—	—	—	—
Pleuragramma antarcticum	—	—	100.0	—	—	100.0	—	100.0
Chionodraco rastrospinosus	100.0	94.4	—	100.0	100.0	75.0	—	96.7
Pseudochaenichthys georgianus	100.0	90.5	100.0	—	—	—	—	100.0
Chaenocephalus aceratus	100.0	100.0	100.0	—	—	—	100.0	100.0
Cryodraco antarcticus	—	—	—	100.0	—	50.0	100.0	25.0
Champsocephalus gunnari	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Gymnodraco acuticeps	—	100.0	—	100.0	100.0	—	—	—
Gerlachea australis	—	—	—	—	—	—	—	100.0
Racovitzia glacialis	—	—	—	—	—	100.0	—	—
Austrolycichthys sp.	—	—	—	—	—	100.0	100.0	96.2
Gymnoscopelus nicholsi	77.8	—	—	100.0	100.0	100.0	75.0	85.7

— Not caught or not examined.

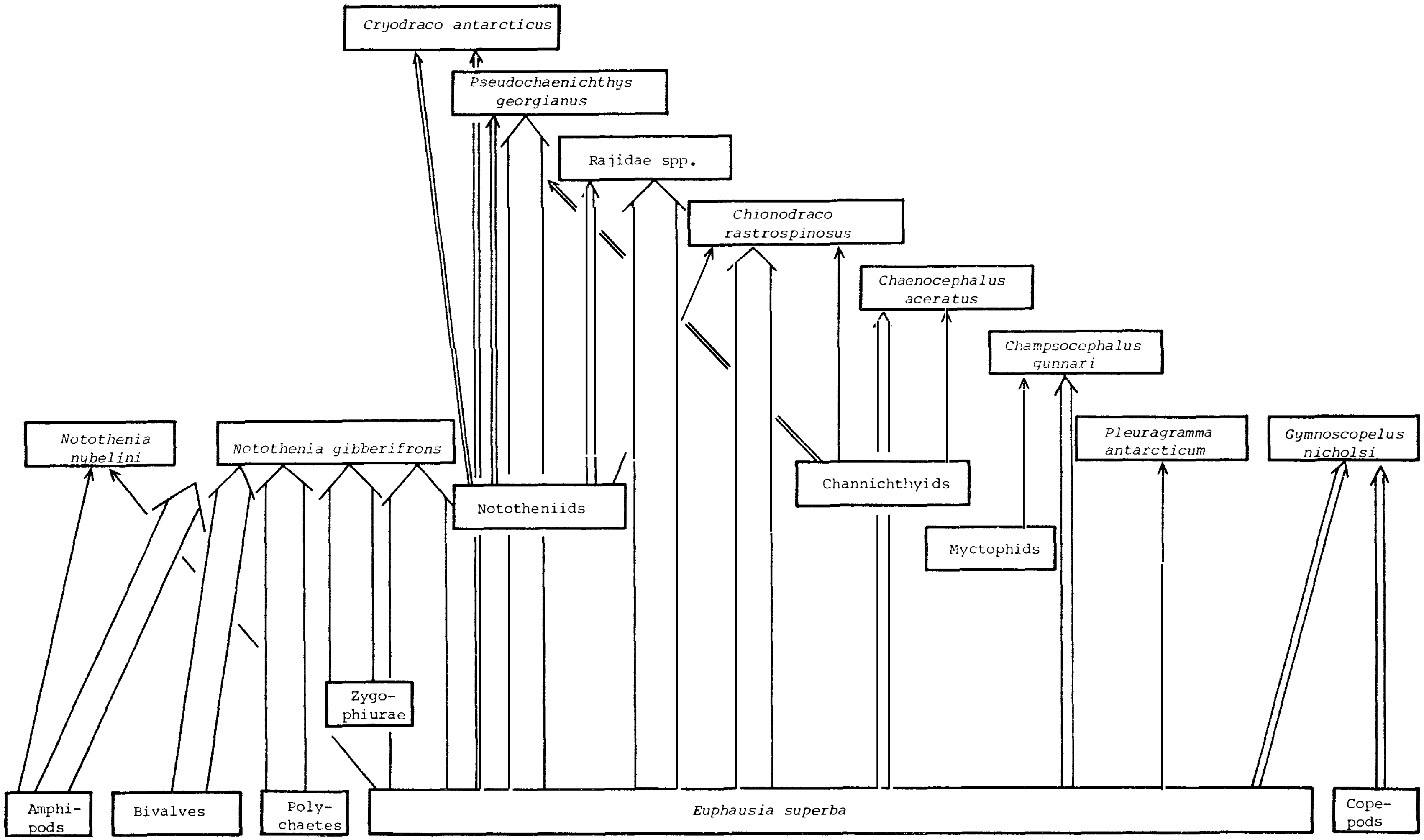

Fig. 9. The food chain of demersal fish community to the north of the South Shetland Islands.

the appearance of being recently ingested suggests that the krill can have a benthopelagic distribution. Further support for the view comes from the observation by PERMITIN (1970) that *Notothenia gibberifrons* does not migrate vertically to feed on the krill.

Figure 9 is an attempt to summarize the food of the benthopelagic and benthic fish and to show the importance of the krill in the diets of these fish. The nototheniid fish are major consumers of the krill and also exploit the benthos to a lesser degree. The channichthyids are also primary consumers of the krill but also feed at a higher trophic level on nototheniids, channichtyids and myctophids which in their term have consumed the krill. Thus, as is indicated by the horizontal scale of Fig. 9, the krill is the most important single food item of these Antarctic demersal fish. Clearly more investigations are required to obtain a full understanding of the predator-prey relationships particularly with regard to the food and feeding of different size groups of fish.

The predators of these fish are unknown but CLARKE (1980) has stated that large squids frequently have fish as their diet. There is a requirement for further quantitive studies on the role of these fish as prey items for a better understanding of the Antarctic marine ecosystem.

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References

CLARKE, M. (1980): Cephalopoda in the diet of sperm whales of the southern hemisphere and their bearing on sperm whale biology. Discovery Rep., **36**, 1–324.

IWAMI, T. and ABE, T. (1982): Notes on the fishes collected during the 1980–1981 exploratory bottom trawl fishing off the South Shetland Islands. Mem. Natl Inst. Polar Res., Spec. Issue, **23**, 55–63.

KAWAMURA, A. (1976): A note on the stomach contents of some fish caught during exploratory trawl fishing for krill. BIOMASS Vol. II; Selected Contributions to the Woods Hole Conference on Marine Living Resource of the Southern Ocean 1976, ed. by S. Z. EL-SAYED *et al.* Cambridge, Scott Polar Res. Inst., 69–71.

NYBELIN, O. (1947): Antarctic fishes. Sci. Res. Norw. Antarct. Exp., 1927–1928, **26**, 1–76.

PERMITIN, Yu. E. (1970): The consumption of krill by Antarctic fishes. Antarctic Ecology, Vol. 1, ed. by M. W. HOLDGATE. London, Academic Press, 177–182.

PERMITIN, Yu. E. and TARVERDIYEVA, M. I. (1972): Feeding of some species of Antarctic fishes in South Georgia Island area. J. Ichthyol., **12**, 104–114.

PERMITIN, Yu. E. and TARVERDIYEVA, M. I. (1978): Feeding of Antarctic cods (Nototheniidae) and ice fish (Chaenichthydae) near the South Orkney Islands. Biol. Morya (Valdivost.), **2**, 75–81.

ROWEDDER, U. (1979): Feeding ecology of the Myctophid *Electrona antarctica*. Meeresfors chung, **27**, 252–263.

TARGETT, T. E. (1981): Trophic ecology and structure of coastal Antarctic fish communities. Mar. Ecol. Prog. Ser., **4**, 243–263.

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