BY-CATCH, GROWTH AND FEEDING OF ANTARCTIC JUVENILE FISH TAKEN IN KRILL (*EUPHAUSIA SUPERBA* DANA) FISHERIES IN THE SOUTH GEORGIA AREA, IN 1992

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Abstract

This paper discusses an investigation of juvenile Antarctic fish caught during krill fishing by the FV *Grigory Kovtun* in the area around South Georgia from May to July 1992. Two species were predominant in the by-catches: *Champsocephalus gunnari* and *Nototheniops larseni*. The frequency of occurrence of juvenile fish was 18.2% when all krill tows were included and 45.5% when only tows made in shelf waters were considered. The abundance of juvenile fish in catches, normalised to one tonne of krill, ranged from 700 to 18 900 individuals. In the case of *C. gunnari*, average values were 966 ± 225 ind./tonne krill and 2 434 ± 579 ind./tonne krill for all trawls and for shelf trawls, respectively. For *N. larseni* the corresponding averages were 557 ± 103 and 1 388 ± 248. The mean standard length of *C. gunnari* was 68.5 to 79.7 mm in May and June and 93 mm in late July. The mean growth rate of this species over this period is estimated to be 0.37 mm per day. In May to June, *N. larseni* juveniles were represented by fingerlings (mean length of 42.4 to 47.4 mm) and yearlings (72.5 to 73.7 mm). In late July the mean length of fingerlings increased to 48.5 mm. The mean daily length increase in *N. larseni* is estimated to be 0.08 mm. The diet, by mass, of both *C. gunnari* fingerlings and *N. larseni* yearlings was dominated by juveniles of *Euphausia superba*. The food bolus in *N. larseni* fingerlings consisted mainly of Chaetognatha, Copepoda and furcilia of *Thysanoessa* spp. According to the data obtained from the Ukrainian krill fishing fleet in the South Georgia area from May to August 1992, the total removals of *C. gunnari* and *N. larseni* resulting from by-catches are estimated to be 34.3 ± 8.0 and 19.8 ± 3.7 million individuals, respectively.

Résumé

Les auteurs présentent une discussion sur l'étude des juvéniles de poissons antarctiques capturés au cours de la pêche de krill par le navire FV *Grigory Kovtun* dans le secteur de la Géorgie du Sud de mai à juillet 1992. Deux espèces dominaient dans les captures accessoires : *Champsocephalus gunnari* et *Nototheniops larseni*. Le taux de fréquence des juvéniles de poissons était de 18,2% quand tous les chalutages étaient pris en compte et de 45,5% lorsque seuls l'étaient les chalutages des eaux du plateau. L'abondance des juvéniles de poissons dans les captures, normalisée par tonne de krill, variait de 700 à 18 900 individus. Dans le cas de *C. gunnari*, les valeurs moyennes étaient de 966 ± 225 individus/tonne de krill pour tous les chalutages et de 2 434 ± 579 individus/tonne de krill pour les chalutages effectués sur le plateau. Pour *N. larseni*, les moyennes respectives étaient de 557 ± 103 et 1 388 ± 248. La longueur moyenne standard de *C. gunnari* était de 68,5 à 79,7 mm en mai et juin et de 93 mm fin juillet. Le taux de croissance moyen de cette espèce au cours de cette période est estimé à 0,37 mm par jour. En mai et juin, les juvéniles de *N. larseni* étaient représentés par des alevins (d'une longueur moyenne de 42,4 à 47,4 mm) et des juvéniles de un an (72,5 à 73,7 mm). Fin juillet, les alevins atteignaient une longueur moyenne de 48,5 mm. La croissance moyenne de *N. larseni* est estimée à 0,08 mm/jour. Les juvéniles d'*Euphausia superba* dominaient en poids dans l'alimentation des alevins de *C. gunnari* et des poissons d'un an de *N. larseni*. Le bol alimentaire des alevins de *N. larseni* consistait principalement en Chaetognatha, copépodes et furcilia de *Thysanoessa* spp. Selon les données fournies par la flottille de pêche de krill ukrainienne opérant dans le secteur de la Géorgie du Sud de mai à août 1992, la capture accessoire totale de *C. gunnari* et de *N. larseni* est estimée respectivement à 34,3 ± 8,0 et 19,8 ± 3,7 millions d'individus.

Резюме

В настоящей работе обсуждается исследование молоди антарктических рыб, пойманных при промысле криля, проводившемся судном *Григорий Ковтун* в районе Южной Георгии в период май-июнь 1992 г. В прилове доминировали два вида - *Champsocephalus gunnari* и *Nototheniops larseni*. Когда были приняты в расчет все траления, частота встречаемости молоди рыб составляла 18,2%, а когда были учтены только траления, проведенные в шельфовых водах - 45,5%. Количество молоди рыбы в уловах, нормализованное на одну тонну криля, колебалось в диапазоне 700 - 18 900 особей. В случае *C. gunnari* средние значения были 966 ± 255 особей/тонну криля (все траления) и 2 434 ± 579 особей/тонну криля (шельфовые траления). В случае *N. larseni* соответствующие величины составили 557 ± 103 и 1 388 ± 248. В мае-июне средняя стандартная длина *C. gunnari* равнялась 68,5 - 79,7 мм, а в конце июля - 93 мм. Средний темп роста этого вида за данный период оценивается в 0,37 мм/день. За период с мая по июнь молодь *N. larseni* была представлена сеголетками (средняя длина 42,4 - 47,4 мм) и годовиками (72,5 и 73,7 мм). В конце июля средняя длина сеголетков возросла до 48,5 мм. Средний ежедневный прирост *N. larseni* оценивается в 0,08 мм. В рационе (по весу) как сеголетков *C. gunnari*, так и годовиков *N. larseni*, преобладала молодь *E. superba*. Пищевые комки у *N. larseni* в основном состояли из Chaetognatha, Copepoda и фурцилий *Thysanoessa* spp. По данным, полученным с ведущих промысел криля украинских судов за период май-август 1992 г., общее изъятие *C. gunnari* и *N. larseni* в результате прилова оценивается соответственно в 34,3 ± 8,0 и 19,8 ± 3,7 млн. особей.

Resumen

Este documento considera un estudio de los peces antárticos juveniles capturados por el buque de pesca *Grigory Kovtun* durante la pesca de kril realizada de mayo a julio de 1992 a la altura de Georgia del Sur. La captura secundaria estuvo compuesta principalmente de *Champsocephalus gunnari* y *Nototheniops larseni*. El índice de ocurrencia de peces juveniles fue de 18.2% cuando se consideró la totalidad de los arrastres de kril, y de 45.5% cuando se consideraron los arrastres hechos en aguas de la plataforma solamente. La abundancia de peces juveniles por tonelada de captura de kril osciló entre 700 y 18 900 ejemplares. En el caso de *C. gunnari*, los valores promedios fueron de 966 ± 225 ejemplares por tonelada de kril, y de 2 434 ± 579 ejemplares por tonelada de kril para todos los arrastres y para los arrastres en aguas de la plataforma, respectivamente. Por otra parte, los promedios correspondientes a *N. larseni* fueron 557 ± 103 y 1 388 ± 248. La talla media normal de *C. gunnari* fue 68.5 y 79.7 mm en mayo y junio, respectivamente y 93 mm a fines de julio. La tasa de crecimiento promedio de esta especie en este período se estima en 0.37 mm por día. La presencia de *N. larseni* juveniles en el período de mayo a junio consistió principalmente de pececillos (talla promedio 42.4 a 47.4 mm) y de peces de un año (72.5 a 73.7 mm). A fines de julio la talla promedio de los pececillos aumentó a 48.5 mm. El crecimiento diario promedio para *N. larseni* se calcula en 0.08 mm. La dieta, en masa, de los pececillos de *C. gunnari* y de los peces de un año de *N. larseni*, estuvo compuesta en su mayoría por juveniles de *Euphausia superba*. El bolo alimenticio en los pececillos de *N. larseni* estuvo compuesto principalmente de Chaetognatha, Copepoda y furcilia de las especies *Thysanoessa*. Los datos de la flota pesquera ucraniana que faenó el kril de mayo a agosto de 1992 en Georgia del Sur, dan una captura secundaria total de *C. gunnari* y *N. larseni* de 34.3 ± 8.0 y 19.8 ± 3.7 millones de ejemplares, respectivamente.

Keywords: by-catch, juvenile fish, krill, fisheries, feeding, growth, South Georgia, Antarctica, CCAMLR

INTRODUCTION

Despite increased interest in the problem of the by-catch of juvenile fish during krill (*Euphausia superba*) fishing, this aspect has not been studied very thoroughly (Rembiszewski *et al.*, 1978; Slosarczyk and Rembiszewski, 1982; Kellermann and Slosarczyk, 1984; Slosarczyk, 1986; Everson *et al.*, 1991; Pankratov and Pakhomov, 1992). In addition, the mortality of juvenile fish, especially where intensive krill fisheries occur around isolated oceanic islands, may have a considerable impact on the recruitment of commercial fish stocks in these areas. In this paper, the distribution, abundance, growth and diet of juvenile fish collected in the South Georgia region during krill fishing are analysed.

MATERIAL AND METHODS

The material was collected from May to July 1992 aboard the FV *Grigory Kovtun* around South Georgia (Subarea 48.3) at depths from 140 to 2 000 m (Figure 1). Hauls were conducted between 10 and 150 m (Table 1) using a modified version of the commercial midwater trawl 74/600 with a mouth area ≈400 m^2 and mesh size ≈10 mm. The catches of 55 trawls made during this operational period were analysed. Of these, only 10 (18.2%) contained juvenile fish. Fish were selected from subsamples of 10 to 100 kg of krill and frozen immediately. Frozen samples were transported to the laboratory and analysed. Subsample counts were used to estimate the total sample abundance by direct extrapolation (Table 1). Juveniles were then analysed for taxonomic identification, stomach content, standard length (with an accuracy of ≈1 mm) and weight (with an accuracy of ≈0.01 g). The main components found in the fish stomachs were measured (euphausiids: from the tip of the rostrum to the end of telson) and weighed. The stomach contents of 108 specimens of *Champsocephalus gunnari* and 73 specimens of *Nototheniops larseni* were analysed. The stomach fullness index (%) was calculated by dividing wet weight of gut contents by total wet weight of the fish. The gut contents of *N. larseni* fingerlings were always completely digested. Consequently, data on their gut contents are expressed simply as the frequency of occurrence of dietary components.

This survey was not ideal for estimating by-catches of juvenile fish. Therefore, for the calculation of the average rate of removal of juvenile fish resulting from by-catches, both the arithmetic mean and the efficient estimator (Pennington, 1983) have been used. According to Pennington (1983), treating the zeros separately can lead to a more accurate estimation of abundances. Our data contained many zero values and were highly skewed to the right (Figure 2). As various tests of normality applied to the data did not reject the assumption that the log of the non-zero values is normally distributed, estimations based on the delta distribution theory were used. For a more detailed discussion of procedures and methodology, see Aitchison and Brown (1969) and Pennington (1983).

The following are the unbiased estimators of the efficient mean (*c*) and variance (*d*) of the delta distribution:

$$c = \frac{m}{n}\, \mathrm{e}^{y}\, G_m\left(\frac{1}{2}S^2\right) \tag{1}$$

$$d = \frac{m}{n}\, \mathrm{e}^{2y}\left[G_m\left(2S^2\right) - \frac{(m-1)}{(n-1)} G_m\left(\frac{m-2}{m-1}S^2\right)\right] \tag{2}$$

where y and S^2 are the sample mean and variance of the log of the non-zero cases, n is the total number of cases, m is the number of non-zero cases and $G_m(t)$ is a matrix function (Pennington, 1983). Solutions for this function were taken from Aitchison and Brown (1969, Table A2).

RESULTS AND DISCUSSION

Composition and Size of By-catches of Juvenile Fish from Krill Fisheries

Two fish species, *C. gunnari* and *N. larseni*, predominated in all the samples. Other species were present in only two catches: a single juvenile of *Harpagifer georgianus* in one, and one specimen belonging to the family Bathydraconidae in the other. In general, each trawl was dominated by one species which usually constituted 82 to 100% of the total fish catch (Table 1). This suggests a high degree of spatial dissociation between juveniles of different species.

Estimates of fish abundance in the catches, normalised to one tonne of krill caught, ranged widely, from 700 to 18 900 specimens (Table 1), with an arithmetic mean for all trawls (55) of 1 401 ± 554 specimens. This is subdivided as follows: 766 ± 414 specimens of *C. gunnari* and 633 ± 376 of *N. larseni*. The true means, estimated for all (55) trawls (1 430 ± 379 ind./tonne krill) and separately for both *C. gunnari* (966 ± 225) and *N. larseni* (557 ± 103), were close to the arithmetic means. The range of juvenile fish by-catches in our samples was similar to the results obtained by Everson *et al.* (1991) in the same area (Table 2).

Using data collected by Everson *et al.* (1991) around South Georgia in 1981, we calculated the arithmetic (1 801 ± 693 ind./tonne krill) and true (4 815 ± 109 ind./tonne krill) mean abundances of *C. gunnari* juveniles. These results are more than two to five times higher than our estimates made in 1992. The difference may be associated with higher abundances of juvenile fish found off the

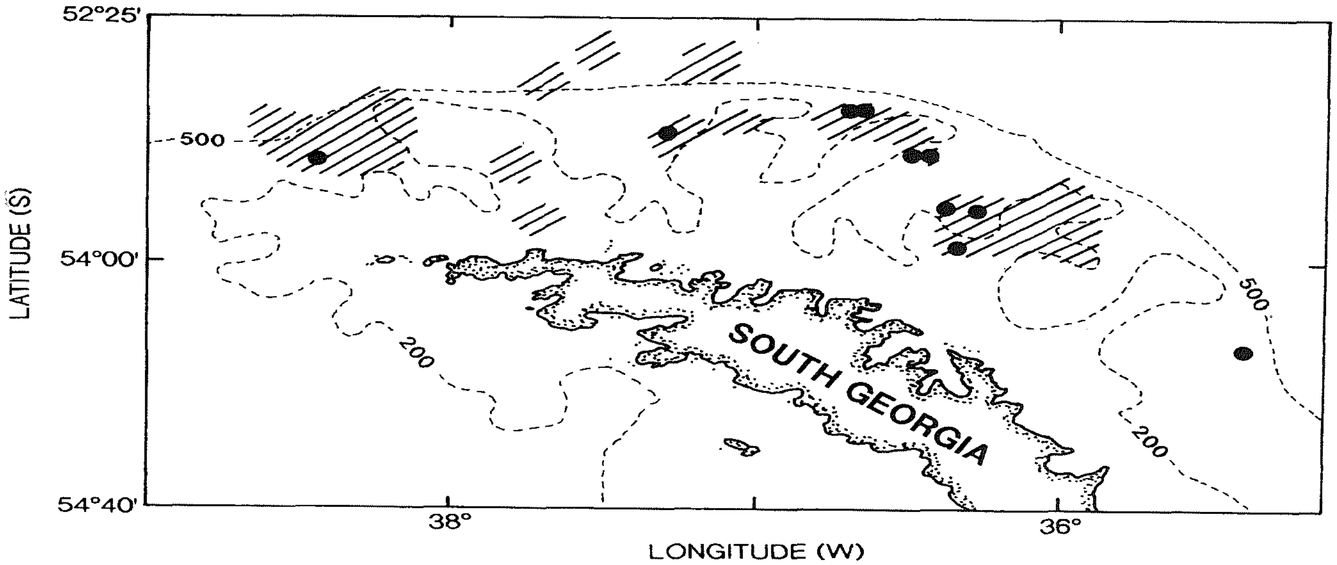

Figure 1: Areas fished by the Ukrainian fleet (shaded) and positions of catches of juvenile fish around South Georgia from May to August 1992.

Table 1: Data on krill hauls containing juvenile fish, conducted near South Georgia Island by the FV *Grigory Kovtun* from May to July 1992.

Sation Number	Coordinates		Date 1992	Fishing Depth (m)	Water Depth (m)	Fishing Time (local)	Krill Catch (kg)	Mass of Sample (kg)	*Champsocephalus gunnari*		*Nototheniops larseni*		Summary: Ind./tonne Krill
	S	W							In Sample	Ind./tonne Krill	In Sample	Ind./tonne Krill	
376	54°14'7	35°25'5	20.05	10	155	16.20-17.10	10 000	100	3	300	4	400	700
463	53°52'5	36°16'0	26.05	10	190	22.30-23.30	600	20	11	550	177	8 850	9 400
480	53°57'1	36°22'5	30.05	10	240	15.10-16.00	8 000	25	13	520	61	2 440	2 960
493	53°53'6	36°24'3	31.05	90	250	09.40-10.15	7 000	25	111	4 440	17	680	5 120
540	53°39'4	36°42'7	03.06	10	200	16.20-17.20	2 000	20	307	15 350	6	300	15 650
549	53°40'6	36°48'3	04.06	10	200	17.45-19.40	1 000	50	208	4 160	15	300	4 480*
665	53°43'0	36°30'4	12.06	100	140	18.15-19.00	8 000	50	2	40	70	1 400	1 440
703	53°43'4	36°31'0	15.06	50	150	21.55-23.05	1 000	50	83	360	18	1 660	2 020
861	53°44'6	38°29'3	24.07	150	265	10.00-11.15	10 000	10	164	16 400	-	-	16 400
902	53°42'5	37°19'2	27.07	30	160	16.35-17.00	2 000	10	-	-	188	18 800	18 900**

* One specimen of Bathydraconidae gen. sp. in the sample
** One specimen of *Harpagifer georgianus* in the sample

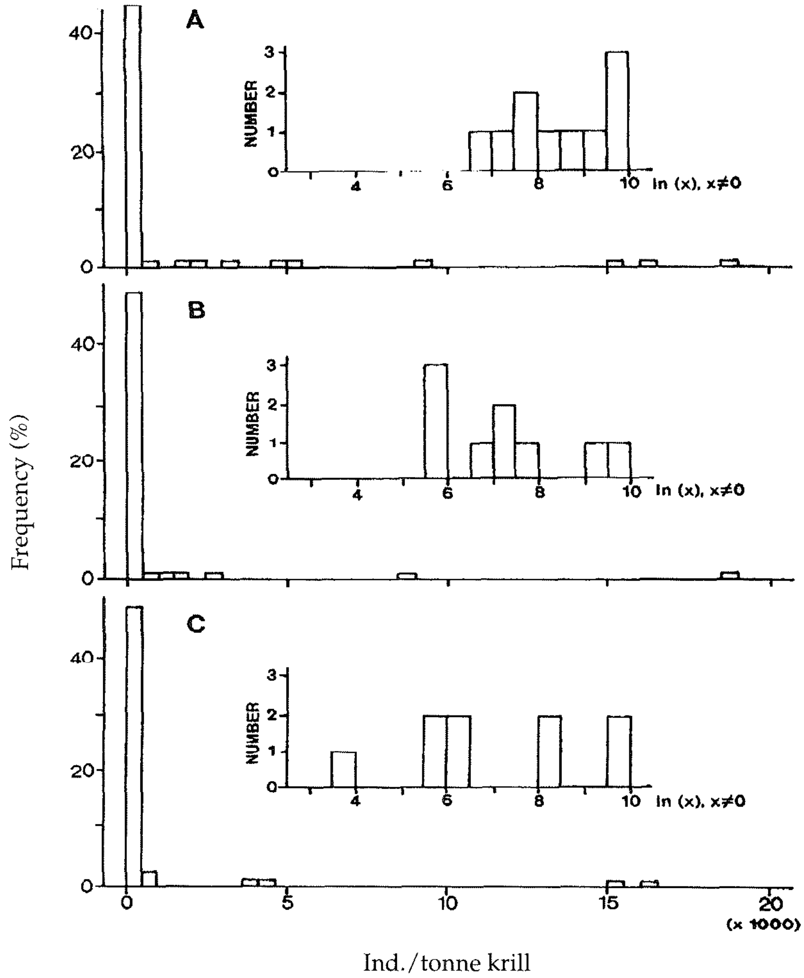

Figure 2: Frequency distributions of the by-catch of juvenile fish around South Georgia from May to July 1992 (A = total juvenile fish; B = *N. larseni*; C = *C. gunnari*). Insets illustrate the distribution of the non-zero values (x) of the by-catch of juvenile fish.

eastern shore of the islands (Everson *et al.*, 1991). Their results also show that the arithmetic and true mean abundances of *N. larseni* juveniles were 624 ± 355 and 2 803 ± 1 070 ind./tonne krill respectively. Although the arithmetic means were similar for the two studies, the true mean calculated from the data of Everson *et al.* (1991) was more than five times higher than that obtained from the data we collected from May to July 1992. According to the most recent Japanese data, collected from July to August 1992, the arithmetic mean of the total by-catch was 2.7 times lower than our estimate (Table 2). In comparison, our values are approximately an order of magnitude lower than those obtained in the Indian sector of the Southern Ocean (Pankratov and Pakhomov, 1992). Also, our results were an order of magnitude higher than the results of Slosarczyk (1986) from the Bransfield Strait and the South Shetland Islands (Table 2).

Juvenile fish were present in 18.2% of krill hauls made around South Georgia in 1992, compared to 36.1% in the same area during 1981 (Everson *et al.*, 1991). In comparison, Slosarczyk (1986) recorded juvenile fish in 72.8% of krill hauls in the Bransfield Strait and the South Shetland Islands. Similarly, Pankratov and Pakhomov (1992) recorded juvenile fish in all krill hauls in the Prydz Bay region (Table 2).

During the period May to July 1992, 22 trawls (40.0% of the total) were undertaken in the shallow waters over the South Georgia shelf (140 to 300 m). The occurrence of juvenile fish in krill hauls above the shelf was considerably higher and specimens were found in 45.5% of all hauls. In 1981, Everson *et al.* (1991) found juvenile fish in 35.0% of all catches in the same area (Table 2). As juvenile fish were found only above the continental shelf, we also calculated both the arithmetic and true means for hauls made only over the shelf (n = 22). These means were ≈2.5 times higher than the values obtained with pooled data (Table 3).

by-catches (up to 18 900 ind./tonne krill) occurred in catches of krill of less than 5 tonnes/hour (Figure 3).

Table 2: Total by-catch (ind./tonne krill) and frequency of occurrence (FO, %) of juvenile fish taken during krill fishing in various parts of the Southern Ocean.

Region	Period	Total By-catch, Mean*	Total By-catch, Min-max	FO (%) Total Samples	FO (%) Inshore Samples	Source
Bransfield Strait, South Shetland Islands	December 1983 - January 1984	164	0 - 845	72.8	94.4	Slosarczyk, 1986
South Georgia	April-May 1981	2 425	0 - 14 457	36.1	35.0	Everson *et al.*, 1991
Prydz Bay region	January - February 1988	51 499	114 - 1 002 075	100.0	100.0	Pankratov & Pakhomov, 1992
South Georgia	May-July 1992	1 401	0 - 18 900	18.2	45.5	This study
South Georgia	July-August 1992	520	?	27.0	?	Iwami, 1993**

* Arithmetic mean
** Cited from SC-CAMLR, 1993

Table 3: Estimated values of the total removals of *C. gunnari* and *N. larseni* juveniles as a result of krill fishing in Subarea 48.3.

Year	Total Krill Catch (tonnes)	*Champsocephalus gunnari* Ind./tonne Krill	*Champsocephalus gunnari* Total (millions)	*Nototheniops larseni* Ind./tonne Krill	*Nototheniops larseni* Total (millions)	Comments
1981	135 252*	1 801 ± 693	243.6 ± 93.7	624 ± 335	84.4 ± 45. 3	Arithmetic mean (AM)
		4 815 ± 1 095	651.2 ± 148.1	2 803 ± 1 070	379.1 ± 144.7	Efficient mean (EM)
1992	35 488**	766 ± 414	27.2 ± 14.7	633 ± 376	22.5 ± 13.3	AM, all region
		966 ± 225	34.3 ± 8.0	557 ± 103	19.8 ± 3.7	EM, all region
		1 914 ± 1 000	?	1 583 ± 916	?	AM, above shelf
		2 434 ± 579	?	1 388 ± 248	?	EM, above shelf

* Krill catch for the whole of 1981 (CCAMLR, 1991)
** Catch for the period May to August 1992 (Ukrainian fleet only)

Spatial and temporal variability in the distribution of juvenile fish around South Georgia is still poorly understood. Data from Tables 2 and 3 show that by-catch levels may vary significantly from region to region and from season to season. This may be explained by factors such as regional hydrographic features, recruitment rate, sampling strategy, species composition, natural mortality of juveniles, horizontal and vertical distribution etc. The effects of these factors are, however, outside the scope of this paper and need to be investigated separately.

As previously observed (Slosarczyk, 1986; Everson *et al.*, 1991; Pankratov and Pakhomov, 1992), the amount of juvenile fish in krill catches is inversely related to krill density. With the exception of a single case, the highest juvenile fish

An estimate of the total removals of juvenile fish during krill fishing can be made using data on the total krill catch in Subarea 48.3 and the mean number of juvenile fish in terms of by-catch/tonne krill (CCAMLR, 1991; Everson *et al.*, 1991). According to the data shown in Table 3, the total removals of *C. gunnari* juveniles in 1981 may be as high as 651.2 ± 148.1 million, while 379.1 ± 144.7 million *N. larseni* juveniles may have been removed during krill fishing at the same time. One should, however, be cautious when comparing these values. Catches analysed for April and May 1981 represent only those made by a research vessel because no commercial fishery had as yet commenced in the area (CCAMLR, 1991). On the other hand, the estimated removal of ≈54 million specimens (34.3 million of *C. gunnari* and 19.8 million of

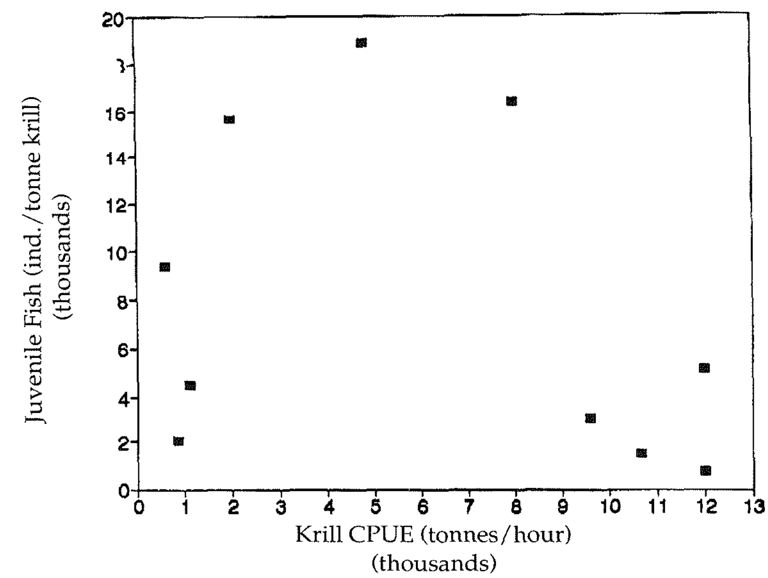

Figure 3: Relationship between the by-catch of juvenile fish (ind./tonne of krill) and the CPUE of krill (tonnes/hour).

N. larseni), calculated using the true means for the whole region during 1992, though approximate, appears to be more reliable. This is because we have used data from the fishing operations of the Ukrainian fleet and recorded all juveniles caught during this period. The total impact of the removal of juvenile fish in the area around South Georgia may be estimated even more accurately if information on the activities of the fishing fleets of other countries becomes available. Unfortunately, we could not use the arithmetic and true means calculated for the island shelf area because we do not have data on the proportion of krill collected in shelf waters relative to the total catch.

Juvenile Fish Length and Age Composition

The standard length of *C. gunnari* caught in May and June 1992 ranged from 64 to 95 mm, with mean lengths of 68.5 to 79.7 mm in various hauls (Figure 4.A). The size of the fingerlings indicated that they had been spawned the previous year (in May and June, according to Burchett *et al.*, 1983). In the second half of July, the mean length of *C. gunnari* had increased to 93 mm, the observed length ranging from 84 to 116 mm (Figure 4.A). Although fish length composition is subject to geographical variability, the juvenile growth rate during the observation period was 11.3 mm per month (≈0.37 mm per day). Such a high growth rate is typical for this species (Kochkin, 1985; North, 1988; White and Burren, 1992).

In May and June 1992, *N. larseni* was represented by specimens of two length classes (Figure 4.B): fingerlings with mean lengths of 42.4 to 47.4 mm and yearlings with mean lengths of 72.5 to 72.7 mm. The minimum and maximum lengths for all hauls were 31 to 59 mm and 64 to 82 mm respectively. Three specimens with standard lengths of 135, 142 and 146 mm were found in a subsample from haul no. 549. In late July the mean length of *N. larseni* fingerlings increased to 48.5 mm. This represents an increase of 2.4 mm per month, or ≈0.08 mm per day. Such a growth rate is typical for this species (Loeb, 1991; White and Burren, 1992).

Juvenile Fish Diet

The gut contents of *C. gunnari* comprised four species only (Table 4). In all samples, *E. superba* juveniles were the dominant component of gut contents, comprising ≈89% of the total mass of the food bolus. The data given in Figure 5 indicate that *C. gunnari* juveniles exhibit considerable size selectivity in krill consumption. *Thysanoessa* spp. occurred frequently in the gut contents, but their proportion by mass never exceeded 8% of the total. The remaining two species may be considered as occasional food items. No significant changes in gut contents were detected during the investigation. The data presented in Figure 6 suggest that there may be a tendency for the length of *E. superba* consumed to increase with increases in the length of *C. gunnari*.

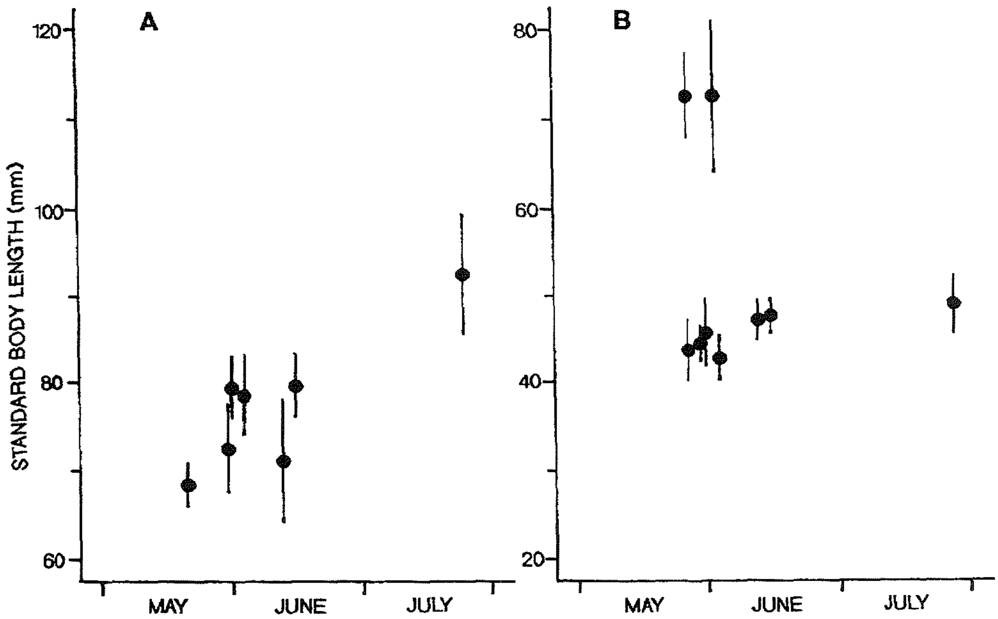

Figure 4: Mean lengths and standard deviation of *C. gunnari* (A) and *N. larseni* (B) juveniles from May to July 1992 in the South Georgia area.

Data on the feeding of *C. gunnari* juveniles on krill concentrations are scarce. Early juvenile stages (less than 30 mm) inhabit the coastal fjords and feed on copepods (Rembiszewski *et al.*, 1978; North and Ward, 1990). After leaving the fjords, they change their diet to *E. superba* (juveniles) and when they reach age 1+, they eat adult *E. superba*. This is their preferred prey item for the remainder of their life cycle (Permitin and Tarverdieva, 1972; Kompowski, 1980; Kock, 1981; Targett, 1981; Burchett *et al.*, 1983; Kozlov *et al.*, 1988; McKenna, 1991; present study).

The gut contents of *N. larseni* fingerlings included 11 taxa (Table 5). Among these, Chaetognatha, Copepoda and furcilia of *Thysanoessa* spp. were the most frequent. Only two species, *E. superba* (juveniles) and *Themisto gaudichaudii*, were found in the gut contents of *N. larseni* yearlings (Table 6). The length distribution of *E. superba* in stomachs of *N. larseni* was similar to that found in *C. gunnari* juveniles (Figure 5). Kellermann (1990) recorded copepods in the diet of *N. larseni* fingerlings from the Antarctic Peninsula area. The diet of adult specimens in different parts of the Atlantic sector of the Southern Ocean is consistent, and includes *E. superba*, Mysidacea, Hyperiidea and Copepoda (Permitin and Tarverdieva, 1972; Chlapowski and Krzeptowski, 1978; Targett, 1981; Daniels, 1982; Barrera-Oro and Tomo, 1987; McKenna, 1991).

The possibility that *C. gunnari* fingerlings may prey on *N. larseni* fingerlings (Table 4) and compete with *N. larseni* yearlings for food (Tables 4 and 5) could provide an explanation for the observed spatial segregation in the distribution of the juveniles of these species.

Table 4: Diet composition of *C. gunnari*, SL = 64 to 116 mm.

Diet Components	*f*,%	*n*	*Cn*,%	*P*,*g*	*Cp*,%
Euphausia superba	91.4	172	61.1	7.063	88.9
Thysanoessa spp.	22.9	105	37.2	0.622	7.8
Euphausiacea (undet.)	1.0	1	0.4	0.028	0.4
Themisto gaudichaudii	2.9	3	1.0	0.157	2.0
Nototheniops larseni	1.0	1	0.4	0.075	0.9
Number of stomachs studied, *n*			108		
Including the empty ones, *n* (%)			3(2.8)		
Stomach fullness index, %			2.43		

Designations: *f*,% - frequency of occurrence of the component in stomachs containing food; *n* - number of individuals; *Cn*,% - proportion by numbers; *P*,*g* - mass of dietary component in grams; *Cp*,% - proportion by mass; SL - standard length.

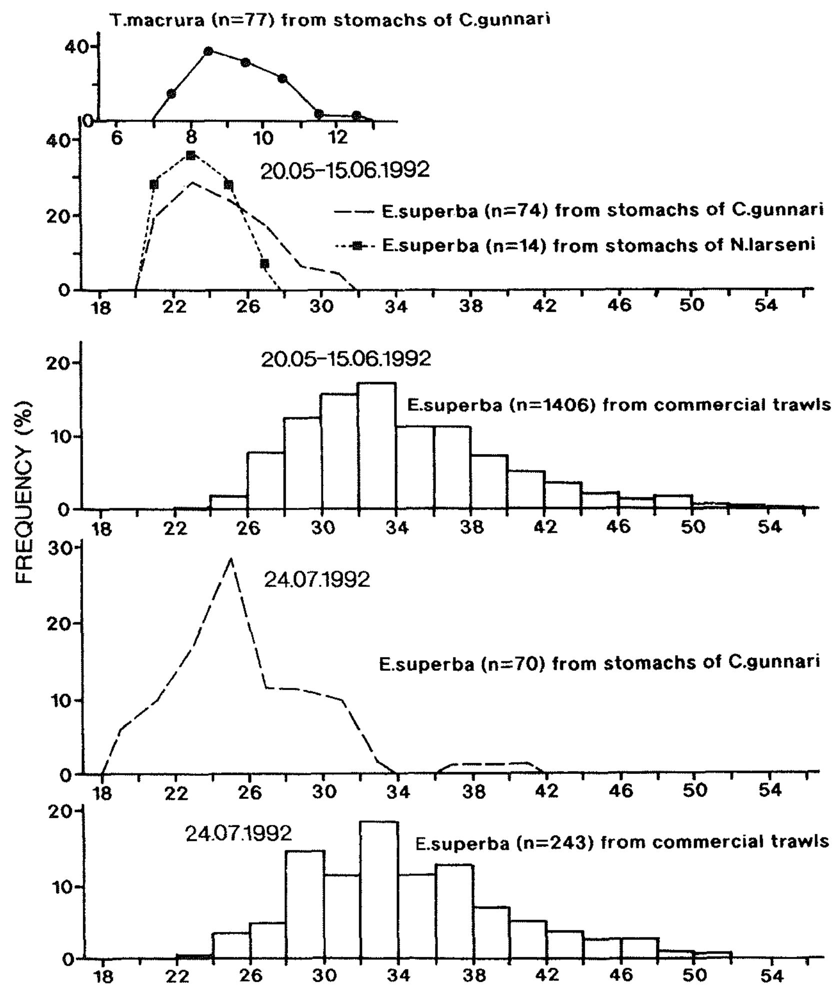

Figure 5: Size distribution of *E. superba* and *Thysanoessa* spp. in stomach samples of *C. gunnari*, *N. larseni* and in commercial trawl catches.

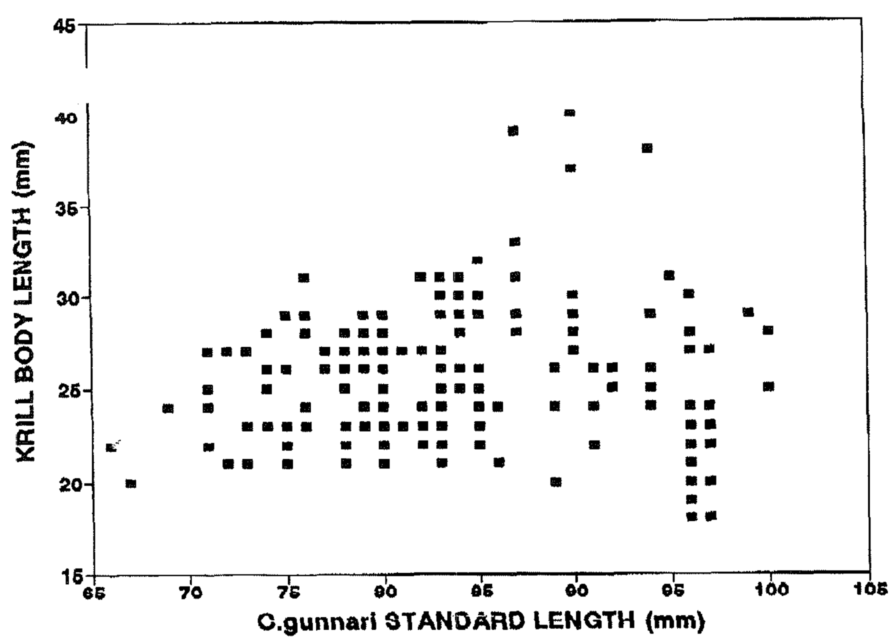

Figure 6: Length of *E. superba* in the diet as a function of the standard length of *C. gunnari* juveniles.

Table 5: Diet composition of *N. larseni*, SL = 37 to 54 mm.

Diet Components	f,%
Calanoides acutus	14.0
Rhincalanus gigas	3.5
Metridia sp.	1.8
Calanoida (other)	42.1
Hyperiidea	1.8
Euphausia (superba)	5.3
Thysanoessa spp.	17.5
Euphausiacea (undet.)	3.5
Polychaeta	1.8
Eukrohnia hamata	1.8
Chaetognatha (other)	50.9
Number of stomachs studied, *n*	63
Including the empty ones, *n* (%)	2(9.5)

Table 6: Diet composition of *N. larseni*, SL = 64 to 82 mm.

Diet Components	f,%	n	Cn,%	P,g	Cp,%
Euphausia superba	90.0	16	88.9	1.287	95.1
Themisto gaudichaudii	20.0	2	11.1	0.066	4.9
Number of stomachs studied, *n*			10		
Including the empty ones, *n* (%)			1(10.0)		
Stomach fullness index, %			3.35		

CONCLUSION

According to our results, the densest accumulations of juveniles of different fish species are spatially discrete. This may be the result of predation of *C. gunnari* on *N. larseni* and interspecific competition between them. At present, as our data on the by-catch of juvenile fish are very limited, it is difficult to compare them with those of previous studies. Therefore, the problem of correctly estimating the total by-catch of juvenile fish during krill fishing and its impact on the recovery of commercial fish stocks requires further investigation. We concur with Everson *et al.* (1991) and Pankratov and Pakhomov (1992) that the problem of the by-catch of juvenile fish could be reduced by shifting krill fishing to the waters outside the continental shelf. Future research should thus be directed at the study of spatial and temporal variability of juvenile fish in commercial krill trawls. It is possible that the total by-catch of juvenile fish may be smaller than the statistical error associated with the estimation of total mortality rates of fish aged 1+. It is therefore very important to estimate the size of the juvenile stock at age 1+ and the rate of natural mortality concurrently with the total taken as a by-catch in the krill fisheries.

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Légendes des tableaux

Tableau 1: Données sur les chalutages de krill contenant des poissons juvéniles effectués autour de la Géorgie du Sud par le navire FV *Grigory Kovtun* de mai à juillet 1992.

Tableau 2: Captures accessoires (individus/tonne de krill) et fréquence de la présence ("FO", en %) des juvéniles de poissons capturés au cours de la pêche de krill en divers secteurs de l'océan Austral.

Tableau 3: Estimations de la capture totale des juvéniles de *C. gunnari* et de *N. larseni* imputable à la pêche de krill dans la sous-zone 48.3.

Tableau 4: Composition du régime alimentaire de *C. gunnari*, SL (longueur standard) = 64 à 116 mm.

Tableau 5: Composition du régime alimentaire de *N. larseni*, SL = 37 à 54 mm.

Tableau 6: Composition du régime alimentaire de *N. larseni*, SL = 64 à 82 mm.

Légendes des figures

Figure 1: Secteurs exploités par la flottille ukrainienne (zone hachurée) et position des captures de poissons juvéniles autour de la Géorgie du Sud de mai à août 1992.

Figure 2: Distribution de fréquences des captures accessoires de poissons juvéniles autour de la Géorgie du Sud de mai à juillet 1992 (A = total des poissons juvéniles; B = *N. larseni*; C = *C. gunnari*). Les encadrés illustrent la distribution des valeurs non nulles (*x*) de la capture accessoire des juvéniles de poissons.

Figure 3: Rapport entre la capture accessoire des poissons juvéniles (individus/tonne de krill) et la CPUE du krill (tonnes/heure).

Figure 4: Longueurs moyennes et écart-type des juvéniles de *C. gunnari* (A) et de *N. larseni* (B) de mai à juillet 1992 dans le secteur de la Géorgie du Sud.

Figure 5: Distribution des tailles de *E. superba* et *Thysanoessa* spp. dans les échantillons stomacaux de *C. gunnari*, *N. larseni* et dans les captures des chalutages commerciaux.

Figure 6: Longueur de *E. superba* présent dans le régime alimentaire en fonction de la longueur standard des juvéniles de *C. gunnari*.

Список таблиц

Таблица 1: Данные о крилевых тралениях, содержащих молодь рыбы. Траления проводились в районе Южной Георгии судном *Григорий Ковтун* в период май-июнь 1992 г.

Таблица 2: Общий прилов (особи/тонну криля) и частота встречаемости (FO, %) молоди рыбы, выловленной при промысле криля в различных частях Южного океана.

Таблица 3: Оценки общего изъятия молоди *C. gunnari* и *N. larseni* в результате промысла криля в Подрайоне 48.3.

Таблица 4: Состав рациона *C. gunnari*, SL = 64 - 116 мм.

Список рисунков

Lista de las tablas

Lista de las figuras

Figura 5: Distribución de tallas de las especies *E. superba* y *Thysanoessa* encontradas en los estómagos de *C. gunnari*, *N. larseni* y en los arrastres comerciales.

Figura 6: Talla de *E. superba* en la dieta en función de la talla estándar de los juveniles de *C. gunnari*.