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NEW DATA ON SPAWNING, HATCHING AND GROWTH OF *CHAMPSOCEPHALUS GUNNARI* ON THE SHELF OF THE KERGUELEN ISLANDS

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Abstract

Combined studies on the inner and outer northeastern part of the Kerguelen shelf during the 1989/90 to 1993/94 period provide new information on the stock of *Champsocephalus gunnari*. A quarterly program of ichthyoplanktonic and bottom trawl surveys over the inner shelf has enabled a new cohort of fish to be identified each year. However, annual variations in abundance have been observed. During the sampling period the 1988 cohort was dominant on the outer shelf. The three-year cycle observed previously seems to be related to the maturation stage of each current cohort and the relative abundance of spawners-at-age during each winter spawning period. Only once have spawners been observed in large numbers on the inner shelf: during the winter of 1991/92. These fish were the first of the 1988 cohort to spawn.

Résumé

Les études combinées des zones interne et externe du plateau nord-est de Kerguelen réalisées de 1989/90 à 1993/94 fournissent de nouvelles informations sur le stock de *Champsocephalus gunnari*. Un programme de campagnes d'évaluation trimestrielles de la zone interne du plateau, tant par prélèvements de l'ichtyoplancton que par chalutages de fond, permet d'identifier une nouvelle cohorte de poissons chaque année. Des variations annuelles d'abondance sont toutefois notées. Pendant la période d'échantillonnage, la cohorte 1988 était dominante sur la partie externe du plateau. Le cycle de trois ans observé précédemment semble être lié au stade de maturation de chaque cohorte existante et à l'abondance relative des reproducteurs par âge pendant chaque période de reproduction hivernale. Il n'a été possible d'observer de reproducteurs en masse sur la partie interne qu'en une seule occasion : pendant l'hiver 1991/92. Ces poissons sont les premiers de la cohorte 1988 à se reproduire.

Резюме

Исследования, проведенные во внутренней и внешней частях северо-восточного сектора шельфа Кергелен за период 1989/90 по 1993/94 гг., дали новую информацию о запасе *Champsocephalus gunnari*. Программа ихтиопланктонных и донных траловых съемок, выполнявшихся каждые три месяца во внутренней части шельфа, позволяла ежегодно идентифицировать новую когорту рыб. Наблюдались ежегодные изменения численности. В течение периода исследования во внешней части шельфа доминировала когорта 1988 г. Ранее наблюдавшийся трехгодичный цикл, по-видимому, связан с этапом созревания каждой имеющейся когорты и относительной численности нерестящихся особей в отдельных возрастных классах в течение каждого зимнего нерестового периода. Большое количество нерестящихся особей наблюдалось во внутренней части шельфа всего лишь один раз: зимой 1991/92 г. Это были впервые отнерестившиеся рыбы из когорты 1988 г.

Resumen

Los estudios combinados efectuados en el sector interno y externo de la zona noreste de la plataforma de Kerguelén durante el período de 1989/90 a 1993/94 ofrecen nuevos antecedentes sobre el stock de *Champsocephalus gunnari*. Un programa de prospecciones de arrastre de fondo y de toma de muestras de ictioplancton efectuado cada tres meses en el interior de la plataforma ha permitido la identificación de una nueva cohorte de peces cada año. No obstante, se han observado variaciones anuales en su abundancia. Durante la época de estudio la cohorte de 1988 prevaleció en el sector externo de la

plataforma. El ciclo de tres años observado anteriormente parece estar relacionado con la fase de madurez de cada una de las cohortes actuales y a la abundancia relativa de los reproductores por edad en cada período de desove invernal. El invierno de 1991/92 ha sido la única vez que se han observado grandes cantidades de peces en desove en el interior de la plataforma. Estos fueron los primeros peces en desovar de la cohorte de 1988.

Keywords: *Champsocephalus gunnari*, Kerguelen Islands, cohort growth, reproduction, demographic structure, CCAMLR

INTRODUCTION

It is currently recognised that two stocks of *Champsocephalus gunnari* exist around the Kerguelen Islands: the shelf stock and the Skif Bank stock (Duhamel, 1987 and 1991). The biomass of the latter is, however, only about 5 to 15% of that of the first (Duhamel and Agnew, 1990).

The Kerguelen Island shelf stock of *C. gunnari*, which has been fished since 1971/72, yielded annual catches up to 30 000 tonnes in the first years of exploitation (Gerasimchuk, 1993). Good catches occurred at about three-yearly intervals with very low catches in between. Monitoring of the fishery, since the establishment of an EEZ (1978), has provided detailed information on the demographic structure, migration patterns, spawning periods and areas, sexual maturation and diet composition (Duhamel and Hureau, 1985; Duhamel, 1987, 1991 and 1993). The early life history of the species has recently been investigated by means of fishery-independent programs (Koubbi *et al.*, 1991; Koubbi, 1992).

Only one cohort appears to contribute to the annual catches. This is different from the situation around South Georgia but seems to be comparable to the catch history around the South Orkney Islands (Kock *et al.*, 1985; Kock, 1991). Since 1980 an abundant cohort has been observed to occur every three years (Duhamel, 1987, 1991 and 1993). This cohort constitutes, usually for a period of one to two years, the bulk of the catches in the fishery, which is based only fish over three years old (legal fish size for the fishery: 25 cm). The biomass of such cohorts has been estimated using both the swept-area method (Duhamel, 1988) and cohort analysis (Duhamel and Agnew, 1990). The second method shows a quick decline in abundance in proportion to growth and, consequently, a cohort disappears from catches at age four to five years. A cohort is therefore only available to the fishery for a short period.

The fishery targets feeding aggregations of *C. gunnari* on the outer shelf and shelf break. Preliminary investigations (Duhamel, 1984) enabled the spawning grounds of the stock to be identified as being located on the northeastern part of the inner shelf. However, no information was available on spawning, hatching and early life history. In 1989 we therefore established a monitoring program to throw light on this part of the reproductive cycle.

MATERIAL AND METHODS

The study was conducted on the northeastern part of the Kerguelen shelf, both on board trawlers ('Atlantic' type, 85 m) fishing on the outer shelf and on the scientific RV *La Curieuse* (25 m) on the inner shelf (Figure 1). The results, when these research operations were carried out simultaneously, were compared.

The inner shelf (depths: 75 to 110 m) was investigated every three months both by bottom trawl (31 m groundrope length, 25 mm mesh size in the codend) and Bongo samplers (two nets having a mouth opening of 63 cm in diameter, and a mesh size of 500 µ, equipped with flow meters) (Table 1). The survey covered a full three-year cycle (spring 1989/90 to spring 1992/93) and comprised 13 cruises. Samples were taken both by bottom trawl (30' duration; 12 to 20 stations, depending on weather and bottom conditions, total 150 hauls) and by Bongo net (oblique tows in the water column from bottom to surface, 28 to 38 stations, total 409 hauls) over grids of standard stations where sampling was carried out simultaneously (Figure 1). Juvenile and adult fish were collected using the first method and the ichthyoplanktonic stages using the second. The trawl catches were sorted and the entire sample of *C. gunnari* weighed and measured. Gonad analysis was carried out on a sub-sample. A mean abundance index was calculated for each cruise using the total number of fish and duration of fishing. The larvae of *C. gunnari* collected in each ichthyoplankton

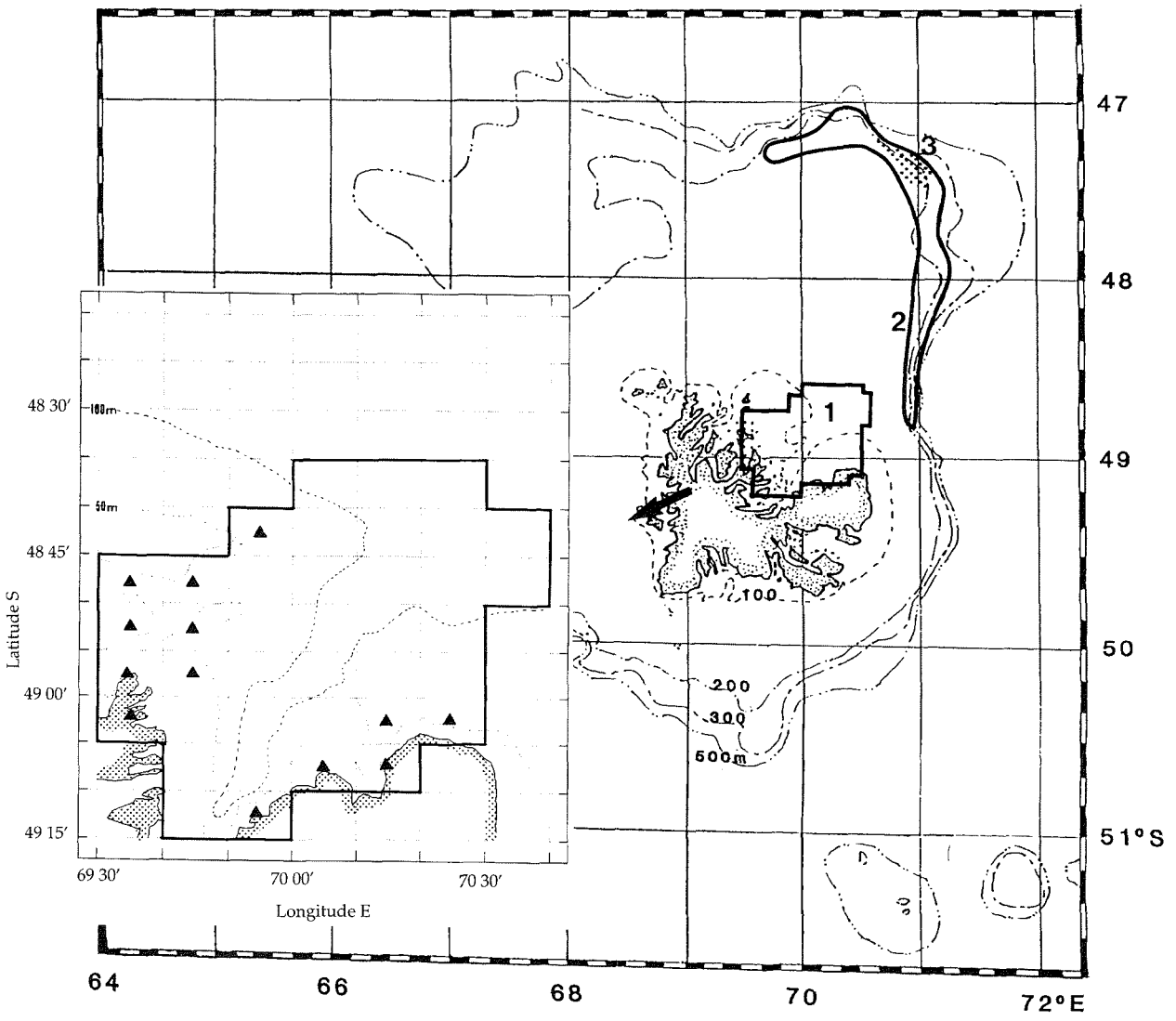

Figure 1: 1 - Grid of stations (one station per 5' latitude x 10' longitude rectangle) used, both with the Bongo sampler and the bottom trawl, during the quarterly monitoring program carried out from 1989 to 1992 in the northeastern inner Kerguelen Island shelf area. Triangles indicate that bottom trawling was impossible at that site because of rough seabed.
2 - Fishing grounds (inside the contour line) for *C. gunnari* (positive catches) for trawlers on the outer shelf during the 1990/91 season.
3 - Fishing grounds (dotted area) for *C. gunnari* (positive catches) for trawlers on the outer shelf during the 1991/92 season.

sample were sorted, measured and their abundance index estimated using the mean number of fish reported per swept cubic metre.

Regular samples of *C. gunnari* were taken by fishery observers on board the trawlers when catches of this species took place on the fishing grounds (Figure 1 and Table 2). Data have been selected for the period 1989/90 to 1993/94. A mesh size of 80 mm was used in the codend of the trawls (groundrope length - 41.7 m). This procedure is followed in an ongoing scientific program devoted to the management of the stocks (Duhamel, 1987). Where directed fishing for *C. gunnari* has taken place, an index of abundance (mean number of fishes by trawled hour) has been used (Duhamel, 1991) to enable the data from the study period to be compared with those collected previously.

Length frequency distributions (LFDs), measurement of individual fish (to the nearest cm below, total length - TL) and gonad stages (five stages according to Everson's scale, 1977) at length have been taken into account for study purposes.

Table 1: Characteristics of the Kerguelen Island inner shelf program carried out every three months from 1989 to 1992 for the bottom trawl and ichthyoplanktonic surveys. Only *C. gunnari* was reported in the catches.

Date	Bottom Trawl					Bongo		
	No. of Stations	Fishing Hours	Catch (no.)	Catch (kg)	Sample Size (no.)	No. of Stations	Filtered Volume (m^3)	No. of Larvae
10-11/1989	14	7.5	295	7.14	295	31	12 532	208
2/1990	4	1.75	45	1.26	45	5	2 239	0
5/1990	0	/	/	/	/	33	10 707	0
8/1990	16	8.08	19 990	1 522.15	1 042	37	14 601	0
11-12/1990	18	9.0	72	3.89	72	28	14 181	1
1/1991	0	/	/	/	/	36	11 802	0
4/1991	13	6.25	269	9.83	269	31	15 482	0
7/1991	17	8.5	2 249	310.65	1 179	34	12 542	0
10/1991	12	6.0	330	10.69	330	36	11 241	43
2/1992	0	/	/	/	/	34	10 158	0
5/1992	20	9.92	296	6.14	287	34	13 673	0
7/1992	16	8.08	209	50.61	207	34	11 725	0
10/1992	20	9.75	368	11.27	333	36	12 333	20

Table 2: Number of *C. gunnari* in monthly samples taken on the fishing grounds of the Kerguelen Island northeastern outer shelf and total catches for the period extending from October 1989 to June 1994. No fishing took place for the months for which there are no records.

Date	Type of Fishing	Catch (tonnes)	Sample Size (no.)
10/1989	exploratory	/	86
12/1989	"	/	382
7/1990	"	10.4	195
8/1990	"	0.3	664
10/1990	"	1.2	74
1/1991	commercial	1 693.0	/
2/1991	"	3 770.4	1 218
3/1991	"	4 593.9	1 468
4/1991	"	2 574.0	/
5/1991	"	16.7	/
11/1991	"	11.3	481
12/1991	"	2.4	199
1/1992	"	30.8	/
10/1993	exploratory	6.0	1 140
11/1993	"	6.1	/
6/1994	"	/	140

RESULTS

Length Frequency Distributions for *C. gunnari* from Trawl Catches

LFDs for *C. gunnari* have been obtained from each quarterly trawl survey on the inner shelf (Figure 2); however, in autumn 1989/90 and the summers of 1990/91 and 1991/92 no surveys were conducted for logistic reasons. The outer shelf has not been investigated (no fishery) during autumn 1989/90, autumn/winter 1990/91 and from summer 1991/92 to spring 1993/94 (Figure 3).

Fish range from 6 to 38 cm in the samples but differences between LFDs in a time series are clearly visible during the whole of the study period. Size groups are identified and one to two modal lengths are dominant in each sample when the number of fish in the samples is large enough ($n > 100$, see Tables 1 and 2). Time series enable the growth of fish groups to be readily monitored.

Only one major size group is currently observed on the outer shelf. Thus, the size group ranging from 16 to 22 cm recorded during summer 1989/90 reached 27 to 36 cm during the spring of 1991/92 (Figure 3). This group was also

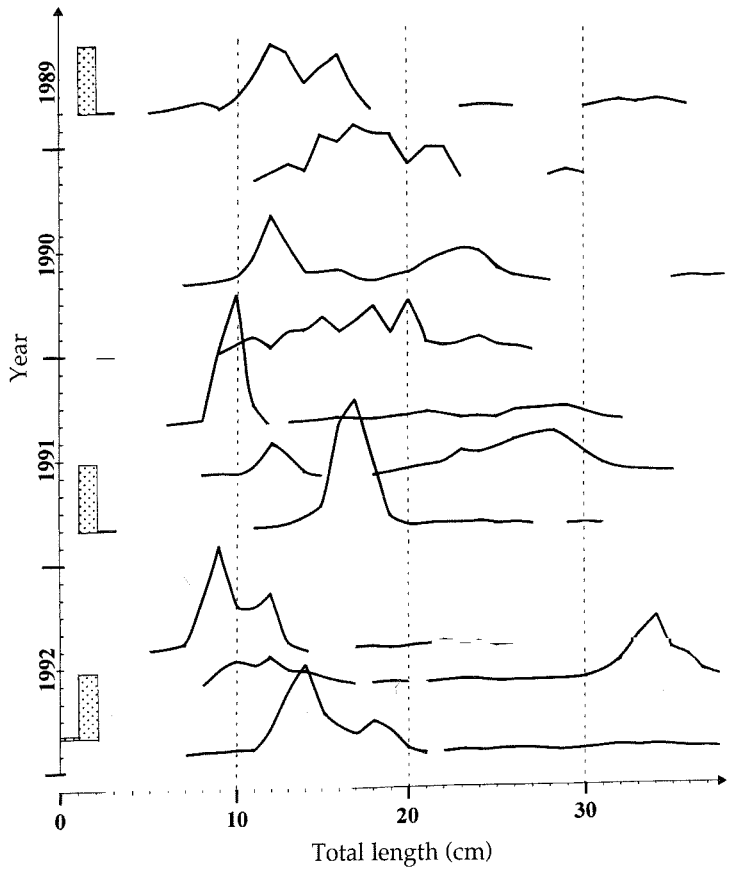

Figure 2: Quarterly LFDs for *C. gunnari* on the northeastern Kerguelen Island inner shelf obtained during the 1989–1992 bottom trawl monitoring surveys. LFDs for *C. gunnari* larvae in the ichthyoplankton samples are also reported (bars).

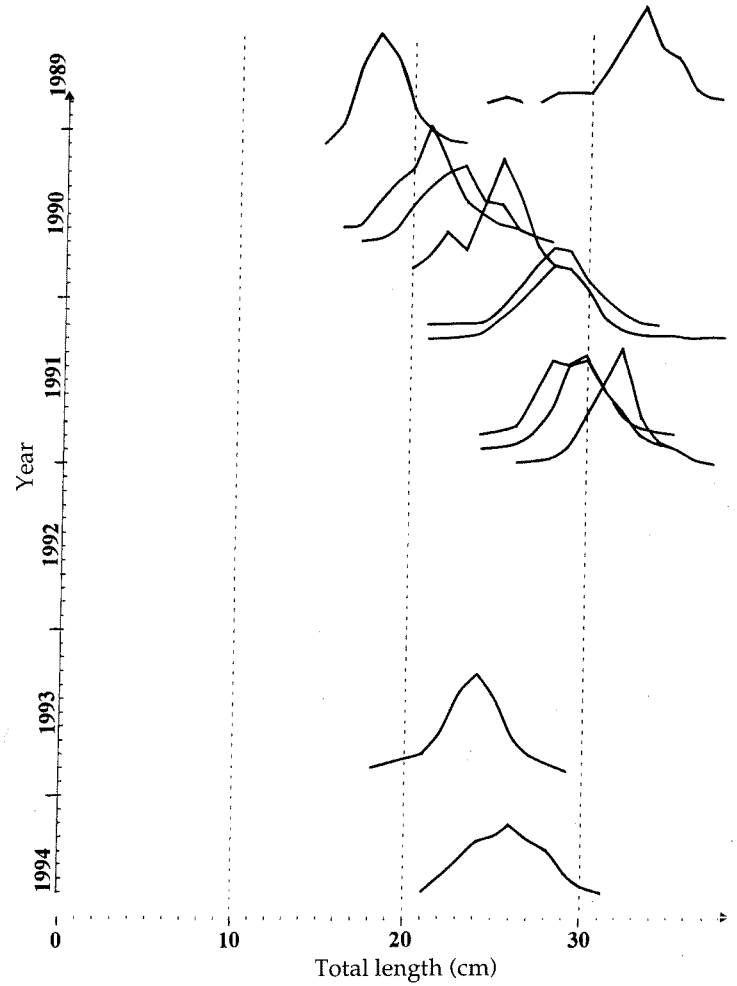

Figure 3: Monthly LFDs for *C. gunnari* on the northeastern Kerguelen Island outer shelf obtained from fishery catches during the period 1989/90 to 1993/94.

observed on the inner shelf during the same period (modal peak to about 23 cm for winter 1990/91 and 28 cm for winter 1991/92) and later (34 cm for winter 1992/93) (Figure 2). Another size group was observed from autumn 1990/91 (7 to 11 cm in size) to the following spring (12 to 19 cm) in the inner shelf samples. A third size group follows a parallel growth to the previous ones in the same area from autumn 1991/92 (6 to 13 cm) to spring 1992/93 (8 to 20 cm). This group is found again in the 1993 and 1994 outer shelf samples. The smallest fish are always recorded during autumn sampling on the inner shelf. It is noteworthy that the largest size groups (up to 20 cm) are not permanently present in the inner shelf. Their presence is mainly noted during the winter. Also noteworthy, from inner shelf samples, is the similarity of LFDs from spring 1989/90 with those of spring 1992/93, three years later.

Maturity Stages of Fish

Fish from the outer shelf samples were not observed to be maturing, in the size group monitored from early 1990 to mid 1991, until they reached a mean size of 24/25 cm TL. All the fish below this limit were still in stages 1 and 2. Only four specimens of a large sample (n = 708, size range: 23 to 34 cm) were reported as being in stage 3 during March 1991, the other fish still being in advanced stage 2. However, stage 3 (developing) is common at the end of autumn. Post-spawning fish (stage 5) were recorded in the summer sample of January 1992 (37 of the 194 specimens analysed, size range: 25 to 35 cm). At the end of June 1994, fish from the size group already observed to be in stage 2 in October 1993, were mainly in advanced stage 3 (116 of the 164 specimens analysed, size range: 22 to 31 cm). Finally, post-spawning fish (stage 5) were present in the spring sample (25 of the 27 specimens, size range: 29 to 38 cm) of November 1989.

Stage 4 (spawning condition) fish are only found in samples taken during the winter season on the inner shelf: in July 1991 most of the fish between 26 and 34 cm (n = 610 of the 1 179 specimens analysed) were in spawning condition, in July 1992 the fish within the range 31 to 38 cm (n = 124 of the 207 specimens analysed) were in spawning condition, but during August 1990 the size range of fish comprised only immature specimens. Stage 5 is found in samples taken during spring (October 1989, size range 31 to 35 cm, n = 11 of the 295 specimens analysed); November 1992, size range 30 to 37 cm, n = 23 of the 333 specimens analysed) as observed on the outer shelf. All the fish from the other samples are in stage 1 or 2 with the exception of the specimens in the size range 25 to 31 cm from the April 1991 sample (n = 48 of the 269 specimens analysed) and rare specimens ranging between 25 and 35 cm (n = 20 of the analysed 287) taken during May 1992, which are all in stage 3.

C. gunnari Larvae in the Ichthyoplanktonic Samples

Larvae were present in the ichthyoplankton only from October to December each year (Figure 4), suggesting a brief planktonic phase. However, mean abundances varied considerably between years:

Period	No. of Larvae/1 000 m^3
late Oct 1989	13.19
end Nov/early Dec 1990	0.07
mid Oct 1991	3.72
late Oct 1992	1.82

The value for 1990 may be negatively biased by the late sampling.

Larvae ranged from 11 to 24 mm in length (Figure 2). Minimum lengths were found in early October, maximum lengths in early December. Hatching seems to occur in early spring (late September to early October). Incubation is likely to take place for about three months up to the above-mentioned hatching period.

Index of Abundance from Trawl Surveys and Fishery Yields

The mean index of abundance is available for 10 surveys of the inner shelf (Figure 5). Values range from 9 to 2 499 *C. gunnari* per hour of fishing. The lowest value was observed during spring 1990/91, the highest during the previous winter and again during the winter of the following year. The other values range between 28 and 50. The insertion of the proportion of immature/mature fish in the figures makes it clear that the first winter peak comprises only immature fish, while the second is dominated by mature fish. The abundance index outside these two periods shows mainly young fish, with the exception of the last winter sample when adult fish exceeded immature ones in number, but at a low level of abundance.

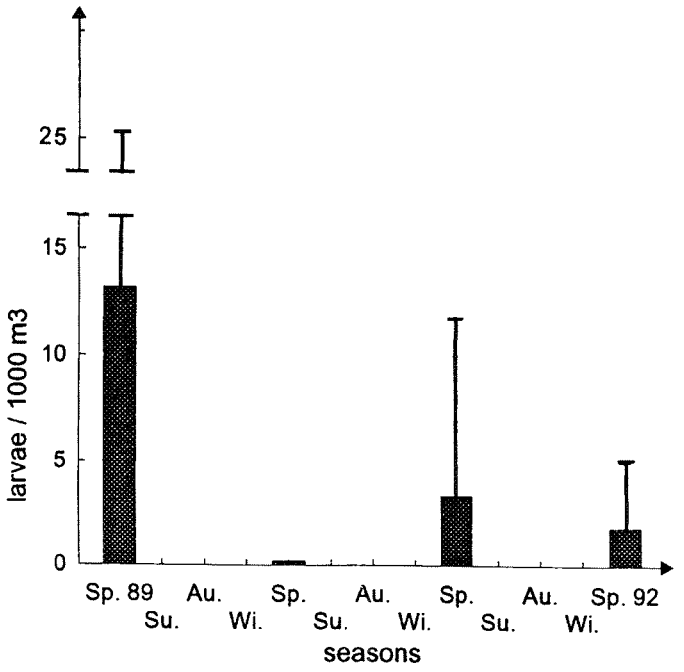

Figure 4: Relative seasonal abundance of *C. gunnari* larvae in the ichthyoplanktonic samples during the 1989-1992 Kerguelen Island inner shelf program. The mean and the standard deviation between the stations of the grid are shown.

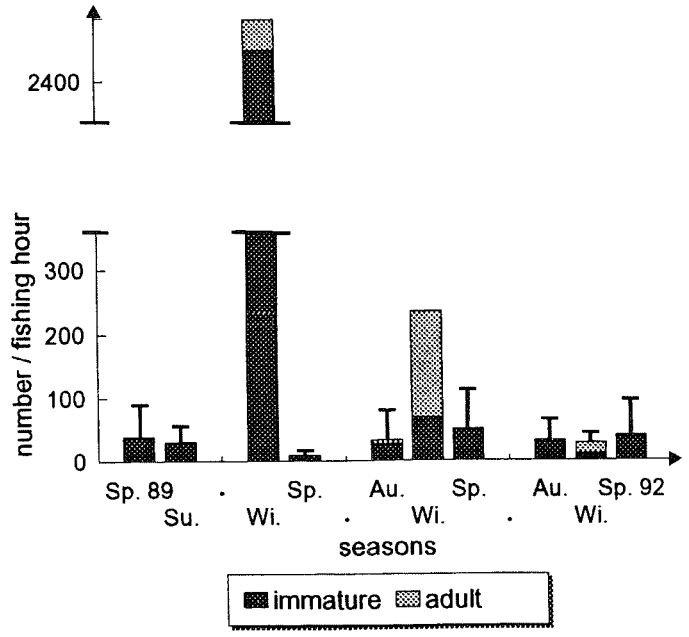

Figure 5: Mean abundance (number of fish per fishing hour) of *C. gunnari* on the northeastern Kerguelen Island inner shelf during the 1989-1992 bottom trawl monitoring program. Proportions of immature and mature fish are included in the values. Standard deviation between catches of the stations grid is reported, except for the first and the second winter (SD = 6 753 and SD = 525 respectively).

A directed fishery was only conducted on the outer shelf during summer/early autumn 1990/91 and the following spring/summer 1991/92. The values of the previously-used mean annual index (Duhamel, 1991), which differs from the indices of the above surveys because characteristics of the fishing gears used are not comparable, are respectively 32 300 and 4 790 individuals per fishing hour. The index shows a clear cline in the abundance of the same size group of fish from one year to another. The area of geographical distribution on the shelf is correlatively reduced (Figure 1).

DISCUSSION

The above results show that the modal size groups correspond to fish spawned during the same period and which form a new cohort. The LFDs observed on the outer shelf confirm the succession of abundant cohorts every three years in this area, described previously (Duhamel, 1987 and 1991). The 1985 cohort (28 to 38 cm) was observed in the 1989/90 spring sample but disappeared later on. The 1988 cohort is recorded from summer 1989/90 to spring 1991/92. It constitutes the bulk of commercial catches reported for summer 1990/91 (12 645 tonnes, Table 2) but its abundance becomes very low during the following season (1991/92), as is shown in the abundance index. A gap appears before the new 1991 cohort is identified. The recent samples taken during the 1993/94 season have enabled it to be identified. Because of the absence of young fish in the outer shelf samples the origin of these cohorts must be sought outside this depth range.

The quarterly inner shelf trawl monitoring program provides new and interesting data. New cohorts are identified each year from routine LFDs during the sampling period. The 1989 cohort is clearly present (first modal peak, mean = 12.7 cm) in the 1990/91 winter LFDs and is also present in the following years (spring and autumn 1990/91, winter and autumn 1991/92). The 1990 cohort exhibits clear modes from autumn 1990/91 to spring 1991/92 but these are indistinct in the subsequent samples. The most recent cohort monitored during the study period is the 1991 one, which is also clearly identified in the samples from autumn 1991/92 to spring 1992/93. Previous cohorts are also present and the 1988 one can be followed from the beginning (spring 1989/90: 8 to 18 cm) to the end of the study period, when it almost attains the maximum size of the Kerguelen shelf stock (winter 1992/93: 30 to 38 cm). The 1985 cohort is still observed during spring 1989/90 (32 to 36 cm) and even winter 1990/91 (36 to 38 cm). However, specimens of 1986 or 1987 cohorts are by now very rarely identified.

The combined use of LFDs from the inner and outer shelf enables the growth of each cohort to be reconstructed. An almost complete growth curve is obtained when the 1988 cohort is monitored for the four years from the first autumn of life. Mean length at each similar life-stage can be obtained for successive cohorts (Table 3). Daily growth increments are available for the first two years of life, which have been well sampled. Values for three cohorts give ranges of between 0.025 and 0.043 cm/day with the maximum increment occurring during spring and the minimum after autumn. Specimens grow more than 10 cm a year during the two first years, after which minimum values are observed.

Differences in LFDs from one area to the other are not related to the selectivity of the mesh size, at least for fish of up to about 16 cm, as can be seen from the LFDs (16 to 22 cm) reported during the summer of 1989/90 for the outer shelf. These differences are, however, related to changes in the habits of fish during growth. Part of the life cycle is consequently clarified. The fish use the inner shelf as a nursery zone for one to two years, then migrate to the outer shelf. This is shown for each cohort, mainly after spring of the second year of growth (Figures 2 and 3), when, except during the winter season, fish of size classes of up to 20 cm TL disappear from the inner shelf samples and are observed on the northeastern part of the outer shelf and shelf break, which is the main feeding area of sub-adult and adult fish (Duhamel, 1991). Sexual maturation involves an annual reverse spawning migration to the inner shelf, which temporarily becomes the spawning ground during the winter, thus confirming previous studies (Duhamel, 1984 and 1987). The 1991/92 winter sample is thus completely different from those of the previous autumn and the following spring. A mass migration of the 1988 cohort is observed, obviously indicated by changes in the abundance index (Figure 4). Part of the 1989 cohort is also present but not in spawning condition (immature fish) and seems to repeat the situation of the winter of 1990/91 when the 1988 cohort was observed but was still immature. The winter reproductive situation of icefish from the inner shelf spawning ground during the three-year study period can be

Table 3: Seasonal mean lengths (cm) of *C. gunnari* cohorts observed from spring 1989/90 to spring 1992/93 in the northeastern part of the Kerguelen Island shelf (a cross indicates that the number of specimens is too low for the mean to be calculated). The bold-faced type highlights the first winter mean values for three successive cohorts.

Cohort	Mean Length (cm)												
1985	32.9												
1988	14.6	18.5		22.5	+	28.2	+	+	29.9	31.7		33.8	
1989				***12.7***	+		+	*22.7*	+		+	+	+
1990							9.7	**12.2**	16.6		21.9	+	+
1991											*9.8*	***11.6***	*14.9*
Season	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
Split-year	**1989/90**			**1990/91**				**1991/92**				**1992/93**	

outlined as follows, taking into account the gonad condition of fish and the values of the percentage of the cohorts in the total sample for each period:

winter 1990/91
- 1985 cohort: few 5-year-old spawners (< 1% of the total sample)
- 1986 and 1987 cohorts: absent
- 1988 cohort: 2-year-old immature fish (97.1% of the sample)
- 1989 cohort: 1-year-old immature fish (2.9% of the sample)

winter 1991/92
- 1988 cohort: first spawning, 3-year-olds or 33 months of life (85.9 % of the total sample)
- 1989 cohort: 2-year-old immature fish (8.1% of the sample)
- 1990 cohort: 1-year-old immature fish (6% of the sample)

winter 1992/93
- 1988 cohort: second spawning, 4-year-olds (60.9% of the total sample)
- 1989 and 1990 cohorts: few spawners of the 1989 cohort, 1990 immature fish (3.9% of the sample)
- 1991 cohort: 1-year-old immature fish (35.8% of the sample).

Such an analysis of the gonad condition of fish present on the inner shelf spawning ground, correlated with the abundance index, shows a low abundance of spawners during 1990/91, a high concentration of spawners during 1991/92 and moderate abundance for the last winter period studied (1992/93). It must be noted that the situation in winter 1989/90 must certainly be close to that reported above for 1992/93 because of the similarity of the spring 1989/90 and 1992/93 LFDs. This would mean that the specimens of the 1985 cohort (about 5% of the spring 1989/90 sample) had spawned twice, that few (0.7%) immature fish of the 1986 cohort were present and that the sample was dominated (94.3%) by 1-year-old immature fish of the abundant 1988 cohort. Furthermore, this confirms the existence of a three-year cycle.

In order to give the full reproductive situation of a cohort, it is necessary to add that it has been observed from previous cohorts that a percentage of the adult fish seems not to participate in the annual spawning when sexually mature (Sosinski, 1981; Duhamel, 1984). During the spawning period these fish, which are in the same size range as those which are spawning, remain on the outer shelf. It would be very useful to evaluate this proportion of the cohort, in order to show the reduction of the standing stock in the feeding area (outer shelf and shelf break) resulting from the spawning migration, and the subsequent increase when spawners return. However, this proportion is difficult to obtain because commercial fishing is prohibited on fishing grounds during the winter season. This situation is comparable to that in South Georgia (Kock, 1989), where 15 to 25% of the population do not spawn each year. No clear explanation can be advanced to explain this phenomenon. In addition, atretic oocytes are frequently observed in a certain (sometimes large) proportion of females' gonads during the post-spawning seasons. This highlights potential problems in reproductive success in some years. Similar observations have been noted previously (Duhamel, 1987) for the Kerguelen shelf stock (data for the cohort 1979 during spring/summer 1982/83). A possible mortality of these females (atretic oocytes filling in the total abdominal cavity) and certainly the fact that it is impossible (due to asynchronism) for these fish to participate in the spawning the following year, are the most probable consequences.

Annual hatching of *C. gunnari* larvae is observed over the time series. Hatching occurs early in spring and the planktonic phase lasts no more than three months, which is short in comparison with other species of the Kerguelen Island shelf (Koubbi, 1992). The size range corresponds to that of newly-hatched larvae of *C. gunnari* observed in South Georgia (North and Ward, 1990). The ichthyoplanktonic results seems to confirm the above results because the occurrence of spring larvae follows the same trend as is observed in the occurrence of spawners on the spawning ground three months earlier (Figures 4 and 5). Thus the annual abundance of *C. gunnari* larvae seems to be related to the density of the winter spawners, reflecting the strength and the state of maturation of the annual cohorts. Finally, the size of larvae during the spring samples enables the growth curve obtained from trawl catches to be completed. Growth of some cohorts can thus be monitored from hatching to the second spawning and after.

The three-year cycle of abundant cohorts (for example 1982, 1985, 1988 and probably 1991), which has been observed on the shelf for two decades (Duhamel, 1987, 1991 and 1993; Gerasimchuk, 1993), seems to be related to the maturation stage of each current cohort and the relative abundance of spawners-at-age during

each winter period. The inner shelf LFD samples exclude the hypothesis that there is only one cohort at any time, appearing every three years. The ichthyoplanktonic surveys also eliminate this assumption. The fishery, adding to the natural mortality, contributes in reducing the level of abundance of each cohort on the outer shelf and could thus be the cause of this cycle. The abundance-at-age of the 1988 cohort is therefore lower than the cohorts studied previously - those of 1979, 1982 and 1985 (Duhamel, 1991). In order to improve management of the stock, the present life cycle would need to be taken into account. A limitation of fishing before the fish reach their fourth year of life would certainly help to change the demographic structure in that the total stock would then comprise more than one abundant cohort.

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