JOINVILLE–D'URVILLE ISLANDS (SUBAREA 48.1) – A FORMER FISHING GROUND FOR THE SPINY ICEFISH (*CHAENODRACO WILSONI*), AT THE TIP OF THE ANTARCTIC PENINSULA – REVISITED

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Abstract

The former fishing ground off Joinville–D'Urville Islands was revisited in the course of the Antarctic Expedition ANT XIX/3 by RV *Polarstern* in February 2002. Five hauls were conducted north of the two islands at depths of 149 to 282 m on 21 February 2002. Published and unpublished reports from fishing operations in the 1970s and 1980s by the Fischkombinat in Rostock (former GDR), Sea Fisheries Institute in Gdynia (Poland) and material available from YugNIRO, Kerch (Ukraine) of what is known of fishing activities in the area were analysed. These data were previously unavailable to CCAMLR. Fishing and the extent of fishing was primarily dependant on whether and to what extent the target species of the fishery, the spiny icefish (*Chaenodraco wilsoni*), formed concentrations. Information on these fishing operations was, however, sparse, being restricted to the two seasons (1978/79 and 1979/80) when Polish and GDR vessels fished in the area. Length compositions from several fishing nations revealed that the fishery targeted primarily fish 25–35 cm long. The fish fauna at the tip of the Antarctic Peninsula represents a combination of low- and high-Antarctic elements. The available information on the biology of *C. wilsoni* was reviewed. Some new information was available on the reproduction and feeding of some of the species. Krill (*Euphausia superba*) formed a major element in the diet of icefish.

Résumé

Au cours de l'expédition antarctique ANT XIX/3, le navire de recherche *Polarstern* est retourné sur l'ancien lieu de pêche au large des îles Joinville–D'Urville en février 2002.

Cinq chalutages ont été effectués le 21 février 2002 au nord des deux îles à des profondeurs de 149 à 282 m. Une analyse a été faite des rapports publiés et non publiés des opérations de pêche connues menées dans le secteur dans les années 1970 et 1980 par le Fischkombinat de Rostock (ex-RDA) et par l'institut des pêches marines de Gdynia (Pologne), ainsi que du matériel disponible auprès de YugNIRO, Kerch (Ukraine). La CCAMLR ne disposait pas encore de ces données. La pêche et l'ampleur de celle-ci dépendaient principalement de la formation de concentrations par l'espèce-cible de la pêcherie, la grande-gueule épineuse (*Chaenodraco wilsoni*) et de l'envergure de ces concentrations. Ces opérations de pêche n'ont toutefois laissé que très peu d'informations qui se limitent aux deux saisons de pêche (1978/79 et 1979/80) des navires polonais et de la RDA dans la région. Les données de composition en longueurs de plusieurs nations engagées dans des activités de pêche révèlent que la pêche visait principalement des poissons de 25–35 cm de long. La faune ichtyologique à la pointe de la péninsule antarctique se compose d'une variété d'éléments des hautes et basses latitudes antarctiques. Les informations disponibles sur la biologie de *C. wilsoni* ont été revues. De nouvelles informations sont disponibles sur la reproduction et l'alimentation de certaines espèces. Le régime alimentaire du poisson des glaces se compose en grand partie de krill (*Euphausia superba*).

Резюме

В феврале 2002 г. НИС *Polarstern* повторно посетило бывший район промысла у о-вов Жуанвиль–Дюрвиль в ходе антарктической экспедиции ANT XIX/3. 21 февраля 2002 г. было проведено пять тралений к северу от этих двух островов на глубинах 149–282 м. Были проанализированы опубликованные и неопубликованные отчеты рыбокомбината в Ростоке (бывшая ГДР) и Института морского рыбного промысла в Гдыне (Польша) о промысловых операциях в 1970-е и 1980-е гг., а также имеющиеся материалы ЮгНИРО в Керчи (Украина) о промысловой деятельности в этом районе. Ранее АНТКОМ не располагал этими данными. Промысел и масштабы промысла в основном зависели от того, формировал ли целевой вид этого промысла, белокровка Вильсона (*Chaenodraco wilsoni*), скопления и насколько большие. Однако информация об этом промысле была скудной и ограничивалась двумя сезонами (1978/79 г. и 1979/80 г.), когда промысел в этом районе вели суда Польши и ГДР. Данные участвовавших в этом промысле стран о размерном составе показывают, что объектом промысла была в основном рыба длиной 25–35 см. Ихтиофауна у оконечности Антарктического п-ова представляет собой комбинацию низко- и высокоантарктических видов. Была рассмотрена имеющаяся информация о биологии *C. wilsoni*. Также имелась новая информация о воспроизводстве и питании некоторых из этих видов. Криль (*Euphausia superba*) был основным элементом рациона ледяной рыбы.

Resumen

En febrero de 2002, durante la Expedición Antártica ANT XIX/3, el barco de investigación *Polarstern* volvió a visitar el antiguo caladero de pesca frente a las islas Joinville–D'Urville. El 21 de febrero de 2002 se realizaron cinco lances al norte de ambas islas, a unos 149 a 282 m de profundidad. Se analizaron los informes publicados e inéditos de la pesca realizada en las décadas de los 70 y 80 bajo la administración estatal de la antigua Alemania Oriental (Fischkombinat Rostock), del Instituto Pesquero en Gdynia (Polonia), y el material proporcionado por YugNIRO, Kerch (Ucrania) sobre las actividades pesqueras conocidas. Anteriormente estos datos no estaban a la disposición de la CCRVMA. La pesca y el esfuerzo pesquero dependieron principalmente de la formación de concentraciones de la especie objetivo, el draco espinudo (*Chaenodraco wilsoni*). La información sobre estas operaciones pesqueras fue escasa, y se limitó a los datos de dos temporadas (1978/79 y 1979/80) cuando los barcos de Polonia y Alemania Oriental explotaron el área. Datos de composición por tallas obtenidos de varios países pesqueros indicaron que la pesquería estuvo dirigida principalmente a peces de 25 a 35 cm de longitud. En el extremo de la Península Antártica la fauna está compuesta por una combinación de especies de peces de bajas y altas latitudes de la Antártida. Se revisaron los datos disponibles sobre la biología de *C. wilsoni*. Se contó con nuevos datos sobre la reproducción y alimentación de algunas de estas especies. El kril (*Euphausia superba*) fue un componente importante de la dieta del draco.

Keywords: Antarctic Peninsula, fish stocks, *Chaenodraco wilsoni*, *Gobionotothen gibberifrons*, CCAMLR

Introduction

The fishery for species such as *Notothenia rossii*, *Champsocephalus gunnari* and *Lepidonotothen squamifrons* which took place around sub-Antarctic and Antarctic islands of the Atlantic and the Indian Ocean sector has been reasonably well documented, both in terms of catch history and biological information on the most abundant species in the fisheries. Information from high-Antarctic fishing grounds is much more sparse. This is particularly true of the fishing ground off Joinville–D'Urville Islands at the tip of the Antarctic Peninsula which was exploited at irregular intervals between 1978/79 and 1989.

Fisheries information from the area was confined to catches of 10 130 and 4 320 tonnes of the spiny icefish (*Chaenodraco wilsoni*) in 1978/79 and 1979/80, reported by Poland and the former GDR (1978/79 only), and a by-catch of ocellated icefish (*Chionodraco rastrospinosus*) of 350 and 390 tonnes respectively (CCAMLR, 1990a, 1990b). Eighty percent of the reported catch was taken by Polish ves-sels and 20% by GDR vessels. Yellow notothenia (*Gobionotothen gibberifrons*), which made up about 20% of the research vessel catch in 2002, and small numbers of icefish species other than *C. wilsoni* and *C. rastrospinosus* were reported as being taken by GDR vessels from January to March 1979 (Gubsch and Kuhlmann, 1979, unpublished data). They were also reported to have been caught by former USSR vessels (L. Pshenichnov, unpublished data) although no catch statistics were submitted to CCAMLR.

Most other information from the area is spread over a few published and many unpublished reports of those fisheries institutions which had scientific observers on board fishing vessels during the course of the fishery. On 21 February 2002, the RV *Polarstern* conducted five hauls northwest of Joinville–D'Urville Islands for the first time (Figure 1). The authors took this opportunity to review historic material collected in the area between 1978 and 1989 in comparison to the new data taken in 2002. Given that the commercial fishery in that area had ceased almost 15 years before and that commercial fishing has been banned in Subarea 48.1 by CCAMLR since the end of the 1989/90 season (CCAMLR, 1990c), this presentation is mostly interesting from a historical point of view and serves to complete CCAMLR's picture of the various fishing grounds.

Material and methods

Trawling was conducted from all vessels using commercial-size bottom trawls. As far as was known, wing spread of the trawls was in the order of 18 to 22 m. Net height was dependant on whether two- or four-panel bottom trawls were used. No information was available on pelagic trawls used to catch *C. wilsoni* off the bottom and in midwater. A small-meshed liner of 40 and 20 mm respectively was used in the codend during research hauls conducted in 1987 and 2002, and possibly earlier when research vessels fished in the area, e.g. the Polish RV *Profesor Siedlecki* in 1980/81 and 1982/83.

The location of fishing stations conducted in 2002 by the *Polarstern* is provided in Figure 1. In order to take the diurnal migration pattern of Antarctic fish into account, trawling was conducted only during daylight hours when fish were known to concentrate on the bottom or in near-bottom layers. Towing time was 30 minutes on the bottom during scientific hauls. Towing time during commercial operations, as far as was known, was up to 90 minutes. Fishing depth in 2002 was 149 to 282 m. During commercial and scouting operations by USSR vessels, fishing was carried out mostly at depths of 270 to 360 m.

The catch composition of the five scientific tows was recorded in terms of weight and number of individuals per species. The by-catch of benthos was recorded in terms of weight. The qualitative composition of the benthos was noted. Length of fish was recorded to the centimetre below from the tip of the snout to the end of the caudal fin. Maturity was classified according to the five-point scale (Everson, 1977; Kock and Kellermann, 1991). Additional measurements (total weight, weights of ovary and testes measured to the gram below on an electronic scale, diet composition and otoliths) were taken from a subsample of the respective species in each haul following standard procedures (Jones et al., 2001). Absolute fecundity was estimated by weighing all oocytes and a subsample of 1 000 oocytes and then extrapolating to calculate the total number of oocytes. Gonadosomatic indices (GSIs) were calculated following procedures described by Kock (1989). Stomachs were analysed according to the 'frequency of occurrence' method (Pillay, 1952; Gjösæter, 1973).

Results

The fishery

Commercial fishing information was only available for two seasons, 1978/79 and 1979/80. Polish

and GDR vessels fished until May 1979. In the season thereafter, only Polish vessels fished in January and February 1980. Catches were variable between months, as can be seen from total catch figures provided by month for the 1978/79 season (Figure 2).

There is little information on how the fishery was conducted, how many vessels participated at a given time in the fishery, how long they fished in the course of a particular season, and how long the fishing season was (except in 1978/79 and 1979/80). Commercial fishing by GDR vessels was only conducted in 1978/79, when at least six GDR vessels (ROS 304 *Erich Weinert*, ROS 307 *Peter Nell*, ROS 332 *Kurt Barthel*, ROS 334 *Eduard Claudius*, ROS 402 *Werner Kube* and ROS 404 *Elvira Eisenschneider*) fished in the area (Gubsch and Hoffmann, pers. comm., 1979). However, these vessels also fished for krill (*Euphausia superba*) and mackerel icefish (*C. gunnari*) in the Elephant Island–South Shetland Islands region in the course of the same season. Attempts to find concentrations of *C. wilsoni* were continued in 1979/80 by the *Werner Kube*. No aggregations of fish were found and fishing ceased after a number of hauls were taken (Gubsch and Hoffmann, pers. comm., 1980). Exploratory fishing by a GDR trawler was also conducted on one or two days in January 1986. No large fish aggregations were found and subsequently, no commercial fishing continued (Gubsch, pers. comm.).

The *Profesor Siedlecki* visited Joinville–D'Urville Islands in 1978/79 at the same time as commercial fishing took place. These exploratory fishing trials were continued in 1980/81, 1983/84 and 1986/87. Nine, three, five and six hauls were conducted in those years (Sosinski and Trella, 2001).

USSR fishing vessels from Murmansk and Kaliningrad fished in the area in most years between 1979 and 1987. Russian vessels fished on the same ground in 1979/80 as did Polish and GDR vessels. However, the number of vessels which participated in the fishery and the amount of fish taken is not known for any of the seasons in which fishing took place.

In November 1984 and January 1987, USSR fishing vessels detected no concentrations of *C. wilsoni* and the fishing effort was low. The USSR vessel *Parallaks* found two concentrations of *C. wilsoni* at 62°20′–62°30′S 55°30′–56°00′W in the northern part of the shelf in January 1986. Catches were in the order of 5–6 tonnes/hour. The estimated biomass in the area was 20 000–25 000 tonnes. Further to the east at 62°20′–62°25′S 55°20′–55°25′W concentrations were larger. Catches varied from 15–20 tonnes/hour. The biomass of these concentrations was estimated to be 70 000–75 000 tonnes (Shust, 1998). Catches declined substantially in the following season. In 1989, the USSR vessel *Pioner Latvii* conducted 90 hauls between 90 and 500 m depth. The species most often encountered were *G. gibberifrons*, *Trematomus eulepidotus* and *Notothenia coriiceps*. *C. wilsoni* was found to be less abundant (Shust, 1998).

Species composition

Species composition around Joinville–D'Urville Islands was only known in qualitative terms (present/absent) from tows conducted between 1978 and 1989 (Anon., 1979, 1987; Cielniaszek, 1981; Gubsch and Kuhlmann, pers. comm., 1979; YugNIRO, unpublished data) and quantitatively only from the five tows carried out in 2002. Data from commercial catches concerned primarily the most abundant species and only occasionally mentioned other species taken. Polish catches, for example, contained 80–98% *C. wilsoni*. Rarer species were easily overlooked and not recorded. Catch information on commercial catches, where known, has been added for reasons of completeness (Table 1). Thirty-six species are currently known to occur in the area (Table 1).

Abundant species found during the cruise in February 2002 were marked '++'. With a few exceptions (rajids, muraenolepids, zoarcids, bothids, myctophids), which made up not more than 3% of the fish catch, all species were members of the Antarctic suborder Notothenioidei.

Chaenodraco wilsoni, target species of commercial fishing

Length compositions in catches from the commercial fishery, scouting vessels and research vessels give a similar picture. A typical example of length compositions obtained from the fishery is provided in Figure 3, which shows length compositions of Polish catches from January to March 1979.

Length compositions of Polish commercial catches were unimodal in most cases. Length in 1978/79 varied from 17–37 cm in January to 19–36 cm (50–310 g) in February and March (Figure 3). No data were available from April and May. In January, 86% of the catches consisted of individuals 23–29 cm in length. In February and March, 86 and 89% of the fish caught were 24–28 cm in length. Mean length varied little from 26 to 26.3 cm in January and March (Cielniaszek, 1981). In 1979/80, fish were slightly larger, with

Table 1: Species of Antarctic fish taken off Joinville–D'Urville Islands from 1978 to 2002.

Species	Anon. 1979	Anon. 1987	FV *Volzhanin* (USSR) 1978[3]	FV *A. Yokhani* (USSR) 1979[3]	FV *Gizhiga* (USSR) 1985[3]	1978	1979	1981	1985	1986	1989	This Paper
Nototheniidae												
Dissostichus mawsoni	+											
Notothenia rossii		+										+
N. coriiceps	+	+				+			+	+		++
Gobionotothen gibberifrons	+	+		+		+	+	+	+	+	+	++
Lepidonotothen larseni	+	+		+				+	+	+		+
L. squamifrons	+[1]			+			+			+		+
L. nudifrons	+	+							+			++
Trematomus centronotus	+											+
T. eulepidotus	+	+							+	+	+	+
T. bernacchii												+
T. hansoni	+	+							+	+		+
T. newnesi	+											+
T. nicolai	+											+
T. scotti	+	+										
Pleuragramma antarcticum		+					+	+				
Artedidraconidae												
Artedidraco skottsbergi		+										+
Pogonophryne marmorata		+										
P. scotti		+										
Pogonophryne spp.	+											
Bathydraconidae												
Parachaenichthys charcoti	+	+										+
Gymnodraco acuticeps	+	+										+
Racovitzia glacialis		+										
Prionodraco evansii	+											
Champsocephalus gunnari	+											
Chaenodraco wilsoni	+	+	+++	+++								+
Chionodraco rastrospinosus	+[2]	+		+			+	+	+	+	+	++
Cryodraco antarcticus	+	+		+		+	+	+	+	+	+	+
Neopagetopsis ionah	+											
Pagetopsis macropterus	+	+										+
Bathyraja maccaini		+										+
B. eatoni		+										+
Raja spp.	+											
Muraenolepis microps	+											
Austrolycichthys spp.	+											
Mancopsetta maculata										+		+
Gymnoscopelus nicholsi							+					

[1] Identified as *Notothenia kempi* (see Schneppenheim et al., 1994).
[2] Identified as *Chionodraco kathleenae* (see Iwami and Kock, 1990).
[3] Catch compositions from the three USSR vessels in 1978, 1979 and 1985 were incomplete.

mean lengths of 28 cm in January and 28.6 cm in February. Length range was 21–34 cm (90–280 g). Mean length in 1980/81 was slightly less at 27.7 cm. The length range was 14–31 cm (80–310 g) (Anon., 1981; Cielniaszek, 1981).

Similar observations were obtained on GDR vessels in 1978/79 (Gubsch, 1982). Length compositions were bimodal in February with peaks at 25 and 29 cm and unimodal in March with a peak at 26 cm (Gubsch, 1982). Fish taken during exploratory fishing by the *Erich Weinert* in January 1986 and research vessel catches by the *Profesor Siedlecki* in November 1986 were mostly 27–35 cm long with a peak at 29.6 and 31.7 cm (Figure 4) (Anon., 1987; Sosinski and Skora, 1988; Gubsch, pers. comm.).

Length compositions from USSR catches over three seasons showed a similar picture (Figure 5). Length compositions consisted primarily of fish 22–32 cm in length. They give a very similar picture to length compositions from commercial Polish catches. Mean lengths and mean weights of *C. wilsoni* caught were 28–30 cm and 160–200 g.

Length compositions of *C. wilsoni* were similar in research vessel catches in 2002. Fish were 16–36 cm long, with the bulk of fish measuring 20–33 cm (Figure 4).

Chionodraco rastrospinosus

Reported catches from the Polish fishery were in the order of 350 tonnes in 1978/79 and 1979/80 (Anon., 1979; Cielniaszek, 1981). Catches of the USSR were unknown. Fish measured 21–44 cm in 1978/79 and 31–42 cm in 1980/81 with the bulk of catches consisting of fish 28–36 cm in length (Anon., 1979; 1981). Fish taken by the *Profesor Siedlecki* in November 1986 were mostly 30–45 cm in length (Sosinski and Skora, 1988). Fish taken in USSR catches over three seasons were variable in length composition with fish caught in 1979 being smaller than those taken in 1984 and 1989 (Figure 6). Fish collected in research vessel catches in 2002 were 27–44 cm long with fish of 32–38 cm in length predominating (Figure 7). Fish of similar size, with the bulk of fish measuring 30–40 cm, were also reported as being taken by the GDR in 1979/80 (Gubsch and Hoffmann, pers. comm., 1980).

Gobionotothen gibberifrons

Catches taken in the Polish fishery in 1978/79 and by the *Profesor Siedlecki* in 1980/81 comprised fish 11–42 cm and 34–48 cm in length, with the bulk of fish measuring 21–39 cm (Anon., 1979, 1981; Cielniaszek, 1981). A similar length composition was obtained by the *Profesor Siedlecki* in November 1986 (Anon., 1987). USSR catches of *G. gibberifrons* in 1979 showed smaller fish, with the bulk of fish measuring 15–35 cm (Figure 8). The length composition of research vessel catches in 2002 (Figure 9) resembled those of the Polish commercial fishery in 1978/79. Fish were either juveniles or (from about 28–30 cm onwards) adults with gonads in resting stage.

Biological information

Reproductive cycle

Chaenodraco wilsoni

Gonads of *C. wilsoni* were either in resting stage or at an early stage of maturation (stage 2, early stage 3) in January–February or were juvenile (stage 1) (Anon., 1979). Larger fish were slightly more advanced in gonad development than smaller fish.

Chionodraco rastrospinosus

Fish taken were largely males and juveniles. The limited number of adult females caught (n = 10) suggested that *C. rastrospinosus* was in the middle of the spawning season. GSIs of females were 15.5 to 20.5, while GSIs of adult males did not exceed 3–4.

Gobionotothen gibberifrons

Gonads of sexually mature *G. gibberifrons* were in resting stage in January to March (Cielniaszek, 1981). Similar observations were obtained in February 2002.

Notothenia coriiceps

All fish taken were sexually mature. Males were more common (60%) than females (40%). More than 22% of the 89 fish caught had gonads in resting stage. The range of GSIs in males and females of maturity stage 3 are shown in Figures 10 and 11. Males were more advanced in gonad development than females. The GSI increased with size in both sexes. This increase was significant in females (r^2 = 0.3798; $p < 0.05$) but not in males (r^2 = 0.0829; $p > 0.05$).

Other species

Material from species other than *C. wilsoni*, *C. rastrospinosus*, *G. gibberifrons* and *N. coriiceps* was too limited to obtain more than an indication of when spawning might take place. Two females of *Trematomus hansoni* had GSIs of 23.1 and 24.8. The limited material suggested that *Artedidraco skottsbergi* is likely to reproduce in austral autumn. Data on *T. newnesi* indicate late autumn spawning. *Pagetopsis macropterus* was likely to reproduce in winter, *L. larseni* in winter and *T. bernacchii* in early spring. In addition to the five individuals of *P. macropterus* investigated in this study, Gubsch (pers. comm.) found in January 1986 that gonads of seven females of *P. macropterus* (27–33cm long) were either resting (stage 2) or in an early stage of maturation (beginning stage 3).

GSIs and fecundity of three species of nototheniids and channichthyids are provided in Table 2.

Age determination

Otoliths of *C. wilsoni* were found to be small and difficult to read. Age was determined in 287 individuals from Polish catches (Cielniaszek, 1981). Fish caught in 1979 were generally found to belong to age classes 2 and 3, with some age 4 and a few age 5 individuals present (n = 79). In 1980, most fish belonged to age classes 3 and 4, with very few 2- and 5-year-old fish present (n = 163) (Cielniaszek, 1981). Ageing, however, was not validated.

Length–weight relationships

Length–weight relationships of *C. wilsoni* were primarily based on fish 17–33 cm in length (Table 3). Length–weight relationships of *C. rastrospinosus*, *G. gibberifrons* and *N. coriiceps* are provided in Table 4.

Food and feeding

The stomach contents of *C. wilsoni*, *C. rastrospinosus and P. macropterus* were investigated (Table 5). Stomachs of *C. wilsoni* contained primarily krill, while *C. rastrospinosus* took krill and fish. Two stomachs (out of five) of *P. macropterus* contained fish. The remaining three stomachs were empty.

Degree of fullness of stomachs of *C. wilsoni*

Information on the degree of fullness of stomachs was provided in Cielniaszek (1981). The proportion of empty stomachs was 5–8% in each of the three seasons (1978/79–1980/81) investigated. Degree of fullness was high (>50–70% of full stomachs) in March 1979, February 1980 and March 1981, but much less (<20% of full stomachs) in January–February 1979 and January 1980 (Cielniaszek, 1981). The highest degrees of fullness of stomachs were observed in the early afternoon between 1300 h and 1400 h (Cielniaszek, 1981).

Discussion

Joinville–D'Urville Islands are located some 60 n miles south of the South Shetland Islands at the tip of the Antarctic Peninsula. The two areas are separated by Bransfield Strait, which contains a number of deep basins of more than 1 000 m in depth (Stein and Heywood, 1994). The strait, with its peculiar geomorphological features such as the narrow shelf and steep slopes, in particular south of the South Shetland Islands, and the presence of Bellingshausen Sea water in the north and the central part and Weddell Sea water in its southern parts, may act as both a geographical and oceanographic barrier to some of the low-Antarctic shallow-water (<500 m) fish species with the exception, to some extent, of their pelagic early life-history stages.

The Joinville–D'Urville Islands shelf is 55–65 km wide and influenced by water masses flowing out of the Weddell Sea. The irregular bottom topography leads to the formation of eddies which accumulate krill concentrations. The area is characterised by a complex coverage of ice. In the ice-free period, drifting ice is frequently observed from the end of October to the beginning of December and in March and April. Frequent ice floes may be also found during the summer, to such an extent that they may impede fishing at times (Shust, 1998).

Joinville–D'Urville Islands is the only high-Antarctic ground in the Atlantic Ocean sector which has been exploited by a commercial fishery. The area was fished from 1978 to 1989 at irregular intervals. The length of the fishing season was dependent on the amount of ice drifting out of the Weddell Sea and along the tip of the Antarctic Peninsula. Fishing usually started in November and lasted until May in some years, such as in 1978/79. Fishing ceased by the end of February in other years. Despite a thorough search through old datafiles in several institutions that were involved in observer programs on board commercial fishing vessels at that time, information on this fishing ground remains fragmentary.

Table 2: GSIs and fecundity in *Trematomus hansoni*, *Artedidraco skottsbergi* and *Pagetopsis macropterus*.

	Length (cm)	GSI	Fecundity	Relative Fecundity	Oocyte Size	No. of Individuals Investigated
T. hansoni	36	24.8	8196	10.5	3.5	1
A. skottsbergi	10	15.0	247	27.4	2.7	1
P. macropterus	33	11.0	2233	7.1	2.9	1

Table 3: Length–weight relationships of *Chaenodraco wilsoni* taken off Joinville–D'Urville Islands in 1978–1980 and 2002.

Year	Time	No. of Fish Investigated	Length Range (cm)	Length–weight Relationship	Remarks/Source
1979	Jan–Mar	100	22–36	$W = 0.005664 \times L^{3.122278}$ $W = 0.020089 \times L^{2.732202}$	Males Females (Anon., 1979)
1979	Feb	618	?	$W = 0.0057 \times L^{3.1223}$	Sosinski, 1999 (King George Island)
1978–1981	Jan–Mar	936	20–35	$W = 0.014618 \times L^{2.771687}$	Maturity stage 1 (Cielniaszek, 1981)
1979–1981	Jan–Mar	505	20–35	$W = 0.017585 \times L^{2.742828}$	Maturity stage 2–3 (Cielniaszek, 1981)
2002	Feb	45	16–35	$W = 0.0037 \times L^{3.2073}$	This paper

Table 4: Length–weight relationships of *Gobionotothen gibberifrons*, *Chionodraco rastrospinosus* and *Notothenia coriiceps* taken off Joinville–D'Urville Islands in February 2002.

Species	No. of Fish Investigated	Length Range (cm)	Length–weight Relationship	Remarks/Source
G. gibberifrons	443	7–43	$W = 0.0015 \times L^{3.5434}$	This paper
C. rastrospinosus	99	26–44	$W = 0.0038 \times L^{3.2041}$	This paper
N. coriiceps	99	30–56	$W = 0.0125 \times L^{3.0750}$	This paper

Table 5: Stomach contents of *Chaenodraco wilsoni* and *Chionodraco rastrospinosus* off Joinville Island in February 2002.

Species	Length Range (cm)	No. of Stomachs Investigated	Proportion Empty (%)	Stomach Content (%)		
				Krill	Fish	*Themisto gaudichaudii*
C. wilsoni	21–35	45	22.2	92.1	-	7.9
C. rastrospinosus	27–44	73	64.4	58.6	41.4	-

Commercial fishing occurred at irregular intervals when the target species of the fishery, *C. wilsoni*, was found to form aggregations in certain areas of the shelf, such as in 1978/79, 1979/80 and 1986 (CCAMLR, 1990a; Shust, 1998). *C. wilsoni* tended to concentrate in comparatively small areas (Shust, 1998; Sosinski and Trella, 2001) which were easily missed during research vessel surveys. Fishable concentrations were detected at depths of 180–350 m, and most frequently between 200 and 300 m (Sosinski and Trella, 2001). Catches in the commercial fishery, as far as was known, were often 5 tonnes/hour and more. The target species, *C. wilsoni*, made up 80% or more of the catch (Cielniaszek, 1981). Catches taken randomly by research vessels over the area rarely exceeded 50–100 kg/30 min and often contained large quantities of other species, such *C. rastrospinosus* and *G. gibberifrons*, while *C. wilsoni* formed only a minor part of the catch.

Near-bottom temperatures were –1.00 to –1.27°C when commercial fishing took place off Joinville Island in 1978/79 and 1979/80 (Gubsch,

1982; Gubsch and Hoffmann, pers. comm.). In the Cosmonauts Sea, *C. wilsoni* tended to form concentrations on the northern part of the shelf on the border between water masses of the Antarctic Circumpolar Current and the coastal currents. Fish made diurnal migrations from near-bottom to surface waters through two bodies of water: intermediate Antarctic Circumpolar Water which began at a depth of 50–70 m in January and extended to close to the bottom with temperatures of –1.4 to –1.7°C and salinities of 34.20 to 34.40‰, and coastal surface water with temperatures from –1° to 2°C and salinities of 32.30 to 34.10‰. These water masses were well separated by both a strong thermocline and a strong halocline. Stratification in the water column was less pronounced in March when Antarctic Circumpolar Water began at a depth of 100–150 m only. Antarctic Circumpolar Water ranged from temperatures of –1.3 to –1.6°C and salinities of 34.30 to 34.50‰. Coastal surface water was colder and more saline in March than in January with values of –0.7 to –0.4°C and 33.9 to 34.05‰ (Herasymchuk and Trozenko, 1988).

With the exception of some qualitative information, catch data from the USSR taken in the area were not available. USSR fishing vessels were known to have trawled in the area, both in midwater and on the bottom, quite extensively between 1978 and 1989. In 1986, for example, large catches were taken, while in other years, such as in 1984 and 1987, catches were known to have been small as no concentrations of *C. wilsoni* were found. Abundance of *C. wilsoni* seemed to fluctuate considerably between years without any impact from the fishery (Shust, 1998).

The other species reported as being taken in some numbers, both in the commercial fishery and in research vessel catches, were *C. rastrospinosus*, *G. gibberifrons* and *N. coriiceps*. Catch data were only provided to CCAMLR by statistical subarea and not by fishing ground. Fine-scale data held in the CCAMLR database which could provide information on the fishing ground were limited to 29 records spread over a number of years and were unfortunately of little help (D. Ramm, pers. comm.). Catch data reported for Subarea 48.1 in the two seasons 1978/79 and 1979/80, which did not differentiate between the South Shetland Islands and Joinville Island, contain *C. rastrospinosus* and G. *gibberifrons.* A small but unknown fraction of the catch of these two species may have been taken off Joinville–D'Urville Islands.

The species inventory off Joinville–D'Urville Islands was found to be a mixture of low- and high-Antarctic species. In contrast to the South Shetland Islands, high-Antarctic species formed the greater part of the species inventory. Low-Antarctic species (primarily *G. gibberifrons, L. larseni* and *L. nudifrons*) still made up a substantial proportion in terms of the fish biomass. The three most abundant low-Antarctic channichthyids, *C. gunnari*, *Chaenocephalus aceratus* and *Parachaenichthys georgianus*, had disappeared and were replaced by high-Antarctic icefish, with *C. wilsoni* and *C. rastrospinosus* prevailing in terms of biomass and numbers.

G. gibberifrons made up more than 30% of the catch in terms of weight in the limited numbers of hauls in 2002. As in the southern Scotia Arc (Kock and Jones, 2004), bathydraconids and artedidraconids were only encountered as single individuals. However, they may be more numerous below 300 m where the *Polarstern* was unable to fish due to lack of time.

C. wilsoni is the only icefish species which spawns outside the autumn–winter period (Kock and Kellermann, 1991; Duhamel et al., 1993). Gubsch (1982), Herasymchuk and Trozenko (1988) and L. Pshenichnov (unpublished data) provided some further information on the reproductive biology of *C. wilsoni*. Fish in the Cosmonauts Sea became sexually mature between 29 and 31 cm which is confirmed by the limited observations in this study from Joinville–D'Urville Islands. Oocyte sizes were 4.4–4.9 mm both off Joinville Island and in the Cosmonauts Sea and thus similar to those of most other channichthyid species, such as *C. aceratus*, *P. georgianus* or *C. rastrospinosus*. They were larger than in the low-Antarctic *C. gunnari* which appears similar in shape, size and ecology to *C. wilsoni*. GSIs were in the range of 19.7 to more than 30 in females in late maturity stage 3 from the Cosmonauts Sea and thus comparable to other icefish species. Spawning took place in November and was likely to be completed in December (Anon., 1987). Fecundity was comparatively low with 1 112 to 2 167 oocytes (please note that fecundity information provided in Herasymchuk and Trozenko (1988) was likely to underestimate fecundity). Fecundity increased with the size of females. Relative fecundity ranged from 6 to 12 oocytes (L. Pshenichnov, unpublished data) and was thus similar to relative fecundity in *C. gunnari* and other icefish. Eggs were sticky and deposited in one batch on the bottom (on silt, sand or small stones). Males stayed close to the eggs for 1–2 months and may guard them. Catches of post-spawning fish were predominantly males when taken close to the bottom and overwhelmingly females when caught in midwater (L. Pshenichnov, unpublished data).

After hatching, larvae, postlarvae and juveniles of *C. wilsoni* spent one or two years in midwater and subsurface waters and moved with the coastal current to the west. Two- to four-year-old fish lived pelagically at 20–120 m over depths of 200–400 m, sometimes forming fairly stable concentrations, and may live in association with the Antarctic silverfish (*Pleuragramma antarcticum).* When fish reached 4 years of age they moved to the east again. They first spawned when 4–5 years old. The maximum age found was 9 years (L. Pshenichnov, unpublished data).

C. wilsoni migrated diurnally in the water column like other channichthyids, such as *C. gunnari*, to feed on macrozooplankton. The composition of the stomach contents depended on what was available in the water column. *E. superba* was the main food item both off Joinville–D'Urville Islands (Gubsch, 1982; Gubsch, pers. comm.; Shust, 1998) and in the Cosmonauts Sea (Herasymchuk and Trozenko, 1988; L. Pshenichnov, unpublished data). In coastal waters and the Ross Sea *E. crystallorophias* and *P. antarcticum* formed the main diet in a limited study by Takahashi and Nemoto (1984). Fish rose in the water column in the evening, sometimes very close to the surface, where they fed on krill, as is confirmed by this limited study. They descended to the bottom again in the morning (Herasymchuk and Trozenko, 1988; L. Pshenichnov, unpublished data).

Age determinations have only been conducted on *C. wilsoni* from Joinville–D'Urville Islands collected in 1978/79 and 1979/80 by Polish scientists. Fish taken by the fishery were primarily 3–5 years old. They were either immature or beginning to mature. This appears to be in agreement with information provided by Herasymchuk and Trozenko (1988) from the Cosmonauts Sea, although no published age estimates have been provided. It should be noted, however, that age determination in *C. wilsoni* has not yet been validated. The largest individual observed was 43 cm long (Shust, 1998).

Although belonging taxonomically to a different genus, *C. wilsoni* appears to be similar in body shape and colouration to *C. gunnari* in the low Antarctic. Like *C. gunnari, C. wilsoni* undertakes regular diurnal migrations to feed on macrozooplankton in the water column at night. Its preferred diet consists of Antarctic krill (Sosinski et al., 1981; Gubsch, 1982; Herasymchuk and Trozenko, 1988) which is also the predominant food item of *C. gunnari* in the southern Scotia Arc. *C. wilsoni* appears to occupy a similar ecological niche in the high Antarctic as *C. gunnari* in the low Antarctic.

C. rastrospinosus appeared to be in the middle of its spawning season when taken in the second half of February. Sosinski et al. (1981) found primarily fish with gonads in resting stage or gonads which just started to mature at the same time of year in 1981. Information on GSIs of *N. coriiceps* was not provided by Sosinski et al. (1981). Maturity stages they observed appear to correspond to the GSIs which were measured in the second half of February 2002. Observations on the reproductive state of *N. coriiceps* confirmed earlier observations on gonad development and spawning in the species (Kock, 1989; Kock et al., 2000). Spawning is likely to occur in May–June. Information on other species was too limited to provide more than an indication of when the spawning season was likely to be. They fit well into data presented previously by Kock (1989), Kock and Kellermann (1991) and Kock et al. (2000) on reproduction and the likely date of spawning.

Icefish are known to feed primarily on krill and fish (e.g. Permitin, 1970; Kock, 1992). C. *wilsoni* fed predominantly on krill off Joinville Island and in the Cosmonauts Sea (Herasymchuk and Trozenko, 1988) and on *E. crystallorophias* close to the Antarctic continent (Takahashi and Nemoto, 1984). *C. rastrospinosus* takes krill and fish, which is corroborated by other studies in the South Shetland Islands (Tarverdiyeva and Pinskaya, 1980; Gröhsler, 1992; Takahashi and Iwami, 1997).

Conclusions

Despite the authors' extensive search through archives of laboratories involved in commercial fishing activities in the Southern Ocean, the information on the fishing ground off Joinville–D'Urville Islands remains limited. It remains unknown how important the fishery on *C. wilsoni* was in those years when fishing took place compared to fishing grounds where *N. rossii* and *C. gunnari* were exploited.

The area off Joinville–D'Urville Islands contains a mixture of demersal fish species of low- and high-Antarctic origin. Thirty-six species were known from the area. The predominant species in terms of their biomass were *C. wilsoni*, *C. rastrospinosus* and *G. gibberifrons*.

Some new information was provided with respect to absolute and relative fecundity, GSI and oocyte size. However, the data were too limited to offer more than indications of when the spawning season of a number of Antarctic species is likely to be. Age determination, which lacks validation, suggests that most *C. wilsoni* present in commercial

catches were 3–5 years old. The staple food of *C. wilsoni* was krill. *C. rastrospinosus* took krill and fish.

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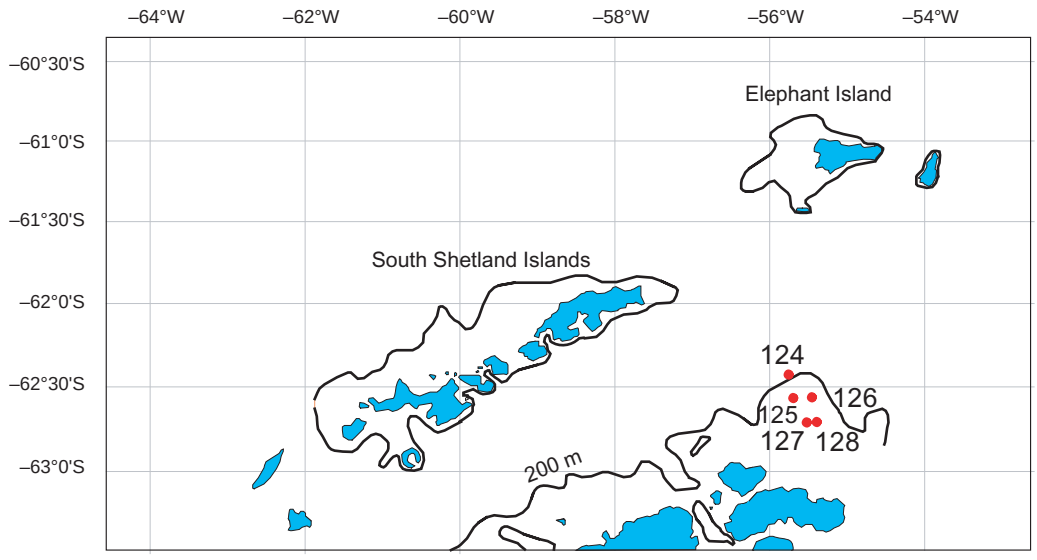


Figure 1: Fishing stations conducted during the cruise of the RV *Polarstern* in the Elephant Island–South Shetland Islands region in February 2002 and off Joinville–D'Urville Islands on 21 February 2002.

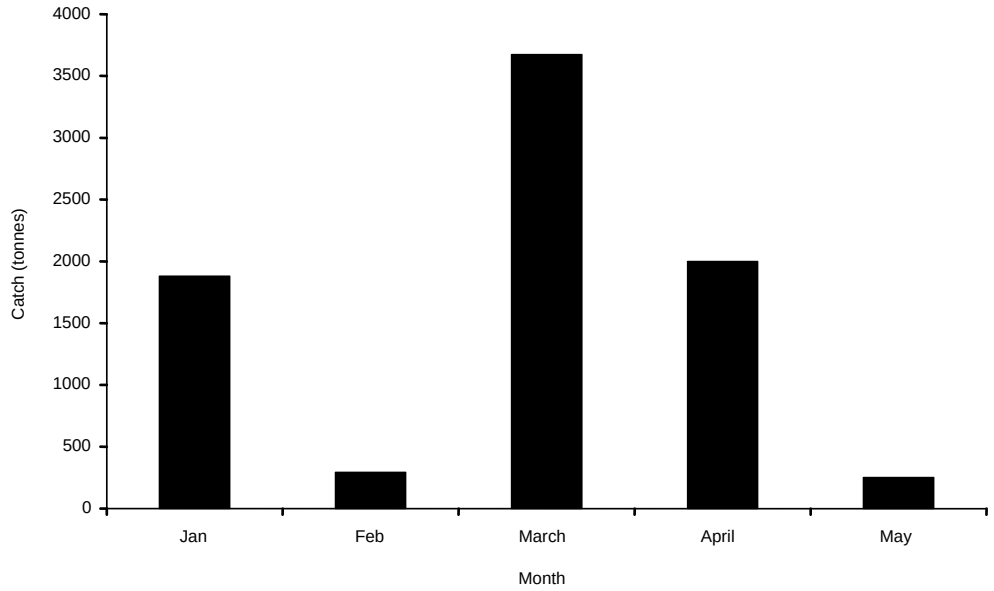


Figure 2: Monthly catches of *Chaenodraco wilsoni* by Polish and former GDR vessels off Joinville–D'Urville Islands in January 1978 to May 1979.

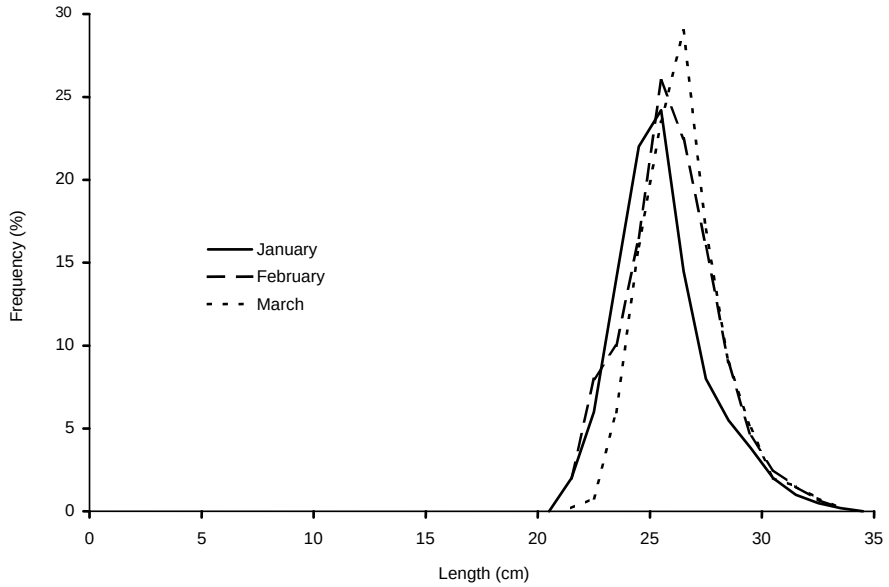


Figure 3: Length compositions of *Chaenodraco wilsoni* off Joinville–D'Urville Islands taken by Polish vessels from January to March 1979.

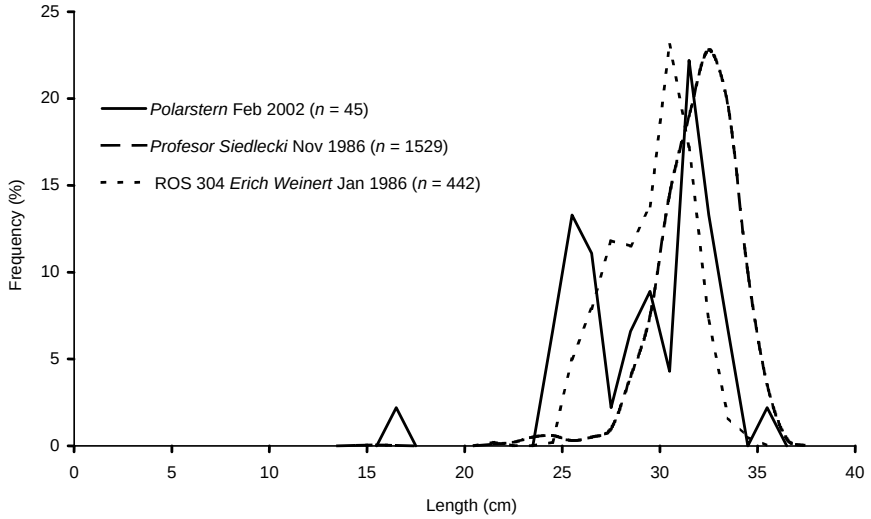


Figure 4: Length compositions of *Chaenodraco wilsoni* off Joinville–D'Urville Islands taken in February 2002 (*Polarstern*), November 1986 (*Profesor Siedlecki*) and January 1986 (*Erich Weinert*).

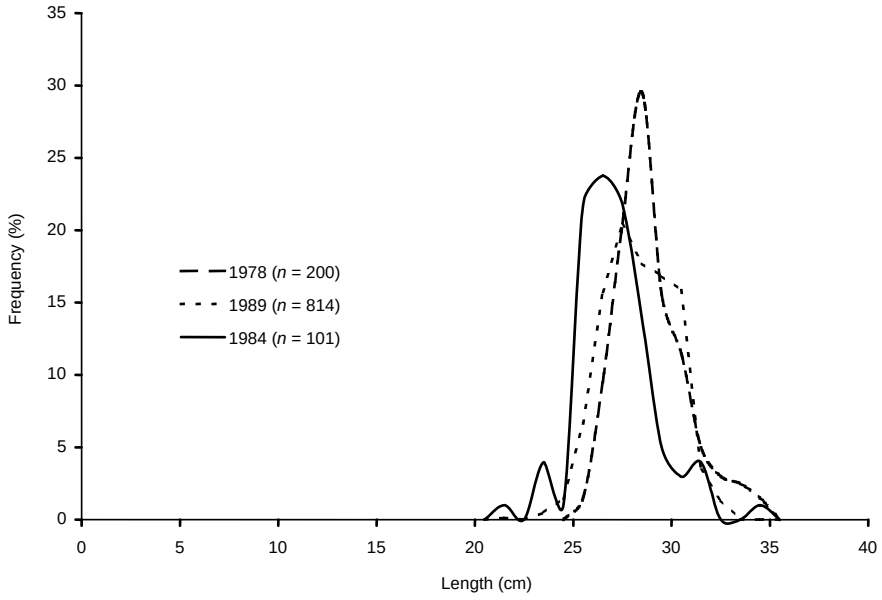


Figure 5: Length compositions of *Chaenodraco wilsoni* off Joinville–D'Urville Islands taken by former USSR vessels in 1978, 1989 and 1984.

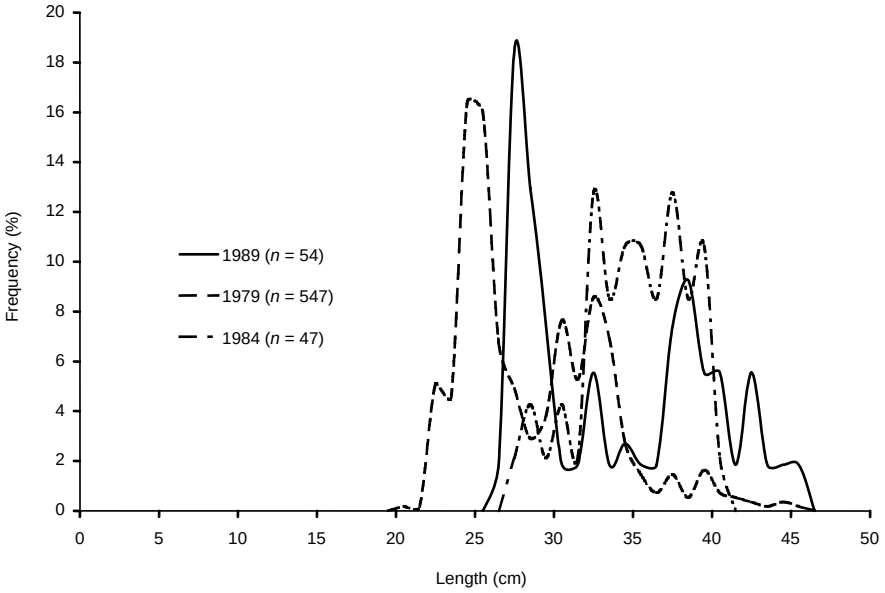


Figure 6: Length compositions of *Chionodraco rastrospinosus* off Joinville–D'Urville Islands taken by former USSR vessels in 1989, 1979 and 1984.

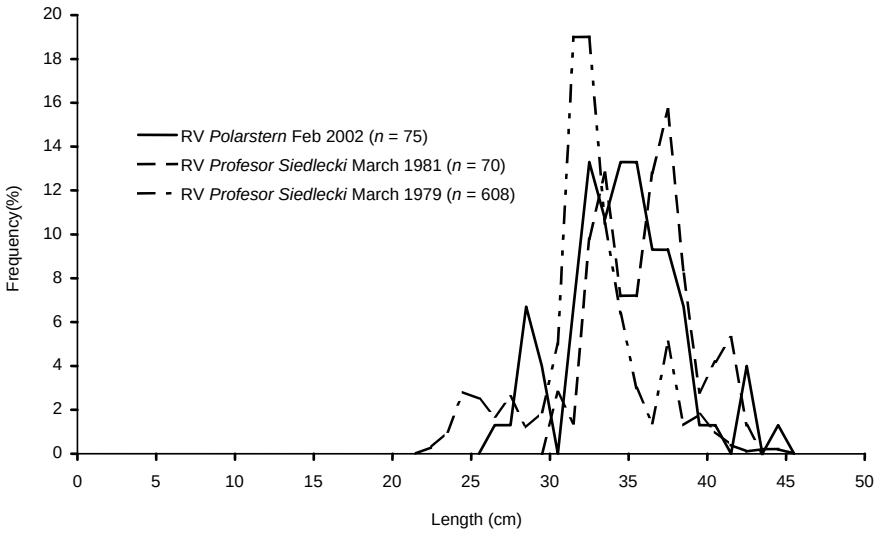


Figure 7: Length compositions of *Chionodraco rastrospinosus* off Joinville–D'Urville Islands in 1979 (*Profesor Siedlecki*), 1981 (*Profesor Siedlecki*) and 2002 (*Polarstern*).

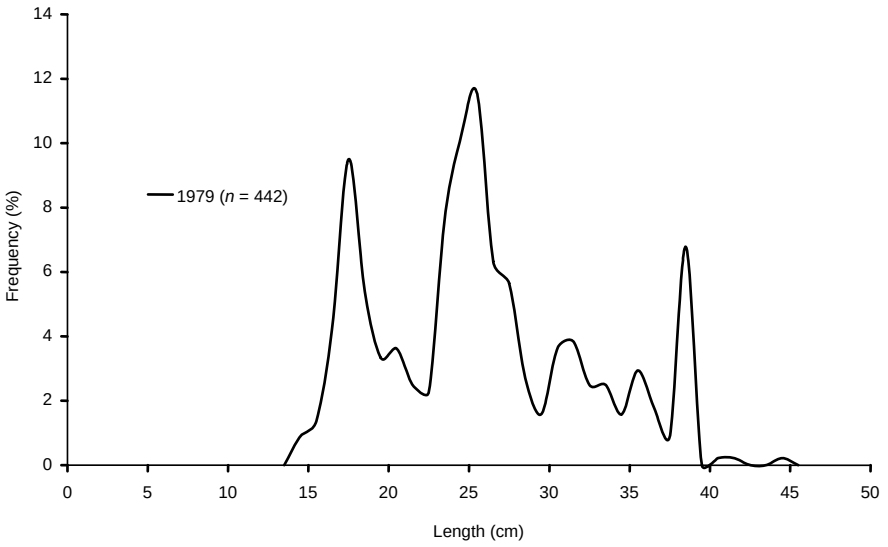


Figure 8: Length compositions of *Gobionotothen gibberifrons* off Joinville–D'Urville Islands taken by former USSR vessels in 1979.

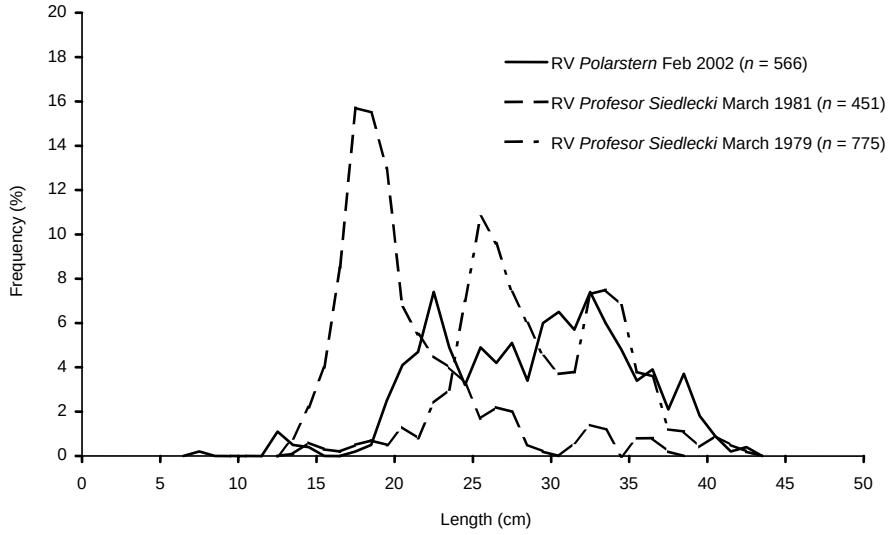


Figure 9: Length compositions of *Gobionotothen gibberifrons* off Joinville–D'Urville Islands taken in 1979 (*Profesor Siedlecki*), 1981 (*Profesor Siedlecki*) and 2002 (*Polarstern*).

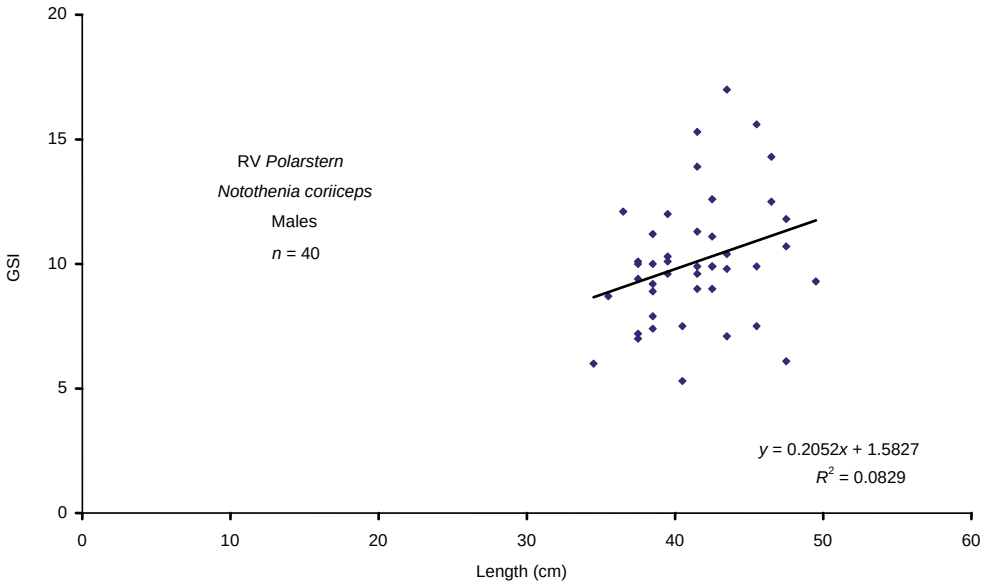
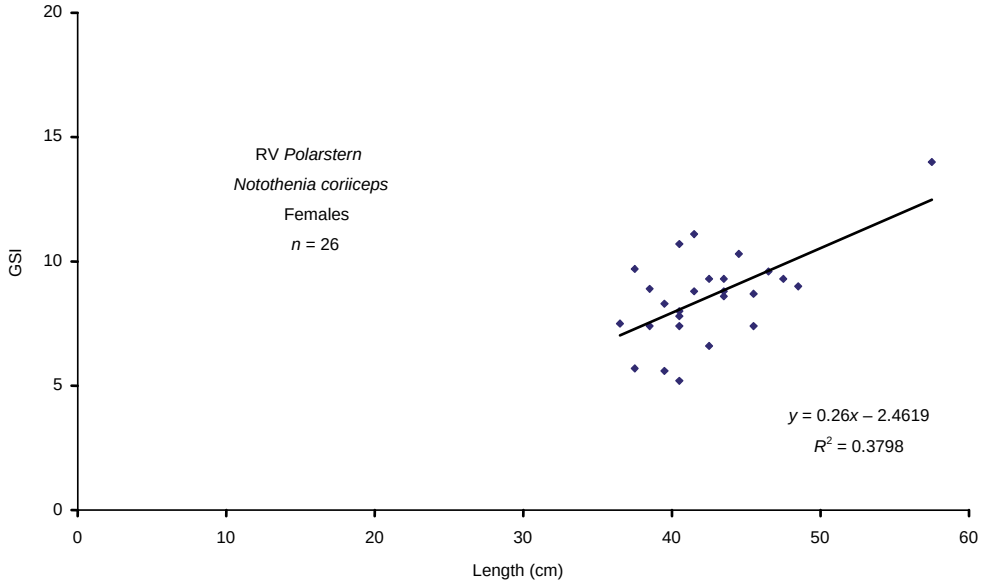


Figure 10: GSIs of male *Notothenia coriiceps* in relation to fish length off Joinville–D'Urville Islands.



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