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Ichthyological and fishery studies of the shelf fishing grounds in the region of Kerguelen Islands (Antarctic)

ABSTRACT: The shelf fishing grounds of Kerguelen Islands and of some neighbouring ocean shallows were studied in April 1975. The occurrence of 15 species representing 9 families was found in the catches. Detailed study of the following five species was performed: *Champocephalus gunnari*, *Channichthys rhinoceratus*, *Notothenia rossi rossi*, *N. squamifrons* and *Dissostichus eleginoides*, all of potential commercial importance. The boundaries of regions with concentrations of *Ch. gunnari* and *N. squamifrons* were determined, the productive and suitable for trawling fishing grounds were localized.

Key words: Antarctic fish

1. Introduction

The first observations and studies of the marine ichthyofauna of Kerguelen Islands were done from the French scientific station in Port aux Français in 1963. The first fishery research was done by Japanese and Russian ships in 1967—1970. Regular hydrographic and biological studies of these waters were started by the French research vessel N. O. "Marion Dufresne" in 1973 (Hureau and Duhamel, 1980).

Material for the present paper was collected from the r/v "Profesor Siedlecki" during the expedition to the Indian Ocean, organized by the Sea Fisheries Institute in 1975. Studies of Kerguelen Islands waters were carried out in period 1—16 April. The shelf on the west and south sides of the Islands, the Skiff Bank and one of the shallows on Kerguelen—Heard Ridge (51°20'S; 72°00'E) were studied. Hydrological studies of the marine environment and bottom analyses were carried out within the complex research project, as well as hydroacoustical observations of the distribution of fish concentrations and ichthyological-fishery studies based on the experimental hauls were done.

The paper presents the results of ichthyological studies and the fishery

characteristics of more important fish species with the background of hydrological conditions of the fishing grounds.

2. Material and methods

The fish for studies were caught a bottom trawl P28/32¹). A total of fifteen experimental hauls were made in the south sector of Kerguelen Islands: shelf, on Skiff Bank and Kerguelen—Heard Ridge (Fig. 1).

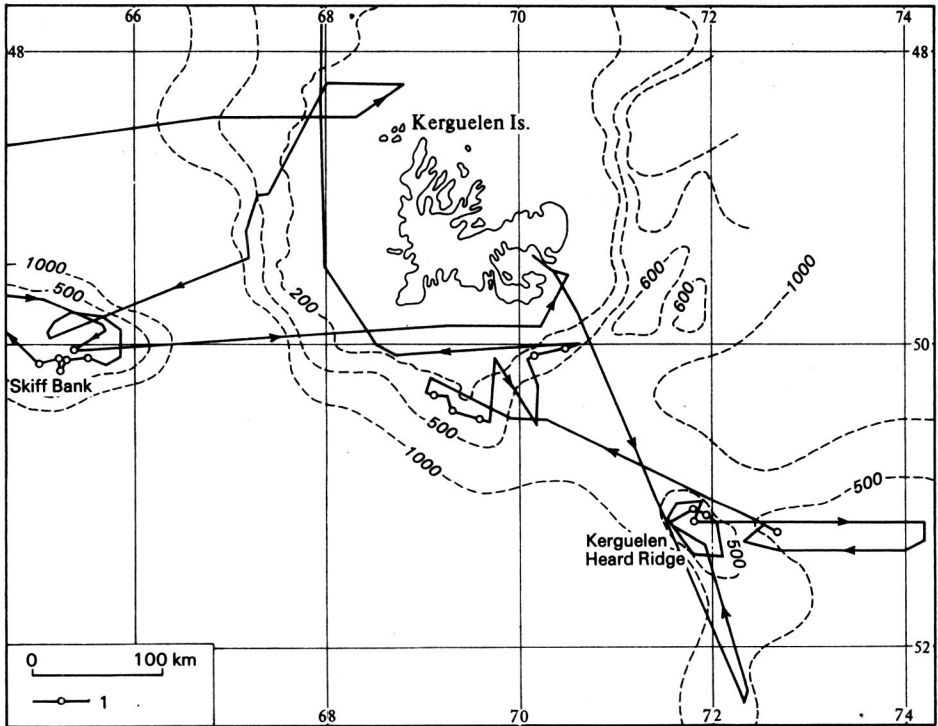


Fig. 1. The cruise of r/v "Profesor Siedlecki" and positions of the experimental hauls (April 1975)

1 — trawl stations.

Hydroacoustical observations were carried out with a vertical echosounder, using the 10 KW transmitter and a stabilized transducer, and with EK 120 echosounder co-working with preciser recorder. While evaluating the distribution of fish concentrations an analog echo integrator was used additionally.

A random fish sample from a catch was sorted to species, weighted and counted for the precise determination of the species composition, total numbers and biomass of the caught fish. The fish of the most numerous species were measured and analysed in detail, determining: total length (L_t),

¹) Length of headline — 28 m, half of the belly perimeter — 32 m, vertical opening — 6 m, distance between the wings — 16—18 m with trawling speed 4.5—5 knots.

individual weight, sex and sexual maturity stage (in 8 degree scale of Maier), filfillment of the stomach with food (in 5 degree scale) and the kind of food. Selected counts and proportional measurements were performed for selected species. The otoliths and scales were collected for the later age determination. The stomachs and a collection of gonads were also preserved for further studies. The numbers of examined fish and of materials collected for further ichthyological studies are shown in Table I.

Table I

The number of studied fish

Species	Length measurements	Ichthyological analyses	Morphological studies	Material preserved for further studies	
				stomachs	gonads
<i>Champscephalus gunnari</i>	3906	656	32	239	90
<i>Channichthys rhinaceratus</i>	91	90	12	5	—
<i>Notothenia squamifrons</i>	633	227	15	7	—
<i>Notothenia rossi rossi</i>	701	206	13	89	28
<i>Dissostichus eleginoides</i>	75	24	8	—	—
Total	5406	1203	80	340	118

3. The region of studies

Kerguelen Archipelago, composed of one large and about 300 smaller islands is surrounded by a broad shelf. There are several shallows on the shelf, separated by long stretches of deeper water. The shallows are the most numerous on the underwater mountainous ridge which joins the Kerguelen and Heard islands and runs further south estward to Antarctic. One of these shallows, located about 90 nautical miles from the Kerguelen Island was studied in detail. The mean depth of the bank is about 300 m. The bottom relief is differentiated, the slopes broad and corrugated, especially on the east side. The leveled central part of the bank is covered with silt and scarce basalt rocks. There are some other shallows west from the Kerguelen Island. The studied Skiff Bank, one of them, has a special fishery importance. This bank, located some 100 nautical miles from the Kerguelen Islands has a flat bottom, suitable for trawling, with mean depth of about 300 m. The shelf surrounding the Kerguelen Islands from west and south is sandy or gravely down to the depth of 200 m with pebbles and basalt stones. The bottom below this depth is covered by silt (Orłowski, in press).

The region of the Kerguelen shelf and of the banks surrounding it is within the subantarctic zone, between the subtropical and antarctic convergences, but much closer to the latter, which occasionally crosses the island region. The surface waters southward from the antarctic convergence have temperature from $+1^{\circ}\text{C}$ in winter to $+3.5^{\circ}\text{C}$ in summer and salinity below $34^{\circ}/_{00}$. North from this convergence the temperature varies from $+2^{\circ}\text{C}$ in winter to $+4^{\circ}\text{C}$ in summer, the salinity is over $34^{\circ}/_{00}$. The cold surface waters of the Antarctic Ocean submerge below the warmer subantarctic

waters in the region of antarctic convergence, becoming the intermediate subantarctic waters, with deep antarctic water below the latter (Hureau 1973). The polar front was located during our studies southward from the explored region. The concentrations of the bottom fish species occurred in intermediate well oxygenated waters with temperature 2–3°C (Furtak and Grelowski, unpublished data).

4. Results

4.1. An introductory characteristics of studied ichthyofauna, its composition and distribution

Twelve bottom (pseudo-abyssal) species and three bathypelagic species (including two determined to the genus) were found in the control catches (Table II). Two of these species: *Raja eatonii* and *Channichthys rhinoceros*

Table II

The species composition of fish in the experimental hauls
(r/v "Profesor Siedlecki" — April 1975)

Taxon	Fishing grounds		
	Skiff Bank	Kerguelen-Heard Shelf Ridge	of Kerguelen Islands
<i>Rajidae</i>			
<i>Raja murrayi</i> Günther	+))		+
<i>Raja eatonii</i> Günther	+	+	+
<i>Muraenolepidae</i>			
<i>Muraenolepis marmoratus</i> Günther		+	+
<i>Nototheniidae</i>			
<i>Notothenia squamifrons</i> Günther	+	++)	++
<i>Notothenia rossi rossi</i> Richardson	++	+	++
<i>Notothenia</i> sp.			+
<i>Dissostichus eleginoides</i> Smitt	+	+	+
<i>Channichthyidae</i>			
<i>Champscephalus gunnari</i> Lönnberg	++	++	++
<i>Channichthys rhinoceros</i> Richardson	+	++	+
<i>Congiopodidae</i>			
<i>Zanclorhynchus spinifer</i> Günther	+	+	+
<i>Bothidae</i>			
<i>Mancopsetta maculata</i> Günther	+		+
<i>Archirosetta slavae</i> Andrijašev	+	+	+
<i>Trichiuridae</i>			
<i>Paradiplospinus gracilis</i> Brauer	+		
<i>Myctophidae</i>			
<i>Gymnoscopelus braueri</i> Lönnberg	+		+
<i>Bathylagidae</i>			
<i>Bathylagus</i> sp.			+

+) single individuals

++) occurrence of fish concentrations

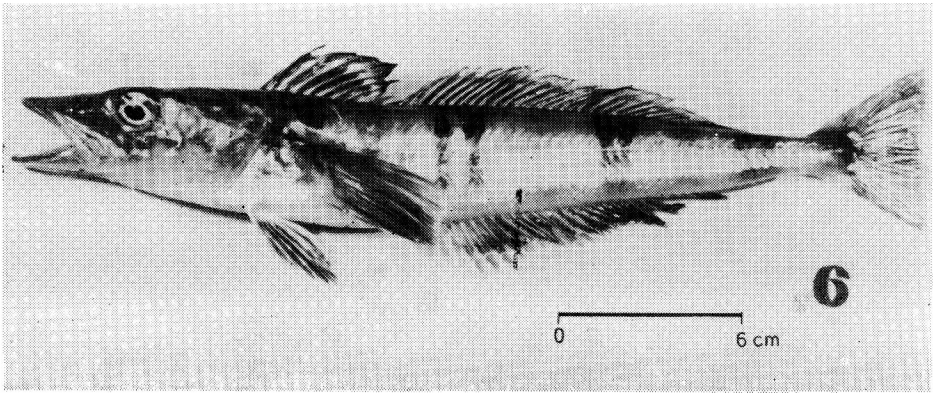


Fig. 2. Antarctic icefish *Champsocephalus gunnari*

Photo A. Malinowski

are listed as endemic for Kerguelen and Heard islands, another three: *Raja murrayi*, *Notothenia squamifrons* and *Zanclus cornutus* — as endemites of the Kerguelen—Macquarie Province (Hureau 1980).

The composition of dominant species changed depending on the studied fishing ground. A considerable dominance of *Champsocephalus gunnari*, forming fairly large feeding or prespawning concentrations, was observed far from the islands, on Skiff Bank, and Kerguelen—Heard Ridge. This species was accompanied on the Skiff Bank by various proportions of *Notothenia rossii*. *Channichthys rhinoceratus* and *Notothenia squamifrons* occurred in the by-catch on the bank of Kerguelen—Heard Ridge. The groupings of the mature *Champsocephalus gunnari* nearly disappeared on the shelf of Kerguelen Islands, but shoals of the juvenile fish of this species occurred with larger concentration of *Notothenia squamifrons*. *Channichthys rhinoceratus* was quite numerous in the by-catch.

4.2. Fishery and ichthyological characteristics of more important fish species

Champsocephalus gunnari Lönnberg (Fig. 2)

The occurrence of mature *Ch. gunnari* concentrations was found on large areas of both studied fishing grounds down to 370 m depth, in near bottom waters with temperature +2.3—2.7°C and oxygen content 6.1—6.4 ml O₂·l⁻¹ (Furtak and Grelowski, unpublished data). An approximate distribution of these concentrations were determined by echosounding and control catches (Fig. 3). The hydroacoustical gearh on board registered the concentrations of *Ch. gunnari* in the form of grainy layers with small density (Figs. 4 and 5) or as numerous small shoals on the bottom or 10—20 m over the bottom (Figs. 6 and 7).

The catch rate for this species varied from 393 to 6299 kg·h⁻¹ (average 1487 kg·h⁻¹), contribution to the total weight of catch was 60.3—94.5% (average 86.5%). An experimental catch from greater depth (366—443 m) gave nonsatisfactory results: the catch rate was 40 kg·h⁻¹, the contribution of *Ch. gunnari* — 2.9%.

The fish length was 25—34 cm (average 29.1 cm) (Fig. 8), weight 100—253 g. The length: weight relationship was:

$$W = 0.002 L^{3.2978}$$

Ch. gunnari was maturing for the spawning period: 42% of fish had the gonads in the IV stadium, 52.8% — in V stadium. The degree of females maturity was greater. The females dominated in numbers (60%). The fish in general did not feed — 96% of studied specimens had empty stomachs. The food of remaining 4% consisted in 84% of *Amphipoda*.

The catch rate of *Ch. gunnari* on the shallow of Kerguelen—Heard Ridge was 1190—12969 kg·h⁻¹ (average 6478 kg·h⁻¹). The contribution to the total weight of catch was 89.5—99.0%. One of the trawls made on a neighbouring shallow, located slightly eastward, was unsuccessful — the total catch rate decreased to 66 kg·h⁻¹. The species composition of the catch was close to

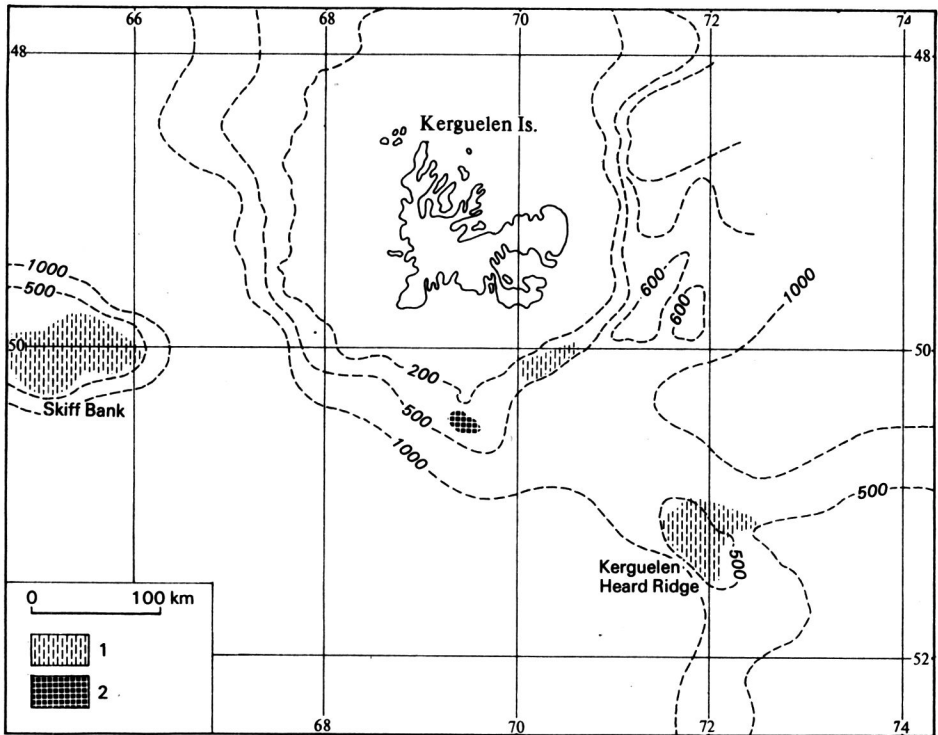


Fig. 3. The distribution of selected bottom fish concentrations in the region of Kerguelen Islands (April 1975)

1 — *Champocephalus gunnari*, 2 — *Notothenia squamifrons*

the one of studied fishing ground, contribution of *Ch. gunnari* was 86.8%. The total length of fish from the shallow of Kerguelen—Heard Ridge was slightly larger than for Skiff Bank and equalled 27—40 cm (average 32.3 cm) (Fig. 8). An increase of the fish length with an increase of the depth of trawling was found. The weight of fish varied from 100 to 480 g. The length: weight relationship was:

$$W = 0.0099 L^{2.8629}$$

The fish gonads were in the III (76%) and IV (23%) stadium. In connexion with relatively low degree of gonads development fish were still feeding: 52% of studied stomach were empty, 25% contained small amounts of food, 17% had full stomachs. The amphipodes were the main food (80—100% of the stomach content).

Concentrations of the juvenile *Ch. gunnari* were discovered in the south sector of the shelf of Kerguelen Islands at the depth of 220—290 m (Fig. 3). The fish occurred in water with the oxygen content of 5.8—6.7 ml O₂·l⁻¹ and with temperature +1.9—2.5°C (Furtak and Grelowski, unpublished data). The particular concentrations of fish had an image of grainy layers (Figs. 9 and 10) with small density. The catch rate of this species was 11 to 3495 kg·h⁻¹

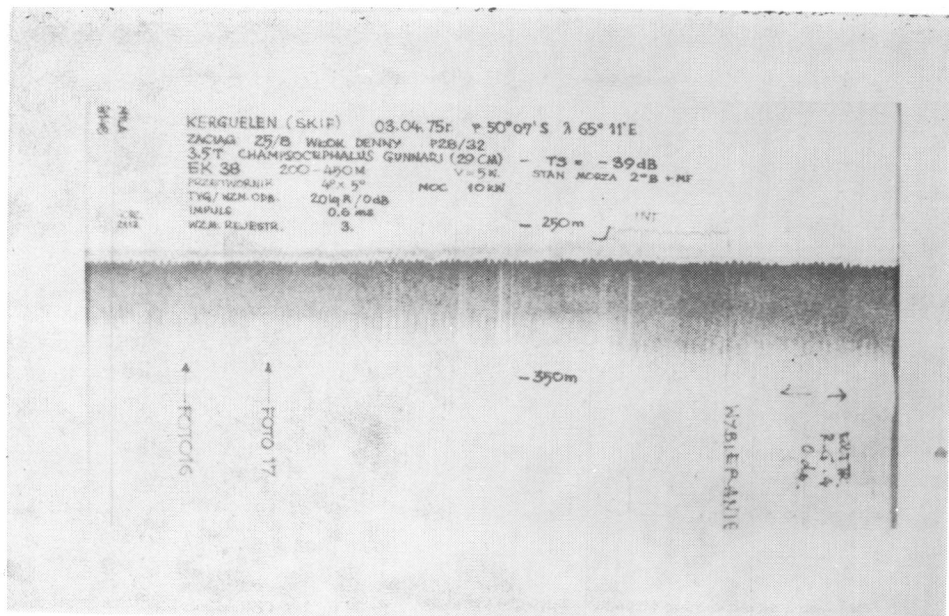


Fig. 4. The zonal concentration of *Champsocephalus gunnari* at the bottom of the Skiff Bank

R/v "Profesor Siedlecki", Simirad EK 38 kHz; transducer $4^{\circ} \times 5^{\circ}$, transmitter power 10 kW, impuls 0.6 ms. The catch rate for *Ch. gunnari* — 1543 kg·h⁻¹.

Photo A. Malinowski

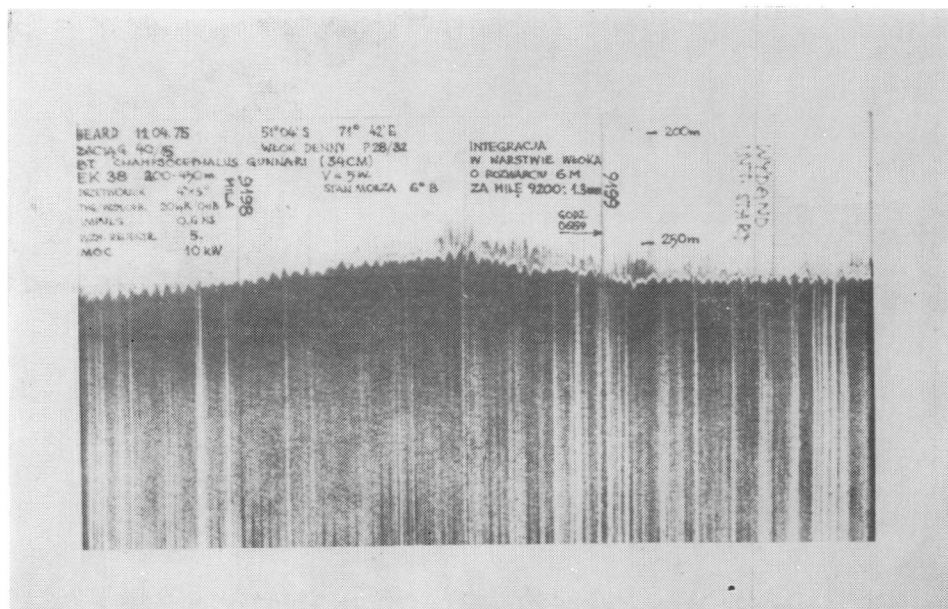


Fig. 5. The concentration of *Champsocephalus gunnari* on the shallow of Kerguelen-Heard Ridge

R/v "Profesor Siedlecki", Simirad 38 kHz; transducer $4^{\circ} \times 5^{\circ}$, transmitter power 10 kW, impuls 0.6 ms. The catch rate for *Ch. gunnari* — 8622 kg·h⁻¹.

Photo A. Malinowski

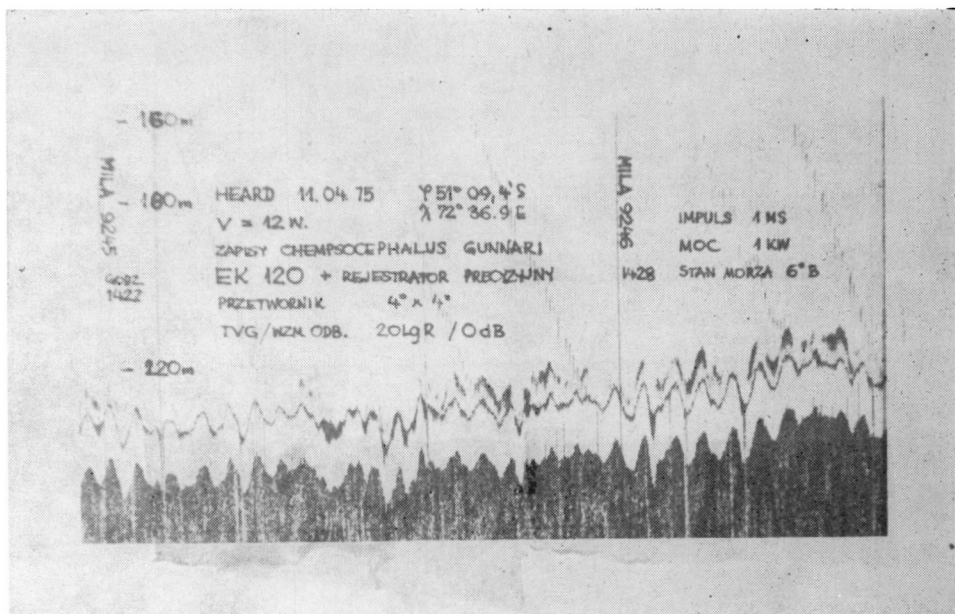


Fig. 6. The banks of *Champsocephalus gunnari* near the bottom of the shallow on Kerguelen-Heard Ridge
 R/v "Profesor Siedlecki", Simirad EK 120 kHz; — preciser-recorder: transducer 4°×4°, transmitter power 1 kW, impuls 1 ms.

Photo A. Malinowski

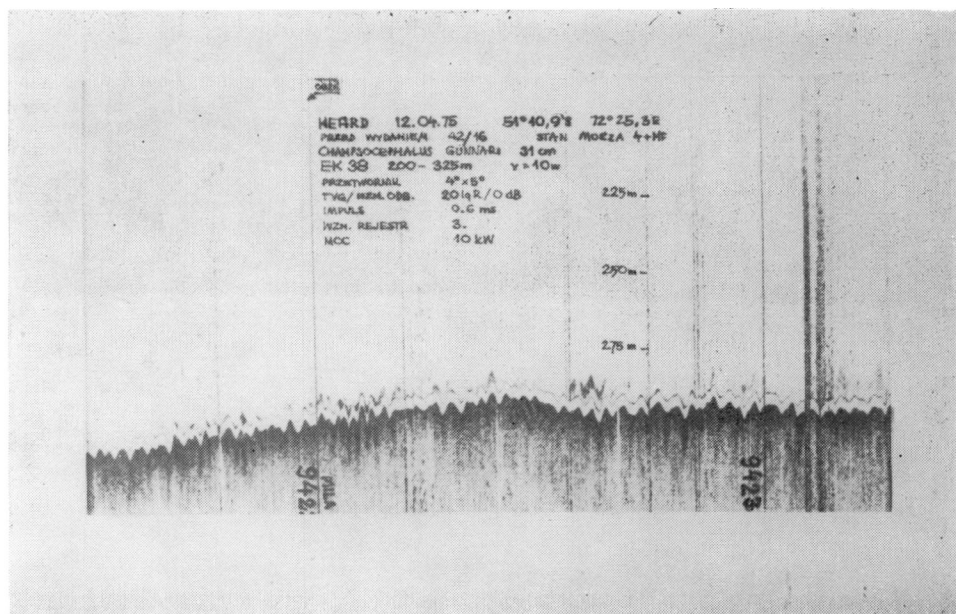


Fig. 7. The near bottom concentrations of *Champsocephalus gunnari* on the shallow of Kerguelen-Heard Ridge
 R/v "Profesor Siedlecki", Simirad EK 38 kHz; transducer 4°×5°, transmitter power 10 kW, impuls 0.6 ms.

Photo A. Malinowski

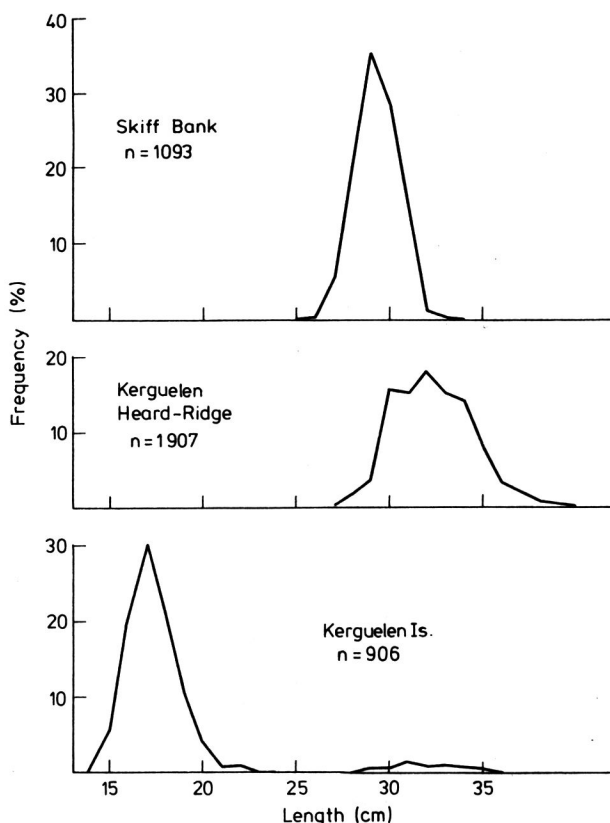


Fig. 8. The size distribution of *Champsocephalus gunnari* (Kerguelen Islands, April 1975)
n — number of individuals.

(average $878 \text{ kg} \cdot \text{h}^{-1}$), the average contribution to the total weight of catch was 66.5%.

The fish length was in general 14—24 cm, small percentage was 29—38 cm long (Fig. 8). The weight of juvenile fish was 16—60 g, of adult — 140—365 g. The length: weight relationship was:

$$W = 0.0034 L^{3.1549}$$

The juvenile fish had gonads in the I stadium, mature fish — in the III and IV one. The stomachs of the majority of fish were full. Food of the juvenile fish consisted in 52% of *Amphipoda*, the rest were the juveniles *Euphausiacea*. Food of the older fish consisted in 85% of *Amphipoda*.

The results of counts and proportional measurements of 32 specimens of *Ch. gunnari* from the whole region of studies are as follows:

— fin rays formula:

$$D: \frac{\text{VIII} - \text{IX} - \text{X}}{3 - 21 - 8} \quad \frac{33 - (34) - 35 - 36 - 37 - 38}{1 \quad 5 - 11 - 12 - 3} \quad \begin{matrix} \text{(number of fin rays)} \\ \text{(number of specimens)} \end{matrix}$$

$$A: \frac{33-34-35-36-37-38}{1-2-7-13-8-1}$$

$$P: \frac{26-27-28}{1-8-1} \text{ (10 studied specimens)}$$

— number of gill rakers on the lower limb of the first arch:

$$NGR: \frac{17-18-19-20}{5-11-10-6}$$

— number of vertebrae:

$$NVe: \frac{59-60-61}{4-22-6}$$

— selected proportion of the fish body:

BD — body depth (% *SL*) — 15.50

HL — head length (% *SL*) — 31.35

IO — width of interorbital (% *HL*) — 23.04

O — diameter of eye (% *HL*) — 20.62

Channichthys rhinoceratus Richardson (Fig. 11)

Fish of this species occurred in the by-catch on all fishing grounds, but mainly on the bank of Kerguelen—Heard Ridge; contribution in the catch weight varied from 0.1 to 13.2%, the catch rate of this species did not exceed $130 \text{ kg} \cdot \text{h}^{-1}$.

The studied individuals from the bank of Kerguelen—Heard Ridge were 22—51 cm long, the largest number of them occurred in the 45—47 cm class. The weight of a fish was 250—1220 g. Small fish were sexually immature, the larger ones had gonads in the IV or V stadium, or were spent, already. The fish stomachs were usually empty, in few full filed up the presence of *Notothenia squamifrons* was noticed. The results of counts are as follows:

— fin rays formula:

$$D: \frac{\text{VI-VII-VIII}}{1-5-6} \quad \frac{31-32-33-34-35}{1-5-3-2-1}$$

$$A: \frac{30-31-34}{4-7-1}$$

$$P: \frac{20-21-22}{2-4-1}$$

— number of bony plates in the upper lateral line:

$$ULL: \frac{84 \quad 72 \quad 69 \quad 66}{1 \quad 2 \quad 2 \quad 1}$$

Notothenia squamifrons Günther (Fig. 12)

Concentrations of *N. squamifrons* were found on the southern shelf of Kerguelena Islands, at the depth of 220—290 m. The water temperature there

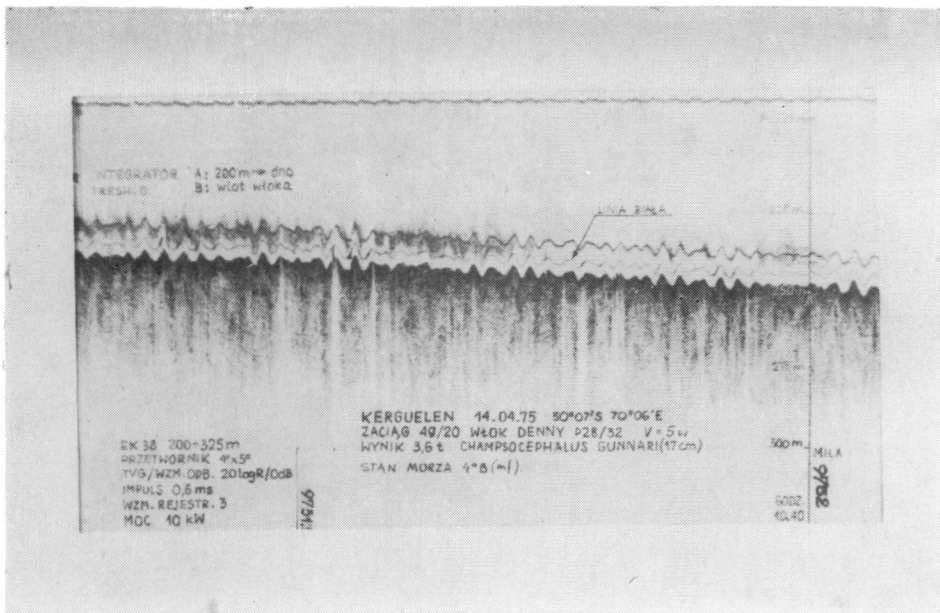


Fig. 9. The longitudinal groupings of juvenile *Champsocephalus gunnari* from the shelf of Kerguelen Islands
 R/v "Profesor Siedlecki", Simirad EK 38 kHz: transducer $4^{\circ} \times 5^{\circ}$, transmitter power 10 kW, impuls 0.6 ms. The catch rate of *Ch. gunnari* — $3496 \text{ kg} \cdot \text{h}^{-1}$

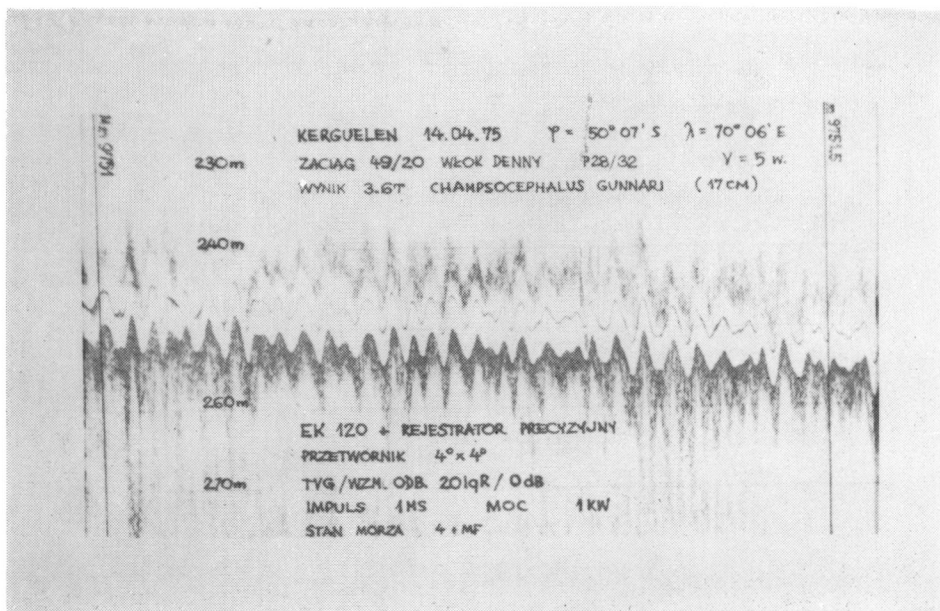


Fig. 10. The concentrations of juvenile *Champsocephalus gunnari* in the form of a grainy belt
 R/v "Profesor Siedlecki", Simirad EK 120 kHz — preciser recorder: transducer $4^{\circ} \times 4^{\circ}$, transmitter power 1 kW, impuls 1 ms. The catch rate for *Ch. gunnari* $3496 \text{ kg} \cdot \text{h}^{-1}$

Photo A. Malinowski

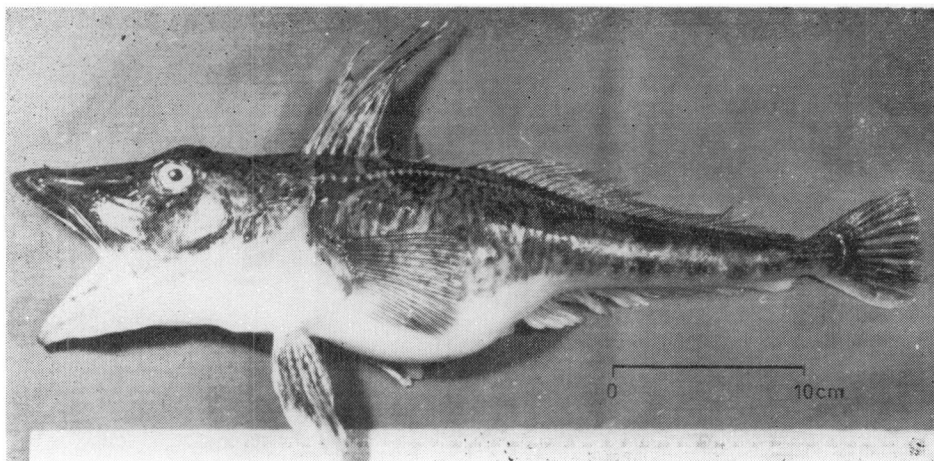


Fig. 11. Longsnouted icefish *Channichthys rhinoceratus*

Photo A. Malinowski

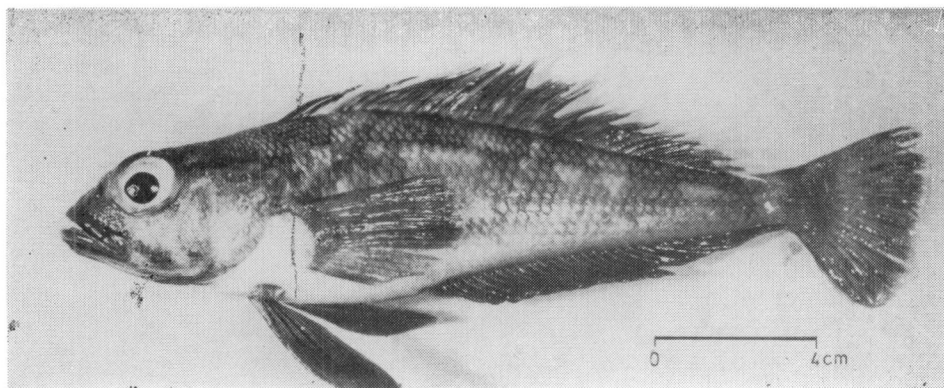


Fig. 12. Scaled *Notothenia squamifrons*

Photo A. Malinowski

was +1.9—2.5°C, the oxygen content — 5.8—6.7 ml O₂·l⁻¹ (Furtak and Grelowski, unpublished data). *Notothenia* formed small shoals giving an image of “teeth”, close to the bottom. Its presence could be detected only with the help of white line or, in the case of bad weather, with the help of stabilized platform of the echosounder transducer. The approximate area of this species occurrence is shown on Figure 3. One of the experimental hauls gave a satisfactory catch rate (1554 kg·h⁻¹), in others, both on the shelf and on the banks this rate did not exceed 120 kg·h⁻¹.

The body length of *N. squamifrons* from the shelf of Kerguelen Islands was 24—51 cm (average 34.4 cm) (Fig. 13). The weight of the fishes varied from 142 to 1840 g. The length: weight relationship was:

$$W = 0.0028 L^{3.3925}$$

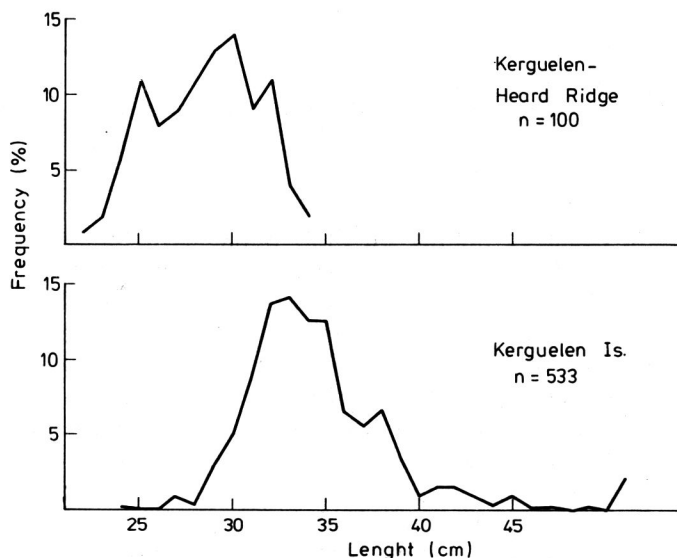


Fig. 13. The size distribution of *Notothenia squamifrons* (Kerguelen Islands, April 1975)
n — number of individuals.

The caught fish were sexually immature, the majority of them had gonads in the II (48%) and III (15%) stadium. The remaining fish were spent with gonads in the VIII stadium. The males slightly prevailed (52%) in the studied samples. The stomachs were empty in 93%. The feeding fish fed on tunicates (50%), crustaceans (20%) and fish (20%). The results of counts are as follows:

— fin rays formula:

$$D: \frac{V-VI}{5-10} \quad \frac{33-34-35}{1-6-8}$$

$$A: \frac{30-31-32-33}{3-3-6-3}$$

$$P: \frac{24-25-26}{3-4-4}$$

— number of gill rakers on the lower limb of the first arch:

$$NGR: \frac{13-14-15-16}{3-4-3-1}$$

N. squamifrons from the bank of Kerguelene—Heard Ridge was smaller, the fish length was 23—35 cm (average 27.5 cm) (Fig. 13). The studied individuals weighted 144—610 g. The weight of fish in particular size classes allows to establish a dependence:

$$W = 0.0074 L^{3.1440}$$

The females dominated (55%) in the studied sample. The distribution of a sample acc. to the stadium of gonads maturity was as follows: the I stadium — 17%, the II — 69%, the III — 14%. The fish were feeding, but not too intensively — the food was found in stomachs of 66% of fish, the rest had empty stomachs.

N. squamifrons occurred sporadically on Skiff Bank. The length of particular individuals and the maturity of gonads were similar to values for this species from Kerguelen—Heard Ridge.

Notothenia rossi rossi Richardson (Fig. 14)

N. rossi rossi occurred mainly on Skiff Bank, as a by-catch of *Ch. gunnari* amounting 5.5—39.7% of the total weight. The catch rate of this species varied from 60 to 425 kg·h⁻¹, and it increased with depth. The highest rates were obtained while fishing in the zone of 300—350 m depth. The short period of observation and a considerable dominance of *Ch. gunnari* did not allow to distinguish the traces of *N. rossi rossi* on the echograms. This species occurred also in not significant numbers in 2 trawls on the southern shelf of the Kerguelen Islands. The catch rate of this species was 16 and 76 kg·h⁻¹.

N. rossi rossi was characterised by the large size. The caught fish were 41—71 cm long (Fig. 15), 57.3 cm on the average. The studied individuals weighted 1000—4500 g. The length: weight relationship was:

$$W = 0.020 L^{2.9057}$$

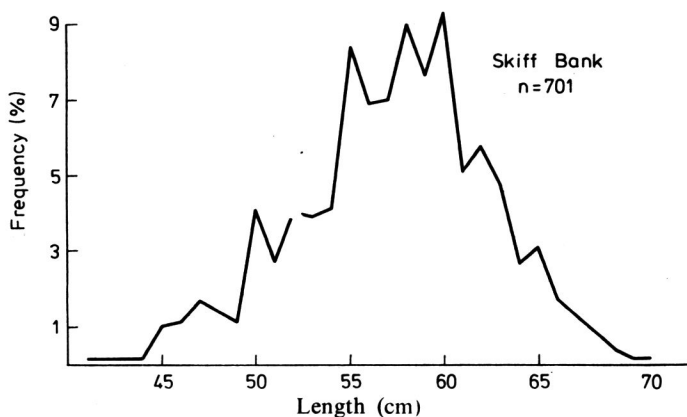


Fig. 15. The size distribution of *Notothenia rossi rossi* (Kerguelen Islands, April 1975)
n — number of individuals.

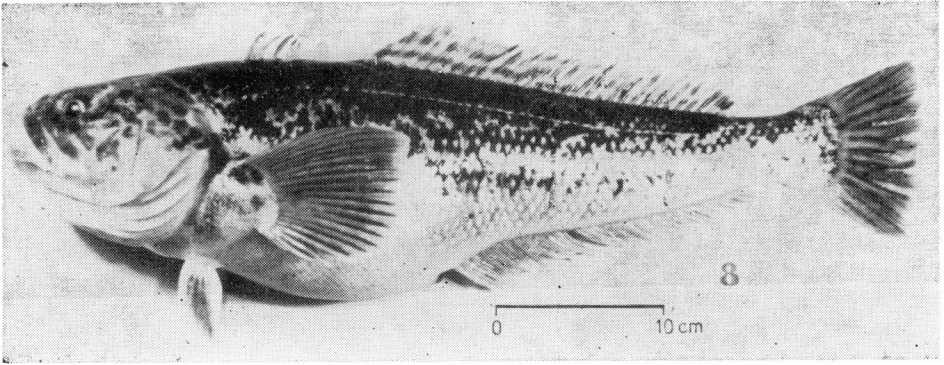


Fig. 14. Marbled *Notothenia rossi rossi*

Photo A. Malinowski

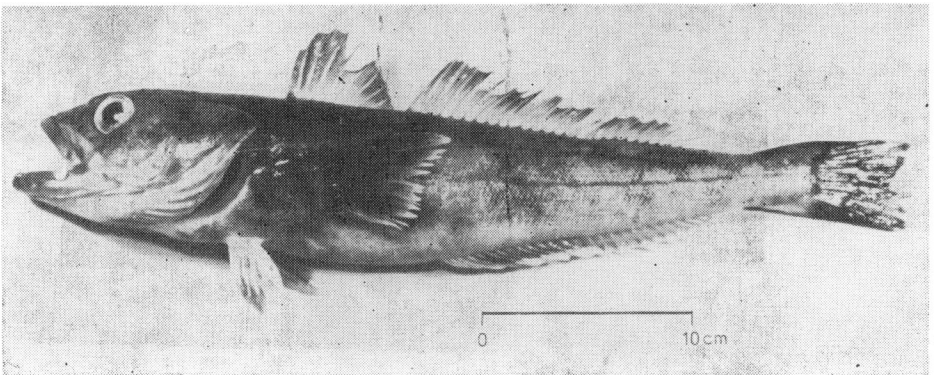


Fig. 16. Patagonian toothfish *Dissostichus eleginoides*

Photo A. Malinowski

Notothenia was maturing for the spawning. The majority of fish had gonads in the IV (67%) and V (24%) stadium. The males (61% of the catch) dominated over the females, similarly as for *Ch. gunnari* from the Skiff Bank. Only 9% of individuals had empty stomachs, the remaining fish had them considerably filled. *Ch. gunnari* was the main food of *Notothenia rossi rossi* — it contributed 86% of the whole food. The results of counts for 13 specimens of *N. rossi rossi* are as follows:

— fin rays formula:

$$D: \frac{IV-V-VI}{2-2-9} \quad \frac{32-33-34-35-36}{1-4-5-2-1}$$

$$A: \frac{26-27-28-29}{1-3-7-2}$$

$$P: \frac{20-21-22}{2-9-2}$$

— number of the gill rakers on the lower limb of the first arch:

$$NGR: \frac{11-12-13-14}{1-4-5-3}$$

Dissostichus eleginoides Smitt (Fig. 16)

The species was caught in small numbers in the by-catch at every fishing ground. Its contribution to the catch was 0.1—6.4%, the catch rate did not exceed $32 \text{ kg} \cdot \text{h}^{-1}$.

D. eleginoides from Skiff Bank was 35—58 cm long. The size classes 37—39 cm were the most numerous. The same species from the shelf of Kerguelen Island had a wider length range — 21—69 cm. Only the fish with gonads in resting stage were found apart from the juvenile individuals. The fin rays formula of 8 studied individuals of *D. eleginoides* is as follows:

$$D: IX-XI, 29-30$$

$$A: 29-30$$

$$P: 25-26$$

5. Discussion

The area of Kerguelen shelf and banks located around it belongs from the biogeographic point of view to Kerguelen—Macquarie Province, one of three provinces of the Antarctica (Hureau 1973). This province covers the water belt from Prince Edward and Marion Islands through Crozet, Kerguelen, Heard and McDonald Islands to Macquarie Island. The unusual benthic (pseudo-abyssal) ichthyofauna of the province, composed in quite a part from endemic species, totals 33 fish species. Twenty eight species were recorded in waters of Kerguelen Island (Hureau 1980). They represent 14 families, with *Nototheniidae* being the most important one. The bottom trawls of

r/v "Profesor Siedlecki" included 12 pseudo-abysal species belonging to 6 families and 3 bathypelagic species from further 3 families. Hureau and Duhamel (1980) distinguished in waters of Kerguelen Islands about 15 fish species of potential interest for fishery, indicating simultaneously that only 2 of them (*Champocephalus gunnari* and *Notothenia squamifrons*) occur very numerously and are exploited intensively. Three further species, although less numerous acc. to these authors, are also of fishery interest (*Notothenia rossi rossi*, *N. magellanica* and *Dissostichus eleginoides*). The results of presented studies are in agreement with opinion of Hureau and Duhamel (1980).

The efficiency of our catches seems to be representative for the studied region, apart from the short period of studies. The catch rate for *Champocephalus gunnari*, which was the basis of our April catches (average for all studied fishing grounds — $2.53 \text{ t} \cdot \text{h}^{-1}$) are quite in an agreement with an average calculated by Hureau and Duhamel (1980) for the period April—November for years 1973—1978 ($2.62 \text{ t} \cdot \text{h}^{-1}$). The catch rate for this species is higher in period April—November, in the contrary to the rates for *Notothenia squamifrons* ($1.26 \text{ t} \cdot \text{h}^{-1}$). An opposite phenomenon occurring during the austral summer is explained by a change of the trawling method in different weather conditions of this season (Hureau and Duhamel, 1980). The catch rate for *N. squamifrons* in our catches is not representative and can not be compared.

A vessel locating the fish on antarctic waters should be equipped with suitable fishfinding equipment, enabling the location of the fish concentrations during the bad weather. The stabilized platform of the echosounder transducer Simrad EK 38 applied on board of r/v "Profesor Siedlecki" could subdue only partially the effects of rapid heels of the boat. Freytag (1977) obtained clear traces of a single *Notothenia rossi marmorata* on his echo records, which we did not achieve in the case of *N. rossi rossi*. However, the echo records from *N. squamifrons* were obtained in the better weather conditions. The already mentioned heels of the boat and the necessity of an application of a longer impulse at large depth of fishing grounds created in our case a thick dead zone over the bottom, where fish echoes were not registered (Orłowski, in press). Better results of fish echolocation were obtained on r/v "Profesor Bogucki" for antarctic waters in the region of Campbell Islands during the antarctic expedition in 1977/1978 (Ślósarczyk, unpublished data). Atlas Fishfinder 790 DS was there applied, with frequency of 33 kHz and 4 KW power with electronically stabilized beam $6^\circ \times 8^\circ$ wide. This type of echosounder was probably used by Freytag (1977). The satisfactory echo records for *Champocephalus gunnari* obtained by us and by Freytag (1977) prove the possibility of the effective detection of white blood fish (*Channichthyidae*) characterised by a weaker target strength than other fish. The raising of the echosounder sensitivity by a few decibels applying the transmitter with high power is a necessity for the localization of the concentrations of these fish (Orłowski, in press).

Some of our observations on the biology of the discussed fish species are compared below with data of other authors: period of forming the pre-spawning concentrations, the possibilities of spawning migrations and the places of concentrating of juvenile forms. In the case of *Champocephalus*

gunnari, the occurrence of older individuals maturing to the autumn spawning was found on both fishing grounds, especially on Skiff Bank. The juvenile individuals were localised only on the shelf of Kerguelen Islands, mainly at the depth of 220—240 m. On the basis of observations of Olsen (1955) made on the shelf of South Georgia it can be assumed that *Ch. gunnari* from waters of the Kerguelen Islands also migrates for spawning in the direction of relatively shallow near shore shelf of the islands from the deeper banks. The maturing *Ch. gunnari*, after reaching the certain age, migrates probably in the reverse direction — to the banks, where it stays till reaching the first sexual maturity. A similar inshore directed spawning migrations were described by Hureau (acc. to Everson 1977) for *Channichthys rhinoceros*. Migration of this species starts in February, spawning takes place from February to March. A certain percentage of fish with gonads in the IV and V stadium was found in our April catches apart from the spent fish. This fact may indicate, apart from a limited number of data, on a prolonged spawning period or on the two years long maturity cycle of *Ch. rhinoceros*. Kock (1979) observed a similar phenomenon for *Champscephalus gunnari* and *Chaenichthys aceratus* from the region of South Georgia. According to Hureau (1970) and Russian fishermen, the spawning of *Notothenia rossi rossi* takes place on the shelf of eastern and south eastern shores of the islands in May and June. *Notothenia rossi* caught by us on the Skiff Bank were maturing to spawning. It can be assumed on the basis of the above information on the time and place of spawning, that *Notothenia rossi* from the bank starts the spawning migration towards the islands, where the juvenile forms find later a shelter in numerous shielded bays (Hureau 1970). Keysner, Tot and Shilov (1974) described the May migration of *N. rossi rossi* from the feeding grounds located north from Kerguelen Islands to the spawning grounds, localised by these authors on the south-east shelf of the islands.

The majority of *Notothenioidea* lives in the near bottom water layers, and this explains a considerable contribution of benthic organisms in their diet. The presence of plankton in their food indicates that some of these fish probably migrate daily to upper layers for feeding (Everson 1977). The food of *Champscephalus gunnari* from the region of South Georgia was in 91.1% composed, acc. to Permitin and Tarverdeva (1972), of planktonic organisms: *Euphausia superba*, *Mysidacea*, *Hyperiidae*. Linkowski and Rembiszewski (1978) observed a similar food composition: *Euphausia superba*, *Parathemisto gaudichaudi* (*Amphipoda*), *Mysidacea*. Our observations showed that the basic food of adult *Ch. gunnari* from the region of Kerguelen Islands were *Amphipoda*, amounting independently from the fishing ground 80—100% of the food weight. Only in the food of juvenile *Ch. gunnari* about 50% of it were *Euphausiacea*. Different food composition of juvenile forms is explained to some extent by plankton studies. The echosounders registered the scattering layers with considerable density suspended in water relatively high in the area adjacent to the one with concentrations of juveniles. The sampling with Isaacs Kidd and Bongo nets allowed to identify these layers: they were formed mainly by *Euphausiacea*, and to lesser extent by *Pteropoda*, *Salpae* and fish larvae. *Amphipoda* and *Isopoda* dominated in the food of *Notothenia rossi rossi* studied by Hureau (1970). His sample of fish, origina-

ting from the shelf, was, however, dominated by fish smaller than 40 cm, and this fact made difficult the comparison with our data, based entirely on analyses of larger (41—71 cm) fish. The basic food of the latter was *Champocephalus gunnari* (86%). Observations of Keysner, Tot and Shilov (1974) made also on the shelf, indicate this time the presence of planktonic organisms: *Euphausia*, *Parathemisto*, *Salpae* and *Ctenophora* in the food of *Notothenia*.

The length:weight relationship for *Notothenia rossi rossi* was given by Hureau (1970), for *N. rossi marmorata* — by Crisp and Carrick (1975). Hureau studied mainly the juvenile fish 8—45 cm long, Crisp and Carrick — only the adolescent fish 19.5—38 cm long. Our material was 41—71 cm long. Apart from these differences, the weight of fish calculated from our equation for the size class (L_t) 5 to 30 cm, vary only 5% from values calculated from an equation of Crisp and Carrick, and these values for class 20—40 cm (L_t) vary $\pm 4\%$ from values obtained with an equation of Hureau.

Selected counts and proportional measurements were made to establish the identification of studied species. The fin rays formula of *Champocephalus gunnari* agrees only partially with formulas of Regan (1913), Norman (1938) and Olsen (1955) for this species from the region of South Georgia; in both dorsal fins and in the anal fin we have observed 1 to 3 rays less for numerous specimens. Our later studies on the banks of South Georgia indicated also a certain difference in the number of vertebrae: 60 to 62 vertebrae were found for 28 individuals of *Ch. gunnari*, with the majority of fish of 61 vertebrae. It can be assumed that apart from the small material studied these differences are not accidental and suggest certain distinctness of the *Ch. gunnari* populations from the South Georgia region and from Kerguelen Islands. The results of counts for *Channichthys rhinoceratus* agree fairly accurately with the results of Norman (1938) and Blanc (1961). Similarly there is a full agreement of our fin rays formulas of *Notothenia rossi rossi* with the results of Hureau (1970). The counts made for *N. squamifrons* agree with the characteristics given by Norman (1938) and Blanc (1961) for the anal and pectoral fins, but the fin rays formula of the dorsal fin is partially different. Certain small differences were also found while comparing the obtained by us number of fin rays of *Dissostichus eleginoides* with the one of Norman (1937).

The fishery observations were carried out jointly with a hydroacoustic team directed on-board by Andrzej Orłowski, M. Sc., this effective colaboration is kindly acknowledged. Analytical studies and fish length measurements were done by ichthyological group headed by Dr. Józef Sosiński, to whom we are very grateful. Prof. dr. Józef Popiel, Scientific Head of the Expedition, kindly helped in the realization of this paper and made valuable remarks.

6. Summary

The studies of the ichthyofauna and the fishing grounds around Kerguelen Islands were done from the board of r/v "Profesor Siedlecki" during the 1—16 April 1975 expedition to the Indian Ocean. The studies covered the shelf of Kerguelen Islands, Skiff Bank and one of the shallows on Kerguelen—Heard Ridge (Fig. 1). Twelve species of pseudo-abysal and

3 species of bathypelagic fish were found in the bottom catches (Table II). Five fish species, more important in catches, were studied in a greater detail.

Concentrations of *Champscephalus gunnari* covered large areas of both studied banks to the depth of 370 m (Fig. 3). Character of those concentrations is shown on the echograms (Figs. 4—7). The catch rate of this species was on the average $1487 \text{ kg} \cdot \text{h}^{-1}$ on the Skiff Bank, and $6478 \text{ kg} \cdot \text{h}^{-1}$ on the bank of Kerguelen Heard Ridge. The mean length of *Ch. gunnari* from the former bank (29.1 cm) was smaller than from the latter one (32.3 cm) (Fig. 8). The fish from the bank of Kerguelen—Heard Ridge were feeding, while the ones from Skiff Bank were in the prespawning period. The basic food of *Ch. gunnari* were *Amphipoda*. Concentrations of the juvenile *Ch. gunnari*, 14—24 cm long (Fig. 8—10) were found in the south sector of the shelf of Kerguelen Islands, at the depth zone of 220—290 m. The average catch rate of the experimental hauls was $878 \text{ kg} \cdot \text{h}^{-1}$. The results of selected counts and proportional measurements of this species may indicate the existence of certain features differing the populations of *Ch. gunnari* from Kerguelen Islands from populations of this species from South Georgia.

A small area occupied by *Notothenia squamifrons* was found in the neighbourhood of the *Ch. gunnari* concentrations (Fig. 3). The experimental haul of *Notothenia* gave good results — $1554 \text{ kg} \cdot \text{h}^{-1}$. The average length of fish was 34.4 cm (Fig. 13). The state of their gonads indicated the spawning in the recent period. The feeding fish fed on various benthic organisms and on the macroplankton.

N. rossi rossi occurred mainly on Skiff Bank in the by-catch of *Ch. gunnari*. The catch rate of this species was $60\text{--}425 \text{ kg} \cdot \text{h}^{-1}$. This species was characterised by fairly large size: length — 41—71 cm, weight — 1000—4500 g. (Fig. 15). *Notothenia* was feeding apart from the well advanced gonads development — the main food was *Ch. gunnari*.

Other two species important for the fisheries were found in the catches apart from the three already mentioned species: *Channichthys rhinoceratus* and *Dissostichus eleginoides*. The catch rate of the former was $130 \text{ kg} \cdot \text{h}^{-1}$, and only $32 \text{ kg} \cdot \text{h}^{-1}$ of the latter.

7. Резюме

Исследования ихтиофауны и тони водной вокруг Кергуленских островов проводились с борта нис „Профессор Седлецки” в период с 1 по 16 апреля 1975, в ходе исследовательского рейса в Индийский океан. Исследования охватывали шельф Кергуленских островов, Банку Скиф и подводный хребет Кергулен-Херд (рис. 1). В донных уловах было установлено присутствие 12 видов превдоабиссальных и 3 вида батипелагических рыб (таблица II). Особое значение в уловах имело 5 видов рыб, которые, следовательно, подлежали подробным исследованиям.

Концентрации *Champscephalus gunnari* занимали заметное пространство обоих исследуемых скоплений до глубины 370 м (рис. 3). Характер этих скоплений иллюстрируют приведенные эхограммы (рис. 4—7). Эффективность уловов этого вида составляет в среднем: в Банке Скиф — $1487 \text{ кг} \cdot \text{час}^{-1}$, в районе хребта Кергулен-Херд — $6478 \text{ кг} \cdot \text{час}^{-1}$. Средняя длина тела *Ch. gunnari* из Банки Скиф (29,1 см) была меньше чем наблюдаемая на хребте Кергулен-Херд (3,3 см) (рис. 8). Рыбы в районе хребта Кергулен-Херд интенсивно питались, тогда как концентрации в Банке Скиф имели явно преднерестовый характер. Основной пищей *Ch. gunnari* были *Amphipoda*. В южном секторе шельфа Кергуленских островов на глубине 220—290 м наблюдались концентрации молоди *Ch. gunnari* с длиной тела 14—24 см (рис. 8—10). Средняя величина контрольных уловов составляла $878 \text{ лг} \cdot \text{час}^{-1}$. Результаты сокращенных меристических и морфометрических исследований этого вида указывают на существование некоторых признаков, отличающих популяции *Ch. gunnari* с района Кергуленских островов и острова Южная Джорджия.

В районе установленной концентрации молоди *Ch. gunnari* на небольшой территории наблюдалось присутствие *Notothenia squamifrons* (рис. 3). Опытный лов дал хороший результат — $1554 \text{ кг} \cdot \text{час}^{-1}$. Средняя длина тела рыб составляла 34,4 см (рис. 13). Состояние их гонад указывало на недавний нерест. Пищей этих рыб были бентосные и макропланктонные организмы.

N. rossi rossi наблюдалась главным образом в Банке Скиф как прилов в уловах *Ch. gunnari*. Эффективность уловов этого вида была в пределах $60\text{--}425 \text{ кг} \cdot \text{час}^{-1}$. *N. rossi rossi* характеризовалась значительными размерами тела: длина 41—71 см, вес 1000—4500 г (рис. 5). Несмотря на заметное развитие гонад нототения интенсивно питалась. В составе пищи преобладали *Ch. gunnari*.

Кроме трех названных в уловах выступали еще два вида, правда, уже менее численны, но тоже важны с точки зрения рыбного промысла: *Channichthys rhinoceros* и *Dissostichus eleginoides*. Эффективность уловов первого составляла $130 \text{ кг} \cdot \text{час}^{-1}$, второго — всего лишь $32 \text{ кг} \cdot \text{час}^{-1}$.

8. Streszczenie

Badania ichtiofauny i łowisk wokół Wyspy Kerguelena prowadzono z pokładu r/v "Profesor Siedlecki", w okresie od 1 do 16 kwietnia 1975 r., w ramach rejsu badawczego na wody Oceanu Indyjskiego. Prace badawcze objęły szelf Wysp Kerguelena, Ławicę Skiff i jedno z wypłyceń na Grzbiecie Kerguelen—Heard (rys. 1). W połowach dennych stwierdzono obecność 12 gatunków ryb pseudoabyssalnych i 3 gatunki batypelagiczne (tabela II). Większe znaczenie w połowach miało 5 gatunków ryb, które poddano szczegółowym badaniom.

Koncentracje *Champscephalus gunnari* zajmowały znaczne przestrzenie obu badanych ławic do głębokości 370 m (rys. 3). Charakter tych skupień przedstawiają załączone echogramy (rys. 4—7). Wydajności połowowe dla gatunku wyniosły średnio: na Ławicy Skiff — $1487 \text{ kg} \cdot \text{h}^{-1}$, na ławicy Grzbietu Kerguelen—Heard — $6478 \text{ kg} \cdot \text{h}^{-1}$. Średnia długość *Ch. gunnari* z Ławicy Skiff (29,1 cm) była mniejsza od obserwowanej na Grzbiecie Kerguelen—Heard (32,3 cm) (rys. 8). Ryby z ławicy Grzbietu Kerguelen—Heard żerowały, natomiast na Ławicy Skiff ich koncentracje miały charakter przedlarowy. Podstawowym pokarmem *Ch. gunnari* były *Amphipoda*. W południowym sektorze szelfu Wysp Kerguelena, w strefie głębokości 220—290 m wykryto koncentracje młodocianego *Ch. gunnari*, o długości ciała od 14 do 24 cm (rys. 8—10). Średnia wydajność połowów kontrolnych wyniosła $878 \text{ kg} \cdot \text{h}^{-1}$. Wyniki skróconych badań merystycznych i morfometrycznych tego gatunku mogą wskazywać na istnienie pewnych cech różniących populacje *Ch. gunnari* z Wysp Kerguelena i z Georgii Południowej.

W sąsiedztwie koncentracji młodocianego *Ch. gunnari* zlokalizowano niewielki obszar zajmowany przez *Notothenia squamifrons* (rys. 3). Próba połowu *Notothenia* dała dobry rezultat — $1554 \text{ kg} \cdot \text{h}^{-1}$. Średnia długość ryb wyniosła 34,4 cm (rys. 13). Stan rozwoju ich gonał wskazywał na niedawno odbyte tarło. Pokarmem ryb żerujących były różne organizmy bentosowe i makroplankton.

N. rossi rossi wystąpiła głównie na Ławicy Skiff w przyłowie *Ch. gunnari*. Wydajność połowowa dla gatunku mieściła się w granicach $60\text{--}425 \text{ kg} \cdot \text{h}^{-1}$. Gatunek cechowały duże rozmiary ciała: długość od 41 do 71 cm, ciężar od 1000 do 4500 g (rys. 15). Pomimo zaawansowanego rozwoju gonał *Notothenia* intensywnie żerowała. W pokarmie stwierdzono głównie *Ch. gunnari*.

Oprócz trzech wymienionych gatunków, w połowach wystąpiły mniej licznie dwa inne, ważne dla rybołówstwa gatunki: *Channichthys rhinoceros* i *Dissostichus eleginoides*. Wydajność połowowa pierwszego z nich osiągała wielkość $130 \text{ kg} \cdot \text{h}^{-1}$, drugiego — zaledwie $32 \text{ kg} \cdot \text{h}^{-1}$.

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