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Biomass estimates of commercial fishes in the South Georgia region (by "swept area" method)

ABSTRACT: The paper presents the results of biomass estimates of commercial fishes in the South Georgia region made by "swept area" method on the basis of catch statistics of a B–22 Polish trawler in the 1980/1981 season. Total biomass was estimated on about 11×10^4 t.

Key words: Antarctic, South Georgia, commercial fishes estimates

1. Introduction

Intensive exploitation of fish and krill (including fish fry) carried out in the Antarctic for the past few years makes it necessary to perform precise estimates and to monitor changes in the biomass of fish stocks in this area (Everson 1977). Preliminary estimates by "swept area" method made — due to a lack of commercial catch data — on the basis of the results obtained by research vessel in the 1975/1976 and 1977/1978 seasons were performed by K. H. Kock who presented them to the SCAR Working Group for the Living Resources of Southern Ocean at a meeting in May, 1980 (Biomass Report Ser. No. 12). Below are presented the results of estimations made also by "swept area" method but on a wider basis of materials collected by ichthyological staff on a typical commercial trawler (B–22), m/t "Libra", which carried out commercial fishing operations off South Georgia for five months in the 1980/1981.

2. Material and method

Between October 21, 1980 and February 13, 1981, the "Libra" made 539 bottom hauls off South Georgia, 507 of which were made in the

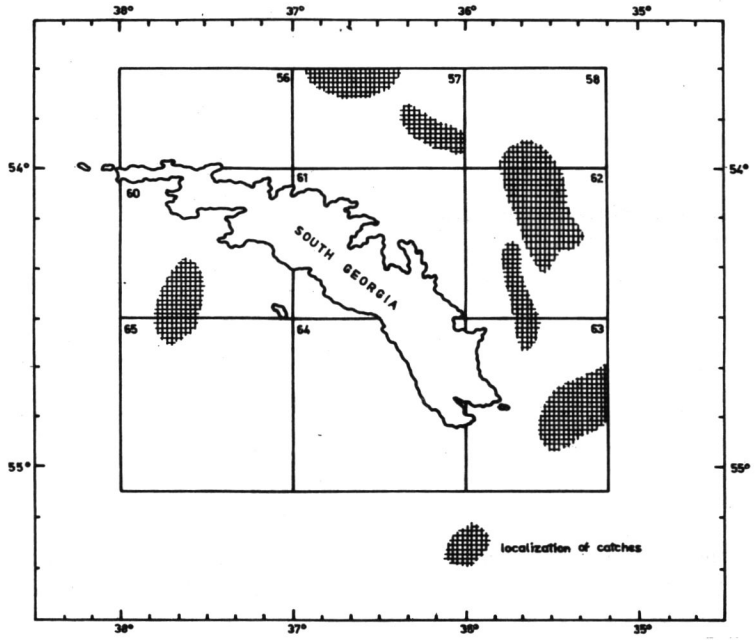

Fig. 1. Surface of fishing grounds swept with bottom trawl by m/t "Libra", taken as a basis of the eatimations

following squares: 57, 58, 60–63, and 65 (Fig. 1). Their surface area and the division into depth zones were determined by Everson[1]. For each of these depth zones (strata), the mean catch per hour was calculated within the 80% confidence limits (Saville 1977). Unit area swept by the trawl was calculated for a horizontal P–32 trawl opening equal to 17.5 m, depending on the vessel speed:

3.7 knots — 119.917 m^2/h
3.8 knots — 123.158 m^2/h
3.9 knots — 126.399 m^2/h

The confidence limit for the mean per stratum is the following:

$$\bar{X}_{st} = \bar{X}_{st} \pm t \cdot \sqrt{\text{var } (\bar{X}_{st})}$$

where: t — value depending on the assumed confidence coefficient and the number of degrees of freedom:

No. of degrees of freedom	Value t (80% confidence limits)
30	1.310
40	1.303

[1] Everson J. Areas of seabed within selected depth ranges in the South West Atlantic and Antarctic Peninsular regions of the Southern Ocean. Paper presented at the II Meeting of the Working Party of Fish Biology. Dammarie-Les-Lys, France, 1980.

60	1.296
up to 120	1.282

The stratified mean of the total area of the species is as follows:

$$\bar{X}_{st} = \sum_{1}^{m} \frac{\bar{X}_m \cdot M}{\text{total area}}$$

where: m — refers to the stratum in which the given species was found,
M — the area of the m-stratum.

The variance of the stratified mean is the following:

$$\text{var}\,(\bar{X}_{st}) = \sum_{1}^{m} \text{var}\,\bar{X}_m \left[\frac{M}{\text{total area}}\right]^2$$

where: $\text{var}\,X_m - \frac{\text{var}\,(X)}{n}$,

$\text{var}\,(X)$ — variance between individual hauls,
n — number of hauls

The relative mean density is the following:

$$\bar{D}_r = \frac{\bar{X}_{st}}{\text{swept area}}$$

The absolute mean density is as follows:

$$\bar{D}_a = \frac{\bar{X}_{st}}{\text{swept area} \cdot c}$$

where: c — catchability coefficient.

Since no data allowing to estimate the coefficient c were available, the gear catching efficiency of 100% was assumed, i.e., $c = 1$, hence $\bar{D}_r = \bar{D}_a$.

Mean biomass was calculated as follows:

$$\bar{B} = \frac{X_{st} \cdot \text{area of species occurrence}}{\text{swept area}}$$

SD — standard deviation in the sample.

3. Results

The results of estimates of this kind, made on the bsis of commericial total biomass estimate are presented in Table I.

Notothenia marmorata, Trematomus hansoni, Raja georgiana

Uneven occurence of these species and great fluctuations of the mean catch resulting in a high standard error indicate that the biomass estimates

based on an extrapolation of mean values for these species for the whole area of the investigated region contain a large error.

Champsocephalus gunnari

Apart from the species mentioned above, the biggest standard error is contained in the mean catch of *Ch. gunnari*. Besides in the case of *Ch. gunnari* there is strong influence of random and systematic errors connected with the fact that this species forms dense concentrations migrating in search of krill.

Notothenia gibberifrons, Pseudochaenichthys georgianus, Chaenocephalus aceratus

The occurence of these three species was most even, which is indicated by small standard errors of the estimated biomass means. That is why estimates concerning stocks of these fish are more precise than in the case of the above-mentioned species.

Dissostichus eleginoides

The biomass of this species was estimated for subdivision 60 and 65 at a depth zone of 250—500 m. The occurrence of *D. eleginoides* in the remaining regions and at other depths was infrequent.

4. Discussion

The results of estimates of this kind, made on the basis of commericial bottom catches, especially as regards regions where many species of fish occur, usually contain considerable random and systematic errors. Their magnitude is difficult to determine. The majority of systematic errors results from not taking into account the fact that fishes at which fishing operations are directed form concentrations (spawning, feeding concentrations) as well as due to the tendency of vessel captains to conduct fishing in the areas of those concentrations. The advantage of the above estimates is the fact they were made on the basis of a large number of hauls, which minimized random errors.

The results of biomass estimates of all commercial fish off South Georgia presented above are similar to those obtained by Kock (1980) (Table II) in the 1977/1978 season on the basis of exploratory fishing of West German research vessels. However, the division of the total biomass into individual species is different.

The relations among the biomass magnitudes of individual species of fish is probably closer to the actual relations in the estimates by Kock (1980) since catches of the "Libra" were directed at *Champsocephalus gunnari*

Table I.

Biomass tons of commercial fishes off South Georgia estimated by "swept area" method

Subdivision	57, 58, 61, 62, 63				57, 58, 61, 62, 63				57, 58, 60, 61, 62, 63, 65				Biomass of species (t)	
Depth zone (m)	50 — 150				150 — 250				250 — 500					
No. of hauls	173				181				163				507	
Species	Mean biomass of species B (t)	SD (%)	t var $\bar{x}_{st}$ (t)	D_r (t/km^2)	Mean biomass of species B (t)	SD (%)	t var $\bar{x}_{st}$ (t)	D_r t(km^2)	Mean biomass of species B (t)	SD (%)	t var $\bar{x}_{st}$ (t)	d_r (t/km^2)	80% confidence limits	Mean
Champsocephalus gunnari	41 313	16	8 303	17.6	26 933	10	3 348	7.2	10 435	15	2 029	2.0	65001—92361	78 681
Pseudochaenichthys georgianus	1 133	14	204	0.5	2 069	9	21[illegible]	0.6	4 555	8	456	0.9	6884—8630	7 757
Chaenocephalus aceratus	873	9	93	0.4	1 856	10	243	0.5	4 141	8	414	0.8	6120—7620	6 870
Notothenia gibberifrons	1 579	8	167	0.7	4 230	11	578	1.1	6 377	5	456	1.3	10985—13387	12 186
Notothenia rossii marmorata									2 071	31	828	0.4	1243—2899	2 071
Trematomus hansoni					152	28	61	0.1	1 615	8	166	0.3	1540—1994	1 767
Dissostichus eleginoides									207	14	41	0.1	166—248	207
Raja georgiana									248	23	83	0.1	165—331	248
Total	44 898	—	8 767	19.1	35 240	—	4 443	9.4	29 649	—	4 473	5.8	92104—127470	109 787

Table II.

Results of biomass estimates of fish off South Georgia (Kock, 1980), in tons.

Species	Season	
	1975/1976	1977/1978
Notothenia marmorata	105.029	9.326
Notothenia gibberifrons	40.094	20.100
Dissostichus eleginoides	13.497	7.322
Champsocephalus gunnari	141.469	34.713
Chaenocephalus aceratus	18.719	18.399
Pseudochaenichthys georgianus	36.401	31.057
	355.209	120.917
Total — "all species"	407.469	133.563

concentrations after they had been discovered, which resulted in a overestimation of this species. This is evident when we compare the estimate with the species composition of catches made off South Georgia in the same season. To reduce the influence of such factors an estimate based on yields attained by a greater number of vessels fishing over a longer period in different parts of the shelves should be made. It should be emphasized that the above mentioned estimates, are based on the assumption that the catchability coefficient of gear is 100%. In this sense, all figures presented in the table are probably underestimated since the assumed unit density of the species biomass is lower than the actual density ($c \cdot d_a = d_r$).

5. Резюме

В работе предпринята попытка определить размеры ресурсов антарктических рыб, являющихся объектом промысловых ловов в районе Южной Георгии. За основу вычислений была принята эффективность выловов польского рыболовного судна м/т "Либра" (Б-22) на местах ловли в районе Южной Георгии за 5 месяцев сезона 1980/1981. Ловы проводились в квадратах: 57, 58, 60—63 и 65 (рис. 1) в трех глубинных зонах: 50—150, 150—250 и 250—500 м. Среднюю эффективность для данной зоны за час вычислено для 80% доверительного интервала, а единичную площадь траления, в зависимости от скорости судна, для 17.5 м раскрытия трала (П-32). Результаты представлены и обсуждены (таблица I).

Дается дискуссия и сравнение результатов, полученных в этой работе, с определением биомассы промысловых рыб, проведенным К. Х. Коком (Kock 1980) на основании данных полученных в рейсах научных суден ФРГ (таблица II). Сопоставленные результаты определений биомассы рыб этого района близки в общей массе, отличаясь однако распределением общей биомассы между отдельными видами. Ловы судна м/т "Либра" с момента обнаружения скоплений кергелены были направлены на эти скопления, что в результате оказалось причиной ее переоценки и повлияло на взаимоотношение размеров биомассы отдельных видов рыб.

6. Streszczenie

W pracy podjęto próbę oszacowania wielkości zasobów ryb antarktycznych będących obiektem połowów przemysłowych w rejonie Georgii Południowej. Podstawę obliczeń stanowiły wydajności połowowe polskiego statku łowczego m/t "Libra" (B-22) uzyskane na łowiskach Georgii Południowej w pięciu miesiącach sezonu 1980/1981. Połowy odbywały się w kwadratach: 57, 58, 60—63 i 65 (rys. 1) w trzech strefach głębokości: 50—150 m, 150—250 m i 250—500 m. Średnią warstwową wydajność godzinną obliczono dla 80% przedziału ufności a jednostkową powierzchnię przetrałowaną, w zależności od szybkości statku, dla 17.5 m rozwarcia włoka (P-32). Przedstawiono i omówiono wyniki (tabela I).

Przeprowadzono dyskusję wyników, porównując je z rezultatami szacowań biomasy ryb przemysłowych tego rejonu, wykonanymi przez K. H. Kocka (1980) na podstawie danych z rejsów badawczych statków RFN (tabela II). Porównane wyniki szacunków biomasy ryb tego rejonu są zbliżone w ogólnej masie, różnią się jednak rozdziałem biomasy ogólnej pomiędzy poszczególne gatunki. Połowy statku m/t "Libra" od chwili wykrycia koncentracji kerguleny nakierowane były na te koncentracje, co stało się przyczyną jej zawyżonego oszacowania i wpłynęło na wzajemny stosunek wielkości biomasy poszczególnych gatunków.

7. References

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