FISH STOCK ASSESSMENT SURVEY IN SUBAREA 48.3

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Abstract

A demersal fish survey in the vicinity of South Georgia, CCAMLR Subarea 48.3, is described. Details are given of positions of hauls, catch rates and size composition of catches. The standing stock of one of the most important commercial species in the area, *Champsocephalus gunnari*, is shown to have undergone a major decline by comparison with results from the 1989/90 season. Other species do not show a similar dramatic reduction. No commercial fishing on *Champsocephalus gunnari* has been reported from the area. It is suggested that this decline may be due to either a massed migration or high mortality.

Résumé

Description d'une campagne d'évaluation des poissons démersaux aux environs de la Géorgie du Sud, sous-zone 48.3 de la CCAMLR. Précisions sur la position des chalutages, les taux de capture et la composition en taille des captures. Il est révélé que le stock existant de l'une des espèces commerciales les plus importantes dans la région, *Champsocephalus gunnari*, a subi un déclin considérable par comparaison aux résultats de la saison 1989/90. D'autres espèces ne paraissent pas présenter une réduction aussi notable. Aucune pêche commerciale de *Champsocephalus gunnari* n'a été déclarée dans la région. Il est suggéré que ce déclin pourrait avoir deux causes possibles : une migration de masse ou une mortalité élevée.

Резюме

Описана съемка демерсальных рыб вблизи Южной Георгии, Подрайон АНТКОМа 48.3. Приведена информация о положениях тралений, темпах вылова и размерном составе уловов. Выявлено значительное уменьшение биомассы одного из наиболее важных коммерческих видов этого района, *Champsocephalus gunnari*, по сравнению с результатами сезона 1989/1990 г. Подобного драматического уменьшения в запасах других видов не обнаружено. Поскольку сведений о коммерческом промысле *Champsocephalus gunnari* из этого района не поступало, предполагается, что упадок мог произойти вследствие массовой миграции или высокой смертности рыб.

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Resumen

En este documento se describe una prospección de peces demersales realizada cerca de Georgia del Sur, en la Subárea 48.3 de la CCRVMA, y se proporcionan detalles de la posición de los lances, índices de capturas y composición por talla de las capturas. Al comparar la población fija de una de las especies comerciales más importantes de este área, *Champsocephalus gunnari*, con los resultados de la temporada 1989/90, se observa que ha ocurrido una gran disminución. Otras especies no presentan una reducción tan drástica. No se ha notificado ninguna pesquería comercial de *C. gunnari* en esta zona. Se sugiere que esta disminución puede deberse a una migración masiva o a una alta mortalidad.

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1. INTRODUCTION

The fish stocks in Subarea 48.3, South Georgia, have been the subject of considerable interest for many years mainly because this area has formed the focus for much of the commercial fishing activity for finfish within the CCAMLR area. The need for further assessment of the stocks within this subarea has been emphasised by the CCAMLR Working Group on Fish Stock Assessment (WG-FSA) (SC-CAMLR, 1990a).

This report presents the results from a fish stock assessment survey undertaken by the United Kingdom in January and February 1991 within Statistical Subarea 48.3 (South Georgia). The main aim of the study was to determine the standing stock of the commercially important demersal fish species with particular reference to the icefish, *Champsocephalus gunnari*. Information is presented in accordance with the recommendations of the Task Group for Information Reported to WG-FSA (SC-CAMLR, 1990a) .

2. SURVEY AREA AND DESIGN

The survey was aimed at providing information representative of the shelf area within Subarea 48.3. Effectively this is the shelf area of South Georgia and Shag Rocks.

The survey design was similar to those of previous years (Parkes *et al.*, 1990) with a series of randomly located trawl stations down to a depth of 500 m. The same three depth strata, 50 to 150, 150 to 250 and 250 to 500 m, were used as on previous surveys. To ensure adequate coverage the area was divided into CCAMLR 'fine-scale rectangles' half a degree of latitude by one degree of longitude. Within each of these rectangles the numbers of stations within each of these depth strata were allocated in proportion to the area of seabed and expected fish concentration of *Champsocephalus* within the stratum. Wherever possible proposed trawling locations were chosen from those successfully sampled on previous surveys. Sampling locations were allocated to all fine-scale rectangles with the exception of those to the south of the centre of South Georgia. These three rectangles, numbers 19, 20 and 24 on Figure 1, are known to contain large areas of bad ground and thus have a high risk of trawl damage.

The survey design provided for 72 stations to be sampled at South Georgia and 12 at Shag Rocks. Due to time constraints and also because some intended sites were unsuitable for fishing not all sites were fished. A total of 66 sites was fished at South Georgia and 12 at Shag Rocks. The locations of the sites actually sampled are shown in Figure 1 and the positions given in Table 1. The mean area assumed to be representative of a station within each depth stratum and at each location is shown in Table 2.

A standard haul duration of 30 minutes with the net on the bottom was used. However if the net came fast, or bad ground was encountered during the tow necessitating early retrieval of the net, providing the net had been on the bottom for more than fifteen minutes the haul was considered representative. All hauls were undertaken during the hours of daylight to minimise the possible underestimation of those species that migrate off the bottom at night.

3. DESCRIPTION OF VESSEL AND SAMPLING METHODS

A stern trawler converted for use as a fishery survey vessel was used for the survey, it had the following characteristics:

Name:	*Falklands Protector*
Call sign:	GYMA
Type:	Stern trawler (modified by conversion of part of hold to laboratories)
Length overall:	69.15 m
Breadth:	12.0 m
Main Power	2500 bhp

Two echosounders were used during the study. A Kelvin Hughes MS 44 echosounder operating at a nominal frequency of 30 kHz was used for bottom detection and a Koden 'Chromascope' operating at 48 kHz was used to indicate the hardness of the bottom. The latter echosounder was also connected to a Biosonics Echosignal Processor for fish quantification and was continually monitored for the presence of schools of fish above the bottom.

A net as close as possible to that used for the *Professor Siedlecki* survey (Parkes *et al.*, 1989) in 1989 was used, full net drawings with nominal mesh sizes are given in Figure 2. All netting was composed of diamond meshes. Mesh sizes were measured, in accordance with CCAMLR procedures, at the end of the survey and the results set out in Table 3. Field trials undertaken by the Sea Fisheries Industry Authority (UK) provided data on the dimensions of the trawl when in operation and these were latter confirmed by tests in a flume tank on a model of the trawl. Equations relating the principal dimensions to the towing speed are as follows:

$$A = [-2.295\ S] + [-78067\ (S^{-10})] + 29.08$$

where **A** = horizontal opening (m), and

S = towing speed (knots)

Positions were fixed using either Global Positioning System (GPS) or by satellite navigator. Satellite navigator fixes were available at irregular intervals of up to six hours. The GPS was operational for only part of the cruise and then, because of the incomplete satellite cover, only for about half the day.

The landed catch of all fish species at each station was measured. Further analyses were made for the following species: *Champsocephalus gunnari, Chaenocephalus aceratus, Pseudochaenichthys georgianus, Notothenia gibberifrons, Notothenia rossii, Notothenia squamifrons, Dissostichus eleginoides* and *Patagonotothen brevicauda guntheri.* Total length (to the nearest centimetre below), sex and maturity (SC-CAMLR, 1989) were determined for a representative sample of fish of these species in the catch. Weight, stomach fullness, otoliths and, where possible, scales, were also taken for particular fish according a pre-determined sampling scheme. Otoliths were read at the Sea Fisheries Institute in Poland.

4. RESULTS

4.1 Distribution of Catches

All species were identified in the catches. Samples of catches from the following species of current or recent commercial importance, *C. gunnari, C. aceratus, P. georgianus, N. gibberifrons, N. rossii, N. squamifrons, D. eleginoides and P. b. guntheri,* were analysed. This involved measurement of length and weight, estimation of sex, maturity stage and stomach fullness, extraction of otoliths and, where appropriate, scales. Other species were counted and their total weight measured.

The number of stations at which individual species were found and the total weight caught within each depth stratum are shown in Table 4 for South Georgia and Table 5 for Shag Rocks. The distribution of catch rates for the major species are shown in Figures 3 to 9.

Several species, *C. gunnari, C. aceratus, P. georgianus and N. gibberifrons*, were widespread around South Georgia, being found at nearly all stations. *N. rossii*, although present at most stations down to 250 m was caught in only one haul from water deeper than 250 m whilst *D. eleginoides* was only caught sporadically.

At Shag Rocks *C. gunnari* was caught at all stations shallower than 250 m while *D. eleginoides* was caught at all except one of the total stations sampled.

At 94% of the stations where it was caught, the catch rates of *C. gunnari* were less than 200 kg for a 30 minute tow. No aggregations suitable for commercial fishing were seen either at South Georgia or Shag Rocks. The two largest catches, one of 696 kg at Shag Rocks and the other of 336 kg from the eastern end of South Georgia, were still very small relative to previous surveys (SC-CAMLR, 1990a). At most stations where *C. gunnari* were caught there was generally an equal or even greater catch of other species.

A single large catch of 1 169 kg of *D. eleginoides* exceeded, by an order of magnitude, catches of this species elsewhere. Although present in all except one haul at Shag Rocks this species only occurred sporadically around South Georgia.

N. rossii was not present at Shag Rocks but was present at South Georgia, although at low catch rates in all except one instance, in hauls from water shallower than 250 m.

P. b. guntheri was taken in small amounts from hauls around Shag Rocks. As on all previous surveys, none were taken from the South Georgia shelf region.

4.2 Standing Stock Estimates

Examination of the distribution of catch rates indicated that there were no outlying values resulting from isolated large catches. There was therefore no need to apply a large haul adjustment (SC-CAMLR, 1990b) to the analyses. Standing stock estimates by the swept area method were made for the species of commercial importance by the same method as used in SC-CAMLR (1990a). The data were stratified by depth zone and for the two regions, South Georgia and Shag Rocks.

Standing stock estimates for the species of current or recent commercial interest are shown in Table 6 for South Georgia and Table 7 for Shag Rocks. The coefficients of variation of the estimates for South Georgia are much lower than from previous surveys indicating a much more uniform distribution with little tendency to aggregation.

4.3 Length to Weight Relationships

Length to weight relationships were determined from measurements made at sea for all the major fish species. The results are summarised in Table 8. Due to the increase in size of the gonads in the months prior to spawning the simple linear relationships set out in Table 8 are not valid necessarily for all sizes and maturity states of fish.

There are some differences between areas and for different maturity stages of the mackerel icefish, *C. gunnari,* and a full analysis for this species is planned.

The equations for *C. aceratus* are valid for most fish in the size range 12 to 72 cm. However, stage 2 and 3 males of length 46 to 56 cm and stage 3 females of 59 to 64 cm were significantly heavier than indicated by the simple logarithmic relationship.

Similar increases were noted for *P. georgianus* where stage 2 and 3 males and females greater than 46 cm total length were heavier than indicated by the equations.

4.4 Length and Age Distributions

Aggregated length distributions for the eight species sampled on the survey are presented in Figures 10 to 17. These have been calculated by weighting the length distributions by the catch-per-unit-effort (total area swept by the net) prior to summing across the stations (equation 1 in Parkes, 1991b).

For *C. gunnari* at South Georgia there is a clear modal peak at 16 cm and a second, less distinct peak at 23 cm (Figure 10). There is no distinct mode for fish >25 cm as there was in last year's survey (Parkes *et al.*, 1990). By contrast, at Shag Rocks two distinct modal values were present at 26 and 32 cm and few small fish were present (Figure 11).

An age/length key was prepared using age data derived from otoliths. Unfortunately, no fish of either 18 or 19 cm were sampled for otoliths. Use of the age/length, in its raw format, would give rise to misleading results because fish of length 18 and 19 cm would not be allocated an age class. Combining the length distributions of *C. gunnari* from Shag Rocks and South Georgia indicates that there is a well defined peak extending from 11 to 20 cm, with a peak at 16 cm and a trough at 20 cm. We have therefore adjusted the age/length key prepared from the raw data by allocating fish of length 18 and 19 cm to age class 1. The revised age/length key, including the values for 18 and 19 cm fish shown in parenthesis, is shown in Table 9. In this form it gives a 'knife-edge' change from age class 1 to age class 2 at 20 cm, which coincides with the trough in the length distribution.

The length frequency distribution for *C. aceratus* (Figure 11) shows modal values at 17, 26, 32 and 49 cm. There are no distinct modes for larger fish due to dimorphic growth rates. Two clear modes, at 24 and 36 cm, are also present for *P. georgianus.*

The distribution for *D. eleginoides* has several modes which are indicative of year classes, these have been analysed further by Everson (1991).

The distributions for *N. rossii* and *N. gibberifrons* each have several peaks although none are sufficiently pronounced to indicate year classes reliably.

Ages of individual fish have been determined from otolith and scale readings and these have been used to provide age distributions in terms of numbers and biomass. The results are shown in Tables 10 and 11.

The data from the age and length distributions have been combined to provide mean length and mean weight at age, these are presented in Tables 12 and 13. All the calculations use

overall age/length keys and, in the case of the mackerel icefish, *C. gunnari*, all fish of length 18 and 19 cm have been assigned to age 1 (SC-CAMLR 1991).

The results for the mackerel icefish, *C. gunnari*, are considered further in a separate paper (Parkes, 1991c).

4.5 Maturity Stages

The length at which 50% of the population are sexually mature, L_{50}, has been derived from the logistic equation used in Everson *et al.* (1991) from samples examined during the survey. The results are given in Table 14. Even though this year's survey was slightly later in the year than the 1990 survey the results are broadly similar for most species.

For *C. gunnari* many of the Stage 2 ovaries looked abnormal and samples were collected for histological examination. A preliminary report is presented in a separate paper (Everson *et al.*, 1991).

4.6 Stomach Contents

The level of stomach fullness from samples examined was estimated and categorisation of the dominant food items was made for the major species. Krill, which have been a major component in the diet of *C. gunnari* in previous years, were rarely the dominant component of the diet in the stomachs examined. The results from this study are examined in a separate paper (Kock *et al.*, 1991).

4.7 Acoustic Observations

Each trawling site was monitored acoustically during the course of the haul, no indications were seen that indicated the presence of large schools of fish. In addition, most trawling sites were examined prior to hauls being made either during the hours of darkness or immediately in advance of fishing. No large schools of fish were detected during these investigations.

5. DISCUSSION

The standing stock estimates for all species, with the exception of *C. gunnari*, are broadly similar to those from the most recent surveys at South Georgia; these are compared in Table 15. A similar picture is not present for surveys at Shag Rocks (Table 16) probably because there are fewer species, fewer surveys and a many fewer hauls in that locality.

The estimated standing stock of *C. gunnari* from this year's survey is very much lower than that from either of the two independent surveys undertaken during 1989/90. It is however broadly similar to those from earlier years with the exception of 1985/86 when a totally different type of net was used.

Acoustic observations indicate that schools of *C. gunnari* were not present anywhere during the current survey, and, that those fish that were present were distributed more or less randomly in the area. Such a distribution would explain the low variance and CV of the standing stock estimate from the trawl survey. We therefore conclude that the standing stock during 1990/91 survey is substantially lower than that from the previous year and is not an artefact of the sampling technique or survey design.

Further evidence for this reduction is available from the commercial fishing fleets in the area. A single Polish trawler *Lepus* was operating in the area and reported catch rates of less than one tonne per day; after several days this vessel left the area. Several Russian trawlers reported to the Harbourmaster, South Georgia, that fishing for *C. gunnari* was extremely poor and that they would move to other grounds.

These observations provide support for the suggestion that there has been a significant reduction in the standing stock of *C. gunnari*. We consider three possible reasons for such a change:

(a) intense fishing between February and December 1990;
(b) migration from the area; and
(c) unusually high natural mortality.

We know of no fishing activity in the area which could have accounted for such a large reduction in standing stock and therefore consider it highly unlikely that the first possibility is the cause.

Any migration would need to take the fish to an area of shelf some considerable distance away. The nearest such shelf area is in the South Orkneys, which, although remote, is not an impossible distance for the fish to migrate. Comparison with samples obtained in that area may confirm whether or not this has occurred .

The third possibility, that there has been an unusually high natural mortality, would be surprising but consistent with the season being characterised by poor krill availability affecting feeding (Kock *et al.*, 1991) and the fish undergoing abnormal gonad maturation processes (Everson *et al.*, 1991). We are investigating all three hypotheses.

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Table 1: Times (GMT-3 hours) and locations of sampled stations.

Station No.	Date		Time		Latitude		Longitude		Depth	Duration
	day	mnth	hr	min	deg	min	deg	min	m	min
1	22	1	6	13	53	19.80	42	44.30	463	27
2	22	1	10	10	53	28.40	42	18.20	232	30
3	22	1	14	20	53	26.00	41	48.00	146	29
4	22	1	18	50	53	37.00	42	7.00	168	30
5	23	1	4	23	53	33.50	41	46.40	139	29
6	23	1	7	10	53	34.10	41	24.50	126	30
7	23	1	9	45	53	34.10	41	24.50	121	30
8	24	1	6	43	53	39.10	41	14.90	135	29
9	24	1	9	15	53	46.60	41	45.90	220	35
10	24	1	12	0	53	47.00	41	21.70	198	25
11	24	1	14	42	53	50.60	41	13.50	196	30
13	25	1	9	17	54	4.50	39	41.50	371	30
14	25	1	13	32	53	50.70	38	37.40	234	24
15	25	1	16	57	53	44.00	38	35.00	318	30
16	25	1	19	35	53	45.40	38	19.50	203	30
17	26	1	4	25	53	38.00	38	6.00	188	30
18	26	1	11	58	53	48.20	38	23.80	183	30
19	26	1	14	32	53	38.00	37	51.00	176	21
20	27	1	4	29	53	54.60	38	2.50	126	30
21	27	1	10	15	53	46.70	37	30.70	121	28
22	27	1	14	57	53	45.80	37	22.00	280	30
23	27	1	17	50	53	38.50	37	10.00	161	30
24	27	1	19	30	53	40.00	37	0.00	212	30
25	28	1	4	26	53	46.50	36	54.00	203	20
26	28	1	6	43	53	43.70	36	37.00	218	30
27	28	1	9	18	53	45.50	36	28.00	304	30
28	28	1	11	45	53	55.00	36	13.50	187	30
29	28	1	15	23	54	1.00	36	26.00	178	28
30	28	1	18	26	53	57.50	35	58.00	287	30
31	29	1	4	32	54	8.00	35	58.00	231	30
32	29	1	9	50	54	14.00	36	36.00	251	30
33	29	1	12	46	54	11.50	36	16.50	183	20
34	29	1	14	56	54	12.80	36	18.30	112	18
35	29	1	17	57	54	11.00	35	48.00	231	30
36	30	1	4	16	54	11.00	35	37.00	192	30
37	30	1	6	30	54	19.00	35	53.50	207	24
38	30	1	9	3	54	20.50	35	53.70	198	30
39	30	1	13	18	54	32.00	35	45.00	174	27
40	30	1	16	34	54	26.00	35	23.00	269	30
41	31	1	4	27	54	33.00	35	16.20	196	26
42	1	2	9	45	54	37.30	35	31.50	124	30
43	1	2	12	30	54	46.00	35	16.50	324	30
44	1	2	16	40	54	47.00	34	55.00	359	30
45	1	2	18	58	54	55.00	34	57.50	181	30
46	2	2	4	34	54	56.60	35	15.10	102	24
47	2	2	6	58	54	58.00	35	23.60	124	30
48	2	2	9	52	55	1.50	35	22.00	113	30
49	2	2	12	25	55	3.80	35	23.00	130	30

Table 1 (continued)

Station No.	Date day	Date mnth	Time hr	Time mi	Latitude deg	Latitude min	Longitude deg	Longitude min	Depth m	Duration min
50	2	2	14	44	55	5.60	35	1.00	139	30
51	2	2	17	4	55	12.20	34	46.40	176	31
52	3	2	4	37	55	28.00	35	20.20	368	30
53	3	2	6	20	55	25.60	35	22.90	210	15
54	3	2	10	10	55	18.00	35	53.00	223	26
55	3	2	12	54	55	4.60	35	44.30	123	30
56	3	2	15	50	54	56.50	35	47.30	154	10
57	3	2	19	20	55	5.90	36	8.00	167	30
58	4	2	5	2	54	50.40	38	13.40	285	30
59	4	2	8	39	54	39.30	38	20.80	188	30
60	4	2	11	51	54	36.80	38	5.40	165	30
61	4	2	13	42	54	32.00	38	15.00	183	19
62	5	2	4	20	54	25.00	37	49.00	172	30
63	5	2	6	0	54	16.00	37	49.00	137	30
64	5	2	11	45	54	15.40	38	2.80	185	29
65	5	2	13	48	54	15.70	38	13.10	243	30
66	5	2	16	43	54	18.60	38	32.70	214	22
67	5	2	19	19	54	8.80	38	36.10	216	30
68	6	2	4	38	54	6.40	38	2.10	134	25
69	6	2	16	21	54	13.50	37	48.20	127	14
70	6	2	19	32	54	9.20	37	50.20	161	6
71	7	2	4	25	54	31.00	38	46.00	229	15
72	7	2	10	22	54	28.70	39	16.40	284	30
73	7	2	13	8	54	16.00	39	0.00	245	15
74	7	2	16	25	54	9.50	39	14.00	223	30
75	7	2	18	33	54	7.00	39	12.00	240	30
76	8	2	4	36	54	7.90	38	51.30	198	3C
77	8	2	6	36	54	10.20	38	46.20	238	30
78	8	2	10	15	53	53.50	38	22.30	134	30
79	8	2	15	58	53	40.30	37	35.30	231	30
80	8	2	18	19	53	41.50	37	29.80	322	24
81	9	2	5	38	53	56.80	36	29.60	185	27
82	9	2	9	S0	53	51.80	37	15.10	284	30
83	9	2	19	15	54	4.20	35	40.00	212	30
84	1	2	5	42	54	17.10	3S	37.40	234	30
85	10	2	9	57	54	25.00	35	54.70	113	30
86	11	2	11	30	53	50.60	40	47.10	350	30
87	11	2	17	13	53	41.00	41	33.90	150	9

Table 2: Sampling coverage around South Georgia and Shag Rocks.

Depth Stratum	Coverage km² Per Station		Number of Stations	
	South Georgia	Shag Rocks	South Georgia	Shag Rocks
50 to 150 m	554	295	16	5
151 to 250 m	519	374	37	5
251 to 500 m	613	805	13	2

Table 3: Mesh size measurements from the bottom trawl used in the 1990/91 South Georgia survey.

	Fornet		Belly		Codend		Liner	
	165	149	124	125	85	97	50	57
	148	148	126	129	92	97	57	57
	148	148	125	128	95	93	53	55
	148	146	128	131	90	96	52	54
	148	149	129	129	93	97	54	53
	149	152	124	127	91	97	56	51
	147	152	127	129	92	95	57	52
	154	148	128	130	94	93	54	54
	158	144	126	125	96	94	55	54
	148	147	128	129	94	94	53	53
Mean:	149.8		127.3		93.8		54.1	
Var:	4.69		2.00		2.84		1.99	

Table 4: Total catch and number of stations at which species were caught from the South Georgia region.

Depth	50 to 150 (m)		150 to 250 (m)		250 to 500 (m)	
	kg	n	kg	n	kg	n
Commercial species:						
C. gunnari	616	15	1 779	36	171	10
C. aceratus	452	15	965	36	103	10
P. georgianus	508	15	1 039	36	51	9
N. gibberifrons	931	15	1 455	37	854	12
N. rossii	408	11	106	24	7	3
N. squamifrons	0	0	2	5	140	11
D. eleginoides	17	7	29	9	26	7
P.b. guntheri	0	0	0	0	0	0
Other species:						
N. augustifrons	0.1	2	0	0	0	0
N. larseni	9.5	8	118	34	21	12
N. nudifrons	14.5	15	27	28	0.4	4
P. hansoni	1.8	5	6.8	7	4.4	1
A. mirus	0.2	9	1.2	20	0.3	6
Diplospinosus spp.	0	0	0.2	2	0.1	3
Electrona spp.	0	1	0.1	2	0	1
Paraliparis spp.	0	0	0 1	4	0.2	2
M. m. antarctica	0	0	1.2	1	5.6	6
Melanostigma spp.	0	0	0	3	0	1
Muranolepis spp.	1.5	4	29	0	9	12
G. nicholsi	0	1	28	13	31	11
P. georgianus	18	14	169	30	1.4	4
P. breviceps	0	0	1.3	5	0.3	3
R. georgiana	30.5	3	59	11	72	7

Table 5: Total catch and number stations at which species were caught from the Shag Rocks region.

Depth	50 to 150 (m)		150 to 250 (m)		250 to 500 (m)	
	kg	n	kg	n	kg	n
Commercial species:						
C. gunnari	774	5	55	5	0	0
C. aceratus	0	0	0	0	0	0
P. georgianus	0	0	3	2	0	0
N. gibberifrons	16	4	6	3	0	0
N. rossii	0	0	0	0	0	0
N. squamifrons	1	1	16	2	41	2
D. eleginoides	120	5	34	4	1 183	2
P.b. guntheri	69	5	42	5	1	1
Other species:						
N. nudifrons	1.6	4	1.2	3	0	0
K. andersoni	0	0	0	1	0	0
A. mirus	0.2	1	0	1	0	0
Diplospinosus spp.	0	0	0	0	0	1
Electrona spp.	0	0	0.2	0	0	0
M. m. antarctica	0.3	1	0	0	0.4	2
Muranolepis spp.	1	1	0.2	1	0.4	2
G. nicholsi	0	0	1.4	1	0	0

Table 6: Biomass estimates for South Georgia of the most common species around South Georgia, calculated using the 'swept area method'. CV = coefficient of variation of the estimate (Saville 1977).

	Depth Stratum				
Species	50 to 150 m	151 to 250 m	251 to 500 m	Total	CV (%)
C. gunnari	5 445	15 256	1 583	22 285	16
C. aceratus	3 888	8 623	963	13 474	15
P. georgianus	4 457	8 902	590	13 948	19
N. gibberifrons	7 832	12 624	7 768	28 224	18
N. rossii	3 335	896	64	4 295	49
D. eleginoides	157	262	465	885	37
N. squamifrons	0	14	1 361	1 374	43
Number of stations	16	37	13	66	

Table 7: Biomass estimates for South Georgia of the most common species around Shag Rocks, calculated using the 'swept area method'. CV = coefficient of variation of the estimate (Saville 1977).

	Depth Stratum				
Species	50 to 150 m	151 to 250 m	251 to 500 m	Total	CV(%)
C. gunnari	3 573	346	0	3 919	75
C. aceratus	0	0	0	0	
P. georgianus	0	15	0	15	62
N. gibberifrons	79	38	0	117	34
N. rossii	0	0	0	0	
D. eleginoides	581	206	18 527	19 315	94
N. squamifrons	3	93	535	631	33
P.b. guntheri	322	245	16	584	45
Number of stations	5	5	2	12	

Table 8: Length/weight relationships from measurements taken during the survey; length in cm, weight in g, (least squares linear regression on $\log_e$ transformed data).

Species		Length/weight relationship (W=L*b)		
	Sex	a	b	Number of fish
C. gunnari	M	3.36	0.00180	230
C. gunnari	F	3.36	0.00180	231
C. aceratus	M	3.69	0.00047	186
C. aceratus	F	3.65	0.00054	232
P. georgianus	M	3.61	0.00095	120
P. georgianus	F	3.53	0.00122	120
N. gibberifrons	M+F	3.28	0.00389	349
N. rossii	M+F	2.94	0.01668	181
D. eleginoides	M+F	317	0.00477	198

Table 9: Age/length key for *C. gunnari* prepared from otolith readings from the *Falklands Protector* survey January/February1991, augmented to allocate lengths 18 and 19 cm to age class 1. Figures in parentheses have been added as explained in section 4.4 of this report.

Age >	0	1	2	3	4	5	6	7	8	9	10
Length 0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0

Table 9 (continued)

Age >	0	1	2	3	4	5	6	7	8	9	10
Length 9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0
12	0	1	0	0	0	0	0	0	0	0	0
13	0	2	0	0	0	0	0	0	0	0	0
14	0	3	0	0	0	0	0	0	0	0	0
15	0	3	0	0	0	0	0	0	0	0	0
16	0	1	0	0	0	0	0	0	0	0	0
17	0	1	0	0	0	0	0	0	0	0	0
18	0	(1)	0	0	0	0	0	0	0	0	0
19	0	(1)	0	0	0	0	0	0	0	0	0
20	0	0	2	0	0	0	0	0	0	0	0
21	0	0	6	0	0	0	0	0	0	0	0
22	0	0	10	0	0	0	0	0	0	0	0
23	0	0	12	0	0	0	0	0	0	0	0
24	0	0	15	0	0	0	0	0	0	0	0
25	0	0	24	0	0	0	0	0	0	0	0
26	0	0	21	1	0	0	0	0	0	0	0
27	0	0	11	6	0	0	0	0	0	0	0
28	0	0	11	11	0	0	0	0	0	0	0
29	0	0	4	10	1	0	0	0	0	0	0
30	0	0	2	11	0	0	0	0	0	0	0
31	0	0	0	18	3	0	0	0	0	0	0
32	0	0	1	22	6	0	0	0	0	0	0
33	0	0	0	12	7	0	0	0	0	0	0
34	0	0	1	12	8	0	0	0	0	0	0
35	0	0	0	11	11	0	0	0	0	0	0
36	0	0	0	10	13	0	0	0	0	0	0
37	0	0	0	7	11	0	0	0	0	0	0
38	0	0	0	4	14	1	0	0	0	0	0
39	0	0	0	3	5	2	0	0	0	0	0
40	0	0	0	1	9	0	0	0	0	0	0
41	0	0	0	0	12	2	0	0	0	0	0
42	0	0	0	0	5	3	0	0	0	0	0
43	0	0	0	0	1	2	0	0	0	0	0
44	0	0	0	0	1	2	0	0	0	0	0
45	0	0	0	0	1	2	0	0	0	0	0
46	0	0	0	0	1	2	0	0	0	0	0
47	0	0	0	0	0	2	1	1	0	0	0
48	0	0	0	0	0	4	3	0	0	0	0
49	0	0	0	0	0	1	3	0	0	0	0
50	0	0	0	0	0	2	1	1	0	0	0
51	0	0	0	0	0	0	1	1	1	0	0
52	0	0	0	0	0	0	2	0	0	0	0
53	0	0	0	0	0	0	1	1	0	0	0
54	0	0	0	0	0	0	0	3	0	0	1
55	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	1	0	0
57	0	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0

Table 10: Age distributions of the catch (numbers %) for length, weight and age samples taken during the survey. All values are for South Georgia, and both sexes except where indicated.

Species	Age (years)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C. gunnari	62.4	17.6	13.8	5.8	0.3	0.1									
C. gunnari Shag Rocks	0.4	44.7	45.0	9.8											
C. aceratus (male)	7.7	19.8	27.8	13.7	5.0	21.2	3.9	0.2	0.4	0.4					
C. aceratus (female)	4.3	17.2	14.4	13.6	10.7	19.8	7.7	5.2	3.6	2.7	0.7				
P. georgianus	10.9	41.6	30.3	11.4	5.8	0.1									
N. gibberifrons		7.2	11.0	11.9	15.1	15.0	15.4	11.0	3.5	3.8	2.3	2.4	1.1		0.4
N. rossii			1.6	3.8	25.5	30.0	19.0	7.9	7.9	3.7	0.7				

Table 11: Age distributions of the catch (biomass %) for length, weight and age samples taken during the survey. All values are for South Georgia, and both sexes except where indicated.

Species	Age (years)												
	1	2	3	4	5	6	7	8	9	10	11	12	13
C. gunnari	17.4	21.2	36.2	21.9	2.3	0.7	0.4						
C. gunnari Shag Rocks	0.1	33.0	51.7	15.1	0.1								
C. aceratus (male)	0.4	4.4	13.4	14.9	7.3	48.1	8.9	0.6	1.0	1.0			
C. aceratus (female)	0.1	2.2	3.6	6.8	9.0	29.8	15.9	14.0	9.2	7.2	2.3		
P. georgianus	1.3	25.4	39.2	22.3	11.6	0.2							
N. gibberifrons		0.9	2.4	4.7	9.0	12.8	17.7	16.3	7.1	9.9	7.2	8.0	4.2
N. rossii			0.4	1.8	16 8	28.1	21.6	10.4	12.8	6 7	1.4		

Table 12: Mean length (cm) at age for length and age samples taken during the survey. All values are for South Georgia, except where indicated.

Species	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14
C. gunnari	15.7	24.7	31.4	35.2	42.2	48.9								
C. gunnari Shag Rocks	18.0 *	26.6	30.3	33.2	39.9*									
C. aceratus (male)	17.8	26.2	32.0	40.0	43.3	49.1	49.1	53.1	51.0	51.0				
C. aceratus (female)	18.1	26.6	31.9	38.4	44.6	52.4	57.4	61.4	60.9	61.2	65.0			
P. georgianus	22.5	35.5	43.5	49.5	49.8	54.0					42.4			
N. gibberifrons		15.6	18.8	22.5	25.4	28.4	31.1	33.7	37.1	40.2	64.2	43.1	44.5	48.0
N. rossii			30.8	39.0	43.5	49.1	52.6	55.2	59.3	61.8				

* Small sample size

Table 13: Mean weight (g) at age for length and age samples taken during the survey. All values are for South Georgia, except where indicated.

Species	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14
C. gunnari (male)	20.4	87.8	191	275	493	780								
C. gunnari (female)	31.2 *	109	169	225	404*					1 147				
C. gunnari (male) Shag Rocks	15.2	114	197	254	415									
C. gunnari (female) Shag Rocks	22.9	111	168	217										
C. aceratus (male)	20.0	81.1	175	394	528	824	823	1 083	939	939				
C. aceratus (female)	21.3	88.3	175	348	589	1 051	1 442	1 870	1 779	1 834	2 236			
P. georgianus (male)	72.5	378	853	1 219	1 208									
P. georgianus (female)	76.0	374	724	1 195	1 347	1 591								
N. gibberifrons		33.3	60.3	108	163	233	314	406	554	714	854	898	995	1 271
N. rossii			404	795	1 112	1 572	1 914	2 213	2 728	3 086	3 479			

* Small sample size

Table 14: Length at which 50% of the population are sexually mature (L_{50}) and percentage of fish by maturity stage from samples collected during the survey. All results refer to South Georgia unless specified.

Species	Sex	L_{50}	Maturity Stage 2	3	4	5
C. gunnari	M	27.3	62.9	36.3	0.8	0.0
C. gunnari	F		86.8	12.4	0.2	0.6
C. gunnari Shag Rocks	M	37.4	19.9	80.1	0.0	0.0
C. gunnari Shag Rocks	F	39.0	45.3	54.5	0.0	0.2
C. aceratus	M	42.7	53.2	46.8	0.0	0.0
C. aceratus	F	40.0	60.2	39.2	0.0	0.6
P. georgianus	M	42.4	43.4	56.2	0.0	0.4
P. georgianus	F	35.1	67.3	32.0	0.0	0.7
N. gibberifrons	M	27.8	82.6	17.2	0.0	0.2
N. gibberifrons	F	27.8	91.5	5.6	0.0	2.9
N. rossii	M	37.0	10.4	89.6	0.0	0.0
N. rossii	F	39.7	25.6	73.7	0.0	0.7
D. eleginoides	M		100.0	0.0	0.0	0.0
D. eleginoides	F		100.0	0.0	0.0	0.0
D. eleginoides Shag Rocks	M	56.4	100.0	0.0	0.0	0.0
D. eleginoides Shag Rocks	F		100.0	0.0	0.0	0.0

Table 15: Comparison of biomass estimates (tonnes) with the results from previous surveys around South Georgia, including coefficient of variation (%).

Species	Season																	
	1984/85		1985/86		1986/87		19886/87		1987/88		1987/88		1988/89		1989/90		1989/90		1990/91	
	A	CV %	B	CV %	C	CV %	D		E	CV %	F		G	CV %	H	CV %	I	CV %	J	CV %
C. gunnari	15821	101	151293	95	50414	18	47312	-	15086	21	17913	-	21069	50	95405	63	333515	42	22285	16
C. aceratus	11542	41	2659	31	11743	13	8621	-	6642	12	6209	-	5770	14	14226	37	14424	26	13474	15
P. georgianus	8134	33	2010	50	5240	15	5520	-	11412	24	9461	-	8278	53	5761	28	12200	28	13948	19
N. gibberifrons	15762	28	3252	28	13544	15	11234	-	7189	13	7621	-	8510	17	12417	28	21891	23	28224	18
N. rossii	12718	100	11471	167	4582	69	1634	-	1049	26	1699	-	2439	54	1481	76	3915	30	4295	49
D. eleginoides	8159	76	-	-	1601	34	1208	-	697	21	674	-	326	66	335	39	3020	33	885	37
N. squamifrons	-	-	-	-	39991	76	13950	-	384	25	409	-	131	98	1690	-	5977	98	1374	43

References:

A - Kock (1985) SC-CAMLR-IV-BG/ll
B - Balguerías *et al.* (1987) (Pelagic Trawl)
C - Gabriel (1987) SC-CAMLR-VI-BG/12
D - Sosinski and Skora (1987)
E - McKenna and Saila (1988) SC-CAMLR-VII-BG/23
F - Sosinski (unpubl.)
G - Parkes *et al.* (1989) WG-FSA-89/6
H - Parkes *et al.* (1990) WG-FSA-90/11
I - USSR *Akademik Knipovich* survey (1990) WG-FSA-90/13
J - UK *Falklands Protector* survey (1991) WG-FSA-91

Table 16: Comparison of biomass estimates (tonnes) with the results from previous surveys around Shag Rocks, including coefficient of variation (%).

Species	Season											
	1985/86		1986/87		1987/88		1989/90		1989/90		1990/91	
	A	CV%	B	CV%	C	CV%	D	CV%	E	CV%	F	CV%
C. gunnari	62867	84	10023	55	1447	78	108653	31	54193	38	3919	75
C. aceratus												
P. georgianus									37	73	15	62
N. gibberifrons	81690	44	363	45	609	10			267	39	117	34
N. rossii												
D. eleginoides			763	40	408	17	1693	21	9631	55	19315	94
N. squamifrons			30	57	42	-	414	55	120	44	631	33
P. b. guntheri			331	45	999	27	1918	45	13608	90	584	45

References:

A - Balguerías *et al.* (1987) (Pelagic Trawl)
B - Gabriel (1987) SC-CAMLR-VI/BG/12
C - McKenna and Saila (1988) SC-CAMLR-VII/BG/23
D - USSR *Akademik Knipovich* survey (1990) WG-FSA-90/13
E - Parkes *et al.* (1990) WG-FSA-90/11
F - UK *Falklands Frotector* survey (1991) WG-FSA-91

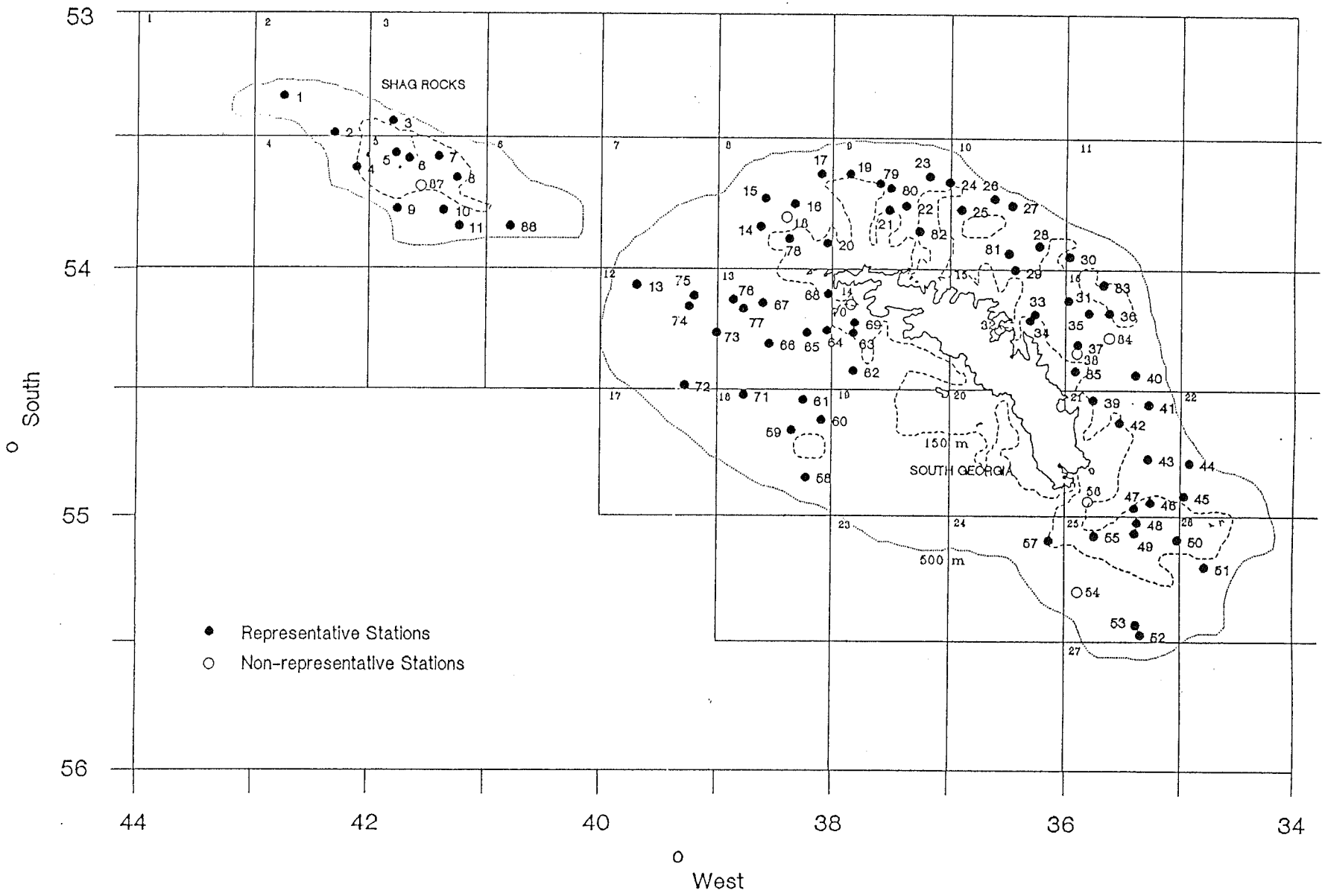


Figure 1: Stations sampled during the *Falklands Protector* survey, January/February 1991.

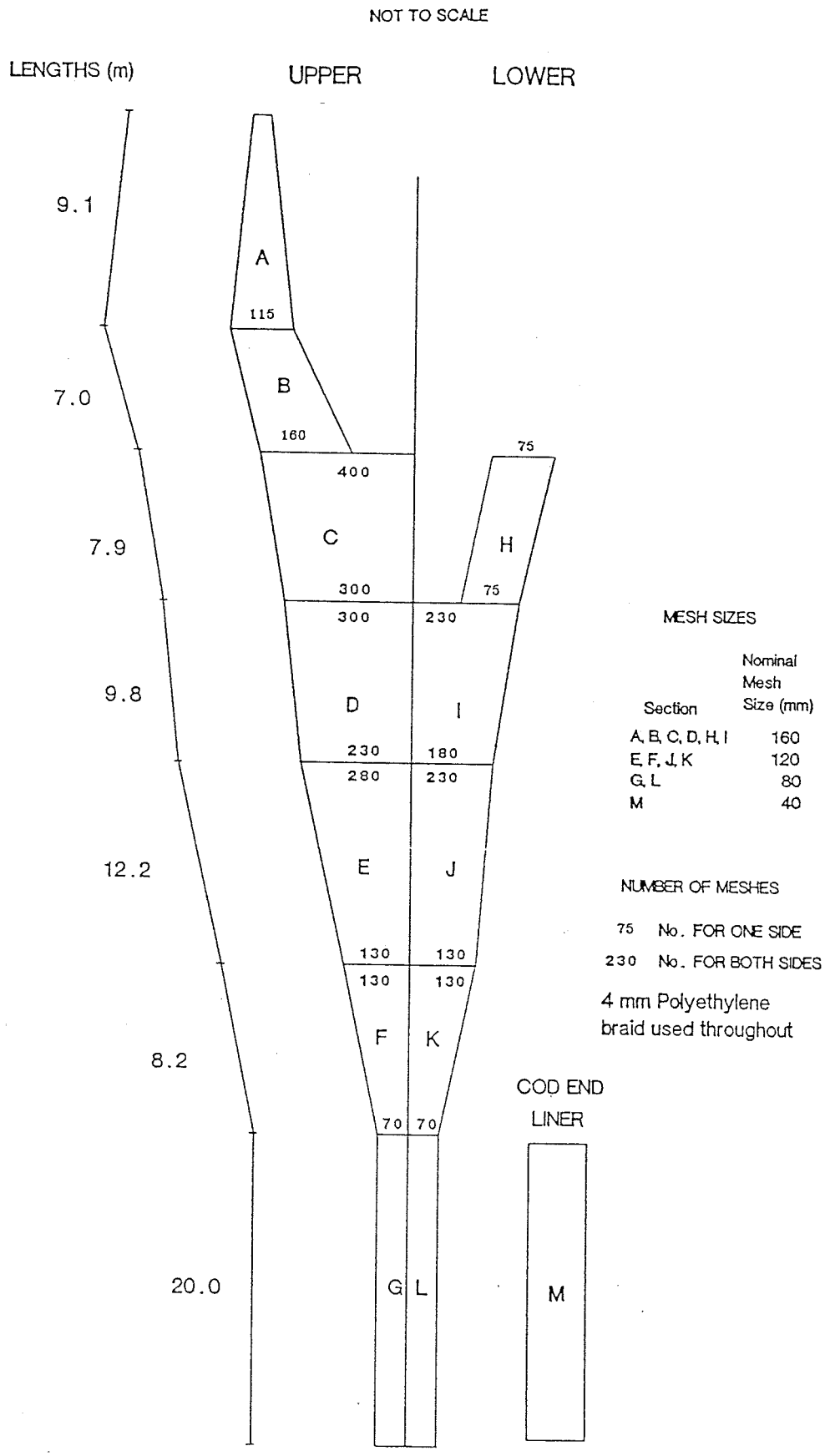


Figure 2a: Construction of the FP-120 Net.

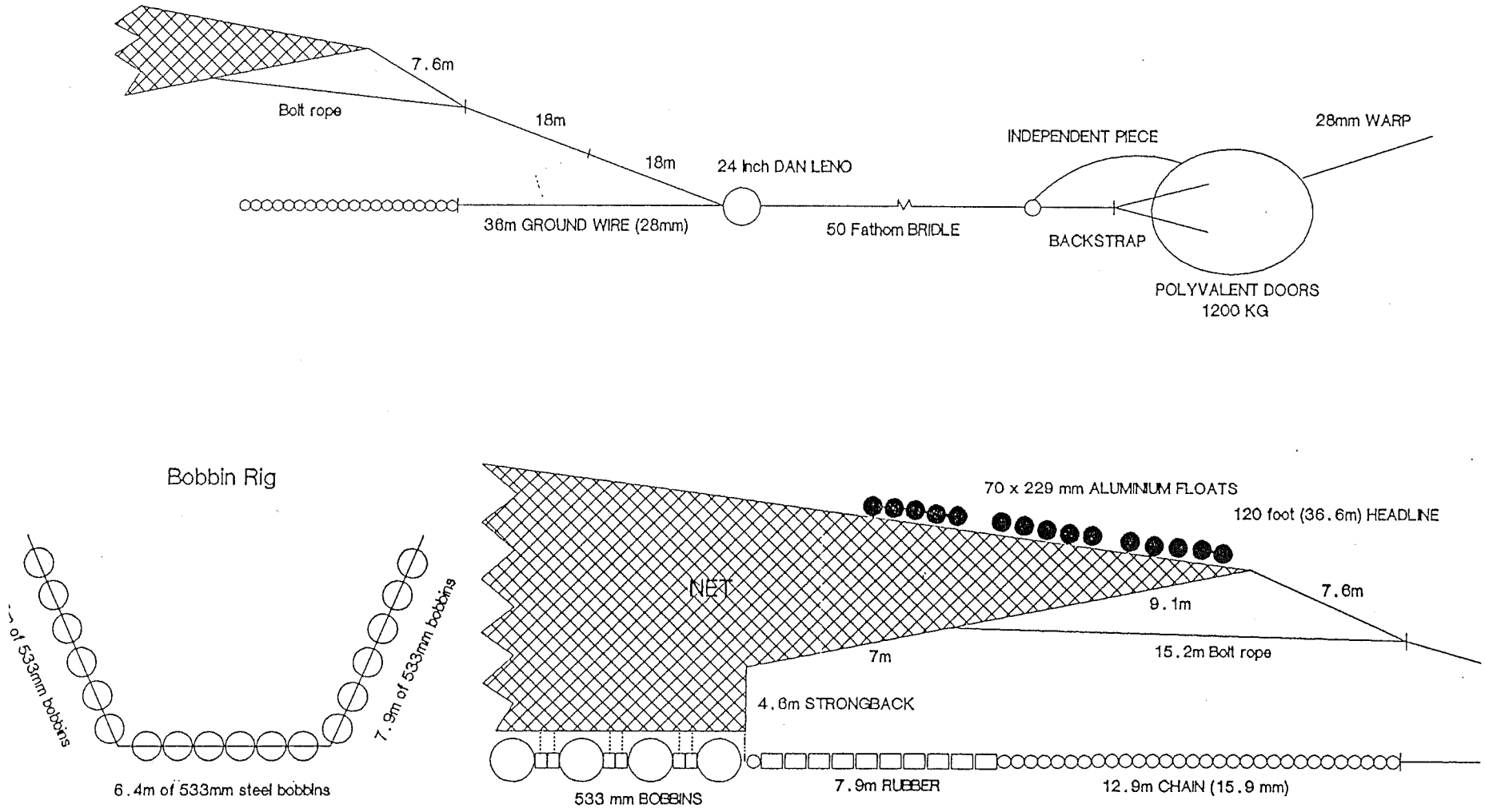


Figure 2b: Rigging of the FP-120 trawl (*Falklands Protector*, January/February 1991).

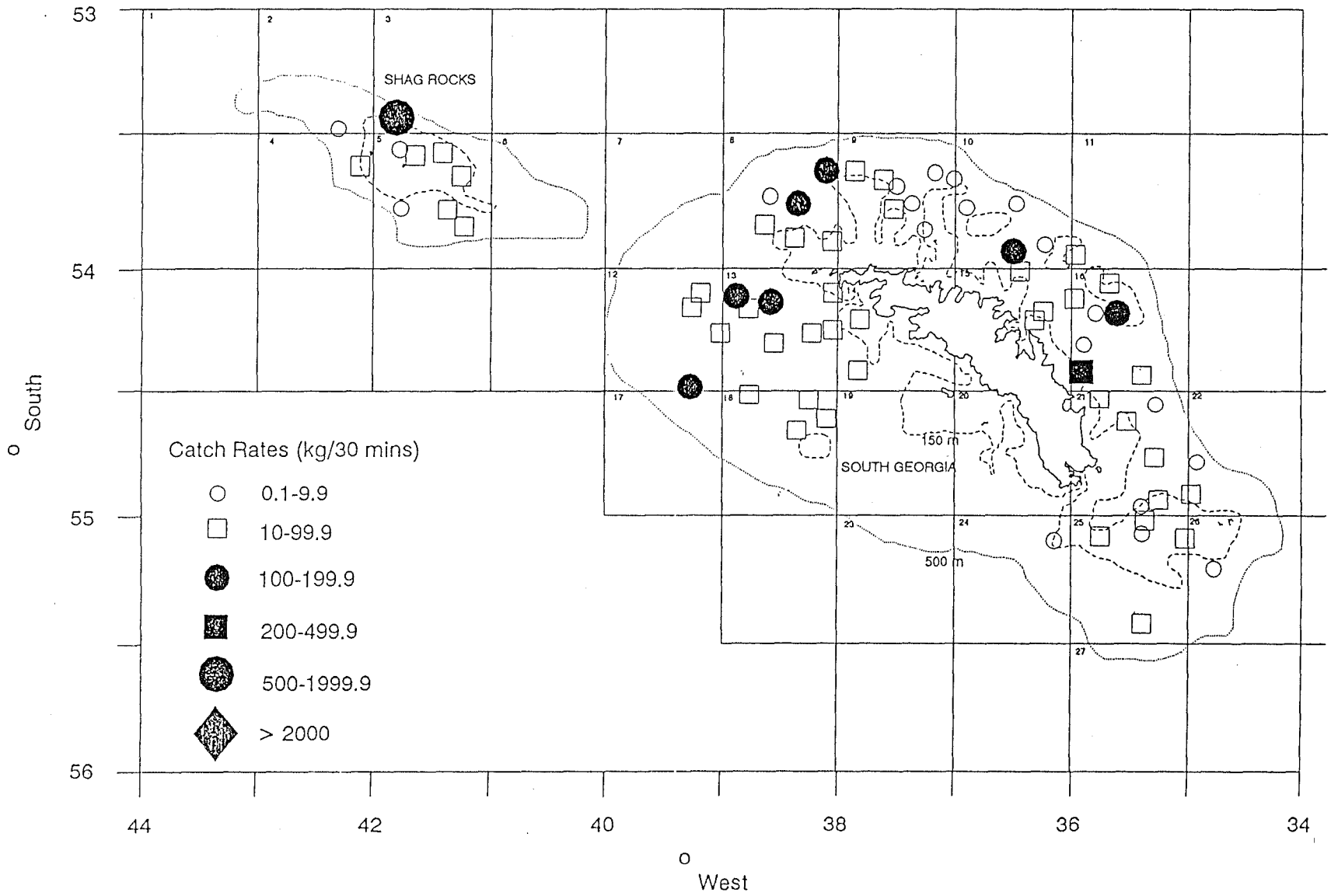


Figure 3: Catch rates, *C. gunnari*, *Falklands Protector*, January/February 1991.

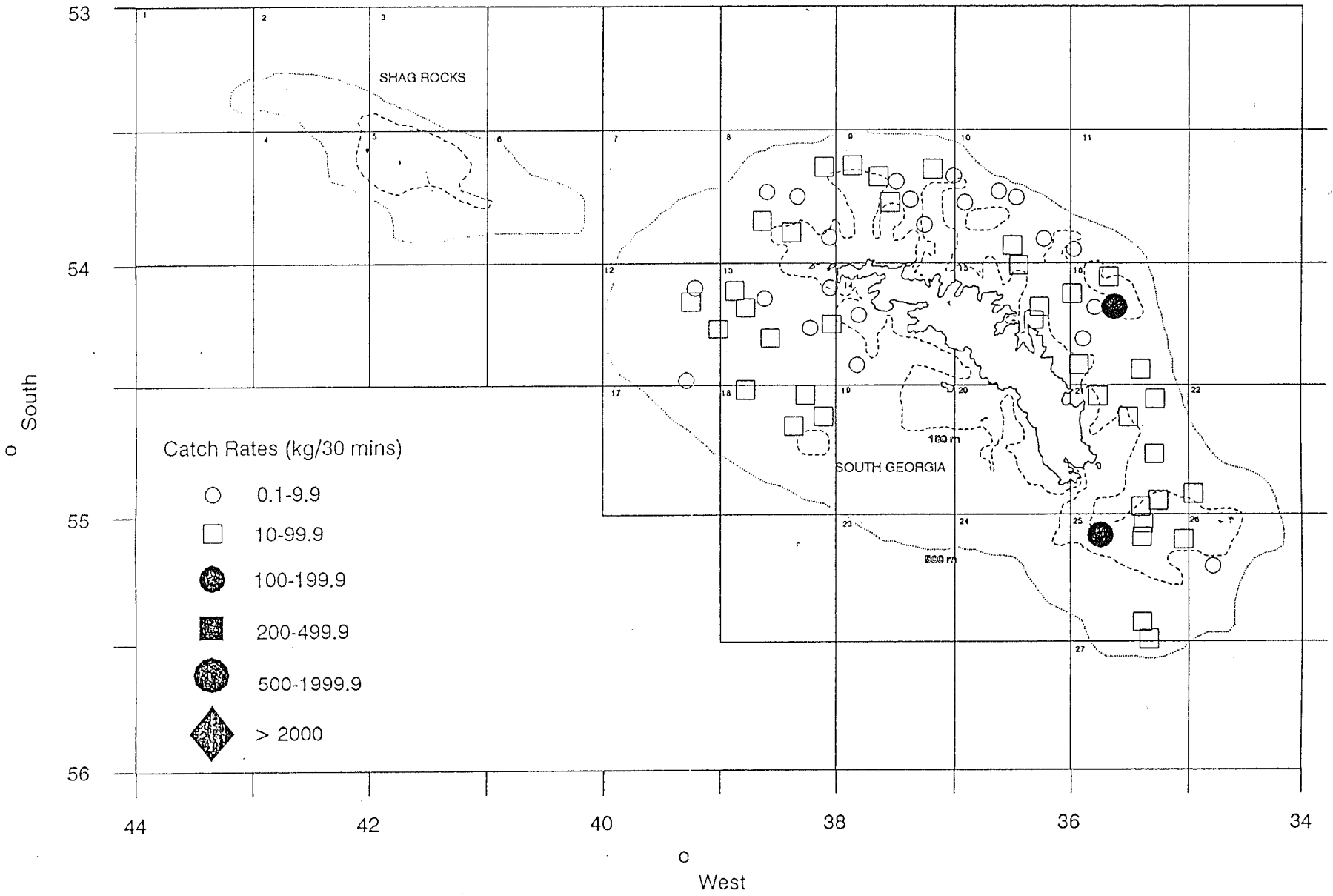


Figure 4: Catch rates, *C. aceratus*, *Falklands Protector*, January/February 1991.

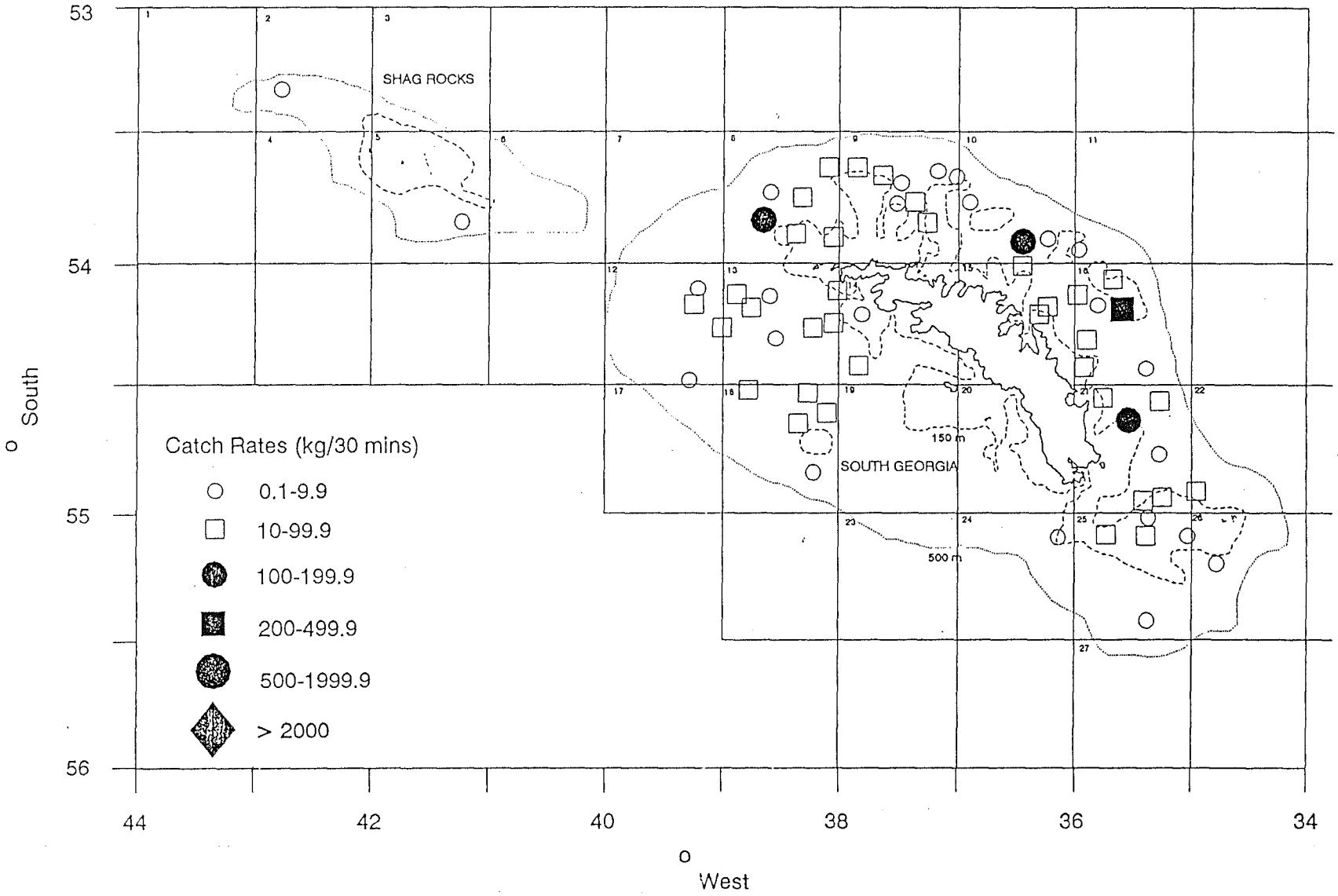


Figure 5: Catch rates, *P. georgianus*, *Falklands Protector*, January/February 1991.

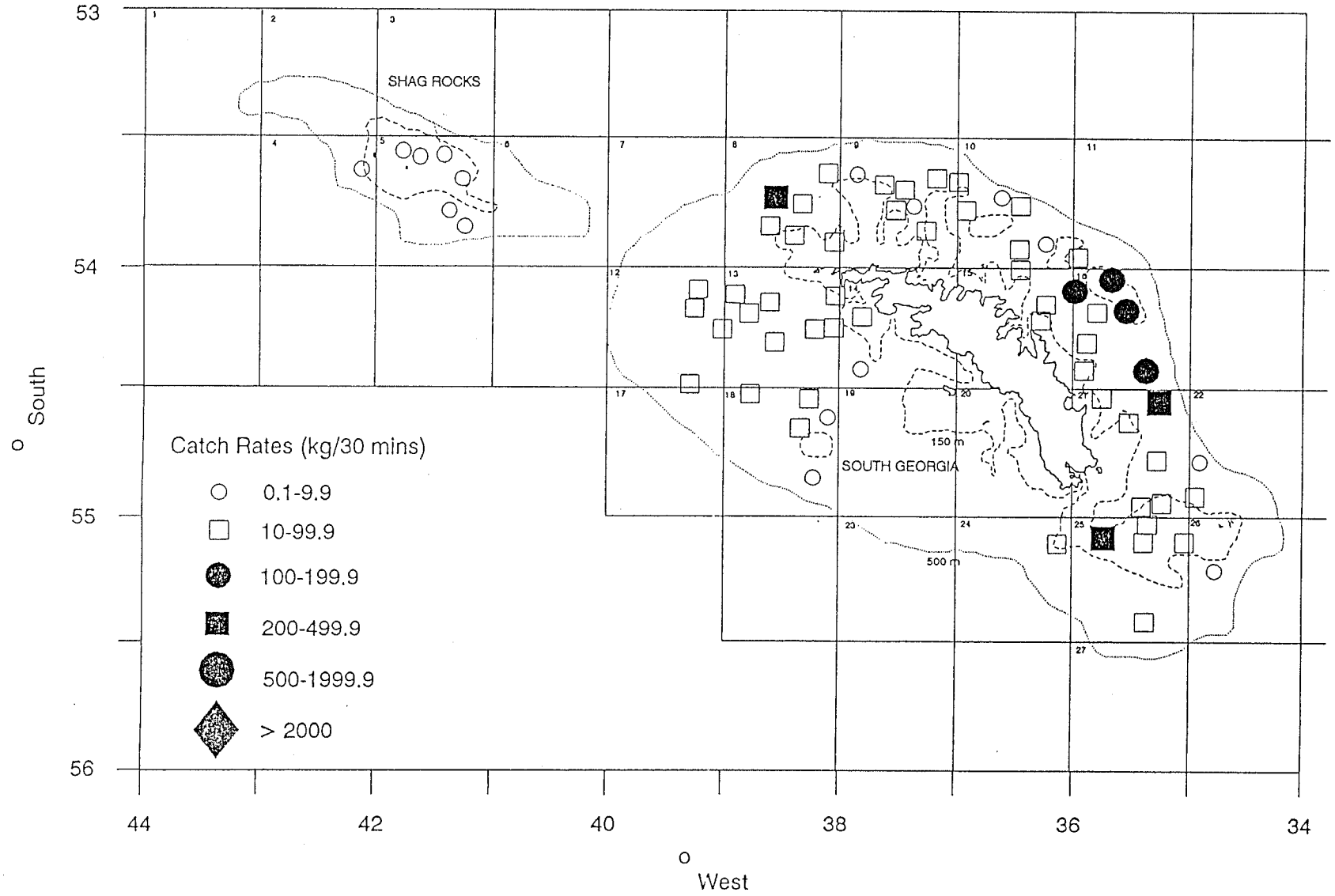
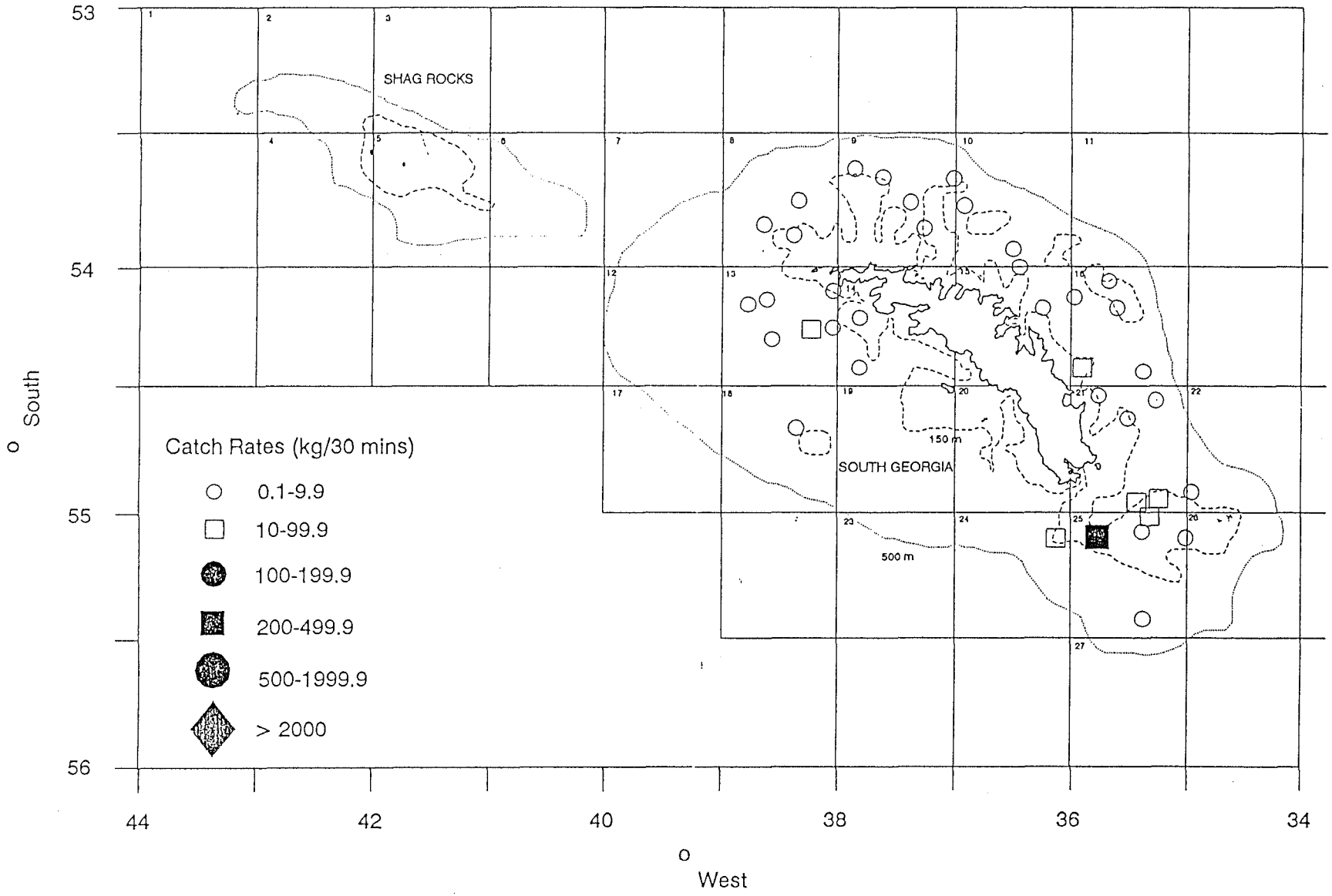


Figure 6: Catch rates, *N. gibberifrons*, *Falklands Protector*, January/February 1991.



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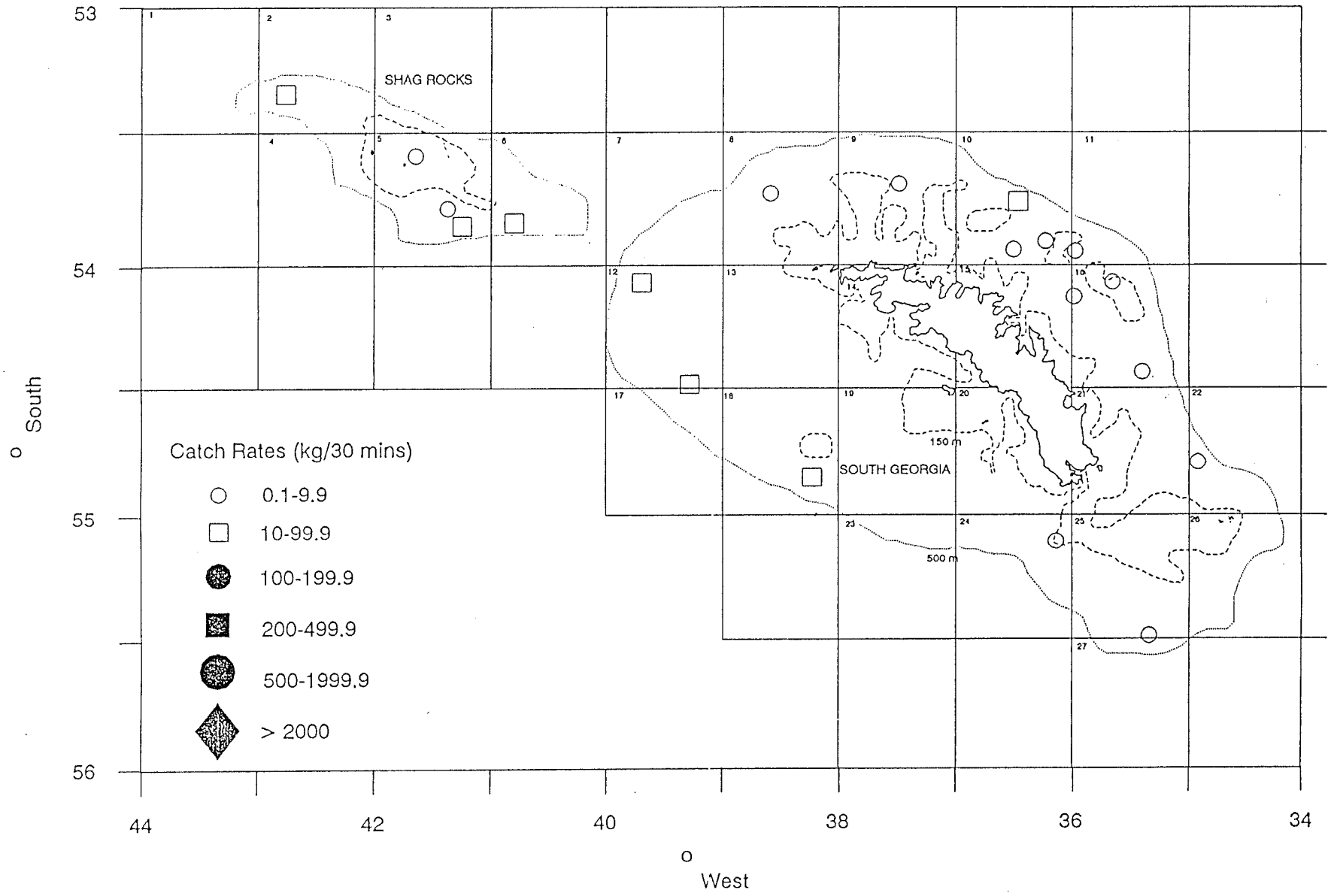

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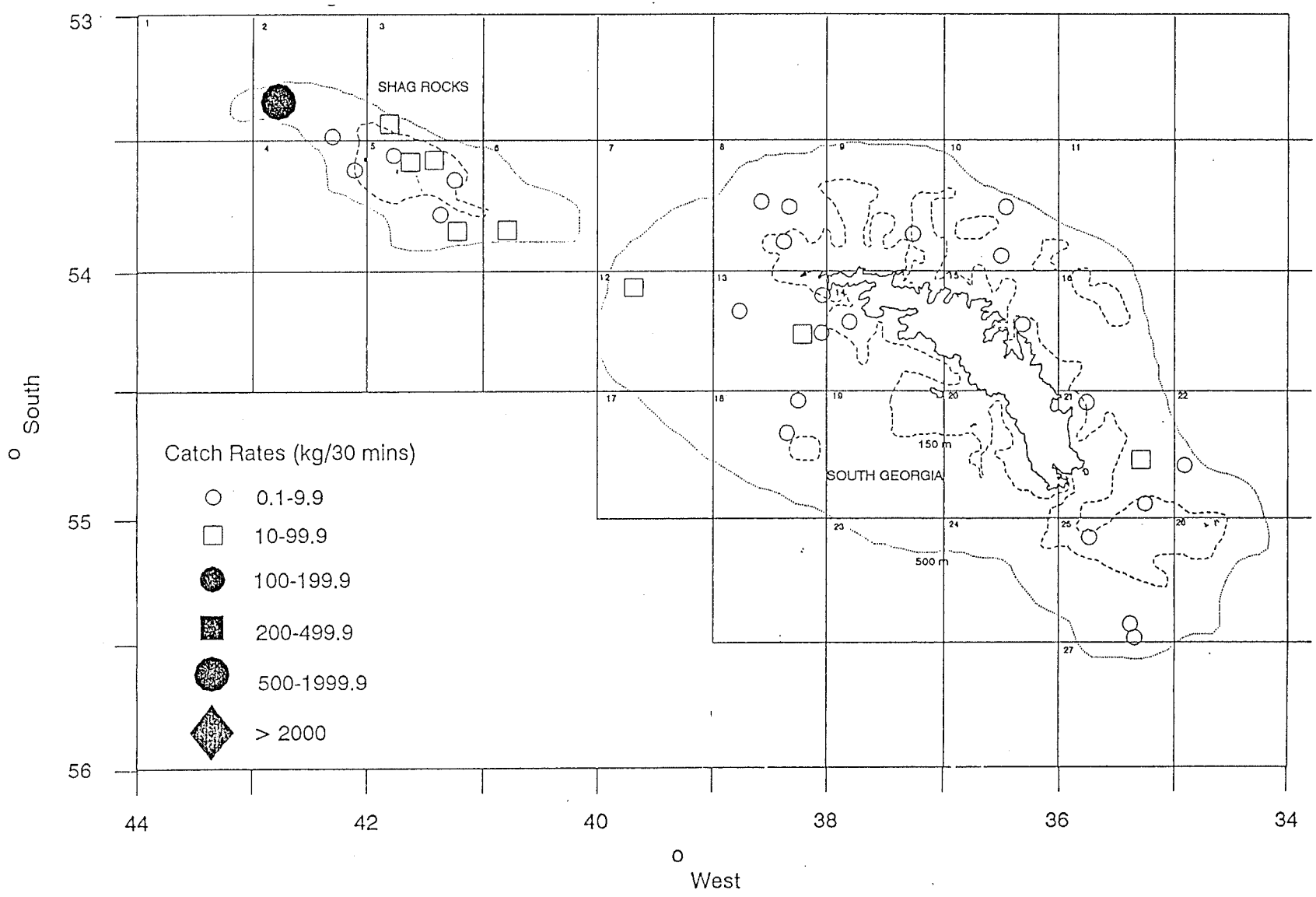

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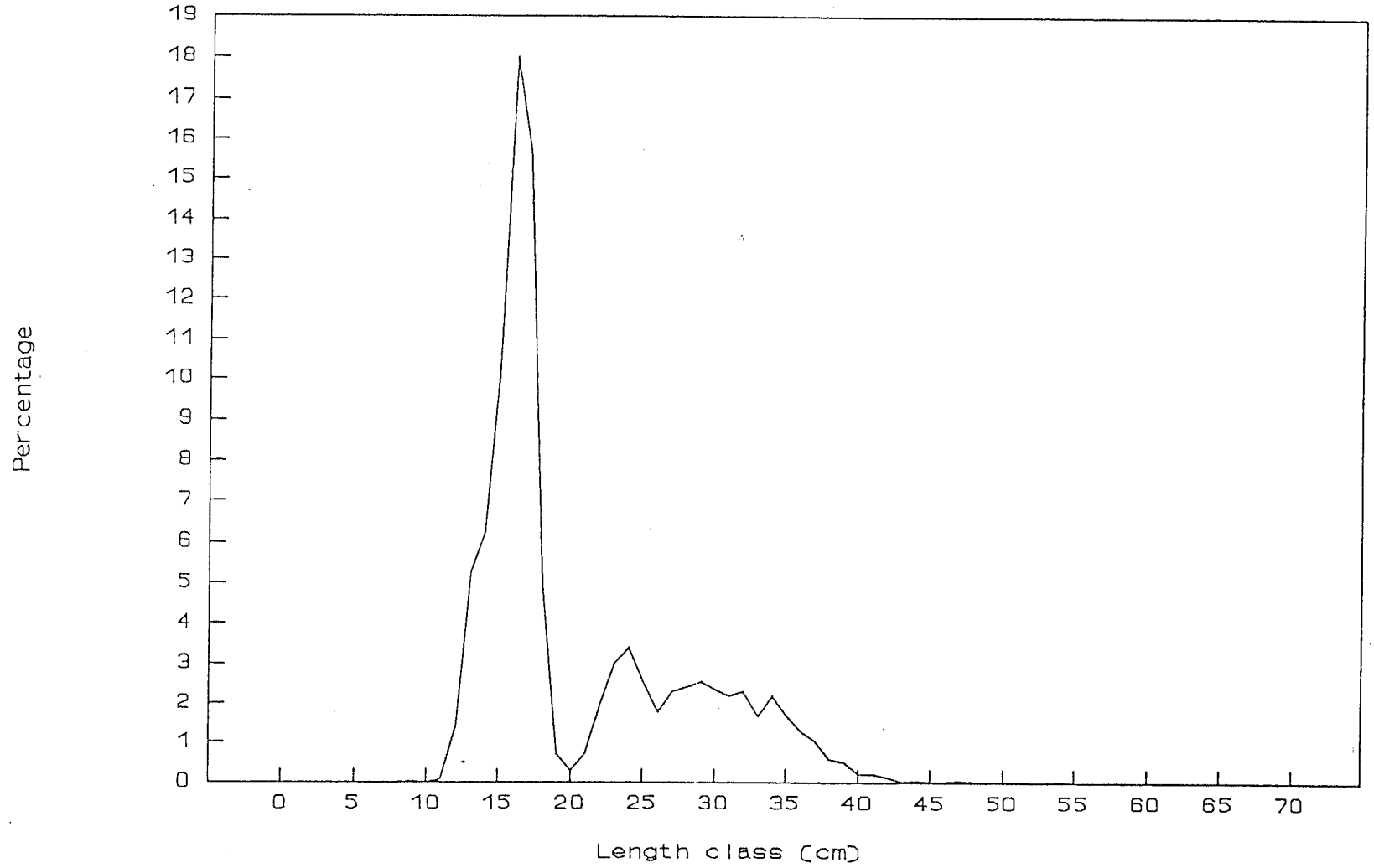

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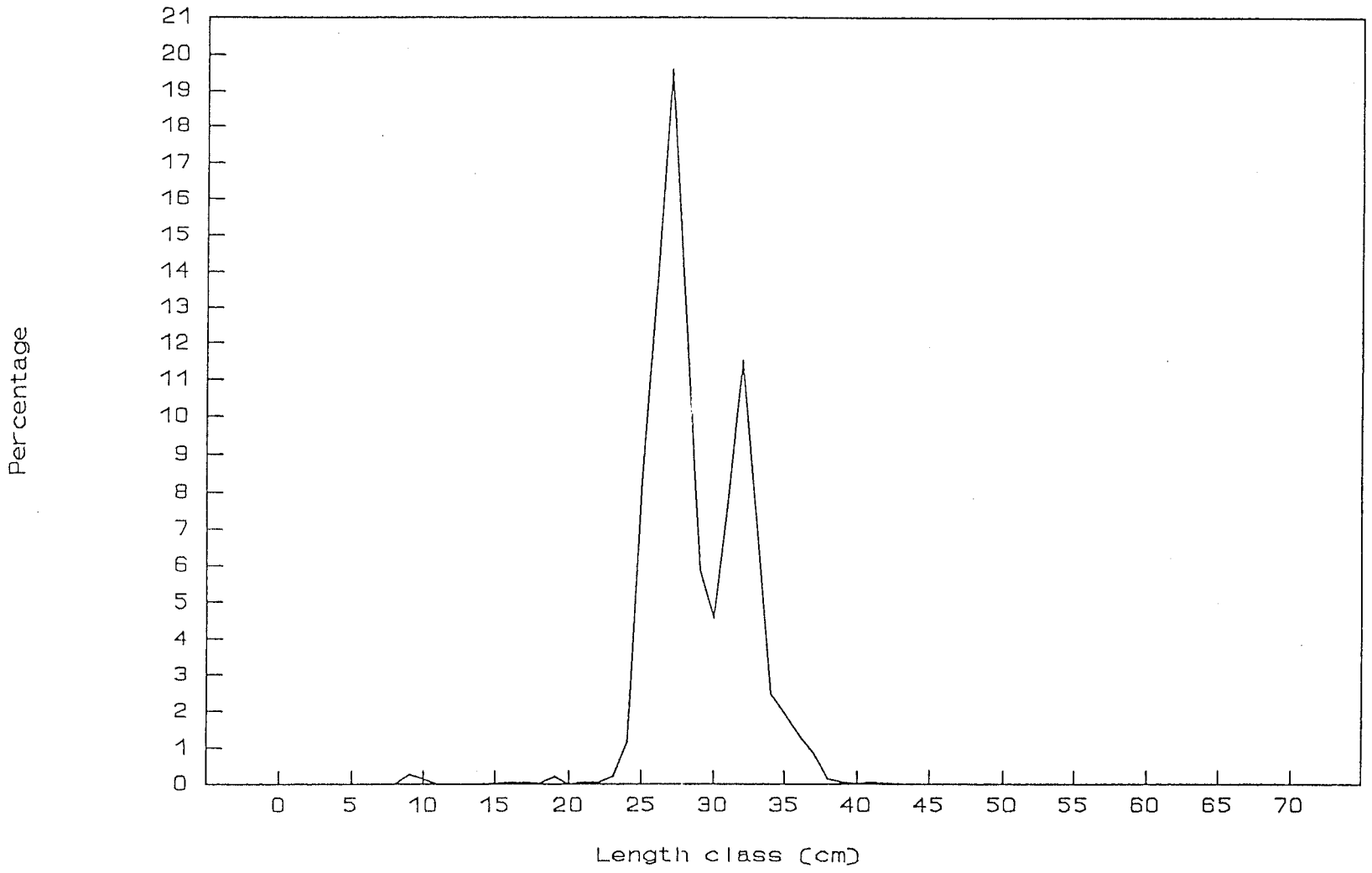

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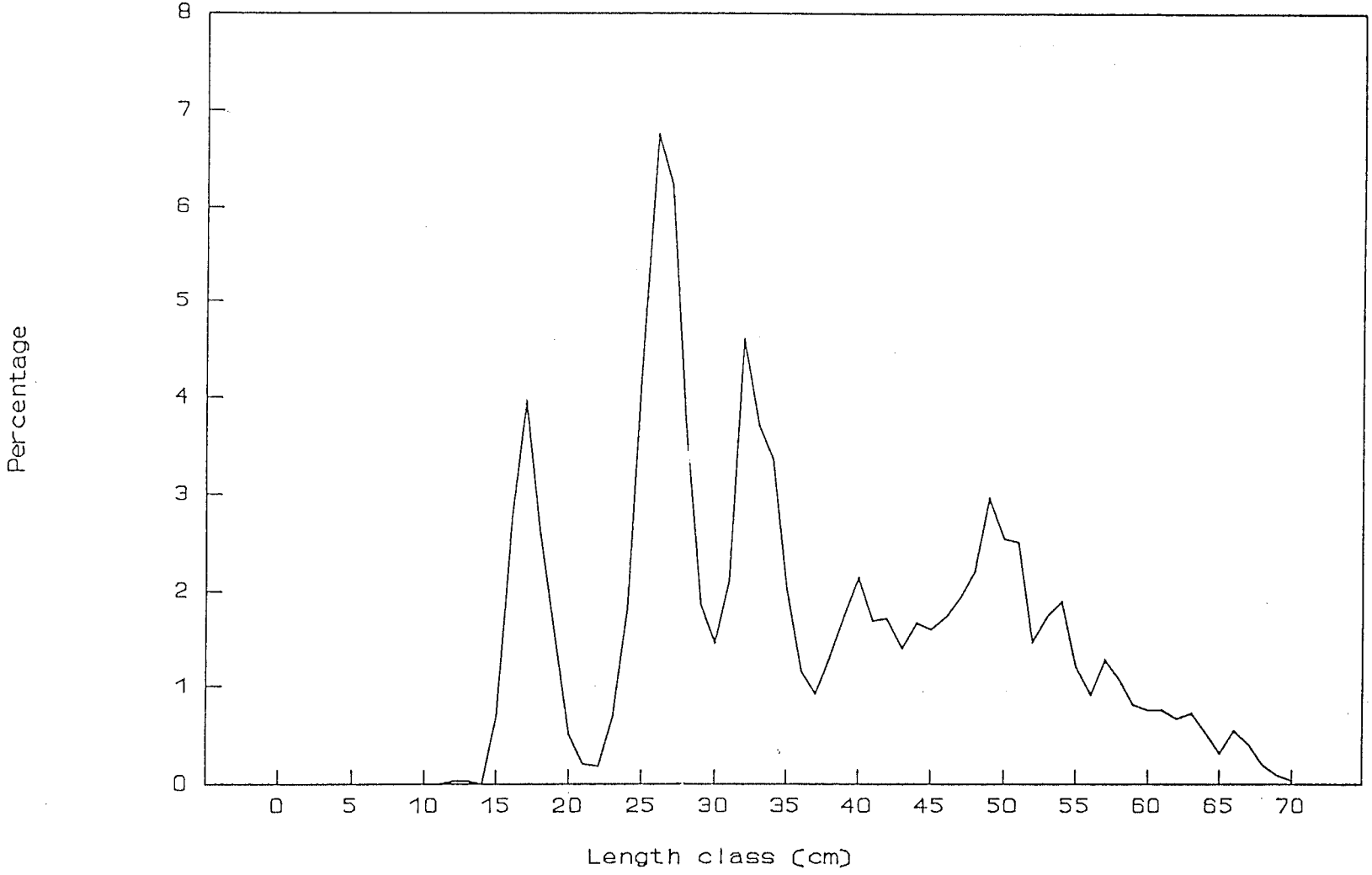

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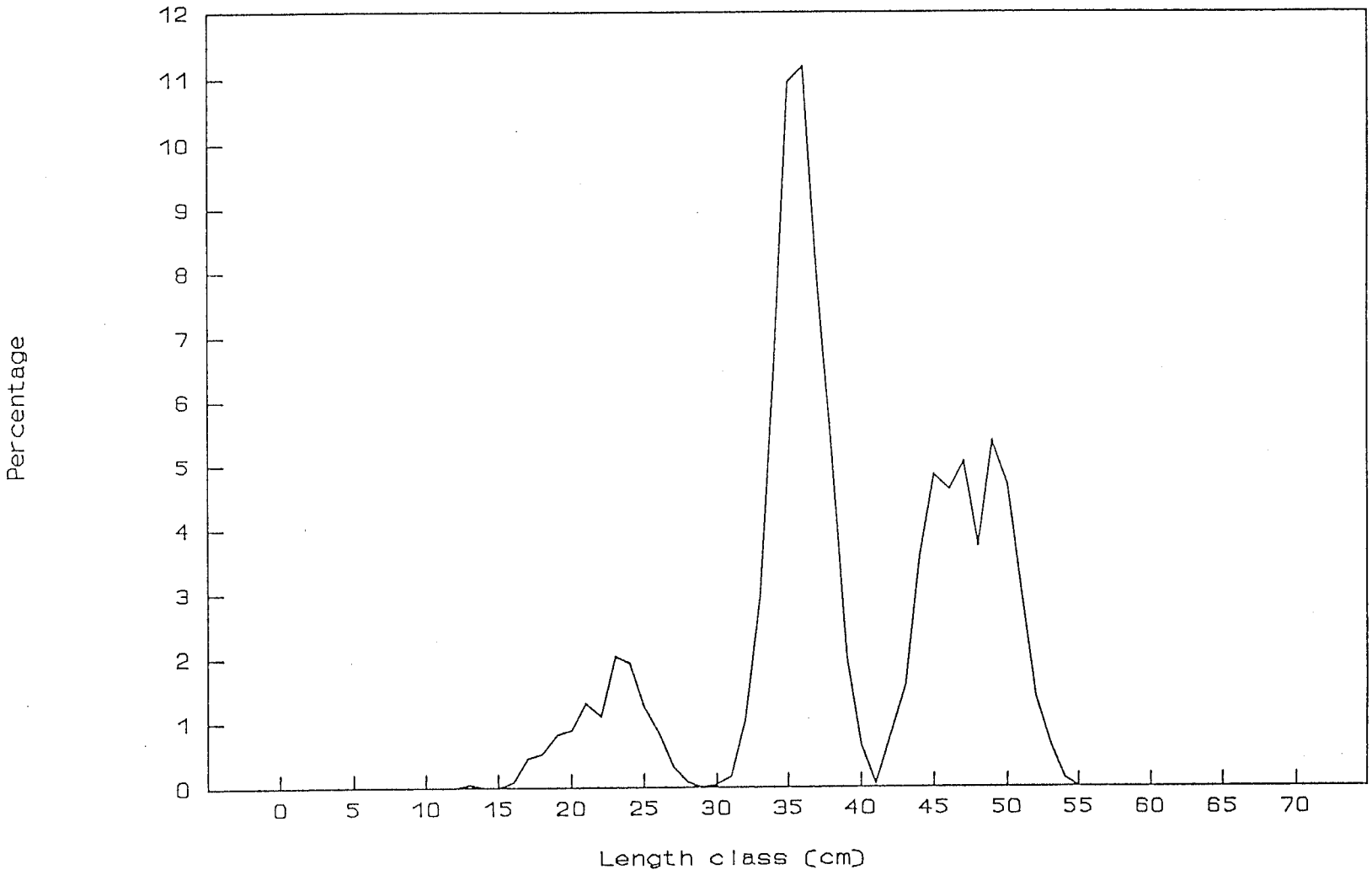

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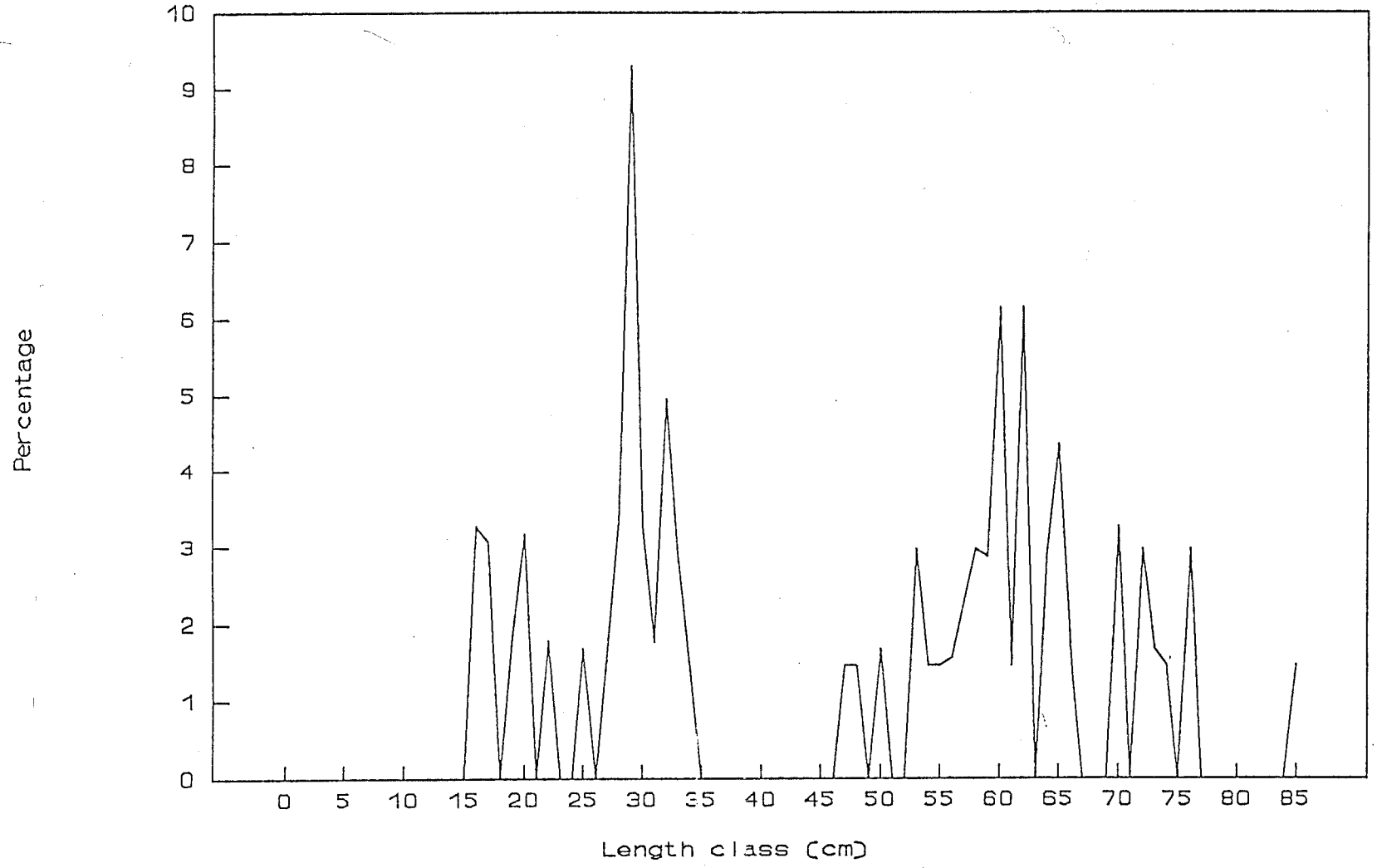

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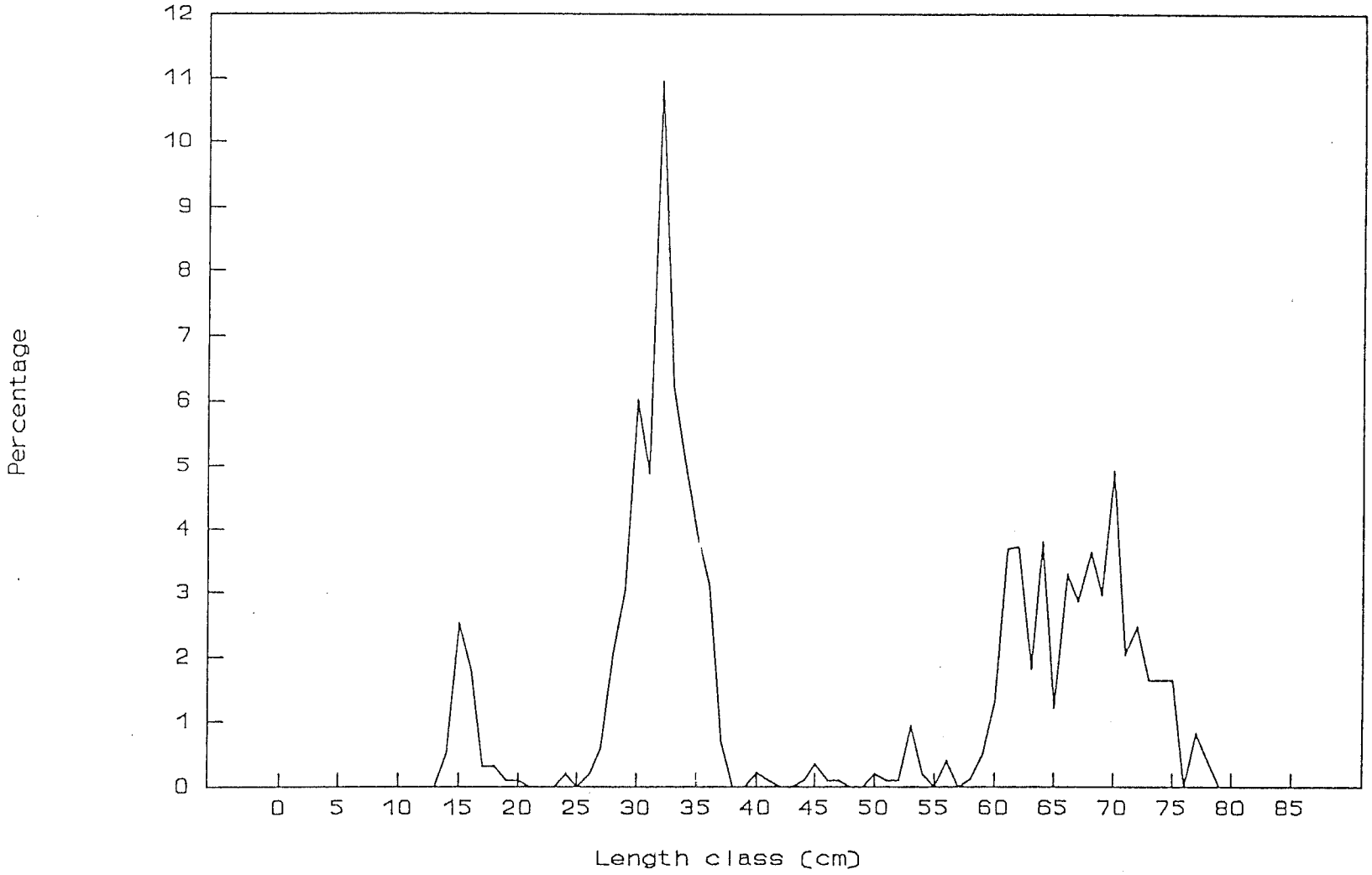

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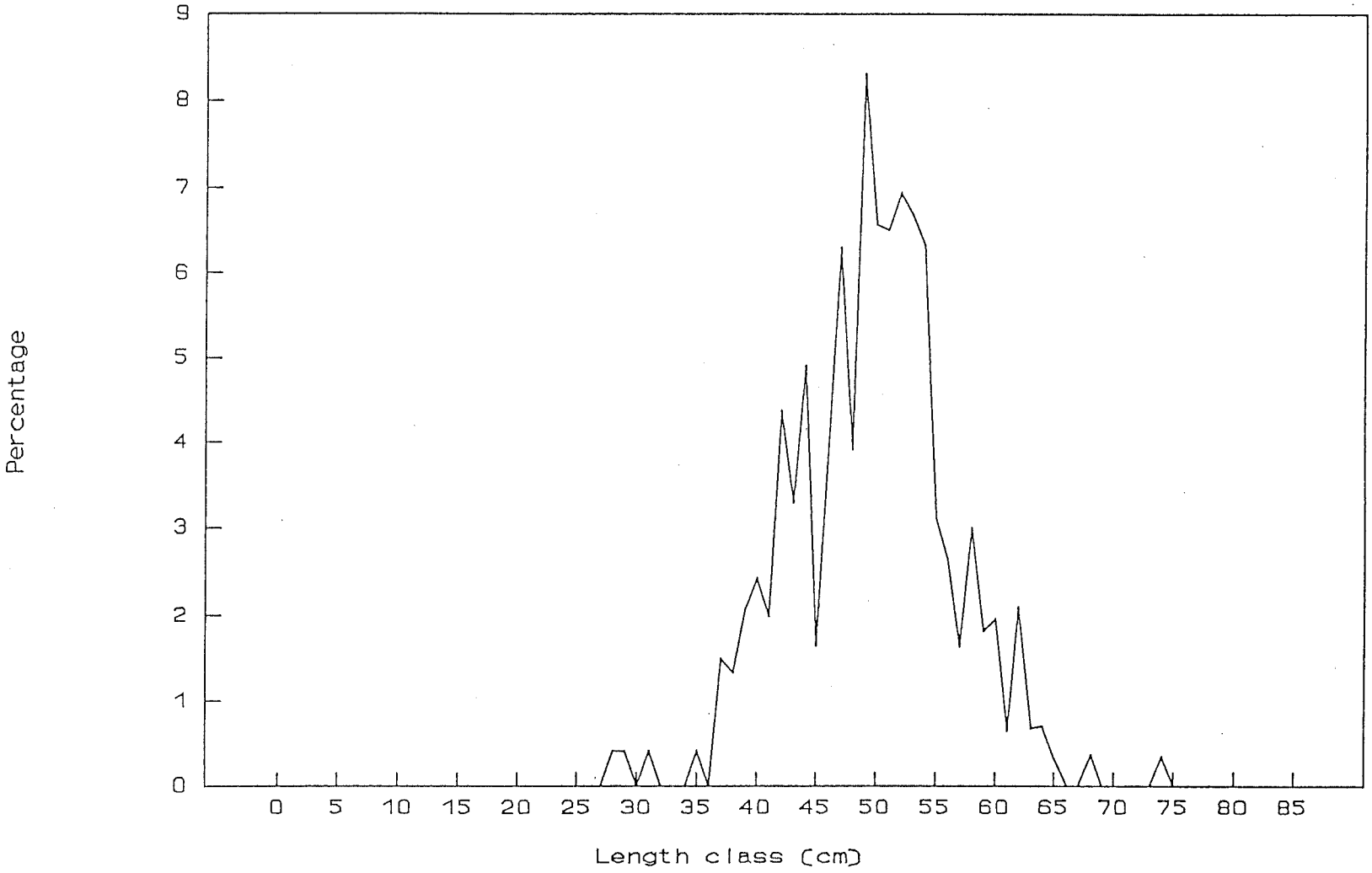

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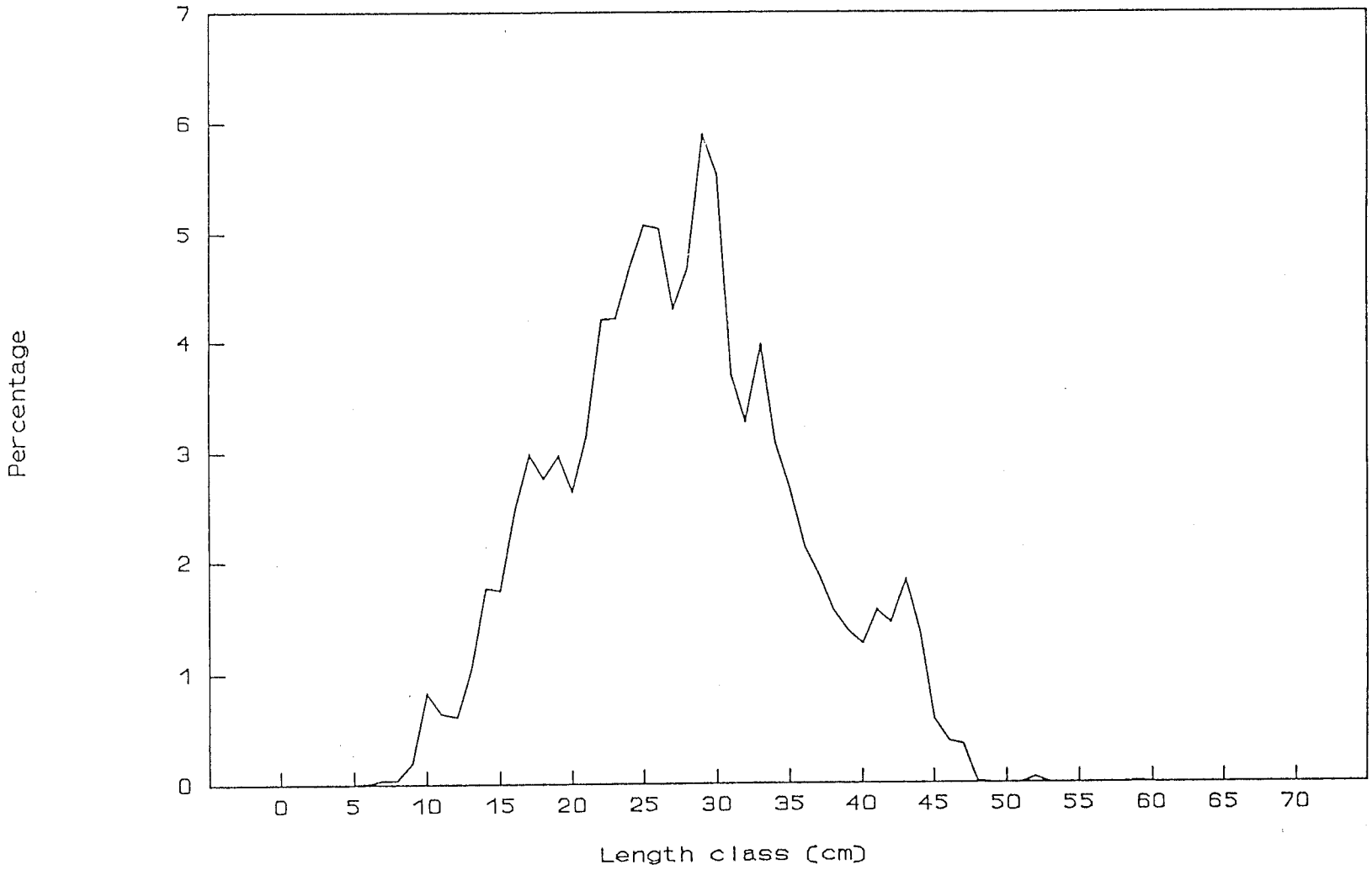

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