SELECTED PAPERS PRESENTED TO THE SCIENTIFIC COMMITTEE OF CCAMLR

1985

COMMUNICATIONS SELECTIONNEES PRESENTEES AU COMITE SCIENTIFIQUE DE LA CCAMLR

1985

ОТОБРАННЫЕ ДОКУМЕНТЫ ПРЕДСТАВЛЕННЫЕ НАУЧНОМУ КОМИТЕТУ АНТКОМ

1985

DOCUMENTOS ESCOGIDOS PRESENTADOS AL COMITE CIENTIFICO DE CCAMLR

1985

Preface

This volume contains the scientific papers presented for consideration of the Scientific Committee at its meeting in 1985. Papers are presented in their original form in the language of submission. Each paper has an abstract translated into all the official languages of CCAMLR. Captions of tables and figures are also translated.

Préface

La plupart des communications présentées au Comité Scientifique pour examen lors de sa réunion de 1985 figurent dans ce volume. Les communications sont présentées sous leur forme originale et dans la langue où elles ont été soumises. Un résumé traduit dans toutes les langues officielles de la CCAMLR est annexé à chaque document. Ont également été traduites les légendes des tableaux et diagrammes.

Введение

Настоящая публикация содержит документы, которые были представлены на рассмотрение Научному комитету на совещании 1985 г. Документы представлены на языке оригинала без перевода их на другие языки. Каждый документ сопровождается резюме, переведенным на все официальные языки АНТКОМ'а. Заголовки таблиц и подписи к рисункам также переведены.

Prefacio

Este volumen contiene los documentos presentados para consideración del Comité Cientifico en su reunión en 1985. Los documentos se presentan en su forma original en el idioma en el cual fueron presentados. Cada documento tiene una sinopsis traducida a todos los idiomas oficiales de CCAMLR También se han traducido los titulos de los cuadros y cifras.

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Abstract

Catch data from a bottom trawl survey in January/February 1985 have been used to estimate stock sizes of the commercially exploited Notothenia rossii, N. guntheri, N. gibberifrons, Dissostichus eleginoides, Champsocephalus gunnari, Chaenocephalus aceratus and Pseudochaenichthys georgianus around South Georgia. Due to the small data base and the scarcity of comparative information the state of N. guntheri and D. eleginoides stocks is difficult to assess. The by-catch species N. gibberifrons, Ch. aceratus and Ps. georgianus have been considerably affected by the fishery. Stock sizes of N. gibberifrons and Ps. georgianus were at a level of about 25 - 40% of that of the pristine state. The stocks most greatly affected by fishing are still N. rossii and C. gunnari. Biomass estimates indicate a reduction in stock size to 10 - 20% of that estimated before the onset of heavy fishing. In C. gunnari the fishery is dependant on the abundance of the recruiting year class. Conservation measures adopted by CCAMLR in 1984 are discussed. Their effect on a recovery of the stocks seems, however, doubtful.

ESTIMATIONS DE LA BIOMASSE DE POISSONS AUTOUR DE LA GEORGIE DU SUD EN JANVIER/FEVRIER 1985

Résumé

Les données de prises à partir d'une étude par chalut de fond en janvier/février 1985 ont servi à évaluer la biomasse, autour de la Géorgie du sud, des espèces suivantes exploitées sur le plan commercial: Notothenia rossii, N. guntheri, N. gibberifrons, Dissostichus eleginoides, Champsocephalus gunnari, Chaenocephalus aceratus et Pseudochaenichthys georgianus. Vu la petite base de données et le peu de renseignements comparatifs, il est difficile d'évaluer l'état des stocks de N. guntheri et D. eleginoides. Les espèces prises accidentellement, N. gibberifons, Ch. aceratus et Ps. georgianus, ont été considérablement affectées par la pêche. Le niveau de la biomasse de N. gibberifrons et Ps. georgianus était d'environ 25-40% du niveau originel. Les stocks les plus sérieusement touchés par la pêche sont encore N. rossii et C. gunnari. Les estimations de biomasse indiquent une réduction de 10-20% du stock évalué avant le début de la pêche intensive. Dans le cas de C. gunnari, l'abondance de la classe d'âge recrutée est primordiale pour la pêche. Les mesures de conservation adoptées par la CCAMLR en 1984 font l'objet d'une discussion. On peut cependant douter de leur effet sur le repeuplement des réserves.

ОЦЕНКА БИОМАССЫ РЫБНЫХ ЗАПАСОВ В РАЙОНЕ О-ВА ЮЖНАЯ ГЕОРГИЯ В ЯНВАРЕ-ФЕВРАЛЕ 1985 г.

Резюме

Данные уловов, полученные путем проведения в январе-феврале 1985 г. съемок донным тралом, использовались для оценки величины запасов Notothenia rossii, N. guntheri, N. gibberifrons, Dissostichus eleginoides, Champsocephalus gunnari, Chaenocephalus aceratus и Pseudochaenichthys georgianus, подвергавшихся коммерческому вылову. Вследствие небольшой базы данных и скудости сведений для сравнения трудно придти к оценке состояния запасов N. guntheri и D. eleginoides. Промысел оказал значительное влияние на запасы видов N. gibberifrons, Ch. aceratus и Ps. georgianus, входящих в состав прилова. Размер запасов N. gibberifrons и Ps. georgianus находятся на уровне около 25-40% первоначальной величины. Запасы N. rossii и C. gunnari продолжают оставаться подверженными влиянию промысла. Оценки биомассы указывают на снижение размера запасов до 10-20% предполагаемой величины до начала интенсивного промысла. Промысел C. gunnari зависит от численности годового класса пополнения. Обсуждаются меры по сохранению, утвержденные АНТКОМ'ом в 1984 г. Их воздействие на восстановление запасов представляется, однако, сомнительным.

CALCULOS DE LA BIOMASA DE LAS RESERVAS DE PECES ALREDEDOR DE GEORGIA DEL SUR EN ENERO/FEBRERO DE 1985

Extracto

Se han utilizado los datos de una inspección de arrastre de fondo en enero/febrero de 1985 para calcular el tamaño de las reservas de las explotaciones comerciales de Notothenia rossii, N. guntheri, N. gibberifrons, Dissostichus eleginoides, Champsocephalus gunnari, Chaenocephalus aceratus y Pseudochaenichthys georgianus alrededor de Georgia del Sur. Debido a que la base de datos es pequeña y la información comparativa es escasa resulta difícil evaluar el estado de N. guntheri y D. eleginoides. Las especies de captura accidental N. gibberifrons, Ch. aceratus y Ps. georgianus han sido afectadas apreciablemente por la pesca. El tamaño

de las reservas de N. gibberifrons y Ps. georgianus estaban a un nivel de aproximadamente un 25-40% del estado original. Las reservas que se encuentran más seriamente afectadas por la pesca siguen siendo N. rossii y C. gunnari. Los cálculos de la biomasa indican una reducción en el tamaño de las reservas de un 10-20% del que se calculaba antes de comenzar la pesca en grandes cantidades. En el caso de C. gunnari la pesquería depende de la abundancia del restablecimiento de la clase-año. Se delibera sobre las medidas de conservación adoptadas por CCAMLR en 1984. Sin embargo, parece ser dudoso el efecto que éstas tengan en la recuperación de las reservas.

1 Introduction

Published information on fish biomass in the Southern Ocean is still very limited. The "swept area" method (SAVILLE, 1977) has become an important tool in assessing Antarctic fish stocks quantitatively both in terms of weight and numbers. The method has its limitations (i.a. CARROTHERS, 1981; KOCK, 1985a) but nevertheless has been shown to provide acceptable results at least for some of the exploited fish stocks around South Georgia and Iles Kerguelen (KOCK, DUHAMEL & HUREAU, 1985).

In this paper catch data from a bottom trawl survey in January/February 1985 have been used to estimate stock sizes of commercially exploited species around South Georgia.

2 Material and methods

Before the survey the area had been stratified into the three depth zones 50 - 150 m, 151 - 250 m and 251 - 500 m based on data in EVERSON (1984). The number of hauls was allotted in proportion of the area of each depth stratum and weighted by the abundance from previous surveys. All sampling stations were chosen randomly but restricted to areas where fishing conditions were known to be moderate or good so as to reduce the chance of damage of the gear.

From 27 January to 10 February 1985 a total of 80 hauls operating the 200' bottom trawl used on previous surveys in the area (STEINBERG, 1978) were carried out by FRV "Walther Herwig" around Shag Rocks (7) and the mainland of South Georgia (73) during daylight hours. The following divisions (according to EVERSON, 1984) have been covered: 54-62, 64, 65, 91-93, 96, 99, 105 (fig. 1) and 89 around Shag Rocks (not shown here). They made up 10 064 nm^2 (= 34 516 km^2) which is 75.7 % of the total area between 50 and 500 m depth (EVERSON, 1984).

The area swept by the net is given by the distance between the tips of the net wings: 23.5 m (= 0.0127 nm) the speed of the vessel (3.5-5.3 kn) and the duration of the haul. Net height was 6 m. Net selection should have been negligible due to the use of a small meshed liner of 20 mm. No data are available to estimate the catchability factor C. A catching efficiency of 100 % (i.e. C=1) had therefore to be adopted as a conservative approach.

3 Results

Evaluations were carried out for the following species: Notothenia guntheri, N. rossii, N. gibberifrons, Dissostichus eleginoides, Champsocephalus gunnari, Chaenocephalus aceratus, Pseudochaenichthys georgianus.

3.1 Notothenia guntheri

Notothenia guntheri , a benthopelagic species, is so far only know from the Shag Rocks area. Evalutions are thus confined to division 89. Length frequency composition (fig. 2) shows that our catches cover a similar length range (9-23 cm) as the Soviet commercial catches (ANON. 1984). Evaluation of mean trawlable biomass is considerably biased by the small number of hauls and the exclusive use of a bottom trawl for the survey. The total biomass of 7256 t is similar or even below the annual catches and for this reason it appears unrealistically low.

3.2 Notothenia rossii

Although the species is known from the entire shelf area the main catches were concentrated to the east and southeast of the island in divisions 61 and 62 (fig. 3, fig. 1) mostly in the 250-500 m depth zone. This stratum was therefore further stratified by the observed fish abundance in estimating the biomass.

Length frequency distribution (fig. 4) indicate that the offshore part of the population was probably adequately covered by the sampling. The bulk of specimens were 45-55 cm long (see KOCK, 1985b). The biomass estimate (table 1) is however considerably biased by the patchy distribution of the species. Even though the variance is very high indicating that the estimated stock size may only be correct to within an order of magnitude it is clear that the stock size is very small and only a small proportion of its unexploited state.

3.3 Notothenia gibberifrons

The species was more or less evenly distributed over the whole shelf area with some larger concentrations in the southeast (fig. 5).The length composition (fig.6) indicates that with the exception of the early juveniles (age class 0 and 1) the entire population had been sampled adequately. In comparison to the latest length frequency (SLOSARCYK et al., 1984) distribution available from 1981/82 the proportion of specimens > 40 cm had slightly increased.

Stock size of 15 762 t (table 1) is obviously still at a low level and was only little more than one third of the 40 000 t estimated for the virgin stock in 1975/76 (KOCK, DUHAMEL & HUREAU, 1984, table 50).

3.4 Champsocephalus gunnari

Except for one haul yielding 1.4 t/30 min catches of C. gunnari were in general less than 100 kg/30 min which indicates an even distribution of the species over the shelf (fig. 7).

The length frequency distribution shows that catches consisted mostly of age classes I (mean length ~ 17 cm) and II (mean length ~ 25 cm) and a minor proportion of age classes III-V. Only single specimens larger than 40 cm was caught (fig. 8).

The biomass estimate was considerably biased by the single haul of 1.4t. Furthermore the benthopelagic mode of life of this species may have led to an underestimate of the actual stock size. Even under these constraints, however, stock size is assumed to be very low in comparison to that of 141 000 t at the onset of large scale commercial fishing in 1975/76 (KOCK,DUHAMEL & HUREAU, 1985).

3.5 Chaenocephalus aceratus

Chaenocephalus aceratus was more or less evenly distributed over the shelf with some larger concentrations in Royal Bay and the station on the eastern shelf where C. gunnari was abundant (fig. 9).

Catches consisted of juveniles from age class I onwards and adults (45 - 60 cm). Individuals larger than 60 cm which were still abundant in 1977/78, were only encountered occasionally (fig. 10).

The biomass estimate of 11 542 t (table 1) is similar to the 10 013 t given by SLOSARCZYK et al. (1984) for 1982/82 and about 62 % of that evaluated for the pristine stock in 1975/76 (KOCK, DUHAMEL & HUREAU, 1985).

3.6 Pseudochaenichthys georgianus

The species was evenly distributed over the shelf forming no concentrations (fig. 11).

Sampling covered mostly older juveniles (30-40 cm) and the adult part of the population. Length composition of the adults shows a distinct peak at 48-49 cm (fig. 12) which is an increase of more than 3 cm in comparison to the latest available length frequency distribution from 1981/82 (SLOSARCZYK et al., 1984).

Evaluated stock size of 8 134 t (table 1) may be an underestimate of the actual stock size as Ps. georgianus exhibits regular vertical migrations. It is nevertheless low (about 25 %) compared to the estimated stock size of 36-39 000 t before the onset of commercial exploitation (KOCK, DUHAMEL & HUREAU, 1985).

3.7 Dissostichus eleginoides

Except for some concentrations observed in the Shag Rocks area D. eleginoides was evenly distributed with catches rarely exceeding 50 kg/30 min. Juveniles of 30-70 cm predominated in the catches (fig. 13). In 1975/76 and 1977/78 catches consisted mostly of individuals of 50-80 cm.

Stock size evaluation was considerably influenced by some catches around Shag Rocks yielding up to 640 kg/30 min. Estimated stock size of 8 159 t may thus be rather inaccurate (table 1). It is in the order of the estimate for 1977/78 (KOCK, DUHAMEL & HUREAU, 1985).

4. Discussion

Due to the small data base and the scarcecity of comparative information from recent years the state of N. guntheri and D.eleginoides stocks is difficult to assess. Our catches of N. guntheri sampled the same length range as given for the Soviet commercial catches. A length composition from February 1979 (NAUMOV et al., 1983) shows the same distinct peak at 15-16 cm as exhibited in fig. 2. The proportion of individuals > 16 cm was, however, considerably larger than in NAUMOV's length frequency distribution. According to Soviet investigations there has been little effect on the stock so far (ANON., 1984), although about 100,000 t had been taken from 1978/79 to 1982/83. In D. eleginoides a considerable decrease in mean length in the catches at the end of the 1970s has been observed compared to 1975/76 - 1977/78 (SLOSARCZYK et al., 1984). A similar trend is evident from our surveys. Due to the low annual catches reported for the species these changes can be hardly attributed to fishing influence. Furthermore it should be noted that it is still not known which proportion of the juvenile part of the population lives actually within the range of the fishery. The Patagonian stock has a vertical range down to 1500 m (KOCK, DUHAMEL & HUREAU, 1985).

Apart from single seasons N. gibberifrons, Ch. aceratus and Ps. georgianus does not appear to have supported a directed fishery. They have nevertheless been considerably affected by the fishery. In Ch. aceratus the proportion of individuals larger than 60 cm, which are exclusively females, has been considerably reduced compared to 1977/78. Mean length in catches of N. gibberifrons and Ps. georgianus in 1981/82 were close to length at sexual maturity after 6 or 7 years of fishing (KOCK, DUHAMEL & HUREAU, 1985). During our survey stock sizes were still at a level of about 25 - 40 % of that of the pristine state in 1975/76. An increase in the proportion of longer (≈ older) individuals in the populations both of N. gibberifrons and Ps. georgianus compared to 1981/82 may, however, indicate a slight improvement of the situation.

The stocks most greatly affected by fishing are still N. rossii (see KOCK, 1985b) and C. gunnari and are in need for conservation measures. Biomass estimate in C. gunnari indicates a reduction in stock size to 10 - 20 % of that estimated for 1975/76. Similar values had, however, been found already at the end of the 1970s in Polish surveys (SLOSARCZYK et al., 1984). Since the period of intensive fishing in 1976/77 when fish older than 5 years (> 35 cm) were still common, recent catches were seen dominated by 3 years old fish (age class II) which is presumably the recruiting year class. Variability in annual catches and CPUE may therefore directly reflect variability in recruitment. The dramatic increase in catches in 1982/83 to 128,000 t can thus partly be explained by the recruitment of one or two abundant year classes. The dependance of the fishery on the abundance of the recruiting year class, however, makes fishing extremely vulnerable to any change in recruitment pattern.

Conservation measures were established by CCAMLR in 1984 which come into force from September 1985. The prohibition of fishing within 12 nm will protect its spawning grounds in nearshore and inshore waters. As far as it is known the spawning grounds have never been fished other than for scientific purposes. No direct effect can thus be expected from that measure.

A minimum mesh size of 80 mm, although its scientific basis (e.g. selectivity experiments) is not known, may increase size at first capture. A more suitable option to rebuild the spawning stock would, however, be to refrain from directed fishing for the species for two years on the premises of a normal recruitment. Minimum mesh size should then be set at 115 mm. Mean selection length ($\hat{=}$ length at first capture, l_c) would then be 32 cm ($\hat{=}$ 3.8 years) (ANON. 1984). This would minimize the risk of recruitment overfishing that may occur at the present state of exploitation and would lead to a more stable situation both in the spawning stock as well as in the fishery. It would furthermore result in a gain in Y/R of about 15 - 20 %.

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Table 1: Mean trawlable biomass (t), standard deviation (s_d) of the mean and mean density D_r around South Georgia in January/February 1985.

	50 - 150 m				151 - 250 m				251 - 500 m				total	
	No. of hauls	Mean trawl. biomass (t)	s_d (%)	D_r (t/nm^2)	No. of hauls	Mean trawl. biomass (t)	s_d (%)	D_r (t/nm^2)	No. of hauls	Mean trawl. biomass (t)	s_d (%)	D_r (t/nm^2)	t	s_d (%)
N. guntheri Shag Rocks	1	5320	-	14.62	5	1902	203	2.66	1	100	-	0.07	7256	47.1
N. rossii	18	177	120.4	0.1	34	4026	101.1	0.97	21	8577	142.1	-	12781	99.9
N. gibberifrons	19	2625	49.6	1.21	39	9900	43.2	2.04	22	3236	33.2	1.07	15762	28.4
C. gunnari	19	999	71.0	0.46	39	13918	117.5	2.88	22	904	66.4	0.30	15821	101.4
Ch. aceratus	19	2904	95.4	1.33	39	6766	57.8	1.39	22	1872	30.5	0.62	11542	40.6
Ps. georgianus	19	1736	47.2	0.80	39	5160	49.9	1.06	22	1238	42.6	0.41	8134	33.0
D. eleginoides	19	1152	204.4	0.53	39	4892	116.9	1.01	22	2115	79.7	0.70	8159	76.5

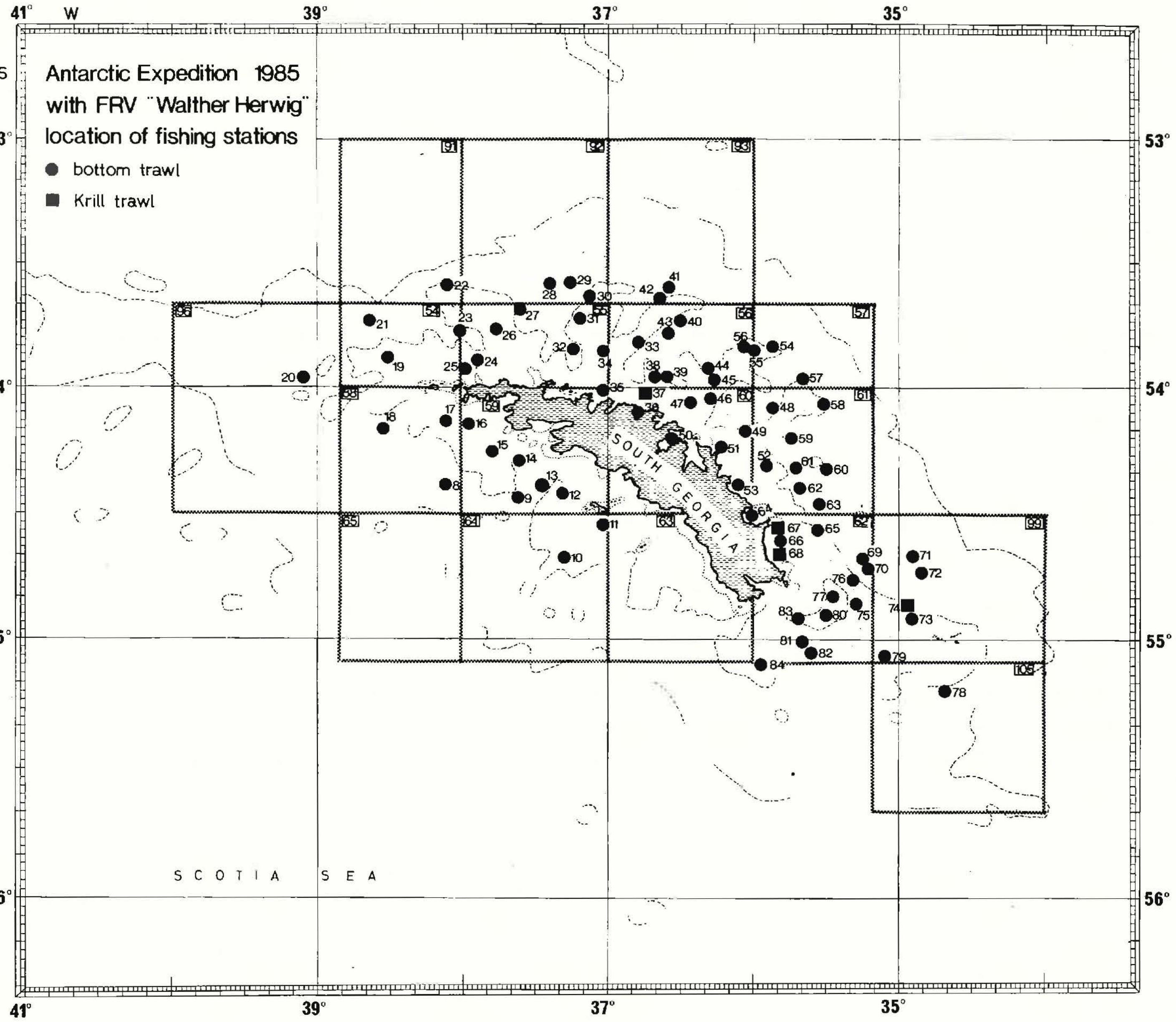
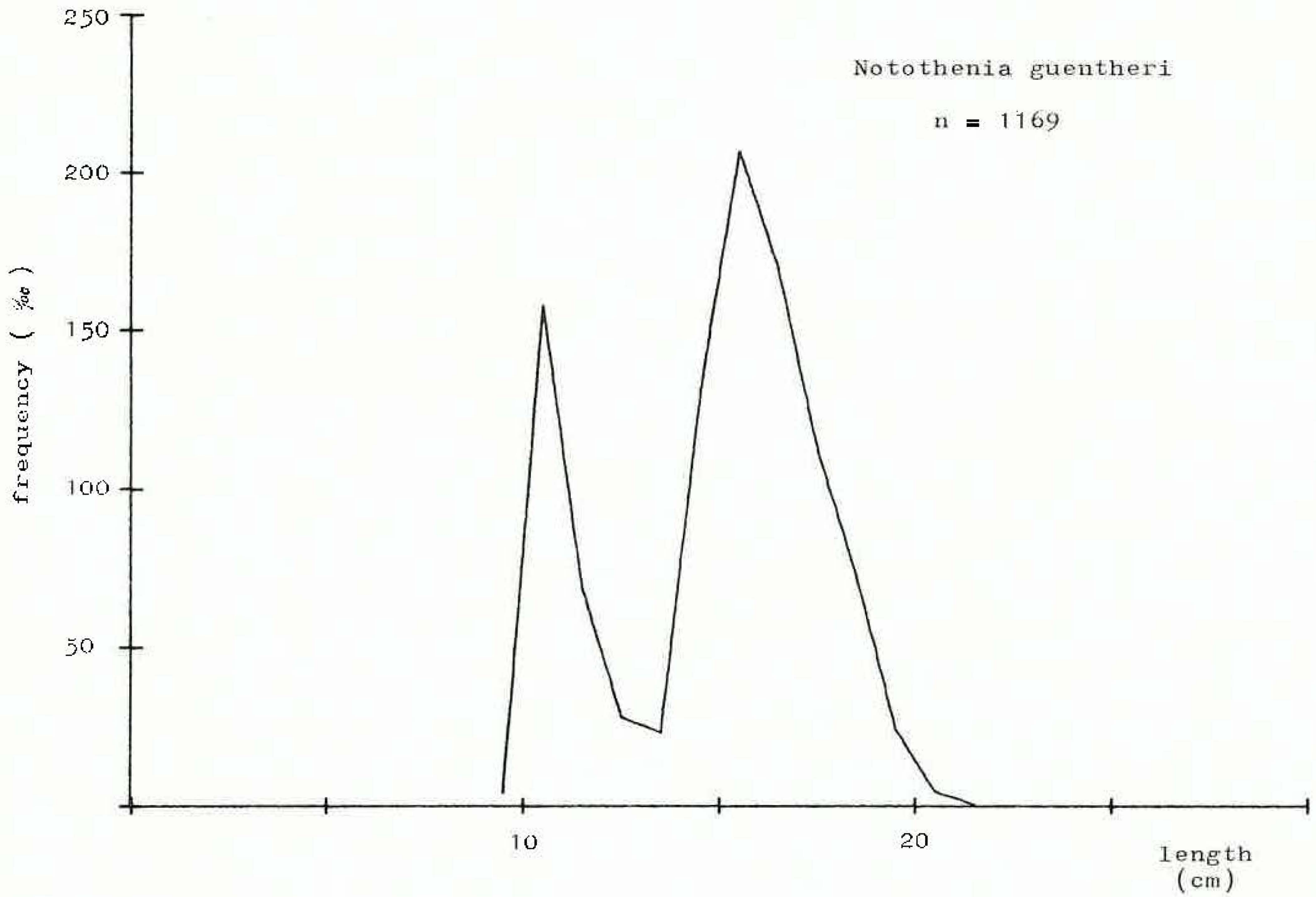


fig. 1: Location of fishing stations



<u>fig. 2</u>: Length frequency distribution of <u>Notothenia guentheri</u> from Shag Rocks

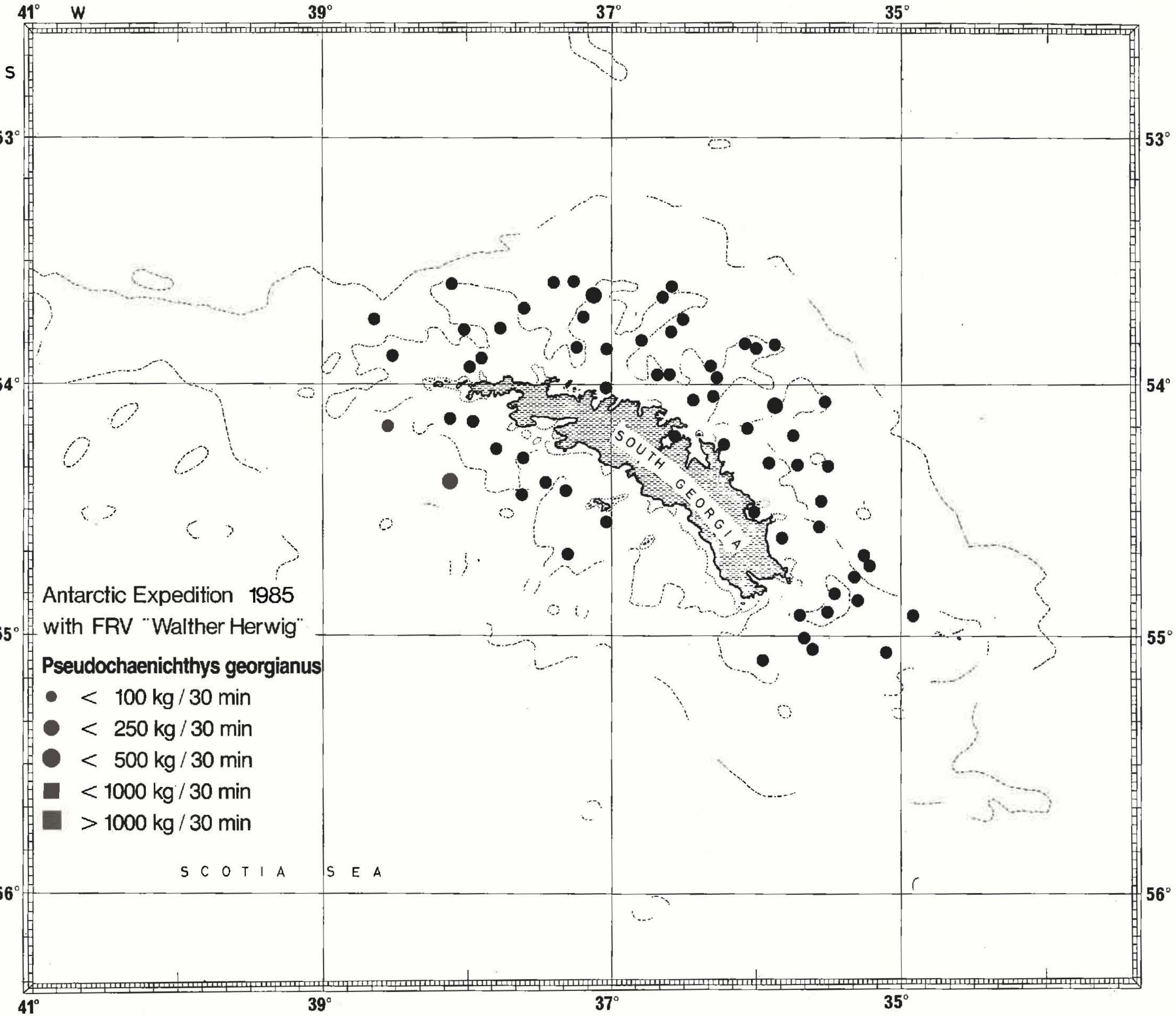


fig. 3: Catches of *Notothenia rossii* around South Georgia

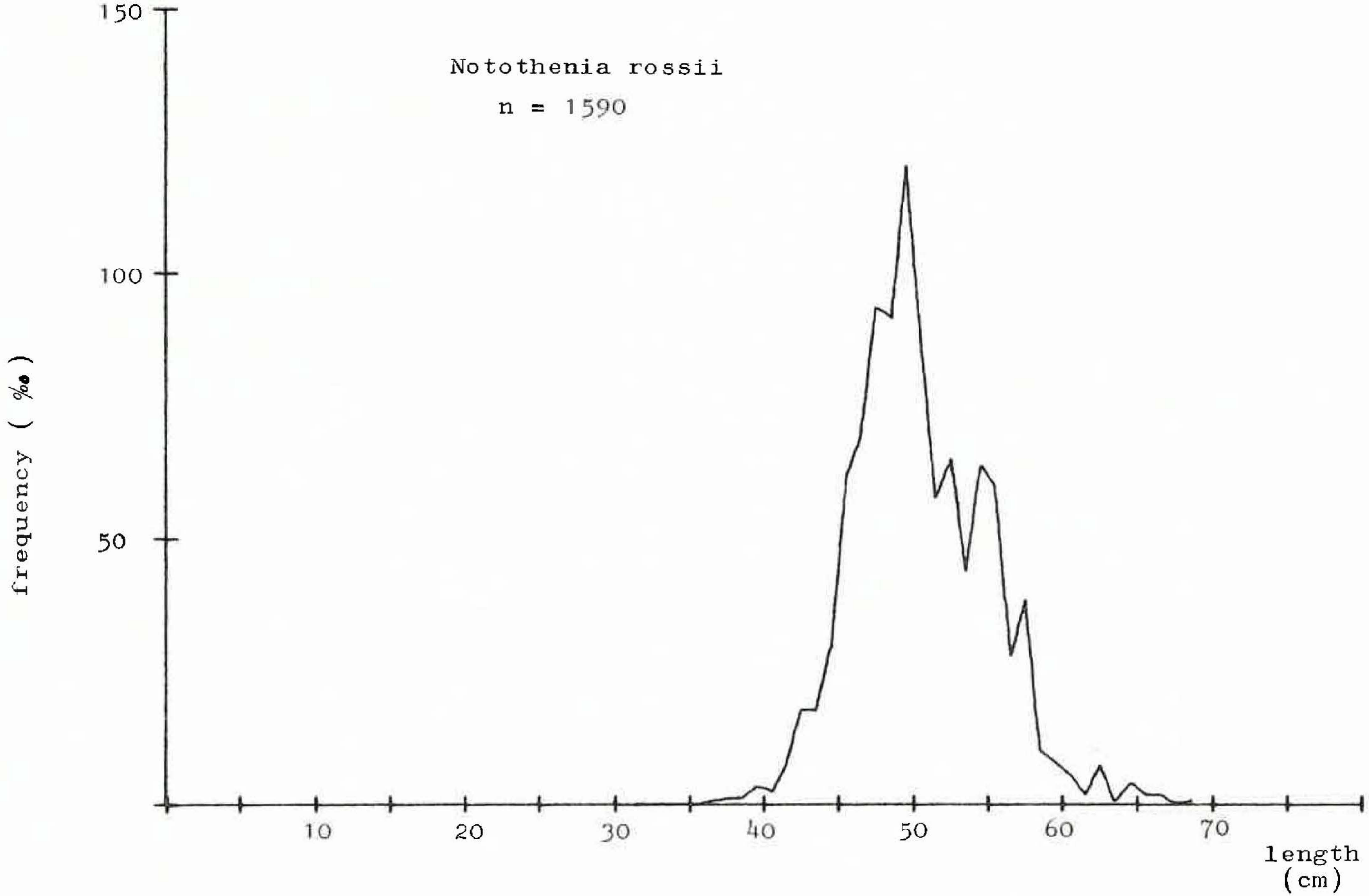


fig. 4: Length frequency distribution of Notothenia rossii from South Georgia

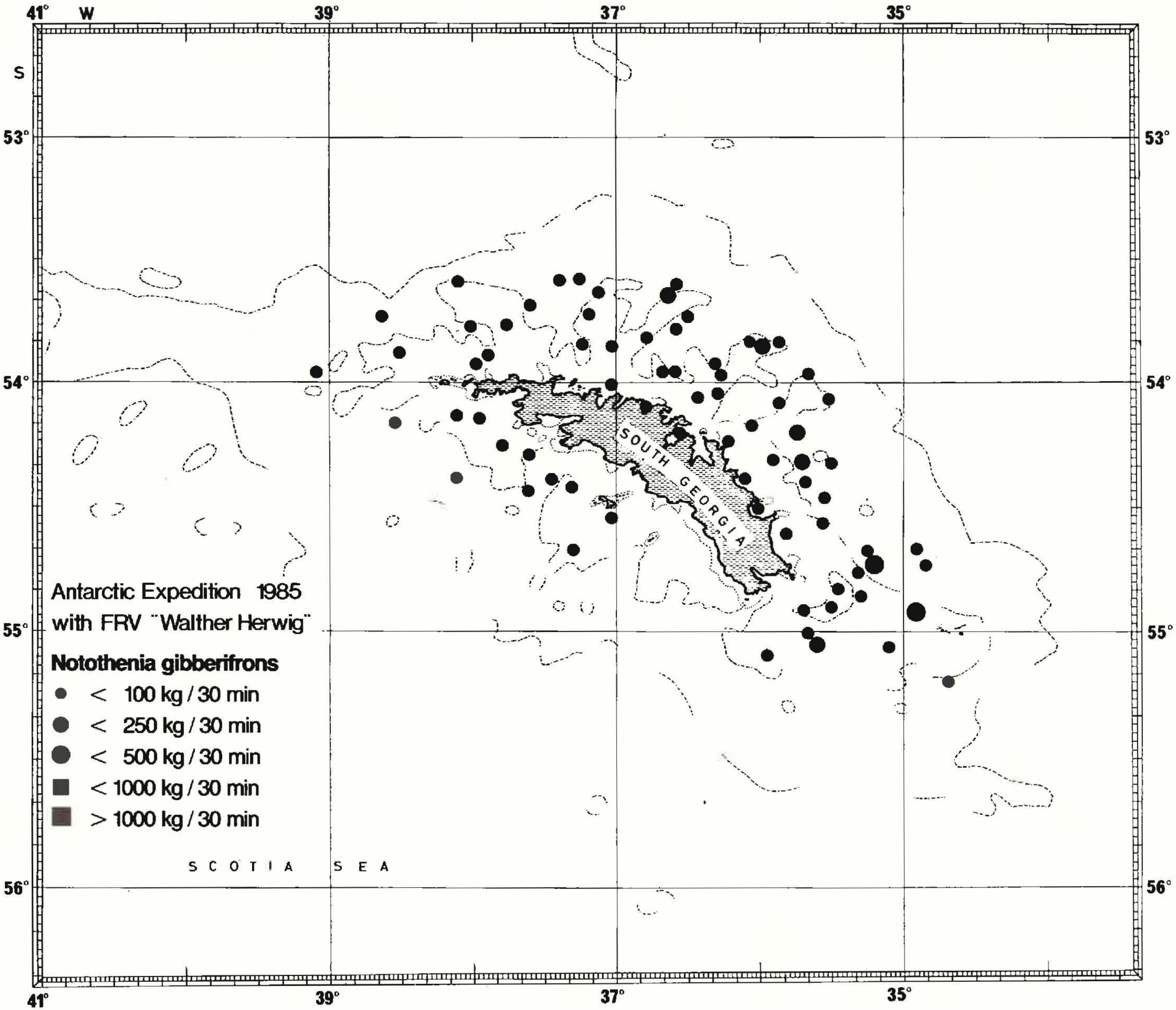


fig. 5: Catches of Notothenia gibberifrons around South Georgia

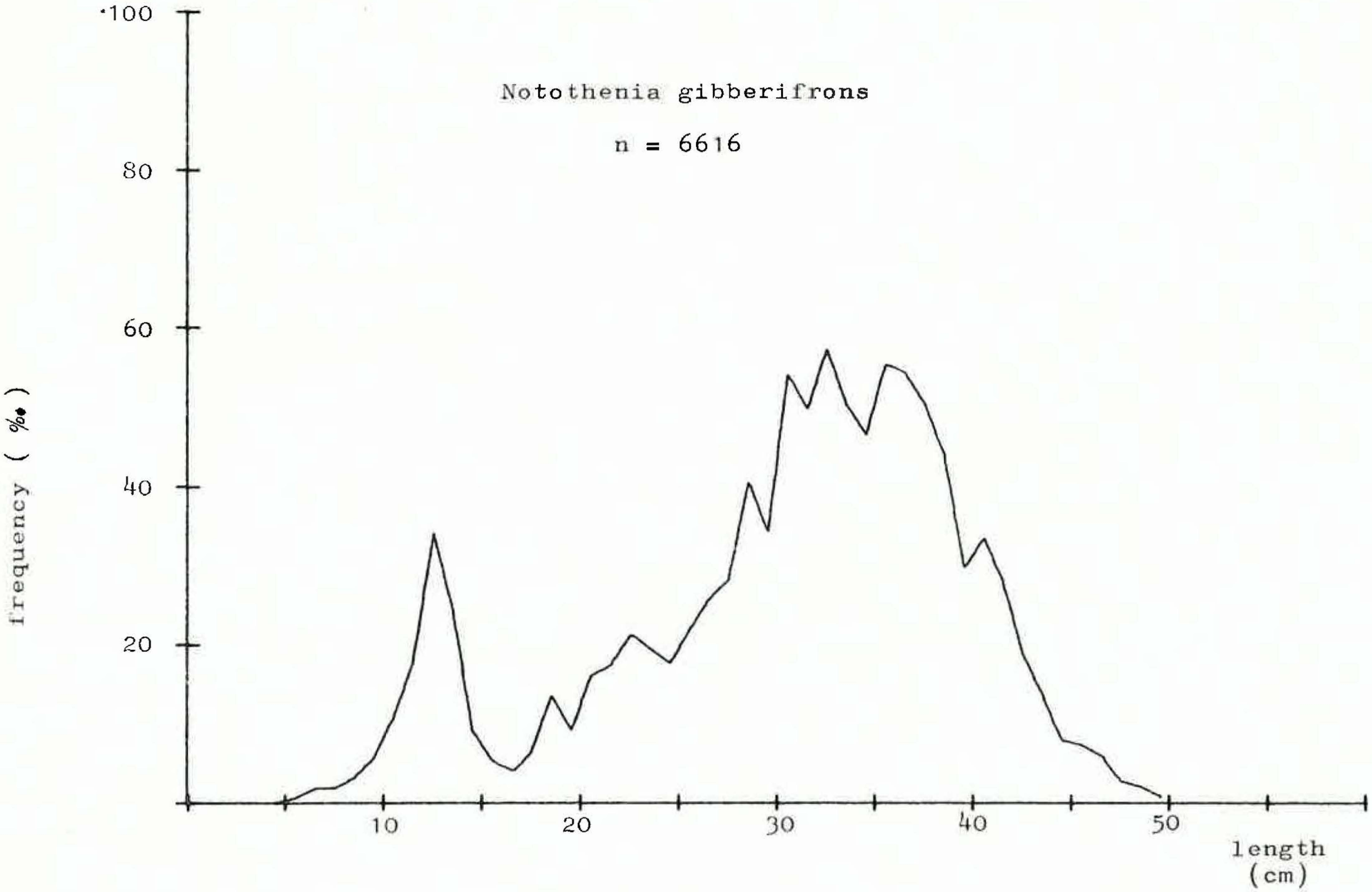


fig. 6: Length frequency distribution of Notothenia gibberifrons from South Georgia

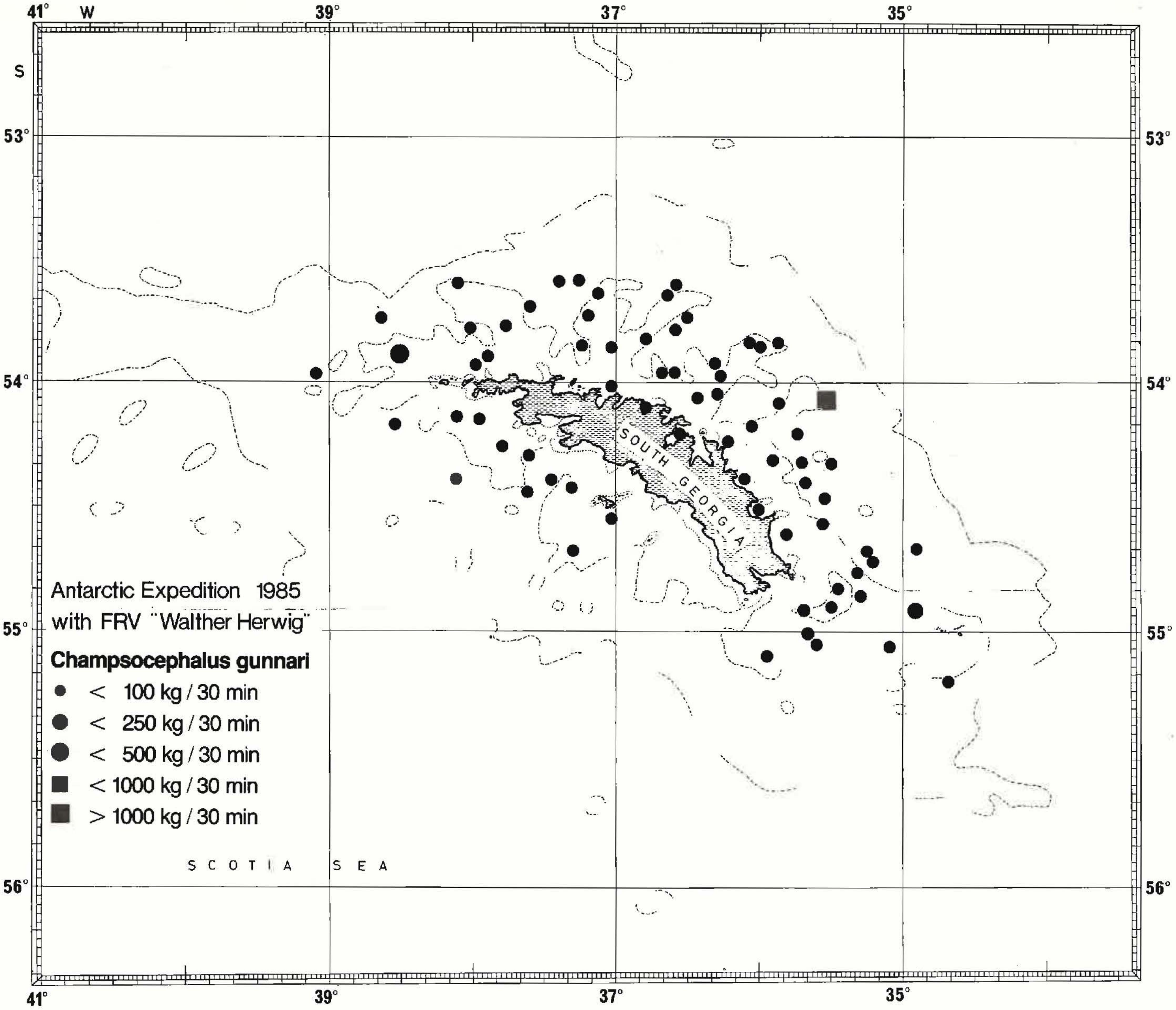
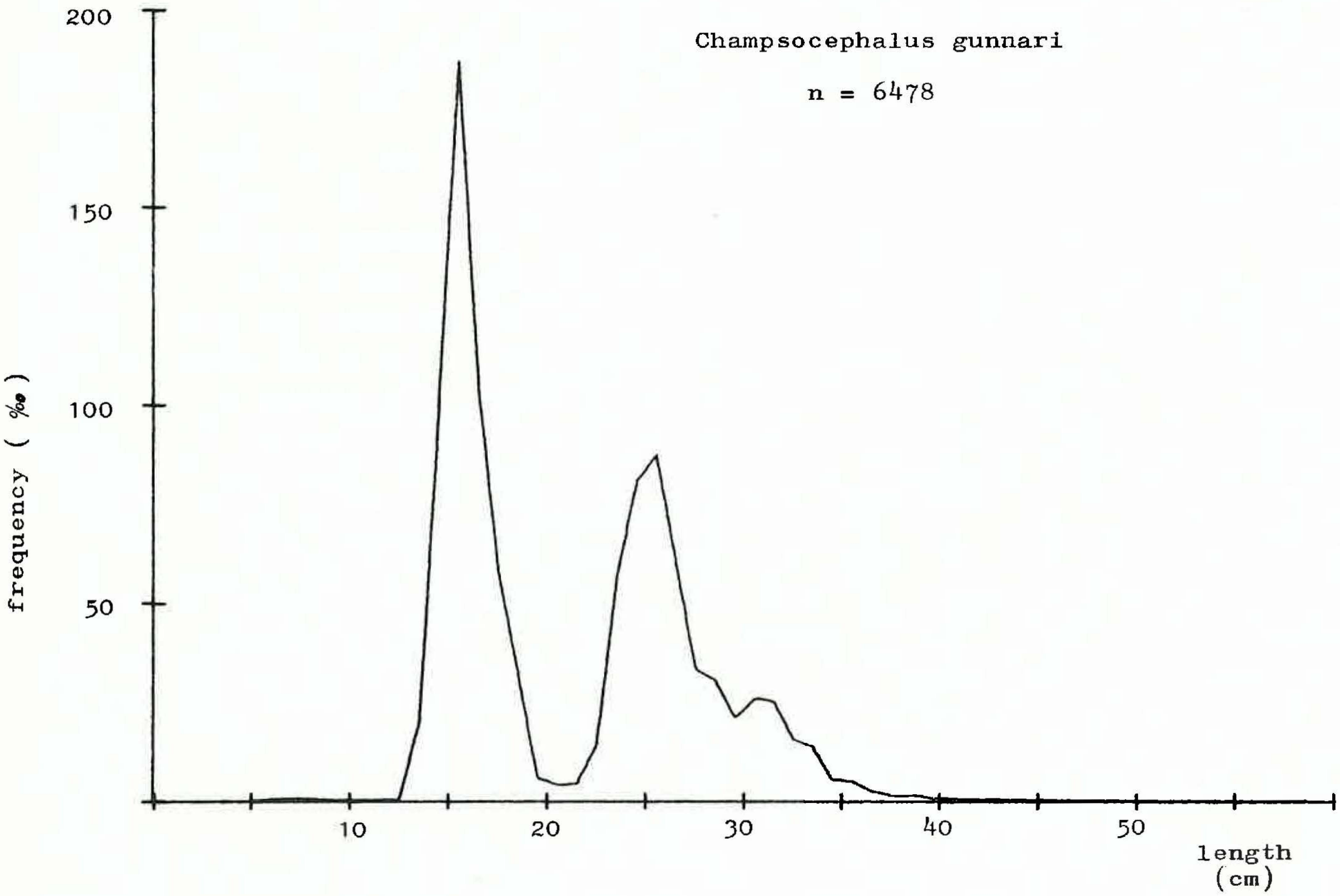


fig. 7: Catches of _Champsocephalus gunnari_ around South Georgia



<u>fig. 8</u>: Length frequency distribution of <u>Champsocephalus gunnari</u> from South Georgia

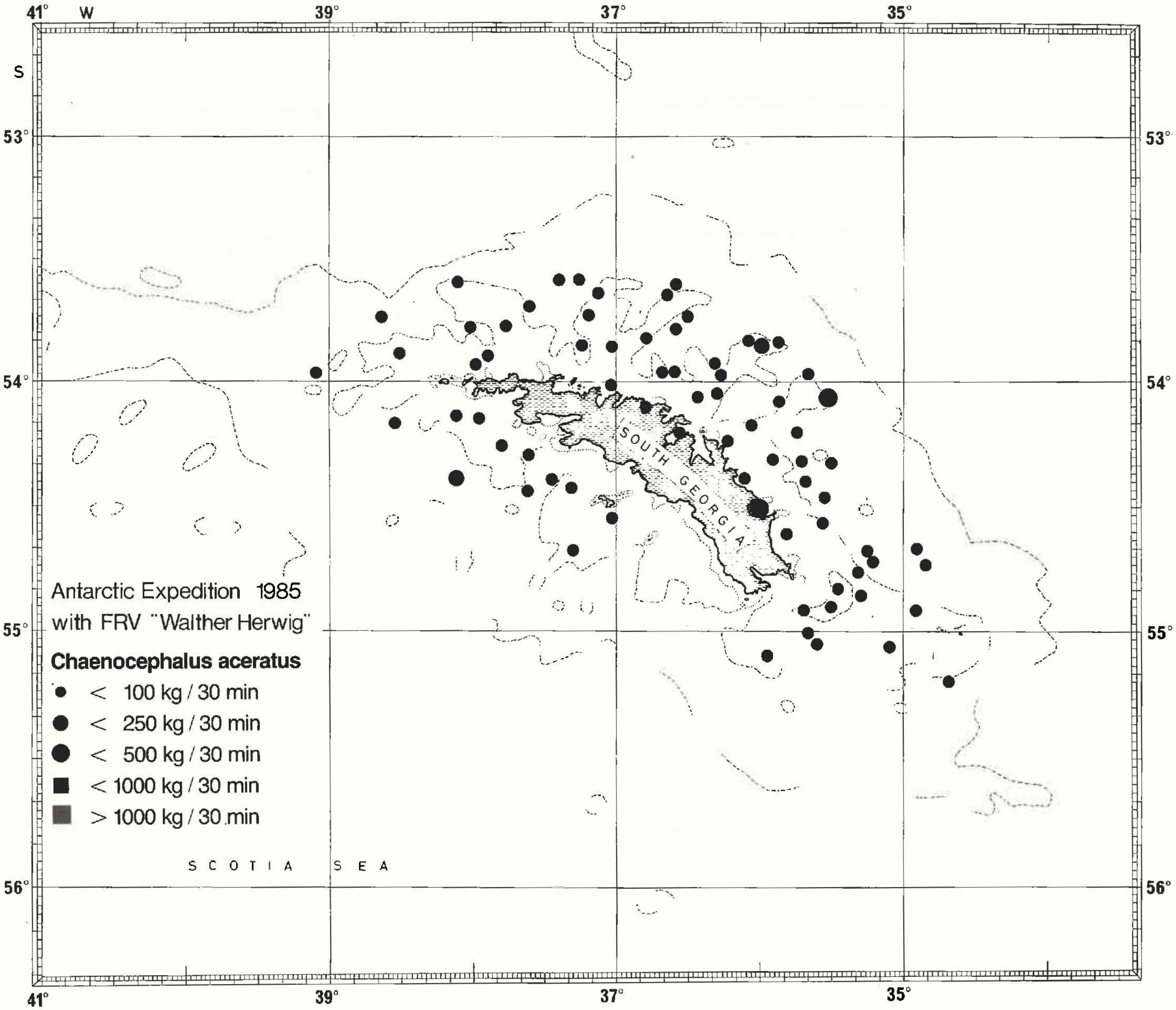


fig. 9: Catches of *Chaenocephalus aceratus* around South Georgia

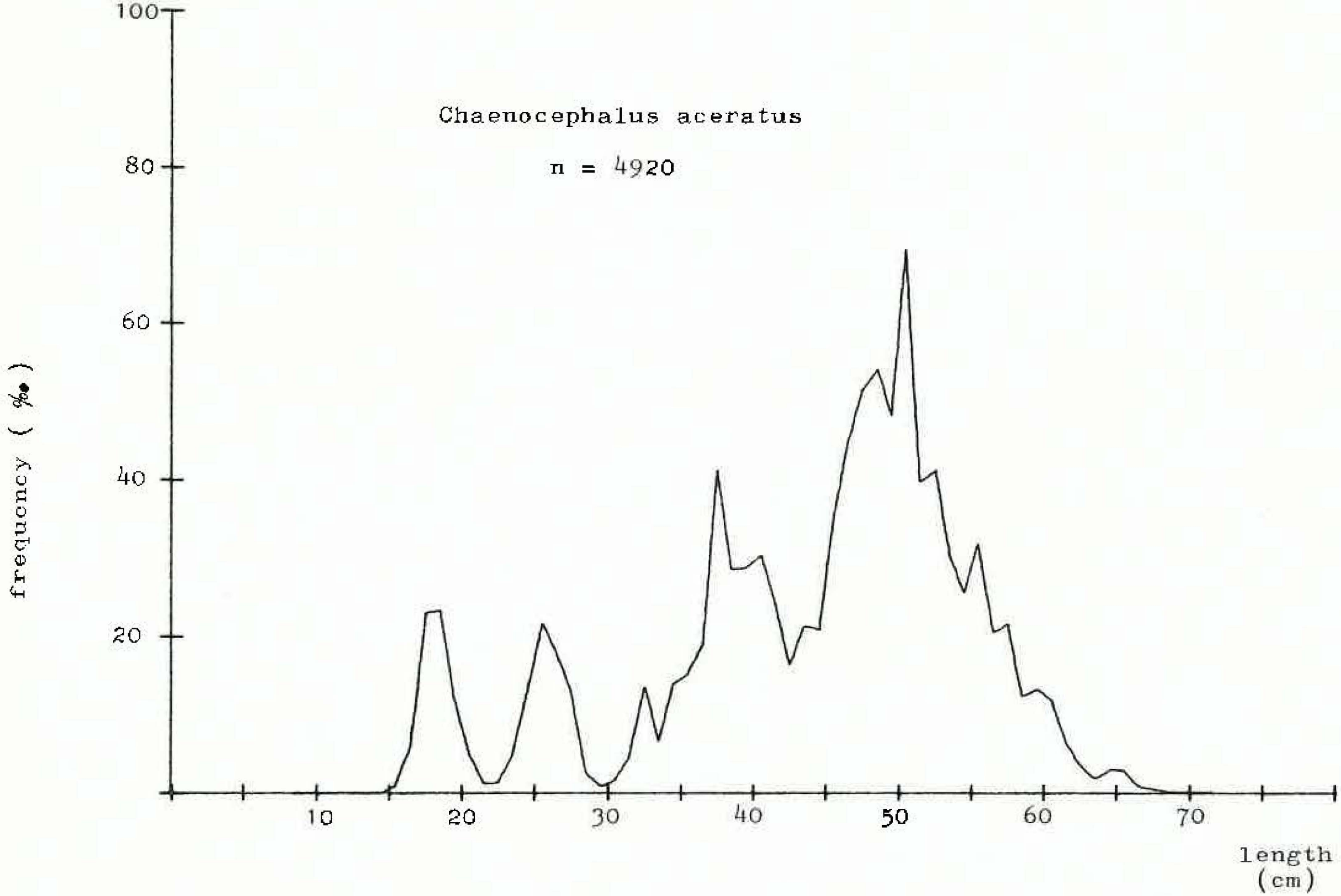


fig. 10: Length frequency distribution of *Chaenocephalus aceratus* from South Georgia

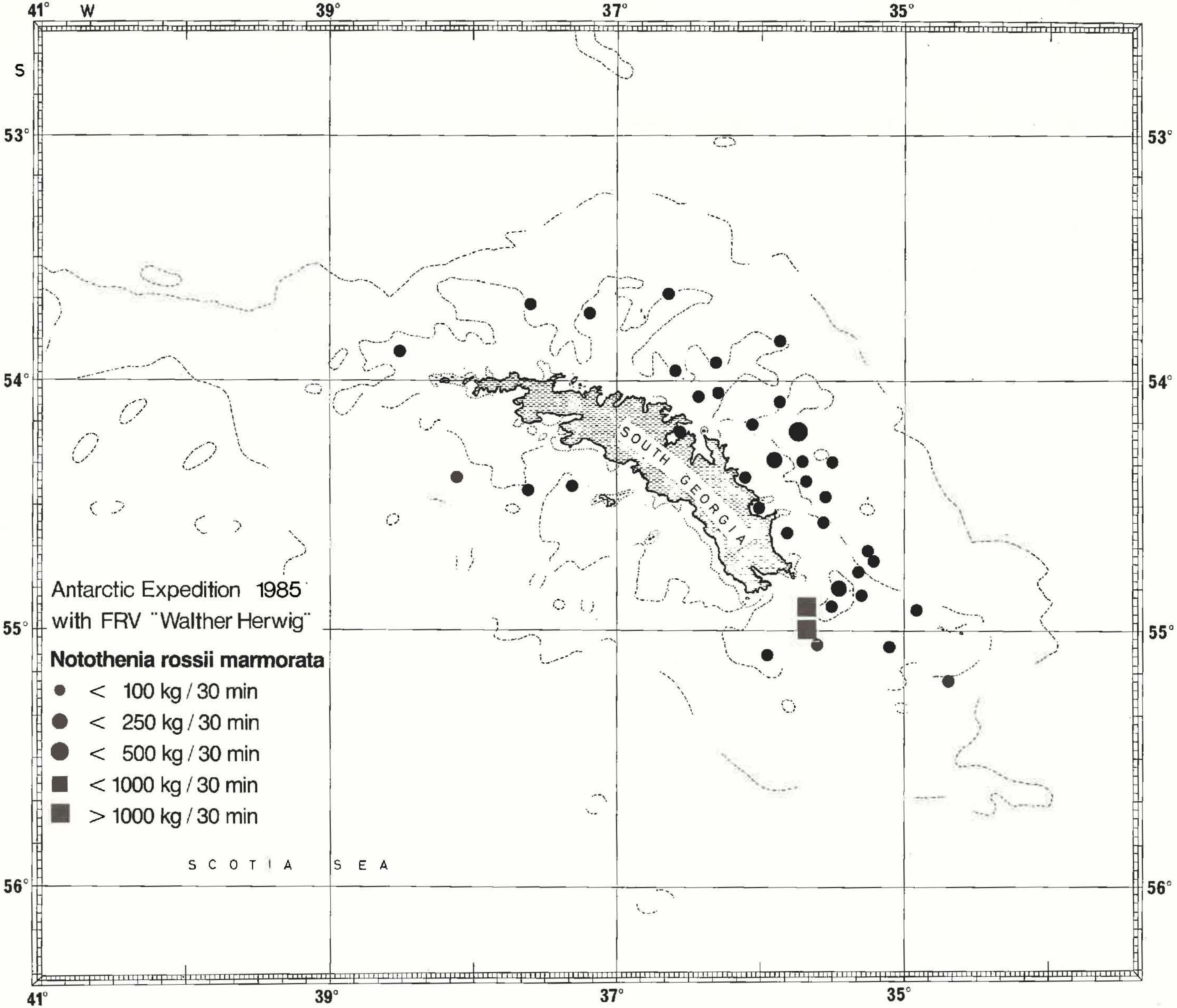


fig. 11: Catches of *Pseudochaenichthys georgianus* around South Georgia

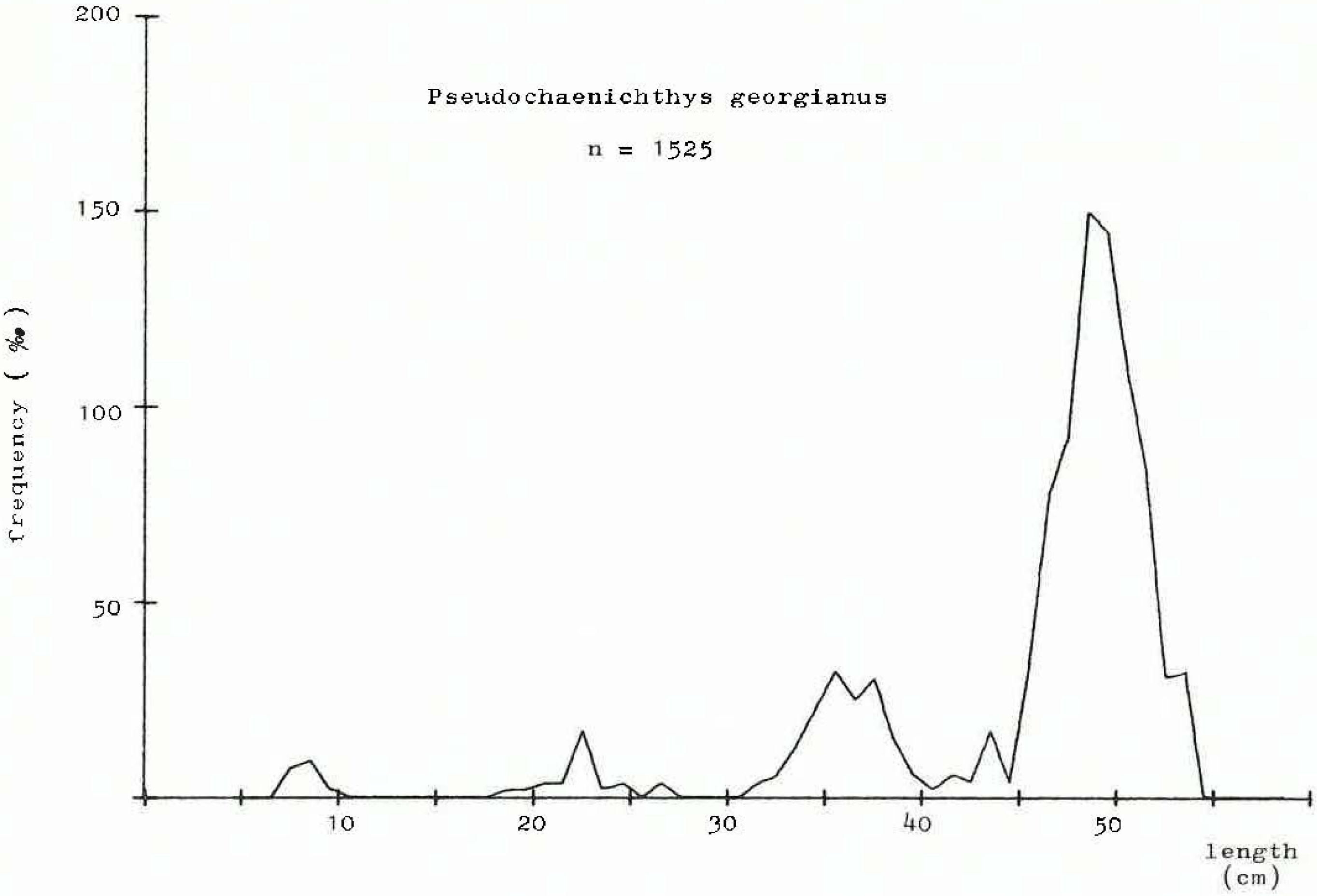
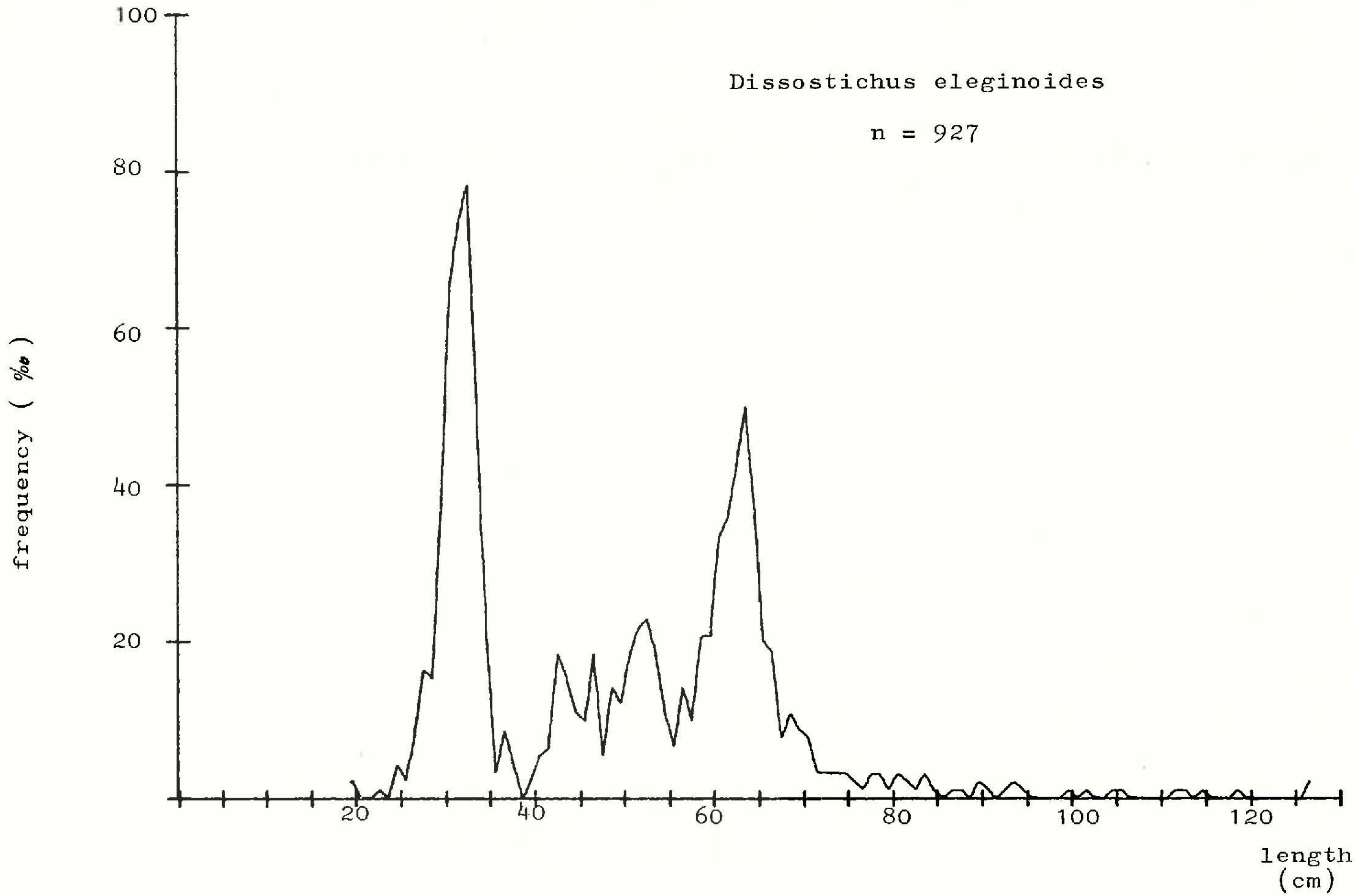


fig. 12: Length frequency distribution of *Pseudochaenichthys georgianus* around South Georgia



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SC-CAMLR-IV/BG/11
1985

PRELIMINARY RESULTS OF INVESTIGATIONS OF THE FEDERAL REPUBLIC OF GERMANY ON NOTOTHENIA ROSSII MARMORATA (FISCHER, 1885) IN JANUARY/FEBRUARY 1985

Abstract

A bottom trawl survey carried out by FRV "Walther Herwig" in January/February 1985 was used to collect further basic data needed for stock assessment purposes, to assess the actual size of Notothenia rossii around South Georgia and Elephant Island and the extent to which the measures adopted by CCAMLR to rebuild the stock around South Georgia might be successful. Although reported catches in recent years have been low, N. rossii around South Georgia is still largely affected by the fishery. Stock size is probably still less than 10% of the pristine stock. Mean length in the catches has only slightly increased since 1981/82 and is still close to length at sexual maturity. The major part of the population consisted of age classes V - VIII. It seems doubtful if the conservation measures adopted in 1984 will really help to rebuild the stock around South Georgia.

RESULTATS PRELIMINAIRES DES ETUDES DE LA REPUBLIQUE FEDERALE D'ALLEMAGNE SUR NOTOTHENIA ROSSII MARMORATA (FISCHER,1885) EN JANVIER/FEVRIER 1985

Résumé

Une étude par chalut de fond menée par le navire de pêche et de recherche "Walther Herwig" en janvier/février 1985 a permis de relever de nouvelles données de base à des fins d'évaluation de stock, pour permettre l'évaluation de la taille de Notothenia rossii autour de la Géorgie du Sud et de l'Ile Eléphant. Le but était aussi d'évaluer le succès éventuel des mesures adoptées par la CCAMLR pour reconstruire le stock autour de la Géorgie du Sud. Bien que les prises déclarées ces dernières années aient été faibles, N. rossii autour de la Géorgie du sud est encore grandement touché par la pêche. Sa biomasse est probablement encore inférieure à 10% du stock originel. La longueur moyenne des prises n'a que légèrement augmenté depuis 1981/82 et est encore proche de la longueur à la maturité sexuelle. La majeure partie de la population comprenait les classes d'âge V - VIII. Il semble peu probable que les mesures de conservation adoptées en 1984 permettront effectivement de reconstruire le stock autour de la Géorgie du Sud.

ПРЕДВАРИТЕЛЬНЫЕ РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ NOTOTHENIA ROSSII MARMORATA (Фишер, 1885), ПРОВОДИВШЕГОСЯ В ЯНВАРЕ-ФЕВРАЛЕ 1985 г. ФЕДЕРАТИВНОЙ РЕСПУБЛИКОЙ ГЕРМАНИИ

Резюме

Проводившаяся в январе-феврале 1985 г. с НИС "Вальтер Хервиг" съемка донным тралом использовалась для сбора дополнительных основных данных, требуемых в целях оценки запасов, чтобы определить фактический размер запаса Notothenia rossii в районе о-вов Южная Георгия и Элефант, а также степень успешности мер, утвержденных АНТКОМ'ом с целью восполнения запаса в районе Южной Георгии. Хотя полученные за последние годы данные говорят о низком вылове, промысел все же в большой мере оказывает влияние на запас N. rossii в районе Южной Георгии. Вероятный размер запаса все еще меньше 10% первоначальной величины. Средняя длина особей в уловах с 1981/82 г. увеличилась только очень незначительно и все еще близка к длине при половозрелости. Основная часть популяции состоит из годовых классов V-VIII. Представляется сомнительным, чтобы меры по сохранению, утвержденные в 1984 г., действительно помогли восстановить запас в районе о-ва Южная Георгия.

RESULTADOS PRELIMINARES DE LAS INVESTIGACIONES DE LA REPUBLICA FEDERAL DE ALEMANIA SOBRE NOTOTHENIA ROSSII MARMORATA (FISCHER, 1885) EN ENERO/FEBRERO DE 1985

Extracto

Se utilizó una inspección de arrastre de fondo efectuada por el FRV "Walther Herwig" en enero/febrero de 1985 para recolectar más datos básicos necesarios para fines de evaluación de reservas, para poder evaluar el tamaño mismo de Notothenia rossii alrededor de Georgia del Sur y de la Isla Elefante y para evaluar hasta que punto podrían tener éxito las medidas aprobadas por CCAMLR para restablecer las reservas alrededor de Georgia del Sur. A pesar de que los informes de las capturas en los últimos años las indican bajas, N. rossii alrededor de Georgia del Sur, sigue siendo afectada en gran parte por la pesca. El tamaño de la reserva probablemente sigue siendo menos del 10% de la reserva original. El largo

medio en las capturas sólo ha aumentado levemente desde 1981/82 y sigue aproximándose a la talla de madurez sexual. La mayor parte de la población consistía de clases de edad V-VIII. Parece dudoso que las medidas de conservación aprobadas en 1984 ayuden realmente a reconstruir la reserva alrededor de Georgia del Sur.

1. Introduction

The Westantarctic subspecies of the marbled notothenia, Notothenia rossii, marmorata, is present around the islands of the Scotia arc (FREYTAG, 1980). Before the onset of large scale commercial exploitation at the end of the 1960s the species was probably one of the most abundant (if not the most abundant) fish species around South Georgia: large near surface concentrations had already been noted by sealers in the early 19th (FANNING, 1833) and whalers in the early 20th centuries (LÖNNBERG, 1906). Dense concentrations occurring regularly off Elephant Island had been reported in the course of the Antarctic Expedition 1975/76 of the Federal Republic of Germany (KOCK, 1978). They were probably commercially fished there in 1979/80 for the first time. Stock sizes around the South Orkney Islands and South Sandwich Islands are obviously much smaller. Concentrations were only reported from the shelf east of Laurie Island in 300 - 400 m depth (ANON, 1984).

Preliminary stock assessments (BIOMASS, 1980; KOCK, DUHAMEL & HUREAU, 1985) based on rather incomplete material up to 1981/82 show that the populations around South Georgia and off Elephant Island have been greatly affected by the fishery and have obviously been reduced to a small fraction of their original sizes.

In September 1984 during its annual meeting CCAMLR established the following measures to help rebuild the spawning stocks around South Georgia principally Notothenia rossii:

- Prohibition of fishing other than for scientific purposes in waters within 12 nautical miles of South Georgia.
- Minimum mesh sizes of 120 mm for directed fishing on Notothenia rossii.

A prohibition of any directed fishing on N. rossii for a number of years, however, which would have been the most suitable option to restore the spawning stock, was not accepted. Fishing vessels are only requested to refrain from directed fishing for the species and to avoid its by-catch in directed fishing for other species in the 1984/85 season.

A bottom trawl survey carried out by FRV "Walther Herwig" in the Scotia arc region in late January/February 1985 gave us the opportunity to collect further basic data needed for stock assessment purposes, to assess the actual state of the stocks around South Georgia and Elephant Island and to indicate the extent to which the measures adopted by CCAMLR to rebuild the stock around South Georgia might be successful. As part of the material collected off Elephant Island is still under investigation this paper deals mainly with the South Georgia stock.

2. Material and methods

Before the survey the area had been stratified into the three depth zones 50 - 150 m, 151 - 250 m and 251 - 500 m based on data in EVERSON (1984). The number of hauls was allotted in proportion of the area of each depth stratum and weighted by the abundance from previous surveys.

Material was collected from 73 hauls around South Georgia (29 January - 10 February) and 37 hauls off Elephant Island (21 - 28 February) using a 200' bottom trawl with a small meshed liner of 20 mm (figs. 1,2).

Total length of the specimens was measured to the nearest cm below, total weight to the nearest 50 g below. Maturity stages were determined according to EVERSON's (1977) five point-scale. Age determination was carried out by means of scales following methods and results of FREYTAG (1980). Fish stock biomass was estimated by the "swept area" method (see KOCK, 1985).

For estimating size at sexual maturity fish have been grouped in 2 cm groups Total length and age versus proportion mature for each sex (L_{50}, A_{50}) seem to conform the logistic equation

$$p = \frac{1}{1 + e^{-(a+bL)}}$$

where
- p = estimated proportion of mature fish
- L = total length
- a = coefficient
- b = coefficient for the steepness of the logistic curve
- (Ni & Sandeman , 1984)

3. Results

3.1 The catches

Around South Georgia catches were mainly confined to the east and southeast of the island where yields varied between 2 and 5100 kg/30 min. The best catches were taken south off Cooper Island (Stations 81, 83) with 1.4 and 5.1 t. In other parts of the shelf only single specimens were caught (fig. 3).

Off Elephant Island N. rossii concentrated west and north of the island where catches from 1 to 1736 kg/30 min could be obtained. Only single specimens were found in other parts of the shelf.

3.2 Biomass estimate

The biomass estimate (table 1) is considerably influenced by the patchy distribution of the species in relation to the small number of hauls, although it has been tried to reduce the variance by restratification of the surveyed area according to the observed differences in abundance (KOCK, 1985a). Even if the estimated stock size might not be very accurate it may indicate the order of magnitude. It can thus be concluded that the biomass of the offshore part of the population is still very low and only a small fraction of the estimated pristine stock size of about 500,000 t (EVERSON, 1977). Evaluation of the stock size off Elephant Island has not been carried out yet.

3.3 Length composition

Around South Georgia length varied from 34 to 73 cm. The bulk of specimens measured 45 - 55 cm (fig. 4). Mean length was 49.9 cm (males: 50.2 cm, females: 51.2 cm).

The length frequency distribution off Elephant Island differed considerably from that of South Georgia: individuals of 40 - 50 cm predominated (fig. 4). Minimum length was 34 cm. No specimen larger than 58 cm had been observed. Mean length was 44.7 cm (males: 44.1 cm, females: 45.3 cm).

3.4 Length - weight relationship

Evaluation of the length - total weight relationship $W_t = a L^b$ was based on the entire length range sampled but the length range of 45 - 55 cm predominated (fig. 5). The equation

$$W = 0.014752 * L^{2.9886}$$
$$(n = 429, r = 0.96)$$

falls, however, within anticipated limits from other equations (KOCK, DUHAMEL & HUREAU, 1985, tab. 3).

3.5 Age composition

Results of age determination were similar to those of FREYTAG (1980) and BURCHETT (1983) (see KOCK, DUHAMEL & HUREAU, 1985, tab. 14). Mean length at age and mean weight at age is set out in table 2. Age classes IV - XIII were present in the stock. Age groups V - VIII, however, predominated (table3). Due to the lack of data from age classes 0 - III (IV) and those older than IX, data were not fitted to a growth curve.

3.6 Length and age at sexual maturity (L_{50},A_{50})

Lengths at sexual maturity for South Georgia and Elephant Island and age at sexual maturity for South Georgia are set out in table 4.

Data base for the estimation of L_{50} for males from South Georgia and females from Elephant Island was small (fig. 6-8). Values in table 4 are approximations and thus given a brackets. Length at sexual maturity in our material was smaller than that estimated by SCHERBICH (1976) in the first years of commercial exploitation. Our data are close to those reported by DUHAMEL (1982) for the Kerguelen subspecies Notothenia rossii rossii.

Maturity in males is reached at a smaller size and about one year earlier than in females.

3.7 Recruitment to the offshore stock

The largest specimens in the inshore (= fjord) stock observed by BURCHETT (1983) were about 44 cm long, the bulk, however, measured less than 40 cm. Recruitment to the offshore part of the population starts at about 35 cm although few individuals less than 40 cm are caught (fig. 4). Due to the lack of quantitative information on recruitment from both parts of the population in the 84/85 season l_r = 40 cm may be taken as reasonable approximation for further analyses. Most of the specimens are then about 5 years old (table 3). Age class VI seems to be the first fully (more than 95 %) recruited age class. Age at recruitment t_r may thus be in the order of about 5 years.

4. Discussion

From our results it is obvious that N. rossii around South Georgia is still largely affected by the fishery although reported catches in recent years (1980/81 - 1982/83) have been low (KOCK, DUHAMEL & HUREAU, 1985, table 30):

a. Stock size is probably still less than 10 % of the pristine stock estimated by EVERSON (1977)

b. Mean length in the catches has only slightly increased (by about 2 cm) since 1981/82 and is still close to length at sexual maturity

c. As in 1981/82 the major part of the population consisted of age classes V - VIII (on the premises that age determinations by SLOSARCZYK et al., 1984 and ours are comparable). This may indicate that the stock has changed little within a 3 years period even under low fishing pressure

d. It is not know if the decrease in length at sexual maturity might be a response of the species to the heavy depletion of the stock or if it might be merely an artefact in the determination of maturity stages by different authors or from the different amount of material investigated.

It seems doubtful if the conservation measures set in force by CCAMLR from September 1985 onwards will really help to rebuild the stock of N. rossii.

Feeding grounds and spawning grounds, as far as they are known are mostly located outside 12 nautical miles of the island, so little effect can be expected from that measure. An increase of minimum mesh size to 120 mm may increase size at first capture. The 50 % retention length of 160 mm mesh size, however, is probably in the order of 43 - 46 cm (see ANON., 1984, p. 30). It can thus be assumed that a codend of 120 mm will still retain nearly all specimens sampled by the net.

It is obvious that the best option to restore the stock of N. rossii around South Georgia would be to stop any directed fishing on the species for a number of years. An alternative approach might be to close certain areas for the fishery, where it is known that N. rossii concentrate. One of these areas might be the region south and southeast of Cooper Island where we observed concentrations during all our surveys in 1975/76, 1977/78 and 1984/85.

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Table 1: Mean trawlable biomass (t), standard deviation (s_d) of the mean and mean density D_r of *Notothenia rossii* around South Georgia in January/February 1985

50 - 150 m				151 - 250 m				251 - 500 m				total	
No. of hauls	Mean trawl. biomass (t)	s_d (%)	D_r (t/nm^2)	No. of hauls	Mean trawl. biomass (t)	s_d (%)	D_r (t/nm^2)	No. of hauls	Mean trawl. biomass (t)	s_d (%)	D_r (t/nm^2)	Mean trawl. biomass (t)	s_d (%)
18	177	120.4	0.1	34	4026	101.1	0.97	21	8577	142.1	-	12781	99.9

Table 2: Mean length (cm) and weight (g) of *Notothenia rossii* from South Georgia in January/February 1985

age class	n	mean length (cm)	mean weight (g) (1)	(2)
4	6	39.8	900	892
5	56	44.4	1236	1237
6	112	47.3	1503	1494
7	97	51.6	1950	1938
8	58	55.4	2432	2396
9	25	58.5	2758	2820
10	7	62.5	3514	3436
11	3	66.2	3916	4080
12	4	66.0	4450	4043
13	1	73.5	5800	5577

(1) direct measurement

(2) from length - weight - relationship $W = 0.014752 \cdot L^{2.9886}$

Table 3: Age - Length - Key of <u>Notothenia rossii</u> from South Georgia

January/ February 1985

Length	age class										
(cm)	4	5	6	7	8	9	10	11	12	13	Σ
34	1										1
35											
36											
37											
38		1	1								2
39	2	2									4
40	1	2									3
41		3									3
42	2	6									8
43		11	6								17
44		7	4								11
45		7	13								20
46		10	21	2							33
47		6	27	5							38
48		1	21	6							28
49			11	6							17
50			6	22							28
51			2	16	4						22
52				13	3						16
53				13	8						21
54				5	5						10
55				5	14	2					21
56				3	12	3					18
57				1	9	5					15
58					2	6					8
59						5					5
60					1	2	3				6
61											
62						2	2				4
63											
64							1	1			2
65								1	2		3
66							1		2		3
67											
68								1			1
69											
70											
71											
72											
73										1	1

Table 4: Length and age at sexual maturity (L_{50}, A_{50}) in *Notothenia rossii*

	South Georgia (KOCK, this paper)	South Georgia (SCHERBICH, 1976)	Elephant Is. (KOCK, this paper)	Kerguelen DUHAMEL, 1982)
L_{50} (cm) ♂	(42.2)	49.1	42.2	43.0
♀	46.9	51.0	(49.0)	48.5
A_{50} (years) ♂	(4.8)	-	-	5.5
♀	6.3	-	-	6.5

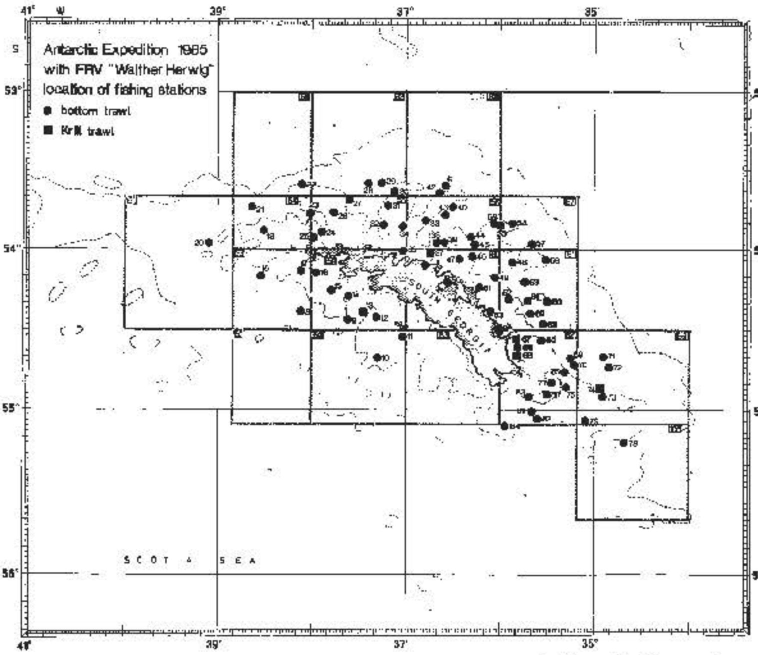

fig. 1: Location of fishing stations around South Georgia

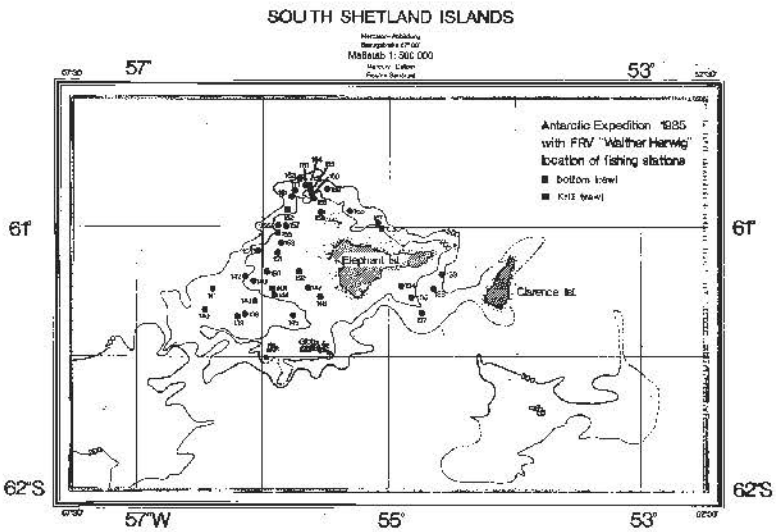

fig. 2: Location of fishing stations around Elephant Island

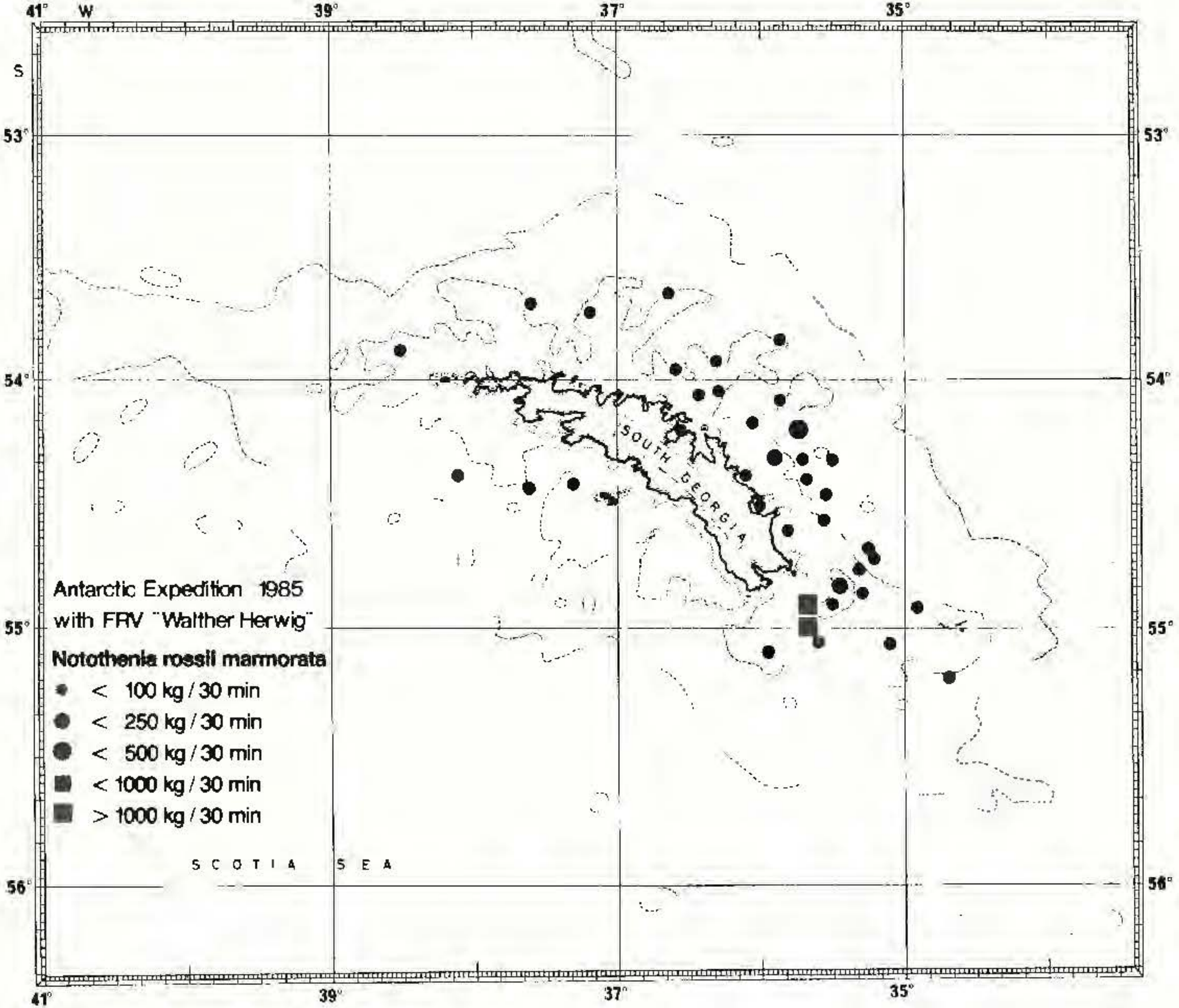

fig. 3: Catches of Notothenia rossii around South Georgia

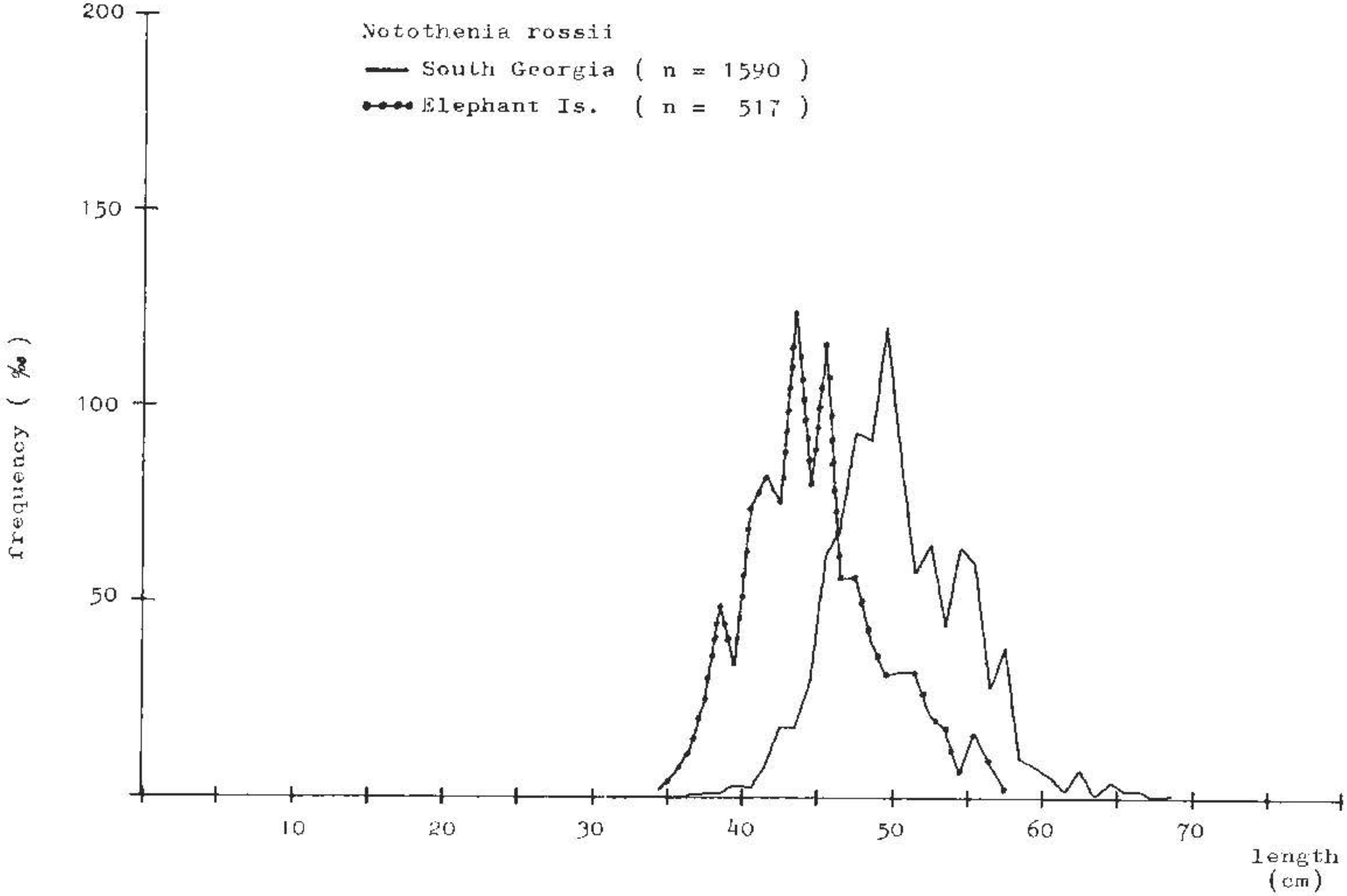

fig. 4: Length frequency distributions of Notothenia rossii from South Georgia and Elephant Island

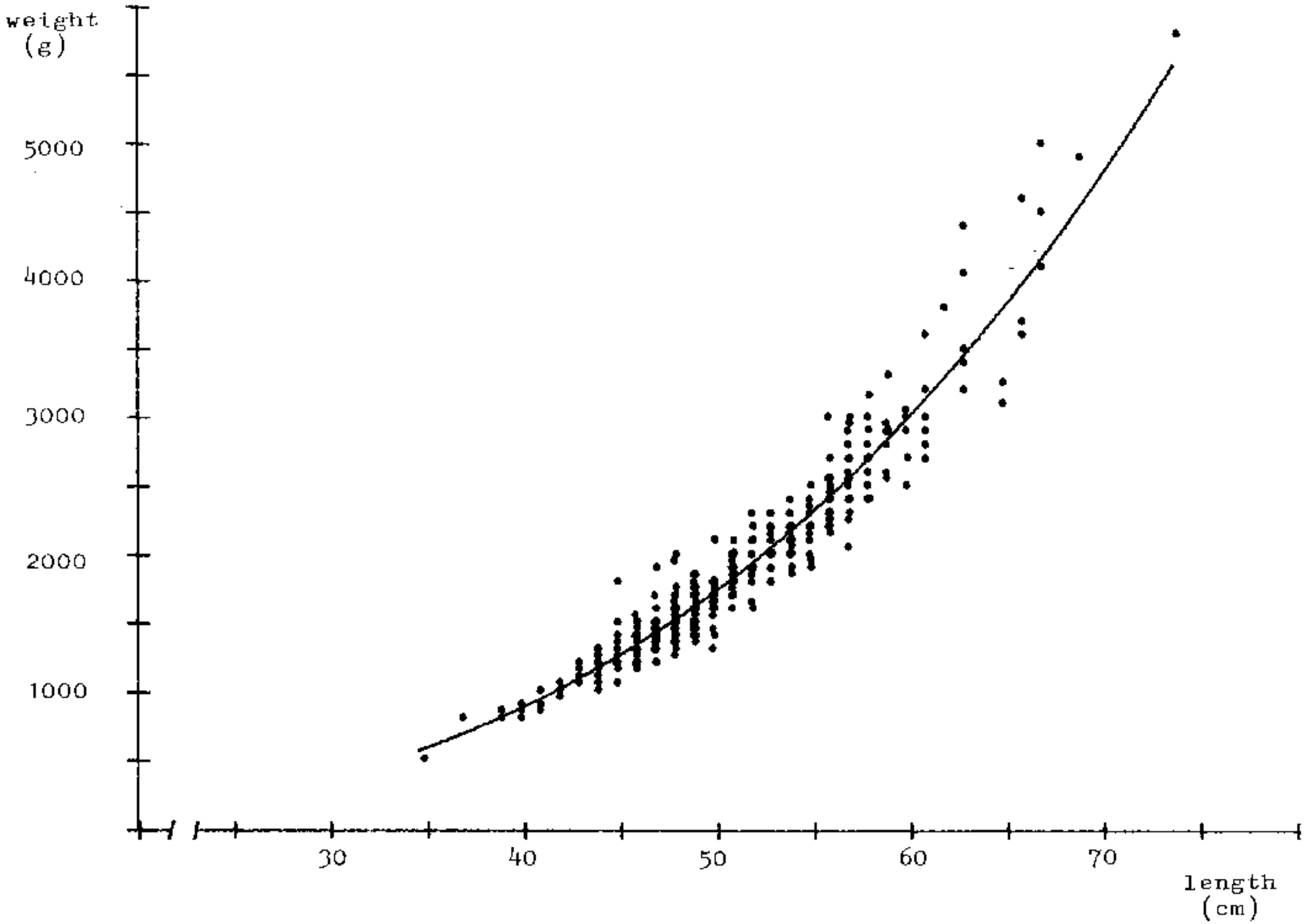

fig. 5: Length - weight relationship for Notothenia rossii from South Georgia

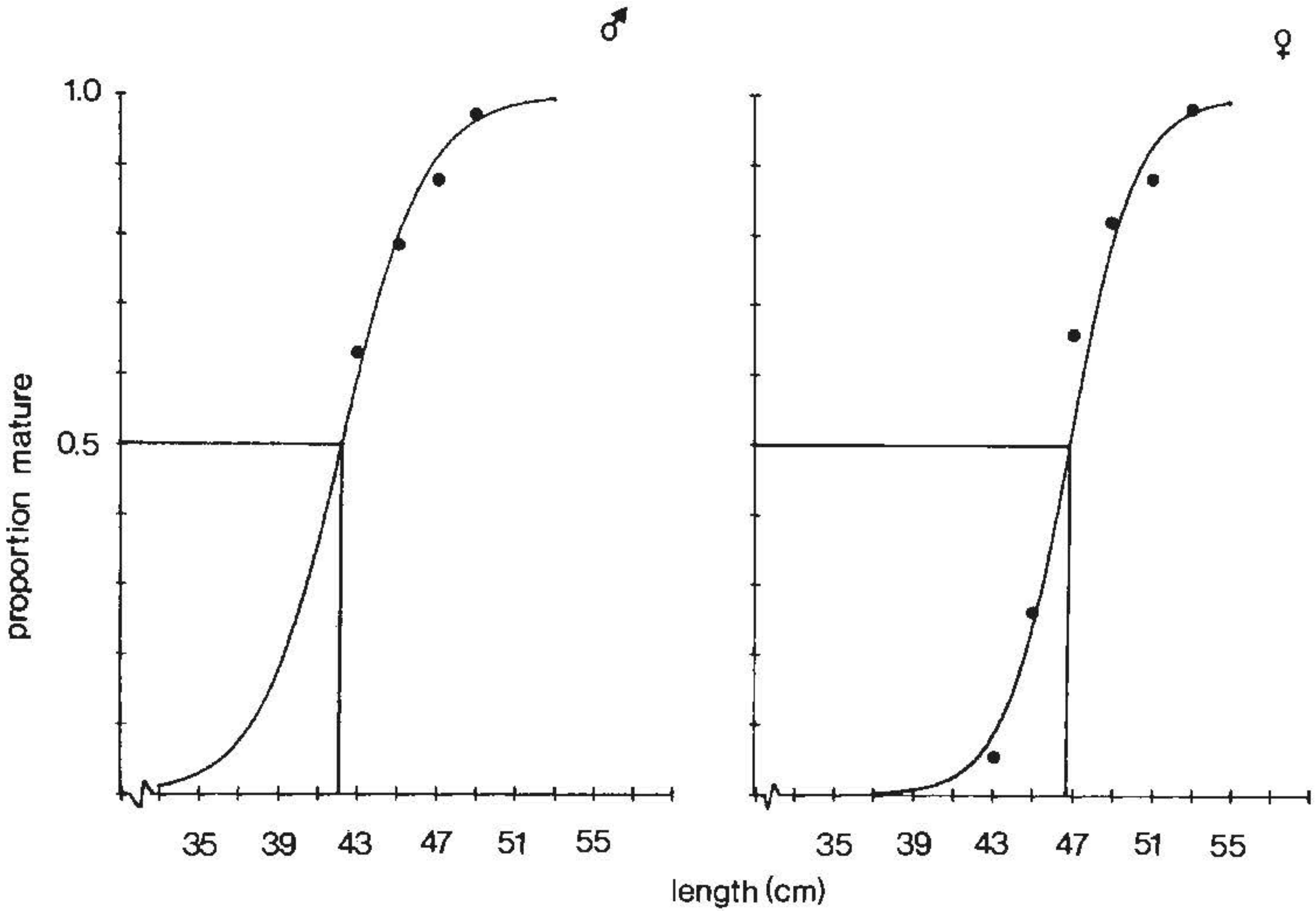

fig. 6: Length at sexual maturity in Notothenia rossii from South Georgia

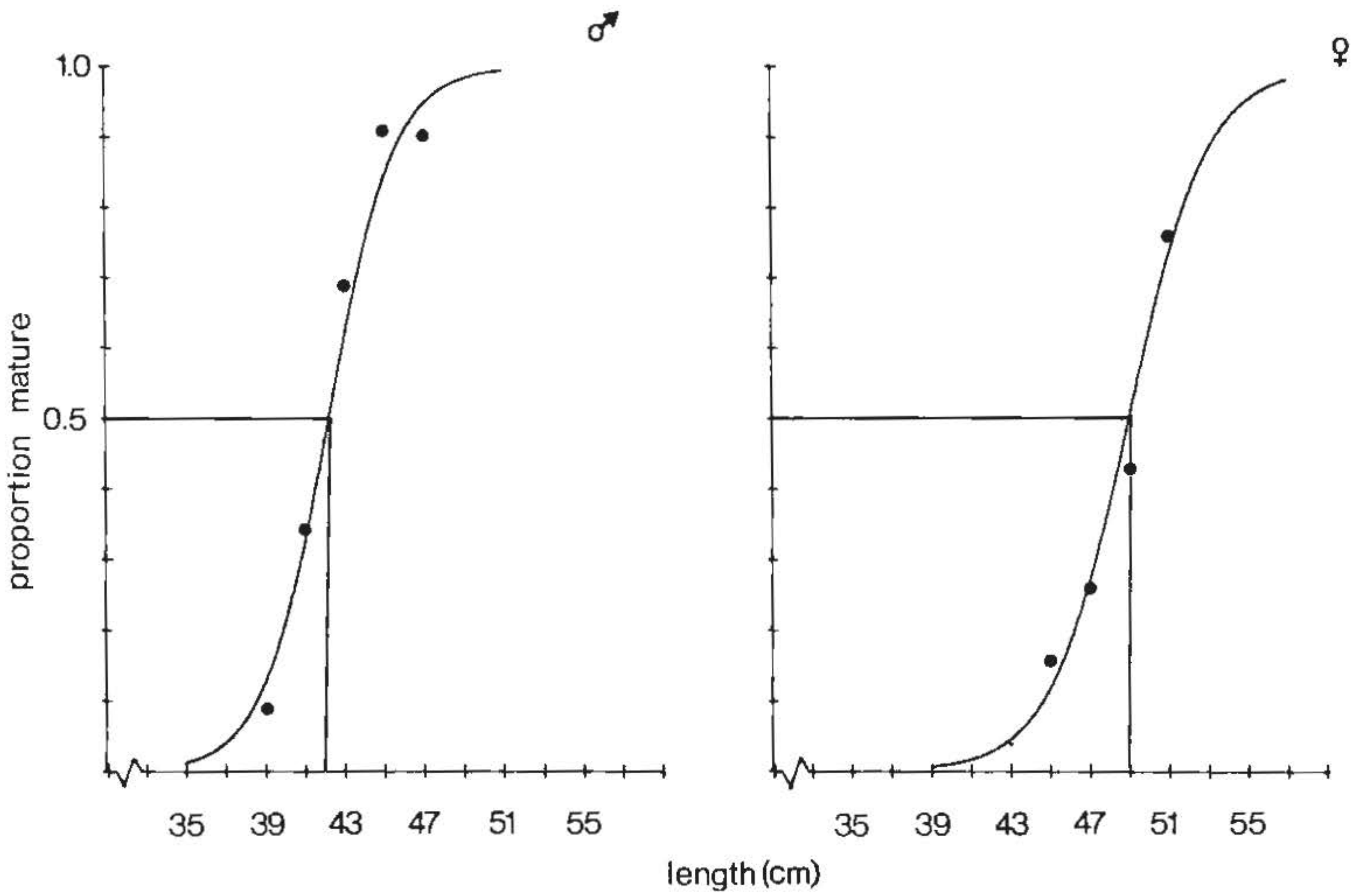

fig. 7: Length at sexual maturity in *Notothenia rossii* from Elephant Island

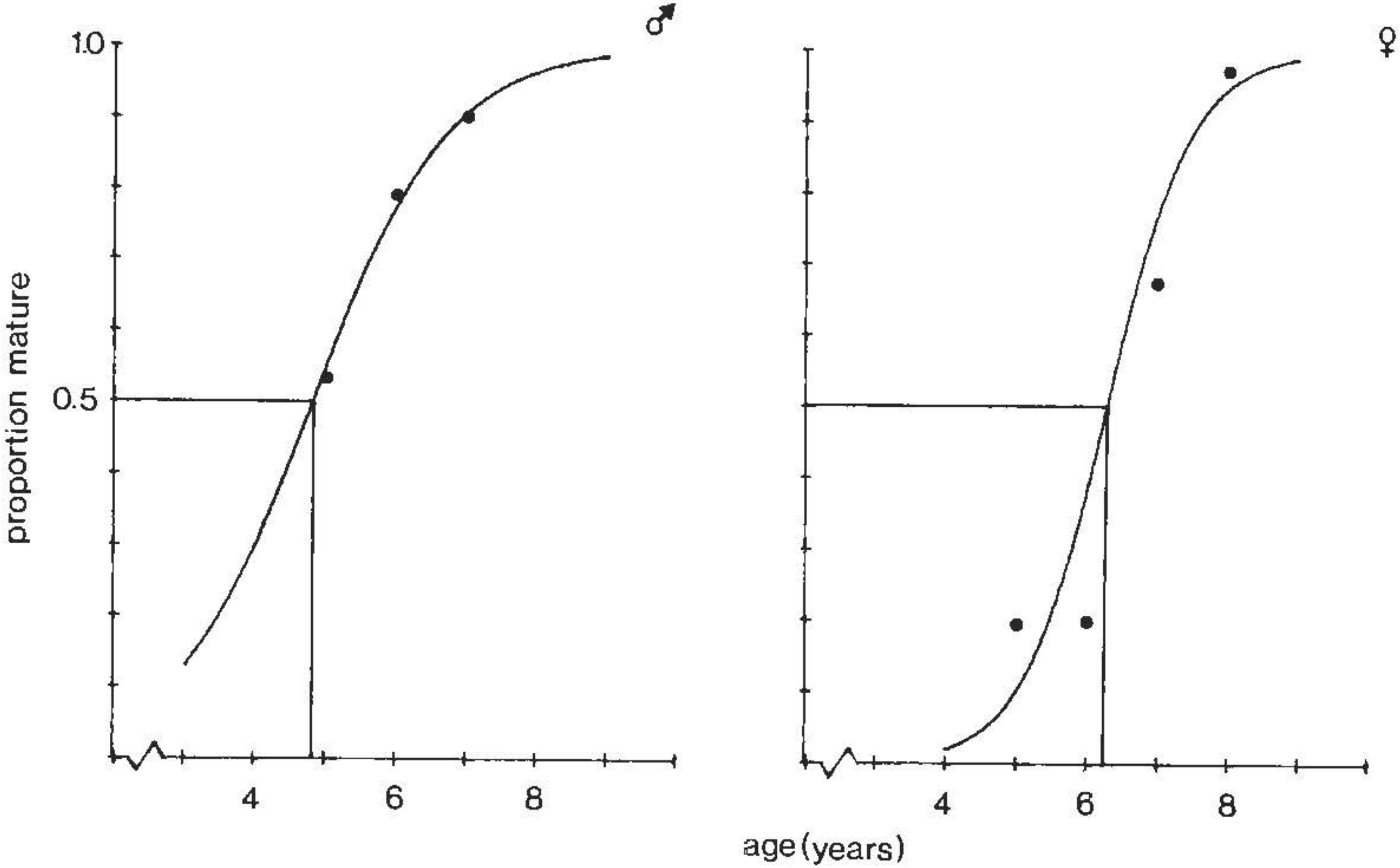

fig. 8: Age at sexual maturity in *Notothenia rossii* from South Georgia

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(South Africa)

SC-CAMLR-IV/BG/2
1985

RESEARCH CURRENTLY BEING UNDERTAKEN BY THE REPUBLIC OF SOUTH AFRICA ON "DEPENDENT AND RELATED SPECIES" WITHIN THE ANTARCTIC MARINE ECOSYSTEM

Abstract

Selected components of the biological sciences programme are described. The primary objective of the sudies being undertaken is to improve our understanding of the ecology of important predators (especially seals and seabirds) and their prey (especially krill and squid) in the Antarctic, and closely related marine ecosystems.

RECHERCHES ENTREPRISES ACTUELLEMENT PAR LA REPUBLIQUE D'AFRIQUE DU SUD SUR "LES ESPECES DEPENDANTES ET VOISINES"

Résumé

Les composantes sélectionnées du programme des sciences biologiques sont décrites. Le principal objectif des études entreprises est d'améliorer notre compréhension de l'écologie des pédateurs importants (surtout les phoques et les oiseaux marins) et de leurs proies (en particulier le krill et le calmar) en Antarctique et dans les écosystèmes marins étroitement liés.

ИССЛЕДОВАНИЯ, ПРОВОДИМЫЕ В НАСТОЯЩЕЕ ВРЕМЯ ЮЖНО-АФРИКАНСКОЙ РЕСПУБЛИКОЙ ПО ВОПРОСУ "ЗАВИСИМЫХ И СВЯЗАННЫХ ВИДОВ" В МОРСКОЙ ЭКОСИСТЕМЕ АНТАРКТИКИ

Резюме

Описаны выделенные компоненты биологической программы. Главной задачей проводимых исследований является усовершенствование знаний об экологии основных хищников (особенно тюленей и морских птиц) и их жертвы (особенно криля и кальмаров) в Антарктике и тесно связанных с ней морских экосистем.

INVESTIGACIONES QUE LA REPUBLICA DE SUDAFRICA ESTA LLEVANDO A CABO ACTUALMENTE RESPECTO A "LAS ESPECIES DEPENDIENTES Y AFINES" DENTRO DEL ECOSISTEMA MARINO ANTARTICO

Extracto

Se describen componentes seleccionados del programa de ciencias biológicas. El objetivo principal de los estudios que se están efectuando es mejorar nuestra

comprensión de la ecología de los depredadores importantes (especialmente las focas y las aves marinas) y sus presas (especialmente el krill y los calamares) en la Antártida, y en los ecosistemas marinos estrechamente relacionados.

INTRODUCTION

South Africa carries out a wide variety of scientific research in the Convention area and on the Sub-antarctic islands. These all fall under the auspices of South African Scientific Committee on Antarctic Research (SASCAR).

This report deals with selected components of the biological sciences programme of the South African National Antarctic Programme. As such, these components are of direct relevance to improving our understanding of the status of and ecological relationship between dependent/related populations of Antarctic marine living resources and their prey.

(1) MARINE MAMMALS

Introduction

Scientists based at the Mammal Research Institute of the University of Pretoria spend up to three months each year in the Antarctic, and from three to eighteen months at a time on Gough Island in the South Atlantic Ocean and on the sub-Antarctic Prince Edward (incorporating Marion Island), Amsterdam and Kerguelen islands in the South Indian Ocean studying the mammals in these regions. Between visits they carry out laboratory and statistical analyses of material and data collected. There is a low species diversity of mammals adapted to the Antarctic and Subantarctic environments, but the few that do occur provide an ideal opportunity for scientists to investigate their interaction with their environment.

Seals

Research on various aspects of the mammal fauna - mainly seals - in the southern oceans and on the islands south of southern Africa, began in earnest during 1973. Since then several projects have been completed and a number are still in progress. Research priorities have been set in accordance with those of national and international programmes, their objectives conforming with those of the South African National Antarctic Programme, the international Scientific Committee on Antarctic Research (SCAR) and the international BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) programme.

Research on the four species of truly Antarctic seals - the Weddell, crabeater, leopard and Ross seals - originally concentrated on their spatial and temporal distribution in the King Haakon VII sea off the Fimbul Ice Shelf, upon which the South African Antarctic base, SANAE is situated. The results indicated that the rarest of the species, the Ross seal, was present in larger numbers in that region than anywhere else surveyed up to that time. A long-term project investigating various aspects of Ross seal population ecology, reproduction and feeding was consequently initiated. This research, conducted in the pack ice from the supply and research ship, S.A. *Agulhas*, is carried out annually during the SANAE relief voyages each austral summer.

Research on different seal populations around the sub-Antarctic islands is carried out since these islands serve as 'platforms' upon which seals breed and moult each year. Studies on several aspects of the biology of the sub-Antarctic fur seal and southern elephant seal are being investigated on temperate Gough Island in the South Atlantic Ocean and on the sub-Antarctic Prince Edward (incorporating Marion Island) and Kerguelen islands in the South Indian Ocean.

Since 1974, studies at Gough Island have concentrated on the behaviour, population ecology and reproductive physiology of the fast expanding fur seal population. This particular population, which now reresents nearly 93 per cent of the world stock of this species, has been estimated at 200 000 and is increasing at a rate of about 16 per cent per year. Distribution of these seals around the shore of the island during the breeding season - in summer - appears to be limited by the seal's inability to physiologically regulate its body temperature during spells of relatively high ambient temperature experienced on the island between October and March. Behavioural adaptations (body postures and local movement) which are of importance in overcoming this problem have been identified. Social organization and seasonal changes in the age and sex composition of the population have also been described. In addition, studies have been undertaken on population dynamic characteristics and reproductive physiology.

Investigations of the fur seal population at Marion Island started during 1973 and soon indicated that two fur seal species were intermingling and possibly interbreeding on the island. The initial study on the abundance, distribution and annual cycle of fur seals was therefore followed by an investigation of the ecological and genetic separation of these species. Considering that the Prince Edward islands are one of the only two localities where both species breed, the results of this study were of importance to the understanding of the mechanisms which make it possible for related species to co-exist.

Research on the elephant seal populations at Gough, Marion and Kerguelen islands (on the latter in co-ordination with France) forms a major component of activities on the sub-Antarctic islands. These investigations began during 1973 and indicate a decrease of 5 to 11 per cent per year in the populations at Marion (4 500) and Kerguelen (118 000) islands. This trend apparently results from competition for food with fishing fleets, although social factors, resulting from differential changes in bull and cow numbers, may also be of importance - the latter aspects is being investigated.

The activities of elephant and fur seals when ashore at Marion Island to breed or moult have an important effect on the nutrient and energy cycles of the plant and invertebrate communities of the adjacent coastal plains. This effect is mainly through trampling and enrichment by manuring. An attempt has been made to quantify these influences.

The long-term monitoring of these seal populations through an intensive tagging programme is providing information on local and large-scale (inter-island) distribution and movement of seals, the age of sexual maturity, longevity and mortality patterns. Environmental variables of importance in the habitat preferences of these species form an important component of the investigation.

Wild Cats

Most of the exotic mammalian species introduced onto sub-Antarctic islands through human activities have had a deleterious effect on the islands, particularly on their birds.

An investigation into the influence of the cat population on Marion Island was initiated during 1974. This indicated that approximately 600 000 petrels were being killed annually by the feral or wild cat population, which was estimated at approximately 2 000. The high rate of annual increase (17-23 per cent per year) of this cat population could eventually have resulted in the burrowing petrel fauna of the island being exterminated, so measures were taken to control the cats. A biological control factor was introduced during 1977 which was successful in reducing the number of cats to about 600 in 1983.

Mice

House mice were introduced to Marion Island through sealing activities. Genetic studies suggest that the present-day mouse population is of Scandinavian origin. Studies of the feeding patterns of these mice indicate that they feed mainly on invertebrates. They are widely distributed around the periphery of the island, seasonal in their breeding activities, and well adapted to survive under the prevailing environmental conditions. Information on the population ecology and its interaction with the fauna and flora of Marion Island is now being analyzed.

(2) SEABIRDS

Introduction

Research on seabirds within the South African National Antarctic Programme is carried out by the Percy FitzPatrick Institute of African Ornithology, University of Cape Town. The scope of the work is primarily ecological, aimed at an improved understanding of how seabirds contribute to the structure and functioning of ecosystems.

South Africa's Prince Edward islands and the seas around the country's continental mainland support some of the most abundant pelagic seabird populations found anywhere in the world. The country is well placed and equipped to take a major share in the international responsibility for seeing that these birds continue to thrive, which depends on the state of the ecosystems of which the birds are an integral part. Man needs to exploit the resources of these ecosystems but should do so only within certain bounds. Ecological studies of pelagic seabirds can help determine these bounds.

A seabird may be defined as one that obtains its food from the sea. Broadly speaking, seabirds may be arranged ecologically as inshore, offshore or pelagic species. Among the inshore birds are the cormorants and gulls, which seldom move out of sight of land and normally roost ashore at night. The gannets are typical representatives of the predominantly fish-eating offshore seabirds which tend not to range beyond the continental edge. Pelagic seabirds can live for many months far from land, obtaining their food from the open sea. The albatrosses, characteristic inhabitants of the Southern Ocean, belong to this community. More than half the seabirds found in South African waters belong to the pelagic group, most of whose members only go ashore to breed on remote oceanic islands.

The seabirds of the world comprise some 250 species, of which about 65 are found in South African waters. However, only 13 species breed within South African territory, excluding the sub-Antarctic oceanic islands of Marion and Prince Edward, and none of these belongs to the pelagic community. In contrast, 26 species breed at the Prince Edward islands, the majority being pelagic.

South African research

South African research on pelagic seabirds in the Southern Ocean is carried out mainly in four areas: the Prince Edward islands; Gough island; the Benguela Current region; and that part of the Southern Ocean bounded by latitudes 30-70 S and longitudes 10 W to 40 E.

Research is primarily ecological, aimed at an improved understanding of how seabirds contribute to the structure and functioning of ecosystems. The continued possibility for exploitation by man of renewable natural resources, such as fish, depends not only on the rate at which they are exploited but on the maintenance of the ecosystem. Thus, much of the direction of South African seabird research is aimed at understanding the ecological roles of seabirds as top-order predators, either of pelagic shoaling fish, such as pilchards and anchovy, in waters around the southern African subcontinent, or of krill and squid in the Southern Ocean.

Birds of the Prince Edward islands

Penguins, petrels, albatrosses, skuas, gulls and terns are among the wide variety of seabirds encountered when voyaging southward from Cape Town. Most of these birds - also the sheathbills and cormorants - breed on islands in the Sub-antarctic ocean. Apart from occasional strays from lower latitudes and a few true land birds, the avian communities of the islands are exclusively marine. The species are either ocean-feeders or are dependent, as scavengers and predators, on other seabirds.

Some of the largest bird colonies in the world are to be found on sub-Antarctic islands. Penguins usually occupy the coastal slopes, cormorants and smaller albatrosses the cliffs, larger albatrosses the higher, flatter ground, and petrels honeycomb the inland surface with their nest-burrows. Marion Island harbours about one million breeding Macaroni penguins, and about 500 000 breeding King penguins, accounting for some 10 and 30 per cent, respectively, of the world populations of these species.

What accounts for this great abundance of birdlife? Birds need a stable, solid surface on which to lay and incubate their eggs and rear their young. Nowhere is the proportion of sea to land greater than in the southern hemisphere between latitudes 40 and 60 degrees S. This vast oceanic area is very productive - especially in the region of the Antarctic Polar Front where cold surface water from Antarctica meets and sinks below the warmer waters of the sub-Antarctic - providing food for millions of seabirds. Most of the sub-Antarctic islands are situated in this region.

Reference to the birds sighted on the Prince Edward islands was made by Captain Cook in 1776, who mentioned seeing 'penguins and shags, the former so numerous that the rocks seemed covered with them as with a crust". Harris, a ship's engineer and sealer, made the first detailed observations of the birds on the islands in 1832. Additional information was collected by members of the Challenger expedition in 1873. No further ornithological records were made until the South Africao annexation of the islands in 1947-48.

The Marion Island ecosystem

In a description of the vegetation on Marion Island given more than 200 years ago, it was stated that the plants are probably especially luxuriant because of a surfeit of the dung of numerous seabirds. About 10 years ago, a long-term research project was initiated by SASCAR, aimed at determining the roles of birds in ecological processes affecting the structure and functioning of the terrestrial ecosystem at Marion Island, more particularly to determine the amounts of essential nutrients transferred by birds from the marine ecosystem to, and within, the terrestrial ecosystem.

Carcasses, feathers, eggs and guano are the main avian products introduced into the island's ecosystem. Of the 26 birds species which breed on Marion Isdland, research was restricted during the 1970's to the relatively conspicuous, large and surface-nesting species. These comprise about 1,5 million birds of 16 species. The balance of the known breeding avifauna, consisting of 10 species of small petrels which nest underground and are mainly active nocturnally, are now being studied.

The results to date show that birds significantly affect virtually all parts of the island's ecosystem. The nutrients introduced, recycled and distributed appear to be crucial for the maintenance of many vital processes. The amount of nitrogen alone introduced annually by avian carcasses, manure, eggs and feathers is about 56 kg/ha or aproximately 12 per cent of the total content of nitrogen in the plant matter (above and below ground) of the island's low-altitude vegetation. The island's soils are inherently deficient in nitrogen.

Avian products deposited annually on Marion island are of the order of 32 000 tones of fresh guano, 500 tonnes of feathers, 350 tonnes of dead birds and 200 tonnes of eggs. The eggs alone contain enough energy to drive a small motor car eight times around the world, or sufficient energy to sustain an active human being for 300 years. These calculations take no account of the input of hundreds of thousands of burrow-nesting petrels.

Seabirds have a profound influence on the island's vegetation, guano and other fertilizing products promoting luxuriant growth of plants, as recorded earlier. On the other hand, the steady tramp of penguin kills vegetation along regular routes, leading to soil erosion. In places the birds even erode bare rock. After rain, which falls almost daily, the sea abutting on the major colonies of breeding penguins is stained with slush and eroding soil. Yet this erosion is part of a cycle returning material to the sea, enriching inshore waters and promoting the production of food for animals which feed close to the coast.

Birds indicate changes in population of prey

The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), of which South Africa is one of the contracting nations, defines these resources as all species of living organisms found south of the Antarctic Polar Front. It thus recognizes the interdependence of all components of the Antarctic marine ecosystem, not only the exploitable ones.

The Antarctic ecosystem differs from other marine ecosystems in the dominant role occupied by krill in the food web. The term "krill" here is used to describe pelagic, shoaling crustaceans generally, not merely the euphausiid Euphausia superba. These small shrimp-like creatures comprise a large part of the zooplankton biomass, and are the main food item contributing either directly or indirectly, to the diets of many seabirds, especially certain penguin species. Significant changes in populations of krill, which may be caused by man's exploitation of them, are likely to affect the populations of many animals, including seabirds, further up the food chain in the Southern Ocean. Currently, the overall consumption of krill by seabirds probably approximates that of either seals or whales.

Since the Prince Edward islands harbour a substantial proportion of these seabirds, South Africa chose to study selected species in this area with a view to using them for monitoring any future changes which might occur in krill populations. This research incorporates three components: first, determination of the diets of the different species, including seasonal and annual variations; secondly, determination of their energy requirements, which vary from species to species according to their life styles; and, thirdly, monitoring of their numbers and breeding success. Similar, but less intensive, studies are also being carried out by South African scientists at Gough Island. This work will provide the information needed to understand the relationship between the population dynamics of these selected secies, chiefly penguins, and of their prey, mainly krill and squid.

Studies of birds at sea

Where do the millions of birds which breed at the Prince Edward islands obtain their prey? Where do they feed, and on what, when not breeding? How important are the seas around South Africa for pelagic seabirds, including populations which breed at the Prince Edward islands? Do these seabirds consume significant quantities of resources exploited by man? Can the distribution of birds at sea be used to predict peculiar oceanographic conditions, perhaps associated with concentrations of the birds' principal prey types, for example krill and fish, which are also exploited by man? What effects do man's exploitation of marine resources have on pelagic seabirds? These and a host of other questions can only be answered fully through studying birds at sea.

One particular project of the international BIOMASS programme accordingly aims to improve current estimates of the amount of krill consumed at sea by the avian community of the Southern Ocean. South African scientists are taking an active part in this programme, providing information on the densities of birds and of their food requirements. For this research South African scientists have available to them two modern, deep-sea research ships, S.A. Agulhas and Africana, supported by a number of smaller vessels, fixed-wing aircraft and helicopters.

This form of ornithological research is part of a fairly recent development in international science. It reflects modern conservation standards which require that the state of the ecosystems as a whole, not merely the effects of exploiting resources, should be taken into account by management authorities.

To overcome these problems, SASCAR established a Prey Identification Service at the Port Elizabeth Museum in 1983 to cater for the needs of those Southern Ocean biologists studying top predators, especially seals and seabirds.

The initial task of the Service is to assemble comprehensive collections of suitable reference material, particularly the less digestible part of fishes, squids and crustaceans, which form the bulk of the prey of top predators in the Southern Ocean. Fresh material is collected where possible, and supplemented with material extracted from specimens held in collections in South Africa or abroad. These reference collections will consist primarily of fish ear stones or otoliths, squid mandibles or beaks and crustacean exoskeletons.

Otoliths, calcareous structures found in the inner ear of nearly all fish with bony skeletons (teleost fishes) vary sufficiently to be identifiable to species in most instances, even when eroded slightly by stomach acid.

Squid beaks, so-called because they resemble the beak of a parrot, are composed of chitin and are extremely resistant to digestion. The identification of squids from their beaks is a comparatively new field, limited somewhat by the innate difficulties of squid taxonomy and man's inability to capture useful numbers of pelagic squids - those that live in the open sea -

(3) SEAFOOD OF SEALS AND SEABIRDS

Introduction

Research aimed at a comprehensive understandings of Southern Ocean food webs and the interaction between predators and prey is an integral and important part of the South African biological research around Marion and Prince Edward islands and in the Southern Ocean.

Report on work

As part of the ecological study of seals and seabirds in relation to their environment, work is focused on their diets. Some of the bird species are potential indicators of the availability of their major prey, particularly squid and krill, and it is therefore important to study their feeding habits.

Information on the diets of these predators is derived almost entirely from the analysis of stomach contents collected from live aimals with the aid of stomach pumps, or from carcasses. As marine predators digest their prey rapidly and efficiently, intact items are rarely found in their stomachs and the identification of most prey items must be based on the less digestible fragments. The specialized nature of such identification's is generally outside the experience of those concerned with more tradional taxonomy of prey groups, and their normal reference material is often ill-suited to the purpose.

especially the larger forms. However, identification to genus is possible and, with some local knowledge, often also identification to species.

The most important crustaceans are euphausiids, amphipods and copepods. Their identification is usually based on traditional features such as the structure of the appendages, mouth parts and carapace.

With these research tools, the Prey Identification Service aims to identify all prey items to the lowest possible classifiable level and eventually to provide estimates of the original body size and mass of each item consumed, using appropriate length to mass relationships derived from reference specimens.

Although the Service at the Port Elizabeth Museum is intended primarily for the use of South African researchers in the National Antarctic Programme, applications for identifications from other biologists both in South Africa and abroad are welcome, since such identifications provide useful comparative information.

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RESULTS OF SOVIET INVESTIGATIONS OF THE DISTRIBUTION AND ECOLOGY OF PELAGIC SQUIDS (OEGOPSIDA) IN THE SOUTHERN OCEAN

Abstract

The USSR has carried out a long-term investigation of the distribution and ecology of pelagic squids (Oegopsida) in the Southern Ocean. In 1965-1977 a total of 326 squid specimens were collected at 124 stations with sampling by midwater nets. 125 specimens of that total were identified as Brachioteuthis riisei. In recent years (1978-1984) the collection was increased by two or three dozen specimens mostly identified as the little-studied Alluroteuthis antarcticus (family Neuleuthidae). 14 species of squid are considered to inhabit permanently the Southern Ocean. They belong to 9 families (13 genera). The pelagic squids are very seldom caught by fishing nets in Antarctic waters and data on squid beaks taken from sperm whale stomachs were also considered.

Up-to-date descriptions of all fourteen species are suggested. Where data are available the description includes geographical distribution, habitat, size, food diet and position of a species in a food web. Such description is also suggested for M. hamiltoni, the data on which come only from beaks found in sperm whale stomachs. All species are divided into three major groups in accordance with their habitats : tropico-subtropical, notal and Antarctic types.

In view of the absence of squid beaks in the bottom sediments in the Antarctic, two hypotheses are suggested : all squids migrate to the Antarctic in the summer seasons from the sub-tropical and notal areas, or the abundance of the true meso- and bathypelagic squids is very low.

It is proposed to concentrate future research on squids in the waters of high bioproductivity south of 60°S.

RESULTATS DES ETUDES SOVIETIQUES SUR LA REPARTITION ET L'ECOLOGIE DES CALMARS PELAGIQUES (OEGOPSIDA) DANS L'OCEAN AUSTRAL

Résumé

L'URSS a mené une étude à long term sur la répartition et l'écologie des calmars pélagiques (Oegopsida) dans l'océan Austral. En 1965-77, au total, 326 spécimens de calmars ont été prélevés à 124 stations par échantillonnage à l'aide de filets mésopélagiques. Sur ce total, 125 spécimens ont été identifiés comme étant de l'espèce Brachioteuthis riisei.

Au cours des dernières années (1978-1984), la collection s'est élargie par le prélèvement de deux ou trois douzaines de spécimens identifiés pour la plupart comme faisant partie de l'espèce peu étudiée Alluroteuthis antarcticus (famille des Neuleuthidae). 14 espèces de calmars habiteraient de manière permanente l'océan Austral. Ces espèces appartiennent à 9 familles (13 genres). Les calmars pélagiques ne sont que très rarement pris au filet dans les eaux antarctiques et les données provenant des becs de calmars trouvés dans les estomacs de cachalots ont également été étudiées.

Des descriptions très récentes de toutes ces quatorze espèces sont suggérées. Dans les cas où les données disponibles le permettent, la description comprend la répartition géographique, l'habitat, la taille, le régime alimentaire et la position de l'espèce dans la chaîne alimentaire. Une description semblable est également suggérée en ce qui concerne l'espèce M. hamiltoni, pour laquelle les données ne proviennent que des becs trouvés dans les estomacs de cachalots. Toutes les espèces sont réparties en trois groupes principaux selon leur habitat: type tropico-subtropical, type notal et type antarctique.

Etant donné l'absence de becs de calmars dans les sédiments de fond en Antarctique, deux hypothèses ont été avancées: tous les calmars émigrent en Antarctique au cours de la saison d'été, quittant les régions subtropicales et notales, ou bien l'abondance des calmars proprement méso- et bathypélagiques est très faible.

On propose de concentrer les futures recherches sur les calmars dans les eaux de haute bioproductivité au sud de 60°S.

РЕЗУЛЬТАТЫ СОВЕТСКИХ ИССЛЕДОВАНИЙ ПО ВОПРОСАМ РАСПРОСТРАНЕНИЯ И ЭКОЛОГИИ ПЕЛАГИЧЕСКИХ КАЛЬМАРОВ (OEGOPSIDA) В ЮЖНОМ ОКЕАНЕ

Резюме

СССР была проведена долгосрочная программа исследований по вопросу распространения и экологии пелагических кальмаров (Oegopsida) в Южном океане. В 1965 -1977 г.г. было собрано в общей сложности 326 образцов кальмаров на 124 станциях при помощи среднеглубинных тралов. 125 образцов из общего числа было определено как принадлежащие к виду Brachioteuthis riisei. В недавнее время (1978-1984 г.г.) коллекция была пополнена двумя или тремя дюжинами образцов, определенных в большинстве случаев как принадлежащие к малоизученному виду Alluroteuthis antarcticus (семейство Neuleuthidae). Считается, что 14 видов кальмаров постоянно обитает в Южном океане. Они принадлежат к 9 семействам (13 родам). Пелагические кальмары очень редко вылавливаются рыболовными сетями в водах Антарктики; были рассмотрены также данные по клювам кальмаров, найденным в желудках кашалотов.

Предлагаются новейшие описания всех четырнадцати видов. При наличии соответствующих данных описания включают в себя географическое распределение, место обитания, размер, пищевой режим и положение вида в трофической цепи. Подобное описание также предлагается и для вида M. hamiltoni, данные по которому были получены только по клювам, найденным в желудках кашалотов. Все виды разделены на три основные группы в соответствии с их местом обитания: тропическо-субтропические, нотальные и антарктические.

Ввиду отсутствия клювов кальмаров в донных отложениях Антарктики предлагаются две гипотезы: все кальмары мигрируют в Антарктику во время летнего периода из субтропических и нотальных областей, либо численность подлинно мезо- и батипелагических кальмаров является весьма низкой.

Предлагается сосредоточить будущие исследования кальмаров в водах высокой биопродуктивности, к югу от 60° ю.ш.

RESULTADOS DE LAS INVESTIGACIONES SOVIETICAS SOBRE LA DISTRIBUCION Y ECOLOGIA DE LOS CALAMARES PELAGICOS (OEGOPSIDA) EN EL OCEANO AUSTRAL

Extracto

La URSS ha llevado a cabo investigaciones a largo plazo sobre la distribución y ecología de los calamares pelágicos (Oegopsida) en el Océano Austral. En 1965-1977 se recolectó un total de 326 especímenes de calamares en 124 estaciones con muestreos hechos por redes semipelágicas. De dicho total 125 especímenes se identificaron como Brachioteuthis riisei. Durante los últimos años (1978-1984) la colección se aumentó en dos o tres docenas de especímenes la mayoría de los cuales han sido identificados como los poco estudiados Alluroteuthis antarcticus (familia Neuleuthidae). Se considera que 14 especies de calamares habitan el Océano Austral permanentemente. Pertenecen a 9 familias (13 géneros). Los calamares pelágicos son capturados muy raras veces por redes pesqueras en las aguas antárticas y también se consideraron los datos sobre los picos de calamar obtenidos de los estómagos de ballenas enanas.

Se sugieren descripciones actualizadas todas estas 14 especies. Donde hay datos disponibles, la descripción incluye la distribución geográfica, habitat, tamaño, dieta

alimenticia, y la ubicación de la especie en la red alimenticia. Tal descripción también se sugiere para M. hamiltoni, los datos sobre los cuales sólo se obtuvieron de los picos hallados en estómagos de ballenas enanas. Todas las especies quedan divididas en tres grupos principales según sus habitats: tipos tropicales-subtropicales, notales y antárticos.

En vista de la abundancia de picos de calamar en los sedimentos de fondo de la Antártida, se sugieren dos hipótesis: todo calamar emigra a la Antártida en las temporadas de verano desde las áreas subtropicales y notales, o la abundancia del verdadero calamar mesopelágico y bathypelágico es muy baja.

Se propone concentrar las investigaciones futuras en los calamares de las aguas de alta bioproductividad al sur de los 60°S.

Less is known of the squids of the Southern Ocean than all other groups of marine animals which nsually occur in this vast region or migrate into Antarctic waters in warmer seasons. This gap in our knowledge of the group of Antarctic pelagic cephalopods seems to be due to the fact that they are rarely caught by fishing gear and the main material available for examination by specialists is represented by samples from the stomach contents of sperm whales taken in the Southern Ocean. The samples collected by such indirect methods consist primarily of beaks, sometimes fragments of bodies, or very rarely intact specimens of squid. Because of rhis, it is difficult not only to study the biology and ecology of squids, bnt even to identify species found in the stomachs of sperm whales.

A total of 326 specimens of Antarctic Squids were collected at 124 stations with midwater hauls in the Southern Ocean during studies carried out by the Soviet Union in the years 1965-1977. Of that total, 125 specimens from 42 stations were identified as Brachioteuthis riisei (Filippova, Yukhov, 1979). In recent years (1978-1984), the collection was increased by two or three dozen specimens taken during Antarctic expeditions carried out by VNIRO and AZCherNIRO in certain areas of the Southern Ocean. Most specimens were identified as the little-studied Alluroteuthis antarcticus (family Neoteuthidae) and as a result the first description made by Odhner (1923) was completed and the identification description of the genus Alluroteuthis and family Neoteuthidae was changed (Filippova, Yukhov, 1982; 1983).

Although squids are not often found in the catches of pelagic fishing gear, the collected data provide a general idea of the spatial distributiou of species in the Southern Ocean. In turn, the analysis of data on the distribution and feeding habits of the sperm whale, the principle consumer of squids, and material on spatial and quantitative distribution of major food species of squids (mesopelagic fish) indicate certain ecological characteristics of this group of nekton animals.

Pelagic squids from the sub-order Oegopsida are widely distributed in the Southern Ocean. As is already known, in contrast to the meridional distribution pattern of species of the sub-order Myopsida, representatives of Oegopsida are characterised by a latitudinal distribntion pattern, their habitats being confined to latitudinal climatic zones of the World Ocean (Zuev, Nesis, 1971). Analysis of the available data indicates that the group of oceanic squids in the Southern Ocean has the same pattern of distribution. This regularity in the distribution pattern of sqnids in the latitudinal climatic zones of the ocean is in full agreement with principles of zonation in the oceauographic and biological structure in the Southern Ocean and with principles of separatiou of two different natural latitudiual zones (Deacon, 1982; Lubimova, 1982; 1983; 1984).

The sub-order Oegopsida includes 23 families, 77-81 genera and 226 species. A considerable part of the species are warm-water cosmopolitans, 36% of all species occur in more than one ocean and 13% occur in more than two oceans. More than half of all species (120) are found in the Atlantic Ocean (Nesis, 1982). Latitudinally, complex species composition (over 60% of all species) is noted for the tropical and sub-tropical waters, whereas to the north and aouth of the equatorial zone, i.e. iu the temperate and particularly in the sub-polar waters of the Northern and Southern Hemispheres, the species composition is much less diverse (Zuev, Nesis, 1971).

It is ascertained that the families Onychoteuthidae, Cranchiidae, Histioteuthidae are diversely represented in the equatorial zone (Akimushkin, 1963; Zeuv, Nesis, 1971; Filippova, 1971; Nesis. 1973). These are the same families which compose the bulk of the species compositiou of squids occurring in the Southern Ocean. The diversity and richness of forms of oceanic squids in the tropical and sub-tropical waters undoubtedly indicate their warm-water origin and their subsequent dispersion from the equatorial zone into the boreal and notal zones in the geological ancient past.

Squids are kuown to be one of the most ancient groups among all existing groups of nekton animals. The fossil ancestors of squids, Belemnitidae, which differ from squids only in the specific gravity of their calcified skeletons, inhabited warm oceanic waters. Their fossilized skeletous are found in the Jurassic layer of Central Europe (Kabanov, 1967, 1983; Akimushkin, 1968). It is evident that the ancient origin and the cosmopolitan character of oceanic aquids Oegopsida, are responsible for their fairly wide distribution in the warm waters of the World Ocean, and for the penetration of some species into the productive areas of the temperate waters of the boreal and notal zones. At the same time, it is substantiated that the distribution of pelagic squids in the temperate waters is limited to some extent as their existence is closely associated with warm currents and their vertical distribution is dependent upon warm-water masses. Therefore, despite the diversity of Oegopsida forms in the Atlantic Ocean, it is shown that the Gulf Stream appears to be a mechanism responsible for such an elementary evolutional factor as isolation of species in the temperate zone. The current is a natural barrier preventing the penetration of species inhabiting and spawning in the mesopelagic layer of the warm North Atlantic water mass[1], beyond its northern boundary. Squids brought by Gulf Stream eddies into cool coastal waters of the Northwest Atlantic, die particularly in the winter-spring season (Froerman, 1983). Similar regularities in the distribution of oceanic squids in the system of warm currents (Kuroshio, East Australian Current, Alaska Current) are also known for the temperate zone of the Pacific in the Northern Hemisphere (Zuev, Nesis, 1971; Berzin, 1971).

No doubt, the same regularity of the distribution of squids Oegopsida should be found in the notal and Antarctic areas of the Southern Hemisphere. Therefore, the data on the feeding habits of sperm whales in the Southern Hemisphere summarised by Soviet researchers (Klumov, 1971), information on squid occurrences in the stomach samples of sperm whales and in fishing gear catches (Filippova, Yukhov, 1979) and on the different types of species habitats (Nesis, 1982), indicate a close association of squids from the Southern Ocean with the Antarctic Circumpolar Current waters (ACC). According to instrumental measurements of depths where sperm whales dive in search of squids (from 400 to 600 m on average ; Yukhov, 1982) and information on the depths of hauls where the most specimens were

[1] The North Central water mass is characterised by high salinity and temperature according to Sverdrup's Classification, 1942, cited by the Russian translation (1974, p114-118) of the Encyclopedia of Oceanography, A. Gordon, New York, 1966.

caught in the Southern Ocean (Filippova, Yukhov, 1979; 1982) we may come to a definite conclusion that the permanent environment of squids in the Antarctic is the Antarctic Deep Warm Water Mass[2]. In view of this fact, the lack of epipelagic forms of oceanic squids in the Antarctic noted by all researchers does not seem to be accidental (Klumov, 1971; Zuev, Nesis, 1971; Filippova, Yukhov, 1979; Nesis, 1982). It is known that the upper 200 m layer in the Antarctic is held by the Antarctic Surface Cool Water Mass which is characterised by constant low salinity and low temperature (it may drop below zero in winter and in summer there is a residual layer of the sub-surface temperature minimum ; Makarov, 1956; Sarukhanyan, 1980).

The attachment of oceanic squids to warm currents and water masses seems to be a general feature in their distribution northwards and southwards from the equatorial zone of the World Ocean, and the main characteristic of their ecology due to thair warm-water origin. No doubt, this characteristic is formed in the process of long-term evolution in Oegopsida as adaptation to the conditions of the temperate and subpolar waters of the World Ocean. Racent paleogeographical, paleoclimatic and paleoceanographic data show that the penetration of oceanic warm-water squids into Antarctic waters probably took place in the early Tertiary period. According to the data (Verbitskij, Kvasov, 1980; Myagkov, 1980; Znachko-Yavorskij, 1980; Zonenshain, 1980; Losev et al., 1980), the early Tertiary period (Paleocene and Eocene) was characterised by the existence of one mainland in the Southern Hemisphere consisting of the modern continents of South America, Australia and Antarctica. At that time, the continent was washed around by warm currents moving away from the equator, and temperate climatic conditions were prevailing in the Antarctic. However, in the early Oligocene when a deep-water strait was formed between Australia and Autarctica, the glaciation of the Antarctic continent started aud was responsible for the predominance of cold currents there. Only

[2] The upper boundary of the Antarctic Deep Warm Water Mass is at the depth of 200m, the lower boundary is 3000-2000 m deep on average (Dencon, 1937; Sarukhanyan, 1980).

three of these equatorial curreuts remain. Such meridional currents existed in the Southeast Indian Ocean and Southwest Pacific up to the mid-Miocene. A warm current originated in the Atlantic, in the coastal water of South America,and penetrated into the Weddell Sea.

Thus the temperate climate in the Antarctic in the Paleocene and Eocene and the existence of three powerful equatorial currents moving south iu the Pacific, Atlantic and Indian Ocean until the mid-Miocene, are likely to have attributed to the penetration and dispersal of the tropical and sub-tropical fauna (Oegopsida) in the Antarctic. Later, in late Miocene-early Pliocene, the Antarctic was separated from South America, resulting in complete isolation of the Antarctic continent and its rapid cooling, an increase in the volume of cool Antarctic waters and the formation of the ACC. The influx of warm water from the equator is confined to the Antarctic Deep Water Mass. This seems to have resulted in the adaptation of warm-water squids to the ACC waters and their associatiou with the Antarctic Warm deep water. At the same time, it is quite evident that only a few species from the sub-order Oegopsida with very rich species composition (226 species), could adapt themselves to the Southern Ocean. The evidence is supported by the fact that the species composition of oceauic squids occurring in the notal and Antarctic areas is extremely poor (Nesis, 1982). Moreover, the most widely distributed species iu the Southern Ocean are not typical for the Antarctic. As is known, endemism is not specific to the group of oceanic squids as a whole (Akimushkin, 1963). Nevertheless, some species are referred to as endemic Antarctic forms because they have never been found to the north of the Antarctic Convergeuce (Filippova, Yukhov, 1979).

Therefore, squids of the Southern Ocean belong to 9 families, 13 genera and 14 species (Table 1). Six families out of nine are monotypic and represented by one genus and one species each. The remaining three families include 1-3 genera and 203 species each ; they are tropical or sub-tropical by origiu : Crauchiidae (3 genera, 3 species), Onychateuthidae (2 genera, 3 species) and Histioteuthidae (1 genus, 2 species). Among the former six families there are two cosmopolitan families (Brachioteuthidae and Bathyteuthidae), a tropical Neoteithidae, a bipolar Gonatidae and two families (Psychroteuthidae and Batoteuthidae) which never occur in the Northern Hemisphere (Nesis, 1982).

Besides the abovementioned species, there are indications that such widely spread cosmopolitan forms as Architeuthis sp., Onychoteuthis banskii, Chiroteuthys veranyi, which permanently inhabit the tropical waters, can penetrate into the Southern Ocean. Their occurrence is known only from the stomach contents of sperm whales both in the Northern Hemisphere and in the sub-tropical and notal waters of the Southern Hemisphere. They are mainly bathypelagic species (Klumov, 1971; Zuev, Nesis, 1971; Nesis, 1982). Since they are not typical for the Southern Ocean they are not included in the list of species contained in Table 1.

Relying on the data summarised by Klumov (1971), Filippova and Yukhov (1979; 1982; 1983), the present analysis includes all materials used by them, data on the analysis of whale stomach contents, data on captures by midwater fishing gears, including data published in other countries and in the monographic review "World Ocean Cephalopods", Nesis (1982). Using all the material, the complex characteristics of each of 14 species occurring in the World Ocean are suggested. Mesonychoteuthis hamiltoni is considered separately as opinions on the distribution of the species in the Antarctic are controversial because they rest only on data on the analyses of stomach contents of sperm whales and are represented mainly by beaks (Klumov, Yukhov, 1975).

Moroteuthis ingens (Smith, 1881) is known to occur in the Southern Ocean according to data on the stomach contents of sperm whales and samples from midwater fishing gear collected at 37 stations between 40° and 55°S. It was encountered on the Patagonion shelf, off Southern Chile, the Falkland Islands, Prince Edward Island, Crozet, Kerguelen, New Zealand and once off South Georgia. It inhabits the bathypelagic layer and is characterised as a circumpolar notal species entering the Antarctic Convergence. The length of the mantle is up to 52 cm. Mesopelagic fish from the family Myctophidae and small-sized squids are found in the diet of some specimens.

Morotheuthis knipovitchi (Filippova, 1972) is known to occur in the Southern Ocean according to data on the stomach contents of sperm whales and from data on catches of midwater fishing gear. It was once found in the stomach of an Antarctic toothfish (Dissostichus mawsoni) withdrawn from the stomach of a sperm whale. It was encountered at 18 stations between 45° and 55°S in the Indian Southern Ocean, between 55° and 65°S in the Atlantic Southern Ocean and some specimens are found at 4 stations in the vicinity of the South Polar Circle. It inhabits the mesopelagic and bathypelagic layers and is characterised as a circumpolar Antarctic species, but it also occurs north of the Antarctic Convergence. The length of the mantle is up to 45 cm. Mesopelagic fish from the family Myctophidae and small-sized squids are found in the diet of some specimens.

Kondakovia longimana (Filippova, 1972) is known to occur in the Southern Ocean according to data on the stomach contents of sperm whales and from midwater net samples collected at 28 stations, including 21 stations in the Pacific Southern Ocean from 56° to 68°S, some specimens in the Atlantic Southern Ocean are found at 60°S and in the waters of the Antarctic Convergence in the Indian Ocean. It inhabits the mesopelagic layer and can rise into the epipelagic layer. It is characterised as a circumpolar Antarctic species, which has not yet been encountered north of the Antarctic Convergence. The length of the mantle is 80-115 cm. Mesopelagic fish from the families Myctophidae and Paralepididae, small-sized squids and Antarctic krill are found in the diet of some specimens.

Galiteuthis glacialis (Chun, 1906) (synonyms G.aspera, Filippova, 1972, Crystalloteuthis glacialis (Chun, 1906) is known to occur in the Southern Ocean according to data on the stomach contents of sperm whales caught off Prince Edward and Crozet Islands and from midwater fishing gear catches at 4 stations in the Scotia Sea. It inhabits the meso- and bathy- pelagic layers and can rise into the lower epipelagic layer ; it is characterised as a circumpolar Antarctic species, but is found also in the notal water north of the Antarctic Convergence. There are no data on the length of the mantle. Feeding habits are not known.

Taonius pavo (LeSueur, 1821) is known from the stomach contents of sperm whales in the Northern Hemisphere as a widely distributed form, but the evidence of its occurence in the diet of sperm whales in the Southern Hemisphere still needs to be proven. It is characterised as a widely distributed but rare tropical-subtropical species. It is supposed to penetrate into the notal waters, but it was not found in the Sonthern Ocean. It seems to occur in the mesopelagic layer. The length of the mantle is up to 40-45 cm. There are no data on the feeding habits.

Histioteuthis atlantica (Hoyle, 1885) and H. eltaninae (N. Voss, 1962) are species which are not typical for the south polar area of the World Ocean. Numerous representatives of the family Histioteuthidae in the sub-tropical and temperate waters occur in the diet of sperm whales. They are distributed everywhere except for the Arctic and Antarctic areas. They inhabit the meso- and bathy- pelagic layers and the abysspelagic layer as well. H. atlantica is characterised as a circumglobal south sub-tropical and notal species. It is supposed to be able to penetrate into the Antarctic Convergence, but no specimens have been found in the Southern Ocean. The length of the mantle is up to 20 cm. There are no data on the feeding habits. H. eltaninae is characterised as a circumglobal notal species. It is encountered off the Falkland Islands and New Zealand. Two specimens were observed in the Antarctic Convergence. The length of the mantle is up to 7 cm. There are no data on feeding habits.

Gonatus antarcticus (Lönnberg, 1898) is known from the stomach contents of sperm whales in the Southern Hemisphere and some specimens were encountered in midwater fishing gear in the notal waters off the Falkland and Crozet Islands. It is distributed up to South Africa aud North Peru, north of the Antarctic Convergence. It inhabits the meso- and bathy- pelagic layers and is characterised as a circumpolar notal species entering the Antarctic Convergence. The length of the mantle is up to 35 cm. There are no data on the feeding habits.

Alluroteuthis antarcticus (Odhner, 1923) is known from the stomach contents of sperm whales and midwater fishing gear catches at 34 stations in the Southern Ocean. There is information that specimens occur infrequently in the diet of sperm whales because of their low abundance. Specimens were caught in the Antarctic Atlantic Ocean south of the Antarctic Convergence from 51^{o} to 65^{o}S, and in the Antarctic Pacific and Antarctic Indian Oceans - up to 67^{o}-69^{o}S. It inhabits the bathypelagic layers, although two specimens were encountered in the epipelagic layer. It is characterised as a circumpolar Antarcic species, no occurrence was registered north of the Antarctic Convergence. The length of the mantle is up to 24-27 cm. The diet of young specimens contains squids including specimens of the same species, and crustaceans : euphansiids (probably Antarctic Krill), hyperiids, mysids. Squids of family Chiroteuthidae, mesopelagic fish, euphausiids (including E. superba[3]) are fonnd in the stomach contents of adult specimens.

Psychroteuthis glacialis (Thiele, 1921) is known in the Southern Ocean from the stomach contents of the Weddell Seal and Antarctic Toothfish extracted from the stomachs of sperm whales. Two specimens were found in the catches of midwater fishing gear at 13 stations and all of them were found south of the Antarctic Convergeuce, up to 69°S. It inhabits the mesopelagic layer, off the Antarctic islands - in the bathyal layer near the bottom. It is supposed to be able to rise into the lower epipelagic layer. It is characterised as a circumpolar Antarctic species. The length of the mantle is up to 44 cm. There are no data on the feeding habits.

Brachioteuthis riisei (Steenstrup, 1882) is known in the Southern Ocean mainly from the catches of midwater fishing gear (125 specimens were collected at 42 stations). Most specimens were collected in the Scotia Sea between the Antarctic Convergence and 60°S. Three specimens were caught in the Indian Ocean : one north of the Antarctic Convergence and two at 60°S. A total of seven specimens were caught in the Pacific Southern Ocean, mainly at 60°S. There are indications of occurrences of this species in the stomach contents of sei whales and fin whales. It inhabits the meso- and epi- pelagic layers but was also fouud in the bathypelagic layer. According to present knowledge it is a cosmopolitan species spread widely in the productive temperate waters of the World Ocean except for the boreal Pacific Ocean. In the Southern Ocean it is characterised as a circumglobal

3 The identification was made by some fragments of euphausiids, so the assumption was made that E. Superba is included in the diet of A. antarcticus (Filippova, Yukhov, 1982).

notal-Antarctic species. According to data on its occurrences in the Atlantic Ocean in particular (125 specimens) the assumption is made that sqnids are concentrated off Sonth Georgia and adjacent waters of the Scotia Sea in the meso- and epi- pelagic layers. The length of the mantle is up to 14 cm. The diet of specimens caught in the Scotia Sea contained euphausiids, including Antarctic krill.

Bathyteuthis abyssicola (Hoyle, 1885) has never been found either in the stomach contents of sperm whales or in midwater fishing gear during the long-term period of Soviet fishery research. At the same time it is believed that the abundance of species is high in the notal area of the Southern Ocean (Roper, 1969). Squids inhabit the bathypelagic layer and young specimens occur occasionally in the lower epipelagic layer. It is characterised as a cosmopolitan species which is widespread in the eutrophic areas of the World Ocean. The distribution is circumglobal in the notal and Antarctic waters. There are indications that abundance is low in the Southern Ocean and therefore the species cannot be a food item for sperm whales as Alluroteuthis antarcticus, (Klumov, 1971). The length of the mantle is up to 6 cm. There are no data on the feeding habits.

Datoteuthis scolops (Young and Roper, 1968) is known in the Southern Ocean from the stomach contents of sperm whales and from the catches of midwater fishing gear. Specimens were caught at 6 stations, 3 of which are in the south west Atlantic in the Antarctic Convergence and north of it. The stomachs of sperm whales caught in the Pacific Southern Ocean contained three specimens, one occurring north of the Bellingshausen Sea. Specimens of the species were not found in the Indian Ocean. It is believed that squid do not migrate and inhabit the bathypelagic layer. It is characterised as a notal-bathypelagic species entering the Antarctic waters. There are no data on the feeding habits.

The abovementioned data indicate that all species of squids occurring in the Southern Ocean in snmmer can be clearly divided into separate groups according to their types of habitats. The tropical-subtropical and notal types of habitat are characteristic of 5 species : T. pavo, H. atlantica, H. eltaninae, G. antarcticus, M. inges.

The notal type is inherent for 3 species : B. riise, B. abyssicola, B. scolops and 5 species belong to the Antarctic type : K. longimana, A. antarcticus, P. glacialis, M. knipovitchi, G. glacialis the last three species of which may be considered as endemic for the Antarctic because they have never been encountered north of the Antarctic Convergence. Unfortuuately, it is not evident to which group we shall refer Mesonychoteuthis hamiltoni (Robson, 1925) since the data on the distribution rely only on the occurreuces of beaks in the stomachs of sperm whales.

It is ascertained that information on the occurrences of beaks of squids in the stomachs of sperm whales is not conclusive enough to draw up a true pattern of the spatial and, moreover, the quantitative distribution of these or other species of Cephalopods. Beaks of squids are not destroyed while the food is digested and they are accumulated in stomachs in large numbers (up to 28000 beaks per stomach), but in general a stomach contains 7000-8000 beaks (Akimushkin, 1963; Betesheva, 1961; Korabel'nikov, 1959; Tarasovich, 1968; Berzin, 1971). Nevertheless, an attempt was made by Soviet investigators to delineate the boundaries of the habitat of M. hamiltoni using such indirect data (Klumov, Yukhov, 1975). It was necessary that such an attempt should be made because no specimens of this species have been caught in the Southern Ocean since it was described by Robaon in 1925. Efforts of many Soviet and foreign expeditions which included special studies of Antarctic Cephalopoda (as U.S. expeditions on board "Eltanin" started in 1962) were fruitless in this respect and until now no specimens have been caught with the exception of four larvae collected in the Pacific Southern Ocean and in the Drake Passage (McSweeny, 1970). Material from the stomachs of sperm whales analysed by Klumov and Yukhov was collected on board the Soviet whaling motherships "Yuri Dolgoruky" (1961-1965) and "Sovetskaya Rossiya" (1966-1968) and consisted only of beaks. Material collected on board "Sovestskaya Ukrania" (1967-1973) contaiued not only beaks, hut also fragments of bodles aud even aome intact animals (Klumov, Yukhov, 1975). In their work they provide the results of the analyses of twenty specimens of M. hamiltoni and, for six of them, the description of exterior and interior morphological features with reference to the places where sperm whales were caught.

Date	Position of Catch	Mantle Length in cm
31.1.1968	62°43'S, 170°05'E	155
4.4.1969	68°43'S, 122°W	65
6.1.1971	41°36'S, 48°50'E	39 and 45 (2 specimens)
1.3.1971	43°00'S, 46°00'E	39
17.3.1972	42°50'S, 31°20'E	47

Unfortunately, no coordinates are given for the remaining specimens, although the lengths of their mantles are provided (from 36 to 200 cm). This indicates that the specimens of M. hamiltoni are larger in size than those of other species occurring in the Southern Ocean. Some morphological and meristic characters of M. hamiltoni are also given in the work. As a result of the study the previously accepted opinion that the species belongs to the family Granchiidae was supported (Clarke, 1966; Roper et al., 1969). The main feature of the family is the preseuce of a coelom which contains a considerable amount of NH_4Cl in its fluids. Owing to a lower deusity of the solution (as compared to sea water) neutral buoyancy of the large-sized squid is sustained, therefore investigators believe that this species is a plankton or a semi-plankton form (Nesis, 1982). Judging from the fact that the mantle of the species is gelatinous, without well developed mantle muscles and fibre structure, the squid seems to be slightly movable, it hovers in the water and drifts with water masses (Klumov, Yukhov, 1975).

The analysis of the stomach contents of the collected squids revealed mesopelagic fish of families Myctophidae and Paralepididae, probably Electroua antarctica, Bymnoscopelus braueri and Paralepis atlantica, and some unidentified squids as the main componeuts. So far as maturity is coucerned, it is assumed that specimens with mantle smaller than 100 cm are immature.

With the same indirect method it is ascertained that the habitat of M. hamiltoni in the Southern Hemisphere extends from 32°-34°S to 68°-70° S, i.e. from the sub-tropical zone to high Antarctic latitudes. The most frequent occurrences of this specimen in the stomach contents of sperm whales are registered in the East Atlantic and West Indian sectors of the Southern Ocean between 18W and 90°E. Echosounder measurements have shown that sperm whales dive to the 500-600 m layer in some areas of the Southern Ocean in search of this species of squid (Klumov, Yukhov, 1975; Yukhov, 1982).

It seems that all the data obtained by Klumov and Yukhov supports the evidence that M. hamiltoni should be characterised as a notal-Antarctic species which inhabits the meso- and bathy- pelagic layers and with the Antarctic Deep Warm Water Mass it penetrates south of the Antarctic Convergence because it is a plankton or semi-plankton form. The Antarctic Deep Warm Water Mass in the Southern Ocean moves southward with a speed of 5-20 cm/sec in the 200-3000/3500 m layer and according to the results of the investigations conducted under the international program POLEX-SOUTH, the centre of this water mass is in the southwest part of the Indian Ocean (Ledenev, 1969; Sarukhanyan, 1981). However, when data on feeding habits of sperm whales in the Southern Ocean for 13 years were summed up, the scope of material on M. hamiltoni from the stomach contents of sperm whales caught south of the Antarctic Convergence appeared considerably greater than that of sperm whales caught in the notal waters. Therefore the authors came to an unexpected conclusion on the distribution of M. hamiltoni in the Southern Ocean. They characterise the species as a circumpolar Antarctic species, with the centre of its habitat being in the Antarctic including high latitude areas south of 60°S. They believe that the squid permanently inhabits the bathypelagic layer and it is restricted within off-bottom cool water mass moving from south to north ; therefore the species, having a planktonic way of life, drifts from the coastal Antarctic waters to the notal and tropical waters.

The conclusion is in contradiction with the warm-water character of the species of the family Cranchhiidae and of the subfamily Taoniinae, representatives of which inhabit the tropical, sub-tropical and temperate waters of the Northern and Southern Hemispheres (Voss, 1980; Nesis, 1982), whereas the Antarctic off-bottom water is characterised by a very low temperature up to -0.5°C. The conclusion also contradicts the authora' own data when they state that M. hamiltoni occurs in abundance at the depth of

500-600 m feeding on mesopelagic fish and at the same time being a prey for sperm whales (Klumov, Yukhov, 1975). However, the upper boundary of the Antarctic off-bottom cool water mass in the coastal waters of the Antarctic is at the depth of 1500-2000 m ; over the whole Antarctic region - the depth of 3000-3500 m; and in the north of the Southern Ocean, north of the Antarctic Convergence, the boundary lies at the depth of 4500-5000 m (Sarukhanyan, 1981).

We believe, therefore, that M. hamiltoni should be tentatively considered as an Antarctic species for the time being, or rather as a notal-Antarctic species until specimens of the species are captured by midwater fishing gear so that the pattern of its distribution in the Southern Ocean can be better understood.

In general, according to the data available, all the species of pelagic squids of the Southern Hemisphere found in the stomachs of sperm whales and in the catches of the midwater fishing gear, are distributed in the Antarctic Circumpolar Current which is the most powerful circnlation system in the World Ocean covering circumpolarly the 0-3000/3500 m layer and having many streams (Neyman, 1961; Deacon, 1937; 1963; Sarnkhanyan, 1980). It is ascertained that the north periphery of the ACC extends in the Atlantic Southern Ocean from the Falkland Islands to 43°S and to 37° in the vicinity of the zero meridian; in the Indian Ocean between 43° and 47°S; in the Pacific Southern Ocean between 47° and 55°S and in the Drake Passage between 50° and 56°S. The principal stream of the ACC moves mainly along the Antarctic Convergence between 50° and 55°S shifting south of Anstralia and New Zealand to 62°-63°S and in the Drake Passage to 56°-59°S. The southern components of the principal stream of the ACC flow along 60°-61°S with some divergences to the north to 57°-58°S in the Scotia Sea and to the south from the Ross sea to the Bellingshausen Sea reaching 66°-68°S. (Trechnikov, Maksimov, Gindysh, 1966; Sarukhanyan, 1980). It is evident that the species of squids with the tropical-subtropical and notal types of habitat are distributed in the north periphery of the ACC (Snb-tropical Convergence which at the same time is a northern boundary of the Southern Ocean). These species do not, as a rnle, reach the Antarctic Convergence. Species with notal-Antarctic and Antarctic types of the habitat are distributed in the principal stream of the ACC, in the Antarctic Convergence and, to the south of it, in the Polar frontal zone, the medium position of which is located between 50^{o} and 60^{o}S in the Atlantic Southern Ocean, between 50^{o} and 55^{o} S in the Indian Ocean and between 57^{o} and 61^{o}S in the Pacific Southern Ocean (Gordon, 1971; Sarukhanyan, 1980). The Antarctic and even notal-Antarctic species can penetrate to fairly high latitudes of the Antarctic (up to 68^{o}-70^{o}S) in southward moving streams of the ACC. Scientists observe cases where fragments of bodies or intact bodies of squids are found in the stomachs of sperm whales and seals in high latitudes. Several cases of captures of some species with midwater fishing gear are registered (Filippova, Yukhov, 1979; 1982; 1983; Yukhov, 1982; Clarke and MacLeod, 1982). This penetration of squids into high latitudes of the Antarctic is facilitated to a considerable extent by powerful quasi-stationary eddies induced in the ACC system (and for some species the phenomenon seems ro be expatriation from the centre of their habitat). The position of eddies of bottom-topographic origin is ascertained in the Drake Passage, Scotia Sea and its adjacent northeast area from the; in the Indiau Ocean between Africa and the coastal Lasarev, Riser-Larsen, Kosmonavtov and Sodruzestvo Seas ; in the Pacific in waters adjacent from the north to the Ross, Amundsen and Bellingshausen Seas (Sarukhanyan, 1980).

It is fairly safe to say that neither Antarctic nor notal-Antarctic squids of the Southern Ocean can live in cool coastal Antarctic waters because their habitat is the Antarctic Deep Warm Water Mass. At the same time the investigations indicate that this water mass is strongly transformed in the coastal seas due to supercooled shelf waters, loses its characteristics and is not observed any more in the vertical structure of water column (Gordon, 1967; 1975; Deacon, Moorey, 1975; Ledenev, 1969; Foster and Garmack, 1976; Sarukhanyan, 1981).

Rare cases of squid captures with midwater fishiug gear during the long-term period of research and indirect data on the distribution and feeding habits of sperm whales in the Southern Ocean provide evidence that this group of species of nekton animals is very scarce in the Antarctic waters south of 60^{o}S. In view of the fact thar many species of meso- and bathy- pelagic squids are the main food species of sperm whales in the Antartic, the relative abundance of squids can be evaluated from the distribution pattern of sperm whales in summer which feed only in places where cephalopods are concentrated (Berzin, 1971; Klumov, 1971).

Long-term investigations of the biology and ecology of the sperm whale and the analysis of all available data, published material and catch statistics of the International Whaling Commission (IWC), summarised in Berzin's monograph (1971), indicate that sperm whales are mainly distributed latitudinally in the zone between 40°-60°S. It is noted that south of 60°S only the large-size solitary male occurs, which constantly moves from area to area and does not gather in groups. Empty whale stomachs are frequently observed which is believed to be the result of unfavourable conditions involving low abundance and species composition of cephalopods (Kirpichnikov, 1949; 1950; Korabelnikov, 1959; Arsenyev, 1969; Berzin, 1971).

Althongh the area of the mass distribution of sperm whales in the Antarctic is confined to 60°S, their habitat extends south of the Antarctic Convergence to 60°-62°S in the Atlantic and Indian Southern Ocean and to 62°-66°S in the Pacific (Berzin, 1971). Therefore, not only the area of mass distribution of sperm whales, but their whole habitat in fact is within the boundaries of the principal stream of the ACC. As was shown previously, the principal stream area differs greatly from other areas of the South Antarctic. It is influenced by the circulation systems of the coastal seas, by the climatic conditions, by the oceanographic and biological structure and therefore, it may be described as a "natural zone of open Antarctic waters" in contrast to a "natural zone of drifting ice" (Lubimova, 1982; 1983; 1984).

It is ascertained that the area of the principal stream of the ACC, which corresponds to the natnral zone of open Antarctic waters, and particnlarly the Polar Frontal Zone is the centre of the habitat of mass plankton-eating mesopelagic species of fish, family Myctophidae. The fish feed on abundant copepod plankton in the 500-600 m layer, the secondary production of which amounts to up to 1.2 milliard tons a year. This type of fish also prevails in the area in terms of biomass (Lubimova, Makarov, Shust, Lisovenko, Zemsky, Studenetskaya, 1983; Lubimova, Shust, Troyanovsky, Semenov, 1983).

Analysis of the stomach contents of squids of families Onychoteuthidae, Cranchiidae and others which are regular food components in the diet of sperm whales and which are found in the stomachs of sperm whales and toothfish, indicates that squids feed mostly on mesopelagic Myctphidae (Yukhov, 1982). Consequently, the area with predominant biomass of notal-Antarctic and Antarctic meso- and bathy- pelagic squids coincides with the area where mesopelagic Myctophidae are in great abundauce and where most sperm whales are distributed, since they usually feed in the areas where squids are concentrated. In other words, meso- and bathy-pelagic squids of the Southern Ocean represent one of the components of the biological structure of a large, fairly isolated mesopelagic ecosystem of the natural zone of open Antarctic waters, the trophic dynamics of which rests upon high secondary production of copepod plankton and the final link of the food web is represented by sperm whales, (Lubimova, 1985b). Besides sperm whales, the final link of the web is very likely to include the Southern Elephant Seal (Mirounga leonina) which is characterised as a notal-Antarctic species (Laws, 1977). In accordance with recent observations the diet of the Elephant Seal contains squids of Gonatidae and Onychoteuthidae (Clark and MacLeod, 1982).

At present it is impossible to determine the quantitative characteristics of trophic relations in the mesopelagic community of the natural zone of open Autarctic waters. In regard to such components of the trophic structure as mass mesopleagic Myctophidae, the first approximate assessment has been made of their quantitative distribution and biomass formed in the Polar Frontal Zone where they form schools (Lubimova, Makarov, Shust et al., 1983). There is information on the abundance of sperm whales in the Southern Hemisphere (statiatics of IWC). An estimation of the annual secondary production of Antarctic copepods has also been obtained (Vorononа, Menshutkin, Tseytlin, 1980). However, there are no direct quantitative data on meso- and bathy- pelagic squids in the Southern Ocean. Furthermore, it has been ascertained that there are no beaks of squids in the bottom sedimeuts south of the Antarctic Convergence. At the same time, the number of beaks found in the bottom sediments in the notal area (50^{o}-30^{o}S) north of the Antarctic Convergence exceeds $100/m^2$ and their number is up to $10000/m^2$ in the Equatorial Zone (Belyaev, 1962). As it is known, this index is the most reliable for the assessment of the abundance of pelagic squids in some of the other areas of the World Ocean (Akimushkin, 1968; Zuev, Nesis, 1971). In view of the absence of beaks in the bottom sediments of the Antarctic it is possible to suggest two hypotheses : either all squids eaten by sperm whales migrate here from the sub-tropical and notal areas in the summer seasons, or the abundance of true Antarctic meso- and bathy- pelagic suqids is very low.

Relying on the study of the spatial and quantitative distribution of pelagic cephalopods in the World Ocean, the well known Soviet malacologist Nesis (1983) distinguishes three latitudinal zones characterised by higher productivity and biomass of oceanic squids : boreal, equatorial and notal. They alternate with four latitudinal zones characterised by a lower biomass : Arctic, central north, central south and Antarctic. In the Southern Hemisphere the maximum biomass is observed in the Sub-tropical Convergence waters (Nesis, 1983), i.e. near the northern boundary of the Southern Ocean. Nesis made an attempt to assess the biomass and relative distribution of cephalopods in the World Ocean using food rations of specific predators (sperm whales and other marine mammals and birds). The cephalopod biomass in the World Ocean is estimated to be 2.2 milliard tons (Akimushkin, 1970), and the biomass of neritic-oceanic and oceanic squids is assessed at the level from 5-6 million tons (Moiseev, 1969) to dozens or hundreds of million tons (Gulland, 1970). According to the estimates made by Nesis the total consumption of pelagic cephalopods by predators in the World Ocean is 175-200 million tons from the present stock and 325-350 million tons from the initial stock. Using the annual P/B coefficient of 3.5-2.0, which related to pelagic cephalopods with a one- and two- year life span and a 50%-grazing factor, Nesis obtained a rough estimate of the total biomass of pelagic squids in the World Ocean which is equal to 115-150 million tons at the present rate of consumption and to 220-280 million tons at the maximum rate of consumption (Nesis, 1983).

It is difficult to say what portion of the total biomass of the mesopelagic community of the natural zone of open Antarctic waters is referred to squids, and as Nesis points out (1983), the the whole Antarctic area is characterised by a lower biomass of pelagic cephalopods. It is even more difficult to assess the abundance of squids occurring in high latitudes of the Antarctic south of 60°S, where the scale of long-term research of baleen whales and Antarctic krill is much broader but the information available on squids is so small.

The study of the biology of squids (feeding habits, reproduction, life history), regularities of spatial and quantitative distribution aud assessment of their biomass iu the Antarctic, are very important for the investigation of the structure and functioning of the Antarctic ecosystems and setting up monitoring. These problems may be resolved on the basis of the analysis of the factual data which can be collected in the course of wide-scale specific research expeditions. At first such investigations should be conducted in the North Antarctic, i.e. in the area influenced by the principal stream of the ACC which corresponds with the uatural zone of open waters, and particularly in the Antarctic Convergence. The area may turn out to be the closest (in terms of productivity) to the region near the Sub-tropic Convergence which is known for a higher biomass of meso- and bathy- pelagic squids. The reasous may be the well known similarity in such important environmental factors as horizontal and vertical circulation of waters, the heat content in the midwater and the character of bioproductive processes at the initial level of the productive cycle (Lubimova, 1982; 1983; 1985a). It does uot seem to be accidental that most species of meso- and bathy- pelagic squids occurring in the Antarctic are knowu for their subtropical-notal and uotal-Antarctic habitats. Special attention should be paid to the notal-Antarctic small-sized squid Brachioteuthis riisei which penetrates into the northern part of the Scotia Sea and into the waters off South Georgia where the abundance of squid seems to be fairly high. Besides, this squid inhabits the meso- and epi-pelagic layer aud can feed, to some or other extent, on mass Antarctic euphausiids, such as the relatively deep-sea Euphausia triacantha and E. superba brought here by the Weddell Sea current. In their turn, the squid can be a food component in the diet of numerous birds, southern fur seal (Aretocephalus gazella), southern elephant seal (Miorounga leonina) and baleen whales on their migration routes to the high Antarctic.

It is worth noting that efforts should be concentrated on the study of the highly productive area where the southern components of the ACC interact with waters of the High-Latitude Modification of the coastal seas. This area is situated in the high Antarctic, south of 60°S, in the region of cyclonic quasi-stationary circulation systems associated with coastal seas. The area corresponds with the natural zone of drifting ice. The area can be comparatively easily found by the high horizontal deep-sea maximum temperature gradient, by the maximum horizontal gradient in the distribntion of Si and Si/P (Maslennikov, 1980; Arzhanova, Mikhaylovskij, 1980; Bogdanov, Solyankin, Rodionov, 1980). In accordance with the analysis of data on the distribution of squids of the Southern Ocean, only a few speciea penetrate into the high latitudes of the Antarctic, up to 67°-69°S. Judging from direct captures of some specimens and findings in the stomach contents of seals of ice forms it is possible to note that such meso- bathy- pelagic squids as Kondakovia longimana, Alluroteuthis antarcticus, Psychroteuthis glacialis can play a certain, unknown at present, role in the trophic dynamics of the ecosystem of this natural zone. As mentioned above, these species can rise into the lower epipelagic layer and can therefore feed on Antarctic krill in places of its heavy abundance. When they are in the lower epipelagic and upper mesopelagic layers, at the depths of 300-400 m (Kooyman, 1966; Yukhov, 1982) they can be a food component in the diet of Sonthern Toothfish, Weddell and Ross seals. At the same time, it is important to ascertain whether these species of squids are permanent inhabitants of the natural zone of drifting ice, whether they migrate from relatively low latitudes of the Antarctic, or penetrate into the high latitudes with the southern components of the ACC in the layer of the Antarctic Deep-sea Warm Water Mass. It is worth recalling that the coastal seas and the adjacent areas up to 58°S in the Atlantic Southern Sea, up to 60°-61°S in the Indian Ocean and up to 64°-67°S in the Pacific Southern Ocean in the autumn-winter period are covered with ice, and as a result the midwater is supercooled and extreme conditions are formed for these warm-water animals.

Table 1

The species composition of squids occurring in the Southern Ocean (from Filippova, Yukhov, 1979)

Families	Species
Onychoteuthidae	Moroteuthis ingens (Smith, 1881)
	Moroteuthis knipovitchi (Filippova, 1972)
	Kondakovia longimana (Filippova, 1972)
Cranchiidae	Mesonychoteuthis hamiltoni (Robson, 1925)
	Galiteuthis glacialis (Chun, 1906)
	[Synon. Crystalloteuthis glacialis (Chun, 1906) and Galiteuthis asper (Filippova, 1972) - Nesis's recent data (1982)]
	Taonius pavo (LeSueur, 1821)
Histioteuthidae	Histioteuthis atlantica (Hoyle, 1885)
	Histioteuthis eltaninae (N. Voss, 1962)
	Parateuthis tunicata (Thiele, 1921[x])
Gonatidae	Gonatus antarcticus (Lönnberg, 1898)
Neoteuthidae	Alluroteuthis antarcticus (Odhner, 1923)
Psychroteuthidae	Psychroteuthis glacialis (Thiele, 1921)
Brachioteuthidae	Brachioteuthis riisei (Steenstrup, 1882)
Bathyteuthidae	Bathyteuthis abyssicola (Hoyle, 1885)
Batoteuthidae	Batoteuthis scolops (Young and Hoper, 1968)

[x] Parateuthis tunicata (Thiele, 1921) is included in the present list arbitrarily because the species was described only by two larvae with mantles 5-8 mm long caught at a depth of over 2000 m in Antarctic waters and since that time no specimens have been encountered. According to the data available, the larvae do not belong to any known family of Oegopsida (the family Insertae sedis according to Nesis, 1982).

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PRELIMINARY ATLAS OF BALAENOPTERID WHALE DISTRIBUTION IN THE SOUTHERN OCEAN BASED ON PELAGIC CATCH DATA

Abstract

A series of 57 computer-generated maps is presented, depicting the locations of pelagic catches of Balaenopterid whales by month between 1931/32-1979/80. Two sets of maps were produced. The first series contains 24 maps of catches by species by month, and the second consists of 30 maps of catches of fin whales for each season from 1952/53-1961/62 for January, February, and March, plus three summary maps of fin whales catches for the years 1952/53-1961/62 combined, for each of the three months.

ATLAS PRELIMINAIRE DE LA REPARTITION DES BALEINES DANS L'OCEAN ARCTIQUE A PARTIR DES DONNEES DE PRISE PELAGIQUE

Résumé

Un ensemble de 57 cartes établies par ordinateur est présenté; elles montrent les positions des prises pélagiques des baleines par mois entre 1931/32-1979/80. Deux séries de cartes ont été produites. La première contient 24 cartes de prises par espèce et par mois, et la seconde se compose de 30 cartes des prises de rorquals communs pour chaque saison de 1952/53-1961/62 pour janvier, février et mars, plus trois cartes récapitulatives des prises de rorquals communs pour les années 1952/53-/961/62 combinées et ceci pour chacun des trois mois.

ПРЕДВАРИТЕЛЬНЫЙ АТЛАС КАРТ РАСПРЕДЕЛЕНИЯ УСАТЫХ КИТОВ В ЮЖНОМ ОКЕАНЕ, СОСТАВЛЕННЫЙ НА ОСНОВЕ ДАННЫХ ПЕЛАГИЧЕСКИХ УЛОВОВ

Резюме

Дается серия из 57 обработанных на ЭВМ карт с указанием местоположения пелагической добычи китов-полосатиков по месяцам в период между 1931/32 и 1979/80 гг. Выпущено два рода карт. К первому принадлежат 24 карты с указанием добычи по видам за каждый месяц, а ко второму - 30 карт с указанием добычи финвалов за январь, февраль и март каждого сезона с 1952/53 г. по 1961/62 г., а также три сводные карты с указанием общей добычи финвалов за все годы с 1952/53 г. по 1961/62 г. за каждый из этих трех месяцев.

ATLAS PRELIMINAR DE LA DISTRIBUCION DE LA BALLENA BALAENOPTERIDA EN EL OCEANO AUSTRAL BASADO EN DATOS DE CAPTURAS PELAGICAS

Extracto

Se presenta una serie de 57 mapas trazados por computadora, los que indican la ubicación de las capturas pelágicas de las ballenas balaenoptéridas por mes entre 1931/32 y 1979/80. Se emitieron dos juegos de mapas. La primera serie contiene 24 mapas de capturas por especie y por mes, y la segunda consiste en 30 mapas de capturas de ballenas de aleta en cada temporada desde 1952/53 hasta 1961/62 para Enero, Febrero y Marzo, además de tres mapas de resumen de las capturas de ballenas de aleta para los años 1952/53 - 1961/62 en conjunto, para cada uno de los tres meses.

Introduction

Prior to their commercial exploitation, the rorquals (Mysticeti : Balaenopteridae) were one of the dominant, top trophic level components of the pelagic ecosystem throughout the Southern Ocean. The six species of this family are characterized by a suite of unique anatomical characteristics that adapt them for filter-feeding on dense swarms of epipelagic macroplanktonic crustaceans by a method referred to as "gulping" or "engulfment" (Nemoto, 1959). Five of the six species have a cosmopolitan distribution and are sympatric throughout much of the Southern Ocean during the summer. These five species are the blue whale (*Balaenoptera musculus*), the fin whale (*B. physalus*), the sei whale (*B. borealis*), the minke whale (*B. acutorostrata*), and the humpback whale (*Megaptera novaeangliae*) (Mackintosh, 1965; Brown and Lockyer, 1984).

From 1925/26 to 1984/85, the pelagic fishery for baleen whales in the Southern Ocean (south of 40°S latitude) killed over one million whales of these five species. In less than 50 years, the populations of four of these species (all except the minke whale) were reduced by 90% or more (Tonnessen and Johnsen, 1982; Mizroch, 1984). The catch records thus provide an unparalleled set of data for evaluating the original distribution patterns, movements, and relative abundance of these species. These data were gathered by the Committee for Whaling Statistics in Sandefjord, Norway, a function recently assumed by the International Whaling Commission in Cambridge, England. A copy of these data is kept on computer tape at the National Marine Mammal Laboratory in Seattle.

Although the current abundance and population trends of depleted stocks are somewhat uncertain (e.g., Breiwick and Braham, 1984), management efforts have been directed at encouraging a recovery of these protected species. As organizations such as the International Whaling Commission (IWC) and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) consider management and conservation strategies, they will require information on interactions among whale stocks, their prey, and commercial fisheries. In particular, data on the spatial and temporal distribution of these components will be desirable.

To date, there have been no summaries of the whale catch data in a convenient, readily available format. Therefore we have produced a preliminary atlas that depicts the seasonal and geographical distribution of the pelagic catches of each of these five species.

One purpose of the atlas is to facilitate management decisions regarding the recovery of depleted whale stocks and possible competition with commercial fisheries for their preferred prey. For example, these data may help identify feeding areas that may be of importance to various whale species. The atlas may also provide a stimulus for further analysis of distribution and food habits data potentially available from whaling catch records.

Methods

A series of computer-generated maps of the Southern Ocean was produced. The pelagic catch data are displayed on a grid of 1° latitude by 2° longitude (111.1 x 170.4 kilometers at 40°S, 111.1 x 111.1 kilometers at 60°S, and 111.1 x 38.9 kilometers at 80°S) with catch density gradients represented by four distinct shading patterns. The shadings were designed to represent the relative abundance of catch records within each map; hence the numerical divisions between shading patterns differed depending on the overall number of whales caught, and the absolute densities are not comparable between maps. The class interval was calculated as a 4-step geometric progression (base 2) with an open-ended upper interval, and the upper limit of the first interval was set at the median (Evans, 1977). The legend on each map indicates the calculated intervals, but since the upper interval was open-ended, the actual maximum was indicated parenthetically.

The catch data shown on the maps are the pelagic data collected by the Bureau of International Whaling Statistics (BIWS) from 1931/32-1979/80. Catches north of 40°S and from land stations were not included. Latitudes and longitudes represent the noon position of the processing ship. The computerized BIWS data were provided by the computing facility of the IWC.

Subsets of the BIWS files were selected to help elucidate spatial and temporal relationships of catch records. Two groups of subfiles were analyzed :

1) general distribution of catches by month (all years pooled),

   and

2) inter-annual changes in the distribution of catches (using fin whales as an example).

The first group of maps focuses on the distribution patterns within seasons. The second group of maps was produced to help assess the extent to which areas of high whale catches changed between seasons. This topic seems particularly important in light of the recent results of surveys for Antarctic krill (Euphausia superba), a preferred prey of several whale species. Those surveys suggest a marked inter-annual variation in the observed abundance of krill at selected study sites.

The maps were produced using a mapping computer package called "WORLD Projection and Mapping Program, Version 3.51" (Philip M. Voxland, University of Minnesota, Minneapolis) on a Burroughs 7800 mainframe computer at the Northwest and Alaska Fisheries Center, Seattle. The coastline and ice shelf data came from the "World Data Bank II" files (U.S. Central Intelligence Agency, Washington, D.C.).

Results

A total of 57 maps were produced :

1) A set of 24 maps (Figs 1-24) depicting the catches, all years combined, for each of the five species in each of the five summer months from December through April (December through March for minke whales as there were no catches in April),

2) A set of 33 maps (Figs 25-57) depicting the catches of fin whales for each season from 1952/53 through 1961/62, in each month from January through March, plus catches for all ten seasons combined for each of the three months.

Discussion

Valid interpretations of the information on these maps can be made only if they are evaluated in the broad context of the life history and ecology of each species, and of the history of whaling operations throughout the Southern Hemisphere. There are striking differences in overall latitudinal distribution of the different whale species ; these maps depict this gross difference clearly. As whalers shifted their attention from one species to another, the geographic focus of operations changed and hence the distribution of catches. In order to interpret these data properly, it is important to differentiate between distribution patterns influenced by natural factors, such as prey distribution, and operational factors, such as a shift in target species.

In the second phase of this project we plan to undertake the following :

1) A summary of the biology of each species especially their food habits, migration, and the annual cycles. Included will be a review of published mark-recapture data.

2) A review of the history of whaling throughout the Southern Hemisphere. This will include complete tabulations of catches (other than the pelagic data which form the basis of the maps) of the following three fisheries : (a) the 19th century open-boat fishery (relevant only for humpback whales); (b) 20th century winter catches north of 40^{o}S; and (c) 20th century shore station catches during the summer south of 40^{o}S. Also included will be a description of technological and legal changes that affected the operations of the whale fishery.

3) Description of the data base for pelagic whaling in the Southern Ocean, an explanation of the computerized mapping procedure, and the rationale for the cartographic conventions that we have used.

4) A detailed statistical analysis for each species (including summary maps, graphs, and tables) of changes in latitudinal and longitudinal distribution and abundance both generally and by sex and reproductive class. This should illuminate migration and segregation patterns.

5) A detailed comparison (including summary maps, graphs, and tables) of temporal and spatial differences between species.

Several additional topics have been suggested by this work, for example :

1) Analysis of food habits data by area and date. A qualitative comparison of prey items recorded in harvested whales may provide insight into seasonal changes in prey and distribution.

2) Comparison of whale and krill catches. Plotting the temporal and spatial relationships between these groups may assist in identifying potential conflicts between recovering whale stocks and their prey.

3) Fine scale comparison of minke whale catch and sea ice distribution. Satellite records of sea ice distribution are available from years during which minke whaling was active. A comparison of these data sets may elucidate the influence of ice on the distribution of this species.

We hope that this atlas will help illuminate the ecological relationships of these species not only to each other, but also to physical, chemical, and biological features of the entire Southern Ocean ecosystem. Moreover, we hope that it will stimulate further questions that could be answered by detailed analysis of this large data base.

Acknowledgements

The authors wish to thank K.C. Zinnel for installing the WORLD Mapping Package on the Northwest and Alaska Fisheries Center (NWAFC) computer, for developing the program used to define the data grids, and for providing consistent good advice as the project progressed. We are also grateful to the computing facility of the NWAFC, the Office of Fishery Information Systems, for their assistance during this project. The systems staff assisted in implementing the WORLD Mapping Package, arranged for disk storage when needed, and the operations staff were especially helpful, conscientious, and expedited plotting operations.

This project was undertaken as a collaborative effort of the U.S. Marine Mammal Commission and the National Marine Mammal Laboratory, NWAFC.

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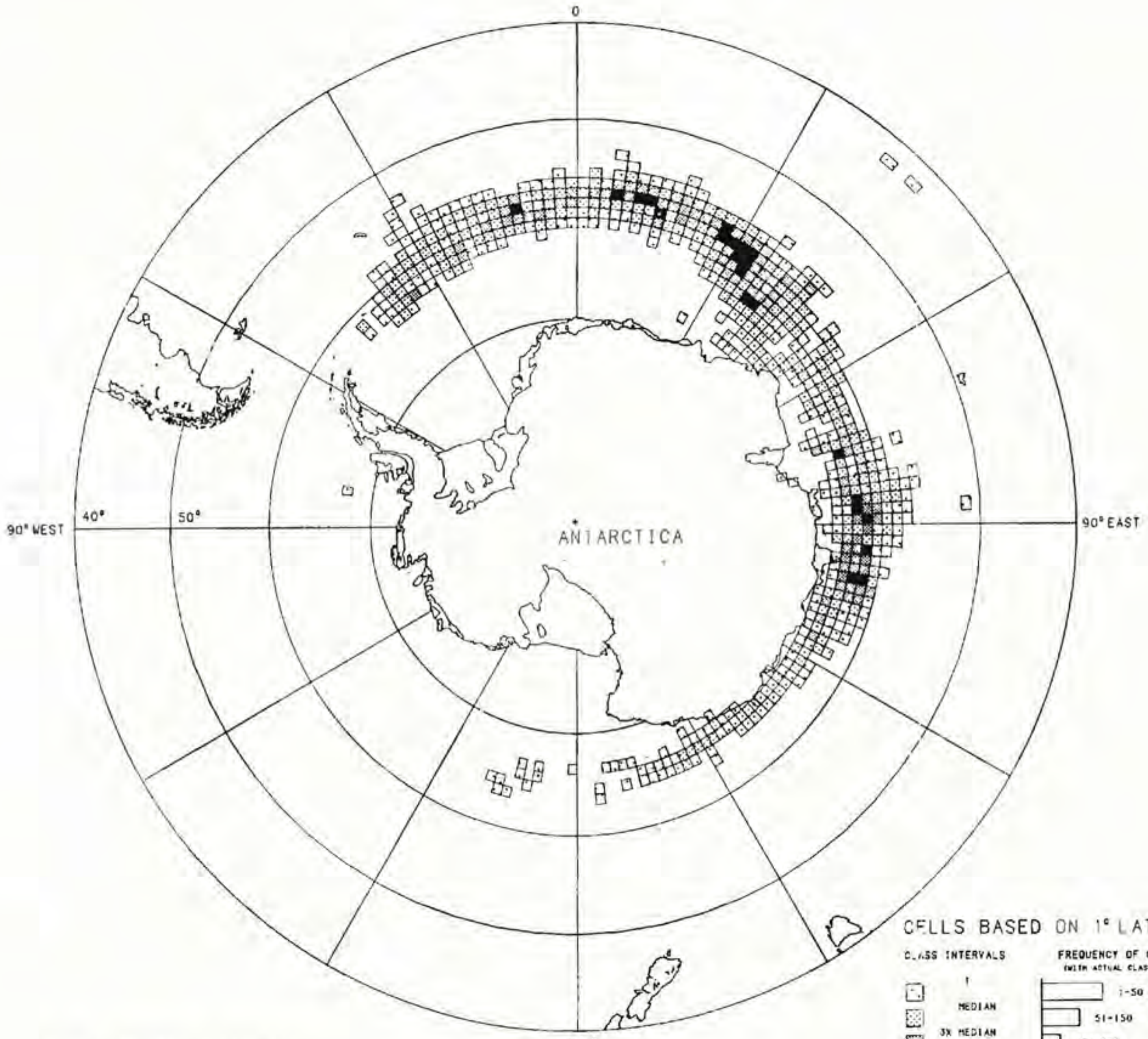
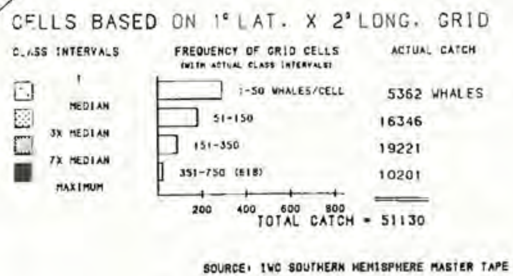
Figure 1.



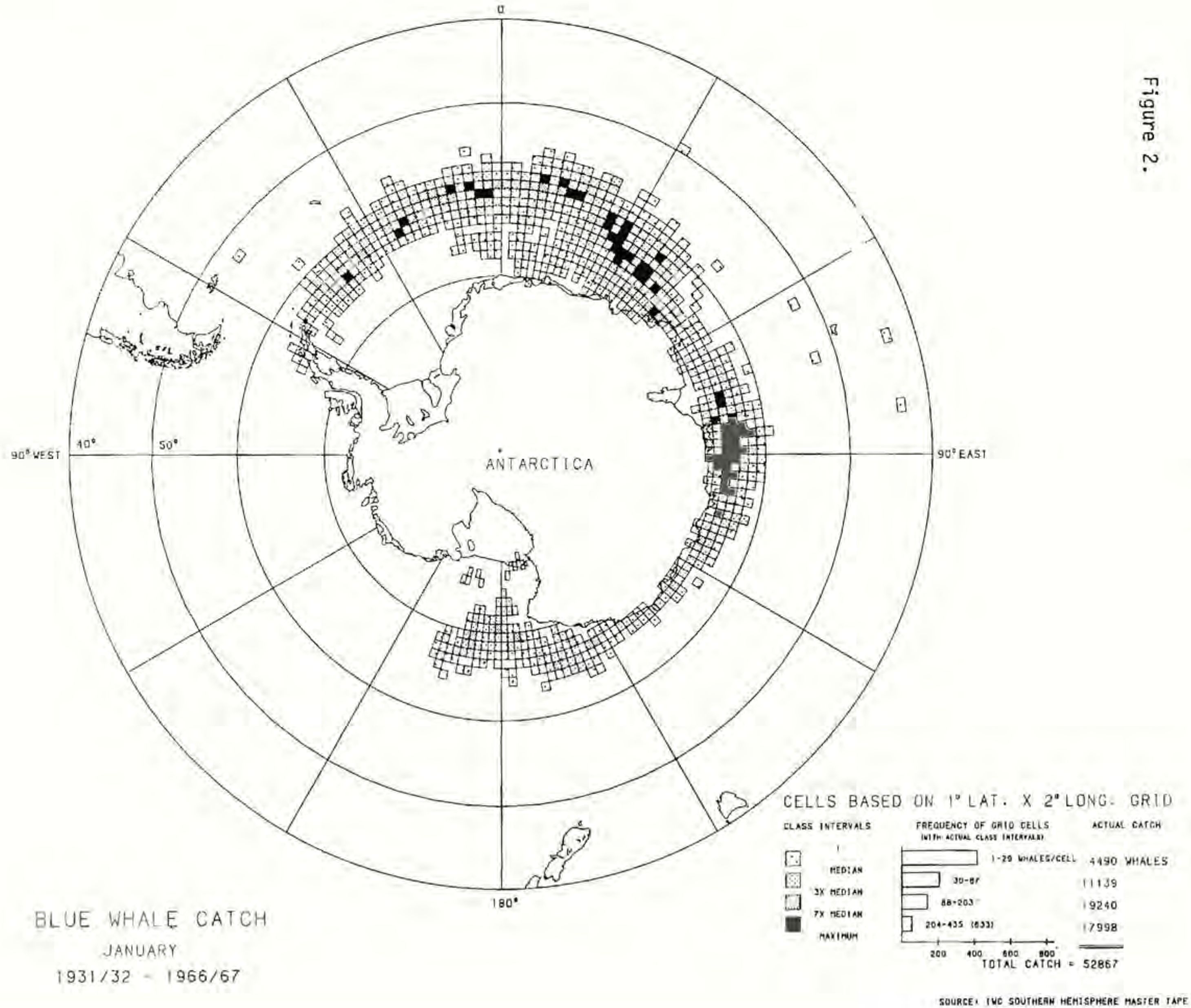


BLUE WHALE CATCH

DECEMBER

1931/32 - 1966/67

Figure 2.

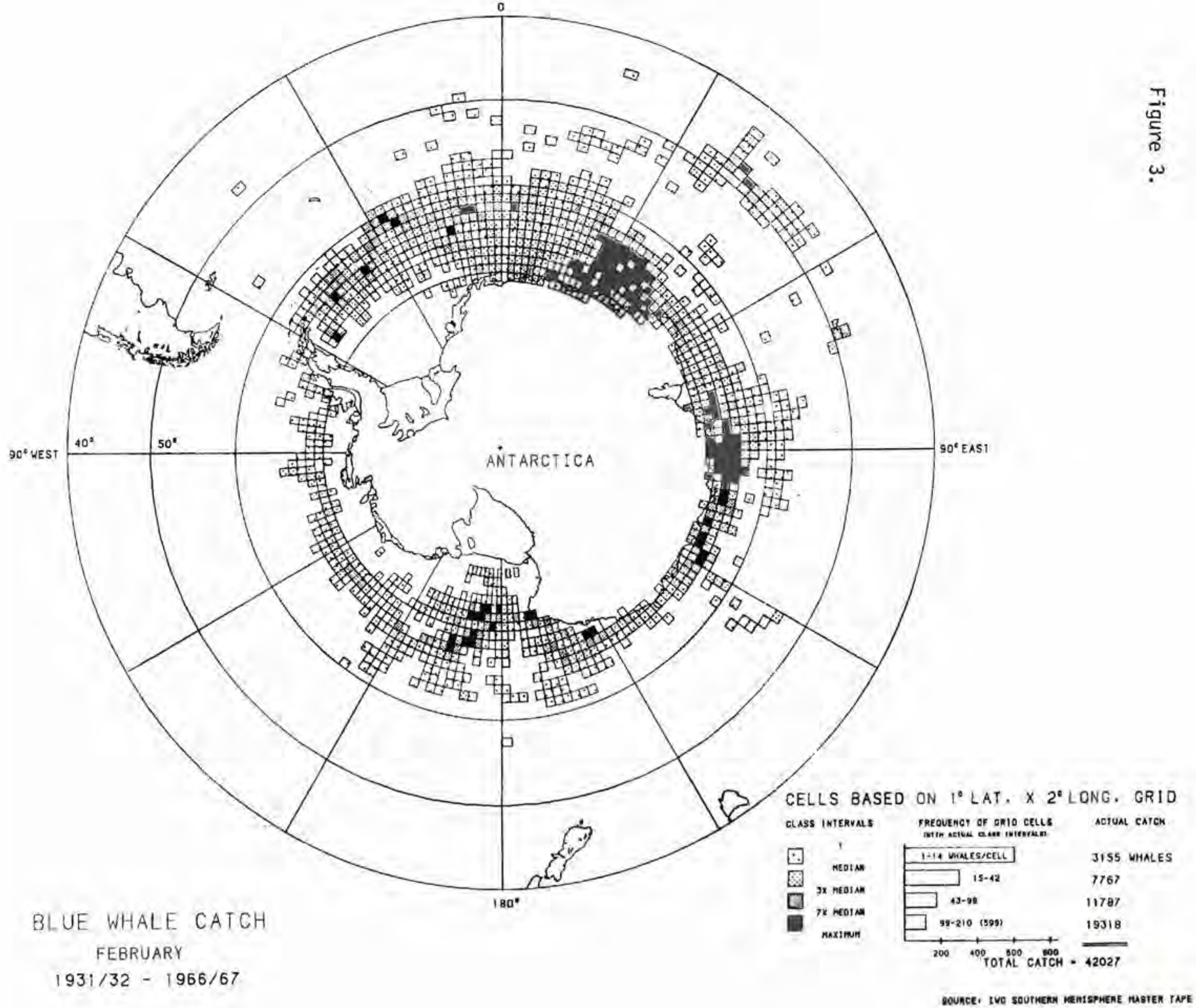


BLUE WHALE CATCH

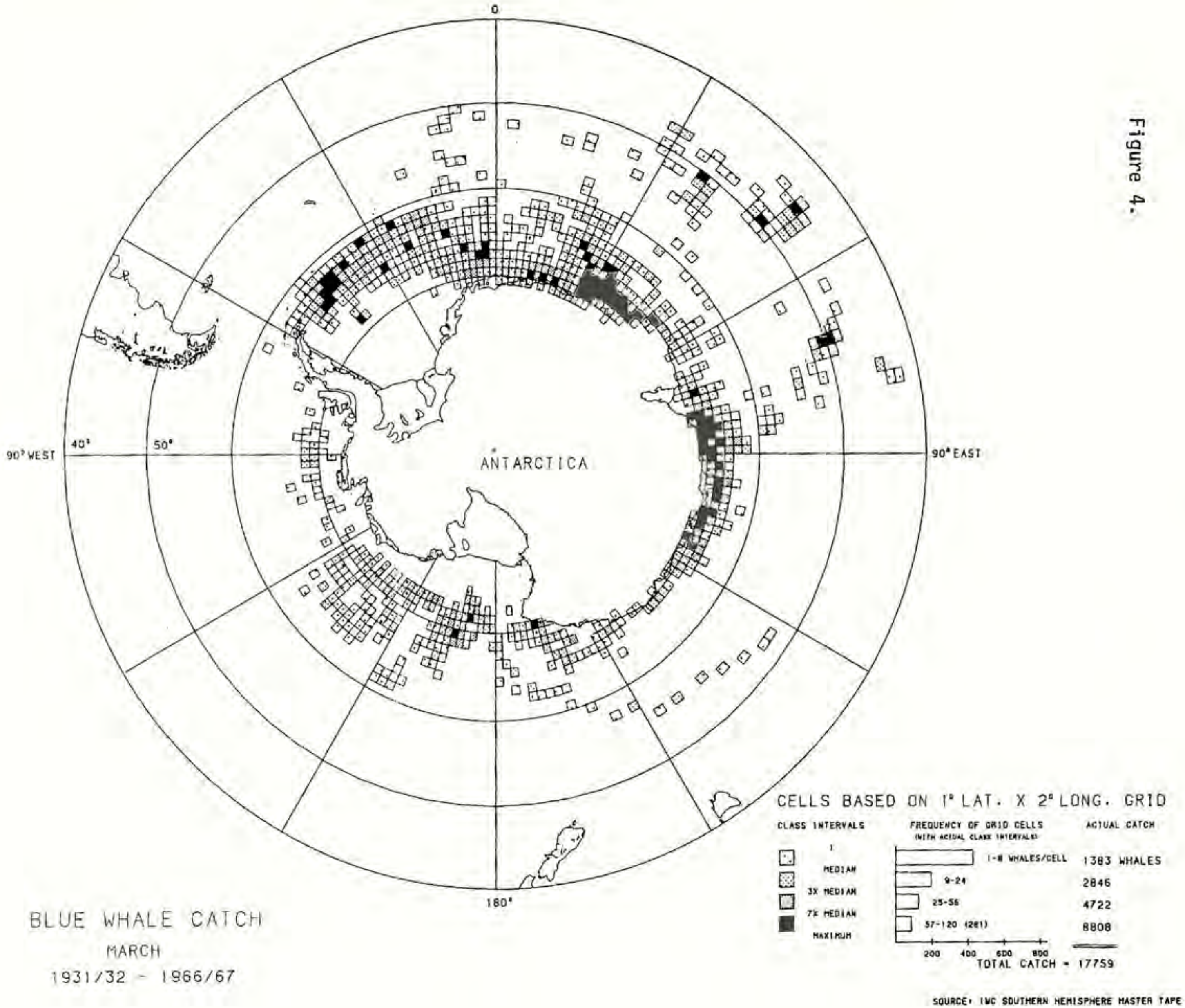
JANUARY

1931/32 - 1966/67

Figure 3.



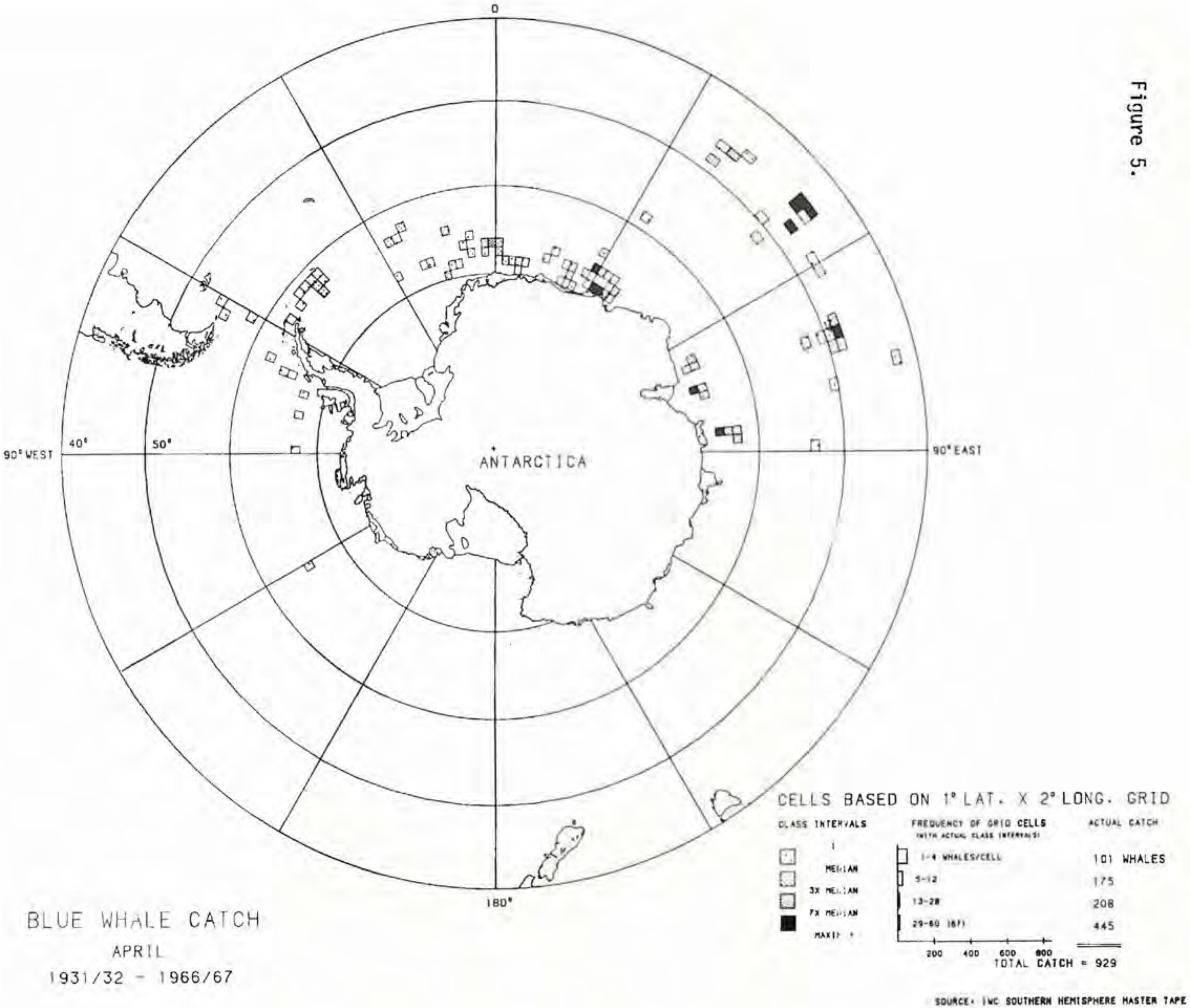
BLUE WHALE CATCH
FEBRUARY
1931/32 - 1966/67



BLUE WHALE CATCH
MARCH
1931/32 - 1966/67

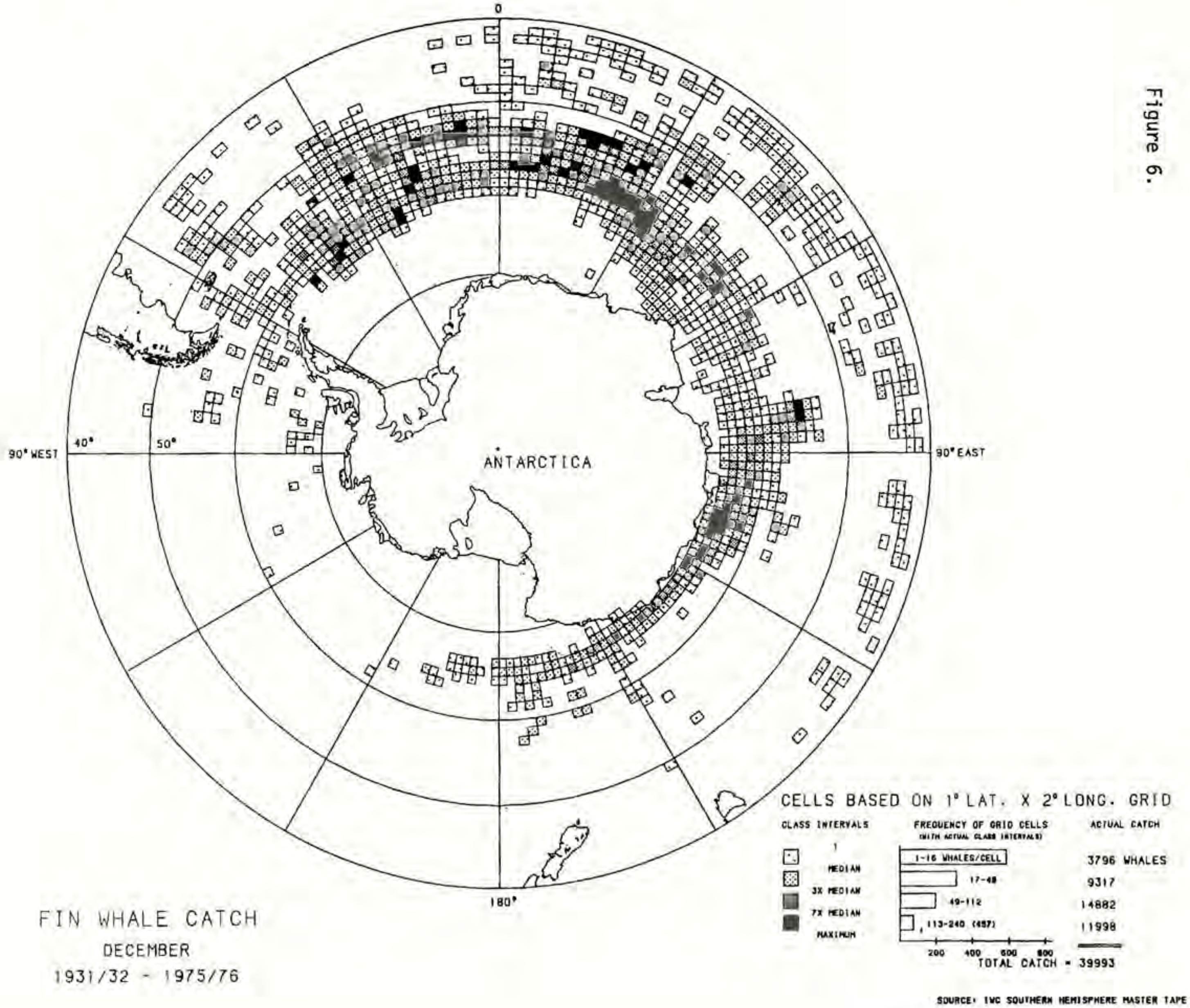
Figure 4.

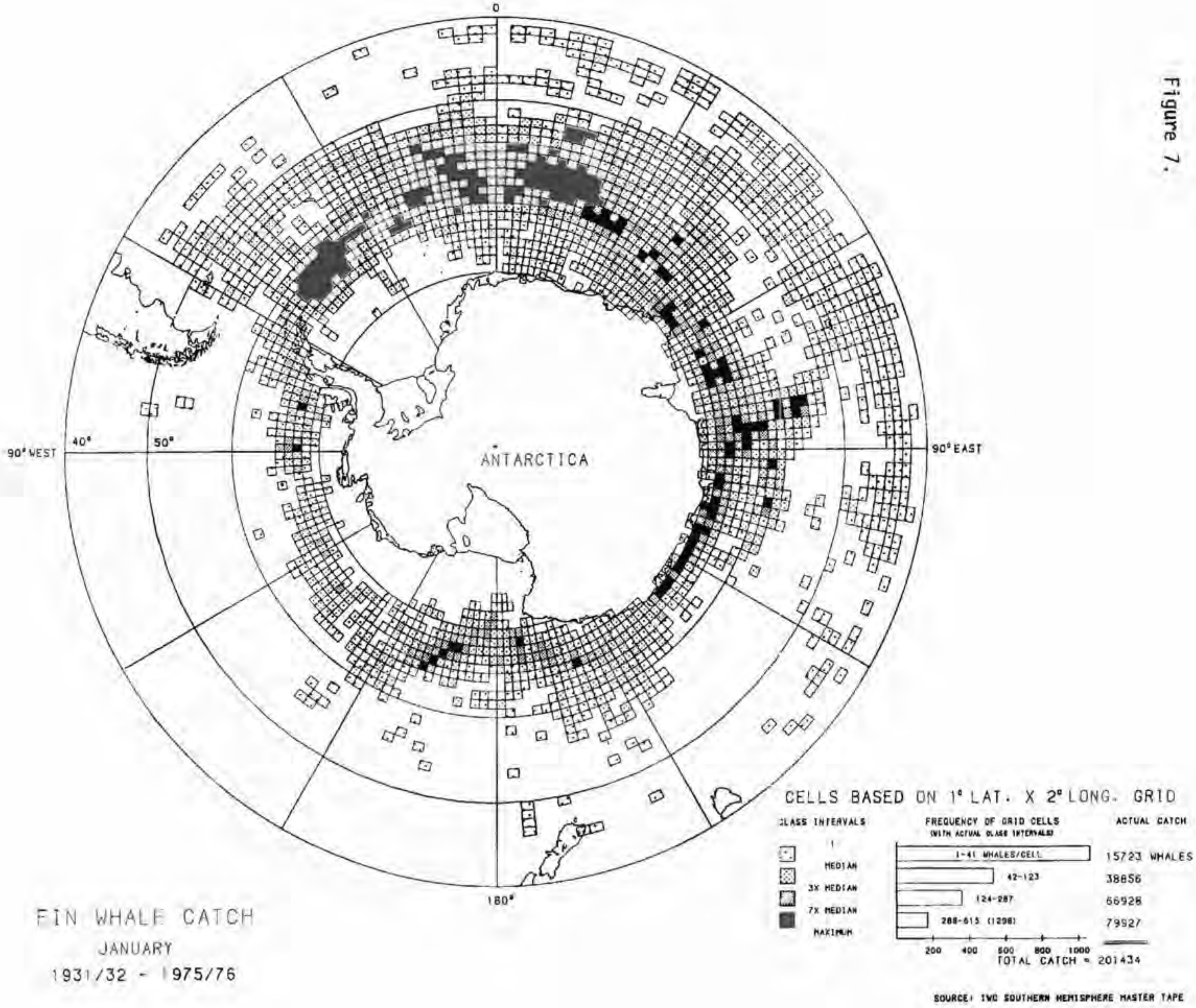
Figure 5.



BLUE WHALE CATCH
APRIL
1931/32 - 1966/67

Figure 6.

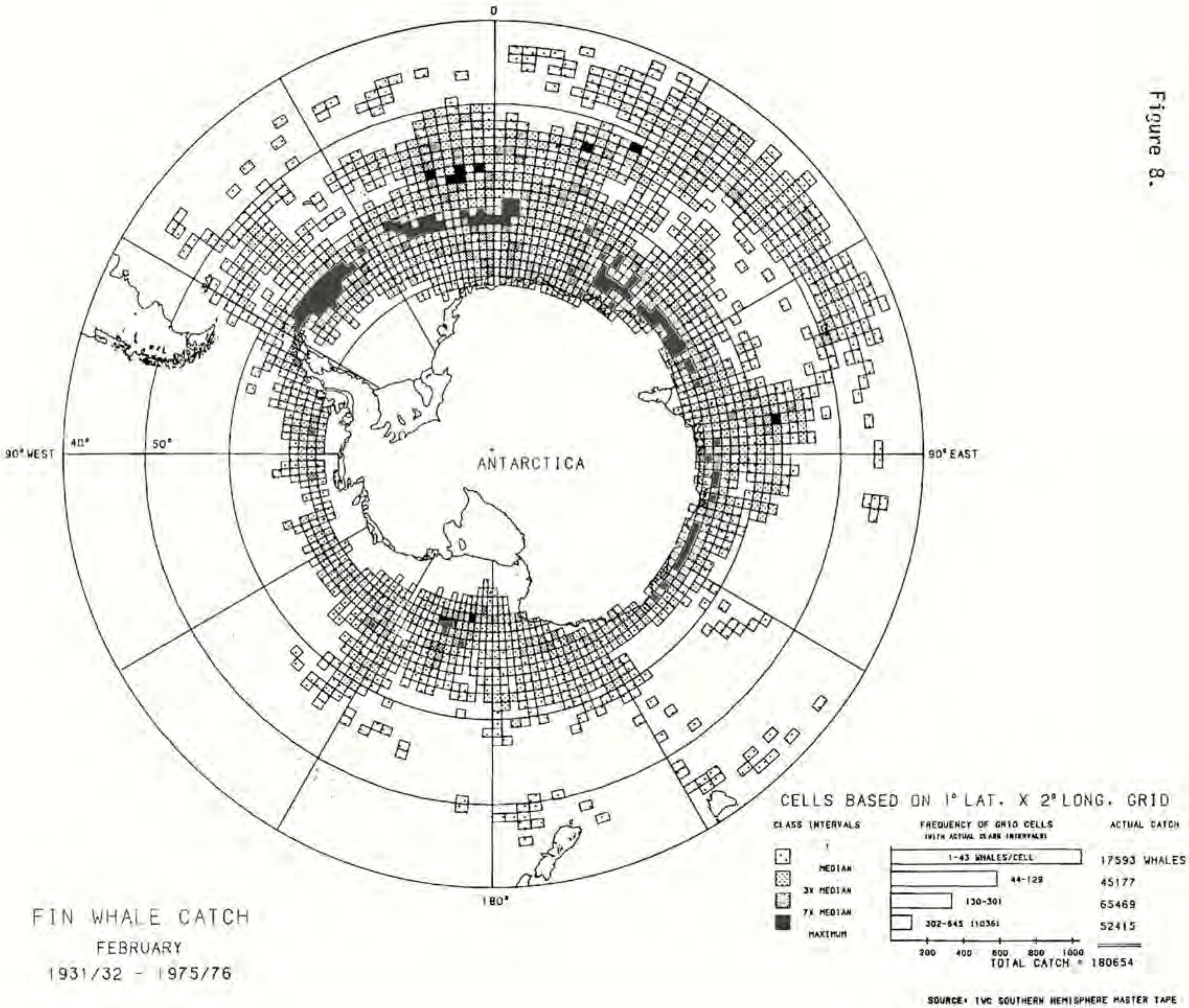

0
90° WEST
40°
50°
ANTARCTICA
90° EAST
180°
CELLS BASED ON 1° LAT. X 2° LONG. GRID
CLASS INTERVALS
1
MEDIAN
3X MEDIAN
7X MEDIAN
MAXIMUM
FREQUENCY OF GRID CELLS
(WITH ACTUAL CLASS INTERVALS)
1-16 WHALES/CELL
17-48
49-112
113-240 (457)
200
400
600
800
ACTUAL CATCH
3796 WHALES
9317
14882
11998
TOTAL CATCH = 39993
FIN WHALE CATCH
DECEMBER
1931/32 - 1975/76
SOURCE: IWC SOUTHERN HEMISPHERE MASTER TAPE



FIN WHALE CATCH
JANUARY
1931/32 - 1975/76

Figure 7.

Figure 8.

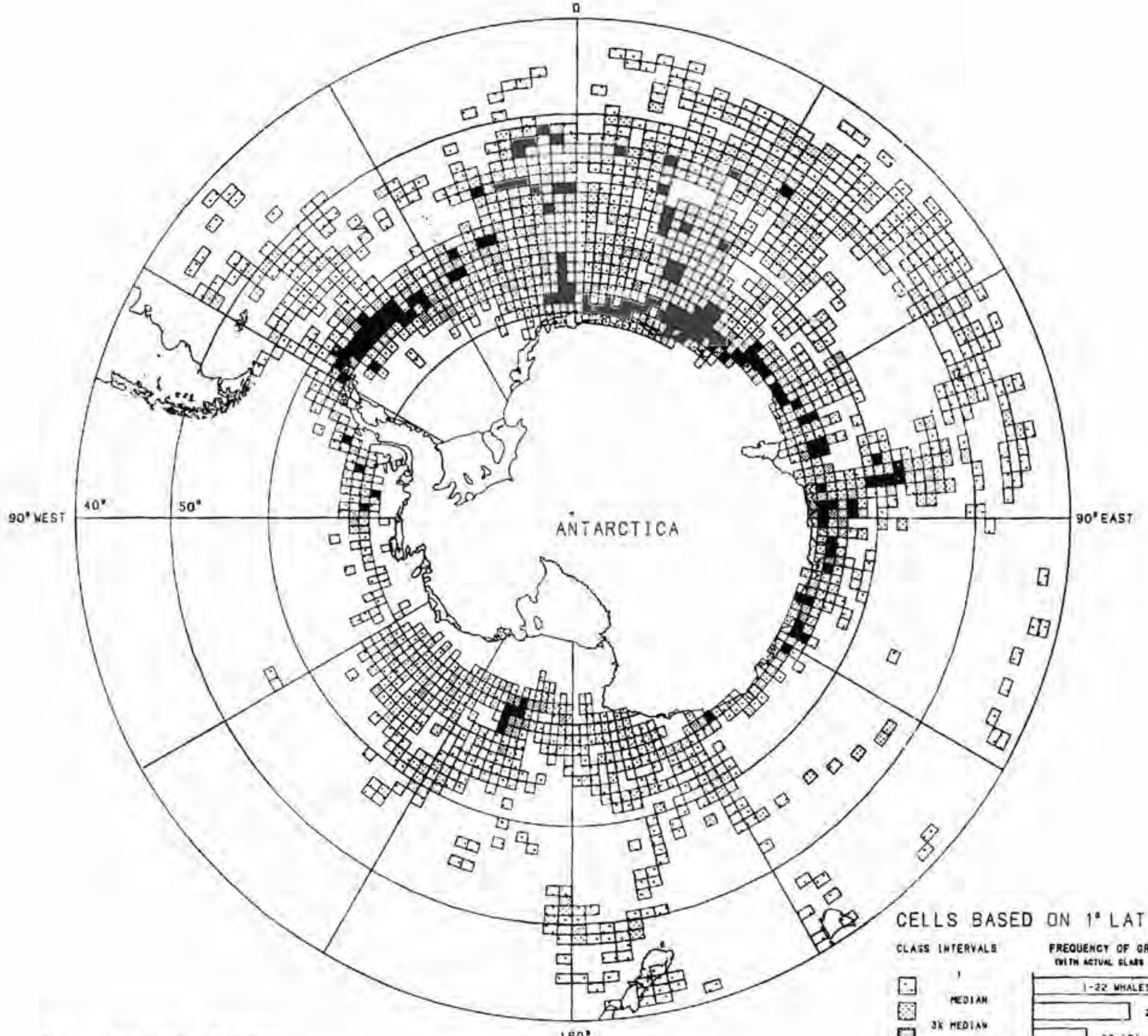


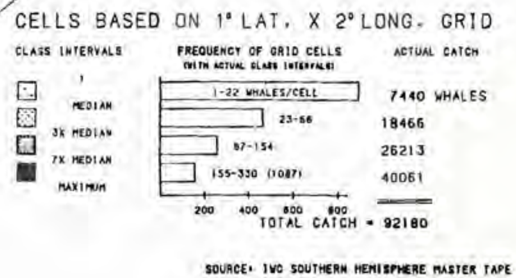
FIN WHALE CATCH

FEBRUARY

1931/32 - 1975/76

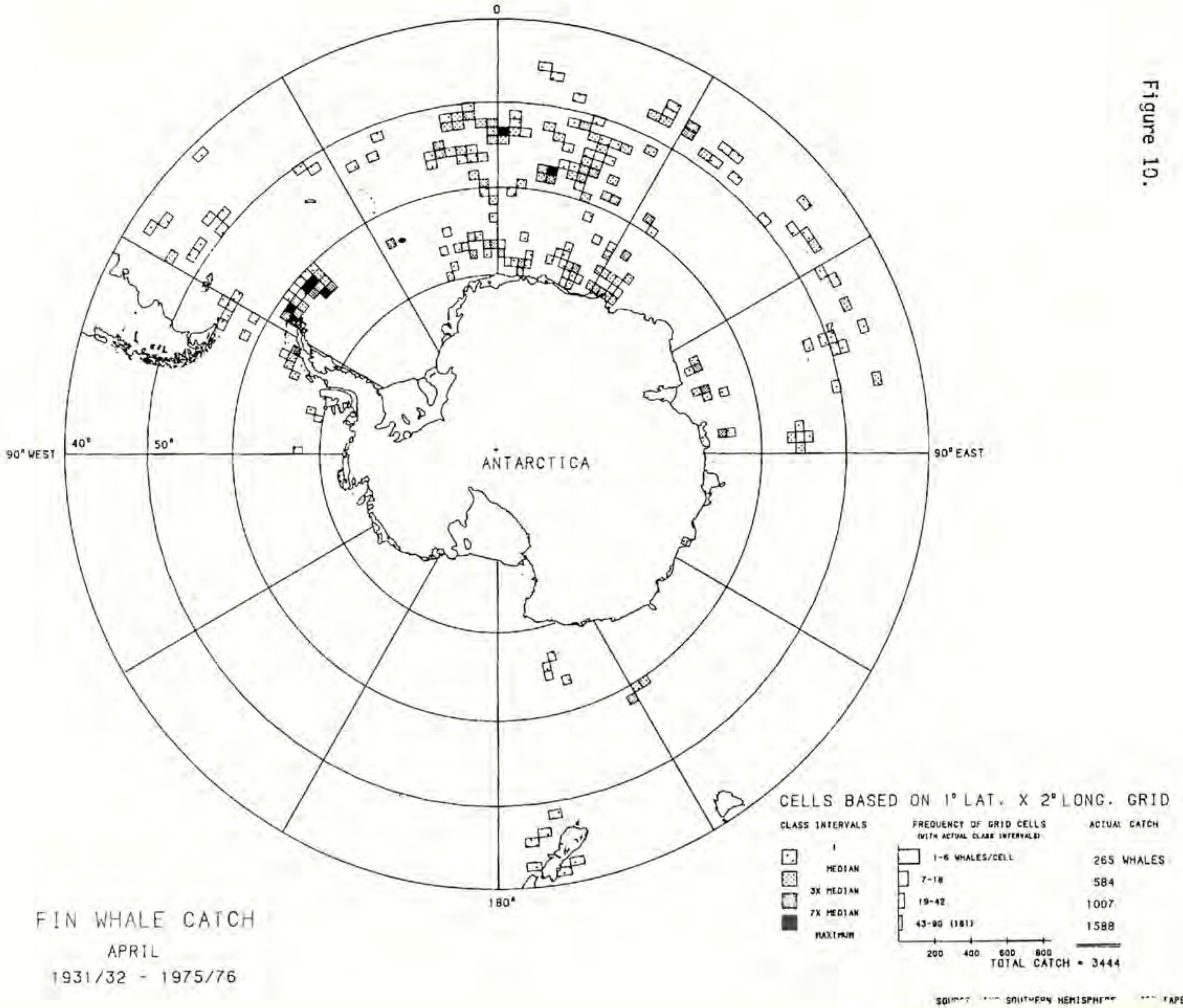
Figure 9.





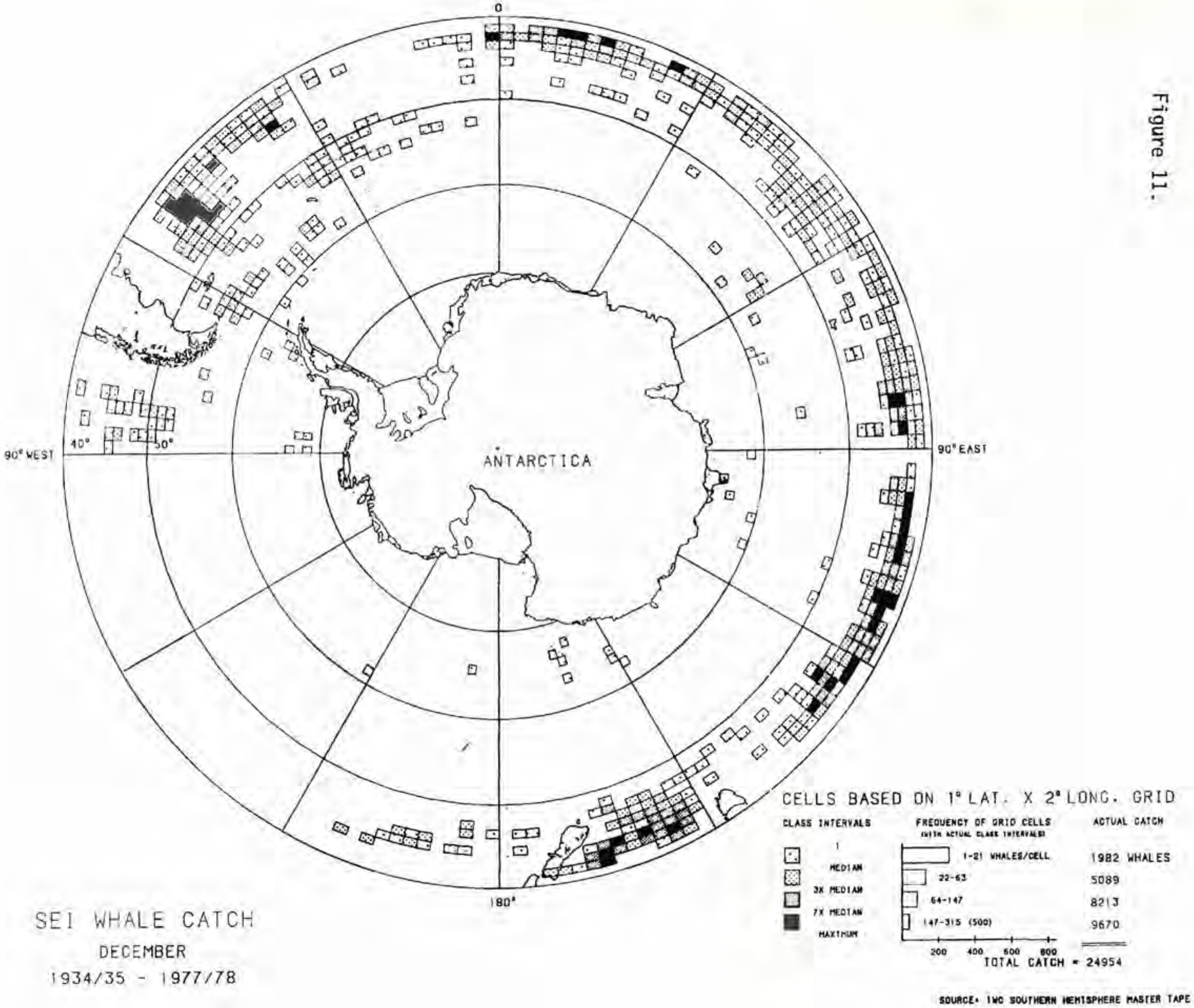
FIN WHALE CATCH
MARCH
1931/32 - 1975/76

Figure 10.



FIN WHALE CATCH
APRIL
1931/32 - 1975/76

Figure 11.

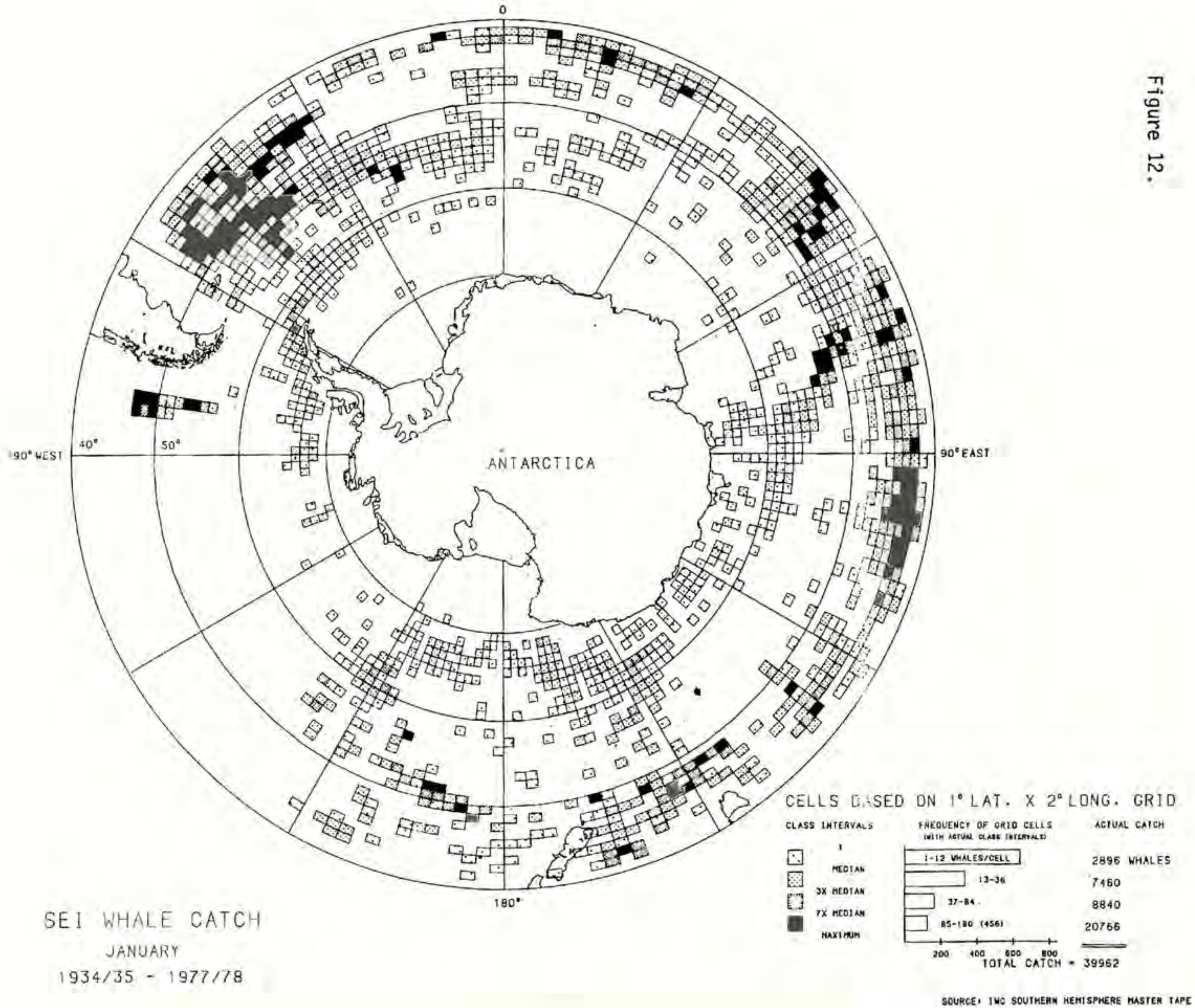


SEI WHALE CATCH

DECEMBER

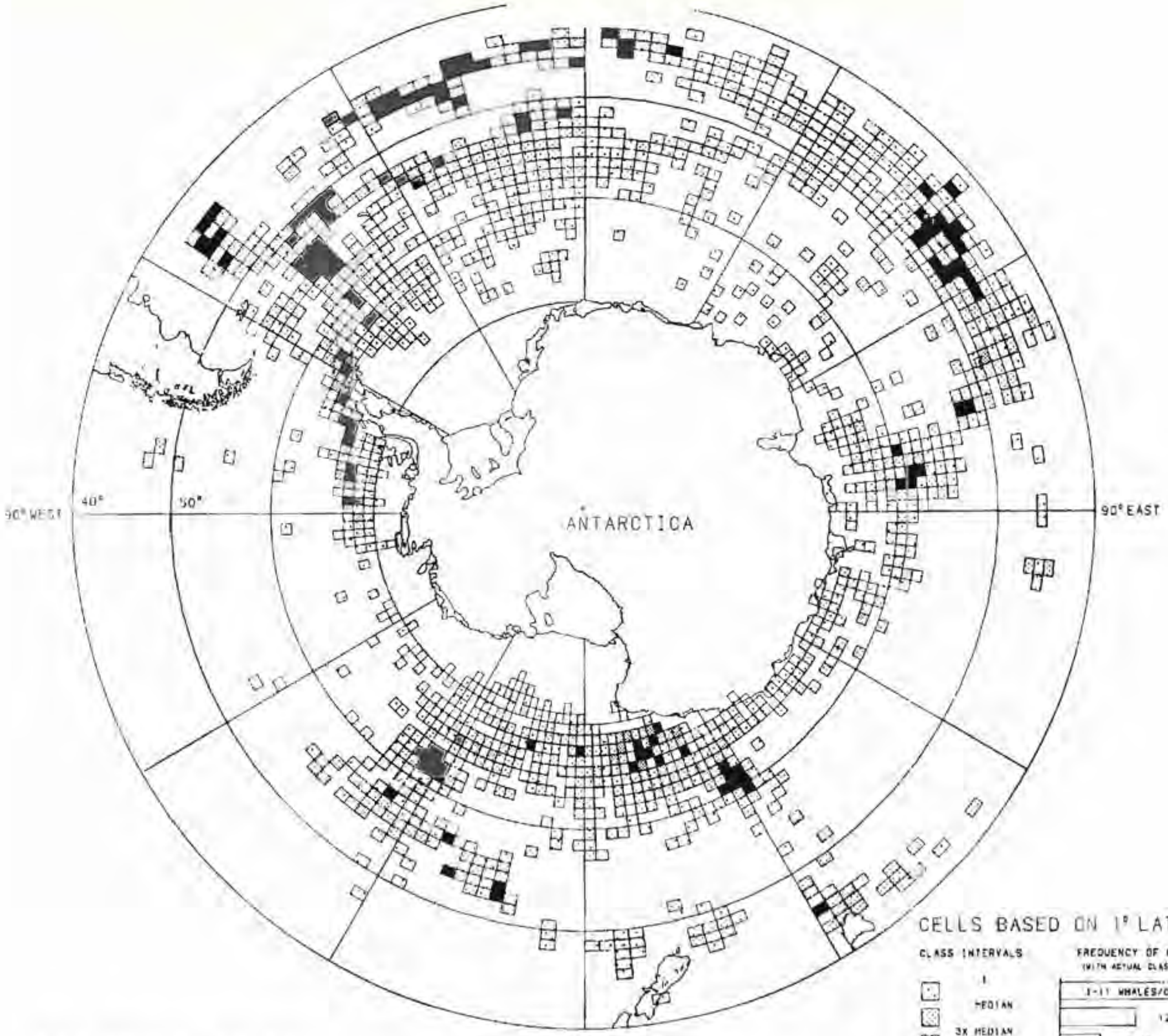
1934/35 - 1977/78

Figure 12.



SEI WHALE CATCH
JANUARY
1934/35 - 1977/78

Figure 13.



CELLS BASED ON 1° LAT. X 2° LONG. GRID

CLASS INTERVALS	FREQUENCY OF GRID CELLS (WITH ACTUAL CLASS INTERVALS)	ACTUAL CATCH
1	1-11 WHALES/CELL	3080 WHALES
MEDIAN	12-33	7311
3X MEDIAN	34-77	9925
7X MEDIAN	78-165 (745)	18863
MAXIMUM		

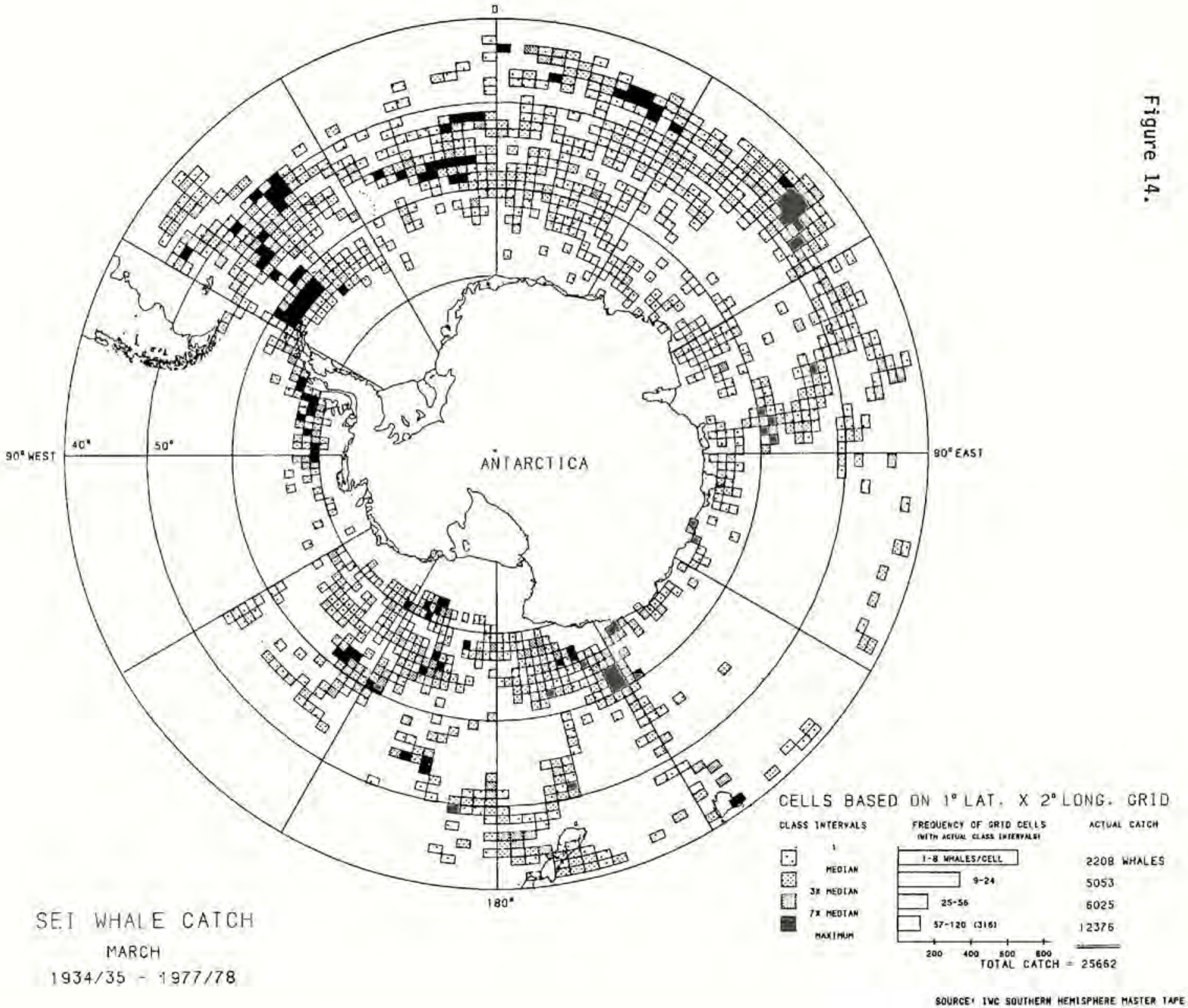
200 400 600 800

TOTAL CATCH = 39179

SOURCE: IWC SOUTHERN HEMISPHERE MASTER TAPE

SEI WHALE CATCH
FEBRUARY
1934/35 - 1977/78

Figure 14.

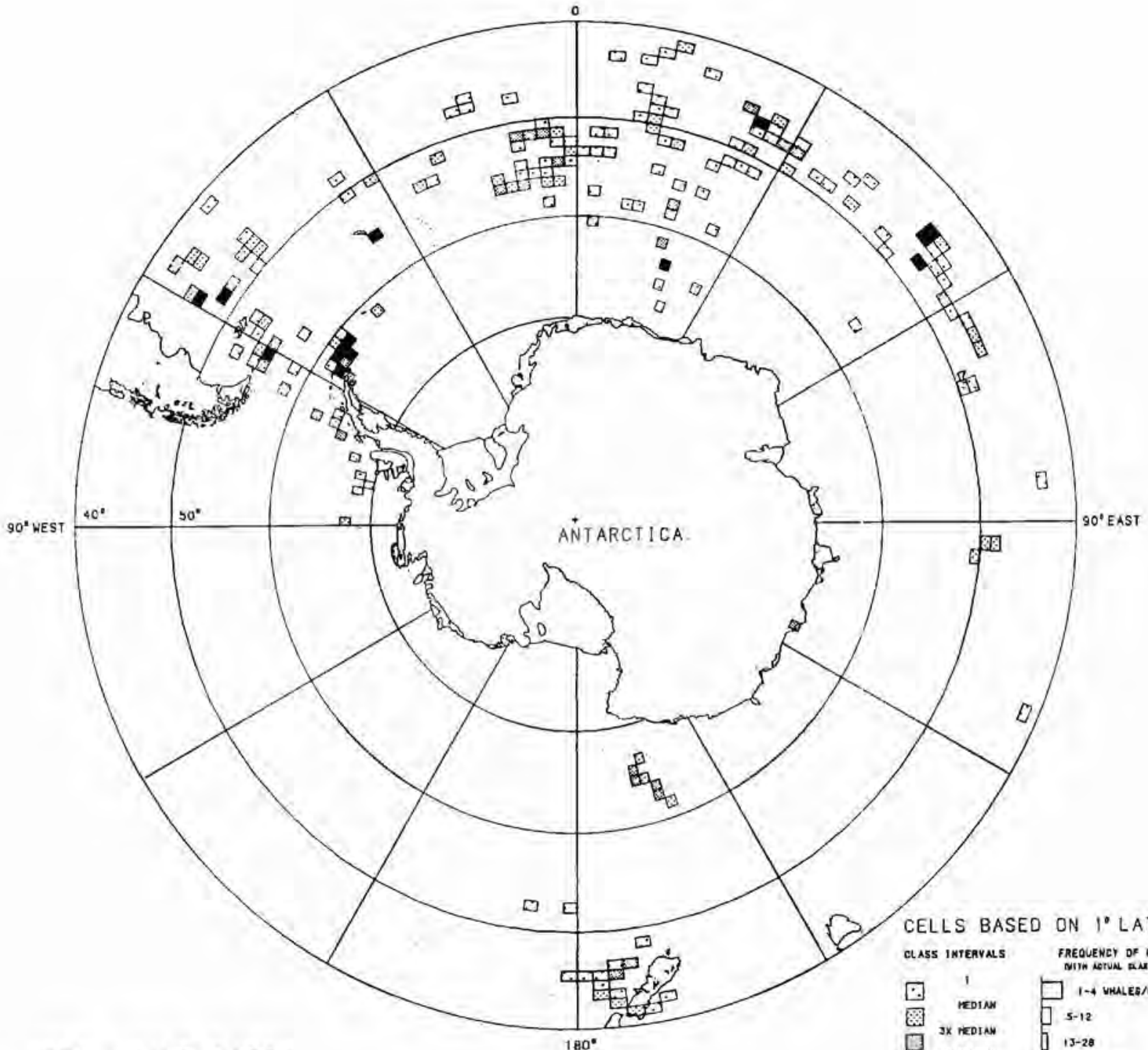


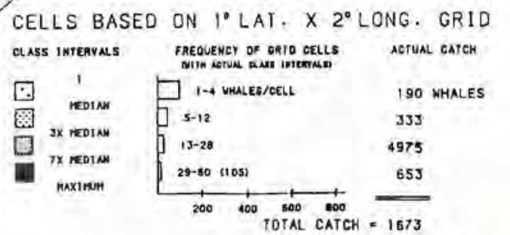
SEI WHALE CATCH

MARCH

1934/35 - 1977/78

Figure 15.





SOURCE: IWC SOUTHERN HEMISPHERE MASTER TAPE

SEI WHALE CATCH

APRIL

1934/35 - 1977/78

Figure 16.

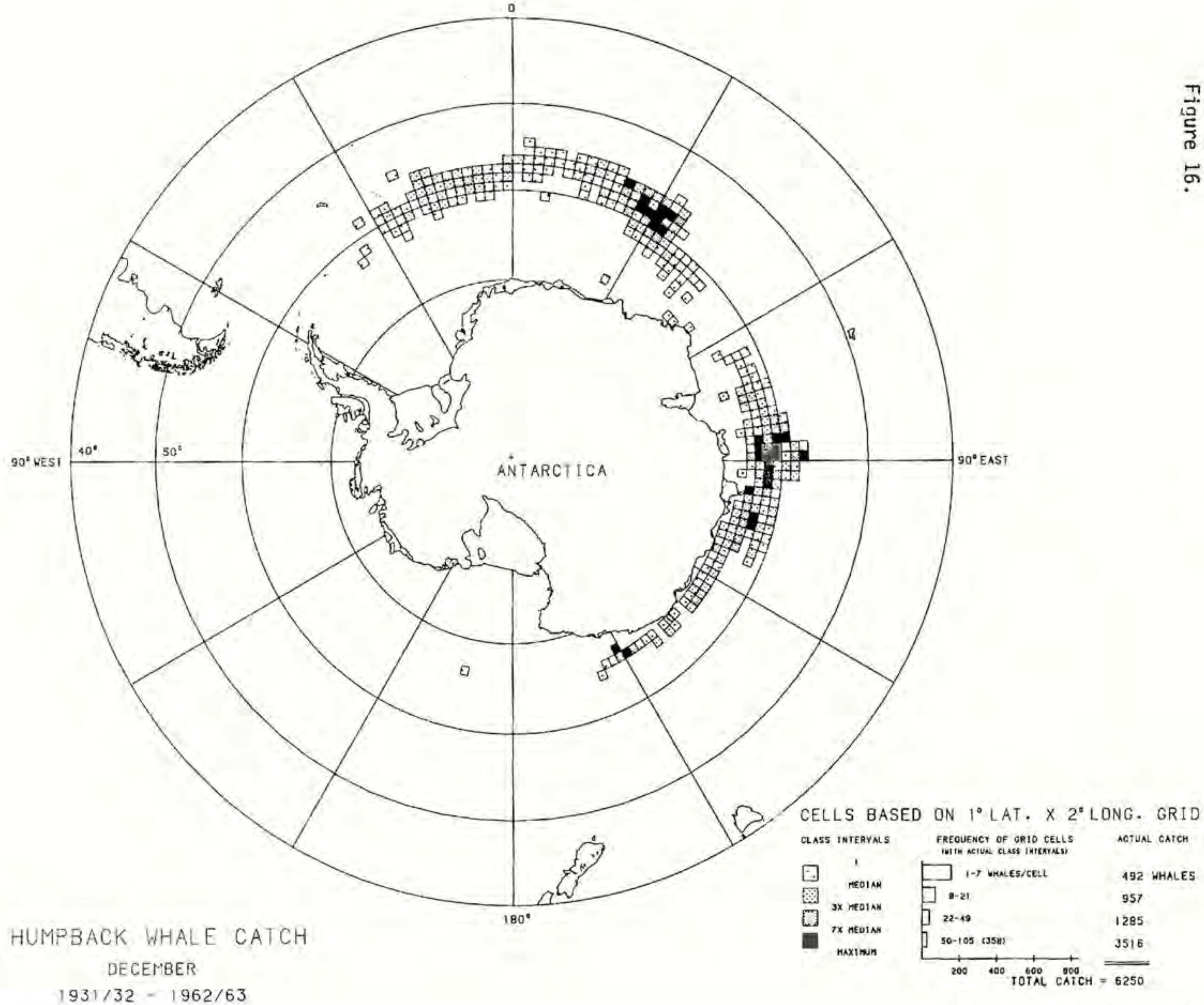
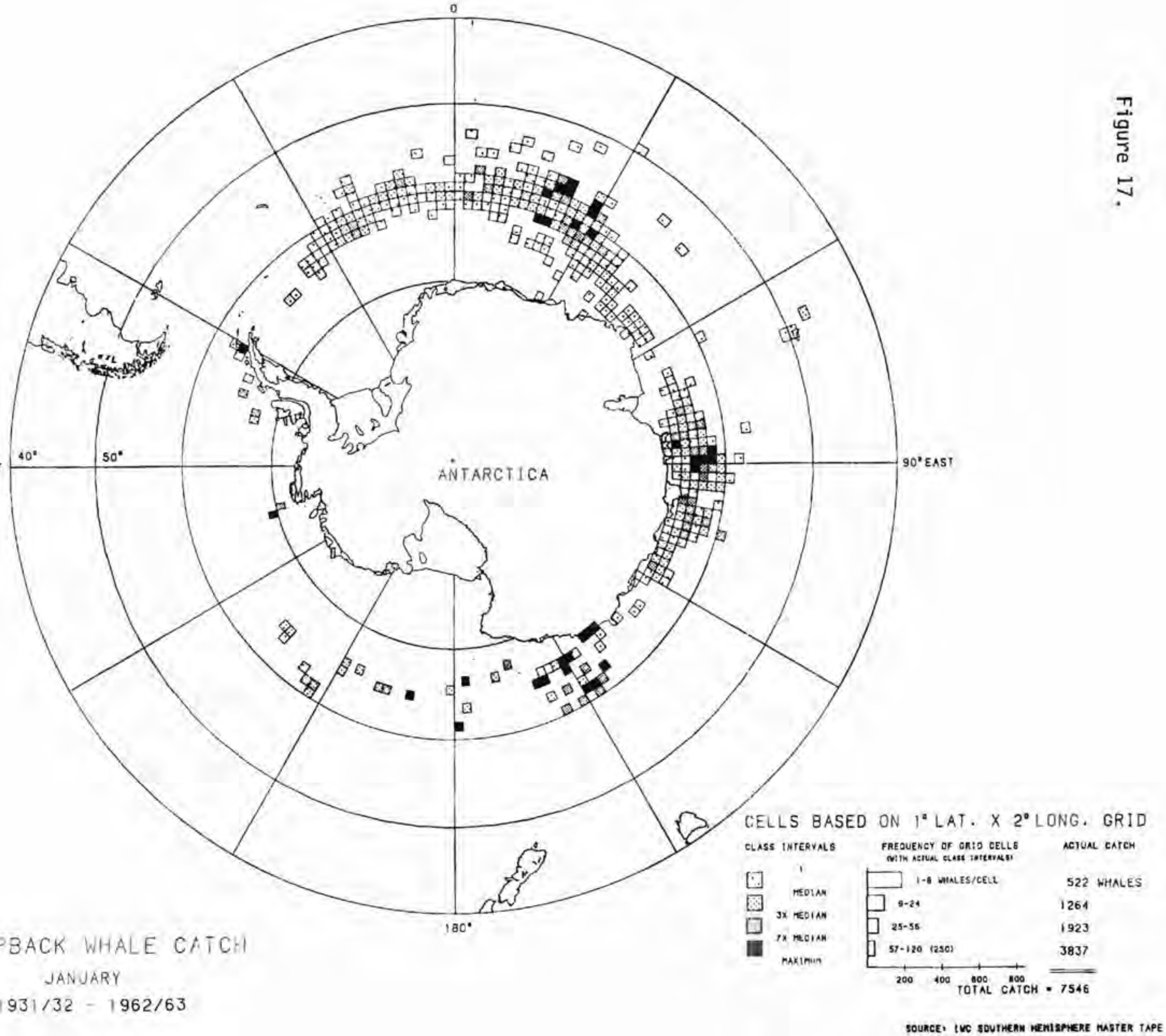
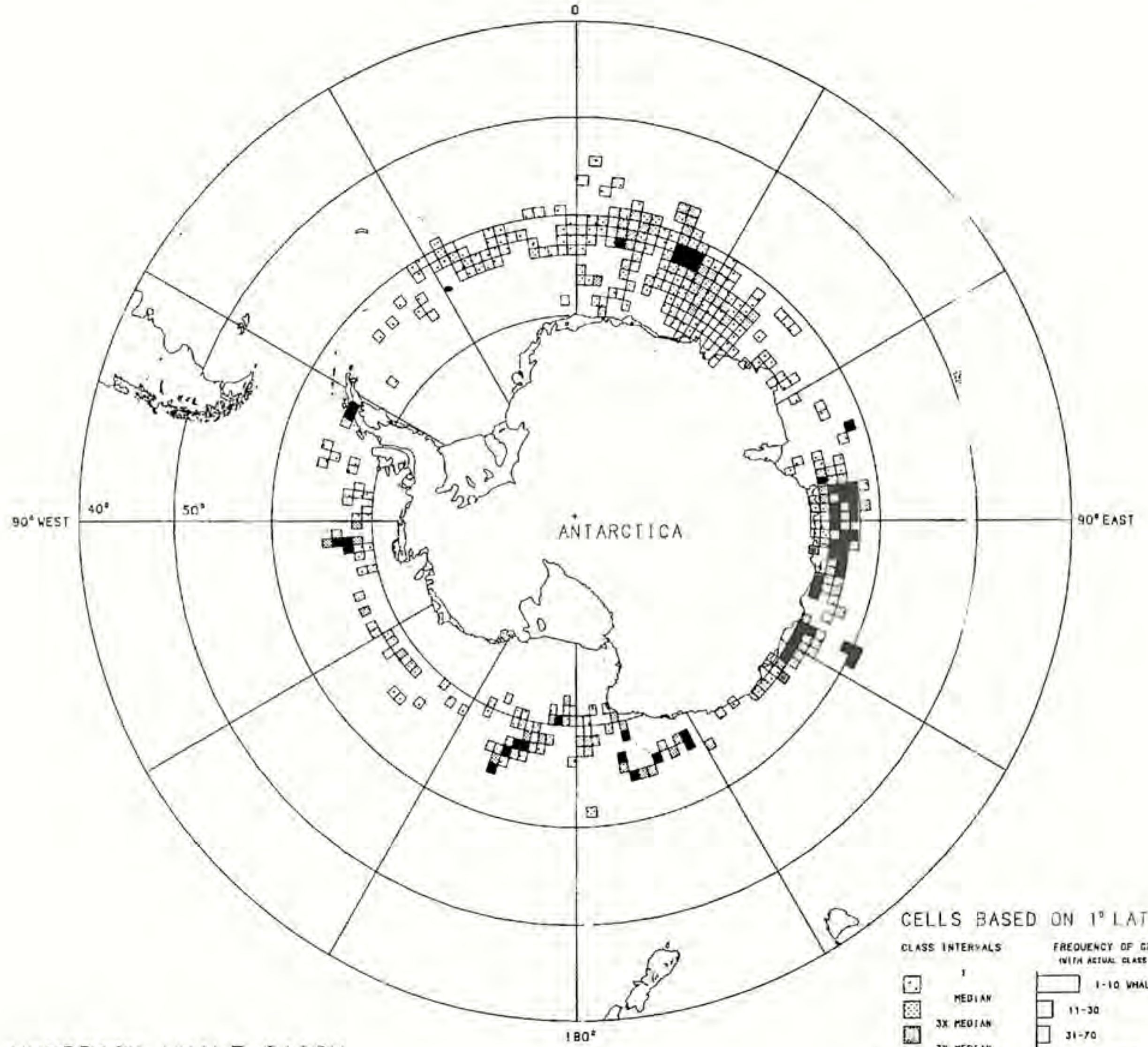

0
90° WEST
40°
50°
90° EAST
180°
ANTARCTICA
CELLS BASED ON 1° LAT. X 2° LONG. GRID
CLASS INTERVALS
1
MEDIAN
3X MEDIAN
7X MEDIAN
MAXIMUM
FREQUENCY OF GRID CELLS
(WITH ACTUAL CLASS INTERVALS)
1-7 WHALES/CELL
8-21
22-49
50-105 (358)
200
400
600
800
ACTUAL CATCH
492 WHALES
957
1285
3516
TOTAL CATCH = 6250
HUMPBACK WHALE CATCH
DECEMBER
1931/32 - 1962/63

Figure 17.



HUMPBACK WHALE CATCH
JANUARY
1931/32 - 1962/63

Figure 18.



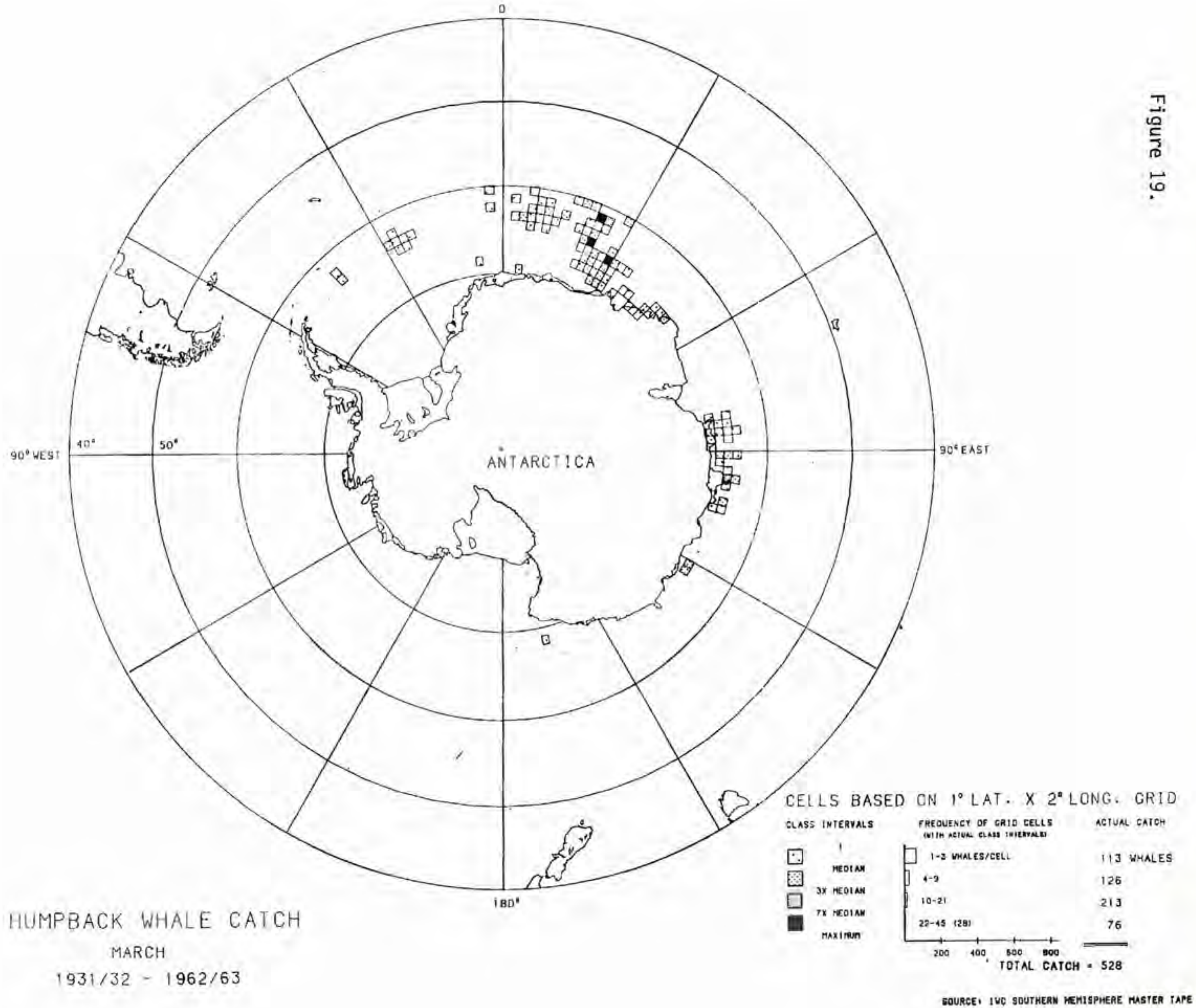
HUMPBACK WHALE CATCH

FEBRUARY

1931/32 - 1962/63

SOURCE: IWC SOUTHERN HEMISPHERE MASTER TAPE

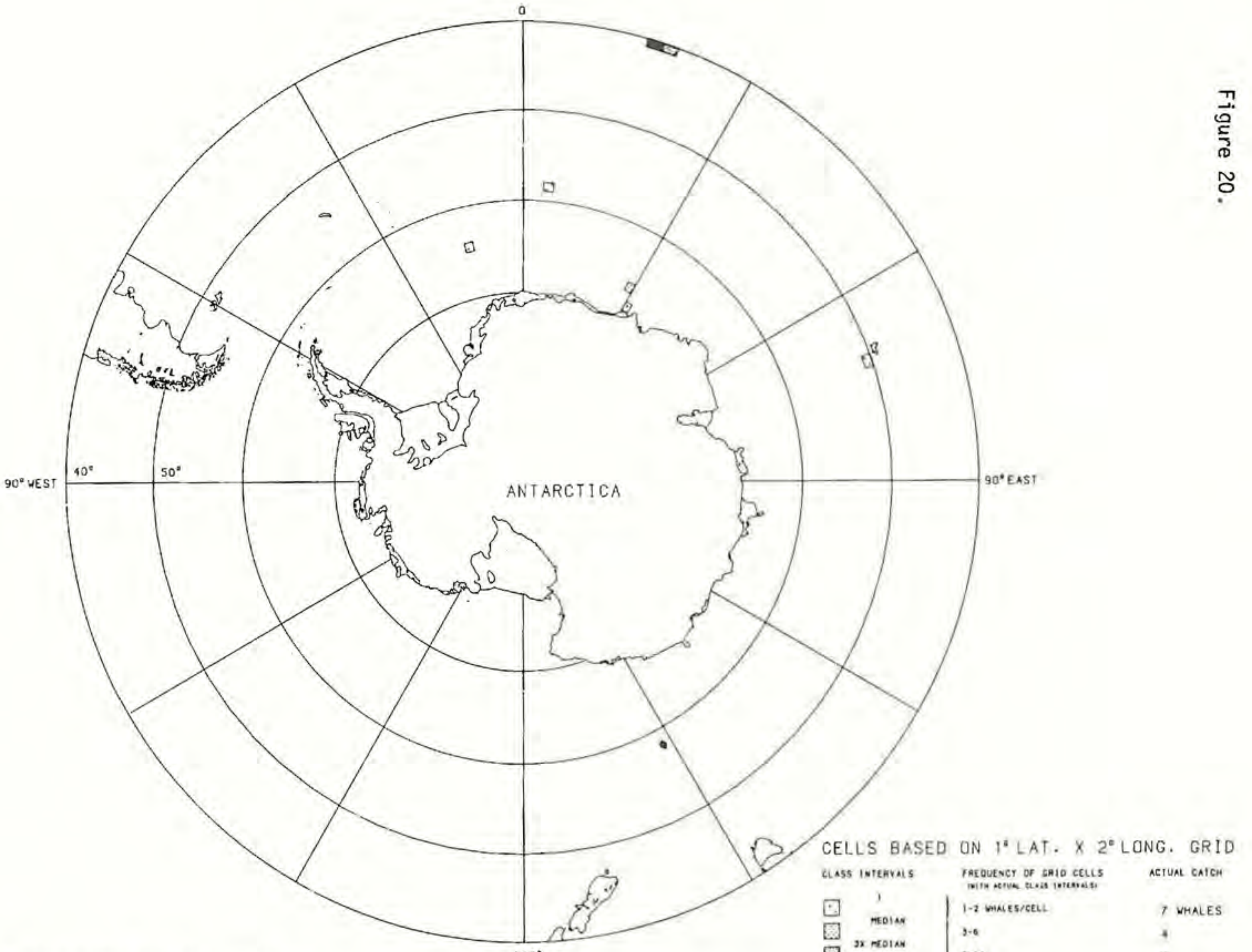
Figure 19.



HUMPBACK WHALE CATCH

MARCH

1931/32 - 1962/63



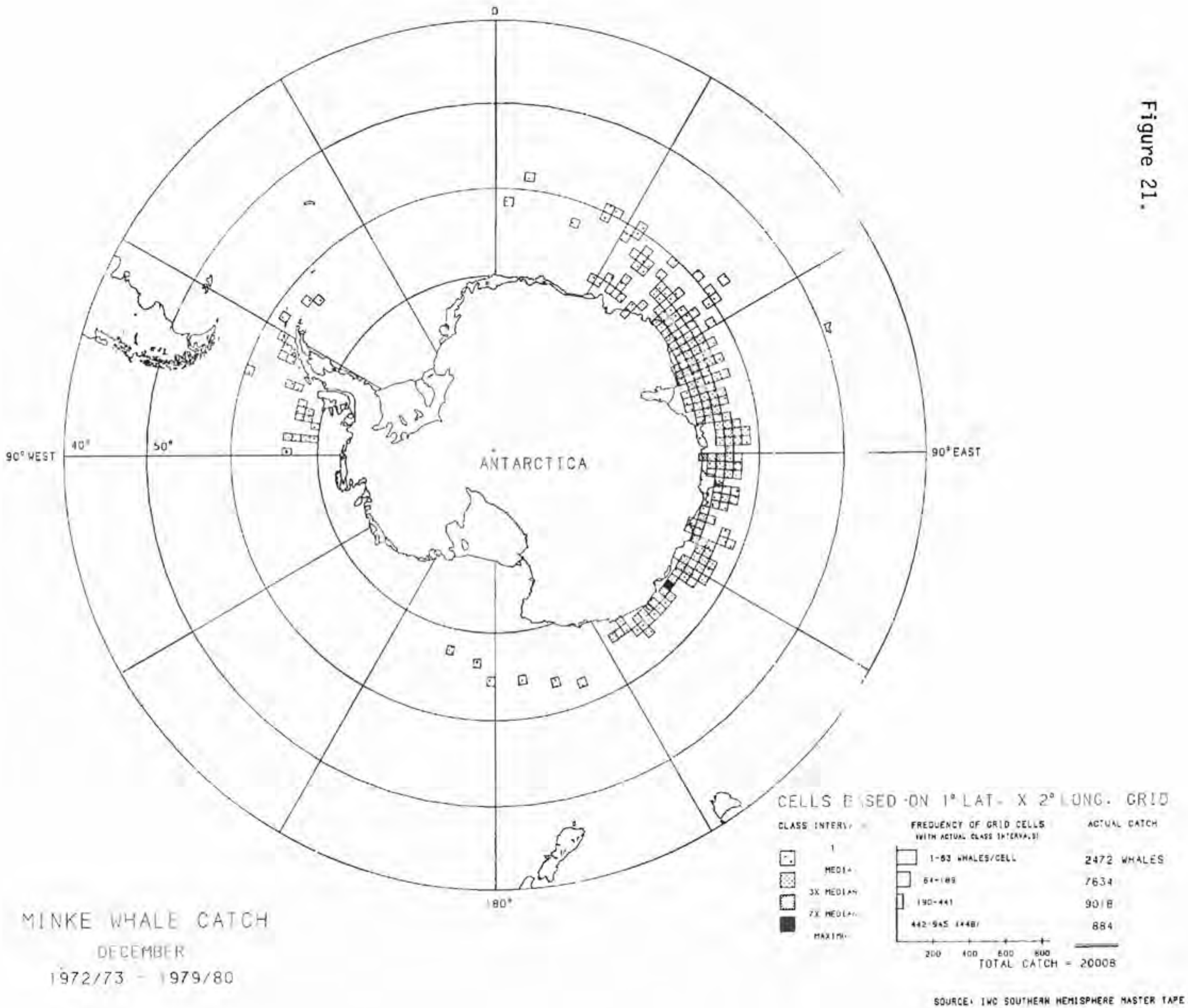
HUMPBACK WHALE CATCH

APRIL

1931/32 - 1962/63

Figure 20.

Figure 21.



MINKE WHALE CATCH
DECEMBER
1972/73 - 1979/80

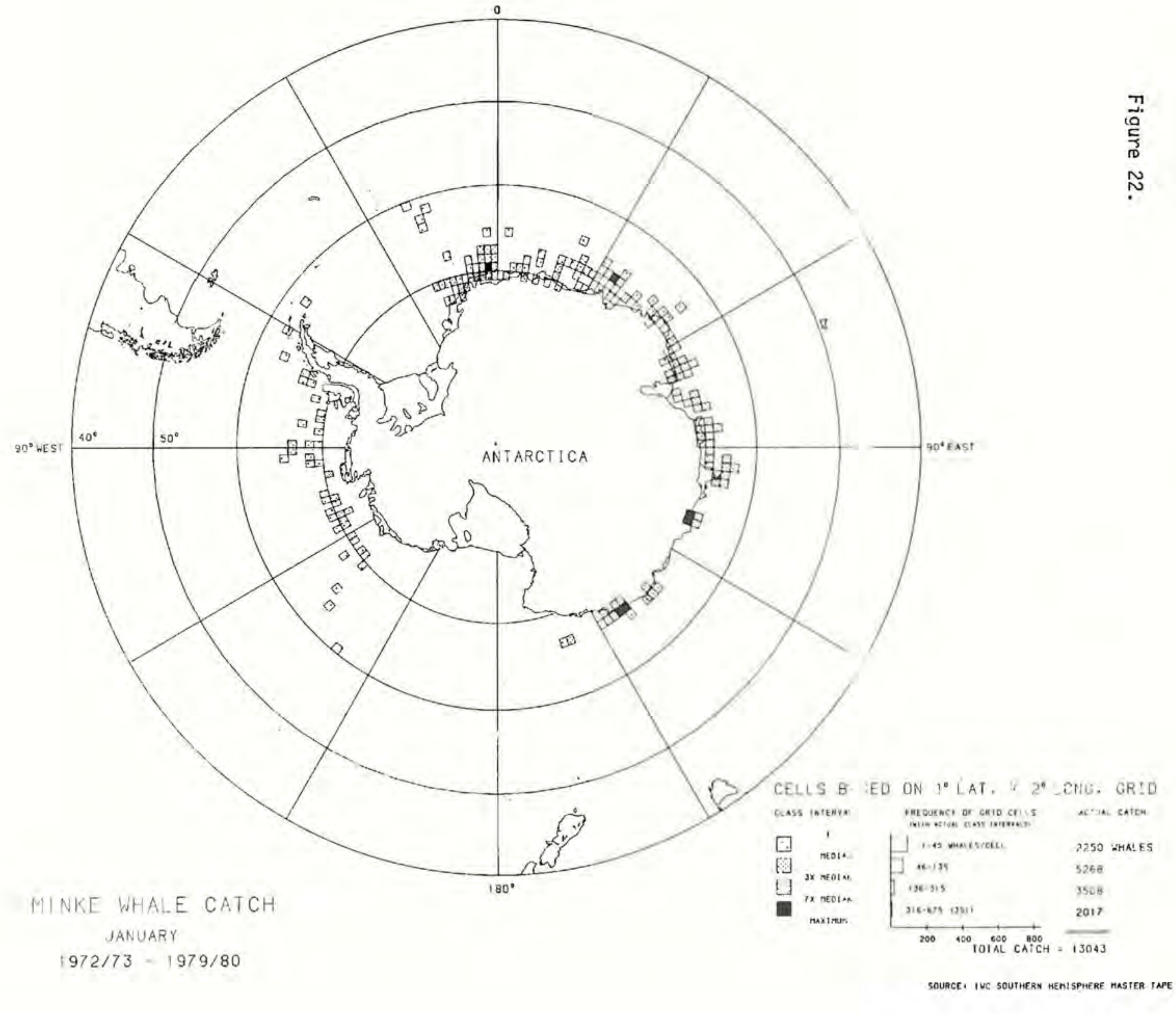
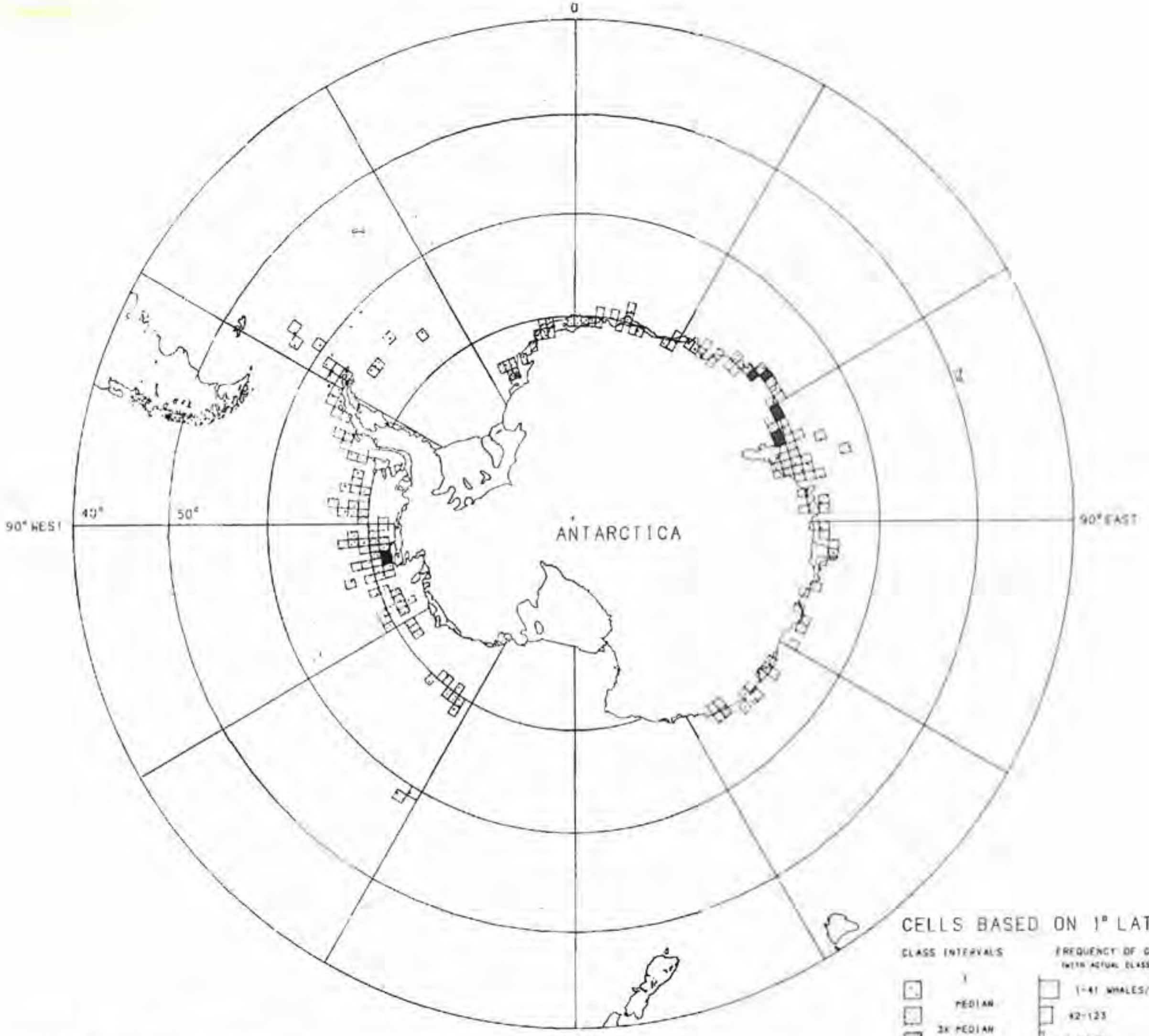
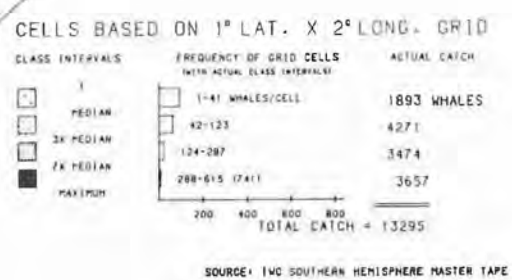

0
90° WEST
40°
50°
ANTARCTICA
90° EAST
180°
MINKE WHALE CATCH
JANUARY
1972/73 - 1979/80
CLASS INTERVAL
MEDIAN
3X MEDIAN
7X MEDIAN
MAXIMUM
FREQUENCY OF GRID CELLS
1-45 WHALES/CELL
46-135
136-315
ACTUAL CATCH
2250 WHALES
5268
3508
2017
200
400
600
800
TOTAL CATCH = 13043
SOURCE: IWC SOUTHERN HEMISPHERE MASTER TAPE

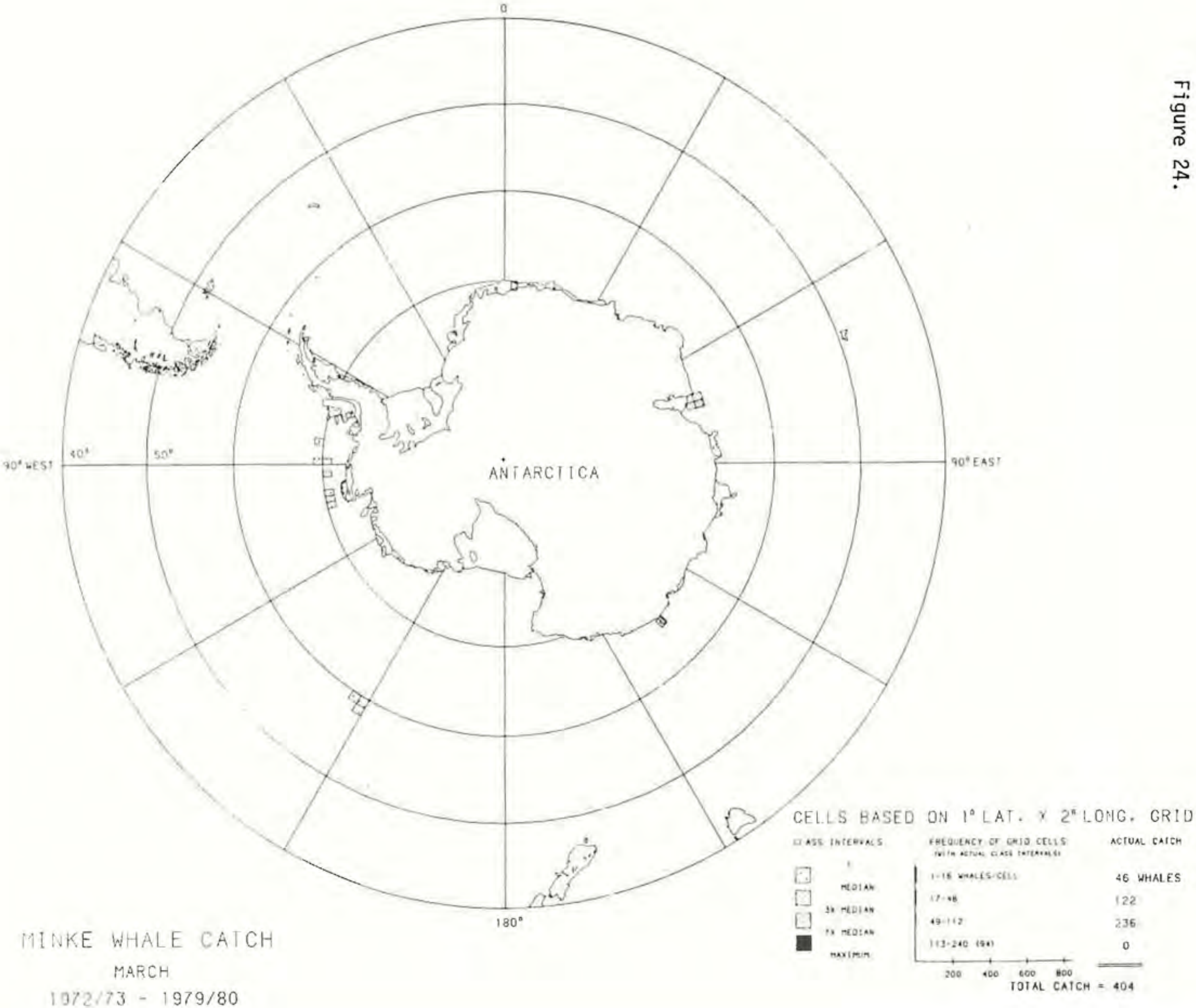
Figure 22.





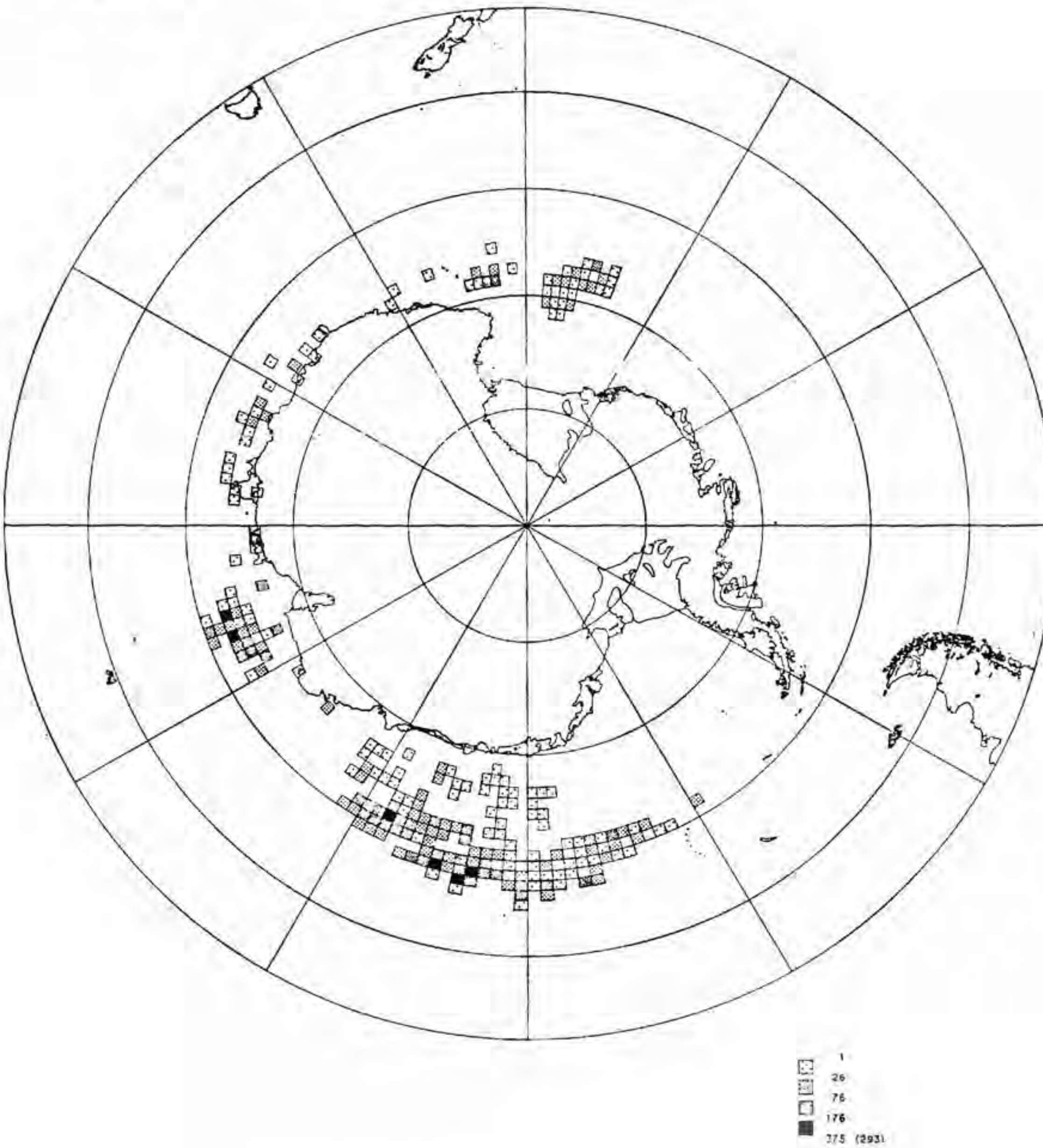
MINKE WHALE CATCH
FEBRUARY
1972/73 - 1979/80

Figure 24.



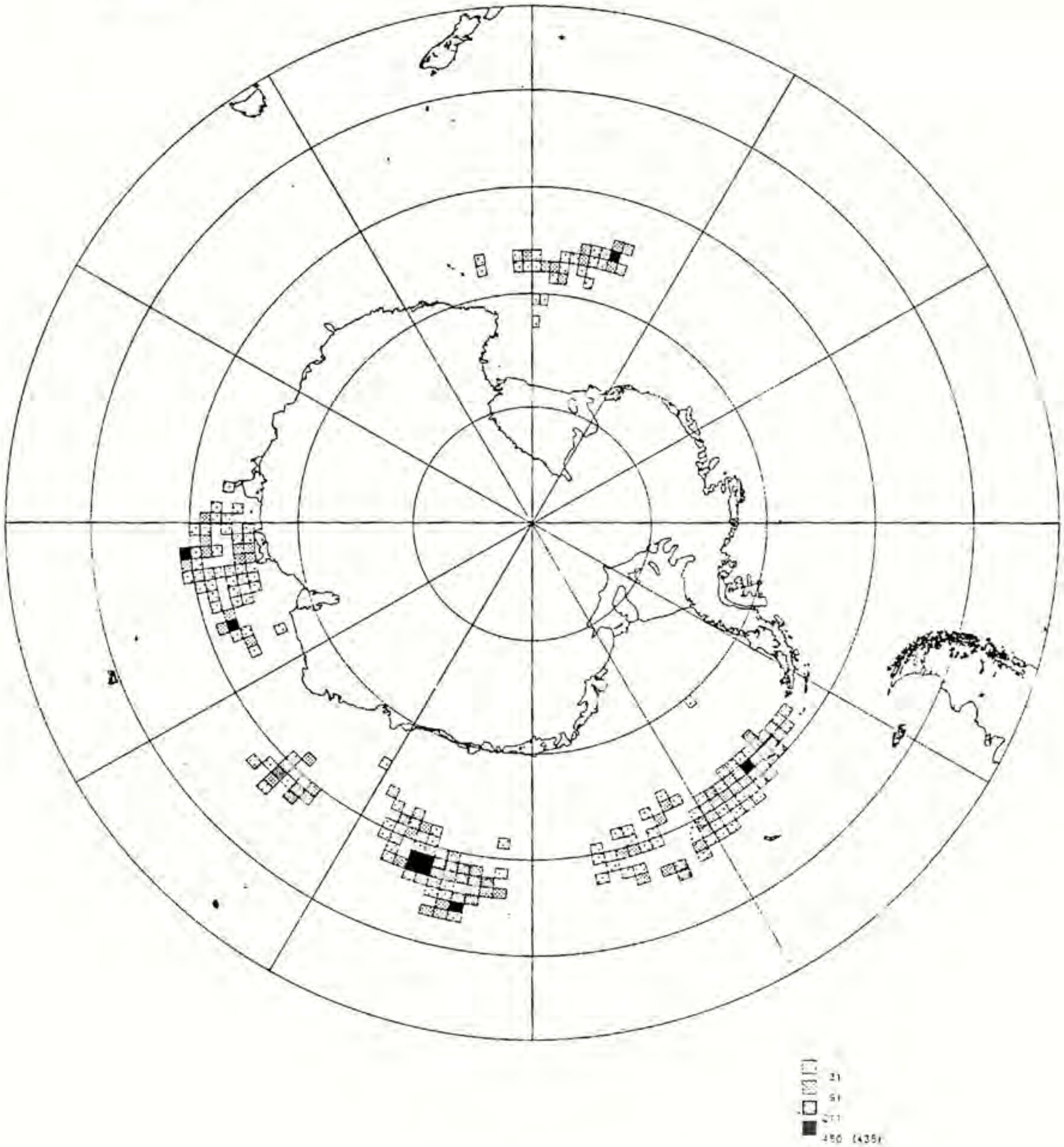
MINKE WHALE CATCH
MARCH
1972/73 - 1979/80

Figure 25.



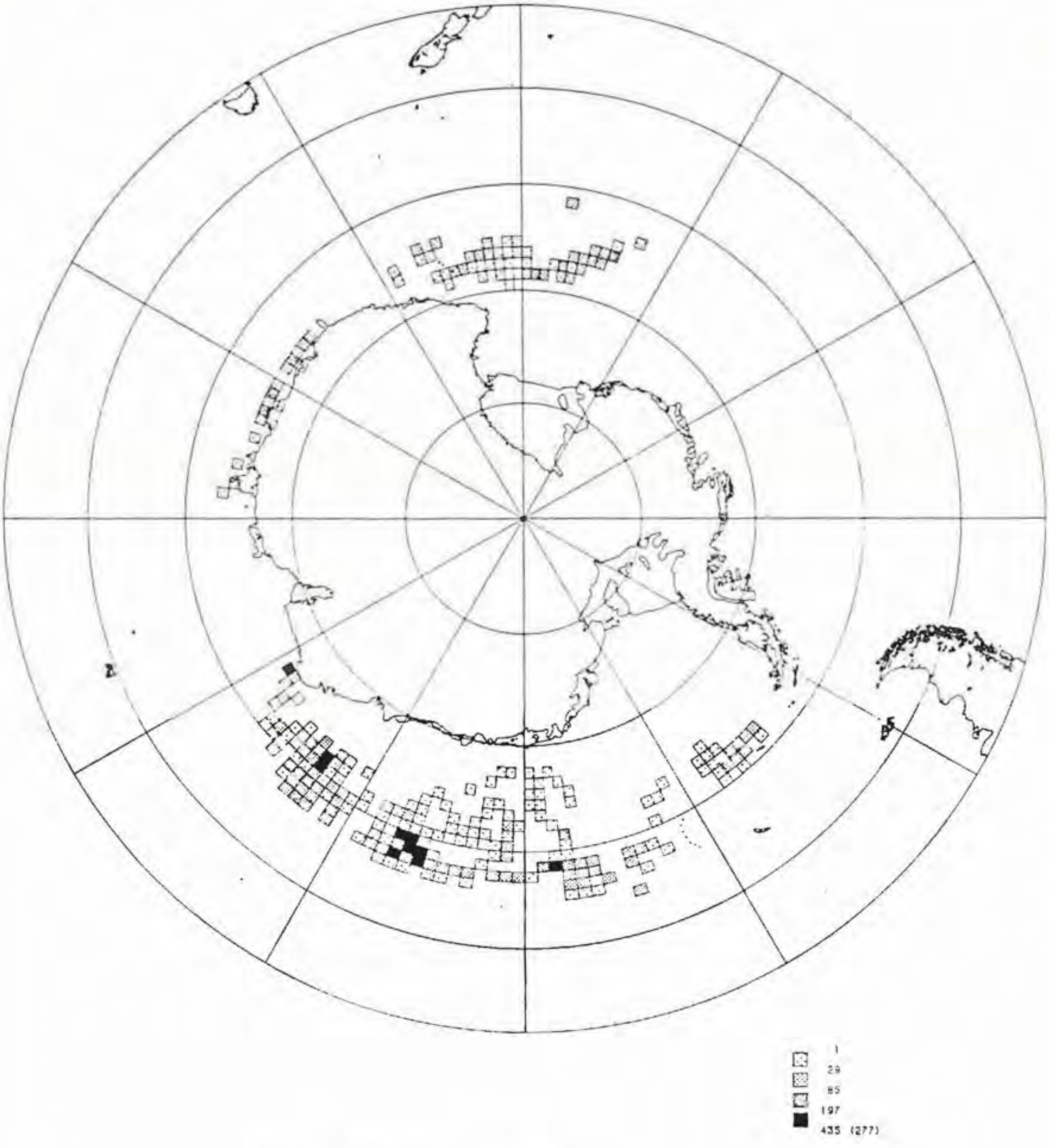
FIN WHALE CATCH IN JANUARY 1952/53

Figure 26.



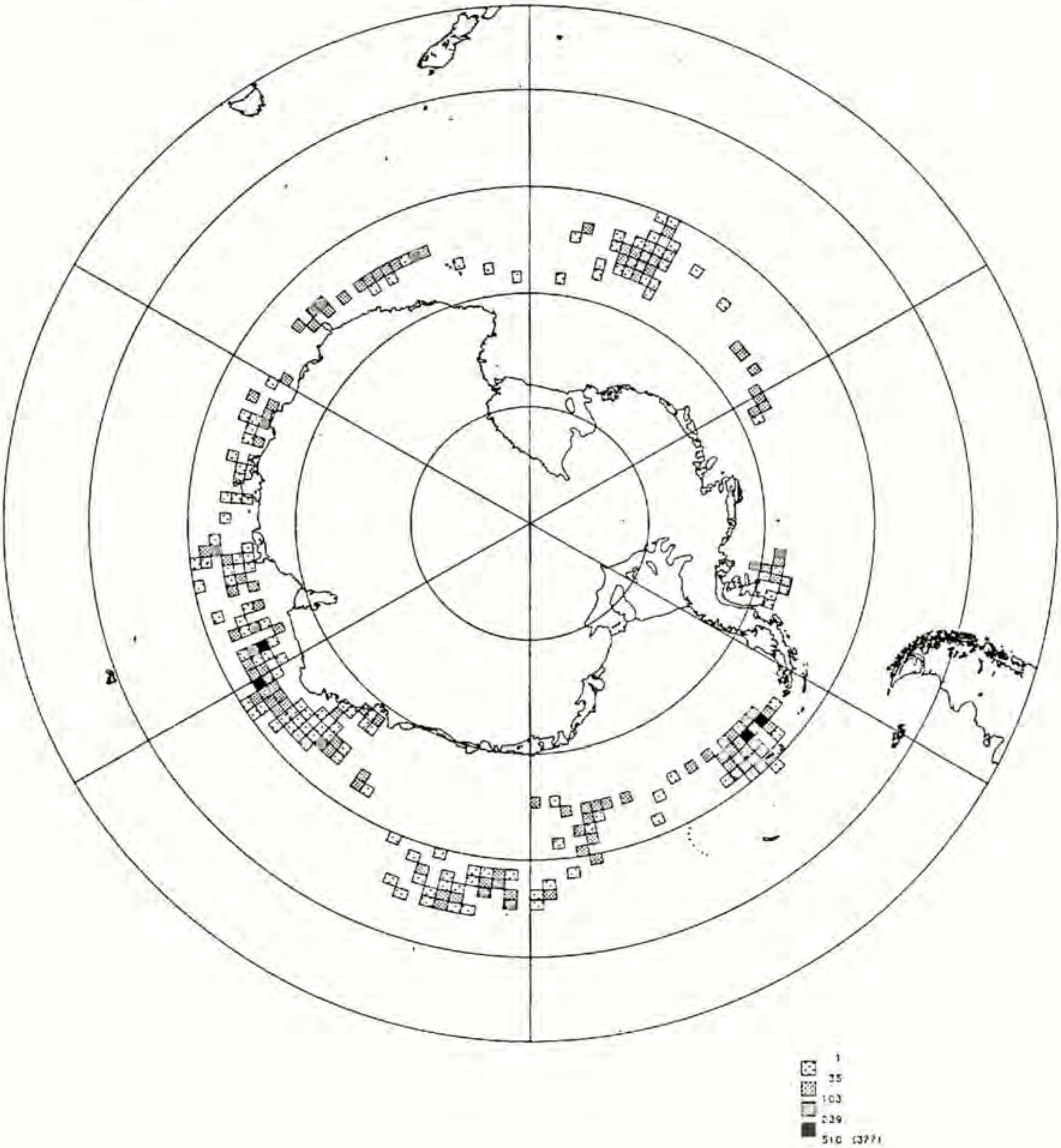
FIN WHALE CATCH IN JANUARY 1953/54

Figure 27.



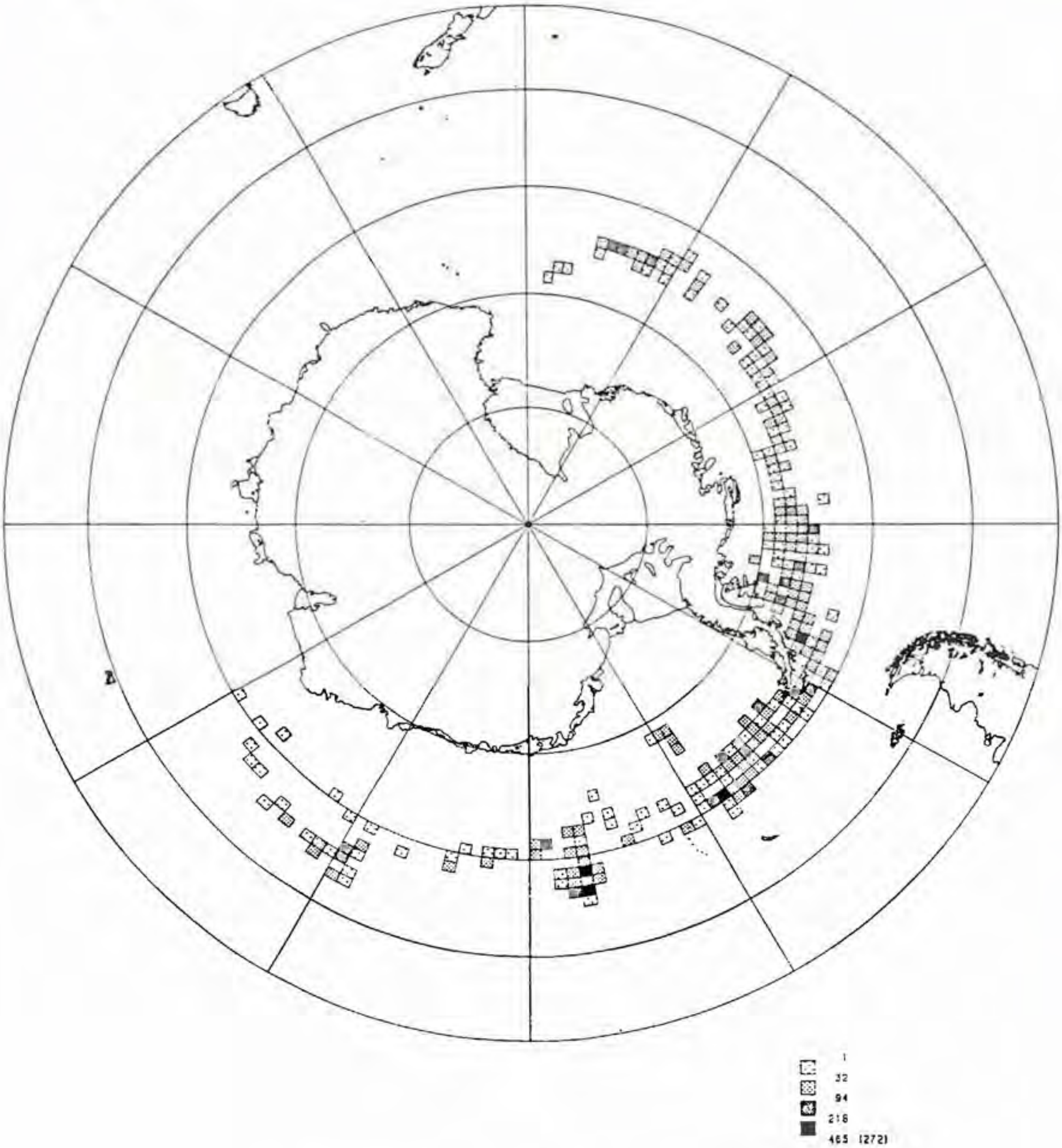
FIN WHALE CATCH IN JANUARY 1954/55

Figure 28.



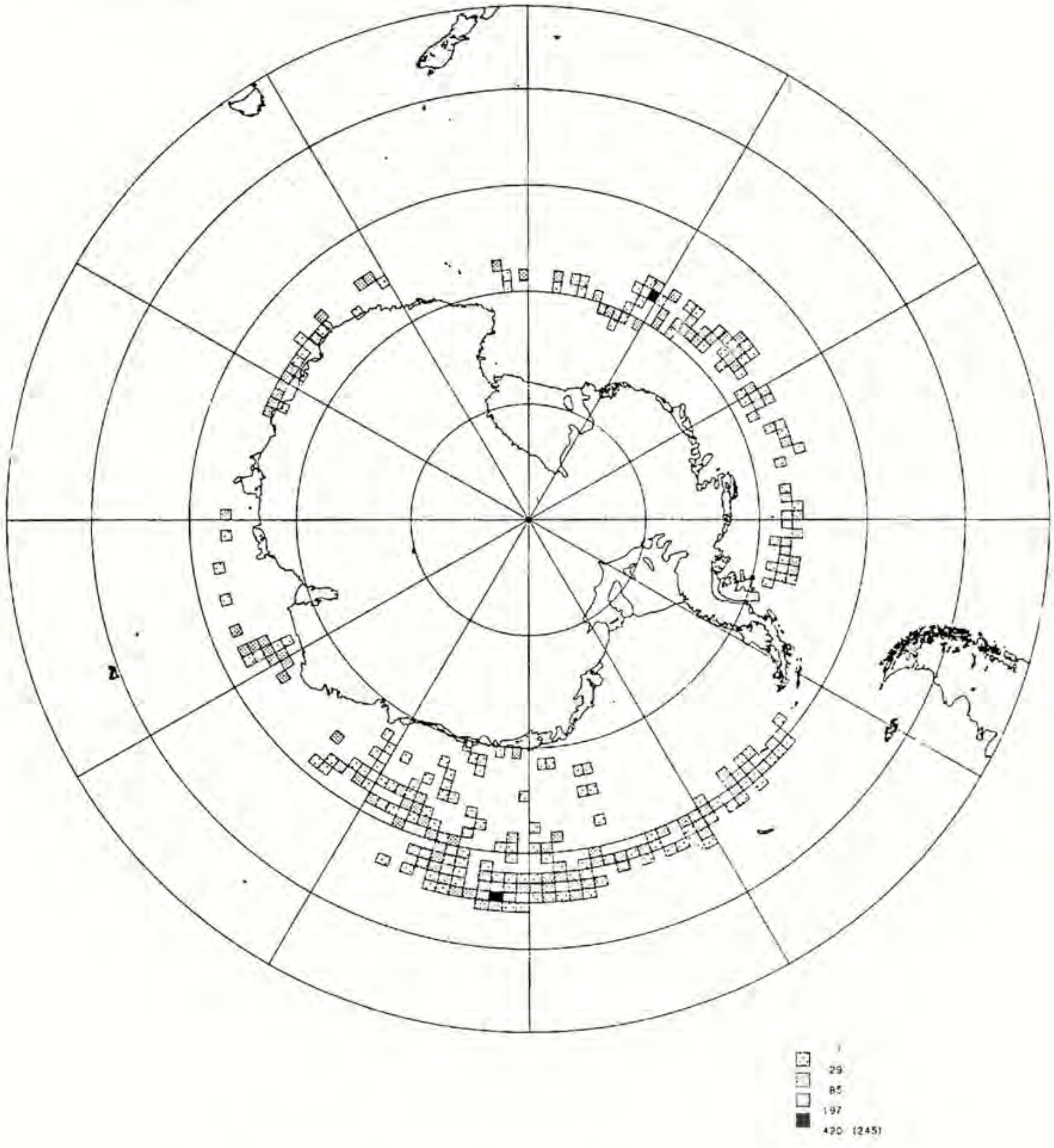
FIN WHALE CATCH IN JANUARY 1955/56

Figure 29.



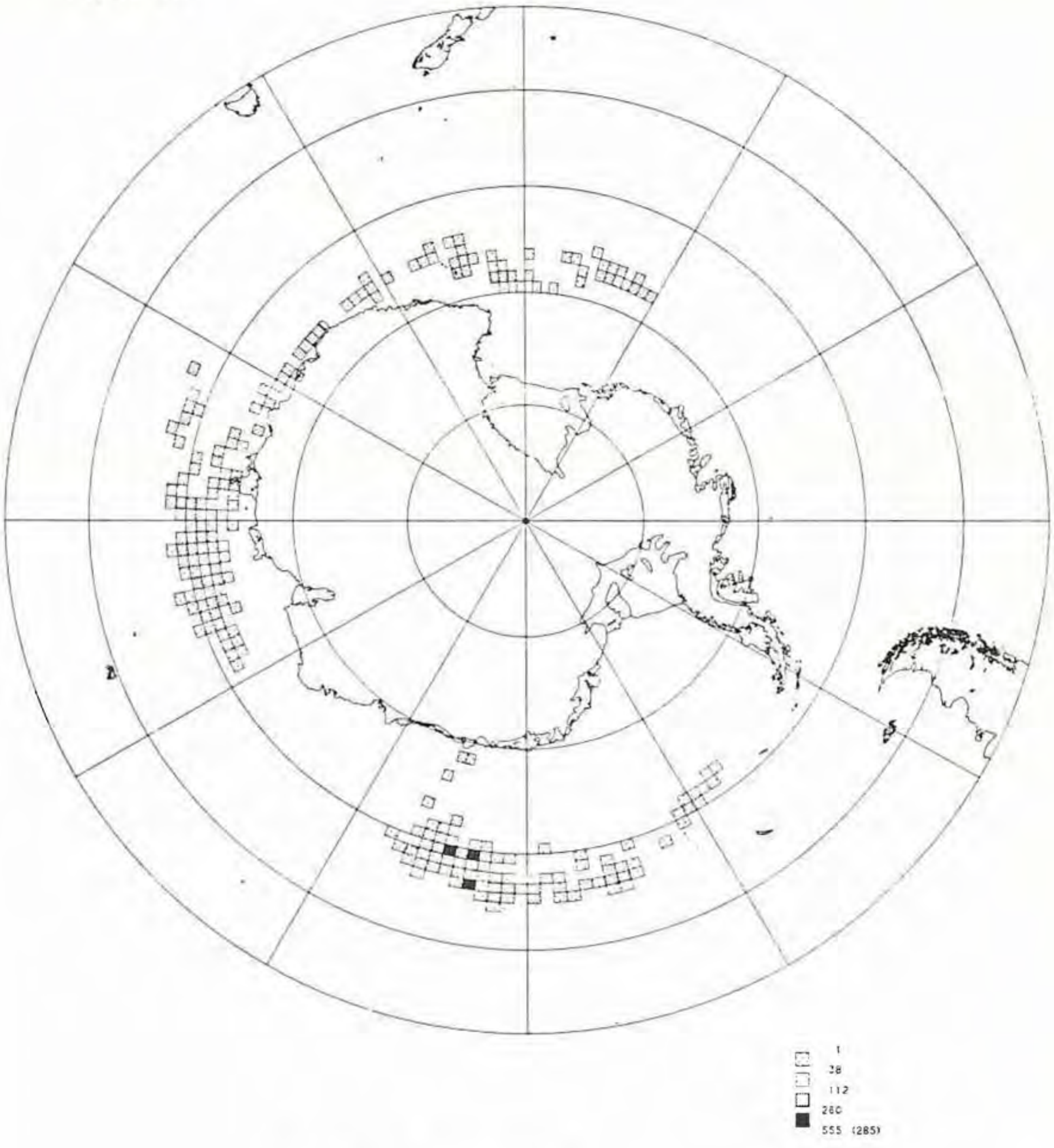
FIN WHALE CATCH IN JANUARY 1956/57

Figure 30



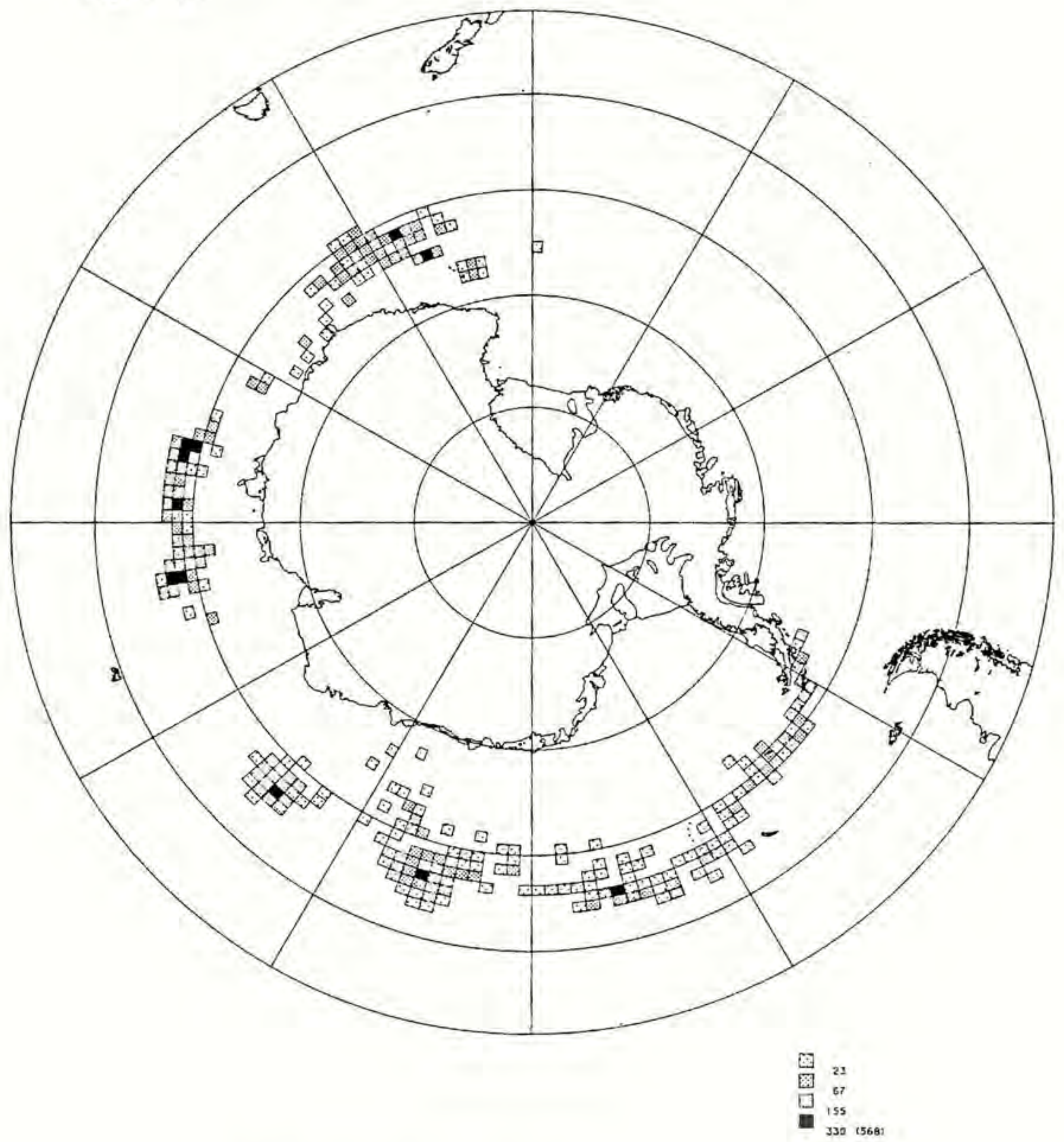
FIN WHALE CATCH IN JANUARY 1957/58

Figure 31.



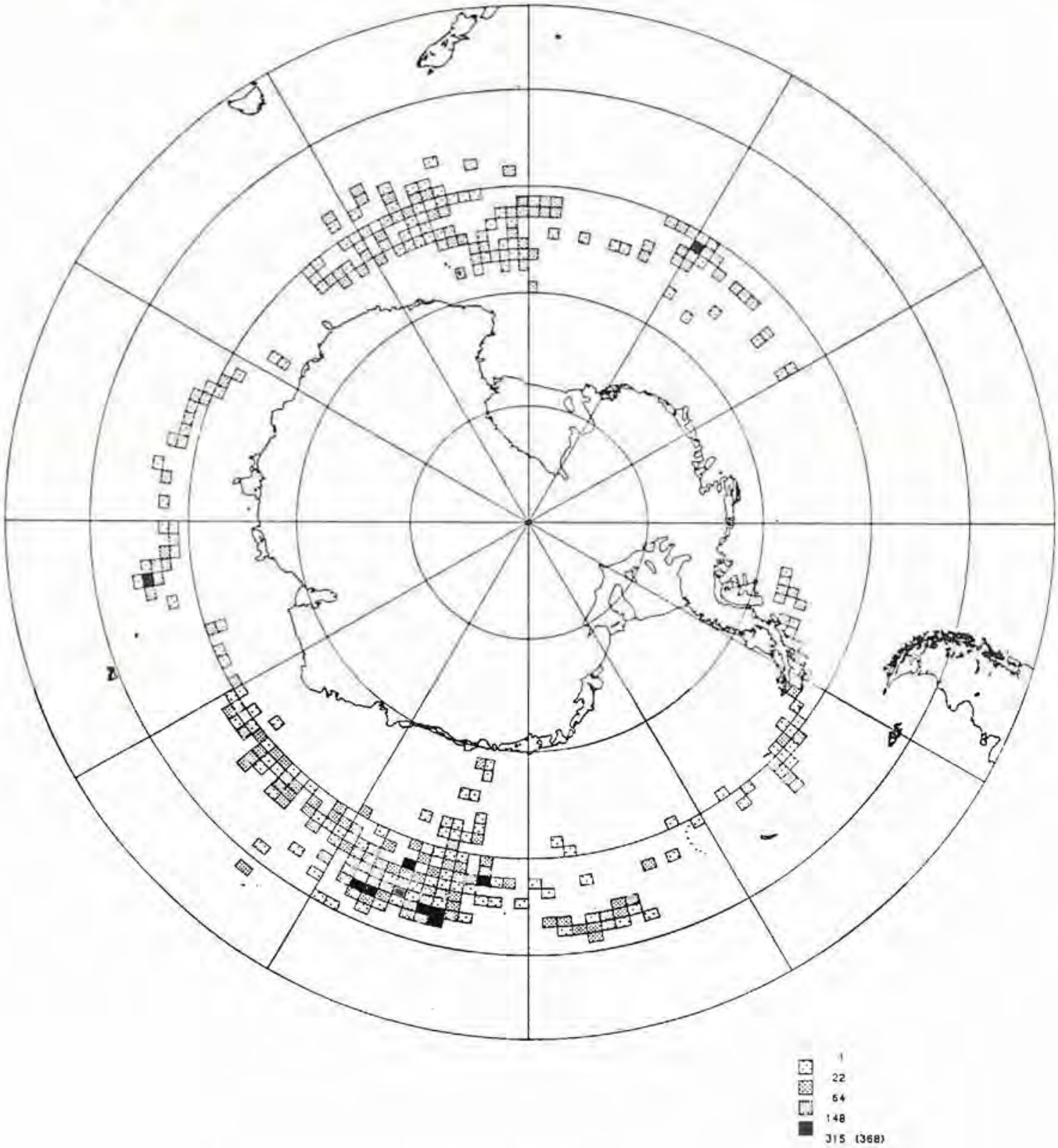
FIN WHALE CATCH IN JANUARY 1958/59

Figure 32.



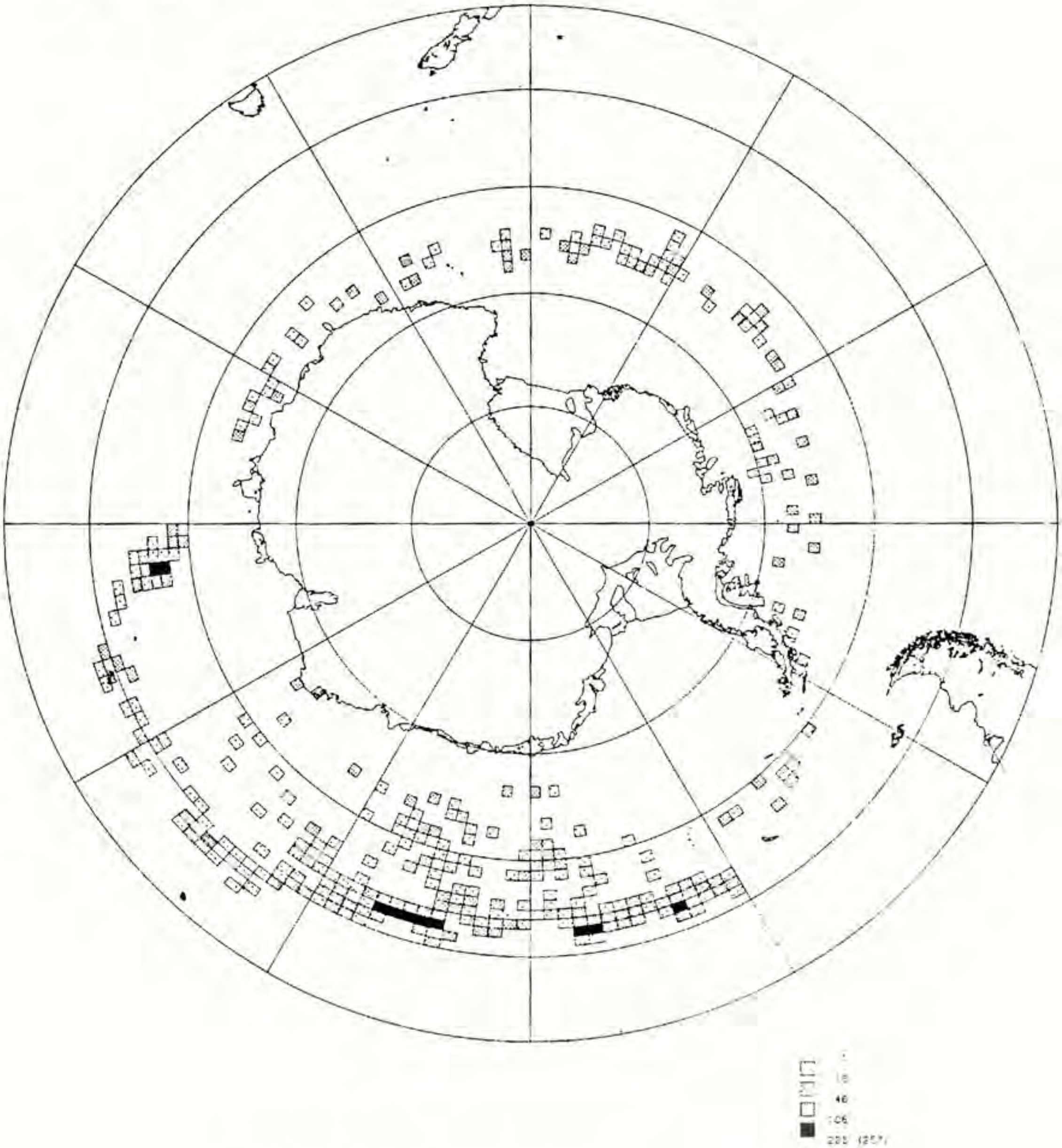
FIN WHALE CATCH IN JANUARY 1959/60

Figure 33.



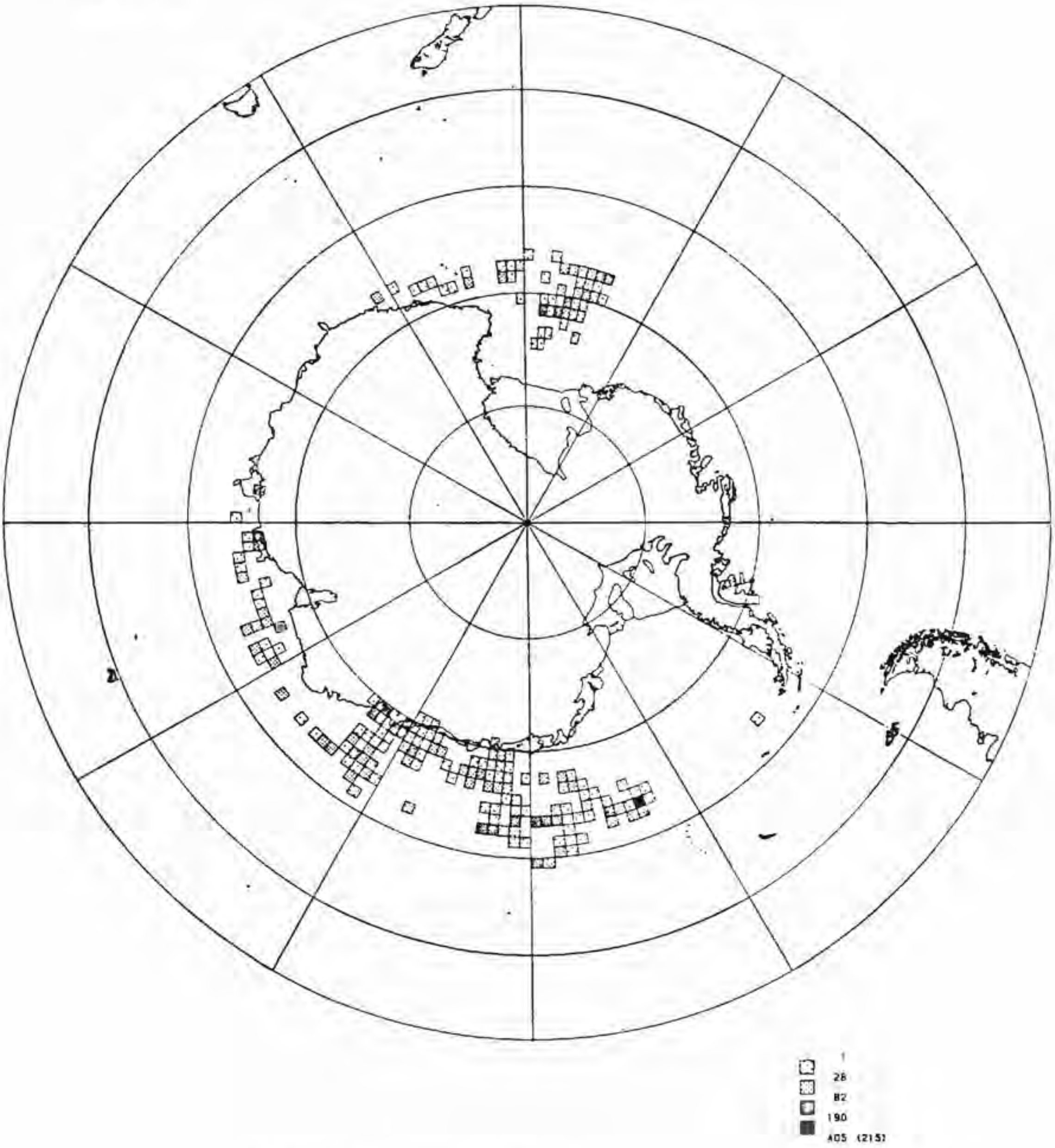
FIN WHALE CATCH IN JANUARY 1960/61

Figure 34.



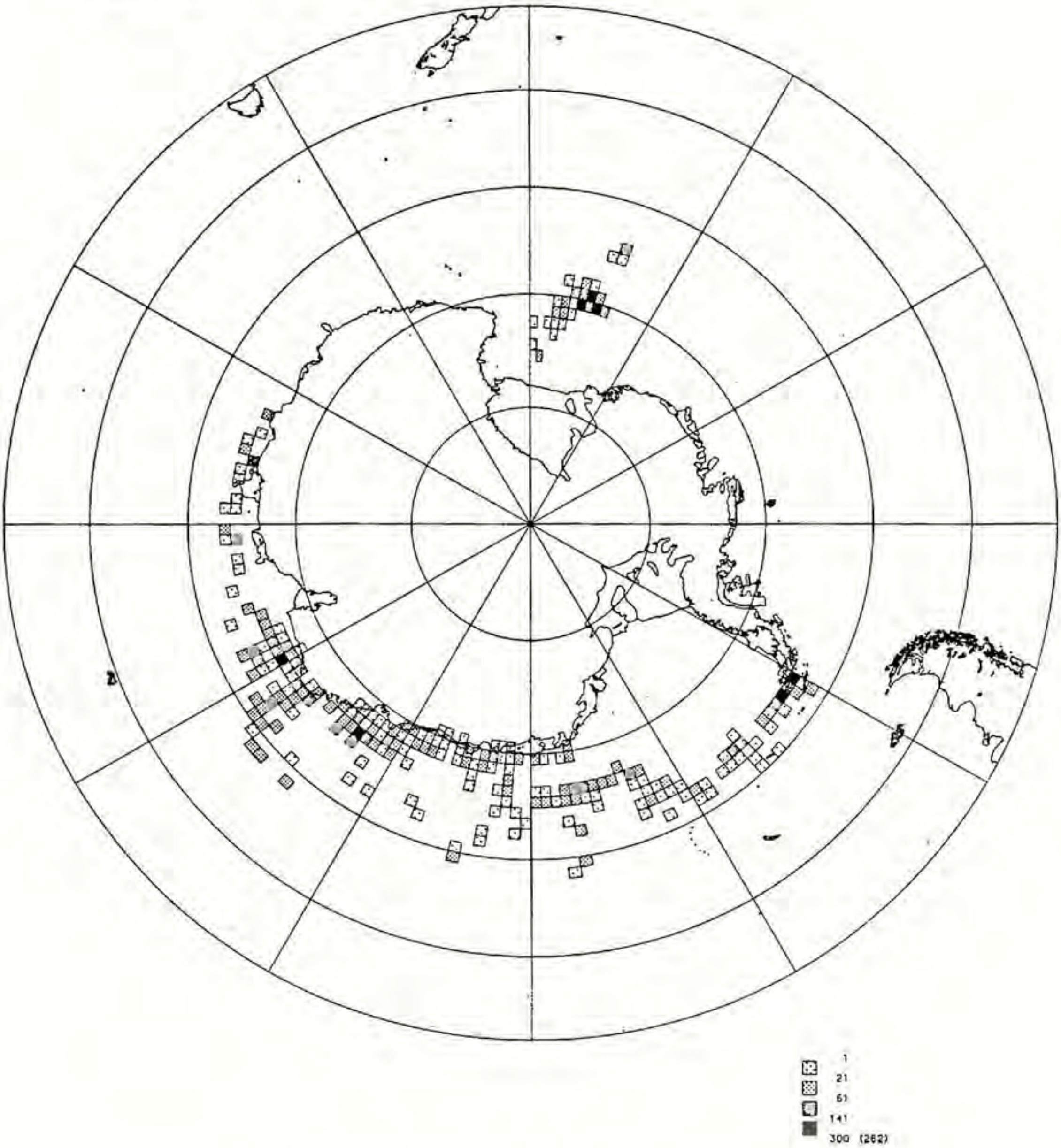
FIN WHALE CATCH IN JANUARY 1961/62

Figure 35.



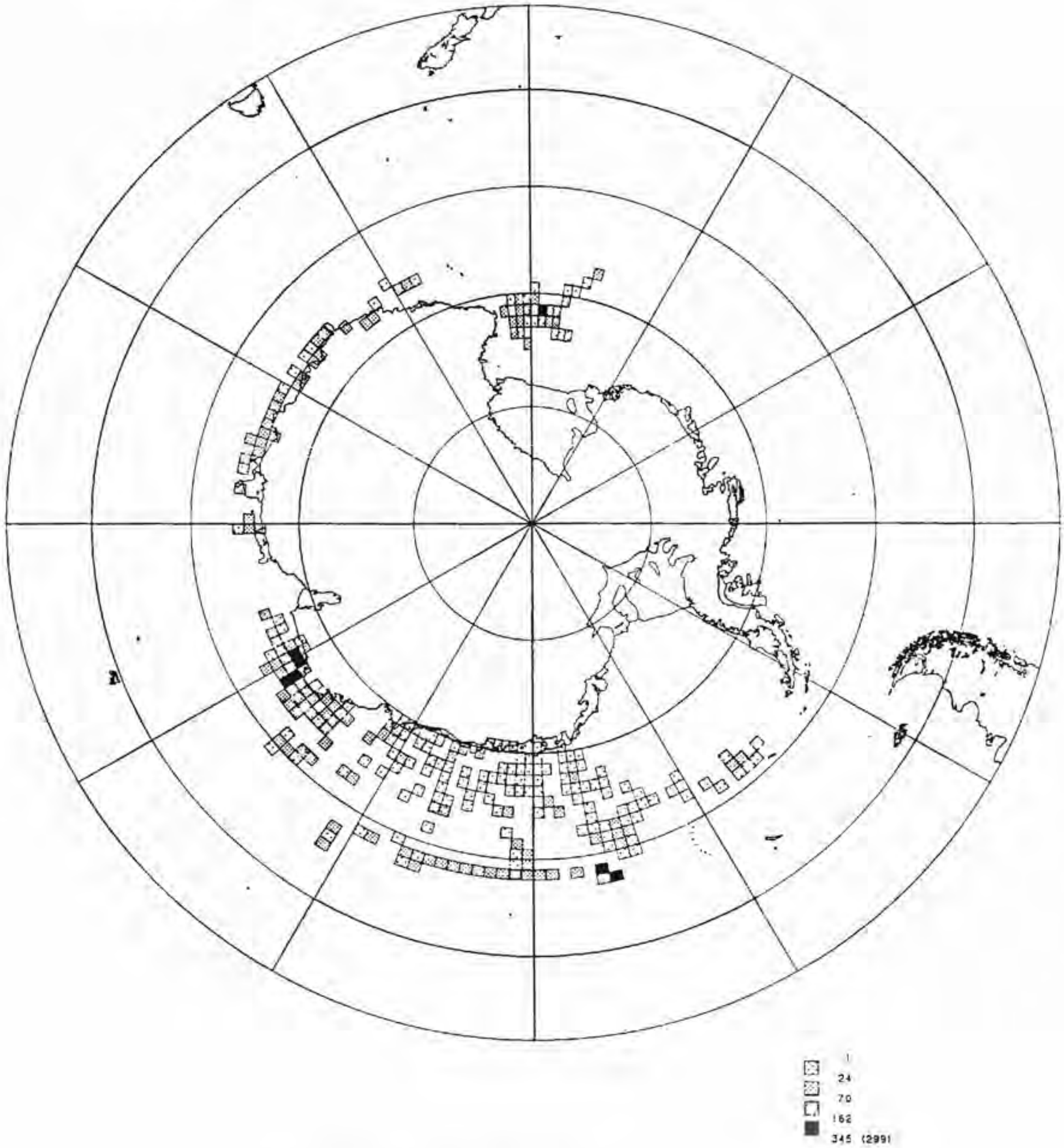
FIN WHALE CATCH IN FEBRUARY 1952/53

Figure 36.



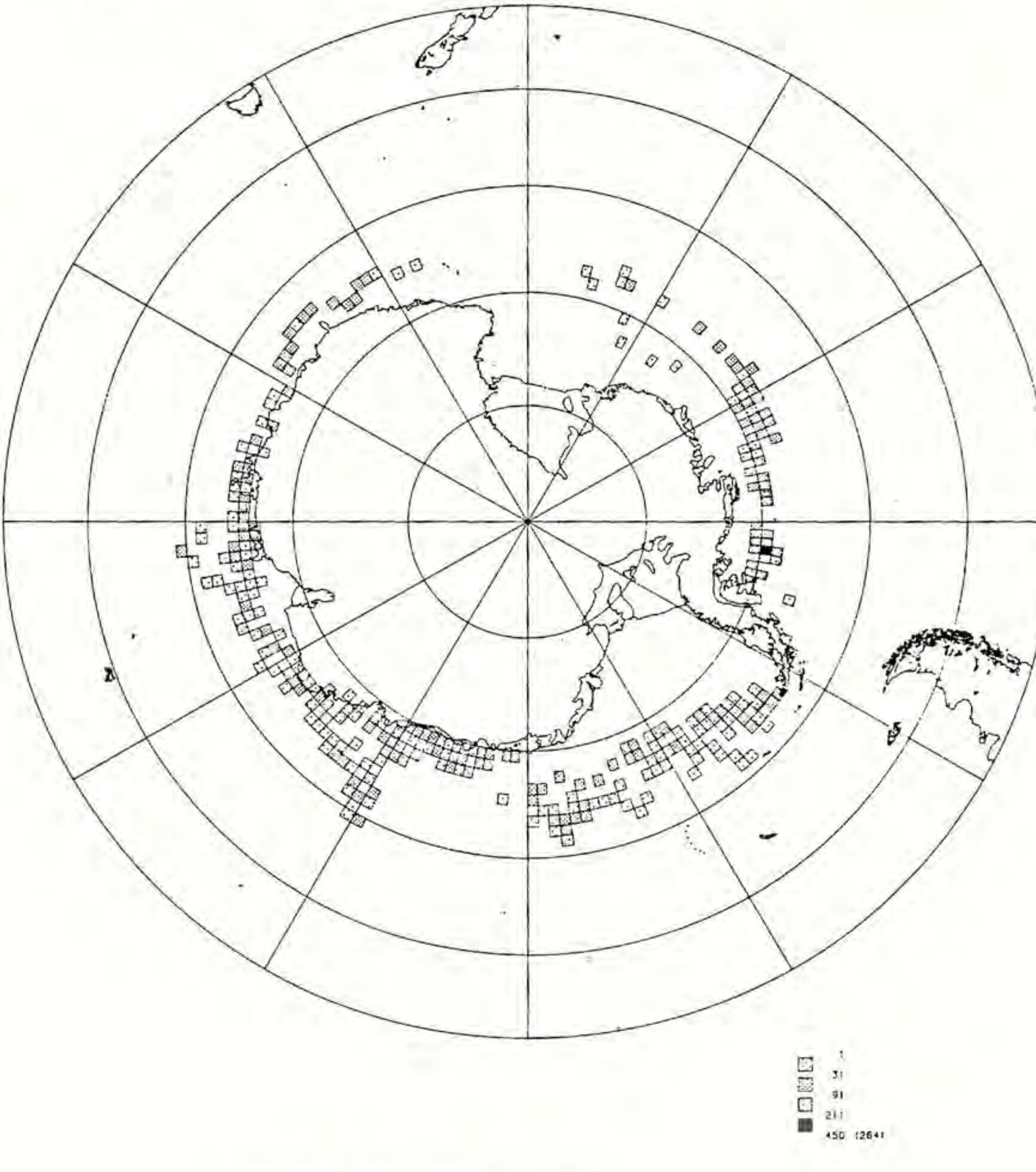
FIN WHALE CATCH IN FEBRUARY 1953/54

Figure 37.



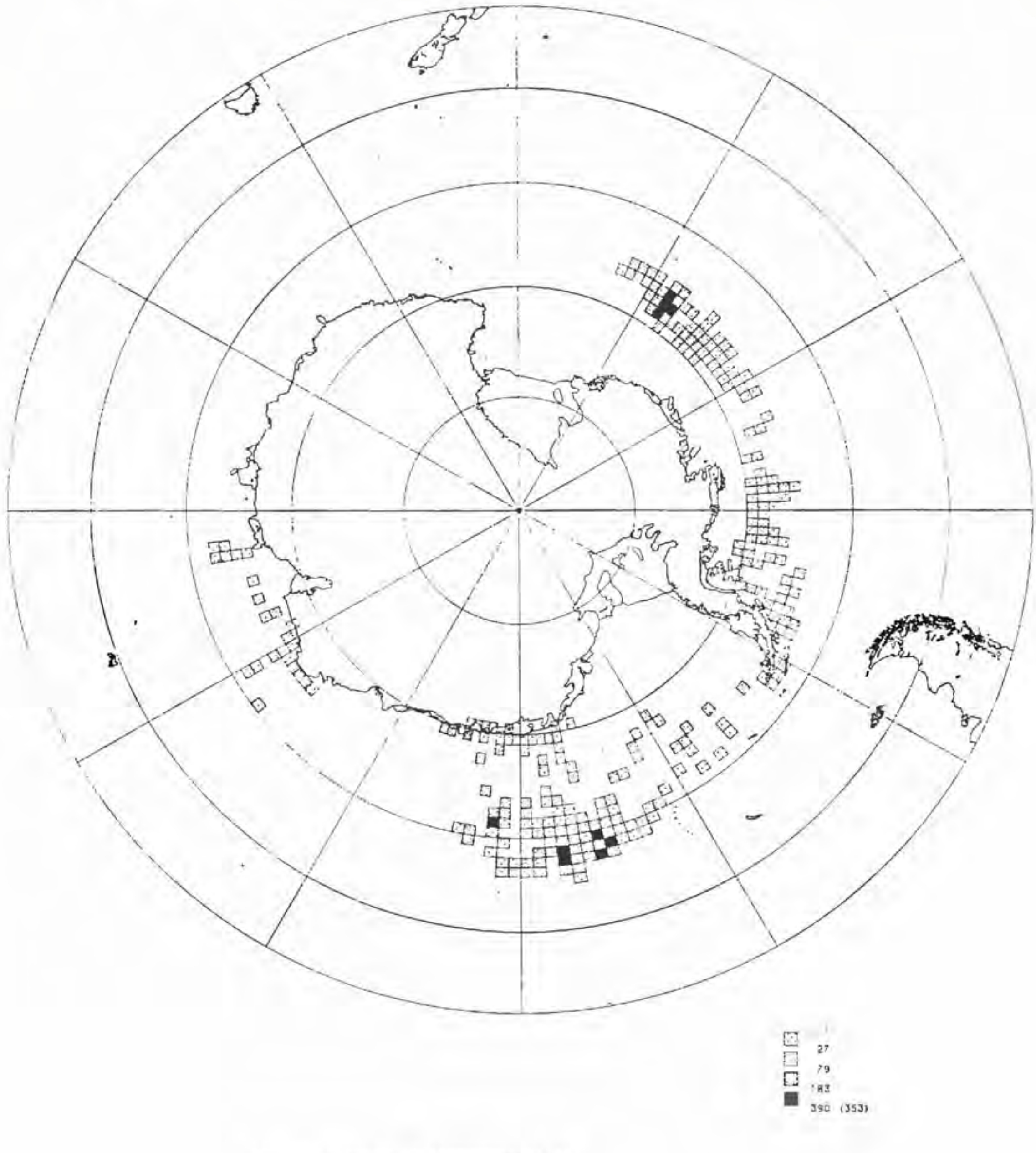
FIN WHALE CATCH IN FEBRUARY 1954/55

Figure 38.



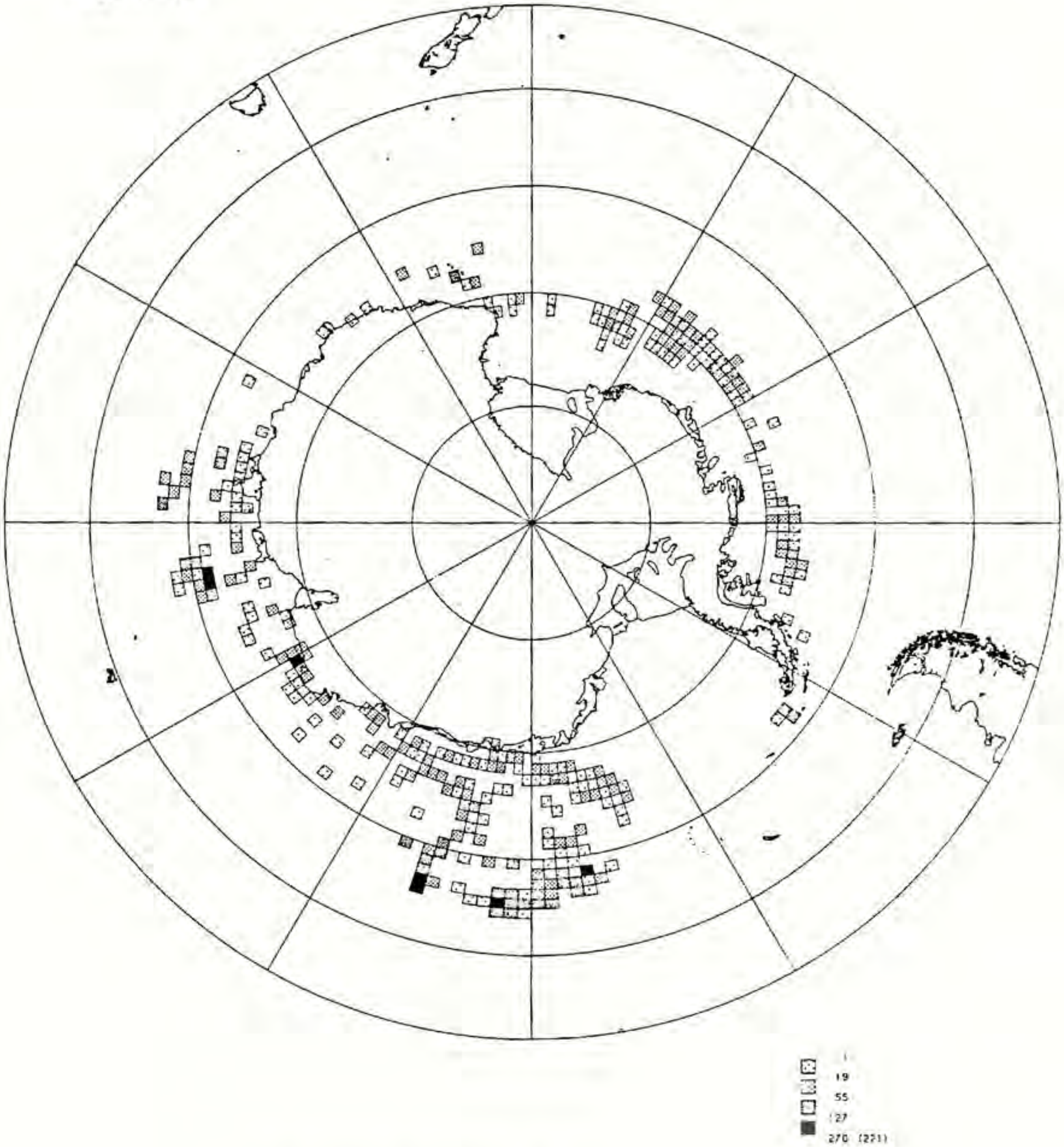
FIN WHALE CATCH IN FEBRUARY 1955/56

Figure 39.



FIN WHALE CATCH IN FEBRUARY 1956/57

Figure 40.



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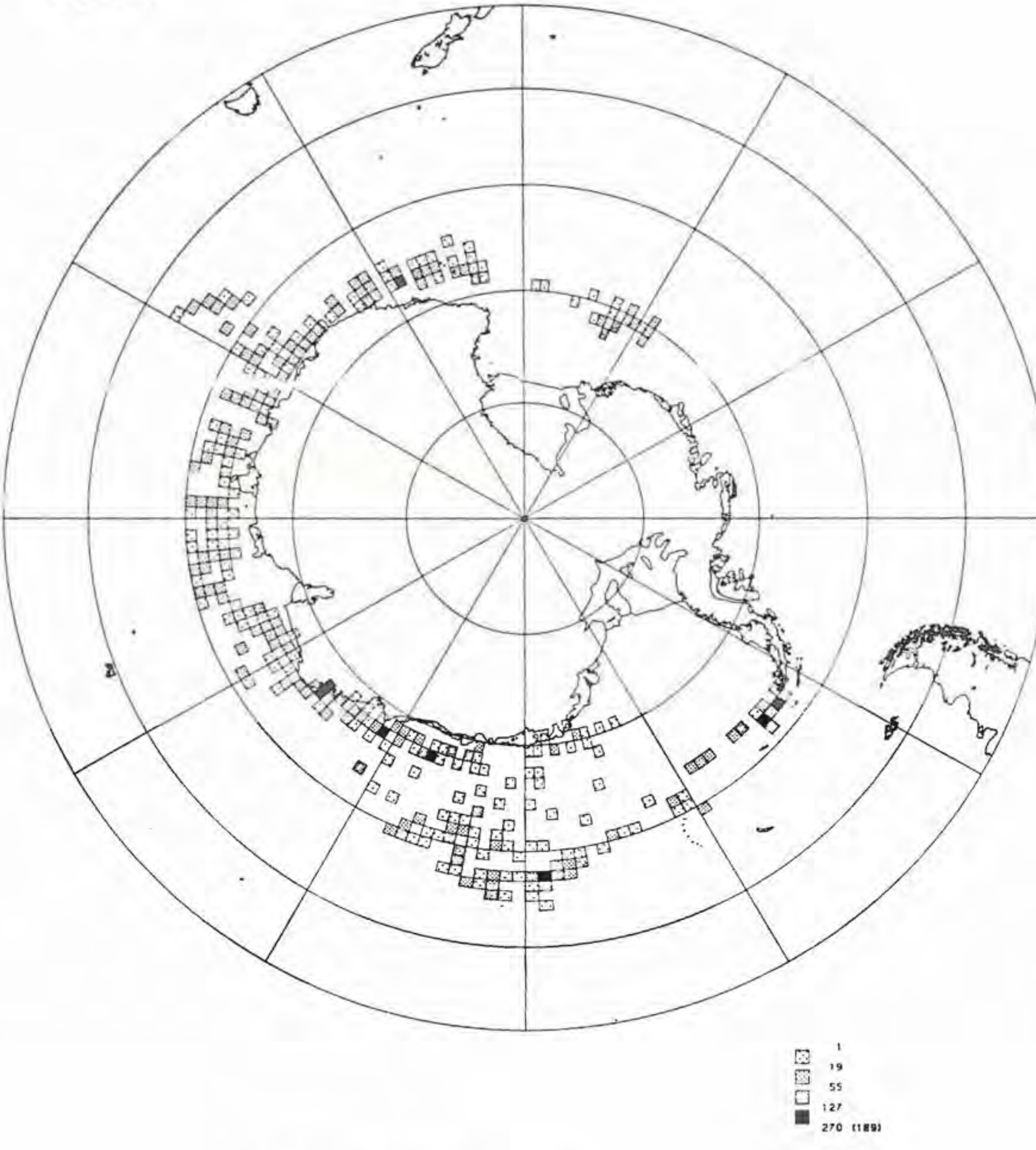
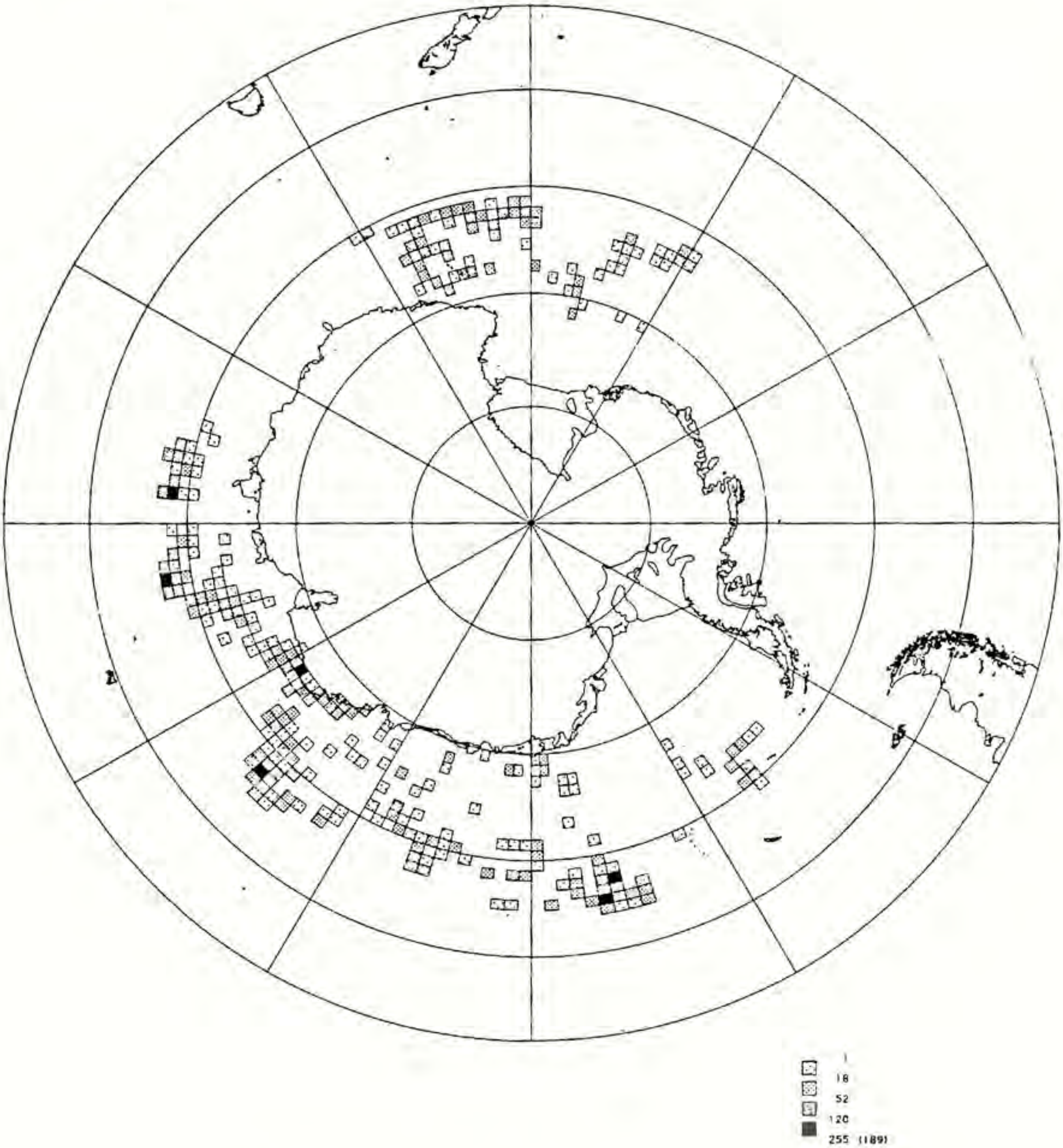


FIN WHALE CATCH IN FEBRUARY 1958/59

Figure 42.



FIN WHALE CATCH IN FEBRUARY 1959/60

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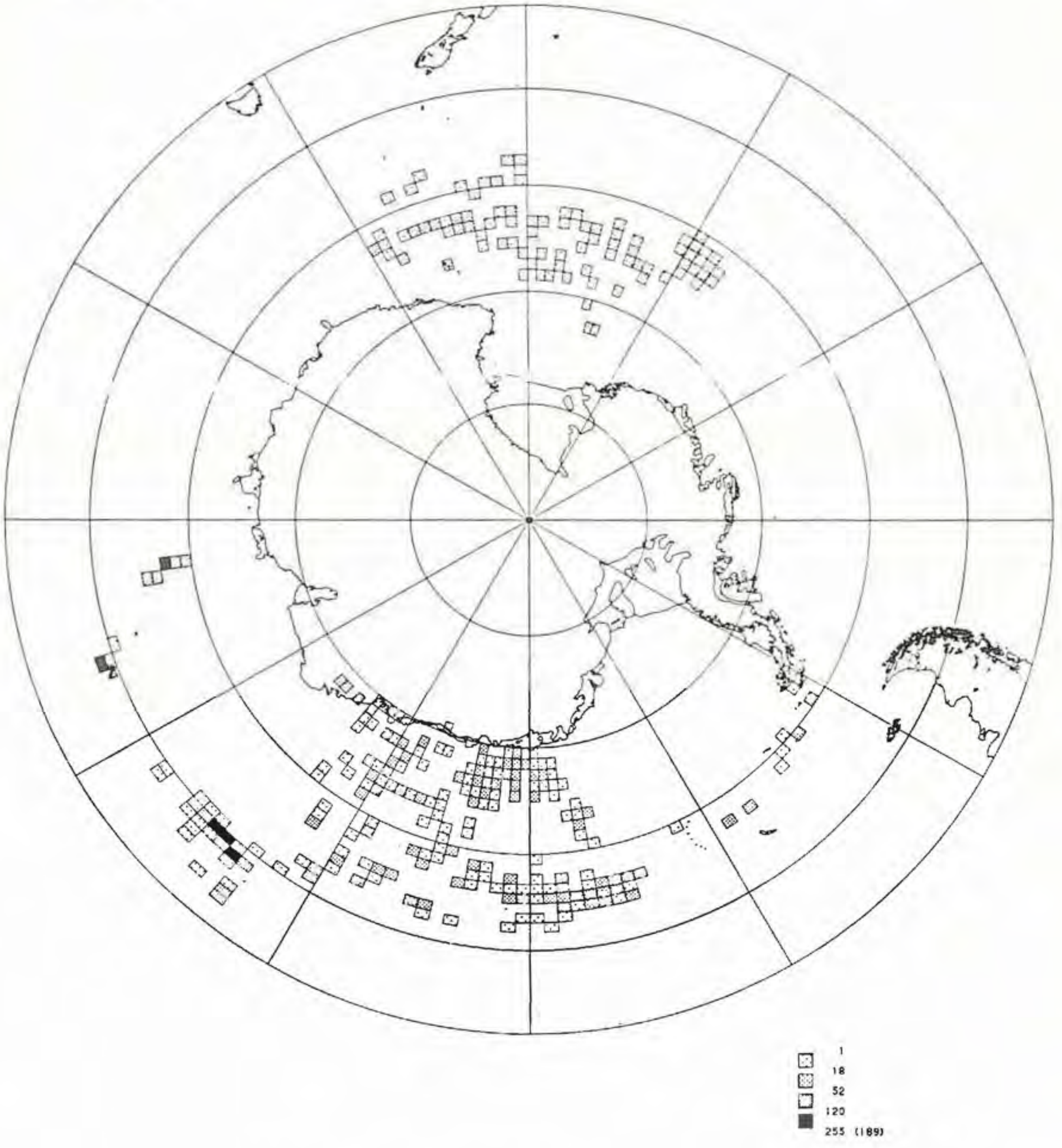

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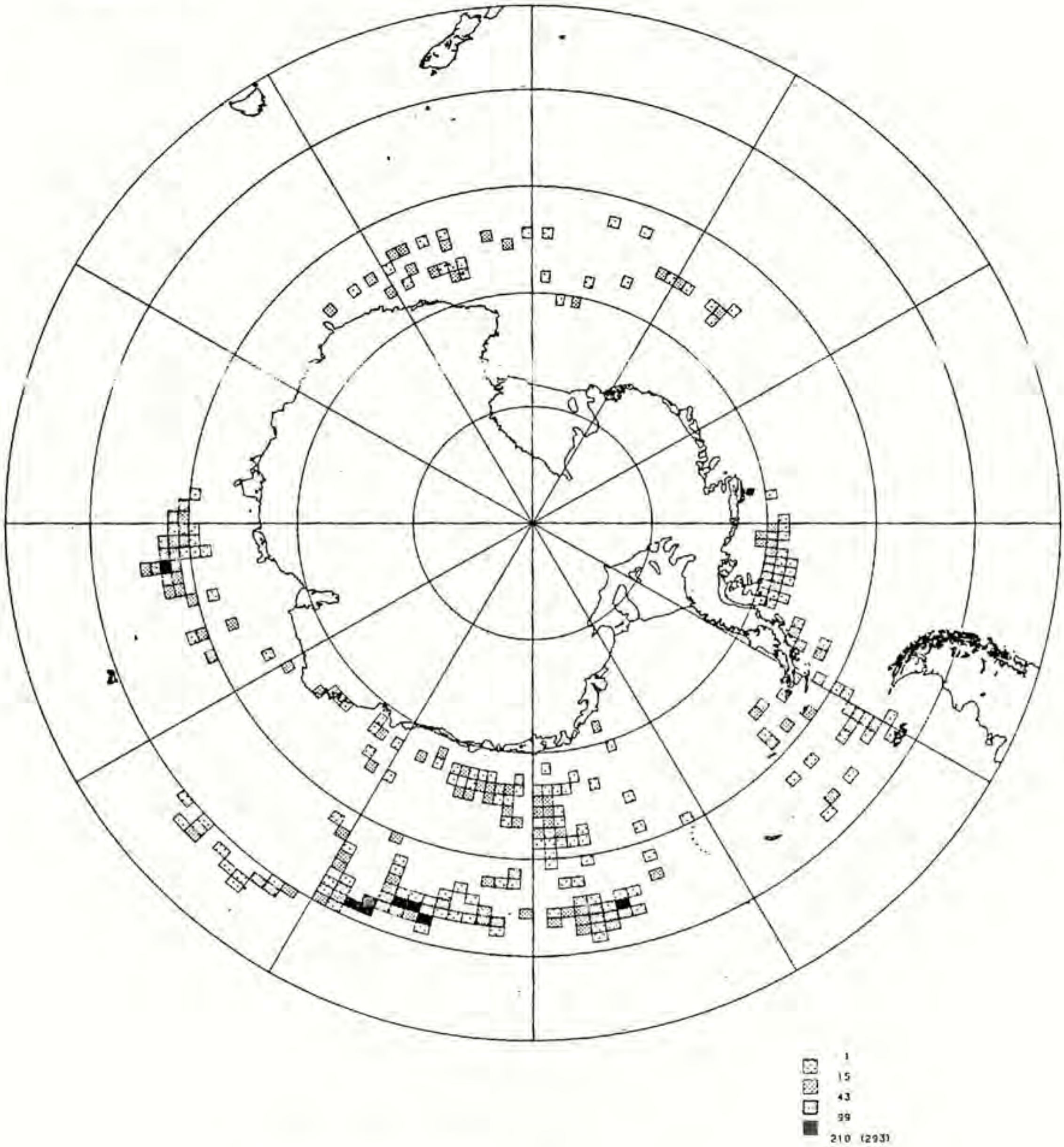

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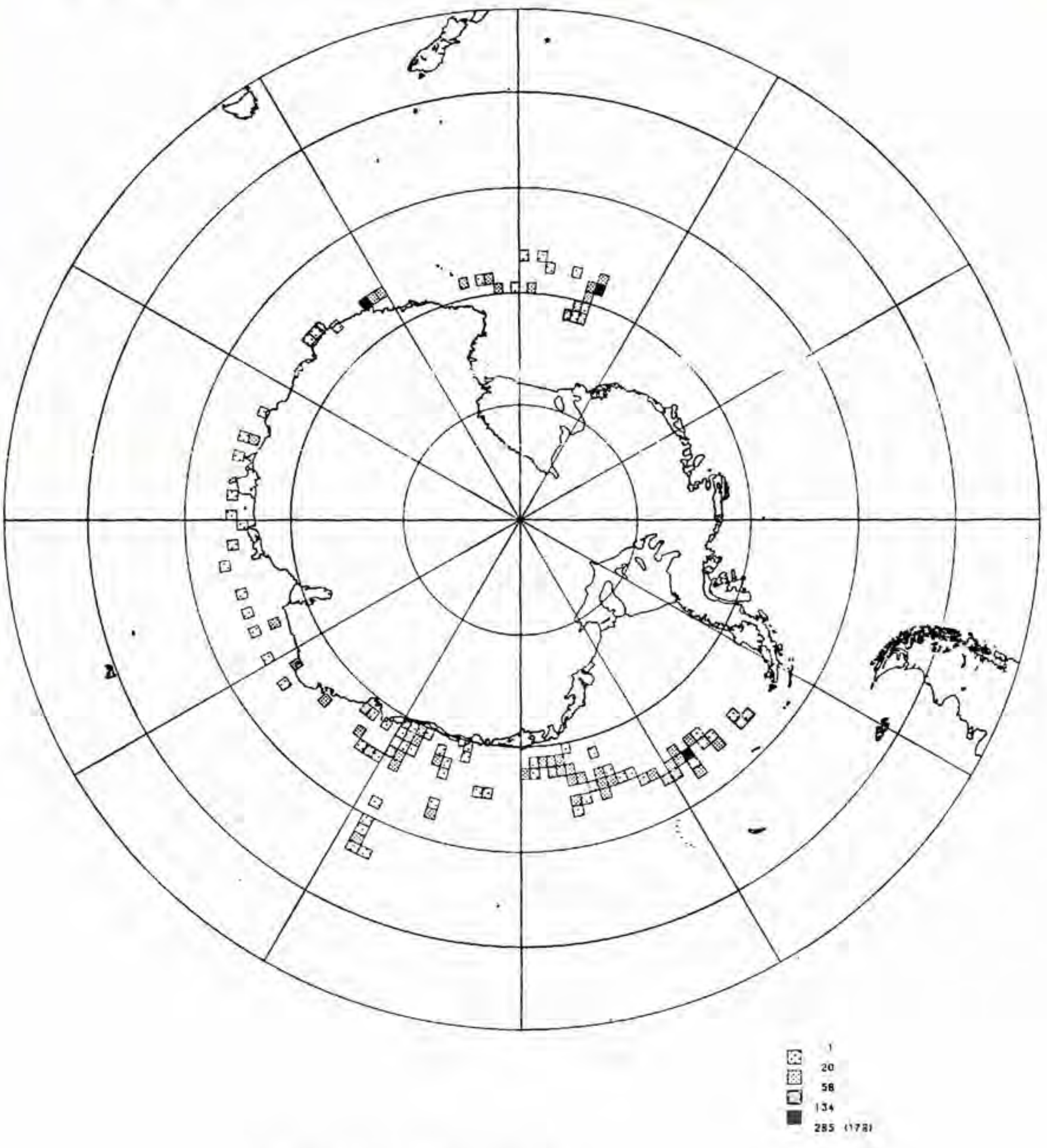

FIN WHALE CATCH IN MARCH 1952/53

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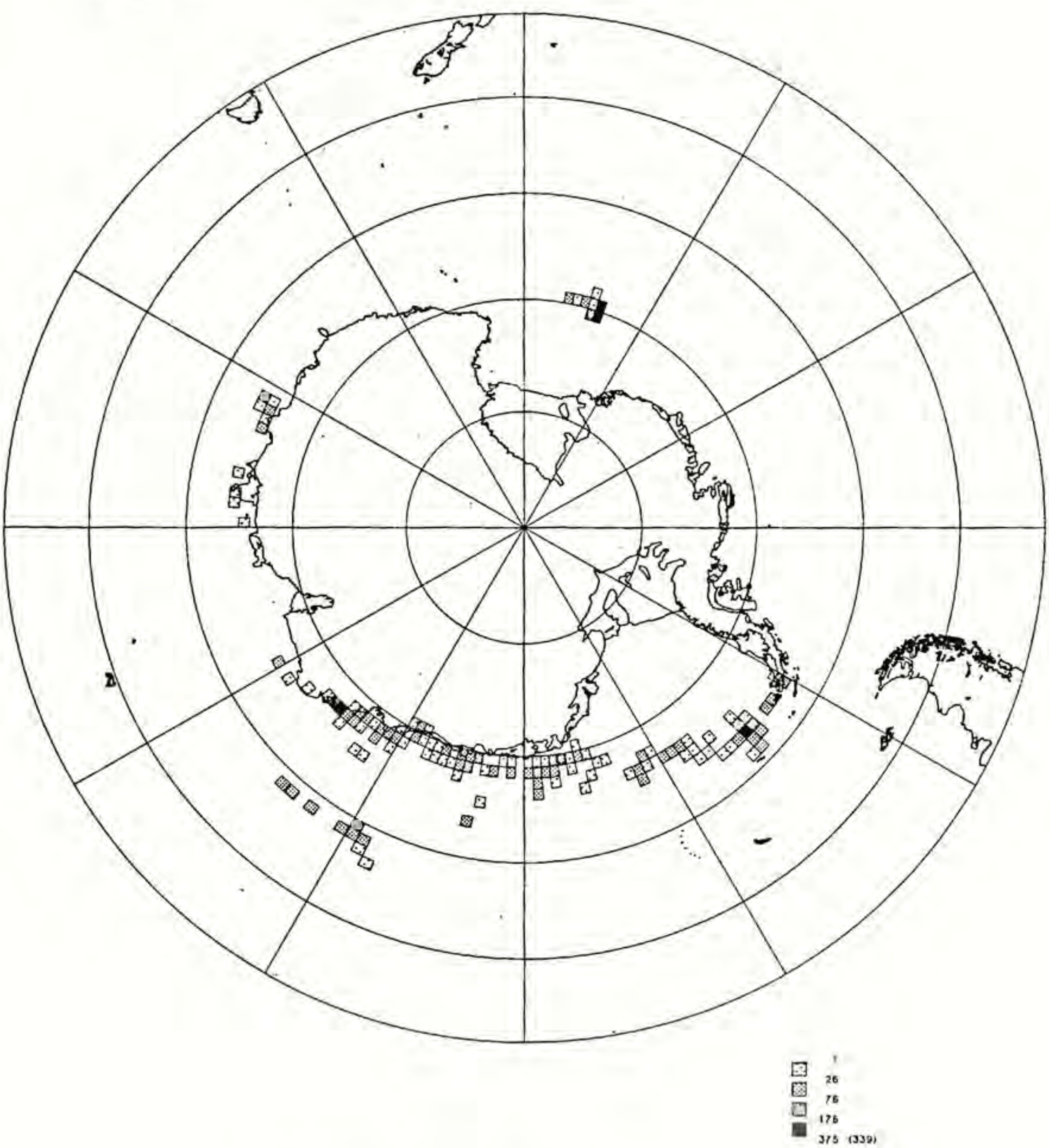

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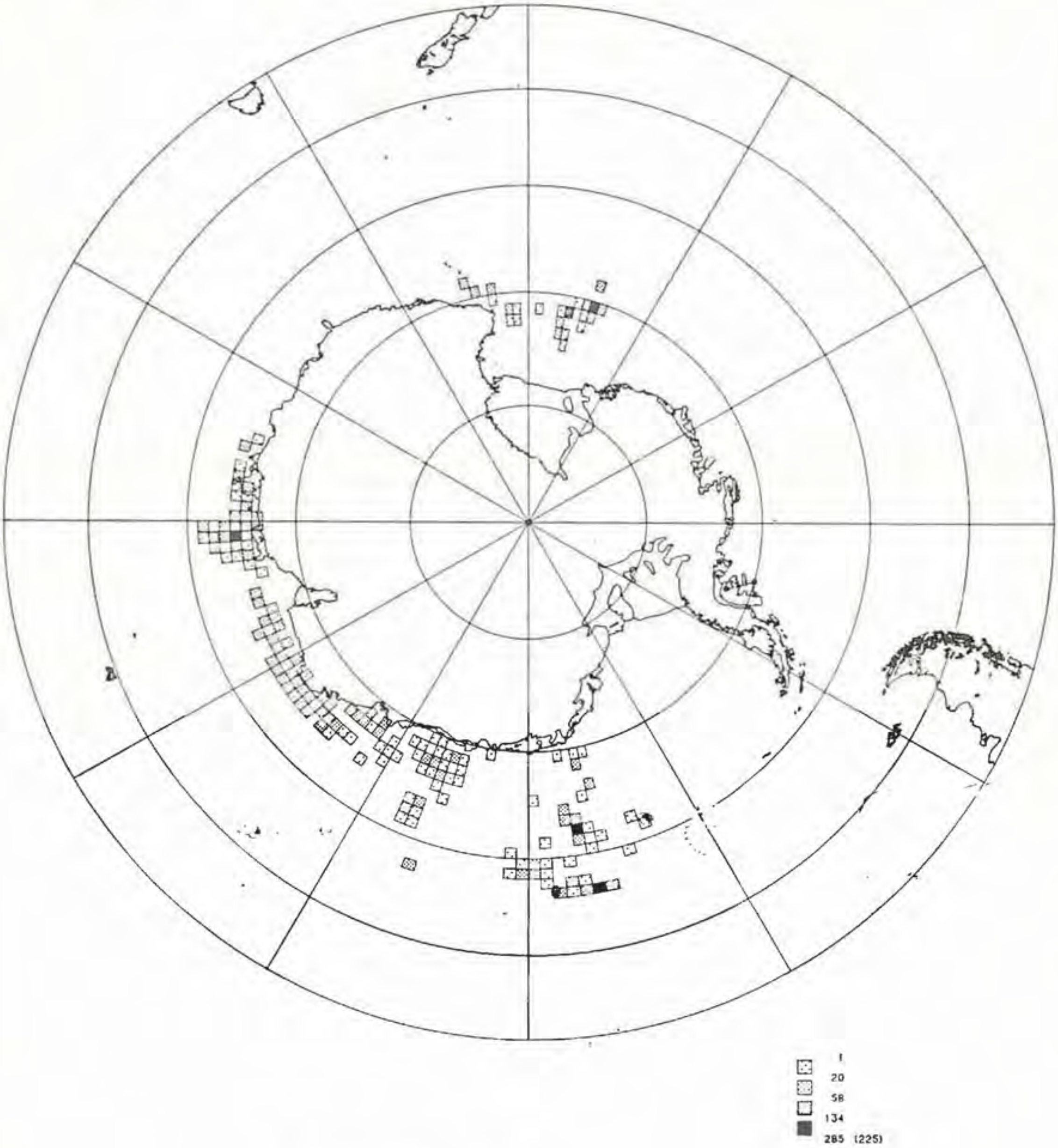

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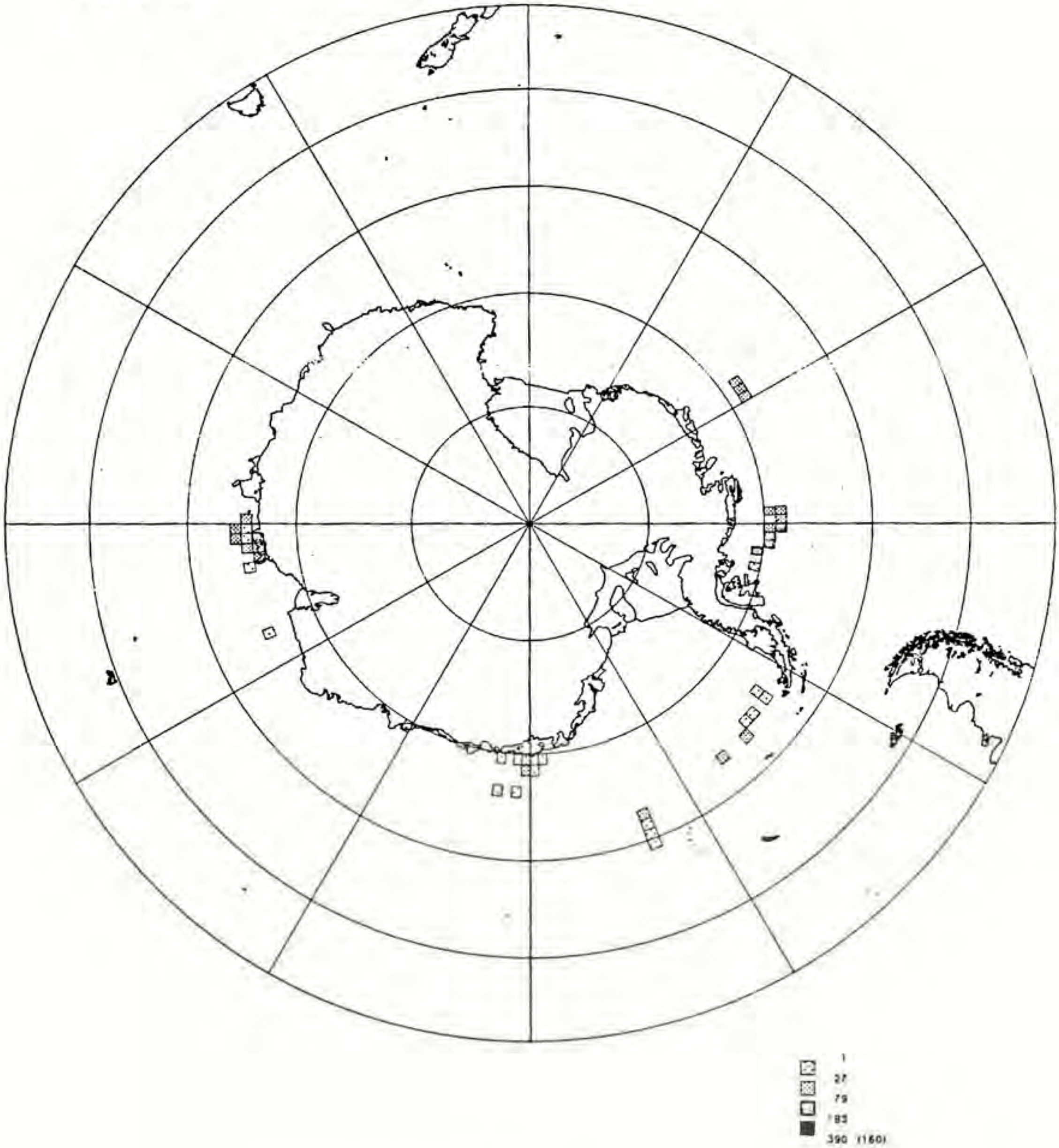

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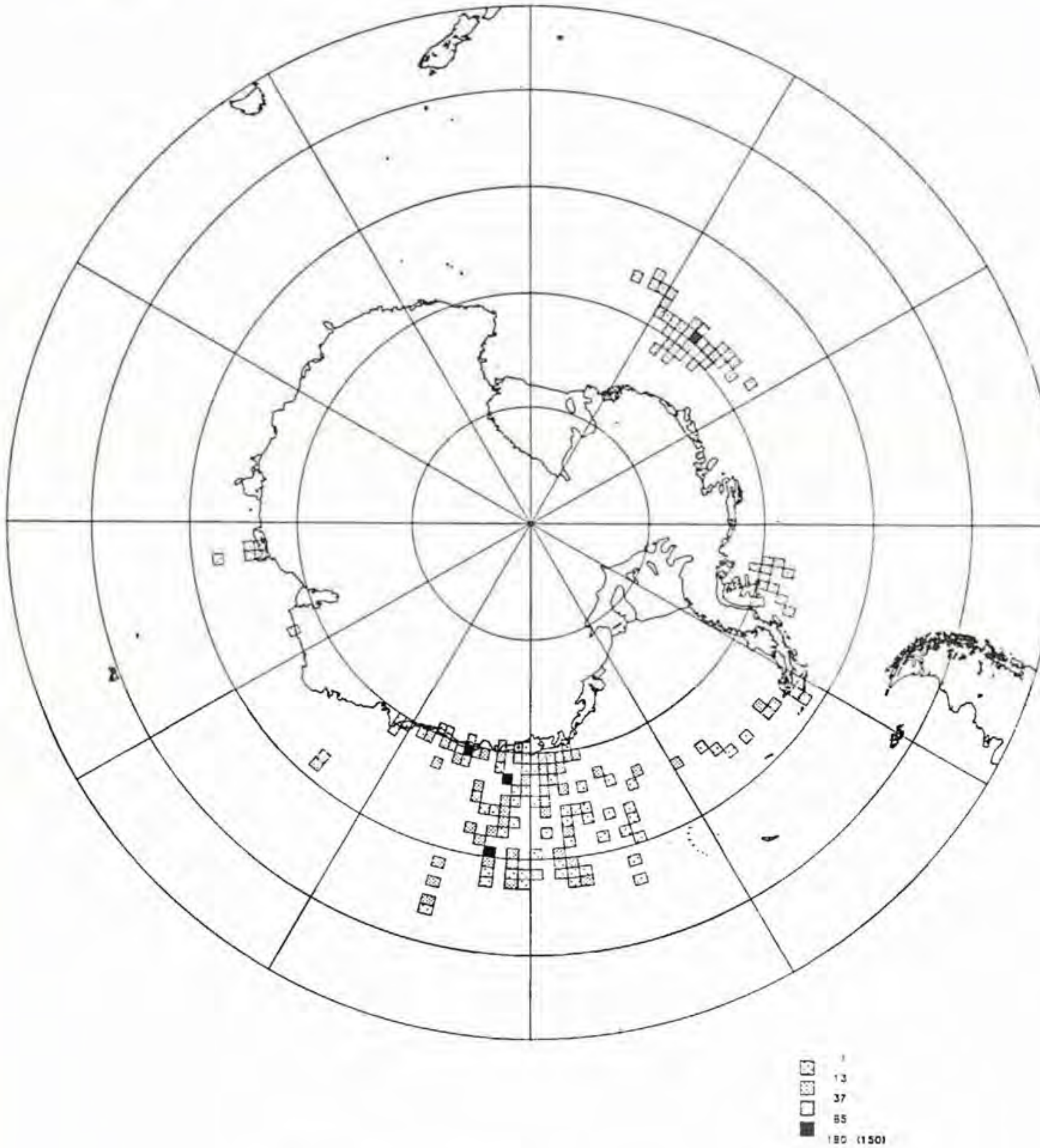
Figure 49.



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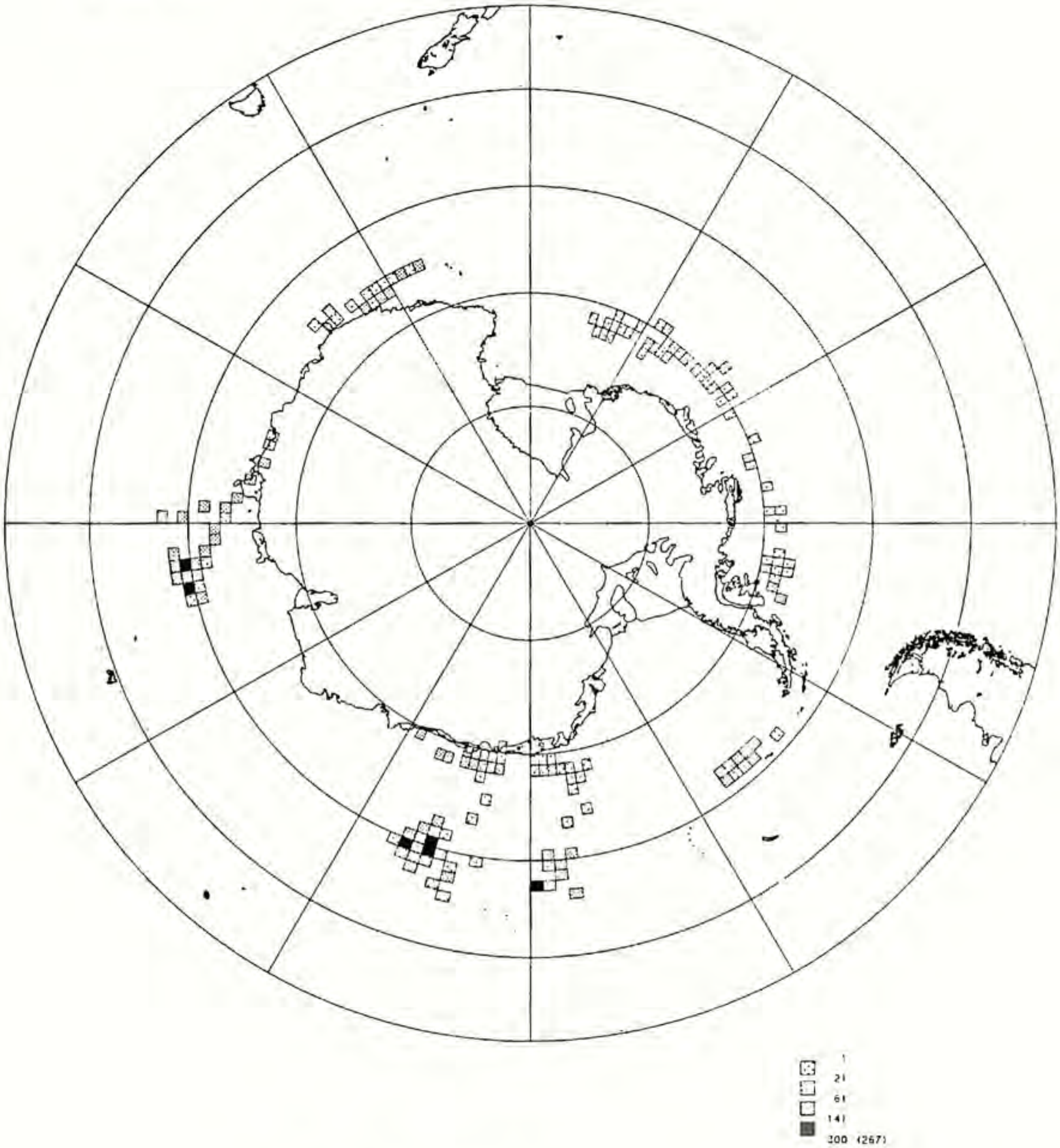

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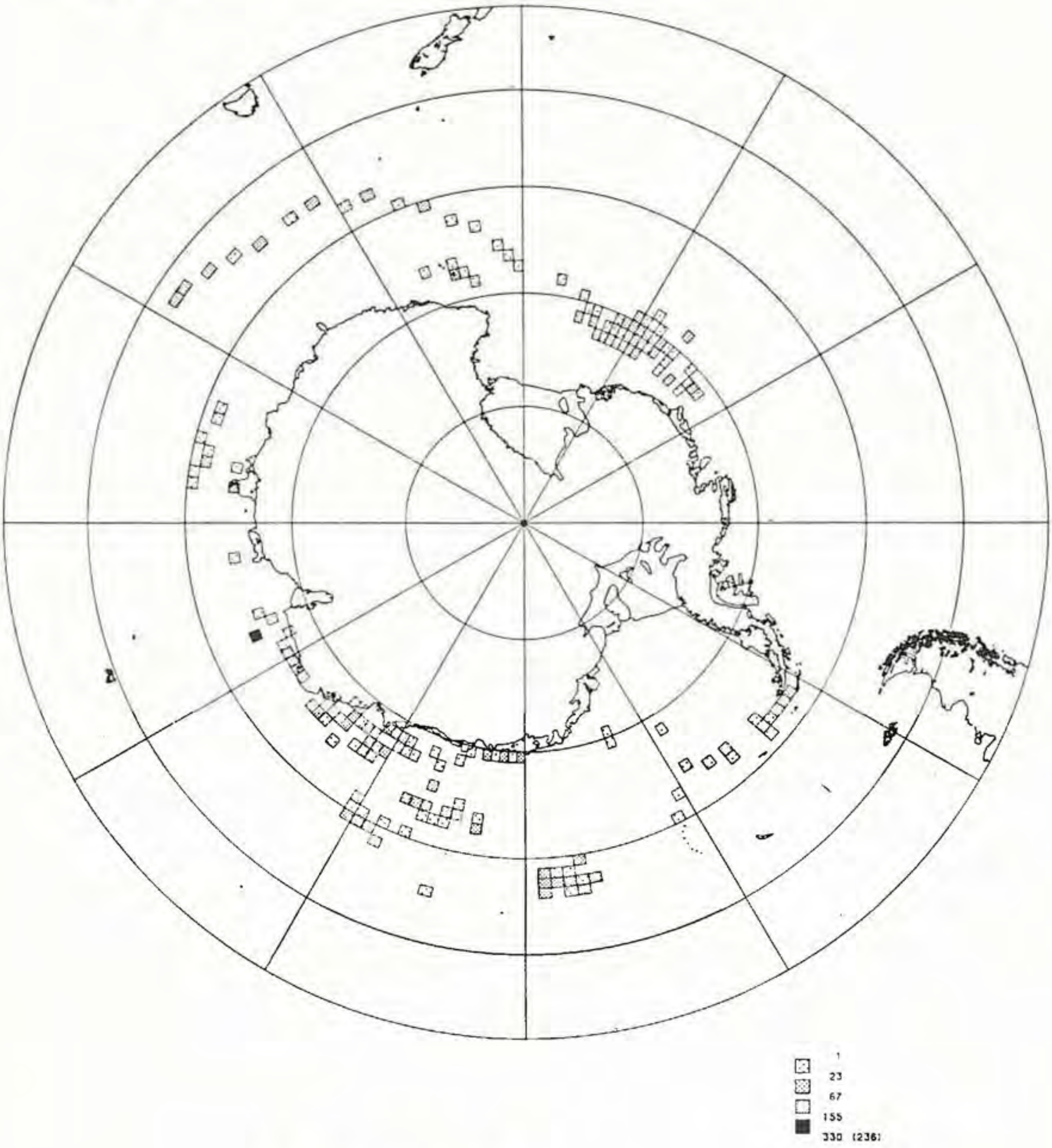

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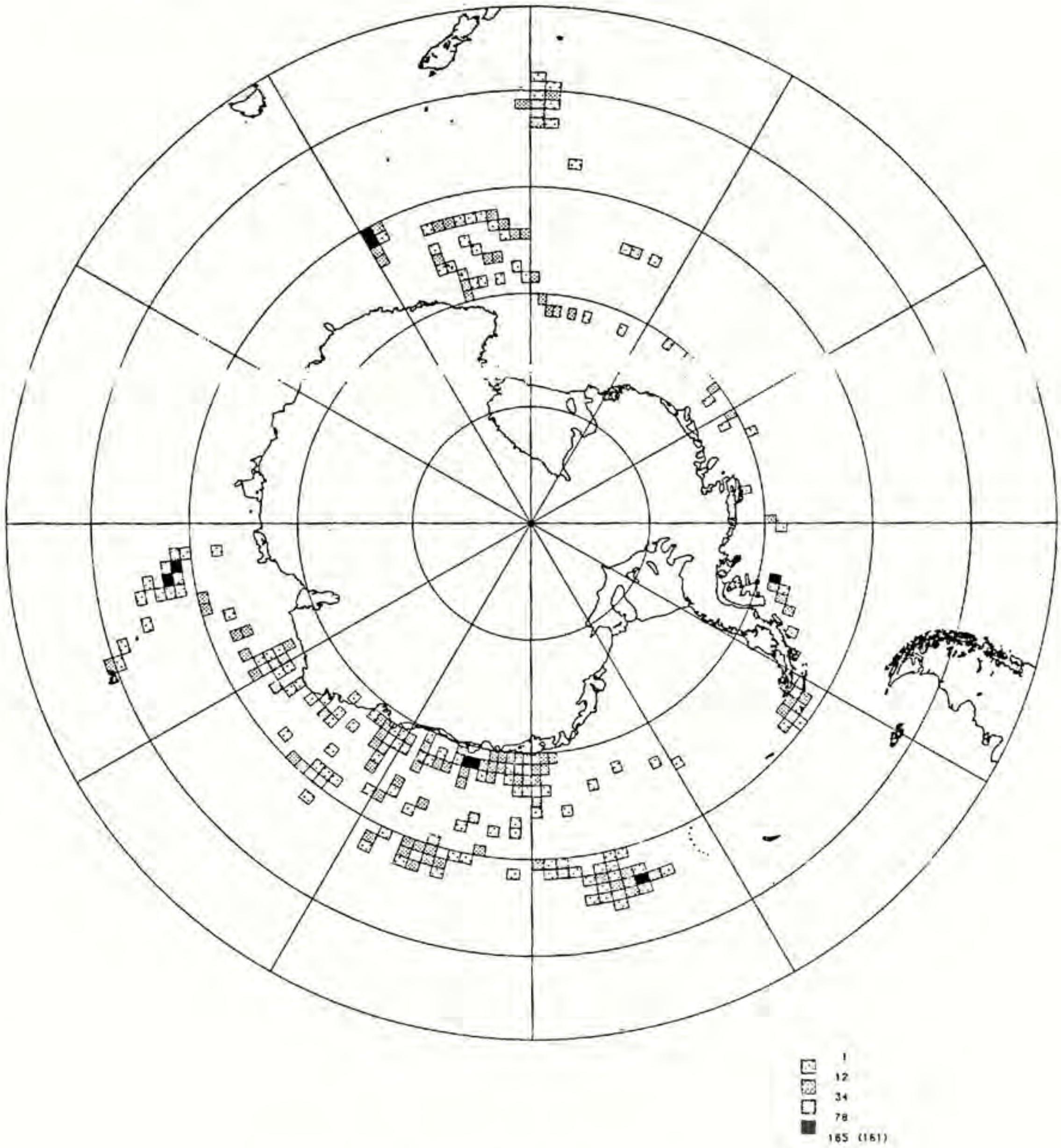

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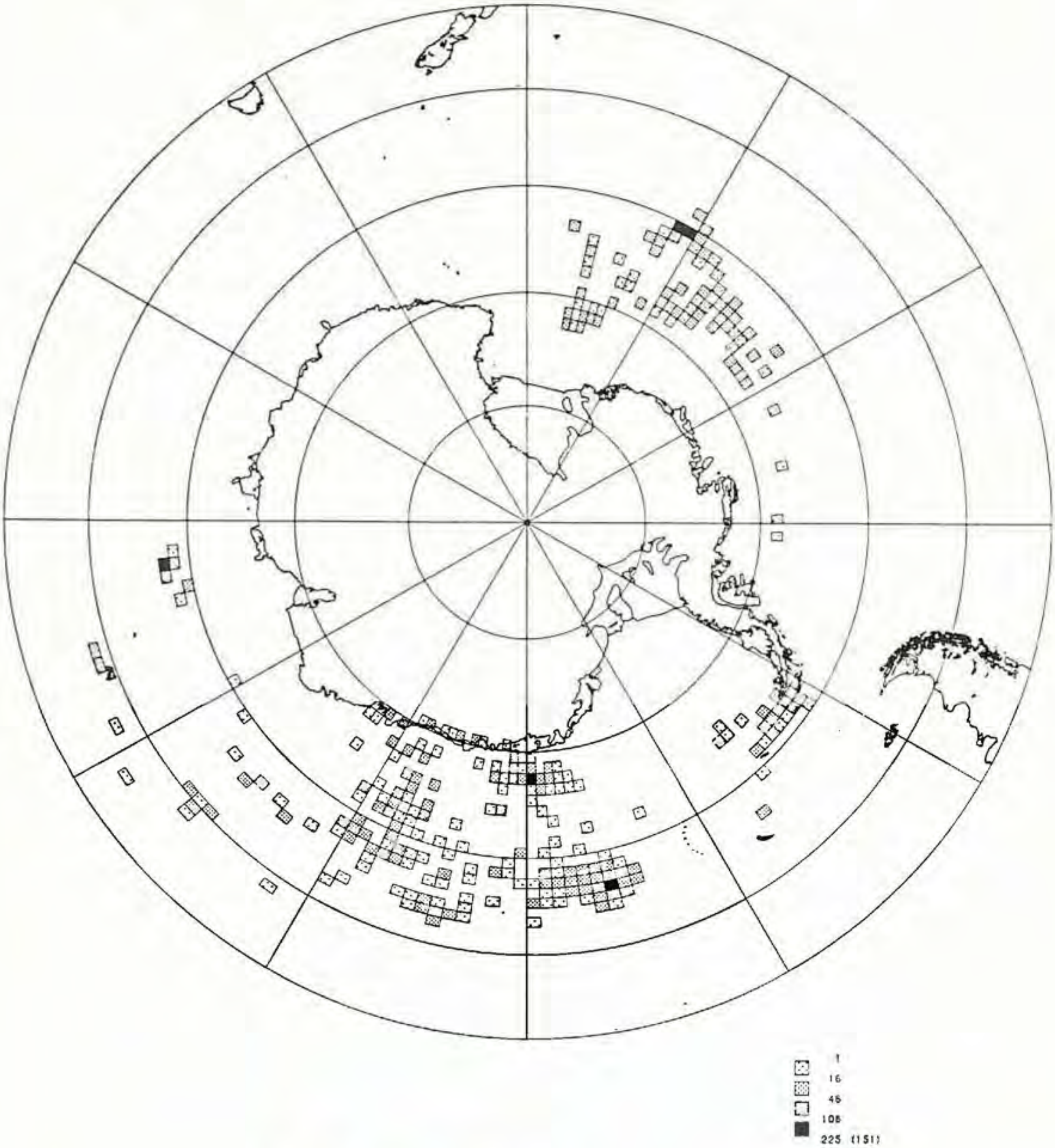

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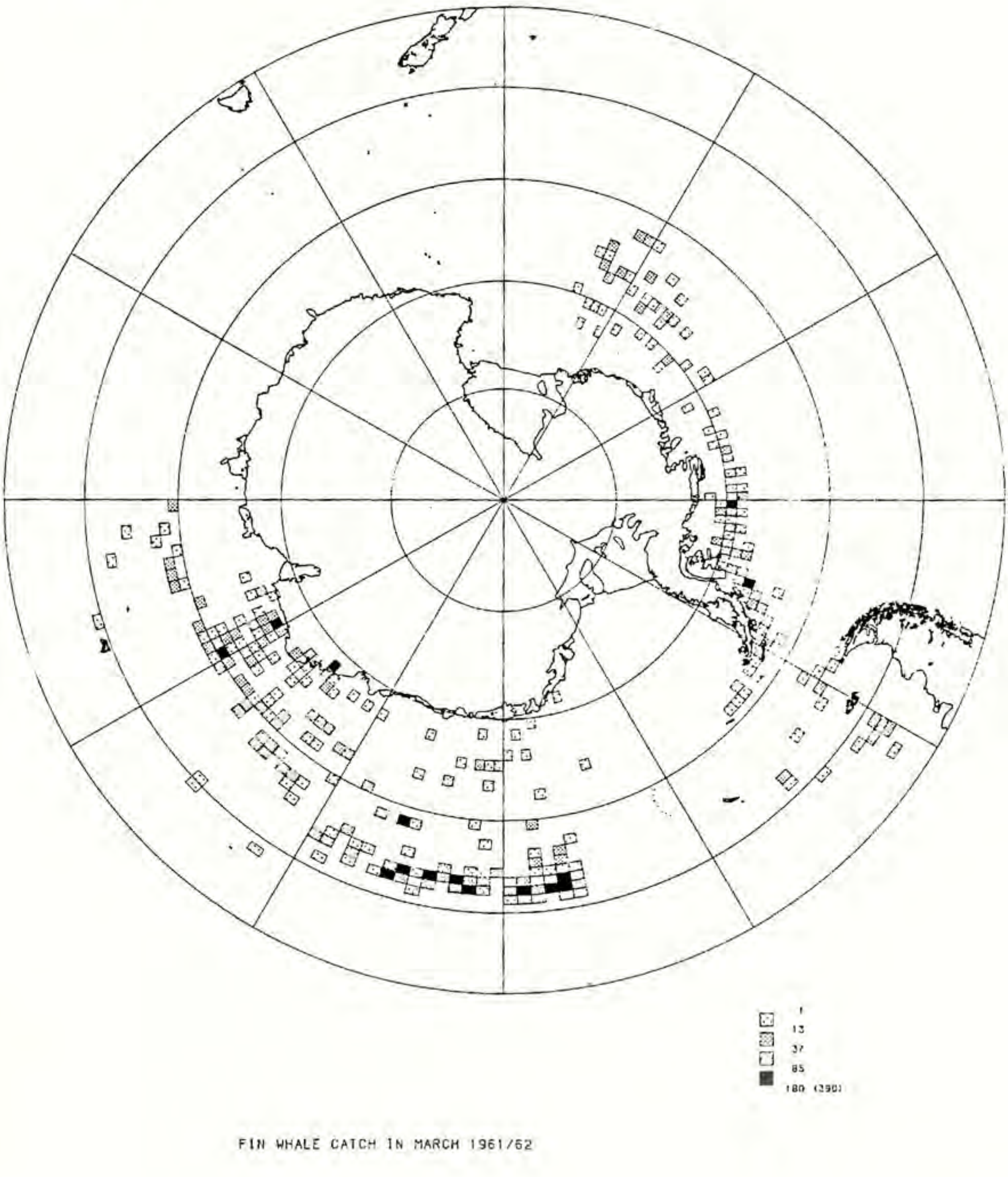

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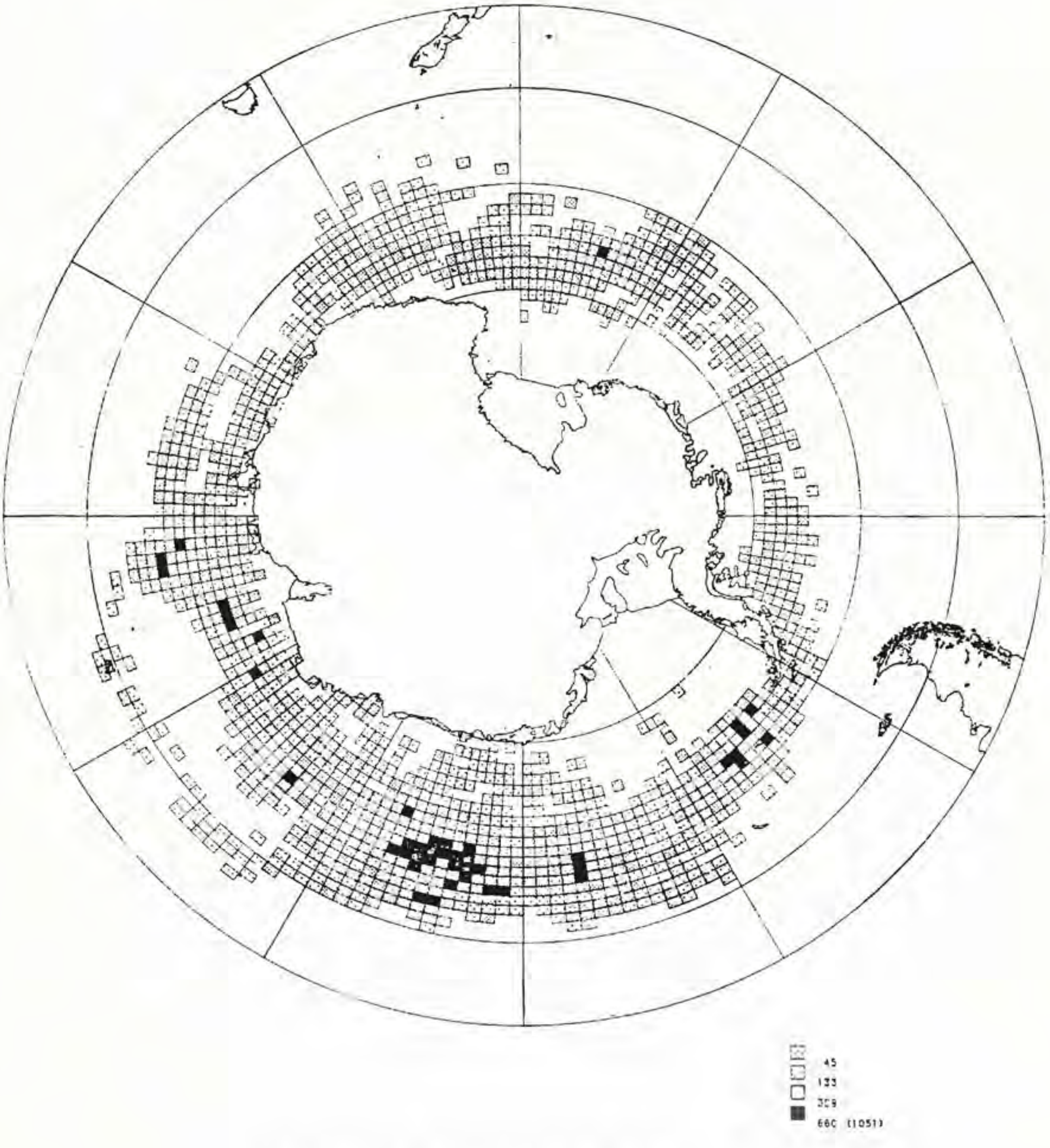

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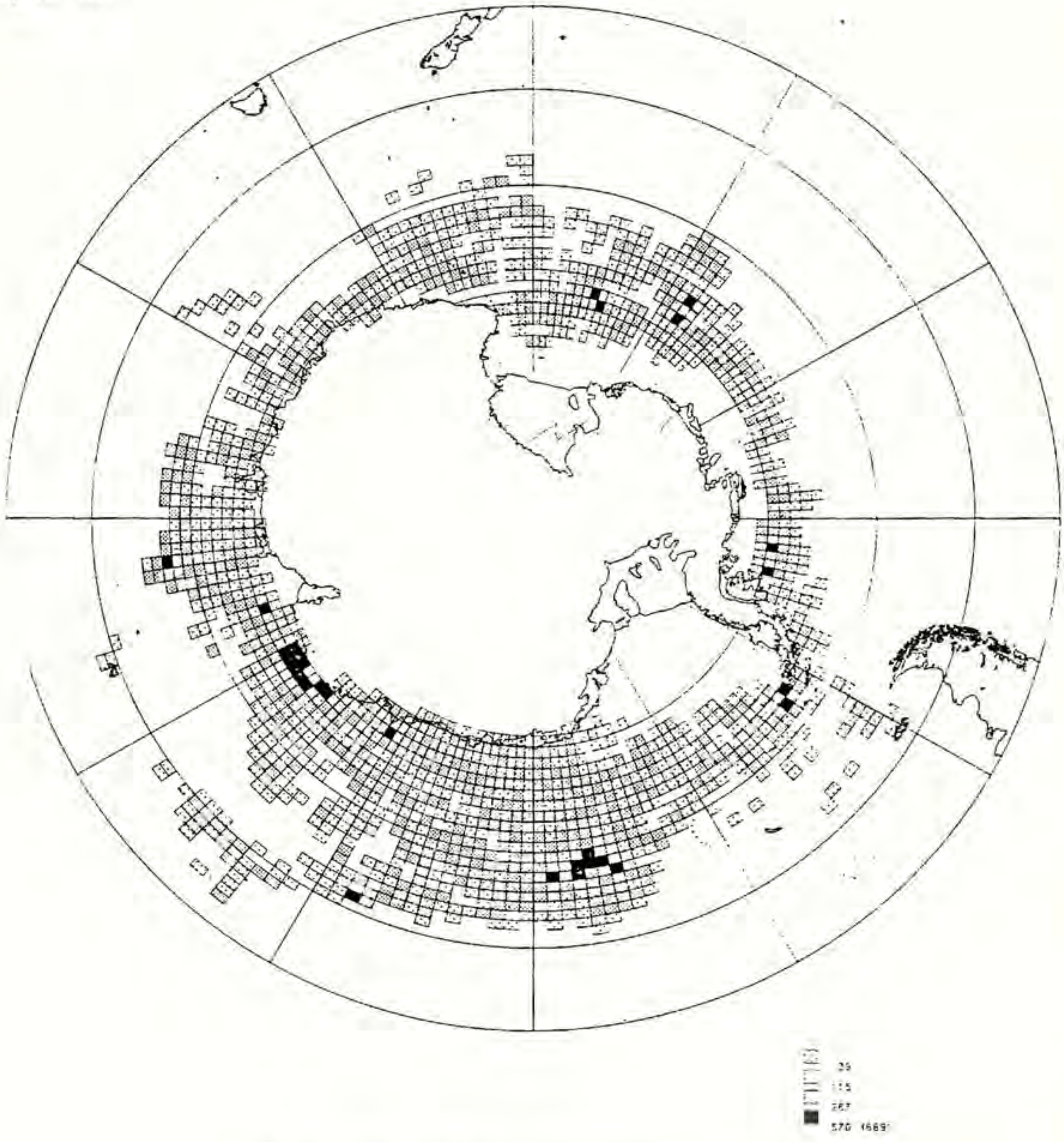

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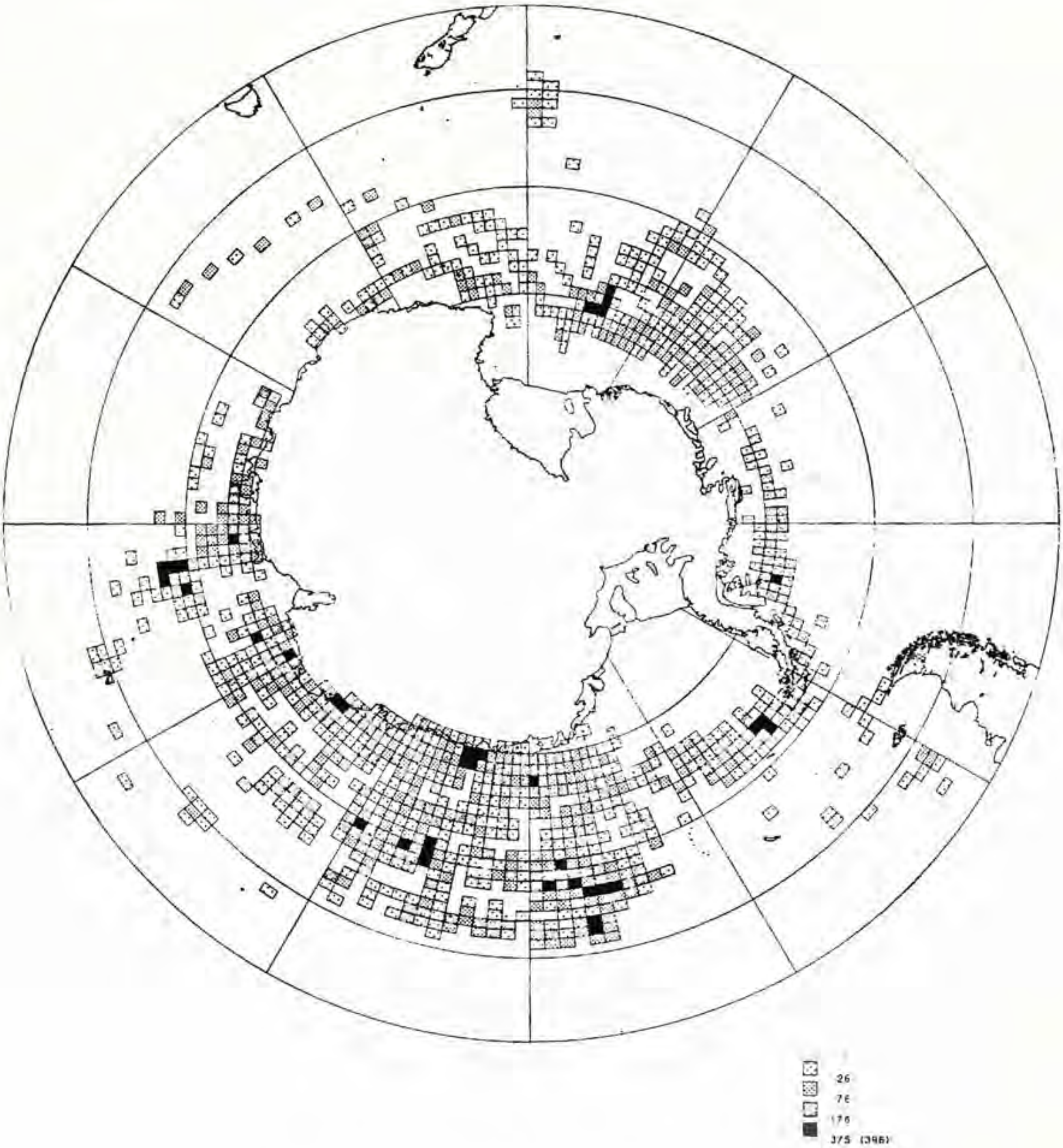

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