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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 1952/53-1961/62 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 BALAELOPTERIDA 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°S; and (c) 20th century shore station catches during the summer south of 40°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

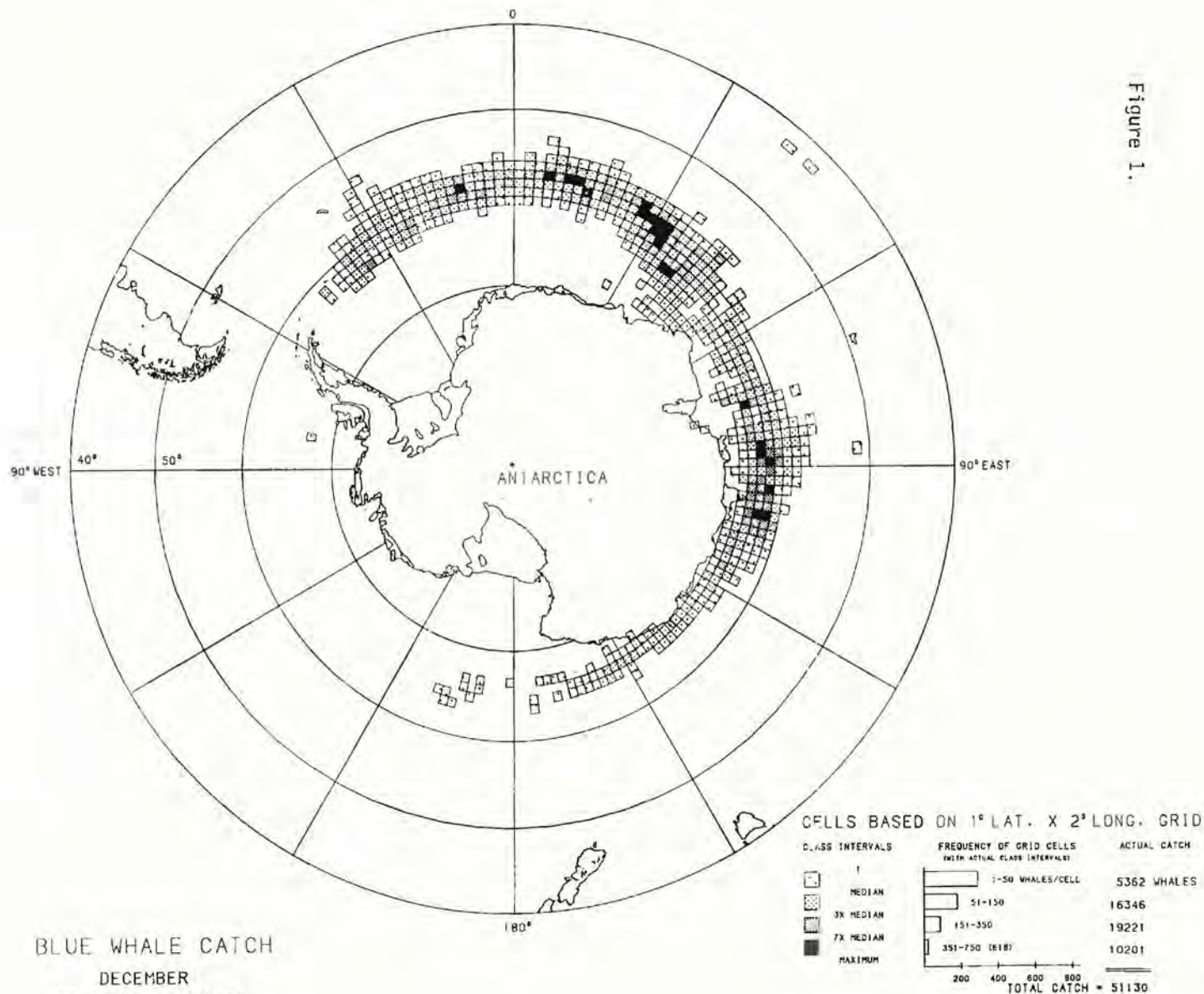
The authors wish to thank K.C. Zinnel for installing the WORLD Mapping Package on the Northwest and Alaska Fisheries Center (NWAFC) computer, for developing the program used to define the data grids, and for providing consistent good advice as the project progressed. We are also grateful to the computing 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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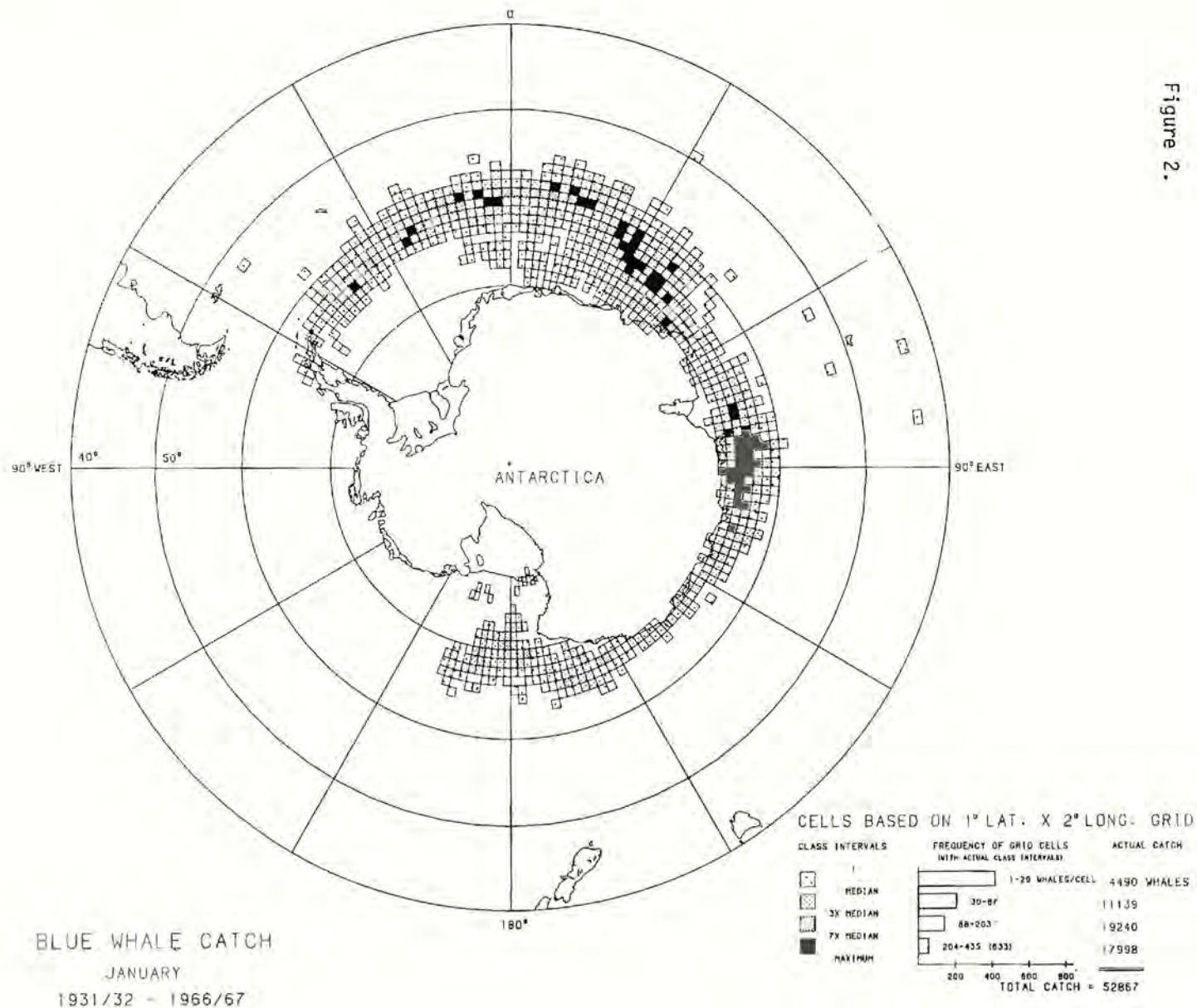
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Figure 1.



BLUE WHALE CATCH
DECEMBER
1931/32 - 1966/67

SOURCE: IWC SOUTHERN HEMISPHERE MASTER TAPE



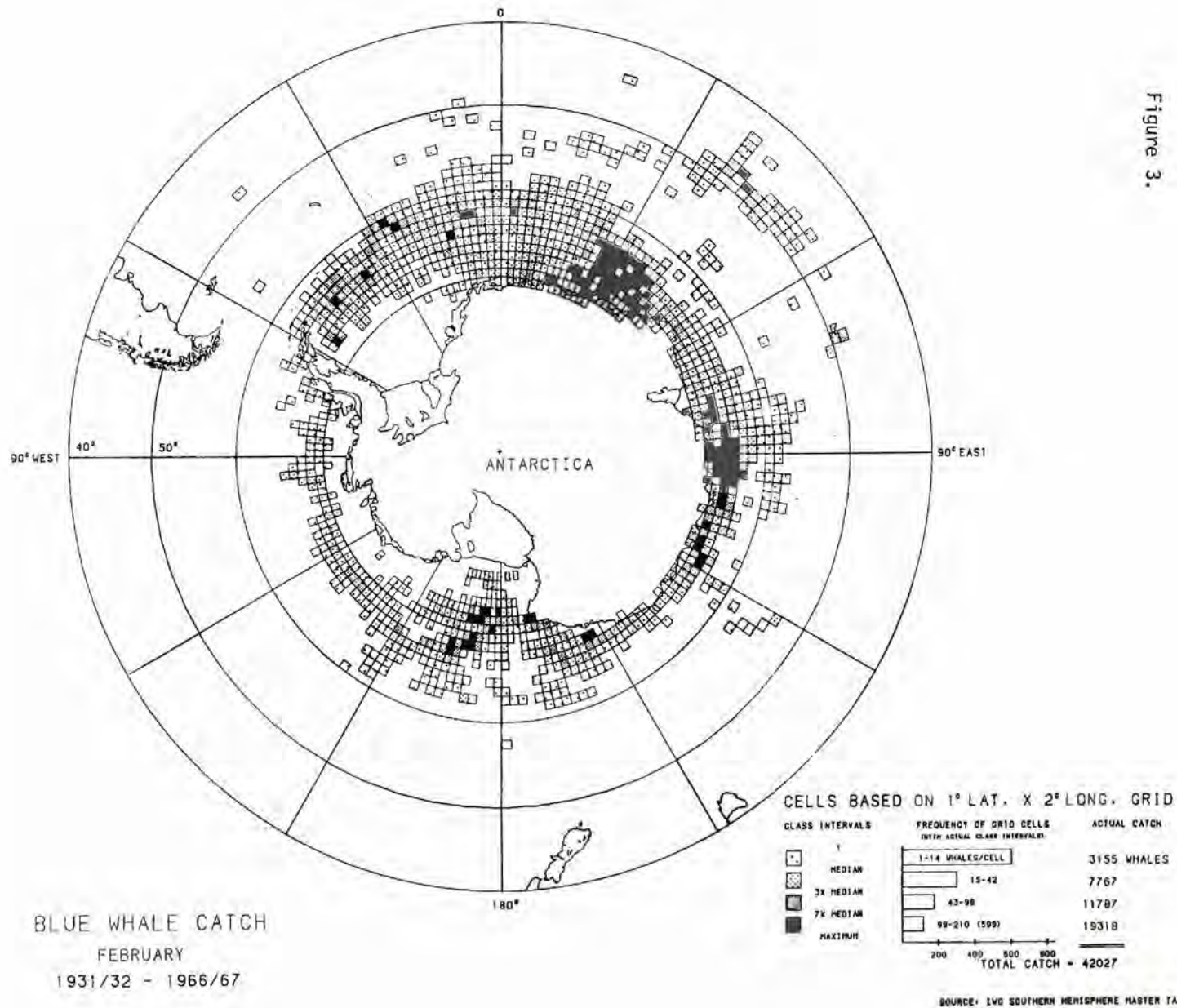
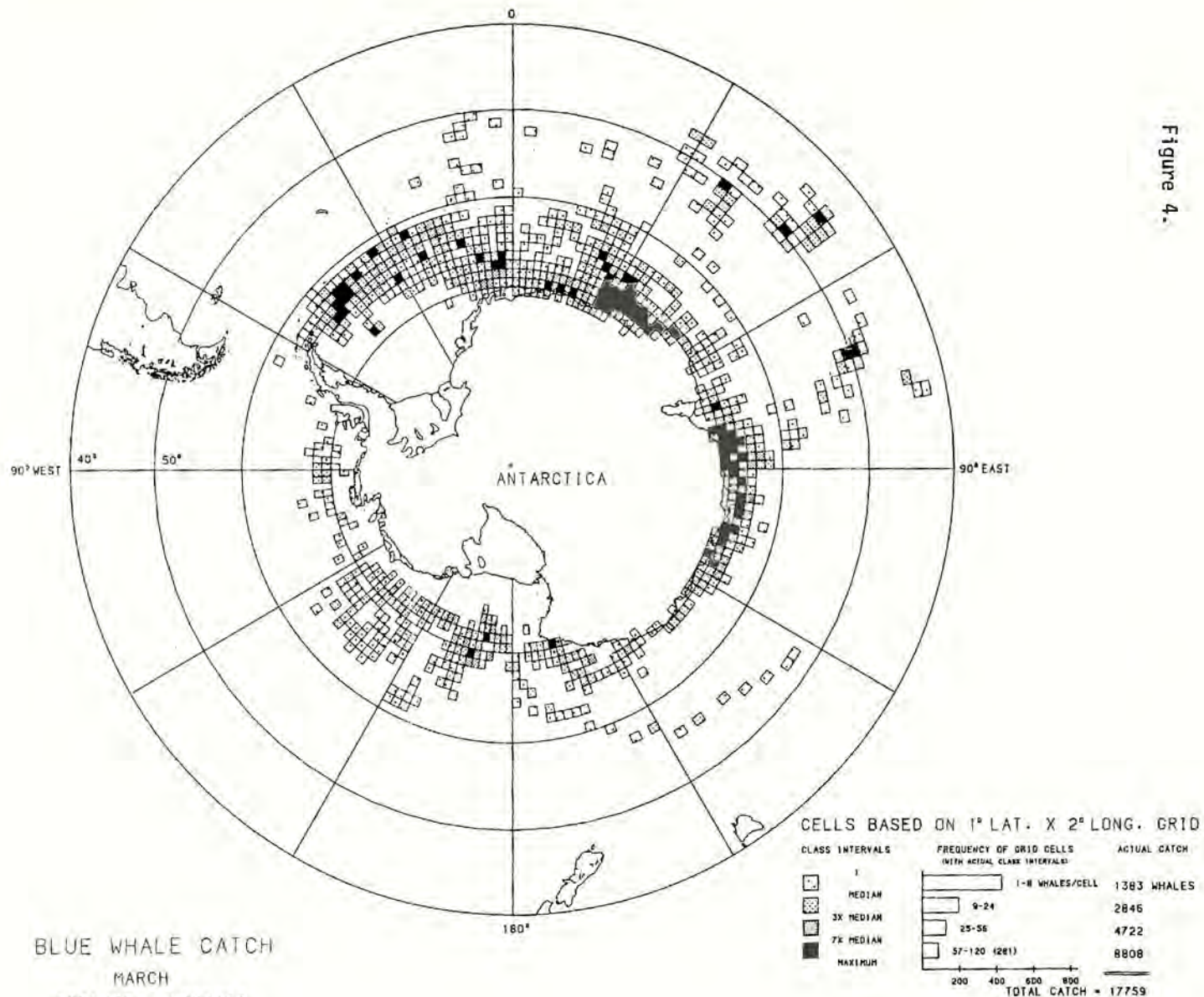
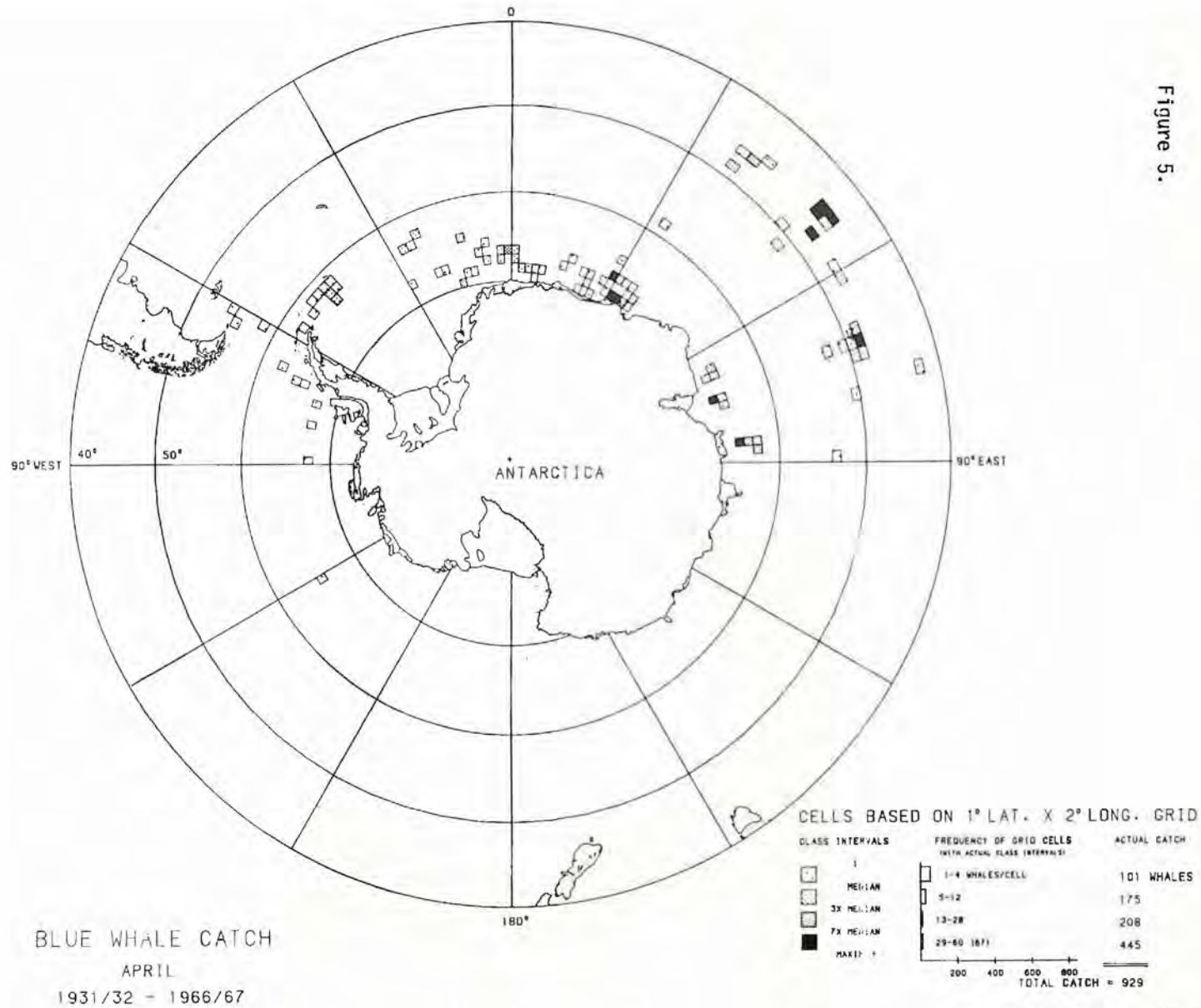


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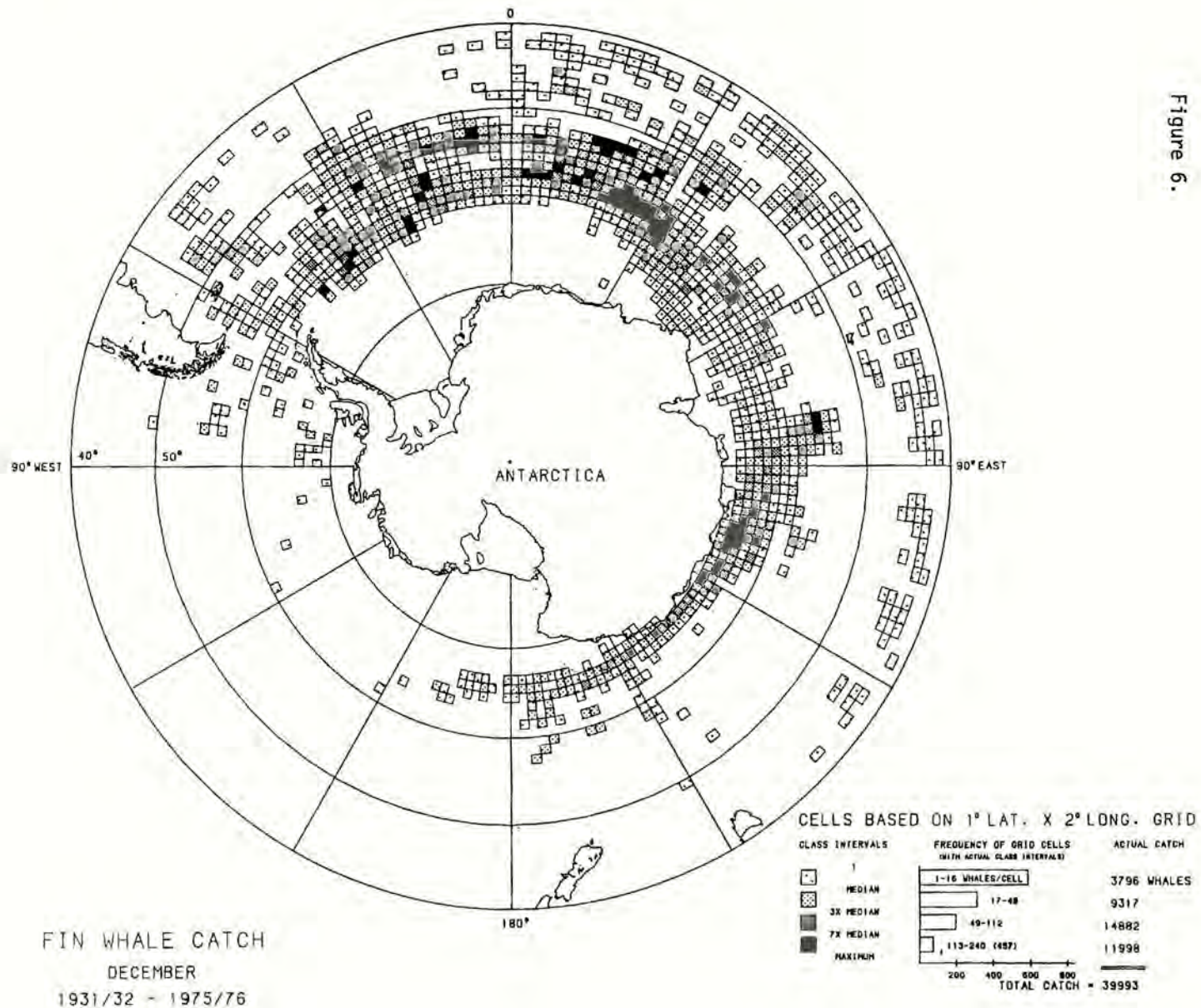


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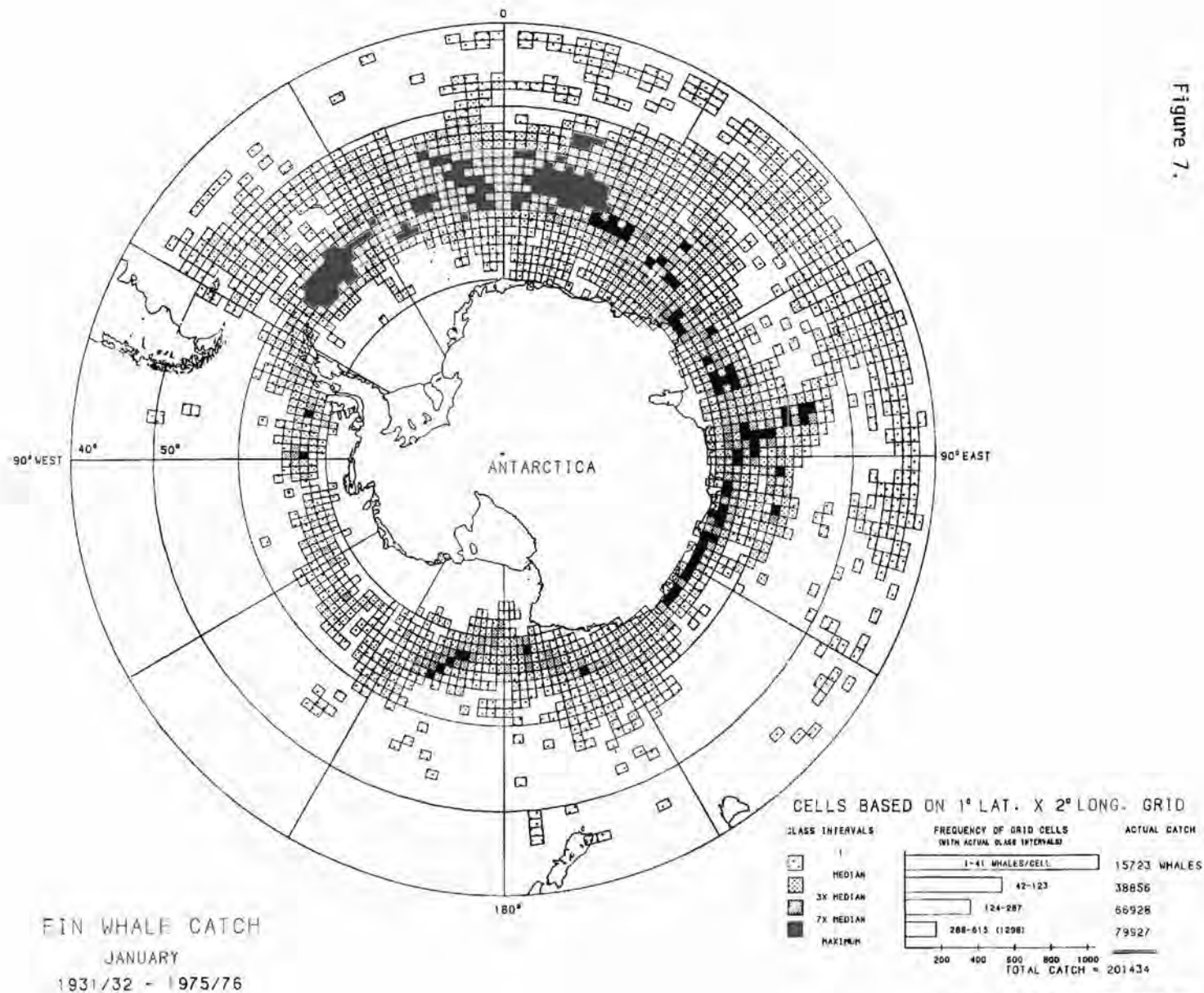
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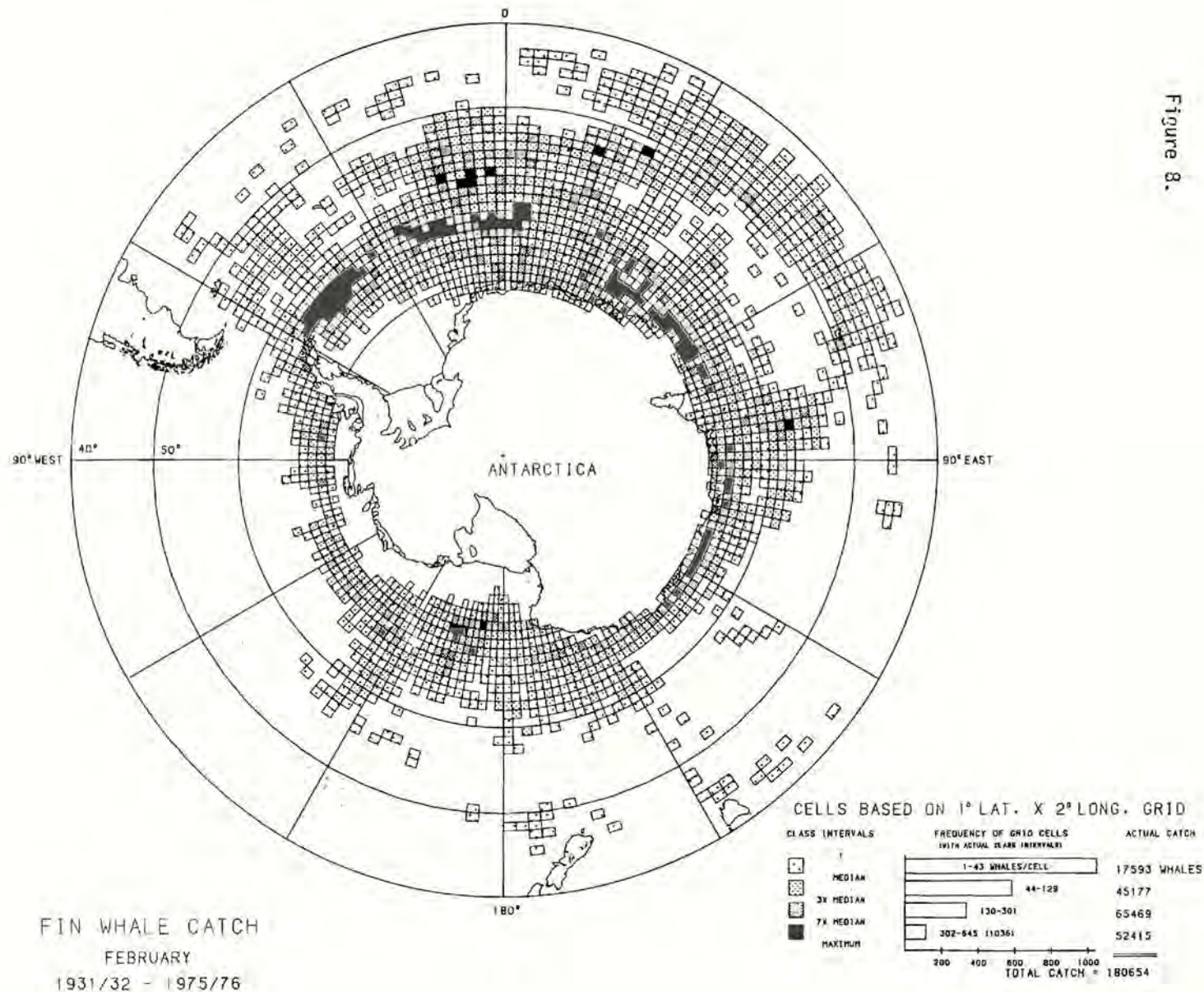


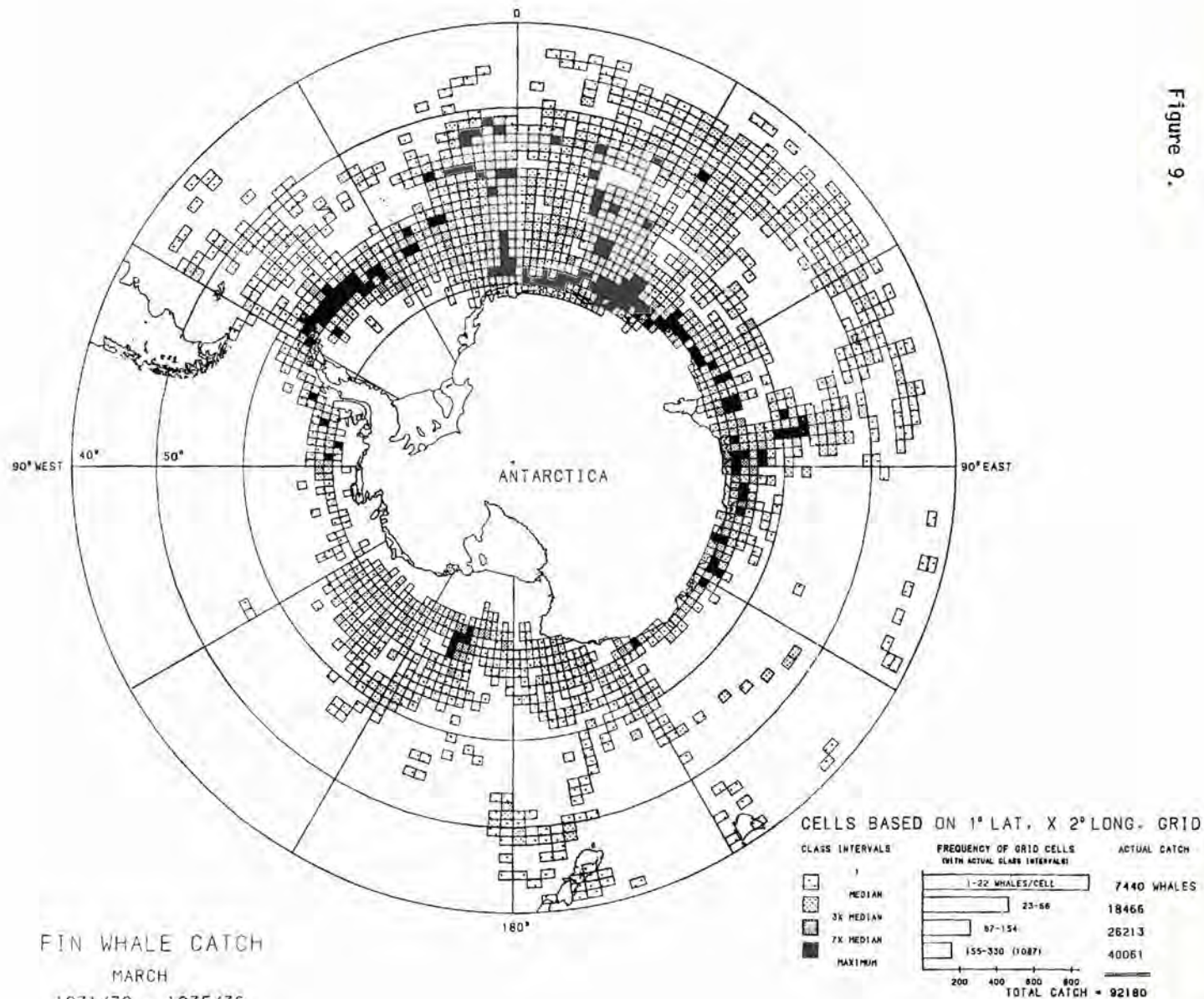
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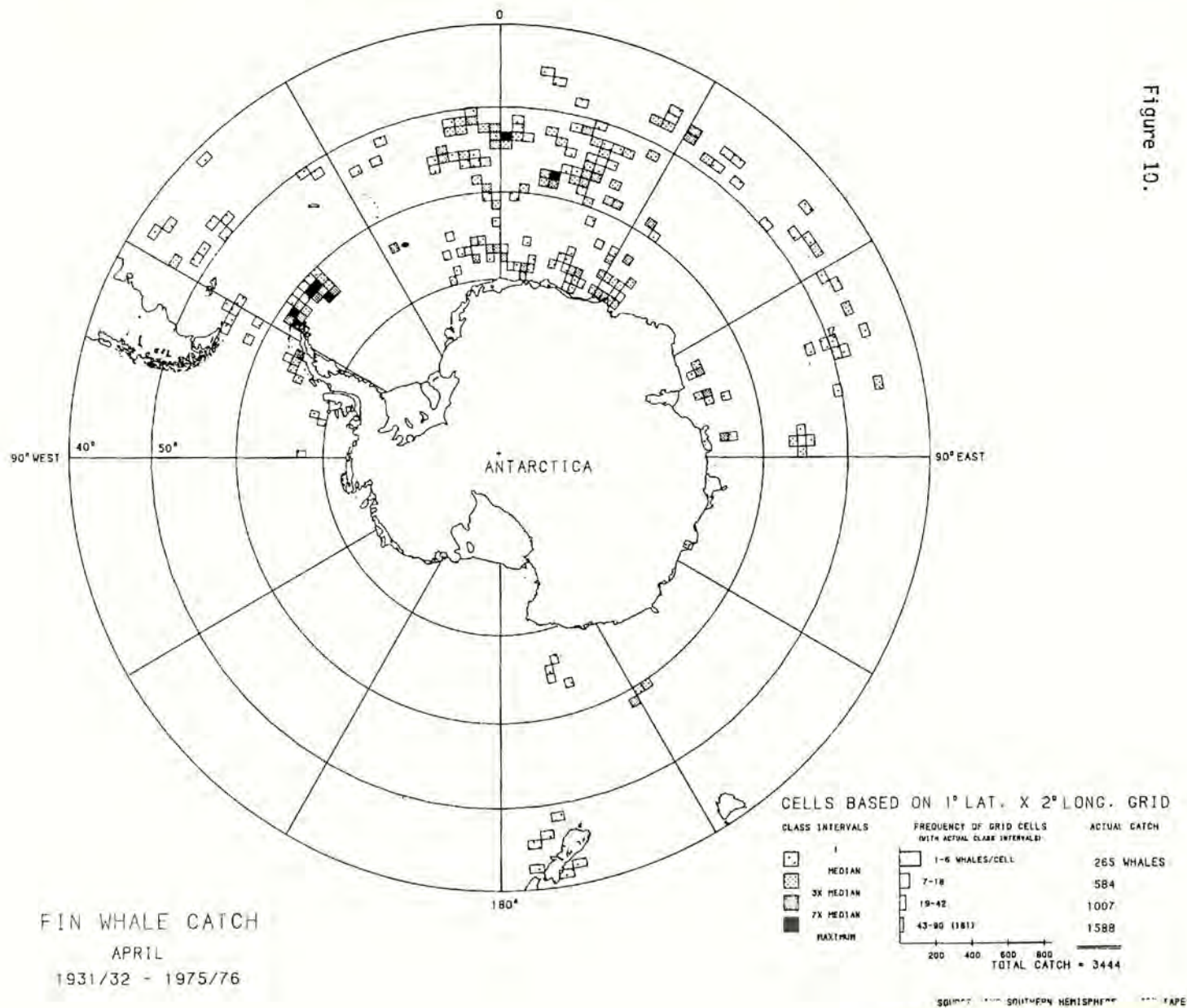
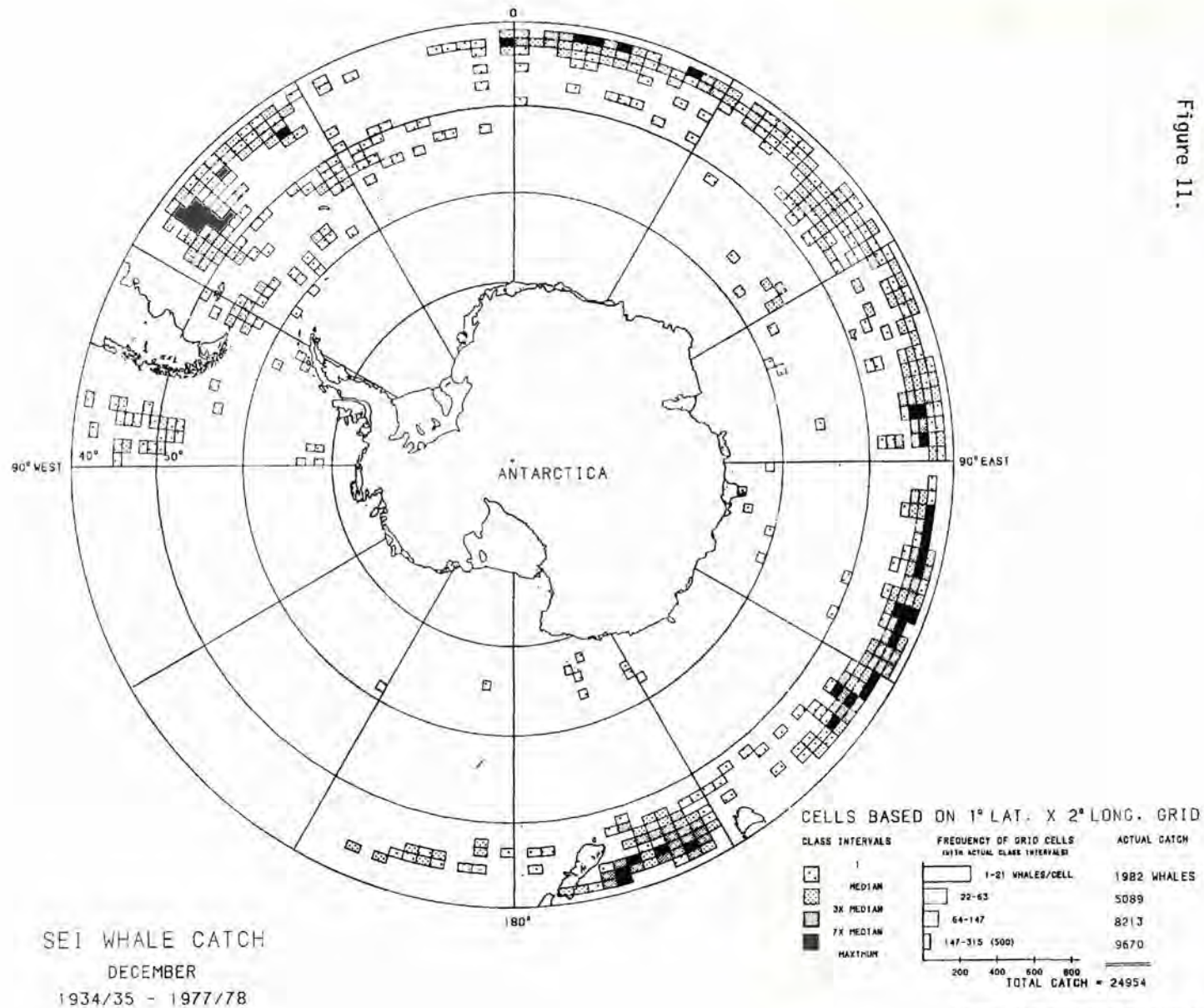


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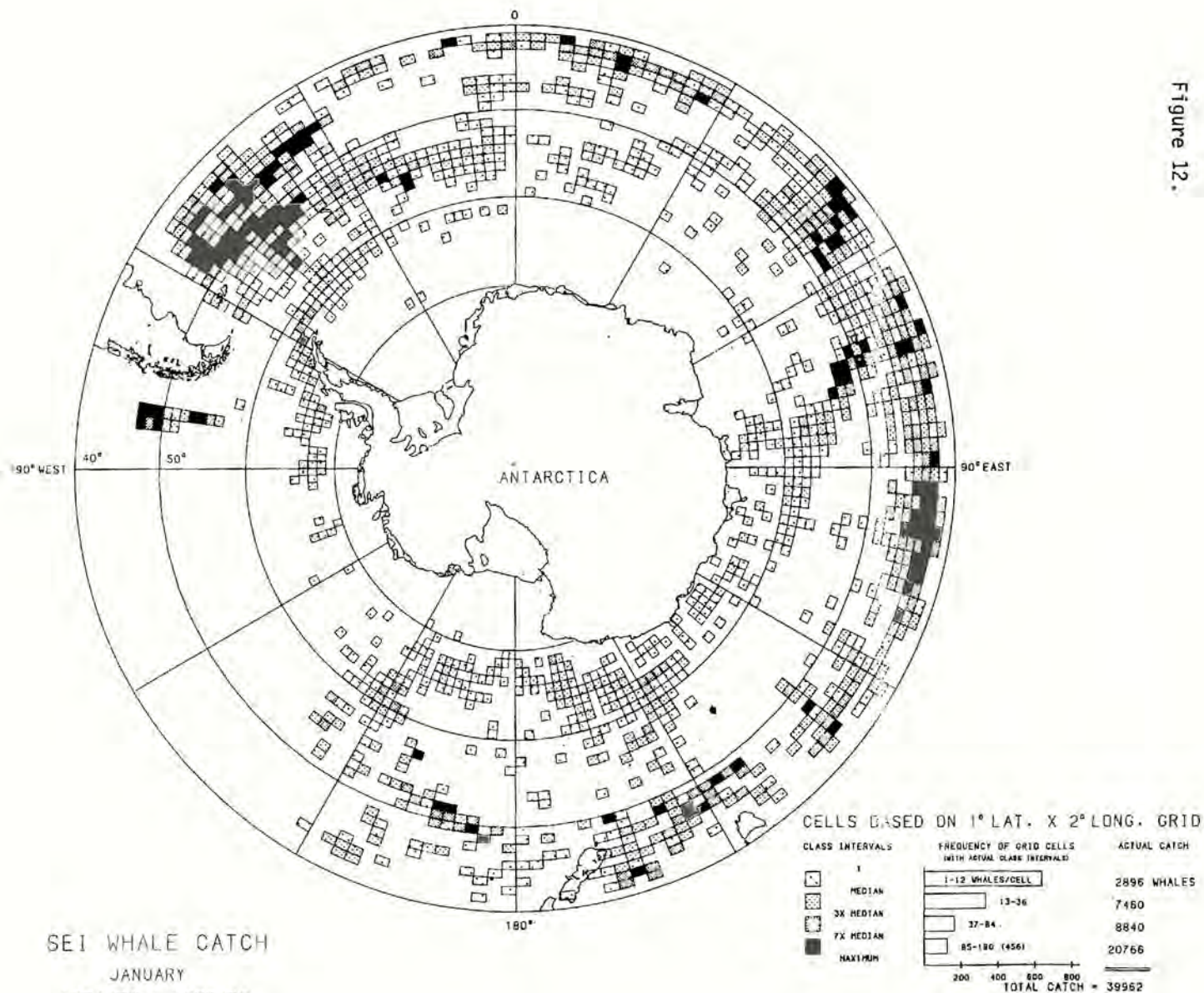
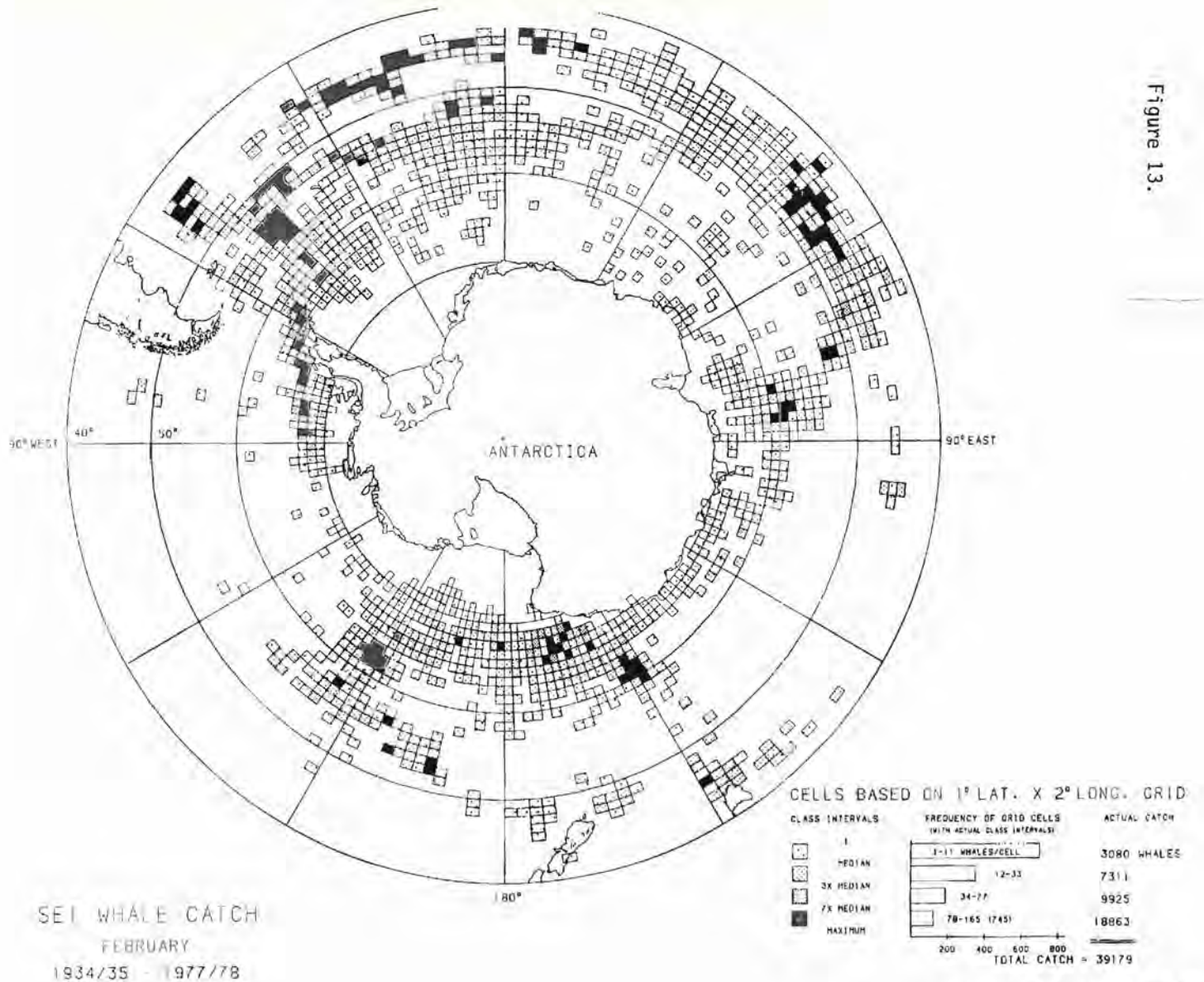


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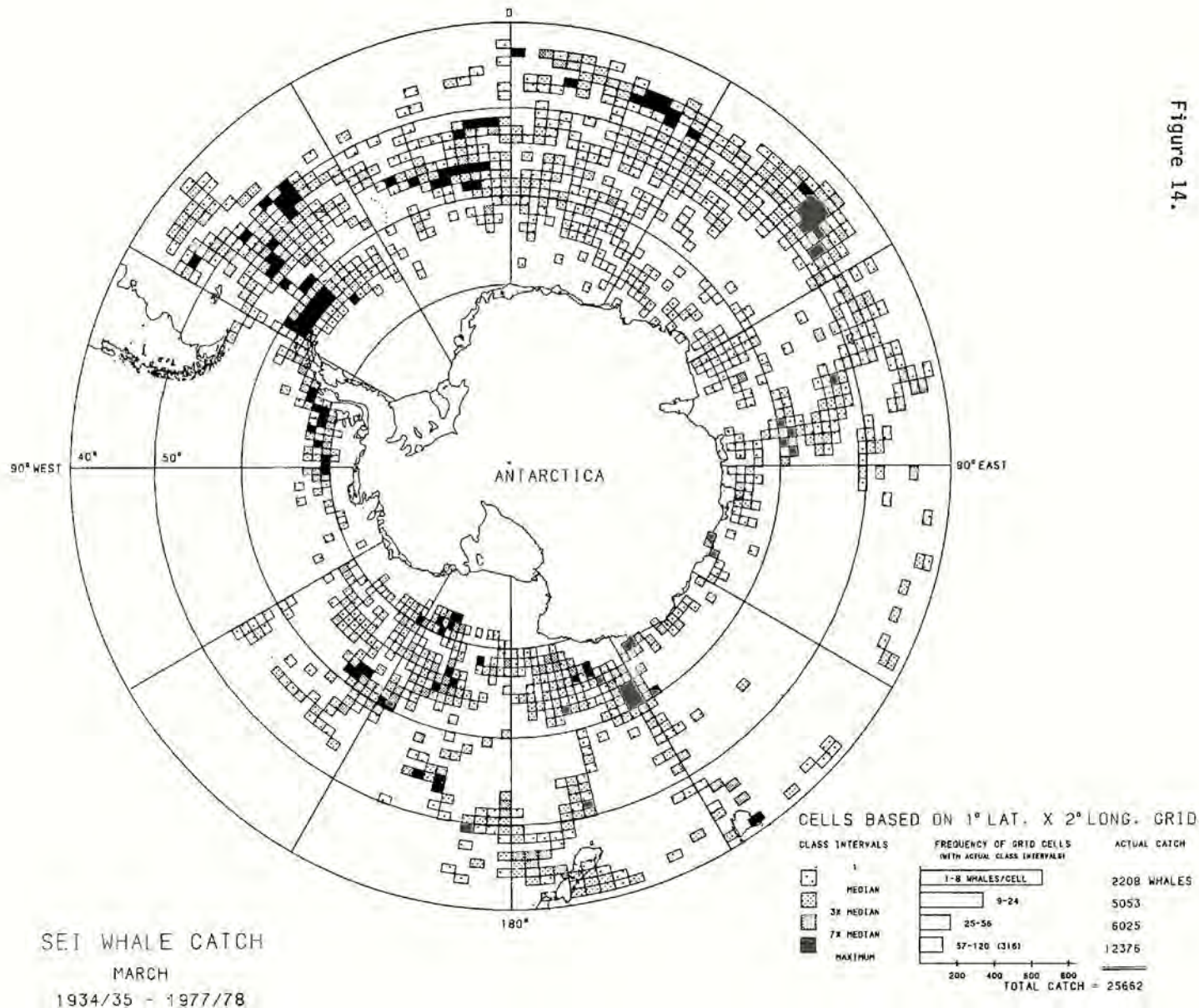
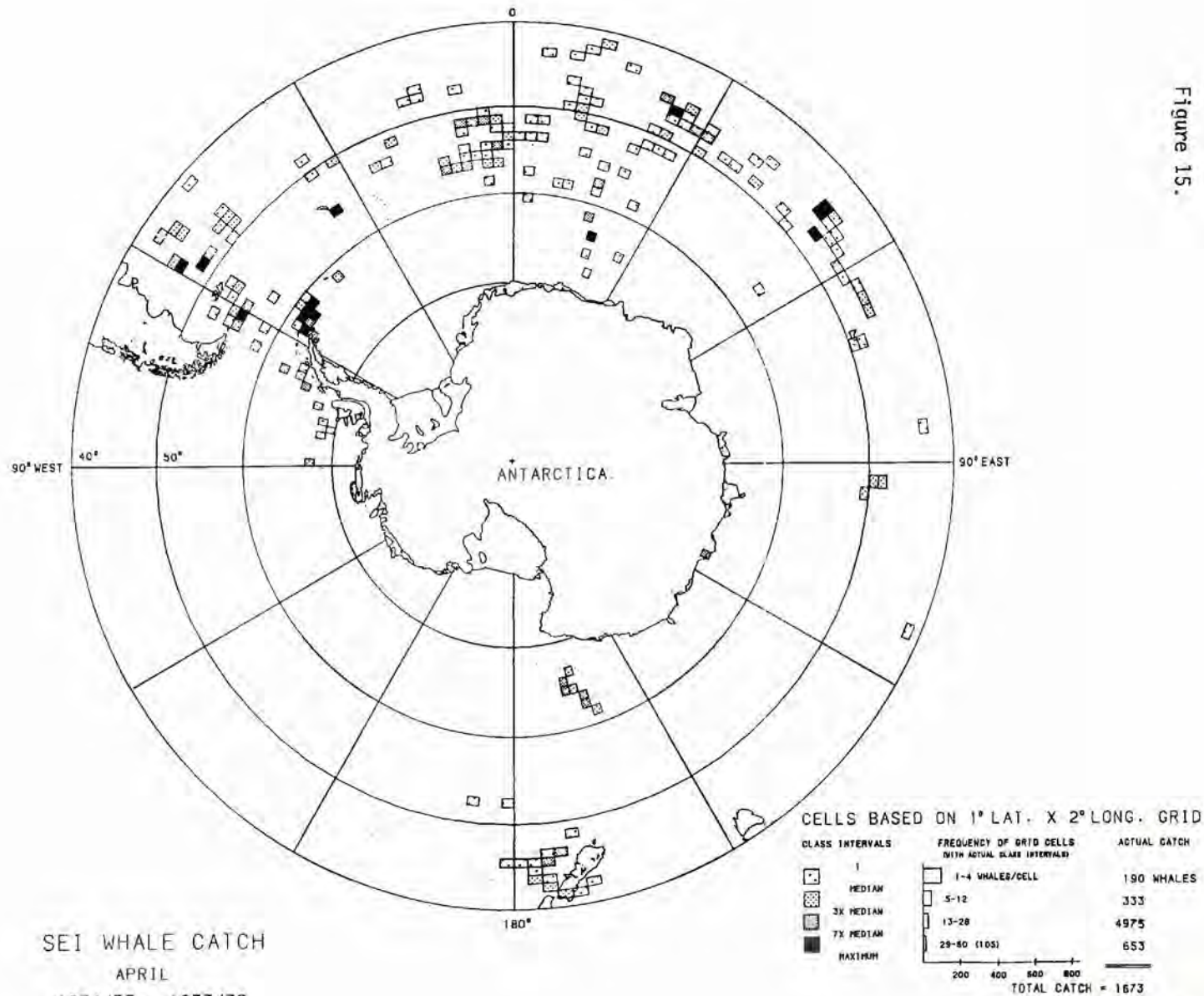


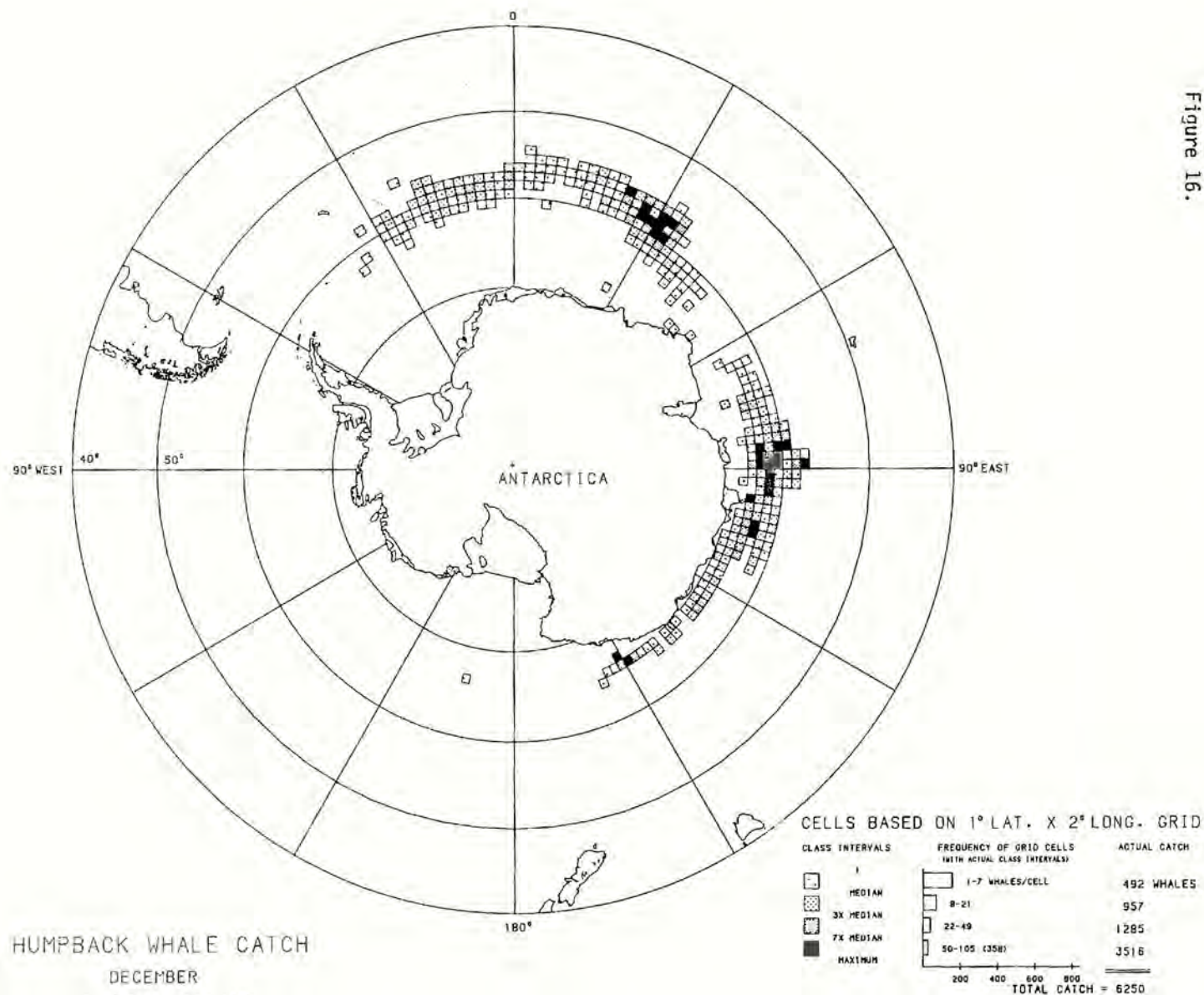
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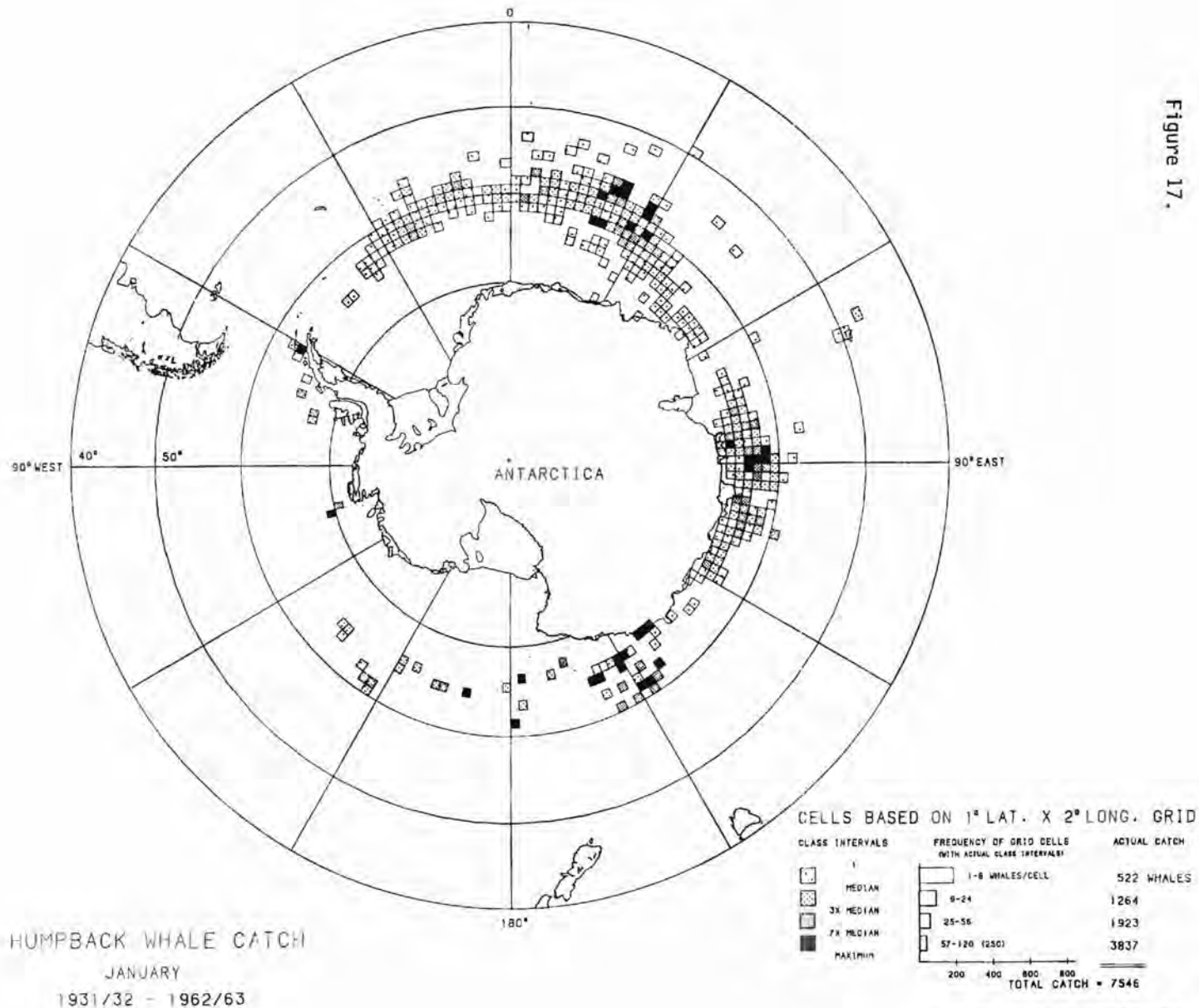


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Figure 15.

Figure 16.





SOURCE: IWC SOUTHERN HEMISPHERE MASTER TAPE

Figure 17.

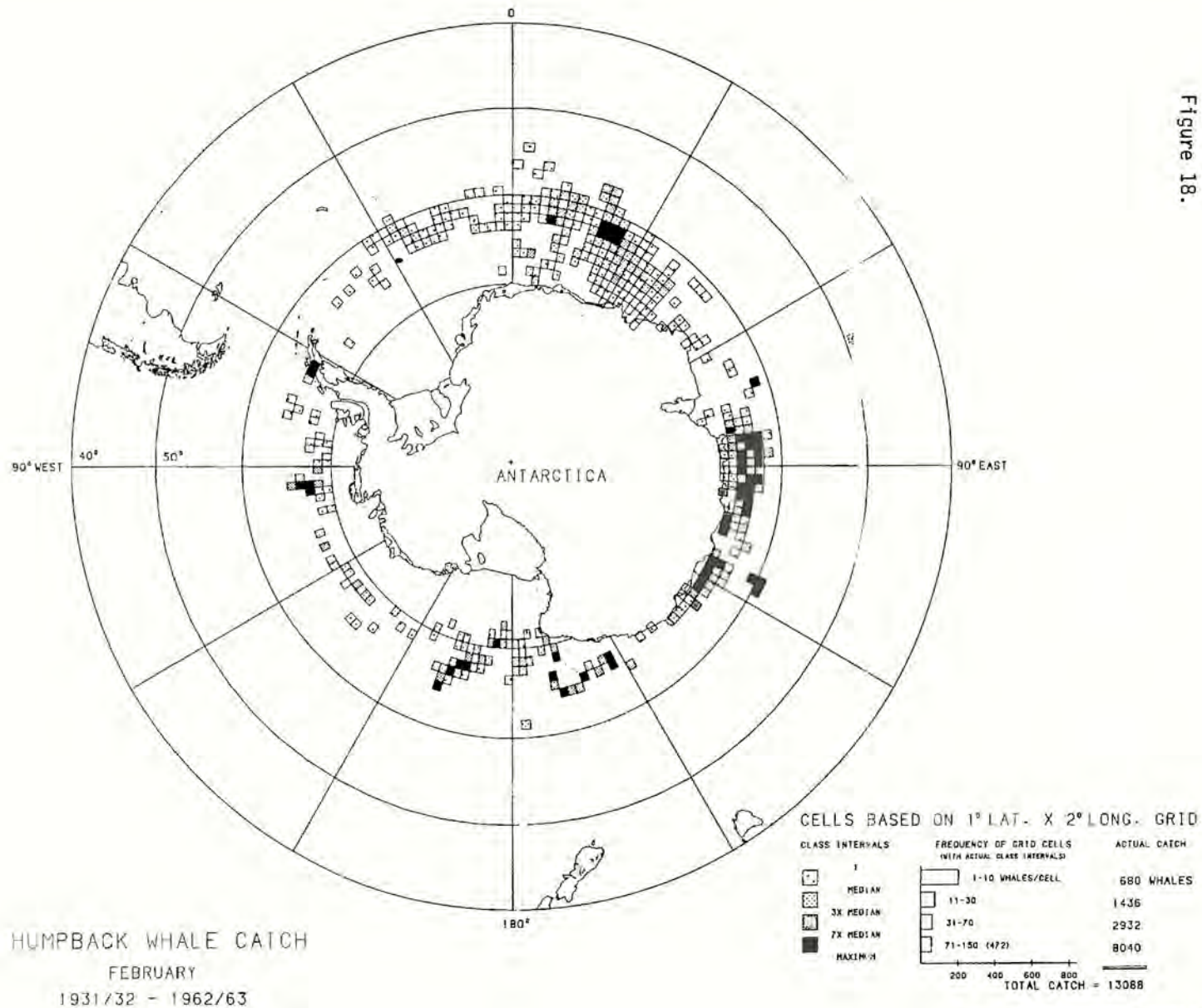
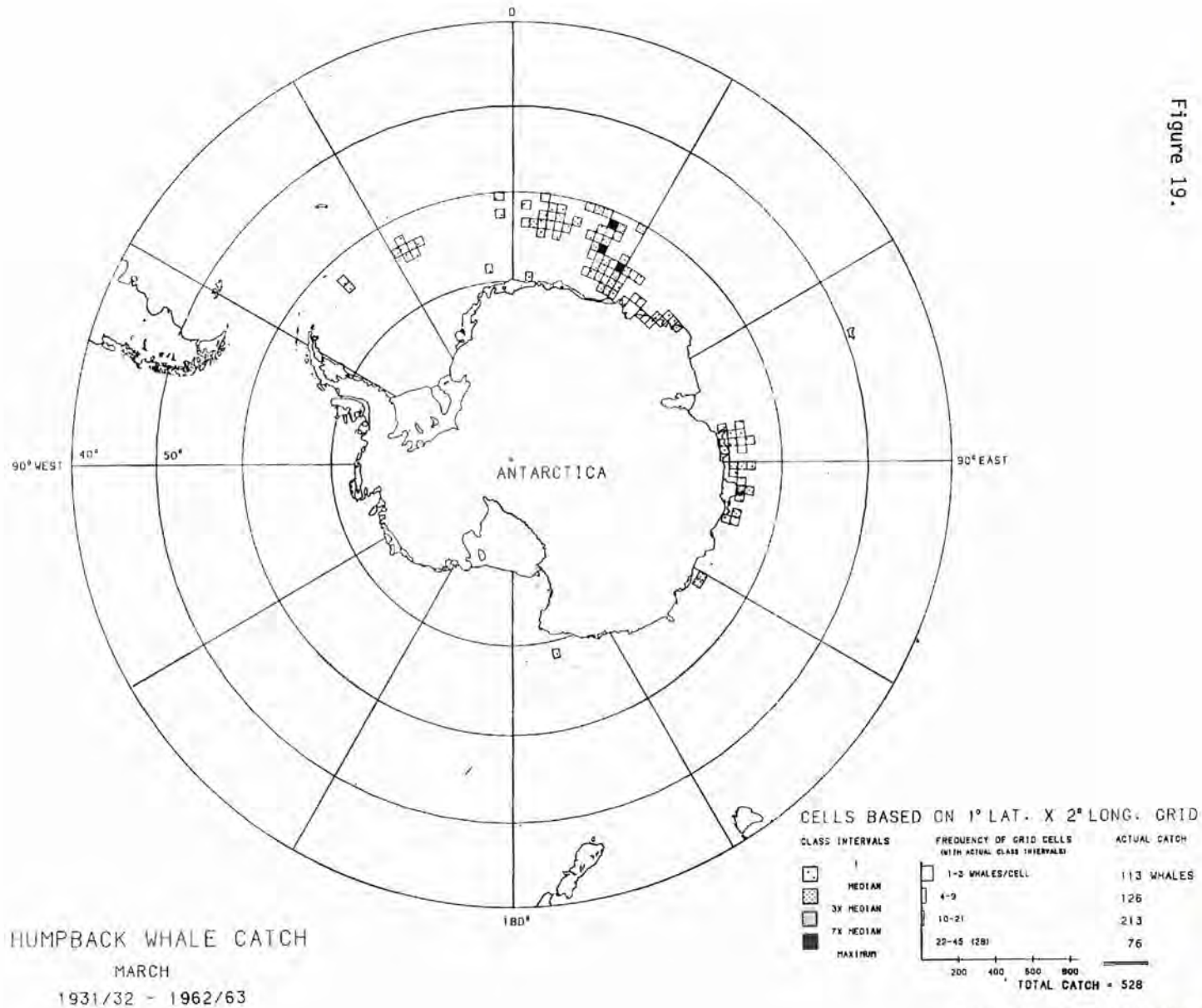


Figure 18.



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Figure 19.

Figure 20.

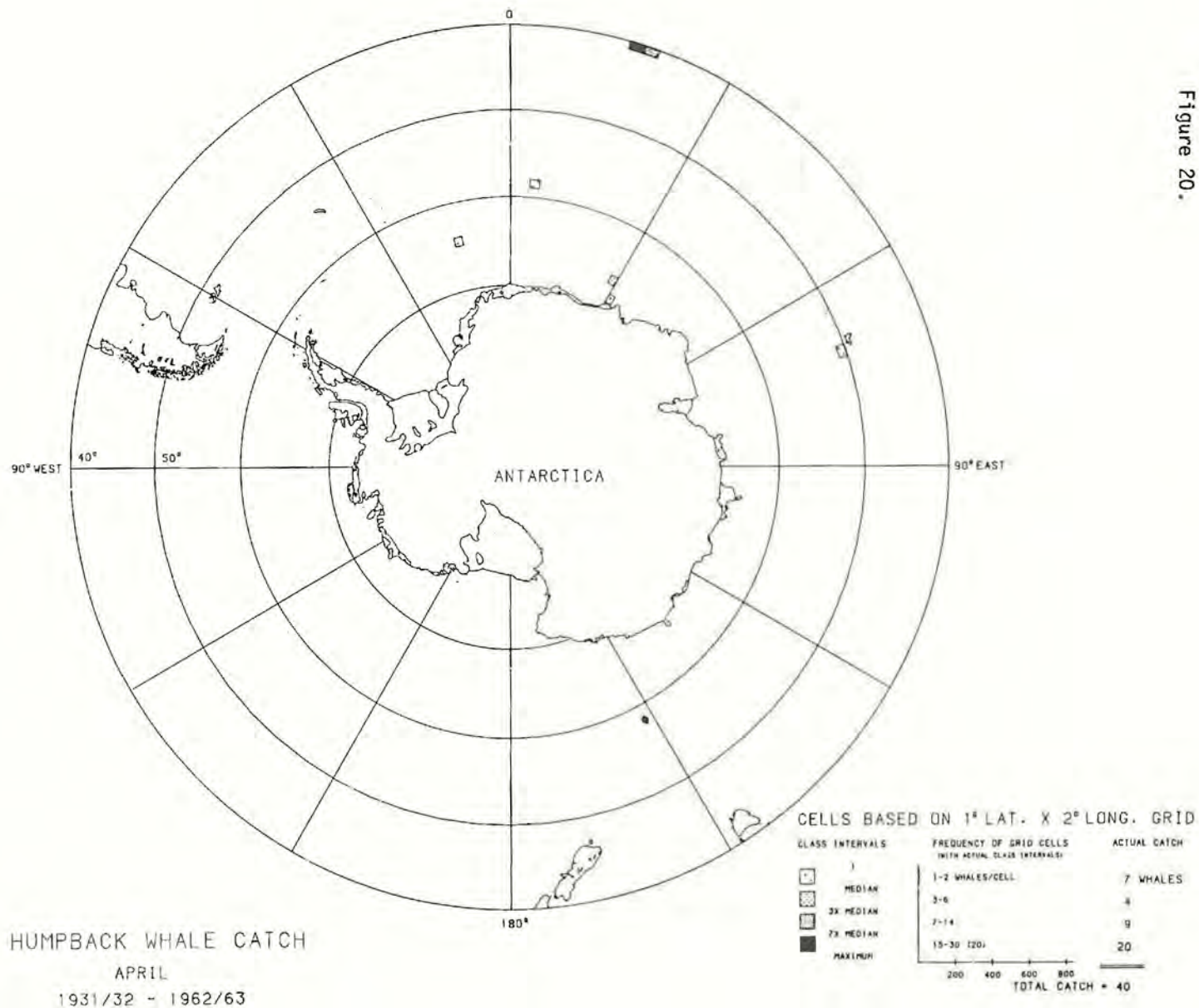
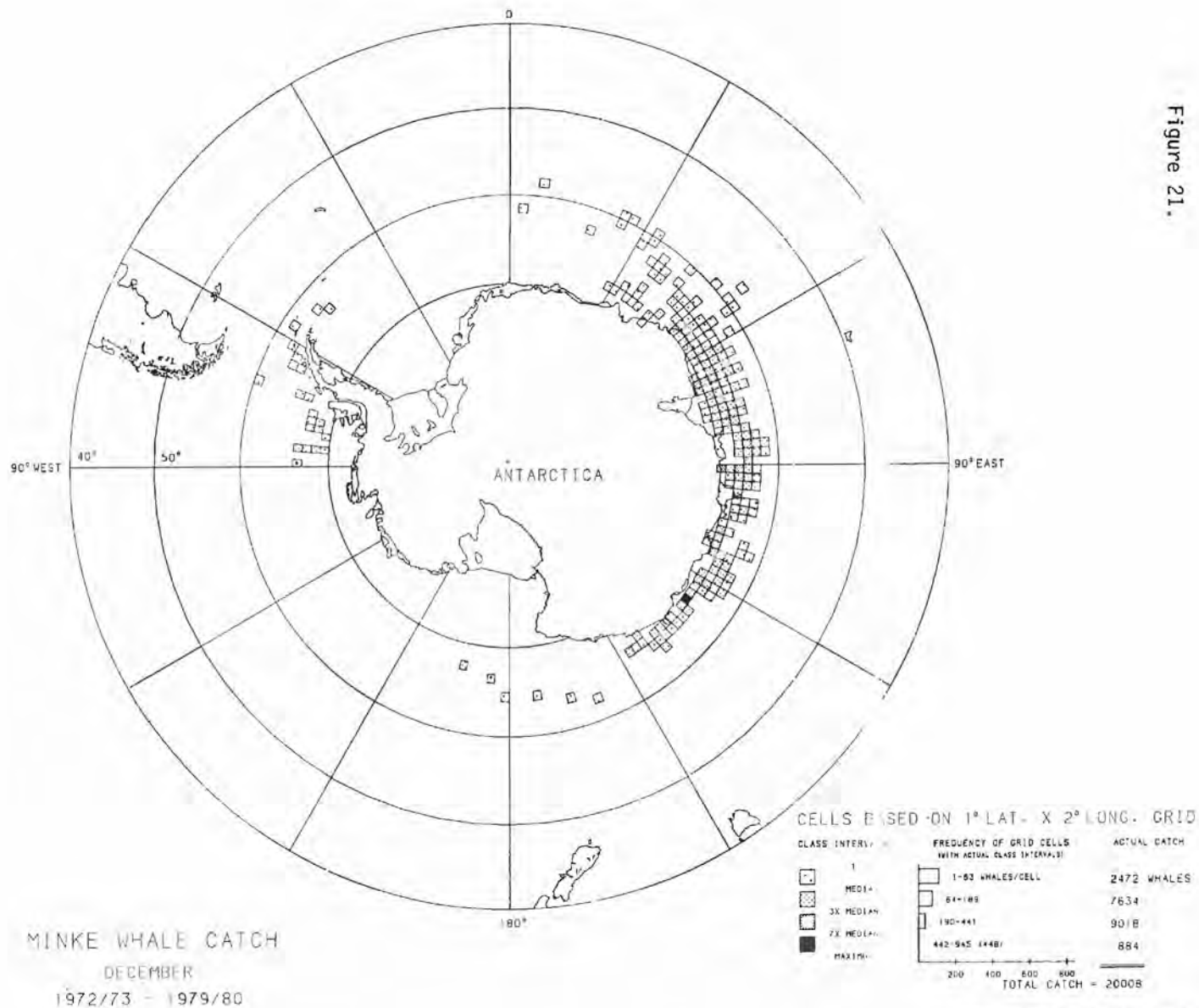
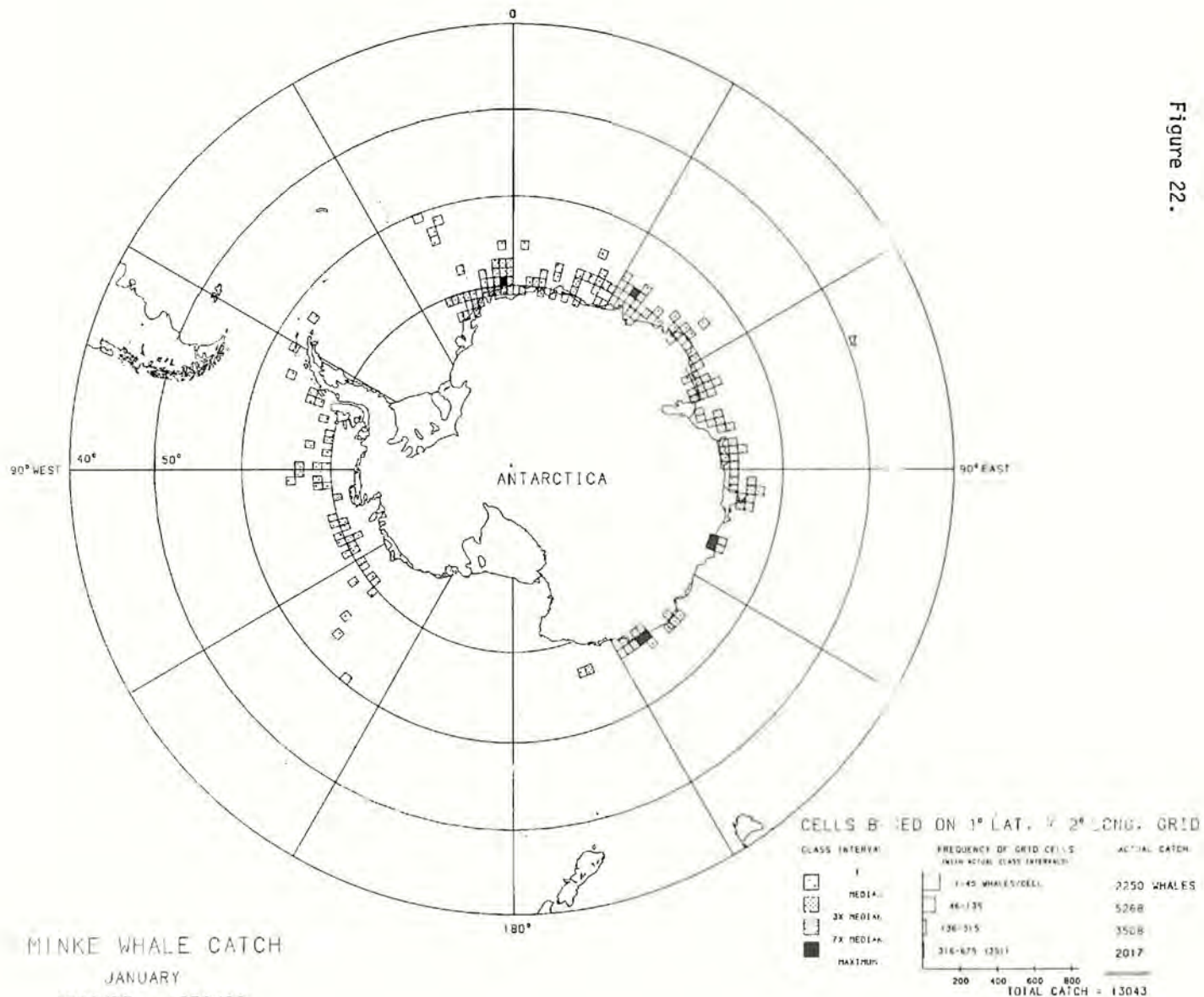


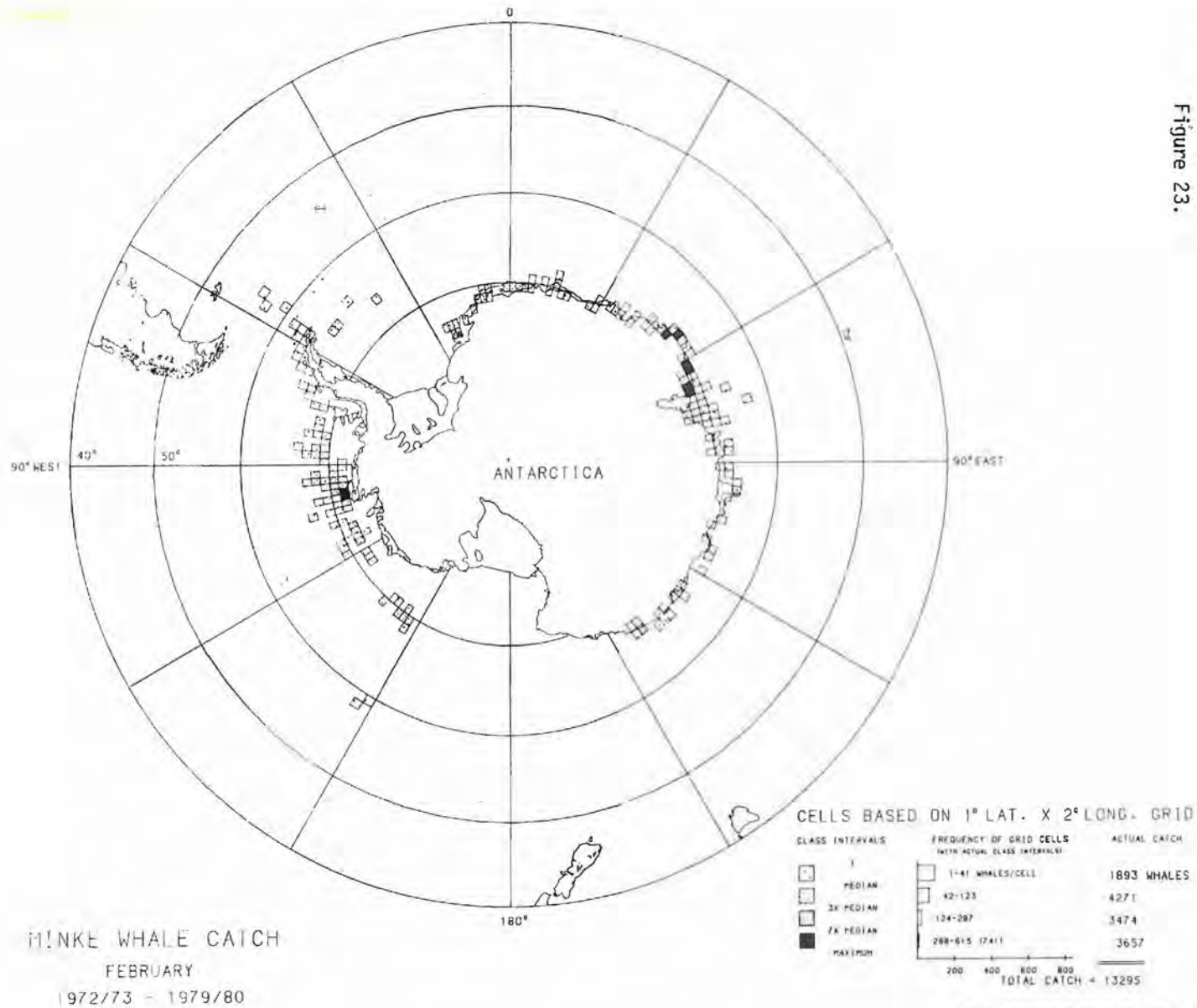
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Figure 22.



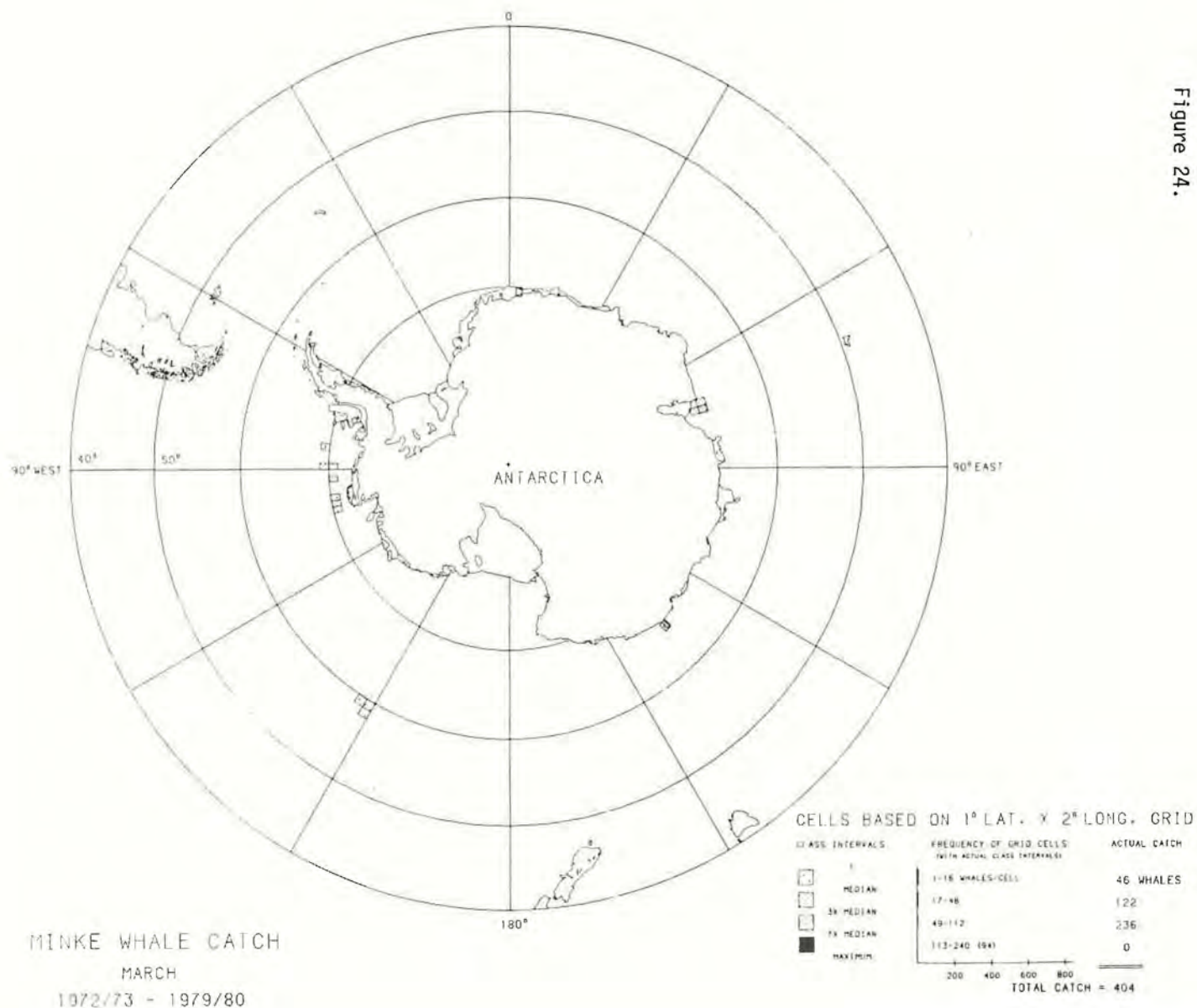
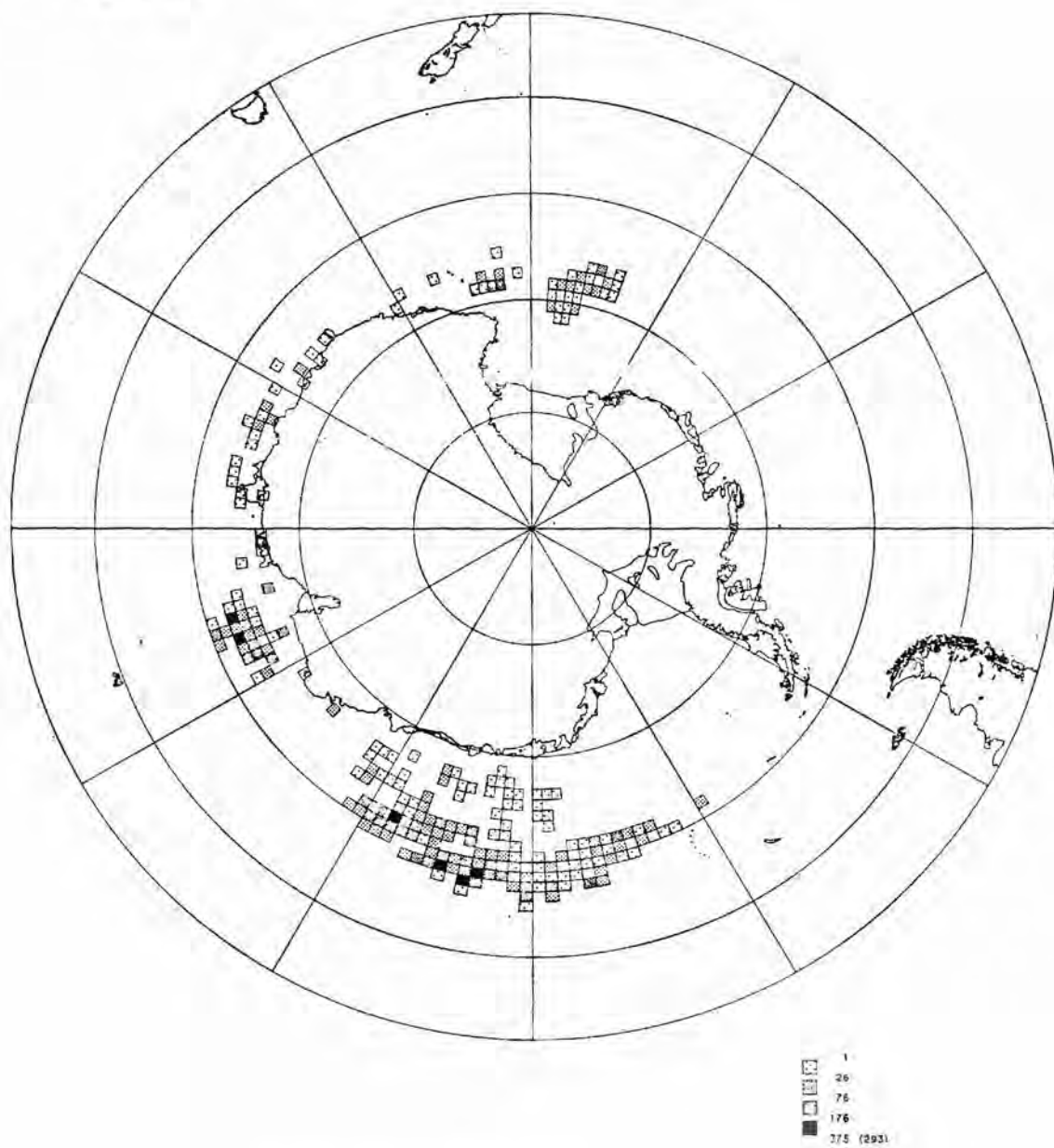


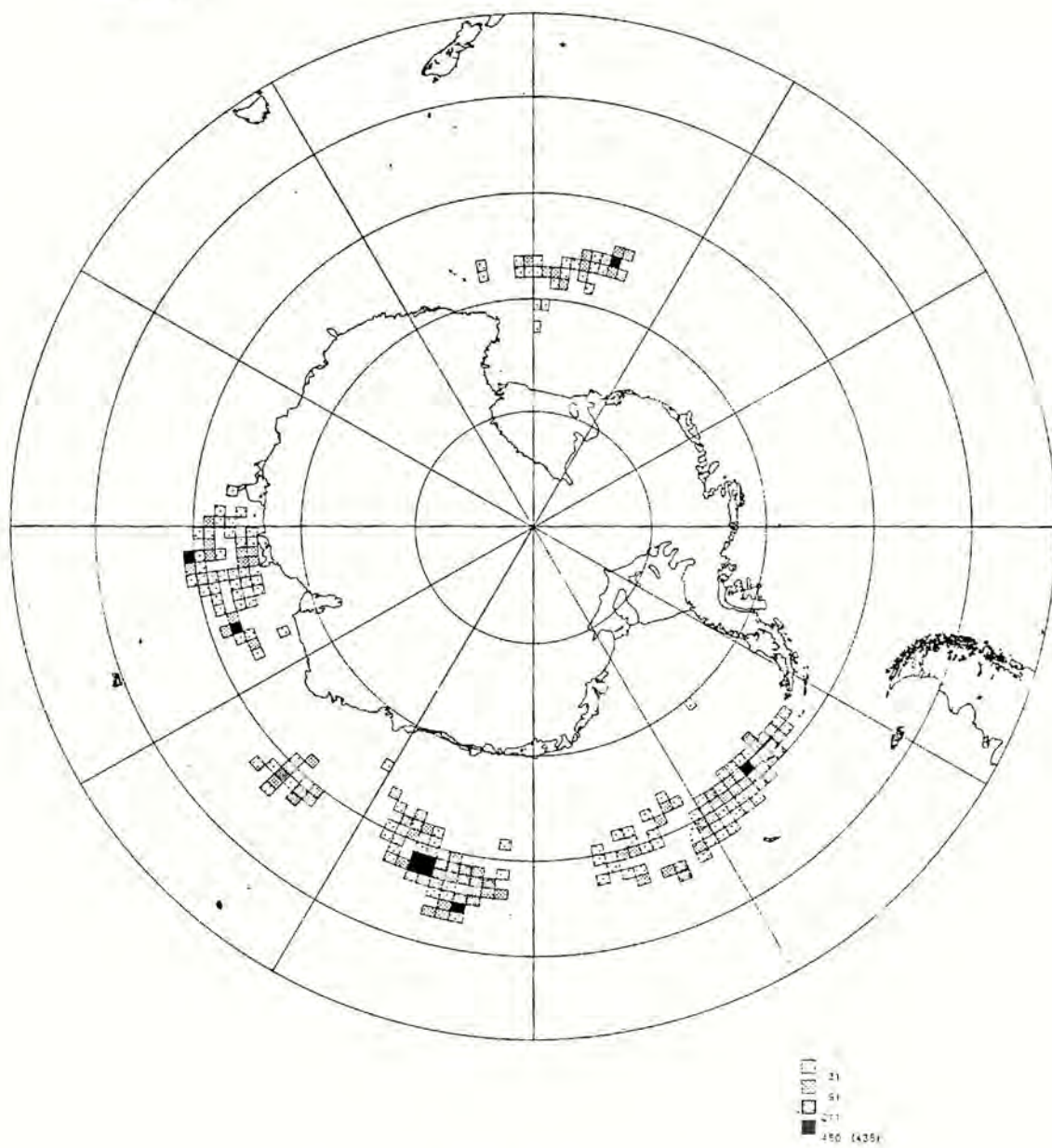
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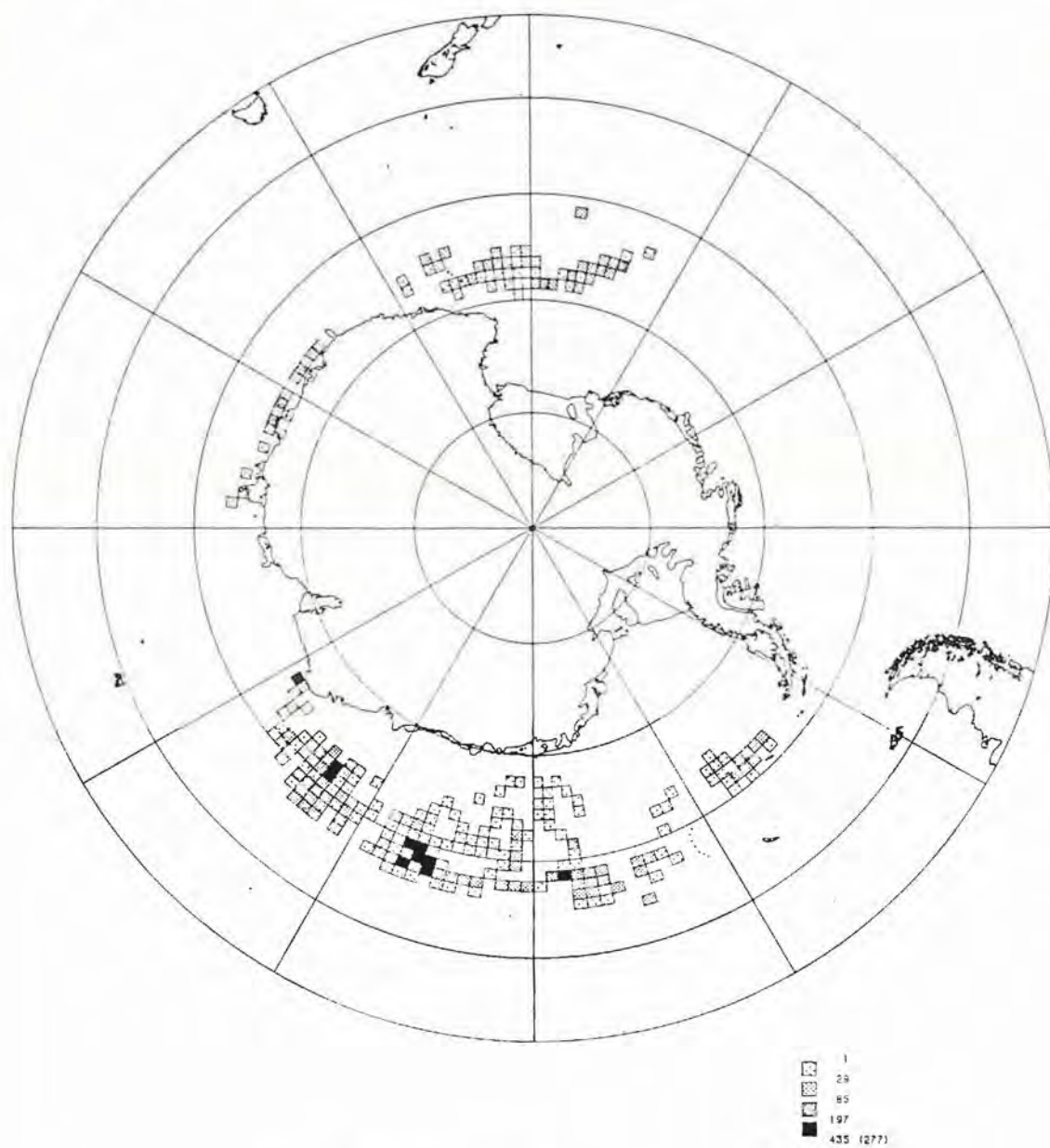
FIN WHALE CATCH IN JANUARY 1952/53

Figure 26.



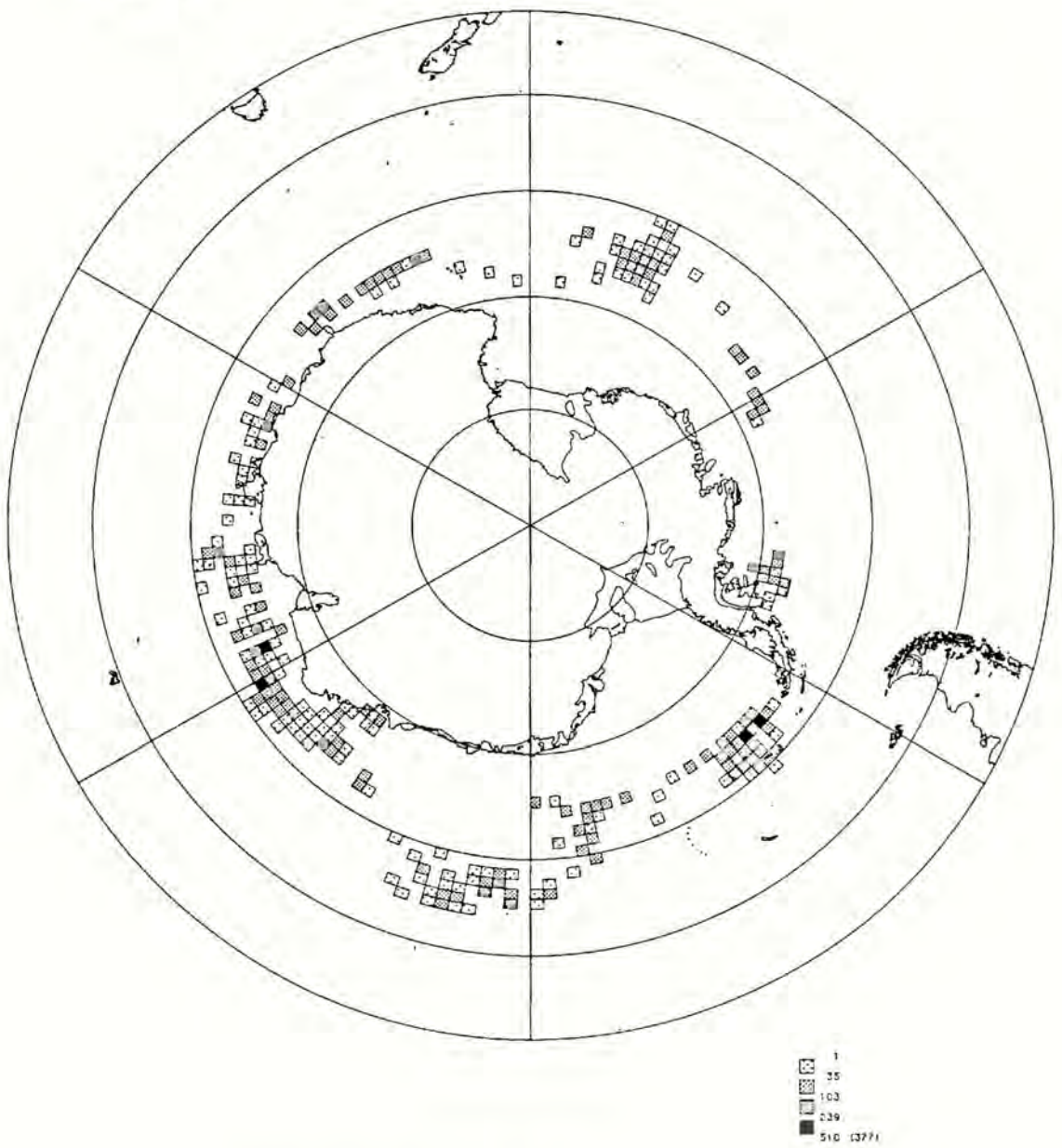
FIN WHALE CATCH IN JANUARY 1953/54

Figure 27.



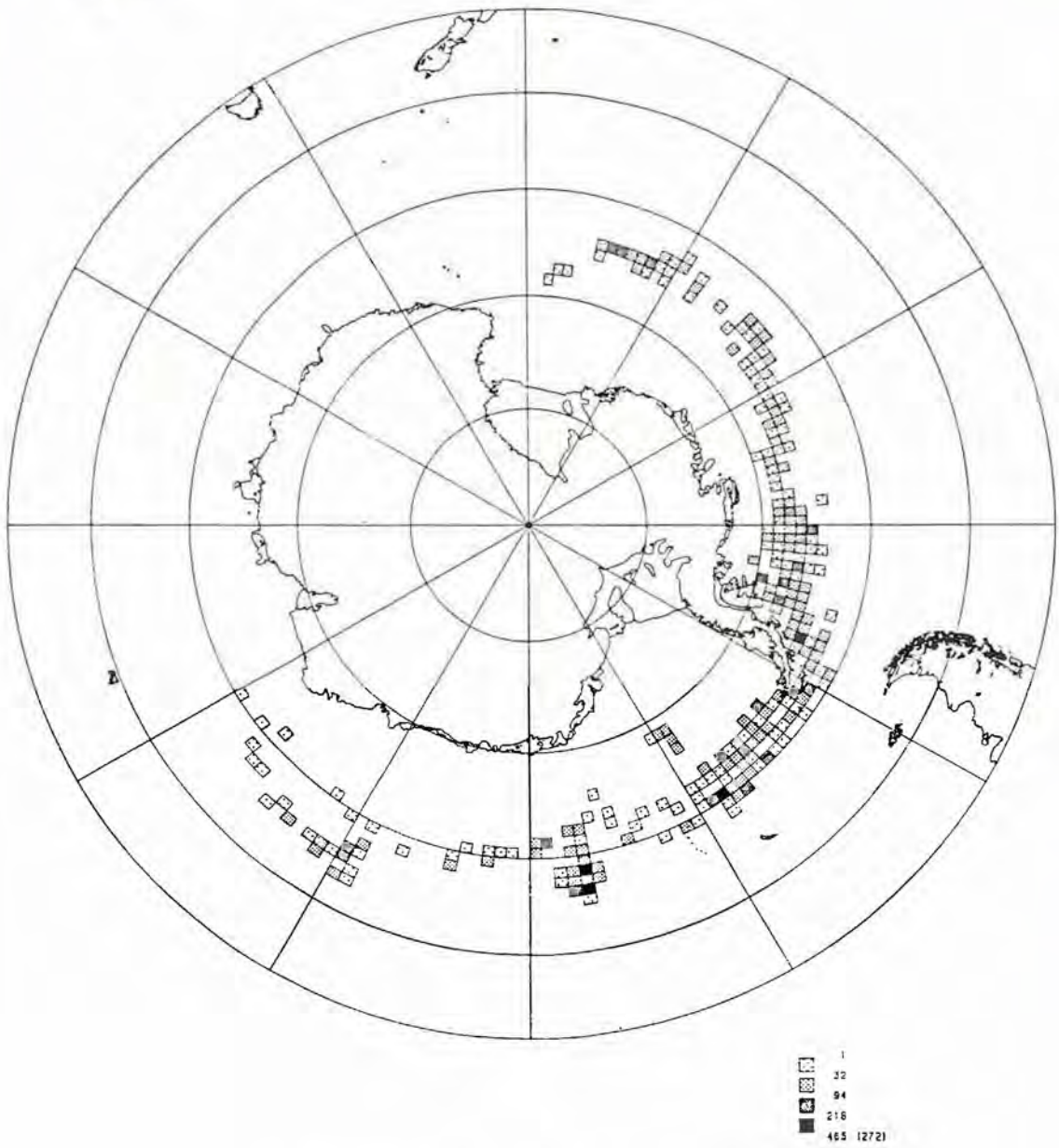
FIN WHALE CATCH IN JANUARY 1954/55

Figure 28.



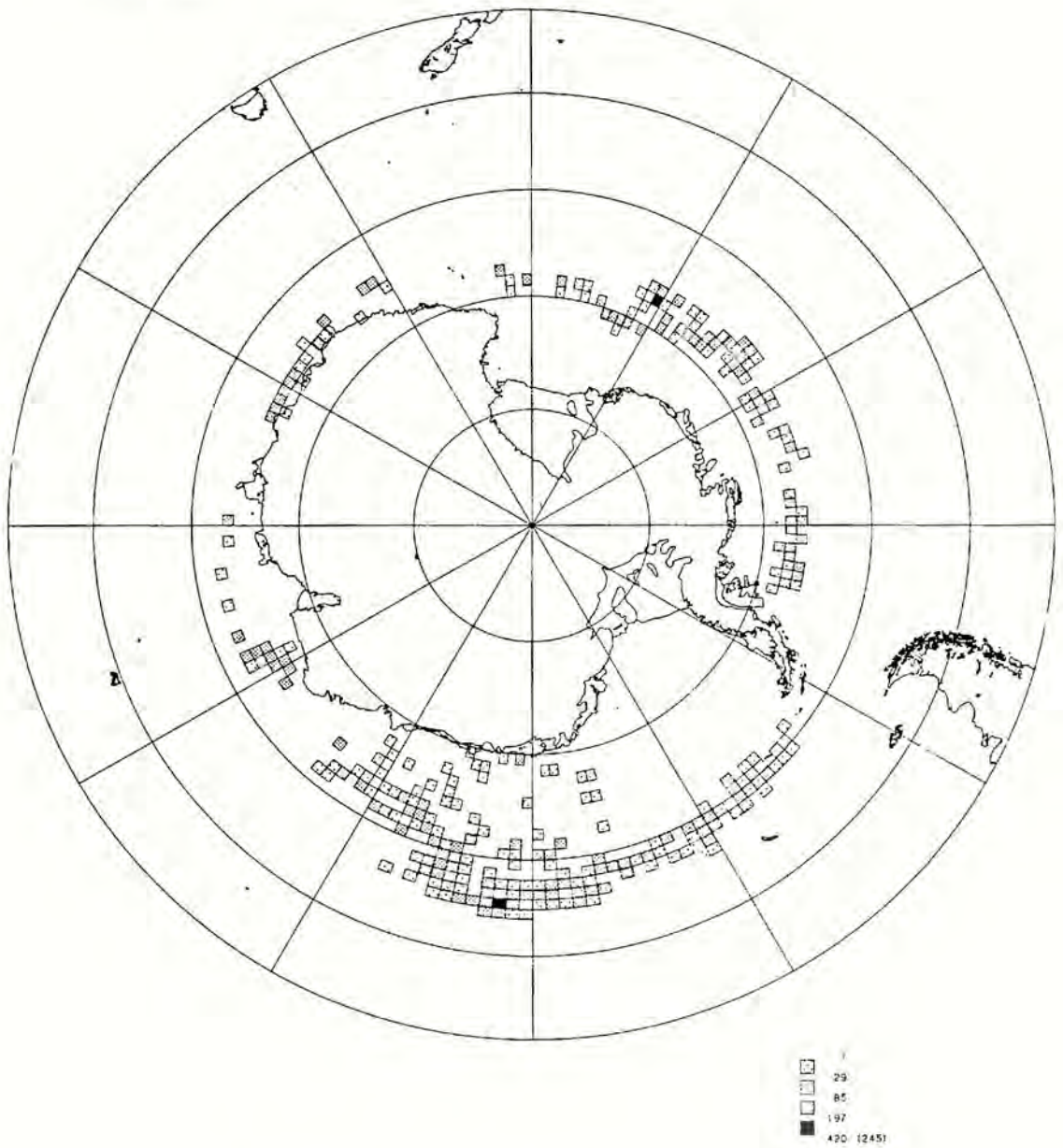
FIN WHALE CATCH IN JANUARY 1955/56

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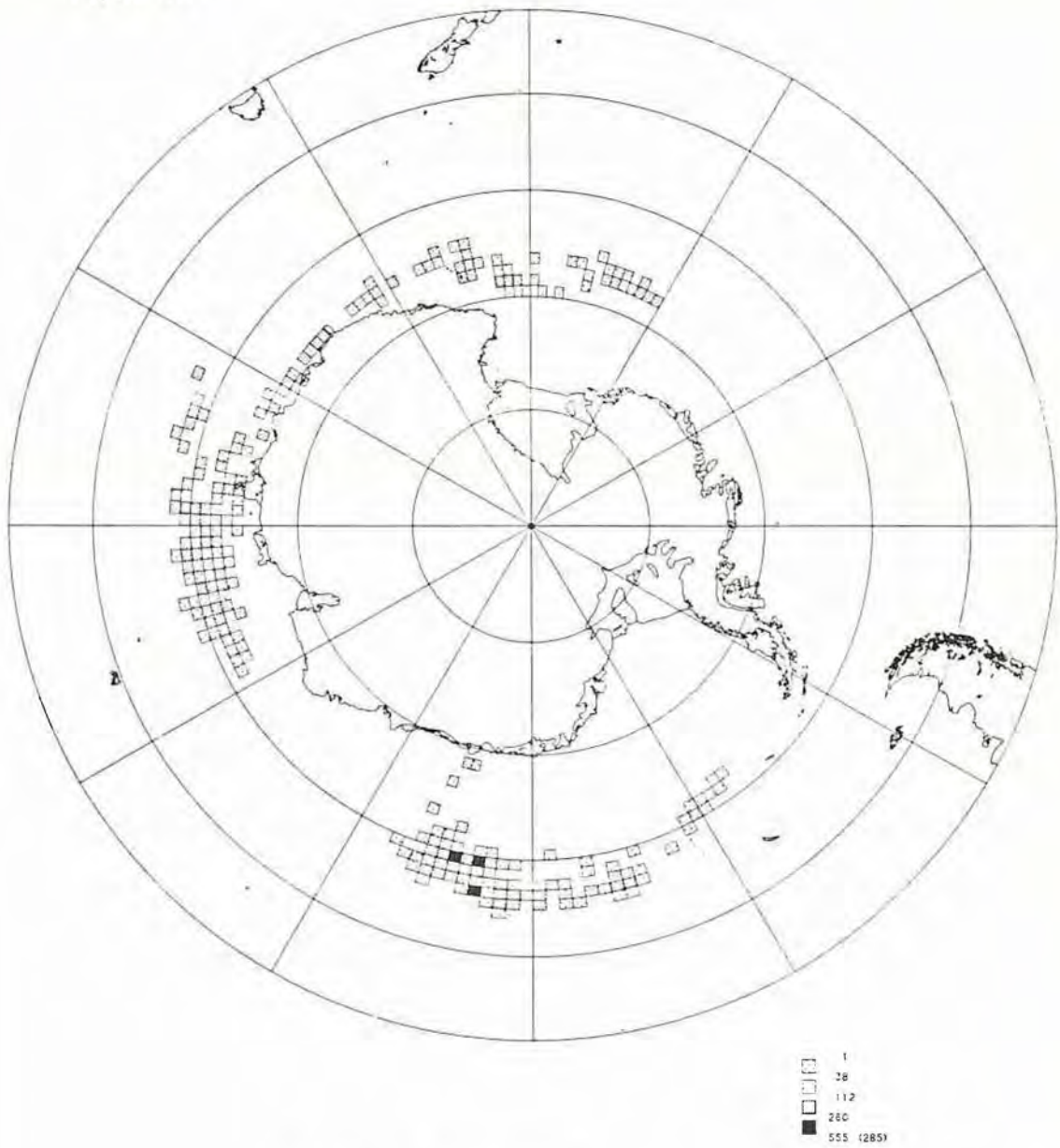
FIN WHALE CATCH IN JANUARY 1956/57

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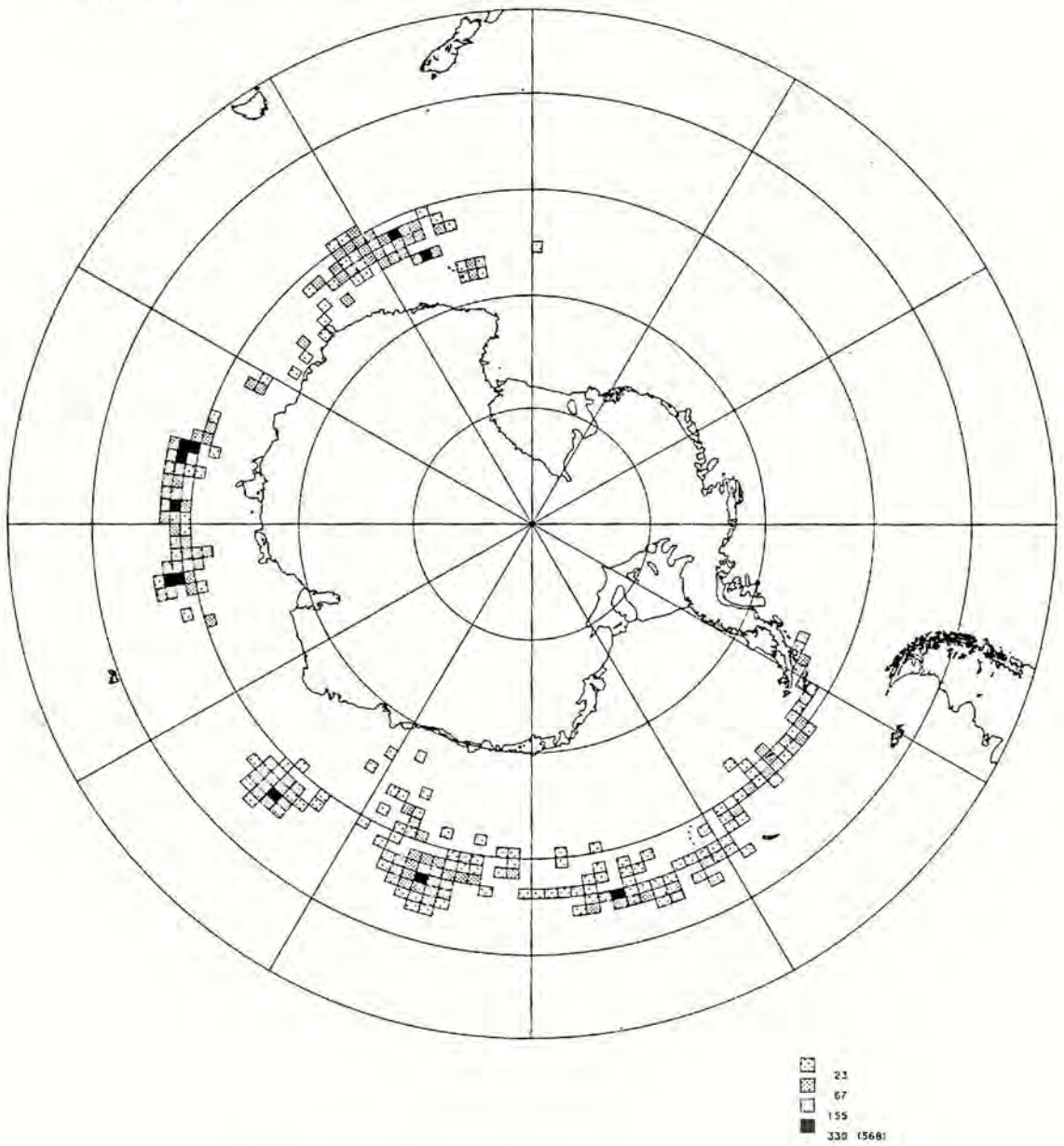
FIN WHALE CATCH IN JANUARY 1957/58

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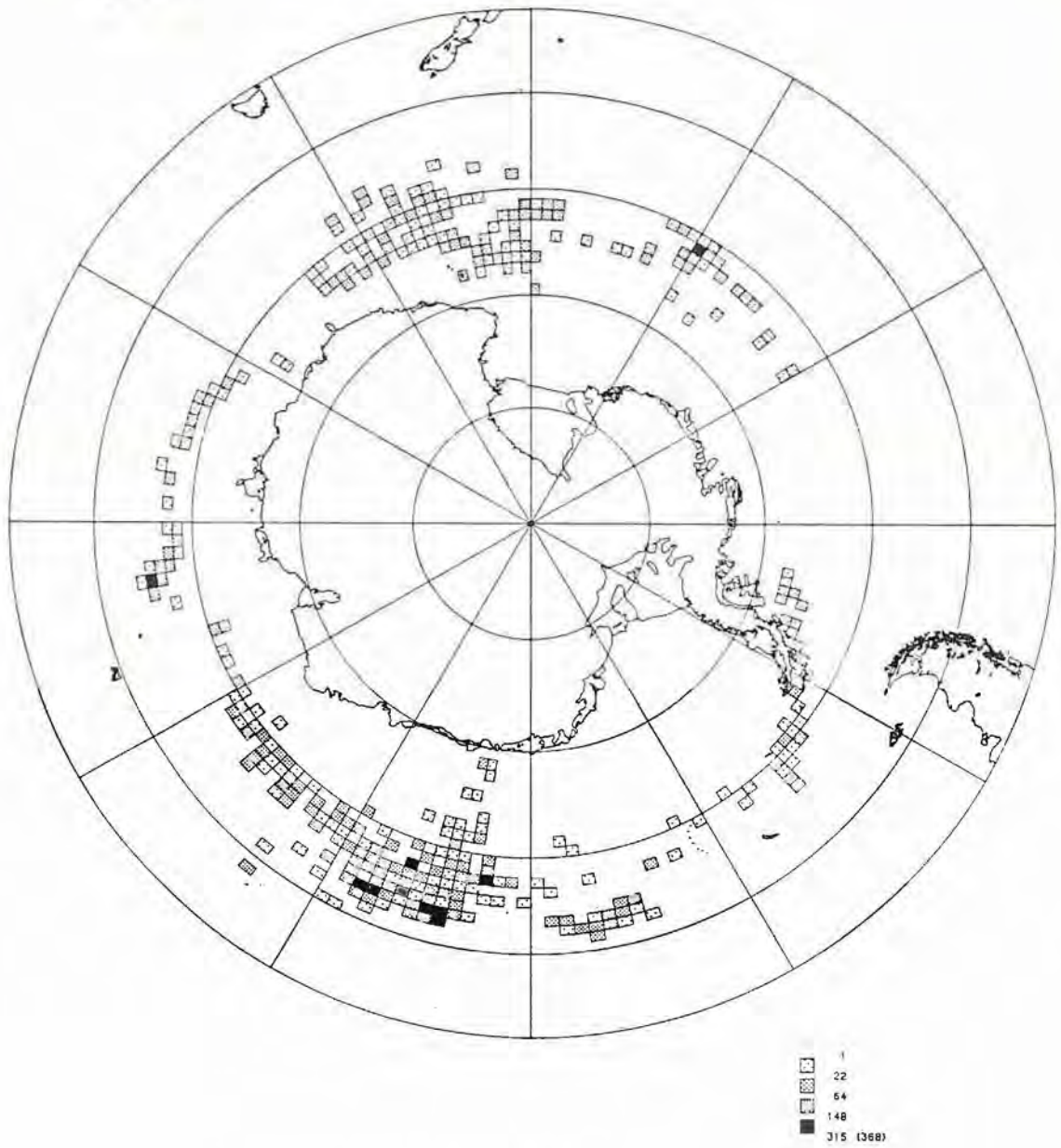
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Figure 32.



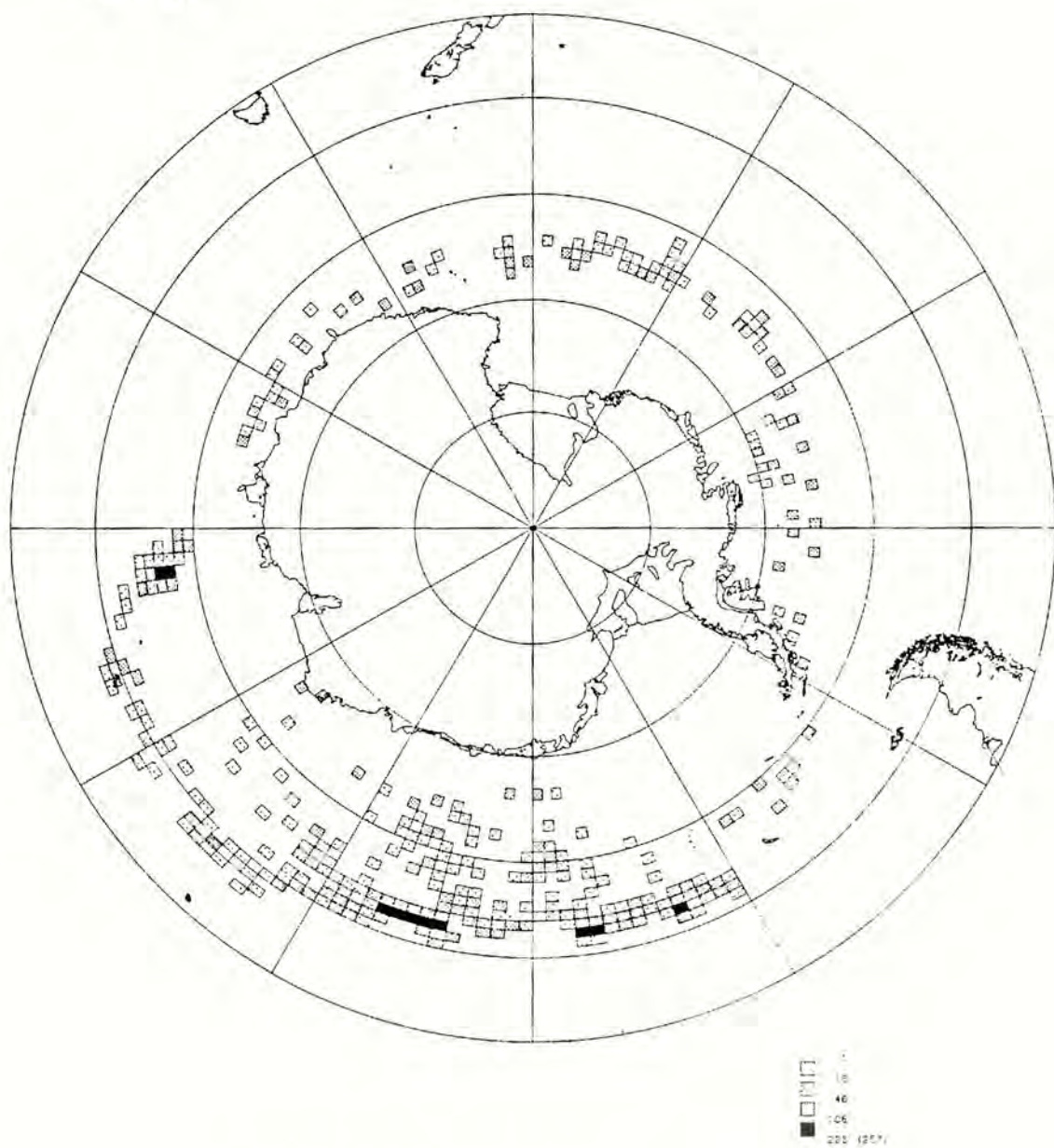
FIN WHALE CATCH IN JANUARY 1959/60

Figure 33.



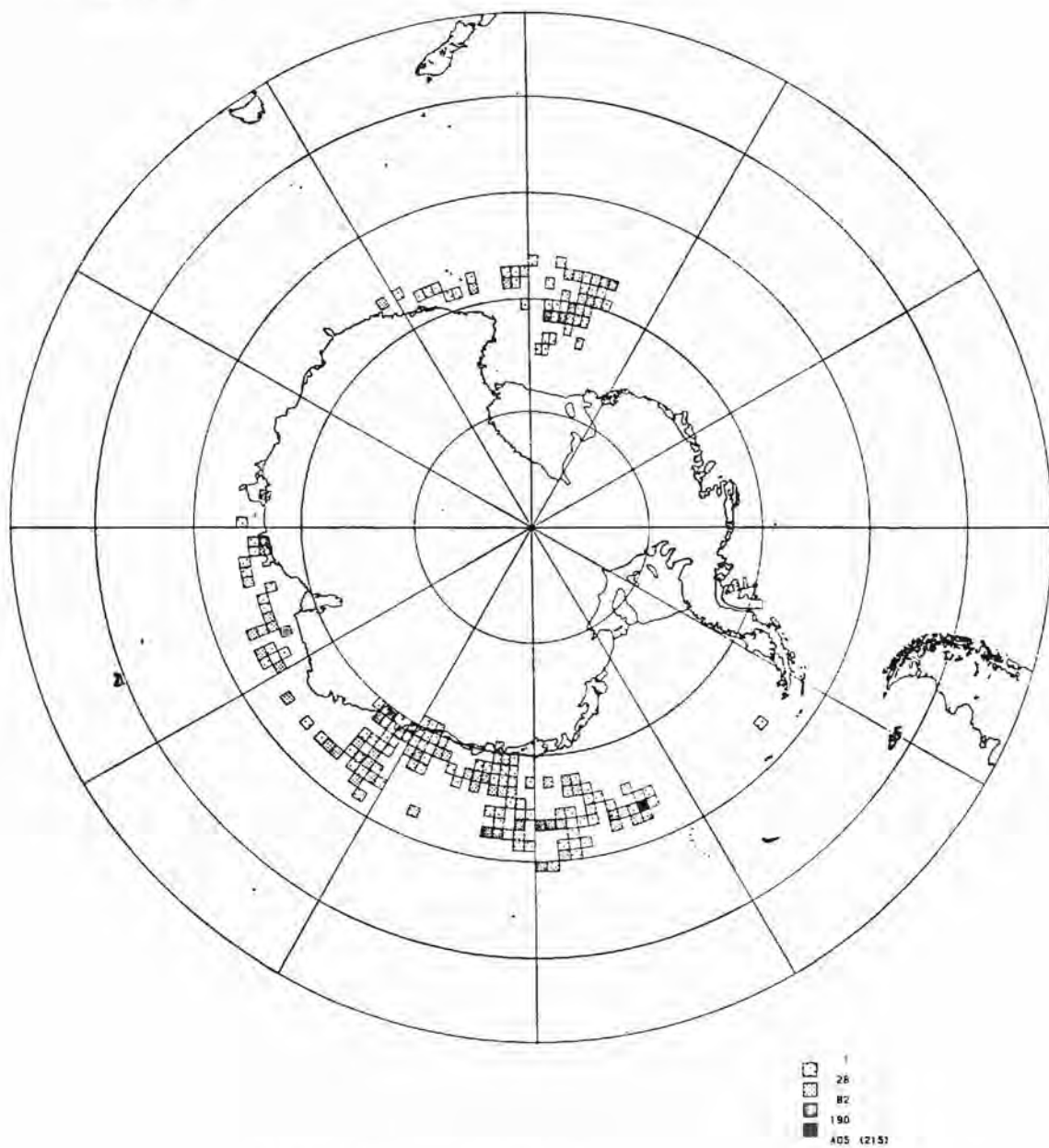
FIN WHALE CATCH IN JANUARY 1960/61

Figure 34.



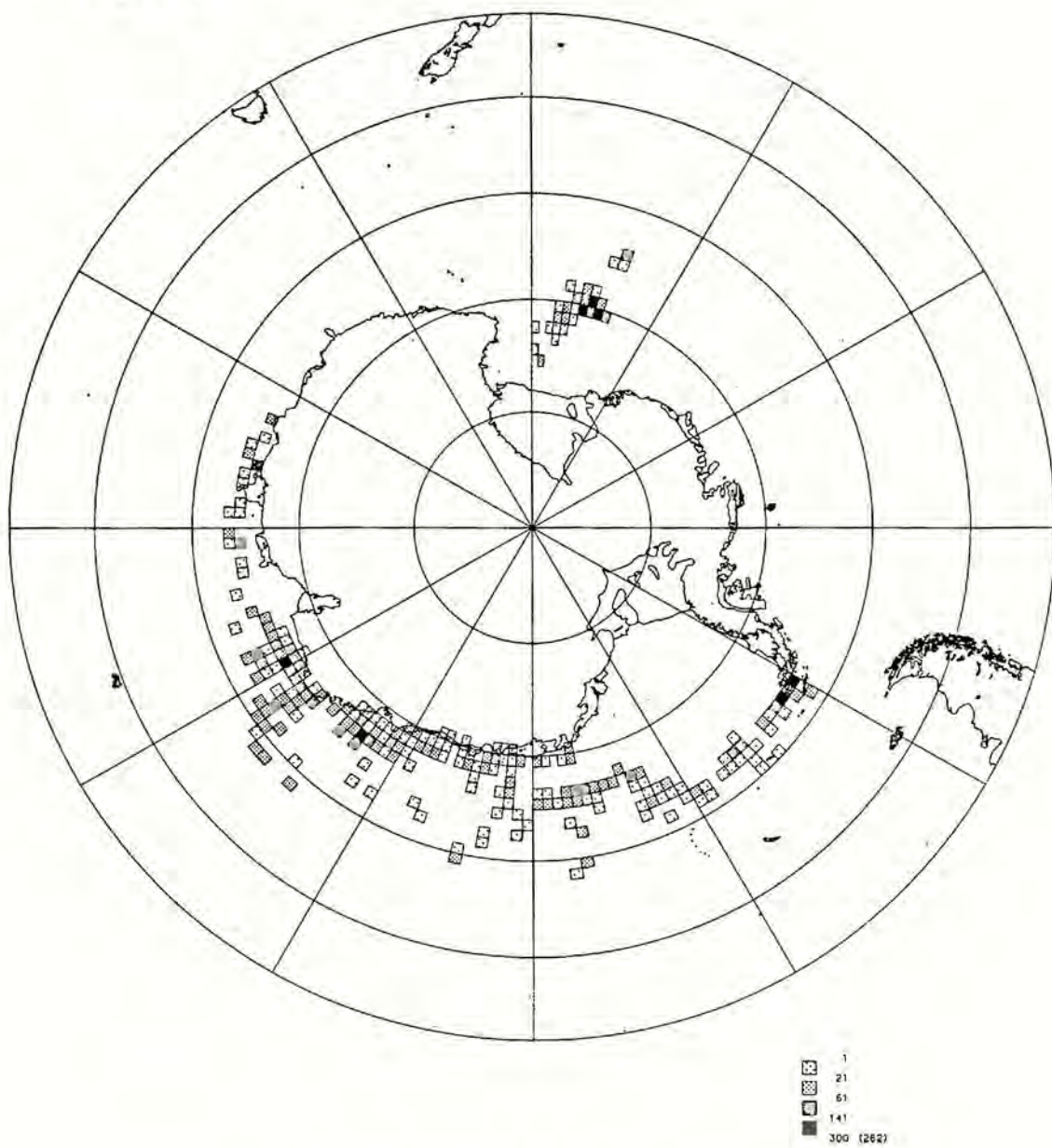
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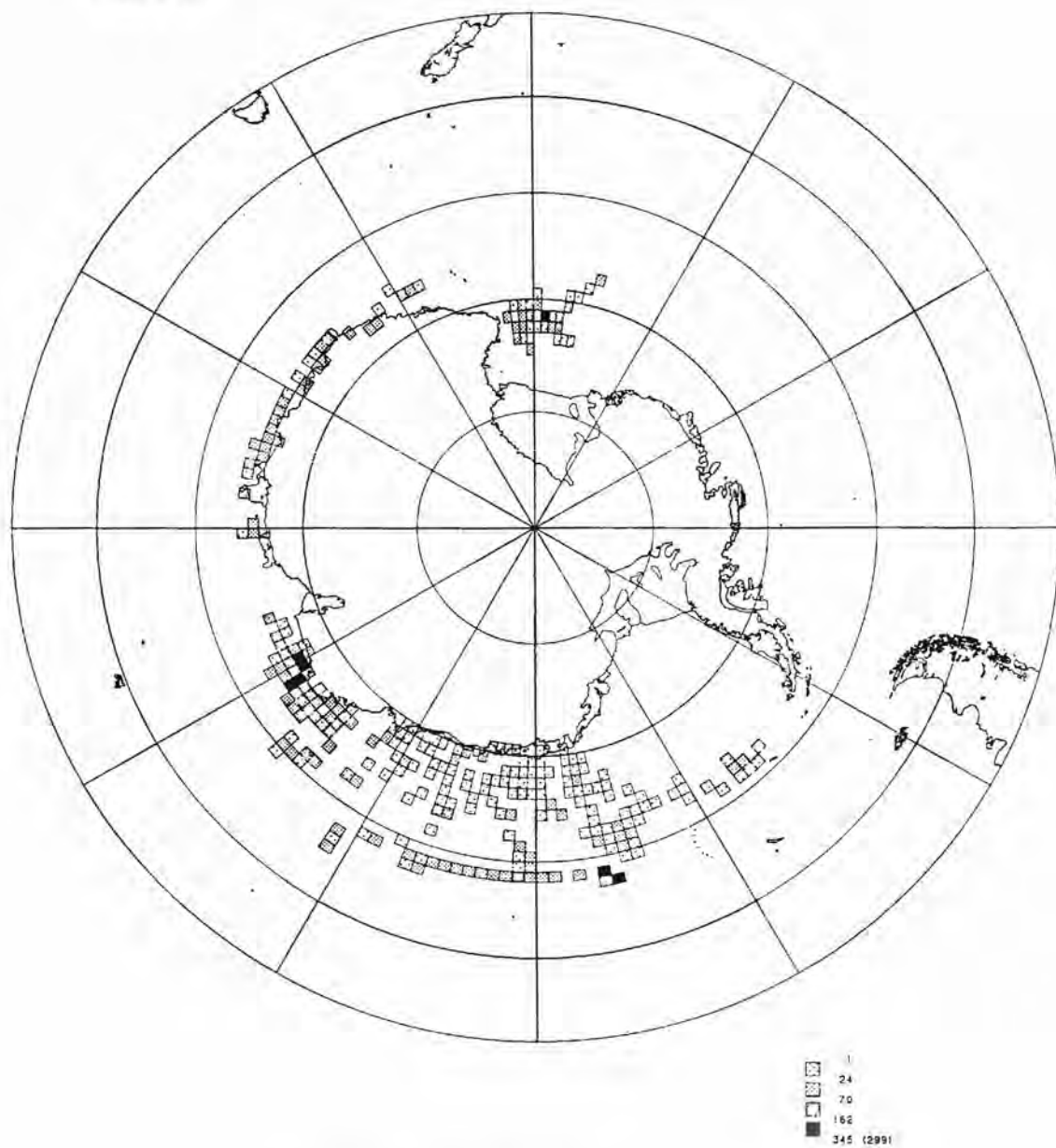
FIN WHALE CATCH : FEBRUARY 1952/53

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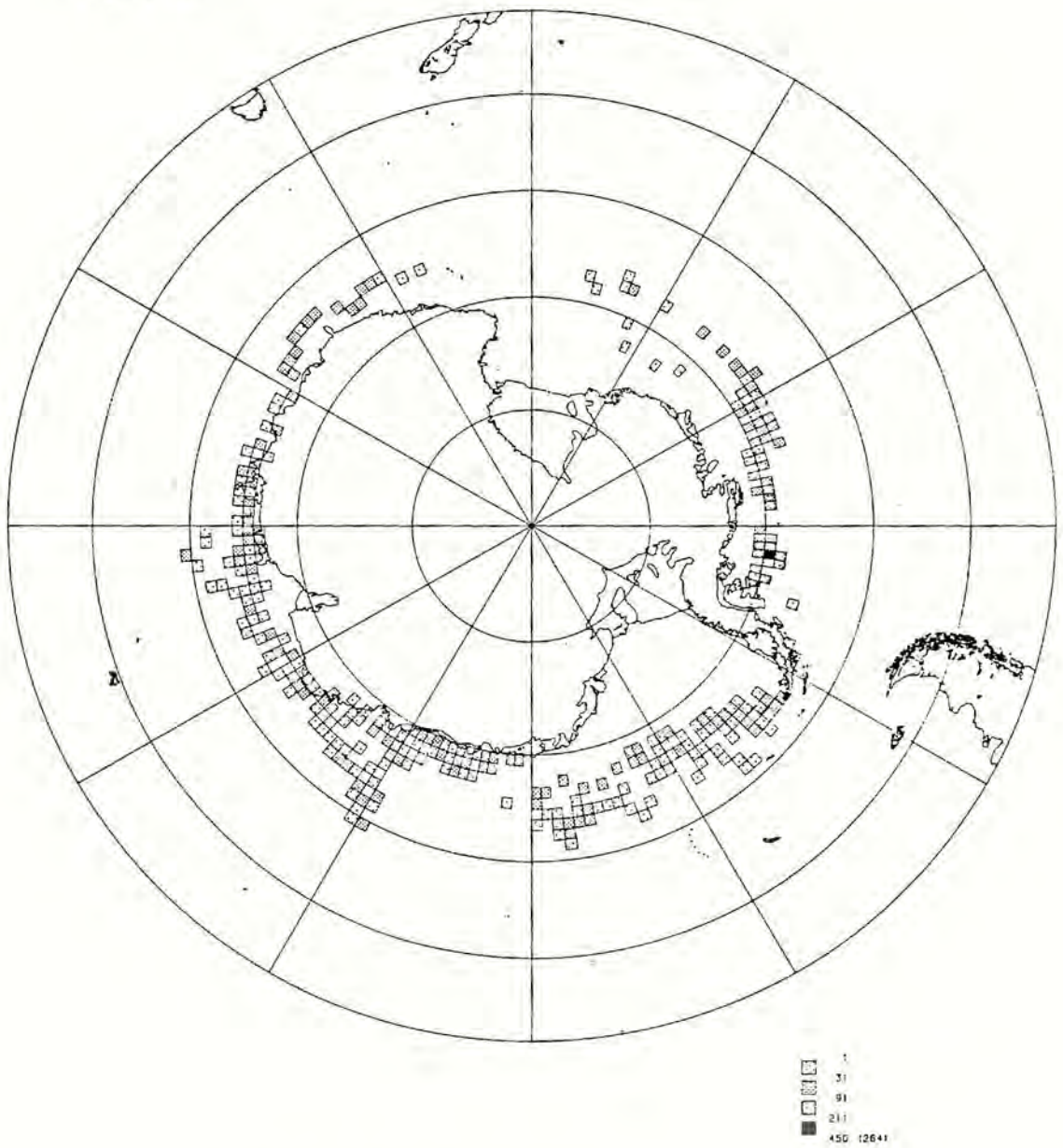
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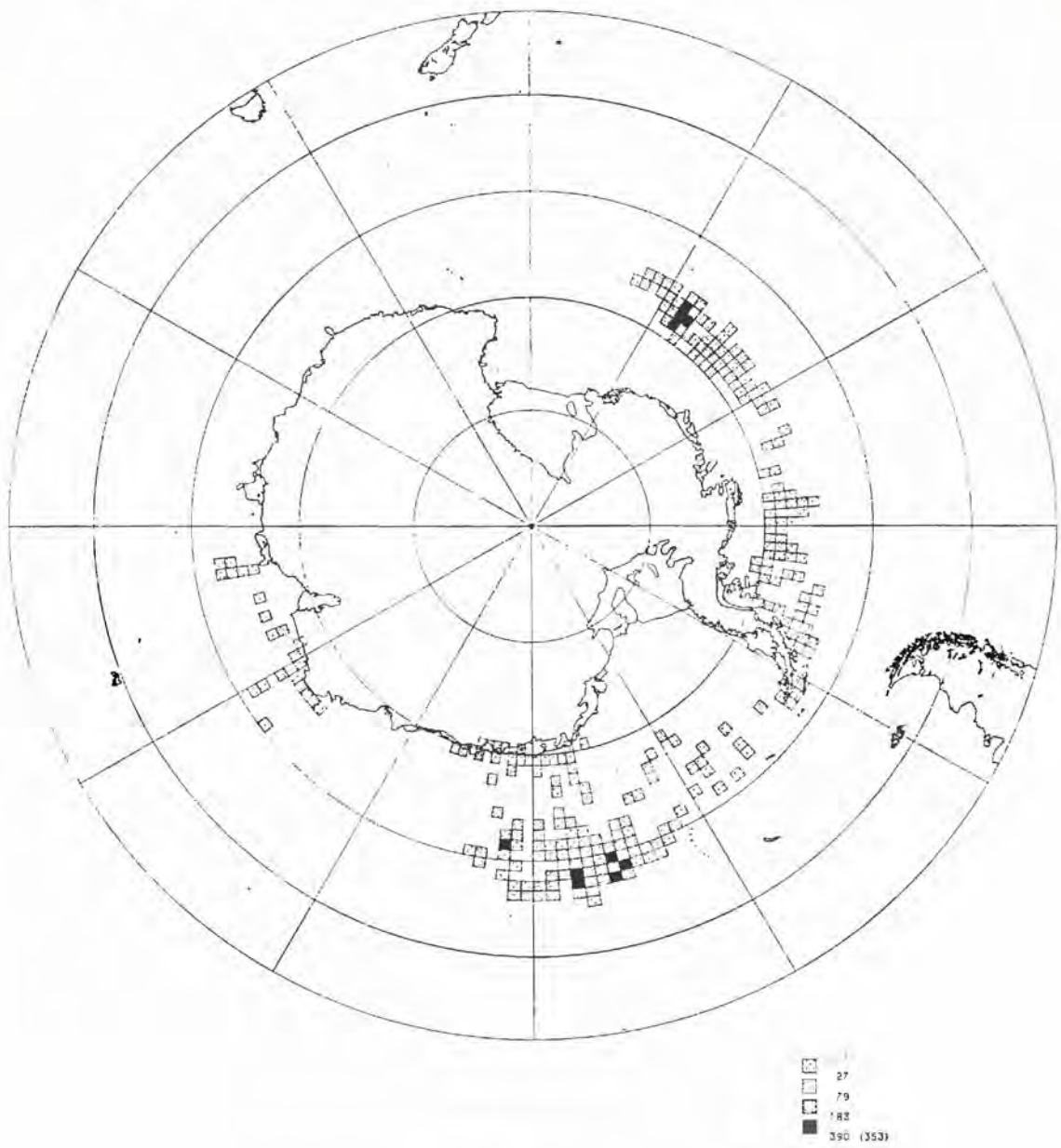
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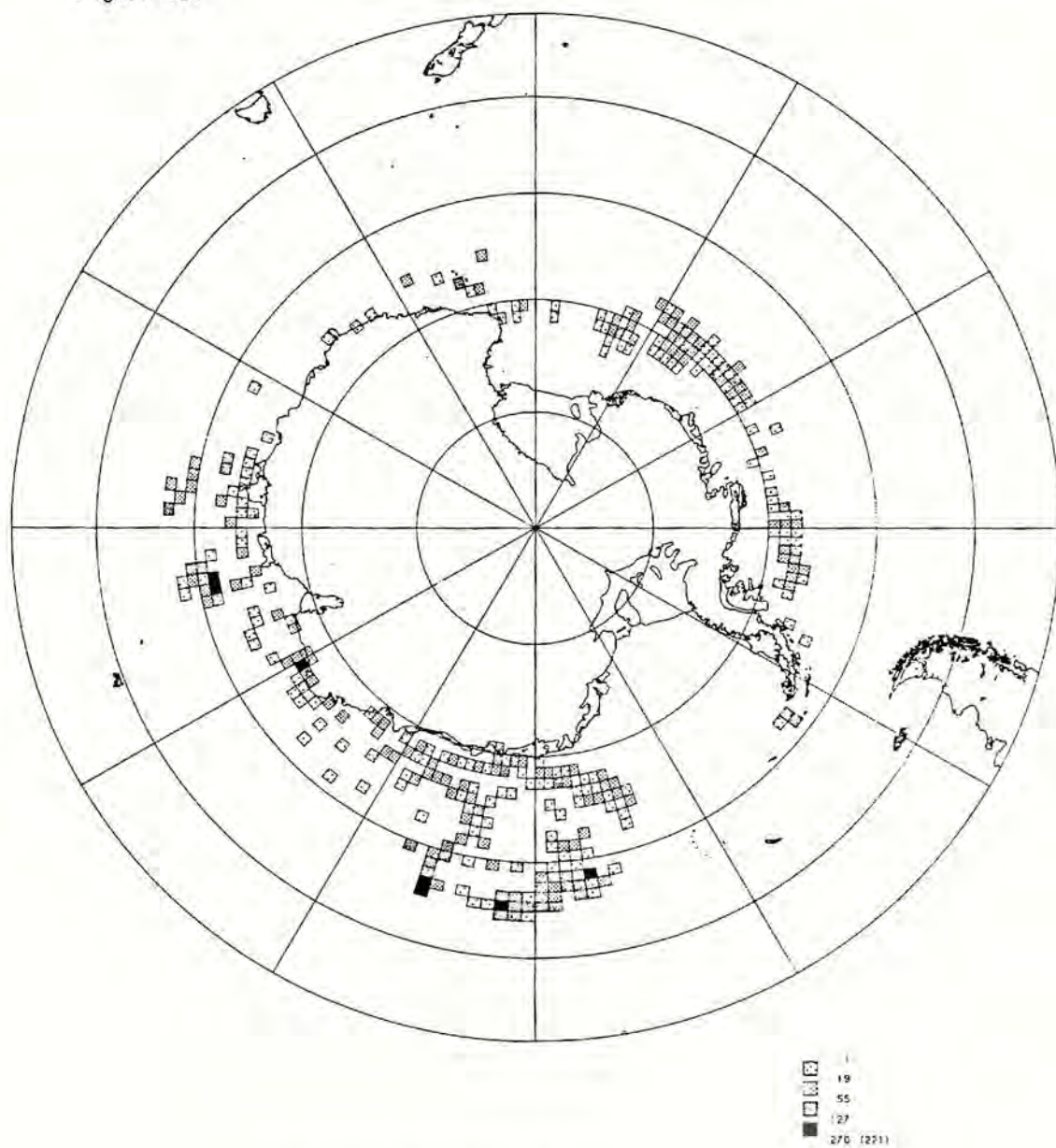
FIN WHALE CATCH IN FEBRUARY 1955/56

Figure 39.



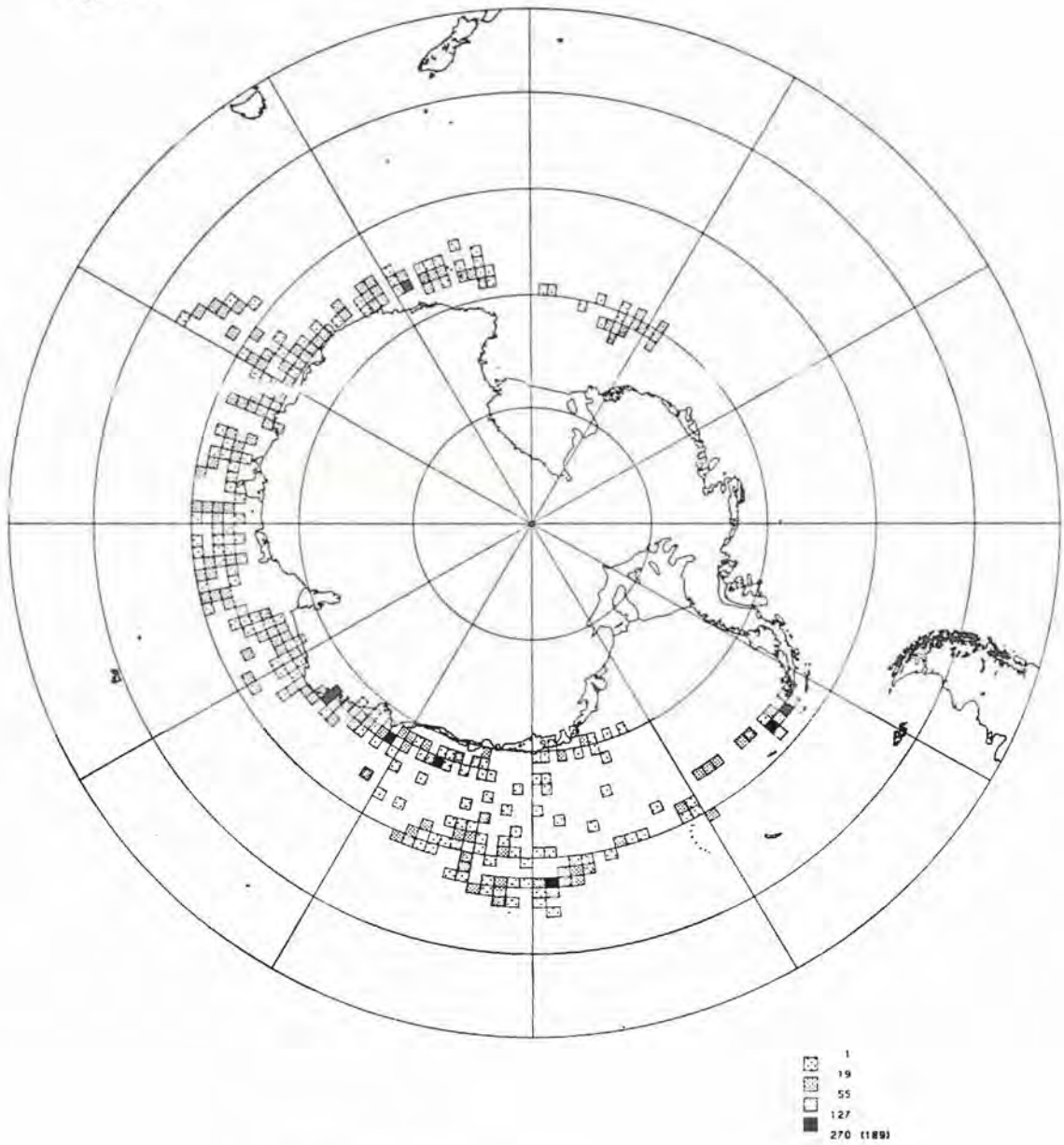
FIN WHALE CATCH IN FEBRUARY 1956/57

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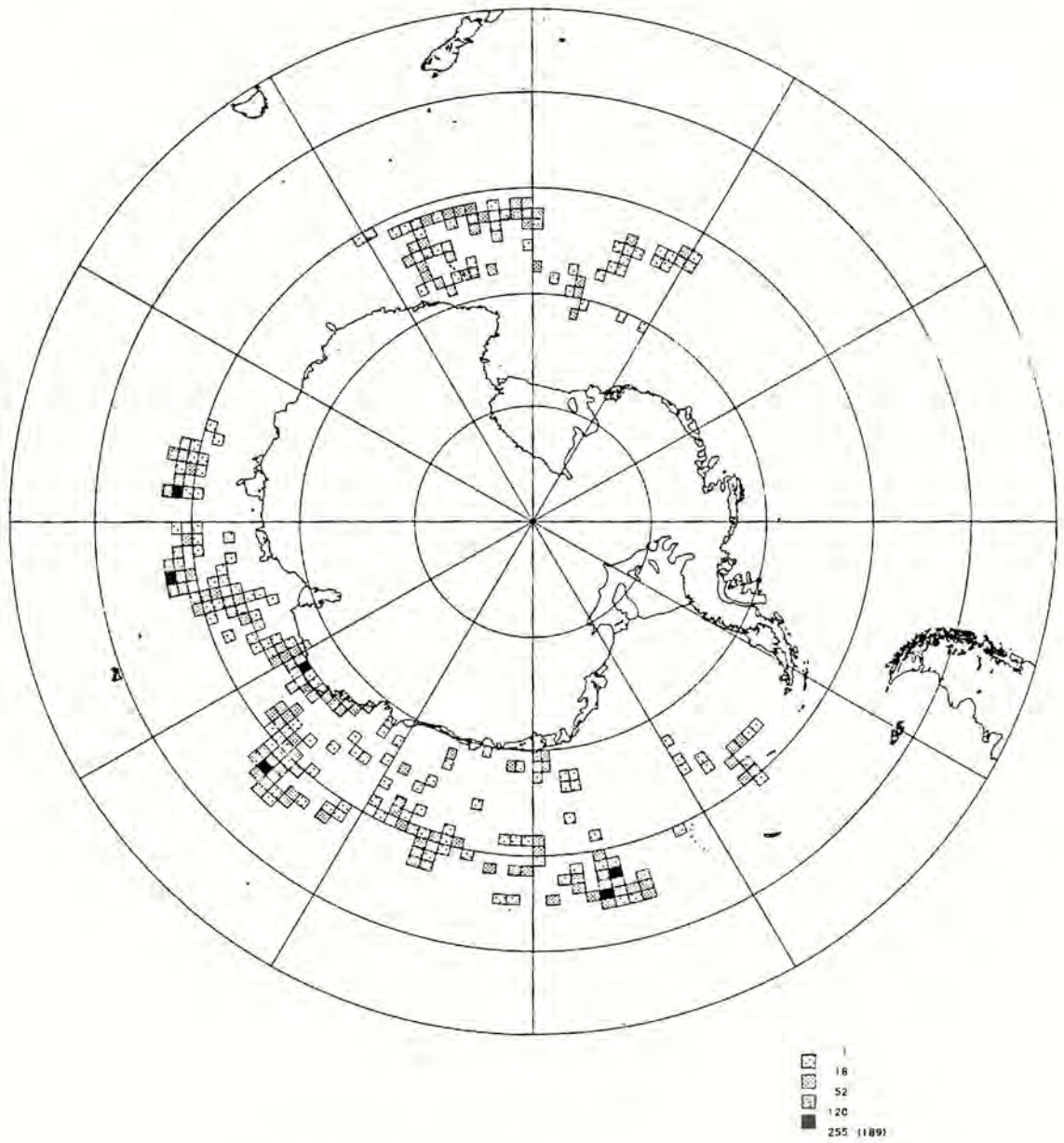
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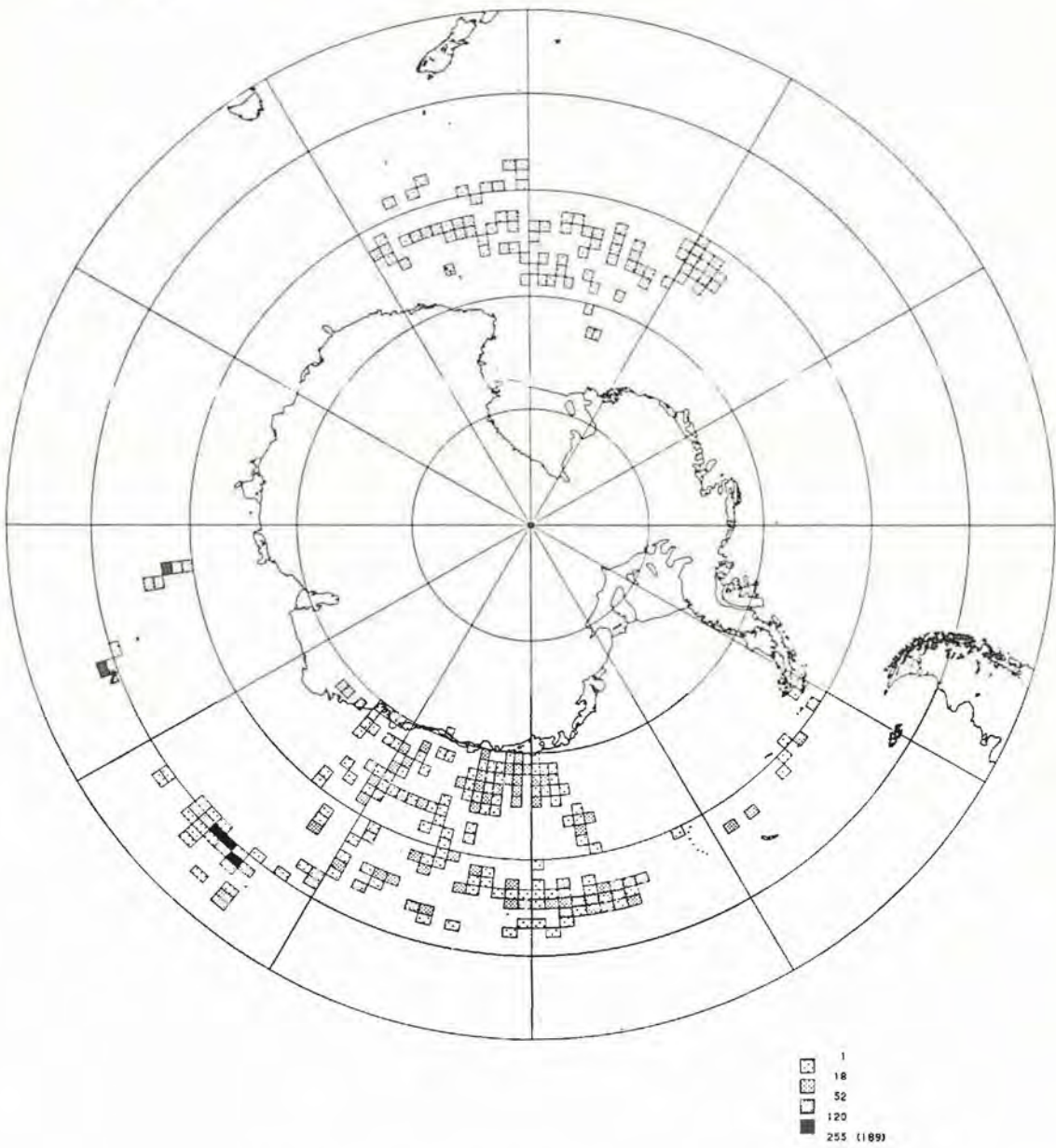
FIN WHALE CATCH IN FEBRUARY 1958/59

Figure 42.



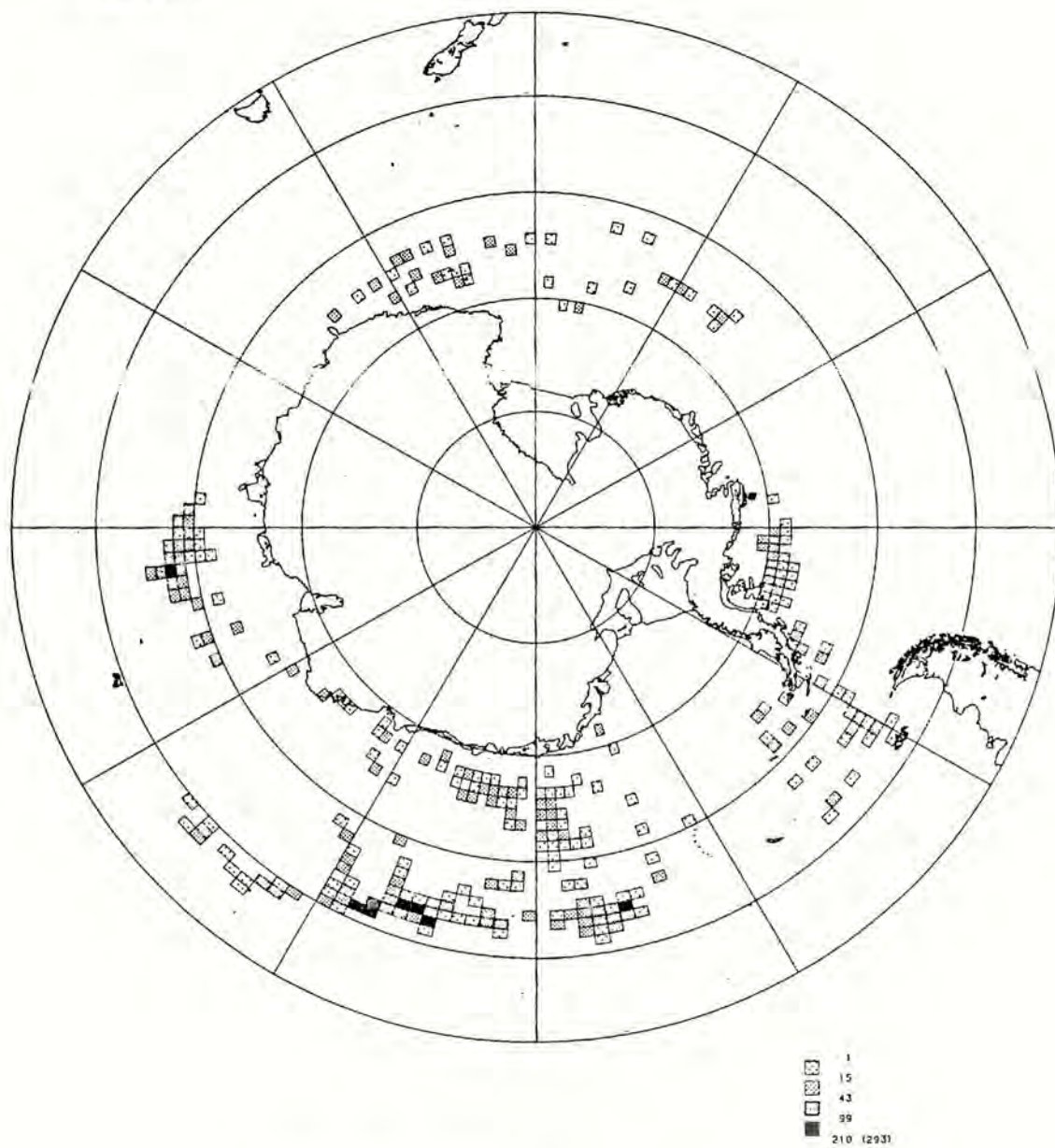
FIN WHALE CATCH IN FEBRUARY 1959/60

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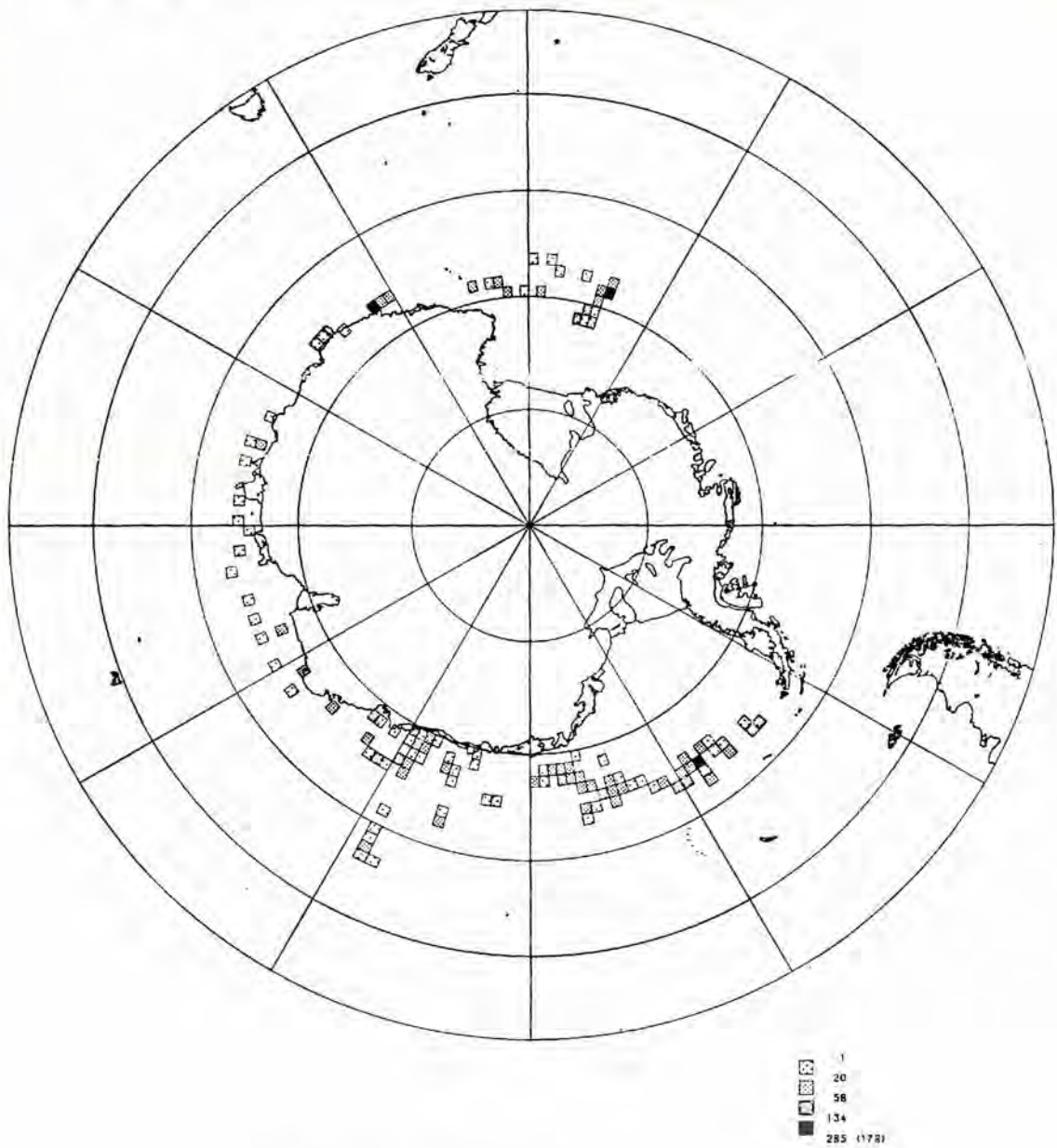
FIN WHALE CATCH IN FEBRUARY 1960/61

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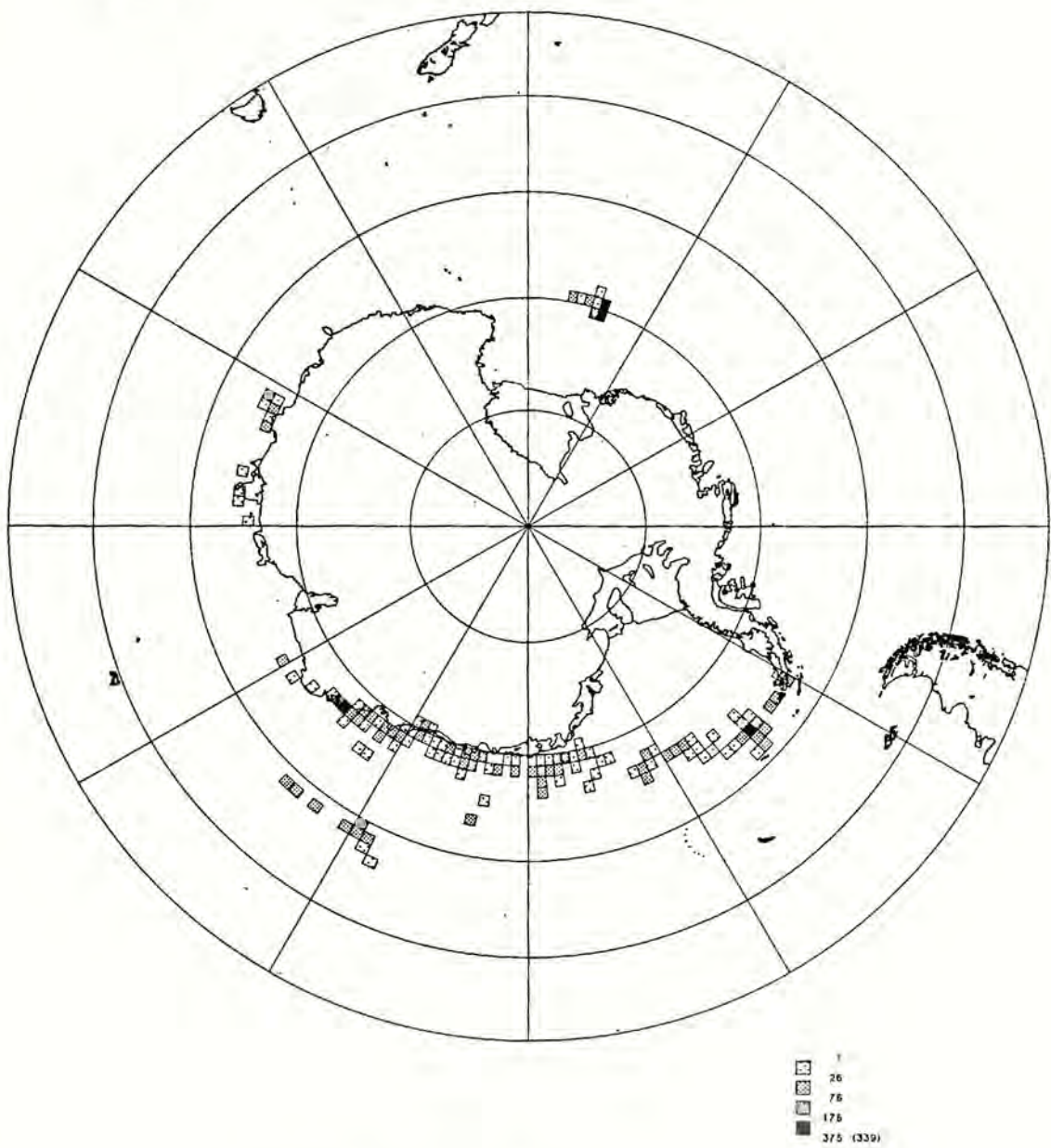
FIN WHALE CATCH IN FEBRUARY 1961/62

Figure 45.



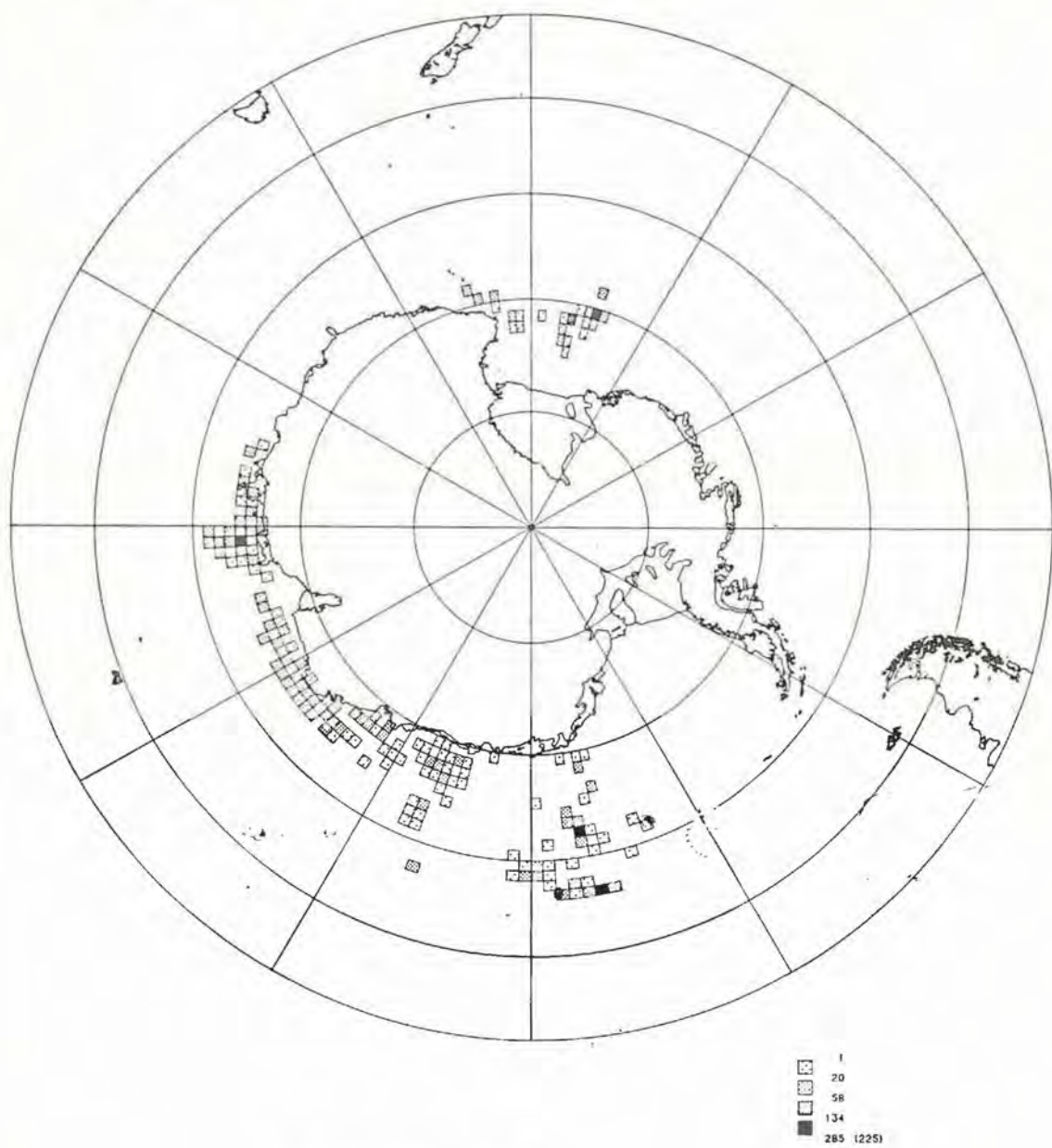
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Figure 46.



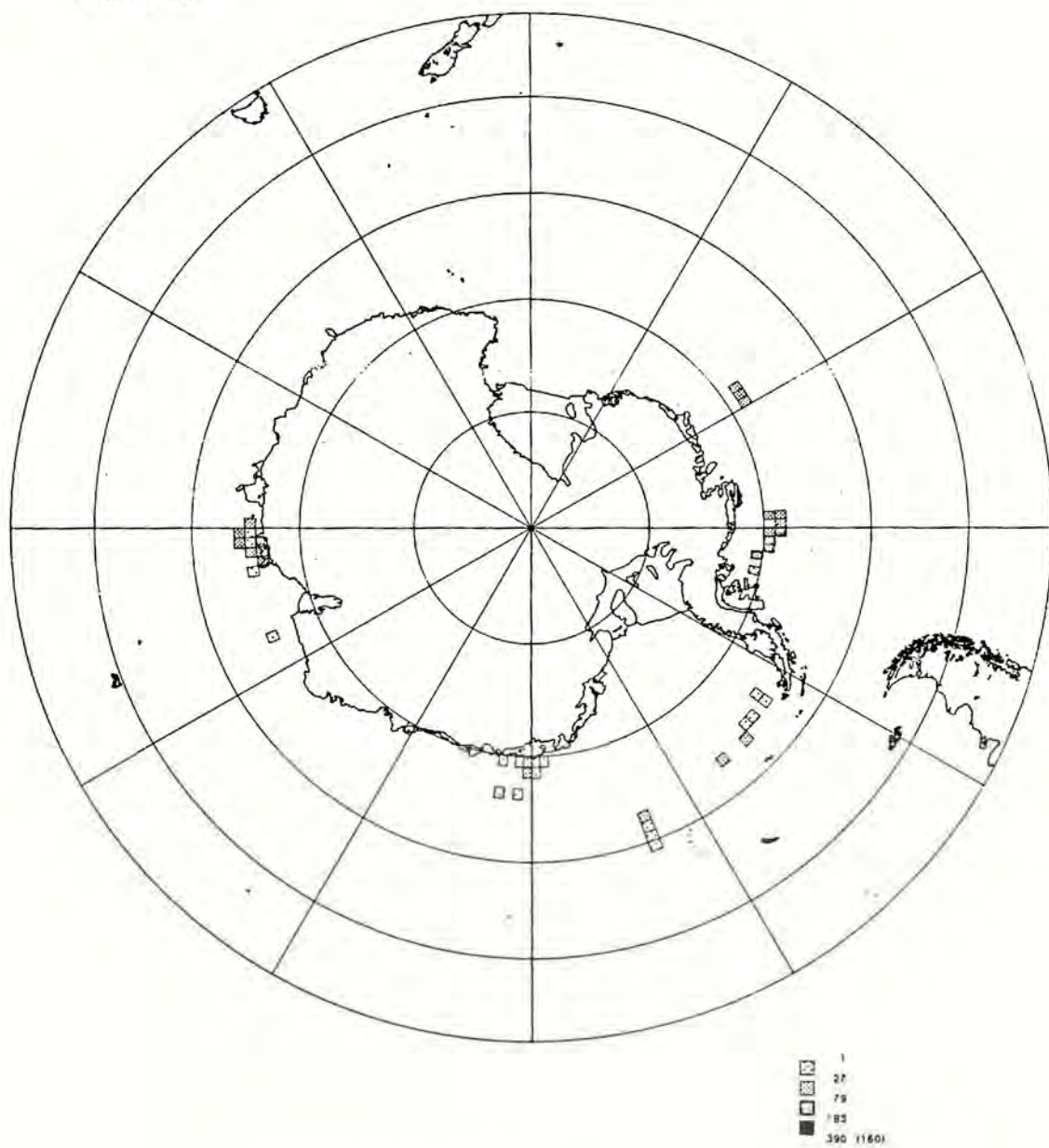
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Figure 47.



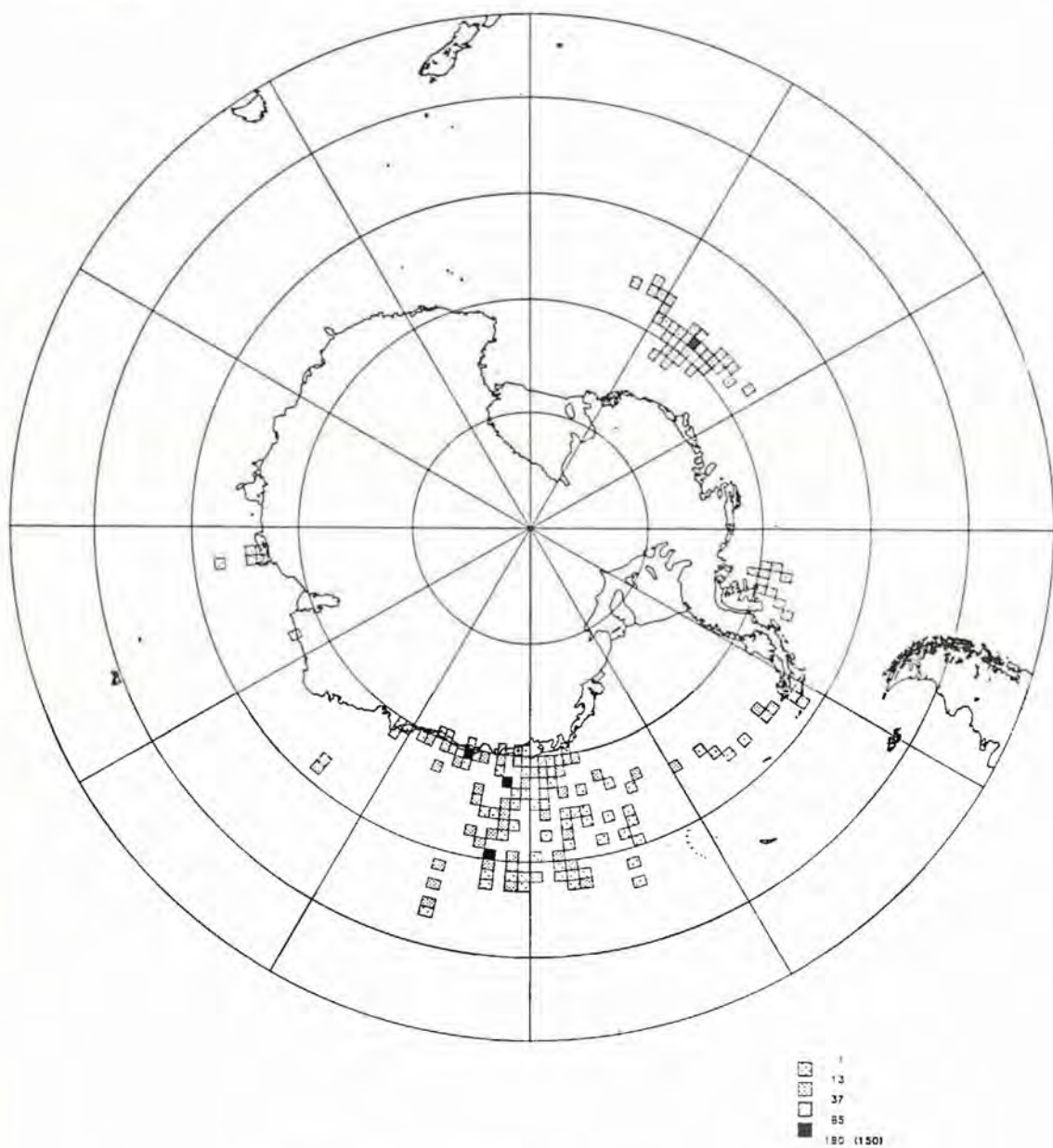
FIN WHALE CATCH IN MARCH 1944/55

Figure 48.



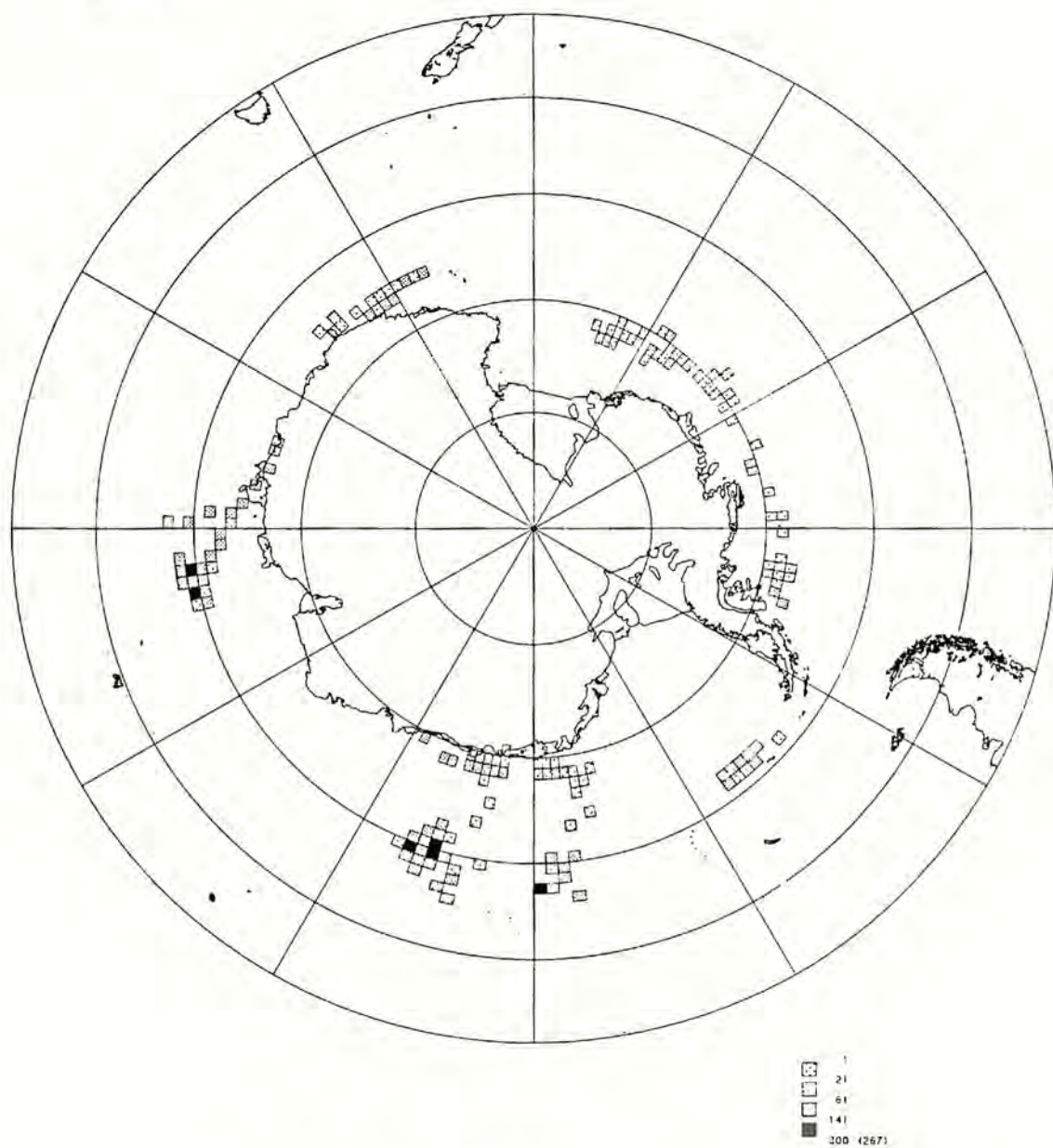
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Figure 49.



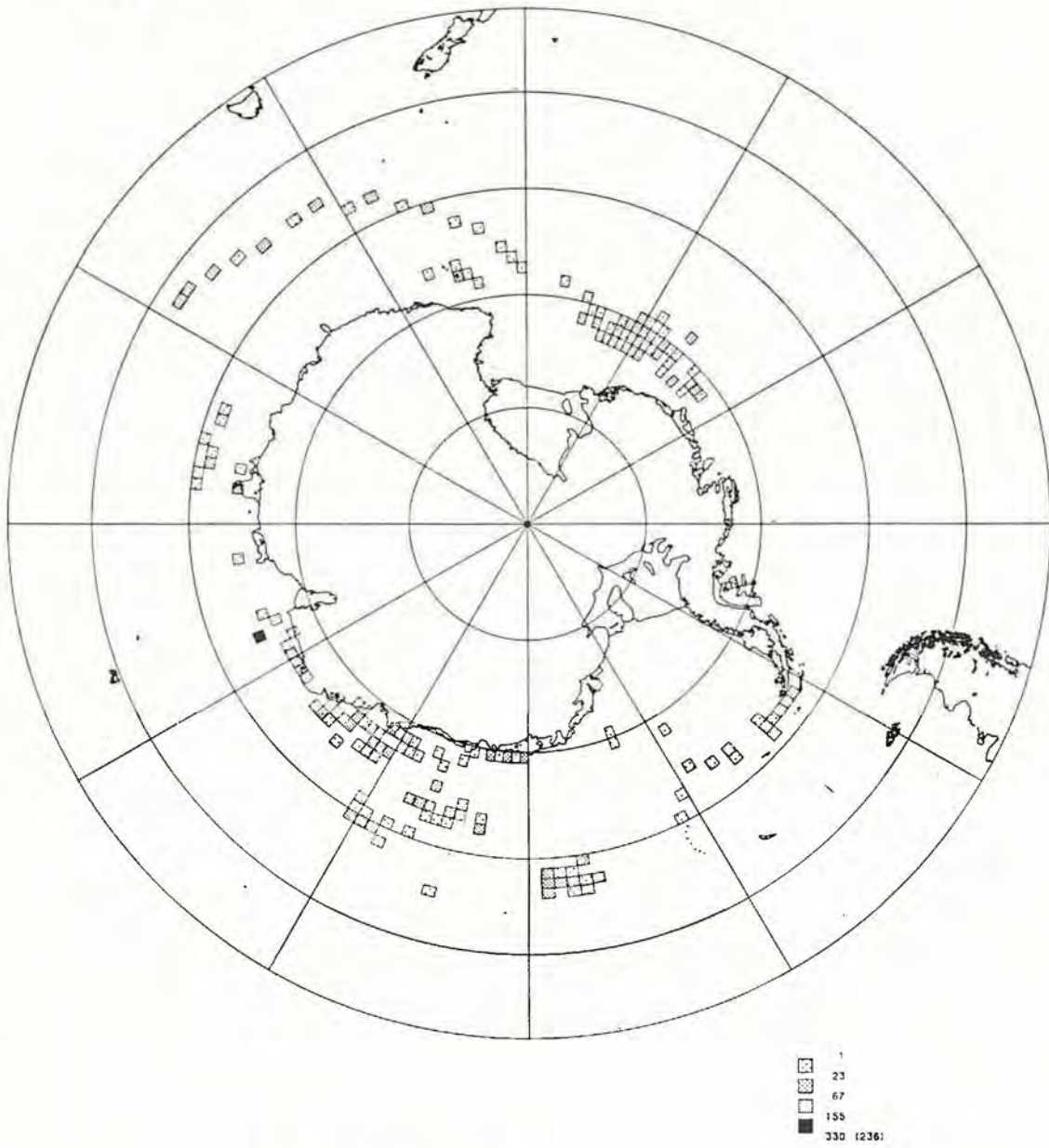
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Figure 50.



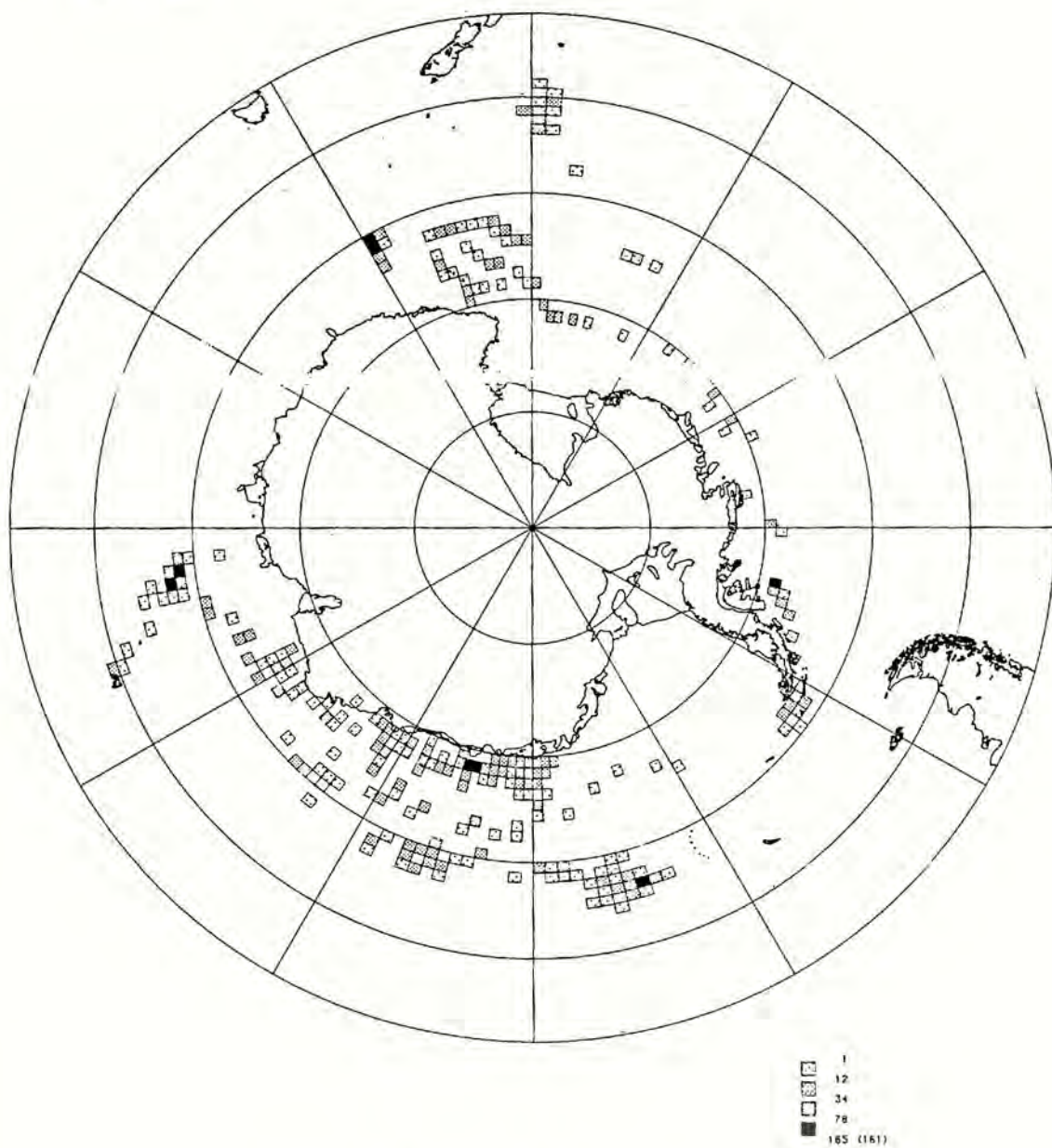
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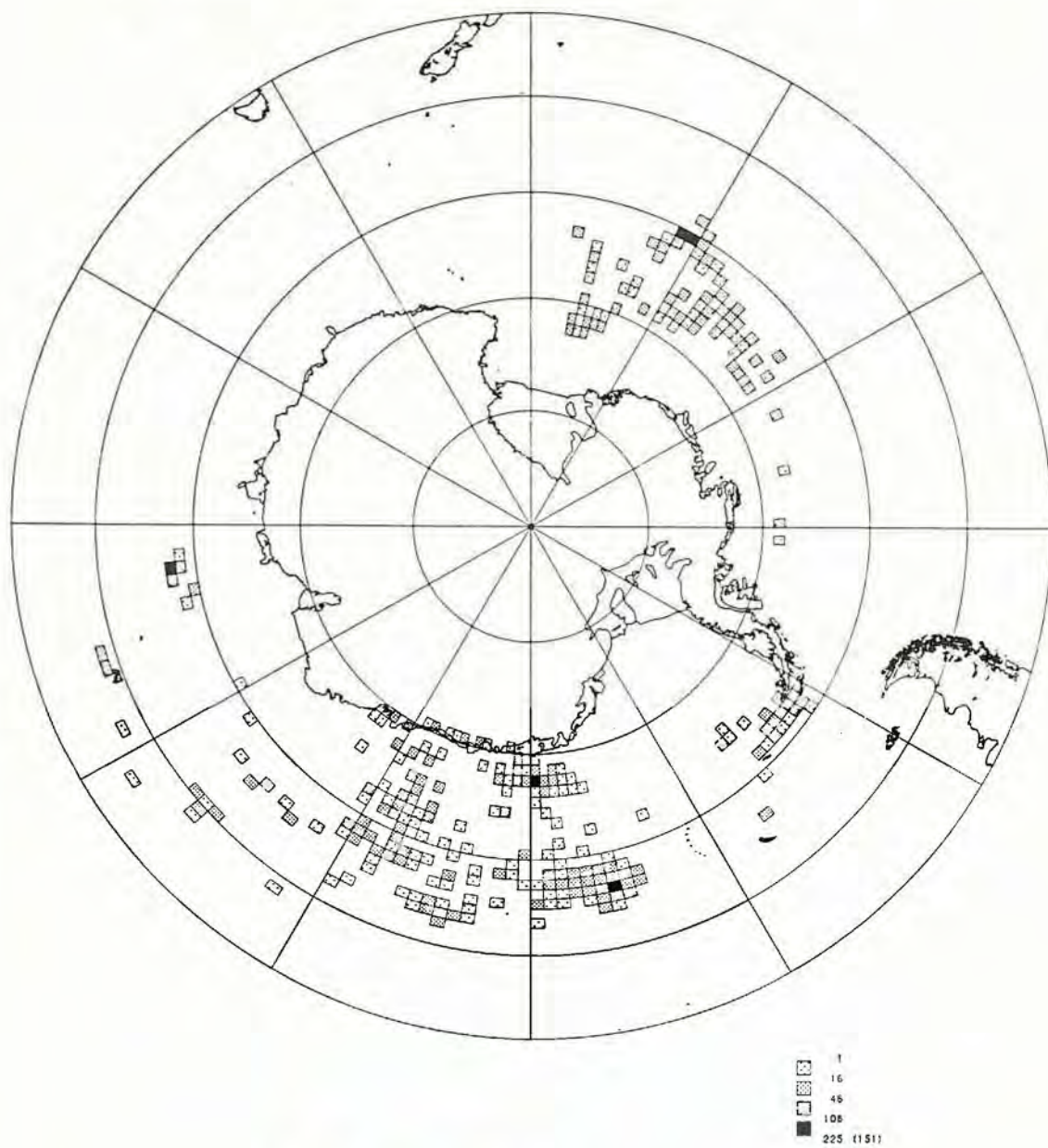
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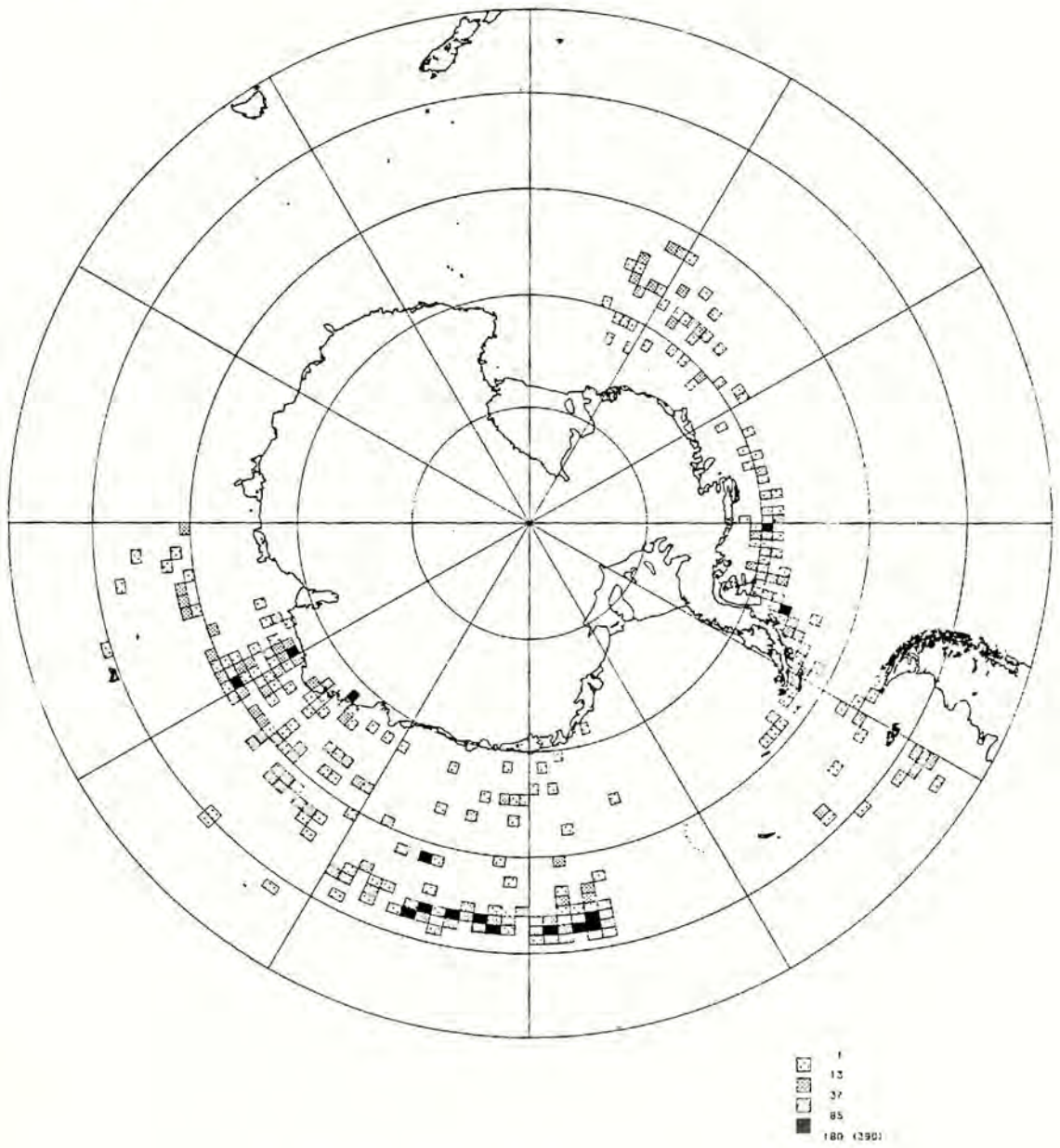
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Figure 53.



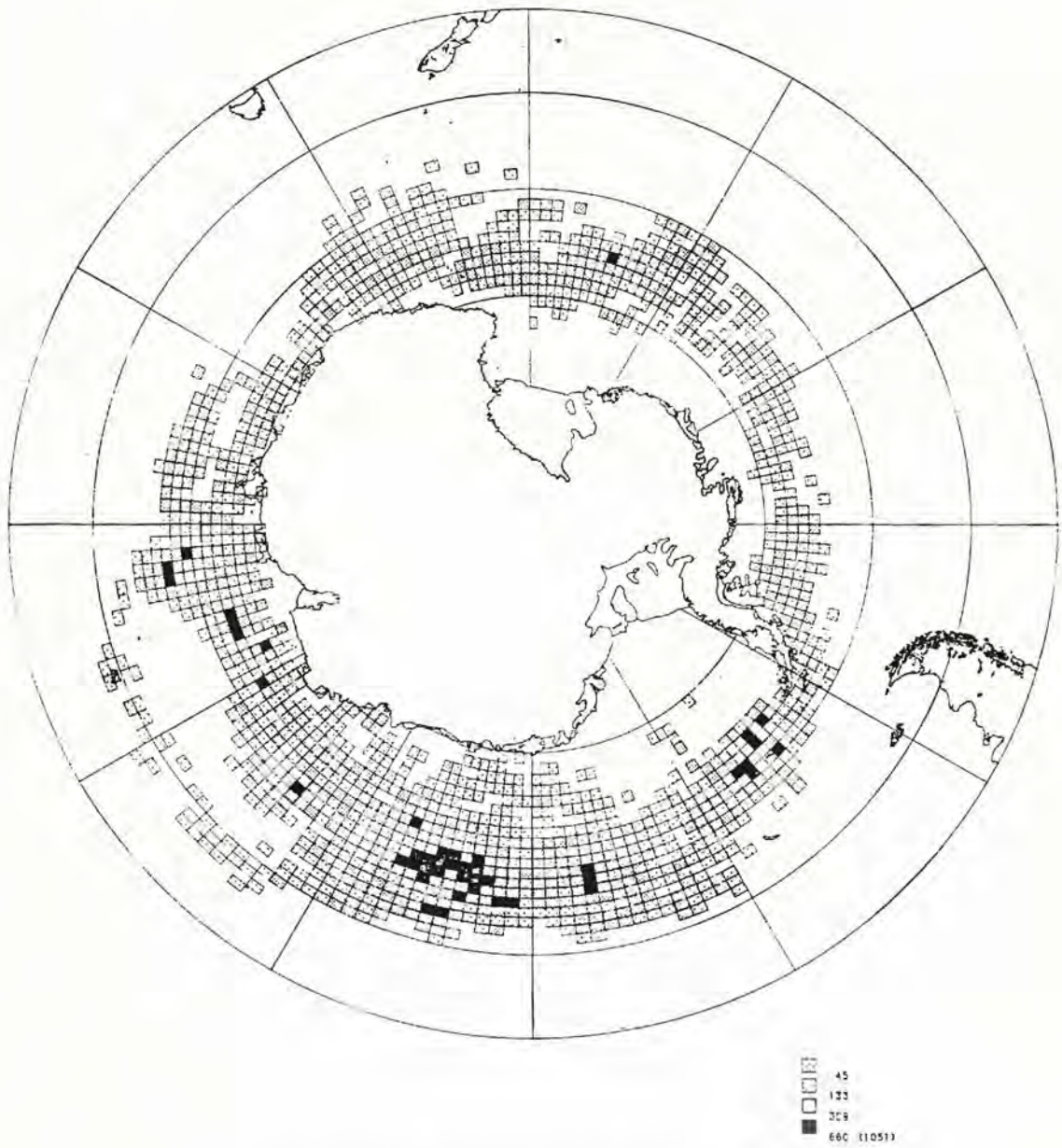
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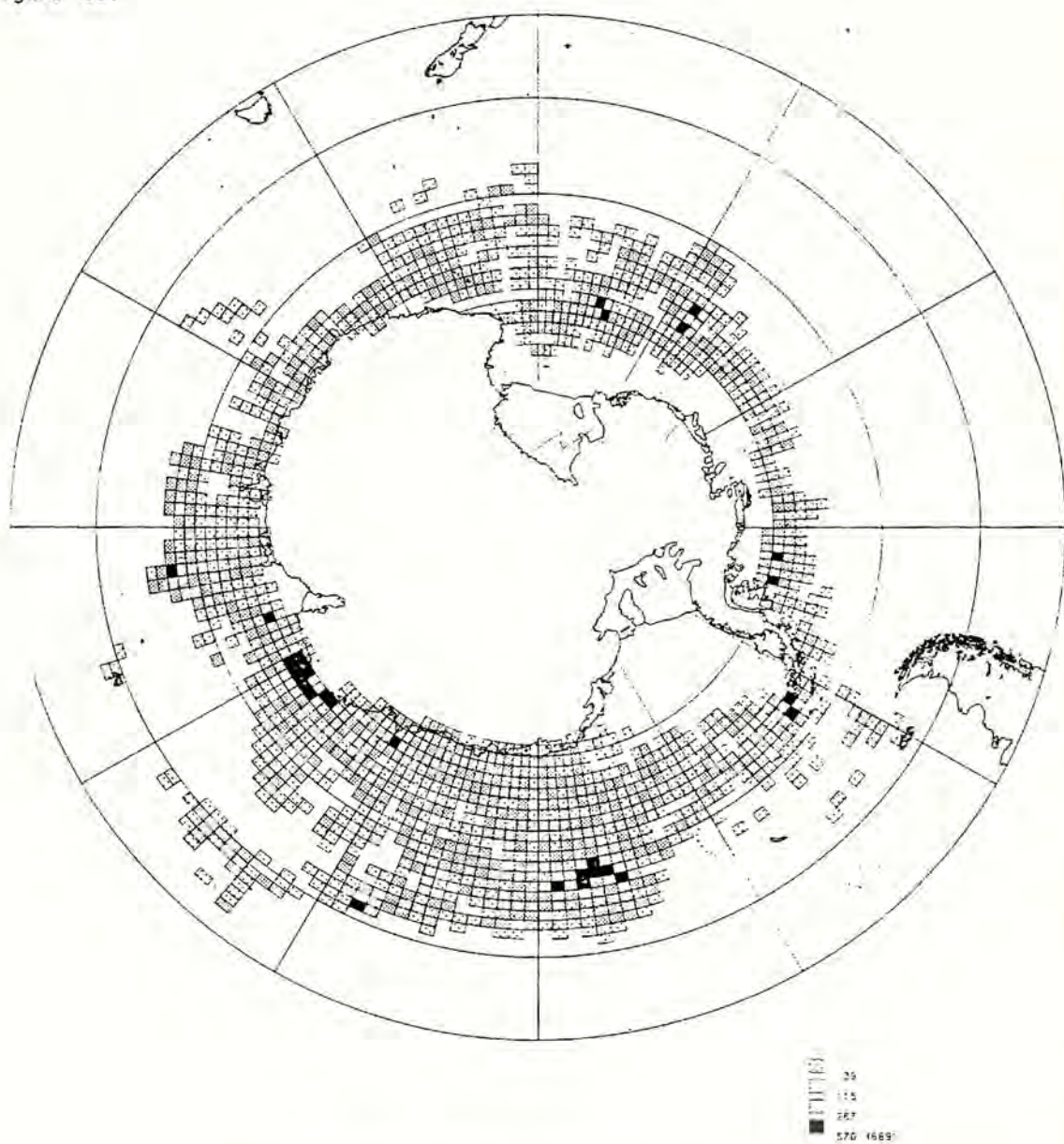
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Figure 55.



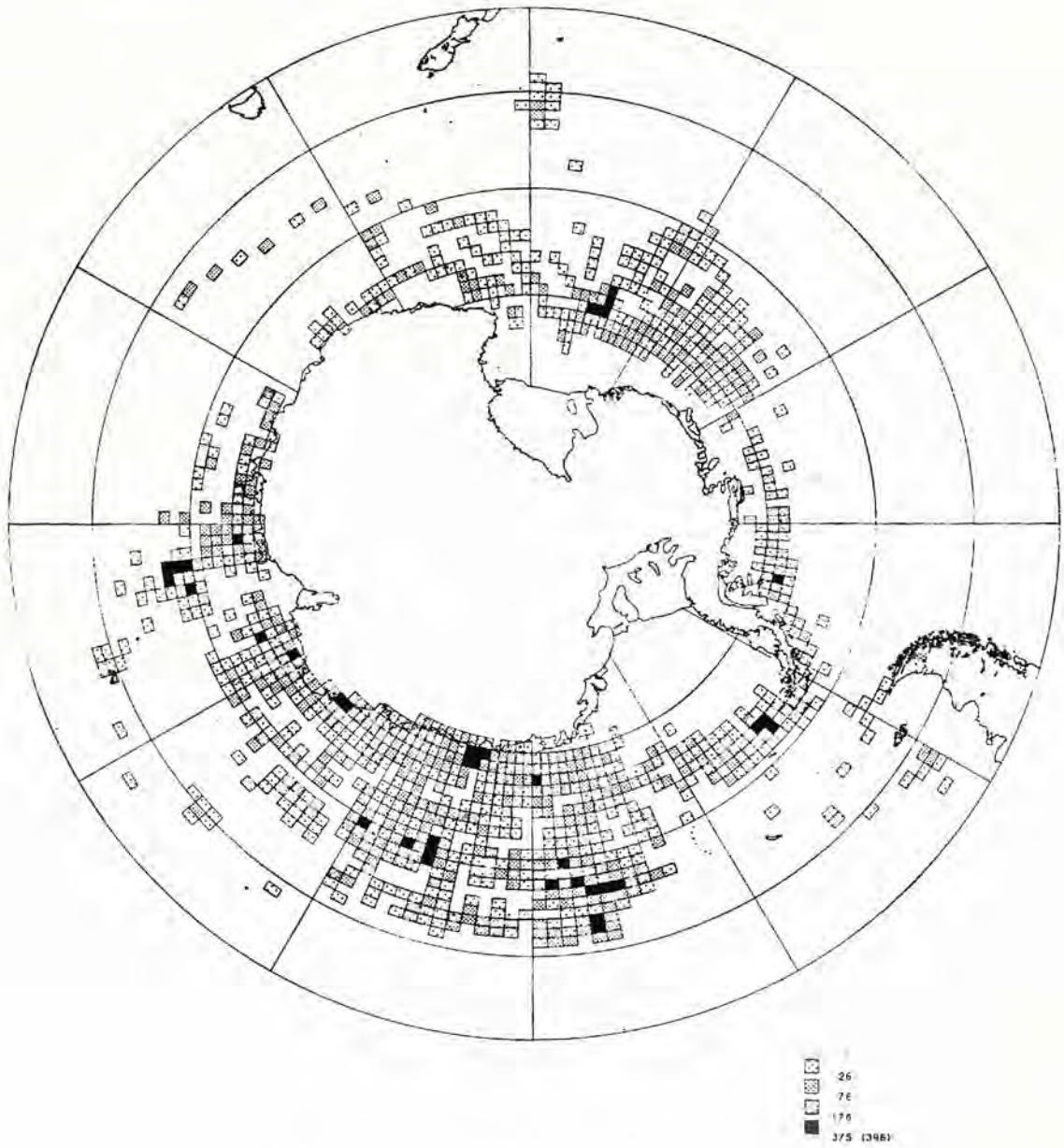
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- Gráfico 21. Captura de ballenas enanas en diciembre de 1972/73-1979/80.
Captura total : 20.008.
- Gráfico 22. Captura de ballenas enanas en enero de 1972/73-1979/80.
Captura total : 13.043.
- Gráfico 23. Captura de ballenas enanas en febrero de 1972/73-1979/80.
Captura total : 13.295.
- Gráfico 24. Captura de ballenas enanas en marzo de 1972/73-1979/80.
Captura total : 404.
- Gráfico 25. Captura de ballenas de aleta en enero de 1952/53.
Captura total : 9.942.
- Gráfico 26. Captura de ballenas de aleta en enero de 1953/54.
Captura total : 11.413.
- Gráfico 27. Captura de ballenas de aleta en enero de 1954/55.
Captura total : 11.128.
- Gráfico 28. Captura de ballenas de aleta en enero de 1955/56.
Captura total : 12.745.
- Gráfico 29. Captura de ballenas de aleta en enero de 1956/57.
Captura total : 10.777.
- Gráfico 30. Captura de ballenas de aleta en enero de 1957/58.
Captura total : 10.746.
- Gráfico 31. Captura de ballenas de aleta en enero de 1958/59.
Captura total : 11.819.
- Gráfico 32. Captura de ballenas de aleta en enero de 1959/60.
Captura total : 10.720.
- Gráfico 33. Captura de ballenas de aleta en enero de 1960/61.
Captura total : 10.714.

- Gráfico 34. Captura de ballenas de aleta en enero de 1961/62.
Captura total : 8.408.
- Gráfico 35. Captura de ballenas de aleta en febrero de 1952/53.
Captura total : 7.405.
- Gráfico 36. Captura de ballenas de aleta en febrero de 1953/54.
Captura total : 8.001.
- Gráfico 37. Captura de ballenas de aleta en febrero de 1954/55.
Captura total : 9.521.
- Gráfico 38. Captura de ballenas de aleta en febrero de 1955/56.
Captura total : 11.036.
- Gráfico 39. Captura de ballenas de aleta en febrero de 1956/57.
Captura total : 11.349.
- Gráfico 40. Captura de ballenas de aleta en febrero de 1957/58.
Captura total : 8.805.
- Gráfico 41. Captura de ballenas de aleta en febrero de 1958/59.
Captura total : 8.616.
- Gráfico 42. Captura de ballenas de aleta en febrero de 1959/60.
Captura total : 8.153.
- Gráfico 43. Captura de ballenas de aleta en febrero de 1960/61.
Captura total : 7.871.
- Gráfico 44. Captura de ballenas de aleta en febrero de 1961/62.
Captura total : 7.001.
- Gráfico 45. Captura de ballenas de aleta en marzo de 1952/53.
Captura total : 3.619.
- Gráfico 46. Captura de ballenas de aleta en marzo de 1953/54.
Captura total : 5.254.
- Gráfico 47. Captura de ballenas de aleta en marzo de 1954/55.
Captura total : 4.954.
- Gráfico 48. Captura de ballenas de aleta en marzo de 1955/56.
Captura total : 1.321.
- Gráfico 49. Captura de ballenas de aleta en marzo de 1956/57.
Captura total : 3.370.
- Gráfico 50. Captura de ballenas de aleta en marzo de 1957/58.
Captura total : 5.511.

- Gráfico 51. Captura de ballenas de aleta en marzo de 1958/59.
Captura total : 5.246.
- Gráfico 52. Captura de ballenas de aleta en marzo de 1959/60.
Captura total : 4.579.
- Gráfico 53. Captura de ballenas de aleta en marzo de 1960/61.
Captura total : 5.983.
- Gráfico 54. Captura de ballenas de aleta en marzo de 1961/62.
Captura total : 6.647.
- Gráfico 55. Captura de ballenas de aleta en enero de 1952/53-1961/62.
Captura total : 108.412.
- Gráfico 56. Captura de ballenas de aleta en febrero de 1952/53-1961/62.
Captura total : 87.758.
- Gráfico 57. Captura de ballenas de aleta en marzo de 1852/53-1961/62.
Captura total : 46.484.

