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## ON THE DISTRIBUTION AND MOVEMENTS OF WHALES ON THE SOUTH GEORGIA AND SOUTH SHETLAND WHALING GROUNDS

by

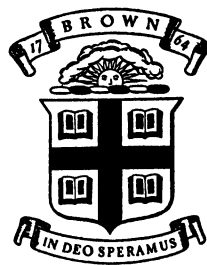
Stanley Kemp, Sc.D., F.R.S., and A. G. Bennett

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ON THE DISTRIBUTION AND MOVEMENTS  
OF WHALES ON THE SOUTH GEORGIA AND  
SOUTH SHETLAND WHALING GROUNDS

By

STANLEY KEMP, Sc.D., F.R.S.

AND

A. G. BENNETT

## CONTENTS

Introduction . . . . .	<i>page</i> 167
Collection and analysis of the data	
Positional data . . . . .	168
Directional data . . . . .	174
Discussion of Results	
South Georgia whaling grounds . . . . .	177
South Shetland whaling grounds . . . . .	184
Plates VII-XLII . . . . .	<i>following page</i> 190

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# ON THE DISTRIBUTION AND MOVEMENTS OF WHALES ON THE SOUTH GEORGIA AND SOUTH SHETLAND WHALING GROUNDS

By Stanley Kemp, Sc.D., F.R.S., and A. G. Bennett

(Plates VII-XLII; text-figs. 1-6)

## INTRODUCTION

IN the year 1922 the Government of the Falkland Islands issued to the whaling companies operating under licence in the Dependencies a form designed to give information on the distribution and movements of whales in the whaling areas. The companies were asked to give the approximate position of each whale that was killed, and if whales were seen to be moving, they were asked to report the direction of movement. The vast majority of the completed forms<sup>1</sup> relate to Blue and Fin whales taken either off South Georgia or the South Shetlands, and it is with the data concerning these species from these two areas that the present paper is concerned.

The information obtained in this way presents a number of interesting features. It demonstrates the particular regions within the areas where whales are accustomed to concentrate, and it shows how these concentrations have shifted during the course of the season. It indicates with some clearness the seasonal variations which have occurred, and, in South Georgia, how greatly the whaling grounds have been extended in recent years. Evidence bearing on the movements of whales is available both from alterations from month to month in the centres of concentration and from the direct observations recorded by the gunners. The results from these two sources are not always in agreement and it would appear that reliable data can only be obtained by whale marking. The first series of marking experiments has unfortunately proved unsuccessful: but methods have been modified in accordance with experience and renewed attempts will be made in the season 1932-3.

In the present state of our knowledge it is difficult, if not impossible, to explain the seasonal variations which these data have brought to light; but as information accumulates on the plankton and hydrology of the areas some of the underlying causes may be discovered.

Few attempts have hitherto been made to ascertain the distribution of whales in whaling areas. Detailed records are usually not kept by the whaling companies and unless arrangements are made beforehand particulars cannot be obtained. Hjort, Lie

<sup>1</sup> The forms are stored in the offices of the Falkland Islands Government at Port Stanley.

and Ruud<sup>1</sup> have, however, published a valuable summary of the catches made in the Antarctic in 1929-30 and 1930-1 by Norwegian pelagic factories, illustrated by charts which cover an area extending from the South Shetland Islands to the Ross Sea. In the northern hemisphere D'Arcy Thompson in 1928<sup>2</sup> analysed data obtained at the Scottish whaling stations and published charts, based on records for seven seasons, which show for each month the positions where Fin and Sei whales were captured. In earlier papers, published in 1918,<sup>3</sup> the same author gave charts showing the positions off the Scottish coast where Nordcapers, Sperm whales and Blue whales had been taken.

### COLLECTION AND ANALYSIS OF THE DATA

The forms, as already mentioned, give information of two kinds, namely the positions where whales were killed and observations on the directions in which whales were moving. The reliability of the records, their limitations and the methods employed in analysis may be conveniently discussed under these two heads.

#### POSITIONAL DATA

The positions recorded for each whale are invariably given by the whalers as bearing and distance from the land, and since the whale-catchers are often out for several days, frequently in thick weather and many miles from the coast, they can only be regarded as rather rough approximations. We think, however, that this does not seriously affect the accuracy of the charts on which the results are summarized, for errors from this source tend to be eliminated by the methods we have employed. It is, moreover, only the main concentrations of whales that show features of interest, and these, so far as they were discovered by the whalers, we believe to be correctly indicated.

As will be seen from Plates XXIII and XL the areas within which whales have been killed, during the seasons with which these results are concerned, are very large. Off the coasts of South Georgia the whaling grounds are some 300 miles both in length and breadth, embracing an area of over 50,000 square miles. At the South Shetlands the grounds extend from east and south of Clarence Island south-west to the Biscoe Archipelago: the length is some 570 miles, the breadth in the middle about 160 miles and the area over 80,000 square miles. It is, however, only on exceptional occasions—when whales are uncommonly scarce or, in the South Shetlands, at particular times of the year—that the more distant parts of the area are visited, and as will be seen from the monthly charts there is thus great variation in the extent of ground covered by the

<sup>1</sup> Hjort, Lie and Ruud, *Norwegian Pelagic Whaling in the Antarctic*. Norsk Vidensk.-Akad. Oslo, Hvalradets Skrifter, No. 3, 1932.

<sup>2</sup> D'Arcy Thompson, *On Whales Landed at the Scottish Whaling Stations during the years 1908-14 and 1920-7*. Fisheries, Scotland, Sci. Invest., III, 1928.

<sup>3</sup> D'Arcy Thompson, *On Whales Landed at the Scottish Whaling Stations, especially during the years 1908-14*, Part I. *Scottish Naturalist*, 1918, p. 197. Parts II, III, *ibid.*, p. 223.

whalers. When whales are plentiful in inshore waters the catchers will naturally not go farther afield, and we have evidently no means of knowing how abundant whales may be in the unexplored parts. When, however, a large area is covered we may be confident that within its limits no considerable concentration of whales existed without being detected. In using the charts as evidence of distribution of whales this limitation must constantly be borne in mind.

During the seasons with which we are dealing whaling in South Georgia was conducted from five land stations and, until 1929-30, from one permanently moored floating factory, all situated on the north-east coast of the island (Fig. 1). The whale-catchers

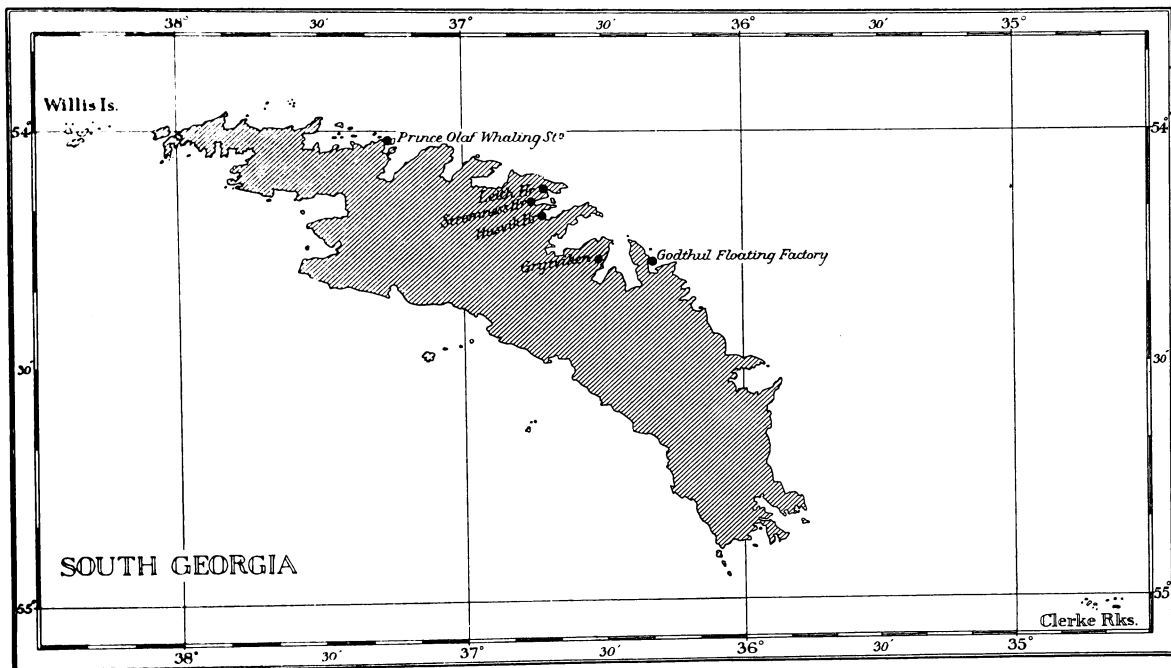


Fig. 1. South Georgia, showing positions of whaling stations.

were thus working from the same base throughout the season. At the South Shetlands conditions were different, for the land is heavily glaciated, and it is only at Deception Island, where the ice is melted by lingering traces of volcanic activity, that the erection of a shore station has been possible. In addition to this station there is a considerable number of floating factories, and these though often moored at Deception Island, were frequently shifted to other harbours. Those most often used were Admiralty Bay in King George Island, Melchior Harbour in Schollaert Channel and Port Lockroy in Neumayr Channel (Fig. 2). Other harbours in Trinity Island and in Gerlache Strait were occasionally used, and in some seasons, when ice conditions were exceptionally favourable, the factories went as far south as the Biscoe Archipelago. On approaching the whaling grounds in the spring the factories were often delayed by pack-ice, and not infrequently they worked for a period along the ice edge in the neighbourhood while awaiting the opportunity to enter Bransfield Strait. Since the whale-catchers do not ordinarily go more than 100 miles from the parent ship, it is evident that the position of

the latter will be reflected in our charts of positions. During most of the period under review there were, however, enough factories employed to cover the whole ground adequately; and since their movements were determined by the positions in which whales were most abundant, we think the limitations to the data are much the same as those on the South Georgia grounds—we believe that within the area examined no large concentration of whales could have existed without being discovered. Heavy

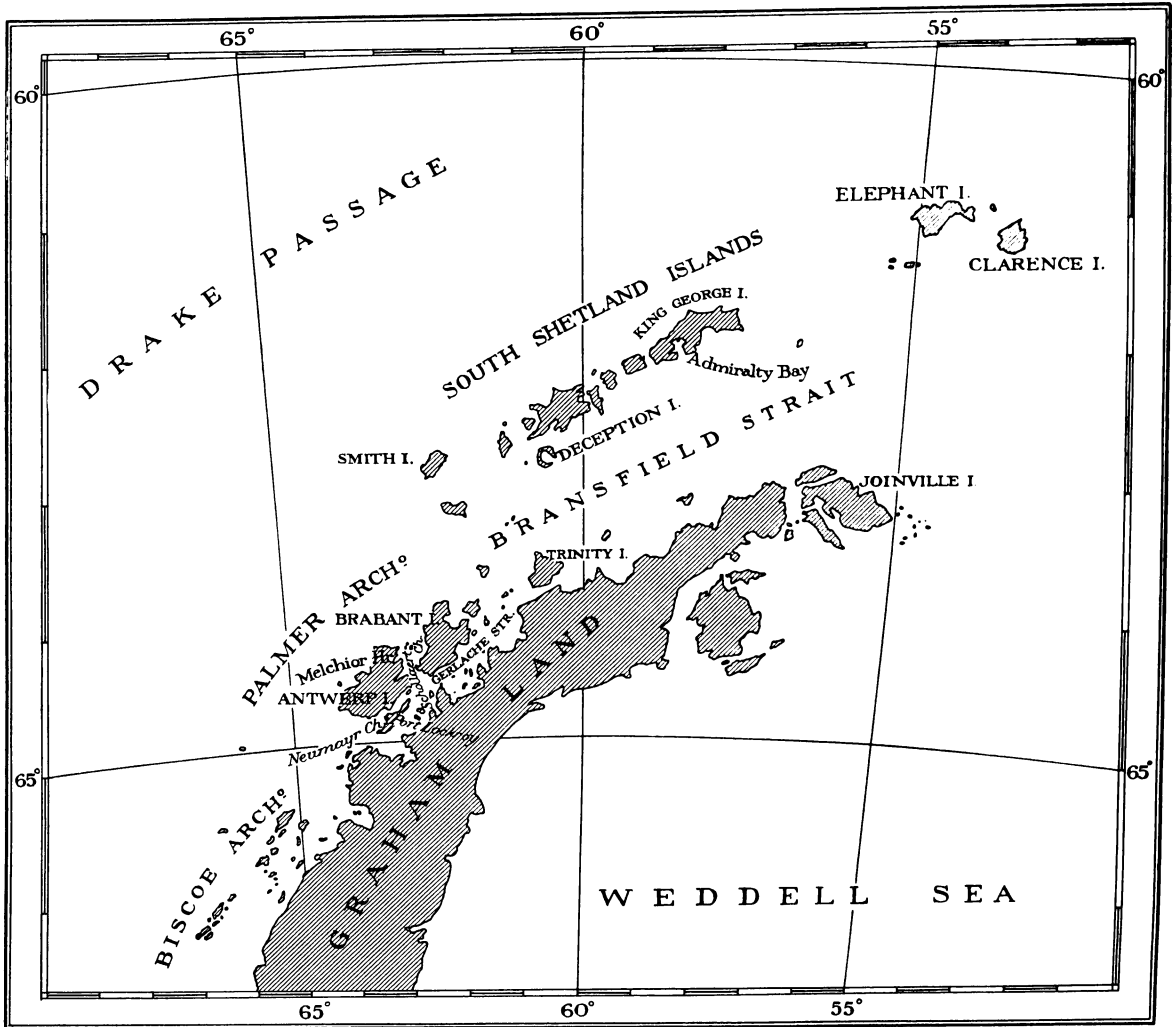


Fig. 2. The South Shetland whaling area.

pack-ice will naturally limit the movement of the factories, but it will equally limit the movements of the whales; for while whales—Blue whales in particular—often concentrate along its margin, they will not penetrate it unless sufficiently open to permit the passage of a vessel.<sup>1</sup>

<sup>1</sup> Captain Jørgen Øre, a veteran among South Shetland whalers, has told us that at the beginning of season 1914-15 he met impenetrable pack-ice, of extreme thickness and with many included icebergs, far to the north of the islands. He sent his catchers long distances afiel to look for an opening; but they could find none, and for some time he worked along the ice-edge, taking Blue whales in good numbers. Then one day the whales vanished: he realized at once that a passage to the south must have opened, and next day he found a way through to Bransfield Strait.



Difficulties have been met with in interpreting some of the forms. Sometimes they have not been filled in with sufficient care, and sometimes, especially in those from the South Shetlands, the gunners have used place-names of their own which are not to be found on any chart. For one reason or another we have had to reject numerous forms as unintelligible, with the result that the number of positions recorded for any season is much below the total number of whales actually killed.

In working up the data the positions were in the first place plotted, with due allowance for magnetic variation, on large-scale charts, separate sheets being used for Fin and Blue whales and for each month of the season. These charts were then divided up into squares of convenient size and the number of whales killed in each square was counted. For the South Georgia grounds the area of each square was a quarter degree of latitude and half a degree of longitude ( $15 \times 17.4$  miles = 261 sq. miles). In the South Shetland area, which is much larger, each square was half a degree of latitude and a whole degree of longitude ( $30 \times 27.6$  miles = 828 sq. miles). Contours have been drawn<sup>1</sup> on the assumption that the number of whales in any one square was concentrated at its centre, and it is these charts which are here reproduced on a greatly reduced scale.<sup>2</sup> By this method it is easy to prepare charts which will represent the total monthly captures throughout the series of seasons, or, indeed, to summarize the whole of the records for one species on a single chart. Such combined charts may show interesting features, but the variation from one season to another is sometimes so great at South Georgia that monthly totals cannot be employed to advantage.

Owing to an error in the original instructions Blue whales were not distinguished from Fin whales in the South Georgia returns for the first half of season 1922-3. The records for this season have therefore been omitted, the data covering eight seasons, from 1923-4 to 1930-1 inclusive. For this period we have been able to chart 29,266 positions, and of these 16,005 relate to Fin whales and 13,261 to Blue whales. The numbers for each month are shown in Tables I and II, with the totals for each season and the total number taken in each season by the combined South Georgia companies.

Data are available from the South Shetlands since 1922-3, but in recent years the returns are not satisfactory owing to the new methods which the whalers have adopted. Prior to 1927-8 the factories were moored throughout the season in one or other of the harbours situated in the South Shetlands and Palmer Archipelago. If the fleet encountered heavy pack-ice when approaching the islands in the spring, it often worked for a short time along the ice-edge in the neighbourhood, moving into Bransfield Strait, and to Admiralty Bay or Deception Island, as soon as the ice permitted. In 1927-8, however, more ambitious pelagic operations began, and on an increasingly large scale.

<sup>1</sup> Charts for individual seasons are contoured by tens up to fifty; those for monthly totals over the whole series of seasons by twenties up to one hundred; those for grand totals by hundreds up to five hundred.

<sup>2</sup> Recent surveys, made during the course of the Discovery Investigations, have led to considerable revision of the coast line of South Georgia and the South Shetlands, and the alterations are incorporated in the latest Admiralty charts. The work of plotting the data presented in this paper began before these surveys were completed; the earlier charts have thus been used and we have thought it best to reproduce these in their original form, without the recent modifications.

TABLE I

*Numbers of Fin whales on the South Georgia grounds with recorded positions of capture*

	1923-4	1924-5	1925-6	1926-7	1927-8	1928-9	1929-30	1930-1
September	—	24	—	—	—	43	88	—
October	38	162	122	56	123	509	219	166
November	88	190	144	158	238	202	349	289
December	134	190	485	106	287	231	566	222
January	154	378	1196	202	279	766	770	231
February	116	305	1188	157	219	541	209	148
March	101	179	683	234	89	332	184	22
April	71	184	850	108	—	98	35	—
May	—	71	476	—	—	—	—	—
Total	702	1683	5144	1021	1235	2722	2420	1078
Total taken by South Georgia Stations	1375	2017	5713	1147	1357	3124	3404	1416

TABLE II

*Numbers of Blue whales on the South Georgia grounds with recorded positions of capture*

	1923-4	1924-5	1925-6	1926-7	1927-8	1928-9	1929-30	1930-1
September	—	17	31	—	—	—	—	—
October	52	197	139	260	312	52	31	188
November	143	590	75	515	662	219	97	237
December	356	730	89	813	556	282	59	236
January	205	420	188	841	272	413	93	117
February	176	377	406	492	68	60	—	50
March	39	373	397	344	17	82	32	—
April	48	309	230	48	—	15	—	—
May	—	137	74	—	—	—	—	—
Total	1019	3150	1629	3313	1887	1123	312	828
Total taken by South Georgia Stations	1926	3514	1845	3670	2125	1564	492	1084

In that year most of the factories spent the early months of the season along the ice-edge near the South Orkney and the South Sandwich Islands, returning later to Bransfield Strait, and in the two following seasons they spent still more time on the Weddell Sea ice-edge and only returned to Bransfield Strait at the end of February. These movements of the factories are reflected in the returns of positions. Since 1927-8 a very

considerable part of the catch has been made to the east, far outside the area with which this report is concerned, and though the land station at Deception remained working throughout the period, returns from the Shetland area for the first half of the season have greatly diminished. So few records of Blue whales for 1929-30 and of both species for 1930-1 are available that they are insufficient for analysis.

The figures for the South Shetland area are thus for eight seasons of Fin whales, 1922-3 to 1929-30, and for seven seasons of Blue whales, 1922-3 to 1928-9<sup>1</sup>. The total number of positions recorded is 18,571, of which 11,849 relate to Fin whales and 6722 to Blue whales. The figures are shown in Tables III and IV, together with

TABLE III

*Numbers of Fin whales on the South Shetland grounds  
with recorded positions of capture*

	1922-3	1923-4	1924-5	1925-6	1926-7	1927-8	1928-9	1929-30
November	—	—	—	—	20			
December	61	126	181	320	260	22	27	51
January	232	298	496	593	342	106	29	85
February	237	460	227	332	396	196	250	355
March	378	213	365	500	556	428	481	571
April	164	127	314	172	677	469	444	288
Total	1072	1224	1583	1917	2251	1221	1231	1350
Total taken by South Shetland factories	1985	1559	1948	2390	3442			

TABLE IV

*Numbers of Blue whales on the South Shetland grounds  
with recorded positions of capture*

	1922-3	1923-4	1924-5	1925-6	1926-7	1927-8	1928-9
October	—	—	20				
November	82	161	181	243	114	113	
December	342	495	229	588	121	189	53
January	340	325	343	318	67	62	62
February	112	91	260	85	72	46	45
March	108	34	133	95	152	83	92
April	57	—	142	490	36	31	95
May	—	—	—	—	—	—	15
Total	1041	1106	1308	1819	562	524	362
Total taken by South Shetland factories	1993	1369	1642	2157	1275		

<sup>1</sup> The Blue whale data for 1929-30 have, however, been incorporated in Plate XL.

the total numbers taken by the whaling vessels in the South Shetland area. The official returns, on which the latter are based, give only the grand totals taken by the South Shetland fleet. The areas in which the whales were taken are not discriminated, and it is thus not possible to include in these tables the total numbers taken in South Shetland waters for seasons 1927-8 and onwards.

#### DIRECTIONAL DATA

In addition to recording the positions in which whales were killed, gunners of the whale-catchers were asked to supply information on the directions in which Blue and Fin whales were seen to be travelling, and on this subject an even larger quantity of data has been collected than of that dealing with positions.

The value of the evidence obtained in this way is not easily estimated. A trained gunner can without question distinguish Blue and Fin whales accurately at a distance of several miles; but to determine the direction of movement, at least to an untrained observer, may be a matter of considerable difficulty. Blue and Fin whales normally blow three or four times in succession, and at each blow are visible at the surface for only a few seconds: they then sound and remain below water for some 10 or 15 minutes. If, as often happens, several whales are in company, they will generally rise to the surface and blow simultaneously. When whales are not plentiful it is possible to be reasonably certain that the same school is being kept under observation; but when they are abundant—and they are sometimes very abundant on Antarctic whaling grounds—the difficulties are greatly increased, so much so that one feels that even gunners with life-long experience may be at fault. On the other hand the whale-catchers can only visit a comparatively small area in the few days they are away from the whaling station or factory ship; they will presumably become acquainted with the general trend of whale movement in the area, and if this has been correctly stated in their returns the observations should have some value.

As might be expected whales are not always travelling. On reaching a locality where food is plentiful they will merely cruise in the neighbourhood, and it is to be imagined that after a full meal they will show little activity. Large numbers of whales have been entered by the gunners as not moving; but the numbers shown as moving are usually in excess and sometimes greatly in excess.

These data on whale movement are of different quality to those which record positions in which whales were killed, for the latter, though they may be rather rough approximations, are ascertained facts, while the former might be regarded merely as an expression of the gunners' opinions. If, however, it were impossible to ascertain direction of movement and the data supplied are mere guess-work, analysis of the returns should demonstrate that the observations are unreliable. As explained below, resultant directions for each month have been worked out, and since these show some measure of consistency they are included in this report. The results, none the less, show wide variation and some of them present very great difficulty in interpretation. It is not improbable that many of the reported movements are merely those of whales cruising slowly about the whaling grounds and are thus of little significance.

In recording direction of movement the whalers used the eight cardinal and sub-cardinal points of the compass, noting the numbers seen travelling in each direction. As will be understood the numbers recorded are much higher than for positions: many more whales are sighted than are killed, and movements of the same whales are doubtless recorded on several occasions. With these records, as with those for positions, a number of forms have had to be rejected as inadequate or unintelligible.

In analysing the data the total numbers for each direction and for each month of the season were found. The directions for each month were then reduced from eight to four by subtraction of those travelling in opposite directions, and thence from four to two by finding the components along two lines at right angles to one another. A resultant direction and number was then obtained by means of traverse tables. We are indebted to Sub-Lieut. R. A. B. Ardley, R.N.R., and Lt.-Cmdr. J. M. Chaplin, R.N., for their valuable assistance in obtaining these resultant values. The resultant directions are shown in Figs. 3-6 (pp. 182-3, 188-9) by means of arrows, and the length of each arrow represents the resultant number of whales travelling in this direction expressed as the percentage of the total number recorded as moving. Records with long arrows thus have greater validity than those with short arrows. Results for any one month are evidently of little value if only a small number of whales was sighted, and if the numbers travelling opposite ways are so evenly balanced that only a small percentage is found moving in the resultant direction the record will also be unimportant. We have omitted all monthly records in which the recorded number of moving whales falls below 50, and we have also omitted those in which the resultant number is less than 10 per cent. of the total number moving.

The numbers of whales for which directions were recorded are shown in Tables V-VIII. The data from South Georgia cover eight seasons, 1923-4 to 1930-1, and comprise observations on 55,210 Fin whales and 17,706 Blue whales. Those for the South Shetlands, for 53,573 Fin whales and 10,761 Blue whales, were obtained during

TABLE V

*Numbers of Fin whales on the South Georgia grounds  
with recorded direction of movement*

	1923-4	1924-5	1925-6	1926-7	1927-8	1928-9	1929-30	1930-1
September	—	64	—	—	—	109	428	—
October	147	616	267	141	373	1907	950	537
November	246	1138	325	527	946	769	1340	1133
December	305	519	1411	393	1272	897	2156	857
January	465	1105	3862	957	956	3586	3170	1037
February	472	865	4015	621	605	1823	(719)	719
March	416	505	1644	(866)	293	1204	561	80
April	230	449	1898	414	—	350	93	—
May	—	208	1249	—	—	—	—	—
Total	2281	5469	14671	3919	4445	10645	9417	4363

TABLE VI

*Numbers of Blue whales on the South Georgia grounds  
with recorded direction of movement*

	1923-4	1924-5	1925-6	1926-7	1927-8	1928-9	1929-30	1930-1
October	78	319	(130)	413	473	63	62	272
November	124	712	74	745	794	393	148	352
December	407	862	88	1380	638	505	86	431
January	267	525	182	1383	325	624	158	212
February	(170)	382	370	834	71	102	—	73
March	57	458	539	432	—	119	—	—
April	85	321	207	—	—	—	—	—
May	—	171	90	—	—	—	—	—
Total	1188	3750	1680	5187	2301	1806	454	1340

TABLE VII

*Numbers of Fin whales on the South Shetland grounds  
with recorded direction of movement*

	1922-3	1923-4	1924-5	1925-6	1926-7	1927-8	1928-9	1929-30	1930-1
November	—	—	116	—	—	—	—	—	—
December	151	490	884	1373	844	118	144	210	237
January	559	1793	2840	3756	1012	461	113	536	(252)
February	1088	2863	1140	1440	1541	1070	1309	1685	540
March	1037	932	1694	2111	2330	1754	2403	3110	562
April	(334)	417	1346	456	(1929)	1592	1734	1194	73
Total	3169	6495	8020	9136	7656	4995	5703	6735	1664

TABLE VIII

*Numbers of Blue whales on the South Shetland grounds  
with recorded direction of movement*

	1922-3	1923-4	1924-5	1925-6	1926-7	1927-8	1928-9	1929-30	1930-1
November	99	198	408	330	(143)	181	—	—	54
December	324	713	449	944	178	307	126	95	124
January	457	425	609	560	62	118	122	107	64
February	189	113	488	(92)	(54)	—	78	74	(75)
March	155	—	211	(118)	167	144	153	—	111
April	118	—	231	675	—	50	194	—	—
May	—	—	—	—	—	—	74	—	—
Total	1342	1449	2396	2719	604	800	747	276	428

the nine seasons 1922-3 to 1930-1. In these tables numbers which have yielded a resultant value of less than 10 per cent and are thus not represented graphically in Figs. 3-6 are enclosed in brackets.

## DISCUSSION OF RESULTS

### SOUTH GEORGIA WHALING GROUNDS

The whaling grounds at South Georgia are visited annually during the southern summer by both Blue and Fin whales. Seasons vary greatly: in some years Fin whales will be taken much more abundantly than Blue, in some years *vice versa*; in some years both species are plentiful and in some both are scarce. These marked fluctuations are no doubt mainly dependent on alterations in the environment, and it appears probable that the predominance of one species over another is determined, at least in some measure, by the position of the ice-edge and the temperature of the water. Interesting evidence bearing on this point has recently been published by Sir Sidney Harmer.<sup>1</sup>

Both species, however, have the same objective in visiting the island. They do so in order to make use of the abundant food supplies that are to be found there. And since the food of Blue and Fin whales is the same, and its presence appears to be largely determined by a system of currents which varies but little, it is to be expected that no differences will be found in the distribution of the two species on the whaling grounds. That this is true is shown by Plate XXIII, in which all recorded positions of capture over a series of eight years are incorporated. It will be seen from the charts that the two species are taken over similar areas and that there is a remarkably close agreement in the contours illustrating regions of concentration.

That the principal whaling grounds lie to the north-east of South Georgia is to be explained on hydrological grounds. It is due to the system of currents which prevails in the neighbourhood of the island. One of the currents, which comes from the Pacific, flows through Drake Passage to the south of Cape Horn, and taking a north-easterly direction passes to the west of South Georgia. As it progresses northwards it comes more and more within the influence of the westerly winds and thus tends to take a more easterly course. The second and more important current is of Weddell Sea origin. It passes round the south-eastern end of South Georgia and then sweeps in a north-westerly direction along the coast. Before, however, it reaches the northern end of the land it meets the first current and the prevailing westerly winds and is reflected backwards to take a north-easterly course. The direction of the Weddell current is thus largely due to the presence of South Georgia and to the position which the island occupies athwart the region where the two streams converge.

*Euphausia superba*, the exclusive food of Blue and Fin whales in the Antarctic, is a pelagic prawn which drifts northwards to South Georgia from higher latitudes, the

<sup>1</sup> Harmer, *Southern Whaling*, Proc. Linn. Soc. London, 1931, p. 131.

greater part coming from the Weddell area. The whaling grounds lie in the lee of South Georgia, and it is here, in the shelter of the island, that the Euphausians are able to congregate.

Turning now to the records for individual seasons, illustrated for Fin whales in Plates VII to XIV and for Blue whales in Plates XV to XXII, it will be seen at once that there is great variation in the positions of the centres of concentration. Some part of this variation is no doubt to be attributed to irregularities in the arrival of different schools of whales. It has been ascertained at the Marine Biological Station<sup>1</sup> that there is no steady flow of whales on to the whaling grounds during the course of the season; on the contrary, the whales tend to arrive in batches, usually rather closely aggregated, of one species, and often with one or other sex or with immature predominating. As some schools arrive others may be leaving, and it is probable that certain schools remain longer on the grounds than others.

But when allowance has been made for these considerations, there still remain certain obvious differences in the distribution of whales in the seasons under review, and it appears that the most significant difference is to be found in the latter half of the season. In some years, in January and February, there is a very definite movement to the south-western side of the island, while in other years no trace of this movement is to be seen. In seasons 1924-5 and 1925-6 (Plates VIII, IX, XVI, XVII) there is no trace of this southward movement in either species, both of which show in the later months a remarkably heavy concentration close inshore to the north-east of the island. In 1923-4 and 1927-8 (Plates VII, XI, XV, XIX) both species show a movement towards the south-west. In 1926-7, when Blue whales preponderated, the concentrations of this species (Plate XVIII) shift round the ends of the island in the later months, but the movement is less marked in Fin whales (Plate X). In 1928-9 the abundance of the two species was reversed: Fin whales, which were very numerous, moved to the south (Plate XII), while this movement is not clearly shown by the smaller numbers of Blue whales (Plate XX). The data for seasons 1929-30 and 1930-1 do not give conclusive results: whales were scarcer and the area covered by the catchers had greatly increased; but except for Blue whales in 1929-30 there are indications that both species tended to move to the south in February and March.

Summarizing the observations it will be seen that when either species occurs in abundance it has moved to the south-western side of the island in the latter half of the season, and that the only exceptions to this statement are the two outstanding seasons 1924-5 and 1925-6. The dense inshore concentrations in these two seasons are perhaps to be explained in terms of hydrology and plankton; but unfortunately the research ships began their work at the end of the 1925-6 season and full surveys of the conditions on the South Georgia whaling grounds only date from 1926-7.

Sir Sidney Harmer, in his valuable account of "Southern Whaling",<sup>2</sup> has shown that

<sup>1</sup> Mackintosh and Wheeler, *Southern Blue and Fin Whales*, Discovery Reports, 1, pp. 458-60 (1929).

<sup>2</sup> *Loc. cit.*, p. 131.



there is a definite correlation between the mean temperature of the air at South Georgia in September and the order in which Blue and Fin whales reach their maxima in the following season. With low temperatures the Blue whale reaches its maximum first and with high temperatures the Fin. Working on these data he has been able to classify the seasons into three groups, but this grouping does not agree with that based on whale movements. The two exceptional seasons as regards movement do not appear in the same groups; 1924-5, with low September temperature, falls in Group I, and 1925 with high September temperature in Group III. This lack of agreement is perhaps to have been anticipated, for the relation which Sir Sidney Harmer has discovered is between events which occur in the early part of the season and it may well be that whale movements in the latter part are due to other causes.

Another feature of interest in the South Georgia returns is the evidence of the great extension of the whaling grounds in recent years. Since whaling began in 1904 the whaling companies have made constant improvements in their whale-catchers, and with increased size and horse-power and greater speed they have been able to work farther afield.

If the South Georgia data for the eight seasons are divided into two four-year periods they yield the results shown in Plate XXIV. Results for Fin and Blue whales are charted separately, and as will be seen they show a very close correspondence. The area covered by the whale-catchers during seasons 1923-4 to 1926-7 is indicated by a fine dotted line, while that for seasons 1927-8 to 1930-1 is limited by a continuous line. The position of the main concentration in each of the four-year periods is also shown.

It will be noticed at once that in each of the species the centre of concentration has shifted some 40 or 50 miles to the east, but with the great variation between individual seasons and the comparatively short periods involved, there must be some uncertainty as to the significance of this movement. A change in the centres of concentration may clearly be brought about by a change in the position of the shoals of Euphausians on which the whales feed, and this in its turn will probably be dependent on changes in the hydrology of the area. For the later seasons some information on these subjects will be available when the surveys made by the research ships have been worked up. If, however, average conditions in the environment were comparable in the two four-year periods, it would appear that the alteration in the centres of concentration can only be explained as a response to intensive whaling: the whales have been scared and no longer venture so close to the island.

The considerable extension of the grounds during the recent four-year period, and the fact that with the same number of whale-catchers fewer whales have been taken, lends support to the generally held opinion that whales are now less abundant than formerly. The data for the two periods may be summarized as shown in Table IX.

The figures indicate heavy depletion of the stock of Fin whales and still heavier depletion of Blue whales; but in view of the short periods which are considered and the great seasonal fluctuations in abundance, they cannot be regarded as reliable and calculations derived from them can only be misleading. The greatest catch of Fin whales ever

made on the South Georgia grounds (5713) was in season 1925-6, and the greatest catch of Blue whales (3670) in 1926-7. Both these maxima fall in the first of our four-year periods. The average number of catchers is approximately the same in each period; but in the second much more time was occupied in towing whales long distances to the shore stations and in consequence less time was spent in hunting.

TABLE IX

	Total number of whales taken at South Georgia stations	Average number of catchers per season	Approximate area of whaling grounds (sq. miles)	Average number of whales killed in 100 sq. miles
Fin whales				
1923-4 to 1926-7	10,252	24.75	27,500	37.3
1927-8 to 1930-1	9,301	25	50,500	18.4
Blue whales				
1923-4 to 1926-7	10,955	24.75	25,000	43.8
1927-8 to 1930-1	5,265	25	41,000	12.8

The results cannot be interpreted as giving more than a strong suggestion that there has been a large reduction in the stock, and the indication is that Blue whales have suffered more heavily than Fin. It is perhaps significant that the great development of pelagic whaling along the Weddell Sea ice-edge falls within the second four-year period and that in this area the incidence of capture falls more heavily on Blue whales.

The figures in the last column of Table IX give only the average density of whales killed on the South Georgia grounds. It will be evident that they were taken in much greater numbers in the centres of concentration and in much smaller numbers on the fringe of the whaling grounds. The greatest concentration during the eight seasons was of Fin whales in 1925-6. In April alone of this season 92 Fin whales per 100 square miles were killed a short distance from the mouth of Cumberland Bay, and in the same area the catches for the whole season amount to 2.8 Fin whales per square mile of whaling ground.

Inspection of the charts for the different seasons gives the impression that the whales generally pass across the grounds in an easterly direction. The first whales of the season are usually taken to the north or north-west of the island. As they increase in number their centres of concentration shift to the east and later, in most seasons, they move towards the southern side of the island. At the end of the season there is considerable variation in position, but the tendency is for whales to occur in the south-east. In some of the charts (Fin whales, 1928-9, Plate XII, affords the best example) the disappearance of a school in the early part of the season and its replacement by later arrivals can be traced.

The impression of a general movement towards the east is borne out in some measure by examination of the directional data, which are summarized, in the manner already explained (p. 175), in Figs. 3 and 4. If the monthly records of direction shown in these figures are resolved into their components along the four cardinal points of the compass the results are as shown in Table X.

TABLE X

	Number of monthly records	Components			
		North	East	South	West
Fin whales					
Number	57	39	43	18	14
Percentage		34	37½	16	12½
Blue whales					
Number	47	21	43	26	4
Percentage		22	46	28	4

It will be seen that in each species the highest number of components is in an easterly direction. In Fin whales there is also a strong northerly component, whereas in Blue whales the southerly component is more pronounced than the northerly.

In all the data hitherto discussed a very close correspondence has been found between the two species of whale. They concentrate in the same areas, and their movements in any season, as determined from monthly records of capture, are usually very much the same. But in these directional data differences between the two species are apparent. The most noteworthy difference is in the records for the earlier months of the season, in which Fin whales were observed to be moving towards the north, while Blue whales were moving east. In this respect the records for both species show a marked degree of consistency.

For this unexpected result we are not able to offer any satisfactory explanation. It might be thought that movements at the beginning of the season would afford an indication of the direction from which whale stocks arrive on the South Georgia grounds. The general inference from other data would be that they arrive from the west, and the strong easterly movement of Blue whales in the early months is in agreement. But it is very difficult to believe that Fin whales arrive from the south. The majority of them have almost certainly passed the winter in warmer waters to the north. If they reach South Georgia from the south, they must first have visited the South Orkney Islands: it seems most improbable that they would take so circuitous a route, and if they had done so we should expect to find that the whalers killed them on the south side of the island at the beginning of the season. The strange difference in recorded movement between the two species is thus unexplained, and it appears probable that the direction from which the schools arrive on the whaling grounds is not to be ascertained from these records.

## DISCOVERY REPORTS

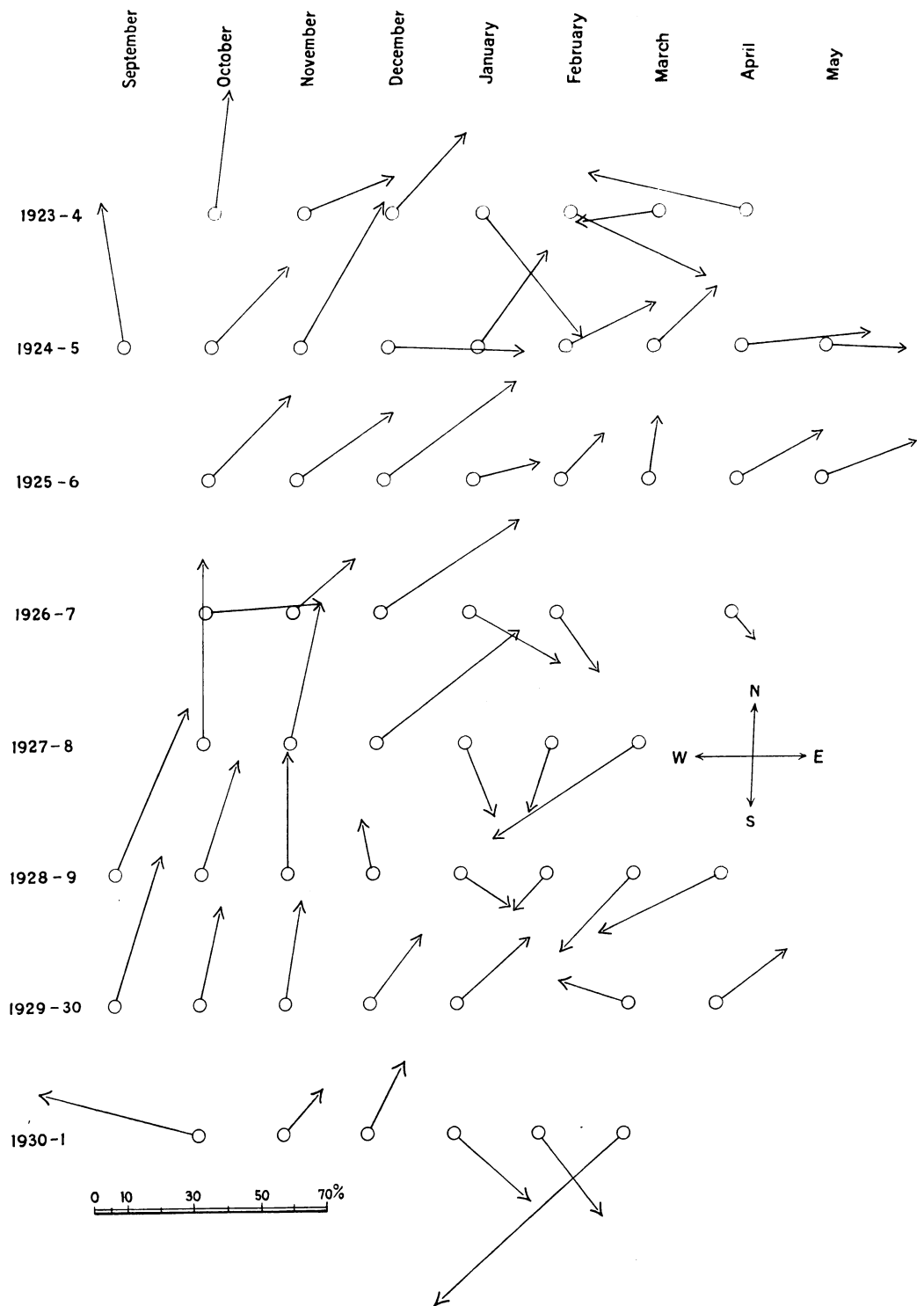


Fig. 3. Recorded movements of Fin whales on the South Georgia grounds. The direction of each arrow is the resultant direction of observed whale movements; the length of the arrow indicates, as shown in the scale, the resultant number moving in this direction, expressed as the percentage of the total.

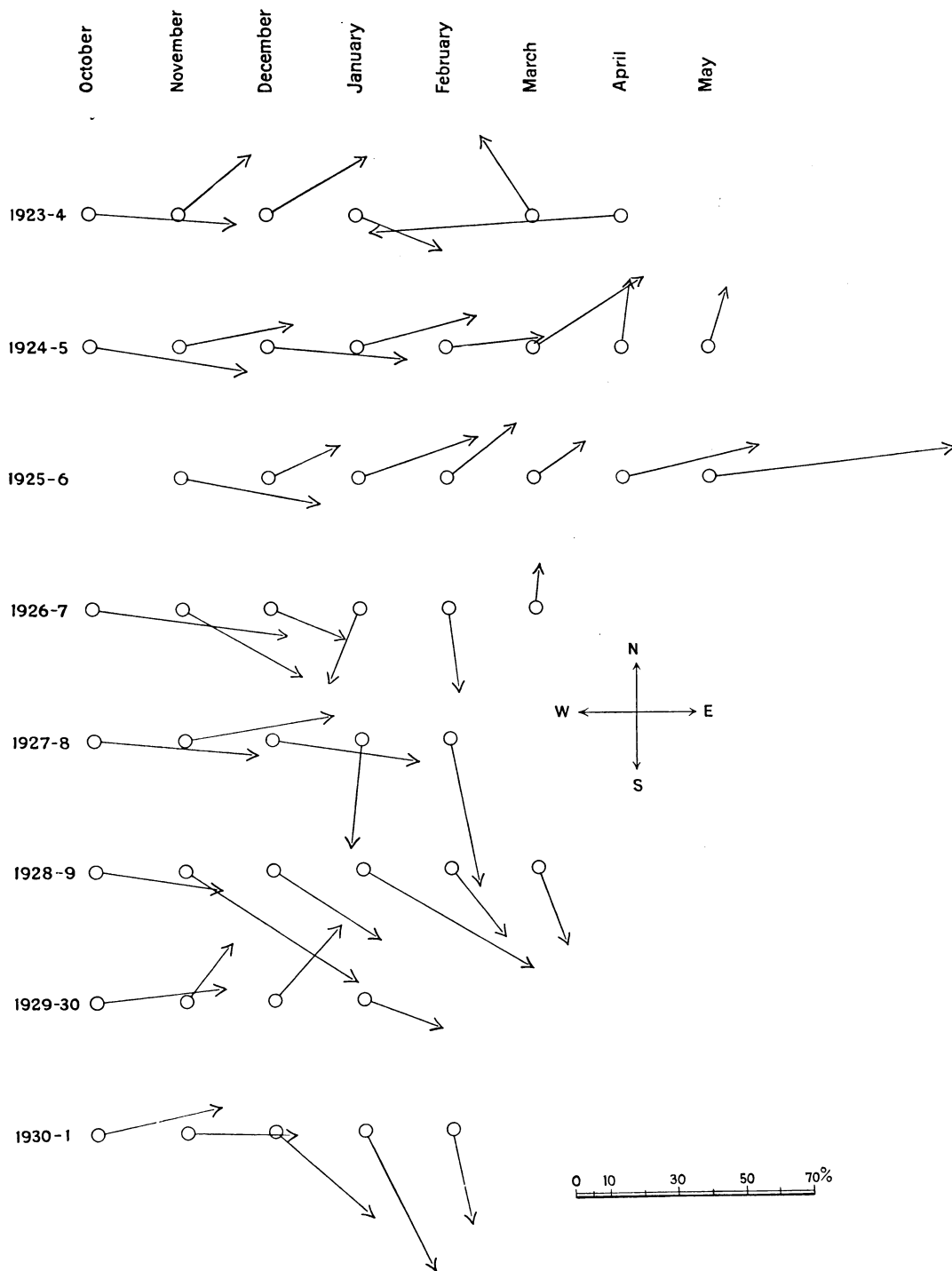


Fig. 4. Recorded movements of Blue whales on the South Georgia grounds. The direction of each arrow is the resultant direction of observed whale movements; the length of the arrow indicates, as shown in the scale, the resultant number moving in this direction, expressed as the percentage of the total.

DISCOVERY REPORTS

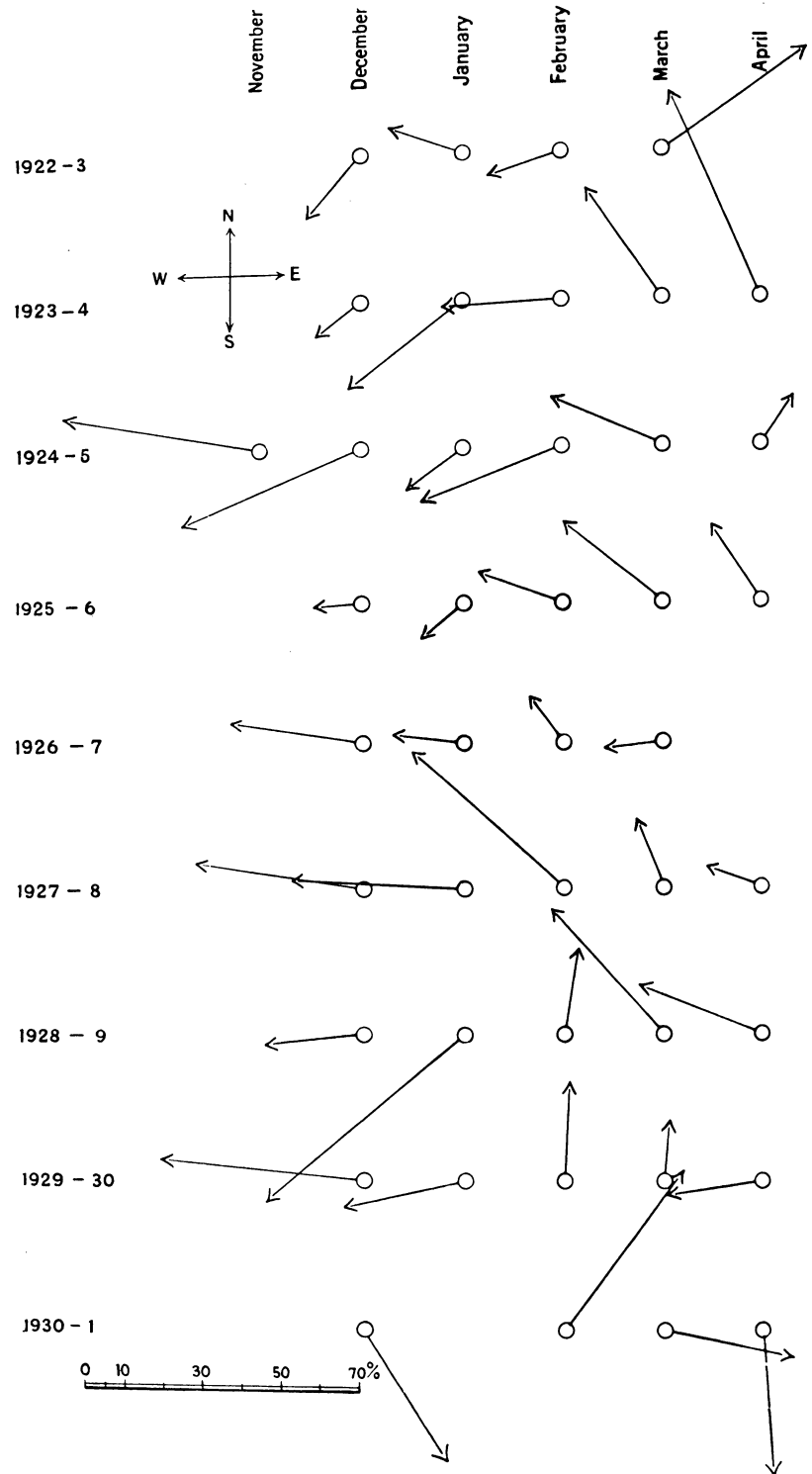


Fig. 5. Recorded movements of Fin whales on the South Shetland grounds. The direction of each arrow is the resultant direction of observed whale movements; the length of the arrow indicates, as shown in the scale, the resultant number moving in this direction, expressed as the percentage of the total.

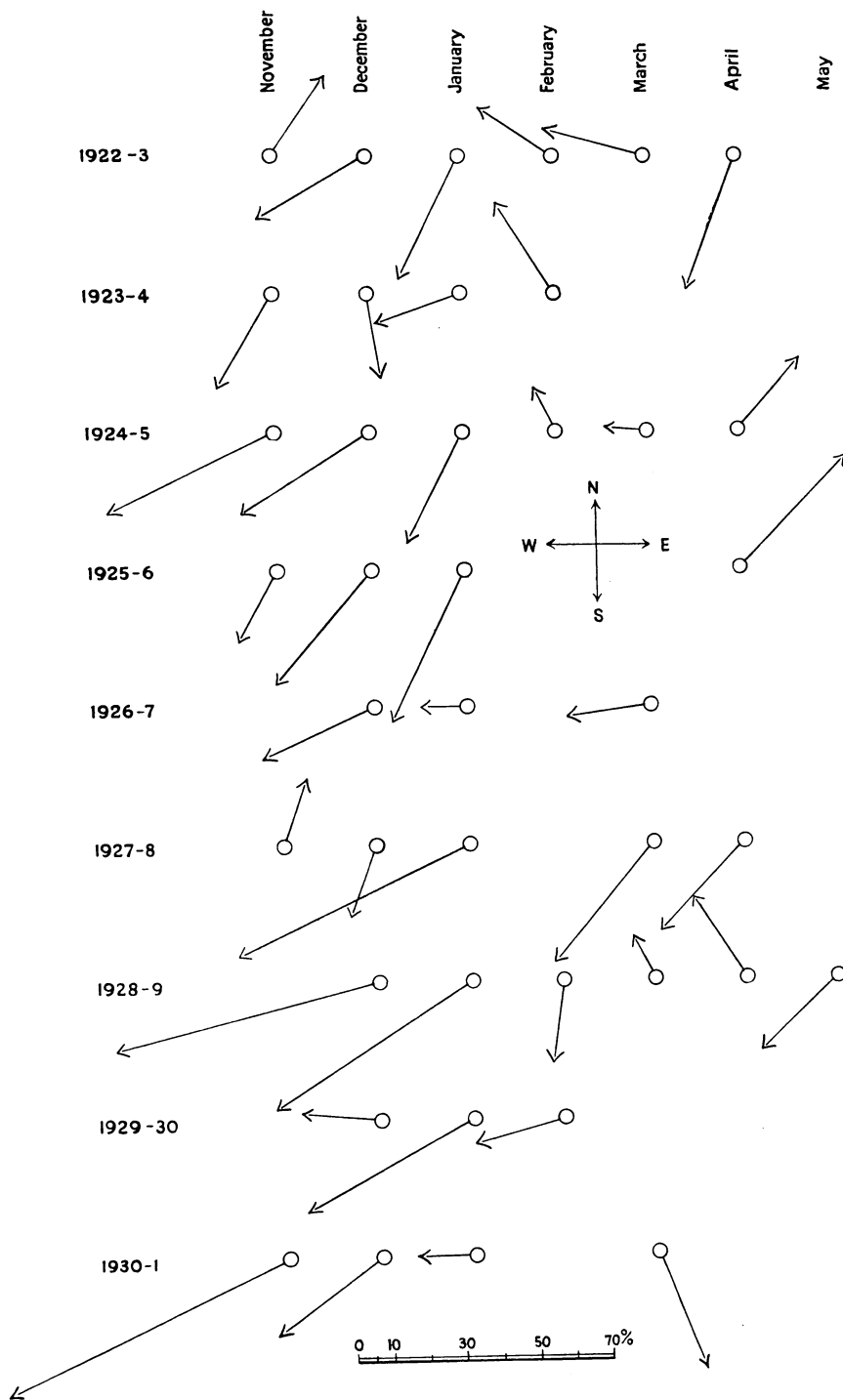


Fig. 6. Recorded movements of Blue whales on the South Shetland grounds. The direction of each arrow is the resultant direction of observed whale movements; the length of the arrow indicates, as shown in the scale, the resultant number moving in this direction, expressed as the percentage of the total.

TABLE XI

	Number of monthly records	Components			
		North	East	South	West
Fin whales					
November to January	18	7	1	11	17
Number		19	3	31	47
Percentage					
February to April	25	18	8	7	17
Number		36	16	14	34
Percentage					
Blue whales					
November to January	24	3	3	19	21
Number		6½	6½	41	46
Percentage					
February to May	17	9	3	8	14
Number		26½	9	23½	41
Percentage					

If, in the middle of the season, some schools of whales were still moving south, while others had commenced their return journey, we should expect the resultant values during this period to be low, for the movements in opposite directions will partially or wholly cancel one another. This is seen with some clearness in the Blue whale data for 1924-5 and 1925-6 (Fig. 6) and also in some other seasons, but with subsequent directions which do not accord with our theory of movement.

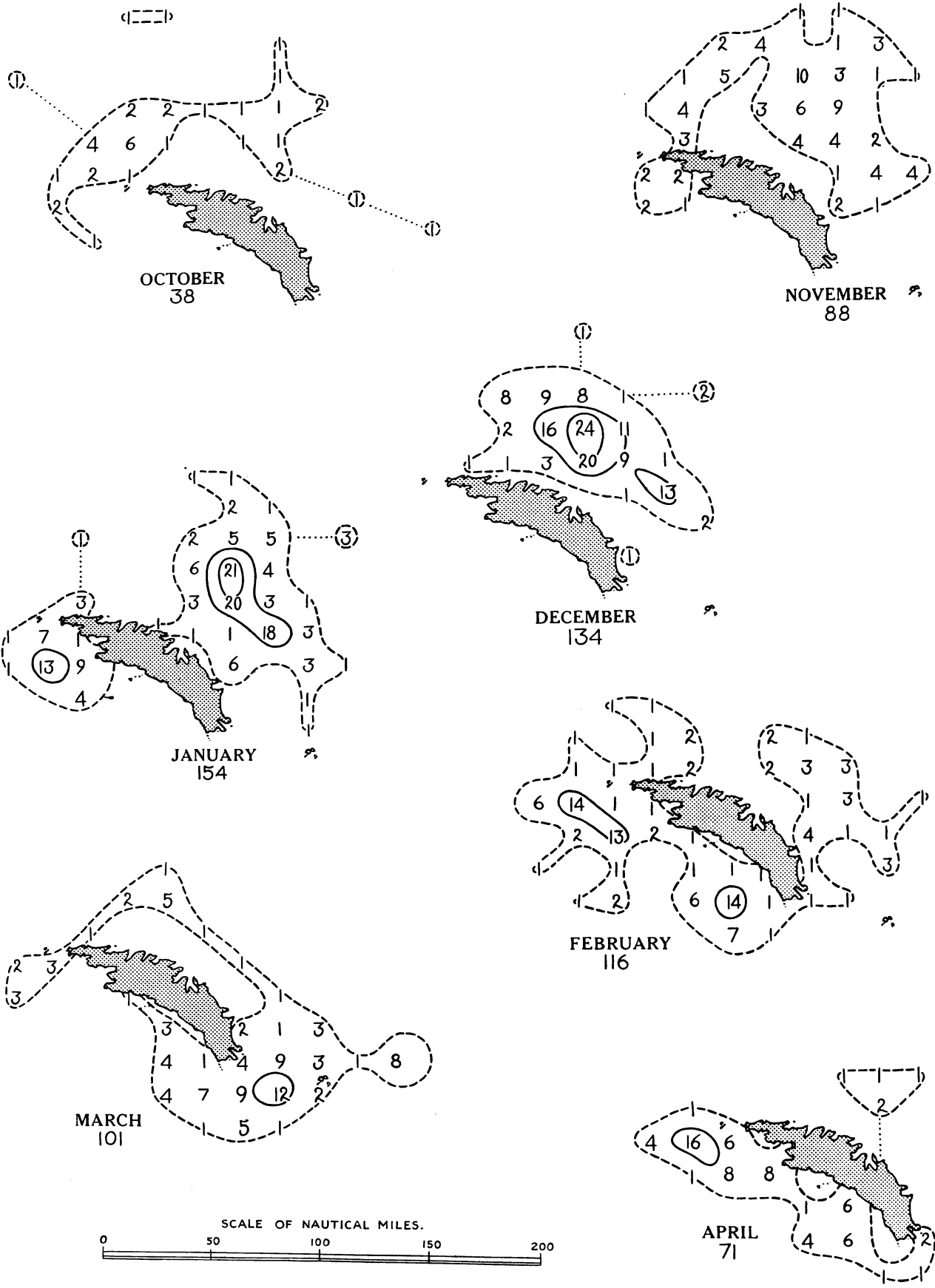
The data for the first half of the season are more consistent than those for the latter half. They indicate that, in general, Blue whales were moving south-westerly, whereas in Fin whales the direction is more westerly, with the southerly component less strongly marked. Similar but more striking directional differences between the two species were found in the early part of the season at South Georgia, and in neither locality is it possible to suggest an explanation.

In the present state of our knowledge little help is to be derived from these data. While they give no clear support to the theory of movement based on the charts of distribution, they do not point to the probability of any different theory. They tend rather to imply that whale movements in the South Shetland area are haphazard and irregular and that no ordered principle of migration is to be discovered; and we think this conclusion most improbable.

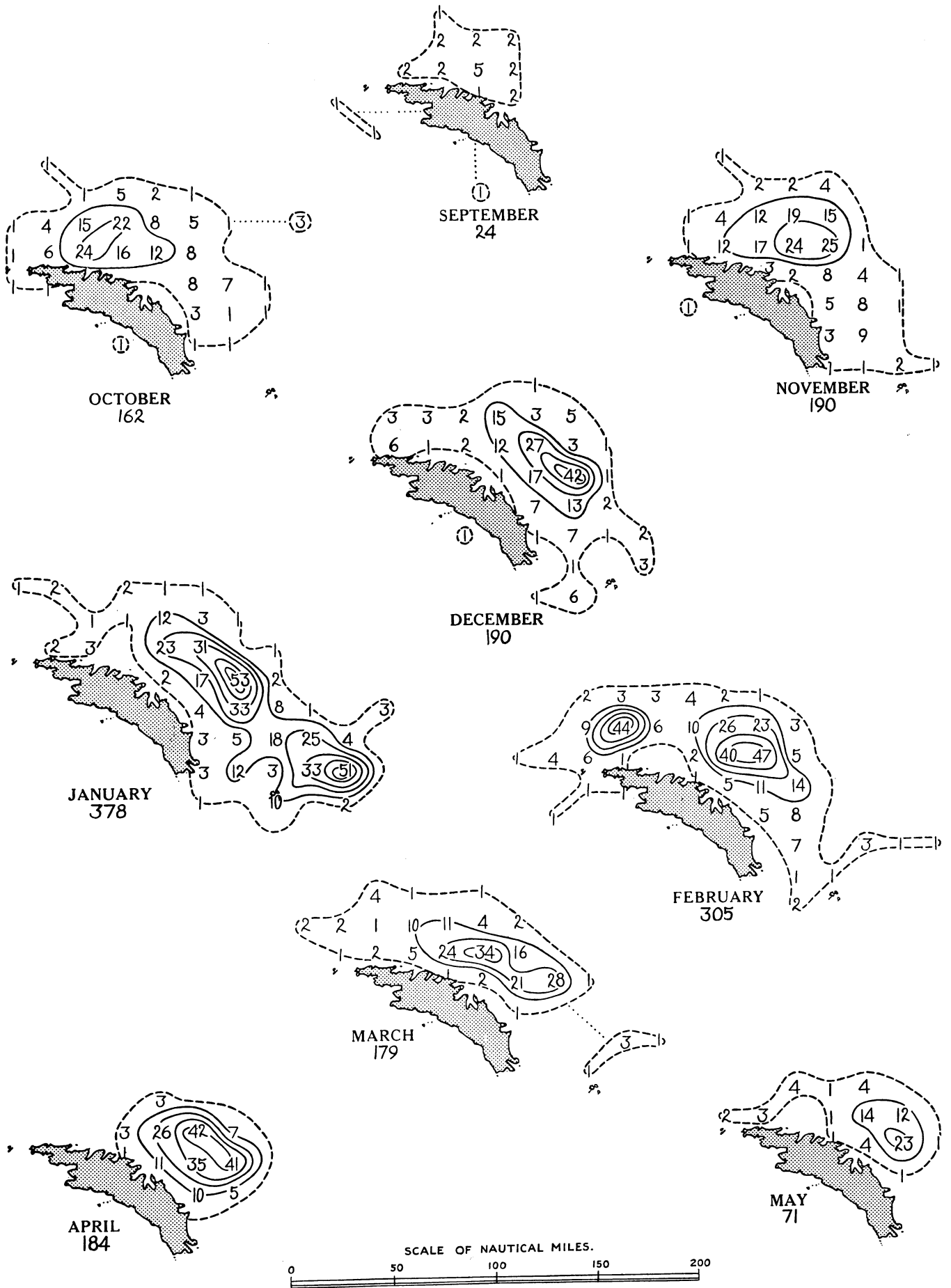




DISCOVERY REPORTS, VOL. VI

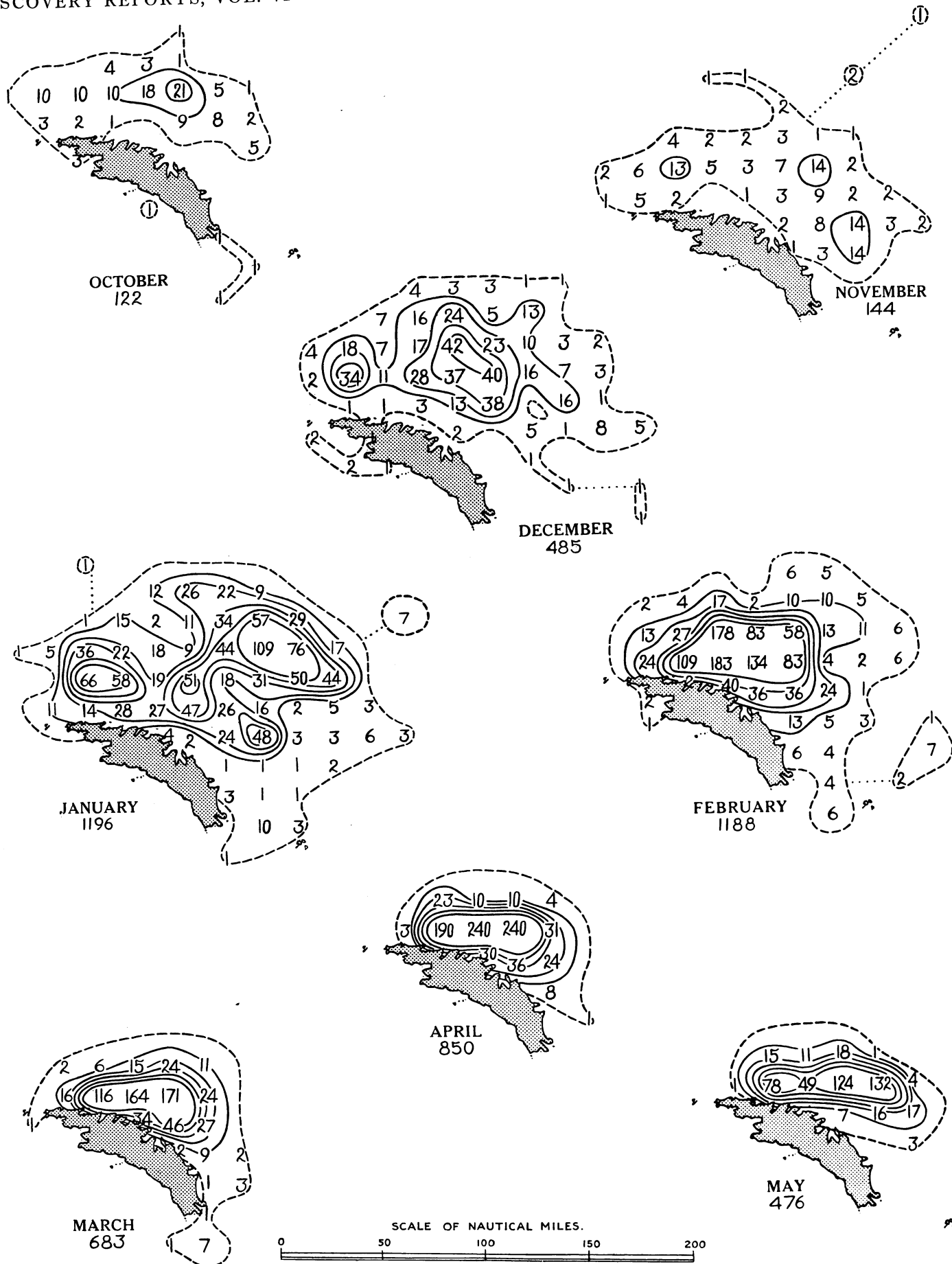


Distribution of Fin whales taken on the South Georgia grounds in season 1923-4

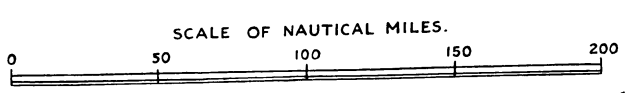
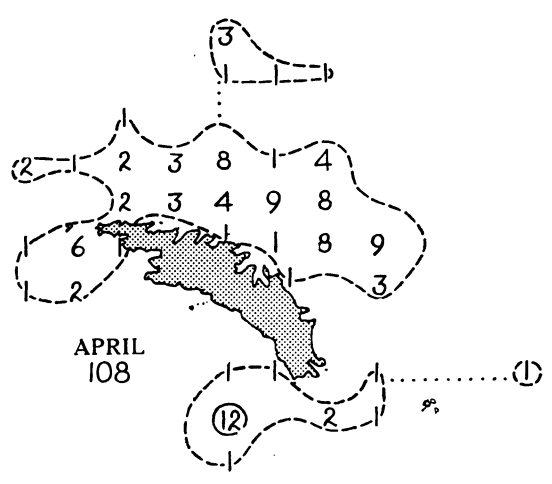
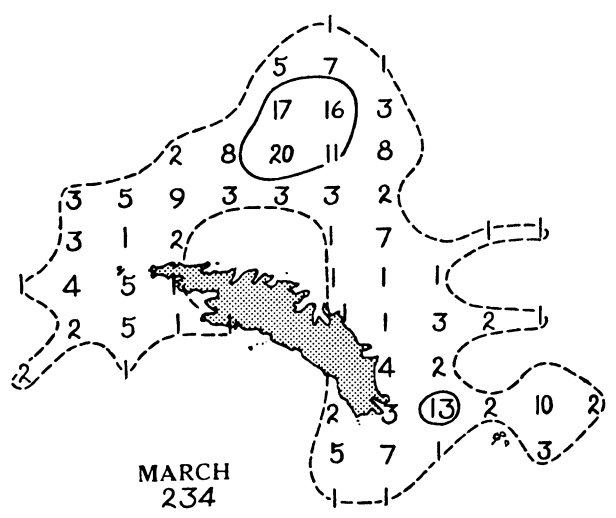
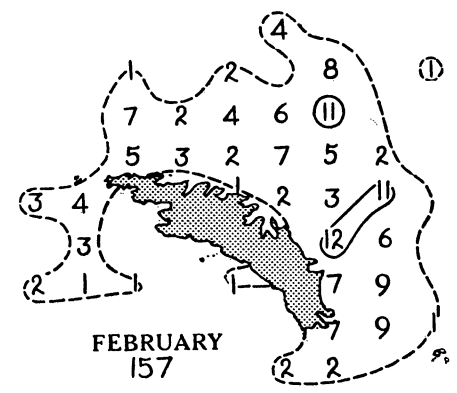
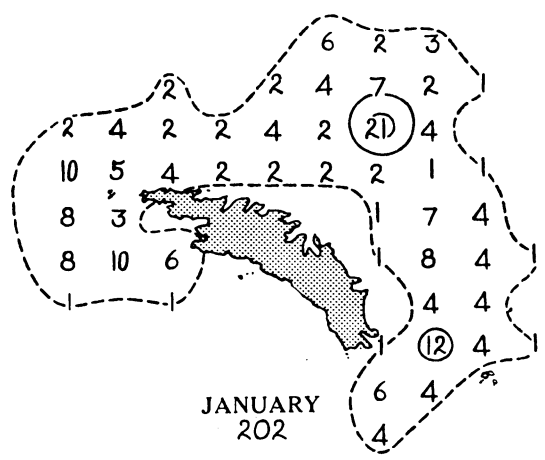
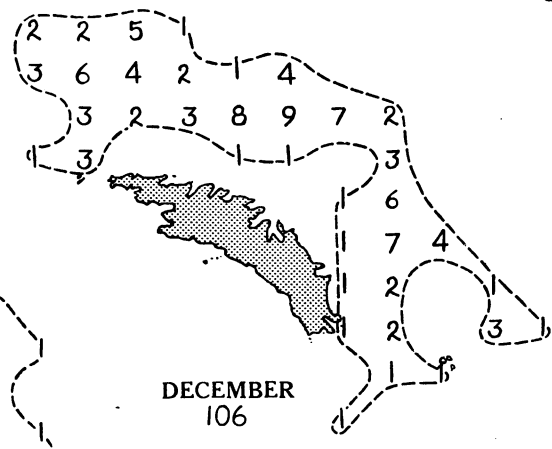
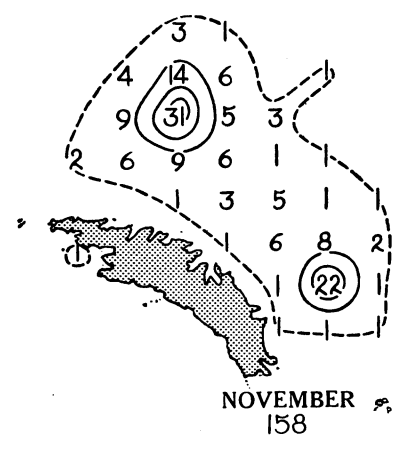
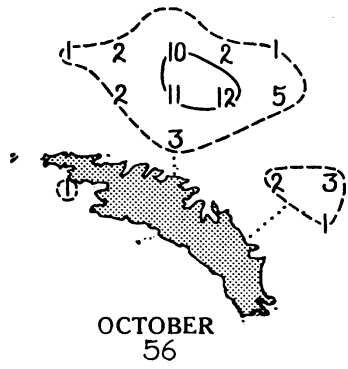


Distribution of Fin whales taken on the South Georgia grounds in season 1924-5

DISCOVERY REPORTS, VOL. VI

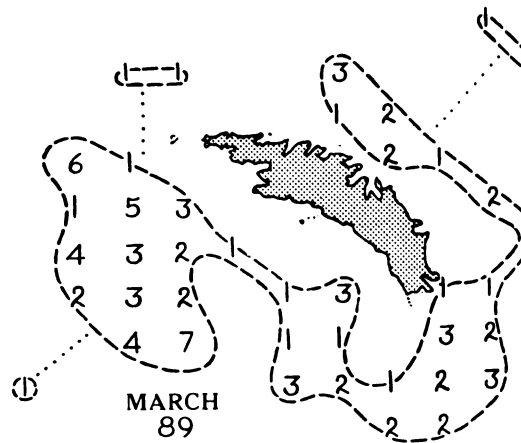
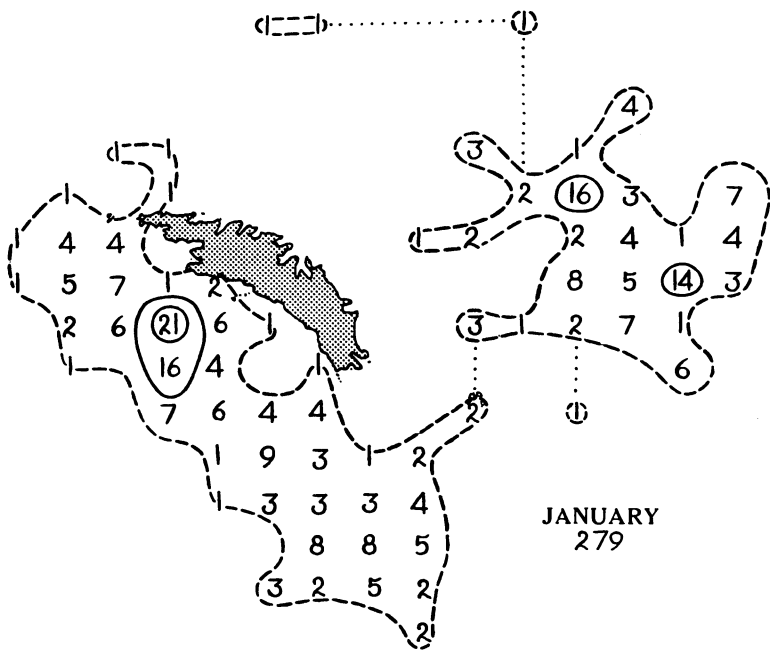
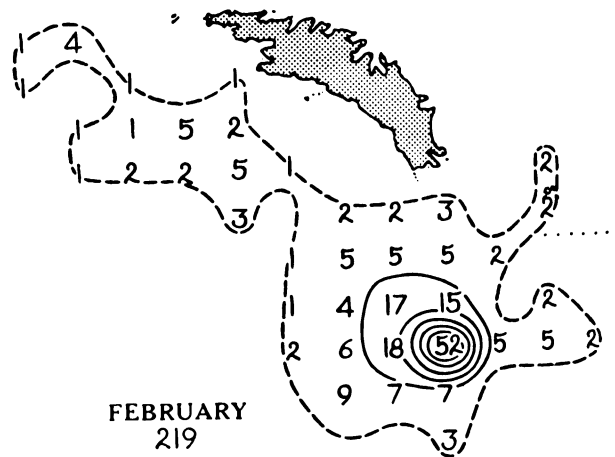
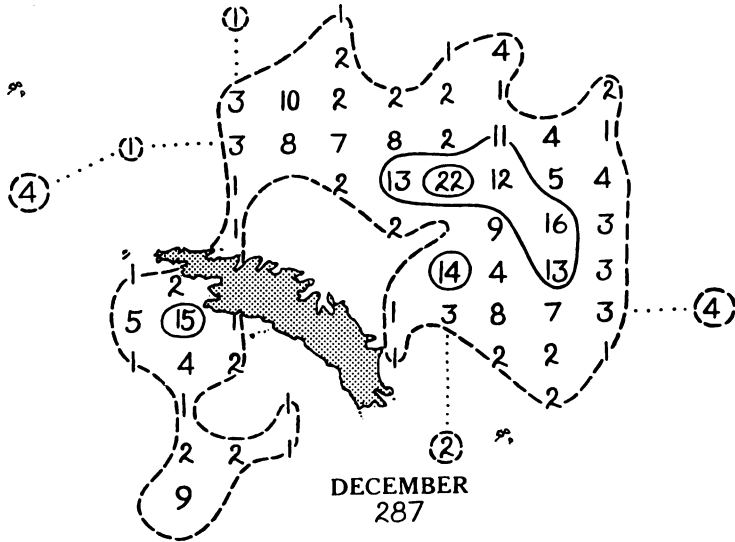
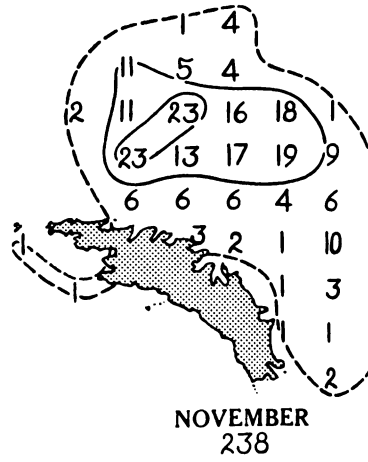
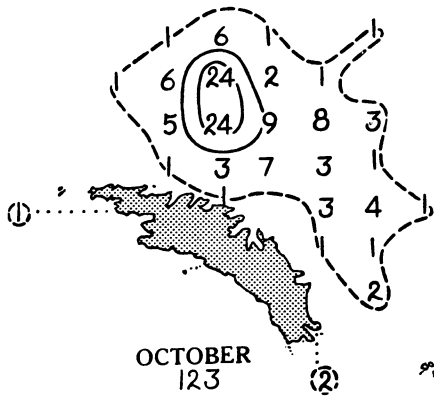


Distribution of Fin whales taken on the South Georgia grounds in season 1925-6

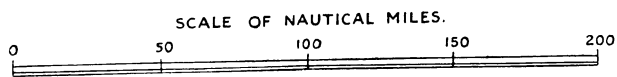
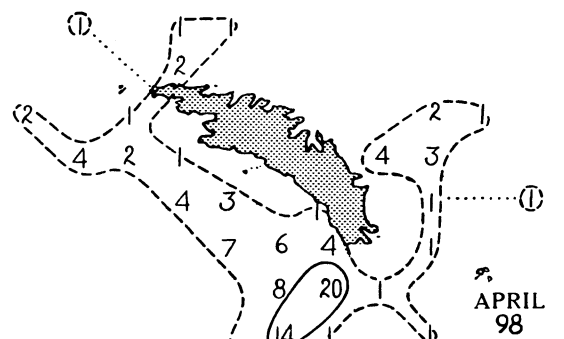
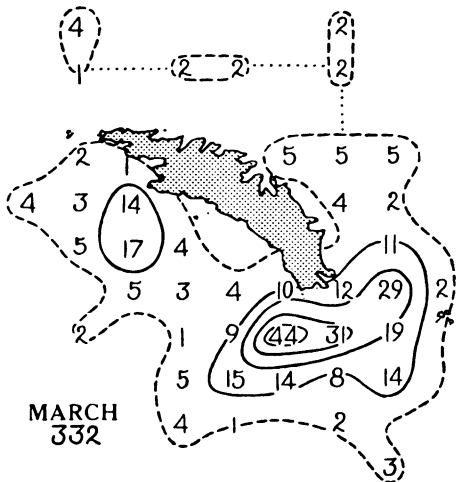
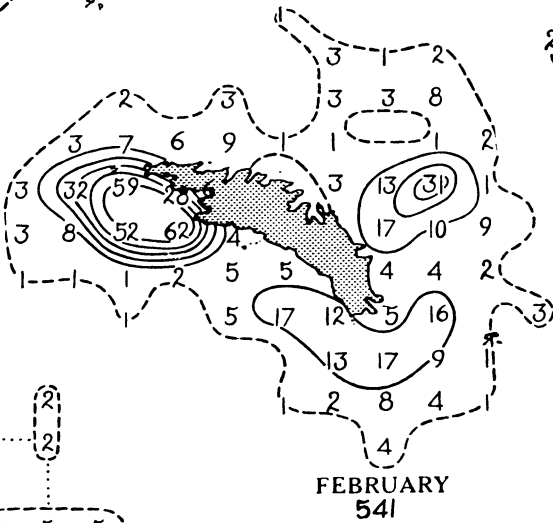
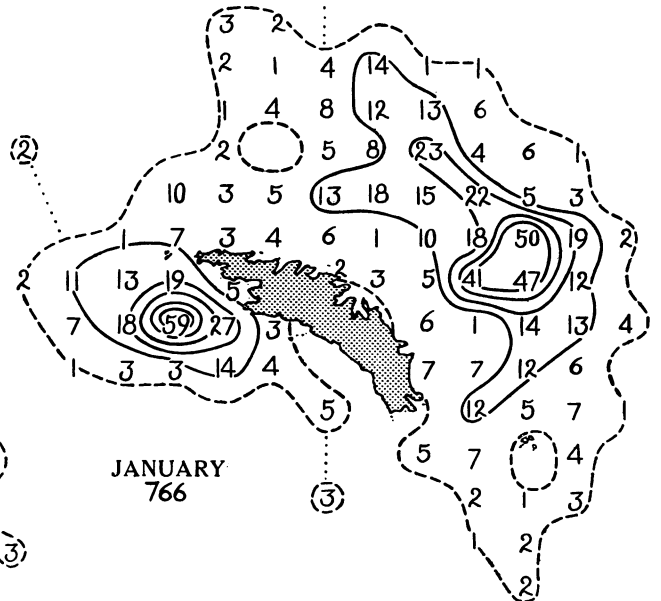
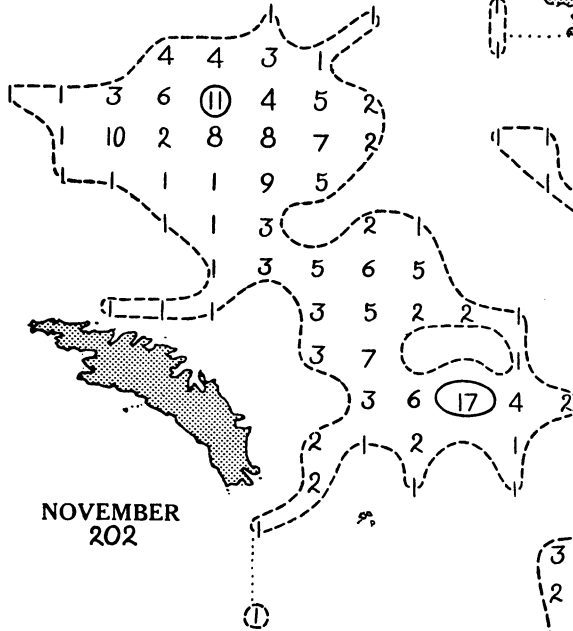
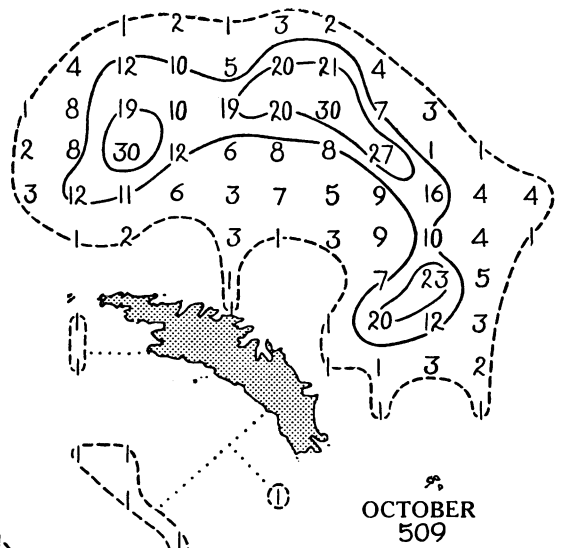
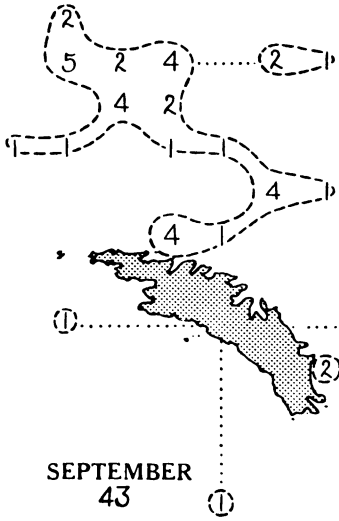


Distribution of Fin whales taken on the South Georgia grounds in season 1926-7

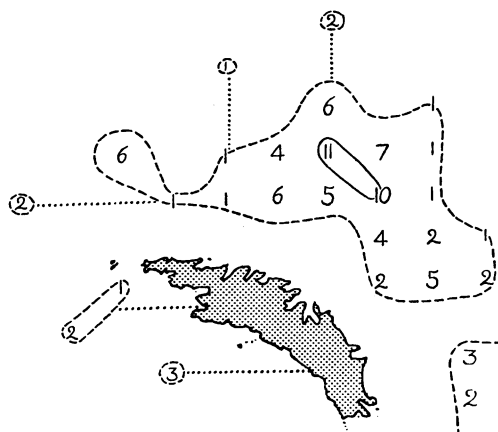
DISCOVERY REPORTS, VOL. VI



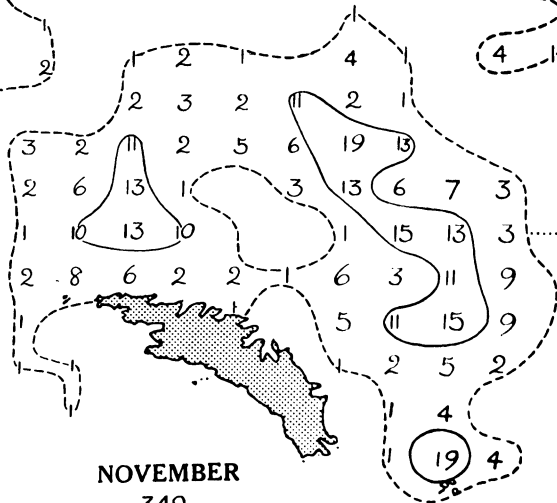
Distribution of Fin whales taken on the South Georgia grounds in season 1927-8



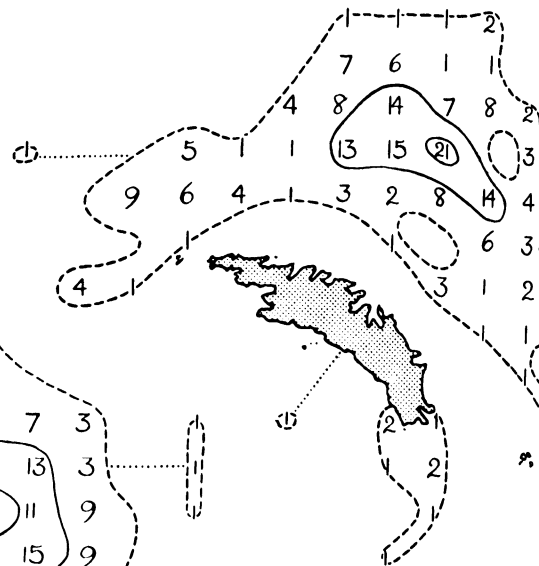
Distribution of Fin whales taken on the South Georgia grounds in season 1928-9



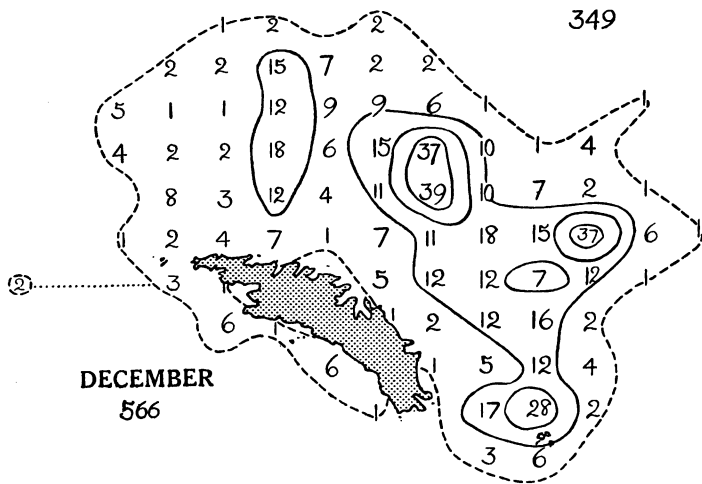
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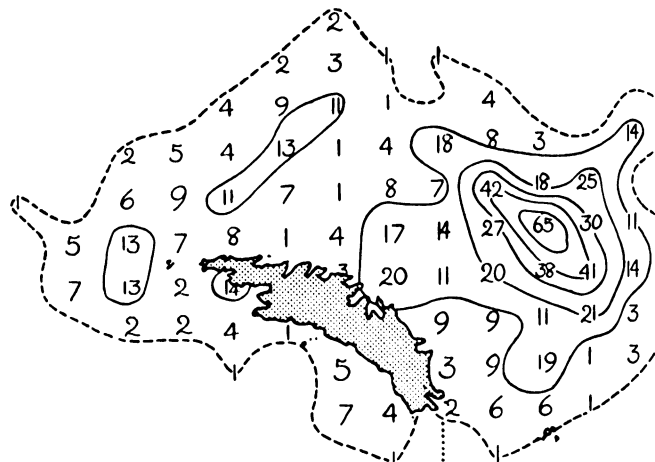
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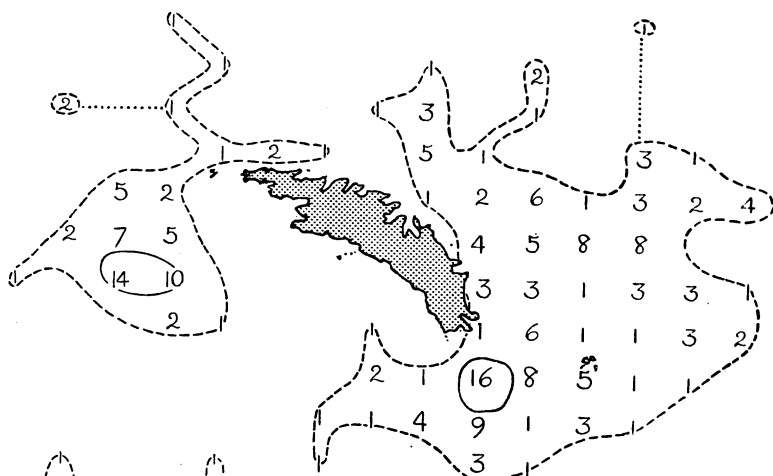
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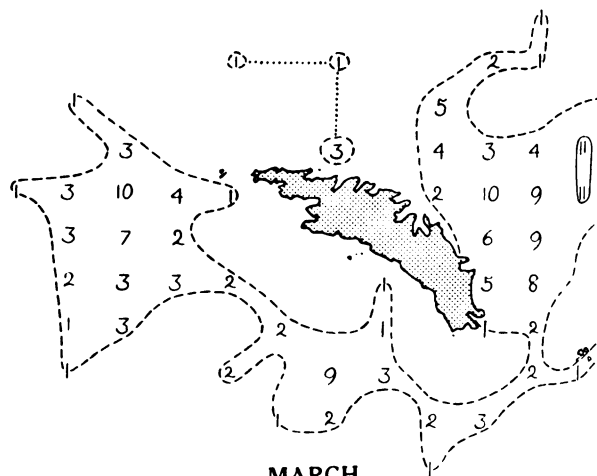
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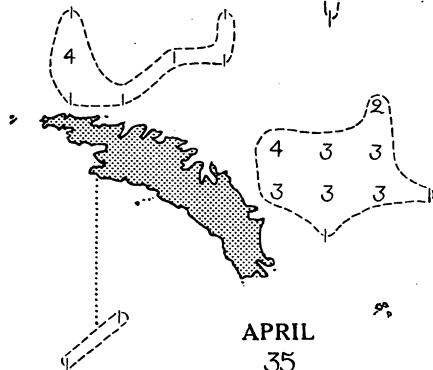
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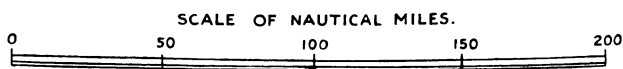
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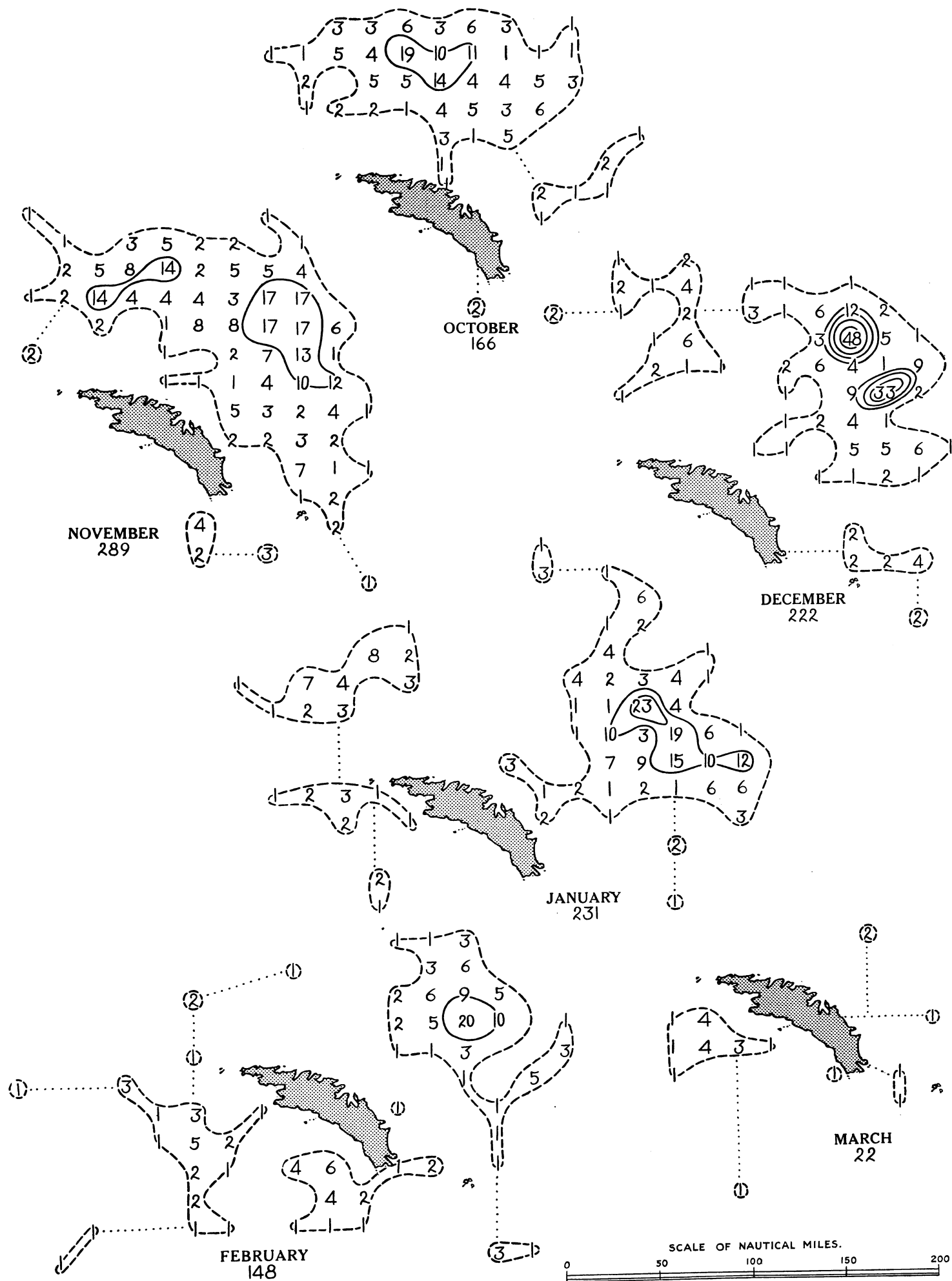


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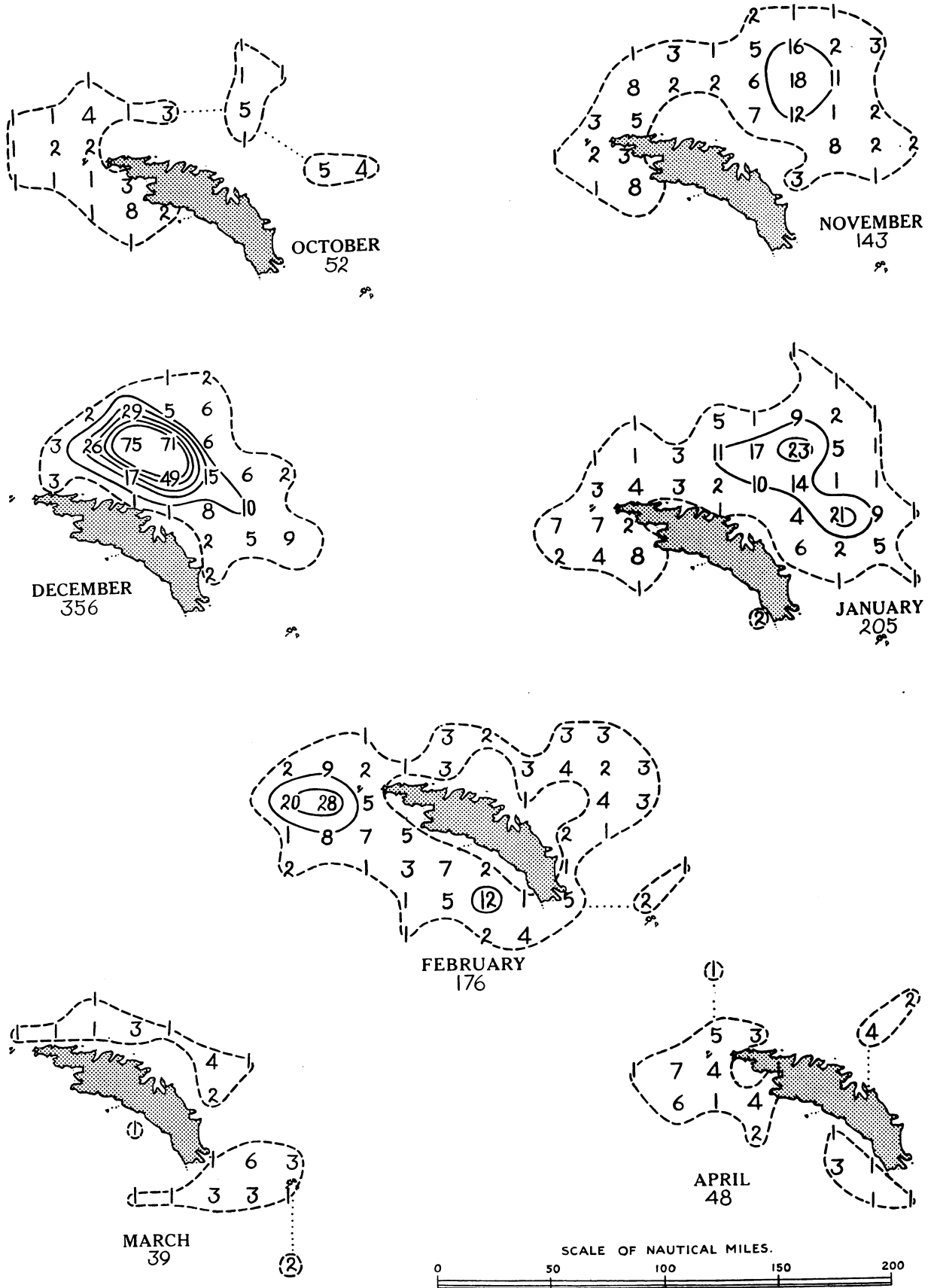


Distribution of Fin whales taken on the South Georgia grounds in season 1929-30

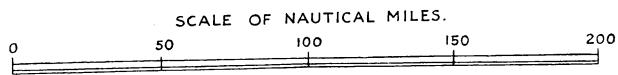
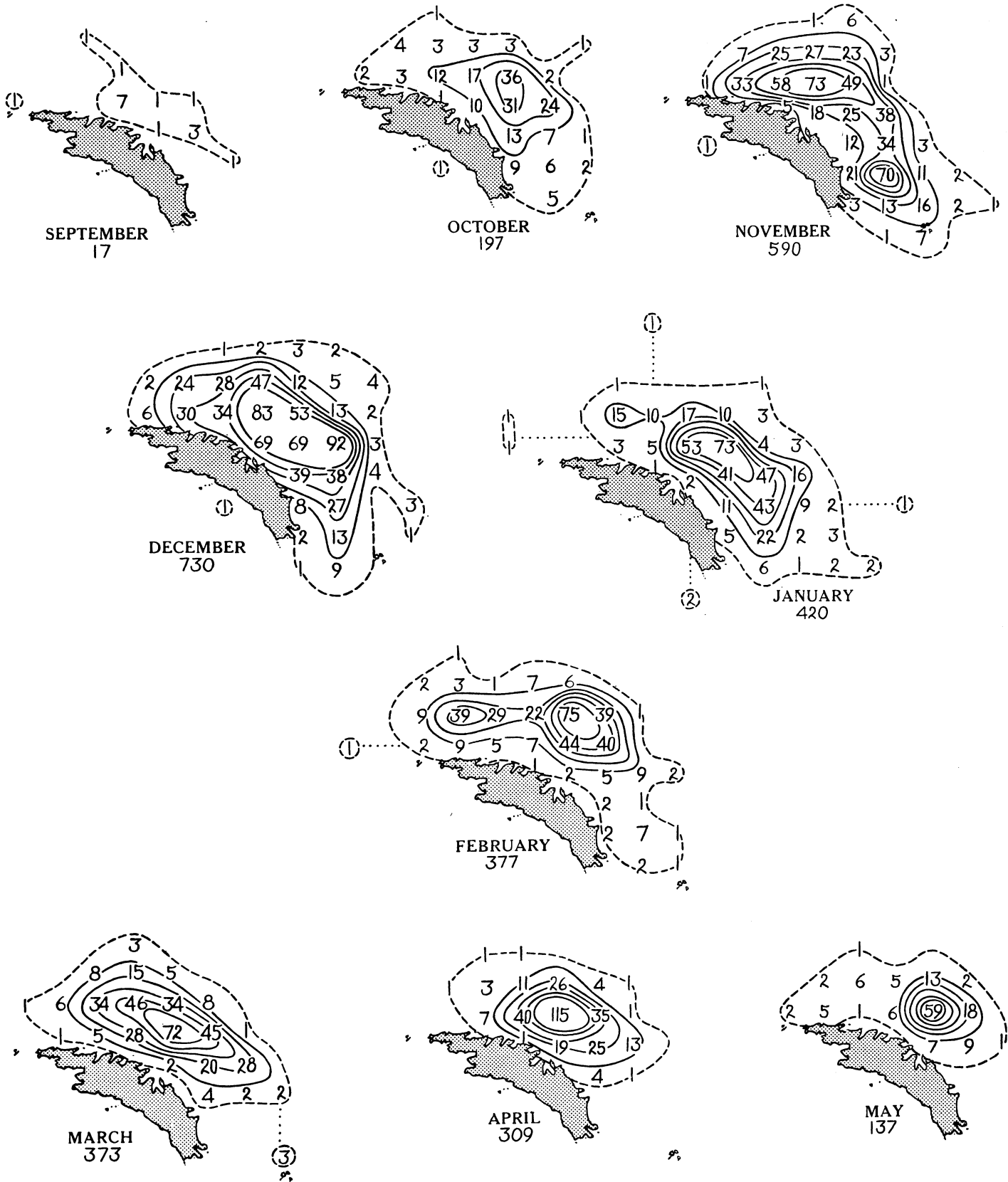




Distribution of Fin whales taken on the South Georgia grounds in season 1930-1

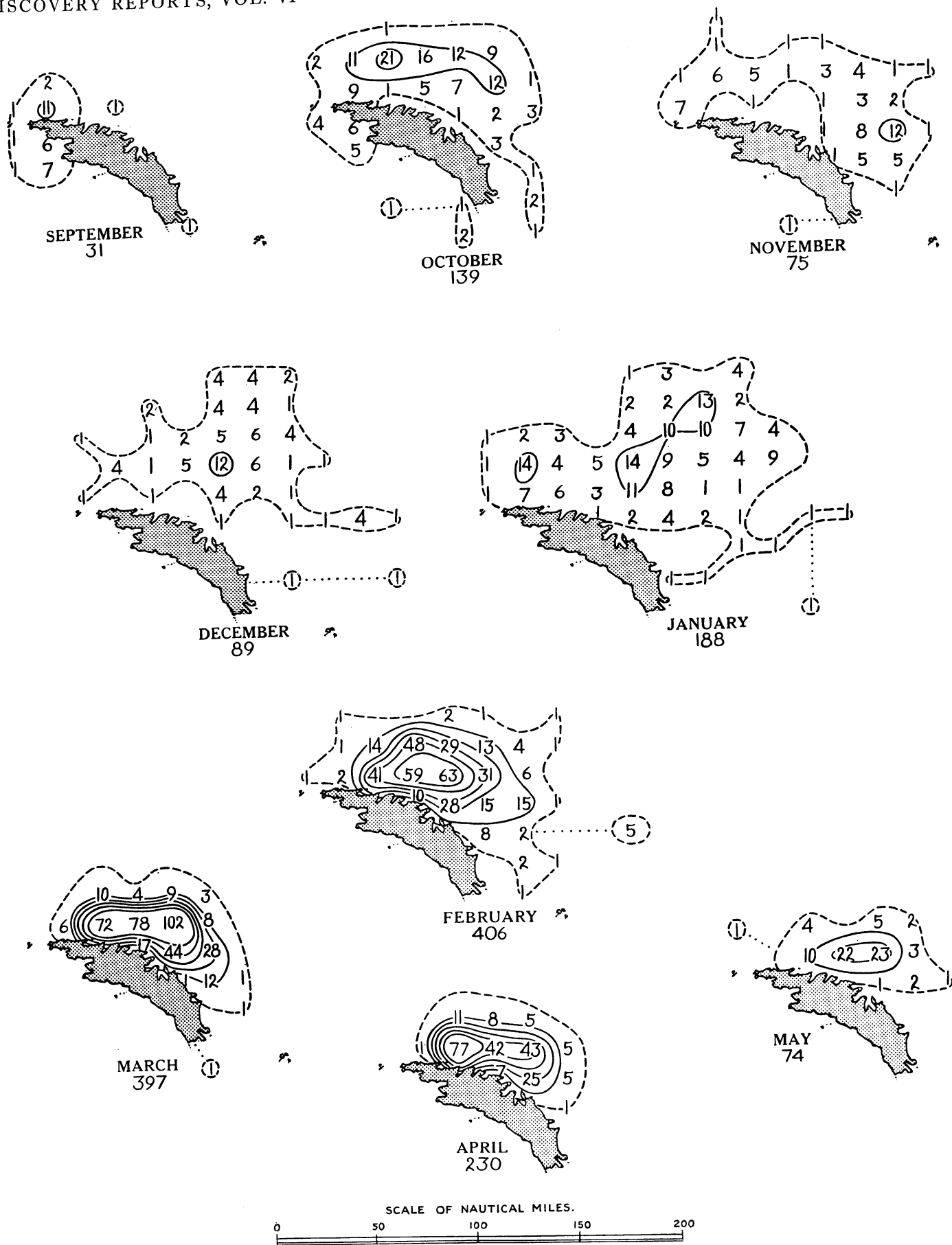


Distribution of Blue whales taken on the South Georgia grounds in season 1923-4

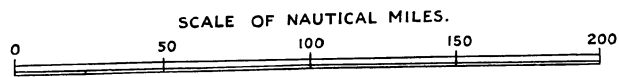
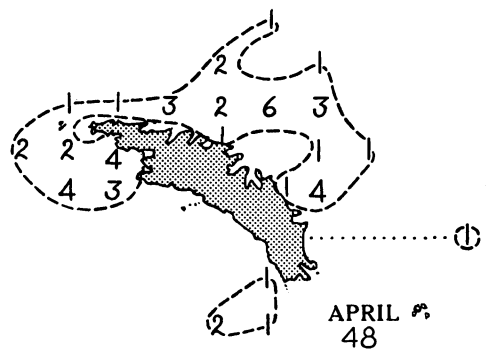
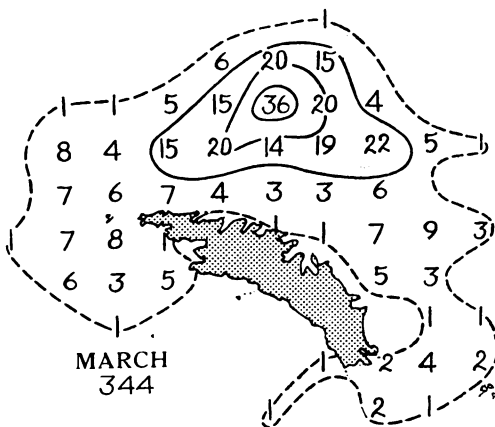
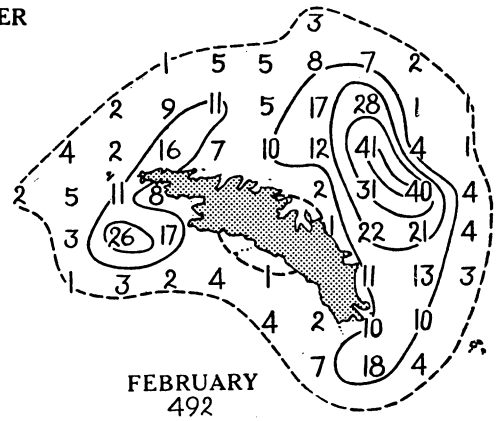
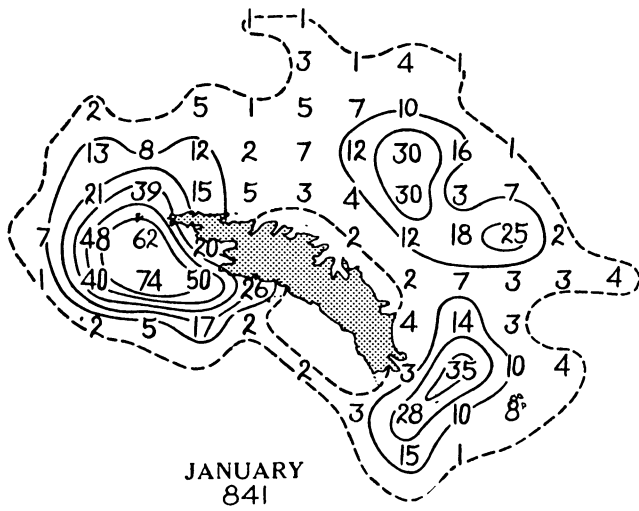
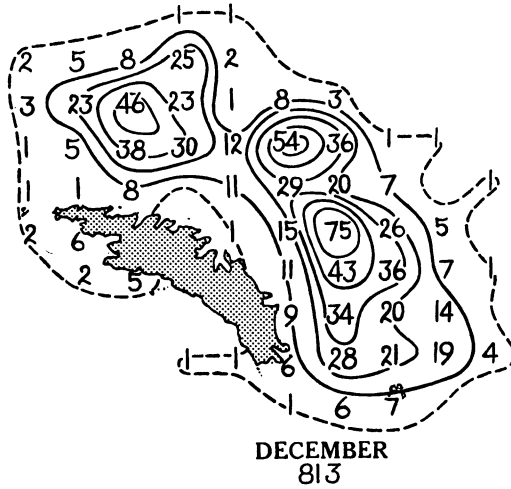
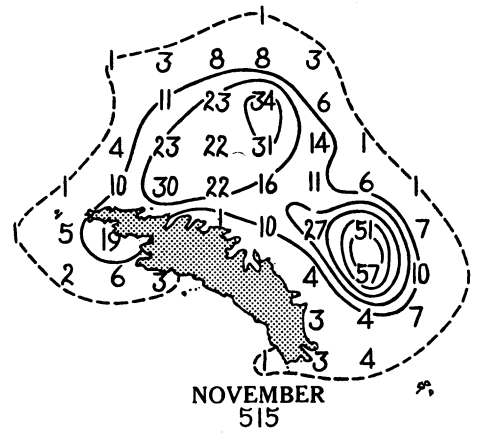
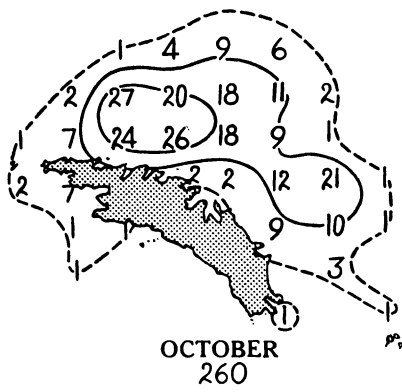


Distribution of Blue whales taken on the South Georgia grounds in season 1924-5

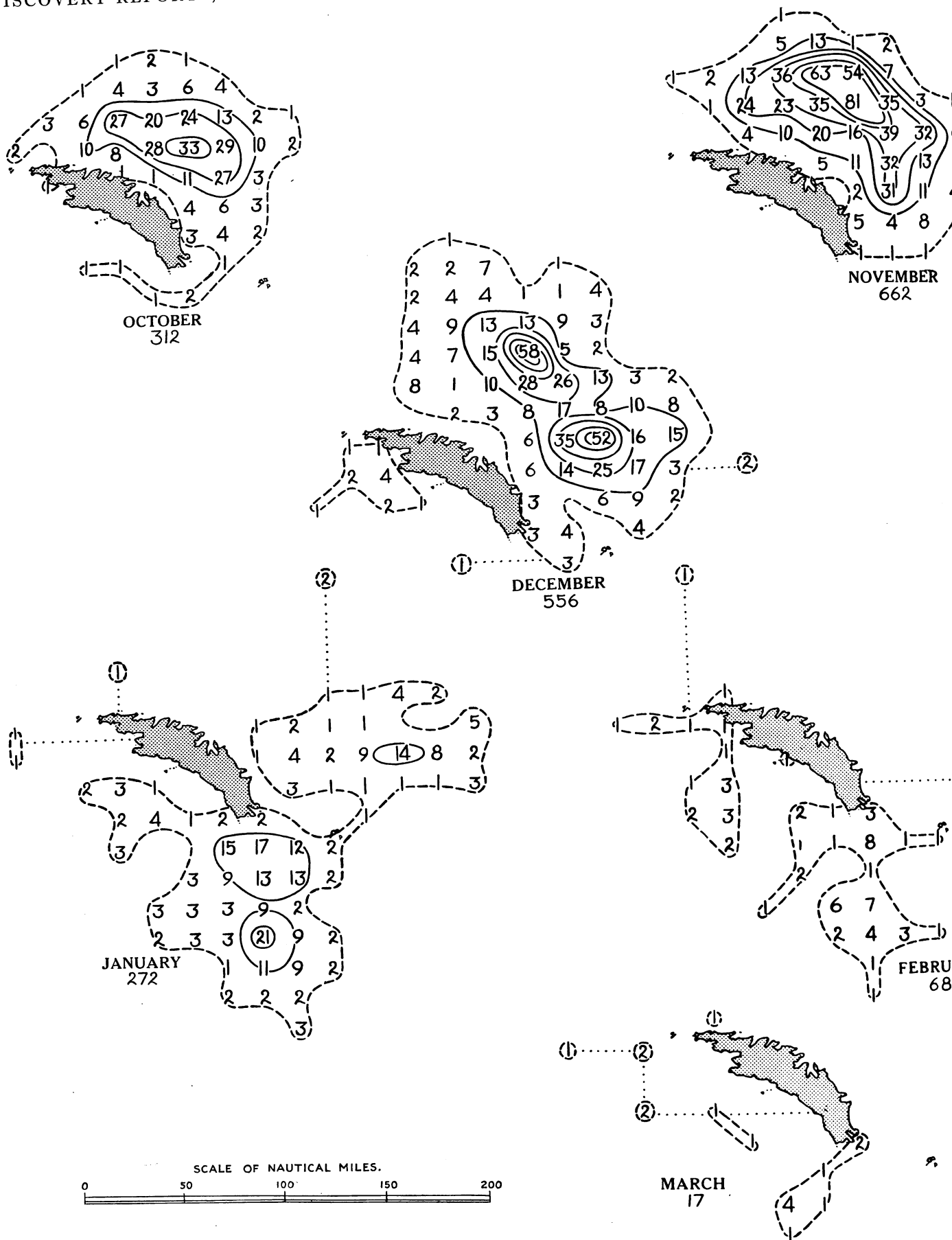
DISCOVERY REPORTS, VOL. VI



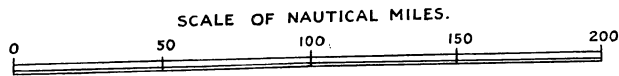
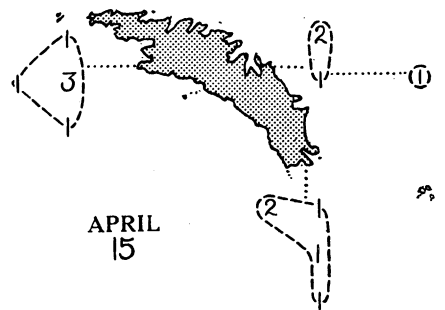
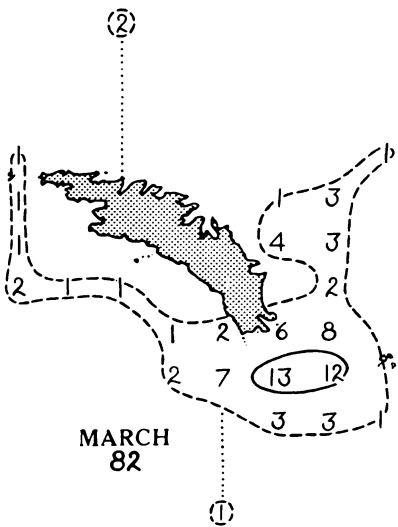
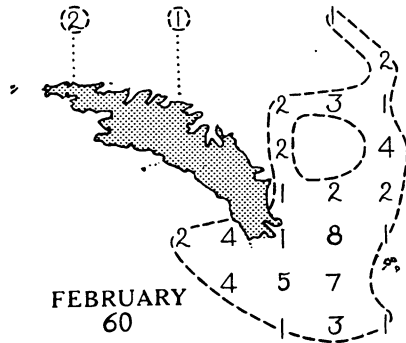
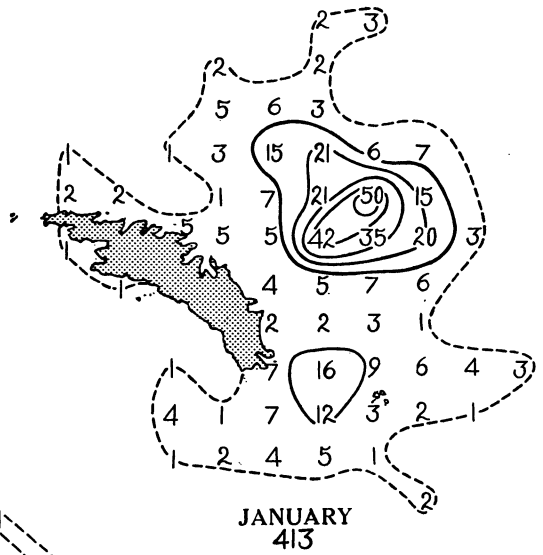
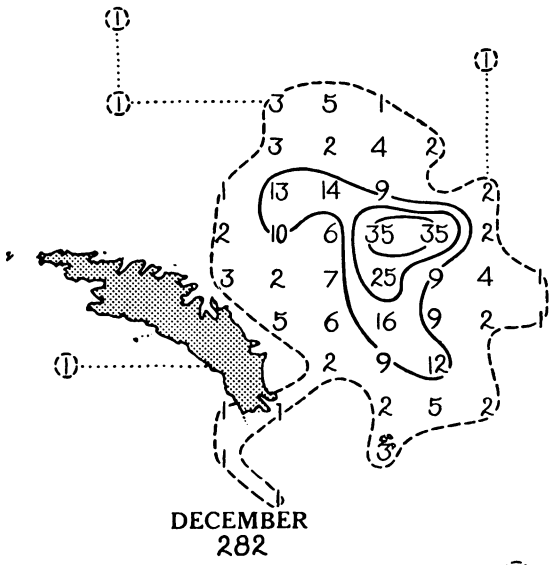
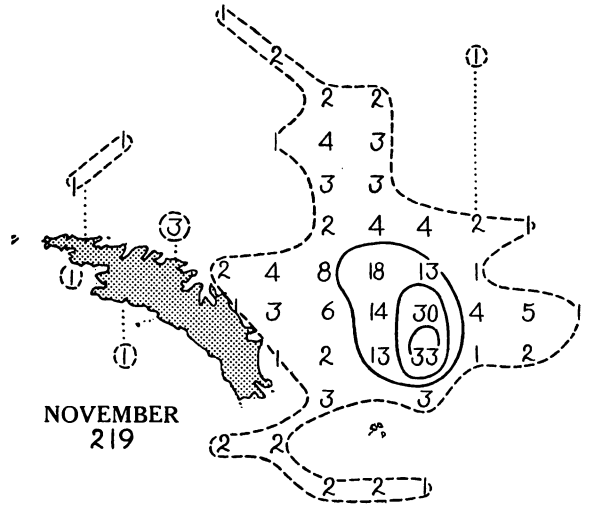
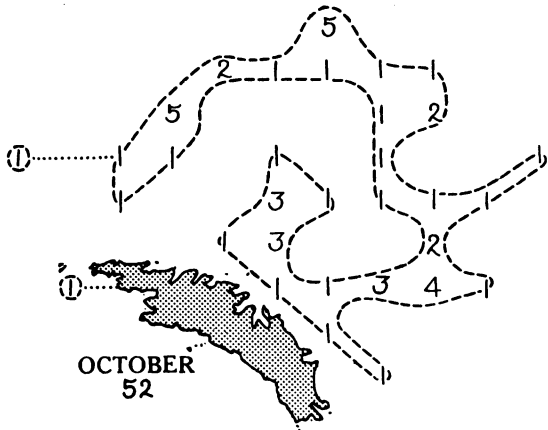
Distribution of Blue whales taken on the South Georgia grounds in season 1925-6



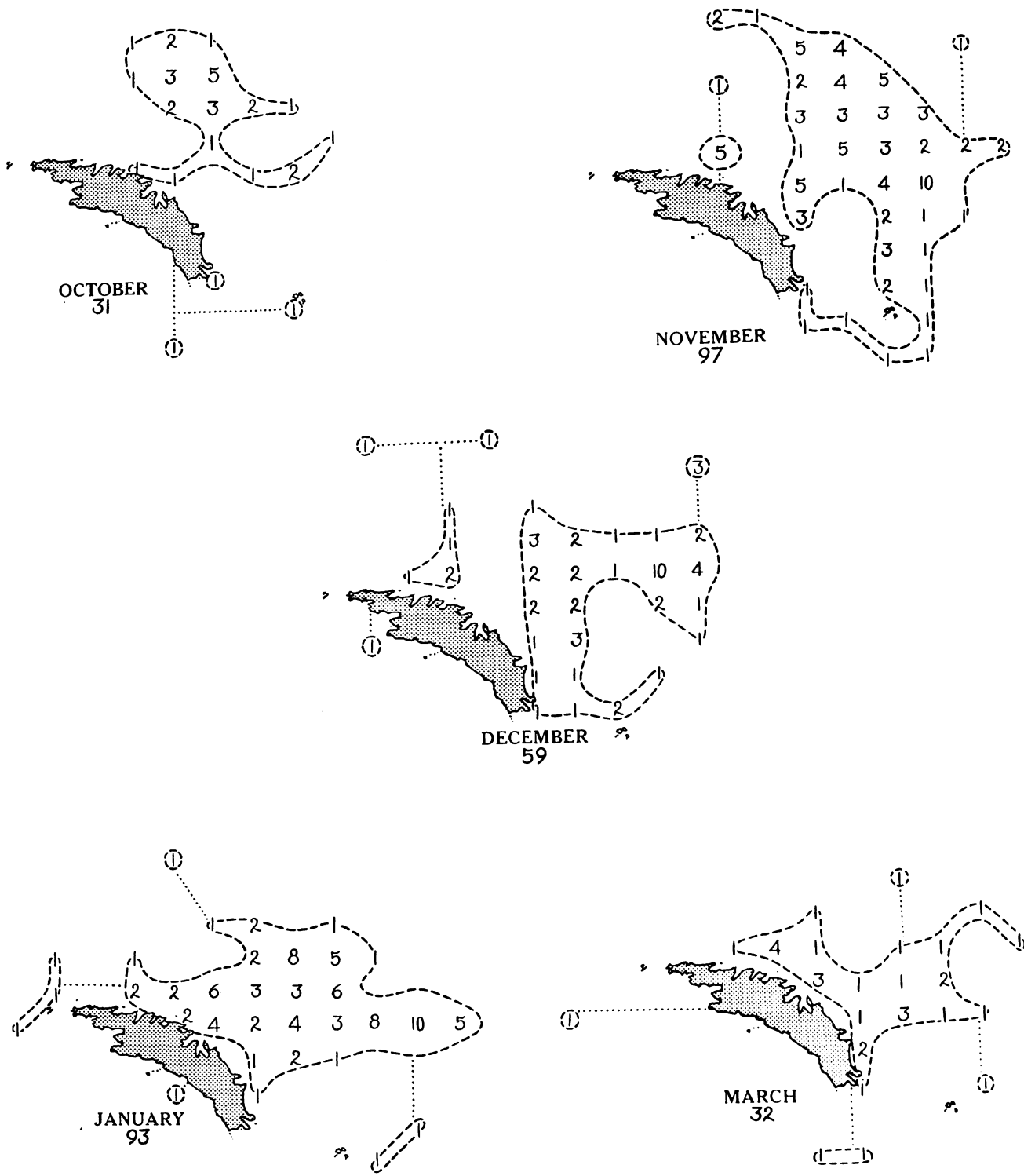
Distribution of Blue whales taken on the South Georgia grounds in season 1926-7



Distribution of Blue whales taken on the South Georgia grounds in season 1927-8

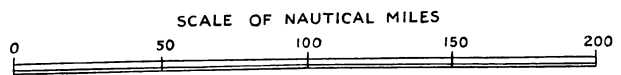
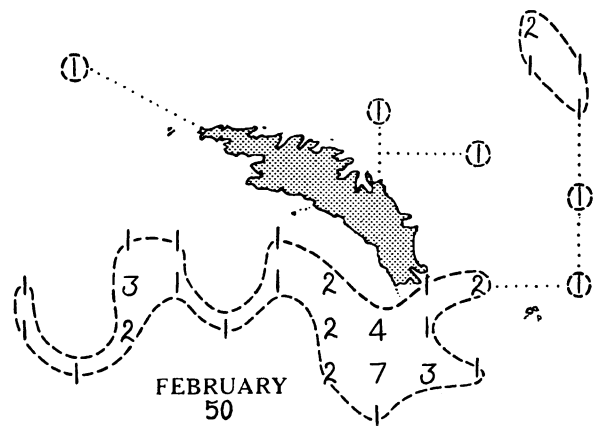
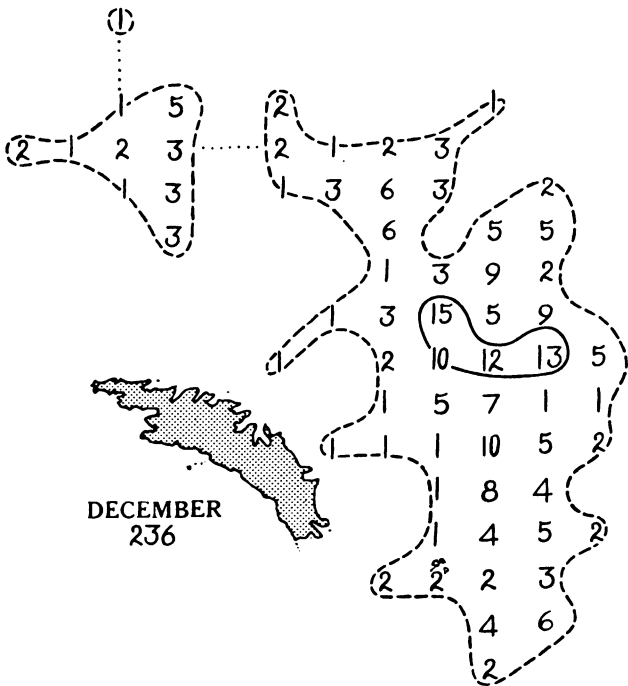
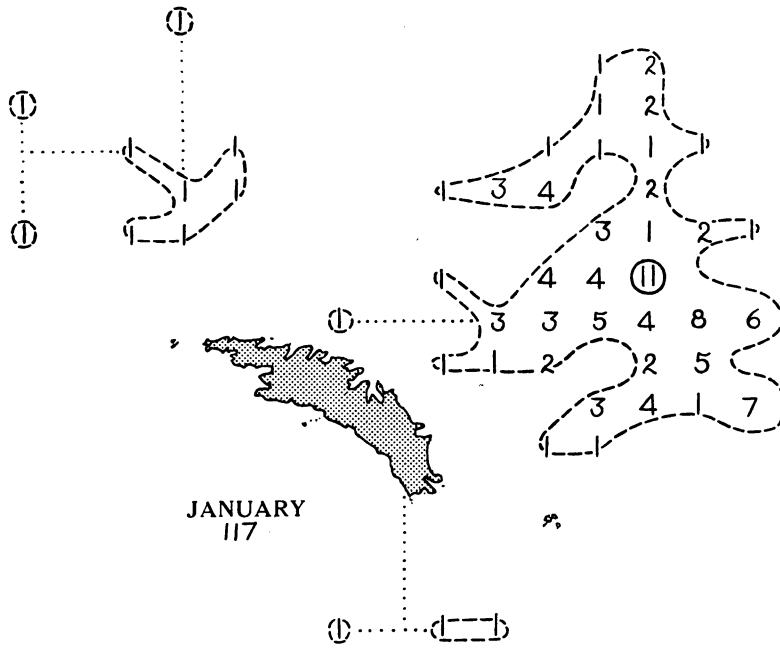
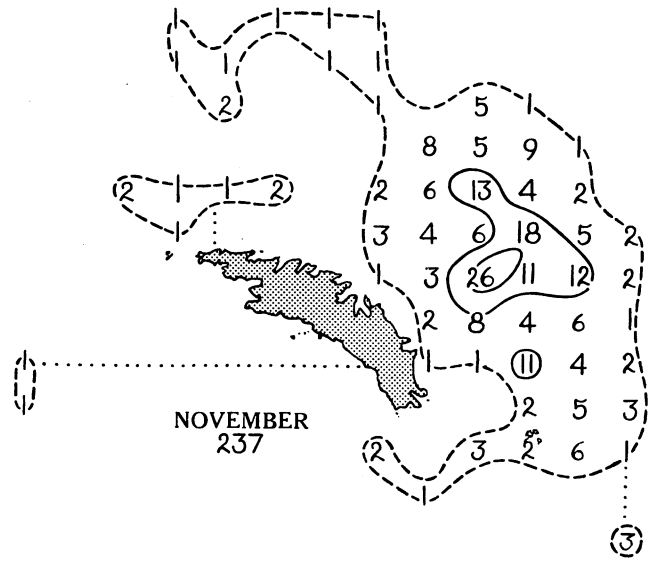
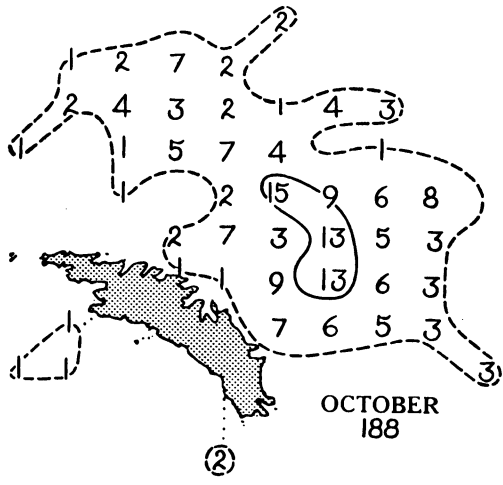


Distribution of Blue whales taken on the South Georgia grounds in season 1928-9

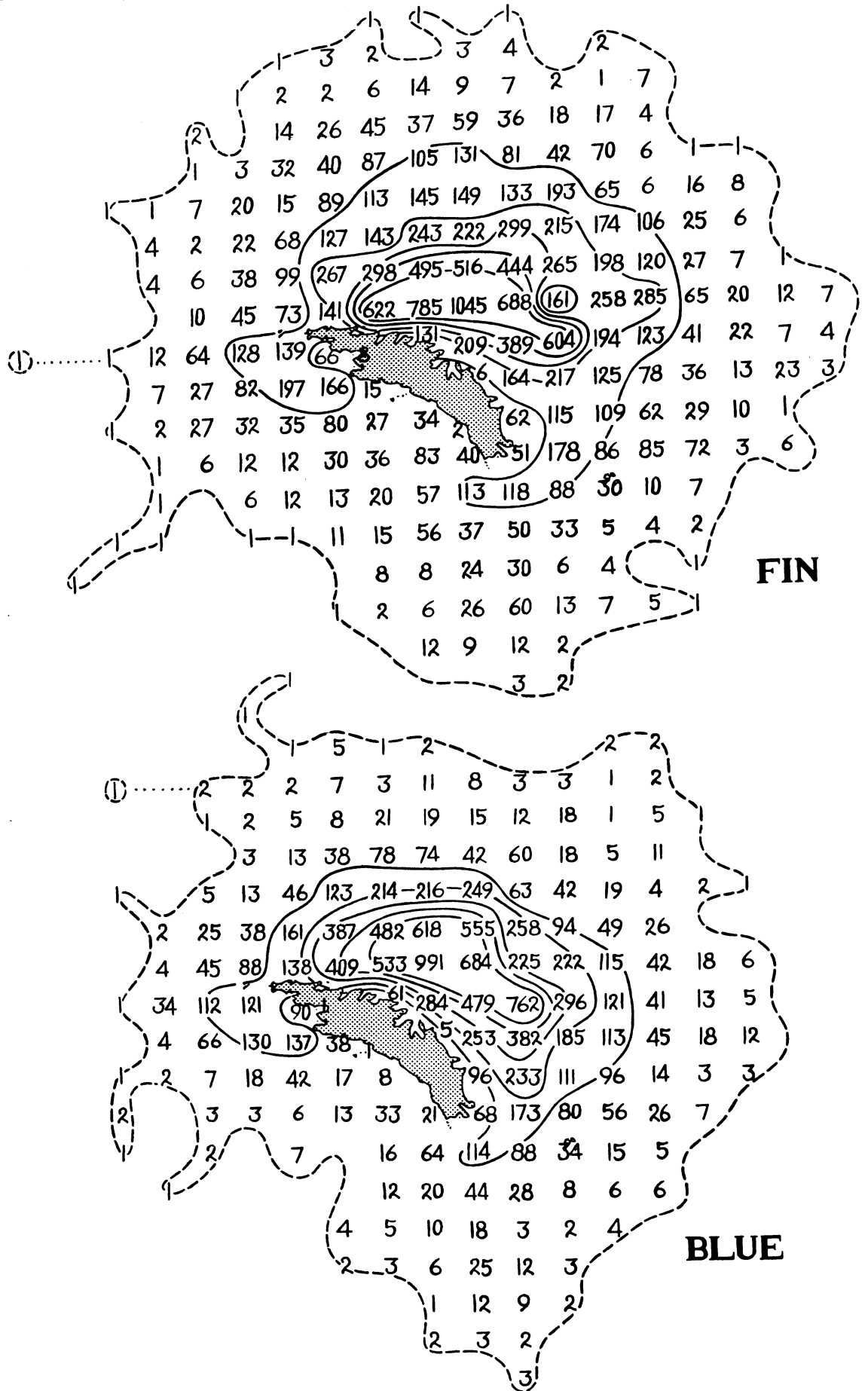


Distribution of Blue whales taken on the South Georgia grounds in season 1929-30

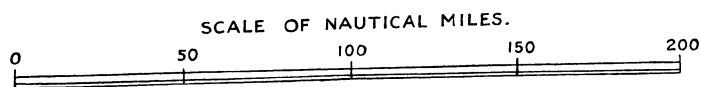
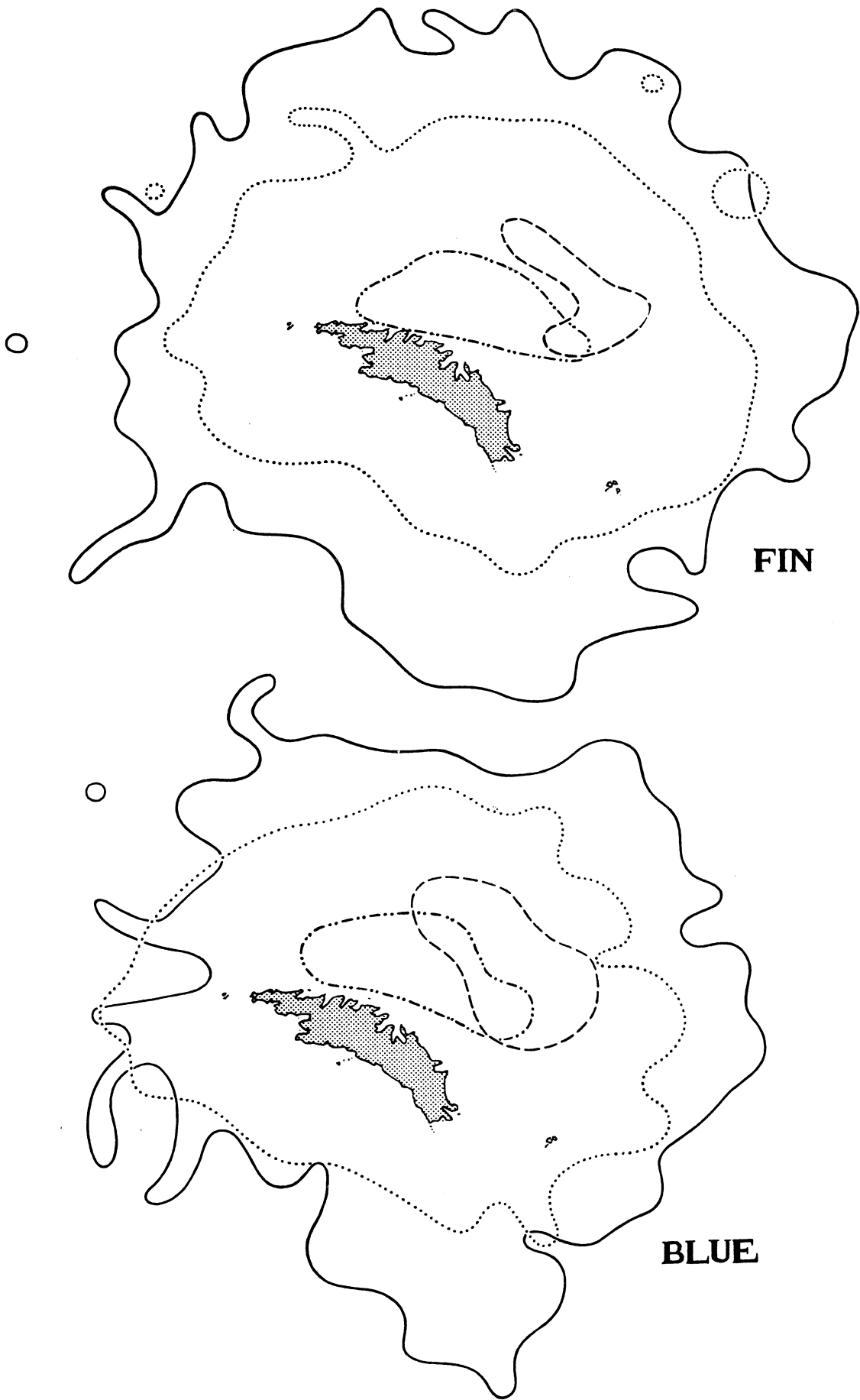




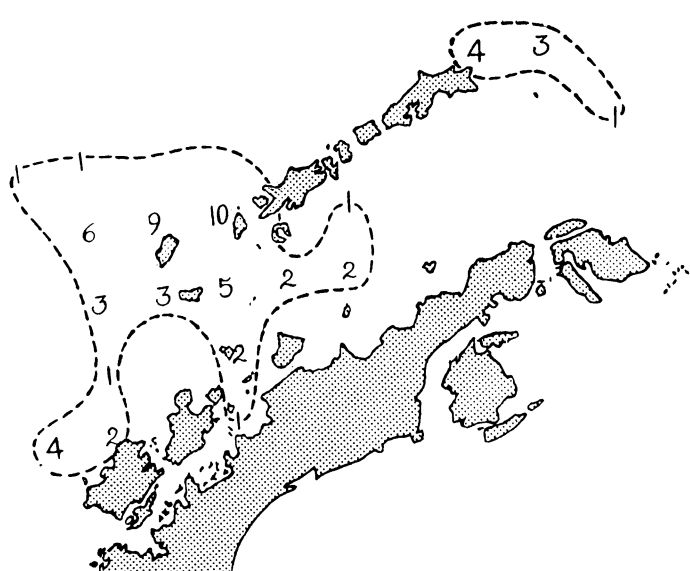
Distribution of Blue whales taken on the South Georgia grounds in season 1930-1



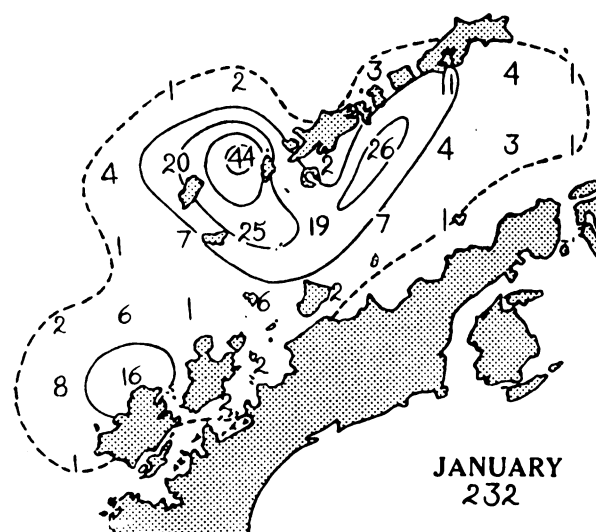
Distribution of Fin and Blue whales on the South Georgia grounds: based on all recorded positions of capture during the eight seasons 1923-4 to 1930-1



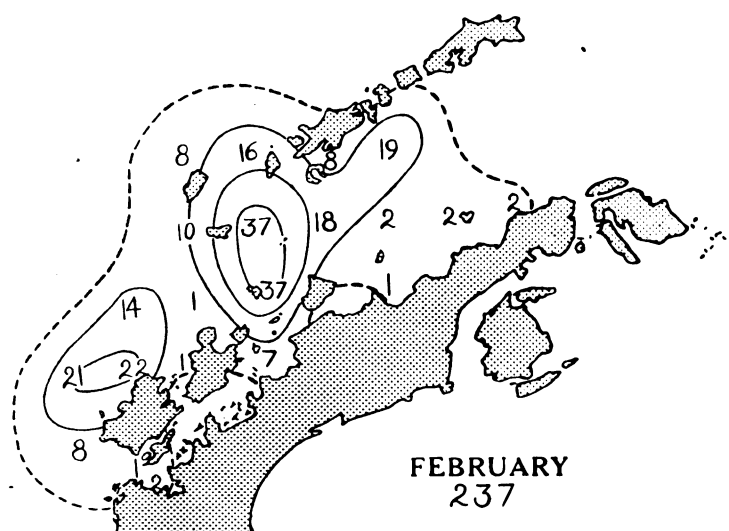
Charts showing the recent extension of the South Georgia whaling grounds  
..... limits of whaling area during seasons 1923-4 to 1926-7  
—— " " " " " 1927-8 to 1930-1  
- - - - main concentration (300 contour) during seasons 1923-4 to 1926-7  
- - - - " " (150 contour) " " 1927-8 to 1930-1



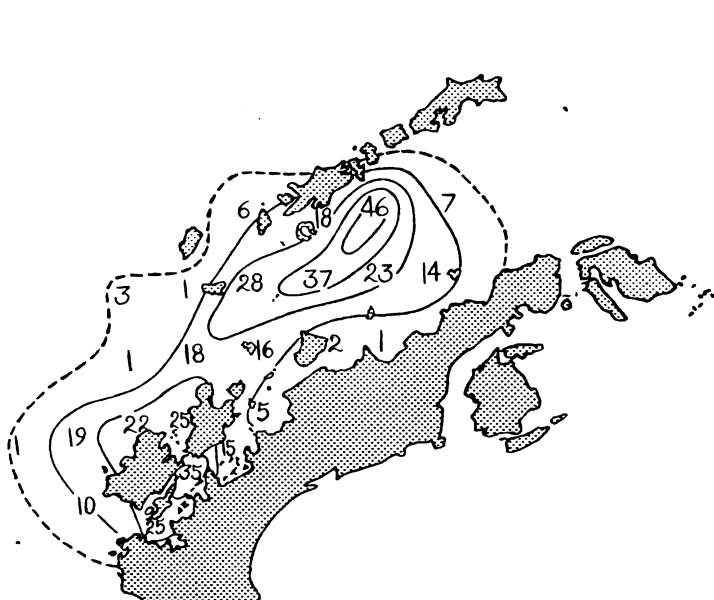
DECEMBER  
61



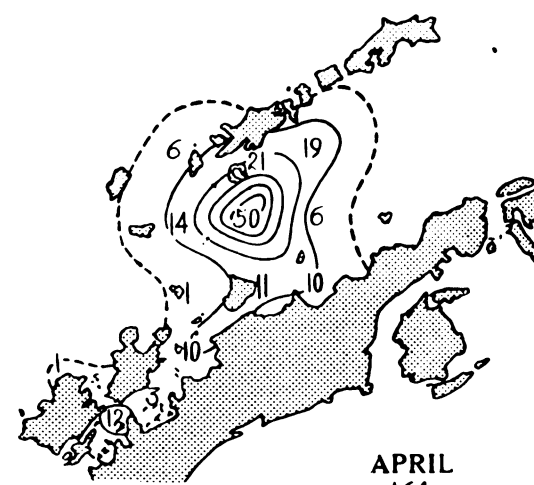
JANUARY  
232



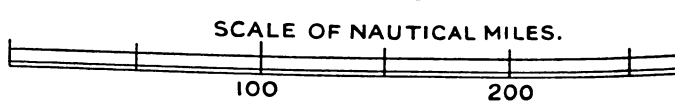
FEBRUARY  
237



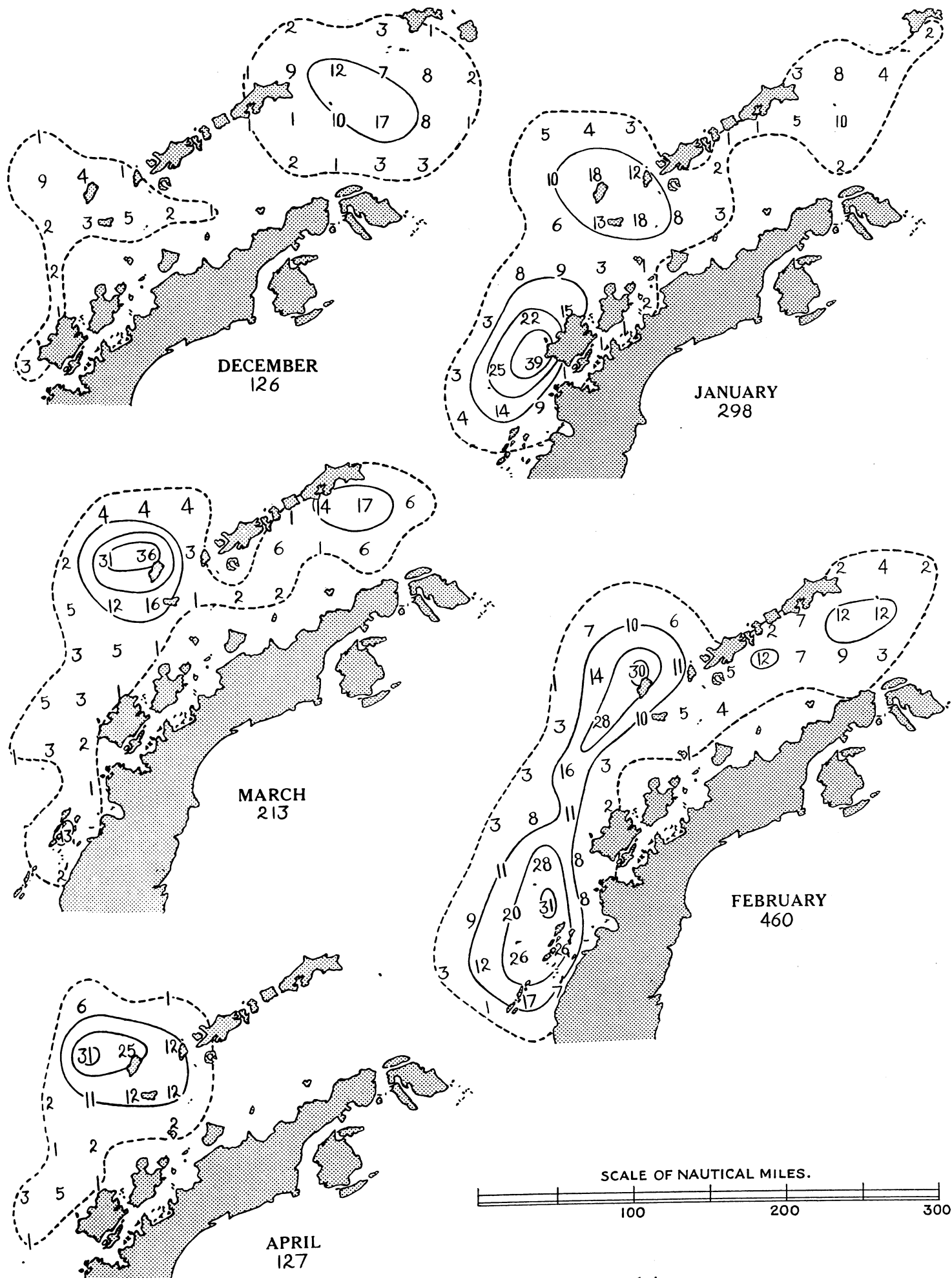
MARCH  
378



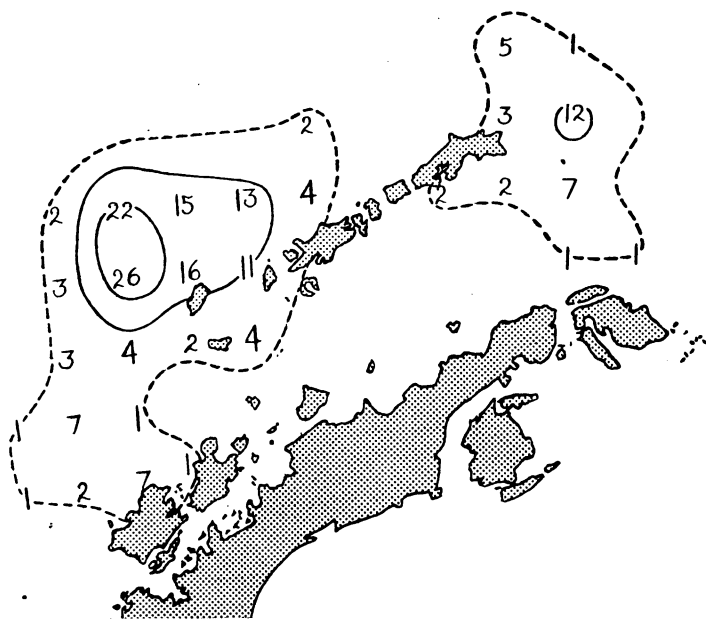
APRIL  
164



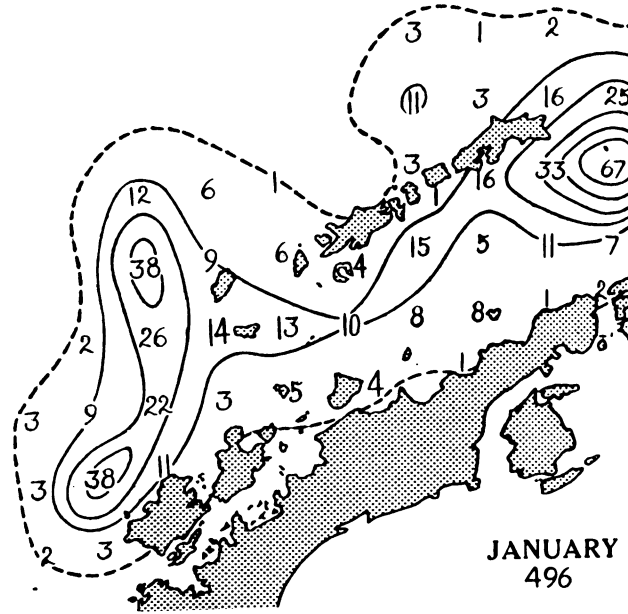
Distribution of Fin whales taken on the South Shetland grounds in season 1922-3



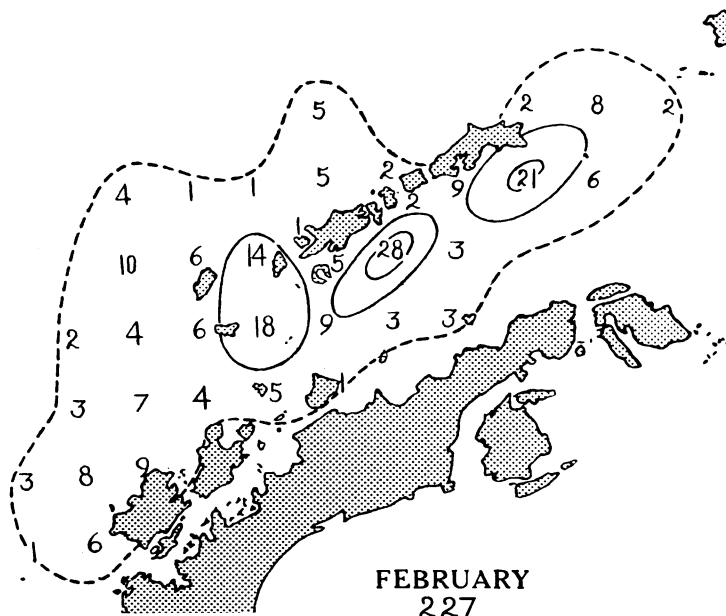
Distribution of Fin whales taken on the South Shetland grounds in season 1923-4



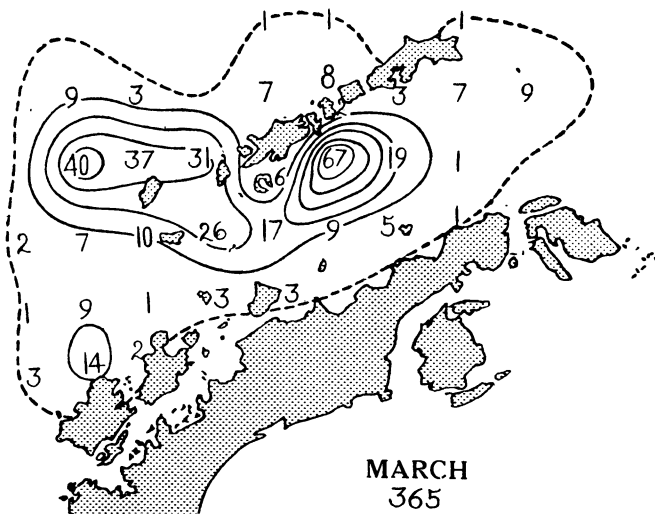
DECEMBER  
181



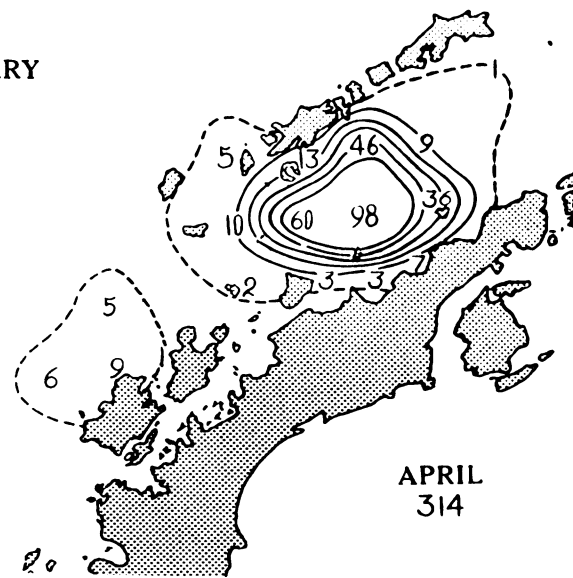
JANUARY  
496



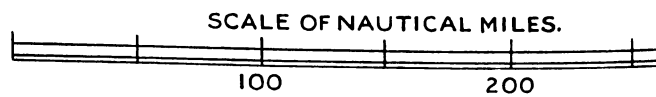
FEBRUARY  
227



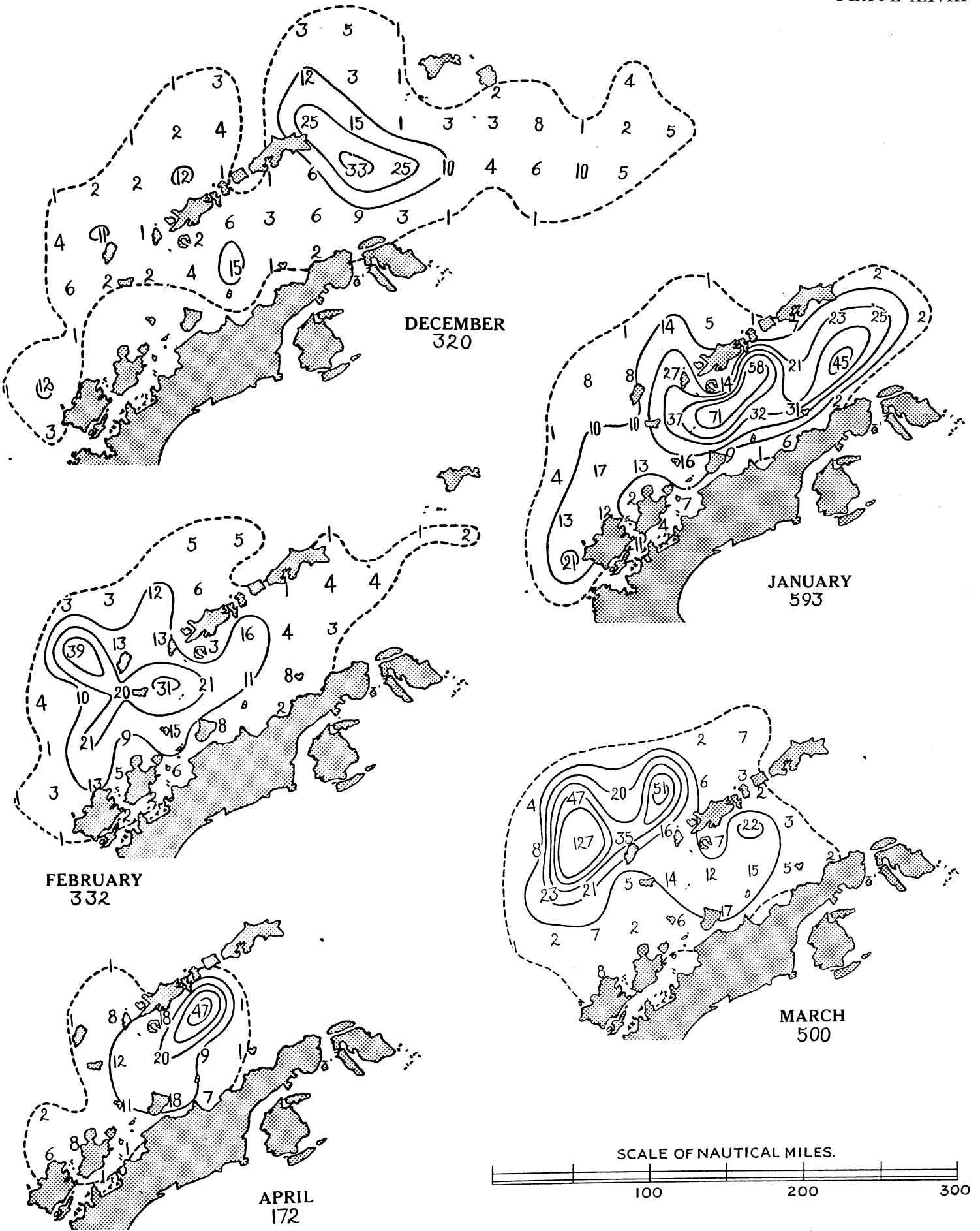
MARCH  
365



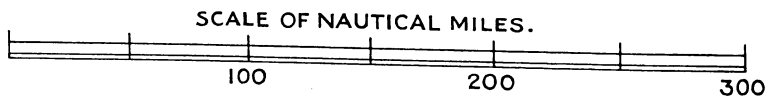
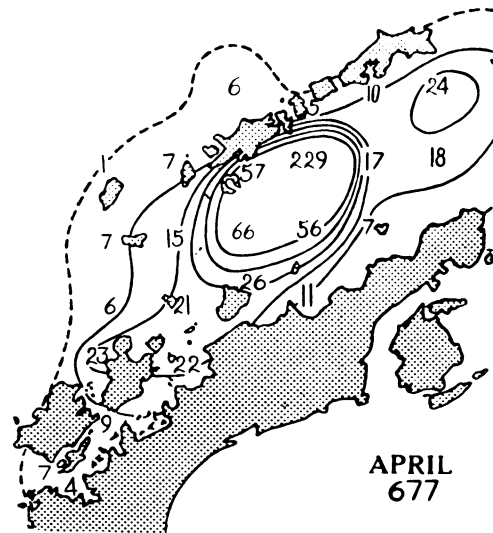
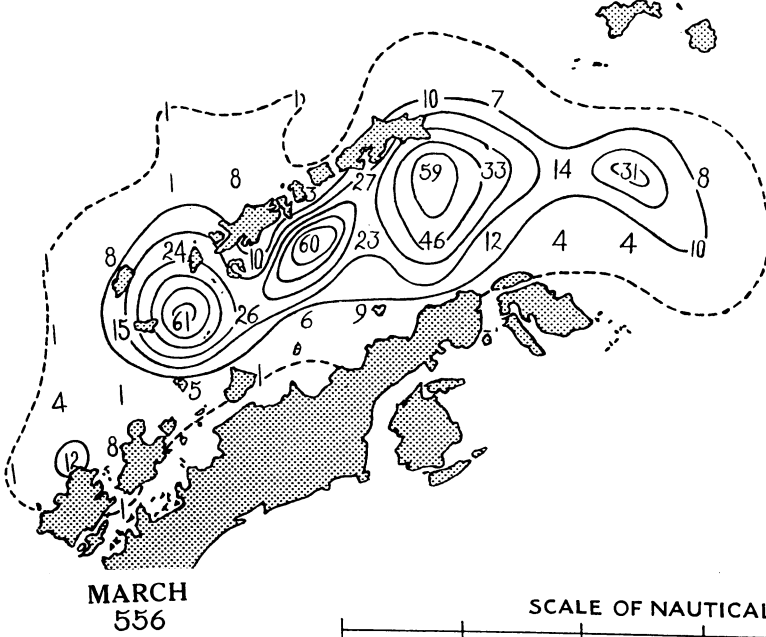
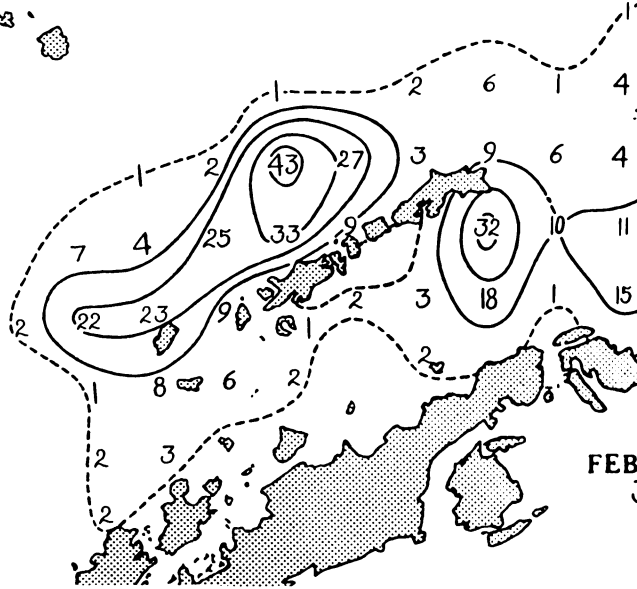
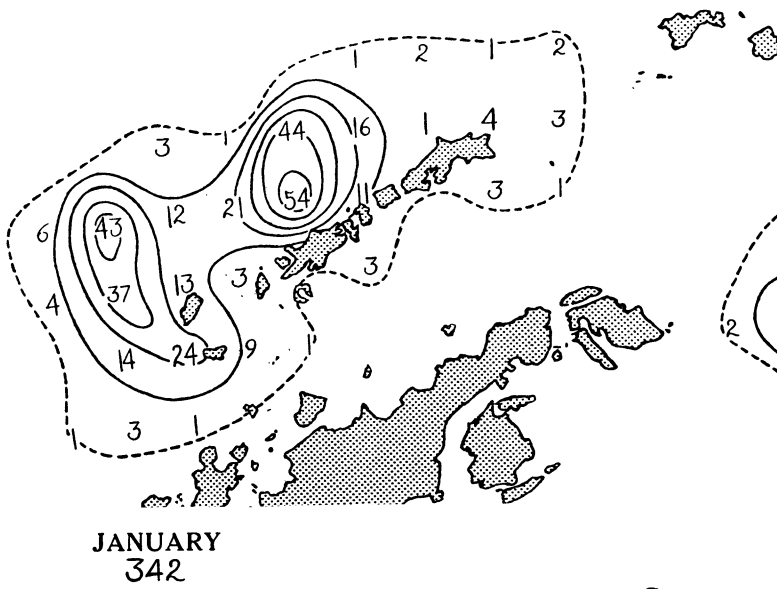
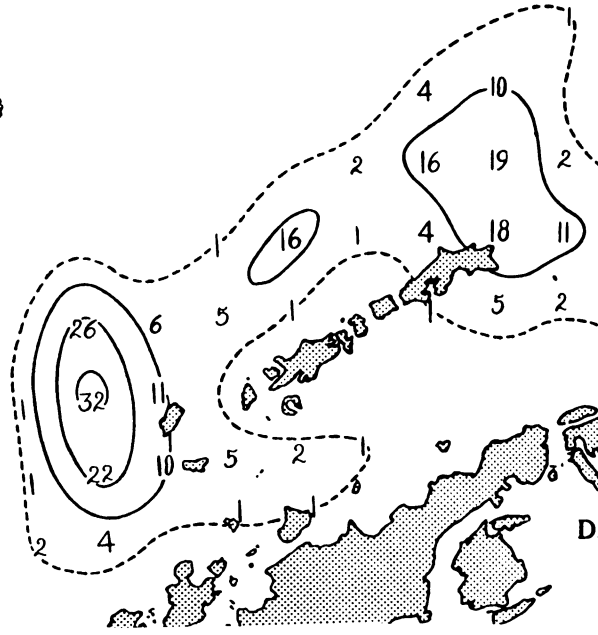
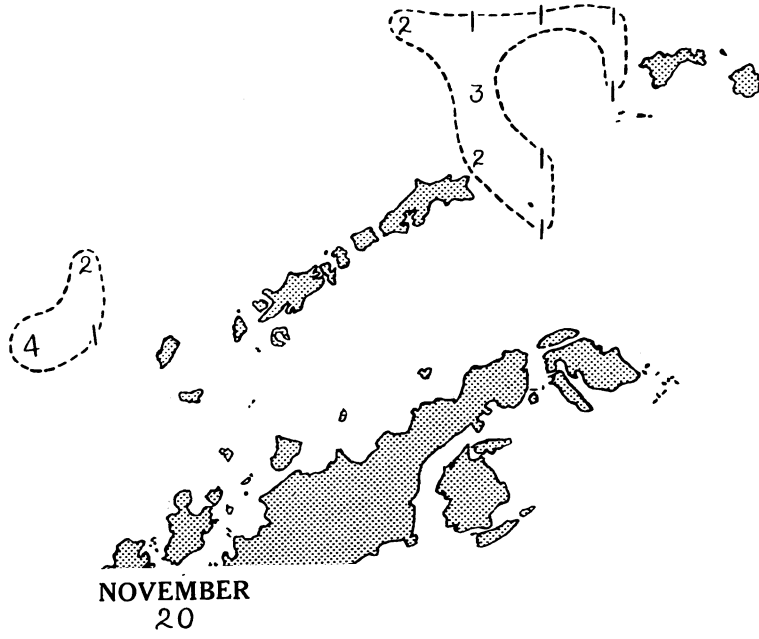
APRIL  
314



Distribution of Fin whales taken on the South Shetland grounds in season 1924-5

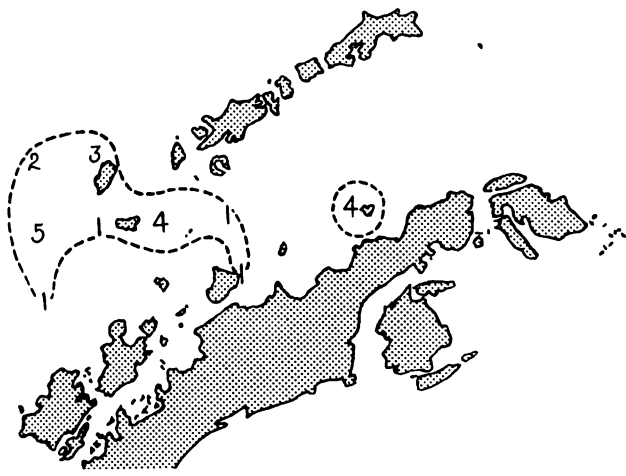


Distribution of Fin whales taken on the South Shetland grounds in season 1925-6

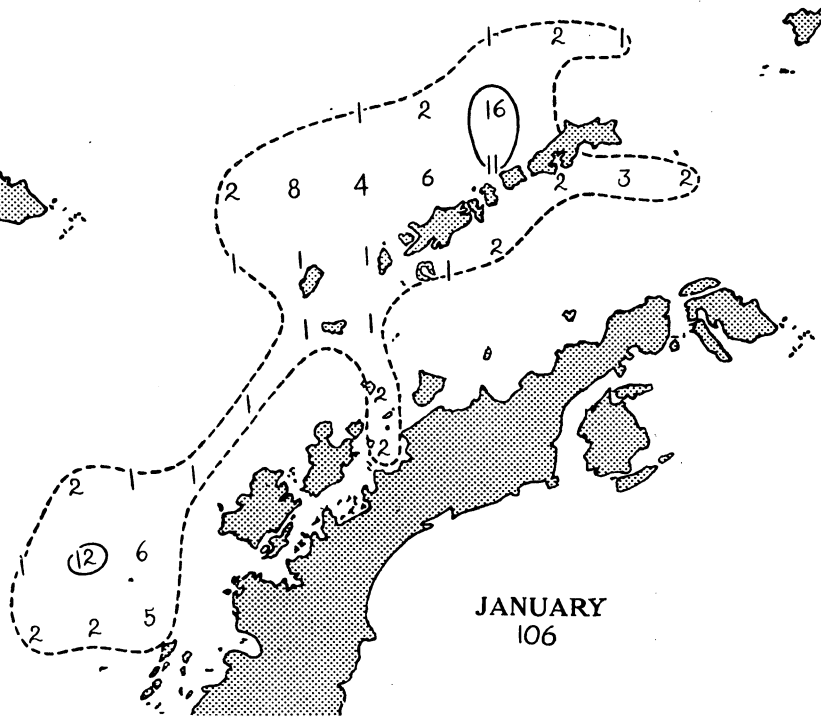


Distribution of Fin whales taken on the South Shetland grounds in season 1926-7

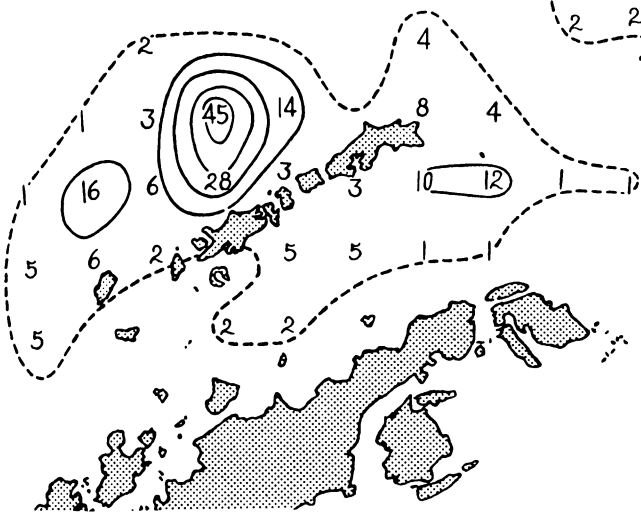




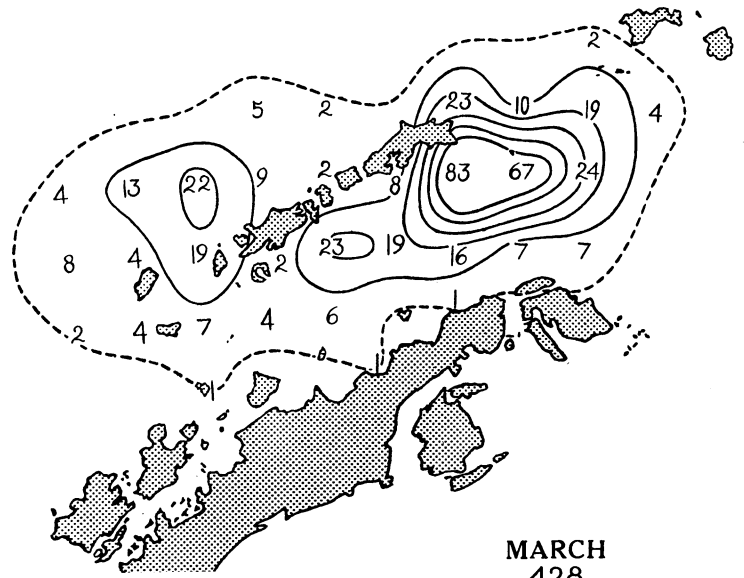
DECEMBER  
22



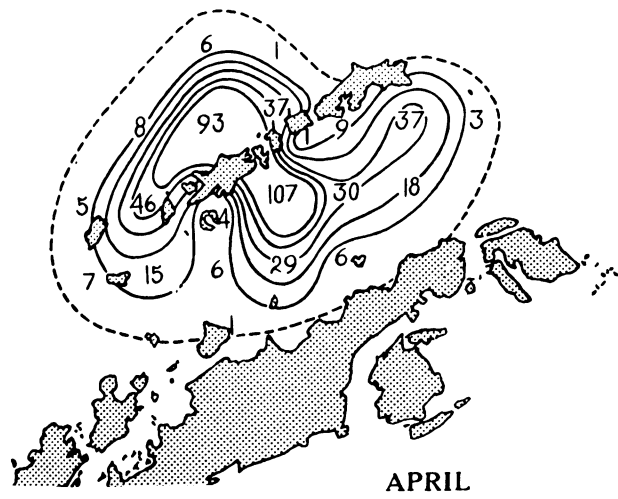
JANUARY  
106



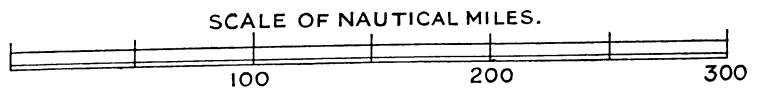
FEBRUARY  
196



MARCH  
428

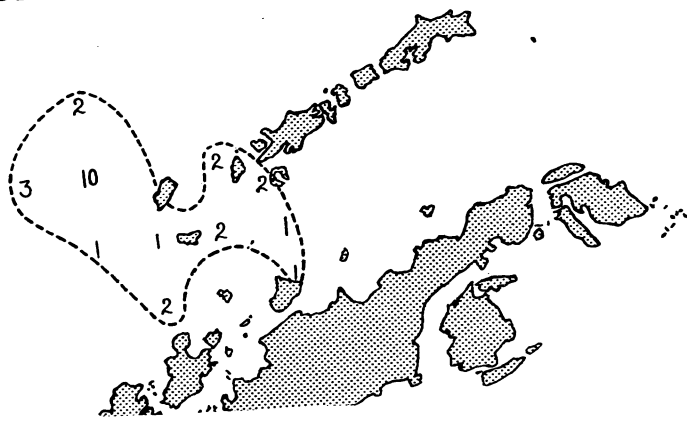


APRIL  
469

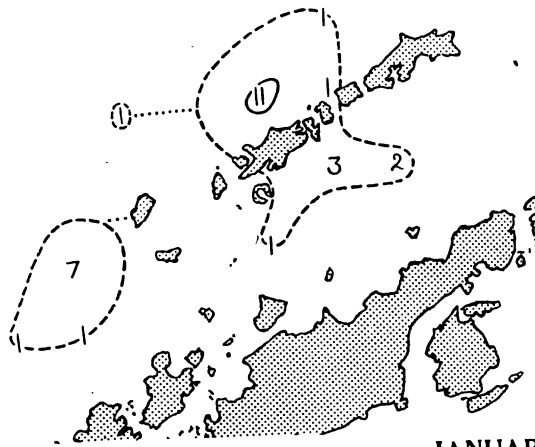


Distribution of Fin whales taken on the South Shetland grounds in season 1927-8

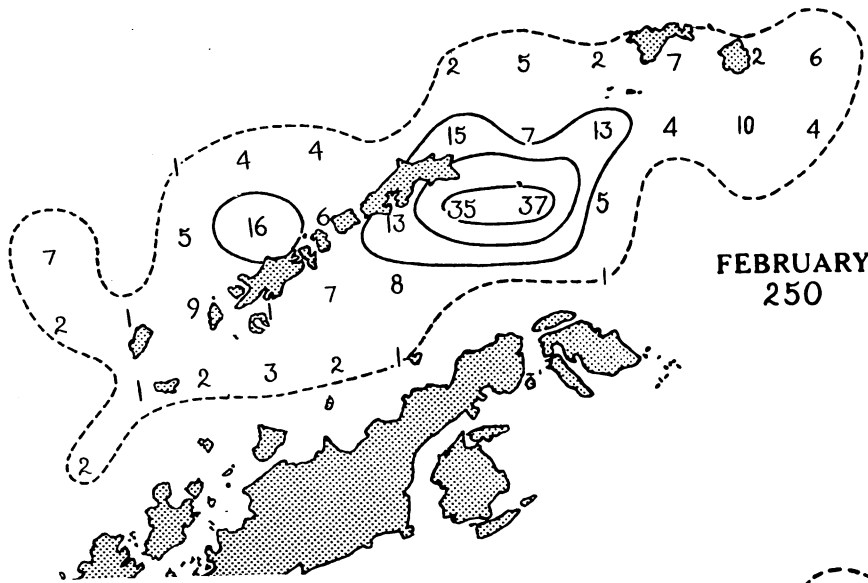
DISCOVERY REPORTS, VOL. VI



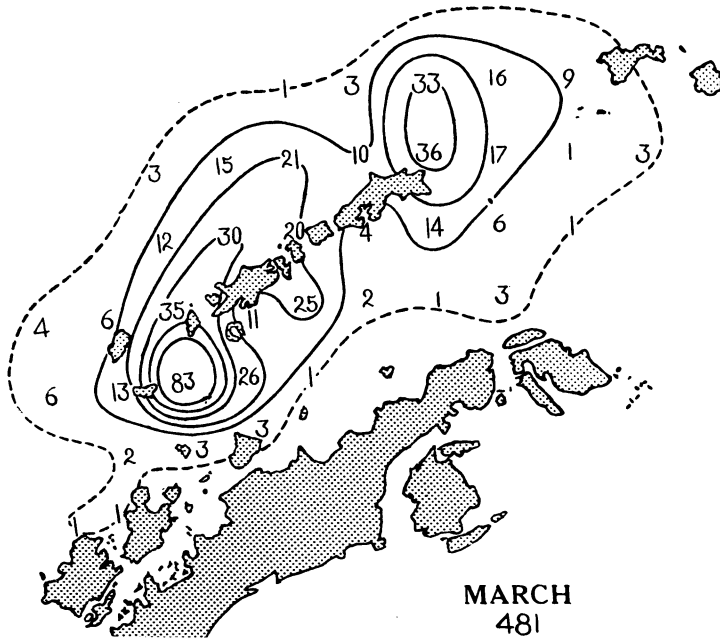
DECEMBER  
27



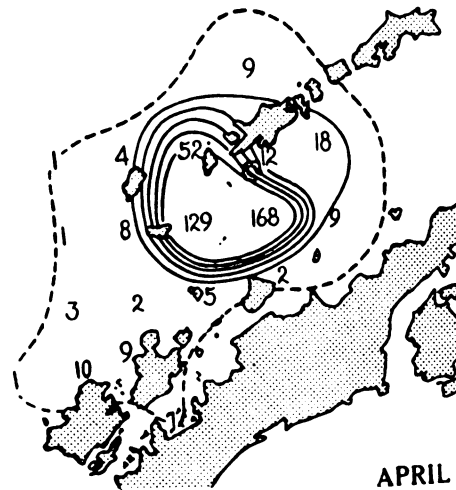
JANUARY  
29



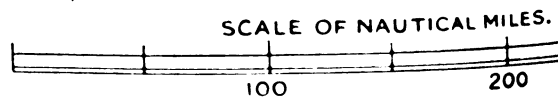
FEBRUARY  
250



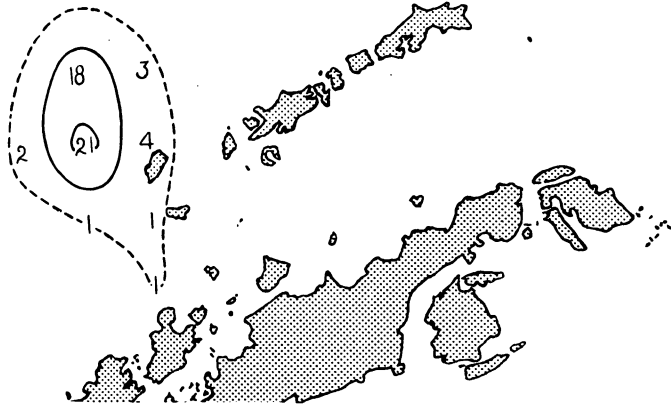
MARCH  
481



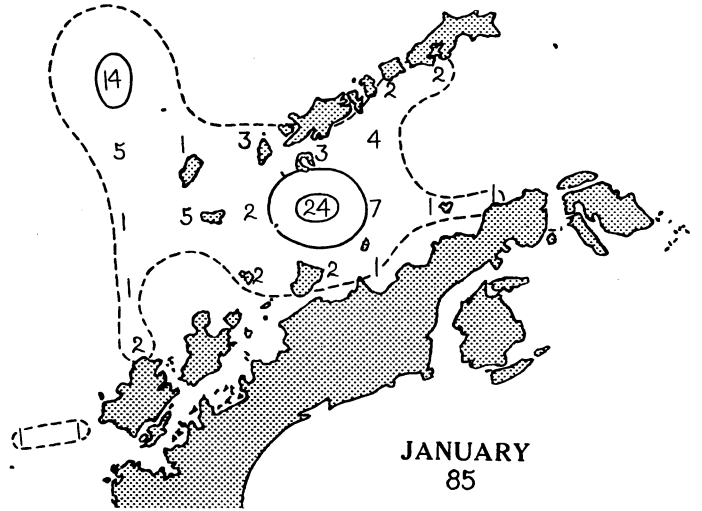
APRIL  
444



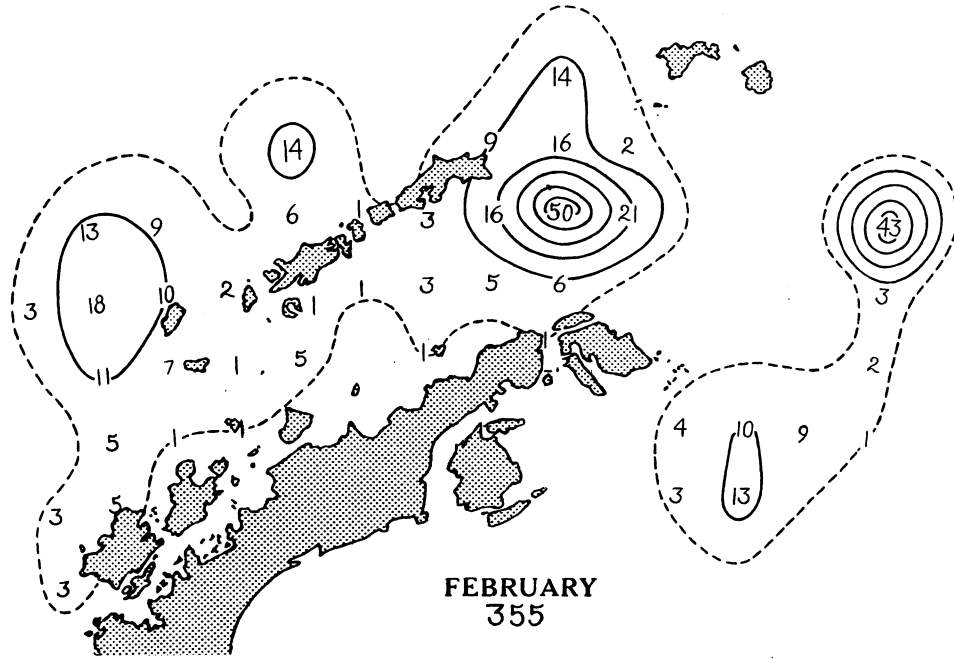
Distribution of Fin whales taken on the South Shetland grounds in season 1928-9



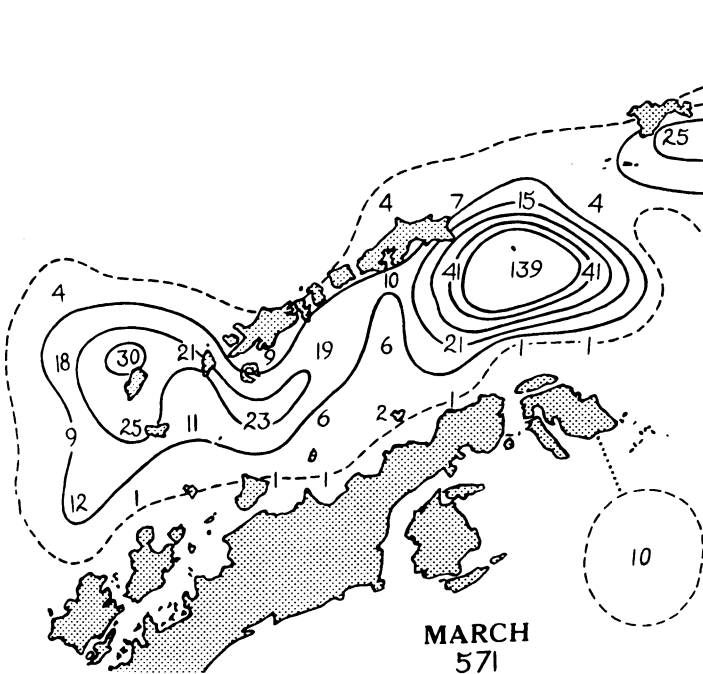
DECEMBER  
51



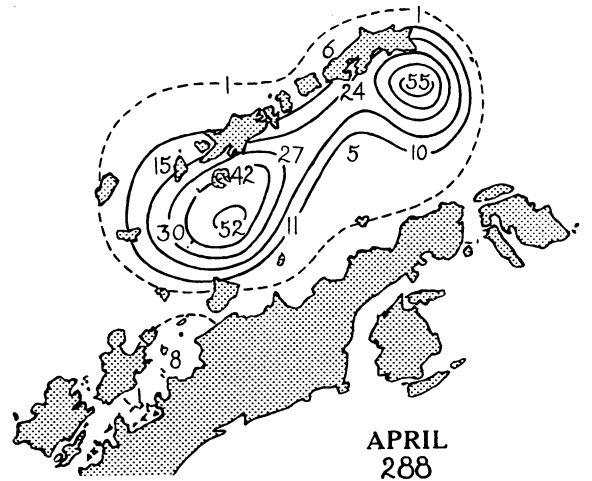
JANUARY  
85



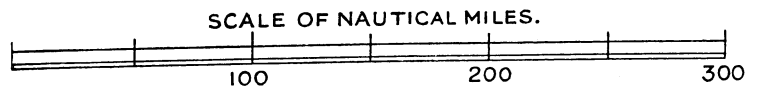
FEBRUARY  
355



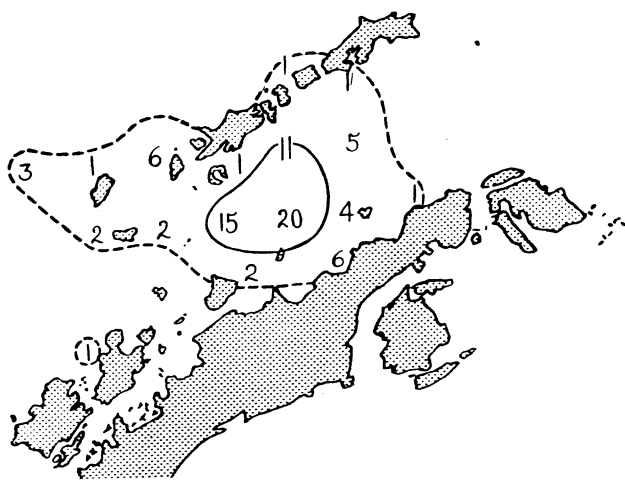
MARCH  
571



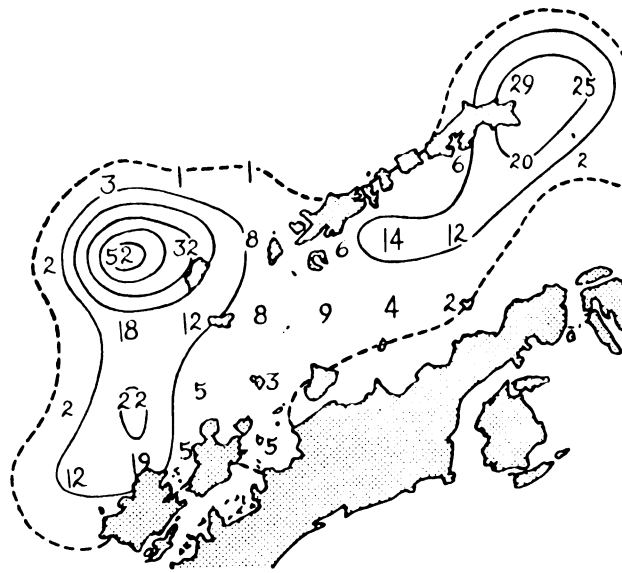
APRIL  
288



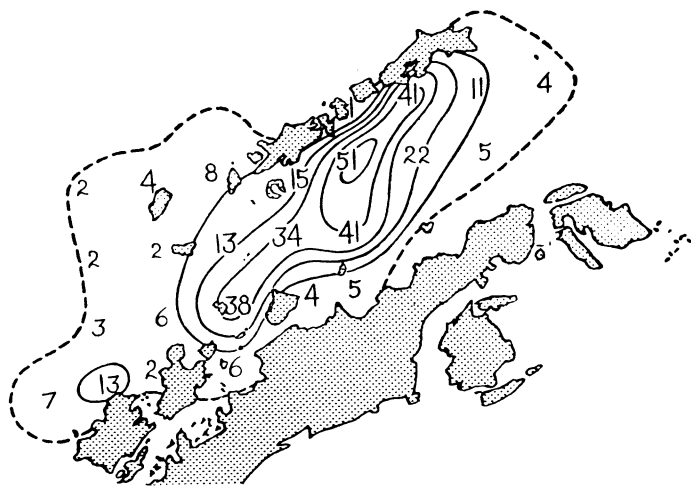
Distribution of Fin whales taken on the South Shetland grounds in season 1929-30



NOVEMBER  
82



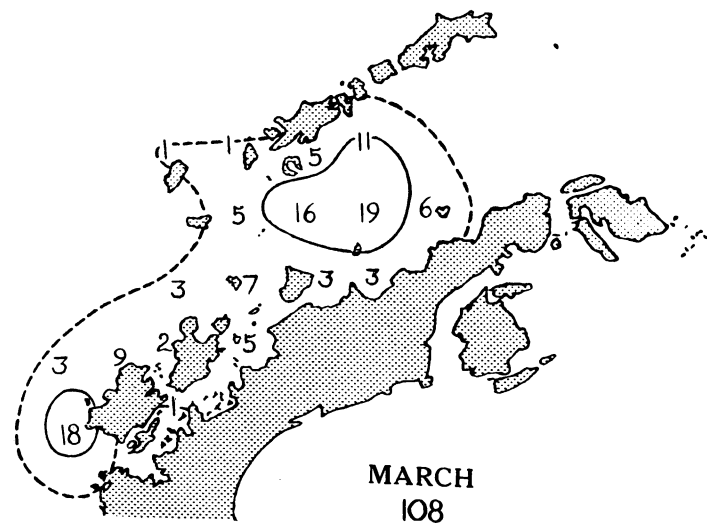
DECEMBER  
342



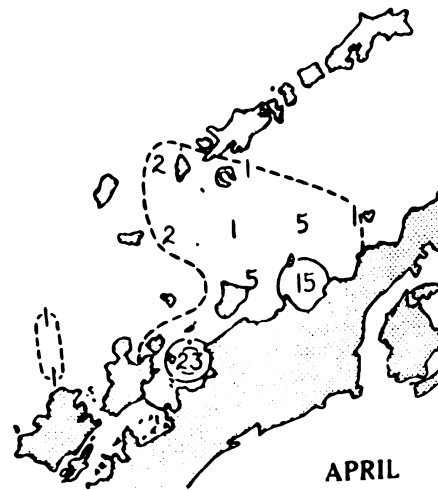
JANUARY  
340



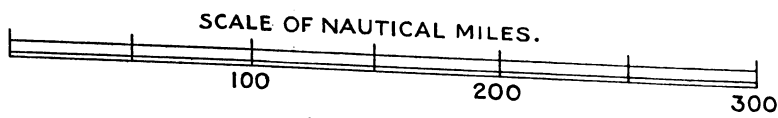
FEBRUARY  
112



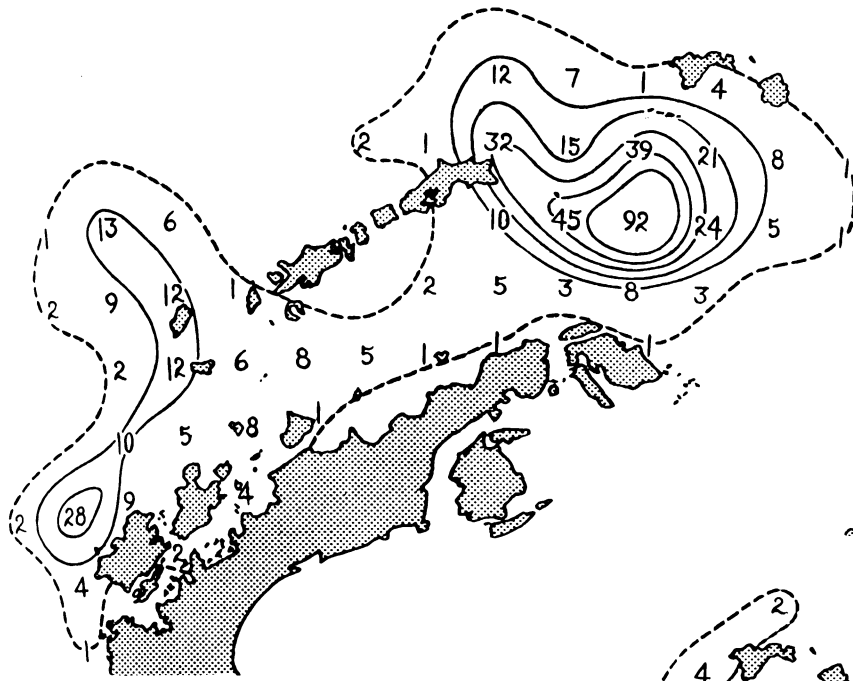
MARCH  
108



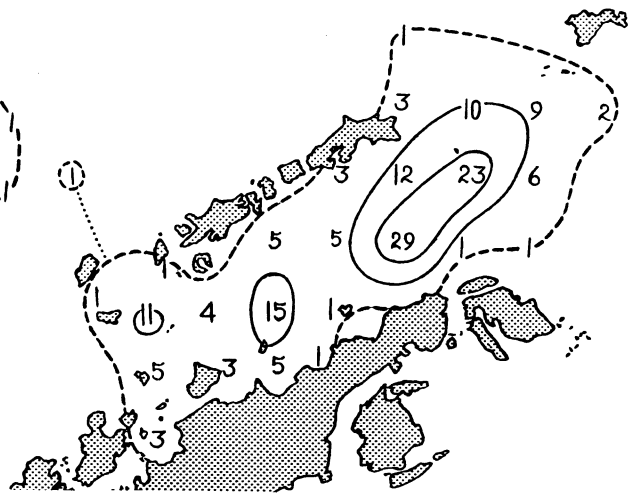
APRIL  
57



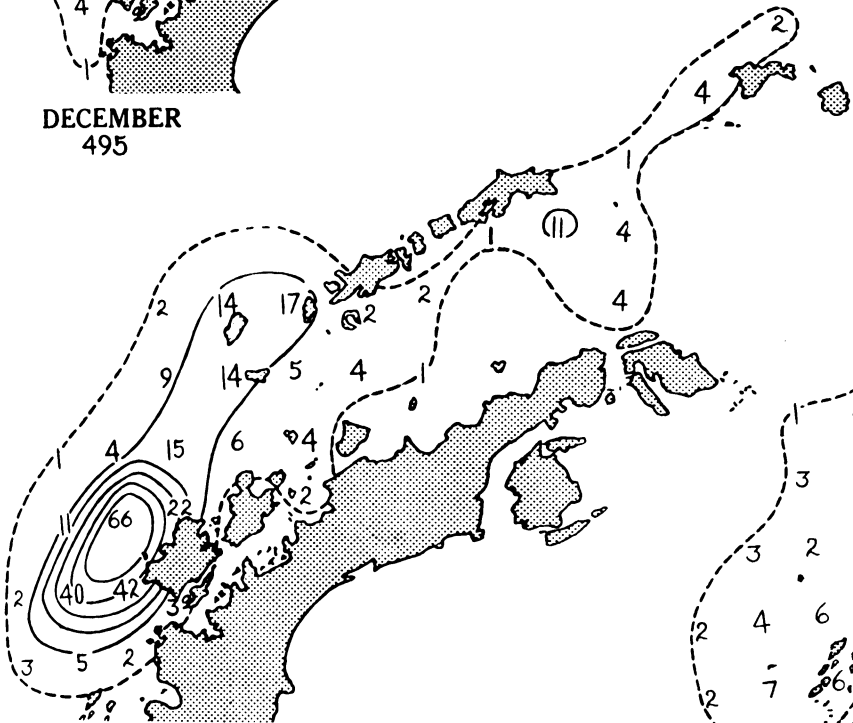
Distribution of Blue whales on the South Shetland grounds in season 1922-3



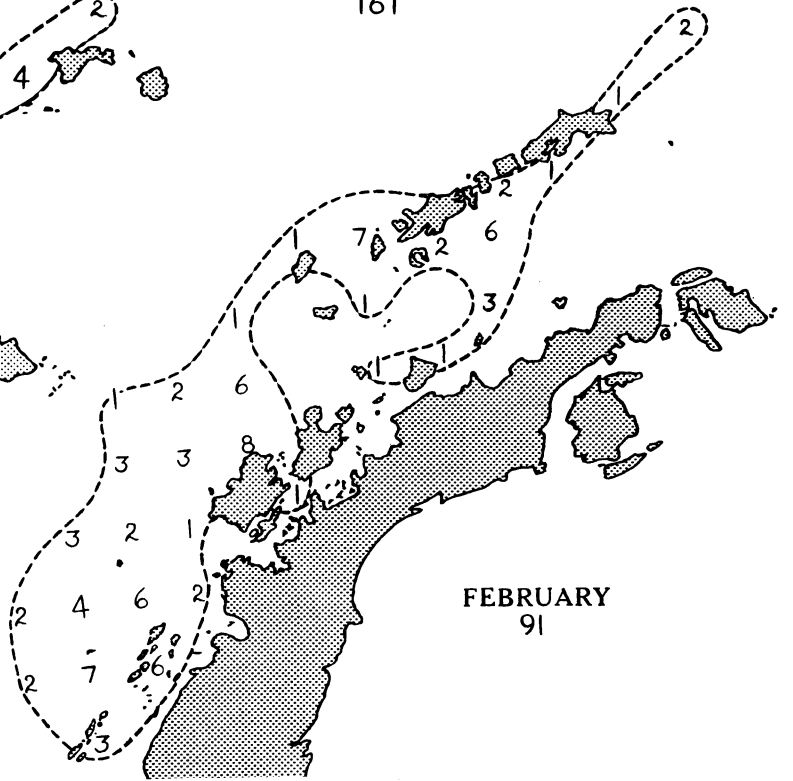
DECEMBER  
495



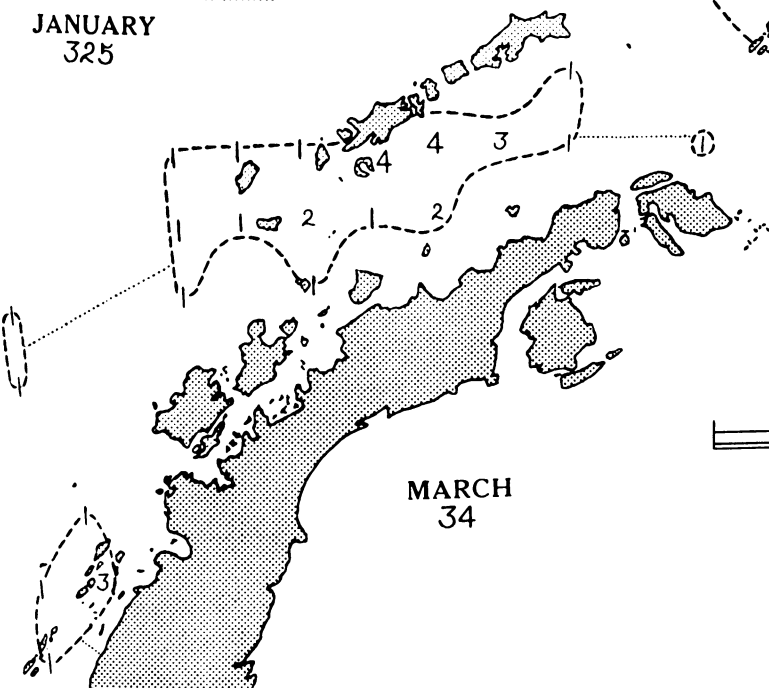
NOVEMBER  
161



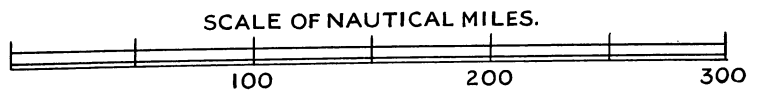
JANUARY  
325



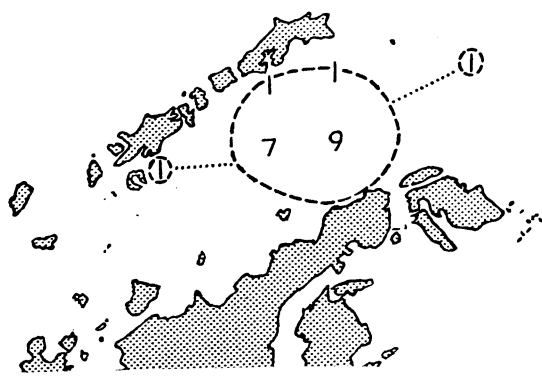
FEBRUARY  
91



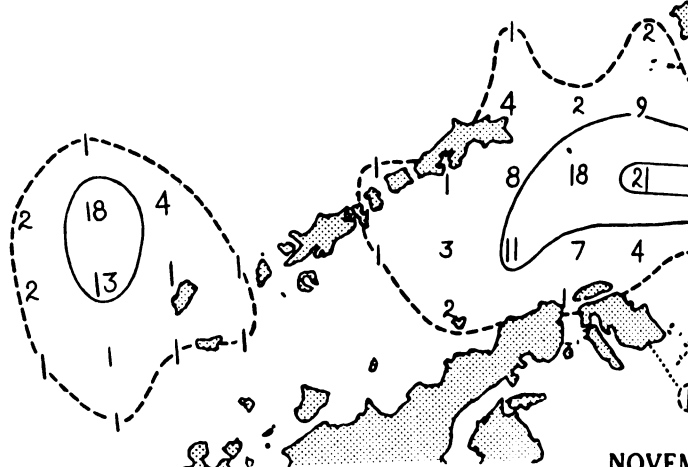
MARCH  
34



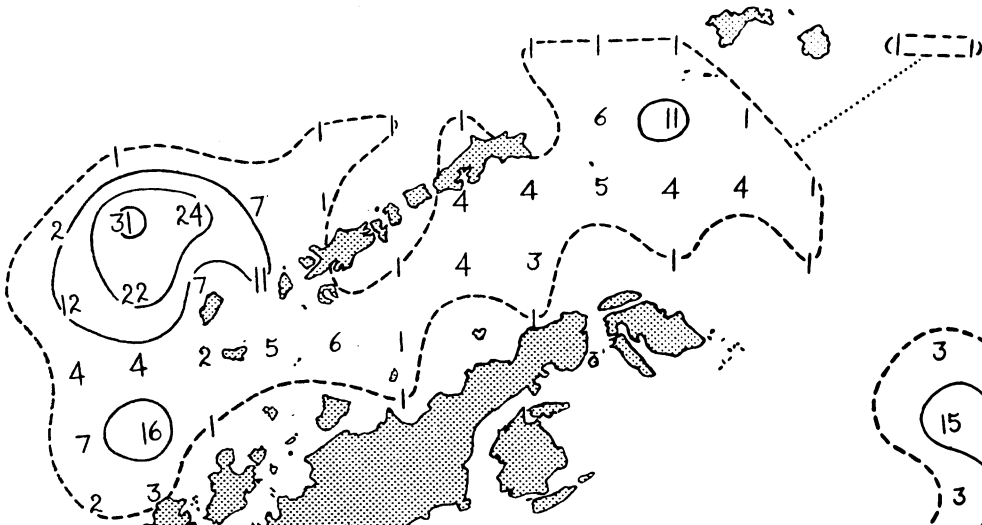
Distribution of Blue whales on the South Shetland grounds in season 1923-4



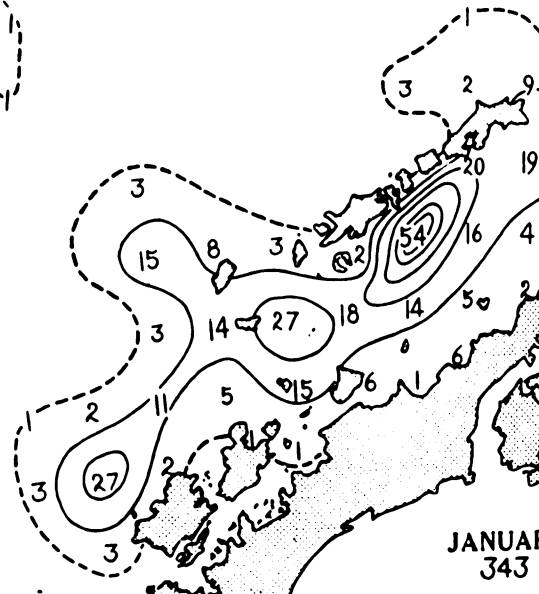
OCTOBER  
20



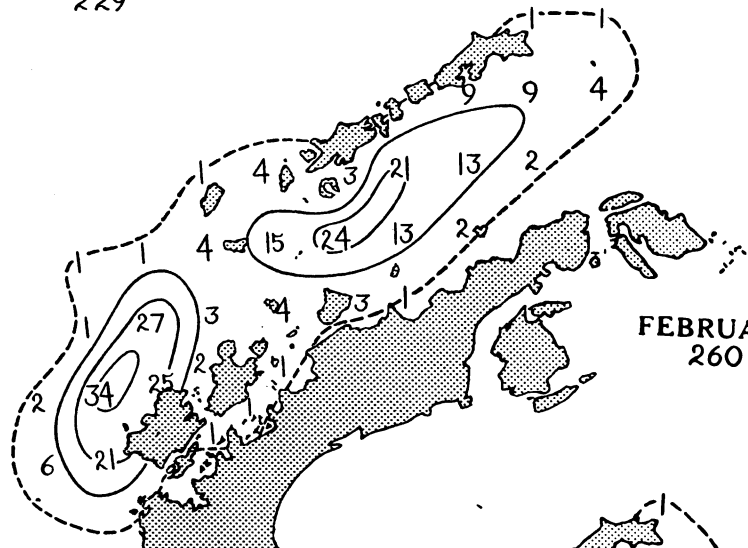
NOVEMBER  
18



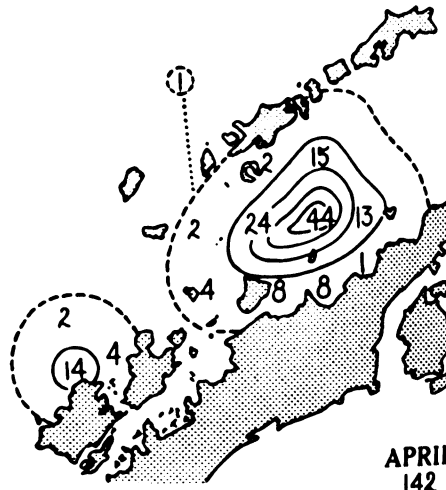
DECEMBER  
29



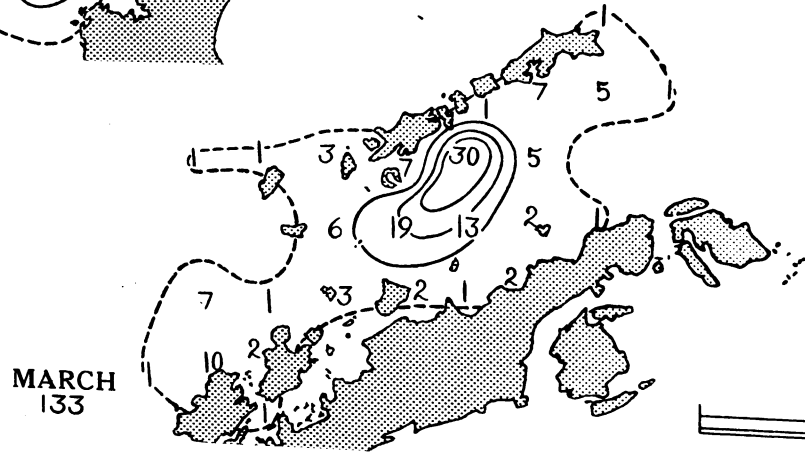
JANUARY  
34



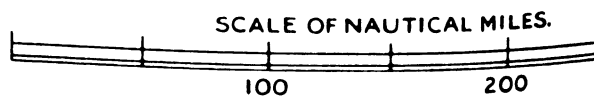
FEBRUARY  
26



APRIL  
14

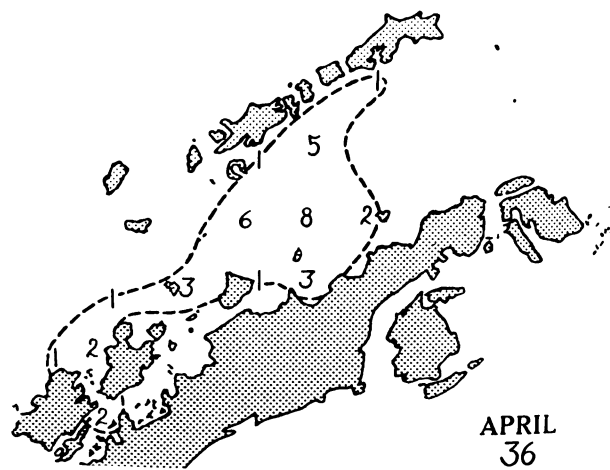
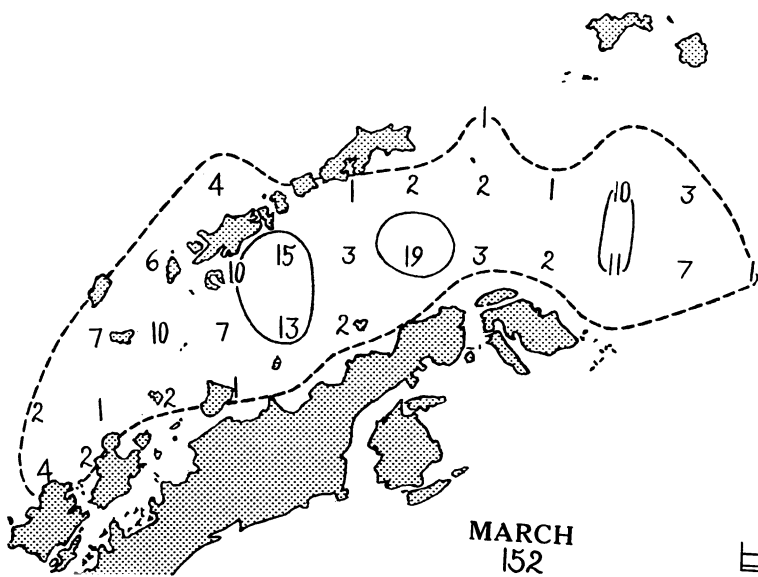
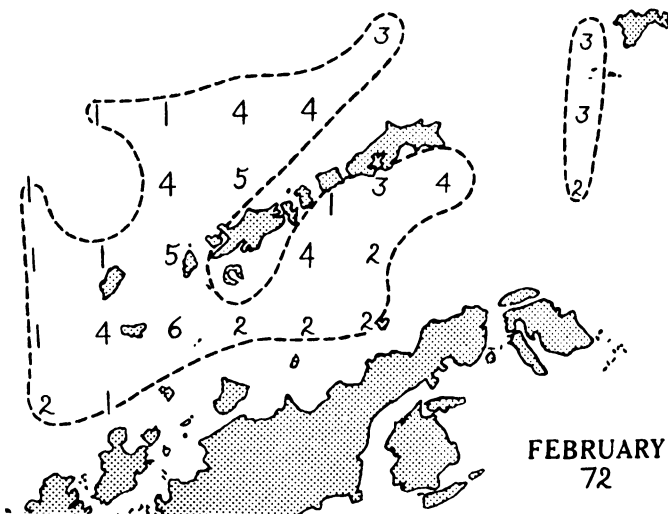
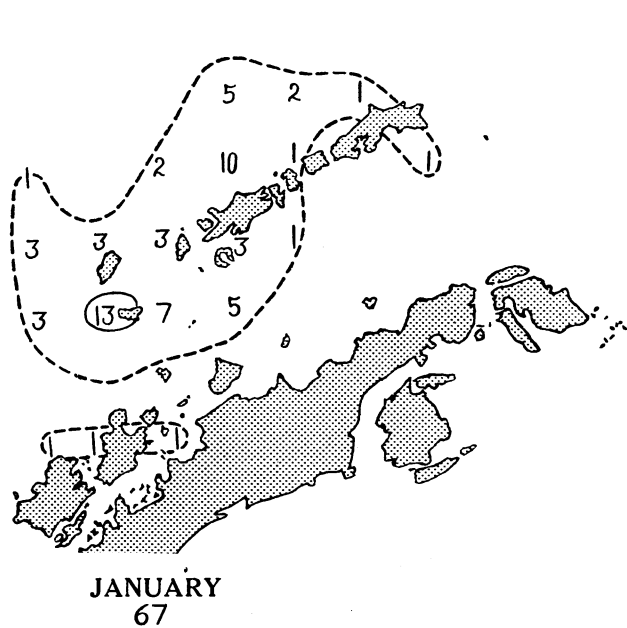
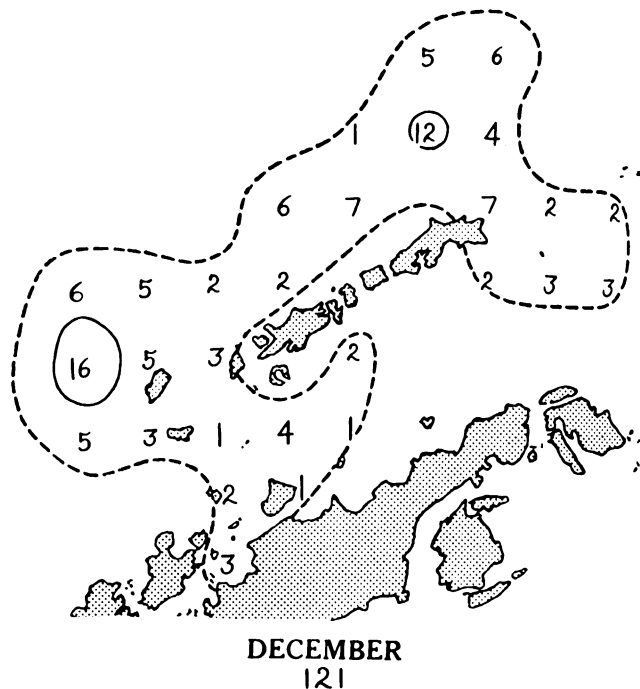
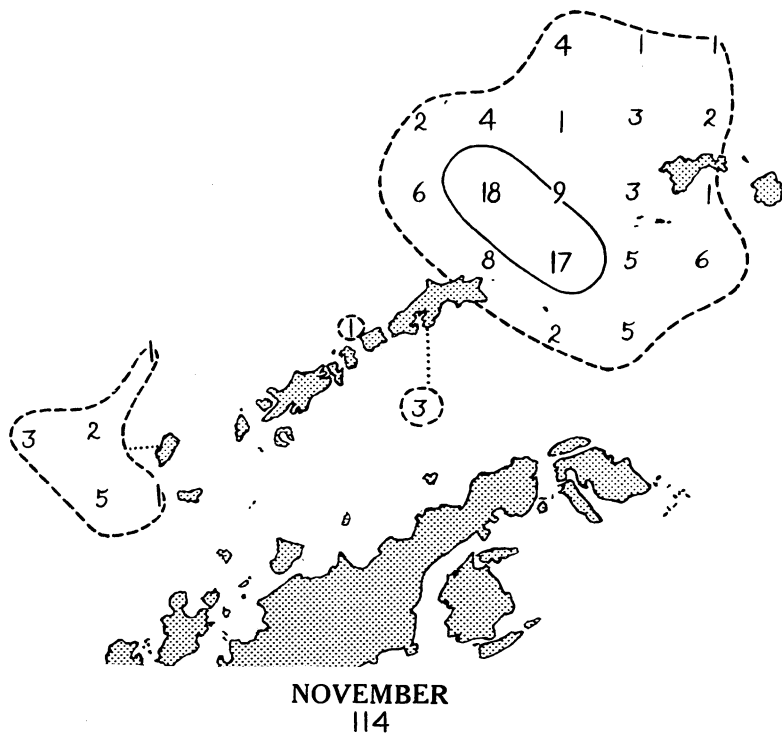


MARCH  
13



Distribution of Blue whales on the South Shetland grounds in season 1924-5

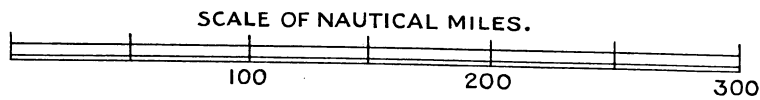
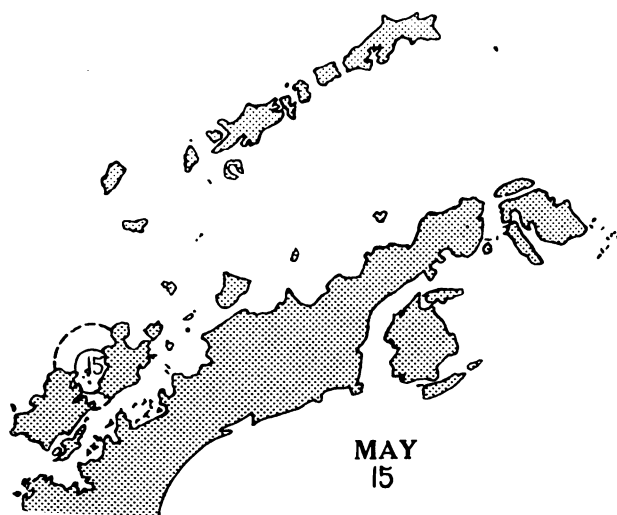
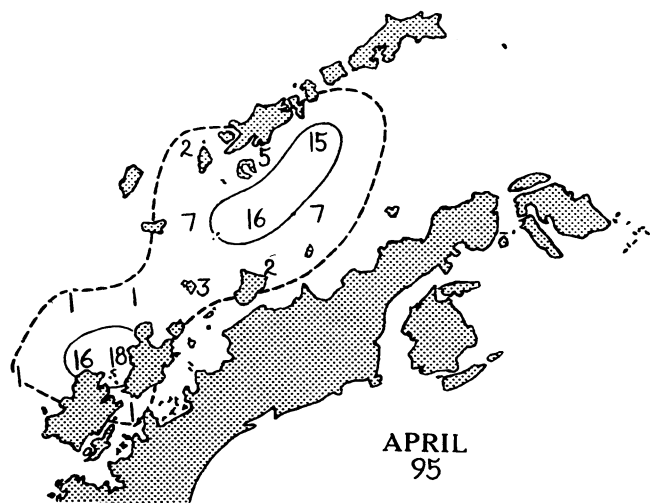
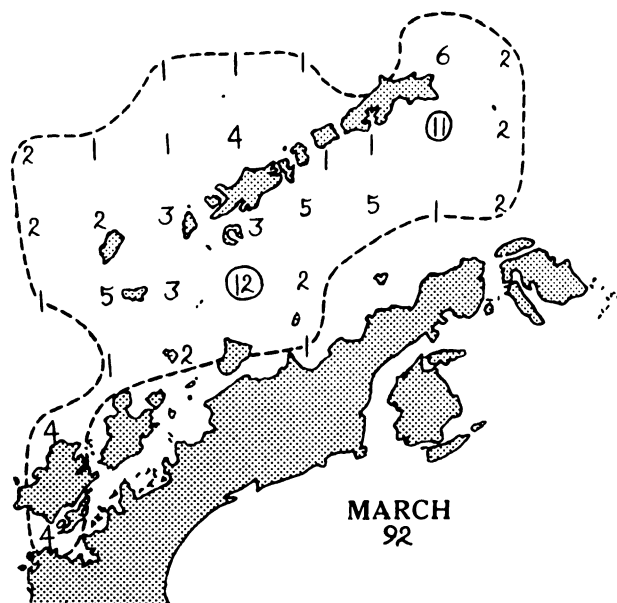
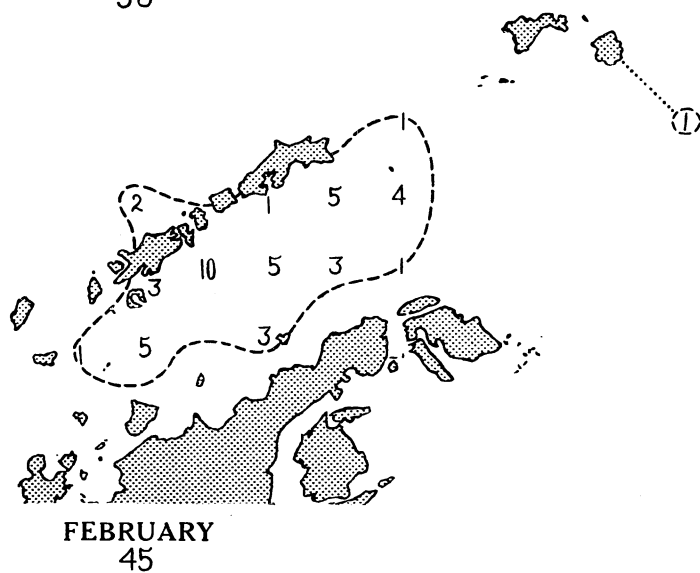
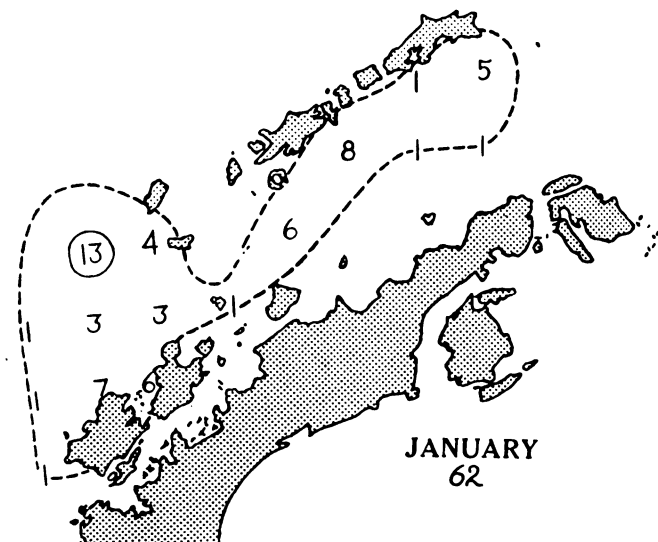
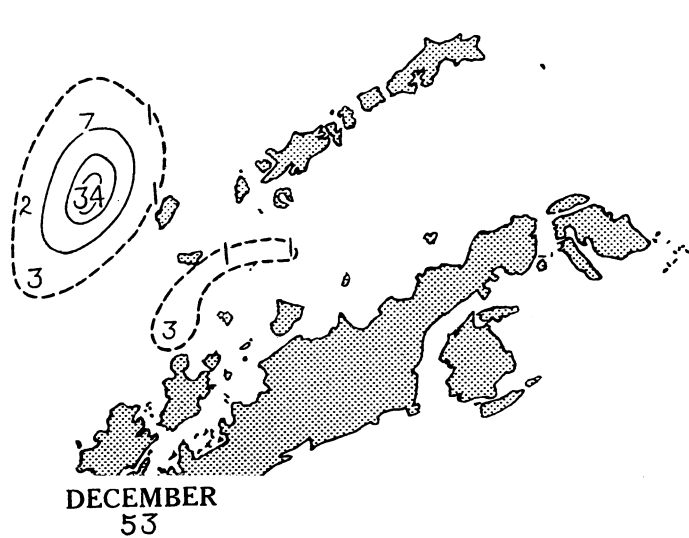




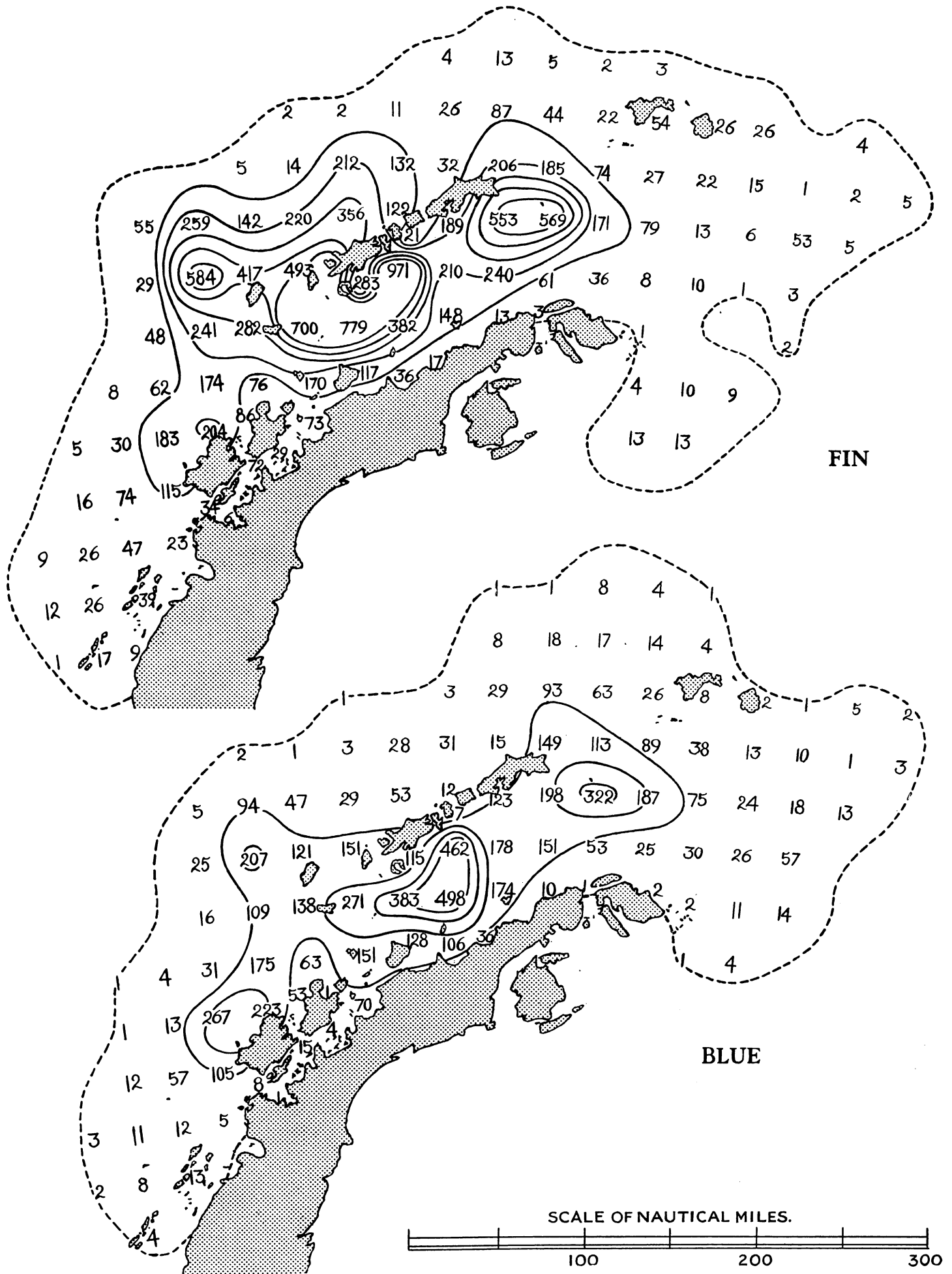
Distribution of Blue whales on the South Shetland grounds in season 1926-7



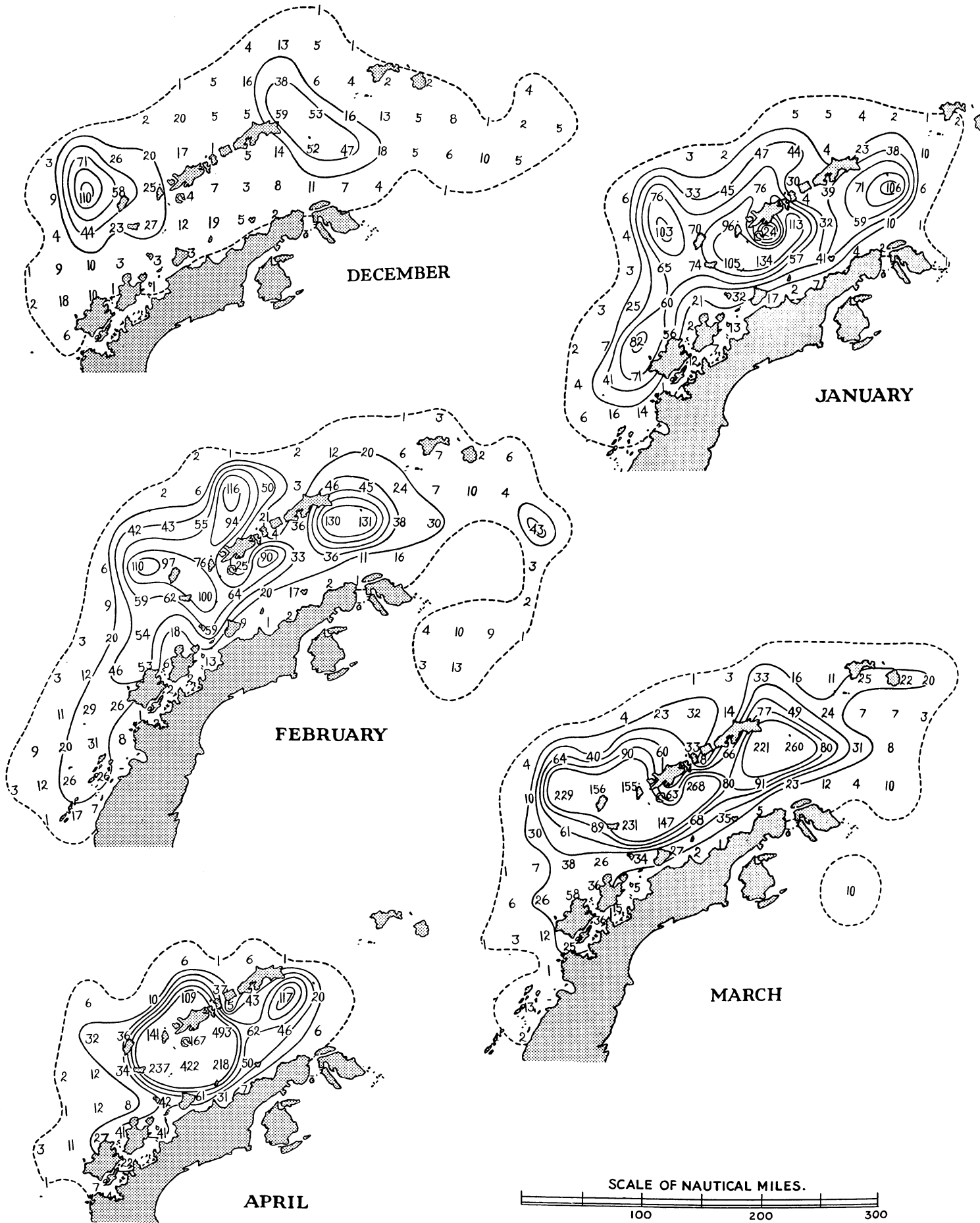




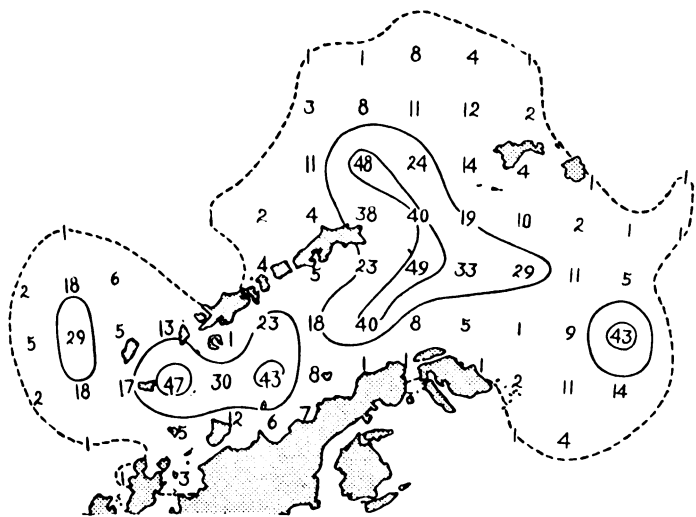
Distribution of Blue whales on the South Shetland grounds in season 1928-9



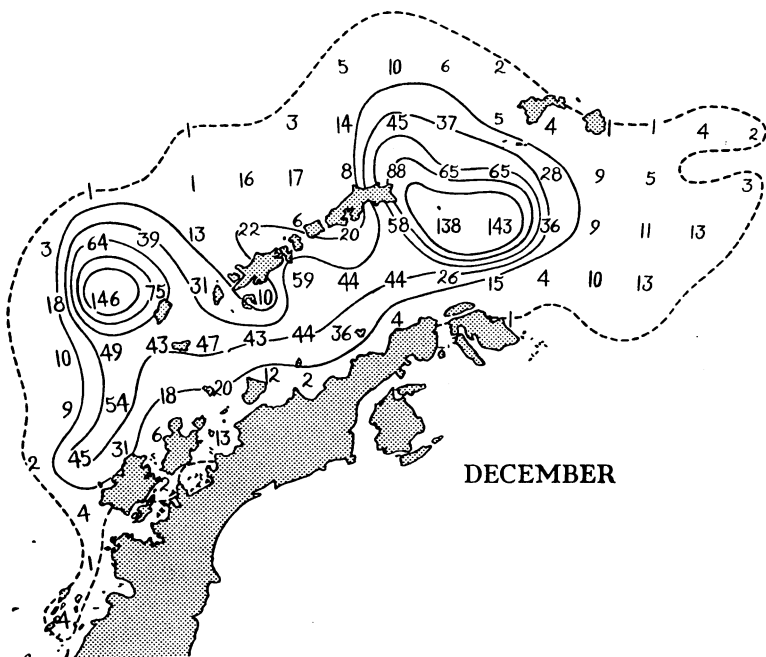
Distribution of Fin and Blue whales on the South Shetland grounds: based on all recorded positions of capture during the eight seasons 1922-3 to 1929-30



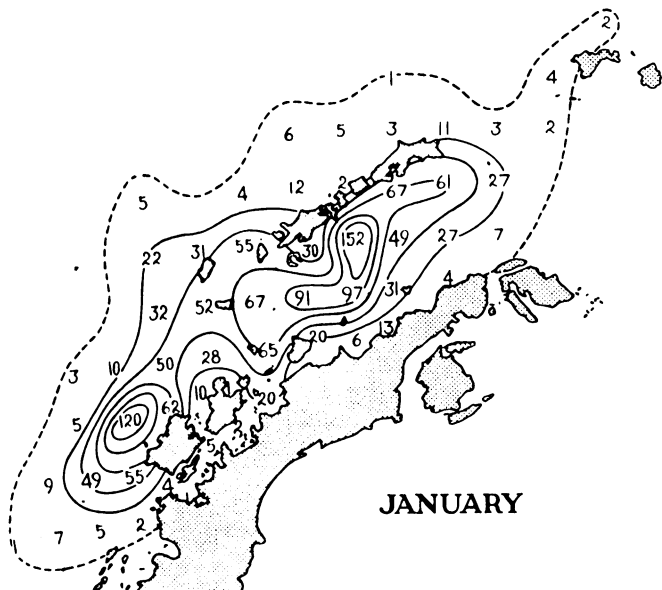
Monthly distribution of Fin whales on the South Shetland grounds: based on monthly totals for the eight seasons 1922-3 to 1929-30



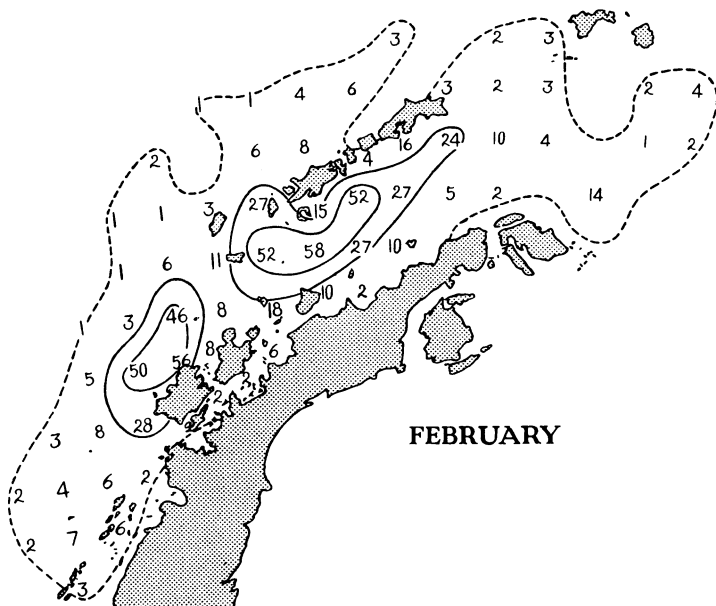
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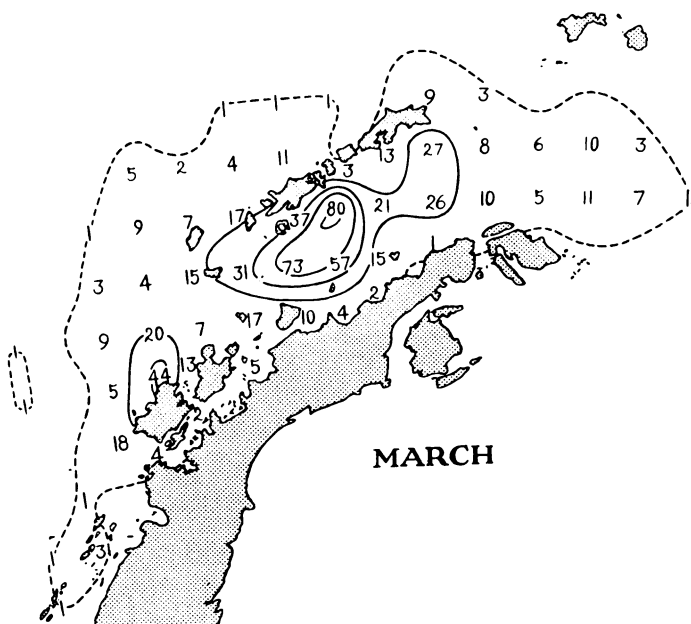
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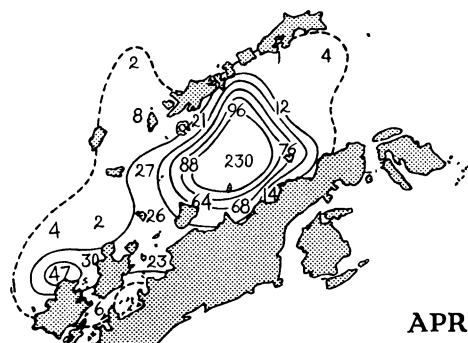
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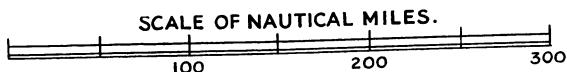
FEBRUARY



MARCH



APRIL



Monthly distribution of Blue whales on the South Shetland grounds: based on monthly totals for the seven seasons 1922-3 to 1928-9

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