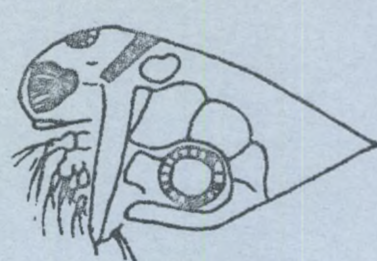

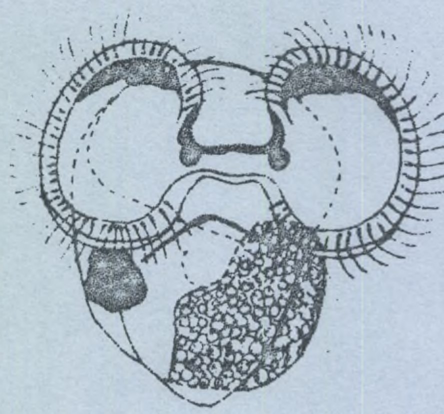

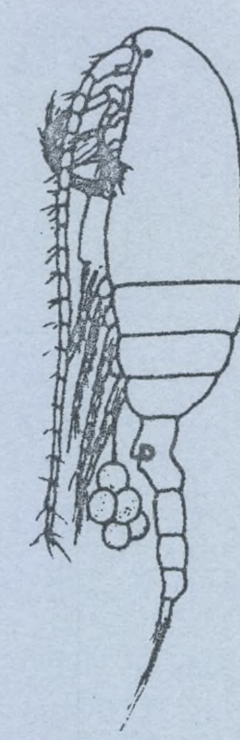

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Changes in productivity and distribution of zooplankton off the coast in the Baltic proper in 1971.

by

Hans Ackefors & Lars Hernroth

September 1973

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CONTENTS

INTRODUCTION

The increasing interest in the Baltic proper during the last decade started mainly due to the many reports by the Swedish hydrographer Fonselius about the stagnation periods with hydrogen sulphide in the bottom waters of the deep basins (see e.g. FONSELIUS, 1970). The periods of stagnation are natural processes having occurred during hundreds of years as a result of the characteristic hydrographical conditions (HALLBERG, 1973). The influence by pollution is difficult to distinguish from such natural events, but the deterioration of the oxygen concentration in bottom waters outside the deep basins indicates that there is probably increasing amounts of sewage water discharged into the Baltic (FONSELIUS, 1969).

Recently the great amount of chlorinated hydrocarbons such as PCB and DDT in fish has called our attention to the Baltic proper (JENSEN et al., 1972). The cod liver e.g. is no longer permitted to be used from fish caught in the southern Baltic proper. This is a far more serious problem than the contamination of mercury although the fish in some coastal areas, where the concentration exceeds 1 mg Hg per kg fish, are banned for the commercial market (cf. ACKEFORS, 1971).

The increasing catches of fish in the Baltic proper from about 310 000 tons in 1961 to about 550 000 tons in 1970 (ACKEFORS & HERNROTH, 1972; ACKEFORS, unpubl.) is interesting, when discussing the biological resources in relation to the increasing fishing and pollution. The contamination of chlorinated hydrocarbons such as DDT and PCB and of heavy metals such as mercury is a threat against the valuable fish resources in the Baltic proper, but the problem of overfishing may also be a question of greatest importance.

In 1972 the initiative to a convention for an international regulation of the fishery in the Baltic proper was taken and in 1973 preparations for a convention concerning pollution were also made. The importance of more intensive biological investigations of the whole ecosystem in the Baltic in order to get scientific data is a matter of great importance. Without such data the commissions responsible for the mentioned coming conventions cannot propose measures against overfishing and pollution.

Several hydrographical and biological models for biological investigations have been presented (e.g. SJÖBERG et al., 1972; JANSSON, 1972). The biological models will try to illustrate the energy flow through the whole ecosystem. Since 1972 our institute is working with the primary and secondary production in the pelagic ecosystem of the Baltic proper. Old results from the 1960's have been recalculated as a first approach to calculate the secondary production of zooplankton (ACKEFORS,1972; ACKEFORS & HERNROTH, 1972; ACKEFORS, unpubl.). The present paper deals with the net production of zooplankton (excluding microzooplankton) and the distribution of the different species off the coast in the Baltic proper in relation to the hydrographical data of 1971. The seasonal distribution of zooplankton 1968-1970 in the same area is evident in ACKEFORS & HERNROTH (1970a, b, 1971).

ACKNOWLEDGEMENTS

This investigation has been supported by grants from "Statens Naturvårdsverk" (contr.nr. 7-71/71) which is greatfully acknowledged. The authors are greatly indebted to Mr. Sven Engström who has been responsible for the work on board R/V "Skagerak" when the samples were taken. We also want to express our thanks to Miss Birgitta Bengtsson, Miss Katarina Karleflo and Mr. Lars Lind who helped us to prepare this paper.

MATERIAL AND METHODS

In 1971 four zooplankton expeditions to the Baltic proper were made. As in our previous investigations (ACKEFORS & HERNROTH, 1970a, b, 1971) a station net consisting of seven stations was used (see fig. 1). During the four expeditions all stations were visited with two exceptions: in January and in December station F 72 was left out. On both occasions due to rough weather. All samples were collected with a Nansen net with a mesh-size of 0.16 mm. At each station the hauls were fractioned according to the following standards: 25-0 m, 50-25 m, 100-50 m, 200-100 m. In the laboratory the samples were sub-sampled in the modified whirling apparatus constructed by KOTT (1953:87) and then counted and analysed to species and for the copepods also to developmental stages.

The hydrographical data have been analysed by the Hydrographical Department, Institute of Marine Research (ANON., 1972a, b).

RESULTS

HYDROGRAPHY

The biological life of the Baltic proper is greatly influenced by the stagnation periods with decreasing oxygen concentration and the development of hydrogen sulphide in the bottom waters. Such a stagnation period with hydrogen sulphide started in 1967 but was broken in the beginning of 1969 when the bottom water of the Bornholm basin (cf. fig. 1) was replaced by oxygen-rich water. In the end of the year this water had reached the Gotland basin and bottom water saturated with hydrogen sulphide was forced to the north. In June 1970, parts of the bottom water in the Gulf of Finland was covered with hydrogen sulphide. At the most northern station (F 72, cf. fig. 1) the hydrogen sulphide was present in the bottom water from at least May to September, 1970

(ACKEFORS & HERNROTH, 1971). The Landsort deep contained now and then hydrogen sulphide in 1969-1970. West of Gotland at station S 41, hydrogen sulphide was present during most of the year 1970. (This area receives some of the water coming from the Bornholm and Gotland basins and the rest is forced toward the north into the Gulf of Finland.)

The oxygen conditions in 1971:

During the investigation in 1971 the oxygen conditions deteriorated. In January there was only hydrogen sulphide in the bottom water at station S 41 (cf. table 2). At that station hydrogen sulphide had been present at the bottom since May 1970. In the end of 1970 there was 20-25 µgat H_2S per l water. In January 1971 the concentration had decreased to 7-9 µgat H_2S per l water. In April no hydrogen sulphide could be detected at that station nor at the other stations. In August, however, hydrogen sulphide had developed at station S 41 as well as at stations S 24 (Bornholm deep) and F 81 (Gotland deep). In December there was only hydrogen sulphide left at station F 81.

The temperature and salinity in 1971:

In January the surface temperature was about 2-4°C. As usual the water temperature was quite uniform from surface to halocline (about 60 m depth). Below the halocline the temperature was 1-3°C higher. In April the surface temperature was slightly lower or 2-3°C. During the investigation in August the surface temperature was 15-16°C. In December the water temperature had decreased to 4-7°C (cf. tables 2-5).

The salinity in the surface water varied from 6.4 ‰ to 8.9 ‰. The lowest value was found in the northern Baltic proper at station F 78 in August and the highest in the southern Baltic at station S 12 in November. The salinity concentration is rather homogenous down to the halocline. The halocline was found at the following levels in 1971: At S 12 below 30 m, at F 78 below 40 m, at S 24 and S 41 below 50 m and at 8 A, F 81 and F 72 below 60 m. The salinity in the bottom waters was in the range of: 13.9-16.6 ‰ (S 12), 15.4-16.0 ‰ (S 24), 10.9-12.7 ‰ (8 A), 12.8 ‰ (F 81), 11.0-11.1 ‰ (F 72), 11.2-11.3 ‰ (F 78) and 10.3-10.5 ‰ (S 41).

ZOOPLANKTON

Cnidaria

Cyanea capillata (L.)

Three specimens were found in 1971. In January one medusae (40 mm ⌀) was found at station F 81 in a net haul between 200 m and 100 m. In April one individual (5 mm) was caught at the same station between 100 m and 50 m and one individual (3 mm) at station 8 A between 80 m and 50 m.

Ctenophora

Pleurobrachia pileus (O.F. MÜLLER)

Ten larvae were caught in a net haul from 25 m depth to surface in January at station S 12.

Rotatoria

Keratella spp.

Three different species occur sparsely off the coast in the northern Baltic proper, viz. *Keratella quadrata quadrata* (MUELLER), *K. quadrata platei* (JÄGERSKIÖLD) and *K. cruciformis eichwaldi* (LEVANDER). The first one of the species is the most common one. In August 350 ind. were caught in a net haul between 25 m and surface at station F 72. This is equal to about 1 800 ind. m^{-2}.

Synchaeta spp.

The authors have not distinguised between the six different species in the Baltic proper: *S. baltica*, *S. curvata*, *S. fennica*, *S. gyrina*, *S. monopus* and *S. triopthalma* (BERZINS, 1960).
The species occured very sparsely in the samples (figs. 2-5), except in August when about 40 000 ind. m^{-2} were found at station F 72. The

main part of the specimens occurred in the net haul between 25 m and surface. Normally all the specimens occur above the 50 m level. In this case we also found about 300 ind. in the net haul from 100 m to 50 m.

In November-December (fig. 5) the species occurred sparsely in the southern Baltic proper except single specimens at station F 78.

Polychaeta

Pygospio elegans CLAPARÈDE

Larvae occured at stations S 12 and S 24 in the Arkona and the Bornholm Sea in January and April. (In 1970 the larvae were found from June to October, cf. ACKEFORS & HERNROTH, 1971.) Most of the larvae occurred in April in net hauls from 25 m to surface. The bottom temperatures were in January about 6°C. In April the temperature was about 2°C at the bottom at station S 12 and 6.5°C at station S 24.

Harmothoe sarsi CLAPARÈDE

Larvae were found on all sampling occasions (figs. 6-9). In January and in December most of them were found in deep net hauls below 50 m depth. The greatest abundance above 50 m level occured in April and August in the northern part of the Gotland Sea. The greatest density of larvae in January and December was about 5 000 ind. m^{-2} in the southern Baltic proper.

Cladocera

Bosmina coregoni maritima (P.E. MÜLLER)

This species occurs normally very sparsely in the first half of the year in the Baltic proper. In 1971 the same pattern of seasonal distribution occurred (figs. 10-13). When the surface water reaches a temperature of 15°C or more the parthenogenetic propagation seems to be very rapid. Like in our previous investigations, the species was very frequent in late summer in the southern Baltic proper. In August more than 1 milj. specimens per m^2 were found at station 8 A. The period of maximum abundance seems to be very short and in October the abundance is already much lower, This time of the year the surface temperature is in the range of 8-10°C (cf. ACKEFORS & HERNROTH, 1971).

Podon spp.

Three species occur in the Baltic proper, viz. Podon intermedius LILLJEBORG, P. polyphemoides LEUCKART (syn. Pleopis polyphemoides, cf. GIESKES, 1971) and P. leuckarti G.O. SARS. The species were not separated this year in the analysis. Most of the specimens, however, belonged to the species P. polyphemoides. Normally the first specimens occur in April and the last specimens disappear in November-December (cf. ACKEFORS, 1969). In 1971 the seasonal distribution is evident in figs. 14-17. Single specimens occured in April. The greatest abundance was found in August when the surface temperature was about 15°C.

Evadne nordmanni LOVÉN

This species is an eurytherm cladoceran and the distribution is normally extended over a long period of the year (figs. 18-21). It has been considered as the most important cladoceran in the Baltic area but you will never find such high abundance as is normal for Bosmina during a short period. 1971 the maximum abundance was found in August at station S 41 where more than 15 000 ind. m^{-2} occured. As is evident from fig. 20 the distribution is very even from south to north. This is a typical distribution pattern for an eurytherm species as Evadne nordmanni.

Copepoda

Limnocalanus macrurus SARS

Limnocalanus macrurus (syn. L. grimaldii (DE GUERNE)) appeared very sparsely during the investigated year. Single specimens were found during all of the four expeditions but the finds were restricted to our three most northern stations F 81, F 78 and F 72. An exception to this is a find at station S 41 in December. As a rule L. macrurus appeared only in the deep hauls (between 200 and 50 m).

Acartia bifilosa GIESBRECHT and A. longiremis LILLJEBORG

Due to the difficulties of distinguishing between young stages of A. bifilosa and A. longiremis no separation of the two species has been made for nauplie and stages I-V. Only adult specimens have been analysed to species. From figs. 22-25 it is evident that Acartia spp. is present during the whole year and its distribution is rather even from south to north. Acartia spp. show a clear preference for the upper water layer (50-0 m) and this is true for all of the four investigated months. The quantitative distribution over the year is rather even although a maximum can be found in August. Nauplie were found during the whole year but their maximum were found in April. Among the adults almost twice as many A. bifilosa as A. longiremis were found.

Eurytemora sp.

The distribution of Eurytemora sp. shows the same pattern 1971 as in our previous investigations, viz. a low number of specimens were found during the year except for a clear maximum in August. The finds were as a rule concentrated to the northern Baltic proper and mostly in the upper 50 m layer. Few nauplie were found and only in August.

Centropages hamatus (LILLJEBORG)

This copepod was present on all sampling occasions but was never very abundant. In April, when the surface temperature was between 2-3°C, the lowest density was found, while August (15-16°C) showed the highest values. As the authors have found in earlier investigations (ACKEFORS & HERNROTH, 1970a, b, 1971) the horizontal distribution of C. hamatus is rather even over the Baltic proper. The vertical distribution however, is rather irregular this year and no general conclusions can therefore be made.

During the winter copepodite stages IV and V dominated but in the April samples adults also began to appear. In August the adults became dominating and during this season the only nauplie of 1971 were found. In the Nov.-December samples, most of the C. hamatus belonged to stages IV-V and I-III.

Pseudocalanus minutus elongatus (BOECK)

Pseudocalanus m. elongatus is together with Temora longicornis the most common species in the Baltic proper. In 1971 P. m. elongatus was abundant at all stations on all sampling occasions. Minimum values were observed in April and maximum values in August. Below 50 m level P. m. elongatus is by far the most common species all through the year. The older developmental stages seem to prefer the deep waters below the halocline while the younger stages are found closer to the surface. Nauplie were found during the whole year between 25 m and surface but were most abundant in April.

Temora longicornis P. MÜLLER

As was mentioned earlier, Temora longicornis is one of the two dominating species in the Baltic plankton fauna. From figs. 38-41 it is evident that T. longicornis is present during the whole year over the whole Baltic proper. In April when the temperature reached its minimum, the smallest number of specimens were found. The greatest abundance appeared in August when the highest temperatures were found. From figs. 38-41 it is also evident that T. longicornis has a clear preference for the depths above 50 m.

During the first half of the year, copepodite stages IV-VI seemed to dominate. In the samples taken in August and Nov.-December, nauplie and copepodite stages I-III also appeared, but the older stages were still dominating.

Oithona similis CLAUS

The distribution of Oithona similis in the Baltic proper follows the flow of the salt bottom water. Thus, O. similis is mainly found in the deep hauls at stations S 12, S 24, 8 A and F 81. The highest abundance was found at the Bornholm deep but on a single occasion one specimen was found as far to the north as F 72 in a haul between 170 and 100 m. The salinity on this occasion was 10.8-11.0 ‰.

Cirripedia

Balanus improvisus DARWIN

Only one Balanus nauplie was found in 1971. This occurred in August at station F 72 in a net haul between 100 and 50 m.

Amphipoda

Hyperia galba MONTAGY

Hyperia galba appeared in two hauls during this investigation. On both occasions in deep hauls during the April expedition. At station F 81 five specimens were found between 200 and 100 m and at station F 72 one specimen appeared between 170 and 100 m.

Gastropoda

As is evident from our previous investigations (ACKEFORS & HERNROTH, 1970a, b, 1971), the appearance of Gastropod larvae is concentrated to the summer and autumn months. In 1971, larvae were found on five occasions in August and once in November. Most of the specimens occurred in the upper 50 m layer.

Lamellibranchiata

Mytilus edulis (L.)

From figs. 46-49 it is evident that larvae of Mytilus edulis are distributed over the whole Baltic proper. The maximum abundance was found in August in the southern Baltic proper. Generally the larvae were concentrated in the upper water mass (50-0 m).

Macoma baltica (L.), Cardium lamarcki REEVE, Mya arenaria (L.)

In this investigation no separation of the three species has been made. The horizontal as well as the vertical distribution (figs. 50-53) of the larvae was rather similar to that of Mytilus edulis.

Chaetognatha

Sagitta elegans baltica RITTER-ZAHONY

The distribution of Sagitta elegans baltica in the Baltic proper is restricted to the areas with high salinity. In this investigation, S. elegans baltica appeared at stations S 12, S 24, 8 A and F 81 but was only abundant at station S 24 where it appeared on all sampling occasions.

Copelata

Fritillaria borealis LOHM

From figs. 54-57 it can be seem that Fritillaria borealis is rather evenly distributed over the Baltic proper. The seasonal fluctuations were fairly small during the year and as a rule the greatest abundance was found in the upper 50 m layer. During the August expedition however, very few specimens were found above the thermocline.

The biomass of zooplankton

The biomass of zooplankton (excluding microzooplankton) has been calculated according to ACKEFORS (1972). The results of the investigation in 1971 are in the same magnitude as the three year mean for 1968-1970 (ACKEFORS & HERNROTH, 1972; ACKEFORS, unpubl.) with a few exceptions. The wet weight expressed as gram per m^2 is evident in figs. 58-61. Those values have been recalculated and expressed as gram carbon per m^2 in figs. 62-65. This can only be done if we accept that the average content of carbon is about 5 % of the wet weight. We know that there is a seasonal fluctuation in carbon content as well as a difference in carbon content for various species. Probably the figure 5 % (40 % of the dry weight) is an underestimation(cf. MARTENS & KRANEIS, 1973).

As is evident from figs. 58-61 the greatest biomass occurred in August. Very high values were reported from station 8 A (37.9 g m^{-2}) and station F 72 (37.7 g m^{-2}). Those values are in the same magnitude as the highest values found in the Bornholm area (ACKEFORS & HERNROTH, 1972). The high value at the most northern station F 72 is conspicuous. The reason is the high density of *Temora longicornis*. Not less than 1 milj. ind. m^{-2} occurred at that station. The main part of *T. longicornis* was found in the net haul between 50 and 25 m. Since the other values of the biomass are also higher than the three year mean 1968-1970, it seems as the production of zooplankton and especially of *T. longicornis* was higher than normal in August 1971. Only one value from station S 24, September 1968, exceeds the mentioned values. On that occasion the biomass value was 41 g m^{-2} wwt.

Taken together, the biomass values in January, 1971, are lower than the three year mean 1968-1970. The mean value for all stations in 1971 was 4.9 g m^{-2} wwt in comparison with 6.9 g m^{-2} wwt 1968-1970. As usual the values in April are lower (cf. ACKEFORS & HERNROTH, 1972) and the mean value was 3.3 g. Both the individual values and the mean, are slightly lower than the three year mean. In August 1971, however, the mean value for all stations is 24.4 g which is higher than the mean values for July-August and September-October in 1968-1970, which were 10 g and 18.7 g respectively. The mean value of 7.2 g for November-December is about the same as earlier values.

The yearly mean value of 9.9 g m^{-2} wwt for all stations in 1971 is very similar to the three year mean value of 9.3 g m^{-2} wwt. This indicates that the slightly lower production in the beginning of the year is compensated by the high production in August. On the other hand it is difficult to compare values, when it is only possible to sample the fauna 4 times a year. However, such years as 1971, when the biomass is higher than normal during the high productivity period from July to October, the total production of zooplankton is probably underestimated when the mean values are used for calculating the secondary production of zooplankton (cf. ACKEFORS, unpubl.). The conclusion is therefore that the production of zooplankton in 1971 was slightly higher than the mean value of 100 g m^{-2} wwt (about 5 g C m^{-2} $year^{-1}$) which ACKEFORS & HERNROTH (1972) calculated for the three year period 1968-1970.

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LEGENDS

Fig. 1. Chart of the Baltic proper.

Figs. 2-57. During 1971 four expeditions to the Baltic proper were made. On two of these occasions all seven of the plankton stations were visited. In January and December station F 72 was left out. The most common species and their seasonal distribution are evident in figs. 2-57. Winter (Dec.-Febr.) is reproduced as white charts, spring (March-May) as yellow charts, summer (June-August) as green charts and autumn (Sept.-Nov.) as blue charts. The abundance appears from the size of the circles. Open circles indicate the two hauls 25-0 m and 50-25 m together and black circles all the deep net hauls together.

	Jan.	April	Aug.	Nov.-Dec.
Synchaeta spp.	2	3	4	5
Harmothoe sarsi	6	7	8	9
Bosmina coregoni maritima	10	11	12	13
Podon sp.	14	15	16	17
Evadne nordmanni	18	19	20	21
Acartia bifilosa Acartia longiremis	22	23	24	25
Eurytemora sp.	26	27	28	29
Centropages hamatus	30	31	32	33
Pseudocalanus minutus elongatus	34	35	36	37
Temora longicornis	38	39	40	41
Oithona similis	42	43	44	45
Mytilus edulis	46	47	48	49
Macoma baltica Cardium lamarcki Mya arenaria	50	51	52	53
Fritillaria borealis	54	55	56	57

Figs. 58-61. Chart illustrating wet weight as g/m^2.

Figs. 62-65. Chart illustrating gram carbon/m^2.

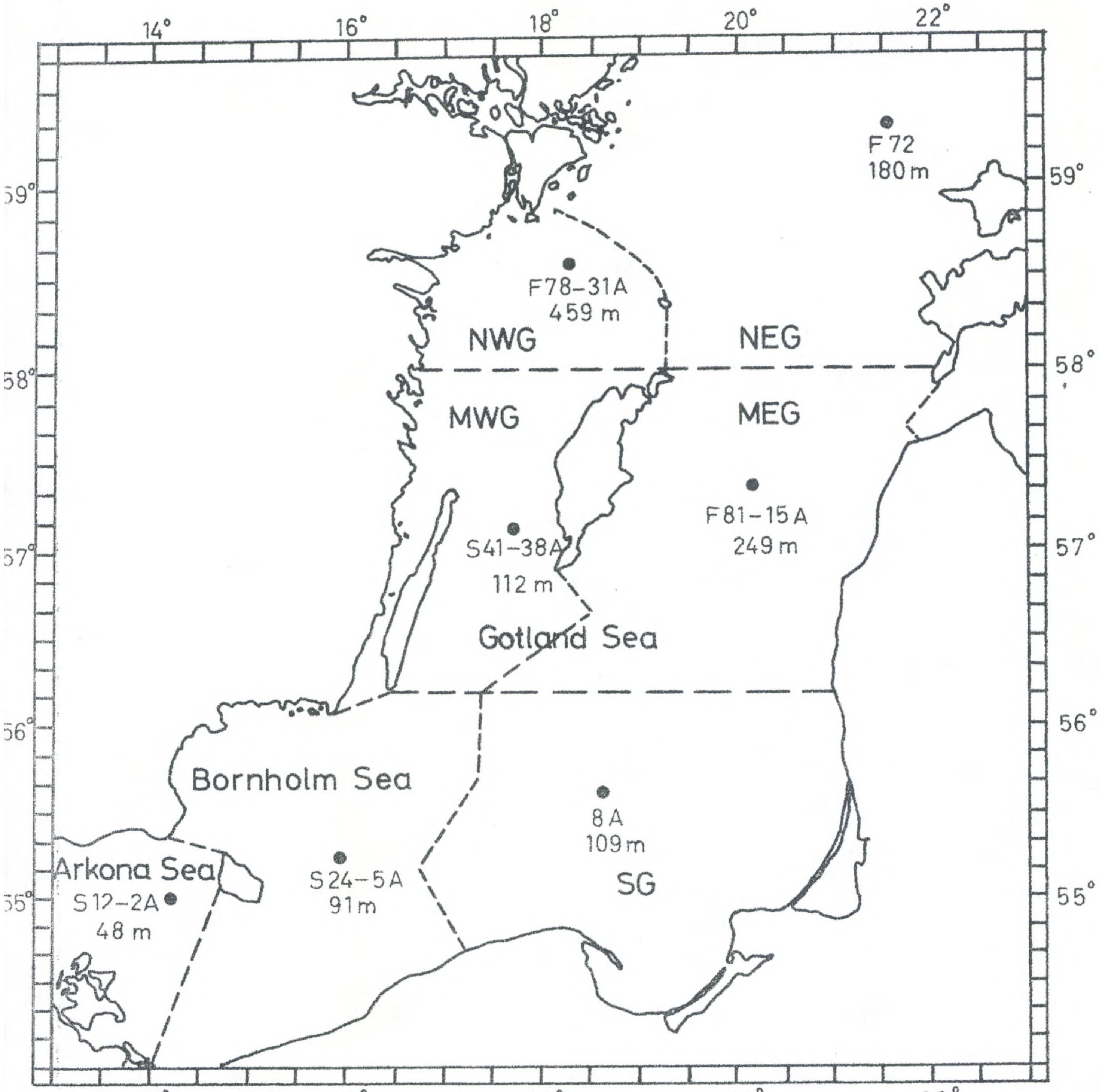
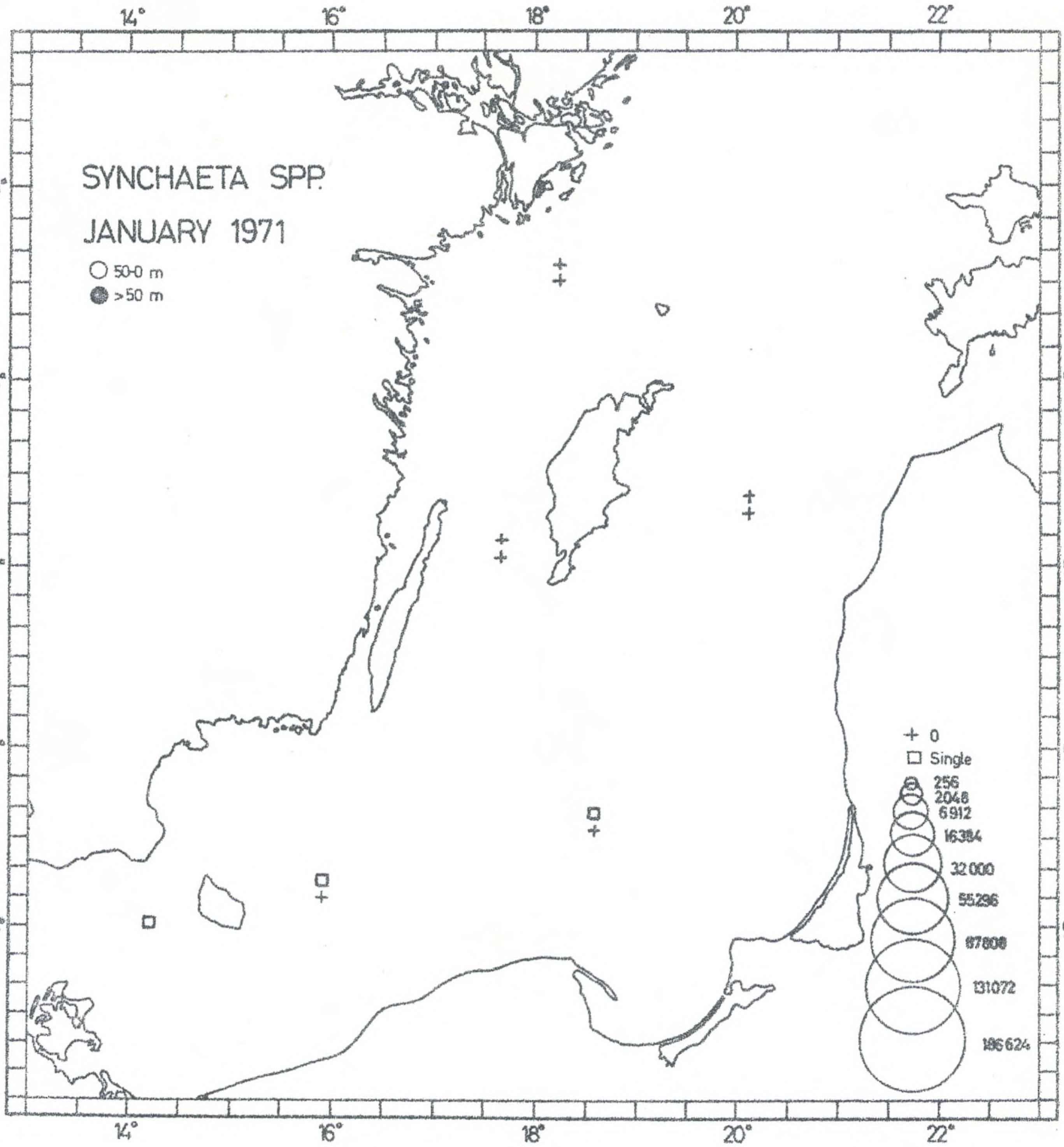


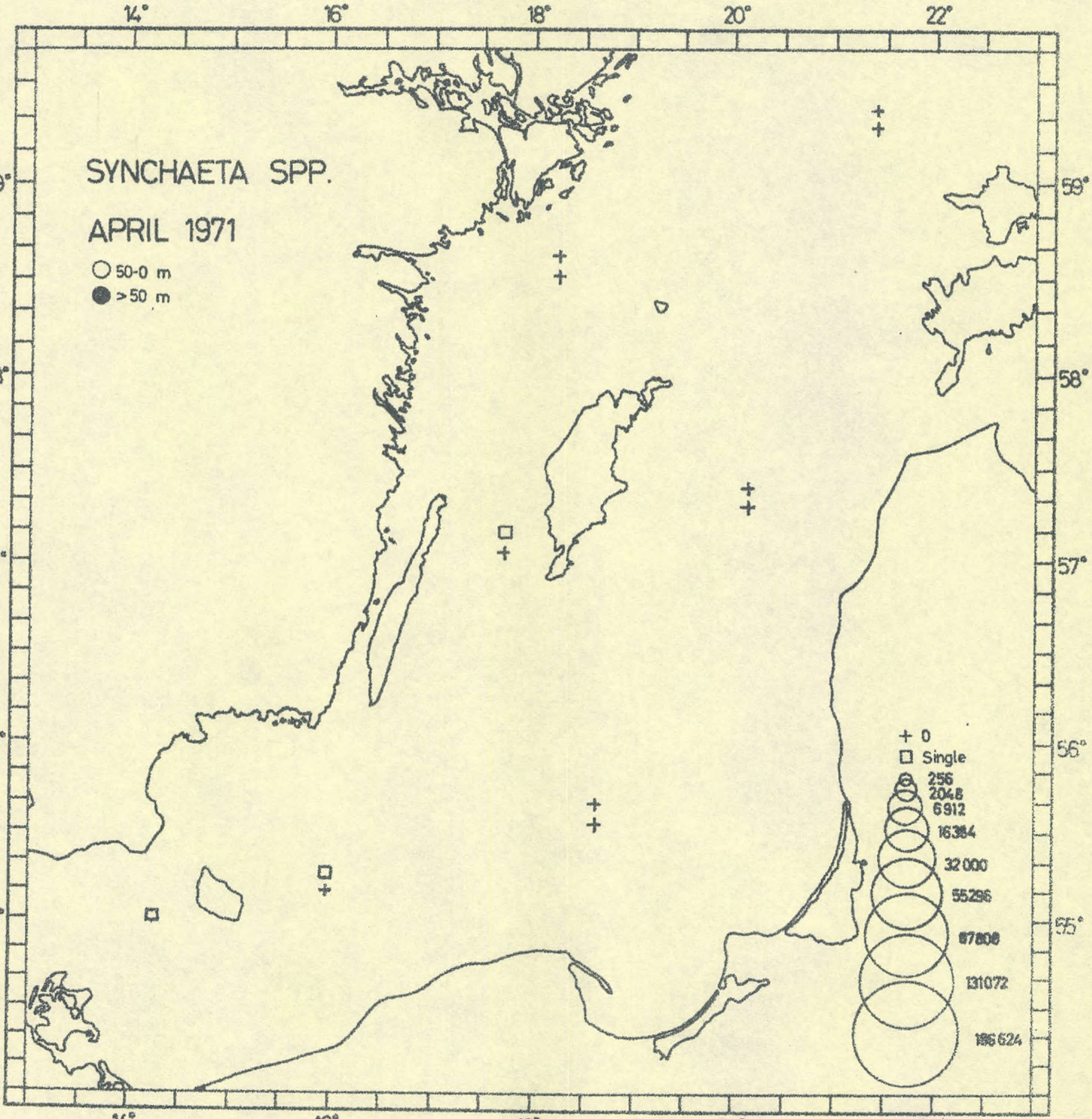
Fig. 1. Chart of the Baltic proper and the three subareas, the Arkona Sea, the Bornholm Sea and the Gotland Sea according to WATTENBERG (1949). The Gotland Sea is devided into an eastern and western part by WATTENBERG. According to ACKEFORS (1969a) the Gotland Sea may be devided into five subareas; the southern (SG), the middle eastern and western (MEG and MWG) and the north-eastern and north-western (NEG and NWG). The seven plankton stations are evident from the chart, in some cases with both old and new symbols as well as the depths.

Fig. 2



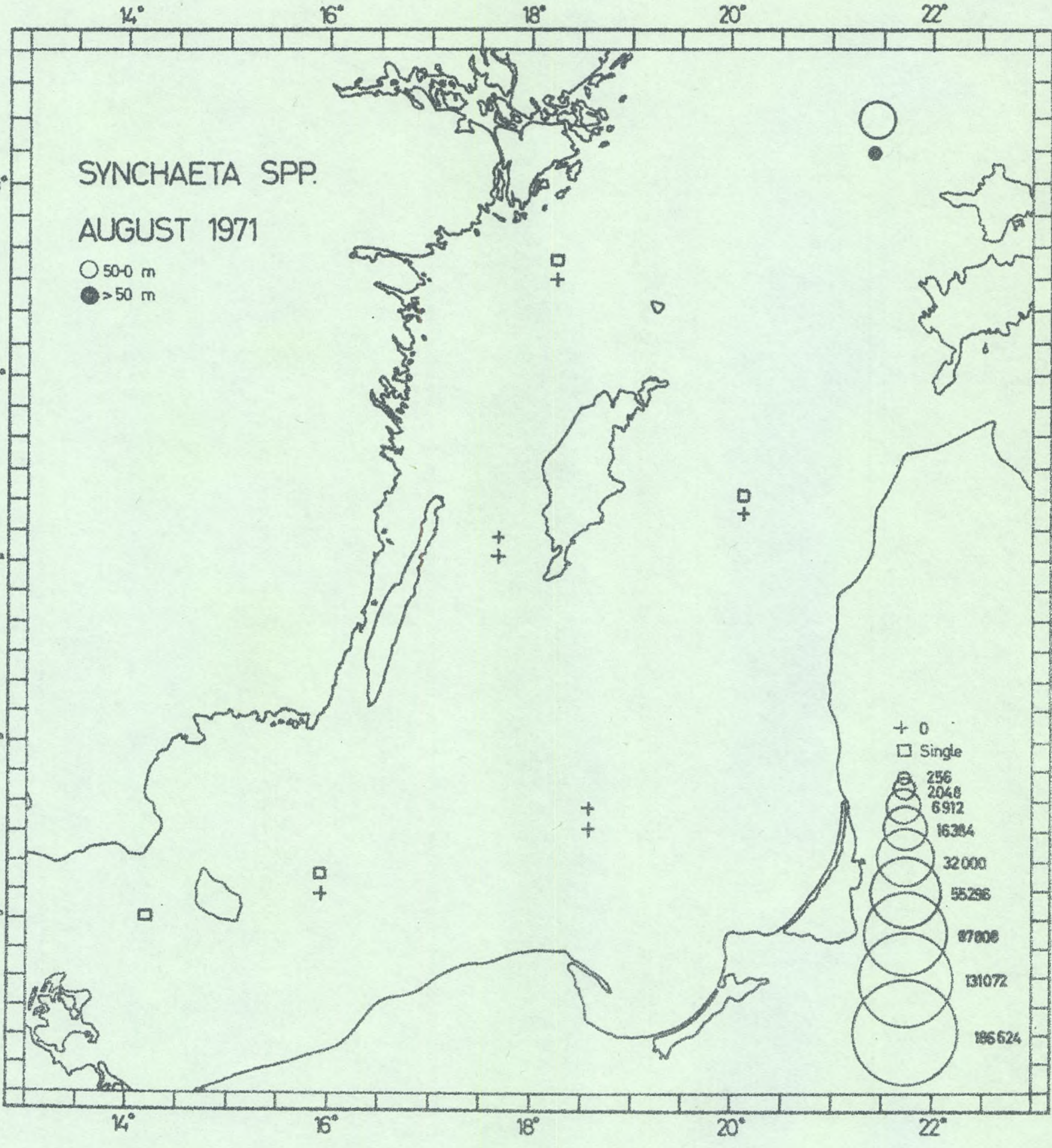
SYNCHAETA SPP.
JANUARY 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.3



SYNCHAETA SPP.
APRIL 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.4



SYNCHAETA SPP.
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Fig.5

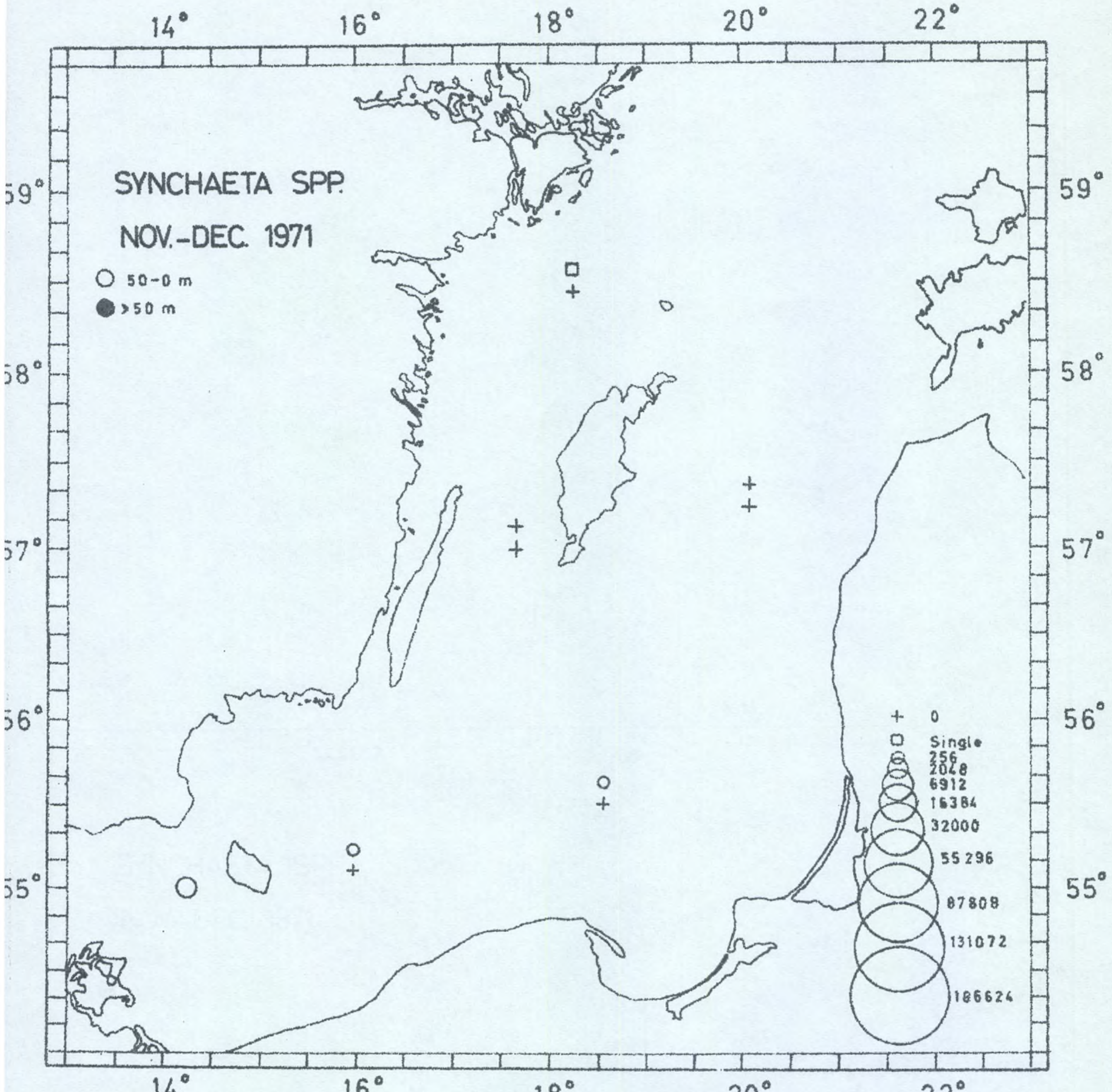

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Fig.6

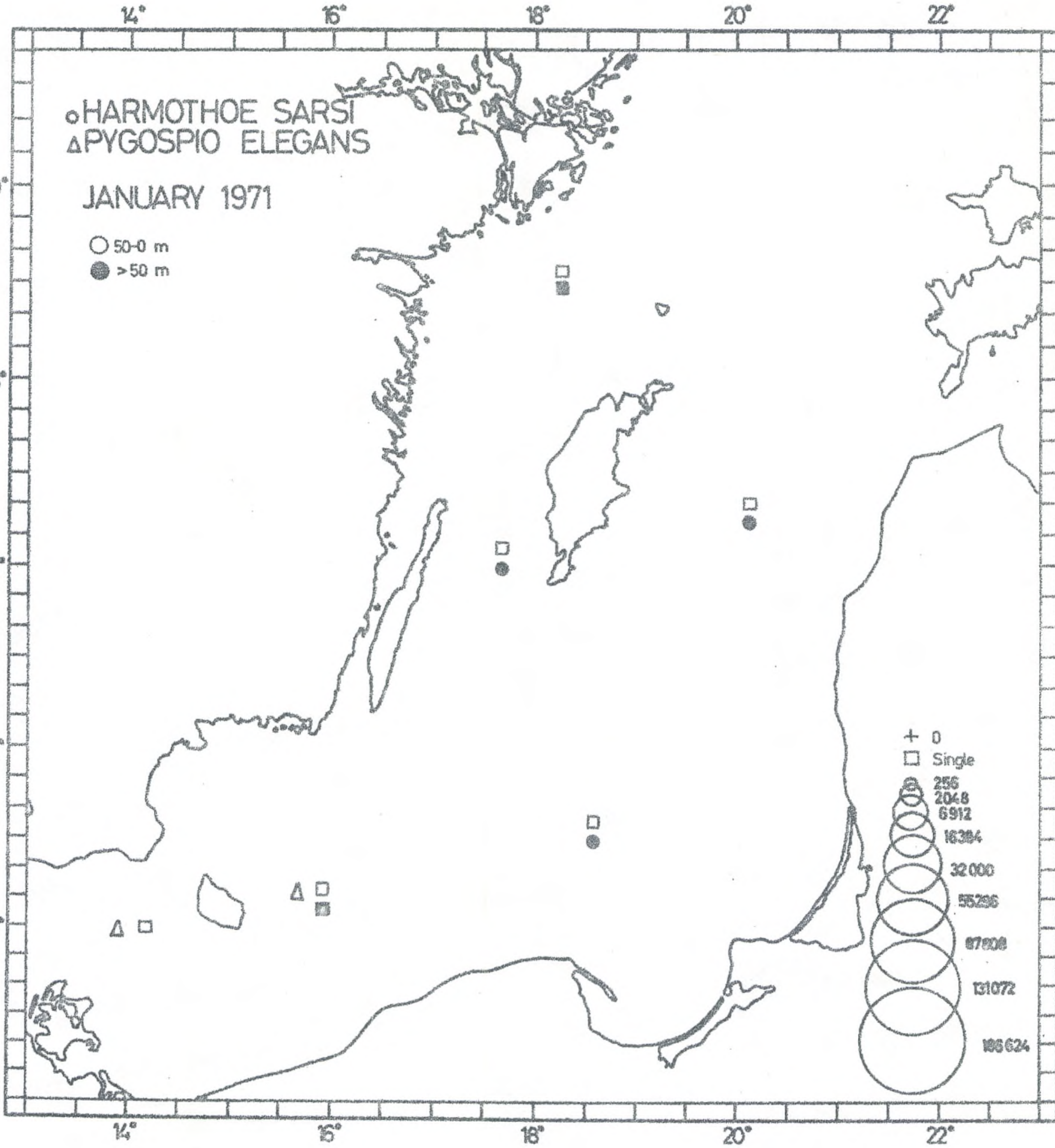

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Fig.7

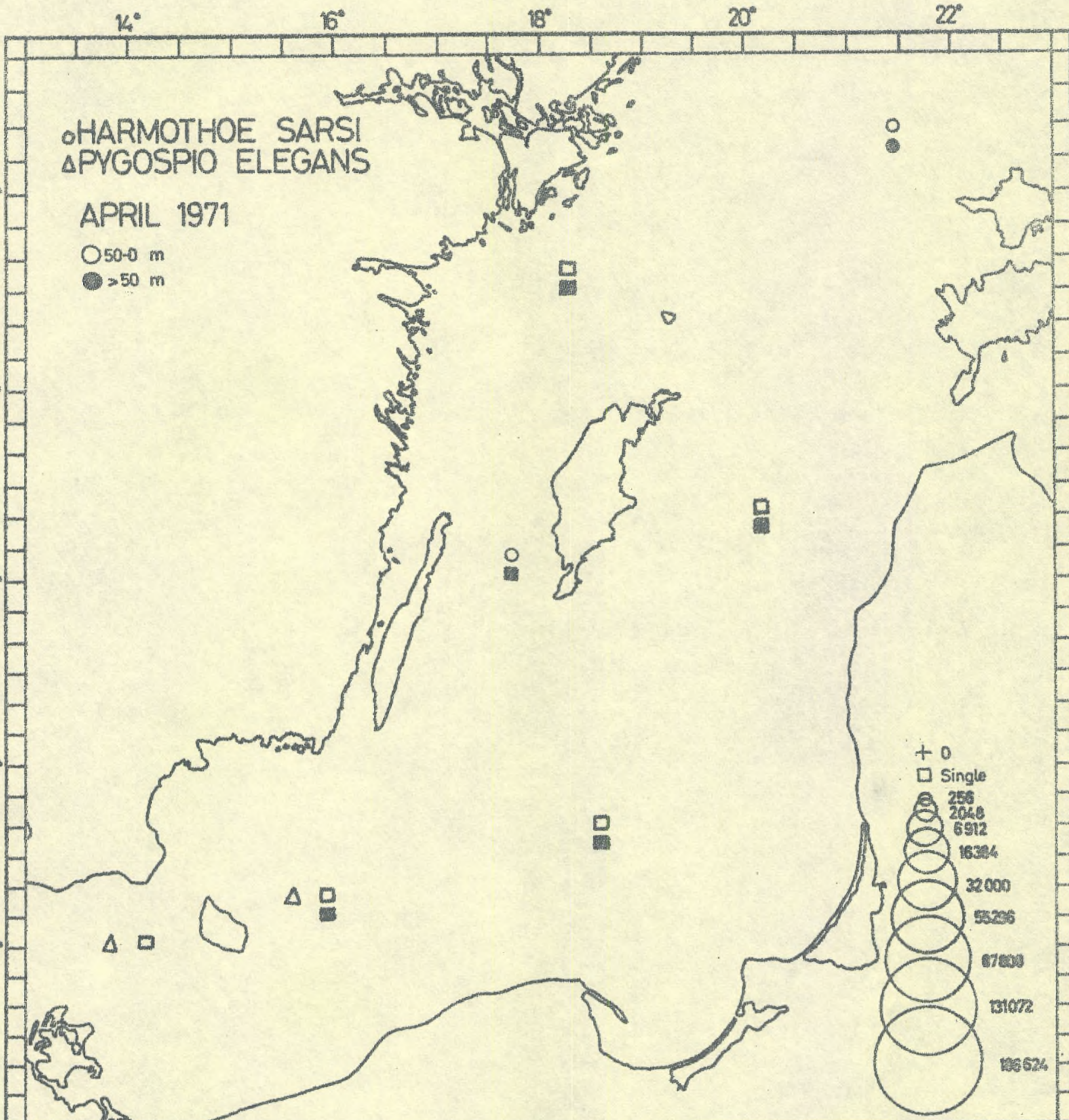

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Fig.8

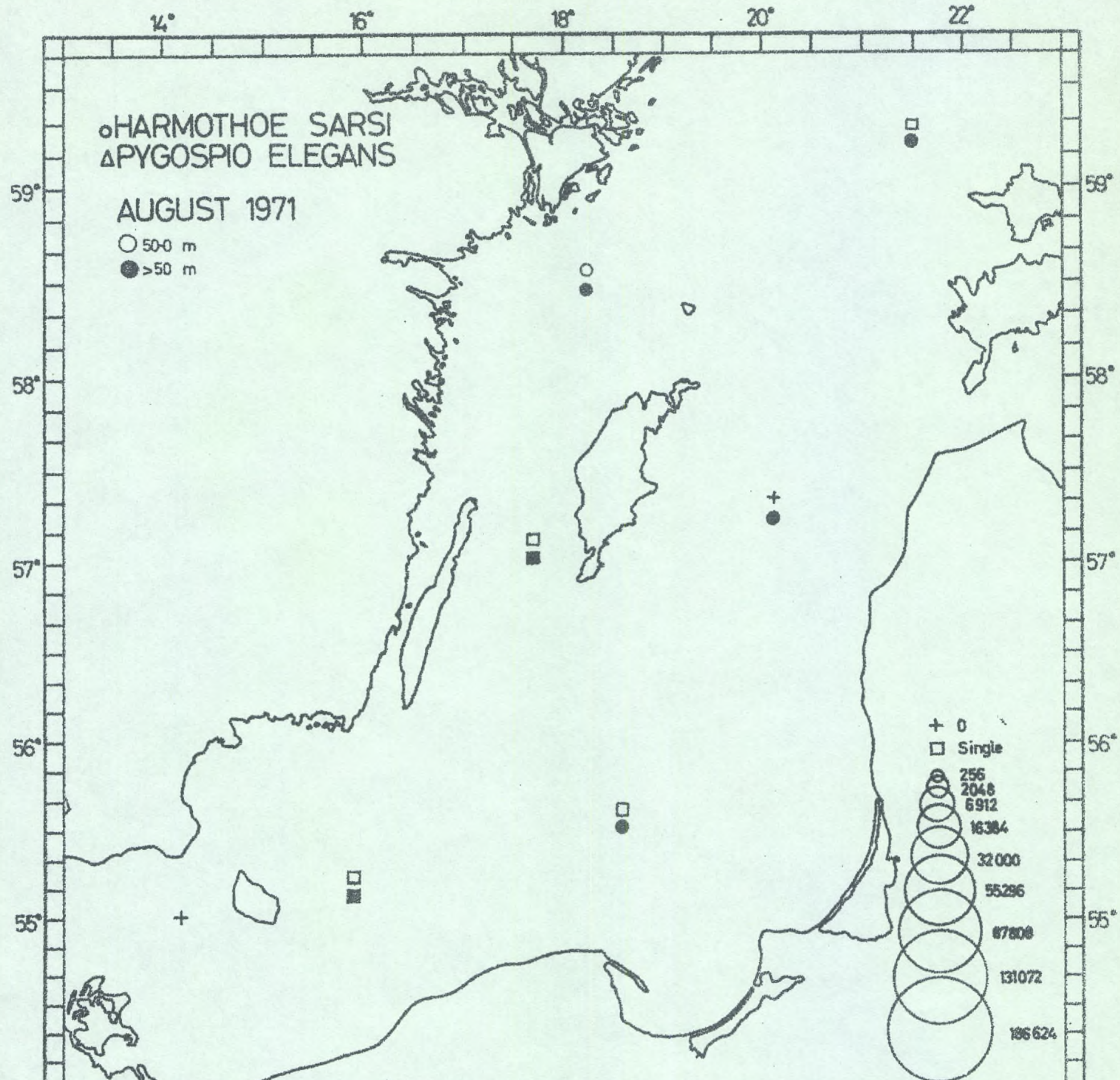

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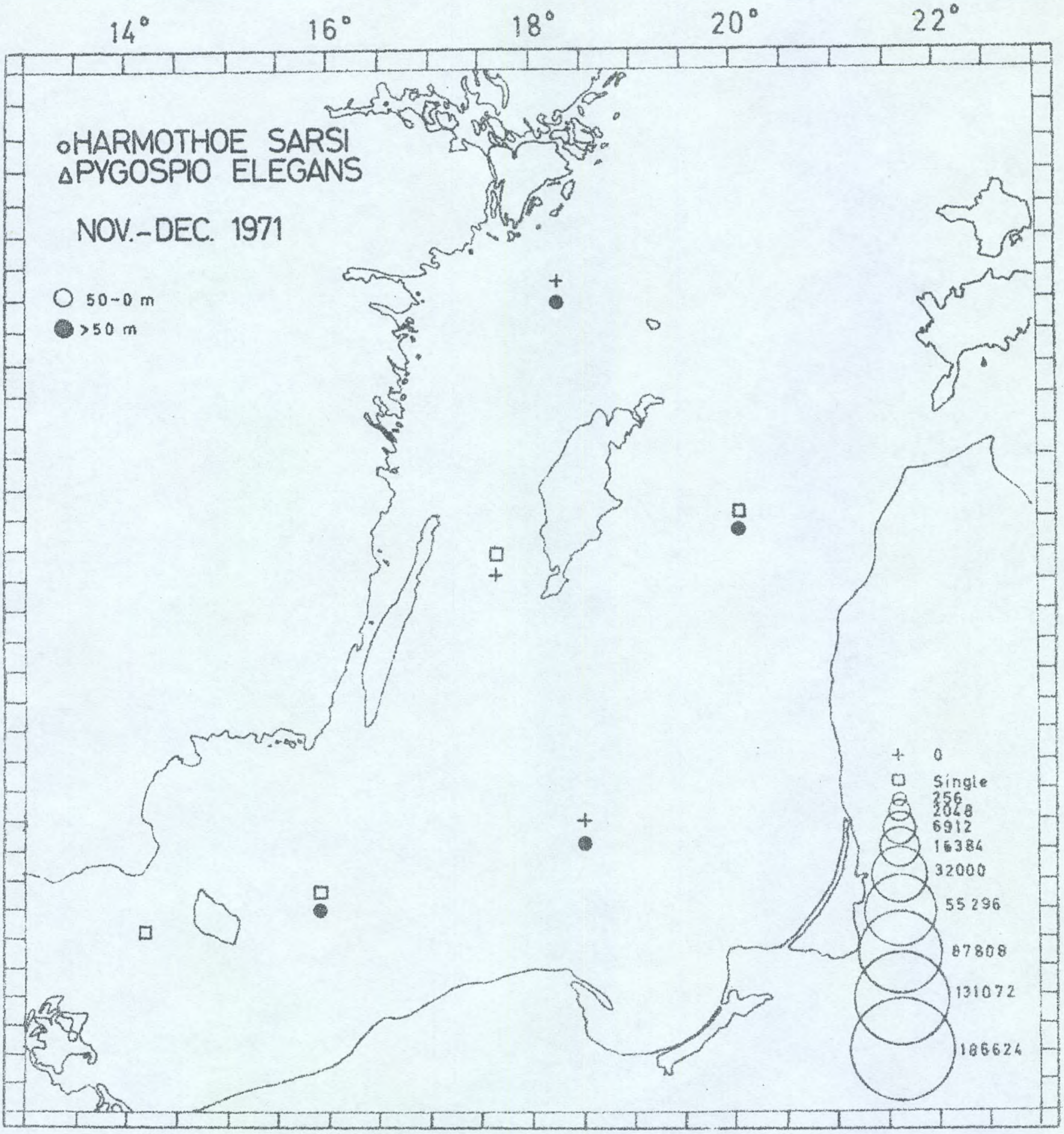
Fig.9



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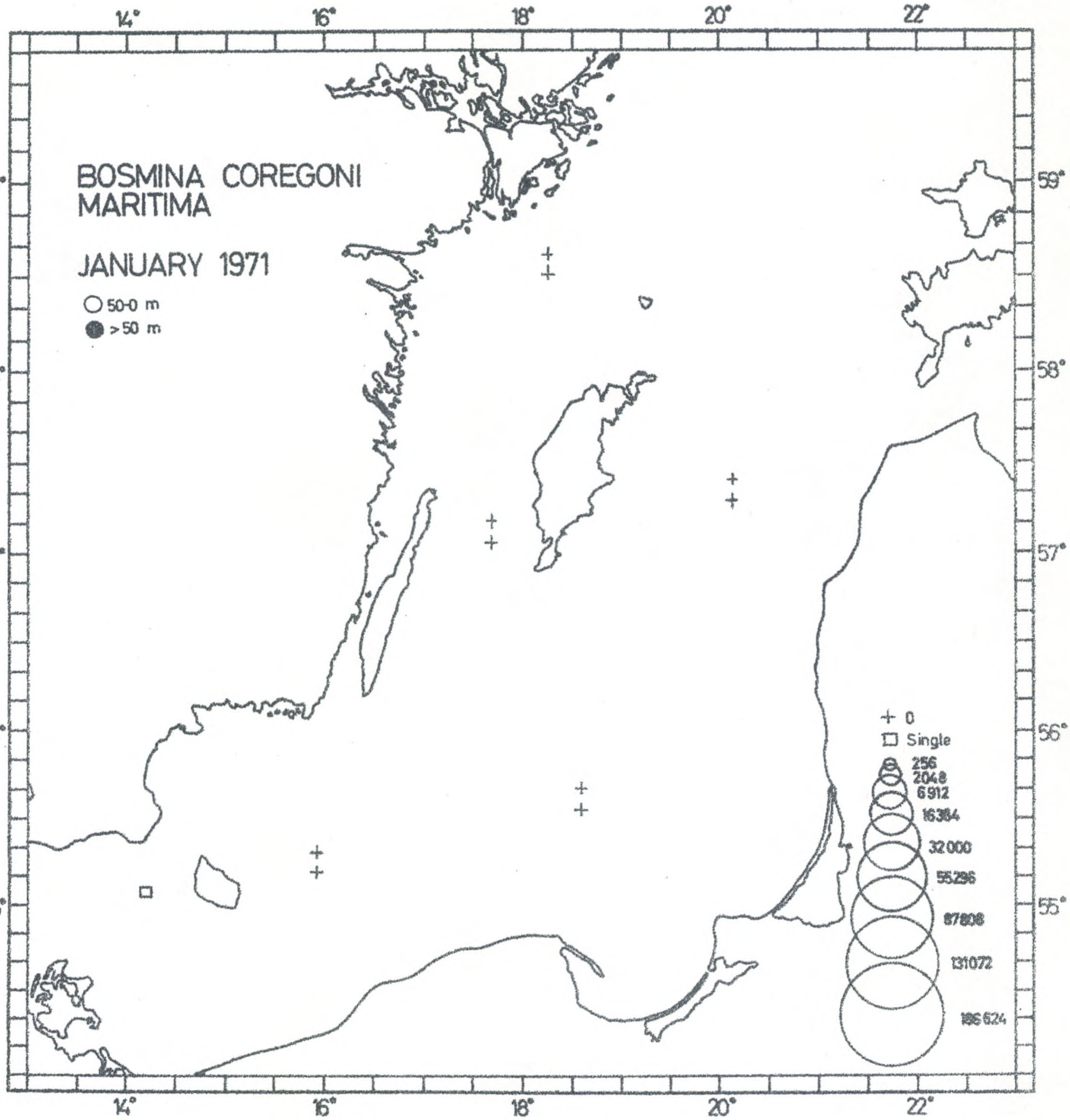

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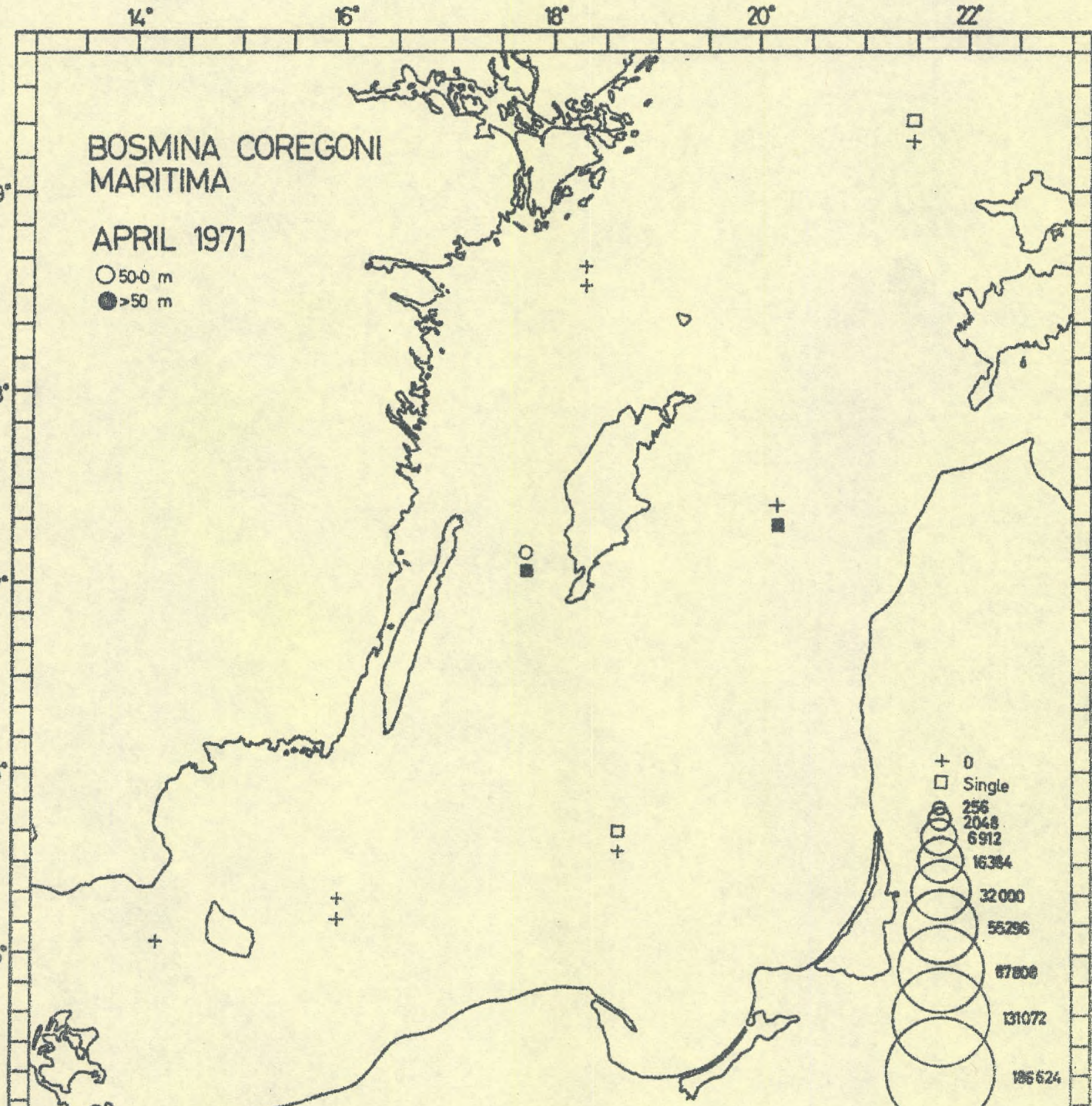

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Fig.12

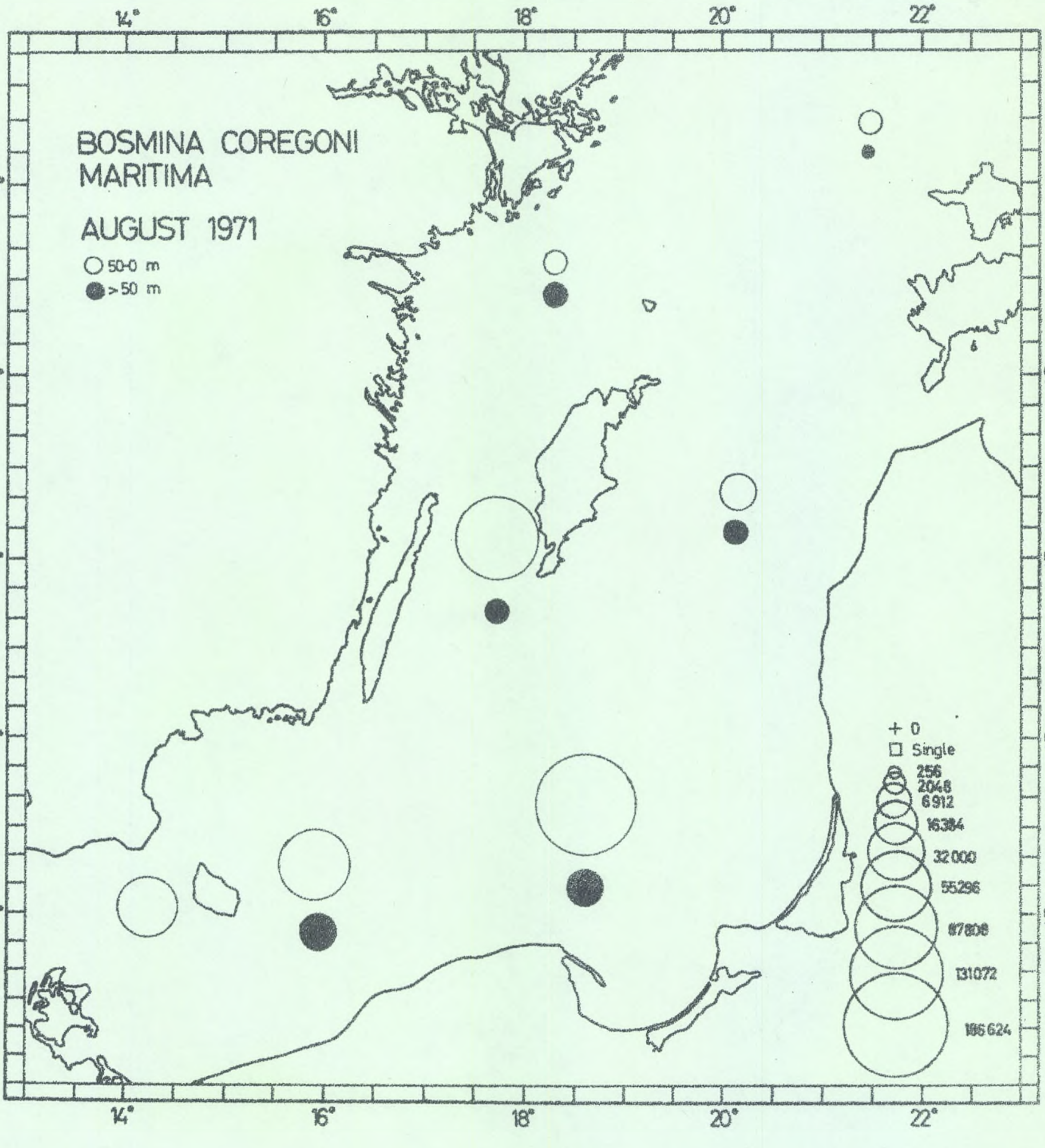
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Fig.13

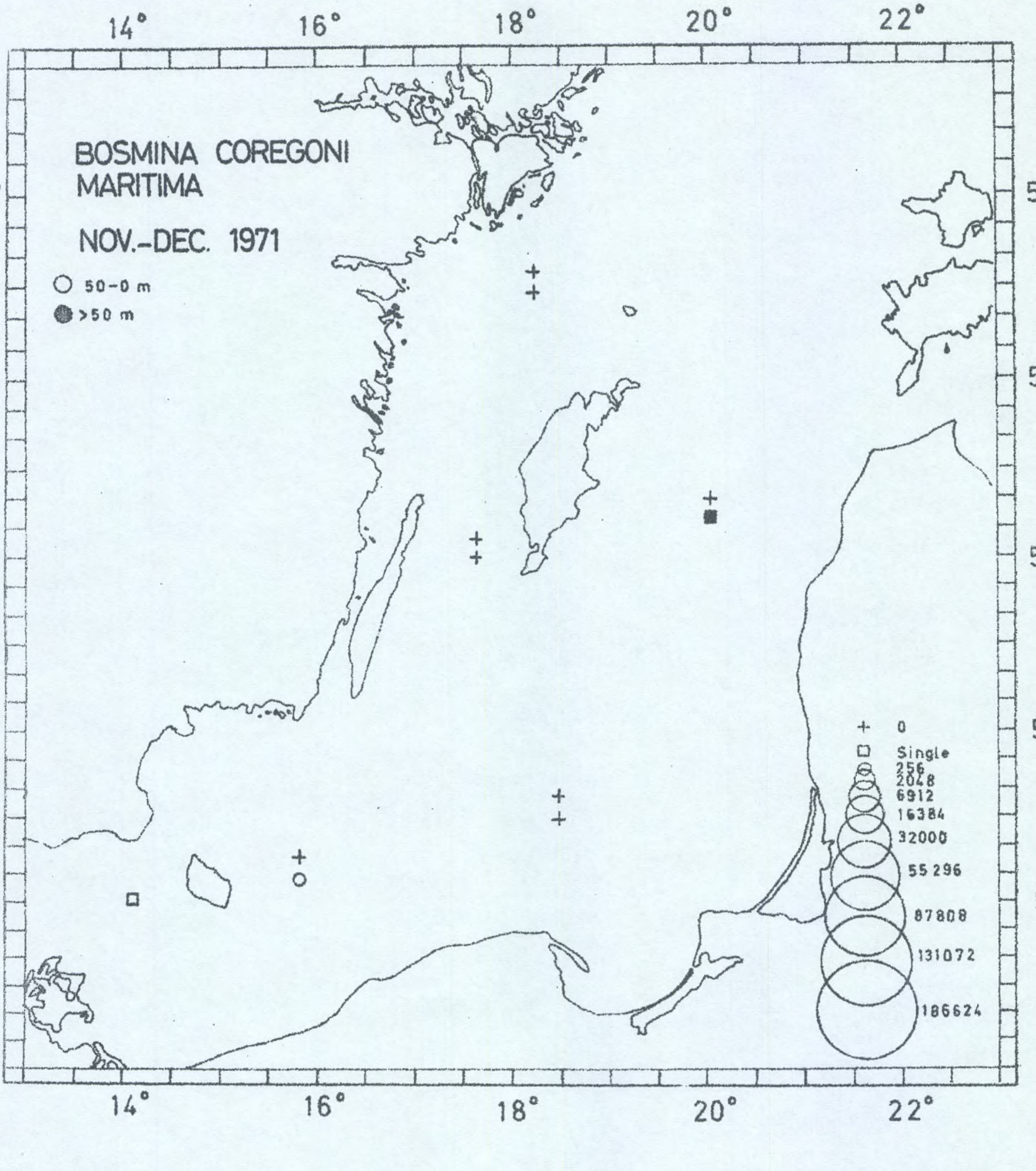
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Fig.14

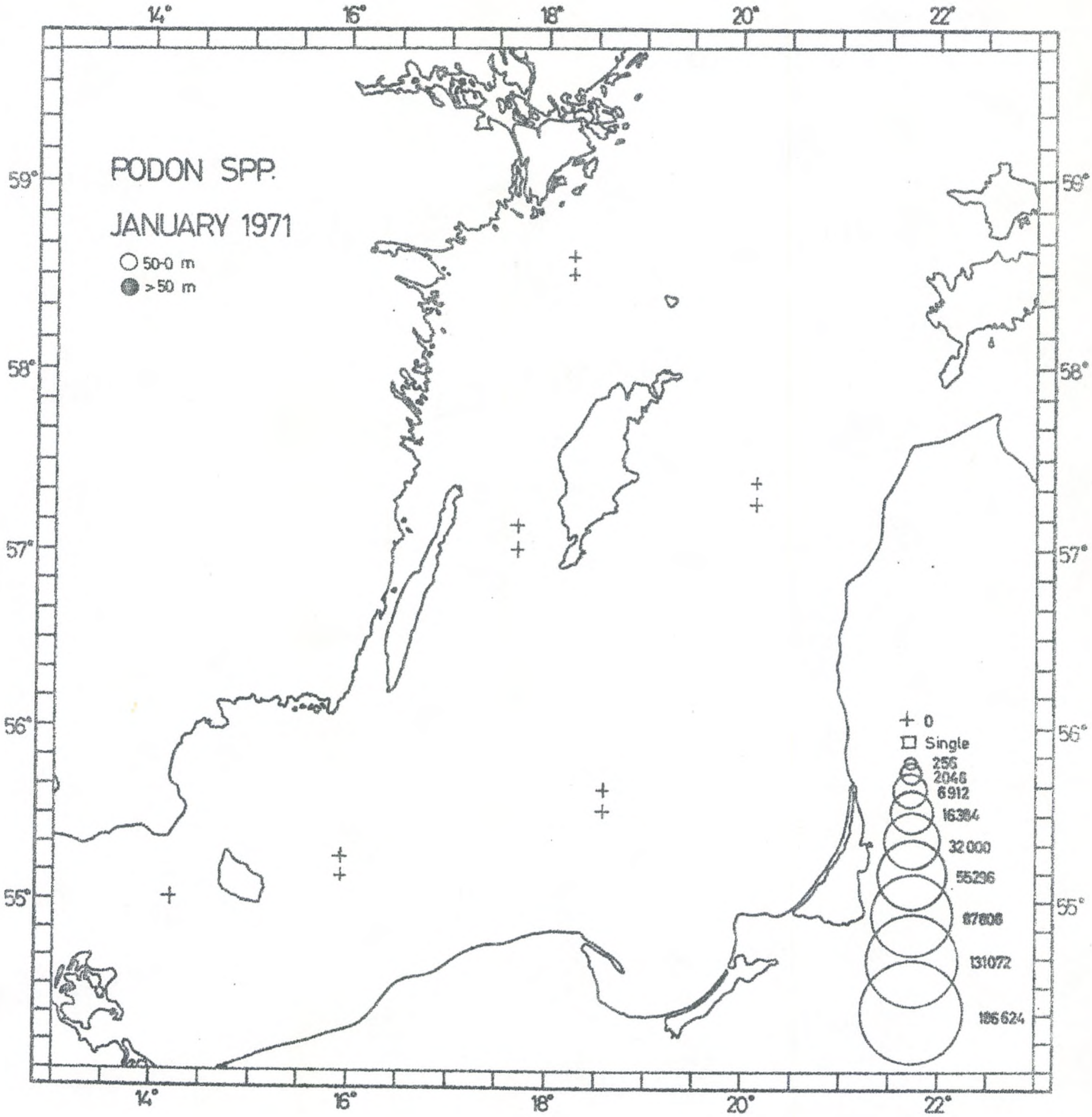

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Fig.15

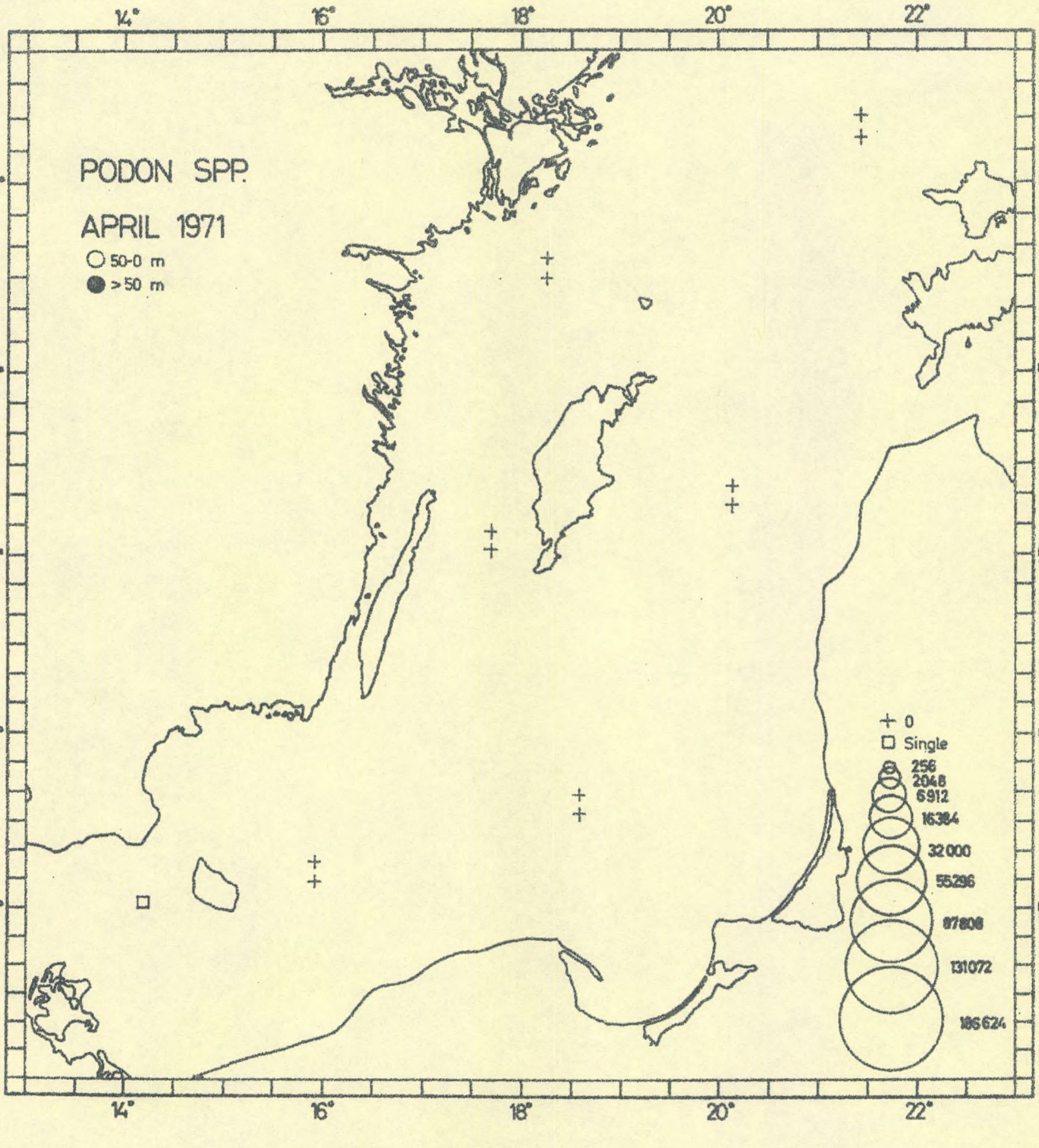

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Fig.16

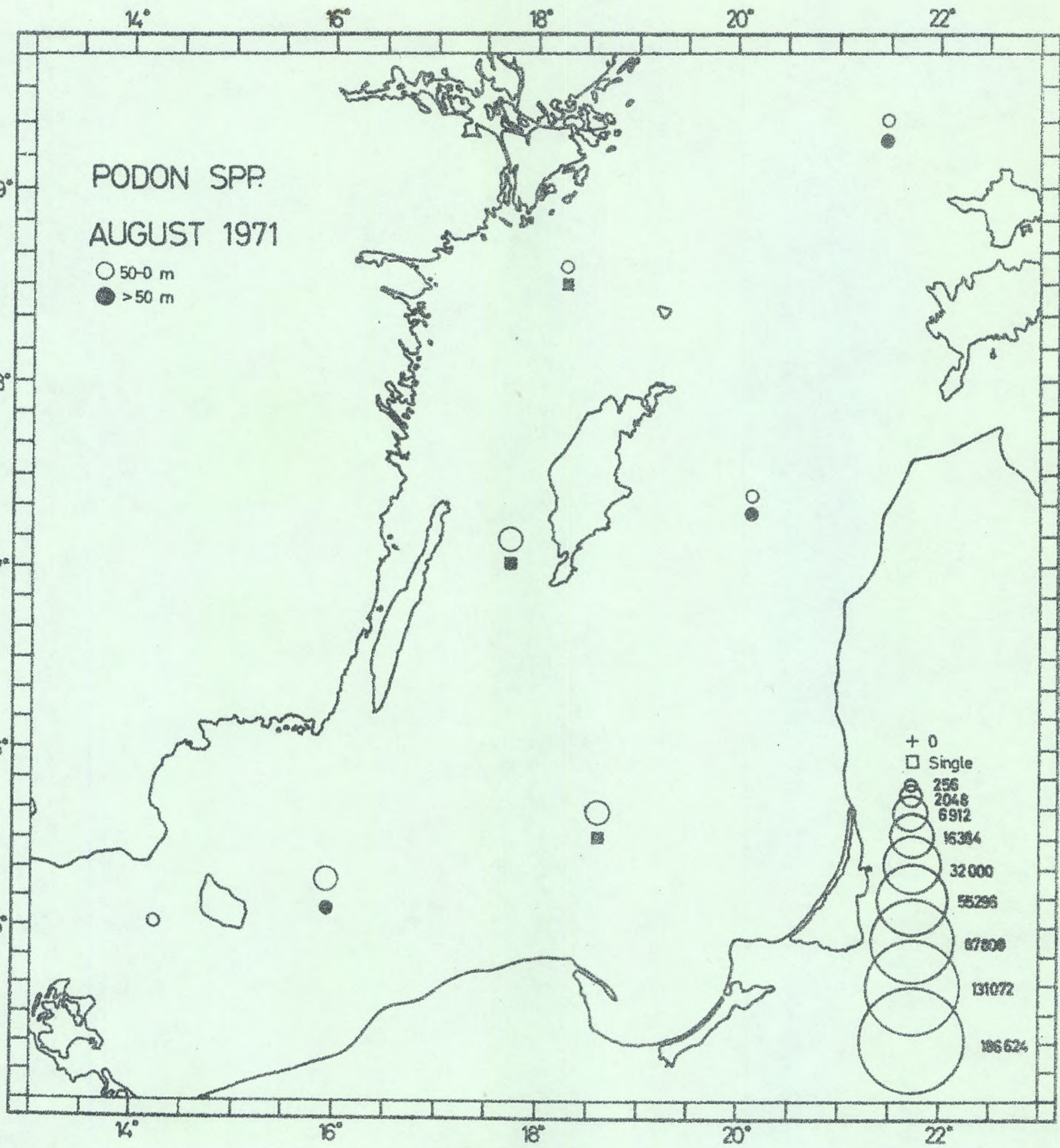
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Fig.17

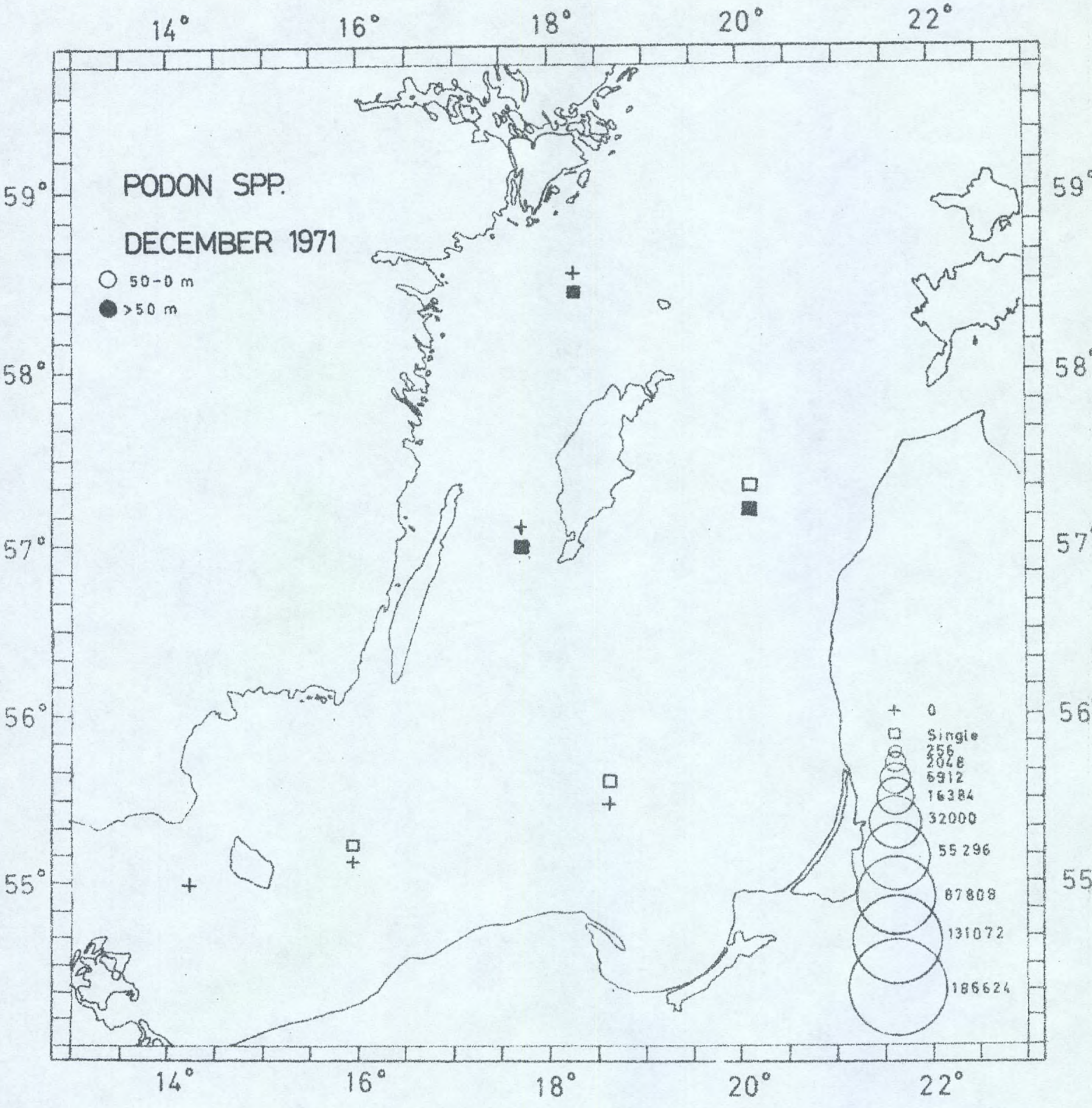

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Fig.18

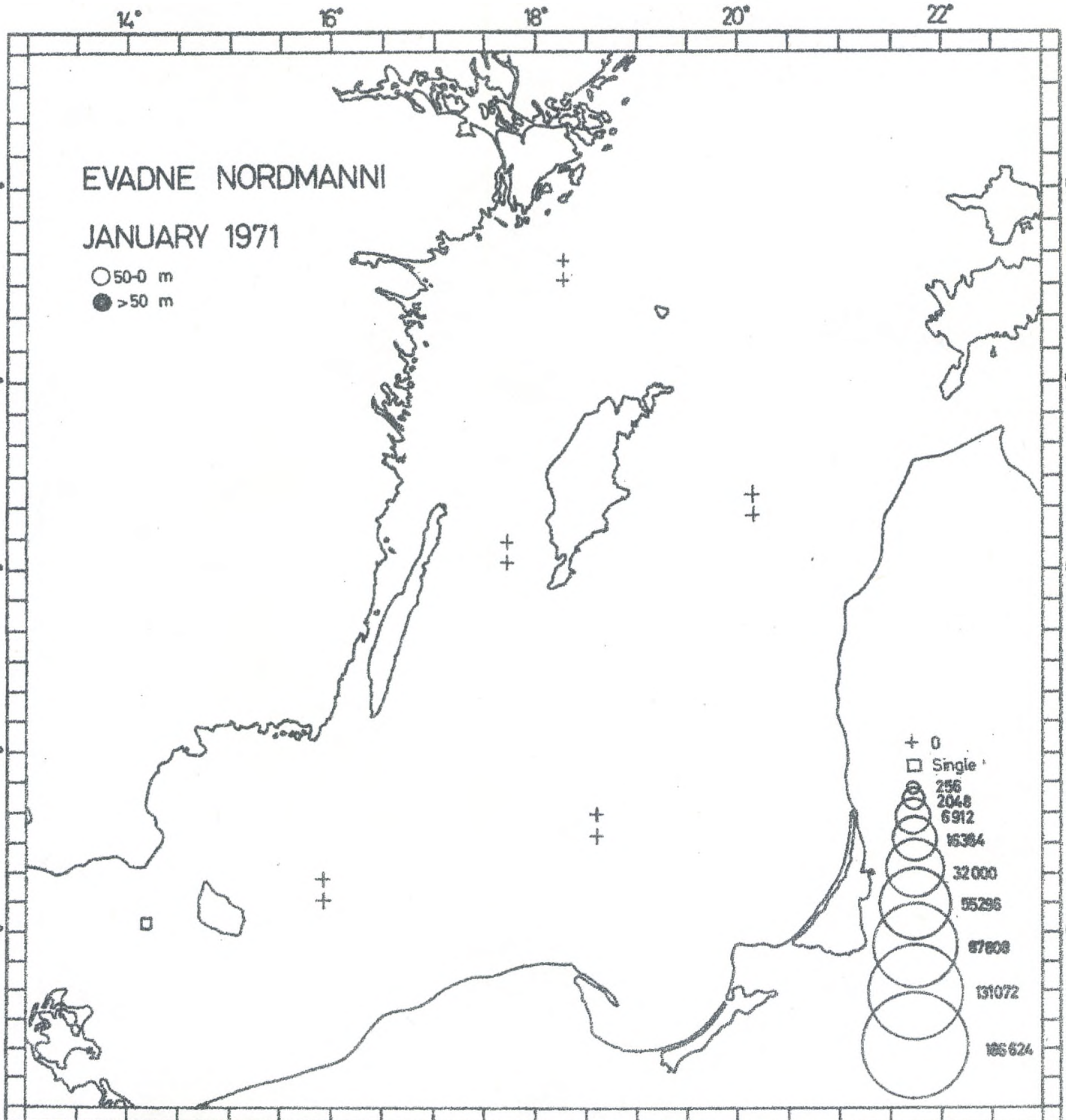
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Fig.19

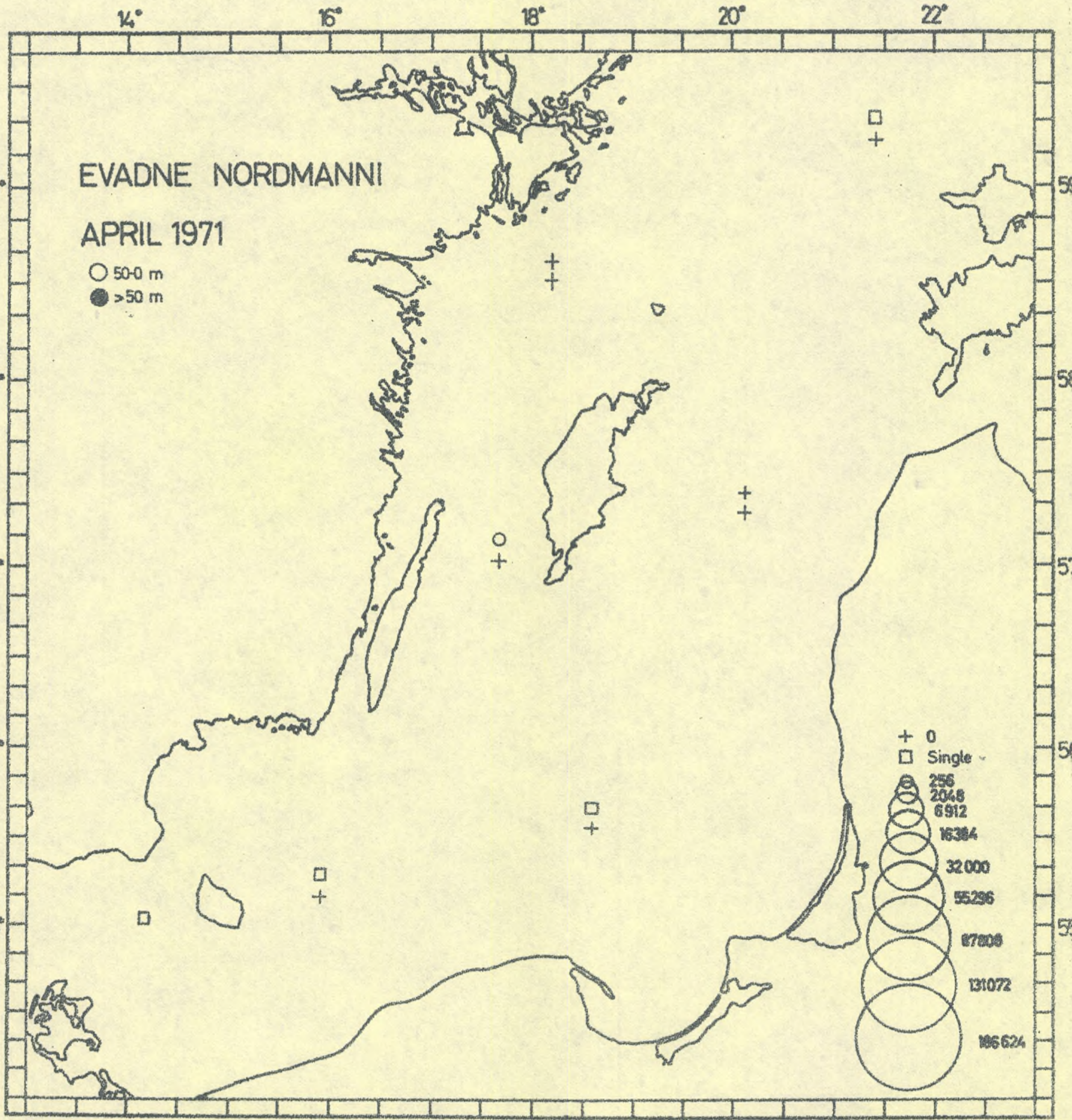

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Fig.20

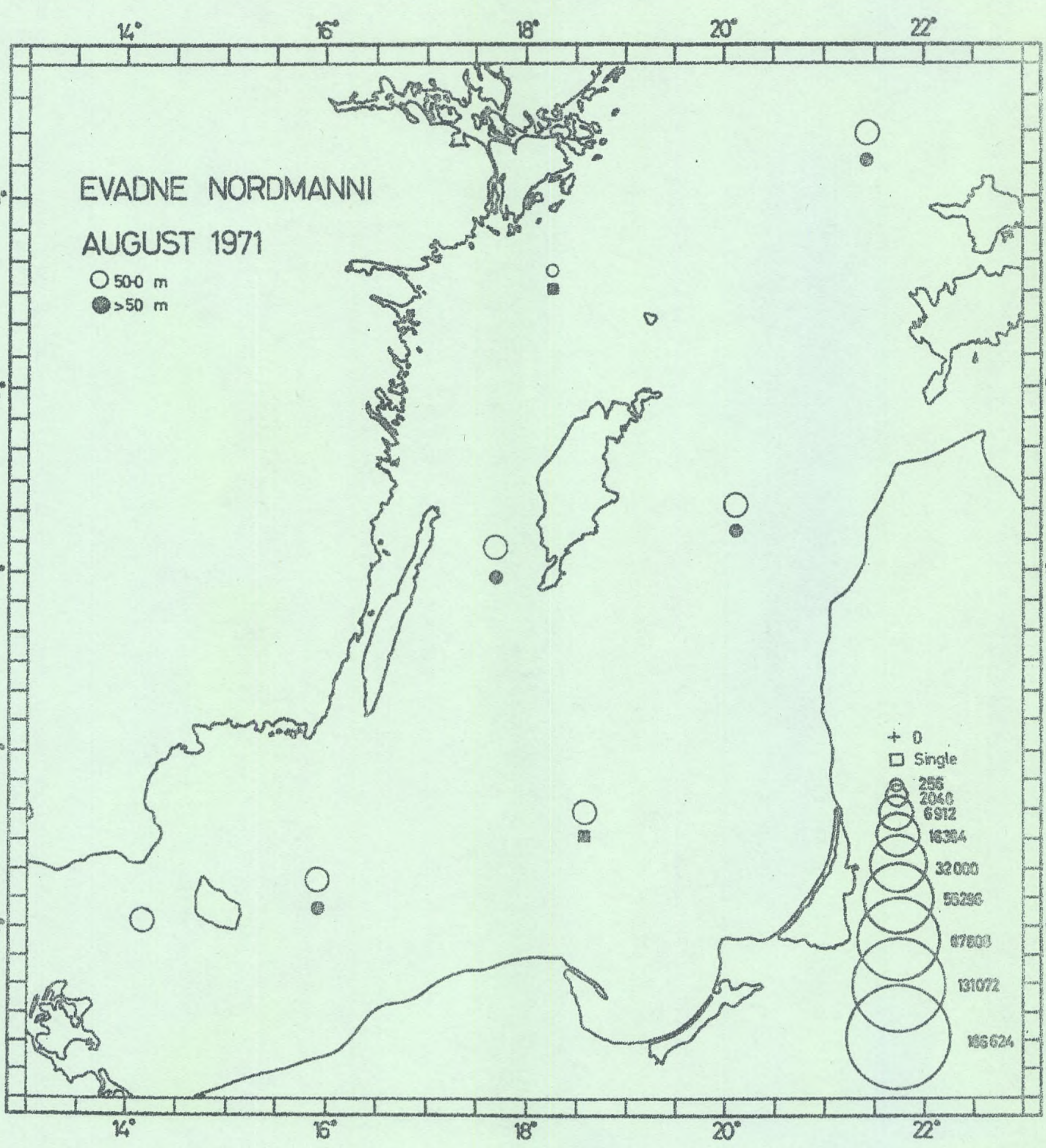

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Fig.21

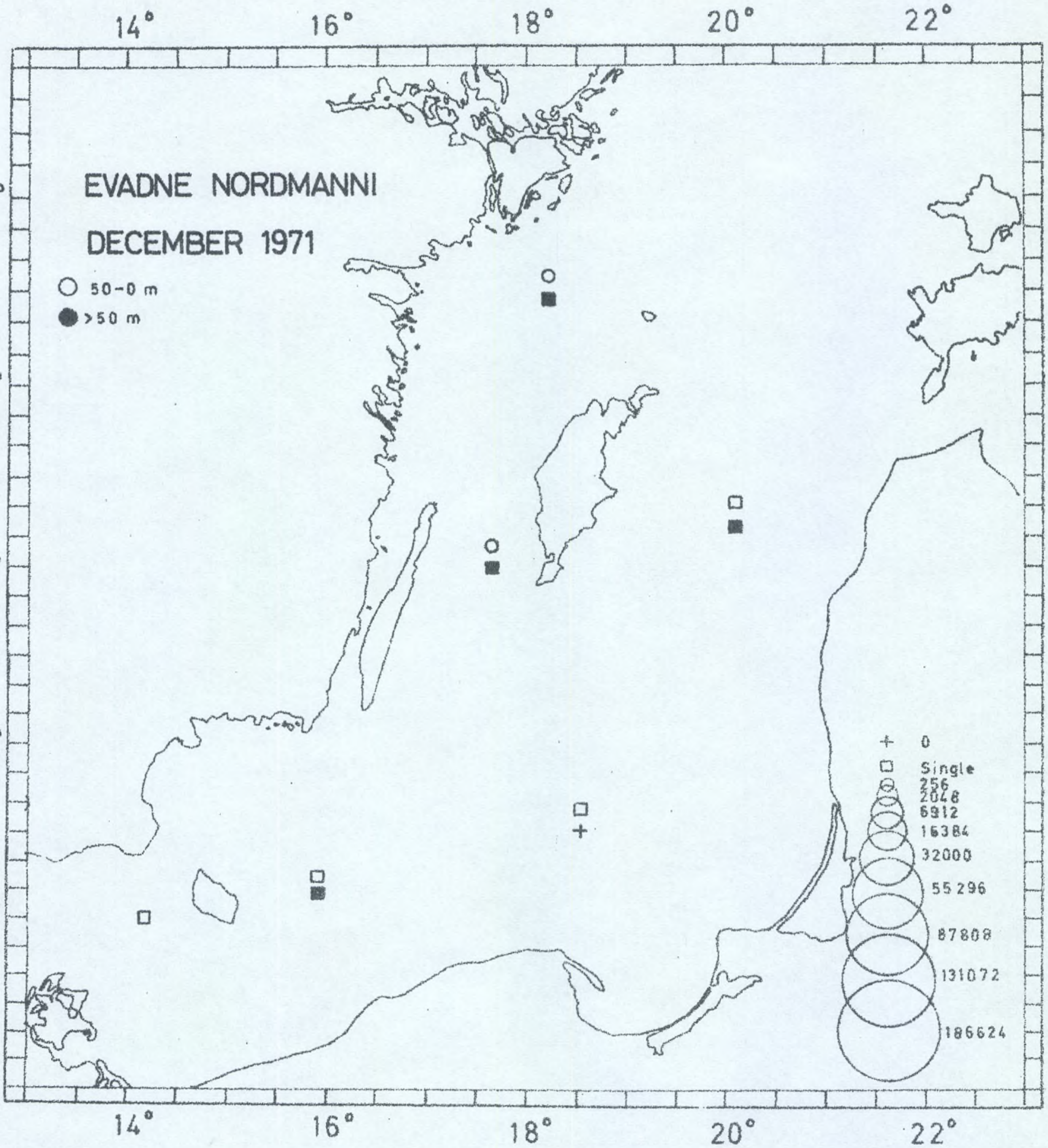

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Fig. 22

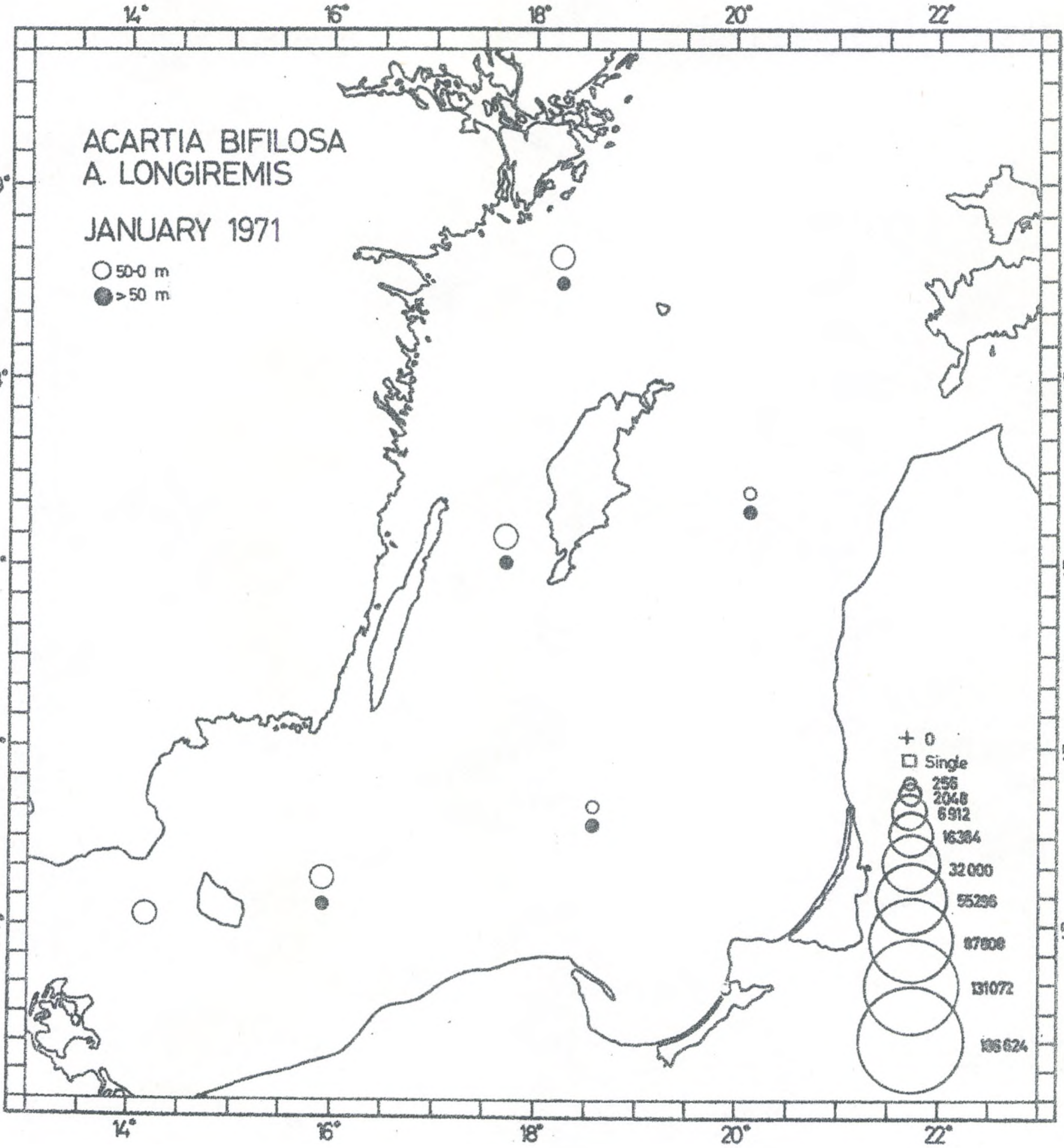
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Fig. 23

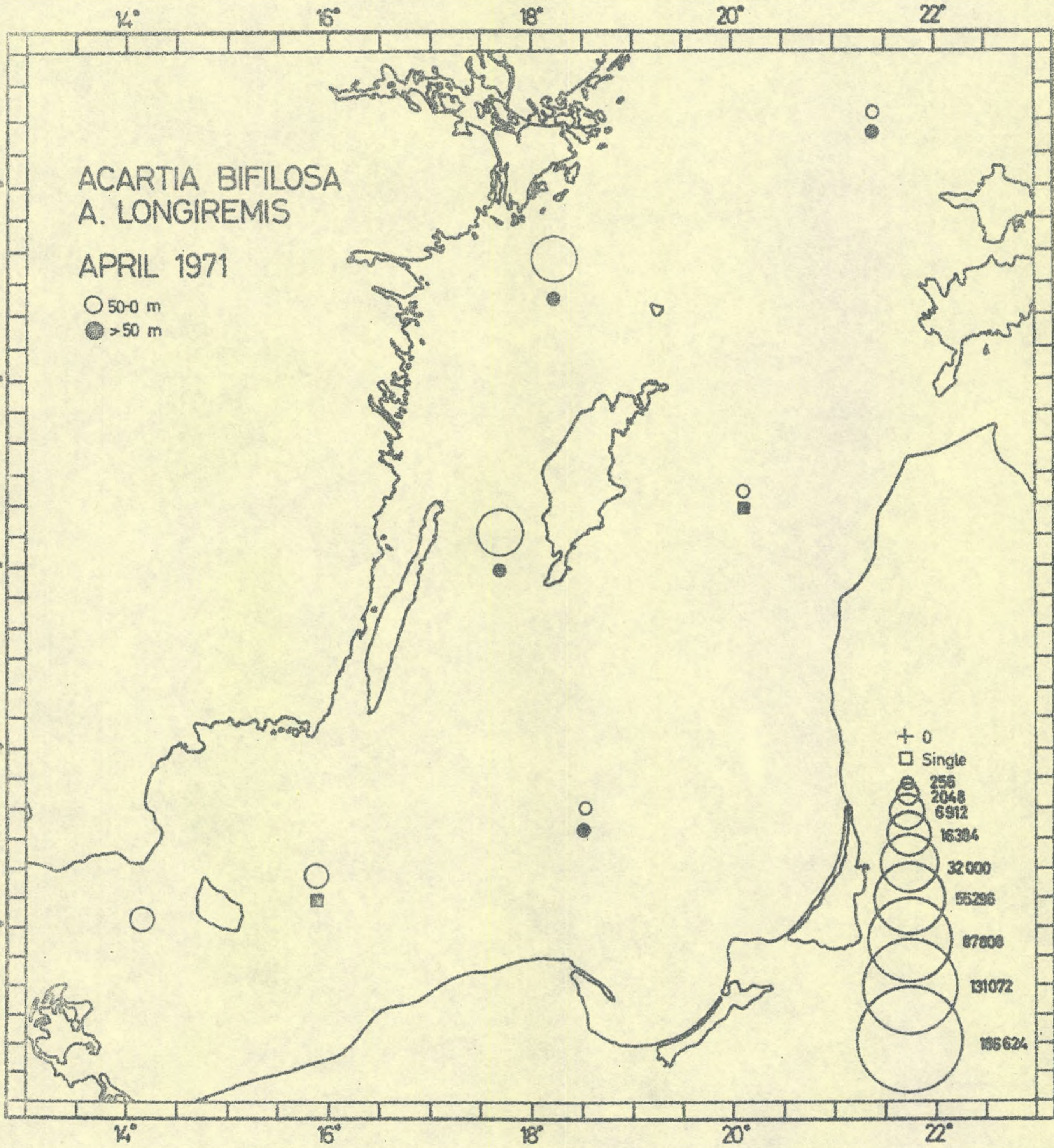

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Fig.24

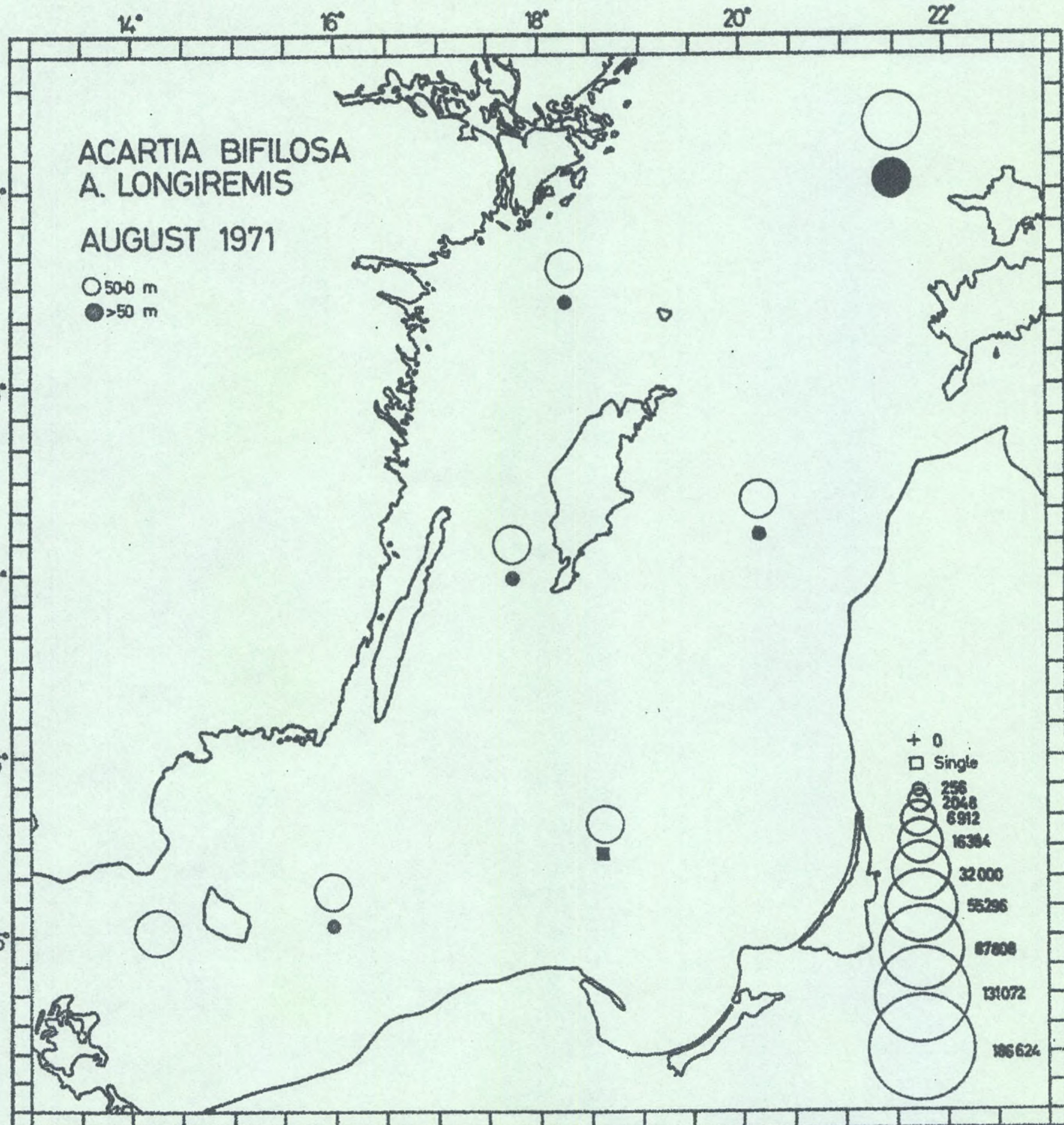
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Fig.25

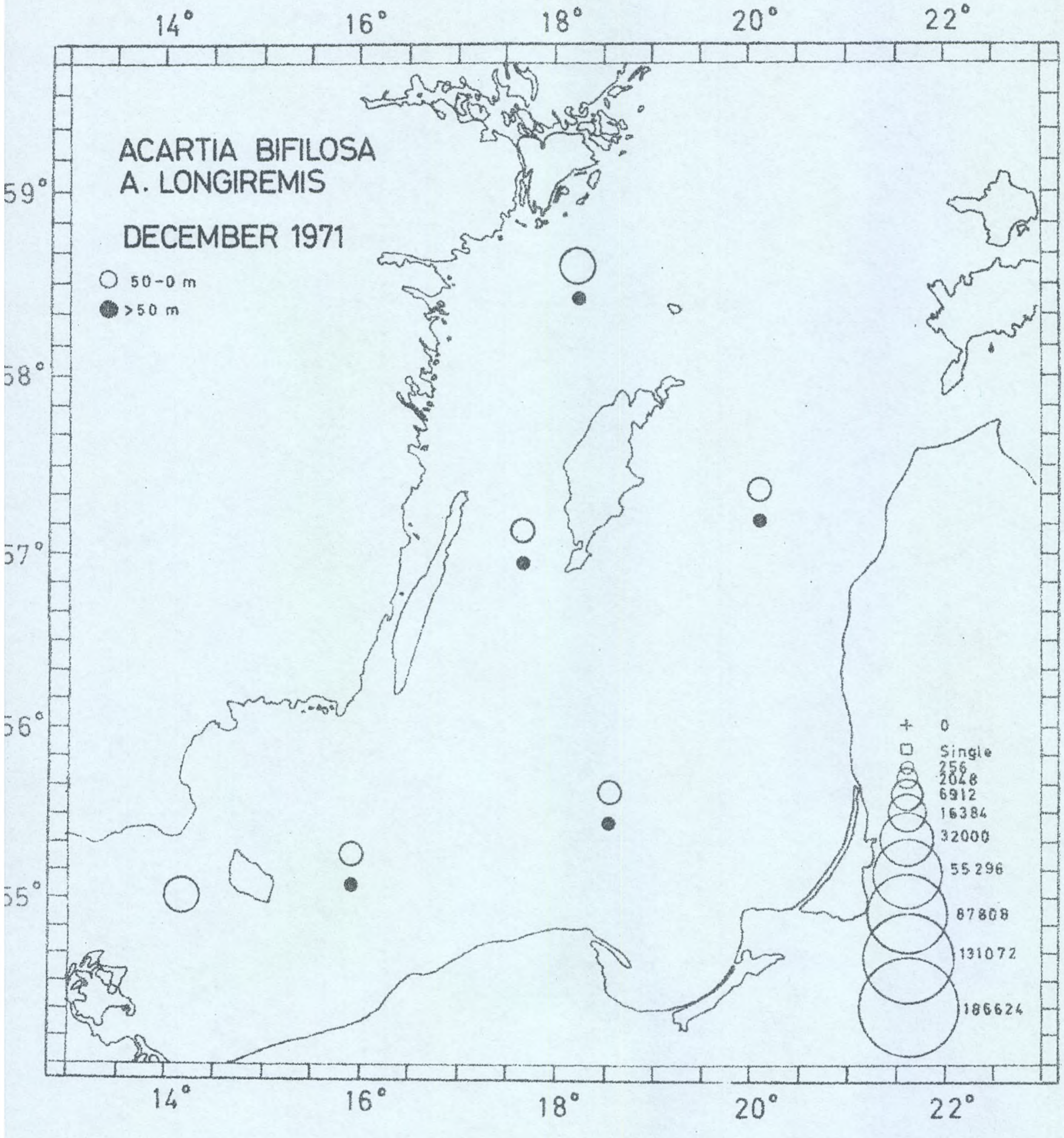

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Fig.26

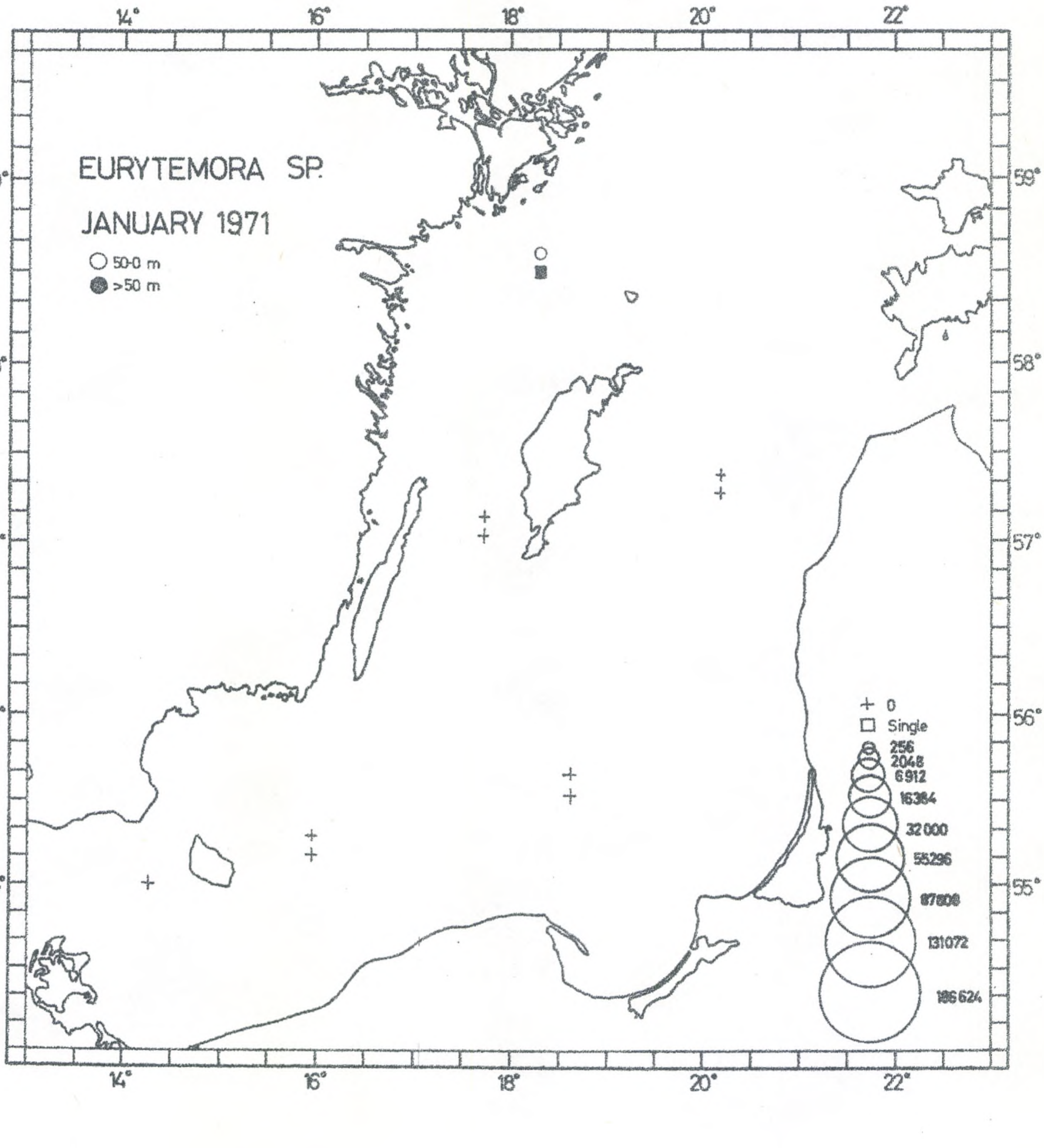

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Fig.27

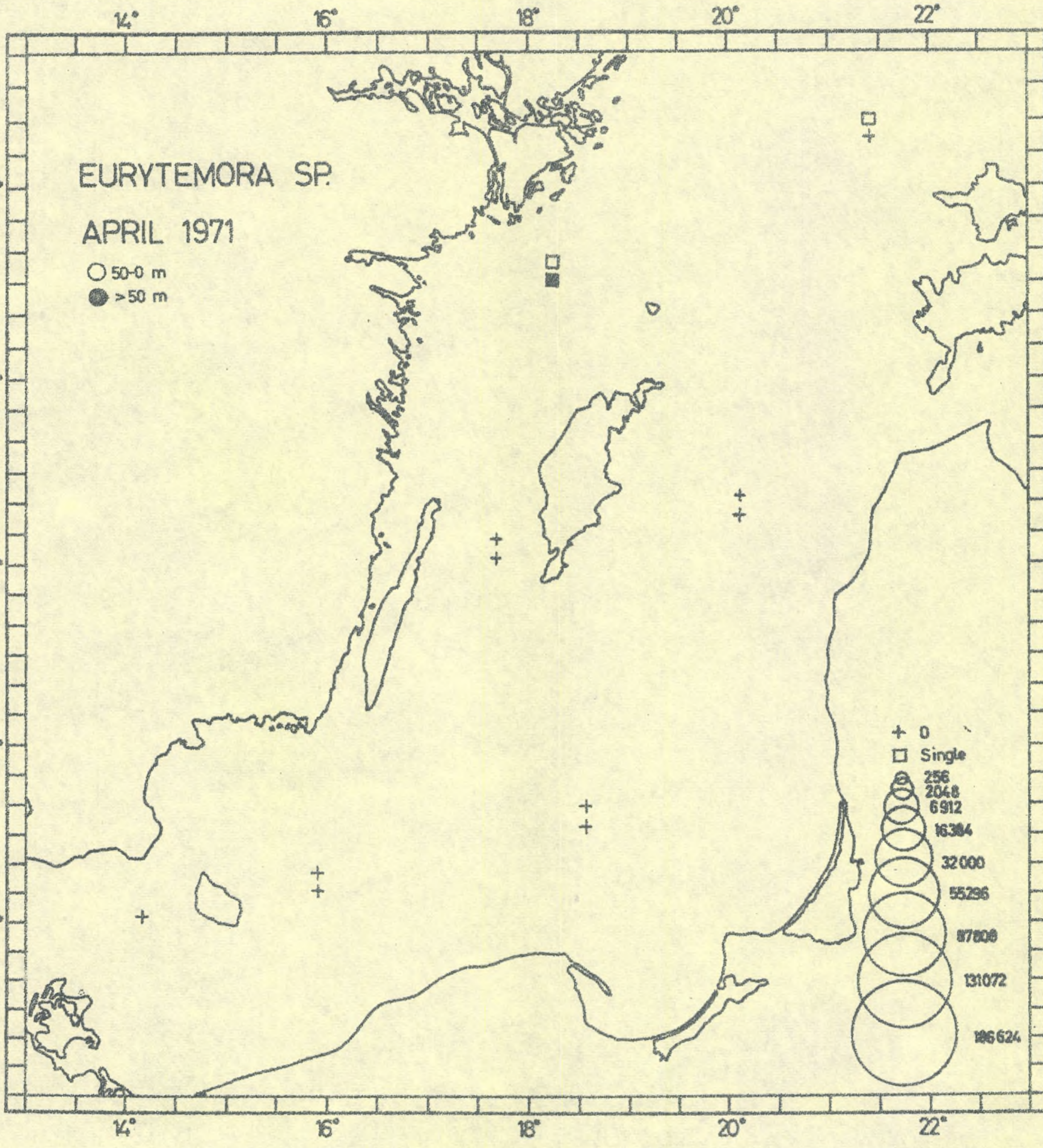

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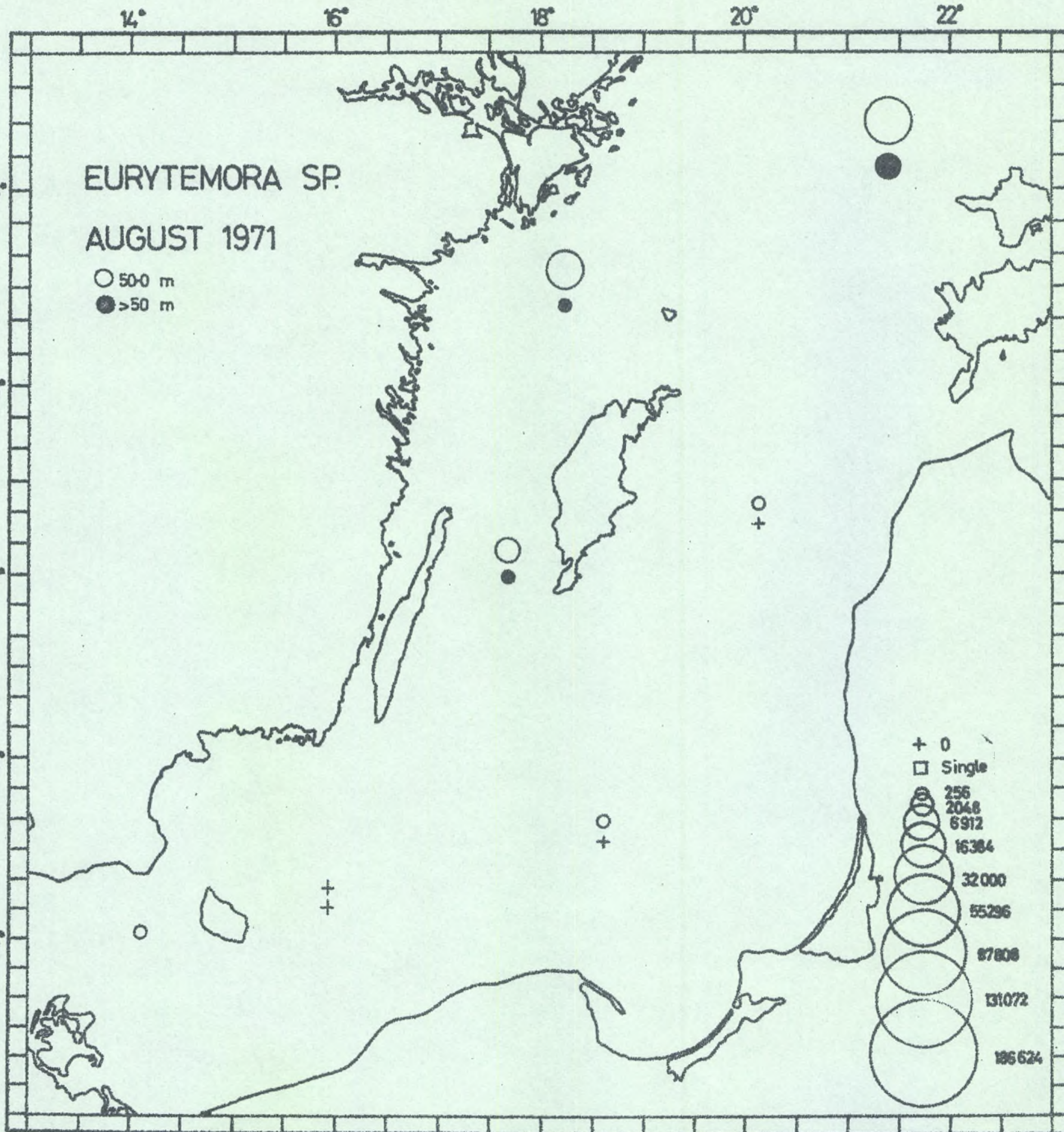
Fig.28



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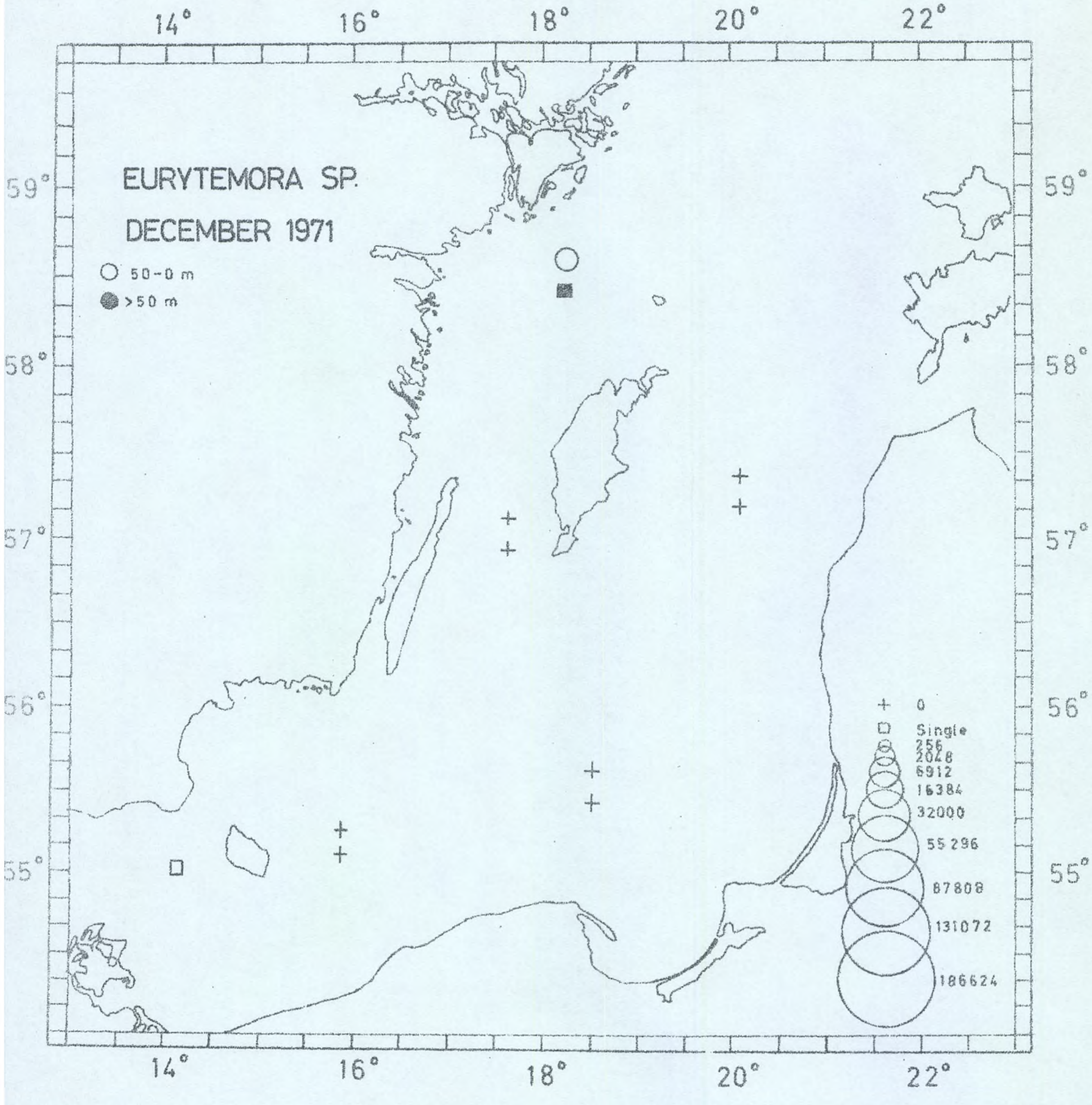

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Fig.30

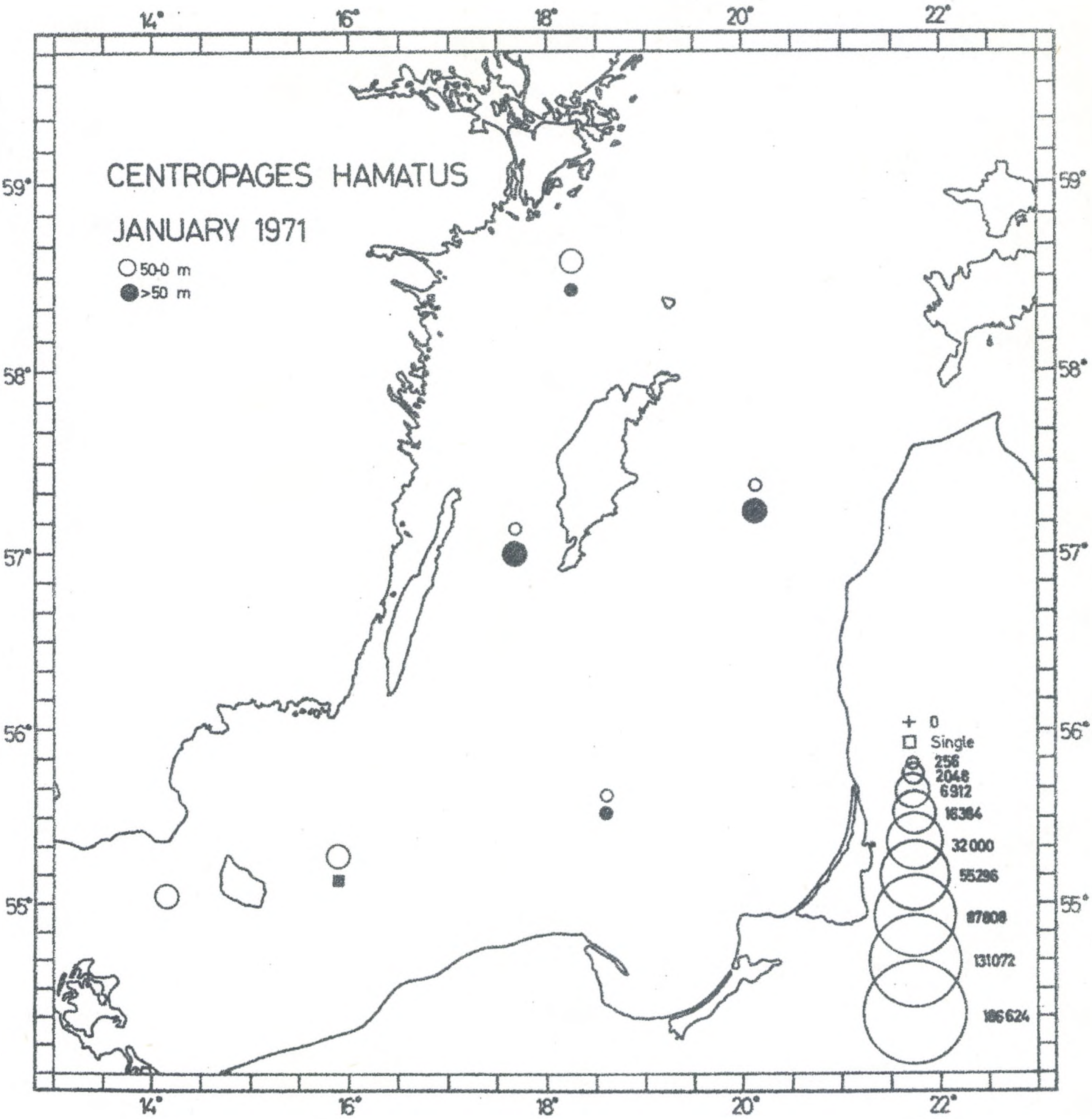

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Fig.31

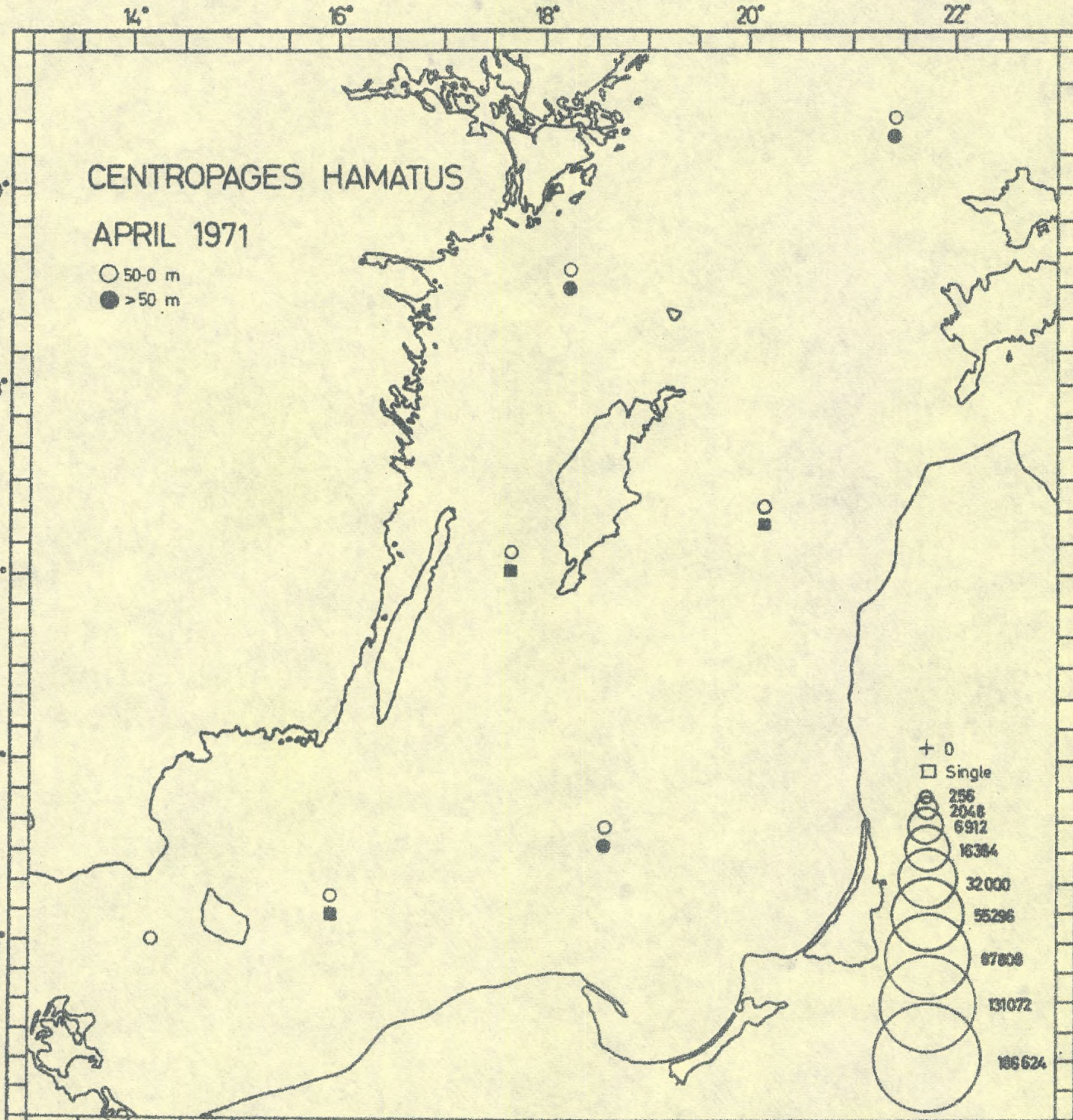
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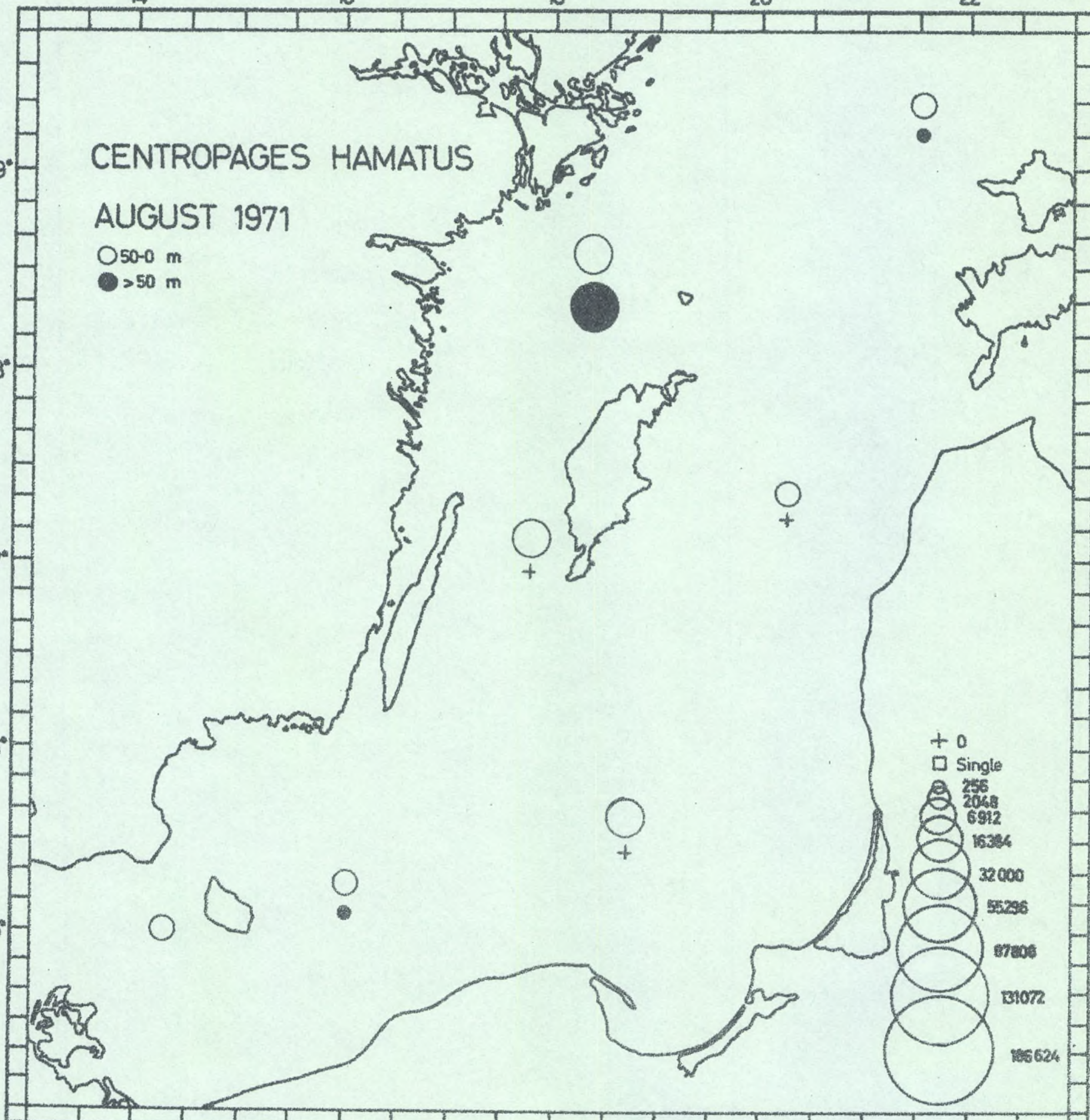
Fig.32



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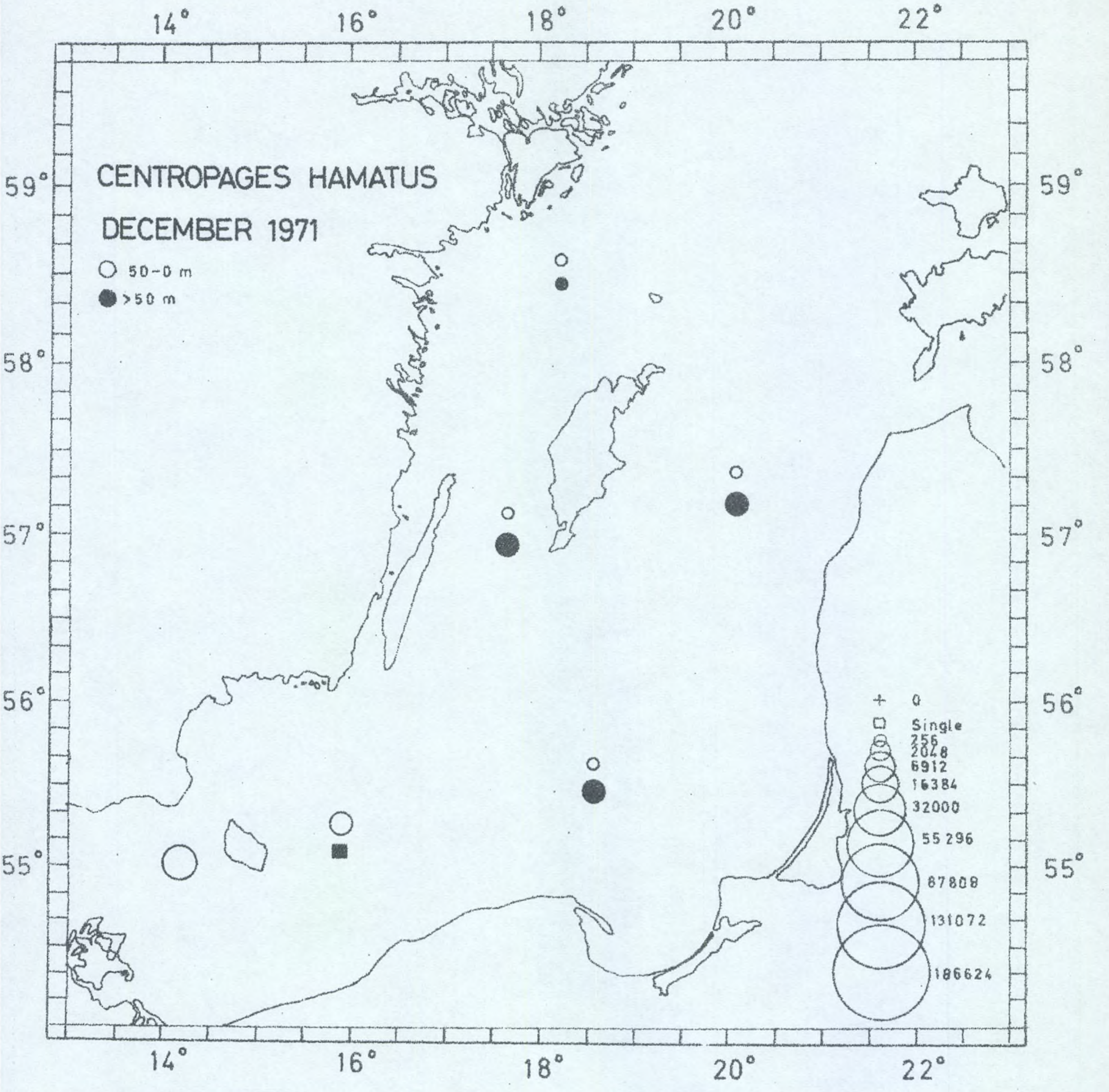
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Fig.34

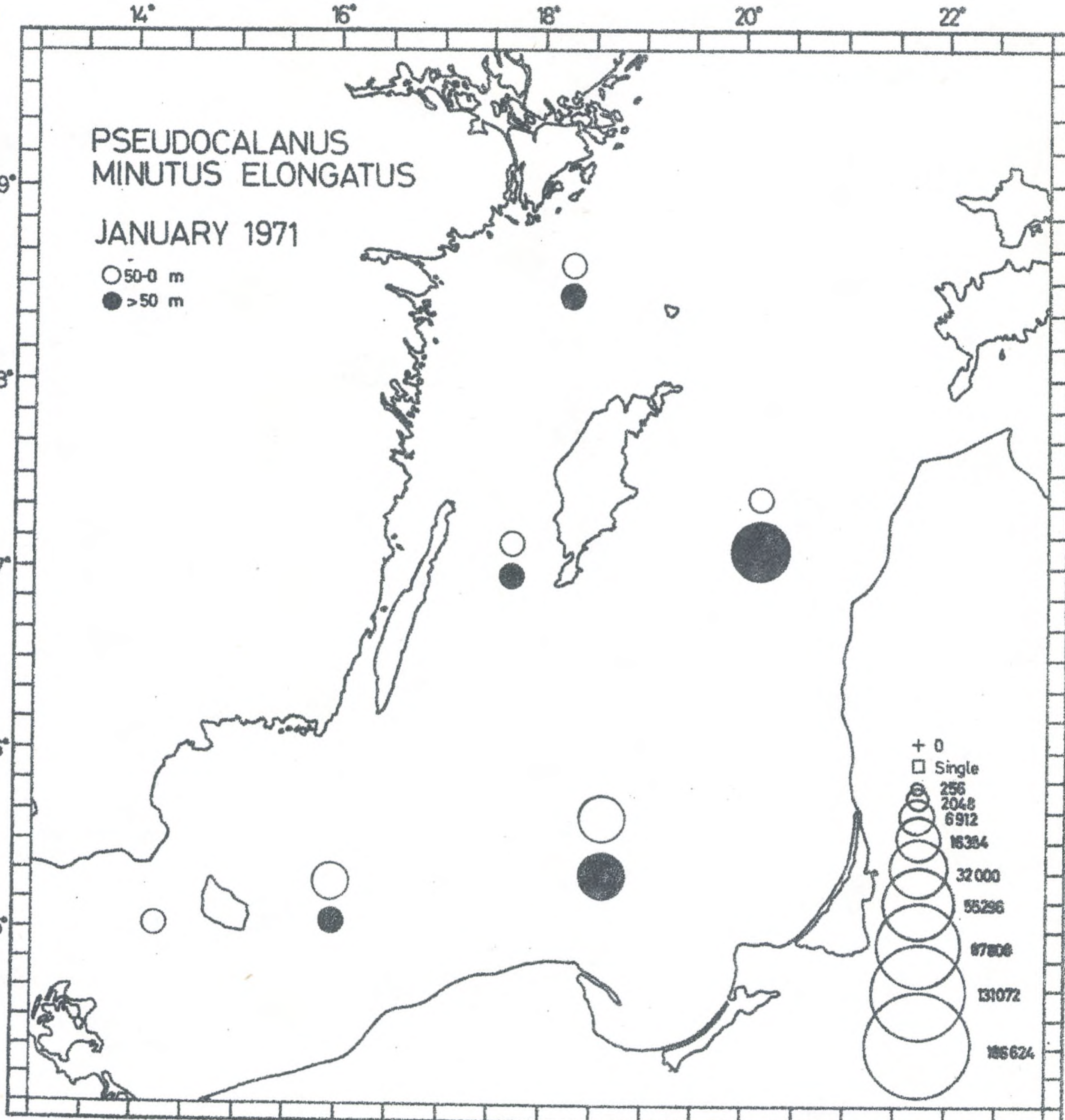
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Fig.35

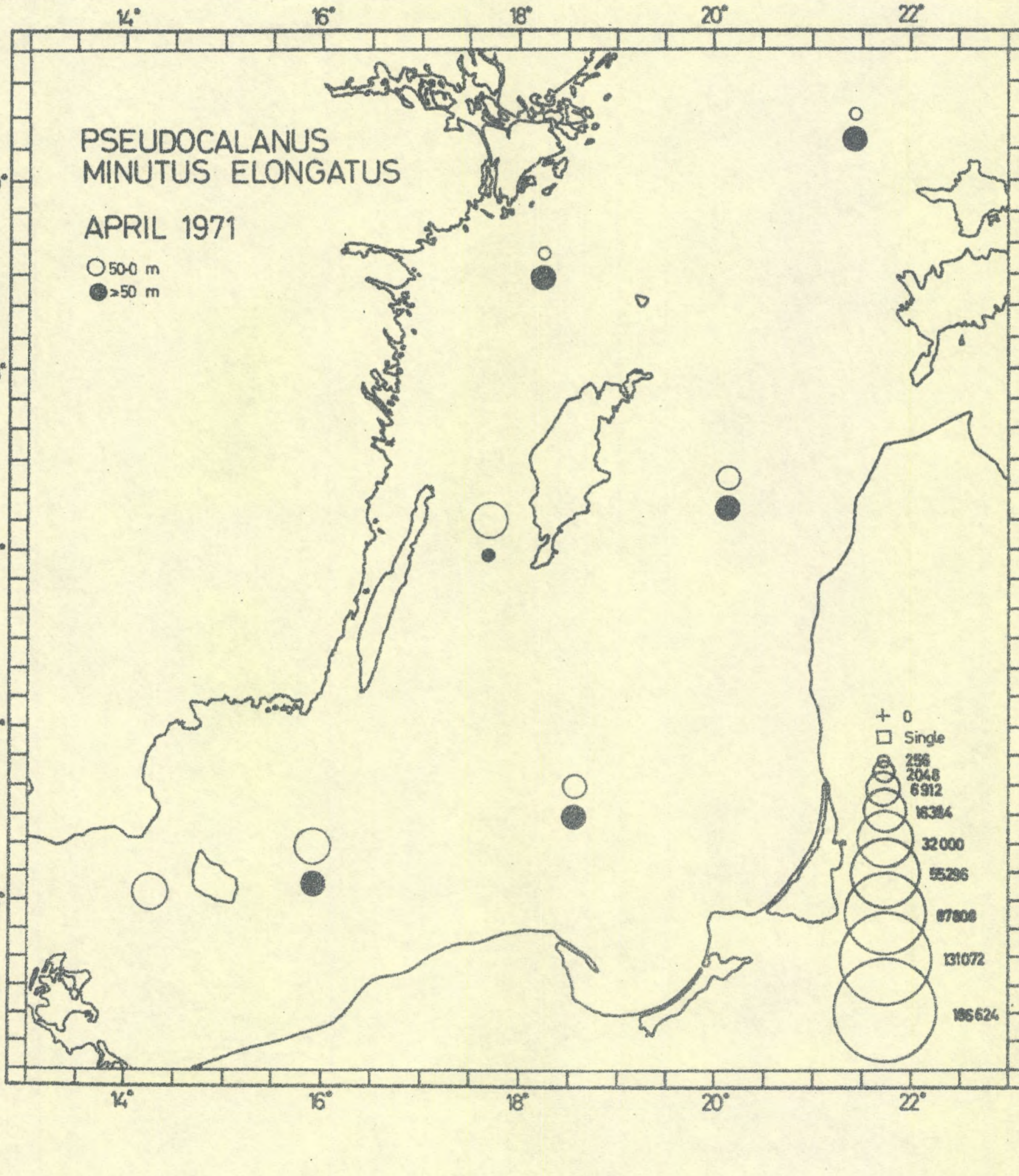

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Fig.36

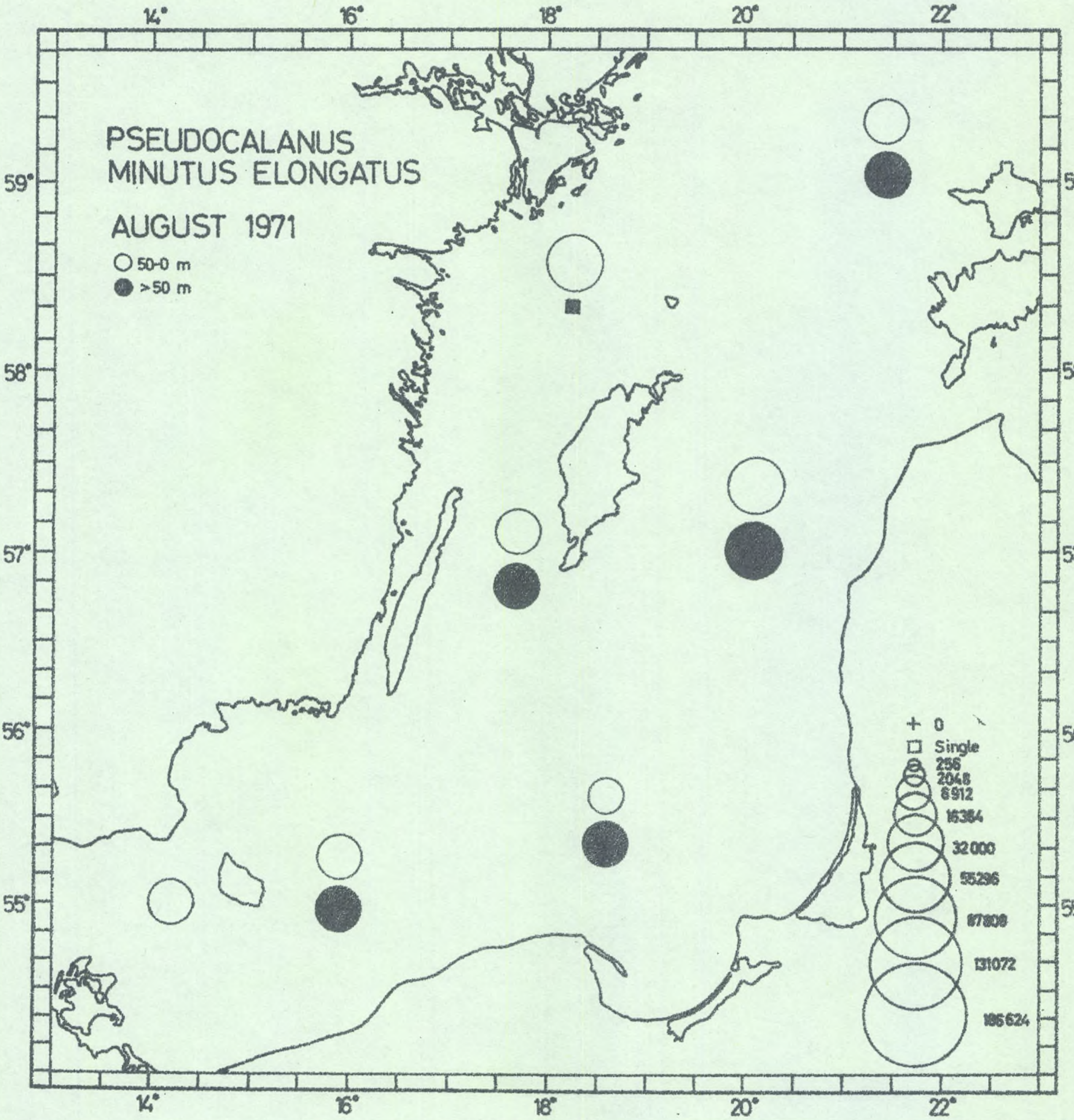
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Fig.37

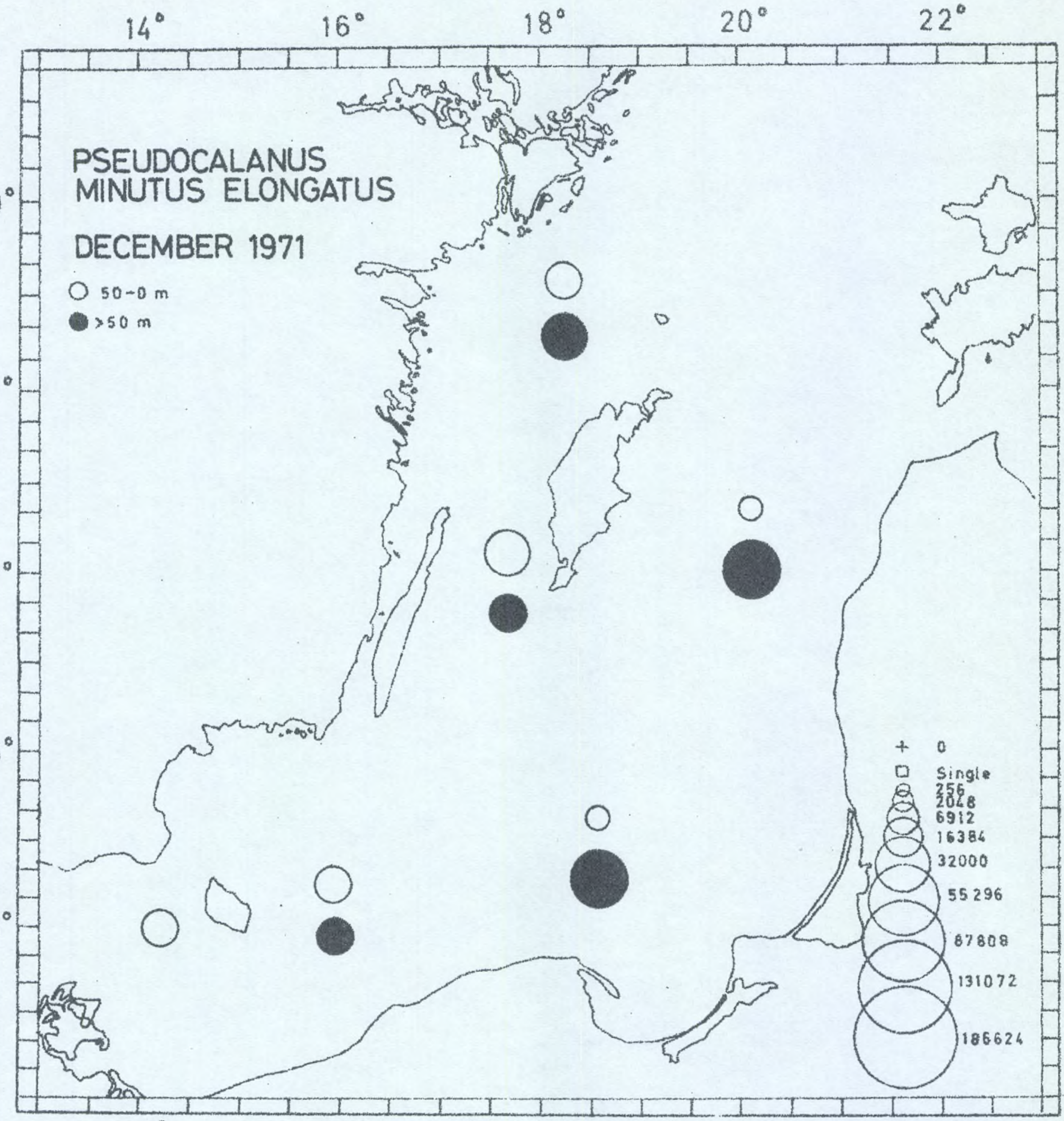

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Fig.38

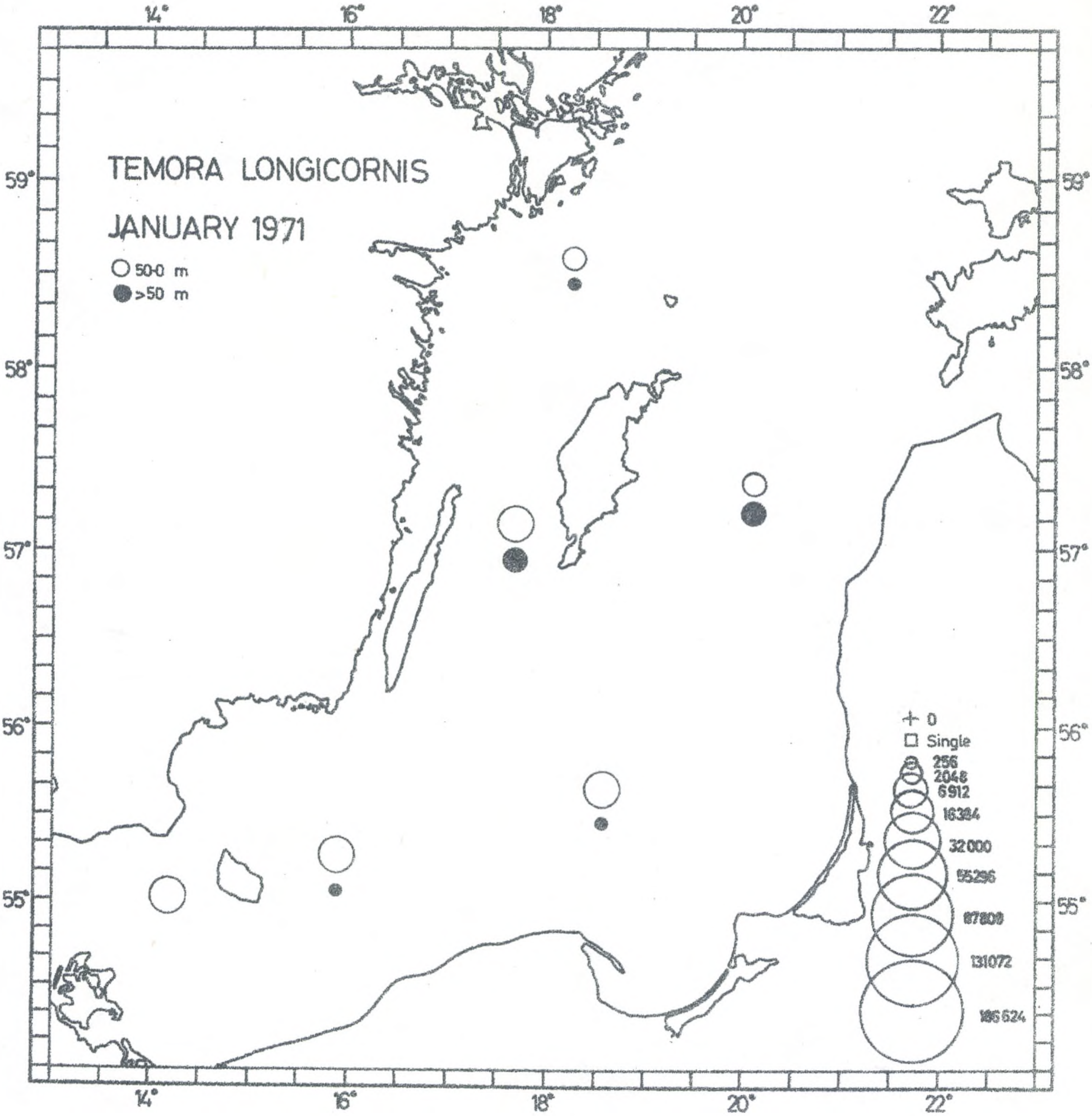
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Fig.39

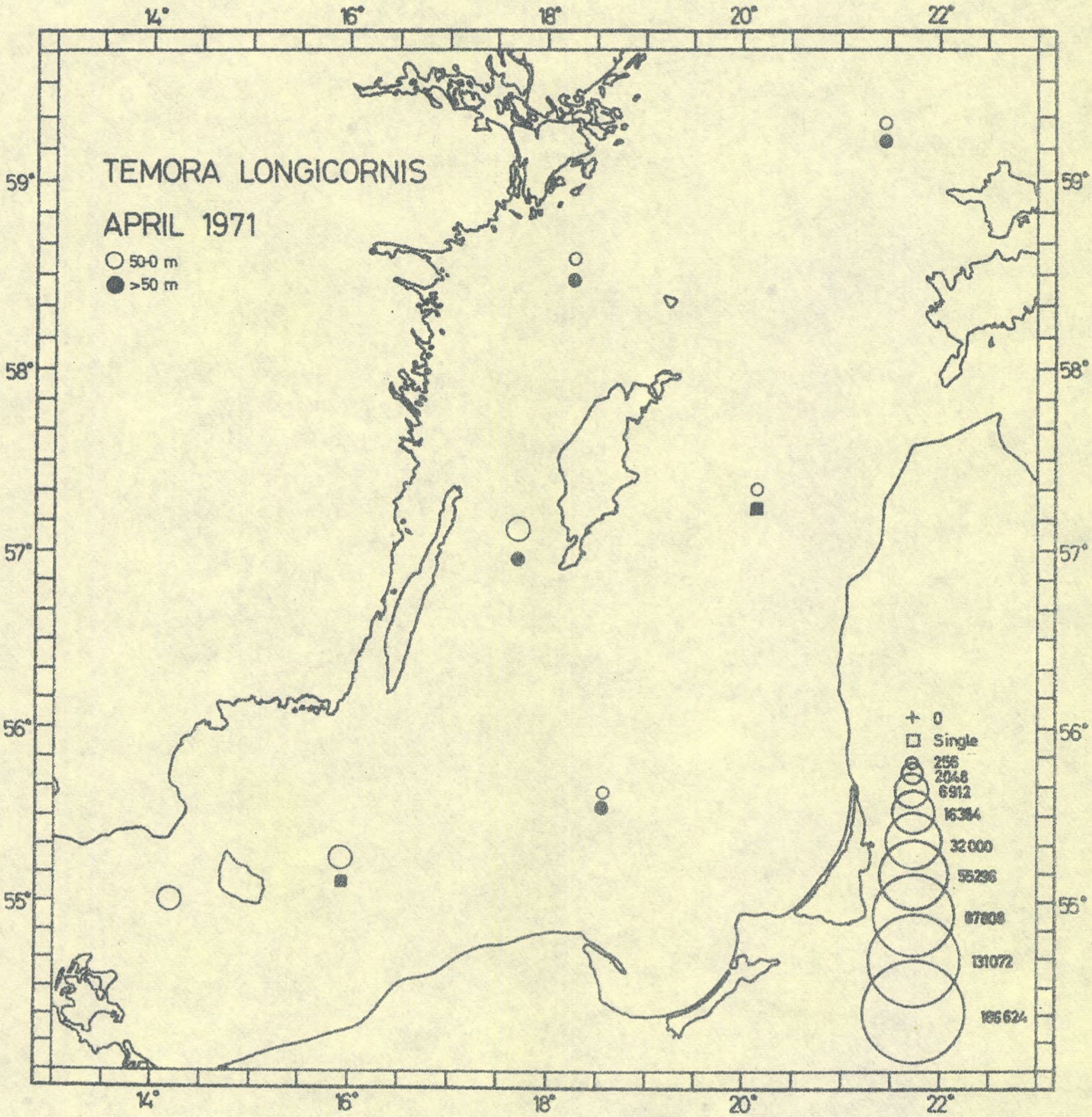
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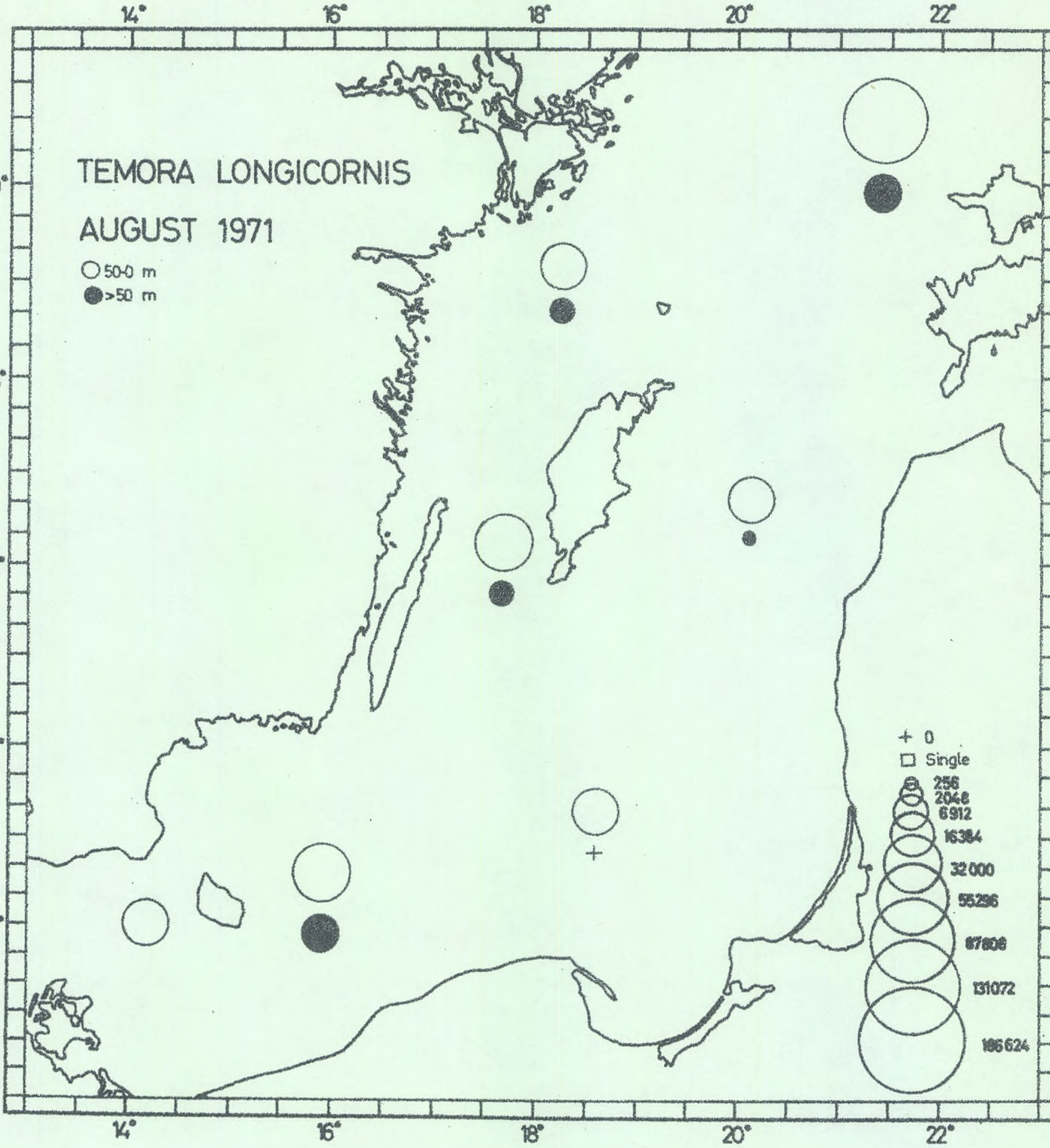
Fig.40



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22°
59°
58°
57°
56°
55°
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.41

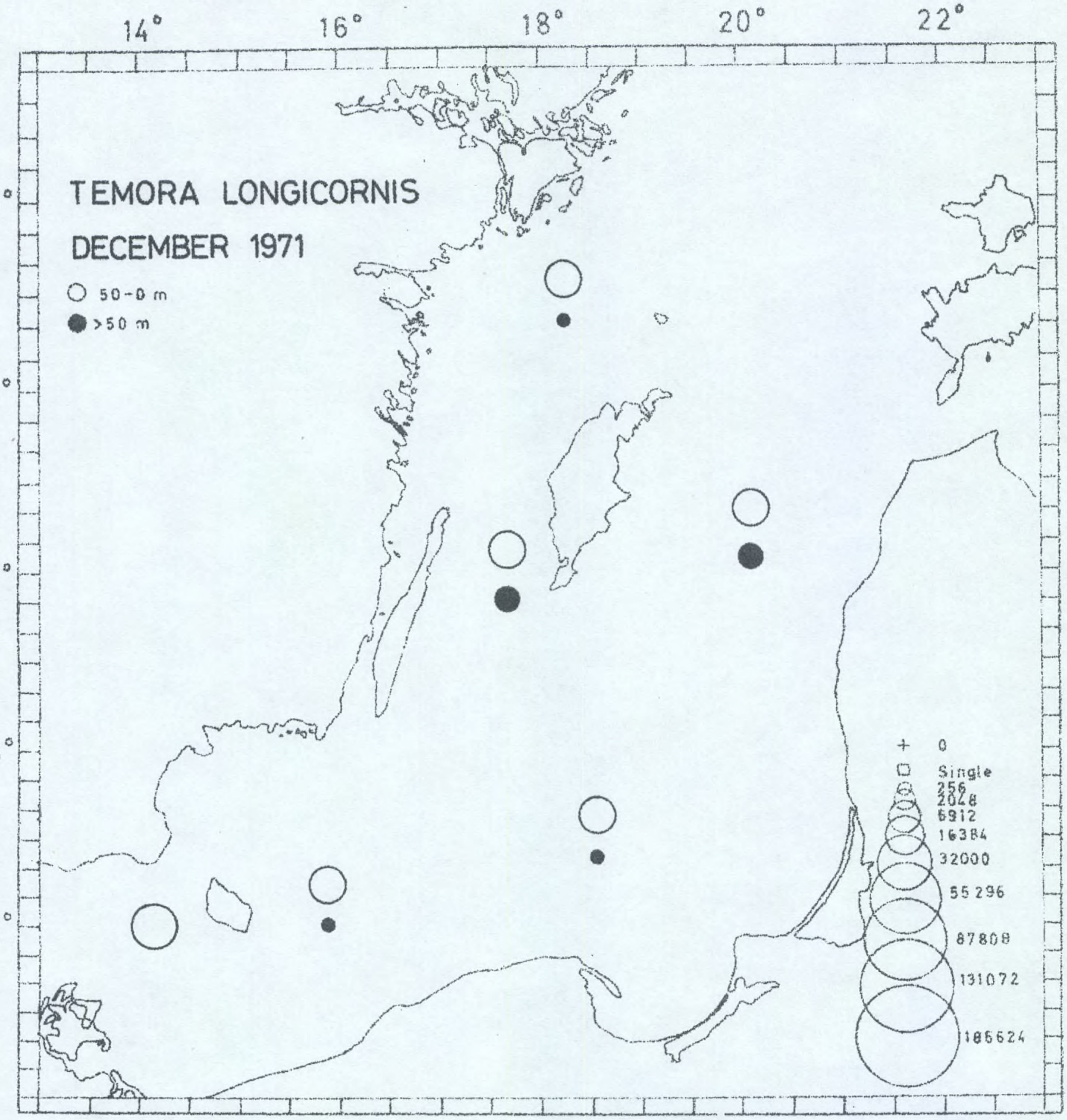
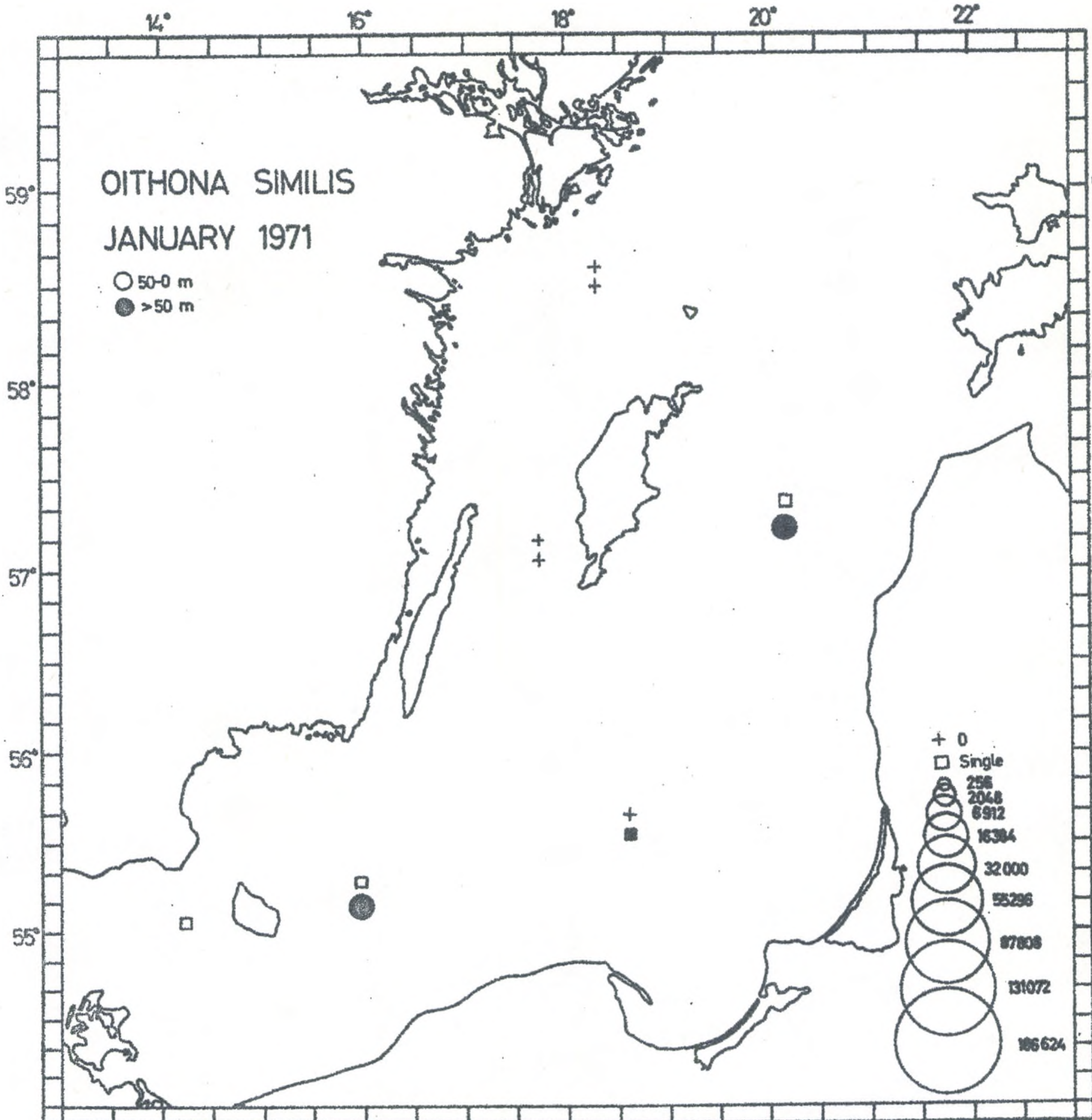

TEMORA LONGICORNIS
DECEMBER 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.42



OITHONA SIMILIS
JANUARY 1971
50-0 m
>50 m
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°

Fig.43

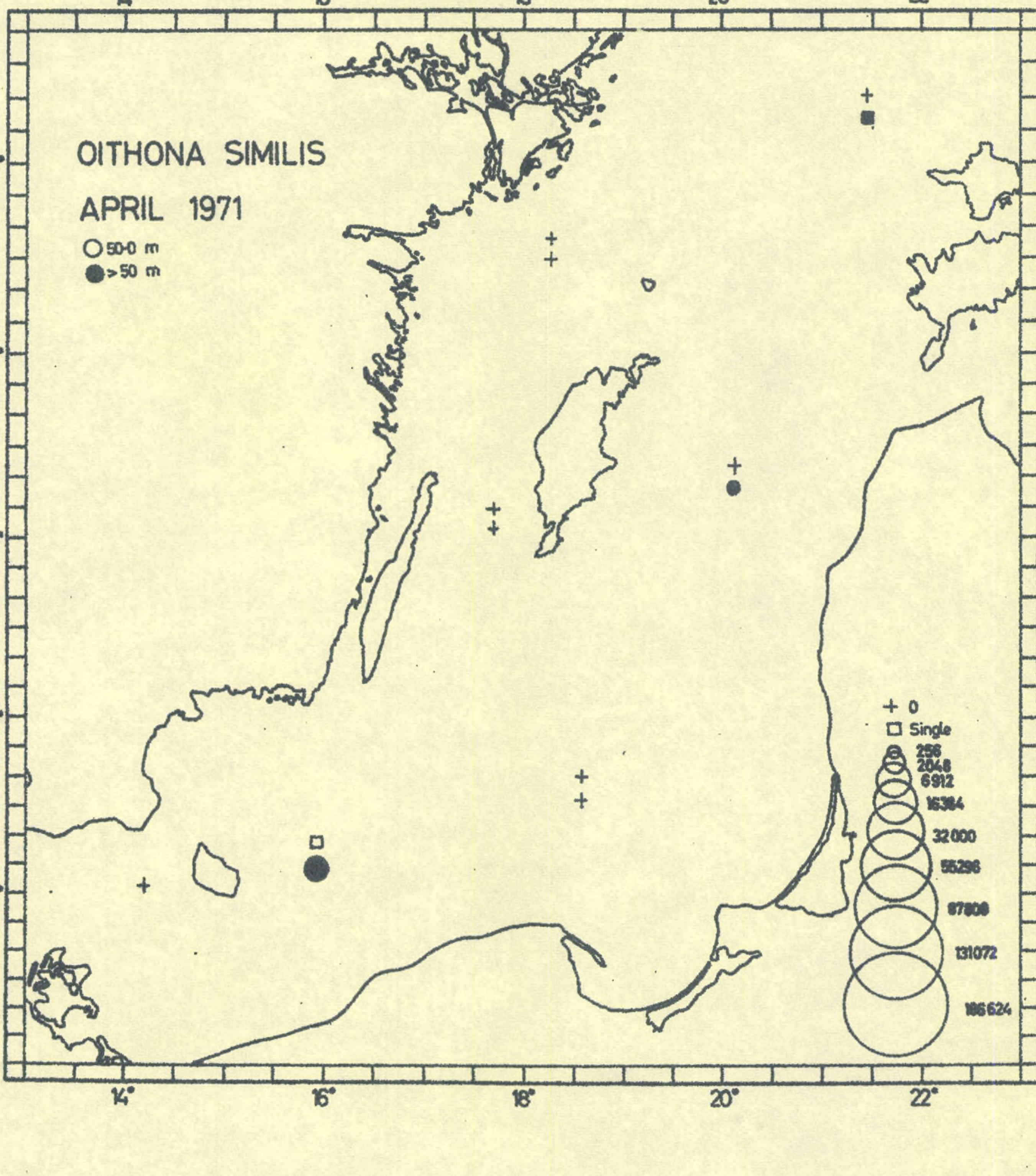
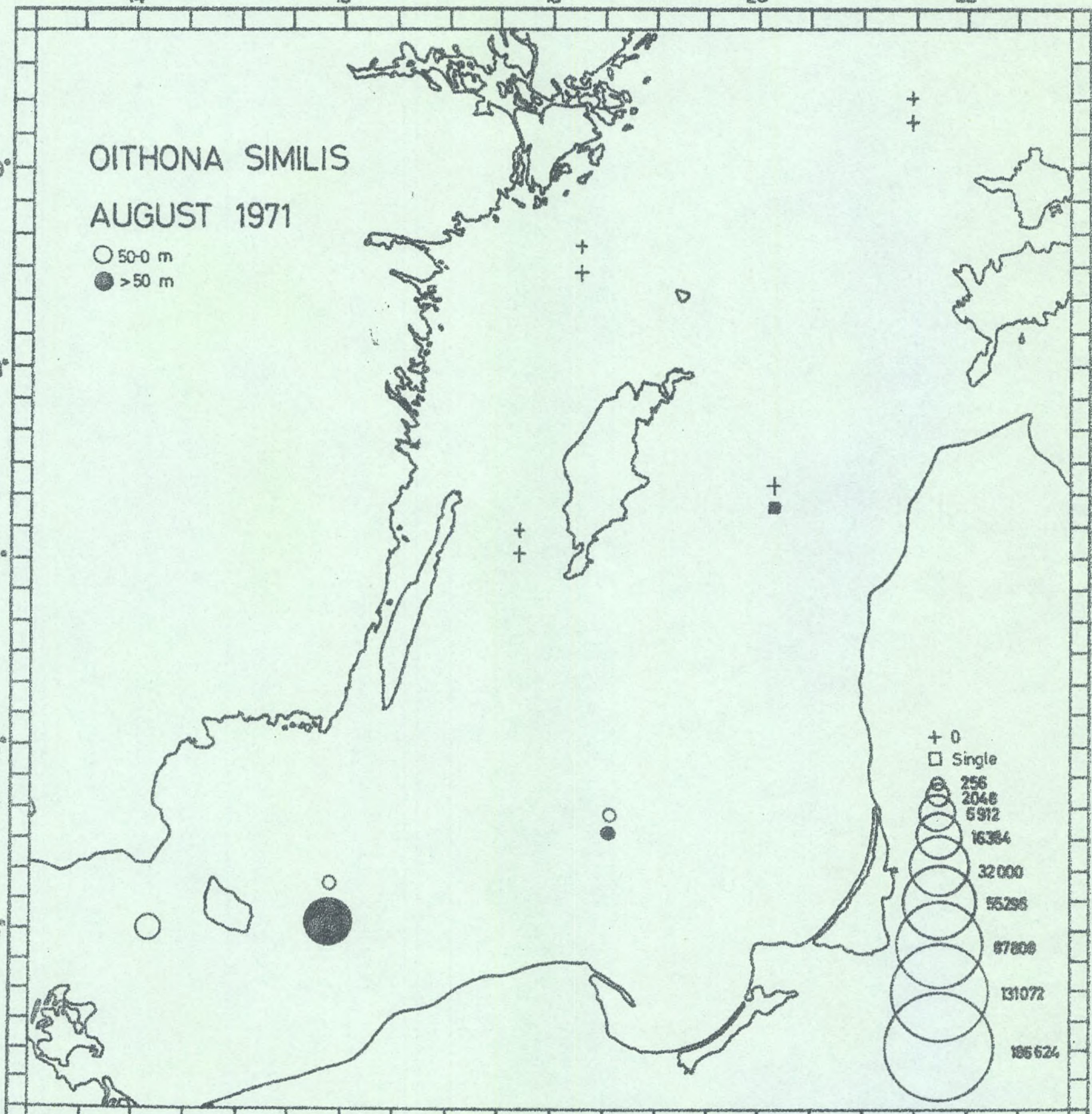
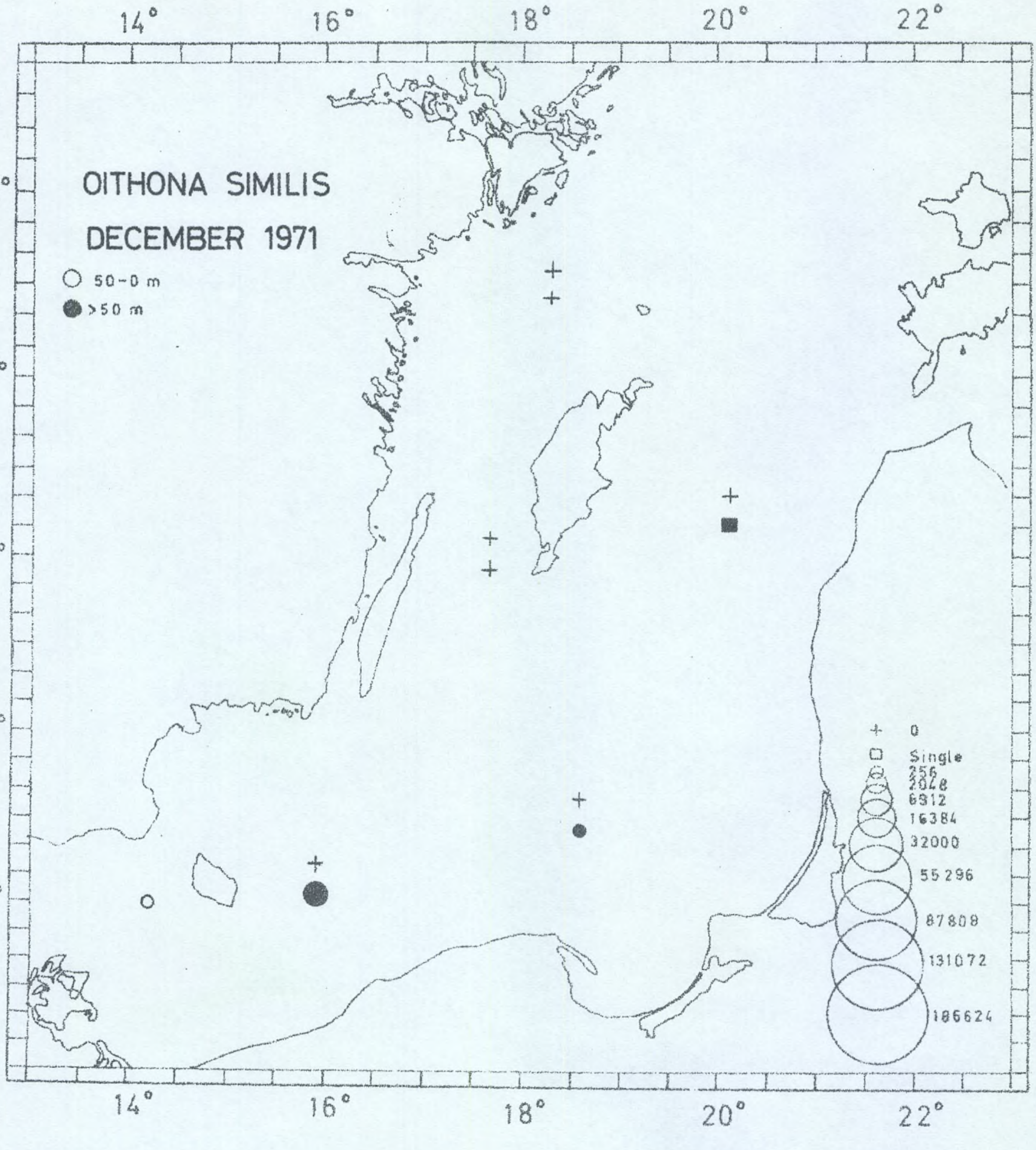

OITHONA SIMILIS
APRIL 1971
50-0 m
>50 m
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°

Fig.44



OITHONA SIMILIS
AUGUST 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.45



OITHONA SIMILIS
DECEMBER 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.46

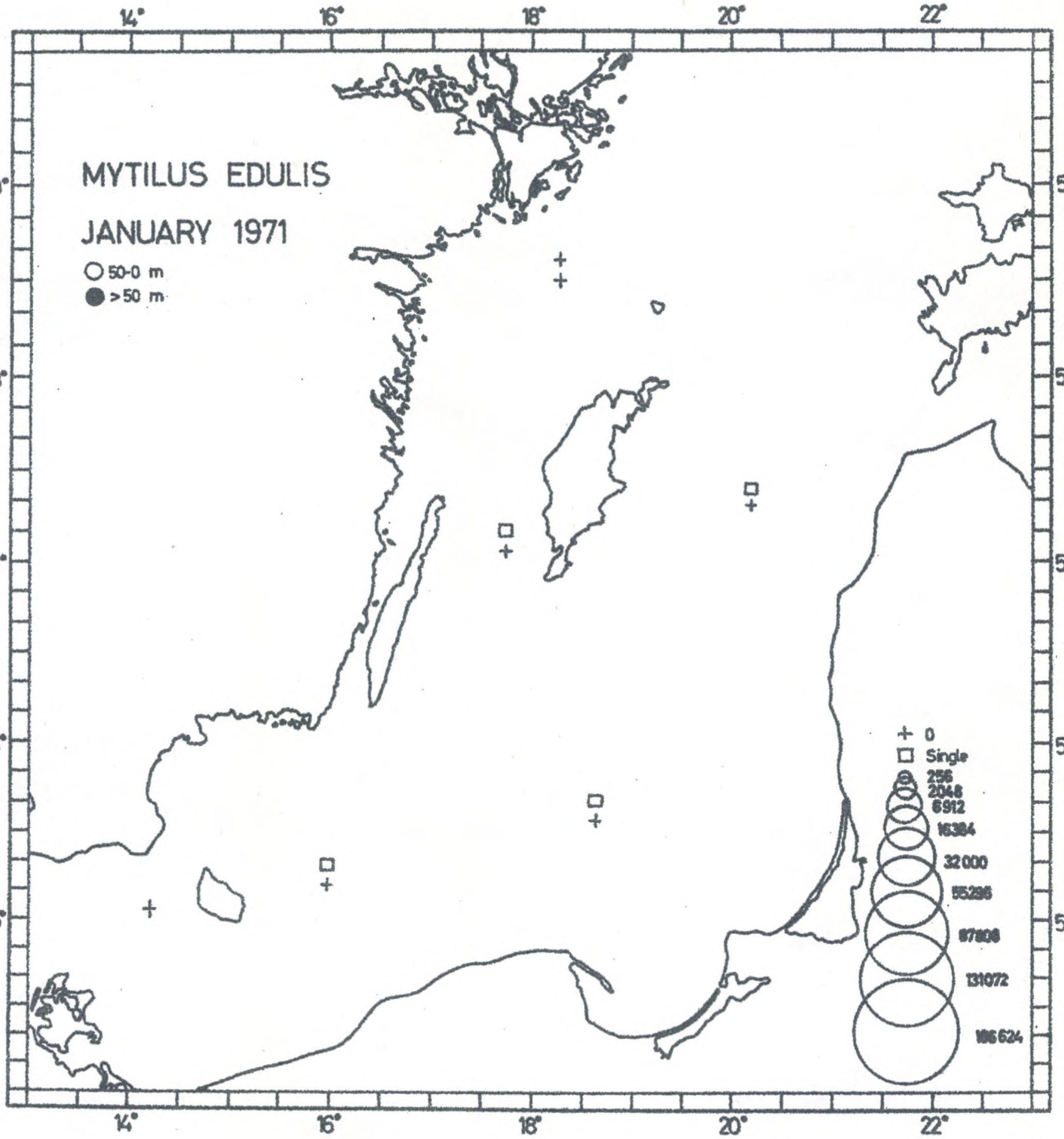
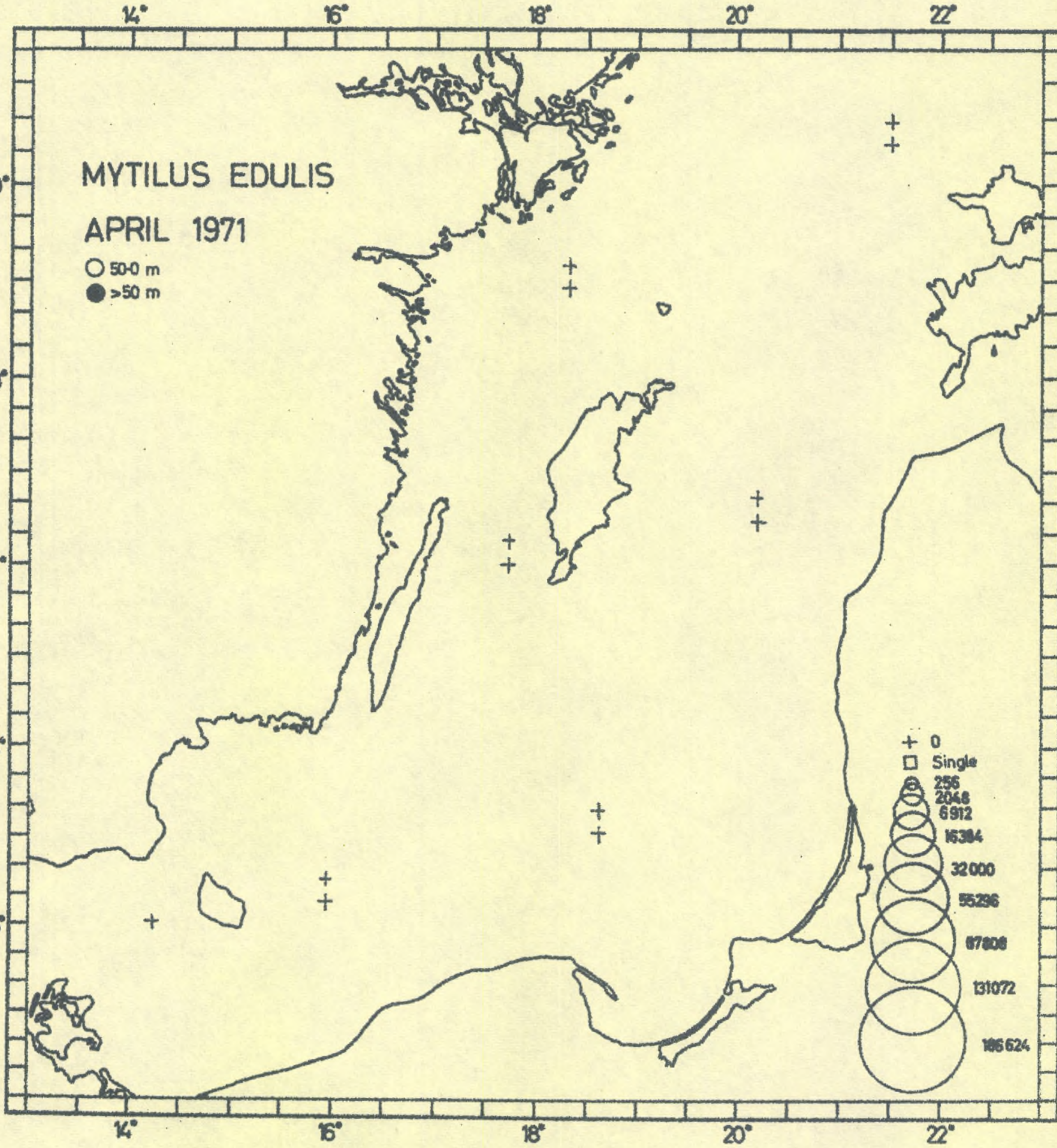
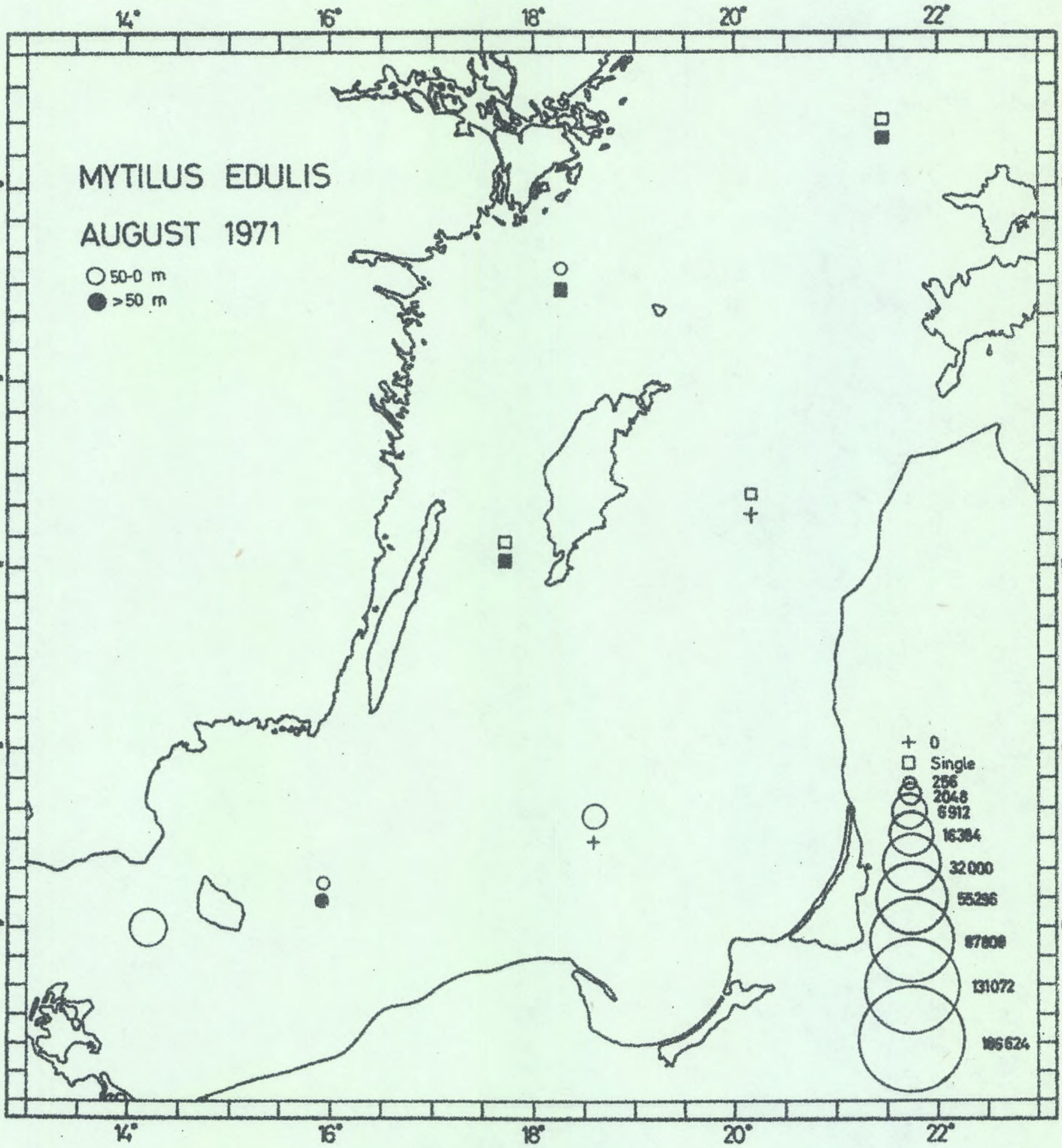

MYTILUS EDULIS
JANUARY 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.47



MYTILUS EDULIS
APRIL 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.48


MYTILUS EDULIS
AUGUST 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

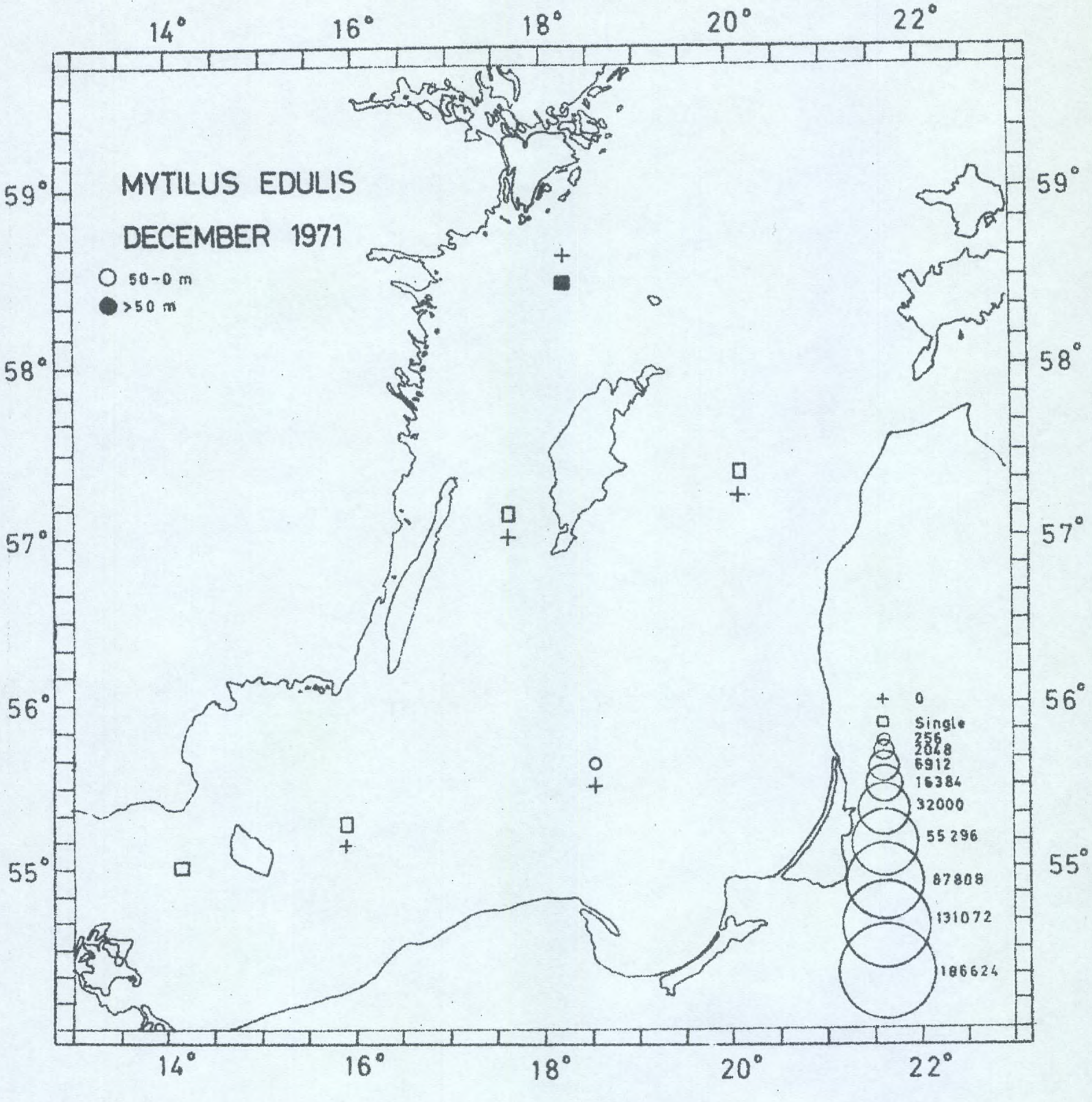

MYTILUS EDULIS
DECEMBER 1971
50-0 m
>50 m
0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°

Fig.50

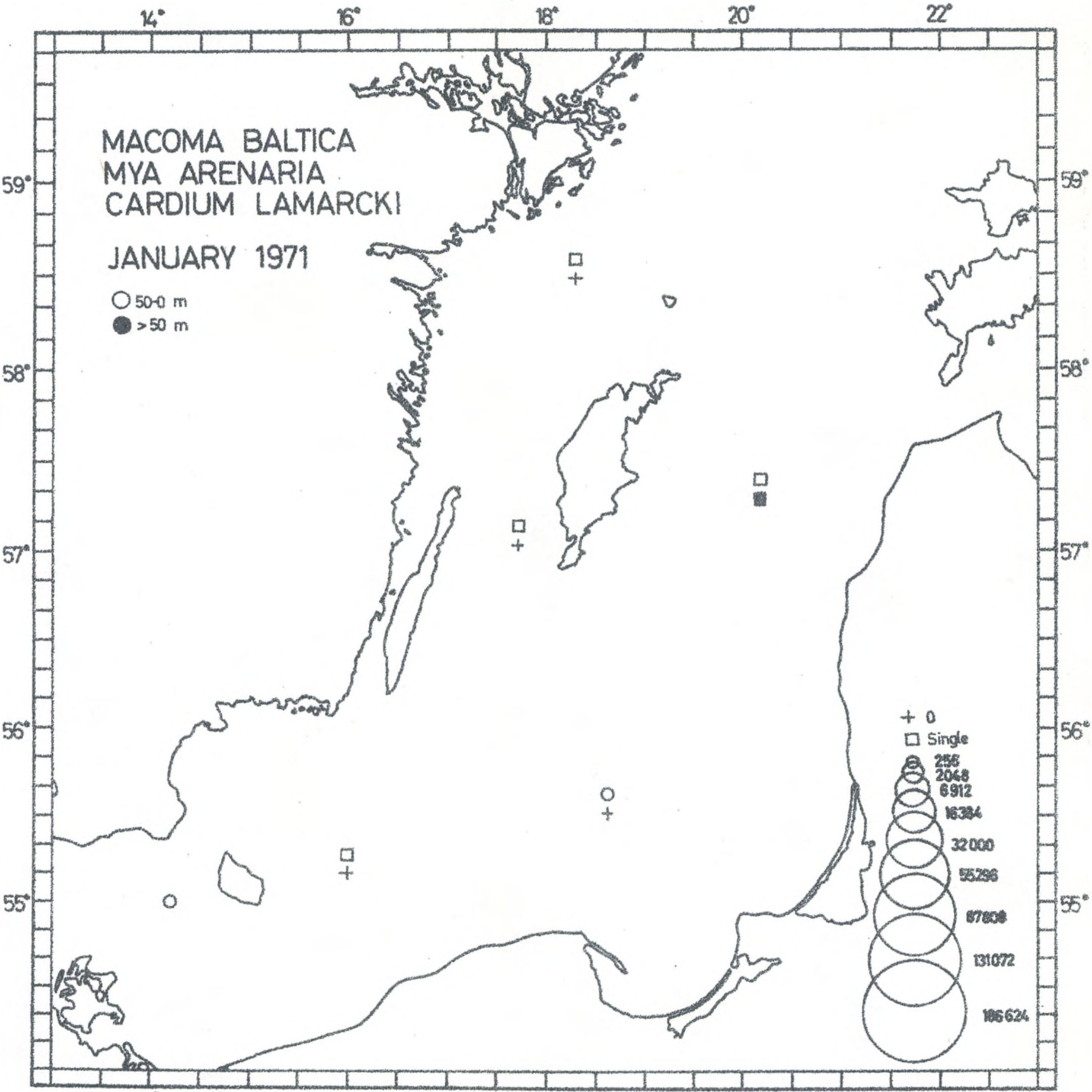
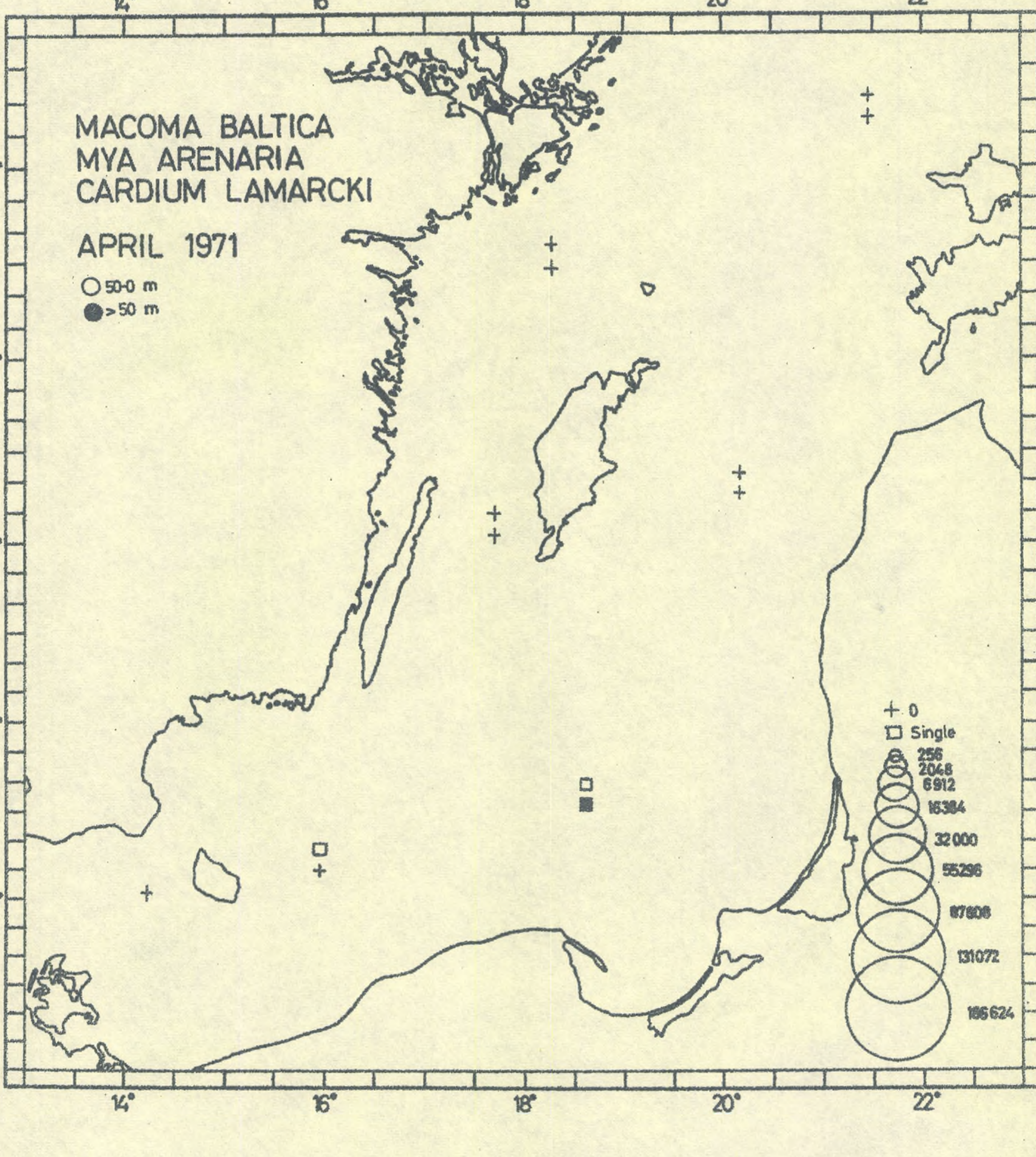

14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
MACOMA BALTICA
MYA ARENARIA
CARDIUM LAMARCKI
JANUARY 1971
50-0 m
>50 m
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig. 51



MACOMA BALTICA
MYA ARENARIA
CARDIUM LAMARCKI
APRIL 1971
50-0 m
>50 m
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624
14°
16°
18°
20°
22°
55°
56°
57°
58°
59°

Fig.52

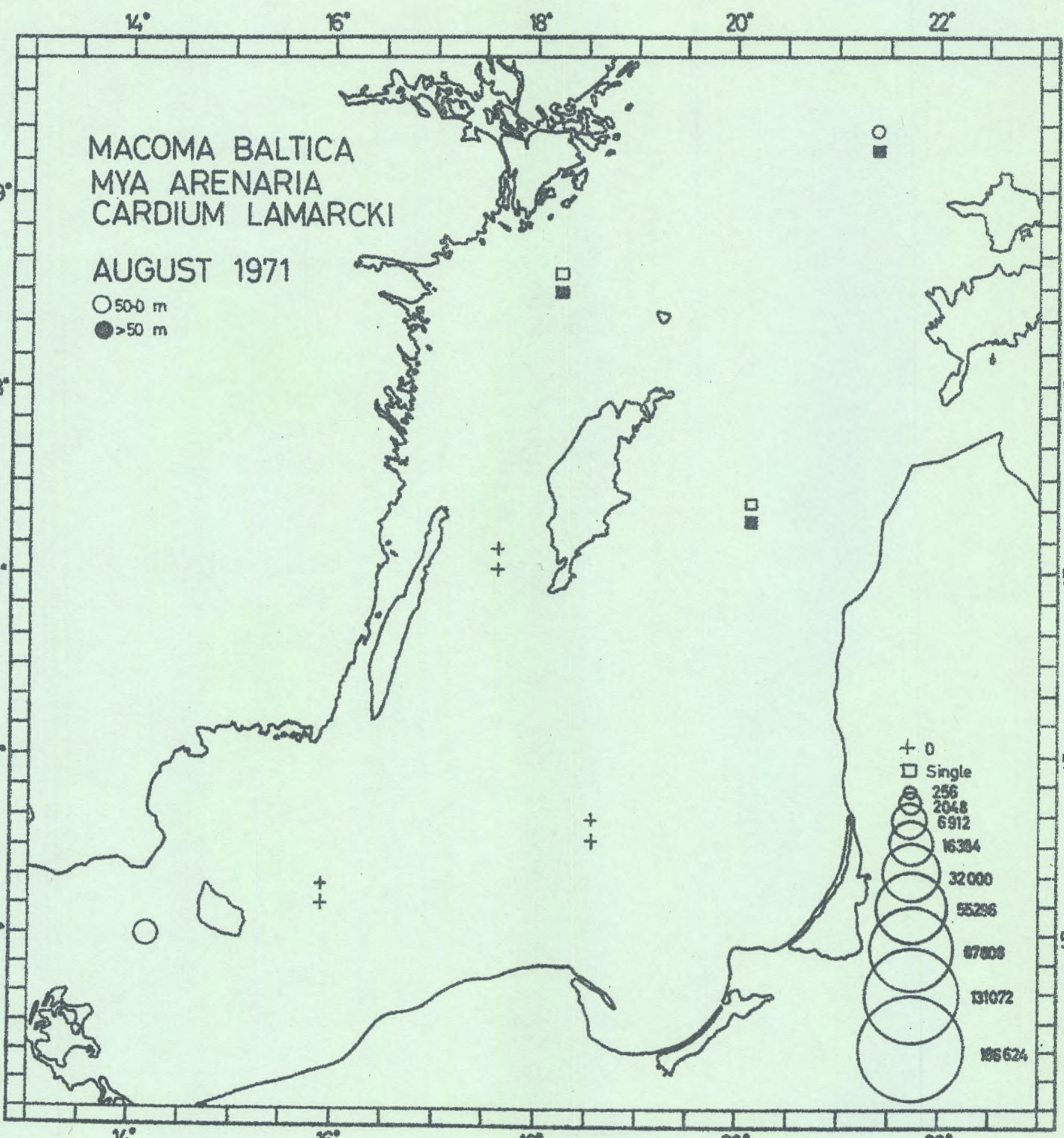

MACOMA BALTICA
MYA ARENARIA
CARDIUM LAMARCKI
AUGUST 1971
50-0 m
>50 m
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
196624
14°
16°
18°
20°
22°
55°
56°
57°
58°
59°

Fig.53

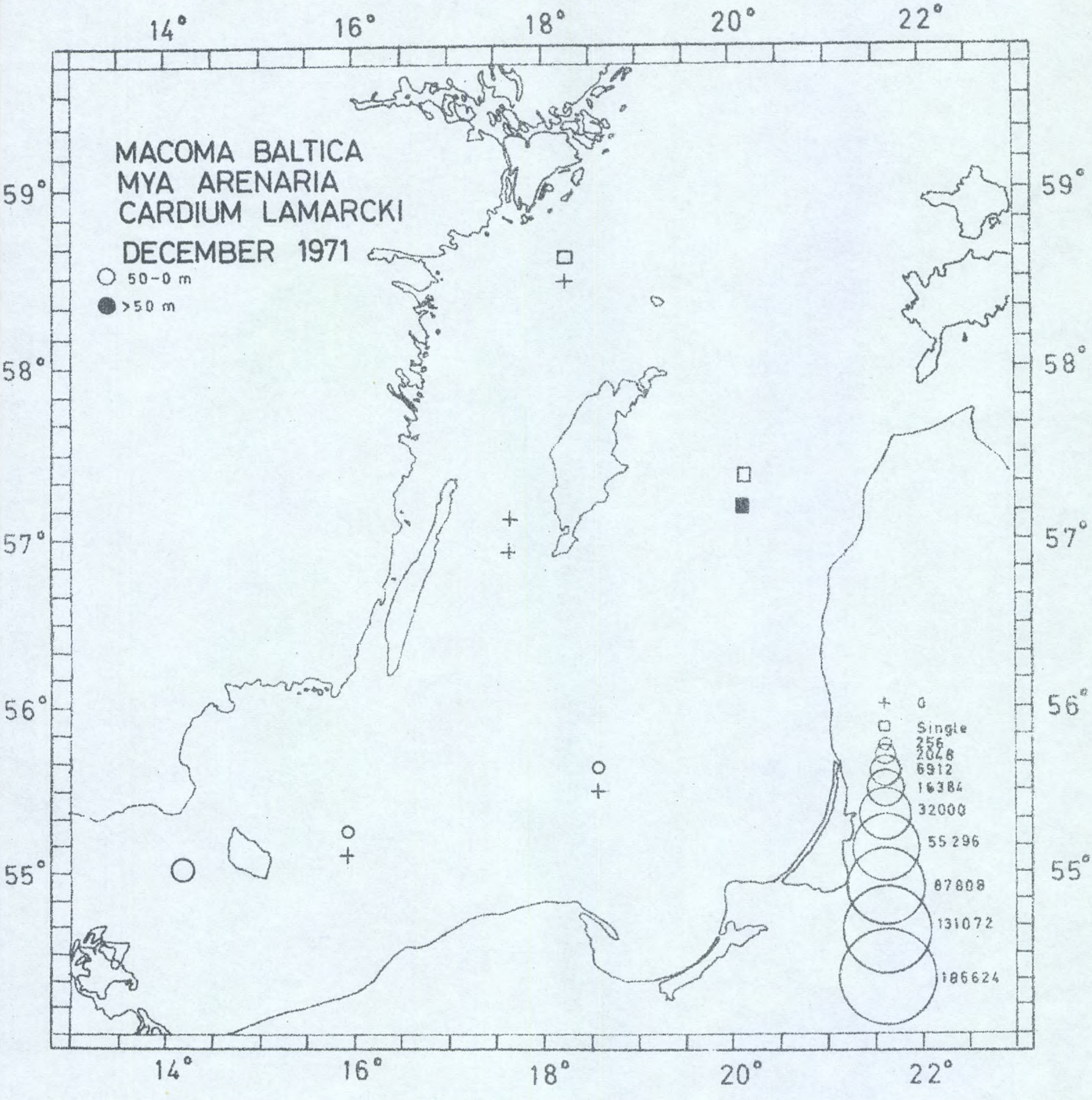
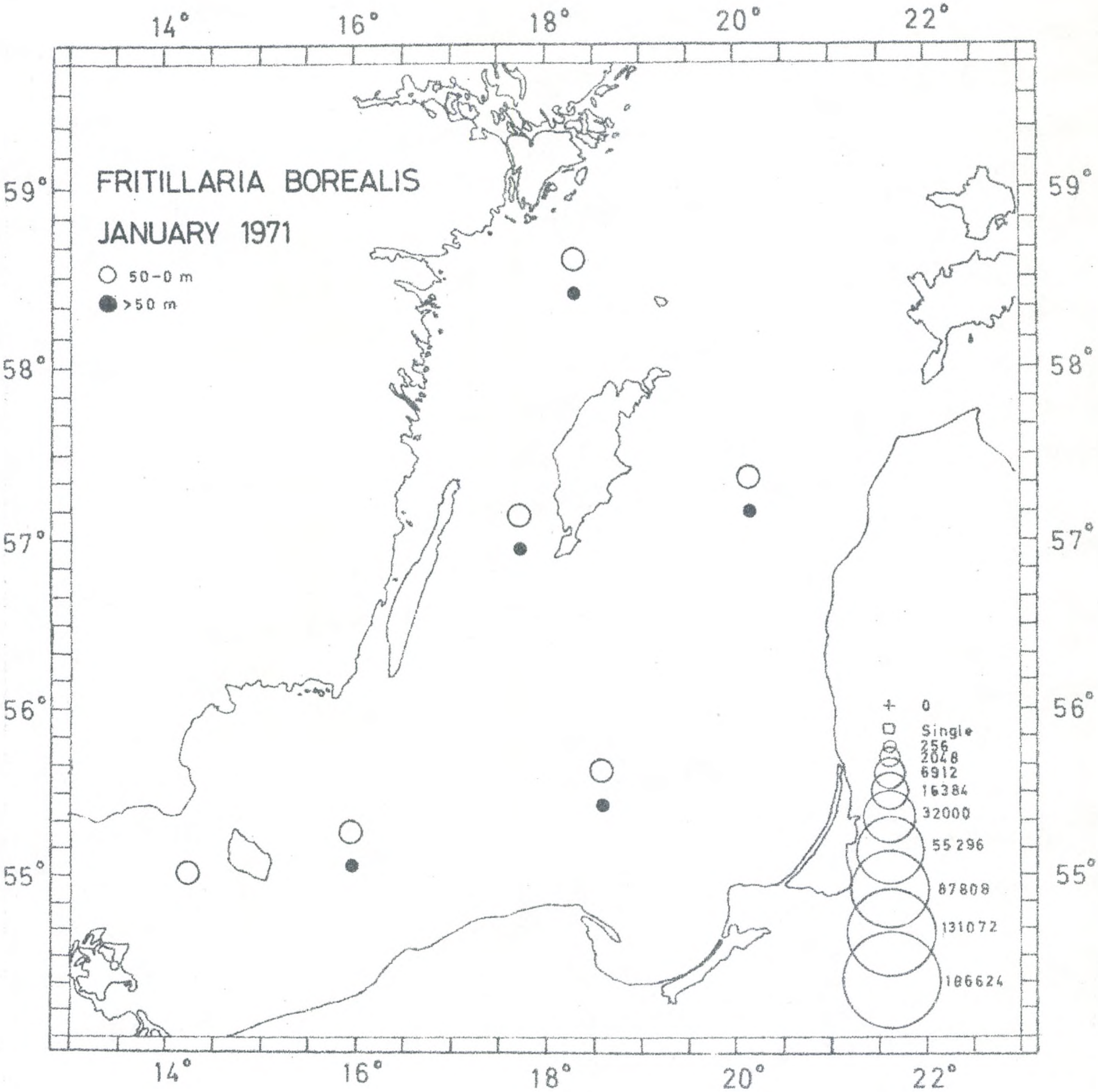
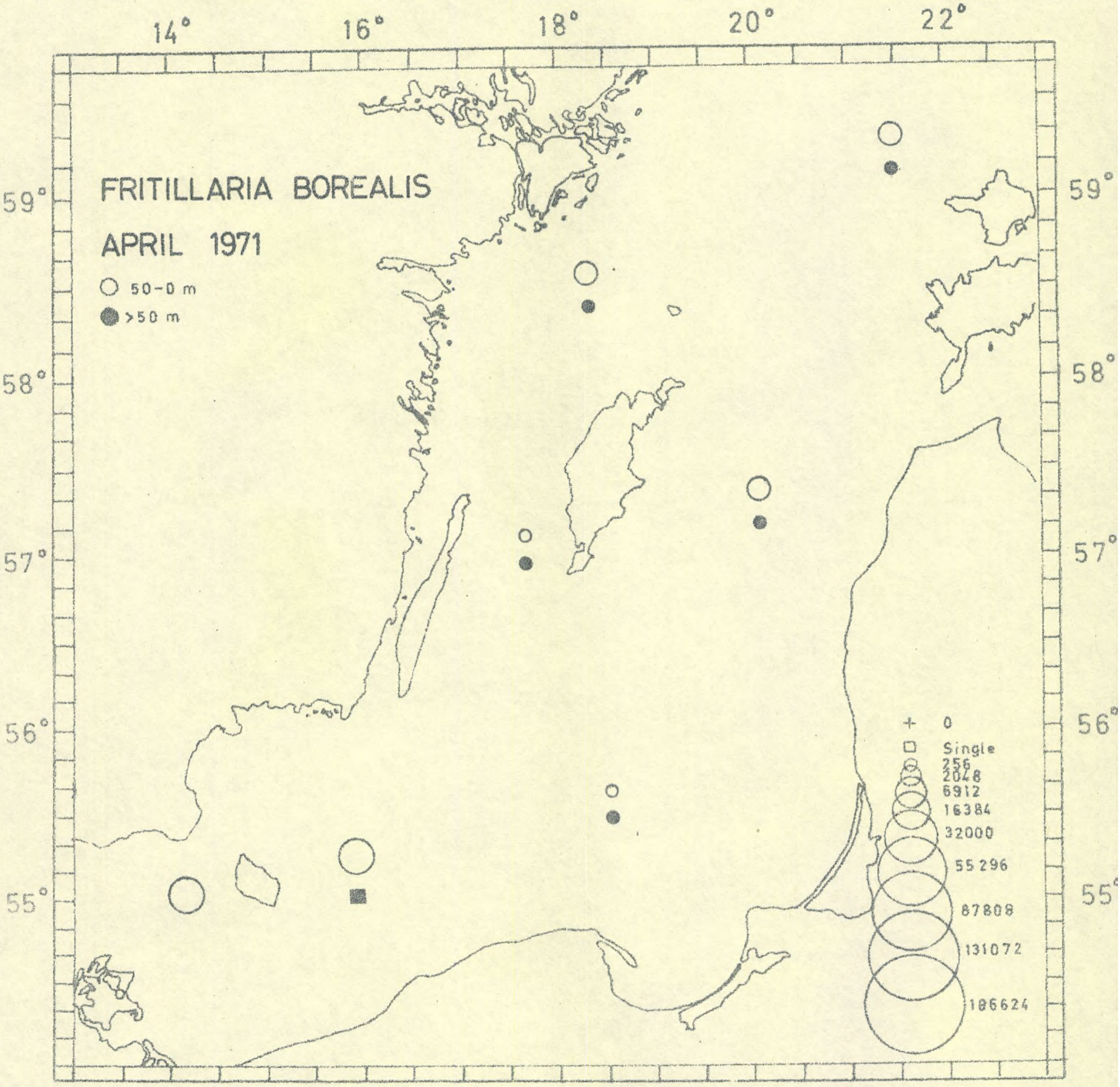

MACOMA BALTICA
MYA ARENARIA
CARDIUM LAMARCKI
DECEMBER 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig. 54



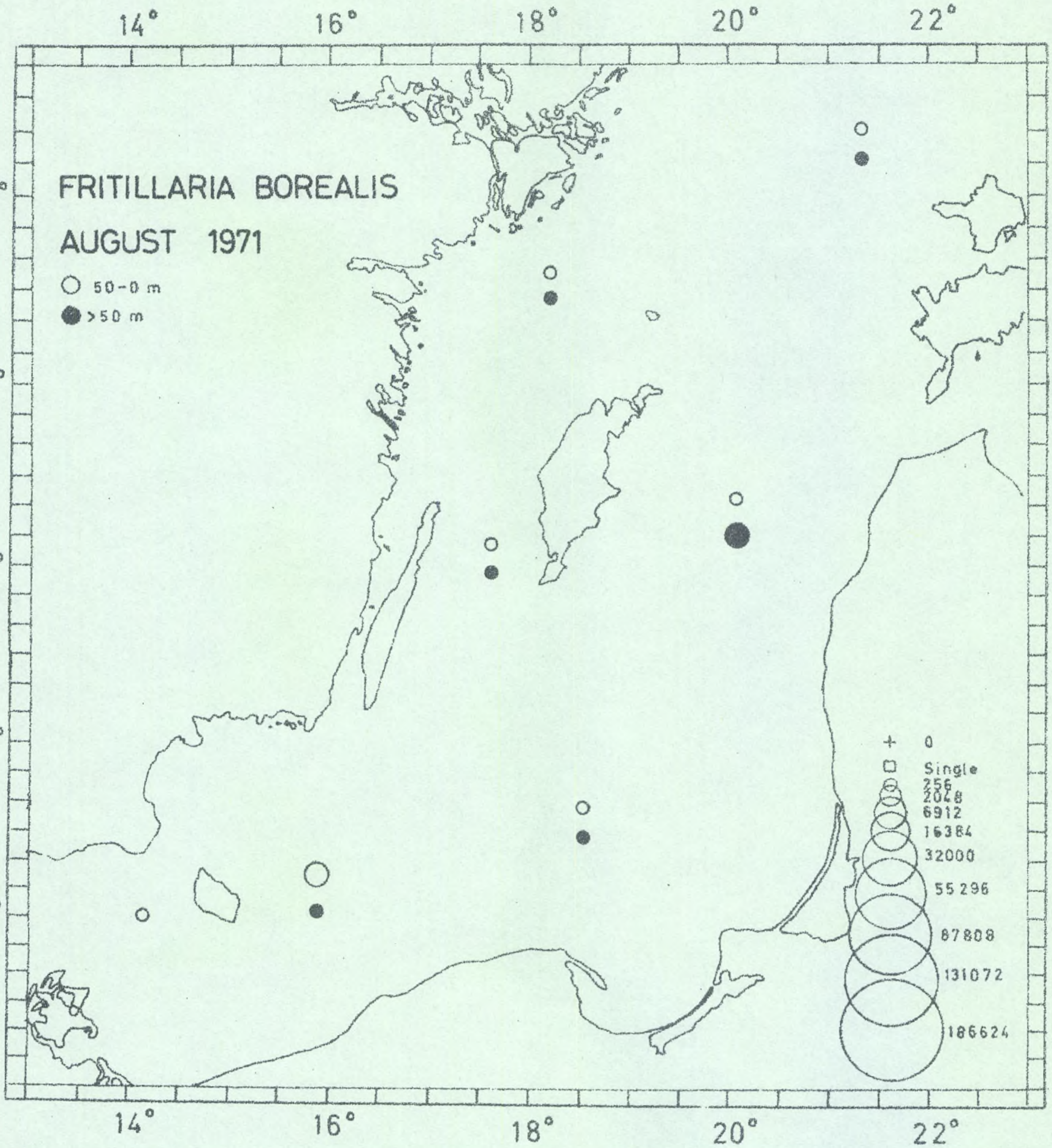
FRITILLARIA BOREALIS
JANUARY 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
+ 0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.55



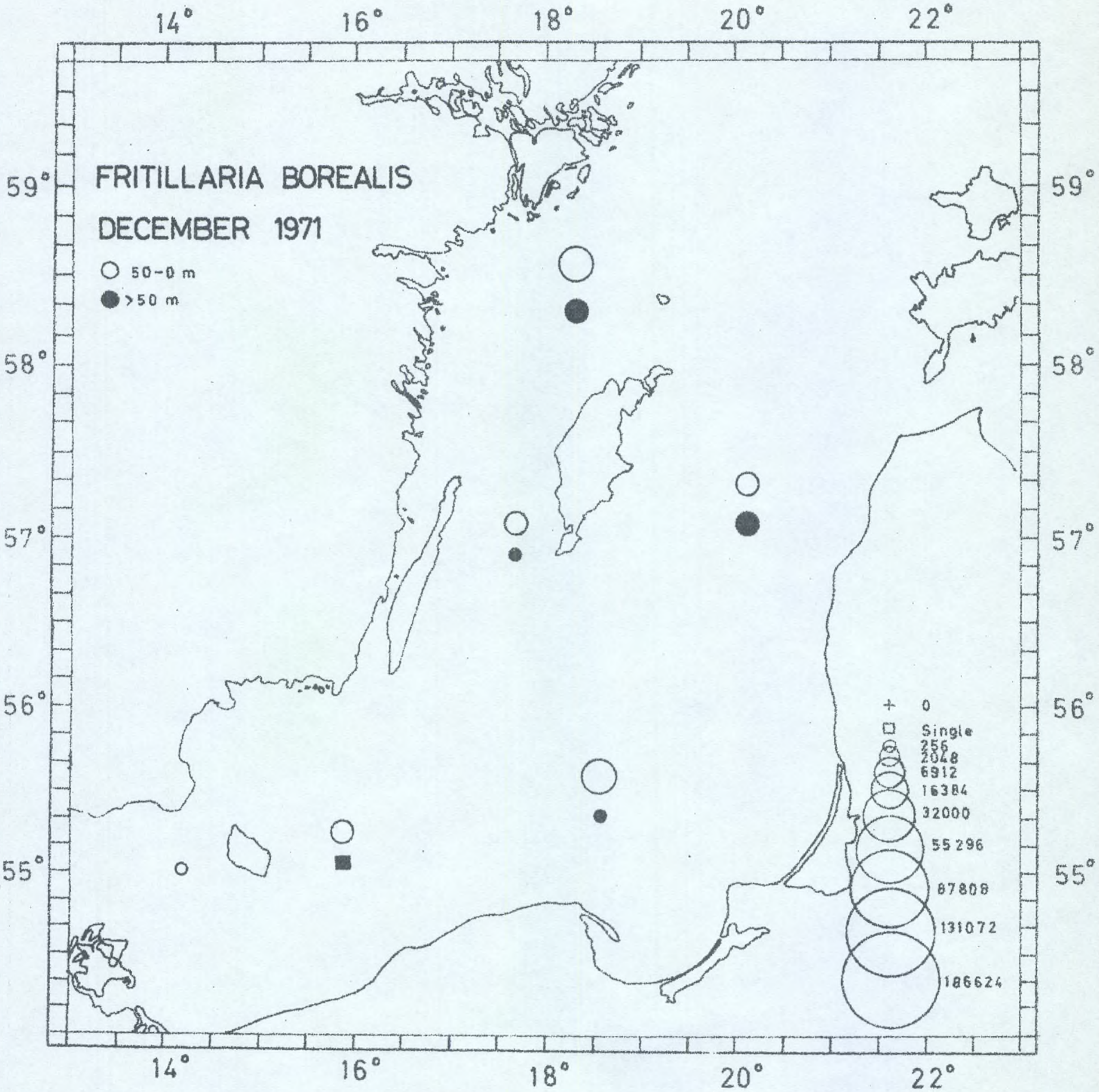
FRITILLARIA BOREALIS
APRIL 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.56



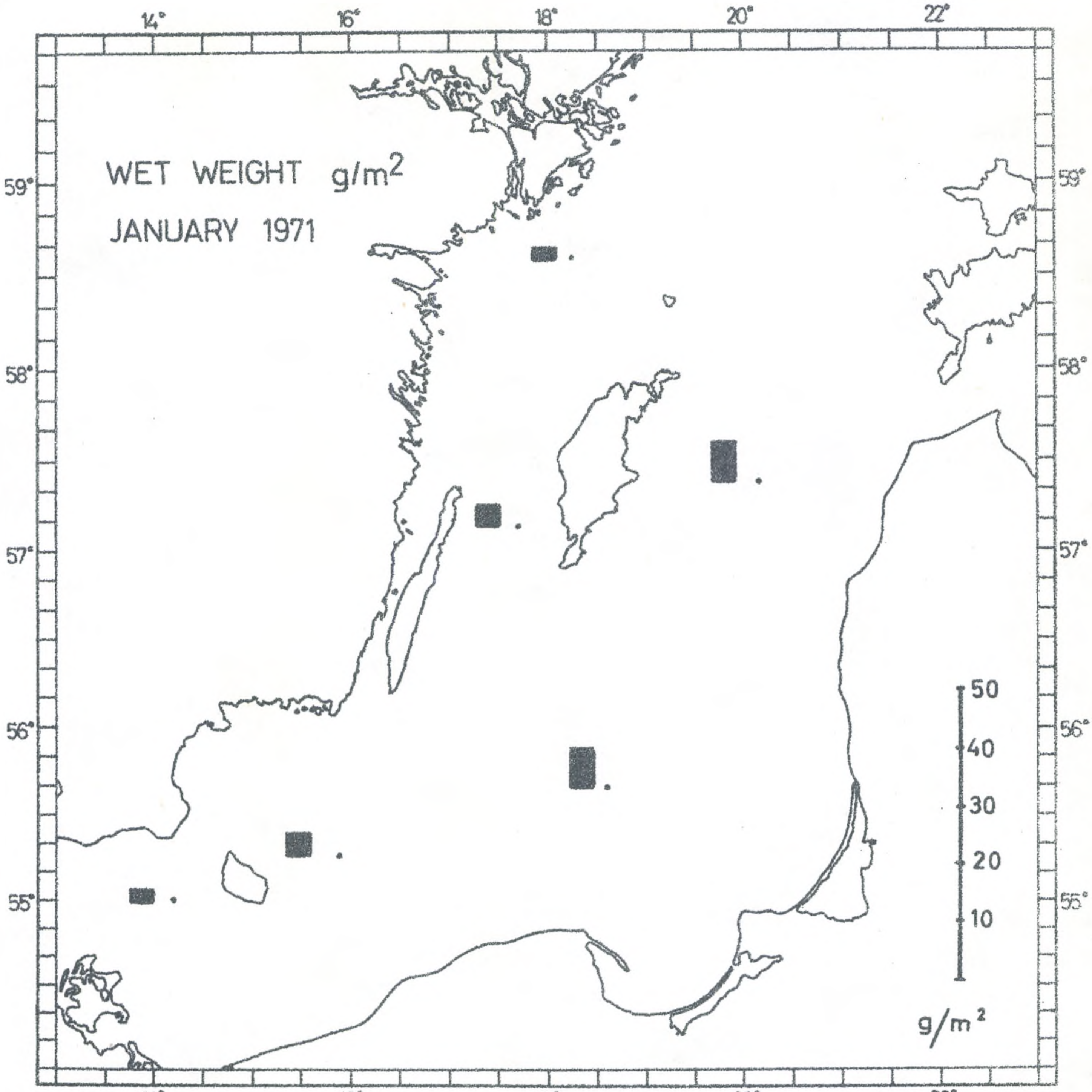
FRITILLARIA BOREALIS
AUGUST 1971
50-0 m
>50 m
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
+ 0
Single
256
2048
6912
16384
32000
55 296
87808
131072
186624

Fig.57



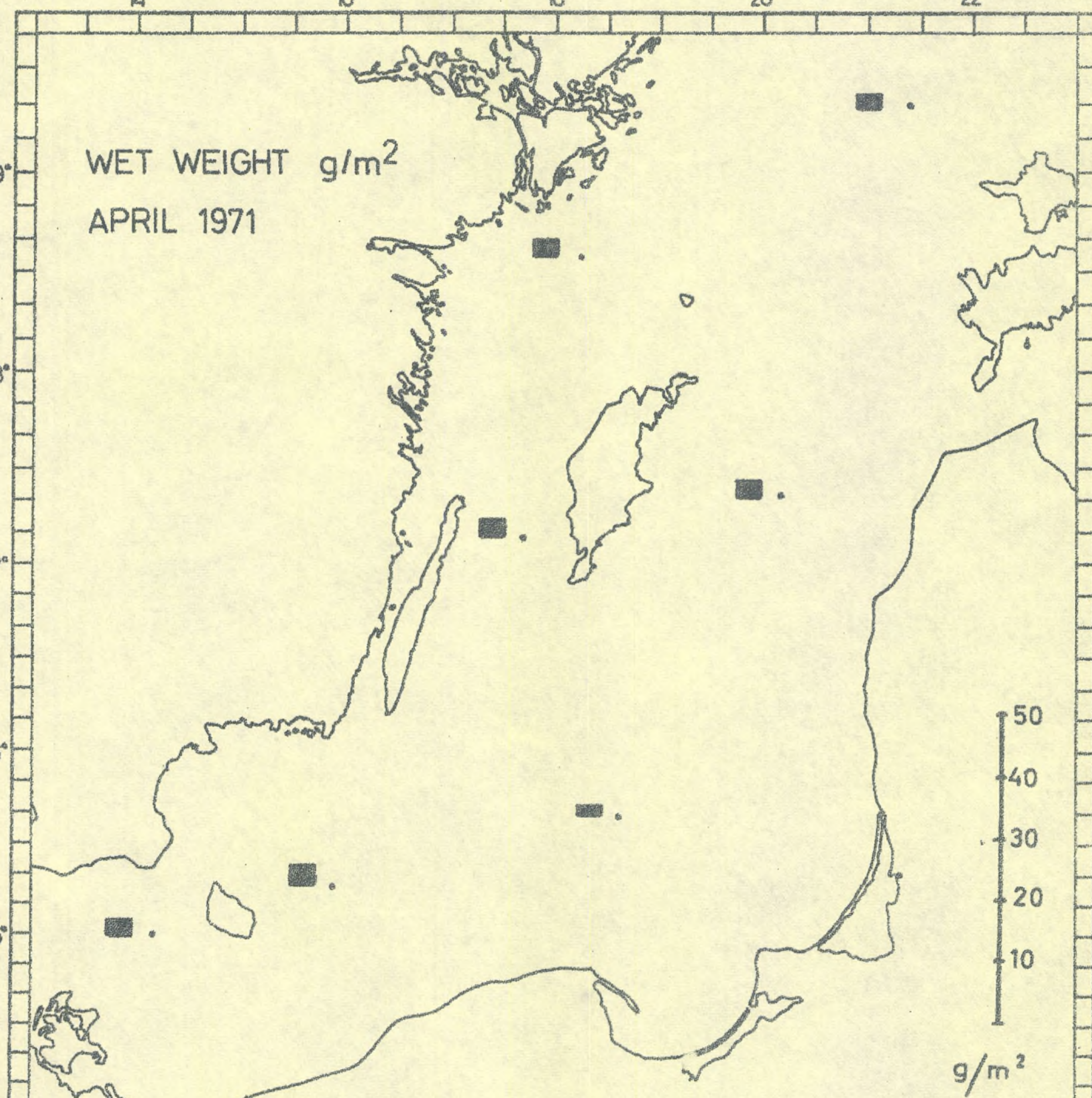
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
FRITILLARIA BOREALIS
DECEMBER 1971
50-0 m
>50 m
0
Single
256
2048
6912
16384
32000
55296
87808
131072
186624

Fig.58



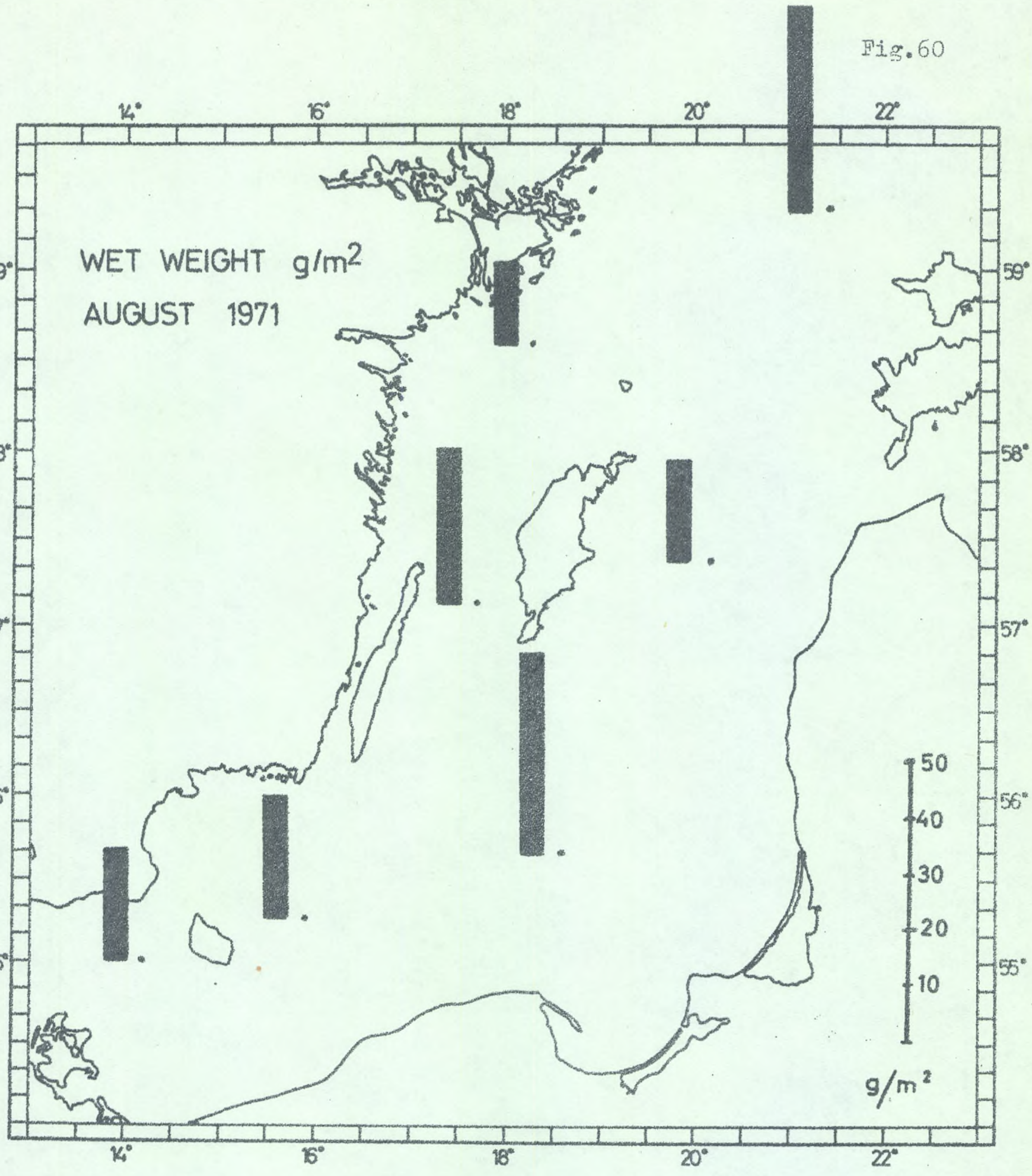
WET WEIGHT g/m2
JANUARY 1971
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
50
40
30
20
10
g/m 2

Fig.59

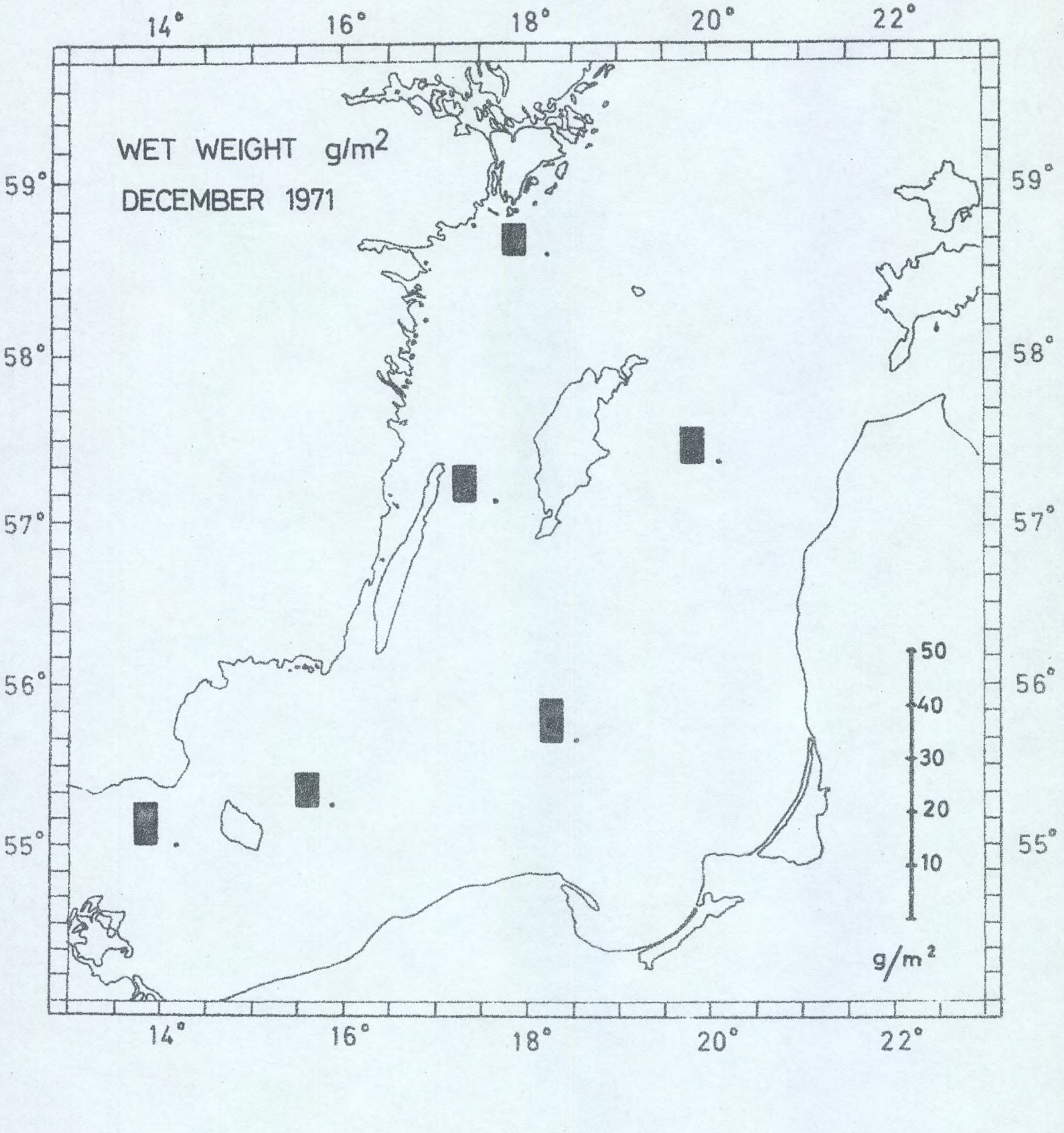


WET WEIGHT g/m²
APRIL 1971
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
50
40
30
20
10
g/m²

Fig.60



WET WEIGHT g/m2
AUGUST 1971
14°
16°
18°
20°
22°
59°
58°
57°
56°
55°
50
40
30
20
10
g/m²



14°
16°
18°
20°
22°
WET WEIGHT g/m2
DECEMBER 1971
59°
58°
57°
56°
55°
50
40
30
20
10
g/m²

Fig.62

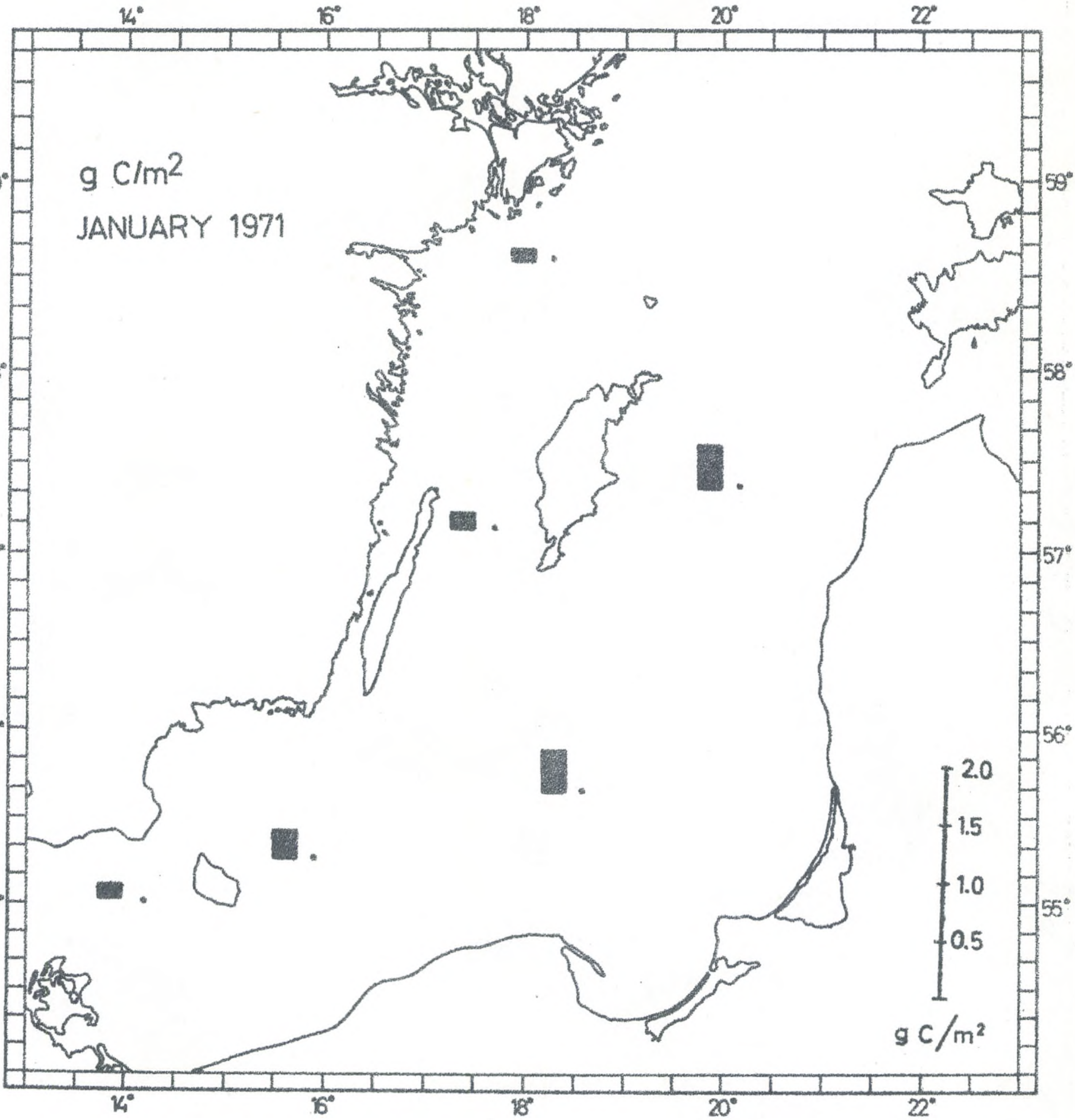


Fig. 63

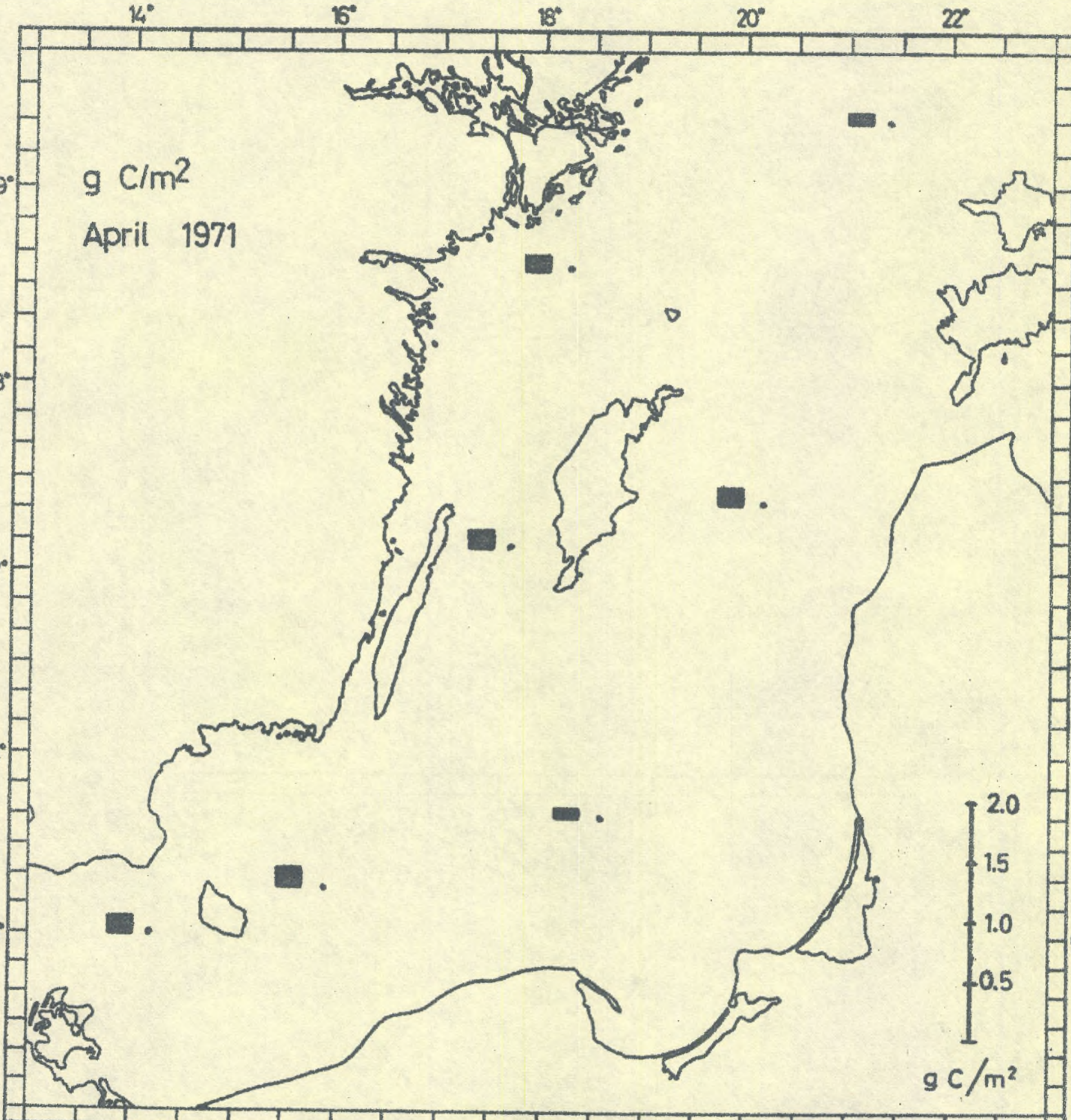
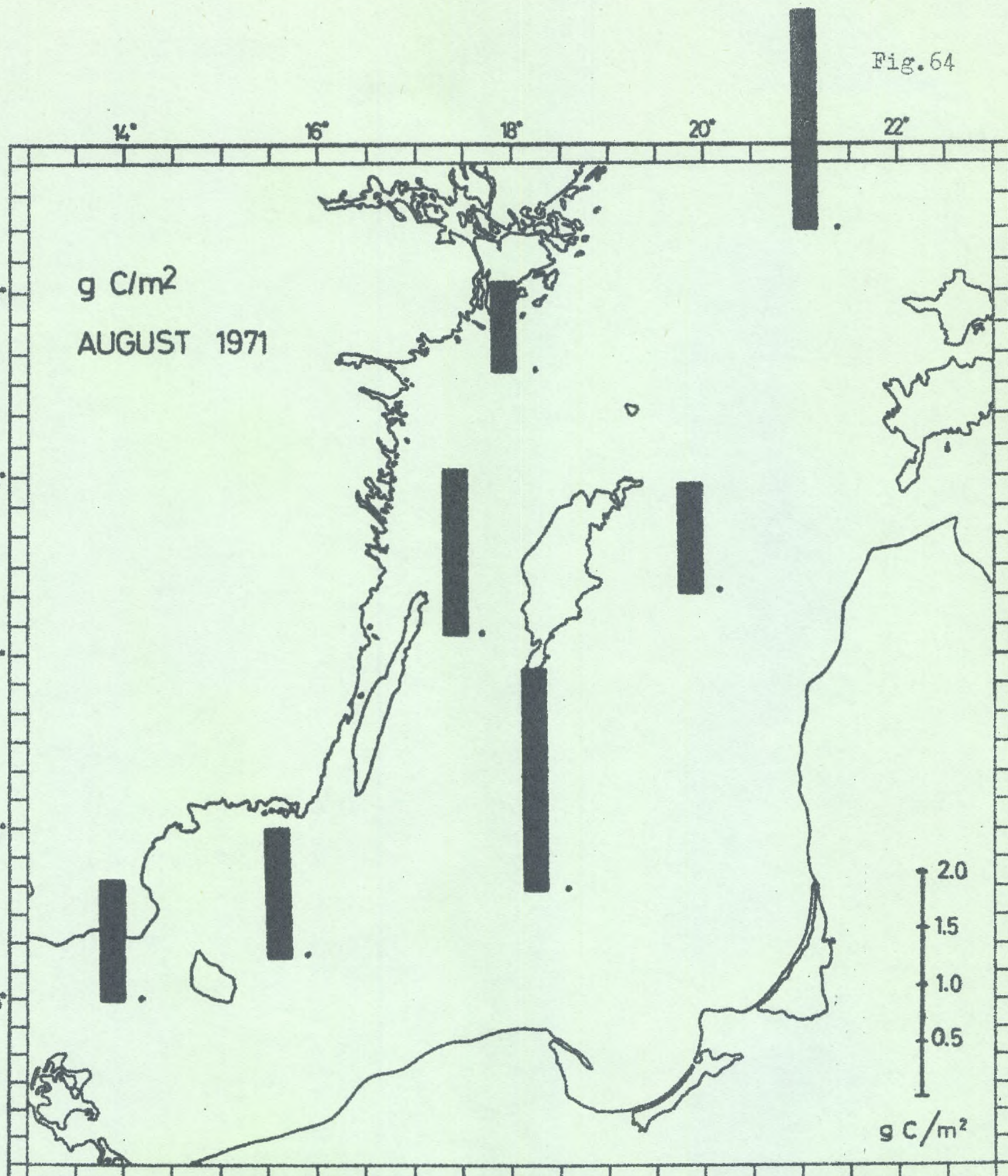


Fig. 64



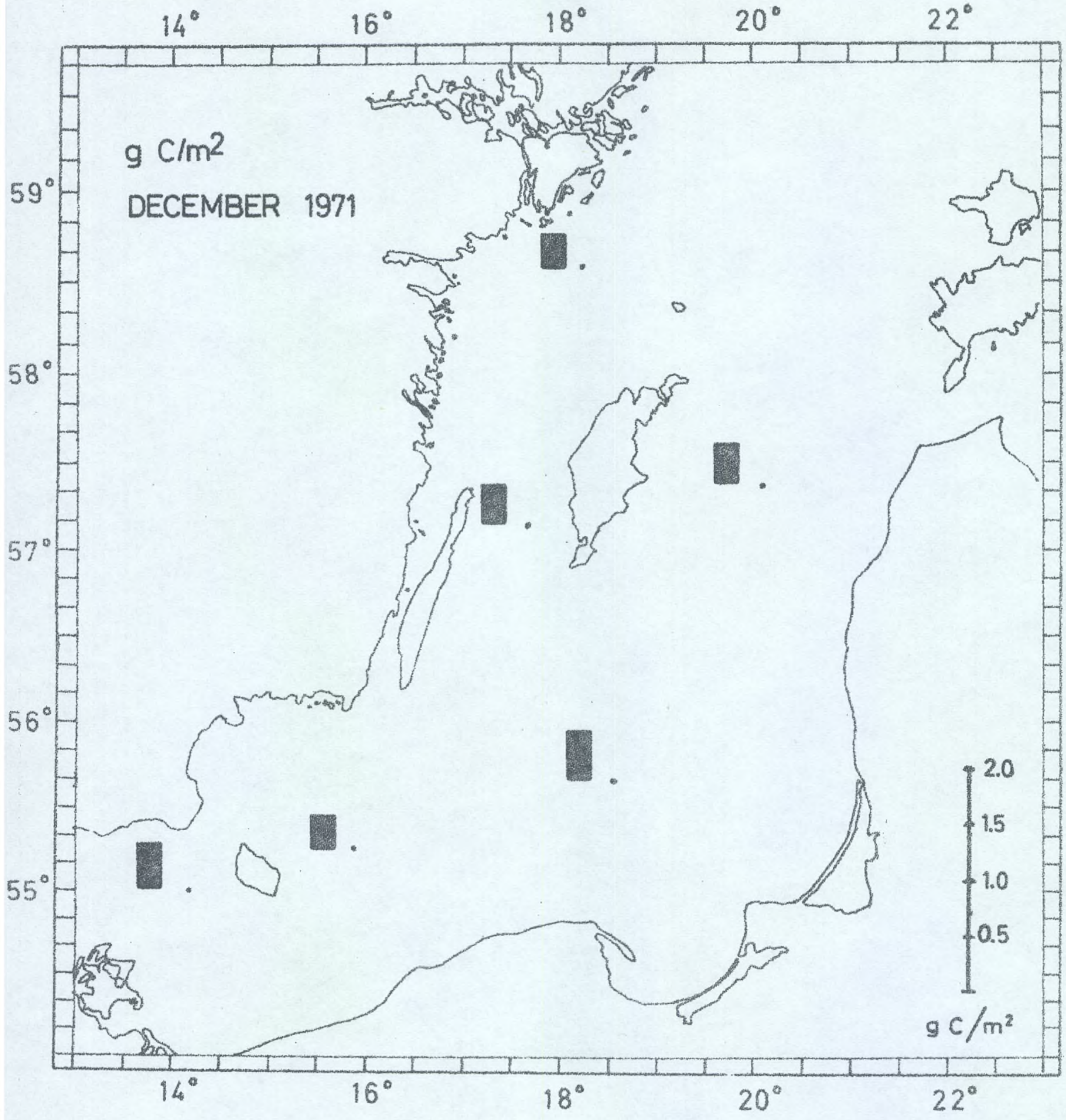

14°
16°
18°
20°
22°
g C/m2
DECEMBER 1971
59°
58°
57°
56°
55°
2.0
1.5
1.0
0.5
g C/m²

Table 1. Plankton stations visited in 1971.

S 12 (2A) Arkona	55°00'N	14°05'E
S 24 (5A) Bornholm Deep	55°15'N	15°59'E
8A "Rysshålan"	55°38'N	18°36'E
F 81 (15A)Gotland Deep	57°20'N	20°03'E
F 72	59°18'N	21°34'E
F 78 (31A)Landsort Deep	58°35'N	18°14'E
S 41 (38A)	57°07'N	17°40'E

Table 2. Temperature,salinity,oxygen.and hydrogen sulphide values at stations S12, S 24, 8A, F81, F78 and S41, January 1971 (ANON. 1972 a)

Station S 12 12 January, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	2.87	7.95	8.82
5	2.85	7.94	8.87
10	2.91	7.97	8.86
15	2.94	8.02	8.76
20	2.93	8.01	8.81
30	3.23	8.04	8.68
40	4.92	8.77	8.18
49	6.38	13.87	5.77

Station S 24 12 January, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	3.05	7.42	8.97
5	3.02	7.42	8.97
10	3.07	7.42	8.90
15	3,06	7.42	8.90
20	3.26	7.44	8.88
30	4.11	7.43	8.92
40	4.03	7.51	8.77
50	3.85	7.55	8.70
60	4.47	7.97	7.90
70	7.55	12.09	4.71
80	8.16	13.86	2.85
91	6.28	16.01	0,36

Station 8 A 13 January, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	3.48	7.55	8.74
5	3.48	7.55	8.73
10	3.46	7.55	8,76
15	3.48	7.54	8.69
20	3.46	7.54	8.76
30	3.50	7.55	8.72
40	3.57	7.56	8.70
50	3.64	7.56	8.71
60	3.61	7.61	8.54
70	4.21	9.89	2.50
80	5.43	11.42	1.73
90	6.80	12.41	2.37
97	6.69	12.67	2.29

Station F 81 14 January, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	3.98	7.59	8.60
5	4.01	7.60	8.53
10	4.00	7.60	8.54
15	4.01	7.60	8.57
20	4.01	7.60	8.61
30	4.00	7.60	8.66
40	4.00	7.60	8.58
50	4.04	7.60	8.60
60	3.97	7.65	8.37
70	4.14	10.23	1.26
80	4.44	10.84	1.17
90	4.55	11.23	1.20
100	4.71	11.58	1.39
125	5.06	12.07	1.01
150	5.40	12.42	0.53
175	5.52	12.58	0.43
200	5.58	12.70	0.36
225	5.64	12.82	0.17
240	5.65	12.82	0.16

Continued

Table 2. (Continued)

Station F 78 18 January, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	2.02	7.07	9.08
5	2.02	7.07	9.06
10	2.04	7.07	9.06
15	2.04	7.07	9.08
20	2.03	7.07	9.08
30	2.01	7.07	9.07
40	3.24	7.34	8.14
50	4.03	8.65	4.45
60	4.25	9.53	2.14
70	4.35	6.77	1.64
80	4.45	10.10	0.95
90	4.49	10.29	0.48
100	5.00		0.45
125	4.68	10.52	0.22
150	4.91	10.92	0.10
200	4.99	11.08	0.22
300	5.01	11.17	0.16
400	5.15	11.30	0.10
425	5.16	11.31	0.10
440	5.11	11.31	0.06

Station S 41 14 January 1971

Depth m	t°C	S ‰	O_2 ml/l	H_2S ugat/l
0	2.88	7.06	8.88	
5	2.80	7.06	8.94	
10	2.78	7.06	8.87	
15	2.77	7.06	8.94	
20	2.79	7.06	8.87	
30	2.74	7.06	8.90	
40	2.69	7.07	8.89	
50	3.56	7.38	7.57	
60	3.91	8.12	5.45	
70	3.97	9.23	2.31	
80	4.42	9.97	0.17	
90	4.65	10.39	0	8.7
100	4.64	10.49		6.2
111		10.49		7.2

Table 3. Temperature, salinity, oxygen and hydrogen sulphide values at stations S 12, S 24, 8 A, F 81, F 72, F 78 and S 41, April 1971 (ANON. 1972 a)

Station S 12 20 April, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	3.93	7.67	9.94
5	3.89	7.66	9.99
10	3.57	7.69	9.58
15	3.11	7.75	9.76
20	2.16	7.90	9.38
30	2.07	8.00	9.26
40	1.82	9.82	8.08
48	1.91	11.84	7.73

Station S 24 21 April, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	2.78	7.47	9.75
5	2.77	7.47	9.83
10	2.77	7.47	9.72
15	2.81	7.48	9.67
20	2.75	7.48	9.66
30	2.52	7.50	9.56
40	2.22	7.53	9.45
50	2.04	7.73	9.07
60	5.82	12.08	4.07
70	7.19	15.00	0.71
80	6.83	15.74	0.16
85	6.54	15.95	0.15

Continued

Correction: Salinity, station F 78, 70 m, shall be: 9.77

Table 3. (Continued)

Station 8 A 21 April, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	2.59	7.60	9.38
5	2.56	7.60	9.46
10	2.52	7.60	9.35
15	2.49	7.60	9.38
20	2.45	7.60	9.44
30	2.42	7.60	9.53
40	2.45	7.60	9.33
50	2.23	7.61	9.29
60	1.78	7.68	9.03
70	3.71	9.32	3.01
80	4.26	10.16	1.17
93	5.10	11.18	1.81

Station F 81 22 April, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	2.56	7.64	9.55
5	2.53	7.63	9.31
10	2.53	7.63	9.29
15	2.57	7.63	9.31
20	2.53	7.63	9.29
30	2.54	7.63	9.23
40	2.51	7.63	9.30
50	2.54	7.63	9.40
60	2.59	8.12	7.37
70	4.39	10.09	2.09
80	4.64	10.68	1.34
90	4.65	11.02	1.06
100	5.23	11.34	1.30
125	5.19	11.91	0.84
150	5.32	12.31	0.71
175	5.44	12.49	0.30
200	5.56	12.67	0.30
225	5.59	12.77	0.17
235	5.62	12.79	0.16

Station F 72 27 April. 1971

Depth m	t°C	S ‰	O_2 ml/l
0	1.70	6.96	10.27
5	1.67	6.96	10.21
10	1.71	6.95	10.21
15	1.75	6.95	10.27
20	1.73	6.95	10.27
30	1.67	6.98	10.18
40	1.59	7.38	9.47
50	1.27	7.54	9.18
60	1.79	7.86	8.13
70	3.84	9.60	2.78
80	4.45	10.41	3.82
90	4.68	10.74	0.63
100	4.70	10.75	0.55
125	4.71	10.88	0.43
150	4.72	10.99	0.34
175	4.79	11.02	0.32

Station F 78 23 April, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	1.91	6.57	10.19
5	1.84	6.57	10.26
10	1.83	6.58	10.19
15	1.84	6.58	10.20
20	1.84	6.94	9.79
30	1.32	7.26	9.42
40	1.25	7.46	9.10
50	2.74	8.30	5.92
60	3.90	9.31	2.73
70	4.25	9.79	1.29
80	4.51	10.10	0.51
90	4.60	10.36	0.39
100	4.67	10.67	0.31
125	4.74	10.81	0.34
150	4.87	10.96	0.28
200	5.02	11.15	0.09
300	5.92	11.19	0.43
400	5.03	11.22	0.27
425	4.88	11.21	0.44

Continued

Table 3. (Continued)

Station S 41 28 April, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	2.44	7.26	9.68
5	2.38	7.26	9.73
10	2.39	7.26	9.77
15	2.40	7.26	9.75
20	2.44	7.27	9.72
30	2.39		9.77
40	2.35	7.27	9.85
50	1.80	7.37	9.44
60	1.92	7.63	8.30
70	3.46	9.00	3.24
80	4.28	9.89	0.86
90	4.44	10.11	0.47
100	4.55	10.24	0.22
113	4.46	10.28	0.36

Table 4. Temperature, salinity, oxygen and hydrogen sulphide values at stations S 12, S 24, 8A, F 81, F 72, F 78 and S 41, August 1971 (ANON. 1972 b)

Station S 12 17 August, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	16.64	7.98	6.96
5	16.66	7.99	6.88
10	16.72	8.00	6.95
15	16.69	8.19	6.55
20	16.72	8.23	6.51
30	12.09	9.03	4.96
40	12.31	14.28	3.66
48	12.55	14.70	3.09

Station S 24 18 August, 1971

Depth m	t°C	S ‰	O_2 ml/l	H_2S ugat/l
0	15.71	7.44	7.13	
5	15.69	7.44	7.02	
10	15.65	7.44	7.08	
15	15.25	7.45	6.96	
20	15.21	7.45	6.89	
30	5.64	7.56	7.58	
40	4.87	7.65	7.72	
50	3.97	8.08	6.88	
60		10.57	4.17	
70	6.68	14.63	0.27	
80	6.71	15.75		6.35
90	6.60	15.79		9.7

Continued

Table 4. (Continued)

Station 8 A 18 August, 1971

Depth m	t °C	S ‰	O_2 ml/l
0	16.64	7.40	5.29
5	15.73	7.40	5.71
10		7.39	5.53
15	16.54	7.39	5.71
20	15.90	7.39	5.95
30	15.13	7.41	5.89
40	8.52	7.52	6.93
50	4.05	7.61	7.87
60	3.23	7.69	7.64
70	3.25	8.53	5.04
80	4.21	9.86	1.03
90	4.63	10.69	0.56
95	4.85	10.88	0.48

Station F 81 19 August, 1971

Depth m	t °C	S ‰	O_2 ml/l	H_2S ugat/l
0	16.16	7.27	7.22	
5	16.20	7.27	7.32	
10	16.09	7.37	7.10	
15	15.56	7.36	7.03	
20	10.58	7.43	6.30	
30	4.37	7.57	7.11	
40	3.39	7.61	7.98	
50	2.94	7.64	7.95	
60	2.53	7.81	6.97	
70	3.82	9.41	2.13	
80	4.48	10.32	0.78	
90	4.63	10.73	0.74	
100	4.91	11.14	0.78	
125	5.33	11.81	0.74	
150	5.43	12.31	0.22	
175	5.53	12.58	0.14	
200	5.60	12.68	0.16	
225	5.62	12.77		2.3
245	5.60	12.76		15.4

Station F 72 24 August, 1971

Depth m	t °C	S ‰	O_2 ml/l
0	15.10	6.57	7.16
5	15.08	6.57	7.13
10	15.06	6.57	7.06
15	15.10	6.57	6.99
20	12.57	7.17	6.43
30	7.68	7.33	7.14
40	4.49	7.44	7.81
50	3.40	7.55	7.91
60	3.02	7.36	7.50
70	2.80	7.66	7.63
80	3.55	9.38	7.68
90			
100	4.49	10.74	0.18
125	4.64	10.91	0.18
150	4.65	10.93	0.12
175	4.63	11.05	0.13

Station F 78 20 August, 1971

Depth m	t °C	S ‰	O_2 ml/l
0	15.18	6.40	7.31
5	15.17	6.40	7.26
10	15.14	6.42	7.20
15	9.48	6.79	7.22
20	7.07	7.10	7.64
30	4.18	7.24	8.35
40	2.75	7.44	8.45
50	2.46	7.74	7.55
60	3.36	9.05	3.33
70	4.13	9.85	1.35
80	3.87	10.18	0.54
90	4.63	10.55	0.21
100	4.73	10.80	0.30
125	4.77	10.98	0.22
150	4.81	11.11	0.19
200	4.89	11.20	0.18
300	4.87	11.23	0.25
400	4.92	11.26	0.24
425	4.89	11.27	0.18
440	4.84	11.33	0.19

Continued

Table 4. (Continued)

Station S 41 25 August, 1971

Depth m	$t^{o}C$	S ‰	O_2 ml/l	H_2S ugat/l
0	16.56	6.90	6.96	
5	16.54	6.90	7.04	
10	16.51	6.90	6.99	
15	16.06	6.91	6.87	
20	11.15	6.98	6.86	
30	4.15	7.26	8.35	
40	2.86	7.42	8.15	
50	2.88	7.55	8.04	
60	3.37	8.55	4.23	
70	4.19	9.83	0.40	
80	4.49	10.19		0.6
90	4.57	10.33		11.7
100	5.07	10.42		12.25
110	4.61	10.39		13.7

Table 5. Temperature, salinity, oxygen and hydrogen sulphide values at stations S 12, S 24, 8 A, F 81, F 78 and S 41, Nov.-Dec. 1971 (ANON. 1972 b)

Station S 12 30 November, 1971

Depth m	$t^{o}C$	S ‰	O_2 ml/l
0	6.95	8.91	7.98
5	6.92	8.89	7.98
10	7.15	9.28	7.92
15	7.22	9.32	7.90
20	7.26	9.39	7.91
30	7.33	9.51	7.88
40	7.81	10.37	7.57
49	10.30	16.57	4.96

Station S 24 1 December, 1971

Depth m	$t^{o}C$	S ‰	O_2 ml/l
0	6.64	7.95	8.04
5	6.58	7.95	8.01
10	6.61	7.95	7.99
15	6.57	7.95	8.04
20	6.59	7.95	8.03
30	6.62	7.95	7.99
40	6.84	7.98	7.93
50	7.40	10.16	3.63
60	10.62	12.74	3.03
70	10.43	14.38	1.68
80	7.72	15.49	0.22
91	7.53	15.40	0.16

Continued

Table 5. (Continued)

Station 8 A 1 December, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	7.01	7.55	8.00
5	6.99	7.55	7.98
10	6.98	7.55	7.98
15	7.03	7.55	8.02
20	6.97	7.55	7.97
30	7.00	7.55	7.95
40	7.01	7.56	7.99
50	7.06	7.56	7.93
60	3.89	9.22	3.17
70	4.78	10.50	0.84
80	4.84	10.93	0.46
90	5.28	11.44	0.26

Station F 81 2 December, 1971

Depth m	t°C	S ‰	O_2 ml/l	H_2S ugat/l
0	6.17	7.48	8.10	
5	6.16	7.47	8.08	
10	6.16	7.47	8.10	
15	6.14	7.48	8.10	
20	6.18	7.47	8.21	
30	6.13	7.47	8.15	
40	6.13	7.47	8.09	
50	6.11	7.47	8.13	
60	6.14	7.47	8.09	
70	6.16	7.48	8.12	
80	3.94	9.05	3.29	
90	4.39	10.16	0.82	
100	4.73	10.74	0.45	
125	5.21	11.61	0.44	
150	5.36	12.19	0.13	
175	5.50	12.52		2.8
200	5.57	12.64		3.7
225	5.61	12.72		16.7
235	5.59	12.77		20.0

Station F 78 3 December, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	4.71	7.19	8.44
5	4.72	7.19	8.41
10	4.72	7.20	8.47
15	3.99	7.19	8.53
20	3.92	7.19	8.45
30	3.95	7.20	8.49
40	4.10	7.20	8.43
50	4.05	7.21	8.43
60	3.85	8.44	4.90
70	3.78	9.17	3.17
80	4.11	9.57	2.38
90	4.16	10.02	1.34
100	4.38	10.32	0.80
125	4.61	10.74	0.19
150	4.69	10.90	0.19
175	4.78	11.00	0.12
200	4.77	11.01	0.12
300	4.82	11.10	0.10
400	4.84	11.11	0.09
440	4.80	11.13	0.14

Station g 41 10 december, 1971

Depth m	t°C	S ‰	O_2 ml/l
0	4.32	7.26	8.43
5	4.28	7.26	8.46
10	4.33	7.26	8.49
15	4.28	7.26	8.49
20	4.30	7.26	8.46
30	4.34	7.28	8.49
40	4.33	7.29	8.48
50	4.34	7.29	8.45
60	4.36	7.36	8.25
70	3.89	9.10	2.98
80	4.30	9.96	0.50
90	4.47	10.27	0.18
100	4.44	10.32	0.10
112	4.52	10.31	0.15

Date and time of the day when the samples were collected

(Deepest samples at the top of each table)

January

S 12	S 24	8 A	F 81
71 1 12 1315	71 1 12 2215	71 1 13 1020	71 1 14 0820
71 1 12 1320	71 1 12 2220	71 1 13 1025	71 1 14 0830
	71 1 12 2225	71 1 13 1030	71 1 14 0835
			71 1 14 0840

S 41	F 78
71 1 14 2255	71 1 18 2225
71 1 14 2305	71 1 18 2220
71 1 14 2310	71 1 18 2215

April

S 12	S 24	8 A	F 81
71 4 20 1540	71 4 21 0125	71 4 21 1320	71 4 22 0550
71 4 20 1545	71 4 21 0130	71 4 21 1325	71 4 22 0600
	71 4 21 0135	71 4 21 1330	71 4 22 0610
			71 4 22 0620

S 41	F 78	F 72
71 4 28 0145	71 4 23 0600	71 4 27 0450
71 4 28 0155	71 4 23 0610	71 4 27 0500
71 4 28 0200	71 4 23 0615	71 4 27 0505
	71 4 23 0620	71 4 27 0510

August

S 12	S 24	8 A	F 81
71 8 17 1810	71 8 18 0730	71 8 18 1900	71 8 19 0955
71 8 17 1815	71 8 18 0735	71 8 18 1905	71 8 19 1000
	71 8 18 0740	71 8 18 1910	71 8 19 1005
			71 8 19 1010

S 41	F 78	F 72
71 8 25 1500	71 8 20 0800	71 8 24 0610
71 8 25 1505	71 8 20 0820	71 8 24 0620
71 8 25 1510	71 8 20 0825	71 8 24 0625
	71 8 20 0925	71 8 24 0630

Nov.-Dec.

S 12	S 24	8 A	F 81
71 11 30 1720	71 12 1 0500	71 12 1 1620	71 12 2 1350
71 11 30 1725	71 12 1 0450	71 12 1 1625	71 12 2 1355
	71 12 1 0445	71 12 1 1630	71 12 2 1400
			71 12 2 1405

S 41	F 78
71 12 10 0445	71 12 3 1100
71 12 10 0450	71 12 3 1110
71 12 10 0455	71 12 3 1120