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Sea Surface Temperature and Salinity in South Icelandic Waters in the period 1868–1965

by

Svend-Aage Malmberg and Geir Magnússon †
Marine Research Institute, Reykjavík

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INTRODUCTION

Mean charts of physical parameters of the sea, such as temperature and salinity, can be a helpful tool in oceanographic and meteorological research, in fishery hydrography studies and other investigations of the physics, chemistry and biology of the sea. The present publication includes charts of sea surface temperature (SST) and sea surface salinity (SSS) in South Icelandic waters. The data presented cover the period 1868–1965 or 98 years, based on publications by Böhnecke (1936) and Krauss (1958) for the North Atlantic as a whole, and by Malmberg (1961, 1962, 1969a) for South Icelandic waters. The previous publications by this author included only a few characteristic features, whereas the charts presented in this paper are based on all data available from the waters south of Iceland up to 1965. These data are kept on file in tabulated form at the Marine Research Institute, Reykjavík.

* *The second author, Geir Magnússon, passed away in 1970. He contributed in a major way to the collection and processing of data and prepared most of the illustrations which are the mainstay of this paper.*

STUDY AREA

The area studied (Fig. 1) extends from 60°–65°N and 10°–25°W, covering an ocean area of about 380,000 km^2. The maximum depths exceeding 2000 m are bordered by the Reykjanes Ridge in the northwest, with depths less than 1000 m, the Icelandic margin in the north, the Iceland-Faroe Ridge in the northeast, with depths less than 500 m, and the Faroe Bank (100 m), Bill Bailey Bank (50–100 m), Lousy Bank (200 m), George Bligh Bank (500 m) and Rockall Bank (sea surface) in the southeast.

This area, sometimes called the Iceland Basin (Dietrich and Ulrich 1968), can be considered a specific oceanographic region of the Northeast Atlantic Ocean.

WATER MASSES

The main water masses in the study area are given in Table 1. A characteristic hydrographic section from the study area, extending from the south coast of Iceland to Rockall, is shown in Fig. 2. In this section Northeast Atlantic Water (AW) occupies the upper 1500 m as it

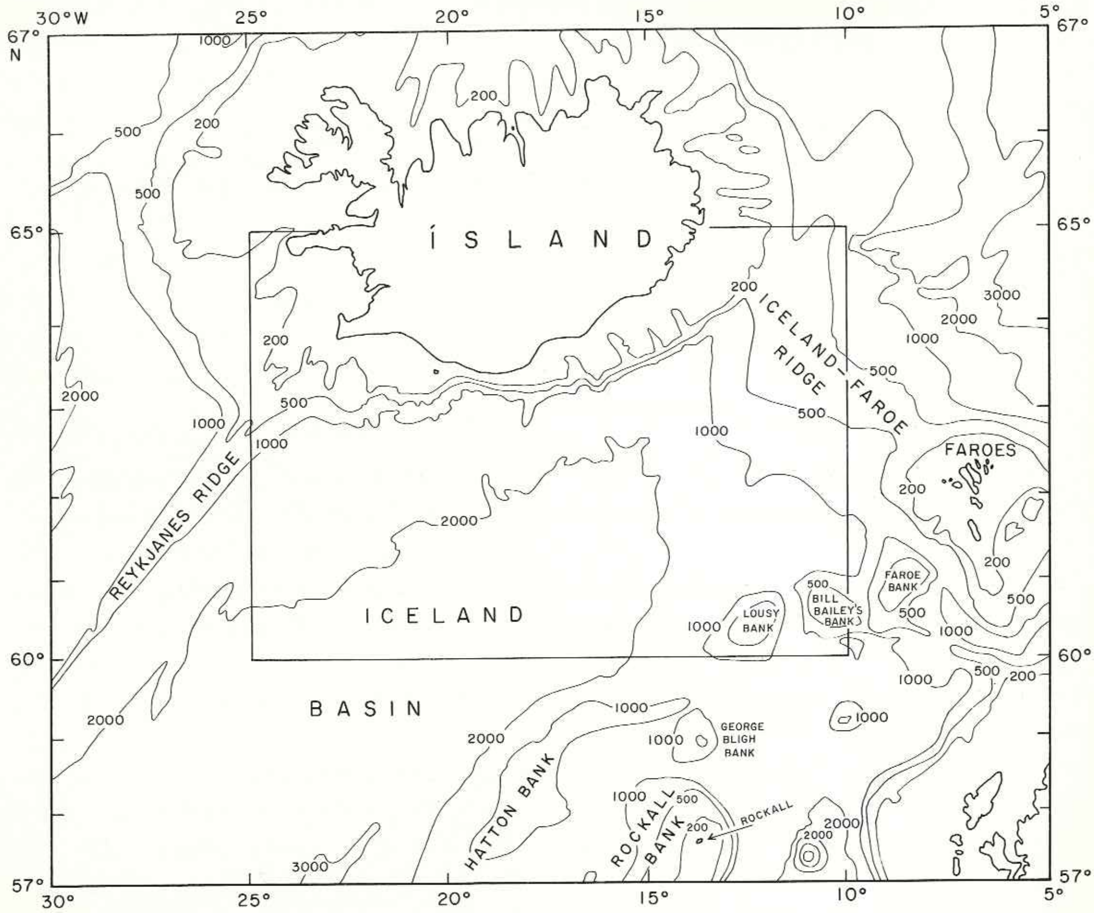

Fig. 1. The area studied and its general bathymetry. Depths in metres.

TABLE 1

Water masses in the study area

Water mass	*Temperature (°C)*	*Salinity (‰)*
Northeast Atlantic Water — modified (AW)	> 6.0	> 35.10
Irminger Sea Water (IW)	~ 4.0	~ 34.90
Arctic Bottom Water (BW)	< 0.0	= 34.92
Modified Arctic Bottom Water (MW)	< 3.0	< 35.00
North Icelandic Winter Water (NW)	~ 2.0	~ 34.85
Icelandic Costal Water (CW)	variable	variable

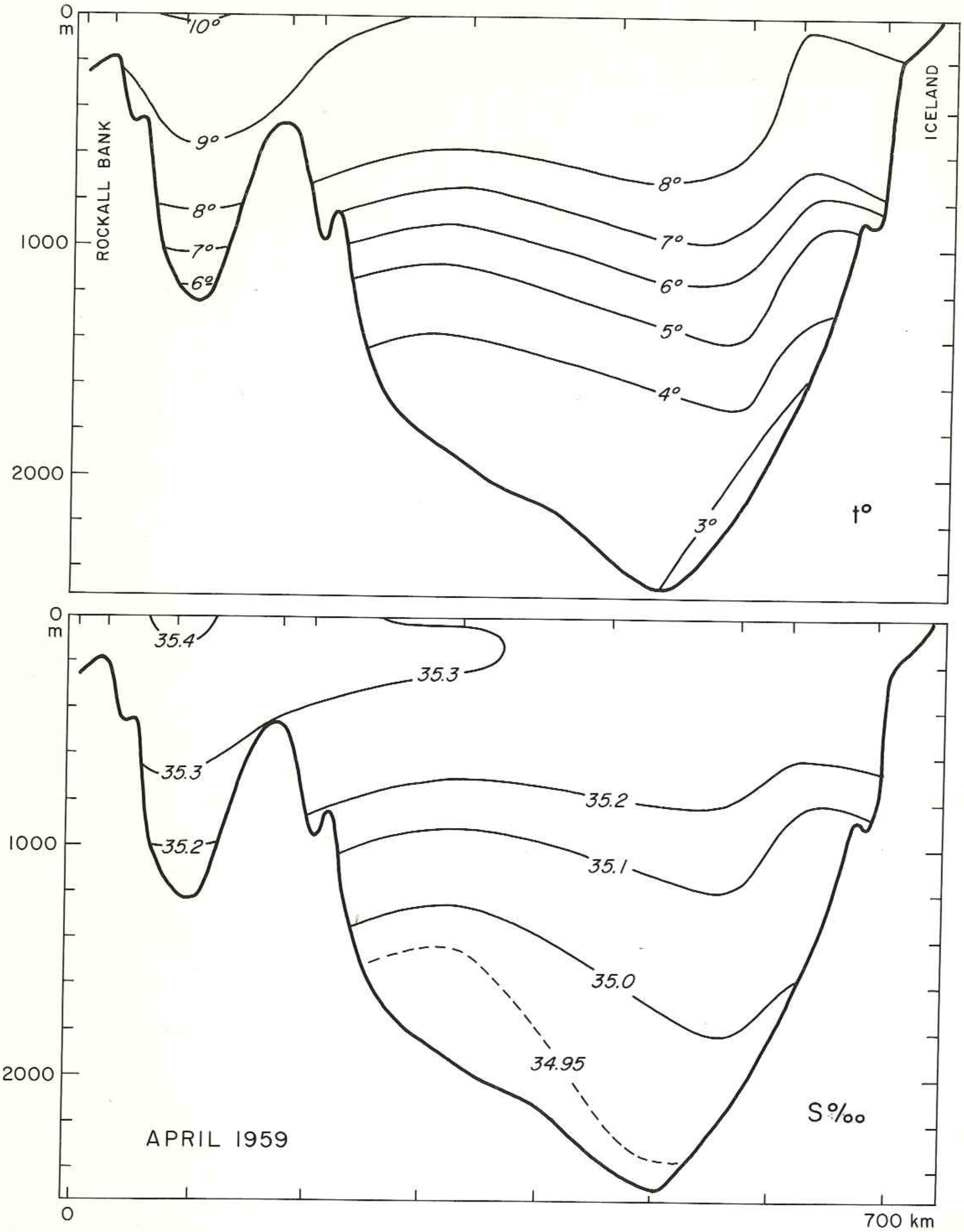

Fig. 2. A hydrographic section across the study area — from the south coast of Iceland to Rockall, April 1959 (After Malmberg 1962).

does in most parts of the area. The other five water masses are found only at the outer limits of the study area and in deep or bottom layers.

MATERIAL AND METHODS

All available SST and SSS data in the area for the period 1868–1965 were derived from the following three sources:

a) 1868–1955; Malmberg 1962 (Krauss 1958, Data lists: Bull., Hydr. 1950–1955).
b) 1951–1960; Data lists: Bull., Hydr. 1951–1956, ICES Oceanographic Data Lists 1957–1960.
c) 1961–1965; Service Hydrographique.

The data derived from these three groups (see Table 2) were processed as follows:

a) In the first group (1868–1955), following the method used by Böhnecke (1936) and Krauss (1958), the area in question was divided into 1° squares, 50 such squares in the southern half of Marsden Square 218 (Fig. 3) and 25 in the southeastern quarter of Marsden Square 219. The data from each 1° square were combined for each month of the year, means calculated and the results presented in charts (Figs. 4–27) and seasonal diagrams (Fig. 29).

b) The observations from the second group of data (1951–1960) were too sparse to permit the preparation of mean charts, except for the months May, June, July and August (Figs. 30–37). The density of observations was somewhat greater in the southern part of the study area than in the northern part. Therefore, for studying variations

TABLE 2

Number of SST and SSS observations per month in the study area during different periods.

Month	*PERIOD*					
	a) 1868–1955		*b) 1951–1960*		*c) 1961–1965*	
	t °C	*S ‰*	*t °C*	*S ‰*	*t °C*	*S ‰*
January	3065	541	355	316	147	144
February	4109	651	285	249	243	111
March	7186	1030	378	329	160	154
April	10378	1146	422	397	167	133
May	10943	1651	599	535	160	159
June	10200	1444	1283	1156	88	90
July	11116	1532	735	693	88	87
August	10677	1614	383	356	71	62
September	11368	1254	370	334	72	71
October	9805	1173	255	228	68	63
November	7131	870	261	263	87	83
December	4417	669	217	206	45	46
Sum	100395	13575	5553	5062	1396	1203

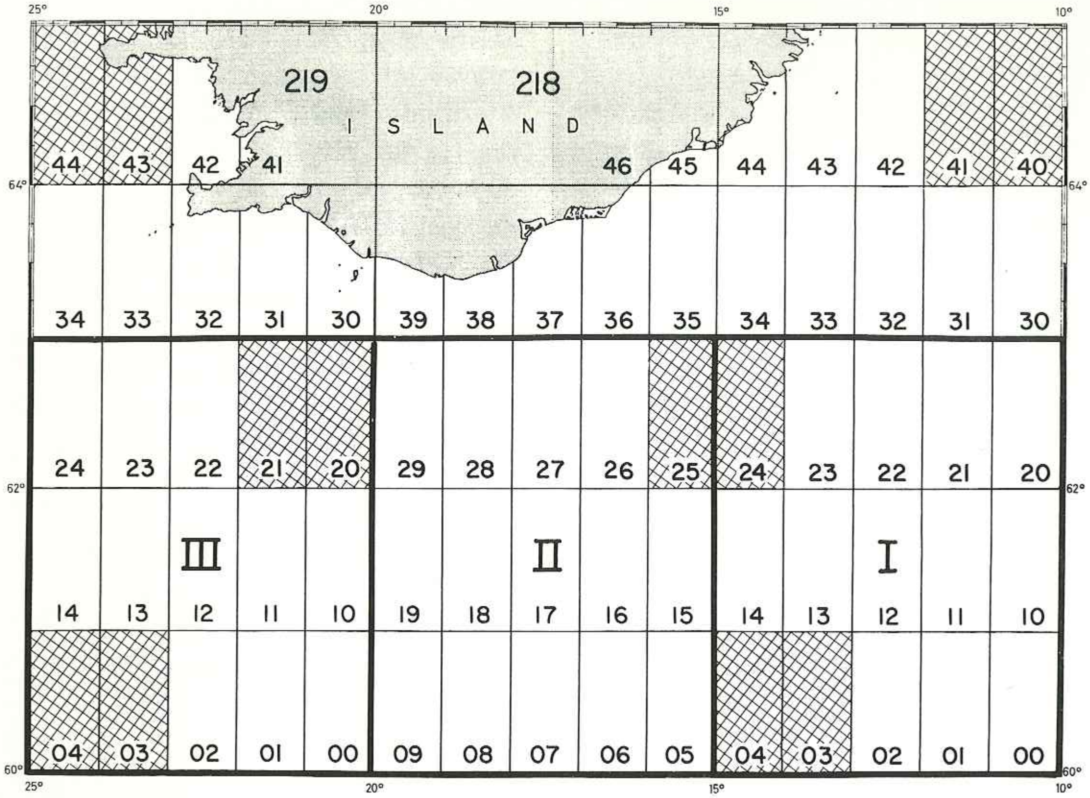

Fig. 3. Marsden Squares (10°) and 1° squares in the study area. Selected subareas are also shown.

by months throughout the whole year, the area south of 63°N was considered. This area was divided into 3 subareas (Fig. 3) and the data from both periods, 1951–1960 and 1961–1965 combined for each subarea. The results are given in Figs. 38 and 39. It will be noted that for the decade 1951–1960 comparatively more data are available in South Icelandic waters than for the period 1961–1965. Investigations in connection with the International Geophysical Year 1957–1958 (Fuglister 1960, Tait 1961, Dietrich 1969) and the "Overflow" project in 1960 (Tait 1967) are most likely the cause.

The original material worked up by Böhnecke and used by Krauss was lost during World War II, making impossible further analyses, such as of year to year variations or standard deviations. Therefore, only means and number of observations are presented for the period 1868–1955. On the other hand all data from the years 1951–1965 are available.

RESULTS

SST and SSS in 1868–1955

a) *Horizontal distribution*. As shown in Figs. 4–27, most part of the near-surface layer in the region studied consists of AW. The SST and SSS decrease slightly northwards, due to admixture with water from the Icelandic shelf and other northerly sources. The frontal zones between the AW of the Northeast Atlantic Drift and the water masses of the East Icelandic Current (NW, CW) and the Irminger Sea (IW) are distinguishable, the former being more pronounced and known as the oceanic polar front. At such boundaries the horizontal gradients of SST and SSS are really stronger than indicated by computed long-term mean values, due to the shifting of the frontal zones with time. The same is true for the conditions along the Icelandic coast as shown in Fig. 28 based on single surveys made in the coastal waters south of Iceland in August and November 1975 and February and May/June 1976.

On the other hand, long-term mean values of SST and SSS can be expected to be fairly representative in most part of the study area due to the wide distribution and the homogeneity of the AW.

In the shelf area off Iceland the SSS isolines follow the coastline with values increasing seawards. The lowest SSS are found in summer at the coast when run-off from land is strongest.

Seasonal variations in the coastal current off Iceland due to seasonal variations in temperature and salinity have been described by Stefánsson (1962). The current flows clockwise around Iceland in summer at least, but it is less strong and even non-existing in winter (Stefánsson and Guðmundsson 1969, Malmberg 1972). An offshore countercurrent may even flow anticlockwise in late winter as suggested by the mean SSS distribution in February and March (Figs. 17 and 18). This supposition must, however, be accepted with great reservation since the salinity observations in the 1° squares in question (Marsden square 218/16, 18 in Fig. 3) were few.

b) *Seasonal variations of SST*. The mean seasonal variations of different subareas (Figs. 3 and 29) show similar features, especially those from that part of the region where AW predominates. The SST maximum is found in August, and the minimum usually in March. In the coastal waters south of Iceland the winter minimum is found in February. In the northeast the vernal temperature increase is delayed to April-May, probably because of the melting drift-ice farther north in the East-Icelandic Current.

The mean annual SST increases towards south and east from 6.6° to 9.6°C. The maximum seasonal SST variation is about 4°C in the region of the AW and 6.9°C in the northwest and 2.5°C in the northeast. These features reflect the current system of the region and variations in stratification. In the northwest the boundaries between water masses change seasonally and influence from land will also be variable. In the northeast currents directed off-shore and reduced stratification due to mixing (Stefánsson 1972) cause relatively low summer temperatures and small seasonal variations in SST.

c) *Seasonal variations of SSS*. Since

the salinity data are more scanty than the temperature data, the seasonal diagrams and mean values of the former may be less reliable (Fig. 29). The similarity of the features apparent in the seasonal variations from one location to another in the study area indicates, however, that the salinity data can be trusted. In the relatively nearshore areas in the northwest and northeast clear annual variations occur, with maxima in February-April and minima in September. This is opposite to the changes in temperature. Runoff lowers the SSS in summer, but in September the winter conditions begin with decreased runoff and increased vertical mixing until April the next spring. The seasonal SSS variations in the main oceanic area are relatively small, ranging from 0.10 to 0.17‰, with two maxima and two minima per year. The minimum found in July-September in the North Atlantic south of Iceland is according to Neumann (1940) due to periodic variations in the salinity of the Labrador Current which influence the North-East Atlantic Drift; the minimum found in winter occurs during the period of maximal precipitation in the area (Markgraf and Bintig 1956).

SST and SSS in 1951–1965

The results revealed no new features with regard to seasonal variations (Fig. 39) and to horizontal distribution in summer, except for an increase in SST and SSS from the period 1868–1955 to 1951–1960 (Figs. 8–11, 20–23, 30–37). There is an overall increase in the year-to-year SST and SSS from 1951–1960 south of 63°N in the study area of about 1°C and 0.06–0.08‰ (Fig. 38). This increase in SST was marked in winter while in summer it was small or even negative as has been shown by Smed (1953–1978) and Rodewald (1972). In the ocean south of Iceland the SSS was in 1953 the lowest of the period 1951–1960. This was also the case in June in a study area northeast of Iceland (67°–69°N, 11°–15°W; Malmberg 1969 b). In 1958 the salinity was at the highest both northeast and south of Iceland in this same period.

CONCLUDING REMARKS

It is hoped that some of the features outlined by these charts could be an incentive for further specific projects. These include:

1) Studies of the current system in the Iceland Basin, which still is comparatively little known.
2) Seasonal studies of the Icelandic coastal current, which is found to be clockwise around the coast in general, but possibly sluggish during late winter.
3) The effect of winds, bottom topography and/or runoff, on the hydrographic conditions in the shelf area south of Iceland.
4) Studies of vertical transport (upwelling) of the water masses along the Icelandic slope and in the submarine valleys on the shelf.
5) Studies of year-to-year variations in SST and SSS in connection with general trends in the North Atlantic.

6) Studies of relationship between conditions at the sea surface and in sub-surface layers in the Iceland Basin.
7) Relationship between hydrographic conditions in the coastal areas south of Iceland, including the Selvogsbanki region, and biological variables, e.g. migrations and spawning of fish such as herring, capelin and cod.

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Ágrip

Hitstig og selta í yfirborði sjávar á hafinu sunnan Íslands

Þessu riti er ætlað að sýna hitastig (SST) og seltu (SSS) í yfirborði sjávar í hafinu fyrir sunnan Ísland, nánar tiltekið milli 60 og 65° norður breiddar og 10 og 25° vestur lengdar. Gildum er raðað eftir reitum og mánuðum. Rætt er stuttlega um uppruna gagna, um hafsvæðið sjálft og helstu sjógerðir þess og lýst efnivið og úrvinnsluháttum. Vikið er að nokkrum einföldum skýringum. Töflur með gögnum og niðurstöðum eru varðveittar á Hafrannsóknastofnuninni. Niðurstöður skýra sig að mestu leyti sjálfar, í myndum og línuritum, ásamt myndatexta. Töflur, myndir og línurit byggjast á tiltækum gögnum frá 1868 til 1965. Efniviðurinn byggist aðallega á ritgerðum eftir þjóðverjana Böhnecke (1936) og Krauss (1958) auk annars höfundar (Malmberg 1961, 1962). Síðast talda ritið spannar lengra tímabil en hin fyrri auk þess sem athugunum fjölgaði almennt á seinni árum. Í ritgerðunum frá 1961 og 1962 birtust þó aðeins einstakir þættir athugananna, og hefur lengi verið haft í huga að birta gögnin í heild. Var ráðist í útgáfu þeirra þar sem upplýsingar um ástand sjávar í yfirborði eru áhugaverðar, m.a. í sambandi við ýmis haffræðileg, veðurfræðileg og líffræðileg viðfangsefni.

Annar höfundur ritsins, Geir Magnússon, lést árið 1970, en hann vann ötullega að söfnun og að miklu leyti að úrvinnslu gagna og að flestum teikningum ritsins.

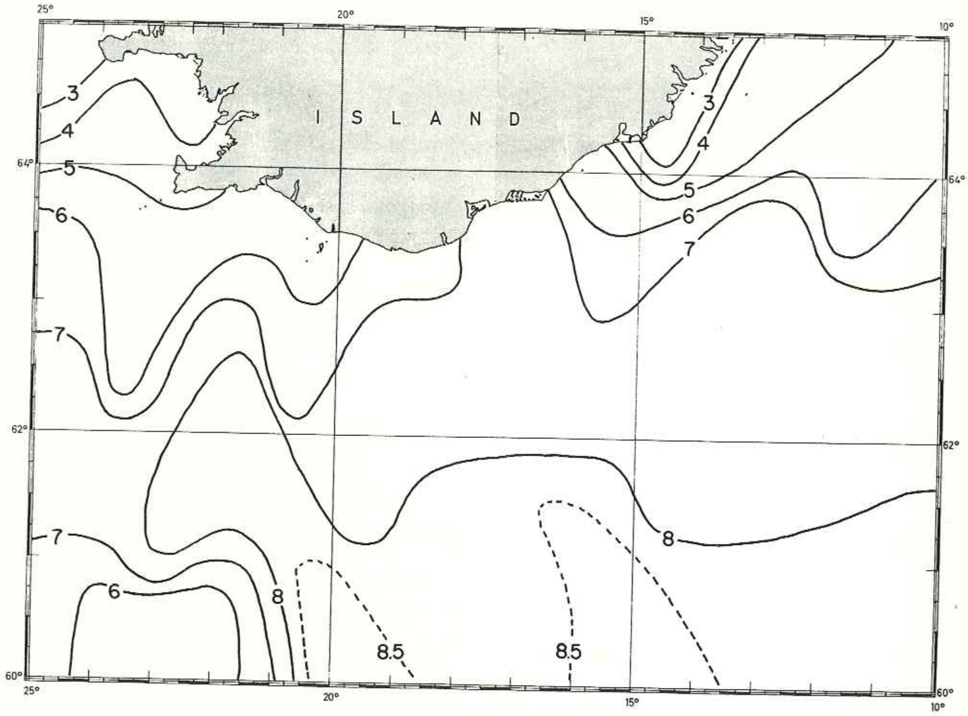

Fig. 4. Mean SST January 1868–1955.

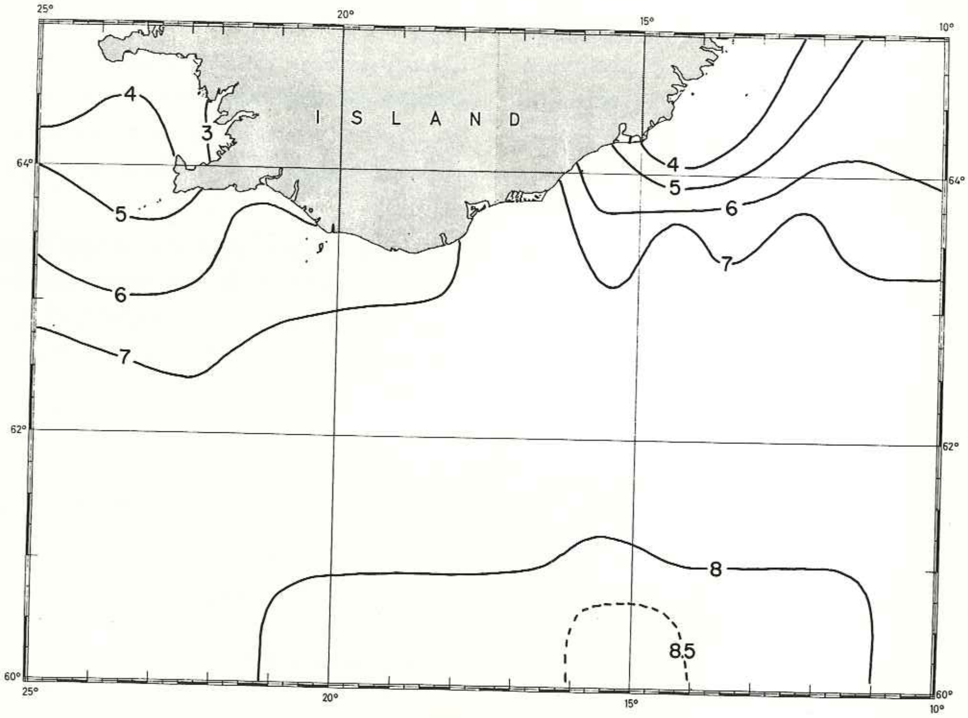

Fig. 5. Mean SST February 1868–1955.

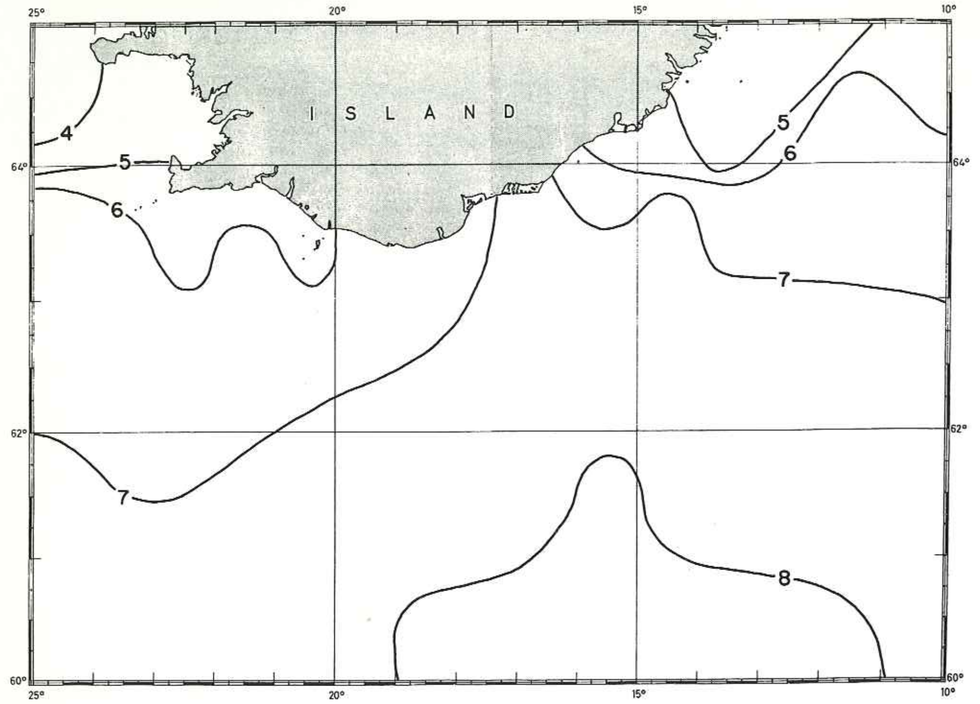

Fig. 6. Mean SST March 1868–1955.

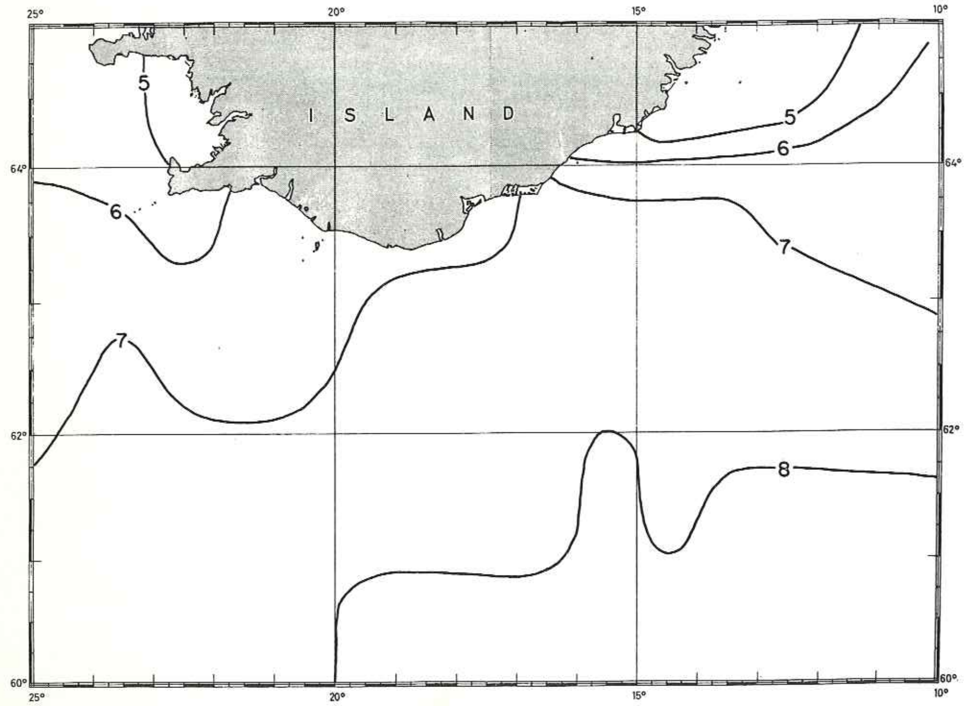

Fig. 7. Mean SST April 1868–1955.

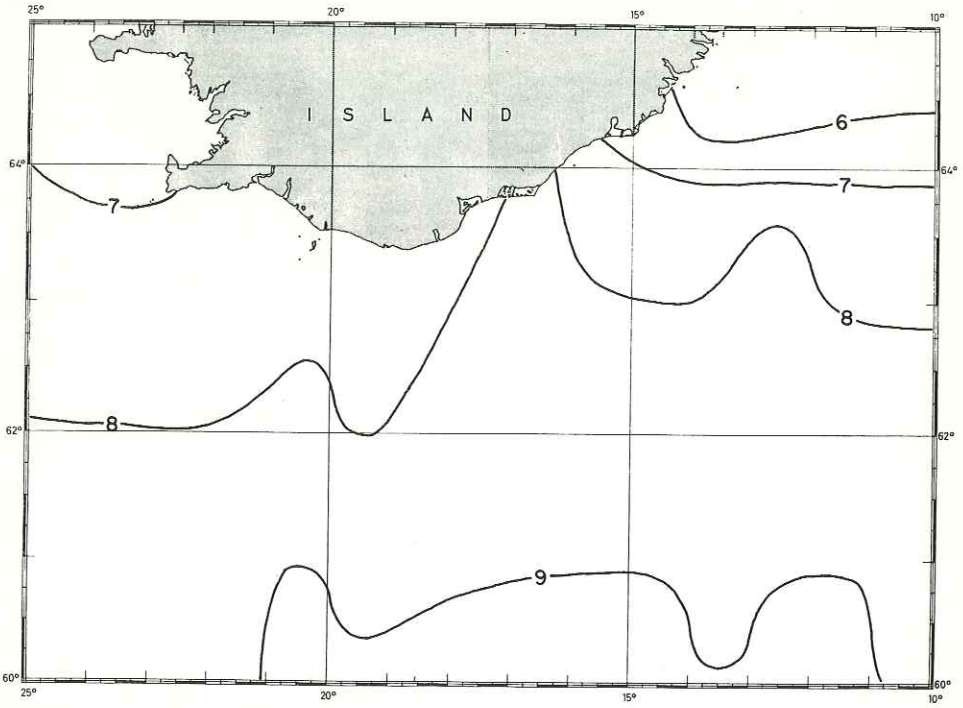

Fig. 8. Mean SST May 1868–1955.

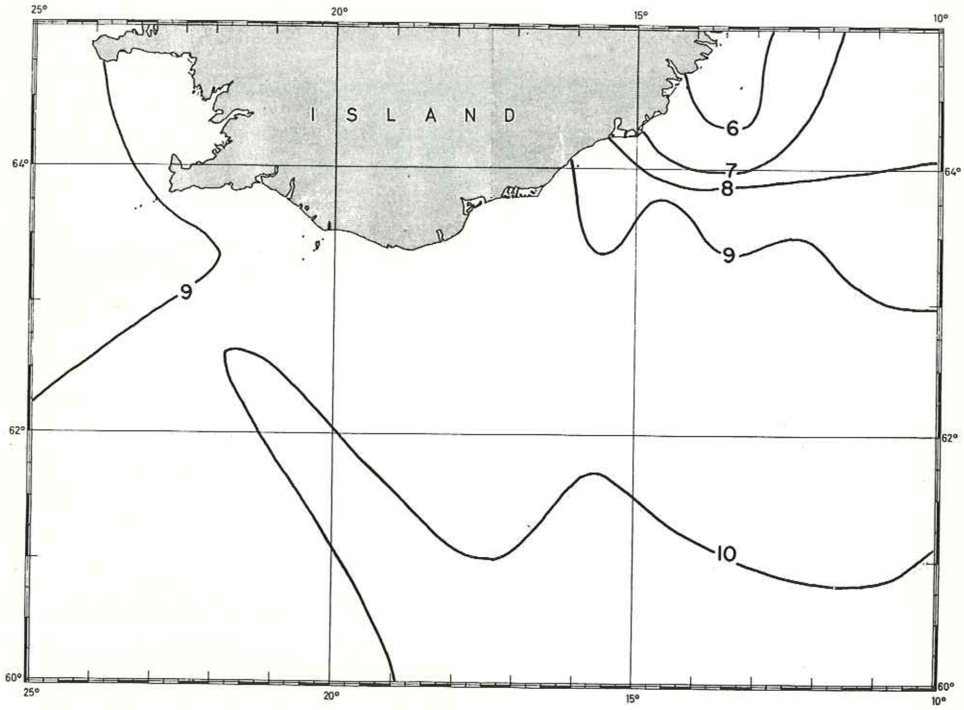

Fig. 9. Mean SST June 1868–1955.

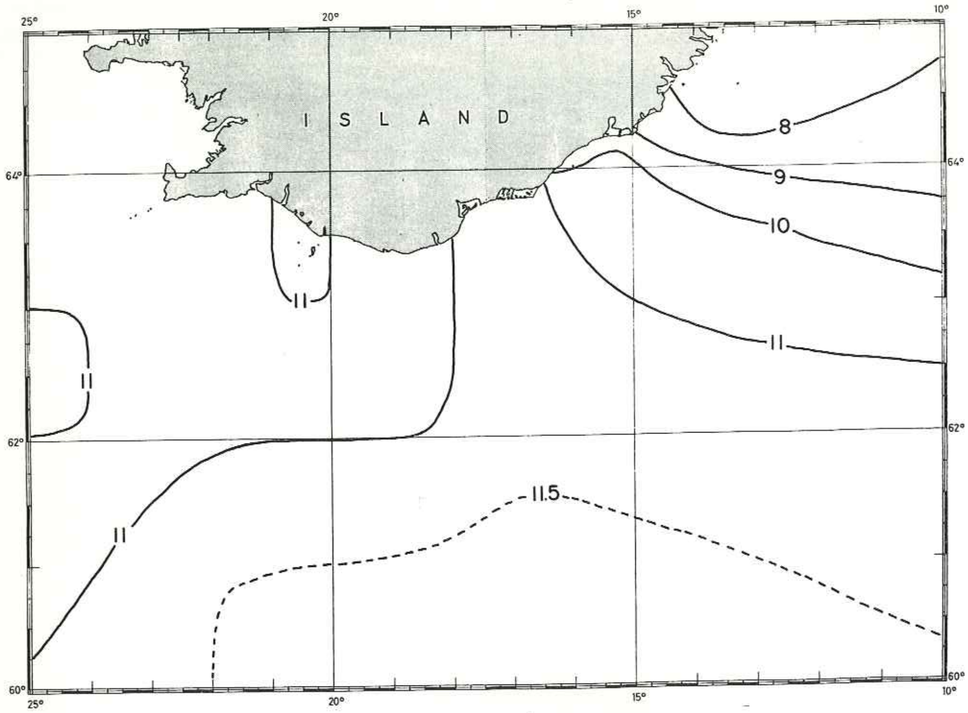

Fig. 10. Mean SST July 1868–1955.

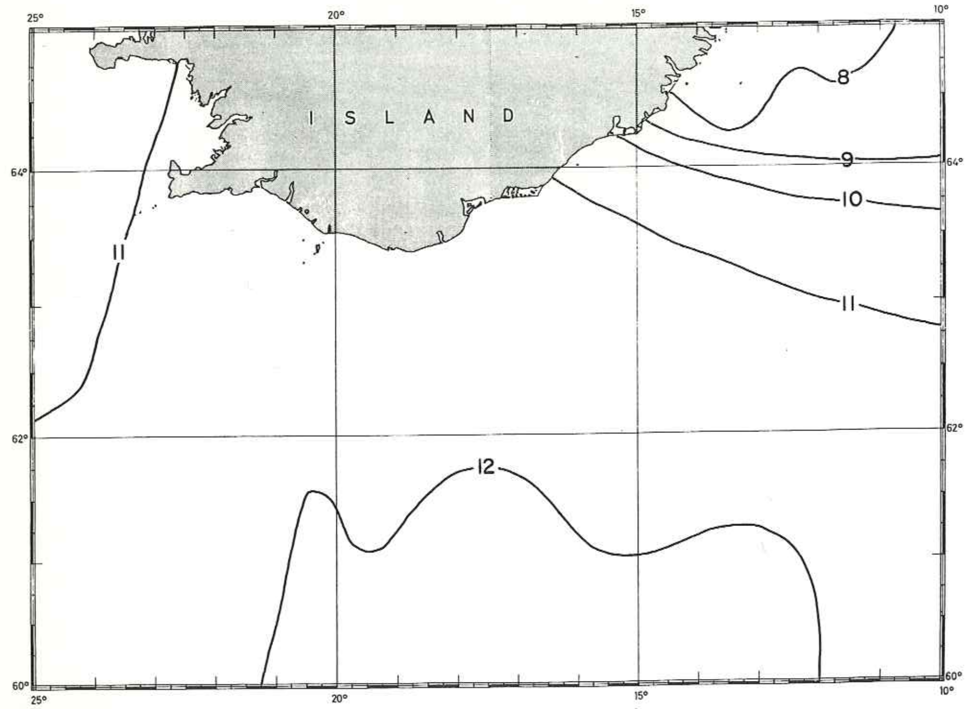

Fig. 11. Mean SST August 1868–1955.

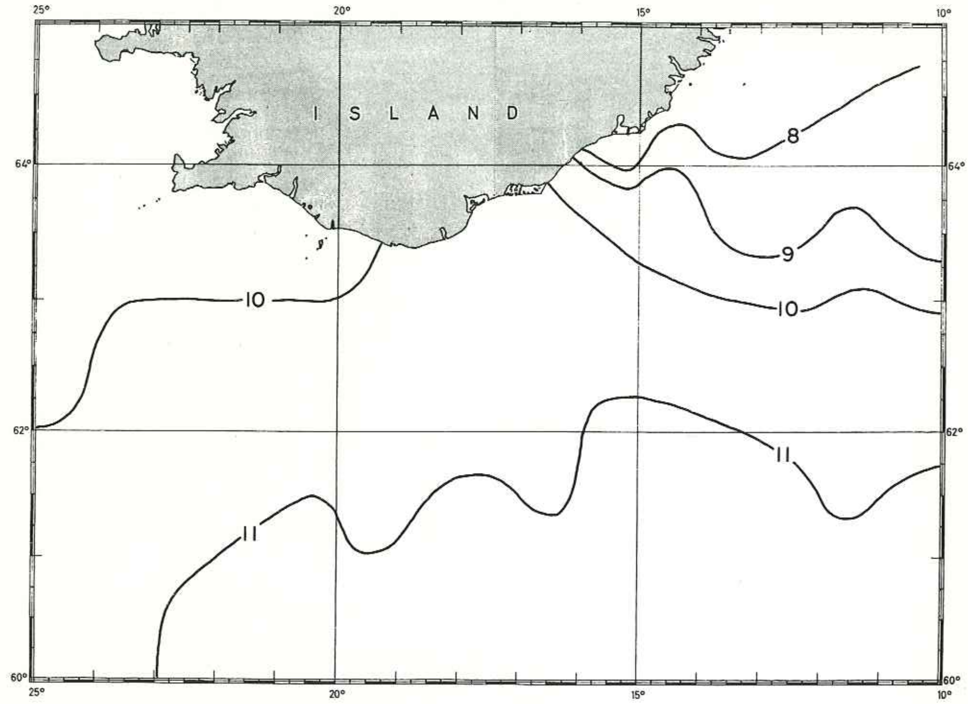

Fig. 12. Mean SST September 1868–1955.

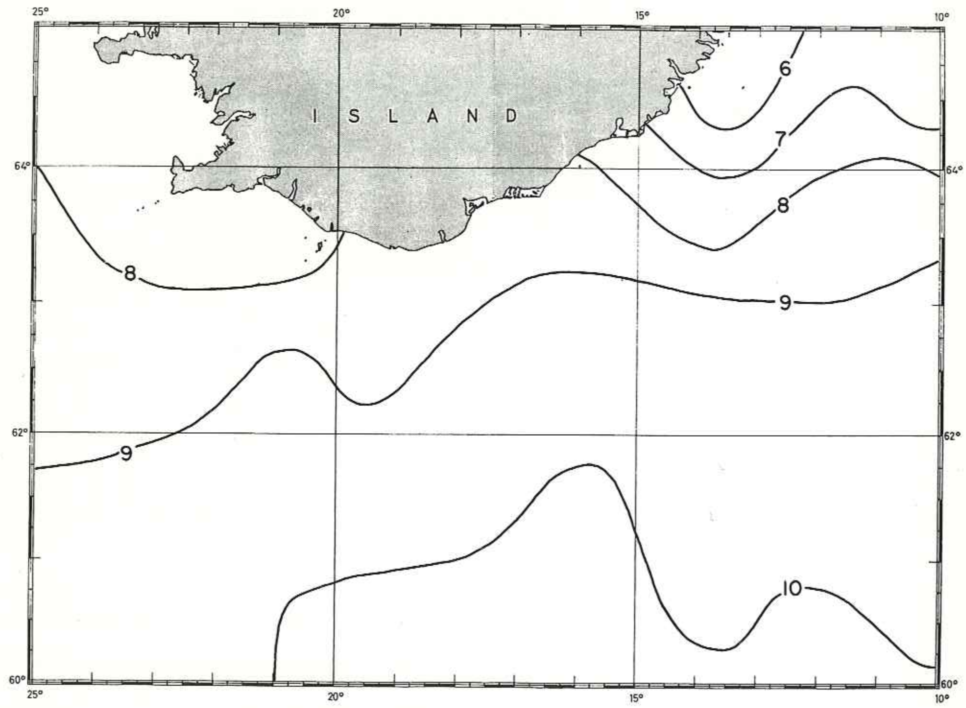

Fig. 13. Mean SST October 1868–1955.

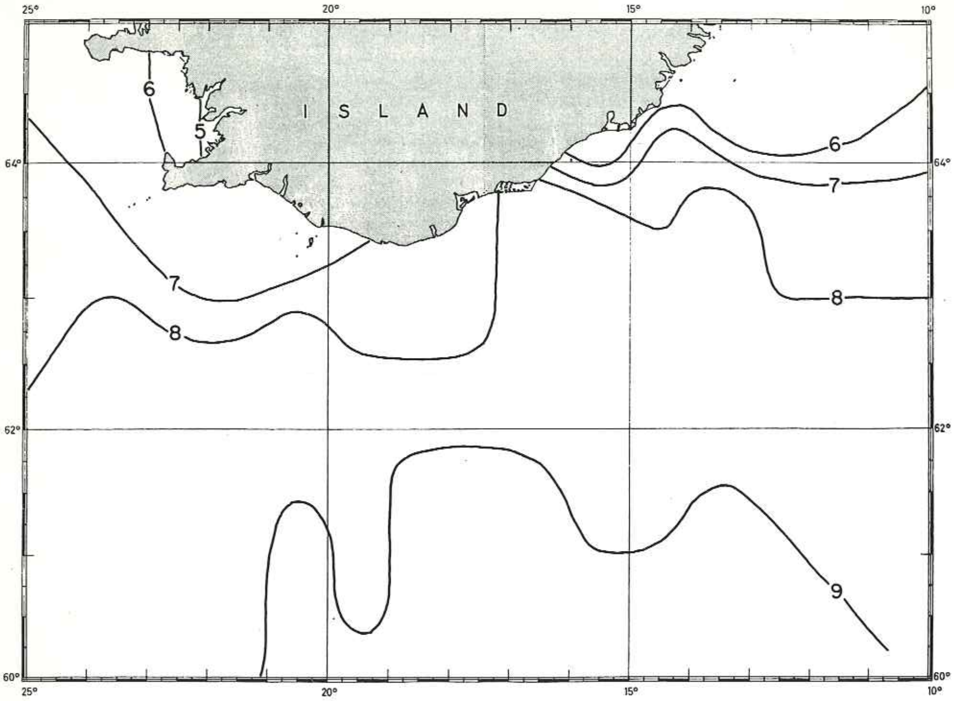

Fig. 14. Mean SST November 1868–1955.

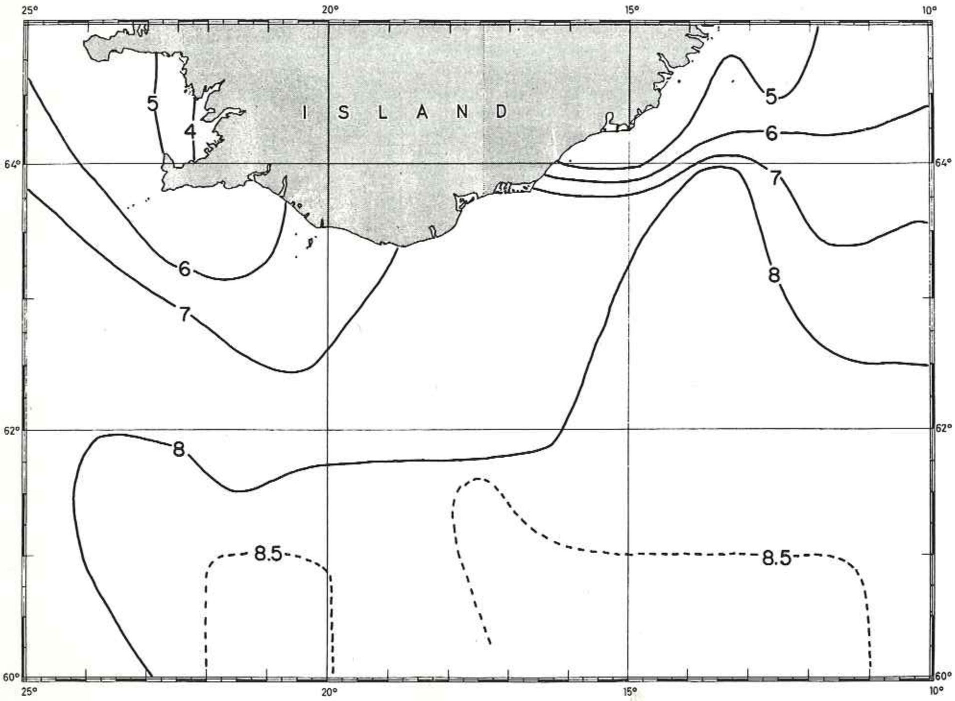

Fig. 15. Mean SST December 1868–1955.

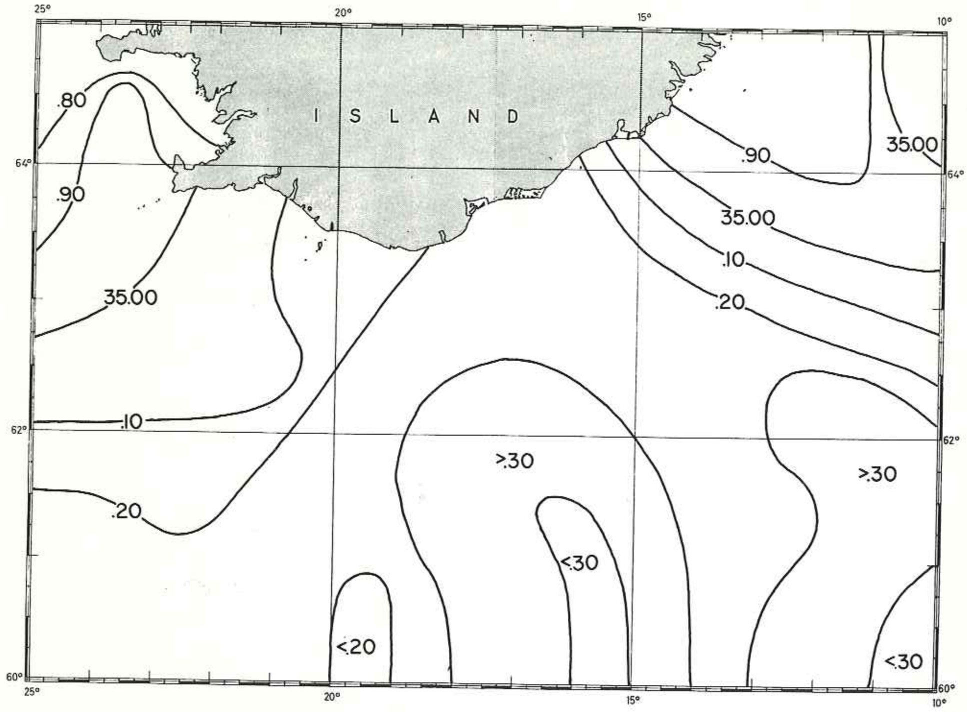

Fig. 16. Mean SSS January 1868–1955.

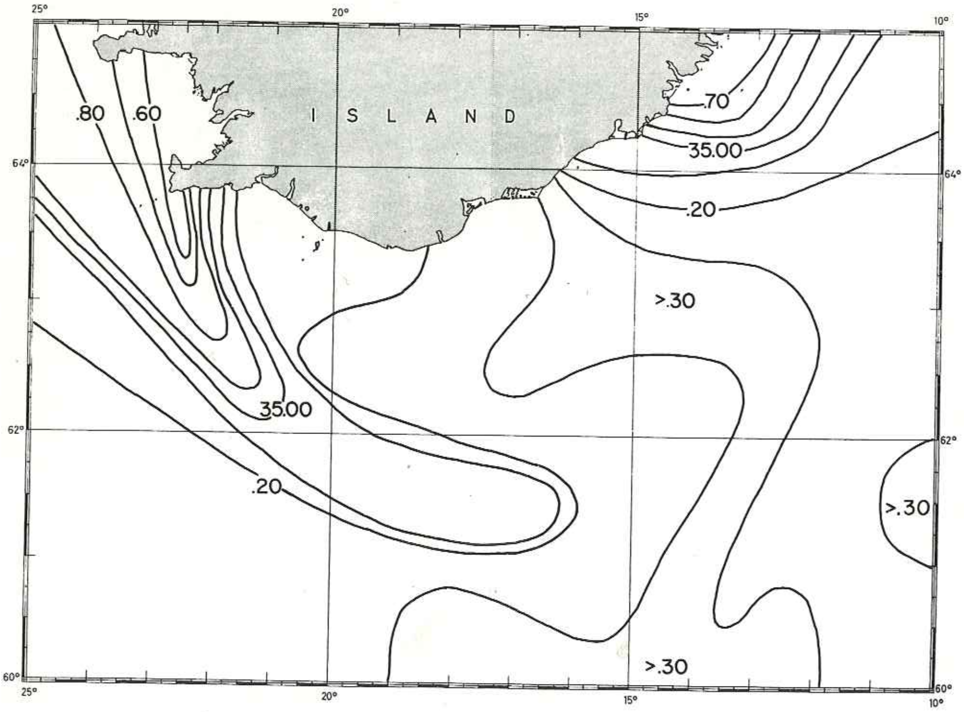

Fig. 17. Mean SSS February 1868–1955.

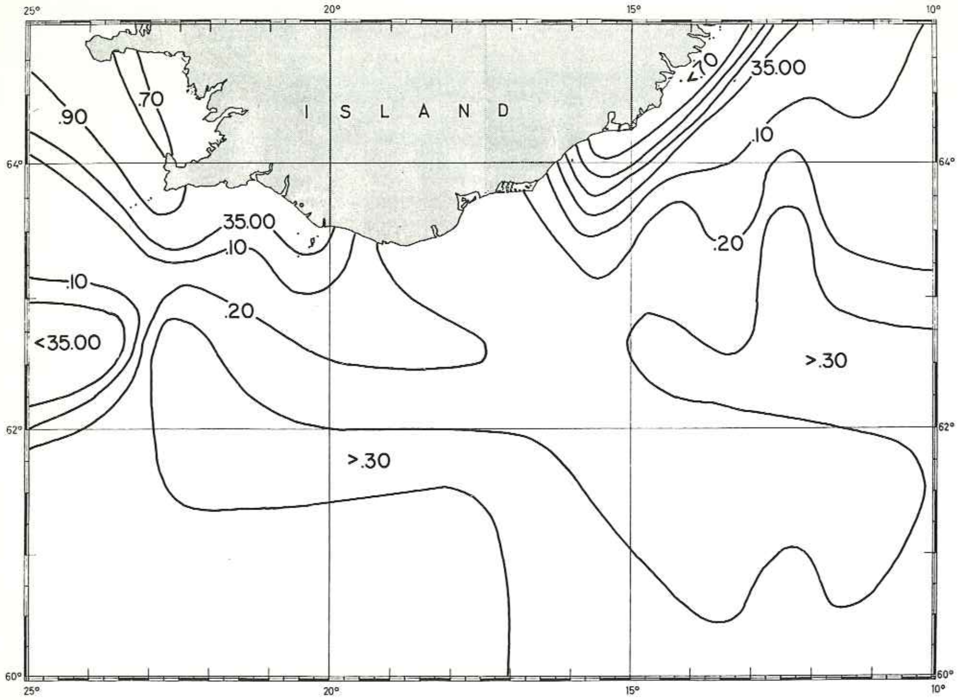

Fig. 18. Mean SSS March 1868–1955.

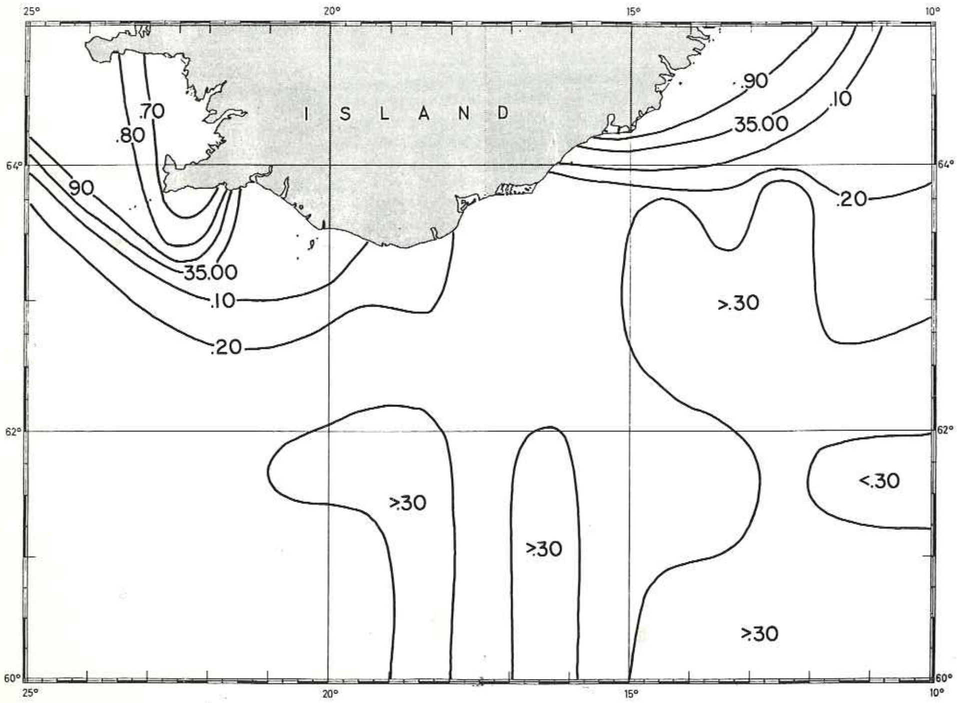

Fig. 19. Mean SSS April 1868–1955.

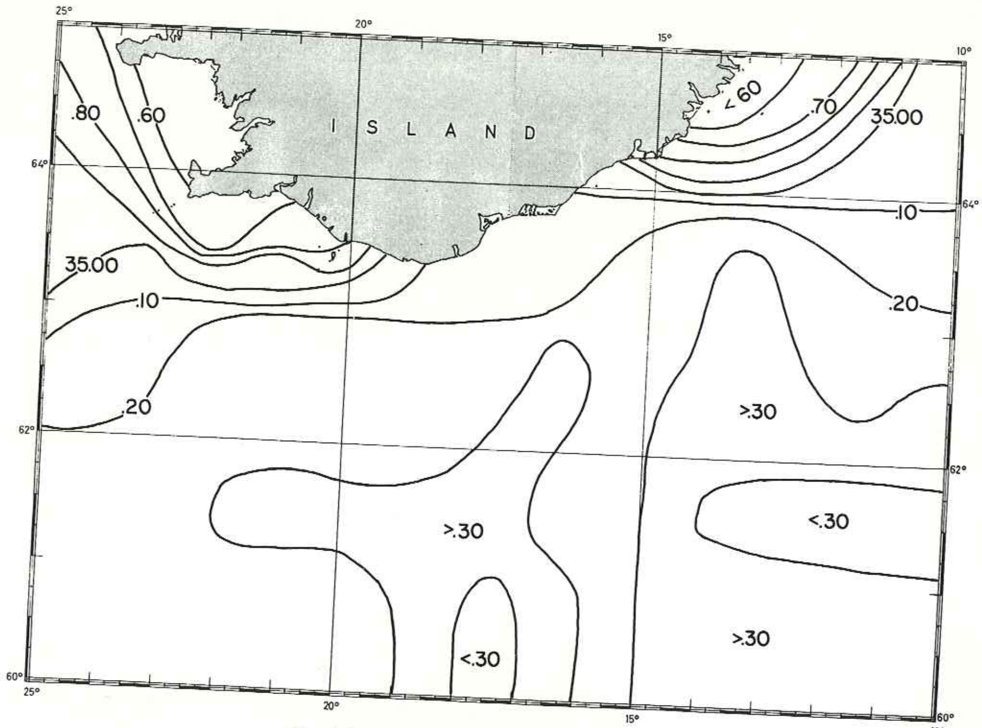

Fig. 20. Mean SSS May 1868–1955.

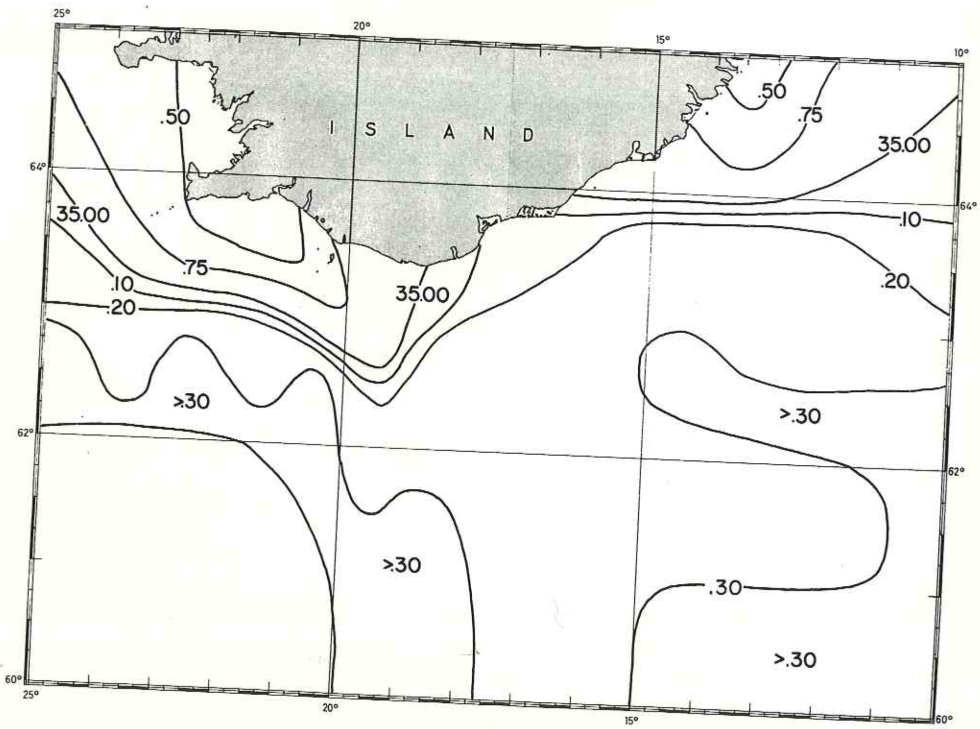

Fig. 21. Mean SSS June 1868–1955.

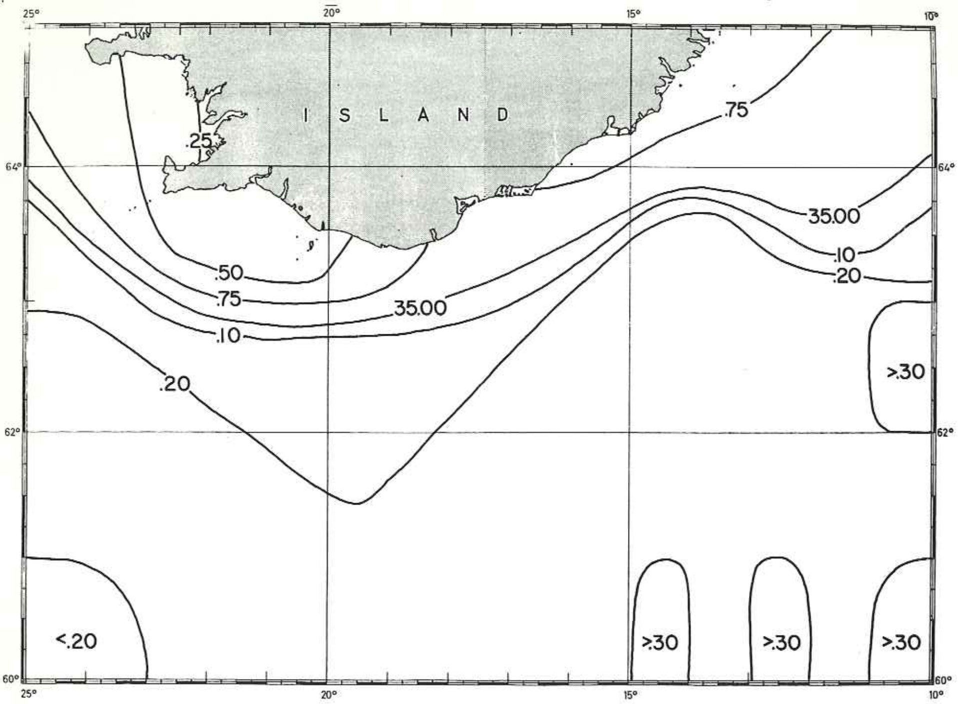

Fig. 22. Mean SSS July 1868–1955.

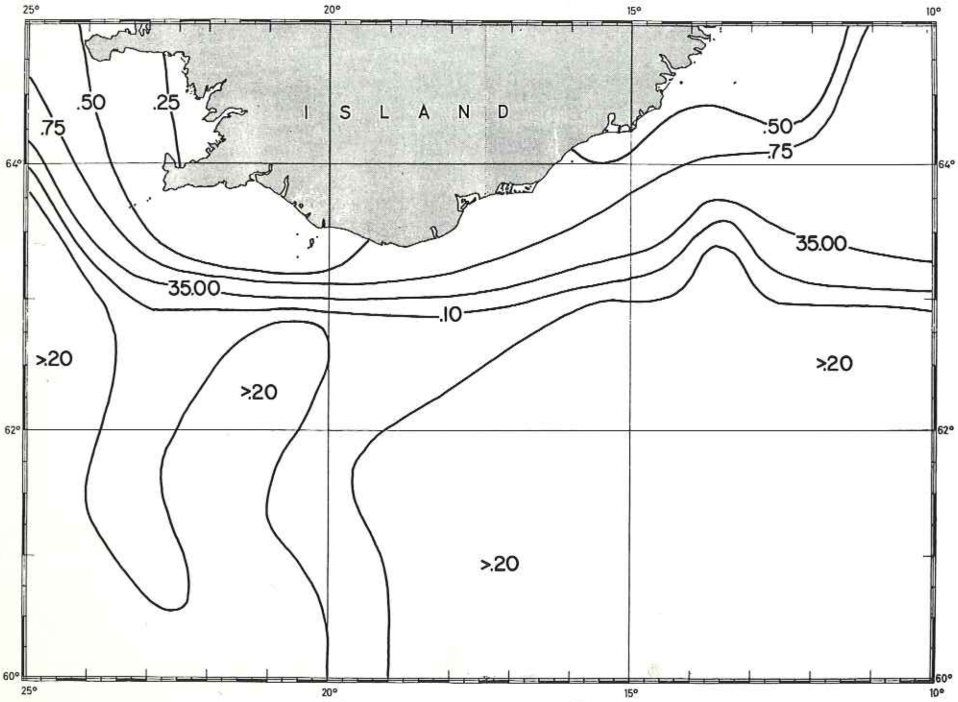

Fig. 23. Mean SSS August 1868–1955.

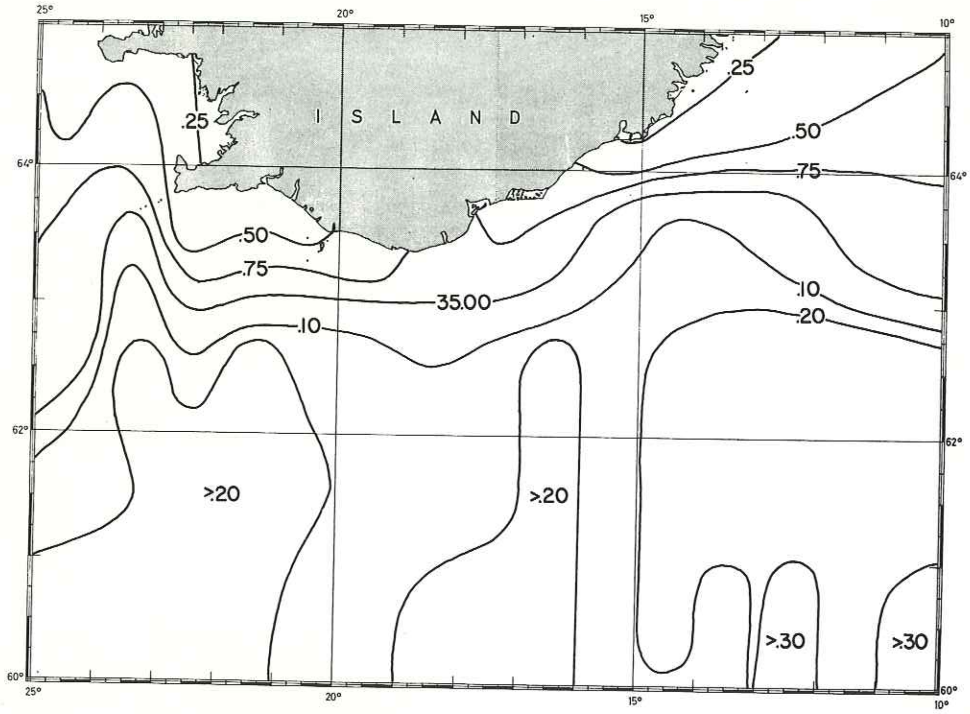

Fig. 24. Mean SSS September 1868–1955.

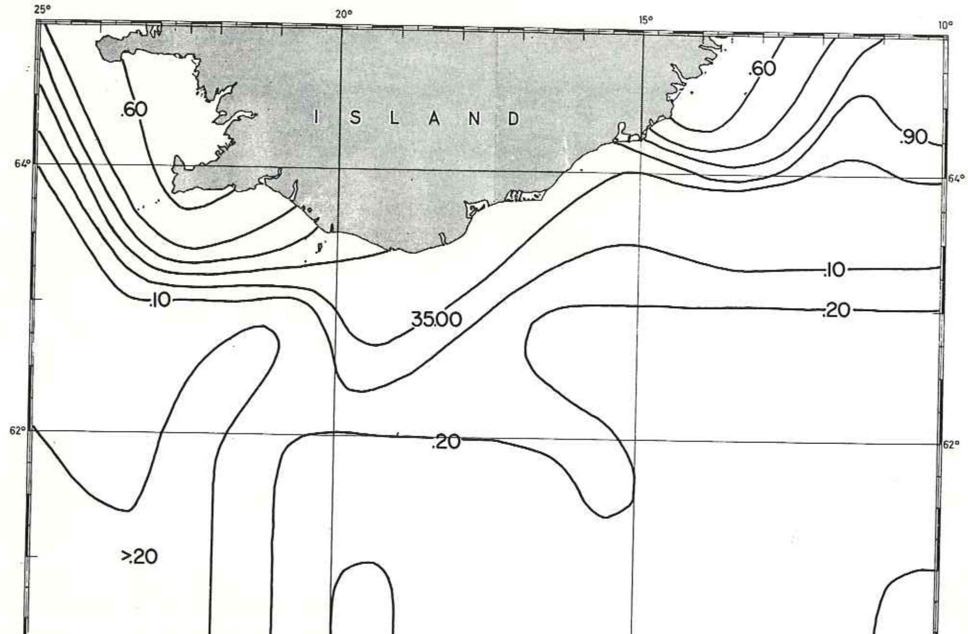

Fig. 25. Mean SSS October 1868–1955.

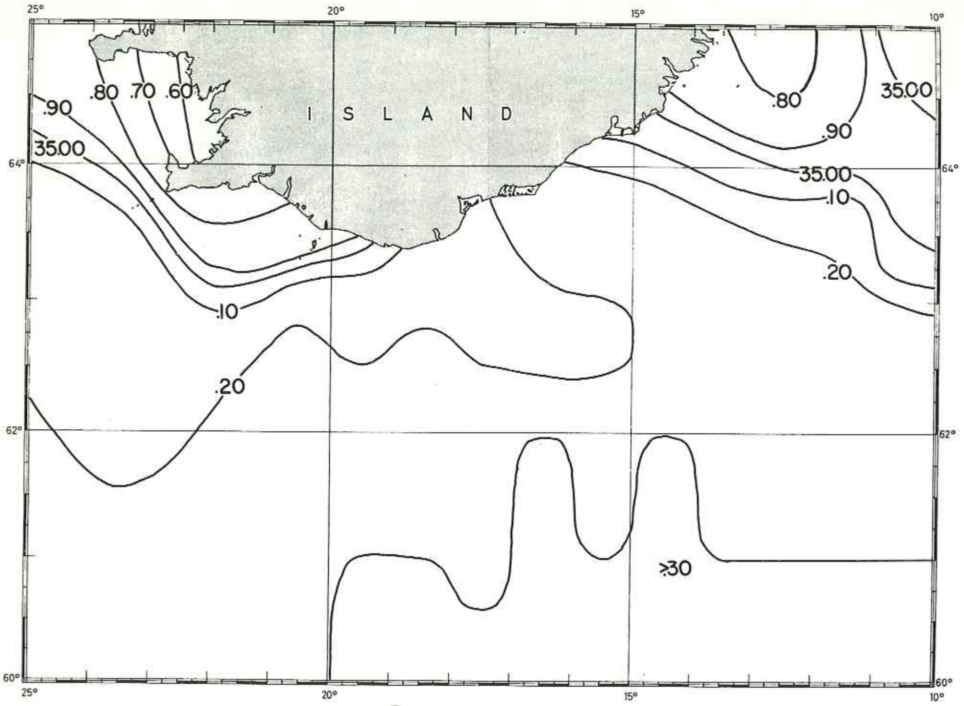

Fig. 26. Mean SSS November 1868–1955.

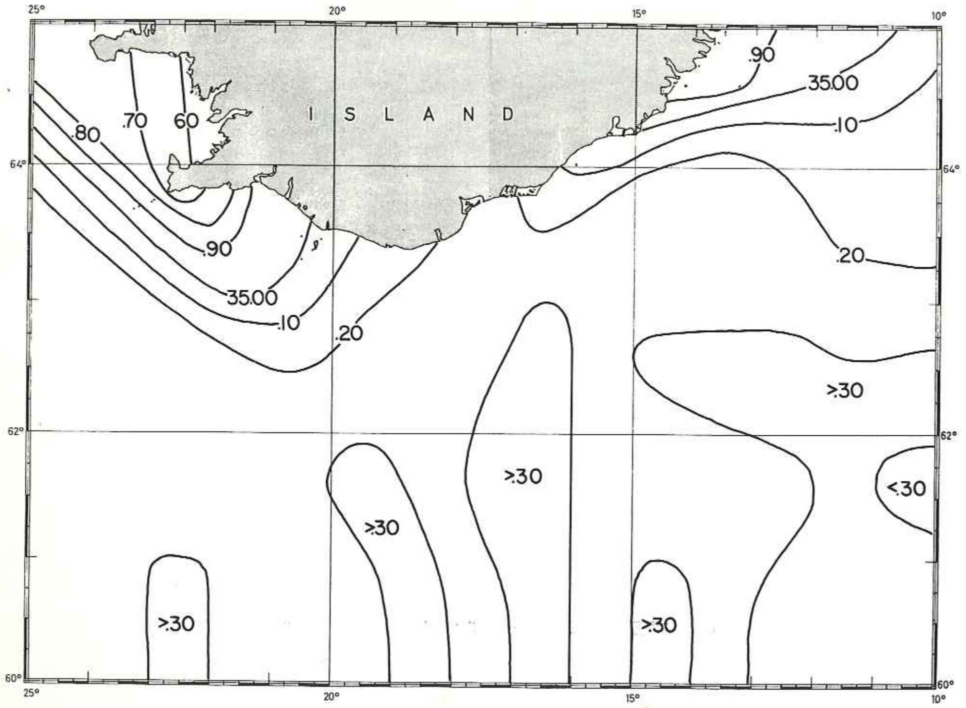

Fig. 27. Mean SSS December 1868–1955.

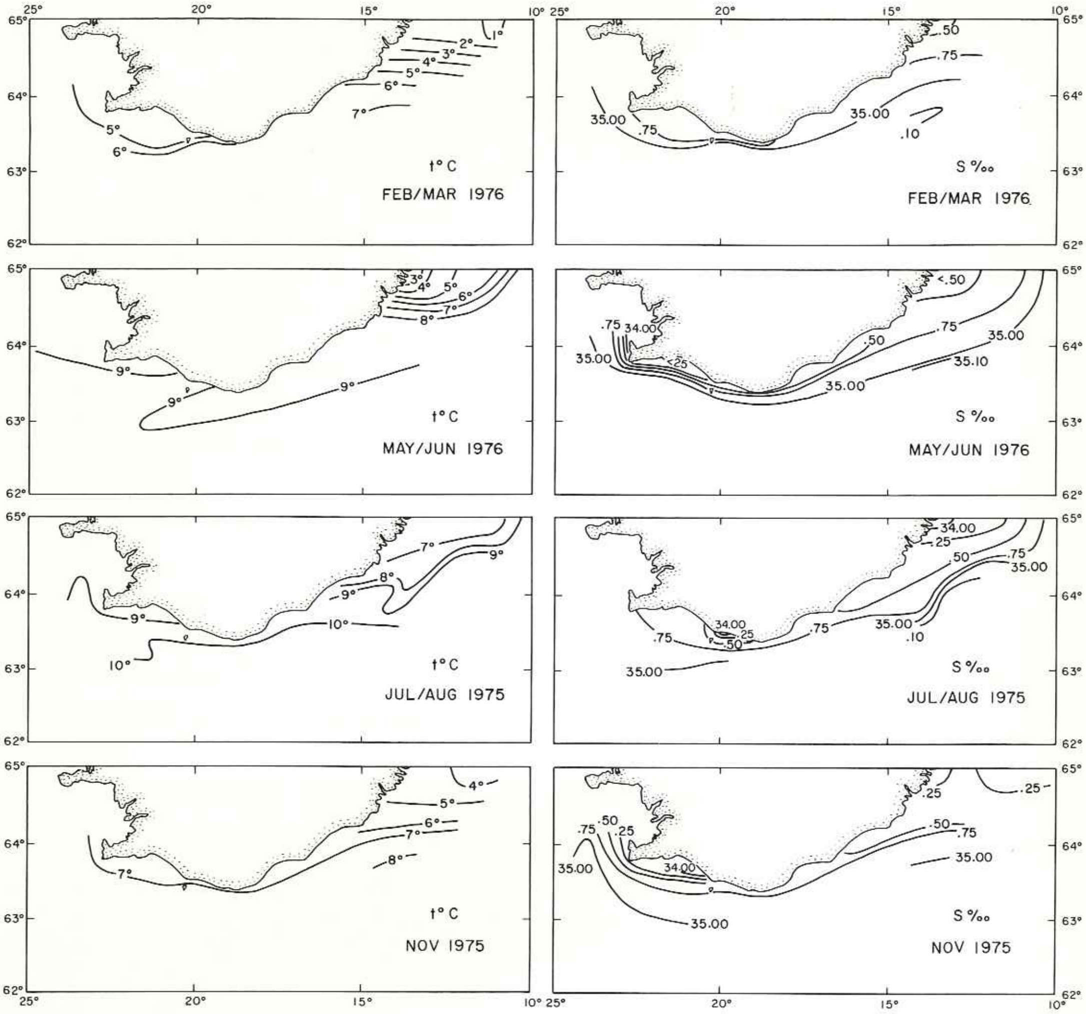

Fig. 28. SST and SSS in South Icelandic waters based on surveys in August and November 1975 and February and May/June 1976.

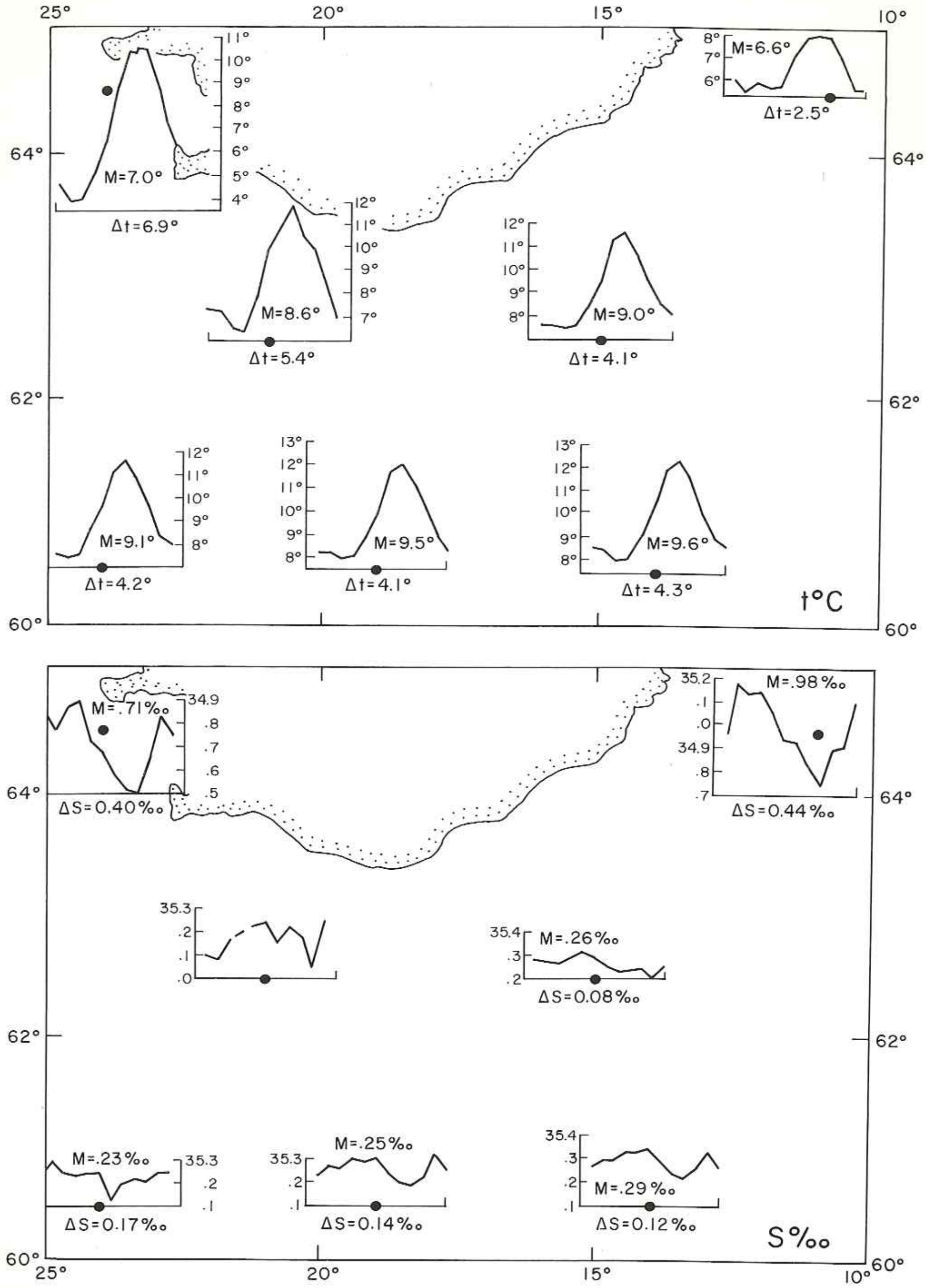

Fig. 29. Mean seasonal variations of SST and SSS 1868–1955 at selected subareas in the study area. (see Fig. 3). The mean value of the same years (M) and the differences (Δ) of the lowest and highest mean monthly values are also shown (After Malmberg 1962).

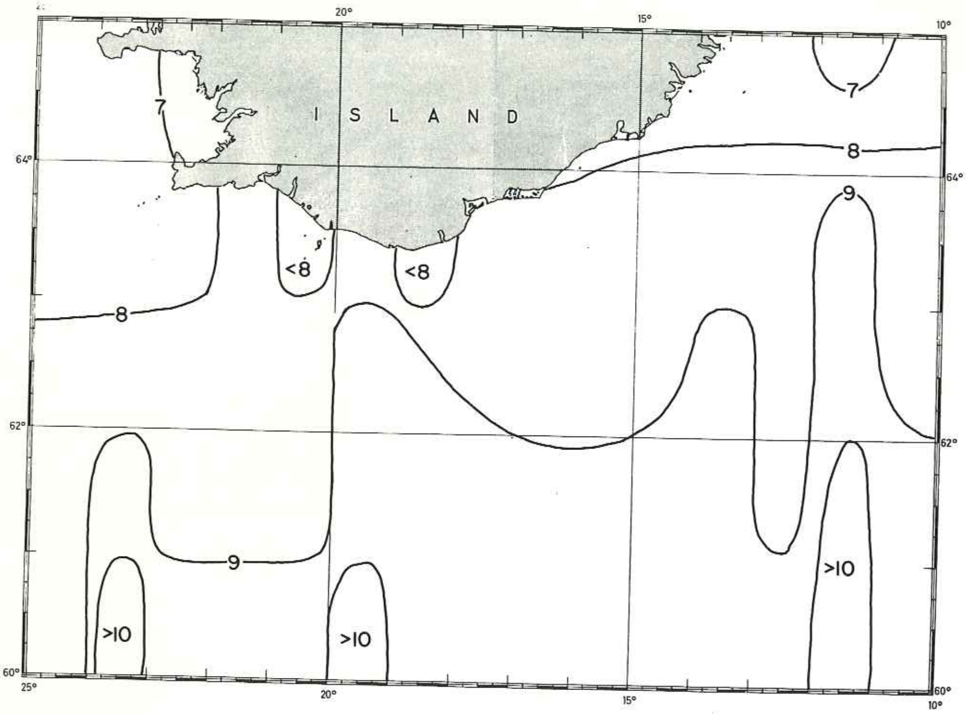

Fig. 30. Mean SST May 1951–1960.

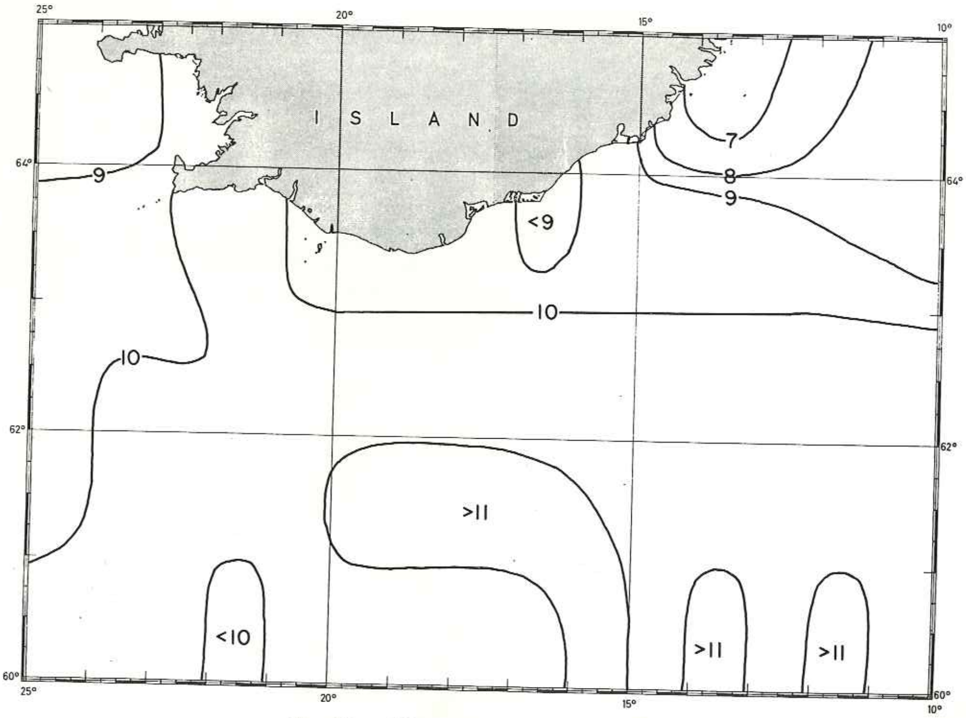

Fig. 31. Mean SST June 1951–1960.

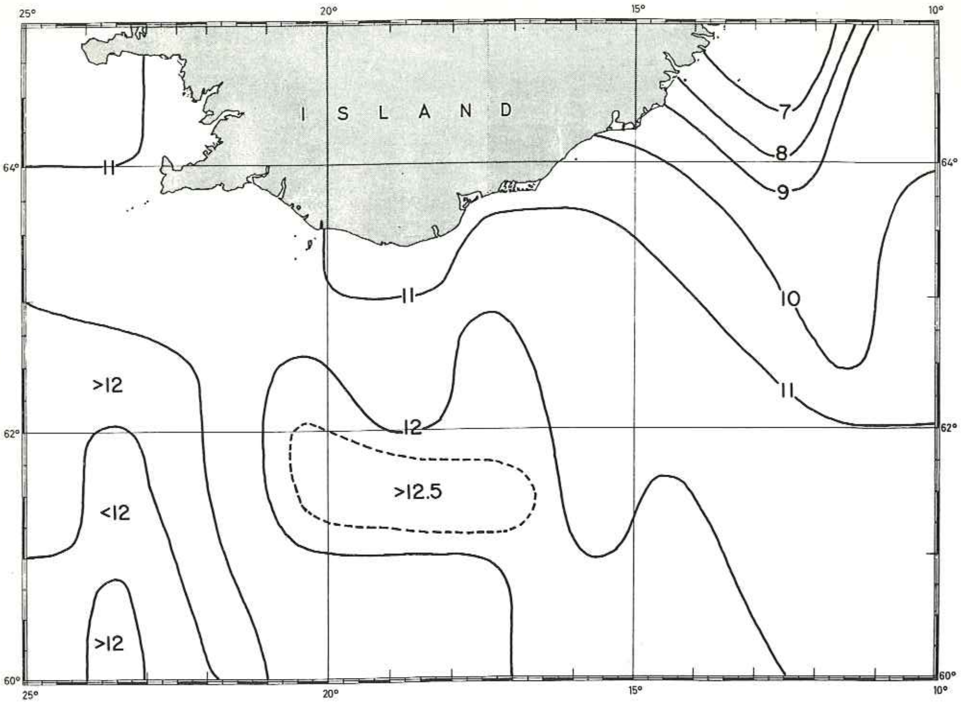

Fig. 32. Mean SST July 1951–1960.

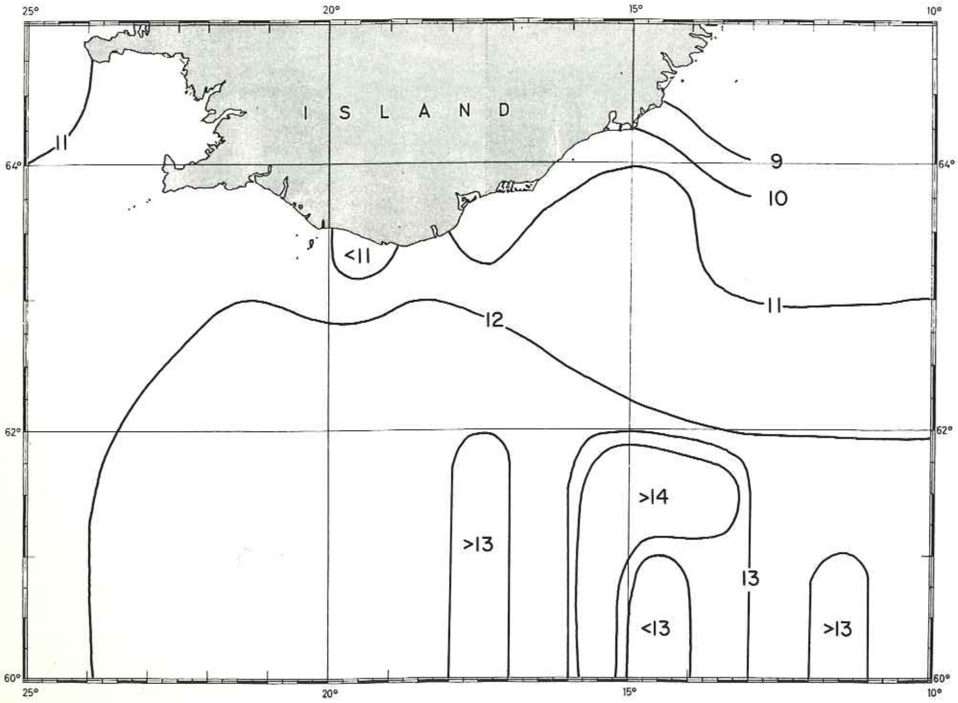

Fig. 33. Mean SST August 1951–1960.

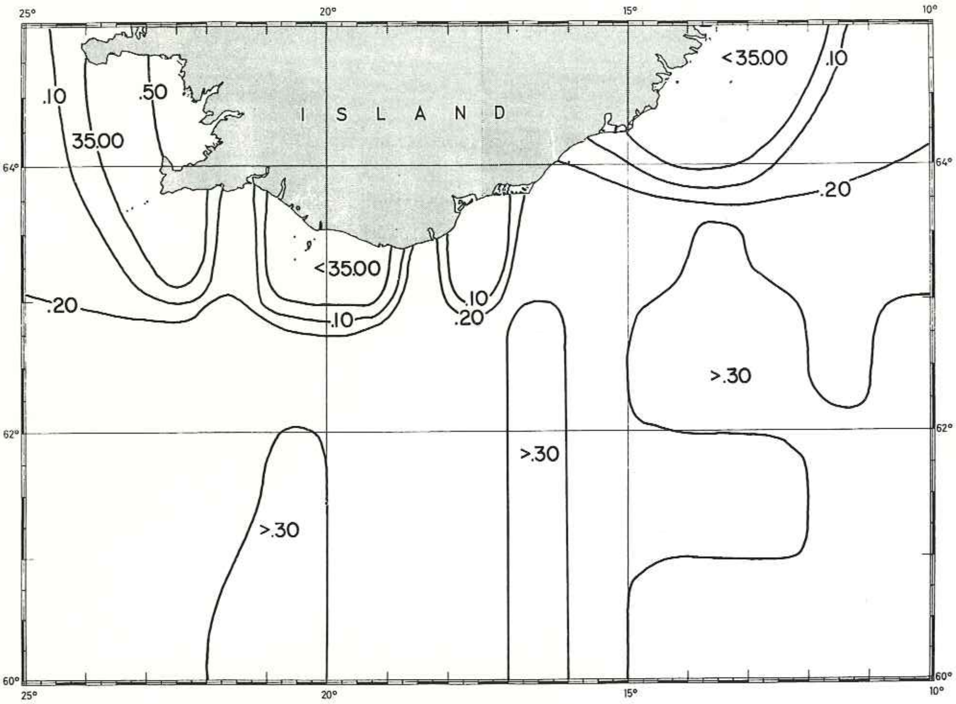

Fig. 34. Mean SSS May 1951–1960.

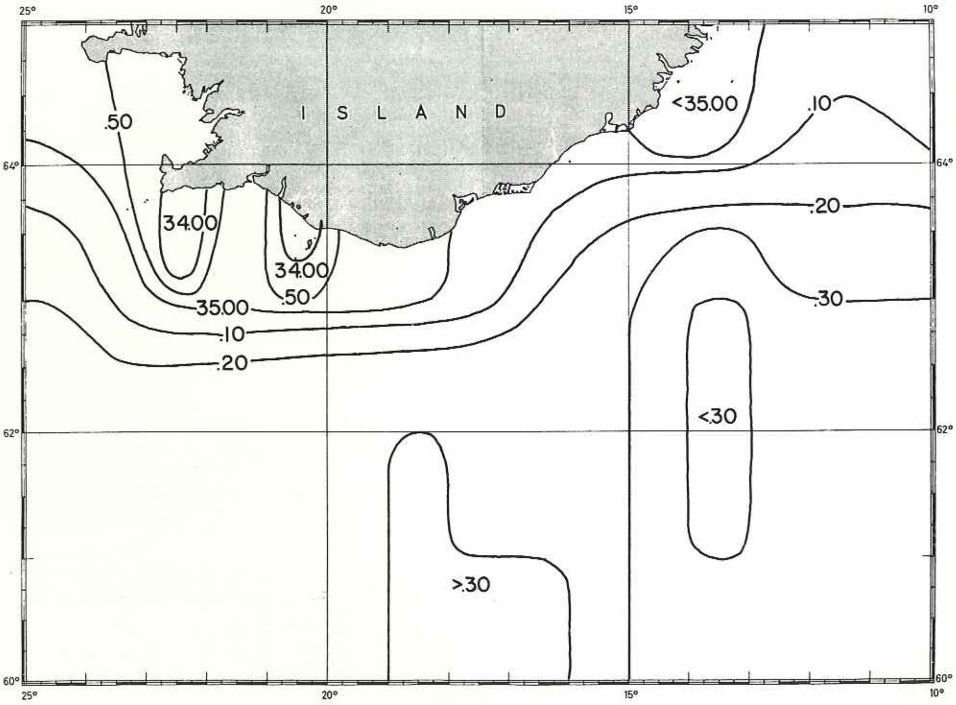

Fig. 35. Mean SSS June 1951–1960.

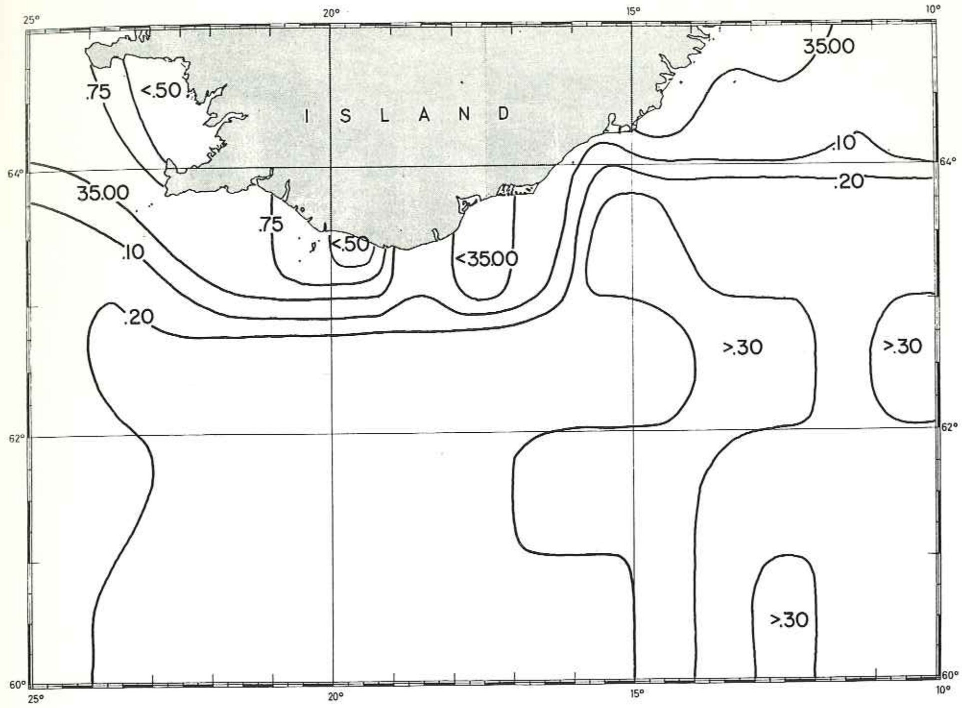

Fig. 36. Mean SSS July 1951–1960.

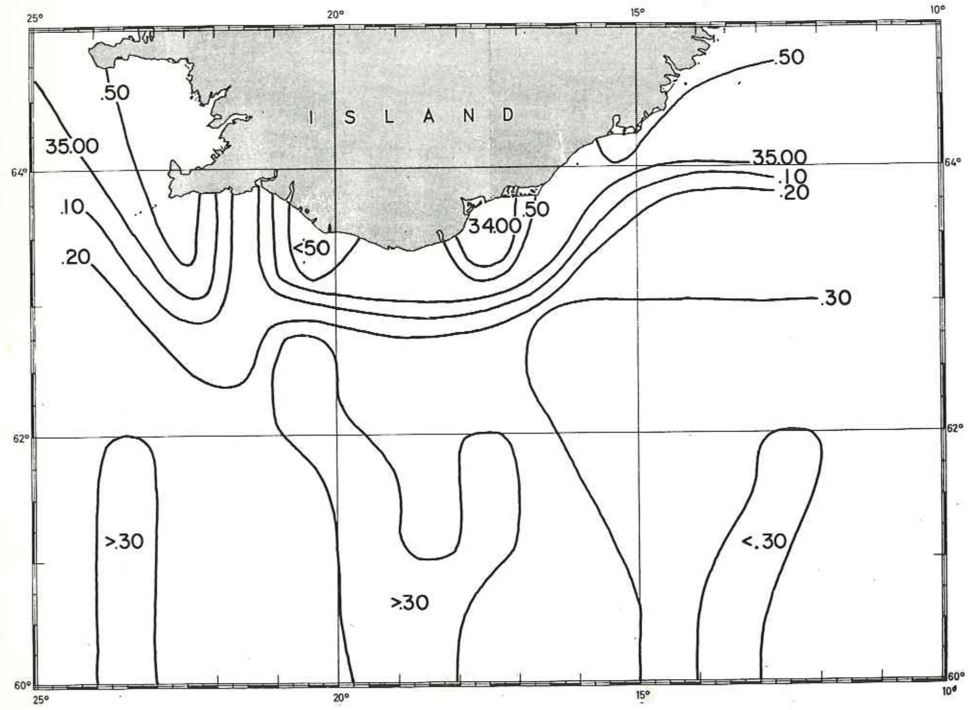

Fig. 37. Mean SSS August 1951–1960.

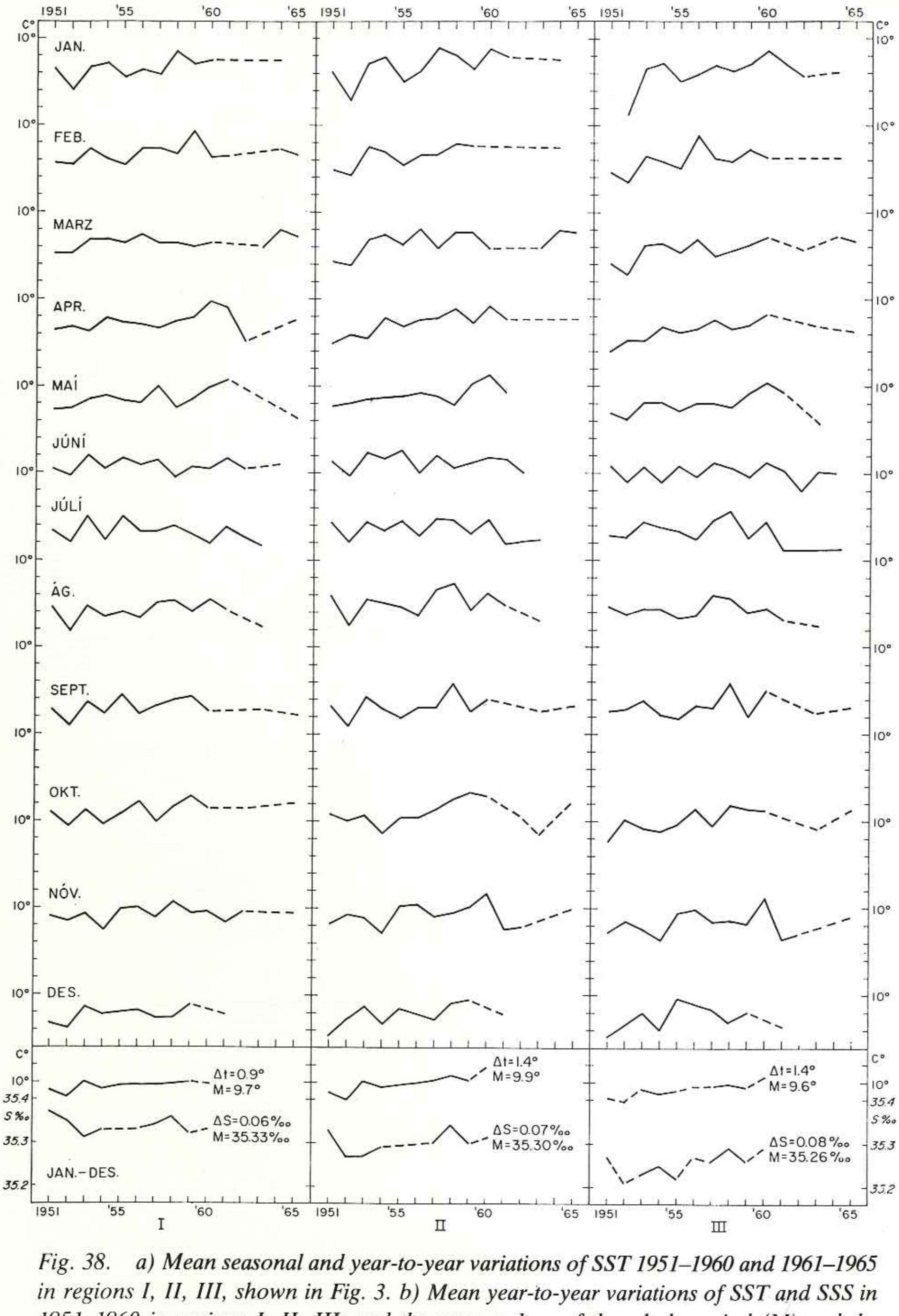

Fig. 38. a) Mean seasonal and year-to-year variations of SST 1951–1960 and 1961–1965 in regions I, II, III, shown in Fig. 3. b) Mean year-to-year variations of SST and SSS in 1951–1960 in regions I, II, III; and the mean values of the whole period (M) and the difference (△) of the lowest and highest mean yearly values in 1951–1960 (After Malmberg 1969).

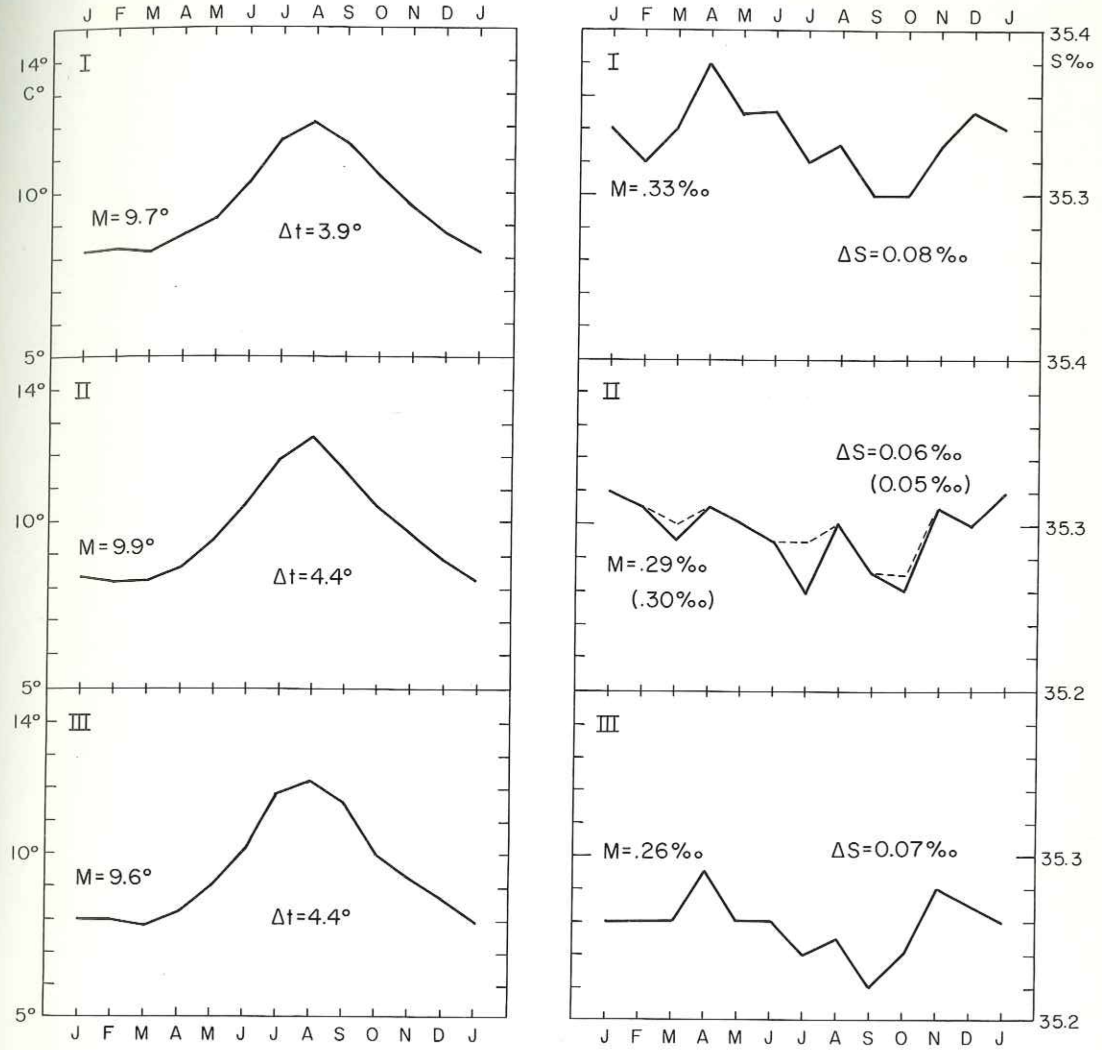

Fig. 39. Mean seasonal variations of SST and SSS 1951–1960 in regions I, II and III (for location see Fig. 3). The mean value of the year (M) and the difference (△) of the lowest and highest mean monthly values are also shown (After Malmberg 1969).