REPORT ON SURVEYS OF THE DISRTIBUTION AND MIGRATIONS OF THE NORWEGIAN SPRING SPAWNING HERRING AND THE ENVIRONMENT OF THE NORWEGIAN SEA AND ADJACENT WATERS DURING THE SPRING AND SUMMER OF 1995

1. INTRODUCTION

In spring and summer of 1995, several surveys were conducted by resarch vessels from the Faroes, Iceland, Norway and Russia. These surveys were coordinated according to the procedure outlined by a planning group, which met in Bergen, Norway during 2-3 March 1995, coordinate surveys of the Norwegian spring spawning herring and environmental conditions in the Norwegian Sea and the techniques to be used in the summer of 1995 (*Anon.* 1995)

The initiative for this coordination was formalized by representatives from the marine research institutes in the Faroes, Iceland, Norway and Russia during a meeting in October 1994. In a "Letter of intent" from that meeting it was *i.a.* stated that:

> Representatives from the institutes will meet in Reykjavik in September 1995 to evaluate the data and try to reach a common conclusion with respect to the distribution of Norwegian spring spawning herring in 1995 and plan future cooperation.

The meeting was held in Reykjvik 11-13 September 1995.

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3. SURVEYS

The following surveys were carried out:

Country	Vessel	Period	Survey grid
N1	"G.O. Sars"	02.03 - 21.03	Fig. 3.1
N2	"G.O. Sars"	18.04 - 27.04	Fig. 3.2
I1	"Bjarni Sæmundsson"	24.04 - 02.05	Fig. 3.3
I2	"Árni Fri›riksson"	11.05 - 28.05	Fig. 3.4
I3	"Bjarni Sæmundsson"	18.05 - 06.06	Fig. 3.5
F1	"Magnus Heinason"	05.06 - 21.06	Fig. 3.6
R1	"Professor Marti"	06.06 - 12.07	Fig. 3.7
I4	"Árni Fri›irksson"	13.06 - 27.06	Fig. 3.8
N3	"G.O. Sars"	26.05 - 22.06	Fig. 3.9
N4	"Johan Hjort"	07.07 - 02.08	Fig. 3.10
N5	"G.O. Sars"	29.07 - 15.08	Fig. 3.11

Reports on these surveys were presented at the meeting and furnished the basis of the present joint report.

4. HERRING DISTRIBUTION AND AGE COMPOSITION

4. 1. *Adult herring*

March

The spawning took place on the coastal banks off the west and northern coast of Norway from about 15 February and towards the end of March in the area between 59•N and 69•30'N.

Figure 4.1 shows the distribution of adult spent herring during the survey by R/V "G.O. Sars" in the period 2/3. - 21/3. 1995. The younger herring, with a length range of 23 - 28 cm, were mainly found in the northern part of the area. Some of these were immature and there was also a small admixture of larger herring(up to 39 cm). The most prominent year classes were those of 1991, 1989, 1990 and 1988. The 1983 year class was also present, but to a small extent.

Further south (Trænabanken-Haltenbanken) the herring were somewhat larger, mainly in the range of 26-34 cm. The year class of 1990 dominated in this area, with varying percantages of the year classes of 1991 and 1992. The 1983 year class was also present.

In the southern part of the distribution area, off Møre, the size range of the herring was 28-38 cm. The most numerous age groups were the the year classes of 1990, 1983 and 1989. The 1988 and 1991 year classes were also present.

In general, the main part of the 1983 year class spawned in the southern part of the spawning area while the spawning grounds farther north were dominated by younger herring, including recruit spawners.

<u>April</u>
Figure 4.2 shows the distribution of herring during the latter part of April. The western border of the adult herring distribution had shifted more than 200 naut. miles to the west as compared to one month earlier. The largest concentrations were found in international waters between approximately 65•N and 68•30'N and 0•-2•W. The southern distribution of the herring seeed to be about 65•N in April.

East of the 0 meridian, south of 67•N, the length distribution ranged mainly from 31-38 cm. The dominant year classes were those of 1989, 1990 and 1983. Farther to the north the length ranged mainly from 26-32 cm with a complete dominance of the 1991 year class.

In the area between the 0 meridian and 01•30'W, the length distribution mainly ranged from 26-34 cm with a predominance of the 1989, 1990 and 1991 year classes. There was also some contribution by the 1983 year class, particularly in the more northern part of the area.

Although large numbers of herring schools were observed in the area from 65•N to 68•N, west of 01•30'W in April, very few samples could be obtained from this westernmost part of the feeding migration which was surveyed by the Icelandic vessel. This was due to the extreme sensitivity of the herring to the disturbance by an approaching fishing gear. In consequence it was almost a chance occurrence to obtain a catch with the small trawl which, due to a mishap, had to be employed on this occasion. The available information indicates a length range of 29-38 cm, with the 1983 year class contributing some 33% by number, almost all of the remainder being made up of the year classes from 1989, 1990 and 1988 in that order.

In general, it seems that the larger and older herring were distributed in the southern part of the survey area as well as farthest to the west. On the other hand, the smaller fish, comprising the younger age groups, were found in the northern and northeastern part.

During daytime, the herring were distributed in schools at depths from 250 to 400 meters. At midnight the schools ascended towards the surface and dissolved. At dawn the herring reorganized in schools and descended towards the deeper water layers again.

East of 2•E the herring seemed to be migrating westwards. Near the 0 meridian there was little migration of the herring schools, while the herring at 2•W seemed to have a slight easterly movement.

May

During the period from the end of April until mid-May the fishery shifted south- and southwestwards (cf. Fig. ??). The data from samples of the commercial catch in the area between about 63•15'N and 64•45'N, from 02•30'W to 05•30'W, during first half of May, indicate some variation in size and age disrtibution with longitude.

East of 3•W the length distribution of the catch was 30-38 cm. The 1983 year class contributed about 10-25% by number, while the remainder of the catch mainly consisted of the 1989 and 1990 year classes (10-25% and 15-35%, respectively). In the area west of 3•W, the length composition was in the range of 33-37 cm, with a complete dominance of the 1983 year class (40-60% by number). As further east, the other main age component was the 1989 year class which, however, did never contribute more than 15% to the catch.

In the third week of May large and dense concentrations were located between 63•30'N and 65•45'N, and 3•and 5•W. Towards the end of the week, the herring in the northern part of the area started a northward migration and were located between about 65•30'N and 66•N, 4•W on 25 May. This movement is clearly reflected in the shift of position of the Icelandic fishing fleet (cf. Fig. ??).

In the fourth week of May large concentrations of herring were also located between 1•30'W and 3•W, between 56•30'N and 66•45'N.

Between 64•N and 65•N the length distribution ranged from 29-39 cm with the highest frequencies within the 31-38 cm range. As earlier in the month, the age distribution was dominated by the 1983 year class on one hand and those of 1989 and 1990 on the other.

South of 64•N, there was a somewhat larger admixture of smaller and younger fish. Thus, the size of the herring ranged from 28 to 38 cm in this area, with the highest frequencies at 30-33 cm and a lower top at 36-38 cm.

The survey recorded herring at about 4•W between 65•30'N and 66•N in the beginning of the fourth week of May These herring had a similar size distribution as recorded previously between 65•N and 64•N, the age composition dominated by the 1983 and 1989-1990 year classes. As mentioned above, the Icelandic fishing fleet had followed a migration from about 64•30'N which explains the similarities of the size and age distributions just described.

The herring in the norteastern part of the distribution area had a length distribution of 28-39 cm, with tops at 31-34 cm and 36-38 cm. The age structure was completely dominated by the 1983 year class (about 40%) with important contributions by the year classes from 1984 and 1988-1990.

In the period 15-25 May an abundance estimate was obtained, using the echosounder/integrator technique. This estimate indicated a total biomass of some 3.7 million tonnes of herring, of which about 33% were recorded in international waters and the remaining 67% in the Faroese EEZ. The movements of the fishing fleet in May and the northward migration, observed during the survey in the third week of May, clearly indicate that the Faroese EEZ must have been occupied by more than two thirds of the herring earlier in the month.

June

As of late May the herring seem to have migrated at a considerable speed northwards. Figure 4.4 shows the distribution in June. This distribution map is based on combined recordings from the cruises of R/Vs "Árni Fri›irksson", "G.O. Sars", "Magnus Heinasson" and "Professor Marty".

The distribution of herring schools, as recorded by sonar, is shown in Figure 4.5.

In the northern part of the distrubution area (north of 69•N, Fig. 4.4) the young immature herring (1992 year class) dominated the recording near the Norwegain coast. However, in the northern distribution area west of the 0 meridian, the older fish dominate (year classes 1990, 1989 and 1983)

In the distribution area south of 69•N and east of the 0 meridian young fish dominated, with the 1991 year class being the most prominent. In the areas west of the 0 meridian older fish of the 1983, 1989 and 1990 year classes were predominant.

July

Figure 4.6 shows the herring recordings obtained during the R/V "Johan Hjort" survey 7/7-2/8 1995. During July the adult herring seem to have been migrating to the north and east and were recorded in deep waters to the northwest of Lofoten. The main part of the herring recordings obtained nearest to the coast derive from young herring.

In the southern part of the distribution area (Haltenbank) the recordings were dominated by young herring, mainly of the 1992 year class. Further north, outside Vesterålen, the 1991 year class was dominating, but there were also considerable amounts of herring of the 1992 year class. Offshore, west of approximately 9•E between 69•N and 71•N, older herring dominated in the samples. In this area, the most numerous year classes were those of 1991, 1990, 1989 and 1983. This age composition is comparable to that recorded west of the 0 meridian in June.

August

Figure 4.7 shows herring recordings obtained by R/V "G.O. Sars" in the period 29/7-15/8 1995. The distribution pattern was in the main similar to that obtained during the previous survey by R/V "Johan Hjort". The large adult herring were recorded in the northeastern part of the distribution area. The northeastern limit of the adult herring distribution could not be determined due to shortage of tine.

Some of the features of stock composition recorded in July, could still be traced in August. In the southern part of the distribution the younger component of the stock predominated (year classes 1991 and 1992). However, the older part of the population, which in July was recorded between 69•N and 71•N, seemed to have migrated northwards and was recorded between 72•N and 74•N, west of approximately 10•E.

A schematic presentation of the feeding migration route of the adult Norwegian spring spawning herring in the summer of 1995 is shown in Figure 4.8.

4.2. Juvenile herring

Herring younger than 3 years are generally distributed in the Barents Sea and in the fjords of North Norway. In years with strong year classes the larger part of these herring will be located in the Barents Sea. At about the age of 3 years (2-4 years), the herring will migrate out into the Norwegian Sea, and remain there for 1-2 years while reaching maturity.

The younger part of the herring population occupying the Norwegian Sea did not perform the extensive migrations of the undertaken by the older part of the population. In spring, these herring were located near the Norwegian coast, but by June they were distributed over large areas of the Norwegian Sea east of 0•E (Fig. 4.4).

The 1991 year class formed a considerable part of this population. By July, these young herring seem to have moved northwards, and by August the main part of them were located off Vesterålen/Lofoten.

In the northern distribution area these herring have been joined by that part of the 1992 year class which had migrated from the nursery areas in the Barents Sea in thesummer of 1995.

5. THE USE OF SONAR IN MAPPING HERRING DISTRIBUTION AND ASSESSING STOCK ABUNDANCE

The experience in mapping the herring distribution in the Norwegian Sea in June 1994 showed that by using only echo sounder and integrator techniques, as much as 75 % of the herring consentrations in the area could remain unrecorded (Misund et al 1995). It was felt that sonar recording seemed to have the potential to give a correct picture of the distribution of herring in the Norwegian sea during the summer period. At the planning meeting in Bergen during 2 -3 March 1995, the use of sonar was given much attention, and a field working procedure for sonar recording of herring in the Norwegian Sea in summer 1995 was defined. It was also decided to perform, as a pilot exercise, an intercalibration of the sonars used on board the various vessels.

The intercalibration took place on 18 June. Between 0400 and 0700 UTC the vessels were organized on a calibration course in position 67•00'N, 04•30'W. The vessels lined up in the following order: R/V "G.O. Sars", R/V "Professor Marti", R/V "Arni Fridriksson", and R/V "Magnus Heinason". The calibration course was run at a speed of 8 knots, with 1 naut. mile spacing between the vessels and with the vessel in front some 2-10• to the port or starboard bow to avoid running in each others propeller wake. The sonars were directed 90• to port, tilted to -10•, and with an observation range of 50m - 300m. The range of the Simrad EK 500 echo sounder was set to 10-500 m. The calibration course was run north along 4•30'W for 30 naut. miles and ended at 67•35'N. The calibration course was run at right angle to the waves of 2 -3 meters height coming from the east. The -10• tilt angle avoided substatial surface reverberation and wave reflections on the sonar records. The calibration area was probably as optimal as possible at that time. Both Icelandic, Faroese and Noregian purse seiners operated in the area suggesting that this was the area were the largest concentrations of herring were situtated.

However, the results from the intercalibration gave little correlation between the number of schools recorded by the different vessels. There may be several reasons for this. In the calibration area there seems to have been a lot of weak recordings, which some obervers have characterized as small schools, others as noise interferece. Another reason for the difference may be that all vessels had different sonars with different detection capabilities.

Due to the variability just described, the present meeting decided not to normalize the sonar records of the different vessels, or to try to translate sonar records to absolute biomass. Instead, the intercalibration was regarded as a pilot experiment. The experience so far seems to indicate that it is very difficult to systematize manually counted sonar records. It seems to be necessary to have some system for automatic counting of sonar records, combined with specified criteria for recognition of herring schools (*e.g.* signal threshold, horizontal extent and time duration). At present only R/V "G.O. Sars" is equipped with such a system.

As mentioned above, the experience from June 1994 indicated that the conditions for applying echo sounding techniques to map the herring distribution were not good. The conditions in 1995 seem to have been better. In March and April 1995 the herring were situated at depths of 250-400 meters during much of the day and thus well suited for echo recording. During the May-June survey, the horizontally ranging sonar and the vertical echosounder/integration gave quite comparable results with regard to recordings of distribution and, to some extent, abundance. Furthermore, the two systems seemed to give comparable results in this respect in July and August.

The conclusion is, therefore, that in the summer of 1995 the echosounder/integration systems seems to have given reliable results with regard to the general distribution pattern of the herring. The distribution of sonar recordings from the joint June survey are shown in Figure 5.1.

6. THE HERRING FISHERY IN THE NORWEGIAN SEA IN THE SUMMER OF 1995

6.1 The Icelandic fishery

The Icelandic fishery started in the last days of April in the international zone. The herring schools kept to depths of 250-400 m most of the time and were difficult to approach at purse seine depths during the short time at night when the herring approached the surface layers. Consequently, only some very small catches could be taken.

In the first week of May the fishery shifted to the northeast of the Faroes, near the border between the Faroese EEZ and the international zone. By the second week of May the fishing area had moved farther southwest and completely into Faroese waters. In the beginning of the fourth week of May, the Icelandic fishing area had moved with the northern component of the fishable stock and reached the border beetween the Faroese EEZ and the international zone.

Due to a wage strike by Icelandic fishermen, no catches were taken in the period 25/5-15/6. When the fleet arrived in the fishing area again, some catches were taken in the international zone north of 67• N. During the week of 18-24 June, the fishery moved to the border area between the EEZs of Jan Mayen and Iceland and international waters, where some catches were taken inside the Icelandic EEZ. After 24 June there was no Icelandic fishery of Norwegian spring spawning herring.

In May the Icelandic catch of Norwegian spring spawning herring was about 139,000 tonnes, of which about 3/4 were taken within the Faroese EEZ and the remainder in international waters. In June some 38,000 tonnes were caught, mostly in international waters but also in the Icelandic EEZ. The total catch amounted to 170,611 tonnes.

Figure 6.1 shows a schematic representation of the spatial and temporal movement of the Icelandic fishery of Norvegian spring spawning herring in 1995, as well as the feeding migration of that part of the stock on which the Icelandic fishery was conducted.

6.2 The Faroese fishery

The Faroese fishery of Norwegian Spring spawning herring started in the beginning of May. The first catches were taken in the area north of the Faroes, but later in May the fishery shifted to the north and northeast to the northern border of the Faroese EEZ. The total catch of herring in Faroese waters was about 50 thous. tonnes.

In the first week of June, two of the Faroese vessels took one load each in the Icelandic EEZ, their total catch being 2,500 tonnes. Around mid-June 4 vessels caught about 5,000 tonnes in international waters after which time the fishery stopped.

Total landings by Faroese vessels in May-June 1995 amounted to 57.000 tonnes.

6.3. The Norwegian fishery

As the Norwegian fishery of the Norwegian spring spawning herring traditionally is conducted in the periods January-March and September-December, only a few large purse seiners followed the westward migration of the herring stock in May and June.

Preliminary catch reports indicate that approximately 4,900 tonnes were caught in international waters, whereas 2,400 tonnes were caught in the Jan Mayen EEZ. These are minor quantities in relation to the expected Norwegian catch in 1995.

7. HYDOGRAPHIC CONDITIONS

<u>April</u>

The temperature at 50 and 300m depth in late April-early May 1995 is shown in Figures 7.1-7.2, respectively. In April no warming of the surface layers had started and the hydrographic data show typical winter conditions in the area east and northeast of Iceland. Thus, temperature at 50 m depth on the Krossanes section was in general around 0.5•C. At this depth on the Langanes-NE section this temperature was observed in the shelf waters while the temperature was -0.5•C in the core of the East-Icelandic Current.

East of the East-Icelandic Current, at 7-8•W, temperatures (50m depth) increased to 2-3•C. The 3• isotherm was located at 1-2•W, except in the northernmost part of the survey area where the 3• isotherm was located at about 5•W.

<u>May</u>

The temperature distribution in the survey area at 50 m and 100 m depths is shown in Figures 7.3-7.4, respectively.

No inflow of Atlantic water was observed into the North Icelandic area where cold Artic water was dominating (0-1•C), which had a wider distribution than ever observed since the beginning of the Icelandic spring investigation series in 1949.

The hydrographic regime of most of the central Norwegian Sea, as reflected by the sea temperature, appeared to be quite uniform. Thus, at a depth of 50 m the temperature ranged from 2-3.5•C in most of the area between 01•30'W and 07•W, north of 63•20'N. At all depths, from 300 m upwards there was a slight increase in temperature towards the northeast. Furthermore, at depths above 100 m, a tongue of water with temperatures above 3•C reached south to 65•N in the area between approximately 5•W and 7•W (Figs. 7.3).

However, the cold water area extended much farther south- and southeastwards than in 1994 and subzero temperatures extended somewhat farther to the east in the northwestern part of the survey area. North of the Faroes, the northern boundary of the warmer water of the North Atlantic Drift was located at about latitude 63•10'-20'N.

At depths in excess of 300-400 m the temperatures in the central Norwegian Sea decreased markedly and zero values were in most cases reached at 500 m.

June

The temperature at 0, 50, and 200 m depth in June 1995 are shown in Figures 7.5-7.7, respectively.

Near the surface the highest temperatures (>9•C) were observed in the southeasternmost part of the investigation area while the lowest temperatures (<3•C) were recorded in the vicinity of Jan Mayen. Over the largest part of the central Norwegian Sea the surface temperatures in June were between 5-8°C.

At 50 m depth the temperatures were generally 1-2° C lower than those at the surface indicating that by this time, a well defined thermocline had been established. At all depths the tempeatures were about about 1°- 2° C higher than in May.

As in May, the eastern border of the East-Icelandic Current was located between 7•30´ and 8•30´W, both at 50 and 200 m. By this time, a well defined thermocline had been established. However, in the uppermost 200 m the warmer water of the Norwegian Sea reached slightly farther west than in May.

July

The temperature at a depth of 3 m, 50 m and 200 m in the eastern Norwegian Sea is shown in Figures 7.8 -7.10.

In the near surface layer, the temperature increased from around 7-8•C in the west to 10-11•C near the Norwegian coast. Below 50 m depth, a frontal area could be distinguished along the continental slope, especially in the southern part of the investigation area, where the temperature at 200 m changed from 3•C to 6•C within a fairly small area.

August

The temperature at 0 m, 50 m and 200 m depth in the eastern and northeastern Norwegian Sea in August 1995 is shown in Figures 7.11-7.13.

A cursory comparison of the horizontal temperature distribution in July and August at the three reference depths, indicates that a warming of about 1•C had in all cases occurred in practically all of the investigated area in the Norwegian Sea.

As compared to the spring survey by R/Vs Bjarni Sæmundsson and Árni Fri›riksson in May-June, a large improvement of the hydrographic hydrographic regime had taken place in the shelf area north and northeast of Iceland (cf. Figs. 7.3, 7.4 and 7.12). Thus, Atlantic water was in August registered off the entire north coast as well as in the area northeast of Iceland, to the east of Langanes as (Fig. 7.12).

8. ZOOPLANKTON BIOMASS AND DISTRIBUTION

The information on zooplankton distribution has been gathered using various sampling gear and therefore it was decided not to attempt the presentation of the results from the different cruises on combined maps. However, in spite of different sampling gears, the results can to some extent be compaired and discussed to provide a general picture of the zooplankton distribution and development.

<u>April</u>
In late April no warming of the surface layers had begun and the phytoplankton spring bloom had not started. In the eastern part of the survey area the zooplankton biomass ranged from 1-78 g dry weight per m^2 (Fig. 8.1), the average being 20 g dry weight per m^2 . At the stations of the lowest biomass the zooplankton was probably still in deep water while on those with highest biomass the animals had already emerged. In the waters somewhat farther to east the biomass was on the average somewhat lower but clearly there appeared to be a gradient of increasing zooplankton biomass from east (<5 g dry weight per m) to west (20 g dry weight per m^2, Fig. 8.1).

<u>May</u>
High denities of zooplankton were recorded in almost all of the investigation area in the Norwegian Sea, on the average about 20 g dry weight per m^2. At approximately the same time last year the zooplankton biomass in the areas where herring were observed, within and east of the Icelandic EEZ, was about 10 g dry weight per m^2. The values observed in the Norwegian Sea during the spring of 1995 are also considerably higher than the long term average zooplankton biomass observed in spring to the north and east of Iceland.

The highest zooplankton biomass was observed in the area from 63•50'N to 64•50'N between 03•30'W and 07•00W (Fig. 8.2). Furthermore, in an extensive area north of 66•N. In the northern area the zooplankton biomass reached >100 g dry weight per m^2 at some stations. The lowest zooplankton biomass was recorded in the southeast- and southernmost parts of the survey area.

A comparison of Figures 4.3 and 8.2 demonstrates that in the southern part of the area, the distrbution of herring was largely confined to the region where the highest biomass of zooplankton was observed.

In the area north of 65•N, herring was mainly observed south of the main concentrations of zooplankton.

C. hyperboreus was the dominating zooplankton species in the western part of the investigation area while *C. finmarchicus* dominated in the eastern part.

<u>June</u>

The surveys showed biomass values of more than 20 g dry weight per m^2 over extensive areas in the Norwegian Sea (Figs. 8.3 and 8.4). The highest values (>30g dry weight per m^2) were observed north of 70•N, or in the areas north of where the herring were observed in June An average zooplankton biomass for all the observation area was about 16-17 g dry weight per m^2, compared to a long term average of about 11 g dry weight per m^2 as measured by Russian investigations.

In the area east of Iceland the average biomass was of a similar level to that observed in both April and May, or about 20 g dry weight per m^2. However, in contrast to that observed during early spring, the zooplankton biomass was more evenly distributed in June (c.f. Figs. 8.2, 8.3 and 8.4)

July

Biomass values for zooplankton are not available from July.

August

Biomass values for zooplankton are not available from August.

10. DISCUSSION

In general, it can be stated that the cooperative study of herring migrations and the environmental conditions of the Norwegian Sea and adjacent waters in spring and summer 1995 were successful. Thus, the movements of the adult part of the Norwegian spring spawning herring could be traced more or less continuously, right from the time of spawning in February-March off the west coast of Norway until the herring reappeared in the general area to the northwest and north of Lofoten in August (cf. Fig. ??).

Furthermore, the herring migrations can be related to the the conditions of the environment, *i.a.* the main water masses of the area, as reflected in the temperature. Thus, after crossing the Norwegian Sea in April and May, the herring met the cold waters of the East Icelandic current in the area between about 63•N and 65•N, 5•-7•W and from there followed the general direction of the Polar Front during their migration north and eastward in June and July to arrive off Lofoten and northern Norway in August. The influence of the food supply on the feeding migration in the summer of 1995 is more obscure, in part probably because of the ample zooplankton biomass in most parts of the Norwegian Sea in May and June.

As planned, large amounts of data were collected on the species composition and development of the plankton community as well as the food, and to some extent the feeding habits of the herring. The analysis of these data is very time consuming and the results will not be available until in a few months time. Consequently, only a rough overview of some of the main features of the zooplankton community of the 1995 survey area could be given in this report.

A successful acoustic estimation of herring biomass in the area from about 63•N to 68•N, between 3•W and 8•W, using the echo sounder/integration technique, was obtained in the latter half of May. Judging by the high biomass recorded, the assessment probably covered most of the mature stock. This was possible due to the herring being distributed below the uppermost 50 m. However, due to inadequate vessel time the eastern border of distribution could not be reached and the ongoing migrations of the stock would have required some three vessels for a comfortably accurate assessment.

On the other hand, the plan to assess herring abundance in June by a school counting technique (Misund ????) did not come off as expected in view of the experience gained in June 1994. The main reason for the failure of the school counting technique in June 1995, was that at the time the stock was both assembled in large, dense aggregations at considerable depth as well as in the near-surface layer. This in turn resulted in an unrealistically low estimate of biomass using the echo sounder/integration technique.

It must be pointed out that the July survey, and in particular that of August, probably did not cover all of the adult herring distribution in the Jan Mayen EEZ in the first case and in the northeastern area off northern Norway in the second. This is a drawback with respect to estimating zonal attachment in July and August.

As it turned out the coordination of survey result presentation by the various groups of scientists, attending the Reykjavík meeting for evaluation of the 1995 survey ressults, left much to be desired. As a result the participants had to spend valuable time on various adjustments necessary for the comparison of data and pondering and evaluation of the results. This part of the work obviously needs reassessing.

There was also a general consensus among the participants that the meeting needed the attendance of hydrographers in order to properly interpret the available hydrographic data, which apart from temperature include information on i.a. salinity and specific gravity.

11. FUTURE WORK

The participants of the meeting agreed unequivocally that the marine research institutes of the Faroes, Iceland, Norway and Russia should continue their joint, coordinated research on the Norwegian spring spawning herring,which began again in 1995 after almost two and a half decades. The biomass of the adult part of this potentially largest herring stock of the world has increased in the last few years due to the recruitment of the large 1983 year class as well as the year classes of 1989 and 1990. Concurrent with this, the stock has again begun to migrate west across the Norwegian Sea in search of food in spring and summer. In 1994 and 1995 the feeding migration thus reached the eastern border of the East Icelandic Current, but did not stop there as usual prior to 1967. A further increase in stock abundance is expected in the next few years, mainly due to the recruitment of the year classes of 1992 and 1993. Therefore, an increased and coordinated research effort is vital for the effective monitoring of stock migrations, composition and abundance in the foreseeable future.

The meeting stressed the necessity for each participating institute to allocate vessel time as soon as possible and circulate information on such descisions the other parties when they have been taken. Apart from monitoring stock movements and environmental conditions in the period March-August, the main aim should be to obtain an estimate of biomass. Given sufficient vessel time, this can in all likelihood be done either by the echo sounder/integration technique in May, or by sonar counting of schools in June-July or both.

The necessity of better coordination of the presentation of survey results was pointed out by all participants of the Reykjavík meeting. The general consensus was that most survey data could be computerized and recorded in a common tabular form. The results could then be assembled quickly and efficiently, making all comparison easier. The need for standardizing basic sampling gear for zooplankton biomass was also stressed.

The meeting also discussed the ageing of the spring spawning herring. While there seemed to be a fairly good agreement among those age readers using scales, it was obviously difficult to determine the age of fish older than 7-8 years when using otoliths. It was agreed that tne Institute of Marine Research, Bergen would prepare reference sets of scales for distribution to the other institutes. However, it was pointed out that herring caught with pelagic trawls often became so descaled that it was impossible to obtain readable scales. Attempts to read the age from otoliths should, therefore, continue.

At the meeting there was unanimous agreement that there was need for further studies of the 1995 survey results, in order to glean as much as possible from that experience for use in planning the coordination of research in the years to come and further define the most important areas of research in space and time. For this purpose, it was decided that a planning group should meet in Thorshavn during 13-15 February 1996.

12. REFERENCES

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Figure 3.1. Cruise tracks and trawl stations, R/V G.O. Sars, 1/3-21/3 1995

Figure 3.2. Cruise tracks and stations, R/V G.O. Sars, 18/4-27/4 1995

Figure 3.3. Cruise tracks and stations, R/V Bjarni Sæmundsson, 24/4-2/5 1995

Figure 3.4. Cruise tracks and stations, R/V Árni Fri›riksson, 11/5-28/5 1995

Figure 3.5. Cruise tracks and stations, R/V Bjarni Sæmundsson, 18/5-6/6 1995

Figure 3.6. Cruise tracks and stations, R/V Magnus Heinason, 3/6-21/6 1995

Figure 3.7. Cruise tracks and stations, R/V Professor Marti, 8/6-12/7 1995

Figure 3.3. Cruise tracks and stations, Árni Fri›riksson, 13/6-27/6 1995

Figure 3.9. Cruise tracks and stations, G.O. Sars, 26/5-22/6 1995

Figure 3.10. Cruise tracks and stations, R/V Johan Hjort, 7/7-2/8 1995

Figure 3.11. Cruise tracks and stations, R/V G.O. Sars 29/7-15/8 1995

Figure 4.1. Herring distribution during 1/3-21/3 1995

Figure 4.2. Herring distribution (SA-values) during 18/4-2/5 1995

Figure 4.3. Herring distribution (SA-values) during 11/5-28/5 1995

Figure 4.4. Herring distribution (SA-values) during 26/5-12/7 1995

Figure 4.5. Herring distribution (number schools/5 naut. miles) during 18/4-2/5 1995

Figure 4.6. Herring distribution (SA-values) during 7/7-2/8 1995

Figure. 8.1. Zooplankton biomass in April (g dry weight /m^2, 50-0 m WP-2 net)

Figure. 8.2. Zooplankton biomass in April (g dry weight /m^2, 200-0 m MOCNESS)

Figure. 8.3. Zooplankton biomass in May (g dry weight /m^2, 50-0 m WP-2 net)

Figure. 8.4. Zooplankton biomass in June (g dry weight /m^2, 50-0 m WP-2 net)

Figure. 8.5. Zooplankton biomass in June (g dry weight /m^2, 200-0 m MOCNESS)

Figure. 8.6. Zooplankton biomass in June (mg wet weight /m^3, 50-0 m Djedy-net)

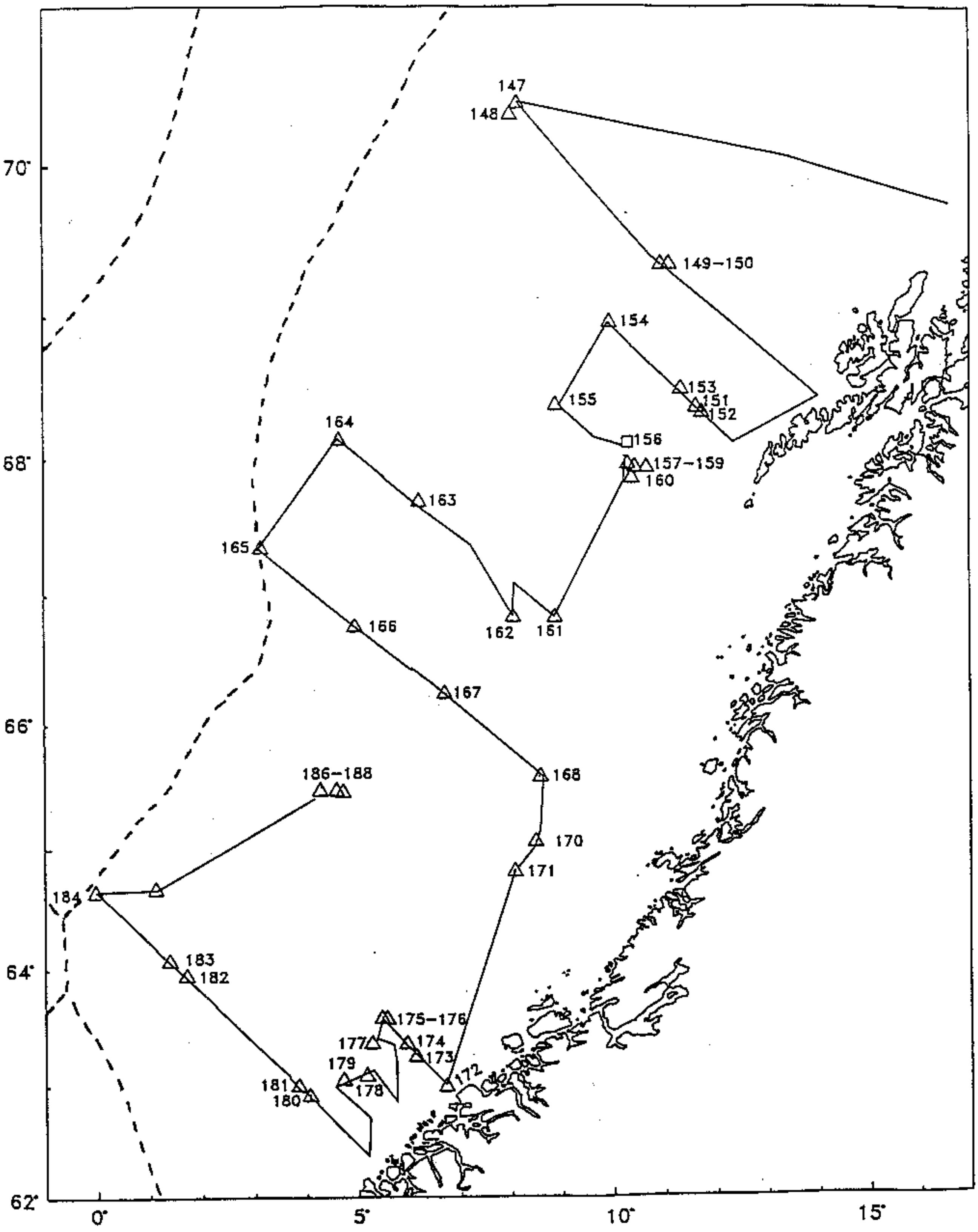

Figure 3.1. Cruise tracks and trawl stations, R/V G.O. Sars, 1/3-21/3 1995

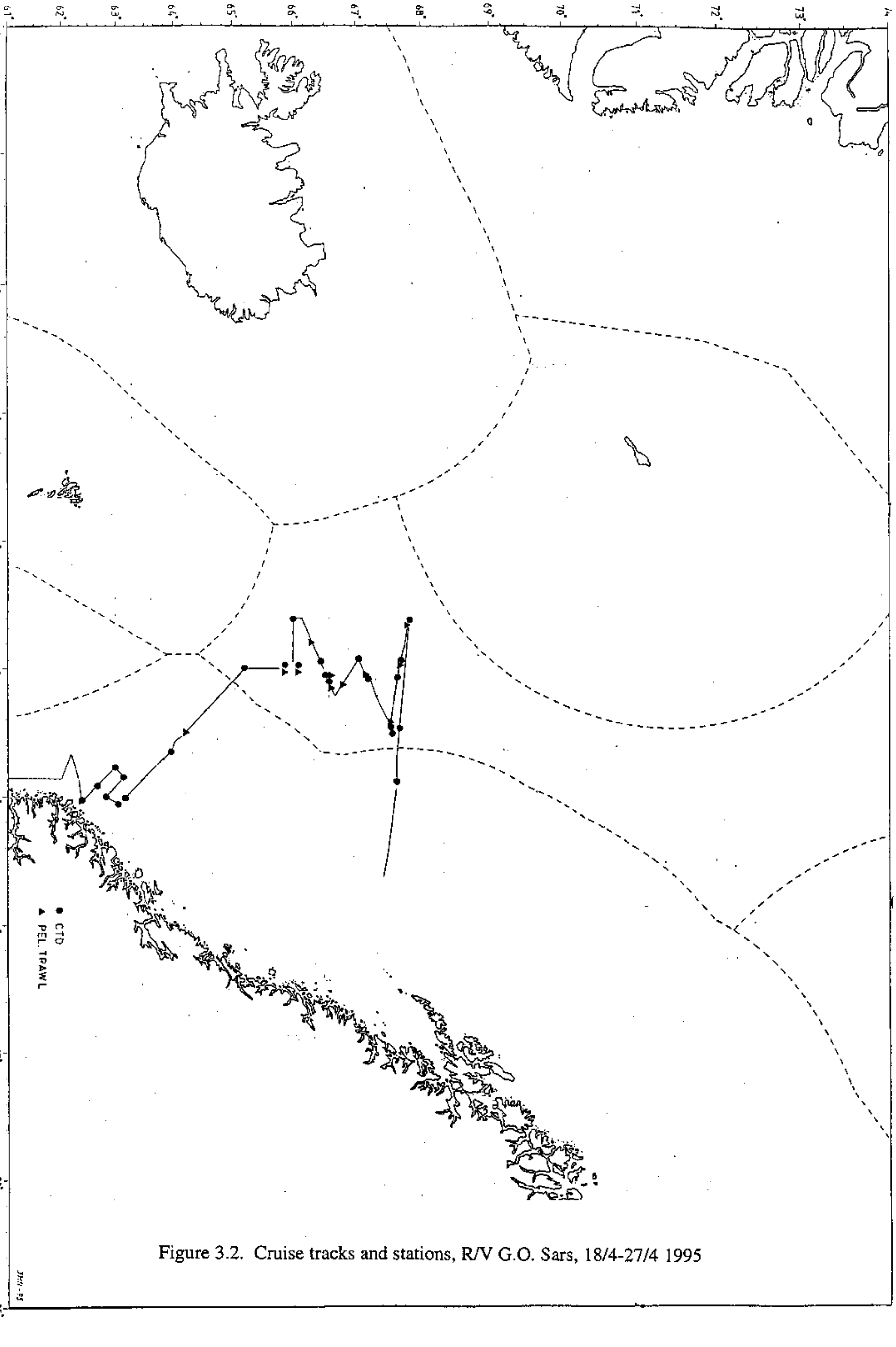

Figure 3.2. Cruise tracks and stations, R/V G.O. Sars, 18/4-27/4 1995

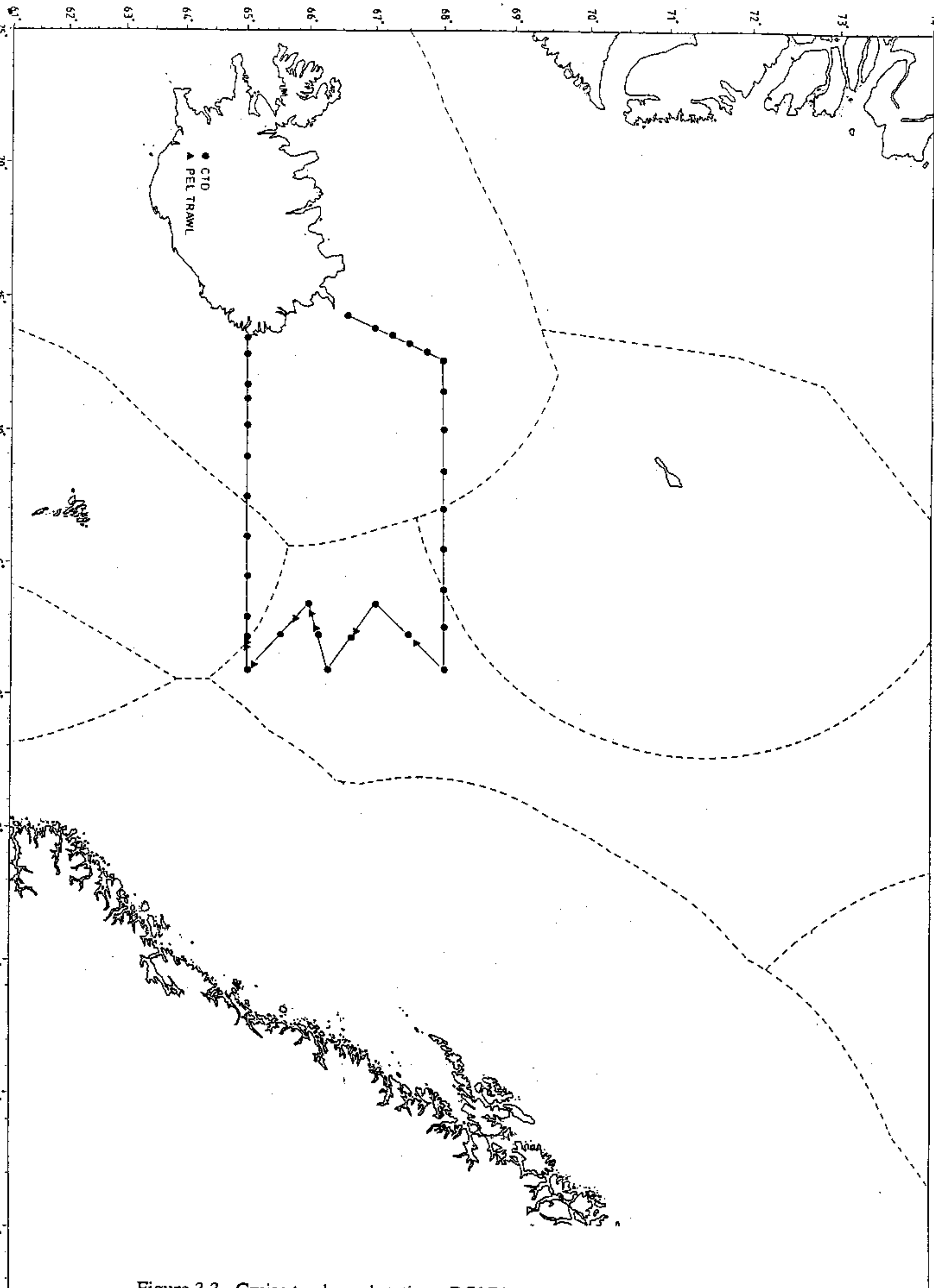

Figure 3.3. Cruise tracks and stations, R/V Bjarni Sæmundsson, 24/4-2/5 1995

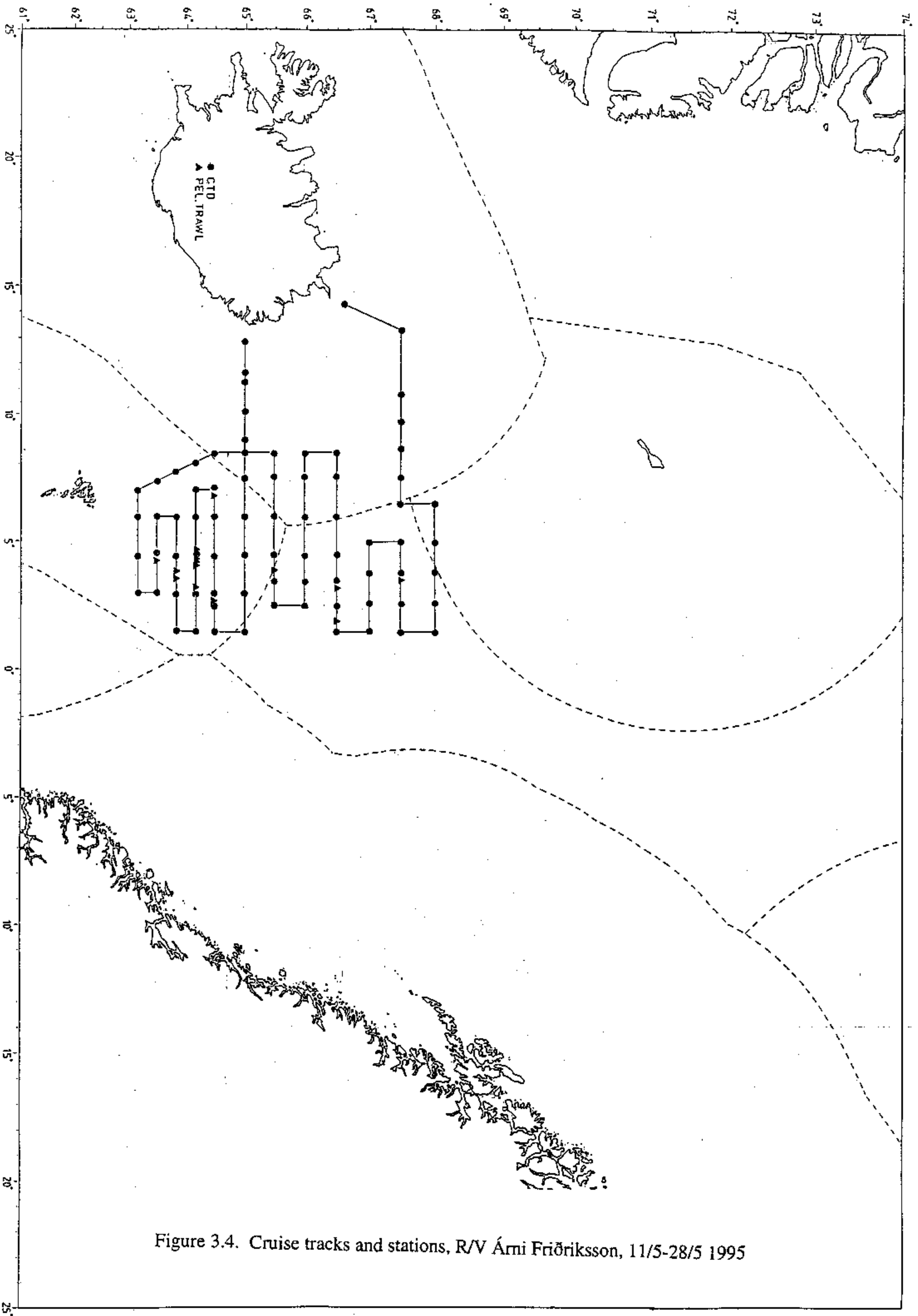

Figure 3.4. Cruise tracks and stations, R/V Árni Friðriksson, 11/5-28/5 1995

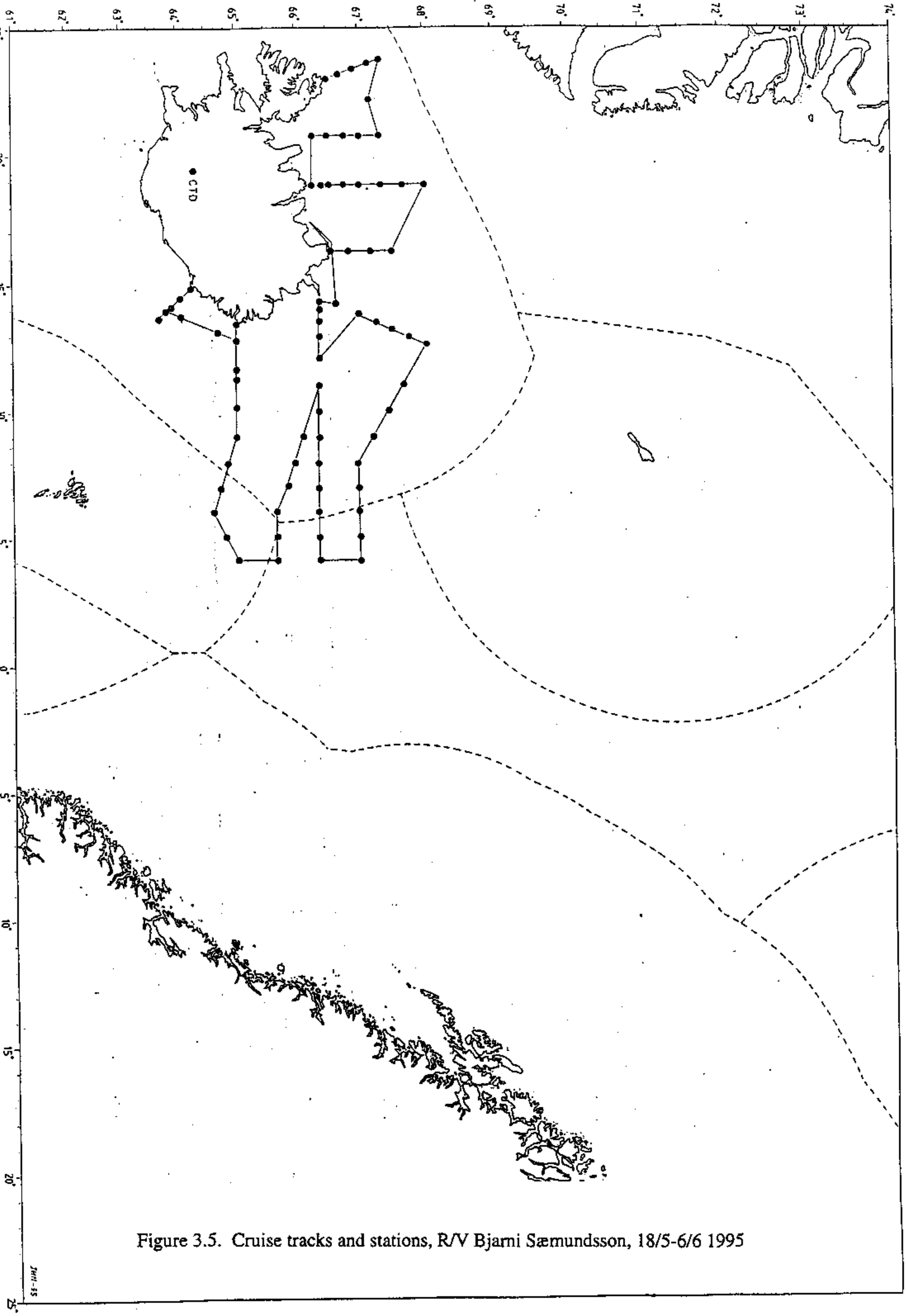

Figure 3.5. Cruise tracks and stations, R/V Bjarni Sæmundsson, 18/5-6/6 1995

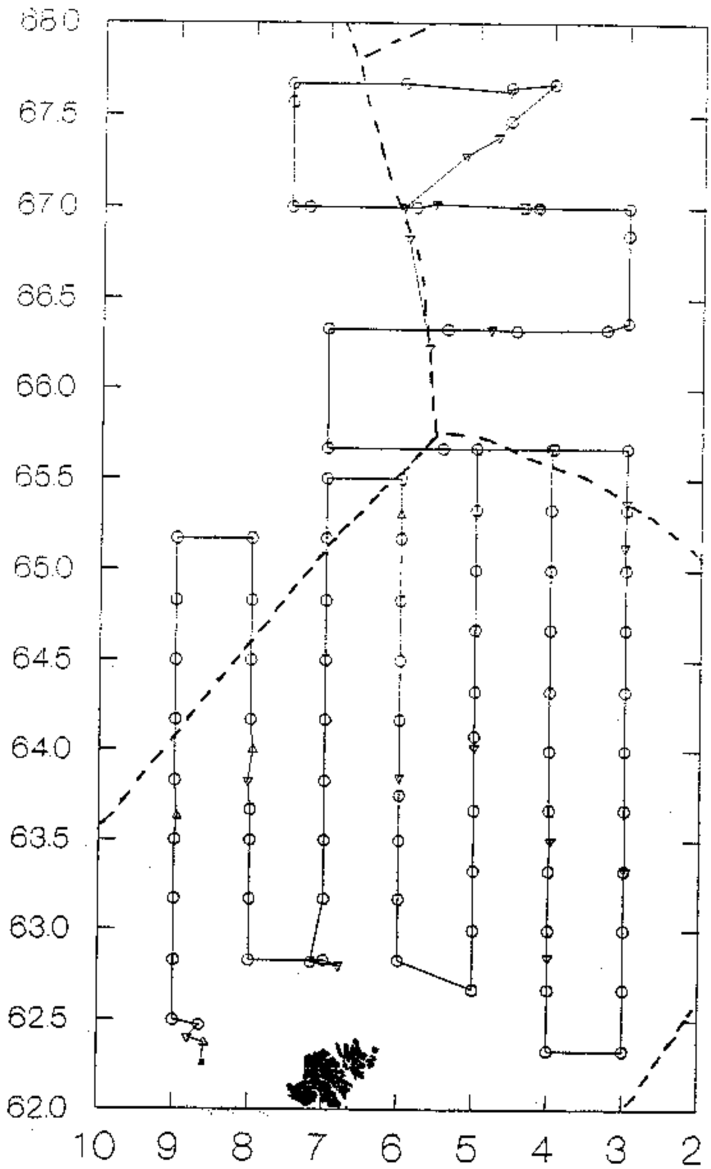

Figure 3.6. Cruise tracks and stations, R/V Magnus Heinason, 3/6-21/6 1995

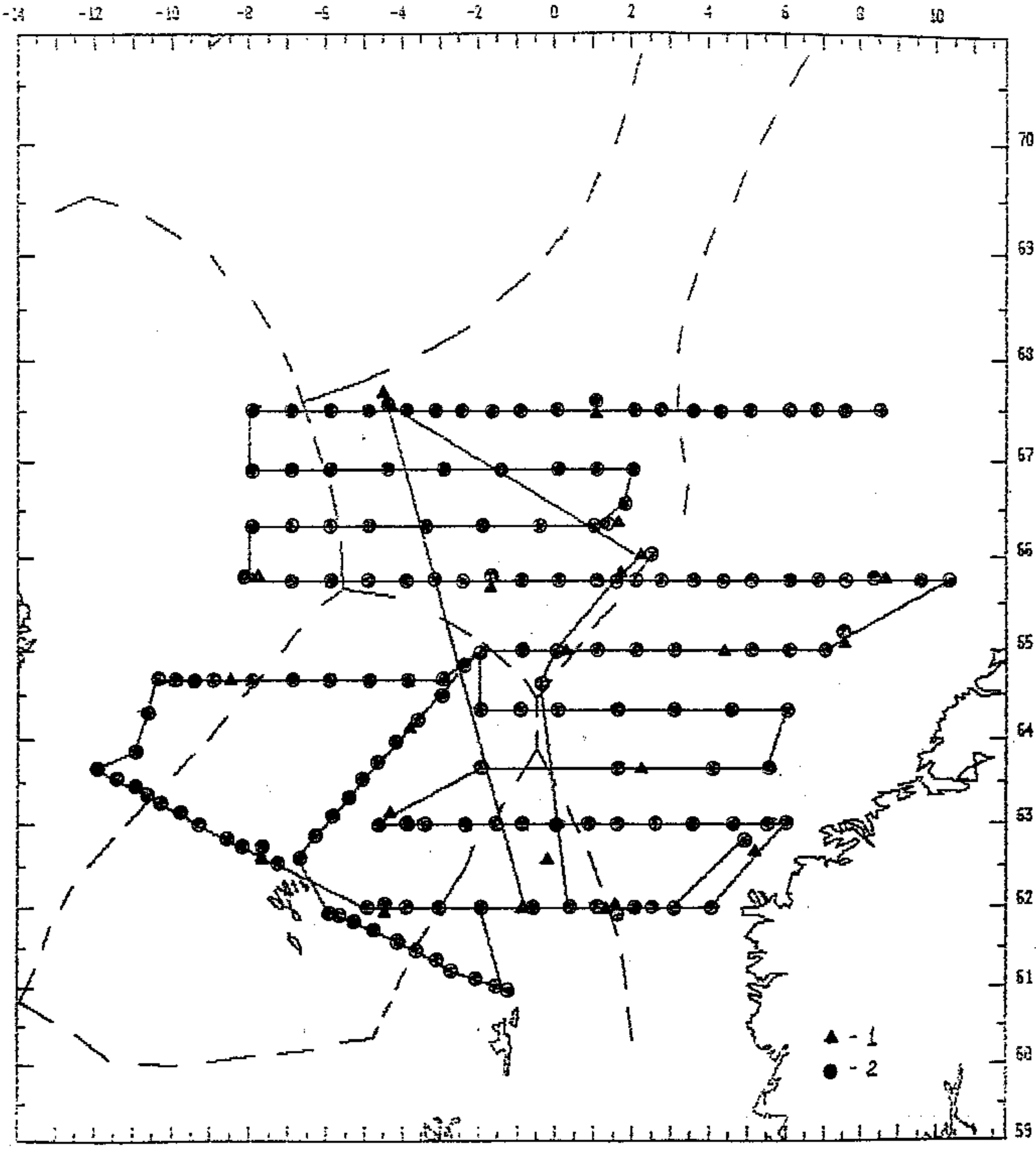

Figure 3.7. Cruise tracks and stations, R/V Professor Marti, 8/6-12/7 1995

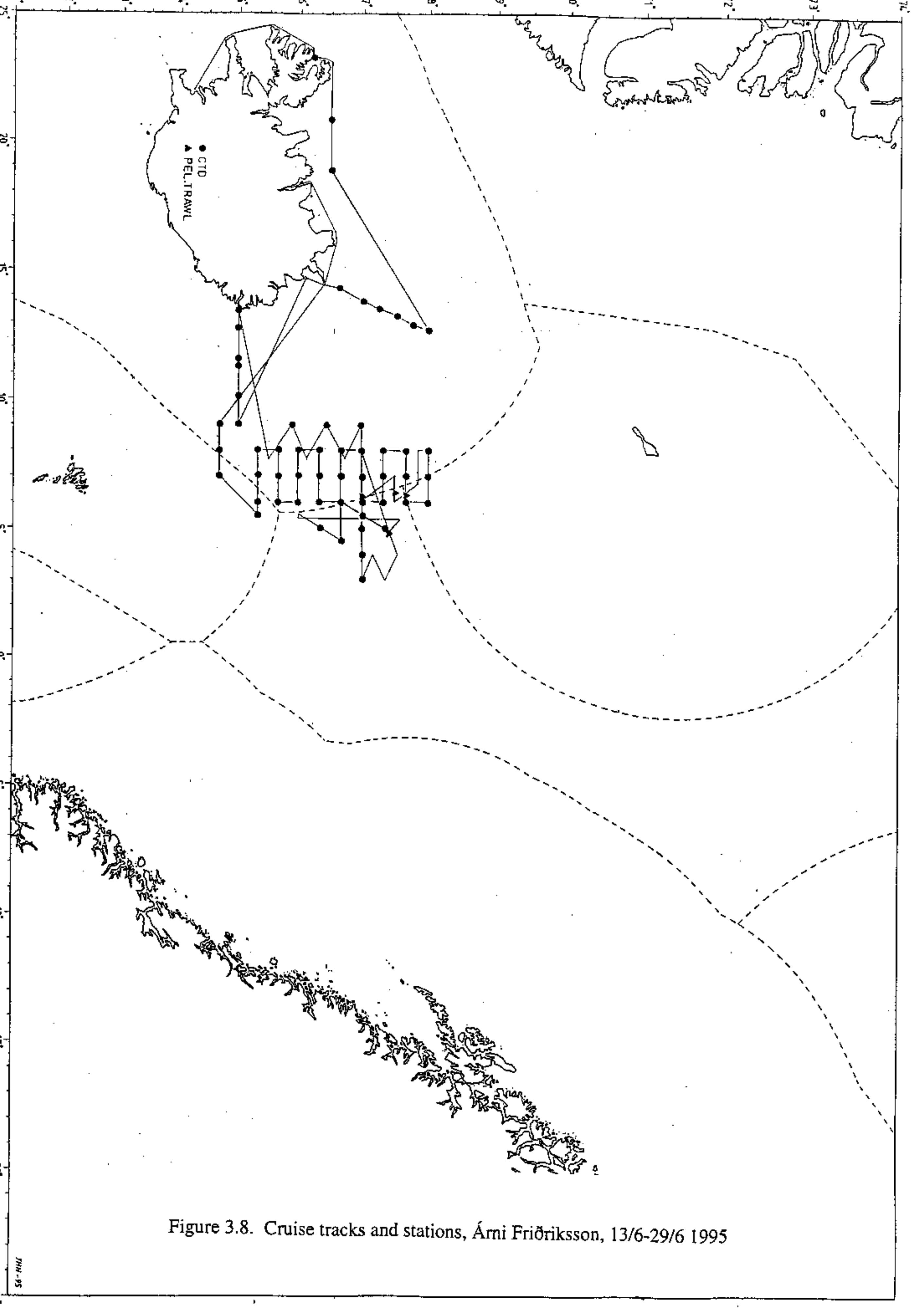

Figure 3.8. Cruise tracks and stations, Árni Friðriksson, 13/6-29/6 1995

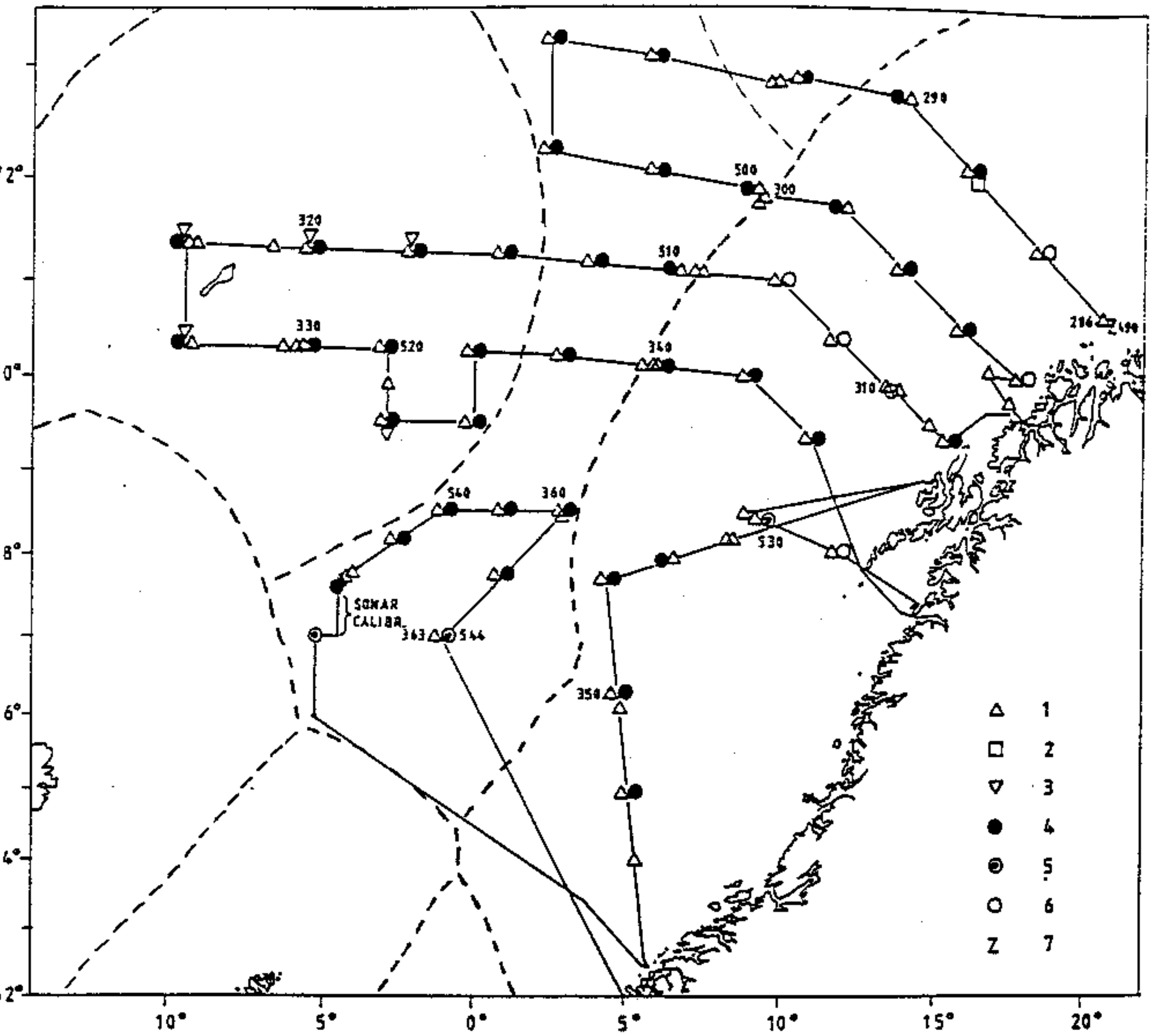

Figure 3.9. Cruise tracks and stations, G.O. Sars, 26/5-22/6 1995

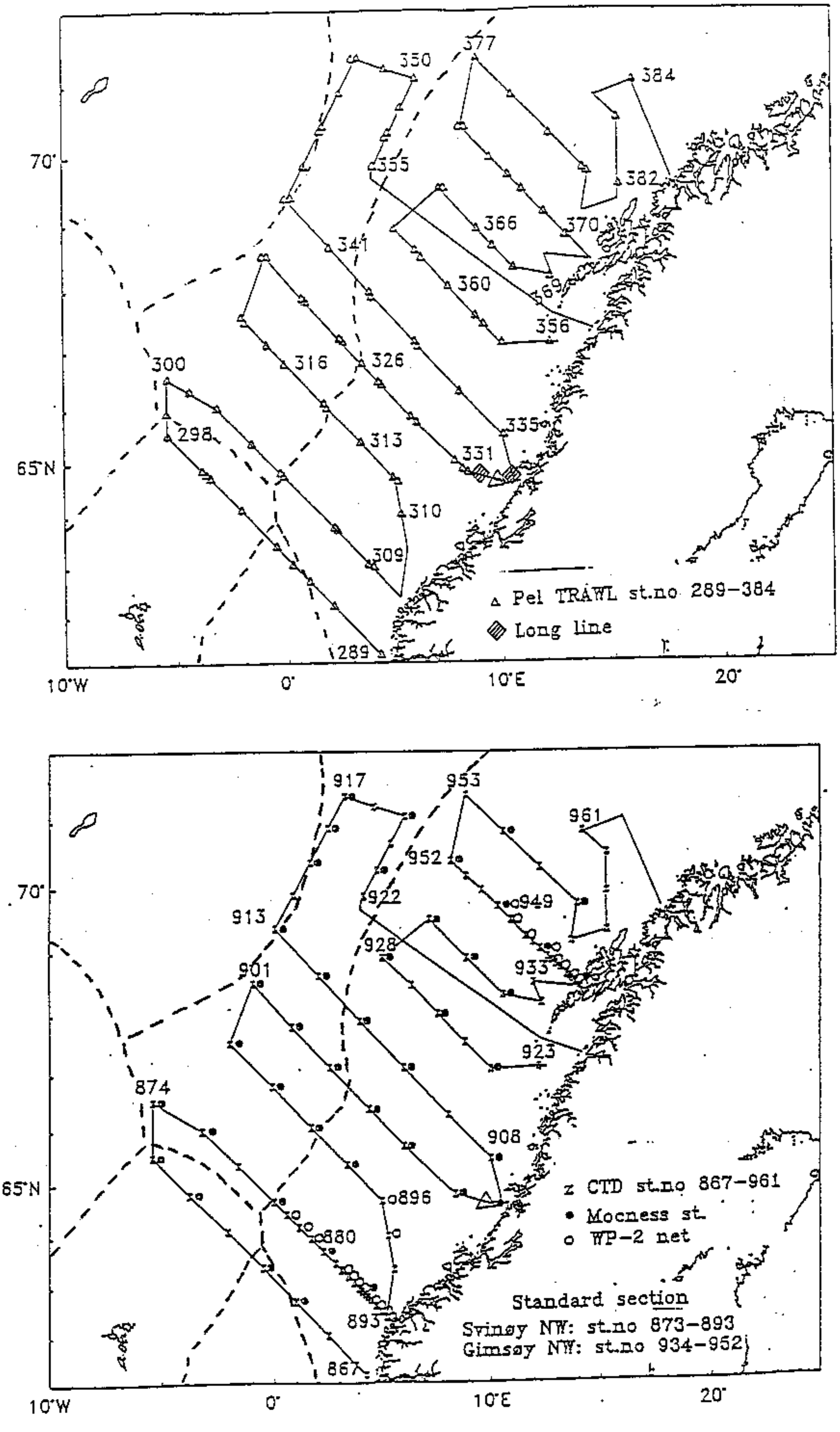

Figure 3.10. Cruise tracks and stations, R/V Johan Hjort, 7/7-2/8 1995

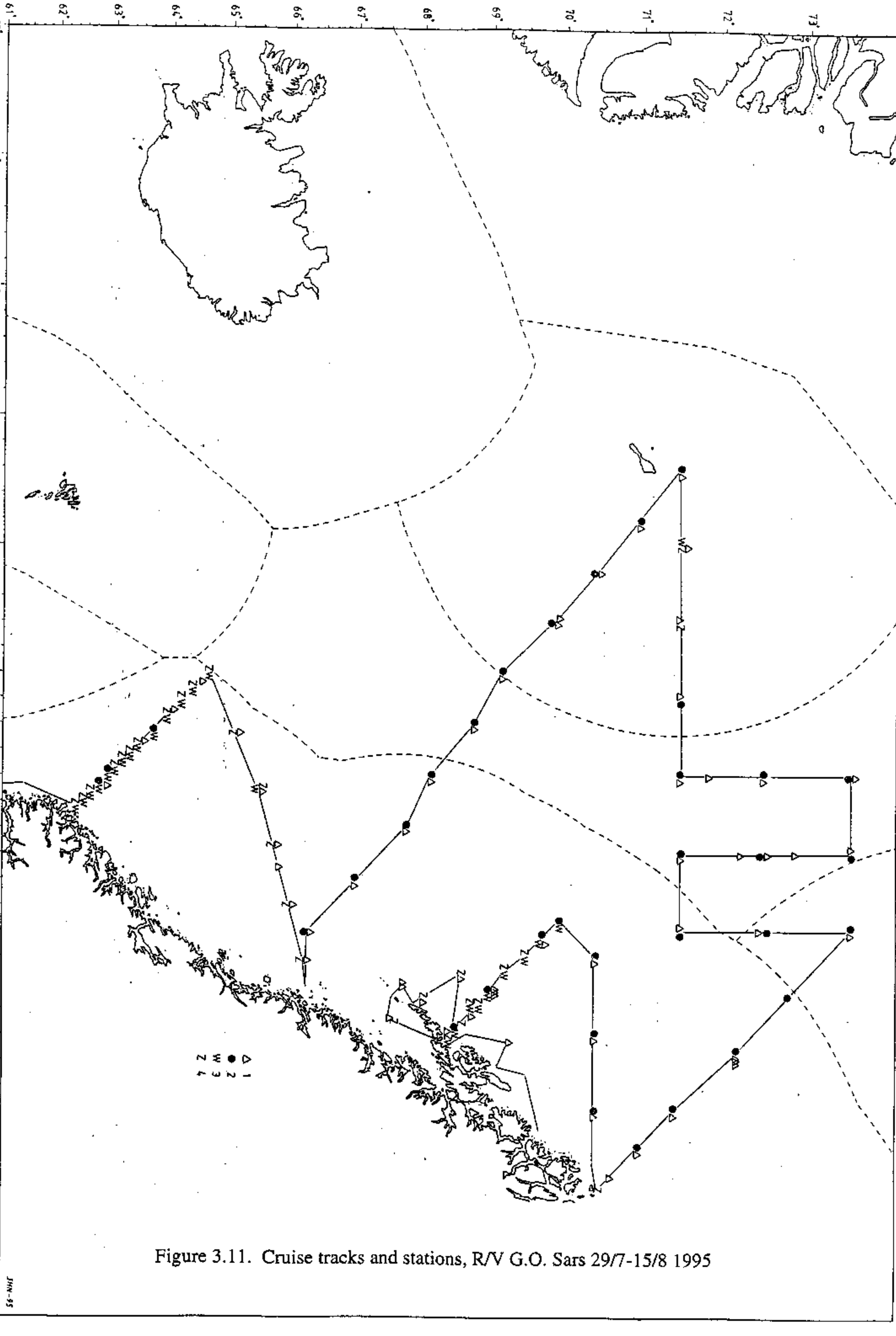

Figure 3.11. Cruise tracks and stations, R/V G.O. Sars 29/7-15/8 1995

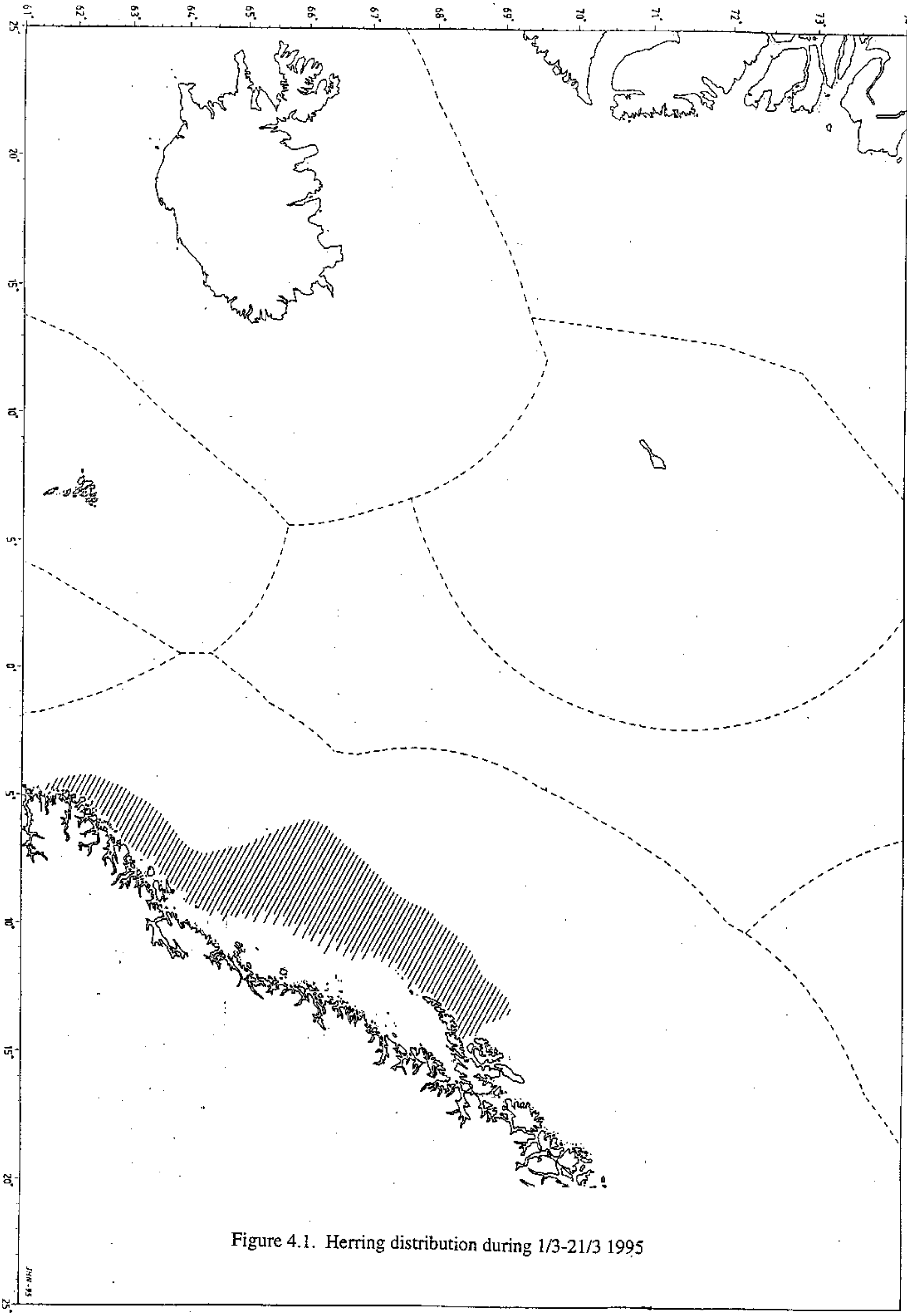

Figure 4.1. Herring distribution during 1/3-21/3 1995

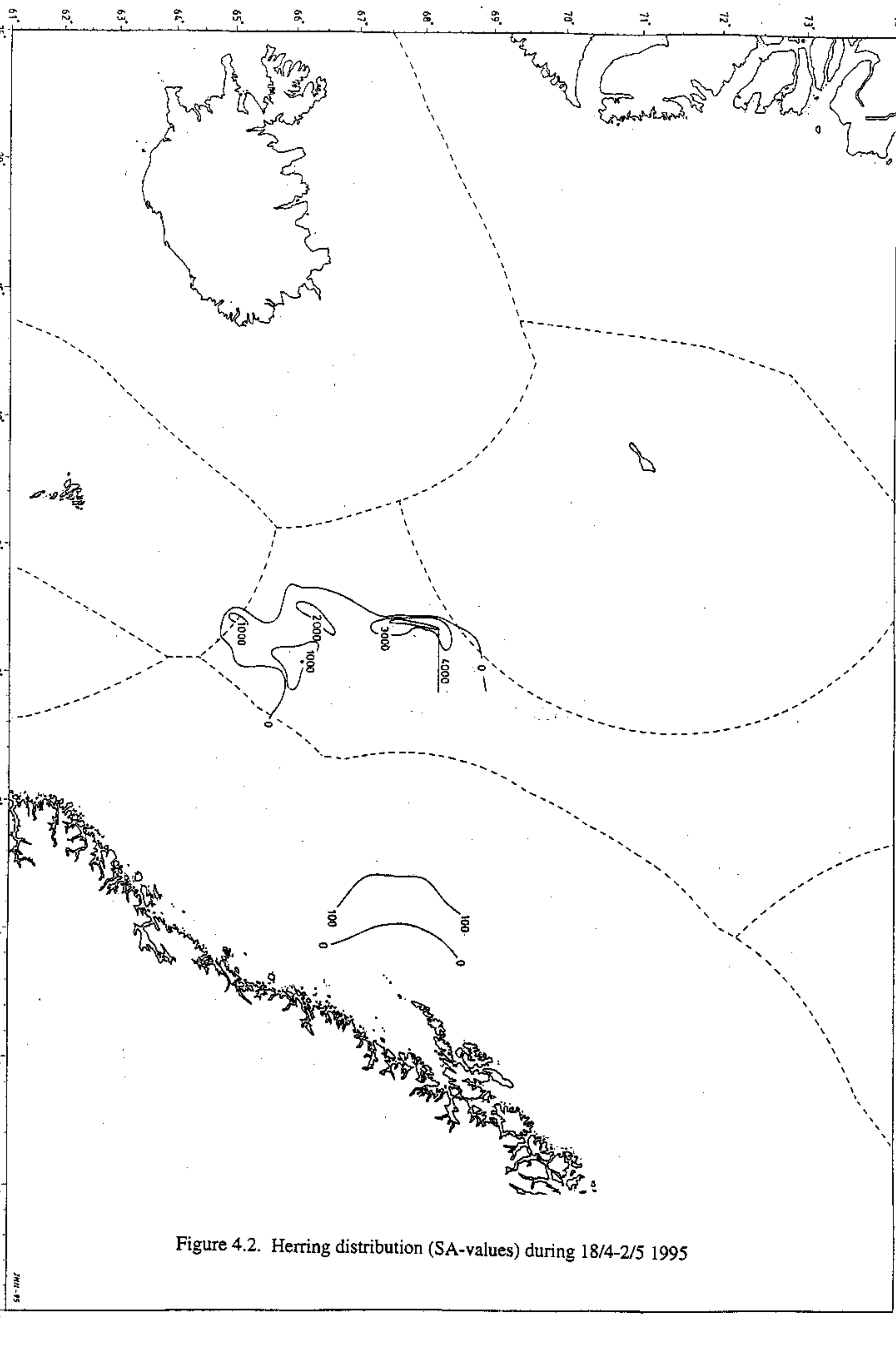

Figure 4.2. Herring distribution (SA-values) during 18/4-2/5 1995

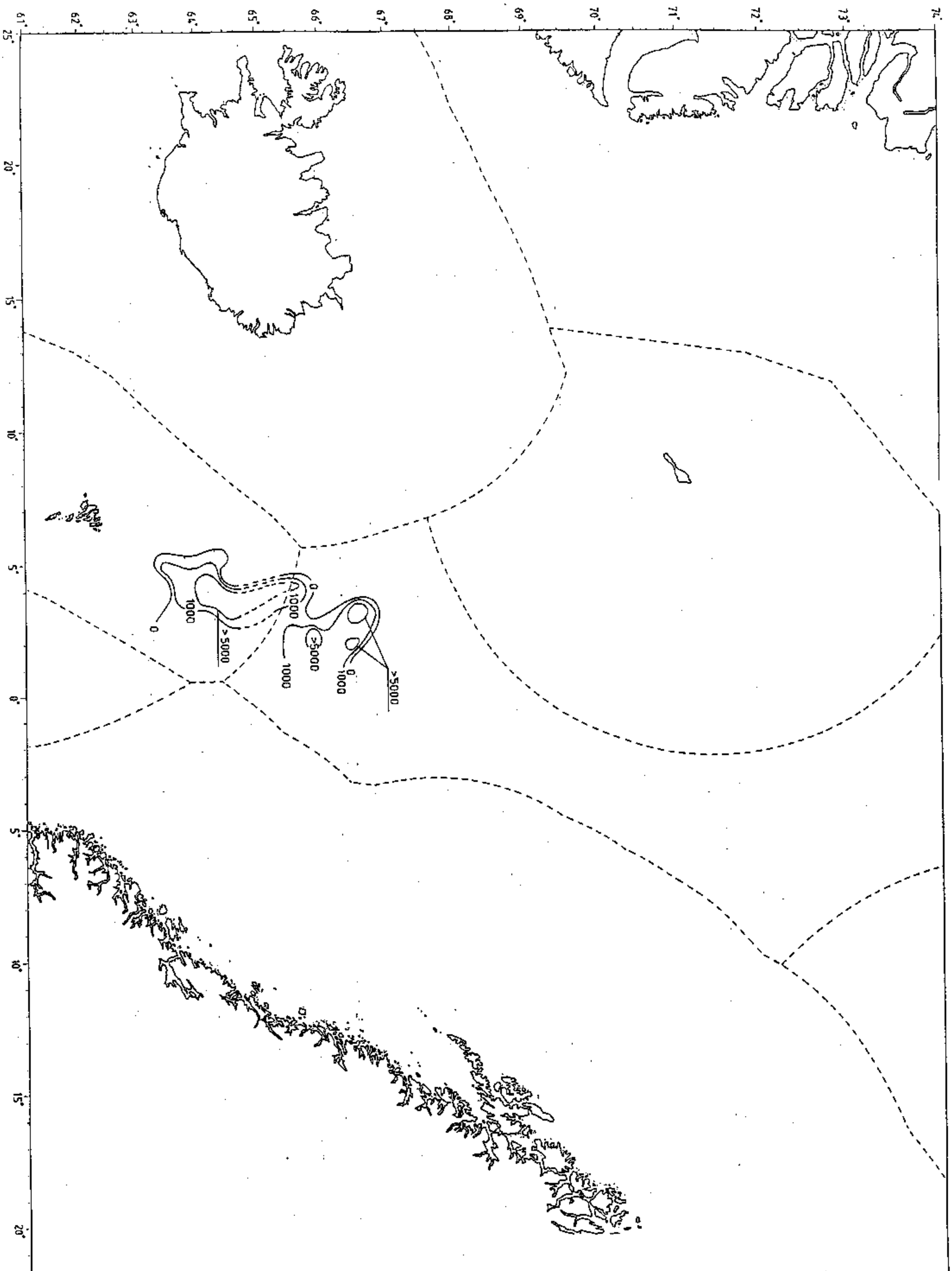

Figure 4.3. Herring distribution (SA-values) during 11/5-28/5 1995

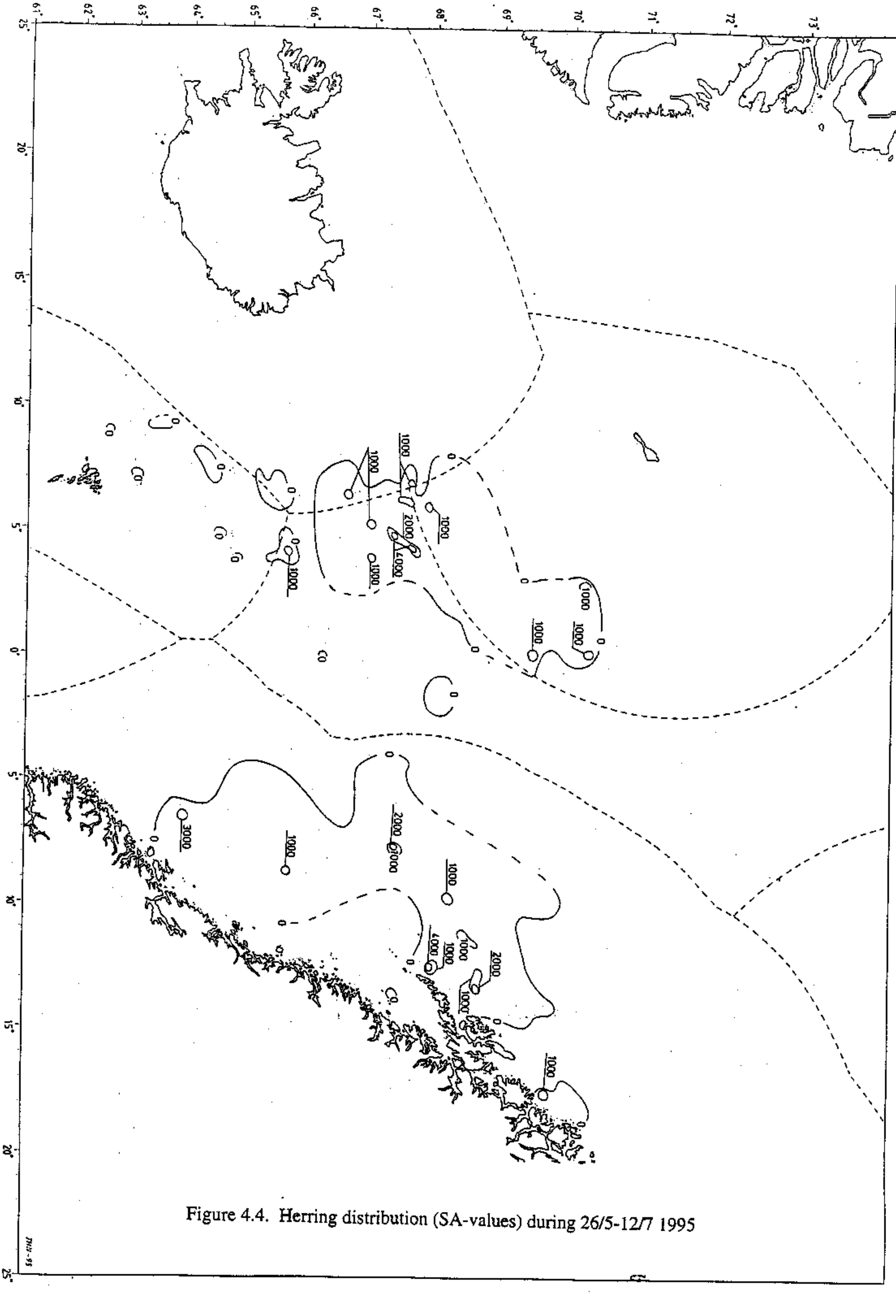

Figure 4.4. Herring distribution (SA-values) during 26/5-12/7 1995

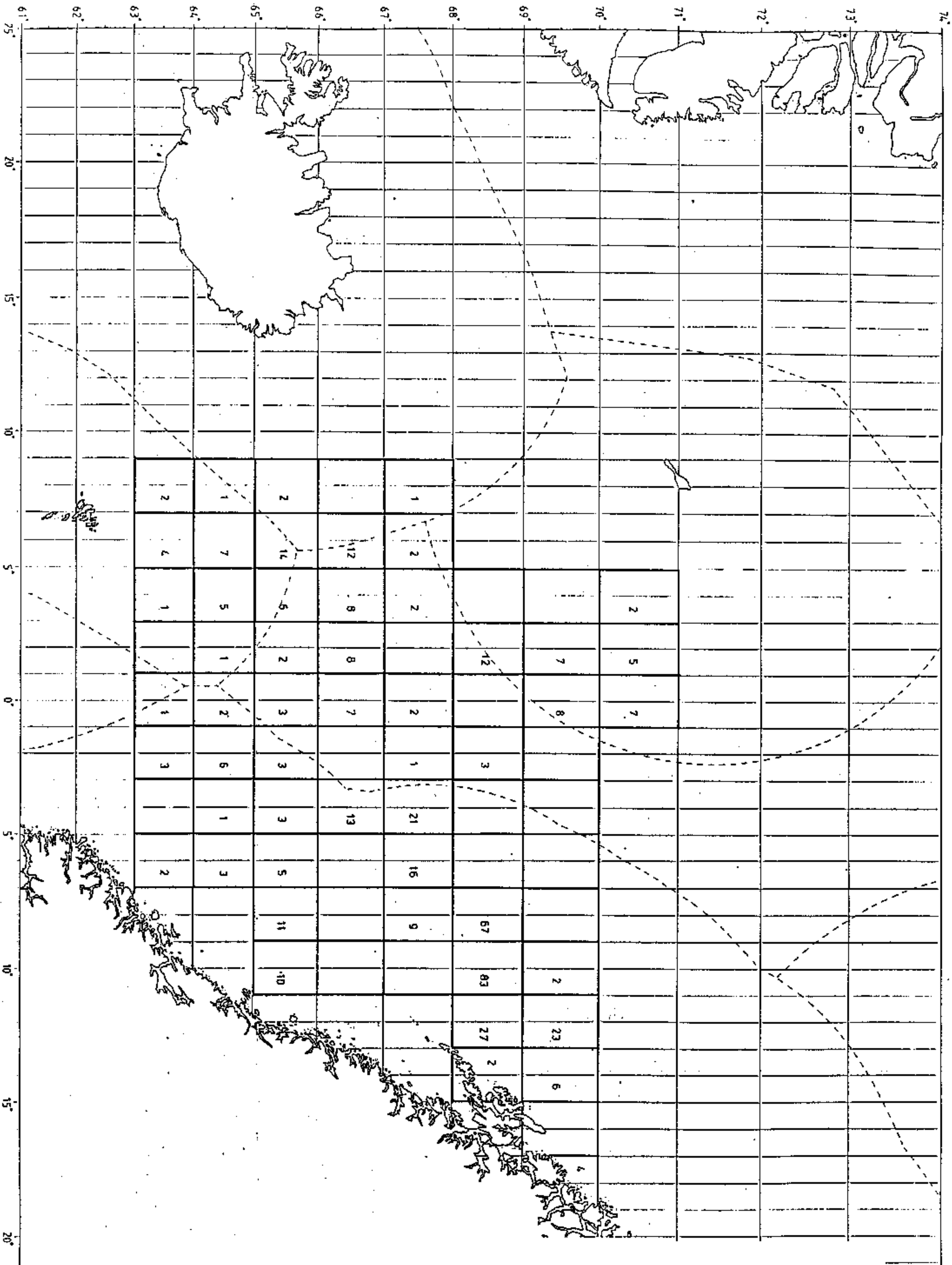

Figure 4.5. Herring distribution (number schools/5 naut. miles) during 18/4-2/5 1995

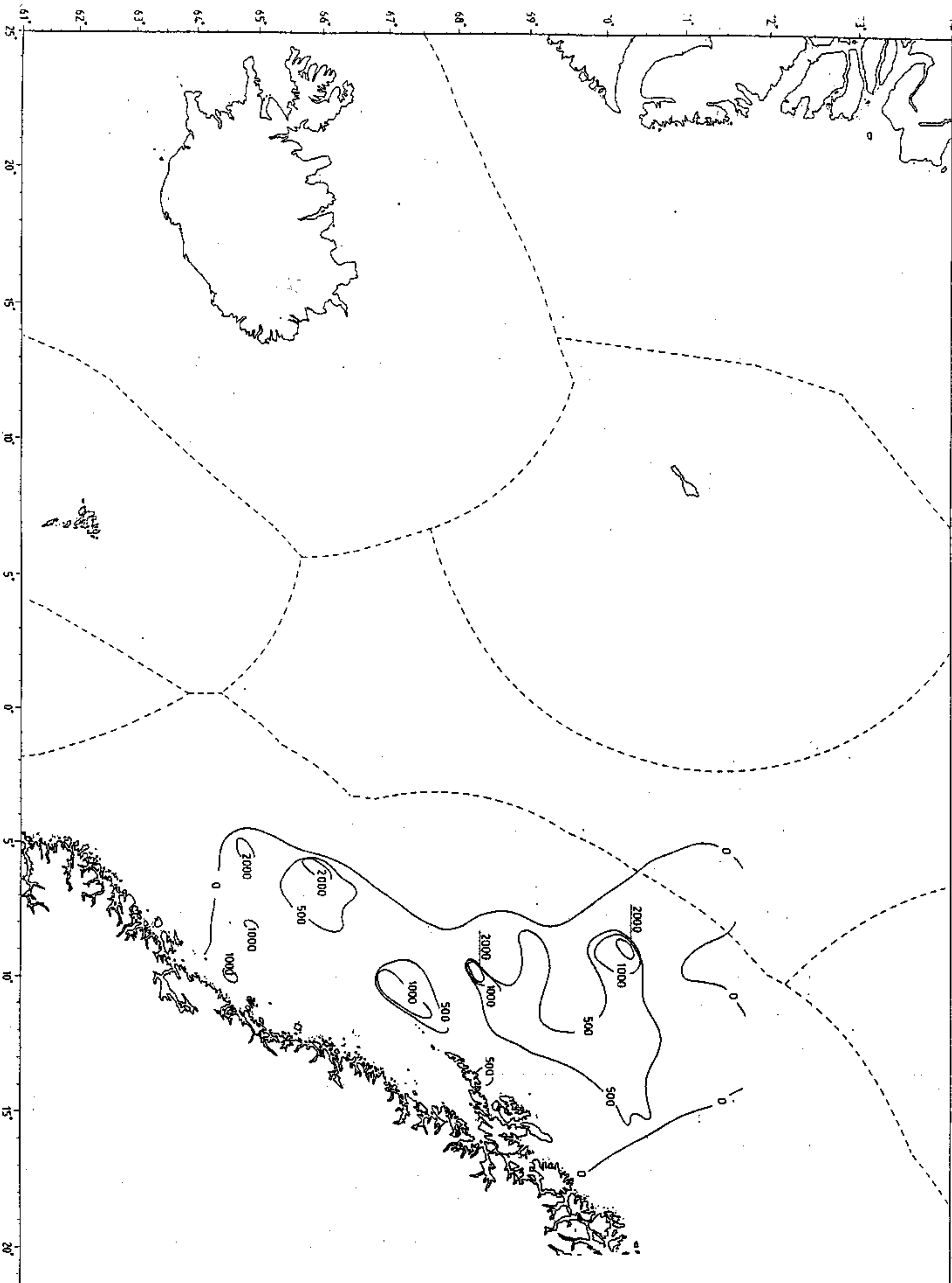

Figure 4.6. Herring distribution (SA-values) during 7/7-2/8 1995

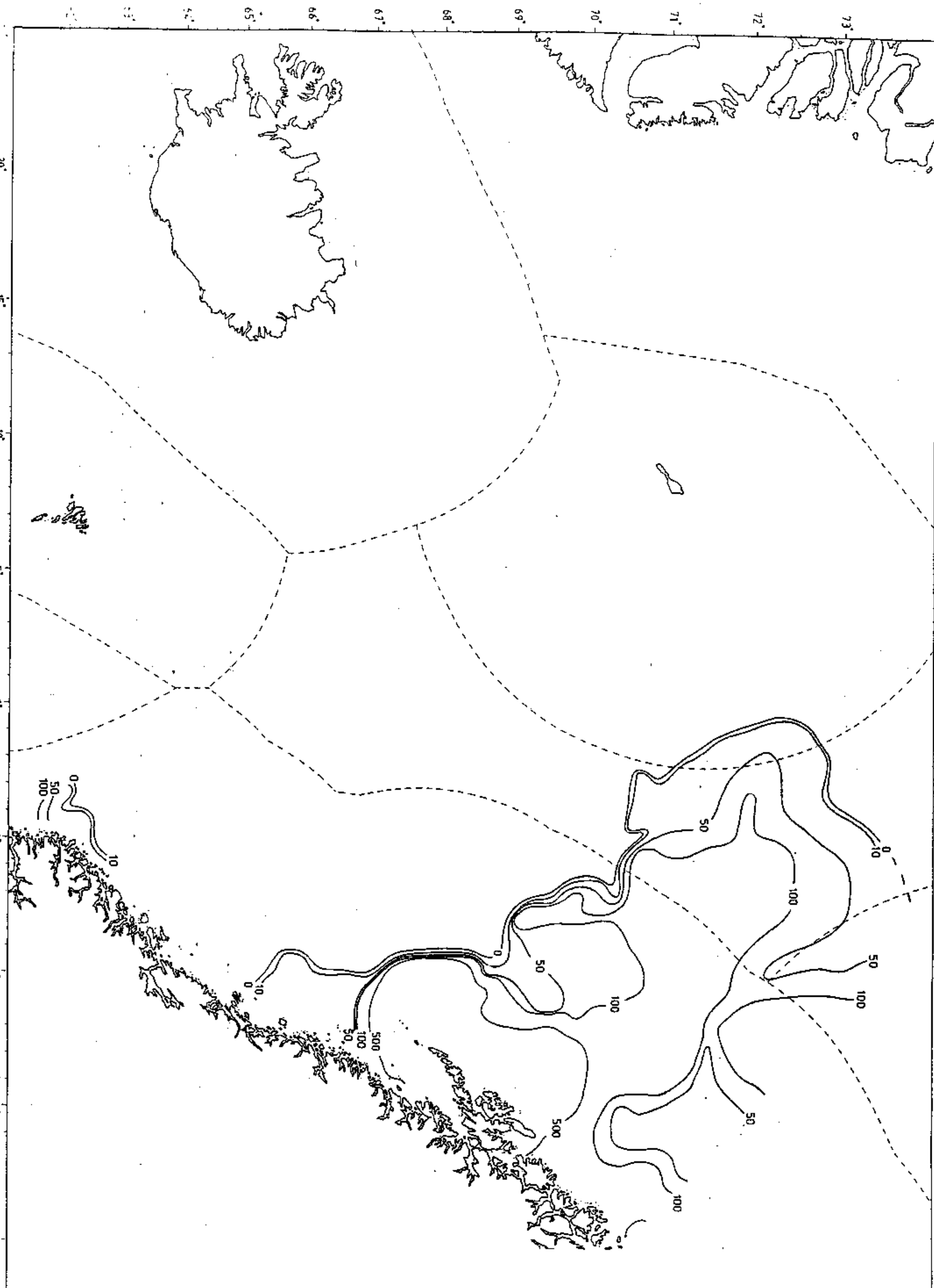

Figure 4.7. Herring distribution (SA-values) during 29/7-15/8 1995

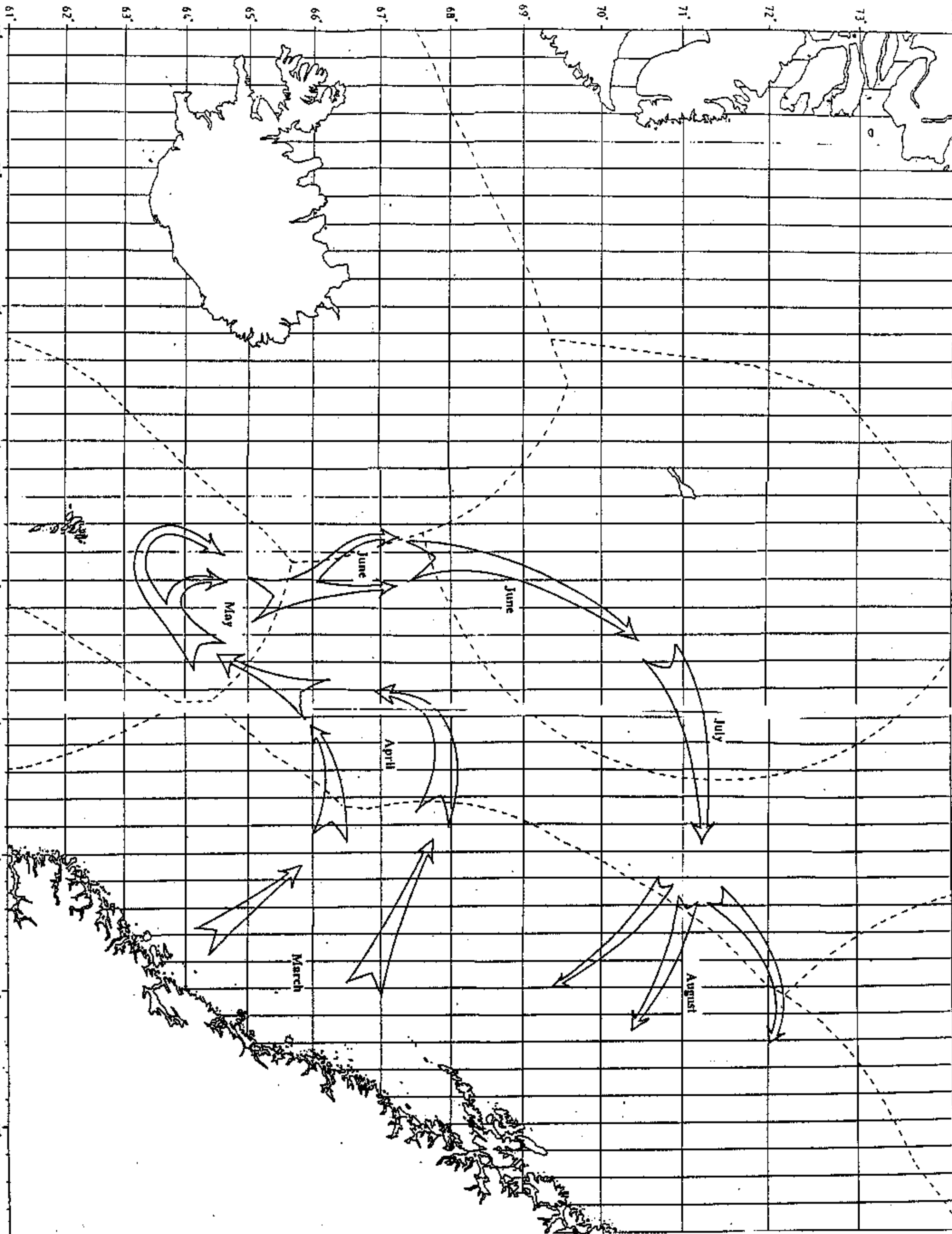

Figure 4.8. A schematic presentation of the general migration pattern of adult Norwegian spring spawning herring from spring until in the autumn of 1995

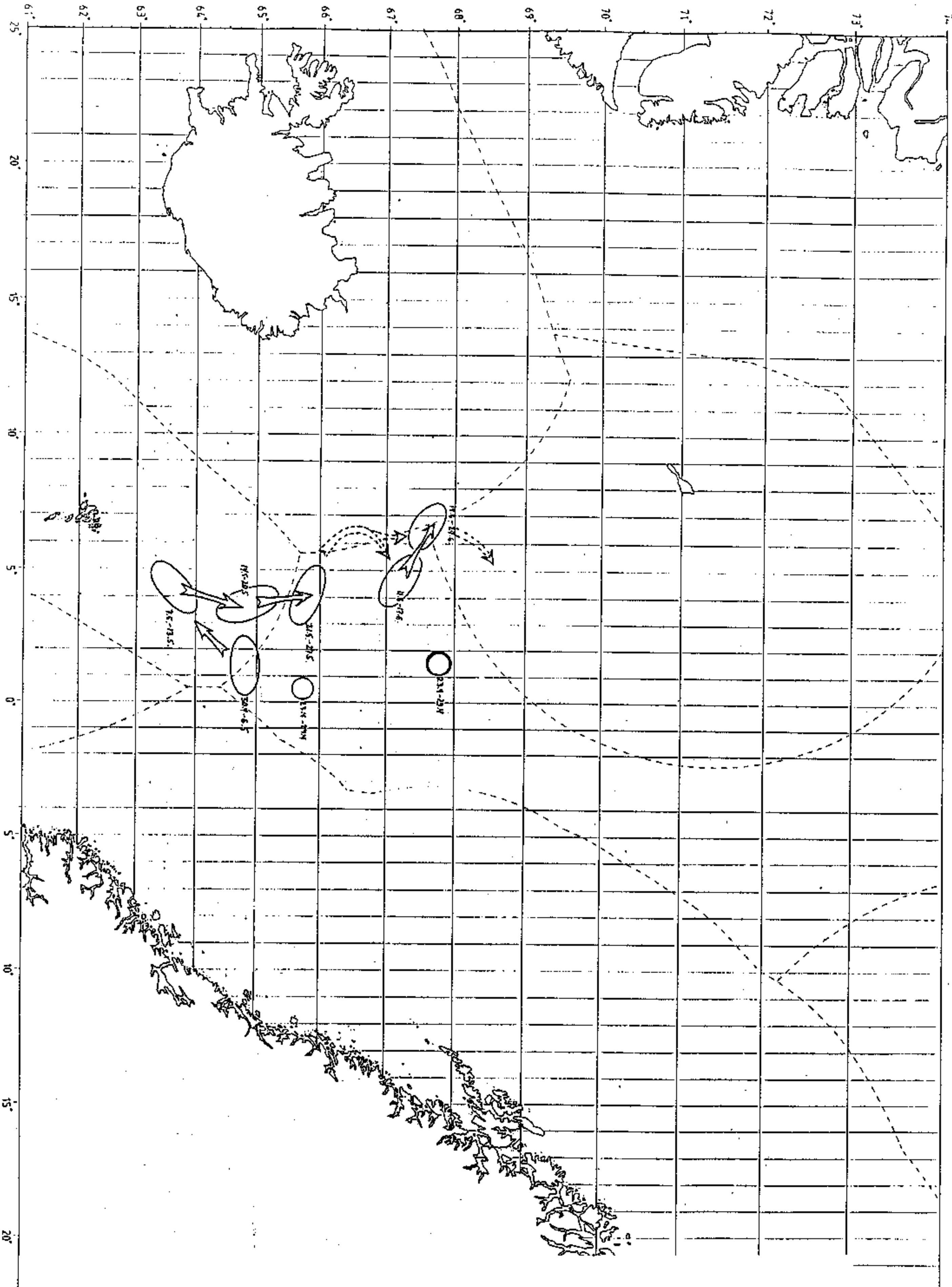

Figure 6.1. The movement of the Icelandic fishing fleet during April-June 1995

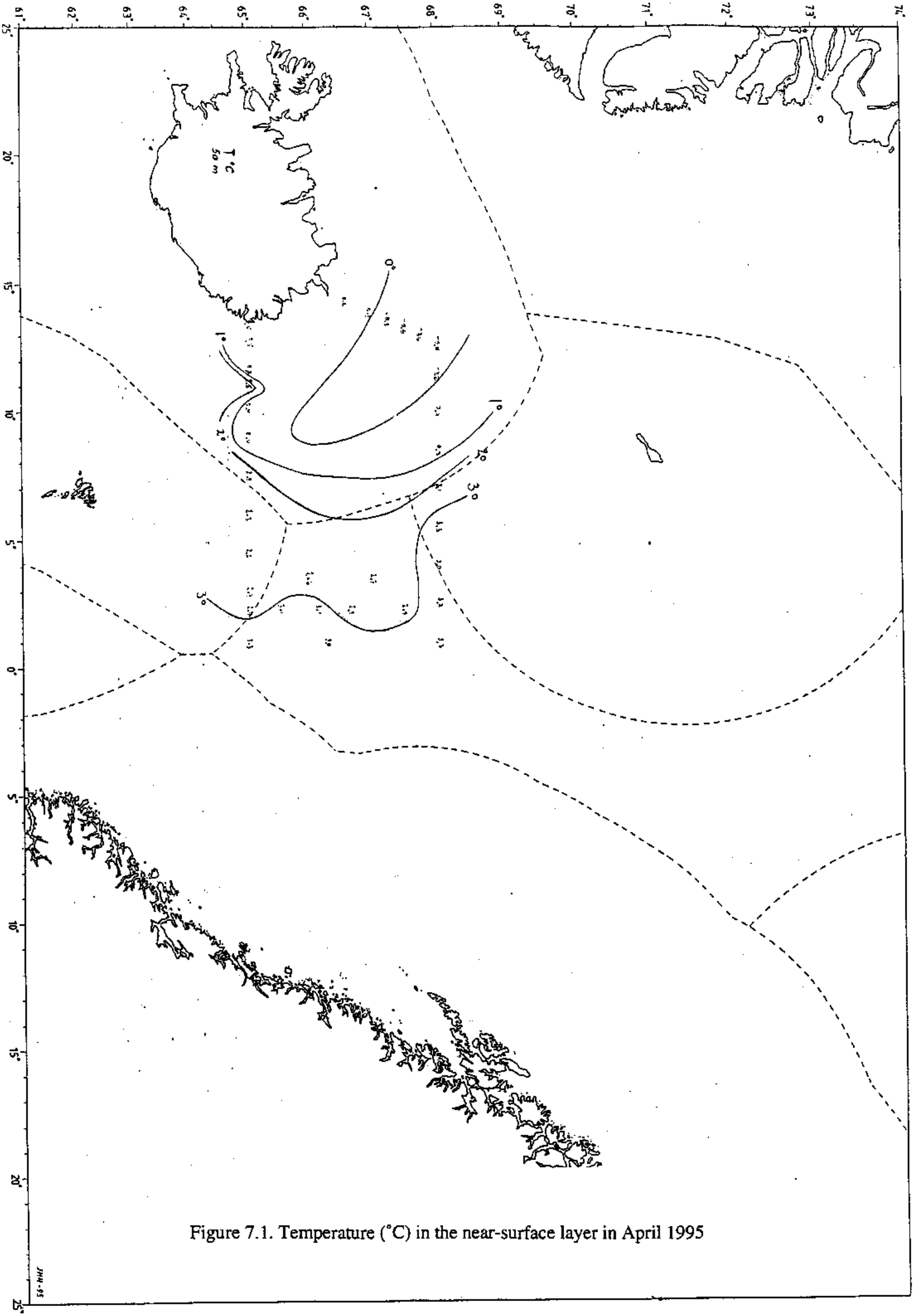

Figure 7.1. Temperature (°C) in the near-surface layer in April 1995

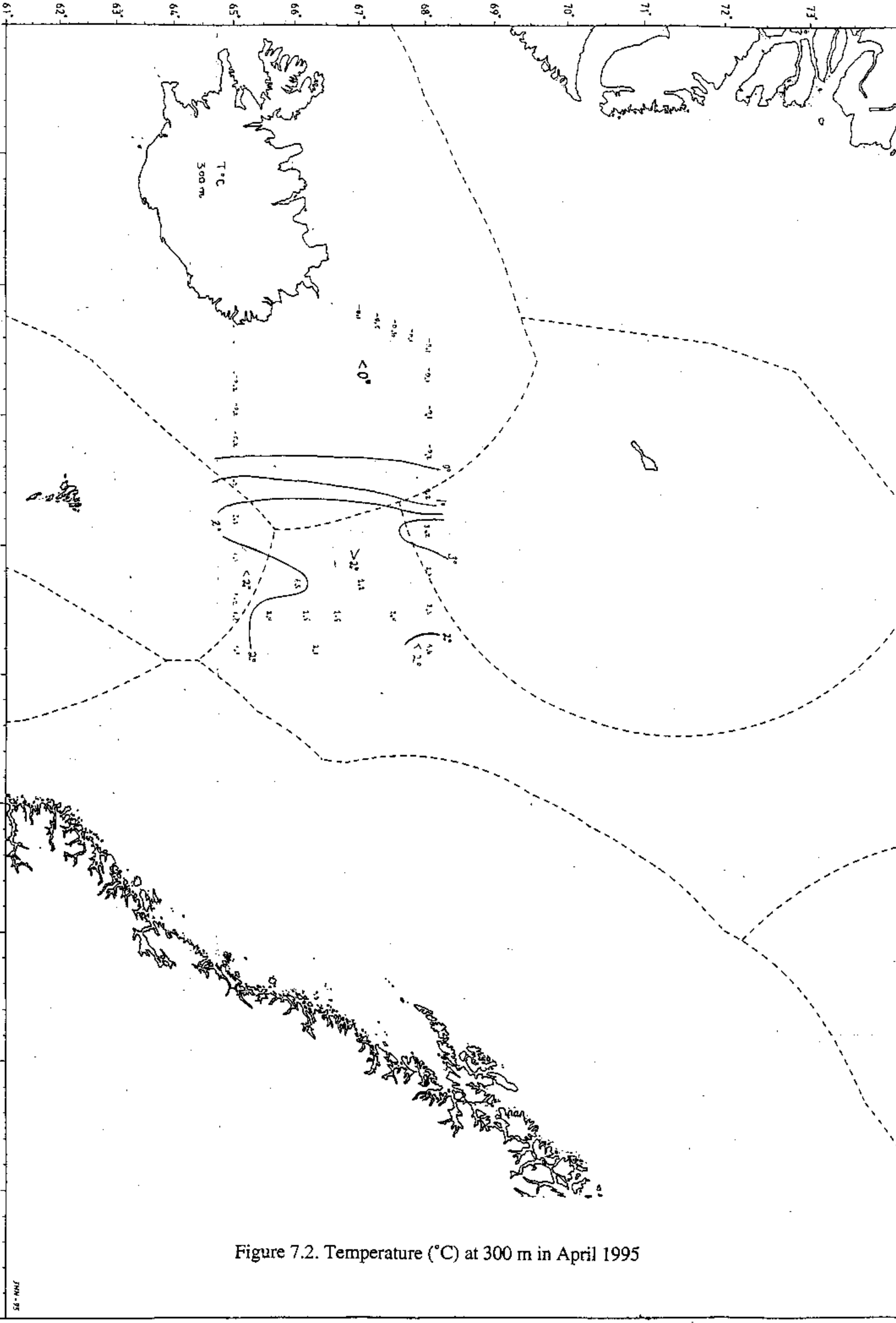

Figure 7.2. Temperature (°C) at 300 m in April 1995

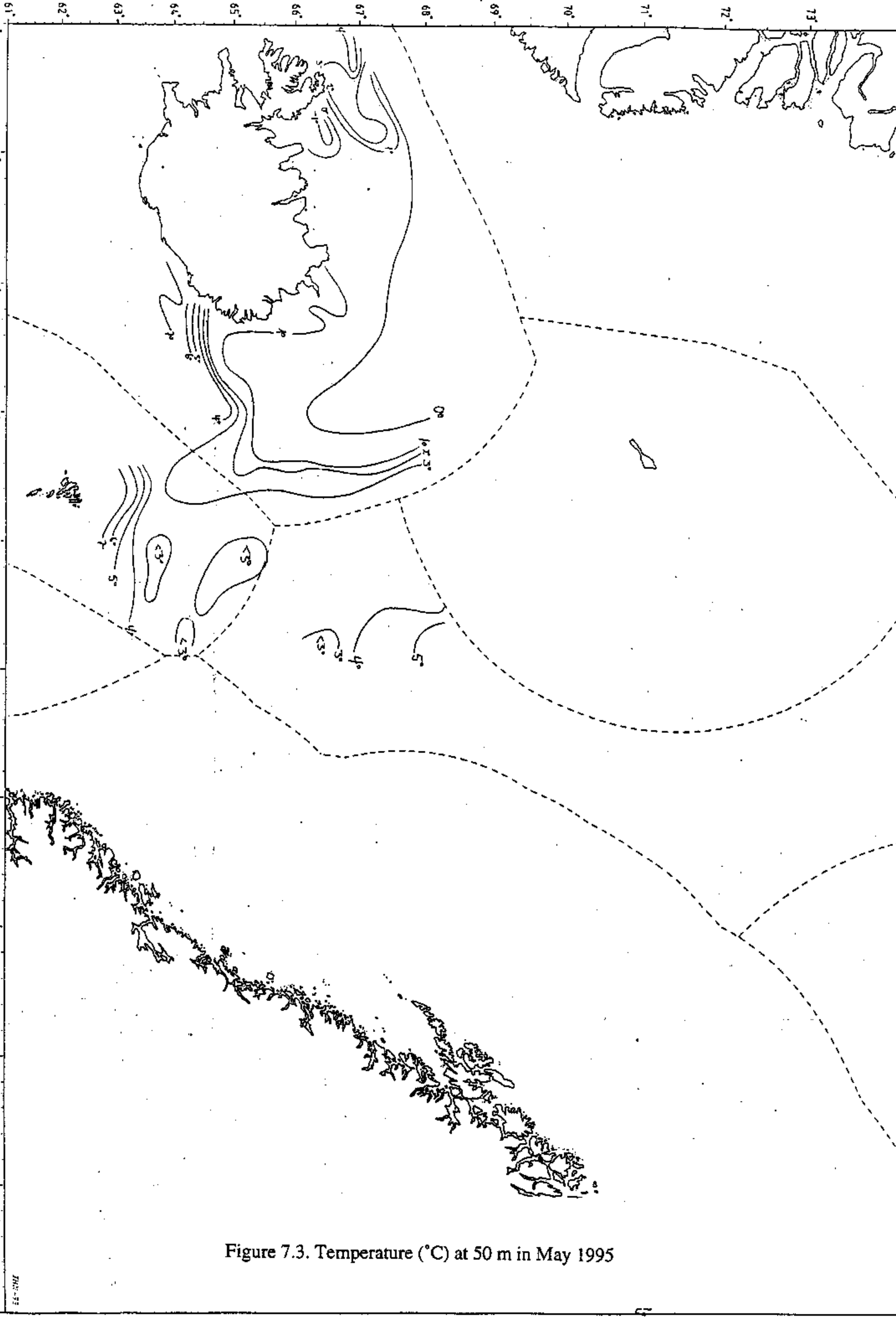

Figure 7.3. Temperature (˚C) at 50 m in May 1995

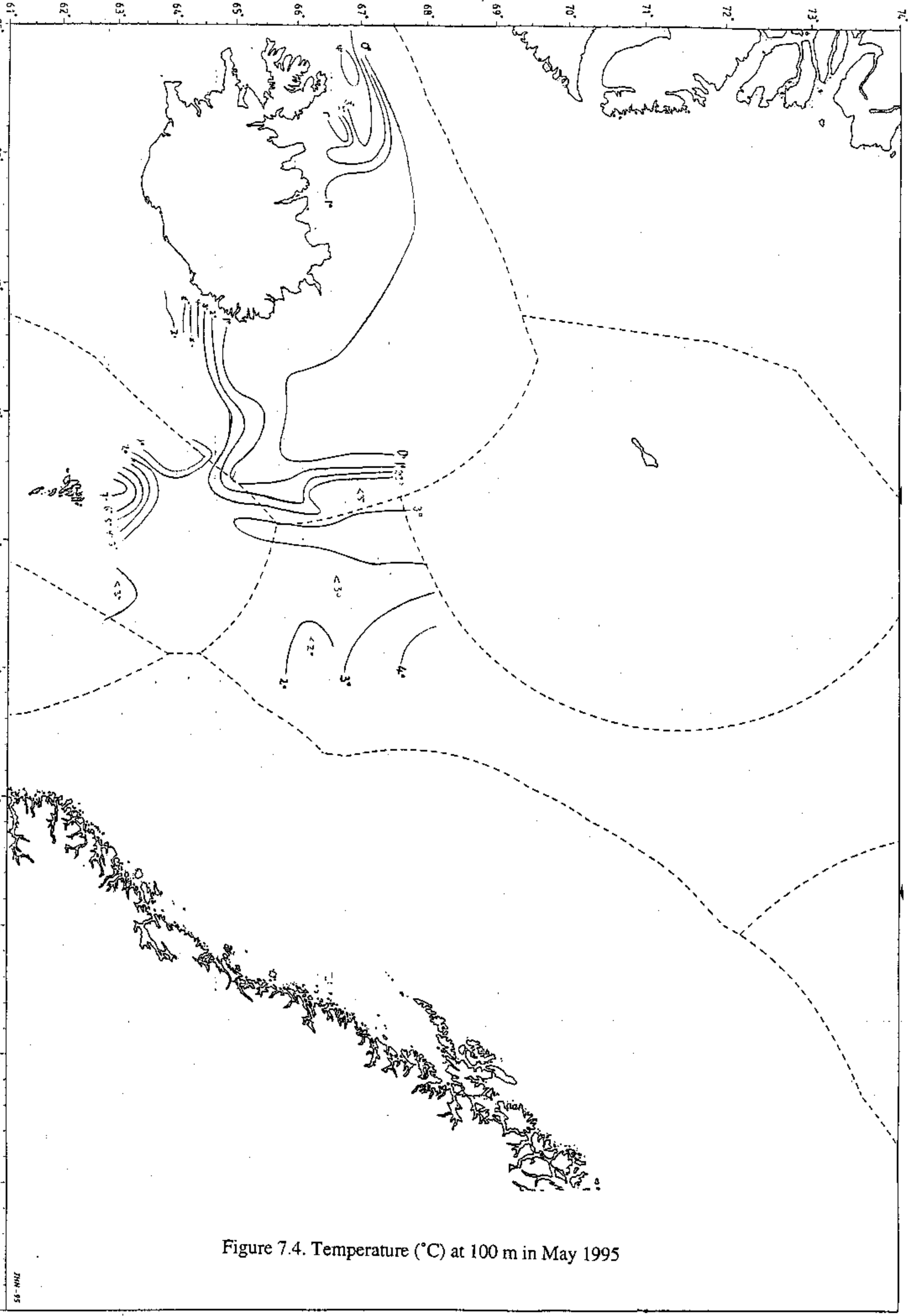

Figure 7.4. Temperature (°C) at 100 m in May 1995

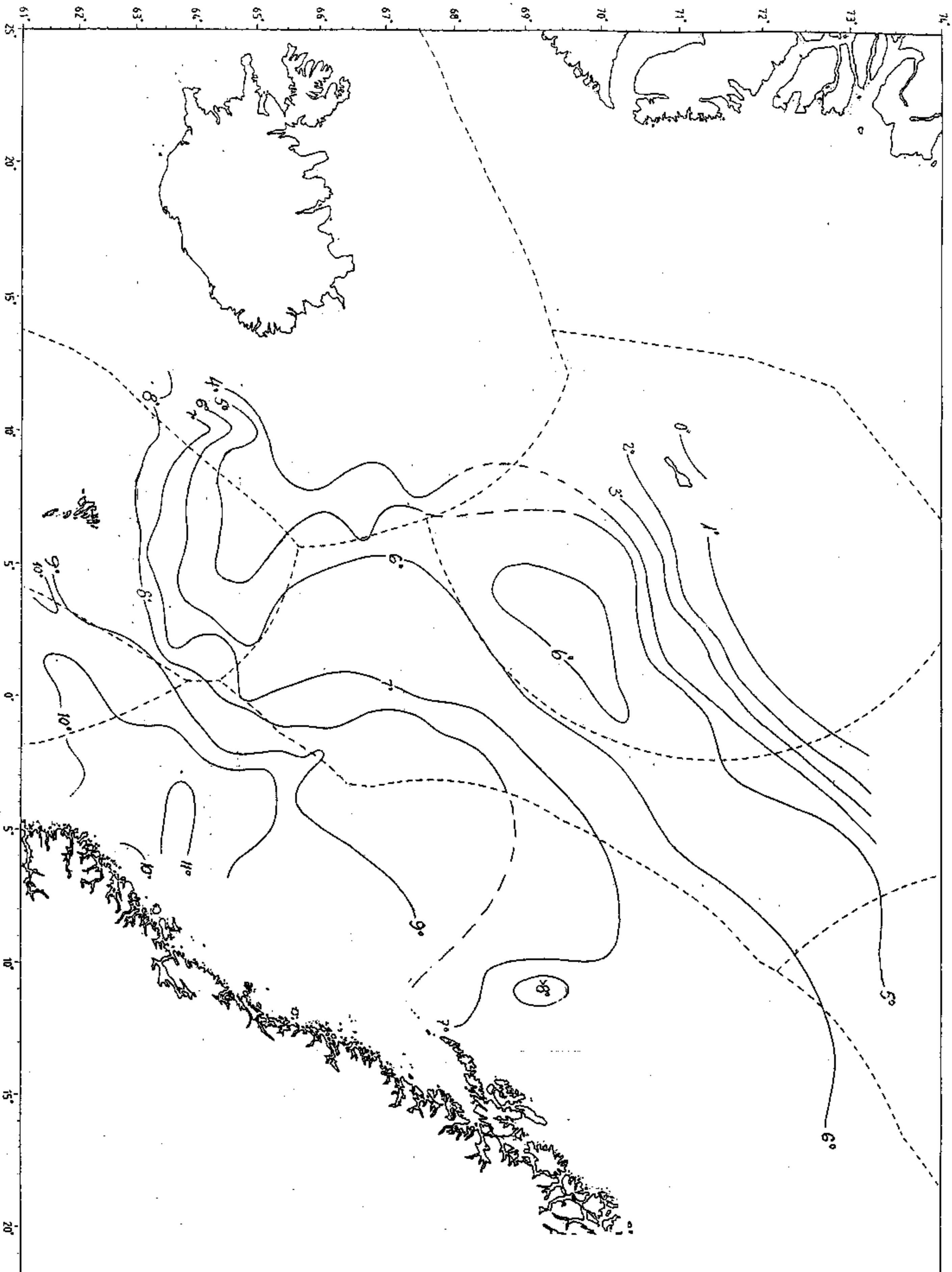

Figure 7.5. Temperature (°C) in the near surface layer in June 1995

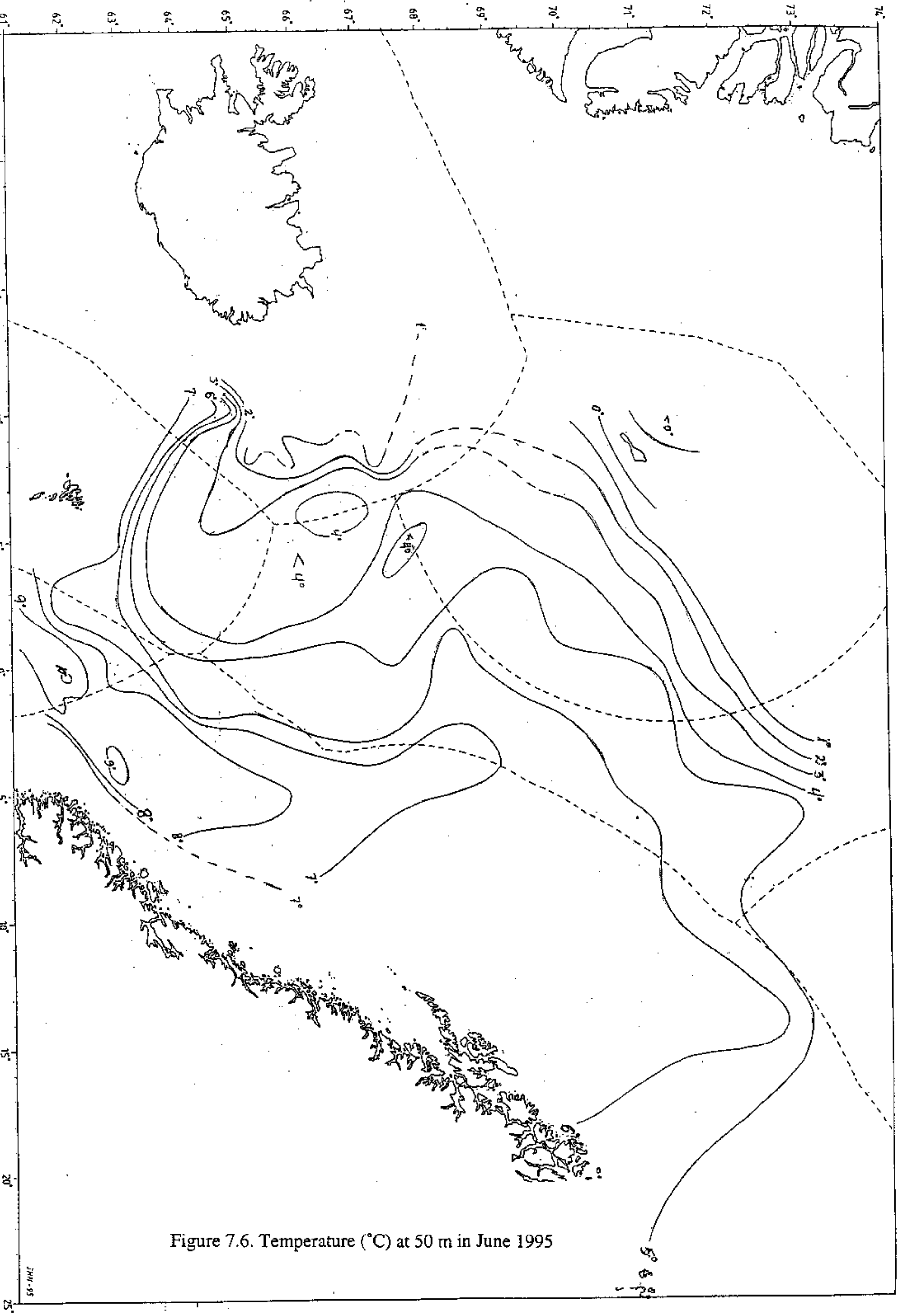

Figure 7.6. Temperature (°C) at 50 m in June 1995

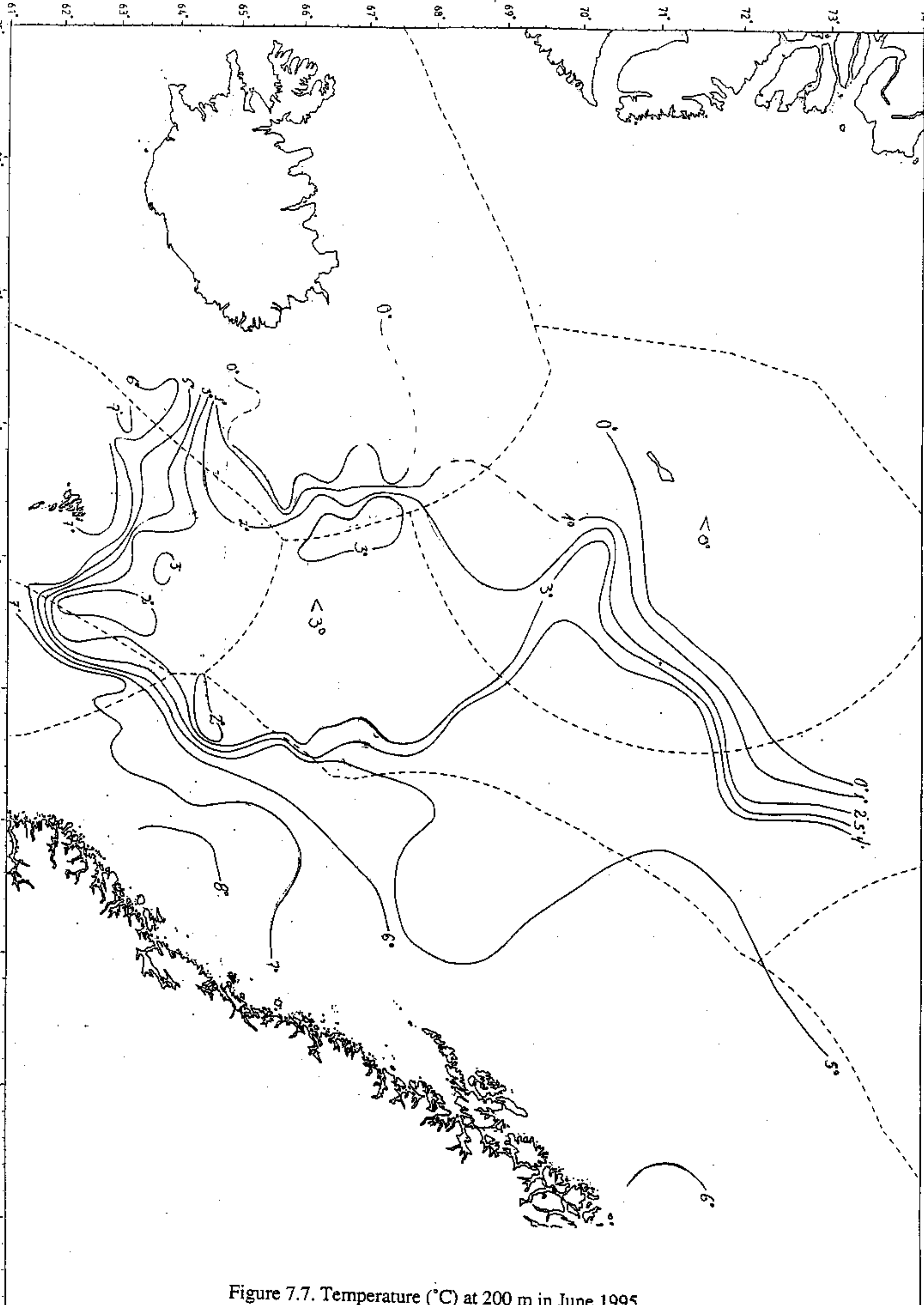

Figure 7.7. Temperature (°C) at 200 m in June 1995

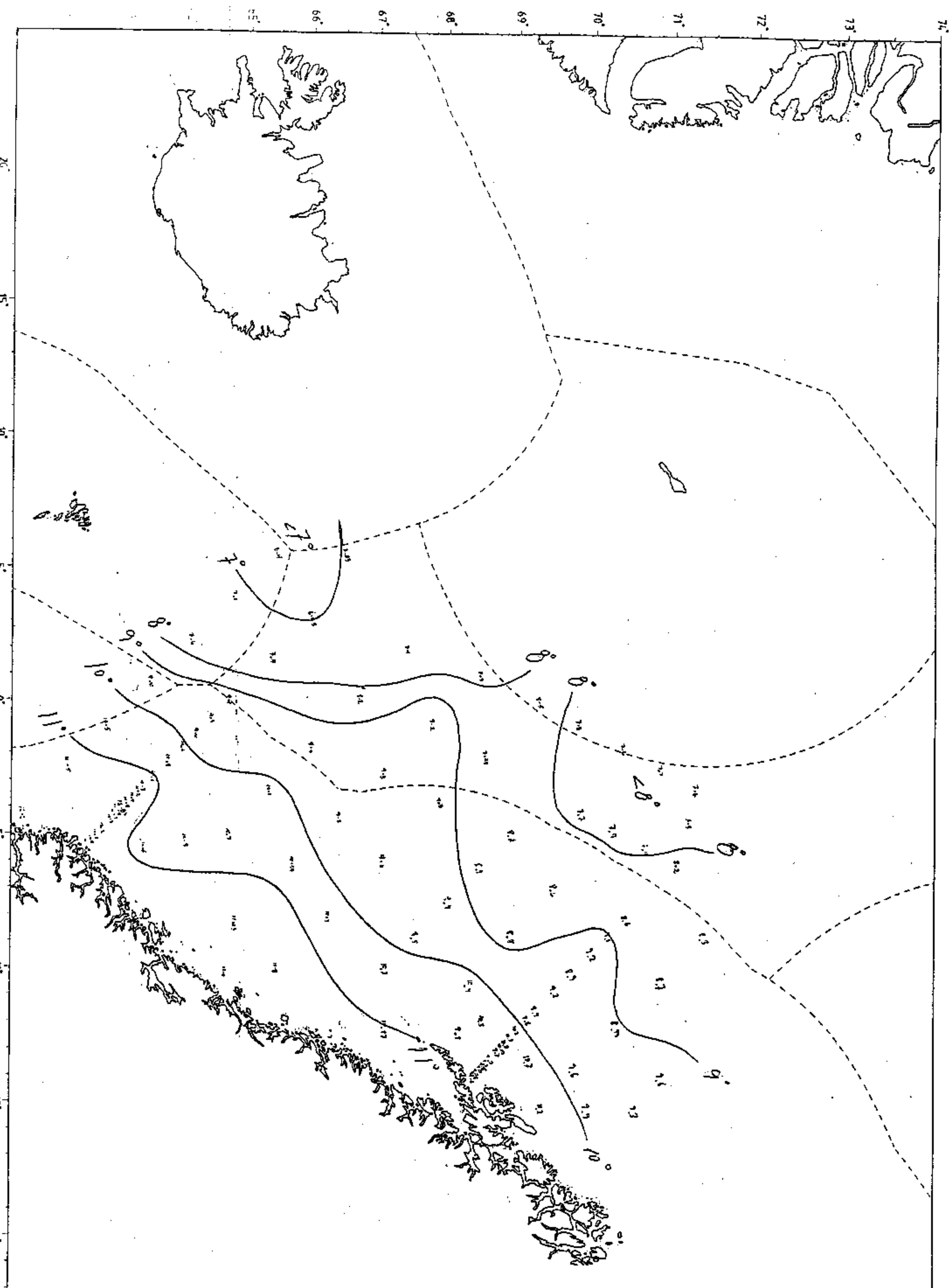

Figure 7.8. Temperature (°C) in the near surface layer in July 1995

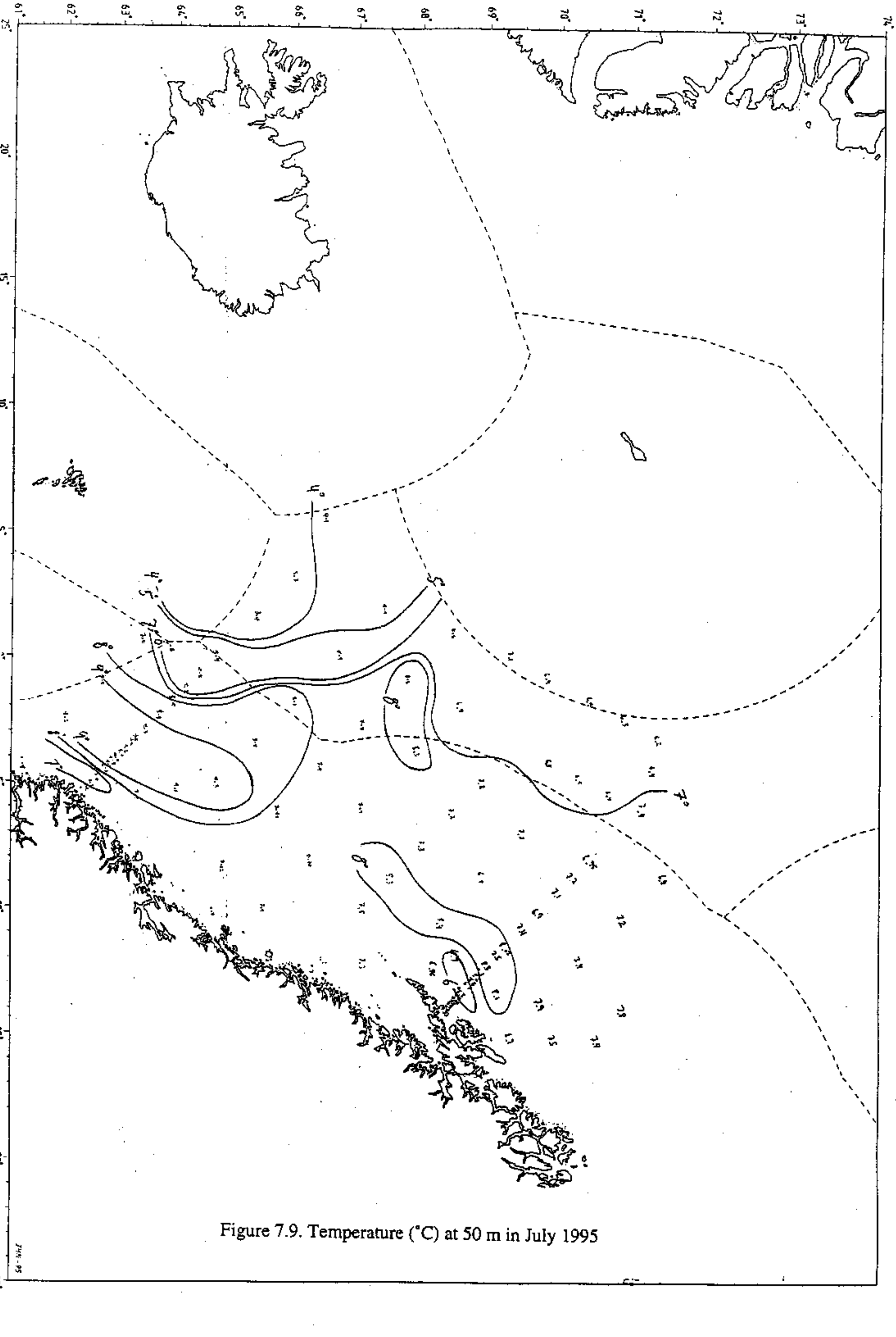

Figure 7.9. Temperature (°C) at 50 m in July 1995

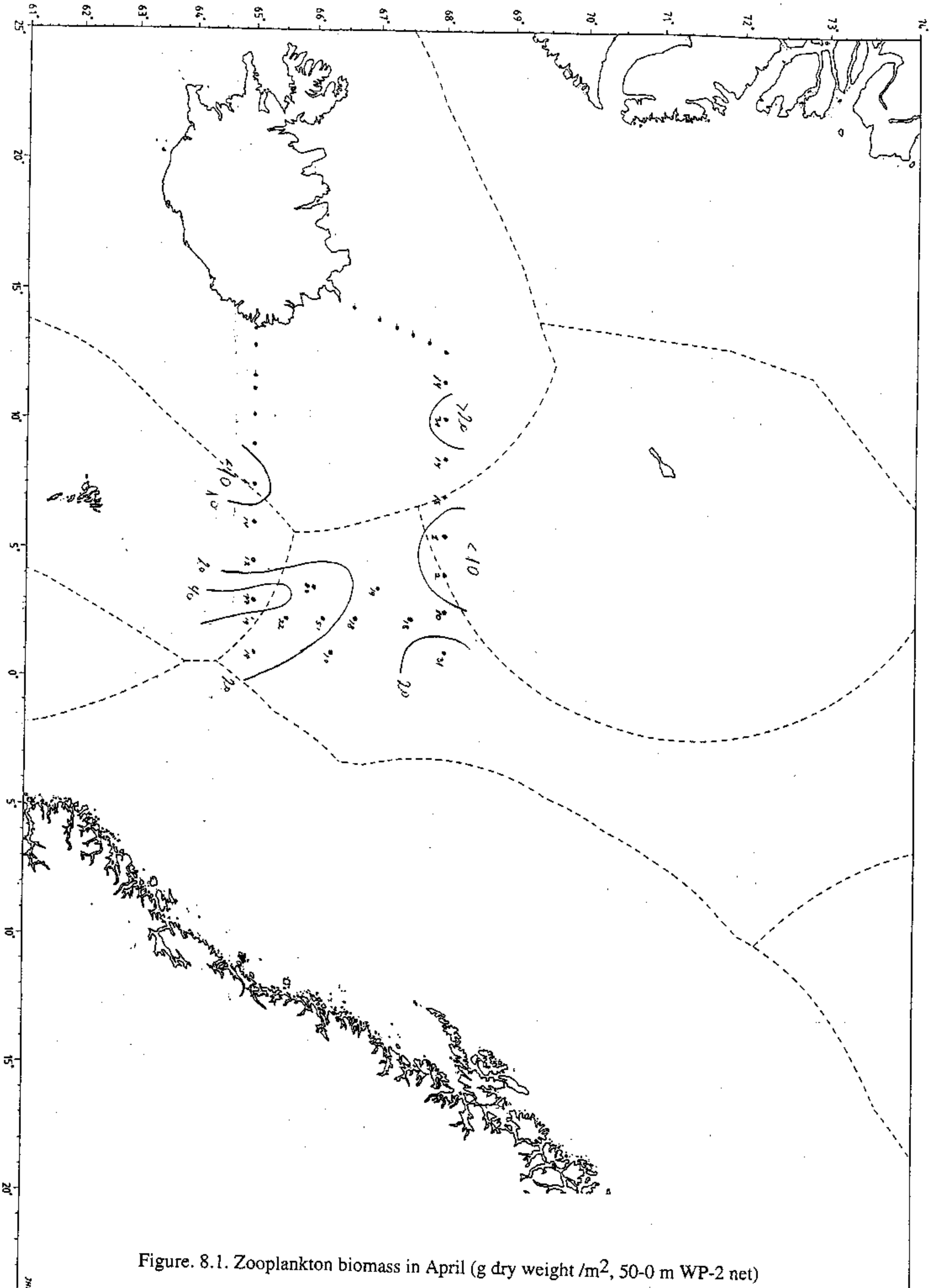

Figure. 8.1. Zooplankton biomass in April (g dry weight /m^2, 50-0 m WP-2 net)

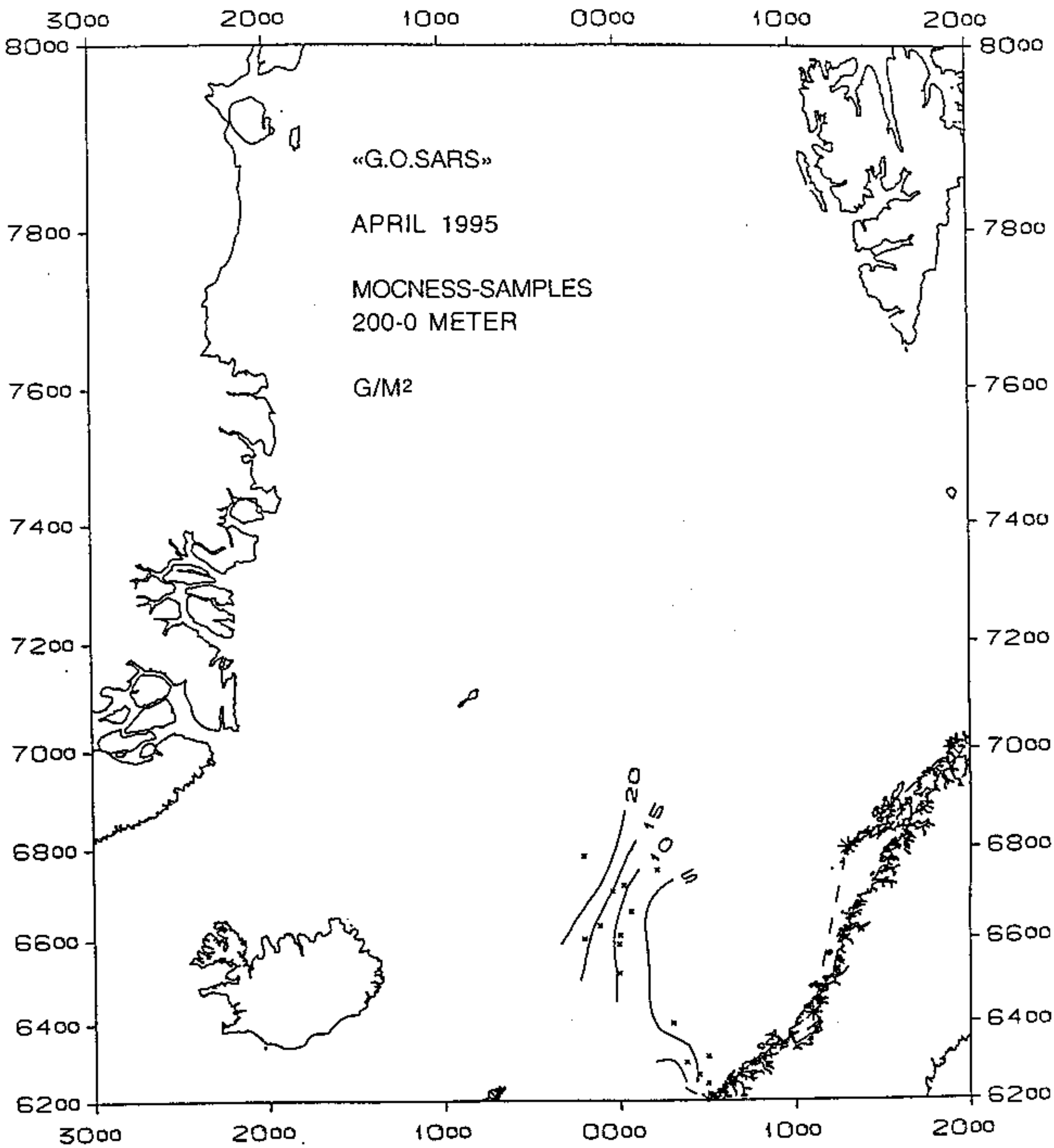

Figure. 8.2. Zooplankton biomass in April (g dry weight /m^2, 200-0 m MOCNESS)

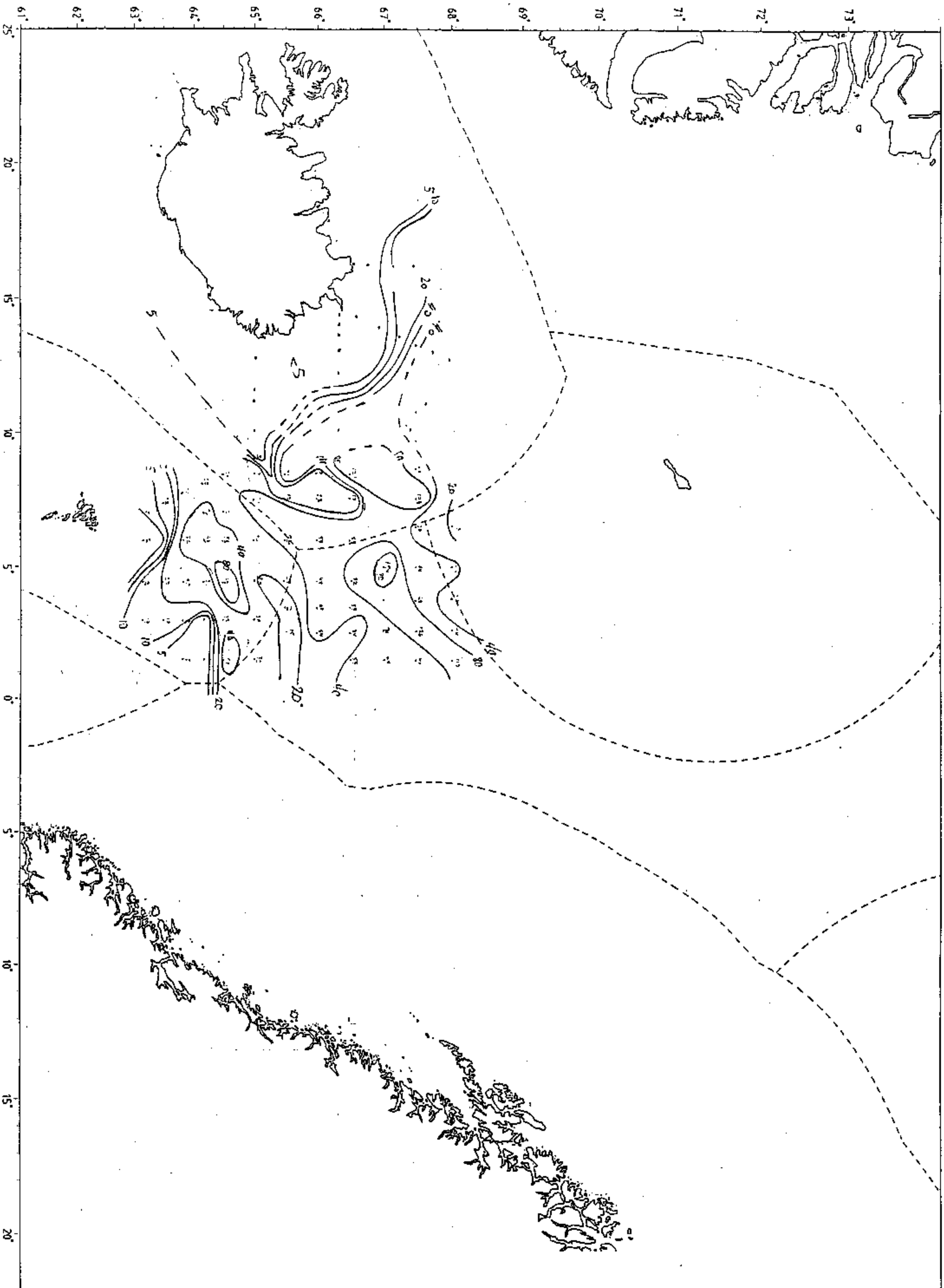

Figure. 8.3. Zooplankton biomass in May (g dry weight /m^2, 50-0 m WP-2 net)

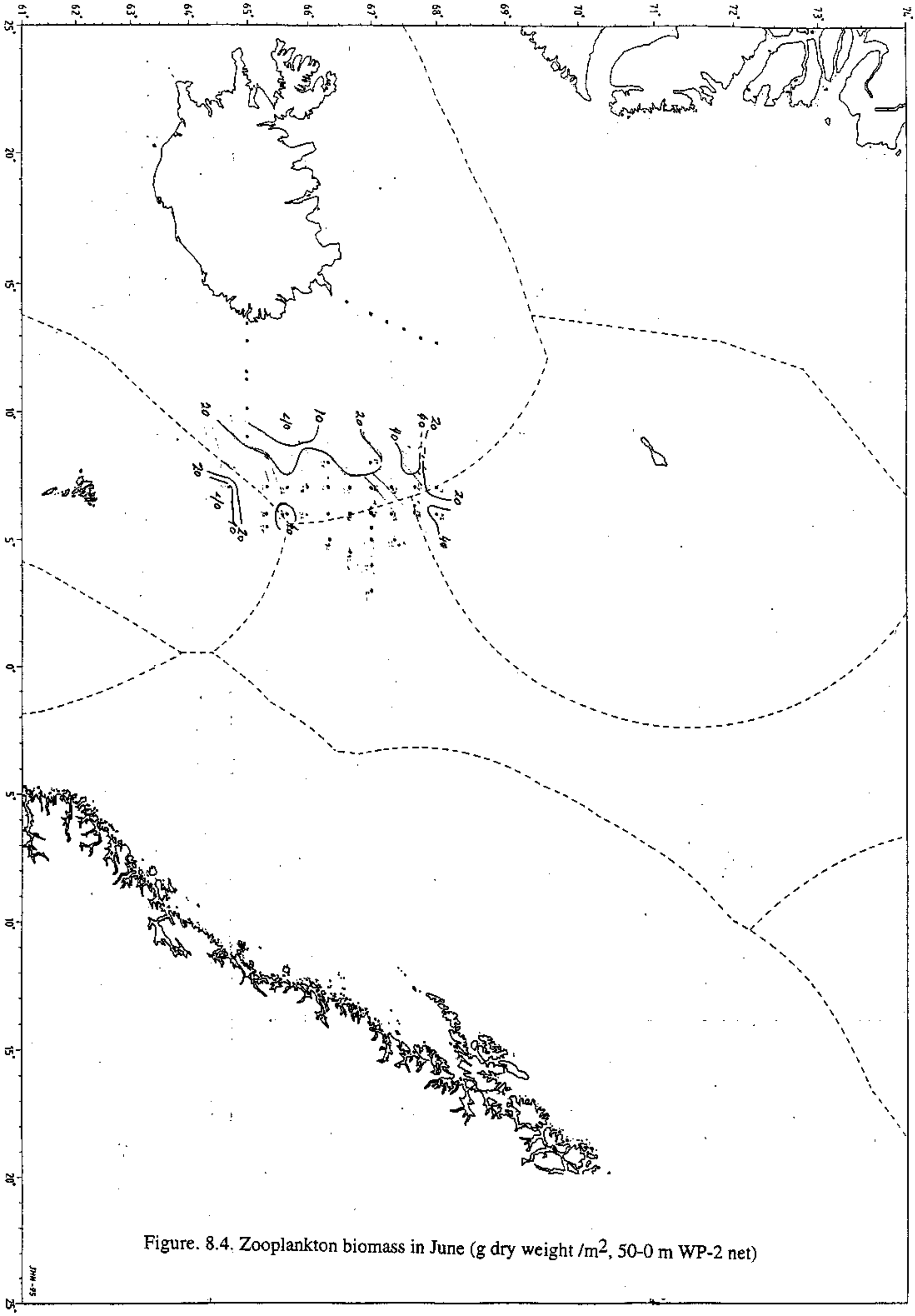

Figure. 8.4. Zooplankton biomass in June (g dry weight /m^2, 50-0 m WP-2 net)

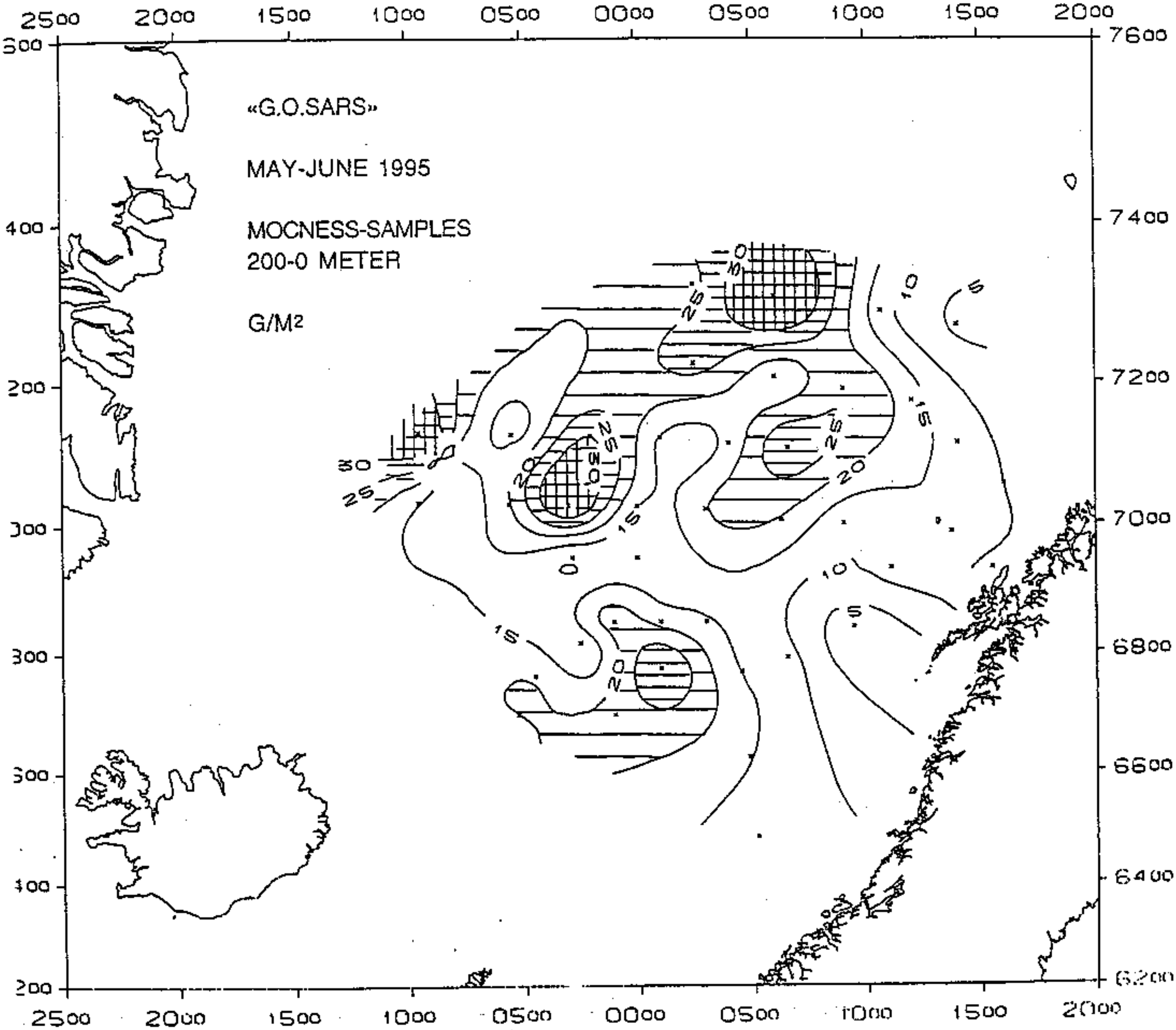

Figure. 8.5. Zooplankton biomass in June (g dry weight /m^2, 200-0 m MOCNESS)

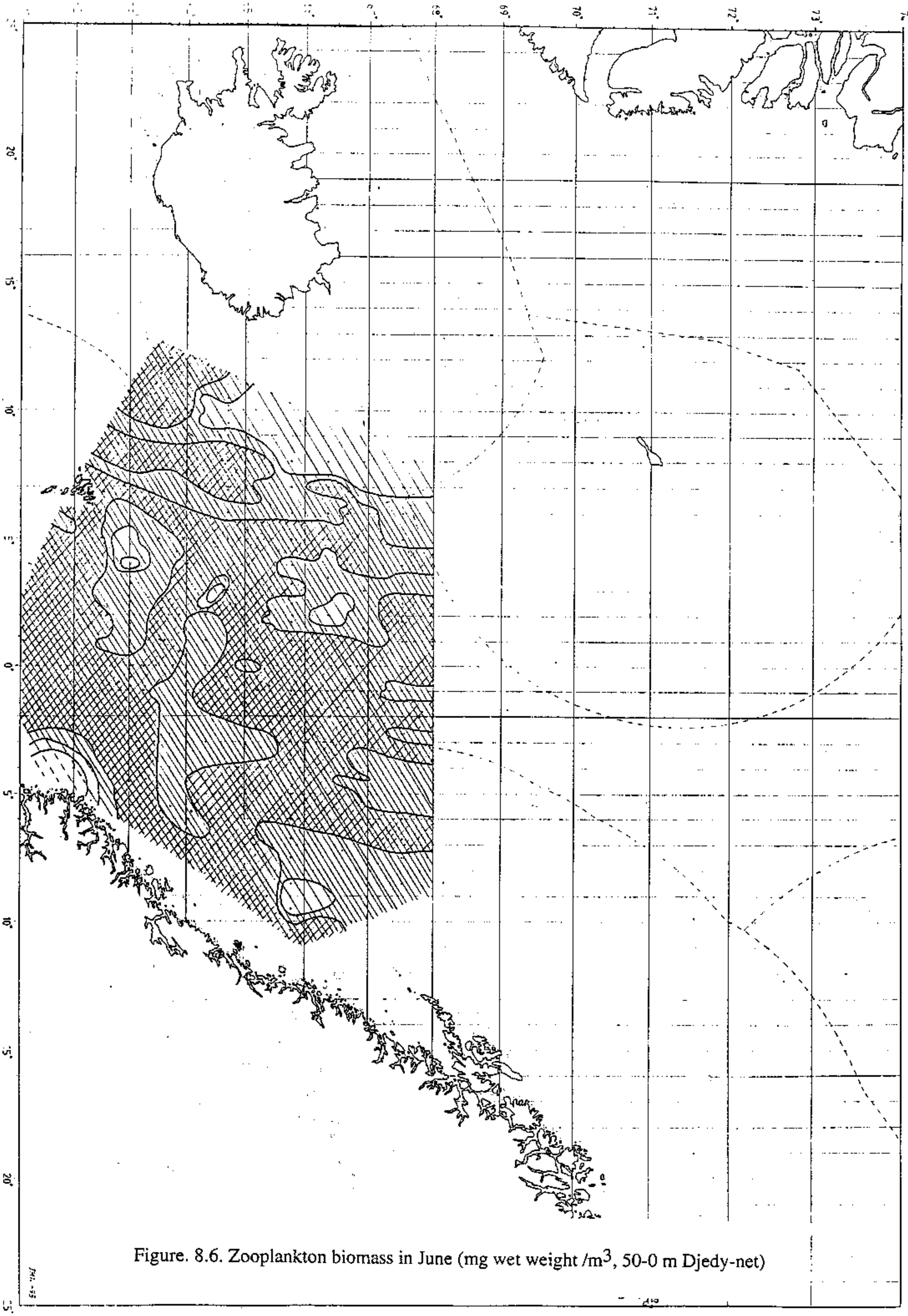

Figure. 8.6. Zooplankton biomass in June (mg wet weight /m^3, 50-0 m Djedy-net)