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Report of the Planning Group on Surveys on Pelagic Fish in the Norwegian Sea 2002

by

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Abstract

The report describes the procedures for the acoustic, hydrographic, plankton, and fish sampling during the ICES co-ordinated surveys in the Norwegian Sea in 2002 (Norway, Faroes, Iceland and Russia). The results of the surveys are presented including the distribution and stock estimates of Norwegian spring-spawning herring, blue whiting and other pelagic fish, and the environment of the Norwegian Sea and adjacent waters in late winter, spring and summer of 2002. The abundance estimates are used in the fish stock assessment in ICES (NPBWWG) and the collection of environmental data further improve the basis for ecosystem modelling of the Northeast Atlantic.

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1 INTRODUCTION

The Norwegian spring spawning herring is a highly migratory and straddling stock carrying out extensive migrations in the NE Atlantic. After a major stock collapse in the late 1960's the stock has been rebuilt and varied from approximately 5 to 10 million tonnes of biomass during the 1990's. During this period the main spawning areas have been situated along the Norwegian coast from approximately 58°N to 69°N, with the main spawning occurring off the Møre coast from approximately 62°N - 64°N. After spawning in February –March the herring have migrated NE-wards towards the Norwegian Sea feeding grounds. In general, the main feeding has taken place along the polar front from the island of Jan Mayen and NE-wards towards Bear Island. During the latter half of the 1990's there has been a gradual shift of migration pattern with the herring migrations shifting north and eastwards. In 2002 this development seems to have stopped and the herring had at more southerly distribution at the end of the feeding season than in 2001. After feeding, the herring have concentrated in August in the northern parts of the Norwegian Sea prior to the southern migration towards the Vestfjord wintering area (68°N, 15°E). Around 15 January the herring have started their southerly spawning migrations. In 2002, the catch of Norwegian spring spawning herring is expected to reach about 850 thousand tonnes, up from about 770 thousand tonnes in 2001.

Besides herring, abundant stocks of Blue Whiting and Mackerel exploit the Norwegian Sea as an important feeding area.

Since 1995, the Faroes, Iceland, Norway, and Russia, and since 1997 also the EU, have coordinated their survey effort on these and the other pelagic fish stocks in the Norwegian Sea. The coordination of the surveys has strongly enhanced the possibility to assess abundance and describe the distribution of the pelagic resources, and their general biology and behaviour in relation to the physical and biological environment (Table 1.1). Based on an ICES recommendation in 1948, similar surveys were conducted under the auspices of ICES from 1950 to the late 70's. National surveys were continued after this time. At the 1996 Annual Science Conference, the Pelagic Committee recommended that the ICES cooperation on the planning and conducting of future surveys on herring and the environment in the Norwegian Sea should be reintroduced. A planning meeting was held in Reykjavik in August 2001 for surveys to be carried out in the summer of 2002 (for methods cf. Holst et al., 1998).

A series of surveys to be carried out by Faroese, Icelandic, Norwegian and Russian vessels in spring and summer 2002, were included in the coordinated programme (Table 1.1), resulting in a relatively good coverage of the areas and relevant species. The surveys were grouped as follows:

May – the Faroese EEZ and Norwegian Sea

May/June – Barents Sea

June – north-eastern Icelandic EEZ, Jan Mayen and central Norwegian Sea

July – central and northern Norwegian Sea

July – Icelandic EEZ

July/August – northern Norwegian Sea and southern part of the Svalbard area

The main objectives of these surveys were to map the distribution and migrations of herring and other pelagic fish and to assess their biomass. Furthermore to monitor environmental conditions of the Norwegian Sea and adjacent waters and estimate the quantity of available food in the sea for herring and other pelagic fishes. The results are presented for the different periods and areas in the same sequence as in the text table above.

Unfortunately the EU has withdrawn its field effort and did not participate in the meeting in 2002, a significant loss to the group.

The results of the coordinated surveys in 2002 were evaluated during a meeting in Bergen in late August 2002 (Table 1.1) and are presented in this paper. The purpose of this paper is to provide a short summary of the surveys and their findings and there is a large potential for exploring the data further. Such effort is highly recommended by the group, but limited time resources have made this task difficult for the individual members of the group.

2 MATERIAL AND METHODS

Data were sampled along transect lines of the hydro-acoustic surveys of the Faroe Islands (Magnus Heinason, 15.05-28.05.2002 (Fig. 2.1)), Iceland (Bjarni Saemundson, 22.05.-28.05.2002 (Fig. 2.2) and 03.06-08.07.2002 (Icelandic area)), Norway (G.O. Sars, 25.04-29.05.2002 (Fig 2.1), 27.07-15.08.2002 (Fig. 2.3-4), and the Russian Federation (F. Nansen, 28.05.-07.06.2002 (Barents Sea, Fig. 2.5), 08.06.-25.06.2002 (Fig. 2.2) and 03.07.-26.07.2002 (Fig. 2.6)). Details are given in Table 2.1.

2.1 Hydrography

The hydrographic observations were made using CTD-Probes. A total of nearly 460 hydrographic stations were made for description of the horizontal distribution of temperature and salinity for the period April-May and June-August (Table 2.1). The MATLAB program from Mathworks Inc. was used to check and prepare the data for plotting. The section plots (Svinøy and Gimsøy) of temperature and salinity were made with MATLAB while horizontal distributions of temperature were plotted with the SURFER program.

2.2 Plankton

A total of 538 plankton hauls were made, which is nearly twice the number of hauls taken in 2001. During May, zooplankton was sampled in vertical hauls from 200-0 m by standard WP-2 net with a 180 µm mesh ("G.O. Sars", "Magnus Heinason"). Russian zooplankton samples were collected in vertical hauls from 0-50 m using a Djedy and Nansen net with a 160 µm mesh ("F. Nansen"). The sampling depths on "Bjarni Saemundson" were 50-0 m on the standard sections around Iceland during late May, while in June both 50-0 m and 200-0 m were sampled on the oceanic stations. The Icelandic data from May were converted to biomasses in 200-0 m using a conversion factor of 1.98 established from simultaneous 50-0 m and 200-0 m net hauls on "Bjarni Saemundson" in 1998.

2.3 Fish sampling

Fish traces identified on the echosounder were sampled by pelagic trawls (vertical openings of 20 - 40 m). With ordinary rigging, the trawls could be used to catch deep fish schools. The trawls were also rigged to catch fish near the surface by removing the weights, extending the upper bridles and attaching buoys to each upper wing.

Subsamples of up to 100 specimens of herring and blue whiting were taken from the trawl catches. The length, weight, sex, maturity stage and stomach contents were recorded. Scales and/or otoliths were taken for age reading of herring and otoliths from blue whiting.

2.4 Acoustics

During the surveys, continuous acoustic recordings of fish and plankton were collected using calibrated echo integration systems (38 kHz Simrad EK500 working at a range of 10 - 500 m). The recordings of area back scattering strength (S_A) per nautical mile were averaged over five nautical miles, and the allocation of area backscattering strengths to species was made by comparison of the appearance of the echo recordings to trawl catches. To record schools near the surface, a horizontal guided sonar was operated from all the vessels.

The equipment of the research vessels was calibrated directly before or during the surveys against a standard calibration spheres.

Acoustic estimate of herring abundance was obtained during the surveys. This was done, either by visual scrutiny of the echo recordings directly from the echograms or by post-processing using the BEI/BI500-system. The allocation of S_A-values to herring was based on the composition of the trawl catches and the appearance of the echorecordings. To estimate the abundance of herring, the allocated S_A-values were averaged for ICES-squares (0.5^o latitude by 1^o longitude). For each statistical square, the unit area density of herring (ρ_A) in number per square nautical mile ($N*nm^{-2}$) was calculated using standard equations (Foote, 1987).

To estimate the total abundance of herring, the unit area abundance for each statistical square was multiplied by the number of square nautical miles in each statistical square and then summed for all the statistical squares within defined sub-areas and for the total area. The biomass was calculated by multiplying abundance in numbers by the average weight of the herring in each statistical square and then sum all squares within defined sub-areas and the total area.

Furthermore, the average length, weight, area density and biomass of each year class were also estimated for each statistical square, for defined subareas and for the total area.

2.5 Aerial surveys

During July and August 2002, aerial surveys for makrel in the Norwegian Sea were carried out by Russia, Norway and the Faroes. Two planes were in the air, one Russian and one Norwegian. Four vessels were at sea, two Norwegian commercial vessels and two Faroese vessels, one research vessel and one commercial vessel. The results from the joint investigations will be presented to the mackerel working group (WGMHSA) in September 2002. In the present report these surveys will be mentioned very briefely (sec. 3.7).

2.6 Seabird counts

Seabird counts were made during the Norwegian survey in the Norwegian Sea from 25/4-29/5 2002, covering the area bound by 62°-75°N and 8°W-20°E. The results were not available to this meeting.

2.7 Whale counting

Whales were counted by two observers from the bridge during the Norwegian survey (R/V "G.O. Sars") in August. Results are not given in this report. For information contact Nils Øien, IMR, Bergen.

3 RESULTS

3.1 Hydrography

3.1.1 General hydrographic features

Two main features of the circulation in the Norwegian Sea, where the herring stock is grazing (see section 3.3), are the Norwegian Atlantic Current (NWAC) and the East Icelandic Current (EIC). The NWAC with its offshoots forms the northern limb of the North Atlantic current system and carries relatively warm and salty water from the North Atlantic into the Nordic Seas while the EIC, on the other hand, carries Arctic waters. To a large extent the EIC water derives from the East Greenland Current, but to a varying extent, some of its waters may also have been formed in the Iceland and Greenland Seas. The EIC flows into the south western Norwegian Sea where its waters subduct under the Atlantic waters to form an intermediate Arctic layer. While such a layer has long been known in the area north of the Faroes and in the Faroe-Shetland Channel, it is only in the last two to three decades that a similar layer has been observed all over the Norwegian Sea.

This circulation pattern creates a water mass structure with warm Atlantic Water in the eastern part of the area and more Arctic conditions in the western part. Due to the influence from the EIC, the NWAC is rather narrow in the southern Norwegian Sea, but when meeting the Vøring Plateau off Mid Norway it is deflected westward, its western branch often reaching the area of Jan Mayen at about 71°N. Further northward in the Lofoten Basin the lateral extent of the Atlantic water gradually narrows again, apparently under topographic influence of the mid-ocean ridge.

It has been shown that atmospheric forcing largely controls the distribution of the water masses in the Nordic Seas. Hence, the lateral extent of the NWAC, and consequently the position of the Arctic Front in the Norwegian Basin, is closely correlated with the large scale distribution of the atmospheric sea level pressure. This is clearly indicated for example by the correlation with the winter index of the North Atlantic Oscillation (NAO). As a result, the Atlantic water now has a far more easterly distribution than it had during the 1950s. Current measurements south in the Norwegian Sea have also shown that high NAO index gives larger Atlantic inflow, along the shelf edge, in the eastern part of the Norwegian Sea.

<u>May – the Faroese EEZ and Norwegian Sea</u>

Figures 3.1.1-3.1.2 show the salinity and the temperature in the Svinøy section for 27-30 April before the start of the seasonal warming. The influence of the EIC is seen in the intermediate layer lying under the Atlantic layer. The intermediate water is of Arctic origin and is characterized by salinities below 34.9 and temperatures below 1^{o}C. The influence of the EIC increased in April/May 2002 compared with May 2001. This can be seen by a comparison of the section plots for Svinøy in April/May 2002 with 2001. West in the section there were colder and fresher water masses in 2002 compared with 2001 (maps for 2001 in: Holst *et al*., 2001).

Figures 3.1.3-3.1.9 show the horizontal temperature distributions at surface, 20, 50, 100, 200, 400 and 500 m depth from the end of April to the end of May 2002. The distribution of the waters carried into the Norwegian Sea by the EIC is clearly indicated at all depths below the seasonal surface layer by a body of relatively cold and fresh water extending eastward from Iceland. These Arctic waters are separated from the Atlantic waters in the eastern part of the area by the Arctic Front which is indicated by closely spaced isotherms. The Front is sharper in the south than in the north. The influence of the EIC in 2002 can also be seen in these maps. For example, at 100 m depth the 5°C isotherm in the southern Norwegian Sea, outside Svinøy, was displaced about 100nm more eastward in 2002 than 2001. Near the surface (20m, Figs. 3.1.4), the temperature was about 1°C lower in southwest for 2002 compared with 2001. In the eastern part of the Norwegian Sea, from south to north the temperature was higher in 2002 than in 2001 for all depths. An area at about 73°N there was an influence of Arctic water in the west. In that area temperatures below 0°C can be seen at 20m depth while the temperature in 2001 in same area was above 2°C. In the central Norwegian Sea, the Lofoten Basin, volume of accumulated Atlantic water increased in 2002 compared with 2001. The main reason for this was an increased vertical distribution of the Atlantic layer in that region.

Figures 3.1.10-3.1.11 show the salinity and the temperature in an extended Gimsøy-NW section, running from Gimsøy (at Lofoten) and into the Greenland Sea for 3-10 June 2002. The Mohns Ridge, separating the Norwegian and Greenland Sea can be seen as large peaks in bottom topography. The Arctic front that separates warm Atlantic waters and cold Arctic waters is topographically controlled. The front is placed over the Mohns Ridge and has sharp east-west gradient in both salinity and temperature. A thin warm surface layer was already developed that time. The Atlantic layer in the Gimsøy section reached deeper in 2002 than in 2001.

May/June – Barents Sea

The maps of distribution of temperature in May-June in the Barents Sea at surface, 50, 100 m and near bottom are shown in Figure 3.1.12-3.1.13. In the Barents Sea at the end of May - beginning of June surface temperature varied from 3.5 °C in east (38°E) up to 8.2 °C in west (25°E). In the area of the North Cape Current the surface isotherm 5°C was situated more to the east than in 2001. In the researched area the surface temperature was higher than last year and maximum deviation reached 1.5°C. The horizontal maps for 50 and 100 m depth showed in 2002 a more eastern extension of waters with temperature higher than 5°C in the coastal branch of the North Cape Current compared with 2001. For most of the investigated area the temperature was 0.3-1.0°C higher in 2002 than in 2001. The temperature in the near-bottom layer was, practically for the whole area, lower in 2002 than last year. Thus, most of the southern part of the Barents Sea was occupied by waters with positive anomalies of temperature, due to both intensive advection of warm Atlantic waters, and increased rates of spring warming.

June – north-eastern Icelandic EEZ, Jan Mayen and central Norwegian Sea

The maps of distribution of temperature in June at surface, 50, 200 and 500 m are shown in Figs. 3.1.14-3.1.17. The core of the EIC (with T < 2,5°C and S < 34,9), west of the Norwegian Sea (at latitude 65°45'N) is situated almost 50 nm more to the west than usual. The EIC was stronger and reached further southeast to 2°W on 63°N. The temperature and salinity of the water in the EIC in a 0-200 m layer (section along 63°00'N) was 0.9°C and 0.1, respectively, lower than normal. In an intermediate layer, 200-500 m, the negative anomalies were respectively 0.8°C and 0.07. Compared with 2001, the temperatures of waters in the EIC were 1.0°C and 0.6°C lower in the upper 200 m and 200-500 m layers, respectively.

July – central and northern Norwegian Sea

Figures 3.1.18-3.1.19 show horizontal maps of temperature at surface, 50, 200 and 500 m in the central and northern part of the Norwegian Sea for July 2002. The surface temperature varied in that area from 5.4°C near Jan-Mayen up to 15.5°C in the eastern part, near Gimsøy. The seasonal warming from June to July of the surface layer was about 2.0°C. In summer 2002, an intensified inflow of Atlantic waters through Faroe-Shetland and the Faroe-Iceland channels into the Norwegian Sea was observed.

The temperatures of the water in the Norwegian Atlantic Current, in the upper 50 m, were 1.8°C above normal in the south and 1.7-2.1°C above normal in the central and north in Norwegian Sea. In the 0-200 m layer the temperatures were 1.2°C above the normal in the south and 0.8-1.0°C above the normal in the central and northern parts. Compared with 2001 the water of the Norwegian Atlantic Current in the upper 200 m layer was 0.6-0.9°C warmer. In an intermediate layer, 200-500 m, the water was in 2002 0.8-1.0°C warmer than in 2001.

July/August – northern Norwegian Sea and southern part of Svalbard area

Figures 3.1.20-3.1.21 show the temperature and salinity in the Svinøy section for 28-30 July, 2002. Due to the seasonal warming a warm surface layer has developed. The surface layer was warmer than normal (about 1-2^{o}C difference) and also compared with 2001 (about 2^{o}C difference). In some areas it had temperatures above 14^{o}C. In the Atlantic layer, both the temperature and salinity were above the normal. Figure 3.1.22 shows time series of the area in the Svinøy section (see Fig. 2.4 for the section) that is occupied of Atlantic water and its averaged temperature for July/August from 1978 to 2002. The averaged temperature in 2002 was 8^{o}C which was the highest value ever since the systematic observations started in 1978. Between 50 and 200 m depth in the core of the inflowing Atlantic water, at the shelf edge, the mean temperature was 9.2^{o}C. That was also the highest ever since 1978 and was 1^{o}C above the normal. Figs. 3.1.23-3.1.24 show horizontal distribution of the temperature at surface and 20 m depth south of Svalbard. The coverage of CTD stations in 2002 was coarse for that area. However, the temperatures at 20 m depth were for most of the area about 1^{o}C higher in 2002 than in 2001.

3.2 Zooplankton

3.2.1 May – the Faroese EEZ and Norwegian Sea

Figure 3.2.1 shows the distribution of the zooplankton biomass (g dw m^{-2}) in 200-0 m in May 2002 in the survey area. The samples were fairly evenly spread over the area. However, the number of samples from the cold water in the west was low. This was partly related to the wide spread of warm Atlantic surface water in the north making a satisfactorily mapping of the cold water too time consuming. The biomass in May 2002 was generally higher than in 2001. For the total area, average biomass of zooplankton was the third highest measured during the years 1997-2002 (Table 3.2.1).

The increase of the total biomass from 2001 to 2002 occurred in the areas both to the east and to the west of 2°W. However, the increase of biomass is most striking in the region east of 2°W (Table 3.2.1). In fact, high biomass was observed in the Norwegian shelf waters, which is rather unusual in May.

3.2.2 June – northeastern Icelandic EEZ, Jan Mayen and central Norwegian Sea

In the Norwegian Sea, the period of "blooming" was completed in June. On the transect along 63°00' "spring" (*Diatommeae*) and "summer" (*Peridinieae*) algae dominated. The age structure of *Calanus finmarchicus* was broad, ranging from nauplii and to adults. Distribution of large and small-sized *Calanus* was different with "the small-sized fraction" towards the west and "large" - towards the east. The average biomass equalled 785 mg m^{-3}, which is equal to that of 2001, but less than the long term mean (1076 mg m^{-3}) (Fig 3.2.2). The highest values of plankton biomass (1000 mg m^{-3} and higher) were found on the junction between the East-Icelandic Current and the branch of the North Atlantic Current passing west of the Faroes (Faroese Current) and in the southeastern area between 63-64°30'N.

3.2.3 July – central and northern Norwegian Sea

In July Peridinieae dominated the phytoplankton. The zooplankton was characterized by a significant amount of *Calanus finmarchicus* CI-CV throughout investigated area. Warm water species of zooplankton and hydromedusae were widely distributed. The average biomass of a zooplankton equalled 878 mg m^{-3}, which is higher than in 2001 - 746 mg m^{-3}). The greatest values of zooplankton biomass (1000 mg m^{-3} and more) were found at 5°W and 5°E (Fig. 3.2.3). Due to the unusually high temperature, the average biomass of zooplankton had increased from June to July. In previous years we observed some lowering of average biomass from June to July, due to high amounts of nauplii and small-sized *C. finmarchicus* (CI-III) in the latter month.

3.2.4 July/August – northern Norwegian Sea and southern part of Svalbard area

The Norwegian survey of the Norwegian Sea in July –August 2002 was carried out with only one vessel as compared to two vessels in 2001. Also, the southern and central Norwegian Sea was not covered except for the Svinøy and Gimsøy standard sections. Thus, comparison with previous years is not feasible. The biomass of the northern Norwegian Sea in July-August increased towards west and north, and ranged from about 3 to 7 g dw m^{-2} (Fig. 3.2.4).

3.3 Norwegian spring spawning herring

3.3.1 May – the Faroese EEZ and Norwegian Sea

The international coordinated herring survey was carried out with two vessels, one from Norway and the other from Faroes, during the time period 25 April –29 May 2002. The survey covered the central and eastern Norwegian Sea from 64°N to 74° 30'N as shown by their cruise tracks (Figure 2.1).

Herring were recorded over large areas as shown in Figure 3.3.1. There appeared to be two main spatial groupings. The first of these concentrations was observed from about 68˚00'N to 70˚00' N, between 07˚E and 04˚E. A corresponding concentration was in 2001 located further to the east and north. In this area the dominating year classes were mainly those from 1991, 1992 and 1988. Another area with high herring densities was located west of Vesterålen. There was a higher contribution of younger year classes in this area, mainly the1998 year class and adolescent herring of the 1999 year class. The outer boundary of the herring distribution was fairly well defined in 2002, with the exception of a small area in the north.

The western boundary of herring distribution was at about 3˚W, but in the north the distribution reached almost to 75˚N. While the size of the area where herring was distributed was similar to that observed in May 2001, the herring were much more evenly distributed and higher in the water column than in 2001. This resulted in fewer instances of mixed concentrations of herring and blue whiting, which generally is distributed at greater depths than herring after the latter have begun to feed. From this it follows that there is less variance associated with the present estimate than that obtained in May 2001. However, it is likely that the May 2002 survey underestimated stock abundance compared to most previous May surveys, due to a relatively high incidence of near-surface distribution, above the recording depth of the transducers.

Based on the acoustic records of the Norwegian and Faroese vessels, the scrutinized acoustic values and the fish samples analysed, a preliminary age segregated estimate was run of herring in the surveyed area. A simple algorithm, weighting the 4 nearest neighbouring squares by 2 while the next second nearest 4 squares were given a weight of 1, was applied. The total herring abundance was estimated to be about 5.1 million tonnes in May 2002 (Table 3.3.1). The age and length distribution of the herring is given in Figure 3.3.2.

3.3.2 May/June Barents Sea

R/V "F. Nansen" carried out a survey in the Barents Sea from 35 to 15°E along the Russian and Norwegian coast during the period 28/5- 07/6 2002 in order to map the distribution, and to produce an abundance estimate of young herring in this area. Young herring were observed mainly within a distance of 50-100 nautical miles along the Norwegian coastline (Fig 3.3.3). The herring were mostly recorded as schools of various densities, mainly in the upper 30 m layer of the water column. In this area some herring were also observed in the immediate surface layer. The herring in the surveyed area consisted mainly of 2 year old fish (88%). The total biomass was estimated to be 121.000 tonnes and the total numbers 4.5 billion individuals (Table 3.3.2).

3.3.3 June – north-eastern Icelandic EEZ, Jan Mayen and central Norwegian Sea

In the third week of May the herring fishery was conducted in two main areas, i.e. around 70˚30'N, 04˚W and 71˚N, 04˚E. However, in the last week of May most of the fishery shifted to the western area and good catches were taken from schools migrating in a northeasterly direction between about 71˚N, 05˚W to 72˚N, 02˚E.

In the period 3/6 – 8/7 2002, Russia and Iceland carried out a survey of the Norwegian Sea along the tracks shown in Figure 2.2. Practically no herring were recorded south of 70˚N. During 9-12 June the Icelandic vessel registered small herring schools as well as scattered herring in the two northernmost tracks, i.e. along 70˚30'N and 71˚N, between about 06˚W and 01˚E (Fig. 3.3.4). Due to time constraints, this survey could only determine the southern- and westernmost distribution boundary of the herring.

In the second week of June, the main fishery was first conducted near 72˚N, between about 01˚W and 04˚E, but then quickly shifted north-eastwards to 73˚30'N, 08˚E. In the third and fourth weeks of June most of the catch was taken at about 76˚N, between 7 and 13˚E. The positions of the Icelandic fishery in May-June 2002 are given in Figs 3.3.5 and 3.3.6.

3.3.4 July – central and northern Norwegian Sea

During the Russian survey in July, herring was found in the eastern part of the survey area (68°00'-71°10'N) from 05° E to 15°E (Figure 3.3.7). The herring were recorded in the uppermost 20 m water layer as separate small schools with a vertical extension 5-15 m. The densest herring concentrations were distributed between 10 and 15°E, and the maximum recording was 720 tonnes/nm^2. The mean lengths of the herring in the samples were 25-29 cm . Within the total area investigated area (21,700 square nautical miles) the total number was estimated to be 7.7 billion individuals corresponding to a biomass of 1.4 million tonnes (Table 3.3.3).

The positions for the Icelandic fishery in July is given in Figure 3.3.8, indicating that the adult herring are at that time distributed north in the Spitzbergen area.

3.3.5 August – northern Norwegian Sea and southern part of Svalbard area

During the period 5-15/8 R/V "G O Sars" surveyed the Norwegian Sea from the Norwegian coast to the Spitzbergen area, between 07^{o}E and 16^{o}E.. Due to time constraints, a comparatively coarse survey gird had to be adopted (Fig 2.3), and as a result neither the eastern nor the western boundaries of the herring distribution were reached . Near the Norwegian coast there was a high density of small schools of 0-group herring (see paragraph 3.4.3). The distribution of adult and adolescent herring is given in Fig 3.3.9. South and east of the hand drawn line in the map the herring concentrations were dominated by adolescent herring of the 1999 year class.

In 2002 the northern boundary was recorded at about 76^{o}N, as compared to approximately 77^{o}N in 2001. Furthermore , the herring probably had a more western distribution in August 2002 than the year before, but the exact western boundary was not located (Figure 3.3.9). The adult herring was very scattered in small near surface schools over the whole distribution area in 2002. It was therefore very difficult to obtain adequate samples by trawling and an acoustic estimate of the total herring stock was not made. Fig 3.3.10 gives the length distribution of herring in the samples taken, but these must be interpreted with care due to the inadequate sampling situation. An estimate of the adolescent herring is given in Table 3.3.4.

3.4 0-group herring

3.4.1 May/June-the Barents Sea

Herring larvae were recorded during the Russian acoustic survey of juvenile herring in the Barents Sea in May-June (Figure 3.4.1). The length of the larvae was 25-45 mm. The occurrence of herring larvae in the area was confirmed by catches of herring larvae during a Norwegian survey on the distribution of larval capelin in June.

3.4.2 June/July- Norwegian Sea

During the Russian survey in June-July herring larvae and 0-group were recorded in the Norwegian Sea (Figure 3.4.2). The length of these herring was 4-9 cm. Observations of 0-group herring in the Norwegian Sea were also made during the Norwegian mackerel/salmon survey in July. These 0-group herring concentrations were recorded in the international water in the Norwegian Sea near the Norwegian EEZ.

3.4.3 August-Northern Norwegian Sea

In the beginning of August large concentrations of 0-group herring were recorded off Troms (Figure 3.4.3) during the "G O Sars" survey. These 0-group herring were mostly recorded as large numbers of schools near to the surface. The mean length of this herring was 10 cm.

3.5 Blue whiting

3.5.1 May – the Faroese EEZ and Norwegian Sea

In May, the densest concentrations of blue whiting were found in the southern Norwegian Sea: north and east of the Faroes, Shetland and off the Norwegian coast, extending to the international zone (Figure 3.5.1). Another concentration was recorded in the northern Norwegian Sea, north of the Lofoten Islands. The surveys did not cover southern half of the Faroese zone where high concentrations were observed in 2001; in other respects the distribution pattern is roughly similar to that of 2001.

The estimate of the total biomass of blue whiting in the survey area is 6.0 million tonnes (Table 3.5.1). With respect to both numbers and biomass, the 2000 year class was the most abundant. This year class comprises almost one half of the total blue whiting biomass in the survey area. Also year classes 1999 and 2001 were fairly abundant (Table 3.5.1).

3.5.2 May/June – Barents Sea

No significant occurrences of blue whiting in the Barents Sea were reported this year by the Russian surveys.

3.5.3 June – north-eastern Icelandic EEZ, Jan Mayen and central Norwegian Sea

In June, blue whiting were distributed over most of the survey area, with main concentrations between 0° and 7°E in the eastern part of the area. Another concentration was observed in the international waters between Jan Mayen and Lofoten. Distribution is presented in Figure 3.5.2. In the survey conducted by R/V "F. Nansen", blue whiting echorecordings were registered mainly as scattered layers at different depths from 150 m to 300 m. The length of blue whiting ranged between 19 and 36 cm with fish of 21-28 cm in length dominating the size distribution. The stock in the survey area of R/V "F. Nansen" was estimated to comprise 20.7 x 10^9 individuals with a total biomass of 1.8 million tonnes (Table 3.5.2). An age disaggregated estimate is not available, but the length distribution suggests dominance of the 2000 year class.

3.5.4 July – central and northern Norwegian Sea

The main concentrations of blue whiting were observed in areas between 0° and 10°E in the southeastern part of the survey area by R/V "F. Nansen". Echo density distribution is presented in Figure 3.5.3. The stock in the survey area was estimated to comprise 13.8 x 10^9 individuals with a total biomass of 1.1 million tonnes (Table 3.5.3). The length of blue whiting ranged between 19 and 31 cm with fish of 22-27 cm in length dominating the size distribution. Age disaggregated estimate is not available, but the length distribution suggests the dominance of the 2000 year class.

3.5.5 July – Icelandic waters

A survey of blue whiting in Icelandic waters was carried out with R/V "Arni Friðriksson". The survey began west of Iceland and continued across the Reykjanes Ridge, then eastward along the shelf edge to the southeast coast. From there the survey continued south to 62˚30' N and north from there northwest of the Faroese EEZ and the international zone to 66˚00' N. Finally, the shelf area off east Iceland to the south coast was surveyed. The coverage was very similar to that of last year.

0-group blue whiting were mainly observed in the uppermost 50m in a small area around 63˚50'N and 13˚50'W, off the southeast coast of Iceland. The 2001 year class, which was very strong as 0-group, was observed as abundant 1-group fish along the south and southwest coasts of Iceland. Two year and older fish were observed in the eastern part of the survey area. The blue whiting distribution in the Icelandic area is given as average S_a-values by statistical squares in Figure 3.5.4.

The total biomass estimate was about 1.9 million tonnes and 23 x 10^9 individuals. The 2001 year class (1-group) was the most abundant year class with estimated 11 x 10^9 individuals. The second most numerous were the year classes from 2000 and 2002. A preliminary age disaggregated biomass estimate is given in Table 3.5.4.

3.5.6 July/August – northern Norwegian Sea and southern part of Svalbard area

The survey effort and coverage in this area has been much reduced from previous years and, consequently, the results obtained are not comparable to the earlier ones.

The abundance of blue whiting was highest in the south-eastern parts of the survey area (Figure 3.5.5). Total population estimate in the survey area shows numerical dominance of the 2001 year class. In terms of biomass, year classes 1999-2001 have even contributions.

3.6 Mackerel

During the Russian survey in the Norwegian Sea in June 2002, mackerel was observed distributed in upper 50 m layer on a wide area from 5°W to east direction up to 10°E (Fig. 3.6.1). All samples of mackerel were taken from near surface catches with water temperature 10.5-13.0°C. Mean length of mackerel in most areas was 37-38 cm except area between

67° and 69°N east from 7°E (dual-mode length 28 and 37 cm). An attempt to make an acoustic estimation of a mackerel has been made by Russia, and the total biomass of mackerel in July was estimated at 1.8 million tonnes and 3.3 billion specimens ($TS(L) = 20\text{Log}(L) - 82$; ICES CM 2002/G:03).

3.7 Aerial surveys

During July and August 2002 aerial surveys for makrel in the Norwegian Sea were carried out by Russia, Norway and the Faroes. Two planes were in the air, one Russian and one Norwegian. Four vessels were at sea, two Norwegian commercial vessels and two Faroese vessels, one research vessel and one commercial vessel. The results from the joint investigations will be presented to the mackerel working group (WGMHSA) in September 2002. In the present report the survey will be mentioned only very briefely.

The Faroese vessels were in the sea from 2-7 August 2002 in the northeastern part of the Faroese EEZ. Unfortunately the Russian aeroplane could not survey the area during this period due to poor visibility (fog). The cruise track from R/V Magnus Heinason is shown in Fig. 3.7.1, with an indication where mackerel was found by the research vessel and the commercial vessel. A Russian fleet was operating in a wider area northeast of the Faroes with daily catches of mackerel ranging from 20-100 tonnes.

The Norwegian combined aerial/trawl survey on mackerel was carried out from 15-25. July 2002 in the eastern part of the Norwegian Sea (Figure 3.7.2). The aeroplane covered much of the same area as the vessels but did not extend as far west as the vessels. The results will be reported to ICES later in the year.

3.8 Seabird counts

Seabird counts were made during the Norwegian survey in the Norwegian Sea from 25/4-29/5 2002, covering the area bound by 62°-75°N and 8°W-20°E. The results were not available to this meeting.

4 DISCUSSION

4.1 Hydrography

The winter NAO index increased in 2002 compared with 2001. The westerly winds were especially strong the first months in 2002 compared with similar period in 2001. This resulted into a more easterly displacement of the Arctic front in the southern Norwegian Sea. Increased wind forcing gave also a larger Atlantic inflow into the Norwegian Sea in the eastern part at the Norwegian shelf edge. Observations of temperature show that the Norwegian Atlantic Current was warmer in May-August, from the southern part of the Norwegian Sea to the Barents Sea, compared with 2001. Both the temperature and the volume of the Atlantic inflow into the Norwegian Sea, at least at the Norwegian shelf edge, increased in 2002 compared with 2001. The mixed layer was warmer in summer 2002 than in 2001 due to increased sun warming.

4.2 Plankton

From 2001 to 2002 there was a large increase in zooplankton biomass in May. This increase mainly occurred in the eastern region, although, higher biomass also was found in the colder water masses to the west. In Icelandic waters the situation had not changed much since 2001, and highest biomass was found in the East-Icelandic Current.

In June the biomass was equal to that in 2001 and in July somewhat higher. Still, biomass in June and July was lower than long term means. The Russian cruises in June and July revealed an early production of *Calanus finmarchicus* in 2002.

4.3 Herring migrations and the environment in 2002

A special feature in 2002 was the occurrence of herring larvae and 0-group in various areas of the Norwegian and Barents Sea. There seem to have been two separate concentrations of 0-group herring.

The first was recorded as larvae in the Barents Sea in May-June (Figure 3.4.1). The probable origin of these is spawning off the more northern parts of the Norwegian coast. It is relatively seldom that larvae are recorded in such concentrations in the Barents Sea in May/beginning of June.

The other concentration was first recorded as a mixture of post-larvae and 0-group in the Norwegian Sea during late June/July (Fig 3.4.2) . The mean length of the herring was 4-8 cm. In the beginning of August large concentrations of 0-group with a mean length of 10 cm were recorded of Northern Norway (Fig 3.4.3). These 0-group herring may be connected to the concentrations in June/July further south in the Norwegian Sea (Fig 3.4.2). This is the first time during the present survey series (since 1995) that such large concentrations 0-group herring are recorded in the Norwegian Sea area in summer. The exact origin of these herring concentrations is presently not known, but they are believed to belong to the Norwegian spring-spawning stock.

Based on all available information, an inferred migration pattern of the adult herring stock during the feeding season in the summer of 2002 was reconstructed. The main sources of information for the reconstruction are given above (Section 3.3) and consist of data from the Norwegian/Faroese survey in May, the Russian/Icelandic survey in June, the Norwegian survey in July/August and, last but not least catch positions of the Icelandic herring fleets during the fishing season.

After spawning along the Norwegian west coast in late February/early March the herring migrated towards north and northwest into the Norwegian Sea (Fig 4.3.1). This early migration was not covered by any survey and we base this very brief description on observations from earlier years.

The first survey in 2002 was the joint Norwegian/Faroese herring survey in May (Fig 2.1). At this time, the herring were spread over an area, stretching approximately from off the Norwegian coast, west to 2-3ºW, and from approximately 64º30'N and north to 74º30'N (Fig 3.3.1). There has been an ongoing northward shift in migration direction from 1996 onwards. However, this shift seems now to have stopped up, the distribution in 2002 does not seem to be further north than in 2001. This can also be seen in the position of the centre of the distribution of the herring for 2002. It is located somewhat to the south and east compared to 2001 (Fig 4.3.2). The vertical distribution in 2002 was also different from that of the other years, with the herring closer to the surface. This indicates an earlier onset of near-surface feeding. The plankton concentrations in the eastern part of the Norwegian Sea were larger in 2002 compared to 2001, indicating that the herring did not necessarily migrate so far westwards. Further, with the recruitment the 1998 year class to the spawning stock the mean length of the herring stock has decreased, indicating also a general decrease in swimming speed of the herring stock.

The survey, carried out in June by "Bjarni Saemundson" and "Fridtjof Nansen" confirm the evidence of the fishery of a continued northern and eastern distribution as compared to previous years. This is in line with fishery position shifts in end of May/early June and onwards (Fig. 3.3.5 and 3.3.6). The Russian/Icelandic survey in June thus indicate a continued migration of the (largest) herring to the west-northwest in late May, after which the herring assumed a definite and rapid migration to the northeast.

In the first half of August the "G.O. Sars" mapped the herring distribution in the northern parts of the Norwegian Sea (Fig. 3.3.9).The northern distribution limit of herring reached far to the north, but not so far north as in 2001. On the basis of the July/August survey results and information from the fishing fleets (Fig 3.3.8) it appears that the herring recorded in the central and north-western Norwegian Sea in May and early June only remained there (e.g. in the Jan Mayen zone) for a very short time before migrating northeast- and northward along the Polar Front . However, the northern border seems not to have been so far north as it was in 2001. By the time of the August survey, the herring was very scattered in the upper water masses and had started on the southern migration, maybe a week earlier than in 2001. Fig 4.3.3 gives the general migration directions in late summer 2002.

4.4 blue whiting

None of the surveys reported in this document were designed for obtaining a total synoptic estimate and general distribution of blue whiting during summer in the Norwegian Sea and adjacent areas. It is therefore not possible to base any conclusions on zonal attachments on these estimates alone.

The biomass estimates of blue whiting from the Faroese area and the Norwegian Sea in May 2002 were slightly higher than in 2001, in spite of the fact that the southern part of the Faroes EEZ was not included in the survey in 2002. Two year old fish dominate the total stock estimate (ca. 50% of the biomass). This survey supports the observations from 2001 that the 2000 year class is a strong one. In contrast, the 2001 year class does not appear to be large.

The biomass estimate of blue whiting from the Icelandic area in July was marginally (ca. 10%) lower in 2002 than in 2001. One year old blue whiting formed the dominant age group, both in numbers and biomass. The 0-group blue whiting appeared much weaker this year than in 1999-2001, indicating that the 2002 year class might be a weak year class, at least in Icelandic waters.

Russian surveys in June-July 2002 indicate slightly lower abundance of blue whiting as compared to 2001. Average length and weight are higher this year than in 2001. This fits the general picture from other surveys that the stock is dominated by 2-year old fish because the strong 2000 year class is dominating in the stock.

The post spawning migration from the south to the feeding areas in the Norwegian Sea past the Faroes could not be determined in 2002 due to the fact that the Faroes survey did not cover the southern part of the Faroese EEZ.

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Table 1.1. Organisational frame of the coordinated herring investigations in the Norwegian Sea, 1995-2002.

Year	Participants	Surveys	Planning meeting	Evaluation meeting
1995	Faroe Islands, Iceland Norway, Russia	11	Bergen, (Anon., 1995a)	Reykjavík (Anon., 1995b)
1996	Faroe Islands, Iceland Norway, Russia	13	Tórshavn, (Anon., 1996a)	Reykjavík (Anon., 1996b)
1997	Faroe Islands, Iceland Norway, Russia, EU	11	Bergen (ICES 1997/H:3)	Reykjavík (Vilhjálmsson, 1997/Y:4)
1998	Faroe Islands, Iceland Norway, Russia, EU	11	Reykjavík (ICES 1997/Assess:14)	Lysekil (Holst et al., 1998/D3)
1999	Faroe Islands, Iceland Norway, Russia, EU	10	Lysekil (Holst et al., 1998/D3)	Hamburg (Holst et al., 1999/D:3)
2000	Faroe Islands, Iceland Norway, Russia, EU	8	Hamburg (no printed planning report)	Tórshavn (Holst et al., 2000/D:03)
2001	Faroe Islands, Iceland Norway, Russia, EU	11	Tórshavn (no printed planning report)	Reykjavik (Holst et al., 2001/D:07)
2002	Faroe Islands, Iceland Norway, Russia	8	Reykjavik (no printed Planning report)	Bergen (This report)

Table 2.1. Surveys conducted in spring and summer 2002 by Faroes, Icelandic, Norwegian and Russian vessels in the North Atlantic and the Barents Sea, which are related to the Norwegian Spring Spawning Herring and blue whiting.

Platform		Survey area	Period	Herring samples	Blue whiting samples	Mackerel samples	Plankton samples	CTD stations
G.O. Sars	NO	62°-75°N, 8°W-20°E	25/4-29/5	43	40		89	89
Magnus Heinason	FA	62°-73°N, 6°W-8°E	15/5-28/5	3	9		44	35
Bjarni Saemundson	IS	63°30-68°N, 9°-15°W	22/5-28/5				29	39
F. Nansen	RU	67°-72°N, 15°-38°E	28/5-07/6	8			40	46
Bjarni Saemundson	IS	67°-71°N, 8°W-5°E	03/6-08/7	1	2		39	39
F. Nansen	RU	63°-68°N,11°W-9°E	08-25/6	1	9	7	63	64
F. Nansen	RU	66°-71°N, 5°W-10°E	03-26/7	10	10	8	100	95
G.O. Sars	NO	62°-77°N, 5°W-16°E	27/7-15/8	27	18	7	134	51

Table 3.2.1. Average zooplankton biomass [g dry weight m^{-2}]. The 1998 and 2001 data on the Faroese shelf were omitted to allow comparison with the other years.

Year	1997	1998	1999	2000	2001	2002
Total area	8.2	13.4	10.6	14.2	11.6	13.1
Region W of 2°W	9.1	13.4	13.5	15.7	11.4	13.7
Region E of 2°W	7.5	14.4	10.2	11.8	8.7	13.6

Table 3.3.1 Acoustic estimate of herring in the Norwegian Sea, May 2002.

	Age																
Length	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Number	Biomass	Mean w
16																	
17																	
18																	
19																	
20	117	23													140	9	63
21	82	82													164	13	76
22	130	441													571	51	86
23	155	1289													1444	151	98
24	144	1727	461												2332	256	110
25	50	1219	1841												3110	389	125
26		1029	1846												2875	397	138
27		378	1746												2124	317	149
28		75	1584												1659	276	166
29		42	882	42											966	178	185
30		20	675	123	20										838	168	201
31			342	342	68	17	17								786	174	222
32		16	115	493	214	33									871	210	241
33				274	187	72	101	72	72						778	208	267
34				129	274	113	387	806	709	306					2724	781	287
35				16	16	124	279	775	1271	574					3055	927	303
36						16	49	246	411	411	33				1166	382	327
37							14	42	28	84	28	42	28	14	280	99	356
38										49		37		12	98	39	396
39									9						9	4	425
40																	
TSN	677	6343	9619	1418	779	375	847	1941	2500	1423	61	78	28	26	26115	.	.
TSB	61.8	740	1473	342	204	106	247	581	757	445	20.7	29.4	9.9	9.8	.	5027.4	29.4
Mean l	22.9	24.9	27.5	32.4	33.4	34.4	34.8	35.2	35.4	35.8	37	38	37.5	38	.	.	
Mean w	91.3	117	153	241	262	283	292	299	303	313	341	375	356	375	.	.	192.5

Table 3.3.2. Age stratified estimate of Norwegian spring spawning herring in the Barents Sea, R/V "F. Nansen", May-June 2002. Numbers in millions, biomass in thousand tonnes, length in cm, mean weight in g.

Age	1	2	Total
Numbers	538	3935	4473
Percent	12.0	88.0	100
Mean length	7.9	29.6	27.9
Biomass	4.3	116.6	120.9
Mean weight	10.4	29.6	29.9

Table 3.3.3 Acoustic estimate of adult Norwegian Spring Spawning Herring in 03-26 July 2002 in the northeastern part of the Norwegian Sea.

Area, square miles 21681.0		The Norvegian Sea	
71°10'-68°00' N		R/F"F.Nansen"	
Length , cm	Average weigth gr.	Number 10^6	Biomass 10^3 tonns
19.0	62.95	5.962	0.375
20.0	73.11	48.213	3.525
21.0	84.30	13.194	1.112
22.0	96.56	19.910	1.923
23.0	109.95	141.143	15.518
24.0	124.50	490.800	61.102
25.0	140.26	1555.989	218.238
26.0	157.28	1508.018	237.179
27.0	175.61	1058.276	185.840
28.0	195.29	1044.048	203.889
29.0	216.37	693.571	150.065
30.0	238.89	405.254	96.811
31.0	262.91	310.020	81.506
32.0	288.46	153.407	44.252
33.0	315.59	70.887	22.372
34.0	344.36	56.589	19.487
35.0	374.80	77.395	29.008
36.0	406.95	51.324	20.886
37.8	440.88	34.148	15.055
38.0	476.61	1.509	0.719
Total:		7739.658	1408.863
Average length, cm 27.09			
Average weight, g 182.03			

Table 3.3.4 Acoustic estimate of adolescent herring in the northern Norwegian Sea, August 2002.

Length	2	3	4	5	6	7	8	9	10	11	Number	Biomass	Mean w
16													
17													
18													
19													
20	385										385	26.6	69
21	533										533	38.8	72.9
22	630										630	51.9	82.5
23	320	213									533	51.9	97.4
24	101	480									581	65.6	112.9
25	167	2176	28								2371	297.6	125.5
26	55	2835	218								3108	430.2	138.4
27	49	1205	320								1574	239.1	151.9
28		508	688								1196	210.7	176.2
29		198	461								659	130.3	197.8
30			361								361	78.8	218.4
31			225								225	55.9	248
32			24								24	5.6	232
33													
34									840		840	233.2	277.8
35					1400						1400	465.1	332.3
36							186	557	372	186	1301	428.7	329.6
37								153			153	63.9	419
38										264	264	102.1	387
39													
40													
TSN	2239	7616	2324	0	1400	0	186	710	1211	450	16138	2976	
TSB	195.9	1052	434.9		465.1		61.2	247.6	355.7	163.3	16136	2976	
Mean l	22.6	26.4	29.		35.5.		36.5	36.7	35.1	37.7			28.6
Mean w	87.5	138.2	187.1.		332.3.		329.6	348.8	293.7	363.3			184.4

Table 3.5.1. Acoustic estimate of blue whiting in the Norwegian Sea in May 2002. Data from R/V "Magnus Heinason" and R/V "G.O. Sars".

Length (cm)\Age (yr)	1	2	3	4	5	6	7	8	9	10	Number (10E6)	Biomass (10E6 kg)	Mean Weight (g)	Length (cm)
17.5	591	0	0	0	0	0	0	0	0	0	591	15.3	25.9	
18.5	3180	0	0	0	0	0	0	0	0	0	3180	98.8	31.1	
19.5	5109	3866	0	0	0	0	0	0	0	0	8975	334.6	37.3	
20.5	4202	13899	0	0	0	0	0	0	0	0	18100	808	44.6	
21.5	2589	12877	0	0	0	0	0	0	0	0	15466	811.6	52.5	
22.5	1259	8990	539	0	0	0	0	0	0	0	10787	666	61.7	
23.5	358	7510	2920	0	0	0	0	0	0	0	10787	766.1	71	
24.5	35	2457	4221	0	0	0	0	0	0	0	6713	547.5	81.6	
25.5	0	1357	4852	305	0	0	0	0	0	0	6514	591.6	90.8	
26.5	0	634	2918	856	32	32	0	0	0	0	4473	460.6	103	
27.5	0	27	906	1625	0	0	0	0	0	0	2557	295	115.4	
28.5	0	0	260	1851	116	87	0	0	0	0	2313	293	126.7	
29.5	0	0	99	829	133	133	0	0	0	0	1193	172.3	144.4	
30.5	0	0	0	176	234	234	0	0	0	0	644	96.9	150.3	
31.5	0	0	0	32	158	63	0	0	0	0	253	40.9	161.4	
32.5	0	0	0	33	33	0	0	0	0	0	67	12.5	187.5	
33.5	0	0	0	0	0	51	0	0	0	0	51	6.4	125	
34.5	0	0	0	0	0	26	0	26	0	0	52	10.9	210	
35.5	0	0	0	0	0	0	0	0	0	0	0	0	.	
36.5	0	0	0	0	0	0	0	0	0	0	0	0	.	
37.5	0	0	0	0	0	0	0	0	0	6	6	1.5	269	
TSN(10^6)	17321	51616	16716	5707	706	626	0	26	0	6	92724	.	.	
TSB(10^6 kg)	733.9	2920.7	1478	695.2	104.1	90.7	0	5.4	0	1.5	.	6029.6	.	
Mean length (cm)	20.1	21.9	25.2	28	30.1	30.3	.	34.5	.	37.5	.	.	.	22.6
Mean weight (g)	42.4	56.6	88.4	121.8	147.4	144.9	.	210	.	269	.	.	65	

Table 3.5.2. Acoustic estimate of blue whiting 8-26 June in 2002. Data from R/V "F.Nansen"

Area: square miles 107310.0		The Norwegian Sea, 63°-67°N	
Length , cm	Average weigth g.	Number 10^6	Biomass 10^3 tonns
19.0	45.9	39.2	1.8
20.0	52.5	172.9	9.1
21.0	59.7	1334.2	79.6
22.0	67.4	2168.8	146.2
23.0	75.8	3590.0	271.9
24.0	84.7	4186.0	354.5
25.0	94.3	4091.3	385.7
26.0	104.5	2419.1	252.8
27.0	115.4	1436.5	165.7
28.0	126.9	689.4	87.5
29.0	139.2	248.0	34.5
30.0	152.1	113.6	17.3
31.0	165.8	102.1	16.9
32.0	180.2	63.5	11.5
33.0	195.4	5.3	1.0
34.0	211.4	25.9	5.5
35.0	228.1	2.1	0.5
36.0	245.6	6.2	1.5
Total:		20694.2	1843.5
Average length, cm 25.7			
Average weight, gr 89.1			

Table 3.5.3. Acoustic estimate of blue whiting 3-26 July in 2002. Data from R/V "F.Nansen".

Area, square miles 81445.8		The Norvegian Sea, 67°-71°N	
Length, cm	Average weigth, g	Number, 10^6 ind.	Biomass 10^3 tonns
19.0	40.0	20.4	0.8
20.0	46.4	194.9	9.1
21.0	53.6	680.7	36.5
22.0	61.4	1650.3	101.3
23.0	69.9	2855.4	199.6
24.0	79.2	2516.1	199.3
25.0	89.2	2538.6	226.5
26.0	100.1	1650.1	165.2
27.0	111.8	1124.6	125.7
28.0	124.4	400.4	49.8
29.0	137.8	107.0	14.7
30.0	152.2	37.2	5.5
31.0	167.5	9.0	1.5
Total:		13784.6	1135.7
Average length, cm 24.19			
Average weight, g 82.39			

Table 3.5.4. Acoustic estimate of blue whiting in the Icelandic EEZ in July 2002. Data from R/V "Árni Fridriksson".

Age	0	1	2	3	4	5	6	7	8	9	Total
Numbers (10^{-6})	3814.5	10785.4	3106.9	1436.2	1723.7	1430.4	726.9	177.7	47.1	4.8	23253.6
Frequency (%)	16.40	46.38	13.36	6.18	7.41	6.15	3.13	0.76	0.20	0.02	100
Mean weight (g)	20.3	69.2	95.5	111.1	126.1	142	157	173.4	267.4	205	79.95
Mean length (cm)	14.8	22.8	24.9	26.2	27.6	29.3	30.6	30.9	36.9	35	23.07
Biomass ($t*10^{-3}$)	77.43	746.35	296.71	159.56	217.36	203.12	114.12	30.81	12.59	0.98	1859.05

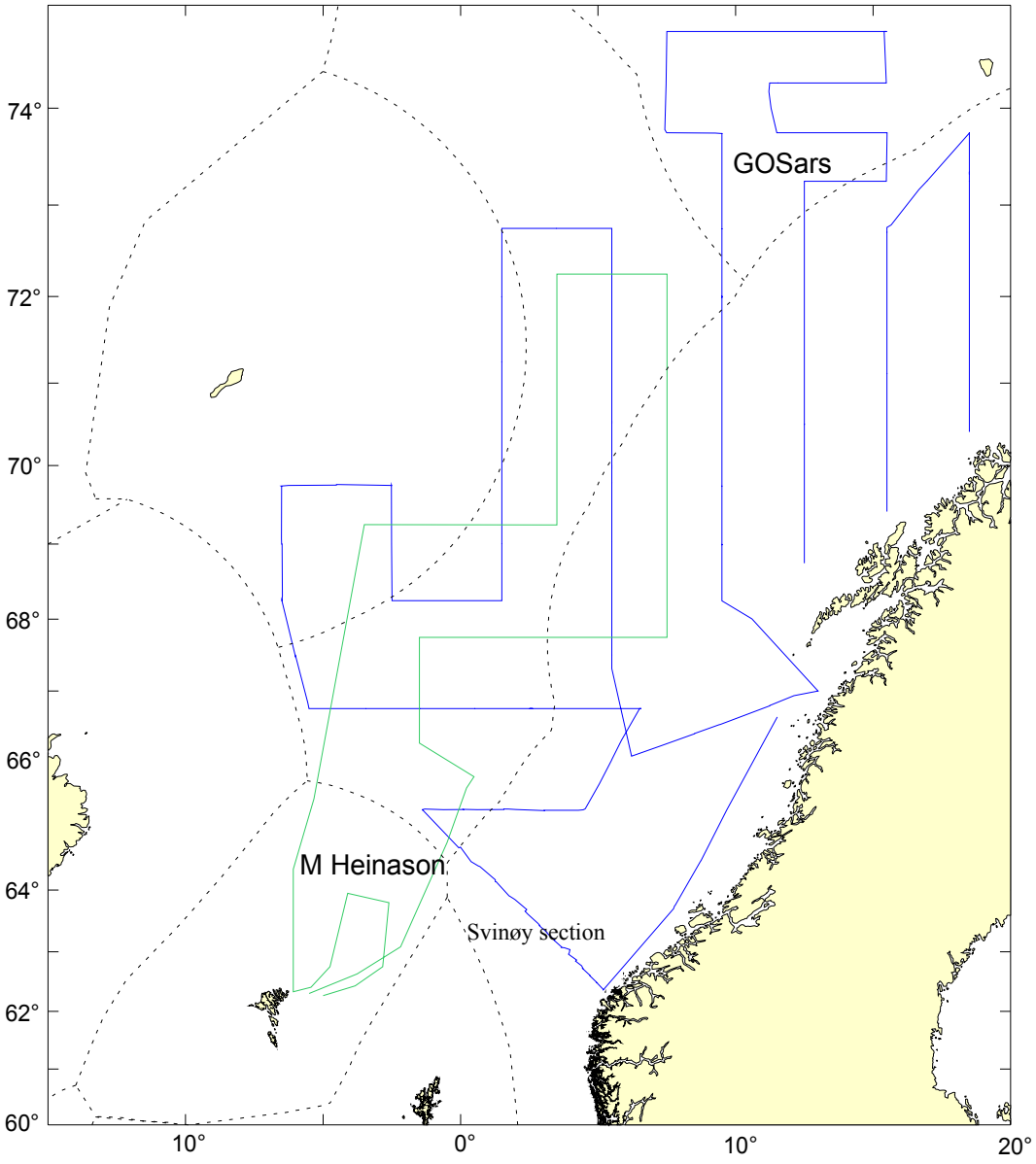

Figure 2.1. Cruise tracks for the Faroese R/V "Magnus Heinason" and the Norwegian R/V "G.O. Sars" in the Norwegian Sea in late April and May 2002.

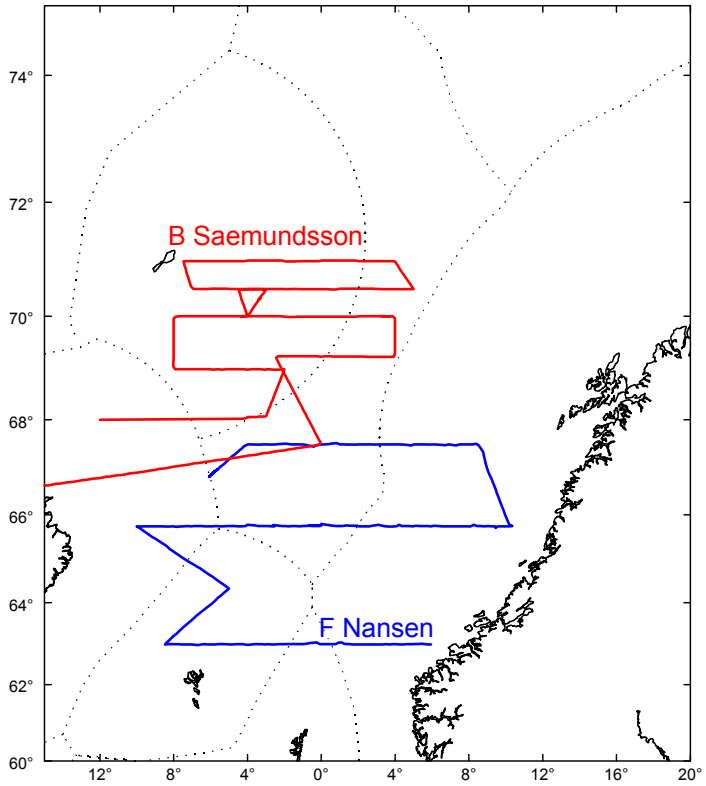

Figure 2.2. Survey transects of the R/V "Bjarni Saemundsson" and R/V "Fridtjof Nansen" in June 2002.

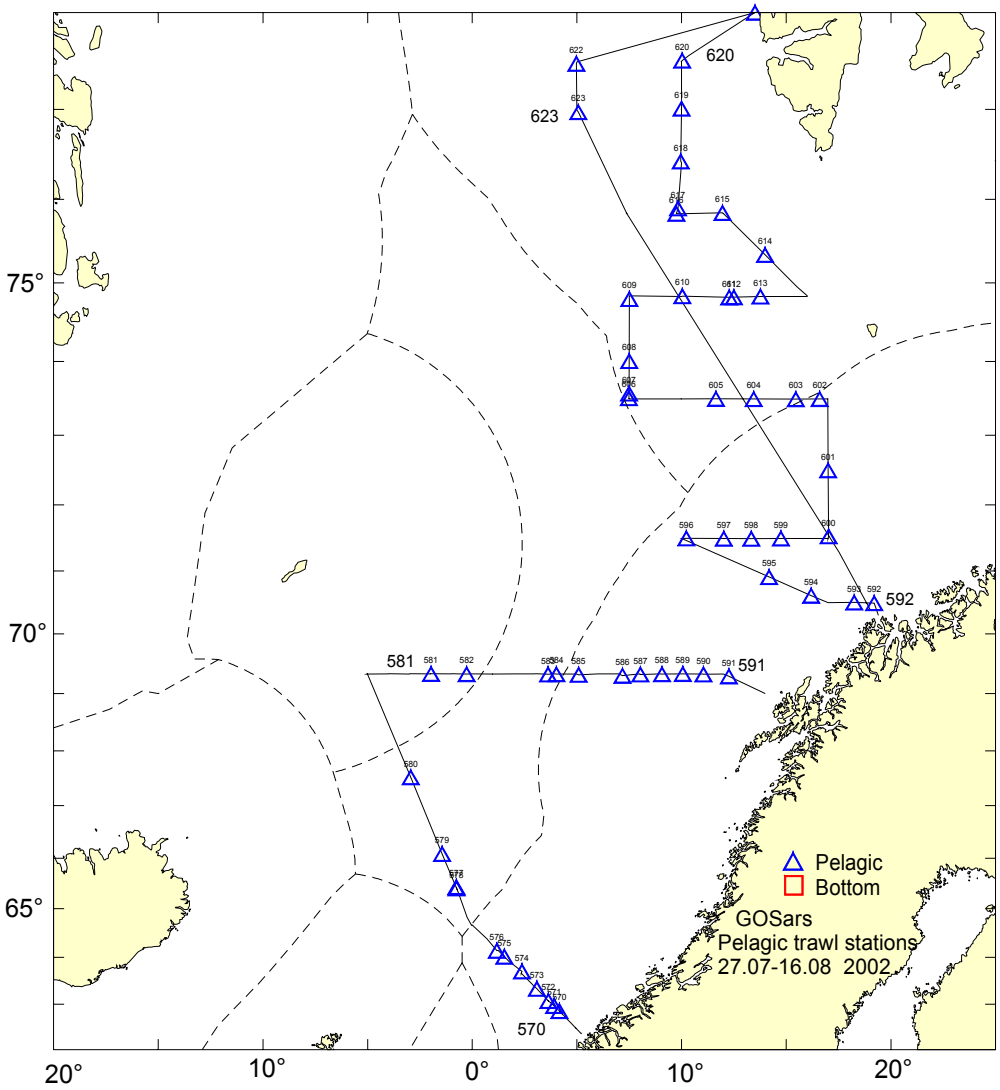

Figure 2.3. Cruise tracks and trawl stations for R/V "G.O. Sars" 27.07-15.08. 2002.

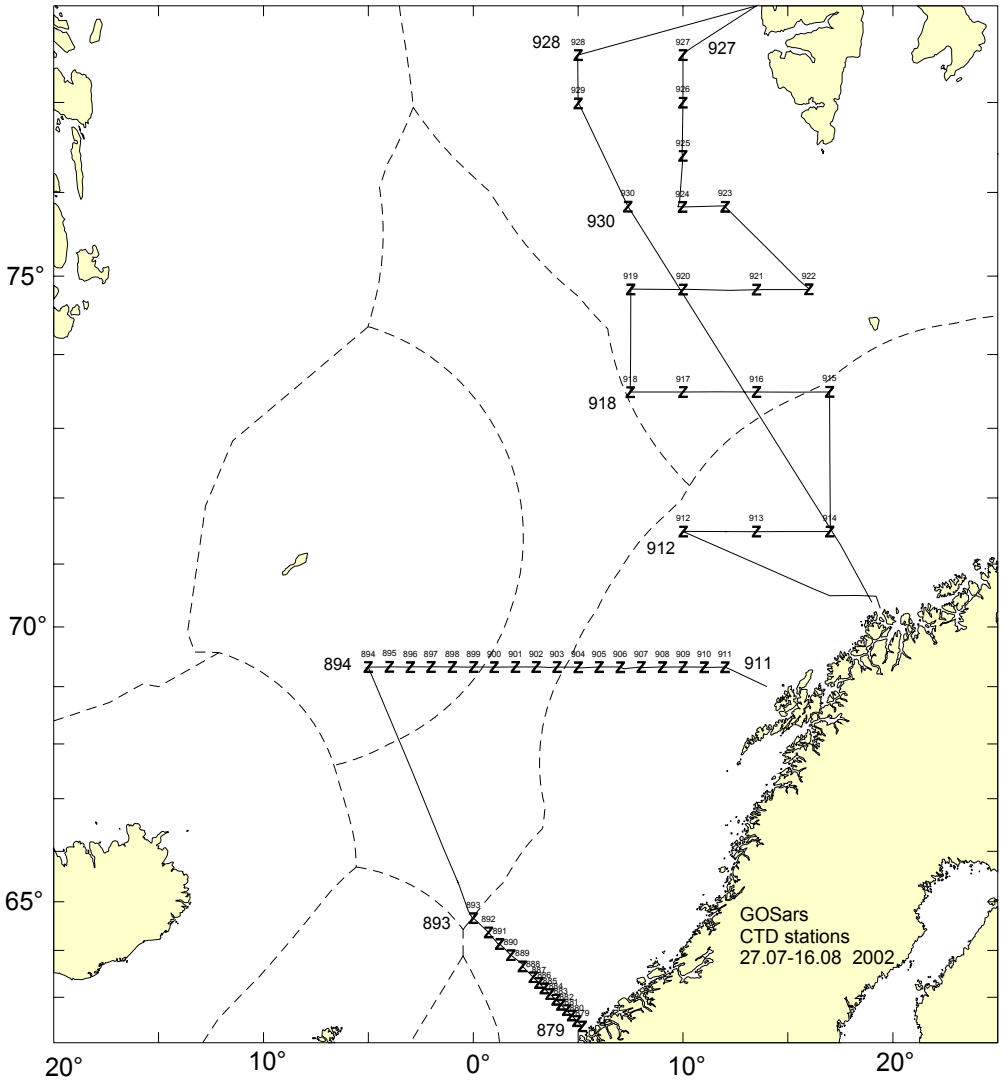

Figure 2.4. Cruise tracks and CTD stations for R/V "G.O. Sars" 27.07-15.08. 2002.

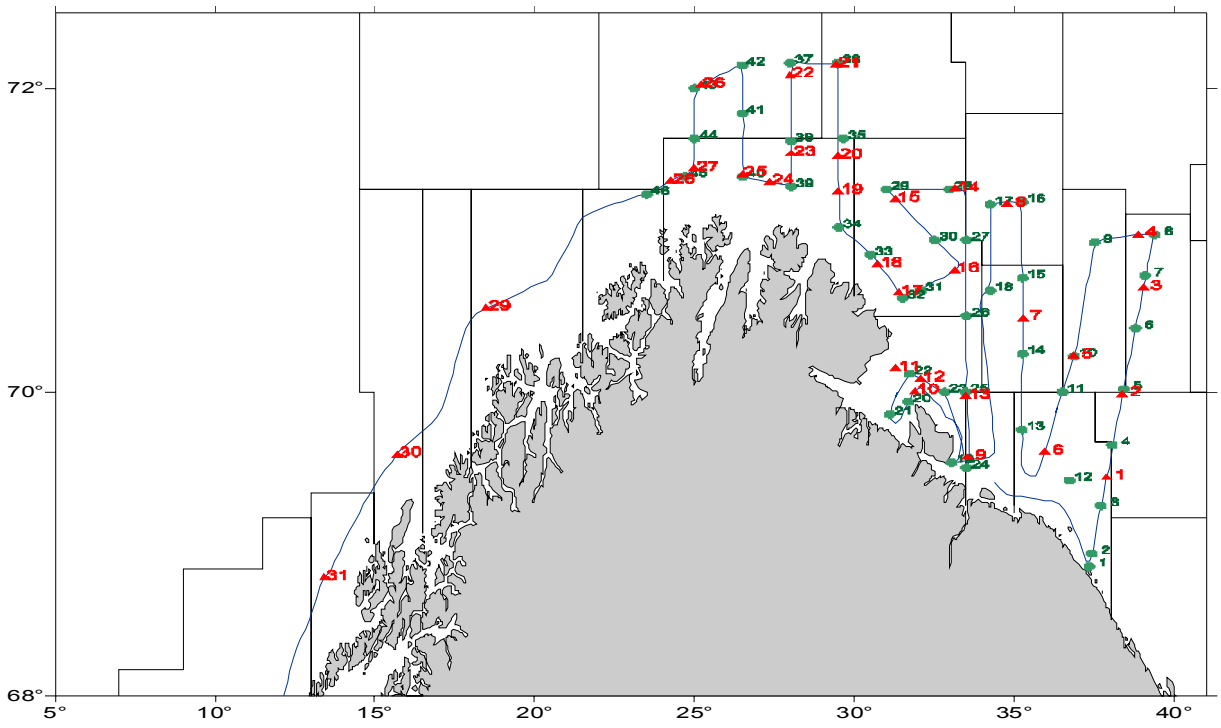

Figure 2.5. Cruise tracks and pelagic trawls (red triangles) and CTD stations (green circles) in the Barents Sea 28.05-07.06.2002. RV "F. Nansen".

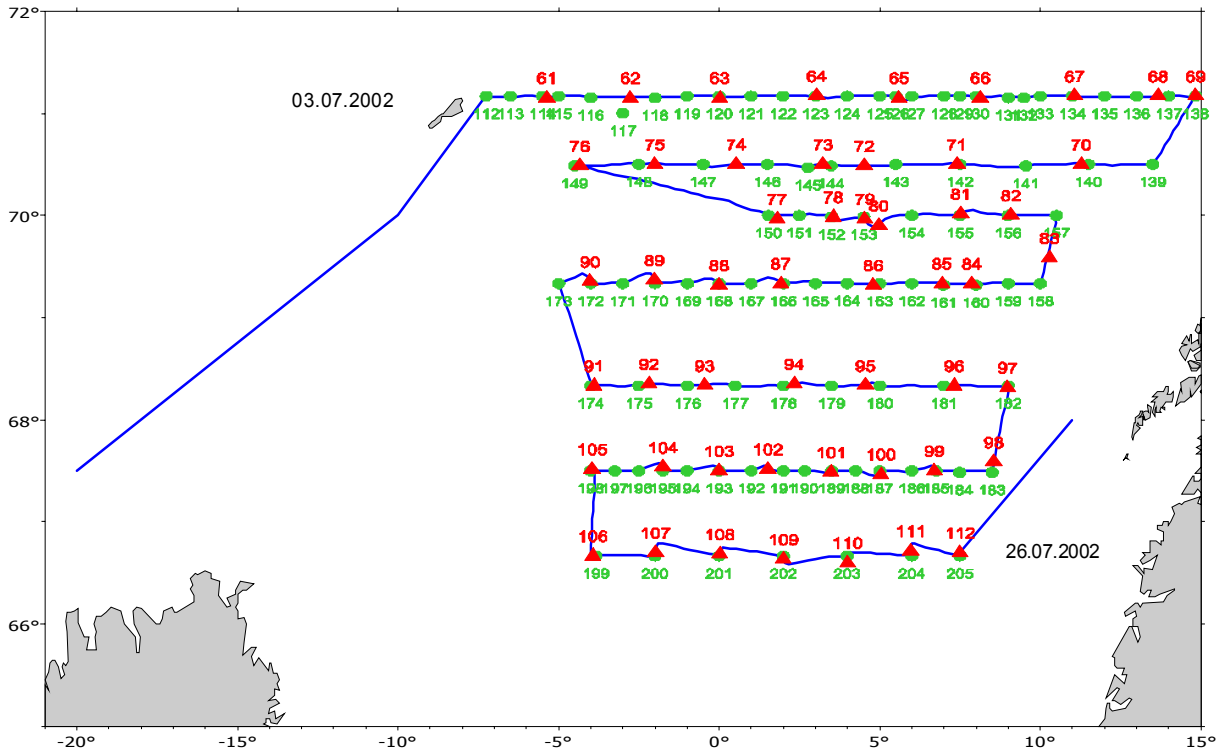

Figure 2.6. Cruise tracks and pelagic trawls (red triangles) and CTD stations (green circles) in the Norwegian Sea 03-26.07.2002. RV "F. Nansen".

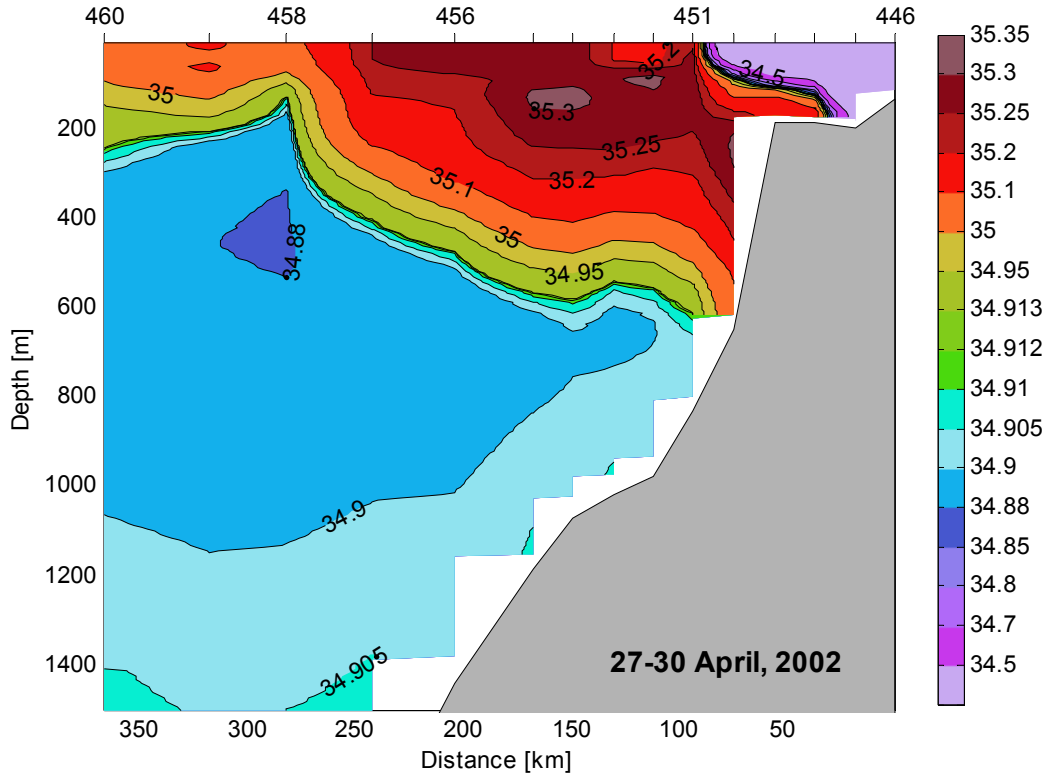

Figure 3.1.1. Salinity in the Svinøy section, 27-30 April 2002.

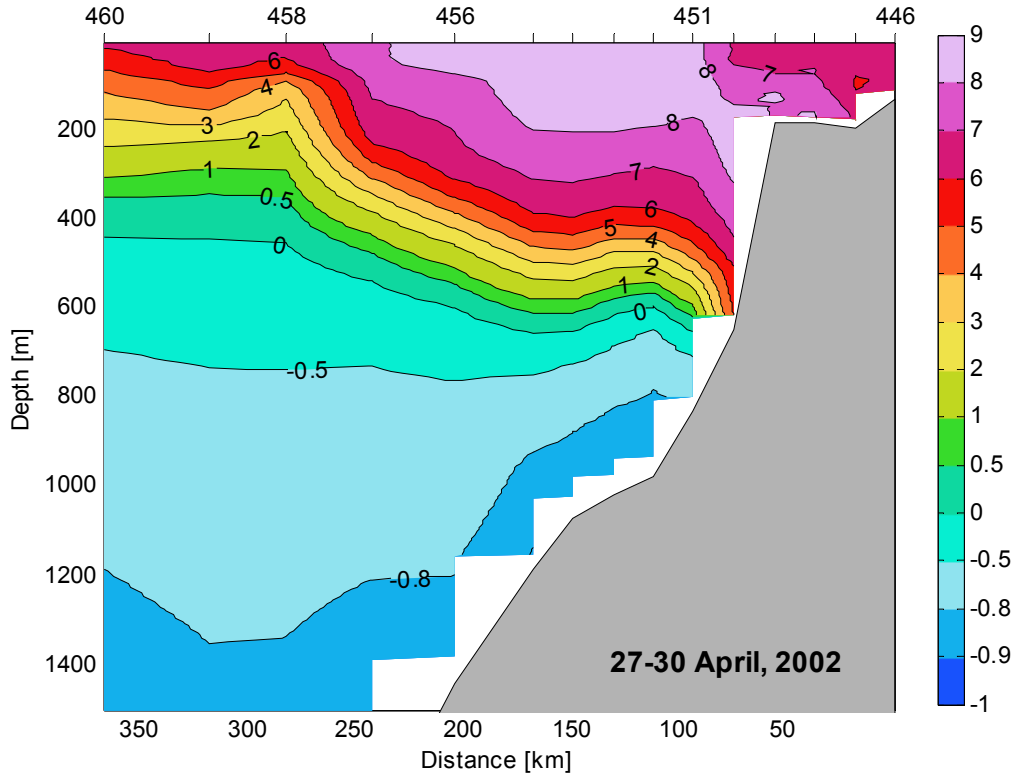

Figure 3.1.2. Potential temperature in the Svinøy section, 27-30 April 2002.

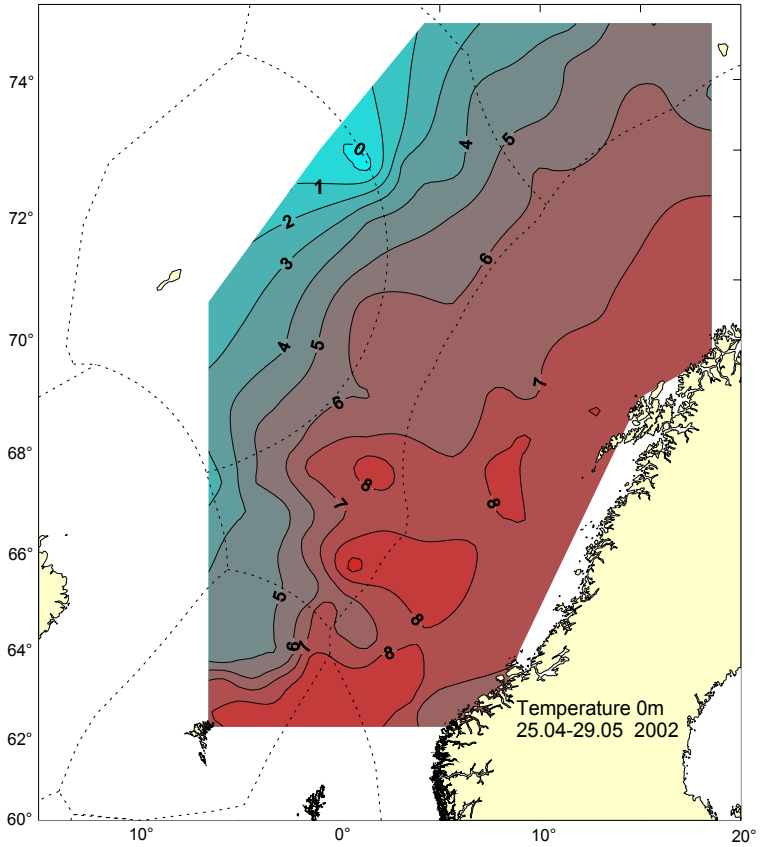

Figure 3.1.3 Surface temperature in May 2002.

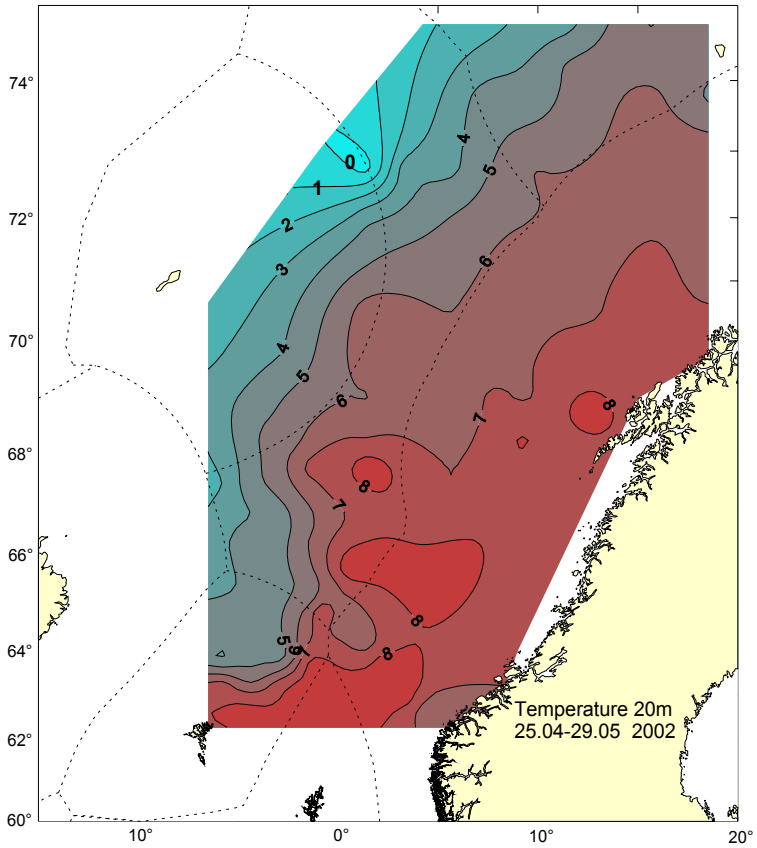

Figure 3.1.4. Temperature at 20 m in May 2002.

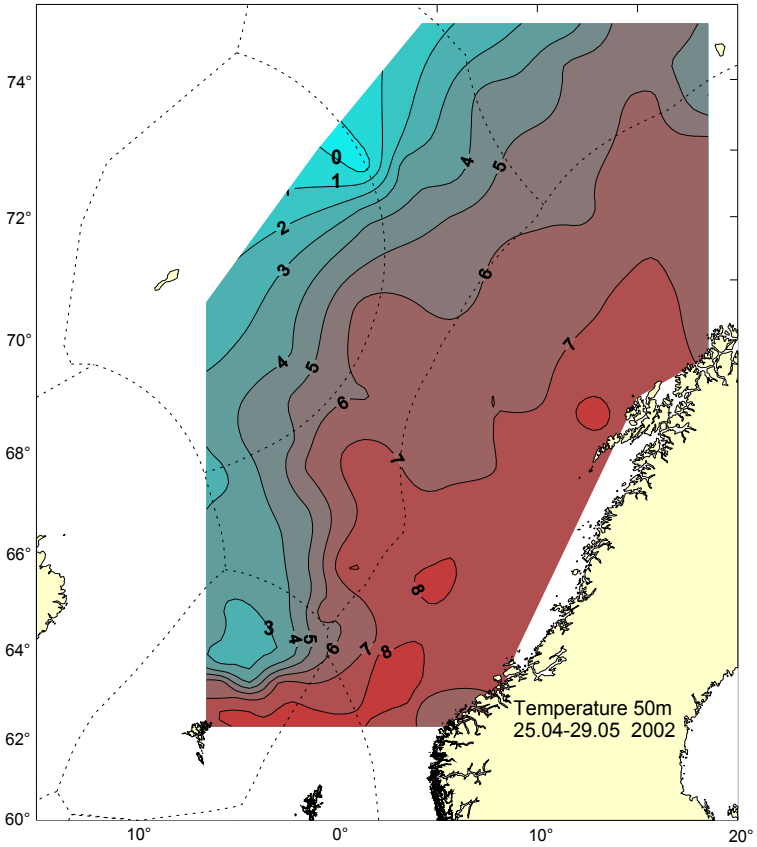

Figure 3.1.5. Temperature at 50 m in May 2002.

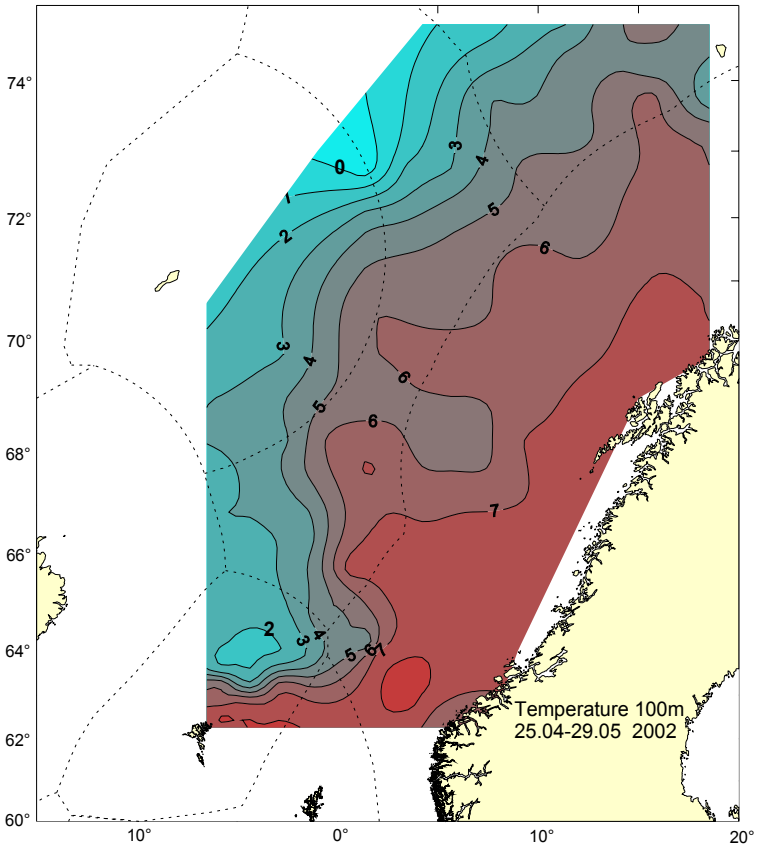

Figure 3.1.6. Temperature at 100 m in May 2002.

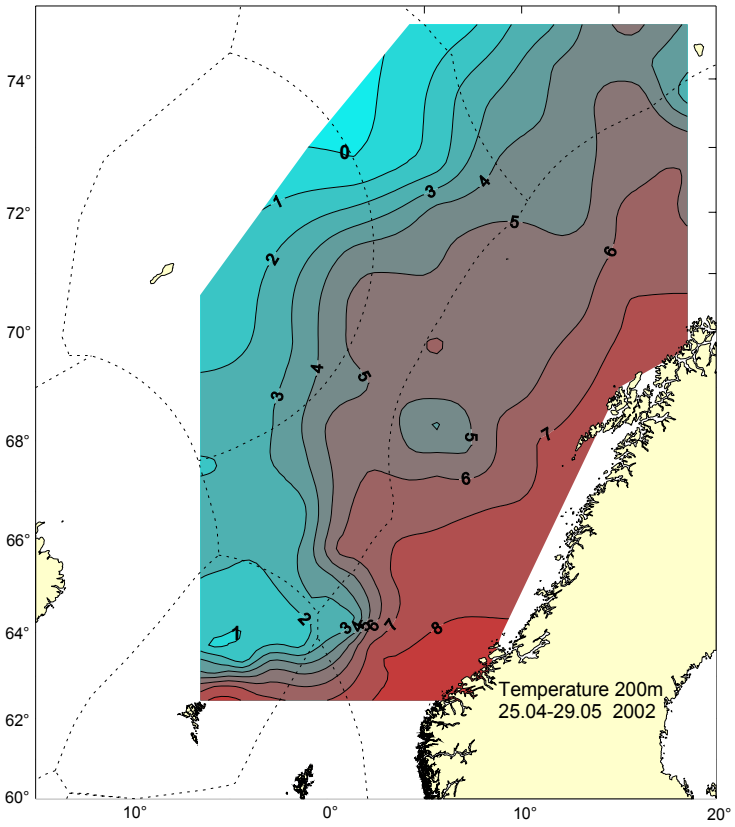

Figure 3.1.7. Temperature at 200 m in May 2002.

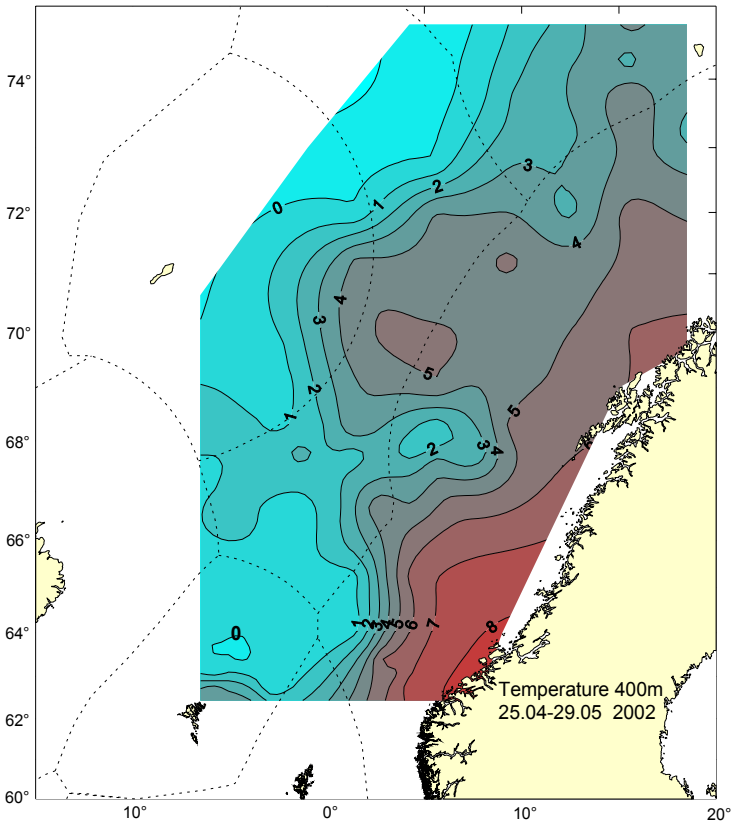

Figure 3.1.8. Temperature at 400 m in May 2002.

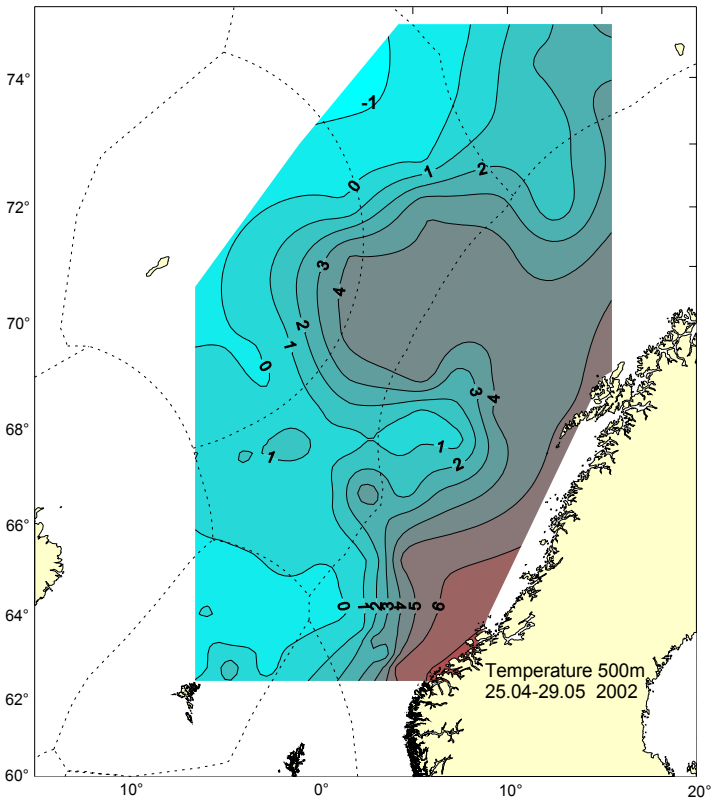

Figure 3.1.9. Temperature at 500 m in May 2002.

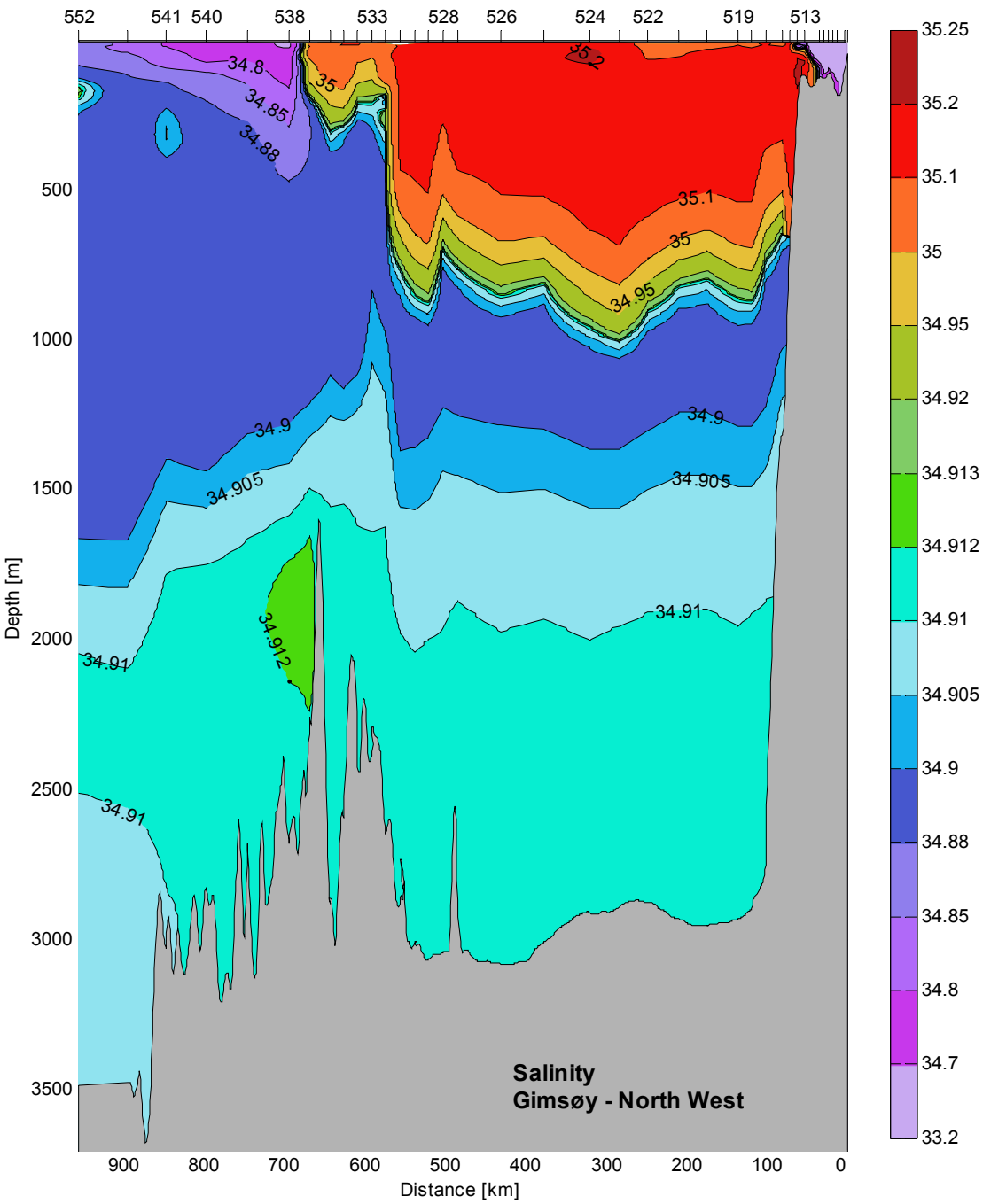

Figure 3.1.10. Salinity in the extended Gimsøy – NW section. Norwegian coast (Gimsøy) is on the right.

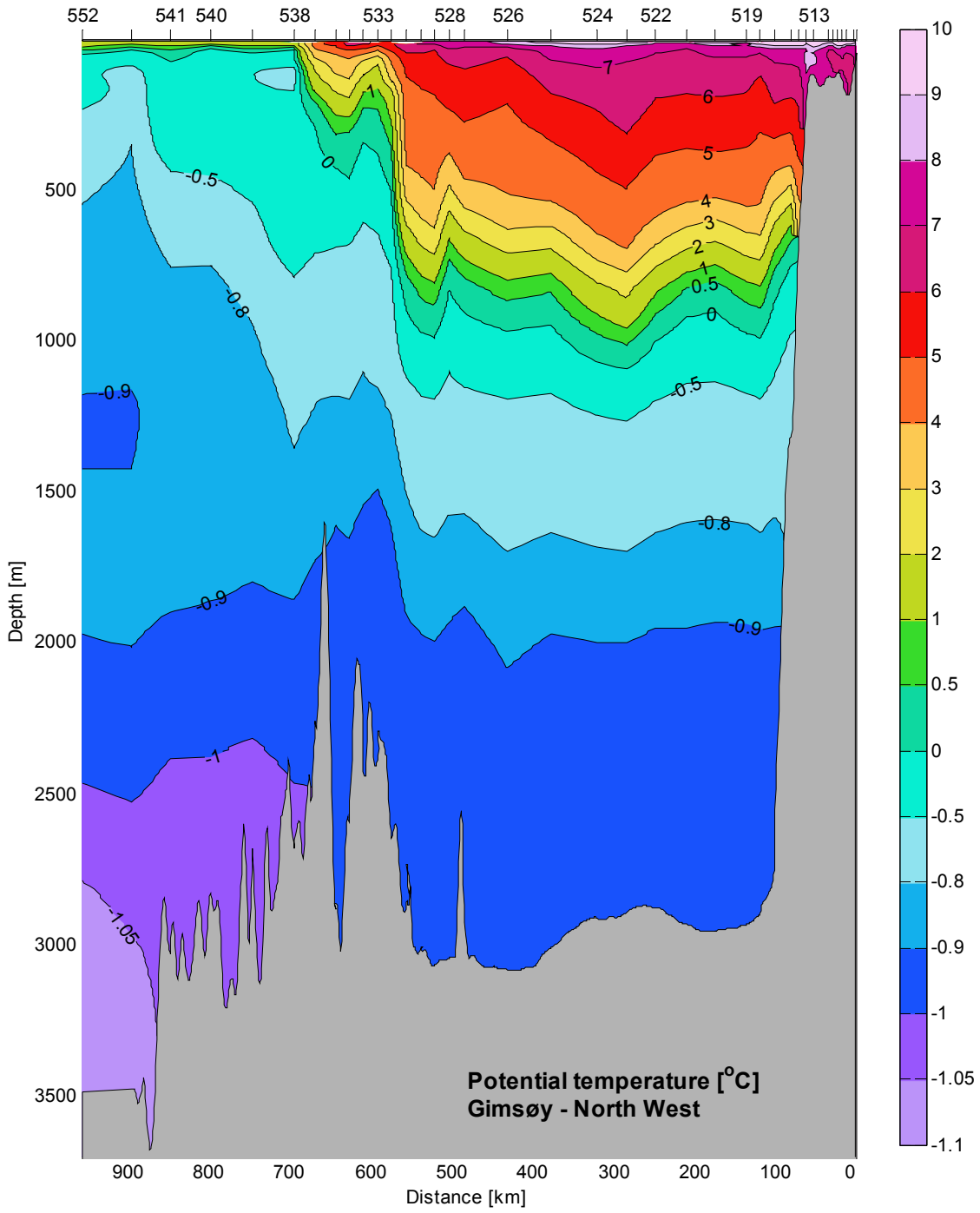

Figure 3.1.11. Potential temperature in the extended Gimsøy – NW section. Norwegian coast (Gimsøy) is on the right.

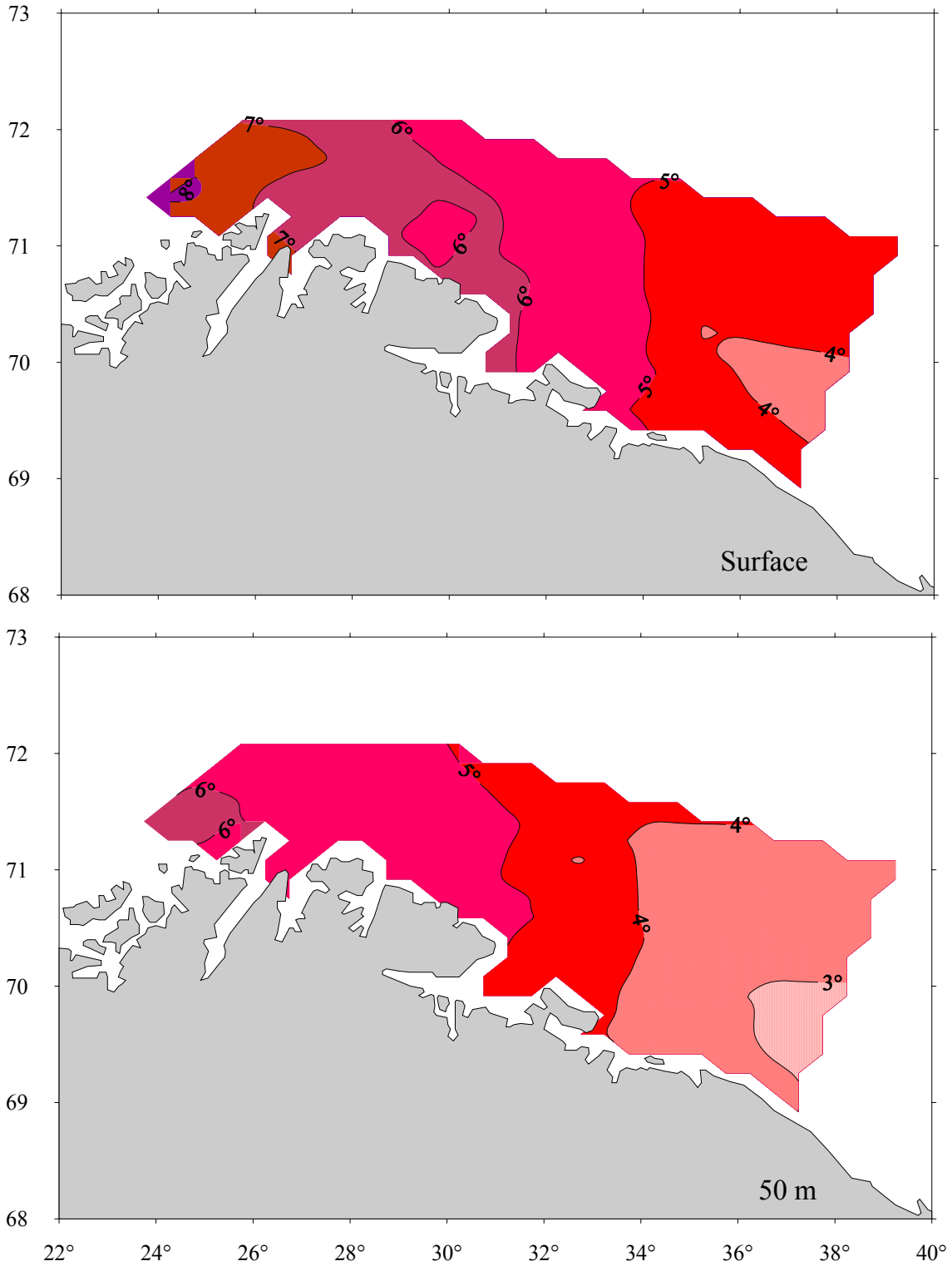

Figure 3.1.12. Temperature at surface and 50 m in the Barents Sea in May-June 2002. RV ".F. Nansen"

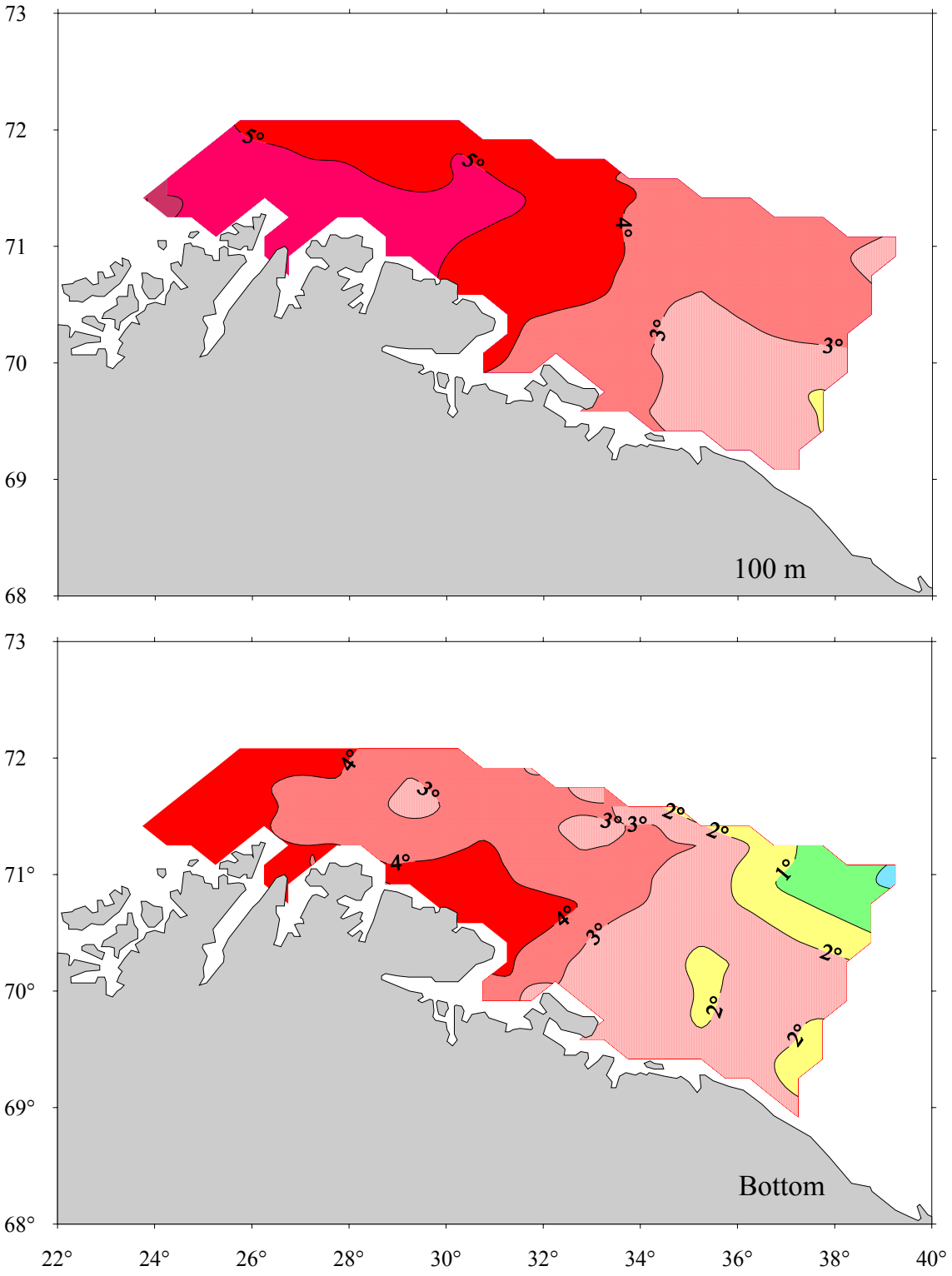

Figure 3.1.13 Temperature at 100 m and near bottom in the Barents Sea in May-June 2002. RV "F. Nansen"

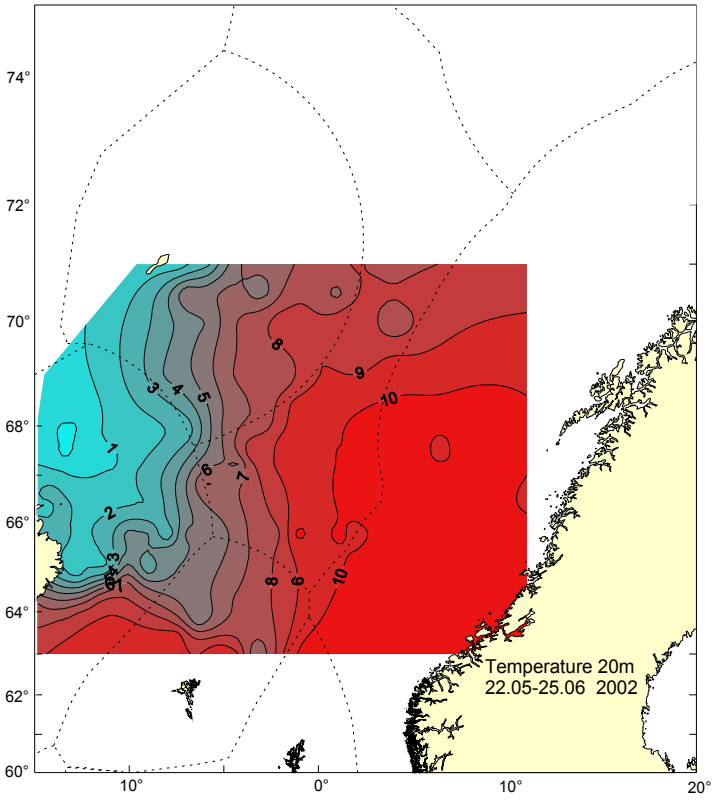

Figure 3.1.14. Temperature at 20 m in June 2002.

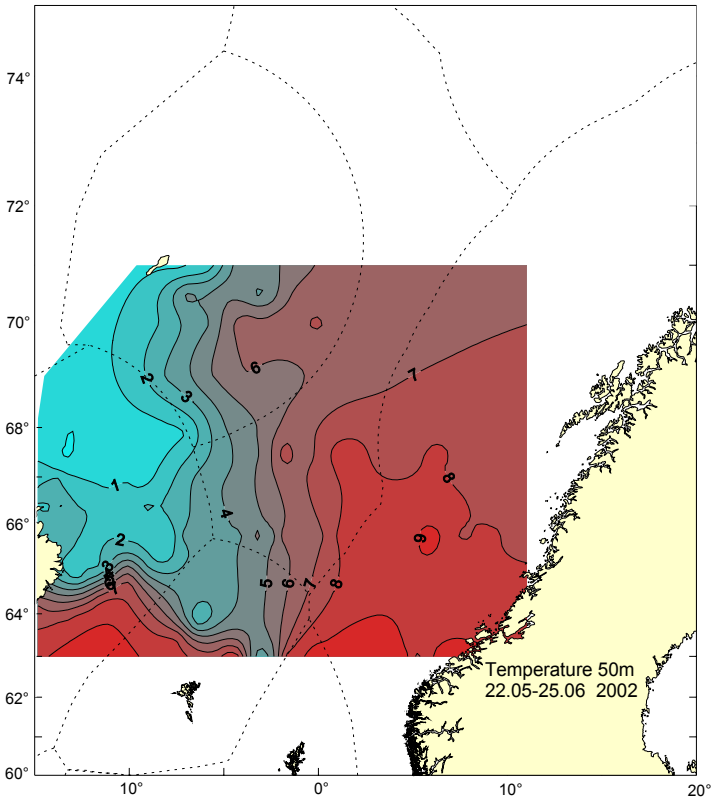

Figure 3.1.15. Temperature at 50 m in June 2002.

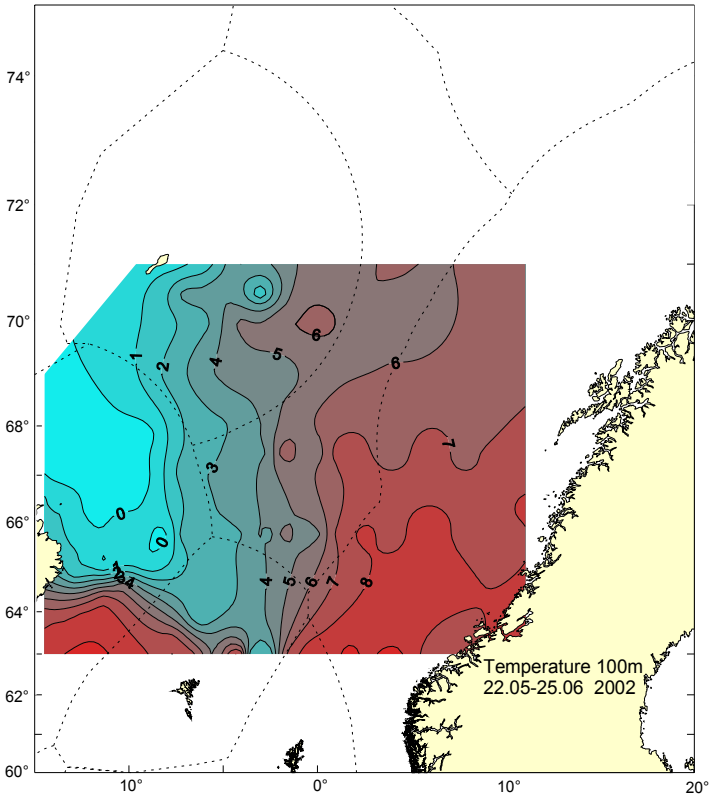

Figure 3.1.16. Temperature at 100 m in June 2002.

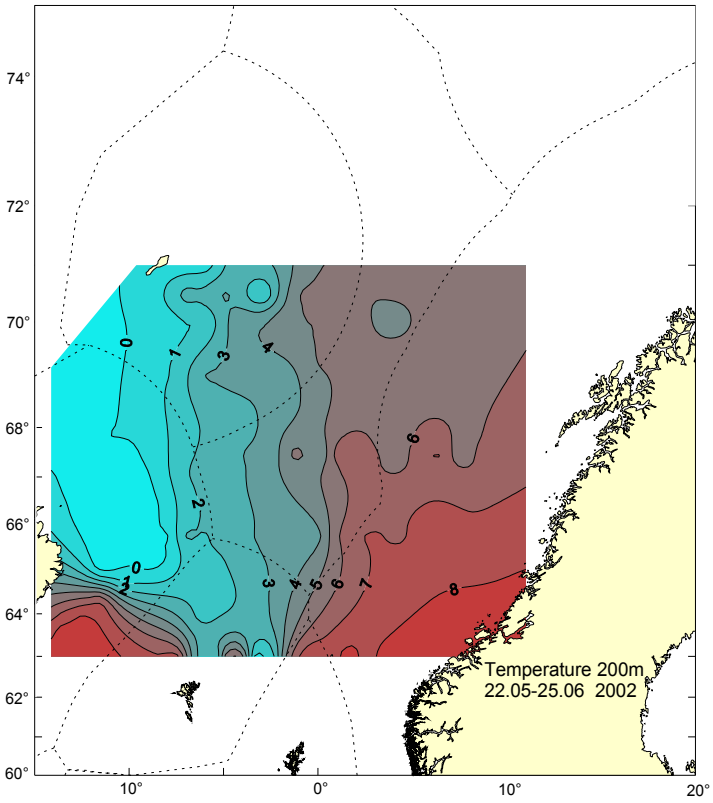

Figure 3.1.17. Temperature at 200 m in June 2002.

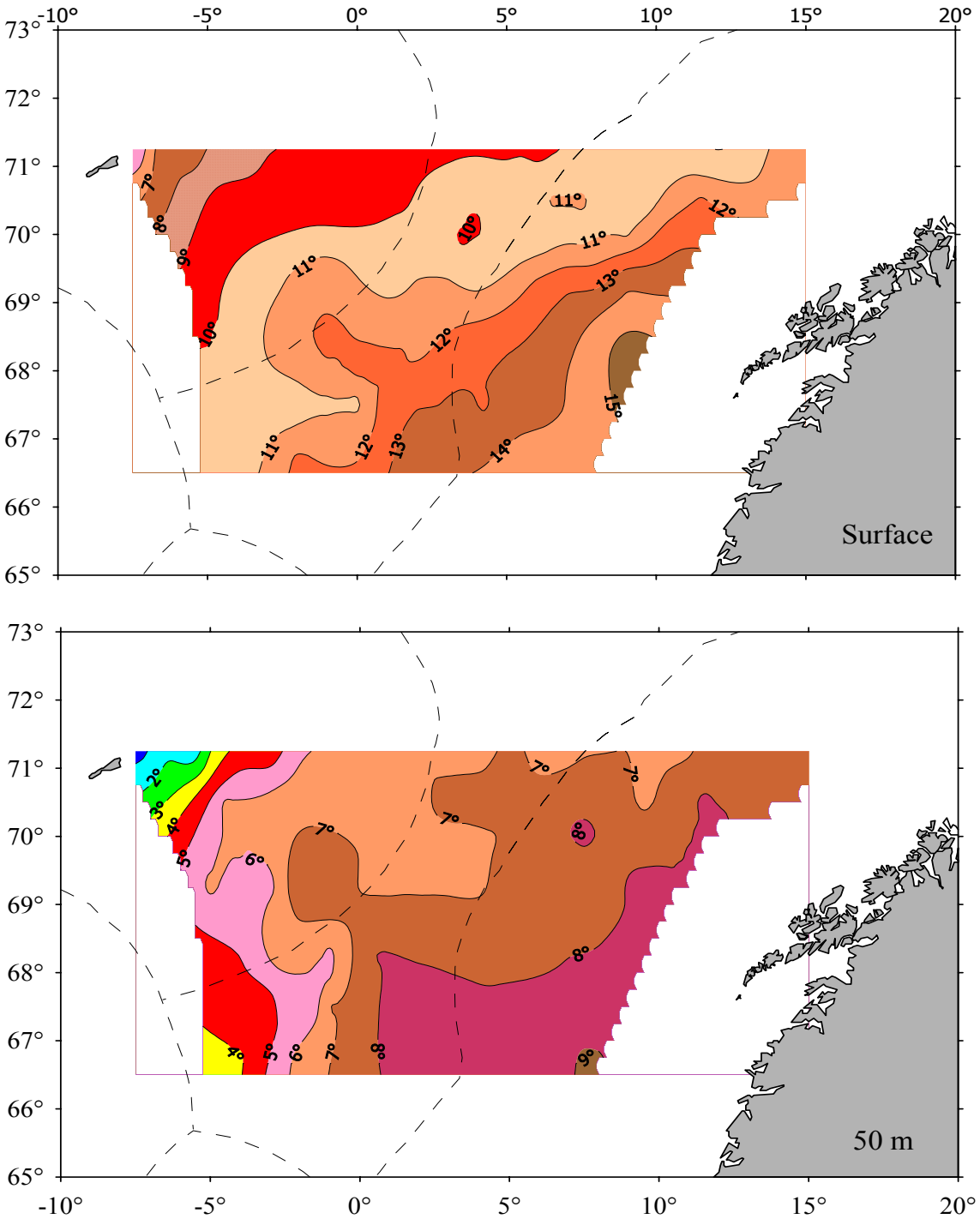

Figure 3.1.18. Temperature (°C) at surface and 50 m in the Norwegian Sea in July 2002. RV "F. Nansen"

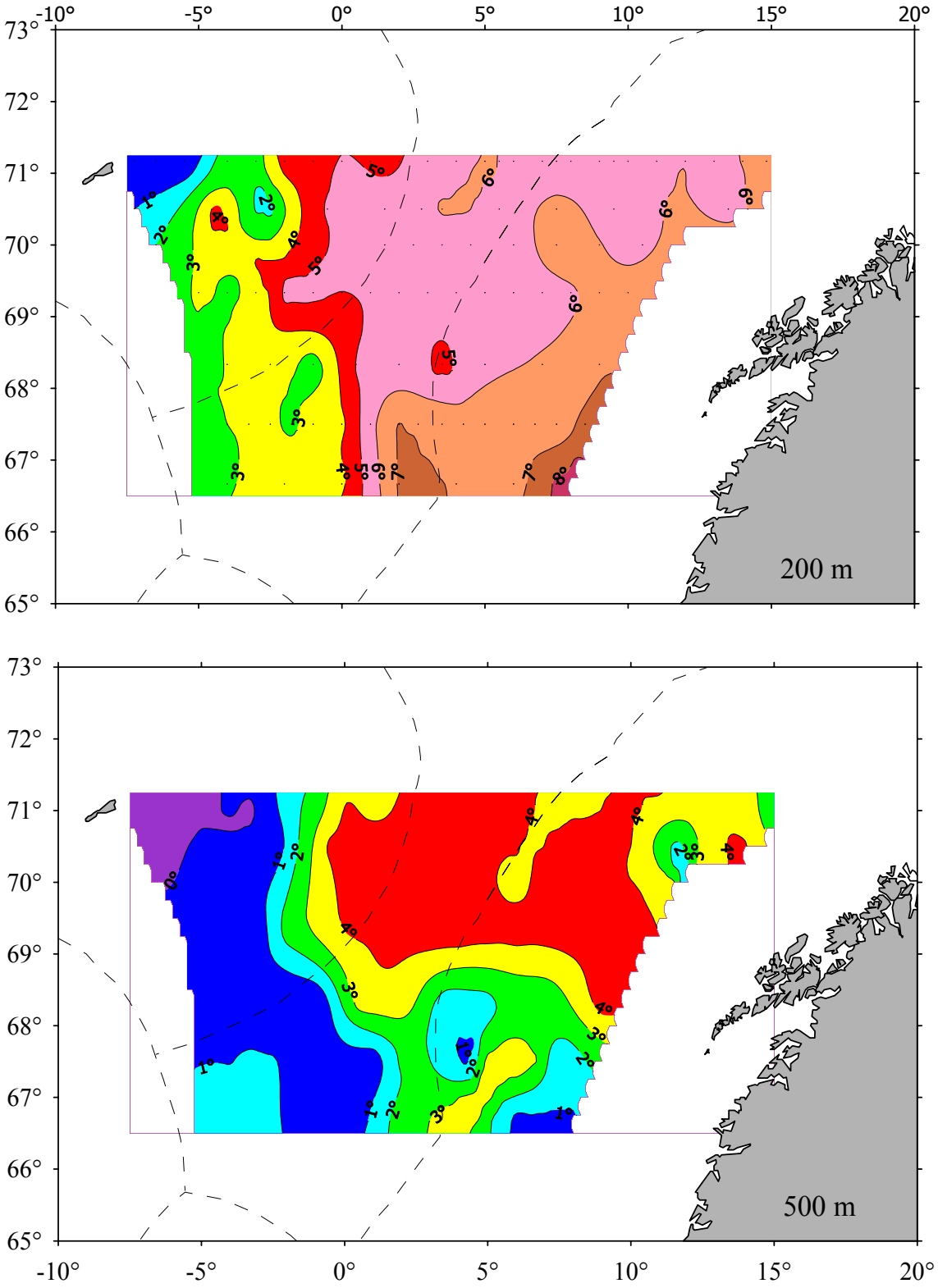

Figure 3.1.19. Temperature (°C) at 200 and 500 m in the Norwegian Sea in July 2002. RV "F. Nansen"

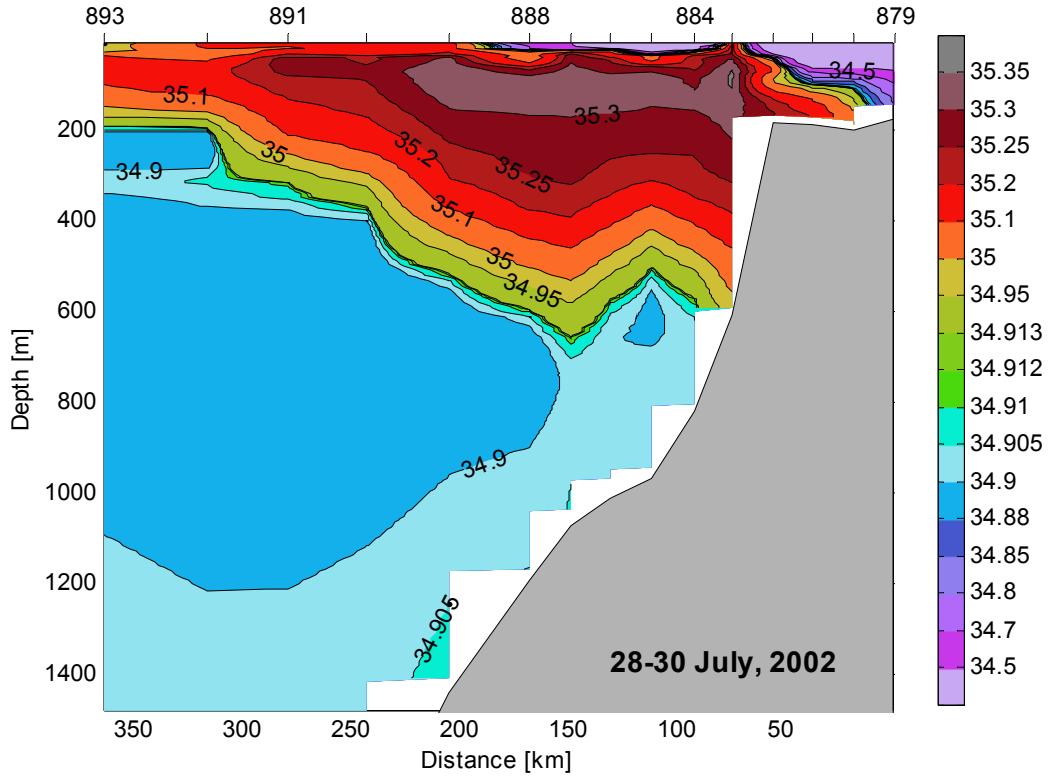

Figure 3.1.20. Salinity in the Svinøy section, 28-30 July 2002.

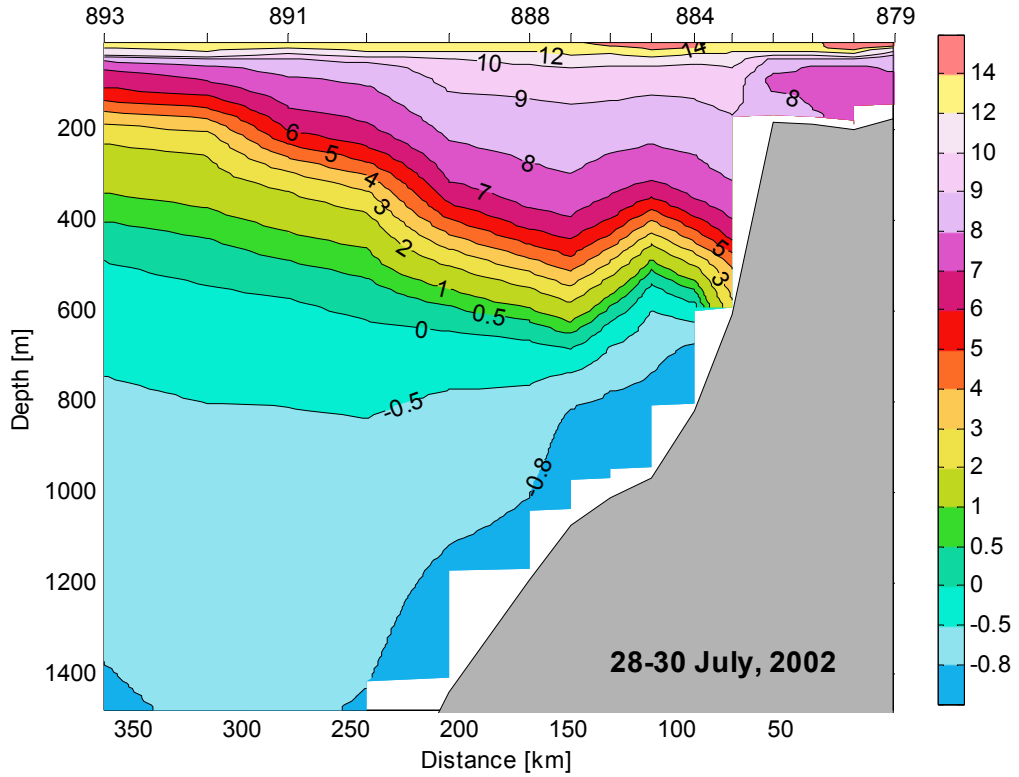

Figure 3.1.21. Potential temperature in the Svinøy section, 28-30 July 2002.

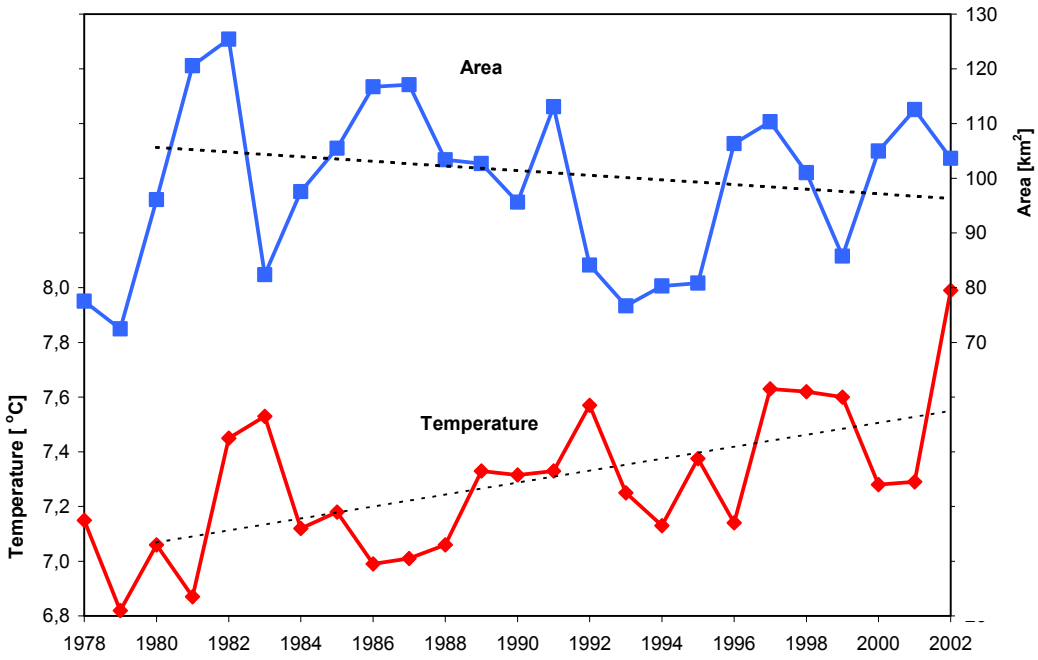

Figure 3.1.22. Time series of area occupied by Atlantic water and its averaged temperature in the Svinøy section for July/August (See Fig. 2.4 for the section).

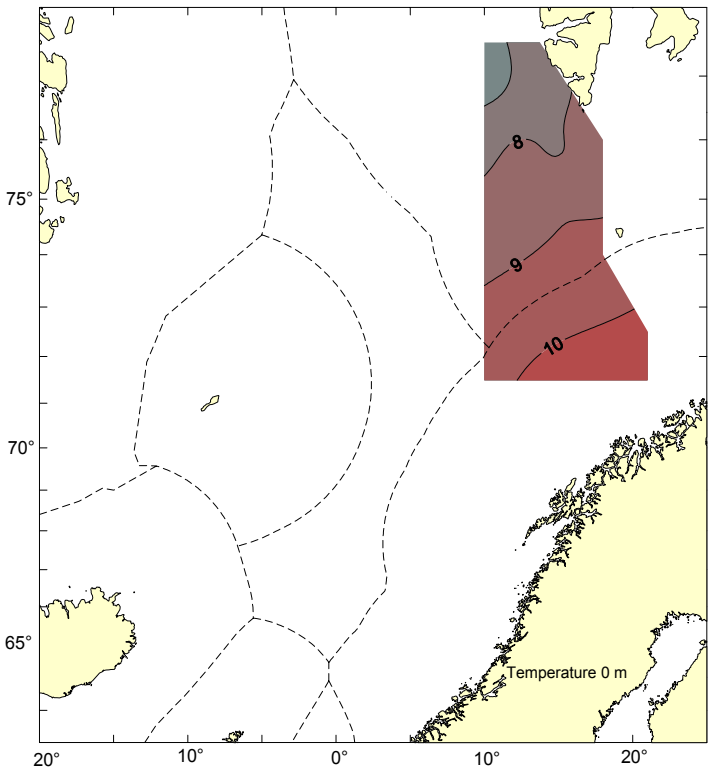

Figure 3.1.23. Surface temperature in July/August 2002.

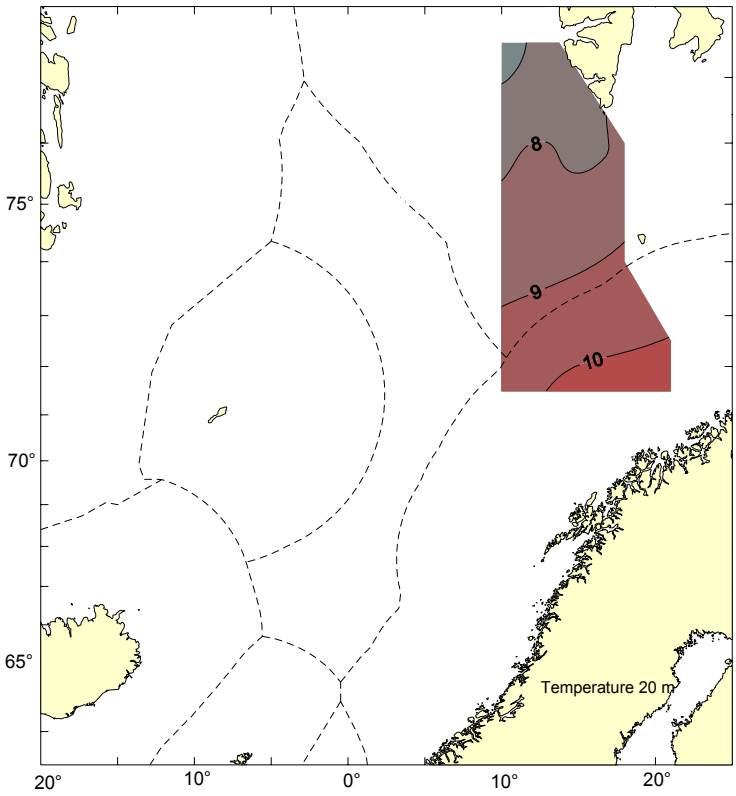

Figure 3.1.24. Temperature at 20 m in July/August 2002.

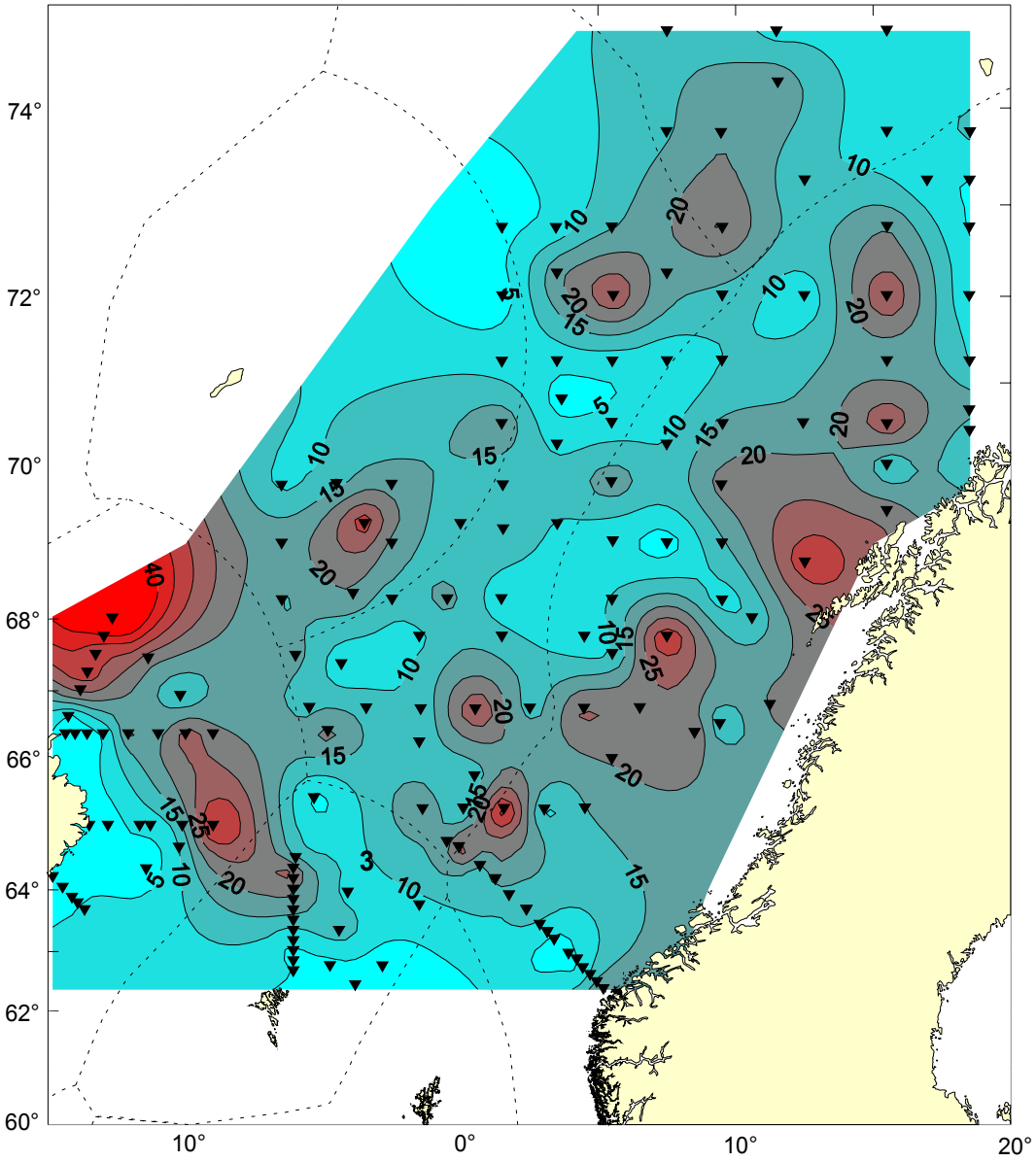

Figure 3.2.1. Zooplankton biomass (g dw m^{-2}) (200-0m) (50-0 m in Icelandic standard sections) in May 2002.

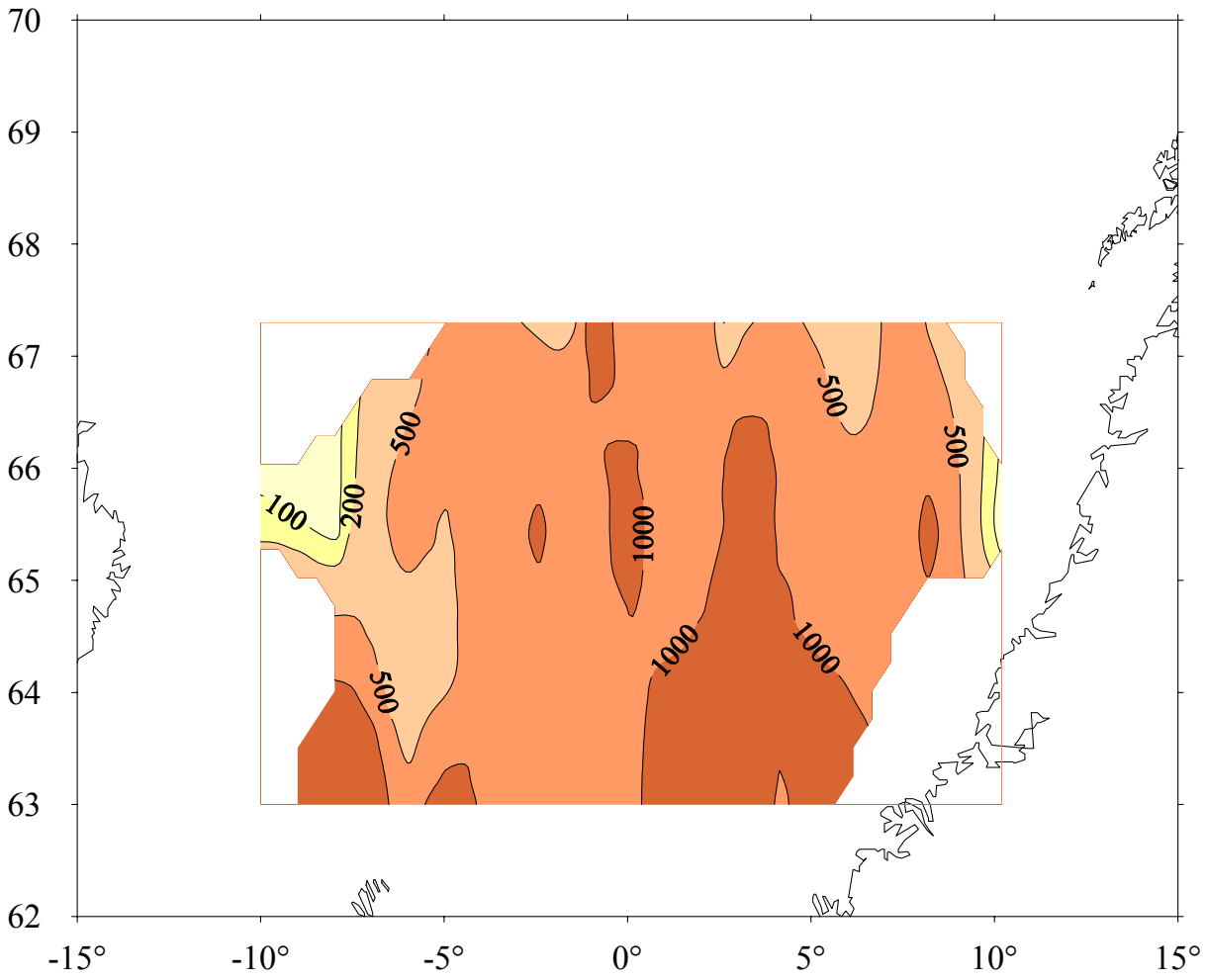

Figure 3.2.2. Distribution of plankton biomass (mg m^{-3}) in layer 50-0 m in June 2002.

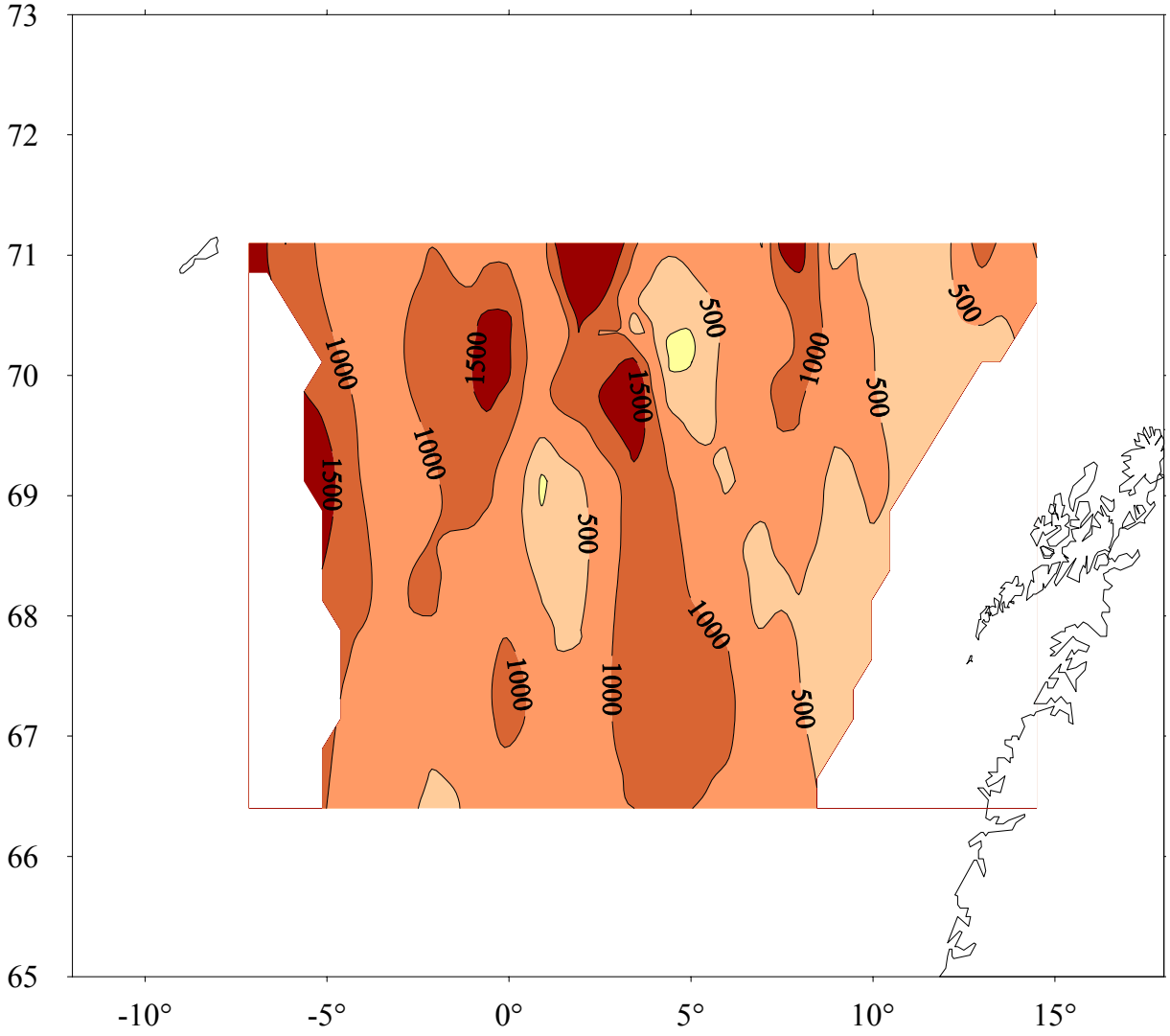

Figure 3.2.3. Distribution of plankton biomass (mg m^{-3}) in layer 50-0 m in July 2002.

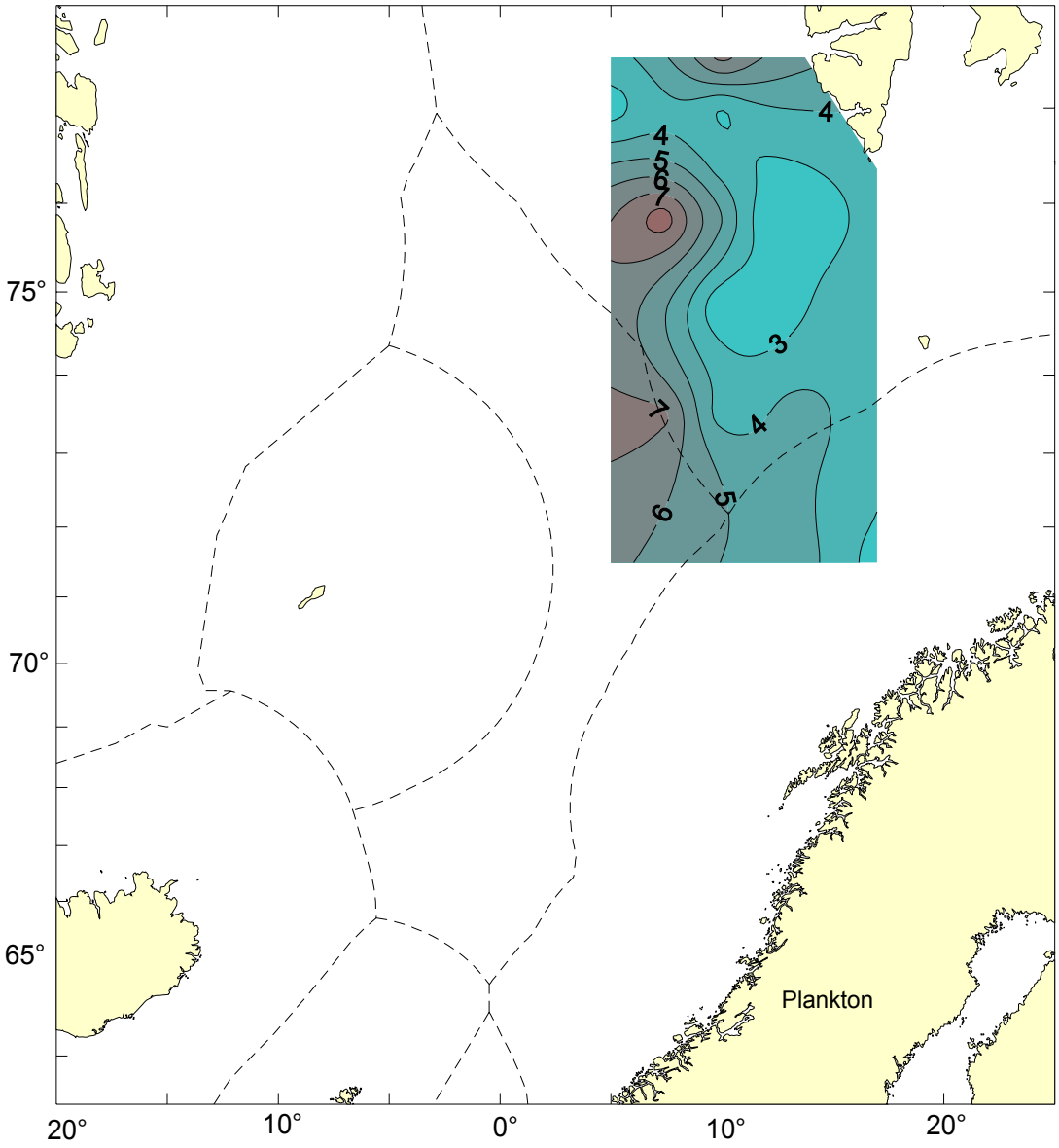

Figure 3.2.4. Zooplankton biomass (g dw m^{-2}) (200-0m) in July to August 2002.

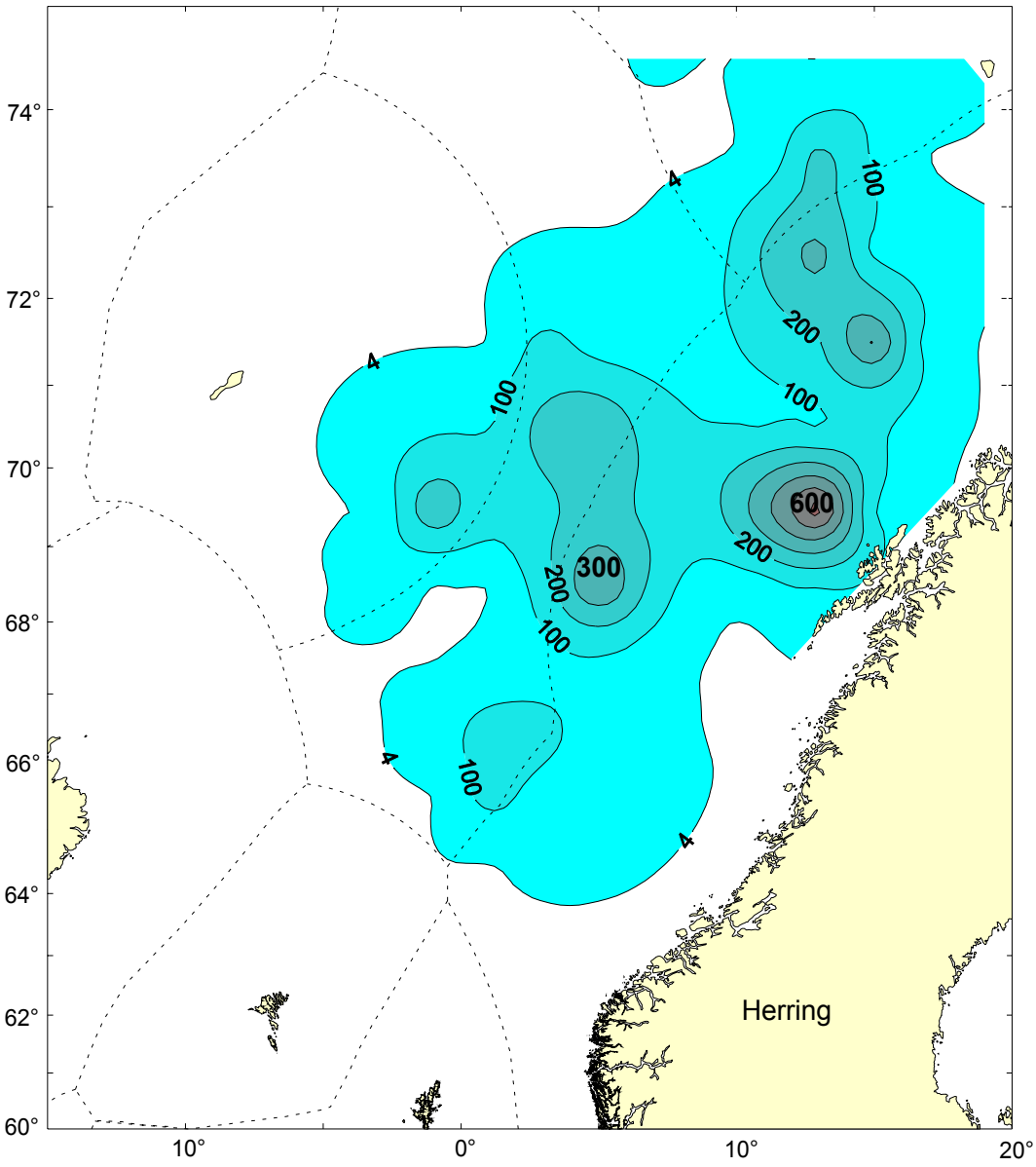

Figure 3.3.1 Distribution of herring in May 2002.

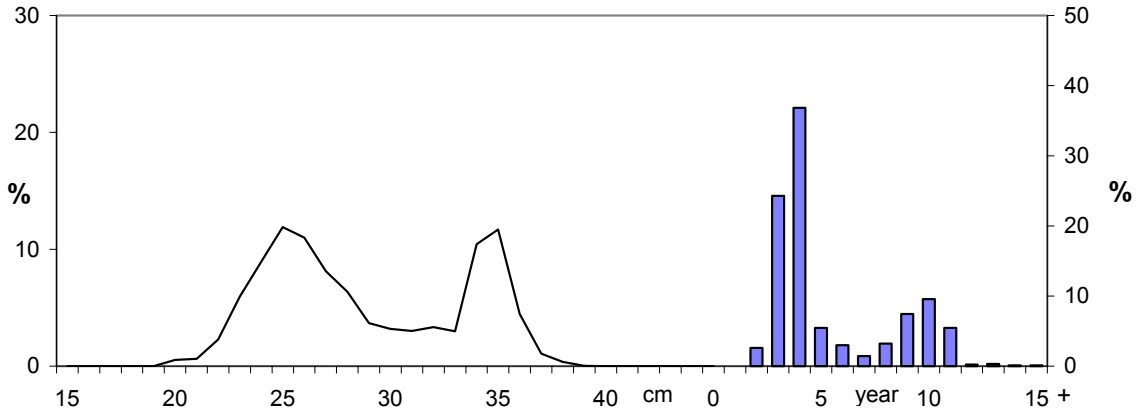

Figure 3.3.2 Length and age distribution of herring in the Norwegian Sea in May 2002

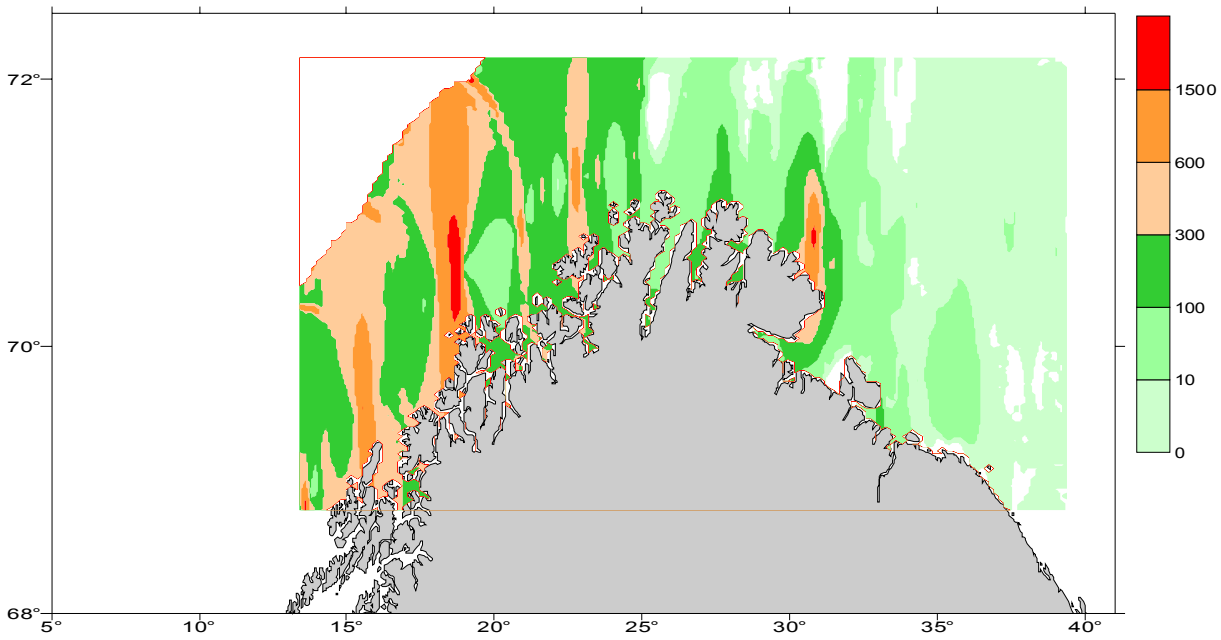

Figure 3.3.3 Distribution of immature Herring in the Barents Sea in May-June 2002. Map of S_A values.

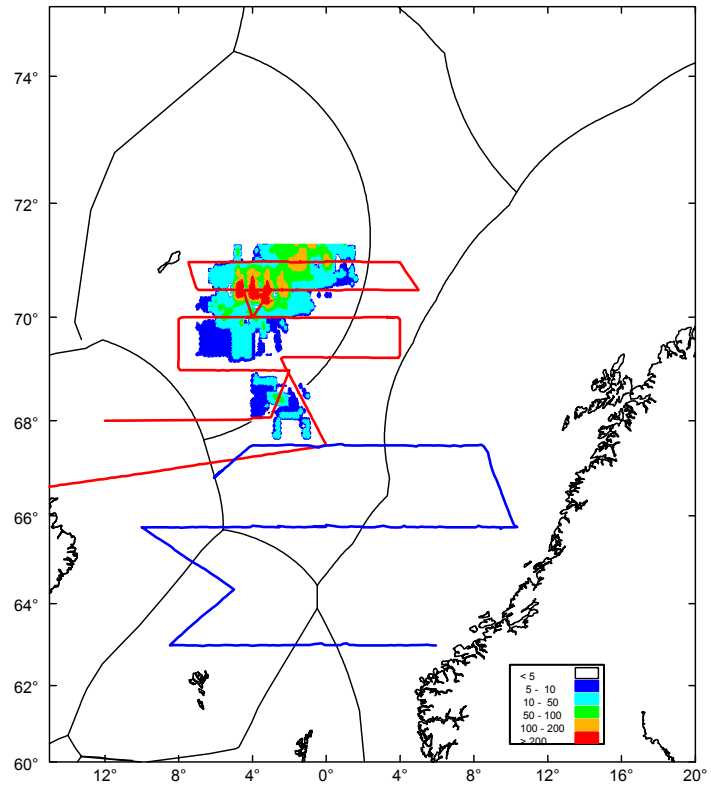

Figure 3.3.4. Distribution of Norwegian spring spawning herring as recorded by R/V "B Saemundson" and "F Nansen" in June 2002.

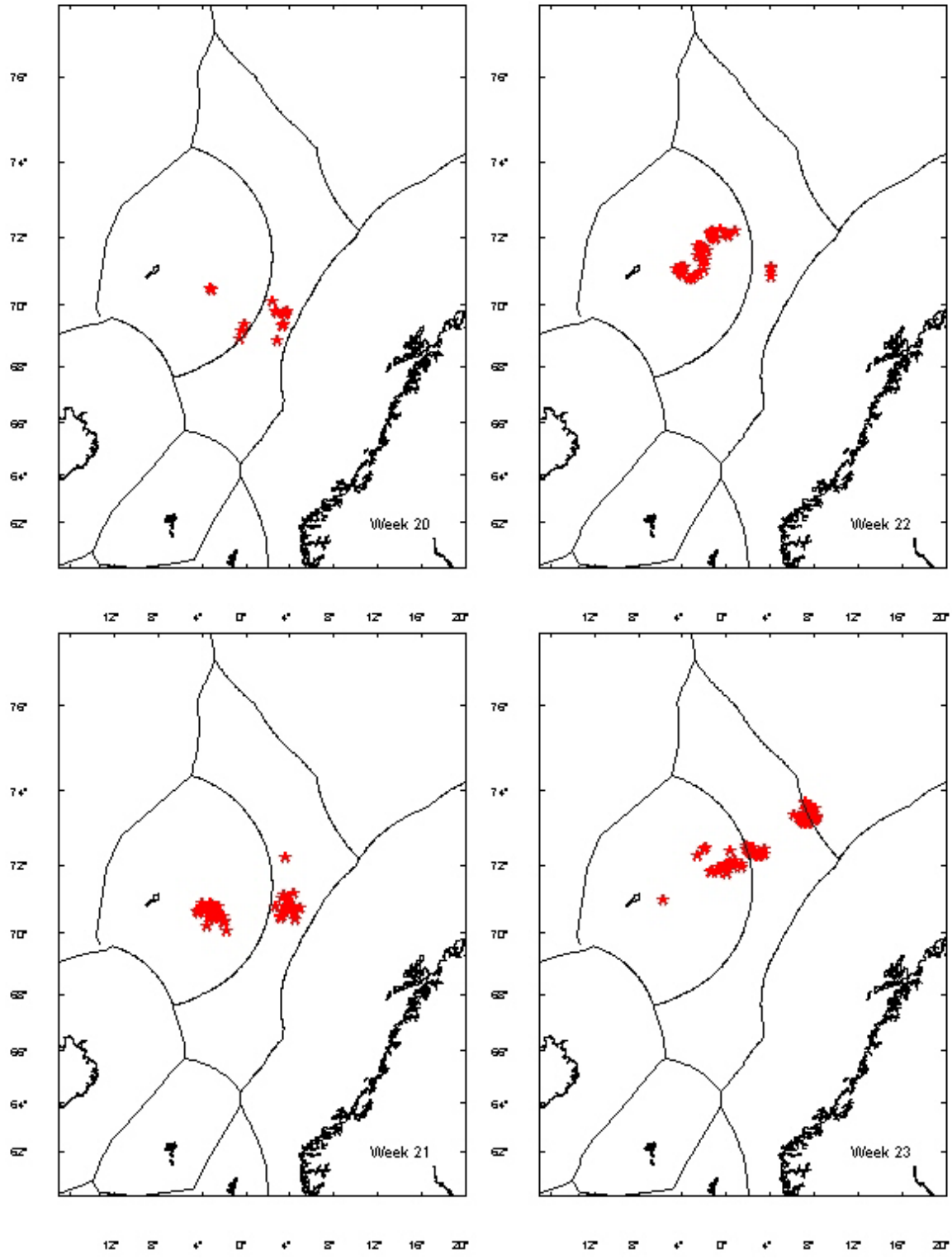

Figure 3.4.5 Posisitions of the Icelandic herring fishery 03.05-08.06 2002

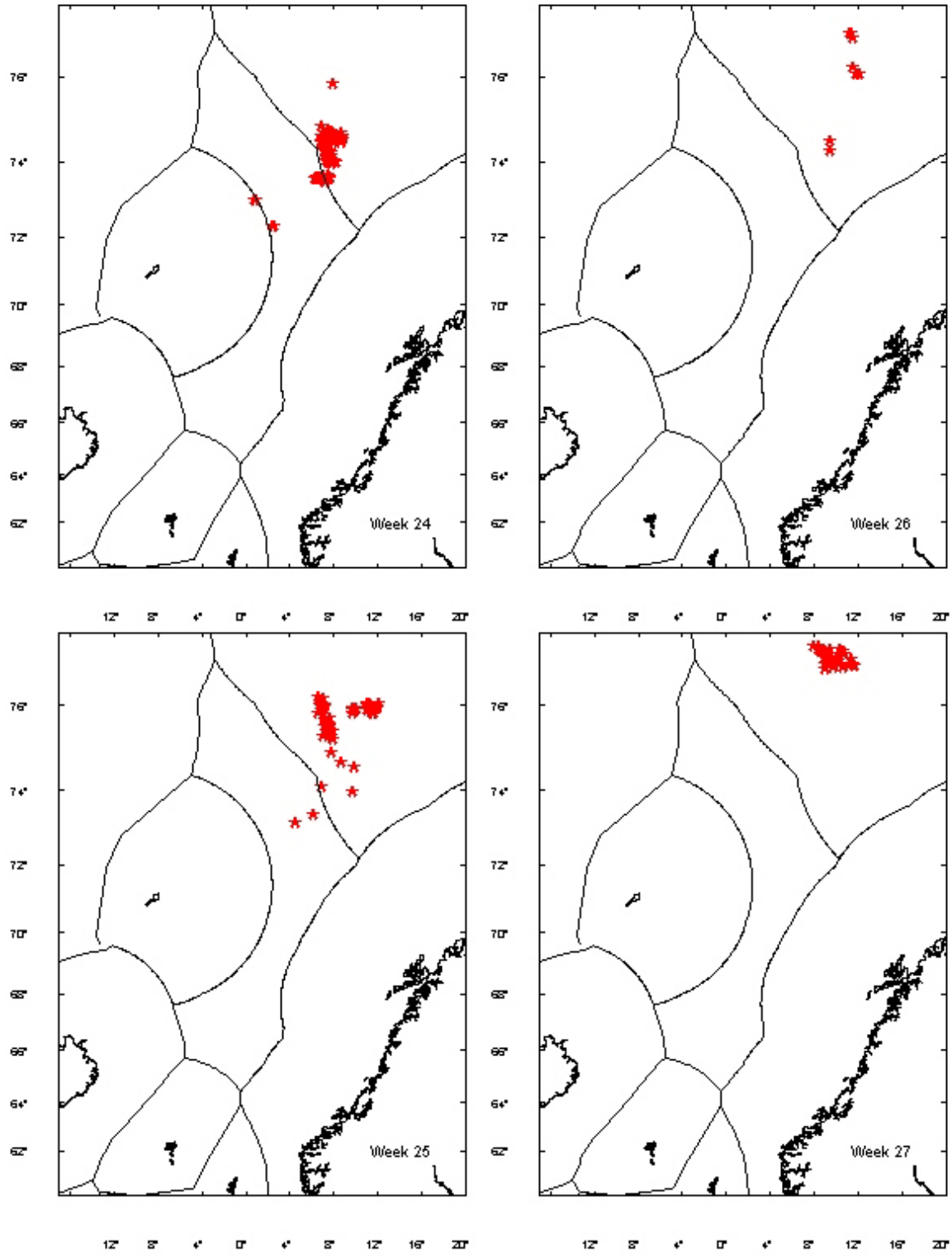

Figure 3.3.6 Posistions of the Icelandic fishery 10.06-06.07 2002

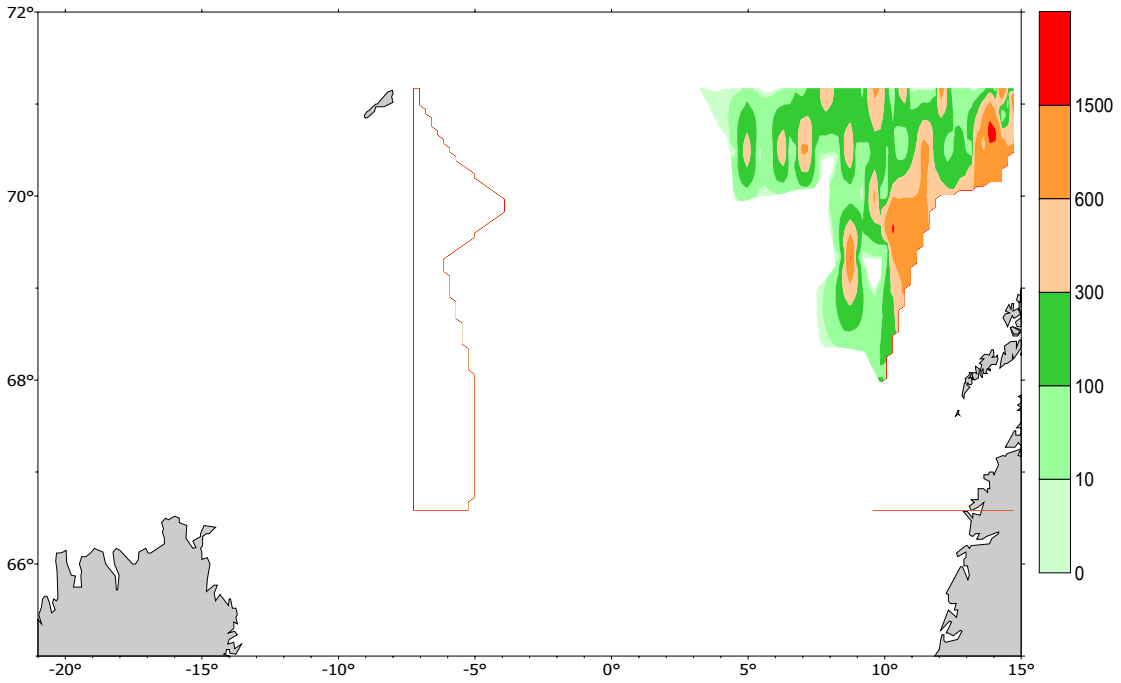

Figure 3.3.7 Distribution of adult and adolescent herring in July 2002. R/V "F Nansen". Map of Sa values.

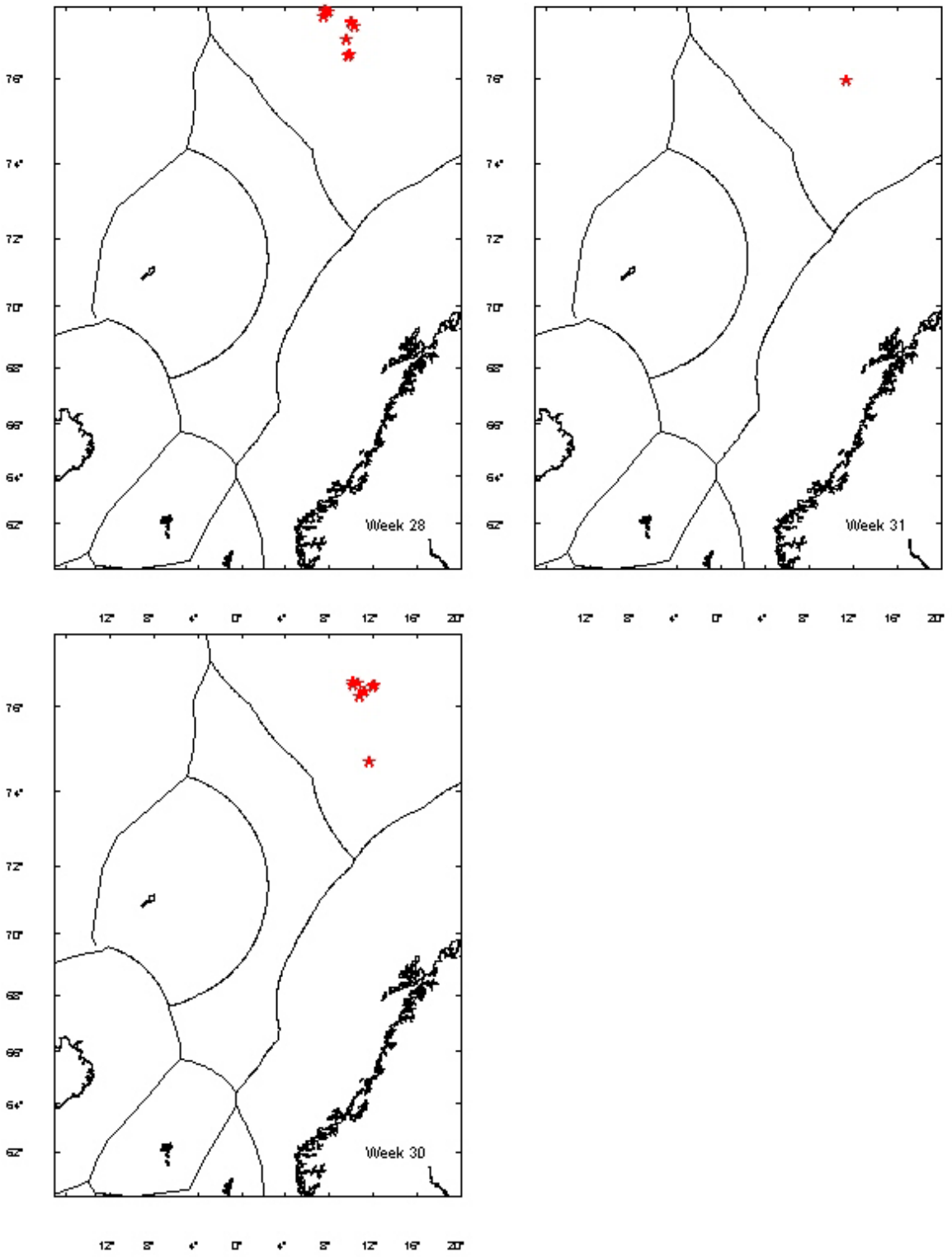

Figure 3.3 8 Figure showning positions of the Icelandic fishery 08.07-27.07 2002

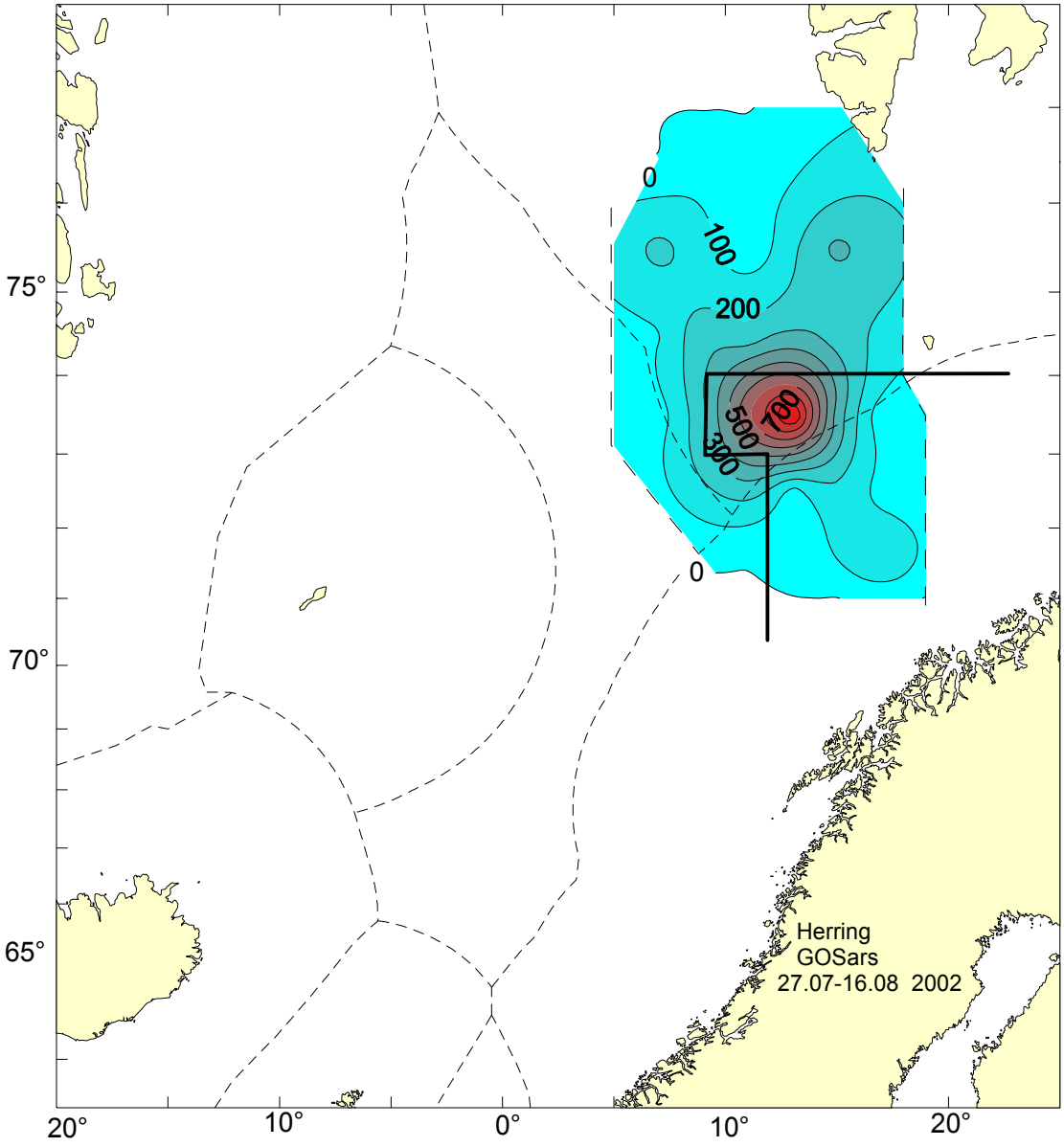

Figure 3.3.9 Distribution of adult and adolescent herring in August 2002. Concentrations to the south and east of the hand-drawn line consists mainly of adolescent herring (1999 year class). Map of S_A values.

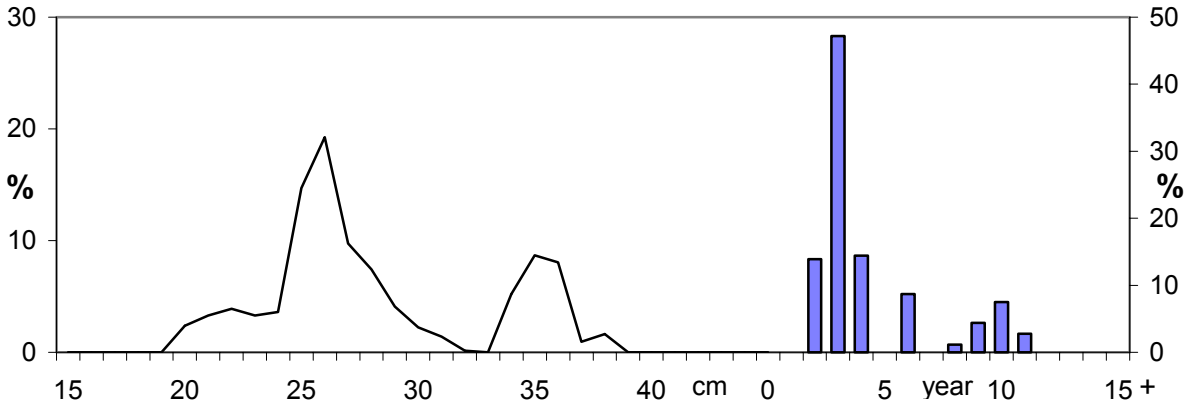

Figure 3.3.10 Length and age distribution of adult and adolescent herring in the northern Norwegian sea in August 2002.

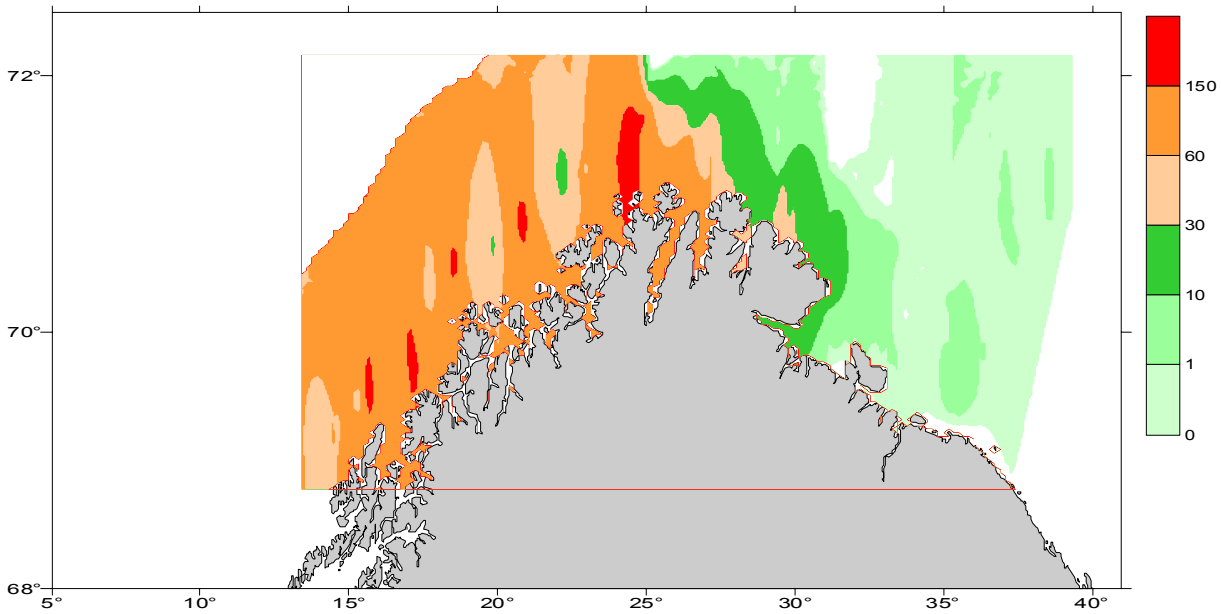

Figure 3.4.1. Distribution of herring larvae's (2002 year class) in the Barents and Norwegian Sea in June. Map of S_A values.

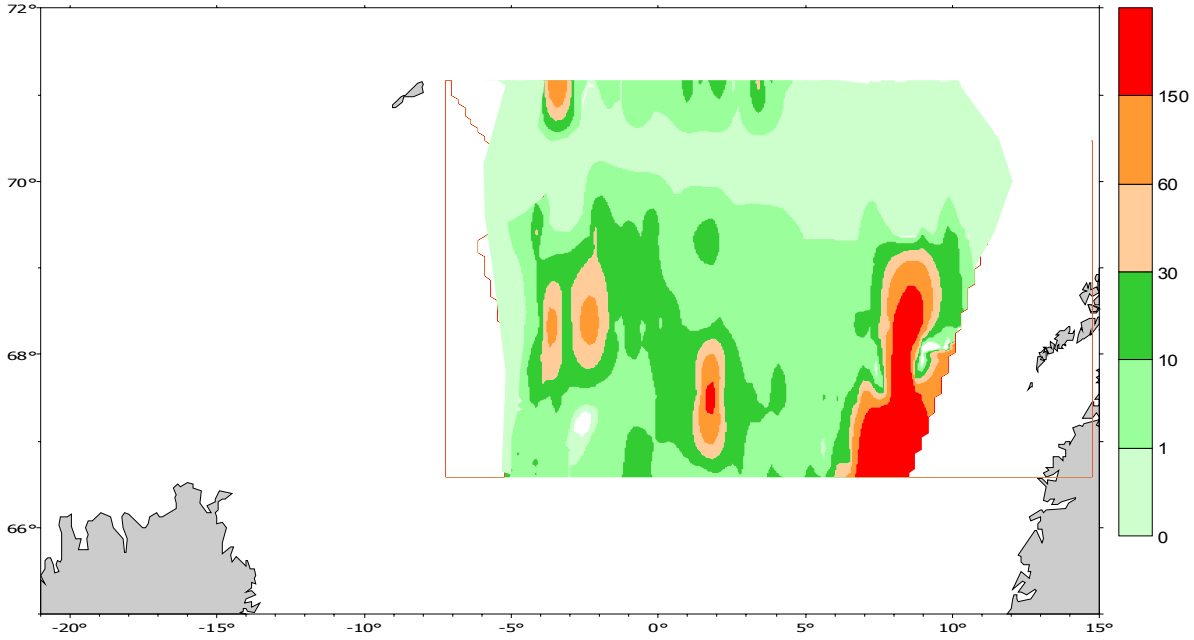

Figure 3.4.2. Distribution of herring larvae and 0-group in the Norwegian Sea in July, map of S_A values.

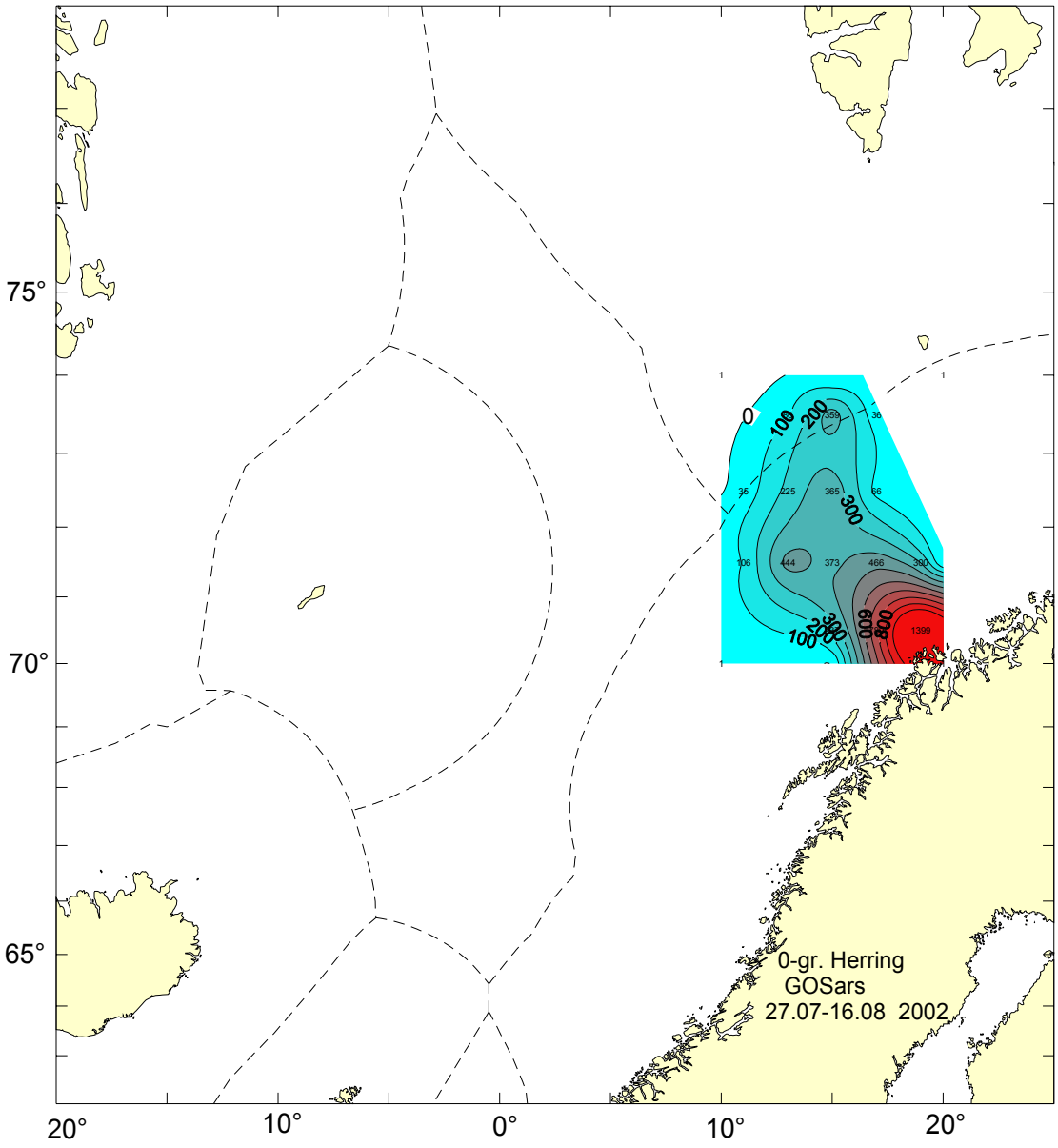

Figure 3.4.3. Distribution of 0-group herring in the Norwegian Sea in August 2002. Map of S_A values.

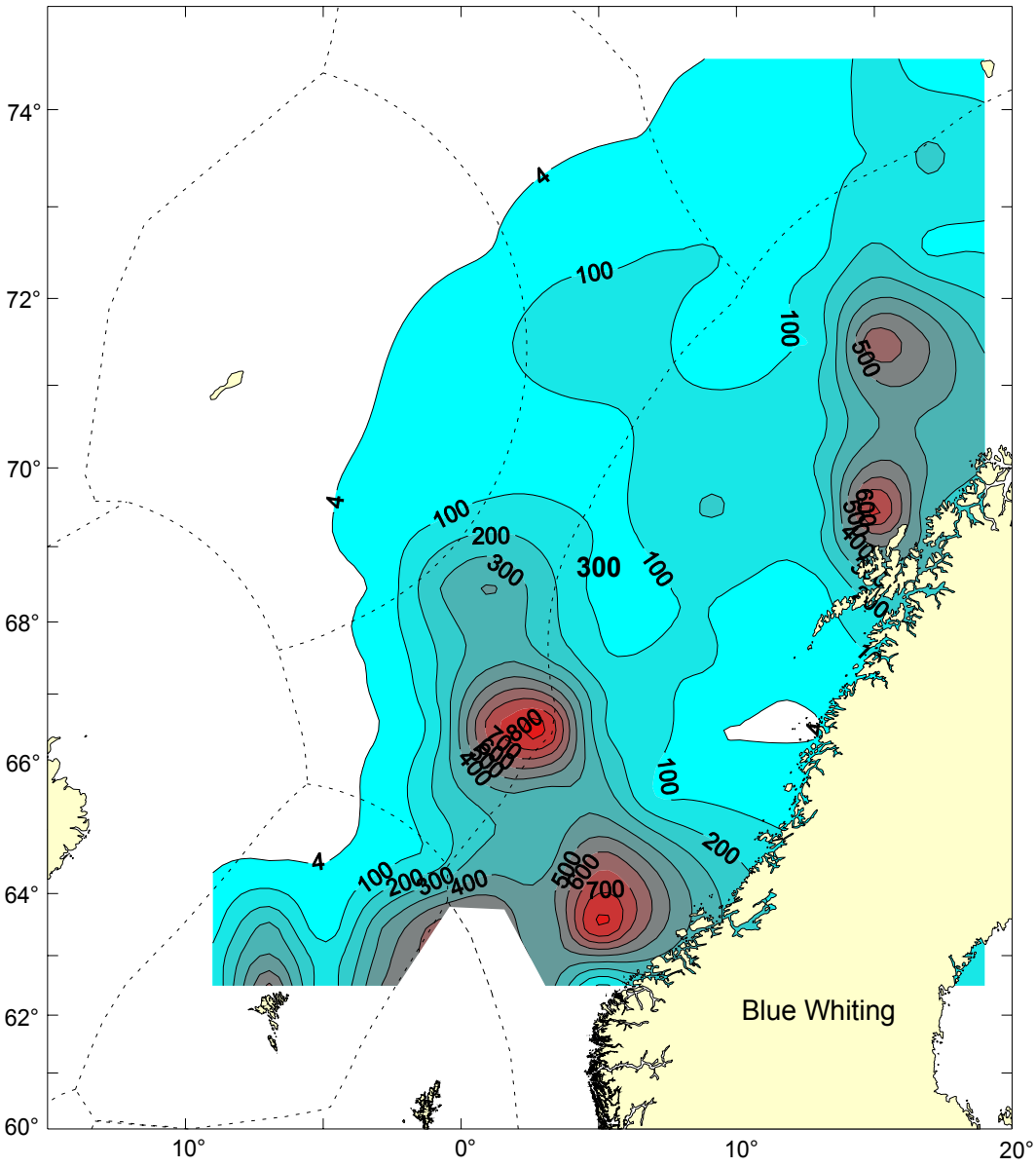

Figure 3.5.1. Distribution of blue whiting (S_A-values) in May 2002. Data from R/V "Magnus Heinason" and R/V "G.O. Sars".

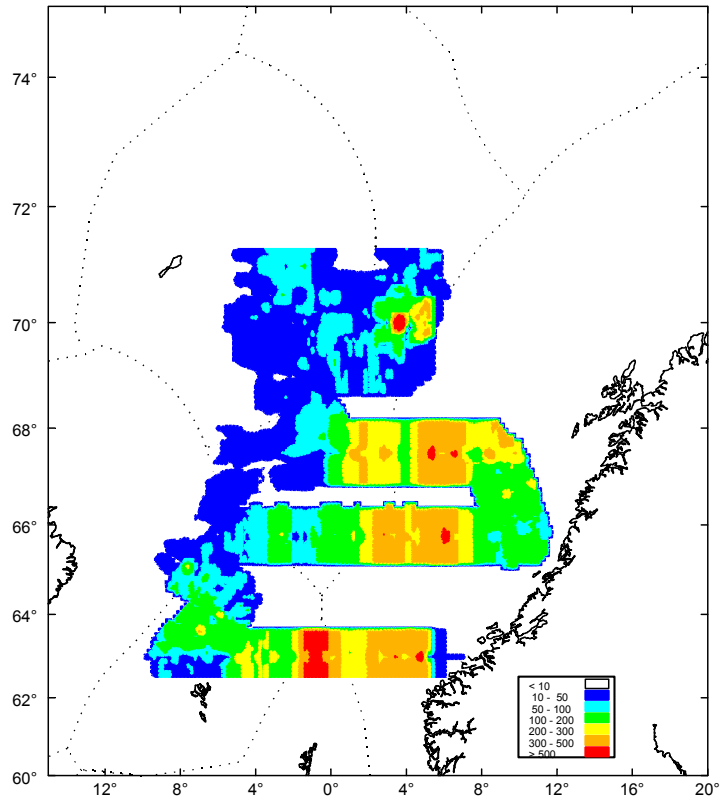

Figure 3.5.2. Distribution of blue whiting (S_A-values) in the central and southern Norwegian Sea as observed by R/V "F. Nansen" and R/V "B. Saemundson" in June 2002.

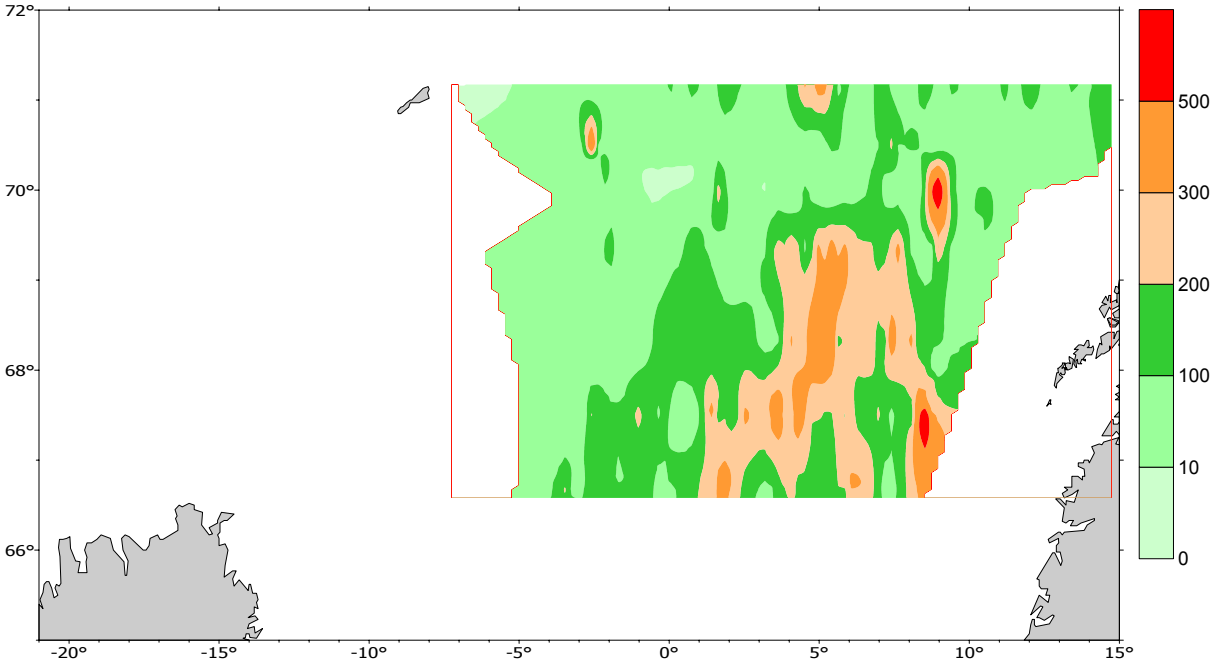

Figure 3.5.3. Distribution of blue whiting (S_A-values) in the central and northern Norwegian Sea in July 2002. Data from R/V "F. Nansen", 3-26 July 2002.

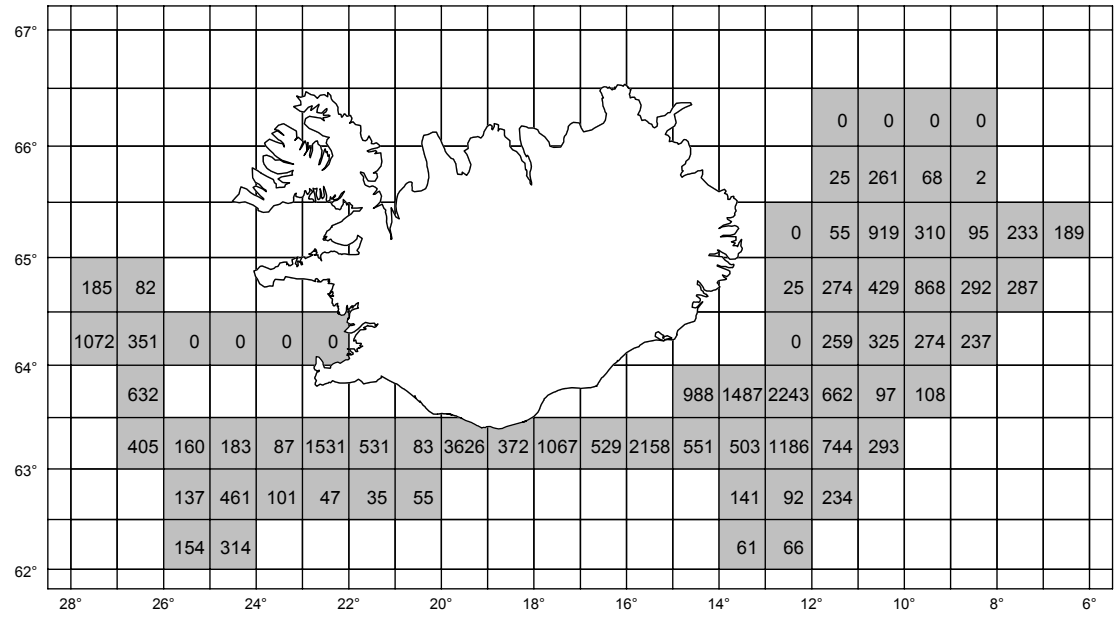

Figure 3.5.4. Distribution of blue whiting (S_a-values) in the Icelandic waters by statistical rectangles. Data from R/V "Arni Fridriksson", 19.-31.7. 2002.

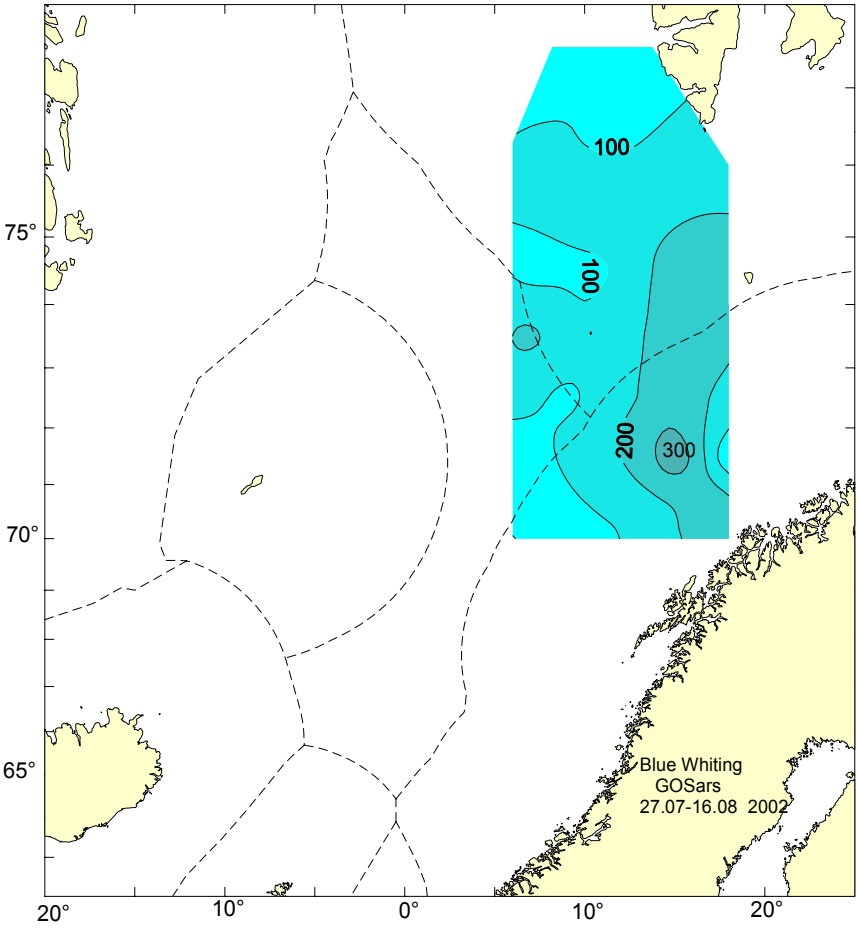

Figure 3.5.5. Distribution of blue whiting (S_A-values) in the northern Norwegian Sea and southern Svalbard area in July-August 2002. Data from R/V "G.O. Sars", 27.7-16.8.2002.

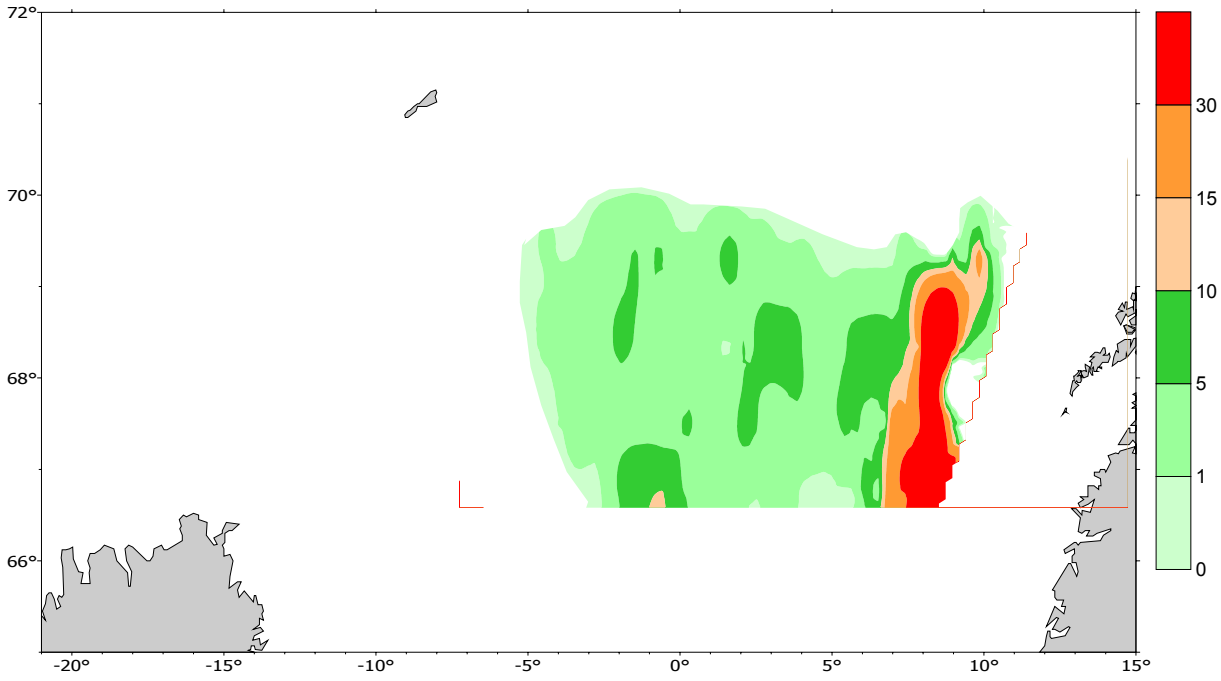

Figure 3.6.1. Distribution of Mackerel in the Norwegian Sea in June 2002. Map of S_A values. Russian survey.

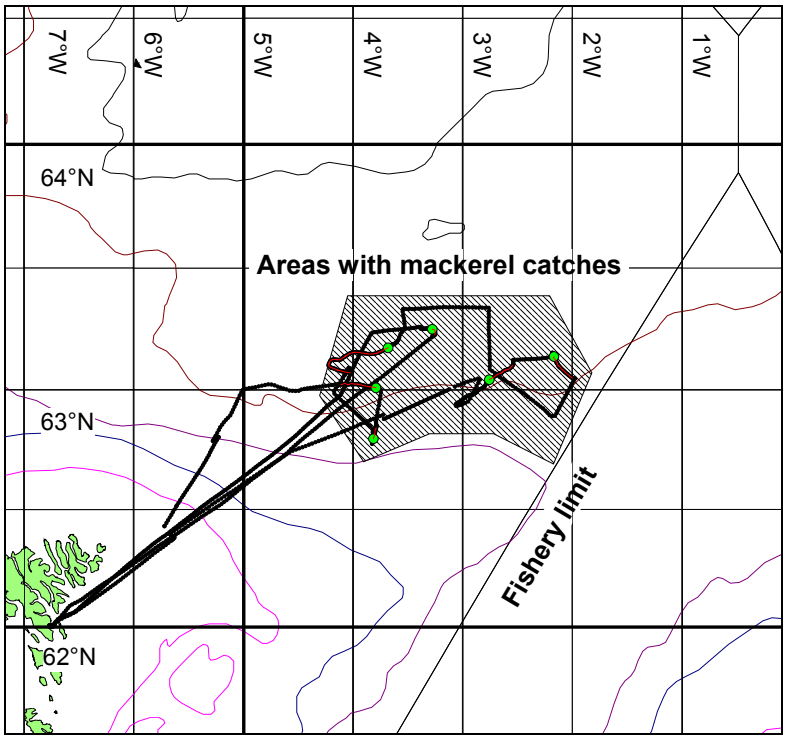

Figure 3.7.1. Cruise tracks for R/V *Magnus Heinason* during the aerial survey on mackerel in early August 2002. The area where mackerel was found is hatched.

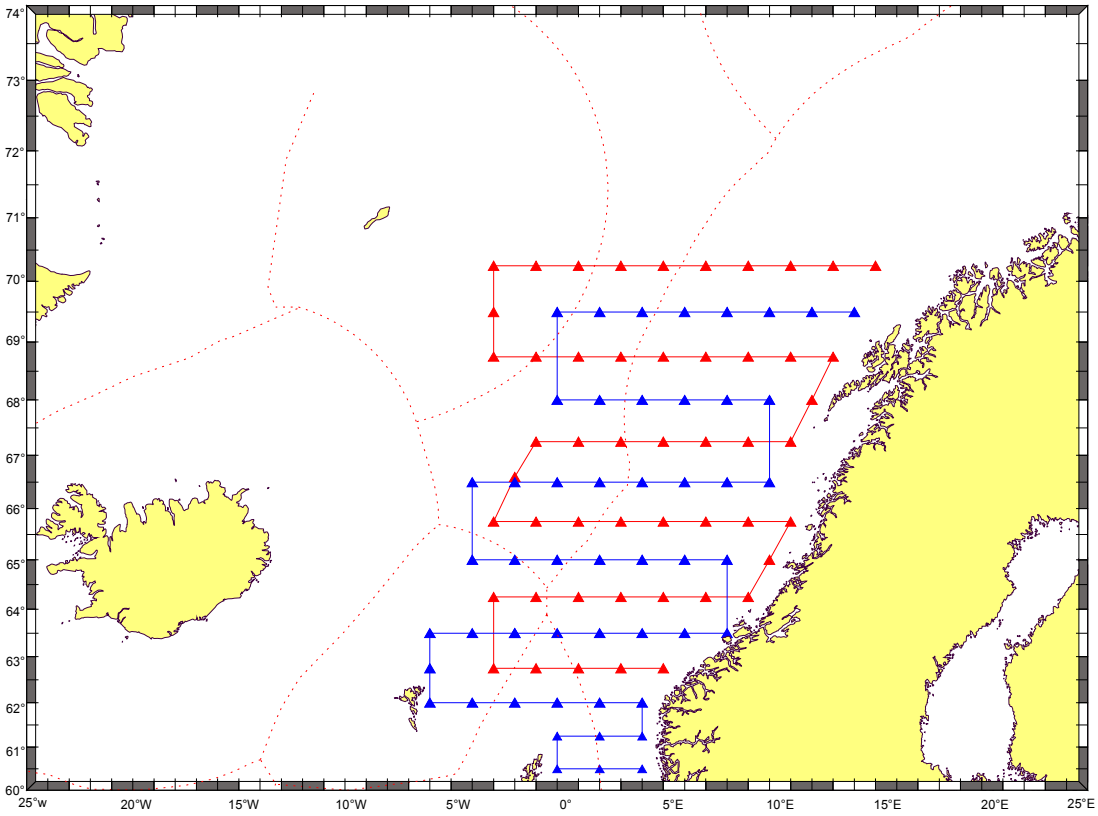

Figure 3.7.2. Cruise tracks for the Norwegian commercial vessels "Trønderbas" (blue line, starting in the south) and "Endre Dyrøy" (red line) during the combined aerial/trawlsurvey in the eastern part of the Norwegian Sea from 15-25. July 2002.

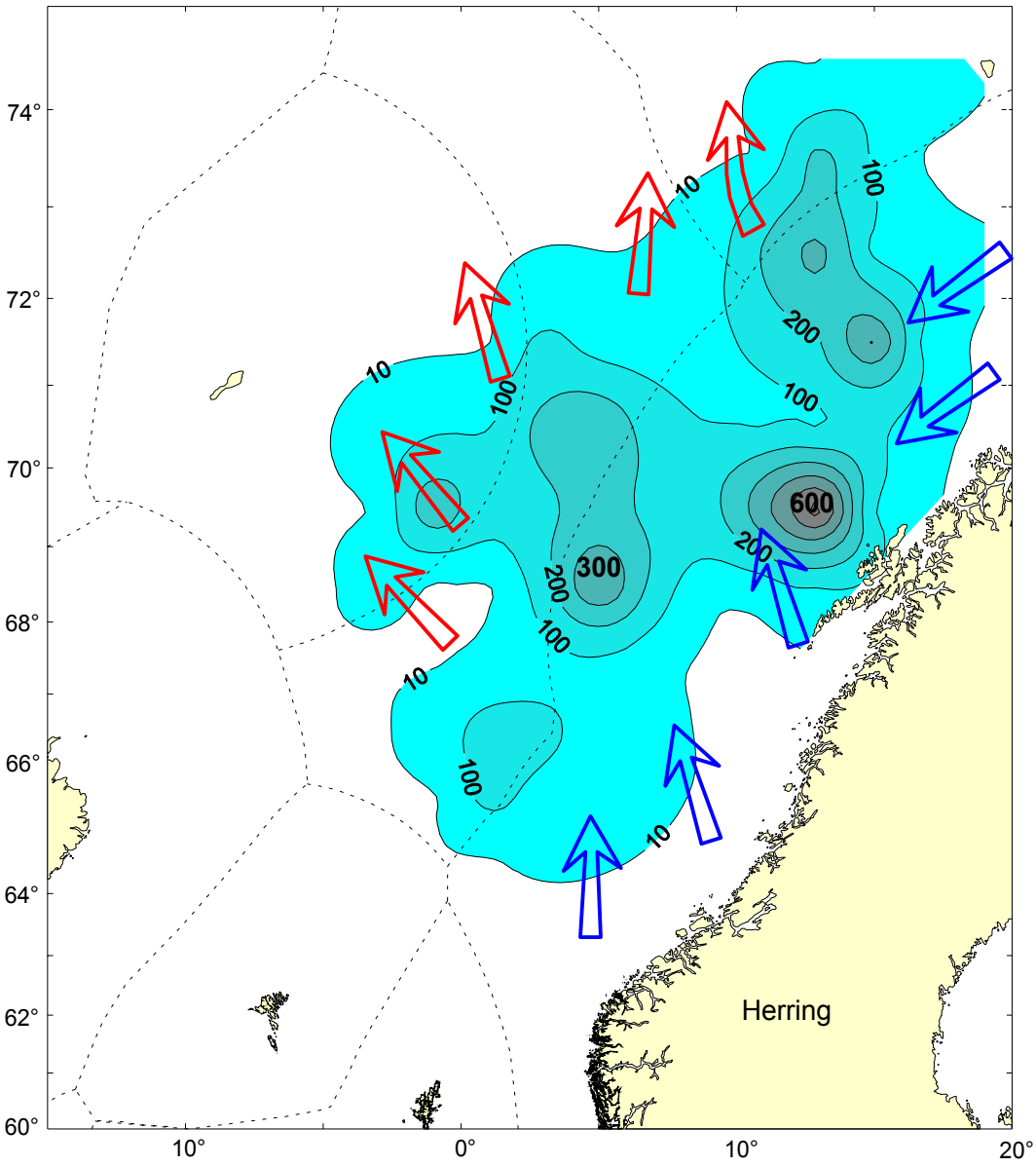

Figure 4.3.1 Distribution of Norwegian spring spawning herring in May 2002. Arrows indicate general migration pattern in spring (blue arrows, near the coast) and early summer (red arrows, oceanic) in 2002.

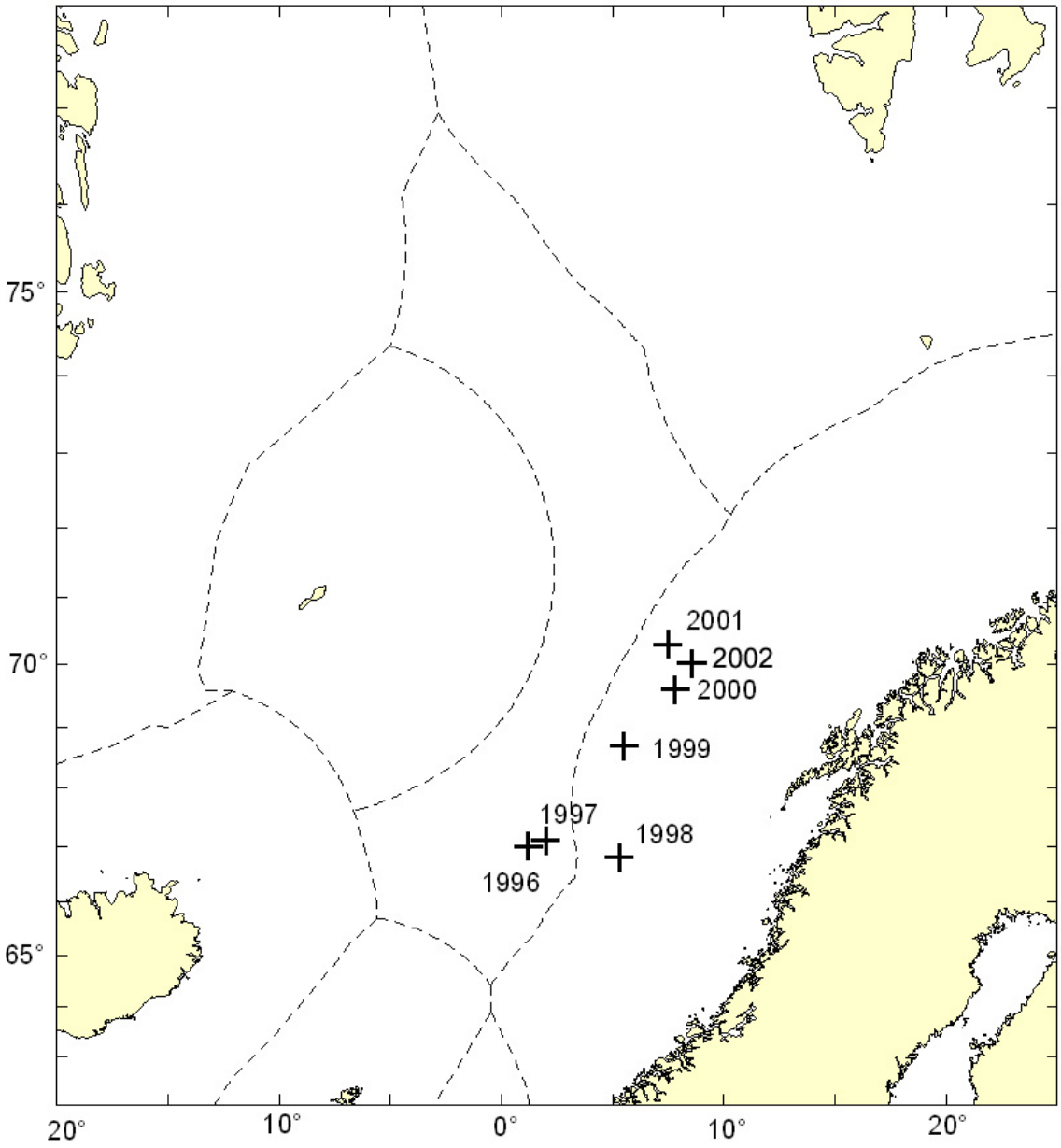

Figure 4.3.2. Centre of gravity of the measured distribution (acoustics) of Norwegian spring spawning herring during May in the years 1996 to 2002.

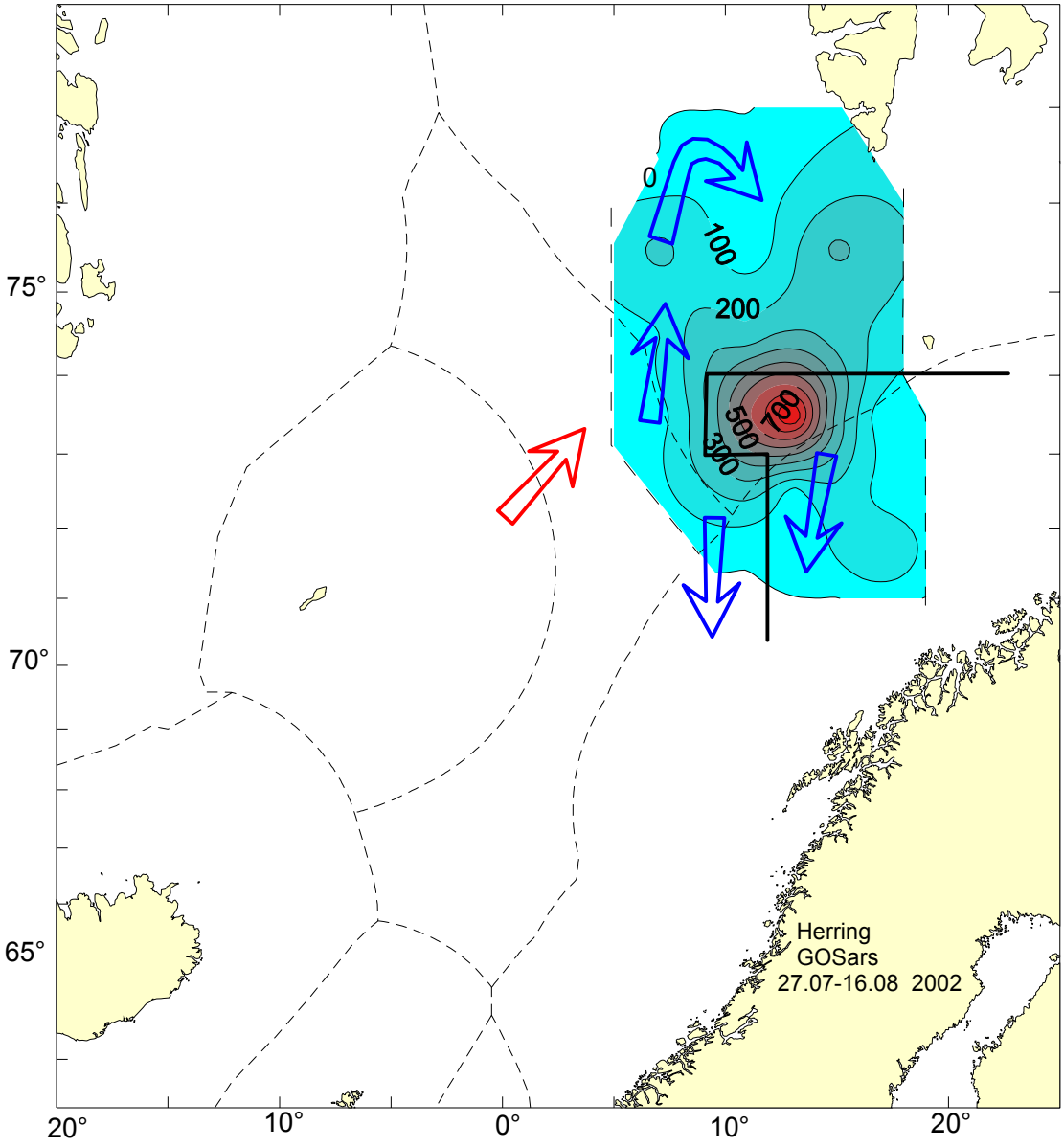

Figure 4.3.3. Distribution of Norwegian spring spawning herring in August 2002. Arrows indicate general migration pattern in July (red arrow, from Jan Mayen) and August (blue arrows) in 2002.