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REPORT OF THE

PLANNING GROUP ON SURVEYS ON PELAGIC FISH IN THE NORWEGIAN SEA

Torshavn, Faroe Islands
16–18 August 2000

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1 INTRODUCTION

1.1 Terms of Reference

The **Planning Group on Surveys on Pelagic Fish in the Norwegian Sea** [PGSPFN] (Chair: Dr J.C. Holst, Norway) will meet in Torshavn, Faroes from 16–18 August 2000 to:

a) consider the migration pattern of the Norwegian spring-spawning herring stock in 2000;

b) consider major hydrographic and zooplanktonic developments since last year. Consider the significance of these developments to the herring stock;

c) evaluate the survey transects carried out in 2000 and consider whether changes could be made to further optimise these with regard to the herring migration and the herring-environment interactions;

d) plan and coordinate the national surveys on the pelagic resources and the environment in the Norwegian Sea in 2001;

e) plan an internationally coordinated survey on Norwegian spring-spawning herring in June 2001;

f) propose Terms of Reference for future work.

The above Terms of Reference are set up to provide ACFM with the information required to respond to requests for advice/information from NEAFC and EC DGXIV.

PGSPFN will report to the WGNPBW, to the Resource Management Committee at the 2000 Annual Science Conference, and to ACFM before its November 2000 meeting.

1.2 Participants

B. Couperus	Netherlands
C. Hammer	Germany
J.C. Holst	Norway
J.A. Jacobsen	Faroe Islands
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1.3 Background information

The Norwegian spring-spawning herring reoccupied the Norwegian Sea as its main feeding area in the early 1990s, after nearly 25 years of absence. This herring stock is now a typical straddling and highly migratory stock, and its migration route crosses the borders of several national EEZs (exclusive economic zones) and international waters. From 1994, an international fishery has taken place during summer in the feeding areas. In 2000 the catch of Norwegian spring spawning herring is expected to reach about 1.2 million tonnes in the Norwegian Sea and along the Norwegian coast.

Since 1995, the Faroes, Iceland, Norway, and Russia, and since 1997 also the EU, have coordinated their survey effort on this and other pelagic fish stocks in the Norwegian Sea. The co-ordination of the surveys has strongly enhanced the possibility to assess and describe the distribution of the pelagic resources, and their general biology and behaviour in relation to the physical and biological environment (Table 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 Hamburg in August 1999 for surveys to be carried out in 2000, (for methods cf. Holst *et al.*, 1998). A total of 10 surveys, to be carried out by Faroese, Icelandic, Norwegian, Russian and

EU-research vessels in spring and summer 2000, were coordinated (Table 1). The main objectives of these surveys were to map the distribution and migration of the herring and other pelagic fish, to assess their biomass, and to monitor environmental conditions of the Norwegian Sea and adjacent waters and the quantity of available food in the sea for herring.

The results of the coordinated surveys in 2000 were evaluated during a meeting in Thórshavn in August 2000 (Table 1). The limited time available for analysis of the data allows only the following brief overview of the main findings of these surveys.

In accordance with an ICES resolution a working group, consisting of scientists from all the laboratories that have participated in these surveys, will meet in Bergen, Norway during 16-20 October 2000. This working group will assemble and organise a common database from the findings of all of the coordinated multi-national surveys carried out since 1995. Furthermore, the working group will compile a report containing descriptions of the database and the developments of the various parameters measured (e.g. hydrography, plankton, pelagic fish migrations, behaviour and abundance) during the 6-year period. The purpose of this work is to build a platform to facilitate more detailed studies of physical and biological processes and interactions in the Norwegian Sea and adjacent waters.

2 MATERIAL AND METHODS

2.1 Hydrography

Oceanographic data were sampled along the transect lines of the hydro-acoustic surveys of the EU (Trident, 17 April - 26 May, 2000, (Figure 1)), the Faroe Islands (Magnus Heinason, 6-28 May, 2000 (Figure 2)), Iceland (Arni Fridriksson, 8-26 May (Figure 1) and 20 July - 4 August, 2000 (Figure 3)), Norway (G.O. Sars, 28 April - 2 June (Figure 1) and 20 July - 17 August (Figure 4)), and the Russian Federation (Persei III, 23 May - 12 June and F. Nansen, 6-28 July, 2000). The observations were made using CTD-Systems. Considerable time had to be allocated for the conversion of the data during the workshop. Total **348** and **137** stations were used to make horizontal distributions of temperature for May and July, respectively.

The MATLAB program from the 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

Zooplankton was sampled in vertical hauls from 200-0 m by standard WP-2 net with a 180 µm mesh (*Tridens, G.O. Sars, Arni Fridriksson,* & *Magnus Heinason*). Russian zooplankton samples were collected in vertical hauls from 0-50m using a Djedy and Nansen net with a 160 µm mesh (*F. Nansen*). The biomasses in 50-0m sampled by the new Icelandic vessel "*Arni Fridriksson*" during July-August 2000 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 Saemundsson*" in 1998.

2.3 Fish sampling

Fish traces identified on the echosounder were sampled by pelagic trawl (vertical openings of 25 - 40 m). With ordinary rigging the trawls could be used to catch deep fish schools. The trawls could also be rigged to catch fish near the surface by removing the weights, extending the upper bridles and attaching two buoys to each upper.

Subsamples of up to 100 specimens of herring and blue whiting were taken from the trawl catches (Tridens: up to 50 specimens, herring only). 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. From each cruise, the data on echo integration recordings of herring, length distribution, zooplankton abundance and temperature, were provided in an agreed format as described above.

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 some of the vessels.

The equipment of the research vessels was calibrated directly before or during the surveys against a standard calibration spheres. An intercalibration has been conducted between the R/V "Tridens" and R/V " G.O. Sars" during the May cruise.

Acoustic estimation of herring abundance was carried out 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 echo recordings. 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 ($\tilde{n}_A$) in number per square nautical mile (N n.mile^{-2}) was calculated using the 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 summing for 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 sub-areas and for the total area.

3 RESULTS

3.1 Hydrography

Two main features of the circulation in the Norwegian Sea, where the herring stock is grazing, 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. The EIC, on the other hand, carries Arctic waters. To a large extent this 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. As a result, the Atlantic water now has a far more easterly distribution than it had during the 1950s and 1960s.

3.1.1 Year 2000

Figures 5-10 show the temperature and salinity in the Svinøy section for 29-30 April and July, 2000 and the differences between the years 2000 and 1999 for July.

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 characterised by salinities below 34.90. The section plot for 29-30 April, 2000 (Figs. 5 and 6) shows the condition before the start of the seasonal warming, while in the section plot for July (Figs. 7 and 8) a warm surface layer has developed. Due to increased strength of northerly winds during the summer, 2000 there has been an increased transport of surface water with low salinities from the Norwegian coast into the Norwegian Sea. This can be seen in the difference plot between July, 2000 and July, 1999 (Figs. 9 and 10). Both temperatures and salinities in the surface layer are lower in 2000 than in 1999. The relatively low salinities in the surface during July, 2000 can also be seen in the Gimsøy section (Figures 11 and 12).

Figures 13-18 show the horizontal temperature distributions at 20, 50, 100, 200, 400 and 500 m depth during April-June 2000. These maps show the water mass characteristics typical for the end of the winter season, undisturbed by seasonal warming. The Figures 19-24 show also the horizontal temperature distributions at similar depths as for April-June, 2000 but for July, 2000 when a seasonal surface layer has developed. The distribution of the waters carried into the Norwegian Sea by the EIC is clearly indicated at all depths 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.

Compared to April-June, 1999 the temperature at 20m depth for April-June, 2000 is colder in the whole area (maps for 1999 in: Holst *et al*., 1999). For instance, the isotherm 4^{o}C reached to about 8^{o}W in 1999 while in 2000 it reached to about 2^{o}W. At 100m depth in April-June, 2000 there is warmer water in the south-eastern part of the Norwegian Sea while in the rest of the area there is a cooling compared to 1999. This cooling is also seen in the plots for greater depths.

In a Russian section at 71^{o}N the summer temperature in the upper 50m has been reduced with 0.1-0.3^{o}C from 1998 to 2000. In a northerly area in the Norwegian Sea based on several Russian sections (taken along the longitudes 71^{o}10´N, 72^{o}00´N, 72^{o}50´N, 73^{o}40´N and 74^{o}30´N) the temperature in the layers 0-200m and 0-500m have increased on average with 0.2-0.7^{o}C from 1998 to 2000.

These observations confirm that there is a strong Arctic influence into the Norwegian Sea and the warm Atlantic water is less accumulated into the central part of the Norwegian Sea but instead it heats more northerly adjacent seas.

3.2 Zooplankton

3.2.1 May

The coverage of the survey area with plankton samples in 2000 was about as high as in the previous year. In 2000 a total of 357 plankton hauls were made, which even slightly exceeds the number of plankton stations in 1999 with 342 hauls. In comparison to the previous year the distribution of samples was more evenly spread over the area, with an increasing density of stations in the area of higher plankton abundance. However, still some clustering of the sampling occurred, due to the partial overlap of the cruises during the survey. Nevertheless, the general distribution of zooplankton biomass in May 2000 is clearly documented in space and time (Figure 25, Table 2).

Taking these uncertainties into account there is a general increase of biomass in 2000 as compared to 1999 for the entire area (approximately +34%). The 2000 biomass is the highest in the time series since 1997, the latter being known to be exceptionally low (Anon. 1999) and being about 42% lower than the present value.

Table 3 Total Zooplankton biomass [g dw*m^{-2}] arithmetic mean. The 1998 data on the Faeroes shelf were omitted to allow comparison with the 1999 and 2000 data.

Year	1997	1998	1999	2000
Total area	8.2	13.4	10.6	14.2
Region W of 2°W	9.1	13.4	13.5	15.7
Region E of 2°W	7.5	14.4	10.2	11.8

The decrease of the total biomass from 1998 to 1999 is taking place in the area east of 2°W (-29.2%).

Figure 25 shows the distribution of the total zooplankton biomass (g dw m^{-2}) in 200-0 m in May 2000 in the survey area. The total zooplankton biomass was generally higher in the western area where dominated by colder water masses. Similar to last year these colder water masses reached much further east than usually observed, adding to the trend observed over the past years. The highest zooplankton abundances were observed in the colder water, reaching about 7° E in the north and about 3° W at its southern extension.

The distribution of the catches of the commercial herring fleets during June and July shows that the Norwegian Spring Spawning Herring had migrated into these colder areas of higher zooplankton biomass and stayed in there during their migration northwards (Figures 32, 34).

3.2.2 July-August

The Norwegian July-August cruise with "G.O.Sars" was still not finished at the time of the PGSPFN meeting. However, the zooplankton data from the first part of the cruise, covering the southern regions, were available. In the present report we also include the Icelandic data from their cruise with "Arni Fridriksson" south and east of Iceland. The Norwegian and Icelandic cruises indicate that the total zooplankton biomass in July-August 2000 (Figs. 26) was lower than in 1999 (Holst *et al*., 1999). Average total zooplankton biomass, calculated for the area south of 70° N based on the Norwegian data only, was estimated at 5.3 g dw m^{-2} in 1998, 10.1 g dw m^{-2} in 1999, and 7.2 g dw m^{-2} in 2000. In 1999 and 2000 biomasses were high in the frontal region between Atlantic water and the Arctic water of the East Iceland Current. In 2000 the Icelandic data showed that biomasses in July-August were high south and east of Iceland as well.

3.3 Herring

3.3.1 April/May

The international coordinated herring survey was carried out under favourable weather conditions during 28/4-2/6 2000. The EU and Norwegian vessels covered the eastern and northernmost parts of the area, while the Icelandic and Faroese vessels covered the western part.

The main herring concentrations were observed from 67°N to 70°30'N, 1°W to 10°E (Figure 27). Smaller concentrations were observed further to the south and east, but in particular to the northeast of this area. The outer boundary of herring distribution was reached in all areas except in the extreme north and east (i.e. north of 72°20'N and east of 19°E. On the basis of the intensity and character of the registrations, made along these borders, it is reasonable to assume that the true zero-line was not far outside the northernmost transects. Thus, there are no indications that the survey missed significant amounts of the adult stock (Figure 27).

The western boundary of herring distribution was at about 2°W (Fig 27, 28), while the northern boundary was north of 72°20'N (Figure 27). As compared to May 1999, the herring had a more northeastern distribution. Thus, the areas of highest concentrations in 2000 were found about 30 nautical miles further to the north and 60 nautical miles further to the east as compared to 1999.

Based on the acoustic registrations of the EU, Icelandic and Norwegian vessels, the scrutinised acoustic integrator values and the analysed fish samples, a preliminary age structured estimate of the herring in the surveyed area was run. In squares within the surveyed area not covered by any vessel, Sa values were interpolated from the neighbouring squares. A simple algorithm, weighting the four nearest neighbouring squares by 2, while the next second nearest four got a weight of 1, was applied. The total herring abundance in the surveyed area was estimated to be 5.8 million t in May 2000 (Table 3).

3.3.2 July

During the period 7-28 July R/V Fridtjof Nansen surveyed the northern part of the Norwegian Sea from 69°N to 74°N between 5°W and 16°E. The herring distribution pattern within the area surveyed resembled a horseshoe, oriented in a northeast direction (Figure 30). The highest densities were recorded farthest to the northwest and northeast, where there was a strong thermocline with surface temperature of 7.5-8.5 °C. The herring were aggregated in small dense schools with a vertical extension of 5-20 m in the uppermost 75 m of the water column. Herring biomass in this are was estimated to be about 2.6 million tonnes comprising 8.5 billion individuals.

3.3.3 July/August

During 20 July-17 August R/V G. O. Sars surveyed the Norwegian Sea as shown in Figure 4. Herring were recorded from 72°N to 76°30'N between 8°E and 16°E as shown in Figure 31. The main herring concentrations during this period were in the area from 72°30'N to 75°N, between 9°E and 16°E. Herring concentrations were particularly high to the west and southwest of Bear Island. The survey again most probably covered the entire stock and it is clear that the bulk of the stock was beginning to aggregate in an area more to the NE than in mid-August 1999 (Holst *et al*., 1999). An acoustic estimate was calculated on the basis of the survey results, yielding an estimate of 4.9 million t.

During 20 July-4 August R/V Arni Fridriksson carried out a survey in the region of the shelf break south of Iceland as well as the area east of Iceland, from about 62°40'N to 66°10'N between about 12°W and 7°W as shown in Figure 3. No herring were recorded during this survey.

3.4 Herring distribution in the Barents Sea

3.4.1 May-June

"Persei III" carried out a survey in the Barents Sea from 25^{o} E to 40^{o} E along the Merman and Norwegian coast during the period 23/5- 12/6 to map the distribution and produce an abundance estimate of young herring in this area. Young herring were observed along coastline at a distance of 50-100 nautical miles (Figure 37). The herring mostly was recorded in schools of various densities, mainly in the upper 50 meter layer of the water masses. The same area they recorded closer to surface. The total biomass is estimated at 1.266 million tonnes and numbers 133.3 bil. sp. (Table 5). The herring of the survey area consisted mainly of 1 years old fish (79 %) and 2 years old fish (20 %).

3.4.2 Herring migrations in 2000

Based on all available information, an inferred migration pattern of the herring stock during the feeding season of the summer of 2000 was reconstructed. The main sources of information for the reconstruction were the international herring survey in May, the "G.O Sars" survey in July/August and catch positions of mainly the Icelandic herring fleet 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 (Figure 32). 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 2000 was the international herring survey in May. At this time the herring had left the Norwegian coast and spread over a large area, stretching approximately from off the Norwegian coast, west to 2ºW and from approx 66ºN and north to 72ºN (Figure 32).

Already in May, both the international survey and the positioning of the fisheries indicated a more northeasterly migration route of the herring in 2000 as compared to 1999 and the years before. In May the center of distribution of the herring stock was observed at approx. 69ºN, 7ºE. This is a significant shift towards NE (Figure 36) as compared to 1999, and appears to be part of an almost continuous northeasterly shift in the distribution pattern, which has been going on at least since 1996 (Figure 36). An exception to this trend was observed in 1998 when the shift was purely eastwards, and not to the north. The vertical distribution in 1998 was also different from that of the other years, with the herring closer to the surface.

Furthermore, the fisheries had a more northeasterly distribution in 2000 (Figures 34, 35) (Holst *et al*., 1999) as compared to 1999, which corresponds well with the survey results.

In June no surveys were carried out, but judging from the available positions of the fisheries (Fig 34) and the general knowledge of the migration pattern, the herring had moved further towards NW with large concentrations of herring feeding in the polar front NE of Jan Mayen (Fig 32). Around the middle of June, the herring turned northeasterly, thus disrupting the general NW direction of the migration until then. This northeasterly migration was continued during the latter half of June and in July (Figure 33) according to fisheries data (Figures 34, 35).

In early August the G.O.Sars mapped the herring distribution. The herring had now migrated further to NE (Figure 33) and was distributed in the areas west of the Bear Island between 72ºN and up to 76º 30'N, between 6ºE and 17ºE. The distribution in August is in accordance with the northeasterly shift observed in May and the distribution in August 2000 is the north-easternmost observed during the period 1996-2000.

When this report was printed (8th September, 2000) the herring was about to turn into the Vestfjord to enter the wintering areas inside the Loften penninsula, in the Vestford, Ofotfjord and Tysfjord. Thus, the migration towards the wintering areas appeared to be as normal. Whether the northeasterly distribution will result in a later arrival on the wintering grounds is uncertain, but it is be reasonable to assume that the latest migrants may arrive later into the fjords this year than usual.

3.4.3 Herring migration and the environment

From 1998 onwards the input of cold Arctic water to the south-western Norwegian Sea in May has increased from year to year, peaking in 2000 with an exceptionally cold and widely distributed Arctic water mass covering the surface waters of the Norwegian Sea west of 0^0 and north of 65^0 N, as defined by the 5^0 C isotherm. During that same time period the average biomass of zooplankton within the cold water has increased. This could imply that the total amount of zooplankton in the cold region increased considerably due to the combined effect of higher concentrations and wider distribution. In the warm Atlantic water east of 2^0 E we have not observed any clear trends in zooplankton biomass.

From 1997 to 2000 the distribution of herring in May has shifted northwards, possibly reflecting the more northerly distribution of cold water. The centre of distribution of the herring stock in May was situated within the Atlantic water masses east of the cold water. However, within a westward protruding tongue of warmer water, with temperatures exceeding 5^0 C, the herring entered the areas of high zooplankton biomass. In June and July catch data from the Icelandic fishing fleet showed that the westward migration within the water masses, being rich on zooplankton, continued and turned north when reaching the Arctic front northeast of Jan Mayen. Unfortunately, due to lack of data it is not possible to conclude whether the whole stock is able to enter this region, exploiting the high biomasses of zooplankton on its way towards north. In addition there are no data showing how the biomass within the coldwater region develops during June and early July. The high fat content of the herring as observed at the end of the feeding season in August 2000 shows that the hydrography and plankton conditions this year suited the herring stock feeding in the Norwegian Sea very well.

3.5 Blue whiting

3.5.1 May-south of the Faroes and the Norwegian Sea

In early May the part of the adult stock of blue whiting stock in the Faroese zone was situated on the southern area with the highest concentrations in the south-western area (Figures 39, 40, 41). The survey on the western side of the isles was limited to the area south of 61°30'N and did not reach the zero line to the west and north in this area (Figure 2). The abundance in the area was slightly less that in 1999, and apparently the post spawning migration had started rather early this year as compared to last year as the fishery had started about two weeks prior to the survey. As a result the largest postspawning concentrations had probably already passed the covered area (i.e. the southern part of the Faroese zone) at the time the survey with R/V *Magnus Heinason* lasted (6-12 May 2000). The international fishery in the Faeroes area in May took place in the Faroe Bank channel, with catches up to 300 t per tow, supporting the suggested migration pattern to the west of the isles this year. There were only small concentrations of blue whiting recorded in the northern parts of the Faroese zone except along the northern shelf edge and in the north-eastern area of the zone.

In the eastern and central parts of the Norwegian Sea blue whiting was distributed over a wide area in the international zone and east to the Norwegian shelf. (Figure 39). The 1999 year-classes constituted most of the blue-whiting biomass, reflecting that the adults were out of this area on their southern spawning migration. The total amount of blue whiting in the area has decreased during the last year due to the maturation of the strong 1995, 1996 and 1997 year-classes.

The concentrations in the southern part of the Faroes zone were mainly adult blue whiting.

3.5.2 July-Norwegian Sea

A survey of the distribution and abundance of blue whiting in the central part of the Norwegian Sea was carried out by R/V *Fritjof Nansen* during 7-31 July. Cruise tracks and the relative distribution (S_A-values) of blue whiting are shown in Figure 38.

The fish was arranged rather evenly on all district of filming. The maximum density (more than 100 ton per sq. mile) was marked on south-east fields, and minimum on north-west (Figure 38). The total abundance estimate was about 1.2 million tonnes, comprising 11.8 billion fish by number. The blue whiting were usually distributed from 150-300 m depth with a length distribution mostly between 24-28 cm corresponding to the 1998 and 1999 year classes.

3.5.3 July-Iceland

During 20 July-4 August a survey was carried out with R/V *Árni Fridriksson* in the area south and east of Iceland as shown in Figure 3. Blue whiting (*Micromesistius poutassou*) were recorded in practically all of the surveyed area, except within the core of the East Icelandic Current off the northern east coast of Iceland. However, densities were in general low, the highest being recorded in places south of Iceland as well and in the trough between Iceland and the Faroes and south of there. The distribution of integrator values (S_A) allocated to blue whiting are shown in Figure 42. A preliminary age structured abundance estimate is given in Table 6 and shows that by far the most important contributors (about 85% by number and 60% by weight) were 0- and 1-group fish. The 0-group blue whiting were mainly recorded off the eastern south coast and in deep waters between 62˚30’N and 63˚10’N, 11˚-15˚W.

3.5.4 July-August Norwegian Sea

During the survey by the RV *G.O.Sars* in July-August blue whiting was found distributed over wide areas in the Norwegian Sea (Figure 43). An acoustic estimate indicated a biomass of blue whiting in the area surveyed of 2.4 million tonne (Table 7). The samples were dominated by the 1999 year class.

3.5.5 Evaluation of blue whiting data

None of the surveys reported in this document were designed at 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 alone.

However, the biomass estimates of blue whiting from the Norwegian Sea and around Iceland in 2000 were only about half the estimates in 1999, indicating a strong reduction in the blue whiting biomass in the surveyed area. Furthermore, the stock is presently dominated by the immature year classes of 1998 and 1999.

The post spawning migration to the feeding areas in the Norwegian Sea past the Faroes and the distribution of feeding blue whiting is very much influenced by the hydrography. The strong influx of East Icelandic Water in to the southern Norwegian Sea in 1999 and 2000 compared to previous years may have favoured a migration to the north trough the Faroe Bank Channel into the areas between Faroes and Iceland (Hansen and Jákupsstovu, 1993). However, these areas were not surveyed in May and there is no evidence to conclude on this.

3.6 Mackerel

Mackerel were caught in 7 trawl hauls in the near-surface layer east of Iceland as shown in Figure 44. The catch ranged from some few individuals to about 3 tonnes. These were large fish, mainly in the length range of 38-42 cm, mean weight 627 g (Figure 45). In all of this area the mackerel occurred mixed with blue whiting and acoustic assessment of abundance was not possible, both due to mixing of the two species and inadequate equipment.

3.7 Mackerel, Horse mackerel, Salmon

In general these species have only been reported to a small extent and the reported observations does not reflect the catches made by the different vessels. Care should therefore be taken in interpreting the geographic distribution of these species from what is reported in the report.

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Table 1. Organisational frame of the coordinated herring investigations in the Norwegian Sea, 1995-2000.

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 (Anon, 1997a)	Reykjavík (Anon, 1997b)
1998	Faroe Islands, Iceland Norway, Russia, EU	11	Reykjavík (Anon, 1997b)	Lysekil (Holst *et al*., 1998)
1999	Faroe Islands, Iceland Norway, Russia, EU	10	Lysekil (anon, 1998)	Hamburg (Holst *et al*., 1999)
2000	Faroe Islands, Iceland Norway, Russia, EU	8	Hamburg (no printed planing report)	Torshavn (this report)

Table 2. Surveys conducted in spring and summer 2000 by Faroes, EU, Icelandic, Norwegian and Russian vessels in the North Atlantic and the Barents Sea, which are related to the Norwegian Spring Spawning Herring.

Vessel		**Survey area**	**Period**	**Herring samples**	**Plankton samples**	**CTD stations**
Tridens	EU	62°-70°N, 5°W-17°E	17.4-26.5	6	38	35
G.O. Sars	NOR	62°-71°30N, 6°W-16°E	28.4-2.6	12	115	115
Arni Fridriksson	ISL	65°-71°N, 9°W-6°30E	8.5-26.5	6	58	57
Magnus Heinason	FAR	60°-70°N, 8°30W-3°E	6.5-28.5	8	118	118
Persei III	RUS	69°-73°N, 25°-40°E	23.5-12.6	4	0	69
Fr. Nansen	RUS	69°-74°N, 5°W-16°E	6.7-28.7	8	112	182
Arni Fridriksson	ISL	62°30-66°N, 22°-5°30W	20.7-4.8	0	59	58
G.O. Sars	NOR	62°N-77°N, 5°W-16°E	20.7-17.8	12	79	79

Table 3. Age stratified estimate of Norwegian spring spawning herring in the Norwegian Sea, R/V Arni Fridriksson, R/V G. O. Sars, R/V Tridens, May, 2000. Numbers in millions, weight in thousand tonnes, length in cm, mean weight in grams.

Norwegian spring spawning herring in the Norwegian Sea, May, 2000

Age	2	3	4	5	6	7	8	9	10	11	13	15+	Total
Numbers	196	1353	2783	92	384	1302	7194	5344	1689	271	114	1135	21857
Percent	0.9	6.2	12.7	0.4	1.8	6.0	32.9	24.5	7.7	1.2	0.5	5.2	100
Mean length	22.09	26.32	29.71	32.97	33.38	33.71	34.24	34.91	35.90	36.73	38.41	38.61	33.58
Weight	14.8	184.8	540.5	23.6	102.5	336.7	1961.9	1540.6	529.8	91.7	44.7	426.8	5798.3
Mean weight	77.5	136.6	194.2	256.1	267.0	258.6	272.7	288.3	313.7	338.2	392.1	376.0	265.3

Table 4. Age stratified estimate of Norwegian spring spawning herring in the northern Norwegian Sea, R/V G. O. Sars, August, 2000. Numbers in millions, weight in thousand tonnes, length in cm, mean weight in grams.

Norwegian spring spawning herring in the Norwegian Sea, August, 2000

Age	2	3	4	5	6	7	8	9	10	11	13	14	15+	Total
Numbers	107	1518	4189	275	448	1064	4936	3372	69	152	6	50	6	16192
Percent	0.7	9.4	25.9	1.7	2.8	6.6	30.5	20.8	0.4	0.9	0.0	0.3	0.0	100
Mean length	25.78	27.79	30.68	33.01	33.82	33.9	34.14	34.58	36.7	35.94	38.25	36.25	38.25	32.68
Weight	15.3	277	1045.6	80.1	147.6	343.7	1669.3	1205.9	26.1	61.9	2.3	20.3	2.5	4897.7
Mean weight	143	182.5	249.6	291.4	329.5	323	338.2	357.6	378.9	407.5	386	405	422	302.5

Table 5. Age stratified estimate of Norwegian spring spawning herring in the Barents Sea, R/V Persei III, May-June 2000. Numbers in millions, biomass in thousand tonnes, length in cm, mean weight in grams.

Norwegian spring spawning herring in the Barents Sea, May-June, 2000

Age	1	2	Total
Numbers	105445	27889	133334
Percent	79.1	20.9	100
Mean length	11.1	14.5	11.3
Biomass	738.9	527.2	1266.1
Mean weight	7.0	18.9	9.5

Table 6. Age stratified preliminary estimate of blue whiting, R/V Arni Fridriksson, July-August, 2000. Numbers in millions, biomass in thousand tonnes, length in cm, mean weight in grams.

Blue whiting in the Icelandic EEZ, July/August, 2000

Age	0	1	2	3	4	5	6	7	8	9	10	Total
Numbers	10683	5559	729	455	1150	434	106	25	1	0	1	19143
Percent	55.8	29.1	3.8	2.4	6.0	2.3	0.6	0.1	+	0	+	100
Average length	13.5	22.3	24.1	26.1	27.6	29.4	32.3	32.0	36.0		28.0	18.0
Average weight	17.5	72.4	88.5	117.0	137.2	163.5	211.0	188.0	245.0		320.3	50.3
Weight	186.9	402.5	64.5	55.3	157.8	71.0	22.3	4.7	0.2		0.3	963.4

Table 7. Age stratified estimate of the Blue Whiting stock in the Norwegian Sea, R/V "G.O.Sars", July-August, 2000. Numbers in millions, weight in thousand tonnes, length in cm mean weight in grams.

Blue Whiting in the Norwegian Sea, July- August, 2000

Age	0	1	2	3	4	5	6	7	Total
Numbers	0.0	25813.0	3298.0	2721.0	3078.0	23.0	46.0	6.0	34985.0
Mean length	0.00	21.79	25.23	26.36	27.61	30.90	33.75	32.75	23.01
Weight	0.0	1471.9	302.6	289.5	385.4	4.1	8.4	1.3	2463.1
Mean weight	0.0	57.0	91.8	106.4	125.2	177.6	182.0	222.0	70.4
Condition	0.0	5.4	5.7	5.8	5.9	6.0	4.7	6.3	5.5

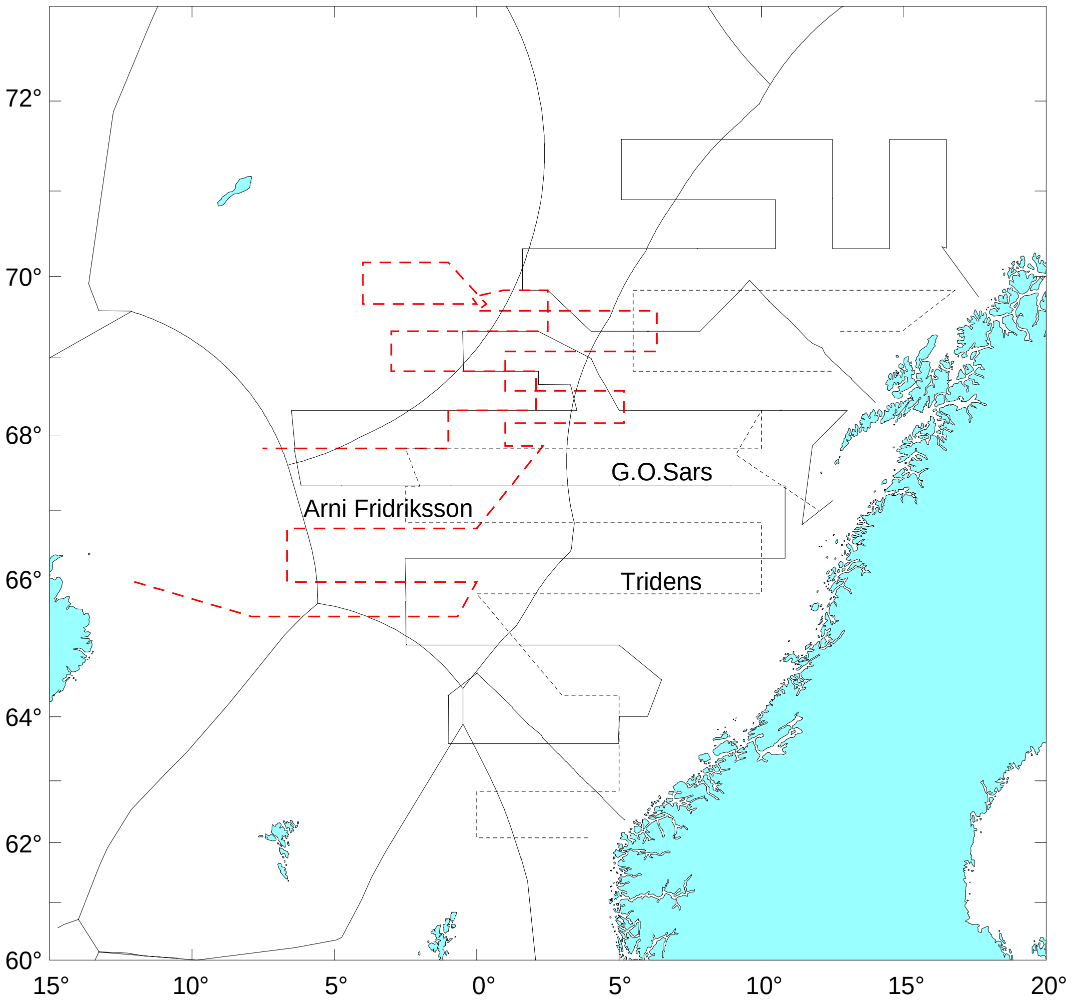

Figure 1. Survey transects of the R/V "Tridens", R/V "Arni Fridriksson" and R/V "G.O.Sars", May 2000. Refer table 2 for dates.

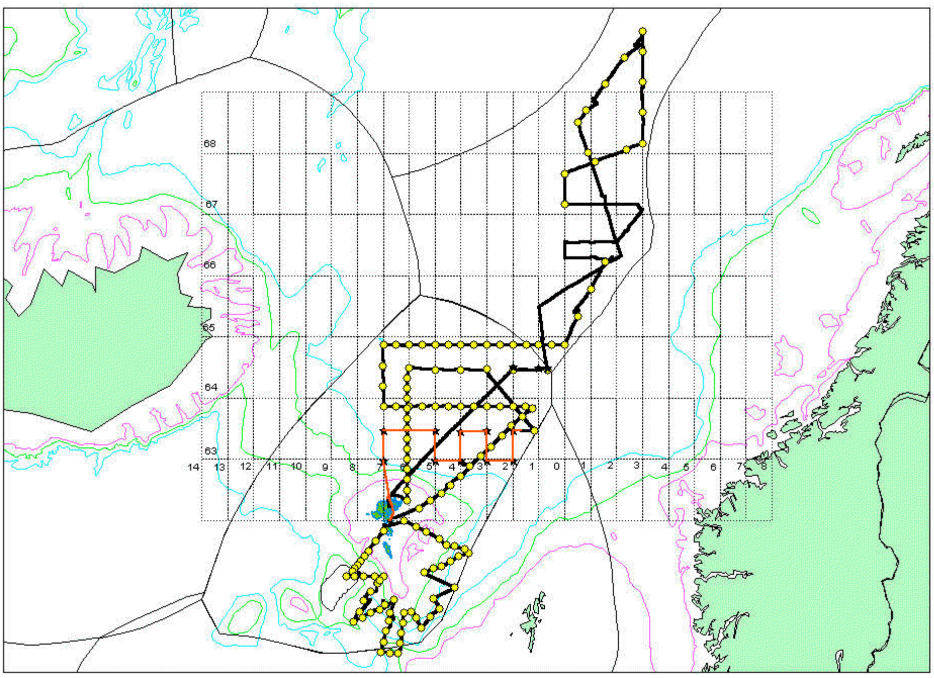

Figure 2. Cruise tracks of R/V *Magnus Heinason* 6-25/5 2000.

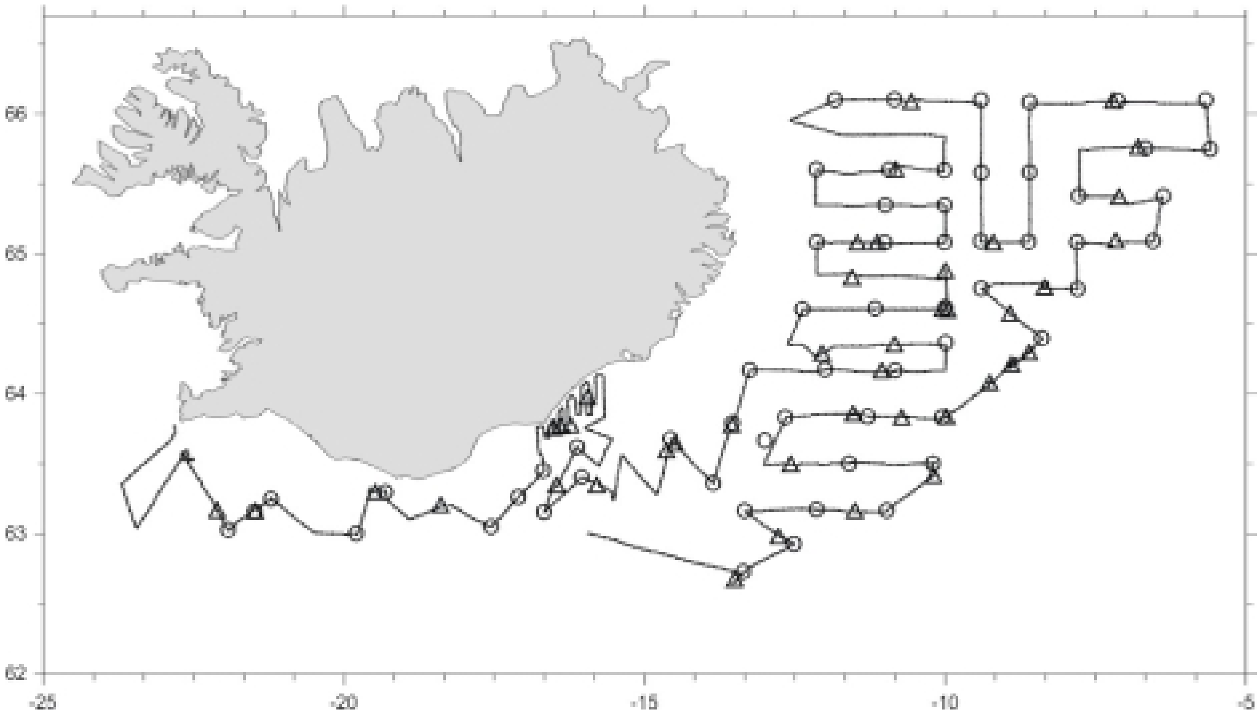

Figure 3. Survey tracks by R/V Arni Fridriksson, 20/7-4/8 2000. Triangles denote sampling locations with pelagic trawl and circles positions of CTD and WP2 stations

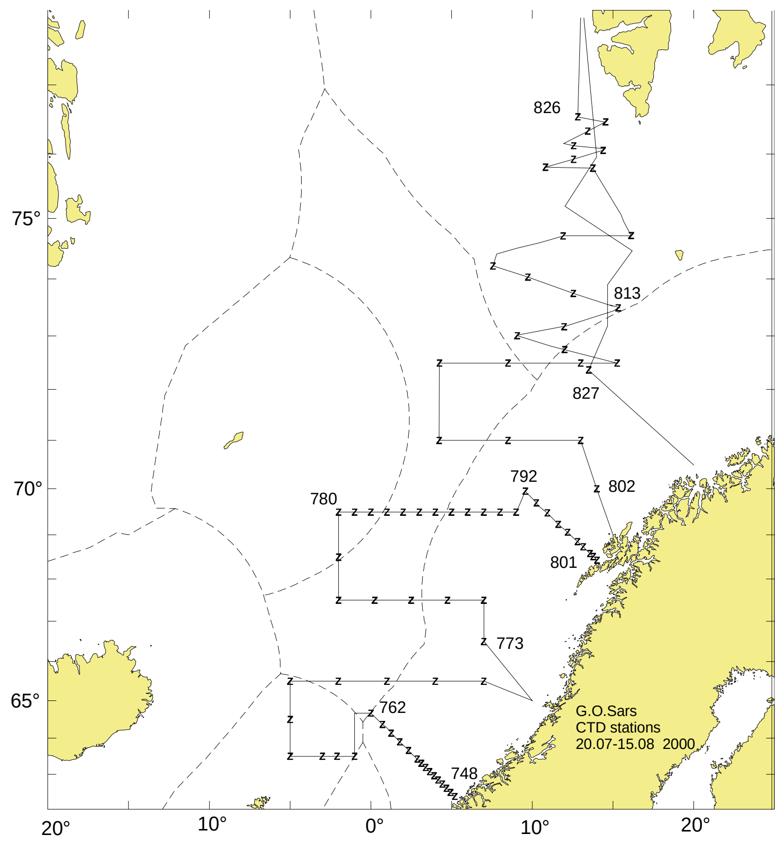

Figure 4. Transects of G.O.Sars during 20th July to 17th August 2000. CTD stations indicated.

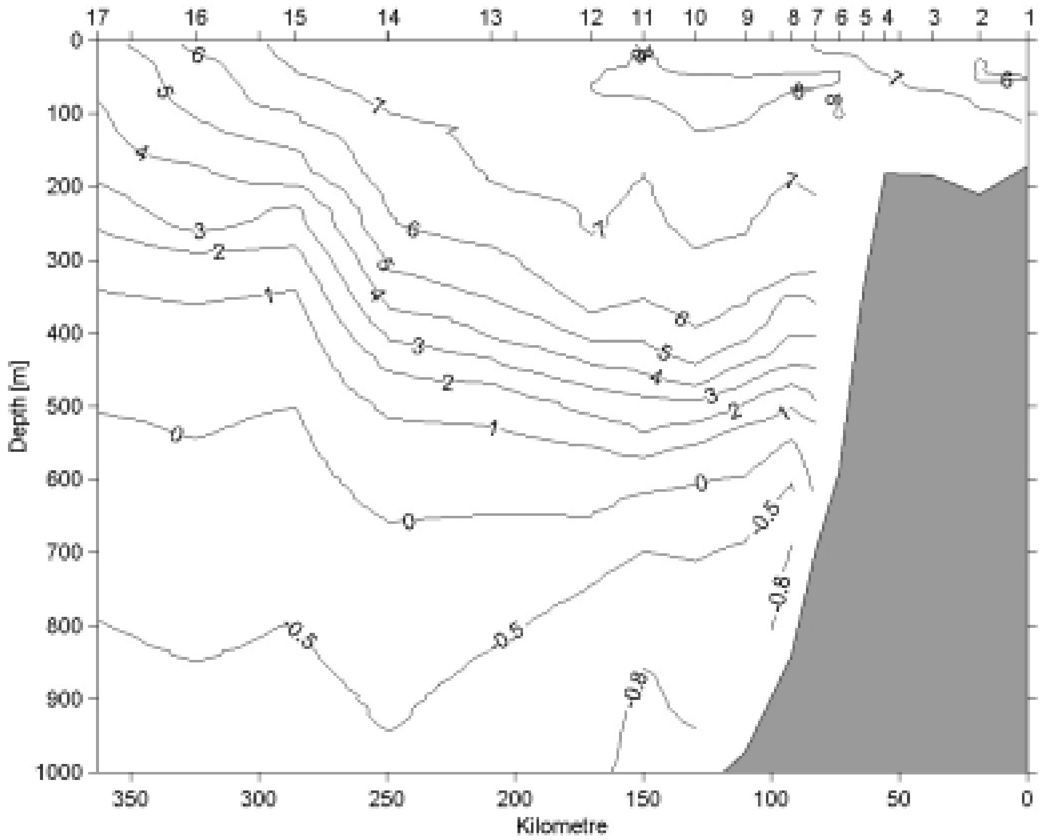

Figure 5. Temperature in the Svinøy section, 29-30 April, 2000.

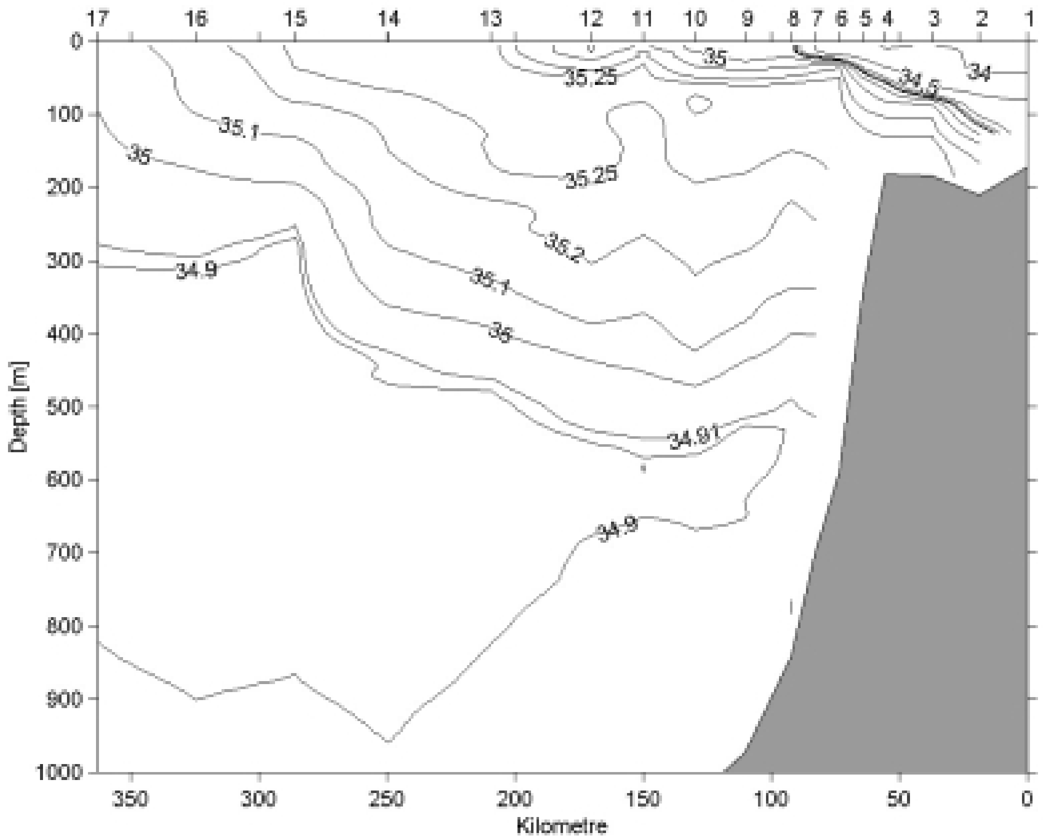

Figure 6. Salinity in the Svinøy section, 29-30 April, 2000.

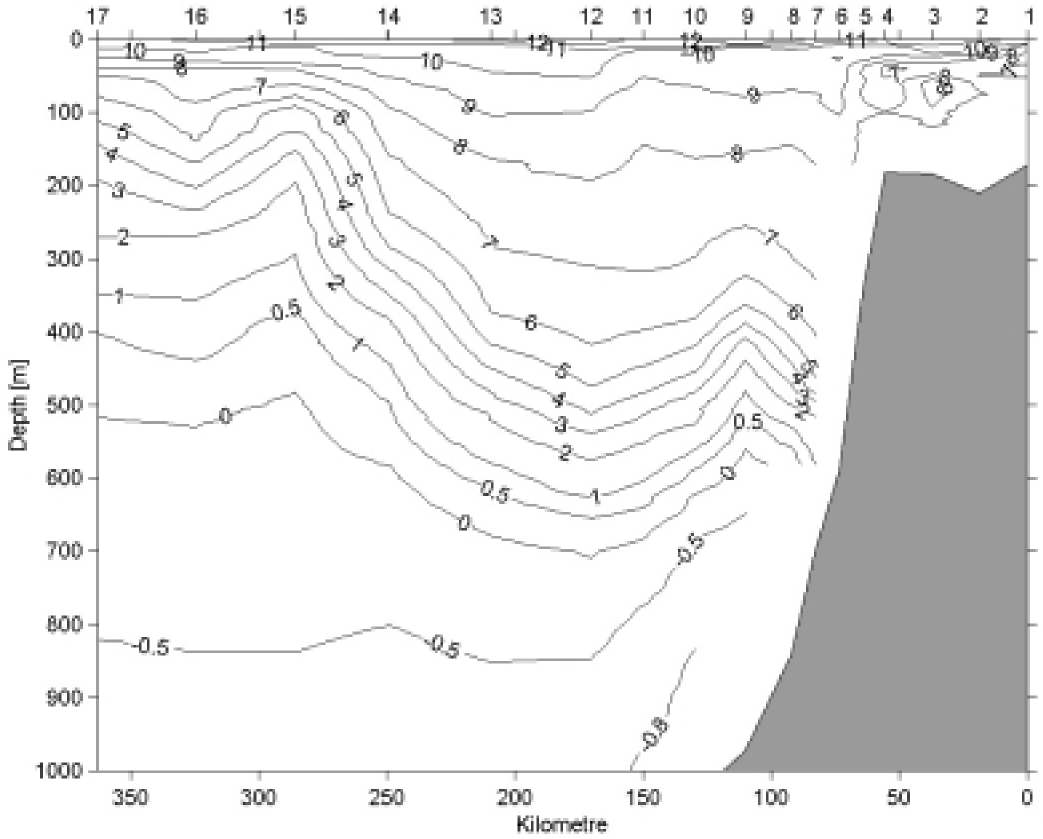

Figure 7. Temperatures in the Svinøy section, July, 2000.

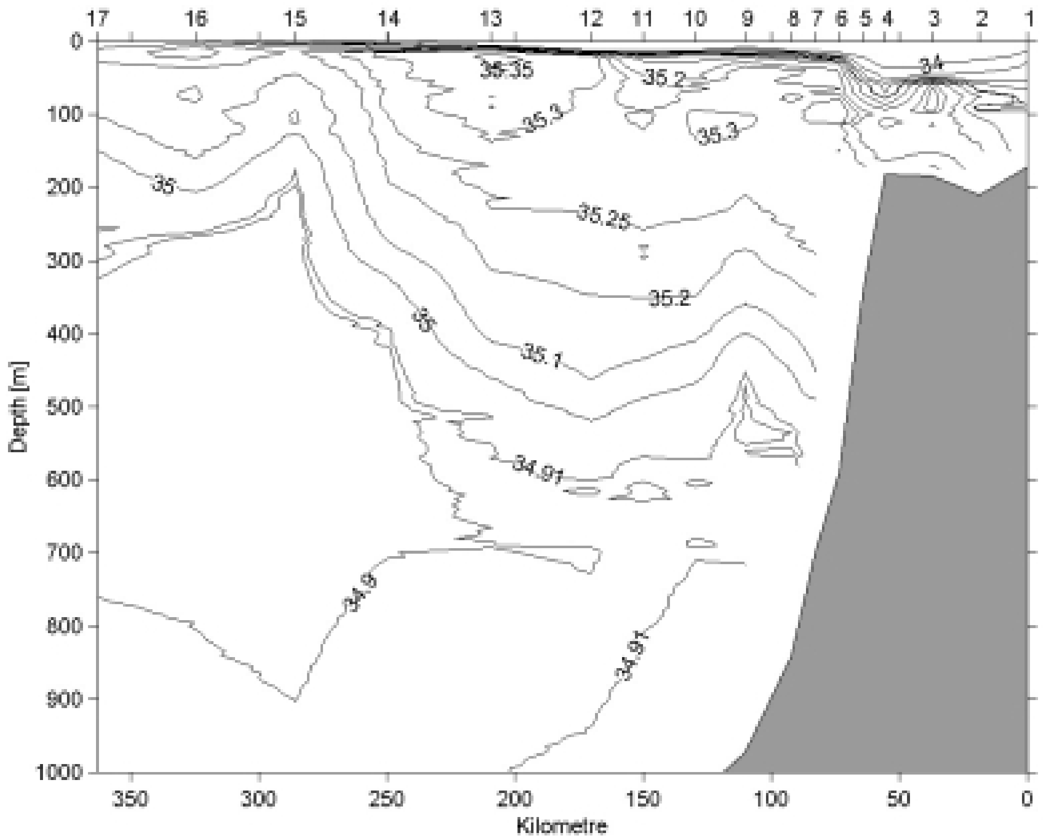

Figure 8. Salinities in the Svinøy section, July, 2000.

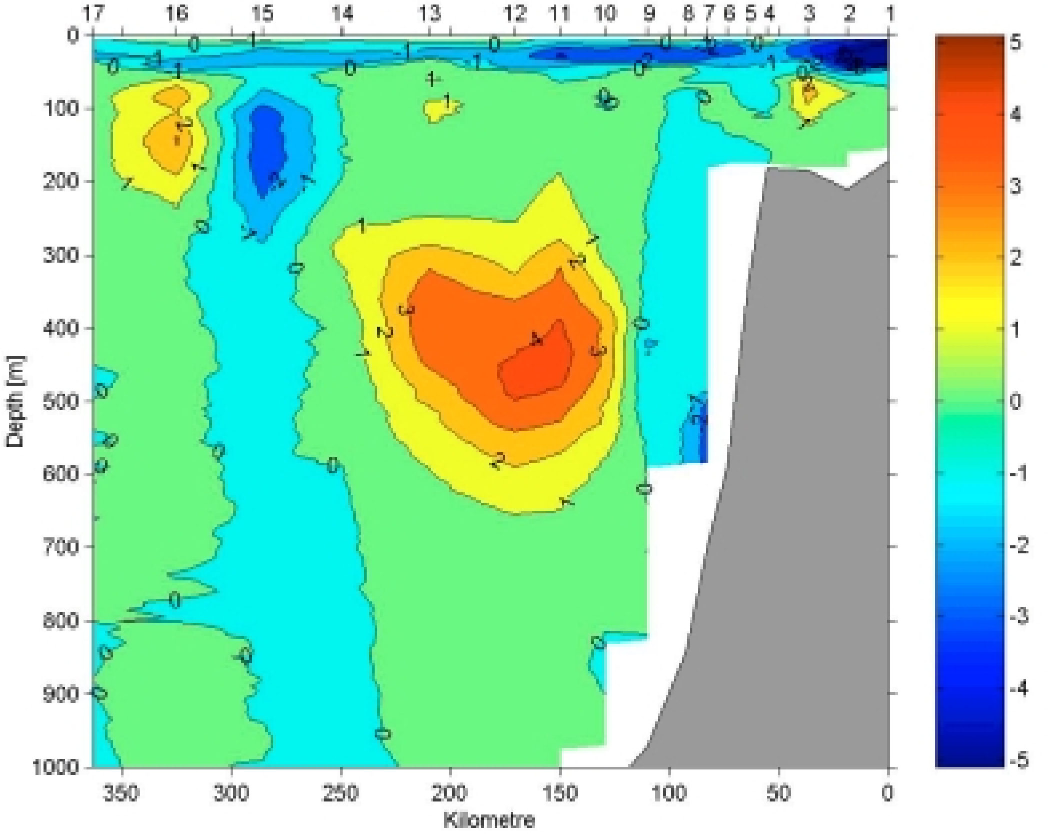

Figure 9. Temperature anomalies in the Svinøy section in July, difference between 1999 and 2000.

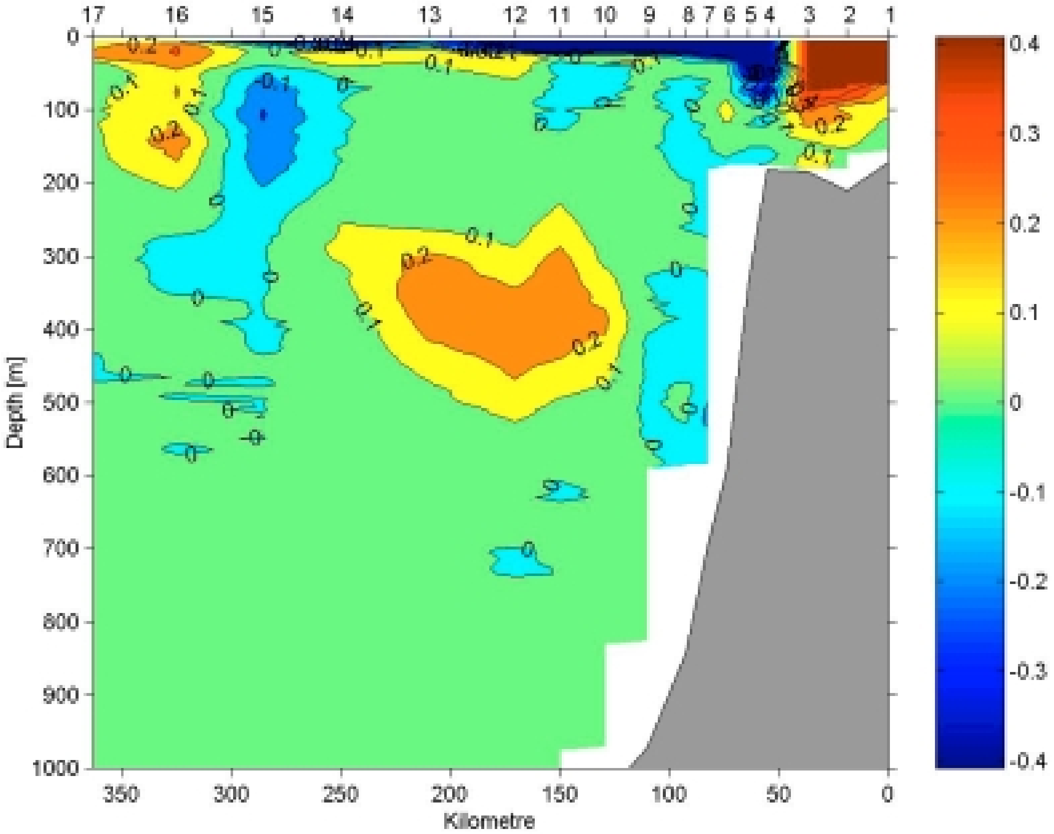

Figure 10. Salinity anomalies in the Svinøy section in July, difference between 1999 and 2000.

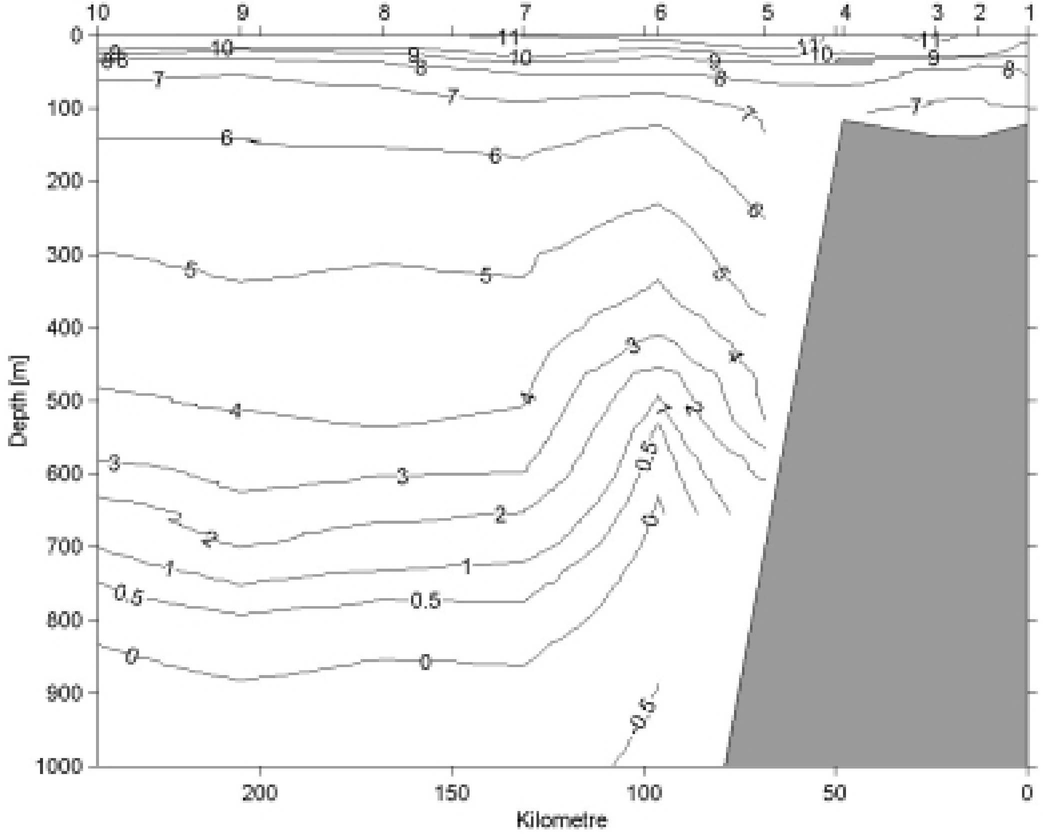

Figure 11. Temperatures in the Gimsøy section, July 2000.

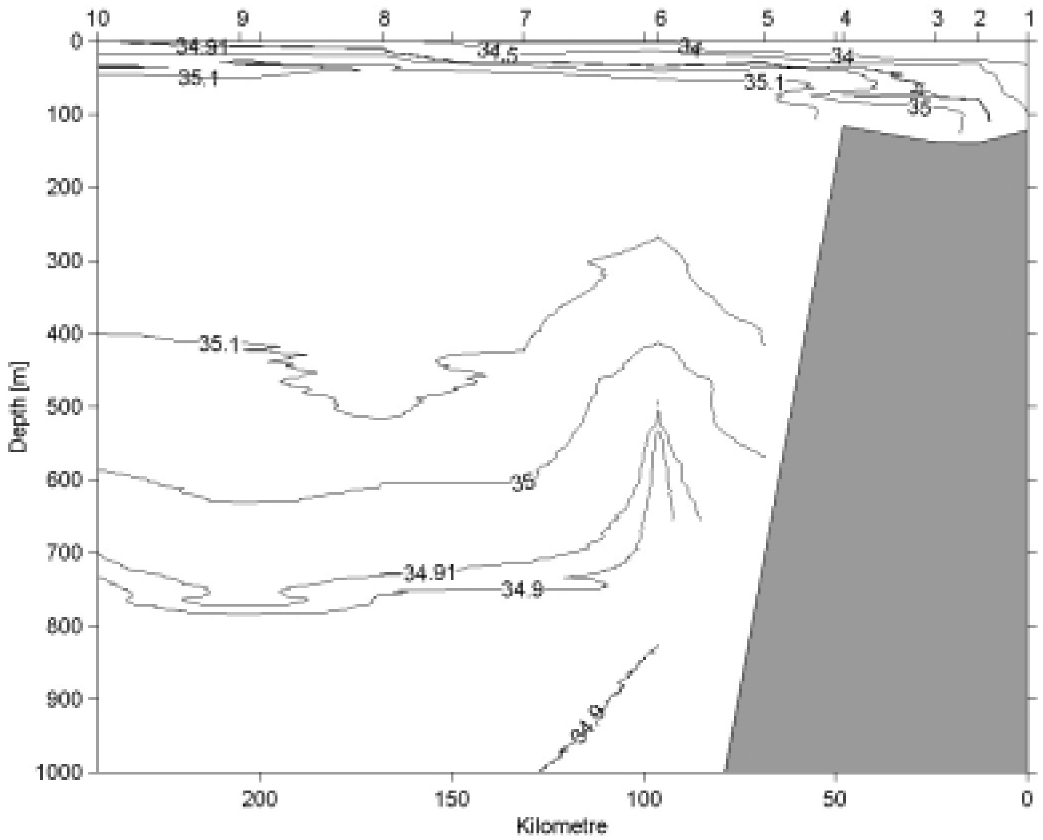

Figure 12. Salinities in the Gimsøy section, July, 2000.

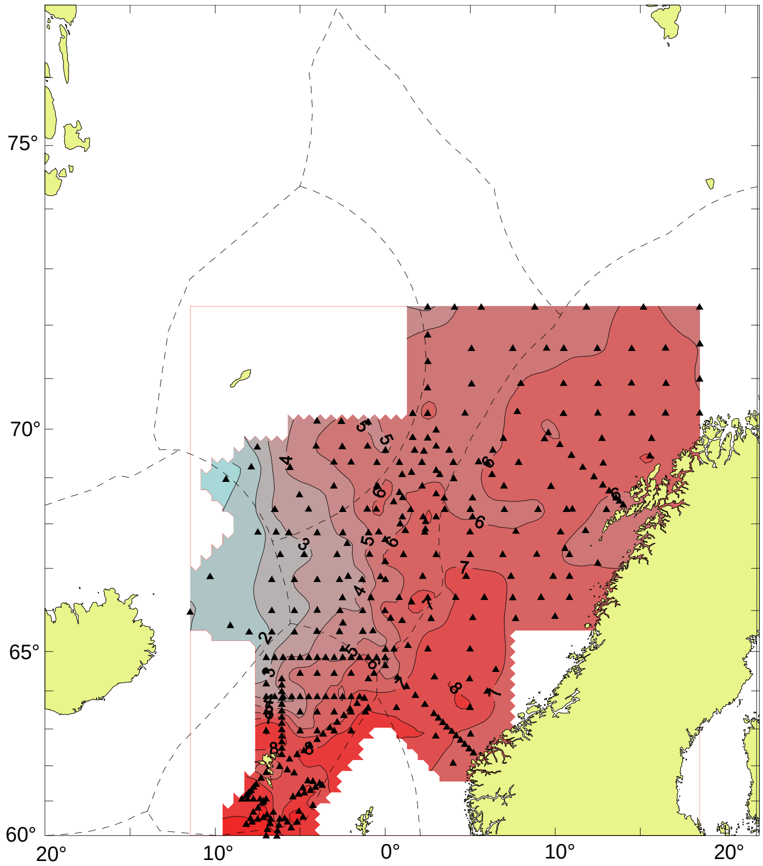

Figure 13. Temperatures at 20 meters in May 2000.

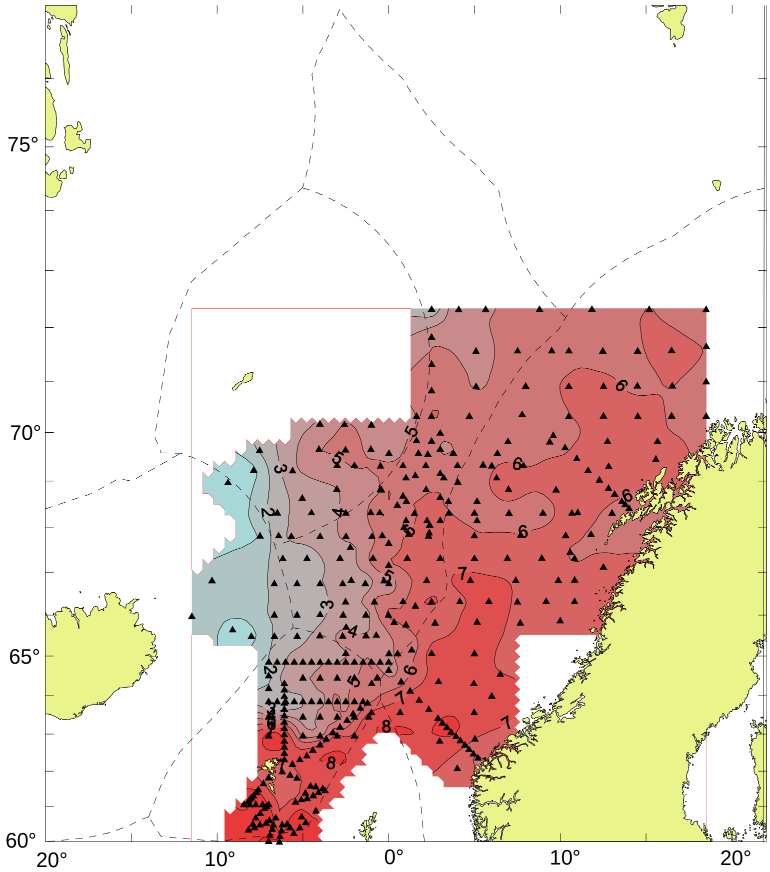

Figure 14. Temperatures at 50 meters in May 2000.

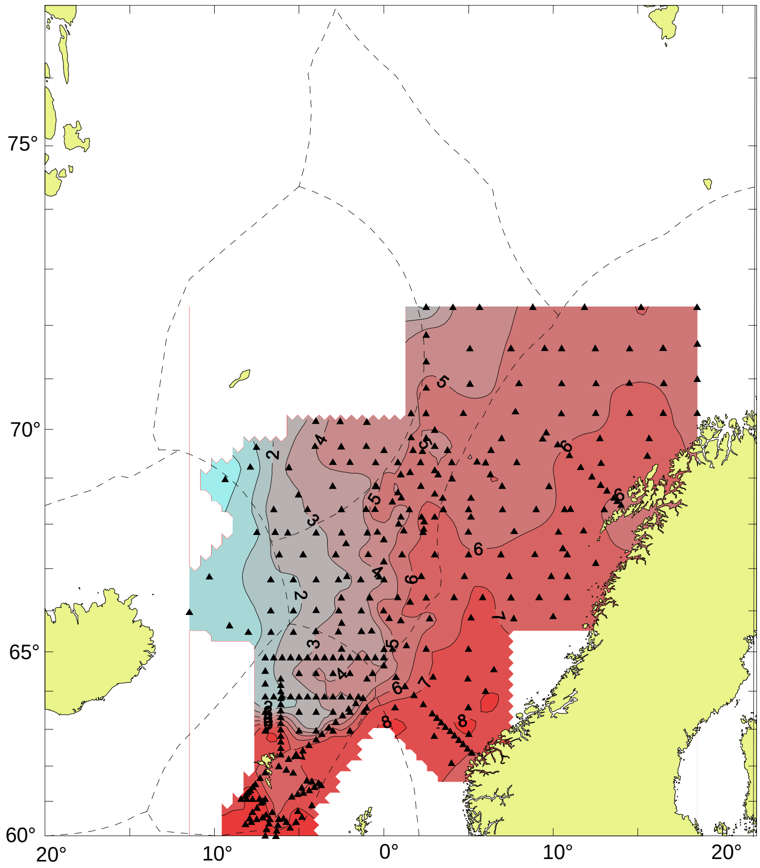

Figure 15. Temperatures at 100 meters in May 2000.

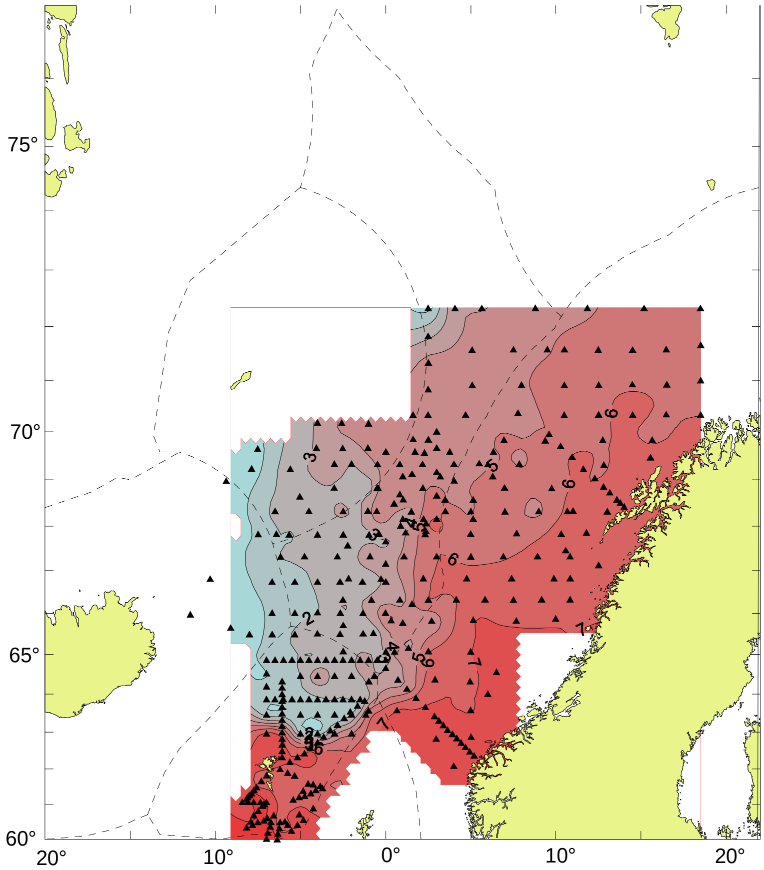

Figure 16. Temperatures at 200 meters in May 2000.

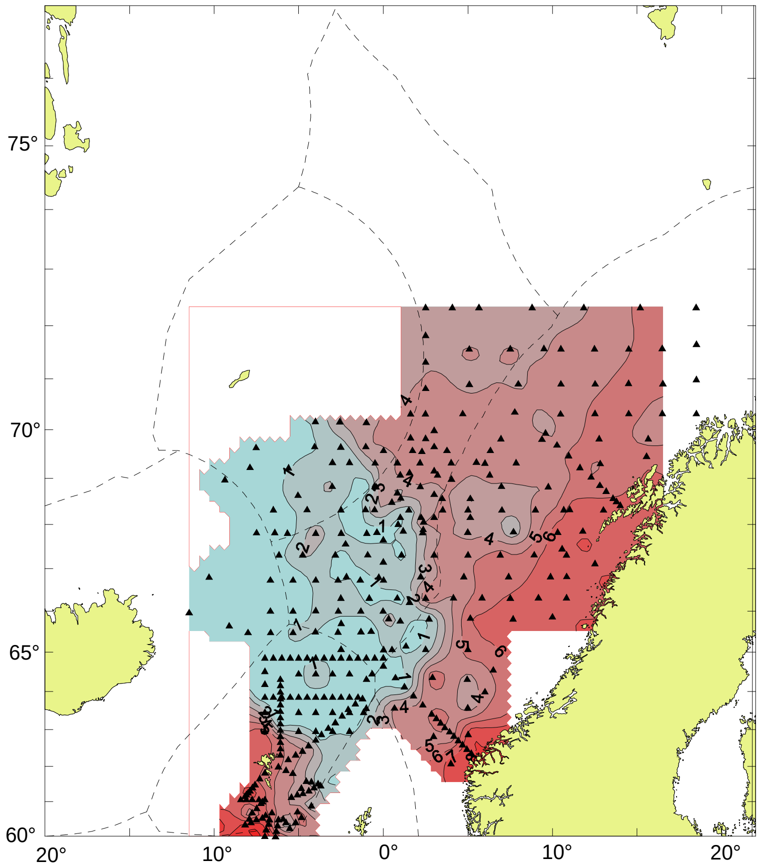

Figure 17. Temperatures at 400 meters in May 2000.

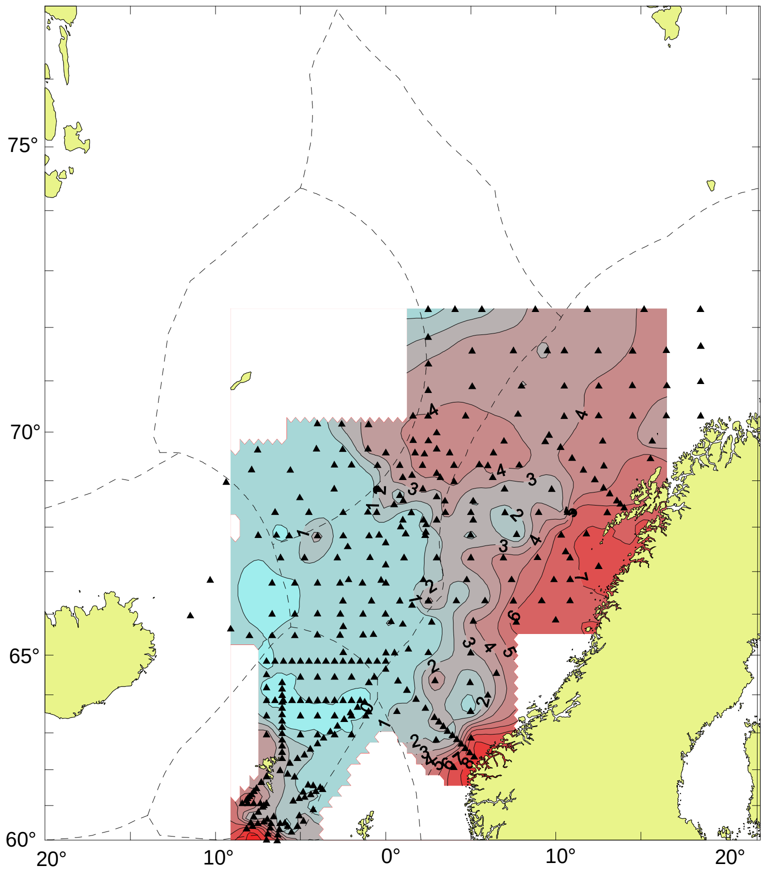

Figure 18. Temperatures at 500 meters in May 2000.

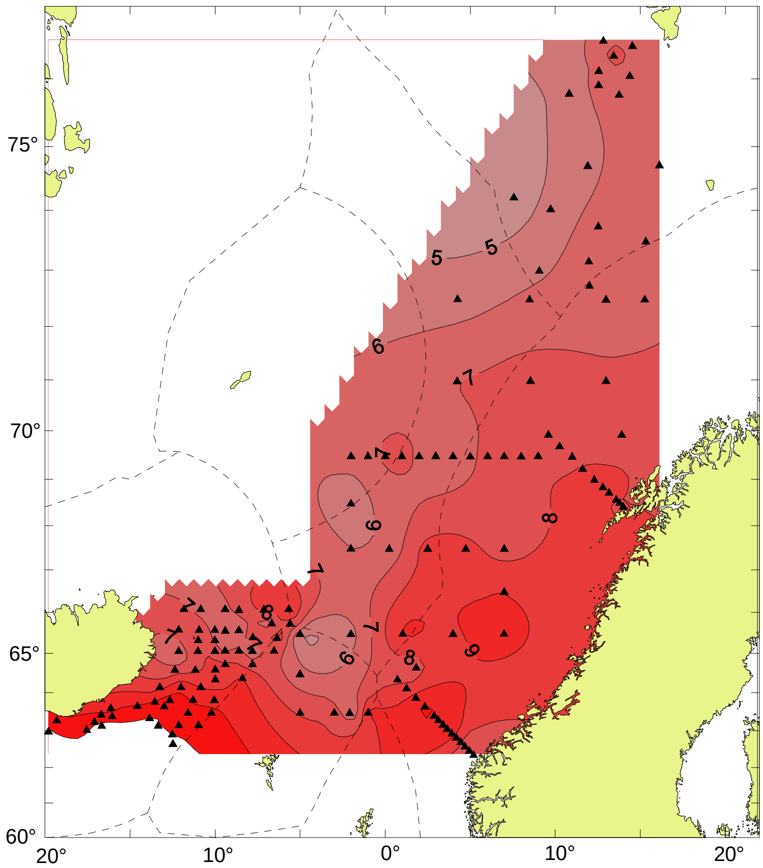

Figure 19. Temperatures at 20 meters in July-August 2000.

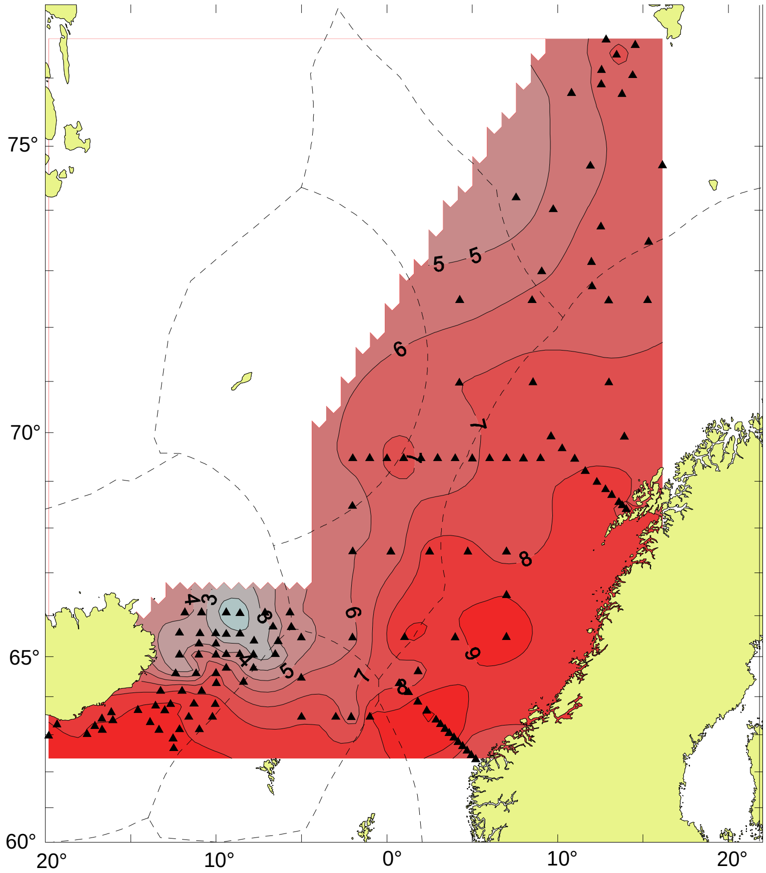

Figure 20. Temperatures at 50 meters in July-August 2000.

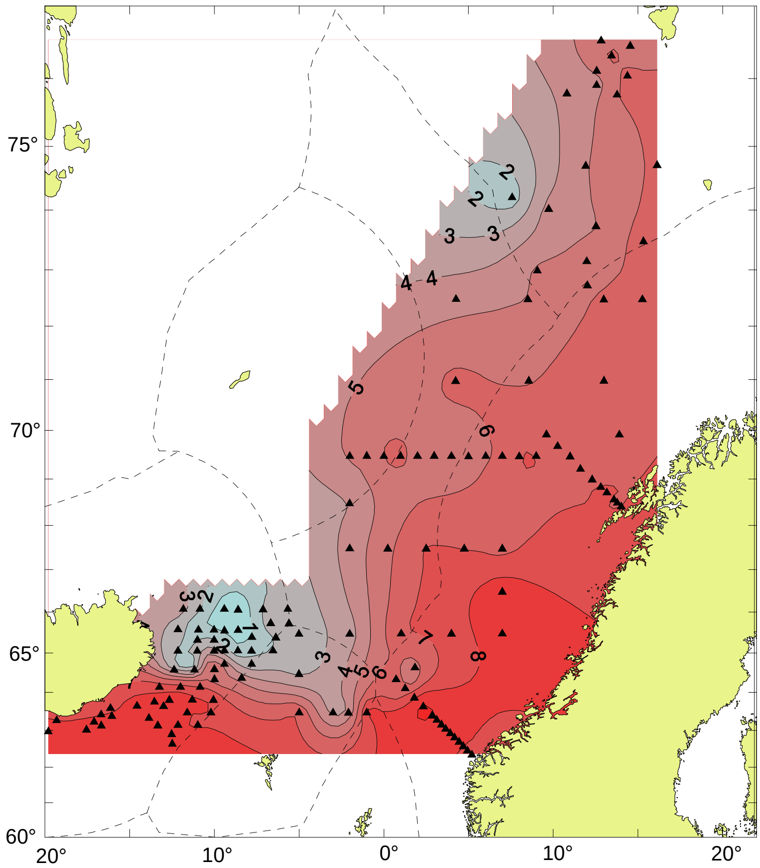

Figure 21. Temperatures at 100 meters in July-August 2000.

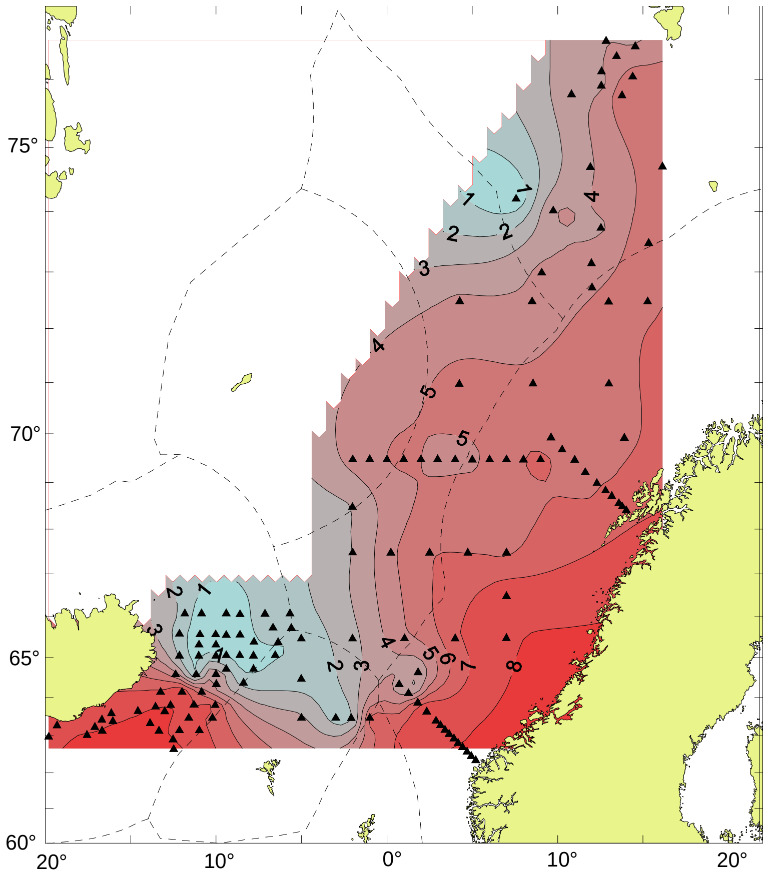

Figure 22. Temperatures at 200 meters in July-August 2000.

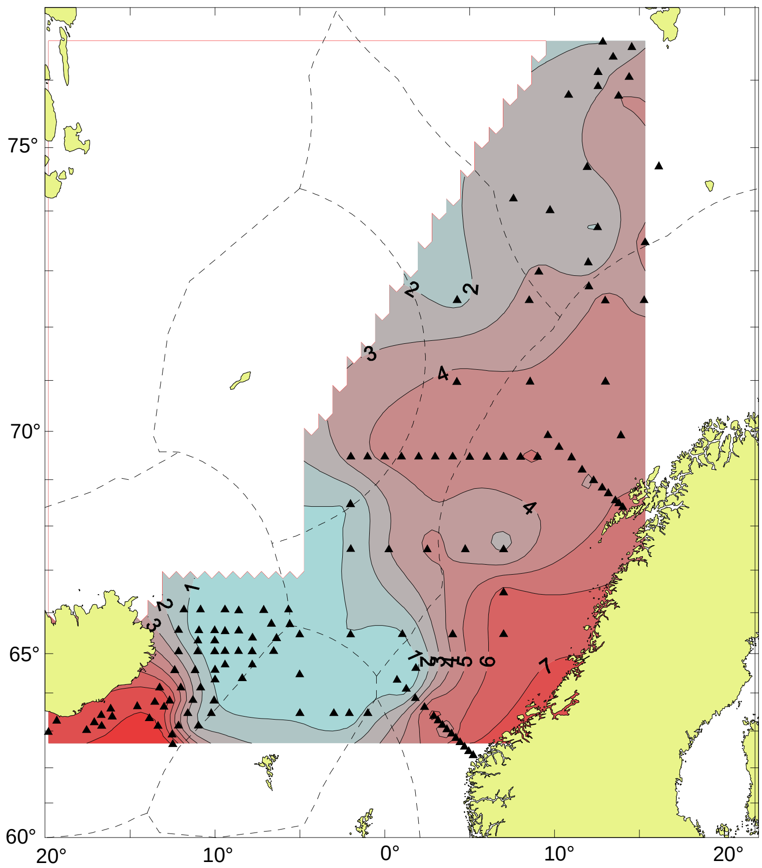

Figure 23. Temperatures at 400 meters in July-August 2000.

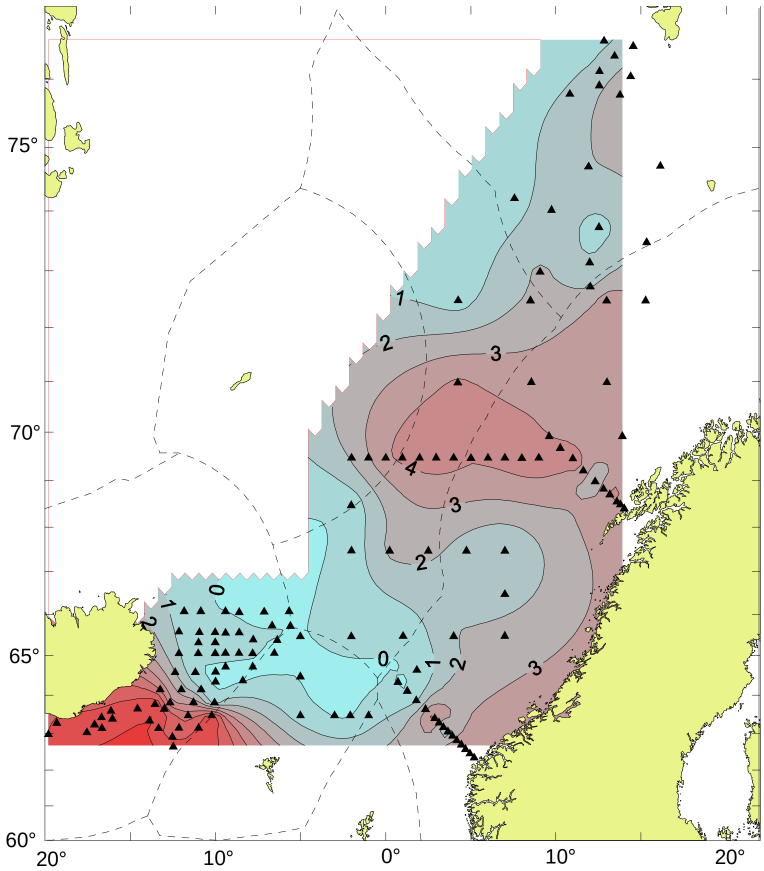

Figure 24. Temperatures at 500 meters in July-August 2000.

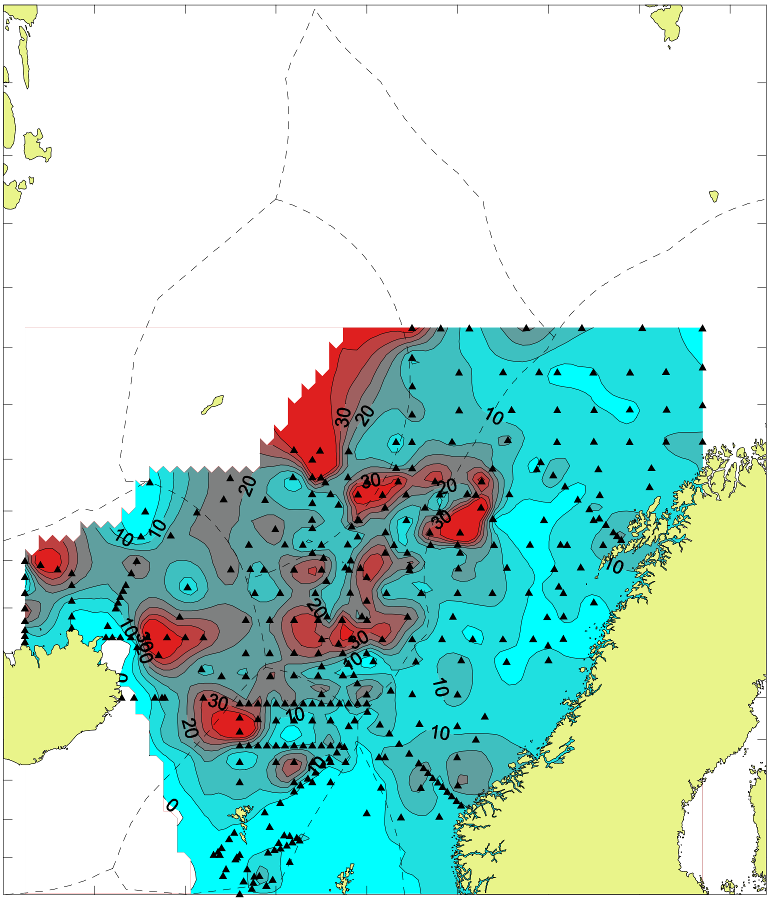

Figure 25. Zooplankton biomass (g dw m^{-2}) (200-0m) in April to June 2000.

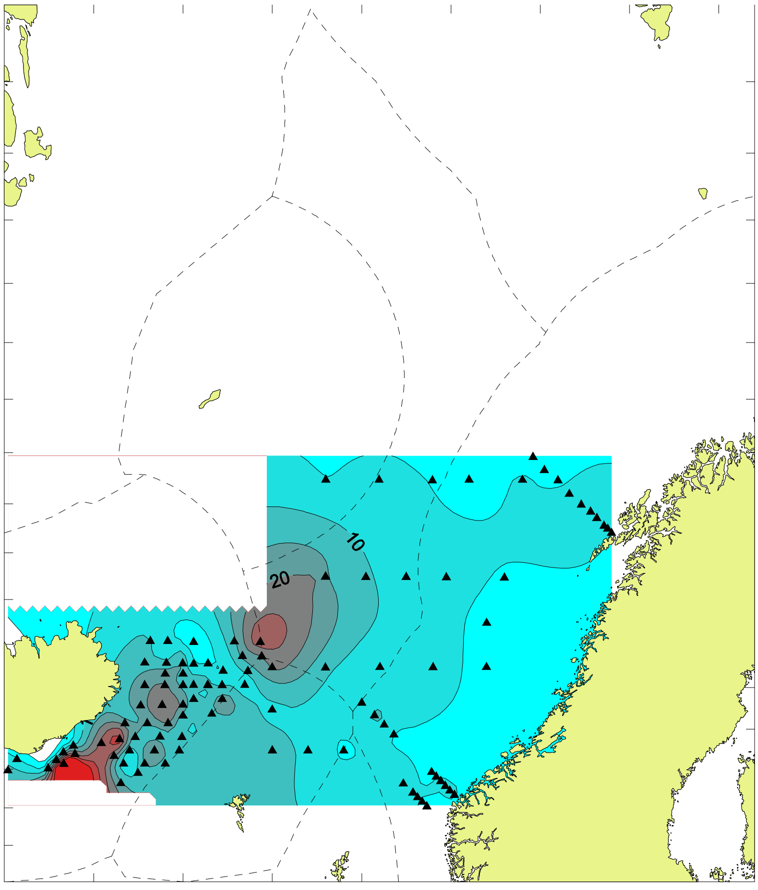

Figure 26. Zooplankton biomass (g dw m^{-2}) (200-0m) in July to August 2000.

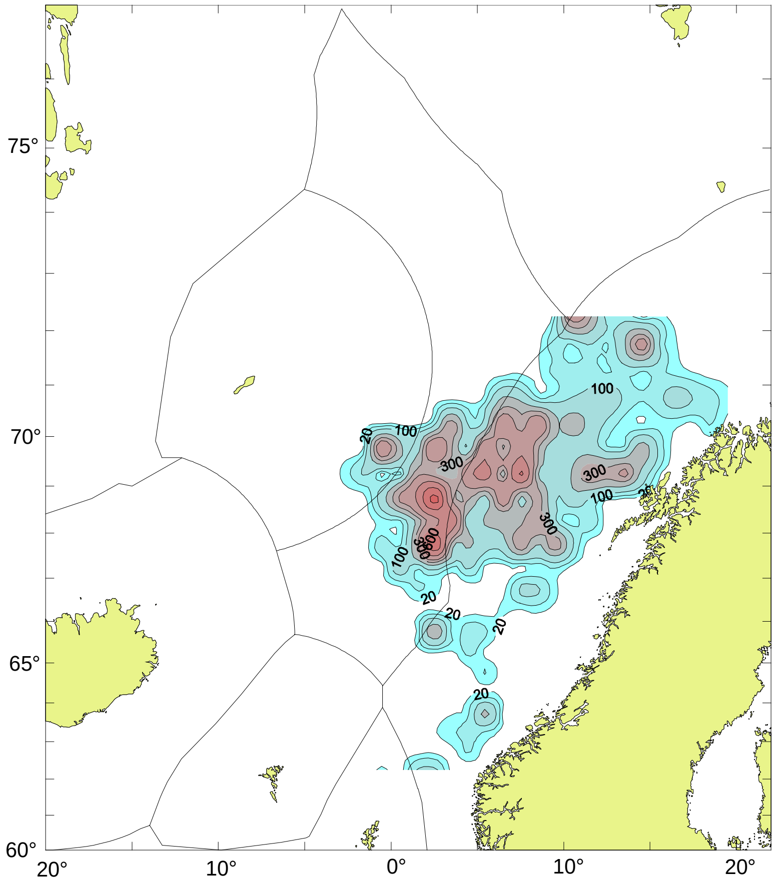

Figure 27. Distribution of Norwegian spring spawning herring as observed by R/V “Tridens”, R/V “Arni Fridriksson” and R/V “G.O.Sars” during the international herring survey in May 2000.

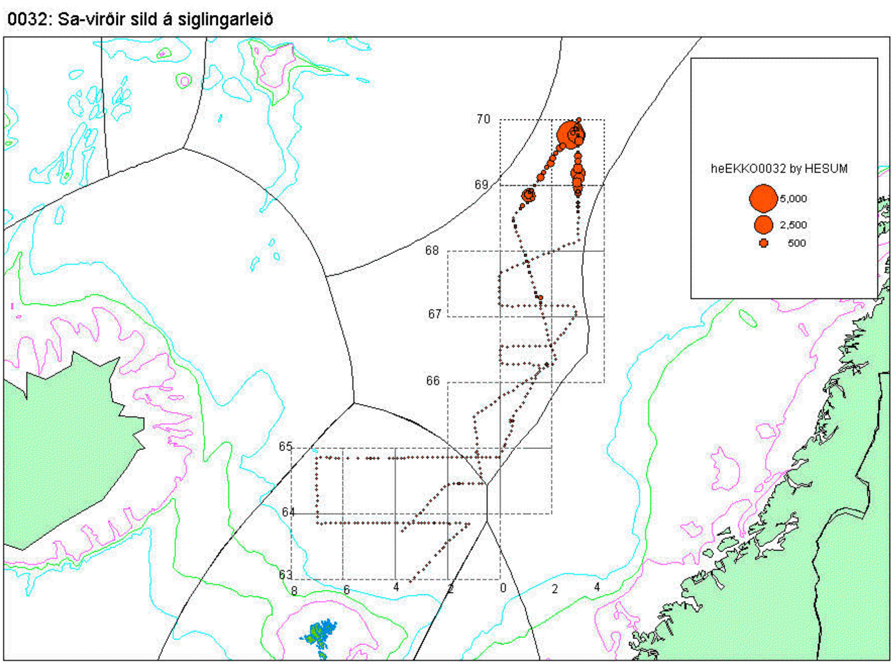

Figure 28. s_A values of spring-spawning from R/V *Magnus Heinason* during 13-25/5 2000.

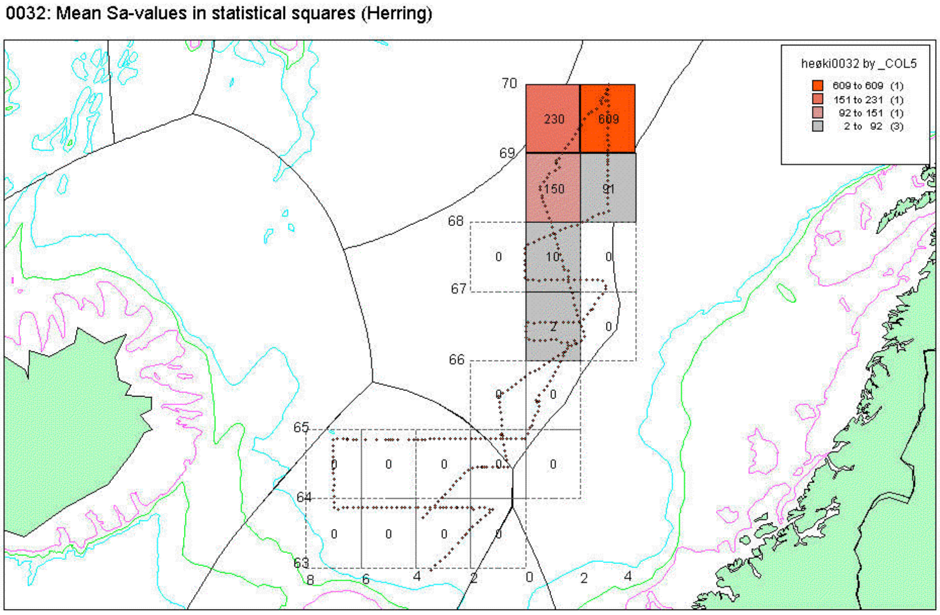

Figure 29 Biomass (t) of spring-spawning herring by ICES squares from R/V *Magnus Heinason* during 13-25/5 2000.

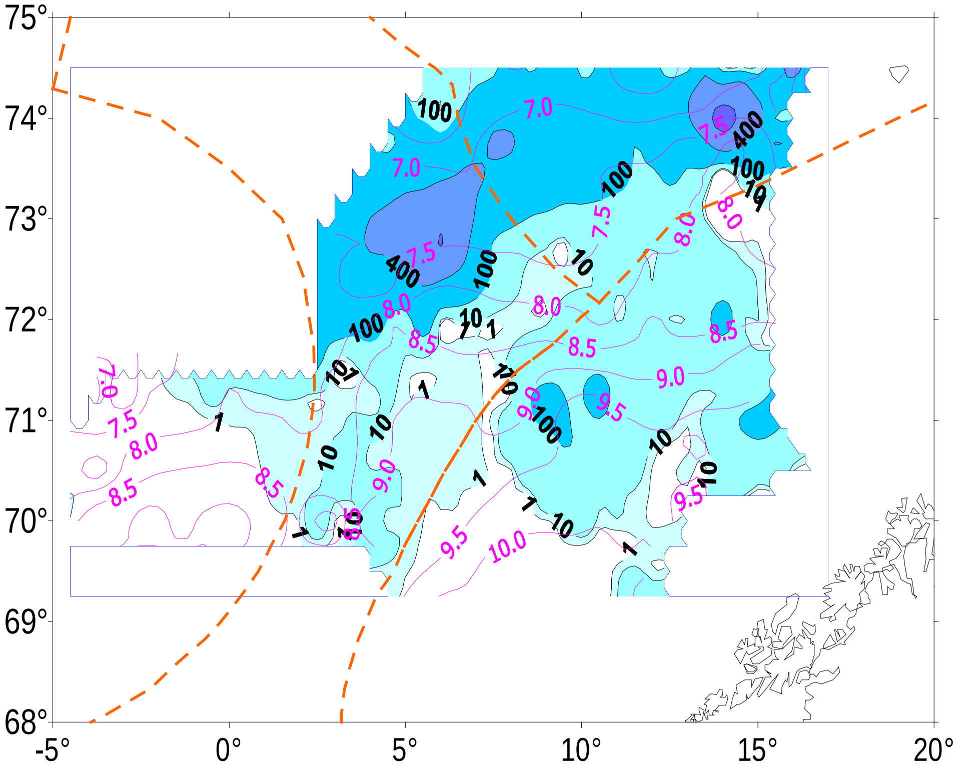

Figure 30. Distribution of herring in the Norwegian Sea and temperature 0 m in July, map of S $_A$ - values . 7-28 July R/V Fridtjof Nansen.

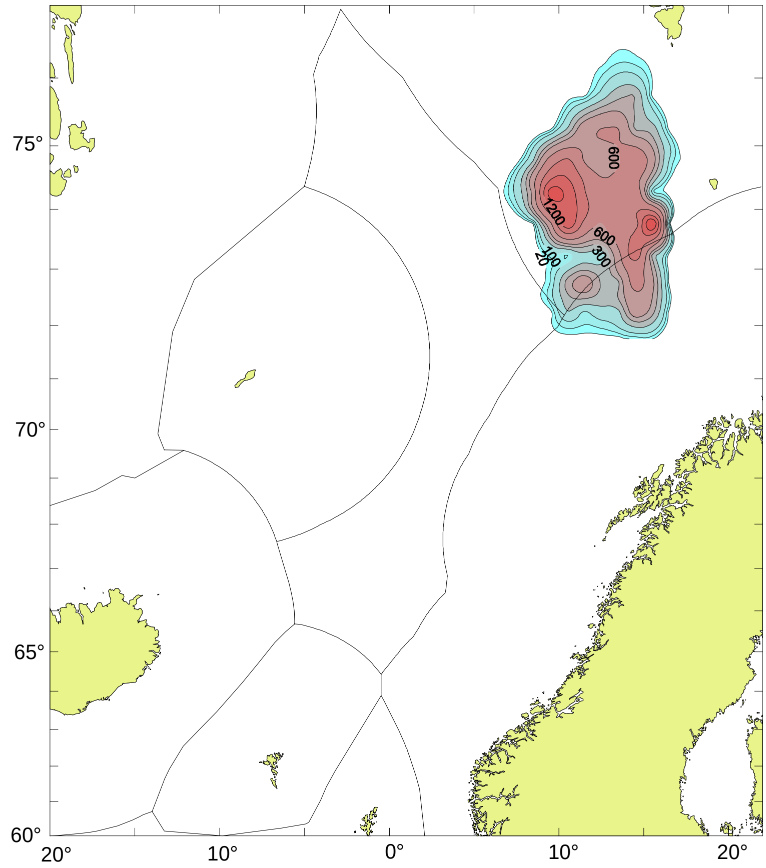

Figure 31. Distribution of Norwegian spring spawning herring as observed by G.O.Sars August 3rd-15th, 2000.

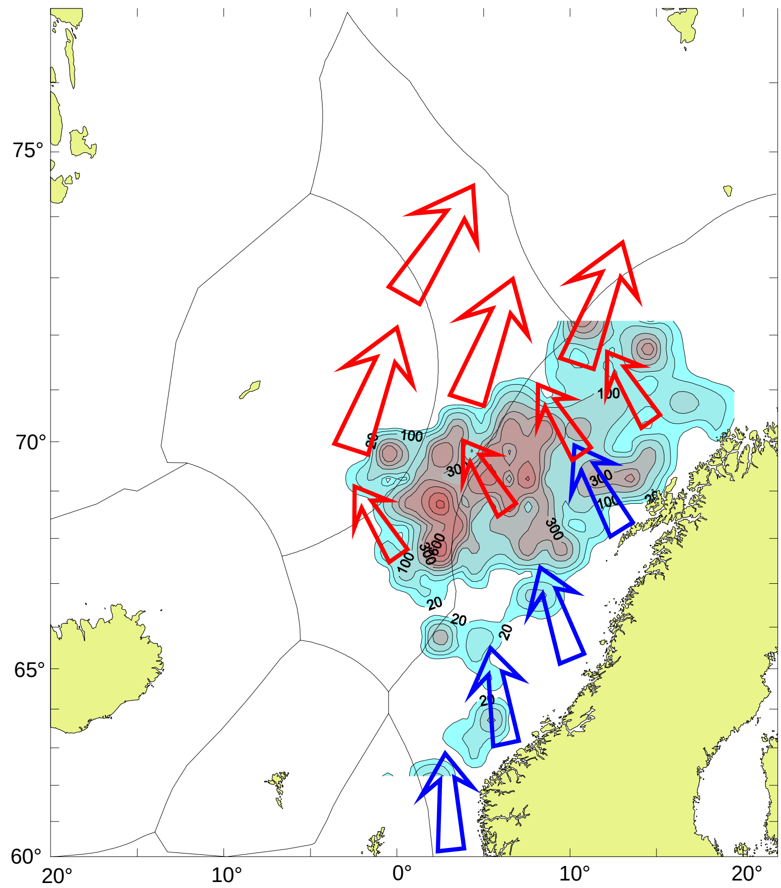

Figure 32. Inferred migration pattern of the Norwegian spring spawning herring in April (blue arrows, pointing into isolines), May (isolines) and June (red arrows, pointing out of isolines) 2000 based on all available information.

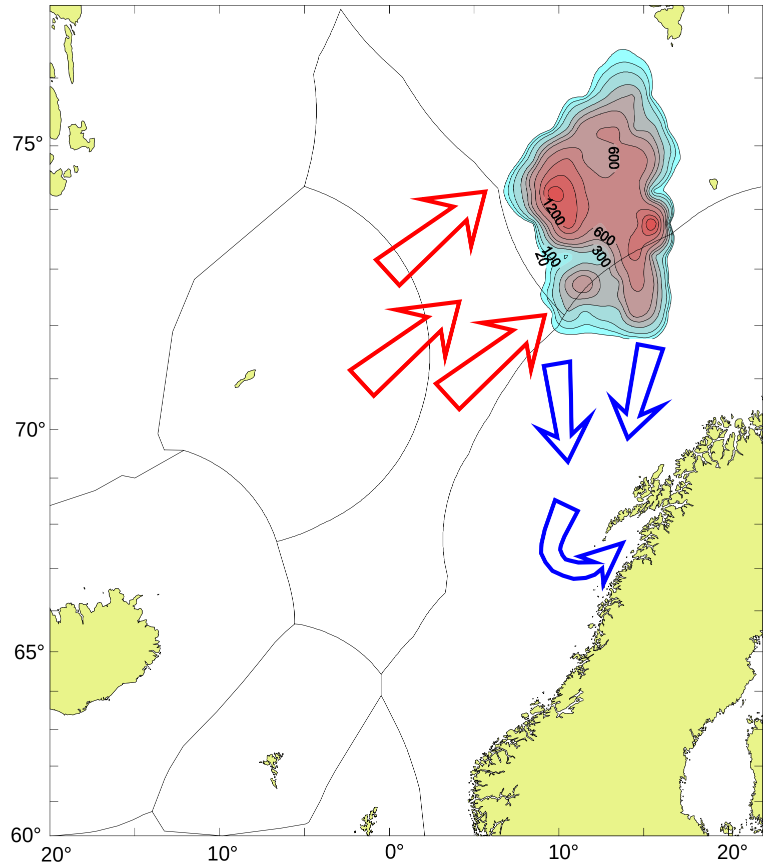

Figure 33. Inferred migration pattern of the Norwegian spring spawning herring in July (red arrows, pointing into isolines), early August (isolines) and September (blue arrows, pointing out of isolines) 2000 based on all available information.

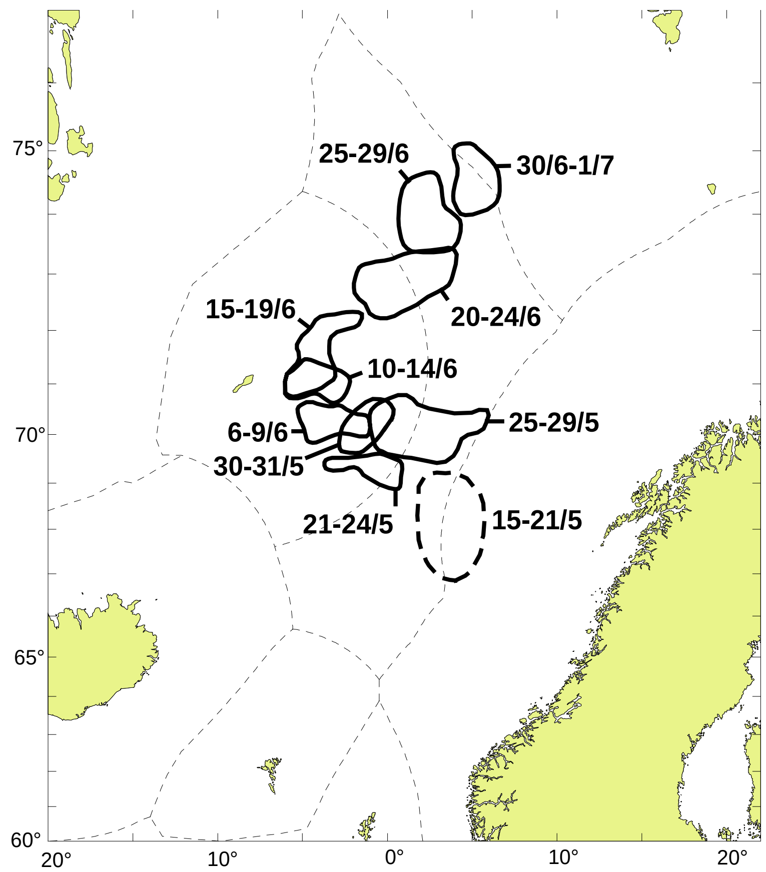

Figure 34. Main herring fishing areas of Faroese (15-21/5) and Icelandic fishing vessels (all other periods) during the summer of 2000.

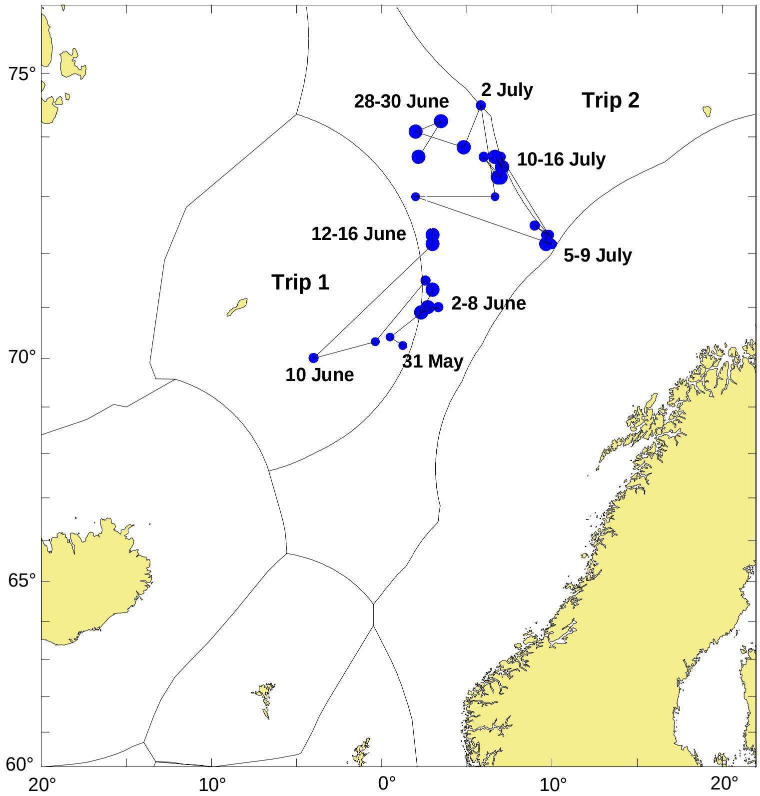

Figure 35. Registrations of herring by period done by MFV "Veronica" (Ireland) during two trips in the Norwegian Sea, June-July 2000. Size of circles indicates amount of herring observed: Very god, moderate and small (very good is largest circle). Courtesy to MFV "Veronica".

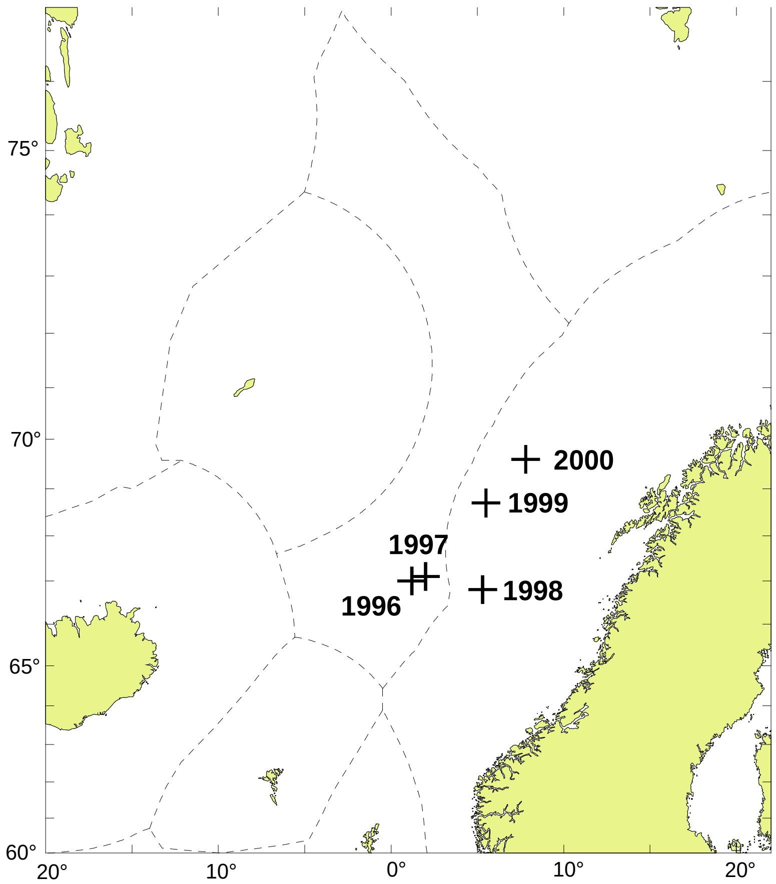

Figure 36. Centre of gravity of the measured distribution of Norwegian spring spawning herring during the years 1996 to 2000.

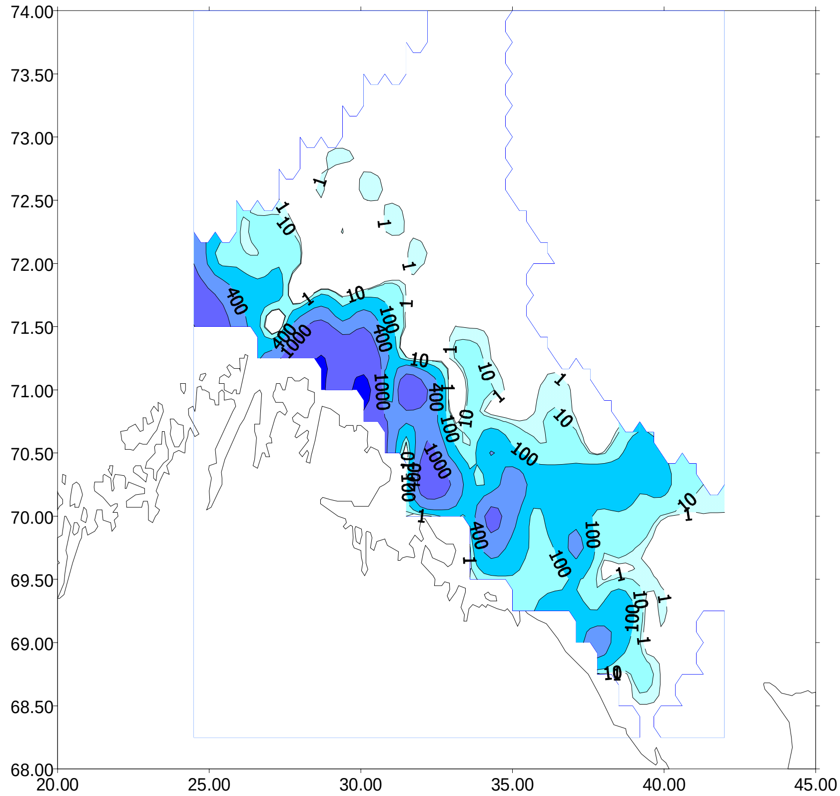

Figure 37. Distribution of herring in the Barents Sea in May-June, map of S $_A$ - values. R/V "Persei III", 23/5- 12/6 2000.

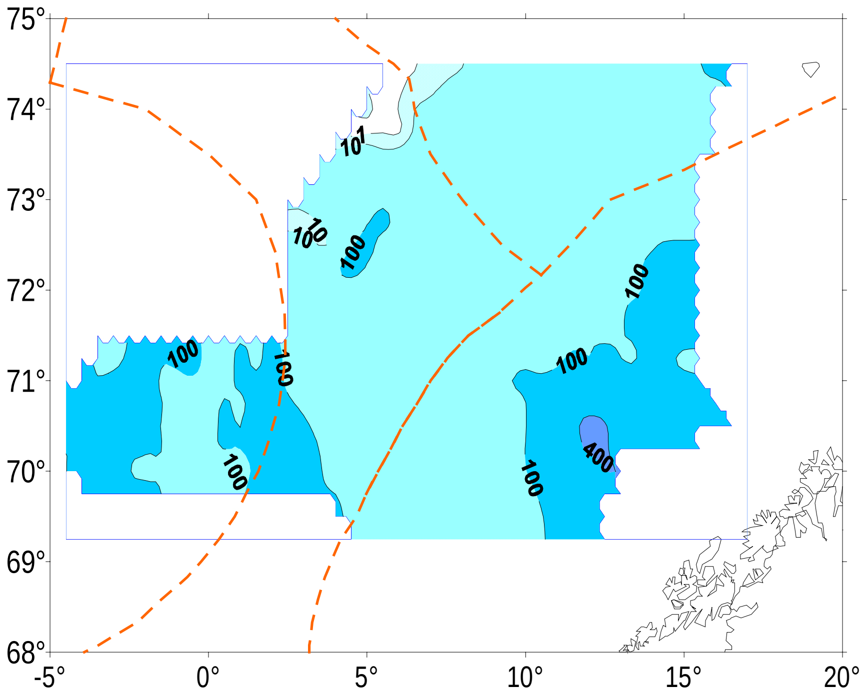

Figure 38. Distribution of Blue Whiting in the Norwegian Sea in July 2000, map of S $_A$ - values. R/V "Fritjof Nansen", 7-31 July 2000.

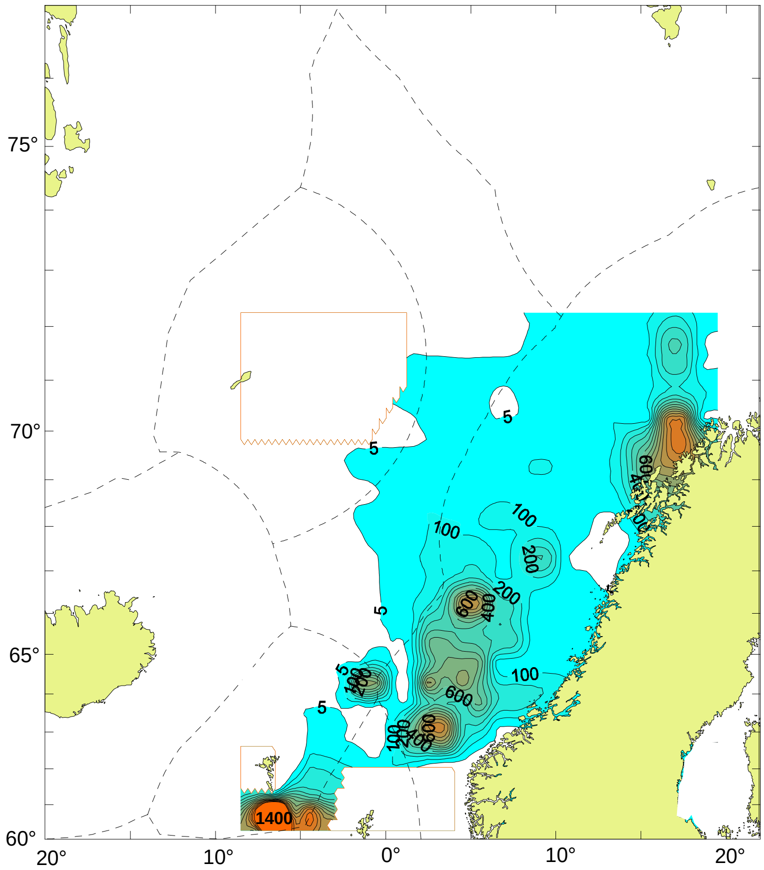

Figure 39. Distribution of blue whiting as observed by R/V "Tridens", R/V "Arni Fridriksson", R/V "G.O.Sars" and R/V "Magnus Heinason" during the international survey in May 2000.

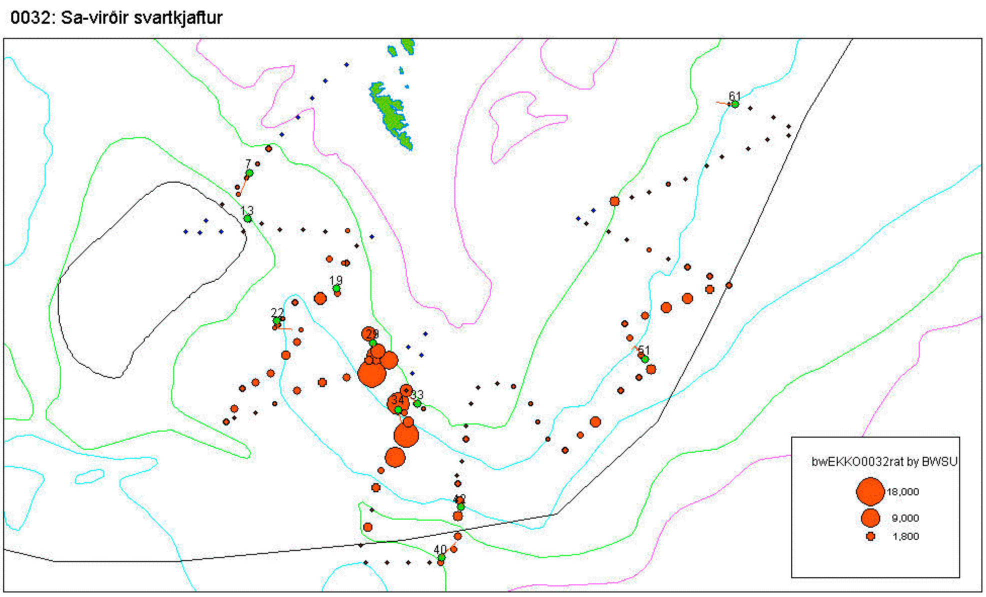

Figure 40. s_A values of blue whiting from R/V *Magnus Heinason* during 6-12/5 2000.

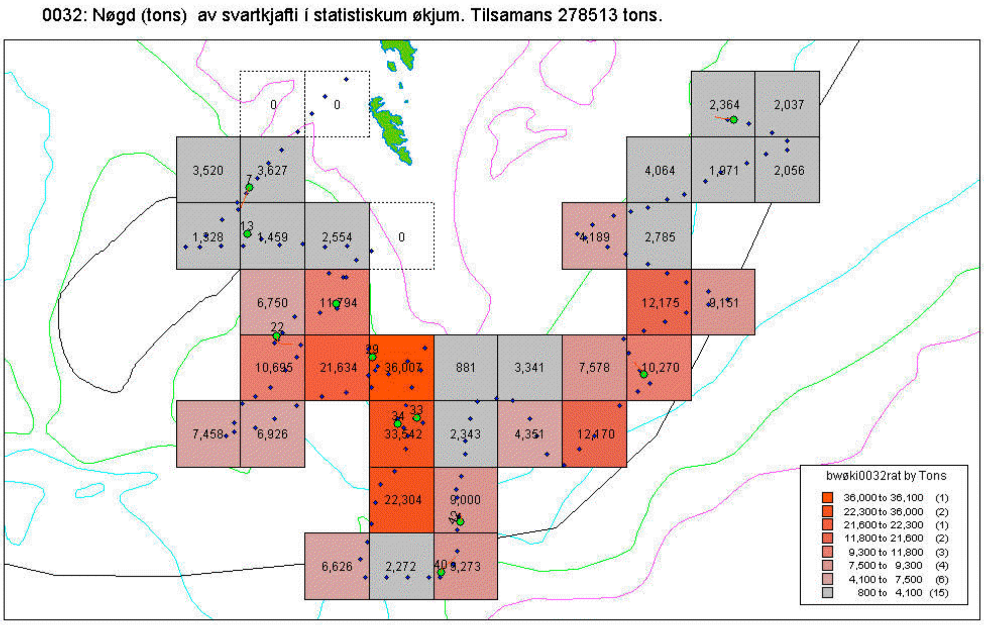

Figure 41. Biomass (t) of blue whiting by ICES squares from R/V *Magnus Heinason* during 6-12/5 2000.

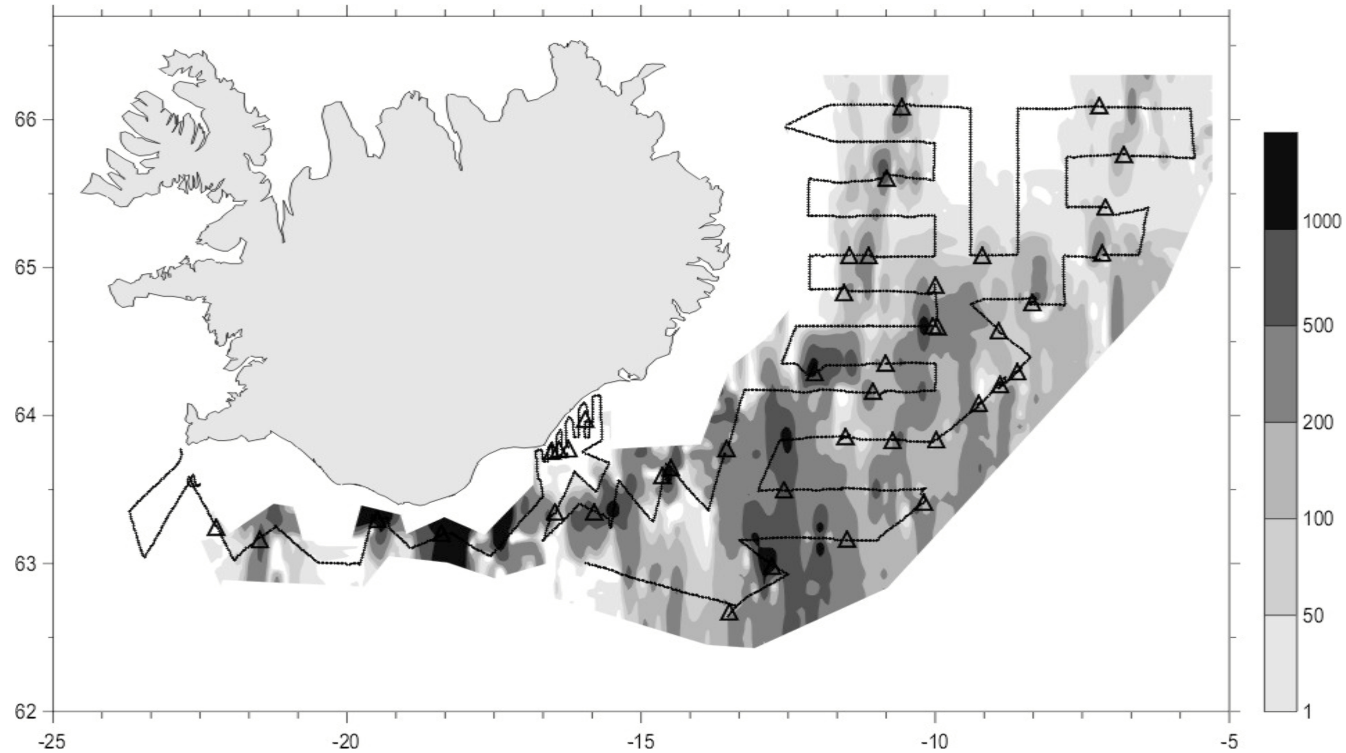

Figure 42. Distribution (S_A-values) of blue whiting, 20/7-4/8 2000. Triangles denote sampling positions. R/V Arni Fridriksson, 20/7-4/8 2000.

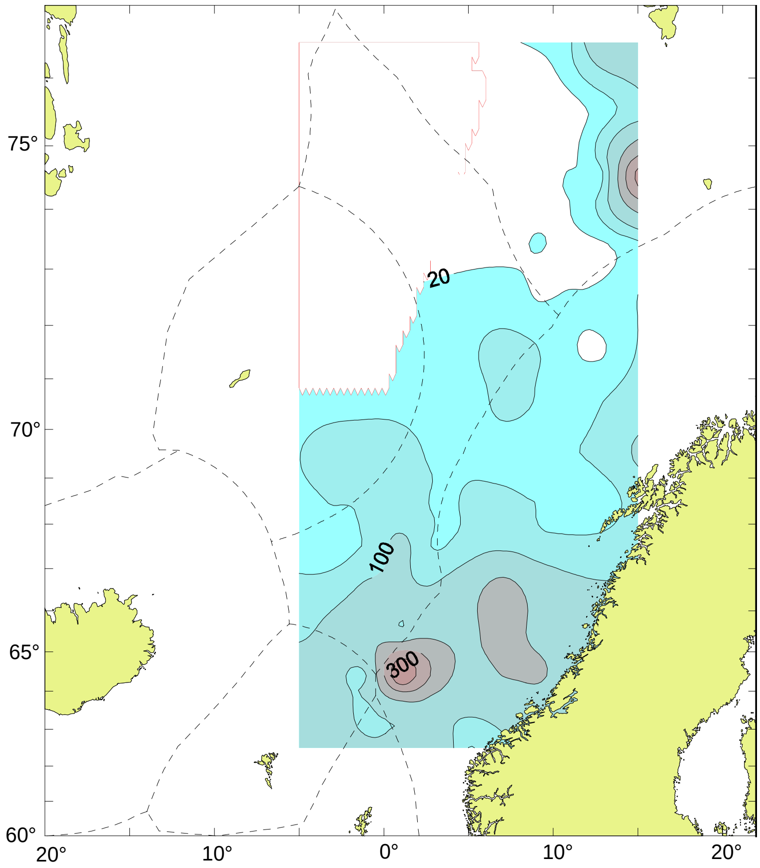

Figure 43. Distribution of blue whiting (Sa values) as observed by G.O.Sars 23rd July – 15th August, 2000.

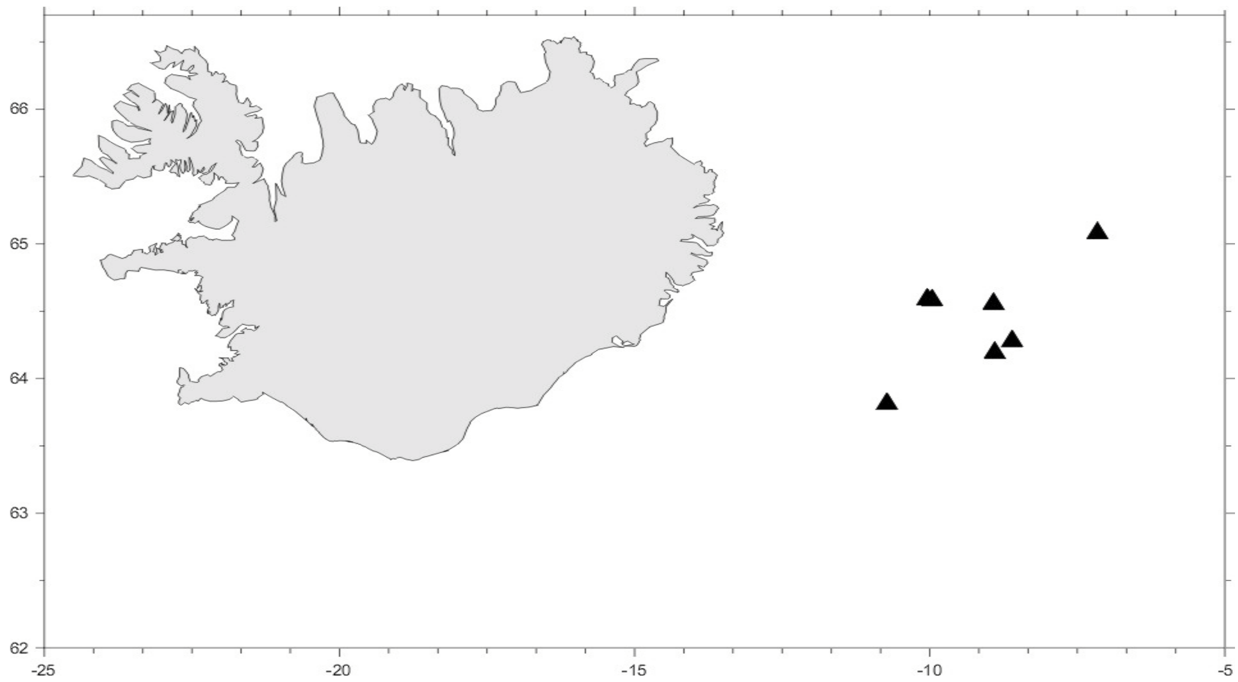

Figure 44. Catch positions of mackerel taken by R/V Arni Fridriksson, 20/7-4/8 2000.

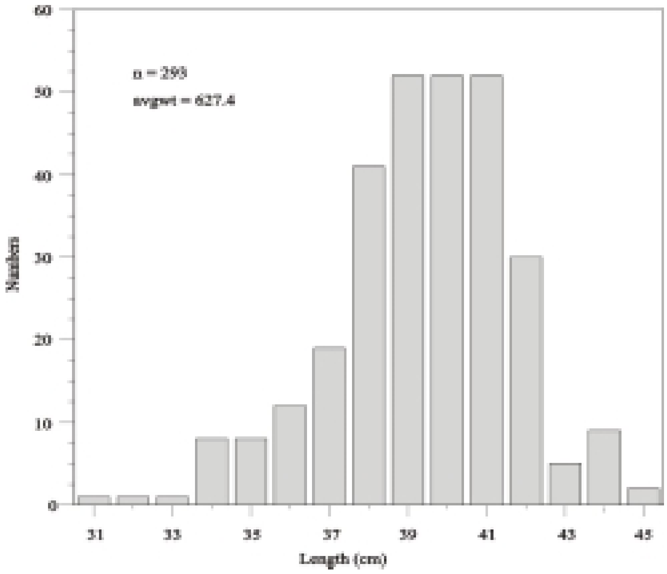

Figure 45. The length distribution of mackerel east of Iceland 20/7-4/8 2000.