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Report on surveys of the distribution, abundance and migrations of the Norwegian spring-spawning herring, other pelagic fish and the environment of the Norwegian Sea and adjacent waters in late winter, spring and summer of 2001

by

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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 have been rebuild and has been varying from approx 5 to 10 million tonnes 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 approx 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 have taken place along the polar front from the Jan Mayen Island and NE-wards towards the Bear Island. During the last half of the 1990's a gradual shift in migration pattern have occurred as the herring migrations have shifted north and eastwards. This development has continued in 2001 as referred later in this report. After feeding the herring have concentrated in August in the northern parts of the Norwegian Sea before the southern migration towards the Vestfjord wintering area (68°N,15°E). Around January 15th the herring have started its southerly spawning migrations. In 2001 the catch of Norwegian spring spawning herring is expected to reach about 850 thousand tonnes, a strong reduction from last years 1.2 million tonnes.

Besides herring abundant stocks of Blue Whiting and Mackerel exploits 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 this and the 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 Thórshavn in August 2000 for surveys to be carried out in the summer of 2001, (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 2001 were evaluated during a meeting in Reykjavik in August 2001 (Table 1) and is presented in this paper. The limited time available for analysis of the data allows only the following brief overview of the main findings of the surveys.

Material and methods

The cruises were carried out generally in east – west transects. Data were sampled along these transect lines of the hydro-acoustic surveys of the EU (*Walther Herwig III*, 27.04 - 26.05.2001, (Fig. 1)), the Faroe Islands (*Magnus Heinason*, 2-27.05.2001 (Fig. 1)), Iceland (*Arni Fridriksson*, 25.05.-08.06.2001 (Fig. 1), 17.-30.07.2001 and 17.-30.07. 2001 (Fig. 4)), Norway (*G.O. Sars*, 03.05-28.05.2001 (Fig 1), *Johan Hjort*, 21.07.-13.08.2001 (Fig. 5) and *G.O. Sars*, 19.07.-14.08.2001 (Fig. 5), and the Russian Federation (*F. Nansen*, 17.5.-05.06.2001 (Barents Sea, Fig. 3) and 08.06.-30.07.2001 (Norwegian Sea, Fig. 2). Details are given in Table 2.

Hydrography

The hydrographic observations were made using CTD-Probes. A total of approx. 640 hydrographic stations were made for the description of the horizontal distribution of temperature and salinity for the period April-May and June-August (Table 2). 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.

Plankton

In addition to the hydrographic sampling, a total of 283 plankton hauls were made, which is less than the total of 357 hauls in the previous year. Zooplankton was sampled in vertical hauls from 200-0 m by standard WP-2 net with a 180 µm mesh (*Walther Herwig III, G.O. Sars, Arni Fridriksson, Magnus Heinasson*). 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 which were sampled in 50-0m by the new Icelandic vessel "*Arni Fridriksson*" during July-August 2001 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.

Fish sampling

Fish traces identified on the echosounder were sampled by pelagic trawl (vertical openings of 20 - 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. However, very few herring were caught on *Walther Herwig III* in the southern part of the distribution area at that time. 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.

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.

Acoustic estimate 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 ($N*nm^{-2}$) 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.

After the May survey a discrepancy was observed between the Sa values of R/V Walter Herwig and those of the R/V Magnus Heinason and R/V Johan Hjort. The Walter Herwig observed consistently lower values in neighbouring squares than the two other vessels. The difference was so large that it was decided not to include the data of the Walter Herwig as this would result in a troublesome estimate. At a later stage it was confirmed that the error was due to settings in the calibration and that the values of WH should be multiplied by a factor of 1.66. At this stage it was unfortunately too late to include the data due to time constraints. The incidence strongly underlines the importance of carrying out intercalibration between the vessels. Comparable errors have earlier been detected during intercalibration experiments.

Aerial surveys and intercalibration with research vessels

In July-August 2001 PINRO continued annual complex airborne research of feeding mackerel in the Norwegian Sea with purpose of study distribution and migration. This research was carried out onboard of aircraft-laboratory Antonov-26 (An-26) “Arktika”.

Airborne research was carried out using the methods developed at PINRO (Anon. 1997c, 1999, Chernook *et. al.* 1997, 1998). Processing, analysis, interpretation, summarizing and presentation of the collected information were done in real time and position. Airborne research has traditionally been supported by information technologies, database and materials provided by satellite surveys. Visual, optical, infrared, VHS methods were used during the flights simultaneously. LIDAR–system installed onboard aircraft was also used this year. Before each flight PINRO aircraft scientific group received by fax information about latest position of vessel, weather data, last data about sea surface temperature, data on depth of thermocline and transparency, and also information about observed and registered of mackerel schools by echosounder and sonar.

Simultaneous joint research of ”Aktika” and R/V "Selvåg Senior" were carried out during July 15-17 (Fig.7). These included making comparison of recording from similar track with some difference in the time, as well as calibration work.

24-29 July, the aircraft surveyed the area east of Iceland, the western part of International waters in the Norwegian Sea included (Fig 8). It was possible to join airborne observations with research vessel investigations. The research vessel *Árni Friðriksson* carried out an annual blue whiting survey in the southern and eastern parts of the Icelandic EEZ during 17-30 July. The precalibrated Simrad echosounder/integrator EK-500/BI500 was used for fish registration. In addition, two horizontal ranging sonars (23 and 400 kHz) with different distance and depth ranges were also used. Most of the locator's targets were checked by echosounder or by pelagic trawling. Sea surface temperature was collected continuously by a sensor with discretion from 5 minutes to 1 hour. Some CTD-stations were taken in the northern part of survey area. Exchange of information about fish distribution, surface temperature, and weather conditions etc. between research vessel and aircraft-laboratory was on a daily basis.

Seabird counts

On *Magnus Heinasson* seabird counts were made along the cruise tracks during the whole survey when the speed was above 4 knots. The method used is known as the "strip transect counting" method, which counts all seabirds in a 90° sector to one side of the vessel. The range counted was from the vessel and 300 m out in the sector divided into 50, 50, 100, and 100 m. The counting was summarised on each 10 min interval where the time and position was recorded.

Results

Hydrography

General hydrographic features

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.

Year 2001

Figures 8-10 show the temperature and salinity in the Svinøy section for May and temperature for July, 2001 while Figures 11-13 show the temperature and salinity in the Gimsøy section for 9-11 June and temperature for July, 2001.

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 34.90 and temperatures below 1^{o}C. The section plots for May, 2001 in the Svinøy and 9-11 June 2001 in the Gimsøy (Figs. 8 and 12) shows the condition before the start of the seasonal warming, while in the section plots for July (Figs. 10 and 11) a warm surface layer has developed. Due to reduced strength of southwesterly winds during the winter 2001 there has been a westward extension of Atlantic water in the Norwegian Sea compared to the condition previous year (maps for 2000 in: Holst et al., 2000). This can be seen by comparing, for instance, 7^{o}C isotherm in the Svinøy section for May 2001 with May 2000.

The section plot for Svinøy shows only minor differences between July 2001 and July 2000. However, in the Gimsøy section, the temperature in the layers below the surface layer has increased with some tenths ^{o}C in July 2001 compared with July 2000. Comparison of the surface layer for 2000 and 2001 is done below for the horizontal maps.

Figs. 14-19 show the horizontal temperature distributions at 20, 50, 100, 200, 400 and 500 m depth during May 2001. These maps show the water mass characteristics typical for the end of the winter season, undisturbed by seasonal warming. The Figs. 21-26 show also the horizontal temperature

distributions at similar depths as for May, 2001 but for July-August, 2001 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 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.

Compared to May, 2000 most of the area is warmer in May, 2001, at least down to 200 m depth (maps for 2000 in: Holst et al., 2000). For instance, near the surface, the 6^{o}C isotherm at 20 m depth reached farther to east in 2001 than in 2000. This can be easily seen in the northern part of the area. Also, the extension of the 7^{o}C isotherm is located farther to the north in May 2001 compared to May 2000. In the deeper layers, below the surface layer, higher temperature is seen at 100 m depth. For instance, there is a larger area with temperature higher than 7^{o}C in May 2001 than in May 2000. For most of the area higher temperature is seen in 2001 than in 2000 except in a small region in the southern part where cold water from the west has reached an area just north of the Faros.

In July-August a warm surface layer is developed which can be seen by comparing the temperature at 0 or 20 m depth with the one for 50 m depth (see Figs. 21-22). The surface layer was much more warmer in July-August 2001 than for similar period in 2000 (maps for 2000 in: Holst et al., 2000). By comparing the two years the difference at 20 m depth is about 2^{o}C for most of the area. Below the surface layer the difference is much less and in some areas insignificant. The latter can be seen in the south-eastern part of the area at 200 m depth. In the central part of the area, at about 69-70 ^{o}N, the extension of the 6^{o}C isotherm at 100 and 200m depth is located farther to the west. In contrast, there is colder water at 100 and 200 m depth in the northern part of area, near the Bear Island, in July-August 2001 than in previously year.

Russian hydrographic sections

In a long term Russian section (taken along the longitudes 65^{o} 45,, 63^{o} , 67^{o} , 67^{o} 45,, 68^{o} 30, ,69^{o} 30, N the Temperature of the Atlantic waters in June-July in the south of the Norwegian Sea and northward 67°N on 0.4-0.6°C was higher than norm, in the central sea - close to long-term mean. Temperature and position of stream of the East-Icelandic Current in west and south part of the sea were close to norm. The thermal condition of the mixed waters, as well as in preceding 5 years was lowered. The negative anomalies in the central area between 64°-67°N in a layer 0-200 m reached up to 0.4-0.6°C.

The important feature of a situation of a summer of 2001 was increasing of advection of the

Atlantic waters penetrating through Faroe-Shetland Channel (FSC). These waters handicap penetration of cold waters of East Icelandic Current to the south off 62-63°N. It has resulted that on a section FSC the positive anomaly of temperature of water in a layer 200-500 м has exceeded norm on 1.6°C, that did not happen since 1972.

Zooplankton

May

Figure 27 shows the distribution of the zooplankton biomass (g dw m^{-2}) in 200-0 m in May 2001 in the survey area. In 2001 a total of 283 plankton hauls were made, as compared to 357 hauls in 2000. The samples were rather evenly spread over the area. However more stations in the west, in the area of higher plankton abundance, would have given a more reliable distribution of zooplankton biomass for that region.

The zooplankton biomass was higher in the south-western area dominated by the colder water masses of the East-Icelandic Current. Similar to last year these colder water masses reached much further east than usually observed. There is a general decrease of biomass in 2001 as compared to 2000 for the entire area (approximately 18%; Tab. 3). The decrease of the total biomass from 2000 to 2001 is taking place in the areas both to the east and to the west of 2°W (about 27%). The 2001 biomass is almost as low as in 1999 but still much higher than in 1997, the latter being known to be exceptionally low (Anon. 1999).

Table 3. Average zooplankton biomass [g dry weight m^{-2}]. The 1998 and 2001 data on the Faeroes shelf were omitted to allow comparison with the other years.

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

July-August

Zooplankton biomass of July-August 2001 was approximately at the same level as zooplankton biomass in 2000 (Fig. 28). As the survey ended as the meeting was going on, no further analysis will be presented in this report.

Herring

April/May

The international coordinated herring survey was carried out with 3 ships during 28 April – 28 May. The Norwegian and EU vessels covered the eastern and northeastern part of the area, while the Faroese vessel worked mainly in the western and nothhwestern parts. The cruise tracks of the three vessels are shown in Figure 1.

Herring were recorded over large areas as shown in Figure 29. The densest concentrations were observed from about 67˚30'N to 70˚30' N, between 07˚E and 01˚E. In this area there were mainly large herring of the 1991 and 1992 year classes. Another area with fairly high herring densities reached from 71˚N to 72˚30'N, between about 09˚E and 14˚E. This area also contained adult, but somewhat smaller, herring. Adolescent herring of the 1988 year class dominated in the easternmost parts of the survey area. The outer boundary was reached in all areas except in the extreme northeast.

The western boundary of herring distribution was at about the zero meridian, while in the north the herring disrtibution reached almost to 74˚N. As compared to May 2000, the herring were distributed even farther to the east and north, the difference amounting to about 1 degrees of latitude and latitude, in the east and north respectively. This is also reflected in the estimated centre of gravity of the stock in May (Figure 38).

Based on the acoustic records of the Norwegian, EU and Faroese vessels, the scrutinized acoustic/integrator values and the fish samples analysed, a preliminary age structured 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 4.5 million tonnes in May 2001 (Table 4).

During 25 May – 8 June Iceland carried out a survey of the western and northwestern parts of the herring distribution area (Fig. 1). Herring schools of varying densities and depth were recorded from about 68˚N to 72˚30'N (Fig. 30). The southernmost records were located at about 1˚W, reaching west to 3˚30'W at 70˚N. From there, the outer boundary of herring distribution followed a northeasterly direction, being near about 71˚30'N at 01˚W and 72˚30'N at 02˚E. East of that, dense schools were recorded along 72˚N, between about 4˚E and 06˚30'E, but there the survey did not reach the northern distribution limit of the herring (Fig. 30).

During the short time, about 10 days, that had elapsed between the joint coordinated survey and the Icelandic survey just described, the westernmost limiit of herring distribution had thus shifted towards the west and northwest by some 30-60 nautical miles (Figure 33).

July-August

During the period 19/7-13/8 the R/V G.O.Sars and R/V Johan Hjort surveyed the Norwegian Sea from 62 N to 78N 5W to 20E (Fig. 5). The herring concentrations could be divided into two major groups. Along the Norwegian coast adolescent herring, mainly of the 1998 year class was observed (Southern area in distribution figure 32, estimate table 5). Based on the general knowledge about the migrations of the adolescent herring out of the Barents Sea it is reasonable to claim that this herring is partly the same as observed by R/V Fritjof Nansen in the western Barents Sea in May-June (Fig. 45, table 6).

Further north, from 70N to 78N, 4E to 12E, the adult part of the herring stock was observed (Total area in distribution figure 32, estimate table 7). This year, the herring appear to have extended the feeding season somewhat as compared to last years, and more typical feeding schools were observed in July-August as compared to 2000. This was also reflected in the fact that it was harder to find the zero-line of herring distribution this year, due to a less well-defined end of herring registrations, both to the west and north.

Herring distribution in the Barents Sea

May-June

"F. Nansen" carried out a survey in the Barents Sea from 24^{o} E to 40 ^{o} E along the Russian and Norwegian coast during the period 17/5- 05/6 to map the distribution and produce an abundance estimate of young herring in this area. Young herring were observed along the coastline at a distance of 50-100 nautical miles (Fig. 45). 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. General records of herring were observed close to the Norwegian 12-mile zone. There are strong indications that part of the herring was arranged inside the Norwegian 12-mile zone and was not surveyed. The total biomass is estimated at 0.803 million tonnes and numbers 16.7 bil. sp. (Table 6). The herring of the survey area consisted mainly of 2 and 3 years old fish (98 %).

Herring migrations in 2001

Based on all available information, an inferred migration pattern of the herring stock during the feeding season in the summer of 2001 was reconstructed. The main sources of information for the reconstruction were the international herring survey in May, the Icelandic survey in May/June, the Norwegian survey in July/August and catch positions of the Icelandic and Faroese 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. 34). 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 2001 was the international joint herring survey in May. At this time, the herring were spread over an area, stretching approximately from off the Norwegian coast, west to 2ºW and from approximately 67ºN and north to 73º30'N (Fig. 34). This confirms the trend of an ongoing shift in the distribution pattern in a northeastern direction from 1996 onwards. Figure 38 shows the center of the distribution of the herring in 1996-2001. An exception to this general 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, indicating an earlier onset of the surface feeding.

The Faroese and Icelandic fisheries in late May and June had a more northeasterly distribution in 2001 (Fig 36, 37) as compared to 1999 and 2000 (Holst et al., 1999 and Holst et al., 2000), which corresponds with the survey results.

The survey carried out in late May and early June by the "Arni Fridriksson" revealed considerable concentrations of large herring near 02ºW, between 68˚30'N - 69˚30'N as well as 71˚N - 71˚30'N and, between 71˚30' and 72˚N, near the zero meridian. The survey also recorded herring in less dense concentrations to about 4-5˚W in the area to the SE, E and NE of Jan Mayen. However, the largest herring concentrations, recorded during this survey, were found north of 72º N and east of 5º E, which corresponds with the Icelandic fishery positions in early June (Fig. 37). The results of the Icelandic survey in May/June thus indicate a continued migration of the largest herring to the west northwest in late May and early June, while herring schools found east of 8˚E during the joint May survey probably migrated in a northerly direction (Fig 34).

The north easterly migration speed of the herring between these two surveys was estimated at about 3-6 nm per day (Fig. 33)

In early August the "Johan Hjort" mapped the herring distribution in the eastern and northern parts of the Norwegian Sea (Fig. 5). In general, the herring were distributed farther to the north than in 2000 reaching in places north of 77ºN. The herring were generally scattered and appeared to be still feeding in the near surface layer. On the basis of the July/August survey results and information from the fishing fleets it appears that the herring recorded in the central and northwestern Norwegian Sea in May and early June only remained there (e.g. in the Jan Mayen zone) for a short time before migrating northeast- and northward along the Polar Front (Fig. 35). In conclusion, the herring migrated farther north in 2001 than in any previous year since 1995. After leaving the spawning grounds in April and May, the general direction of the feeding migration was to the NW. In the latter half of June the herring, previously found to the east of Jan Mayen, migrated to the northeast and joined the more eastern and north migrating components of the stock. The northward migration continued in July and early August when the northernmost distribution limit was observed at approximately 77˚N. By mid-August, there were no signs of a southward migration, suggesting an unusually late arrival, or at least final arrival, to the wintering grounds in the Vestfjord area in autumn 2001.

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 when Arctic water masses generally covered the surface waters of the Norwegian Sea west of 0^0, as defined by the 5^0 C isotherm. In addition the zooplankton biomass within the Arctic water masses has increased. As a result of both the total amount of zooplankton in the Norwegian Sea has probably increased, as indicated by the increasing trend in average zooplankton concentrations until 2000 (Tab. 3). In the warm Atlantic water east of 2^0 E we have not observed any clear trends in zooplankton biomass. In 2001 the eastern limit of cold water, as defined by the 5^0 C isotherm, was found more to the west; at about 3^0 W. At the same time the biomass of zooplankton in both cold and warm water was reduced. Thus, total zooplankton biomass available for the herring was probably lower in May 2001.

From 1997 to 2000 the distribution of herring in May has shifted northwards, possibly reflecting the ecological effect of increased flow of cold water into the southwestern Norwegian Sea. In May 2000 the center of distribution of the herring stock was situated within the Atlantic water masses east of the cold water. In June and July 2000 catch data from the Icelandic fishing fleet indicated a

westward migration into the cold water masses, being rich on zooplankton. At the Arctic front northeast of Jan Mayen the herring turned northwards. In July-August 2000 the herring was concentrated in a small area to the west of the Bear Island. The feeding seemed to have come to an end. In 2001 we observed a further northwards displacement of the center of the stock. As opposed to 2000 the herring after May 2001 headed more northwards and during July-August the herring was still feeding very far north, some schools even entered far into the atmospherically warmed surface layer of the Greenland Sea. The late feeding and the extreme northwards migration of the herring in 2001 may be related both to the lower zooplankton biomass and the enormous year class of I-group blue whiting filling up the southern and central Norwegian Sea. Length dependent migration, with large fish swimming longer than small ones, may also be a factor in explaining the steadily northerly displacement of the feeding migration seen since 1995. The distribution of the old herring as compared to the incoming yearclasses may be become a key in understanding this phenomenon.

Blue whiting

May, the Faroese EEZ and Norwegian Sea

In May, the part of the adult stock of blue whiting found in the Faroese zone, was mainly located to the south and southeast of the Faroes, also high concentrations were observed in the northeast area (Fig. 39). Blue whiting concentrations were much more scattered in the area west and north of the isles, where the survey was limited to 10˚W and 65˚N. The zero line was not reached in this part of the area surveyed (Fig. 39). The concentrations in the southern part of the Faroese zone were mainly adult blue whiting. The total estimated biomass in this area was 774 thousand tonnes (Table 8).

In the eastern and central parts of the Norwegian Sea, blue whiting was distributed over a wide area with the highest concentrations to the west of the Norwegian shelf. (Fig. 39). The blue whiting were usually distributed from 0-200 m depth. The 1999 and 2000 year-classes constituted about 75% of a total biomass of 4.5 million tonnes (Table 9), indicating good recruitment of these year-classes.

June-July, northern part of the Faroese EEZ and Norwegian Sea

At the time of the survey by R/V “Fritjof Nansen” (9 June - 23 July 2001), blue whiting were distributed over most of the surveyed area with the main concentrations to the south of 65^{o}N, eastwards from 3^{o}W and in the northwestern part of the Norwegian Sea (Fig. 46). Blue whiting were registered mainly as scattering layers at different depths from 150 m to 300 m. The echo density distribution is presented in Figure 39. The length distribution was mostly between 17-27 cm (Table 10-11) corresponding to the 1999 and 2000 year classes.

The total biomass, recorded in June in the southern part of the Norwegian Sea, was estimated at about 2.4 million tonnes and 32.79 billion fish, while about 1.3 million tonnes and 14.9 billion fish were recorded in the northern part in July (Tables 10 and 11 respectively).

July-Iceland

A survey of blue whiting in Icelandic waters was carried out with R/V Árni Friðriksson during 17-30 July 2001 (Fig. 4). The survey began west of the Reykjanes peninsula (Southwest Iceland) and continued eastward along the shelf to the southeast coast. The survey continued south to 62˚20 N and from there north to 66˚00 N between Iceland and the EEZ of the Faroes and the western border of the International Zone. In addition, R/V Bjarni Sæmundsson surveyed the area west of Iceland, from 64˚N to 67˚N during 12-14 August

Blue whiting were recorded in the shelf area and at the shelf edge, south, southeast and east of Iceland and in nearly all the areas surveyed farther offshore, mostly at 350 - 450 m. depth. The densest recordings were observed in and near the shelf area at the southeast coast. Furthermore, 0-group blue whiting were observed as relatively dense schools at 15 - 100 m depth over and at the shelf edge in several locations off the west-, southwest-, south-, and southeast coast and in the oceanic area from 63° 00' N - 63° 30'N between 11°W and 13° W. The blue whiting distribution in the survey area is given as average Sa-values by statistical squares in Figure 42.

The total biomass estimate was just over two million tonnes and 40.7 x 10^9 individuals. The 2001 year class (0-group) was by far the most numerous or 27.5 billion fish (68% in number). The second most numerous were the year classes from 2000 and 1999. A preliminary age disaggregated biomass estimate is given in Table 12.

July-August Norway

During the period 19th July-14th August the R/V G.O.Sars and R/V Johan Hjort covered the Norwegian Sea from approx. 62°N to 77°N, from the Norwegian coast and west to about 5°W in the southern part and between 5°E and 11°E in the northern part. Blue whiting was found throughout the covered area (Fig. 43). In addition the R/V Jan Mayen and R/V Michel Sars covered the western Barents Sea (these data are only referred for completeness, no maps given for the surveys). The total estimate for Blue Whiting in the Norwegian Sea areas covered by GOS and JH

was 5.9 million tonnes (Table 13), while the total including the Barents Sea covered by JM and MS was 7.6 million tonnes (Table 14).

Evaluation of the blue whiting data

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.

However, the biomass estimates of blue whiting from the Faroese area and the Norwegian Sea in 2001 were about twice the estimates in 2000, consisting of mainly one year old fish (50% of the biomass). This indicates that the 2000 year-class might be a strong one. Generally the blue whiting stock is presently dominated by the immature year classes of 1999 and 2000.

The biomass estimate of blue whiting from the Icelandic area was also much higher in 2001 than in 2000 (67% higher) and in fact higher than in any previous survey. The 0-group blue whiting was even more numerous in Icelandic waters than in 1999 and 2000 indicating that this also may be a strong year class.

The post spawning migration from south 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 apparently weaker strength of the East Icelandic Water in to the southern Norwegian Sea in 2001 compared to previous years may have favoured a migration to the east trough the Faroe - Shetland Channel (Hansen and Jákupsstovu, 1993). However, the coverage west of the Faroes in May was not extensive enough to conclude on this (Fig. 1).

Aerial surveys and intercalibration with research vessels

The flights tracks of the research aircraft and the research vessels are shown in Figure 6 and 7.
In Figures 40-41 the final result of air surveys research obtained during three flights in July is presented. In this map is presented distribution of sea surface temperature, observed marine mammals (whales, killer whales, dolphins and etc.), schools and birds, various kinds of objects and effects on sea surface.

During research air surveys in July 15-17 we made “aircraft-laboratory – R/V "Selvåg Senior" calibration studies. This was done by 2 or 3 repeated flying over vessel. This allowed a reliable comparison between aircraft and vessel data. The main observations for comparison were sea surface temperature and water transparency. Preliminary post processing showed, that aircraft data

coincided close to 100 % with vessel data. Data on transparency measured onboard of vessel by Secchi dick and onboard of aircraft-laboratory by LIDAR were the equal to the accuracy of a meter.

On 27 July a point intercalibration between vessel and aircraft was made during flights in the northern part of survey area (Fig. 6). RV Árni Friðriksson had drifted and collected data about weather conditions, surface temperature, water transparency, termocline depth and echosounder registrations, while the aircraft was flown directly over the vessel and took the same measurements. Preliminary post processing showed, that aircraft data coincide almost 100% with the vessel data. Data on transparency measured onboard of vessel by Secchi dick and onboard of aircraft-laboratory by LIDAR were the same with an accuracy of 1 meter. The research vessel passed along one aircraft track made during that day. The data collected were also the same as the aircraft data. During the following day, the research vessel sailed along another aircraft track made two days before. On the whole, the temperature regime was same, but due to a previous storm the highest gradient zones had disappeared.

As showed by preliminary results of joint PINRO aircraft-laboratory and research vessels, there is a high agreement in the environmental data collected during the coverage of the same area. In some areas where the vessel passed a long time after the aircraft the data showed changes in space structure of sea surface temperature. In areas covered with a long time lag, the new data showed clear changes in the space structure of sea surface temperature and transparency.
The area covered at high speed by of the aircraft-laboratory during one flight (5-6 hours) is very significant. For comparison, the research vessel needs 5-7 days for a satisfactory coverage of the same area. Discretion and accuracy of aircraft data are similar to the research vessel. The disadvantage is that the airborne investigations are very dependent on weather conditions.
The aircraft has no possibility to check fish schools for species and size composition during the flights. As a consequence, own biological data are not available and such data should be to taken by a research vessel. Therefore, when it comes to covering the distribution and migration of mackerel, the most effective strategy giving the highest quality of data involves a combination of airborne and vessel efforts. Based on the obtained experience, we think that similar approaches also can be used during research of herring and capelin distribution and migration. This will be tested in the future.

Mackerel

Western mackerel

A survey of the distribution and abundance of Western mackerel in the southern and central part of the Norwegian Sea was carried out by R/V *Fritjof Nansen* during June-July 2001. Relative

distribution (S_A-values) of Western mackerel are shown in figure 48. Mackerel was observed in a wide area from the Faroes and NE-wards up to 71°N and 7°E. All samples of mackerel were taken from near surface catches under water temperature 8.3-10.3^{o}C. Mean length of mackerel in south areas was 33-34 cm instead 35-37 cm in northeast area (Fig. 49). The total biomass of mackerel was estimated at 0.94 million tonnes and abundance was about 2.5 bill. sp.

Norwegian Sea July-August

During the combined aerial/vessel study in July-August the F/V Selvåg Senior made surface trawl hauls along the survey track. Catches ranging up to 4000 kg/20 min haul were made (Fig. 50). Only parts of the international and Norwegian zones were covered during the survey. The highest catch rates were observed in the Norwegian zone during this survey.

Seabird counts

The results of the seabird counts were summarized along a transect from south of the Faroes (60°N) to the northern edge of the 200 nm EEZ in the north (65°N) between 5 and 7°W (Fig.44). The variation of the density of selected species of seabirds, i.e. Puffin (*Fratercula arctica*), Guillemot (*Uria aalge*), and Fulmar (*Fulmarus glacialis*) are shown as a line plot (Fig. 44) with smoothed average density profiles. The preliminary results show densities between 2 and 10 specimens of fulmar south and north off the Faroe plateau (green line on Fig 44). The density of puffin and guillemot was higher in the southern part of the Faroese area as compared to the northern part.

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Tables

Table 1. Organisational frame of the coordinated herring investigations in the Norwegian Sea, 1995-2001.

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 planning report)	Torshavn (Holst et al., 2000)
2001	Faroe Islands, Iceland Norway, Russia, EU	11	Torshavn (no printed planning report)	Reykjavik (this report)

Table 2. Surveys conducted in spring and summer 2001 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.

Platform		**Survey area**	**Period**	**Herring samples**	**Blue whiting samples**	**Plankton samples**	**CTD stations**
Walther Herwig III	EU	62°-71°N, 6°W-17°E	27.4-25.5	1	0	47	45
Johan Hjort	NO	62°-74°N, 4°W-18°E	3.5-28.5	17	17	70	70
F. Nansen	RU	68°-73°N, 24°E-40°E	17.5-5.6	15	0	60	70
Arni Fridriksson	IS	66°-72°N, 08°-07°E	25.5-8.6	6	9	40	40
F. Nansen	RU	60°-71°N, 11°W-15°E	9.6-30.7	17	15	146	160
Arni Fridriksson	IS	62°-66°N, 06°W-27°W	17.6.-30.7	1	26	0	0
Magnus Heinason	FA	60°-73°N, 9°W-16°E	2.5-27.5	3	16	99	111
Johan Hjort	NO	67°N-78°N, 4°E-22°E	21.7-14.8	42	8	59	83
G.O.Sars	NO	62°N-70°N, 6°W-14°E	19.8-14.8	0	?	74	61
Bjarni Saemundson	IS	64°-67°N, 24°W-28°W	12-14.8.	0	6	?	?

Table 4. Age stratified estimate of Norwegian spring spawning herring in the Norwegian Sea, R/V Johan Hjort and R/V Magnus Heinasson, May, 2001. Numbers in millions, weight in thousand tonnes, length in cm, mean weight in grams.

Norwegian spring spawning herring in the Norwegian Sea, May, 2001

Age	2	3	4	5	6	7	8	9	10	11	12 15+	Sum
Numbers	1540	8312	1430	1463	179	204	3215	5433	1220	94	178	85	23353
Mean length	20.42	23.59	29.74	32.24	34.15	34.04	33.97	34.43	35.03	35.85	37.26	37.98	29.23
Weight	99.1	851.4	282.1	366.4	51.2	55.1	914.6	1599	370.4	30	63.3	30.8	4713.9
Mean weight	64.3	102.4	197.3	250.4	286.3	270.3	284.5	294.4	303.6	319.2	355.5	362.9	201.9

Table 5. Age stratified estimate of adolescent Norwegian herring off the Norwegian coast, R/V Johan Hjort, July-August, 2001. Numbers in millions, weight in thousand tonnes, length in cm, mean weight in grams. OBS! This is a sub-estimate of table 5, i.e. these numbers are included in table 5.

Adolescent Norwegian spring spawning herring off the Norwegian coast, July-August, 2001

Age	1	2	3	4	5	Total
Numbers	22	857	4619	413	105	6016
Mean length	21.3	23.1	25.6	29.6	31.1	25.7
Weight	1.9	91.5	692.2	95.0	28.5	909.1
Mean weight	86.0	106.8	149.9	230.2	270.6	154.0

Table 6. Age stratified estimate of Norwegian spring spawning herring in the Barents Sea, R/V "F. Nansen", May-June 2001. 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	3	Total
Numbers	302	7643	8757	16702
Percent	2.0	46.0	52.0	100
Mean length	7.4	17.8	20.7	19.2
Biomass	3.4	285.7	513.8	802.8
Mean weight	11.3	37.4	58.7	48.1

Table 7. Age stratified estimate of Norwegian spring spawning herring in the northern Norwegian Sea, R/V Johan Hjort, July-August, 2001. Numbers in millions, weight in thousand tonnes, length in cm, mean weight in grams. OBS! This is a total estimate and includes table 6.

Norwegian spring spawning herring in the Norwegian Sea, July-August, 2001

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	16	Total
Numbers	22	915	5869	1038	1146	124	437	912	1844	1526	174	52	16	42	14116
Mean length	21.3	23.0	25.9	30.3	32.6	33.8	34.3	34.5	34.8	34.8	35.9	36.6	36.5	37.2	29.8
Weight	1.9	96.3	909.8	252.0	346.6	41.5	149.8	315.6	648.0	537.1	64.9	20.2	6.3	16.6	3406.5
Mean weight	85.0	105.3	155.0	242.8	302.5	335.6	342.8	346.1	351.4	352.0	372.3	387.6	385.3	398	241.3

Table 8. Age stratified abundance estimates of post-spawning blue whiting in the Faroes area during May 2001. Biomass in thousand tonnes, number in millions, L= mean total length (cm), and W= mean weight (g).

Blue Whiting in the Faroes area, May, 2001

Faroese area	Age									
May 2001	1	2	3	4	5	6	7	8	9	Total
Biomass	154	110	104	323	63	4	4	10	2	774
Number	3,180	1,364	1,157	3,121	499	31	19	52	10	9,433
L (cm)	19	23.7	26.1	27.3	29.4	31.9	34.5	33.5	34	26.8
W (g)	40	75	91	105	128	160	193	193	180	105

Table 9. Age stratified estimate of the Blue Whiting stock in the Norwegian Sea, R/V Johan Hjort, May, 2001. Numbers in millions, weight in thousand tonnes, length in cm mean weight in grams.

Blue Whiting in the Norwegian Sea, May, 2001

Age	1	2	3	4	5	Total
Numbers	80505	22291	3519	596	336	107247
Mean length	18.2	23.2	25.7	28.4	28.2	19.6
Weight	2543.6	1557.6	332.8	81.3	43.1	4558.3
Mean weight	31.6	69.9	94.6	136.5	128.2	42.5

Table 10. Acoustic estimate of blue whiting the Norwegian Sea, R/V F.Nansen, 09-30 June 2001.

Area: square miles 121260.0		The Norwegian sea	
67°30'-61°00' N		R/F"F.Nansen"	
Length cm	Average weigth g	Number 10^6	Biomass 10^3 tonnes
15.0	19.69	22.49	0.44
16.0	23.70	22.49	0.53
17.0	28.21	641.03	18.08
18.0	33.24	1855.62	61.68
19.0	38.82	3430.08	133.17
20.0	44.99	3643.76	163.93
21.0	51.76	3013.97	156.00
22.0	59.16	1821.88	107.78
23.0	67.22	2552.88	171.60
24.0	75.97	3576.28	271.67
25.0	85.42	3452.58	294.93
26.0	95.62	2687.84	257.00
27.0	106.57	2586.62	275.66
28.0	118.32	2069.30	244.83
29.0	130.88	888.45	116.28
30.0	144.27	337.39	48.68
31.0	158.54	89.97	14.26
32.0	173.69	56.23	9.77
33.0	189.76	11.25	2.13
34.0	206.77	22.49	4.65
35.0			
36.0	243.71	11.25	2.74
Total:		**32793.84**	**2355.82**
Average length (cm) 23.1			
Average weight (g) 71.8			

Table 11. Acoustic estimate of blue whiting the Norwegian Sea, R/V F.Nansen, 02-23 July 2001.

Area, square miles 77396.6		The Norwegian sea	
71°10'-68°00' N		R/F"F.Nansen"	
Length cm	Average weigth g.	Number 10^6	Biomass 10^3 tonnes
15.0	19.69	2.272	0.045
16.0	23.70	38.624	0.915
17.0	28.21	254.466	7.178
18.0	33.24	645.254	21.449
19.0	38.82	1149.642	44.635
20.0	44.99	1729.007	77.785
21.0	51.76	1781.264	92.194
22.	59.16	1499.533	88.711
23.0	67.22	1658.575	111.489
24.0	75.97	1717.647	130.481
25.0	85.42	1420.013	121.300
26.0	95.62	1106.474	105.796
27.0	106.57	808.839	86.199
28.0	118.32	504.388	59.677
29.0	130.88	313.539	41.035
30.0	144.27	147.681	21.307
31.0	158.54	86.337	13.688
32.0	173.69	27.264	4.736
33.0	189.76	4.544	0.862
34.0	206.77	9.088	1.879
35.0	224.75	4.544	1.021
38.0	284.72	2.272	0.647
39.0	306.80	2.272	0.697
Total:		**14913.541**	**1033.725**
Average length (cm)	**22.9**		
Average weight (g)	**69.3**		

Table 12. Age stratified estimate of the Blue Whiting stock in the Icelandic zone during 17th –30th July 2001 by R/V Árni Friðriksson. Biomass in thousand tonnes, number in billions, L= mean total length (cm), and W= mean weight (g).

Age	0	1	2	3	4	5	6	7	8	9	Total
Number	27305	4090	5215	1657	1614	398	132	37	6	2	40456
%	67.5	10.1	12.9	4.1	4.0	1.0	0.3	0.1	0.0	0.0	100
W	24	72	109	127	143	165	169	218	194	234	50.8
L	15.1	22.4	25.3	26.4	26.7	29.9	31.8	32.6	33	37	18.3
Biomass	660.7	294.5	568.4	210.5	230.8	65.6	22.4	8.1	1.1	0.4	2062.5

Table 13. Age stratified estimate of Blue Whiting in the Norwegian Sea, R/V G.O.Sars and R/V Johan Hjort, 19 July- 14 August, 2001. Numbers in millions, weight in thousand tonnes, length in cm, mean weight in grams.

Blue Whiting in the Norwegian Sea, July – August, 2001

Age	0	1	2	3	4	5	6	7	8	9	Total
Numbers	641	61470	22051	7883	3225	1824	156	12	0	68	97330
Mean length	16.32	20.18	24.00	25.55	27.14	28.28	29.47	31.17	0.00	38.49	21.86
Weigth	15.9	2866.3	1714.5	713.1	342.0	216.4	19.4	1.8	0.0	23.4	5913.0
Mean weigth	24.8	46.6	77.8	90.5	106.1	118.7	124.5	147.5	0.0	344.7	60.8
Condition	5.7	5.5	5.6	5.4	5.3	5.2	4.9	4.9	0.0	6.0	5.5

Table 14. Age stratified estimate of Blue Whiting in the Norwegian Sea, R/V G.O.Sars and R/V Johan Hjort, 19 July- 14 August, 2001 and Barents Sea (R/V Jan Mayen and R/V Michael Sars same period). Numbers in millions, weight in thousand tonnes, length in cm, mean weight in grams.

BEAM version : 4.9

NUMBER BY AGE-LENGTH FOR SPECIES
SPECIES : KOLMULE

Length (cm)	Age/Year class 0	1	2	3	4	5	6	7	8	9	Number (1E6)	Biomass (1E6kg)	Mean Weight (g)
11.0 - 12.0	20	0	0	0	0	0	0	0	0	0	20	0.2	8.1
12.0 - 13.0	7	0	0	0	0	0	0	0	0	0	7	0.1	10.5
13.0 - 14.0	5	0	0	0	0	0	0	0	0	0	5	0.1	13.2
14.0 - 15.0	20	2	0	0	0	0	0	0	0	0	23	0.4	16.5
15.0 - 16.0	324	108	0	0	0	0	0	0	0	0	433	9.3	21.5
16.0 - 17.0	288	1323	0	0	0	0	0	0	0	0	1610	37.9	23.6
17.0 - 18.0	194	4599	0	0	0	0	0	0	0	0	4794	132.5	27.6
18.0 - 19.0	0	10983	59	0	0	0	0	0	0	0	11042	355.8	32.2
19.0 - 20.0	0	13802	0	0	0	0	0	0	0	0	13802	524.9	38.0
20.0 - 21.0	0	13290	128	0	0	0	0	0	0	0	13418	646.7	48.2
21.0 - 22.0	0	10891	398	0	0	0	0	0	0	0	11290	658.8	58.4
22.0 - 23.0	0	6503	3300	146	0	0	0	0	0	0	9948	673.7	67.7
23.0 - 24.0	0	1984	8957	536	0	0	0	0	0	0	11478	855.7	74.5

24.0 - 25.0	0	49	6218	2672	194	0	0	0	0	0	9132	750.8	82.2	
25.0 - 26.0	0	43	3949	3820	773	129	0	0	0	0	8713	793.2	91.0	
26.0 - 27.0	0	0	1103	2418	1565	533	36	0	0	0	5655	572.0	101.1	
27.0 - 28.0	0	0	129	850	2319	1263	26	0	0	0	4587	513.4	111.9	
28.0 - 29.0	0	0	27	186	1437	1491	80	0	0	0	3221	389.5	120.9	
29.0 - 30.0	0	0	0	36	716	1432	143	0	0	0	2328	310.8	133.5	
30.0 - 31.0	0	0	0	0	137	868	229	46	0	0	1280	188.4	147.3	
31.0 - 32.0	0	0	0	0	0	359	103	51	0	0	514	83.2	161.9	
32.0 - 33.0	0	0	0	0	0	66	0	0	66	0	133	23.1	174.0	
33.0 - 34.0	0	0	0	0	0	0	66	66	0	0	132	23.0	174.0	
34.0 - 35.0	0	0	0	0	0	0	114	0	0	0	114	22.7	200.0	
35.0 - 36.0	0	0	0	0	0	0	0	0	0	128	128	21.1	165.0	
36.0 - 37.0	0	0	0	0	0	0	0	0	0	44	44	12.4	279.7	
37.0 - 38.0	0	0	0	0	0	0	0	0	0	40	40	12.3	303.9	
38.0 - 39.0	0	0	0	0	0	0	0	0	0	47	47	16.8	359.0	
39.0 - 40.0	0	0	0	0	0	0	0	0	0	1	1	0.5	356.4	
40.0 - 41.0	0	0	0	0	0	0	0	0	0	9	9	3.5	384.8	
41.0 - 42.0	0	0	0	0	0	0	0	0	0	0	0	0.0	.	
42.0 - 43.0	0	0	0	0	0	0	0	0	0	0	0	0.0	.	
43.0 - 44.0	0	0	0	0	0	0	0	0	0	9	9	4.3	479.1	
TSN(1000000)	859	63578	24267	10664	7142	6142	795	163	66	279	113956	.	.	
TSB(1000000 kg)	19.8	2911.7	1922.3	984.3	793.8	776.1	119.8	26.6	11.6	70.8	.	7636.7	.	
Mean length (cm)	16.1	20.1	24.0	25.6	27.4	28.8	30.8	32.0	32.5	36.9	.	.	.	22.5
Mean weight (g)	23.0	45.8	79.2	92.3	111.1	126.4	150.6	162.7	174.0	254.1	.	.	67.0	

Figures

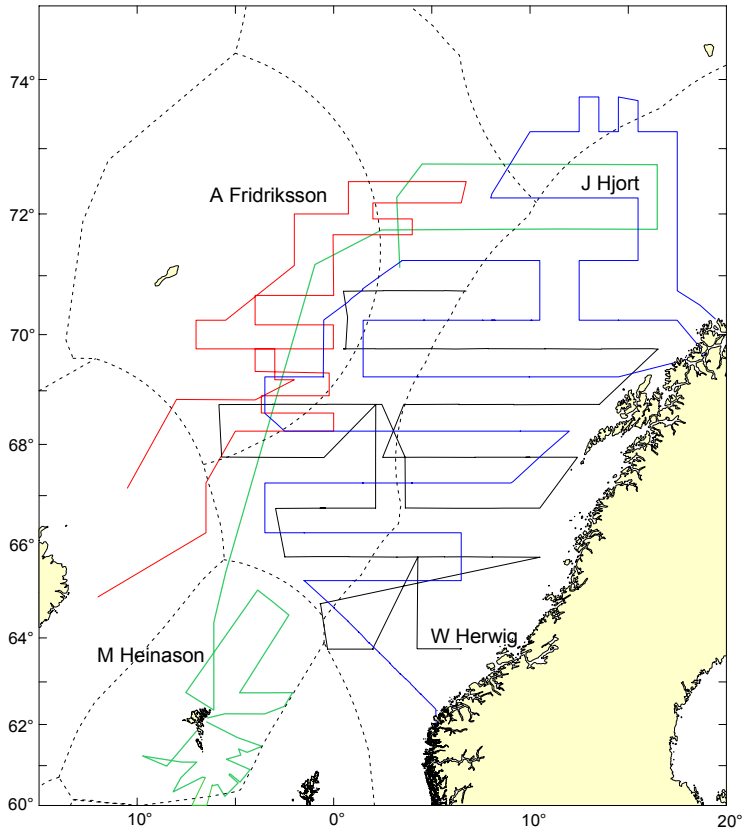


Figure 1. Survey transects of the R/V “Walter Herwig”, R/V “Arni Fridriksson”, R/V “Magnus Heinason” and R/V “Johan Hjort”, May 2001. Refer table 2 for dates.

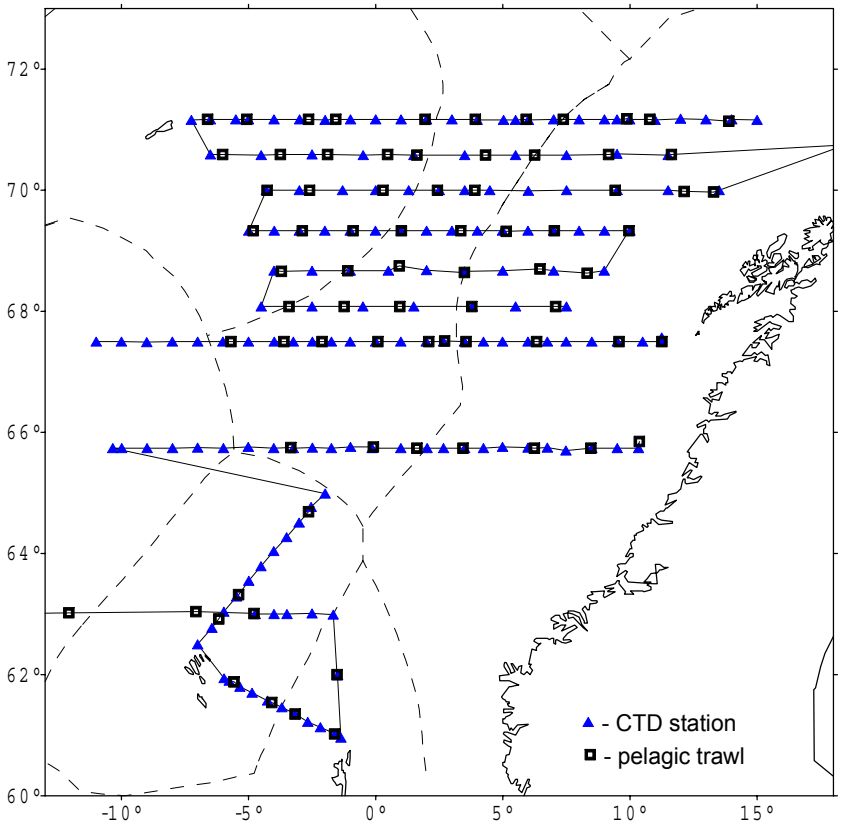


Fig. 2. Survey tracks with fishing and CTD stations by R/V “‘F. Nansen” in the Norwegian Sea, 08/6-25/7 2001.

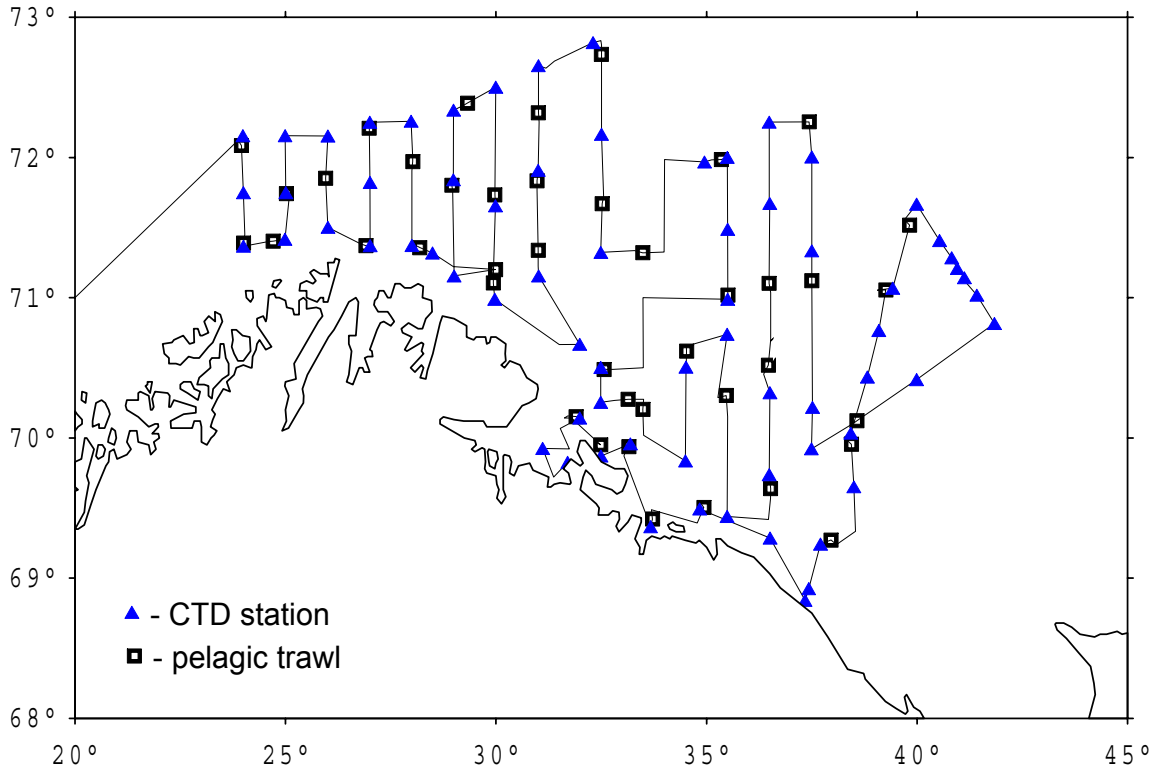


Fig. 3. Cruise track with fishing and CTD stations, R/V "'F. Nansen" in the Barents Sea, 17/5-06/6 2001.

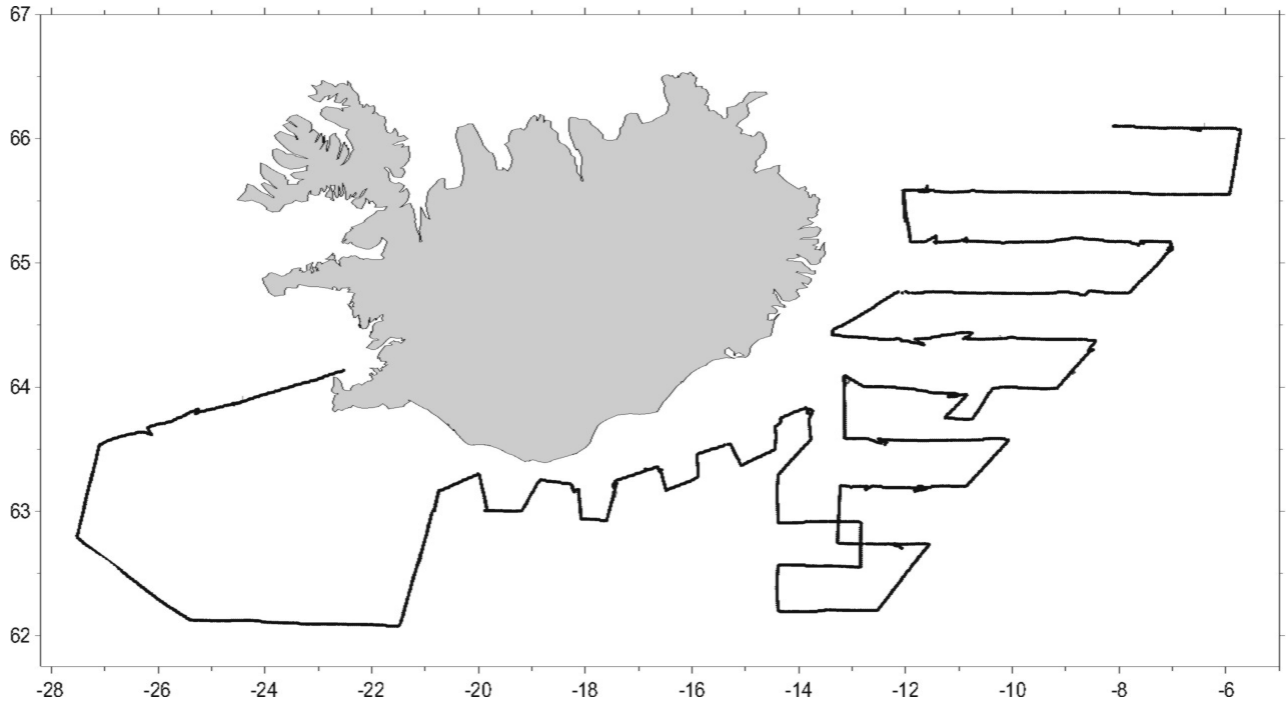


Figure 4. Survey tracks, R/V Arni Fridriksson, 17-30 July 2001.

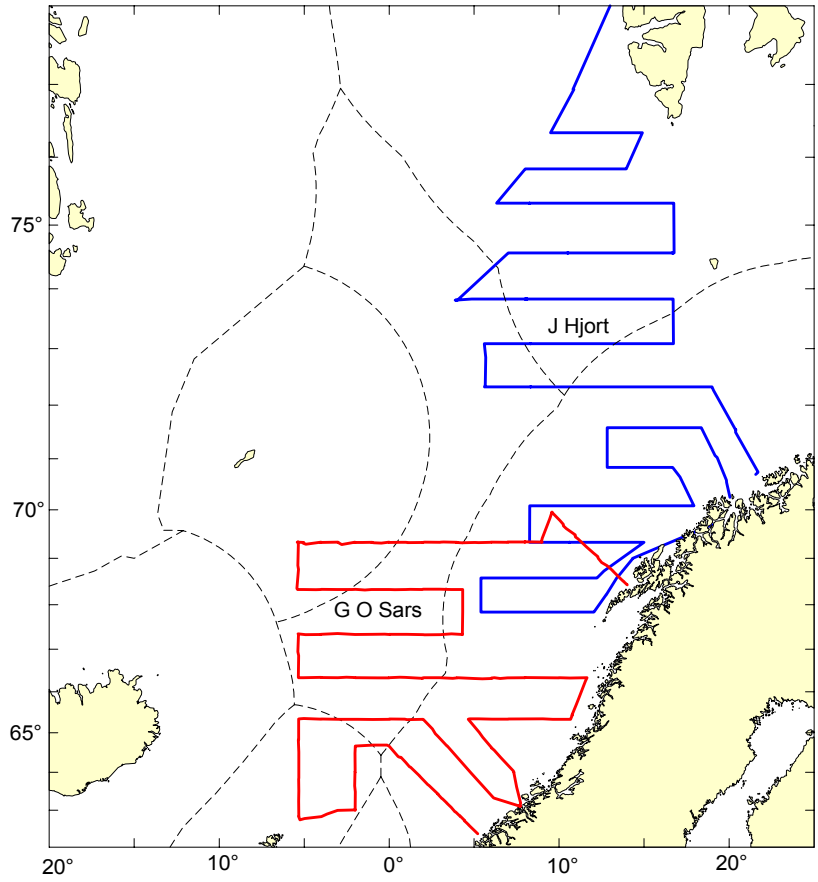


Figure 5. Transects of G.O.Sars during 19th July to 14th August 2001 and Johan Hjort during 21th to 14th August 2001.

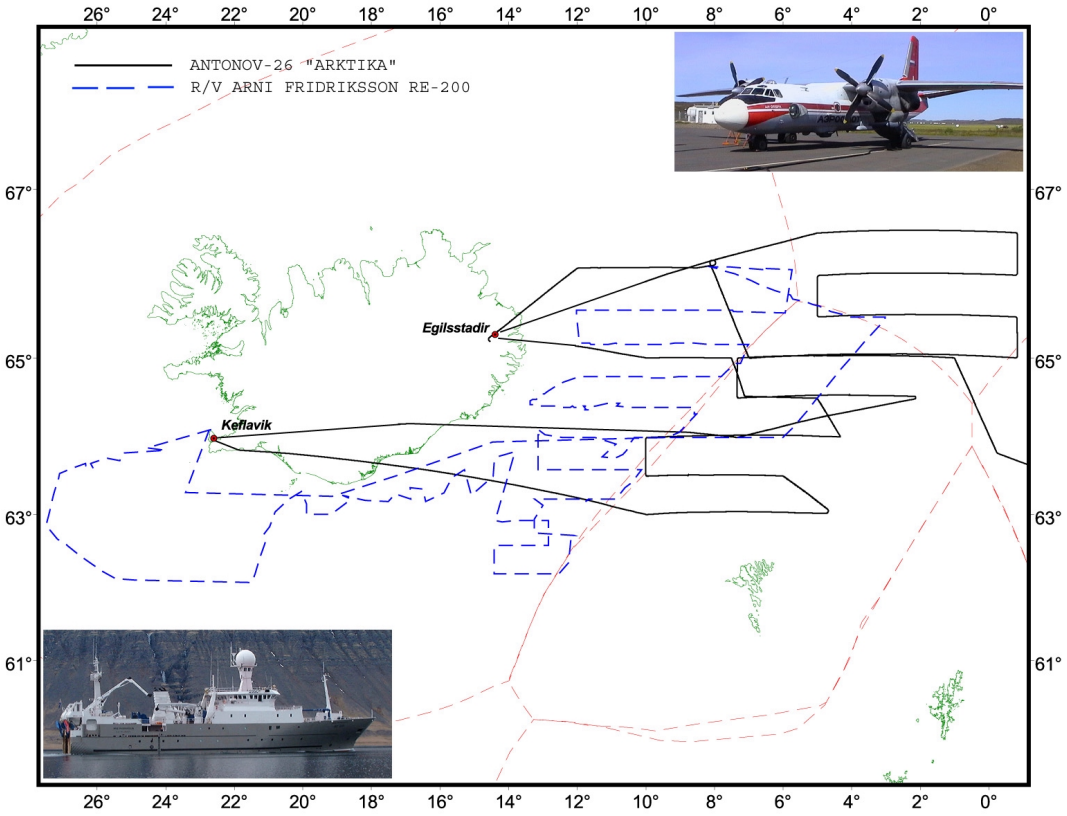


Figure 6. Flights tracks of aircraft-laboratory ANTONOV-26 “Arktika” and cruise track of RV “Árni Friðriksson RE-200”. July 2001.

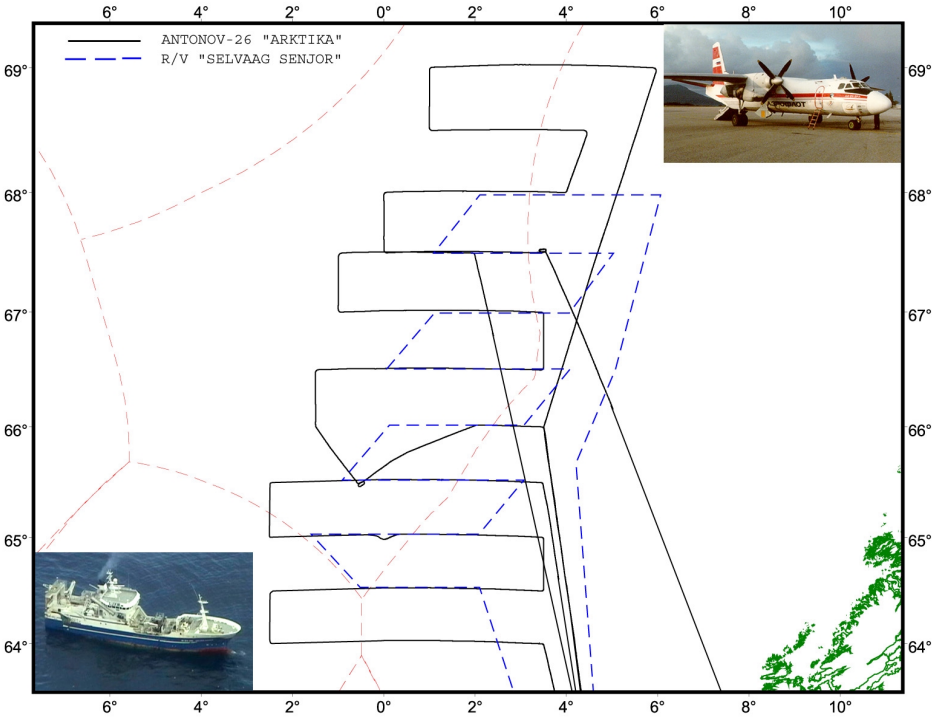


Figure 7. Flights tracks of aircraft-laboratory AN-26 “Arktika” and cruise track of RV “Selvåg Senior”. July 2001.

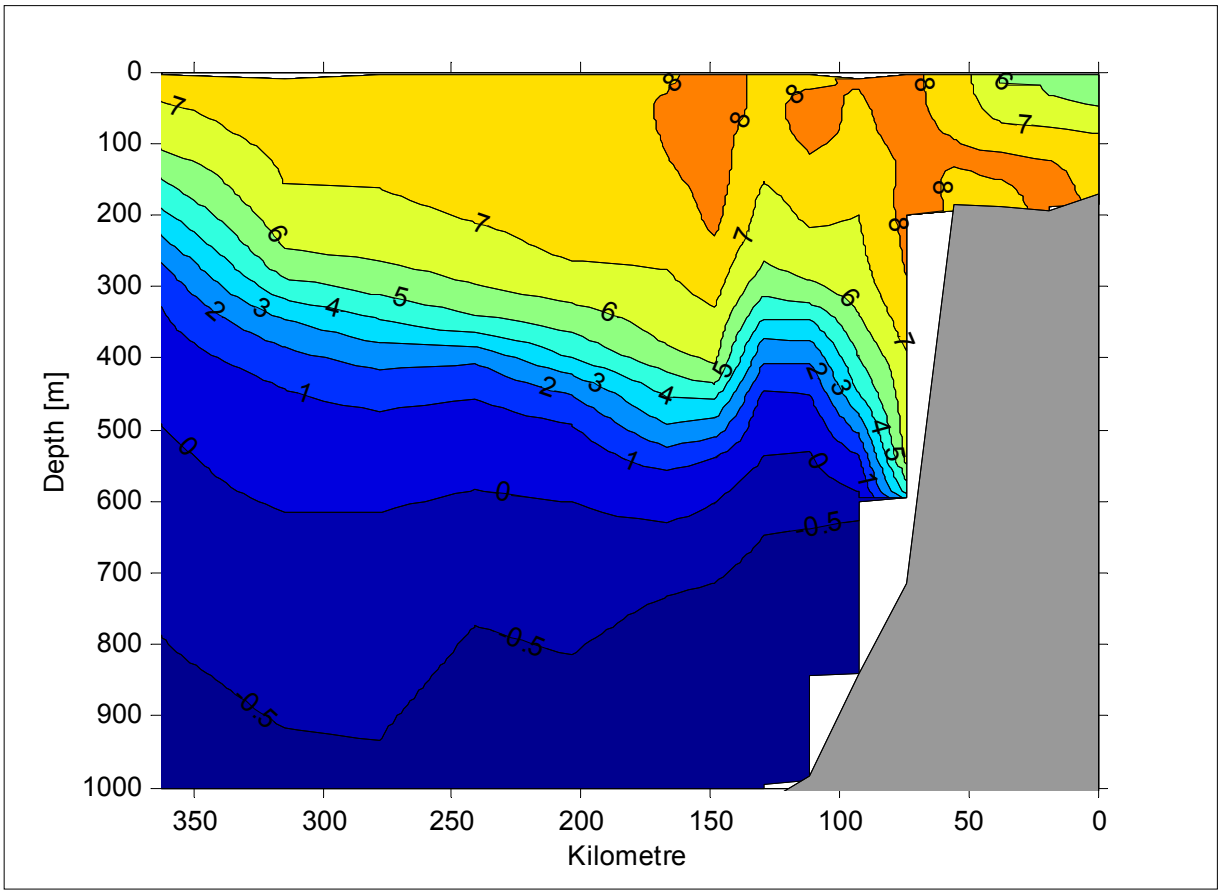


Figure 8. Temperatures in the Svinøy section, 4-6-May, 2001.

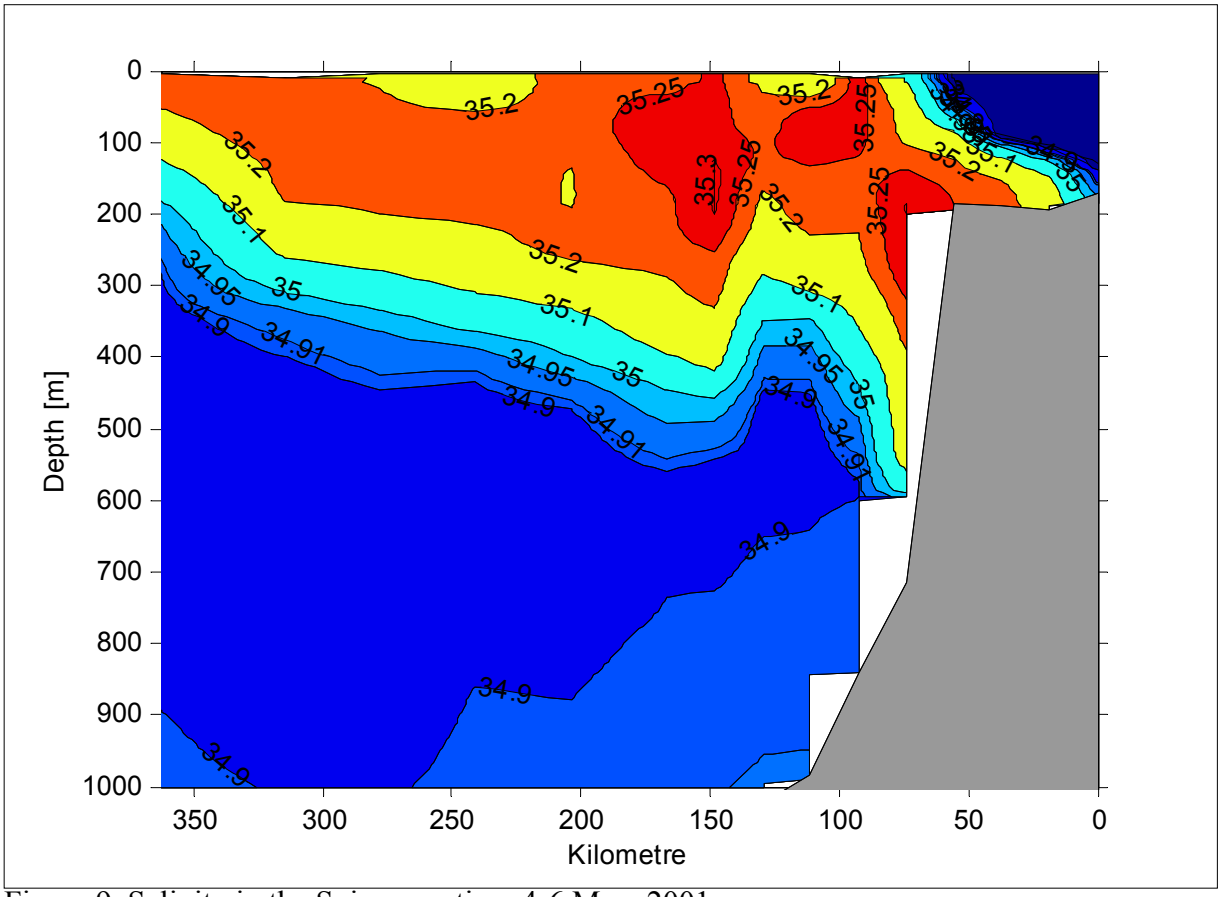


Figure 9. Salinity in the Svinøy section, 4-6 May, 2001.

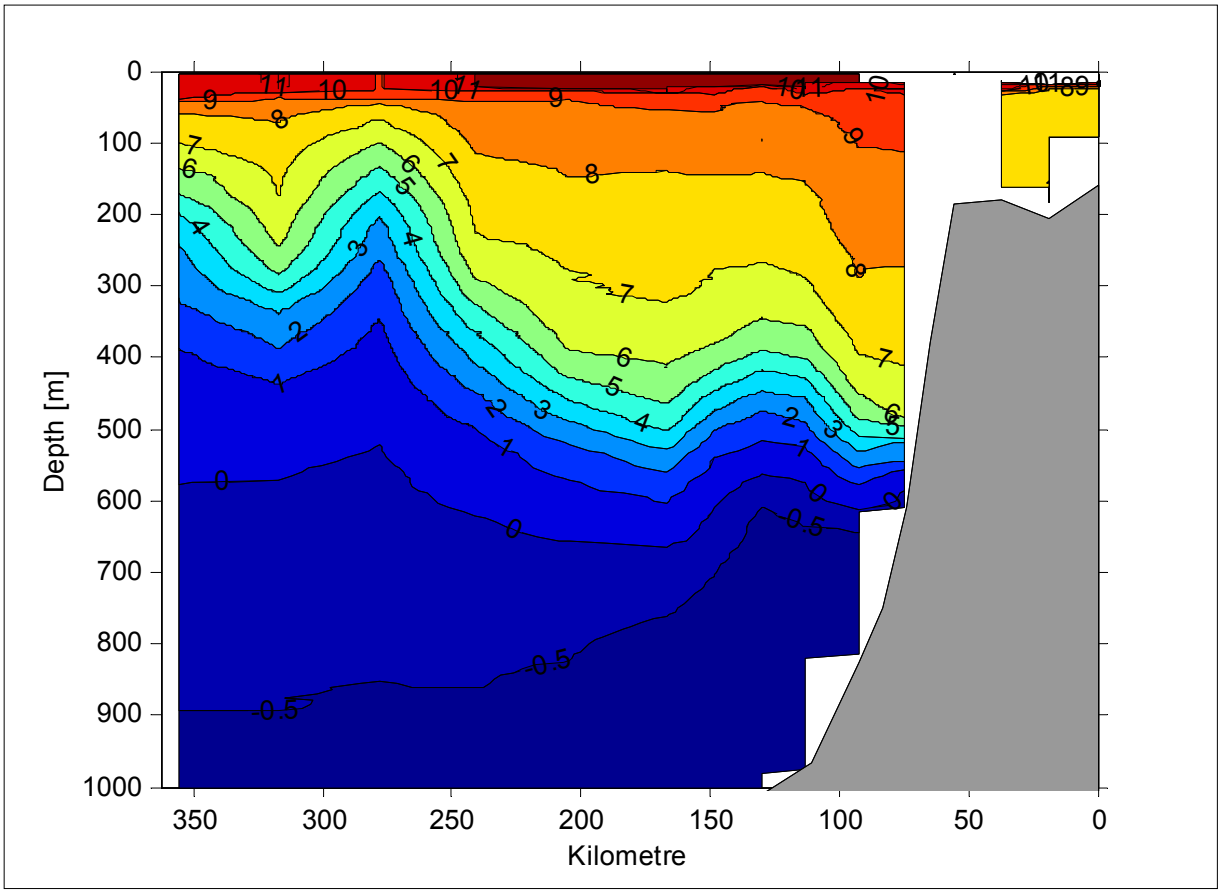


Figure 10. Temperatures in the Svinøy section, 20-22 July, 2001.

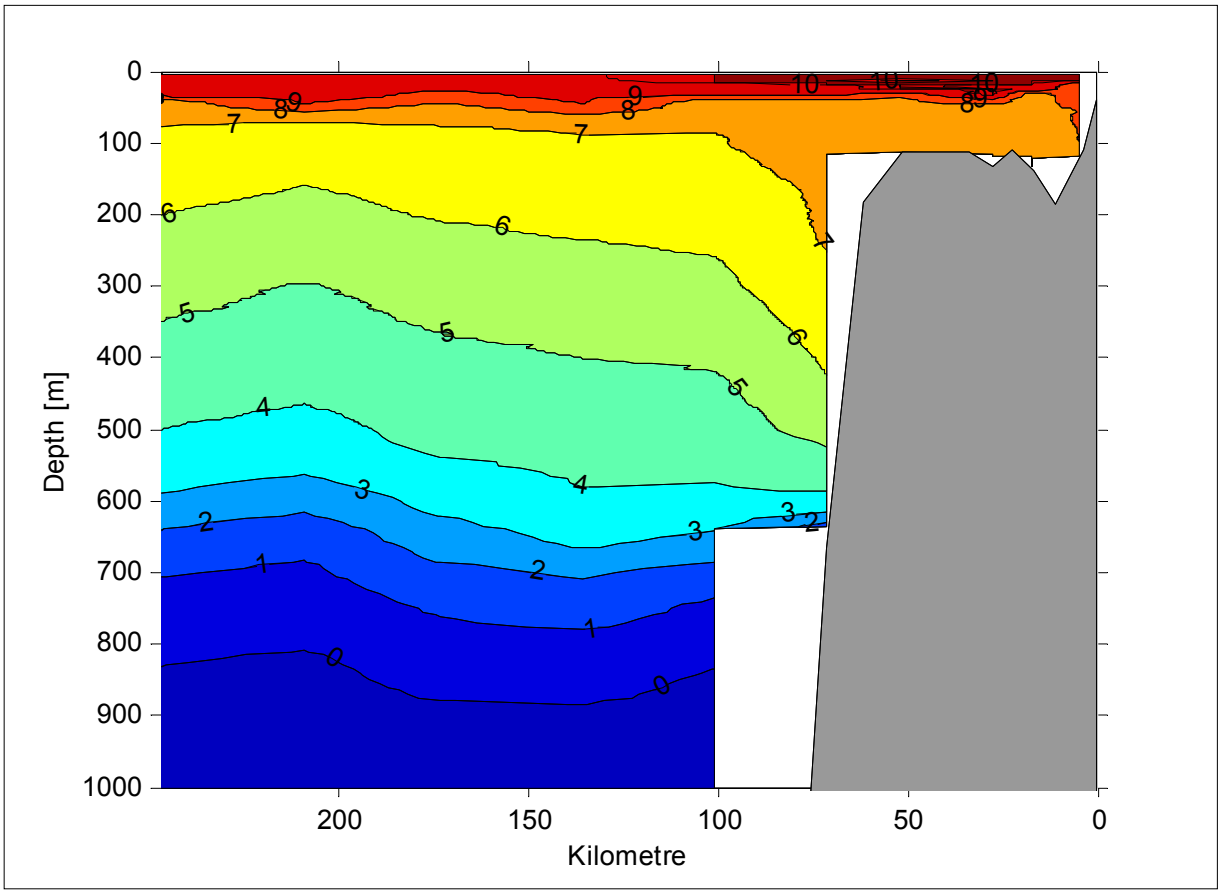


Figure 11. Temperatures in the Gimsøy section, 10-12 August 2001.

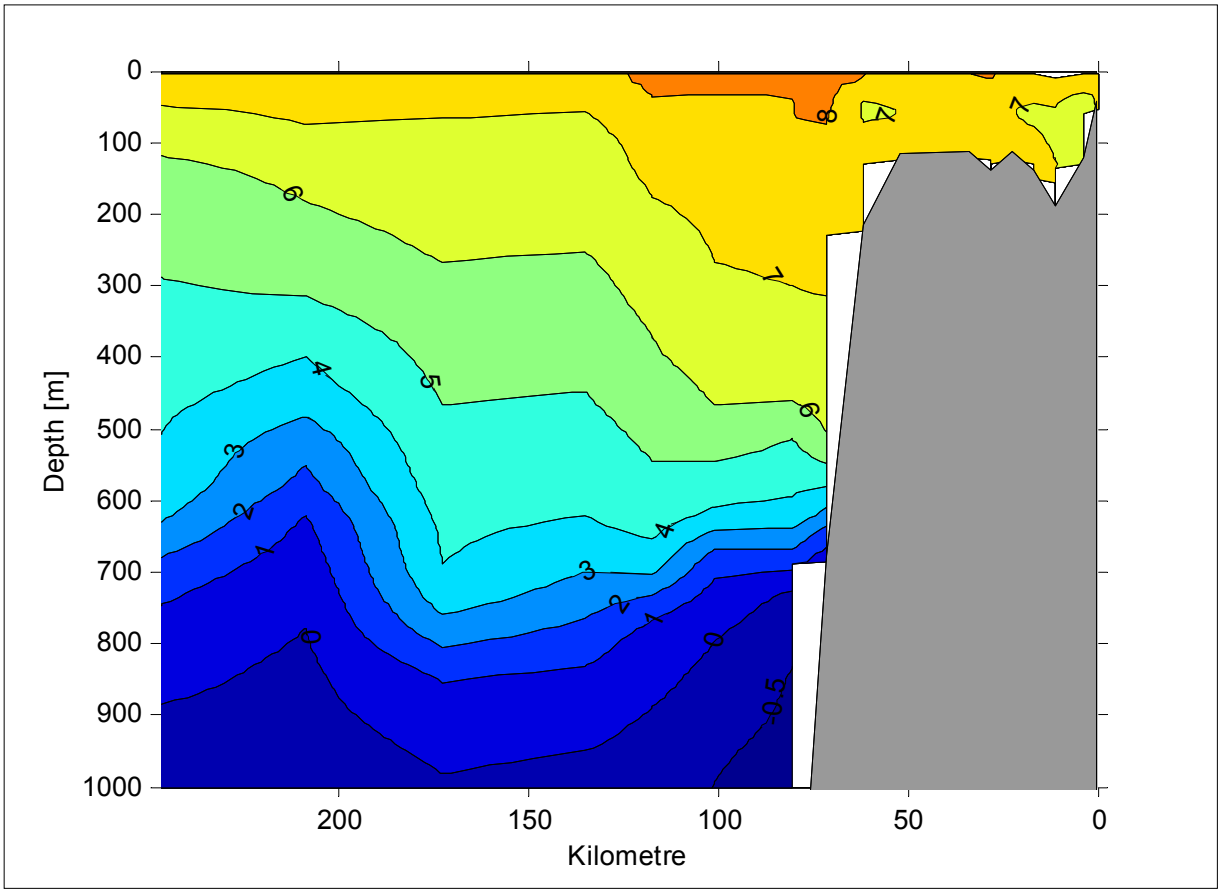


Fig 12. Temperature in the Gimsøy section, 9-11 June 2001.

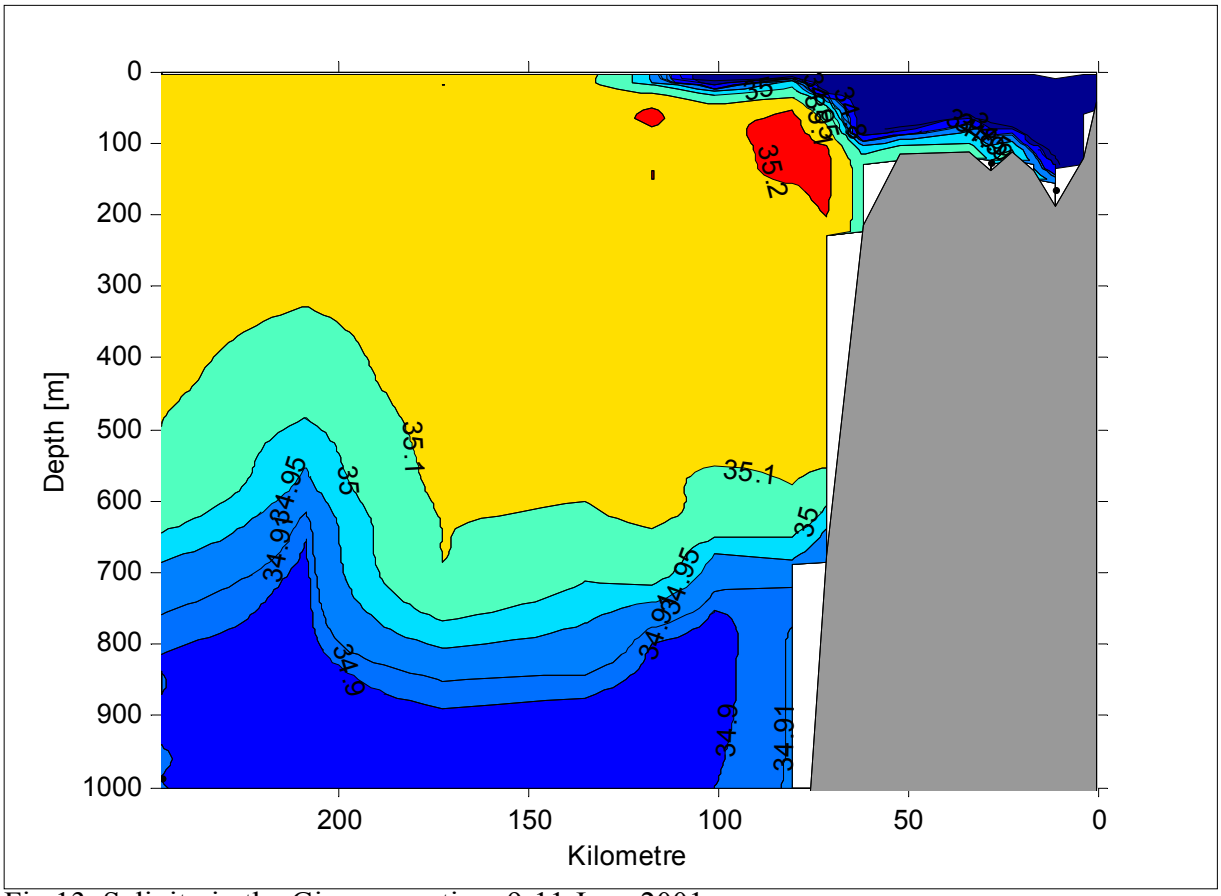


Fig 13. Salinity in the Gimsøy section, 9-11 June 2001

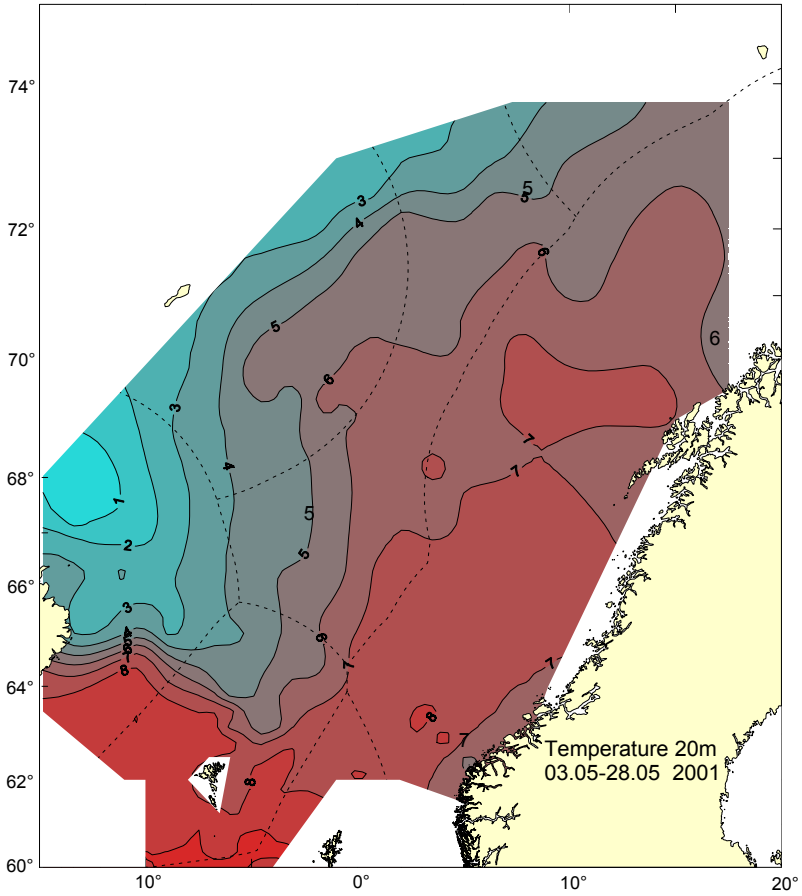


Figure 14. Temperatures at 20 meters in May 2001.

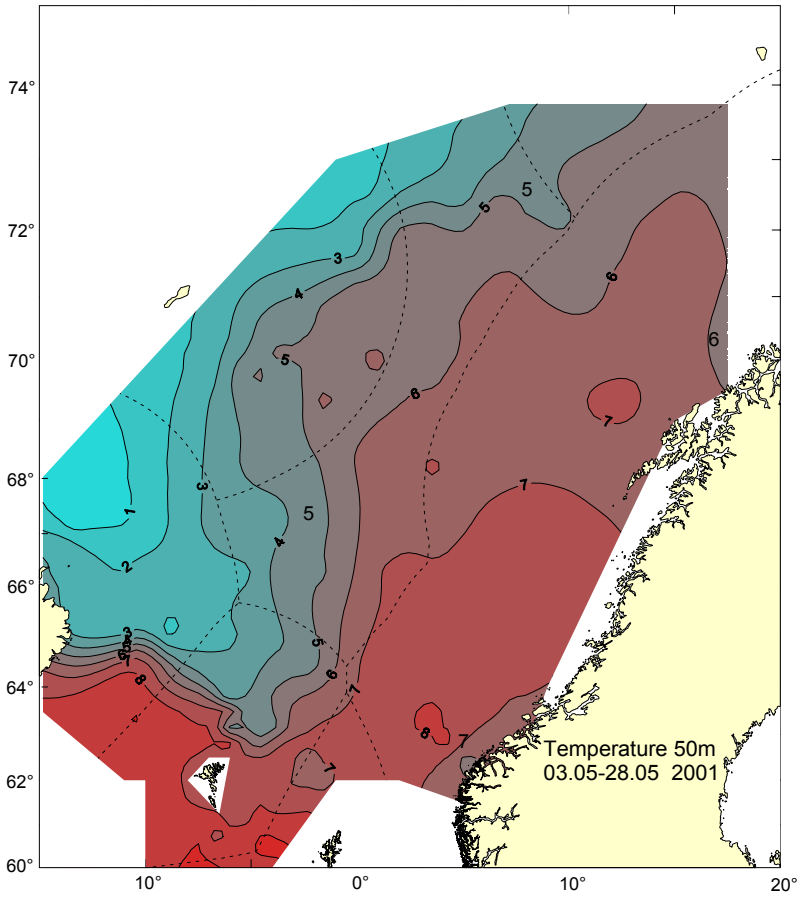


Figure 15. Temperatures at 50 meters in May 2001.

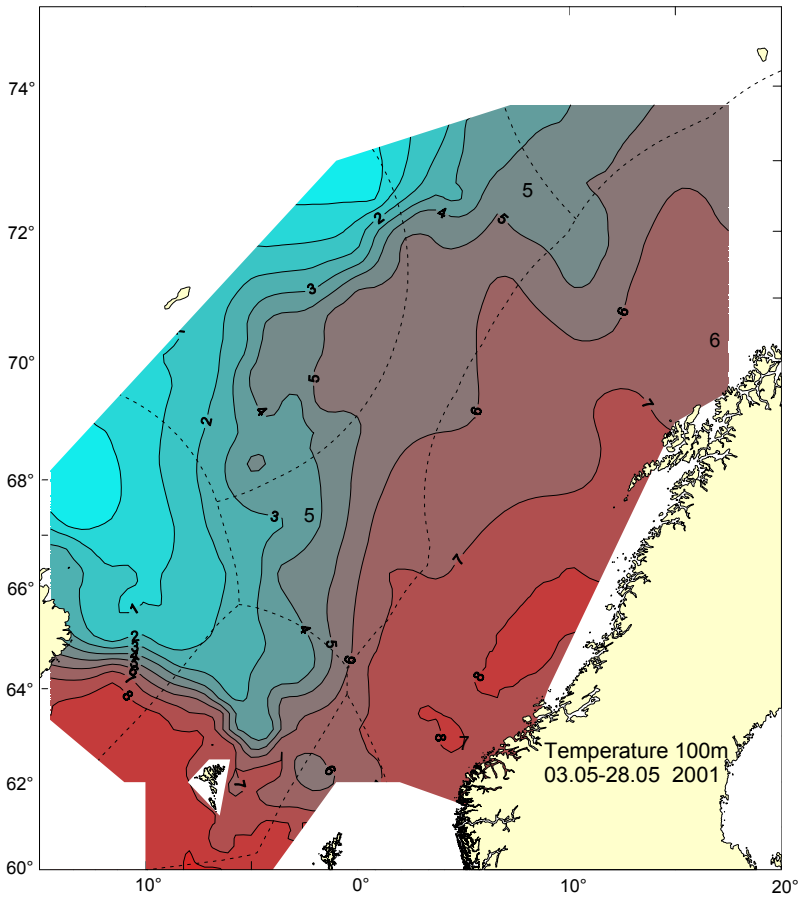


Figure 16. Temperatures at 100 meters in May 2001.

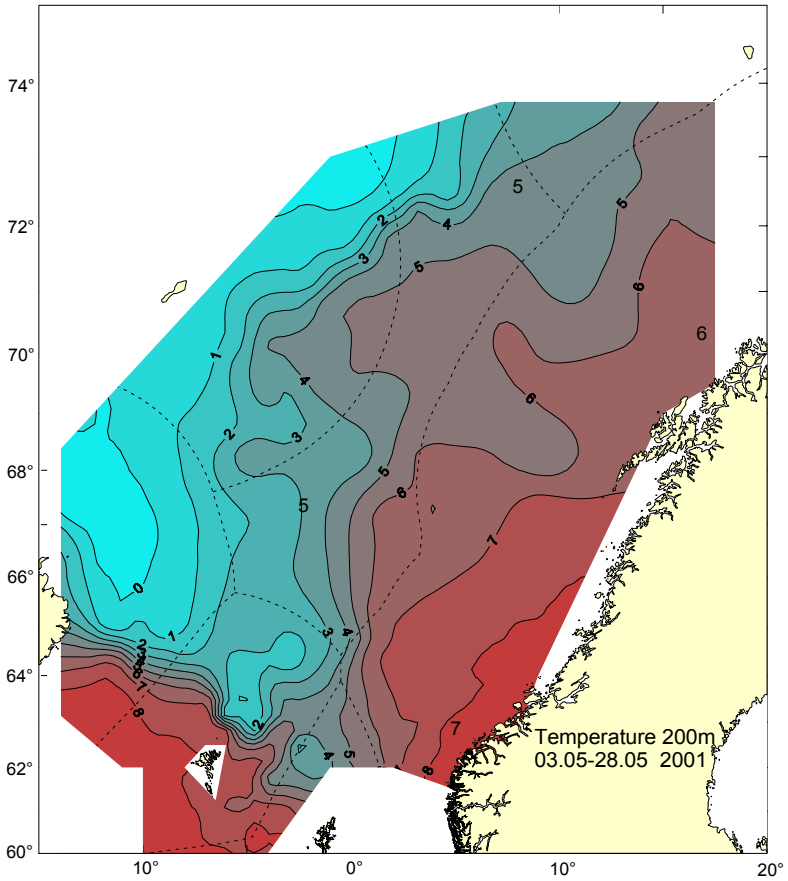


Figure 17. Temperatures at 200 meters in May 2001.

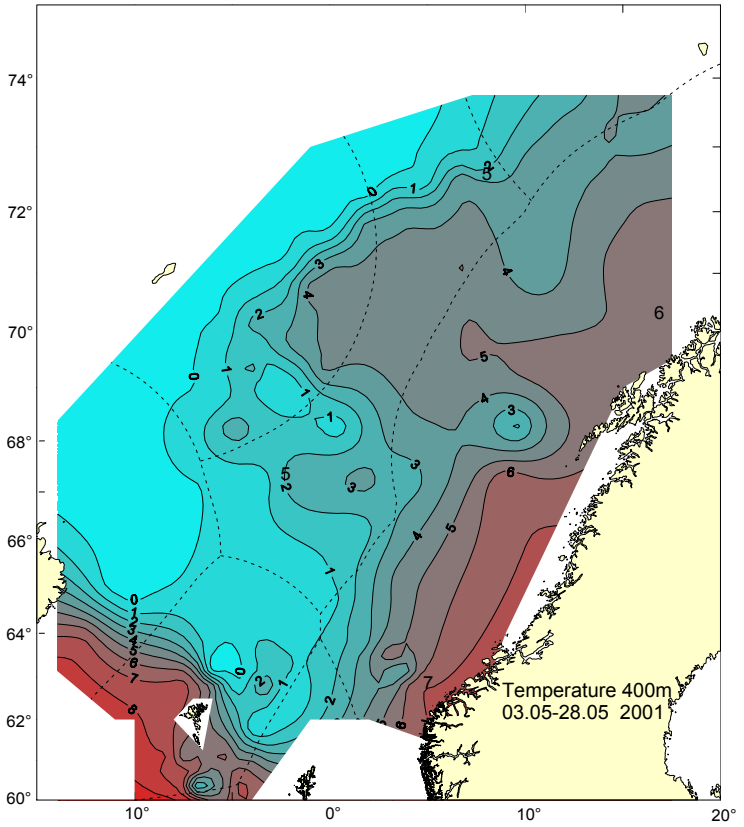


Figure 18. Temperatures at 400 meters in May 2001.

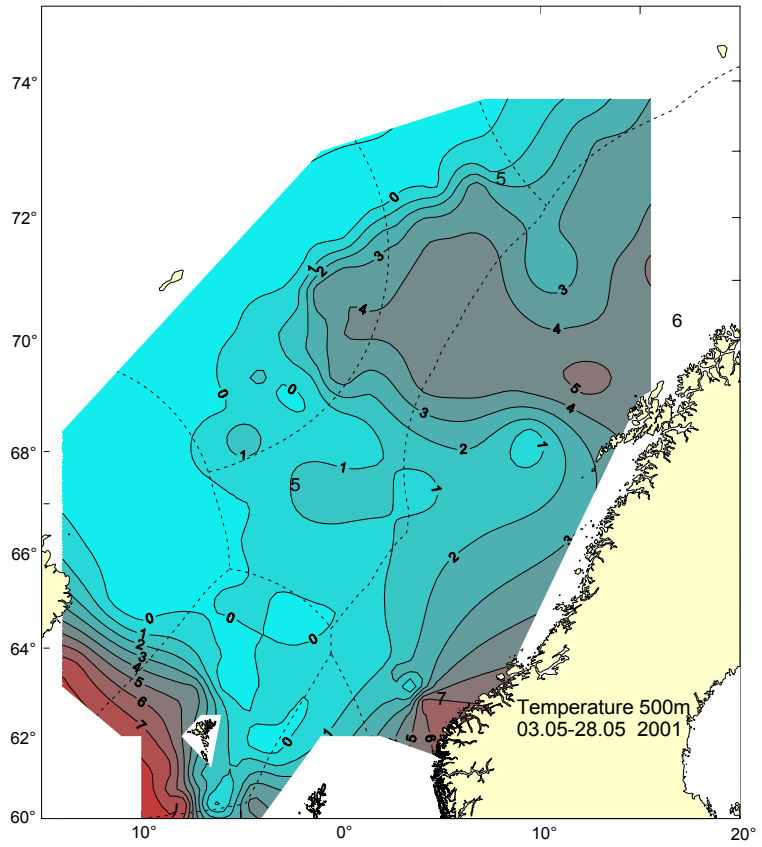


Figure 19. Temperatures at 500 meters in May 2001.

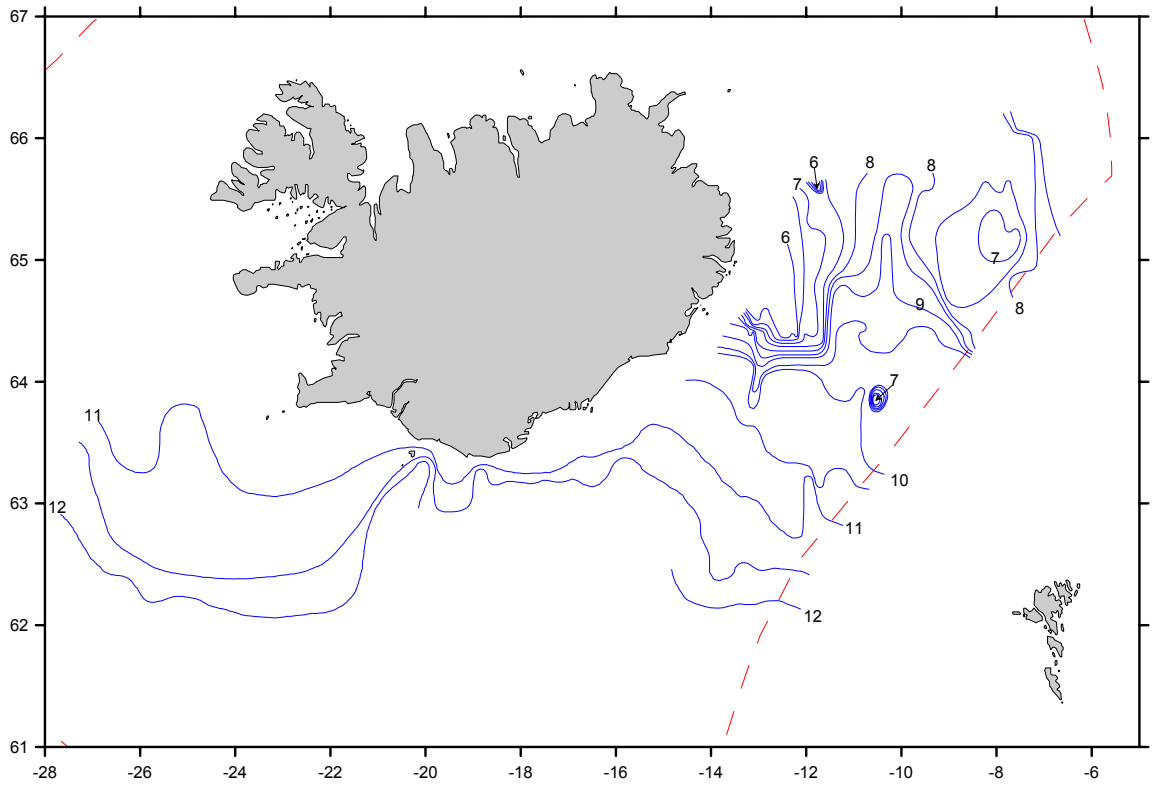


Figure 20. Sea surface temperature observed by RV “Árni Friðriksson”. July 2001.

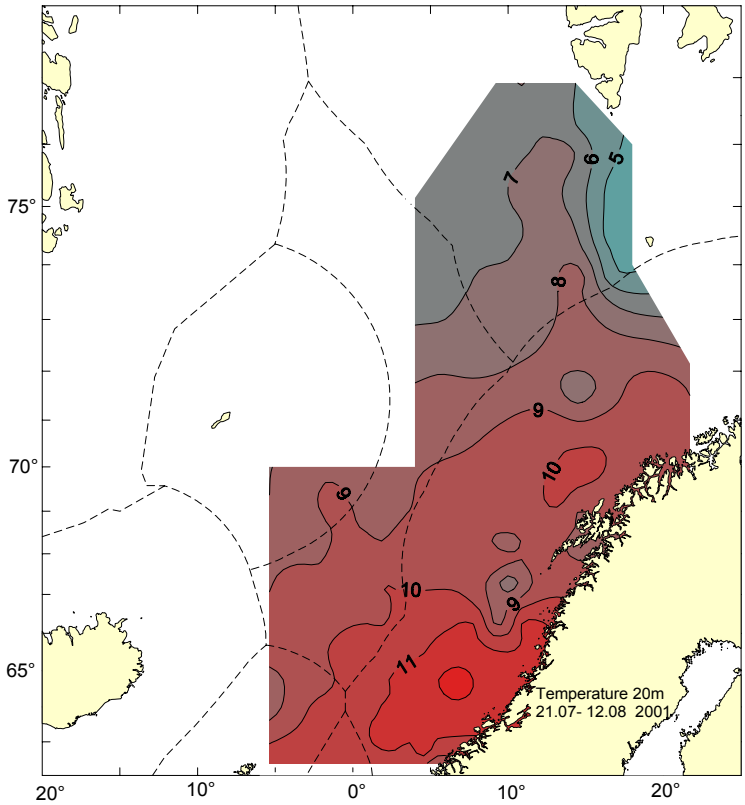


Figure 21. Temperatures at 20 meters in July-August 2001.

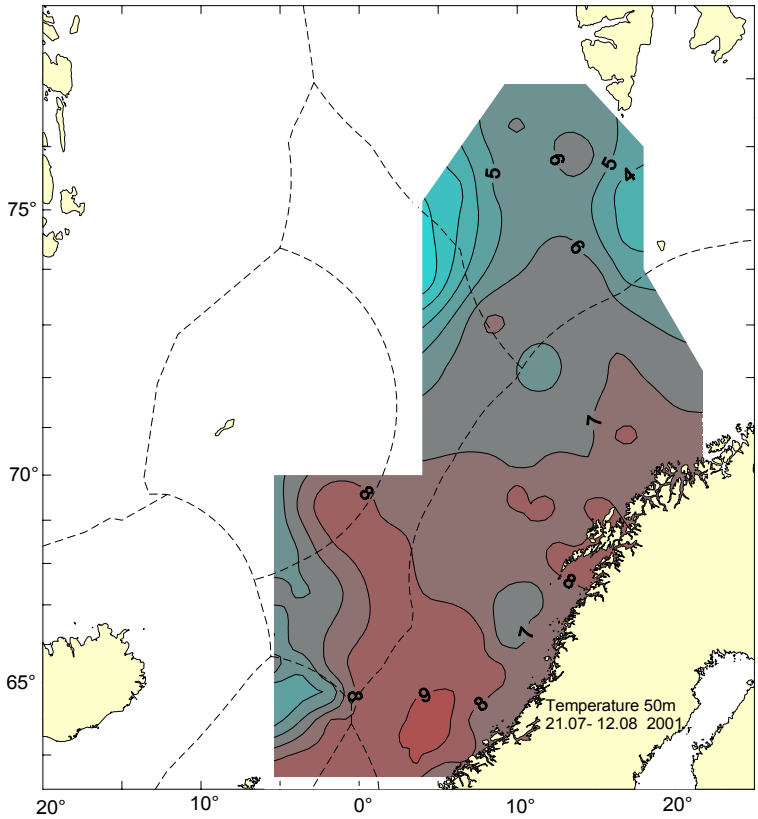


Figure 22. Temperatures at 50 meters in July-August 2001.

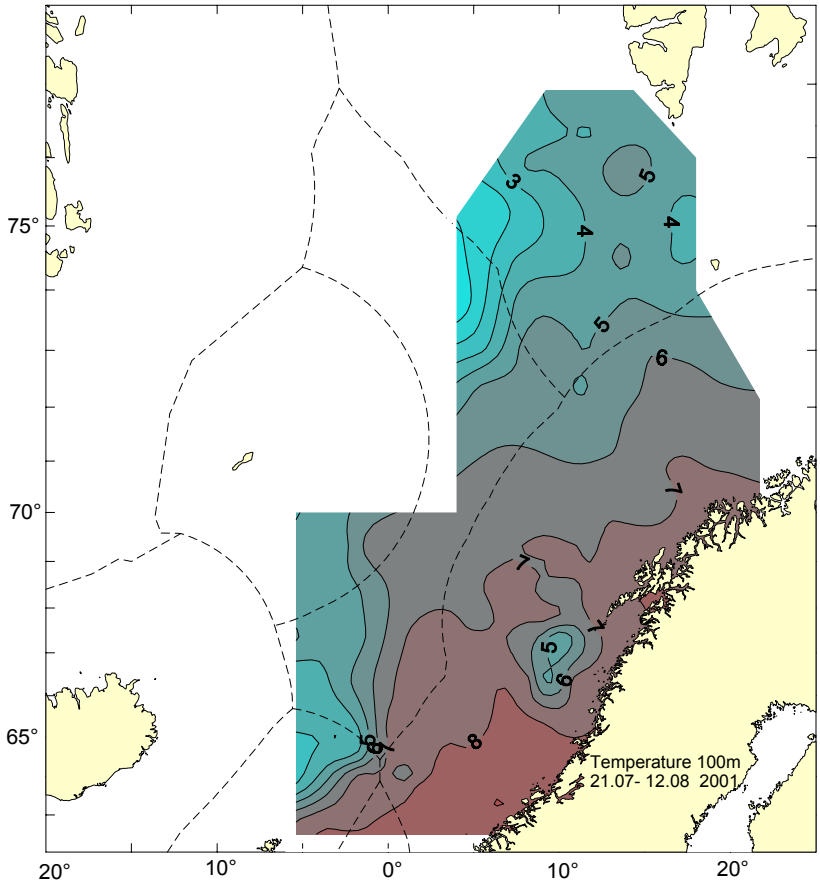


Figure 23. Temperatures at 100 meters in July-August 2001.

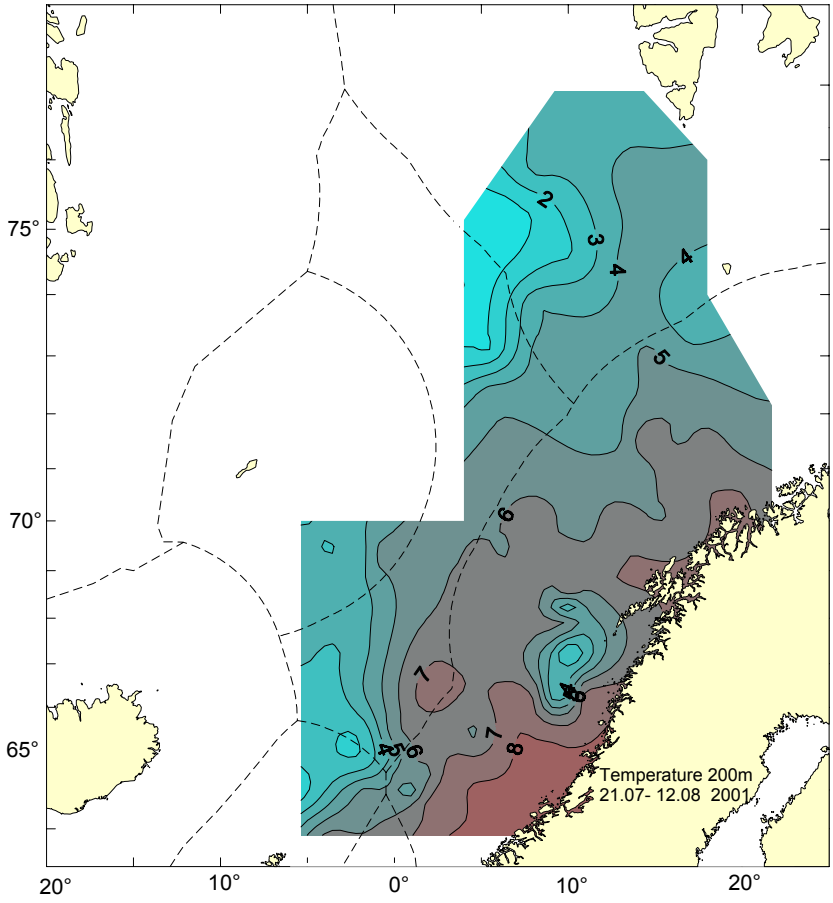


Figure 24. Temperatures at 200 meters in July-August 2001.

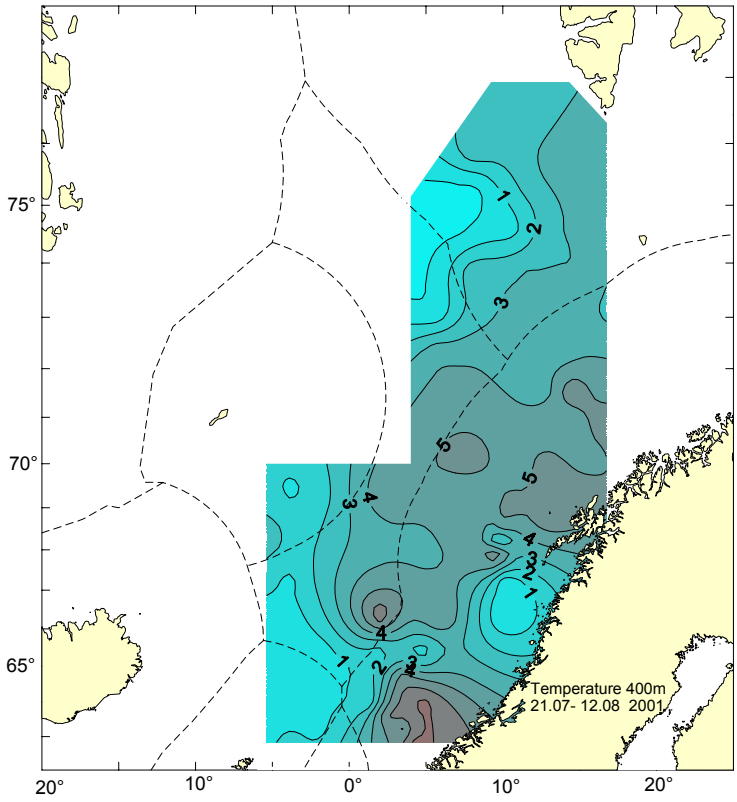


Figure 25. Temperatures at 400 meters in July-August 2001.

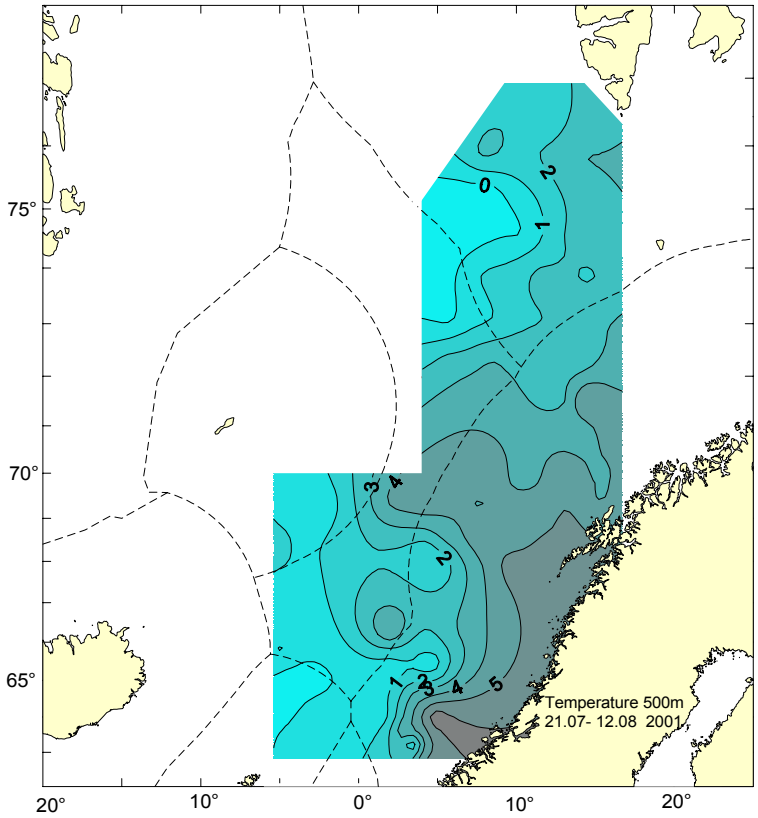


Figure 26. Temperatures at 500 meters in July-August 2001.

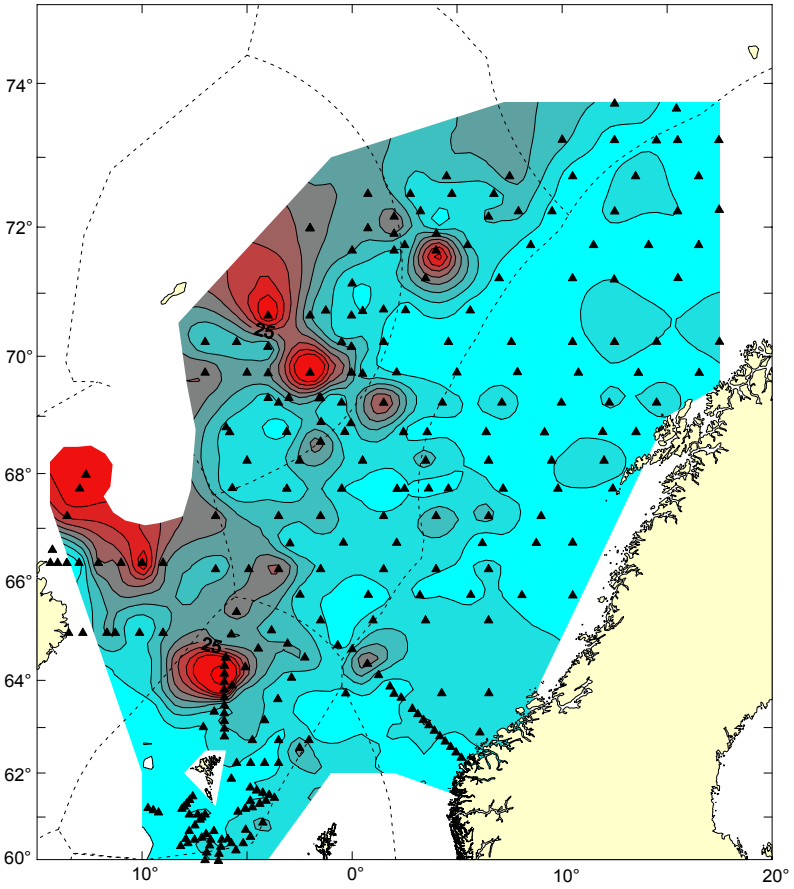


Figure 27. Zooplankton biomass (g dw m^{-2}) (200-0m) in May 2001.

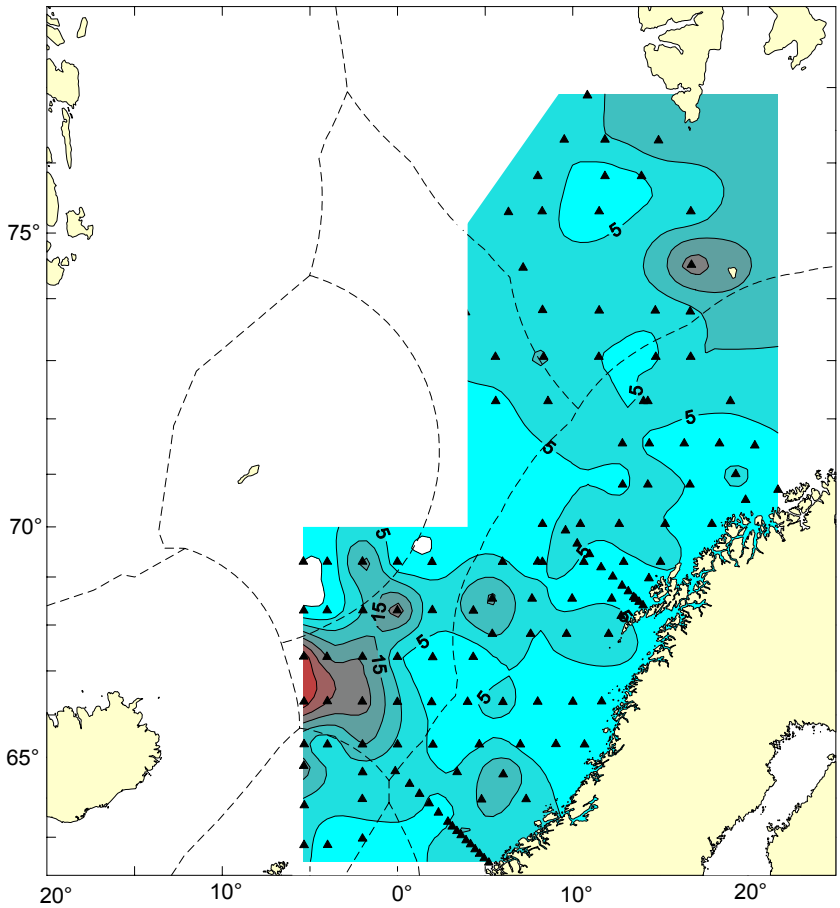


Figure 28. Zooplankton biomass (g dw m^{-2}) (200-0m) in July to August 2001.

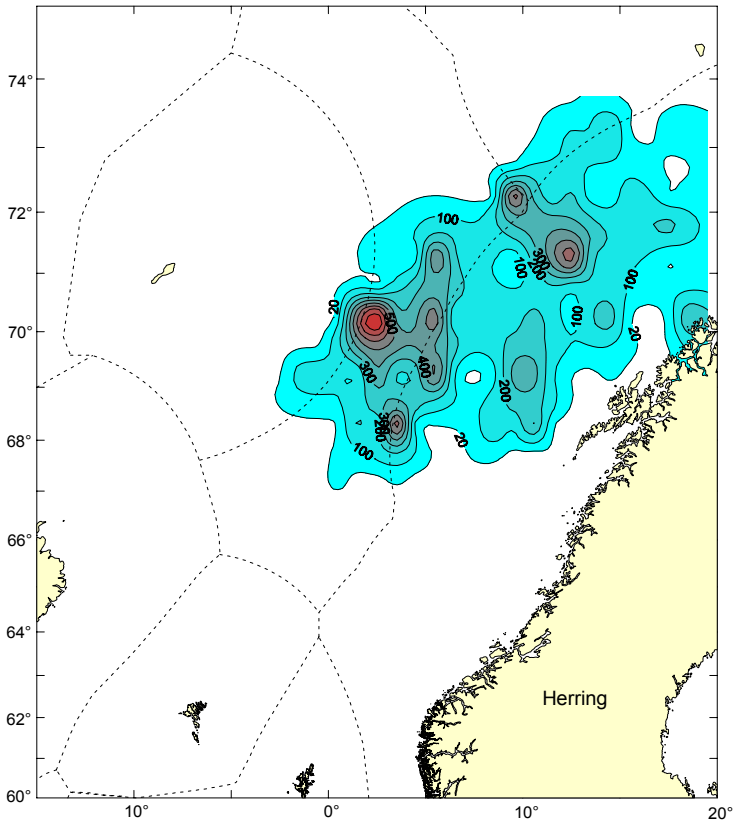


Figure 29. Distribution of Norwegian spring spawning herring as observed by R/V "Magnus Heinason" and R/V "Johan Hjort" during the international herring survey in May 2001.

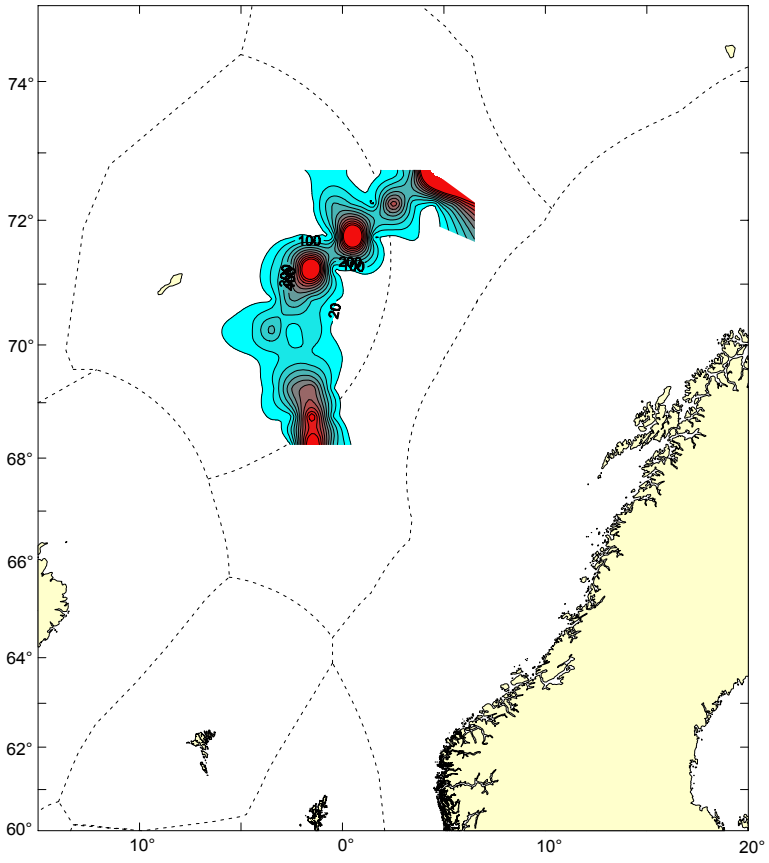


Figure 30. Distribution of herring as recorded by Arni Fridriksson 25/5-8/6, 2001. Incomplete coverage of herring stock in eastern part, eastern border not realistic. See survey transect figure 1 and herring distribution approx 14 days before, figure 29.

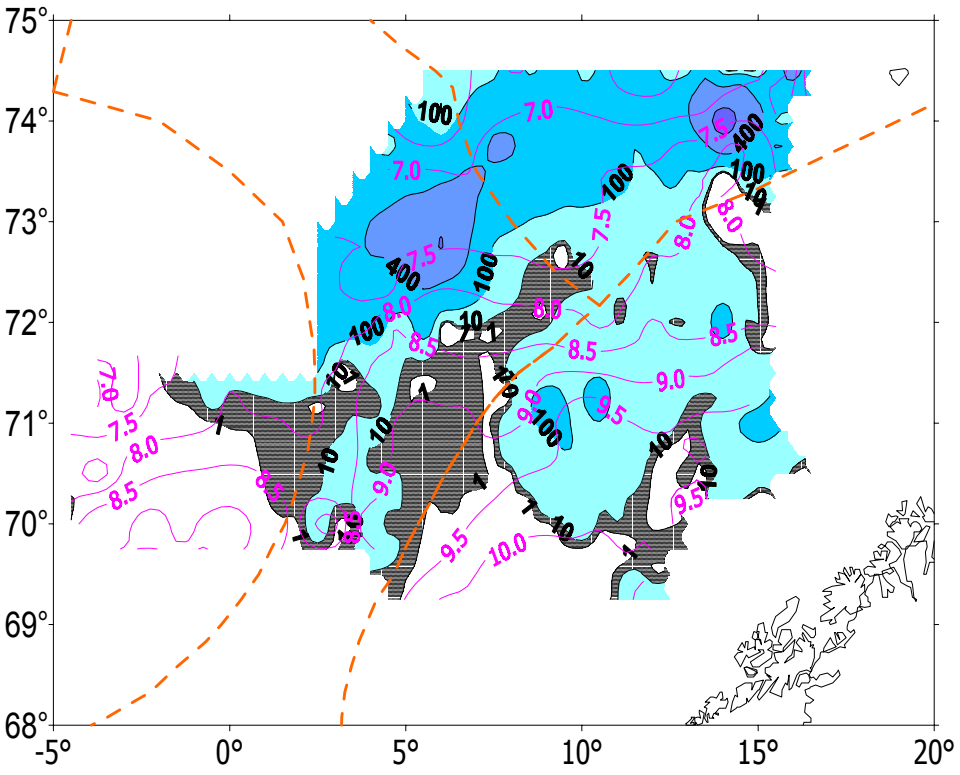


Figure 31. Distribution of herring in the Norwegian Sea and temperature 0 m in July, map of S_A - values . 7-28 July R/V Fridtjof Nansen.

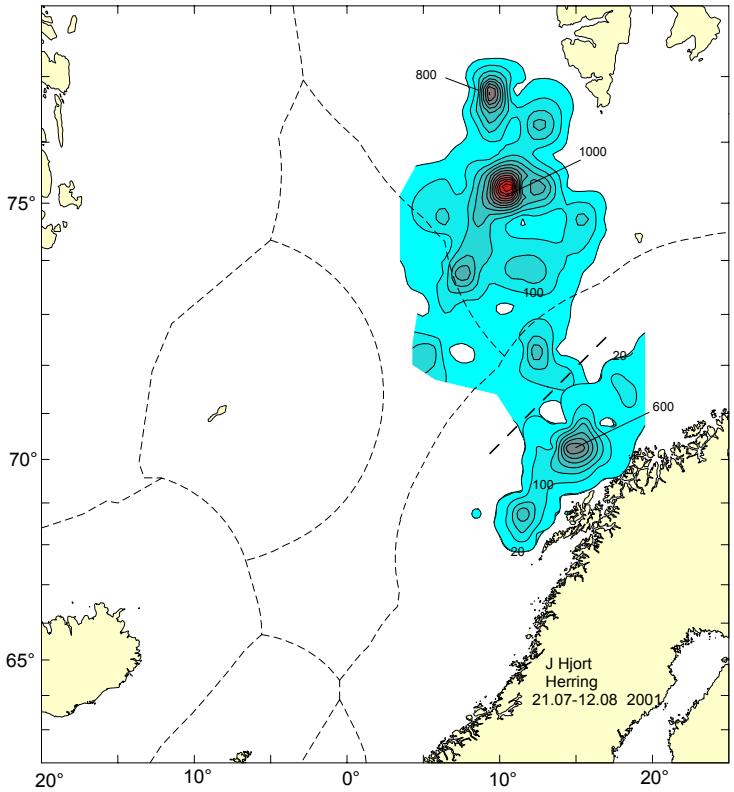


Figure 32. Distribution of Norwegian spring spawning herring as observed by Johan Hjort July 21th-August 14th 2001. Northern distribution is adult herring, southern is adolescent. Coarsely stippled line refers to areas of estimates.

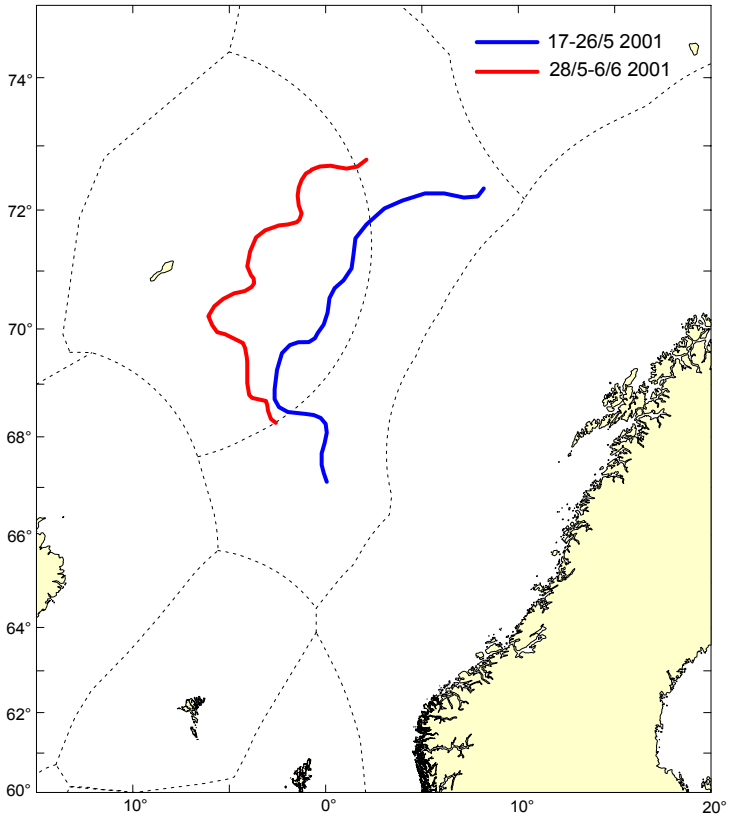


Figure 33. Western border of herring observed during the international survey in May 2001 and the Icelandic survey in late May early June. Time lag approx 14 days.

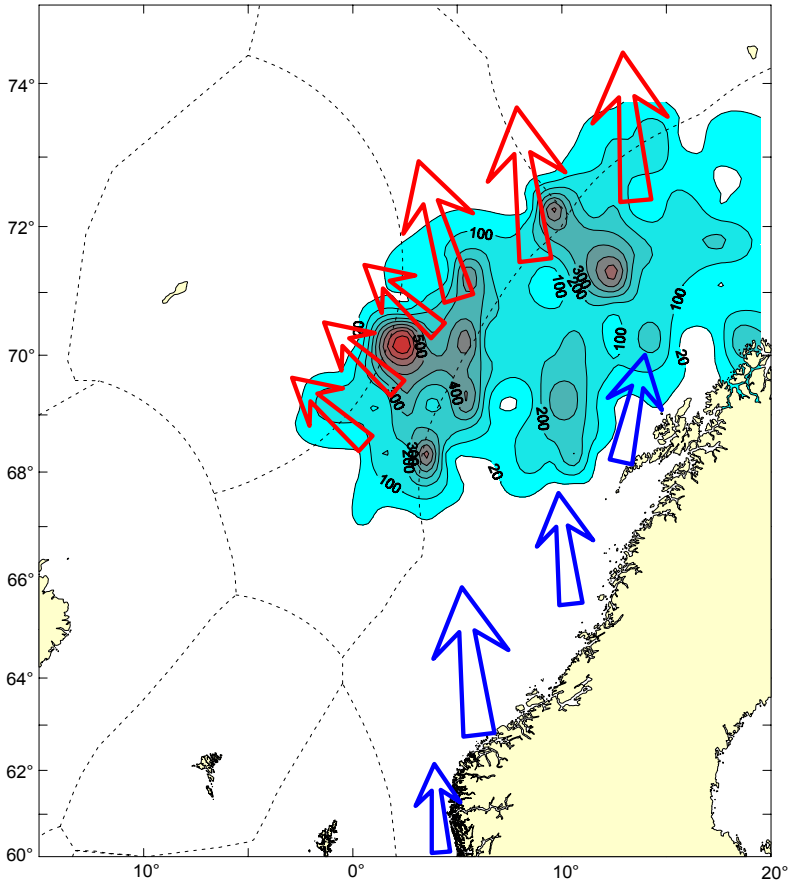


Figure 34. Inferred migration pattern of the Norwegian spring spawning herring in April (blue arrows, pointing into isolines), May (isolines) and June (red arrows, pointing out of isolines) 2001 based on all available information.

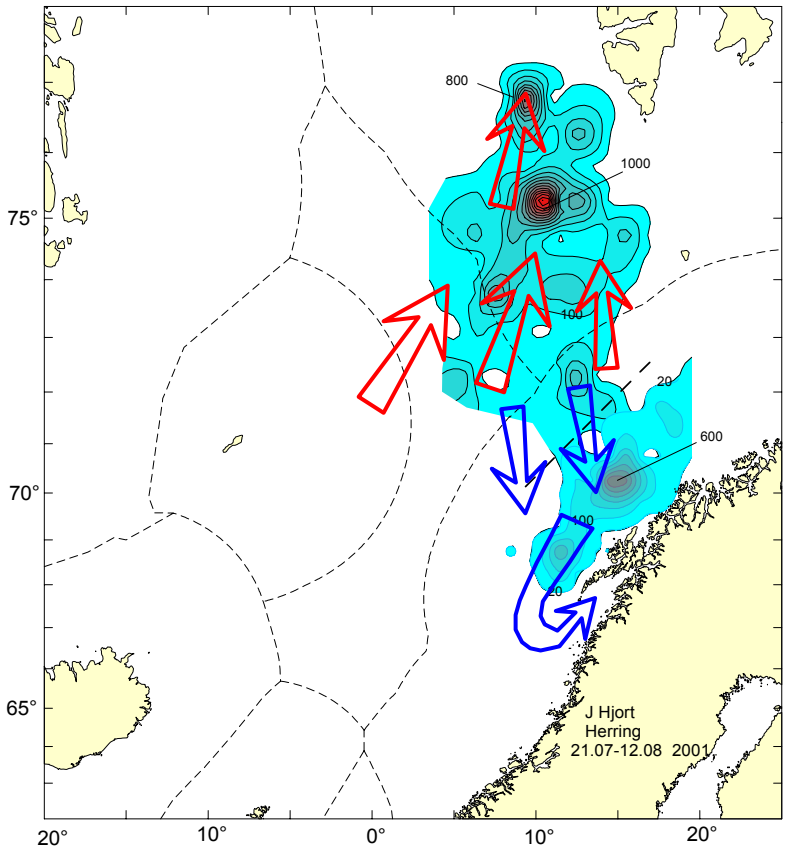


Figure 35. Inferred migration pattern of the Norwegian spring spawning herring in July (red arrows, pointing into isolines), early August (isolines) and September (blue arrows, pointing out of isolines) 2001 based on all available information.

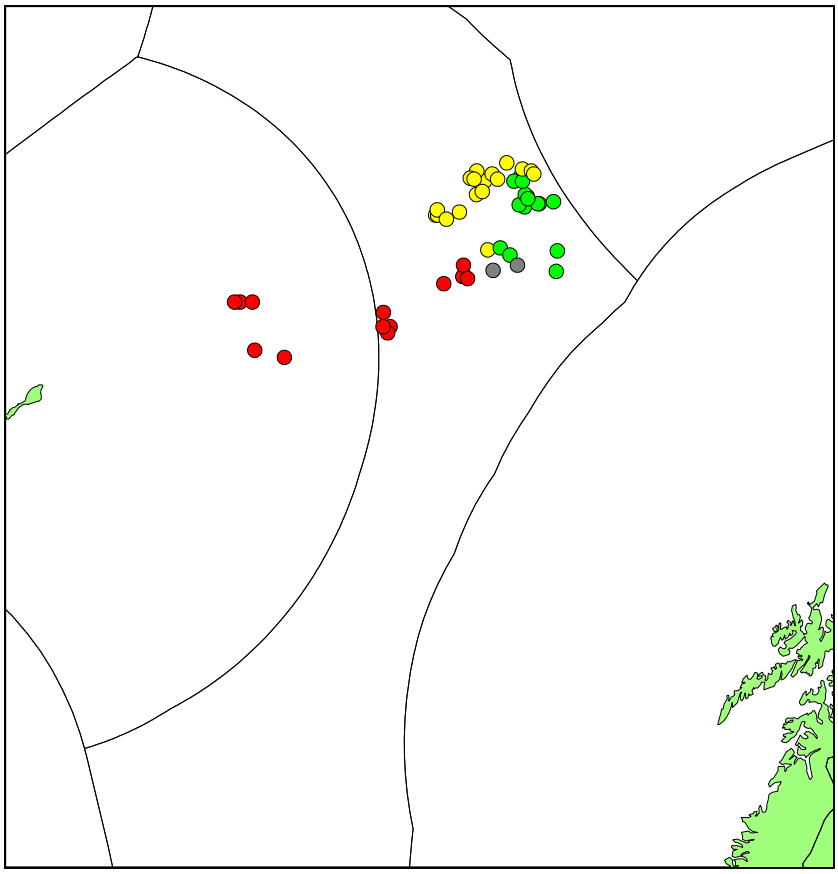


Figure 36. Fishing locations of Faroese vessels on NSSH in the Norwegian Sea in June 2001. Green dots week no. 23 (first of June), Yellow dots week 24, Gray dots week no 25, and red dots week 26 (end of June).

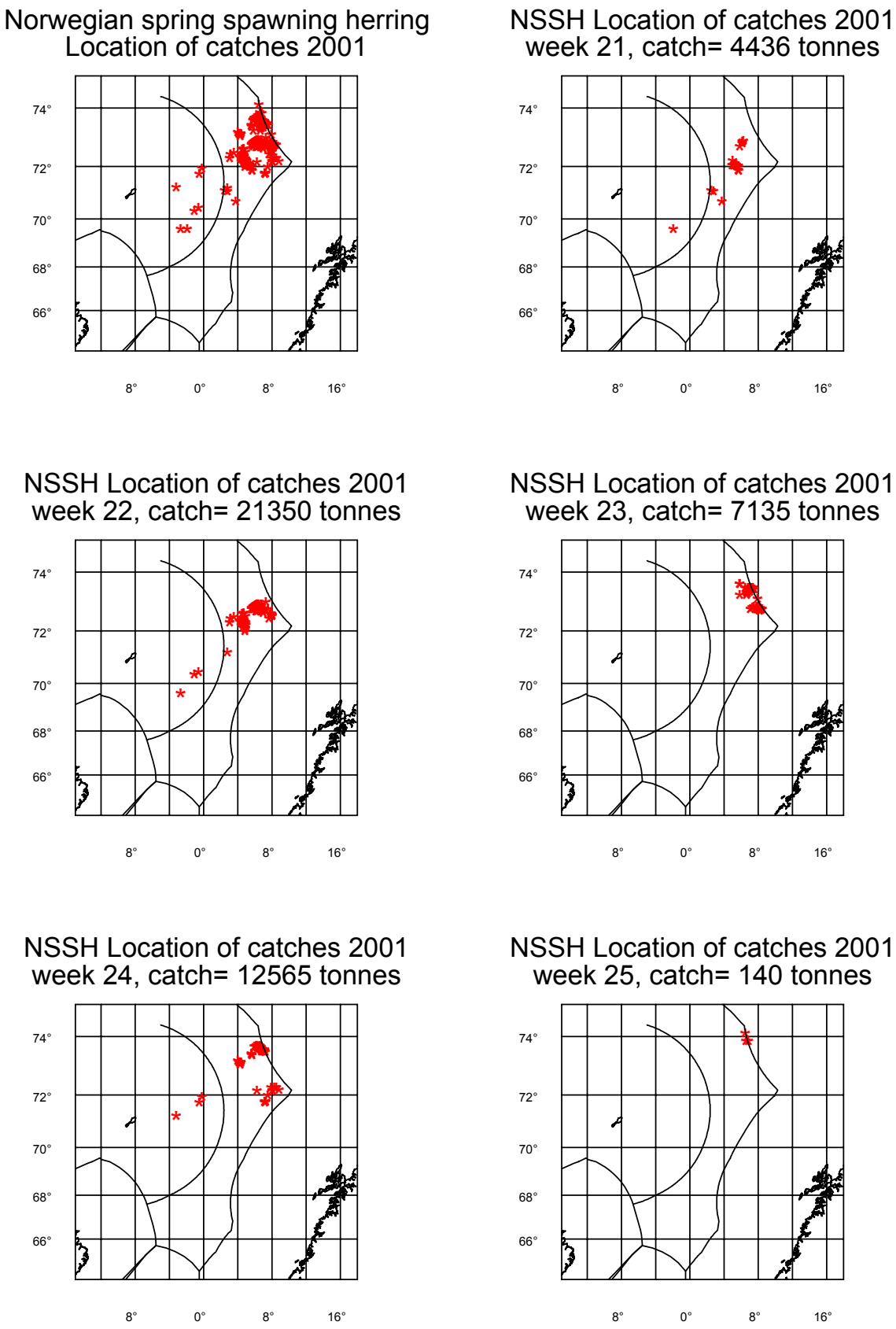


Figure 37. Positions of Icelandic commercial catches according to logbooks, 21/5 – 18/6 2001.

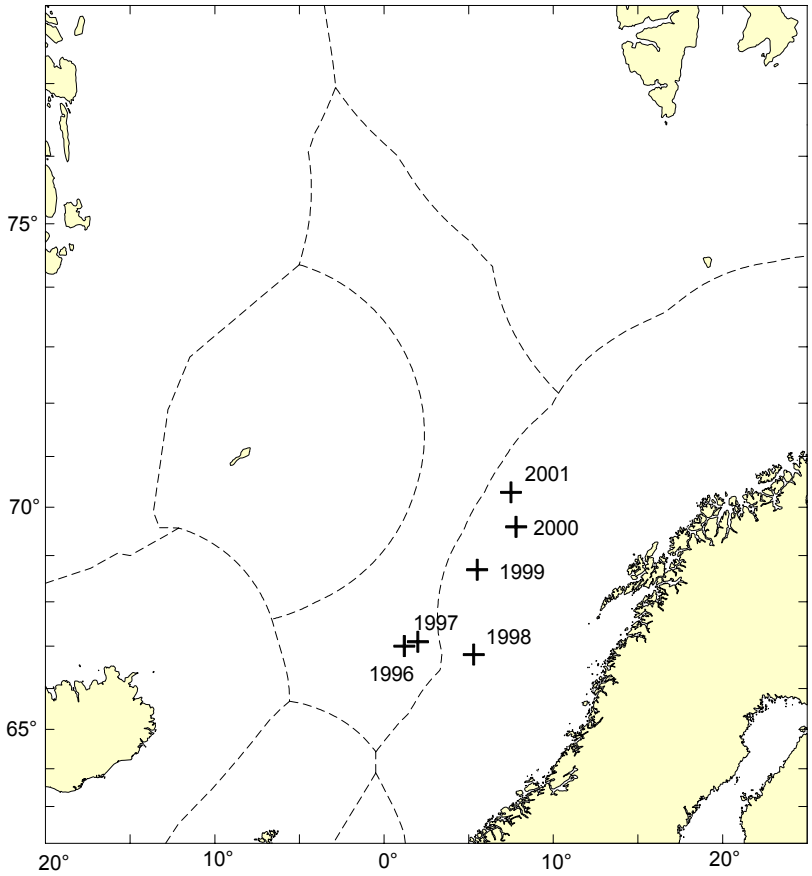


Figure 38. Centre of gravity of the measured distribution of Norwegian spring spawning herring during May in the years 1996 to 2001.

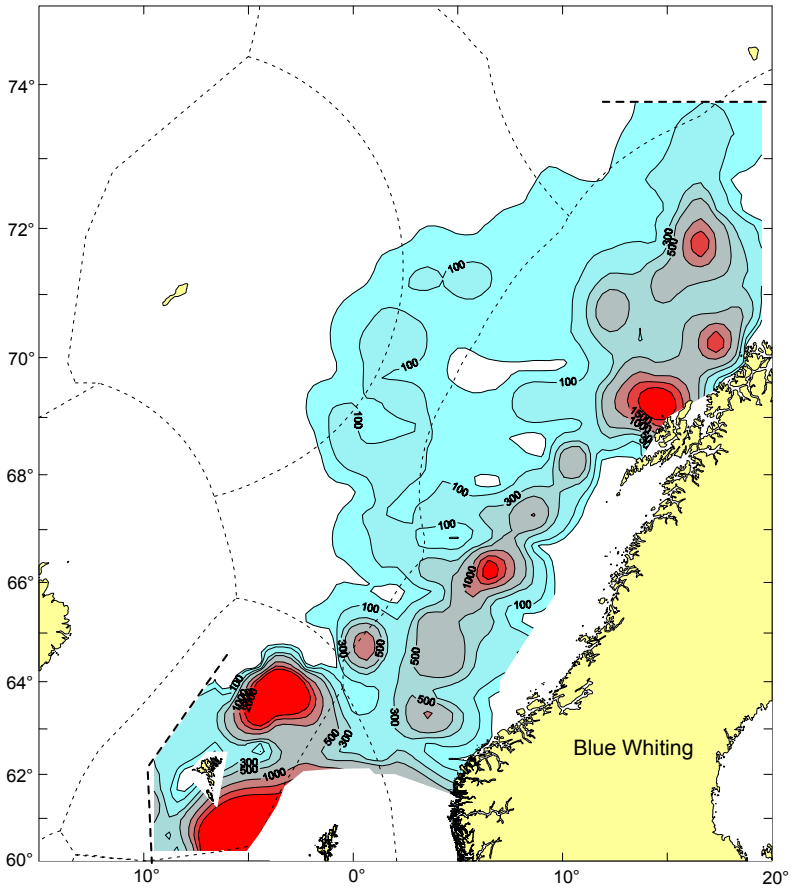


Figure 39. Distribution of blue whiting as observed by R/V "Johan Hjort", R/V "Walter Herwig" and R/V "Magnus Heinason" during the international survey in May 2001.

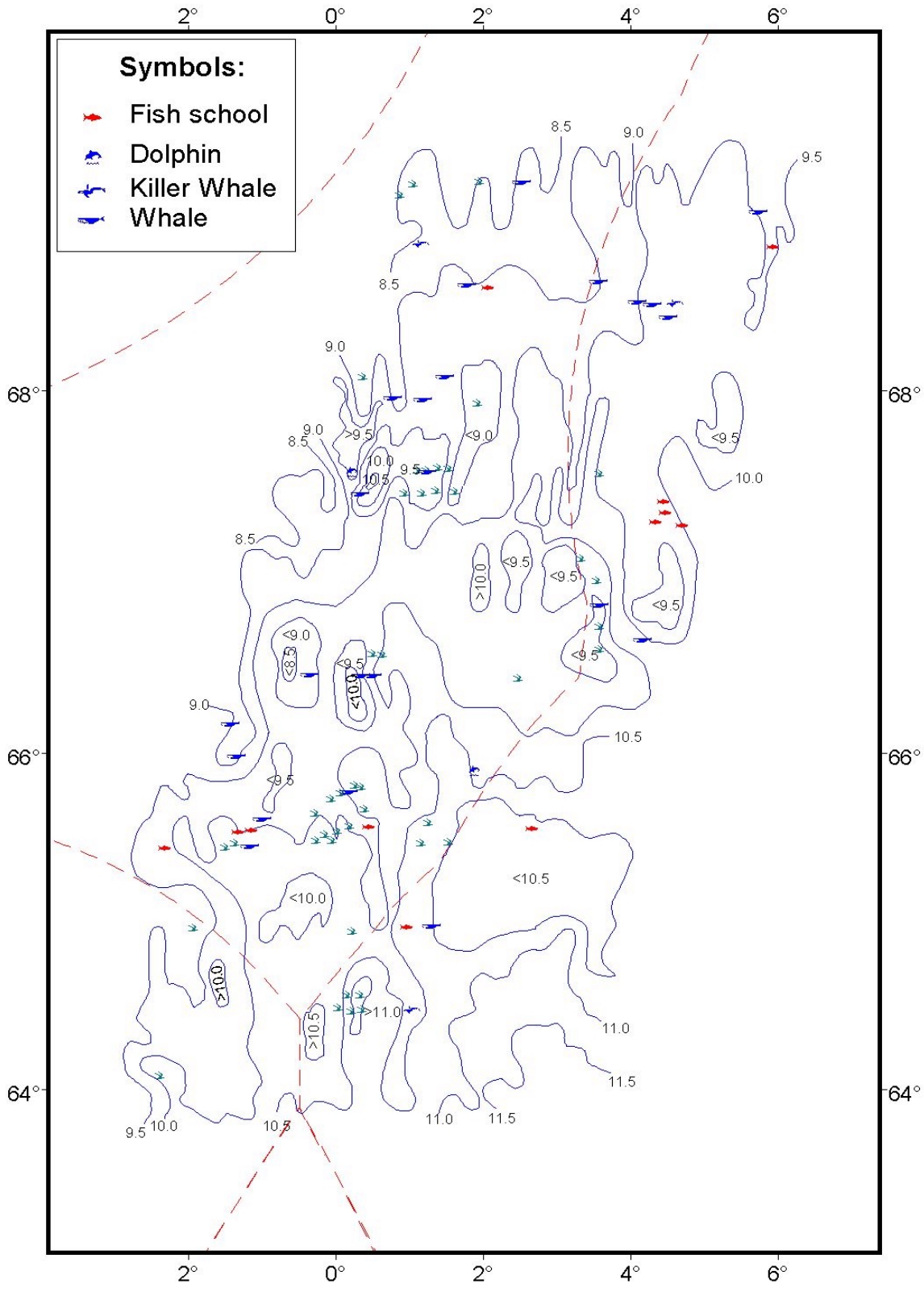


Figure 40. Sea surface temperature, marine animals and fish schools observed visually by aircraft and vessel. July 2001.

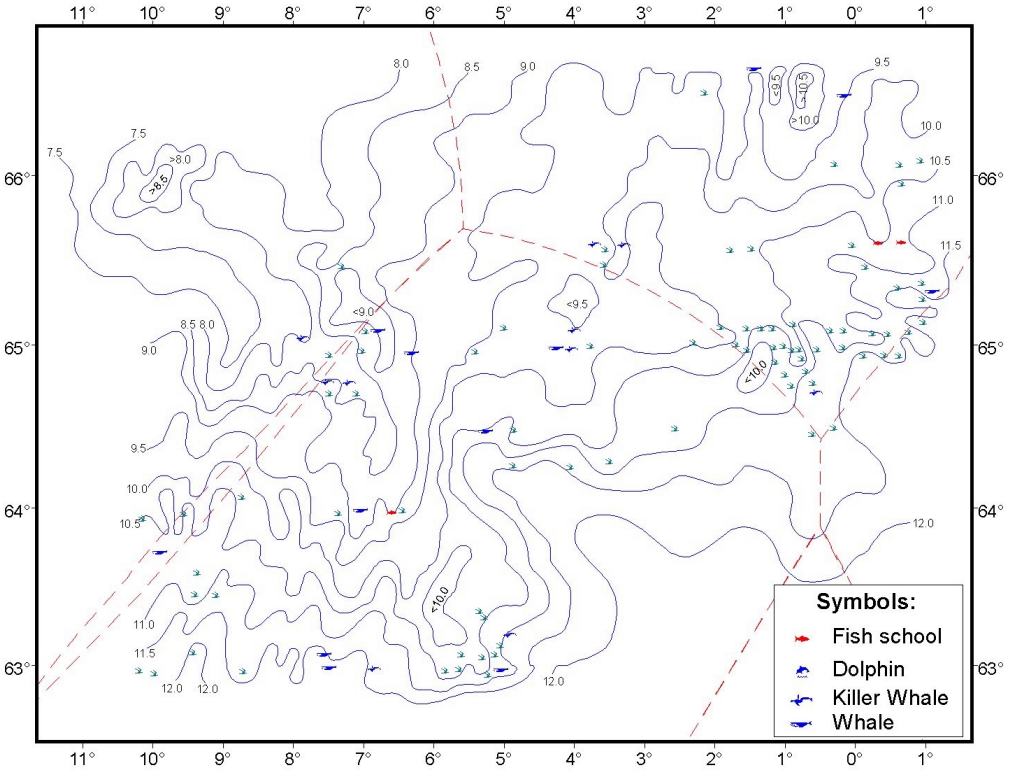


Figure 41. Sea surface temperature, marine animals and schools observed visually by aircraft-laboratory ANTONOV-26 "Arktika". July 2001.

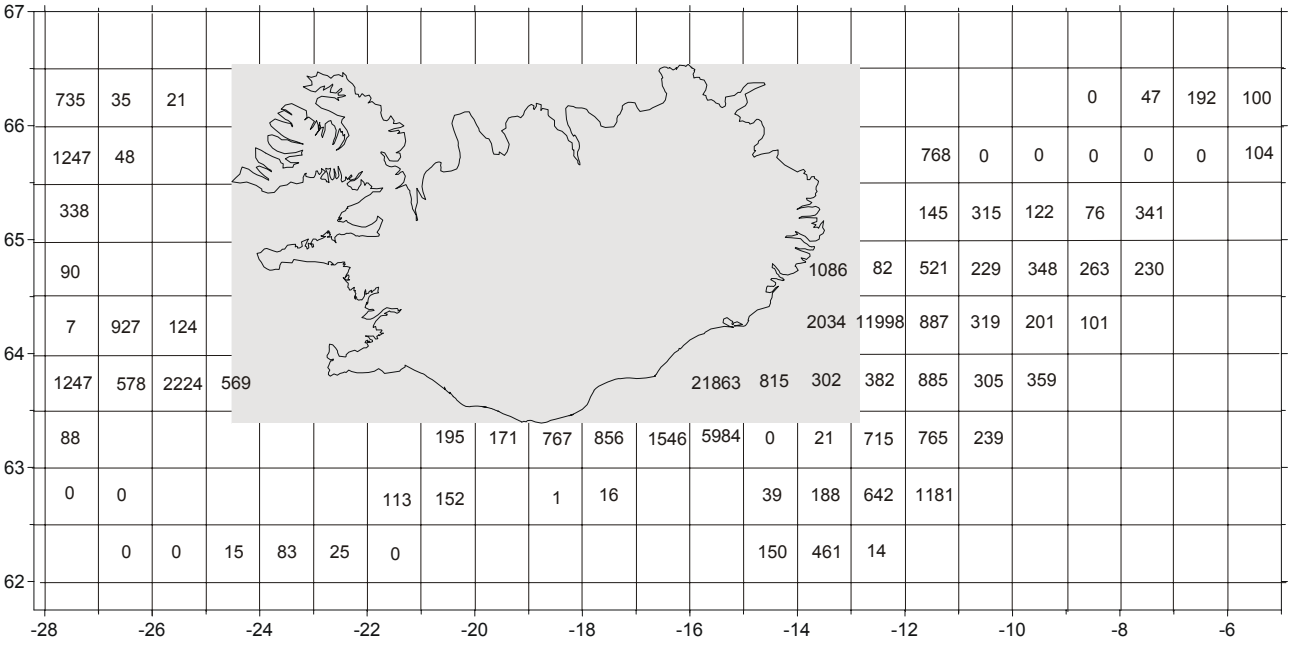


Figure 42. Distribution of blue whiting (Sa-values) by statistical rectangles, R/V Arni Fridriksson (17-30 July) and Bjarni Sæmundsson (12-14 August) 2001.

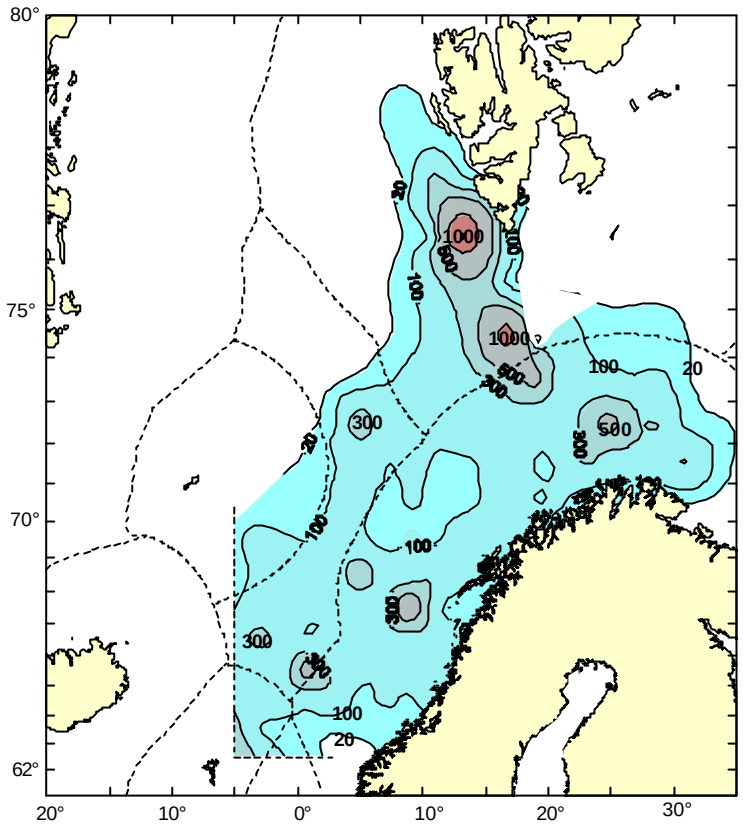


Figure 43. Distribution of blue whiting (Sa values) as observed by R/V G.O.Sars and R/V Johan Hjort, 19th July – 14th August, 2001. (With the addition of data from R/V Jan Mayen and R/V Michael Sars in the Barents Sea. See figure 5 for coverage of GOS and JH).

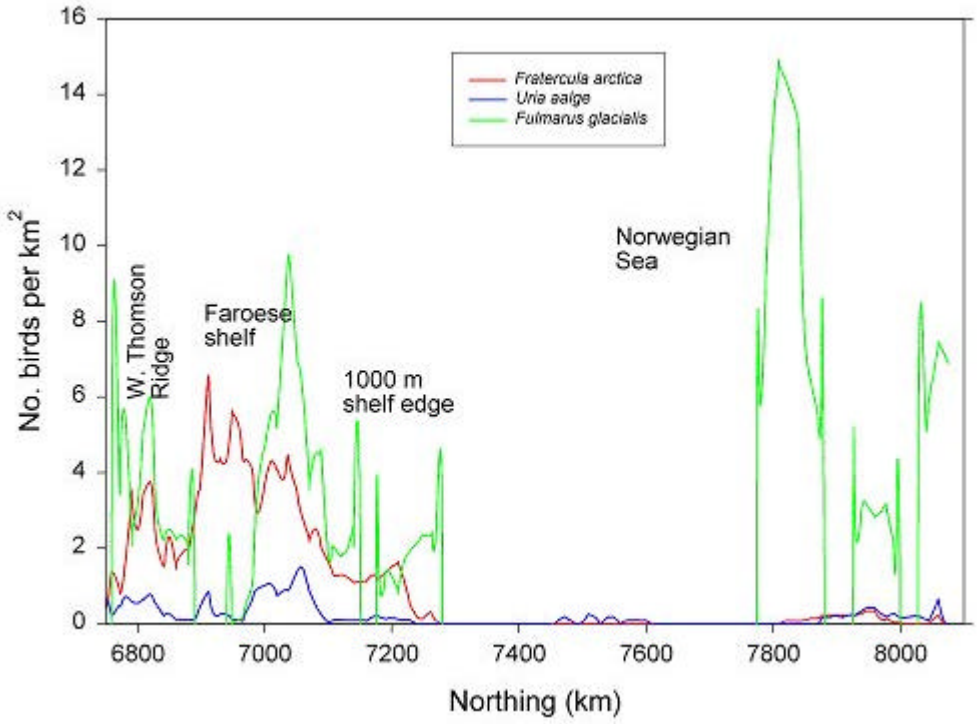


Figure 44. The variation of the density of selected species of seabirds, i.e. Puffin (*Fratercula arctica*), Guillemot (*Uria aalge*), and Fulmar (*Fulmarus glacialis*) observed onboard R/V *Magnus Heinason*. The lines show smoothed average density profiles from south (60°N) to north (65°N) between 5 and 7°W.

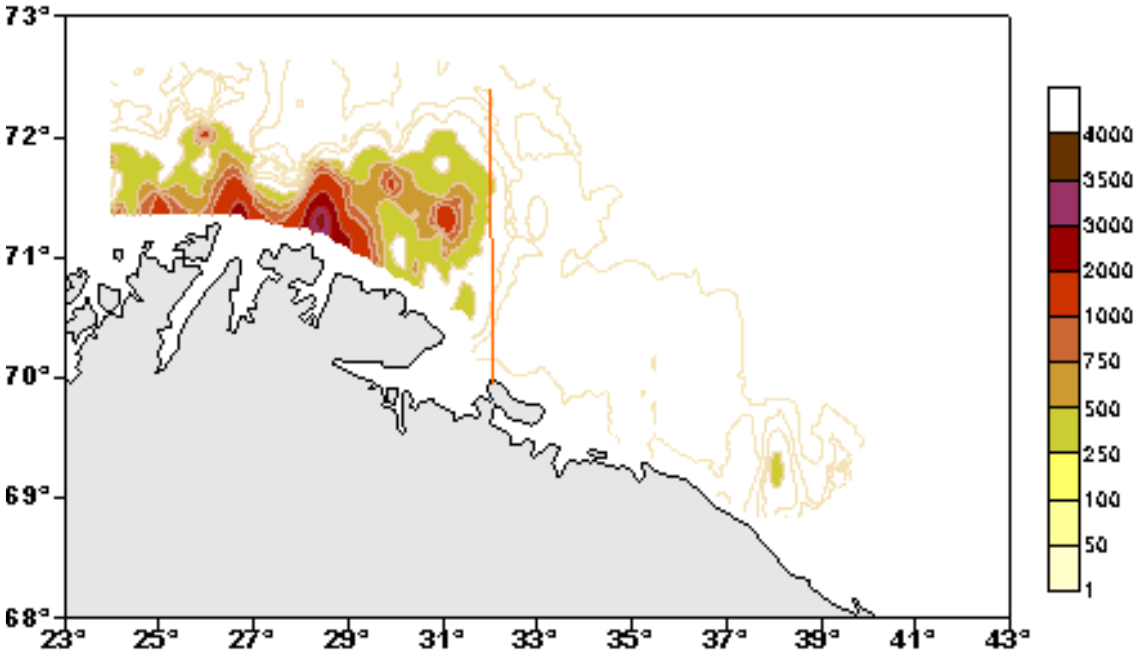


Fig. 45. Distribution (S_A-values) of adolescent Norwegian Spring-Spawning Herring, 17/05-05/06 2001.

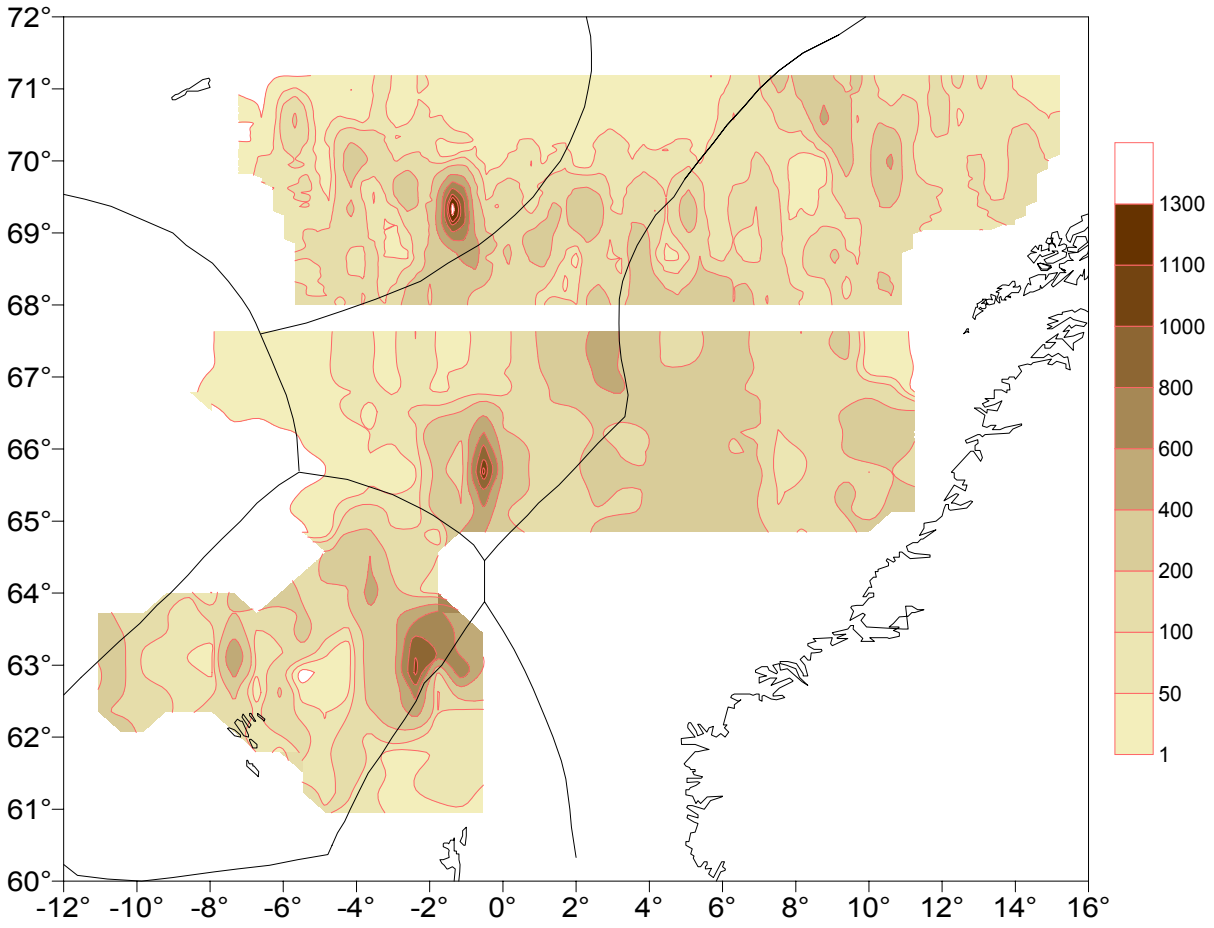
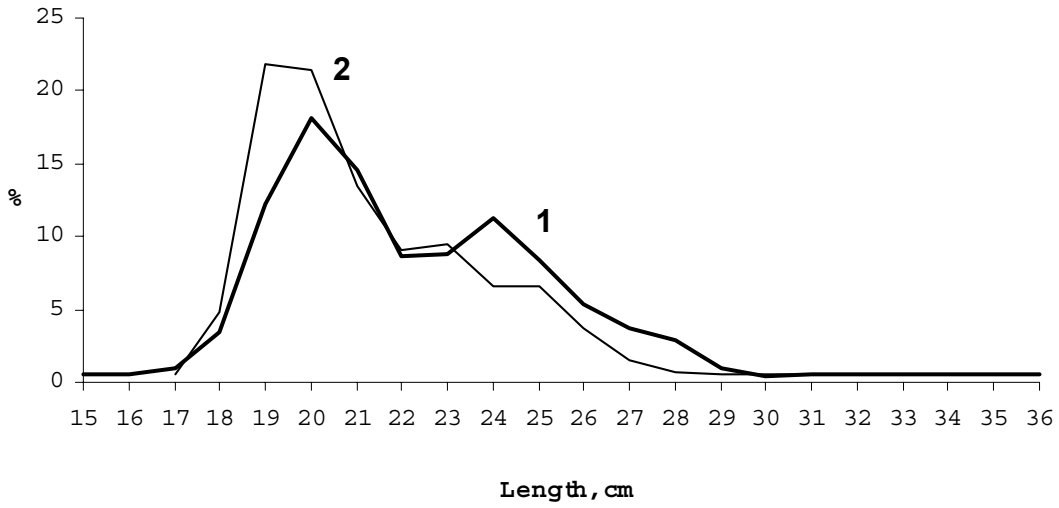


Fig. 46. Distribution of Blue Whiting in the Norwegian Sea , map of S_A - values in June-July 2001.



1- Southern part(June), 2-Northern part of the Norwegian Sea(July).

Fig. 47. Length composition of Blue Whiting in June-July 2001.

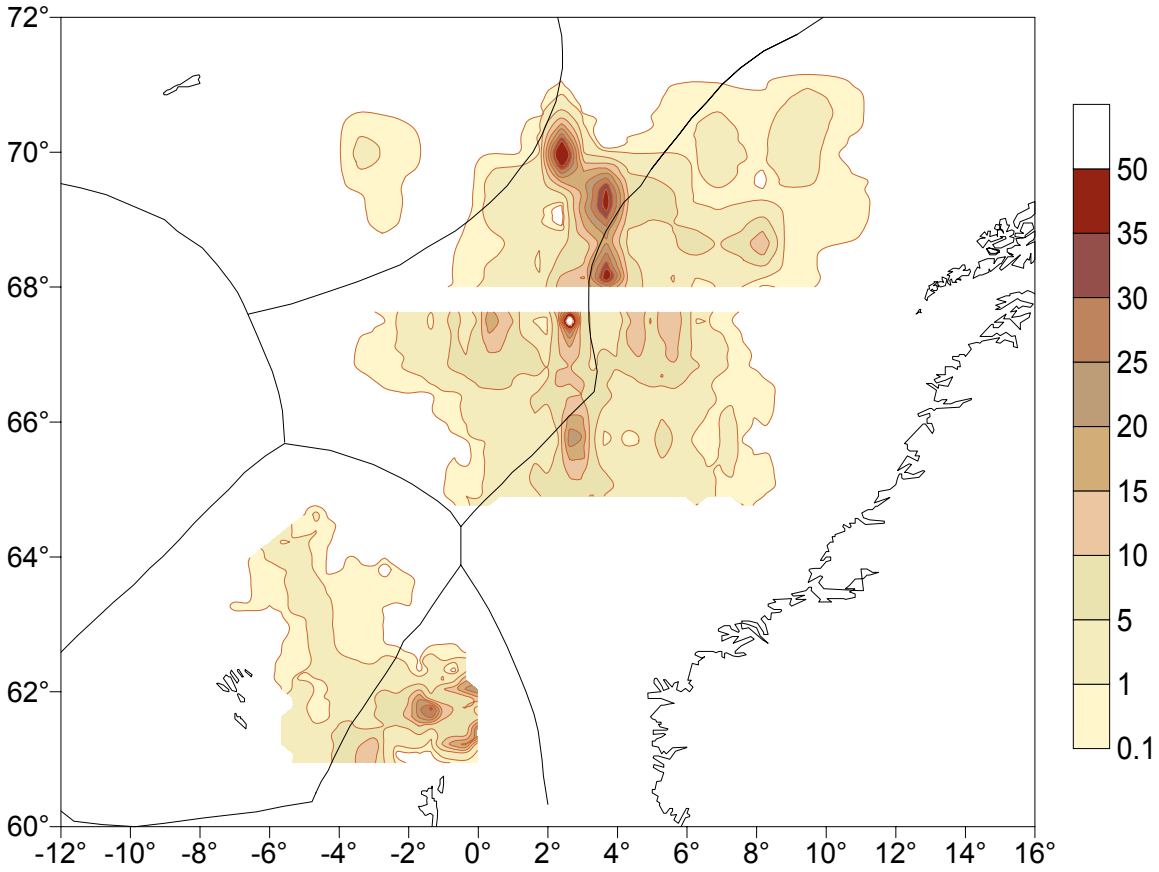
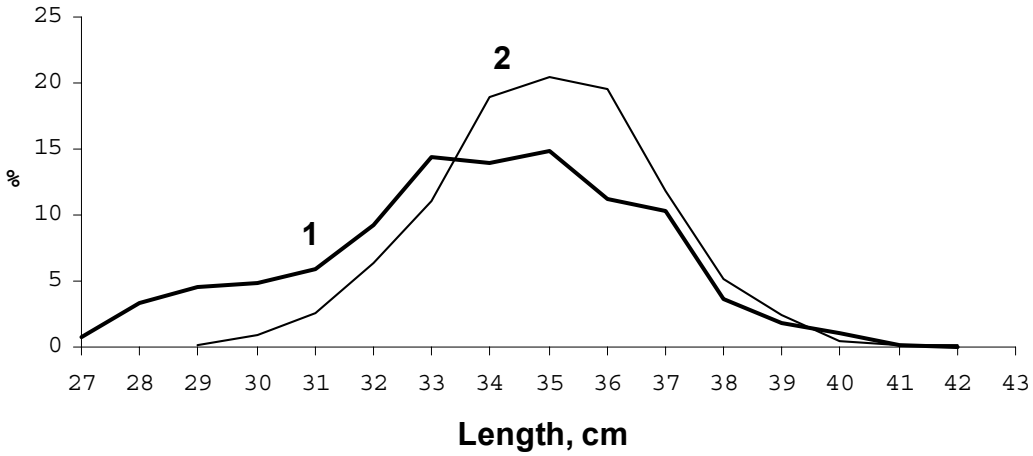


Fig. 48. Distribution of Mackerel in the Norwegian Sea in June - July 2001.



1- Southern part (June), 2-Northern part of the Norwegian Sea (July).

Fig. 49. Length composition of Mackerel in June - July 2001.

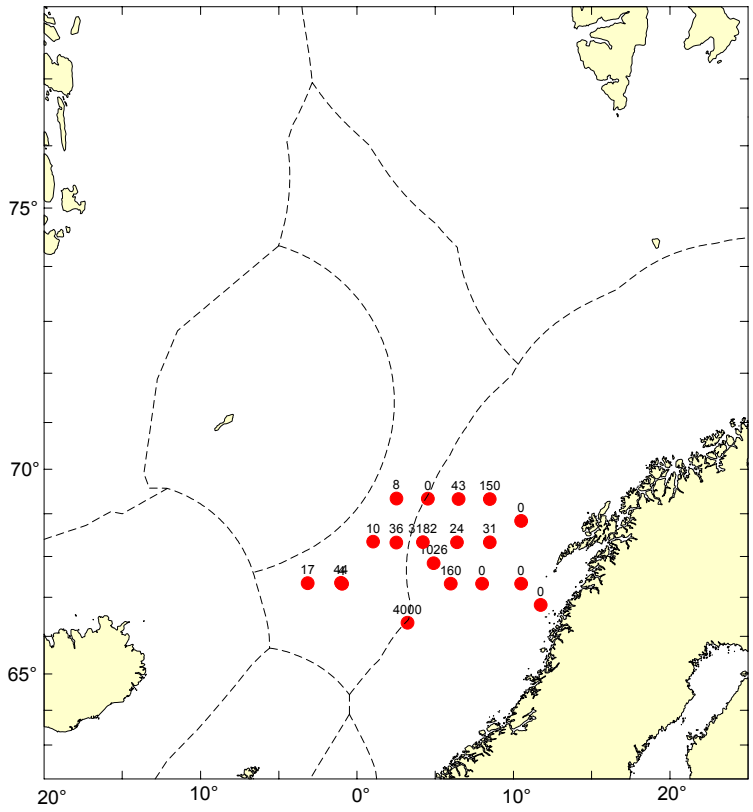


Figure 50. Catches of mackerel made by F/V Selvåg Senior (kg/20min haul), 25th July – 5th August 2001.