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Joint Norwegian-Russian monitoring of 0-group fish on autumn surveys in the Barents Sea, 1965-2023

Institute of Marine Research – IMR

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Joint Norwegian-Russian monitoring of 0-group fish on autumn surveys in the Barents Sea, 1965-2023

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Content

1 - Introduction

A joint Norwegian-Russian survey of 0-group fish (here defined as fish hatched earlier in the same calendar year) in the Barents Sea was started in September 1965 with the motivation to provide initial information on year class strength of commercially important fish stocks (ICES 1965, Eriksen and Prozorkevich 2011). The survey initially used echosounders to record 0-group fish combined with trawl sampling to identify the composition of the acoustic backscatter (Dragesund and Olsen 1965). The joint 0-group survey was continued the following years with participation also by the United Kingdom from 1966 to 1976. Intercalibration of the echosounders was done before the start of the survey to improve comparability of results obtained by different research vessels (Dragesund 1970, Dragesund et al. 2008).

The acoustic information was used in a semiquantitative manner by classifying the echo-sounder paper recordings into 5 categories from no (0) to very dense (4) recordings (Dragesund et al. 2008). The number of fish caught in supporting trawl catches was additionally used to distinguish between scattered and dense concentrations on distribution maps (Haug and Nakken 1977). While trawling in the first period was guided by the echo-sounder results, ICES advised in 1980 on a standardized trawling procedure (stepwise in the upper 60 m; see later section) which has been followed from 1981 onwards. At the same time, the 0-group survey shifted from a combined acoustic-trawl survey to a standardized trawl survey (Dragesund et al. 2008, Eriksen and Prozorkevich 2011). From 1981 onwards, all vessles have used the same type of trawl, a fine-meshed commercial trawl (‘Harstad’) designed to catch capelin (Nakken and Raknes 1996, Dragesund et al. 2008). This trawl has a rectangular opening of about 20 by 20 m.

The results from the survey have been calculated and expressed as a set of 0-group fish abundance indices of the main commercial species of fish found in the Barents Sea (Dingsør 2005, Eriksen et al. 2009, Eriksen and Prozorkevich 2011). The abundance values have also been converted to 0-group fish biomass by multiplying numbers with mean weight of the 0-group fish that are recorded routinely during the surveys (Eriksen et al. 2011, 2017b).

0-group fish play dual roles in the ecosystem. They are the recruiting life stages of fish stocks that are of great ecological and economic importance, and variation in recruitment, as reflected at the 0-group stage, plays large roles for the dynamics of the fish stocks as well as the wider ecosystem through trophic interactions. In addition, the 0-group fish are planktonivorous and constitute a substantial component among the pelagic fish in the ecosystem. This is the case not only for true pelagic species, such as capelin and herring, but also for demersal species, such as cod and haddock, before they settle to near the seafloor later in autumn.

Time series of 0-group abundance and biomass have been used in descriptions and analyses of the Barents Sea ecosystem (e.g. Eriksen et al. 2017, ICES WGIBAR 2018). We are currently expanding these analyses to address in more detail the roles of 0-group fish in relation to recruitment variability and stock dynamics of major fish species, and for the structure and energy flow in food webs of the Barents Sea ecosystem. In the project ‘Trophic Interactions in the Barents Sea: steps towards Integrated Ecosystem Assessment’ (TIBIA) and ICES working group “Integrated ecosystem assessment in the Barents Sea” (WGIBAR), we were using a subdivision of the Barents Sea into 15 subregions (polygons) (Fig. 1). We are using this subdivision (but with 13 polygons only due to lack of coverage in two northeastern polygons) to provide spatially resolved estimates of biomass of major ecosystem components, such as zooplankton, benthos, and fish, including 0-group.

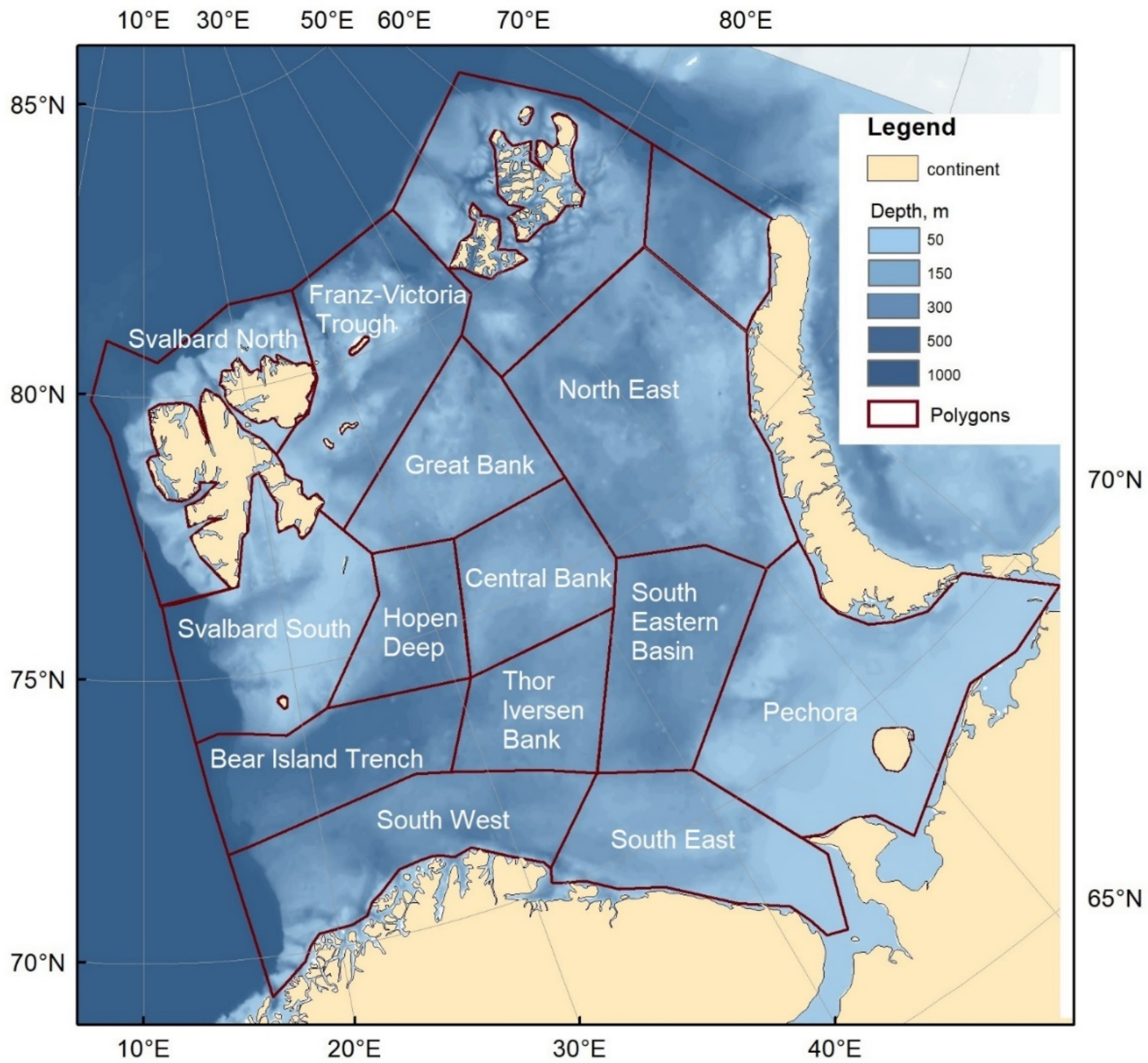


Figure 1. Map showing subdivision of the Barents Sea into 15 WGIBAR-subareas (regions) used to calculate estimates of 0-group abundance based on the Barents Sea autumn surveys (including the Barents Sea ecosystem survey (BESS) since 2004).

In this communication, we provide an updated overview of the joint Norwegian-Russian 0-group investigations in the Barents Sea. We describe the procedures of sampling, analyses, and calculation of results, and discuss associated sources of error. One particular source of error with trawl sampling of small fish is the catchability: to what extent do the 0-group fish escape through the meshes of the trawl as function of fish length, what are the roles of herding, and how is low and variable catchability corrected for (Eriksen et al. 2009). We have used the TIBIA/WGIBAR subdivision to provide spatially resolved estimates of 0-group abundance of major species of fish collected in the 0-group survey. The new abundance estimates by TIBIA polygons are compared with the previous set of abundance indices as reported by Eriksen et al. (2009) and Eriksen and Prozorkevitch (2011). Eriksen and Prozorkevitch (2011) provided distribution maps of four species of fish (capelin, herring, cod and haddock) for each year from 1980 to 2008. Here we provide a new and updated set of distribution maps from 1980 to 2023 for the same 4 species as well as for polar cod and redfish (*Sebastes* spp.) (included here in part 7. Spatial distribution). We consider the spatial and temporal coverage of the surveys and note years where incomplete coverage or timing could have influenced the results (Part 6. Survey area and coverage).

2 - Development of the 0-group monitoring

2.1 - From acoustics to trawl-based survey

The international 0-group survey in the Barents Sea shifted from an acoustic survey, where trawling was used to identify the species of 0-group fish in the acoustic layers, to a standardized trawl survey where acoustic records are used mainly to guide sampling (e.g. add extra steps in the vertical if acoustic records suggest that 0-group fish are distributed below 60 m depth) (Dragesund et al. 2008). A study performed in autumn 1963 on abundance and distribution of 0-group fish from acoustic records in the Barents Sea, suggested that it would be feasible to carry out an 0-group survey in autumn based on acoustic methodology (Dragesund and Olsen 1965). At this time, it was known that 0-group fish were abundant in the surface layers of the Barents Sea, stemming from spawning at ‘up-stream’ spawning grounds further south. An echo integrator had also been constructed, which facilitated the treatment of the acoustic recordings (Dragesund et al. 2008). Based on the initial investigation in 1963, and follow-up studies in 1964, it was decided to start a joint international 0-group survey in autumn 1965. The results and experiences from the first four years of the survey (1965-1968) were reported as an ICES publication in 1970 (Dragesund 1970).

The feasibility of an acoustic survey of 0-group fish in the Barents Sea was at the time considered positively, being an early and inspirational case of the general development of fisheries acoustics, where abundance of fish is estimated from acoustic records combined with trawl catches to help identify the acoustic scatterers and allocate the acoustic signals among them (Dragesund et al. 2008). However, it became apparent that use of the acoustic method for 0-group fish was a challenge due to the commonly mixed occurrences of the different species as well as abundant presence of other scatterers such as krill and jellyfishes, as well as 1-group capelin. This led to a shift in emphasis from acoustics to trawling as the basis for the survey.

2.2 - Standardized trawling procedure

The “Harstad” trawl is designed to capture small fish and has been the standard equipment since around 1980 for the 0-group fish survey, the capelin survey, and later the ecosystem survey (Anon. 1980, Eriksen and Gjøsæter 2013). In the first years of the survey, pelagic trawl hauls were taken frequently, usually no more than 40 nautical miles (nm) apart, targeting acoustic scattering layers to help identify and quantify the contribution by 0-group fish (Dragesund et al. 2008). In addition, some trawl hauls in the surface layer were also taken in areas where there were no clear acoustic records of 0-group fish. Based on advice from ICES, a new trawling procedure was introduced in 1980. This has since been the standard trawling procedure where the trawl is operated in steps with the headline at 0 m, 20 m and 40 m. With a nominal trawl opening of 20x20 m, this provides an integrated sample from the upper 60 m of the water column. The trawling procedure prescribes a towing speed of 3 knots and a tow distance of 0.5 nm for each depth interval (Fig. 2). Additional tows with the headline at 60 and 80 m, and with distance of 0.5 nm, were made when dense concentration was recorded deeper than 60 m on the echo-sounder.

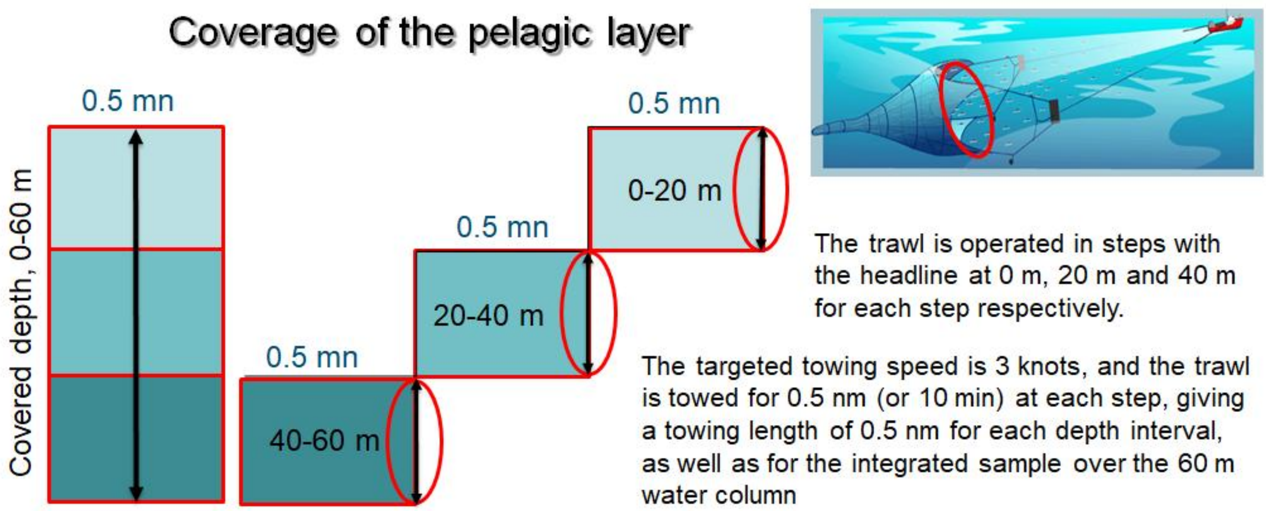


Figure 2. Schematic representation of a pelagic trawling (standard 0-group trawling), indicating three depth steps with headlines at surface (0 m), 20 m and 40 m. With a theoretic trawl opening of 20x20m, this provides an integrated sampling over the upper 60m water column .

Standardization has been an important aspect of the joint 0-group survey in the Barents Sea since its beginning in 1965. The same echo sounders were used on Norwegian and Soviet/Russian vessels in the early years, and inter-ship acoustic calibrations were carried out by comparing results from the same areas (Dragesund et al. 2008). The survey has been a large-scale, multi-ship operation with 3-6 vessels taking part annually. The vessels used in the first years were built as side-trawlers, being gradually replaced between 1970 and 1979 with larger stern-trawlers, better equipped and capable of operating larger trawls (Dragesund et al. 2008). From 1980 all participating vessels have used the same small-meshed sampling 'standard' trawl – the 'Harstad' trawl. This trawl is constructed with seven panels, with mesh size (un-stretched) decreasing from 100 mm in the first (front) panel to 30 mm in the last panel and 8 mm in a codend (Godø et al. 1993). While the trawl is considered standard and has been used on both Norwegian and Russian vessels, there have been adaptations and differences in rigging due to the Norwegian vessels initiated towing at the surface and the Russian vessels initiated towing at depth.

2.3 - Sample processing and analyses

When the trawl comes on deck, the trawl is shaken well, to allow for fish adhering to the trawl meshes to fall back into the trawl cod end or to the deck. This is to ensure that the calculated biomass and numbers of individuals are as accurate as possible, and to avoid fish from earlier hauls contaminating later samples. The problem of fish being trapped between trawl meshes is greatest at stations with a lot of 0-group capelin. The part of the catch that falls to the deck, usually in poor condition, is collected and processed separately. The sample from the deck is identified to species and weighed per species. The weight of the deck sample is added to the rest of the sample on a species basis to give the total sample weight for each species.

Catch processing in the fish laboratory starts with all jellyfish and larger fish (such as lumpfish) being sorted out to make the rest easier to handle. Jellyfish and larger fish are weighed separately. Sometimes it is necessary to remove excess of water so that the sample weight is affected as little as possible by the water. In the case of large catches, a sub-sample is taken. When sub-sampling, a conversion factor is used to calculate the total weight of all groups in the catch. A factor is calculated as the total weight divided by the sub-sample weight. The samples from the trawl are processed immediately after the catch is removed from the trawl. 0-group fish of different species, as well as other components of the catch (e.g. krill and pelagically distributed small non-commercial fishes), are sorted into groups that are weighed separately. The total weight of the catch is determined as the sum weight of the components. The extra variance introduced by subsampling has not been studied formally but is believed to be low compared to the high variance associated with the trawl samples of 0-group fish.

The 0-group fish are determined to the species level, while some of the small non-commercial species (families Agonidae, Stichaeidae, Cottidae and Myctophidae) could be determined to genus or family level (due to taxonomic difficulties, available expertise, and time constraint). Before 2014, 100 individuals of each species/group (if available) were weighed and separately length measured (to nearest mm on Norwegian and 0.5 mm on Russian vessels). The length sample weight and total catch weight are used to calculate the total number of fish caught. From 2014, the number of fish that were length measured was reduced to 30 individuals (based on statistical considerations described in Pennington and Helle, 2013).

3 - Calculation of abundance indices and quality control of databases

Various ways of calculating abundance indices have been used during the history of the survey. In the early years of the survey, from 1965, the echo abundance was subjectively evaluated from the paper recordings (echograms) on a scale from 0 to 4 (0 - no recording, 1 - very scattered, 2 - scattered, 3 - dense, 4 - very dense). This information was then used during the first 6 years (1965-1970) to classify year-class strength as poor, average, or strong by expert judgement (Dragesund et al. 2008).

3.1 - Area index

The acoustic information was subsequently used to construct a quantitative (or semi-quantitative) abundance index, the so-called ***area index*** (Haug and Nakken 1977). Maps of distribution of various 0-group species had been prepared for the annual reports based on the 0 - 4 scale visual grading of paper echograms, guided by results on the 0-group fish counts in the supporting trawl hauls. Classification of the acoustic records was done for every nautical mile sailed along survey lines, with three density grades used to plot the results onto maps: absent, scattered, and dense (Dragesund et al. 2008). Haug and Nakken (1977) established empirical relationships between trawl catches and the 4 density grades (very scattered, scattered, dense, very dense). They noted some inconsistencies in the grading between vessels and years, and established criteria in terms of number of fishes per haul to help standardize the distinction between scattered and dense records of 0-group fish of four species (cod, capelin, redfish, and polar cod).

Haug and Nakken (1977) used the criteria to draw new distribution maps for the four species of 0-group fish for the years 1965-1972. The area index was calculated as the sum of the integrated area on the map with low abundance (scattered), plus the area with high abundance (dense) multiplied by factor 10. This factor was an approximation based on the empirical data (Haug and Nakken 1977). The area index was calculated for six species (cod, capelin, haddock, redfish, polar cod, and long rough dab) for the years 1965-1972. Average index values were used to reclassify year-class strength in each year in this (relatively short) period as average, poor, or strong (Haug and Nakken 1977).

The area index was calculated in subsequent years as one of two methods (the other was the logarithmic index; see below) used to produce time series from the 0-group survey (Dragesund et al. 2008). It became apparent that the area index had shown an increasing trend from 1965 until the early 1990s. Nakken and Raknes (1996) provided a correction to the area index time series by assuming that capture efficiency had increased proportional to the size of the trawls (trawl opening ("mouth") area) used in the survey. They used the arithmetic mean trawl opening for the survey participating vessels (and trawls) each year, which they considered a rough approximation since differences in geography and catches among the vessels were not taken into account (which would have required much work). The correction represented more than a doubling of the area index values between 1970 and 1984 (Nakken and Raknes 1996). Nakken and Raknes (1996) also attempted an alternative method for correction, using the trend in the sum of index values for cod, haddock and redfish as an expression for the trend in overall capture efficiency. However, this depended strongly on an increasing trend for redfish, and it was uncertain how much of this increase was due to increased capture efficiency.

The corrected area index time series was updated annually and reported in the annual report from the 0-group survey to ICES. Nakken and Raknes (1996) provided corrections for cod, haddock, and redfish. Subsequently, similar corrections were made for Greenland halibut, long rough dab, and polar cod. The area index for herring was calculated by Toresen (1985) for the period 1965-1984. Dragesund et al. (2008) provided a graphical representation (in their Fig. 6.6, page 127) of the area indices for the 1965-2000 period for 7 species of 0-group fish (cod, haddock, herring, redfish, capelin, and polar cod,) (based on ICES 2003).

3.2 - Logarithmic index

The logarithmic index was developed by Randa (1984). The catch in numbers of 0-group fish at each station was log-transformed (natural logarithm, ln), and mean densities (catch rates per nautical mile) were calculated for 17 strata (geographical areas) of the 0-group survey area in the Barents Sea. The overall abundance index for a species was then calculated as the area-weighted mean logarithmic abundance, adjusted for the proportion of hauls with no catch. The method is based on the log-normal theory, and it allows confidence intervals to be calculated based on normal theory (Randa 1984). Randa (1982) showed that log-transformation normalized the catch data for 0-group cod (for the 1965-1979 period).

Randa (1984) took into account the different trawls used in the early years of the joint 0-group survey by estimating ‘relative fishing power’ (relative to R/V “G.O. Sars”, 1971-1979) for each of the participating vessels.

The logarithmic index was calculated by Randa (1984) for cod and haddock, and by Toresen (1985) for herring. These indices were updated and included in the annual reports to ICES from the joint 0-group survey.

The logarithmic index was further developed as one of two alternative indices by Dingsør (2005; the other was an arithmetic index based on stratified sample mean; see below), which he called the ‘Pennington estimator’ (Pennington 1996). While the 0-group data largely follow a log-normal distribution, they usually have many low values close to zero which may bias log-normal-based estimators. A cut level for low values (set at 20 % of the average abundance density in each stratum) was used to reduce the bias from low values and achieve better fit to log-normal distribution for the remaining values above the cut level (Folmer and Pennington 2000). Dingsør (2005) calculated time series of the logarithmic ‘Pennington estimator’ (with standard errors) for cod, haddock, capelin, redfish, and herring for the years 1980-2002. The index was calculated both with and without correction for capture efficiency (see section ‘Capture efficiency’) for cod and haddock. Dingsør (2005) compared the ‘Pennington estimator’ index with the old area index and the previous logarithmic index. He found similar trends but also some discrepancies, notably for some of the species in the 1980s (see Figs 4 and 5 in Dingsør 2005).

Dingsør (2005) recommended using the ‘Pennington estimator’ as the most appropriate method and new standard for presenting 0-group abundance indices in the Barents Sea. However, the arithmetic abundance index based on the ‘stratified sample mean’ method turned out to be the preferred index for routine use. With the start of the joint ecosystem survey (where the 0-group survey became an integral part) in 2004, the arithmetic (total abundance) index was used, and the logarithmic index was no longer calculated after 2004.

3.3 - Total abundance indices

At the transition to the joint ecosystem survey in 2004, a new abundance index was developed by Gjert E. Dingsør and Dmitry Prozorkevich and used for the 0-group results from the survey in 2004 (Anon. 2005, Dingsør 2005). The index was based on a ***stratified sample mean estimator***, reflecting the mean areal density of 0-group fish in the survey area. The density of fish in length groups (number of fish per nm^2) was calculated for each trawl station, and mean density was calculated for each of 23 strata of the total survey area of the Barents Sea (Fig. 3; Dingsør (2005) used a division into only 4 larger strata). The stratified sample mean estimator of abundance was then calculated as the overall mean density of 0-group fish, by weighting the strata means by the proportion of the survey area in each stratum. The area covered with survey stations within each stratum was determined using GIS software.

The 23 0-group strata were combined into larger areas (north-western, northern, western, central, eastern and coastal; Fig. 3) used in Eriksen at al. 2009, 2011, 2012, and 2014. Later, in the project TIBIA, the Barents Sea was divided into 15 subareas (polygons, see Fig. 1). The division is based on topography and oceanography and is a modification (with some subdivision) of the system used by Eriksen et al. (2017) in a summary analysis of distribution of pelagic biomasses in the Barents Sea. At the ICES WGIBAR meeting in 2018 (ICES WGIBAR 2018), the division of the Barents Sea into 15 polygons was presented and adopted for use in reporting status and changes in the ecosystem.

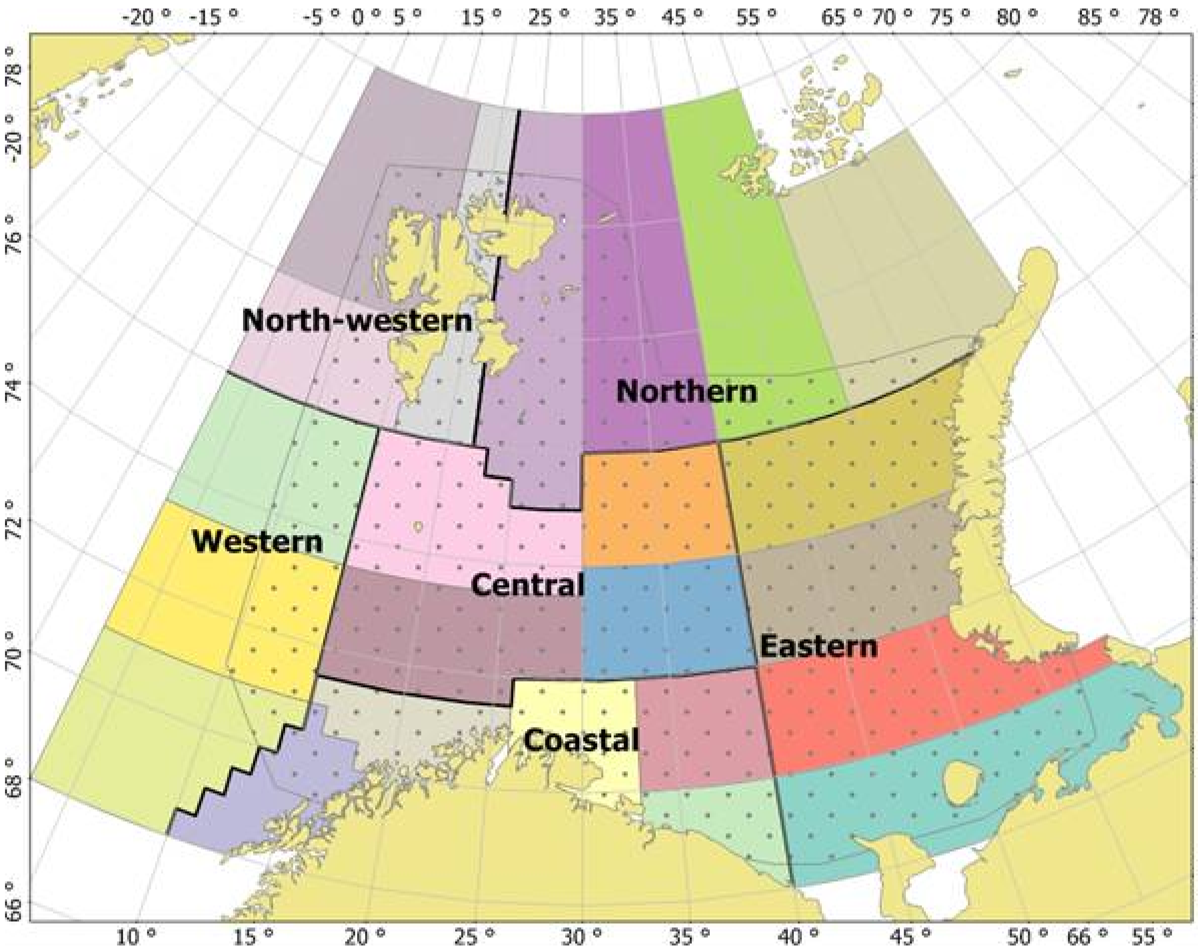


Figure 3. The Barents Sea 0-group strata system, consisting of 23 strata shown in different colours. 0-group survey coverage area is shown by dots at 0-group strata system. The 23 strata have been used for compilation of data in Barents Sea fish stock assessments.

The stratified sample mean estimator was expressed as a ***total abundance index*** by using the total area covered in the survey (sum of polygon mean density of fish, per nm^2, multiplied by polygons coverage in nm^2). The total abundance index was calculated both without and with length correction for low capture efficiency for small fish (see section ‘Capture efficiency’). These two sets of indices (corrected and non-corrected) were calculated back to 1980 for capelin, cod, haddock, herring, saithe, and polar cod, as were uncorrected values for redfish, Greenland halibut, and long rough dab (Tables 2.2 and 2.3 in Anon. 2005). The new total abundance index is calculated with variance and confidence intervals based on the variation in 0-group abundance among sampling stations. At the time it was agreed that the new total abundance index without correction would be the ‘official’ one, while the corrected index was ‘additional’.

Dingsør (2005) showed that the stratified sample mean estimator corresponded closely to the log-normal based 'Pennington estimator', with both showing similar temporal patterns from 1980 to 2002 (for cod, haddock, capelin, herring and redfish; see his Table 2).

The total abundance index was used for 0-group data for the next years of the ecosystem survey with some adjustments of the time series (in 2005 and 2007). The former logarithmic index was discontinued in 2005, while the old area index former reported in parallel to the new set of indices (total abundance, corrected and uncorrected) until (and including) 2007 when it also was discontinued.

An 'overhaul' of the total abundance index was done in 2009. It had become apparent that there were many mistakes and errors in the data (e.g., punching errors when data were transferred from paper sampling sheets to the computer), and inconsistencies between the data held in data bases of the two institutions conducting the surveys (IMR and PINRO). A major effort was therefore made over a three-year period to check the quality of the data, using cruise logbooks and original data records dating back to 1980.

New sets of total abundance indices based on the quality assured data were calculated and reported by Eriksen et al. (2009). This work included indices corrected for capture efficiency and uncorrected indices for cod, haddock, capelin, herring, saithe, and polar cod, and uncorrected indices for redfish, Greenland halibut, and long rough dab, from 1980 onwards (see Table 2 in Eriksen et al. 2009). The corrections were from slight to substantial in some cases (species and years). However, the broad temporal patterns and trends in 0-group year-class strength did not change much, reflecting that the amplitude of changes in abundance was generally much larger than the corrections (Eriksen et al. 2009). The estimation was carried out in SAS software and the indices of fish abundance for the 0-group are presented in part 9.1.

Eriksen et al. (2009) showed that the revised set of total abundance indices were positively correlated with the old area index for cod, haddock, capelin, and herring (r = 0.80-0.89). The abundance indices were also positively correlated with estimated abundances of the year classes as 1-group for capelin (r = 0.81-0.82), and 3-year old for haddock (r = 0.43-0.49).

Abundance and biomass estimates were calculated by different software during the last four decades: SAS (for the new 23 fisheries subareas, 1980-2017, 0-group strata and WGIBAR polygons) and MatLab (for the new 15 WGIBAR- polygons (for the period between 1980 and 2018, ICES WGIBAR 2018) and R (for the new 15 WGIBAR-subareas (2003-202 3). Due to software upgrading (which led to challenges with script running in SAS) and personal resource limitation (MatLab), it was decided to develop R-scripts (R core Team, 2023) for estimation of abundance and biomass indices. Two data sets (abundance and biomass indices calculated by R and SAS) were analyzed for similarities and were found to be highly significantly correlated (for capelin r=0.95, cod r=0.99, haddock r=0.94, herring r=0.98 and polar cod r=0.94).

During development of R scripts for abundance and biomass estimation, some errors in the IMR database were detected, that most likely occurred when all historical data were converted from an old to the new "Biotic" format. Apparently, some algorithms failed, which created duplicate rows of existing fish observations and recalculated total weight or abundance. A new quality check was carried out on the data in the new data format, which was corrected back to 2004. The older data (1980-2003) in the IMR database. have not been checked and corrected, and it is uncertain how many errors there are in this part. We note that the data compiled and used in this report were extracted from the database at an earlier stage and are not affected by these errors.

The last "official" updated time series of the abundance and biomass of the 0-group fish are reported in the BESS report 2023 (available at https://www.hi.no/hi/nettrapporter/imr-pinro-en-2024-2) and in Part 9.4 of this report.

4 - Capture efficiency

Small juvenile fish, especially herring, pass through the meshes of the first panels of the Harstad trawl. This gives a low capture efficiency of the trawl when catch is referenced to the mouth opening of the trawl (Godø et al. 1993). The effect is inevitable due to the low maximum swimming speed of small 0-group fish relative to the mesh size and speed of the trawl. This was clearly demonstrated in experiments in the early 1990s, comparing catches of 0-group fish in the standard trawl with catches obtained with a specially designed 0-group trawl with finer meshes (Godø et al. 1993, Hylen et al. 1995).

The experimental trawl was smaller with mouth opening of 30 m^2 (compared to 300 m^2 for the standard trawl for a specific configuration of 20 m x 15 m), and mesh size decreased from 200 mm in the front panel to 10 mm in the cod end (Godø et al. 1993, Valdemarsen and Misund 1995). Experiments comparing the standard trawl and the experimental trawl were done in the Barents Sea in August 1991 (Godø et al. 1993), and during the 0-group survey in August/September 1992 and 1993 (Hylen et al. 1995). Both studies gave consistent results, with sampling efficiency (comparing density of 0-group fish in numbers per nm^2) around 3-4 times higher for the experimental trawl compared to the standard trawl for 0-group cod and haddock. Furthermore, there was a clear size selection, where juveniles smaller than 5 cm were captured to very low extent with the standard trawl (Godø et al. 1993). The capture efficiency was strongly size-dependent, increasing from around 10 % for 5 cm long juveniles to nearly 100 % for 10-cm long fish for the standard trawl relative to the experimental trawl (Hylen et al. 1995). For even larger juveniles (>10 cm), there were evidence that they were more effectively captured with the standard trawl, suggesting that they were either herded into the larger trawl or having some avoidance of the smaller experimental trawl (Godø et al. 1993, Hylen et al. 1995).

In addition to a size effect, Hylen et al. (1995) found indication of a considerable effect of density of 0-group fish on capture efficiency. Using acoustic recordings as reference, they found a clear and significant positive effect of fish density (as reflected in trawl catches) on capture efficiency (trawl catch relative to acoustically recorded density). Hylen et al. (1995) explained this relationship by density-dependent herding, with increasing degree of herding (either in front of or inside the trawl) with increasing density of fish.

Mamylov (1999) developed a theoretic model of capture efficiency by trawl. The model assumed that the lowest capture efficiency for small fish (4.5 cm and 12.5cm) was equal to the ratio between the cross-sectional area of the cod-end and the mouth opening of the trawl, which he set at 0.1, corresponding to a maximum correction factor of 10. He assumed the capture efficiency of large 0-group fish was equal to 1, i.e. all fish that passed the mouth opening were collected in the cod-end. The equation is Keff = 31.177*exp (-0.2708*L) and illustrated graphically in Figure 4.

Later, PINRO carried out several investigations, and of 1205 analysed trawl catches, 131 trawl catches were selected in which mainly one species was present (Mamylov 2004, Prozorkevich 2010, 2012). The trawl catches in terms of numbers and size of 0-group fish were converted (using target strength relationship) and expressed in units of acoustic backscattering. The acoustic data were scrutinized, and selected portions of the data were regressed against the trawl data expressed in the same units. The equations give very high factors for fish smaller than 4 cm (because of linear extrapolation), and therefore the maximum Keff (gadoids=8, herring =30 and capelin =4) was used for these small fish. The results from these experiments were close to the theoretical model, but they varied between species.

The correction curve for herring is very different, being much steeper than the lines for gadoids and capelin shown in Figure 4. For juvenile herring <6 cm long, the correction factor is higher than 10 (30 at 4 cm length), which is a theoretical maximum. For juvenile herring >10 cm, the correction factor is <1, corresponding to capture efficiency >1 (>100 %). This would imply active herding by doors and bridles in front of the trawl. While this cannot be ruled out, the very low capture efficiency in the low end, and the high capture efficiency in the high end, suggest that the steepness of the herring curve may be an artefact.

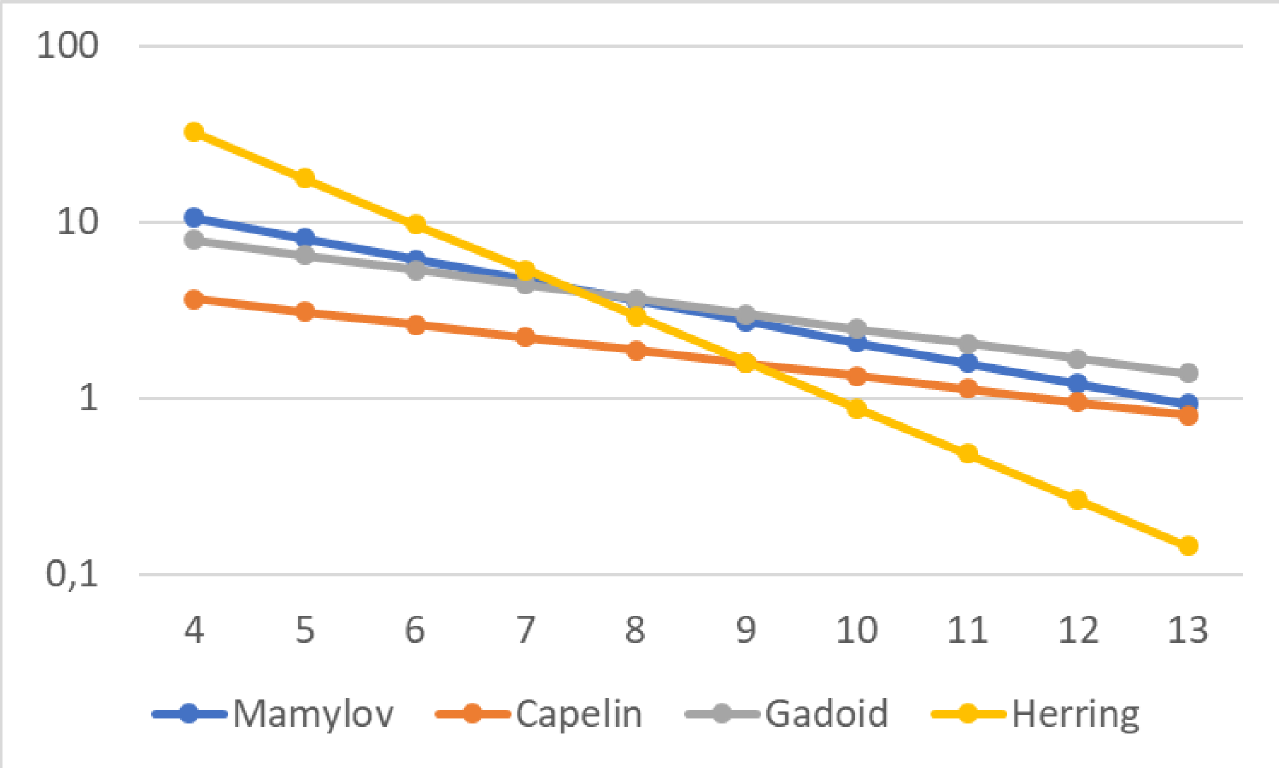


*Figure 4. Correction factors (Keff) for capture efficiency as a function of length (L in cm) of 0-group fish on log scale. The equation from theoretic model is Keff = 31.177*exp(-0.2708*L) (Mamylov 1999). The equations for capelin (Keff = 7.2075*exp(-0.1688*L), gadoids (Keff = 17.065*exp(-0.1932*L), and herring (Keff = 357.23*exp(-0.6007*L) are from Prozorkevich (2012).*

HG: Det er kanskje betre å kalle "Mamylov" for "theoretical model" brukt i teksten. Jeg synes det er ok å bruke Mamylov.

Hylen et al. (1995) provided similar empirical relationships for capture efficiency and correction factors for cod and haddock, using the experimental trawl as a reference for the catches obtained with the standard trawl. The relations from Hylen et al. (1995) have been plotted in Figure 5 using equations (2 and 3) from Dingsør (2005). The lines for cod and haddock are curvilinear on this log-scale plot because the equation is of a different form (declines exponentially to 1 rather than to zero). Apart from this, the line for cod from Hylen et al. (1995) is very similar to the Mamylov line. The haddock line is also close to the Mamylov line for fish in the size range from 8.5 to 13 cm. The haddock line swings upwards at low fish length, to values over 10 for fish <7 cm; again, this is possibly an artefact due to large variation in the underlying data (see Hylen et al. 1995, their tables 3 and 6).

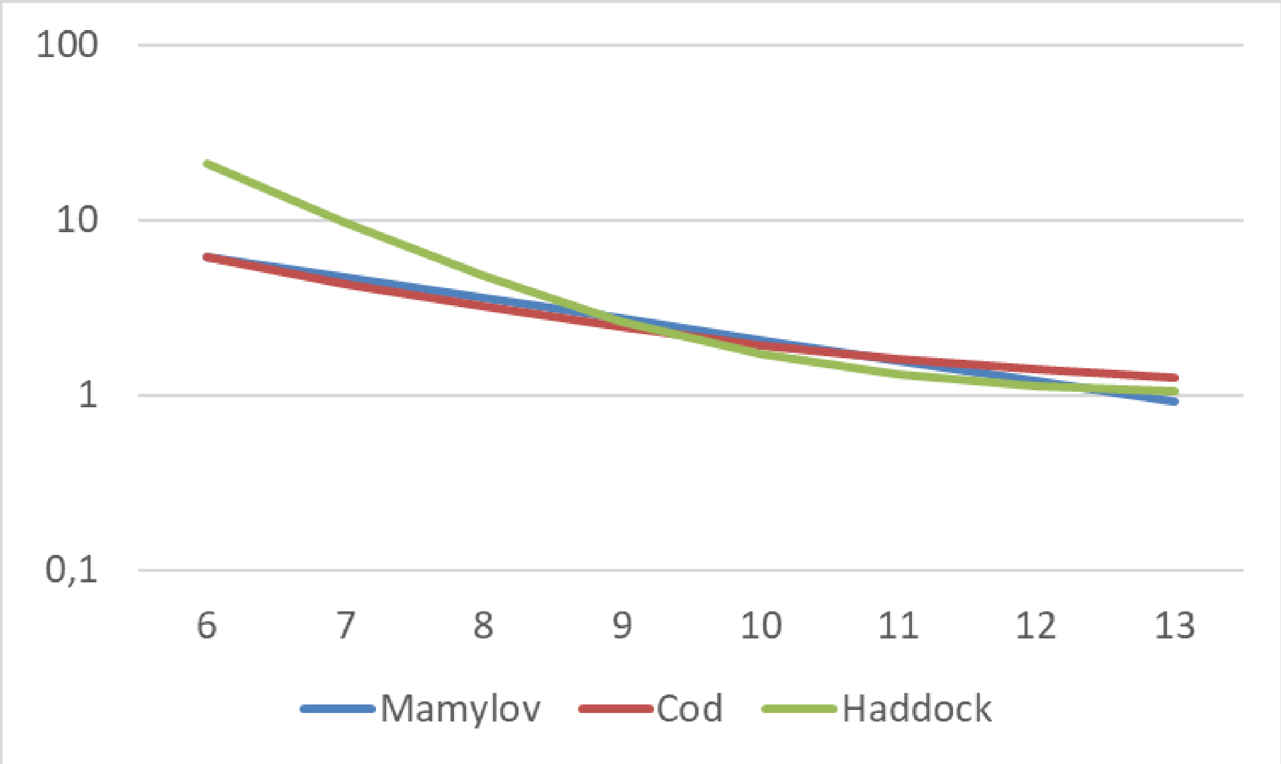


*Figure 5. Correction factors (Keff) for capture efficiency as a function of length (L - cm) of 0-group cod and haddock from Hylen et al. (1995) with equations from Dingsør (2005): cod - Keff = 1 + exp(4.158-0.422*L), haddock - Keff = 1 + exp(8.031-0.838*L). The relation from Mamylov (2004) is the same as in Figure 4.*

The correction factors for gadoids, capelin and herring in Fig. 4 were used to correct the total abundance indices from the 0-group survey by Dingsør (2005) and Eriksen et al. (2009). Corrections were done for cod, haddock, saithe, and polar cod using the equation for gadoids, and for capelin and herring with their respective equations. The time series of abundance of 0-group fish of redfish, Greenland halibut, and long rough dab were not corrected, and uncorrected indices were used by Eriksen et al. (2009). The corrected abundance time series were used by Eriksen et al. (2011, 2017) where abundance was converted to biomass of 0-group fish.

In 2013-2016, several experiments were performed to study escapement of 0-group fish through the trawl panels and clogging of 0-group fish (BESS reports for 2013-2016, available at https://www.hi.no/hi/nettrapporter?y=2024&query=&serie=imr-pinro&fast_serie=) with the aim to develop a new 0-group fish trawl. The trawl is designed to obtain constant trawl geometry independent of warp length and to obtain reduced clogging and escapement compared to the standard Harstad trawl. Unfortunately, the newly developed 0-group trawl with fine inner nets and constant opening was too heavy to be towed by the old Russian vessel. It was therefore decided that, for the time being, the Harstad trawl would be used as the standard trawl on all vessels participating in the BESS.

5 - Vertical distribution

The timing and general design of the 0-group fish survey is to allow sampling of the 0-group part of populations of the different species while they still are in the upper pelagic zone. The early studies that used acoustic recordings, showed that the 0-group fishes were generally distributed in the upper 60 m water layer in early autumn, where they are feeding on zooplankton. This observation was the basis for the standard trawling procedure with three steps covering the 0-60 m depth interval (Fig. 2). The procedure is also to include one or two additional deeper steps (to 80 or 100 m) if the acoustic records show deeper distribution of 0-group fish.

There is little information in the literature about when cod change from pelagic life-stage to a demersal life-stage in the Barents Sea. Several studies from other areas have shown that there is no clear relationship between fish age (in days) and fish length (in mm), and that fish of similar length settle at different times (Hussy et al. 2003; Anon. 2009). Boitsov et al. (1996) found that the transition (settlement) is a rather long process that occurs in September-October in the Spitsbergen area and in October-November in the southern Barents Sea. The settlement of cod and their food items occurs gradually and it is likely to be connected with a convection mixing of water layers and deepening of the thermocline layer (Ozhigin et al. 1999). It is assumed that haddock follows a similar pattern to cod, with the transition occurring gradually during the autumn (Dingsør 2005; Anon. 2006, 2009).

When the 0-group survey became a part of the ecosystem survey (in 2004), bottom trawl samples were also taken. Some 0-group cod were collected by the bottom trawl indicating most likely cod settlement, although ‘contamination’ by 0-group cod from the water column when the bottom trawl was retrieved may also have contributed to the catch. The data indicated varied settlement pattern between years and areas. Prozorkevich and Eriksen (2013) examined 0-group cod distribution based on pelagic and bottom trawl for the years 2005-2012 (Figure 6). They found that numbers of cod taken by demersal trawl were generally low, varying between 0.2 and 1.1%, suggesting that the settled part of the 0-group of cod population is too small to influence 0-group abundance indices markedly. The study suggested that there was no strong relationship between fish settlement and year class strength. However, during some of the most recent years, 0-group fish, notably cod, haddock and capelin, were found to be abundant in the 100-150 m depth layer possibly reflecting early descent from the upper pelagic layer.

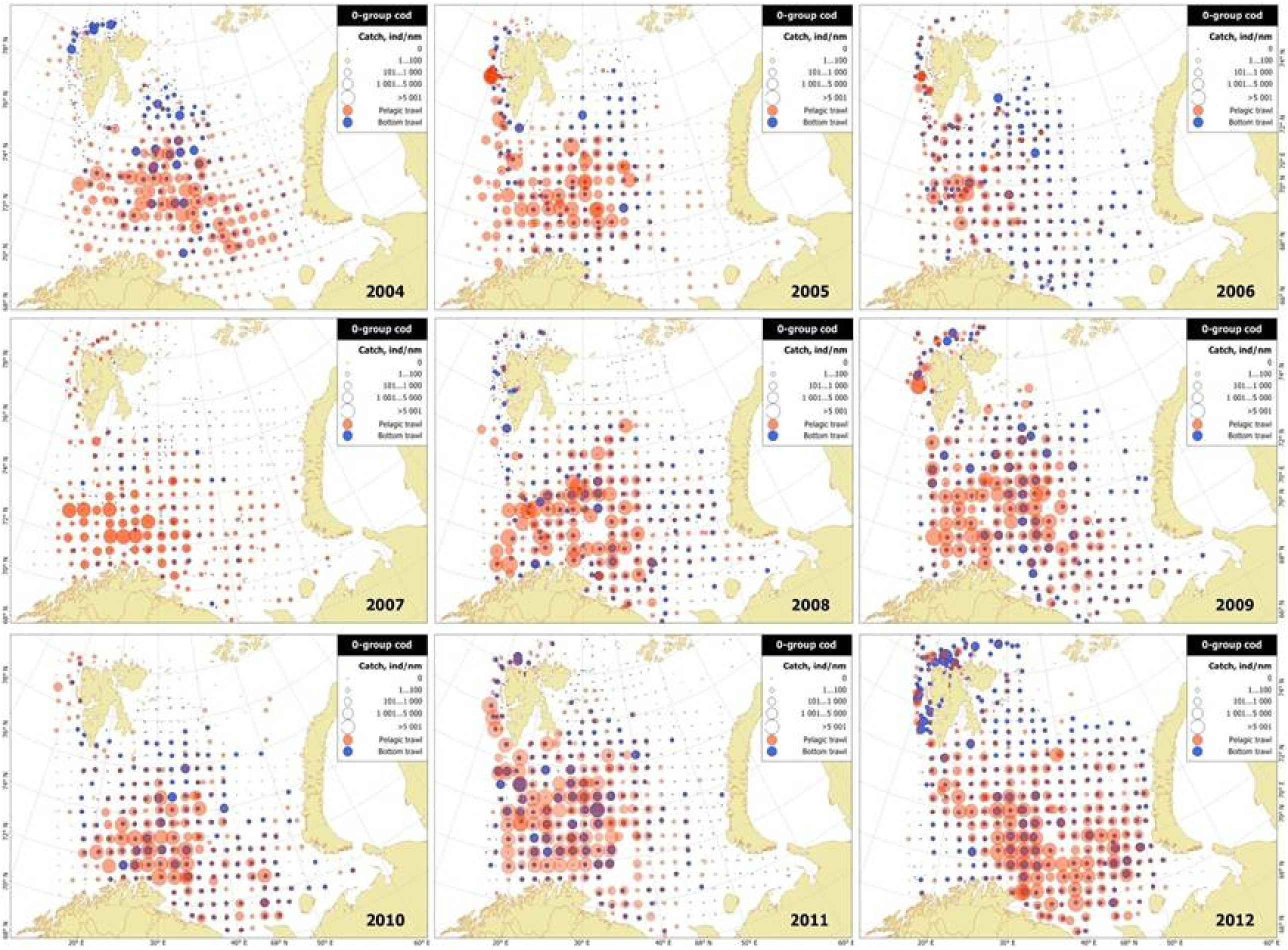


Figure 6. 0-group catches of cod taken by pelagic (red) and bottom (blue) trawl in 2005-2012. Higher demersal records than pelagic records at ecosystem survey stations may indicate cod settlement (Figure 4 in Prozorkevich and Eriksen 2013).

6 - Survey area and coverage

0-group fish of the different commercial species, taken together, occupy much of the area of the Barents Sea. Capelin and cod are most widely distributed, haddock and redfish are distributed mainly in the western and central areas, herring in the southern, central and western areas, while polar cod is distributed in the eastern and northern Barents Sea (see maps in Part 7).

The survey area has included the western, southern, and central Barents Sea during the whole survey period. The survey has been operated with 4-6 research vessels each year (Table 1). The vessels have covered different parts of the surveyed area, and cruise lines with sampling stations have been planned so that sampling effort is spread out more or less evenly over the survey area. One reason for this is the aim to monitor distribution and abundance of 0-group fish of several species that have different distribution patterns. The 0-group investigations have also been integrated with other survey elements, into what was called multi-species surveys from the late 1980s, and ecosystem survey from 2004 (Eriksen et al. 2018). Due to the many different purposes of the cruises, a stratified sampling design with higher effort in core areas of 0-group distribution and lower effort elsewhere, has not been used. The distance between trawl stations was about 30 miles until 1994 and 35 miles thereafter (Eriksen et al. 2018).

Table 1. Overview of participating vessels and dates for the annual 0-group surveys in the Barents Sea, 1965-2023. Note that the north-eastern-most part of the Barents Sea (polygons Franz-Josef Land and St. Anna Trough, see Fig. 1) have never been covered. For area covered each year, see maps in section 7.

Year	Vessel name	Start of the survey	End of the survey
1965	Akademik Knipovich	03.09	17.09
1965	Jastreb	03.09	17.09
1965	Johan Hjort	03.09	17.09
1965	G.O. Sars	03.09	17.09
1966	Akademik Knipovich	27.08	10.09
1966	Fridtjof Nansen	27.08	10.09
1966	Johan Hjort	27.08	10.09
1966	G.O. Sars	27.08	10.09
1966	Ernest Holt	27.08	10.09
1967	Akademik Knipovich	24.08	09.09
1967	Fridtjof Nansen	24.08	09.09
1967	Johan Hjort	24.08	09.09
1967	G.O. Sars	24.08	09.09
1967	Ernest Holt	24.08	09.09
1968	Akademik Knipovich	25.08	09.09
1968	Fridtjof Nansen	25.08	09.09
1968	Johan Hjort	25.08	09.09
1968	G.O. Sars	25.08	09.09
1968	Ernest Holt	25.08	09.09
1969	Akademik Knipovich	24.08	07.09

1969	Fridtjof Nansen	24.08	07.09
1969	Johan Hjort	24.08	07.09
1969	G.O. Sars	24.08	07.09
1969	Ernest Holt	24.08	07.09
1970	Akademik Knipovich	23.08	11.09
1970	Fridtjof Nansen	23.08	11.09
1970	Johan Hjort	23.08	11.09
1970	G.O. Sars	23.08	11.09
1971	Akademik Knipovich	20.08	11.09
1971	Fridtjof Nansen	20.08	11.09
1971	G.O. Sars	20.08	11.09
1971	Johan Hjort	20.08	11.09
1971	Cirolana	20.08	11.09
1972	Akademik Knipovich	26.08	10.09
1972	Fridtjof Nansen	26.08	10.09
1972	Poisk	26.08	10.09
1972	Johan Hjort	26.08	10.09
1972	G.O. Sars	26.08	10.09
1973	Fridtjof Nansen	26.08	12.09
1973	Poisk	26.08	12.09
1973	Johan Hjort	26.08	12.09
1973	G.O. Sars	26.08	12.09
1973	Cirolana	26.08	12.09
1974	Akademik Knipovich	27.08	12.09
1974	Poisk	27.08	12.09
1974	G.O. Sars	27.08	12.09
1974	Havdrøn	27.08	12.09
1974	Cirolana	27.08	12.09
1975	Fridtjof Nansen	25.08	07.09
1975	Poisk	25.08	07.09
1975	Johan Hjort	25.08	07.09
1975	G.O. Sars	25.08	07.09
1975	Cirolana	25.08	07.09
1976	Odissey	25.08	07.09
1976	Fridtjof Nansen	25.08	07.09
1976	Johan Hjort	25.08	07.09
1976	G.O. Sars	25.08	07.09

1976	Cirolana	25.08	07.09
1977	G.O. Sars	22.08	11.09
1977	Johan Hjort	20.08	11.09
1977	Odissey	31.08	11.09
1977	Fridtjof Nansen	26.08	11.09
1977	Poisk	25.08	11.09
1978	G.O. Sars	25.08	10.09
1978	Johan Hjort	20.08	10.09
1978	Poisk	25.08	10.09
1978	Fridtjof Nansen	25.08	08.09
1979	Johan Hjort	26.08	14.09
1979	G.O. Sars	19.08	14.09
1979	Poisk	29.08	14.09
1979	Akhill	01.09	03.09
1980	Johan Hjort	16.08	07.09
1980	G.O. Sars	16.08	07.09
1980	Michael Sars	16.08	08.09
1980	Poisk	22.08	08.09
1981	Johan Hjort	21.08	05.09
1981	G.O. Sars	14.08	04.09
1981	Michael Sars	12.08	04.09
1981	Persey III	22.08	06.09
1981	Akhill	23.08	01.09
1982	Johan Hjort	18.08	05.09
1982	G.O. Sars	18.08	05.09
1982	Michael Sars	21.08	11.09
1982	Persey III	31.08	05.09
1982	Poisk	23.08	05.09
1982	Protsion	28.08	30.08
1982	Protsion	11.09	14.09
1983	Eldjarn	21.08	08.09
1983	G.O. Sars	21.08	05.09
1983	Michael Sars	21.08	05.09
1983	Persey III	22.08	05.09
1983	Poisk	24.08	03.09
1983	Alaid	20.08	26.08
1984	Eldjarn	12.08	05.09

1984	G.O. Sars	19.08	03.09
1984	Håkon Mosby	19.08	05.09
1984	Persey III	20.08	30.08
1984	Poisk	26.08	29.08
1984	Alaid	20.08	27.08
1984	Kokshaysk	27.08	02.09
1985	Eldjarn	19.08	04.09
1985	G.O. Sars	19.08	03.09
1985	Håkon Mosby	20.08	02.09
1985	Michael Sars	17.08	19.08
1985	Kokshaysk	23.08	02.09
1985	Vilnyus	25.08	01.09
1986	Eldjarn	20.08	04.09
1986	G.O. Sars	11.08	04.09
1986	Håkon Mosby	20.08	03.09
1986	Kokshaysk	21.08	01.09
1986	Vilnyus	20.08	02.09
1987	Eldjarn	17.08	03.09
1987	G.O. Sars	17.08	03.09
1987	Håkon Mosby	20.08	03.09
1987	Artemida	18.08	28.08
1987	Vilnyus	20.08	01.09
1988	Eldjarn	22.08	06.09
1988	G.O. Sars	22.08	07.09
1988	Håkon Mosby	20.08	03.09
1988	Artemida	21.08	02.09
1988	Professor Marty	26.08	04.09
1989	Eldjarn	22.08	11.09
1989	G.O. Sars	21.08	11.09
1989	Michael Sars	22.08	11.09
1989	Professor Marty	20.08	08.09
1989	PINRO	20.08	09.09
1990	Eldjarn	21.08	05.09
1990	G.O. Sars	21.08	05.09
1990	Michael Sars	16.08	05.09
1990	Professor Marty	16.08	04.09
1990	PINRO	20.08	04.09

1991	Johan Hjort	08.08	09.09
1991	G.O. Sars	19.08	09.09
1991	Michael Sars	15.08	09.09
1991	Professor Marty	15.08	06.09
1991	Fridtjof Nansen	18.08	06.09
1992	Johan Hjort	17.08	03.09
1992	G.O. Sars	18.08	07.09
1992	Michael Sars	13.08	07.09
1992	Professor Marty	17.08	28.08
1992	Fridtjof Nansen	24.08	05.09
1992	Akhill	13.08	15.08
1992	Akhill	05.09	06.09
1993	Johan Hjort	16.08	08.09
1993	G.O. Sars	17.08	07.09
1993	Professor Marty	22.08	08.09
1993	PINRO	23.08	06.09
1994	Michael Sars	16.08	20.08
1994	Johan Hjort	17.08	06.09
1994	G.O. Sars	20.08	07.09
1994	Professor Marty	02.09	08.09
1994	Atlantida	24.08	08.09
1994	Fridtjof Nansen	27.08	08.09
1995	Michael Sars	22.08	09.09
1995	Johan Hjort	25.08	10.09
1995	G.O. Sars	16.08	10.09
1995	Professor Marty	05.09	11.09
1995	Fridtjof Nansen	26.08	11.09
1996	Michael Sars	22.08	10.09
1996	Johan Hjort	24.08	10.09
1996	G.O. Sars	17.08	10.09
1996	Atlantida	15.08	10.09
1996	Persey III	24.08	10.09
1997	Johan Hjort	20.08	08.09
1997	G.O. Sars	19.08	08.09
1997	Atlantida	21.08	06.09
1997	Persey III	15.08	06.09
1998	Fridtjof Nansen	19.08	05.09

1998	Atlantida	08.08	03.09
1998	G.O. Sars	26.08	07.09
1998	Johan Hjort	25.08	08.09
1998	M. Sars	25.08	04.09
1999	Atlantniro	15.08	02.09
1999	G.O. Sars	27.08	06.09
1999	Johan Hjort	22.08	07.09
1999	Persey 4	22.08	03.09
2000	Atlantniro	22.08	01.09
2000	Fridtjof Nansen	19.08	03.09
2000	G.O. Sars	20.08	03.09
2000	Johan Hjort	18.08	07.09
2001	G.O. Sars	16.06	08.09
2001	Johan Hjort	20.08	08.09
2001	Atlantniro	10.08	03.09
2001	Fridtjof Nansen	12.08	03.09
2002	G.O. Sars	16.06	08.09
2002	Johan Hjort	24.08	08.09
2002	Atlantniro	10.08	08.09
2002	Fridtjof Nansen	29.08	08.09
2003	Johan Hjort	05.08	02.10
2003	G.O. Sars	27.07	01.09
2003	Jan Mayen	01.09	16.09
2003	Tsivilsk	07.09	02.10
2003	Smolensk	25.08	02.10
2004	Jan Mayen	04.08	01.10
2004	Johan Hjort	01.08	04.10
2004	Smolensk	06.08	02.10
2004	Fridtjof Nansen	07.08	02.10
2005	G.O. Sars	06.08	30.09
2005	Johan Hjort	01.08	08.09
2005	Jan Mayen	04.08	04.09
2005	Smolensk	09.08	26.09
2005	Fridtjof Nansen	17.08	26.09
2006	G.O. Sars	18.08	28.09
2006	Johan Hjort	14.08	20.09
2006	Jan Mayen	08.08	17.08

2006	Jan Mayen	11.09	29.09
2006	Smolensk	16.08	29.09
2006	Fridtjof Nansen	11.08	05.10
2007	G.O. Sars	14.08	30.09
2007	Johan Hjort	01.08	31.08
2007	Johan Hjort	14.09	26.09
2007	Jan Mayen	10.09	27.09
2007	Smolensk	07.08	28.09
2007	Vilnyus	06.08	23.09
2008	G.O. Sars	19.08	30.09
2008	Johan Hjort	01.09	16.09
2008	Jan Mayen	08.09	24.09
2008	Vilnus	08.08	26.09
2008	Atlantic star	01.08	10.08
2009	G.O. Sars	20.08	05.09
2009	Johan Hjort	23.08	03.09
2009	Jan Mayen	10.09	27.09
2009	Vilnus	07.08	29.09
2010	G.O. Sars	24.08	11.09
2010	Johan Hjort	29.08	22.09
2010	Helmar Hanssen	26.08	12.09
2010	Vilnus	14.08	21.09
2011	Chriastine E.	27.08	17.09
2011	Johan Hjort	31.08	05.10
2011	Helmar Hanssen	09.08	24.08
2011	Vilnus	11.08	02.10
2012	G.O. Sars	18.08	12.09
2012	Johan Hjort	16.08	30.09
2012	Helmar Hanssen	06.08	05.09
2012	Vilnus	08.08	29.09
2013	G.O. Sars	23.08	19.09
2013	Johan Hjort	04.08	01.10
2013	Helmar Hanssen	19.08	01.09
2013	Vilnus	09.08	01.11
2014	G.O. Sars	23.08	19.09
2014	Johan Hjort	14.08	01.10
2014	Helmar Hanssen	19.08	01.09

2014	Vilnus	09.08	03.10
2015	G.O. Sars	11.09	09.10
2015	Johan Hjort	13.08	04.10
2015	Helmar Hanssen	17.08	07.09
2015	Vilnus	19.08	09.10
2016	Eros	17.08	20.09
2016	Johan Hjort	19.08	30.09
2016	Helmar Hanssen	24.09	05.10
2016	Fridtjof Nansen	09.08	30.09
2017	G.O.Sars	24.08	28.09
2017	Johan Hjort	21.08	04.10
2017	Helmar Hanssen	21.08	07.09
2017	Vilnyus	24.08	17.10
2017	G.O.Sars	24.08	28.09
2017	Johan Hjort	21.08	04.10
2017	Helmar Hanssen	21.08	07.09
2017	Vilnyus	24.08	17.10
2018	G.O.Sars	07.09	27.09
2018	Johan Hjort	21.08	29.09
2018	Helmar Hanssen	14.09	29.09
2018	Vilnyus	24.08	29.09
2019	G.O.Sars	14.08	09.09
2019	Johan Hjort	21.08	29.09
2019	Helmar Hanssen	22.09	02.10
2019	Vilnyus	16.08	29.09
2020	G.O.Sars	12.08	05.09
2020	Johan Hjort	21.08	28.09
2020	Kronprins Haakon	15.09	08.10
2020	Vilnyus	29.09	11.11
2021	G.O.Sars	21.08	09.10
2021	Johan Hjort	19.08	25.09
2021	Helmar Hanssen	13.09	30.09
2021	Vilnyus	12.08	25.09
2022	G.O.Sars	16.08	09.09
2022	Johan Hjort	19.08	03.10
2023	G.O.Sars	20.08	14.09
2023	Johan Hjort	25.08	30.09

2023	Kronprins Haakon	16.09	30.9
2023	Vilnyus	13.08	24.09

The survey has generally been run from south to north in the Barents Sea; that is, the research vessels have started in south and worked their way northwards. This is a broad pattern and there are many exceptions in specific years. Maps with cruise lines and station positions for the different research vessels are included in annual cruise reports that are available electronically (Table 2). The cruise lines are generally placed either in S-N or W-E directions, although zig-zag or more irregular patterns have also sometimes been used to obtain a good coverage of the survey area within the limits of time and ship availability.

A change in survey lines was made in the mid-1990s. From 1980 and up to 1994 (and also in 1997), the S-N survey lines followed longitudes and the E-W lines followed latitudes. From 1995 onwards (except 1997), the survey lines were placed equidistant (35 nm apart). The grid was oriented true North along the 30^o E longitude, while it deviated in NW direction in the western Barents Sea, and in NE direction in the eastern Barents Sea. A consequence of this was an opening of the sampling grid in the northern end, compared to when the lines followed longitudes.

The surveyed area has expanded northward in concert with reduction of sea ice in the Barents Sea. This can be seen from the maps with station locations in Part 7. A summary of the northern boundary of the survey area in three sectors is illustrated in Fig. 7.

In the Svalbard (Spitsbergen Archipelago) sector, the survey area has extended up along the west side of Spitsbergen to around 80-81^{o}N. Up to 2004, the survey extended north to 80-80.5^{o}N, while from 2006 it extended north to 81^{o}N or beyond (Fig. 7). The northwestern corner of Spitsbergen lies just south of 80^{o}N. With the northward extension from 2006, there was also an eastward extension to cover the waters north of Svalbard (Spitsbergen Archipelago) , east to 20-35^{o}E. In three of the years, the waters west of Spitsbergen was either not sampled (2016) or only partially sampled (north to 78 ^{o} N; 1999 and 2005).

In a sector through the central Barents Sea, east of Svalbard (Spitsbergen Archipelago) and east to about 38^{o}E, the sampling extended north to 76-77 ^{o}N in the years up to 2002 (except for two years, 1989 and 1991), while from 2004 the survey area extended north to 78 ^{o}N or beyond (Fig. 7). The northward shift reflects a change to less sea ice and more open water in the northern Barents Sea, while the large variability in recent year reflects variable ice conditions. A similar northward extension is seen for the area east of 38^o E, but with considerable variation among years reflecting variable sea ice conditions as well as vessel availability (Fig. 7).

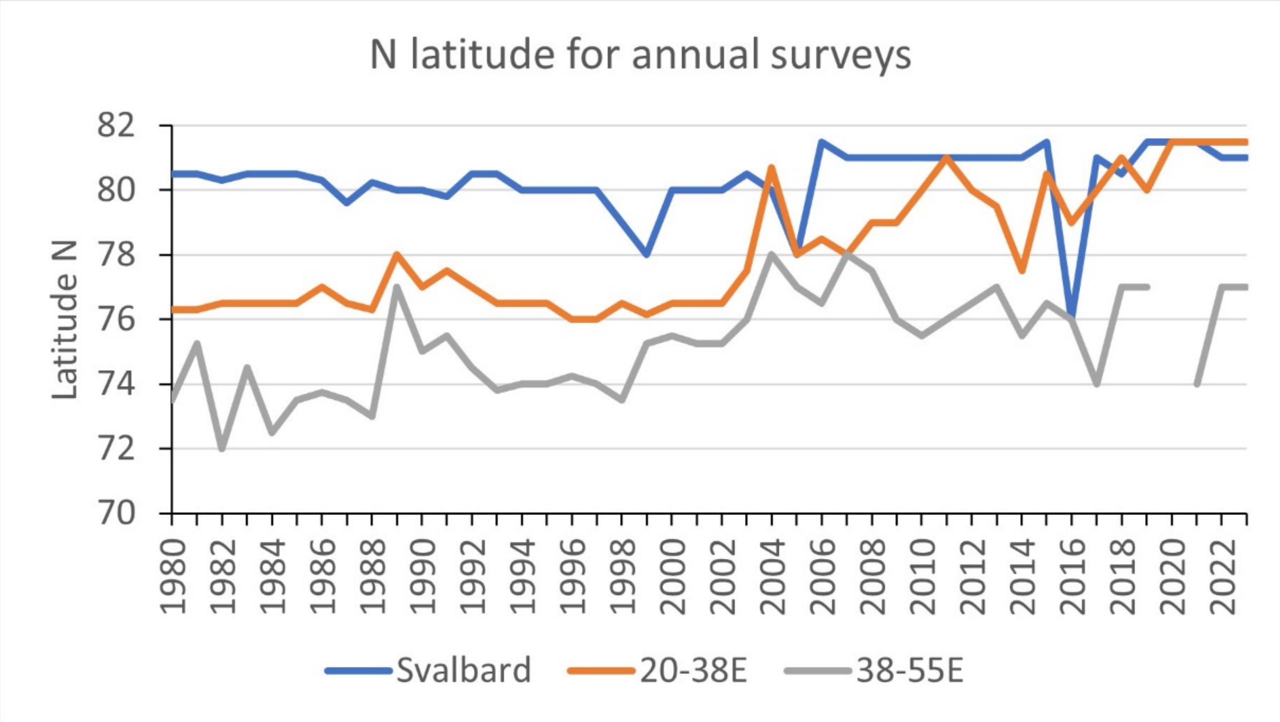


Figure 7. The northern boundary of the survey area in three sectors: Svalbard (Spitsbergen Archipelago) sector, area between 20 and 38°E and area between 38-55°E.

The survey is semi-synoptic since it takes about 3-4 weeks, or in some cases longer, to complete the survey of 0-group distribution. The 0-group survey typically started in mid-August (10-20 August) and ended in early September (5-15 September). This was the case during the 1980s and 90s when the 0-group investigations were done as a separate cruise, or as the first part of a combined multispecies cruise. This pattern with a main part of sampling in the second half of August and the first part of September has continued after 2004 when the 0-group survey became part of the ecosystem survey, although there has been an extension of sampling later in September as the survey has extended northward (described in the following).

Table 2. Reports from Joint Norwegian-Russian (IMR-PINRO) 0-group cruises in the Barents Sea, 1965-20 23 . The annual survey reports for 1965-1996 are available as ICES Council Meeting Reports, while the annual survey reports for 1998-2023 are available in the IMR/PINRO Joint Report Series from the IMR web page (Rapporter Havforskningsinstituttet (hi.no).

Survey year	Author	Year	Title	ICES	IMR/PINRO Joint Report Series	Pages
1965	Anon.	1965	Preliminary Report of the joint Soviet-Norwegian investigations in the Barents Sea and adjacent waters September 1965	CM 1965/No. 161		
1966	Anon.	1966	Preliminary Report of the joint international 0-group fish survey in the Barents Sea and adjacent waters August/Sept 1966	CM 1966/H:23		17
1967	Anon.	1967	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August/September 1967	C.M. 1967/H:31		18
1968	Anon.	1968	Preliminary Report of the 0-group fish survey in the Barents Sea and adjacent waters August-September 1968	C.M. 1968/H:25		12
1969	Anon.	1969	Preliminary Report of the 0-group fish survey in the Barents Sea and adjacent waters August-September 1969	C.M. 1969/F:34		14

1970	Anon.	1970	Preliminary Report of joint Soviet-Norwegian 0-group fish survey in the Barents Sea and adjacent waters August-September 1970	C.M. 1970/H:34		13
1971	Anon.	1971	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1971	C.M. 1971/H:32		14
1972	Anon.	1972	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1972	C. M.1973/H:15		16
1973	Anon.	1973	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1973	C.M. 1973/H:25		28
1974	Anon.	1974	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1974	C.M. 1974/H:33		23
1975	Anon.	1975	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1975	C.M. 1975/H:48		23
1976	Anon.	1976	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1976	C.M. 1976/H:43		26
1977	Anon.	1977	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1977	C.M. 1977/H:45		26
1978	Anon.	1978	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1978	CM 1978/H:33		26
1979	Anon.	1979	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1979	CM 1979/H:65		26
1980	Anon.	1980	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1980	CM 1980/G:53		26
1981	Anon.	1981	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1981	CM 1981/G:78		28
1982	Anon.	1982	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1982	CM 1982/G:44		28
1983	Anon.	1983	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1983	CM 1983/G:35		28
1984	Anon.	1984	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1984	C.M. 1984/H:36		28
1985	Anon.	1985	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1985	C.M. 1985/G:75		28
1986	Anon.	1986	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1986	C.M. 1986/G:78		28

1987	Anon.	1987	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1987	C.M. 1987/G:38		32
1988	Anon.	1988	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1988	C.M. 1988/G:45		38
1989	Anon.	1989	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1989	C.M. 1989/G:40		40
1990	Anon.	1990	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1990	C.M. 1990/G:46		36
1991	Anon.	1991	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1991	C.M. 1991/G:50		34
1992	Anon.	1992	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1992	C.M. 1992/G:82		33
1993	Anon.	1994	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1993	C.M. 1994/G:3		38
1994	Anon.	1995	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1994	C.M. 1995/G:xx		36
1995	Anon.	1996	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1995	C.M. 1996/G:xx		36
1996	Anon.	1996	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1996	C.M. 1996/G:31		38
1997	Anon.	1997	Preliminary Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1997			25
1998	Anon.	2001	Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1998		No. 2/2001	26
1999	Anon.	2001	Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 1999		No. 3/2001	27
2000	Anon.	2001	Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 2000		No. 4/2001	26
2001	Anon.	2001	Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 2001		No. 8/2001	26
2002	Anon.	2002	Report of the international 0-group fish survey in the Barents Sea and adjacent waters August-September 2002		No. 3/2002	28
2003	Anon.	2003	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea, August – October 2003.		No. 2/2003	55
2004	Anon.	2004	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea, August – October 2004, Volume 1		No. 3/2004	71
2005	Anon.	2005	Survey report from the Joint Norwegian/Russian ecosystem survey in the Barents Sea August-October 2005, Volume 1		No. 3/2005	99
2006	Anon.	2006	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea August-October 2006 (vol.1).		No. 2/2006	97

2007	Anon.	2007	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea August-October 2007 (vol.1).		No. 4/2007	97
2008	Anon.	2009	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea August-October 2008 volume 1.		No. 1/2009	103
2009	Anon.	2009	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea August-October 2009 (adopted vol.)		No. 2/2010	118
2010	Anon.	2010	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea August-September 2010.		No. 4/2010	108
2011	Anon.	2011	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea August-October 2011		No. 3/2011	118
2012	Eriksen	2012	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea August-October 2012		No. 2/2012	139
2013	Prokhorova	2013	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-October 2013		No. 4/2013	131
2014	Eriksen	2015	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-October 2014		No. 1/2015	153
2015	Prozorkevich and Sunnanå	2016	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-October 2015		No. 1/2016	77
2016	Prozorkevich and Sunnanå	2017	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-October 2016		No. 2/2017	101
2017	Prozorkevich et al.	2018	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-October 2017		No. 2/2018	97
2018	van der Meeren and Prozorkevich	2019	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-October 2018		No. 2/2019	85
2019	Prozorkevich and van der Meeren	2020	Survey report from the joint Norwegian/ Russian ecosystem survey in the Barents Sea and adjacent waters August-October 2019.		No. 1/2020	93
2020	van der Meeren and Prozorkevich	2021	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-November 2020		No. 1/2021	123
2021	Prozorkevich and van der Meeren	2022	Survey report from the joint Norwegian/Russian ecosystem survey in the Barents Sea and adjacent waters, August-September 2021		No. 2/2022	111
2022	van der Meeren and Prozorkevich	2023	Survey report from the joint Norwegian/Russian Ecosystem Survey in the Barents Sea and the adjacent waters August-December 2022		No. 2023-10	
2023	Prozorkevich and van der Meeren	2024	Survey report (Part 1) from the joint Norwegian/Russian Ecosystem Survey in the Barents Sea and the adjacent waters August-October 2023		No. 2024-2	

7 - Spatial distribution of 0-group fish in 1980-2023

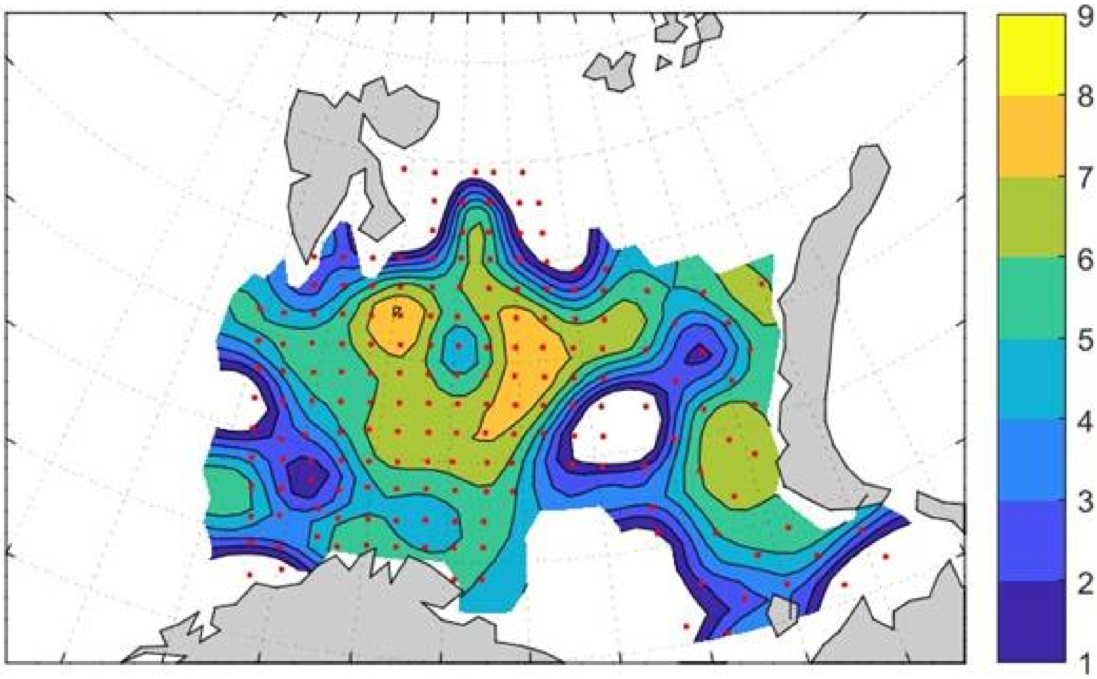


Figure 8. Distribution of 0-group capelin in 2016.

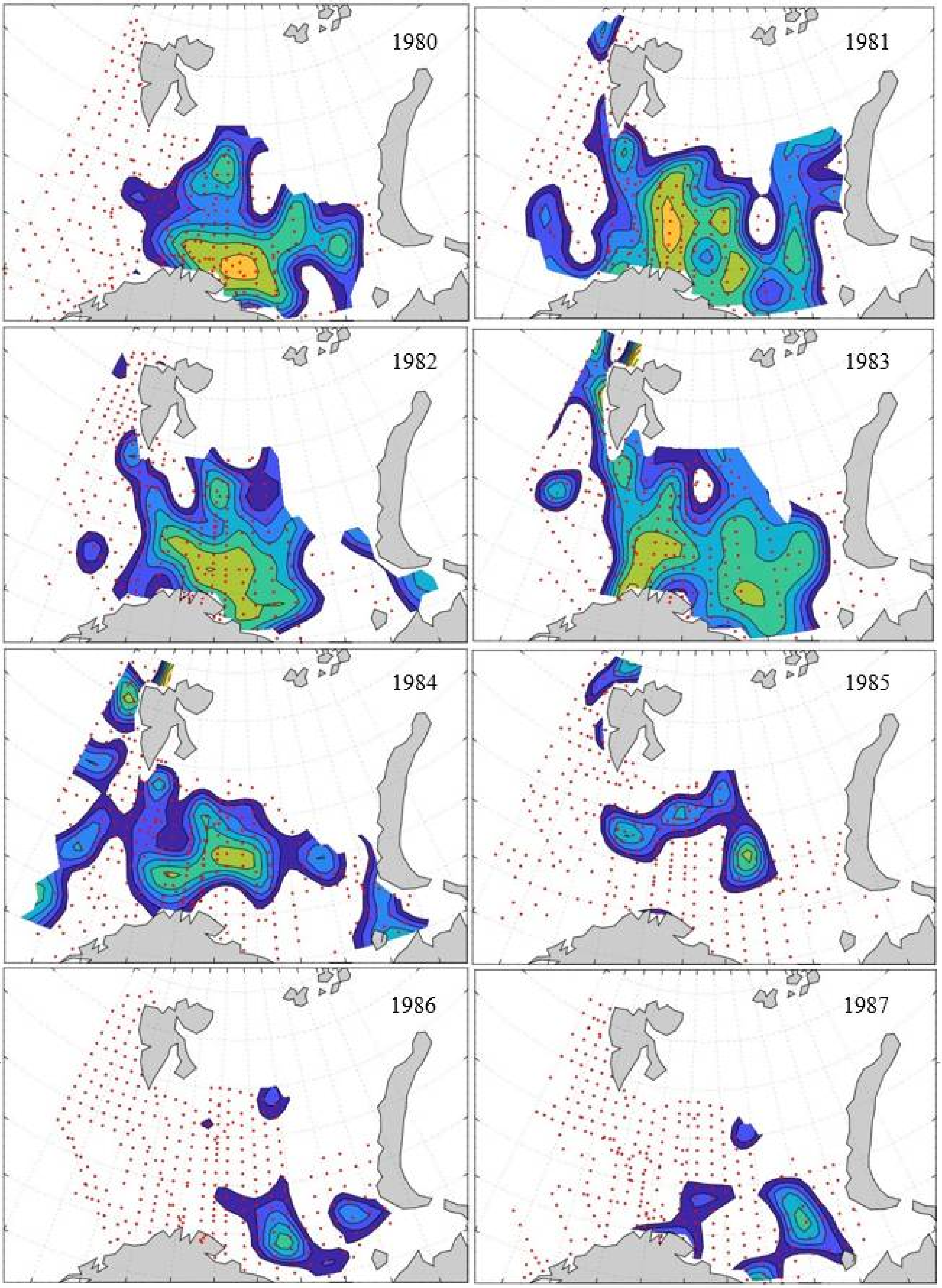
In this section, maps of spatial distribution of 0-group density of six species are shown, based on log transformed abundance per station (colored). The species are: Atlantic capelin *Mallotus villosus* , Atlantic cod *Gadus morhua* , haddock *Melanogrammus aeglefinus* , Atlantic herring *Clupea harengus* , polar cod *Boreogadus saida* , and redfish (*Sebastes* spp.).

Species abundance at stations have been estimated, based on species catches at station, by standard methods (Eriksen et al. 2009), taking into account the opening of trawl, vessels speed, towing distance, and number of depths layers covered (see section 2.3). The abundances have been corrected for size-dependent catch efficiency for all species except redfish *Sebastes* spp. (section 4). Abundances are given as areal density of 0-group, expressed as number of individuals per square nautical miles.

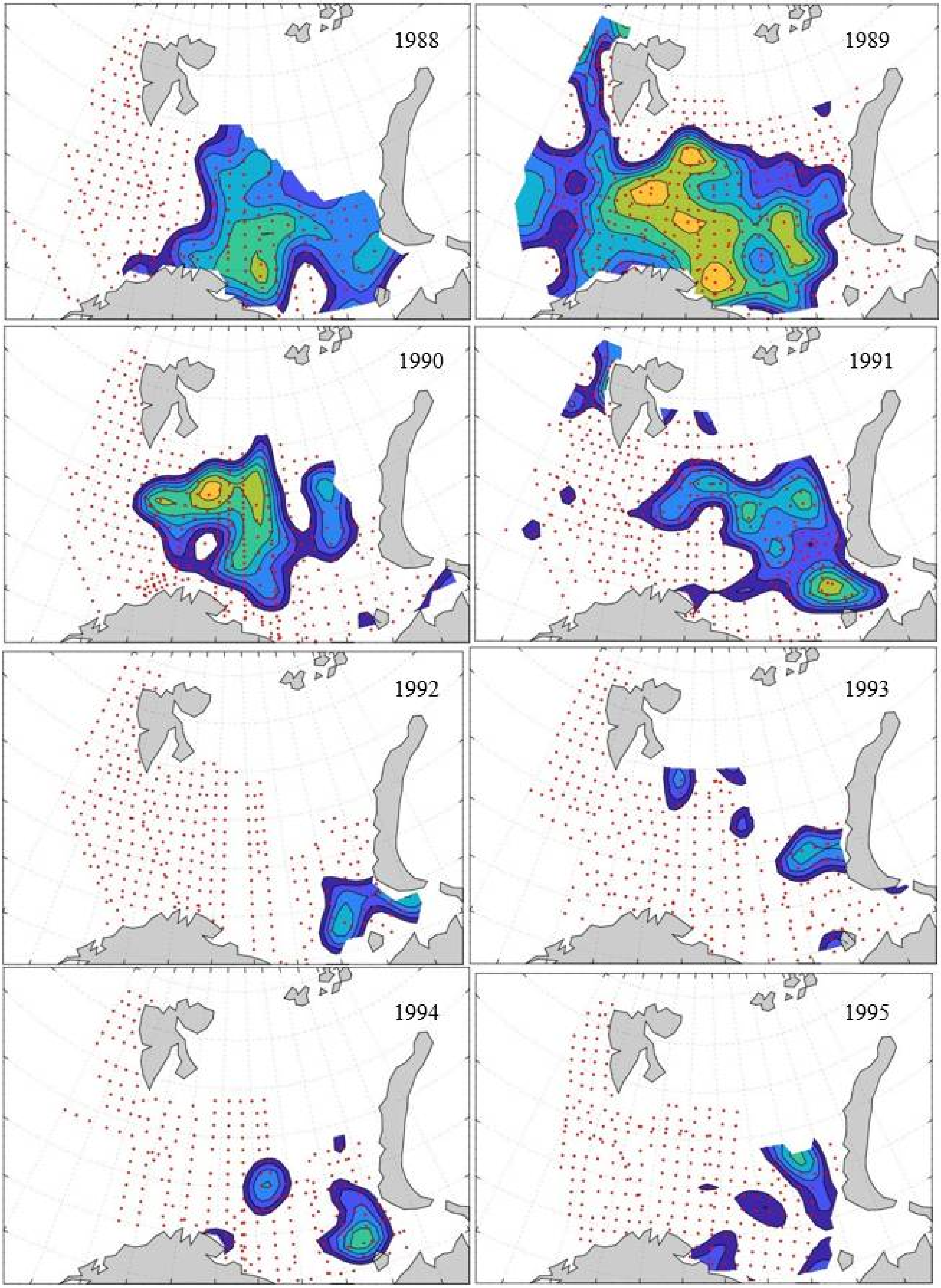
Abundance is shown by color, where light yellow indicates highest value, and dark blue lowest value. The scale is log10, with steps of one log10 unit, corresponding to factor 10. It ranges from >100 million individuals per (nautical miles)^2 to <100 individuals per (nautical miles)^2 . Stations are shown by red dots.

0-group capelin are generally widespread in the Barents Sea (except 1985-86 and 1992-1995) and occurrence area has varied from 116 to 1130 thousand km^2. Distribution of 0-group herring was widest in 1983, 1992, 2016 and in 2022-2023, and it seems that larger occupation area was not related to occurrence of strong year classes. 0-group cod are generally widely distributed and abundant year classes seem to be observed on larger area. Haddock were widespread in 2004, 2008, 2017 and 2023, and varied from 62 to 630 thousand km^2. Redfish and polar cod 0-group distributions are generally more restricted than for cod, capelin, haddock, and herring. The widest distribution was observed in 1982-83 (515 thousand km^2, redfish) and 1999 and 2005 (560 thousand km^2 , polar cod).

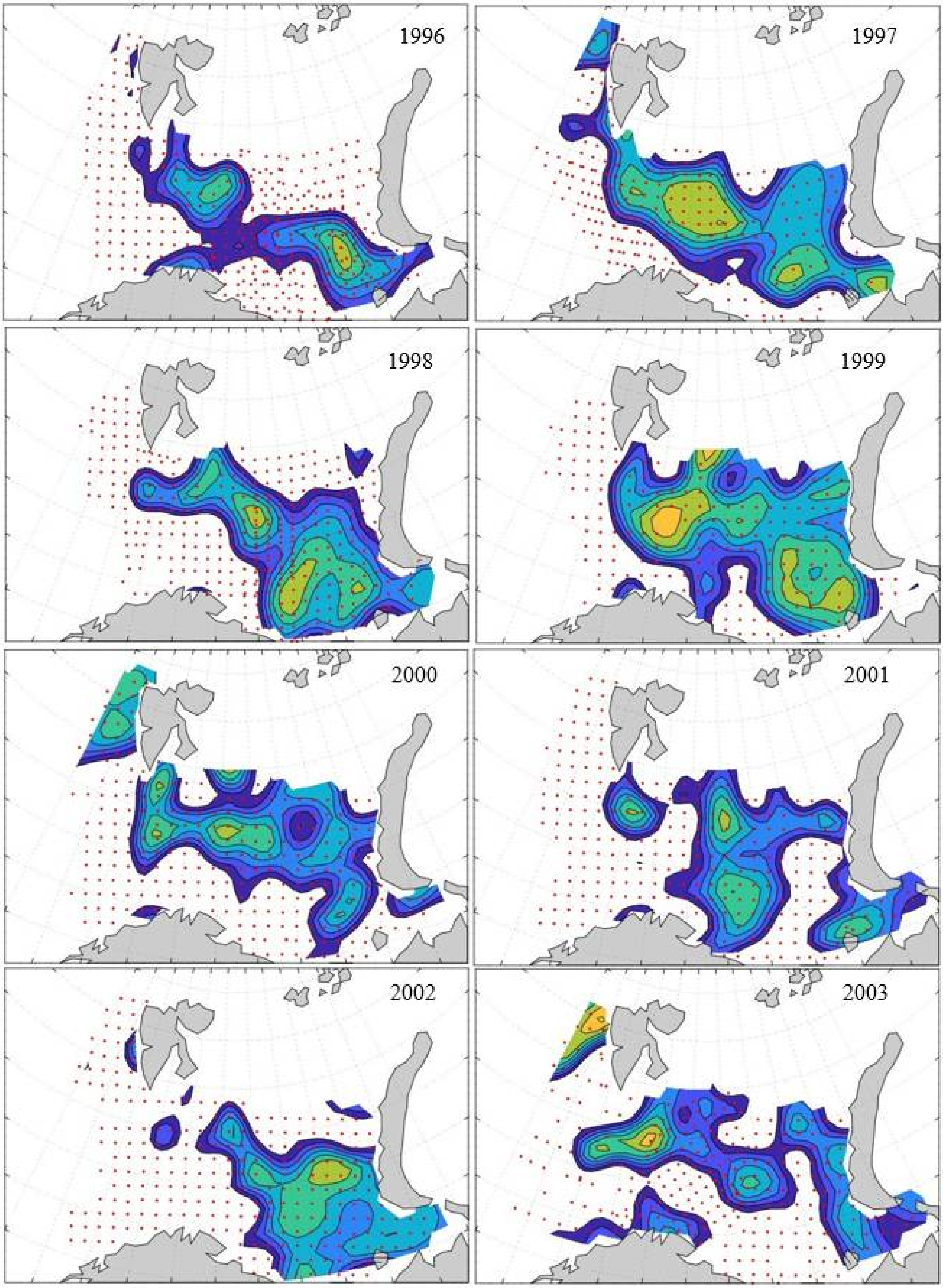
7.1 - Capelin



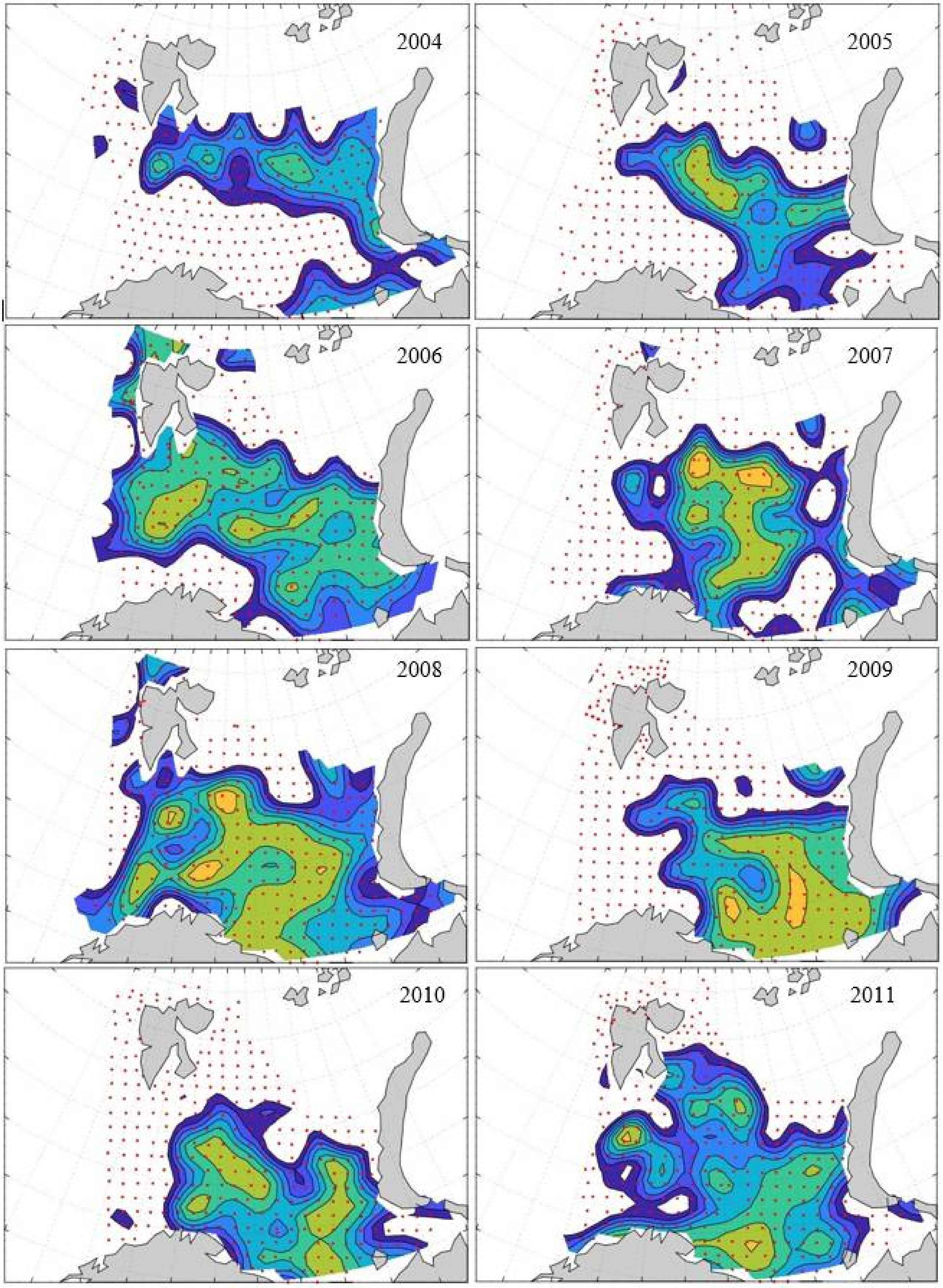
Figur 9. Distribution of 0-group capelin between 1980-1987.



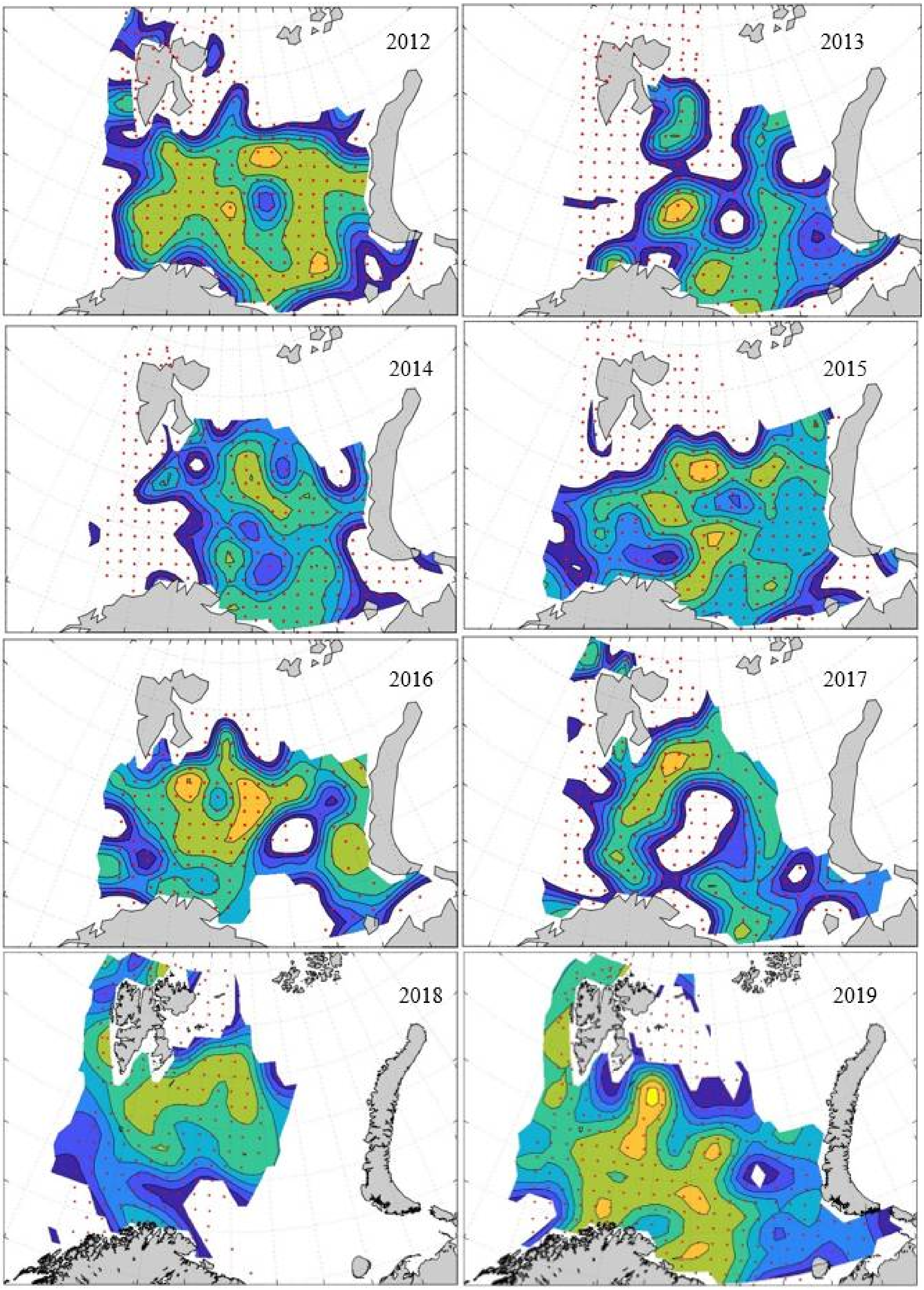
Figur 10. Distribution of 0-group capelin between 1988-1995.



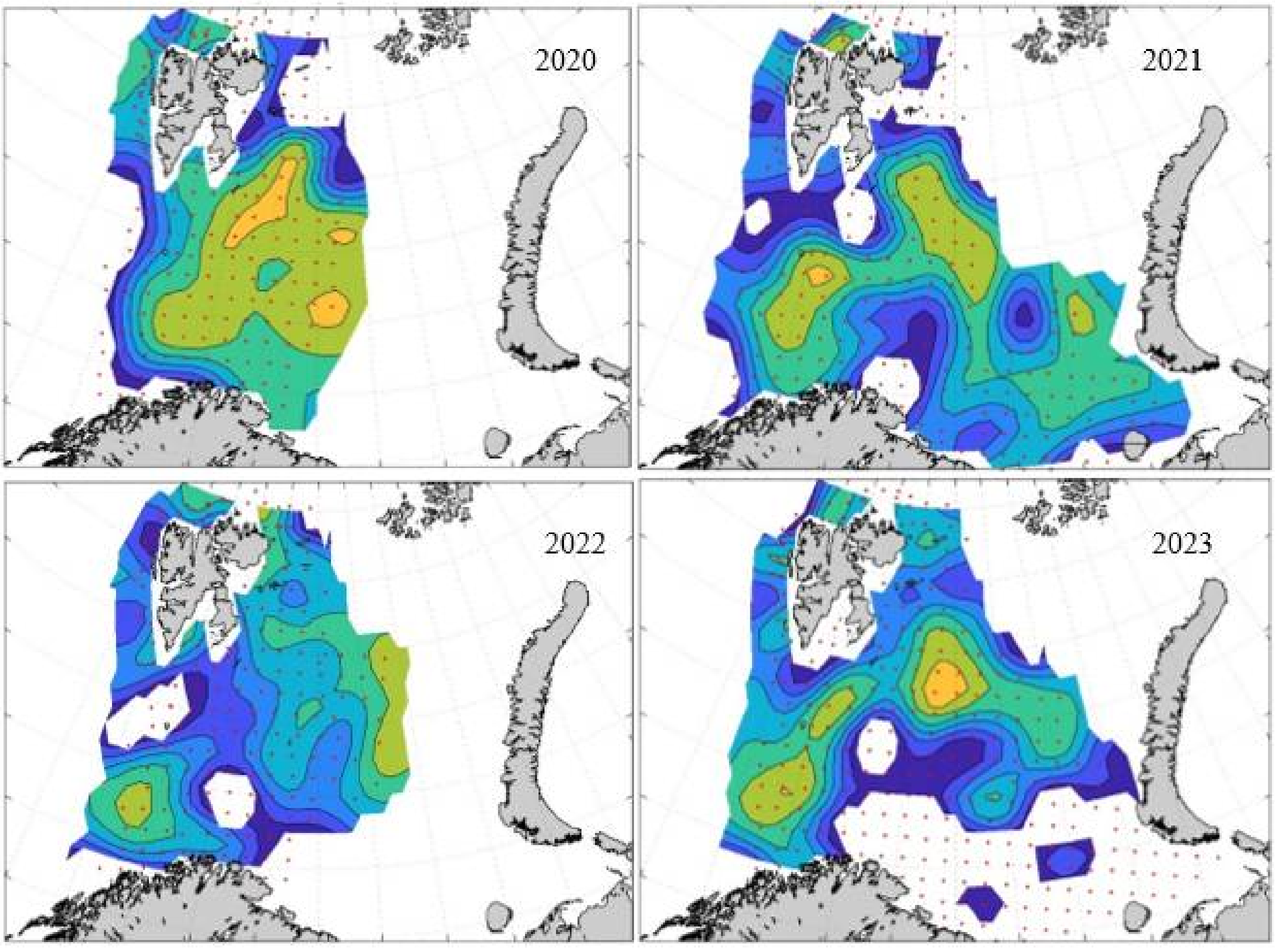
Figur 11. Distribution of 0-group capelin between 1996-2003.



Figur 12. Distribution of 0-group capelin between 2004-2011.

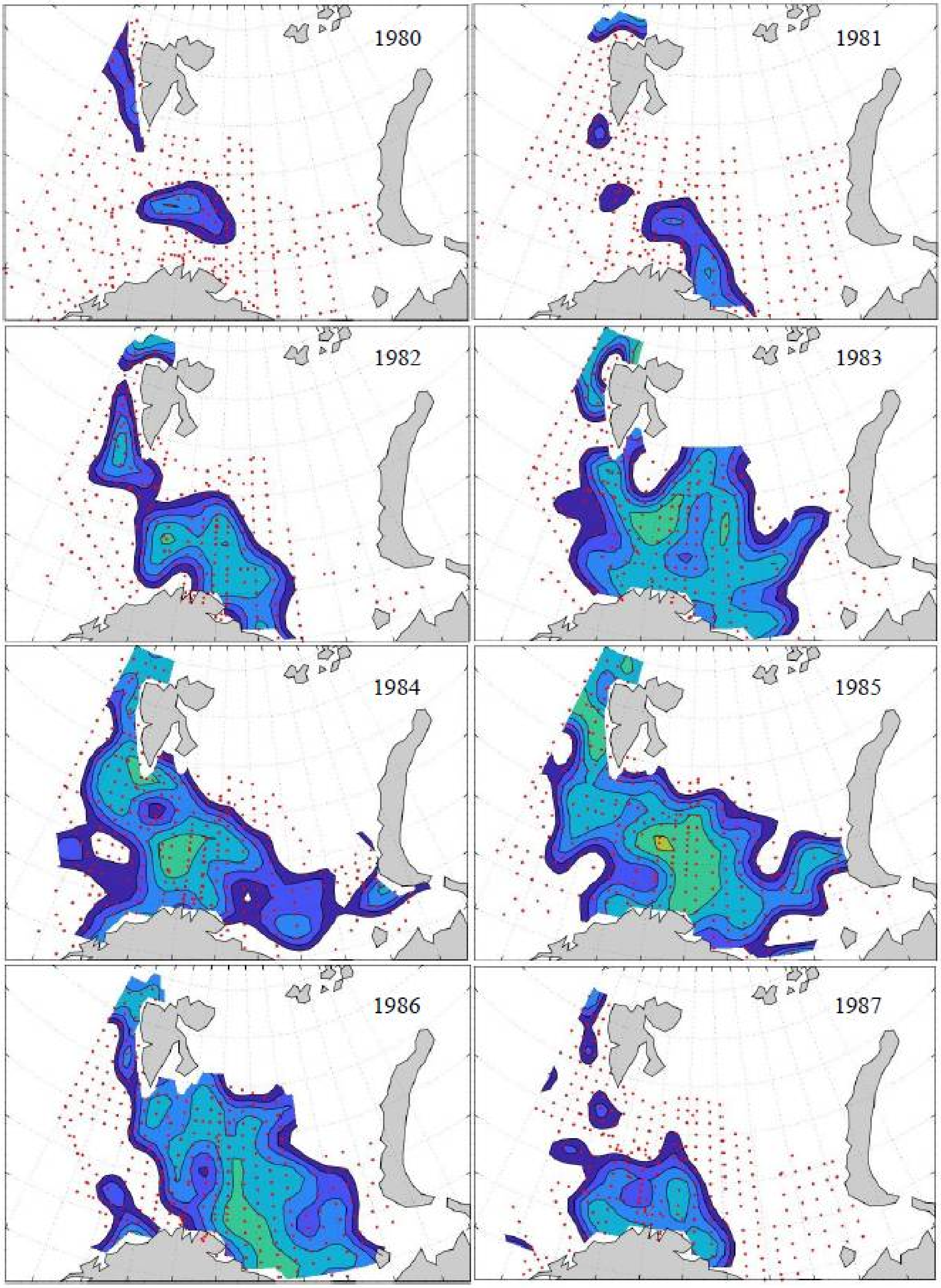


Figur 13. Distribution of 0-group capelin between 2012-2019.

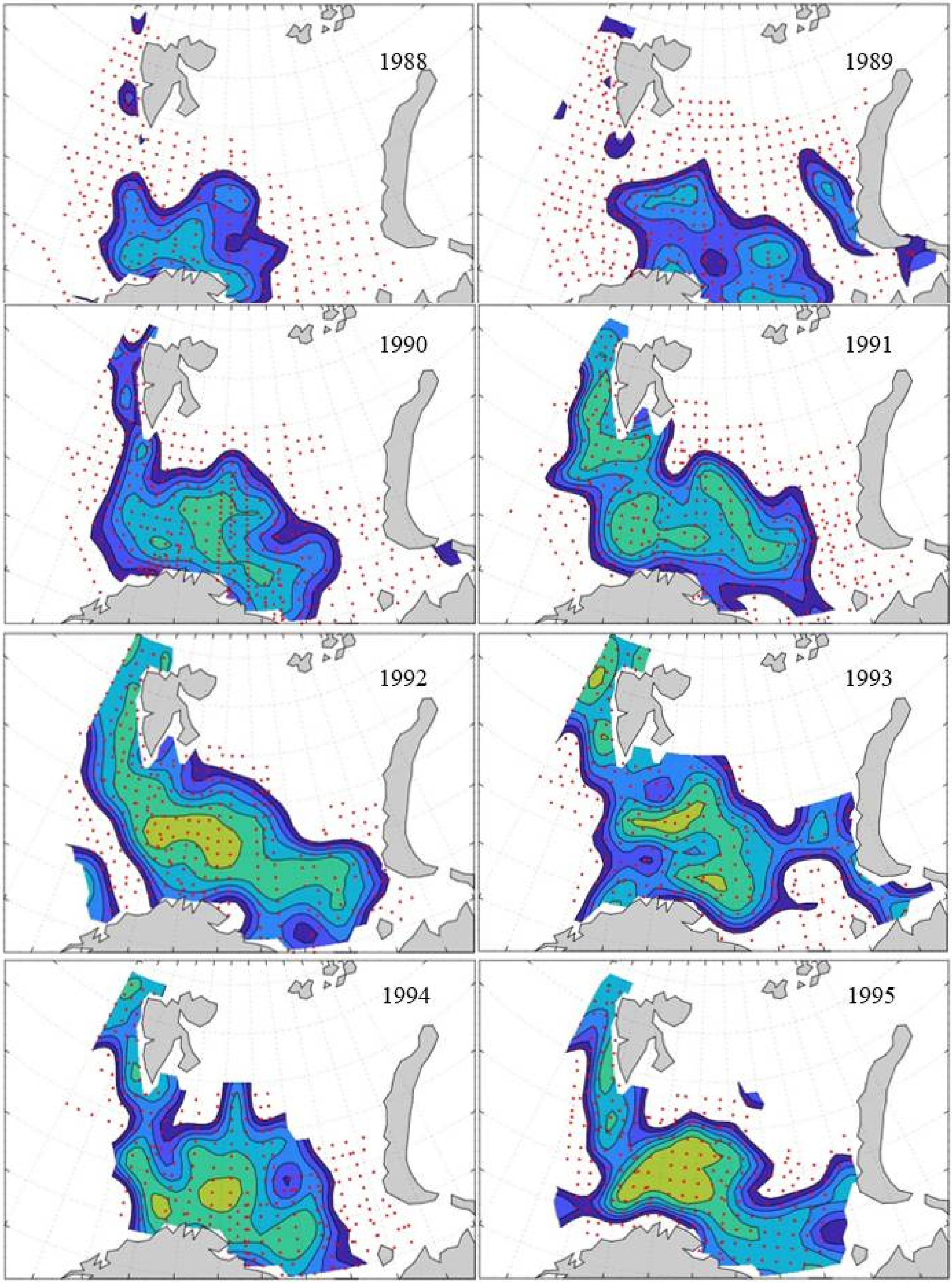


Figur 14. Distribution of 0-group capelin between 2020-2023.

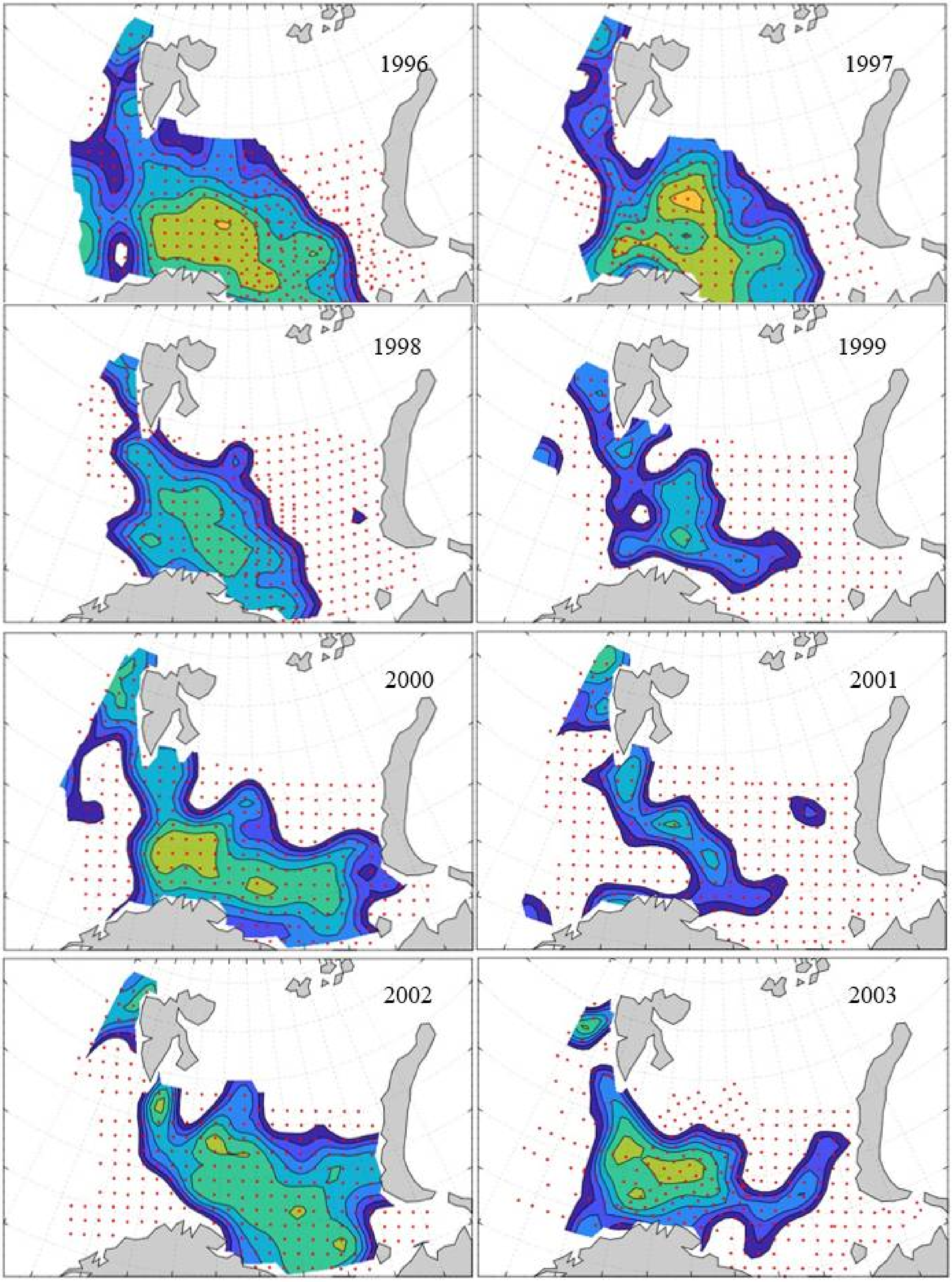
7.2 - Cod



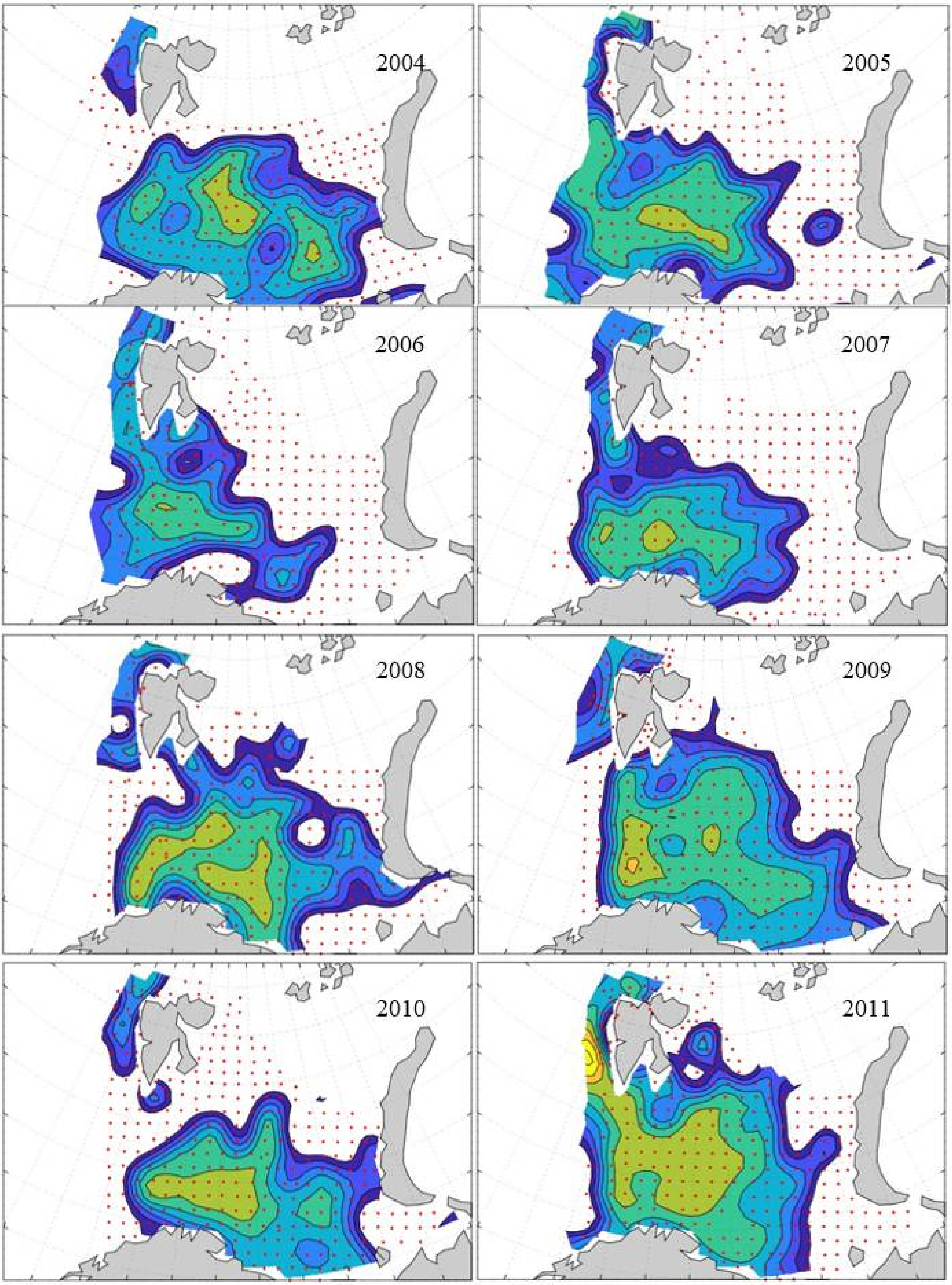
Figur 15. Distribution of 0-group cod between 1980-1987.



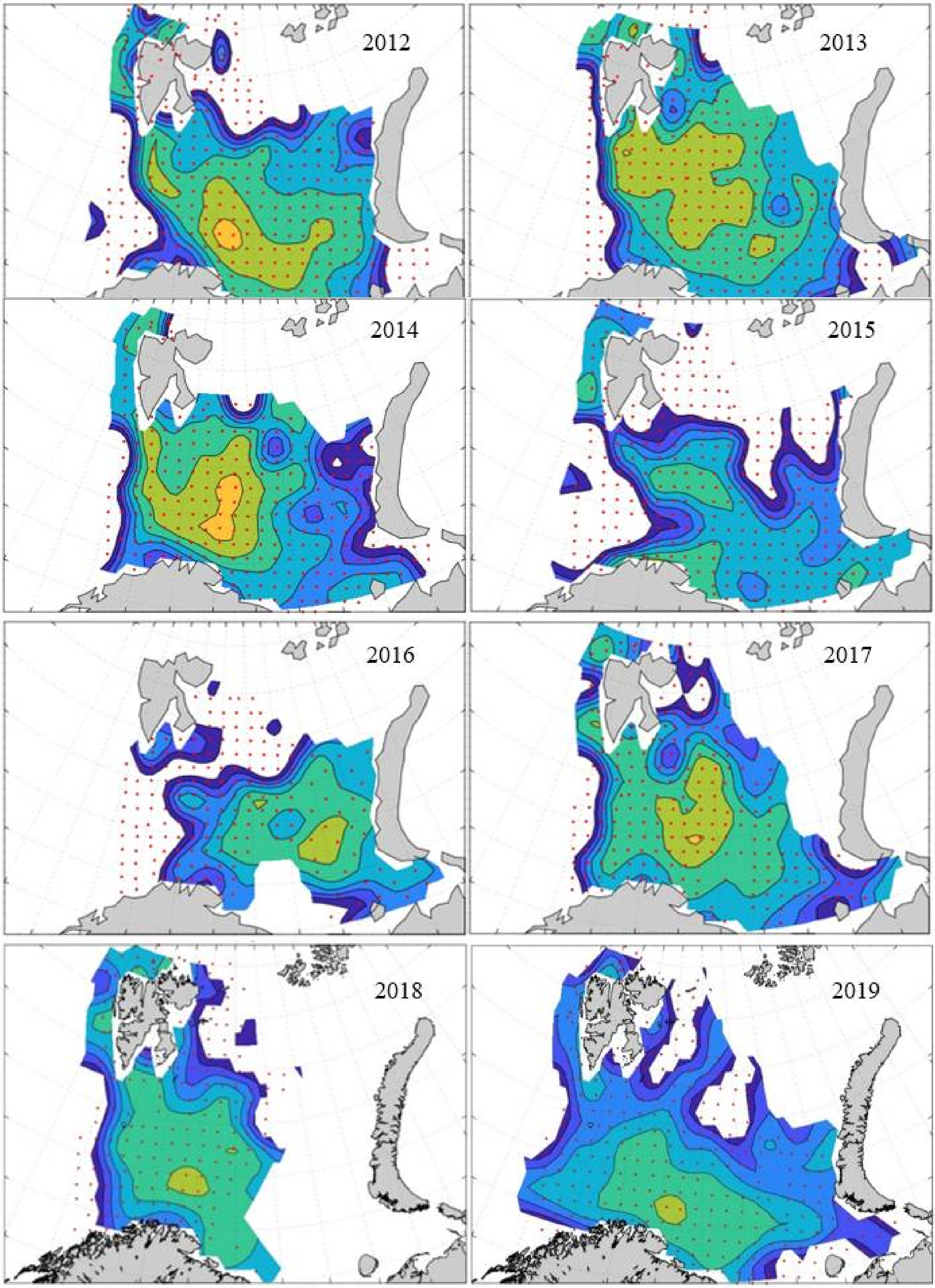
Figur 16. Distribution of 0-group cod between 1988-1995.



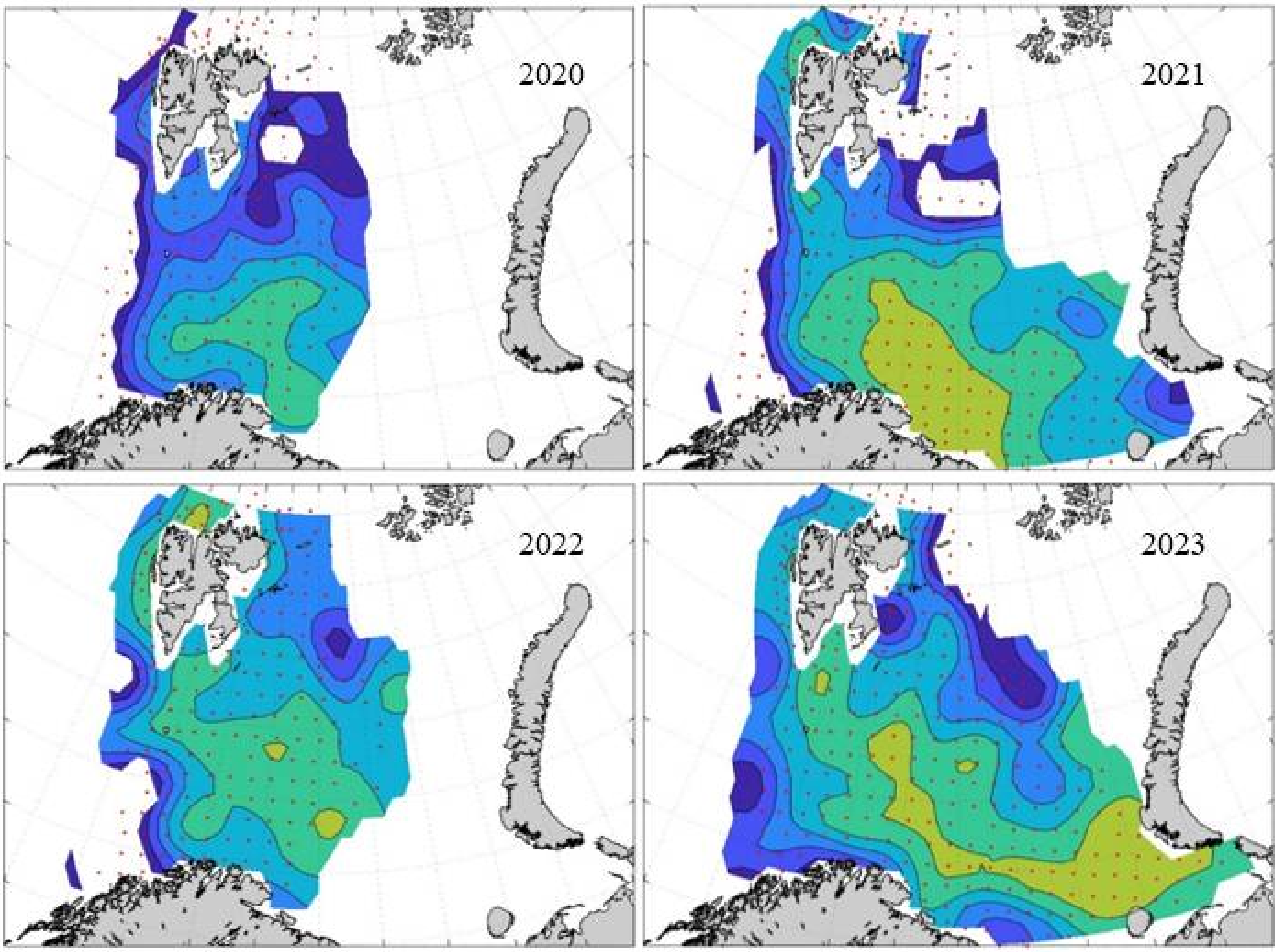
Figur 17. Distribution of 0-group cod between 1996-2003.



Figur 18. Distribution of 0-group cod between 2004-2011.

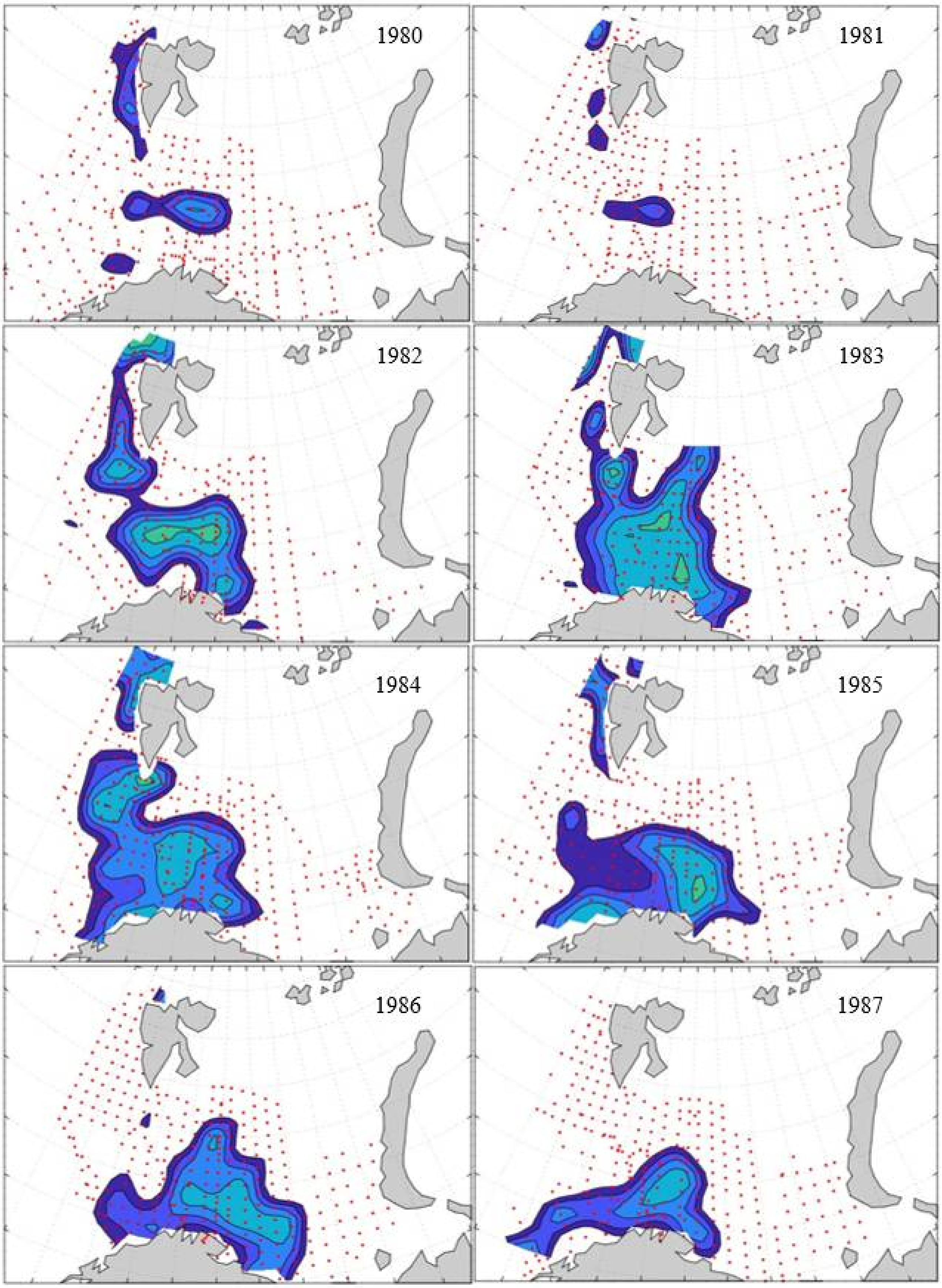


Figur 19. Distribution of 0-group cod between 2012-2019.

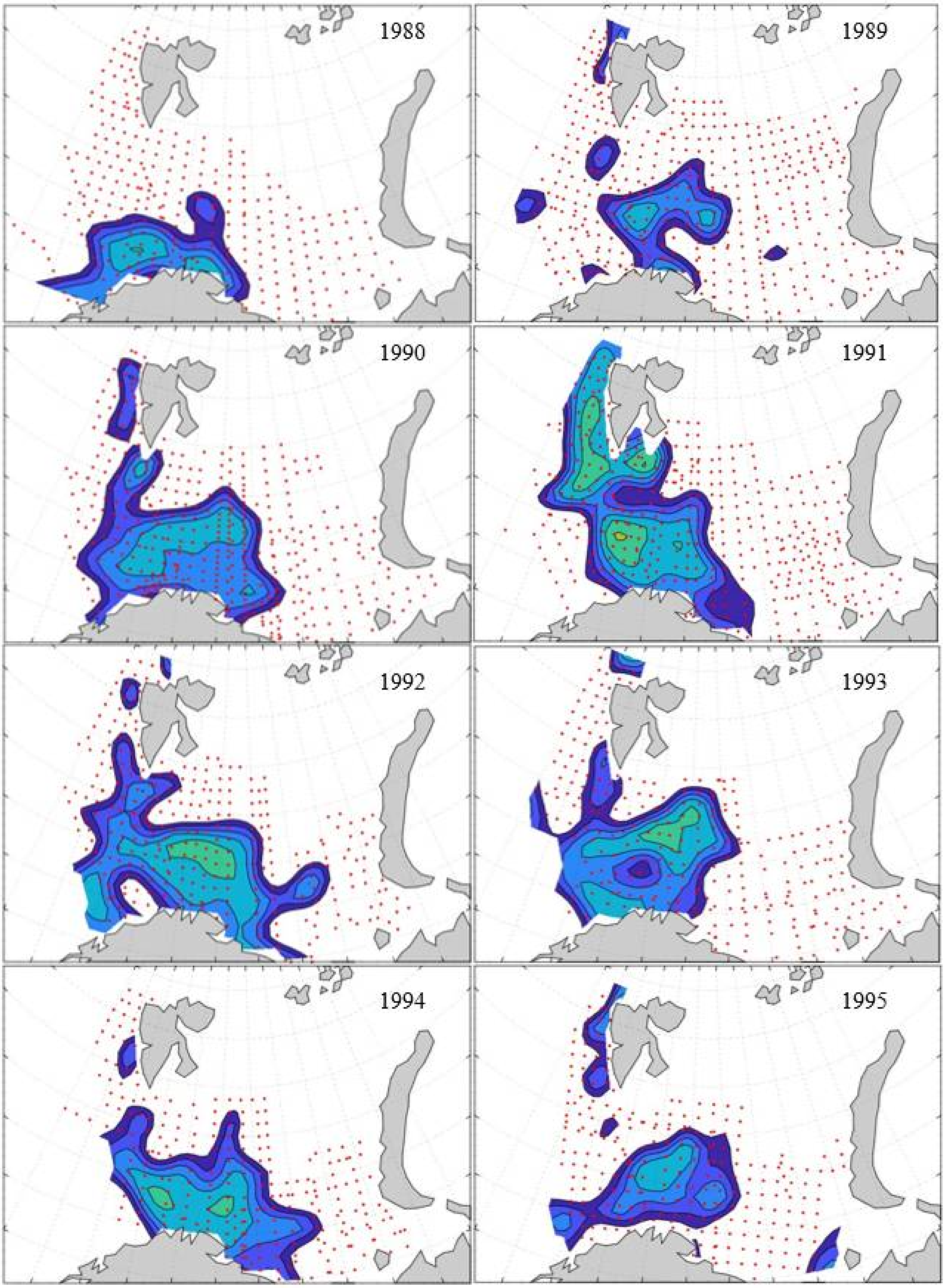


Figur 20. Distribution of 0-group cod between 2020-2023.

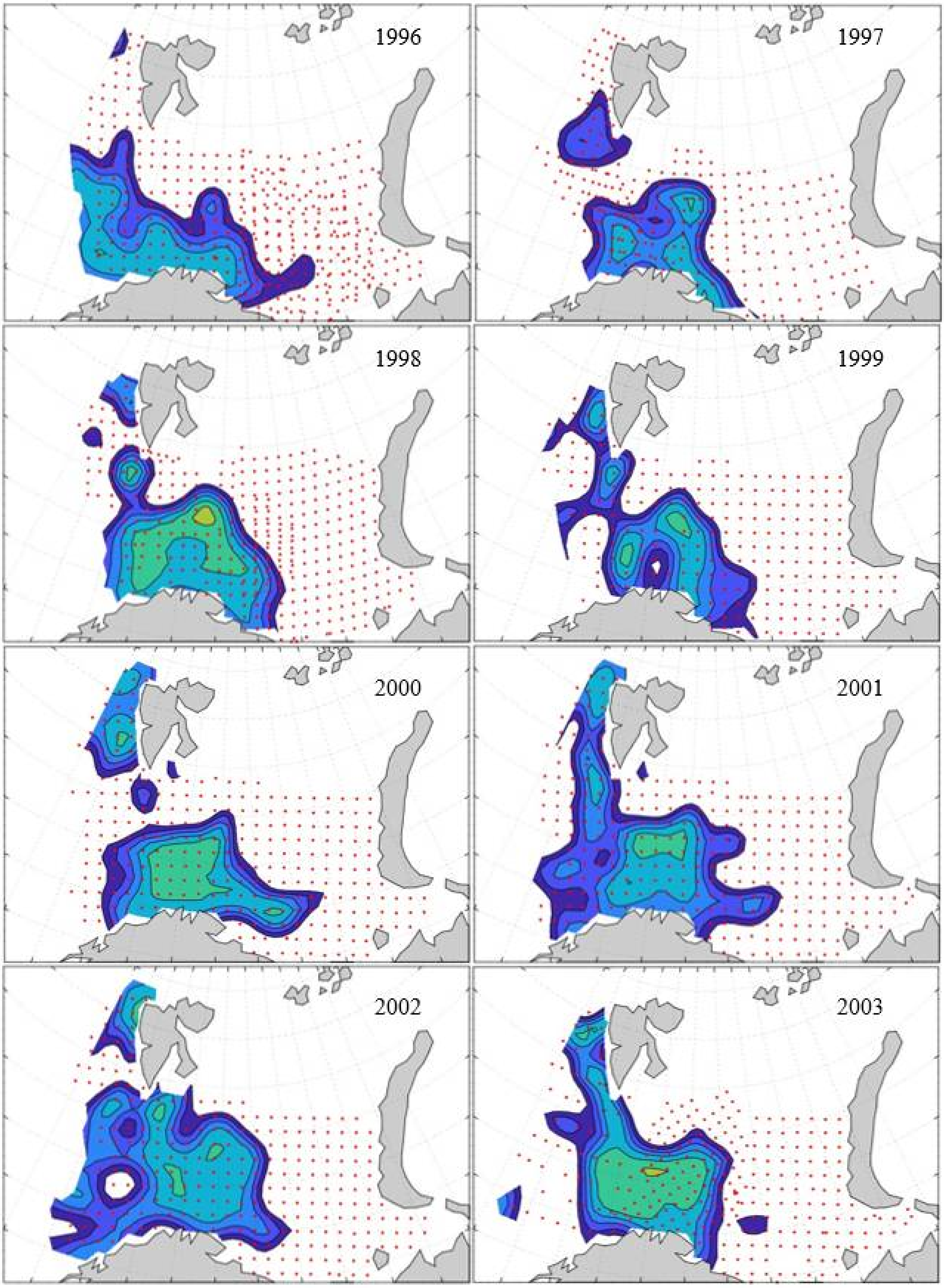
7.3 - Haddock



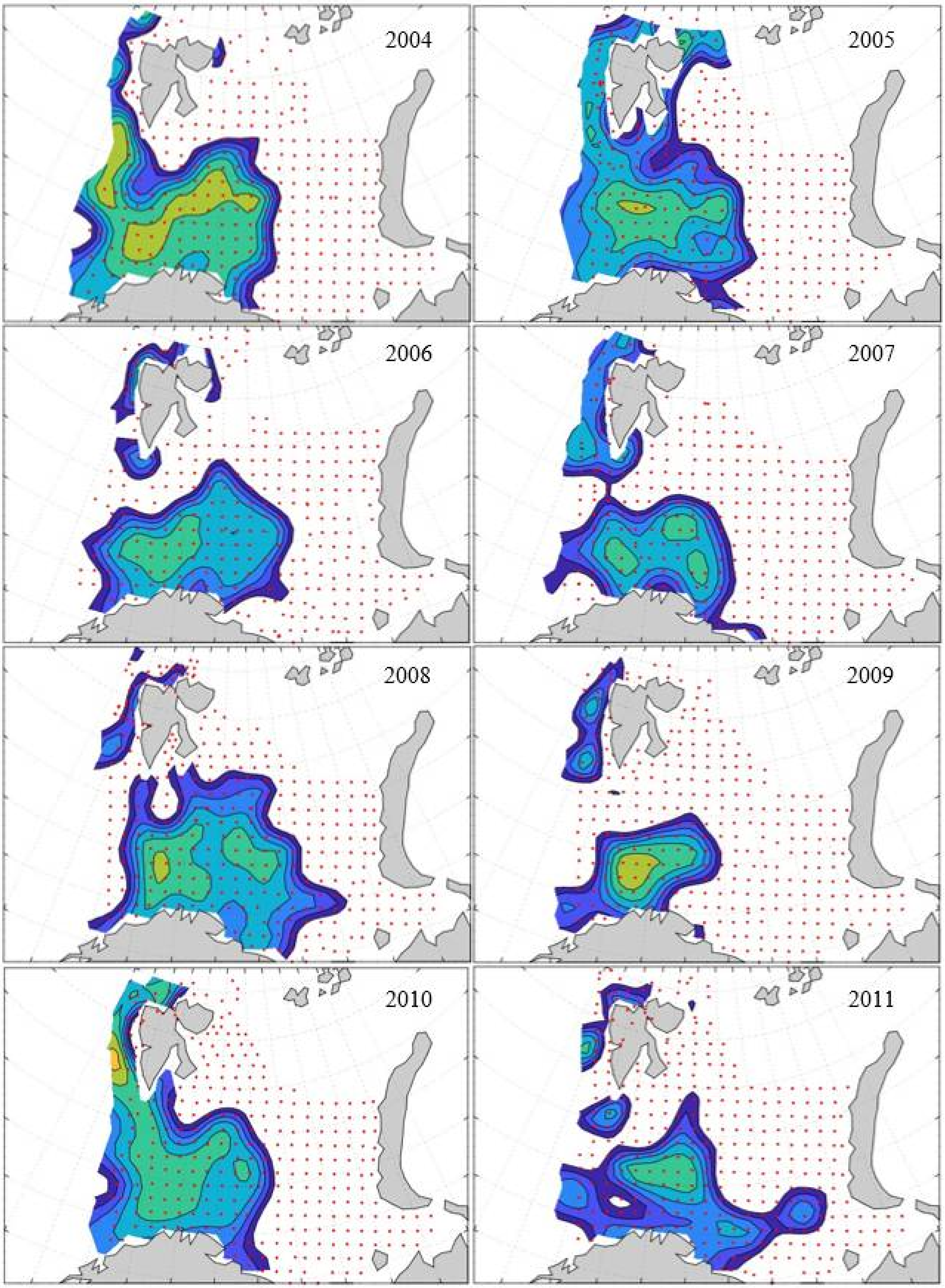
Figur 21. Distribution of 0-group haddock between 1980-1987.



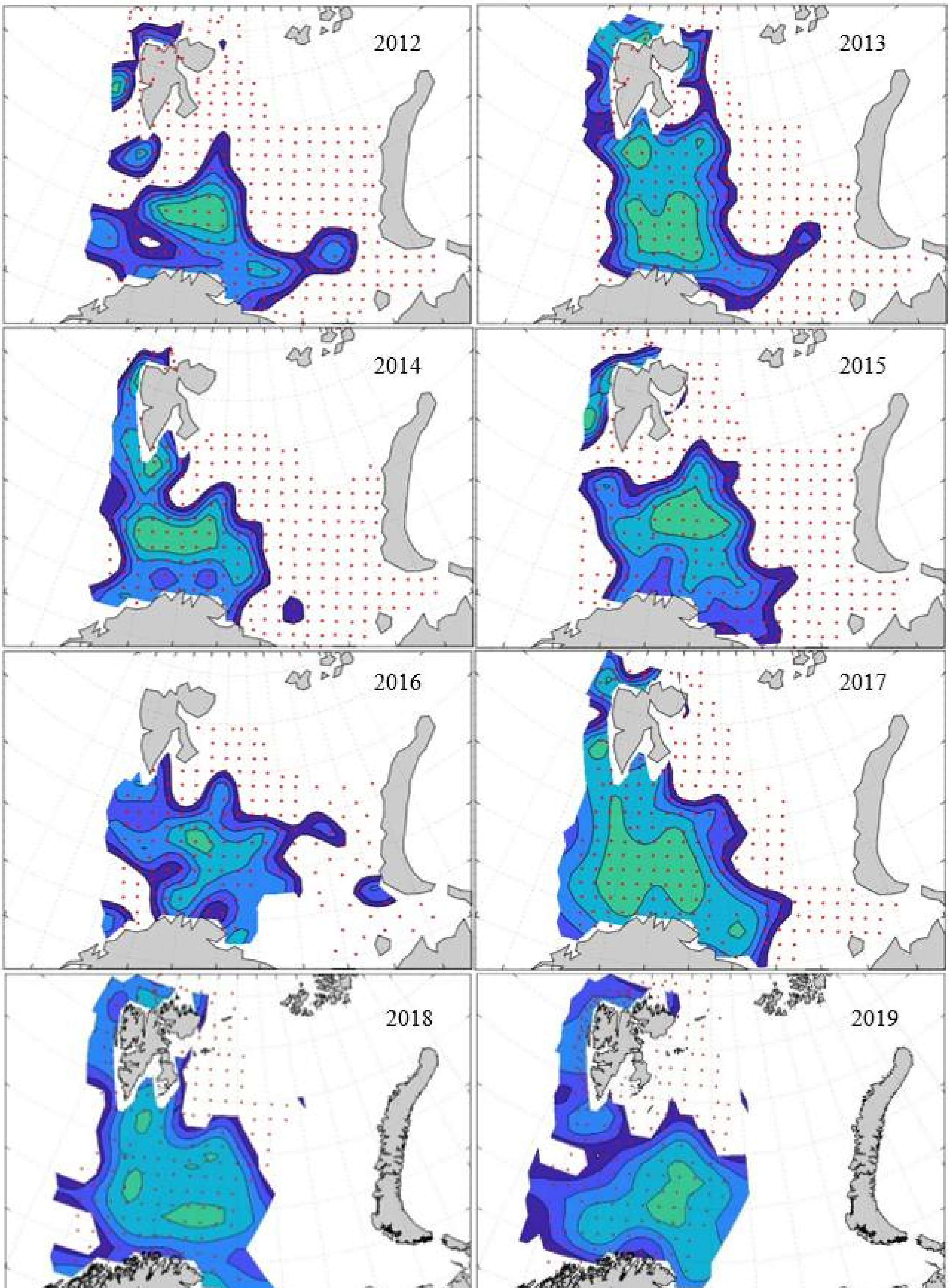
Figur 22. Distribution of 0-group haddock between 1988-1995.



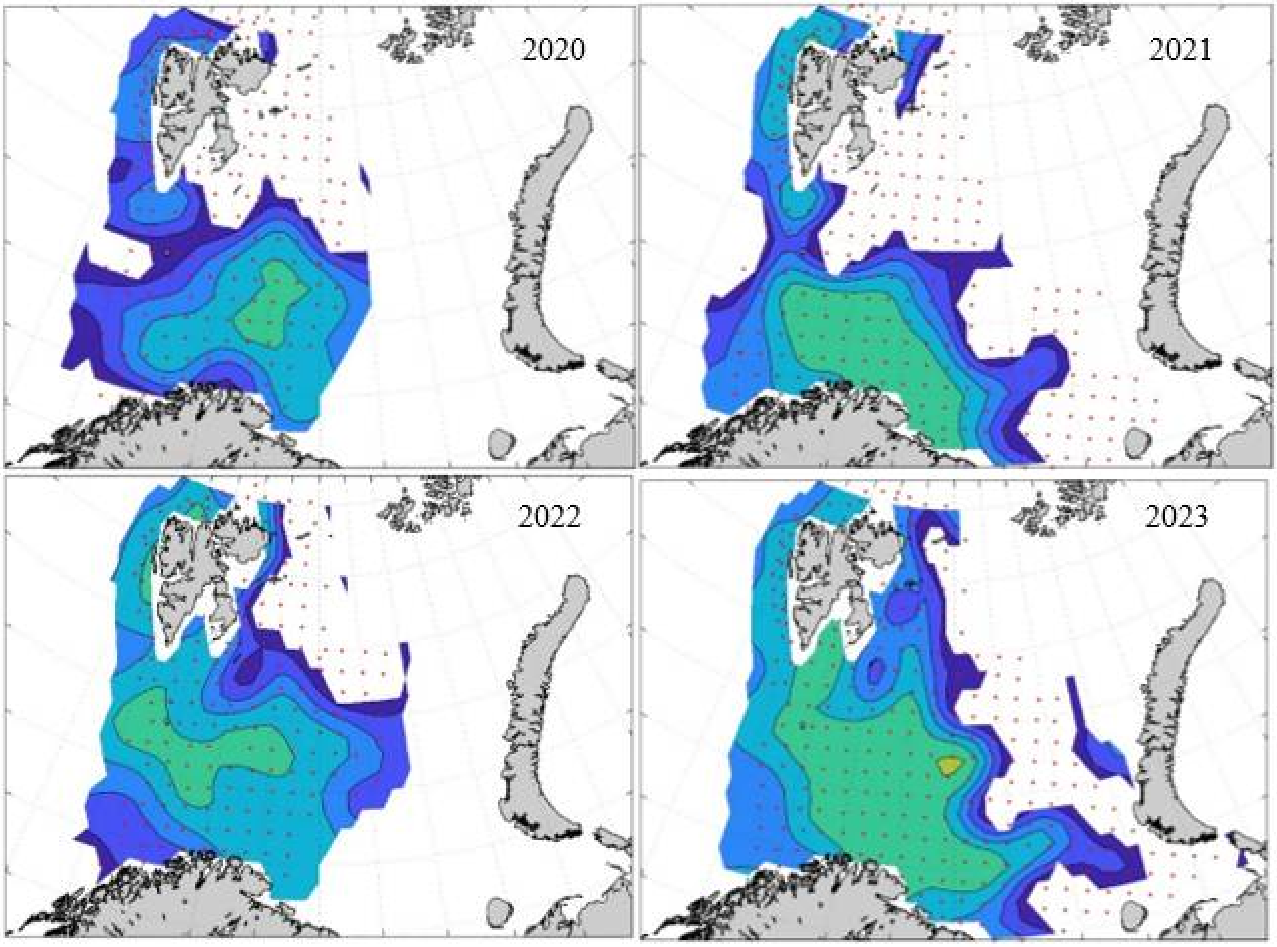
Figur 23. Distribution of 0-group haddock between 1996-2003.



Figur 24. Distribution of 0-group haddock between 2004-2011.

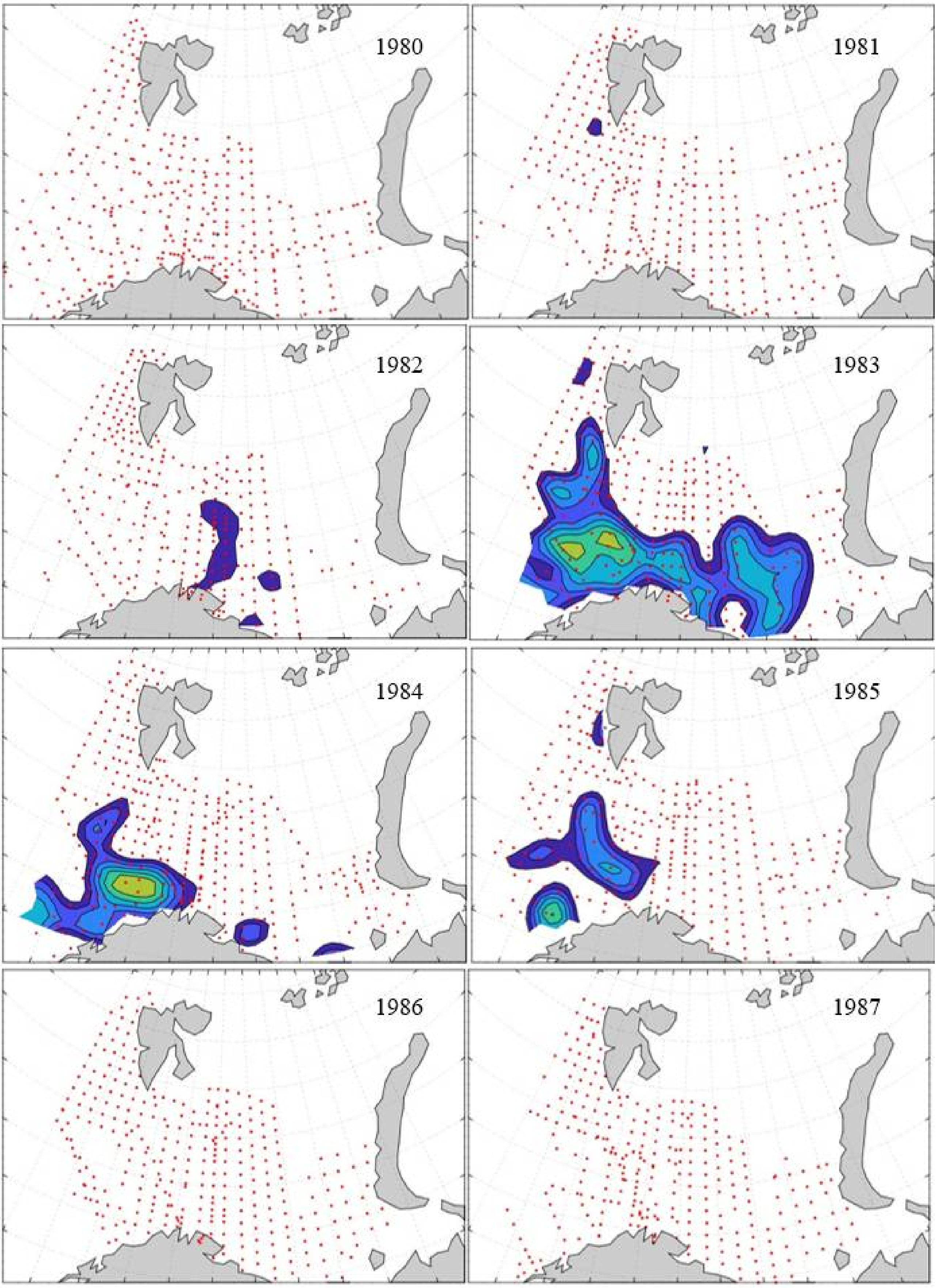


Figur 25. Distribution of 0-group haddock between 2012-2019.

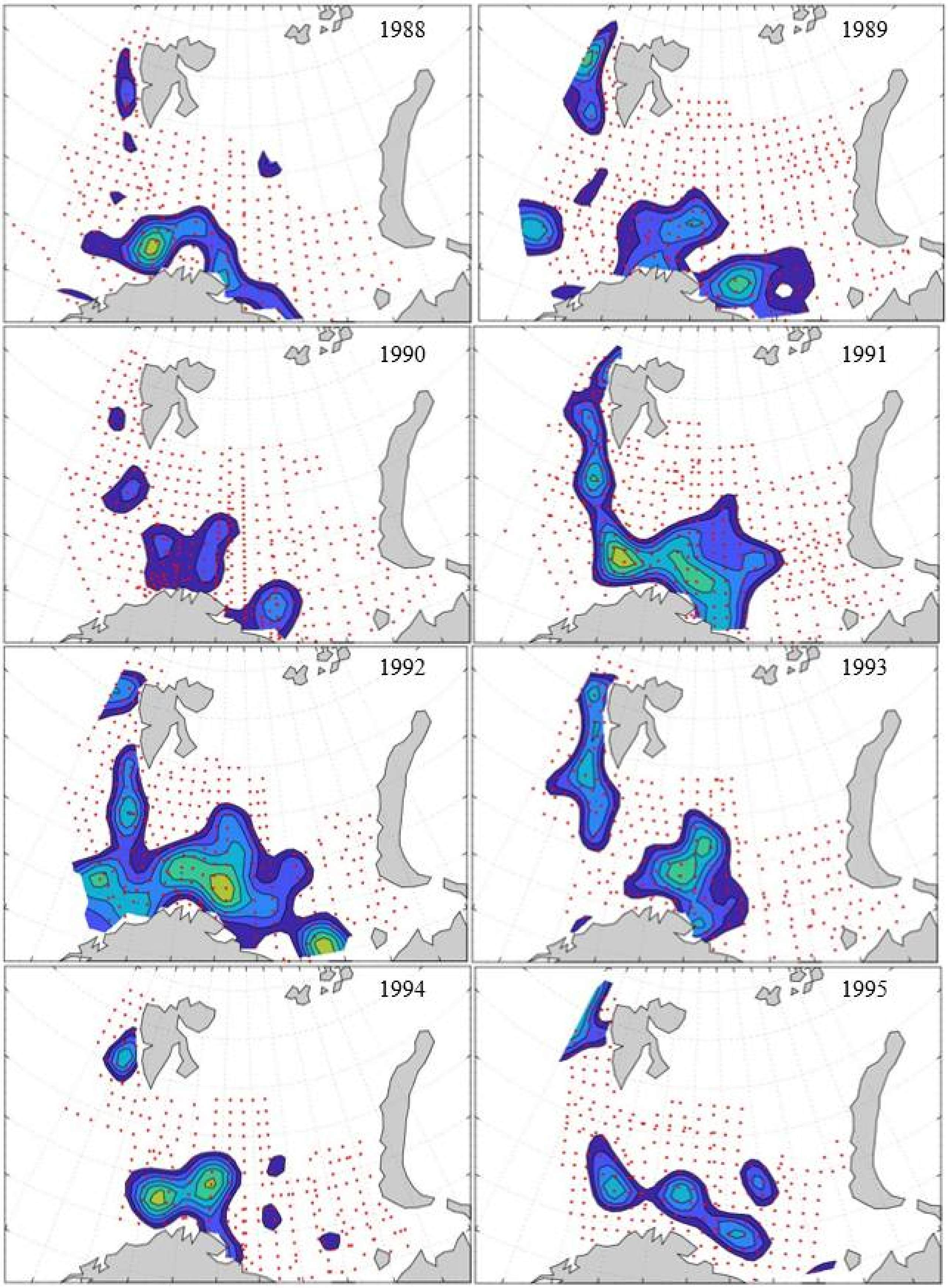


Figur 26. Distribution of 0-group haddock between 2020-2023.

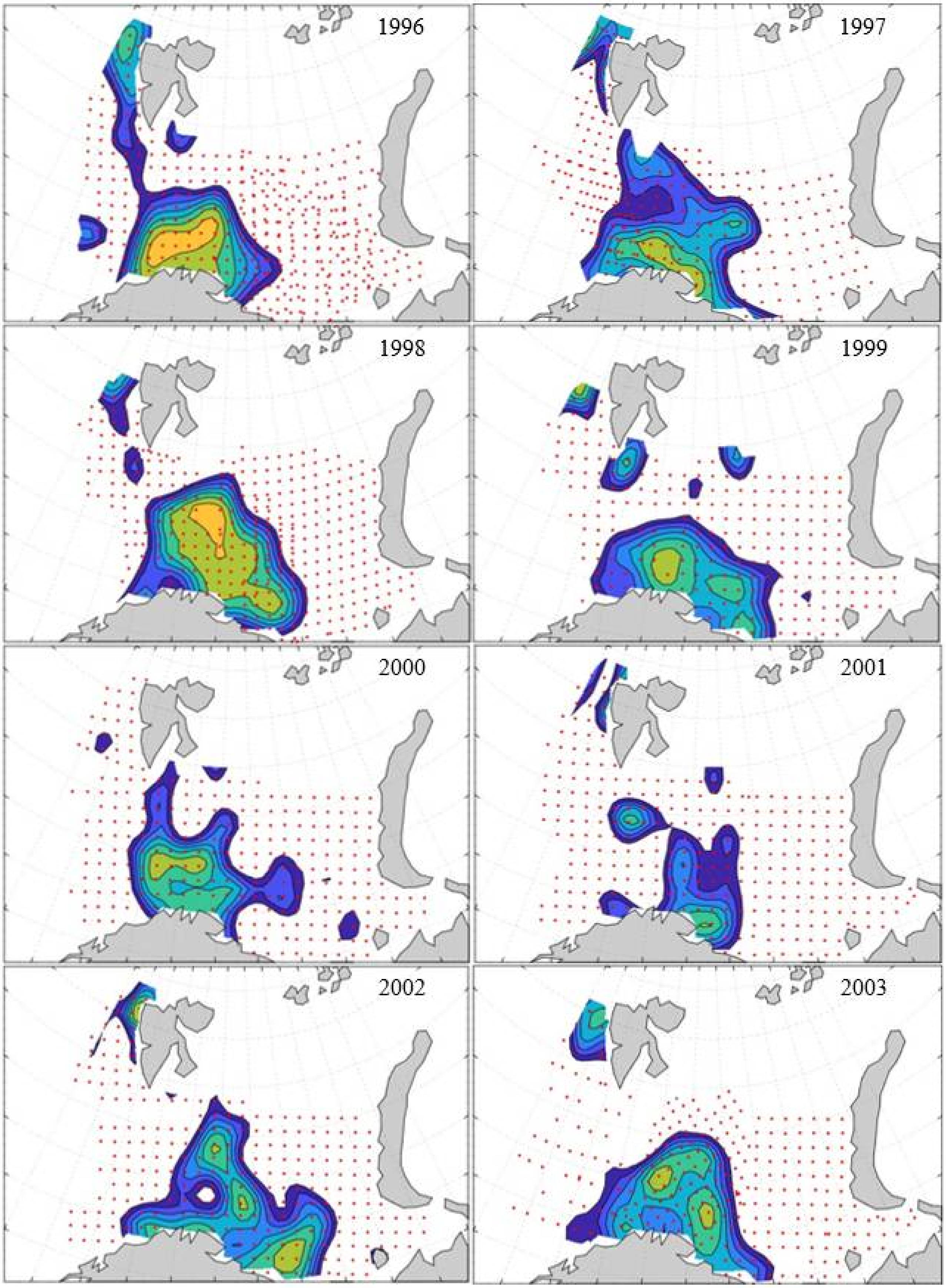
7.4 - Herring



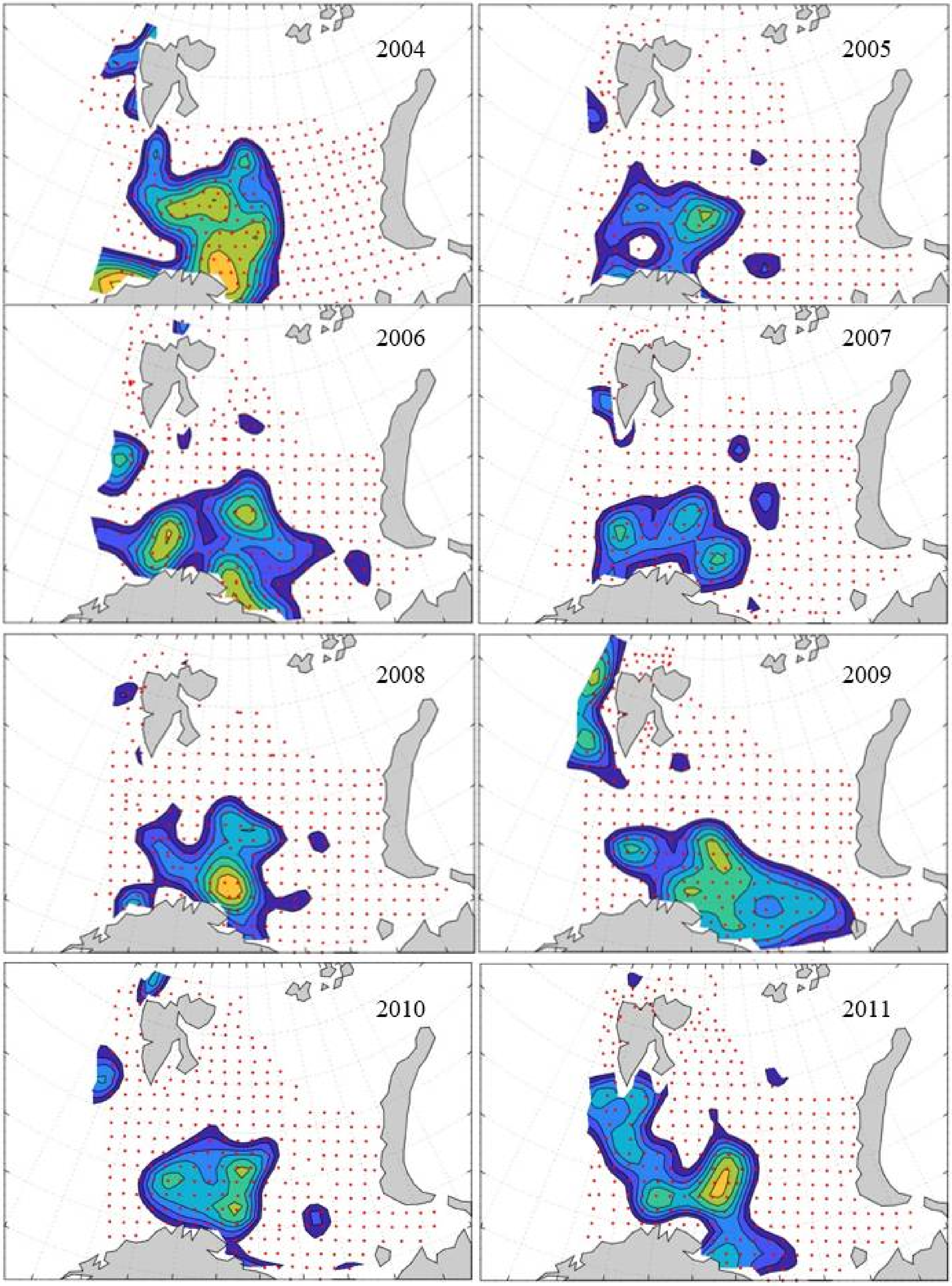
Figur 27. Distribution of 0-group herring between 1980-1987.



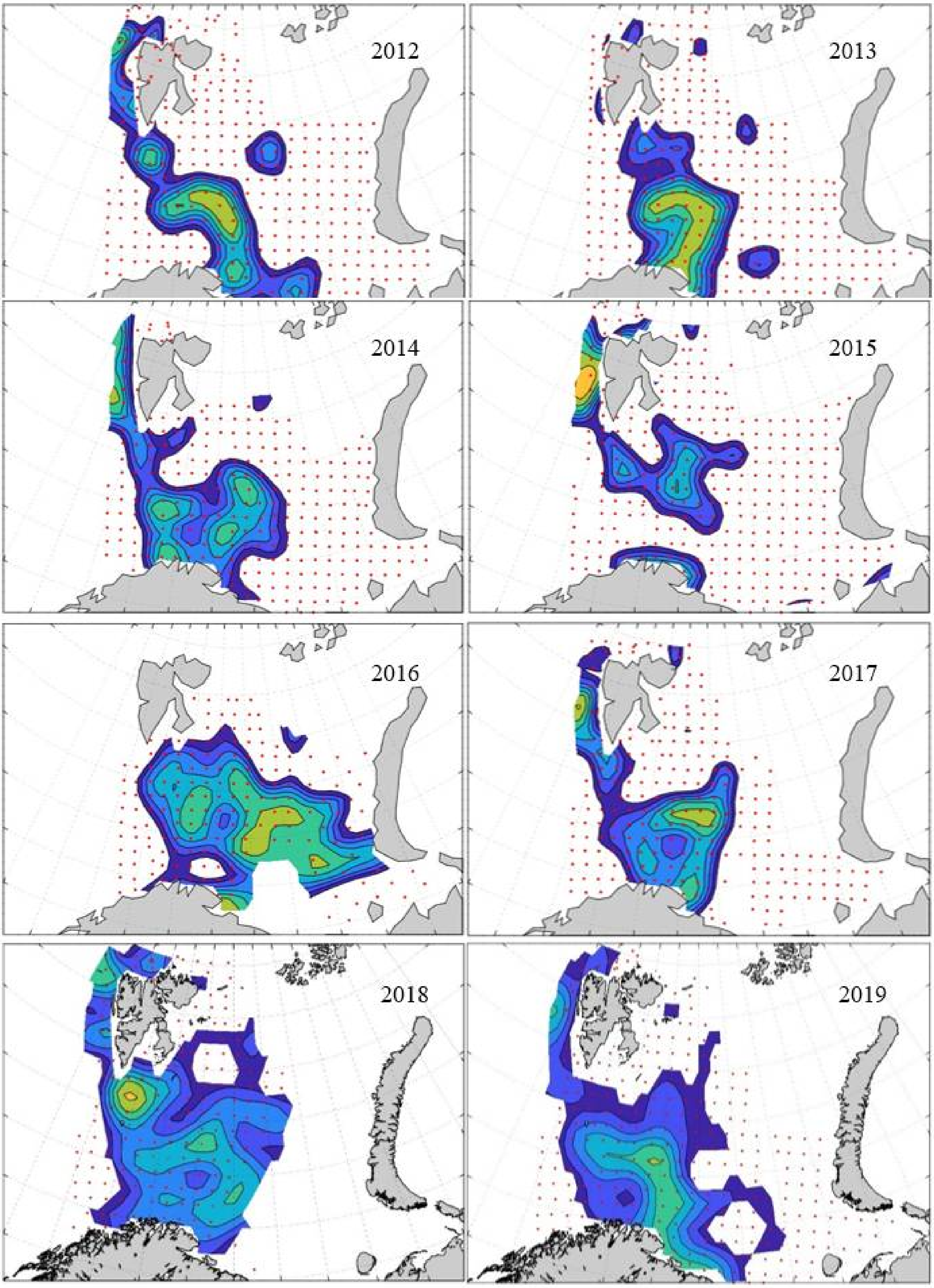
Figur 28. Distribution of 0-group herring between 1988-1995.



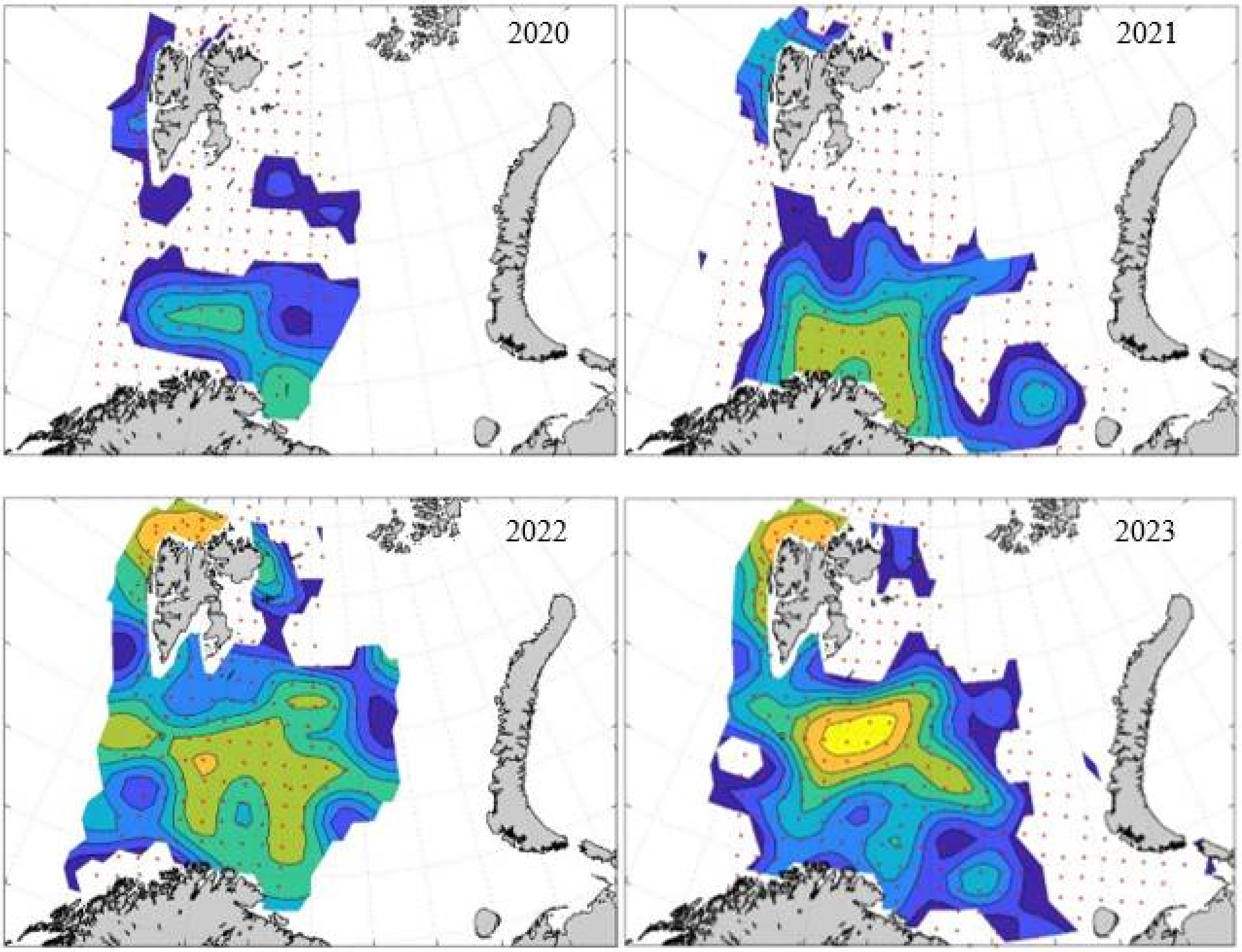
Figur 29. Distribution of 0-group herring between 1996-2003.



Figur 30. Distribution of 0-group herring between 2004-2011.

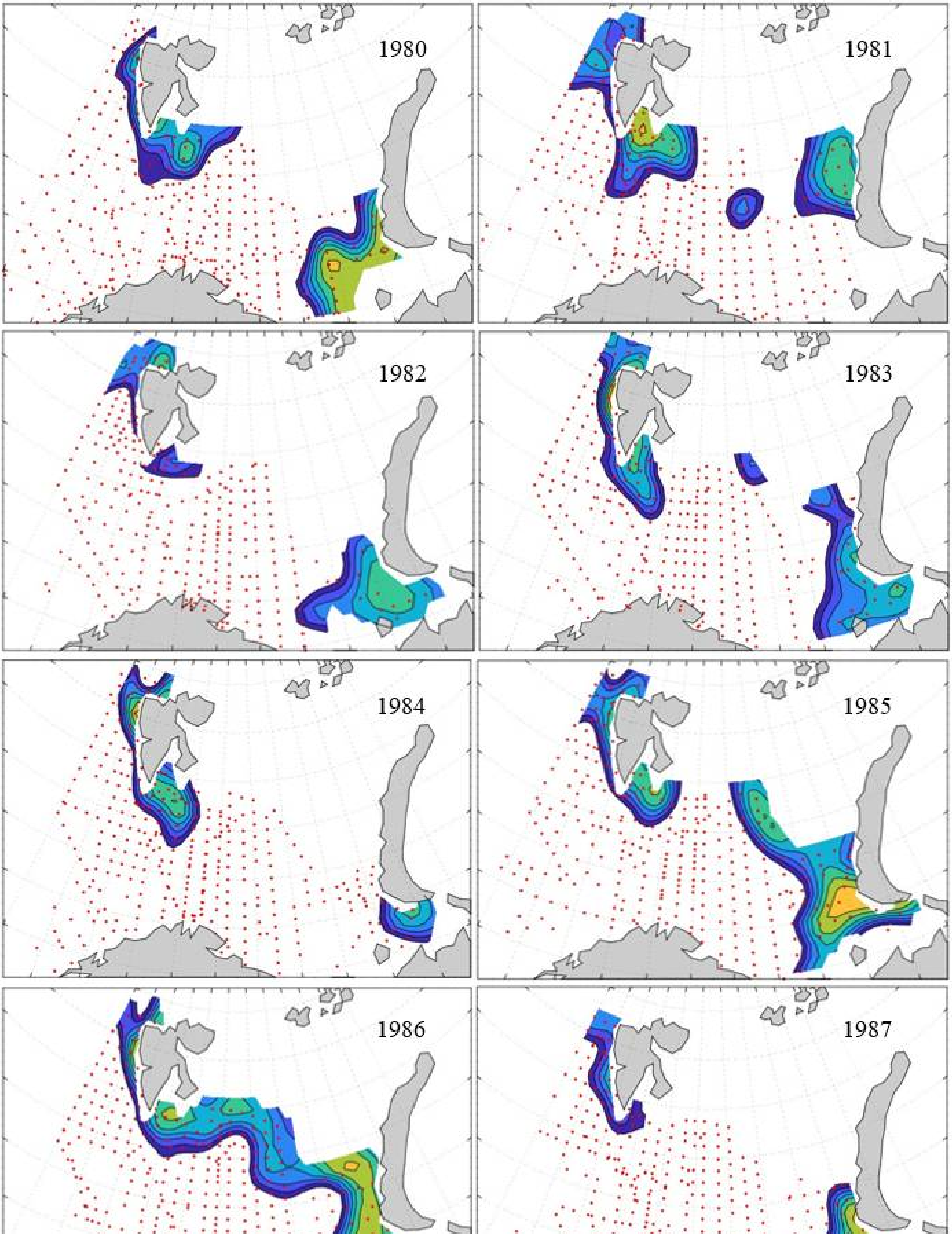


Figur 31. Distribution of 0-group herring between 2012-2019.

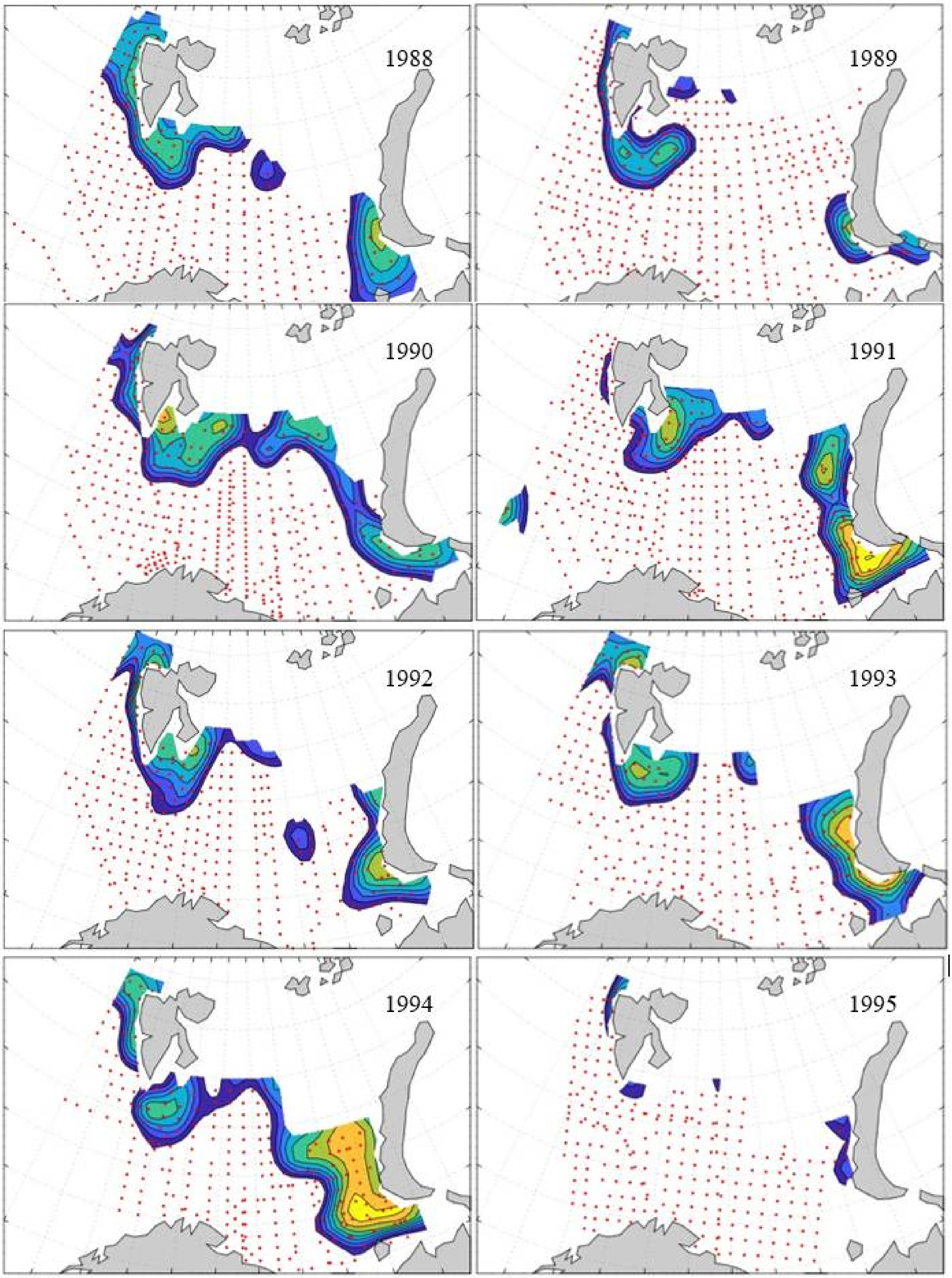


Figur 32. Distribution of 0-group herring between 2020-2023.

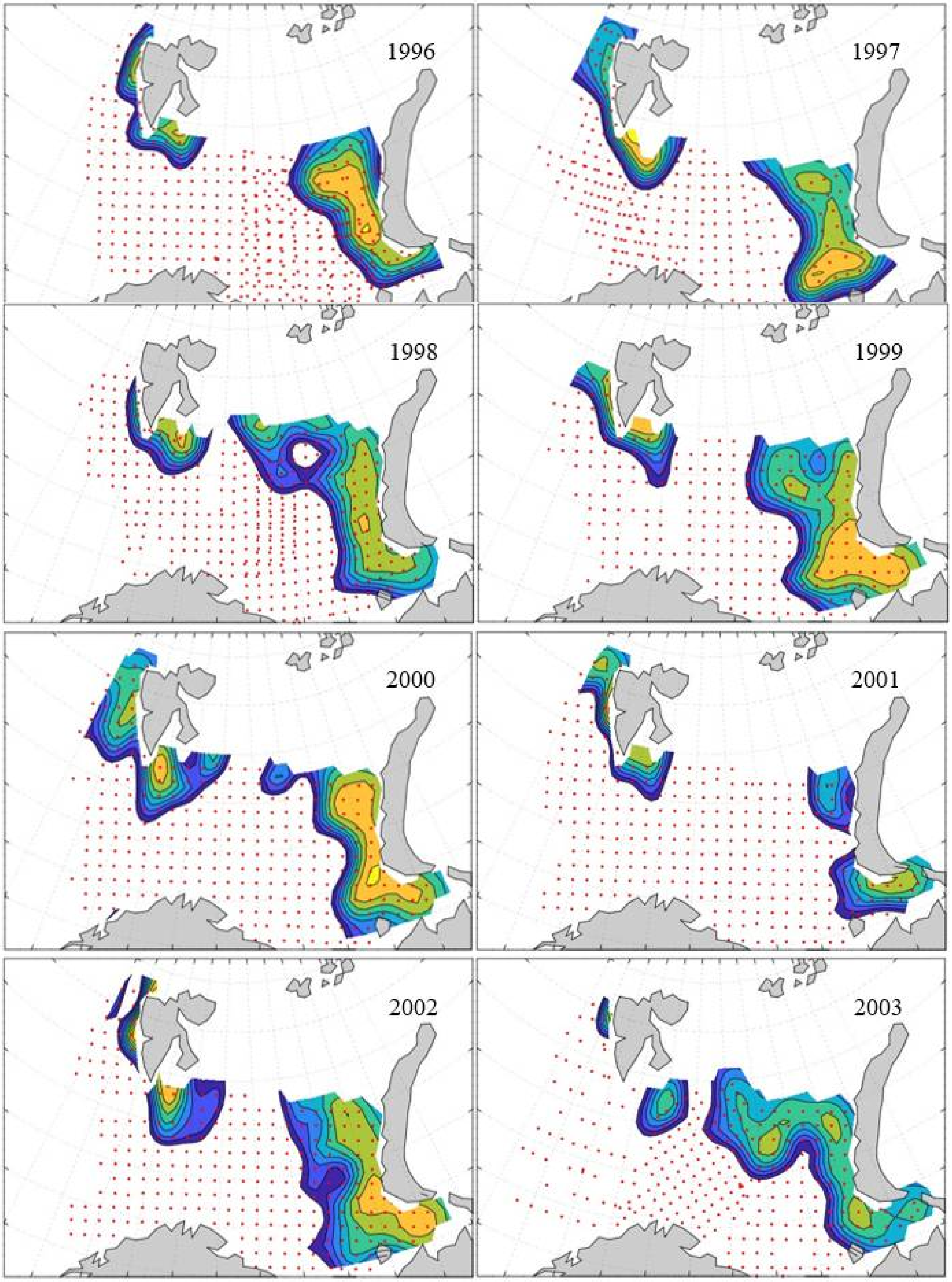
7.5 - Polar cod



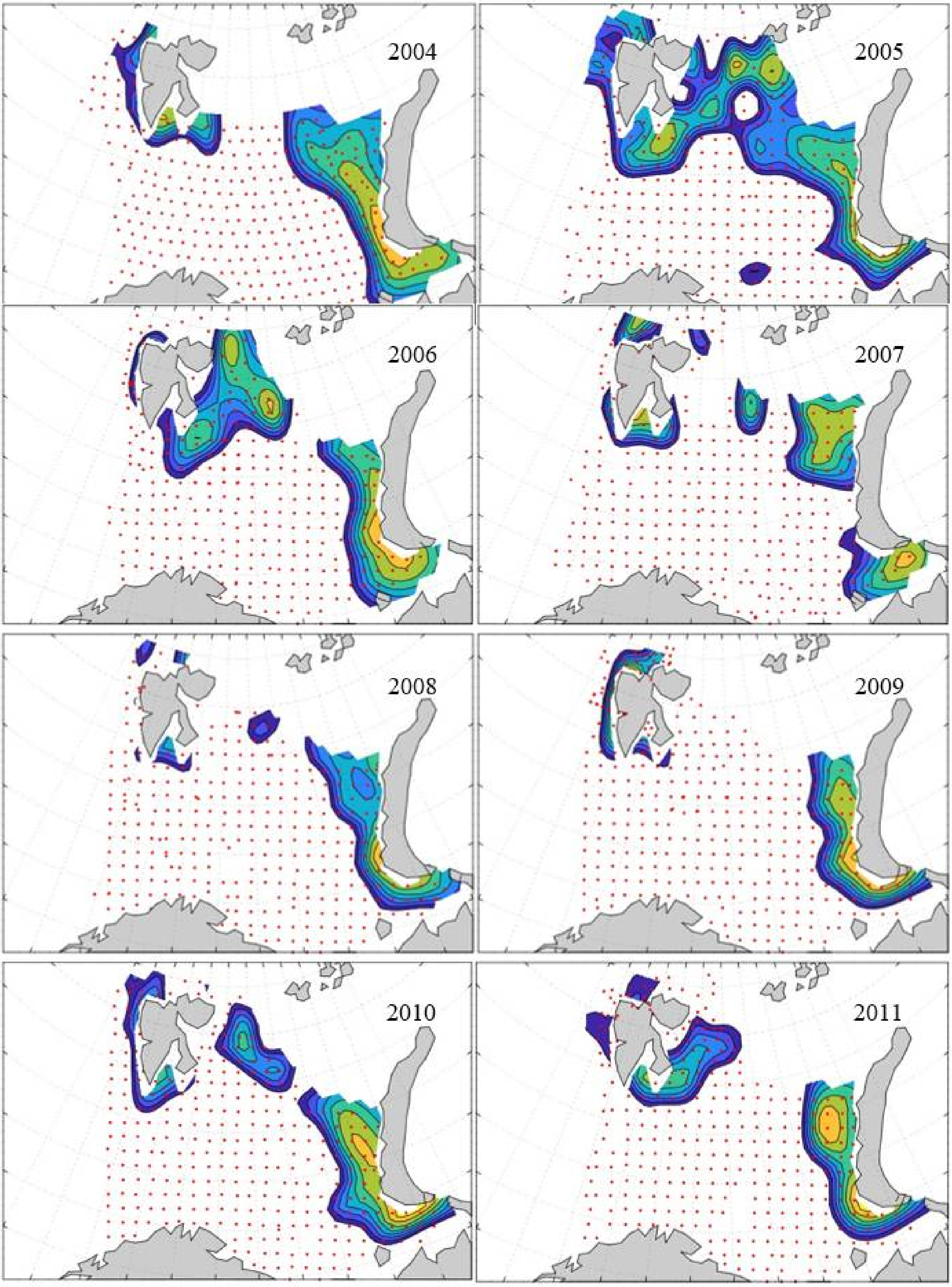
Figur 33. Distribution of 0-group polar cod between 1980-1987.



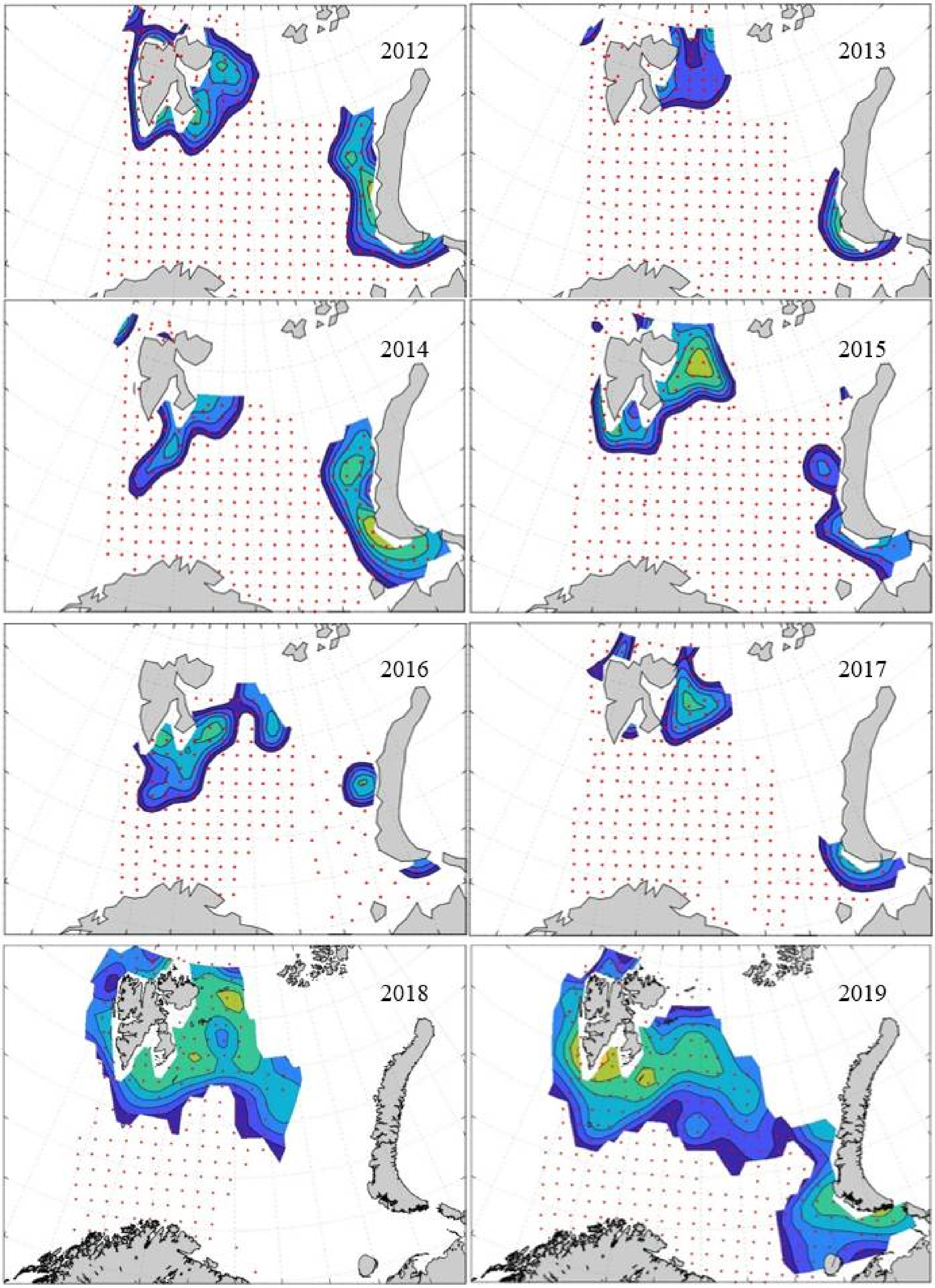
Figur 34. Distribution of 0-group polar cod between 1988-1995.



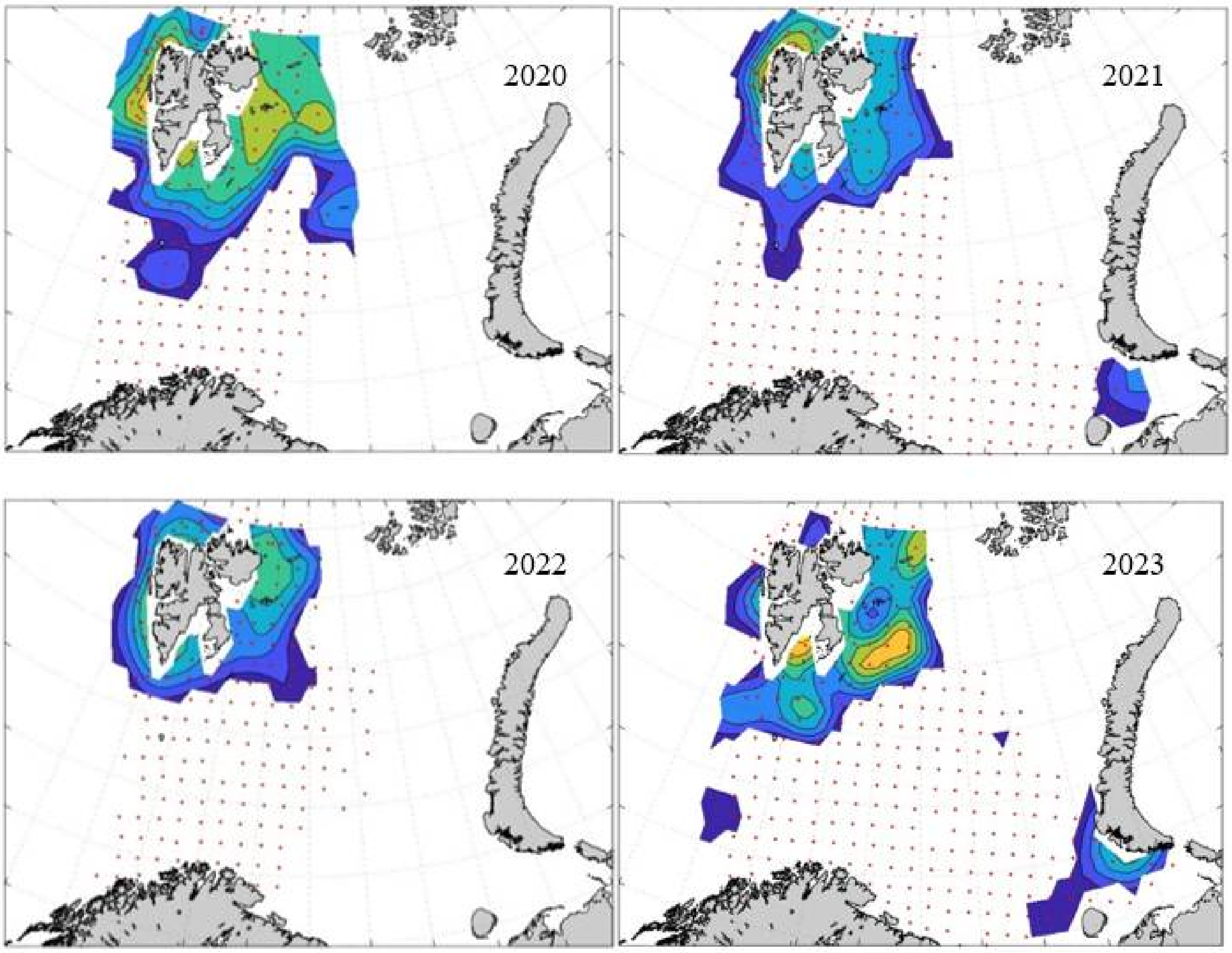
Figur 35. Distribution og 0-group polar cod between 1996-2003.



Figur 36. Distribution of 0-group polar cod between 2004-2011.

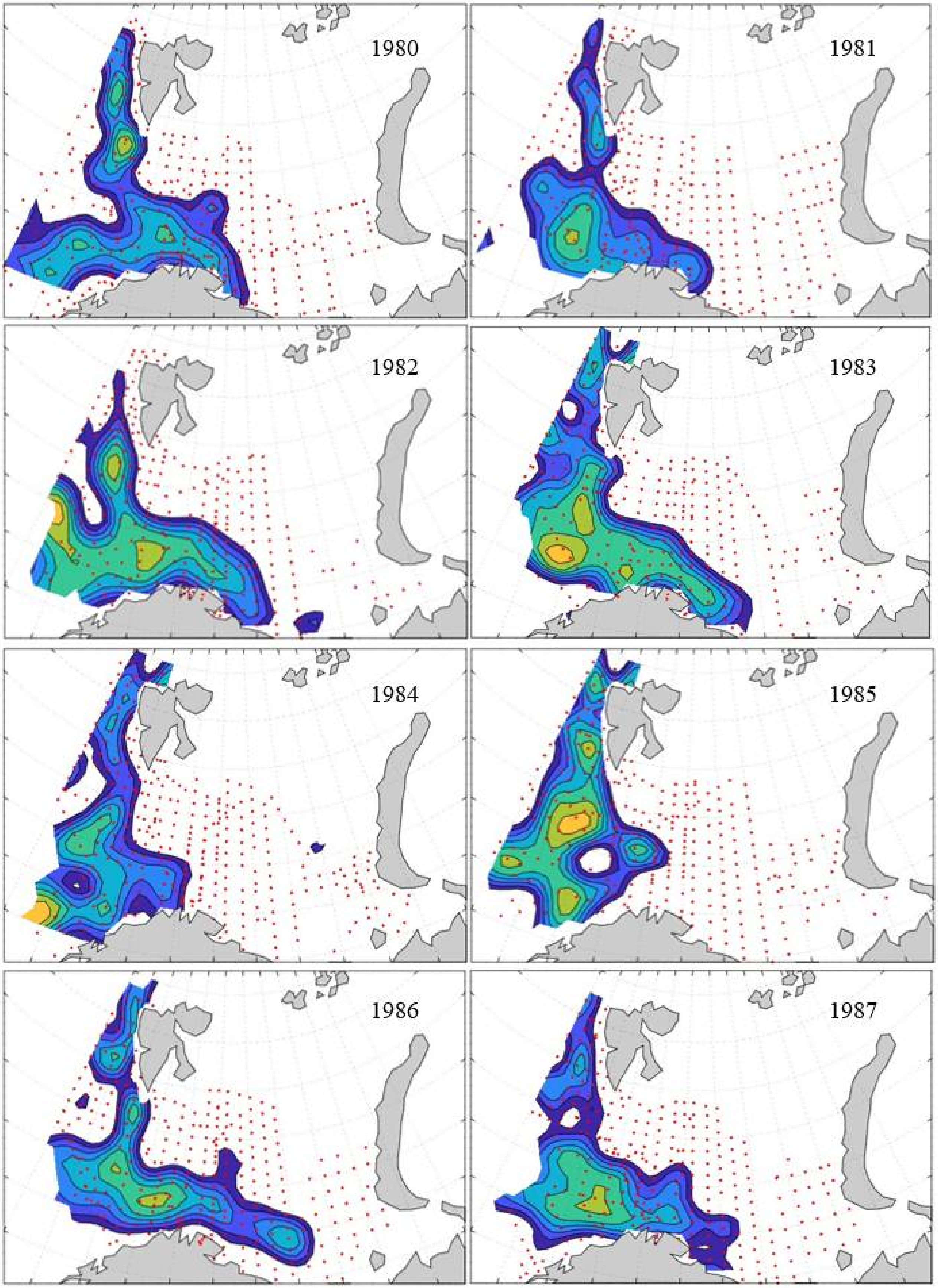


Figur 37. Distribution of 0-group polar cod between 2012-2019.

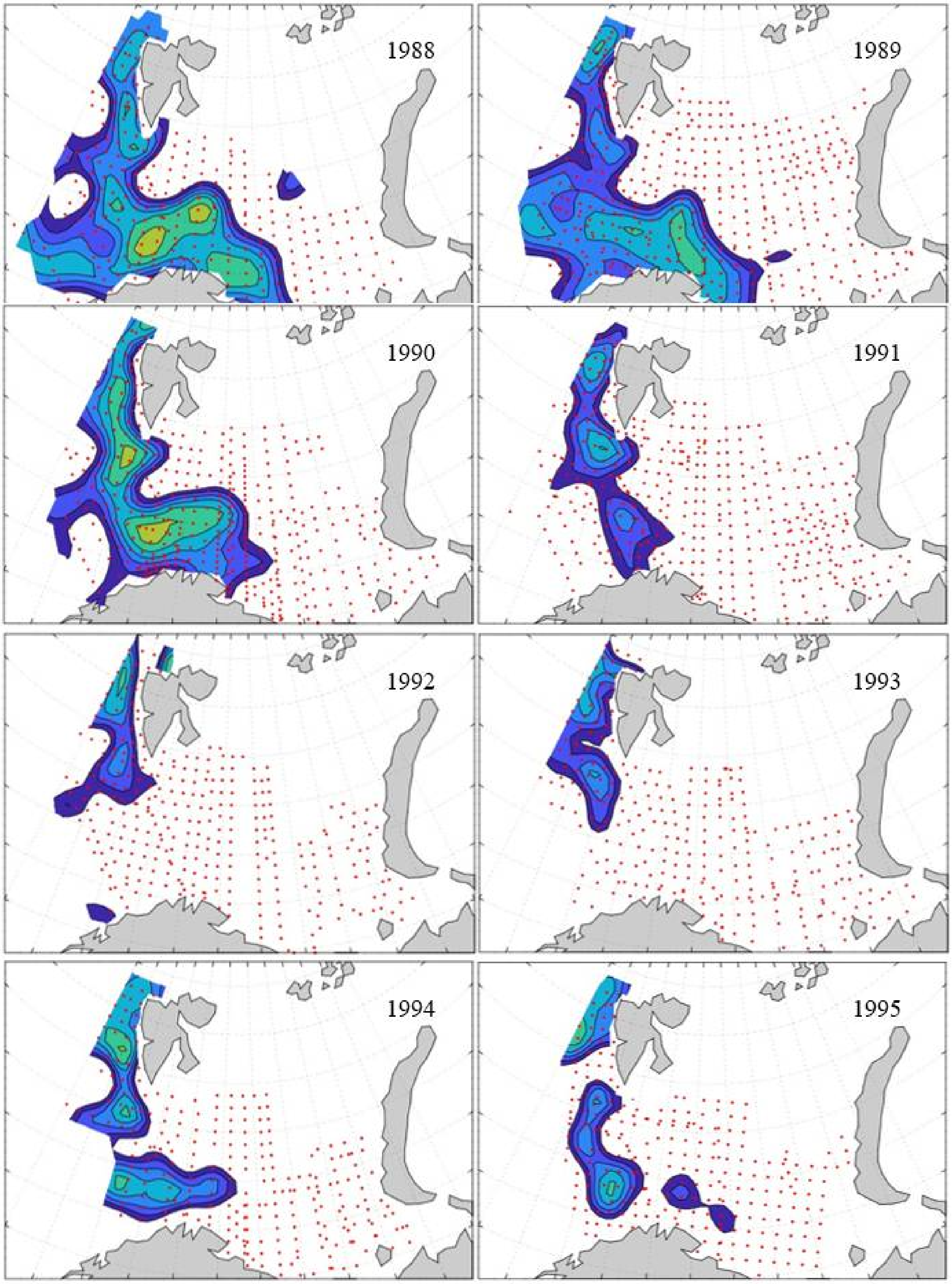


Figur 38. Distribution of 0-group polar cod between 2020-2023.

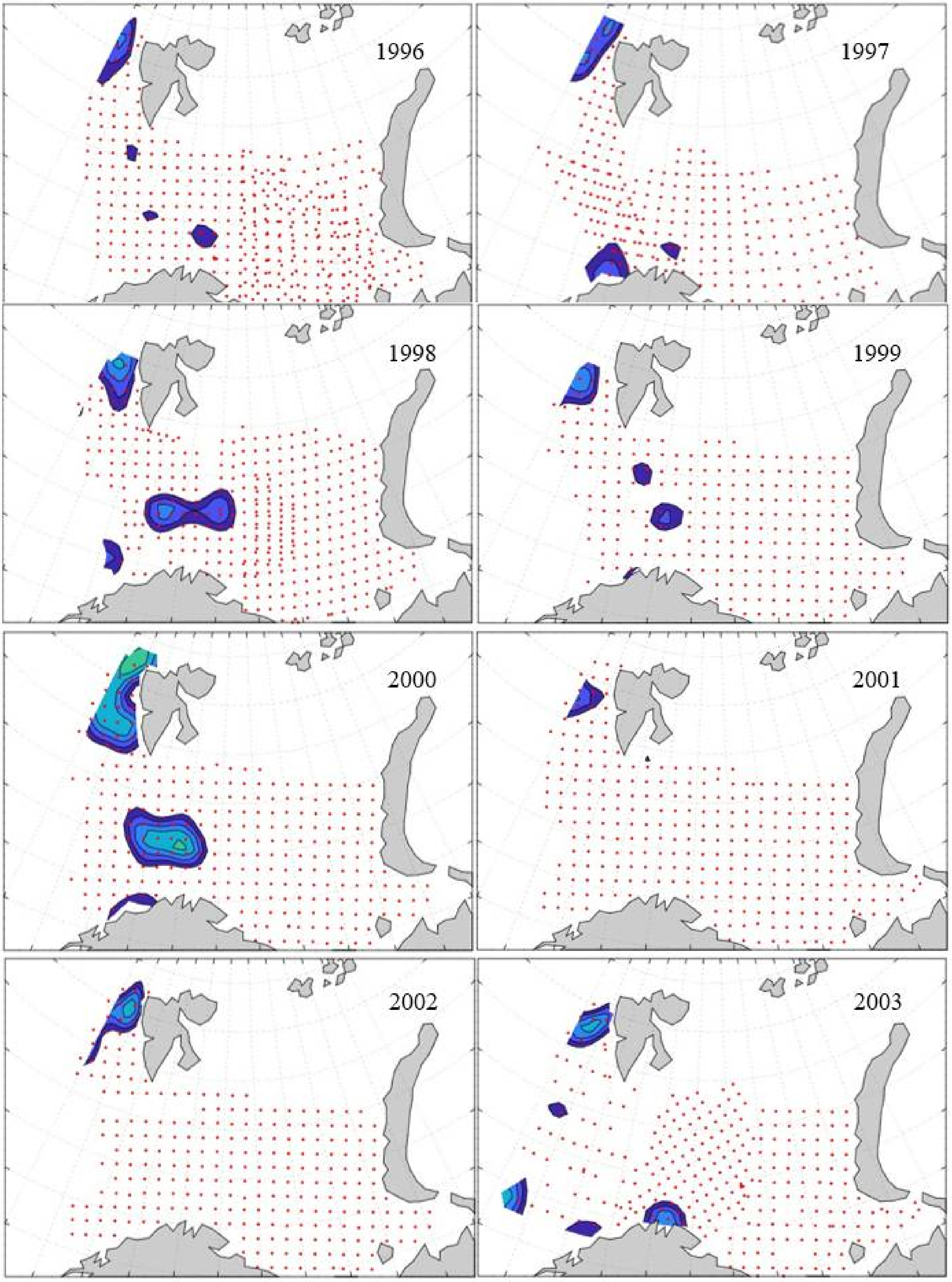
7.6 - Redfish



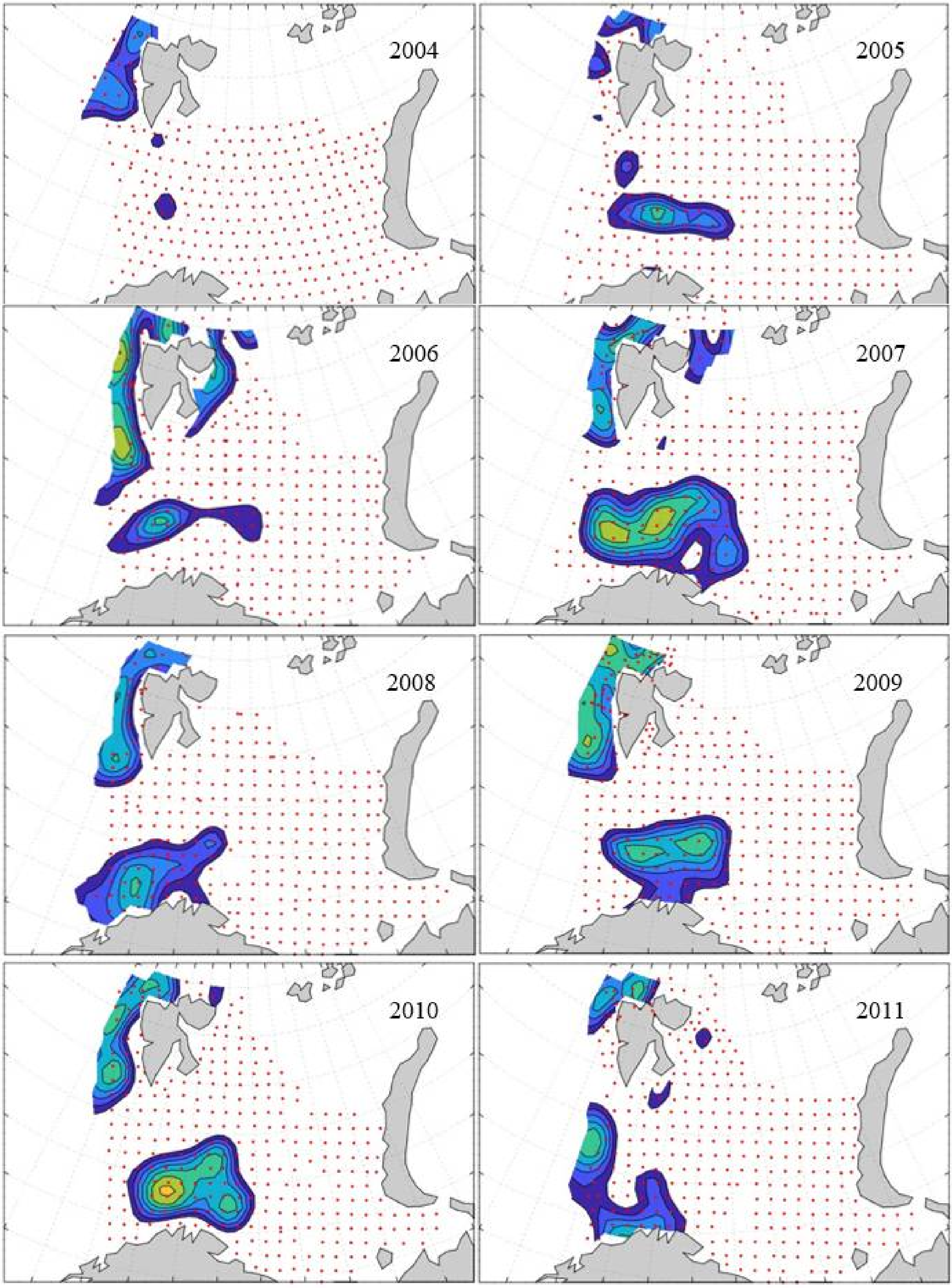
Figur 39. Distribution of 0-group redfish between 1980-1987.



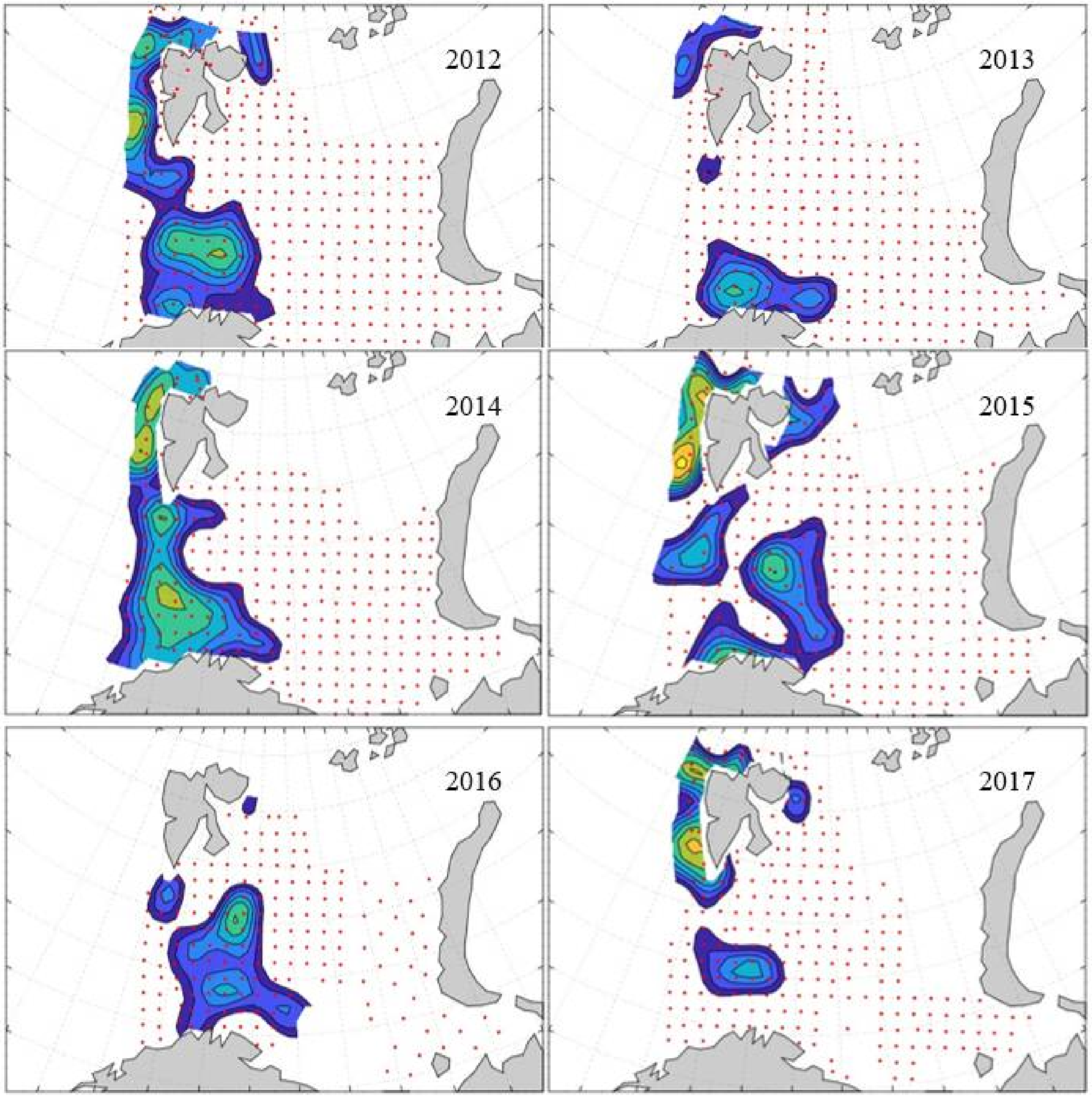
Figur 40. Distribution of 0-group redfish between 1988-1995.



Figur 41. Distribution of 0-group redfish between 1996-2003.



Figur 42. Distribution of 0-group redfish between 2004-2011.



Figur 43. Distribution of 0-group redfish between 2012-2017.

8 - Abundance and biomass indices

Abundance and biomass estimates were calculated by different software during the last for decades: SAS (for the 23 strata, see Fig. 3, 1980-2017), MatLab (for the new 15 TIBIA/WGIBAR- polygons (see Fig. 1, 1980-2018, WGIBAR 2018) and R (for the 15 WGIBAR- polygons (2003-2023).

8.1 - Indices calculated in SAS

Table 3. 0-group abundance indices (in millions) with 95% confidence limits, not corrected for capture efficiency. These indices have been reported to ICES WG groups (AFWG, WGWIDE and WGIBAR).

Year	Capelin			Cod			Haddock			
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundanc index
1980	197278	131674	262883	72	38	105	59	38	81	
1981	123870	71852	175888	48	33	64	15	7	22	
1982	168128	35275	300982	651	466	835	649	486	812	20
1983	100042	56325	143759	3924	1749	6099	1356	904	1809	4055
1984	68051	43308	92794	5284	2889	7679	1295	937	1653	631
1985	21267	1638	40896	15484	7603	23365	695	397	992	723
1986	11409	98	22721	2054	1509	2599	592	367	817	
1987	1209	435	1983	167	86	249	126	76	176	
1988	19624	3821	35427	507	296	718	387	157	618	868
1989	251485	201110	301861	717	404	1030	173	117	228	419
1990	36475	24372	48578	6612	3573	9651	1148	847	1450	950
1991	57390	24772	90007	10874	7860	13888	3857	2907	4807	8117
1992	970	105	1835	44583	24730	64437	1617	1150	2083	3718
1993	330	125	534	38015	15944	60086	1502	911	2092	6150
1994	5386	0	10915	21677	11980	31375	1695	825	2566	1488
1995	862	0	1812	74930	38459	111401	472	269	675	130
1996	44268	22447	66089	66047	42607	89488	1049	782	1316	5716
1997	54802	22682	86922	67061	49487	84634	600	420	780	4580
1998	33841	21406	46277	7050	4209	9890	5964	3800	8128	7949
1999	85306	45266	125346	1289	135	2442	1137	368	1906	1593
2000	39813	1069	78556	26177	14287	38068	2907	1851	3962	4961
2001	33646	0	85901	908	152	1663	1706	1113	2299	84
2002	19426	10648	28205	19157	11015	27300	1843	1276	2410	2335

2003	94902	41128	148676	17304	10225	24383	7910	3757	12063	2857
2004	16901	2619	31183	19408	14119	24696	19372	12727	26016	**13605**
2005	42354	12517	72192	21789	14947	28631	**33637**	24645	42630	2653
2006	168059	103577	232540	7801	3605	11996	11209	7413	15005	6853
2007	161594	87683	235504	9896	5993	13799	2873	1820	3925	2231
2008	288799	178860	398738	52975	31839	74111	2742	830	4655	1591
2009	189747	113135	266360	54579	37311	71846	13040	7988	18093	1891
2010	91730	57545	125914	40635	20307	60962	7268	4530	10006	2036
2011	175836	3876	347796	**119736**	66423	173048	7441	5251	9631	1367
2012	**310519**	225728	395311	105176	37917	172435	1814	762	2866	2648
2013	94673	28224	161122	90108	62788	117428	7235	4721	9749	7097
2014	48933	5599	92267	102977	72975	132980	4185	2217	6153	1667
2015	147961	87971	207951	8744	3008	14479	6005	2816	9194	1120
2016	274050	157185	390915	16872	9942	23801	4029	1952	6107	3295
2017	72486	36535	108438	69371	46841	91901	9205	6081	12329	3211
Mean	93511			30280			4442			2858
Median	62721			17088			1760			1964

Table 4. 0-group abundance indices (in millions) with 95% confidence limits, not corrected for capture efficiency. These indices have been reported to ICES WG groups (AFWG, WGWIDE and WGIBAR).

Year	Saithe			Gr halibut			Long rough dab			Polar cod (eas
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confide
1980	3	0	6	111	35	187	1273	883	1664	28958	9784
1981	0	0	0	74	46	101	556	300	813	595	226
1982	143	0	371	39	11	68	1013	698	1328	1435	144
1983	239	83	394	41	22	59	420	264	577	1246	0
1984	1339	407	2271	31	18	45	60	43	77	127	0
1985	12	1	23	48	29	67	265	110	420	19220	4989
1986	1	0	2	**112**	60	164	**6846**	4941	8752	12938	2355
1987	1	0	1	35	23	47	804	411	1197	7694	0

1988	17	4	30	8	3	13	205	113	297	383	9
1989	1	0	3	1	0	3	180	100	260	199	0
1990	11	2	20	1	0	2	55	26	84	399	129
1991	4	2	6	1	0	2	90	49	131	88292	39856
1992	159	86	233	9	0	17	121	25	218	7539	0
1993	366	0	913	4	2	7	56	25	87	41207	0
1994	2	0	5	39	0	93	1696	1083	2309	**267997**	151917
1995	148	68	229	15	5	24	229	39	419	1	0
1996	131	57	204	6	3	9	41	2	79	70134	43196
1997	78	37	120	5	3	7	97	44	150	33580	18788
1998	86	39	133	8	3	12	27	13	42	11223	6849
1999	136	68	204	14	8	21	105	1	210	129980	82936
2000	206	111	301	43	17	69	233	120	346	116121	67589
2001	20	0	46	51	20	83	162	78	246	3697	658
2002	553	108	998	51	0	112	731	342	1121	96954	57530
2003	65	0	146	13	0	34	78	45	110	11211	6100
2004	**1400**	865	1936	72	29	115	36	20	52	37156	19040
2005	55	37	74	10	4	15	200	109	291	6545	3202
2006	139	56	221	11	2	21	707	434	979	26016	9997
2007	53	6	100	1	0	2	262	46	479	25883	8494
2008	45	22	69	6	0	13	956	410	1502	6649	845
2009	22	0	46	7	4	10	115	51	179	23570	9661
2010	402	126	678	14	8	20	128	18	238	31338	13644
2011	27	0	59	20	11	29	58	23	93	37431	15083
2012	69	2	135	30	16	43	173	0	416	4173	48
2013	3	1	5	21	13	28	5	0	14	1634	0
2014	1	0	2	10	3	16	309	89	528	2779	737
2015	47	0	101	27	2	52	575	361	789	128	18
2016	3	0	7	6	1	12	601	0	1267	258	0
2017	127	2	252	8	1	14	72	27	117	43	0
Mean	161			26			514			30388	
Median	54			14			190			9453	

Table 5. 0-group abundance indices (in millions) with 95% confidence limits, corrected for capture efficiency. These indices have been reported to ICES WG groups (AFWG, WGWIDE and WGIBAR).

Year	Capelin			Cod			Haddock			
	Abundance index	Confidence limit		Abundance index	Confidence limit		Abundance index	Confidence limit		Abundar index
1980	740289	495187	985391	276	131	421	265	169	361	
1981	477260	273493	681026	289	201	377	75	34	117	
1982	599596	145299	1053893	3480	2540	4421	2927	2200	3655	2
1983	340200	191122	489278	19299	9538	29061	6217	3978	8456	195
1984	275233	161408	389057	24326	14489	34164	5512	3981	7043	27
1985	63771	5893	121648	66630	32914	100346	2457	1520	3393	20
1986	41814	642	82986	10509	7719	13299	2579	1621	3537	
1987	4032	1458	6607	1035	504	1565	708	432	984	
1988	65127	12101	118153	2570	1519	3622	1661	630	2693	60
1989	862394	690983	1033806	2775	1624	3925	650	448	852	17
1990	115636	77306	153966	23593	13426	33759	3122	2318	3926	15
1991	169455	74078	264832	40631	29843	51419	13713	10530	16897	267
1992	2337	250	4423	166276	92113	240438	4739	3217	6262	83
1993	952	289	1616	133046	58312	207779	3785	2335	5236	291
1994	13898	70	27725	70761	39933	101589	4470	2354	6586	103
1995	2869	0	6032	233885	114258	353512	1203	686	1720	11
1996	136674	69801	203546	280916	188630	373203	2632	1999	3265	549
1997	189372	80734	298011	294607	218967	370247	1983	1391	2575	463
1998	113390	70516	156263	24951	15827	34076	14116	9524	18707	476
1999	287760	143243	432278	4150	944	7355	2740	1018	4463	35
2000	140837	6551	275123	108093	58416	157770	10906	6837	14975	469
2001	90181	0	217345	4150	798	7502	4649	3189	6109	10
2002	67130	36971	97288	76146	42253	110040	4381	2998	5764	151
2003	340877	146178	535575	81977	47715	116240	30792	15352	46232	177
2004	53950	11999	95900	65969	47743	84195	39303	26359	52246	773
2005	148466	51669	245263	72137	50662	93611	91606	67869	115343	125
2006	515770	325776	705764	25061	11469	38653	28505	18754	38256	294
2007	480069	272313	687825	42628	26652	58605	8401	5587	11214	144

2008	995101	627202	1362999	234144	131081	337208	9864	1144	18585	201
2009	673027	423386	922668	185457	123375	247540	33339	19707	46970	104
2010	318569	201973	435166	135355	68199	202511	23669	14503	32834	117
2011	594248	58009	1130487	448005	251499	644511	19114	14209	24018	83
2012	988600	728754	1248445	410757	170242	651273	5281	2626	7936	177
2013	316020	127310	504731	385430	269640	501219	16665	11161	22169	289
2014	163630	31980	295280	464124	323330	604919	11765	6160	17371	136
2015	457481	274631	640331	37474	17244	57704	15089	6204	23973	82
2016	778784	479130	1078438	53796	30970	76622	5504	2791	8216	79
2017	213787	112459	315115	233275	150239	316310	19484	12902	26067	153
LTM	314184			114452			11740			163

8.2 - Indices calculated in MatLab

Table 6. TIBIA indices (spatial abundance indices, for description see the ICES WGIBAR report 2018). See Fig. 1 for geographical location of the polygons.

Cod	South West	Bear Island Trench	Thor Iversen Bank	Hopen Deep	Svalbard South	Svalbard North	South East	Pechora	Southeastern Basin
1980	14	105	17	9	23	77	308	2	1
1981	60	76	21	4	40	36	58	9	2
1982	681	821	831	84	79	158	280	78	118
1983	3834	9218	2158	2378	1963	607	419	261	837
1984	2831	10005	620	277	3207	3450	153	407	241
1985	8493	18649	17373	2496	1768	4114	870	3293	1656
1986	1924	915	2458	992	350	828	3255	731	458
1987	651	142	62	4	17	30	78	11	4
1988	1695	193	84	57	35	23	203	28	31
1989	220	132	106	289	88	24	884	226	859
1990	11078	7475	2794	537	331	172	1681	141	174
1991	4695	11160	5986	2011	9673	2687	437	529	3562
1992	8054	89406	22281	15198	27081	9933	1243	8158	3896
1993	8305	52603	6285	27191	12251	23728	1145	1017	670

1994	35784	25071	25861	592	1638	1312	5783	1294	1741
1995	39488	127900	41212	32416	13179	6412	4924	8697	2971
1996	109606	79362	67857	19478	3007	1135	36476	5406	7629
1997	109864	90949	72791	33075	2304	1194	40852	3210	8427
1998	8241	9301	3688	2357	1580	375	3358	212	353
1999	3386	799	712	298	419	135	94	25	44
2000	50934	50590	15260	719	3150	1511	4827	3318	4164
2001	100	436	148	978	566	3285	25	15	30
2002	4144	4638	16823	4247	2240	3641	7749	13484	20847
2003	21667	35319	15673	2070	3316	3853	173	331	445
2004	4068	13373	33009	9136	3233	411	1520	2453	7767
2005	11557	31115	18420	6372	3130	1095	238	292	381
2006	2257	17266	2165	1088	3105	670	80	245	112
2007	23416	18297	4271	638	927	170	392	243	134
2008	100687	81327	39620	15985	2162	387	13314	1267	5033
2009	62546	48804	33402	12376	10941	3214	4518	1790	11189
2010	55299	38258	48624	2931	693	236	5952	6106	2243
2011	60634	80339	56483	49804	79384	80504	6668	1276	1068
2012	113561	53296	187437	10932	8784	2381	40446	16052	33580
2013	14183	24469	86007	47430	124718	11069	4150	5500	22959
2014	107234	99179	200391	57055	21080	3377	2089	2347	4358
2015	11742	3756	9561	7827	1116	1176	2677	5026	1395
2016	1355	235	11134	395	409	1244	725	7694	40237

Table 7. TIBIA indices (spatial abundance indices, for description see the ICES WGIBAR report 2018). See Fig. 1 for geographical location of the polygons.

Haddock	South West	Bear Island Trench	Thor Iversen Bank	Hopen Deep	Svalbard South	Svalbard North	South East	Pechora	Southeas Basir
1980	38	118	14	2	58	51	1072	3	
1981	8	35	1	715	10	17	1078	1	
1982	327	1182	513	86	111	253	22	56	

1983	1873	2247	537	368	553	236	102	53
1984	1625	1462	131	66	997	710	12	47
1985	904	448	598	30	18	166	44	22
1986	868	512	383	282	48	15	350	54
1987	353	182	73	9	14	6	9	8
1988	1052	339	31	11	16	13	13	19
1989	138	233	104	76	23	27	20	3
1990	821	1114	446	100	214	80	100	12
1991	2222	4126	381	89	3886	1501	54	45
1992	933	2036	1854	260	262	121	98	61
1993	435	1885	188	970	344	123	5	12
1994	2609	1115	981	51	141	52	183	42
1995	242	555	235	266	69	94	4	33
1996	1416	227	149	19	36	16	130	29
1997	1183	484	271	139	168	27	120	22
1998	6910	5457	1602	1969	1527	692	220	82
1999	1434	732	1041	175	91	147	72	13
2000	5270	5635	919	105	393	586	216	68
2001	904	2339	541	238	463	386	20	10
2002	605	1626	516	414	745	2324	16	19
2003	7663	15314	2229	479	1089	4835	46	61
2004	22112	15476	3325	2387	1828	187	2015	217
2005	27758	31640	14462	10324	4741	704	359	311
2006	3194	15846	5466	1649	2193	1448	42	271
2007	4467	2866	779	386	78	79	59	42
2008	5858	4253	531	272	92	92	93	31
2009	16348	10001	4044	1310	804	215	434	167
2010	10937	12642	1286	140	104	203	33	90
2011	4643	6451	1127	1076	2939	2531	38	56
2012	662	2580	1648	334	191	82	95	41
2013	4061	3407	1381	892	4613	1713	125	38

2014	1595	8233	704	143	1349	147	20	44
2015	2145	5922	3850	5585	584	238	110	66
2016	2109	1548	1221	664	234	126	208	77
2017	8552	6048	1509	758	1841	669	608	270

Table 8. TIBIA indices (spatial abundance indices, for description see the ICES WGIBAR report 2018). See Fig. 1 for geographical location of the polygons.

Herring	South West	Bear Island Trench	Thor Iversen Bank	Hopen Deep	Svalbard South	Svalbard North	South East	Pechora	Southeastern Basin	C
1980	18	15	35	2	3	2	1	1596	1	
1981	1151	2	490	0	13	13	0	2596	419	
1982	406	104	110	20	17	17	128	66	48	
1983	81526	87079	22081	771	7840	5925	3989	1717	1135	
1984	12914	2402	349	42	307	75	13756	1160	461	
1985	7324	2300	116	38	385	196	20	351	346	
1986	33	21	11	3	3	0	8	2	0	
1987	48	3	515	1	1314	885	443	954	1211	
1988	37876	15593	3902	145	2189	3749	1399	745	409	
1989	4937	662	1332	125	2409	1531	5718	349	1130	
1990	13379	1646	368	57	201	63	1332	196	213	
1991	62320	123652	21113	2187	13193	19045	1447	841	3696	
1992	35154	17679	22565	2311	4092	5047	6661	7300	1035	
1993	40044	20483	47686	9024	25873	62637	1380	1183	1885	
1994	86872	48930	36841	1204	2083	588	1822	1112	584	
1995	3010	3380	2242	39	2005	736	307	229	1044	
1996	373641	143713	62166	4324	13345	3385	20896	5092	2992	
1997	274891	134164	34564	24021	52196	2930	22821	5065	1159	
1998	117297	182691	166423	103930	12641	3333	36894	4519	14277	
1999	27826	2592	3995	159	3689	1858	3671	882	3441	
2000	201135	308221	24741	5107	8166	1934	1015	2148	1447	
2001	1387	1033	4233	1676	1497	1139	1022	35	216	

2002	10266	6416	13498	8486	848	67397	27990	35085	10364
2003	43422	89450	11789	10012	2742	4585	1493	396	517
2004	591985	93707	99155	31259	5919	2498	24668	3491	8575
2005	2719	30373	83041	5670	565	212	17214	1587	2368
2006	159046	27844	9887	5862	1640	411	63346	4410	3440
2007	109637	58283	6862	303	1201	218	407	731	186
2008	111704	40955	73806	2601	1972	241	22669	932	2257
2009	45142	29609	13432	867	3424	5298	5614	818	1277
2010	39173	11617	68658	3704	417	205	5975	3116	8890
2011	12779	15358	40843	1715	14451	1954	2897	434	2034
2012	9421	51674	96660	3162	887	1152	4495	569	2503
2013	98059	107419	90108	19283	19963	1059	3941	881	2367
2014	47341	49054	22133	1079	20780	789	425	678	2820
2015	1612	6480	1521	4820	5584	64878	1769	347	83
2016	3557	3508	21370	31989	2029	1328	15129	5647	19492
2017	32094	25604	74644	7661	3392	4243	39586	2619	7120

Table 9. TIBIA indices (spatial abundance indices, for description see the ICES WGIBAR report 2018). See Fig. 1 for geographical location of the polygons.

Capelin	South West	Bear Island Trench	Thor Iversen Bank	Hopen Deep	Svalbard South	Svalbard North	South East	Pechora	Southeast Basin
1980	364057	19370	129488	13978	3758	2857	101385	14751	41
1981	131645	140672	107016	53307	8333	3296	38752	6861	15
1982	132237	104173	108715	4864	90832	84577	17285	14751	12
1983	83436	35909	39443	6132	57022	119756	10863	24418	9
1984	24047	56188	40605	49989	20949	29477	584	3343	4
1985	1379	8474	24383	4722	13902	2295	467	2663	30
1986	465	39	696	59	105	94	32401	17473	4
1987	164	20	67	4	12	12	1813	1689	
1988	27671	704	20842	647	210	147	3848	2139	17
1989	126506	163575	141517	93926	25478	10234	140295	20742	124

1990	5868	4218	29128	38217	9220	344	1882	6835	6
1991	2565	31482	21068	55350	6162	14659	1850	39458	30
1992	4	2	13	3	10	4	88	4801	
1993	7	5	23	183	162	3	22	209	
1994	186	35	220	12	74	58	2279	14807	1
1995	58	14	537	11	16	11	66	6509	3
1996	8944	18713	12424	54779	7436	580	2109	27808	10
1997	9479	77357	76240	34157	25159	1291	1236	21153	4
1998	1541	2551	19546	21383	6923	781	18067	12252	25
1999	7448	26474	27599	94005	15695	1256	1442	45430	23
2000	2104	38763	10218	44904	47327	8013	327	4521	1
2001	1111	4549	6367	1181	8089	315	3675	103599	2
2002	219	45	2267	753	278	509	3986	22367	42
2003	12980	80026	7903	84031	181125	155421	343	1797	1
2004	560	8618	664	2772	9806	213	6172	4091	1
2005	505	1592	41975	32251	1166	268	635	3346	19
2006	6009	86042	134696	127174	71731	62415	5899	21063	39
2007	4182	5599	78865	76100	5944	432	13247	7522	94
2008	80336	156283	165986	234694	129445	998	126790	28499	161
2009	18867	9497	136231	7702	1109	668	90446	230294	196
2010	22033	8776	51375	80889	5073	347	13991	59533	85
2011	23430	101645	7853	66186	327507	2426	114432	47185	35
2012	128379	109680	112339	154320	80582	1574	32590	67242	110
2013	14984	33424	40398	17442	3185	527	57468	9943	30
2014	4424	2256	10236	12352	4691	342	21403	11851	14
2015	95523	57795	55254	67510	7843	832	20493	9549	22
2016	13236	55564	101165	170358	200812	44444	18323	55396	20
2017	9625	12616	996	43687	47318	2181	12779	4024	5

Table 10. TIBIA indices (spatial abundance indices, for description see the ICES WGIBAR report 2018). See Fig. 1 for geographical location of the polygons.

Polar cod	South West	Bear Island Trench	Thor Iversen Bank	Hopen Deep	Svalbard South	Svalbard North	South East	Pechora	Southeastern Basin	Cent Ban
1980	1059	691	2010	359	25200	70776	3182	402493	66633	17
1981	160	313	187	2218	53535	4795	44	1791	466	2
1982	11	22	13	22	1130	19923	21	4364	128	[illegible]
1983	93	186	13	113	4360	81925	45	3289	201	2
1984	214	572	75	449	32973	10106	34	1563	283	1
1985	296	163	904	211	15640	1854	956	219598	15787	26
1986	161	710	202	689	38668	9807	537	92519	35368	2
1987	36	13	55	22	596	648	260	227020	707	2
1988	105	955	56	650	29169	12734	17	6811	214	3
1989	539	4464	285	11148	139423	30072	43	2426	135	8
1990	569	763	129	3339	168245	119581	76	3527	84	3
1991	1222	4304	1298	20097	291732	4333	2736	679190	26712	30
1992	663	5033	174	638	30695	45903	252	76429	1266	5
1993	849	478	739	444	36069	88545	934	487154	25248	14
1994	1807	847	638	237	12575	2608	941	1427208	140936	7
1995	1	1	0	2	41	365	4	24	1	
1996	1999	2979	733	3946	140281	7550	1621	409651	185865	17
1997	976	2004	196	1086	163485	12405	2225	402750	9831	13
1998	765	1708	158	612	87848	43166	192	80580	13851	5
1999	1889	555	1174	1497	23754	53460	1542	1114824	106162	29
2000	1410	4899	660	5510	281318	13505	1083	446544	73195	21
2001	233	525	57	270	24232	171716	122	29364	348	1
2002	1060	1664	742	1676	108699	188194	1416	540371	46915	11
2003	152	51	2483	221	2590	39582	218	35127	21740	74
2004	649	104	328	200	3751	2669	490	322929	20269	2
2005	59	263	46	238	15306	4727	38	25272	550	5
2006	395	70	92	403	1791	1317	274	230604	4760	5
2007	222	88	76	31	7250	12064	299	230416	774	1
2008	47	6	39	10	353	285	63	38481	742	[illegible]

2009	472	127	178	158	4056	119499	152	132900	11445	2
2010	311	61	390	307	7788	376	258	220614	22075	4
2011	290	112	758	276	6980	245	310	134038	8363	20
2012	192	466	74	161	3699	50191	73	9844	4557	1
2013	46	16	18	7	23	54	32	14379	295	
2014	37	180	29	1387	3893	69	30	17948	1147	
2015	77	559	38	173	16399	9887	24	577	52	
2016	212	1276	48	729	8826	11370	228	203	266	
2017	12	33	9	121	4458	253	6	382	26	

Table 11. TIBIA indices (spatial abundance indices, for description see the ICES WGIBAR report 2018). See Fig. 1 for geographical location of the polygons.

Redfish	South West	Bear Island Trench	Thor Iversen Bank	Hopen Deep	Svalbard South	Svalbard North	South East	Pechora	Southeas Basin
1980	3279	7631	1968	176	19944	139044	116	1657	
1981	5457	11813	304	1528	133417	8471	98	2225	
1982	28644	26794	649	282	6883	2537	264	1538	
1983	25543	64300	494	659	41303	3545	1676	1410	
1984	13706	1708	76	42	2575	1338	45	421	
1985	6769	34507	586	589	20750	195800	170	4301	
1986	41955	52036	6686	713	4064	6530	342	887	
1987	11053	9935	60	69	407	249	40	258	
1988	19695	21508	1342	2373	10042	20357	2291	1349	
1989	3118	2360	523	66	722	5402	609	50	
1990	13521	18884	2216	373	25169	23422	63	285	
1991	1668	2501	46	165	14412	4119	12	122	
1992	20	75	7	6	394	10542	10	141	
1993	11	19	2	3	88	4438	4	22	
1994	3944	11547	120	80	4261	12948	32	312	
1995	2441	2433	37	28	1425	598	15	210	
1996	16	6	3	0	2	5	0	0	

1997	145	4	2	1	2	5	2	2
1998	61	731	76	21	35	58	1	4
1999	17	6	1	1	12	8	0	0
2000	3652	5549	391	111	207	2166	36	34
2001	0	0	0	0	7	1	0	0
2002	0	0	0	0	2	146	0	1
2003	34	1	1	0	1	182	0	0
2004	35	720	12	16	34	222	1	4
2005	647	12430	916	62	468	225	15	34
2006	1466	7544	735	120	4943	4000	14	182
2007	51685	103056	10833	10604	1225	3317	124	754
2008	4224	3759	141	81	622	270	9	28
2009	1905	6981	2005	669	3764	31543	53	291
2010	34467	31929	2346	400	776	2276	71	244
2011	279	696	16	135	6934	576	3	20
2012	3271	41675	13845	2954	5010	7904	195	237
2013	920	56	120	5	15	25	8	3
2014	6128	21389	107	229	12071	36182	36	297
2015	7332	9943	409	5334	10212	57542	103	336
2016	491	1057	385	9595	2901	510	325	132
2017	290	1532	19	34	4094	57588	77	752

8.3 - Abundance indices calculated in SAS (1980-2017) and R (2018-2023)

Table 12. The modern official 0-group abundance indices (corrected for capture efficiency, KEFF) calculated in SAS (1980-2017) and R (since 2018). Abundance is given as total number of individuals in millions. Redfish abundance is given as both uncorrected numbers and numbers corrected with a KEFF of 3.8. These indices have been reported to the ICES WG groups (AFWG, WGWIDE and WGIBAR).

Years	Cod	Haddock	Capelin	Polar cod	Herring	Redfish	Redfish_KEFF
1980	276	265	740289	286097	77	277873	1055917
1981	289	75	477260	51037	37	153279	582460
1982	3480	2927	599596	12008	2519	106140	403332
1983	19299	6217	340200	88518	195446	172392	655090
1984	24326	5512	275233	27187	27354	83182	316092

1985	66630	2457	63771	149927	20081	412777	1568553
1986	10509	2579	41814	121513	93	91621	348160
1987	1035	708	4032	64802	49	23747	90239
1988	2570	1661	65127	43721	60782	107027	406703
1989	2775	650	862394	165449	17956	16092	61150
1990	23593	3122	115636	249681	15172	94790	360202
1991	40631	13713	169455	1105262	267644	41499	157696
1992	166276	4739	2337	130504	83909	13782	52372
1993	133046	3785	952	367416	291468	5458	20740
1994	70761	4470	13898	2188460	103891	52258	198580
1995	233885	1203	2869	201	11018	11816	44901
1996	280916	2632	136674	634691	549608	28	106
1997	294607	1983	189372	359912	463243	132	502
1998	24951	14116	113390	192483	476065	755	2869
1999	4150	2740	287760	1178164	35932	46	175
2000	108093	10906	140837	1107286	469626	7530	28614
2001	4150	4649	90181	148110	10008	6	23
2002	76146	4381	67130	1044788	151514	130	494
2003	81977	30792	340877	95313	177676	216	821
2004	65969	39303	53950	293578	773891	862	3274
2005	72137	91606	148466	70633	125927	12676	48168
2006	25061	28505	515770	198678	294649	20403	77531
2007	42628	8401	480069	213914	144002	156548	594884
2008	234144	9864	995101	43276	201046	9962	37857
2009	185457	33339	673027	323677	104233	49939	189768
2010	135355	23669	318569	279474	117087	66392	252289
2011	448005	19114	594248	254193	83051	7026	26698
2012	410757	5281	988600	150332	177189	58535	222432
2013	385430	16665	316020	12393	289391	928	3528
2014	464124	11765	163630	22647	136305	77658	295099
2015	37474	15089	457481	50380	82749	101653	386283

2016	53796	5504	778784	10832	79439	12941	49175
2017	233275	19484	213787	70971	153763	43561	165530
2018	79914	9313	657267	112278	57572	60889	60889
2019	67629	2460	1630176	196153	48254	240553	240553
2020	19740	6314	1811118	429165	11636	799276	799276
2021	206432	25387	364610	135895	205373	85864	85864
2022	71863	20988	152869	352153	2015797	72597	72597
2023	231081	50403	574441	7614233	3624101	101995	101995
LTM	116924	12926	387024	469259	276287	83019	228852

Red font identifies years with lack of coverage of the eastern Barents Sea.

8.4 - Biomass indices calculated in SAS (1980-2017) and R (2018-2023)

Table 13. The modern official 0-group biomass indices (thousand tonnes) calculated in SAS (1980-2017) and R (since 2018). These indices have been reported to ICES WG groups (AFWG, WGWIDE and WGIBAR).

Year	Capelin	Cod	Haddock	Herring	Polar cod	Redfish	Total biomass
1980	92	0	1	0	124	356	574
1981	61	0	0	0	22	197	281
1982	117	5	14	3	5	136	280
1983	86	54	47	554	38	221	1000
1984	100	60	37	132	12	107	447
1985	24	158	16	69	65	611	943
1986	6	16	12	0	53	122	208
1987	1	1	2	0	28	12	44
1988	16	4	9	105	19	161	315
1989	183	8	4	47	72	21	335
1990	32	84	31	69	108	210	536
1991	68	131	88	820	480	49	1635
1992	2	533	42	340	57	28	1002
1993	0	478	40	686	159	4	1367

1994	9	292	45	172	950	102	1571
1995	1	1053	13	16	0	19	1102
1996	48	795	29	742	276	0	1890
1997	37	656	15	629	156	0	1493
1998	26	88	161	947	84	1	1307
1999	67	18	31	156	511	0	784
2000	25	274	66	659	481	9	1514
2001	56	9	47	11	64	0	187
2002	15	215	53	397	454	0	1132
2003	56	159	188	458	41	0	902
2004	16	245	525	1997	127	1	2911
2005	37	287	859	295	31	22	1530
2006	175	112	309	782	86	33	1498
2007	173	100	74	279	93	362	1081
2008	197	554	72	210	19	8	1060
2009	119	738	346	243	140	168	1755
2010	65	548	174	233	121	213	1355
2011	136	1449	201	156	110	11	2063
2012	304	1193	45	295	65	109	2012
2013	77	895	202	871	5	1	2051
2014	42	987	107	218	10	151	1514
2015	151	99	160	137	22	160	729
2016	358	245	116	275	5	39	1039
2017	87	845	235	359	31	91	1649
2018	164	80	9	58	56	20	387
2019	526	132	22	28	95	69	872
2020	453	20	6	12	215	266	972
2021	577	365	172	95	138	20	1367
2022	38	72	21	2016	176	24	2347
2023	233	440	367	1587	681	31	3339

Mean	115	330	114	390	147	95	1140

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