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Discussions

Spatially explicit estimates of stocks sizes, structure and biomass of herring and blue whiting, and catch data of bluefin tuna

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Abstract

The north Atlantic is a productive marine region which has supported important commercial fisheries for centuries. Many of these fisheries have exploited the pelagic species, including herring, blue whiting and tuna. Here we present data on the distribution of herring and blue whiting based on surveys in the Norwegian Sea, the Bay of Biscay and Celtic Sea. We also present catch data on bluefin tuna, which has been depleted for decades, but historically used to be a key predator on the other pelagic stocks during summer. The results show that there have been substantial changes in the herring and blue whiting distribution during the 1990s and early 2000s. The earliest bluefin tuna catches noted were in 1907. The catches in the Norwegian Sea area peaked in the 1950s and there have been very small catches since the 1980s. The catches in the Mediterranean on the other hand peaked in the late 1990, and had subsequently a strong reduction.

Referenced data sets

Norwegian spring spawning herring (biomass data Norwegian Sea survey):

- http://doi.pangaea.de/10.1594/PANGAEA.827221
- http://doi.pangaea.de/10.1594/PANGAEA.827197
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- http://doi.pangaea.de/10.1594/PANGAEA.827190
- http://doi.pangaea.de/10.1594/PANGAEA.819799

Blue whiting:

- http://doi.pangaea.de/10.1594/PANGAEA.817175 (bottom trawl survey data in Bay of Biscay and Celtic Sea)
- http://doi.pangaea.de/10.1594/PANGAEA.819117 (acoustic NASC values for Bay of Biscay)
- http://doi.pangaea.de/10.1594/PANGAEA.827374 (biomass data Norwegian Sea survey)
- http://doi.pangaea.de/10.1594/PANGAEA.827380 (biomass data Norwegian Sea survey)
- http://doi.pangaea.de/10.1594/PANGAEA.827379 (biomass data Norwegian Sea survey)
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- http://doi.pangaea.de/10.1594/PANGAEA.827373 (biomass data Norwegian Sea survey)
- http://doi.pangaea.de/10.1594/PANGAEA.827372 (biomass data Norwegian Sea survey)

Bluefin tuna:

- http://doi.pangaea.de/10.1594/PANGAEA.828295 (catch data for 1906–1949)
- http://doi.pangaea.de/10.1594/PANGAEA.828297 (catch data for 1950–2010)

1 Introduction

1.1 Key pelagic fish stocks in the Northeast Atlantic

The north Atlantic is a productive marine region which has supported important commercial fisheries for centuries. Many of these fisheries have exploited the pelagic (mainly open-water, surface-living) species, such as herring (*Clupea harengus* Linnaeus 1758) and blue whiting (*Micromesistius poutassou* Risso 1826). These species are primarily, though not exclusively, zooplanktivores (Fridriksson, 1944; Prokopchuk and Sentyabov, 2006; Pinnegar et al., 2014) and thus are important links in the food web between zooplankton and piscivores (e.g., cod, seals, whales, seabirds). The biomasses of herring and blue whiting, and a few other pelagic fish species (e.g., mackerel *Scomber scombrus* Linnaeus 1758) are so high that they attract many seasonal migrants to the region. Hence, upper trophic level predators such as bluefin tuna (*Thunnus thynnus* Linnaeus 1758), and some species of marine mammals and seabirds have evolved migratory behaviours to inhabit this region for feeding in summer months (Mather et al., 1995). Fisheries therefore must be conducted in ways that are sustainable not only for the fishing industry, but also for the targeted fish species, other

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species in the food web that depend on them for food and more generally for maintaining healthy, resilient ecosystems.

Maintaining sustainable populations and ecosystems generally requires direct monitoring of population status and their fisheries (Hilborn and Branch, 2013; Pauly, 2013). Such data can provide a basis for fisheries management decisions (e.g., quotas). Two of the most important types of monitoring information are research vessel surveys of fish abundance and distribution, and records of commercial catches of targeted and bycatch species. These data can reveal when and where the fish were located and when and where they were being exploited. The data can then be compared in time and space and be used in models with other data (e.g., fishing effort, fish sizes and ages) to estimate whether populations are stable, declining or increasing. When provided with this knowledge, fishery managers can make decisions on future quotas and identify possible conservation actions (e.g., minimum size limits, implementation of closed areas or seasons for fishing) that can reduce the risk of stock collapses and local extinctions.

1.2 Norwegian spring-spawning (NSS) herring

Since the late 1960s many herring stocks have collapsed and subsequently recovered, at least to some extent. The main reason for the collapse of most stocks has been high fishing pressure on both young and adult herring and poor recruitment during the pre-collapse period likely due to unfavourable environmental condition (Dragesund et al., 1980). In addition there have been a few years of global environmental conditions where good or strong recruitment was observed for most herring stocks within the North Atlantic (e.g. 1983). Between 1968 and 1977 the NSS herring spawning stock biomass (SSB) declined to less than 0.2 million t with a minimum occurring in 1971 (Toresen and Østvedt, 2000). Fishing mortality F was as high as 1.5 during the pre-collapse period (Dragesund et al., 1980), but since 1994 it has ranged from 0.18 to 0.24 in accordance with the long term management plan (ICES, 2013).

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The spawning stock biomass of NSS herring increased steadily from 1988 to 1999, followed by a decline from 1999 to 2002, increased SSB from 2003 to 2009 and a more rapid decrease in SSB from 2009–2013 due to lack of strong recruitment since 2004 (ICES, 2013). Norwegian spring-spawning herring has changed its distribution and migration pattern substantially during the last decades in terms of spawning, feeding and overwintering areas (Fig. 1). The centre of gravity for adult Norwegian spring-spawning herring has shifted substantially between 1996 and 2011 (Fig. 1). From 1996 to 2003 the centre of gravity in the feeding distribution moved north/northeast by almost 4° latitude. This represents a distance of 445 km. This northern shifted was followed by a backward southern shift from 2003 to 2011 of the same magnitude.

In the last two decades the NSS herring fishery has been the largest herring fishery in the Atlantic with landings ranging from 0.969 to 1.687 million t between 2005 and 2013 (ICES, 2013), not so far from the pre-collapse catches that approached 2 million t in 1968 (Toresen and Østvedt, 2000). Usually, the NSS herring fishery takes place in the Norwegian Sea during the summer and autumn and in coastal areas during the autumn and the winter, including the spawning period (ICES, 2013).

1.3 Blue whiting

Blue whiting are widely distributed over the Northeast Atlantic with the dominant spawning area situated to the west of the British Isles. It has a major feeding migration and summer distribution north all the way up to Spitzbergen and into the Barents Sea and southward down to the Bay of Biscay and the Iberian coast (Fig. 2). Blue whiting SSB has been fluctuating around 2 million t from 1981 to 1997. From 1997 to 2004 the SSB increased rapidly to about 7 million t, followed be a similarly rapid decline from 2005 until 2011 and a subsequent increase to a SSB of 5.5 million t in 2013 (ICES, 2013).

The fishery on blue whiting has displayed a dramatic "boom and bust" dynamic over the past two decades (ICES, 2013). The modern commercial fishery on this stock began in the late 1970s and early 1980s. Landings during the 1980s and early 1990s were typically between 0.500 and 1 million t. However, the late 1990s and early 2000s saw

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a succession of extremely strong year classes, starting with the 1995 cohort, typically a factor of four to ten times greater than that observed during the previous 15 years. When the first of these cohorts reached maturity in 1998, the spawning stock biomass expanded rapidly and the landings from the fishery nearly doubled from one year to the next (0.64 million t in 1997, 1.13 million t in 1998). The fishery continued to grow into the early 2000s on the back of the strong year classes, and in 2004 landings reached 2.4 million t, an increase of 400 % in just seven years. At this point, blue whiting was the largest fishery in the North Atlantic, ahead of herring, and the third largest marine capture fishery in the world (FAO, 2010). The subsequent decline of the fishery has, however, proved to be equally dramatic. Year class strength from the 2005–2009 cohorts were comparable to, or even lower than, those prior to 1995 (ICES, 2013). The 2010–2012 cohorts are then apparently above average size. The extremely large fishery could not be sustained under these conditions of reduced productivity and rapid reductions in allowable catch followed. Landings were reduced by 75 % in the space of five years.

1.4 Bluefin tuna

Bluefin tuna historically have migrated into the Norwegian and North Seas, preying on the high concentrations of pelagic fish in this area during summer (MacKenzie and Myers, 2007; Mather et al., 1995). While in this region they were targeted by fishing vessels from several nations. The fishery developed in the 1920s–1940s, peaked in the 1950s and declined in the mid-late 1960s before ending in the mid-1970s. The species has since then been rarely seen and has not supported commercial or recreational fisheries. Reasons for the disappearance are unclear but probably due to a combination of fishing, climatic and ecosystem factors (Fromentin, 2009; Tiews, 1978).

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1.5 Objectives

Here we provide new data on the spatial distribution of herring and blue whiting in the north east Atlantic that have been compiled by research vessels operated by several nations in the region during the years 2004–2012. For NSS herring, data from the international PGNAPES survey in May in the Norwegian Sea is presented. Furthermore, data from three surveys are presented here for blue whiting: the international PGNAPES survey in May in the Norwegian Sea, the French pelagic survey (PELGAS) and the demersal bottom trawl surveys (EVHOE). We have also compiled and presented a long time series of the commercial catches of bluefin tuna in this region resolved by different spatial regions and countries. These data will help understand the causes of fluctuations in abundance and distribution of these species and contribute to the wider objectives of a large European Union project (Euro-Basin) investigating how climate variability and fisheries affect food webs and biogeochemical fluxes in the off-shelf regions of the northeast Atlantic Ocean. Additional brief backgrounds of the species biology and fisheries are given in Methods. The survey and catch data reported here have been submitted to the PANGAEA website.

2 Methods

2.1 Data sources and geographic region of coverage

The survey and catch data described here cover a wide area of the northeast Atlantic. The region is divided into smaller units for fishery and ecosystem management purposes by ICES (International Council for the Exploration of the Sea) (Figs. 3 and 4). The historical data on Norwegian spring-spawning (NSS) herring and blue whiting in the Northeast Atlantic originate from various national and international surveys aimed at mapping the major distribution and estimate abundances and demographic structure of these large pelagic planktivorous fish species (e.g. ICES, 2009, 2011). The

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vast majority of data on Norwegian spring-spawning herring are coming from the annual international herring survey carried out in May–June in the Norwegian Sea (ICES, 2013). Overall historical and present data on blue whiting are primarily from the Norwegian Sea from 1997–2011, the annual international blue whiting survey carried out on the spawning grounds to the west of the British Isles in March–April 2004–2011 (ICES, 2011) and the nursery grounds in the Bay of Biscay and Celtic Sea in 1987–2012.

2.2 Norwegian Sea acoustic survey

The description of the sampling is given below (ICES, 2009). Catches from trawl hauls were sorted and weighed; fish were identified to species level, when possible, and other taxa to higher taxonomic levels. Normally a subsample of 50–100 herring and blue whiting were sexed, aged, and measured for length and weight, and their maturity status were estimated using established methods. An additional sample of 50–250 fish was measured for length.

Acoustic estimates of herring and blue whiting abundance were obtained during the surveys. This was carried out by visual scrutiny of the echogram and post-processing software. The allocation of NASC (MacLennan et al., 2002) values to herring, blue whiting and other acoustic targets were based on the composition of the trawl catches and the appearance of echo recordings. To estimate the abundance, the allocated NASC values were averaged for ICES rectangles (0.5° latitude by 1° longitude). For each statistical rectangle, the unit area density of fish in number per square nautical mile ($\mathrm{N\,nm^{-2}}$) was calculated using standard equations (Foote et al., 1987; Toresen et al., 1998). Traditionally the following target strength (TS) function has been used:

$$\text{Blue whiting:} \quad \mathrm{TS} = 21.8\log(L) - 72.8\,\mathrm{dB}$$

$$\text{Herring:} \quad \mathrm{TS} = 20.0\log(L) - 71.9\,\mathrm{dB}.$$

Note that in 2012, the TS function was changed for blue whiting in all the main acoustic surveys within ICES ($\mathrm{TS} = 20\log(L) - 65.2\,\mathrm{dB}$; ICES, 2012), but the abundance es-

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timates in the PANGAEA database are based on the previously used function. To estimate the total abundance of fish, the unit area abundance for each statistical square was multiplied by the number of square nautical miles in each statistical rectangle then summed for all the statistical rectangles within defined subareas and over the total area. Biomass was calculated by multiplying abundance in numbers by the average weight of the fish in each statistical rectangle then summing all rectangles within defined subareas and over the total area. The Norwegian BEAM software (Totland and Godø, 2001) was used to make estimates of total biomass and numbers of individuals by age and length in the whole survey area and within different subareas.

2.3 French acoustic PELGAS survey

Acoustic surveys were carried out every year in the Bay of Biscay in May from 2000 to 2012 (except 2001) onboard the research vessel Thalassa which is equipped with a Simrad EK60 echosounder operating at five frequencies (18, 38, 70, 120 and 200 kHz; 7° beam angle at −3 dB and 1.024 ms pulse length for all frequencies) at 6 m depth on the fixed vessel keel. Only the data collected at 38 kHz were used here. The survey protocol for acoustic data collection has been stable since 2000. Systematic parallel transects (12 nm distance) perpendicular to the French coast were carried out. The survey covered the continental shelf from 20 m depth to the shelf break about 200 m (in certain years more offshore). Acoustic data were only collected during day time. During night the pelagic target species are usually dispersed and found close to the sea surface and therefore "disappear" in the blind layer of the echo sounder, which extends between the surface and 8 m depth. The calibration method has been stable over time.

Acoustic data were acquired with the Movies+ and Hermes software and archived in the international hydro-acoustic data format (HAC) applying a −100 dB threshold. The identification of species and size classes comprising fish echo traces heavily depends on identification via trawl hauls performed by R/V *Thalassa* using pelagic trawl (2 doors, headline: 76 m, foot rope: 70 m). Echograms were scrutinized in real time and trawl

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hauls were performed as often as possible. The criteria for performing an identification haul included: observation of numerous fish echotraces over several elementary distance sampling units (EDSU) or of very dense fish echotraces in one EDSU; changes in the echotrace characteristics (morphology, density or position in the water column); observation of an echotrace type fished on previous transects, but never fished on the current transect.

The scrutinized echo traces were integrated over the water column by EDSU providing nautical area backscattering coefficients (NASC, $m^2\,nmi^{-2}$). For deriving biomass and abundance estimates, acoustic energies where converted by applying catch ratios, length distributions and weighted by abundance of fish in the area surrounding haul. Further information on the survey and the data analysis methods can be found in Doray et al. (2010).

The objective of the PELGAS survey is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species of the survey are anchovy and sardine but sprat, horse mackerel, mackerel and blue whiting are also covered. The identification of species and size classes comprising fish echotraces heavily depends on identification via trawl hauls performed by R/V *Thalassa* using the pelagic trawl (Doray et al., 2010).

2.4 Bay of Biscay and Celtic Sea bottom trawl survey

The EVHOE survey has been conducted onboard R/V *Thalassa* annually in autumn since 1987 in the Bay of Biscay and since 1997 in the Celtic Sea. The vessel was changed in 1997, but this did not impact the catchability of blue whiting (Pelletier, 1998). From 50 to 100 stations are trawled with a grande ouverture verticale (GOV) bottom trawl according to a stratified random design based on bottom depth and latitude. The catch is identified to species and individually measured. Further details on the survey protocol can be found online at https://datras.ices.dk/Documents/Manuals/EVHOEManual.doc.

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2.5 Bluefin tuna catch data in northern European waters (ICES Areas II–VII)

Bluefin tuna catch data were extracted from the ICES catch databases for the time periods 1903–1949 and 1950–2010. The catch database versions used in this report were those available on the ICES website (http://www.ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx) and downloaded on 21 January 2014. The data in the ICES catch data bases are derived from ICES Bulletin Statistiques which are annual statistical reports containing fishery data for north-east Atlantic countries (Lassen et al., 2012). The data contained in those reports have been entered by ICES into the existing catch database. The data contained in the ICES catch database are resolved by species, year, country, and sea region (known as ICES areas). For this report, we were most interested in the sea areas north of the Bay of Biscay, because this was the former summer foraging habitat until its disappearance in the 1970s and because catches in this region have undergone large fluctuations (see above) whose reasons remain unclear (Fromentin, 2009; MacKenzie and Myers, 2007; Mather et al., 1995; Tiews, 1978). We extracted data by year, country and region and made time series plots of the data to illustrate and compare temporal-spatial trends, and to identify which countries and/or regions had largest catches.

We are also aware of some historical catch data which are not presently included in the ICES catch databases; these data have been identified in various fishery reports, museum records and scientific literature (MacKenzie and Myers, 2007), and are included in the database described here and available at the PANGAEA website. The data sources not included in the ICES catch database are identified with notes in the online data files.

The ICES areas considered are only part of the entire spatial domain over which the bluefin tuna fishery is managed, which covers the north Atlantic east of 45° longitude and includes the Mediterranean and Black Seas (ICCAT, 2012). Catches for these areas (i. e., northeast Atlantic and Mediterranean, including Black Sea) are available from the International Commission for the Conservation of Atlantic Tunas (ICCAT), which is

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the agency responsible management of bluefin tuna in the Atlantic and Mediterranean. We extracted and plotted the ICCAT catch data (total international landings) to enable comparison of the total international landings in the entire stock management area with the ICES data for the northern region. In principle, the catch data reported to ICES should be the same as those reported to ICCAT, but in some instances there may be some minor differences (Lassen et al., 2012), which are not considered further here.

3 Results and discussion

3.1 Spatially explicit estimates of stocks sizes, structure, biomass of Norwegian spring-spawning herring

The spawning stock biomass of NSS herring has increased steadily from 1988 to 1999, followed by a decline from 1999 to 2002, increased SSB from 2003 to 2009 and a more rapid decrease in SSB from 2009–2011 due to lack of recruitment since 2004. The centre of gravity for adult NSS herring shifted substantially from 1996 to 2011 (Fig. 5). From 1996 to 2003 the centre of gravity moved north/northeast with almost 4° latitude. This represents a distance of 445 km. From 2003 to 2011 a similar shift of 4° latitude (445 km) in centre of gravity in the opposite direction towards south/southwest has been evident. Maps of herring distribution and aggregation patterns, primarily from the international May survey from 1995 to 2011, are provided below based on acoustic estimates (NASC values) in forms of mean 5 nautical mile values (Figs. 6 and 7). Changes in both distribution and aggregation patterns are evident between years, with a pronounced shift and expansion of herring migrating north/northeastwards from 1996–2003, followed by an interesting shift and retraction towards south and southwest from 2003 to 2011.

Norwegian spring-spawning herring has changed its distribution and migration pattern substantially during the last decades in terms of spawning, feeding and overwintering areas (Fig. 1). Maps of herring distribution and aggregation patterns, primarily from

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the international May survey from 2004 to 2011, are provided in PANGAEA. Examples of the data on herring distribution are shown in Figs. 4–6 below.

3.2 Spatially explicit estimates of stocks sizes, structure, biomass of blue whiting

Blue whiting spawning stock biomass (SSB) fluctuated widely over the last three decades. Examples of concurrent changes in the spatial distribution of the stock in May are shown in Figs. 9–11. The pronounced increase in stock abundance during this period is illustrated by the expansion in distribution.

3.3 Spatial blue whiting estimates in the Bay of Biscay

Spatial blue whiting biomass estimates in the Bay of Biscay for two contrasting years are shown in Fig. 12. The year 2002 was a typical year with little blue whiting biomass in the water column on the shelf while in 2010 blue whiting was found in high abundance on the continental shelf. It has to be noted that as the survey is targeting anchovy and sardine, the transect lines end in general when schools of blue whiting are encountered. As adult blue whiting are distributed along the shelf edge further offshore, the PELGAS surveys do not cover the full distribution of this species in the Bay of Biscay.

The gridded average distribution of blue whiting across the years 1997–2011 is shown in Fig. 13. This map of the demersal part of the blue whiting stock, primarily made up of young-of-the-year shows that they are distributed along the outer parts of shelf edge of the Bay of Biscay and Celtic Sea, similarly to the pelagic adult part of the population in Fig. 12.

3.4 Bluefin tuna catches – temporal, spatial and national distributions

The ICES catch database (version 21 January 2014) for the Areas I–VII first reports bluefin tuna data from 1931. Landings in this region were first reported to ICES by Germany for region IV (North Sea). Landings increased in the subsequent two decades

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and additional nations (e.g., Denmark, Norway, Sweden) reported catches from other areas (e.g., Norwegian Sea, Skagerrak-Kattegat-Belt Sea-Øresund; Figs. 14–16).

There is a notable omission of data from the version of the ICES catch database downloaded for this work. The data omitted are those from Norway. These data are however present in the original ICES Bulletins Statistiques and have earlier been reported in the literature (e.g., MacKenzie and Myers, 2007) and are included in the ICCAT database. The omitted landings are substantial because Norway had the largest catches of all countries in the region considered in this report until the fishery in this area declined in the mid-1960s–early 1970s. Moreover, Norway was the first country in this region to report its landings to ICES (starting in 1927; ICES Bull. Stat.). The Norwegian landings which are in the ICES Bull. Stat., but which are omitted from the ICES catch database are those for 1927–1949 for areas II, III and IV.

Aside from the omission of early officially-reported Norwegian landings, there are additional landings by Norway (Tangen, 1999) and a few other countries from the early decades of the 20th century which are not included in the ICES Bull. Stat. or the present version of the ICES catch database. The earliest bluefin tuna catches noted (1907) were those by a French herring boat fishing at Dogger Bank in the southern North Sea. Several more years of French tuna catches in this area are available in French fishery reports (Statistiques de Pêches Maritimes; MacKenzie and Myers, 2007). Norwegian, Swedish and Danish fishermen also caught bluefin tuna in the Norwegian Sea and Skagerrak-Kattegat in the 1910s-1920s, and thus before these governments began reporting the landings to ICES (Fig. 16).

The vast majority of the catches (96 % by weight in the whole time period 1906–2010) were taken in Areas II–IV, and the rest were in areas VI–VII. Norway, Denmark, Germany, Sweden and France were responsible for 99.8 % of the total reported landings during 1906–2010; Norway's share was largest (73 %), followed by Denmark (11 %; Fig. 17).

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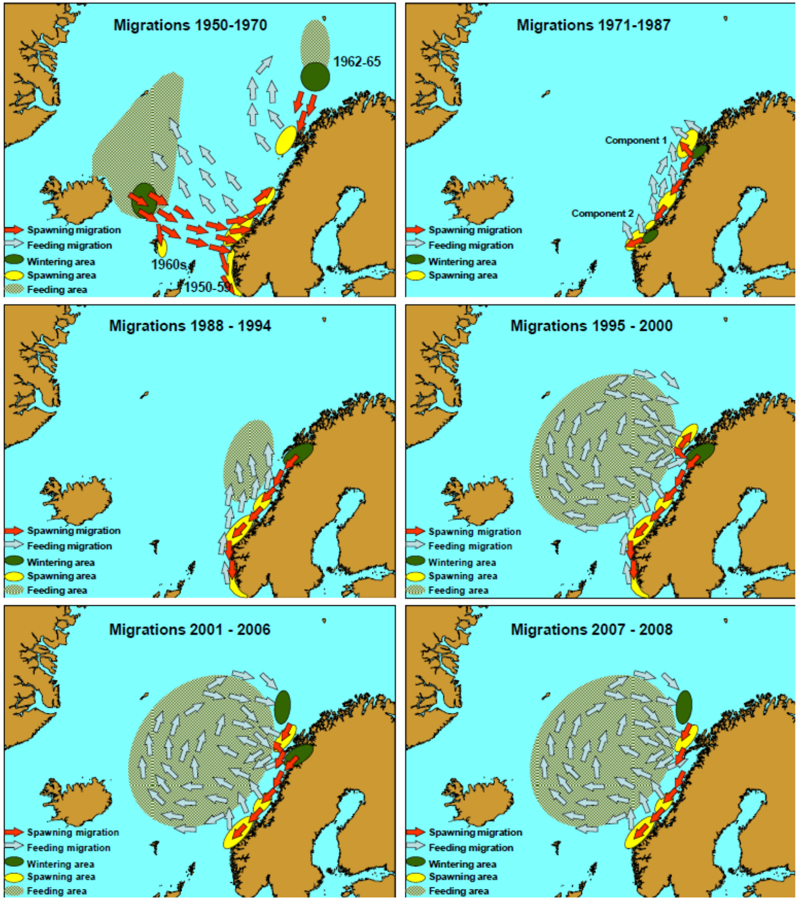

Figure 1. Schematic overview of historical changes in the adult NSS herring seasonal migration pattern. Reproduced with permission from Slotte and Skaret (2010).

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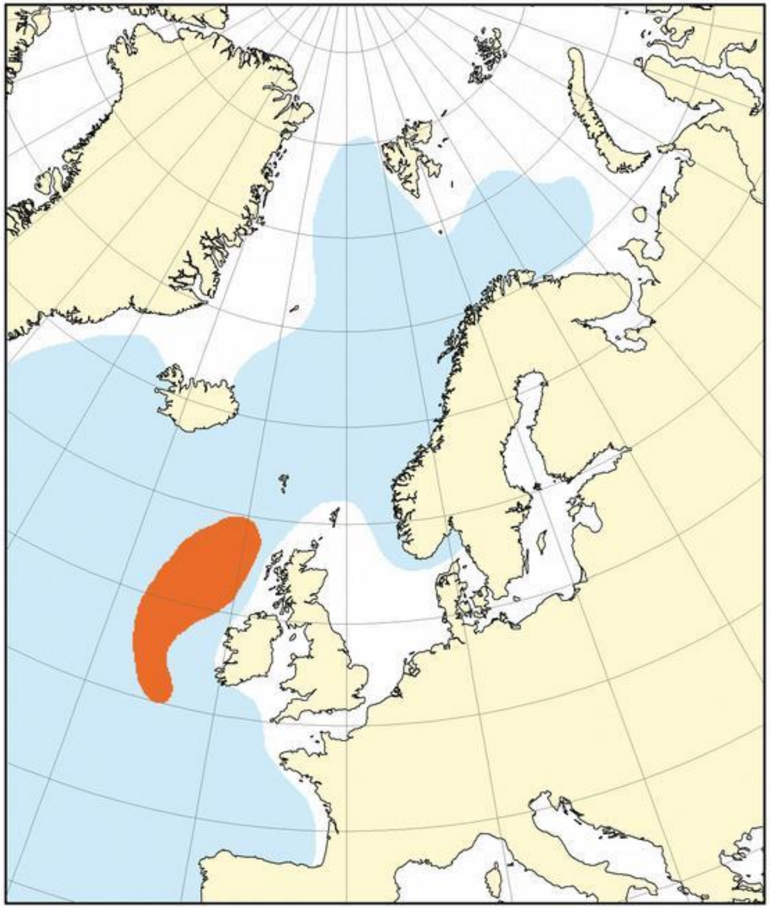

Figure 2. Schematic overview of overall distribution (blue) and spawning area (orange) for blue whiting.

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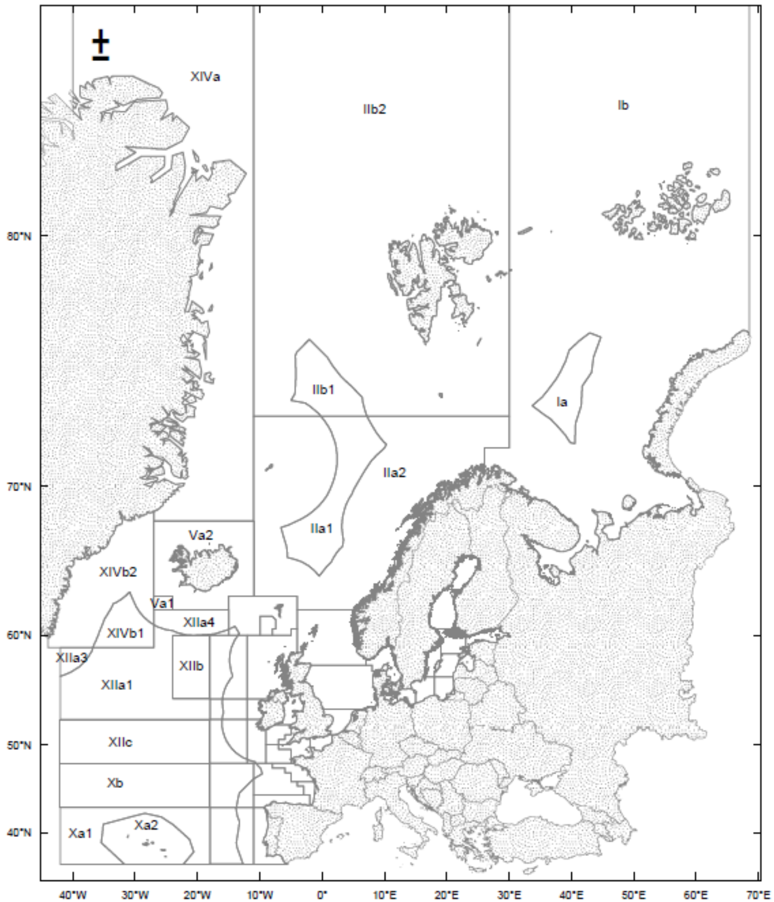

Figure 3. Locations of ICES fishery management areas in the Northeast Atlantic Ocean.

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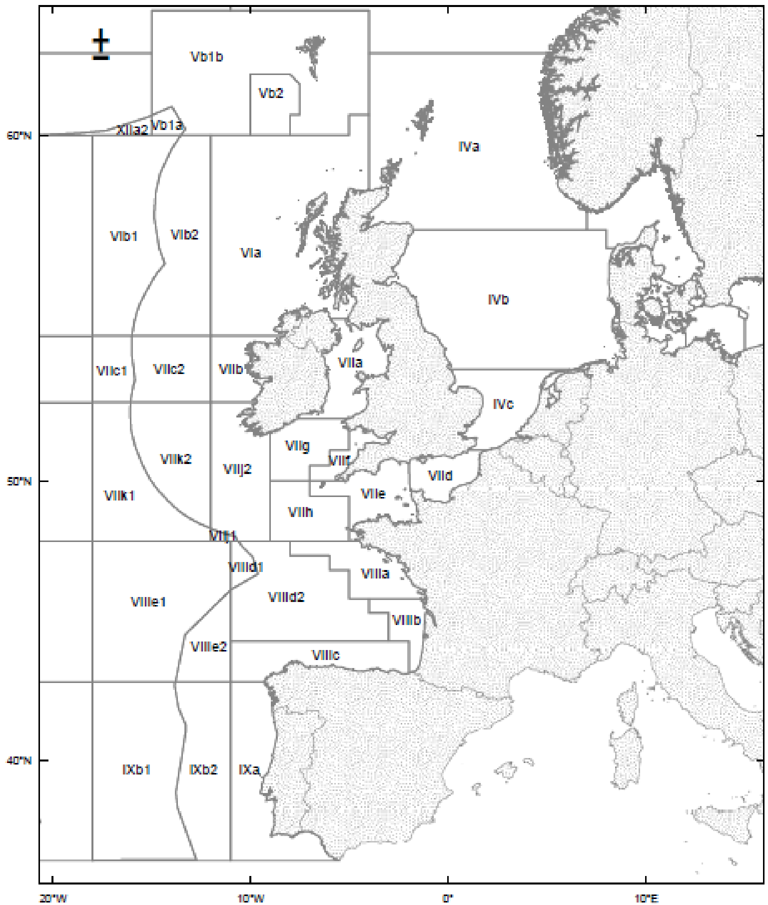

Figure 4. Locations of ICES fishery management areas on the northern European shelf-shelfbreak region.

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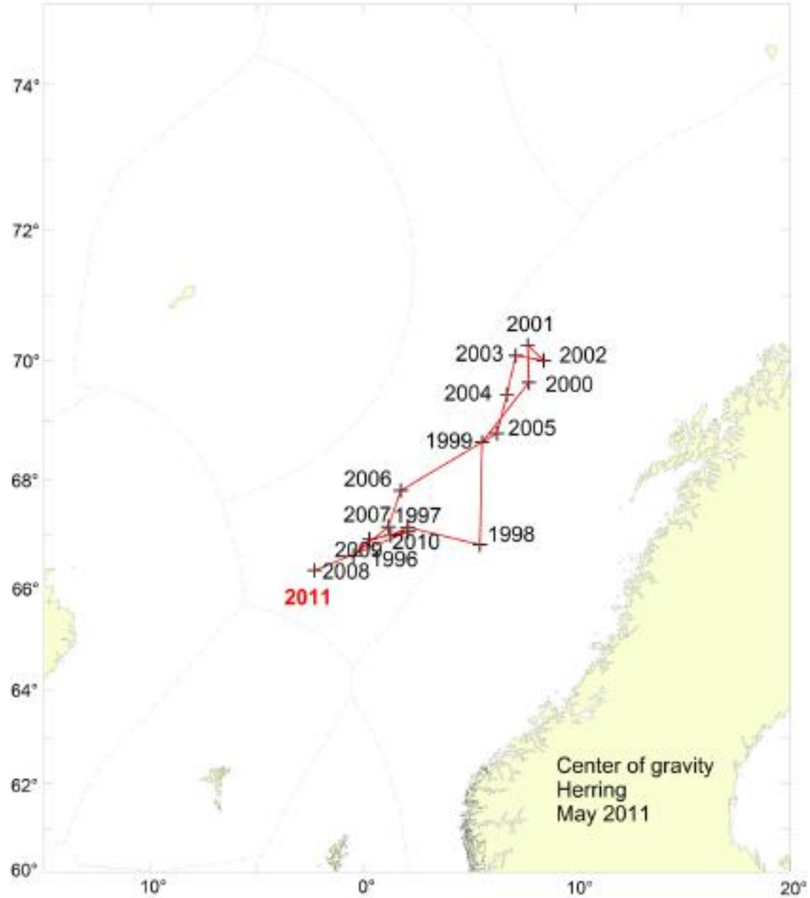

Figure 5. Centre of gravity of Norwegian spring-spawning herring during the period 1996–2011 derived from acoustic data.

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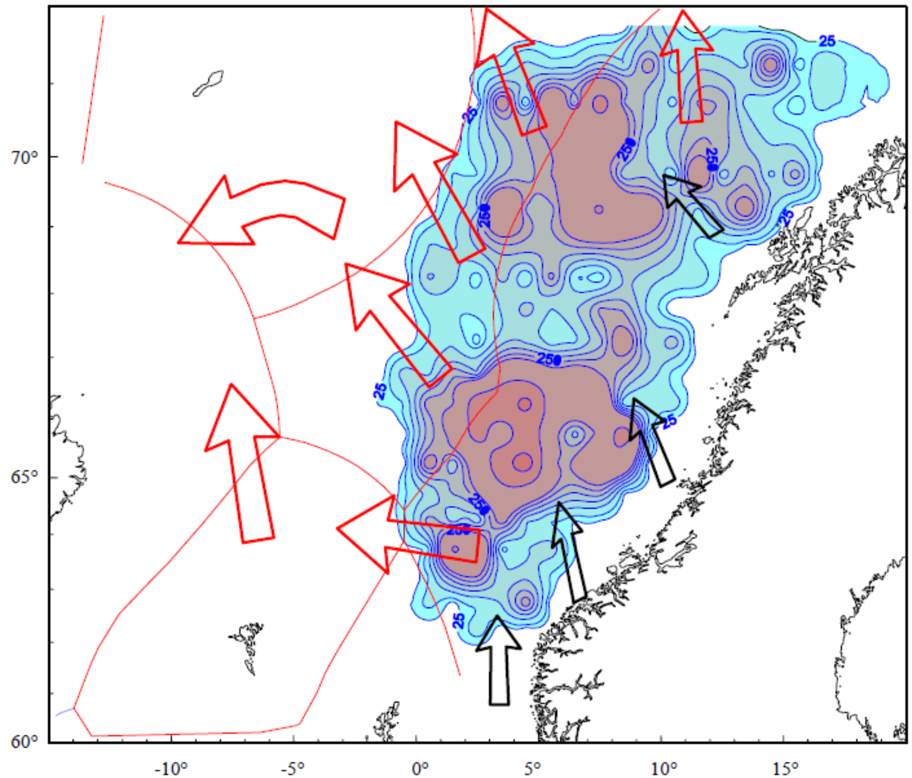

Figure 6. Distribution of Norwegian spring-spawning herring as measured by R/V *G.O. Sars* and R/V *Argos* in April–May 1998. Complete coverage of the adult stock. Small (black in colours) arraows: anticipated migrations from March to May. Large (red in colours) arrows: anticipated migrations from May to June. Arrow size not proportional to biomass movement.

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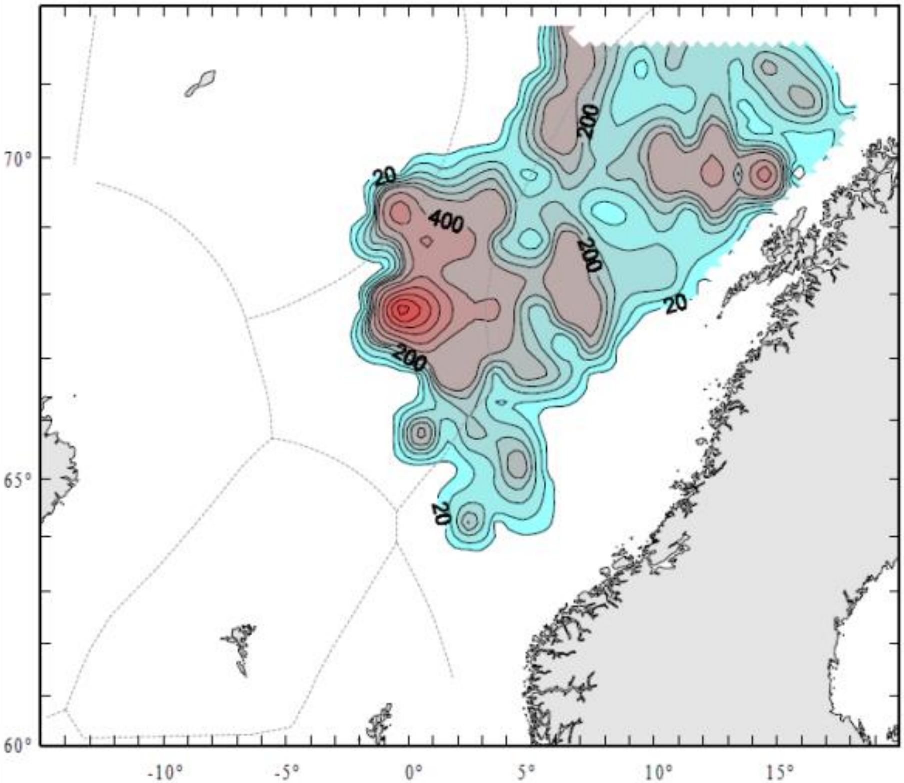

Figure 7. Distribution of Norwegian spring-spawning herring in May 1999 as measured by R/V *Arni Fridriksson*, R/V *G.O. Sars*, R/V *Manus Heinasson* and R/V *Walther Herwig III* during the international coordinated herring survey.

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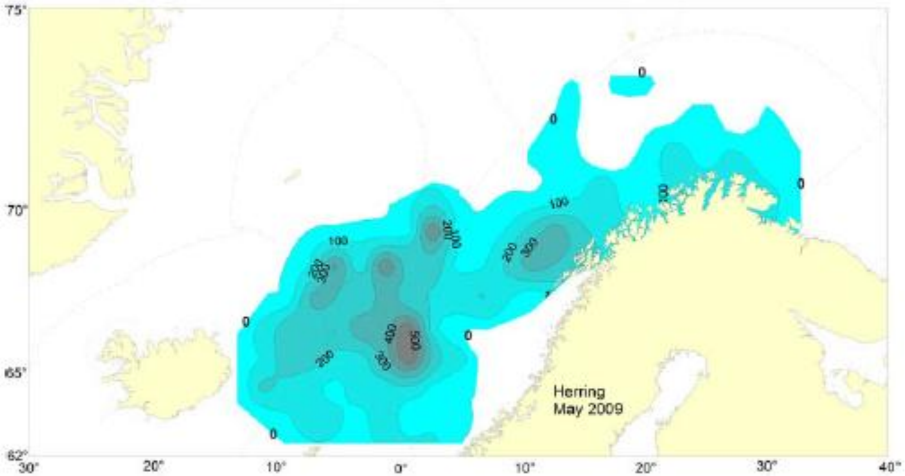

Figure 8. Distribution of Norwegian spring-spawning herring as measured during the International survey in April–June 2009 in terms of NASC values based on combined 5 nmi values.

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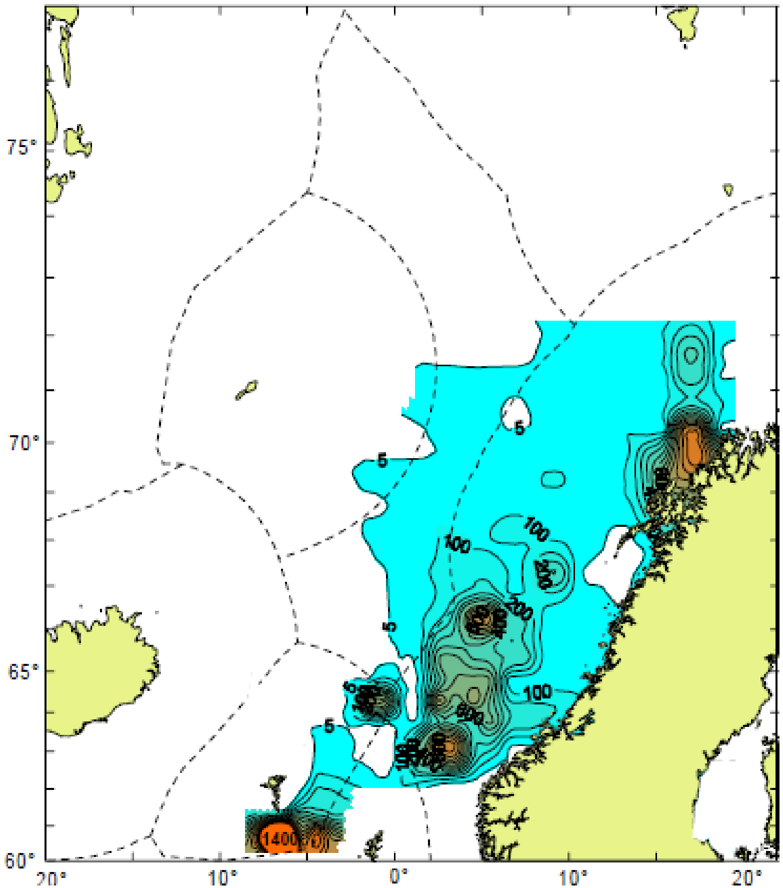

Figure 9. Distribution of blue whiting as observed by R/V *Tridens*, R/V *Arni Fridriksson*, R/V *G.O. Sars* and R/V *Magnus Heinason* during the international survey in May 2000.

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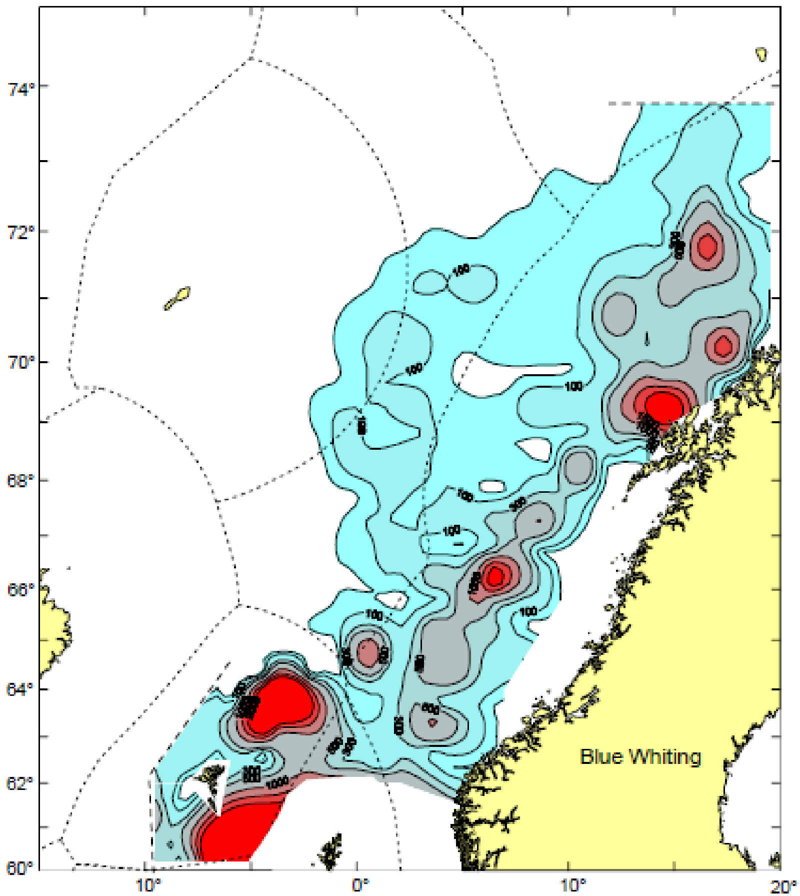

Figure 10. Distribution of blue whiting as observed by R/V *Johan Hjort*, R/V *Walther Herwig*, and R/V *Magnus Heinason* during the international survey in May 2001.

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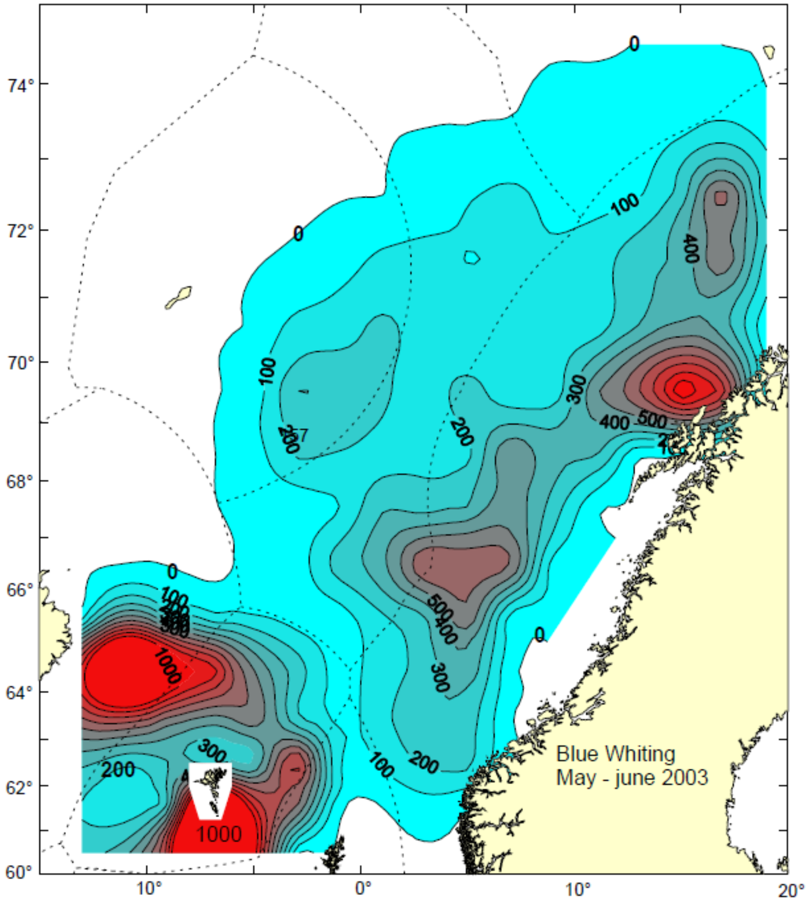

Figure 11. Distribution of blue whiting (NASC values) in May–June 2003. Data from R/V *Magnus Heinason*, R/V *Arni Fridriksson* and R/V *G.O. Sars*.

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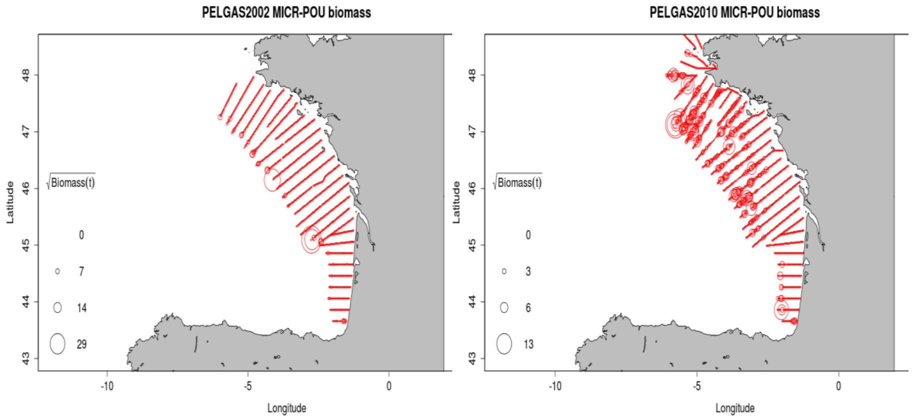

Figure 12. Blue whiting biomass estimates by EDSU for 2002 (typical year) and 2010 (high biomass).

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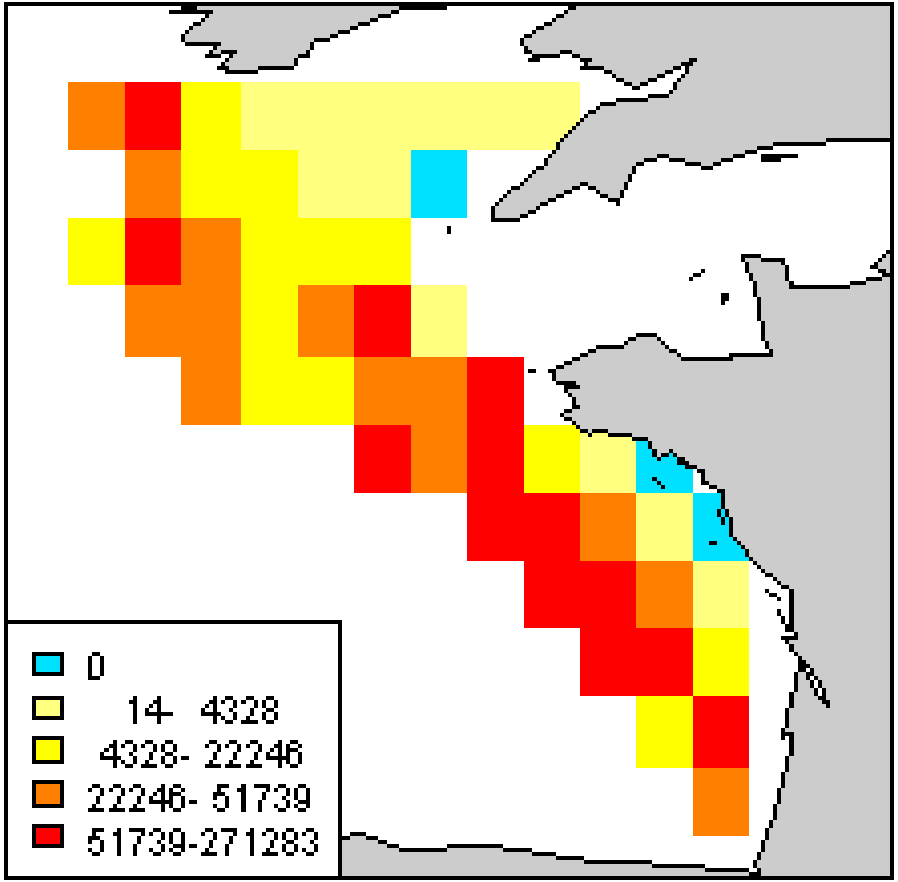

Figure 13. Average density (numbers per km^2) of blue whiting during autumn in the period 1997–2011 in the Bay of Biscay and Celtic Sea.

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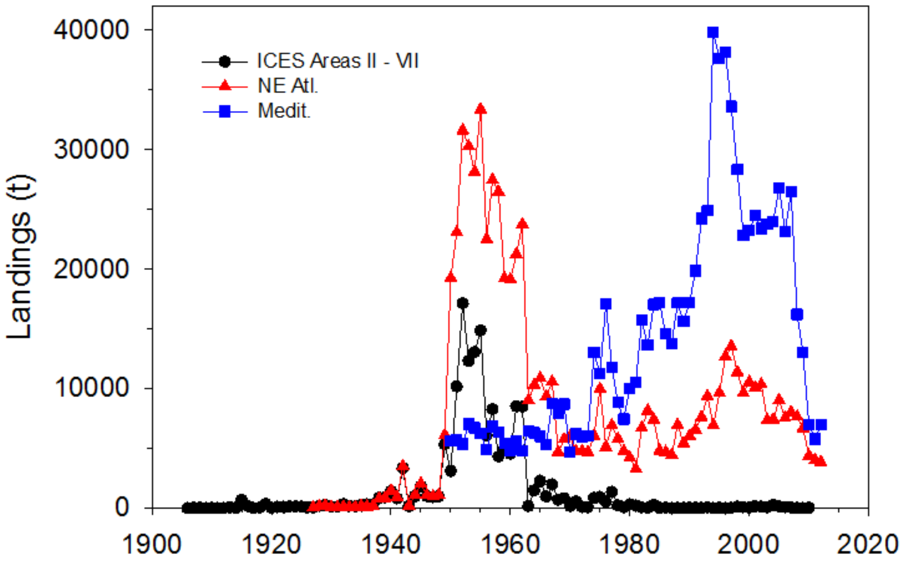

Figure 14. Temporal variability in reported catches of bluefin tuna, *Thunnus thynnus*, in different geographic areas. ICES Areas II–VII correspond approximately to the Norwegian Sea south to the Celtic Sea and continental shelf west of Ireland and the UK (see Fig. 3). NE Atlantic includes the entire northeast Atlantic and Mediterranean Sea. Data sources include ICES catch databases (versions downloaded 21 January 2014) and other historical sources – see PANGAEA link for details.

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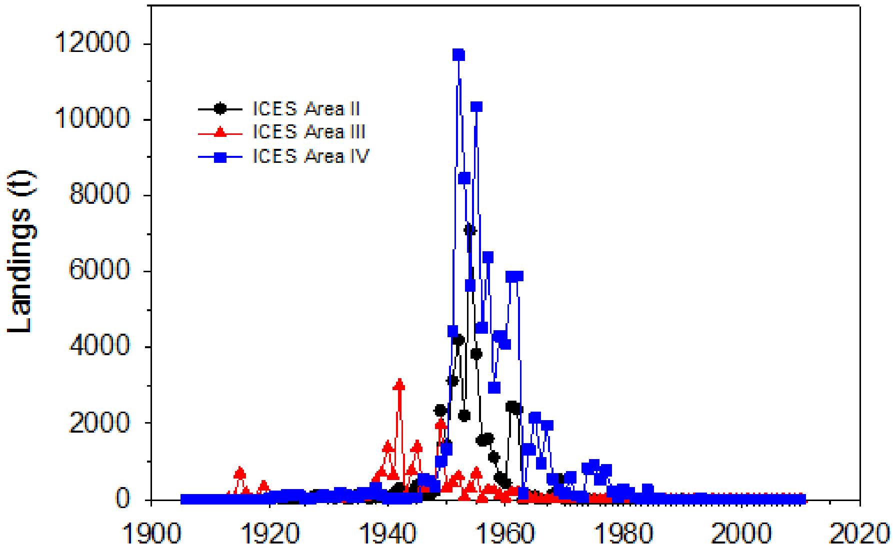

Figure 15. Temporal variability in reported catches of bluefin tuna, *Thunnus thynnus*, in different geographic areas. Areas II, III and IV represent approximately the Norwegian Sea, Skagerrak-Kattegat-Belt Sea-Øresund, and North Sea respectively (see Fig. 4). Data sources include ICES catch databases (versions downloaded 21 January 2014) and other historical sources – see PANGAEA link for details.

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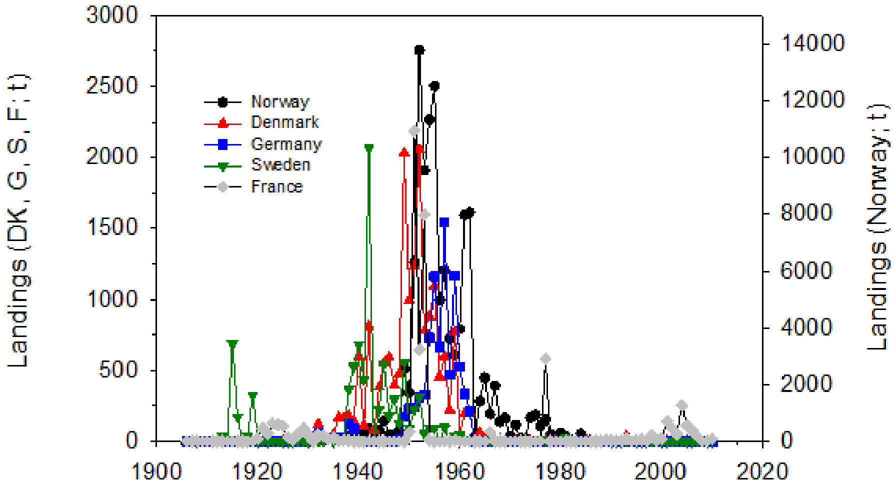

Figure 16. Temporal variability in reported catches of bluefin tuna, *Thunnus thynnus*, in ICES Areas II–VII, by the countries with largest proportions of reported landings. Note that the Norwegian data are scaled on the right axis with a different scaling from the other countries. Most (96 %) landings occurred in Areas II–IV. Data sources include ICES catch databases (versions downloaded 21 January 2014) and other historical sources – see PANGAEA link for details.

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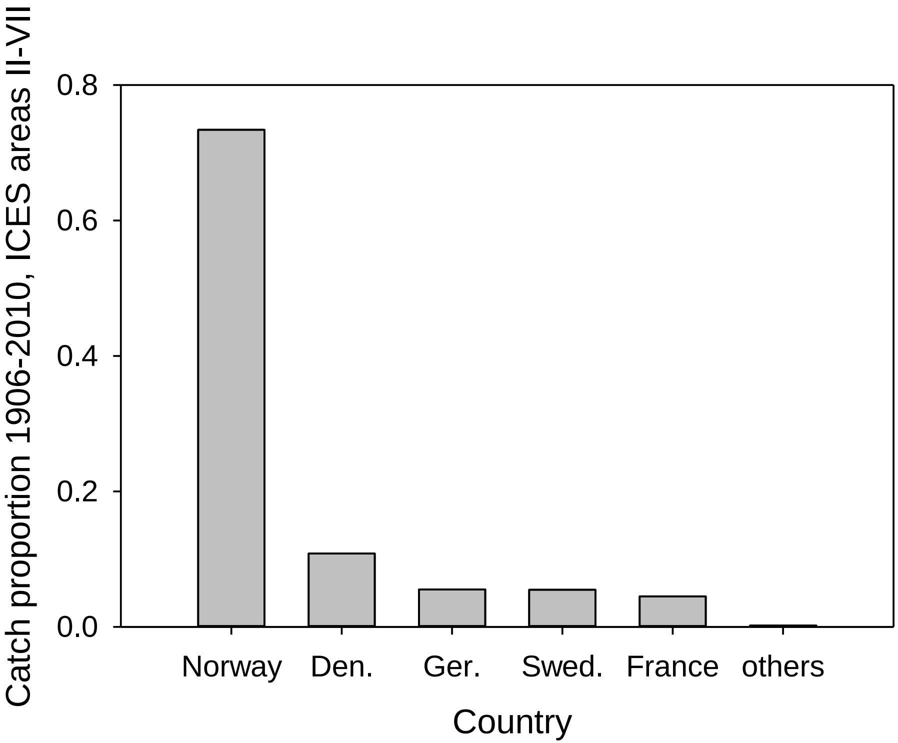

Figure 17. Proportion of total landings in ICES Areas II-VII during 1906–2010. Data sources include ICES catch databases (versions downloaded 21 January 2014) and other historical sources – see PANGAEA link for details.

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