**Working Document to**

**Working Group on Northeast Atlantic Pelagic Ecosystem Surveys (WGNAPES)**

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# Cruise report from the coordinated ecosystem survey (IESSNS) with M/V "Libas", M/V "Finnur Fridi" and R/V "Arni Fridriksson" in the Norwegian Sea and surrounding waters, 18 July-31 August 2011

Leif Nøttestad, Jens Christian Holst, Kjell Rong Utne, Øyvind Tangen, Valantine Anthonypillai, Åsmund Skålevik, Kjell Arne Mork

Institute of Marine Research, Bergen, Norway

Guðmundur J. Óskarsson, Sveinn Sveinbjörnsson, Ásta Guðmundsdóttir, Sigurður Jónsson, Jacob Matthew Kasper

Marine Research Institute, Reykjavik, Iceland

Högni Debes, Leon Smith, Jan Arge Jacobsen

Faroese Marine Research Institute, Tórshavn, Faroe Islands

## Introduction

In July-August 2011, two chartered trawlers/purse seiners, M/V Libas (Norway), M/V "Finnur Fridi" (Faroe Islands), and the research vessel R/V "Arni Friðriksson" (Iceland) participated in the joint ecosystem survey (IESSNS) in the Norwegian Sea and surrounding waters. The seven weeks cruises are part of a long-term project to collect updated and relevant data on abundance, distribution, aggregation, migration and ecology of northeast Atlantic mackerel and other major pelagic species. Major aims of the survey were to quantify abundance, spatiotemporal distribution, aggregation and feeding ecology of Northeast Atlantic mackerel in relation to distribution of other pelagic fish species, oceanographic conditions and prey communities. The survey was initiated by Norway in the Norwegian Sea in the 1990's. Faroe Islands and Iceland have been participating on the joint ecosystem survey since 2009, but the Icelandic survey results for 2009 were not included in a joint cruise report that year..

## Material and methods

Coordination of the survey was done by correspondence during the spring and summer 2011. The participating vessels together with their effective survey periods are listed in Table 1.

Figure 2 shows the cruise tracks and the CTD/WP-2 stations and Figure 3 the cruise tracks and the trawl stations.

In general, the weather was mostly calm with excellent survey conditions for oceanographic monitoring, plankton sampling, acoustic registrations and pelagic trawling. Some bad weather with gail force in the northern part of the survey area, did not affect the survey other than reducing the survey speed for a limited period. Bad weather and unfavourable conditions in the westernmost part of the surveyed area, resulted in some delays because the research vessel had to wait for improved weather in order to continue the planned survey. Overall, the weather conditions did not affect the quality of the various scientific data collection during the survey for any of the involved survey vessels.

During this year's survey a new pelagic trawl, Multpelt 832, was used by the Icelandic and the Faroese vessels. This trawl is a product of a cooperation of participating institutes in designing and construction of a standardized sampling trawl for this survey in the future for all participants. The work lead by John Willy Valdemarsen, Institute of Marine Research (IMR), Bergen, Norway,, has been ongoing for a year and was finalized during meetings of fishing gear experts and skippers at meetings in January and May 2011..

**Table 1**. Survey effort by vessel in the July-Aust survey in 2011.

| Vessel | Effective survey period | Length of cruise track (nmi) | Trawl stations | CTD stations | Plankton station |
|---|---|---|---|---|---|
| Arni Friðriksson | 3/8–31/8 | 5365 | 107 | 150 | 101 |
| Finnur Fríði | 8/8–19/8 | 2050 | 29 | 28 | 28 |
| Libas | 18/7–10/8 | 3991 | 59 | 61 | 60 |
| Total | 18/7–31/8 | 11406 | 195 | 239 | 189 |

## Hydrography and Zooplankton

The hydrographical and plankton stations by survey are shown in Figure x.

Libas and Finnur Fridi were equipped with SAIV SD200 CTD sensor recording temperature, salinity, pressure (depth) from the surface down to 500 m, or when applicable as linked to maximum bottom depth. The SAIV sensor was programmed to record data every 2 seconds and the speed of the wire during measurements was set to 0.5 m/s providing data approximately every 1 m in the water column. The sensor was positioned at about 1 m depth for 1 min at each station in order to let the instrument sensors adapt to the seawater from being stored dry between stations on the vessel. CTD data from the downcast were used for further analyses. Sea surface temperature (6 m depth) was also recorded manually from a bottom-mounted temperature sensor with a display on the bridge systematically every hour during cruising between stations for both vessels.

Arni Fridriksson and Finnur Fridi were equipped with a SEABIRD CTD sensor with a water rosette that was applied during the entire cruise. On Finnur Fridi CTD profiles were taken down to 500 m depth, while on Arni Fridriksson it was down to 200 m depth, except for the standardized hydrographic transects where the stations were worked down to 2000m when depth allowed.

Zooplankton was sampled with a WP2-net on all vessels. Mesh sizes were 180µm (Libas) and 200µm (Arni Fridriksson and Finnur Fridi). The net was hauled vertically from a depth of 200 m (or bottom depth at shallower stations) to the surface at a speed of 0.5 m/s. All samples were split in two, one half preserved for species identification and enumeration, and the other half dried and weighed.

Zooplankton sampling was performed on each predefined station; 60 stations on Libas, 101 stations on Arni Fridriksson and 28 stations on Finnur Fridi.

## Trawl sampling

Catches from trawl hauls was sorted and weighed; fish were identified to species level, when possible, and other taxa to higher taxonomic levels. The full biological sampling at each trawl station varied between nations and is presented in Table 2.

**Table 2.** Summary of biological sampling in the survey 2011 for the three participating countries. Numbers denote the maximum number of individuals sampled for each species for the different determinations.

| | Species | Faroes | Iceland | Norway |
|---|---|---|---|---|
| Length measurements | Mackerel | 100 | 100 | 100 |
| | Herring | 100 | 300 | 100 |
| | Blue whiting | 100 | 100 | 100 |
| | Other fish sp. | 0 | 50 | 25 |
| Weighed, sexed and maturity determination | Mackerel | 10 | 50 | 25 |
| | Herring | 10 | 100 | 25 |
| | Blue whiting | 10 | 50 | 25 |
| | Other fish sp. | 10* | 0 | 0 |
| Otoliths/scales collected | Mackerel | 10 | 50 | 25 |
| | Herring | 10 | 100 | 25 |
| | Blue whiting | 10 | 50 | 25 |
| | Other fish sp. | 0 | 0 | 0 |
| Stomach sampling | Mackerel | 10 | 10 | 10 |
| | Herring | 10 | 10 | 10 |
| | Blue whiting | 10 | 10 | 10 |
| | Other fish sp. | 0 | 0 | 10* |

*Depends on species

The Icelandic and the Faroes vessels used the newly designed and constructed Multpelt 832 pelagic trawl aimed for standardization of fishing gear used in the survey while the Norwegian vessel used a different type of pelagic trawl as the main tool for biological sampling. The most important properties of the trawls during the survey and their operation were as shown Table 3.

**Table 3.** Properties and operations of the sampling trawls in the July/August survey 2011 used by the different vessels.

| | M/V Finnur Fridi | R/V Arni Friðriksson | M/V Libas |
|---|---|---|---|
| Trawl type | Multpelt 832 | Multpelt 832 | Egersund/Blue whiting |
| Trawl doors | 7.5 m², 2038 kg | 7.0 m², 1400 kg | 10 m² |
| Wire type | Dynema | Dynex | |
| Wire length (m) | 450 on average | 200-220 | 200-220 |
| Bridles length (m) | Upper 60, lower 68.4 | Upper 60, lower 66 | |
| Rigging of headline/wings | Three fenders (buoyancy, 720 kg each) + floatrope, 90m, buoyancy 1982 kg | Kite/glider | None |
| Weights (kg) | 375 on each lower wings | No Weights | No Weights |
| Circumference (m) | 832 | 832 | 890 |
| Mesh size in codend (mm) | 40 | 40 | 30-40 |
| **Operation:** | | | |
| Typical towing speed (kn) | 4.7 on average | 5.0-5.6 | 4.0-5.0 |
| Fishing approach | Towed in a curve | Towed in a gentle curve | Towed in a curve |
| Typical depth of the headline (m) | 0 | 0 | 10 |
| Mean horizontal opening (m) | 60 | 45 | 70 |
| Mean vertical opening (m) | 27.7 | 28.5 | 35 |

## Acoustics

The acoustic equipment onboard Libas, Finnur Fridi and Arni Fridriksson was calibrated prior to the cruises using standard hydro-acoustic procedure for each operating frequency (Foote, 1987). The frequencies calibrated involved 18, 38, 70, 120 and 200 kHz on Libas, 38, 120 and 200 kHz on Finnur Fridi and 18, 38, 120 and 200 kHz on Arni Fridriksson. CTD measurements were taken in order to get the correct sound velocity as input to the echosounder calibration settings. Salient acoustic settings are summarized in the text table below.

## Cruise tracks

Libas, Finni Fridur and Arni Fridriksson followed predetermined survey lines with pre-selected pelagic trawl stations and occasionally performed pelagic trawl stations on registration from acoustics (herring and blue whiting) (Figure 1). An adaptive survey design was also adopted, due to uncertain geographical distribution of our main pelagic planktivorous schooling fish species. The cruising speed was between 10-14.0 knots if the weather permitted, otherwise the cruising speed was adapted to the weather situation.

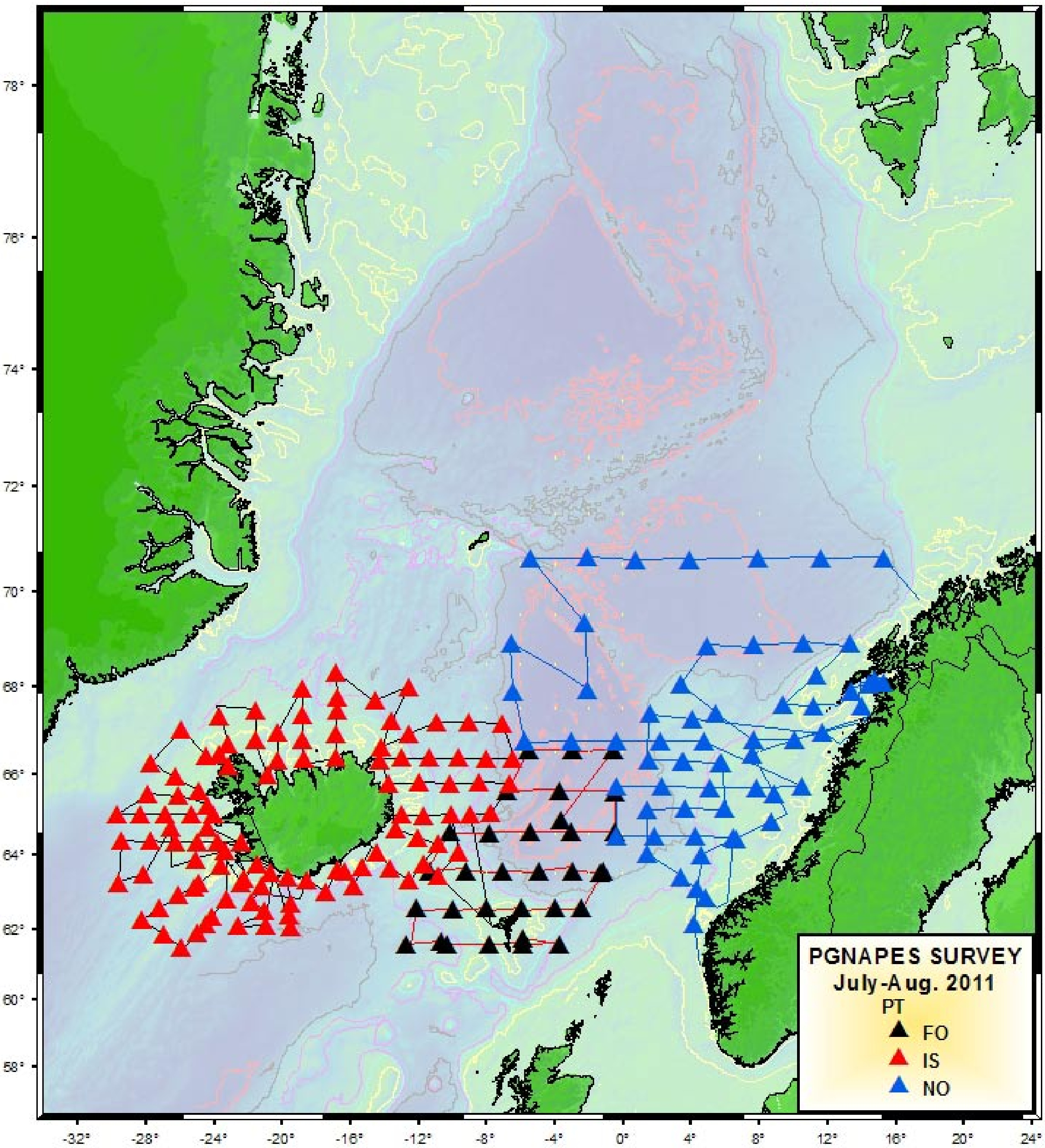


**Figure 1.** Cruise tracks and pelagic trawl stations shown for M/V "Libas" (Norway) in blue, M/V "Finnur Fridi" (Faroe Islands) in black R/V "Arni Fridriksson" (Iceland) in red within the covered areas of the Norwegian Sea and surrounding waters from 18. July to 31. August 2011.

CTD sensors in combination with WP2 plankton net samples from the surface and down to maximum 200 m depth were taken systematically on almost every pelagic trawl station onboard all three vessels (Figure 2).

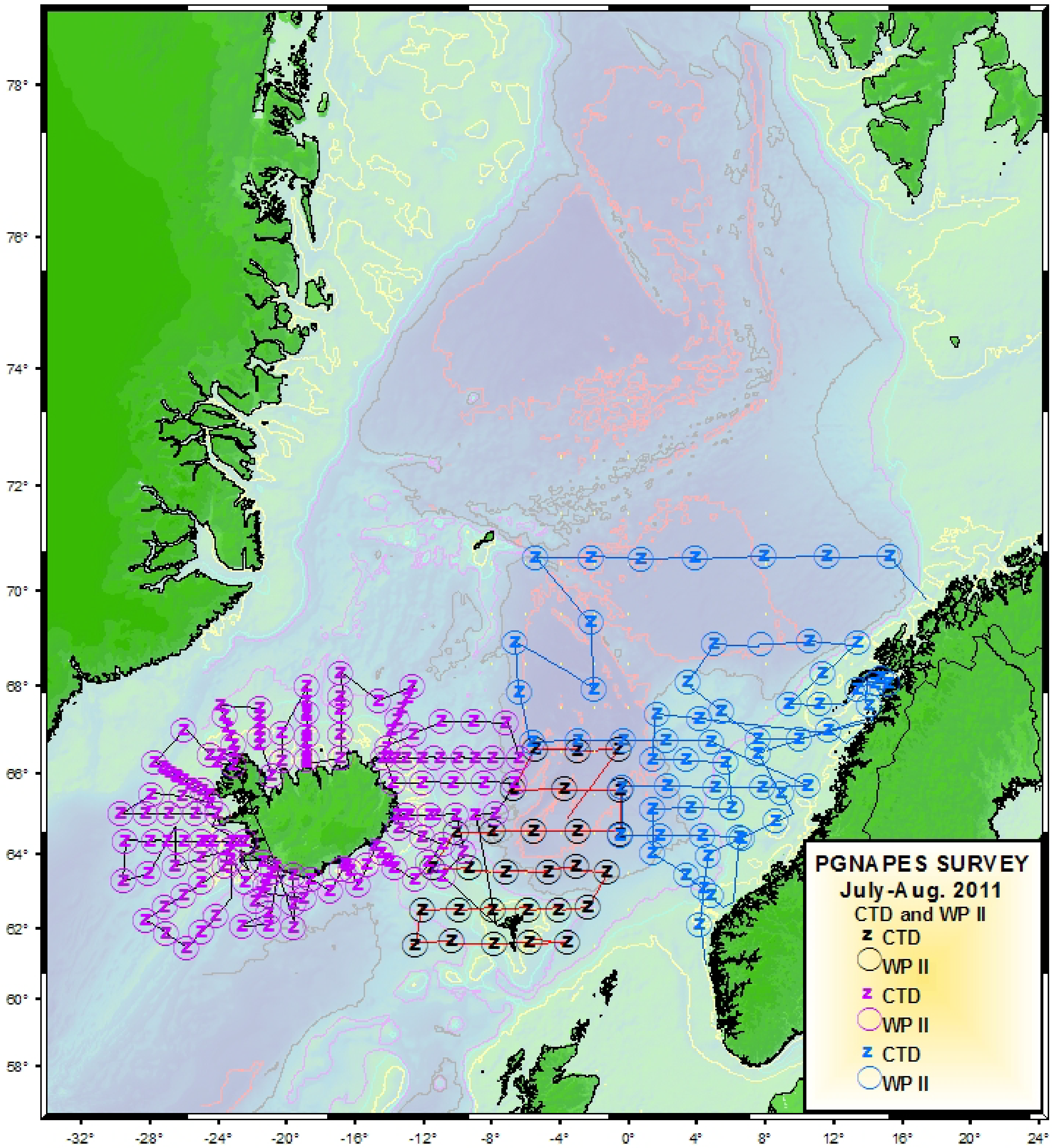


**Figure 2.** CTD stations (0-500 m) using SEABIRD (Arni Fridriksson) and SAIV SD200 (Finnur Fridi and Libas) CTD sensors and WP2 plankton net samples (0-200 m). These were taken systematically on almost every pelagic trawl station on all three vessels

The survey was based on scientific echosounders using 38 kHz frequency as the main for the abundance estimate. A summary of acoustic settings is given in Table 4.

**Table 4.** Acoustic instruments and settings for the primary frequency in the July/August survey in 2011.

| | M/V Finnur Fríði | R/V Arni Friðriksson | M/V Libas |
|---|---|---|---|
| Echo sounder | Simrad EK60 | Simrad EK 60 | Simrad EK 60 |
| Frequency (kHz) | **38,** 120, 200 | **38**, 18, 120, 200 | 18, **38**, 70, 120, 200 |
| Primary transducer | ES38B | ES38B | ES38B serial |
| Transducer installation | Hull | Drop keel | Drop keel |
| Transducer depth (m) | 4 | 8 | 7 |
| Upper integration limit (m) | 7 | 15 | 15 |
| Absorption coeff. (dB/km) | 9.7 | 10 | 9.9 |
| Pulse length (ms) | 1.024 | 1.024 | 1.024 |
| Band width (kHz) | 2.43 | 2.425 | 2.425 |
| Transmitter power (W) | 2000 | 2000 | 2000 |
| Angle sensitivity (dB) | 21.9 | 21.9 | 21.9 |
| 2-way beam angle (dB) | -21.1 | -20.9 | -20.6 |
| Sv Transducer gain (dB) | 24.87 | 24.64 | 23.27 |
| $s_A$ correction (dB) | -0.60 | -0.84 | -0.65 |
| alongship: | 6.89 | 7.31 | 7.01 |
| athw. ship: | 6.87 | 6.95 | 7.11 |
| Maximum range (m) | 500 | 750 | 750 |
| Post processing software | Sonardata Echoview 5.0 | LSSS | LSSS |

Generally, acoustic recordings were scrutinized using the LSSS or Echoview softwares on daily basis and species identified and partitioned using catch information, characteristic of the recordings, and frequency between integration on 38 kHz and on other frequencies by a scientist experienced in viewing echograms.

Acoustic estimates of herring and blue whiting abundance were obtained during the surveys in a same way as e.g. done in the International ecosystem survey in the Nordic Seas in May (ICES 2011). However, due to the fact that few trawl hauls were undertaken to verify potential blue whiting acoustic registrations, the abundance estimate of it was given a low priority in compiling this survey report. The acoustic methods were unchanged from last year (ICES 2011).

## Swept area index and biomass estimation

The swept area estimation approach was the same as that used in ICES (2011, Annex 4 in the WGNAPES report). Rectangle average mackerel swept area index (kg/km$^2$) was used, based on nominal horizontal opening for the different survey trawls (Table 3).

Due to lack of comprehensive coverage and low observed densities in the northern part of the survey area, the swept area estimate is based on observations between 61°N and 69°N. Rectangle dimensions were 1° latitude by 2° longitude. Allocation of the biomass to exclusive economic zones (EEZs) was done in the same way as in 2010, i.e.: **a)** allocation of sea area to EEZs is based on a table taken from a NEAFC blue whiting report, and **b)** sea area proportion of rectangles overlapping land were calculated with polygon clipping in R using packages 'geoextras' and 'geo' (available on http://r-forge.r-project.org) and 'maps', 'mapdata' (available on http://cran.r-project.org) (Jónsson et al. 2011; Björnsson 2010; Becker and Wilks 2010, R Development Core Team 2011). Estimation of sea area proportion was improved from that used in 2010.

An experimental bootstrap approach to estimating uncertainty was used this year. The bootstrap units were the 1° lat by 2° lon rectangle biomass estimates themselves, across the whole area. The total biomass for each bootstrap replicate was summed and stored in a vector of bootstrap biomass estimates, yielding bootstrap CV and 90% CI. Number of replicates was 100 thousands. For this report we bootstrapped both occupied and interpolated rectangle values (Fig. 19).

N-Atlantic EEZs shown as overlays on some of the figures in this report were taken from shapefiles on http://www.vliz.be/vmdcdata/marbound/.

# Results

## Hydrography

There have been considerable changes in the temperature regime in the Norwegian Sea and adjacent waters the last couple of years compared to a 20 years average. However, in July/August 2011 these changes seem to be less pronounced compared to previous periods (Figure 3). It must be mentioned that the NOAA sea surface temperature measurements (SST) are sensitive to the weather condition (i.e. wind and cloudiness) prior to and during the observations and do therefore not necessarily reflect the oceanographic condition of the water masses in the areas, as seen when comparing detailed features of SSTs one month apart (Fig. 3 and Fig. 4).

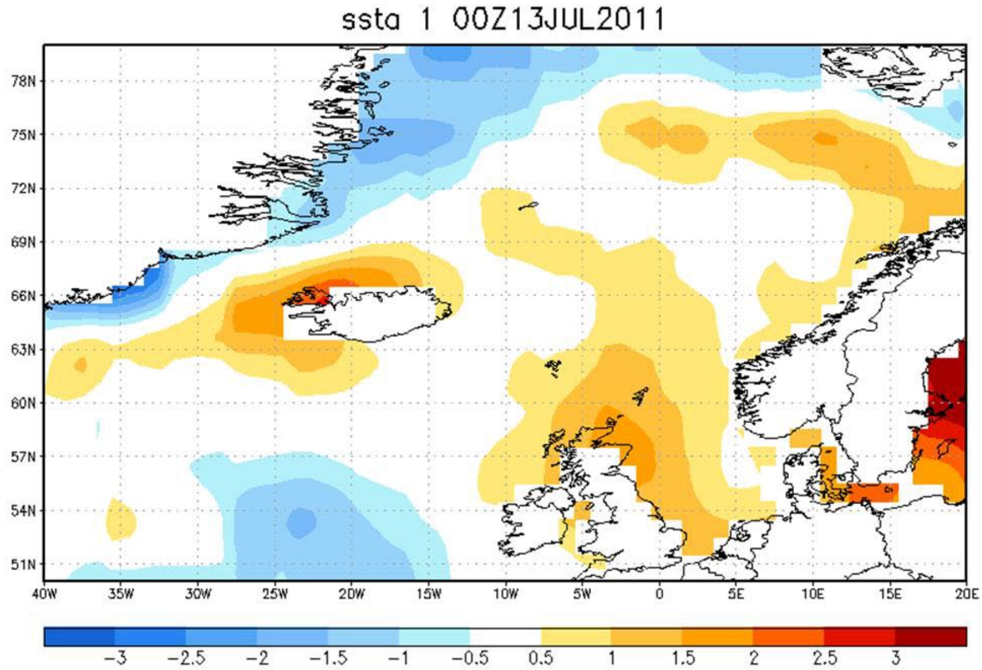


**Figure 3.** Sea surface temperature anomalies (°C; centered in week 28, mid July 2011) showing warm and cold conditions in comparison to a 20 year average.

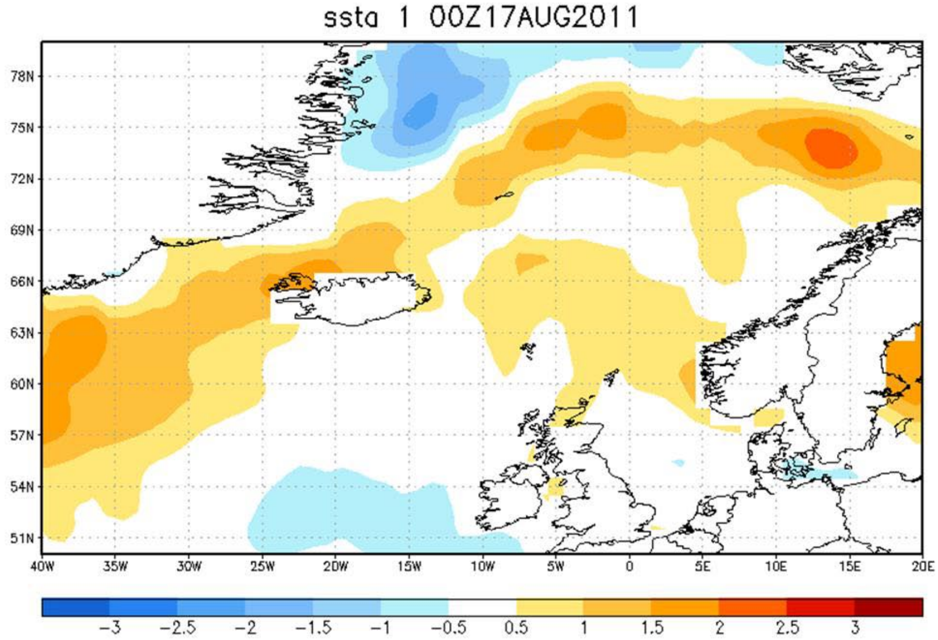


**Figure 4.** Sea surface temperature anomalies (°C; centered in week 33, mid August 2011) showing warm and cold conditions in comparison to a 20 year average.

The temperature at depth based on CTD measurements from the three participating vessels is shown in Figures 5 - 10. The temperature in the upper layers (10m and 20m) shows warm water of Atlantic origin covering most of the survey area. The temperature was highest in the eastern Norwegian Sea where it reached 13°C, and west of Iceland where it was 12°C. The front between the cold East Icelandic water and the warmer Atlantic water (the Iceland-Faroe Front, IFF) which usually is located in the south western Norwegian Sea, was not visible in these layers. Instead warm Atlantic water extended as far north as the survey area in the Norwegian Sea, as well as north of Iceland. North/northwest of Iceland the temperature was lower reaching 4°C. The temperature distribution at 50m depth was different than in the surface layers, especially in the south western Norwegian Sea, where the cold East Icelandic water and features like the IFF were clearly detected. This indicates stratification, with warm Atlantic water in the upper layers, and a sharp thermocline between 20m and 50m depth with a temperature difference of up to 6°C in certain areas. In deeper layers the same main features were detected as described for 50m depth. South and west of Iceland, warm Atlantic water dominated the entire water column with temperature of 7-9°C at 400m depth. In the eastern Norwegian Sea warm Atlantic water was also detected down to 400m depth.

Compared to 2010, there are similarities in the overall temperature distribution in the upper layers of the water column. However, in the eastern Norwegian Sea this layer was warmer in 2011, while the water mass south of Iceland was colder. In the deeper layers the pattern was the same both years.

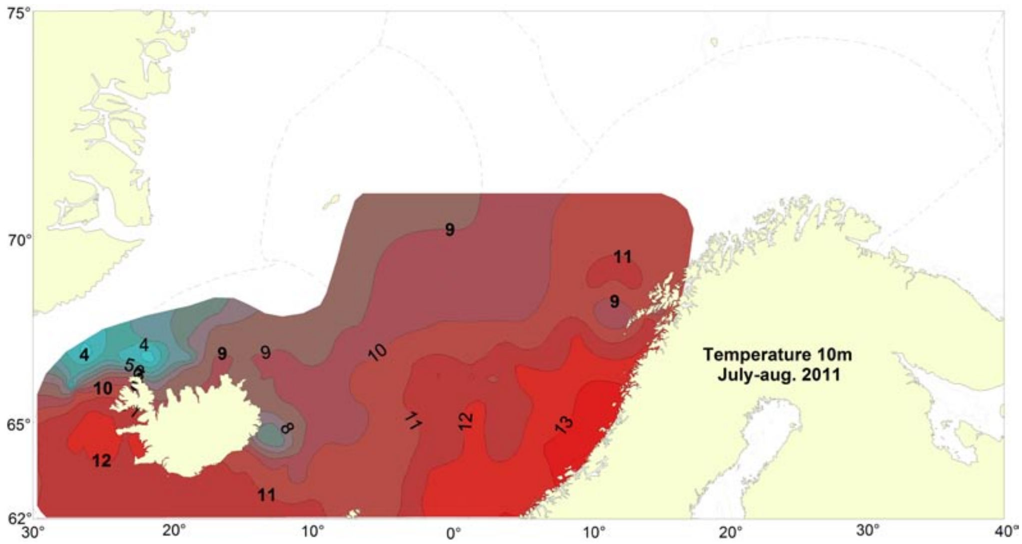


**Figure 5.** Temperature (°C) at 10 m depth in the Norwegian Sea and surrounding waters, 18 July - 31 August 2011.

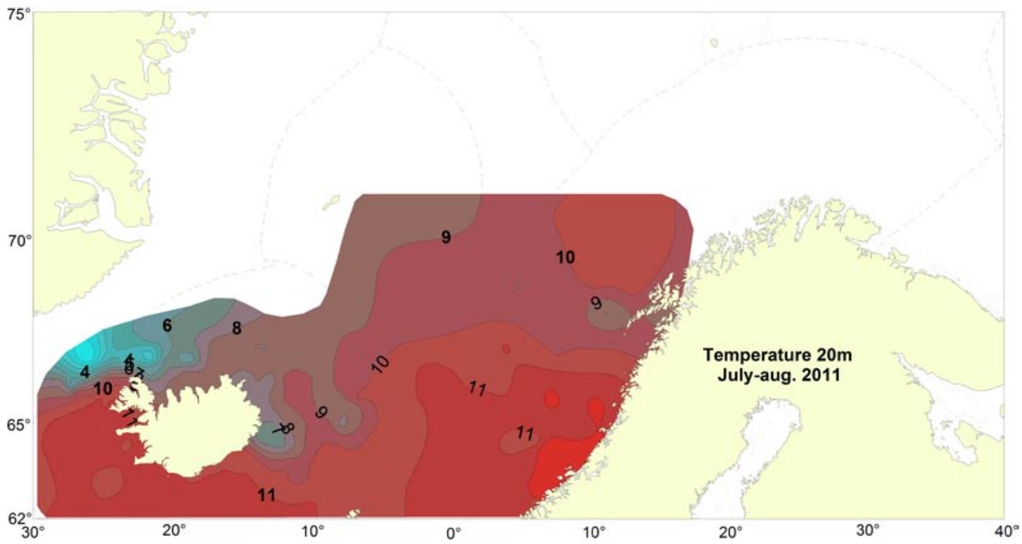


**Figure 6.** Temperature (°C) at 20 m depth in the Norwegian Sea and surrounding waters, 18 July – 31 August 2011.

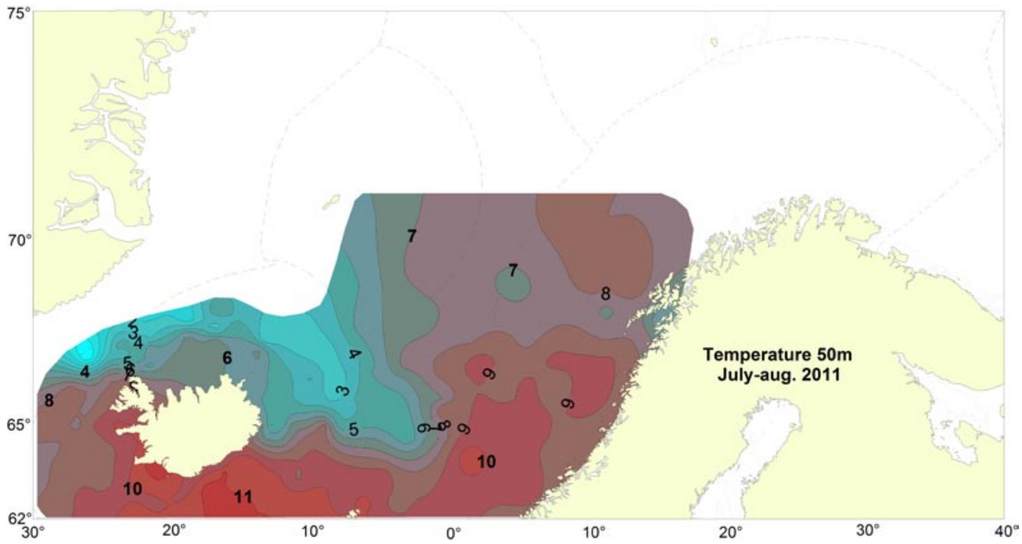


**Figure 7.** Temperature (°C) at 50 m depth in the Norwegian Sea and surrounding waters, 18 July -31 August 2011.

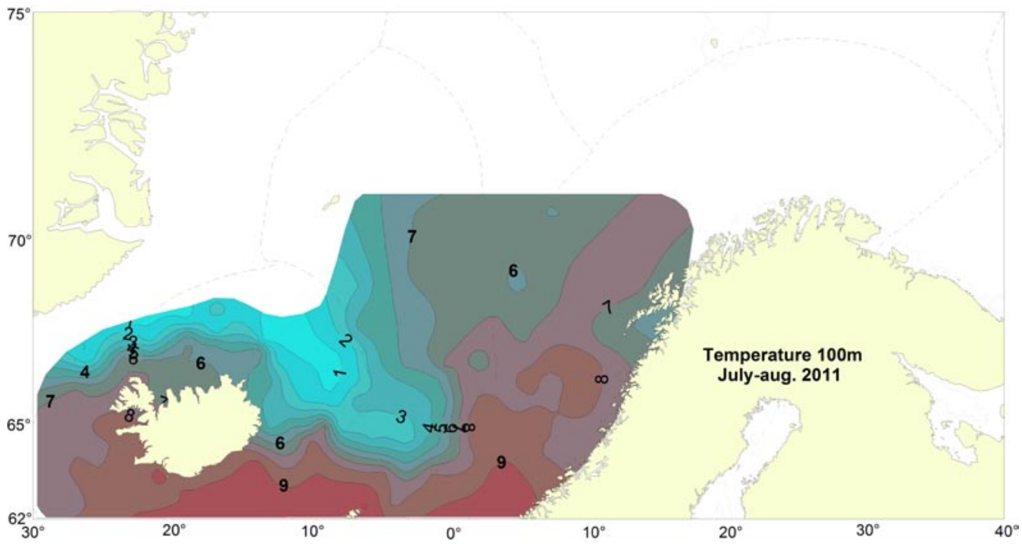


**Figure 8.** Temperature (°C) at 100 m depth in the Norwegian Sea and surrounding waters, 18 July -31 August 2011.

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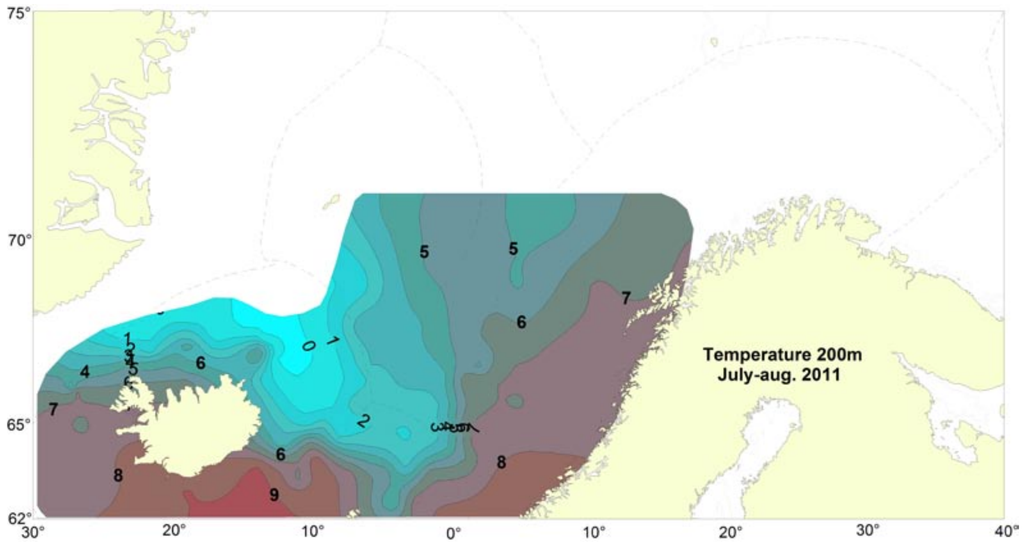


**Figure 9.** Temperature (°C) at 200 m depth in the Norwegian Sea and surrounding waters, 18 July -31 August 2011.

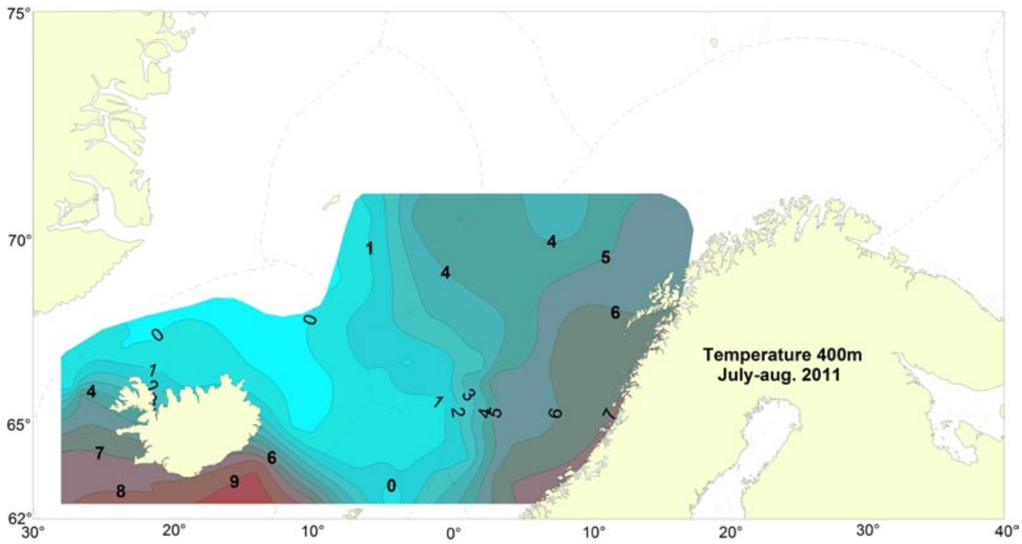


**Figure 10.** Temperature (°C) at 400 m depth in the Norwegian Sea and surrounding waters, 18 July -31 August 2011.

## Zooplankton

The zooplankton biomass was generally low throughout the survey area, especially in the central and eastern Norwegian Sea (Fig. 11). This is the same pattern that was observed during the 2010 surveys. The biomass was slightly higher in the south western Norwegian Sea, and west of Iceland in the frontal area between the warm Atlantic water and the colder Arctic water. The zooplankton samples for species identification have not been examined in detail, but the general impression was that *Calanus finmarchicus*, *Chaetognatha* and to some degree amphipods dominated the samples in the central and western survey area, while *Limacina retroversa* in addition was also observed in the eastern Norwegian Sea.

The low biomass of zooplankton is in agreement with the decreasing trend that has been observed in the zooplankton biomass in the Norwegian Sea in the May survey for more than a decade (ICES 2011).

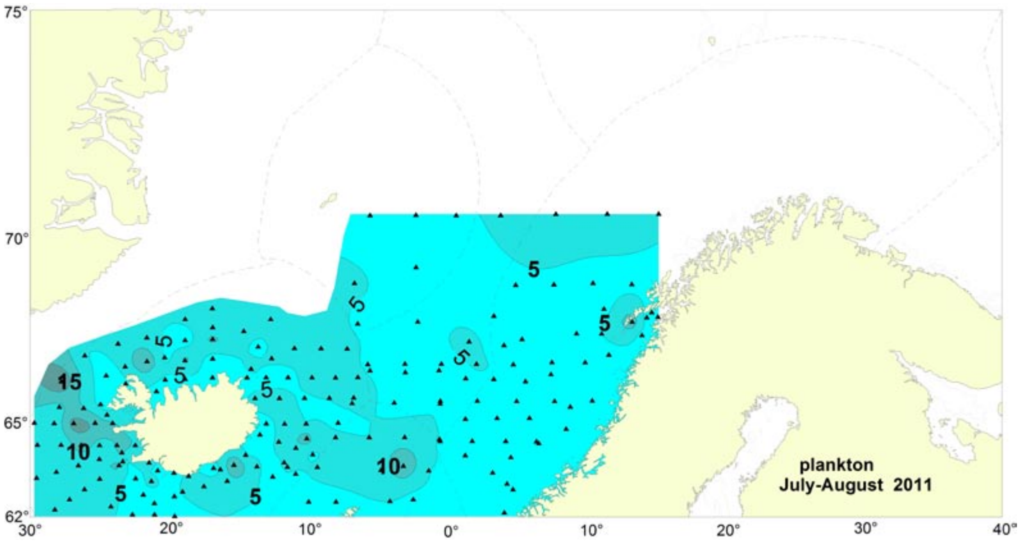


**Figure 11.** Zooplankton biomass (g dw/m$^2$, 0-200m) in the Norwegian Sea and surrounding waters, 18 July -31 August 2011.

## Pelagic fish species

### Mackerel

The total mackerel catches (kg) taken during the joint ecosystem survey is presented in standardized rectangles in Figure 12. The map is showing different concentrations of mackerel from zero catch to more than 500 kg.

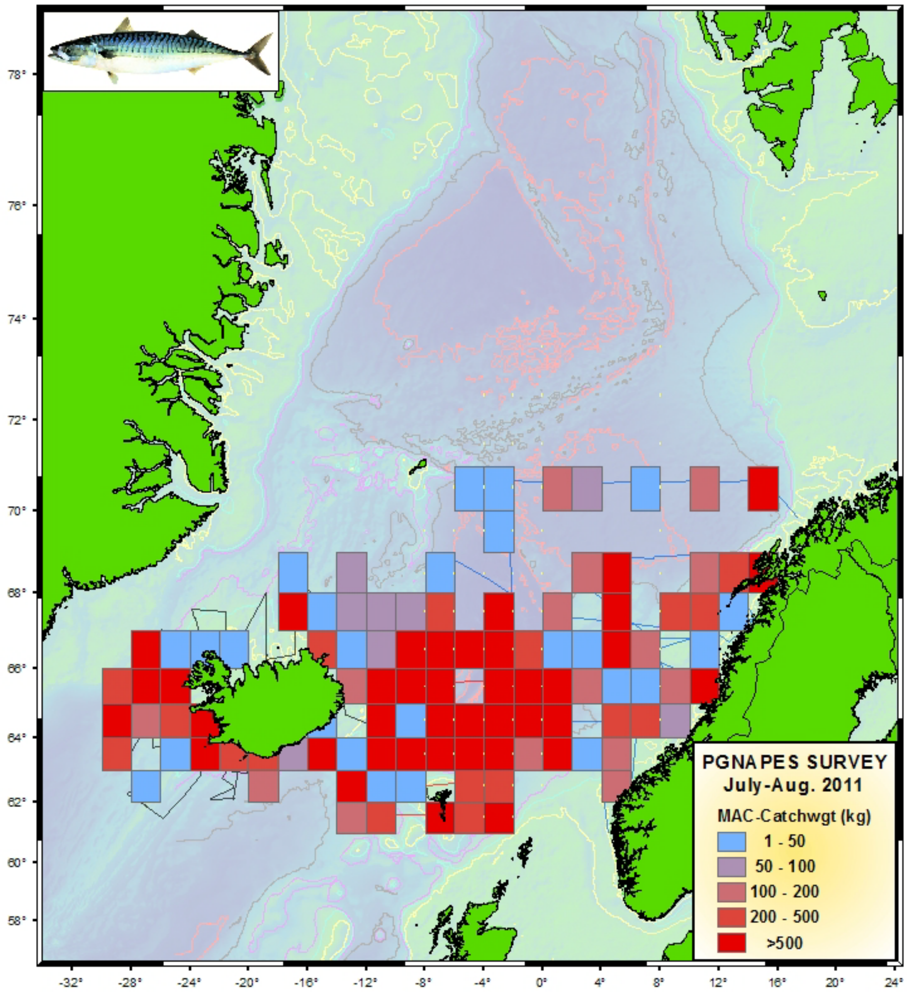


**Figure 12.** Catches of mackerel in kg represented in standarized rectangles. Light blue represents small catches (1-50 kg), while dark red represents catches of more than 500 kg mackerel.

The mackerel catch rates (kg/nmi) from pelagic trawling onboard Libas, Finnur Fridi and Arni Fridriksson from 18. July to 31. August 2011 are shown in Figure 13.

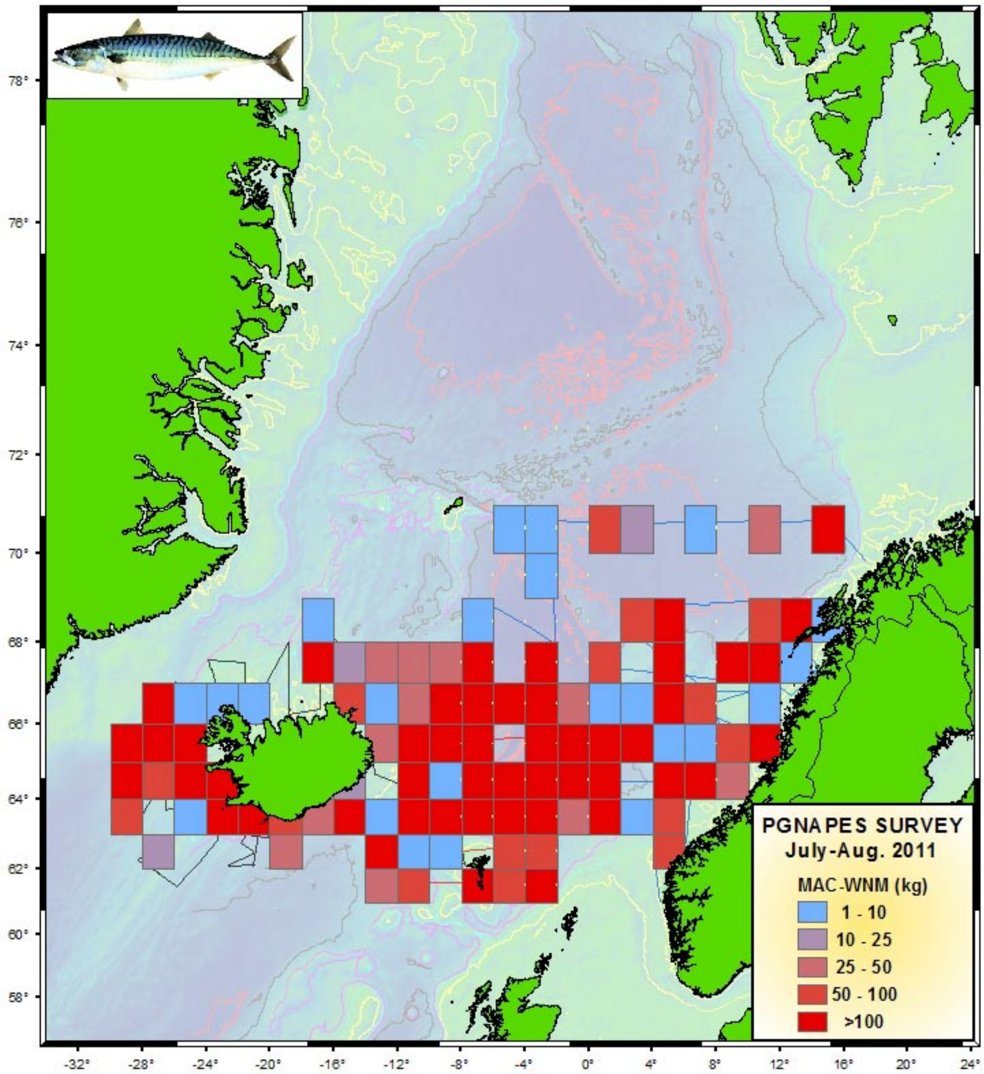


**Figure 13.** Mackerel catch rates presented in rectangles as kg/nmi from standarized pelagic trawling. Light blue represent low catch rates (1-10 kg/nmi), while dark red represent high catch rates (> 100 kg/nmi).

The length distribution of NEA mackerel during the joint ecosystem survey showed a pronounced length dependent distribution pattern both with regard to latitude and longitude. The largest mackerel were found in the northernmost and westernmost part of the covered area in July-August 2011 (Figure 14). Note the presence of 0-group mackerel (20 cm length) in the southern part of the mapped area. In addition mackerel 0-group was observed southwest of the Faroe Islands; the length of these individuals was 16-19 cm (data not shown).

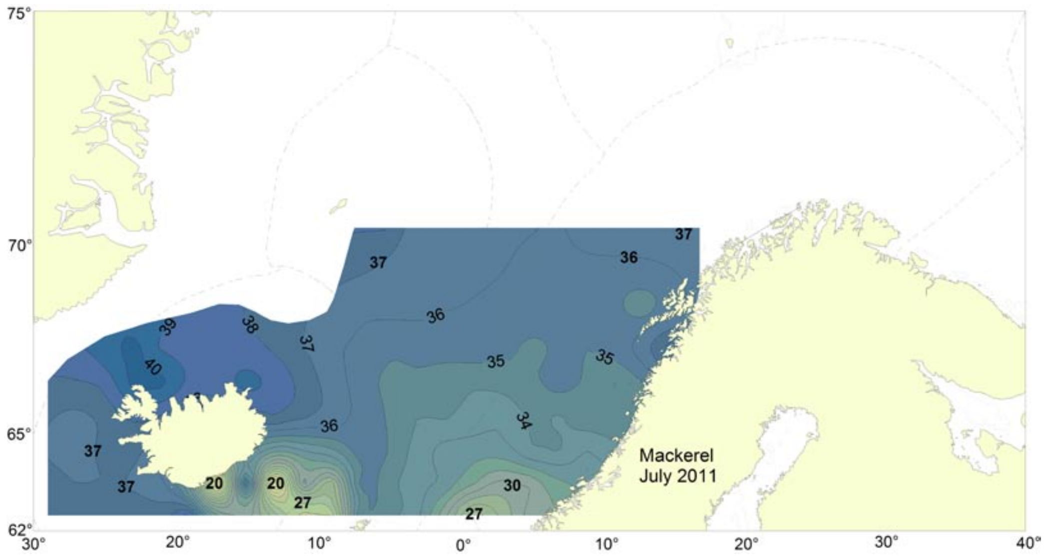


**Figure 14.** Average length distribution of NEA mackerel from the joint ecosystem survey with M/V "Libas", M/V "Finnur Fridi" and R/V "Arni Fridriksson" in the Norwegian Sea and surrounding waters between 18. July and 31. August 2011.

Mackerel caught in the pelagic trawl hauls on Libas, Finnur Fridi and Arni Fridriksson varied from 16 cm to 45 cm in length with the individuals between 33-35 cm dominating in the abundance. The mackerel weight (g) varied between 50 to 900 g (Figure 15). The 2005-year class of mackerel together with the 2006-year class dominated the mackerel population in the Norwegian Sea with around 45% in number (Figure 16).

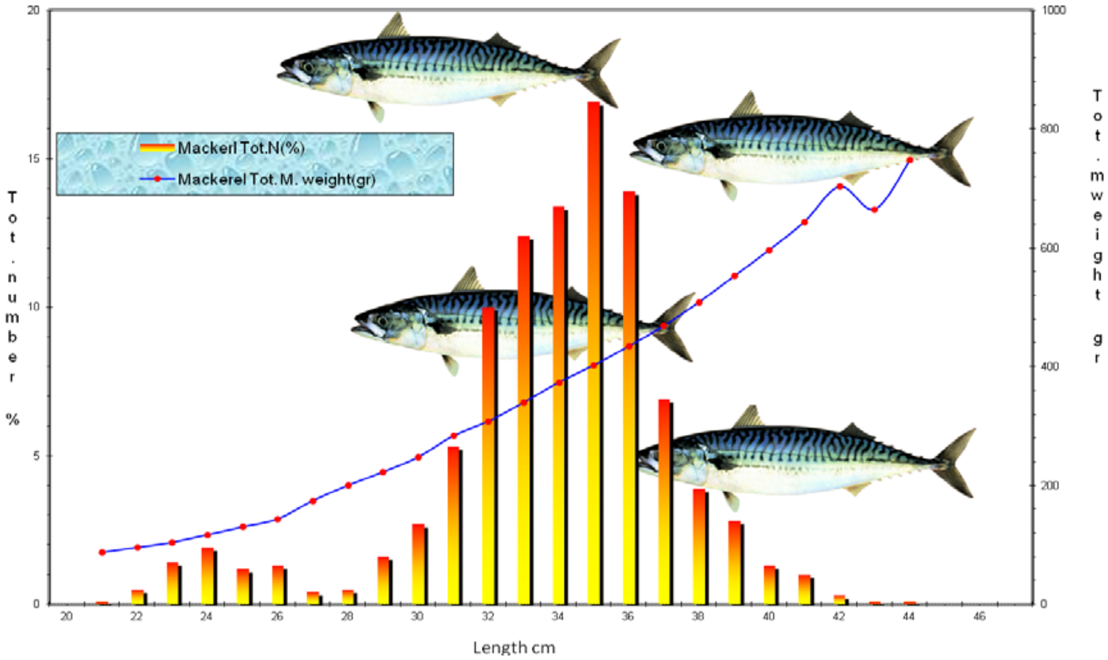


**Figure 15.** Total length (cm) and weight (g) distribution in percent (%) for mackerel in all catches.

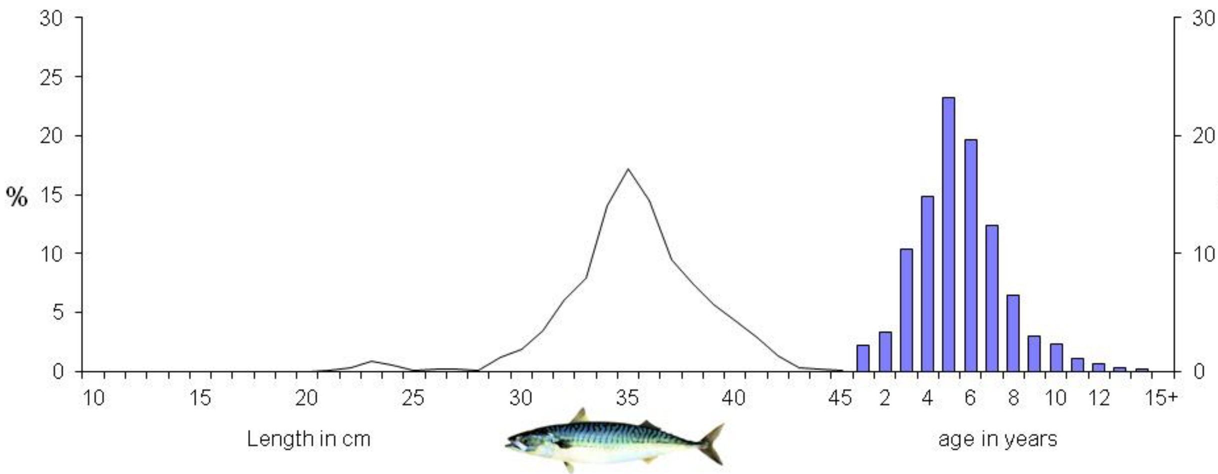


**Figure 16.** Age and length distribution in percent (%) of Atlantic mackerel in the Norwegian Sea.

The spatial distribution and overlap between the major pelagic fish species from the joint ecosystem survey in the Nordic Seas are shown in Figure 17.

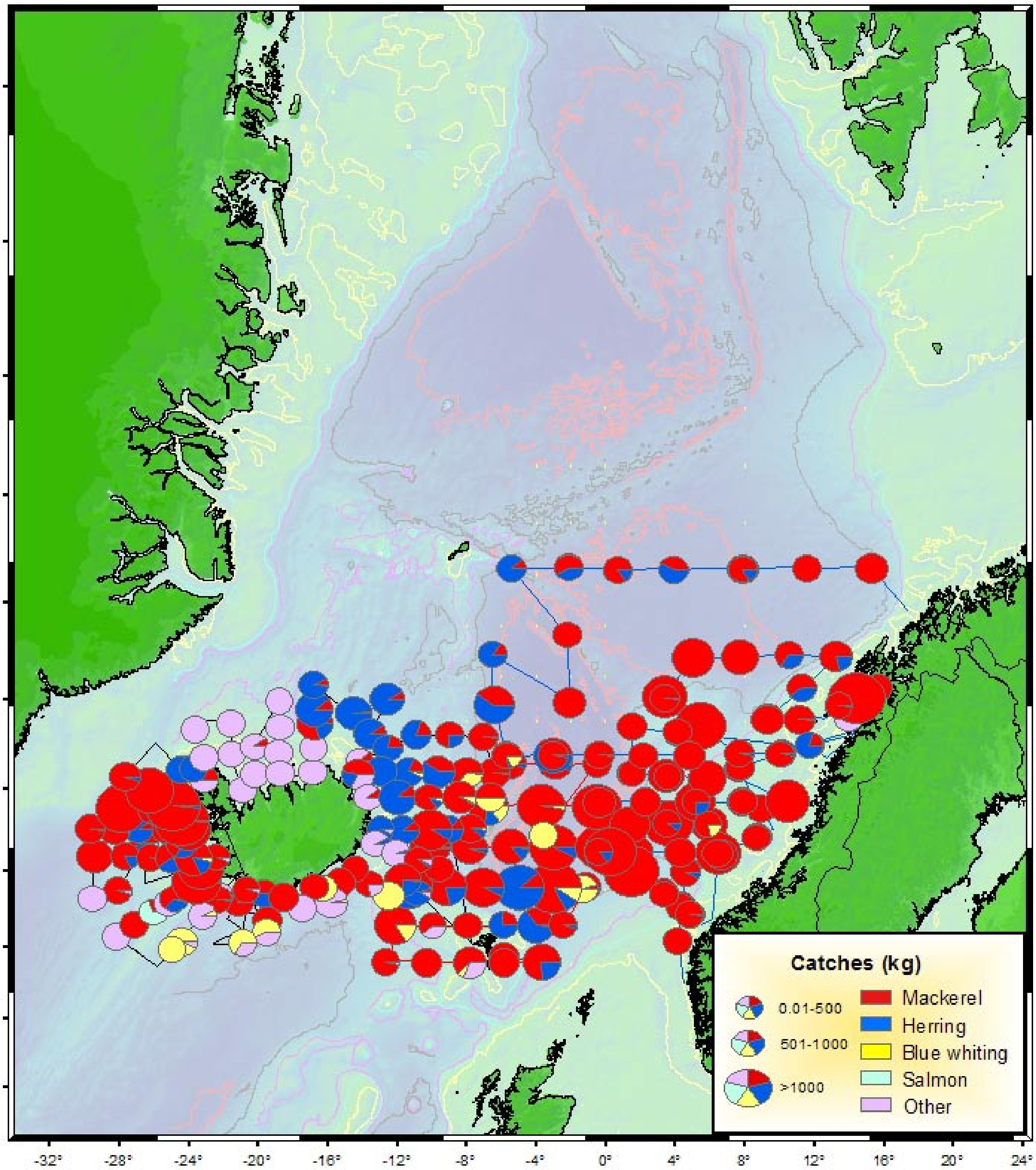


**Figure 17.** Distribution and spatial overlap between mackerel (red), herring (blue), blue whiting (yellow) and salmon (violet) from joint ecosystem surveys conducted onboard M/V "Libas" (Norway), M/V "Finnur Fridi" (Faroe Islands) and R/V "Arni Fridriksson" (Iceland) in the Norwegian Sea and surrounding waters between 18.. July and 31. August 2011.

The swept area estimates of mackerel biomass were based on average catches of mackerel within rectangles of 1° latitude and 2° longitude and measurements of horizontal opening of the trawls (Table above), which gave catch indices (kg/km$^2$; Fig. 18). An interpolation for rectangles not covered was only done for those that had adjacent rectangles with one or more tows on three or four sides. Total number of rectangles interpolated was 12 (Fig. 19). The interpolation was done by taking the average values of all adjacent rectangles. The swept area estimates for the different rectangles is shown in Fig. 19 and in more graphical manners in Fig. 20. Biomass estimates were also done for the different EEZs (Table 5). With the realized coverage and our estimation approach a small percentage is allocated to the Jan Mayen area (0.2%) and the EU EEZ (1.3%). It has to be noted that these values are affected by the incomplete coverage of the survey in 2011. The swept area index estimates of total mackerel biomass changed from 2.7 to 2.5 Mt, an 8% reduction, and the area of the index was reduced by 11%, when we omitted the interpolation shown in Figure 19. The bootstrap CV increased from 0.14 when interpolated rectangles were included in the bootstrap to 0.15 for non-interpolated rectangles only.

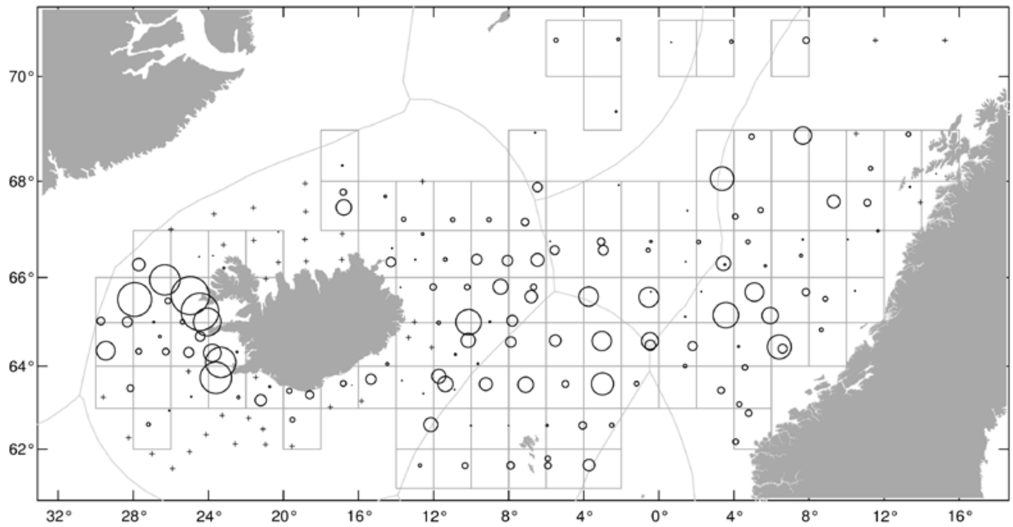


**Fig. 18.** Stations and catches of mackerel in July/August 2011 where the circles size is propotional to square root of catch (kg/km²) and stations with zero catches are denoted with +.

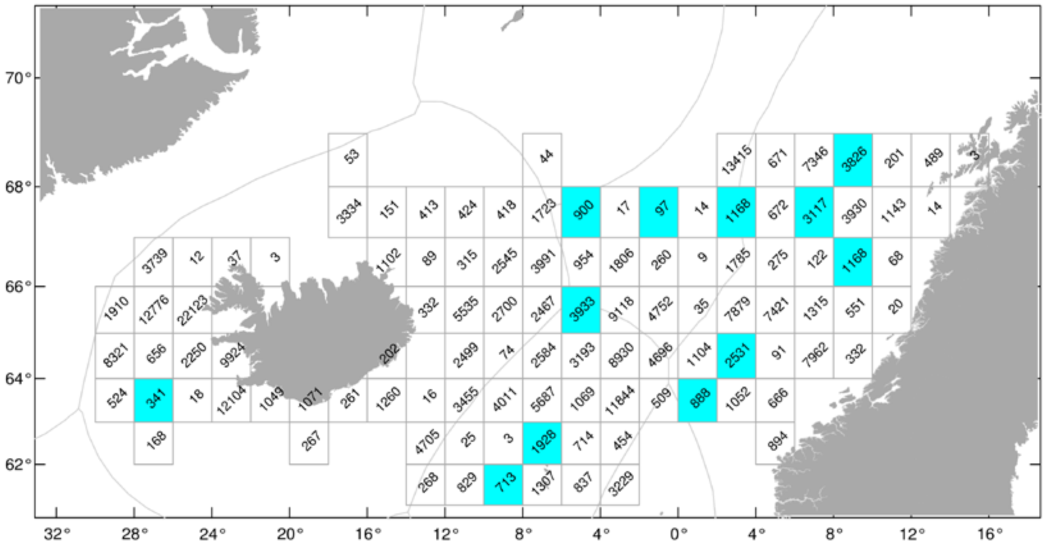


**Fig. 19.** Mean mackerel catch index (kg/km) in 1° lat. by 2° lon. rectangles from swept area estimates in July/August 2011, where interpolated rectangles are denoted with blue shading.

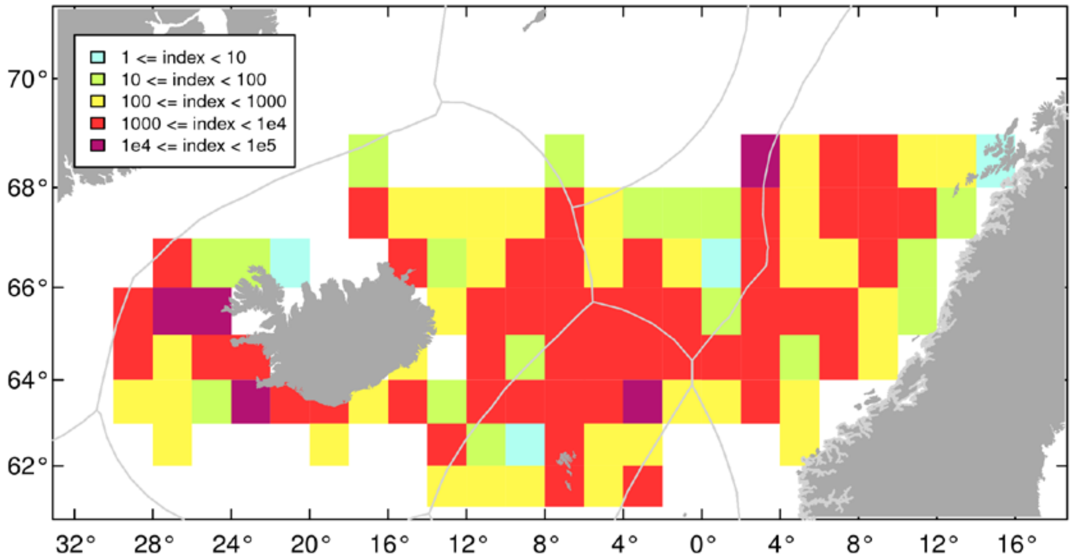


**Fig. 20.** Mean mackerel catch index (kg/km²) for mackerel the July/August 2011 survey represented graphically. Colouring of index levels is the same as in the last IESSNS survey report (ICES 2011).

**Table 5.** Swept area estimates of NEA mackerel biomass in the different EEZs according to the coordinated ecosystem survey in July-August 2011 along with bootstrap uncertainty of total biomass estimate.

| | Area (thous. km²) | Biomass (thous. tonnes) | Bootstrap CV | Bootstrap 90% CI | Biomass% * |
|---|---|---|---|---|---|
| Total | 1061 | 2690 | 0.14 | 2086-3345 | |
| Faroese EEZ | 212 | 592 | | | 22.0 |
| Icelandic EEZ | 420 | 1143 | | | 42.5 |
| Norwegian EEZ | 301 | 612 | | | 22.8 |
| International waters | 128 | 294 | | | 10.9 |

* A small percentage of the estimate was in EU and Jan Mayen EEZs (see text above).

## Norwegian Spring-spawning herring

The Norwegian spring-spawning (NSS) herring (*Clupea harengus*) was acoustically recorded and biological samples were taken at all pelagic trawl stations where herring was present in the upper water masses. Due to an incomplete overall coverage of the major distribution of NSS herring and mixture with other herring populations, an abundance estimation based on acoustic measurements has not been conducted for the joint ecosystem survey in July-August 2011.

Norwegian summer spawning herring were also sampled and acoustically monitored in the Vestfjord and Lofoten area in northern Norway, whereas Icelandic summer spawning herring were sampled in the western and eastern part of Iceland. In the northern Faroes waters herring juveniles (20-24cm) of unknown origin, for the time being, were observed. The otoliths growth patterns resembles the growth pattern of NSS herring, however more detailed studies are needed to confirm this.

The Sa values south of 66’N show that NSS herring to a large extent was concentrated in the south western Norwegian Sea during summer 2011 (Fig. 21). This is somewhat different compared to 2010 when a larger proportion of the herring were located northeast of Iceland. The most likely reason for this change in the distribution pattern was the presence of colder water northeast of Iceland in 2011 earlier during the summer, which might have prevented the usual northward migration of the herring during summer and thus a longer retention of the herring in the southwestern Norwegian Sea north of the Faroe Islands. The same indications were also observed in the Joint International Ecosystem Survey in May 2011, targeting herring.

The presence of colder water earlier in the season in the western Norwegian Sea compared to last year might to some degree have prevented the northward migration of mackerel and herring. This most likely resulted in a larger proportion of the mackerel migrating westwards south of Iceland, and the longer retention of NSS herring in the south western Norwegian Sea north of the Faroe Islands compared to 2010. It should be noted that even though the acoustic measurements did not show large concentrations of herring NE of Iceland (Fig. 21), the biggest catches of herring in the whole study area were taken there (Fig. 17). This indicates that the herring there was mainly in the surface waters and possibly above the transducer and therefore poorly represented in the acoustic measurements. This could be the case for other areas as well where the herring is staying high in the water column actively feeding.

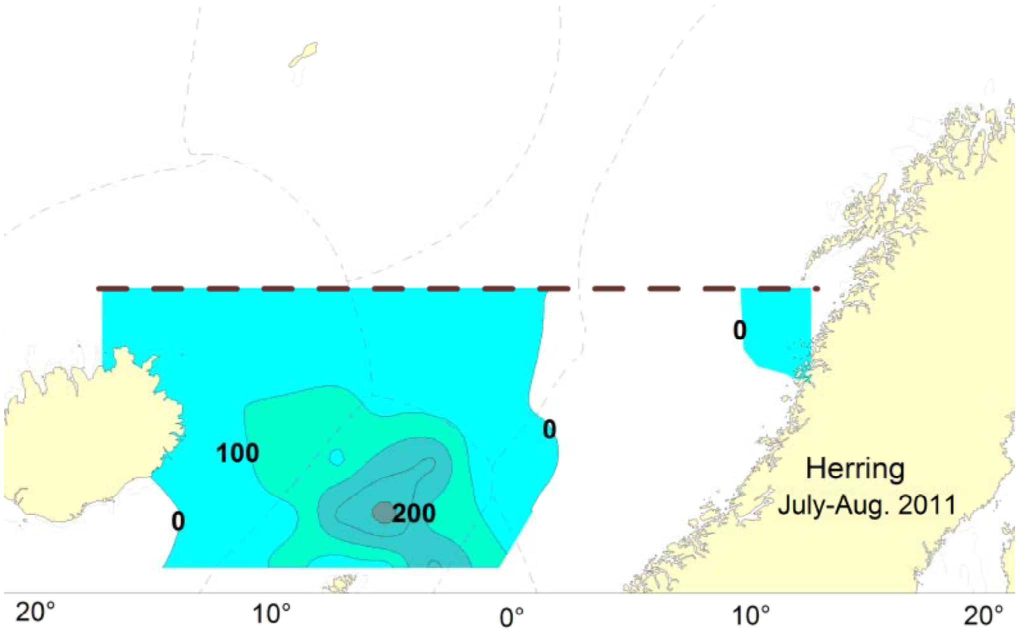


**Figure 21.** Contours of $S_A$/Nautical Area Scattering Coefficient (NASC) values of herring along the cruise track, 18 July -31 August 2011. Due to lack of coverage only data south of 66'N are included.

Norwegian spring-spawning herring had a length distribution from 19-40 cm with a peak at 33 cm, and a weight ranging mainly from 100-400 gram (Figure 22).

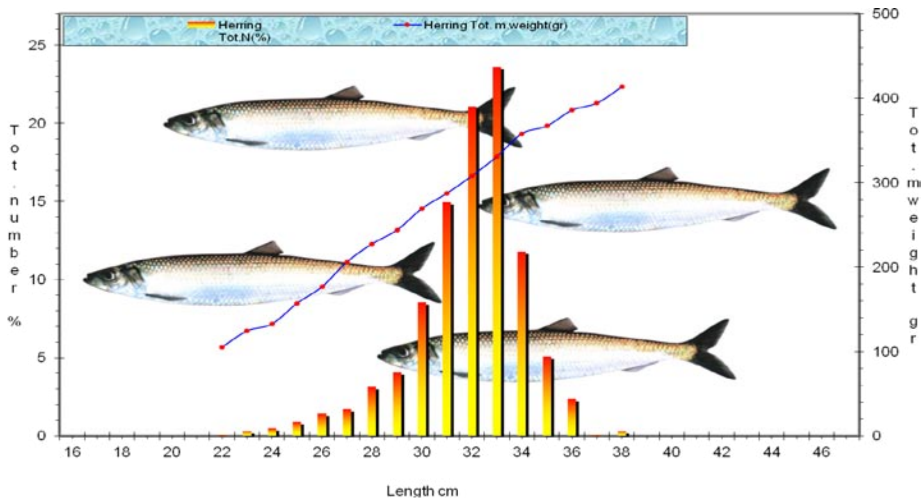


**Figure 22.** Length and weight distribution of herring in the pelagic trawl catches.

The age distribution in herring shows dominance of the 2004 year class, while in 2010 the 2002 year class dominated in the samples (Figure 23). The 2004 year class constituted about 25% of the total samples in number. Note that the length and age structure of herring represents different herring stocks, e.g. Norwegian summer-spawners, herring and Icelandic summer-spawners east of Iceland.

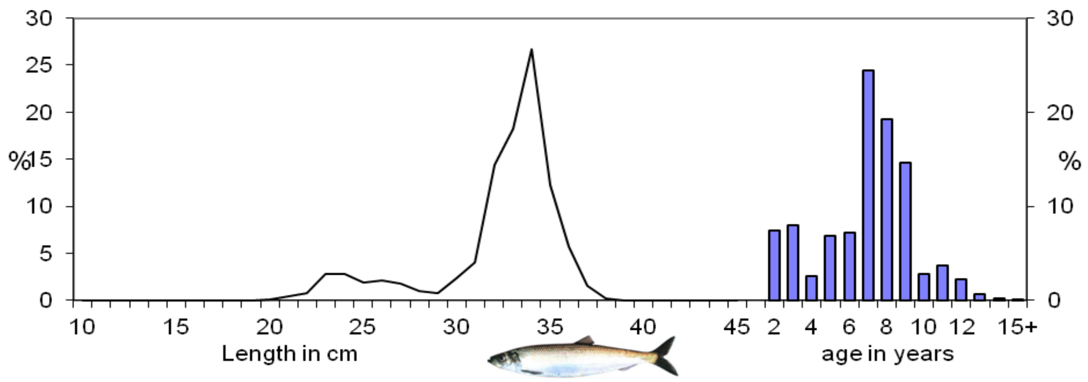


**Figure 23.** Herring age and length distribution in the pelagic trawl catches.

## Blue whiting

The survey is not designed or performed in an ideal way for abundance estimates of blue whiting. It involves that frequency of trawl hauls on acoustic registrations at some depths is generally less than needed to get a valid estimate of the species and length compositions. Thus abundance estimate of blue whiting is not provided here. Blue whiting was observed in trawl hauls in most areas covered in the survey, with the biggest catches south of Iceland and south-western part of the Norwegian Sea. In the Icelandic waters and south of the Faroes, it was mainly juveniles (0 and 1 year old) while adults occupied the Norwegian Sea. No age distributions are provided in this report because of limited trawl samples.

## Lumpfish

Lumpfish (*Cyclopterus lumpus*) is among the most widely distributed species caught in the IESSNS survey. Swept area estimates indicate highest concentrations of lumpfish near the coastal spawning grounds of Norway and Iceland, yet a widely pelagic distribution of fish is noted (Figure 24). The lack of fish caught around Faroe Islands suggests that this region is not important for spawning or feeding. Variations in the distance from shore of various length classes could be an indicator of year class distribution or favourable feeding grounds for different life-history stages. A wide range of lumpfish sizes were caught in the surveys (6-54cm) and adults (>25cm) were found throughout the survey area, from costal to pelagic waters. The continuity of the stock raises some important management questions which will be addressed with further analyses of the IESSNS lumpfish data and with genetic analysis in the future.

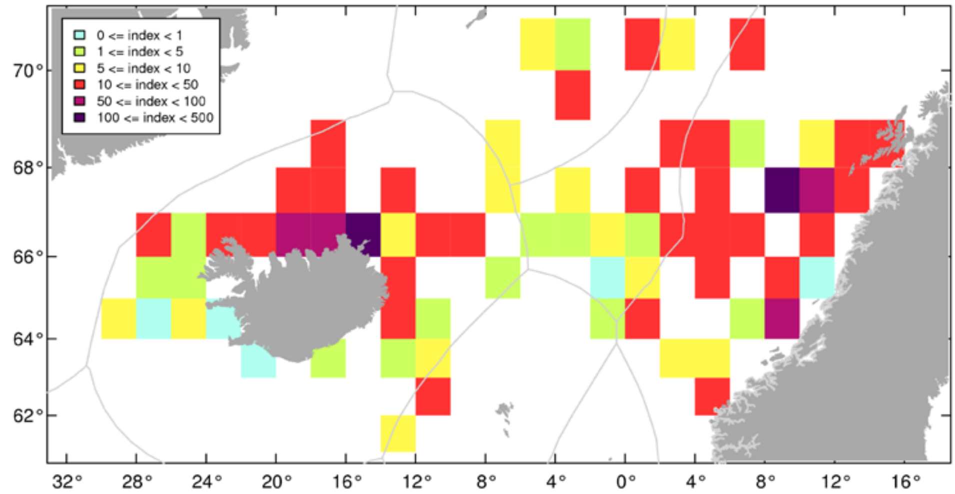


**Fig. 24.** Rectangle average swept area index (kg/km²) for lumpfish in the July/August 2011 survey.

## Discussion

The coordinated ecosystem survey in 2011 did not entirely cover the distribution of the target species, mackerel, herring and blue whiting. July-August is the feeding period for the three major pelagic species and during this time they have their maximum geographical distribution. One of the main aims of this joint survey is to map the distribution and estimate abundance of NEA mackerel, NSS herring and blue whiting in the Norwegian Sea and surrounding waters. This goal was not fully achieved because of incomplete coverage. The main reasons were that Norway participated with one vessel compared to two in 2010 and the lack of synchronization between nations when planning cruise time, cruise tracks and cruise progression (see Nøttestad et al. 2010). Ideally we should strive to reach beyond the distribution of all target species in all directions. Regarding this year's survey, this information was lacking in most areas, but especially west of Iceland, in the northern Norwegian Sea, southern Norwegian Sea and south/southeast of Iceland. In order to improve this for the 2012 survey it is recommended that we through correspondence and a pre-survey video conference plan the combined survey design together, and aim to include survey time for an adaptive survey at sea.

The incomplete coverage in some regions will affect the calculated zonal distribution of mackerel biomass in the various EEZs as shown Table 5. Therefore there is a need to expand the survey coverage to cover the entire distribution of the stock. In order to reach this goal and to obtain a more holistic and comprehensive understanding of mackerel abundance and distribution, participation by EU is encouraged.

The survey results indicate that the mackerel reached further west and was in higher concentrations west of Iceland in comparison to last year. On the other hand the concentration on the continental shelf east of Iceland was lower in 2011 compared to 2010. The cold temperature condition east of Iceland for most of the summer as e.g. observed in the May survey (ICES 2011) could have caused these changes, i.e. forcing the mackerel further west for feeding. In other areas the distribution was relatively homogenous and comparable to last year, but it must be highlighted that reduced coverage in this year's survey prevents a detailed comparison.

The survey covered only a part of the distribution area of Norwegian spring-spawning herring, thus no abundance estimates were done. Its distribution within the covered area was somewhat different than in the previous year. A concentration found in 2010 east of Iceland (around 10°W) was much less pronounced in 2011 while the concentrations in the northern part of the Faroese EEZ was similar in both years. This is believed to be a consequence of the strength of the cold East Iceland Current (EIC) and relatively little warming of its surface waters in the early part of the summer. Similarly, no herring was observed in the EIC waters in the May survey in 2011, which differed from the four earlier years (ICES 2011).

The shallow distribution and absence of dense schooling behavior in both mackerel and herring within most of the study area in July-August, makes the quantitative estimation of especially mackerel and herring challenging. Based on multibeam sonar and visual observations, concentrations of these species occurred above and close to the transducer depth and would therefore not be detected by the downward oriented echosounders. Furthermore, pronounced vessel avoidance during summer feeding may complicate these studies even further. Nevertheless, we are progressing in this area of science, and recommend the further use of acoustics (echosounders and sonars) for the coordinated ecosystem survey in the years to come (see Nøttestad and Jacobsen 2009 and Nøttestad et al. 2010).

Information on stomach content of the three main pelagic species (mackerel, herring and blue whiting), combined with concurrent information on zooplankton and the hydrographic conditions are of paramount importance for a more thorough and detailed understanding of the feeding ecology, potential inter-specific feeding competition, spatiotemporal overlap and migration patterns of mackerel, herring and blue whiting in the Norwegian Sea and surrounding waters. Although only parts of these data are currently available at the different institutes, they might prove very valuable in the future. We therefore recommend continuing systematic sampling and diet analyses on the coordinated ecosystem survey in the future.

The newly designed pelagic sampling trawl for scientific purposes (Multpelt 832), should be used as the new standard sampling trawl for pelagic fish onboard all vessels participating in the joint ecosystem survey (IESSNS) in July-August. Standardization of the survey has not been fully reached yet in terms of trawling and trawl rigging. This standardization is related to following parameters: towing time and speed, type of trawl doors, and rigging of the trawl doors, best functional warp length, sweep lines, rigging of the headlines (floats, buoys, kite), sensors on the trawl doors and headline to measure the three dimensional trawl geometry and cod end. No weights attached to the pelagic sampling trawl would possibly be beneficial when trawling for mackerel very close to the surface and save valuable time at sea. This should be addressed at a meeting with gear experts and skippers prior to the 2012 survey.

The survey period extended for about seven weeks from 18th July to 31st August in 2011. Due to the fact that the mackerel is a highly migratory species, the different countries should strive to minimize the total period spent at the joint ecosystem survey to maximum five weeks, in order to obtain as good and robust data on mackerel abundance and distribution as possible. The group agreed that the period from 7th July to 15th August was suitable as the maximum time window in the future. The distance between each trawl station should be around 50-60 nmi by all countries in order to obtain comparable and representative samples, be able to cover extensive areas and reach the zero lines for selected target species. It would also be beneficial to standardize the survey design in the direction of performing predominantly east-west courses, in order to reduce the potential double-counting of migratory mackerel during the main feeding season in summer.

Inter-calibration of both acoustic instrumentation and pelagic trawling is a sound way to calibrate and standardize among survey vessels the performance of biological sampling of fish and plankton, acoustic scrutinizing procedures and oceanographic monitoring. The involved vessels should agree upon a dedicated meeting point where such an inter-calibration can take place during the overall survey period.

Obtaining a high degree of standardization in planning, survey design and performance, data collection and analyses between countries is highly beneficial for all and may have significant impacts and improve the results by increasing the scientific quality and reducing the uncertainties involved.

Based on opportunistic observations on board all the three vessels, there was a common census that whales were in low numbers in the 2011 survey compared to previous years. Systematic observations onboard all the vessels is encouraged as they can provide important ecological information.

## Recommendations

### General recommendations

- Participation by EU in the survey is recommended and encouraged by the group in order to be able to expand the survey coverage to cover the entire distribution of the stock and thereby obtain a more holistic and comprehensive understanding of mackerel abundance and distribution.

### To the participants in the survey

- The transects should in general be spaced with a distance of around 50-60 nmi between them in east-west direction. When working in coastal waters some compromise needs to be done in some areas with perpendicular north-south transects to the coast.
- Next year's survey should take place within a five weeks period from 7 July- 15 August.
- In order to have as good information as possible about the summer distribution of the NEA mackerel survey transects should be extended to reach beyond the distribution.
- When the time frame and duration of the various national surveys has been decided a meeting, e.g. video-conference meeting, should be organised at which a general survey and inter-calibration plan for all participating vessels should be drawn up.
- The new Multpelt 832 trawl should be used as a standard sampling trawl for pelagic fish onboard all vessels participating in the IESSNS survey in 2012.
- Further standardization of the new trawl and how it is operated during trawling is needed and should be addressed at a meeting with gear experts and skippers prior to the 2012 survey. Experimenting with different solutions should also be completed prior the 2012 survey.

- This survey has the potential to provide novel information about biology, distribution and abundance of lumpfish so samples of lumpfish obtained should be measured and recorded in the same way on the vessels as those for the main pelagic fish species.
- Standardization of software used for scrutinizing would be an improvement and LSSS is recommended for this purpose.
- It is recommended that the number of fish taken to biological measurements and determination should be standardized in the survey, or as follows for mackerel, herring, blue whiting and capelin: Length and weight measurements 100; Ageing 25; Stomach sampling 10.
- Work on scientific manuscript intended for publication in high standard journal and based on data from the IESSNS survey should be initiated as soon as possible in order to strengthen and improve the scientific background and recognition of the survey.
- Systematic observations of marine mammals should be done onboard the vessels during the survey as they can provide important information in ecological context.
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## Participants on the surveys

**R/V Árni Friðriksson:**

Sveinn Sveinbjörnsson, Marine Research Institute, Reykjavík, Iceland

Björn Sigurðarson, Marine Research Institute, Reykjavík, Iceland

Páll Valgeirsson, Marine Research Institute, Reykjavík, Iceland

Hildur Pétursdóttir, Marine Research Institute, Reykjavík, Iceland

Gunnhildur Bogadóttir, Marine Research Institute, Reykjavík, Iceland

Ragnhildur Ólafsdóttir, Marine Research Institute, Reykjavík, Iceland

Magnús Daníelsson, Marine Research Institute, Reykjavík, Iceland

Agnar M. Sigurðsson, Marine Research Institute, Reykjavík, Iceland

Gerður Pálsdóttir, Marine Research Institute, Reykjavík, Iceland

Alice Benoit –Cattin, Marine Research Institute, Reykjavík, Iceland

**M/V Finnur Fridi:**

Høgni Debes, Faroe Marine Research Institute, Torshavn, Faroe

Ebba Mortensen, Faroe Marine Research Institute, Torshavn, Faroe

Eirikur Danielsen, Faroe Marine Research Institute, Torshavn, Faroe

**M/V Libas:**

Leif Nøttestad, Institute of Marine Research, Bergen, Norway

Jens Christian Holst, Institute of Marine Research, Bergen, Norway

Kjell Rong Utne, Institute of Marine Research, Bergen, Norway

Matteo Bernasconi, Institute of Marine Research, Bergen, Norway

Andreas Nieuwjahr, Institute of Marine Research, Bergen, Norway

Katie Thomas, Institute of Marine Research, Bergen, Norway

Ørjan Sørensen, Institute of Marine Research, Bergen, Norway

Kristin Westman, University of Bergen, Norway

Amelia O'Connor, Linfield University, USA

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