ICES WGIPS REPORT 2016

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First Interim Report of the Working Group of International Pelagic Surveys (WGIPS)

18–22 January 2016

Dublin, Ireland

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International Council for the Exploration of the Sea

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Contents

Executive summary

The Working Group of International Pelagic Surveys (WGIPS) met in Dublin, Ireland on 18–22 January 2016, under the chairmanship of Sascha Fässler, Netherlands, and Matthias Schaber, Germany. This was the first meeting within a multi-annual ToR term. The core objectives of the Expert Group are to combine and review results of annual pelagic ecosystem surveys to provide indices for the stocks of herring, sprat, mackerel, boarfish, and blue whiting in the Northeast Atlantic, Norwegian Sea, North Sea, and Western Baltic; and to coordinate timing, coverage, and methodologies for the upcoming 2016 surveys.

In addition, the meeting focused on evaluation and implementation of a new software package (StoX) for abundance estimates in WGIPS coordinated surveys. It will allow for a documented, more transparent and standardized approach to estimate survey indices. Consequently, abundance estimation methods for herring surveys in the North Sea and adjacent waters, which were previously based on amalgamating individual nationally adopted methods, were harmonized following a preceding workshop, the Workshop on evaluating current national acoustic abundance estimation methods for HERAS surveys (WKEVAL). Ongoing developments of an ICES database to store acoustic survey data were facilitated. Further examples of auxiliary pelagic ecosystem surveying methodology (zooplankton sampling, acoustic multibeam systems, and camera setups) currently applied by some survey participants were assessed and documented.

Scrutinisation procedures employed for the analysis of raw acoustic data from WGIPS coordinated surveys were evaluated at the Workshop on scrutinisation procedures for pelagic ecosystem surveys (WKSCRUT) and results shared among the group. A harmonization in scrutinisation procedures applied by Denmark and participants covering adjacent areas in the HERAS survey (Norway and Germany) will be initiated. Additionally, a special session will be held during the next WGIPS meeting to allow participants of different surveys to review, evaluate, and compare scrutinisation approaches. The results of both actions will be used to update the survey manual. Stock and spawning component splitting methods applicable to herring in the North Sea, and areas 3a and 6a were reviewed and it was concluded that these need to be harmonized and data collection for alternative splitting methods continued or initiated.

Results from the WGIPS surveys in 2015 and coordination plans for the 2016 individual and multinational pelagic acoustic and larvae surveys in Northeast Atlantic waters (Multinational surveys: IBWSS, IESNS, IESSNS, HERAS, IHLS, and individual surveys: CSHAS, BFAS, ISAS, PELTIC, GERAS) are given in Annexes 4, 5, and 6 of this interim report.

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1 Administrative details

Working Group name

Working Group of International Pelagic Surveys (WGIPS)

Year of Appointment within the current cycle

2015

Reporting year within the current cycle (1, 2 or 3)

1

Chair(s)

Sascha Fässler, The Netherlands

Matthias Schaber, Germany

Meeting venue

Dublin, Ireland

Meeting dates

18–22 January 2016

2 Terms of Reference a) – i)

a) Combine and review annual ecosystem survey data to provide: indices of abundance and spatial distribution for the stocks of herring, sprat, mackerel, boarfish, and blue whiting in Northeast Atlantic waters.

b) Coordinate the timing, area, effort allocation, and methodologies for individual and multinational acoustic and larvae surveys on pelagic resources in the Northeast Atlantic waters covered (Multinational surveys: IBWSS, IESNS, IESSNS, HERAS, IHLS and individual surveys: CSHAS, BFAS, ISAS, PELTIC, GERAS).

c) Adopt standardized analysis methodology and data storage format utilizing the ICES pelagic database repository for all acoustically derived abundance estimates of WGIPS coordinated surveys.

d) Periodically review and update the WGIPS acoustic survey manual to address and maintain monitoring requirements for pelagic ecosystem surveys.

e) Review and evaluate survey designs across all WGIPS coordinated surveys to ensure the integrity of survey deliverables.

f) Assess and compare scrutinisation procedures employed for the analysis of raw acoustic data from WGIPS coordinated surveys.

g) Develop alternative analysis methods (e.g. using geostatistics) to monitor the pelagic ecosystem by extracting metrics from the collected survey data other than those required for single-species stock assessments.

h) Assess auxiliary pelagic ecosystem surveying technology (e.g. optical technology, multibeam, and wideband acoustics) to: (i) achieve monitoring of different ecosystem components, and/or (ii) derive ecosystem indicators from surveys covered by WGIPS.

i) Develop and refine methods to derive stock- or spawning component-specific survey indices for herring based on biological criteria (e.g. otolith shape analysis or morphometric measurements).

3 Summary of Work plan

Year 1:

General meeting, preceded by three post-cruise meetings, which collate data of multinational surveys.

Workshop to evaluate and develop joint methods from current participant-specific acoustic abundance estimation methods used in the HERAS surveys (WKEVAL).

Workshop to standardize scrutinisation procedures for pelagic ecosystem surveys covered by the WG (WKSCRUT).

Session to familiarise Working Group (WG) members with the use of the new standardized acoustic survey analysis tool (StoX) and data storage format from the ICES pelagic database repository.

Session to review and evaluate survey designs across all WGIPS coordinated surveys done in Year 1; and coordinate planning and discuss designs for surveys taking place in Year 2.

Session to review and provide possible updates for the WGIPS acoustic survey manual.

Session to: (i) explore alternative analysis methods (e.g. geostatistics); and (ii) assess and document auxiliary pelagic ecosystem surveying methodology (e.g. optical technology, multibeam and wideband acoustics), in order to monitor components of the wider ecosystem and derive ecosystem indicators from surveys covered by WGIPS.

Session to review and adapt stock and spawning component splitting methods applicable to herring in the North Sea, and areas 3a and 6a; and plan methods used on surveys in Year 2 accordingly.

Contributing to Session C "Ecosystem Monitoring in Practice" at the 2015 ICES ASC through active involvement of WG members as session convener and presenters.

Contributing a paper analysing the HERAS survey time-series to the ICES Symposium on "Marine Ecosystem Acoustics (SOMEACOUSTICS).

Submission of a manuscript on blue whiting distribution from the WGIPS survey time-series to a peer reviewed Journal.

4 List of Outcomes and Achievements of the WG in this delivery period

The following outcomes and achievements were obtained during this delivery period:

Indices for the stocks of herring, sprat, mackerel, boarfish, and blue whiting in Northeast Atlantic waters from annual ecosystem surveys as fishery-independent data for analytical assessment purposes in HAWG[1] and WGWIDE[2]:

- North Sea autumn spawning herring numbers, biomass, maturity proportion, mean weight, and length-at-age, from the ICES Coordinated Acoustic Survey in the Skagerrak and Kattegat, the North Sea, West of Scotland, and the Malin Shelf area (HERAS).
- Western Baltic spring-spawning herring numbers, biomass, maturity proportion, mean weight, and length-at-age, from the HERAS.
- West of Scotland autumn spawning herring numbers, biomass, maturity proportion, mean weight, and length-at-age, from the HERAS.
- Malin Shelf herring (areas 6aN-S, 7b,c) numbers, biomass, maturity proportion, mean weight, and length-at-age, from the HERAS.
- Sprat in the North Sea (Subarea 4) numbers, biomass, mean weight, and length-at-age, from the HERAS.
- Sprat in Division 3a numbers, biomass, mean weight, and length-at-age, from the HERAS.
- Norwegian spring-spawning herring numbers, biomass, mean weight, and length-at-age, from the International Ecosystem Survey in the Nordic Sea (IESNS).
- Blue whiting numbers, biomass, mean weight, and length-at-age, from the International Ecosystem Survey in the Nordic Sea (IESNS).
- Mackerel numbers, biomass, mean weight, and length-at-age, from the International Ecosystem Summer Survey in the Nordic Sea (IESSNS).
- Norwegian spring-spawning herring numbers, biomass, mean weight, and length-at-age, from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS).
- Blue Whiting numbers, biomass, maturity proportion, mean weight, and length-at-age, from the ICES International Blue Whiting Spawning stock Survey (IBWSS).
- Irish Sea and North Channel (area 7a), autumn spawning herring, numbers, biomass, distribution maturity proportion, mean weight, and length-at-age.
- Sprat, numbers, biomass, mean weight, and length-at-age.

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1 Herring Assessment Working Group for the Area South of 62°N

2 Working Group on Widely Distributed Stocks

- Western Baltic Spring-spawning Herring (including and excluding Central Baltic Herring) as well as sprat numbers, biomass, and mean weight-at-age by area for the Western Baltic (ICES Subdivisions 21, 22, 23, and 24) from the German Acoustic Autumn Survey (GERAS) of the Baltic International Acoustic Survey (BIAS).
- Boarfish numbers, biomass, maturity proportion, mean weight, and length-at-age, from the Boarfish Acoustic Survey (BFAS).
- Celtic Sea herring numbers, biomass, maturity proportion, mean weight, and length-at-age, from the Celtic Sea herring Acoustic Survey (CSHAS).
- Review of herring larvae surveys conducted prior to or ongoing during the meeting (International Herring Larvae Surveys, IHLS).

Other ecosystem survey-derived operational products:

- Zooplankton distribution in the Norwegian Sea based on dry weight samples from the IESNS and IESSNS.
- Recorded observations of marine mammals in the Norwegian Sea during the International Ecosystem Summer Survey in the Nordic Seas (IESSNS).

Other outcomes and achievements:

- StoX comparison working document;
- Comments and input to development of the ICES Acoustic database;
- WKSCRUT report;
- WKEVAL report;
- Overview of currently applied auxiliary pelagic ecosystem sampling technology;
- Investigation of possibilities to improve stock and spawning component splitting methods;
- Organization of 2015 ASC theme session;
- 2016 survey plans;
- Survey planning scripts;
- Submission of a jointly authored manuscript on blue whiting distribution.

5 Progress report on ToRs and work plan

ToR's and work plan were covered as planned, with particular focus on:

- Use and evaluation of the StoX software package recently adopted for abundance estimates in WGIPS coordinated surveys.
- Harmonizing current national acoustic abundance estimation methods for HERAS surveys; and future adoption of an ICES database to store acoustic survey data.
- Combination and review of annual ecosystem survey data including discussion of results and identified issues; review and evaluation of survey designs and plans for 2016 surveys.
- Assess and document examples of auxiliary pelagic ecosystem surveying methodology.

Results of different ecosystem surveys conducted in 2015 and disseminated during preceding post-cruise meetings were shown. The combined results provided indices of abundance and distribution for stocks of herring, sprat, mackerel, boarfish, and blue whiting in Northeast Atlantic waters (*ToR a*). Timing, planning, and methods applied for individual (CSHAS, BFAS, ISAS, PELTIC, GERAS) and multinational (IBWSS, IESNS, IESSNS, HERAS, IHLS) surveys were discussed and evaluated (*ToR b,c*). An introduction and demonstration of the new StoX acoustic survey data analysis software was given (*ToR c*). Joint methods from current participant-specific acoustic abundance estimation methods used in the HERAS surveys were evaluated and developed at WKEVAL and used for deriving of the survey estimate (*ToR c*). Work was done to provide quantitative differences between previous and new methods and evaluate performance of new sampling designs (*ToR e*). The group was satisfied with the results generated using the new method, as the estimates derived from the methodology previously applied were contained within the uncertainty range (95% confidence interval) of the StoX estimates. Shortcomings and implications of the new data format for the new ICES acoustic database were discussed with the ICES Data Centre (*ToR c*). Designs and plans of the different surveys for 2016 were established and agreed (*ToR e*).

For 2016, 25 individual surveys are planned in total, including 4 multinational surveys.

Scrutinisation procedures employed for the analysis of raw acoustic data from WGIPS coordinated surveys were evaluated at a preceding workshop (WKSCRUT) and results shared among the group (*ToR f*). An ad-hoc subgroup was established that will (by correspondence) evaluate a harmonization in scrutinisation procedures applied by Denmark and participants covering adjacent areas in the HERAS survey (Norway and Germany). Additionally, it was decided that a special session should be held during the next WGIPS meeting, where participants of different surveys review, evaluate, and compare scrutinisation approaches using recommendations made and established at WKSCRUT (*ToR f*). The results of both actions will be used to update the survey manual (*ToR d*). A session was held at the meeting to present and document examples of auxiliary pelagic ecosystem surveying methodology currently applied by individual survey participants (*ToR h*). Stock and spawning component splitting methods applicable to herring in the North Sea, and areas 3a and 6a were reviewed (*ToR i*). The conclusion was that these methods will need to be harmonized in future and data collection for alternative splitting methods to be continued (e.g. genetics) or initiated (e.g. otoliths for Downs herring).

A manuscript was presented at the ICES Symposium on Marine Ecosystem Acoustics (SOMEACOUSTICS) looking at spatial distribution patterns of herring and sprat in the North Sea using geostatistics (*ToR g*). The group contributed to session C ("Ecosystem Monitoring in Practice") at the 2015 ICES ASC through active involvement as session convener and presenters (*ToR g*), and a manuscript on blue whiting distribution from the WGIPS survey time-series is currently submitted to a peer reviewed Journal (*ToR g*).

No changes in ToR have been proposed.

6 Revisions to the work plan and justification

No changes were done in the work plan.

7 Next meetings

The next meeting of WGIPS will be held in Reykjavik, Iceland on 16–20 January 2017.

The 2018 meeting is provisionally proposed to be held in Amsterdam, Netherlands, on 15–19 January 2018.

Annex 1: List of participants

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Annex 2: Recommendations

Recommendation	Adressed to
Due to different methods currently applied during HERAS surveys for splitting of herring stocks into autumn and spring spawners, WGIPS recommends that the assessment working group initiate standardization and/or calibration of different methods used for stock splitting in both catch and survey data.	HAWG, WGBIOP
The data currently contained in the discontinued 4.3 FishFrame Acoustic database need to be archived in an accessible format. Within the process of establishing a new ICES Acoustic database, The ICES Data Centre is recommended to contact DTU Aqua directly to facilitate the archiving process.	ICES Data Centre
The Simrad EK60 scientific echosounder, commonly used in WGIPS surveys, will no longer be available for purchase as it has been superseded by the Simrad EK80 broadband system. A quantitative study needs to be undertaken to confirm that collected 38 kHz narrowband data are comparable between both systems.	WGFAST

Annex 3: Agenda

Monday

09:00

- Meeting opens
- Review of TOR for this year and WGIPS multi-annual plan
- Review of recommendations for WGIPS from other expert groups
- Presentation and demonstration of StoX software package recently adopted for abundance estimates in WGIPS coordinated surveys

14:00

- Meeting report tasks
- Discussion of contents of this year's report, reporting structure and review of post cruise meeting format
- Combination and review of annual ecosystem survey data: Herring Larval survey in 2015 and plan for 2016

Tuesday

09:00

- Report status
- Presentation: Results of the Workshop on evaluating current national acoustic abundance estimation methods for HERAS surveys (WKEVAL) 2015
- Combination and review of annual ecosystem survey data: Review of co-ordinated Acoustic surveys in 2015, including plenary discussion of results and identified issues

  -International acoustic survey in North Sea, West of Scotland and Malin Shelf (HERAS) (including Sprat in the North Sea and 3a)

  -Malin Shelf (MSHAS)

  -Western Baltic

14:00

  -International blue whiting spawning stock survey (IBWSS)

  -International ecosystem survey in the Nordic Seas (IESNS)

  -Coordinated Nordic Seas ecosystem survey (IESSNS)

  -Celtic Sea herring (CSHAS)

  -Celtic Sea, English Channel (PELTIC)

  -Boarfish acoustic survey (BFAS)

- Plenary discussion on identified survey issues

Wednesday

09:00

- Report status
- Presentation of Session C "Ecosystem Monitoring in Practice" at the 2015 ICES ASC
- Update on EFARO – ICES data collection initiative
- Plenary discussion on results of WKEVAL and WKIACTDB and their implications for WGIPS
- Review and evaluate survey designs and 2016 plans across all WGIPS surveys within survey subgroups

14:00

- Review of answers to recommendations for WGIPS from other expert groups
- Plenary discussion of coordinated survey planning and designs for 2016 surveys
- Presentation: Results of the Workshop on scrutinisation procedures for pelagic ecosystem surveys (WKSCRUT) 2015); Plenary discussion of results of WKSCRUT and implications for WGIPS: Assessment and comparison of scrutinisation procedures employed for the analysis of raw acoustic data from WGIPS coordinated surveys

Thursday

09:00

- Report status
- Theme Session on Pelagic Ecosystem Monitoring to: (i) explore alternative analysis methods (e.g. geostatistics); and (ii) assess and document examples of auxiliary pelagic ecosystem surveying methodology
- Subgroup Theme Session to review and adapt stock and spawning component-splitting methods applicable to herring in the North Sea, and areas 3a and 6a; and plan methods used on surveys in 2016 accordingly.
- Update on new data requests and existing projects
  - sampling of data for maturity study on herring in the North Sea (WGBIOP)
  - sampling of otoliths for discrimination of Downs herring in the North Sea
  - Update report on continuation of SGHERWAY sampling protocol for herring surveys west of 4°W.

14:00

- Recommendations to other groups
- Session to review and provide possible updates for the WGIPS acoustic survey manual
- Discussion of ongoing publications of the group
- Collection of material for the final report

Friday

09:00

- Review of final report

12:00

- Meeting closes

Annex 4: Post Cruise Reports

Annex 4a: International Blue Whiting Spawning Stock Survey (IBWSS)

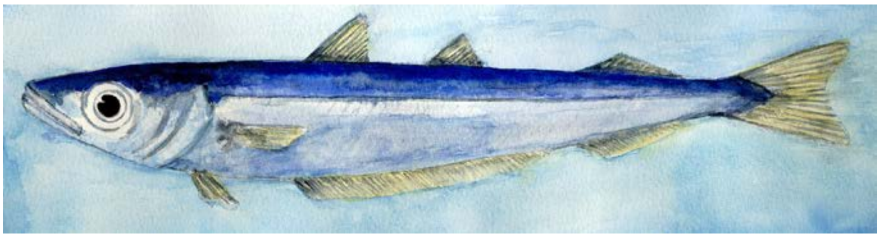
Working Document

Working Group on International Pelagic Surveys

Copenhagen, Denmark, 19-23 January 2015

Working Group on Widely Distributed Stocks

San Sebastian, Spain, 26-31 August 2015



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS) SPRING 2015

Ebba Mortensen[4^*], Jan Arge Jacobsen[4], Leon Smith[4*], Mourits M. Joensen[4], Poul Vestergaard[4], Eydna Í Homrum[4^]

R/V Magnus Heinason

Kees Bakker[1], Ben Scoulding[1], Thomas Pasterkamp[1], Dirk Burggraaf[1], Eric Armstrong[6], Dirk Thijssen[8], Simon Wieser[7], Stéphanie Levesque[5], Helen O'Neill[1], Sascha Fässler[1*], Bram Couperus[1*]

R/V Tridens

Ciaran O'Donnel[5*], Cormac Nolan[5], Graham Johnston[5], Niall Keogh[9], Inge van der Knaap[10], Aleksandra Borawska[10] , Mairead O'Donovan

R/V Celtic Explorer

Alexander Pronyuk[3], Sergey Kharlin[3], Tatiana Sergeeva[3], Yurii Firsov[3], Valery Ignashkin[3*]

R/V Fritjof Nansen

Åge Høines[2*], Øyvind Tangen[2*], Valantine Anthonypillai[2]

R/V G.O. Sars

1 Institute for Marine Resources & Ecosystem Studies, IJmuiden, The Netherlands
2 Institute of Marine Research, Bergen, Norway
3 PINRO, Murmansk, Russia
4 Faroe Marine Research Institute, Tórshavn, Faroe Islands

5 Marine Institute, Galway, Ireland
6 Marine Scotland Marine Laboratory, Aberdeen, Scotland, United Kingdom
7 Johann Heinrich von Thünen-Institut, Hamburg, Germany
8 Danish Institute for Fisheries Research, Denmark
9 BirdWatch, Ireland
10 Irish Whale and Dolphin Group, Ireland
* Participated in post cruise meeting,
^ Survey coordinator

Material and methods

Survey planning and Coordination

Coordination of the survey was initiated in the meeting of the Working Group on International Pelagic Surveys (WGIPS) and continued by correspondence until the start of the survey. During the survey effort was refined and adjusted by the coordinator based on real time observations. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Fritjof Nansen	PINRO, Murmansk, Russia	23/3 – 10/4
Celtic Explorer	Marine Institute, Ireland	23/3 – 10/4
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	25/3 – 8/4
Tridens	Institute for Marine Resources & Ecosystem Studies (IMARES), the Netherlands	23/3 – 8/4
G.O. Sars	Institute of Marine Research, Norway	25/3 – 7/4

The survey design used and described in ICES (2014) allowed for a flexible setup of transects and good coverage of the spawning aggregations. Considering weather conditions were by no means optimal during the survey period the good quality coverage of the stock was achieved. Transects undertaken by all vessels were consistent in spatial coverage and timing, delivering full coverage of the respective distribution areas within 17 days.

Cruise tracks and trawl stations for each participant vessel are shown in Figure 1. The CTD stations are shown in Figure 2. All vessels except Magnus Heinason worked in a northerly direction (Figure 3). Daily communication between vessels was maintained during the survey (via email and internet weblog) through the coordinator exchanging blue whiting distribution data, echograms, fleet activity and biological information.

Sampling equipment

All vessels employed a midwater trawl for biological sampling, the properties of which are given in Table 5. Acoustic equipment for data collection and processing are presented in Table 2. The survey and abundance estimates are based on acoustic data collected with scientific echo sounders using a frequency of 38 kHz. All transducers were calibrated with a standard calibration sphere (Foote et al. 1987) prior, during or directly after the survey. Acoustic settings by vessel are summarised in Table 2.

Acoustic Intercalibration

Inter-vessel acoustic calibrations are carried out when participant vessels are working within the same general area and time and weather conditions allow for an exercise to be carried out. The procedure follows the methods described by Simmonds and MacLennan 2007. This year, no intercalibration was carried out due to weather induced time constraints.

Biological sampling

All components of the catch from the trawl hauls were sorted and weighed; fish and other taxa were identified to species level. The level of blue whiting sampling by vessel is shown in Table 1.

Hydrographic sampling

Hydrographic sampling by way of vertical CTD casts were carried out by each participant vessel at predetermined locations (Figure 2 and Table 1) capped at a maximum depth of 1000 m (Magnus Heinason 600m) in open water. Hydrographic equipment specifications are summarised in Table 5.

Acoustic data processing

Acoustic scrutiny was based on categorisation by experienced experts aided by trawl composition information. Post-processing software and procedures differed among the vessels:

On Fridtjof Nansen, the LSSS software was used as the primary post-processing tool for acoustic data. Data were partitioned into the following categories: blue whiting, plankton, mesopelagic species and other species. The acoustic recordings were scrutinized once per day.

On Celtic Explorer, acoustic data were backed up every 24 hrs and scrutinised using Myriax's EchoView (V 5.4) post-processing software for the previous day's work. Data was partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

On Magnus Heinason, acoustic data were scrutinised every 24 hrs on board using Myriax's EchoView (V 6.1) post processing software. Data were partitioned into the following categories: plankton (<200 m depth layer), mesopelagic species, blue whiting and krill. Partitioning of data into the above categories was based on trawl samples.

On Tridens, acoustic data were backed up continuously and scrutinised every 24 hrs using Myrix's Echoview (V 6.1) post-processing software. Blue whiting were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

On G.O. Sars, the acoustic recordings were scrutinized using the Large Scale Survey System (LSSS) once or twice per day. Data was partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

Acoustic data analysis

The acoustic data were analysed with a SAS based routine called "BEAM" (Totland and Godø 2001) and used to calculate age and length stratified estimates of total biomass and abundance (numbers of individuals) within the survey area as a whole and within sub-areas (i.e., the main areas in the terminology of BEAM). Strata of 1º latitude by 2º longitude were used. The area of a stratum was adjusted, when necessary, to correspond with the area that was representatively covered by the survey track. This was particularly important in the shelf break zone where high densities of blue whiting dropped quickly to zero at depths less than 200 m.

To obtain an estimate of length distribution within each stratum, all length samples within that stratum were used. If the focal stratum was not sampled representatively, additional samples from the adjacent strata were used. In such cases, only samples representing a similar kind of registration that dominated the focal stratum were included. Because this includes a degree of subjectivity, the sensitivity of the estimate with respect to the selected samples was crudely assessed by studying the influence of these samples on the length distribution in the stratum. No weighting of individual trawl samples was used because of differences in trawls and numbers of fish sampled and measurements. The number of fish in the stratum is then calculated from the total acoustic density and the length composition of fish.

The methodology is in general terms described by Toresen et al. (1998). More information on this survey is given by, e.g., Anon. (1982) and Monstad (1986). Following the decisions made at the “Workshop on implementing a new TS relationship for blue whiting abundance estimates (WKTSBLUES)” (ICES 2012), the following target strength (TS)-to-fish length (L) relationship (Pedersen et al. 2011) used is:

$$TS = 20 \log10 (L) - 65.2$$

For conversion from acoustic density (sA, m2/n.m.2) to fish density (ρ) the following relationship was used:

$$\rho = sA / \langle\sigma\rangle,$$

where $\langle\sigma\rangle = 3.795 \cdot 10^{-6} L^{2.00}$ is the average acoustic backscattering cross-section (m^2). The total estimated abundance by stratum is redistributed into length classes using the length distribution estimated from trawl samples. Biomass estimates and age-specific estimates are calculated for main areas using age-length and length-weight keys that are obtained by using estimated numbers in each length class within strata as the weighting variable of individual data.

BEAM does not distinguish between mature and immature individuals, and calculations dealing with only mature fish were therefore carried out separately after the final BEAM run for each sub-area. Proportions of mature individuals at length and age were estimated with logistic regression by weighting individual observations with estimated numbers within length class and stratum (variable ’popw’ in the standard output dataset ’vgear’ of BEAM). The estimates of spawning stock biomass and numbers of mature individuals by age and length were obtained by multiplying the numbers of individuals in each age and length class by estimated proportions of mature individuals. Spawning stock biomass is then obtained by multiplication of numbers at length by mean weight at length; this is valid assuming that immature and mature individuals have the same length-weight relationship.

This year the postcruise meeting participants were introduced to the StoX application, and had the opportunity during the meeting to run the application on an individual basis. StoX is open source software developed at IMR, Norway to calculate survey estimates from acoustic and swept area surveys. The program is a stand-alone application build with Java for easy sharing and further development in cooperation with other institutes.The Stox application produced comparable results as BEAM. In contrast to BEAM, StoX requires that the analysed survey is planned and run based on a statistical design. In the current version of StoX the stratified transect design model developed by Jolly and Hampton (1990) is implemented.

Results

Distribution of blue whiting

In total 6,891 nmi (nautical miles) of survey transects were completed and the total area of all the sub areas covered was 123,840 nmi.² (Figure 1, Tables 1 and 3). This represented a reduction of 16% in total surveyed transects and 1% in surveyed areas compared to last year. Coverage was considered sufficient and still takes into account expected distributions on the Rockall and Porcupine Banks.

In the Hebrides core area blue whiting distribution was more confined to the shelf edge and did not extend widely into the deep waters of the Rockall Trough as seen in the previous year. However, the maximum SA values observed in the survey were recorded in open water away from the shelf slope at 52,333 m²/nmi² (northwest of the Hebrides) and 51431 m²/nmi² (north of the Porcupine bank) (Figure 9).

The highest concentrations of blue whiting were recorded in the Hebrides core area but the corresponding biomass observed was 61% less than in the previous year. The same pattern was observed in the N. Porcupine and Rockall areas where 64% and 88% less biomass was observed respectively compared to last year. Quantities of blue whiting found in the South Porcupine and Faroe/Shetland area were comparable to 2014. Medium and high density registrations were firmly concentrated along the shelf slope extending maximum a few miles from the shelf edge (Figures 4 and 5).

Stock size

The estimated total abundance of blue whiting for the 2015 international survey was 1.38 million tonnes, representing an abundance of 16.6x10^9 individuals (Figure 6, Tables 3 and 4). Spawning stock was estimated at 1.1 million tonnes and 11.2x10^9 individuals. In comparison to the 2014 survey estimate, this represents a decrease of -58% in the observed stock biomass and a related decrease in stock numbers of 47%.

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Change from 2014 (%)
Biomass	Total	2.6	3.4	3.6	2.6	2	1.3	1.6	2.2	3.4	3.3	1.4	-58%
(mill. t)	Mature	2.4	3.3	3.6	2.6	2	1.3	1.5	2.2	3.2	3	1.1	-63%
Numbers	Total	29	34.7	33.5	22.1	15.2	9.3	12.1	18.2	27	31.1	16.6	-47%
(10^9)	Mature	26.7	33.8	32.9	21.7	15.0	8.9	9.7	16.5	24.4	26.4	11.2	-58%
Survey area (nm^2)		172,000	170,000	135,000	127,000	133,900	109,320	68,851	88,746	87,895	125,319	123,840	-1%

The Hebrides core area was found to contain 44% of the total biomass observed during the survey, which is lower than seen in previous years (48% of the stock found in this area in 2014; 73% in 2013; and 71% in 2012). Distribution of biomass within this core area tended more towards the southern part, as in 2014. The Faroes/Shetland and North Porcupine areas ranked second and third highest contributing 25% and 23% to the total respectively. Compared to the previous year (see text table below). Considerably less biomass was observed in the Rockall, Hebrides and North Porcupine areas in 2015, while a small increase was observed in the Faroes/Shetland area. In the South Porcupine area a small increase was observed, however, this area accounted for only 4% of the observed biomass. The breakdown of survey biomass by sub area is shown below:

		Biomass (million tonnes)				
		2014		2015		
	Sub-area		% of total		% of total	Change (%)
I	S. Porcupine Bank	0.03	1	0.06	4	90%
II	N. Porcupine Bank	0.86	27	0.31	23	-64%
III	Hebrides	1.54	48	0.61	44	-61%
IV	Faroes/Shetland	0.34	10	0.35	25	2%
V	Rockall	0.47	15	0.06	4	-88%

Stock composition

Individuals of ages 1 to 15 years were observed during the survey.

The stock biomass within the survey area is dominated by age classes 1, 2, and 4 of the 2014, 2013 and 2011 year classes respectively (Table 4 and Figure 10). The main contribution (80%) to the spawning stock biomass were the age groups 4, 2, 5 and 3, in order of importance (Table 4), with 4-year old fish contributing 32% to total biomass.

The contribution of the Hebrides core area which is historically the most productive area were consistently more than 50% of the SSB (spawning stock biomass) back in time. However, since 2013 this figure has dropped below 50% (48% in 2013, 44% in 2014). Similar to 2014, the North Porcupine area contained a significant portion of the spawning stock. Mean lengths and weights of the fish caught in the Hebrides area were highest in the entire survey (Figures 7 and 8). The Faroe/Shetland subarea was dominated by mainly 1 and 2 year old fish and Porcupine sub-areas were dominated by 2 and 4 year old fish. One year old fish was mainly observed in subarea IV (Faroes-Shetland). The oldest fish (>8+) were predominantly observed in the Hebrides core area (Figure 11).

The Faroese/Shetland sub-area was found to contain significant proportion of young blue whiting (1-3 years), all together 83% (288,400) of the total biomass and 83% (4831 million individuals) of the total abundance in that area. This is close to the proportions seen last year (70% and 85% respectively).

The large blue whiting found in previous years on the Rockall Bank were not observed this year. In 2015 only 18% (numbers) of the fish here were mature, compared to 97% in 2014.

Immature blue whiting were represented to various extents in all sub areas in 2015 (Figure 11). Maturity analysis of survey samples indicate that 9% of 1-year old, 66% of 2-year old and 83% of 3-year old fish were mature as compared to the 2014 estimates, where 14% of 1-year old fish, 56% of 2-year old fish and 90% of 3-year old fish were considered mature (Table 4). Overall, immature blue whiting from the 2015 estimate represented 17% (239,000t) of the total biomass and 32% (5380 million) of the total abundance recorded during the survey, compared to 7.4% (biomass) and 15% (abundance) respectively in 2014. Thus a drastic redusction in the mature portion of the blue whiting stock from 2014.

Hydrography

A combined total of 139 CTD casts were undertaken over the course of the survey (Table 1). Horizontal plots of temperature and salinity at depths of 50m, 100m, 200m and 500m as derived from vertical CTD casts are displayed in Figures 12-15 respectively.

Concluding remarks

Main results

- The 12th International Blue Whiting Spawning stock Survey 2015 shows a marked decrease in total stock biomass of 58% with a corresponding reduction in abundance by 47% when compared to the 2014 estimate.
- Weather conditions were moderate/poor for the duration of the survey and a period of about 48hrs was lost in a single consecutive period due to very poor conditions.
- Area coverage was comparable with the 2014 (1% reduction) whereas survey effort (transect mileage) was 16% lower. The reduction in transect mileage was a consequence of changes in transect spacing (from 10 to 15nmi) within the Hebrides area due to weather induced downtime. Survey effort was reallocated after careful consideration to ensure that full geographical coverage was maintained in the core spawning areas using the remaining available survey time.
- 80% of the total biomass was observed in target areas surveyed by more than one vessel.

- The survey was carried out over 17 days and well within the recommended 21 day time window.
- Estimated uncertainty around the mean acoustic density (spatio-temporal variability) is low in 2015 and at the same time the estimated stock size showed the sharpest decline in the time series.
- The stock biomass within the survey area was dominated by age classes 2, 4, 1 and 3 of the 2013, 2011, 2014 and 2012 year classes respectively, contributing 70% of total stock biomass.
- Mean length (24.6cm from 28cm in 2014) and weight (83g from 120g) are lower than in 2014 and in previous years. This can be attributed to the increasing contribution of young fish within the standing stock.
- A strong signal of 1 and 2-year old fish (2014 and 2013 year classes) was evident across the entire survey area as well as in traditional young fish areas of Rockall and Faroes/Shetland. The core areas Hebrides and Porcupine contained notable amounts of 1 and 2 year old fish. The total biomass of immature fish represented 239,000t the same as in 2014 but this is much more prominent this year due to the reduced SSB.

Interpretation of the results

- The 2015 estimate of abundance can be considered as robust. Stock containment was achieved for both core and peripheral stock areas. Survey effort although reduced was carefully considered to ensure full coverage was achieved with the resources available and is not considered to be responsible for the large reduction in biomass observed this year.
- The bulk of the mature stock was located from the north Porcupine to the Hebrides core area in a narrow corridor close to the shelf edge. This is in contrast to the generally more dense and dispersed western distribution extending into the Rockall Trough observed in 2014 and was unexpected. However, a drastic 54% reduction of the spawing stock was observed in 2015, and this was mainly in the the Rockall area and in the Hebrides and north Porcuine areas, traditionally core areas at spawning time. This large reduction was not expected acknowledging the 2014 results.
- The estimated amount of immature blue whiting was on the contrary at a high level in 2015, similar to 2014, indicating recruiting year-classes. This was especially evident in the northern Faroe/Shetland area and in the Rockall area.
- Reports indicate that large volumes of blue whiting were taken by the international fleet working outside the Irish EEZ to the southwest of the Porcupine Bank again this year prior to the survey (Feb/Mar).
- Cohort tracking through the time series was not possible in 2015 as the age structure of the stock was notably different with the absence the previous year’s strongest age classes namely the 4, 5 and 6 year old fish. As the survey area was covered using comparable effort, geographical coverage and timing it is difficult to ascertain the reasoning behind the absence of the preiously dominant age classes. However, the high intensity of fishing effort in the southwest of Ireland prior to the survey could be linked.

Recommendations

- The age structure of the blue whiting from commercial catches in international waters outside the Irish EEZ (southwest Porcupine Bank) prior to the survey warrants further investigation by WGWIDE. Do the missing survey age classes appear in significant numbers in catches from this area?
- The group recommends that StoX is used as the primary computation tool for blue whiting biomass from 2016 onwards and that a retrospective calculation of the entire time series (2004-2015) is carried out and presented at WGWIDE 2016.

- All participants with the capacity to do so are encouraged to collect WP2 and fluorescence data and submit the data to the database accordingly.
- It is the responsibility of individual survey participants to ensure that all data are screened prior to submission to the PGNAPES data base following the details outlined in the WGIPS survey manual.
- All group members are requested to supply maturity data to the database using a 7 point blue whiting maturity stage key in to ensure consistency across data submissions.
- As agreed during WGIPS 2015 meeting participants are asked to submit scrutinised inter-transect data to the database.

Achievements

- The entire survey area (c.124,000nmi²) was covered within 17 days and within the recommended 21 day maximum.
- Survey data were uploaded to the database prior to the meeting as agreed.
- A global estimate of abundance was run in parallel with Beam using StoX software and good agreement was achieved. StoX developers were on hand during the meeting to assist in user set up and a walk through processing tasks. This is an important step to avoid a situation where the group is reliant on a few users familiar with the software. The group will provide feedback to the developers to aid in the functionality of future versions.

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Table 1. Survey effort by vessel. March-April 2015.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton sampling	Aged fish	Length-measured fish
Celtic Explorer	23/3-8/4	1467	10	27	-	0	1650
Magnus Heinason	26/3-6/4	1050	8	21	21	249	1002
G.O.Sars	26/3- 7/4	1514	13	25	18	774	2600
Tridens	24/3-7/4	1785	10	30	-	900	900
Fritjof Nansen	29/3-10/4	1620	7	36	-	500	1885
Total	23/3-10/4	7,436	48	139	39	2,423	8,037

Table 2. Acoustic instruments and settings for the primary frequency. March-April 2015.

	Fridtjof Nansen	Celtic Explorer	Magnus Heinason	Tridens	G.O. Sars
Echo sounder	Simrad EK60	Simrad EK 60	Simrad EK60	Simrad EK 60	Simrad EK 60
Frequency (kHz)	**38**	**38**, 18, 120, 200	**38**	18, **38**, 70, 120, 200, 333	18, 70, **38**, 120, 200, 333
Primary transducer	ES38B	ES 38B	ES38B	ES 38B	ES 38B
Transducer installation	Hull	Drop keel	Hull	Drop keel	Drop keel
Transducer depth (m)	5	8.7	3	8	8.5
Upper integration limit (m)	10	15	7	15	15
Absorption coeff. (dB/km)	10	9.9	10.2	10	8.4
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.425	2.43	2.43	2.43
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-20.6	-20.6	-20.8	-20.6	-20.8
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.52	25.89	25.57	26.26	25.22
s_A correction (dB)	-0.64	-0.8	-0.7	-0.53	-0.76
3 dB beam width (dg)					
alongship:	6.99	6.95	6.98	7	7.14
athw. ship:	6.99	6.98	7.07	6.95	7.07
Maximum range (m)	750	1000	750	750	750
Post processing software	LSSS	Myriax Echoview	Myriax Echoview	Myriax Echoview	LSSS

Table 3. Assessment factors of blue whiting for IBWSS March-April 2015.

Sub-area			Numbers (10^9)			Biomass (10^6 tonnes)			Mean weight	Mean length	Density
		nmi²	Mature	Total	%mature	Mature	Total	%mature	g	cm	ton/n.mile²
I	S. Porcupine Bank	9,149	0.51	0.54	94	0.1	0.1	96	104.8	28.2	6.2
II	N. Porcupine Bank	15,194	3.02	3.52	86	0.3	0.3	91	88.9	26.4	20.5
III	Hebrides	37,800	4.96	6.01	83	0.5	0.6	91	100.8	26.5	16.0
IV	Faroes/ Shetland	24,058	2.49	5.21	48	0.2	0.3	66	66.4	22	14.4
V	Rockall	37,638	0.23	1.31	18	0.0	0.1	42	43.1	19.3	1.5
Tot.		123,839	11.21	16.59	68	1.1	1.4	83	83.0	24.6	11.1

Table 4. Survey stock estimate of blue whiting, March-April 2015.

	Age in years (year class)										Numbe	Bioma	Mean	Prop.
Length	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**			**weight**	**mature**
(cm)	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**		**($*10^{-6}$)**	**(10^6 kg)**	**(g)**	**(%)**
11.0 – 12.0	1										1	0	11	0
12.0 – 13.0	0										0	0	11	0
13.0 – 14.0	13										13	0.1	11	0
14.0 – 15.0	53										53	0.7	14	0
15.0 – 16.0	121	6									127	2.3	18	0
16.0 – 17.0	399	31									430	9.2	22	0
17.0 – 18.0	820	153									973	26.3	27	0
18.0 – 19.0	900	138		6							1044	32.8	32	13
19.0 – 20.0	796	110		0							906	33	37	14
20.0 – 21.0	319	75		0							394	17.2	44	14
21.0 – 22.0	95	199	17	0							311	16.9	54	52
22.0 – 23.0	13	784	86	0							883	54.5	62	62
23.0 – 24.0	0	1456	377	43							1876	126.8	68	74
24.0 – 25.0		1252	355	132	62						1801	136.9	76	75
25.0 – 26.0		399	424	410	91	7					1331	113.8	86	85
26.0 – 27.0		75	363	894	271	8					1611	148.9	92	94
27.0 – 28.0		31	154	943	354	47					1529	153.4	100	98
28.0 – 29.0		4	75	643	267	28					1017	111.8	110	100
29.0 – 30.0			14	425	239	63	16				757	93.5	124	100
30.0 – 31.0			0	132	188	37	0	4	4		365	51.8	142	100
31.0 – 32.0			0	59	83	28	9	7	14	38	238	38.4	161	100
32.0 – 33.0			0	20	41	28	3	19	45	71	227	42.5	187	100
33.0 – 34.0			0	0	42	17	38	23	23	38	181	35.2	197	100
34.0 – 35.0			6	6	29	31	18	6	26	62	184	41.9	226	100
35.0 – 36.0					12	19	3	15	23	65	137	32.8	240	100
36.0 – 37.0					3	6	15	5	38	16	83	20.4	249	100
37.0 – 38.0						12	7	0	18	22	59	15.8	270	100
38.0 – 39.0						4	10	0	0	12	26	8.3	313	100
39.0 – 40.0								0	9	1	10	2.6	249	100
40.0 – 41.0								0	0	0	0	0		100
41.0 – 42.0								0	8	0	8	2.8	337	100
42.0 – 43.0								3	0	2	5	2.4	520	100
43.0 – 44.0										0	0	0		100
44.0 – 45.0										0	0	0		100
45.0 – 46.0										8	8	3.9	465	100
TSN (10^6)	3530	4713	1871	3713	1682	335	119	82	208	335	16588	1377		
TSB (10^6 kg)	110.7	319	157.8	376	195.2	52	25.5	18.7	47.3	74.9	1377			
Mean length (cm)	18.4	23.2	25.3	27.5	28.6	31	34	33.9	34.9	34.7				
Mean weight (g)	31	68	84	101	116	155	215	230	228	225				
Condition (g/dm³)														
% mature*	9	66	83	95	97	99	100	100	100	100				
SSB	10.4	209.4	131.1	357.4	189.1	51.6	25.5	18.7	47.3	74.9	1115.5			

Table 5. Country and vessel specific details, March-April 2015

Parameter	Fritjof Nansen	Celtic Explorer	Magnus Heinason	Tridens	G.O. Sars
Trawl dimensions					
Circumference (m)	716	768	640	1120	832
Vertical opening (m)	50	50	40	30-70	45
Mesh size in codend (mm)	16	20	40	±20	40
Typical towing speed (kn)	3.2-3.9	3.5-4.0	3.0-4.0	3.5-4.0	3.0-3.5
Plankton sampling	0	0	21	0	25
Sampling net	-	-	WP2 plankton net	-	WP2 plankton net
Standard sampling depth (m)	-	-	200	-	400
Hydrographic sampling					
CTD Unit	SBE19plus	SBE911	SBE25	SBE911	SBE911
Standard sampling depth (m)	1000	1000	600	1000	1000

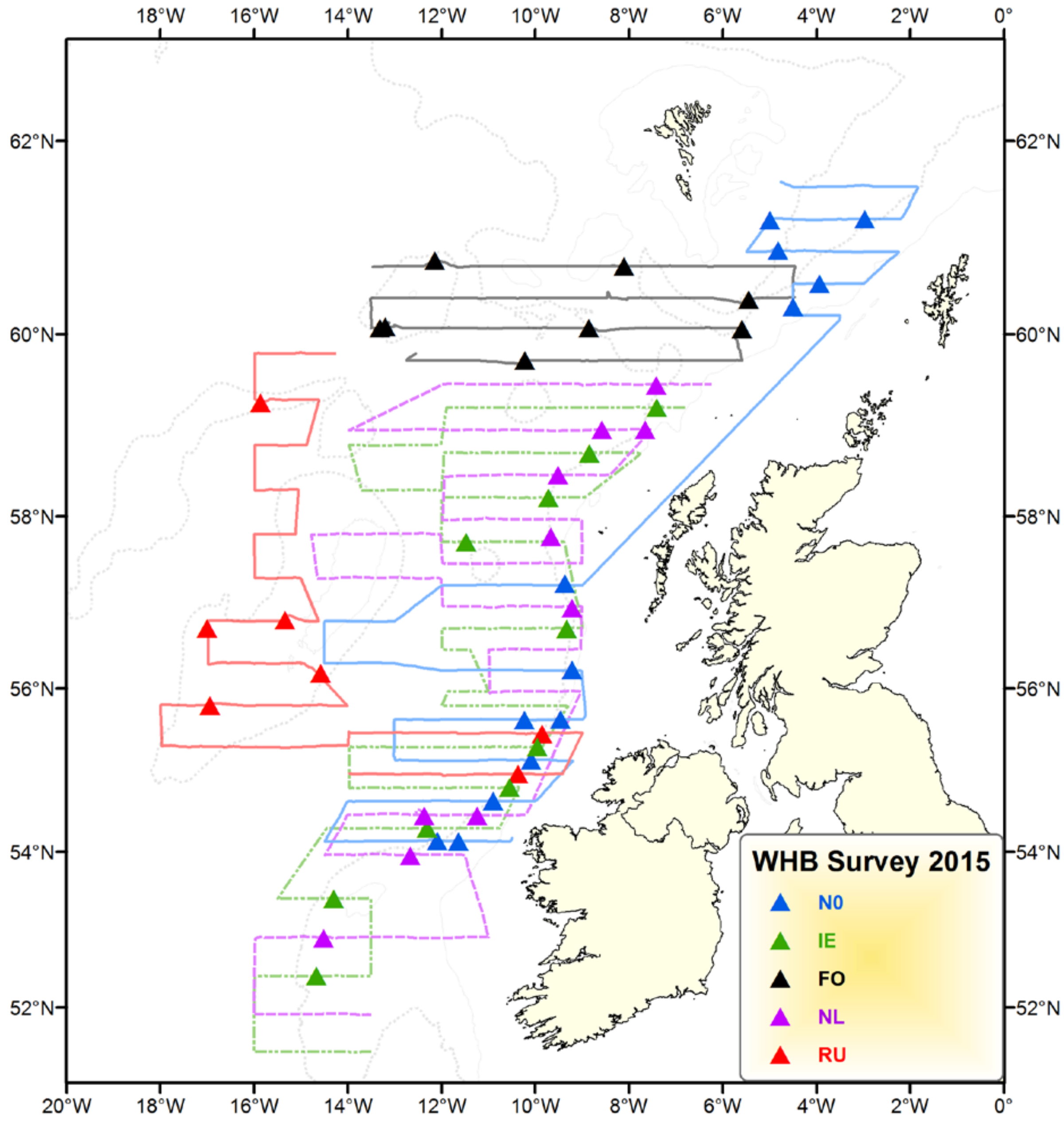


Figure 1. Vessel cruise tracks and trawl stations of the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2015. IE: Ireland (Celtic Explorer); FO: Faroe Islands (Magnus Heinason); NL: Netherlands (Tridens); RU: Russia (Fritjof Nansen); NO: Norway (G.O. Sars).

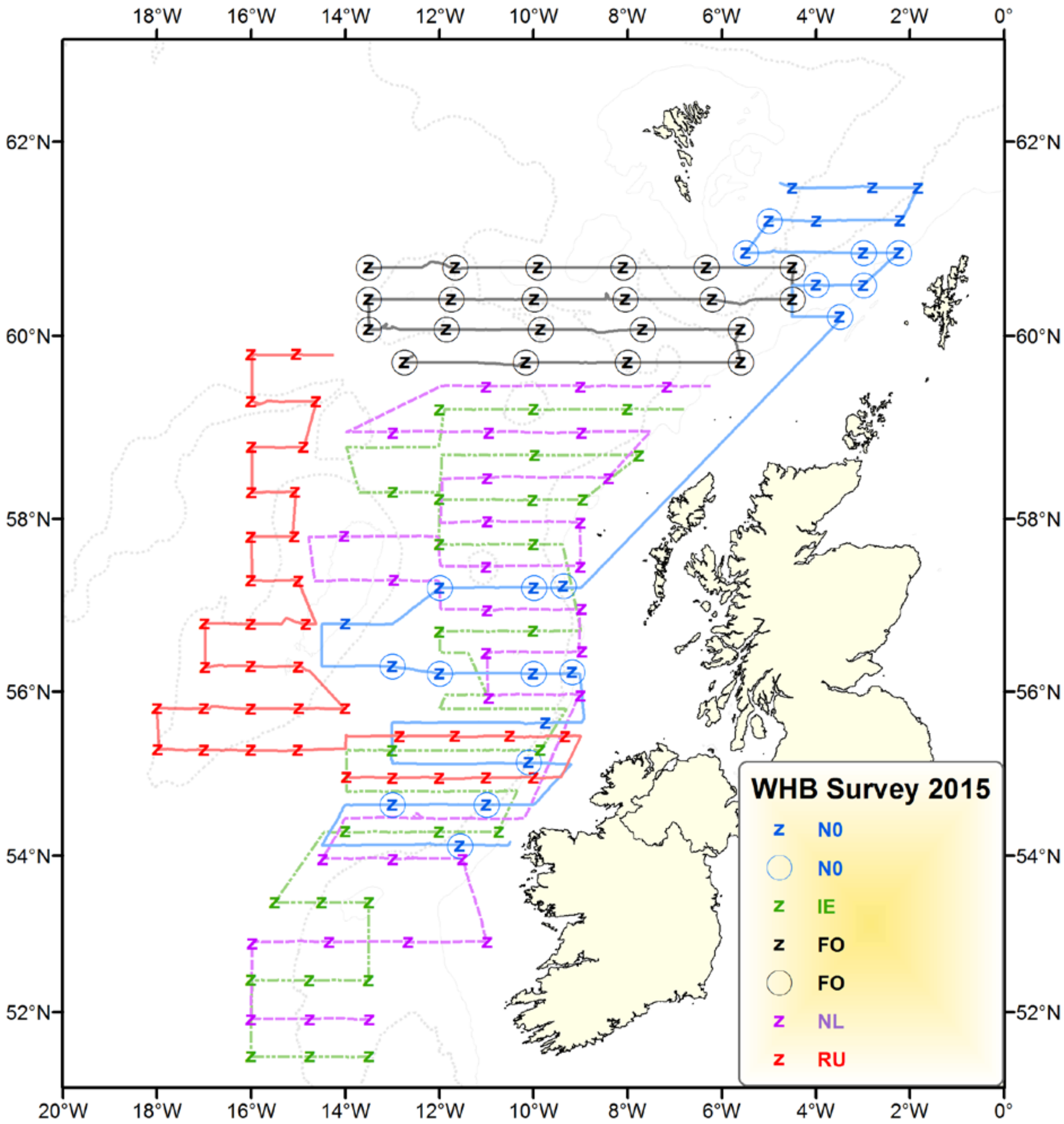


Figure 2. CTD stations overlaid onto vessel cruise tracks for the combined survey ('z'). Circles represent plankton trawls. green: Celtic Explorer; black: Magnus Heinason; purple: Tridens; red: Fritjof Nansen; blue: G.O. Sars. March-April 2015.

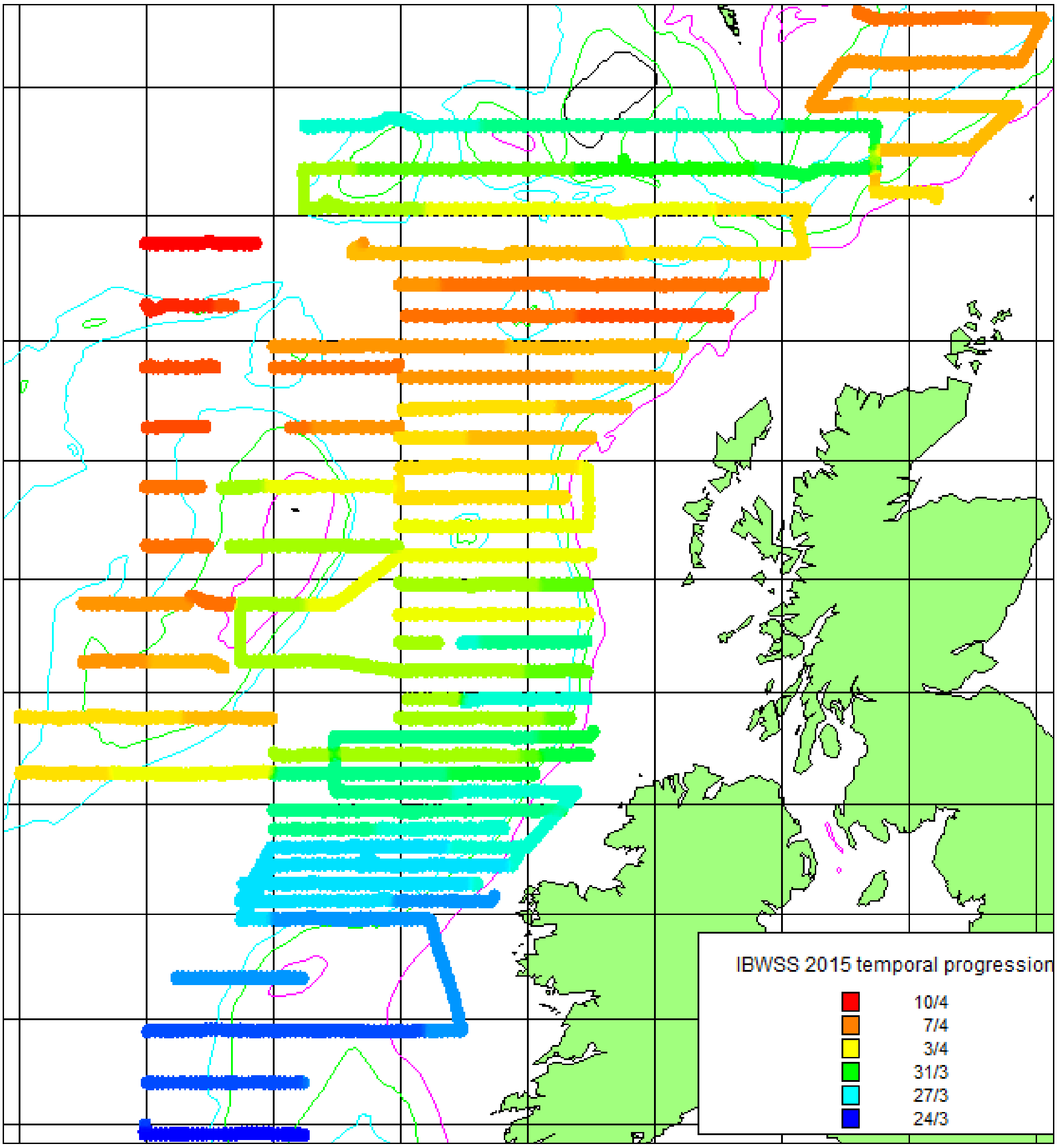


Figure 3. Temporal progression for the International Blue Whiting Spawning Stock Survey (IBWSS), 24. March – 10. April 2015.

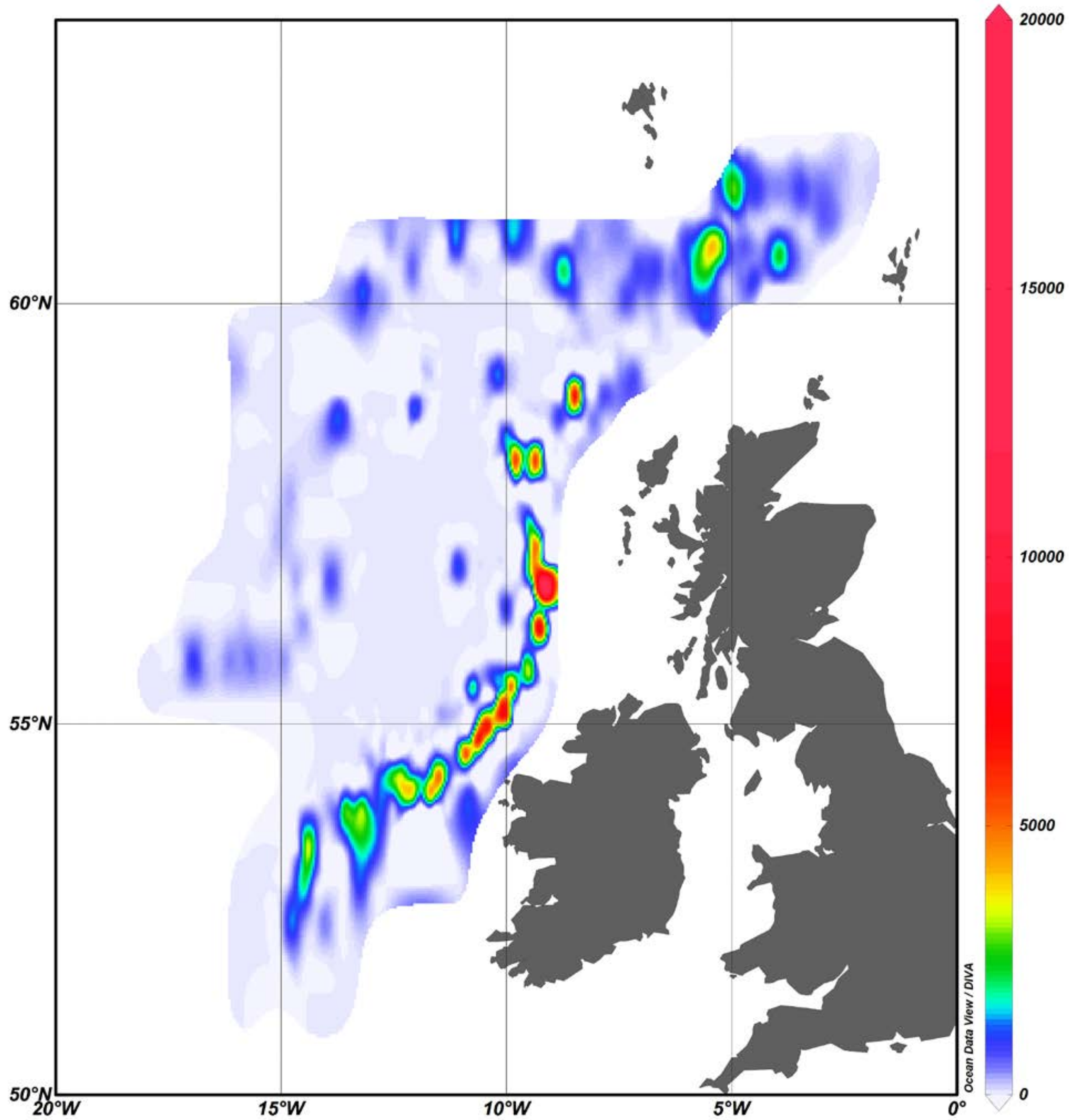


Figure 4. Map of blue whiting acoustic density (s_A, $m^2/n.m.^2$) , March–April 2015.

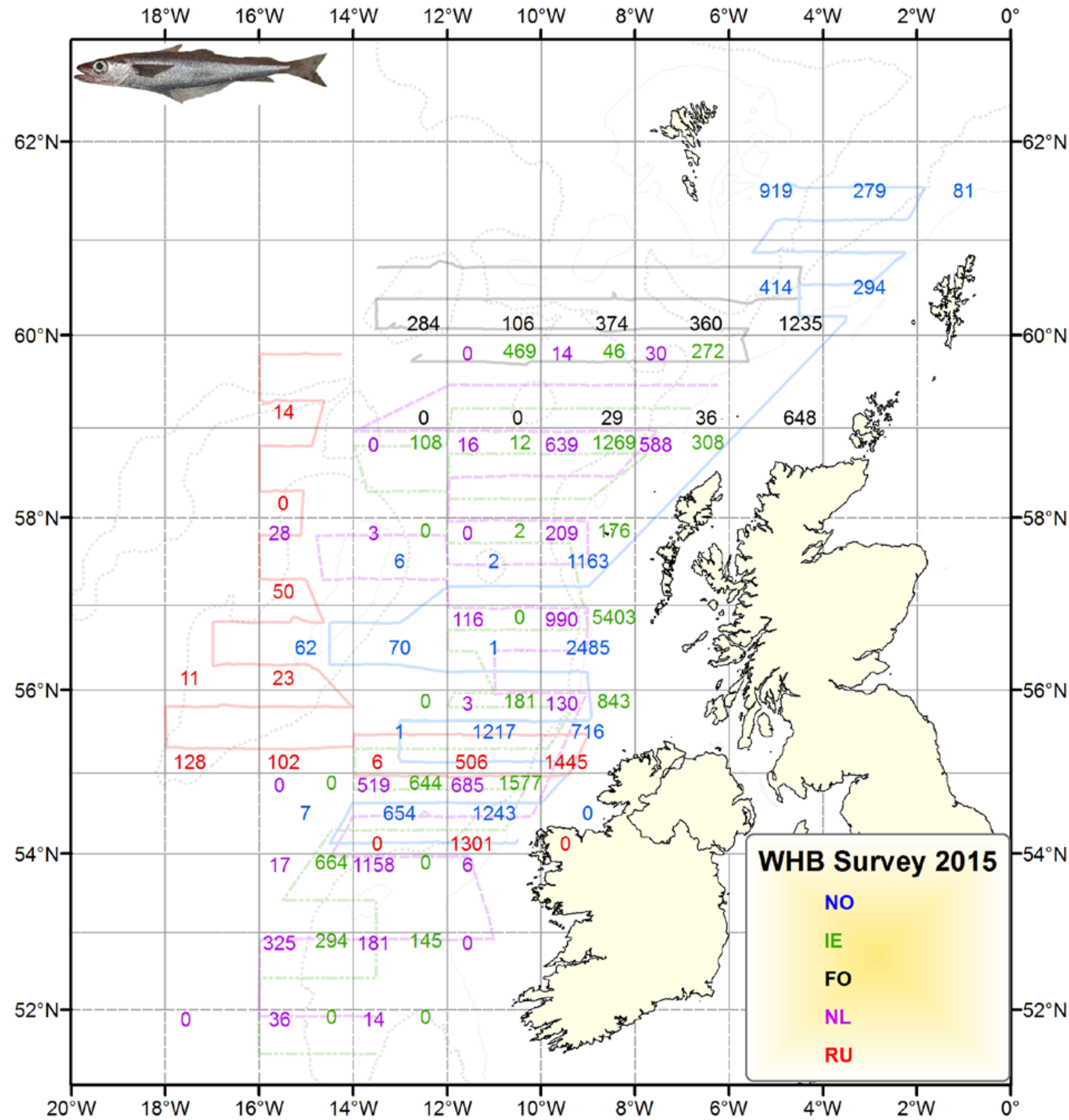


Figure 5. Mean blue whiting acoustic density (s_A, $m^2/n.m.^2$) for IBWSS 2015 by individual vessel: Celtic Explorer: green, Magnus Heinason: black, Tridens: purple, Fritjof Nansen: red, G.O. Sars: blue. March-April 2015.

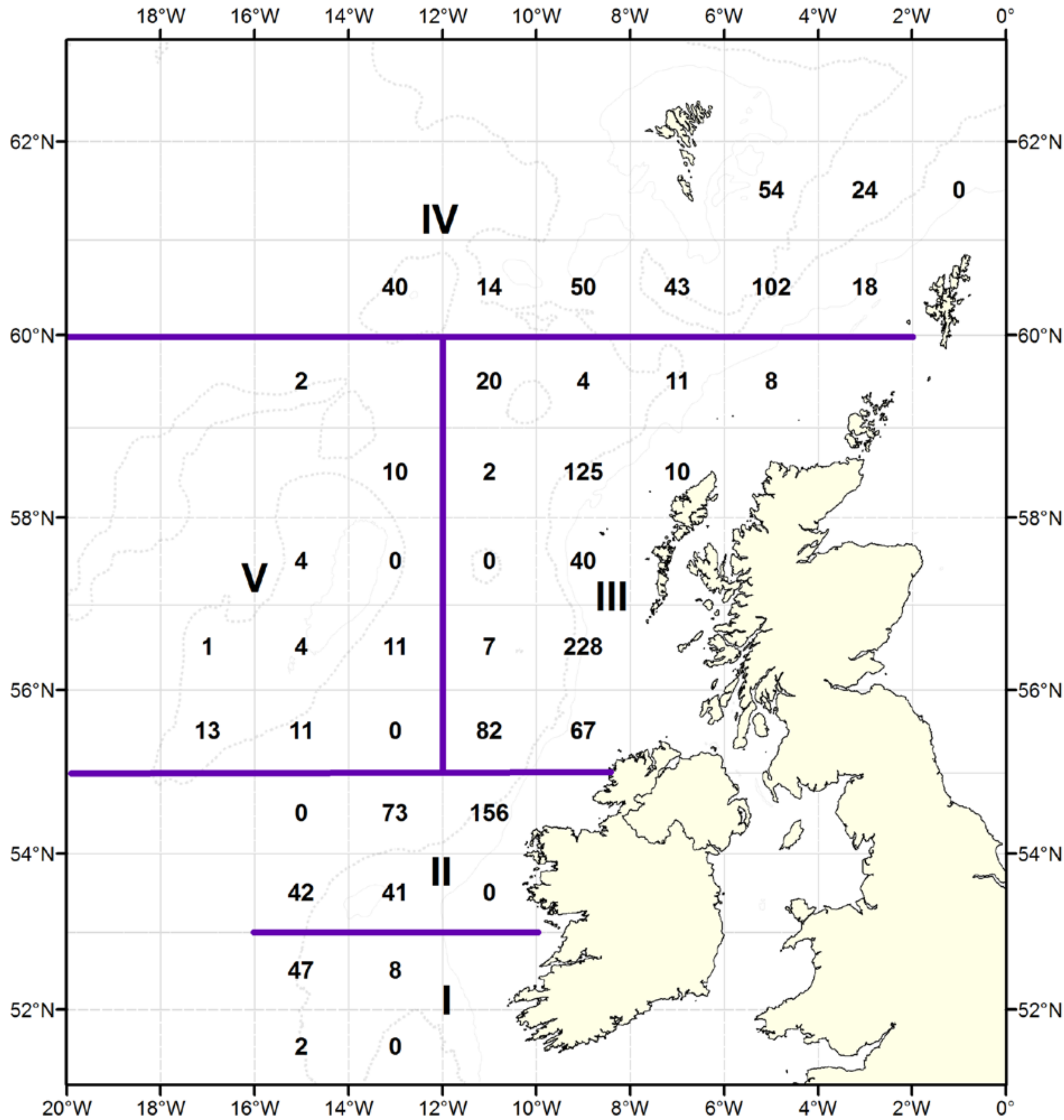


Figure 6. Blue whiting biomass (x1000t) from IBWSS 2015 by sub-area as used in the assessment.

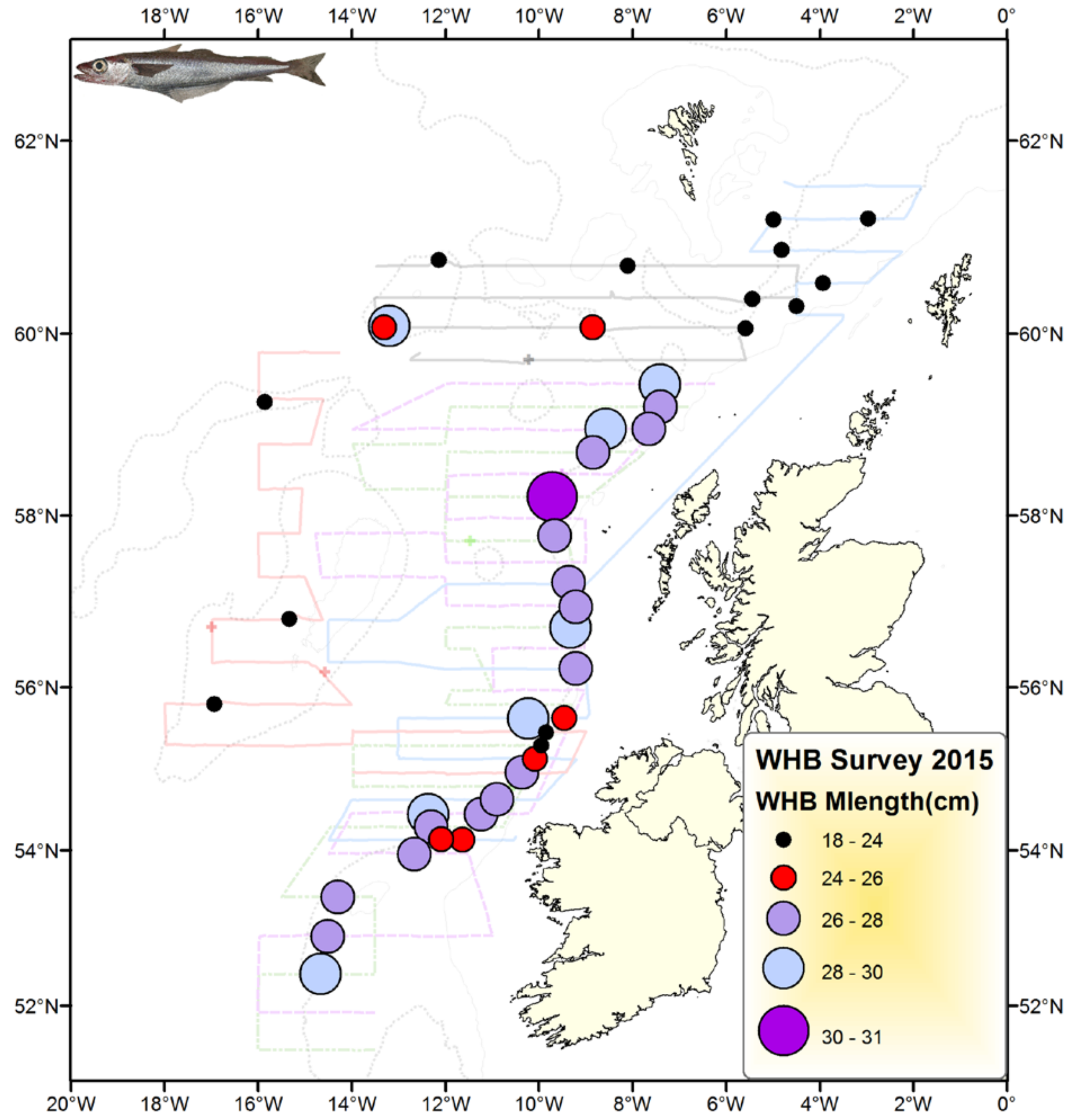


Figure 7. Mean length of blue whiting caught in trawl catches during IBWSS 2015 by individual vessels in March- April 2015. Crosses indicate hauls with zero blue whiting catches.

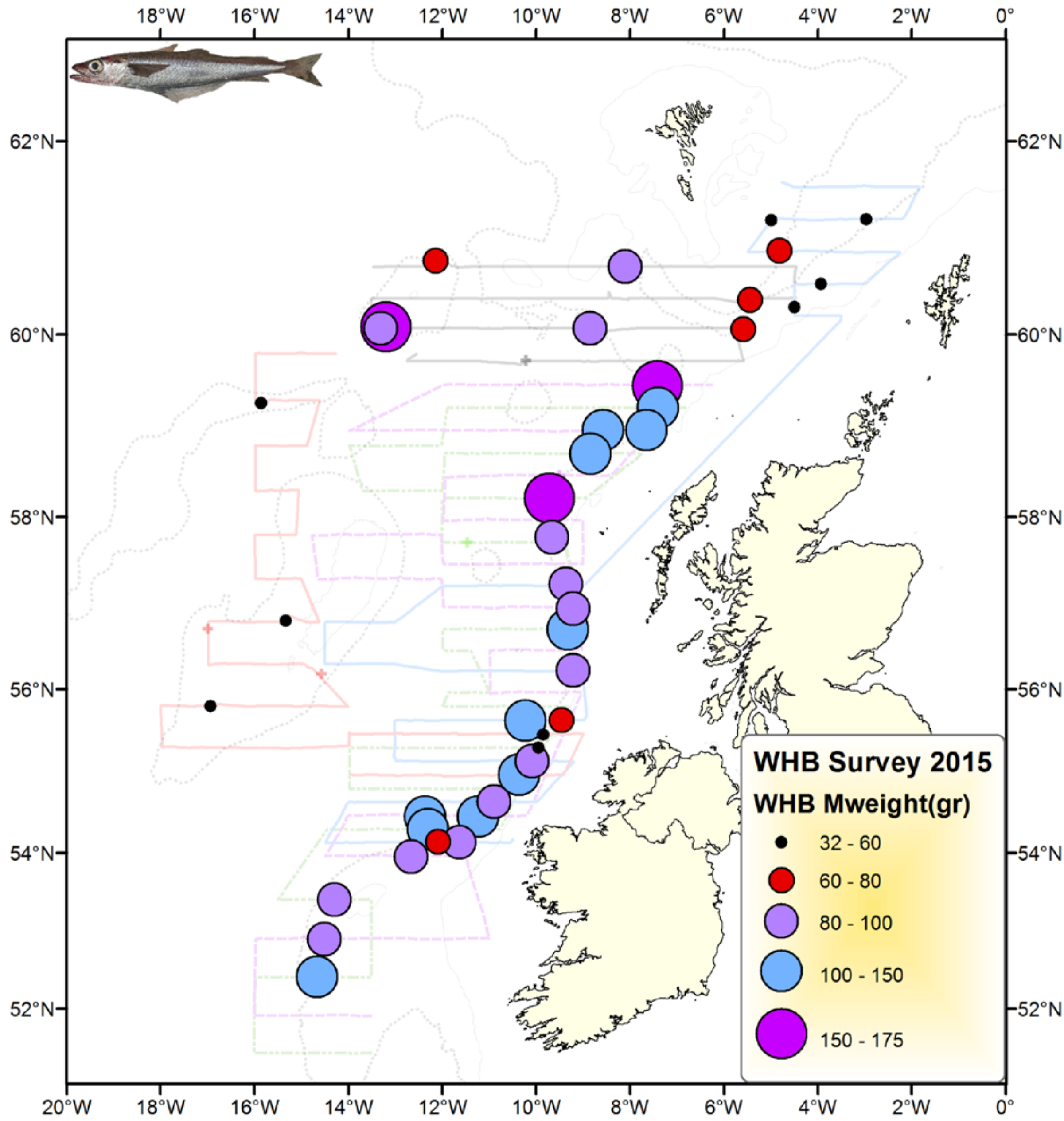
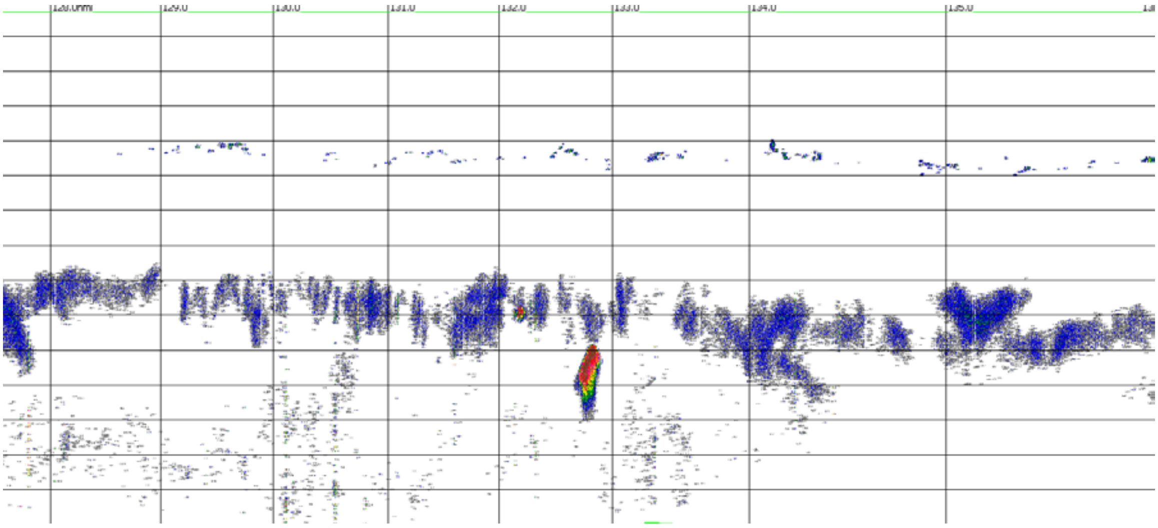
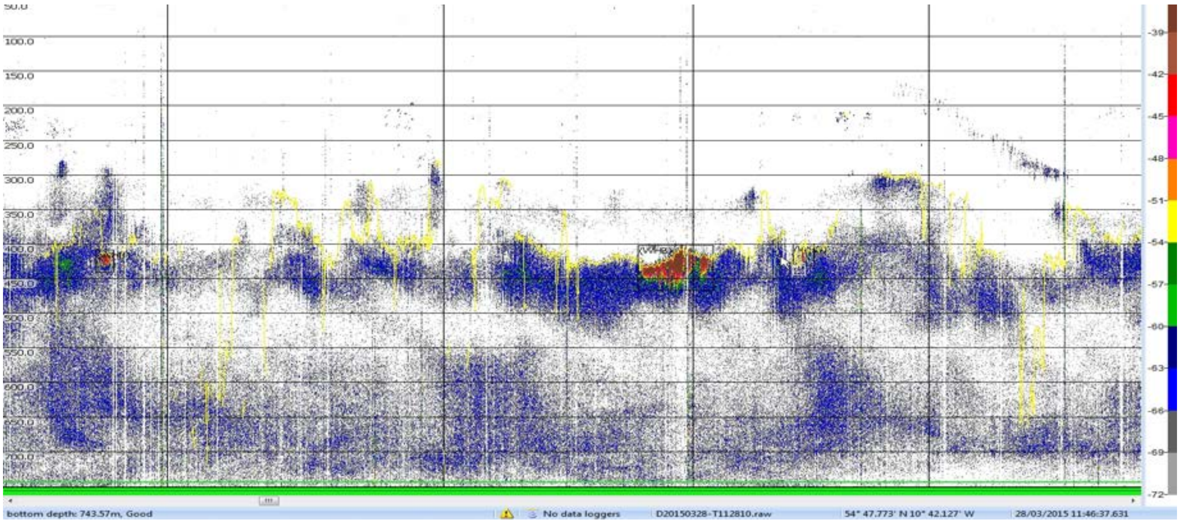


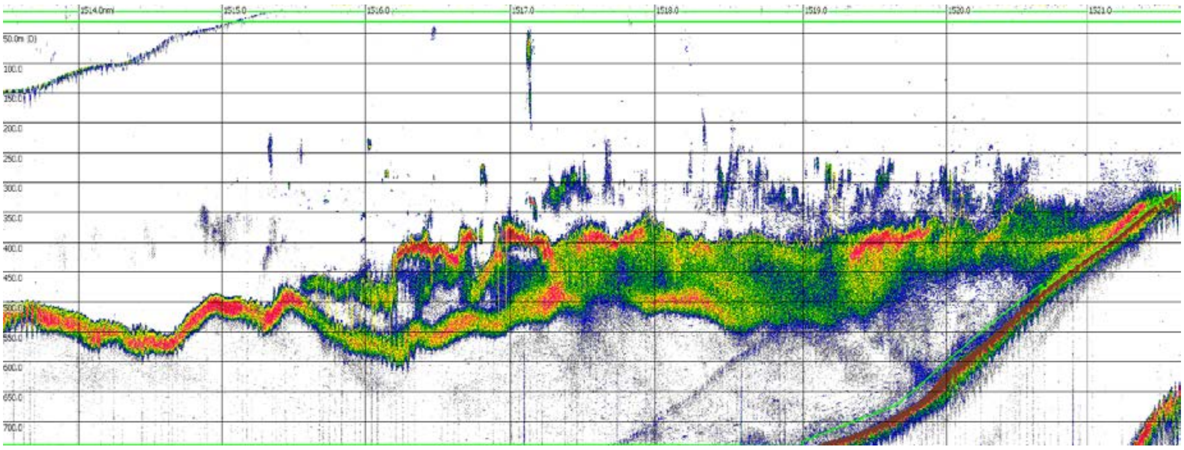
Figure 8. Mean weight of blue whiting caught in trawl catches during IBWSS 2015 by individual vessels in March- April 2015. Crosses indicate hauls with zero blue whiting catches.



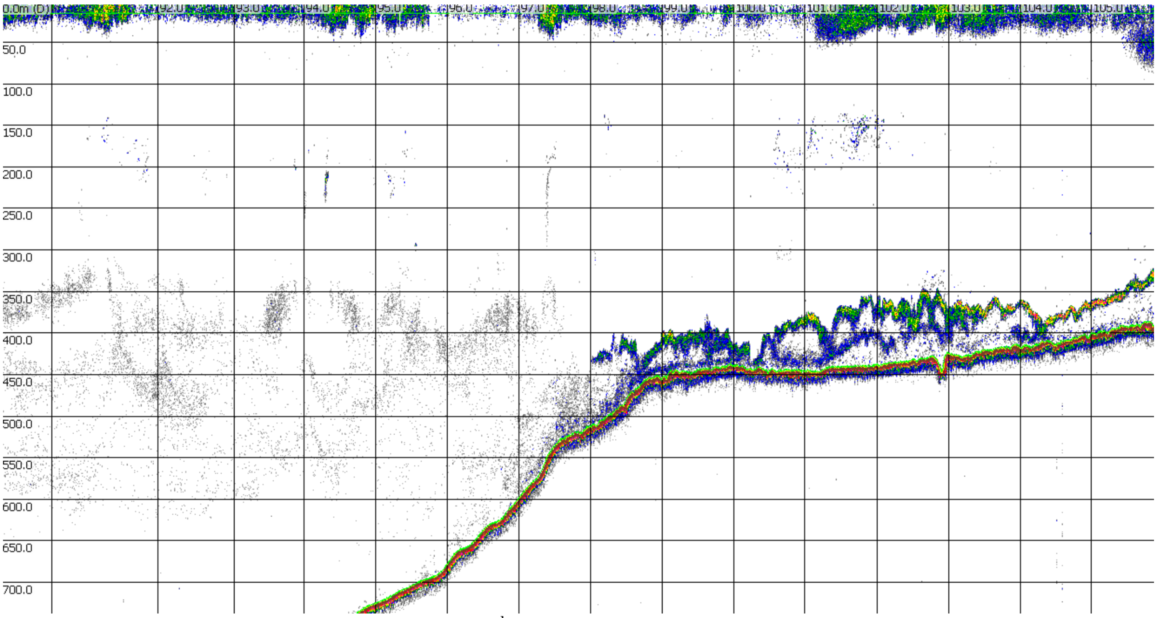
a). Highest acoustic density observed by interval in the 2015 IBWSS (s_A = 52,333 m^2/nm^2). The blue whiting echotraces were recorded by the RV Tridens west of the shelf break in open water at 58.97N 8.55W in the Hebrides target area. Echotraces were observed 15 nmi west of the shelf break in open water. The school was between 500-600m depth. Depth intervals represent 50m.



b). The highest density single blue whiting echotrace (s_A = 51,431 $m^2/mile^2$) recorded by the RV Celtic Explorer in open water to the north Porcupine sub area.



c). Large and expansive high density blue whiting echotrace recorded by RV Celtic Explorer in the Hebrides sub area.



d). Blue whiting schools observed on the 25th March by RV Tridens when approaching the shelf edge of the northern Porcupine Bank.

Figure 9. Echograms of interest encountered during the combined International blue whiting survey in March-April 2015.

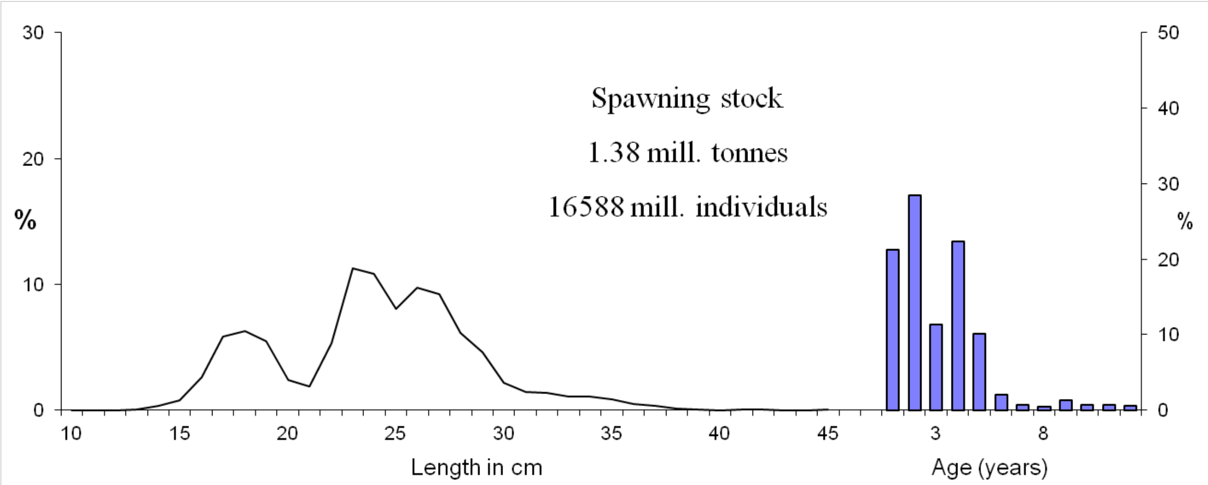


Figure 10. Length and age distributions (numbers) of total stock of blue whiting. Spawning stock biomass is given. March-April 2015.

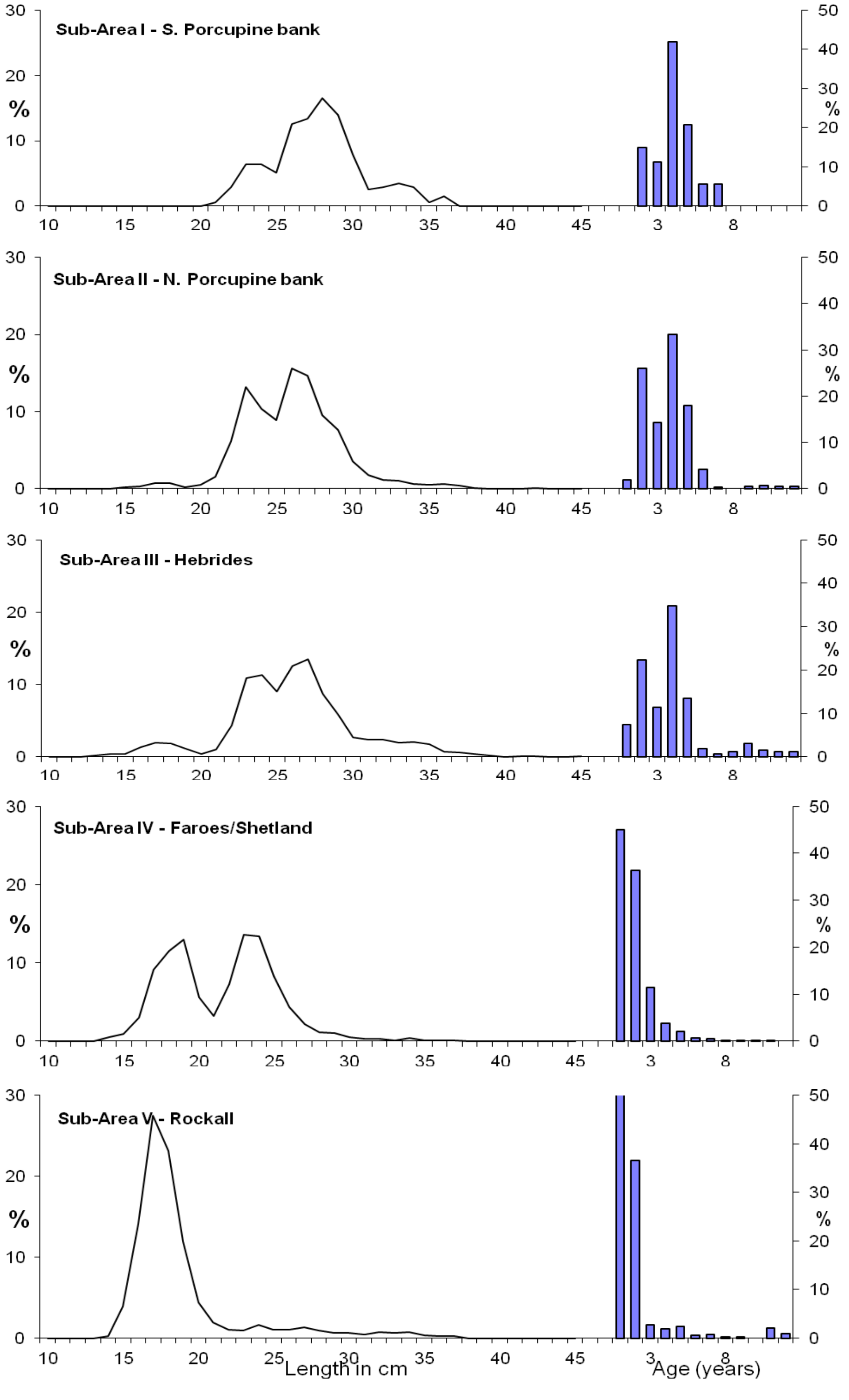


Figure 11. Length and age distribution (numbers) of blue whiting by covered sub-area (I–V). March-April 2015.

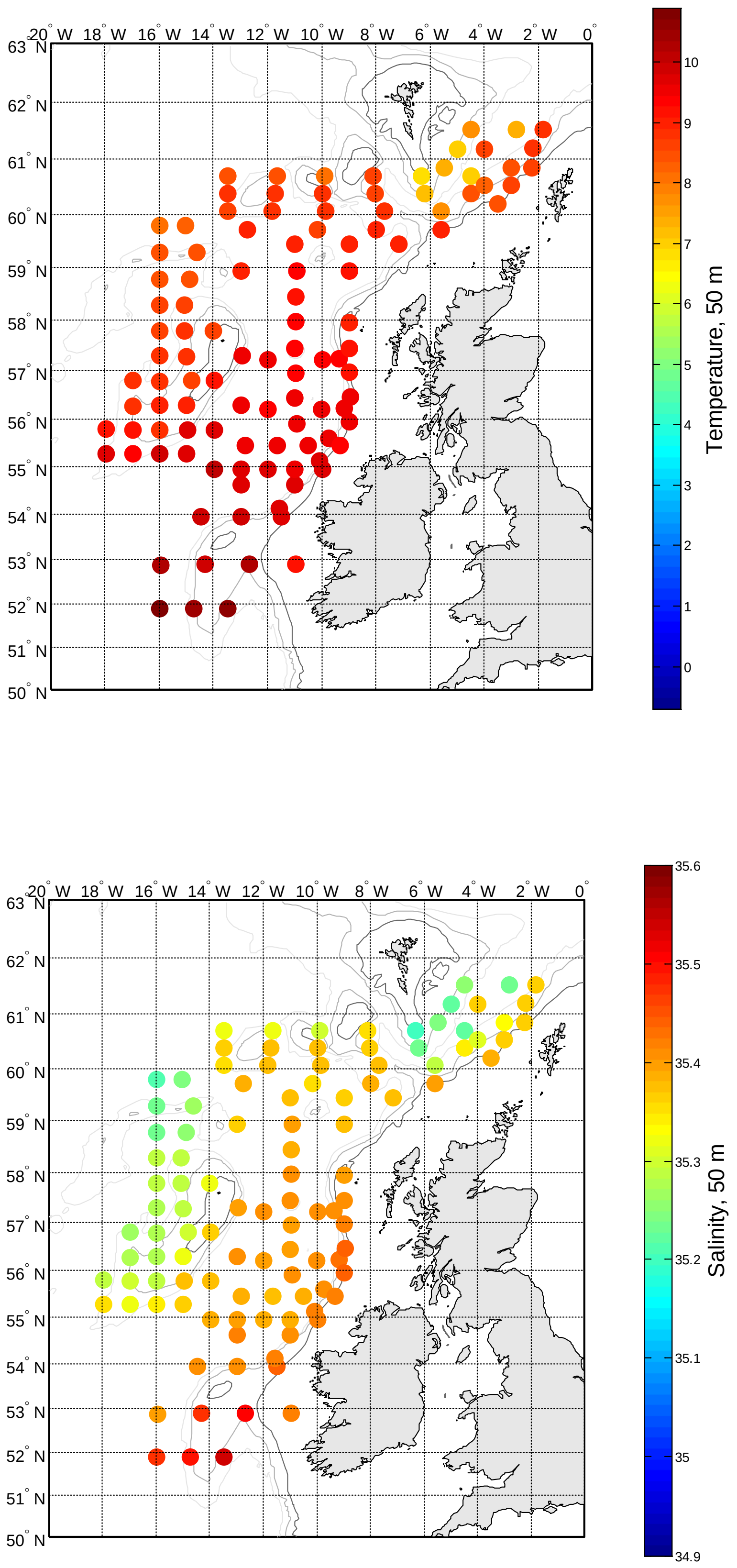


Figure 12. Horizontal temperature (top panel) and salinity (bottom panel) at 50m subsurface as derived from vertical CTD casts. March-April 2015.

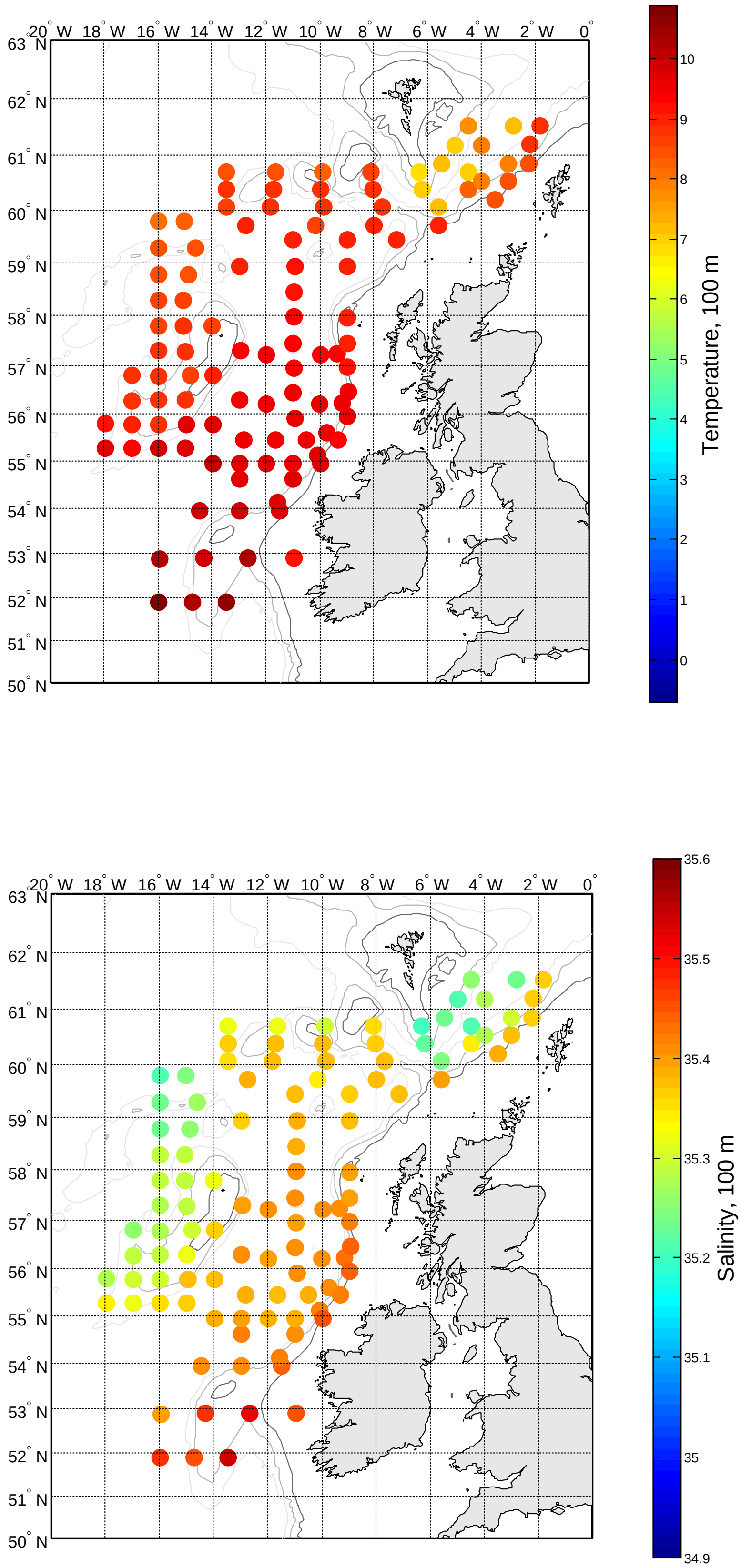
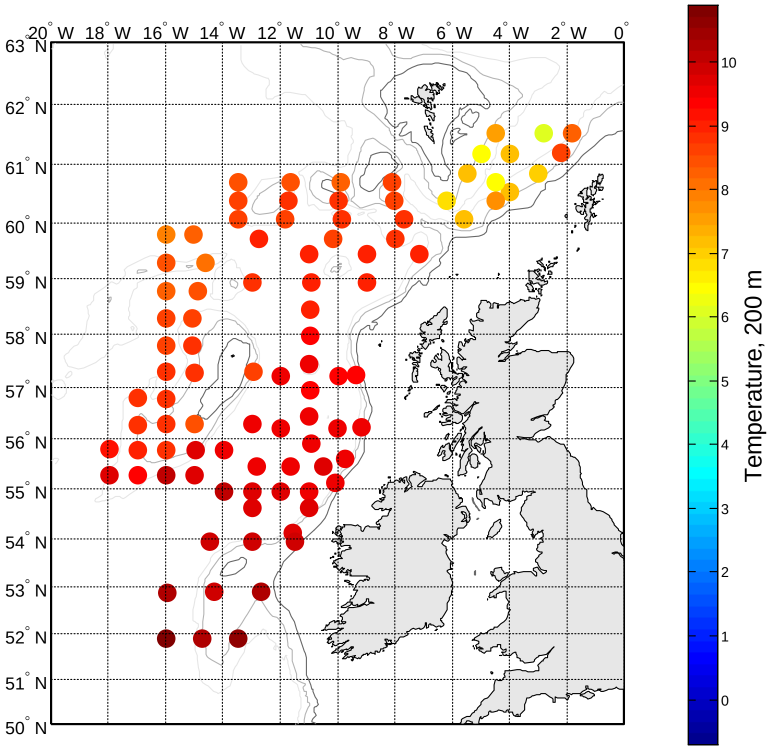


Figure 13. Horizontal temperature (top panel) and salinity (bottom panel) at 100m subsurface as derived from vertical CTD casts. March-April 2015.



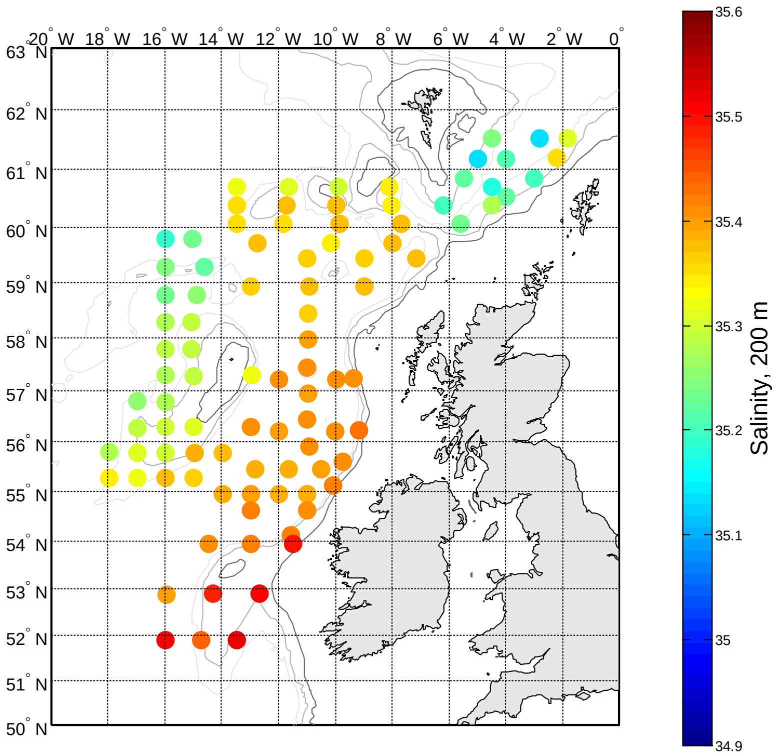
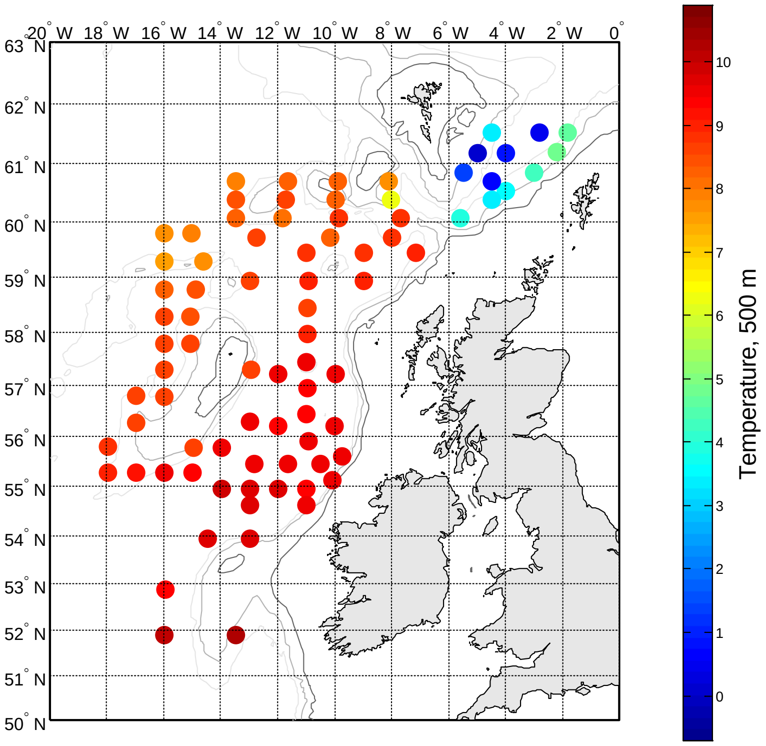


Figure 14. Horizontal temperature (top panel) and salinity (bottom panel) at 200m subsurface as derived from vertical CTD casts. March-April 2015.



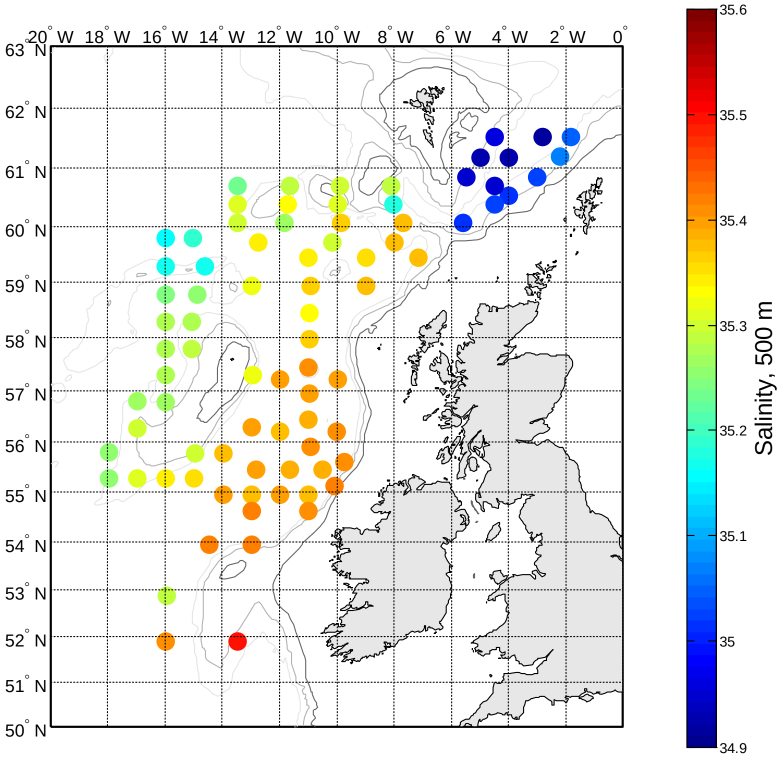


Figure 15. Horizontal temperature (top panel) and salinity (bottom panel) at 500m subsurface as derived from vertical CTD casts. March-April 2015.

Appendix 1. Uncertainty in the acoustic observations and its implications on the stock estimate

The exercise to estimate uncertainty in acoustic blue whiting observations and the consequences of this uncertainty to stock estimates is repeated using the same procedure as in previous years (Appendix 3 in Heino et al. 2007).

When calculating stock estimates from acoustic surveys, the data (acoustics density [s_A] allocated to blue whiting, in units of m^2/n.m.^{2}) from each vessel are expressed as average values over so-called EDSUs (equivalent distance sampling unit) ranging between 1 and 5 n.m. Acoustic density for each survey stratum (subarea with similar fish length distributions) is calculated as an average across all observations (EDSUs) within a stratum, weighted by the length of survey track behind each observation. Normally, these values are then converted to stratum-specific biomass estimates based on information on mean length-at-age of fish in the stratum and the assumed acoustic target strength of the fish; the total survey biomass estimate is the sum of stratum-specific estimates. In the precision estimation exercise routinely performed for the International Blue Whiting Spawning stock Survey (IBWSS), the whole estimation procedure is not repeated, but instead, uncertainty in global mean acoustic density estimates is characterized. As mean size of blue whiting does not vary very much in the survey area, uncertainty in mean acoustic density provides a conservative estimate of uncertainty in total-stock biomass.

Bootstrapping is used to estimate uncertainty in the mean acoustic density. It is calculated by stratum, treating observations from all vessels equally and using lengths of survey track behind each observation as weights when calculating mean density. With 1000 such bootstrap replicates for each stratum, 1000 bootstrap estimates of mean acoustic density, weighted by the stratum areas, are calculated. Bootstrapped mean acoustic density is the mean of these 1000 bootstrap estimates, and confidence limits can be obtained as quantiles of that distribution.

Figure 1 shows the results of this exercise with the data from the 2015 survey as well as nine earlier international surveys. Mean acoustic density over the survey area was 316.6 m^2/n.m.^{2} (as compared to 698.5 m^2/n.m.^{2} in 2014) with 95% confidence interval being 284.4 (lower) and 357.1 (upper) m^2/n.m.^{2}. Relative to the mean, the approximate 95% confidence limits are –10.1% and +12.8%, and 50% confidence limits are –3.8% and +3.5%. This level of uncertainty in acoustic densities is comparable to previous years. Overall, mean acoustic density has shown a consistent decrease annually from 2007 to 2010 and an increase thereafter until 2013. In 2014, the observed mean acoustic density has dropped slightly and this year it has decreased again considerably compared to last year.

Figure 2 summarises the results and puts them in the biomass context. The overall trend indicates a continued decrease year-on-year in biomass from 2007–2011 for this stock. The uncertainty around the decline in biomass from 2008 to 2011 is more than could be accounted for from spatial heterogeneity alone and is regarded as statistically significant. The biomass estimate from 2010 was omitted in the assessment process due to coverage problems in the survey and a resulting possibility of biomass underestimation. The 2014 estimate showed a slightly decreasing trend in biomass when compared to the previous two years. This year, the biomass dropped again in a similar level previously observed in the years after 2007. However, the decline in biomass observed this year is the most sharpest in the time series.

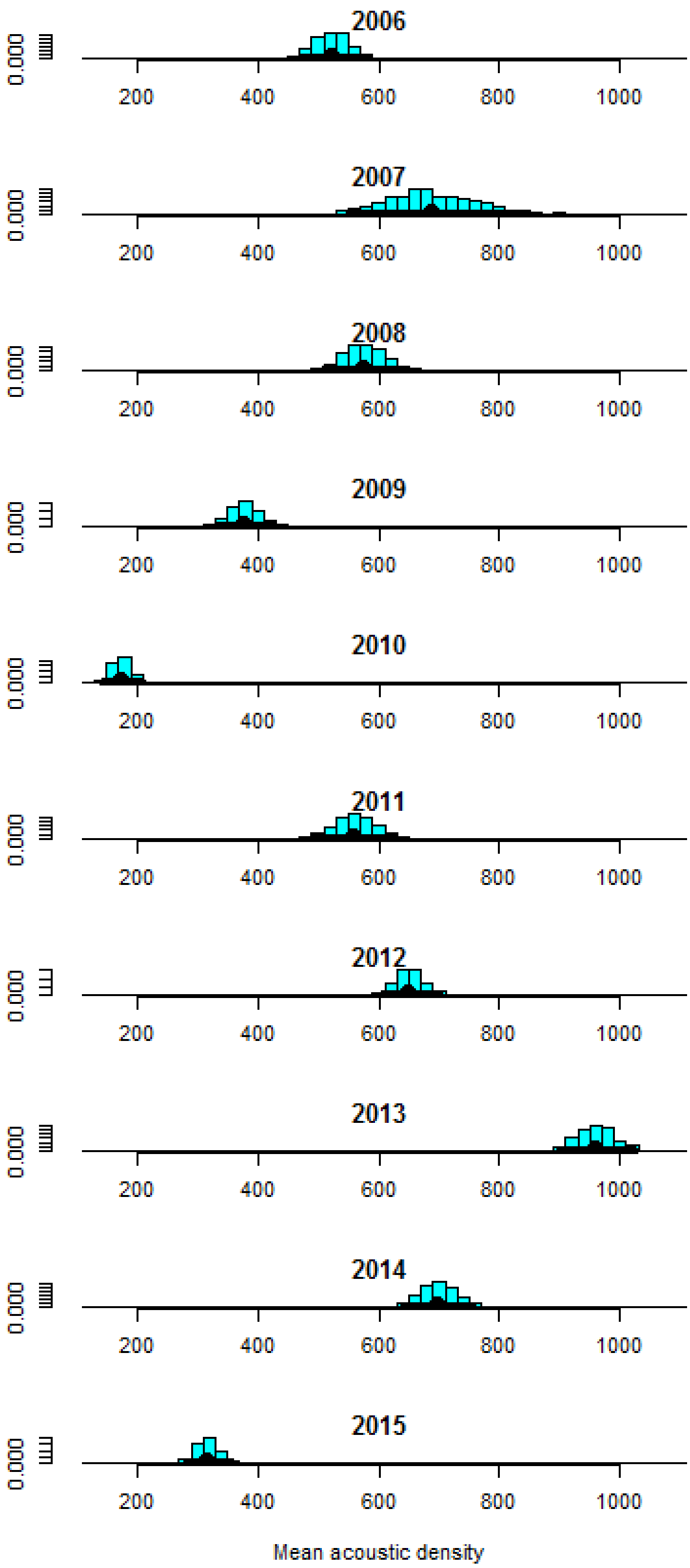


Figure 1. Distribution of mean acoustic density (in $m^2/n.m.^2$) by year based on 1000 bootstrap replicates of acoustic data from blue whiting surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

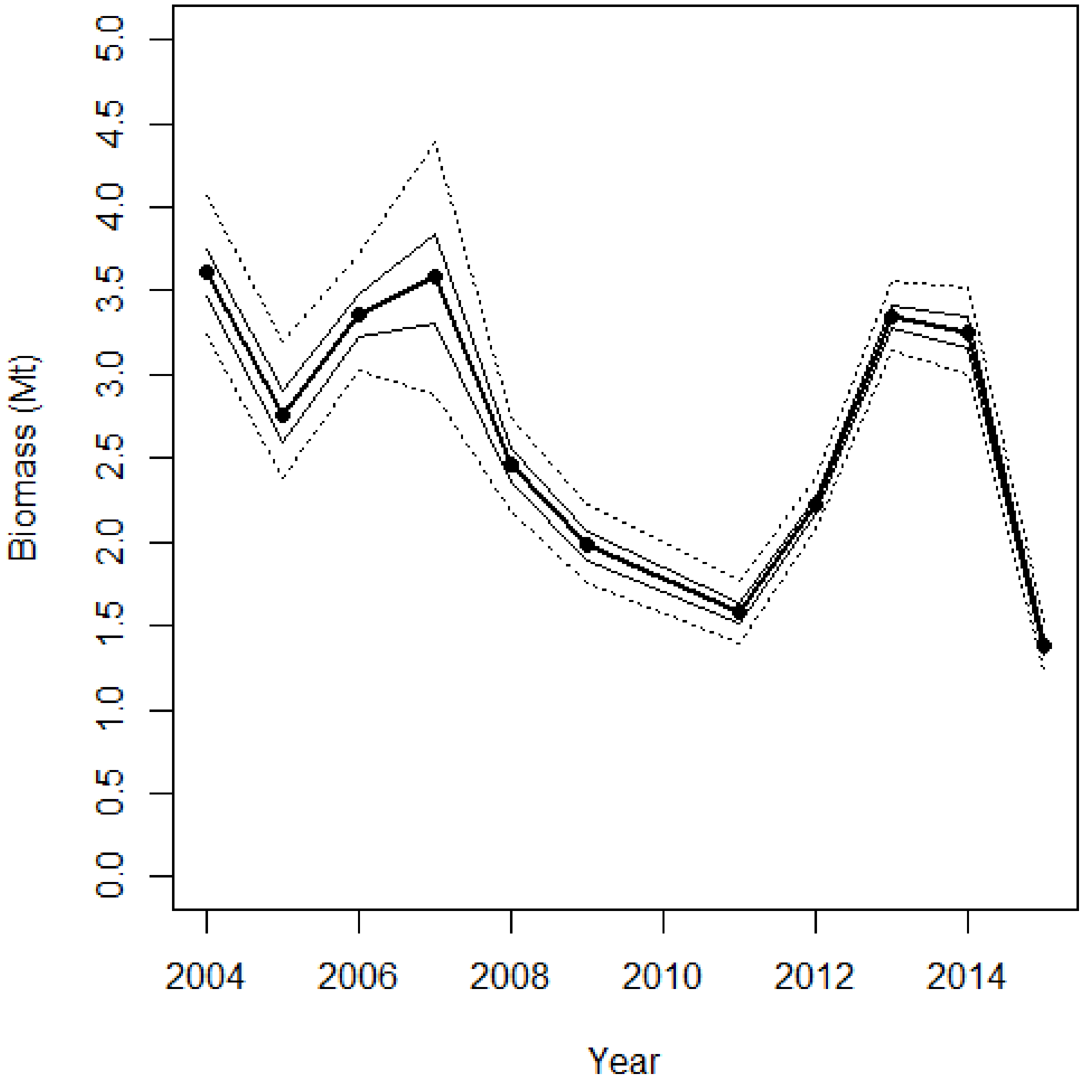


Figure 2. Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations from the mean values. These confidence limits only account for spatio-temporal variability in acoustic observations.

Appendix 2. Planned acoustic survey of the NE Atlantic blue whiting spawning grounds (IBWSS) in 2016

Five vessels representing the Faroe Islands, the Netherlands (EU-coordinated), Ireland (EU-coordinated), Norway and Russia are expected to participate in the 2016 spawning stock survey.

Survey timing and design were discussed during the meeting. The group decided that in 2016, the survey design should follow the principle of the one used during the four previous surveys. The focus will still be on a good coverage of the shelf slope in areas II and III. Survey design will remain adaptive to information received and will be finalized during the WGIPS 2016 meeting taking into account information from WGWIDE.

The design is based on variable transect spacing, ranging from 30 nmi in areas containing less dense aggregation (e.g. subarea I, south Porcupine), to a minimum of 10 nmi in the core survey area (subarea III, Hebrides) (Figure 4.1).

Survey extension in terms of coverage (51–61ºN) will be in line with the previous year to ensure containment of the stock and survey timing will also remain fixed as in previous years.

Preliminary cruise tracks for the 2016 survey are presented in Figure 1. Detailed cruise lines for each ship will be circulated by the coordinator (Ebba Mortensen, FAMRI) to the group as soon as final vessel availability and dates have been communicated (after WGIPS, latest by the end of January 2016).

As the survey is planned with inter-vessel cooperation in mind it is vitally important that participants stick to the planned transect positioning to ensure that survey effort is evenly allocated.

The survey will be carried out according to survey procedures described in the "MANUAL FOR INTERNATIONAL PELAGIC SURVEYS (IPS)" (WGIPS report 2012).

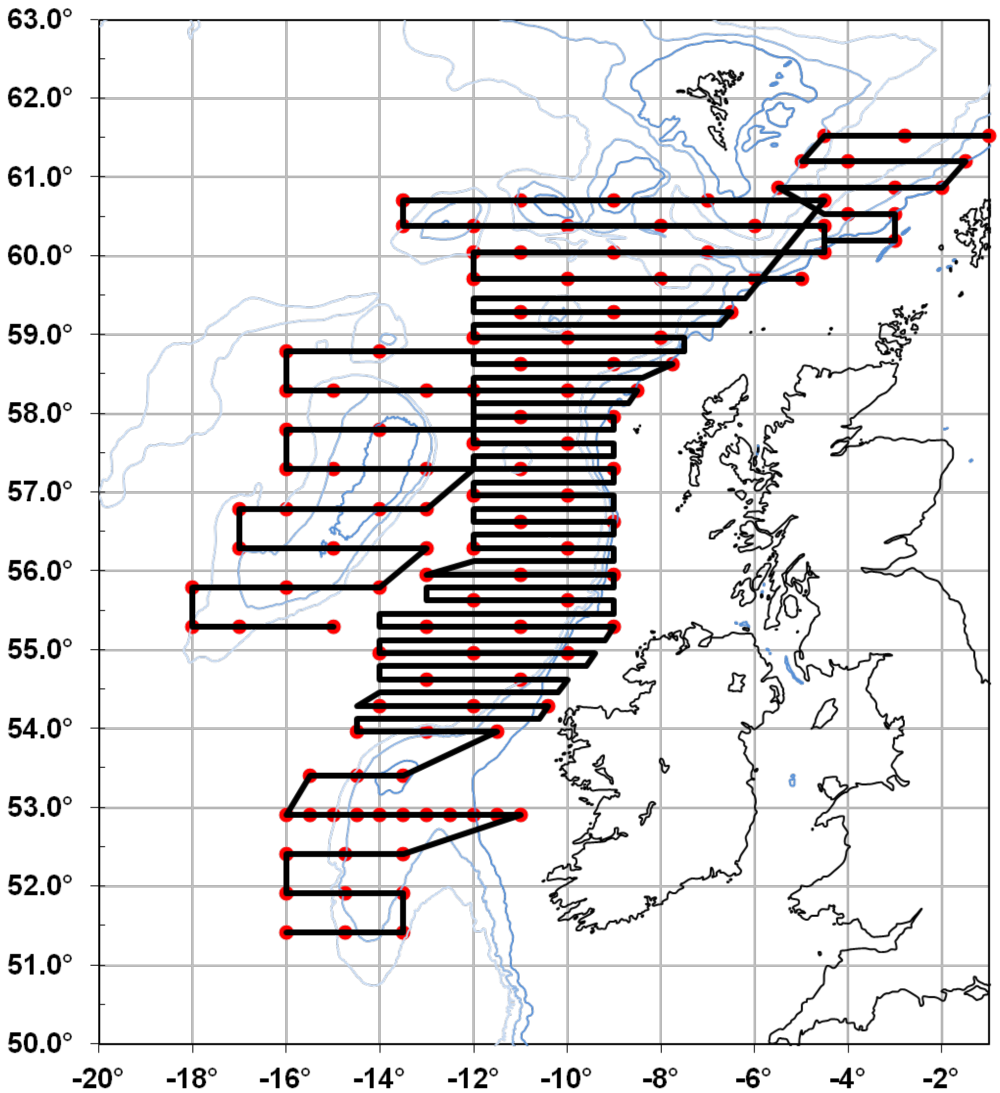


Figure 16. Preliminary survey tracks and CTD stations for the combined 2016 International Blue Whiting Spawning stock Survey (IBWSS).

Table 6. Preliminary individual vessel dates for the 2016 International Blue Whiting Spawning stock Survey (IBWSS). Final vessel dates will be submitted to the coordinator by the end of the WGIPS meeting in January 2016.

Ship	Nation	Active survey time (days)	Preliminary survey dates
Fritjof Nansen	Russia	19	18.3.2016 – 6.4.2016
Celtic Explorer	Ireland (EU)	14	23.3.2016 – 6.4.2016
G.O. Sars	Norway	14	23.3.2016 – 6.4.2016
Tridens	Netherlands (EU)	15	21.3.2016 – 5.4.2016
Magnus Heinason	Faroe Islands	12	23.3.2016 – 6.4.2016

Annex 4b: IESNS

Working Document

Post-cruise meeting of Working Group on International Pelagic Surveys (WGIPS)

Copenhagen, Denmark, 16 –18 of June 2015

Working Group on Widely distributed Stocks

San Sebastian, Spain, 25–31 August 2015

INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) IN April – June 2015

Maxim Rybakov[4], Tatjana Sergeeva[4], Olga Goncharova[4]
R/V Fridtjof Nansen

Øyvind Tangen[2], Valantine Anthonypillai[2], Are Salthaug[2], Åge Høines[2], Kjell Arne Mork[2], Webjørn Melle[2],
RV G. O. Sars

Karl-Johan Stæhr[3], Bram Couperus[6,] Mathias Kloppmann[8]
RV Dana

Guðmundur J. Óskarsson[7], Sveinn Sveinbjörnsson[7], Héðinn Valdimarsson[7], Ástþór Gíslason
RV Árni Friðriksson

Eydna í Homrum[5], Ebba Mortensen[5,] Poul Vestergaard[5], Jens Arni Thomassen[5] , Leon Smith[5*]
RV Magnus Heinason

2 Institute of Marine Research, Bergen, Norway

3 DTU-Aqua, Denmark

4 PINRO, Murmansk, Russia

5 Faroese Marine Research Institute, Tórshavn, Faroe Islands

6 IMARES, IJmuiden, The Netherlands

7 Marine Research Institute, Reykjavik, Iceland

8 vTI-SF, Hamburg, Germany

Introduction

In April-June 2015, five research vessels; RV Dana, Denmark (joined survey by Denmark, Germany, Ireland, The Netherlands, Sweden and UK), RV Magnus Heinason, Faroe Islands, RV Arni Friðriksson, Island, RV G.O. Sars, Norway and RV Fridtjof Nansen, Russia participated in the International ecosystem survey in the Nordic Seas (IESNS). The survey area was split into three Subareas: Area I, Barents Sea area, Area II, Northern and central Norwegian Sea Area, and Area III, the South-Western Area (Figure 1). The aim of the survey was to cover the whole distribution area of the Norwegian Spring-spawning herring with the objective of estimating the total biomass of the herring stock, in addition to collect data on plankton and hydrographical conditions in the area. The survey was initiated by the Faroese, Iceland, Norway and Russia in 1995. Since 1997 also the EU participated (except 2002 and 2003) and from 2004 onwards it was more integrated into an ecosystem survey. This report is compilation of data from this International survey stored in the PGNAPES databases and supported by national survey reports from each survey (Dana: Couperus, Staehr, Kloppmann 2015, Magnus Heinason: í Homrum, Mortensen, FAMRI 1516-2015, Arni Friðriksson: Oskarsson and Sveinbjornsson 2015, Fridtjof Nansen: Rybakov PINRO 2015 and G.O. Sars: not (yet) available.

Material and methods

Coordination of the survey was done during the WGIPS meeting jan. 2015. The participating vessels together with their effective survey periods are listed in the table below:

Vessel	Institute	Survey period
Dana	Danish Institute for Fisheries Research, Denmark	28/5–23/5
G. O. Sars	Institute of Marine Research, Bergen, Norway	29/4-3/6
Fridtjof Nansen	PINRO, Russia	02/6–28/6
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	30/4- 14/5
Arni Friðriksson	Marine Research Institute, Island	29/4-22/5

Figure 2 shows the cruise tracks and the CTD/WP-2 stations and Figure 3 the cruise tracks and the trawl stations. Survey effort by each vessel is detailed in Table 1. Frequent contacts were maintained between the vessels during the course of the survey, primarily through electronic mail.

In general, the weather condition did not affect the survey even if there were some days that were not favourable. In the central area the weather conditions were generally good during the survey.

The survey was based on scientific echosounders using 38 kHz frequency. Transducers were calibrated with the standard sphere calibration (Foote *et al.*, 1987) prior to the survey. Salient acoustic settings are summarized in the text table below.

Acoustic instruments and settings for the primary frequency (boldface).

	Dana	G.O. Sars	Arni Friðriksson	Magnus Heinason	Fridtjof Nansen
Echo sounder	Simrad EK 60	Simrad EK 60	Simrad EK60	Simrad EK60	Simrad EK60
Frequency (kHz)	**38**	**38**, 18, 70, 120, 200, 333	**38**, 18, 120, 200	**38**,200	**38,** 120
Primary transducer	ES38BP	ES 38B - Serial	ES38B	ES38B	ES38B
Transducer installation	Towed body	Drop keel	Drop keel	Hull	Hull
Transducer depth (m)	3	8.5	8	3	5.2
Upper integration limit (m)	5	15	15	7	10
Absorption coeff. (dB/km)	6.9	10.1	10	10.2	10
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.425	2.425	2425	2.425
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-20.5	-20.8	-20.9	-20.8	-20.6
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.33	25.17	24.64	25.57	25.52
s_A correction (dB)	-0.55	-0.61	-0.84	-0.7	-0.64
3 dB beam width (dg)					
alongship:	6.73	7.24	7.31	6.98	6.99
athw. ship:	6.77	7.26	6.95	7.07	6.99
Maximum range (m)	500	500	750	500	450
Post processing software	LSSS	LSSS	LSSS	Sonardata Echoview 6.1	LSSS

Post-processing software differed among the vessels but all participants used the same post-processing procedure, which is according to an agreement at a PGNAPES scrutinizing workshop in Bergen in February 2009 (ICES WKCHOSCRU 2009), and "Notes from acoustic Scrutinizing workshop in relation to the IESNS", Reykjavík 3.-5. March 2015.

Generally, acoustic recordings were scrutinized with the different software (see table above) 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.

All vessels used a large or medium-sized pelagic trawl as the main tool for biological sampling. The salient properties of the trawls are as follows:

	Dana	G.O.Sars	Arni Friðriksson	Magnus Heinason	Fridtjof Nansen
Circumference (m)		832	640	640	500
Vertical opening (m)	25-35	45–50	45–55	45–55	50
Mesh size in codend (mm)		40	40	40	16
Typical towing speed (kn)	3.0-40	4.0–4.5	3.0–4.5	3.0–4.0	3.7–4.8

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 30–100 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 70–300 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 echo recordings using post-processing systems. The allocation of NASC-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 over squares of 1° latitude × 2° longitude. For each square, the unit area density of fish in number per square nautical mile (N*nm-2) was calculated using standard equations (Foote *et al.*, 1987; Toresen *et al.*, 1998). The following target strength (TS) function was used:

Blue whiting: TS = 20 log(L) – 65.2 dB (rev. acc. ICES CM 2012/SSGESST:01)

Herring: TS = 20.0 log(L) – 71.9 dB

The target strength for herring is the traditionally one used while this target strength for blue whiting was first applied in 2012 (ICES 2012).

To estimate the total abundance of fish, the unit area abundance for each square was multiplied by the area in each statistical square then summed for all the squares 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.

As last year, the whole survey area was divided into 5 geographical strata (Figure 4). For each of the strata, east-west transects (except for stratum 6 in the Barents Sea with north-south transects) were decided prior to the survey. Within each stratum, parallel transects with equal distance were used. The distance between transects was based on available survey time, and the starting point of the first transect in each stratum was randomized. This approach allows for robust statistical analyses of uncertainty of the acoustic estimates.

A new software package (StoX) is under development at IMR, Norway. The first version of StoX was released earlier this year. StoX is an open source software with an infrastructure hosting various types of survey estimation programs for acoustic surveys and trawl surveys (swept area). The program is a stand-alone application build with Java for easy sharing and further development in cooperation with other institutes. The underlying high resolution data matrix structure ensures future implementations of e.g. depth dependent target strength and high resolution length and species information collected with camera systems. Despite this complexity, the execution of an index calculation can easily be governed from user interface and an interactive GIS module, or by accessing the Java function library and parameter set using external software like R. Accessing StoX from external software may be an efficient way to process time series or to perform boot-strapping on one dataset, where for each run, the content of the parameter dataset is altered. In the first version a stratified transect design is assumed (e.g. like the IESNS survey design this year) and standard statistical methods to estimate mean and variance of abundance can be be used. Other methods will be implemented, however, expert specification demands, documentation and statistical rigorousness is essential in the development of StoX. The software was tested on data collected on this year's IESNS survey and the biomass estimate was fairly similar (results will be presented at a later stage in a separate report). The StoX software will replace the BEAM program from next year onwards.

The hydrographical and plankton stations by survey are shown in Figure 2. All vessels collected hydrographical data using a SBE 911 CTD. Maximum sampling depth was 1000 m. Beside the hydrographical sampling from the vessels listed above, hydrographical data from two fixed hydrographical transects (Langanes-NE and Langanes-E; Figure 5; total 14 stations) north east of Iceland were also used. They were sampled in the spring survey around Iceland by RV Bjarni Sæmundsson during 20-30 May 2015 using the same kind of CTD as the other vessels.

Zooplankton was sampled by a WPII on all vessels except the Russian vessel which used a Djedi net, according to the standard procedure for the surveys. Mesh sizes were 180 or 200 μm. The net was hauled vertically from 200 m or the bottom to the surface. All samples were split in two and one half was preserved in formalin while the other half was dried and weighed. On the Danish, the Icelandic and the Norwegian vessels the samples for dry weight were size fractionated before drying. Data are presented as g dry weight per m^2.

Results

Hydrography

The temperature distributions in the ocean at selected depths between surface and 400 m depths are shown in Figures 6-11. The temperatures at the surface ranged from 0°C in the Iceland Sea to 9°C in the southern part of the Norwegian Sea. The Arctic front was encountered slightly below 65°N east of Iceland extending eastwards towards the 0° Meridian where it turned almost straight northwards up 70°N. The front was visible throughout the observed water column. The warmer North Atlantic water formed a broad tongue that stretched far northwards along the Norwegian coast with temperatures > 7 °C to 71° N in the surface layers.

Relative to a 20 years long-term mean, from 1995 to 2014, the temperatures at all depths in the vicinity of the Faroese were considerable lower in 2015 compared to the long-term mean (Figures 12-15). There, the anomaly was maximum 2°C. The cold conditions reflect the relative low temperatures in the Sub Polar Gyre that have propagated northeastward into the southern Norwegian Sea. North of about 61°N the temperatures at all depth were in general higher than the long term mean for most of the area. In this area the temperatures were about 0.25-0.75 °C above the mean but in some areas the anomalies were higher (e.g., over the Vøring Plateu, northeast of Jan Mayen, and at the entrance to the Barents Sea).

Similar pattern was observed at 0-50 m depth at the standard hydrographic sections northeast off Iceland (Langanes E, Figure 5), where the temperature was lower than in the year before while the salinity was higher (Figures 16- and 17). However, for the deeper waters the temperature was at high level (Figure 18).

Zooplankton

Biomass of zooplankton dry weight and sampling stations are shown in Figure 19. Sampling stations were evenly spread over the area, and most oceanographic regions were covered. The zooplankton biomass was relatively uniform over the whole area, with the highest values northeast of Iceland and in coastal areas of northern Norway. The average value for the Norwegian Sea (between 14°W and 20°E) was 6.5 g dry weight m^{-2}, which is a decrease from last year's value (Figure 20). The average value for the continental slope south and west of Iceland (west of 14°W) was 1.3 g dry weight m^{-2}.

In the Barents Sea (east of 20°E), the mean zooplankton biomass was 0.80 g dry weight m^{-2}. It was noted that the Djedy net applied by the Russian vessel in Barents Sea seems to be less effective in catching zooplankton in comparison to WP2 net applied by other vessels in an overlapping area. Thus, the biomass estimates for the Barents Sea are not directly comparable to the other areas, but are comparable among years within the Barents Sea.

Norwegian Spring-spawning herring

Survey coverage in the Norwegian Sea was considered adequate in 2015 and in line with previous years. It is therefore recommended that the results can be used for assessment purpose. The herring was distributed over a comparable area as in 2014 but the highest density was observed further east than in the latest years (Figures 21 and 22). The center of gravity of the acoustic recordings of herring reflects the distribution and correspondingly shifted in a southeasterly direction compared to 2014 (Figure 23). Overall the herring density was relatively low. Different from previous four years, young herring (age 6 and younger) was observed north of 70°N, although much less than in 2010.

As in previous years the smallest fish were found in the eastern area of the Norwegian Sea where size and age were found to increase to the west and south (Figure 24). Correspondingly, it was mainly older herring that appeared in the southwestern areas (area III).

The herring stock is now dominated by 6 year old herring (2009 year class) in numbers but 9, 10 and 11 year old herring (the 2006, 2005 and 2004 year classes) are also numerous (Table 2). This is the first time since 2008 that the 2004 year class is not the most abundant. The 2009 year class appears to be the largest of the younger age groups even it appears to be only around 70% of average size of six year olds in the times series since 1997. In biomass, however, the 2004 year class is still the largest. The four year classes from 2004, 2005, 2006 and 2009 contribute 19%, 11%, 12% and 17% respectively to the total biomass in the Norwegian Sea. The relatively high abundance of the 2005 year class might be caused by age reading errors mentioned in the Discussion section.

The total biomass estimate of herring in the Norwegian Sea from the 2014 survey was 5.4 million tons. This estimate is 0.3 million tonnes higher than in 2014. The biomass decreased from 2009 to 2012, but in the last 4 years has been around 5 million tonnes (Figure 25).

The investigations of herring in the Barents Sea covered the area from 45°E to the 21°00′ E. The total abundance estimate was lower than in the last two years, with 2996 million individuals of age 1 (mean length of 12.4 cm and weight of 11.6 g), 8129 million individuals of age 2 (mean length of 18 cm and mean weight of 36.8 g), 957 million individuals of age 3 herring (mean length of 21.4 cm and mean weight of 62.8 g) and 265 million individuals of age 4 herring (mean length of 26.1 cm and mean weight of 109.2 g). Only very few older herring were observed.

The total number of herring recorded in the Norwegian Sea was 14.1 billion in the northeastern area and 6.9 billion in the southwestern area, compared to 13.0 and 9.6 billion in the northeastern and 7.4 and 6.9 billion in the southwestern area in 2013 and 2014, respectively.

Blue whiting

The total biomass of blue whiting registered during the IESNS survey in 2015 was 0.89 million tons (Table 3), which is an increase from the biomass estimate in 2014 (0.63). The stock estimate in number for 2015 is 16 billion, which is about 75% higher than in 2014. The increase in abundance is caused by more young fish in the stock. Age one is dominating the estimate (53% of the biomass and 76% by number).

An estimate was also made from a subset of the data or a “standard survey area” between 8°W–20°E and north of 63°N, which has been used as an indicator of the abundance of blue whiting in the Norwegian Sea because the spatial coverage in this area provides a coherent time-series with adequate spatial coverage. This standard survey area estimate is used as an abundance index in WGWIDE. The age-disaggregated total stock estimate in the “standard area” is presented in Table 4, showing that the blue whiting in this index area was also dominated by fish at age 1 both in terms of numbers and biomass.

The distribution of blue whiting in 2015 was similar to 2014, but with higher abundance estimates in the eastern and southern part of the Norwegian Sea, along the Norwegian continental slope, as well as southwest of Iceland. The main concentrations were observed both in connection with the continental slopes of Norway and south and southwest Iceland and in the open sea in the southern part of the Norwegian Sea (Figures 26 and 27). The mean length of blue whiting is shown in Figure 28. It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

Mackerel

In later years an increasing amount of mackerel has been observed in the Norwegian Sea during the combined survey in May targeting herring and blue whiting. The edge of the distribution has also been found progressively further north and west. However, the mackerel was mainly found in the eastern part of the survey area up to 67°N in May 2015, with few exceptions at western stations further south. It should be noted, however, that the sampling may not provide a representative picture of mackerel distribution because of its vertical distribution and relatively low trawling speed.

Stomach samples from the three pelagic species (herring, blue whiting and mackerel) were collected by the Norwegian and Faroese vessels. These samples have however, not been analyzed yet and will be reported by other means later.

The distribution of the pelagic fish stocks is apparently linked to the temperature within the distribution area as shown on profiles of the two transects across the whole Norwegian Sea (Figure 29). For example, the herring was not found in surface waters (0-100m) in waters below 3°C as in the western part of the Norwegian Sea, even if found in colder waters deeper down. Blue whiting was on the other hand limited to waters above 2°C.

Discussion

Hydrography

Discussions related to the oceanographic condition in April/July 2014 are provided in the results section above, while more general patterns are introduced in this section.

Two main features of the circulation in the Norwegian Sea, where the herring stock is grazing, are the Norwegian Atlantic Current (NWAC) and the East Icelandic Current (EIC). The NWAC with its offshoots forms the northern limb of the North Atlantic current system and carries relatively warm and salty water from the North Atlantic into the Nordic Seas. The EIC, on the other hand, carries Arctic waters. To a large extent this water derives from the East Greenland Current, but to a varying extent, some of its waters may also have been formed in the Iceland and Greenland Seas. The EIC flows into the southwestern Norwegian Sea where its waters subduct under the

Atlantic waters to form an intermediate Arctic layer. While such a layer has long been known in the area north of the Faroes and in the Faroe-Shetland Channel, it is only in the last three decades that a similar layer has been observed all over the Norwegian Sea.

This circulation pattern creates a water mass structure with warm Atlantic Water in the eastern part of the area and more Arctic conditions in the western part. The NWAC is rather narrow in the southern Norwegian Sea, but when meeting the Vøring Plateau off Mid Norway it is deflected westward. The western branch of the NWAC reaches the area of Jan Mayen at about 71°N. Further northward in the Lofoten Basin the lateral extent of the Atlantic water gradually narrows again, apparently under topographic influence of the mid-ocean ridge. It has been shown that atmospheric forcing largely controls the distribution of the water masses in the Nordic Seas. Hence, the lateral extent of the NWAC, and consequently the position of the Arctic Front, that separates the warm North Atlantic waters from the cold Arctic waters, is correlated with the large-scale distribution of the atmospheric sea level pressure.

The temperature east of Iceland in the 0-50m layer in May 2015 (Figure 16 and 17) was lower than in 2014, but this is smaller deviation than observed west, south and southeast of Iceland in the same survey (1-2°C lower in upper layers). Thus the colder conditions around the Faroes (Figures 12-14) are not considered to be related to increased flow in the East Icelandic current, but to the changed conditions in the North Atlantic Current and the lower temperature in the Sub Polar Gyre, seen as a negative SST anomaly and which has been progressing northeastwards during this spring. So the colder anomaly on the Iceland Faroes Ridge is probably more related to these colder conditions from the west and south and could be influencing the Norwegian Sea this summer. These colder surface (and upper layers) are related to strongly positive NAO and cold/fresh waters on the Canadian site of the Atlantic this winter and spring.

Plankton

The zooplankton biomass has been estimated since 1995 and the time series was re-evaluated by WGINOR in 2014 (Figure 20; ICES 2014). After a severe decline from 2003 until 2009 (~4 g/m^2), the biomass showed an upward trend for 5 years and reached 9.5 g/m^2 in 2014. In this year's survey the biomass index for plankton declined, and if it is related to the colder temperature this spring, predation pressure or by other means is unknown. Similar results were obtained from this year's hydrographic spring survey around Iceland where biomass of zooplankton was below average all around Iceland, except in the south were it was around average (http://www.hafro.is/undir.php?ID=19&nanar=1REF=3&fID=20733).

The reason for this fluctuation in the zooplankton biomass is not obvious to us. The unusually high biomass of pelagic fish feeding on zooplankton has been suggested to be one of the main causes for the reduction in zooplankton biomass. However, carnivorous zooplankton and not pelagic fish are the main predators of zooplankton in the Norwegian Sea (Skjoldal *et al.*, 2004), and we do not have good data on the development of the carnivorous zoo-plankton stocks. A fairly strong positive relationship between NAO and zooplankton biomass was observed, particularly during the late 1990s. However, this relationship seems to be less pronounced now, and the biomass index decline now despite a positive NAO the last two winters. The linkage between sea temperature and zooplankton abundance is also not fully understood and needs further explorations.

The zooplankton biomass in Barents Sea (east of 20°E) was lower (0.80 g m^{-2}) than in 2014, 2013 and 2012 (1.6, 1.5 and 1.7 g dry weight m^{-2}, respectively). However, as stated above, the biomass estimates for the Barents Sea taken with the Djedi net are not directly comparable to the other areas taken by WP2 nets, but are comparable among years within the Barents Sea. Also, it must be noted that this year's survey in Barents Sea was two weeks later than normally.

Summing up, the reason for the observed changes in zooplankton biomass is not clear to us and more research to reveal this is recommended. Quantitative researches on carnivorous zooplankton stocks (such as krill and amphipods) across the whole survey area, is an important step in that direction and needs a further effort by all participating countries.

The estimations of average biomass of zooplankton, discussed above, have included the whole areas covered by the survey vessels each year. However, it has been noted that the research effort can vary by a lot in the continental slope area south and west off Iceland. For that reason, and to get biomass indices representative for Norwegian Sea it self, it is recommended to re-estimate the whole time series and limit the area to east of 14°W and west of 17°E. The data are not yet all in the NAPES database so this could not be done at the meeting where this report was prepared, but will hopefully be done in relation to work of WGINOR (ICES 2014).

Norwegian spring-spawning herring

The Norwegian spring-spawning herring is characterized by large dynamics with regard to migration pattern. This applies to wintering, spawning and feeding area. The following discussion will mainly concentrate on the distribution and situation in the feeding areas in May, but no attempt was done to draw up the likely feeding migration that is believed to be comparable to recent years.

The amount of herring measured in the 2015 survey was 6% higher than in 2014. The biomass estimates in the last seven years has fluctuated with apparent downward trend since 2009 (Figure 25). The uncertainty, or the CV, round the estimates is estimated to be less than 30% for each of the age groups 3-12 for the years 2009 – 2013 (Stenevik, *et.al*., 2015).

The approach of dividing the survey area into strata, which was used in 2014 for the first time, is considered as valid improvements in terms of securing equivalent coverage among years and allow for robust statistical analyses of uncertainty of the acoustic estimates in the future.

In the last years there have been concerns regarding age reading of herring, because the age distributions from the different participants have showed differences. This is also the case in 2015 (Figure 30). For example, there was an apparent difference in the age distribution in Stratum 4 between the Icelandic and the Norwegian vessel with respect to age groups 10-12 years, which might be a consequence of a "drift" of 2004 year class into the 2003 and 2005 year classes during the ageing. However, the differences may also reflect differing spatial distribution of age groups, and partly, they may reflect variable growth conditions for the stock, and consequently growth rate as seen on the fish scales and otoliths. In spring 2014 an otolith and scale exchange was conducted, initiated by PGCCDBS (Godiksen, 2014). The report stated that the agreement among readers was low (67%) and it was recommended to conduct a larger scale exchange where both scales and otoliths are sampled from the same fish. Thus, the survey group stretch the need for an age-reading workshop for the primary herring age-readers prior to the 2016 IESNS survey. Consequently, the parties involved in the survey will in the coming months collect pairs of otoliths and scales for using at the workshop.

At the IESNS 2014 post-cruise meeting, there were concerns with the acoustic estimates, because the registrations of Dana and G.O. Sars on neighbouring transects were significantly different. The group identified two possible reasons for the discrepancy: 1) Time-lag or 2) differences in scrutiny procedures. Therefore it was stated that there was an urgent need for a workshop to review scrutinizing procedures. There is a planned scrutinizing workshop for all surveys within WGIPS in Hamburg in September 2015, but the group agreed, that IESNS needed a scrutinizing workshop prior to this year's survey. Thus, participants from all four vessels covering the adult herring stock met in Reykjavík in March 2015. The conclusions from that meeting were that the differences in scrutinizing procedures among the participants were believed to be of minor importance for the total estimate of Norwegian Spring Spawning herring in IESNS 2014 (Anon. 2015). Additionally, it was recommended that in the future the participants bring the acoustic data to the post-cruise meeting and spend some hours in the beginning to go through potential problems regarding the scrutinizing.

In IESNS 2015 there were again discrepancies between neighbouring transects of Dana and G.O. Sars on the Norwegian shelf. During the first hours of the meeting these discrepancies were analysed and discussed and the conclusion was that scrutinizing procedures were not believed to be the cause of the differences; rather it was believed to be related to patchy distribution of the herring.

Blue whiting

The abundance estimate of blue whiting in the IESNS survey 2015 showed an increase from the last years. A positive sign in development of the stock size was first observed in the 2011 survey where blue whiting at age 1 and 2 were in higher numbers than the previous years. This year, the number of 1 year old blue whiting was high in both the standard area (Table 4) and the total area west of 20°E (Table 3), and the biomass was dominated by 1 year old.

General recommendations and comments

Recommendation	Adressed to
1. The survey group recommends again that an age reading workshop will be held as soon as possible, and prior to the 2016 survey. This is to follow up on issues identified following analyses of otoliths and scales exchanges in 2014. Pairs of otoliths and scales from herring will be collected in the coming months for this purpose.	ACOM, WGWIDE, WGBIOP
2. Establishment of quantitative researches on carnivorous zooplankton stocks (such as krill and amphipods) across the whole survey area are recommended. It would require use of standardized fishing gears, such as the krill trawl used by Norway in recent years and Iceland in 2014.	Participating countries, WGWIDE, WGIPS

Next years post-cruise meeting

Preliminary dates are 14-16 June, in Ijmuiden, Netherland.

Concluding remarks

- The temperatures at all depths in the vicinity of the Faroese and southeast of Iceland were considerable lower in 2015 compared to the long-term mean, reflecting the relative low temperatures in the Sub Polar Gyre that have propagated northeastward into the southern Norwegian Sea.
- The index of plankton biomass in the Norwegian Sea declined after an increase since 2010.
- The biomass estimate of NSSH in 2015 was 6 % higher compared to last year.
- NSSH was dominated by the 2009 year class followed by the 2004 year class in numbers.
- No strong year classes of NSSH were observed in the Barents Sea indicating poor recruitment since 2004.
- The number of blue whiting measured in the 2015 survey area was 75% higher than in 2014.
- Age 1 (2014 yc) blue whiting is dominating the acoustic estimate in the "Standard area" (53% of the biomass and 76% by numbers).

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Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in April-June 2015.

Vessel	Effective survey period	Effective acoustic cruise track (nm)	Trawl stations	Aged fish (HER)	Length fish (HER)	CTD stations	Plankton station
Dana	3/5-21/5	3320	30	419	1324	36	35
G.O.Sars	29/4–3/6	3887	68	595	1946	72	84
Fridtjof Nansen	02/6–27/6	3289	24	156	607	66	63
Magnus Heinason	30/4–14/5	1724	9	267	455	21	21
Árni Friðriksson	29/4–22/5	4021	29	766	2762	53	49
Total	29/4–27/6	16241	160	2203	7094	248	252

Table 2. Age and length-stratified abundance estimates of Norwegian spring-spawning herring in April-June 2015 for total area and abstracts of estimates for subareas I, II and III.

Length	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Number	Biomass	Weight
10	31															31	0.1	6
11	47															47	0.4	8
12	2918															2918	34.3	11.8
13	0	201														201	3.1	15.4
14		113														113	2	17.7
15		183														183	4.2	22.9
16		993														993	28.1	28.3
17		2782														2782	91.2	32.8
18		1545	0													1545	60.3	39
19		1700	241													1941	87.4	45
20		644	170													814	44.6	54.7
21		71	264													335	21.4	63.8
22		43	79													122	9.5	77.8
23		18	224													242	20.4	84.4
24		45	22	59												126	11.7	92.7
25		18	54	99												171	20.2	118.4
26		0	85	314												399	50.8	127.3
27		10	19	256	10											295	44.1	149
28			117	259	77	40	9	15								517	85.3	164.9
29			120	511	218	418	58	0	9							1334	246	184.4
30			0	691	369	611	332	74	0	0	37					2114	431.3	204
31			0	415	720	652	395	247	197	49	59					2734	601.2	219.9
32			0	155	202	642	38	9	59	38	38	20				1201	292.8	244
33			10	56	173	806	114	62	147	124	42	13	13	10		1570	412.7	263
34			0	0	100	493	175	284	630	502	554	79	51	9	9	2886	815.3	282.4
35			0	0	20	160	129	343	738	706	1367	260	110	51	20	3904	1163.7	298.1
36			0	15	0	20	35	178	442	465	998	356	267	131	41	2948	927	314.6
37								6	29	93	238	126	220	66	46	824	275.6	334.4
38								6	0	6	26	22	28	6	3	97	34.5	356.8
39										13	0	2	2	5	2	24	8.3	354.2
Number 10^6	2996	8366	1405	2830	1889	3842	1285	1224	2251	1996	3359	878	691	278	121	33411	5827.5	
Biomass 10^3 t	34.9	319	128.6	519.6	417.3	913.4	304.7	333	645.1	588.2	1007.9	270.5	218.7	87.8	38.6	5827.3		5827.5
Mean length cm	12.4	18.2	23.3	29.5	31.4	32.3	32.3	34.1	34.9	35.3	35.6	36.1	36.5	36.5	36.7			27.3
Mean weight g	11.6	38.1	91.5	183.7	220.8	237.8	237.3	272.1	286.6	294.8	299.9	308.3	316.9	315.3	318			174.4

Table 2. (cont'd)

Area I

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	2996	8129	957	265	9	7	1	1	0	0	0					12365
Biomass 10^3 t	34.7	299	60.2	28.9	1.4	1.2	0.2	0.2	0	0	0					425.7
Mean length cm	12.4	18	21.4	26.1	28.7	29.4	30.1	28.8	0	0	0					17.1
Mean weight g	11.6	36.8	62.8	109	167	180	194	168	0	0	0					34.4

Area II

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	245	401	2210	1681	2993	1080	841	1354	883	1603	350	312	104	39	14096
Biomass 10^3 t		20.7	60.4	418	366	690	250	222	383	258	479	106	96.9	32.5	11.9	3395

Area III

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	0	47	354	201	842	204	383	896	1113	1756	528	378	174	82	6876
Biomass 10^3 t	0	0	8	72.2	49.6	222	54.1	111	262	330	528	165	122	55.2	26.8	2006.3

Area II and III

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
Number 10^6	0	245	448	2564	1882	3835	1284	1224	2250	1996	3359	878	690	278	121	21054
Biomass 10^3 t	0	20.7	68.4	491	416	912	305	333	645	588	1008	271	219	87.7	38.7	5401.5
Mean length cm		22.7	27.4	29.9	31.5	32.3	32.3	34.2	34.9	35.3	35.6	36.1	36.6	36.5	36.7	
Mean weight g		84.9	151	193	221	238	238	274	287	296	300	310	319	317	321	

Table 3. Age and length-stratified abundance estimates of blue whiting in April-June 2015, west of 20°E for total area and abstracts of estimates for subareas II and III.

Length	1	2	3	4	5	6	7	8	9	10	11	12+	Number 10^6	Biomass 10^3 t	Mean Weight
14	8	0	0	0	0	0	0	0	0	0	0		8	0.1	15
15	36	7	0	0	0	0	0	0	0	0	0		43	0.8	20
16	429	0	0	0	0	0	0	0	0	0	0		429	10.2	24
17	1621	11	0	0	0	0	0	0	0	0	0		1632	46.6	29
18	3359	35	0	0	0	0	0	0	0	0	0		3394	112.6	33
19	3158	39	0	0	0	0	0	0	0	0	0		3197	122.8	38
20	1432	57	0	0	8	0	0	0	0	0	0		1497	65.5	44
21	472	85	11	0	0	0	0	0	0	0	0		568	29.3	52
22	108	412	30	6	0	0	0	0	0	0	0		556	35.3	64
23	19	881	83	6	0	0	0	0	0	0	0		989	73.0	74
24	9	844	207	21	0	0	0	0	0	0	0		1081	90.1	83
25	0	460	135	15	17	0	0	0	0	0	0		627	59.3	95
26	0	167	211	56	8	0	0	0	0	0	0		442	47.8	108
27	0	23	152	93	23	0	0	0	0	0	0		291	36.7	127
28	0	6	110	109	47	10	0	0	0	0	0		282	39.7	141
29	0	7	32	86	36	7	4	0	2	0	0		174	26.5	152
30	0	1	13	19	23	24	3	0	0	1	0	1	85	14.6	167
31	0	2	12	22	15	24	0	12	2	3	5	2	99	18.4	187
32	0	0	0	15	2	24	0	1	1	6	2	1	52	10.9	209
33	0	0	0	2	19	4	5	11	7	2	1	6	57	13.3	237
34	0	0	0	1	13	6	13	9	5	6	3	5	61	15.6	251
35	0	0	0	0	1	0	6	3	4	2	11	10	37	9.7	273
36	0	0	1	0	0	1	7	1	1	1	1	0	13	3.8	274
37	0	0	0	0	0	0	1	2	0	0	1	8	12	3.7	295
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	274
39	0	0	0	0	0	0	0	0	2	0	0	0	2	0.5	273
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	340
Number 10^6	10651	3037	997	451	212	100	39	39	24	21	24	33	15628	887	
Biomass 10^3 t	386	238.4	105.7	61.1	33.3	18.8	9.7	9.1	5.9	5	5.8	8.4		887.2	
Length cm	19	23.9	26.1	28.2	29.3	31.4	34.1	33.6	34.1	33.4	34.3	36		21.1	
Weight g	36.2	78.5	106.1	135.3	156.8	189.1	244.5	229.9	239.1	218.3	239.8	280		56.8	

Area 2

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	9666	2000	587	313	115	43	13	17	10	17	16	8	12805
Biomass 10^3 t	341.2	152.3	61.5	40.5	15.7	7.4	2.7	3.9	2	3.8	3.7	1.9	637
Length cm	18.9	23.7	26.1	28	28.3	31.2	34.1	34.4	32.7	33.2	33.8	33.6	20.4
Weight g	35.3	76.2	104.7	130.2	135.7	175.3	222	228.7	200.6	207.3	218.7	220	49.7

Area 3

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	987	1038	408	139	95	58	28	22	16	5	7	25	2828
Biomass 10^3 t	44.8	86.1	44.2	20.6	17.5	11.4	7	5.2	3.9	1.2	2.1	6.5	250.5
Length cm	20.4	24.3	26.1	28.5	30.5	31.5	34.1	33	35	34.5	35.5	35.8	24.1
Weight g	45.5	83	108.1	146.7	182.4	199.4	254.4	230.8	265.3	261.2	289.9	290	88.7

Area 2 and 3 (Norwegian Sea)

Age	1	2	3	4	5	6	7	8	9	10	11	12+	Total
Number 10^6	10651	3037	997	451	212	100	39	39	24	21	24	33	15628
Biomass 10^3 t	386	238.4	105.7	61.1	33.3	18.8	9.7	9.1	5.9	5	5.8	8.4	887.2
Length cm	19	23.9	26.1	28.2	29.3	31.4	34.1	33.6	34.1	33.4	34.3	36	21.1
Weight g	36.2	78.5	106.1	135.3	156.8	189.1	244.5	229.9	239.1	218.3	239.8	280	56.8

Table 4. Blue whiting in "Standard Area" 8°W - 20°E and north of 63°N in IESNS 2015.

Length	1	2	3	4	5	6	7	8	9	10	11	12+	Number	Biomass	Weight
10													0		
11													0		
12													0		
13													0		
14	4	0	0	0	0	0	0	0	0	0	0	0	4	0.1	14.5
15	29	0	0	0	0	0	0	0	0	0	0	0	29	0.6	20.8
16	385	0	0	0	0	0	0	0	0	0	0	0	385	9.1	23.6
17	1458	12	0	0	0	0	0	0	0	0	0	0	1470	41.9	28.5
18	2933	37	0	0	0	0	0	0	0	0	0	0	2970	98.5	33.2
19	2607	30	0	0	0	0	0	0	0	0	0	0	2637	101.1	38.3
20	1026	24	0	0	0	0	0	0	0	0	0	0	1050	45.6	43.4
21	235	44	6	0	0	0	0	0	0	0	0	0	285	14.7	51.5
22	42	271	18	6	0	0	0	0	0	0	0	0	337	21.6	64.1
23	0	475	23	6	0	0	0	0	0	0	0	0	504	37.4	74.1
24	9	426	86	18	0	0	0	0	0	0	0	0	539	44.8	83.1
25	0	247	70	8	16	0	0	0	0	0	0	0	341	32.5	94.8
26	0	80	122	42	8	0	0	0	0	0	0	0	252	27.4	108.6
27	0	15	98	59	15	0	0	0	0	0	0	0	187	23.6	126.5
28	0	0	51	73	27	4	0	0	0	0	0	0	155	21.6	139.1
29	0	7	24	56	20	7	2	0	2	0	0	0	118	17.6	150.7
30	0	1	13	19	12	15	3	0	0	1	0	1	65	10.9	165.5
31	0	2	3	14	9	7	0	5	2	3	5	2	52	9.6	183
32	0	0	0	6	3	6	0	1	1	6	3	1	27	5.8	204
33	0	0	0	2	5	4	2	3	3	3	1	2	25	5.2	225.4
34	0	0	0	1	4	2	5	5	1	3	4	1	26	6.1	238.8
35	0	0	0	0	1	0	3	3	1	2	4	4	18	4.6	259.3
36	0	0	1	0	0	1	2	1	1	1	1	0	8	2.4	263.6
37	0	0	0	0	0	0	1	3	0	0	1	2	7	2	290.6
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	274
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	394.1
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	340
41													0		
42													0		
43													0		
Number 10^6	8728	1671	515	310	120	46	18	21	11	19	19	13	11491	585	
Biomass 10^3 t	308.6	129.6	56.4	41.5	17.5	8.4	3.9	4.9	2.4	4.4	4.3	3	584.9		584.9
Length cm	18.9	23.8	26.4	28.1	29	31.2	33.6	34.2	33	33.2	33.9	35			20.5
Weight g	35.4	77.5	109.2	133.3	147.3	179.9	222.4	232.7	211.6	215.3	228.2	229.5			50.9

Figures

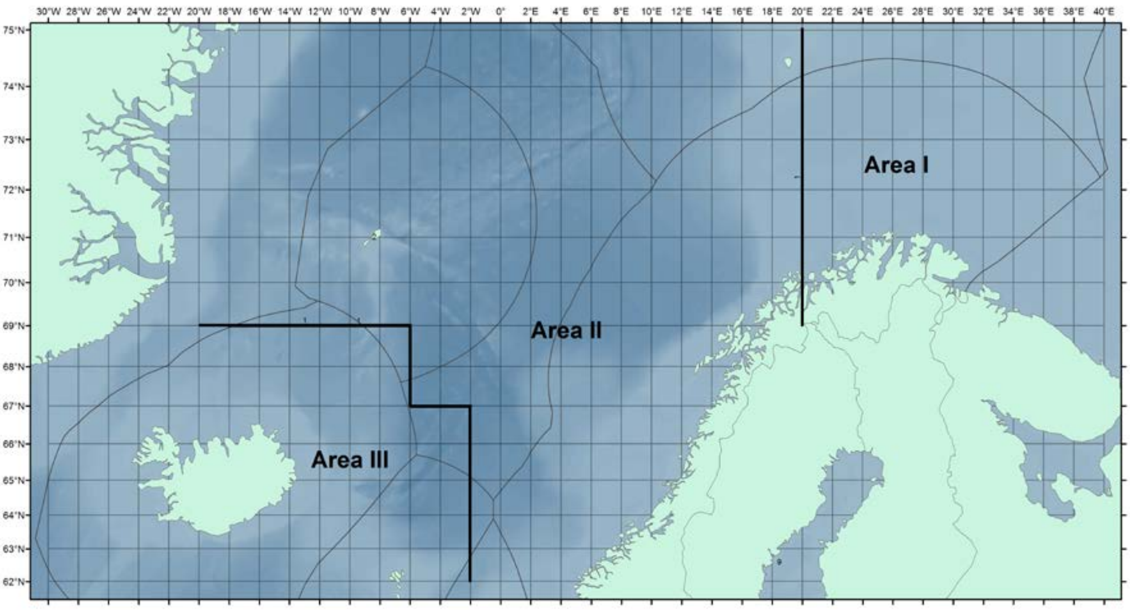

Figure 1. Areas defined for acoustic estimation of blue whiting and Norwegian spring-spawning herring in the Nordic Seas.

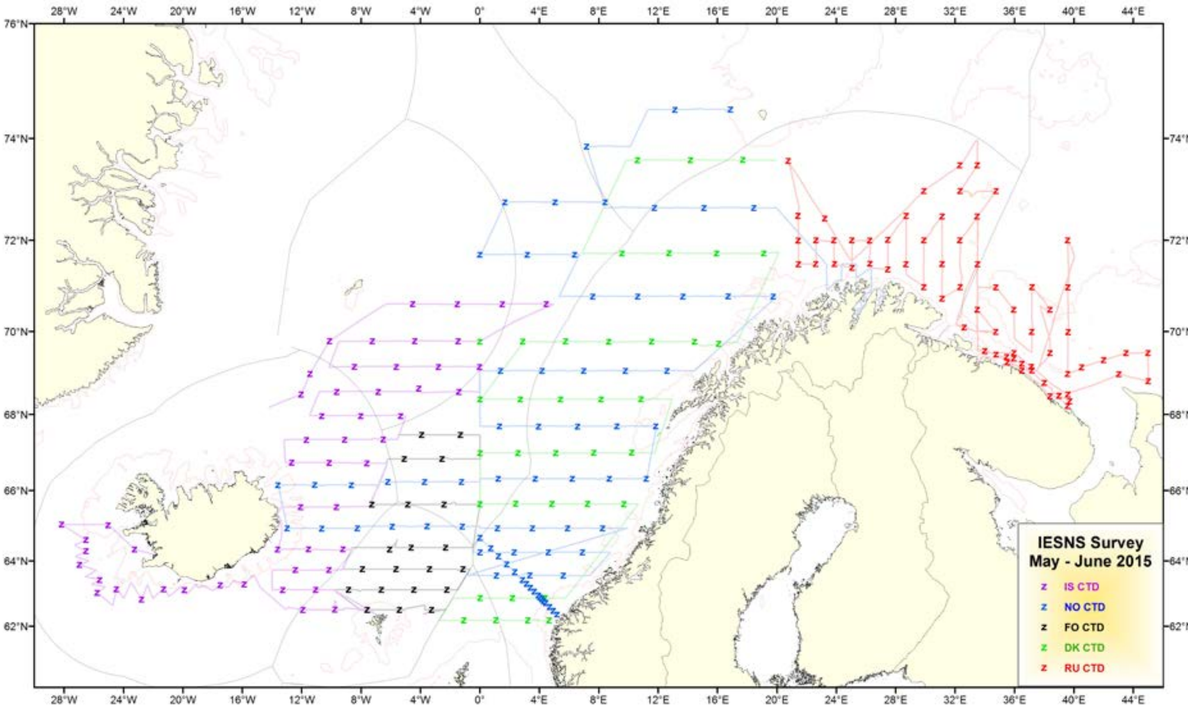

Figure 2. Cruise track and CTD stations by country for the International ecosystem survey in the Nordic Seas in April-June 2015.

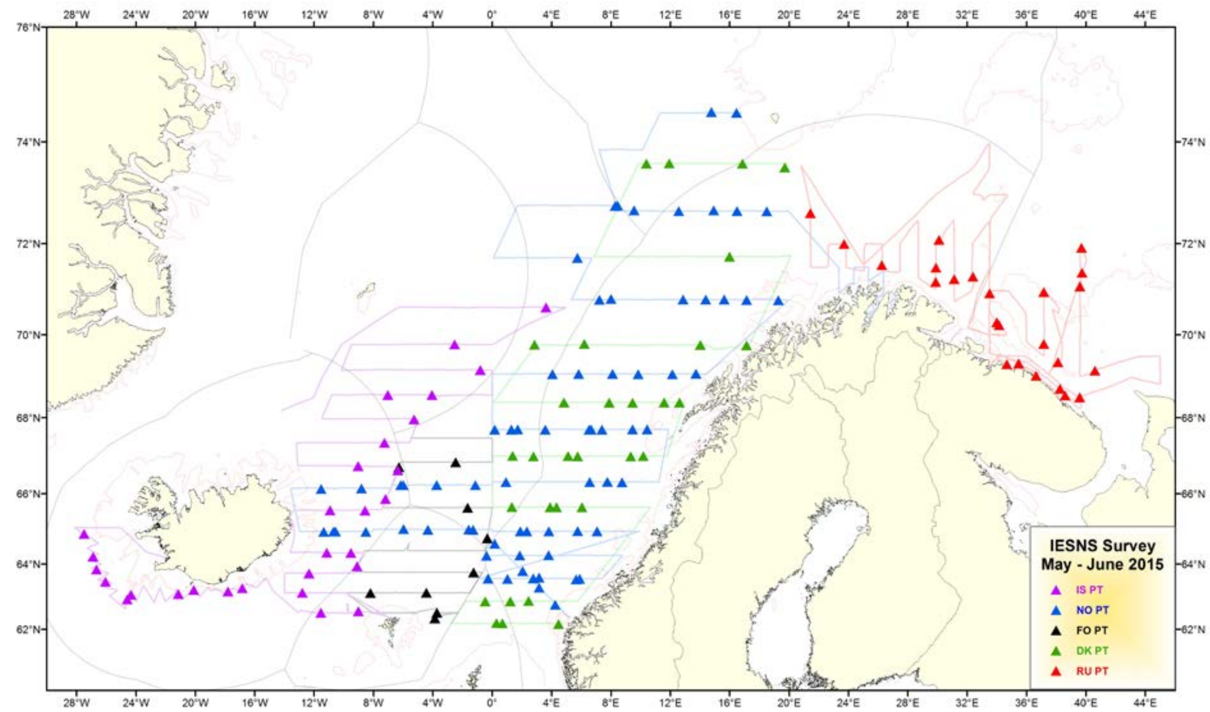

Figure 3. Cruise tracks during the International North East Atlantic Ecosystem Survey in April-May 2015 and location of trawl stations.

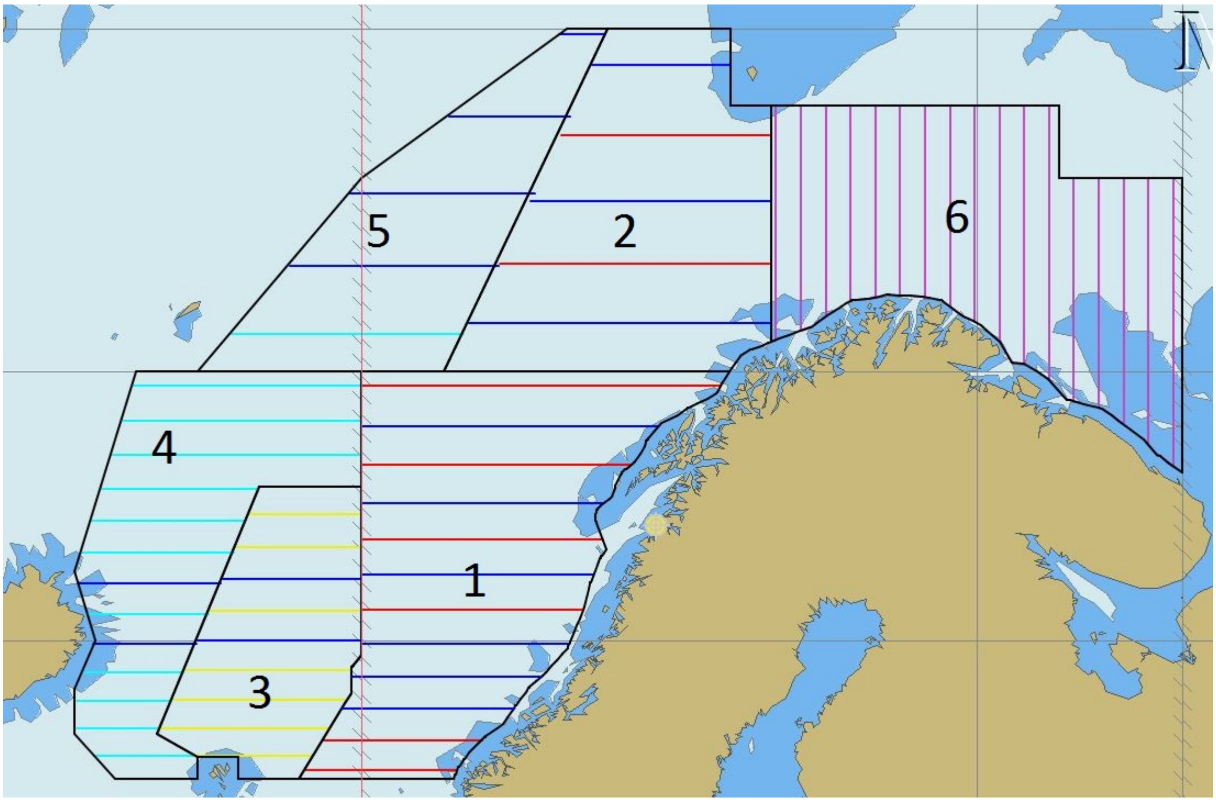

Figure 4. The strata and transects used in the IESNS survey 2015.

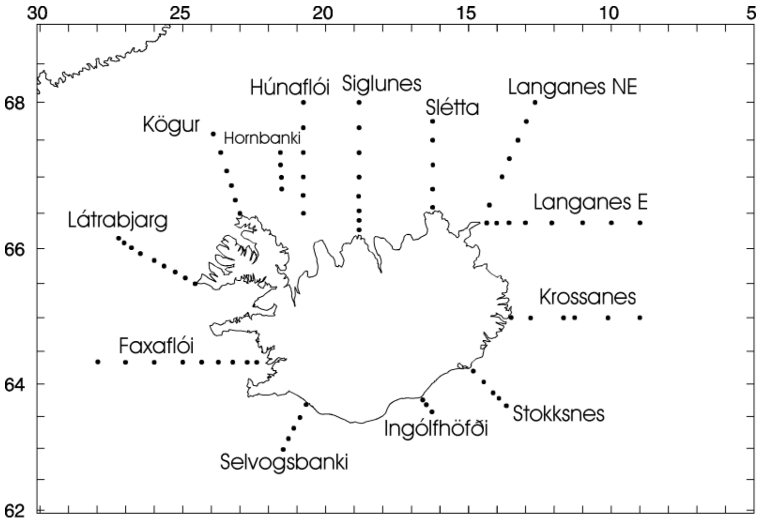

Figure 5. Location of the fixed Icelandic hydrographic sections referred to in the text and Figures 16-18.

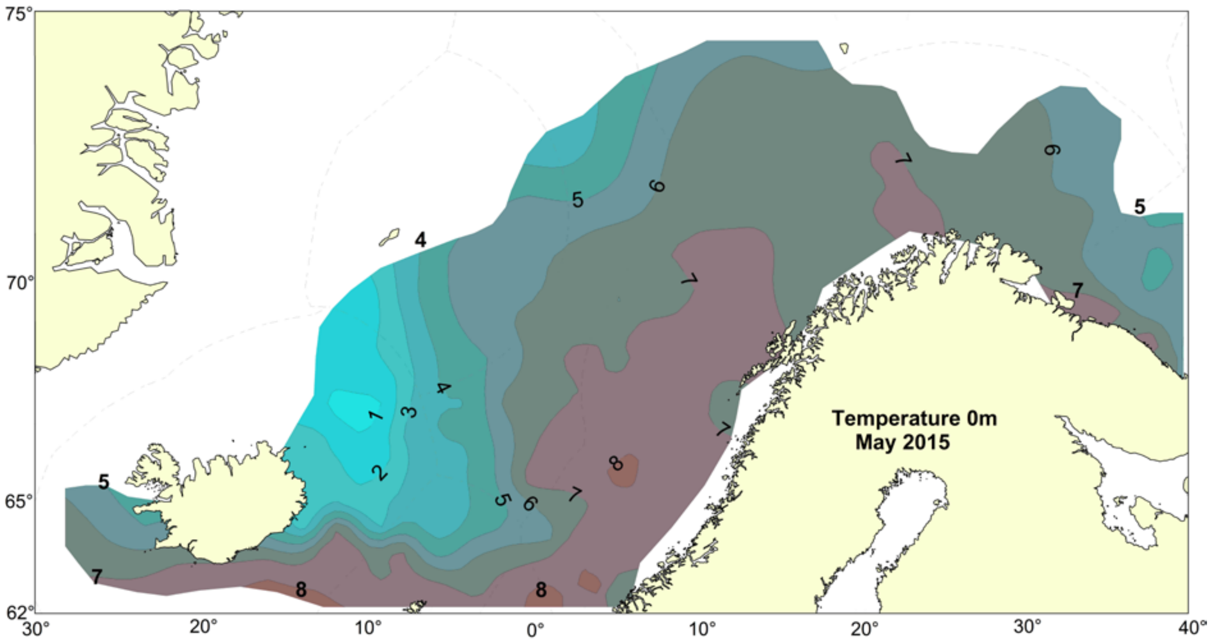

Figure 6. The horizontal sea surface temperature distribution in April-June 2015.

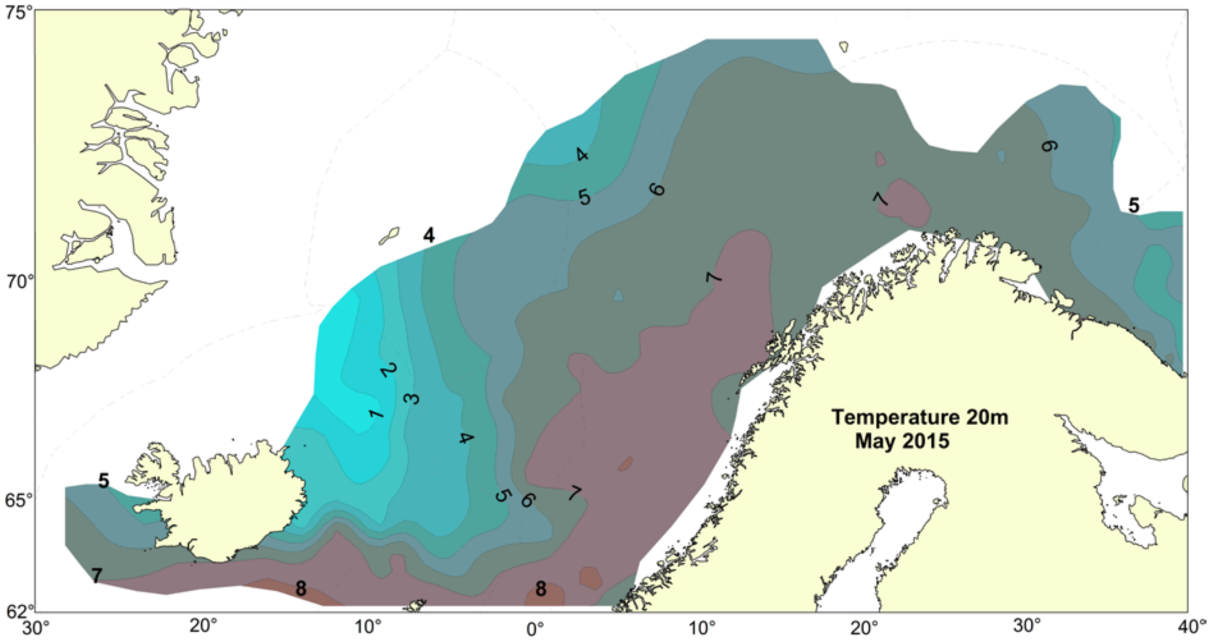

Figure 7. The horizontal distribution of temperatures at 20 m depth in April-June 2015.

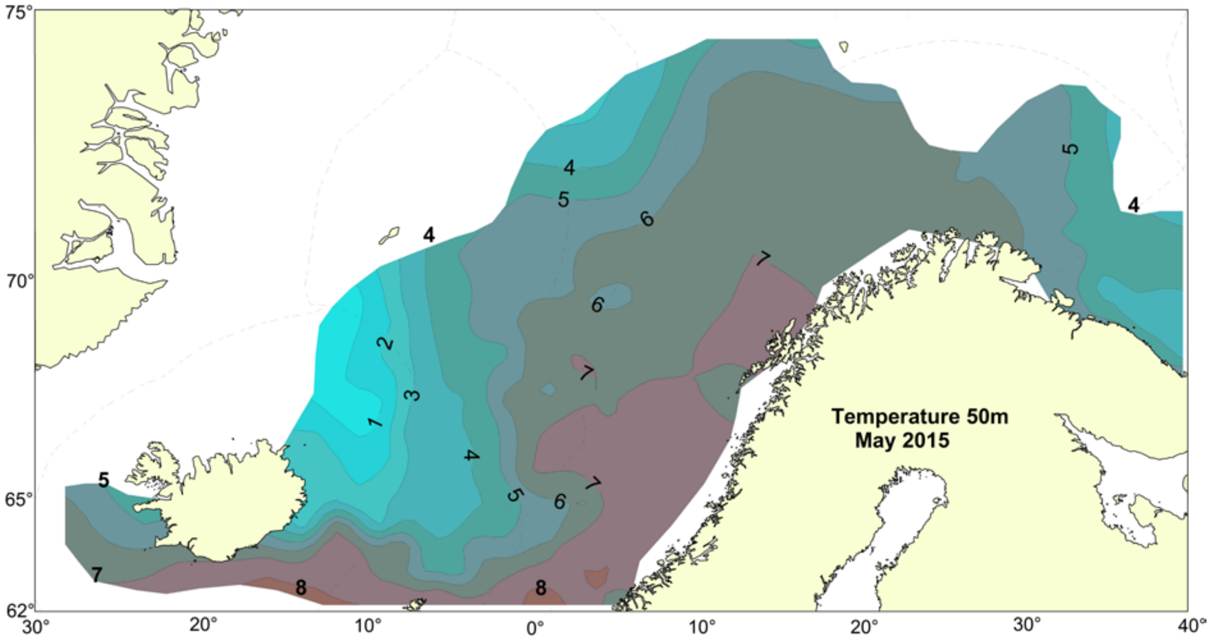

Figure 8. The horizontal distribution of temperatures at 50 m depth in April-June 2015.

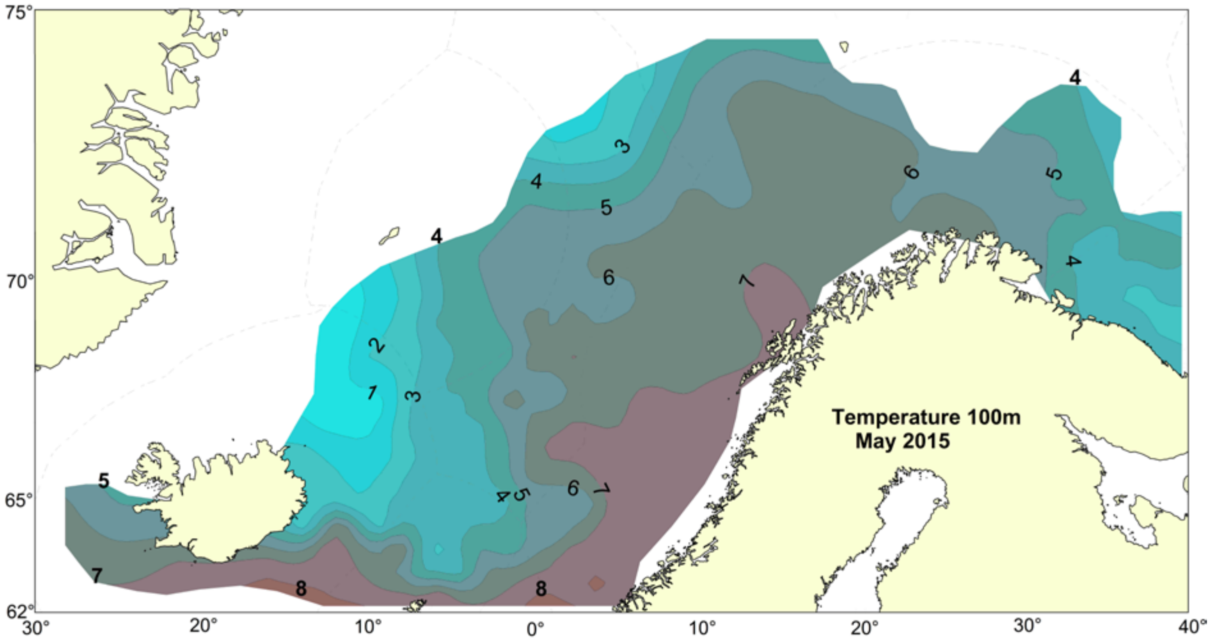

Figure 9. The horizontal distribution of temperatures at 100 m depth in April-June 2015.

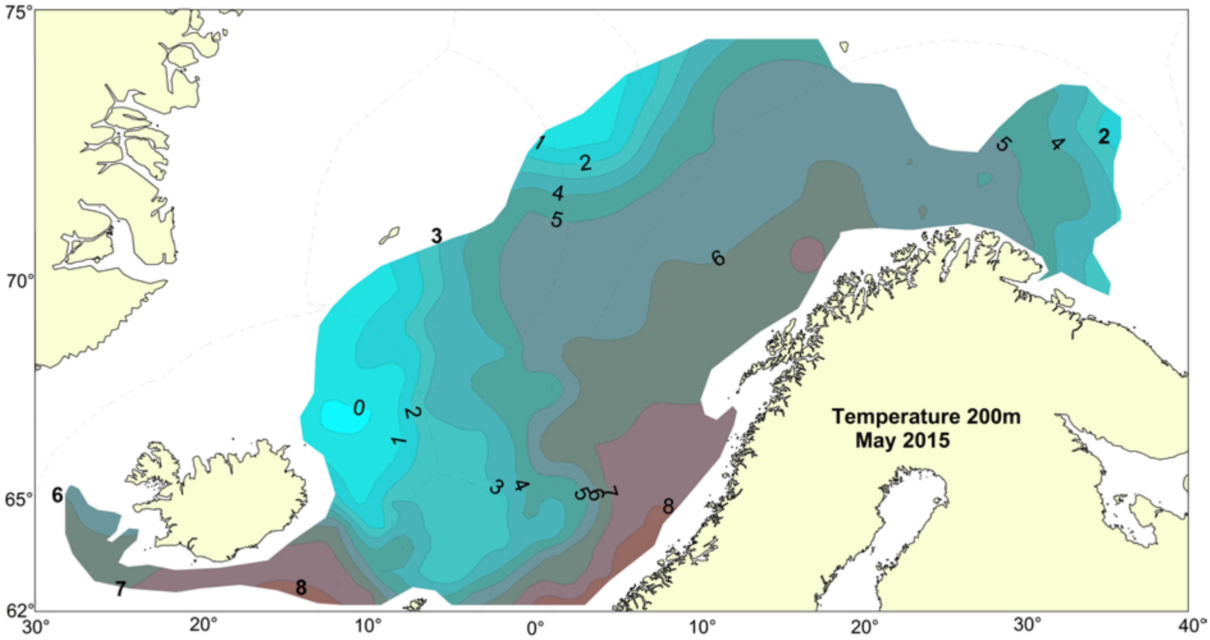

Figure 10. The horizontal distribution of temperatures at 200 m depth in April-June 2015.

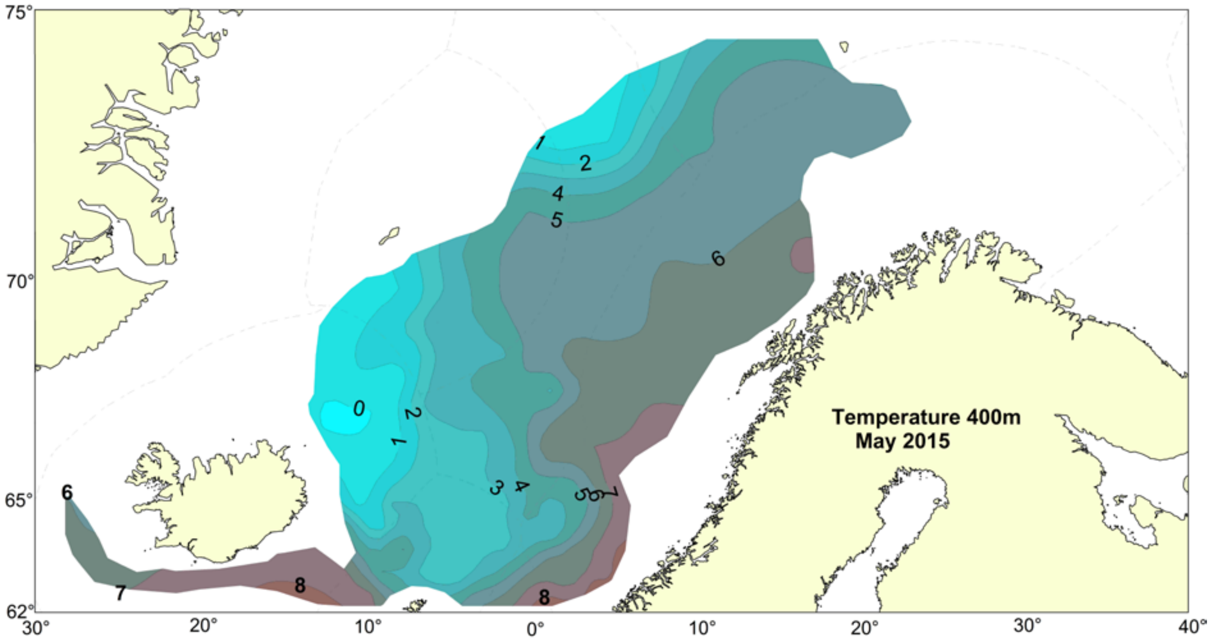

Figure 11. The horizontal distribution of temperatures at 400 m depth in April-June 2015.

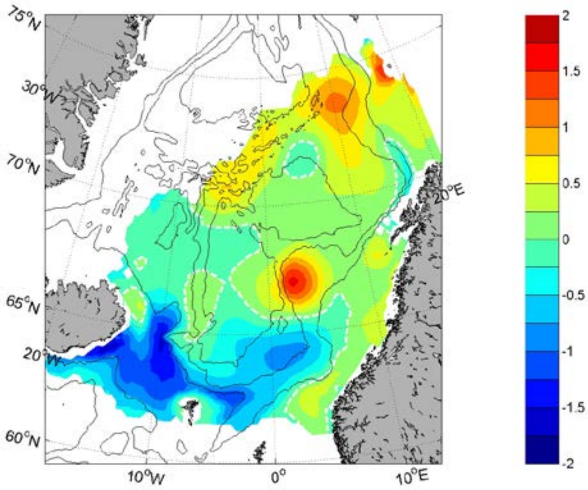

Figure 12. Temperature anomaly at 20 m depth for May 2015. Reference period: 1995-2015.

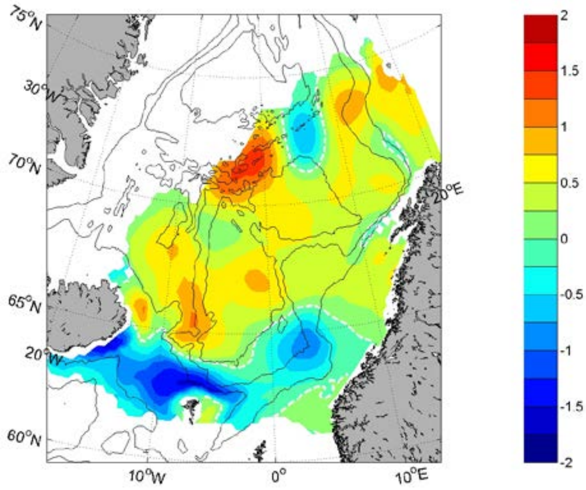

Figure 13. Temperature anomaly at 100 m depth in May 2015. Reference period: 1995-2015.

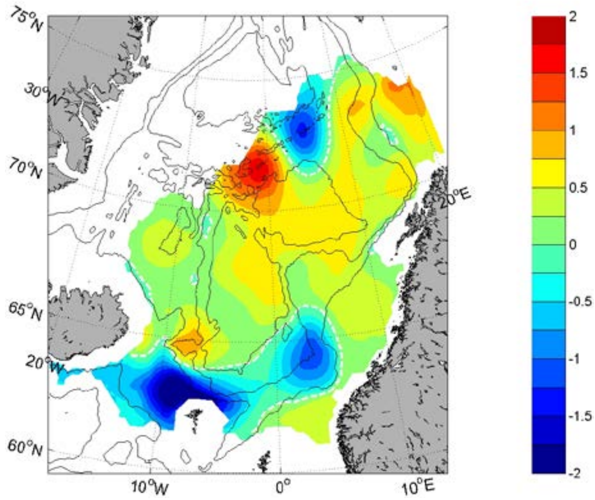

Figure 14. Temperature anomaly at 200 m depth in May 2015. Reference period: 1995-2015.

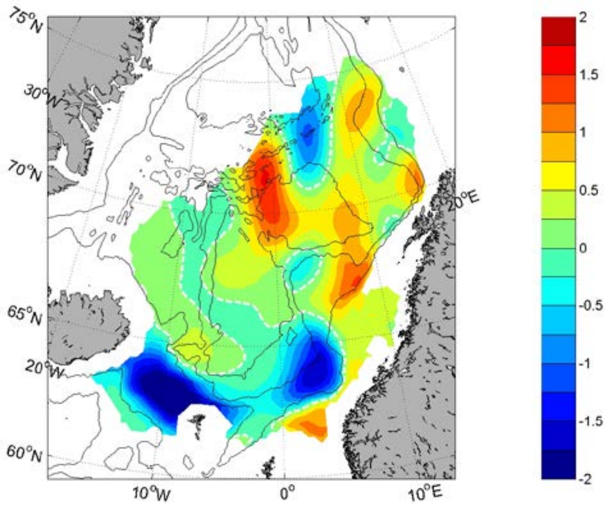

Figure 15. Temperature anomaly at 400 m depth in May 2015. Reference period: 1995-2015.

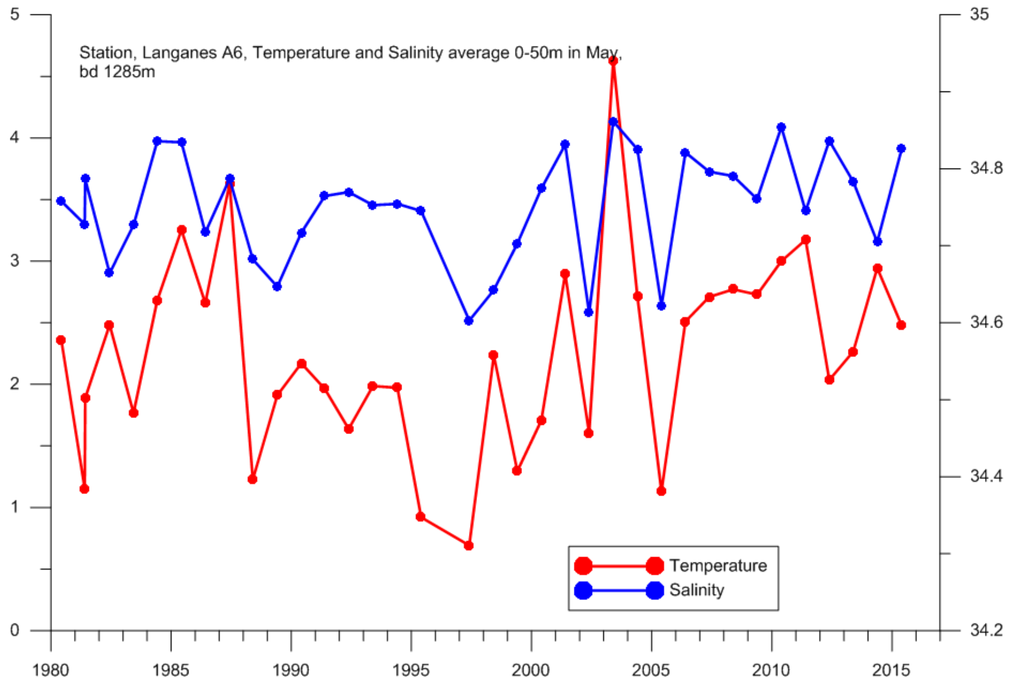

Figure 16. Temperature and salinity in May 2015 east of Iceland, at station Langanes A6 (66°22'N, 11°00'W). Depth averaged 0-50m.

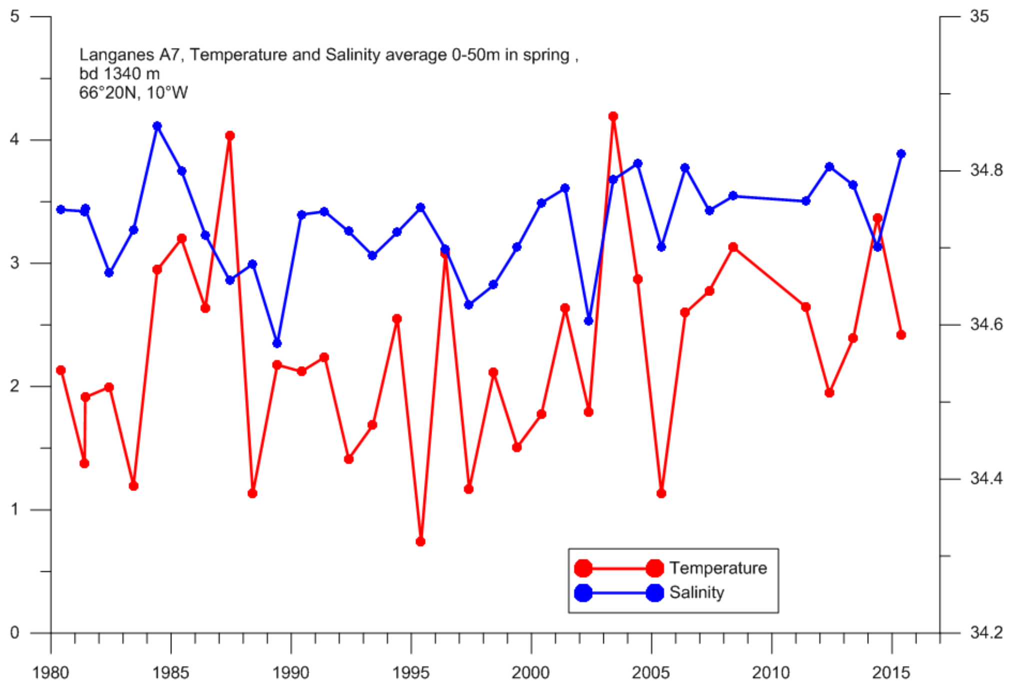

Figure 17. Temperature and salinity in May 2015 east of Iceland, at station Langanes A7 (66°22'N, 10°00'W). Depth average 0-50m.

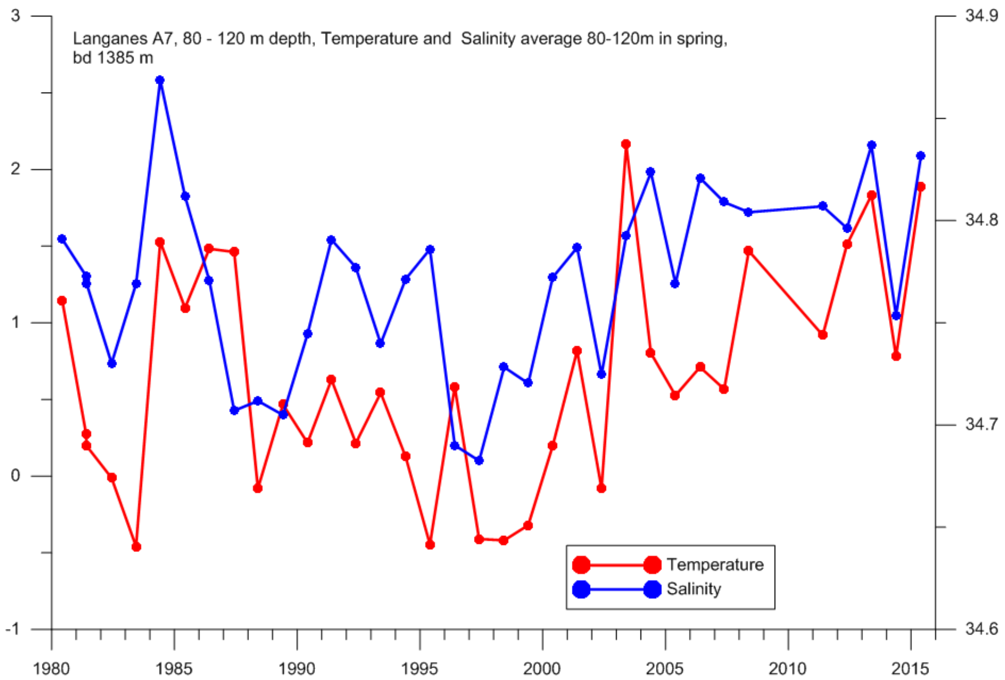

Figure 18. Temperature and salinity in May 2015 east of Iceland at station Langanes A7 (66°22′N, 10°00′W). Depth average 80-120m.

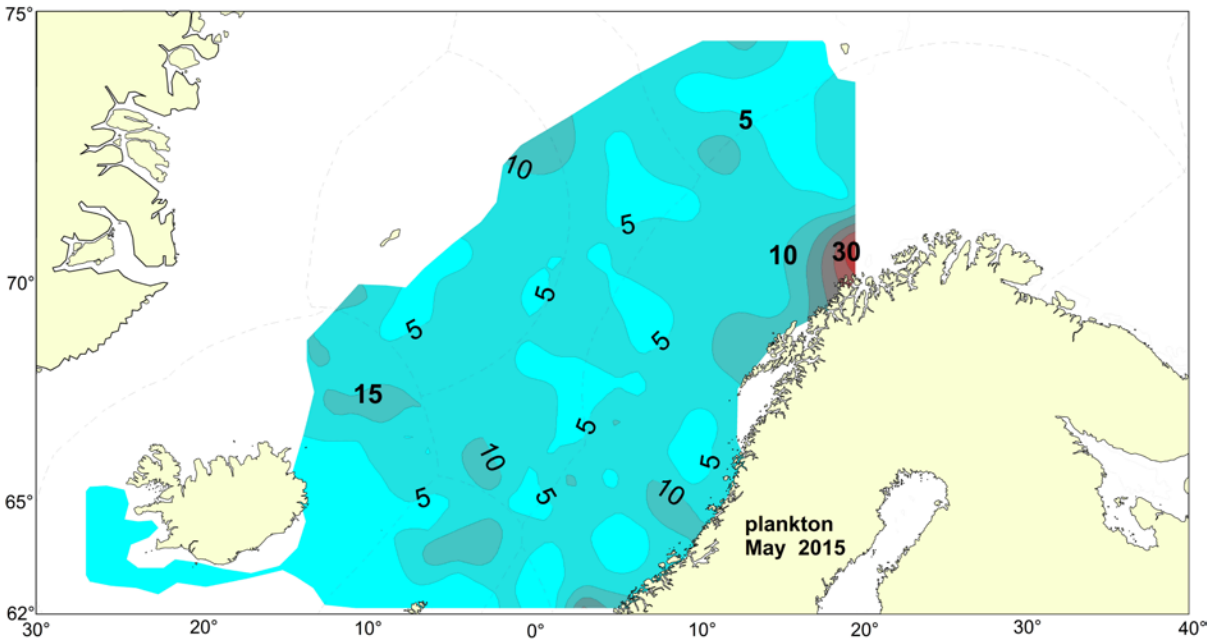

Figure 19. Zooplankton biomass (g dw m-2; 200–0 m in April-June 2015.

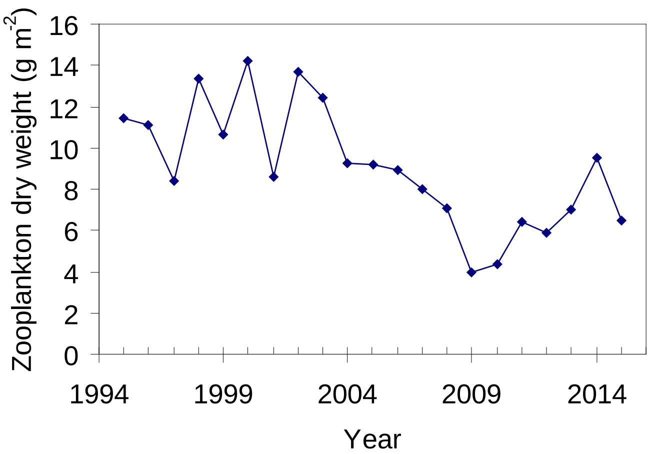

Figure 20. The annual mean dry weight of zooplankton across the whole coverage area in the May surveys in the Norwegian Sea and adjacent waters from 1997 to 2015.

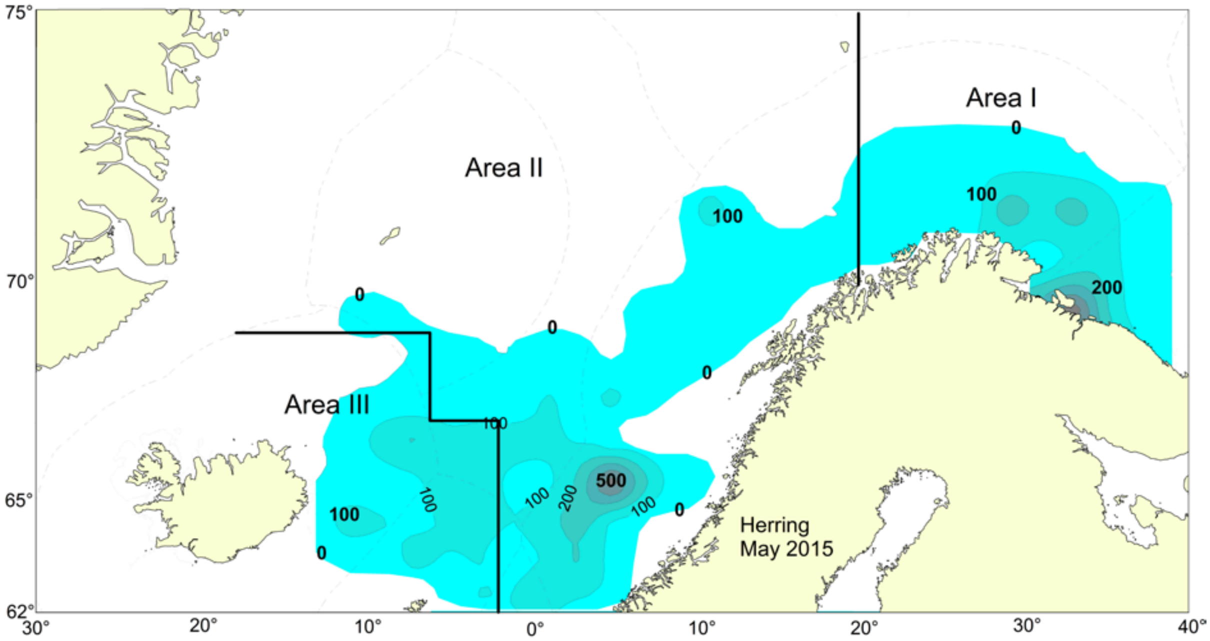

Figure 21. Distribution of Norwegian spring-spawning herring as measured during the International survey in April-June 2015 in terms of s_A-values (m^2/nm^2) based on combined 5 nm values.

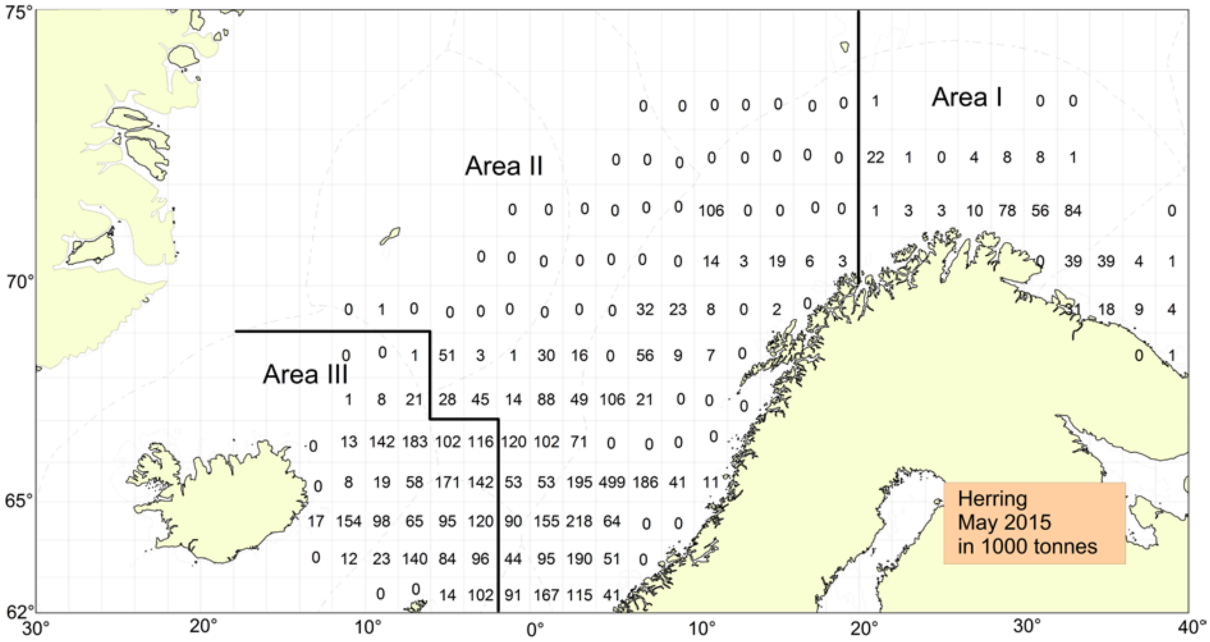

Figure 22. Norwegian spring-spawning herring biomass from IESNS 2015 by sub-area.

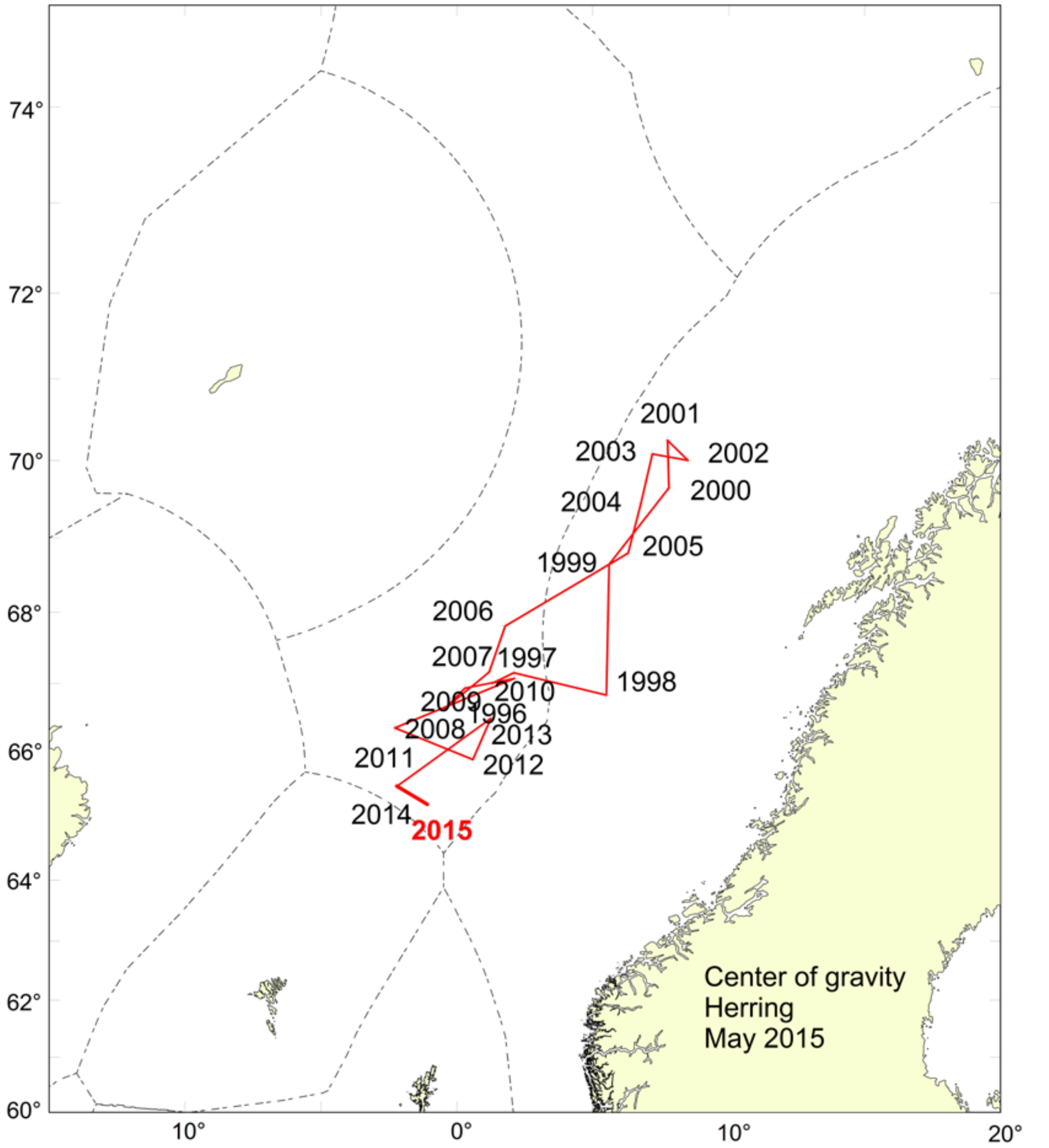

Figure 23. Centre of gravity of herring during the period 1996-2015 derived from acoustic. Acoustic data from area II and III only, i.e. west of 20° E

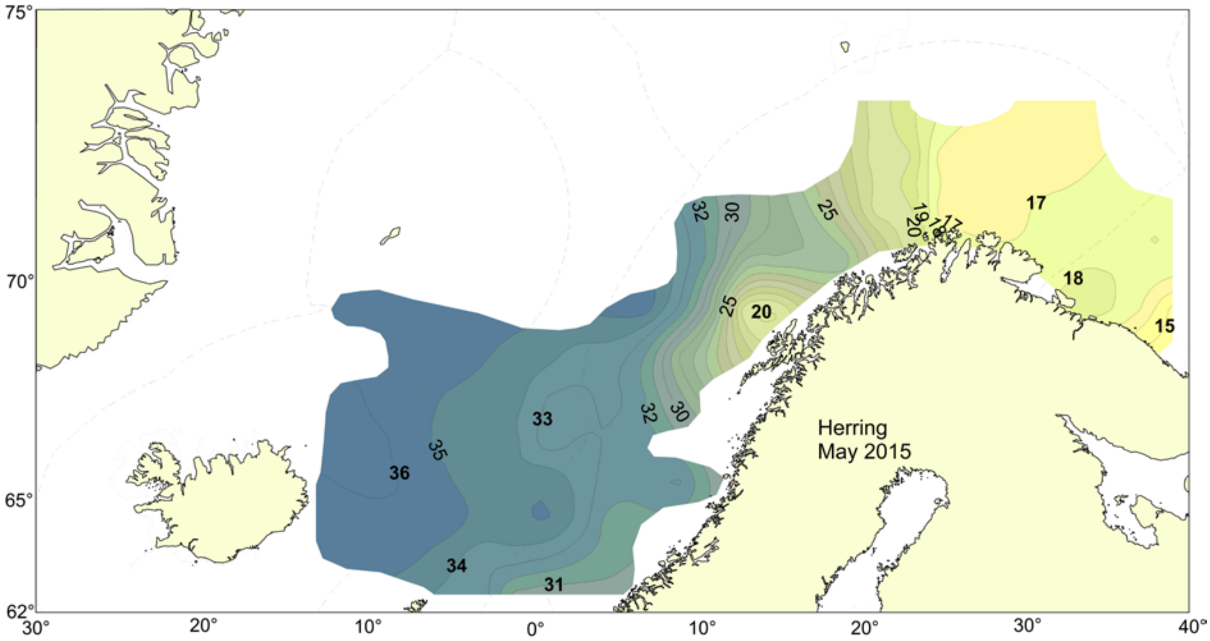

Figure 24. Mean length of Norwegian spring-spawning herring as measured during the International survey in April-June 2015.

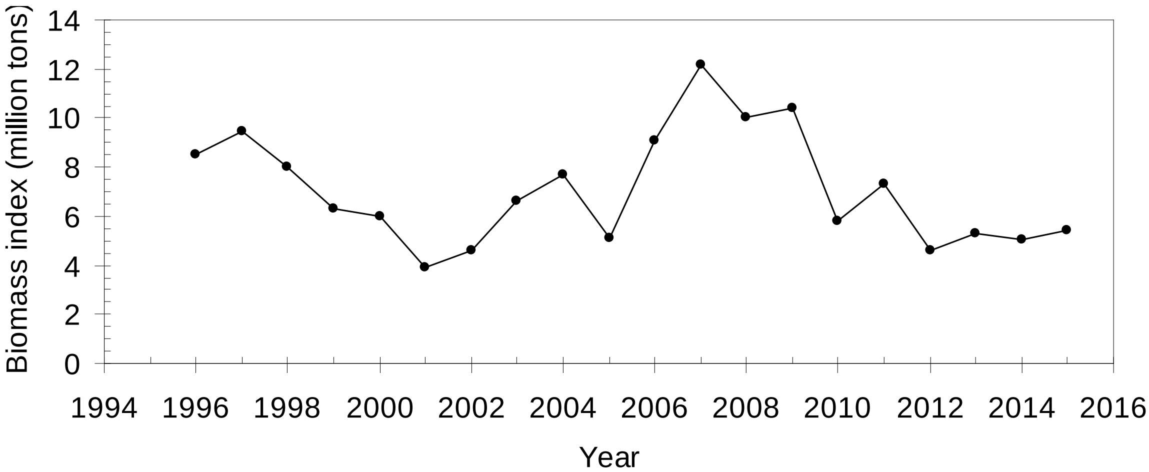

Figure 25. The annual biomass index of Norwegian-spring spawning herring in the May surveys in the Norwegian Sea and adjacent waters from 1996 to 2015.

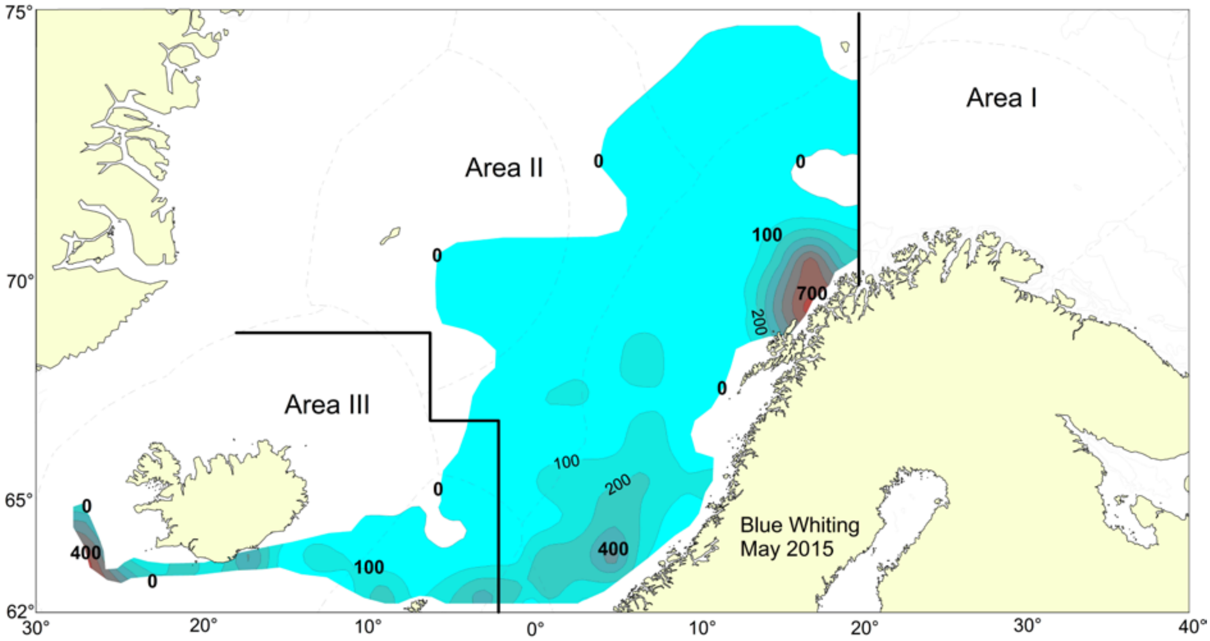

Figure 26. Distribution of blue whiting as measured during the International survey in April-June 2015 in terms of s_A-values (m^2/nm^2) based on combined 5 nm values. The standard area is shown on the map.

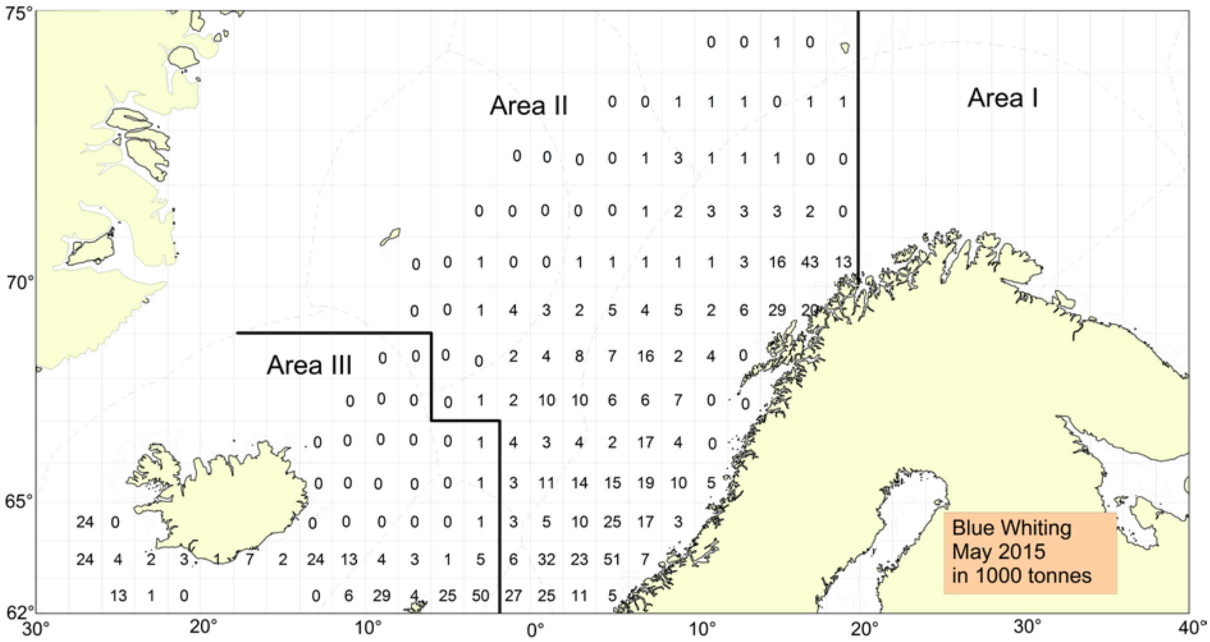

Figure 27. Blue whiting biomass from IESNS 2015 by sub-area.

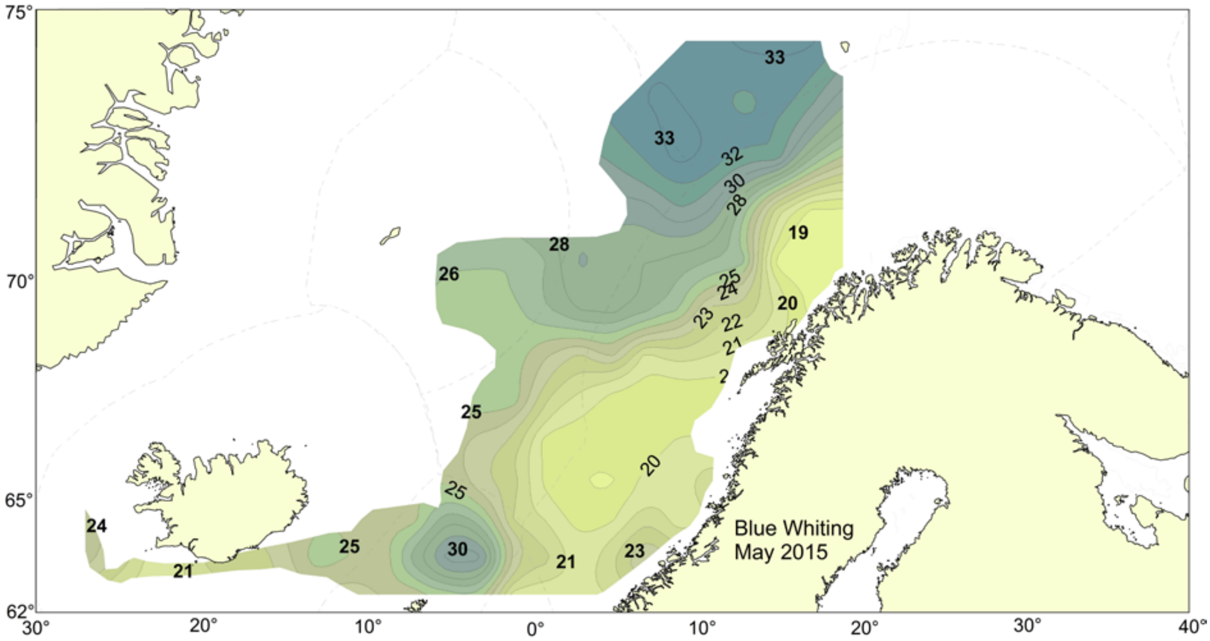

Figure 28. Mean length (cm) of blue whiting recorded in the North-east Atlantic Ecosystem Survey in April–June 2015.

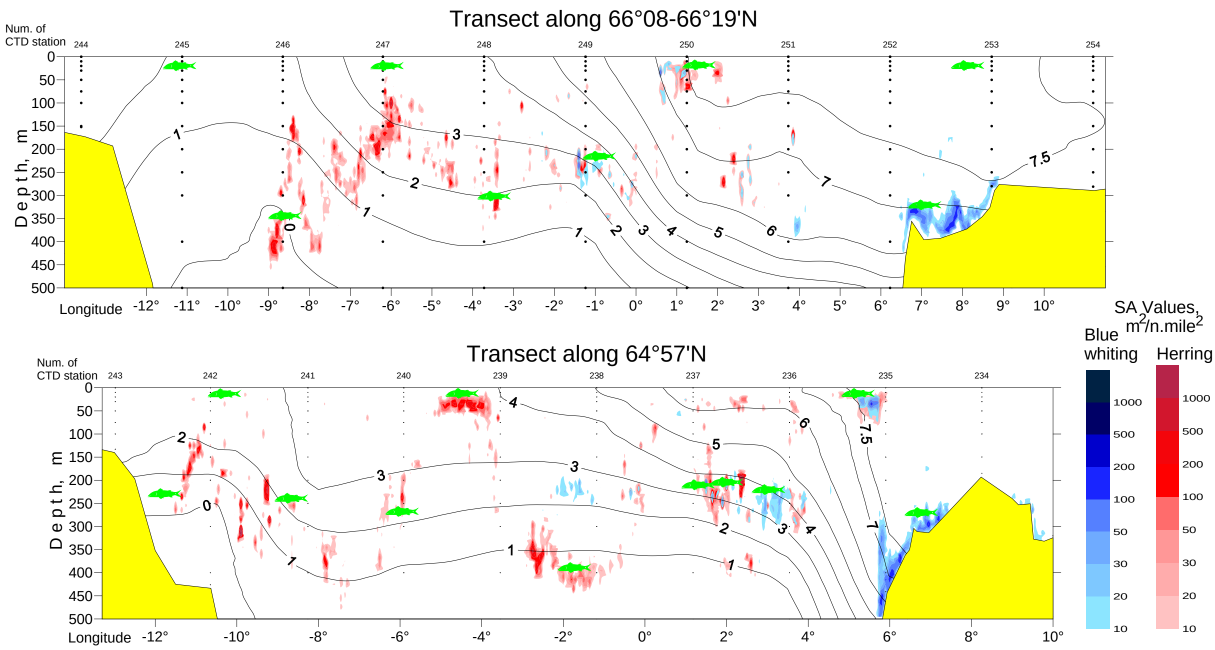

Figure 29. Acoustic values of blue whiting (blue) and NSS-herring (red), location of trawl stations (green fish), and temperature profile (lines) along two transects across the whole Norwegian Sea in May 2015 taken by G.O Sars (Figures produced by Evgeny Sentyabov, PINRO).

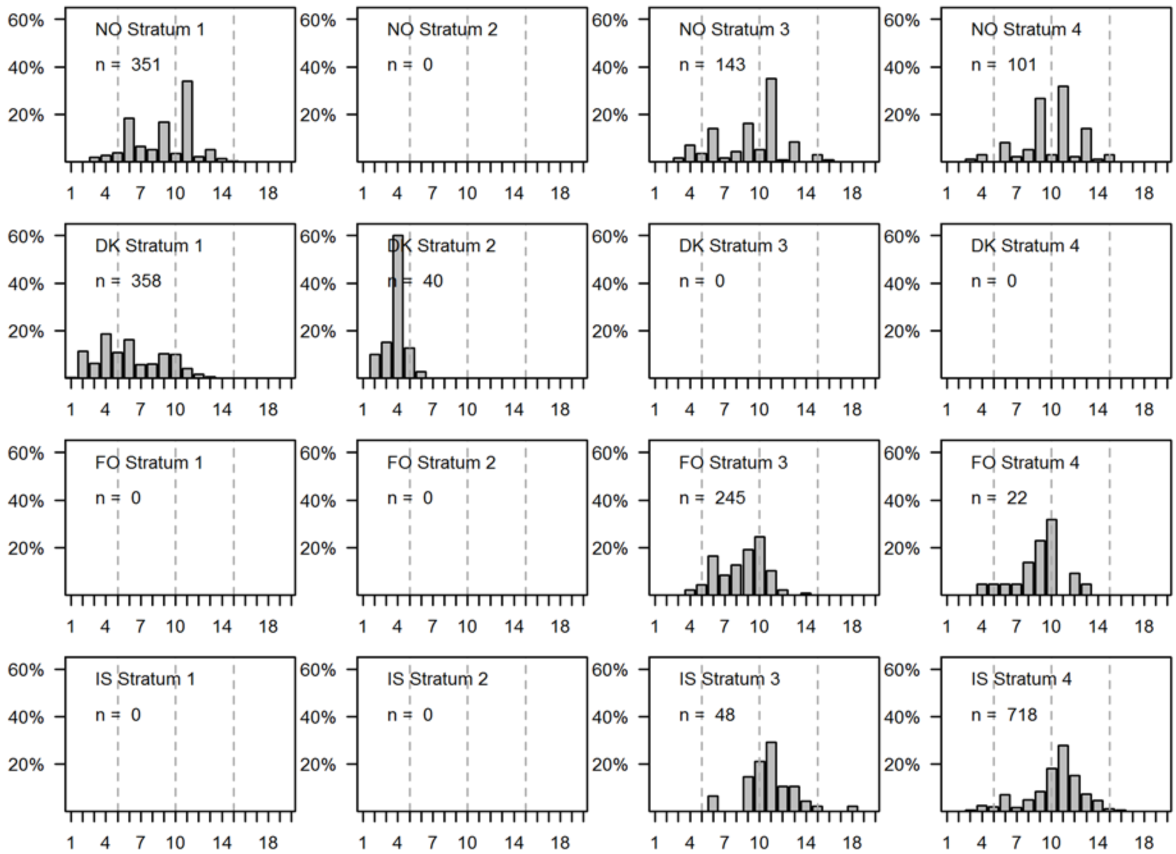

Figure 30. Comparison of the age distributions of NSS-herring by stratum and vessel in IESNS 2015.

Annex 4c: The 2015 ICES Coordinated Acoustic Survey in the Skagerrak and Kattegat, the North Sea, West of Scotland and the Malin Shelf area

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Six surveys were carried out during late June and July covering most of the continental shelf in the North Sea, West of Scotland and the Malin Shelf. The surveys are presented here as a summary in the report of the ICES Working Group for International Pelagic Surveys (WGIPS) and component survey reports are available individually on request. The global estimates of herring and sprat from these surveys are reported here. The global survey results provide spatial distributions of herring and sprat and total abundance by number and biomass at age as well as mean weight and fraction mature at age.

The estimate of North Sea autumn spawning herring spawning stock biomass is slightly lower than previous year at 2.3 million tonnes but is comprised of a similar number of fish (2015: 14 222 mill. fish, 2014: 14 392 mill. fish).

The 2015 estimate of Western Baltic spring-spawning herring SSB is 207 000 tonnes and 1 447 million herring. This is nearly a doubling of the 2014 estimates of 128 000 tonnes and 791 million fish and brings the stock back in line with abundances observed in the period prior to 2009.

The West of Scotland estimate (VIaN) of SSB is 387 000 tonnes and 1 935 million herring, a considerable increase over the 2014 estimate of 272 000 tonnes and 1 400 million fish.

The SSB estimate for the Malin Shelf area (divisions VIaN-S and VIIb,c) is 430 000 tonnes and 2 181 million herring. This is a significant increase on 2014 estimates of 285 000 tonnes and 1471 million fish.

The total abundance of North Sea sprat (Subarea IV) in 2015 was estimated at 58 745 million individuals and the biomass at 712 000 tonnes (Table 5.10). This is the fourth and second highest estimate observed in the time series, in terms of abundance and biomass, respectively. The stock is dominated by 1- and 2-year-old sprat.

In Division IIIa, the sprat abundance is estimated at 1 394 million individuals and the biomass at 18 515 tonnes. This is below average both in terms of abundance and biomass. The stock is dominated by 1-year-old sprat.

The Irish Sea survey program is reported separately in the WGIPS report (Annex 5b).

Introduction

Six surveys were carried out during late June and July covering most of the continental shelf north of 52°N in the North Sea and to the west of Scotland and Ireland to a northern limit of 62°N. The eastern edge of the survey area was bounded by the Norwegian, Danish, Swedish and German coastline and to the west by the shelf edge at around 200 m depth. Individual survey reports from participants are available on request from the nation responsible. The vessels, areas and dates of cruises are given in Table 5.1 and in Figure 5.1.

Table 5.1. Vessels, areas and cruise dates during the 2015 herring acoustic surveys.

Vessel	Period	Area	Rectangles
Celtic Explorer (IRL)	24 June – 14 July	53°30'-58°30'N ,12°-4°W	36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4, 46E2-E5, 47E3-E6, 48E4-E5, 49E5
Scotia (SCO)	25 June – 14 July	58°30'-62°N, 4°W-2°E	46E6-F1, 47E6-F1, 48E6-F1, 49E6-F1, 50E7-F1, 51E8-F1
Johan Hjort (NOR)	25 June – 15 July	56°30'-62°N, 2°-6°E	42F2-F5, 43F2-F5, 44F2-F5, 45F2-F5, 46F2-F4, 47F2-F4, 48F2-F4, 49F2-F4, 50F2-F4, 51F2-F4, 52F2-F4
Tridens (NED)	22 June – 17 July	54°25'– 58°24'N, 3° W–5°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F4, 41E7-F4, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	26 June – 16 July	52°-56.5°N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F2-F7, 37F2-F8, 38F2-F7, 39F2-F7, 40F6-F7, 41F5
Dana (DEN) OXBH	25 June – 8 July	Kattegat and North of 56°N, east of 6°E	41F6-F7, 41G1-G2, 42F6-F7, 42G0-G2, 43F6-G1, 44F6-G1, 45F8-G1, 46F9-G0

Methods

Survey design and acoustic data collection

The acoustic surveys were carried out using Simrad EK60 38 kHz echosounders with transducers mounted either on the hull, drop keel or in towed bodies. Echo integration and further data analyses were carried out using either LSSS (Large Scale Survey System), Myriax Echoview or Echoann software. The survey tracks were selected to cover the whole area with sampling intensities based on the herring densities of previous years. Transect spacing of 7.5, 15 and 30 nautical miles were used in various parts of the area according to perceived abundance and variance from previous years' surveys. The survey was designed to be analysed using rectangle based estimation with ICES rectangles as the analysis unit. Tracks were planned to ensure a minimum of one length of track in each ICES rectangle covered.

The following target strength to fish length relationships were used to analyse the data:

herring	TS = 20 log L - 71.2 dB
sprat	TS = 20 log L - 71.2 dB
gadoids	TS = 20 log L - 67.5 dB
mackerel	TS = 21.7 log L - 84.9 dB

Data analysis

Due to the cessation of support for the FishFrame database and analysis tool traditionally used by the group to combine acoustic and biological data from individual surveys into global estimates a move to using a new analysis tool had to be taken in 2015 (ICES 2015).

The 2015 disaggregated biological and acoustic data were delivered to an interim database held at the ICES data centre and the data was analysed using the newly developed analysis software StoX (Annex 9).

Acoustic and biological data were combined to provide an overall global estimate. Estimates of numbers-at-age, maturity stage and mean weights-at-age were calculated by individual survey strata (Figure 5.2). The data were combined to provide estimates of the North Sea autumn spawning herring, Western Baltic spring-spawning herring, West of Scotland (VIaN) herring and Malin Shelf herring stocks (VIaN-S and VIIb-c) as well as North Sea sprat and sprat in IIIa.

Stock definitions

North Sea Autumn Spawning herring

Includes all herring encountered in the North Sea between 4°W and 2°E and south of 56°N [56.5°N between 2-6°E] (strata 6 – 8 and 11 – 21 in Figure 5.2). East of 2°E and north of 56°N [56.5°N between 2-6°E], in strata 1 – 5 and 9 – 10, herring is split into North Sea autumn spawners and Western Baltic spring spawners (Figure 5.2). In strata 9 – 10 this is done based on analysis of number of vertebrae and in strata 1 – 5 this is done based on otolith shape analysis.

Western Baltic spring spawning herring:

The allocation to the Western Baltic spring spawning stock is partly a geographical assignment and partly a biological assignment based on the vertebrae and otolith shape analysis mention above. The stock splitting methodologies are only applied within strata 1 – 5 and 9 – 10 (Figure 5.3). Recently Germany has also conducted analysis of otoliths to deduct stock membership of herring in the southern area, and in 2015 two herring from 41F5 was allocated as WBSS. As this rectangle previously has not been included in the stock split this was ignored in the 2015 analysis to preserve continuity with the time series, but opens a discussion on the geographical limits of the application of the stock splitting analysis.

Malin Shelf Herring:

Includes all herring in the stock complex located in ICES areas VIa and VIIb. The survey area is bounded in the west and north by the 200m depth contour, in the south by the 53.5°N latitude, and in the east by the 4°W longitude (strata 22 – 27 in Figure 5.2). It surveys herring of VIaN and VIaS spawning origin in mixed feeding aggregations on the Malin Shelf. Work is in progress to split the abundance and biomass estimations by spawning origin (VIaN vs VIaS) but this has been as yet unsuccessful. The differentiation between VIa herring and North Sea herring across the 4°W line of longitude is purely geographically based. In 2015 one vessel covered the entire Malin Shelf area so no combining of data was required in StoX.

West of Scotland (VIaN) herring

This is simply a subset of the Malin Shelf herring abundance\biomass estimate based purely on geographical location (strata 22 – 24 in Figure 5.2). All herring recorded north of the 56°N line of latitude and east of the 7°W line of longitude are reported as West of Scotland (VIaN). The remainder of the estimated abundance\biomass is considered VIaS + VIIbc. As mentioned previously, work is underway to improve on this geographical split.

VIaS and VIIbc are not reported separately but can be calculated by subtracting the West of Scotland estimates from the Malin Shelf estimates.

North Sea sprat:

All sprat recorded in the North Sea geographical area (ICES area IV) are included in the North Sea sprat stock. Sprat is however very rarely recorded in the northern part in strata 9 – 10 and 14 – 21 (Figure 5.2). Strata 3 and 4 straddles the border between sprat in the North Sea and IIIa sprat and only the half of each of these strata contained within ICES area IV contributes to the sprat in the North Sea estimate.

Div. IIIa Sprat

Sprat in IIIa is also a geographically delimited stock. All sprat in strata 1 – 2 are include and any sprat in strata 3 – 4 recorded to the east of the border between ICES Subarea IV and ICES Div. IIIa are included.

Acoustic Survey Results for 2015

Herring

The NASC values attributed to herring in the HERAS surveys are shown in Figure 5.3.

The estimate of North Sea autumn spawning herring spawning stock biomass has decreased from 2.6 million tonnes in 2014 to 2.3 million tonnes this year (Table 5.6, Figure 5.11).

The abundance of mature fish of 14 222 million in 2015 is comparable to the 2014 estimate of 14 392 million (Table 5.2). The drop in SSB is caused by a significant decrease in the mean weight of the mature fish from 181.4 g in 2015 to 160.3 g this year. This is due to a combination of two factors. The mean weight is decreased for all ages apart from 1 winter ringers this year compared to last year. In addition the stock has seen a large increase in 2 winter ring fish and a small decrease in abundance of all older ages in effect shifting the abundance to a larger amount of smaller fish.

The abundance of immature fish in the stock has decreased dramatically this year from 46 947 million in 2014 to 10 285 in 2015. This drop is caused mainly by an almost complete absence of 0 winter ring fish. The 1 winter ring abundance is also reduced to approximately half of last year’s estimate bringing it back in line with the long term average. (Table 5.6, Figure 5.5).

Maturities were lower than last year with 70% of 2 winter ringers and 90% of 3 winter ringers mature. 100% maturity was only reported above age 7 (Table 5.2). The presence of immature fish above age 4 indicates a shift in reporting by the group. Previously all fish above age 4 has been assumed mature. This year however it was agreed that observed maturities would be reported and it would be left to the assessment working group to decide whether to assume 100% maturity above a certain age.

The 2008 and 2009 year classes (5 and 6-winter ringers this year) continues to be strong and are consistent with the high estimate of 1-wr fish in 2010 and 2011 (Table 5.6). The 2007 year class (7-winter rings this year) continues to grow very slow and mean weight continues to be below that of the following year class (Table 5.2).

The distribution of adult herring in the North Sea is still concentrated in the areas east and north of Scotland (Figure 5.3). Similarly to last year the distribution is stretching south in the western North Sea.

The 2015 estimate of Western Baltic spring-spawning herring SSB is 207 000 tonnes and 1 447 million herring (Table 5.3). In terms of biomass the spawning stock nearly doubled and increased by 79 000 tonnes. The amount of mature fish also was twice as high as the numbers measured in 2014 (791 million). The stock is dominated by 1 and 2 ring fishes. The abundance of 1 and 2 ringers increased by a factor of 4 and 3 respectively when compared to last year's estimate, and is in a comparable order of magnitude as it has been in the past (Table 5.7, Figure 5.6). The numbers of older herring (3+ group) in the stock has continued to be relatively low, but numbers have increased from the low values that had been observed for six years in a row before. When compared to 2014, the mean weight at age has increased considerably for herring aged 0 but decreased for all ages above (exception age 3 with similar weight at age between years).

The West of Scotland (VIaN) estimate of SSB is 387 000 tonnes (1 935 million herring) (Table 5.4), a 115 000 tonne increase over the 2014 estimate. In 2014 4 and 5 winter-ring fish dominated the age composition of the standing stock and these cohorts have been successfully tracked in 2015 with 5 and 6 winter-ring fish comprising 19% and 22% of the total abundance, respectively. However, the largest proportion of herring observed in 2015 were the 4 winter-ring fish, which accounted for 32% of the total abundance. No 1 winter-ring herring were recorded. Long-term indices of abundance per age class for West of Scotland herring are provided in Table 5.8 and Figure 5.7.

The SSB estimate for the Malin Shelf area (divisions VIa and VIIb,c) is 430 000 tonnes and 2 181 million herring (Table 5.5). This is a 145 000 tonnes increase on 2014, which was the second lowest SSB estimate in the time series (Figure 5.1). The estimate is also dominated by 4, 5, and 6 winter ringed fish. The overall maturity ratio was 0.96. The similarities between the West of Scotland and Malin Shelf indices reflect the fact that so few herring were observed in VIaS and VIIb,c. Age disaggregated survey abundance indices for Malin Shelf herring since 2008 are given in Table 5.9 and Figure 5.8.

The area covered during the individual acoustic surveys is given in Figure 5.1. The survey strata used for the analysis are shown in Figure 5.2, and magnitudes of acoustic herring and sprat detections (nautical area scattering coefficients) for 15 nmi intervals are given in Figures 5.3 and 5.4, respectively. The survey provides numbers at age for the different herring and sprat stocks (North Sea autumn-spawners, Western Baltic spring-spawners, West of Scotland, Malin Shelf herring, North Sea sprat and Div. IIIa sprat) and the time series of these are given in Figures 5.5-5.10. The time series of abundance for the four herring stocks (North Sea autumn-spawners, Western Baltic spring-spawners, West of Scotland and Malin Shelf herring) are given in Tables 5.6 – 5.9 and illustrated in Figures 5.11 -5.14, respectively. In each of them, a 3 year running mean is included to show the general trend more clearly.

Estimated survey uncertainty per numbers at age by survey participant for both herring and sprat are shown in Figures 5.15. and 5.16.

Sprat in the North Sea and Division IIIa

Sprat data were available from RV "Solea", RV "Tridens", and RV "Dana". No sprat were observed in the northern part of the North Sea surveyed by MRV "Scotia" and RV "Johan Hjort". In the Dutch survey sprat was found in coastal areas: the Moray Firth and south of 56°, in particular off Flamborough (37F0). In 2014, no sprat was found in this part of the survey, and the coastal distribution of sprat probably explains the high variability in abundances between years. In the German survey area, sprat as in previous years were distributed throughout the whole survey area. Highest sprat densities were measured in the German Bight (especially around Helgoland Island) but also in the south-eastern part of the covered survey area along the UK and Dutch coast. However, sprat were not present in all catches (as in 2014) but in 39 out of 55 hauls (71 %). Sprat was also found in small amounts in the North Sea areas surveyed by the Danish survey. In the 2015 acoustic surveys, sprat was found further north than in 2014, but concentrated in the southern part of the North Sea, with the highest abundances and biomass in an area below 55° N. The southern limit of the surveyed area is at 52° N. There is no indication that the southern limit of the sprat stock distribution has been reached; it is likely that sprat can be found even further south in the English Channel. The sprat distribution in the North Sea and Division IIIa in terms of abundance and biomass per strata is shown in

Table 5.17. The NASC values attributed to sprat in the Danish, Dutch and German survey are shown in Figure 5.4.

The total abundance of North Sea sprat (Subarea IV) in 2015 was estimated at 58 745 million individuals and the biomass at 712 000 tonnes (Table 5.10). This is the fourth and second highest estimate observed in the time series, in terms of abundance and biomass, respectively. Compared to the 2014 estimate, the historic high of the time series, abundance and biomass have decreased by 33 and 2%, respectively (Table 5.11, Figure 5.9). Both the 2015 and the 2014 sprat biomass are about twice as high as the long term average for the survey time series. The stock was dominated by 1- and 2-year-old sprat (77% of biomass), and most sprat were found to be mature (82%) (Table 5.10).

An age-disaggregated time-series of North Sea sprat abundance and biomass (ICES Subarea IV), as obtained from the acoustic survey, is given in Table 5.11. Note that for 2003, information on the sprat distribution in the North Sea is available from one nation only.

In Division IIIa, sprat were mostly found in the Kattegat (highest concentration on the border between 44G0 and 43G0) and, in smaller amounts, in the Skagerrak area (44F9-G0), as in 2014. This is in contrast to 2013, when sprat was only seen in the Kattegat. The abundance is estimated at 1386 million individuals, increased by 52% compared to the 913 million individuals in 2014 (Tables 5.12-5.13). The biomass has increased by 83% to 18 500 tonnes. 1-year-old sprat dominate the stock (61% in numbers and 52% in biomass), while also the 3+ group was a large proportion of the stock. The age-disaggregated time-series of sprat abundance and biomass in Division IIIa are given in Table 5.13 and Figure 5.10.

Quality considerations

Changing analysis tool

The global estimates for 2015 were for the first time calculated based on disaggregated acoustic and biological data delivered to the group allowing a level of transparency and discussion on data collection and standardisation issues not readily achieved before.

The effect of changing from one analysis method to another was investigated and reported in full in Annex 9 of this report. The nationally calculated total abundances at age and maturity, which would previously have been collated to produce global estimates in FishFrame, were contrasted to the number at age and maturity calculated independently for each nation in the StoX software. The settings applied there were then used to calculate the overall abundances.

It was shown that the effect of changing the calculation method to StoX had very little effect on the resulting indices carried forward to the stock assessment process. The group is therefore confident that the latest index at age is comparable to the existing time series.

Scrutiny of Danish acoustic data

The StoX software has a function to partition mixed species echotraces based on splitting by species specific target strength (TS). This functionality was used in the 2015 analysis to partition German and Danish data to sprat and herring. In the German survey area, mixed aggregations of clupeids makes scrutiny to species level difficult and necessitates the use of allocation of echotraces to a mixed clupeid class for partitioning in the post processing. In the Danish area scrutiny however is only taken to the level of distinguishing between fish or not fish, and the echo traces are then partitioned based entirely on composition of trawl catches. This approach is not compatible with best practice anymore and it should be possible to use modern acoustics species discrimination techniques to narrow the allocation to at least clupeid or pelagic fish mixes. Denmark has agreed to work with Norway and Germany that survey bordering strata and therefore encounter echotraces similar to those encountered in the Danish area to standardise Danish scrutiny methods to align with those used by all other participants.

Stock splitting methods

At the present two different methods are used within the survey to assign herring in the splitting area (strata 1 – 5 and 9 – 10) to the North Sea autumn spawning stock or the Western Baltic spring spawning stock. These methods have been developed independently within national laboratories, but have not been calibrated against each other so far. To ensure resilience in the consistency over the time series the two methods should be calibrated against each other. But ideally, the method should be standardised across the surveys to use one common method for all splitting between the two stocks.

In addition, the method used by Norway does not provide stock information at the individual fish level and it is therefore not at the present possible to analyse the Norwegian component of the survey within an overall StoX project for the two herring stocks. This means that at the present time it is still not possible to routinely produce uncertainty estimates for the herring stocks.

VIaN and VIaS: Work has been ongoing for a number of years to split the Malin Shelf herring survey into VIaN and VIaS spawning components using morphological (body and otolith) differences. To date, the successful classification rate has been unsatisfactory so both stocks of herring are reported as one from this survey. Genetic techniques are now being investigated to facilitate this split.

Maturity

This year, portions of immature fish > age 3 were reported. This is because for the first time no assumptions were made about constant maturity and those actually observed in the surveys are reported in this report. In the past, fish 5 wr or older were all assumed mature by definition in the reported result. This is a decision that should be made in the assessment working group for each assessment, as the underlying data should be collected and reported as actually observed.

Survey uncertainty

The use of the StoX software for survey abundance estimation, concurrent availability of disaggregated survey data, and application of a transect-based approach allowed for an estimate of survey uncertainty. These were provided by survey participant and age group for both herring and sprat (Figures 5.15. and 5.16.). While observed uncertainties for herring were generally expectedly higher for youngest and oldest ages, indices provided by some participants also had a high uncertainty level for intermediate ages. This was especially true for Danish, German and Dutch observations on North Sea autumn spawning herring, where CV values above 40% were estimated. This may suggest that the historic transect design proposed a decade ago and still used may not be representative of the current distribution pattern anymore. To reduce the CVs the design and methodology should be adapted for example by optimising transect design (spacing) in areas covered by these nations. CVs observed for sprat were generally higher than for herring, but more similar among nations. This may suggest that the survey design, which is geared towards optimally sampling herring, may be less suitable for sprat.

Recommendations:

1) Danish acoustic data scrutiny review to be carried out and brought in line with rest of group. Bordering nations with experience of similar conditions (Norway and Germany) to work with Denmark.

2) Stock splitting procedures to be reviewed and common protocol to be developed for WBSS and NSAS – at individual fish level. Ask HAWG to put forward a recommendation for a joint work shop to accomplish this.

3) Reporting format. In this interim period the reporting outputs are restricted compared to usual. Visualisations of adult versus juvenile distributions and distribution by age groups and maturity levels cannot be easily produced at the present, but standard methods for producing such maps should be developed by the group for use with the new analysis outputs.

References

ICES (2015). Report of the Workshop on evaluating current national acoustic abundance estimation methods for HERAS surveys (WKEVAL), 24-28 August 2015, ICES Headquarters, Copenhagen, Denmark. ICES CM 2015/SSGIEOM:16. 48 pp.

ICES 2015c. Manual for International Pelagic Surveys (IPS). Series of ICES Survey Protocols SISP 9 – IPS. 92pp.

Tables and Figures

Table 5.2. Total numbers (millions) and biomass (thousands of tonnes) of North Sea autumn spawning herring in the area surveyed in the acoustic surveys June - July 2015 with mean weights and mean lengths by age in winter rings.

Age (ring)	Numbers	Biomass	Maturity	Weight(g)	Length (cm)
0	386	2	0.00	4.0	8.1
1	6 714	331	0.00	49.3	18.2
2	9 495	1 148	0.70	120.9	24.0
3	2 831	414	0.90	146.4	25.6
4	1 591	292	0.96	183.5	27.5
5	1 549	309	0.98	199.6	28.1
6	926	204	0.99	220.1	29.0
7	520	107	1.00	205.4	28.9
8	275	58	1.00	210.0	29.3
9+	221	51	1.00	229.1	30.2
Immature	**10 285**	**635**		**61.7**	**19.1**
Mature	**14 222**	**2 280**		**160.3**	**26.2**
Total	**24 508**	**2 915**	**0.58**	**119.0**	**23.2**

Table 5.3. Total numbers (millions) and biomass (thousands of tonnes) of Western Baltic spring spawning herring in the area surveyed in the acoustic surveys June-July 2015, with mean weights, mean length and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	2	0	0.00	14.2	13.3
1	1 949	61	0.01	31.5	16.1
2	1 244	106	0.37	85.4	21.7
3	446	55	0.74	122.7	24.5
4	224	34	0.85	150.9	26.2
5	171	30	0.97	177.1	27.5
6	82	17	0.97	202.3	28.7
7	89	18	1.00	198.9	28.8
8+	115	25	1.00	218.9	29.6
Immature	**2 875**	**139**		**48.4**	**17.8**
Mature	**1 447**	**207**		**143.1**	**25.5**
Total	**4 322**	**346**	**0.33**	**80.1**	**20.4**

Table 5.4. Total numbers (millions) and biomass (thousands of tonnes) of autumn spawning West of Scotland herring in the area surveyed in the acoustic surveys July 2015, with mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0		154.8	25.8
1	0	0		183.4	27.3
2	122	19	0.58	195.3	27.9
3	325	60	0.92	204.7	28.4
4	650	127	0.99	211.3	28.9
5	378	77	0.98	217.3	29.4
6	442	93	1.00	215.3	29.1
7	83	18	0.97	220.0	30.0
8	23	5	1.00	154.8	25.8
9+	2	0	1.00	183.4	27.3
Immature	**89**	**12**		**137.9**	**25.1**
Mature	**1935**	**387**		**200.1**	**28.2**
Total	**2024**	**399**	**0.96**	**197.4**	**28.0**

Table 5.5. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring (VIaN-S, VIIb,c) June-July 2015. Mean weights, mean lengths and fraction mature by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0			
1	0	0			
2	212	30	0.48	139.9	25.0
3	397	70	0.85	176.7	26.9
4	747	144	0.99	192.9	27.7
5	423	86	0.98	202.3	28.3
6	476	100	1.00	210.4	28.8
7	90	19	0.97	215.8	29.3
8	24	5	1	214.5	29.1
9+	2	0	1	220.0	30.0
Immature	190	25		130.9	24.6
Mature	2181	430		197.1	28.0
Total	2372	455	0.92	191.8	27.7

Table 5.6. Estimates of North Sea autumn spawners (millions) at age and SSB from acoustic surveys, 1986–2015. For 1986 the estimates are the sum of those from the Division IVa summer survey, the Division IVb autumn survey, and the Divisions IVc, VIId winter survey. The 1987 to 2014 estimates are from summer surveys in Divisions IVa,b,c and IIIa excluding estimates of Western Baltic spring spawners. For 1999 and 2000, the Kattegat was excluded from the results because it was not surveyed. Total numbers include 0-ringers from 2008 onwards.

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1986	1,639	3,206	1,637	833	135	36	24	6	8	7,542	942
1987	13,736	4,303	955	657	368	77	38	11	20	20,165	817
1988	6,431	4,202	1,732	528	349	174	43	23	14	13,496	897
1989	6,333	3,726	3,751	1,612	488	281	120	44	22	16,377	1,637
1990	6,249	2,971	3,530	3,370	1,349	395	211	134	43	18,262	2,174
1991	3,182	2,834	1,501	2,102	1,984	748	262	112	56	12,781	1,874
1992	6,351	4,179	1,633	1,397	1,510	1,311	474	155	163	17,173	1,545
1993	10,399	3,710	1,855	909	795	788	546	178	116	19,326	1,216
1994	3,646	3,280	957	429	363	321	238	220	132	13,003	1,035
1995	4,202	3,799	2,056	656	272	175	135	110	84	11,220	1,082
1996	6,198	4,557	2,824	1,087	311	99	83	133	206	18,786	1,446
1997	9,416	6,363	3,287	1,696	692	259	79	78	158	22,028	1,780
1998	4,449	5,747	2,520	1,625	982	445	170	45	121	16,104	1,792
1999	5,087	3,078	4,725	1,116	506	314	139	54	87	15,107	1,534
2000	24,735	2,922	2,156	3,139	1,006	483	266	120	97	34,928	1,833
2001	6,837	12,290	3,083	1,462	1,676	450	170	98	59	26,124	2,622
2002	23,055	4,875	8,220	1,390	795	1,031	244	121	150	39,881	2,948
2003	9,829	18,949	3,081	4,189	675	495	568	146	178	38,110	2,999
2004	5,183	3,415	9,191	2,167	2,590	317	328	342	186	23,722	2,584
2005	3,113	1,890	3,436	5,609	1,211	1,172	140	127	107	16,805	1,868
2006	6,823	3,772	1,997	2,098	4,175	618	562	84	70	20,199	2,130
2007	6,261	2,750	1,848	898	806	1,323	243	152	65	14,346	1,203
2008	3,714	2,853	1,709	1,485	809	712	1,749	185	270	20,355	1,784
2009	4,655	5,632	2,553	1,023	1,077	674	638	1,142	578	31,526	2,591
2010	14,577	4,237	4,216	2,453	1,246	1,332	688	1,110	1,619	43,705	3,027
2011	10,119	4,166	2,534	2,173	1,016	651	688	440	1,207	25,524	2,431
2012	7,437	4,718	4,067	1,738	1,209	593	247	218	478	23,641	2,269
2013	6,388	2,683	3,031	2,895	1,546	849	464	250	592	36,484	2,261
2014	11,634	4,918	2,827	2,939	1,791	1,236	669	211	250	61,339	2,610
2015	6,714	9,495	2,831	1,591	1,549	926	520	275	221	24,508	2,280

Table 5.7. Numbers at age (millions) of Western Baltic spring spawning herring at age (winter rings) from acoustic surveys 1992 to 2015. The 1999 survey was incomplete due to the lack of participation by RV "Dana".

Year/Age	1	2	3	4	5	6	7	8+	Total	3+ group
1992	277	2,092	1,799	1,593	556	197	122	20	10,509	4,287
1993	103	2,768	1,274	598	434	154	63	13	5,779	2,536
1994	5	413	935	501	239	186	62	34	3,339	1,957
1995	2,199	1,887	1,022	1,270	255	174	39	21	6,867	2,781
1996	1,091	1,005	247	141	119	37	20	13	2,673	577
1997	128	715	787	166	67	69	80	77	2,088	1,245
1998	138	1,682	901	282	111	51	31	53	3,248	1,428
1999	1,367	1,143	523	135	28	3	2	1	3,201	691
2000	1,509	1,891	674	364	186	56	7	10	4,696	1,295
2001	66	641	452	153	96	38	23	12	1,481	774
2002	3,346	1,576	1,392	524	88	40	18	19	7,002	2,081
2003	1,833	1,110	395	323	103	25	12	5	3,807	864
2004	1,668	930	726	307	184	72	22	18	3,926	1,328
2005	2,687	1,342	464	201	103	84	37	21	4,939	910
2006	2,081	2,217	1,780	490	180	27	10	0.1	6,791	2,487
2007	3,918	3,621	933	499	154	34	26	14	9,200	1,661
2008	5,852	1,160	843	333	274	176	45	44	8,839	1,715
2009	565	398	205	161	82	85	39	65	1,602	638
2010	999	511	254	115	65	24	28	34	2,030	519
2011	2,980	473	259	163	70	53	22	46	4,067	614
2012	1,018	1,081	236	87	76	33	14	60	2,605	505
2013	49	627	525	53	30	12	8	15	1,319	643
2014	513	415	176	248	28	37	26	42	1,798	556
2015	1,949	1,244	446	224	171	82	89	115	4,322	1,127

Table 5.8. Numbers at age (millions) and SSB (thousands of tonnes) of West of Scotland autumn spawning herring at age (winter rings) from acoustic surveys 1993 to 2015. In 1997 the survey was carried out one month early in June as opposed to July when all the other surveys were carried out.

Year/Age	1	2	3	4	5	6	7	8	9+	SSB:
1993	3	750	681	653	544	865	284	152	156	866
1994	494	542	608	286	307	268	407	174	132	534
1995	441	1,103	473	450	153	187	169	237	202	452
1996	41	577	803	329	95	61	77	78	115	370
1997	792	642	286	167	66	50	16	29	24	141
1998	1,221	795	667	471	179	79	28	14	37	376
1999	534	322	1,389	432	308	139	87	28	35	460
2000	448	316	337	900	393	248	200	95	65	500
2001	313	1,062	218	173	438	133	103	52	35	359
2002	425	436	1,437	200	162	424	152	68	60	549
2003	439	1,039	933	1,472	181	129	347	114	75	739
2004	564	275	760	442	577	56	62	82	76	396
2005	50	243	230	423	245	153	13	39	27	168
2006	112	835	388	285	582	415	227	22	59	472
2007	0	126	294	202	145	347	243	163	32	299
2008	48	233	912	669	340	272	721	366	264	788
2009	346	187	264	430	374	219	187	500	456	579
2010	425	489	398	150	143	95	63	48	188	253
2011	22	185	733	451	204	220	199	113	263	458
2012	792	179	729	471	241	107	107	56	105	375
2013	0	137	320	600	162	69	61	24	37	256
2014	1031	243	218	469	519	143	30	19	11	272
2015	0	122	325	650	378	442	83	23	2	387

Table 5.9. Numbers at age (winter rings, millions) and SSB (thousands of tonnes) of the Malin Shelf acoustic survey (VIaN-S, VIIb,c) time seriesfrom 2008 to 2015.

Year/Age	1	2	3	4	5	6	7	8	9+	SSB:
2008	312	290	998	720	363	331	744	386	274	842
2009	928	265	274	444	380	225	193	500	456	593
2010	300	376	374	242	173	146	102	100	297	366
2011	63	257	900	485	213	228	205	113	264	494
2012	796	548	832	518	249	115	111	57	105	427
2013	0	212	435	672	195	71	61	29	37	282
2014	1031	281	243	502	534	148	33	19	13	285
2015	0	212	397	747	423	476	90	24	2	430

Table 5.10. Sprat in the North Sea (Subarea IV): Abundance, biomass, mean weight and mean length by age and maturity (i = immature, m = mature) from the summer 2015 North Sea acoustic survey (HERAS).

Age	Abundance (million)	Biomass (1000 t)	Mean weight (g)	Mean length (cm)
0i	198	0	1.2	5.9
1i	8,915	56	6.3	9.5
1m	17,326	183	10.5	11.1
2i	1,483	16	10.9	11.3
2m	20,991	296	14.1	12.3
3i	102	1	11.3	11.4
3m	9,247	152	16.4	13.0
4m	441	8	18.0	13.5
5m	9	0	19.6	13.5
6m	0	0	-	-
Immature	10,698	74	6.9	9.7
Mature	48,014	638	13.3	12.0
Total	58,745	712	12.1	11.6

Table 5.11. Time-series of sprat abundance and biomass (ICES Subarea IV) as obtained from the summer North Sea acoustic survey (HERAS) time series 2000-2015. The surveyed area has expanded over the years. Only figures from 2004 and onwards are broadly comparable. In 2003, information on sprat abundance is available from one nation only.

	Abundance (million)					Biomass (1000 t)				
Year/Age	0	1	2	3+	Sum	0	1	2	3+	Sum
2015	198	26,241	22,474	9,799	58,711	0	239	312	161	712
2014	5,828	58,405	20,164	3,823	88,219	9	429	228	62	728
2013	454	9,332	6,273	1,600	17,660	2	71	74	25	172
2012	7,807	21,912	12,541	3,205	45,466	27	177	150	55	409
2011	0	26,536	13,660	2,430	42,625	0	212	188	44	444
2010	1,991	19,492	13,743	798	36,023	22	163	177	14	376
2009	0	47,520	16,488	1,183	65,191	0	346	189	21	556
2008	0	17,165	7,410	549	25,125	0	161	101	9	271
2007	0	37,250	5,513	1,869	44,631	0	258	66	29	353
2006*	0	21,862	19,916	760	42,537	0	159	265	12	436
2005*	0	69,798	2,526	350	72,674	0	475	33	6	513
2004*	17,401	28,940	5,312	367	52,019	19	267	73	6	366
2003*	0	25,294	3,983	338	29,615	0	198	61	6	266
2002	0	15,769	3,687	207	19,664	0	167	55	4	226
2001	0	12,639	1,812	110	14,561	0	97	24	2	122

2000	0	11,569	6,407	180	18,156	0	100	92	3	196

*** re-calculated using FishFrame.**

Table 5.12. Sprat in Division IIIa: Abundance, biomass, mean weight and length by age and maturity from the summer 2015 North Sea acoustic survey (HERAS).

Age	Abundance (million)	Biomass (tonnes)	Mean weight (g)	Mean length (cm)
0i	0.3	1	2.9	7.5
1i	547.4	5421	9.9	10.7
1m	293.5	4149	14.1	12.0
2i	112.7	1385	12.3	12.0
2m	89.3	1320	14.8	12.1
3m+	342.6	6176	18.0	13.7
Immature	660.4	6806	10.3	10.9
Mature	725.4	11646	16.1	12.8
Total	1393.7	18515	13.3	11.9

Table 5.13. Time-series of sprat abundance and biomass (ICES Div. IIIa) as obtained from the summer North Sea acoustic survey (HERAS) time series 2006-2015.

	Abundance (million)					Biomass (1000 t)				
Year/Age	0	1	2	3+	Sum	0	1	2	3+	Sum
2015	0.3	840.8	202.0	342.6	1,385.8	0.0	9.6	2.7	6.2	18.5
2014	29.6	614.5	109.8	159.4	913.3	0.1	4.8	1.8	3.4	10.1
2013	1.4	14.5	68.8	448.6	533.3	0.0	0.2	1.2	9.6	10.9
2012	0.3	123.9	290.1	1,488.0	1,902.3	0.0	1.2	5.0	31.4	37.6
2011	0.0	45.4	546.9	981.9	1,574.2	0.0	0.5	9.1	17.8	27.5
2010	0.0	836.1	343.8	376.3	1,556.2	0.0	7.3	4.9	6.4	18.6
2009	0.0	169.5	432.4	1,631.9	2,233.8	0.0	1.8	6.5	28.3	36.6
2008	0.0	23.0	457.8	291.2	772.0	0.0	0.2	6.3	5.8	12.3
2007	0.0	5,611.9	323.9	382.9	6,318.7	0.0	47.9	3.8	6.5	58.2
2006	86.0	61.3	1451.9	653.0	2,252.2	0.3	0.6	21.2	11.5	33.6

Table 5.14. North Sea autumn spawning herring. Total abundance, biomass, mean weight and percent mature by strata. Strata numbers corresponds to numbering in Figure 5.2.

Strata	Abundance (mill)	Biomass (kt)	Mean weight (g)	% Mature
1	244	6	25	0%
2	271	11	42	0%
3	475	27	57	1%
4	524	20	38	1%
5	165	6	38	4%
6	3 825	395	103	56%
7	5 442	660	121	75%
8	1 062	72	68	22%
9	4 383	426	97	34%
10	705	130	185	77%
11	398	10	25	0%
12	439	5	12	0%
13	11	0	17	0%
14	998	206	206	100%
15	39	8	206	100%
16	937	207	221	98%
17	415	58	139	74%
18	2 267	378	167	89%
19	1 483	194	131	69%
20	369	85	231	100%
21	55	9	171	90%

Table 5.15. Western Baltic spring spawning herring. Total abundance, biomass, mean weight and percent mature by strata. Strata numbers corresponds to numbering in Figure 5.2.

Strata	Abundance (mill)	Biomass (kt)	Mean weight (g)	% Mature
1	708	20	28.9	8%
2	503	18	35.3	12%
3	348	17	48.7	17%
4	648	36	55.0	20%
5	832	57	68.4	37%
9	592	85	143.6	68%
10	690	113	164.3	63%

Table 5.16. Malin shelf and VIaN herring. Total abundance, biomass, mean weight and percent mature by strata. The VIaN herring geographic subset is comprised of strata marked with *.

Strata	Abundance (mill)	Biomass (kt)	Mean weight (g)	% Mature
22*	0	0		
23*	1 624	325	200	97%
24*	400	75	186	88%
25	103	17	160	68%
26	115	18	159	75%
27	129	20	158	70%

Table 5.17. North Sea sprat and Div. IIIa sprat. Total abundance, biomass, mean weight and percent mature by strata. Strata numbers corresponds to numbering in Figure 5.2. Strata 3 and 4 are divided into East (E) and West (W) along the border between ICES Divisions IVa and IIIa.

Stock	Strata	Abundance (mill)	Biomass (t)	Mean weight (g)	% Mature
Div. IIIa sprat	1	576	7 277	12.6	48%
	2	531	6 637	12.5	50%
	3E	279	4 538	16.3	65%
	4E	576	7 277	12.6	48%
North Sea sprat	3W	333	4 160	12.5	28%
	4W	3 224	43 436	13.5	99%
	5	17 626	275 347	15.6	98%
	6	17 829	185 252	10.4	79%
	7	15 203	157 460	10.4	64%
	8	4 042	39 504	9.8	82%
	11	228	3 495	15.3	59%
	12	226	3 456	15.3	59%
	13	333	4 160	12.5	28%

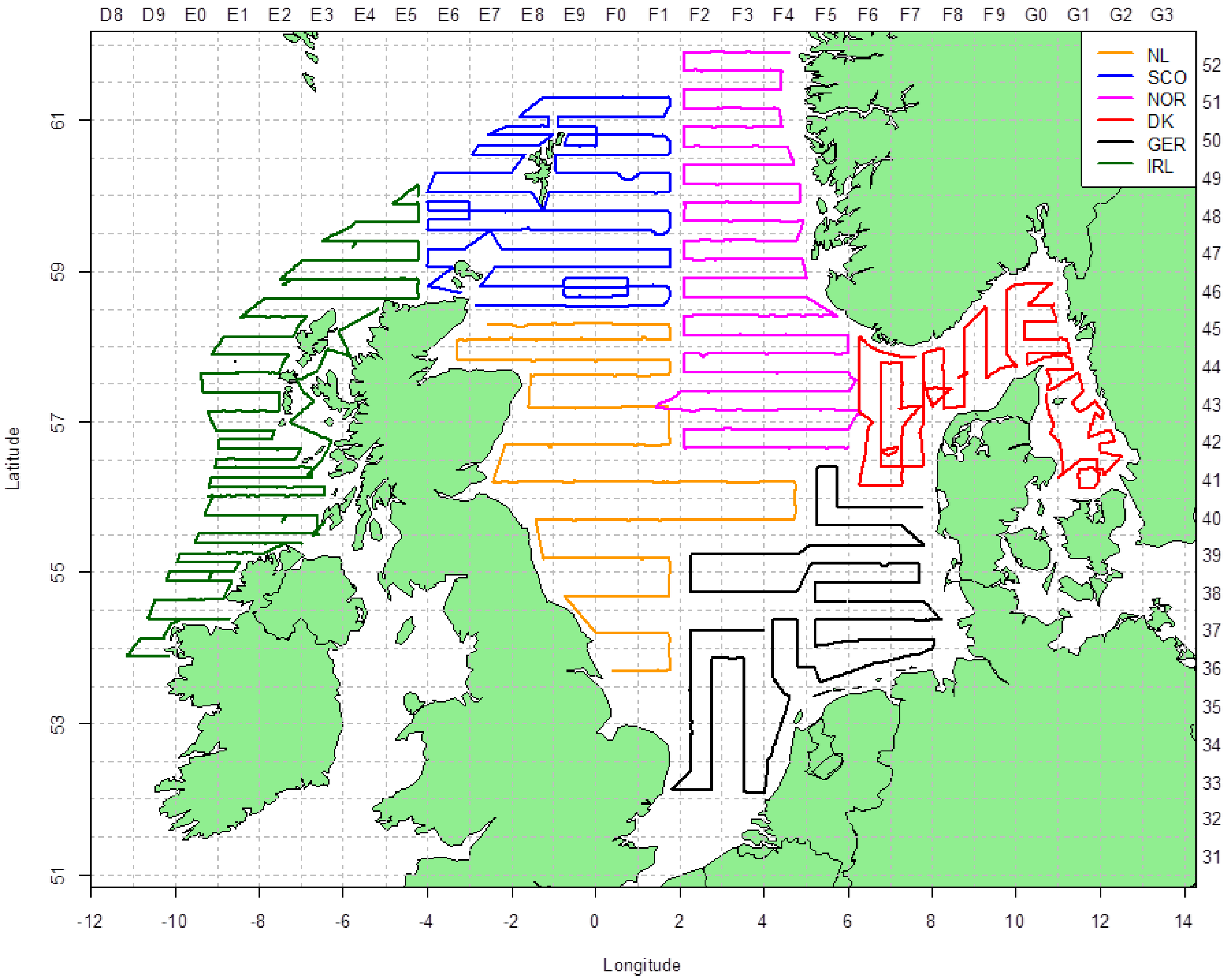

Figure 5.1. Survey area coverage in the pelagic acoustic surveys in 2015 and individual vessel tracks by nation (IRL = Celtic Explorer; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea).

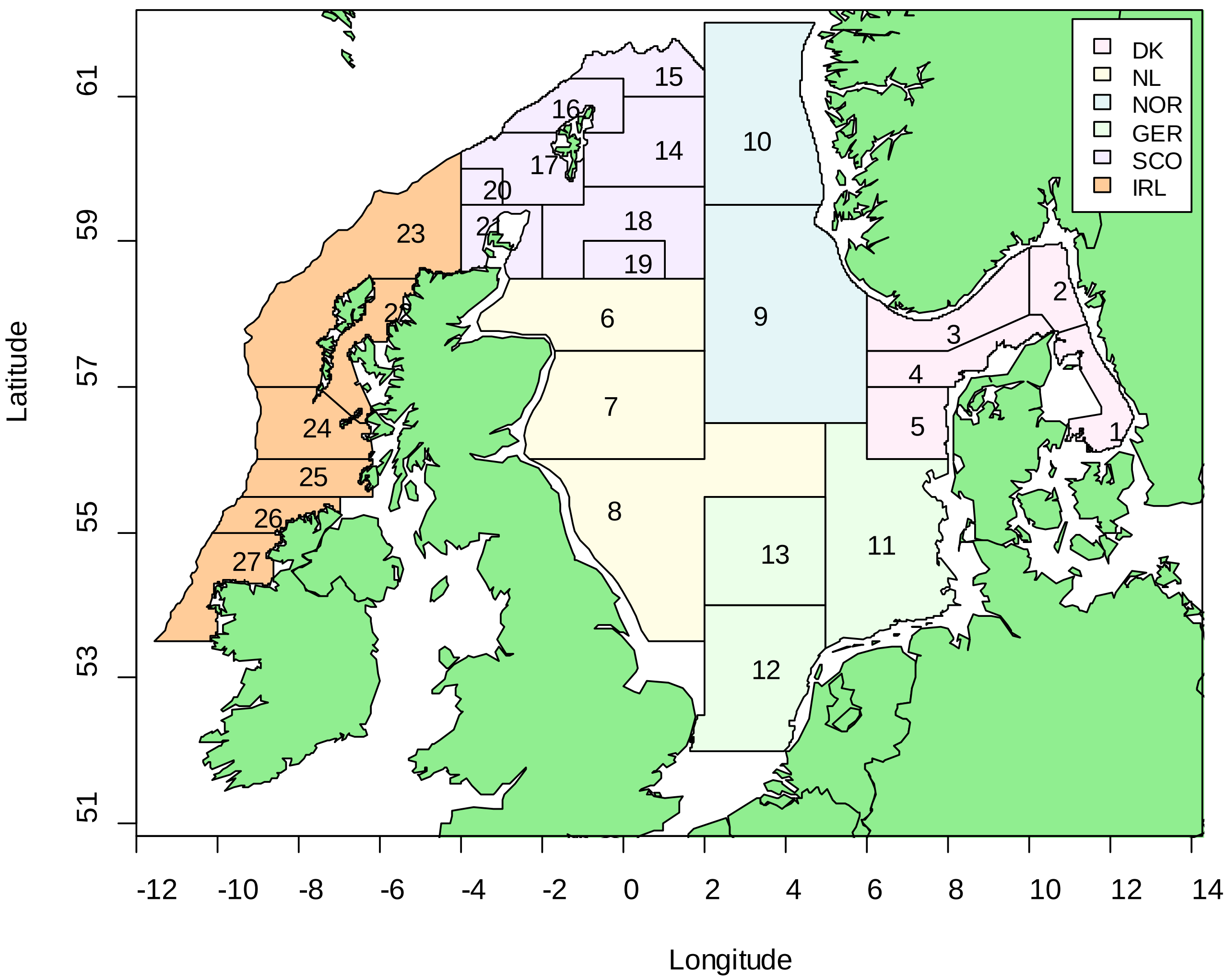

Figure 5.2. Stratification used in the StoX analysis of the HERAS survey 2015. Strata covered by different vessels are indicated by colour coding.

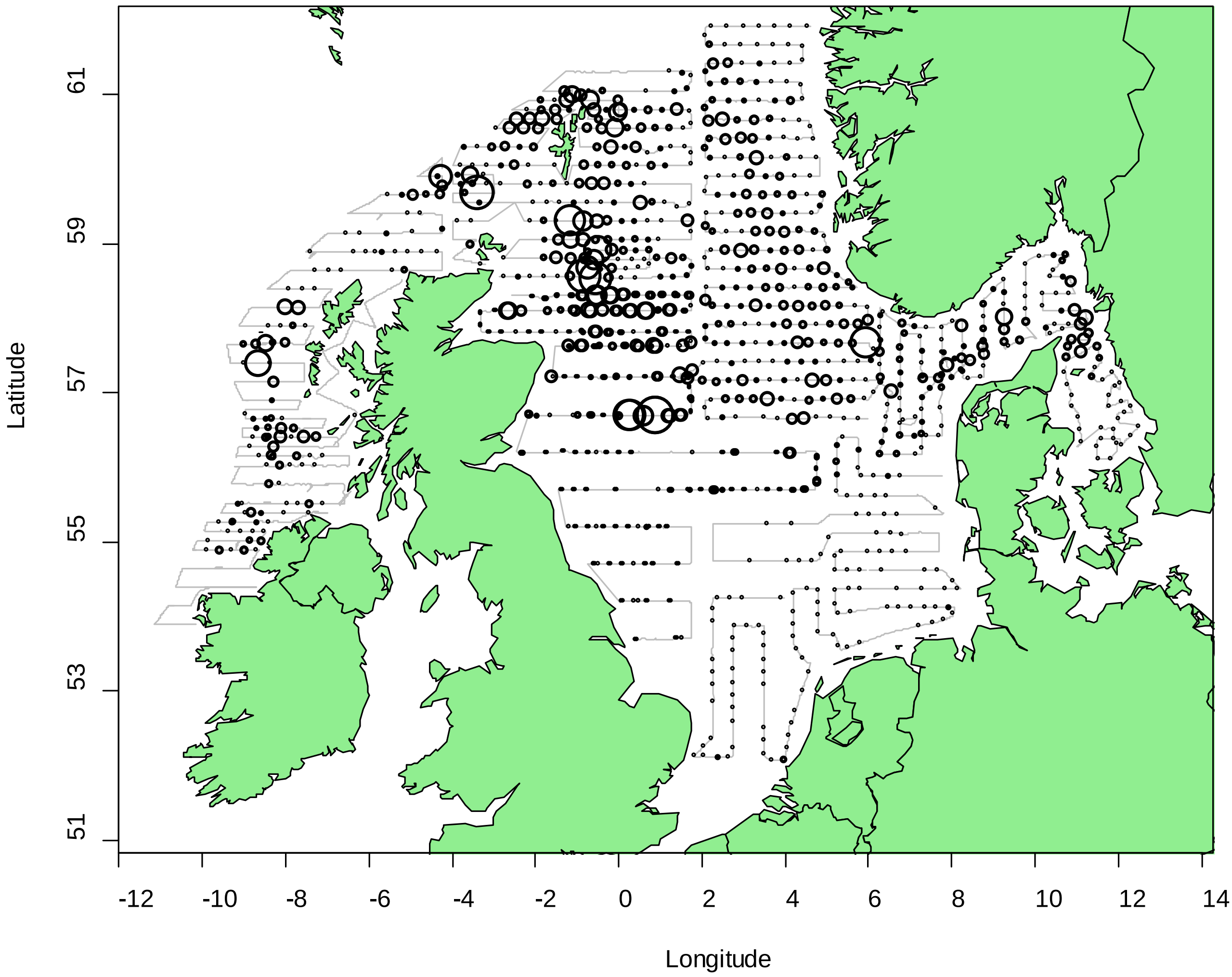

Figure 5.3. Distribution of NASC attributed to herring in HERAS in 2015. Cruise tracks are outlined in light grey with circles representing size and location of herring aggregations. NASC values are resampled at 15 nm intervals along the cruise track.

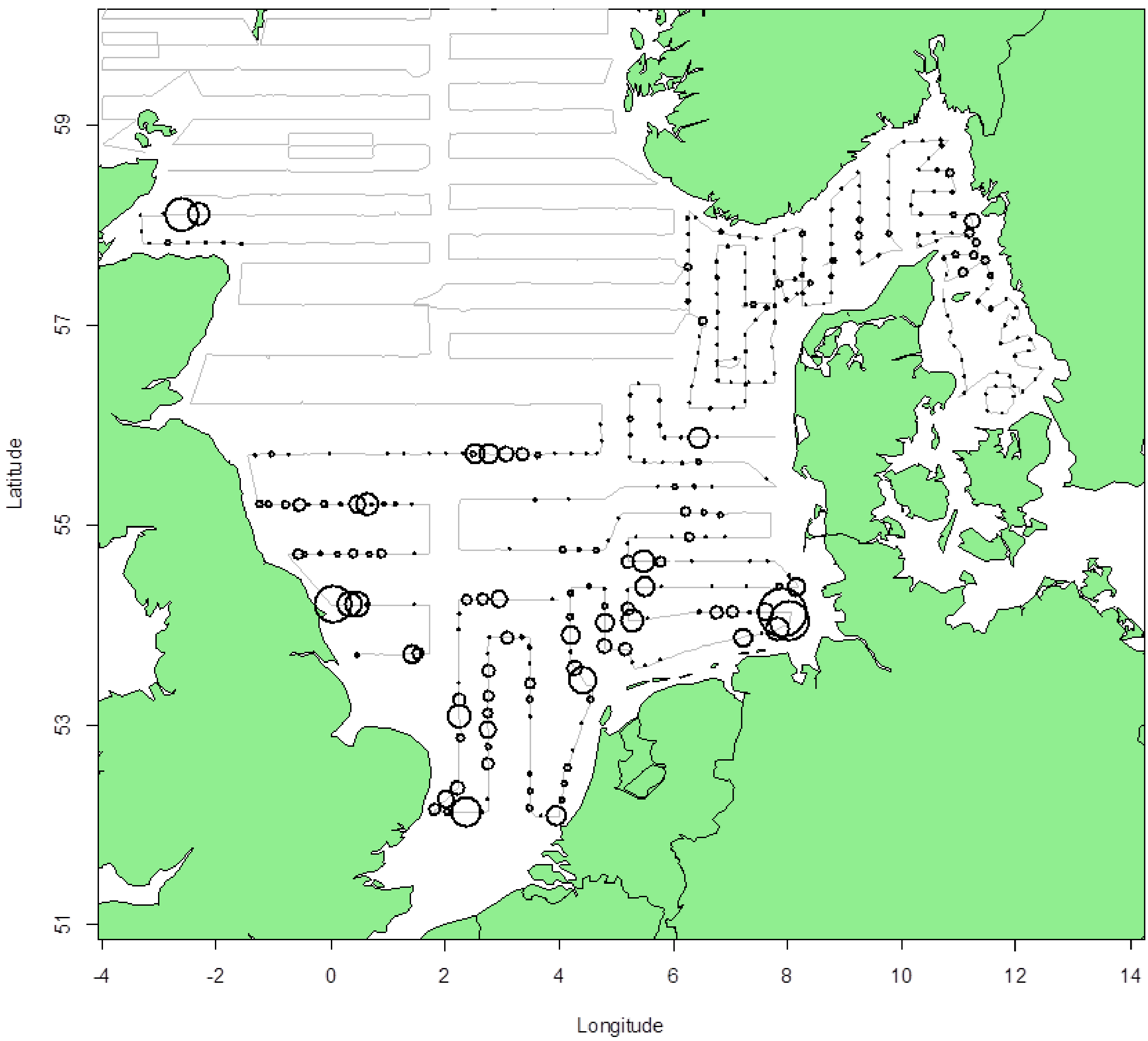

Figure 5.4. Distribution of NASC attributed to sprat in HERAS in 2015. Cruise tracks are outlined in light grey with circles representing size and location of sprat aggregations. NASC values are resampled at 10 nm intervals along the cruise track.

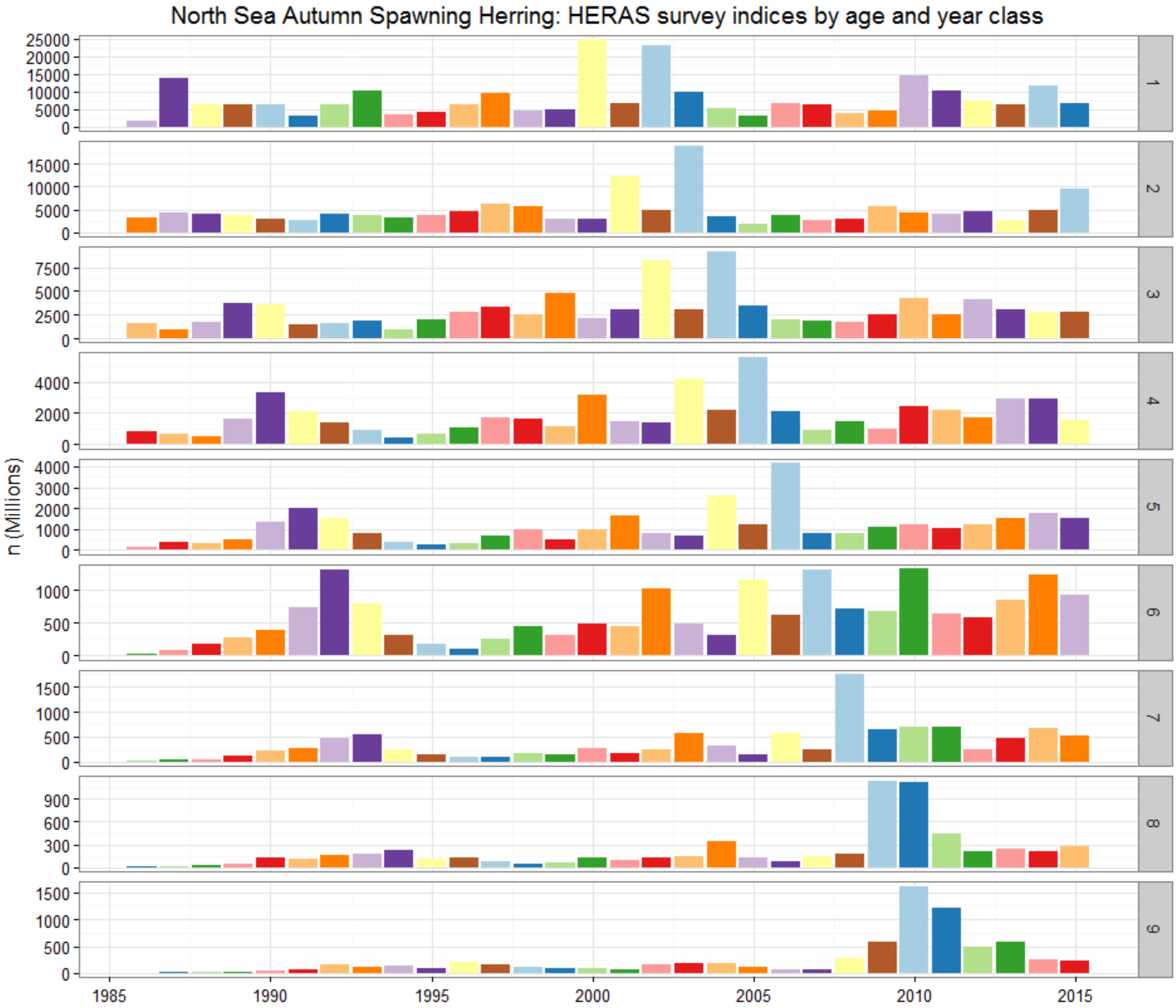

Figure 5.5. North Sea autumn spawning Herring: HERAS indices (millions) by age (winter rings) and year class from the acoustic surveys 1986-2015. Age 9 includes ages 9 and older. Note diverging scales of abundance between ages.

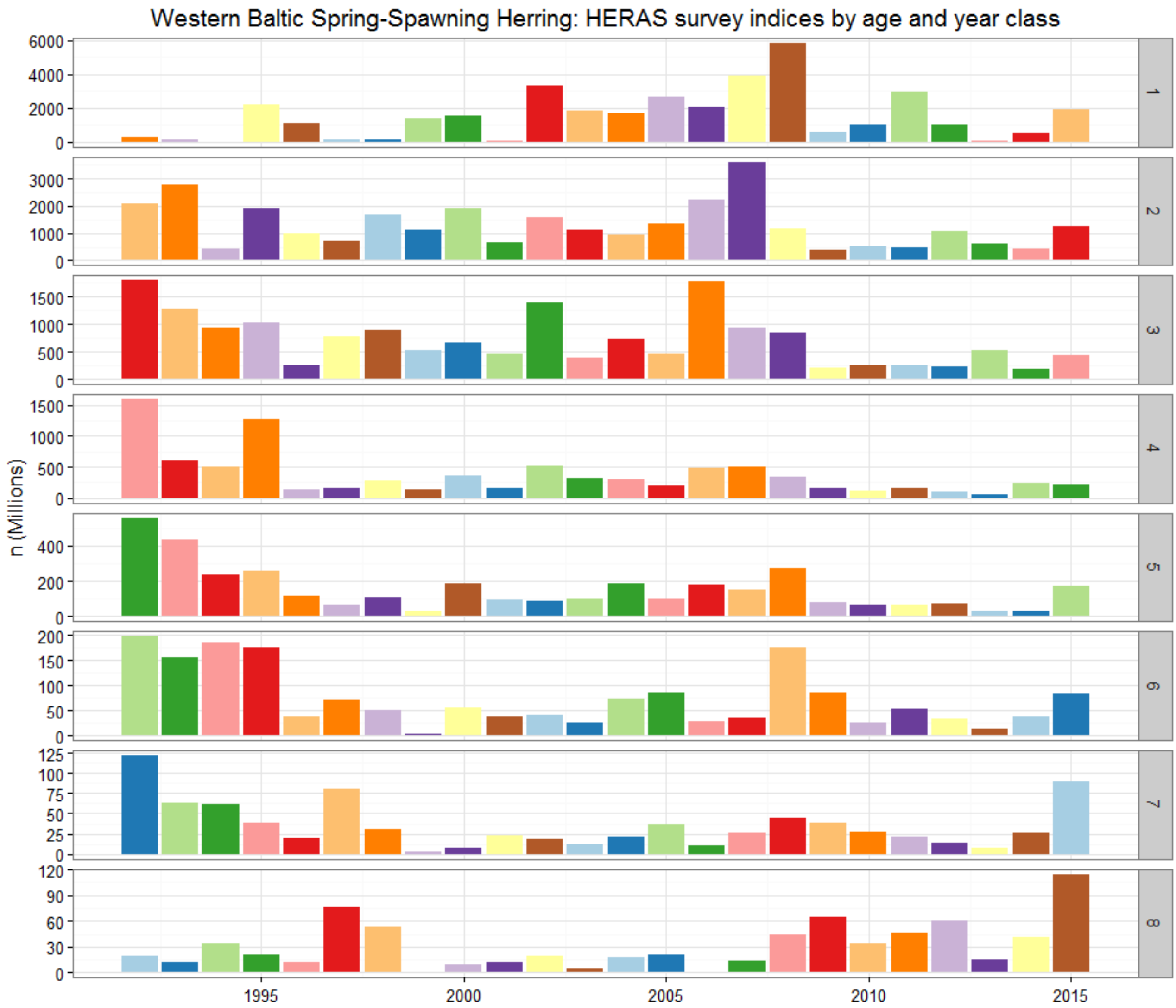

Figure 5.6. Western Baltic spring spawning Herring: HERAS indices (millions) by age (winter rings) and year class from the acoustic surveys 1992-2015. Age 8 includes ages 8 and older. Note diverging scales of abundance between ages.

Figure 5.7. West of Scotland (VIaN) autumn spawning herring: HERAS indices (millions) by age (winter rings) and year class from the acoustic surveys 1993-2015. Age 9 includes ages 9 and older.

Figure 5.8. Malin Shelf Herring (VIaN-S, VIIb,c): HERAS indices (millions) by age (winter rings) and year class from the acoustic surveys 2008-2015. Age 9 includes ages 9 and older.

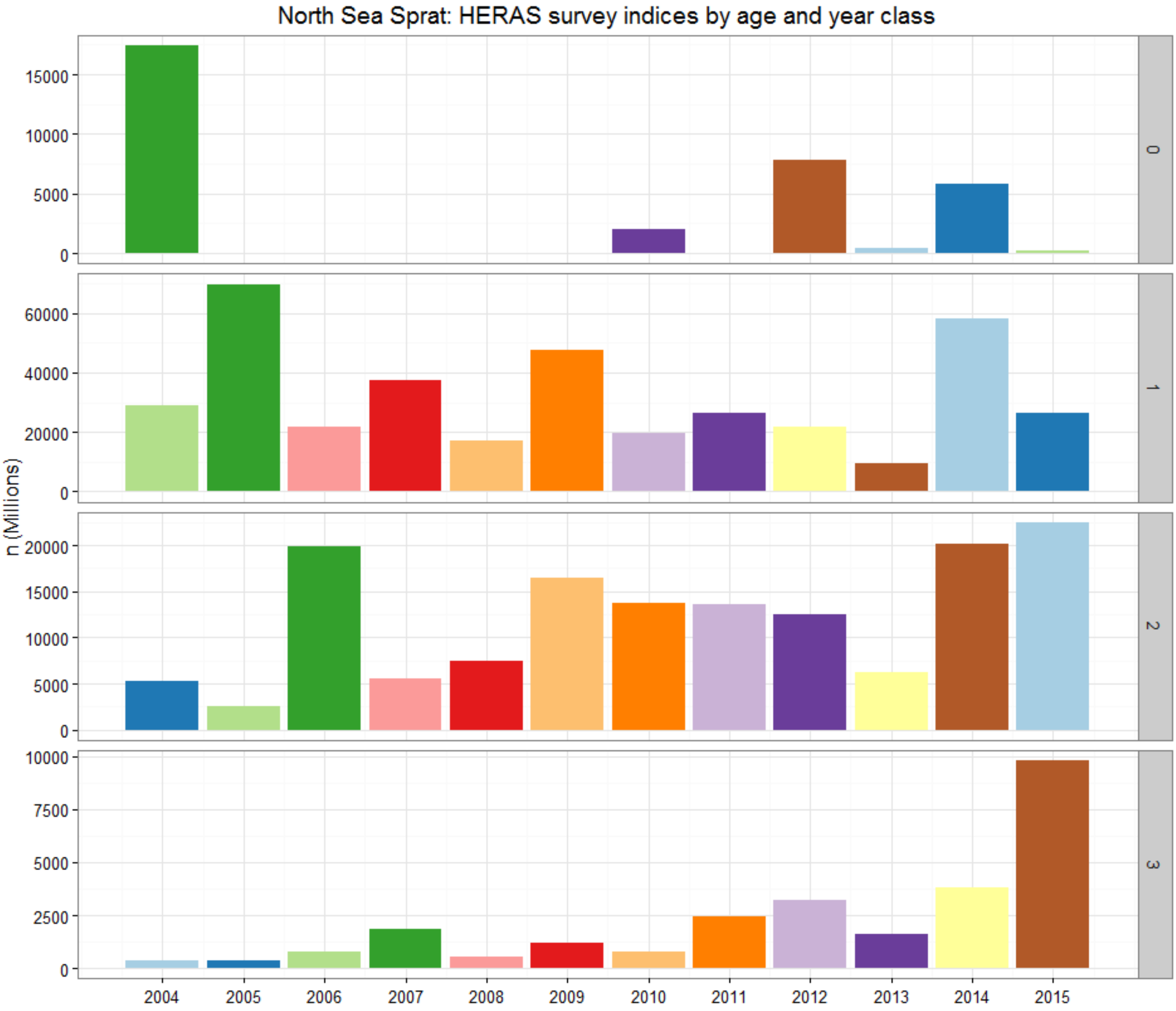

Figure 5.9. North Sea Sprat: HERAS indices (millions) by age (winter rings) and year class from the acoustic surveys 2004-2015. Age 3 includes ages 3 and older. Note diverging scales of abundance between ages.

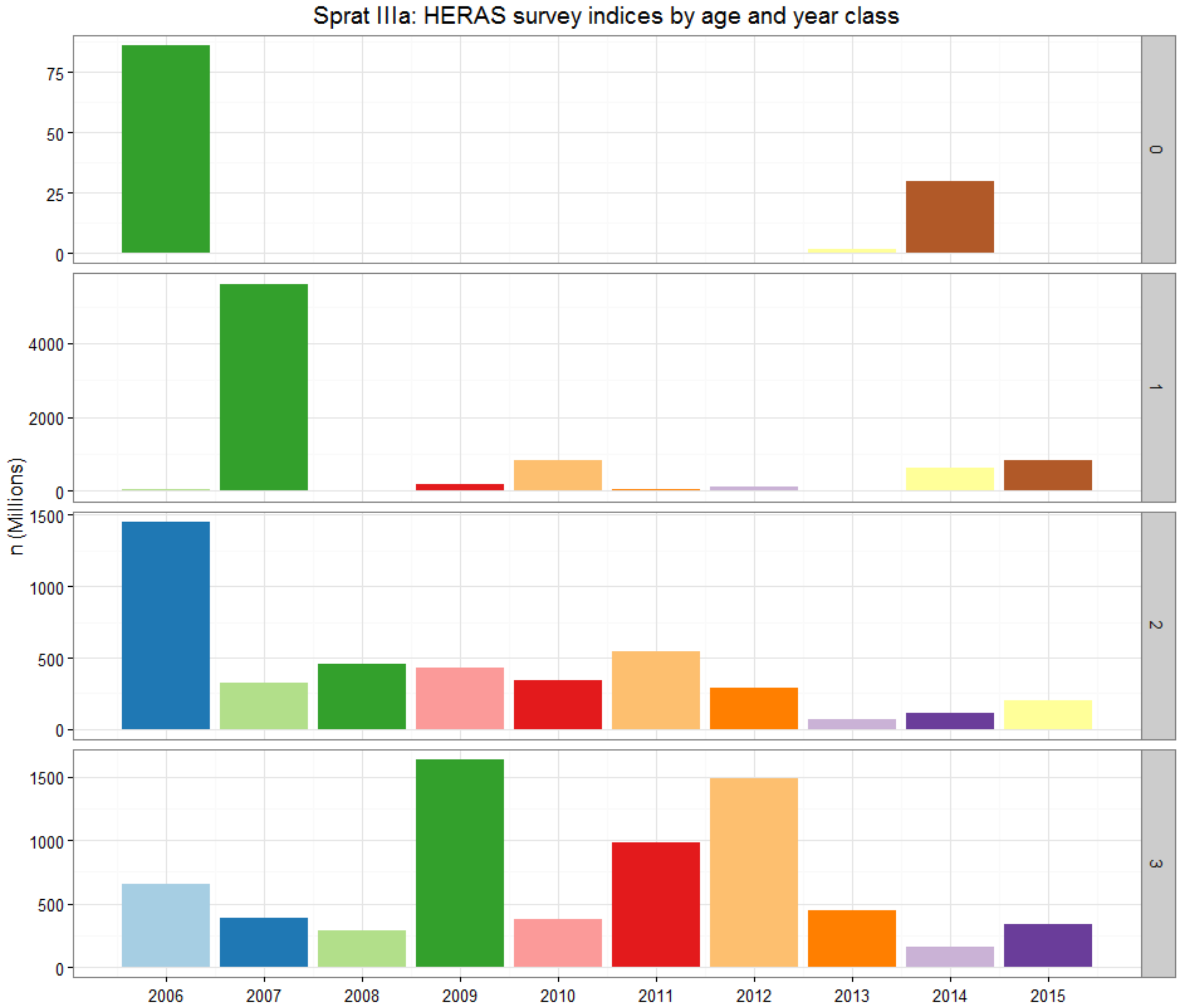

Figure 5.10. Sprat in Division IIIa: HERAS indices (millions) by age (winter rings) and year class from the acoustic surveys 2006-2015. Age 3 includes ages 3 and older. Note diverging scales of abundance between ages.

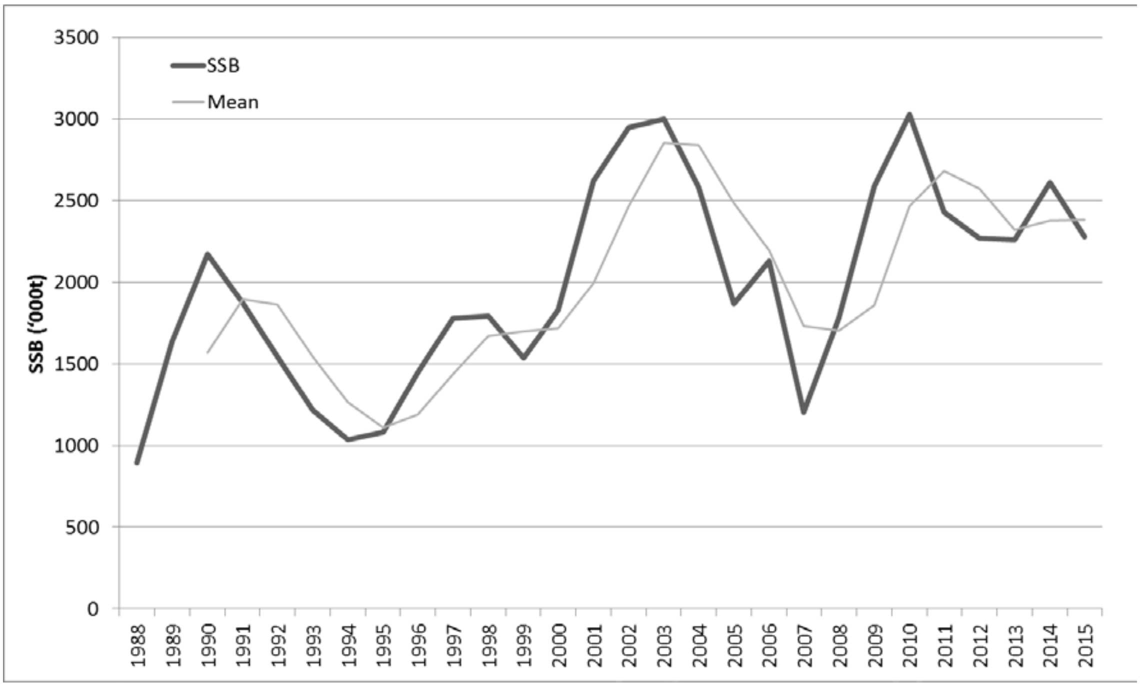

Figure 5.11. Time series of SSB of North Sea autumn spawning herring with three year running mean.

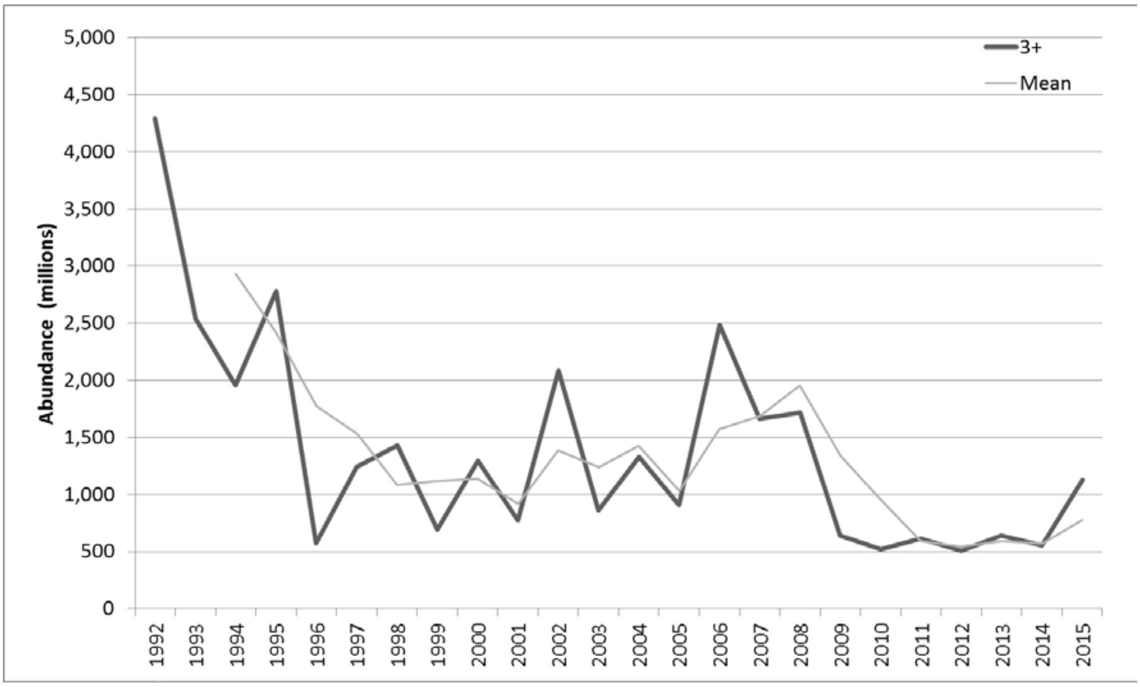

Figure 5.12. Time series of 3+ abundance of Western Baltic spring-spawning herring with three year running mean.

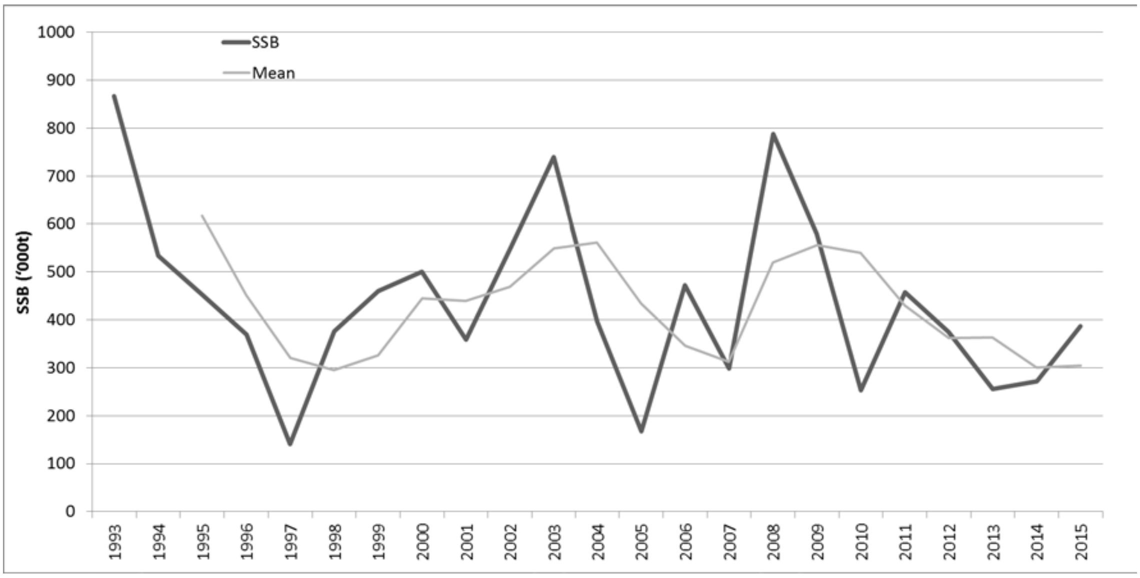

Figure 5.13. Time series of SSB of West of Scotland herring (geographical subset of Malin Shelf herring) with three year running mean.

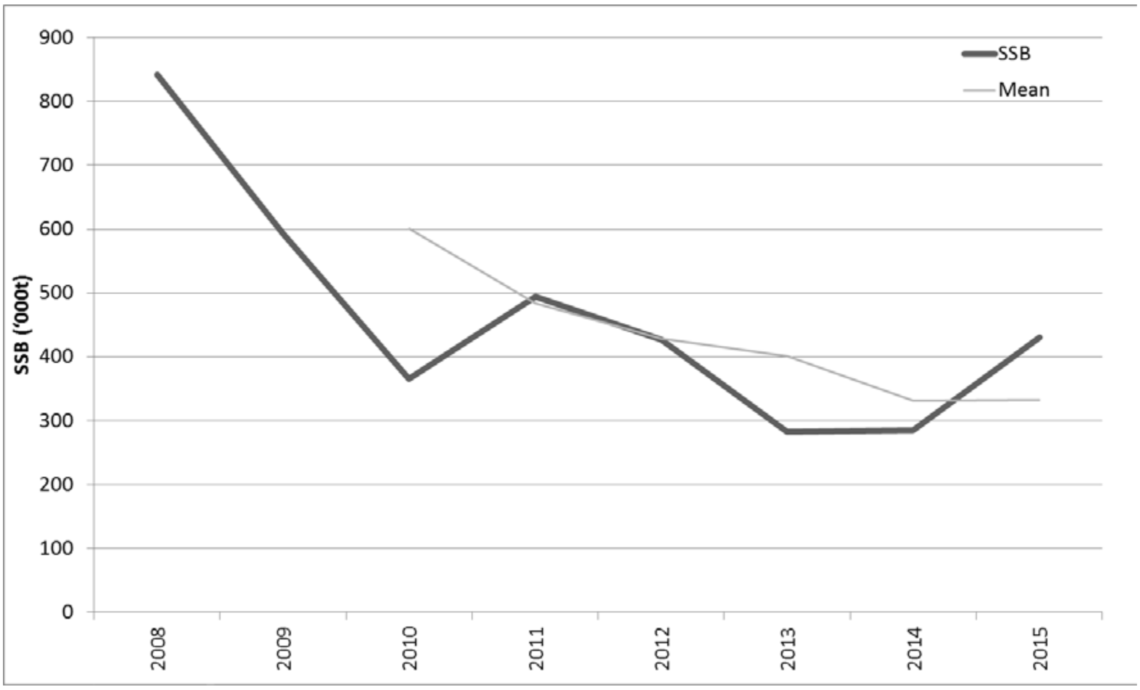

Figure 5.14. Time series of SSB of Malin Shelf herring with three year running mean.

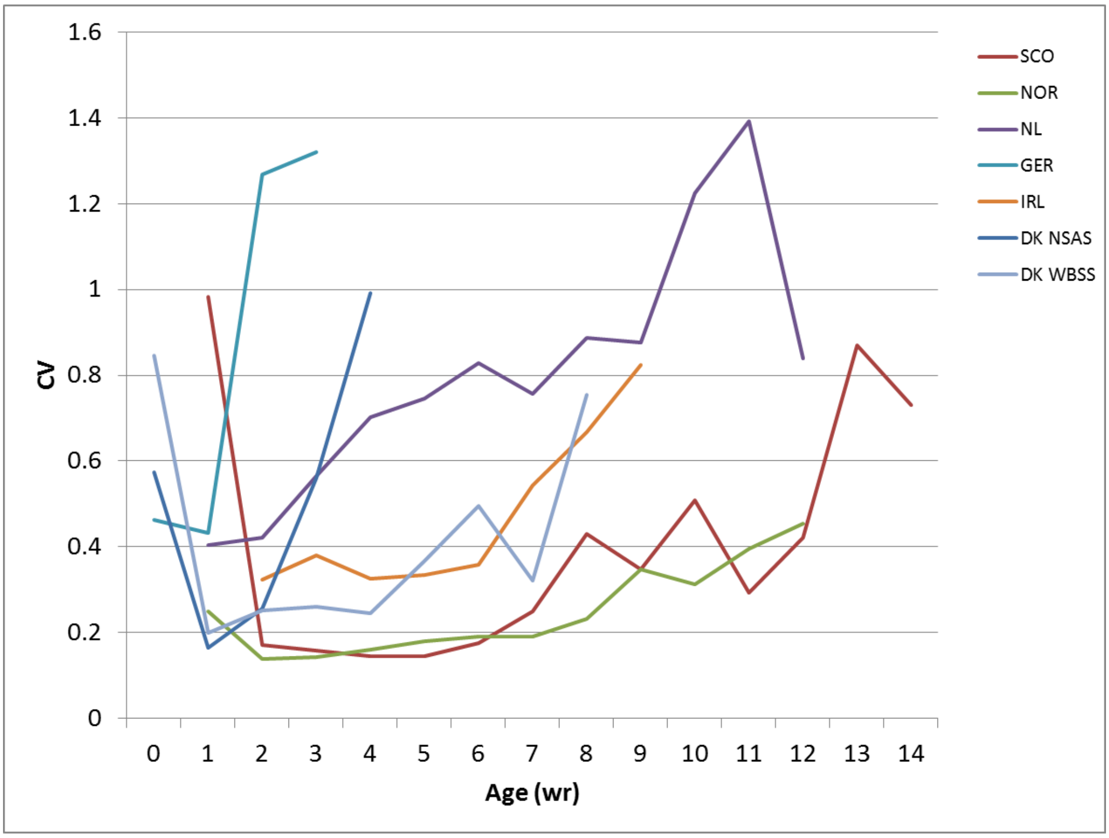

Figure 5.15. CV on abundance at age for herring in each national survey from the analysis in StoX.

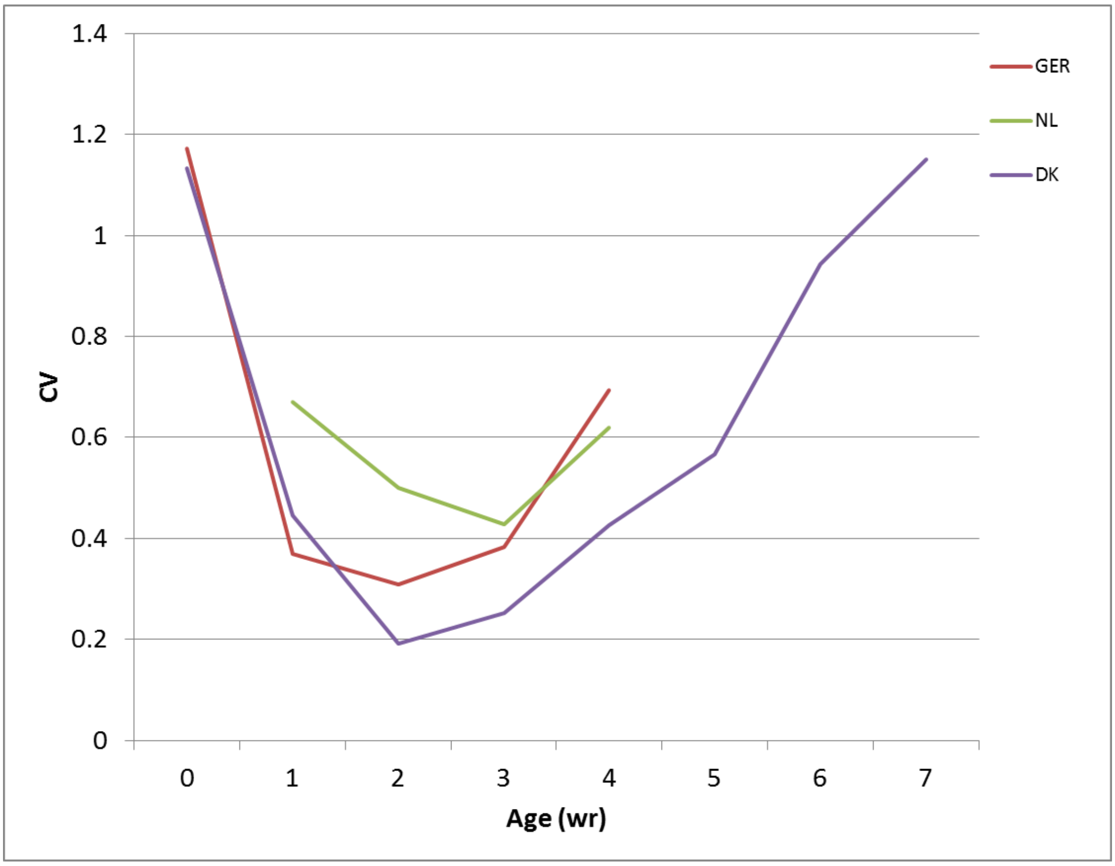

Figure 5.16. CV on abundance at age for sprat in each national survey from the analysis in StoX.

Annex 4d: IESSNS

Working Document to

ICES Working Group on Widely Distributed Stocks (WGWIDE), AZTI-Tecnalia, Pasaia, Spain, 25 – 31 August 2015

Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) with M/V ”Brennholm”, M/V “Eros”, M/V “Christian í Grótinum” and R/V “Árni Friðriksson”, 1 July - 10 August 2015

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Executive summary

The international ecosystem summer survey in the Nordic Seas (IESSNS) was performed during 1 July to 10 August 2015 on four vessels from Norway (2), Iceland (1) and Faroes (1). Greenland chartered the Icelandic vessel for 12 days to cover the East Greenland area. A standardised pelagic trawl swept area method was used to obtain abundance indices and study the spatial distribution NEA mackerel in relation to other pelagic fish stocks, ecological and environmental factors in the Nordic Seas as in recent years. One of the main objectives is to provide age-disaggregated abundance indices on an annual basis with uncertainty estimates for NEA mackerel applicable as a tuning series in the stock assessment.

The total swept area biomass index of NEA mackerel in summer 2015 was 7.7 million tonnes distributed over an area of 2.7 million square kilometres in the Nordic Seas. The estimate in 2015 is 1.3 million tonnes lower than in 2014 (9.0 million tonnes), when it was distributed over an area of 2.4 million square kilometres. The 2011-year class contributed with 28% of numbers followed by the 2010-year class with 22%. The 2012 year class had 12% in number. Altogether 71% of the estimated number of mackerel was less than 6 years old. The internal consistency plot for age-disaggregated year classes has improved since the benchmark in 2014 by the inclusion of two more survey years. This is especially apparent for younger ages. There is now good internal consistency for 1-10 years old mackerel, except between age 5 and 6.

Mackerel was observed in most of the surveyed area, and the zero boundaries were found in the large majority of areas. The mackerel had a more patchy distribution in July-August 2015 based on the trawl catches compared to previous years. The mackerel were also present in smaller quantities in the northernmost and westernmost regions of the surveyed area compared to the last few years.

Norwegian spring-spawning (NSS) herring was measured acoustically during the survey and the abundance index of age 4+ came to 22.7 billions, which is comparable to the May survey index in 2015 of 20.3 billions. The 2004, 2005 and 2009 year classes were most abundant in the survey. The NSS herring was mainly found north of the Faroe Islands and to the east and north off Iceland. Small concentrations were found in the northern and eastern areas, while herring had low concentrations in the central part of the Norwegian Sea.

The spatio-temporal overlap between NEA mackerel and NSS herring in July-August 2015 was highest in the south-eastern, southern and south-western part of the Norwegian Sea. Herring was most densely aggregated in areas where zooplankton concentrations where high compared to other regions. Mackerel, on the other hand, was distributed in most of the surveyed area, and in areas with more varying zooplankton concentrations.

Blue whiting was not prioritized during this IESSNS survey, hence no trawling was conducted on acoustic registrations of blue whiting. Additionally, acoustic registrations were limited to the upper 200 m in part of the survey area. Thus the results of the survey can neither be used to quantify nor map the distribution of blue whiting in the Nordic Seas in the summer 2015.

Lumpfish of all sizes were caught in the upper 30 m of the water column practically distributed everywhere within the total surveyed area. North Atlantic salmon, represented as postsmolt, grilse and adults, were mainly caught in central part of the Norwegian Sea during the IESSNS survey.

The SST in July-August 2015 was 1-2°C colder compared to 2014 throughout the surveyed area. The SST was close to the long term average for the last 20 years. This is in contrast to the generally increasing SST observed during last decade for most of the area, particularly in the Irminger Sea area.

The average concentration of zooplankton in the Norwegian Sea in July-August 2015 was slightly lower than in 2014, or 7.2 g/m^2 compared to 8.1 g/m^2 in 2014. West and south of Iceland and in east Greenlandic waters the average concentrations were higher than in 2014.

Dedicated whale observations (North Atlantic Sighting Survey (NASS)) were performed on the Icelandic vessel for the entire survey. These data are not available yet. Opportunistic whale observations were done by the two Norwegian vessels during the survey. Higher densities of especially fin whales, humpback whales and white beaked dolphins were observed off the coast of Finnmark and into the southern part of the Barents Sea.

Introduction

In July-August 2015, four vessels; the chartered trawler/purse seiners M/V "Brennholm" and M/V "Eros" from Norway, and M/V "Christian í Grótinum" from Faroe Islands, and the research vessel R/V "Árni Friðriksson" from Iceland, participated in the joint ecosystem survey (IESSNS) in the Norwegian Sea and surrounding waters. The vessel M/V "Birtingur" from Iceland had been chartered to participate on the IESSNS survey on behalf of Greenland, and cover part of Greenland waters in the western regions, but due to engine breakdown at the start of the survey it was not possible for "Birtingur" to participate. "Árni Friðriksson" then had to take over and conduct six of the planned stations in Greenland waters appointed initially to M/V "Birtingur". The five week coordinated survey from 1st of July to 10th of August 2015 is part of a long-term project to annually collect data on abundance, distribution, aggregation, migration and ecology of northeast Atlantic mackerel (*Scomber scombrus*) and other major pelagic species. Major aims of the survey were to quantify abundance, spatio-temporal distribution, aggregation and feeding ecology of Northeast Atlantic mackerel in relation to distribution of other pelagic fish species such as Norwegian spring-spawning herring (*Clupea harengus*), oceanographic conditions and prey communities. Dedicated whale observations were conducted on the Icelandic research vessel as part of the 2015 North Atlantic Sighting Survey. Opportunistic whale observations were conducted on the Norwegian vessels in order to collect data on distribution and aggregation of marine mammals in relation to potential prey species and the physical environment. The pelagic trawl survey was initiated by Norway in the Norwegian Sea in the beginning of the 1990s. Faroe Islands and Iceland participated in the joint mackerel-ecosystem survey since 2009.

The main objective of the IESSNS survey in relation to quantitative assessment is to provide reliable and consistent age-disaggregated abundance indices of NEA mackerel. WKPELA meeting was held in ICES HQ in Copenhagen from the 21-27 February 2014, to benchmark the assessment of mackerel in the Northeast Atlantic. In the case of NEA mackerel the previous assessment was not considered to give a reliable estimate of the development of the stock, and this assessment was limited by lack of independent age-structured indices. There was an agreement during the benchmark meeting to include age-structured indices on adults from the IESSNS swept-area trawl survey. It was decided back then that an age-disaggregated time-series for analytical assessment should be restricted to adult mackerel at age 6 years and older. New data and results from the IESSNS mackerel-ecosystem surveys in July-August 2014 and 2015 providing a longer time series (2007, 2010-2015) used for swept area abundance estimation on NEA mackerel. In addition, methodological and statistical changes and improvements in the survey design, age-disaggregated abundance estimations on the total biomass and on different age-groups including uncertainty estimates have improved the quality and consistency of the NEA mackerel abundance estimation. A manuscript entitled "Quantifying changes in abundance, biomass and spatial distribution of Northeast Atlantic (NEA) mackerel (*Scomber scombrus*) in the Nordic Seas from 2007 to 2014", based on swept area data and results from IESSNS surveys has been accepted for publication in ICES Journal of Marine Science. A preliminary run estimating the abundance of NEA mackerel by swept area analyses using the newly developed software program StoX was conducted by scientists at the Institute of Marine Research in Norway. A direct comparison between socalled "banana shape" (curved) pelagic trawl towing at the surface and "straight forward" trawl towing where performed in Norwegian, Icelandic and Greenland waters during the IESSNS survey in July-August 2015.

The Norwegian Spring Spawning (NSS) herring, in addition to other herring populations within the survey area, were mapped using acoustic methodology including standardized line transects. NSS herring was scrutinized using the primary echosounder frequency of 38 kHz. The abundance estimation on NSS herring was conducted using the program Beam in similar way as conducted during the International Ecosystem Spring Survey in the Nordic Sea (IESNS) in May-June 2015. It must be noted that even if the IESSNS covers the spatial distribution of blue whiting adequately very few deep trawl hauls were taken on likely acoustic registrations of blue whiting and acoustic registrations deeper than 200 m were not scrutinized in part of the survey area. Thus, the results of the survey can neither be used to quantify, nor map the distribution of blue whiting in the Nordic Seas in the summer 2015. This situation is similar as for the IESSNS in the summer 2014.

Material and methods

Coordination of the survey was done during an international meeting in Reykjavik, Iceland in April 2015 and by correspondence in spring and summer 2015. The participating vessels together with their effective survey periods are listed in Table 1. One additional ship, M/S *Birtingur* was chartered, staffed and equipped by the Greenlandic Institute of Natural Resources. However, the engine of M/S *Birtingur* failed and the ship had to abort the survey. This led to less survey effort in SW Greenland and western international waters than planned.

In general, the weather conditions were calm with good survey conditions on the Norwegian vessels "Brennholm" and "Eros" for oceanographic monitoring, plankton sampling, acoustic registrations and pelagic trawling. Nevertheless some days onboard Brennholm and Eros had somewhat unfavourable conditions, although not hampering any scientific activities. The same was the case on the Faroese vessel "Christian í Grótinum" which experienced good weather conditions except for two days. "Árni Friðriksson" also experienced some windy days, in the southern part of Iceland in the beginning of the survey, but the adverse conditions did not affect the quality of the various scientific data collected during the survey to any extent.

During the survey the special designed pelagic trawl, Multpelt 832, was used by all four participating vessels for the fourth consecutive year. This trawl is a product of cooperation between participating institutes in designing and constructing a standardized sampling trawl for the IESSNS. The work was lead by trawl gear scientist John Willy Valdemarsen, Institute of Marine Research (IMR), Bergen, Norway, and has been in good progress and improved steadily for five years now. The design of the trawl was finalized during meetings of fishing gear experts and skippers at meetings in January and May 2011. Further discussions on modifications in standardization between the rigging and operation of Multpelt 832 was done during a trawl expert meeting in Copenhagen 17-18 August 2012, in parallel with the post-cruise meeting for the joint ecosystem survey, and then at the WKNAMMM workshop and tank experiments on a prototype (1:32) of the Multpelt 832 pelagic trawl, conducted as a sequence of trials in Hirtshals, Denmark from 26 to 28 February 2013 (ICES 2013a). The swept area methodology was also presented and discussed during the WGISDAA workshop in Dublin, Ireland in May 2013 (ICES 2013b). The standardization and quantification of catchability from the Multpelt 832 pelagic trawl was further discussed during the mackerel benchmark in Copenhagen in February 2014. Recommendations and requests coming out of the mackerel benchmark have further been implemented and improved on all the four vessels involved during the IESSNS survey in July-August 2014 and in July-August 2015. Working documents and scientific manuscripts have been written on swept area abundance estimation of NEA mackerel, survey design as well as standardization and improvements on the survey methodology based on the pelagic trawling with the Multpelt 832 sampling trawl (Nøttestad et al. accepted for publication in ICES Journal of Marine Science).

Table 1. Survey effort by each of the four vessels in the IESSNS survey in 2015.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton stations

Árni Friðriksson	6/7-10/8	7166	92	92	92
Christian í Grótinum	3/7- 19/7	2969	43	40	40
Brennholm	3/7-28/7	4395	52	52	52
Eros	1/7-28/7	4511	48	47	47
Total	2/7-12/8	16072	282	281	272

Hydrography and Zooplankton

The hydrographical and plankton stations by all vessels combined are shown in Figure 2. Árni Friðriksson was equipped with a SEABIRD CTD sensor with a water rosette that was applied during the entire cruise. Christian í Grótinum was equipped with a mini SEABIRD SBE 25+ CTD sensor, and Brennholm and Eros were equipped with SEABIRD CTD sensors. The CTD-sensors were used for recording temperature, salinity and pressure (depth) from the surface down to 500 m, or to the bottom when at shallower depths.

All vessels collected and recorded also oceanographic data from the surface either applying a thermosalinograph (temperature and salinity) placed at approximately 6 m depth underneath the surface or a thermograph logging temperatures continuously near the surface throughout the survey.

Zooplankton was sampled with a WP2-net on all vessels. Mesh sizes were 180 μm (Brennholm and Eros) and 200 μm (Árni Friðriksson and Christian í Grótinum). 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. Detailed description of the zooplankton and CTD sampling is provided in the survey manual (ICES 2014b).

This year, it was possible to take all planned CTD and plankton stations. The number of stations taken by the different vessels is provided in Table 1.

Light measurements were done during all trawl hauls. These data have not yet been analysed and therefore the results are not presented in this report, but will be reported later.

Trawl sampling

Trawl catches were 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. On Christian í Grótinum, trawl catches were sub-sampled - 100 kg (if it was clean catch of either herring or mackerel) to 200 kg (if it was a mixture of herring and mackerel); otherwise the same sample processing protocol was followed as on the other three vessels.

All vessels used the Multpelt 832 pelagic trawl and continued and improved standardization of fishing gear and deployment was emphasised in the survey (see ICES 2013a; ICES 2014c; Valdemarsen et al. (submitted manuscript); Rosen et al. (submitted manuscript)). Standardization and documentation/quantification of effective trawl width trawl depth and catch efficiency was improved according to requests during the mackerel benchmark (ICES 2014c). The most important properties of the Multpelt 832 trawls and their rigging during operation on the survey for participating vessels are given in Table 3.

Table 2. Summary of biological sampling in the survey from 1July – 10 August 2015 by the four participating countries. Numbers denote the maximum number of individuals sampled for each species for the different determinations.

	Species	Faroes	Iceland	Norway
Length measurements	Mackerel	200/100*	150	100
	Herring	200/100*	200	100
	Blue whiting	200/100*	50	100
	Other fish sp.	0	50	25
Weighed, sexed and maturity determination	Mackerel	20	50	25
	Herring	20	50	25
	Blue whiting	50	50	25
	Other fish sp.	0	10	0
Otoliths/scales collected	Mackerel	20	25	25
	Herring	20	50	25
	Blue whiting	50	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
Tissue for genotyping	Mackerel	0	350	900
	Herring	50	50	

*200 length measurements. 100 are also weighed

Table 3. Trawl settings and operation details during the international mackerel survey in the Nordic Seas in July-August 2015. The column for influence indicates observed differences between vessels likely to influence performance. Influence is categorized as 0 (no influence) and + (some influence).

Properties	**Brennholm**	**Árni Friðriksson**	**Eros**	**Christian í Grótinum**	**Influence**
Trawl producer	Egersund Trawl AS	Tornet/Hampiðjan (50:50)	Egersund Trawl AS	Vónin	0
Warp in front of doors	Dyneema – 32 mm	Dynex-34 mm	Dyneema -32 mm	Dynema – 34mm	+
Warp length during towing	350 m	350 m	350 m	350 m	0
Difference in warp length port/starboard	0-4 m	3-12 m	0-4 m	5-12 m	0
Weight at the lower wing ends	400 kg	170 kg	300 kg	400kgSB 500kgPS	0
Setback in metres	6 m	6 m	6 m	6 m	+
Type of trawl door	Seaflex adjustable hatches	Jupiter	Seaflex adjustable hatches	Injector F-15	0
Weight of traw door	2000 kg	2200 kg	1700 kg	2000 kg	+
Area trawl door	9 m² 75% hatches (effective 6.5m²)	7 m²	7.5 m² 25% hatches (effective 6.5m²)	6 m²	+
Towing speed (GPS) in knots	4.8 (4.5-5.2)	4.9 (3.4-5.4)	4.8 (4.5-5.2)	4.5 (3.3-5.3)	+
Trawl height	28-35	27-30	29-35	36-52	+
Door distance	110-117 m	110-114 m	110-117 m	104-113	+
Trawl width*	-	-	-	-	+
Turn radius	5-10 degrees turn	5-10 degrees turn	5-10 degrees turn	5-10 degrees turn	+
A fish lock in front end of cod-end	Yes	Yes	Yes	Yes	+
Trawl door depth (port and starboard)	10-18, 10-17 m	8-13, 10-15 m	5-12, 7-14 m	5-15 m	+
Headline depth	0-1 m	0-1 m	0-1 m	0-1 m	+
Float arrangements on the headline	Kite +2 buoys on each wing	Kite + 2 buoys on wings	Kite + 2 buoys on each wingtip	Kite + 2 buoys on wingtips	+
Weighing of catch	All weighted	All weighted	All weighted	All weighted	+

Marine mammal observations

Dedicated whales observations were conducted onboard R/V "Árni Friðriksson" during the entire surveys from 6th of July until 10th of August 2015. Opportunistic observations of marine mammals were conducted by trained scientific personnel and crew members from the bridge between 1st and 28th of July 2015 onboard the Norwegian chartered vessels M/V "Brennholm" and M/V "Eros", respectively. The priority periods of observing were during the transport stretches from one trawl station to another. Observations were done 24 h per day if the visibility was sufficient for marine mammal sightings. Digital filming and photos were taken whenever possible on each registration from scientists onboard.

Underwater camera observations during trawling

All vessels employed an underwater video camera (GoPro HD Hero 3 Black Edition, www.gopro.com) or high definition Sony camera in the trawl to observe mackerel behaviour during trawling. The camera was put in a waterproof box which tolerated pressure down to approximately 100 m depth,

The goal of the video recordings was to observe and assess: individual and schooling behaviour, escapement from the cod end and through meshes, patchiness and swimming performance of mackerel. No light source was employed with cameras, hence, recordings were limited to day light hours. Video recordings were collected at about 20 % of trawl stations onboard Brennholm and Eros. Onboard Christian í Grótinum video recordings were collected at 15% of trawl stations and on a total of 15 trawl stations taken by RV Árni Friðriksson. Analyses of the recording material are underway and will be presented by other means when available.

Photo 1. GoPro camera inside a waterproof box, mounted on steel frame and ready for employment in trawl on Finnur Fríði IESSNS 2014.

Photo 2. GoPro camera attached to inside of trawl by fish lock on Finnur Fríði IESSNS 2014. The steel frame was tied to trawl, at each corner using rope.

Acoustics

Multifrequency echosounder

The acoustic equipment onboard Brennholm and Eros were calibrated 29th of June 2015 for 18, 38 and 200 kHz. Árni Friðriksson was also calibrated on 10th of April 2015 for the frequencies 18, 38, 120 and 200 kHz and Christian í Grótinum was calibrated on 29-30th June 2015 for 38, 120 and 200 kHz prior to the cruise. All vessels used standard hydro-acoustic calibration procedure for each operating frequency (Foote, 1987). CTD measurements were taken in order to get the correct sound velocity as input to the echosounder calibration settings.

Generally, acoustic recordings were scrutinized on daily basis using the softwares LSSS onboard Eros, Brennholm and Árni Friðriksson, and Echoview onboard Christian í Grótinum. Species were 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.

For acoustic abundance estimation of the NSS herring stock 38 kHz was used as the main frequency while it was 200 kHz for the NEA mackerel. However, it has to be noted that acoustic data collected on mackerel have substantial limitations as it is conducted now, due to different reasons, including the low target strength of mackerel and the distribution of the majority of the mackerel in the acoustic dead zone shallower than the face of the acoustic transducers with or without a drop keel installed in the hull. A summary of acoustic settings is given in Table 4.

Acoustic estimates of herring 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 2014a) and detailed in the manual for the surveys (ICES 2014b).

Table 4. Acoustic instruments and settings for the primary frequency in the July/August survey in 2015.

	M/V Brennholm	R/V Árni Friðriksson	M/V Eros	M/V Chr. í Grótinum
Echo sounder	Simrad EK60	Simrad EK 60	Simrad EK 60	Simrad EK 60
Frequency (kHz)	18, 38, 70, 120, 200	18, 38, 120, 200	18, 38, 70, 120, 200	38,120, 200
Primary transducer	ES38B	ES38B	ES38B	ES38B
Transducer installation	Drop keel	Drop keel	Drop keel	Hull
Transducer depth (m)	9	8	9	5
Upper integration limit (m)	15	15	15	12
Absorption coeff. (dB/km)	9.9	10	9.9	9.9
Pulse length (ms)	1.024	1.024	1.024	1.024
Band width (kHz)	2.43	2.425	2.425	2.43
Transmitter power (W)	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-21.1	-20.9	-20.6	-20.7
TS Transducer gain (dB)	24.87	24.64	23.27	26.44
s_A correction (dB)	-0.60	-0.84	-0.65	-0.66
alongship:	6.89	7.31	7.01	7.07
athw. ship:	6.87	6.95	7.11	7.06
Maximum range (m)	500	500 (750 in Greenlandic waters)	500	500
Post processing software	LSSS	LSSS	LSSS	Sonardata Echoview 6.x

Multibeam sonar

M/V “Brennholm” and M/V “Eros” were equipped with the Simrad fisheries sonars SX90 (frequency range: 111.5-115.5 kHz), with a scientific output incorporated which allow the storing of the beam data for post-processing. One of the objectives in this survey was to continue the test of the software module “Processing system for fisheries omni-directional sonar, PROFOS” in LSSS at the Institute of Marine Research in Norway. The first test was done during the 2010 survey, and the basic processing was described in the cruise report (Nøttestad et al., 2010). The PROFOS module is in a late development phase and for this survey, functionalities for school enhancement by image processing techniques and for automatic school detection have been incorporated (Nøttestad et al., 2012; 2013).

Acoustic doppler current profiler (ADCP)

M/V “Brennholm” are equipped with a scientific ADCP, RDI Ocean surveyor, operating at 75 kHz and/or 150 kHz. The data collected within large areas of the Norwegian coast, Norwegian Sea and southern part of the Barents Sea during the survey will be quality checked and used for later analysis.

Cruise tracks

M/V “Brennholm”, M/V “Eros”, M/V “Chr. í Grótinum” and R/V “Árni Friðriksson” followed predetermined survey lines with pre-selected surface trawl stations (Figure 1). An adaptive survey design was also adopted although to a small extent, due to uncertain geographical distribution of our main pelagic planktivorous schooling fish species. The main adaptation was in the Icelandic-south stratum where it was extended southwards to determine the zero line of mackerel distribution. The cruising speed was between 10-12.0 knots if the weather permitted otherwise the cruising speed was adapted to the weather situation.

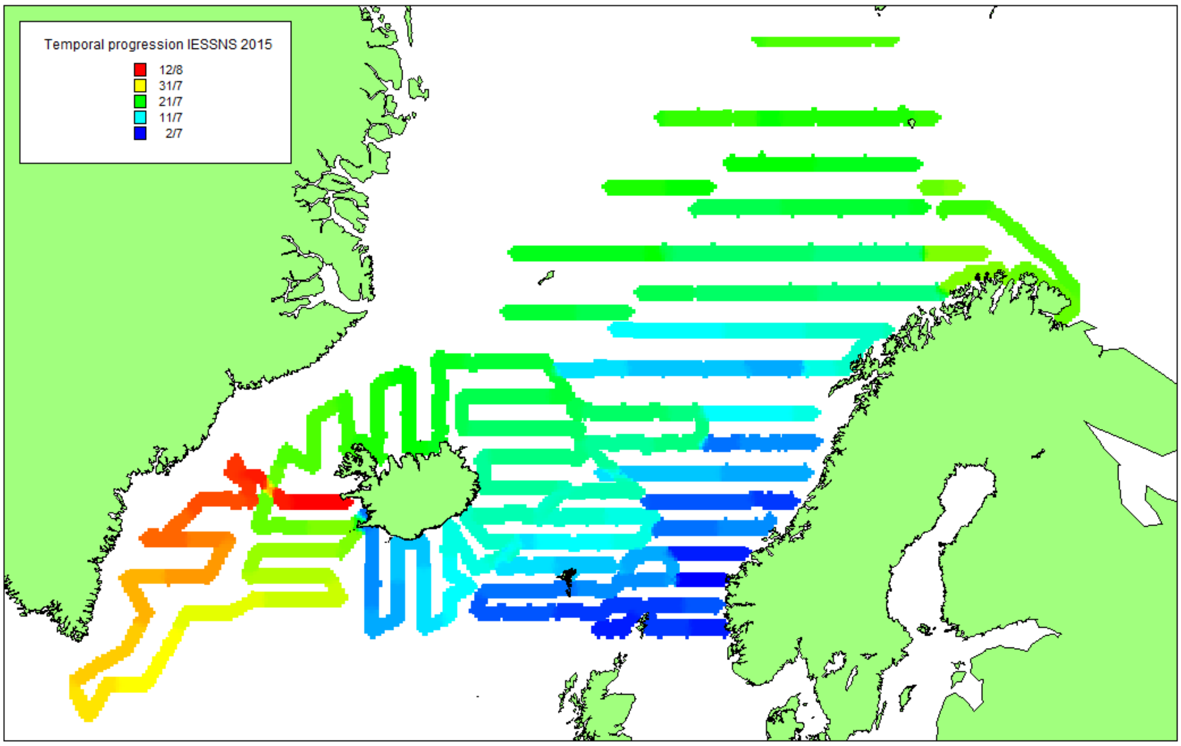


Figure 1. Cruise tracks showing the temporal progression from blue (2/7) to red (12/10) within the covered areas of the Norwegian Sea and surrounding waters from 1st of July to 10th of August 2015.

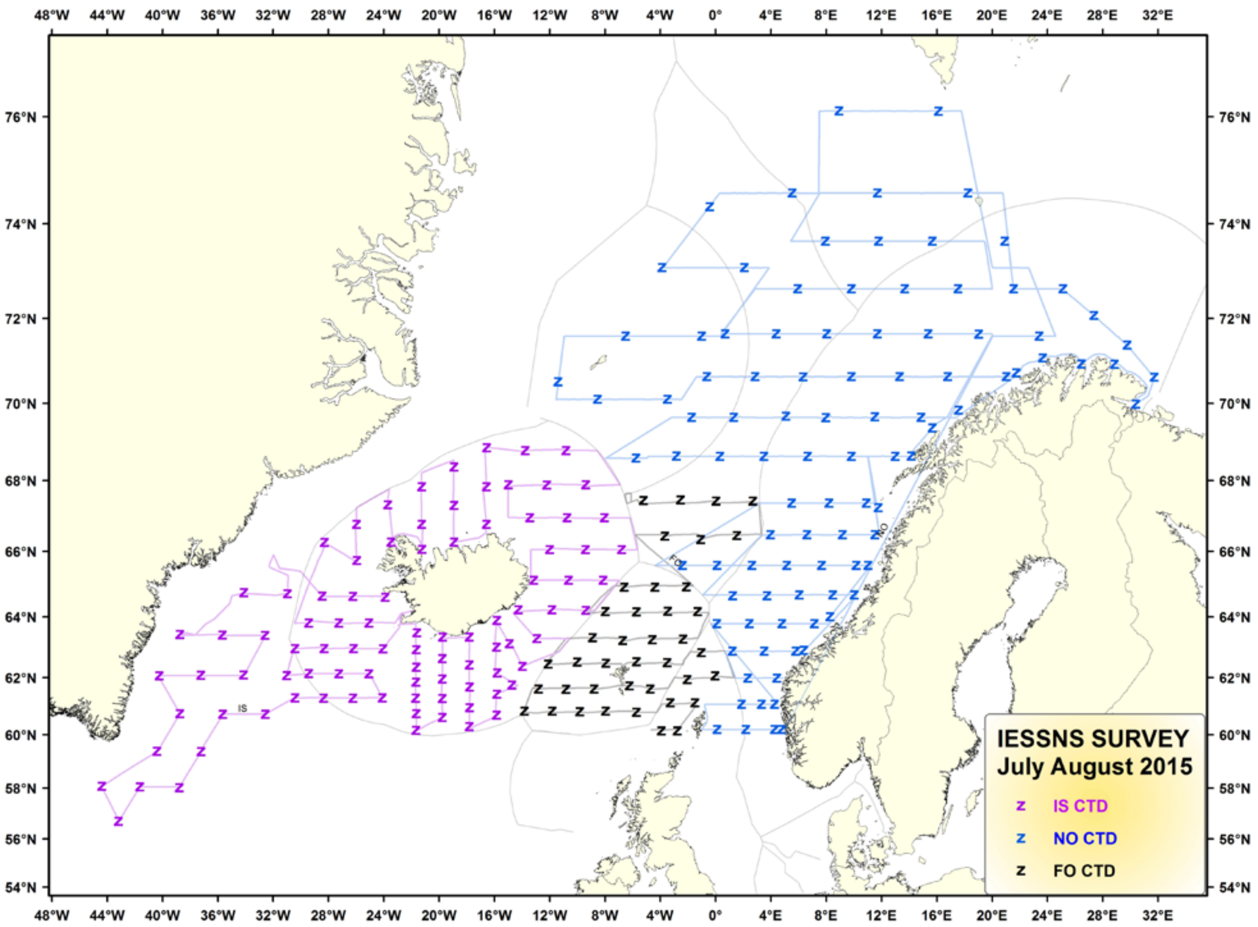


Figure 2. CTD stations (0-500 m) using SEABIRD SBE 37 (Arni Fridriksson, purple) SEABIRD SB 25+ (Christian í Grótinum, black) and SAIV SD200 (Brennholm and Eros, blue) CTD sensors and WP2 plankton net samples (0-200 m depth). These were taken systematically on every pelagic trawl station on all four vessels.

Swept area index and biomass estimation

The swept area estimate is based on catches in the whole area covered in the survey, or between 56°N and 76°N and 44°W and 32°E. Rectangle dimensions were 2° latitude by 4° longitude, i.e. the rectangle size was increased as compared to that used in estimates from previous years. This was done to make up for an increased distance between the trawl stations in some of the strata and thereby avoid interpolation of number of rectangles. Allocation of the biomass to exclusive economic zones (EEZs) was done in the same way as in 2010-2014 (see Annex 1).

In order to calculate a swept area estimate, the horizontal width of the trawl opening is required. It is assumed that no mackerel is distributed below the ground rope (vertical opening of the trawl). Average trawl door spread, vertical trawl opening and tow speed were sampled on each vessel for all stations. Two different kinds of data are available, manually reported values from log books (one value per station) and digitally recorded data from trawl sensors. The digtally recorded data were analysed as follows: Average door spread and vertical opening were calculated for each station, then the average values per station were used to calculate mean, maximum (max), minimum (min) and standard deviation (st.dev.) for each vessel. Horizontal opening of the trawl was calculated by a formula using average values of trawl door horizontal spread and tow speed for each vessel. The results of the measurements and estimations for the four vessels are given in Table 5. Based on these results average horizontal trawl opening used in the swept area calculations was set at the following vessel specific values given as 'Horizontal trawl opening (m)' in Table 5.

Table 5. Descriptive statistics for trawl door spread, vertical trawl opening and tow speed for each vessel. Two different kinds of data were analyzed, manually reported values from log books (one value per station) and digitally recorded data from trawl sensors (*). Digitally recorded data were filtered prior to calculations; for trawl door spread all values < 80 m and > 140 m were deleted, and for opening vertical spread all values < 20 m and > 50 were deleted. Next, average door spread and vertical opening was calculated for each station, then the average values per station were used to calculate overall mean, maximum (max), minimum (min) and standard deviation (st.dev.) for each vessel. Number of trawl stations used in calculations is also reported. For Árni Friðriksson, trawl door spread is reported both for log book data and digital trawl sensor data (*). Horizontal trawl opening (**) was calculated using average vessel values for trawl door spread and tow speed (details in Table 6).

	Chr. í Grótinum	RV Árni Friðriksson		Brennholm	Eros
Trawl doors horizontal spread (m)					
Number of stations	43*	53*	90	52	48
mean	108*	111*	109	118.2	120
max	113*	116*	121	122	125
min	104*	104*	80	115	116
st. dev.	2.6*	2.5*	5	4.4	4
Vertical trawl opening (m)					
Number of stations	43*	48*	86	52	48
mean	39.7*	35*	36	31	33
max	52*	43*	55	36	38
min	36*	31*	30	28	29
st. dev.	2.9*	2.4*	3.5	4	4
Horizontal trawl opening (m) **					
mean	60.7	63		66	67
Speed (over ground, nmi)					
Number of stations	43	53*	92	52	48
mean	4.5	4.9*	4.9	5.0	4.8
max	5.3	5.4*	5.4	5.7	6.0
min	3.3	4.2*	3.4	4.1	4.2
st. dev.	0.4	0.2*	0.2	0.3	0.2

Horizontal trawl opening was calculated using average vessel values for trawl door spread and tow speed (Table 6). The estimates in the formulae were based on a flume tank simulations in 2013 (Hirtshals, Denmark) where formulas were developed from the for the horizontal trawl opening as a function of door spread, for two towing speeds, 4.5 and 5 knots:

Towing speed 4.5 knots: Horizontal opening (m) = 0.441 * Doorspread (m) + 13.094

Towing speed 5.0 knots: Horizontal opening (m) = 0.3959 * Doorspread (m) + 20.094

Table 6. Horizontal trawl opening as a function of trawl door spread and towing speed. Relationship based on simulations of horizontal opening of the Multpelt 832 trawl towed at 4.5 and 5 knots, representing the speed range in the 2014 survey, for various door spread. See text for details.

Door	Towing speed (knots)					
spread (m)	4.5	4.6	4.7	4.8	4.9	5
100	57.2	57.7	58.2	58.7	59.2	59.7
101	57.6	58.1	58.6	59.1	59.6	60.1
102	58.1	58.6	59.0	59.5	60.0	60.5
103	58.5	59.0	59.5	59.9	60.4	60.9
104	59.0	59.4	59.9	60.3	60.8	61.3
105	59.4	59.9	60.3	60.8	61.2	61.7
106	59.8	60.3	60.7	61.2	61.6	62.1
107	60.3	60.7	61.2	61.6	62.0	62.5
108	60.7	61.1	61.6	62.0	62.4	62.9
109	61.2	61.6	62.0	62.4	62.8	63.2
110	61.6	62.0	62.4	62.8	63.2	63.6
111	62.0	62.4	62.8	63.2	63.6	64.0
112	62.5	62.9	63.3	63.7	64.0	64.4
113	62.9	63.3	63.7	64.1	64.4	64.8
114	63.4	63.7	64.1	64.5	64.9	65.2
115	63.8	64.2	64.5	64.9	65.3	65.6
116	64.3	64.6	65.0	65.3	65.7	66.0
117	64.7	65.0	65.4	65.7	66.1	66.4
118	65.1	65.5	65.8	66.1	66.5	66.8
119	65.6	65.9	66.2	66.6	66.9	67.2
120	66.0	66.3	66.6	67.0	67.3	67.6

Results

Hydrography

The temperature in the surface layer from Iceland over Jan Mayen and to Svalbard was 1-2°C warmer in July 2015 than the average for the last 20 years (Figure 3). In the central and eastern part of the Norwegian Sea the SST was close to the 20 year average. South of the Greenland-Scotland ridge the SST was about 1 °C lower than the 20 year average. In 2014 much warmer SSTs were observed north of Iceland (Figure 4) and generally warmer in the whole Northeast Atlantic.

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 between years (Figures 3 and 4). However, since the anomaly is now based on averages values over whole July, it should give representative results of the surface temperature.

The upper layer (< 20 m depth) was 1-2°C colder in 2015 compared to 2014 more or less throughout the surveyed area (Figures 5 and 6). However, the temperature in the upper layer was more than 6°C, except along the north-western margin of the surveyed area where it was lower. In the deeper layers (50 m and deeper), the hydrographic features in the area were similar to 2013 and 2014. At all depths there was a clear signal from the cold East Icelandic Current, which originates from the East Greenland Current.

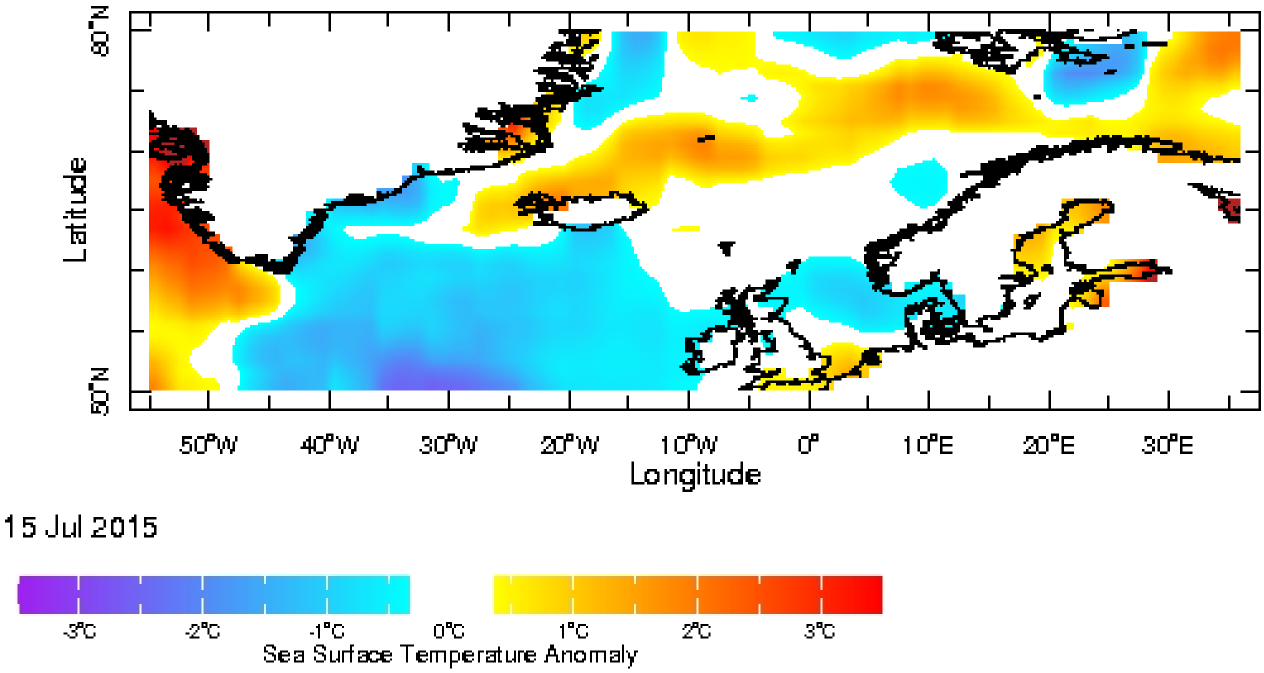


Figure 3. Sea surface temperature anomaly in July (°C; centered for mid July 2015) showing warm and cold conditions in comparison to a 20 year average.

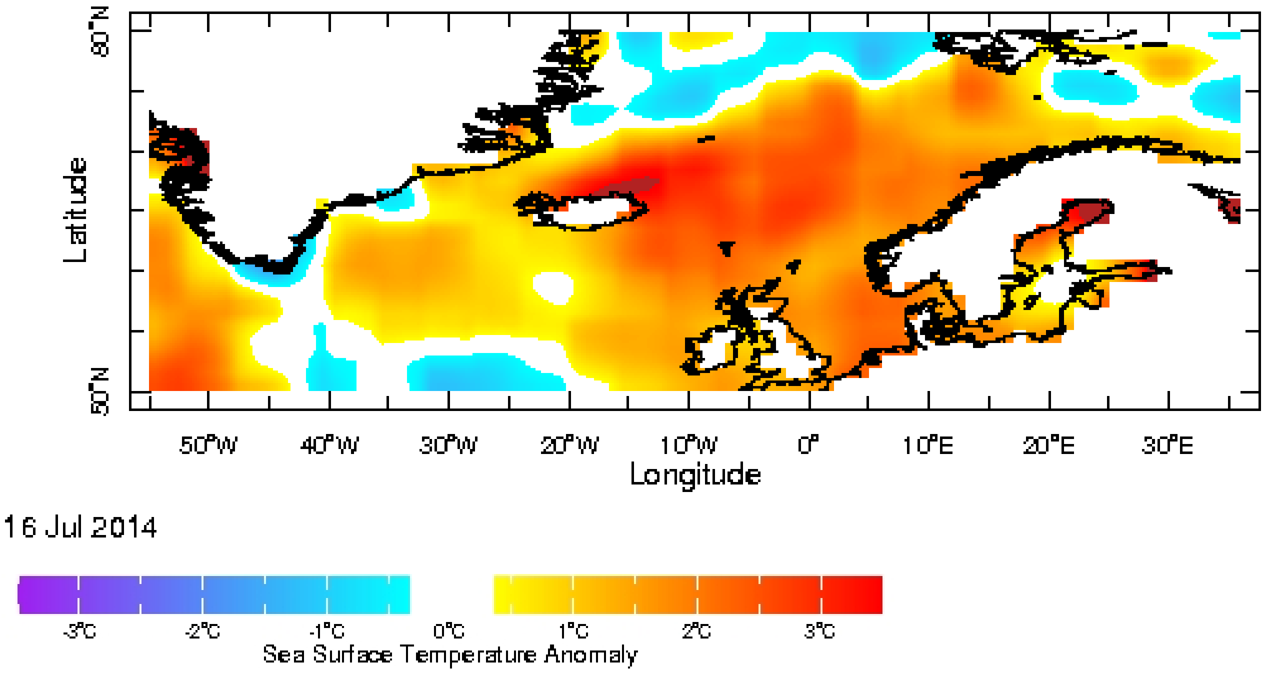


Figure 4. Sea surface temperature anomaly in July (°C; centered for mid July 2014) showing warm and cold conditions in comparison to a 20 year average.

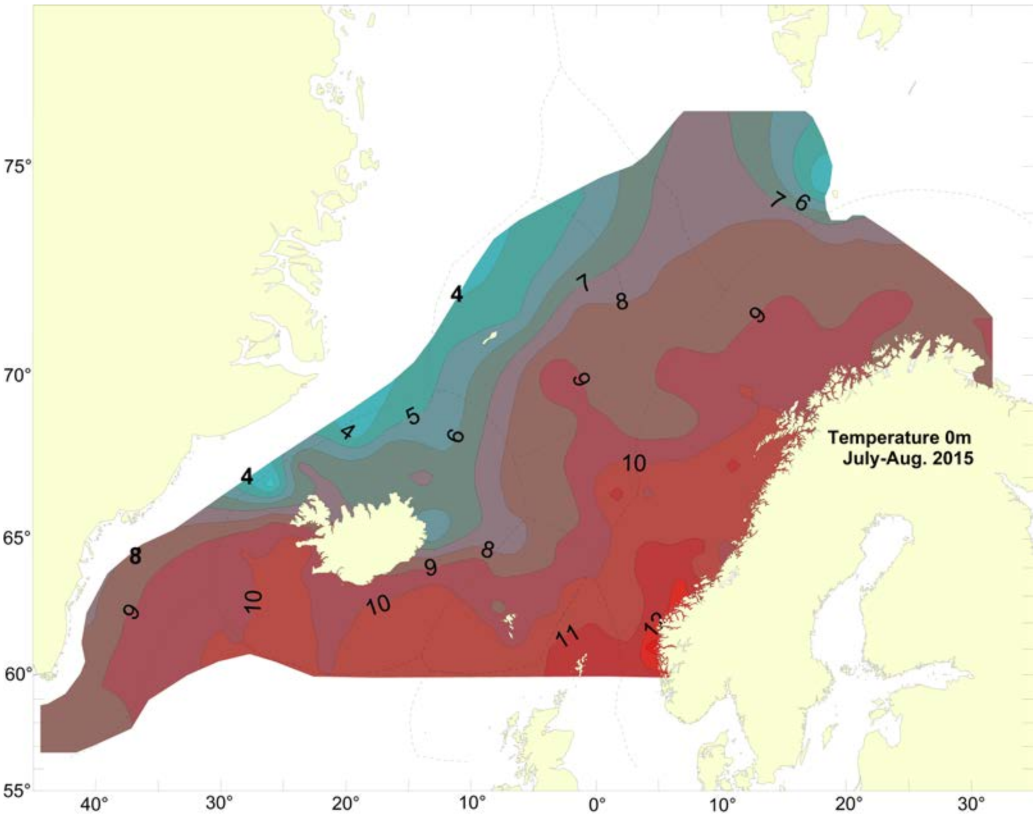


Figure 5. Temperature (°C) at 0 m depth in the Norwegian Sea and surrounding waters in July/August 2015.

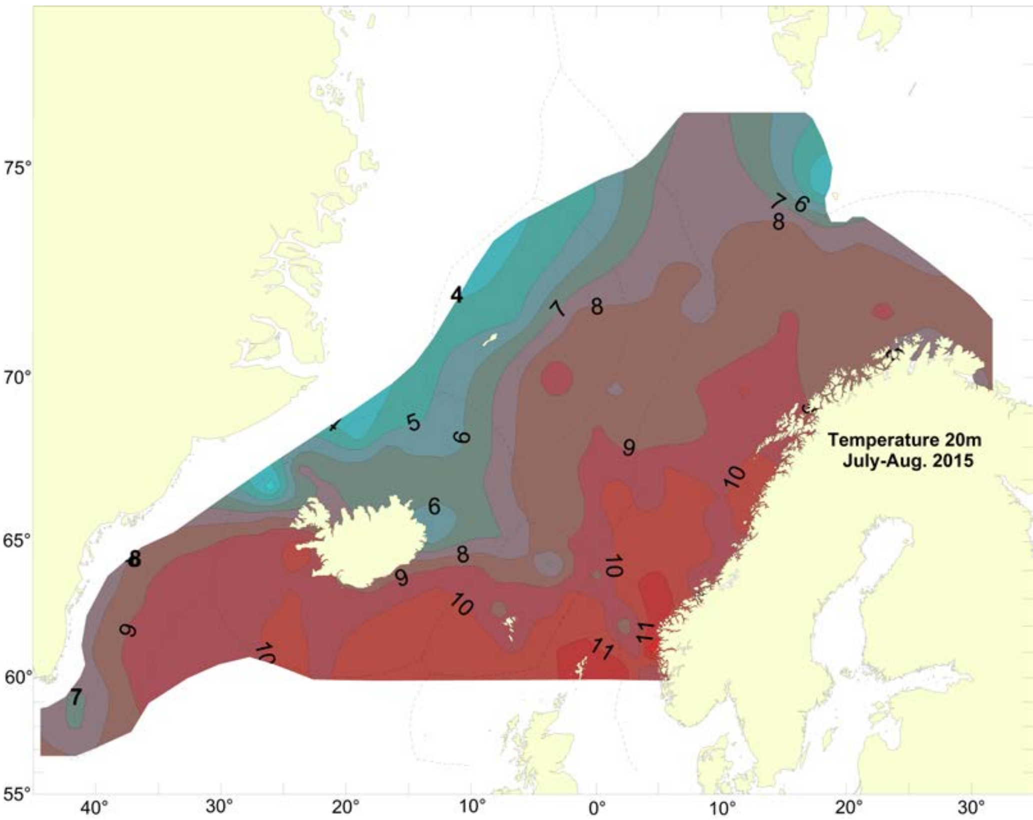


Figure 6. Temperature (°C) at 20 m depth in the Norwegian Sea and surrounding waters in July/August 2015.

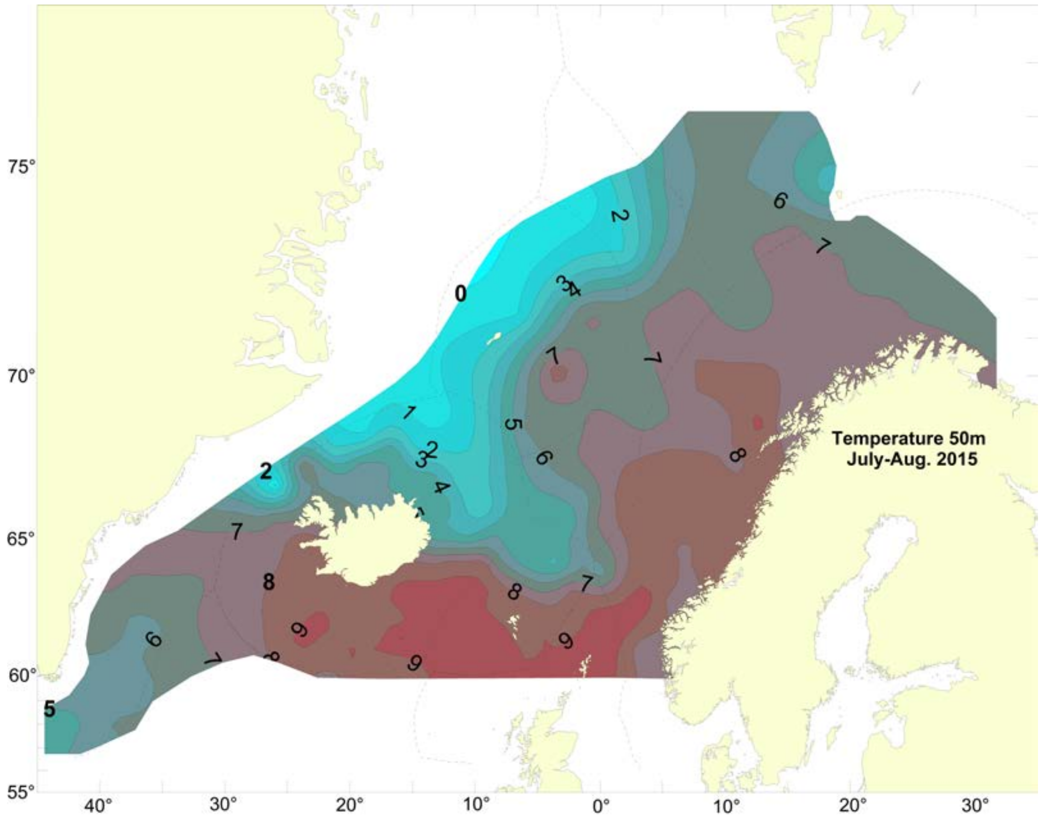


Figure 7. Temperature (°C) at 50 m depth in the Norwegian Sea and surrounding waters in July/August 2015.

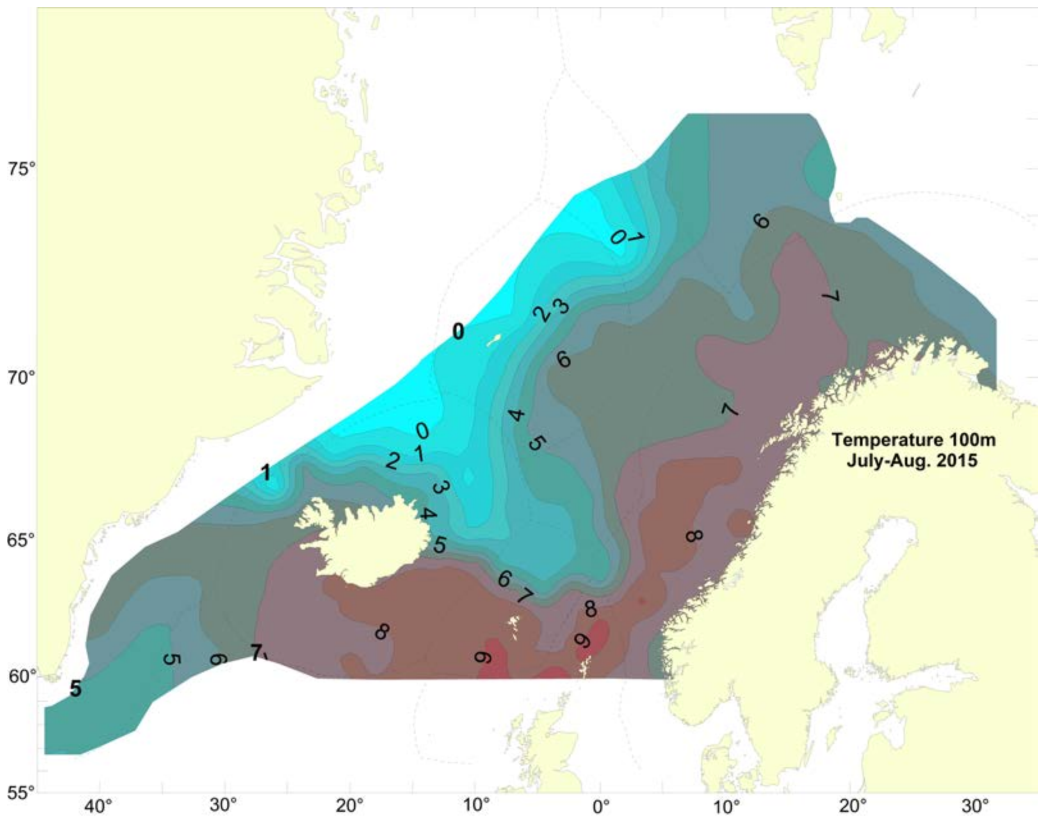


Figure 8. Temperature (°C) at 100 m depth in the Norwegian Sea and surrounding waters in July/August 2015.

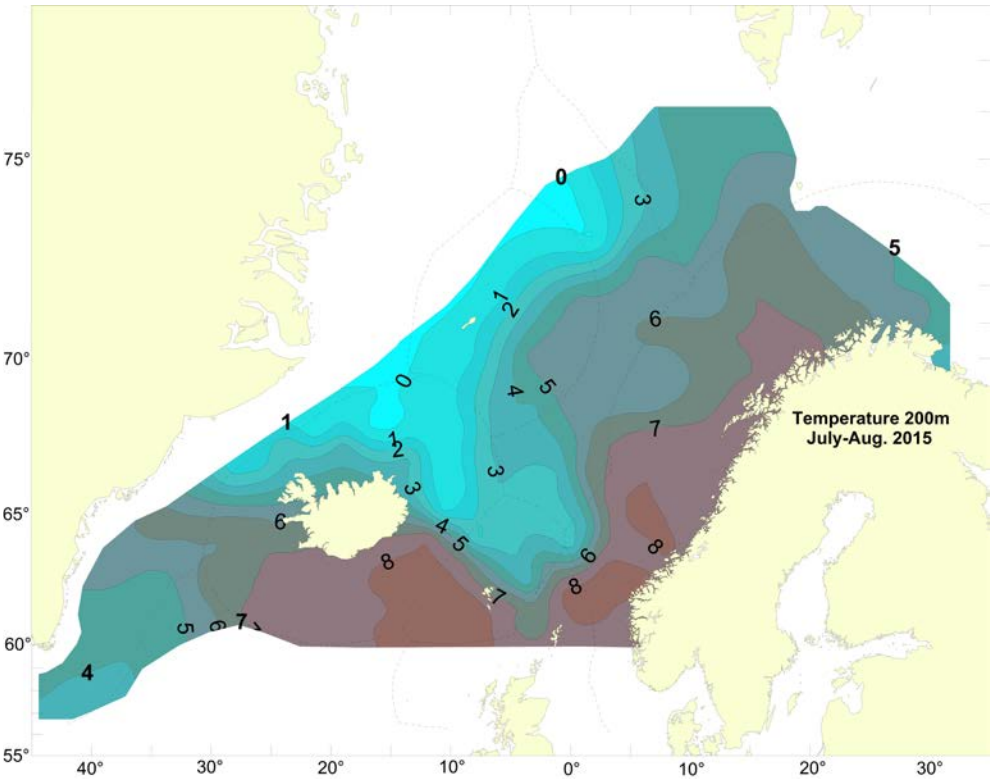


Figure 9. Temperature (°C) at 200 m depth in the Norwegian Sea and surrounding waters in July/August 2015.

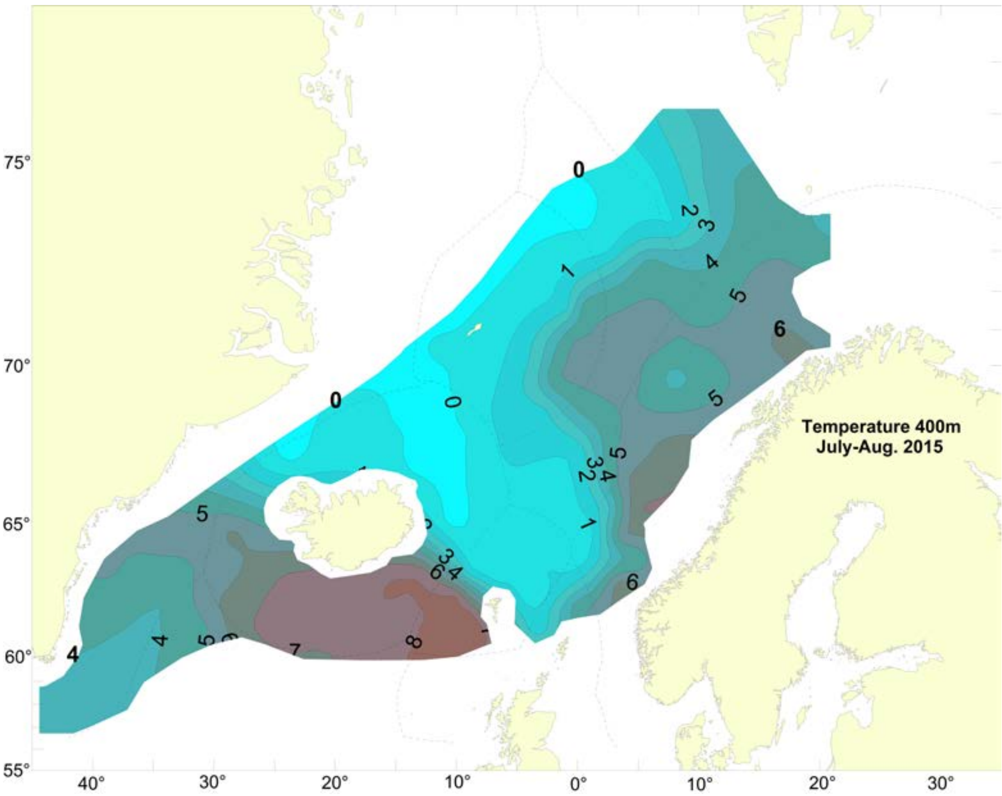


Figure 10. Temperature (°C) at 400 m depth in the Norwegian Sea and surrounding waters in July/August 2015.

Zooplankton

The average plankton biomass in the Norwegian Sea (north of 61°N and between 14°W and 17°E) in July-August was 7.4 g/m2, slightly lower than in 2014 and 2013 (8.1 g/m^2 and 8.4 g/m^2 respectively) (Table 7). However, the plankton concentrations were high in the northeastern part of the Icelandic area and the northern part of the Faroese area (Figure 11), as they also were in 2014 and 2013. The plankton density south and west of Iceland, as well as in the Greenlandic waters, was in the higher and highest range in the relatively short time series (Table 7). The concentrations in the central part of the Norwegian Sea were lower than in 2014, as were the concentrations in the north-eastern part (Svalbard area).

The zooplankton samples for species identification have not been examined in detail.

The decreased biomass of zooplankton in the Norwegian Sea as compared to 2014 is in agreement with what has been observed in the IESNS survey in May (ICES, 2015), where the zooplankton estimate in 2015 also decreased, compared to 2014. These data, however, need to be treated with some care, due to various amounts of phytoplankton between years and areas in the samples influencing the total amount of zooplankton (g dry weight/m^2) which is relevant as available food for pelagic planktivorous fish.

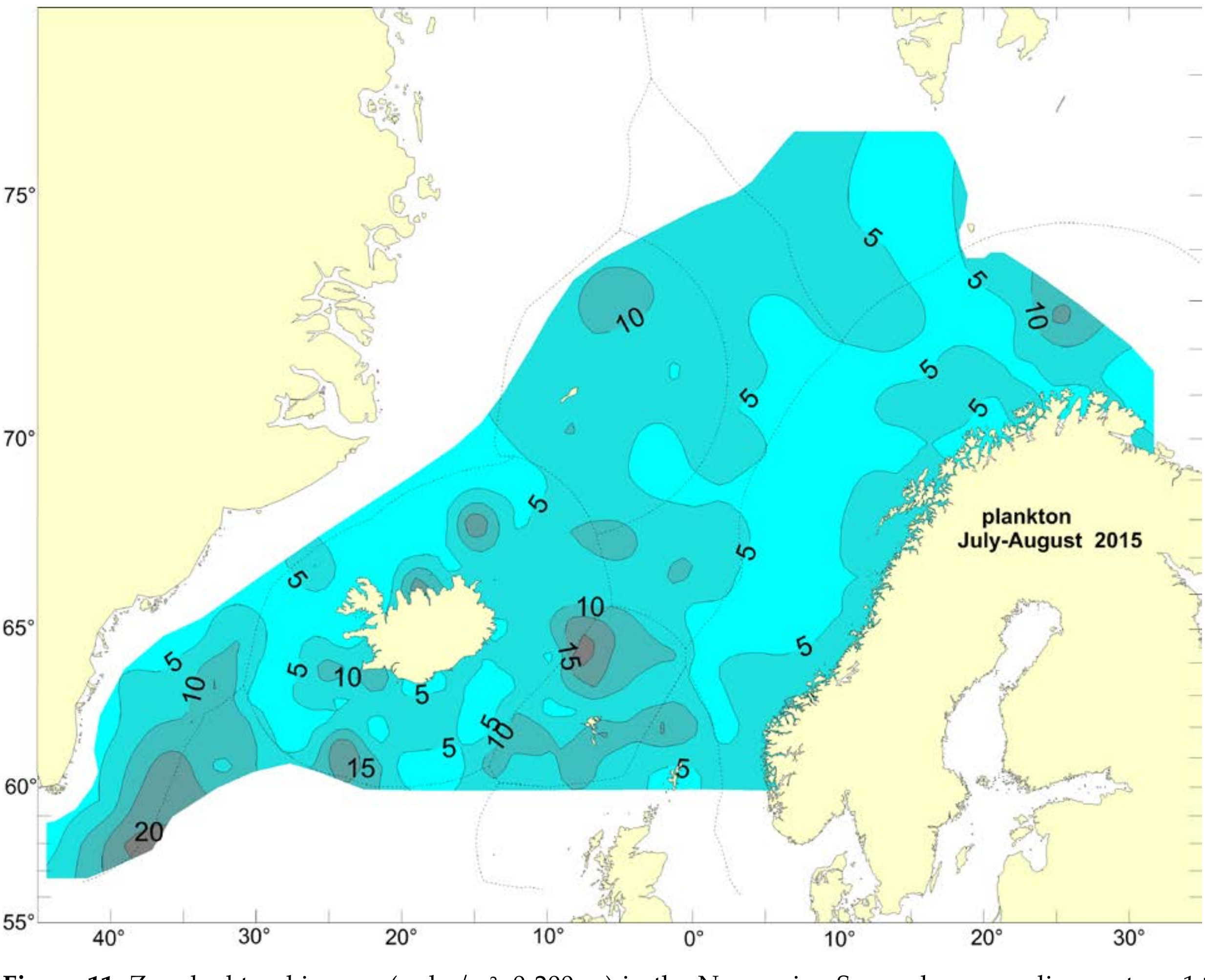


Figure 11. Zooplankton biomass (g dw/m^2, 0-200 m) in the Norwegian Sea and surrounding waters, 1st of July - 10th of August 2015.

Table 7. The time-series of zooplankton dry weight in IESSNS during 2010 to 2015 for Norwegian Sea (between 17°E and 14°W and north of 61°N), Icelandic waters (between 14°W and 30°W) and Greenlandic waters (west of 30°W). The number of samples is given in parentheses.

	Dry weight of zooplankton (mg/m2)			
Year	Norwegian Sea	Icelandic waters	Greenlandic waters	Total survey area
2010	6250 (168)	9276 (8)*		6387 (176)
2011	4622 (110)	7058 (61)		5491 (171)
2012	6014 (139)	5926 (55)	10086 (2)	6031 (196)
2013	8581 (188)	9990 (49)	13787 (14)	9147 (251)
2014	8155 (175)	4834 (47)	5308 (33)	7174 (255)
2015	7339 (138)	9064 (49)	15865 (20)	8705 (207)

	Dry weight of zooplankton (mg/m^2)		
Year	Norwegian Sea	Icelandic waters	Greenlandic waters
2010	6232 (172)	9276 (8)*	
2011	4622 (110)	7058 (61)	
2012	5998 (140)	5926 (55)	10086 (2)
2013	8421 (195)	9990 (49)	13787 (14)
2014	8138 (182)	4834 (47)	5308 (33)
2015	7353 (152)	9064 (49)	15865 (20)

*No plankton samples on the Icelandic vessel, only by Norwegian vessel north off Iceland.

Pelagic fish species

Mackerel

The total mackerel catches (kg) taken during the joint mackerel-ecosystem survey with the Multpelt 832 quantitative sampling trawl is presented in 2*4° rectangles in Figure 12. The map is showing different concentrations of mackerel from zero catch to more than 5000 kg.

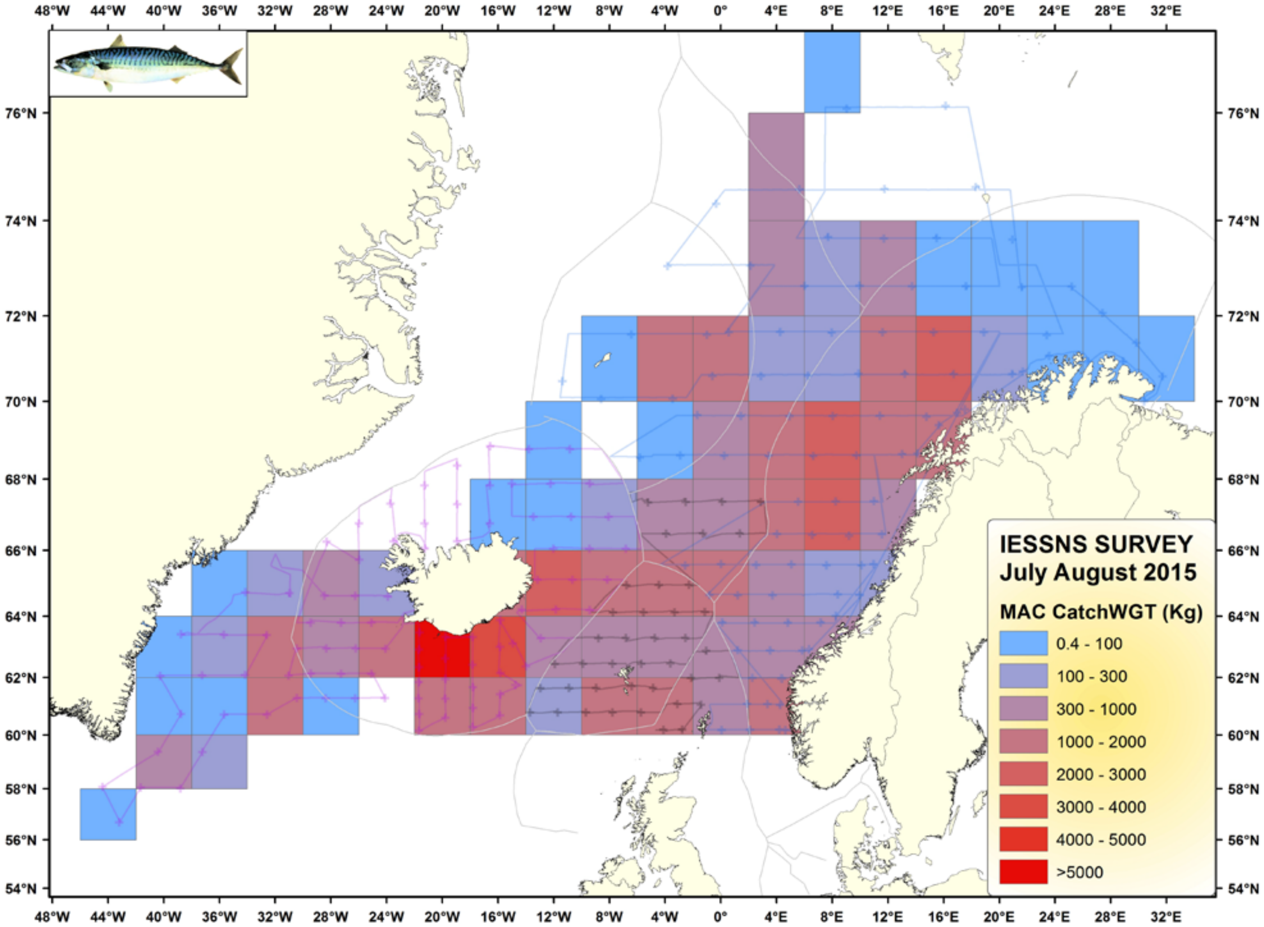


Figure 12. Catches of mackerel in kg represented in standardized rectangles (2° lat. x 4° lon.). Light blue represents small catches (0.3-100 kg), while dark red represents catches of more than 5000 kg mackerel after 30 min standardized towing with the Multpelt 832 pelagic trawl. Vessel tracks are shown as continuous lines. Trawl stations are marked as small crosses for each vessel. Empty rectangles surrounded by three or more were interpolated in the calculations on biomass/abundance and density indices.

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 (including northeast in the Barents Sea) and westernmost part of the covered area in July-August 2015 (Figure 13).

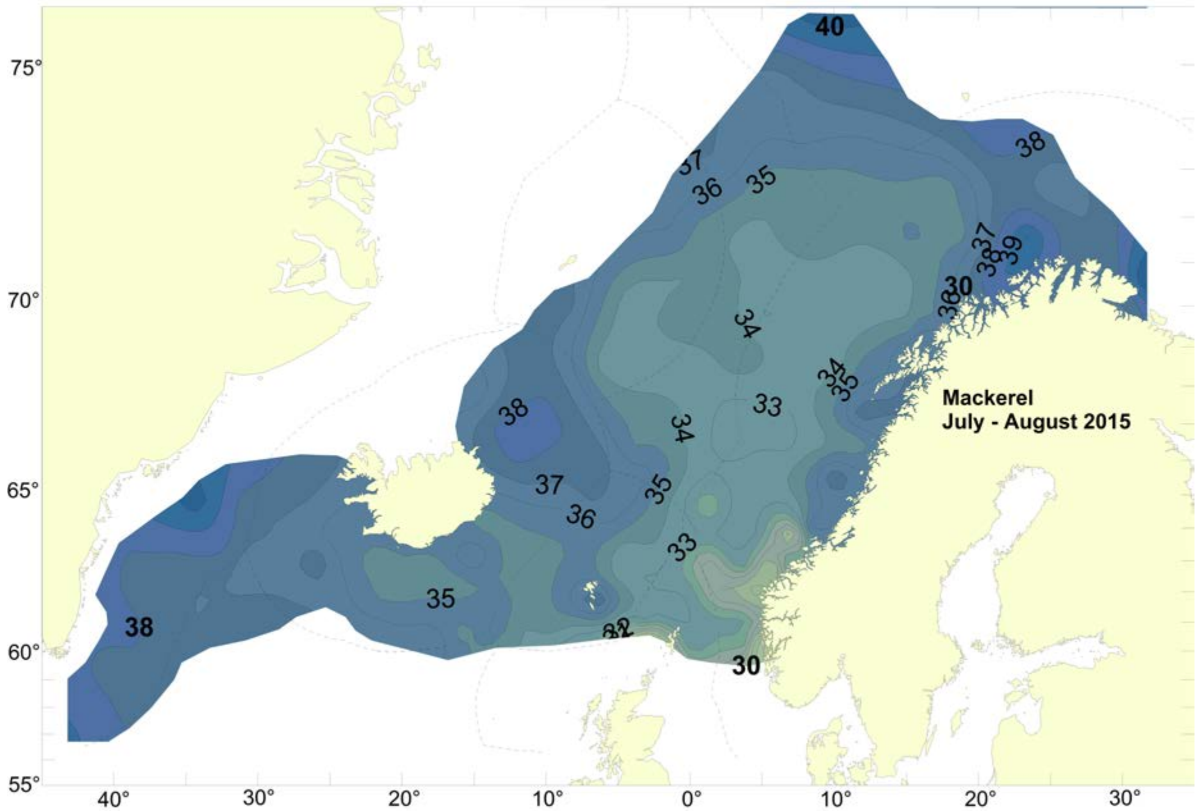


Figure 13. Average length distribution of NEA mackerel from the joint ecosystem survey with M/V "Brennholm", M/V "Eros", M/V "Christian í Grótinum" and R/V "Árni Friðriksson" in the Nordic Seas between 1st of July and 10th of August 2015.

Mackerel caught in the pelagic trawl hauls on the four vessels varied from 24 cm to 46 cm in length with the individuals between 30-33 cm and 35-38 cm dominating in the abundance. The mackerel weight (g) varied between 180 to 820 g (Figure 14). Some juvenile mackerel were caught in July-August 2015. The spatial distribution and overlap between the major pelagic fish species (mackerel, herring, blue whiting, salmon, lumpsucker) from the joint ecosystem survey in the Nordic Seas according to the catches are shown in Figure 15.

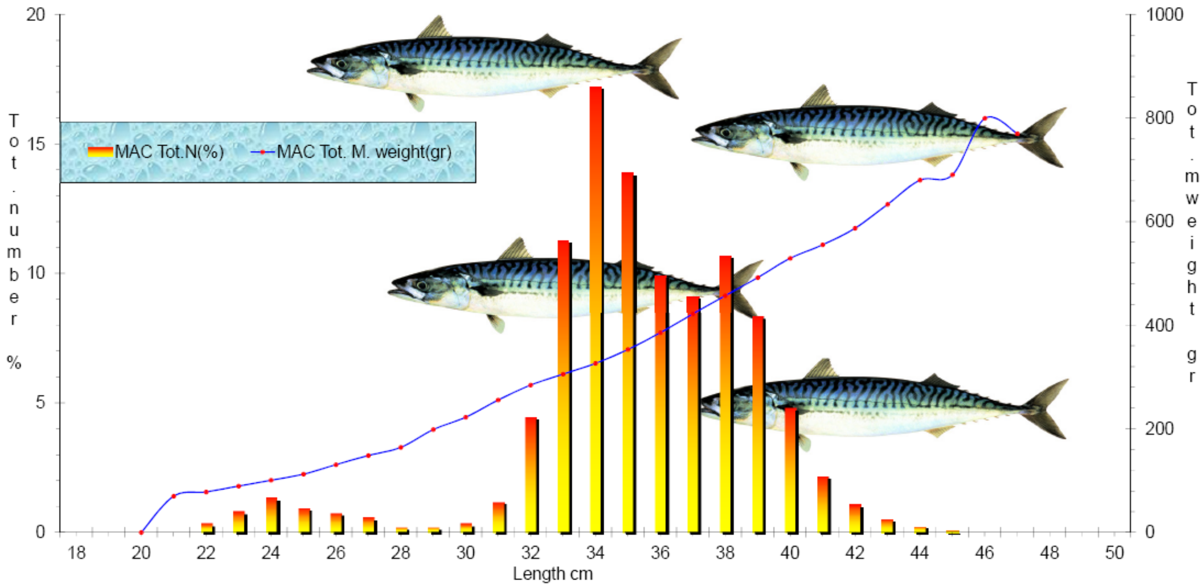


Figure 14. Length (cm) and weight (g) distribution in percent (%) for mackerel sampled in the trawl catches. Note that these values are not weighed with catch or area size and can therefore divide from the estimation of length distribution in the stock (not provided).

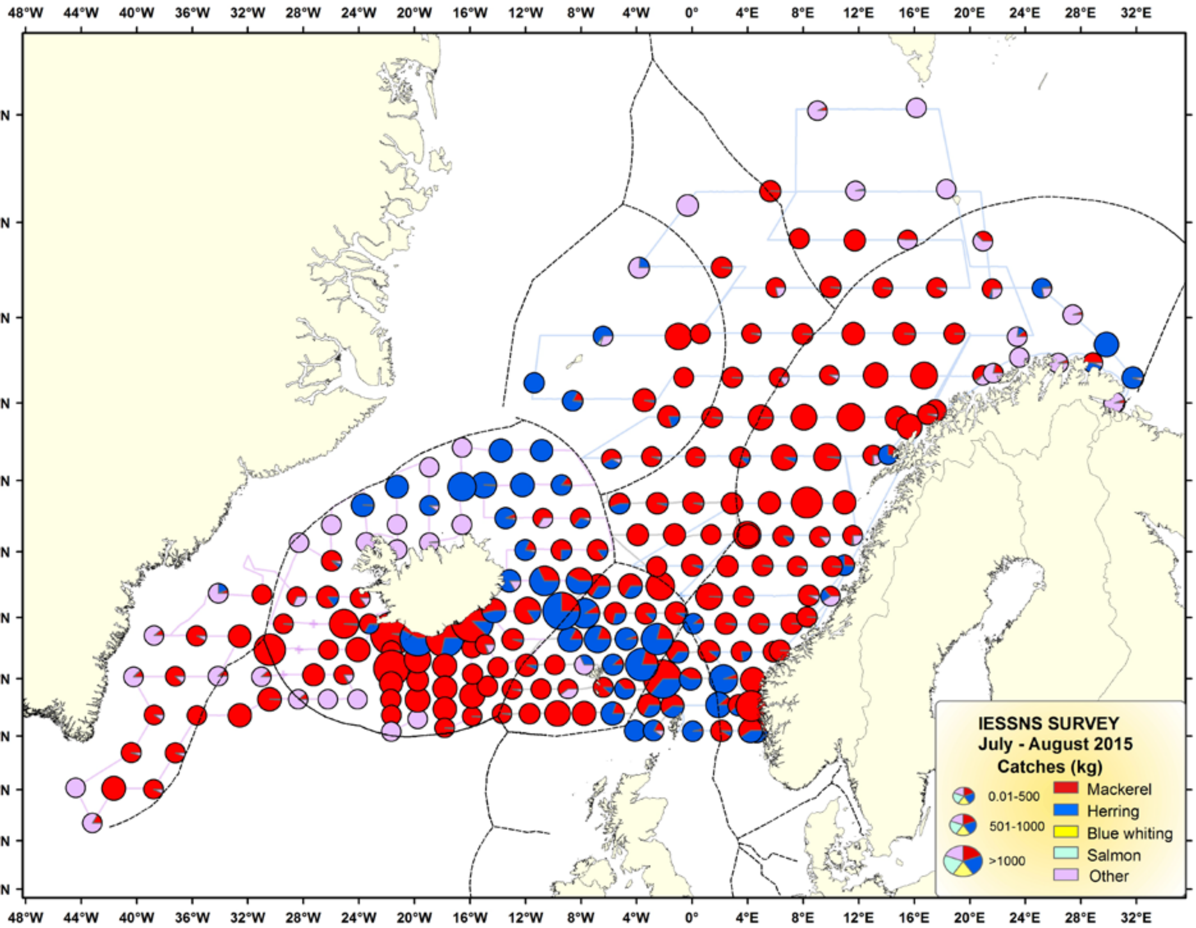


Figure 15. Distribution and spatial overlap between mackerel (red), herring (blue), blue whiting (yellow) and salmon (turquoise) from joint ecosystem surveys conducted onboard M/V "Brennholm" and M/V "Eros" (Norway), M/V "Christian í Grótinum" (Faroe Islands) and R/V "Árni Friðriksson" (Iceland) in the Norwegian Sea and surrounding waters between 1st of July to 10th of August 2015. Vessel tracks are shown as continuous lines.

Swept area analyses from standardized pelagic trawling with Multpelt 832

The swept area estimates of mackerel biomass in July-August 2015 were based on average catches of mackerel within rectangles of 2° latitude and 4° longitude and scaled by the width of horizontal opening of the trawls (Table 5), which gave catch indices (kg/km²; Figure 16). With the increase in rectangle size (from 1° by 2° rectangles used previously) there was no need for interpolating values to rectangles not covered but assumed to hold mackerel. The swept area estimates for the different rectangles are shown in Figure 17 and in a different graphical way in Figure 18. The total biomass estimate came to 7.7 million tonnes, which was allocated to the different EEZs as in previous years (Annex 1). This estimate was based on the standard method using the average horizontal trawl opening by each participating vessel (around 65 m, see Table 5). A further assumption was that all mackerel inside the trawl opening are caught.

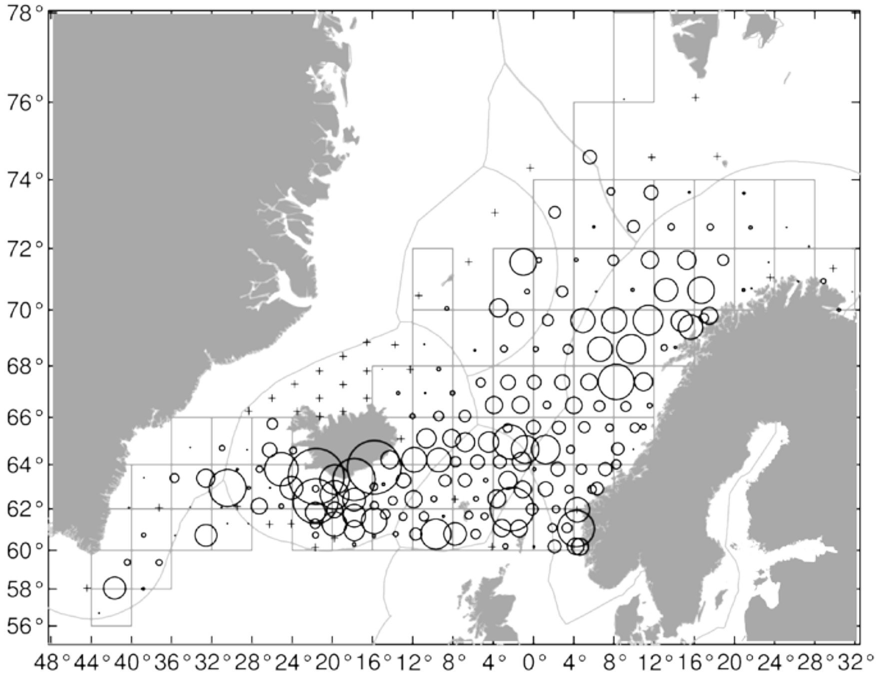


Figure 16. Stations and catches of mackerel in July/August 2015 where the circles size is proportional to square root of catch (kg/km²) and stations with zero catches are denoted with +. Rectangle grid (2° by 4°) used for averaging overlayed.

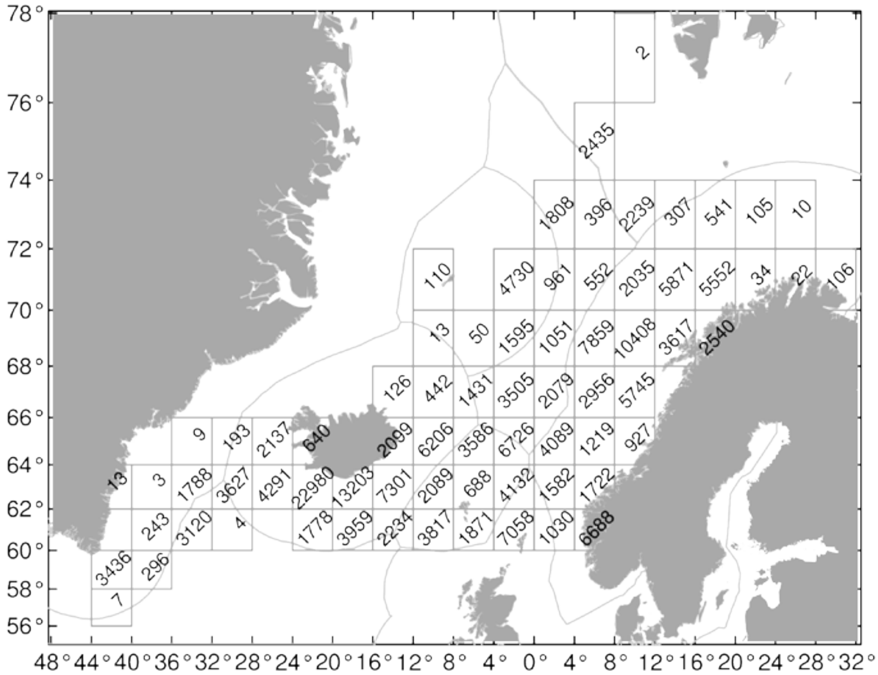


Figure 17. Standardized mackerel catch rates (kg/km²) in 2° lat. by 4° lon. rectangles from swept area estimates in July/August 2015. Rectangles with no catch are not indicated on the map – refer to Figure 18.

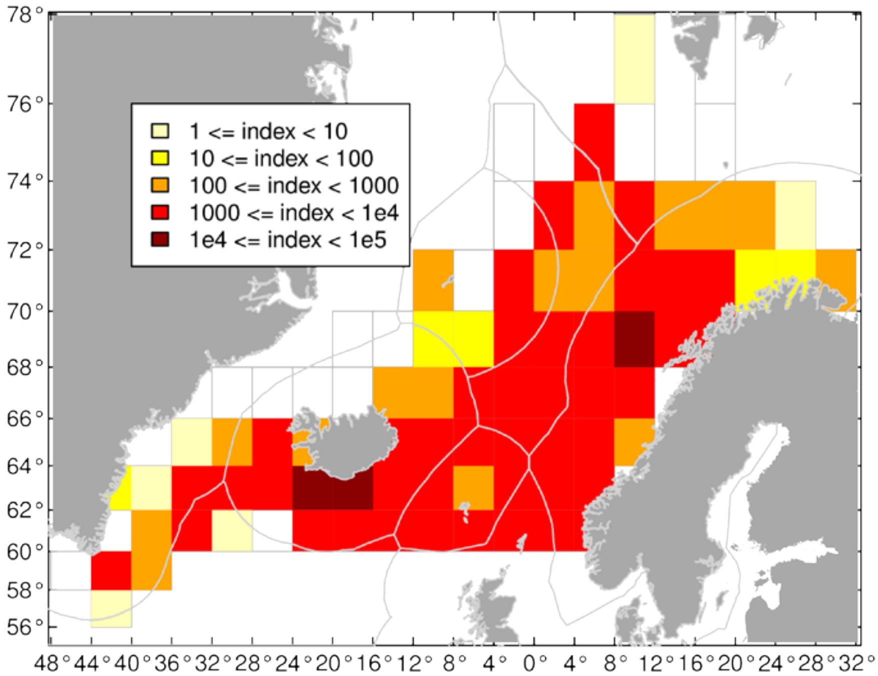


Figure 18. Standardized mackerel catch rates (kg/km²) for mackerel in the July/August 2015 survey represented graphically.

Age-disaggregated indices from IESSNS obtained using the swept-area methodology were first estimated and introduced in the Benchmark assessment of the mackerel stock in 2014 (Nøttestad et al. 2014). The same methodology was used now and the series were updated with the 2014 and 2015 data to be used as input data into the analytical assessment of the stock (Table 8). The 2015 results show that 2011-year class contributed with 28% in number followed by the 2010-year class with 22% (Fig. 19). The 2012 year class contribute to with 12% in numbers followed by the 6 and 7 years old represented with less than 10% each in numbers. Altogether 71% of the estimated number of mackerel was less than 6 years old in the IESSNS 2015. The internal consistency plot for age-disaggregated year classes has improved since the benchmark in 2014 by the inclusion of two more survey years (2014 and 2015). This is especially apparent for younger ages (1-5 years). There is now good internal consistency for 1-10 years old mackerel, except between ages 5 and 6.

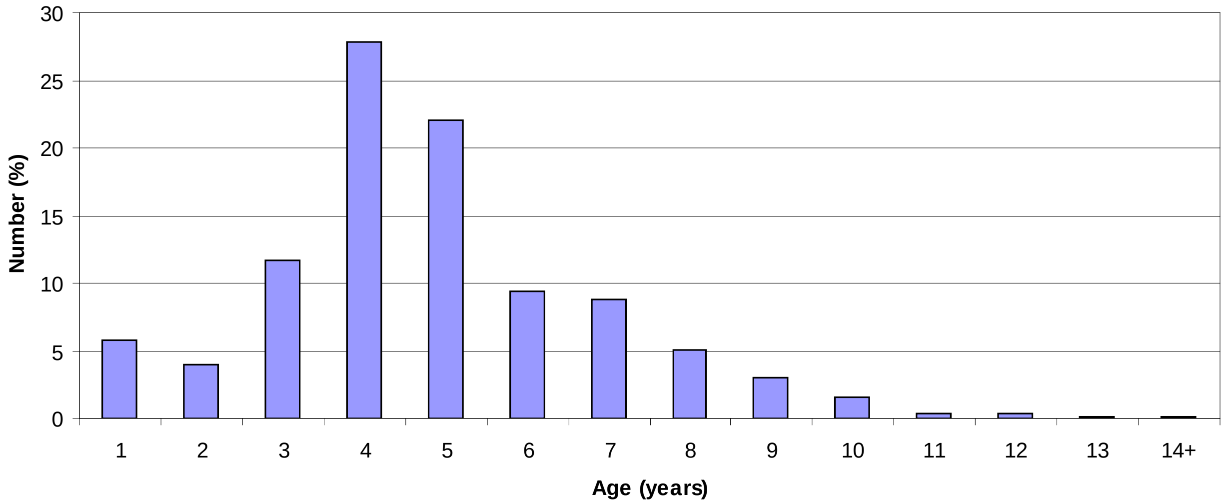


Figure 19. Age distribution in percent (%) of Atlantic mackerel, in the Nordic Seas from1st of July to 10th of August 2015.

In 2015, and swept area estimation of mackerel abundance was also done in a stratified manner with the software StoX (Annex 3). This was done for three main reasons, (1) for a comparison to the traditionally applied method where calculations are done on rectangles basis (in contrast to strata), (2) to get an uncertainty estimation of the indices, and (3) this is the method is a likely candidate to be used in the future for estimation of swept are abundance indices of NEA mackerel from the IESSNS survey. StoX is an open source software developed at the Institute of Marine Research (IMR) in Norway to calculate survey estimates from acoustic and swept area surveys.

Table 8. Time series of the IESSNS showing (a) age-disaggregated abundance indices of mackerel, (b) survey area covered where each age class is observed, and (c) swept-area density index (km^{-2}), which is applied in the analytical assessment of mackerel (limited to age 6+).

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)	Habitat range (mill, km^2)
(a) Number of individuals (billions)															
2007	1.331	1.861	0.896	0.238	1	0.16	0.055	0.039	0.029	0.011	0.009	0.003	0.011	0.002	0.99
2010	0.019	2.768	1.485	3.954	3.123	1.277	0.555	0.385	0.236	0.063	0.041	0.031	0.016	0.005	1.75
2011	0.209	0.251	0.861	1.103	1.616	1.211	0.564	0.276	0.121	0.062	0.057	0.017	0.011	0.001	1.2
2012	0.497	4.991	1.223	2.111	1.822	2.415	1.642	0.652	0.342	0.119	0.067	0.019	0.006	0.006	1.5
2013	0.064	7.776	8.987	2.137	2.906	2.874	2.679	1.266	0.451	0.192	0.161	0.042	0.008	0.022	2.41
2014	0.008	0.579	7.795	5.138	2.605	2.624	2.673	1.686	0.739	0.36	0.086	0.054	0.02	0.004	2.45
2015	1.199	0.830	2.411	5.765	4.558	1.944	1.833	1.039	0.617	0.320	0.075	0.071	0.037	0.022	2.69
(b) Area covered where an age class is observed (km^2)															
2007	0.832	0.832	0.832	0.832	0.832	0.830	0.831	0.829	0.820	0.847	0.865	0.720	0.834	0.788	
2010	6.128	2.059	2.052	2.034	2.032	2.028	2.030	2.027	2.032	2.034	2.023	2.002	2.050	2.039	
2011	1.217	1.216	1.218	1.217	1.217	1.217	1.216	1.219	1.212	1.208	1.223	1.220	1.182	0.992	
2012	2.330	1.892	1.846	1.845	1.842	1.842	1.844	1.842	1.842	1.838	2.041	1.861	2.463	1.974	
2013	0.291	2.596	2.255	2.224	2.175	2.209	2.228	2.210	2.313	2.438	2.344	2.730	2.048	2.302	
2014	0.150	0.500	3.800	2.350	1.160	1.140	1.160	0.790	0.430	0.280	0.110	0.110	0.060	0.011	
2015	2.769	0.525	1.116	2.372	1.809	0.762	0.692	0.433	0.269	0.166	0.062	0.063	0.048	0.057	
(c) Density index (thousands per km^2)															
2007	1.599	2.236	1.077	0.286	1.202	0.193	0.066	0.047	0.035	0.013	0.010	0.004	0.013	0.003	
2010	0.003	1.345	0.724	1.944	1.537	0.630	0.273	0.190	0.116	0.031	0.020	0.015	0.008	0.002	
2011	0.172	0.206	0.707	0.907	1.328	0.995	0.464	0.226	0.100	0.051	0.047	0.014	0.009	0.001	
2012	0.213	2.637	0.663	1.144	0.989	1.311	0.890	0.354	0.186	0.065	0.033	0.010	0.002	0.003	
2013	0.006	2.995	3.985	0.961	1.336	1.301	1.202	0.573	0.195	0.079	0.069	0.015	0.004	0.010	
2014	0.150	0.500	3.800	2.350	1.160	1.140	1.160	0.790	0.430	0.280	0.110	0.110	0.060	0.011	
2015	2.769	0.525	1.116	2.372	1.809	0.762	0.692	0.433	0.269	0.166	0.062	0.063	0.048	0.057	

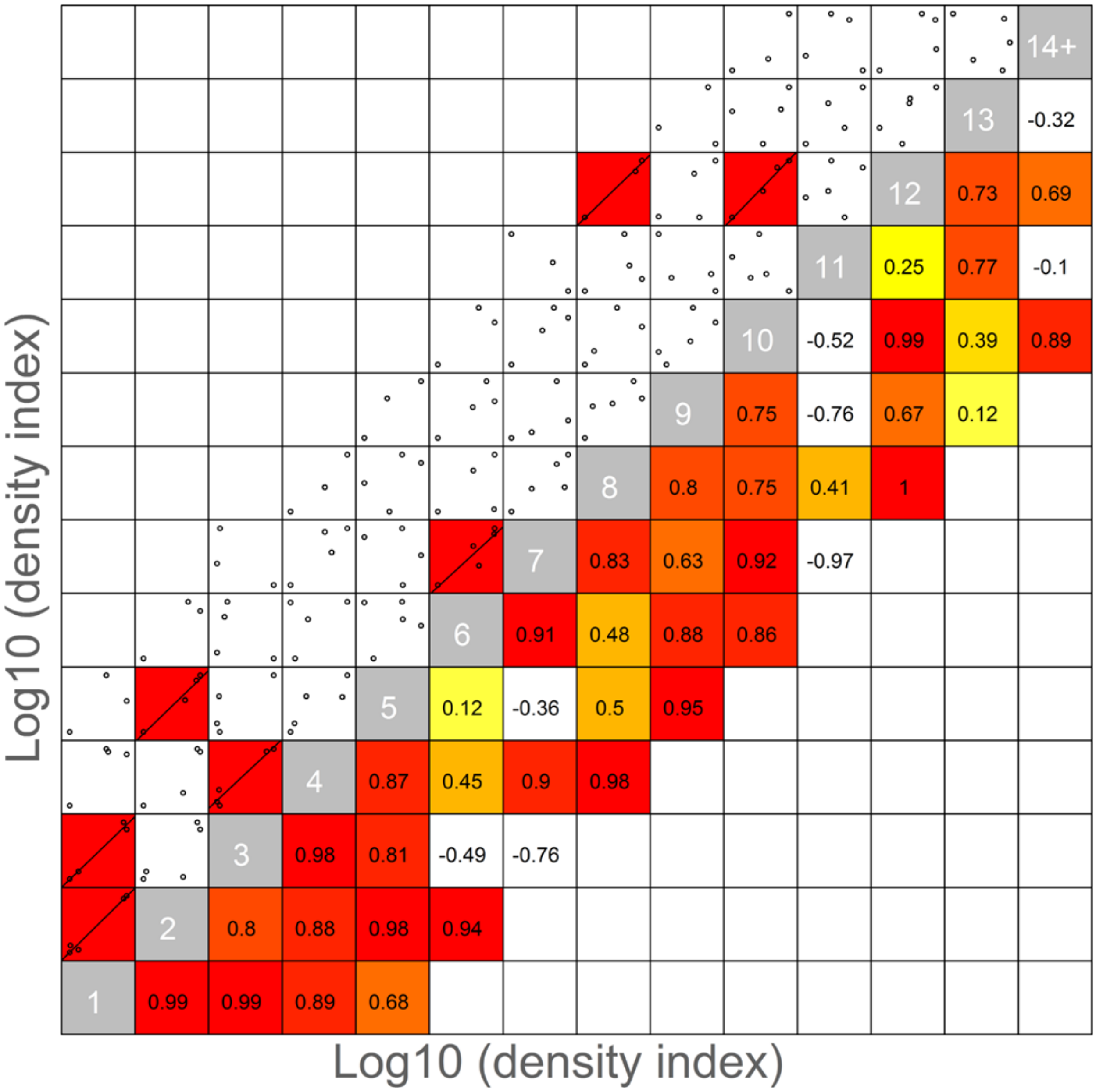


Figure 20. Internal consistency of mackerel density index. Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*p<0.05*) are indicated by regression lines and red cells in upper left half. Correlation coefficients (r) are given in the lower right half.

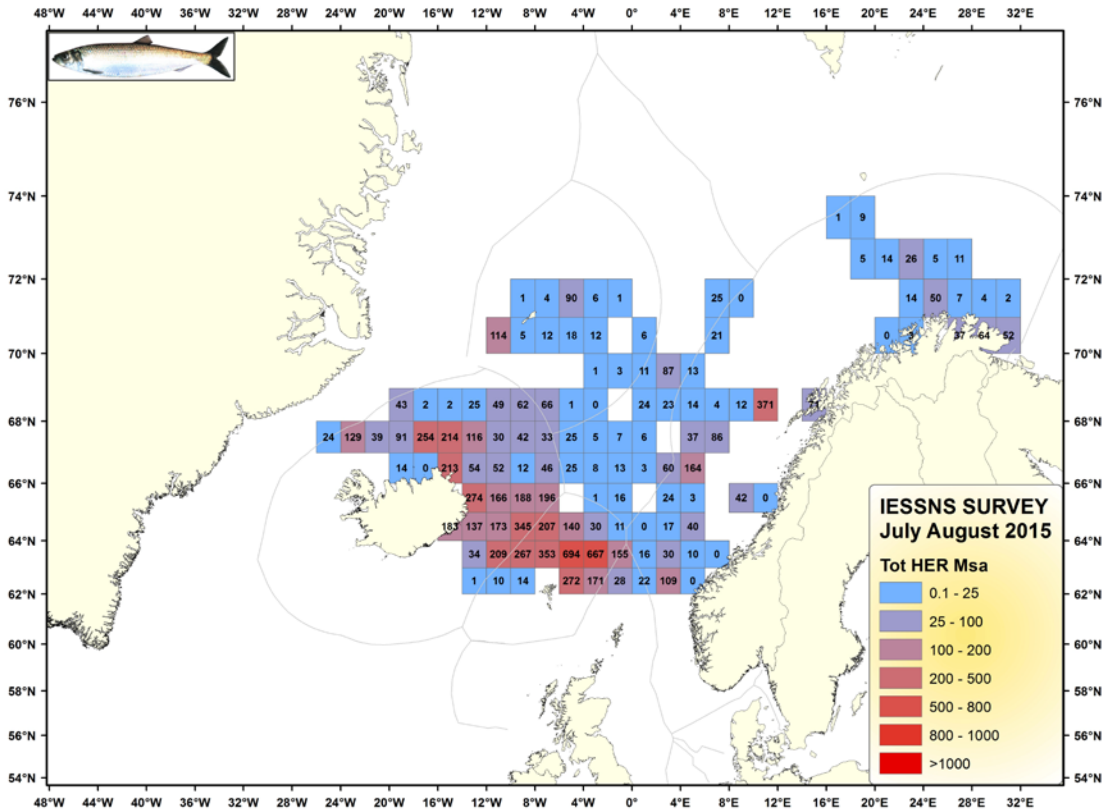
Multibeam sonar recordings

Multibeam sonar recordings were conducted and recorded onboard the two Norwegian vessels Brennholm and Eros. The mackerel schools detected were of small size predominantly with low density and appearing more as individual fish or loose aggregations. They were detected swimming in the upper 5-30 m of the water column throughout the day. However, within large proportions of the mackerel distribution areas based on the Multpelt trawling we could only detect any mackerel on the multibeam sonars (Simrad SH80 and Simrad SX90) when the mackerel were swimming in more concentrated shoals and aggregations. Even if we maximized the ping rate on both the multibeam sonars and multi-frequency echosounders including an array of frequencies from 18 to 333 kHz, the mackerel were practically invisible for the multibeam sonars as well as for the multifrequency echosounders. The main reason is probably due to very loose aggregations/shoals close to the surface thereby providing extremely low detection probability on any acoustic instrumentation including multi-frequency echosounder and high and low frequency multibeam sonars. We could sometimes detect nothing or very little on the sonars but still got medium to high catches of mackerel during surface trawling with the Multpelt 832 pelagic sampling trawl, also suggesting very dispersed mackerel concentrations.

Norwegian spring-spawning herring

Norwegian spring-spawning herring (NSS) was recorded in the eastern part of the area surveyed (Figure 21). The western boundary of its distribution was at 14°W south of Iceland and further west than probably observed for decades north of Iceland or at 23°35W and few individuals in catches at the northern most transect in Greenlandic waters at 34°08W. The herring observed west of these boundaries belonged to the Icelandic summer-spawning herring according to trawl samples (not shown on Figures 21a, b). The acoustic values indicated that NSS herring had the highest density in the western periphery of its distribution, or north of the Faroes and east and north of Iceland (Figure 21a, b). The abundance was low in the northern and eastern areas, and herring was relatively absent from the mid Norwegian Sea. The periphery of the distribution of adult part of NSS herring was considered to be reached in all directions, which means a better spatial coverage than in recent years. It was only towards north between 14-20°W where some herring might be missing (Figure 21b and 15).

The biomass estimate of NSS herring age 4+ came to 7.7 million tons and the total number was 22.7 billions based on the acoustic recordings in July-August 2015 using the primary frequency of 38 kHz and the biological measurements of herring caught in the trawl tows. The length of the NSS herring ranged from 19-40 cm with a peak at 35 cm and a smaller peak at 30 cm (Figure 22). The weighed mean length was 34.3 cm from the whole estimations and the weighed mean weight was 335.9 g compared to 33.4 cm and 329.6 g, respectively, in the 2014 IESSNS.



(b)

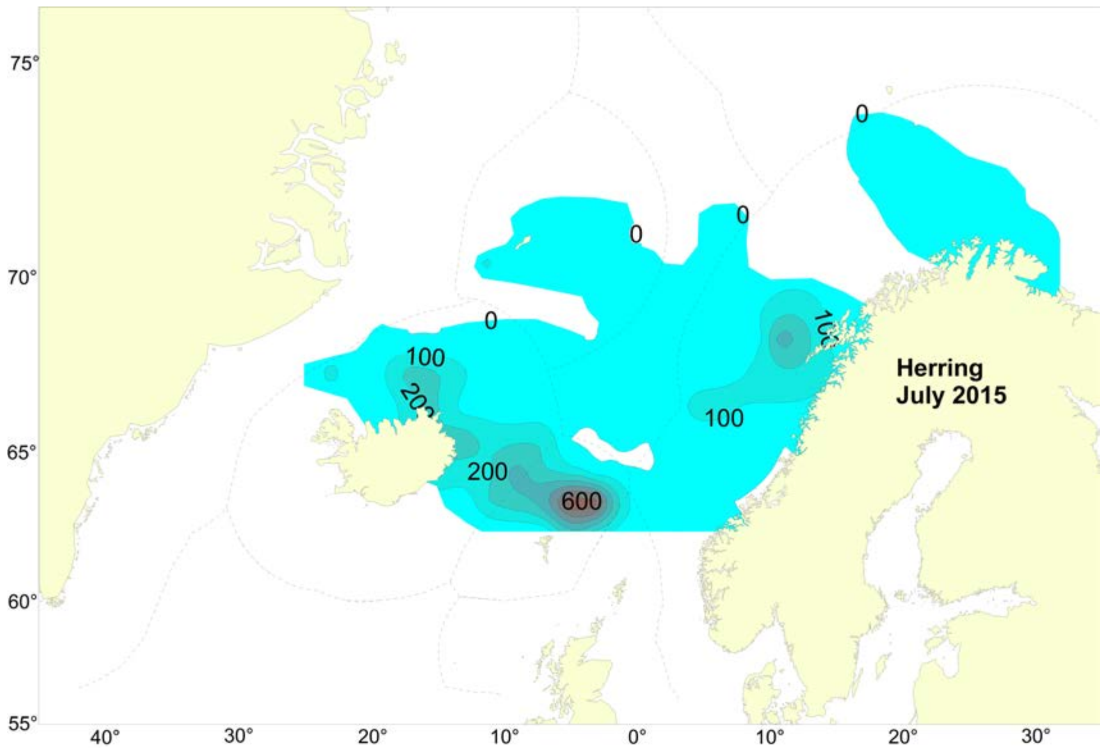


Figure 21. The sA/Nautical Area Scattering Coefficient (NASC) values of Norwegian spring-spawning herring along the cruise track, 1st of July to 10th of August 2015 (a) within a rectangles and (b) shown on a contour plot.

The age distribution in NSS herring shows dominance of the 2004 year class with about 19% in numbers of the acoustic estimate, followed by the 2005 and 2009 year classes (14% each) (Figure 22).

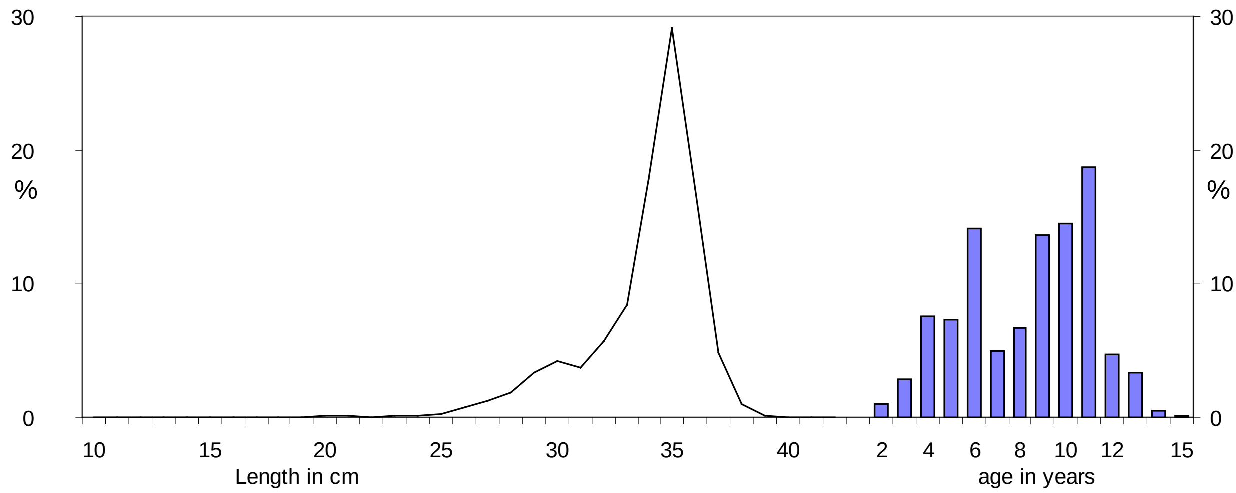


Figure 22. Age and length distribution of Norwegian spring-spawning herring from 1st of July to 10th of August 2015.

The length distribution measured on herring showed overall a pronounced length dependent migration pattern, with the largest individuals (>34 cm) furthest west and northwest (Figure 23).

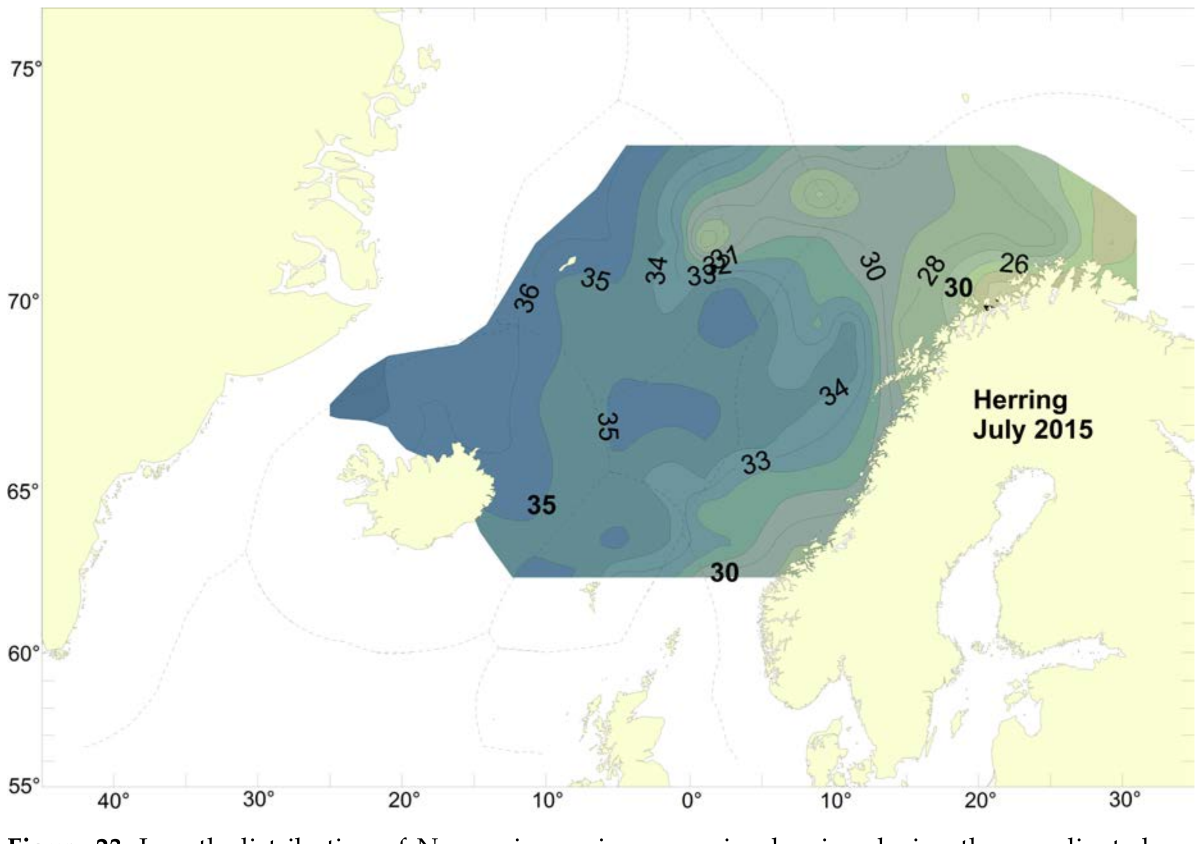


Figure 23. Length distribution of Norwegian spring-spawning herring during the coordinated ecosystem survey 1st of July to 10th of August 2015.

Blue whiting

No results are presented for blue whiting in 2015 because only two deep trawl hauls were taken on acoustic registrations of blue whiting. See an explanation in the Introduction chapter.

Lumpfish (*Cyclopterus lumpus*)

Lumpfish was caught in 78% of trawl stations (Fig. 24). Of stations with mackerel present, the mean weight of the lumpfish catches was 48 kg (114 stations) while 71 kg (23 stations) where mackerel was absent. There was a north-south pattern in lumpfish occurrence. Lumpfish was present at majority of stations north of 65°N, whereas lumpfish was scarce south of 65°N, excluding Greenland waters. Of note, total trawl catch at each trawl station were processed on board Árni Friðriksson, Brennholm and Eros whereas a subsample of 100 kg to 200 kg was processed on Finnur Fríði. Therefore, small catches (< 10 kg) of lumpfish might be missing from the survey track of Finnur Fríði (black crosses). However, it is unlikely that larger catches of lumpfish would have gone unnoticed by crew during sub-sampling of catch on Finnur Fríði. Generally, the mean length and mean weight of the lumpfish was highest in the coastal waters and lowest in the open sea.

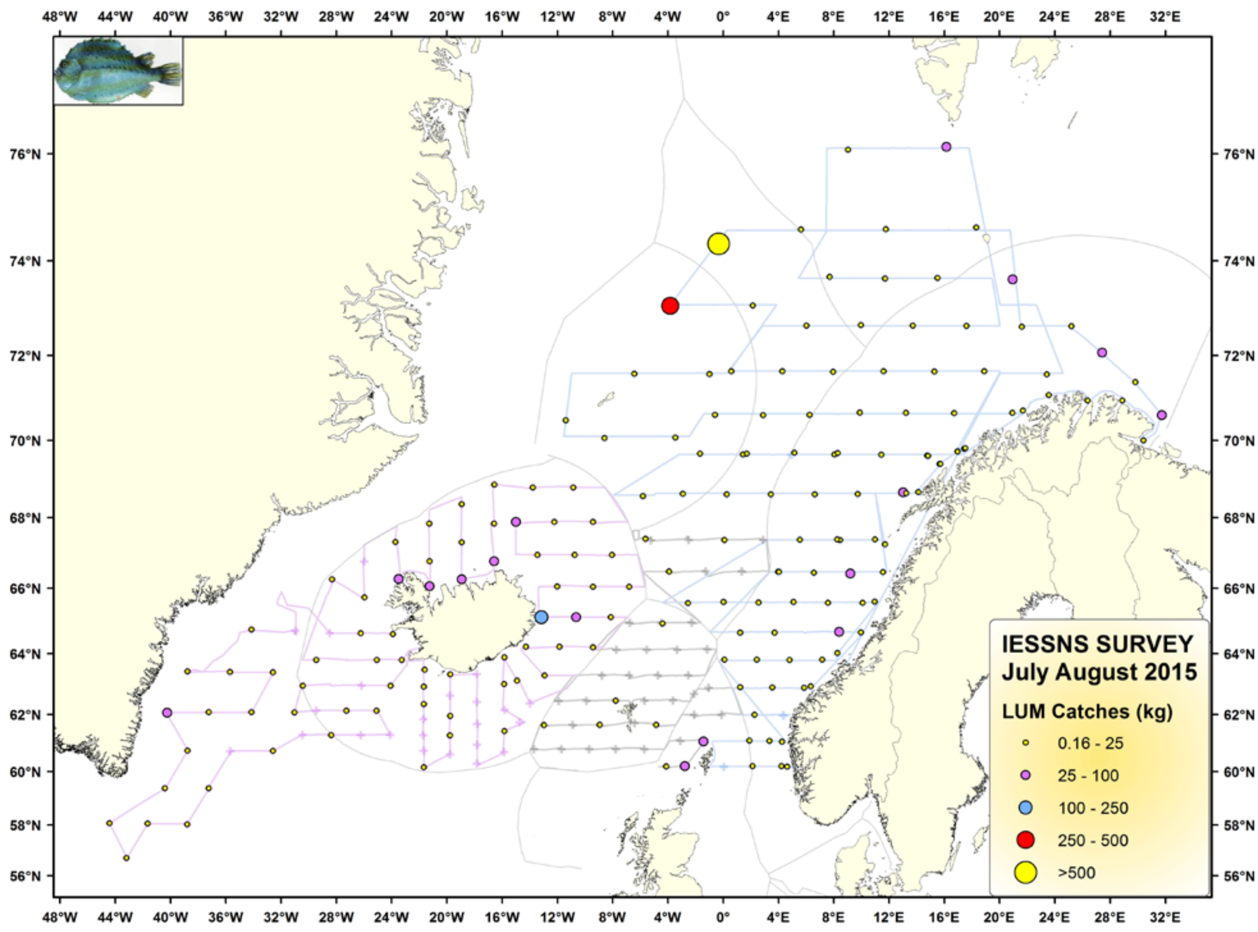


Figure 24. Lumpfish catches at surface trawl stations during the IESSNS survey in July and August 2015.

Salmon (*Salmo salar*)

North Atlantic salmon (*Salmo salar*) were caught both in coastal and offshore areas in the upper 30 m of the water column with the Multpelt 832 pelagic sampling trawl, during the IESSNS survey in July-August 2015.

The salmon weight ranged from 300 gram to 7.2 kg in size, dominated by salmon weighing between 1-3 kg. The length of the salmon ranged from 21 cm to 85 cm, with a large majority of the salmon >40 cm in length.

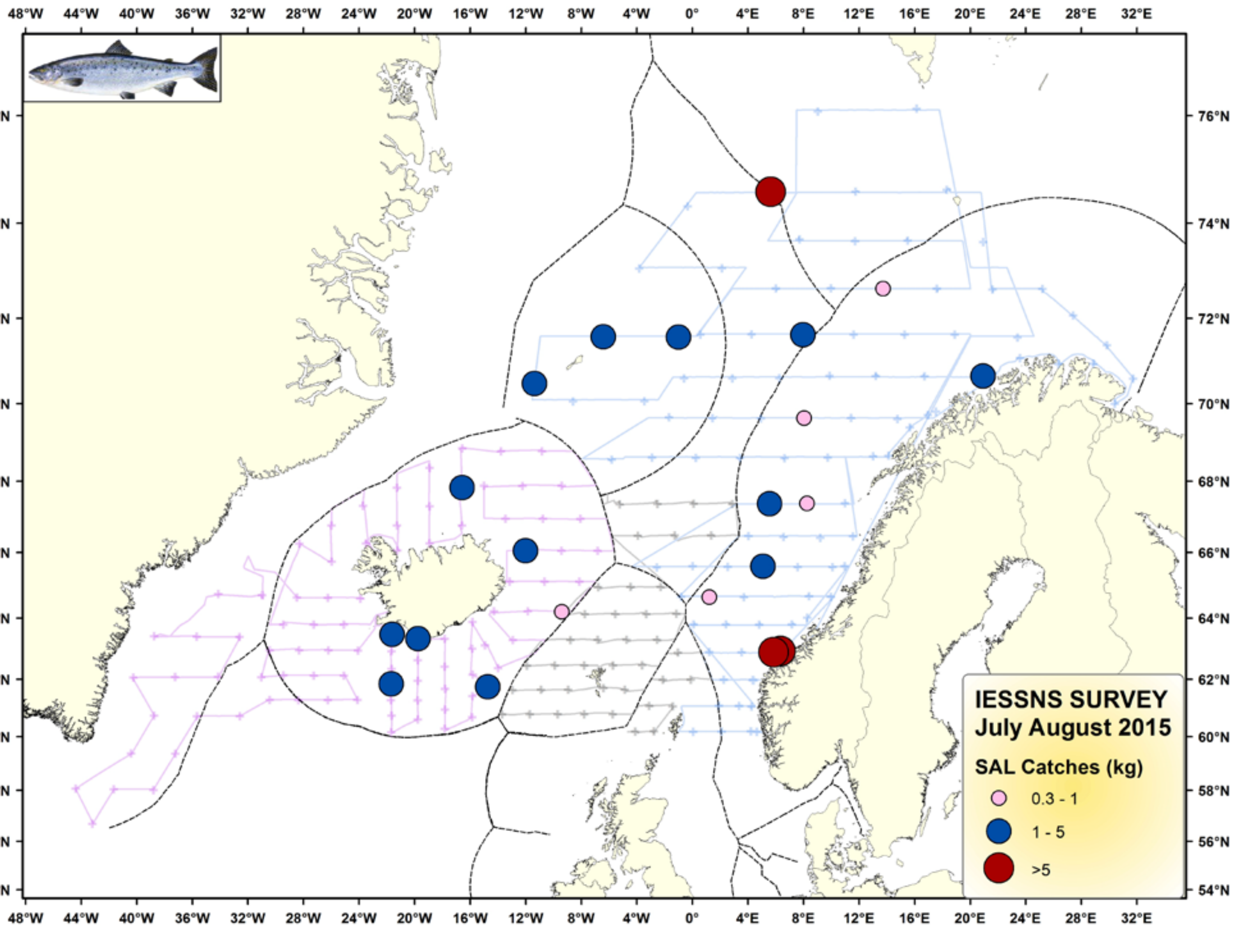


Figure 25. Salmon catches at surface trawl stations during the IESSNS survey in July and August 2015.

Marine Mammal Observations

Totally 340 marine mammals and 6 different species were observed onboard M/V “Brennholm” and M/V “Eros” from 1st to 28th of July 2015 (Figure 26). Altogether 6 groups of killer whales were found mostly in the central part of the Norwegian Sea in close association with mackerel. High densities of especially fin whales, humpback whales and white beaked dolphins were observed in the northern part of the Norwegian Sea, off the coast of Finnmark and into the southern part of the Barents Sea. Very few marine mammals were sighted in the southern part of the covered area including the northern part of the North Sea, and central Norwegian Sea south of 67°N (Figure 26).

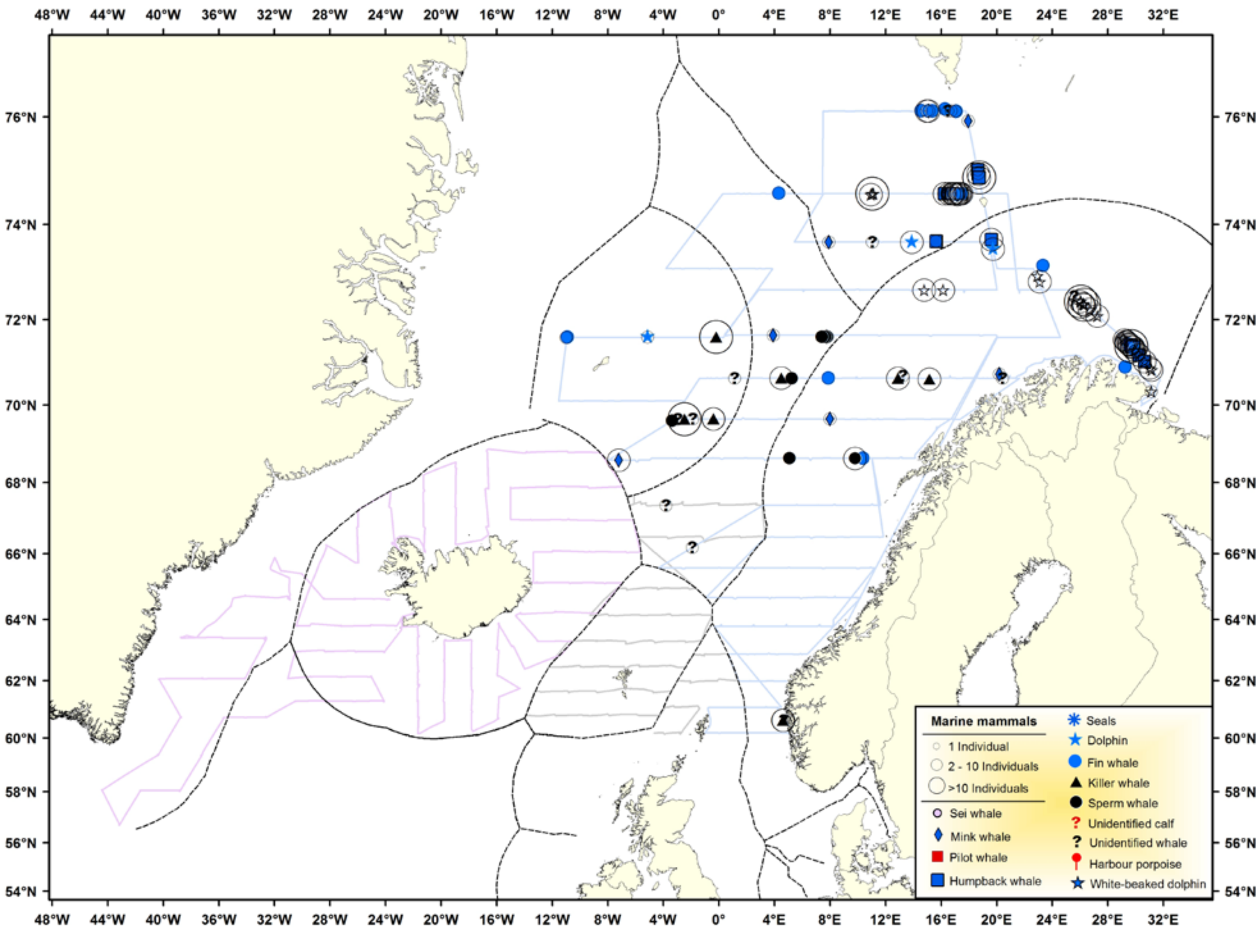


Figure 26. Overview of all marine mammals sighted onboard M/V "Brennholm" and M/V "Eros" in the Norwegian Sea and surrounding waters from 1st to 28th of July 2015.

Discussion

The international coordinated ecosystem survey in the Norwegian Sea and adjacent areas (IESSNS) was performed during 1 July to 10 August 2015 by four vessels from Norway (2), Iceland (1) and Faroese (1), beside that the Icelandic vessel was rented by Greenland to cover Greenlandic waters. The survey coverage was comparable to previous years and the same protocol was followed (ICES 2014b). A major part of the survey is a standardised surface trawling at predefined locations, which has been used for a swept area abundance estimation of NEA mackerel since 2007, although not in all years. The method is analogous to the various bottom trawl surveys run for many demersal stocks.

The total swept area biomass index of NEA mackerel in summer 2015 was 7.7 million tonnes distributed over an area of 2.7 million square kilometres in the Nordic Seas. This is 1.3 million tonnes lower abundance index than in 2014 when it was record high. The average density decreased also from previous two years from around 3.65 tonnes/km^2 to 2.86 tonnes/km^2. The reason for the decrease in the total biomass index of mackerel and density is not fully known, but could be a consequence of both adult and juvenile mackerel being outside of the survey area (e.g. in the North Sea and north and west of the British Isles), less fishable during surface trawling, due to different behaviour including possible higher patchiness compared to previous years, and/or that the abundance index from the IESSNS swept area survey in 2015 is simply reflecting the development of the stock size. None of these possible reasons can be excluded. However, the distribution of the mackerel and consequently also the feeding migration differed from previous years, with relatively less abundance in the northernmost and westernmost regions while much more in the area south of Iceland. Moreover, mackerel had relatively high density in the southeastern area covered (Figure 16), which all together could imply that higher proportion of the stock might have been missed in this year's survey because of a more pronounced southerly distribution. This emphasizes the necessity of covering the potential distribution areas further south (in the North Sea and west of the British Isles) as a part of IESSNS and recommended below.

The reasons the changes in the mackerel distribution from previous years are uncertain but are considered to be related to environmental factors. Relatively cold surface waters southeast of Iceland, around the Faroese and in the southern part of the Norwegian Sea in the spring 2015, as presented by the May survey results (ICES 2015), might for example had contributed to these changes. This needs however, further examination later including a broader scientific approach.

The 2011-year class of mackerel contributed with 28% of numbers followed by the 2010-year class with 22%. The 2012 year class had 12% in number. Altogether 71% of the estimated number of mackerel was less than 6 years old. The internal consistency plot for age-disaggregated year classes has improved since the benchmark in 2014 by the inclusion of two more survey years. This is especially apparent for younger ages. There is now good internal consistency for 1-10 years old mackerel, except between age 5 and 6. The reason for the low consistency around age 5 is unknown, but could partly be due to similar abundance estimates of these two consecutive cohorts aged 5 and 6. The improved consistency for young NEA mackerel in the IESSNS survey should be taken into consideration by ICES WGWIDE, specifically by including estimates of younger mackerel 1-5 years of age, and not only age 6+ mackerel, from the IESSNS survey into the assessment of NEA mackerel abundance. This is also important since altogether 71% of the estimated number of mackerel was less than 6 years old and are therefore not used in current assessment.

The overlap between mackerel and NSS herring was highest in the south-western part of the Norwegian Sea (Faroe and east Icelandic area) according to the catch compositions in the survey (Figure 15), which is similar to 2014. In the areas where herring and mackerel overlap an inter-specific competition for food between the species can be expected. According to Langøy *et al.* (2012), Debes *et al.* (2012), and Oskarsson *et al.* (2015) the herring may suffer in this competition, the mackerel had higher stomach fullness index than herring and the herring stomach composition is different from previous periods. Langøy et al (2012) and Debes et al. (2012) also found that mackerel target more prey species compared to herring and mackerel may thus be a stronger competitor and more robust in periods with low zooplankton abundances.

The groups recommends on the timing of the survey in the future that the survey period should be four weeks and the mid-point should be around 20 July. The main argument for this timeframe, is to make the survey as synoptic as possible in space and time, and at the same time be able to finalize data and report for inclusion in the assessment for the same year. The mid-point of the survey is therefore earlier than the assumed maximum distribution of the mackerel stock.

The acoustic abundance index of Norwegian spring-spawning herring at age 4+ came to 22.7 billions, which is comparable to the May survey index in 2015 of 20.3 billions (~10% difference; ICES 2015). The age composition in these two surveys was also similar with a tendency for a higher contribution of older age groups in the July/August survey compare to the May survey, where 65% vs. 53% were at age 7+ and 35% vs. 47 at age 4-6, respectively. These differences in age composition for NSS herring between the IESNS and IESSNS surveys could be due to the fact the IESSNS in July-August is only catching herring in the upper 30 m, whereas herring is also caught in deeper waters during the IESNS in May-June.

Systematic biological data on lumpfish has been collected during the entire survey and there exist a lot of interesting results on distribution, length and weight composition etc. These lumpfish data need to be further analysed in the future.

Systematic biological data on North Atlantic salmon caught during the IESSNS has also been collected. All the salmon samples have been frozen for later analyses and can be applied for a range of different scientific investigations in the future.

The temperature in the surface (SST) layer from Iceland over Jan Mayen and to Svalbard was 1-2°C warmer in July 2015 than the average for the last 20 years. In the central and eastern part of the Norwegian Sea the SST was close to the 20 year average, while around 1°C below the average south of Iceland and in Greenland Sea. The SST in July 2015 was generally colder than in July 2014 across the whole Northeast Atlantic. Despite the cooler surface waters south of Iceland, the mackerel density has never been measured as high. It should be considered in this context that the temperature there was in the range of 9-11°C, which is well above the temperature often restraining the mackerel distribution of ~6°C.

The concentrations of zooplankton in the Norwegian Sea were lower in 2015 than in 2014 (7.4 g dry weight/m^2 and 8.6 g/m^2 respectively). In the IESNS survey in May 2015 a decrease was also observed compared to 2014. There seem to be higher concentrations of zooplankton in southern areas off Iceland and Greenland than observed in previous years.

Whale observations were done by the two Norwegian vessels during the survey. The number of marine mammal sightings was generally very low in the central and eastern part of the Norwegian Sea but with considerable higher numbers of especially fin whales in the northern Norwegian Sea and into the Barents Sea. Groups of killer whales were mostly observed in central Norwegian Sea, whereas fin and humpback whales where mainly observed near Jan Mayen, Bear Island and the southwestern part of the Barents Sea and off the coast of Finnmark. High numbers of white beaked dolphins appeared in the northern part of the Norwegian Sea, in southern part of the Barents Sea and along the coast of Finnmark.

The swept-area estimate was as in previous years based on the standard method using the average horizontal trawl opening by each participating vessel (ranging from 61 to 67 m; Table 5), assuming that all mackerel inside the trawl opening are caught, i.e. no escape through the meshes. Further, that no mackerel is distributed below the trawl. Uncertainties in such a method include e.g. possible escape of fish through the meshes leading to an underestimation of the estimate. If, on the other hand, mackerel is herded into the trawl paths by the trawl doors and bridles, the method overestimates the abundance. The main effort in this year’s survey to systematically quantify the catchability of the trawl and improve the standardization, was to undertake a comparison between trawling in banana and straight forward. This will require further parwise trawl hauls in the future, but the results of the tows undertaken in 2015 seems to point towards less catches in the banana tows even if not statistically significant (Annex 2).

Results on total abundance index without uncertainty estimates using the swept area method on the NEA mackerel using the new program StoX, are presented in Annex 3. These analyses are preliminary and need more careful consideration especially related to the uncertainty estimates of the total abundance index and the different age groups 1-10 years old, before these results can be used into the assessment of NEA mackerel.

Recommendations

General recommendations

Recommendation	To whom
The survey period should be restricted to maximum 4 weeks. The mid-point of the survey should be around 20 July each year.	Norway, Faroe Islands, Iceland, Greenland
Increase the survey effort in Greenlandic and international waters in the western part of the survey area to cover the NEA mackerel stock completely during the summer feeding.	Greenland
Encourage EU to join the IESSNS survey in order to obtain an even better synoptic and to include the southern part of the mackerel distribution during summer. Develop a method that can sample the mackerel representatively in the North West European shelf Seas south of 58.5N. Investigate the horizontal distribution and abundance of mackerel if standardized trawling in the surface (0-30 m) can be used to measure the abundance of mackerel in in the North West European shelf Seas south of 58.5N.	EU
The age disaggregated indices from IESSNS are considered to give a valid signal about year class sizes from age 1-10 as indicated by the consistency plots. It is therefore recommended that WGWIDE consider using the entire time and age series of estimates from the IESSNS survey in the analytical assessment of the mackerel stock.	WGWIDE
We recommend that observers collect sighting information of marine mammals and birds on all vessels.	Norway, Faroe Islands, Iceland, Greenland

Survey participants

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We greatly appreciate and thank skippers and crew members onboard M/V "Brennholm", M/V "Eros", M/V "Christian í Grótinum" and R/V "Árni Friðriksson" for outstanding collaboration and practical assistance on the joint mackerel-ecosystem cruise in the Nordic Seas from 1st of July to 10th of August 2015.

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Annex 1

Swept area biomass estimates in the different exclusive economical zones (EEZs)

Allocation of the total swept area estimate of mackerel biomass to exclusive economic zones (EEZs) given in Table A1 was done in R with a selection of spatial packages (see 'Task View: Spatial' on http://cran.r-project.org). These included notably 'rgeos' for polygon clipping, and package 'geo' (http://r-forge.r-project.org), i.e. for rectangle manipulation and graphical presentation (R Development Core Team 2014, Bivand and Rundel 2014, Björnsson et al. 2014). EEZs in the Northeast Atlantic were taken from shape files available on http://marineregions.org (low resolution version, downloaded in late 2012 as: World_EEZ_v7_20121120_LR.zip).

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Table A1. Swept area estimates of NEA mackerel biomass in the different Exclusive Economic Zones (EEZs) according to the international coordinated ecosystem (IESSNS) survey in July-August 2014. Area calculated from rectangles where mackerel was present. Note that area calculations in the 2013 were incorrect (included covered rectangles without mackerel).

Exclusive economic zone / international area	Area (in thous. km^2)	Biomass (in thous. tonnes)	Biomass (%)
EU	101	444	5.8
Norwegian	721	2114	27.5
Icelandic	587	2866	37.3
Faroese	268	795	10.3
Jan Mayen	172	241	3.1
International north	260	579	7.5
International west	147	225	2.9
Greenland	358	321	4.2
Spitzbergen	81	103	1.3
Total	2695	7688	99.9

Annex 2

WGIPS working document 01

Comparing "banana" and "straight forward" towing for mackerel

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b) DTU AQUA – National Institute of Aquatic Resources, Charlottenlund, Denmark

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Abstract

Mackerel is a fast swimmer that is assumed to avoid disturbances such as the wake of a ship. This is potentially biasing density estimates of mackerel based on swept-area estimates from surface trawling. Trawling in a straight line with the trawl in the ship's wake has therefore been assumed to lead to an underestimate of the mackerel density in the sea. An alternative trawling strategy has been implemented by the International Ecosystem Summer Survey in the Nordic Seas (IESSNS), namely trawling in a curve to keep the trawl outside the wake. However, if mackerel avoids the wake of the ship in a horizontal direction, then the IESSNS solution will lead to an over-estimation of the true density. Swept area based stock estimates from surface trawling is of great value to stock assessment of epipelagic fish species, such as the economically and ecologically important North-East Atlantic mackerel. It is therefore imperative to quantify this bias.

In this study, the effect of horizontal avoidance on catch rates of mackerel was estimated from a series of trawl experiments. The catch rates were not found to differ significantly between straight trawling in the wake and curved trawling on the side of the wake. It is therefore concluded that there is no substantial horizontal avoidance of the ship and the ships wake. Vertical avoidance was not investigated in the present study.

Straight trawling in the general direction of the survey is easier and less time consuming than curved trawling. It is therefore recommended that standardized surface trawling for mackerel is done in a straight direction, if the results presented herein can be supported by additional experiments (more data). It is furthermore needed to verify if the trawl was directly in the wake in all the straight tows. Side-ways drifting due to wind could place the trawl of the side of the wake so it would in reality resemble a curved haul.

Materials and methods

Experimental surface trawling was done at 21 locations by R/V Árni Friðriksson, M/V Eros and M/V Brennholm during the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) in mid-summer 2015 (Figure 1). On each location trawling was done in straight and curved lines, respectively. The survey protocol is available in Valdemarsen et al. (2014) and (Nøttestad et al., in review). The density of mackerel d (kg nmi-2) was estimated for each trawl haul by dividing the total catch of mackerel (kg) with an estimate of swept area (= the trawl haul distance × the horizontal opening of the trawl) (Nøttestad et al., in review; Valdemarsen et al., 2014). The data are plotted in Figure 2.

The effect on the catch rates of curved trawling relative to straight trawling was estimated as a catchability factor (*CF*) for all permutations on each location:

$CF = d_{Curved} / d_{Straight}$

The box-and-whiskers-plot of *CF* estimates were made using the "boxplot()"-function in the R package "stats" v.3.0.1 (R Core Team, 2013). Boxes indicate the following quartiles: 25 %, 75 % and 50 % (median). Dots indicate outliers defined as observations that exceed 0.67 times the quartiles. The whiskers indicate the most extreme observations, excluding the outliers.

Results

CF ranged from 0.0 to 10.4 and was not found to be statistically significantly different from 1 (Figure 3).

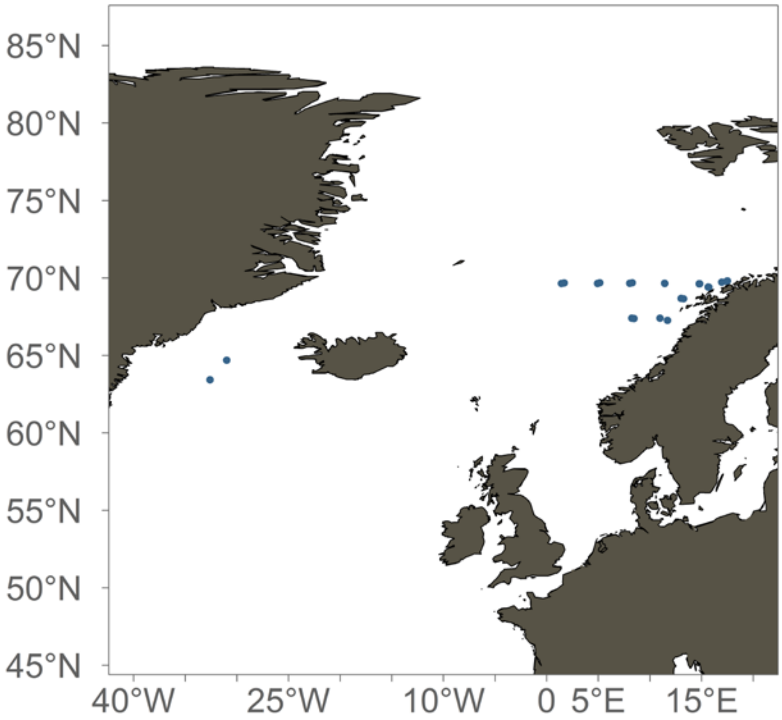

Figure 1. Map of trawl stations with direct comparison between banana shaped towing and straight forward towing for NEA mackerel with the Multpelt 832 sampling trawl.

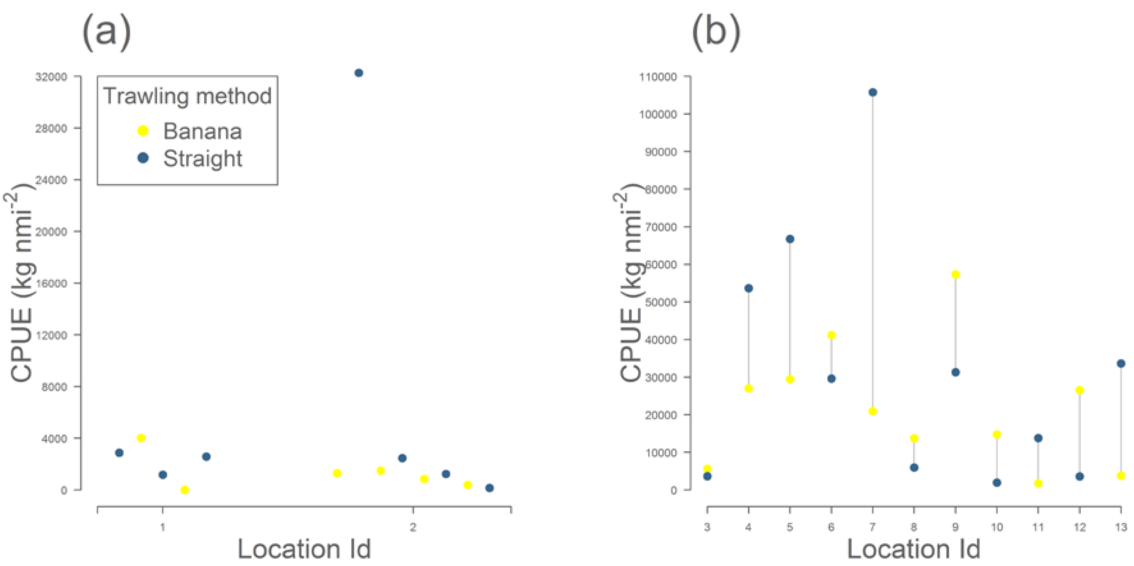

Figure 2. Catch of mackerel per swept nmi^2 by location and trawling method (straight or curved).

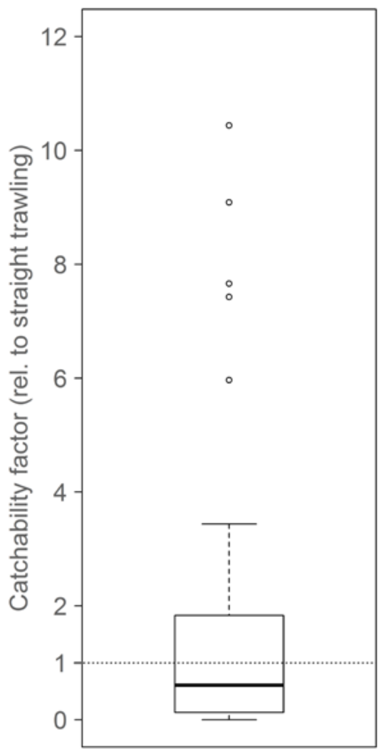

Figure 3. The effect of trawling method on the catch rate indicated by the Catchability Factor (*CF*). Boxes indicate the following quartiles: 25 %, 75 % and 50 % (median). Dots indicate outliers defined as observations that exceed 0.67 times the quartiles. The whiskers indicate the most extreme observations, excluding the outliers.

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Annex 3

Swept area biomass estimates of mackerel using StoX

By E. Johnsen, A. Totland, Å. Skålevik, S. Lid and N.O. Handegard

StoX is open source software developed at IMR, Norway to calculate survey estimates from acoustic and swept area surveys. The program is a stand-alone application build with Java for easy sharing and further development in cooperation with other institutes. The underlying high resolution data matrix structure ensures future implementations of e.g. depth dependent target strength and high resolution length and species information collected with camera systems. Despite this complexity, the execution of an index calculation can easily be governed from user interface and an interactive GIS module, or by accessing the Java function library and parameter set using external software like R. Accessing StoX from external software may be an efficient way to process time series or to perform boot-strapping on one dataset, where for each run, the content of the parameter dataset is altered. Various statistical survey design models can be implemented in the R-library, however, in the current version of StoX the stratified transect design model developed by Jolly and Hampton (1990)[*] s implemented. StoX has been tested on the 2014 IESNS survey and Norwegian acoustic sandeel and cod surveys. When new statistical methods are implemented it is regarded essential that expert specification demands, documentation and statistical rigorousness is available. According to the plan, a test version of the software will be available for people outside IMR by the end of March 2014.

StoX was applied on the survey data from the IESSNS 2015 survey and the main results are presented below. This year’s survey design was in a more stratified manner than in previous years to fulfil the condition made by such an approach.

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[*]Jolly, G. M., and I. Hampton. "A stratified random transect design for acoustic surveys of fish stocks (1990)." *Canadian Journal of Fisheries and Aquatic Sciences* 47:7: 1282-1291.

Table A3. Swept-area biomass estimation of mackerel in July/August 2015 for the whole IESSNS survey area as based on calculation in StoX.

Length cm	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Number	Biomass	Mean Weight (g)
21-22	2407															31209	2407	77.1
22-23	14149															159439	14149	88.7
23-24	25264															251577	25264	100.4
24-25	19922															176217	19922	113.1
25-26	16571															125063	16571	132.5
26-27	11480	877														82059	12357	150.6
27-28	2243	452														16287	2696	165.5
28-29	3255	2728														28960	5983	206.6
29-30		11159	2388													60899	13547	222.5
30-31		49508	14626	3637												262305	67771	258.4
31-32		81179	81789	119326	4441											1001928	286735	286.2
32-33		91746	130611	453376	101837	1386										2525911	778956	308.4
33-34		28672	295352	579940	275095	19750	1415		1142	1266						3650372	1202631	329.5
34-35		6490	160486	492027	350970	41708	27178	7160	293	-						3054724	1089680	356.7
35-36		16292	67670	196225	290306	123461	72019	22435	1464	3532						2037820	793404	389.3
36-37			41272	130274	228463	208552	108507	56141	28670	6354						1901538	810971	426.5
37-38			4434	68604	209499	195014	231726	128000	82889	31754	4750	939	852			2077017	958461	461.5
38-39			13676	30979	158364	131082	140878	103147	65173	20269	10511	2004	1169			1363656	677252	496.6
39-40			2823	23325	57980	85046	74017	58893	48562	22412	18431	10082	624	1407		758636	406200	535.4
40-41				512	11623	26193	38154	30791	24708	12790	3329	4812	987			271932	153898	565.9
41-42				2093	1437	7252	18931	8624	8714	9690	10309	2914	1461			120859	71423	591.0
42-43					1237	1641	14168	10601	615	1122	1502	1770	868			53323	33524	628.7
43-44					339				3582	1624	369	673	679	300	350	11468	7916	690.2
44-45								1652	-	961	1180	4324				11376	8117	713.5
45-46					1549											1836	1549	843.6
46-47							37									47	37	770.0
TSN (1000)	629866	632132	2091490	5372034	4547603	2323577	1992431	1169733	715249	305664	134957	73707	1837 9	4554	679	20012055		
TSB (tons)	95292	289102	815127	2100316	1693140	841085	727030	427443	265811	111772	50380	27519	6640	1707	350		7452713	
Mean length (cm)	23.3	31.2	32.7	33.1	34.6	36.0	36.6	36.9	37.3	37.7	38.6	39.6	39.5	39.3	42.6			
Mean weight (g)	103.0	278.3	320.6	333.0	380.4	428.3	446.5	458.2	473.4	470.7	505.0	511.8	500	534	733			372.4
N (%)	3.1	3.2	10.5	26.8	22.7	11.6	10.0	5.8	3.6	1.5	0.7	0.4	0.1	0.0	0.0	100		
Biomass (%)	1.3	3.9	10.9	28.2	22.7	11.3	9.8	5.7	3.6	1.5	0.7	0.4	0.1	0.0	0.0		100	

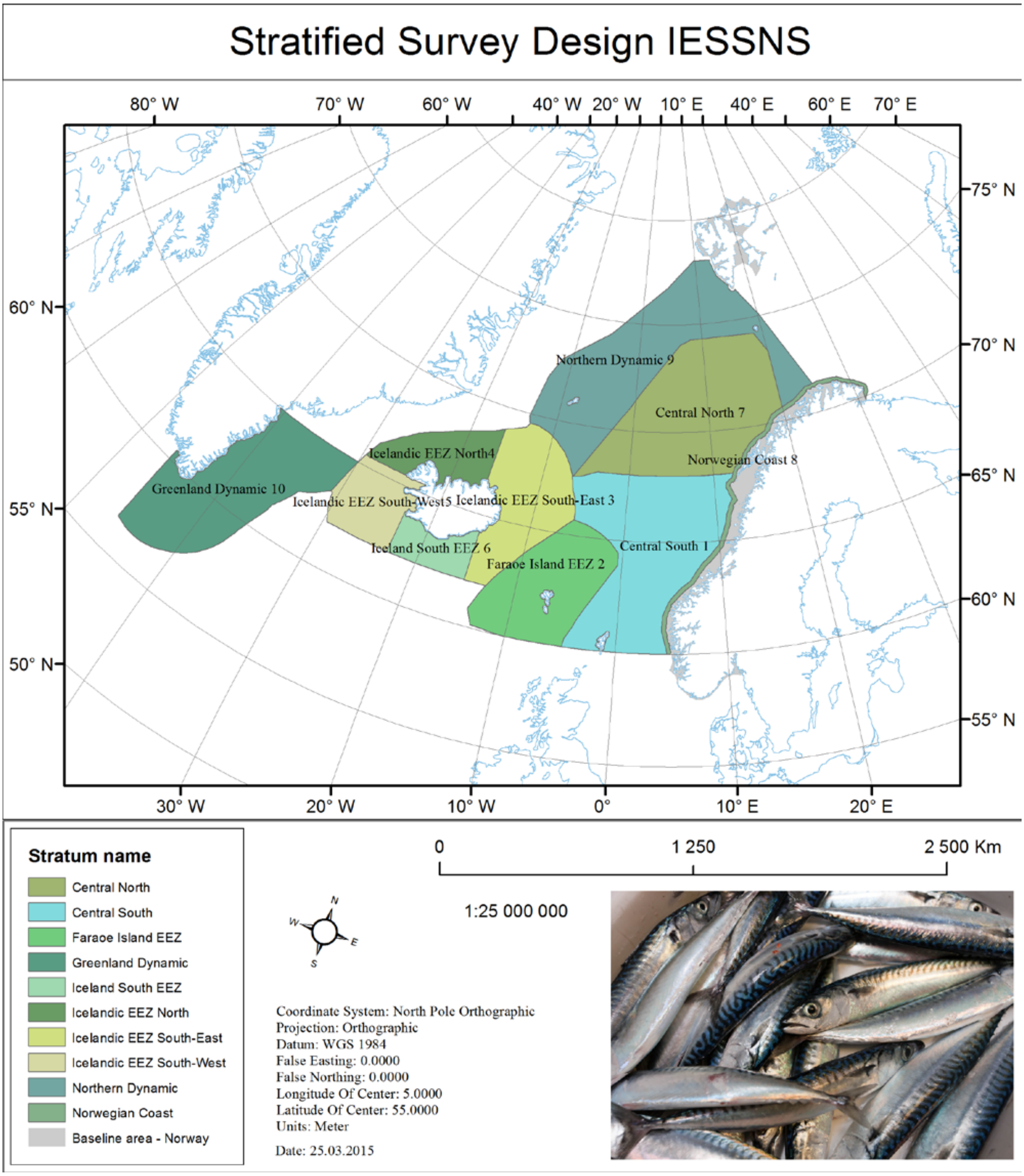

Figure A3.1. Map showing the ten stratum used in StoX for estimation of mackerel biomass indices in July-August 2015 during the IESSNS.

Annex 5: Individual survey cruise reports

Annex 5a: Western Baltic

Survey report for FRV “Solea”

German Acoustic Autumn Survey (GERAS)

01 – 19 October 2015

Tomas Gröhsler [1] & Matthias Schaber [2]
Thünen Institute of
[1] Baltic Sea Fisheries (TI-OF), Rostock
[2] Sea Fisheries (TI-SF), Hamburg

1 INTRODUCTION

Background: The joint German/Danish GERAS survey is part of the Baltic International Acoustic Survey (BIAS), which is co-ordinated by the Baltic International Fish Survey Working Group (WGBIFS) and is conducted within the scope of the ICES Working Group for International Pelagic Surveys (WGIPS). Further WGBIFS contributors to the Baltic survey are national fisheries research institutes of Sweden, Poland, Finland, Latvia, Estonia, Lithuania and Russia. FRV “Solea” participated for the 28th time. The survey area covered the western Baltic Sea including Kattegat, Belt Sea, Sound and Arkona Sea (ICES Subdivisions 21, 22, 23 and 24). The survey effort was comparable to former years.

Objectives: The survey has the main objective to annually assess the clupeoid resources of herring and sprat in the Baltic Sea in autumn. The reported acoustic survey is conducted every year to supply the ICES

- Herring Assessment Working Group for the Area South of 62°N (HAWG) and
- Baltic Fisheries Assessment Working Group (WGBFAS)

with an index value for the stock size of herring and sprat in the Western Baltic area (Kattegat/Subdivisions 21 and Subdivisions 22, 23 and 24).

2 SURVEY DESCRIPTION & METHODS

2.1 Personnel

Calibration of acoustic equipment (01.-03.10.2015)

Matthias Schaber	Scientist in charge	TI-SF
Verena Kalter	Acoustics	TI-SF
Ben Stefanowitsch	Acoustics	TI-SF

Acoustic survey (03.-19.10.2015)

Matthias Schaber	Scientist in charge (03.-12.10.2015)	TI-SF
Tomas Gröhsler	Scientist in charge (12.-19.10.2015)	TI-OF
Ina Hennings	Biology (12.-19.10.2015)	TI-OF
Steffen Hagemann	Biology (03.-12.10.2015)	TI-OF
Verena Kalter	Biology	TI-SF
Mario Koth	Biology	TI-OF
Thomas Møller	Biology	DTU Aqua/Denmark
Ben Stefanowitsch	Acoustics	TI-SF

2.2 Narrative

The 710th cruise of FRV "SOLEA" represents the 28th subsequent GERAS survey. FRV "SOLEA" left the port of Rostock/Marienehe on 01 October 2015. The acoustic survey covered the whole area of Subdivisions (SD) 21, 22, 23 and 24. Due to varying weather conditions in the survey area the following survey schedule was accomplished:

- Arkona Sea (SD 24) 03. - 06.10.
- Belt Sea (SD 22) 06. - 07.10
- Sound (SD 23) 07. - 08.10.
- Arkona Sea (SD 24) 08. - 10.10.
- Belt Sea (SD 22) 10. - 14.10.
- Kattegat (SD 21) 14. - 18.10.

The survey ended on 19 October 2015 in Rostock/Marienehe.

2.3 Survey design

ICES statistical rectangles were used as strata for all Subdivisions (ICES, 2014). The area was limited by the 10 m depth line. The survey area in the Western Baltic Sea is characterised by a number of islands and sounds. Consequently, parallel transects would lead to an unsuitable coverage of the survey area. Therefore a zig-zag track was adopted to cover all depth strata regularly and sufficiently. Overall regular cruise track length was 1 230 nm covering a survey area of 13 206 nm^2 (Figure 1).

2.4 Calibration

Calibration of both 38 and 120 kHz transducer took place off Kühlungsborn at good overall weather conditions. The 38 kHz transducer was calibrated three times at two different pulse lengths, the 120 kHz transducer twice at two different pulse lengths. Calibration results were considered very good based on the calculated RMS values.

The calibration procedure was carried out as described in the "Manual for the Baltic International Acoustic Surveys (BIAS)" (ICES, 2014). Calibration results for the 38 kHz transducer are given in Table 1.

2.5 Acoustic data collection

All acoustic investigations were performed during night time to account for the more pelagic distribution of clupeids during that time. The main pelagic species of interest were herring and sprat. The acoustic equipment used was a Simrad scientific echosounder EK60 operated at 38 kHz (120 kHz). Specific settings of the hydroacoustic equipment were used as described in the "Manual for the Baltic International Acoustic Survey (BIAS)" (ICES, 2014). Corresponding settings are listed in Table 1. Echo-integration, i.e. the integration and allocation of NASC values to species abundance and biomass was accomplished using Myriax Echoview 6.0 post-processing software. Mean volume back scattering values (s_v) were integrated over 1 nm intervals from ca. 8 m below the surface (depending on surface turbulence) to ca. 0.5 m over the seafloor. Interferences from surface turbulence, bottom structures and scattering layers were removed from the echogram.

2.6 Biological data – fishing trawls

Trawl hauls were conducted with a pelagic gear "PSN388" in midwater layers as well as near the seafloor. Mesh size in the codend was 10 mm. It was planned to carry out at least two hauls per ICES statistical rectangle. Both trawling depth and net opening were continuously controlled by a netsonde during fishing operations. Trawl depth was chosen in accordance with echo distributions on the echogram. Normally, a vertical net opening of about 7-9 m was achieved. The trawling time usually lasted 30 minutes but was shortened when echograms and netsounder indicated large catches. From each haul sub-samples were taken to determine length and weight of fish. Samples of herring and sprat were frozen for additional investigations (e.g. determining sex, maturity, age).

2.7 Hydrographic data

Hydrographic conditions were measured after each trawl haul and in regular distances on the survey transect. On each corresponding station, vertical profiles of temperature, salinity and oxygen concentration were measured using a "Seabird SBE 19 plus" CTD. Water samples for calibration purposes (salinity) were taken on every station, while water samples for Winkler titration and calibration of oxygen measurements were taken and processed at least once per day. Altogether, 80 CTD-profiles were measured (Fig. 5).

2.8 Data analysis

The pelagic target species sprat and herring are often distributed in mixed layers together with other species. Thus, echorecordings cannot be allocated to a single species. Therefore the species composition allocated to echorecordings was based on corresponding trawl catch results. For each rectangle species composition and length distributions were determined as the unweighted mean of all trawl results in this rectangle. From these distributions the mean acoustic cross section σ was calculated according to the following target strength-length (TS) relation:

	TS	References
Clupeoids	= 20 log L (cm) - 71.2	ICES 1983
Gadoids	= 20 log L (cm) - 67.5	Foote et al. 1986

The total number of fish (total N) in one rectangle was estimated as the product of the mean area scattering cross section (s_A) and the rectangle area, divided by the corresponding mean cross section. The total number was separated into herring and sprat according to the mean catch composition.
In accordance with the guidelines in the "Manual for the Baltic International Acoustic Surveys (BIAS)" (ICES, 2014) further calculations were performed as follows:

Fish species considered:

Clupea harengus
Engraulis encrasicolus
Gadus morhua
Gasterosteus aculeatus

Melanogrammus aeglefinus
Merlangius merlangus
Sprattus sprattus
Trachinus draco
Trisopterus esmarkii

Exclusion of trawl hauls with very low catch level:

Haul No.	Rectangle	Subdivision (SD)
29, 31	38G0	22
44, 45	41G1	21
47, 49	42G2	21
54	43G1	21

Despite low catch levels of both herring and sprat the following hauls were not excluded from the analysis as they were the only trawl hauls conducted in the corresponding rectangles and thus provided the only available information on species composition in these rectangles:

Haul No.	Rectangle	Subdivision (SD)
12	39G1	22
13, 34	39G0	22
25	37G1	22
32, 33	38G0	22
35	39F9	22
36, 37, 40	40G0	22
38	41G0	22
39	40G1	22
43	41G0	21

Usage of neighbouring trawl information for rectangles which contain only acoustic investigations:

Rectangle/SD to be filled	with Haul No.	of Rectangle/SD
40F9/22	36, 37, 40	40G0/22
39G2/23	17, 24	39G2/24
37G4/24	5, 8, 9	38G4/24

3 RESULTS

3.1 Acoustic data

Statistics on survey area, mean S_A (NASC), mean scattering cross section σ, estimated total number of fish, as well as proportion of herring and sprat per SD/rectangle are shown in Table 6.

Figure 4 depicts the spatial distribution of mean NASC values (5 nm intervals) along the transectes measured in 2015.

In almost all rectangles surveyed, mean NASC values per nautical mile were distinctly below the observations recorded in 2014 and also below the long-time survey average. On ICES subdivision scale, mean NASC values were lower than in the previous year in SD 21, 22 and 24 while in SD 23 mean NASC values were higher than in 2014.

In SD 21, mean NASC per 1 nm EDSU was lower in than both the previous year and the long-time survey average in all rectangles surveyed. As in the previous year, increased aggregations of clupeids were measured in the northern part of the Kattegat (rectangle 43G1), but mean and overall NASC values also in this area were significantly lower than in 2014.

Also in SD 22, mean NASC values recorded were lower than the previous year and the survey average in all rectangle surveyed. Notable but small aggregations of clupeids were only recorded in the western part of Kiel Bight (38G0) and north/east of Fehmarn Island (38G1, 37G1) while the distribution was irregular along the rest of the survey transect in the remaining parts of the subdivision.

The large aggregations of big herring that can be observed annually in SD 23 in the Öre Sound were again present in autumn 2015. NASC values in rectangle 40G2 covering the aggregation hotspot in this area were slightly lower than the high levels measured in 2014 but still significantly higher than the long-time survey average. Like in 2014 the herring aggregations expanded north towards the narrow Helsingör/Helsingborg strait into rectangle 41G2 with corresponding NASC values similar to the previous year.

As in 2014, highest fish densities in SD 24 were recorded north and east of Rügen Island and also in the central parts of the Arkona Sea (37G3, 38G3 and southern 39G3). In most of the rectangles surveyed however, mean NASC values were lower than in the previous year. In rectangles 38G4 (southeastern Arkona Sea) and 39G2 (northwestern Arkona Sea, near Öre Sound mouth), NASC values were above the 2014 results (but below average).

3.2 Biological data

In total 59 trawl hauls were conducted:

Subdivision	No. of Hauls
21	19
22	18
23	3
24	19

Altogether, 1 745 individual herring, 904 sprat and 272 European anchovies were frozen for further investigations (e.g. determining sex, maturity, age). Results of catch compositions by Subdivision are presented in Tables 2-5. Altogether, 39 different species were recorded. Herring were caught in 58, sprat in 54 hauls. As in the previous year, mean catch rates per station (kg 0.5 h^{-1}) were lowest in SD 22 and highest in SD 23. In contrast to the last year where sardines (*Sardina pilchardus*) were caught in SD 21, this species did not appear in 2015 catches. As in last year anchovy (*Engraulis encrasicolus*) was present in most catches. Anchovies were caught throughout the survey area (exception SD 23) in 43 out of 59 hauls, including the majority of hauls in SD 21. In some hauls in SD 22, anchovies contributed the bulk of clupeid catches.

Figures 2 and 3 show relative length-frequency distributions of **herring** and sprat in ICES subdivisions 21, 22, 23 and 24 for the years 2014 and 2015. Compared to results from the previous survey in 2014, the following conclusions for herring can be drawn (Fig. 2):

- Catches in SD 21 show a bimodal distribution characterized by the presence of the incoming year class (<=15 cm) and older herring (>15 cm) in 2015. This is in contrast to 2014, where the fraction of older herring was mostly absent.
- SD 22 shows the incoming year class with only one mode at 10.75 cm while in 2014 two modes were observed at 12.75 cm and 15.25 cm. Older fishes show another mode at 16.75 cm (17.75 cm in 2014). In contrast to previous year this year's results show fewer larger herring.
- In SD 23, larger herring (> 20 cm) dominate catches. The contribution of larger herring is more pronounced compared to the previous year when herring of the incoming year class were present with two modes at ca. 7.25 cm and at 11.75 cm.
- In SD 24, the herring length-frequency distribution is characterized by the incoming year class (<=15.00 cm) and older herring (>15 cm), whereas in 2014 it was dominated by the incoming year class (mode at 11.25 cm) with only few older fishes.
- Altogether, the present contribution of the incoming year class (ca. <15 cm) seemed to be less pronounced than in the previous year.

Relative length-frequency distributions of **sprat** in the years 2014 and 2015 (Fig. 3) can be characterized as follows:

- In SD 21, 22 and 23 catch numbers of the incoming year class (<= 10 cm) are virtually absent in 2015. The catches are now mostly dominated by the contribution of larger sprat (ca. >10 cm). The highest contribution of very large sprat is found in SD 23 (mode at 15.75 cm).
- In SD 24, the sprat length-frequency distribution is similar compared to 2014 with a bimodal distribution of both incoming year class (< 10 cm) and older sprat.
- Altogether, the present contribution of the incoming year class (ca. <10 cm) is very low.

3.3 Biomass and abundance estimates

In the western Baltic, the distribution areas of two stocks, the Western Baltic Spring Spawning herring (WBSSH) and the Central Baltic herring (CBH) overlap. Survey results from recent years indicated that in SD 24, which is part of the WBSSH management area, a considerable fraction of CBH is present and correspondingly erroneously allocated to WBSSH stock indices (ICES, 2013). Accordingly, a stock separation function (SF) based on growth parameters derived from 2005 to 2010 has been developed to quantify the proportion of CBH and WBSSH in the area (Gröhsler et al., 2013; Gröhsler et al., 2016). The estimates of the growth parameters based on baseline samples of WBSSH and CBH in 2011-2014 and in 2015 support the applicability of SF (Oeberst et al., 2013, WD Oeberst et al., 2014; WD Oeberst et al., 2015; WD Oeberst et al., 2016). Beside in SD 24, the SF was finally also applied to ICES rectangle 39G2 (SD 23 area) since biological samples of 39G2 (SD 24 area) were used to raise the corresponding recorded Sa values.

The age-length distribution of herring in SD 22 in 2015 for the first time indicated a higher contribution of older fish of CBH origin. Thus, the SF was also applied in SD 22.

The present results in SD 23 further show an unusual, very high contribution of mature herring (percentage of maturity stages ≥6 in 2015: 31 %; mean 1994-2014: 3 %), which cannot be considered of WBSSH origin. Accordingly, the fraction of 'mature' herring has not been taken into account in the final analysis.

The ICES Herring Assessment Working Group for the area south of 62° N (HAWG)) is yearly supplied with an index for this survey (GERAS), which now excludes CBH in 2005-2015 and in general covers the total standard survey area, excluding ICES rectangles 43G1 and 43G2 in SD 21 and 37G3 and 37G4 in SD 24, which were not covered in 1994-2004.

3.3.1 Estimates incl. Central Baltic herring

The total abundance of herring and sprat is presented in Table 6. Estimated numbers of herring and sprat by age group and SD/rectangle are given in Table 7 and Table 10. Corresponding mean weights by age group and SD/rectangle are shown in Table 8 and Table 11. Estimates of herring and sprat biomass by age group and SD/rectangle are summarised in Table 9 and Table 12.

The **herring** stock in Subdivisions 21-24 was estimated to be 3.7 x 10^9 fish (Table 7) or 240.5 x 10^3 tonnes (Table 9). For the included area of Subdivisions 22-24 the number of herring was calculated to be 3.35 x 10^9 fish or 229.1 x 10^3 tonnes. In contrast to former years, where the overall abundance estimate was dominated by young herring (age 0-1), the results in 2015 show a higher contribution of age 2 (Figure 2 and Table 7).

The estimated **sprat** stock in Subdivisions 21-24 was 7.4 x 10^9 fish (Table 10) or 75.6 x 10^3 tonnes (Table 12). For the included area of Subdivisions 22-24 the number of sprat was calculated to be 6.8 x 10^9 fish or 69.3 x 10^3 tonnes. The overall abundance estimate was dominated by the incoming year class (Figure 3 and Table 10).

3.3.2 Estimates excl. Central Baltic herring in SDs 22&24 and mature herring in SD 23

Estimated numbers of **herring excluding CBH** in SDs 22-24 or mature herring (stages ≥6) in SD 23 by age group and SD/rectangle for 2015 are given in Table 13. Corresponding herring mean weights by age group and SD/rectangle are shown in Table 14. Estimates of herring biomass excluding CBH by age group and SD/rectangle are summarised in Table 15. Removal of the CBH fraction in SDs 22 and 24 from herring GERAS indices in 2015 resulted in biomass reductions of 10.1 % with corresponding reductions in numbers of 13.9 % (0.8 and 0.7 %, respectively in 2014; Fig. 5). Further removal of all mature herring in SD 23 from herring GERAS indices in 2015 gave an overall biomass reduction of 35.7 % with corresponding reductions in numbers of 25.6 % (Fig. 5).

3.4 Hydrographic data

In addition to the trawl hauls, vertical profiles of temperature, salinity and oxygen concentration were measured on a station grid covering the whole survey area. Altogether, hydrography profiles were measured on 84 stations. CTD stations as well as horizontal gradients of temperature, salinity and oxygen concentration both at the surface and at the seafloor are displayed in Figure 6.

Like in 2014, surface temperatures were comparatively high especially in the Arkona Sea. Overall surface temperatures ranged from ca. 11.5 °C in SD 21 to 15.5 °C in the southeastern SD 24. Bottom temperatures in the southern Kattegat were higher than surface temperatures with values around 14.5 °C, while in the northern Kattegat in deeper water temperatures at the seafloor were around 8.5 °C. In the remaining survey area, especially in SD 22 and SD 24, seafloor temperatures were similar to surface temperatures. Surface salinities ranged from ca. 22 psu in the Kattegat to ca. 8 psu in the eastern Arkona Sea. Bottom salinities showed a similar gradient but were generally higher in the range of 35 psu (northern part of survey area in SD 21) to ca. 9.5 psu (SD 24). Surface layers were well oxygenated throughout the survey area. Signs of oxygen depletion were as in previous years evident in bottom layers of some areas in SD 22. In SD 22, oxygen depletion in the inner and southern Mecklenburg Bight as well as the southern part of the little Belt and the eastern Kiel Bight had proceeded to almost anoxic conditions near the seafloor.

4 DISCUSSION

Compared to 2014, the present estimates of **herring (incl. CBH)** show a significant decrease in stock biomass or abundance:

Herring	Difference compared to 2014	
Area	Numbers (%)	Biomass (%)
Subdivisions 22-24	-28	-27
Subdivisions 21-24	-70	-40

The significant decrease in 2015 was mainly driven by lower numbers or biomass estimates of age groups 0-1 and 4-6, which were somehow compensated by higher values of age groups 2-3 and 7-8+. The strength of the new incoming year class in 2015 was the lowest observed in the time series since 1994.

As in the years before 2014, some older and bigger herring were detected in the northern and northwestern parts of SD 24. These were herring that already had started to migrate out of the Sound (SD 23). It is assumed that these migrations are triggered by hydrographic conditions in a way that barotropic inflow events in late summer and early autumn prevent deoxygenation in the Sound. This leads to prolonged aggregations of herring in the Sound (Miethe et al., 2014). In 2015, such migration of big herring was already partially detected during the survey period, indicating that according hydrographic conditions were met driving herring out of the Sound (see also bottom oxygen concentrations measured in the area, Figure 6). The higher contribution of older herring (ages 3-8+) diminished when excluding CBH by applying the SF but remained clearly detectable. Elimination of CHB in SD 24 lead – regarding the GERAS index covering the standard survey area - to differences of -9.9 % in numbers or -13.6 % in biomass.

The overall decrease in numbers and biomass was also evident in SD 22, showing far lower estimates of age groups 0 and 1 than in 2014. Before 2014 this area was characterised by almost exclusively small, young herring. Since 2014 the amount of older, small sized herring (TL < 20 cm and ages 3-8) - most likely of CBH origin – steadily increased and now showed the highest contribution in 2015. Therefore it was decided for the first time in 2015 to apply the SF also in SD 22 when compiling the final GERAS index. However, excluding CBH by applying the SF also in SD 22 further lead to only very small differences of <-1 % in numbers or biomass (overall -10.1 % in numbers or -13.9 % in biomass).

As in former years, SD 23, which is seen as an important transition and aggregation area for the WBSSH stock during its spawning migration – showed a high contribution of large herring. However, in contrast to former years, which only gave a small fraction of mature herring (maturity stages >=6: mean contribution 1994 – 2014: 3 %), this year's estimates increased to 31 %. The presence of distinct numbers of mature herring in SD 23 most likely could be related to North Sea autumn spawning herring, which could have migrated into this area, probably driven by prolonged inflow events bringing high salinity water masses into this area. This would not be in contrast to other herring already migrating southward out of the Sound driven by hydrographic conditions as immigration by NSAS and emigration by WBSSH could be driven by temporally decoupled hydrographic factors discussed above. It has been suggested that variations in temperature and salinity, indicating changes in water masses, could affect distribution patterns of herring in the North Sea (Maravelias and Reid, 1995; Röckmann et al., 2011).

Since the present high fraction of mature herring at the survey time of GERAS cannot be assigned to WBSSH, it was decided to remove all mature herring from the final index results. This further reduction lead to overall final differences of --25.6 % in numbers or -35.7 % in biomass.

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6 FIGURES AND TABLES

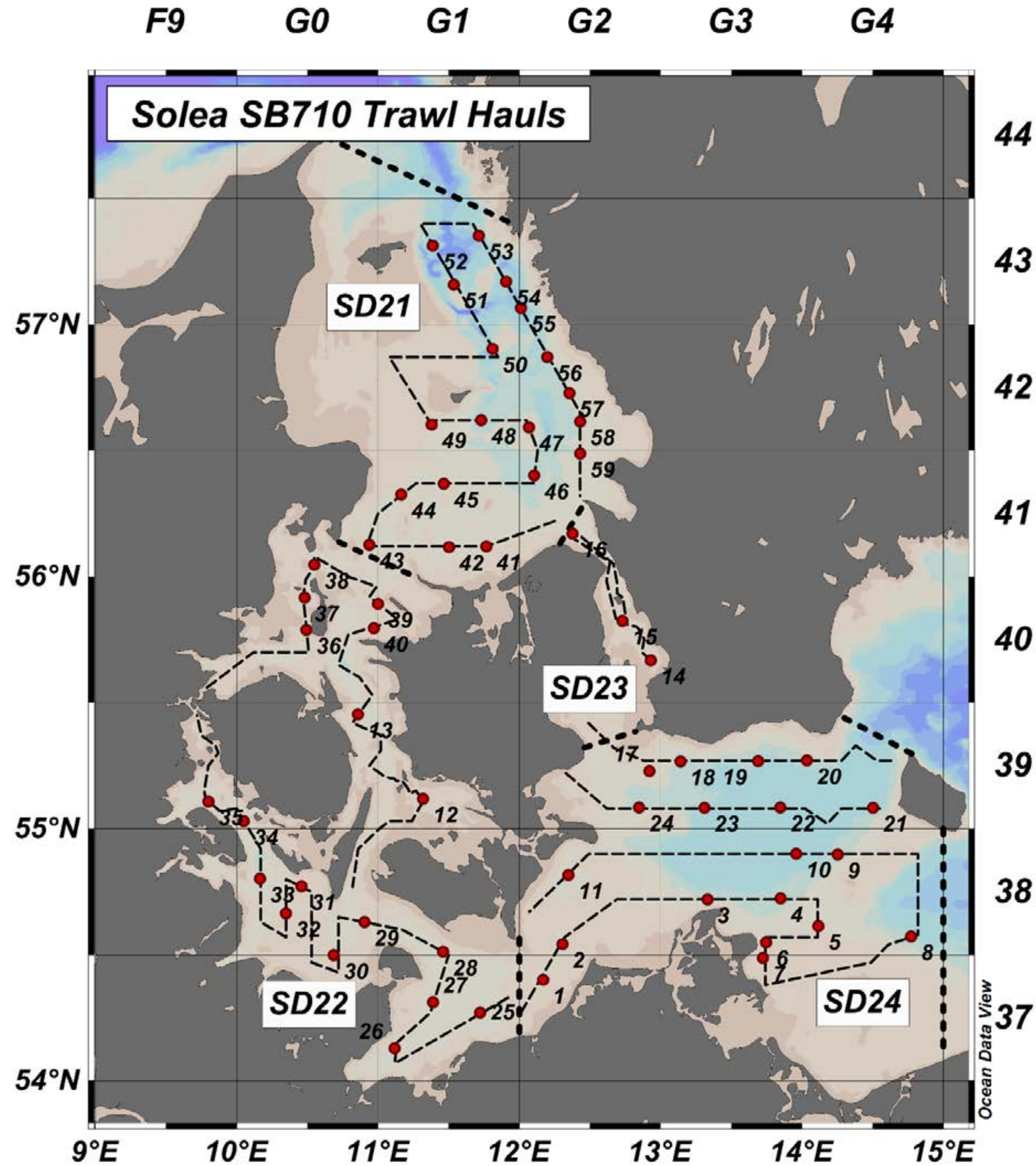


Figure 1: FRV "Solea", cruise 710/2015. Cruise track (lines) and fishery hauls (dots). ICES statistical rectangles are indicated in the top and right axis. Thick dashed lines separate ICES subdivisions (SD).

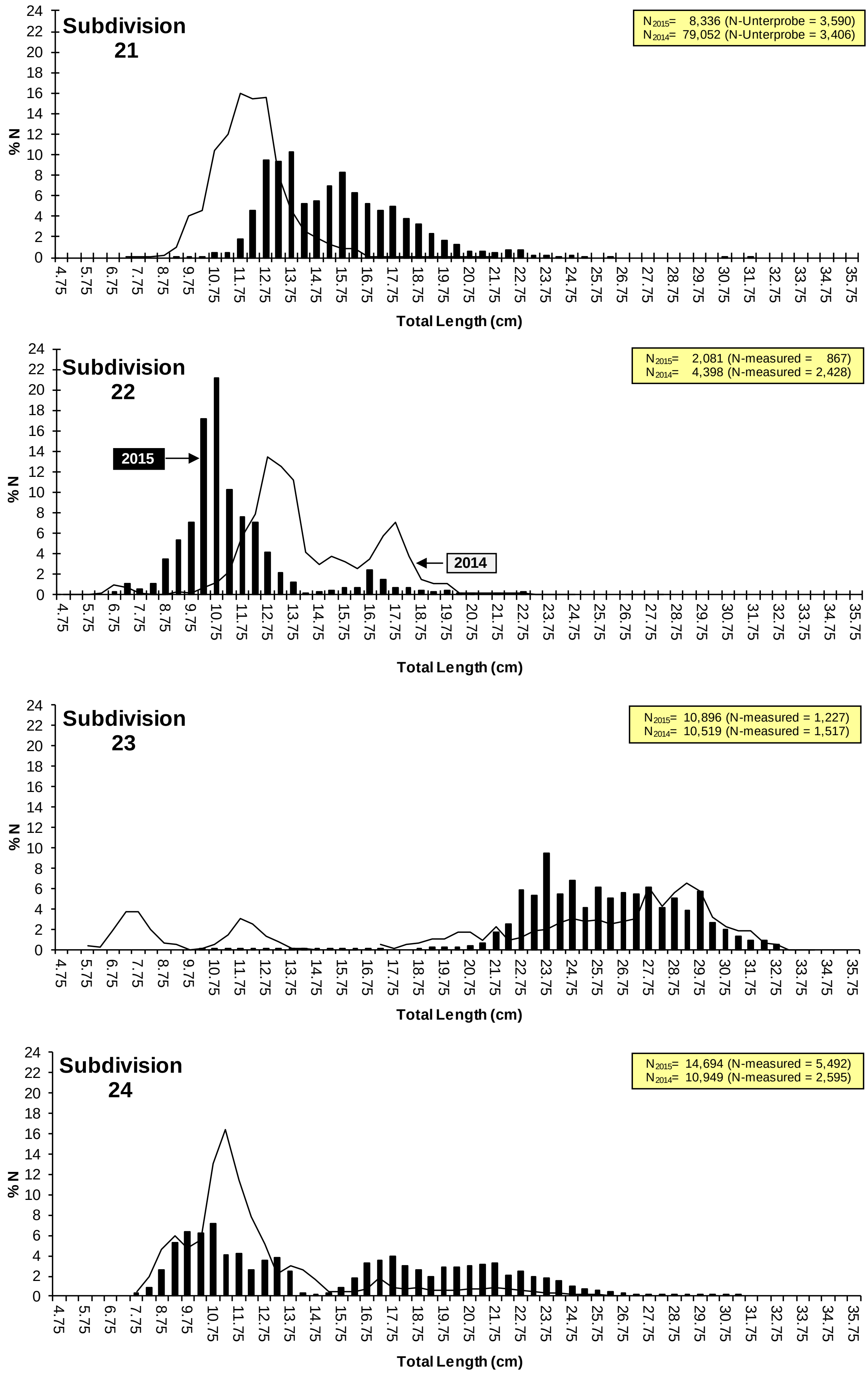


Figure 2: FRV "Solea," cruise 710/2015: Herring (*Clupea harengus*) length-frequency distribution compared to previous year (cruise 694/2014).

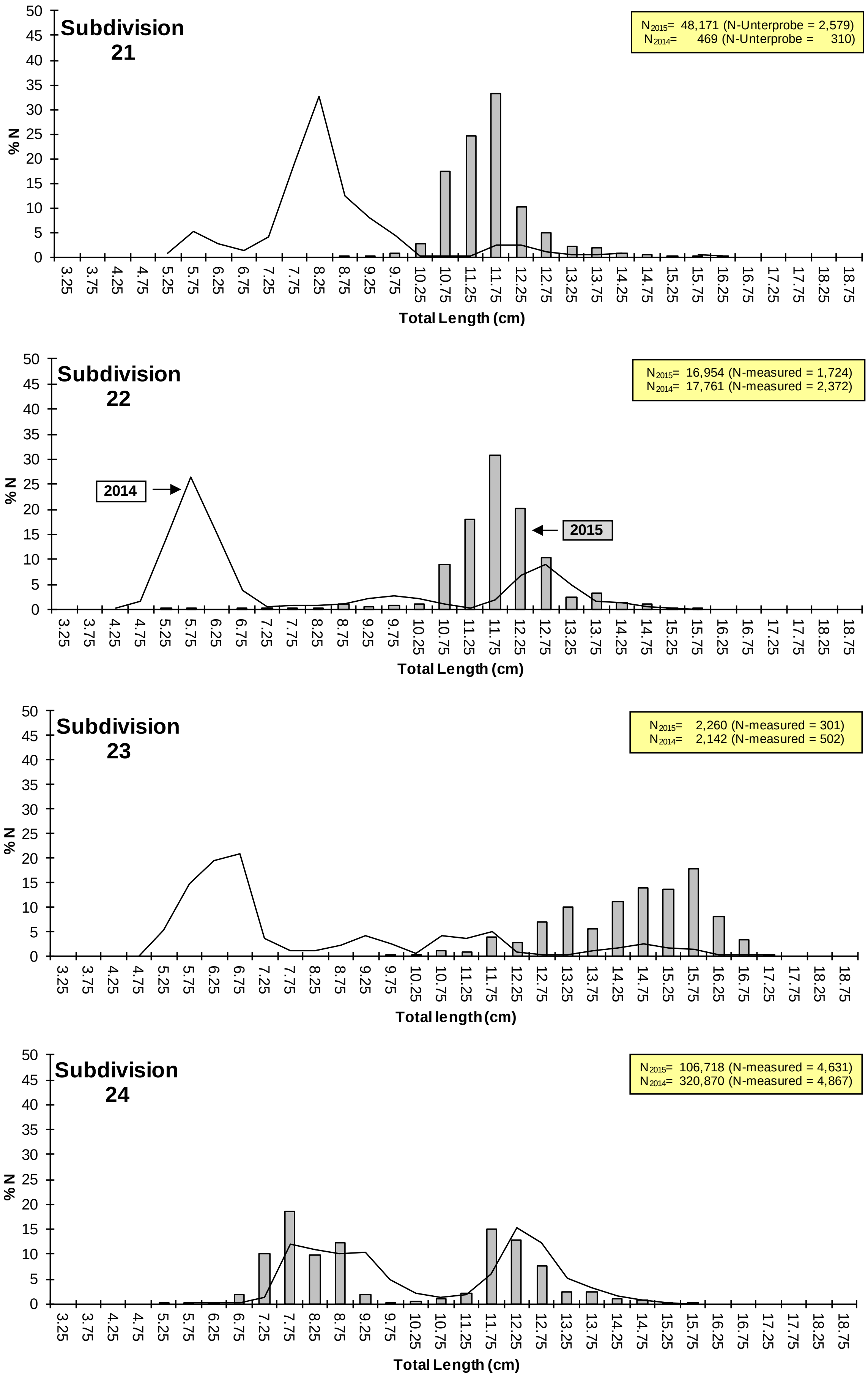


Figure 3: **FRV "Solea", cruise 710/2015: Sprat (*Sprattus sprattus*) length-frequency distribution compared to previous year (cruise 694/2014).**

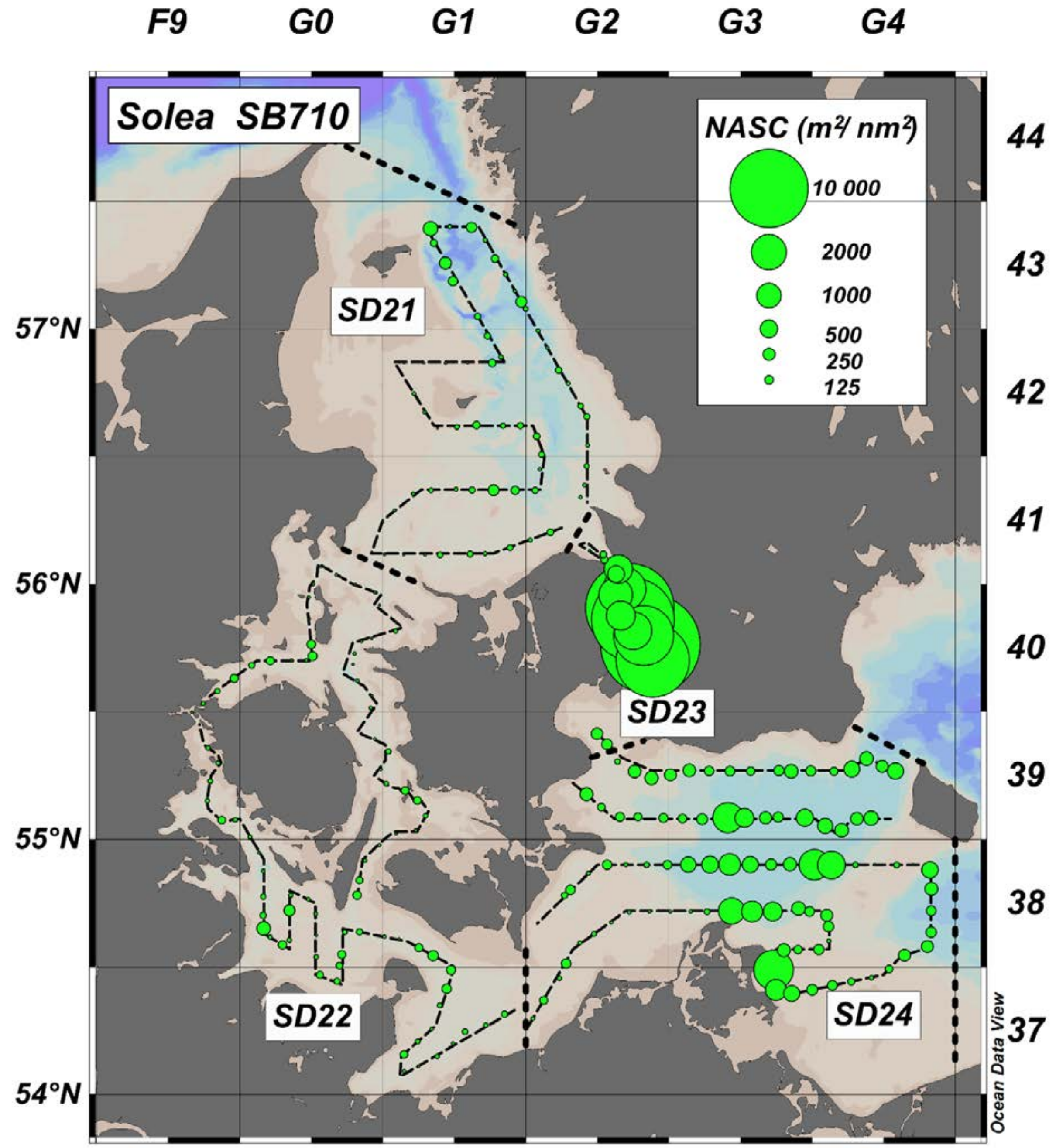


Figure 4: FRV "Solea", cruise 710/2015. Cruisetrack (lines) and mean NASC (5 nm intervals). ICES statistical rectangles are indicated in the top and right axis. Thick dashed lines separate ICES subdivisions (SD).

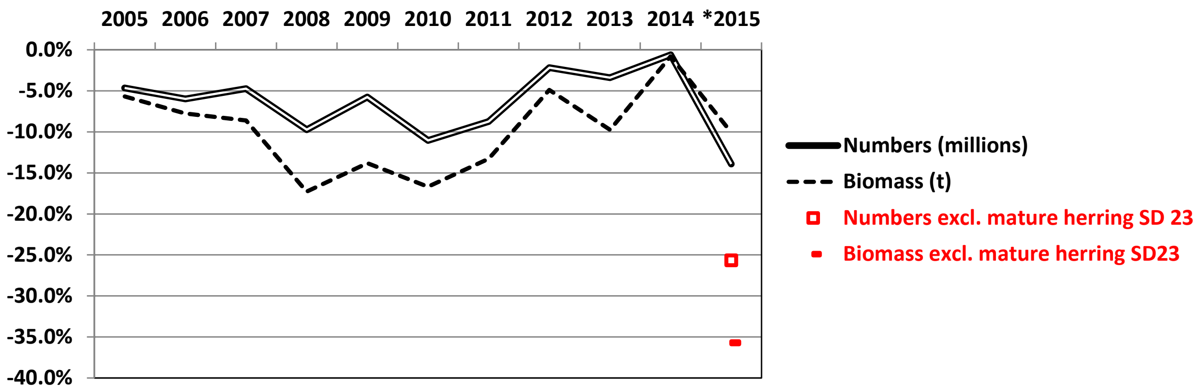


Figure 5 Relative changes in abundance and biomass of Western Baltic Spring Spawning herring in ICES Subdivisions 21-24 (2005-2015) after application of the stock separation function (SF, Gröhsler et al., 2013) to the abundance and biomass index generated from German acoustic survey data (GERAS). *2015 = excl. CBH also in SD 22.

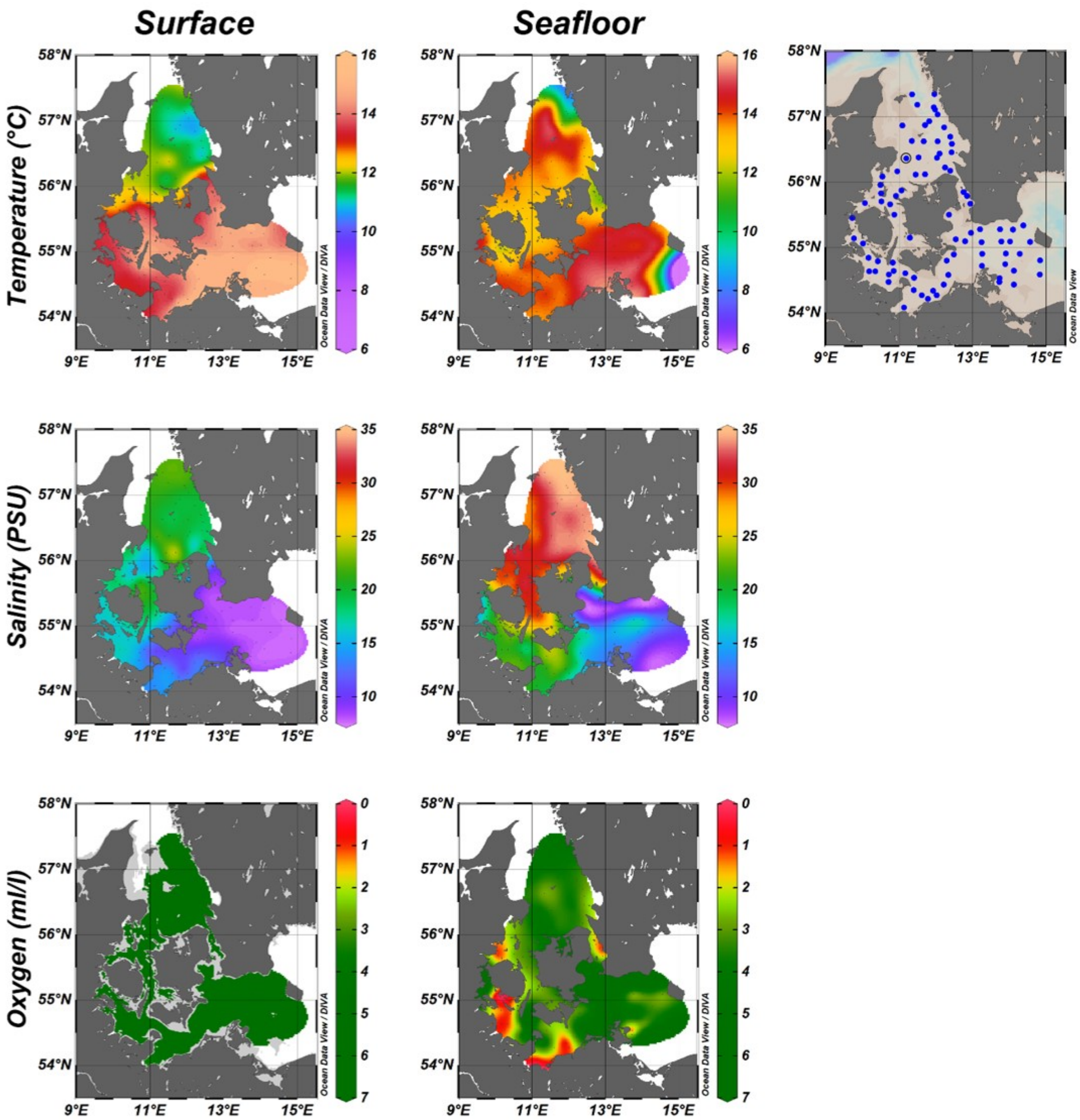


Figure 6: FRV "Solea" cruise 710/2015: Hydrography. CTD stations are depicted as blue dots in the area map (far right). Temperature (°C, top panels), salinity (PSU, middle panels and oxygen concentration (ml/l, lower panels) at the surface (left) and near the seafloor (right). Surface oxygen concentration levels are displayed at 5 m depth.

Table 1: FRV "Solea", cruise 710/2015. Simrad EK60 calibration report.

```
#  Calibration  Version   2.1.0.12
#
#  Date:  01.10.2015
#
#  Comments: Querab Kühlungsborn, 54°11.5 N, 11°47.8 E, treibend
#
#
#  Reference Target:
#    TS                   -42.37 dB           Min. Distance     16.00 m
#    TS Deviation               2.0 dB        Max. Distance     18.00 m
#
#  Transducer:  ES38B  Serial No.   30545
#    Frequency            38000 Hz       Beamtype                 Split
#    Gain                 26.16 dB       Two Way Beam Angle   -20.6 dB
#    Athw. Angle Sens.       21.70       Along. Angle Sens.      21.70
#    Athw. Beam Angle     7.06 deg       Along. Beam Angle    7.03 deg
#    Athw. Offset Angle  -0.03 deg       Along. Offset Angle -0.03 deg
#    SaCorrection         -0.58 dB       Depth                 4.20  m
#
#  Transceiver:  GPT  38 kHz 009072056b06 2-1 ES38B
#    Pulse Duration       1.024 ms       Sample Interval     0.190   m
#    Power                 2000  W       Receiver Bandwidth   2.43 kHz
#
#  Sounder Type:
#    EK60 Version  2.2.0
#
#  TS Detection:
#    Min. Value           -50.0 dB       Min. Spacing             100 %
#    Max. Beam Comp.        6.0 dB       Min. Echolength           80 %
#    Max. Phase Dev.          8.0        Max. Echolength          180 %
#
#  Environment:
#    Absorption Coeff.   4.3 dB/km       Sound Velocity     1487.0 m/s
#
#  Beam Model results:
#    Transducer Gain    = 26.25 dB       SaCorrection       = -0.50 dB
#    Athw. Beam Angle   = 7.16 deg       Along. Beam Angle  = 7.15 deg
#    Athw. Offset Angle =-0.04 deg       Along. Offset Angle=-0.01 deg
#
#  Data deviation from beam model:
#    RMS =    0.21 dB
#    Max =    0.63 dB  No. =   152  Athw. = -2.9 deg  Along =  4.0 deg
#    Min =   -1.26 dB  No. =   133  Athw. =  3.3 deg  Along =  3.2 deg
#
#  Data deviation from polynomial model:
#    RMS =    0.17 dB
#    Max =    0.55 dB  No. =   152  Athw. = -2.9 deg  Along =  4.0 deg
#    Min =   -1.12 dB  No. =   133  Athw. =  3.3 deg  Along =  3.2 deg
```

Table 2: FRV "Solea", cruise 710/2015. Catch composition (kg 0.5h-1) by trawl haul in SD 21.

Haul No.	41	42	43	44	45	46	47	48	49	50	51
Species/ ICES Rectangle	41G1	41G1	41G0	41G1	41G1	41G2	42G2	42G1	42G1	42G1	43G1
CLUPEA HARENGUS	2.59	55.21	1.55	1.52	1.31	8.87	1.41	8.9	0.18	6.86	5.71
CRANGON CRANGON											
CRYSTALLOGOBIUS LINEARIS											+
CTENOLABRUS RUPESTRIS	0.01										
CYCLOPTERUS LUMPUS	0.19										
ENGRAULIS ENCRASICOLUS	0.01		0.02	0.16	0.02	0.16	0.02	0.82		0.08	0.070
EUTRIGLA GURNARDUS			0.02		0.11			0.22			
GADUS MORHUA				2.30	2.48		0.75				
GASTEROSTEUS ACULEATUS	0.01	0.01									
HIPPOGLOSSOIDES PLATESSOIDES											
LIMANDA LIMANDA	0.06		0.44					4.98	0.11		
LOLIGO FORBESI	0.01	+	0.01	+			+	+		0.05	0.08
MERLANGIUS MERLANGUS	0.01	0.02	0.00	0.01	+	+	0.41	2.71	0.12	0.05	0.07
MERLUCCIUS MERLUCCIUS											
MYSIDACEA											
NEPHROPS NORVEGICUS											
PLEURONECTES PLATESSA								0.09			
POMATOSCHISTUS MINUTUS											0
SCOMBER SCOMBRUS				8.77	16.92	5.66	1.1		7.57	0.64	17.54
SCOPHTHALMUS RHOMBUS											
SEPIOLA											0.01
SPRATTUS SPRATTUS	2.07	1.91	1.31	0.05	0.09	109.16	0.09	216.67		0.07	1.98
SQUALUS ACANTHIAS											6.51
SYNGNATHUS TYPHLE	+										
TRACHINUS DRACO	1.09	0.21	0.07	0.17	0.12	0.2	0.28	7.64	0.43	0.26	2.62
TRACHURUS TRACHURUS	0.03	0.01	+	+	+	0.01	+	+		0.01	0.13
TRISOPTERUS ESMARKI											+
Total	**6.08**	**57.37**	**3.42**	**12.98**	**21.05**	**124.06**	**4.06**	**242.03**	**8.41**	**8.02**	**34.72**
Medusae	4.55	0.78	1.83	3.05	0.00	0.27	0.36	1.34	3.67	0.54	0.03

Haul No.	52	53	54	55	56	57	58	59	Total
Species/ ICES Rectangle	43G1	43G1	43G1	43G2	42G2	42G2	42G2	41G2	
CLUPEA HARENGUS	3.58	36.20		5.64	16.64	16.32	5.92	26.72	**205.13**
CRANGON CRANGON		0.07						+	**0.07**
CRYSTALLOGOBIUS LINEARIS			+	+	+		+		**+**
CTENOLABRUS RUPESTRIS									**0.01**
CYCLOPTERUS LUMPUS									**0.19**
ENGRAULIS ENCRASICOLUS	0.02	0.03	0.31	+	0.08	0.05	0.08	0.01	**1.94**
EUTRIGLA GURNARDUS	0.18				0.10	0.04	0.22	0.29	**1.18**
GADUS MORHUA				0.65	3.92	16.00	8.90	9.04	**44.04**
GASTEROSTEUS ACULEATUS									**0.02**
HIPPOGLOSSOIDES PLATESSOIDES	0.02	0.17							**0.19**
LIMANDA LIMANDA	0.13	0.03			0.34	0.37	0.36	0.03	**6.85**
LOLIGO FORBESI	0.04	0.01	0.10	0.01	0.01	0.02	0.05	0.03	**0.42**
MERLANGIUS MERLANGUS	0.61	5.32	0.21	0.59	0.81	0.30	1.25	0.44	**12.93**
MERLUCCIUS MERLUCCIUS		0.14	0.00	0.02		0.23	0.37	0.09	**0.85**
MYSIDACEA	+	0.02	+						**0.02**
NEPHROPS NORVEGICUS				0.05					**0.05**
PLEURONECTES PLATESSA						0.66	1.26		**2.01**
POMATOSCHISTUS MINUTUS		+	+				+		**+**
SCOMBER SCOMBRUS	1.28				0.15	0.16			**59.79**
SCOPHTHALMUS RHOMBUS						0.56			**0.56**
SEPIOLA	0.02	0.01	+	+	0.11		0.03	0.01	**0.19**
SPRATTUS SPRATTUS	9.28	0.46		0.44	61.88	79.34	29.18	26.34	**540.32**
SQUALUS ACANTHIAS		1.35			2.25				**10.11**
SYNGNATHUS TYPHLE									**+**
TRACHINUS DRACO	0.31		0.07	0.9	1.06	1.04	1.05	0.59	**18.11**
TRACHURUS TRACHURUS	0.01	+	+			0.02	0.02		**0.24**
TRISOPTERUS ESMARKI	0.14	0.84		0.01					**0.99**
Total	**15.62**	**44.65**	**0.69**	**8.31**	**87.35**	**115.11**	**48.69**	**63.59**	**906.21**
Medusae	0.12	0.00	0.43	0.10	0.00	0.00	0.00	0.33	**17.40**

+ = < 0.01 kg

Table 3: FRV "Solea", cruise 710/2015. Catch composition (kg $0.5h^{-1}$) by trawl haul in SD 22.

Haul No.	12	13	25	26	27	28	29	30	31	32	33
Species/ ICES Rectangle	39G1	39G0	37G1	37G1	37G1	38G1	38G0	37G0	38G0	38G0	38G0
AGONUS CATAPHRACTUS											
CARCINUS						0.07	0.05				
CLUPEA HARENGUS	0.01	0.11	0.46	1.54	2.49	11.40	0.52	2.62	0.09	0.50	0.51
CRANGON CRANGON									+		+
CRYSTALLOGOBIUS LINEARIS	+						+	+			
CTENOLABRUS RUPESTRIS	0.05										
CYCLOPTERUS LUMPUS							0.32				
ENGRAULIS ENCRASICOLUS	0.09	0.03	0.11	0.03	0.20	3.02	0.72	0.03	0.28	0.72	2.89
GADUS MORHUA					3.27	0.16		5.90			
GASTEROSTEUS ACULEATUS	2.48		0.08		0.03	0.17				0.04	+
GOBIUS NIGER	0.03					0.06					
HIPPOGLOSSOIDES PLATESSOIDES					0.17						
LIMANDA LIMANDA	0.56		0.05		2.58	4.19	0.13	19.26	1.94	3.57	
LOLIGO FORBESI										0.00	
MELANOGRAMMUS AEGLEFINUS				0.66							
MERLANGIUS MERLANGUS			0.11		0.55	0.18		0.39	+	+	0.01
MYOXOCEPHALUS SCORPIUS	0.21										
PLATICHTHYS FLESUS					0.23			6.22	0.42	0.80	
PLEURONECTES PLATESSA								11.35			
POMATOSCHISTUS MINUTUS	0.01				+	+		0.01	+	+	
PSETTA MAXIMA								2.18			
SCOPHTHALMUS RHOMBUS											
SOLEA VULGARIS						0.06		0.36			
SPRATTUS SPRATTUS	+	0.06	7.61	0.06	94.09	41.47	0.05	38.42	0.09	4.59	0.10
SYMPHODUS MELOPS	0.02										
SYNGNATHUS TYPHLE	+					+			+	+	+
TRACHINUS DRACO								0.08		0.02	
TRACHURUS TRACHURUS			0							0	
Total	**3.46**	**0.20**	**8.42**	**2.29**	**103.61**	**60.78**	**1.79**	**86.82**	**2.82**	**10.24**	**3.51**
Medusae	0.01	0.63	2.78	0.33	0.16	0.60	0.49	7.86	4.47	1.22	1.47

Haul No.	34	35	36	37	38	39	40	Total
Species/ ICES Rectangle	39G0	39F9	40G0	40G0	41G0	40G1	40G0	
AGONUS CATAPHRACTUS						0.02		**0.02**
CARCINUS								**0.12**
CLUPEA HARENGUS	0.05	0.46	0.10	0.12	0.03	0.21	0.03	**21.25**
CRANGON CRANGON								**+**
CRYSTALLOGOBIUS LINEARIS			+					**+**
CTENOLABRUS RUPESTRIS					0.01	+	0.02	**0.08**
CYCLOPTERUS LUMPUS								**0.32**
ENGRAULIS ENCRASICOLUS		0.24	0.02	0.03	0.09	0.01	0.09	**8.60**
GADUS MORHUA					0.09			**9.42**
GASTEROSTEUS ACULEATUS	0.77	4.51		0.01	0.01	+	0.02	**8.12**
GOBIUS NIGER					+			**0.09**
HIPPOGLOSSOIDES PLATESSOIDES								**0.17**
LIMANDA LIMANDA	0.02	0.72		0.06	0.56	0.31	0.08	**34.03**
LOLIGO FORBESI					0.02	0.01	+	**0.03**
MELANOGRAMMUS AEGLEFINUS								**0.66**
MERLANGIUS MERLANGUS		+	0.01	+		+	0.01	**1.26**
MYOXOCEPHALUS SCORPIUS					0.14			**0.35**
PLATICHTHYS FLESUS					0.12			**7.79**
PLEURONECTES PLATESSA								**11.35**
POMATOSCHISTUS MINUTUS						0.00		**0.02**
PSETTA MAXIMA								**2.18**
SCOPHTHALMUS RHOMBUS				0.16				**0.16**
SOLEA VULGARIS								**0.42**
SPRATTUS SPRATTUS	0.14	0.14		0.01		0.72		**187.55**
SYMPHODUS MELOPS							0.10	**0.12**
SYNGNATHUS TYPHLE								**+**
TRACHINUS DRACO				0.04	0.05	1.14	0.09	**1.42**
TRACHURUS TRACHURUS				0.01	+	+		**0.01**
Total	**0.98**	**6.07**	**0.13**	**0.44**	**1.12**	**2.42**	**0.44**	**295.54**
Medusae	0.49	3.23	15.90	6.00	5.15	2.50	0.18	**53.47**

+ = < 0.01 kg

Table 4: FRV "Solea", cruise 710/2015. Catch composition (kg 0.5h[-1]) by trawl haul in SD 23.

Haul No.	14	15	16	Total
Species/ICES Rectangle	40G2	40G2	41G2	
CARCINUS	0.07			**0.07**
CLUPEA HARENGUS	644.34	778.58	0.72	**1423.64**
CTENOLABRUS RUPESTRIS			0.02	**0.02**
EUTRIGLA GURNARDUS			0.06	**0.06**
GADUS MORHUA	289.41	114.47		**403.88**
LIMANDA LIMANDA	0.24		6.73	**6.97**
LOLIGO FORBESI			0.01	**0.01**
MELANOGRAMMUS AEGLEFINUS		2.29		**2.29**
MERLANGIUS MERLANGUS		1.27	0.15	**1.42**
PLATICHTHYS FLESUS		0.56		**0.56**
SPRATTUS SPRATTUS	0.85	41.90	0.64	**43.39**
SYNGNATHUS TYPHLE		+		**+**
TRACHINUS DRACO			0.39	**0.39**
TRACHURUS TRACHURUS			+	**+**
Total	**934.91**	**939.07**	**8.72**	**1882.70**
Medusae	0.00	0.00	0.24	**0.24**

+ = < 0.01 kg

Table 5: FRV "Solea", cruise 710/2015. Catch composition (kg 0.5h[-1]) by trawl haul in SD 24.

Haul No.	1	2	3	4	5	6	7	8	9	10	11
Species/ICES Rectangle	37G2	38G2	38G3	38G3	38G4	38G3	37G3	38G4	38G4	38G3	38G2
AGONUS CATAPHRACTUS											
CLUPEA HARENGUS	1.85	7.05	4.61	10.10	58.99	13.25	52.54	68.34	7.95	12.02	7.74
CRANGON CRANGON											
CRYSTALLOGOBIUS LINEARIS				+							
CYCLOPTERUS LUMPUS		0.32									
ENGRAULIS ENCRASICOLUS	0.05	0.01	0.06		0.04	0.04	0.05				
EUTRIGLA GURNARDUS											
GADUS MORHUA			0.77		20.86	8.06	4.41	2.63	4.48	0.49	
GASTEROSTEUS ACULEATUS		+	+	+							0.19
GOBIUS NIGER											0.03
LEANDER											
LIMANDA LIMANDA			0.46			0.07					0.65
MERLANGIUS MERLANGUS	0.01	0.01	0.20	3.85	0.42	0.19			0.56	2.72	
MYOXOCEPHALUS SCORPIUS								0.18			
OSMERUS EPERLANUS				0.04	0.01	0.06					
PLATICHTHYS FLESUS			0.45	0.84	0.13	1.58	1.06	0.13	0.26	0.16	1.14
PLEURONECTES PLATESSA		0.18	1.64								0.21
POMATOSCHISTUS MINUTUS		+	0.01	+				+	+	+	+
PSETTA MAXIMA											0.68
RUTILUS RUTILUS							3.42				
SCOMBER SCOMBRUS				0.97							
SPRATTUS SPRATTUS	0.47	20.5	108.06	233.89	2.64	51.59	131.01	1.64	6.35	27.26	18.76
SYNGNATHUS TYPHLE											
TRACHINUS DRACO											0.04
TRACHURUS TRACHURUS			0.01								
Total	**2.38**	**28.07**	**116.27**	**249.69**	**83.09**	**74.84**	**192.49**	**72.92**	**19.60**	**42.65**	**29.44**
Medusae	0.99	0.07	0.52	0.67	0.08	1.90	0.02	1.39	7.85	1.10	0.31

Haul No.	17	18	19	20	21	22	23	24	Total
Species/ICES Rectangle	39G2	39G3	39G3	39G4	39G4	39G3	39G3	39G2	
AGONUS CATAPHRACTUS								+	**+**
CLUPEA HARENGUS	13.46	11.27	12.83	36.08	77.74	34.78	12.63	20.33	**463.56**
CRANGON CRANGON	+	+		+			+	+	**+**
CRYSTALLOGOBIUS LINEARIS									**+**
CYCLOPTERUS LUMPUS									**0.32**
ENGRAULIS ENCRASICOLUS				0.01			0.01	0.02	**0.29**
EUTRIGLA GURNARDUS	0.06								**0.06**
GADUS MORHUA	1.02	3.17	7.58	1.70	0.47	1.35			**56.99**
GASTEROSTEUS ACULEATUS								+	**0.19**
GOBIUS NIGER								+	**0.03**
LEANDER	0.01								**0.01**
LIMANDA LIMANDA				0.14			0.09		**1.41**
MERLANGIUS MERLANGUS			0.33		6.43	19.91	+	0.03	**34.66**
MYOXOCEPHALUS SCORPIUS									**0.18**
OSMERUS EPERLANUS									**0.11**
PLATICHTHYS FLESUS	0.26	0.64		0.22		1.36	0.85		**9.08**
PLEURONECTES PLATESSA			0.33	0.09					**2.45**
POMATOSCHISTUS MINUTUS	0.00	0.01	0.01	0.02			0.22	0.01	**0.28**
PSETTA MAXIMA				0.48					**1.16**
RUTILUS RUTILUS									**3.42**
SCOMBER SCOMBRUS			0.24						**1.21**
SPRATTUS SPRATTUS	22.25	21.83	48.8	10.61	0.34	16.86	10.61	49.67	**783.14**
SYNGNATHUS TYPHLE								+	**+**
TRACHINUS DRACO									**0.04**
TRACHURUS TRACHURUS									**0.01**
Total	**37.06**	**36.92**	**70.12**	**49.35**	**84.98**	**74.26**	**24.41**	**70.06**	**1358.60**
Medusae	4.52	2.26	0.40	3.64	0.30	1.02	2.36	0.96	**30.34**

+ = < 0.01 kg

Table 6: FRV "Solea", cruise 710/2015. Survey statistics by area.

Sub-division	ICES Rectangle	Area (nm²)	Sa (m²/NM²)	Sigma (cm²)	N total (million)	Herring (%)	Sprat (%)	NHerring (million)	NSprat (million)
21	41G0	108.1	7.3	1.732	4.56	34.08	58.1	1.55	2.65
21	41G1	946.8	56.0	2.621	202.29	60.17	28.16	121.71	56.97
21	41G2	432.3	43.0	1.518	122.46	18.61	80.75	22.79	98.89
21	42G1	884.2	34.4	2.162	140.69	45.69	49.26	64.28	69.3
21	42G2	606.8	41.2	1.498	166.89	11.2	87.28	18.69	145.66
21	43G1	699.0	123.1	2.281	377.23	47.27	40.64	178.33	153.32
21	43G2	107.0	30.0	2.786	11.52	83.4	7.78	9.61	0.9
21	Total	3,784.2			1,025.64			416.96	527.69
22	37G0	209.9	74.4	1.472	106.09	3.43	96.16	3.64	102.02
22	37G1	723.3	57.4	1.315	315.72	31.96	64.43	100.91	203.43
22	38G0	735.3	55.4	0.913	446.17	6.86	29.93	30.6	133.55
22	38G1	173.2	84.8	1.189	123.53	21.42	67.55	26.46	83.44
22	39F9	159.3	36.7	0.327	178.79	1.3	0.68	2.33	1.22
22	39G0	201.7	20.9	0.829	50.85	21.09	21.23	10.72	10.79
22	39G1	250.0	43.7	0.262	416.98	0.08	0.04	0.35	0.18
22	40F9	51.3	43.6	0.985	22.71	23.86	1.23	5.42	0.28
22	40G0	538.1	39.2	0.985	214.15	23.86	1.23	51.11	2.64
22	40G1	174.5	19.1	2.846	11.71	8.49	52.83	0.99	6.19
22	41G0	173.1	13.1	0.923	24.57	5.17	0	1.27	0
22	Total	3,389.7			1,911.27			233.80	543.74
23	39G2	130.9	205.6	1.691	159.15	28.14	71.68	44.79	114.07
23	40G2	164.0	6018.4	7.534	1310.08	84.21	12.74	1103.23	166.95
23	41G2	72.3	426.0	1.997	154.23	35.54	46.99	54.82	72.47
23	Total	367.2			1,623.46			1,202.84	353.49
24	37G2	192.4	57.7	1.039	106.85	73	24.04	78	25.68
24	37G3	167.7	506.1	0.687	1235.41	5.69	94.25	70.3	1164.40
24	37G4	875.1	86.1	3.655	206.15	67.65	30.61	139.46	63.10
24	38G2	832.9	57.9	1.125	428.67	30.36	67.41	130.13	288.97
24	38G3	865.7	472.1	1.336	3059.11	4.56	95.15	139.45	2910.70
24	38G4	1034.8	308.8	3.655	874.27	67.65	30.61	591.45	267.58
24	39G2	406.1	173.7	1.691	417.15	28.14	71.68	117.40	298.99
24	39G3	765.0	322.0	2.137	1152.69	28.22	70.60	325.29	813.79
24	39G4	524.8	299.4	4.263	368.58	71.09	27.53	262.02	101.47
24	Total	5,664.5			7,848.88			1,853.50	5,934.68
22-24	Total	9,421.4			11,383.61			3,290.14	6,831.91
21-24	Total	13,205.6			12,409.25			3,707.10	7,359.60

Table 7: FRV "Solea", cruise 710/2015. Numbers (millions) of herring incl. CBH by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	0.97	0.39	0.14	0.04						1.54
21	41G1	26.59	77.15	16.09	1.20	0.45				0.23	121.71
21	41G2	12.64	9.18	0.83	0.12	0.02					22.79
21	42G1	9.10	52.82	2.21	0.07	0.07				0.01	64.28
21	42G2	9.76	8.48	0.40	0.02	0.01				0.02	18.69
21	43G1	74.88	91.01	11.42	0.40	0.26	0.14			0.21	178.32
21	43G2	3.40	5.96	0.25	0.01						9.62
21	Total	137.34	244.99	31.34	1.86	0.81	0.14	0.00	0.00	0.47	416.95
22	37G0	1.58	1.31	0.23	0.22	0.19	0.05	0.01	0.03	0.01	3.63
22	37G1	88.98	4.79	2.05	0.83	2.01	0.42	1.26	0.48	0.11	100.93
22	38G0	29.12	0.97	0.23	0.06	0.12	0.05			0.05	30.60
22	38G1	25.29	0.88	0.05	0.04	0.20					26.46
22	39F9	2.33									2.33
22	39G0	8.12	2.10	0.11	0.14	0.25					10.72
22	39G1	0.35									0.35
22	40F9	5.16		0.17		0.09					5.42
22	40G0	48.68		1.62		0.81					51.11
22	40G1	0.66	0.13	0.08	0.04	0.08					0.99
22	41G0	1.27									1.27
22	Total	211.54	10.18	4.54	1.33	3.75	0.52	1.27	0.51	0.17	233.81
23	39G2	29.29	6.94	2.11	2.49	1.46	0.64	0.81	0.80	0.26	44.80
23	40G2	1.07	59.79	400.02	261.05	115.76	88.25	101.7	43.69	31.9	1,103.23
23	41G2	42.74	10.22		0.93	0.93					54.82
23	Total	73.10	76.95	402.13	264.47	118.15	88.89	102.51	44.49	32.16	1,202.85
24	37G2	75.18	1.48	0.33	0.45	0.33	0.04	0.09	0.09		77.99
24	37G3	46.32	5.92	6.06	3.11	2.75	1.38	1.65	2.08	1.04	70.31
24	37G4	15.08	23.15	34.70	16.08	13.91	8.80	10.62	10.86	6.27	139.47
24	38G2	126.01	2.77	0.43	0.57	0.13	0.04	0.11	0.07		130.13
24	38G3	44.36	25.00	21.85	13.27	11.36	5.70	6.61	7.68	3.62	139.45
24	38G4	63.95	98.16	147.18	68.18	59.01	37.32	45.02	46.05	26.57	591.44
24	39G2	76.78	18.18	5.53	6.53	3.82	1.67	2.11	2.10	0.67	117.39
24	39G3	154.72	48.42	41.20	22.95	17.05	9.95	11.34	12.93	6.74	325.30
24	39G4	7.23	30.25	54.06	39.19	42.38	24.74	25.57	22.56	16.05	262.03
24	Total	609.63	253.33	311.34	170.33	150.74	89.64	103.12	104.42	60.96	1,853.51
22-24	Total	894.27	340.46	718.01	436.13	272.64	179.05	206.90	149.42	93.29	3,290.17
21-24	Total	1,031.61	585.45	749.35	437.99	273.45	179.19	206.90	149.42	93.76	3,707.12

Table 8: FRV "Solea", cruise 710/2015. Mean weight (g) of herring incl. CBH by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	12.35	37.59	64.35	84.14	40.30					25.33
21	41G1	14.23	35.30	56.23	63.91	40.30				56.40	33.80
21	41G2	12.99	27.77	57.49	93.53	40.30				56.40	21.01
21	42G1	15.32	27.54	31.95	40.30	40.30				56.40	25.99
21	42G2	14.00	25.04	46.63	65.78	40.30				195.37	19.97
21	43G1	14.48	30.58	49.90	54.40	40.30	232.00			56.40	25.31
21	43G2	15.75	24.37	33.16	58.67	40.30					21.59
21	Total	14.33	30.97	51.97	63.31	40.30	232.00			62.31	27.33
22	37G0	9.82	27.77	40.06	35.39	34.07	39.01	43.67	37.79	41.00	21.85
22	37G1	8.82	30.30	39.96	34.44	37.17	40.06	44.08	41.78	41.00	12.01
22	38G0	8.47	26.49	39.16	25.21	34.47	41.00			41.00	9.51
22	38G1	7.40	27.21	29.00	28.64	54.42					8.49
22	39F9	10.72									10.72
22	39G0	9.30	27.40	29.56	25.67	30.30					13.76
22	39G1	7.60									7.60
22	40F9	10.07		61.33		61.33					12.53
22	40G0	10.07		61.33		61.33					12.51
22	40G1	12.09	32.17	58.87	33.93	45.39					22.08
22	41G0	10.49									10.49
22	Total	8.99	28.77	48.31	33.07	43.36	40.05	44.08	41.55	41.00	11.65
23	39G2	9.85	29.09	45.12	34.35	44.17	51.10	47.79	46.42	63.95	19.21
23	40G2	14.00	81.21	106.07	130.00	150.49	170.17	186.74	183.70	203.77	133.42
23	41G2	11.90	19.05		30.00	28.00					13.81
23	Total	11.11	68.25	105.75	128.75	148.21	169.31	185.64	181.23	202.64	123.72
24	37G2	6.97	28.11	37.30	29.97	35.84	48.31	38.18	38.18		7.85
24	37G3	6.96	31.09	54.20	45.30	47.56	55.16	57.29	52.18	64.29	20.66
24	37G4	7.77	33.25	57.92	53.33	62.08	68.19	68.92	59.86	75.59	50.72
24	38G2	7.09	25.09	26.52	28.72	34.37	33.13	33.89	34.31		7.70
24	38G3	6.57	32.49	54.87	45.96	51.47	62.82	59.99	54.29	67.77	35.24
24	38G4	7.77	33.25	57.92	53.33	62.08	68.19	68.92	59.86	75.59	50.72
24	39G2	9.85	29.09	45.12	34.35	44.17	51.10	47.79	46.42	63.95	19.20
24	39G3	12.17	29.24	54.66	47.74	56.89	61.77	61.87	56.75	68.29	31.13
24	39G4	12.13	32.73	63.23	89.34	101.79	93.87	91.82	78.24	87.58	76.91
24	Total	8.81	31.88	57.83	59.27	71.06	73.68	72.57	62.58	77.15	41.86
22-24	Total	9.04	40.01	84.61	101.32	104.11	121.06	128.42	97.83	120.35	69.64
21-24	Total	9.75	36.23	83.24	101.16	103.92	121.15	128.42	97.83	120.06	64.88

Table 9: FRV "Solea", cruise 710/2015. Total biomass (t) of herring incl. CBH by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	12.0	14.7	9.0	3.4						39.0
21	41G1	378.4	2,723.4	904.7	76.7	18.1				13.0	4,114.3
21	41G2	164.2	254.9	47.7	11.2	0.8					478.9
21	42G1	139.4	1,454.7	70.6	2.8	2.8				0.6	1,670.9
21	42G2	136.6	212.3	18.7	1.3	0.4				3.9	373.3
21	43G1	1,084.3	2,783.1	569.9	21.8	10.5	32.5			11.8	4,513.8
21	43G2	53.6	145.3	8.3	0.6						207.7
21	Total	1,968.4	7,588.3	1,628.9	117.8	32.6	32.5	0.0	0.0	29.3	11,397.8
22	37G0	15.5	36.4	9.2	7.8	6.5	2.0	0.4	1.1	0.4	79.3
22	37G1	784.8	145.1	81.9	28.6	74.7	16.8	55.5	20.1	4.5	1,212.1
22	38G0	246.7	25.7	9.0	1.5	4.1	2.1			2.1	291.1
22	38G1	187.2	23.9	1.5	1.2	10.9					224.6
22	39F9	25.0									25.0
22	39G0	75.5	57.5	3.3	3.6	7.6					147.5
22	39G1	2.7									2.7
22	40F9	52.0		10.4		5.5					67.9
22	40G0	490.2		99.4		49.7					639.2
22	40G1	8.0	4.2	4.7	1.4	3.6					21.9
22	41G0	13.3									13.3
22	Total	1,900.8	292.9	219.3	43.99	162.6	20.8	55.98	21.18	7.0	2,724.5
23	39G2	288.5	201.9	95.2	85.53	64.5	32.7	38.71	37.14	16.6	860.8
23	40G2	15.0	4,855.6	42,430.1	33,936.5	17,420.7	15,017.5	18,991.5	8,025.9	6,500.3	147,192.9
23	41G2	508.6	194.7		27.9	26.0					757.2
23	Total	812.1	5,252.1	42,525.3	34,049.9	17,511.3	15,050.2	19,030.2	8,063.0	6,516.9	148,811.0
24	37G2	524.0	41.6	12.3	13.5	11.8	1.9	3.4	3.4		612.0
24	37G3	322.4	184.1	328.5	140.9	130.8	76.1	94.5	108.5	66.9	1,452.6
24	37G4	117.2	769.7	2,009.8	857.6	863.5	600.1	731.9	650.1	474.0	7,073.8
24	38G2	893.4	69.5	11.4	16.4	4.5	1.3	3.7	2.4		1,002.6
24	38G3	291.5	812.3	1,198.9	609.9	584.7	358.1	396.5	417.0	245.3	4,914.1
24	38G4	496.9	3,263.8	8,524.7	3,636.0	3,663.3	2,544.9	3,102.8	2,756.6	2,008.4	29,997.4
24	39G2	756.3	528.9	249.5	224.3	168.7	85.3	100.8	97.5	42.9	2,254.2
24	39G3	1,882.9	1,415.8	2,252.0	1,095.6	970.0	614.6	701.6	733.8	460.3	10,126.6
24	39G4	87.7	990.1	3,418.2	3,501.2	4,313.9	2,322.3	2,347.8	1,765.1	1,405.7	20,152.0
24	Total	5,372.2	8,075.7	18,005.3	10,095.4	10,711.2	6,604.7	7,483.2	6,534.3	4,703.4	77,585.4
22-24	Total	8,085.1	13,620.7	60,749.9	44,189.3	28,385.1	21,675.7	26,569.4	14,618.5	11,227.2	229,120.8
21-24	Total	10,053.5	21,209.0	62,378.8	44,307.1	28,417.7	21,708.2	26,569.4	14,618.5	11,256.5	240,518.6

Table 10: FRV "Solea", cruise 710/2015. Numbers (millions) of sprat by age and area.

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0		2.15	0.24	0.26						2.65
21	41G1		36.46	11.14	8.77	0.57	0.03				56.97
21	41G2		84.26	8.10	5.73	0.68	0.11				98.88
21	42G1		41.80	10.58	4.97	6.06	5.09	0.79			69.29
21	42G2		131.52	6.64	5.65	1.38	0.45	0.01			145.65
21	43G1		119.36	10.95	9.38	8.01	5.02	0.59			153.31
21	43G2		0.22	0.21	0.20	0.18	0.08	0.01			0.90
21	Total	0.00	415.77	47.86	34.96	16.88	10.78	1.40	0.00	0.00	527.65
22	37G0		93.56	3.34	1.35	3.46	0.32				102.03
22	37G1	64.60	125.82	7.24	2.17	3.12	0.50				203.45
22	38G0	0.03	117.21	6.72	1.09	7.59	0.91				133.55
22	38G1	3.70	78.96	0.58	0.16	0.05					83.45
22	39F9	0.31	0.91								1.22
22	39G0	4.53	6.26								10.79
22	39G1	0.18									0.18
22	40F9		0.28								0.28
22	40G0		2.64								2.64
22	40G1		6.09	0.07	0.03	0.01					6.20
22	41G0										0.00
22	Total	73.35	431.73	17.95	4.80	14.23	1.73	0.00	0.00	0.00	543.79
23	39G2	0.42	68.33	26.02	12.14	5.31	0.81	0.79	0.03	0.22	114.07
23	40G2		52.23	19.39	23.05	42.46	17.43	7.65	3.37	1.37	166.95
23	41G2		69.52	1.09	0.86	0.75	0.12	0.05	0.09		72.48
23	Total	0.42	190.08	46.50	36.05	48.52	18.36	8.49	3.49	1.59	353.50
24	37G2	17.48	6.68	0.84	0.27	0.29	0.06	0.03	0.02		25.67
24	37G3	1,147.61	14.75	1.62	0.21	0.21					1,164.40
24	37G4	0.36	21.42	18.33	12.36	6.84	1.69	1.45	0.28	0.37	63.10
24	38G2	94.21	152.75	27.38	8.82	5.19	0.24	0.24		0.14	288.97
24	38G3	738.30	1,686.12	336.60	88.30	52.71	3.88	3.95	0.16	0.69	2,910.71
24	38G4	1.53	90.82	77.72	52.43	29.03	7.15	6.15	1.20	1.56	267.59
24	39G2	1.09	179.11	68.19	31.83	13.92	2.13	2.08	0.08	0.56	298.99
24	39G3	0.82	343.46	247.76	132.13	58.66	13.76	13.41	0.57	3.20	813.77
24	39G4	0.27	18.17	31.83	29.02	15.79	2.65	2.37	0.31	1.06	101.47
24	Total	2,001.67	2,513.28	810.27	355.37	182.64	31.56	29.68	2.62	7.58	5,934.67
22-24	Total	2,075.44	3,135.09	874.72	396.22	245.39	51.65	38.17	6.11	9.17	6,831.96
21-24	Total	2,075.44	3,550.86	922.58	431.18	262.27	62.43	39.57	6.11	9.17	7,359.61

Table 11: FRV "Solea", cruise 710/2015. Mean weight (g) of sprat by age and area.

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0		11.88	13.89	13.84						12.25
21	41G1		12.38	15.02	14.54	17.76	19.55				13.29
21	41G2		10.63	15.33	14.86	18.25	19.55				11.32
21	42G1		10.95	16.89	16.78	22.55	24.02	25.33			14.41
21	42G2		10.72	15.30	15.35	19.93	20.96	23.80			11.23
21	43G1		8.64	16.87	17.88	21.79	23.38	24.60			11.02
21	43G2		11.80	17.43	18.95	21.49	22.76	24.28			17.75
21	Total		10.28	15.95	15.96	21.63	23.53	25.00			11.84
22	37G0		11.00	15.54	15.99	16.99	17.85				11.44
22	37G1	4.11	11.43	14.46	14.77	16.75	18.64				9.35
22	38G0	5.75	10.28	16.18	16.19	16.26	16.23				11.00
22	38G1	4.26	10.35	13.90	13.96	15.00					10.11
22	39F9	1.87	7.75								6.26
22	39G0	3.74	10.23								7.51
22	39G1	3.38									3.38
22	40F9		8.46								8.46
22	40G0		8.46								8.46
22	40G1		11.60	13.43	13.57	15.00					11.64
22	41G0										
22	Total	4.08	10.78	15.28	15.40	16.54	17.23				10.24
23	39G2	1.46	12.95	14.53	15.46	15.76	17.24	17.17	20.65	17.21	13.74
23	40G2		14.11	17.98	20.33	22.63	23.14	23.33	22.81	24.89	19.21
23	41G2		9.17	16.7	17.07	19.66	18.57	21.34	21.34		9.52
23	Total	1.46	11.89	16.02	18.61	21.83	22.85	22.75	22.75	23.83	15.46
24	37G2	3.19	11.41	12.22	14.42	15.88	20.65	20.65	20.65		5.96
24	37G3	3.09	9.57	10.50	12.25	12.25					3.19
24	37G4	5.10	13.06	15.59	16.89	18.17	18.56	18.26	22.09	17.21	15.38
24	38G2	3.57	11.66	12.76	14.29	13.53	16.72	16.72		17.21	9.25
24	38G3	3.55	11.77	12.61	14.26	13.98	17.44	17.55	20.65	17.21	9.91
24	38G4	5.10	13.06	15.59	16.89	18.17	18.56	18.26	22.09	17.21	15.39
24	39G2	1.46	12.95	14.53	15.46	15.76	17.24	17.17	20.65	17.21	13.74
24	39G3	2.39	13.21	15.26	16.25	17.00	17.28	17.22	20.65	17.21	14.75
24	39G4	4.09	14.10	16.18	17.24	18.24	18.38	18.13	22.32	17.21	16.53
24	Total	3.28	12.10	14.08	15.83	16.27	17.75	17.60	21.66	17.21	9.82
22-24	Total	3.31	11.91	14.20	16.08	17.38	19.55	18.74	22.28	18.36	10.14
21-24	Total	3.31	11.72	14.29	16.07	17.66	20.23	18.96	22.28	18.36	10.27

Table 12: FRV "Solea", cruise 710/2015. Total biomass (t) of sprat by age and area.

Sub-division	Rectangle/ Age group	0	1	2	3	4	5	6	7	8+	Total
21	41G0		25.5	3.3	3.6						32.5
21	41G1		451.4	167.3	127.5	10.1	0.6				756.9
21	41G2		895.7	124.2	85.2	12.4	2.2				1,119.6
21	42G1		457.7	178.7	83.4	136.7	122.3	20.0			998.7
21	42G2		1,409.9	101.6	86.7	27.5	9.4	0.2			1,635.4
21	43G1		1,031.3	184.7	167.7	174.5	117.4	14.5			1,690.1
21	43G2		2.6	3.7	3.8	3.9	1.8	0.2			16.0
21	Total	0.0	4,274.1	763.5	557.9	365.1	253.6	35.0	0.0	0.0	6,249.2
22	37G0		1,029.2	51.9	21.6	58.8	5.7				1,167.2
22	37G1	265.5	1,438.1	104.7	32.1	52.3	9.3				1,902.0
22	38G0	0.2	1,204.9	108.7	17.7	123.4	14.8				1,469.7
22	38G1	15.8	817.2	8.1	2.2	0.8					844.0
22	39F9	0.6	7.1								7.6
22	39G0	16.9	64.0								81.0
22	39G1	0.6									0.6
22	40F9		2.4								2.4
22	40G0		22.3								22.3
22	40G1		70.6	0.9	0.4	0.2					72.1
22	41G0										0.0
22	Total	299.6	4,655.9	274.3	73.9	235.4	29.8	0.0	0.0	0.0	5,568.9
23	39G2	0.6	884.9	378.1	187.7	83.7	14.0	13.6	0.6	3.8	1,566.9
23	40G2		737.0	348.6	468.6	960.9	403.3	178.5	76.9	34.1	3,207.9
23	41G2		637.5	18.2	14.7	14.8	2.2	1.1	1.9		690.4
23	Total	0.6	2,259.3	744.9	671.0	1,059.3	419.5	193.1	79.4	37.9	5,465.1
24	37G2	55.8	76.2	10.3	3.9	4.6	1.2	0.6	0.4		153.0
24	37G3	3,546.1	141.2	17.0	2.6	2.6					3,709.4
24	37G4	1.8	279.8	285.8	208.8	124.3	31.4	26.5	6.2	6.4	970.8
24	38G2	336.3	1,781.1	349.4	126.0	70.2	4.0	4.0		2.4	2,673.5
24	38G3	2,621.0	19,845.6	4,244.5	1,259.2	736.9	67.7	69.3	3.3	11.9	28,859.3
24	38G4	7.8	1,186.1	1,211.7	885.5	527.5	132.7	112.3	26.5	26.9	4,116.9
24	39G2	1.6	2,319.5	990.8	492.1	219.4	36.7	35.7	1.7	9.6	4,107.1
24	39G3	2.0	4,537.1	3,780.8	2,147.1	997.2	237.8	230.9	11.8	55.1	11,999.8
24	39G4	1.1	256.2	515.0	500.3	288.0	48.7	43.0	6.9	18.2	1,677.5
24	Total	6,573.5	30,422.7	11,405.2	5,625.5	2,970.7	560.2	522.3	56.8	130.5	58,267.2
22-24	Total	6,873.6	37,337.9	12,424.4	6,370.4	4,265.3	1,009.5	715.4	136.2	168.3	69,301.1
21-24	Total	6,873.6	41,612.0	13,187.9	6,928.3	4,630.4	1,263.1	750.4	136.2	168.3	75,550.3

Table 13: FRV "Solea", cruise 710/2015. Numbers (m) of herring excl. CBH and mature herring (maturity stages ≥6) in SD 23 by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0	0.97	0.39	0.14	0.04						1.54
21	41G1	26.59	77.15	16.09	1.20	0.45				0.23	121.71
21	41G2	12.64	9.18	0.83	0.12	0.02					22.79
21	42G1	9.10	52.82	2.21	0.07	0.07				0.01	64.28
21	42G2	9.76	8.48	0.40	0.02	0.01				0.02	18.69
21	43G1	74.88	91.01	11.42	0.40	0.26	0.14			0.21	178.32
21	43G2	3.40	5.96	0.25	0.01						9.62
21	Total	137.34	244.99	31.34	1.86	0.81	0.14	0.00	0.00	0.47	416.95
22	37G0	1.58	1.23	0.09							2.90
22	37G1	88.68	4.39	1.12							94.19
22	38G0	29.37	0.68								30.05
22	38G1	25.29	0.75			0.13					26.17
22	39F9	2.33									2.33
22	39G0	8.04	2.16								10.20
22	39G1	0.35									0.35
22	40F9	5.15		0.18							5.33
22	40G0	48.55		1.70							50.26
22	40G1	0.66	0.13	0.07							0.87
22	41G0	1.27									1.27
22	Total	211.28	9.35	3.16	0.00	0.13	0.00	0.00	0.00	0.00	223.92
23	39G2	29.29	6.33	1.21	0.14	0.15	0.07	0.05	0.01	0.02	37.27
23	40G2	1.10	57.20	243.02	148.00	66.59	67.14	64.06	39.24	29.21	715.55
23	41G2	42.75	10.21	0.00	0.93	0.93	0.00	0.00	0.00	0.00	54.82
23	Total	73.14	73.75	244.23	149.07	67.66	67.21	64.11	39.25	29.23	807.64
24	37G2	75.18	1.28	0.14							76.60
24	37G3	46.32	5.02	5.30	0.86	0.38	0.19	0.26	0.03	0.03	58.39
24	37G4	15.08	22.65	31.76	7.17	5.40	2.51	2.05	0.49	0.73	87.84
24	38G2	126.01	1.81								127.82
24	38G3	44.36	24.36	18.65	3.80	2.34	1.19	0.88	0.23	0.26	96.07
24	38G4	63.95	96.08	134.71	30.39	22.91	10.63	8.70	2.08	3.09	372.54
24	39G2	76.78	16.60	3.18	0.36	0.40	0.19	0.14	0.02	0.05	97.72
24	39G3	154.72	40.71	35.53	7.31	4.54	1.97	1.62	0.57	0.62	247.59
24	39G4	7.23	28.85	50.75	29.02	31.29	14.42	10.73	4.96	4.39	181.64
24	Total	609.63	237.36	280.02	78.91	67.26	31.10	24.38	8.38	9.17	1,346.21
22-24	Total	894.05	320.46	527.41	227.98	135.05	98.31	88.49	47.63	38.40	2,377.76
21-24	Total	1,031.39	565.45	558.75	229.84	135.86	98.45	88.49	47.63	38.87	2,794.71

Table 14: FRV "Solea", cruise 710/2015. Mean weight (g) of herring excl. CBH and mature herring (maturity stages ≥6) in SD 23 by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total	
21	41G0	12.35	37.59	64.35	84.14	40.30					25.33	
21	41G1	14.23	35.30	56.23	63.91	40.30				56.40	33.80	
21	41G2	12.99	27.77	57.49	93.53	40.30				56.40	21.01	
21	42G1	15.32	27.54	31.95	40.30	40.30				56.40	25.99	
21	42G2	14.00	25.04	46.63	65.78	40.30				195.37	19.97	
21	43G1	14.48	30.58	49.90	54.40	40.30	232.00			56.40	25.31	
21	43G2	15.75	24.37	33.16	58.67	40.30					21.59	
21	Total	14.33	30.97	51.97	63.31	40.30	232.00			62.31	27.33	
22	37G0	9.57	28.08	47.38							18.55	
22	37G1	8.51	31.08	42.64							9.96	
22	38G0	7.56	27.70								8.01	
22	38G1	7.14	28.06			66.00					8.03	
22	39F9	10.34									10.34	
22	39G0	9.38	27.11								13.14	excl. CBH
22	39G1	7.29									7.29	
22	40F9	9.92		63.00							11.71	
22	40G0	9.92		63.00							11.71	
22	40G1	11.88	32.15	63.00							19.32	
22	41G0	11.88									11.88	
22	Total	8.66	29.30	55.38		66.00					10.21	
23	39G2	9.51	30.74	56.96	81.46	99.25	90.09	91.82	91.31	105.04	15.62	
23	40G2	13.75	78.63	90.44	111.33	130.88	174.72	185.95	192.68	208.84	124.36	excl.
23	41G2	11.64	18.61		29.00	26.00					13.48	maturity >=6
23	Total	10.82	66.21	90.27	110.79	129.37	174.63	185.88	192.65	208.77	111.81	
24	37G2	6.63	29.52	51.36							7.09	
24	37G3	6.56	34.18	59.58	71.97	80.88	87.50	89.04	100.17	100.17	15.92	
24	37G4	7.37	34.32	62.54	76.49	89.99	89.28	100.16	99.11	123.39	50.97	
24	38G2	6.75	27.96								7.05	
24	38G3	6.18	33.50	60.96	76.41	91.75	95.47	93.44	99.29	96.15	30.98	excl. CBH
24	38G4	7.37	34.32	62.54	76.49	89.99	89.28	100.16	99.11	123.39	50.97	
24	39G2	9.51	30.74	56.96	81.46	99.25	90.09	91.82	91.31	105.04	15.63	
24	39G3	11.82	32.19	60.76	77.96	95.45	94.53	96.25	102.80	108.99	27.34	
24	39G4	11.85	34.19	67.15	104.16	117.15	109.79	118.40	117.96	116.61	83.24	
24	Total	8.45	33.53	62.92	86.77	103.06	99.35	107.52	110.51	118.22	38.80	
22-24	Total	8.70	40.92	75.54	102.48	116.20	150.81	164.29	178.20	187.14	60.91	
21-24	Total	9.45	36.61	74.22	102.16	115.75	150.93	164.29	178.20	185.63	55.90	

Table 15: FRV "Solea", cruise 710/2015. Total biomass (t) of herring excl. CBH and mature herring (maturity stages ≥6) in SD 23 by age/W-rings and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total	
21	41G0	12.0	14.7	9.0	3.4						39.0	
21	41G1	378.4	2723.4	904.7	76.7	18.1				13.0	4114.3	
21	41G2	164.2	254.9	47.7	11.2	0.8					478.9	
21	42G1	139.4	1454.7	70.6	2.8	2.8				0.6	1670.9	
21	42G2	136.6	212.3	18.7	1.3	0.4				3.9	373.3	
21	43G1	1084.3	2783.1	569.9	21.8	10.5	32.5			11.8	4513.8	
21	43G2	53.6	145.3	8.3	0.6						207.7	
21	Total	1968.4	7588.3	1628.9	117.8	32.6	32.5	0.0	0.0	29.3	11397.8	
22	37G0	15.2	34.6	4.1							53.8	
22	37G1	754.4	136.5	47.6							938.5	
22	38G0	221.9	18.9								240.8	
22	38G1	180.6	21.0			8.6					210.2	
22	39F9	24.1									24.1	
22	39G0	75.4	58.6								134.0	excl. CBH
22	39G1	2.6									2.6	
22	40F9	51.1		11.4							62.4	
22	40G0	481.4		107.3							588.8	
22	40G1	7.8	4.3	4.6							16.7	
22	41G0	15.1									15.1	
22	Total	1829.5	273.9	175.0	0.0	8.6	0.0	0.0	0.0	0.0	2287.0	
23	39G2	278.6	194.6	68.9	11.4	14.9	6.3	4.6	0.9	2.1	582.3	
23	40G2	15.2	4498.0	21978.3	16477.2	8714.4	11729.7	11911.3	7560.5	6099.6	88984.1	excl.
23	41G2	497.7	190.1		27.0	24.1					738.8	maturity >=6
23	Total	791.4	4882.7	22047.2	16515.5	8753.4	11736.0	11915.8	7561.4	6101.7	90305.1	
24	37G2	498.4	37.8	7.2	0.0	0.0	0.0	0.0	0.0	0.0	543.4	
24	37G3	303.9	171.6	315.8	61.9	30.7	16.6	23.2	3.0	3.0	929.6	
24	37G4	111.1	777.4	1986.3	548.4	486.0	224.1	205.3	48.6	90.1	4477.2	
24	38G2	850.6	50.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	901.2	
24	38G3	274.1	816.1	1136.9	290.4	214.7	113.6	82.2	22.8	25.0	2975.8	excl. CBH
24	38G4	471.3	3297.5	8424.8	2324.5	2061.7	949.1	871.4	206.2	381.3	18987.6	
24	39G2	730.2	510.3	181.1	29.3	39.7	17.1	12.9	1.8	5.3	1527.7	
24	39G3	1828.8	1310.5	2158.8	569.9	433.3	186.2	155.9	58.6	67.6	6769.6	
24	39G4	85.7	986.4	3407.9	3022.7	3665.6	1583.2	1270.4	585.1	511.9	15118.9	
24	Total	5154.1	7958.0	17618.7	6847.2	6931.7	3089.9	2621.3	926.1	1084.1	52231.0	
22-24	Total	7775.0	13114.6	39840.9	23362.7	15693.6	14825.9	14537.2	8487.5	7185.8	144823.1	
21-24	Total	9743.4	20702.9	41469.8	23480.4	15726.3	14858.4	14537.2	8487.5	7215.1	156220.9	

Annex 5b: Northern Ireland

Survey report for RV Corystes

25th August – 13th September 2014

Pieter-Jan Schön and Gavin Mcneill Agri-Food and Biosciences Institute (AFBI),

Belfast, Northern Ireland

1. INTRODUCTION

Acoustic surveys of the northern Irish Sea (ICES Area VIIaN) have been carried by the Agri-Food and Biosciences Institute (AFBI), formerly the Department of Agriculture and Rural Development for Northern Ireland (DARD), since 1991. This report covers the routine Irish Sea survey in the autumn.

2. SURVEY DESCRIPTION & METHODS

2.1 Personnel

Pieter-Jan Schön (SIC)
Mathieu Lundy
Peter McCorriston
Ian McCausland
Jim McArdle
Sarah Simpson
Vanessa Brown

2.2 Narrative

The vessel departed Belfast at 2200 on the 25th August and proceeded to the east coast of the Isle of Man for acoustic calibration off Laxey on the 26th August. The survey started on the peripheral Irish Sea transects, transect 119, to the west of the Solway Firth on the 27th August and continued to the completion of transect 94 to the east of Carlingford Lough on the 31st August, at which point the ship returned to Belfast for a staff change.

The survey recommenced on 5th September and concluded on the 13th September during which, the remaining peripheral Irish Sea transects and 2 further set of transects around the Isle of Man were completed. Sea conditions were reasonably good during both legs of the survey.

Survey design

The survey design of systematic, parallel transects covers approximately 620 nm (Figure 5B.1). The position of the set of widely-spaced (8-10 nm) transects around the periphery of the Irish Sea is randomized within +/- 4 nm of a baseline position each year. Transect spacing is reduced to 2 nm in strata around the Isle of Man to improve precision of estimates of adult herring biomass. Relatively lower effort is deployed around the periphery of the Irish Sea where the acoustic targets comprise mainly extended school groups of sprats and 0-group herring. Although this survey design yields high-precision estimates for these small clupeoids due to their extended distribution, the probability of encountering highly aggregated and patchy schools of larger herring remains low around the periphery of the Irish Sea compared with around the Isle of Man. Survey design and methodology adheres to the methods laid out in the WGIPS acoustic survey manual.

2.4 Calibration

The hull mounted Simrad EK60 acoustic system with 38 kHz split-beam was calibrated on the 26th August off Laxey on the east coast of the Isle of Man. Conditions were good and the calibration results satisfactory. All procedures were according to those defined in the survey manual. Summary of calibration results are presented in Table 5B.1.

2.5 Acoustic data collection

Acoustic data were only collected during 24hrs a day, except in coastal areas on the English and Irish coasts were data collection was restricted to daylight hours (0600-2100). Acoustic data at 38 kHz are collected in 15-minute elementary distance sampling units (EDSU's) with the vessel steaming at 10 knots. A Simrad EK-60 echosounder with hull-mounted split-beam transducer is employed, and data are logged and analysed using SonarData Echoview software. The system settings are given in Table 5B.1.

2.6 Biological data – fishing stations

Targets are identified where possible by aimed midwater trawling fitted with a sprat brailer. The net was fished with a vertical mouth opening of approximately 15m, which was observed using a Scanmar "Trawleye" netsounder. To facilitate determining the position of the net in the water column, a Scanmar depth sensor is also fitted to the headline.

Trawl catches are sorted to species level and then weighted. Depending on the number of fish, the sorted catch is normally sub-sampled for length measurements. Length frequencies are recorded in 0.5 cm length classes. Individual length-weight data are collected for all fish species contributing to the catches. Random samples of 50 herring (1+ gp) are taken from each catch for recording of biological parameters (length, weight, sex and maturity) and removal of otoliths for age determination.

2.7 Hydrographic data

Surface temperature and salinity were recorded using the through-flow thermosalinograph, and logged together with DGPS position at 1-minute intervals.

2.8 Data analysis

EDSUs were defined by 15 minute intervals which represented 2.5 nm per EDSU, assuming a survey speed of 10 knots. The surface-area backscattering (NASC) estimates are calculated for schools, school groups and scattering layers using a threshold of -60 dB. Targets in each 15-minute interval were allocated to species or species mixes by scrutinizing the echo charts together with acoustic records during trawling and maps of NASC values indicating location of trawls relative to school groups. In some cases, trawls with similar species and size composition are combined to give a more robust estimate of population length composition. Data were analysed using quarter rectangles of 15′ by 30′.

The single-species or mixed-species mean target strength (*TS*) is calculated from trawl data for each interval as $10 \log \{(\Sigma_{s,l} N_{s,l}.10^{0.1.TS_{s,l}}) / \Sigma_{s,l} N_{s,l}\}$ where $N_{s,l}$ is the number of fish of species *s* in length class *l*. The values recommended by ICES for the parameters *a* and *b* of the length -*TS* relationship $TS = a \log(l) + b$ are used: a = 20 (all species); b = -71.2 (herring, sprat, horse mackerel), -84.9 (mackerel) and -67.5 (gadoids). The weighted mean *TS* is applied to the NASC value to give numbers per square nautical mile. For herring, this is further decomposed into densities by age class according to the length frequencies in the relevant target-identification trawls and the survey age–length key. Mean weights-at-age, calculated from length-weight parameters for the survey, is used to calculate biomass of herring from the estimated numbers-at-age. The weighted mean fish density is estimated for each survey stratum (Figure 5B.1) using distance covered in each 15-minute EDSU as weighting factors, and raised by stratum surface area. Approximate standard errors are computed for the biomass estimates based on the variation between EDSUs within strata.

3. RESULTS

3.1 Biological data

Sampling intensity was relatively high during the 2014 survey with 35 successful trawls completed. Table 5B.2 gives the positions, catch composition and mean length by species for these trawl hauls. Thirty hauls contained herring to be used in the analysis, but only 10 hauls contained large numbers/proportions of herring. The length frequency distributions of these hauls are illustrated in Figure 5B.2. Length frequency distributions reflect the general juvenile/adult herring distributions within the sampling area.

The resulting weight-length relationship for herring was calculated from the sampling information as $W = 0.00273*L^{3.343}$ (length measured in cm). The preliminary age length key (Table 5B.3) used in the analysis indicate that the population is composed of juveniles and adults fish (age 0-9).

3.2 Acoustic data

The distribution of the NASC values assigned to herring and to clupeoid mixes (juvenile herring and sprat) are presented in Figure 5B.3 and for herring only in Figure 5B.4. The highest abundance of herring was west Isle of Man and south off the Mull of Galloway.

3.3 Biomass estimates

The estimated biomass and number of herring and sprat by strata are given in Table 5B.4. The total number estimate comprises of ~73% age 0, ~10% age 1, ~6% age 2, ~6% age 3, ~3% age 4 and 3% age 5+.

4. DISCUSSION

The herring stock estimate in the survey area (Irish Sea/North Channel) was estimated to be 105,637t The major contribution of ages to the total estimates is from ages 0 fish by number and weight.

The herring were fairly widely distributed within mixed schools at low abundance, with a few distinct high abundance areas. The largest herring aggregations were found northeast of the Isle of Man and off the Northern Ireland coast.

Sprat and 0-group herring were distributed around the periphery of the Irish Sea, with the most abundance of 0-group herring in the north and north east. The bulk of 1+ herring targets in 2014 were observed northwest of the Isle of Man and south from the Mull of Galloway (southwestern corner of stratum 5 and northwestern corner of stratum 7; Figure 5B.1&4), with a fairly scattered lower abundance observed throughout the Irish Sea (Figure 5B.4). The length frequencies generated from these trawls highlight the spatial heterogeneous nature of herring age groups in the Irish Sea (Figure 5B.2).

The estimate of herring SSB of 61 705 t for 2014 is slightly higher than the 2013 estimate, and the biomass estimate of 79 866 t for 1+ ringers is, also higher than the 2013 estimate. Whilst the biomass estimate is slightly higher than that 2013, it remains significantly lower than the 2010 and 2011 estimates, which are the highest in the time series. More than a third of the 1+biomass estimate was to the north of the Isle of Man. This is an area of mixed size fish and the survey was mismatched with the migration of the main spawning biomass, as indicated by the high abundance of herring observed by the fishery on the Douglas Bank post survey. Results of a successive acoustic survey conducted later in September confirmed this. The evidence of higher abundance of spawning herring suggests poor reflection of the current age structure and abundance of the herring population in the Irish Sea.

5 TABLES AND FIGURES

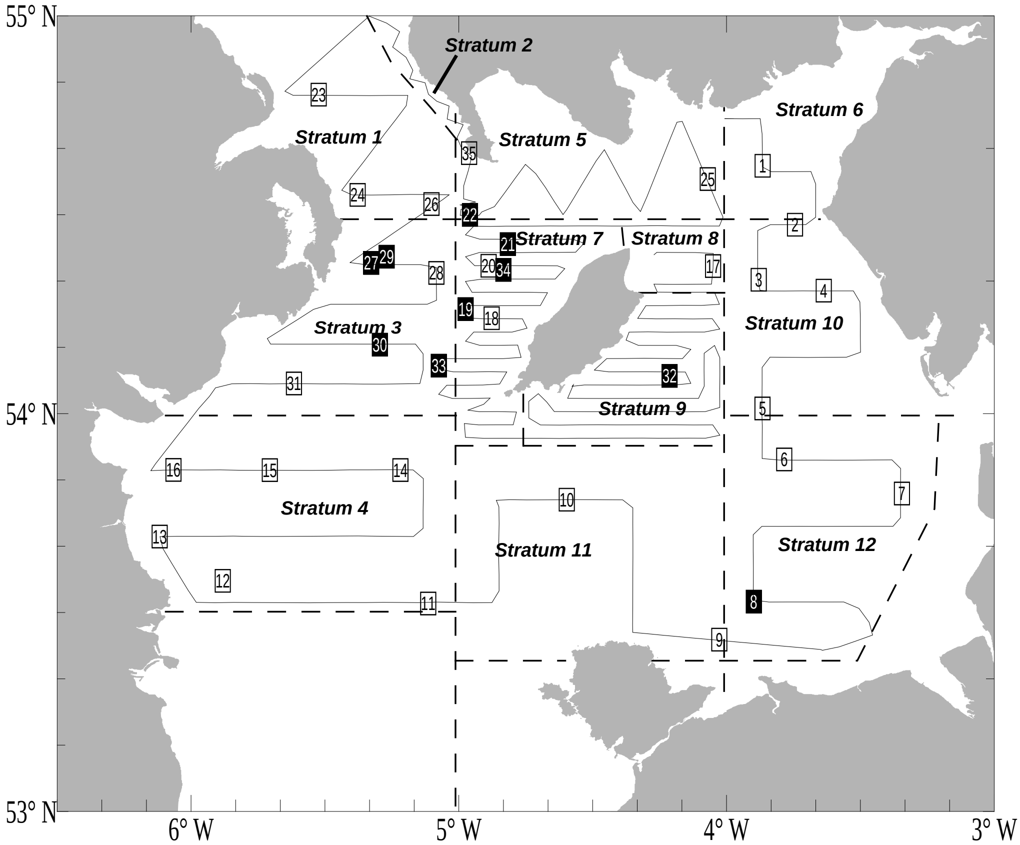


Figure 5B.1: Acoustic survey tracks with trawl positions of the 2014 Irish Sea and North Channel survey on RV "Corystes". Filled squares indicate trawls in which significant numbers of herring were caught or trawls with a high proportion of herring, while open squares indicate trawls with few or no herring.

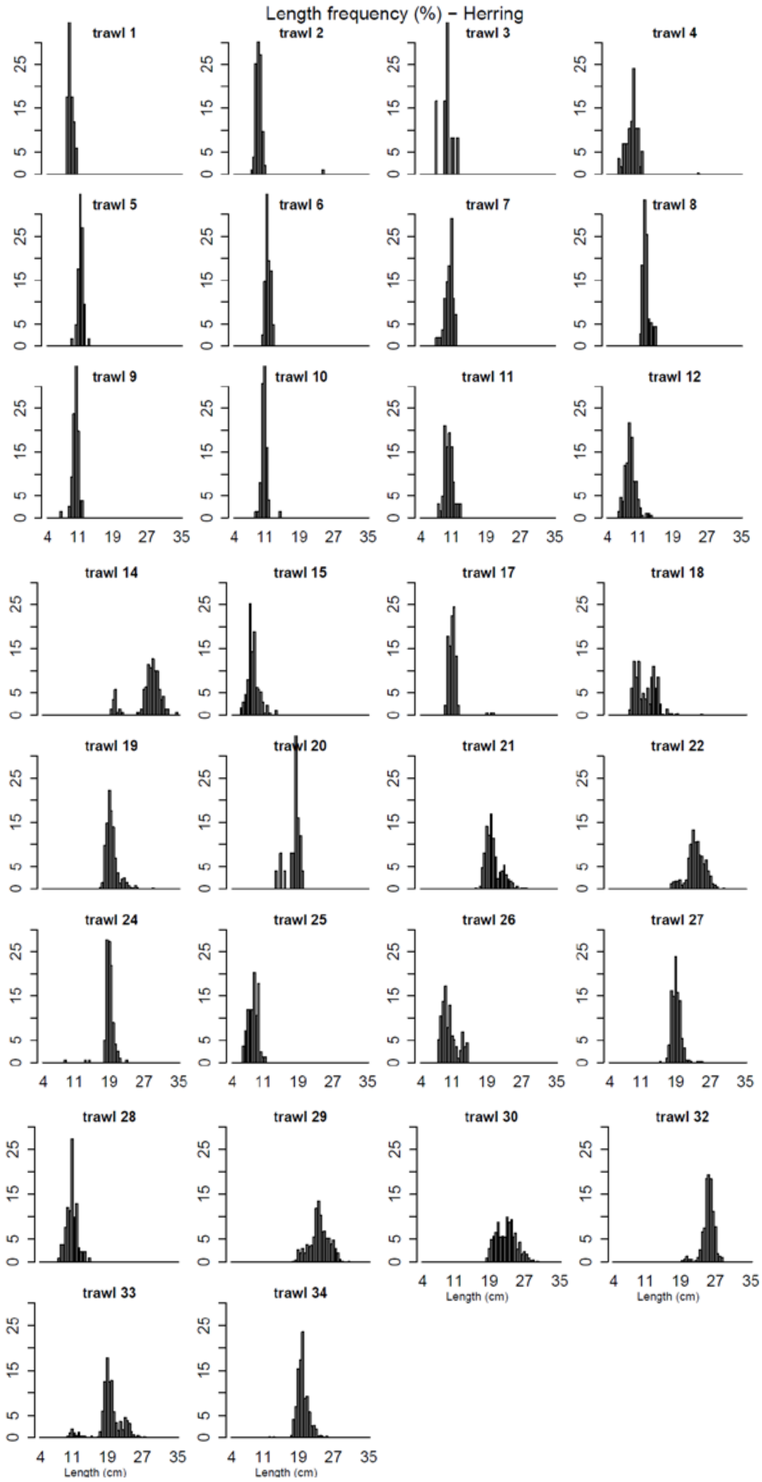


Figure 5B.2: Percentage length compositions of herring in each trawl sample in the September 2014 Irish Sea and North Channel acoustic survey on RV "Corystes".

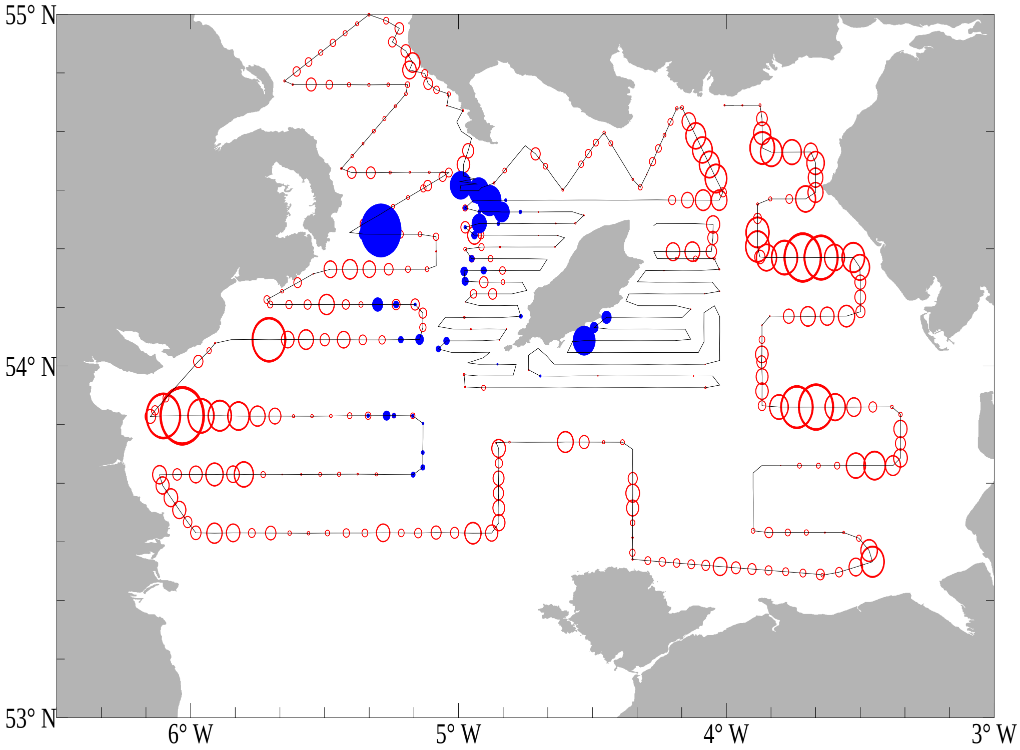


Figure 5B.3: Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values (size of elipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2014 acoustic survey on RV "Corystes". (a) Solid circles are for herring NASC values (maximum value was 17000) and (b) open circles are for clupeoid mix NASC, which include juvenile herring and sprat (maximum value was 20900).

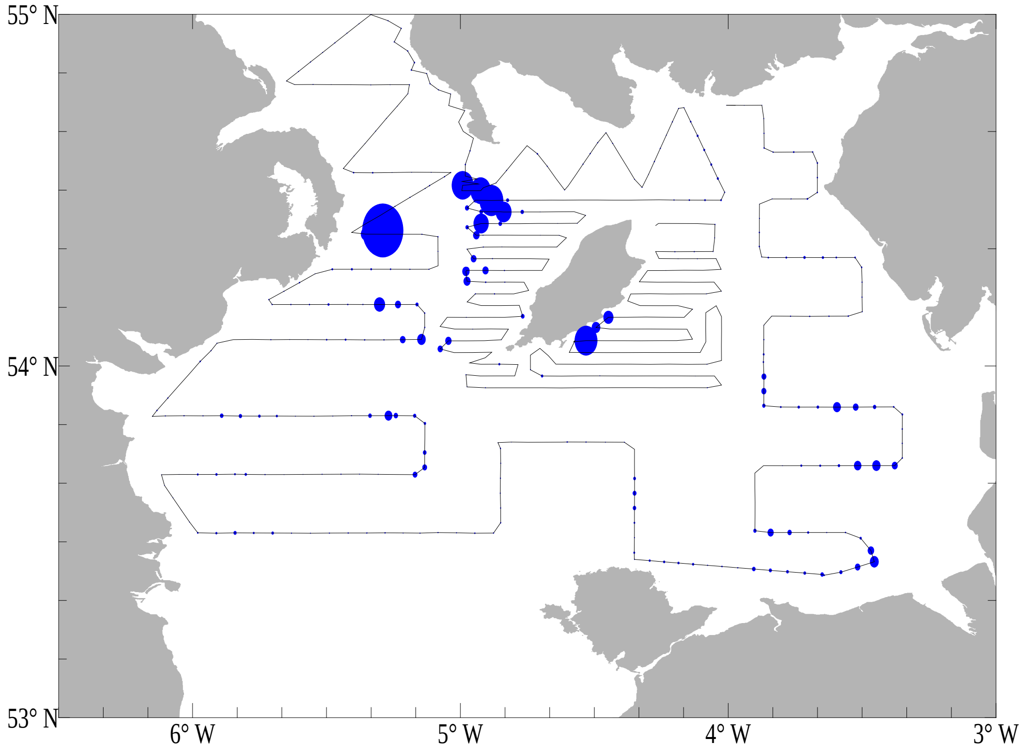


Figure 5B.4: Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values for assigned herring only (size of ellipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2014 acoustic survey on RV "Corystes" (maximum value was 17000).

Table 5B.1: Simrad EK60 and analysis settings used on the 2013 and 2014 Irish Sea and North Channel herring acoustic survey on RV "Corystes"

TRANSCEIVER MENU		
Year	2013	2014
Frequency	38 kHz	38 kHz
Sound speed	1511.5 $m.s^{-1}$	1513.9$m.s^{-1}$
Max. Power	2000 W	2000 W
Default Transducer Sv gain	24.74 dB	24.80 dB
Athw. Beam Angle Athw. Offset Angle Along. Beam Angle Along. Offset Angle	6.89 deg 0.05 deg 6.88 deg 0.16 deg	6.93 deg 0.05 deg 6.95 deg 0.12 deg
Calibration details		
TS of sphere	-33.6 dB	-33.6 dB
Range to sphere in calibration	12.1 m	12.1m
Log Menu		
Integration performed in Echoview post-processing based on 15 minute EDSUs		
Operation Menu		
Ping interval	0.7 s	0.7 s
Analysis settings		
Bottom margin (backstep)	0.5 m	0.5 m
Integration start (absolute) depth	8 m	8 m
Sv gain threshold	-60 dB	-60 dB

Table 5B.2: Catch composition and position of hauls undertaken by the RV *Corystes* during the Irish Sea/North Channel survey, September 2014.

		Shooting details						Total fish	percentage composition of fish by weight							Mean length (cm)		Invertebrate catch (kg)		
Tow	Date	Time	Lat.		Long.		depth (m)	catch kg.	sprat	herring	mackerel	scad	anchovy	whiting	other fish	sprat	herring	cephalopods	euphausiids	Pasiphaea
1	27/08/2014	08:04	54	37.4	3	51.9	28	33	97.78	0.29	1.90	0.00	0.02	0.00	0.00	5.9	9.5			
2	27/08/2014	11:05	54	28.5	3	44.7	29	57	90.77	1.42	2.98	0.00	0.06	3.32	1.44	5.7	10.0			
3	27/08/2014	13:40	54	20.2	3	52.8	46	355	98.72	0.48	0.78	0.00	0.00	0.01	0.02	5.7	10.2			
4	27/08/2014	16:07	54	18.6	3	38.2	38	405	97.41	0.86	1.40	0.00	0.33	0.00	0.00	6.4	9.8			
5	27/08/2014	20:37	54	0.8	3	51.9	38	233	97.19	2.38	0.17	0.00	0.10	0.00	0.15	8.4	11.8			
6	28/08/2014	08:07	53	53.1	3	47.1	38	566	96.61	0.73	0.62	0.00	1.99	0.04	0.00	8.7	12.0			
7	28/08/2014	11:18	53	48.0	3	20.7	23	182	97.18	1.57	0.05	0.01	0.00	0.92	0.27	5.6	10.7			
8	28/08/2014	17:09	53	31.7	3	53.9	50	184	50.60	47.08	2.17	0.14	0.01	0.00	0.00	12.1	13.1			
9	29/08/2014	10:12	53	25.9	4	1.6	44	756	93.05	1.01	5.78	0.00	0.13	0.00	0.03	7.1	10.7			
10	29/08/2014	20:32	53	47.0	4	35.8	69	128	98.00	1.25	0.58	0.00	0.00	0.05	0.12	6.4	11.1			
11	30/08/2014	08:53	53	31.4	5	6.9	76	67	92.31	0.67	5.87	0.00	0.00	0.05	1.10	6.6	10.6			
12	30/08/2014	14:05	53	34.8	5	52.9	57	196	87.18	12.38	0.10	0.00	0.00	0.07	0.27	5.9	9.4			
13	30/08/2014	17:02	53	41.5	6	7.0	20	338	62.46	0.04	35.22	0.00	0.00	1.78	0.49	5.7	12.5			
14	31/08/2014	06:42	53	51.5	5	13.1	66	156	0.00	25.91	0.00	0.00	0.00	72.49	1.60		17.3			
15	31/08/2014	10:44	53	51.5	5	42.4	82	301	92.66	3.85	3.49	0.00	0.00	0.00	0.00	6.6	9.0			
16	31/08/2014	13:29	53	51.5	6	3.9	35	645	99.53	0.20	0.26	0.00	0.00	0.01	0.00	6.9	14.2			
17	05/09/2014	19:19	54	22.3	4	3.0	44	400	96.42	0.44	2.94	0.00	0.18	0.02	0.00	7.0	11.4			
18	07/09/2014	08:48	54	14.4	5	52.6	67	337	92.53	4.13	3.12	0.00	0.00	0.01	0.22	7.2	12.3			
19	07/09/2014	10:29	54	15.8	4	58.5	109	999	0.00	50.85	2.16	0.00	0.00	45.32	1.66		19.8			
20	07/09/2014	17:15	54	22.3	4	53.3	71	202	97.08	0.61	0.60	0.00	0.00	1.42	0.28	10.4	18.3			
21	07/09/2014	22:50	54	25.6	4	49.0	58	636	0.00	98.89	0.83	0.00	0.00	0.17	0.11		20.7			
22	08/09/2014	03:25	54	30.0	4	57.5	106	1050	0.00	94.64	0.00	0.00	0.00	0.04	5.31		23.9			
23	08/09/2014	15:57	54	48.1	5	31.4	105	49	95.49	0.06	4.37	0.01	0.00	0.07	0.00	6.6	10.3			
24	08/09/2014	20:22	54	33.0	5	22.7	63	79	45.02	15.77	0.91	0.01	0.00	10.10	28.20	6.4	19.3			
25	09/09/2014	07:16	54	35.4	4	4.2	39	46	80.05	1.50	17.64	0.00	0.10	0.00	0.71	5.9	9.0			
26	09/09/2014	14:02	54	31.6	5	6.1	135	81	58.03	1.89	39.91	0.00	0.00	0.02	0.14	6.1	10.7			
27	09/09/2014	17:18	54	22.7	5	19.6	77	2000	0.00	100.00	0.00	0.00	0.00	0.00	0.00		19.4			
28	09/09/2014	19:23	54	21.2	5	5.0	124	17	0.31	7.68	0.99	0.00	0.00	87.89	3.13	6.1	11.2			
29	09/09/2014	23:53	54	23.7	5	16.2	111	3500	0.00	100.00	0.00	0.00	0.00	0.00	0.00		24.0			
30	10/09/2014	10:52	54	10.4	5	17.7	75	878	0.00	91.88	1.42	0.00	0.00	5.38	1.33		23.1			
31	10/09/2014	14:41	54	4.6	5	36.9	52	307	98.03	0.11	1.37	0.00	0.00	0.28	0.21	6.4	11.1			
32	11/09/2014	14:36	54	5.7	4	12.8	44	421	0.00	81.21	15.53	0.00	0.00	0.00	3.27		25.7			
33	12/09/2014	12:56	54	7.2	5	4.5	98	525	0.79	59.64	0.97	0.00	0.00	38.40	0.19	5.9	19.9			
34	13/09/2014	02:56	54	21.67	4	50.01	48	98	1.02	76.73	7.03	0.00	0.00	6.72	8.51	6.2	20.2			
35	13/09/2014	22:22	54	39.29	4	57.68	29	134	91.98	0.00	1.81	0.00	0.00	4.33	1.88	7.1				

Table 5B.3: Preliminary age-length key for herring from which otoliths were removed at sea during the Irish Sea/North Channel survey. Data are numbers of fish at age in each length class in samples collected from each trawl.

	Age class (rings, or ages assuming 1 January birthdate)										
Length (cm)	0	1	2	3	4	5	6	7	8	9	Total
6	1										1
6.5	4										4
7	5										5
7.5	6										6
8	9										9
8.5	11										11
9	17										17
9.5	18										18
10	18										18
10.5	18										18
11	19										19
11.5	17										17
12	17										17
12.5	14										14
13	10										10
13.5	11										11
14	11										11
14.5	7										7
15	6										6
15.5	5										5
16	2	1									3
16.5		3									3
17	1	7									8
17.5	1	14									15
18		26									26
18.5		27									27
19		29									29
19.5		38									38
20		34	6								40
20.5		32	5								37
21		19	4								23
21.5		8	13								21
22		3	12	1							16
22.5		1	19	6							26
23			14	10							24
23.5			11	8	2						21
24			7	18	4		1				30
24.5			4	11	4	2					21
25				14	6	2					22
25.5				6	9	2					17
26				3	10	2	3				18
26.5				1	13	5	1				20
27					5	3	2	1	1		12
27.5					5	5	4	1			15
28					2	7			1	1	11
28.5						3	1		2		6
29						1	1	1	1		4
29.5										1	1
30									1		1
30.5						1					1
Total	228	242	95	78	60	33	13	3	6	2	760

Table 5B.4: Acoustic survey estimates of biomass (t) and numbers ('000) of herring and sprat by survey stratum from the AFBI acoustic surveys in 2014.

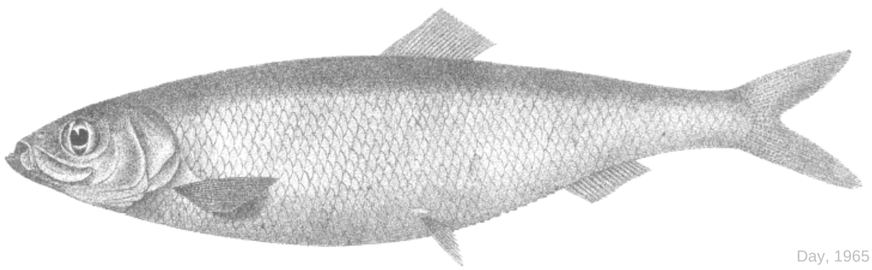
STRATUM	NO. SPRAT	BIOMASS SPRAT	NO. HER	BIOMASS HER
1	2700374	4830	11533	488
2	1589591	2996	5620	228
3	13539283	24695	415808	39163
4	43983436	82248	352497	5274
5	8790664	13363	190177	17145
6	12801725	18836	21083	122
7	536101	3447	137479	11310
8	2039307	3625	6043	33
9	6808	19	57381	9126
10	50481323	83038	110156	767
11	25443355	50641	317109	4687
12	17204091	79375	1096179	17294
Total	179116058	367113	2721065	105637

Annex 5c: CSAS

FSS Survey Series: 2015/04

Celtic Sea Herring Acoustic Survey Cruise Report 2015

02 - 22 October, 2015



Day, 1965

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Fisheries Ecosystems Advisory Services

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1 Introduction

In the southwest of Ireland and the Celtic Sea (ICES Divisions VIIaS, g & j), herring are an important commercial species to the pelagic and polyvalent fleet. The local fleet is composed of dry hold polyvalent vessels and a smaller number of large purpose built refrigerated seawater vessels (RSW). The stock is composed of both autumn and winter spawning components with the latter dominating. The fishery targets pre-spawning and spawning aggregations in Q3-4. The Irish commercial fishery has historically taken place within 1-20nmi (nautical miles) of the coast. Since the mid-2000s RSW fleet have actively targeted offshore aggregations migrating from summer feeding in the south Celtic Sea. In VIIj, the fishery is traditionally active from mid-November and is concentrated within several miles of the coast. The VIIaS fishery peaks towards the year end in December, but may be active from mid-October depending on location. In VIIg, along the south coast herring are targeted from October to January at a number of known spawning sites and surrounding areas. Overall, the protracted spawning period of the two components extends from October through to January, with annual variation of up to 3 weeks. Spawning occurs in successive waves in a number of well known locations including large scale grounds and small discreet spawning beds. Since 2008 ICES division VIIaS (spawning box C) has been closed to fishing for vessels over 15m to protect first time spawners. For those vessels less than 15m a small allocation of the quota is given to this ‘sentinel’ fishery operating within the closed area.

The stock structure and discrimination of herring in this area has been investigated recently. Hatfield et al. (2007) has shown the Celtic Sea stock to be fairly discrete. However, it is known that fish in the eastern Celtic Sea recruit from nursery areas in the Irish Sea, returning to the Celtic Sea as young adults (Brophy et al. 2002; Molloy et al., 1993). The stock identity of VIIj herring is less clear, though there is evidence that they have linkages with VIIb and VIaS (ICES, 1994; Grainger, 1978). Molloy (1968) identified possible linkages between young fish in VIIj and those of the Celtic Sea herring. For the purpose of stock assessment and management divisions VIIaS, VIIg and VIIj have been combined since 1982.

For a period in the 1970s and1980s, larval surveys were conducted for herring in this area. However, since 1989, acoustic surveys have been carried out, and currently are the only tuning indices available for this stock. In the Celtic Sea and VIIj, herring acoustic surveys have been carried out since 1989, and this survey is the 21st in the overall acoustic series or the tenth in the modified time series conducted exclusively in October.

The geographical confines of the annual 21 day survey have been modified in recent years to include areas to the south of the main winter spawning grounds in an effort to identify the whereabouts of winter spawning fish before the annual inshore spawning migration. Spatial resolution of acoustic transects has been increased over the entire south coast survey area. The acoustic component of the survey has been further complemented since 2004 by detailed hydrographic, marine mammal and seabird surveys.

2 Materials and Methods

2.1 Scientific Personnel

Organisation	Name	Capacity	Leg
FEAS	Ciaran O'Donnell	Aco (SIC)	All
FEAS	Graham Johnston	Aco	All
FEAS	Robert Bunn	Aco	All
FEAS	Susan Beattie	Aco	2
FEAS	Dermot Fee	Bio	All
FEAS	Grainne Ni Choncuir	Bio	All
FEAS	Helen McCormick	Bio	1
FEAS	Turloch Smith	Bio	2
BWI	Niall Keogh	SBO	All
BWI	Deirdre Reidy	SBO	All
BWI	Andrew Power	SBO	All
BWI	Inge van der Knapp	Aco/SBO	1/2
IWDG	Mairead Donovan	MMO	All
IS&W FPO	Francis Griffin	Industry Rep	All
INFOMAR	Slava Sobolev	MBES	All
INFOMAR	Oisin McManus	MBES	All
INFOMAR	Mekayla Dale	MBES	All

*SBO- Seabird observer, MMO- marine mammal observer

2.2 Survey Plan

2.2.1 Survey objectives

The primary survey objectives are listed below:

- Carry out a pre-determined survey cruise track in core survey area
- Investigate high abundance herring aggregations using adaptive survey techniques Use the EM 2040 Bathy metric multibeam to map the extent of herring aggregations during adaptive surveys
- Determine an age stratified estimate of relative abundance of herring within the survey area (ICES Divisions VIIj, VIIg and VIIaS)
- Collect biological samples from directed trawling on insonified fish echotraces to determine age structure and maturity state of the herring stock
- Determine estimates of biomass and abundance for other small pelagic species within the survey area
- Collect physical oceanography data from vertical profiles from a deployed sensor array

- Survey by visual observations marine mammal and seabird abundance and distribution (ESAS-European Seabirds At Sea methodology) during the survey

2.2.2 Area of operation

The autumn 2015 survey covered the area from Loop Head in ICES Division VIIb (Figure 1) in Co. Clare and extended south along the western seaboard covering the main bays and inlets in Divisions VIIj , VIIg & VIIaS. The survey started in the southwest and worked in an easterly direction covering offshore strata and then working east to west along the coast. Bays in the southwest were survey last.

The survey was broken into 3 main components (Table 1). The first, a broad scale survey, was carried out to contain the stock within the survey confines and was based on the distribution of herring from previous years. A broad scale survey composed of 8 strata formed the boundary component of the survey. Broad scale outer lying areas are important transit areas for herring migrating to inshore spawning areas from offshore summer feeding grounds. The second component focused exclusively on known spawning areas and was made up of 1 stratum. The third component consisted of specific adaptive surveys focused on offshore aggregations.

2.2.3 Survey design

2.2.3.1 Core survey

A change in survey design was implemented in 2015 by consolidating inshore strata into a single stratum with uniform transect spacing (2 nmi) and increasing transect spacing in the offshore strata from 2 to 4 nmi spacing. Core geographical coverage was maintained as was sampling and analysis methodology.

A parallel transect design was used with transects running perpendicular to the coastline and lines of bathymetry where possible. Offshore extension reached up to 70 nmi (nautical miles). Transect resolution was set at between 2-8 nmi for the broad scale survey and increased to 2 nmi for the spawning ground inshore stratum. Bay areas were surveyed using a zigzag transect approach to maximise area coverage. Transect start points within each stratum are randomised each year within established baseline stratum bounds.

In total the core survey accounted for 2,336 nmi of transects covering an area of 6,580 nmi^2 (Table 1).

2.2.3.2 Adaptive survey

In 2015 time was allocated to adaptive sampling in high abundance areas identified during the core survey. Two candidate areas were identified as containing high herring abundance and were located outside of core survey coverage falling between transects.

Each candidate area was scouted using a Simrad SP70 long range low frequency omni sonar (range 20-30 kHz, *26 kHz applied) to determine geographical extent of target aggregations. A survey plan was then designed with transects running perpendicular to the lines of bathymetry. Parallel transects were spaced at 300 m apart to ensure the full overlapping coverage of the EM2040 multibeam swath (300 kHz) in order that the full extent of the aggregation was contained. The EK60 and EM2040 multibeam systems were run in parallel to provide quantitative and spatial data respectively. Survey design followed methods described in Simmonds and MacLennan (2005) for adaptive surveys. Individual transects were run in parallel crossing the extent of the herring aggregation with the end point determined when no further herring were observed for 100m.

Directed fishing trawls and in-trawl optics were used to determine echotrace identification as applied during routine surveying operations.

Combined, the two adaptive surveys accounted for 210nmi of transects covering an area of 59 nmi^2 (Table 1).

2.3 Equipment and system details and specifications

2.3.1 Acoustic array

Equipment settings for the acoustic equipment were determined before the start of the survey program and were based on established settings employed by FEAS on previous surveys (O'Donnell *et al.,* 2004). The acoustic settings for the EK60 38 kHz transducer are shown in Table 2.

Acoustic data were collected using the Simrad EK60 scientific echosounder. The Simrad split-beam transducers are mounted within the vessel's drop keel and lowered to the working depth of 3.3m below the vessel's hull or 8.8m sub surface. Four operating frequencies were used during the survey (18, 38, 120 and 200 kHz) for trace recognition purposes, with the 38 kHz data used to generate the abundance estimate.

While on survey track the vessel is normally propelled using DC twin electric motor propulsion system with power supplied from 1 main diesel engine, so in effect providing "silent cruising" as compared to normal operations (Anon, 2002). During fishing operations normal two-engine operations were employed to provide sufficient power to tow the net.

For the EM2040 bathymetric multibeam a manual fixed angular coverage was used (60° opening angle) to standardise the volume of water sampled. Pulse type and ping rate were set to auto to optimise data acquisition and the sampling frequency was set at 300 kHz to minimise interference on the EK60. The ping rate on the EK60 was maintained at 4 sec^{-1} while the EM2040 auto setting produced a ping rate of 3.5 sec^{-1}.

2.3.2 Calibration of acoustic equipment

A calibration of the EK60 was carried out in Dunmanus Bay on the 3rd of October at the start of the survey and again in the same location at the end of the survey (20th October). Both calibrations were carried out during hours of daylight and all frequencies were calibrated.

2.4 Survey protocols

2.4.1 Acoustic data acquisition

Acoustic data were observed and recorded onto the hard-drive of the processing unit using the equipment settings from previous surveys (Table 2). The "RAW files" were logged via a continuous Ethernet connection to the vessels server and the ER60 hard drive as a backup in the event of data loss. In addition, as a further back up a hard copy was stored on an external hard drive. Myriax Echoview® Echolog (Version 5) live viewer was used to display the echogram during data collection to allow the scientists to scroll through echograms noting the locations and depths of fish shoals. A member of the scientific crew monitored the equipment continually. Time and location (GPS position) data was recorded for each transect within each strata. This log was used to monitor the time spent off track during fishing operations and hydrographic stations plus any other important observations.

2.4.2 Echogram scrutinisation

Acoustic data was backed up every 24 hrs and scrutinised using Echoview® (V 5) post processing software. Partitioning of data into the categories shown below was largely subjective and was performed by a scientist experienced in scrutinising echograms.

The NASC (Nautical Area Scattering Coefficient) values from each herring region were allocated to one of 4 categories after inspection of the echograms. Categories identified on the basis of trace recognition were as follows:

1. "Definitely herring" echo-traces or traces were identified on the basis of captures of herring from the fishing trawls which had sampled the echo-traces directly, and on large marks which had the characteristics of "definite" herring traces (i.e. very high intensity (red), narrow inverted tear-shaped marks either directly on the bottom or in mid-water and in the case of spawning shoals very dense aggregations in close proximity to the seabed).

2. "Probably herring" were attributed to smaller echo-traces that had not been fished but which had the characteristic of "definite" herring traces.

3. "Herring in a mixture" were attributed to NASC values arising from all fish traces in which herring were thought to be contained, owing to the presence of a proportion of herring within the nearest trawl haul or within a haul that had been carried out on similar echo-traces in similar water depths.

4. "Possibly herring" were attributed to small echo-traces outside areas where fishing was carried out, but which had the characteristics of definite herring traces.

The RAW files were imported into Echoview for post-processing. The echograms were divided into transects. Echotraces belonging to one of the four categories above were identified visually and echo integration was performed on the enclosed regions. The echograms were analysed at a threshold of -70 dB and where necessary plankton was filtered out by thresholding at –65 dB.

The allocated echo integrator counts (NASC values) from these categories were used to estimate the herring numbers according to the method of Dalen and Nakken (1983).

The TS/length relationships used predominantly for the Celtic Sea Herring Survey are those recommended by the acoustic survey planning group based at 38 kHz (ICES, 1994):

Herring	TS =	20logL – 71.2 dB per individual (L = length in cm)
Sprat	TS =	20logL – 71.2 dB per individual (L = length in cm)
Mackerel	TS =	20logL – 84.9 dB per individual (L = length in cm)

Horse mackerel TS = 20logL – 67.5 dB per individual (L = length in cm)

Anchovy TS = 20logL – 71.2 dB per individual (L = length in cm)

The TS length relationship used for gadoids was a general physoclist relationship (Foote, 1987):

Gadoids TS = 20logL – 67.5 dB per individual (L = length in cm)

2.4.3 Biological sampling

A single pelagic midwater trawl with the dimensions of 19 m in length (LOA) and 6 m at the wing ends and a fishing circle of 330 m was employed during the survey (Figure 12). Mesh size in the wings was 3.3 m through to 5 cm in the cod-end. The net was fished with a vertical mouth opening of approximately 9m, which was observed using a cable linked “BEL Reeson” netsonde (50 kHz). The net was also fitted with a Scanmar depth sensor. Spread between the trawl doors was monitored using Scanmar distance sensors, all sensors being configured and viewed through a Scanmar Scanbas system.

All components of the catch from the trawl hauls were sorted and weighed; fish and other taxa were identified to species level. Fish samples were divided into species composition by weight. Species other than the herring were weighed as a component of the catch. Length frequency and length weight data were collected for each component of the catch. Length measurements of herring, sprat and pilchard were taken to the nearest 0.5 cm below. Age, length, weight, sex and maturity data were recorded for individual herring within a random 50 fish sample from each trawl haul, where possible. All herring were aged onboard. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

Decisions to fish on particular echo-traces were largely subjective and an attempt was made to target marks in all areas of concentration not just high density shoals. No bottom trawl gear was used during this survey. However, the small size of the midwater gear used and its manoeuvrability in relation to the vessel power allowed samples at or below 1m from the bottom to be taken in areas of clean ground.

2.4.4 Oceanographic data collection

Oceanographic stations were carried out during the survey at predetermined locations along the track. Data on temperature, depth and salinity were collected using a calibrated Seabird 911 sampler at 1 m subsurface and 3 m above the seabed.

2.4.5 Marine mammal and seabird observations

2.4.5.1 Marine Mammal sighting survey

During the survey an observer kept a daylight watch on marine mammals from the crow’s nest (18 m above sea level) when weather allowed or from the bridge (11 m).

During cetacean observations, watch effort was focused on an area dead ahead of the vessel and 45º to either side using a transect approach. Sightings in an area up to 90º either side of the vessel were recorded. The area was constantly scanned during these hours by eye and with binoculars. Ship’s position, course and speed were recorded, environmental conditions were recorded every 15 minutes and included, sea state, visibility, cloud cover, swell height, precipitation, wind speed and wind direction. For each sighting the following data were recorded: time, location, species, distance, bearing and number of animals (adults, juveniles and calves) and behaviour. Relative abundance (RA) of cetaceans was calculated in terms of number of animals sighted per hour surveyed (aph). RA calculations for porpoise, dolphin species and minke whales were made using data collected in Beaufort sea state ≤ 3. RA calculations for large whale species were made using data collected in Beaufort sea state ≤ 5.

2.4.5.2 Seabird sighting survey

A standardized line transect method with sub-bands to allow correction for species detection bias and 'snapshots' to account for flying birds was used (following recommendations of Tasker *et al.* 1984; Komdeur *et al*.1992; Camphuysen *et al*. 2004), as outlined below.

Two observers (a primary observer and a primary recorder, who also acted as a secondary observer), in rotation from a pool of three surveyors, were allocated to survey shifts of two hours, surveying from 08.00 (or first light) to 18.00 hours (dusk) each day. Environmental conditions, including wind force and direction, sea state, swell height, visibility and cloud cover, and the ship's speed and heading were recorded at 2-hourly intervals during surveys. In the intervening time, any changes to environmental conditions were also noted, so that a discreet set of environmental conditions was obtained for each 5-minute interval. No surveys were conducted in conditions greater than sea state 5, when high swell made working on deck unsafe or when visibility was reduced to less than 300 m.

The seabird observation platform was the wheelhouse deck, which is 10.5m above the waterline and provided a good view of the survey area. The survey area was defined as a 300m wide band operated on one side (in a 90° arc from bow to beam) and ahead of the ship. This survey band was sub-divided (A = 0-50 m from the ship, B = 50-100 m, C = 100-200 m, D = 200-300 m, E > 300 m) to subsequently allow correction of differences in detection probability with distance from the observer. A fixed-interval range finder (Heinemann 1981) was used to periodically check distance estimates. The area was scanned by eye, with binoculars used only to confirm species identification.

All birds seen on the water within the survey area were counted, and those recorded within the 300 m band, were noted as 'in transect'. All flying birds within the survey area were also noted, but only those recorded during a 'snapshot' were regarded as 'in transect'. This method avoids overestimating bird numbers in flight (Tasker *et al*. 1984). The frequency of the snapshot scan was ship-speed dependent, such that they were timed to occur at the moment the ship passed from one survey block (300 m x 300 m) to the next. Survey time intervals were set at 5 minutes. Additional bird species observed outside the survey area were also recorded and added to the species list for the research cruise, but these will not be included in maps of seabird abundance or density.

On acoustic survey transects the vessel had an average speed of 10 knots, while speed was reduced to 4 knots for trawling effort. Tows lasted around 45 minutes and were mostly separated by extended sessions of steaming at 10 knots, so that few birds were attracted to the ship. CTD stations were conducted on some transects, during which the vessel remained stationary for, on average, 18 minutes. Seabird surveying was interrupted while the ship was stationary at CTD stations and while towing since this can attract large numbers of birds. Where fish sampling operations were prolonged or at close intervals, seabird surveying was only recommenced after a period (45min – 1hr) of prolonged steaming at 10 knots, allowing the associating birds to disperse. Any bird recorded in the survey area that stayed with the ship for more than 2 minutes was regarded as being associated with the survey vessel (Camphuysen *et al.* 2004) and was coded as such (to be excluded from abundance and density calculations).

The daily total count data per day for each species is presented along with the daily survey effort. It is envisaged that this data will be analysed in the future and the seabird abundance (birds per km traveled), and seabird density (birds per km^2) will be mapped per 1⁄4 ICES rectangle (15' latitude x 30' longitude), allowing comparison to the results of previous seabird surveys in Irish waters (e.g. Hall *et al*. in press, Mackey *et al*. 2004, Pollock *et al*. 1997). Through further analysis, species-specific correction factors will be applied to birds observed on the water. It is also hoped to combine this analysis with the results of the cetacean observation and acoustic survey. The binomial species names for the birds recorded are presented in the species accounts.

All visible marine litter was also recorded during bird observations. The litter was identified or described as accurately as possible; quantity, size and distance from the boat was noted. When possible, pictures of the objects were taken.

2.5 Analysis methods

2.5.1 Echogram partitioning

The analysis produced density values of abundance and biomass per nautical mile squared for each transect and mark category for each target species. These were then averaged over each stratum (weighted by transect length) and biomass and abundance estimated by applying the stratum area and summing the strata estimates. Note that interconnecting inshore and offshore inter-transects were not included in the analysis. Total estimates and age and maturity breakdowns were calculated. Coefficient of variation (cv, standard error divided by the estimate) was estimated in the usual way after assuming that transects were equally spatially distributed within a stratum and that they were statistically independent.

Biomass was calculated from numbers using length-weight relationships determined from the trawl samples taken during the survey for each of the analysis areas.

Herring weight (grams) $= 0.0265 * L^{3.3511}$ (L = length in cm)

Mackerel weight (grams) $= 0.0096 * L^{2.9073}$ (L = length in cm)

Sprat weight (grams) $= 0.0037 * L^{3.3063}$ (L = length in cm)

2.5.2 Abundance estimate

The recordings of area back scattering strength (NASC) per nautical mile were averaged over a one nautical mile EDSU (elementary distance sampling unit), and the allocation of NASC values to herring and other acoustic targets was based on the composition of the trawl catches and the appearance of the echotraces.

To estimate the abundance, the allocated NASC values were averaged by survey strata. For each stratum, the unit area density of fish (S_A) in number per square nautical mile ($N * nmi^{-2}$) was calculated using standard equations (Foote et al. 1987, Toresen *et al*. 1998).

NASC values assigned according to scrutinisation methods (section 2.3.5) were used to estimate the target species numbers according to the method of Dalen and Nakken (1983).

To estimate the total abundance of fish, the unit area abundance for each stratum was multiplied by the number of square nautical miles within the strata and then summed for all strata to provide the total survey area. Biomass estimation was calculated by multiplying abundance in numbers by the average weight of the fish in each strata and then sum of all squares by strata and summed for the total area.

2.5.3 Adaptive survey data

In the standard fisheries acoustic surveys, the elementary distance sampling unit (EDSU) is the length of transect along which acoustic measurements are averaged in a single sample (Simmonds and MacLennan, 2005). The choice of how long to make the EDSU is a balance between capturing the spatial structure of a population and reducing the correlation between successive samples (Simmonds and MacLennan, 2005). For the core survey an EDSU of 1 nmi is used as standard. However, for adaptive surveys an EDSU of 0.05 nmi (100 m) was applied. This shorter EDSU was selected based on work carried out by Barbeaux, et al (2013) for surveying discreet aggregations of fish at high resolution.

The calculation of abundance used the same methodology applied for core surveys described above.

3 Results

3.1 Celtic Sea herring stock

3.1.1 Herring biomass and abundance

Herring	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	184	24,710	100.0
Mixture	0	0	0.0
Probably	0	0	0.0
Possibly			
Total estimate	184	24,710	100
		12	
SSB Estimate			
Definitely	184	24,710	100.0
Mixture	0	0	0.0

For the core survey a total of three single herring echotraces were identified during routine ‘on-track’ observations. The echotraces occurred in a localised area within the Smalls offshore stratum and it was evident that they formed part of a much more substantial aggregation occurring off-track. The presence of aggregations occurring between survey transects initiated a fine spatial resolution survey approach in two key areas; the ‘Trench’ and ‘Smalls’ (Figure 2).

The Trench strata focused on a discreet area (5 nmi²) along a shallow gully containing herring. Two surveys were carried out on the same aggregation; one during daylight hours and again at night. The Smalls strata focused on a wider area (20 nmi²) straddling the 100m depth contour of the western edge of the Celtic Deep. This area was identified as containing a single high density herring aggregation extending over 1.5 nmi along the 100 m contour. Four replicate adaptive surveys were carried out on this aggregation; one complete survey of the aggregation and 3 further surveys with a seven day time interval. The three further surveys consisted of; one complete daylight survey; and a complete night/day survey (Table 1)

Total herring biomass was calculated from two high resolution adaptive strata; the daylight survey of the Trench area and the combined day/night survey of the Smalls strata and were chosen as the best candidate surveys. Within these strata 1,235 echotraces were identified as ‘definitely herring’ (EDSU = 100 m).

Herring TSB (total stock biomass) and abundance (TSN) estimates were 24,710 t and 184 million individuals (CV 18.4%) respectively. No immature fish were encountered during the adaptive surveys.

A breakdown of herring stock abundance and biomass by age, maturity, size and stratum is shown in Tables 4-10.

3.1.2 Herring distribution

A total of 27 trawl hauls were carried out during the survey (Figure 2), with 3 hauls containing >50% herring by weight of catch (Table 3).

Herring distribution was limited to offshore strata. During the core survey herring were identified in low numbers from mixed catches from the eastern survey area and in the smalls stratum (Figure 3 No estimate of biomass was calculated from these echotraces due to the low numbers encountered.

Stratum 10 (Trench) contained herring located close to the seabed (0-2 m) running linearly along the gully. The extent of the echotraces was mapped using the EM2040 bathymetric multibeam and extended up to 600 m length and 250 m wide (Figure 6a).

Stratum 14 & 15 (Smalls) this area was found to contain a large expansive aggregation of herring centred on the 100 m depth contour extending for between one and two nautical mile sin each plane (Figure 6b & c). This aggregation was surveyed using 4 separate surveys with a temporal gap of one week between the first and second events.

3.1.3 Herring stock composition

A total of 149 herring were aged from survey samples in addition to 1,250 length measurements and 300 length-weights recorded (Table 4). Herring age samples ranged from 2-8 winter-rings (Tables 5 & 6, Figure 5).

Three winter-ring herring dominated the 2015 adaptive survey estimate representing over 24% of TSB and 26% of TSN (Table 5 and 6). The 4 winter-ring age group were ranked second representing 23% of TSB and 22% of TSN. The third most dominate age group was 5 winter-ring group contributing 23% to the TSB and 21% to TSN.

Maturity analysis of samples taken from the 3 hauls undertaken during the adaptive surveys contained 100% mature fish (Tables 7 & 8, Figure 5). Mature herring (stages 3 to 8) sampled during the survey were in a pre-spawning state and comprised predominantly of stages 3-4 (93%). Less than 2% of fish (n=2) were spent observed during the survey and this is consistent with the dominant winter spawning stock component.

3.2 Other pelagic species

3.2.1 Sprat

Sprat	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	19,418	77,157	92.1
Mixture	1,980	6,622	7.9
Probably	0	0	0.0
Total estimate	21,398	83,779	100

Sprat were found in 6 of 9 survey strata and sampled in 20 of 27 hauls (Figure 4, Table 3). In total 3,164 individual length measurements and 1,834 length/weight measurements were recorded. Mean length was 8.6 cm and mean weight was 5 g (8.2 cm and 4 g in 2014). Individuals ranged from 5.5 to 14. cm in length and 1 to 26 g in weight.

In total 829 individual sprat echotraces were identified during the core survey (Table 12). The highest concentration of biomass was observed offshore and accounted for 85% of total biomass and 95% of the total abundance (Table 12). Very high density echotraces of sprat were observed offshore (Figure 6e).

Inshore coastal waters accounted for the remaining 15.2% of stock biomass, where the Mizen and Dunmanus Bay strata were the main contributors (Figure 6f).

3.3 Oceanography

A total of 57 CTD stations were carried out. However, due to problems with the sensor suite during the survey, data from a number of stations (n=8) stations were deemed unusable. Surface plots of temperature and salinity are presented for the 5 and 20m depth profiles (Figures 7 & 8), while profiles for 40m and 60m profiles are overlaid with herring NASC data (Figures 9 & 10).

Sea surface temperature, as measured at 5 m, was relatively warm with temperatures above 14.5ºC for the larger area to a maximum of 15.4°C. Surface salinity follows a similar pattern and is relatively stable throughout the area with the exception of river plumes (Figure 7). Temperature and salinity profiles at 20 m depth (Figure 8) follow a similar stable pattern indicating the thermocline is located below 20 m, The influence of the cooler, less saline water along the south coast in the form of the Irish Sea Front is evident at 20 m.

Below 40 m depth warmer water dominates the eastern survey area where the bulk of herring and sprat biomass was observed (Figure 9 & 10). Herring were located primarily in waters above 15°C and close to a frontal boundary region. When located offshore herring are most frequently found in or around this thermohaline boundary region.

3.4 Marine mammal and seabird observations

3.4.1 Marine mammal sightings

Visual survey effort was recorded on 18 days between 3rd and 20th October inclusive amounting to a total of 108 hours and 50 minutes ‘on effort’. All dedicated effort was recorded from the crow’s nest and for 80% of the survey effort there was one dedicated observer. For the remaining 20% of the time there were two or more observers contributing to ‘on effort’ sightings. Effort was on average 6 hours and 3 minutes per day but ranged from a daily minimum of 2 hours and 19 minutes to a maximum of 9 hours and 12 minutes. 72% of survey effort was recorded whilst transecting the main survey lines at standard survey speed (c.10 knots) with the remaining 28% of effort occurring simultaneous to fishing effort or whilst completing shorter more condensed survey lines off the standard transect lines.

Sea state during observation hours ranged from Beaufort sea state 1 to 5. Out of the total time ‘on effort’ 1% was recorded as sea state 1; 13% as sea state 2; 22% was recorded as sea state 3; sea state 4 accounted for 46% of the time; sea state 5 was recorded 16% of survey time and the remaining 2% of observations were conducted in sea state 6.There was no swell (<1 m) for 38% of the total effort duration. “Light” swell (1 m) was recorded during 52% of effort and the swell was classified as “moderate” (1 to 2 m) for the remaining 10% of the time.

Visibility ranged from greater than 20 km to less than 1 km. For the most part (84% of the time) visibility was greater than 10 km whilst on survey effort. Visibility was between 6 and 10 km for 15% of the time surveyed and between 1 and 5 km for 1% of the time. Poor visibility (< 1 km) accounted for just 0.03% (1 hour and 50 minutes) of the total survey effort. Rain was recorded on five days during 7% of survey time but was always light and its effect on survey conditions would have been reflected in visibility records.

Visual encounters

A total of 93 sightings of identified cetacean species were made, comprising a minimum of 1,088 individuals (Table 13). There were a further 10 whale sightings of 11 individuals and two cetacean encounters of two individuals that were not identified to species level and similarly five unidentified dolphin sightings comprising an estimated

35 animals. The sightings counted include those recorded during dedicated survey effort as well as incidental sightings made by other scientific personnel and the ship's crew.

Summary

The presence of seven different cetacean species and the occurrence of multi-species feeding aggregations indicate the continued importance of the waters of the Celtic sea as a foraging ground for cetaceans. Previous research has identified the autumn as being within peak season for minke, humpback and fin whales in waters off the Irish south coast due to the foraging potential provided by high concentrations of pelagic schooling fish at that time of year (Wall *et al*., 2013). This year was the first time killer whales were recorded during the Celtic Sea herring survey, bringing the total number of species recorded during 12 Celtic Sea Herring Acoustic Surveys (2004 to 2015) to 11 (Table 14). Previous distribution records for killer whales have been dominated by inshore sightings of the species (Wall, *et al*., 2013), the sighting on this survey, 90 km south of Waterford, is likely to have been due to the high density of herring in the area at the time. The other species recorded this year had all been observed during one or more previous years. Common dolphins were again by far the most frequently observed species with a high number of sightings close to the average of previous years. Although it is imprudent to compare sightings locations and rates with previous years without accounting for the potential effects of environmental variables on detection rates it is worth mentioning that fin whale encounters were, like the 2014 survey, mainly in the eastern portion of the survey area off the Waterford coast. In contrast minke whale sightings were more widespread this year with some occurring further offshore to the south of Waterford, compared to last year's survey when all minke whale records were from coastal waters off Co. Cork. 2015 represents the fifth year with observations of humpback whale. The most intensive feeding activity was observed in areas where sprat were the dominant prey species. Areas with multi-species sightings were also recorded in coincidence with high herring concentrations.

A full summary by species is provided in Annex 1.

3.4.2 Seabird sightings and marine litter

A total of 53.52 hours (3,211 minutes) of seabird surveys was conducted across thirteen days between 3rd and 20th October 2015.

A cumulative total of 13,341 individual seabirds of 24 species was recorded, of which 6,275 were noted as 'off survey', outside of dedicated survey time or associating with the vessel and as such will be excluded from future analysis of abundance and density. A synopsis of daily totals for all seabird species recorded is presented in Table 15. In addition, daily totals for 21 species of migrant terrestrial birds recorded on or around the vessel are also presented (Table 16).

The seabird team recorded presence of marine litter or debris observed in transect areas. Details of distance from the survey vessel, estimated size, material involved, colour and any branding were noted. Recording of marine litter using this format has been ongoing during CSHAS surveys since 2013, data of which is being compiled for future analysis.

4 Discussion and Conclusions

4.1 Discussion

The objectives of the survey were carried out successfully and as planned. No down-time was recorded and excellent weather conditions prevailed allowing for extended marine mammal and seabird survey effort.

Time was allocated to conduct adaptive surveys on off-track herring aggregations for quantitative and behavioural studies. As few on-track herring echotraces were encountered during the core survey the biomass estimate presented here was determined from the adaptive survey data. High abundance areas identified during the co-occurring fishery provided detailed real time information on the location and movements of aggregations. This year offshore fishing effort was almost exclusively restricted to a single discrete location and was surveyed as a focus area and closely resembled the situation in 2014. Adaptive surveys were carried out using established methods for data collection and analysis thus providing quantitative data for estimates of biomass. Using the EM2040 bathymetric multibeam (MBES) and the EK60 systems in harmony allowed the spatial extent of large offshore herring aggregations to be mapped for the first time.

The spatial mapping survey used a high intensity transect spacing of 300 m. Beam opening angles on the MB were manually set to standardise the volume of water sampled while ensuring the spatial integrity of successive EK60 transects as a means to reduce the effects of double counting. The swath coverage by ping of the MB systems was 400m compared to 11m for the single beam EK60. Large aggregations of herring observed at the Smalls stratum (#14&15) were found to be spatially stable over a period of seven days between successive surveys which was surprising given the stock is in a period of spawning migration. Changes in aggregation morphology over the 24 hr diel cycle were observed with herring in both adaptive and geographically distinct surveys exhibiting clear differences in day/night behaviour. Common to both areas was the preference of herring for deeper waters during daylight hours and a diffuse shoaling pattern with a large spatial footprint and in close contact with the seabed (thin and flat). During hours of darkness, herring in both areas were observed to form tightly packed shoals, increasing in vertical height while reducing the spatial footprint (tall and thin). During this transition phase shoals were seen to move by distances of up 1.5 nmi into shallower waters before returning to depth with the onset of daylight.

Although not an absolute measure of biomass the adaptive surveys provide a high degree of spatial resolution. Understanding the behaviour of offshore aggregations allows for the core survey design to be optimised so increasing the precision of annual estimates.

Sprat distribution over recent years has been characterised by the presence of high density aggregations 0-group fish in inshore water, namely around the southwest. Offshore areas are more commonly associated with mixed aggregations consisting of several age cohorts. In 2015 the 0-group sprat were found in large numbers in offshore waters. Conversely, inshore waters were dominated by older, likely the same age cohort, individuals occurring in large numbers. The presence of older fish close inshore is more related to conditions observed in November/December when SST is lower.

These schools of larger fish attracted multispecies feeding aggregations of marine mammals, tuna and seabirds.

4.2 Conclusions

- Very low herring abundance was observed during the core survey coverage. Observations of herring were limited to two discrete areas located offshore during off-track adaptive surveys.
- No herring schools were recorded on the inshore spawning grounds. A small quantity of herring was observed in mixed species aggregations in the eastern survey area but was not reported here.
- Herring TSB (total stock biomass) and abundance (TSN) estimates were 24,710 t and 184 million individuals (CV 18.4%) respectively from the adaptive survey data.
- Three winter-ring herring dominated the 2015 estimate (24% of TSB & 26% of TSN), followed by 4 winter-ring (23% of TSB & 22% of TSN) and the 5 winter-ring group (23% of TSB & 21% of TSN). No immature fish were observed from catches within the adaptive strata.
- The 2015 estimate of abundance was determined from adaptive surveys and so is not considered as comparable to the current time series or representative of the larger stock.
- The distribution of the stock observed during the survey was substantiated by the co-occurring fishery that was centered offshore. As a result it is not possible to say if the stock was contained within the survey area and may therefore not be a representative measure of abundance.

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5 Tables and Figures

Table 1. Survey Strata detail of core survey (strata 1-9) and adaptive surveys (strata 10-15).

Strata no.	Strata name	Survey type	Transect type	Active transects	Transect spacing (nmi)	Transect mileage (nmi)	Strata area (nmi²)
1	Mizen	Broad scale	Parallel	8	8	274.9	1381.6
2	Offshore	Broad scale	Parallel	4	24	802.0	2291.7
3	Smalls	Broad scale	Parallel	4	13	363.2	1307.2
4	Inshore	Spaw ning grd	Parallel	2	34	720.8	1335.9
5	Dunmanus	Broad scale	Zigzag	8	na	18.3	28.4
6	Bantry	Broad scale	Zigzag	6	na	25.8	37.4
7	Kenmre	Broad scale	Zigzag	5	na	21.3	56.9
8	Dingle	Broad scale	Zigzag	10	na	33.4	82.2
9	Kerry Head	Broad scale	Parallel	2	na	76.5	58.5
			Total	49		2,336.2	6,579.8
10	Trench (d)	Adaptive	Parallel	7	0.05	8.4	5.1
11	Trench (n)	Adaptive	Parallel	8	0.05	9.6	5.3
12	Smalls (d)	Adaptive	Parallel	14	0.05	49.0	12.9
13	Smalls 2 (d)	Adaptive	Parallel	19	0.05	50.5	13.4
14	Smalls 3 (d)	Adaptive	Parallel	11	0.05	42.3	6.8
15	Smalls 3 (n)	Adaptive	Parallel	20	0.05	49.7	15.3
			Total	79		209.5	58.8
			Grand total	128		2545.7	6638.6

d = daylight hrs, n = nightime

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Table 2. Calibration report: Simrad EK60 echosounder at 38 kHz.

Echo Sounder System Calibration

Vessel : R/V Celtic Explorer		Date : 03/10/2015	
Echo sounder : ER60 PC		Locality : Dunmanus Bay	
Type of Sphere : CU-38,1	TS_{Sphere}: -33.50 dB (Corrected for soundvelocity or t,S)	Depth(Sea floor) 33 m	

Calibration Version 2.1.0.11

Comments:
Dunmanus Bay, flat calm

Reference Target:

TS	-33.52 dB	Min. Distance	17.00 m
TS Deviation	5.0 dB	Max. Distance	22.00 m

Transducer: ES38B Serial No. 30227

Frequency	38000 Hz	Beamtype	Split
Gain	25.82 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	6.93 deg	Along. Beam Angle	6.91 deg
Athw. Offset Angle	-0.06 deg	Along. Offset Angl	-0.04 deg
SaCorrection	-0.67 dB	Depth	8.8 m

Transceiver: GPT 38 kHz 009072033933 1 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.193 m
Power	2000 W	Receiver Bandwidth	2.43 kHz

Sounder Type:
ER60 Version 2.2.1

TS Detection:

Min. Value	-50.0 dB	Min. Spacing	100 %
Max. Beam Comp.	6.0 dB	Min. Echolength	80 %
Max. Phase Dev.	8.0	Max. Echolength	180 %

Environment:

Absorption Coeff.	9.0 dB/km	Sound Velocity	1505.2 m/s

Beam Model results:

Transducer Gain =	25.79 dB	SaCorrection =	-0.63 dB
Athw. Beam Angle =	7.06 deg	Along. Beam Angle =	7.04 deg
Athw. Offset Angle =	-0.04 deg	Along. Offset Angle=	-0.04 deg

Data deviation from beam model:
RMS = 0.08 dB
Max = 0.27 dB No. = 180 Athw. = 2.8 deg Along = 3.7 deg
Min = -0.35 dB No. = 365 Athw. = 4.6 deg Along = -1.5 deg

Data deviation from polynomial model:
RMS = 0.05 dB
Max = 0.17 dB No. = 180 Athw. = 2.8 deg Along = 3.7 deg
Min = -0.28 dB No. = 179 Athw. = 2.3 deg Along = 3.3 deg

Comments :

Wind Force : 1 **Wind Directioı** SE
Raw Data File: \\Expfileclstr\ER-60_Data\CSHAS_2015\RAW ER60 Files\Calibration\CSHAS_2015
Calibration File: \\Expfileclstr\ER-60_Data\ER-60\Calibrations_2015\CSHAS 2015\38 KHZ

Calibration : Ciaran O'Donnell

Table 3. Catch table from directed trawl hauls.

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target (m)	Bulk Catch (Kg)	Herring %	Mackerel %	Scad %	Sprat %	Pilchard %	Others* %
1	03.10.15	51.54	-10.04	19:12	71	60	176.0	0.1	2.3	0.0	96.3		1.3
2	05.10.15	51.19	-8.34	14:33	103	0	18.1		5.6	0.2			94.2
3	06.10.15	51.47	-7.91	09:39	87	0	220.0			0.7			99.3
4	07.10.15	51.25	-7.38	08:31	95	15	104.9	0.1	13.4	0.1	80.1		6.3
5	07.10.15	51.16	-7.27	13:28	95	35	91.2		0.0	0.3	91.5		8.2
6	07.10.15	51.12	-7.24	23:30	114	0	2500.0	100.0					
7	08.10.15	51.22	-7.06	10:49	92	35	77.0				96.5		3.5
8	08.10.15	51.75	-7.04	16:10	75	0	41.0			8.8	85.4		5.8
9	09.10.15	51.38	-6.74	08:47	86	35	113.5		0.0		98.6		1.4
10	09.10.15	51.41	-6.74	09:54	86	35	127.1		11.1		87.9		1.0
11	09.10.15	51.14	-6.63	15:02	106	45	117.0	0.5	2.8	0.6	88.9		7.2
12	10.10.15	51.31	-6.53	07:38	90	0-45	3500.0	98.1	2				0.4
13	11.10.15	51.79	-6.20	07:45	97	35-50	178.7	0.0	3.9	4.3	89.5		2.2
14	11.10.15	51.51	-6.01	15:04	107	75	150.0	13.3	0.6	2.1	37.0		47.0
15	12.10.15	51.23	-6.09	00:00	60	0-10	154.1	0.4	0.2	3.9	73.4		22.1
16	12.10.15	52.01	-6.68	17:51	60	10	220.0	0.1	99.4	0.0			0.5
17	13.10.15	52.02	-6.95	09:18	52	0-40	7.0	6.4	21.2	64.2		2.8	5.3
18	13.10.15	51.87	-7.01	12:38	68	0-8	0.0						
19	14.10.15	51.81	-7.33	13:54	76	0-5	200.0	0.1	65.8	0.2	32.8		1.1
20	15.10.15	52.04	-7.49	07:42	31	0-9	180.0	0.5	4.2		95.3		
21	15.10.15	51.73	-7.55	13:54	77	0-8	150.0		34.7	1.2	63.6		0.5
22	16.10.15	51.28	-6.63	09:00	89	25-65	32.0	19.9		0.2	73.7		6.2
23	16.10.15	51.23	-6.58	19:43	107	0-10	750.0	95.3			0.8		3.9
24	16.10.15	51.30	-6.53	21:28	100	0	350.0	1.5			5.4		93.2
25	17.10.15	51.85	-7.68	08:11	50	13-20	91.8	0.0	48.7	0.3	38.5	10.6	1.9
26	17.10.15	51.65	-7.77	13:53	81	0-15	87.3		0.8	2.1	85.9		11.2
27	19.10.15	51.54	-9.72	13:01	43	0-20	300.0		1.7		97.6		0.6

* Including pelagic, demersal fish and invertebrate

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Table 4. Length-frequency of herring hauls from adaptive strata used in the analysis. Haul 6 = Trench, Hauls 12 & 23 = Smalls.

Haul	6	12	23	
length (cm)				Total
11				
11.5				
12				
12.5				
13				
13.5				
14				
14.5				
15				
15.5				
16				
16.5				
17				
17.5				
18				
18.5				
19				
19.5				
20				
20.5				
21	1			1
21.5	0		1	1
22	4		3	7
22.5	11	1	6	18
23	16	0	10	26
23.5	44	4	23	71
24	39	6	15	60
24.5	60	14	55	129
25	38	19	46	103
25.5	52	41	59	152
26	52	38	41	131
26.5	47	60	60	167
27	25	30	26	81
27.5	10	31	25	66
28	10	9	10	29
28.5	6	2	2	10
29	2	1	2	5
29.5	2			2
30				
30.5				
31				
31.5				
32				
32.5				
33				
Total	419	256	384	1,059

Table 5. Total biomass (000's tonnes) of herring at age (winter rings) by strata.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
10	0	0	0.2	0.3	0.2	0.2	0	0	0			0.9
14_15	0	0	4	5.9	5.6	5.6	1	0.9	0.8			23.8
Total	0	0	4.3	6.1	5.7	5.8	1.1	0.9	0.8			24.7
%	0	0	17.3	24.7	23.2	23.3	4.4	3.7	3.4			100

Table 6. Herring abundance (millions) at age (winter rings) by strata.

Strata	0	1	2	3	4	5	6	7	8	9	10	Total
10	0	0	2	2	1	1	0	0	0			7
14_15	0	0	38	46	40	37	7	5	4			177
Total	0	0.0	40.1	48.1	41.2	37.7	6.8	5.5	4.6			184.0
%	0	0.0	21.8	26.2	22.4	20.5	3.7	3.0	2.5			100
Cv (%)	0	0.0	21.1	19.0	17.7	16.8	16.9	16.6	17.2			18.4

Table 7. Herring biomass (000's tonnes) at maturity by strata.

Strata	Imm	Mature	Spent	Total
10	0.0	0.9	0.0	0.9
14_15	0.0	23.5	0.3	23.8
Total	0.0	24.4	0.3	24.7
%	0.0	0	0	0.0

Table 8. Herring abundance (millions) at maturity by strata.

Strata	Imm	Mature	Spent	Total
10	0.0	7.4	0.1	7.4
14_15	0.0	174.5	2.0	176.6
Total	0.0	181.9	2.1	184.0
%	0.0	0.0	0.0	0.0

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Table 9. Herring length at age (winter rings) as abundance (millions) and biomass (000’s tonnes).

Length	Age (Rings)											Abund	Biomass	Mn wt
(cm)	0	1	2	3	4	5	6	7	8	9	10	(mils)	000's t	(g)
11														
11.5														
12														
12.5														
13														
13.5														
14														
14.5														
15														
15.5														
16														
16.5														
17														
17.5														
18														
18.5														
19														
19.5														
20														
20.5														
21			0.0									0.0	0.0	61.3
21.5			0.4									0.4	0.0	74.7
22			1.2									1.2	0.1	80.7
22.5			2.6									2.6	0.2	86.8
23			4.2									4.2	0.4	93.4
23.5			10.2									10.2	1.0	100.2
24			2.2	5.0								7.2	0.8	107.4
24.5			16	8.0								24.0	2.8	115.0
25			1.2	12.1	7.3							20.6	2.5	122.9
25.5			1.3	12.1	12.1	2.7						28.2	3.7	131.3
26			0.8	6.2	7.7	4.6	0.8	0.8				20.9	2.9	140.0
26.5				4.7	8.2	14.1	3.5					30.5	4.6	149.1
27					3.7	10.1						13.7	2.2	158.7
27.5					2.2	5.5	1.1	3.3	1.1			13.2	2.2	168.6
28						0.7	1.4	1.4	1.4			5.0	0.9	178.9
28.5									1.1			1.1	0.2	189.0
29									0.9			0.9	0.2	201.0
29.5									0.0			0.04	0.01	188.5
30														
30.5														
31														
31.5														
32														
32.5														
33														
33.5														
TSN (mil)			40.1	48.1	41.2	37.7	6.83	5.5	4.6			184.0	-	-
TSB ('000s t)			4.3	6.1	5.7	5.8	1.1	0.9	0.8			-	24.7	-
Mn Wt (g)			107	127	139	153	158	167	183			-	-	-
Mn length (cm)			23.9	25.2	25.9	26.7	26.9	27.4	28.2			-	-	-

Table 10. Herring biomass and abundance by survey strata.

Category Stratum	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass ('000t)	SSB ('000t)	Abundance millions
10	7	69	69	0	0	0	0.9	0	0	0.9	0.9	7.4
14_15	32	1166	1166	0	0	6	23.8	0	0	23.8	23.8	176.6
Total	39	1235	1235	0	0	5	24.7	0	0	24.7	24.7	184.0

Table 11. Survey time series. Abundance in millions, biomass in 000's tonnes). Age in winter rings. Estimate includes 'Smalls' strata from 2011 onwards.

Season Age (Rings)	1995 1996	1996 1997	1997 1998	1998 1999	1999 2000	2000 2001	2001 2002	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010	2010 2011	2011 2012	2012 2013	2013 2014	2014 2015	2015* 2016
0	202	3	-	0	-	25	40	0	24	-	2	-	1	2	239	5	0.1	31	3.8	0	0
1	25	164	-	30	-	102	28	42	13	-	65	21	106	63	381	346	342	270	698	41	0
2	157	795	-	186	-	112	187	185	62	-	137	211	70	295	112	549	479	856	291	117	40
3	38	262	-	133	-	13	213	151	60	-	28	48	220	111	210	156	299	615	197	112	48
4	34	53	-	165	-	2	42	30	17	-	54	14	31	162	57	193	47	330	43.7	69	41
5	5	43	-	87	-	1	47	7	5	-	22	11	9	27	125	65	71	49	37.9	20	38
6	3	1	-	25	-	0	33	7	1	-	5	1	13	6	12	91	24	121	9.8	24	7
7	1	15	-	24	-	0	24	3	0	-	1	-	4	5	4	7	33	25	4.7	7	6
8	2	0	-	4	-	0	15	0	0	-	0	-	1	-	6	3	4	23	0	17	5
9	2	2	-	2	-	0	52	0	0	-	0	-	0	-	1	-	2	3	0.2	1	0
Abundance	469	1338	-	656	-	256	681	423	183	-	312	305	454	671	1,147	1,414	1,300	2,322	1,286	408	184
SSB	36	151	-	100	-	20	95	41	20	-	33	36	46	93	91	122	122	246	71	48	24.7
CV	53	26	-	36	-	100	88	49	34	-	48	35	25	20	24	20	28	25	28	59.1	18.4

*** Adaptive, not core survey**

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Table 12. Sprat biomass and abundance by survey strata.

Category Stratum	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass ('000t)	Abundance millions
Mizen	8	43	43	0	0	50	1.8	0	0	1.8	167.3
Offshore	24	511	450	61	0	38	65.5	5.6	0	71.0	20287.7
Inshore	34	211	202	9	0	38	9.2	1	0	10.3	879.8
Dunmanus	7	31	31	0	0	14	0.4	0	0	0.4	31.1
Bantry	6	11	11	0	0	67	0	0	0	0.0	3.4
Kenmare	5	0	0	0	0	100	0	0	0	0.0	0.0
Dingle	10	22	22	0	0	70	0.2	0	0	0.2	28.2
Kerry Hd	10	0	0	0	0	100	0	0	0	0.0	0.0
Total	104	829	759	70	0	51	77.1	6.6	0	83.7	21,398
Cv (%)	-	-	-	-	-	-	-	-	-		

Table 13. Summary of cetacean species sightings

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Species	No. of sightings	No. of individuals	Group size range
Humpback whale	3	3	1
Fin whale	7	17	1 - 5
Minke whale	9	16	1 - 4
Killer whale	1	3	3
Common bottlenose dolphin	1	3	3
Short-beaked common dolphin	71	≥1045	1 - 200
Harbour porpoise	1	1	1
Unidentified whale	10	11	1 - 2
Unidentified dolphin	5	35	4 - 10
Unidentified cetacean	2	2	1
Totals	110	≥1136	1 - 200

Table 14. Summary of cetacean species sightings.

Species	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Humpback whale	P	-	-	1 (1)	-	-	1 (2)	-	-	-	-	3 (3)
Fin whale	P	-	5 (5)	3 (5)	9 (28)	4 (7)	3 (6)	25 (49)	20 (7-12)	1 (3+)	13 (24)	7 (17)
Minke whale	P	-	7 (7)	13 (15)	7 (7)	13 (14)	4 (4)	6 (6)	6 (6)	5 (5)	4 (4)	9 (16)
Killer whale	-	-	-	-	-	-	-	-	-	-	-	1 (3)
Long-finned pilot whale	-	-	-	1 (16)	-	-	-	-	-	-	-	-
Risso's dolphin	-	-	-	2 (30)	-	2 (5)	1 (3)	-	-	-	1 (2)	-
Bottlenose dolphin	P	P	-	1 (4)	-	-	-	-	2 (6)	2 (13)	1 (1)	1 (3)
Common dolphin	P	P	P	65 (2126)	78 (1849)	40 (814)	73 (774)	83 (814)	52 (411)	57 (305)	76 (2171)	71 (1045)
White-beaked dolphin	P	-	-	-	-	-	-	-	-	-	-	-
White-sided dolphin	-	-	-	1 (70)	-	-	-	-	-	-	-	-
Harbour porpoise	P	-	-	3 (9)	3 (7)	-	2 (13)	-	5 (17)	-	3 (5)	1 (1)

Table 15. Total number of sea bird species recorded.

Vernacular Name	Scientific Name	On Survey	Off Survey	Total
Fulmar	*Fulmarus glacialis*	253	71	324
Sooty Shearwater	*Puffinus griseus*	35	80	115
Manx Shearwater	*Puffinus puffinus*	12	217	229
Balearic Shearwater	*Puffinus mauretanicus*	1		1
European Storm-petrel	*Hydrobates pelagicus*	151	321	472
Gannet	*Morus bassanus*	4867	3488	8355
Shag	*Phalacrocorax aristotelis*	17	4	21
Pomarine Skua	*Stercorarius pomarinus*		7	7
Arctic Skua	*Stercorarius parasiticus*	1	4	5
Long-tailed Skua	*Stercorarius longicaudus*		1	1
Great Skua	*Stercorarius skua*	53	158	211
Puffin	*Fratercula arctica*	10	7	17
Black Guillemot	*Cepphus grylle*		3	3
Razorbill	*Alca torda*	114	3	117
Guillemot	*Uria aalge*	830	2	832
Razorbill / Guillemot		36		36
Kittiwake	*Rissa tridactyla*	360	42	402
Black-headed Gull	*Chroicocephalus ridibundus*		24	24
Little Gull	*Hydrocoloeus minutus*	1		1
Mediterranean Gull	*Larus melanocephalus*	1	4	5
Common Gull	*Larus canus*	12	2	14
Lesser Black-backed Gull	*Larus fuscus*	112	1241	1353
Herring Gull	*Larus argentatus*	40	215	255
Yellow-legged Gull	*Larus michahellis*		1	1
Great Black-backed Gull	*Larus marinus*	140	140	280
Unidentified Large Gull sp.	*Larus sp.*	20	240	260
Total		7066	6275	13341

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Table 16. Totals of migrant terrestrial bird species recorded.

Vernacular Name	Scientific Name	Total
Teal	*Anas crecca*	1
Turnstone	*Arenaria interpres*	2
Dunlin	*Calidris alpina*	1
Snipe	*Gallinago gallinago*	4
Short-eared Owl	*Asio flammeus*	1
Merlin	*Falco columbarius*	2
Goldcrest	*Regulus regulus*	1
Skylark	*Alauda arvensis*	5
Swallow	*Hirundo rustica*	10
Chiffchaff	*Phylloscopus collybita*	2
Blackcap	*Sylvia atricapilla*	1
Starling	*Sturnus vulgaris*	2
Redwing	*Turdus iliacus*	11
Spotted Flycatcher	*Muscicapa striata*	1
Black Redstart	*Phoenicurus ochruros*	1
Grey Wagtail	*Motacilla cinerea*	1
‘alba' wagtail	*Motacilla alba/yarrellii*	1
Richard's Pipit	*Anthus richardi*	1
Meadow Pipit	*Anthus campestris*	41
Rock Pipit	*Anthus petrosus*	1
Linnet	*Linaria cannabina*	1
Goldfinch	*Carduelis carduelis*	2
	Total	93

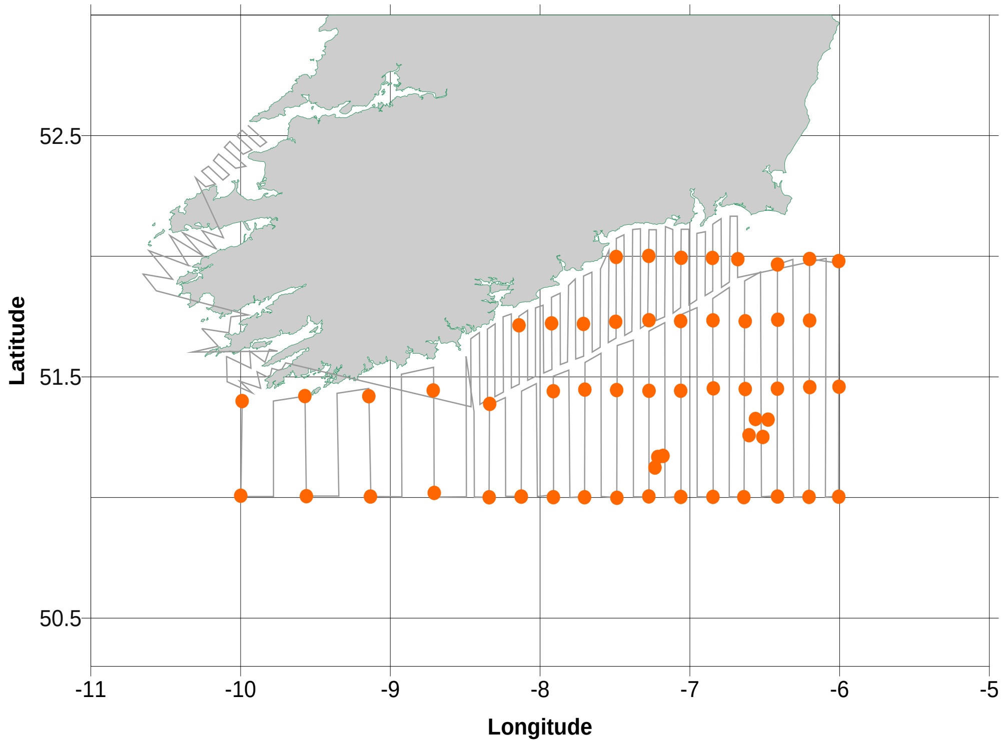


Figure 1. Cruise track (grey line) with hydrographic stations in orange.

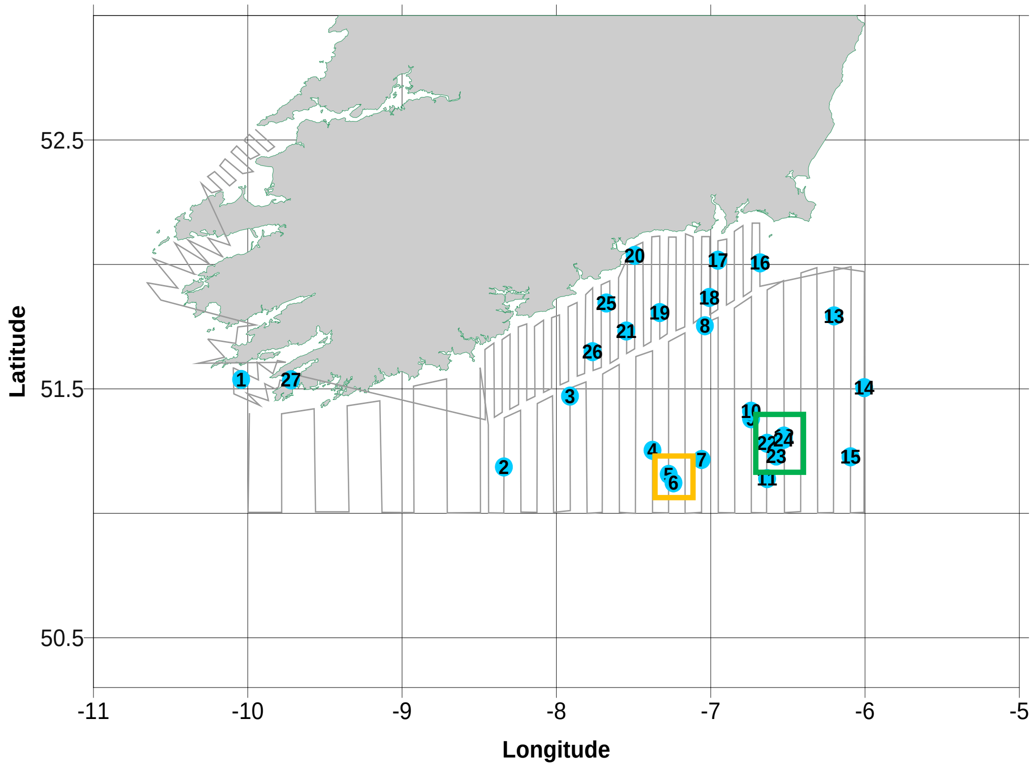


Figure 2. Directed midwater trawl positions. Detailed are the Trench (orange) and Smalls (green) adaptive survey areas.

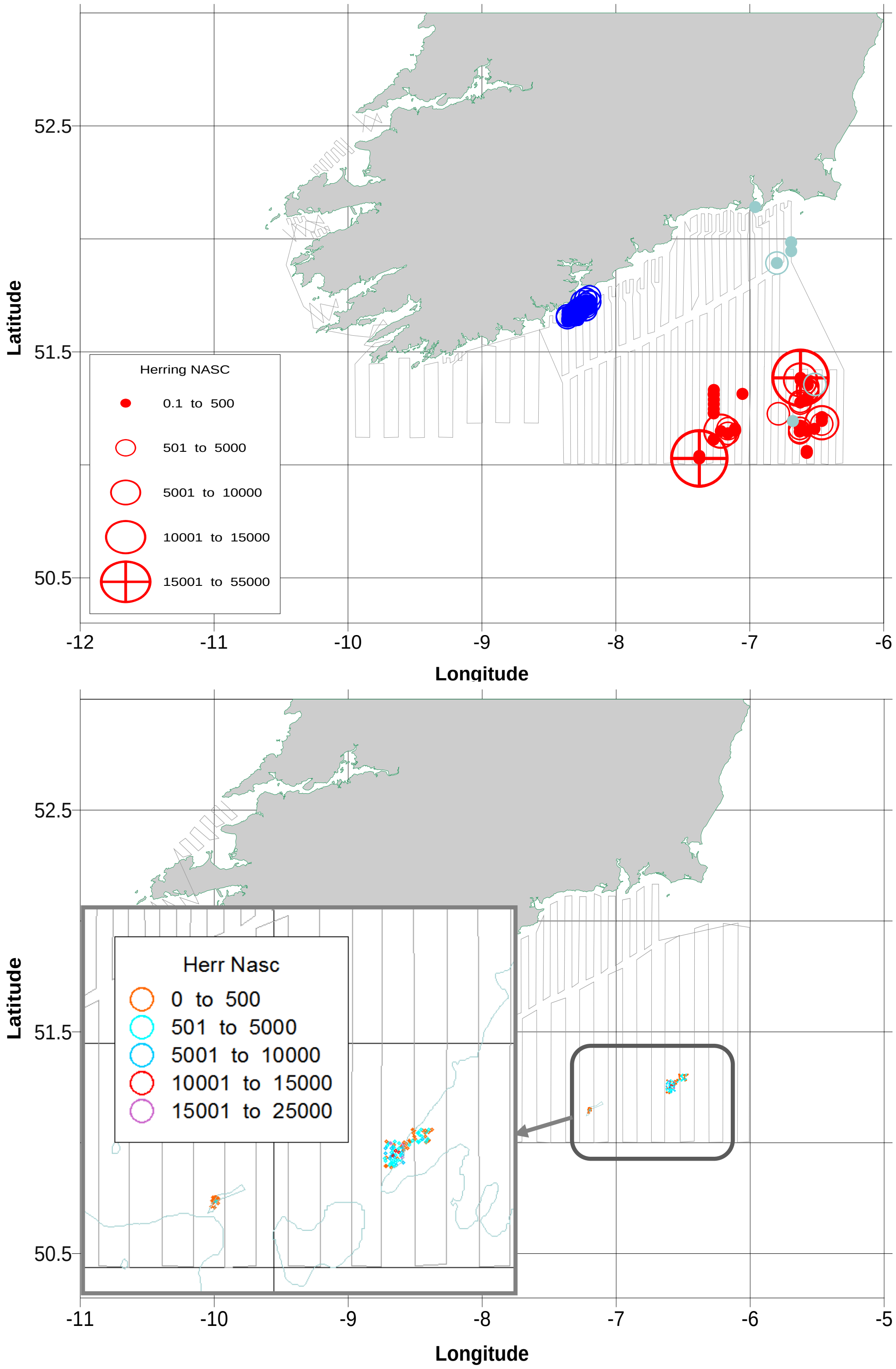


Figure 3. Weighted herring NASC (Nautical area scattering coefficient) plot of the distribution of "definitely" and "probably" categories (red circles), "mixed herring" (blue) and "possibly herring" (teal). Top Panel 2014, bottom panel 2015 for adaptive strata. Note: In 2015 the presence of herring echotraces in relation to core survey transects (vertical grey lines).

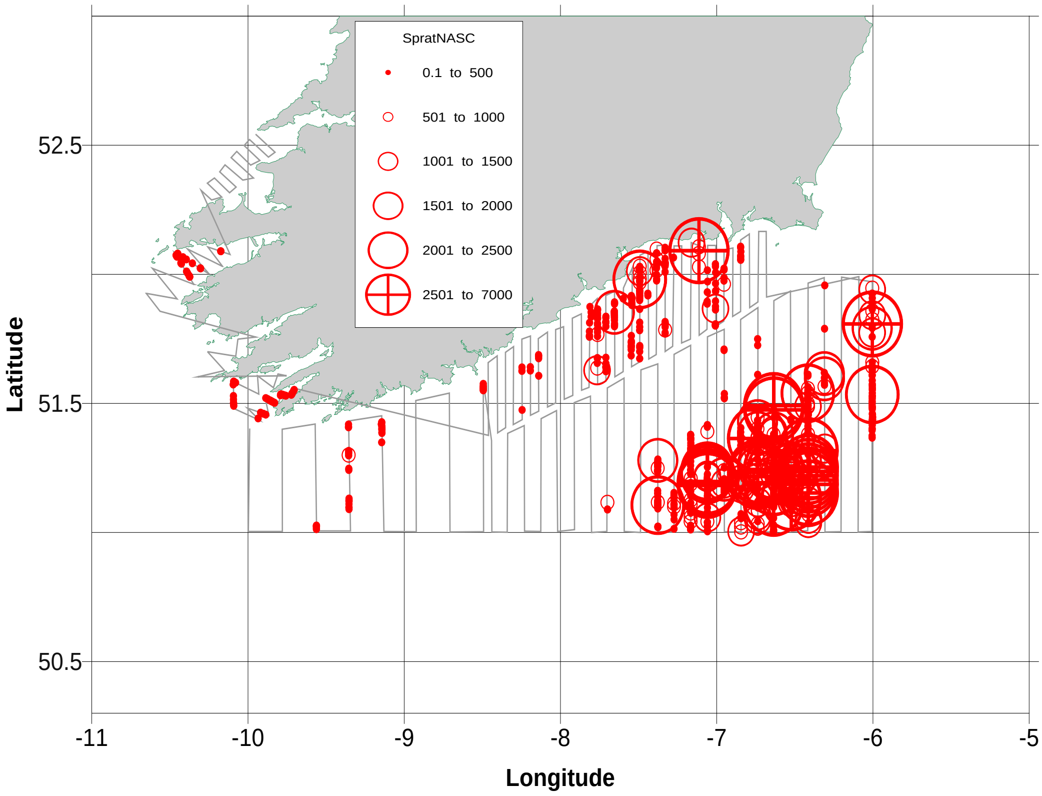
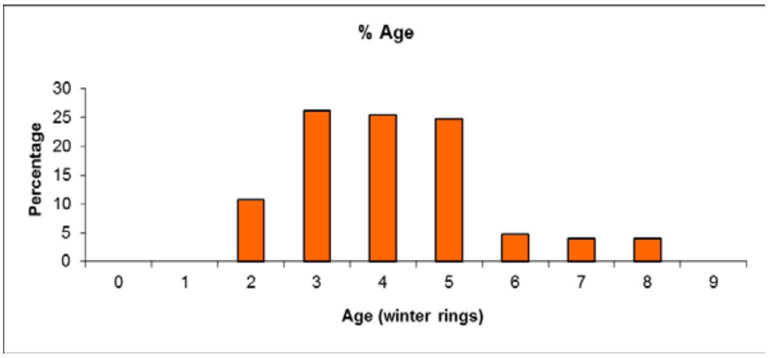


Figure 4. Weighted Sprat NASC (Nautical area scattering coefficient) distribution of "definitely" (red) sprat categories.



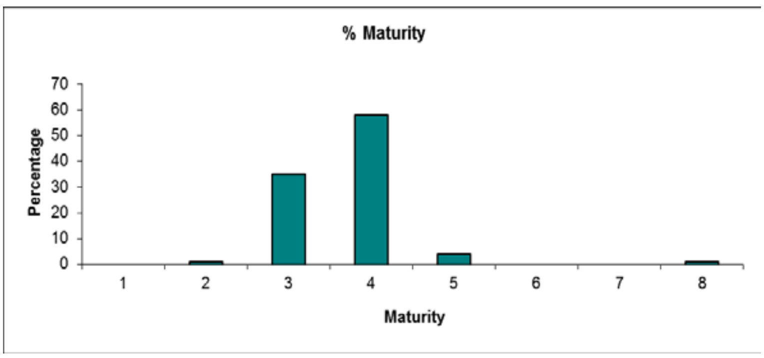


Figure 5. Percentage age and maturity of aged herring samples used in the analysis (n=149).

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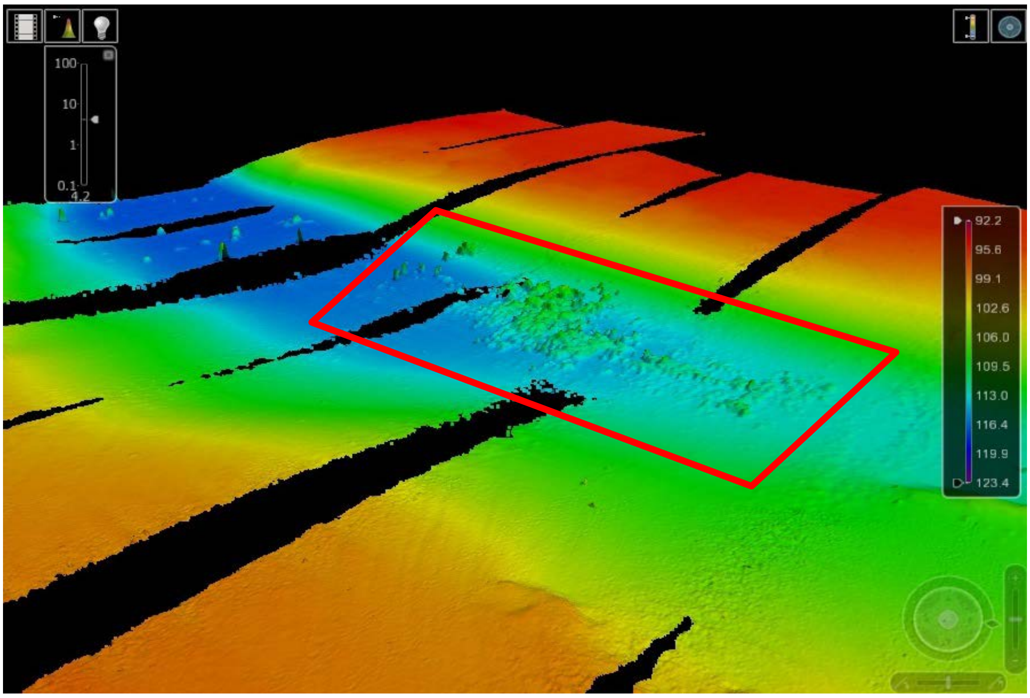
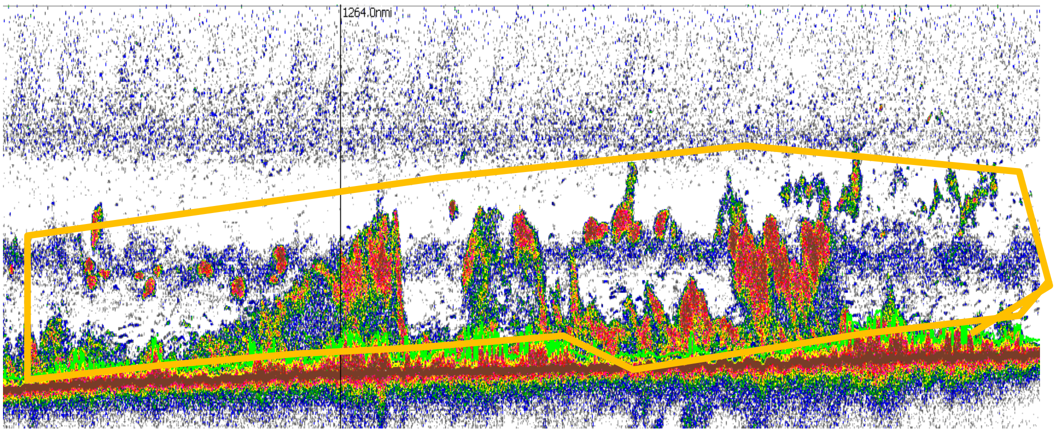
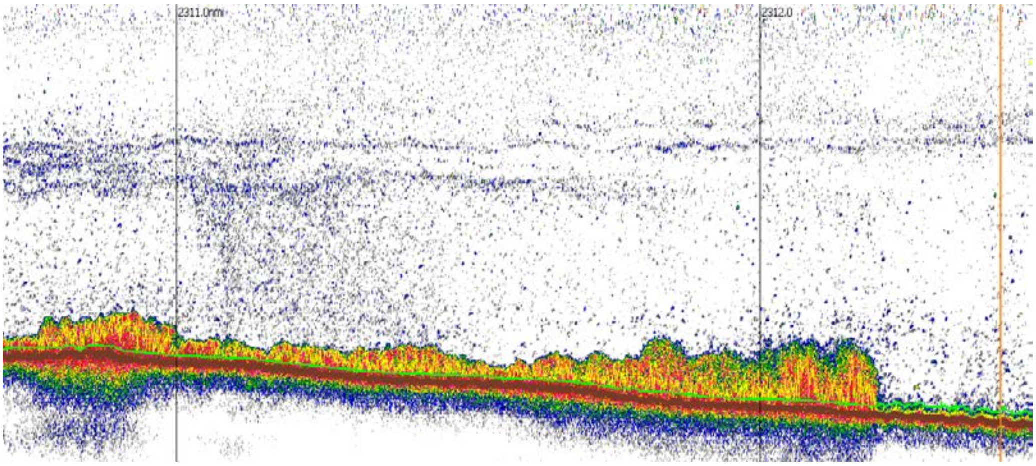


a). *Multibeam image (EM2040, 300 kHz) of herring (within red box) lying close to the bottom located within the Trench survey area during daylight hours. Aggregation extends for ~600 m along the trench and is ~250 m wide.*

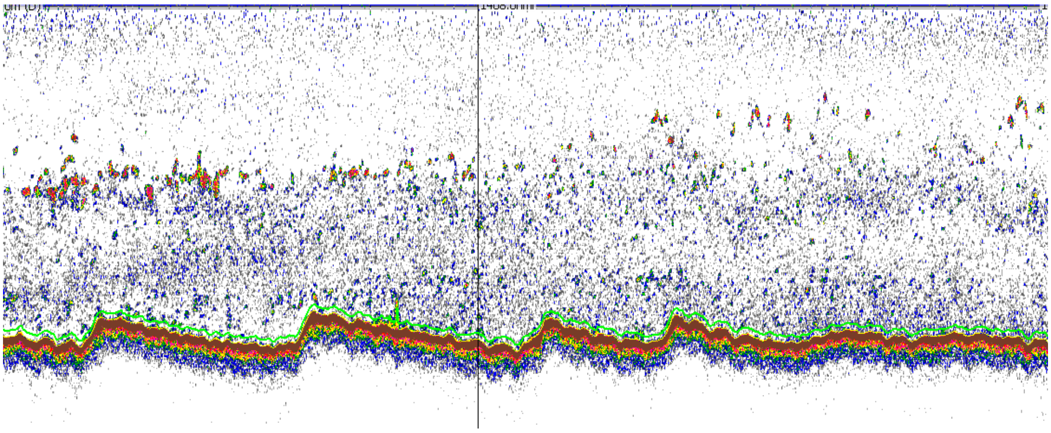


b). *High density echotrace containing herring (under green line) and sprat (orange box), recorded offshore in the Celtic Sea prior to Haul 12. Observed in daylight in the Smalls adaptive stratum, (#14) water depth 90 m.*

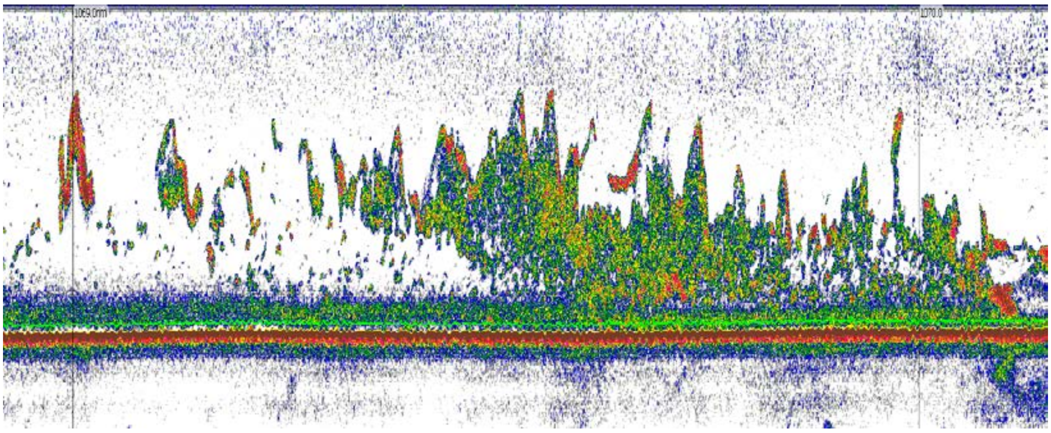
Figure 6. Images of herring recorded using a). the EM2040 multibeam (300 kHz) and b). EK60 (38 kHz)



c). *High density herring bottom echotrace observed at night recorded offshore in the 'Smalls' adaptive strata (#15). Water depth 93 m Vertical black bands represent 1 nmi.*

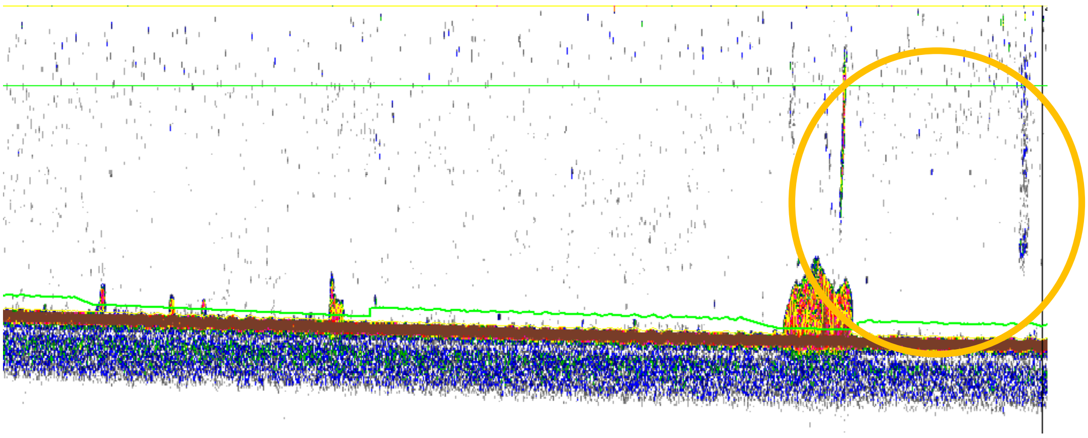


d). *Mixed species echotrace containing sprat (90%) recorded in the offshore strata prior to haul 13. Water depth 97 m.*



e). *Very high density sprat echotrace recorded offshore over c.1.5 nmi in length prior to Haul 09. Water depth 8 6m.*

Figure 6a-f. Continued.



f). *High density sprat echotraces recorded in Dunmanus Bay offshore prior to Haul 27. Water depth 43 m. Detailed (orange) are echotraces of common dolphins actively diving to feed on sprat.*

Figure 6a-f. Continued.

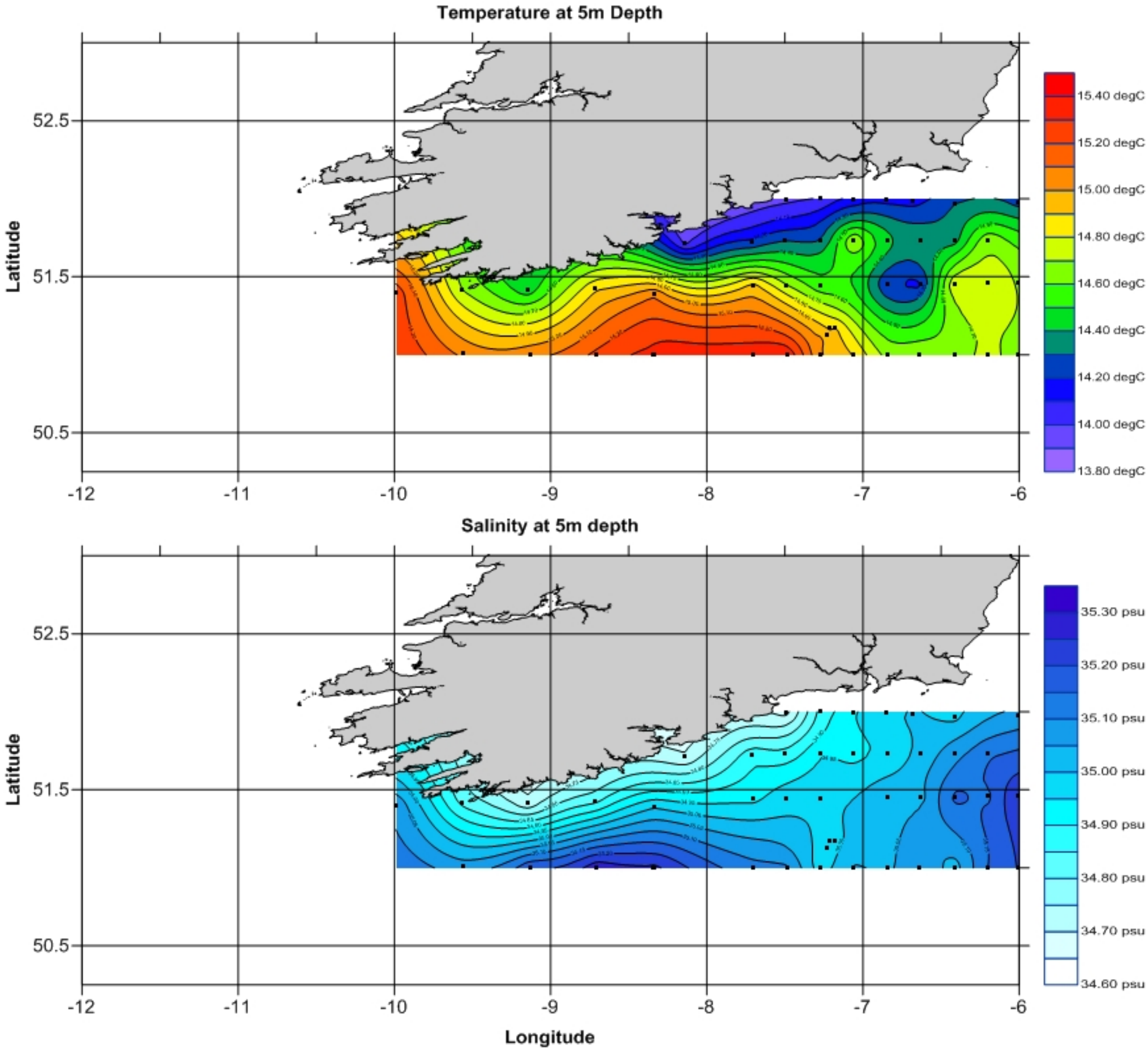


Figure 7. Surface (5m) plots of temperature and salinity compiled from CTD cast data. Station positions shown as block dots (n=49).

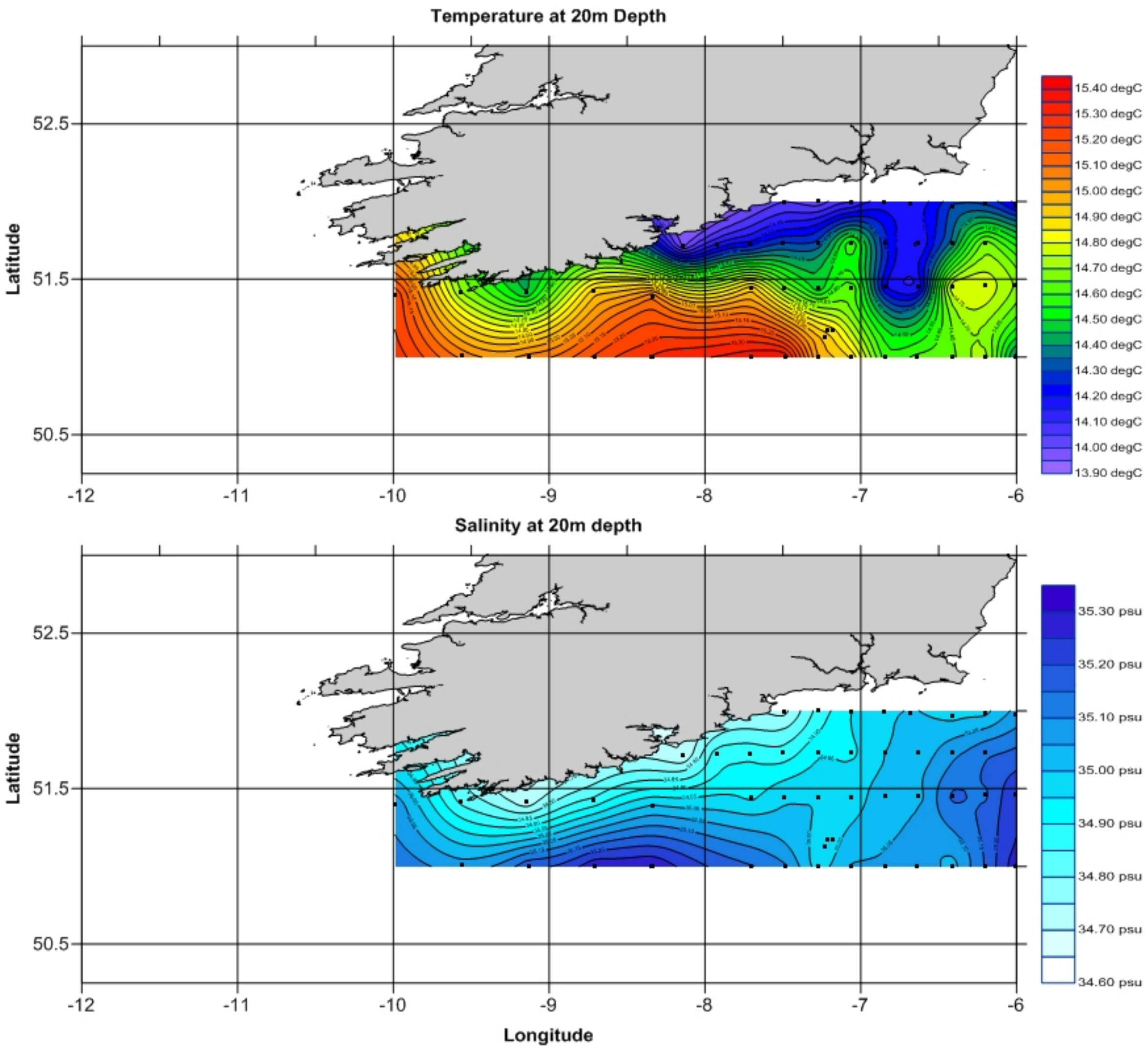


Figure 8. Surface (20m) plots of temperature and salinity compiled from CTD cast data. Station positions shown as block dots (n=49).

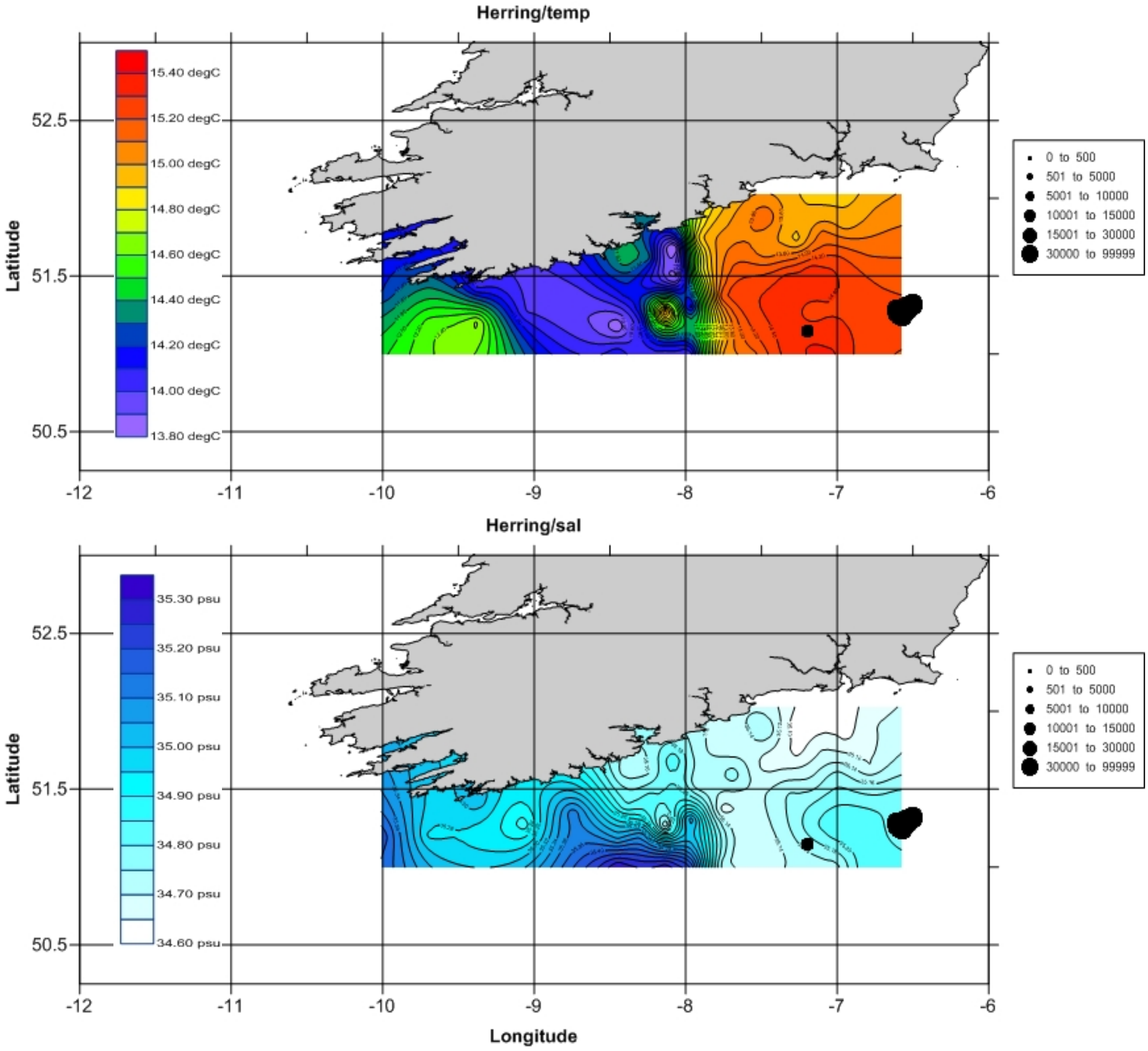


Figure 9. Habitat plots of temperature and salinity at 40m overlaid with herring NASC values (black circles).

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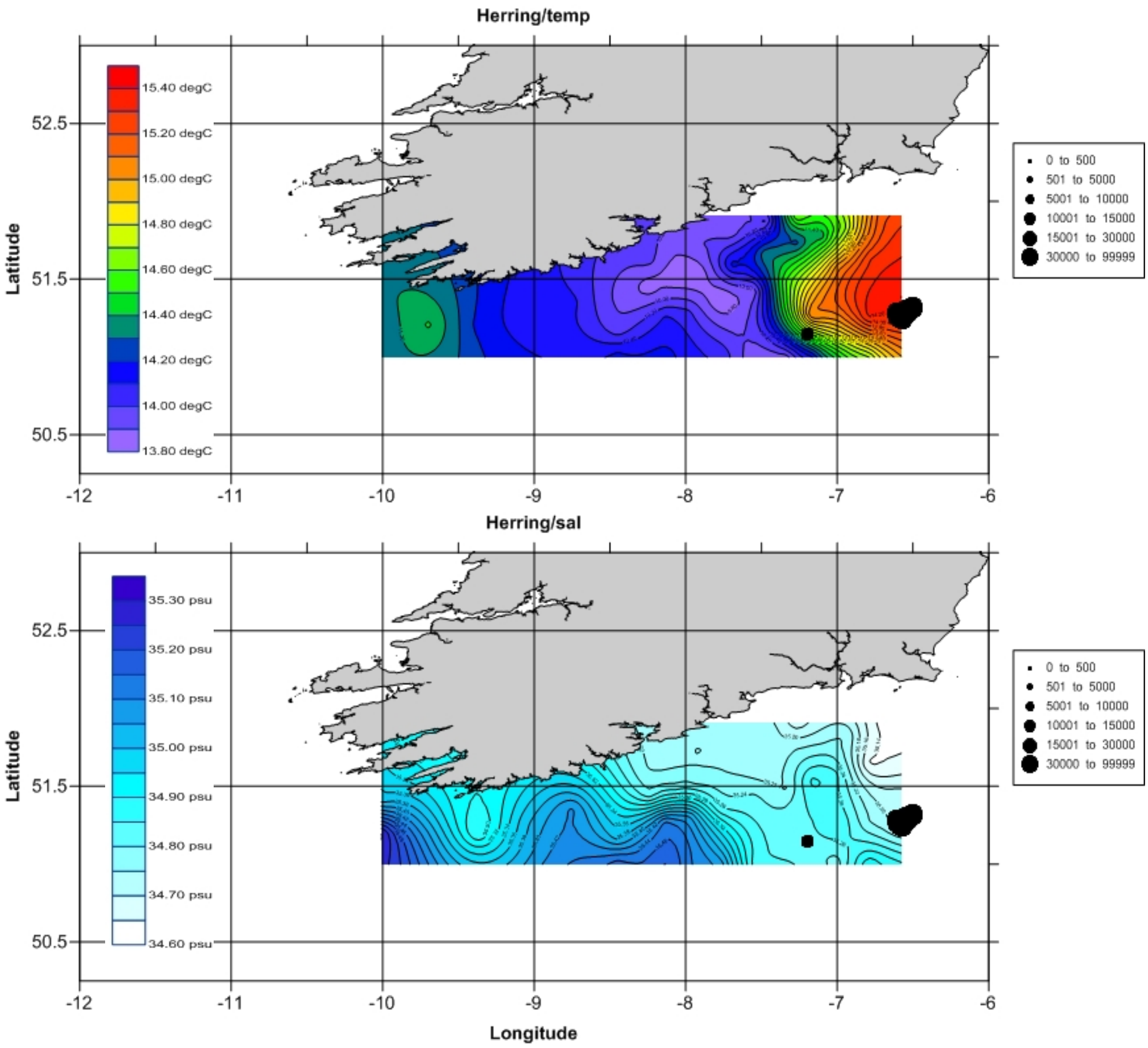

Figure 10. Habitat plots of temperature and salinity at 60m overlaid with herring NASC values (acoustic density) shown as black circles.

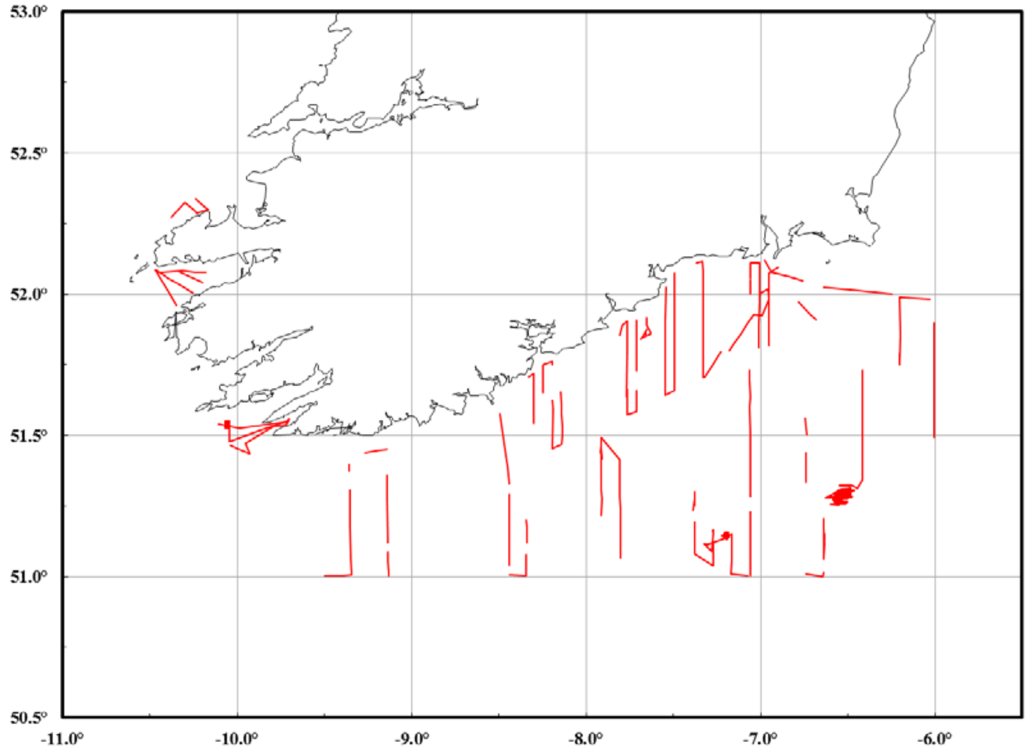

Figure 11. Marine mammal and seabird survey effort showing portion of the acoustic survey track where watch effort was attained.

HERRING MIDWATER TRAWL

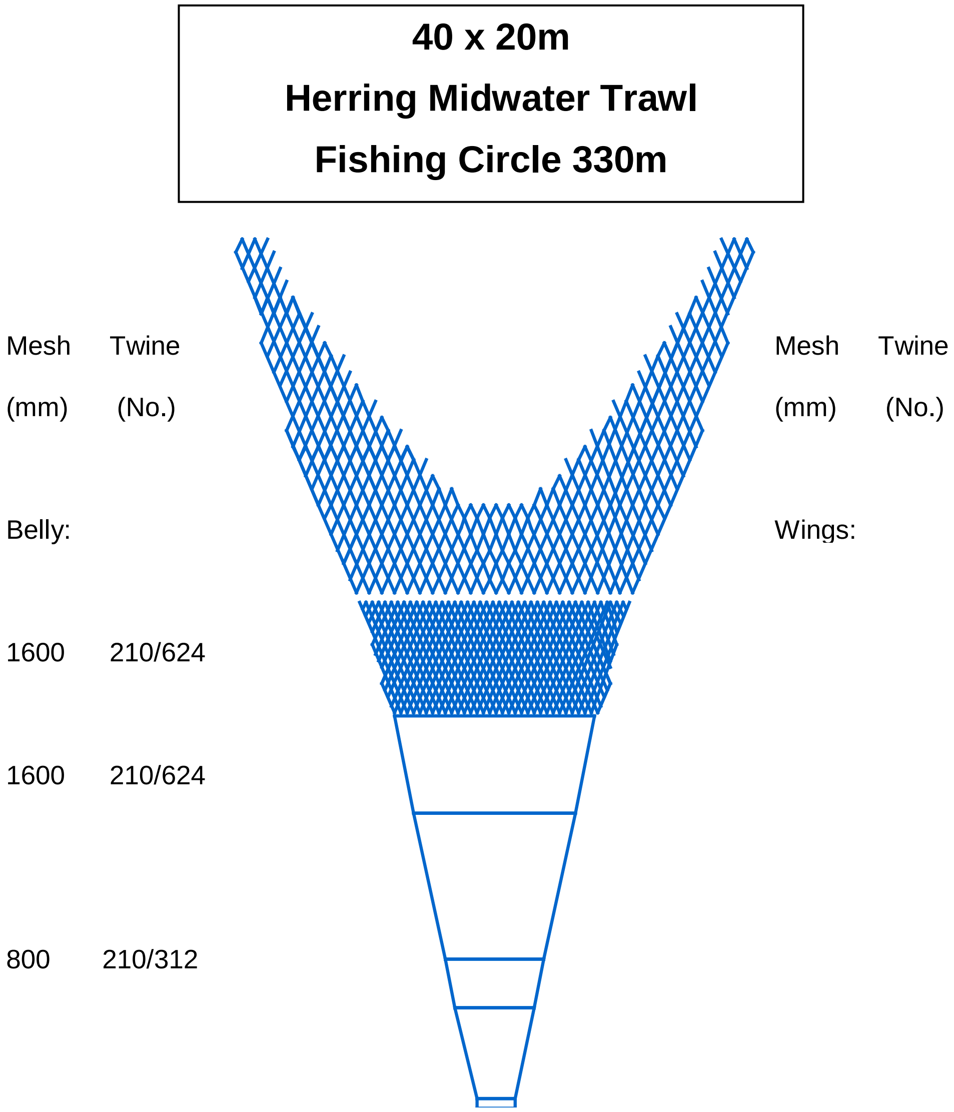

Figure 12. Single herring midwater trawl net plan and layout. Celtic Sea herring acoustic survey, October 2012.

Note: All mesh sizes given in half meshes; schematic does not include 32m brailer.

6 Annex 1

Cetacean species account.

Humpback whale (*Megaptera novaeangliae*)

Humpback whales were encountered three times (two sightings were 'on effort' and one incidental) over the course of the survey involving a minimum of three individuals. The first two sightings were during the same day south of the Beara peninsula (refer to map in Figure 1 below) in an area with intensive feeding activity and as the sightings were greater than six hours apart it is indeterminable whether they were of the same individual or two different animals. Fish samples in this area confirmed the presence of sprat (*Sprattus sprattus*). The third sighting occurred further offshore, c. 90 km south of the Saltee islands, Co. Wexford, an area where hauls confirmed a high density of herring (*Clupea harengus*).

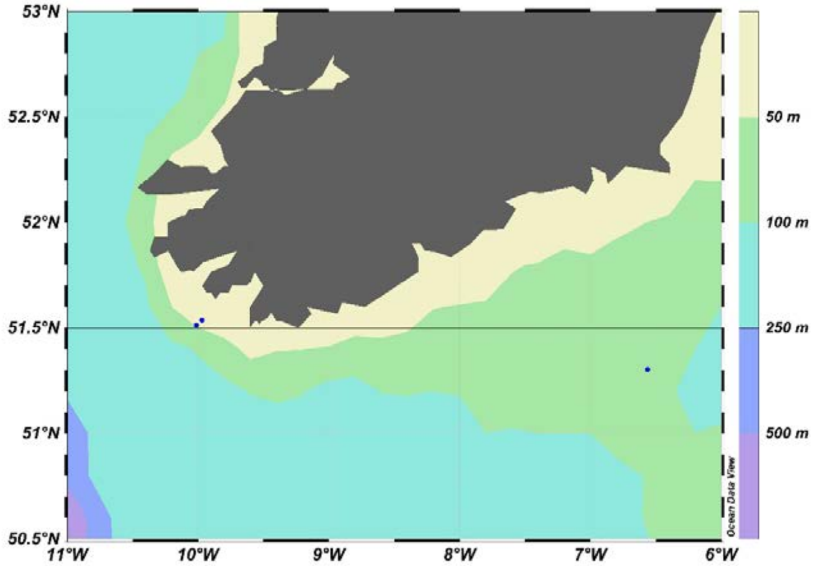

Figure 1. Map illustrating humpback whale sighting locations. Map prepared using Ocean Data View software (Schlitzer, 2015).

Image 1. Humpback whale south of Beara peninsula, Co. Cork on 03.10.2015 © Niall T. Keogh.

Fin whale (*Balaenoptera physalus*)

There were seven fin whale sightings involving a total of 17 individuals. Group sizes ranged between one and five animals. Five of the sightings were off the Waterford coast (refer to map in Figure 2 below). The other two were south of Beara amongst a mixed species group feeding on sprat and as there were two sightings in the same area within a seven hour period the later sighting may represent a resighting of the same animals. Likewise, animals observed east of Mine Head over two days may have been the same individuals. Although there was no intensive feeding observed in this area fish hauls confirmed the presence of relatively big sprat and there were common dolphins and minke whales observed in the same general area. There was one sighting of a single animal associated with the highest occurrence of herring in the fishing grounds south of Wexford. The quality of fin images captured was insufficient for reliable photo ID comparison with the existing IWDG catalogue.

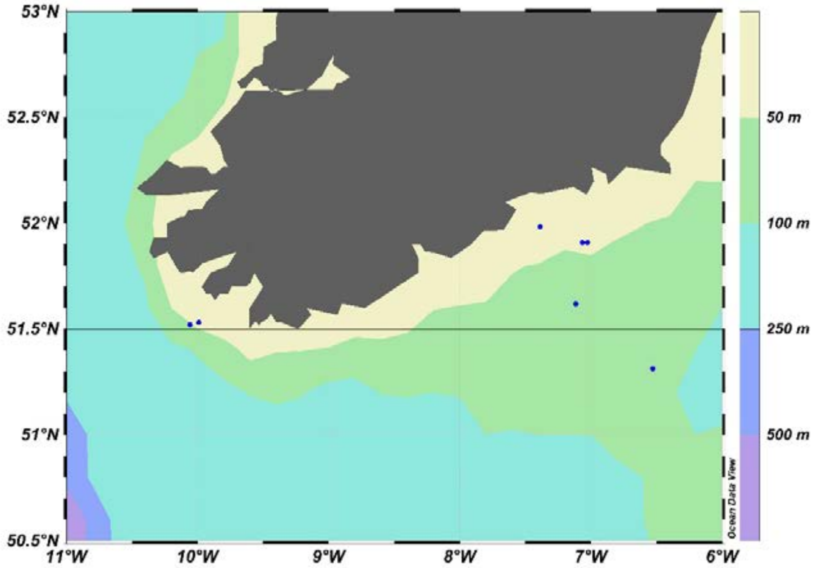

Figure 2. Map illustrating fin whale sighting locations. Map prepared using Ocean Data View software (Schlitzer, 2015).

Image 2. Fin whale east of Mine Head, Co. Waterford on 15.10.2015 © Mairéad O'Donovan

Minke whale (*Balaenoptera acutorostrata*)

There were nine minke whale sightings, five of which were of single animals and the others were groups of up to four animals. Six of the sightings were relatively close to shore (refer to map in Figure 3 below) and these all coincided with common dolphin sightings in the same area. On three of these occasions fish samples confirmed sprat to be main prey species present at the time. Two groups of three and four animals were both observed on the same day south of the Beara peninsula in an area of intensive mixed species feeding activity on sprat. As there were almost eight hours between the two records it's possible that the same animals were counted twice. The furthest offshore sightings were two of single animals south of the Nymphe bank, about 120 km southeast of Helvick head, Co. Waterford. These sightings were in an area featuring a relatively deep gully where fish hauls confirmed the presence of herring and sprat.

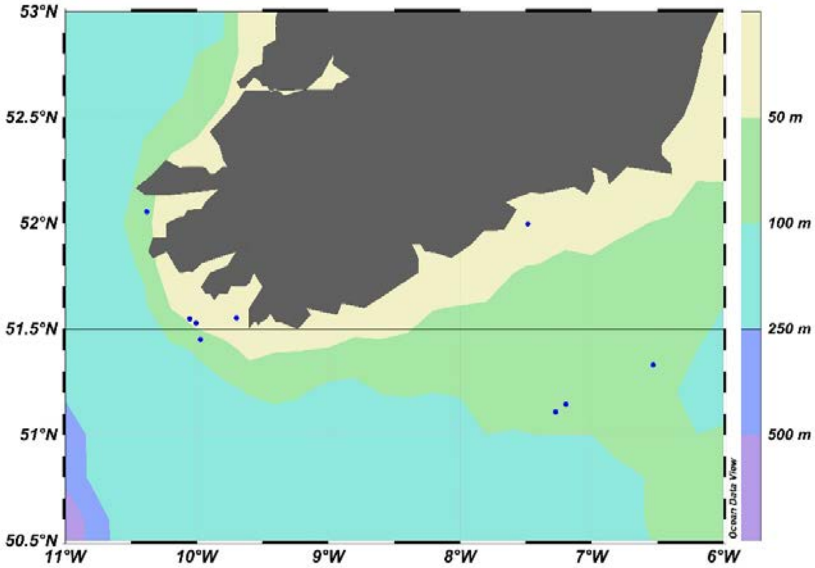

Figure 3. Map illustrating minke whale sighting locations. Map prepared using Ocean Data View software (Schlitzer, 2015).

Image 3. Minke whale in Dunmanus bay, Co. Cork on 19.10.2015 © Inge van der Knapp

Killer whale (*Orcinus orca*)

Killer whales were observed incidentally on one occasion by the chief scientist and a number of the ship's crew. Three individuals were reported within 500 m of the vessel whilst the fishing gear was being deployed. The location was within an expansive high density area of herring with a relatively high number of fishing vessels, approximately 90 km south of the Saltee islands, Co. Wexford (refer to the map in Figure 4 below). There were common dolphins recorded within seven minutes of the orca sighting.

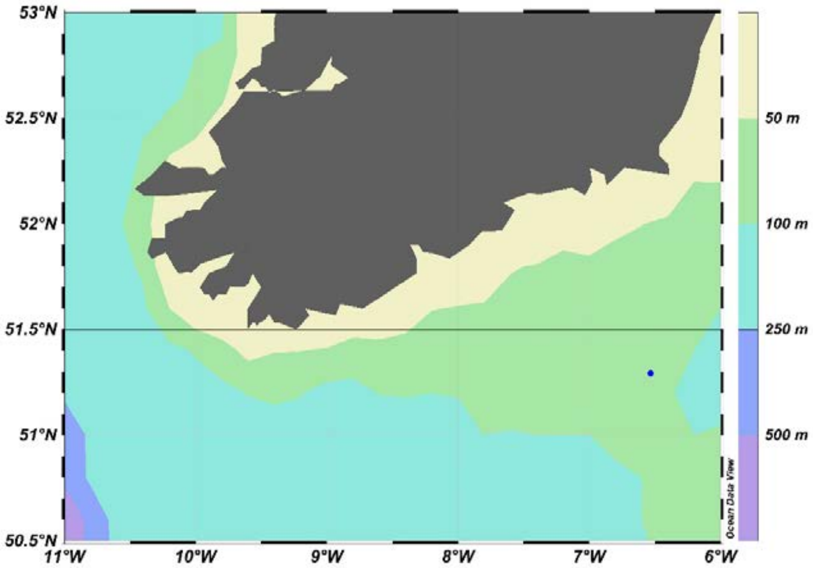

Figure 4. Map illustrating orca sighting location. Map prepared using Ocean Data View software (Schlitzer, 2015).

Common bottlenose dolphin (*Tursiops truncatus*)

There was one bottlenose dolphin encounter of three individuals, including one juvenile animal. The colouration of the animals suggested that they were of the species' in-shore ecotype. The sighting occurred 90 km southeast of the Cork coast (refer to the map in Figure 5 below).

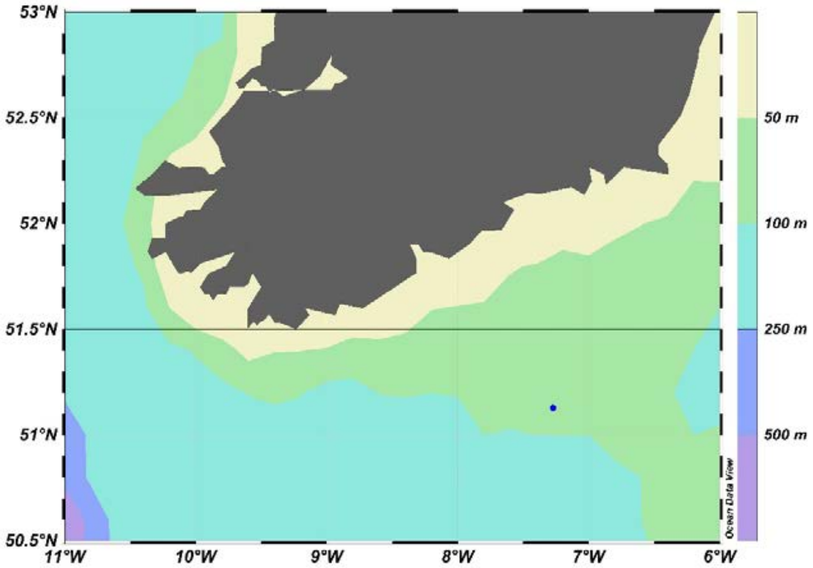

Figure 5. Map illustrating bottlenose dolphin sighting location. Map prepared using Ocean Data View software (Schlitzer, 2015).

Short-beaked common dolphin (*Delphinus delphis*)

Common dolphins accounted for 71 of the total number of sightings and the largest group sizes (≥ 200 animals). Some groups associated with the vessel for more than one hour. There were juveniles and/or calves observed on seven occasions. Common dolphins were recorded amongst multi-species feeding groups off the Beara peninsula and individuals of the species were present on six out of nine occasions when minke whales were recorded. Although the map illustrating sightings distribution (refer to Figure 6) appears to indicate a higher density of sightings inshore this may be due to the survey line set-up (shorter lines closer together) rather than an actual higher relative abundance.

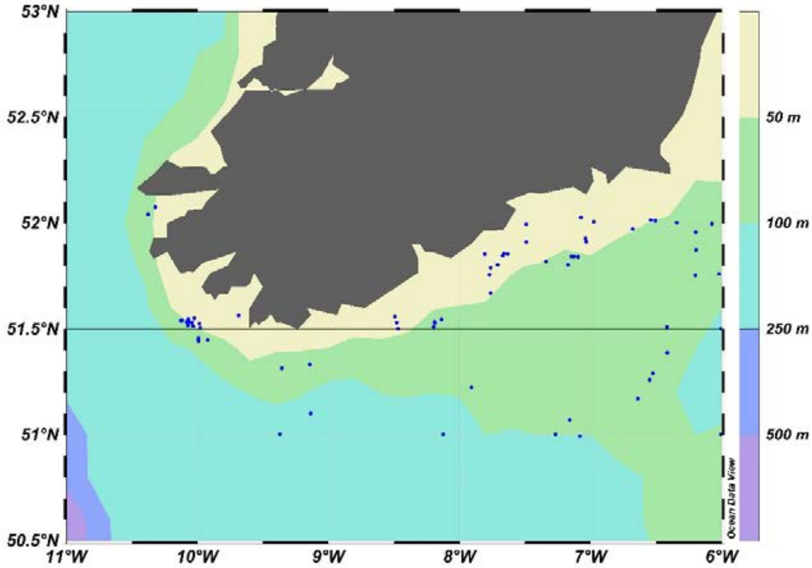

Figure 6. Map illustrating common dolphin sighting locations. Map prepared using Ocean Data View software (Schlitzer, 2015).

Image 4. Common dolphins south of Co. Waterford on 14.10.2015 © Mairéad O'Donovan

Harbour porpoise (*Phocoena phocoena*)

There was one incidental sighting of a single harbour porpoise made by a seabird observer south of the Beara peninsula close to an area with high feeding activity focussed on sprat. The inshore location of the sighting is typical of this coastal species (refer to the map in Figure 7 below).

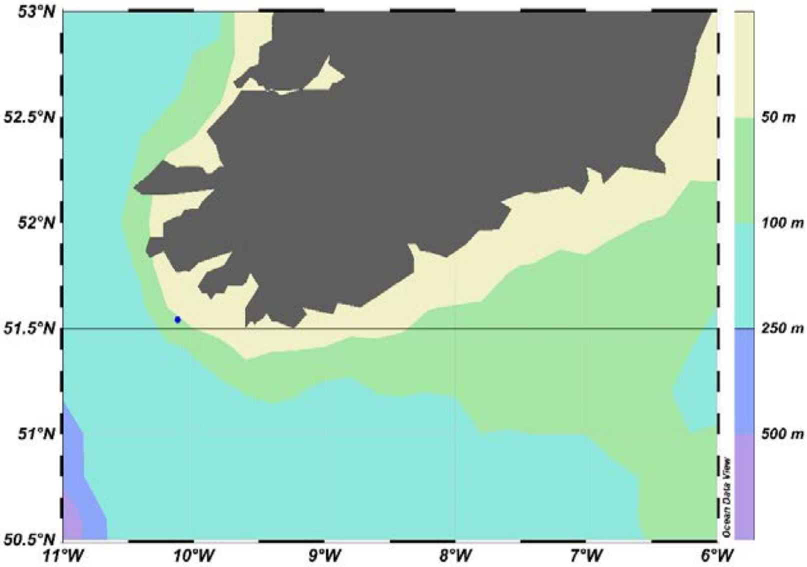

Figure 7. Map illustrating harbour porpoise sighting location. Map prepared using Ocean Data View software (Schlitzer, 2015).

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Unidentified cetaceans

There were 17 sightings of unidentified animals. 10 of these were recorded as unidentified whale, five as unidentified dolphin and two as cetacean (refer to Figures 8 and 9 below). Unidentified dolphin group sizes ranged between four and ten animals. There was one record of two unidentified whales but otherwise the remainder of unidentified animal sightings were of single animals.

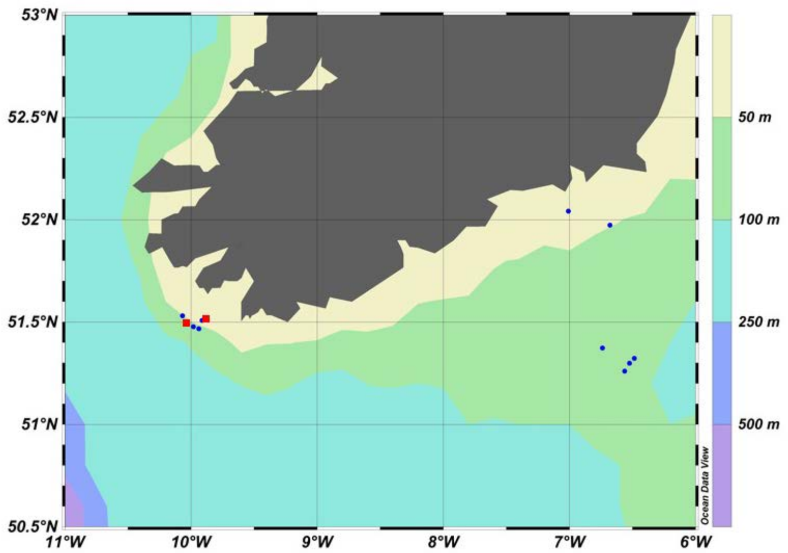


Figure 8. Map illustrating unidentified whale and cetacean sighting locations. Unidentified whale sightings are represented by blue circles, unidentified cetaceans by red squares. Map prepared using Ocean Data View software (Schlitzer, 2015).

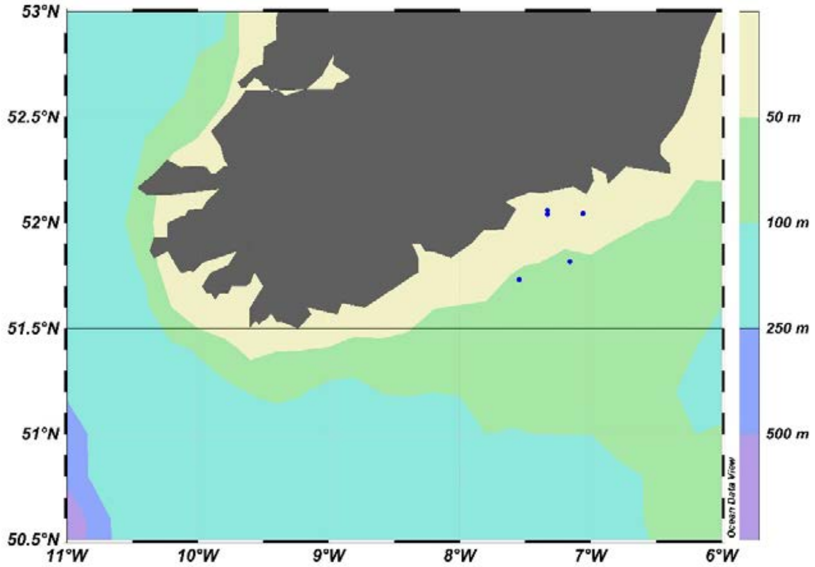


Figure 9. Map illustrating unidentified dolphin sighting locations. Map prepared using Ocean Data View software (Schlitzer, 2015).

Other species of marine megafauna

Bluefin tuna (*Thunnus thynnus*) were recorded on 9 occasions with a total of 42 individuals, all south of the Waterford and Wexford coasts (refer to map in Figure 10 below). The group sizes observed ranged between one and 12 animals and during several encounters animals appeared to be feeding and there was associated bird activity. There was one sighting of an unidentified turtle species made by one of the seabird observers approximately 110 km southeast of Carnsore point.

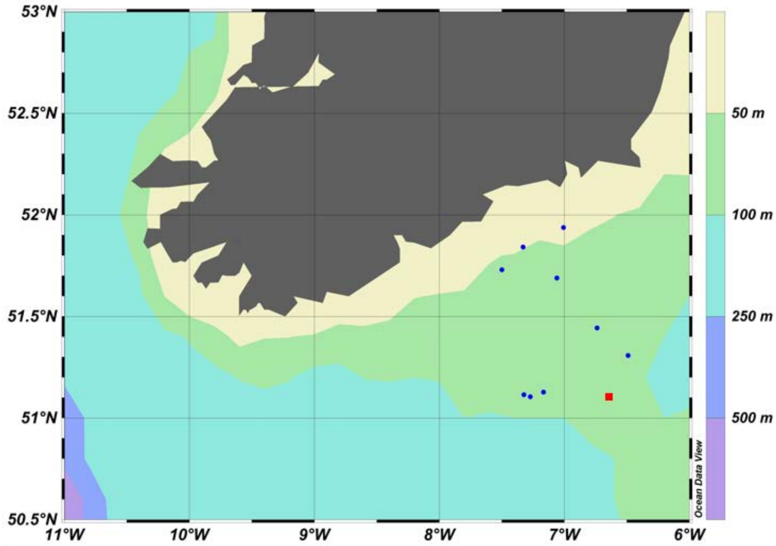


Figure 10. Map illustrating sighting locations of other marine megafauna. Tuna are represented by blue circles, turtles by red squares. Map prepared using Ocean Data View software (Schlitzer, 2015).

The only seal sightings were recorded on or near the Blasket islands off the coast of Co. Kerry whilst transiting through the Blasket sound. A minimum of 267 grey seals (*Halichoerus grypus*) including pups were photographed hauled out on the beach or within a few metres of the shore on Blascaod Mór. Shortly after an unidentified seal, presumably a grey seal, was observed by a seabird observer further north in the Blasket sound.

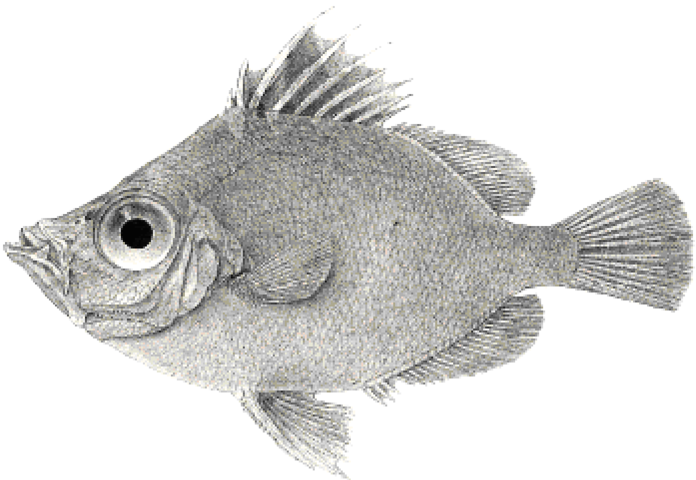
Image 5. Grey seals hauled out on An Blascaod Mór © Mairéad O'Donovan

Annex 5d: Boarfish

FEAS Survey Series: 2015/03

Boarfish Acoustic Survey Cruise Report

10 July – 31 July, 2015



Day (1966)

MFV Felucca

Ciaran O'Donnell and Cormac Nolan

The Marine Institute, Fisheries Ecosystems Advisory Services

Table of Contents

1 Introduction

From the early 1970s the abundance of boarfish (*Capros aper*) was seen to increase exponentially and distribution spread increasingly northwards along the western seaboard and Bay of Biscay (Blanchard and Vandermeirsch, 2005). At the same time, boarfish were caught in increasing quantities in both pelagic and demersal fisheries. This in turn resulted in damage to more commercially valuable target species. Exploratory fishing for boarfish by Irish vessels began in the later 1980s when commercial quantities were encountered during the spring horse mackerel (*Trachurus* trachurus) and mackerel (*Scrombrus scomber*) fisheries in northern Biscay. Several landings were made into Ireland for fishmeal during this time but due to logistical problems related to handling this species was not favoured by processors. Interest increased again temporarily in the mid-1990s when Dutch pelagic vessels landed frozen samples to determine if a market could be developed for human consumption.

During the early 2000s Irish landings were relatively small (<700t per year) and it was not until 2006 that a directed fishery developed. Fishing was undertaken primarily by vessels from the Castletownbere and Killybegs RSW fleets (refrigerated seawater vessels) that targeted boarfish from northern Biscay to the southern Celtic Sea. In 2007-08 vessels from Scotland and Denmark also began targeting boarfish in quantity. Irish landings are primarily landed into fishmeal plants in Denmark and the Faroe Islands with increasing amounts being landed in Killybegs in recent years. The boarfish fishery bridged an important gap between the short season fisheries for horse mackerel, mackerel and blue whiting (*Micromesistius poutassou*). As the fishery develops new markets and uses are being explored including human consumption and bio marine ingredients.

A precautionary interim management plan was adopted in November 2010 covering ICES Divisions VI, VII and VIII and an EU TAC of 33,000 t was set. Of this the Irish allocation for 2011 was 22,000 t. This precautionary TAC was based on 50-75% of total landings from the period 2007-2009 which peaked at over 83,400 t (2009). Landings in 2010 reached over 137,000t prior to the introduction of TAC control. In addition to the TAC, seasonal closures were implemented; from September 1- October 31 (Division VIIg) to protect herring feeding and pre spawning aggregations and from March 15–August 31 where mackerel are frequently encountered as a large bycatch. A catch rule ceiling of 5% bycatch was also implemented within the fishery where boarfish are taken with other TAC controlled species. In 2015 the EU TAC was set at 53,296 t with an Irish allocation of 36,830 t.

This survey represents the fifth dedicated research survey for boarfish in the time series. The commercial fishing vessel MFV *Felucca* was employed for the survey and the vessels hull mounted transducer was calibrated for scientific output.

Data from this survey will be presented to the ICES assessment Working Group for Widely Distributed Stocks (WGWIDE) meeting in August 2015 and as part of the ICES Planning Group meeting for International Pelagic Surveys (WGIPS) meeting in January 2016 (WGIPS).

2 Materials and Methods

2.1 Scientific Personnel

Organisation	Name	Capacity
FEAS	Ciaran O'Donnell	Acoustics (SIC)
FEAS	Macdara O 'Cuaig	Analyst
FEAS	Michael McAuliffe	Analyst
Contractor	John Cunningham	Contractor

2.2 Survey Plan

2.2.1 Survey objectives

The primary survey objectives of the survey are listed below:

- Collect integrated and calibrated acoustic data on boarfish (*Capros aper*) aggregations within the pre-determined survey area
- Determine the biomass and abundance of boarfish by age within the survey area
- Collect biological samples from directed trawling on insonified echotraces to determine age structure and maturity state of survey stock as well as to identify echotrace to species.
- Determine the extent and behaviour of boarfish aggregations within the survey area to aid the design of future surveys
- Dovetail with the RV Celtic Explorer in the northern area to ensure close spatio-temporal alignment and synoptic coverage

2.2.2 Area of operation and survey design

The survey started on the Porcupine Bank before moving to survey the shelf sea between 53°40'N and 47°30'N from north to south (Figure 1). Area coverage was based on the distribution of catches from the previous surveys (O'Donnell *et al.* 2011).Timing was planned to coincide with the arrival of the RV *Celtic Explorer* in the northern survey area to ensure a continuous, quasi-synoptic coverage of the combined area.

In total 3,999 nmi (nautical miles) of cruise track was completed by both vessels using 133 transects and related to a total area coverage of 58,292 nmi². Transect spacing was set at 15 nmi for the *Felucca* and 15 and 7.5 nmi for the *C. Explorer* component. For the area covered by the *C. Explorer* only strata (ICES rectangles) bordering the shelf edge were considered during the analysis.

Coverage extended in coastal areas from the c.50 m contour to the shelf slope (250 m). An elementary distance sampling unit (EDSU) of 1 nmi was used during the analysis of combined survey data.

The survey was carried out from 04:00–00:00 each day for both surveys to coincide with the hours of daylight when boarfish are most often observed in homogenous schools. During the hours of darkness boarfish schools tend to disperse into mixed species scattering layers.

2.3 Sampling protocols and equipment specifications

2.3.1 Acoustic equipment

Equipment settings were determined before the start of the survey and are based on established settings employed on previous surveys (O'Donnell *et al.,* 2004 & 2011).

Acoustic data were collected using a Simrad EK 60 scientific echosounder topside unit. A Simrad ES-38B (38 KHz) split-beam transducer mounted on the vessels hull was calibrated and used throughout the survey. Vessel details and set up are provided in Appendix 1.

Cruising speed was largely determined by the weather and the effects on the quality of acoustic data. Where possible cruising speed was maintained at 10kts.

2.3.2 Calibration of acoustic equipment

The EK 60 was calibrated in Donegal Bay prior to the start of the survey in calm conditions. The calibration was carried out using standard methodology as described by Foote *et al.* (1987). Results of the calibration are presented in Table 1.

2.3.4 Acoustic data acquisition

Acoustic data were recorded onto the hard-drive of the processing unit. The "RAW files" were logged via a continuous Ethernet connection as "EK5" files to a laptop and a HDD hard drive as a backup. Sonar Data's Myriax Echoview® Live viewer (V6.1) was used to display echograms in real time and to allow the scientists to scroll through noting the locations and depths of target schools to a log file. A member of the scientific crew monitored the equipment continually. Time and location were recorded for each transect start/end position within each stratum. This log was also used to monitor "off track events" such as fishing operations.

2.3.5 Echogram scrutinisation

Acoustic data was backed up every 24 hrs and scrutinised using Echoview® post processing software (V6.1). The scrutiny process involved the allocation of echotraces (schools) to particular species or species mix categories, based on the information from the directed trawl hauls.

The NASC (Nautical Area Scattering Coefficient) values from each boarfish echotrace were allocated to one of 4 categories after scrutiny of the echograms. Categories identified on the basis of echotrace scrutiny were as follows:

1. "<u>Definitely boarfish</u>" echotraces were identified on the basis of captures of boarfish from the fishing trawls which were sampled directly. Based on the directly sampled schools we also characterised echotrace as definitely boarfish which appeared very similar on the echogram i.e. , large marks which showed as very high intensity (red), located high in the water column (day) and as strong circular schools.

2. "<u>Probably boarfish</u>" were attributed to smaller echotraces that had not been fished but which had similar characteristics to "definite" boarfish traces.

3. "<u>Boarfish in a mixture</u>" were attributed to NASC values arising from all fish traces in which boarfish were contained, based on the presence of a proportion of boarfish in the catch or within the nearest trawl haul. Boarfish were often taken during trawling in mixed species layers during the hours of darkness.

4. "<u>Possibly boarfish</u>" were attributed to small echotraces outside areas where fishing was carried out, but which had the characteristics of definite boarfish traces.

This set of categories allowed us to present the biomass estimates in terms of the best estimate (Cats 1-3), the minimum estimate (Cat 1 + 3), and the maximum estimate (Cats 1-4).

Echograms were divided into transects. Off track events, such as trawl hauls and hydrographic stations were excluded from further analysis. Echo integration was performed on regions which were defined by enclosing selected parts of the echogram that corresponded to one of the four categories above. The echograms were generally analysed and echo-integrals calculated, at a threshold of -70 dB, where necessary heavy backscatter from plankton was filtered out by thresholding at –65 dB.

2.3.6 Biological sampling

A single pelagic midwater trawl with the dimensions of 296 m in total length with a 78 m brailer (codend) was used during the survey. The horizontal net spread averaged 90m from wing to wing Mesh size in the wings was 12.8 m through to 2 cm in the cod-end liner. The net was fished with a vertical mouth opening averaging 50m observed using a cable linked Simrad FS 900 netsonde (200 kHz). The net was fitted with Marport catch and tunnel sensors to monitor the amount catch entering the trawl.

An independent light and video/stills camera system was located in the end section of the net and positioned close to the brailer to record fish behaviour in the trawl and to verify trawl catches composition with echotrace identification. Details of camera rig and positioning within the trawl are provided in Appendix 2.

All components of the catch were sorted to species level and weight by species was recorded. For species other than boarfish, length and weight measurements were taken for 100 individuals per trawl in addition to a c.300 fish length frequency sample. Length, weight, sex and maturity data were recorded for individual boarfish in a random 50 fish sample from each trawl haul. In addition a further 100 length/weight and 300 fish length frequency measurements were taken from each haul. Due to the complexity of aging boarfish, no aging was carried out onboard and samples were analysed back in the lab. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

The decision to fish on particular echotraces was based on both the distance from other fishing operations on similar schools, and on the difference between recently observed echotraces and others previously sampled.

2.4 Analysis methods

2.4.1 Abundance estimates

The recordings of area back scattering strength (NASC) per nautical mile were averaged over a one nautical mile EDSU (Elementary sampling distance unit), and the allocation of NASC value to boarfish and other acoustic targets was based on the composition of the trawl catches and the appearance of the echotraces.

To estimate the abundance, the allocated NASC values were averaged for ICES statistical rectangles (1° latitude by 2° longitude). For each statistical area, the unit area density of fish (S_A) in number per square nautical mile ($N{*}nmi^{-2}$) was calculated using standard equations (Foote et al. 1987, Toresen *et al*. 1998).

NASC values assigned according to scrutinisation methods (section 2.3.5) were used to estimate the boarfish numbers according to the method of Dalen and Nakken (1983).

The following TS-length relationships used were those recommended by the acoustic survey planning group (ICES, 1994):

Herring	TS =	$20\log_{10}L - 71.2$ dB per individual (L = length in cm)
Sprat	TS =	$20\log_{10}L - 71.2$ dB per individual (L = length in cm)
Mackerel	TS =	$20\log_{10}L - 84.9$ dB per individual (L = length in cm)
Horse mackerel	TS =	$20\log_{10}L - 67.5$ dB per individual (L = length in cm)

The TS length relationship used for gadoids was a general physoclist relationship (Foote, 1987):

Gadoids	TS =	$20\log_{10}L - 67.4$ dB per individual (L = length in cm)

For boarfish (*Capros aper*) a species specific TS length relationship was applied based on theoretical swimbladder modelling (Fässler *et al.* 2013).

Boarfish TS = $20\log_{10}L - 66.2$ dB per individual (L = length in cm)

To estimate the total abundance of fish, the unit area abundance for each statistical rectangle was multiplied by the number of square nautical miles in each statistical rectangle and then summed for all statistical rectangles for the total area. Biomass estimation was calculated by multiplying abundance in numbers by the average weight of the fish in each statistical rectangle and then sum of all squares by rectangle and summed for the total area.

3 Results

3.1 Boarfish abundance and distribution

The results presented here are a composite of data collected during this survey and the Malin Shelf herring acoustic survey (RV *Celtic Explorer*). Surveys were timed to ensure a continuous quasi-synoptic coverage over 42 days without interruption from north (59°30'N) to south (47°30'N).

Twenty hauls were carried out by the *Felucca* during the survey, 14 of which contained boarfish (Figure 1, Table 2). An additional 4 carried out by the *C. Explorer* were used in the analysis. In total, 4,168 lengths and 1,500 length/weight measurements were taken in addition to 695 individual boarfish otoliths collected for aging.

3.1.2 Boarfish biomass and abundance

A full breakdown of the stock estimate is presented by strata, age, length, maturity, biomass, and abundance in Tables 4-8 and Figures 3 & 4.

Boarfish	Abund (mils)	Biomass (t)	% contribution
Total estimate			
Definitely	3,742	215,337	92.6
Probably	206	13,990	6.0
Mixture	48	3,307	1.4
Total estimate	**3,996**	**232,634**	**100**
Possibly	-	-	
SSB Estimate			
Definelty	3,211	209,363	92.4
Probably	206	13,990	6.2
Mixture	48	3,306	1.5
SSB estimate	**3,465**	**226,659**	**100**
Possibly	-	-	

3.1.3 Boarfish distribution

Overall, total stock biomass was 19% higher than during the same time in 2014 and measured using comparable survey effort. Geographical distribution of boarfish followed a similar pattern to previous years with core spawning areas containing the largest abundance. In 2015 as in 2014, northern and western areas contained more biomass than observed pre-2014. Combined, the Northern, Porcupine Bank and Western areas contained almost 50% of total biomass (61% in 2014) for 41% of the geographical area covered.

A total of 681 boarfish echotraces were identified during the survey. Of this 92.6% were categorised as 'definitely' boarfish (603 echotraces), 6% as 'probably' (49) and 1.4% of 'boarfish in a mixture' (29 echotraces). A full breakdown of school categorisation, abundance and biomass by ICES statistical rectangle is provided in Table 9. A total of 70 ICES rectangles were covered by the survey representing combined area coverage of 58,292 nmi², an increase of 4% from 2014.

Of the biomass observed in 2015 the southern area contained the largest proportion of stock (over 50.5%), ranking second was the western area where 21.6% of biomass was recorded. The northern area and Porcupine Bank contributed 17.2% and 10.7% respectively.

On the Porcupine Bank, boarfish were observed in a cluster of medium to high density echotraces located close to the shelf edge (Figure 2 & Figure 5a). This pattern of distribution is typical for this area. The total number of boarfish echotraces (n=52) was lower than in 2014 but of higher overall acoustic density resulting in a biomass of c.25,000 t or 10.7% of total and greater than 2014 (c.14,000 t).

The northern area contributed 17.2% (39,900 t) to the total biomass and 14.9% (595.6 million) to total abundance and is comparable to 2014 (32,000 t). The number and acoustic density of echotraces were similar to last year (Figures 2 & 5b).

The western area contributed 21.6% (50,300 t) to total biomass and 18.5% (738.9 million) to total abundance. This area was characterised by clusters of medium and high density echotraces predominantly located below the thermocline and west of 11ºW. This east/west distribution pattern is most likely influenced by the Irish Shelf Front with boarfish preferring the oceanic side (Figures 2 & 5c).

The southern area contributed 50.5% (117,400t) to total biomass and 61% (2902.7 million) to total abundance. Distribution was comparable to previous years with boarfish observed mid-shelf on the banks such as the Jones's Bank and in greater number in 2 areas along the shelf edge (Figures 2, 5d-e & 8).

3.1.4 Boarfish stock structure

An age length key (ALK) compiled from survey and commercial samples collected from 2011-2014 was used during the analysis of survey data (Figure 3). This ALK was used in place of a survey specific key due to the unavailability of aged samples during the analysis.

Age distribution as determined from the survey indicates the stock is dominated by the following age classes in terms of biomass: 15+, 10, 7 and 9 year old fish representing over 69% of the total biomass and 15+, 7, 10 and 9 years in terms of abundance (Figure 3, Tables 5 & 6).

Immature fish (< 9.7 cm TL) were observed predominantly in the southern area mid-shelf and in much smaller numbers in the western area (Tables 7 & 8). Immature boarfish were generally observed in low numbers in catches containing mature individuals. A single high density surface layer targeted during Haul 14 (Table 2, Figure 5f) exclusively contained juvenile boarfish. In total the biomass of immature boarfish was estimated at 6,000 t (2.6%) representing 13.3% of total abundance most of which can be attributed to this juvenile aggregation.

3.2 Other pelagics

3.2.1 Horse mackerel

Horse mackerel (*Trachurus trachurus*) were encountered in 45% of survey hauls often occurring in catches with boarfish (Table 2, Figures 5g & 10).

A total of 289 echotraces were assigned to horse mackerel and 884 length measurements and 489 length and weights were recorded. The modal length of horse mackerel was 31.25 cm (range 13-39 cm) and mean weight was 276 g.

Horse mackerel were widely distributed throughout the survey area from the Porcupine Bank to the southern Celtic Sea occurring mainly as low and medium density echotraces spaced over a wide area. Maturity sampling indicated that spawning was well underway throughout the survey range. The number of echotraces and size range of individuals were comparable with 2014. Horse mackerel were observed during daytime not only as single species echotraces on the bottom but also as surface scattering layers mixed with mackerel and to a lesser extent boarfish. This behaviour would have implications for the precision of future acoustic abundance estimates for horse mackerel due to the availability of horse mackerel to acoustic sampling techniques.

3.2.2 Blue whiting

Blue whiting (*Micromesistius poutassou*) were widespread throughout the survey occurring in 20% of trawl catches. Acoustically, juvenile blue whiting were the most abundant species observed in 2015 and almost consistently throughout the survey time series to date. High density clusters of juvenile 0-group fish dominated the mid the Celtic Sea from 48°N - 51°N (Figure 5h).

A total of 346 blue whiting were measured and 300 length and weights were recorded. The modal length occurred at 14.4 cm (range 11-18 cm) and mean weight was 19g.

3.3 Trawl mounted camera

A camera system was installed in the trawl close to the joining section of the brailer (codend) and the main body of the net. The system was used as a means to help groundtruth acoustic observations and catch composition against the corresponding trawled echotrace. Camera and lighting specification are detailed in Appendix 2.

Positioning within the trawl was determined and marked out prior to the survey. The camera was installed in the top section of the net on the 120mm mesh line (full mesh) along the central line. The lights (x2) were positioned 50cm behind the camera and 50cm to the side to prevent glare. The camera and lights were positioned looking backwards at the mouth of the brailer. In this position the diameter of the net was in the region of 4.5m tapering to a brailer diameter of 3.7m.

The system was deployed in a total of 10 hauls (Table 2, Figures 7-10) and proved very useful not only for groundtruthing but also as a means of recording behaviour of target species and gear performance. The positioning of the system close to the coded was used as a visual means of determining the composition of the catch that was committed to the brailer and thus would appear in the end sample.

4 Discussion and conclusions

4.1 Discussion

Overall, the survey can be considered a success with all components of the work program completed as planned with no downtime. Survey design, timing and geographical coverage were maintained in 2015 using baselines established in 2012. Weather conditions were average and as the acoustic calibration was undertaken pre-survey this allowed time to increase geographical coverage (4%) and transect mileage (16%) from 2014 levels.

The total number of boarfish echotraces was higher than in 2014 (401 ‘definitely’ boarfish in 2014 vs 603 in 2015). The largest single echotrace in observed in 2015 was one third of the maximum observed in 2014. Echotrace identification was considered accurate with over 92% of the total biomass attributed to the ‘definitely’ category and supported by comprehensive trawling over the survey area (a 10% increase from 2014).

Overall, the total stock biomass was almost 20% higher than at the same time in 2014 and measured using comparable survey effort. Biomass was higher for all areas compared with 2014 with the exception of the western area (-34%). Over 50% of total biomass was observed in the southern region (Celtic Sea) while the remainder was split across the northern (17.2%), western (21.6%) and Porcupine (10.7%) areas. Historically the southern area has contained upwards of 60% of the total biomass.

The stock is considered to be well contained within the survey area but some doubts still exist regarding the southern limit. Information from the IFREMER PELGAS acoustic survey in the Bay of Biscay (May-June) confirms that for the first time in several years boarfish were observed in number in the northern Biscay (Pierre Pettitgas *pers comm.*). As boarfish were observed at the southern limit of this survey area it is likely that the stock was not fully contained and thus a portion of the stock remains unquantified. In previous years southern containment was considered adequate. Northward distribution was bounded by the surveys northern limits (*C. Explorer*) and eastward transects were discontinued only when detections of boarfish were not observed for several clear miles following established protocols.

4.2 Conclusions

Acoustically derived estimates of abundance are used as a relative index of the stock present within the survey area at the time of surveying. The survey therefore acts as a ‘snapshot’ of the stock and should not be considered as a measure of absolute stock abundance. The use of an abundance index allows for the percentage change between successive estimates to be tracked over time to reveal trends in stock abundance as the time series develops.

Stock containment in the south remains and issue for the survey. Unquantified biomass from further south is not considered to be substantial this year or in previous years but will affect the overall estimate to a degree.

The age profile of the stock as determined from trawl samples is comparable to previous years with the bulk of the stock dominated by the oldest fish (15+ years). The 7-10 year old fish remain the next dominate group of cohorts within the time series thus validating the ability of the survey to capture the age structure of the spawning population.

Overall the 2015 estimate is considered as an accurate reflection of the biomass on the ground during the time of the survey for equal and comparable survey effort (CV 17%). The overall trend of stock decline perceived within the survey time series was somewhat alleviated this year by a small increase in biomass. However, a single point estimate cannot be considered in isolation and several successive points are required to validate any trend.

4.3 Recommendations

The following recommendations are based on observations made during the survey and are provided as a means of improving future surveys.

- All efforts should be made to ensure good containment of the stock in the southern region of the survey.
- Continued participation in the annual ICES WGACEGG meeting to facilitate acoustic data and knowledge exchange between participant countries surveying in the Celtic Sea and Bay of Biscay. Namely, Ireland, UK and France.
- It is recommended that the use of optics within the trawl for groundtruthing of echotrace composition be continued and developed where possible for future use.
- The survey is due to continue onboard the RV *Celtic Explorer* from 2016 onwards and it is recommended that multi frequency analysis be used to help identify echotraces in problematic areas in the Celtic Sea.
- Hydrographic and oceanographic sampling will help to determine the thermal preference of boarfish and thus distribution during spawning.
- It is recommended that this survey from 2016 starts producing age stratified abundance estimates horse mackerel given the multi frequency suite available onboard the *Explorer*.

Acknowledgements

We would like to express our thanks and gratitude to Denis Carberry (Skipper) and crew of the FV *Felucca* for their good will and professionalism during the survey. The help and knowledge imparted during the survey was invaluable in helping to understand the behaviour of this species.

This survey is co funded by the Killybegs Fishermens' Organisation, the Irish Fish Producers Organisation and the Irish South and West Fish Producers Organisation. The collection and analysis of survey data and report writing was undertaken Marine Institute.

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Table 1. Survey settings and calibration report (38 kHz) for the tow body system (Simrad EK 60 echosounder).

Echo Sounder System Calibration Report

Vessel :	F/V Felucca	Date :	06.07.15
Echo sounder :	Hull mounted	Locality :	Donegal Bay
Type of Sphere : CU 64	TS_{Sphere}: -33.50 dB	Depth (Sea floor) :	38 m

Calibration Version 2.1.0.12

Comments:
Offshore drift calibration. Weather conditions good

Reference Target:

TS	-33.52 dB	Min. Distance	10.0m
TS Deviation	5 dB	Max. Distance	12.5m

Transducer: ES38B Serial No.

Frequency	38000 Hz	Beam type	Split
Gain	26.21 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	7.10 deg	Along. Beam Angle	7.06 deg
Athw. Offset Angle	0.12 deg	Along. Offset Angle	-0.05 deg
Sa Correction	-0.61 dB	Depth	3.50 m

Transceiver: GPT 38 kHz 009072033933 1 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.192 m
Power	2000 W	Receiver Bandwidth	2.43 kHz

Sounder Type:
ER60 Version 2.2.1

TS Detection:

Min. Value	-50.0 dB	Min. Spacing	100 %
Max. Beam Comp.	6.0 dB	Min. Echolength	80 %
Max. Phase Dev.	8.0	Max.Echolength	180 %

Environment:

Absorption Coeff.	9.3 dB/km	Sound Velocity	1501.9 m/s

Beam Model results:

Transducer Gain =	26.21 dB	Sa Correction =	-0.61 dB
Athw. Beam Angle =	7.10 deg	Along. Beam Angle	7.06 deg
Athw. Offset Angle =	0.12 deg	Along. Offset Angle	-0.05 deg

Data deviation from beam model:
RMS = 0.12 dB
Max = 0.41 dB No. = 204 Athw. = -2.9 deg Along = -2.8 deg
Min = -0.60 dB No. = 156 Athw. = 4.4 deg Along = 0.8 deg

Data deviation from polynomial model:
RMS = 0.10 dB
Max = 0.30 dB No. = 204 Athw. = -2.9 deg Along = -2.8 deg
Min = -0.44 dB No. = 156 Athw. = 4.4 deg Along = 0.8 deg

Comments :
Flat calm conditions
Wind Force : 2-5 kn. **Wind Direction :** SW
Raw Data File: C:\Program files\Simrad\Scientific\EK60\Data\Calibration\BFAS 2015\Hull mounted
Calibration File: C:\Program files\Simrad\Scientific\EK60\Data\Calibration\BFAS 2015\Hull mounted

Calibration : Ciaran O'Donnell

Table 2. Catch composition and position of hauls undertaken by the MFV *Felucca* and for the Celtic Explorer.

Felucca

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target btm (m)	Bulk Catch (Kg)	Boarfish %	Mackerel %	Herring %	H Mack %	Others^ %
1	12.07.15	52.66	-14.00	14:38	267	50-100	3,500	99.5	0.5			
2	13.07.15	53.65	-11.40	10:25	214	65	2,500	94.2	0.2		5.6	
3	14.07.15	53.14	-11.54	07:53	140	65	500	72.0	25.0		3.0	
4	14.07.15	53.14	-10.51	13:15	100	13-25	300					100.0
5*	15.07.15	52.40	-11.03	13:32	122	0-35	500	1.0	53.0		41.6	4.4
6*	15.07.15	52.40	-11.56	16:58	165	65	8,000	73.7	3.0		23.4	
7*	17.07.15	50.89	-9.34	13:48	116	0-35	200	16.5	40.1		8.4	35.0
8*	17.07.15	50.88	-10.15	18:30	123	0-50	8,000	92.6	1.1		6.4	
9	18.07.15	50.63	-9.21	11:22	110	0-25	2,000	81.4	15.4		2.2	1.0
10*	18.07.15	50.66	-8.43	16:03	106	13-45	100		34.2		65.7	0.1
11*	19.07.15	50.38	-10.21	13:44	142	70-110	10,000		1.4			98.6
12*	20.07.15	50.13	-9.42	06:52	140	0-17	3,000					100.0
13*	20.07.15	49.88	-7.94	19:37	109	0-15	1,000		55.2		38.3	6.5
14	21.07.15	49.89	-9.62	10:01	120	20-70	5,000	100.0				
15*	22.07.15	49.38	-8.11	15:34	136	0-20	5,000	12.0				88.0
16	24.07.15	49.87	-9.59	12:42	170	0-25	1,500	100.0				
17*	25.07.15	48.63	-8.60	10:00	170	35-55	5,000	100.0				
18	26.07.15	48.38	-8.60	12:25	177	0-35	2,000	100.0				
19	27.07.15	47.89	-6.97	17:43	170	65-140	8,000					100.0
20*	28.07.15	47.40	-6.05	12:21	157	0-20	3,000	100.0				

^ Includes non-target pelagic/demersal species and other taxa
*Camera installed in trawl

Table 2. Continued

Celtic Explorer

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target btm (m)	Bulk Catch (Kg)	Boarfish %	Mackerel %	Herring %	H Mack %	Others^ %
7	03.07.15	58.42	-8.97	20:07			7	0.2	83.3			16.5
16	09.07.15	2.84	-9.05	05:44			62	17.4	48.2	31.9	1.4	1.0
19	11.07.15	12.28	-10.20	09:12			4,000	100.0				
22	13.07.15	45.95	-10.77	05:09			97	98.6	0.7			0.7

^ Includes non-target pelagic/demersal species and other taxa

Table 3. Normalised age/length key compiled from commercial catch and survey samples collected during 2011-2014.

	Age (yrs)														
Length (cm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
6	1.00														
6.5	1.00														
7	0.50	0.50													
7.5	0.50	0.50													
8		1.00													
8.5		0.50	0.50												
9		0.50	0.50												
9.5			1.00												
10			1.00												
10.5			0.13	0.67	0.20										
11			0.02	0.60	0.29	0.04	0.04								
11.5				0.12	0.28	0.28	0.24	0.03	0.03	0.01					
12				0.04	0.17	0.22	0.37	0.12	0.08						0.01
12.5					0.04	0.08	0.36	0.31	0.12	0.05	0.02		0.01	0.01	0.01
13					0.02	0.03	0.26	0.24	0.20	0.10	0.05	0.02	0.03	0.01	0.04
13.5					0.01	0.03	0.22	0.19	0.18	0.12	0.05	0.04	0.04	0.02	0.10
14							0.06	0.09	0.19	0.24	0.09	0.03	0.08	0.01	0.22
14.5						0.02	0.02	0.03	0.05	0.13	0.02	0.09	0.09	0.09	0.47
15							0.03	0.03		0.06	0.06	0.06	0.15	0.06	0.56
15.5										0.09	0.00	0.00	0.00	0.09	0.83
16															1.00
16.5															1.00
17															1.00
17.5															1.00
18															1.00
18.5															1.00

Table 4. Boarfish length at age (years) as abundance (millions) and biomass (000's tonnes).

Length (cm)	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Abundance (millions)	Biomass (000s t)	Mn wt (g)
4.5																		
5																		
5.5																		
6	3.51															3.51	0.02	6
6.5	38.6															38.58	0.29	7.4
7	51.2	51.2														102.36	0.93	9.1
7.5	105	105														210.5	2.3	11.0
8		151														151.5	2.0	13.2
8.5		9.6	9.6													19.2	0.3	15.6
9		1.75	1.75													3.5	0.1	18.3
9.5			2.34													2.3	0.1	21.3
10			1.8													1.8	0.0	24.6
10.5			0.69	3.5	1.0											5.2	0.2	28.2
11			0.51	14.8	7.2	1.0	1.0									24.6	0.8	32.1
11.5				9.16	21.4	21.4	18.3	2.0	2.0	1.0						75.4	2.7	36.3
12				6.89	29.3	37.9	65.5	20.7	13.8						1.7	175.7	7.2	41.0
12.5					10.4	18.8	87.7	77.3	29.2	12.5	4.2		2.1	2.1	2.1	246.5	11.3	45.9
13					6.5	13	101	91	78.0	39.0	19.5	6.5	9.7	3.3	16.2	383.3	19.7	51.3
13.5					4.24	12.7	106	93.2	89	59.3	25.4	21.2	17.0	8.5	46.6	483.0	27.5	57.0
14							40	53.3	120	147	53.3	20.0	46.7	6.7	133	619.9	39.2	63.2
14.5						7.19	7.19	14.4	21.6	57.5	7.19	43.2	43.2	43.2	216	460.3	32.1	69.7
15							11.1	11.1		22.1	22.1	22.1	55.3	22.1	210	376.1	28.9	76.7
15.5										22				22	209	253.3	21.3	84.2
16															174	174.3	16.1	92.1
16.5															92.1	92.1	9.3	100.4
17															68.7	68.7	7.5	109.2
17.5															17	17.0	2.0	118.6
18															5.91	5.91	0.76	128.4
18.5															1.55	1.55	0.22	138.7
19																		
19.5																		
20																		
SSN			3.48	34	79.9	112	437	363	354	360	132	113	174	108	1195	3,464.5		
SSB			0.089	1.18	3.29	5.12	22.5	19.7	20.1	22.8	8.21	7.51	11.8	7.73	96.7		226.7	
Mn wt (g)	9.7	11.9	18.7	34.6	41.1	45.7	51.4	54.2	57	63.4	62.3	66.5	67.6	71.7	80.9			
Mn L (cm)	7.4	7.9	9.3	11.5	12.2	12.7	13.2	13.5	13.7	14.2	14.2	14.5	14.6	14.9	15.5			

Table 5. Boarfish total biomass (000's tonnes) at age (years) by ICES statistical rectangle.

Region	Strata	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
North	45E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2
	44E0	0	0	0	0	0	0.1	0.5	0.5	0.6	0.8	0.3	0.3	0.4	0.3	2.9	6.6
	44E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
	43E0	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0.1	0.1	0.1	0.5	1.1
	43E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	42E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	42E1	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.2	0.4
	41E0	0	0	0	0	0	0	0.2	0.2	0.3	0.3	0.1	0.1	0.2	0.1	1.3	2.9
	41E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	40E0	0	0	0	0	0	0.1	0.4	0.4	0.5	0.6	0.2	0.2	0.3	0.2	2	5
	39E0	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0	0.1	0.1	0.5	1.1
	38D9	0	0	0	0	0	0.1	0.5	0.5	0.7	0.9	0.3	0.3	0.5	0.4	3.4	7.6
	37D9	0	0	0	0	0.1	0.2	1.3	1.3	1.6	1.9	0.7	0.6	1	0.6	5.6	14.8
	39D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
Porc	36D6	0	0	0	0	0	0	0.2	0.2	0.3	0.3	0.1	0.1	0.2	0.1	1.1	2.6
	35D5	0	0	0	0	0	0.1	0.7	0.7	0.8	1.4	0.5	0.6	1	0.7	8.5	15
	35D6	0	0	0	0	0	0	0.2	0.2	0.2	0.4	0.2	0.2	0.3	0.2	2.5	4.4
	34D5	0	0	0	0	0	0	0.1	0.1	0.2	0.3	0.1	0.1	0.2	0.1	1.7	3
	34D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West	36D8	0	0	0	0	0.1	0.2	1.4	1.3	1.5	1.8	0.7	0.6	1	0.6	6.1	15.3
	36D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	35D7	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0	0.1	0	0.3	0.8
	35D8	0	0	0	0	0.1	0.1	0.7	0.7	0.8	1	0.4	0.4	0.6	0.4	3.5	8.6
	35D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	34D7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	34D8	0	0	0	0	0	0.1	0.5	0.5	0.6	1	0.4	0.4	0.6	0.5	5.3	9.9
	34D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D8	0	0	0	0	0.1	0.1	0.9	0.9	1	1.3	0.5	0.5	0.8	0.5	5.7	12.3
	33D9	0	0	0	0	0	0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.7	1.5
	32D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2
	32D9	0	0	0	0	0	0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.8	1.7
South	31D8	0	0	0	0	0	0	0.2	0.2	0.2	0.3	0.1	0.1	0.2	0.1	2.2	3.8
	31D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	31E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30D9	0	0	0	0	0	0	0.2	0.2	0.2	0.3	0.1	0.1	0.2	0.1	1.7	3
	30E0	0	0	0	0	0	0.1	0.3	0.2	0.3	0.4	0.1	0.1	0.2	0.2	5.4	7.3
	30E1	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0	0	0	1.7	2.2
	30E2	0	0	0	0.1	0.1	0.2	0.8	0.6	0.7	1	0.3	0.3	0.5	0.5	17	22.1
	29D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	29D9	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.4	0.7
	29E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.4
	29E1	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0	0.1	0	1.7	2.2
	29E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28E0	1.9	3.7	0.2	0	0	0	0	0	0	0	0	0	0	0	0	5.8
	28E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	27D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	27D9	0	0	0	0	0.1	0.2	0.5	0.4	0.3	0.3	0.1	0.1	0.1	0.1	0.5	2.7
	27E0	0	0	0	0	0.1	0.1	0.3	0.2	0.2	0.2	0.1	0	0.1	0	0.3	1.7
	27E1	0	0	0	0.1	0.2	0.3	0.8	0.6	0.5	0.4	0.2	0.1	0.2	0.1	1	4.7
	27E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26D9	0	0	0	0	0	0	0.1	0.1	0	0	0	0	0	0	0.1	0.4
	26E0	0	0	0	0.1	0.4	0.5	1.5	1.1	0.9	0.7	0.3	0.2	0.3	0.2	1.4	7.8
	26E1	0	0	0	0.2	0.5	0.6	2.1	1.5	1.2	0.9	0.3	0.2	0.3	0.2	1.7	9.8
	26E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25E0	0	0	0	0	0.1	0.1	0.3	0.2	0.2	0.2	0.1	0	0.1	0	0.3	1.6
	25E1	0	0	0	0.2	0.6	0.9	3.3	2.7	2.3	1.8	0.7	0.5	0.7	0.4	3.3	17.4
	25E2	0	0	0	0	0.1	0.1	0.6	0.5	0.4	0.3	0.1	0.1	0.1	0.1	0.6	3
	25E3	0	0	0	0	0	0	0.1	0.1	0.1	0.1	0	0	0	0	0.1	0.4
	24E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	24E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	24E4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	23E3	0	0	0	0.1	0.3	0.4	1.7	1.5	1.6	1.6	0.6	0.4	0.6	0.3	2.4	11.5
	23E4	0	0	0	0.1	0.2	0.3	1.4	1.2	1.3	1.2	0.4	0.3	0.5	0.2	1.9	8.9
	Total	1.9	3.8	0.3	1.2	3.3	5.1	22.5	19.7	20.1	22.8	8.2	7.5	11.8	7.7	96.7	232.6
	%	0.8	1.6	0.1	0.5	1.4	2.2	9.7	8.5	8.7	9.8	3.5	3.2	5.1	3.3	41.5	100

Table 6. Boarfish total abundance (millions) at age (years) by ICES statistical rectangle.

Region	Strata	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
North	45E1	0	0	0	1.0	13.0	37.0	0.2	0.2	0.3	0.4	0.1	0.1	0.2	0.1	1.1	2.9
	44E0	0	0	0	47.0	0.4	1.2	8.0	8.1	9.7	12.2	4.1	4.4	6.3	4.4	38.3	97.2
	44E1	0	0	0	1.0	5.0	14.0	93.0	94.0	0.1	0.1	48.0	51.0	74.0	51.0	0.4	1.1
	43E0	0	0	0	8.0	72.0	0.2	1.4	1.4	1.7	2.1	0.7	0.8	1.1	0.7	6.5	16.6
	43E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	42E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	42E1	0	0	0	3.0	27.0	8.0	0.5	0.5	0.6	0.8	0.3	0.3	0.4	0.3	2.5	6.3
	41E0	0	0	0	2.0	0.2	0.5	3.5	3.5	4.2	5.3	1.8	1.9	2.7	1.9	16.7	42.3
	41E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	40E0	0	0	0.1	29.0	0.4	1.0	6.8	6.8	8.2	9.7	3.4	3.2	4.7	3.0	26.9	74.0
	39E0	0	0	22.0	7.0	8.0	0.2	1.5	1.5	1.8	2.2	0.8	0.7	1.1	0.7	6.3	17.0
	38D9	0	0	0	54.0	0.5	1.4	9.2	9.3	11.1	14.1	4.7	5.1	7.3	5.0	44.1	111.9
	37D9	0	0	0	37.0	1.1	3.1	23.0	22.7	26.6	29.7	10.9	9.7	14.4	8.5	75.1	224.8
	39D9	0	0	0	1.0	6.0	18.0	0.1	0.1	0.1	0.2	62.0	66.0	95.0	65.0	0.6	1.5
Porc	36D6	0	0	0	46.0	0.4	0.7	4.3	4.0	4.3	4.8	1.8	1.6	2.6	1.5	13.8	39.8
	35D5	0	0	0	0.0	0.4	1.4	11.0	11.6	13.9	21.0	7.7	8.0	13.5	9.1	105.0	202.5
	35D6	0	0	0	0.0	0.1	0.4	3.3	3.4	4.1	6.2	2.3	2.4	4.0	2.7	31.0	59.8
	34D5	0	0	0	0.0	73.0	0.3	2.2	2.3	2.8	4.2	1.5	1.6	2.7	1.8	20.9	40.3
	34D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West	36D8	0	0	0.0	0.3	2.1	4.2	24.9	23.2	25.0	28.1	10.6	9.4	14.9	8.8	80.1	231.6
	36D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	35D7	0	0	44.0	4.0	0.1	0.2	1.1	1.0	1.1	1.4	0.5	0.5	0.8	0.5	4.1	11.4
	35D8	0	0	0.4	0.4	1.2	2.3	12.5	11.8	13.1	15.8	5.8	5.9	9.0	5.6	46.4	130.1
	35D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	34D7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	34D8	0	0	0.1	0.1	0.5	1.3	9.0	9.1	10.6	14.8	5.4	5.6	9.2	6.1	65.6	137.5
	34D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	33D8	0	0	12.0	0.4	1.2	2.5	16.3	15.7	17.1	20.2	7.6	7.1	11.3	7.1	71.8	178.3
	33D9	0	0	1.0	51.0	0.1	0.3	2.0	1.9	2.1	2.5	0.9	0.9	1.4	0.9	8.9	22.1
	32D8	0	0	0	7.0	21.0	44.0	0.3	0.3	0.3	0.4	0.1	0.1	0.2	0.1	1.3	3.2
	32D9	0	0	2.0	57.0	0.2	0.3	2.2	2.2	2.4	2.8	1.1	1.0	1.6	1.0	9.9	24.6
South	31D8	0	0	41.0	0.3	0.5	0.7	3.9	3.7	4.0	5.0	1.8	1.7	2.8	1.8	25.5	51.8
	31D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	31E0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30D9	0	0	33.0	0.3	0.4	0.6	3.1	2.9	3.2	4.0	1.5	1.4	2.2	1.4	20.3	41.2
	30E0	0	0	0.4	0.6	1.1	1.5	5.5	4.5	4.4	5.5	1.8	1.8	2.9	2.3	57.4	89.6
	30E1	0	0	0.2	0.2	0.3	0.4	1.5	1.2	1.1	1.4	0.5	0.5	0.7	0.6	17.5	26.1
	30E2	0	0	1.6	2.4	3.6	4.4	14.9	12.0	11.5	14.8	4.7	4.7	7.4	6.3	178.4	266.5
	29D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	29D9	0	0	7.0	6.0	83.0	0.1	0.7	0.6	0.7	0.9	0.3	0.3	0.5	0.3	4.5	9.1
	29E0	0	0	26.0	4.0	59.0	73.0	0.2	0.2	0.2	0.2	78.0	78.0	0.1	0.1	3.0	4.4
	29E1	0	0	0.2	0.2	0.4	0.4	1.5	1.2	1.1	1.5	0.5	0.5	0.7	0.6	17.7	26.5
	29E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28D9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28E0	196.5	314.8	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	521.7
	28E1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	27D8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	27D9	74.0	0.2	21.0	1.4	3.3	4.0	11.2	7.7	6.2	4.4	1.6	1.1	1.6	0.9	7.0	50.7
	27E0	1.7	2.8	0.1	0.9	2.1	2.5	7.0	4.9	3.9	2.8	1.0	0.7	1.0	0.5	4.4	36.3
	27E1	0	0	0.2	4.0	6.0	6.6	17.9	12.2	9.9	7.3	2.8	1.9	3.0	1.5	13.4	86.7
	27E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26D9	11.0	33.0	3.0	0.2	0.5	0.6	1.7	1.2	0.9	0.7	0.2	0.2	0.2	0.1	1.0	7.6
	26E0	0.2	0.6	61.0	4.0	9.5	11.7	32.6	22.5	17.9	12.6	4.8	3.2	4.6	2.4	2025.0	146.7
	26E1	0	0	67.0	4.8	12.2	15.3	43.9	30.6	23.0	15.0	6.0	3.5	5.5	2.8	23.6	186.3
	26E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26E3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	25E0	0	0	0.1	0.6	1.4	1.8	6.4	4.9	3.9	2.9	1.1	0.7	1.0	0.6	4.4	29.6
	25E1	0	0	1.4	6.8	15.1	19.8	68.7	52.7	41.8	30.9	11.6	7.6	10.8	6.3	47.2	320.6
	25E2	0	0	0.2	1.1	2.6	3.4	11.7	8.9	7.1	5.2	2.0	1.3	1.8	1.1	8.0	54.4
	25E3	0	16.0	17.0	9.0	0.2	0.3	1.2	1.0	1.0	0.9	0.3	0.2	0.3	0.2	1.2	6.9
	24E2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	24E3	0	0	0.0	1.0	3.0	4.0	14.0	12.0	12.0	11.0	4.0	3.0	4.0	2.0	15.0	84.0
	24E4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	23E3	0	0.5	0.5	2.6	6.6	8.9	33.9	27.8	28.5	25.5	9.5	6.5	9.6	4.5	35.1	199.9
	23E4	0	0.4	0.4	2.0	5.1	6.9	26.5	21.6	22.2	19.9	7.4	5.1	7.5	3.5	27.4	155.9
	Total	198.5	319.2	16.65	34.35	8043	112	437.4	362.9	353.5	360.2	131.7	113	173.9	107.8	1195	3995.8
	%	5.0	8.0	0.4	0.9	2.0	2.8	10.9	9.1	8.8	9.0	3.3	2.8	4.4	2.7	29.9	100
	CV	99	99	63.4	22.9	21.6	19.4	17.1	16.1	14.1	12.2	12.2	11.3	11.3	11.3	10.5	NA

Table 7. Boarfish biomass (000's tonnes) by maturity by ICES statistical rectangle.

Region	Strata	Imm	Mature	Spent	Total
North	45E1	0	0.2	0	0.2
	44E0	0	6.6	0	6.6
	44E1	0	0.1	0	0.1
	43E0	0	1.1	0	1.1
	43E1	0	0	0	0
	42E0	0	0	0	0
	42E1	0	0.4	0	0.4
	41E0	0	2.9	0	2.9
	41E1	0	0	0	0
	40E0	0	5	0	5
	39E0	0	1.1	0	1.1
	38D9	0	7.6	0	7.6
	37D9	0	14.8	0	14.8
	39D9	0	0.1	0	0.1
Porc	36D6	0	2.6	0	2.6
	35D5	0	15	0	15
	35D6	0	4.4	0	4.4
	34D5	0	3	0	3
	34D6	0	0	0	0
	33D5	0	0	0	0
	33D6	0	0	0	0
West	36D8	0	15.3	0	15.3
	36D9	0	0	0	0
	35D7	0	0.8	0	0.8
	35D8	0	8.6	0	8.6
	35D9	0	0	0	0
	34D7	0	0	0	0
	34D8	0	9.9	0	9.9
	34D9	0	0	0	0
	33D8	0	12.3	0	12.3
	33D9	0	1.5	0	1.5
	32D8	0	0.2	0	0.2
	32D9	0	1.7	0	1.7
South	31D8	0	3.8	0	3.8
	31D9	0	0	0	0
	31E0	0	0	0	0
	30D8	0	0	0	0
	30D9	0	3	0	3
	30E0	0	7.3	0	7.3
	30E1	0	2.2	0	2.2
	30E2	0	22.1	0	22.1
	29D8	0	0	0	0
	29D9	0	0.7	0	0.7
	29E0	0	0.4	0	0.4
	29E1	0	2.2	0	2.2
	29E2	0	0	0	0
	28D8	0	0	0	0
	28D9	0	0	0	0
	28E0	5.8	0	0	5.8
	28E1	0	0	0	0
	28E2	0	0	0	0
	27D8	0	0	0	0
	27D9	0	2.7	0	2.7
	27E0	0.1	1.7	0	1.7
	27E1	0	4.7	0	4.7
	27E2	0	0	0	0
	26D9	0	0.4	0	0.4
	26E0	0	7.7	0	7.8
	26E1	0	9.8	0	9.8
	26E2	0	0	0	0
	26E3	0	0	0	0
	25E0	0	1.6	0	1.6
	25E1	0	17.4	0	17.4
	25E2	0	3	0	3
	25E3	0	0.4	0	0.4
	24E2	0	0	0	0
	24E3	0	0	0	0
	24E4	0	0	0	0
	23E3	0	11.5	0	11.5
	23E4	0	8.9	0	8.9
	Total	6	226.7	0	232.6
	%	2.6	97.4	0	100

Table 8. Boarfish abundance (millions) by maturity by ICES statistical rectangle.

Region	Strata	Imm	Mature	Spent	Total
North	45E1	0	2.9	0	2.9
	44E0	0	97.2	0	97.2
	44E1	0	1.1	0	1.1
	43E0	0	16.6	0	16.6
	43E1	0	0	0	0
	42E0	0	0	0	0
	42E1	0	6.3	0	6.3
	41E0	0	42.3	0	42.3
	41E1	0	0	0	0
	40E0	0	74.0	0	74.0
	39E0	0	17.0	0	17.0
	38D9	0	111.9	0	111.9
	37D9	0	224.8	0	224.8
	39D9	0	1.5	0	1.5
Porc	36D6	0	39.8	0	39.8
	35D5	0	202.5	0	202.5
	35D6	0	59.8	0	59.8
	34D5	0	40.3	0	40.3
	34D6	0	0	0	0
	33D5	0	0	0	0
	33D6	0	0	0	0
West	36D8	0	231.6	0	231.6
	36D9	0	0.0	0	0.0
	35D7	0	11.4	0	11.4
	35D8	0.1	130.1	0	130.1
	35D9	0	0	0	0
	34D7	0	0	0	0
	34D8	0	137.5	0	137.5
	34D9	0	0	0	0
	33D8	0	178.3	0	178.3
	33D9	0	22.1	0	22.1
	32D8	0	3.2	0	3.2
	32D9	0	24.6	0	24.6
South	31D8	0	51.7	0	51.8
	31D9	0	0	0	0
	31E0	0	0	0	0
	30D8	0	0	0	0
	30D9	0	41.2	0	41.2
	30E0	0.2	89.5	0	89.6
	30E1	0.1	26.0	0	26.1
	30E2	0.7	265.9	0	266.5
	29D8	0	0	0	0
	29D9	0	9.1	0	9.1
	29E0	0	4.4	0	4.4
	29E1	0.1	26.4	0	26.5
	29E2	0	0	0	0
	28D8	0	0	0	0
	28D9	0	0	0	0
	28E0	521.7	0.0	0	521.7
	28E1	0	0	0	0
	28E2	0	0	0	0
	27D8	0	0	0	0
	27D9	0.3	50.4	0	50.7
	27E0	4.6	31.8	0	36.3
	27E1	0.1	86.6	0	86.7
	27E2	0	0	0	0
	26D9	0	7.6	0	7.6
	26E0	0.8	145.9	0	146.7
	26E1	0	186.3	0	186.3
	26E2	0	0	0	0
	26E3	0	0.0	0	0
	25E0	0.1	29.5	0	29.6
	25E1	0.8	319.8	0	320.6
	25E2	0.1	54.3	0	54.4
	25E3	0	6.9	0	6.9
	24E2	0	0	0	0
	24E3	0	0.1	0	0.1
	24E4	0	0	0	0
	23E3	0.9	199.0	0	199.9
	23E4	0.7	155.2	0	155.9
	Total	531.3	3464.5	0	3995.8
	%	13.3	86.7	0	100

Table 9. Boarfish biomass and abundance by ICES statistical rectangle.

Region	Strata	No. transects	No. schools	Def schools	Prob schools	Mix schools	% zeros	Def Biomass	Prob Biomass	Mix Biomass	Biomass (000't)	SSB (000't)	Abundance millions
North	45E1	2	3	0	3	0	50	0	0.2	0	0.2	0.2	2.9
	44E0	2	5	0	5	0	50	0	6.6	0	6.6	6.6	97.2
	44E1	2	1	0	1	0	50	0	0.1	0	0.1	0.1	1.1
	43E0	2	8	0	8	0	50	0	1.1	0	1.1	1.1	16.6
	43E1	2	0	0	0	0	100	0	0	0	0	0	0
	42E0	2	0	0	0	0	100	0	0	0	0	0	0
	42E1	4	3	0	3	0	75	0	0.4	0	0.4	0.4	6.3
	41E0	4	8	0	8	0	0	0	2.9	0	2.9	2.9	42.3
	41E1	4	0	0	0	0	100	0	0	0	0	0	0
	40E0	2	23	9	0	14	0	3.3	0	1.6	5	5	74.0
	39E0	4	28	23	0	5	25	0.9	0	0.3	1.1	1.1	17.0
	38D9	2	25	25	0	0	0	7.6	0	0	7.6	7.6	111.9
	37D9	2	26	26	0	0	0	14.8	0	0	14.8	14.8	224.8
	39D9	1	3	3	0	0	0	0.1	0	0	0.1	0.1	1.5
Porc	36D6	1	11	0	11	0	0	0	2.6	0	2.6	2.6	39.8
	35D5	2	21	21	0	0	0	15	0	0	15	15	202.5
	35D6	2	16	16	0	0	0	4.4	0	0	4.4	4.4	59.8
	34D5	2	15	15	0	0	0	3	0	0	3	3	40.3
	34D6	1	0	0	0	0	100	0	0	0	0	0	0
	33D5	1	0	0	0	0	100	0	0	0	0	0	0
	33D6	2	0	0	0	0	100	0	0	0	0	0	0
West	36D8	1	25	25	0	0	0	15.3	0	0	15.3	15.3	231.6
	36D9	1	0	0	0	0	100	0	0	0	0	0	0
	35D7	2	1	1	0	0	50	0.8	0	0	0.8	0.8	11.4
	35D8	2	31	31	0	0	0	8.6	0	0	8.6	8.6	130.1
	35D9	2	0	0	0	0	100	0	0	0	0	0	0
	34D7	2	0	0	0	0	100	0	0	0	0	0	0
	34D8	2	25	25	0	0	0	9.9	0	0	9.9	9.9	137.5
	34D9	2	0	0	0	0	100	0	0	0	0	0	0
	33D8	2	16	16	0	0	0	12.3	0	0	12.3	12.3	178.3
	33D9	2	12	12	0	0	50	1.5	0	0	1.5	1.5	22.1
	32D8	2	3	3	0	0	50	0.2	0	0	0.2	0.2	3.2
	32D9	2	3	3	0	0	50	1.7	0	0	1.7	1.7	24.6
South	31D8	2	6	6	0	0	50	3.8	0	0	3.8	3.8	51.8
	31D9	2	0	0	0	0	100	0	0	0	0	0	0
	31E0	1	0	0	0	0	100	0	0	0	0	0	0
	30D8	1	0	0	0	0	100	0	0	0	0	0	0
	30D9	2	6	6	0	0	50	3	0	0	3	3	41.2
	30E0	2	26	16	0	10	0	5.9	0	1.4	7.3	7.3	89.6
	30E1	1	6	6	0	0	0	2.2	0	0	2.2	2.2	26.1
	30E2	1	27	27	0	0	0	22.1	0	0	22.1	22.1	266.5
	29D8	2	0	0	0	0	100	0	0	0	0	0	0
	29D9	2	2	2	0	0	50	0.7	0	0	0.7	0.7	9.1
	29E0	2	1	1	0	0	50	0.4	0	0	0.4	0.4	4.4
	29E1	2	10	10	0	0	50	2.2	0	0	2.2	2.2	26.5
	29E2	2	0	0	0	0	100	0	0	0	0	0	0
	28D8	2	0	0	0	0	100	0	0	0	0	0	0
	28D9	2	0	0	0	0	100	0	0	0	0	0	0
	28E0	2	8	8	0	0	50	5.8	0	0	5.8	0	521.7
	28E1	2	0	0	0	0	100	0	0	0	0	0	0
	28E2	2	0	0	0	0	100	0	0	0	0	0	0
	27D8	2	0	0	0	0	100	0	0	0	0	0	0
	27D9	2	13	13	0	0	50	2.7	0	0	2.7	2.7	50.7
	27E0	2	9	9	0	0	0	1.7	0	0	1.7	1.7	36.3
	27E1	2	13	13	0	0	50	4.7	0	0	4.7	4.7	86.7
	27E2	1	0	0	0	0	100	0	0	0	0	0	0
	26D9	2	2	2	0	0	50	0.4	0	0	0.4	0.4	7.6
	26E0	2	40	40	0	0	0	7.8	0	0	7.8	7.7	146.7
	26E1	2	37	37	0	0	0	9.8	0	0	9.8	9.8	186.3
	26E2	2	0	0	0	0	100	0	0	0	0	0	0
	26E3	1	0	0	0	0	100	0	0	0	0	0	0
	25E0	1	5	5	0	0	0	1.6	0	0	1.6	1.6	29.6
	25E1	2	45	45	0	0	50	17.4	0	0	17.4	17.4	320.6
	25E2	2	16	16	0	0	50	3	0	0	3	3	54.4
	25E3	2	2	2	0	0	50	0.4	0	0	0.4	0.4	6.9
	24E2	2	0	0	0	0	100	0	0	0	0	0	0
	24E3	2	1	1	0	0	50	0	0	0	0	0	0.1
	24E4	1	0	0	0	0	100	0	0	0	0	0	0
	23E3	1	40	40	0	0	0	11.5	0	0	11.5	11.5	199.9
	23E4	1	21	21	0	0	0	8.9	0	0	8.9	8.9	155.9
	Total	132	648	580	39	29	-	215.3	14	3.3	232.6	226.7	3995.8
	CV (%)	-	-	-	-	-	-	-	-	-	11.4	NA	17

Table 10. Boarfish survey time series.
Note: 2011 estimate has been revised for daylight hours only in line with current methods.

Age (Yrs)	2011	2012	2013	2014	2015
0	-	-	-	-	-
1	5.0	21.5	-	-	198.5
2	11.6	10.8	78.0	-	319.2
3	57.8	174.1	1,842.9	15.0	16.6
4	187.4	64.8	696.4	98.2	34.3
5	436.7	95.0	381.6	102.3	80.0
6	1,165.9	736.1	253.8	104.9	112.0
7	1,184.2	973.8	1,056.6	414.6	437.4
8	703.6	758.9	879.4	343.8	362.9
9	1,094.5	848.6	800.9	341.9	353.5
10	1,031.5	955.9	703.8	332.3	360.0
11	332.9	650.9	263.7	129.9	131.7
12	653.3	1,099.7	202.9	104.9	113.0
13	336.0	857.2	296.6	166.4	174.0
14	385.0	655.8	169.8	88.5	108.0
15+	3,519.0	6,353.7	1,464.3	855.1	1195.0
TSN (mil)	11,104	14,257	9,091	3,098	3,996
TSB ('000t)	670,176	863,446	439,890	187,779	232,634
SSB ('000t)	669,392	861,544	423,158	187,654	226,659
CV	21.2	10.6	17.5	15.1	17.0

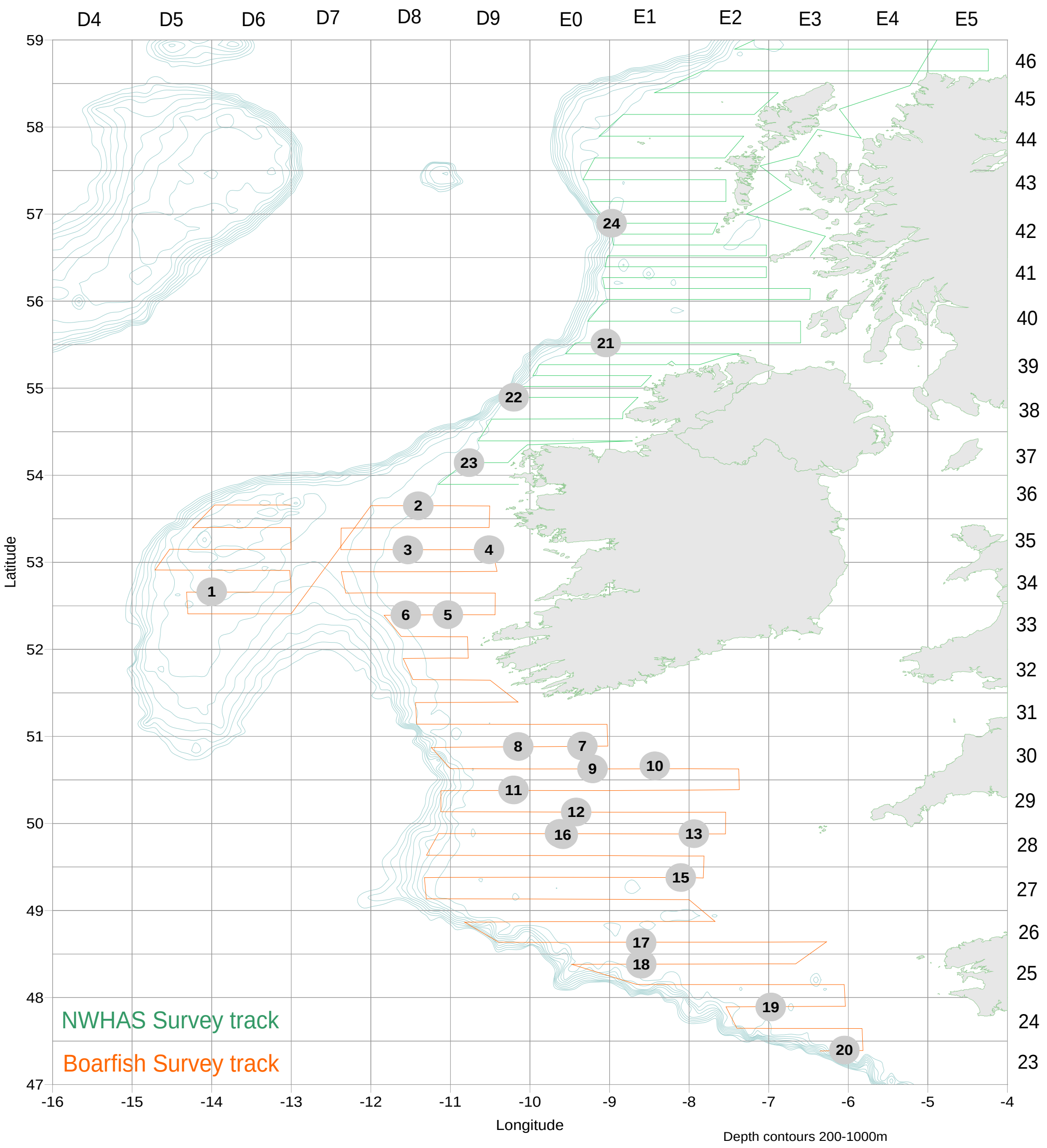


Figure 1. Cruise tracks and numbered haul positions for the FV *Felucca* (orange track) and RV *Celtic Explorer* (green track).

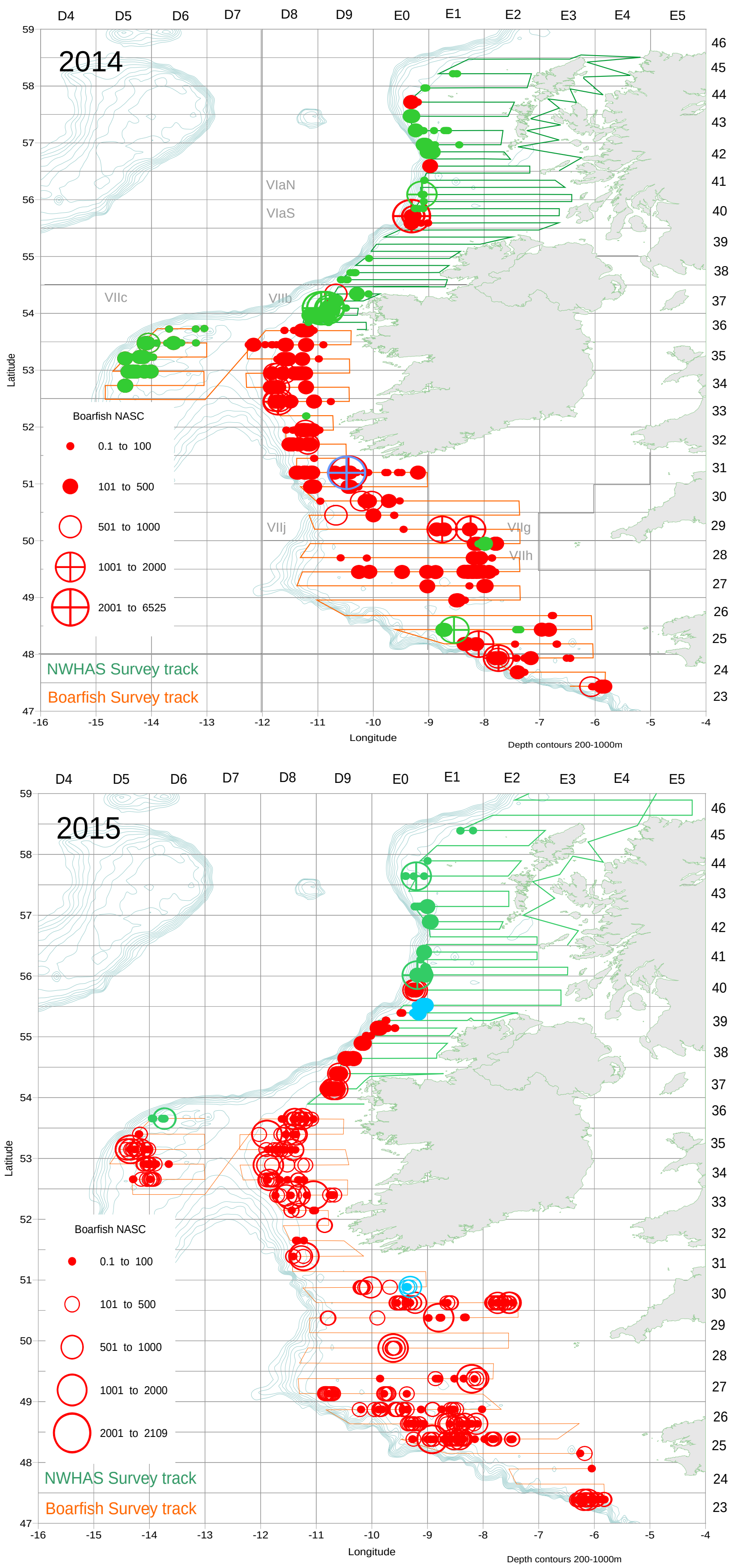
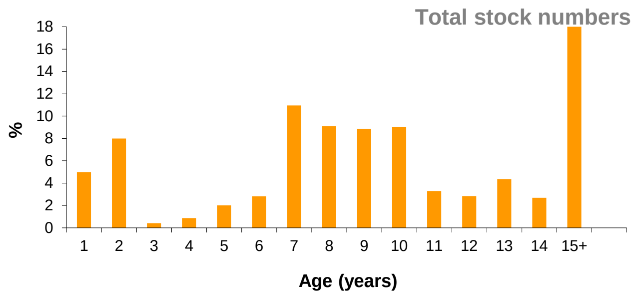


Figure 2. NASC plot of boarfish distribution. Circle size proportional to NASC value. Red circles represent 'definitely' boarfish, green; 'probably boarfish' and blue; 'boarfish mix'.



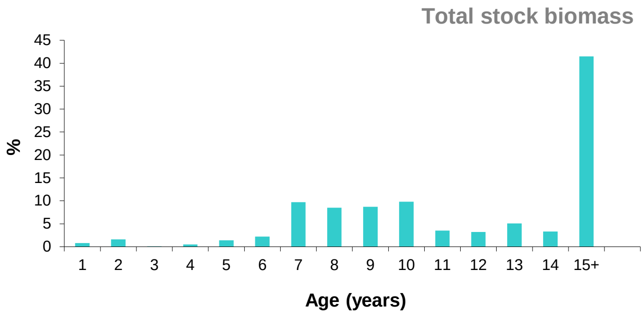
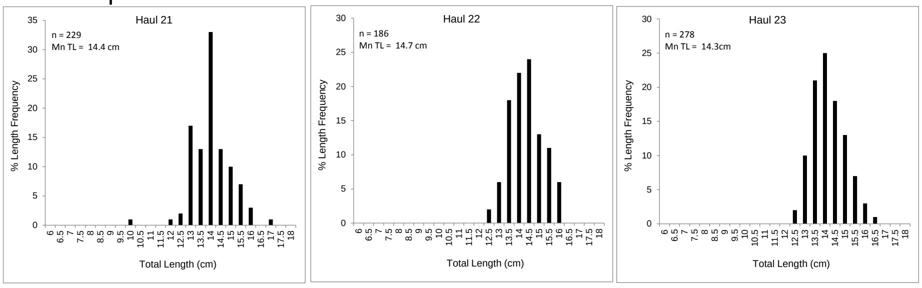


Figure 3. Percentage of total stock numbers (top) and total stock biomass (bottom) by age.

Celtic Explorer Hauls



Felucca Hauls

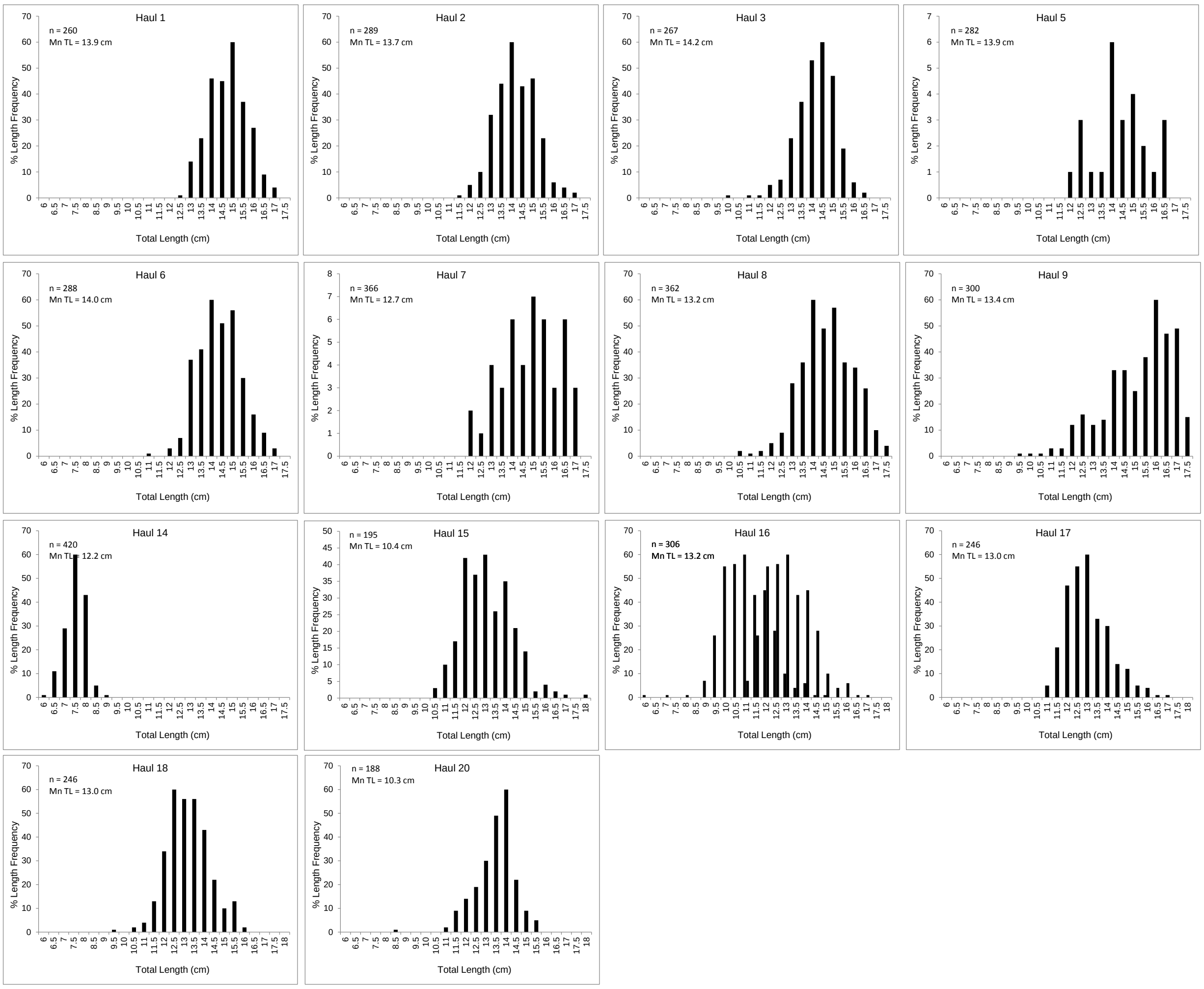
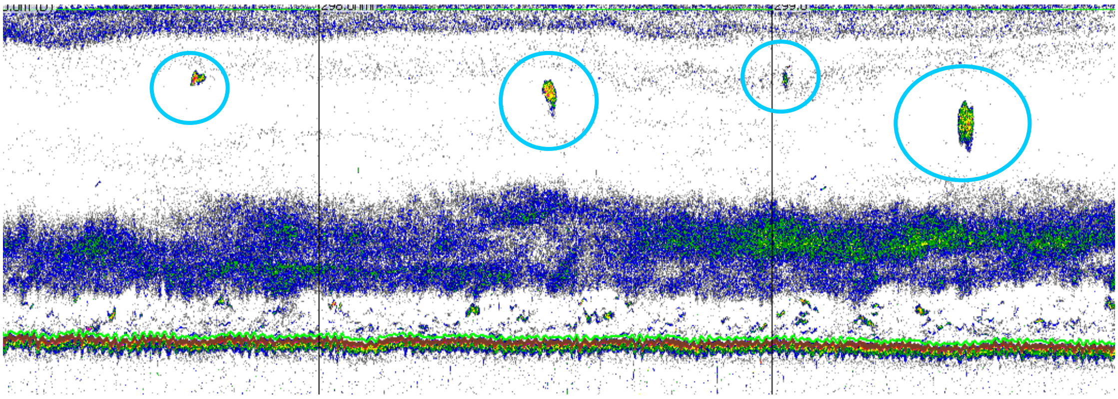
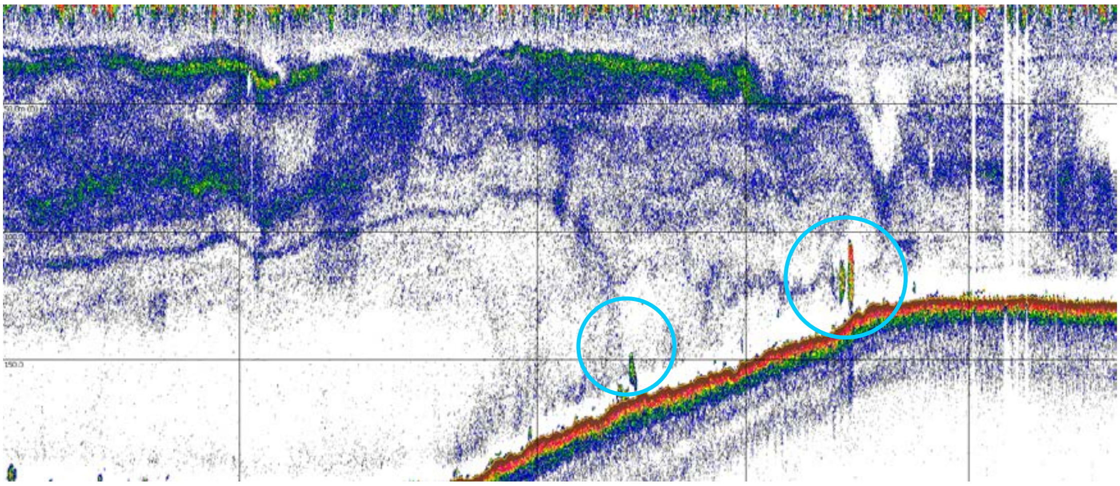


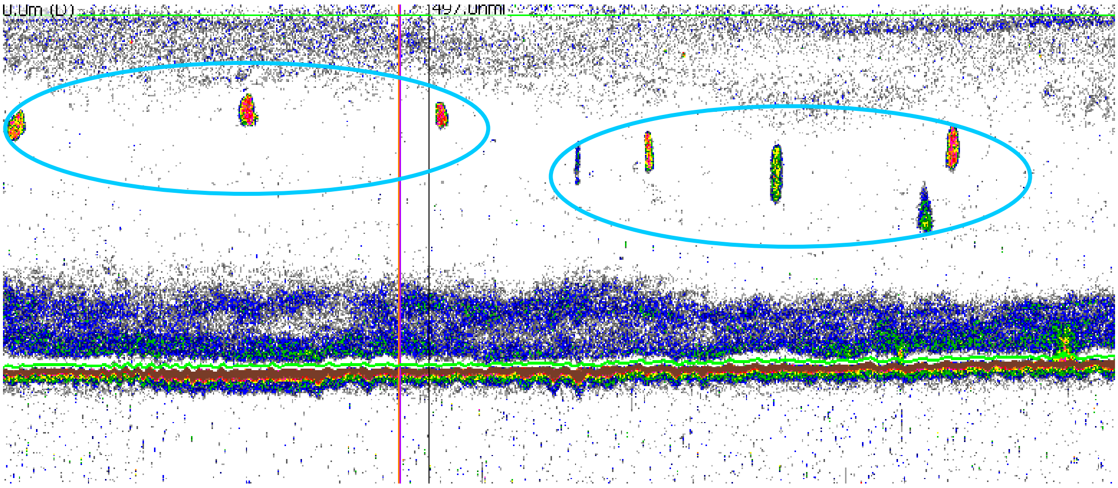
Figure 4. Mean length and length distribution of boarfish by haul.



a). High density boarfish echotraces (circled) observed to on the **Porcupine Bank**. Bottom depth is 210 m with boarfish at 35-60 m below the surface. Haul 01.

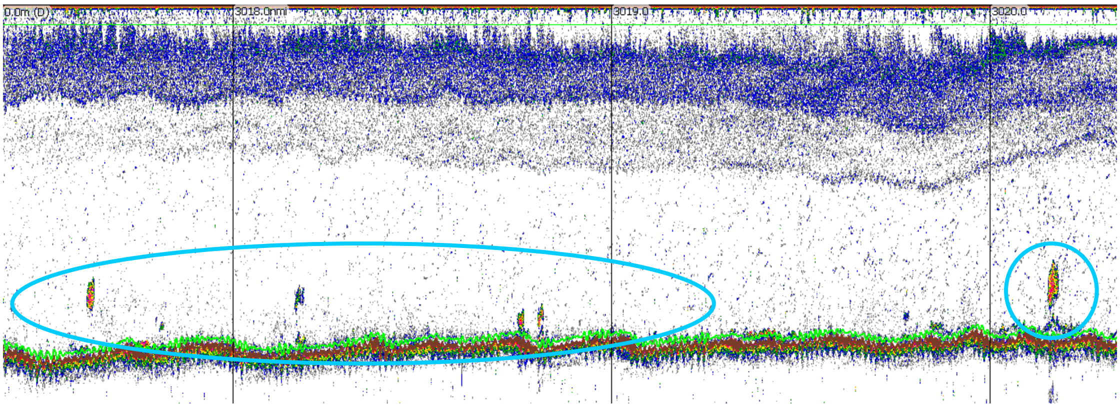


b). Boarfish echotraces from **northern area** (54°-59°N). recorded prior to Haul 22 by the *Celtic Explorer.* Bottom depth is 190 m with targets at 0-30 m.

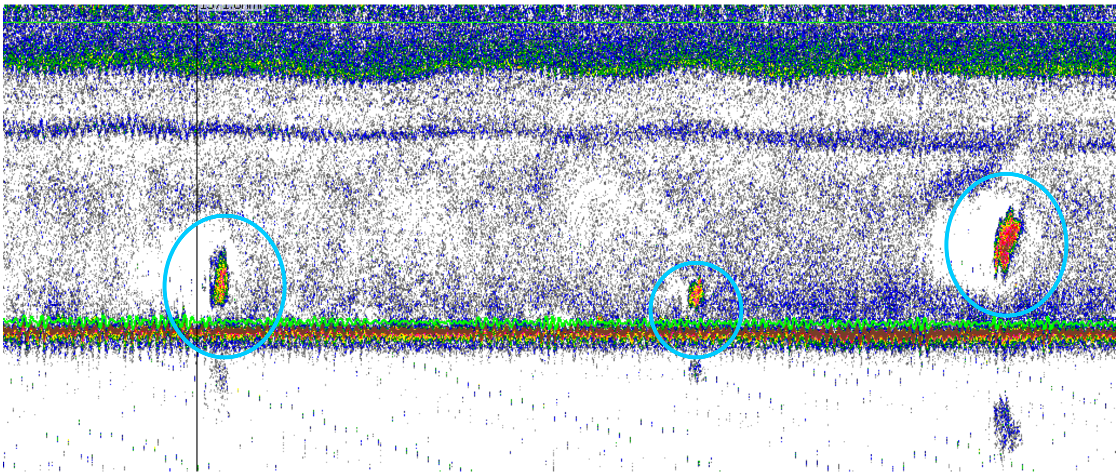


c). Cluster of high density midwater boarfish schools (circled) from the **western area** (51°-54°N). Recorded prior to Haul 02. Bottom depth is 150 m with target schools at 40-70 m.

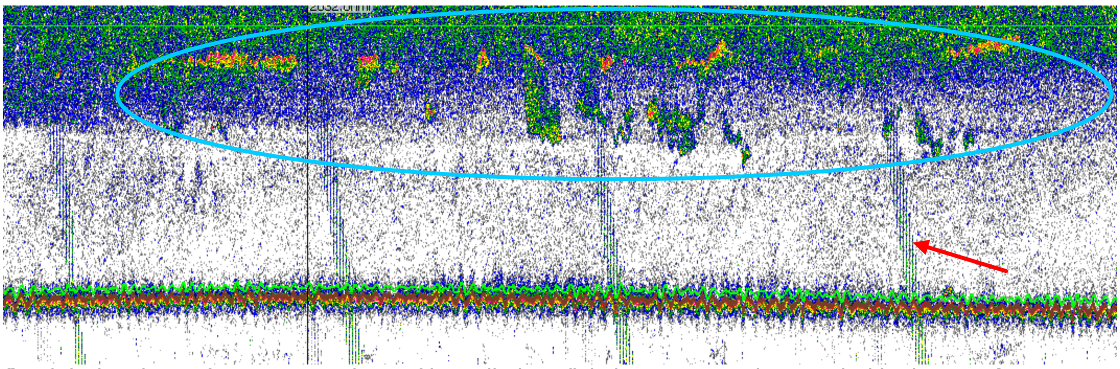
Figures 5a-h. Echotraces recorded at 38 kHz. Note: vertical bands on echograms represent 1 nmi (nautical mile) sampling intervals.



d). High density boarfish echotraces recorded prior to Haul 18 located close to the shelf edge in the **southern area** (51°'30-47°N). Bottom depth is 194 m with targets extending from 0-35 m off the bottom.

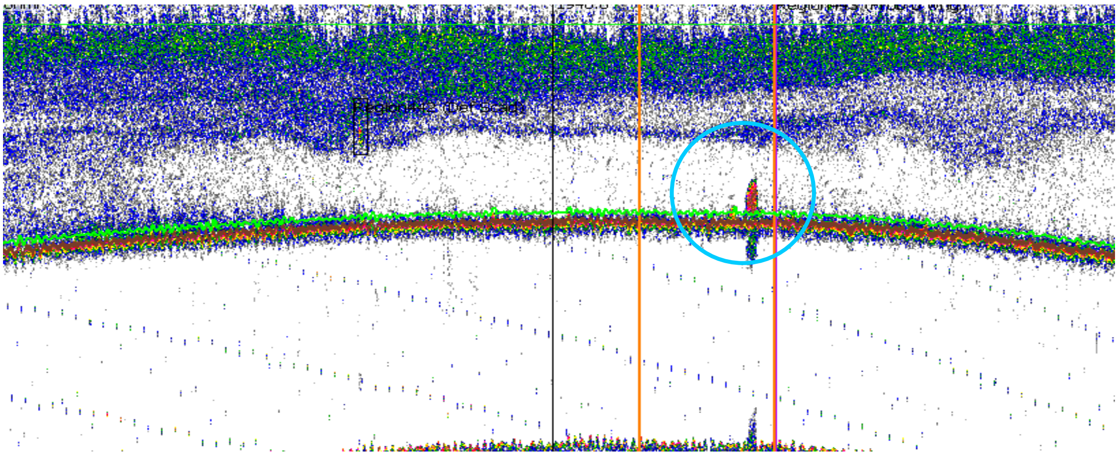


e). High density near bottom echotraces of boarfish typical of those encountered on the banks in the **southern area** (51°'30-47°N). Echogram recorded during to Haul 08. Bottom depth is 95 m with targets extending from 5-50 m off the bottom.

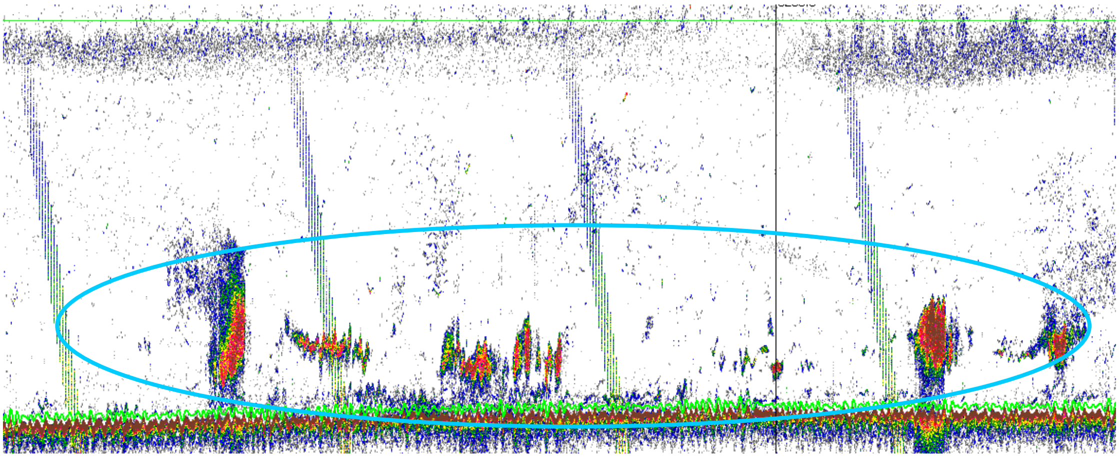


f). High density surface aggregations of juvenile boarfish (Mn L=7.5 cm), recorded in the **southern area** (51°'30-47°N) during Haul 14. Bottom depth is 120 m with targets extending from 20-70 m subsurface. Note: electronic interference (red arrow) is from the low frequency onmi directional sonar (25 kHz) used during fishing operations.

Figures 5a-h. continued.



g). Typical horse mackerel echotrace recorded in the **southern area** (51°'30-47°N) prior to Haul 13. Bottom depth is 109 m with targets occurring between 0-15 m.



h). High-density aggregations of 0-group juvenile blue whiting observed in the **southern area** (51°'30-47°N), recorded prior to Haul 19. Bottom depth is 165 m and schools extend vertically up to 45m.

Figures 5a-h. continued.

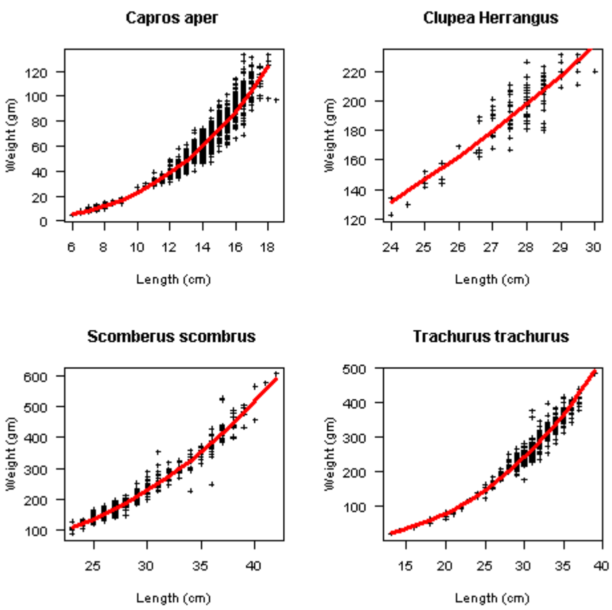


Figure 6. Length weight plots of major trawl component species.

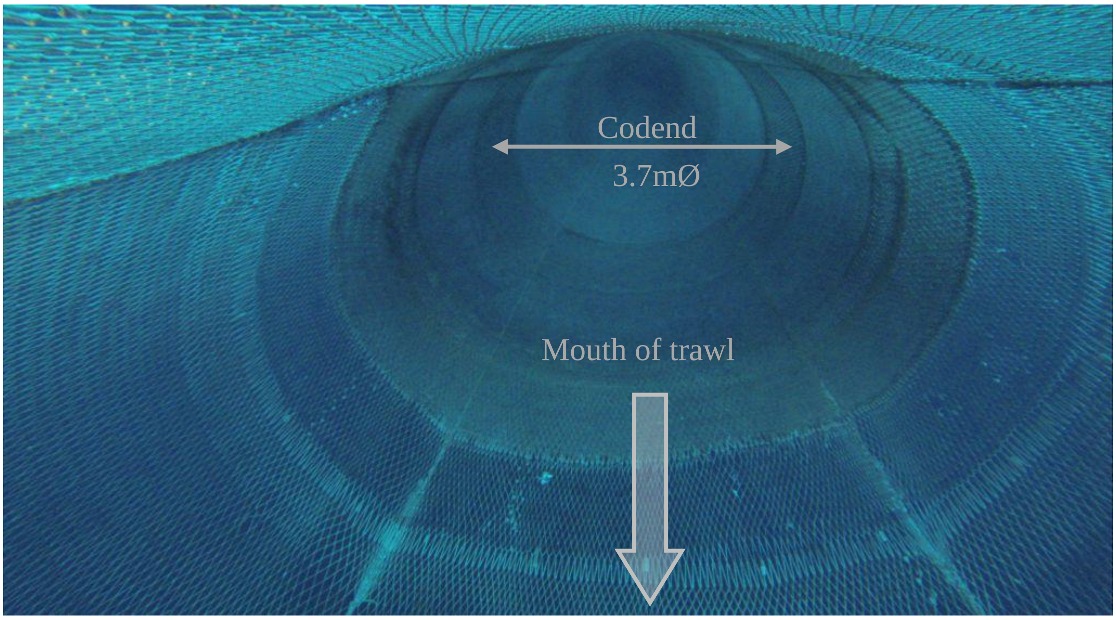


Figure 7. Unobstructed view of 4 panel single midwater trawl with standardised camera positioning.

Figure 8. Haul 20. Catch 3.0 t of 100% boarfish sampled within 0-20 m of the bottom with a water depth of 157m. Failing lights in the trawl resulted in darker image.

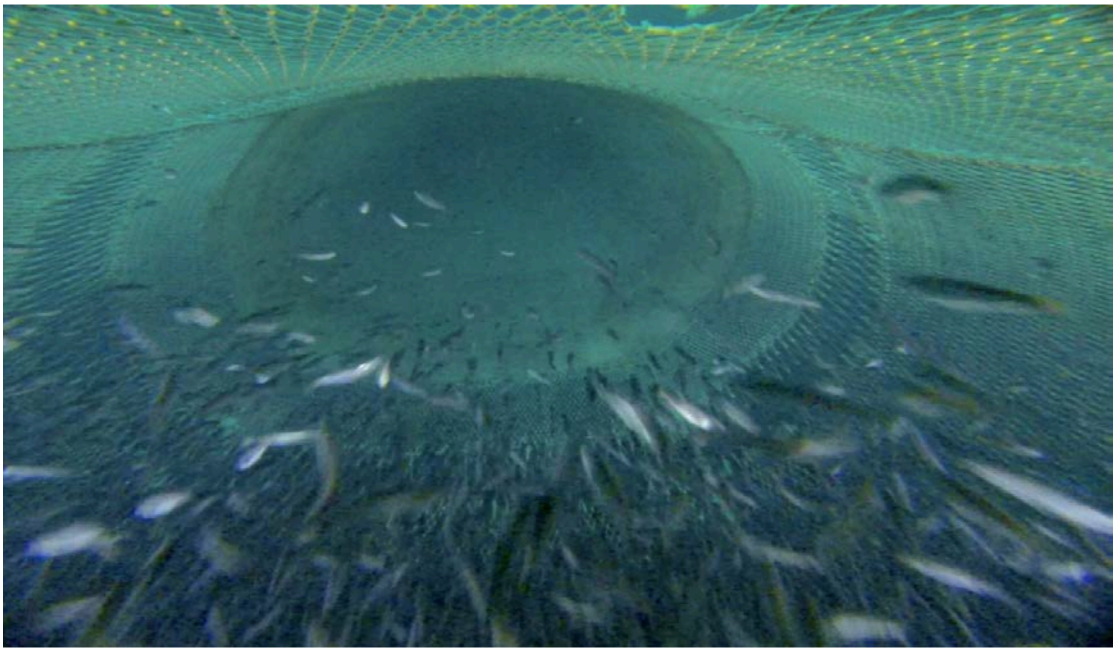


Figure 9. Haul 12. Catch 3 t of 100% juvenile blue whiting sampled within 0-17m of the bottom with a water depth of 140 m.

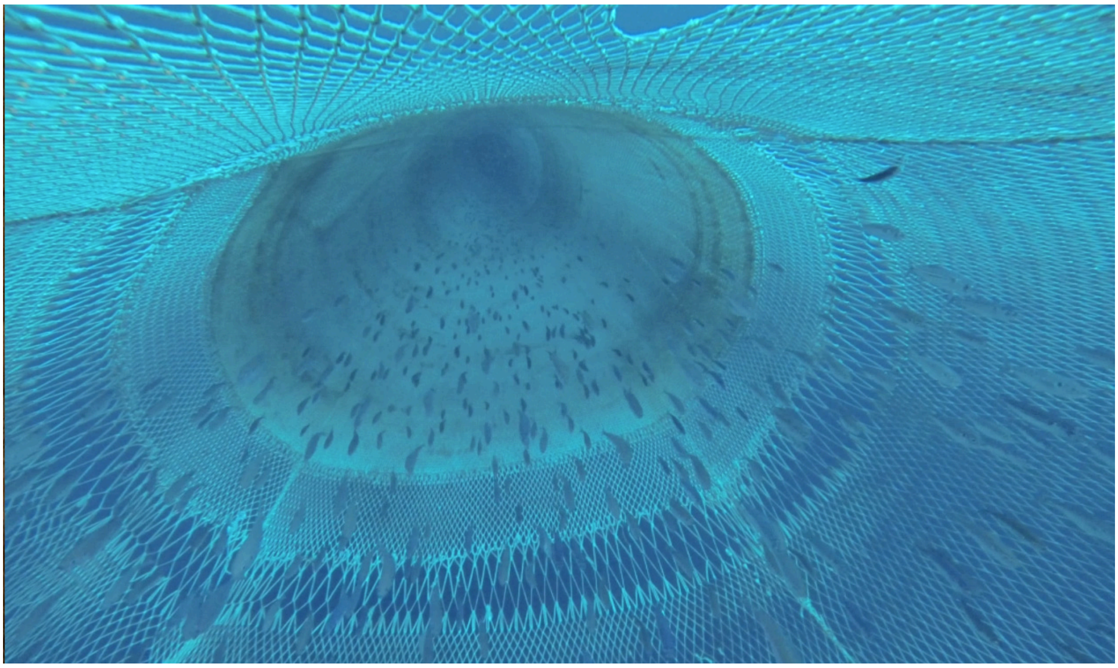


Figure 10. Haul 13. Catch 1 t, composition horse mackerel (38%), mackerel (55%), pilchard (0.1%) and a female blue shark (*Prionace glauca)*. Trawl within 15m of the bottom, water depth of 109m.

Appendix 1

Details of the charter vessel.

Figure 1. FV *Felucca* (SO 108). 54m LOA

Figure 2. Top side monitoring station located on the bridge. Laptop (left) running Echoview and EK 60 topside PC unit (right).

<u>Vessel details:</u>

Name:	MFV Felucca
Call sign:	EIGC
Type:	Fishing vessel (Pelagic RSW)
Registered:	Sligo, Ireland
LOA:	58 m
Beam:	11 m
GT:	1,093 t
IMO No.:	9131981
MMSI No.:	250000097

Appendix 2

Details of the in-trawl camera rig and positioning within the trawl.

The camera is a GoPro Hero 3+ black edition (www.gopro.com)
The camera allows a wide range of settings for stills and video capture. Details of settings are provided in the GoPro user manual (GoPro User Manual).

The camera housing
The camera housing is certified to a depth of 2,750m and is milled from a single block of anodised 6061 aircraft grade aluminium. The housing weighs 497 gr. The dimensions are: Length 8.3cm, Width 6.5cm, Height 5.4cm.

Light source
Light is provided by two modified Nautilux dive torches with an output of 2000 lumens. Modification increased the beam width to 120º from a narrow original spec. The torches have 3 constant light settings: High (2000 lumens), Medium (1400 Lumens), Low (600 Lumens). The high setting was used during the survey and provided c.2.5 hours of light more than enough for our needs. The light colour is neutral white at 4000K and provided by 3 x Cree XML LEDS.

Light housing
Lights were housed within two aluminium canisters depth rated to 1,250m.The outside dimensions of the cylindrical canister are 18cm long 18cm with a diameter of 7.6cm.

Mounting plates
Mounting plates were fabricated using polyethylene backing plates and strengthened using 316 grade stainless steel flat bar supports. A protective roll cage was constructed to protect the units during shooting and hauling. Both the camera and lights were attached to the mounting plates using adjustable angle mounts to fine tun field of view and illumination.

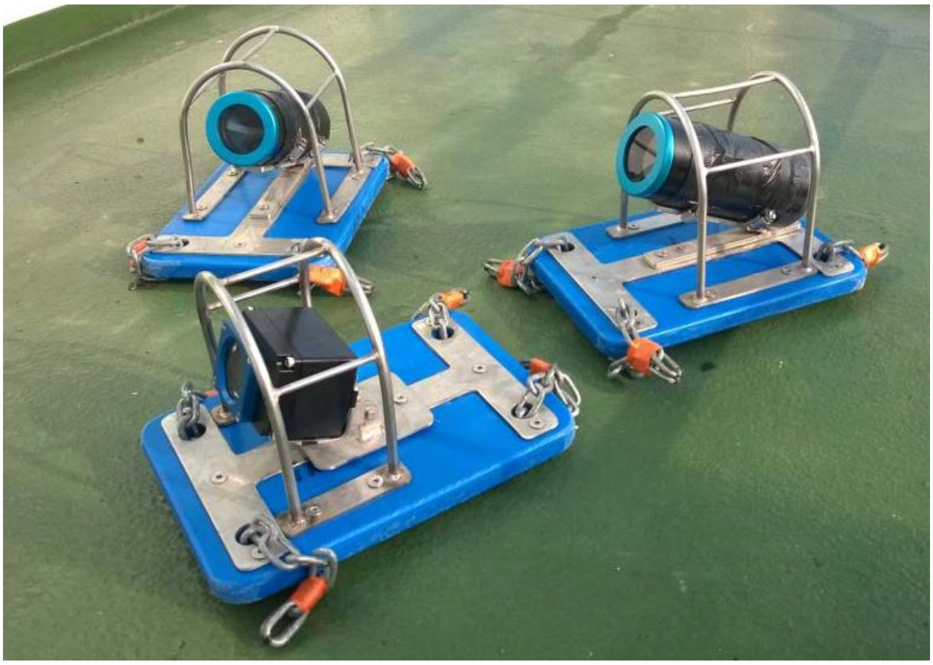


Figure 1 Camera (bottom) and lights on mounting plates.

Mounting within the trawl
Positioning of the camera was determined prior to the survey and marked out to allow ease of installation at sea. The rig was installed in the top of the net with the camera positioned along the mid line at a distance of 6m from the entrance to the brailer. The lights were positioned at 0.5m behind the camera and 0.5m to either side. This positioning allowed the entire net circle

within the field of view. Camera and lights were positioned facing backwards towards the brailer.

Mounting plates were installed upside down within the trawl through pre-cut holes and secured using screw lock clips to fixed mounting points. The rig was installed and removed for each trawl haul.

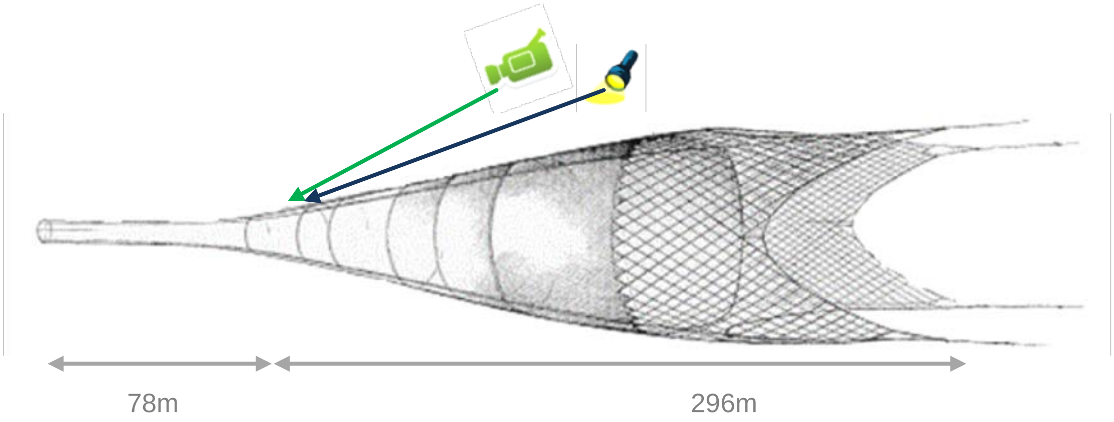


Figure 2 Schematic of pelagic trawl and positioning of camera and light rig. Rig was positioned on the top sheet (60mm half mesh) facing the mouth of the brailer. Net has a fishing circle of 1,050m with a vertical opening of c.50m.

<u>Data collection</u>
Continuous video was recorded for each for the duration of each haul and recorded onto a MicroSD card within the camera. Viewing was carried out post trawl using GoPro software.

Annex 5e: Peltic

DRAFT Survey report CEND22_15

PELTIC15: Small pelagic fish in the coastal waters of the western Channel and Celtic Sea

Jeroen van der Kooij, Elisa Capuzzo, Joana Silva, Mike Bailey

Survey report CEND22_15

PELTIC15: Small pelagic fish in the coastal waters of the western Channel and Celtic Sea

Jeroen van der Kooij, Elisa Capuzzo, Joana Silva, Mike Bailey

1. Outline of the survey

STAFF:

Part 1 (3rd -13th of October)	Part 2 (13– 21st of October)
1. Jeroen van der Kooij (SIC)	Jeroen van der Kooij (SIC)
2. Elisa Capuzzo (2IC)	Elisa Capuzzo (2IC)
3. Joana Silva (2IC)	Joana Silva (2IC)
4. John Pinnegar	Dave Brown
5. Dave Brown	Ken May
6. Buster Rook Bishop	Richard Humphreys
7. Richard Humphreys	Matt Eade
8. Matt Eade	Paul Bouch
9. Paul Bouch	James Pettigrew
10. James Pettigrew	Phil Lamb (PhD student)
11. Samantha Barnett	Mike Bailey (observer)
12. Philip Lamb (PhD student)	Pete Akers (observer)
13. Mike Bailey (observer)	Jack Lucas (observer)
14. Pete Akers (observer)	
15. Jack Lucas (observer)	

1.2. **Duration**: 3rd –21st of October

1.3 Location

Western Channel and Celtic Sea coastal zone (embarking in Portland and disembarking in Swansea)

1.4 Objectives

1. To carry out the third in a series of five annual multidisciplinary pelagic survey of the Western Channel and Celtic Sea waters to map, estimate the biomass of-, and gain insight into the population of the small pelagic fish community (sprat, sardine, mackerel, anchovy, horse mackerel, herring).

a. To carry out a fisheries acoustic survey during daylight only using four operating frequencies (38, 120, 200 and 333 kHz) to investigate:
   - distribution of small pelagic species
   - abundance of small pelagic species
   - distribution of the pelagic species in relation to their environment

b. To trawl for small pelagic species using a 20x40m herring (mid-water) trawl (taking the Cosmos Fotø and Engels 800 as back up) in order to obtain information on:
   - Species- and size composition of acoustic marks
   - Age-composition and distribution, from all small pelagic species
   - Length weight and maturity information on pelagic species
   - Stomach contents (stomach will be extracted frozen for future work)

2. To collect plankton samples using 2 different mesh ringnets (80 µm, and 270 µm mesh) at fixed stations along the acoustic transects at night and at a subset of trawl stations during the day. Samples will be processed aboard:
   a. Ichtyoplankton (eggs and larvae, 270 µm) of pelagic species will be identified and counted onboard and combined with information from maturity to identify spawning areas.
   b. Zooplankton will be stored for further analysis back in the lab.
3. Water column sampling. At fixed stations along the acoustic transect, an ESM2 will be deployed to obtain a vertical profile of the water column. Water column profiles and water samples will provide information on chlorophyll concentration, dissolved oxygen concentration, salinity, temperature, inorganic nutrients concentration and the relevant QAQC samples for calibration of the equipment. Water samples will be collected and fixed on board for analysis post-hoc.
4. To record the locations, species, numbers and activities of seabirds and marine mammals in the survey area during daylight hours.
5. Additional high resolution ESAS observations will be conducted on critically endangered Balearic shearwaters and other seabirds as part of a collaborative Defra funded project between MarineLife, Natural England and Cefas.
6. Ferrybox Continuous CTD/Thermo-salinigraph/pCO2. Continuously collect oceanographic data at the sea surface (4 m depth) during steaming.
7. To conduct further experiments with the online flow-cytometer to obtain continuous data on phytoplankton functional groups in collaboration with project JERICO NEXT.
8. To collect discrete samples of phytoplankton and micro-zooplankton at predetermined 18 primary stations for further analysis back to the lab (species composition, abundance, biomass and size distribution)
9. To collect water samples for nutrient and TA/DIC analysis in support of a programme on ocean acidification (Naomi Greenwood) to continue autumn time-series in area.
10. To map the acoustically derived zooplankton densities using the new 333 kHz frequency and compare it with data collected under 2 (and where possible 7) as part of Defra project HAZARD.
11. To collect genetic samples of gut contents and jellyfish for a UEA PhD studentship aiming to identify and quantify predation of jellyfish (Philip Lamb)
12. To collect and freeze samples of jellyfish for isotope work (Clive Trueman, NOC)
13. To quantify the size, biomass, distribution of the gelatinous species as part of a collaboration with the Nerc-Defra funded Marine Ecosystem Research Programme (MERP)

1.5 Narrative

Cefas staff joined the RV Cefas Endeavour in the afternoon of Friday the 2nd of October. The vessel left Portland the following morning at 6:00 AM of the 3rd of October and steamed straight to the calibration site off Portland Head (50° 36.180 N, 002° 35.762 W), to calibrate the echosounders. During the first calibration attempt which commenced at 9:00, slack tide was just missed and currents rapidly became too strong (+0.8 knots) so the attempt was interrupted until next the next slack tide at ~14:30. Instead a toolbox talk, muster drill and safety walks with all scientific staff were conducted before lunch. The aim was to use the two hours between lunch and scheduled resumption of the calibration to conduct shakedown tows with the ESM2, and plankton nets. However as those gears were prepared for deployment, a distress call came in at 13:30 requiring the RV Cefas Endeavour to abandon all planned operations and leave the calibration site to aid a yacht which had engine issues and could not move due to lack of wind. Despite the fact that there was no threat to life and the engine was working again, the RV's searider had to act as safety vessel and escort the yacht back into port. At approximately 16:30 the searider was back onboard the RV. However by this time the slack tide window was missed again rendering the calibration futile; even a shakedown tow with the pelagic trawl was by this point not possible due to specialist fishing staff on deck (bowson) being out of their 12 hours. The next slack tide was due after sunset and as the calibration spheres had not been located and previous experience had demonstrated that doing that in darkness was pointless, it was decided to postpone the calibration until a suitable future window and start the first of the primary stations that evening continuing through the night.

On Saturday morning the 4th of October survey started proper commencing with the eastern most of the acoustic transects. Similar to last year's survey, fisheries acoustic transects, trawling and bird and mammal observations were conducted during daylight hours only, and CTD and plankton stations were covered during the night. The first trawl of the survey took a bit of time; firstly after the trawl was shot it appeared that the wrong trawl rigged. Secondly after the correct trawl was rigged on the netdrum 1½ hours later, the crew needed to get familiar with the gear. After only a few trawl operations this improved notably and before long the quickest recorded time to the survey series was achieved consistently to shoot and retrieve the trawl gear. For the duration of the survey, when appropriate, the pelagic trawl was deployed to ascertain the species- and length composition of acoustic targets, or 'marks'. In total 23 valid tows were made, the highest for the survey series.

On the morning of 13th October, after completing all but two transects in the western Channel and most of the Isles of Scilly sub-area, the Endeavour steamed to Falmouth for a planned staff changeover which commenced at 8:00. J. Pinnegar, S. Barnett and B. Rook Bishop left the vessel, whilst K. May joined.

After changeover, at 10:15 BST the Endeavour sailed to the start of the last two transects left in the Channel subarea which were completed that day. After completion of the necessary CTD and plankton stations the Endeavour steamed overnight to complete the last of the Isles of Scilly subarea on the 14th of October and set an eastwards course to begin the survey of the Bristol Channel sub-area. Between the 15th and the 18th of October all but four of the south-west to north east running transects were completed in the Bristol Channel sub-area and on the night of the 18th saw the last of the primary CTD and zooplankton stations completed. This year distinct "bands" of fish biomass were present parallel to the coast both halfway along the transects and at the end of the transects. Prior to completing the last four of the conventional Bristol Channel transects, the excellent forecast for the Monday lead to a decision to run the 100 nmi transect from the inner Bristol Channel to the Celtic Deep on the 19th of October. Two planned transects were completed on the 20th of October and deteriorating weather conditions meant that only one trawl could be performed in the morning.

Weather conditions throughout the survey were exceptionally favourable with the worst conditions on the 5th of October not exceeding much beyond 30 knots of wind. Unusually most of the wind was from an easterly direction.

On the morning of the 21st the Endeavour completed the final two transect which ran from the north Devon coast into Swansea bay where the pilot was booked for 13:00. The RV Cefas Endeavour docked at 15:00 in Swansea port.

2. Material and Methods

2.1. Study area

The survey were conducted according to the PELTIC survey grid (Figure 1) established in 2012. Acoustic transects, plankton and water sampling were undertaken along the predefined transects, undertaken in a generally east to west direction for the first half of the survey, then a south-west to north east direction for the second half of the survey. Trawls were undertaken opportunistically, depending on the presence and type of acoustic marks observed.

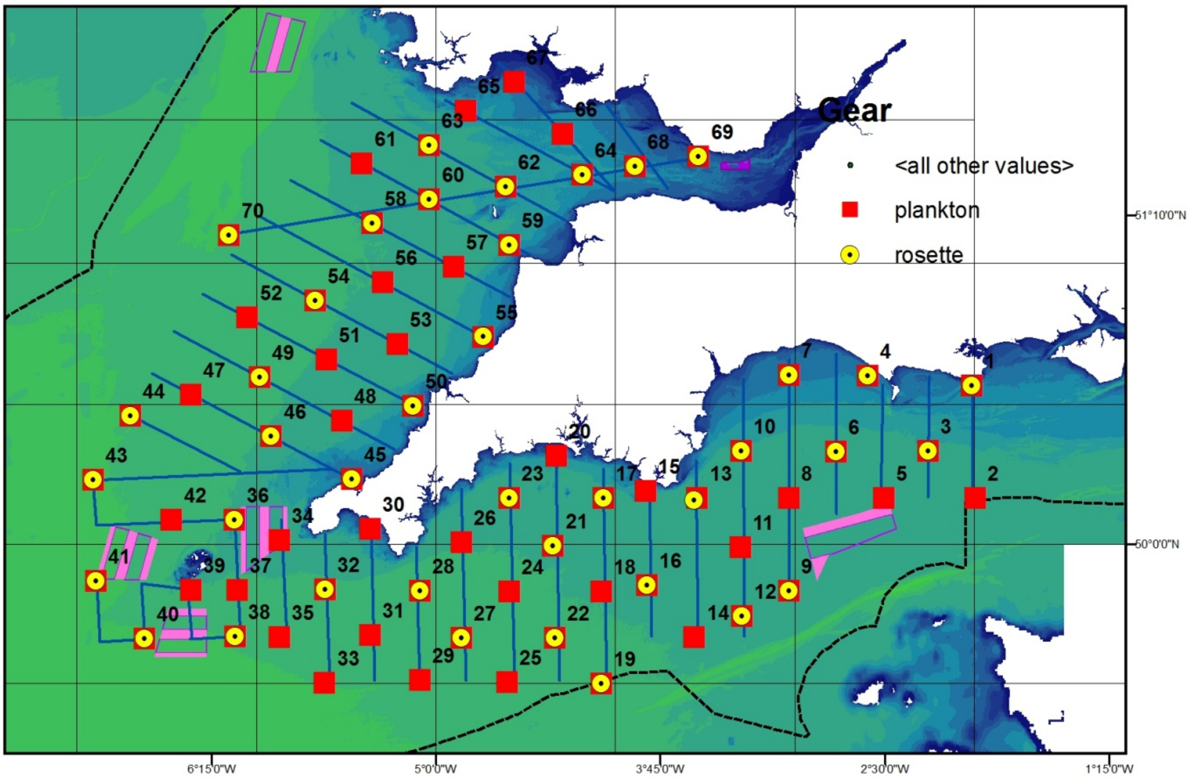


Figure 1. Overview of the survey area, with the acoustic transect (blue lines), plankton stations (red squares) and hydrographic stations (Yellow circles).

2.2 Fisheries acoustics

2.2.1. Acquisition

Due to the lack of a successful calibration at the start of the survey, the calibration settings from the previous survey were loaded. This excluded calibration settings for the 333 kHz which was not available for calibration at the time.

Fisheries acoustics were recorded along the pre-designed transects (Fig. 1) at the four operating frequencies (38, 120, 200 and 333 kHz). The transducers were mounted on a drop keel which was lowered to 3.0 m below the hull, 8.3 m below the sea surface. Pulse duration was set to 0.512 ms for the 38-200 kHz frequencies and to 1.024 for the 333 kHz frequency (as better results were obtained) and the ping rate was set to 0.5 pings s^{-1}. Due to the exceptionally favourable weather conditions, acoustic data were of very high standard. Poor quality surface data due to aeration was only encountered on the 5th and 21st of October and at no time was it necessary to hold acoustic data collection altogether. At all times on-transect live acoustic data were monitored and when unidentified acoustic marks appeared the trawl was shot where possible to identify these marks.

2.2.2. Processing

Acoustic data were cleaned, which included removal of data collected during fishing operations. Both the on-transect data and those collected during the steam between transects were retained. Only the former was used for further biomass estimates but the inter-transect data was retained and cleaned for future studies on spatial distribution of predators and prey. A surface exclusion line was set at 13 m and acoustic data below 1 m above the seabed were also removed to exclude the strong signals from the seabed. Large amounts of plankton were present throughout the survey, often represented in layers on all three acoustic frequencies (although at different strengths depending on the organisms). Fish schools and plankton were often mixed and a simple extraction of fish echoes was not possible. Therefore to distinguish between organisms with different acoustic properties (echotypes) a multi-frequency algorithm developed in 2012 was refined to separate echograms for each of the echotypes (Fig. 2). The echogram with only the echoes from fish with swimbladders was then scrutinised and attributed to individual species based on expertise and the nearest relevant trawls, using imagery of sonar and netsonde collected during the trawling process to assess the sampling performance in relation to the acoustic marks.

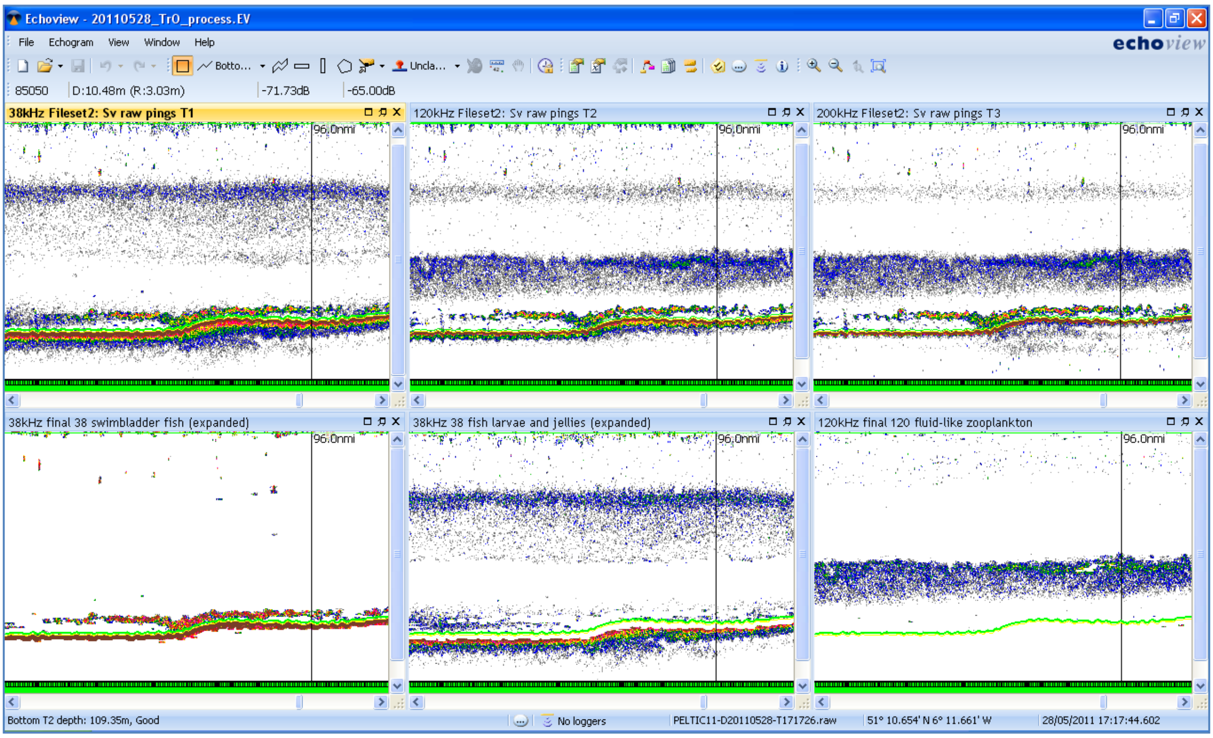


Figure 2. Dataflow of algorithm (top) used to divide the acoustic data by echotype. Screen-shot example (bottom) with raw echograms of 38, 120 and 200 kHz (top panels) and three examples of extracted echotypes (bottom panel from left to righ): fish with swimbladder (sardine schools at surface and myctophids layer near seabed), fish larvae/ jellyfish and zooplankton (dense krill layer).

In the case of mackerel a separate algorithm was used (following Korneliussen 2010). An additional bad weather filter was developed which removed “empty” pings as a result of adverse weather conditions. This was applied only on files which were affected by bad weather.

2.3 Fishing and catch sampling

A heavy duty ‘herring’ trawl (20 x 40m v d K Herring trawl, KT nets) was used to sample the pelagic community for the purpose of validating acoustic marks and collecting biological samples. The trawl was tested and tuned during the morning of the 2nd of October by experimenting with different weights, speeds and warp. A wireless 50 kHz Marport net-sonde was mounted on the head-rope of the trawl at the mouth of the net, which allowed for live monitoring of the trawling performance. In general, the trawl performed well and caught a broad range of species and size classes.

Fish were sorted to species and size categories before the total catch was weighed and measured using the Cefas Electronic Data Collection (EDC) system. In the case of very large catches, subsamples were taken before weighing and measuring. The sex and maturity of the pelagic species in each trawl was assessed (up to 10 per length class of mackerel, sprat, sardine, anchovy, horse mackerel, garfish, herring), and their otoliths and stomachs were dissected out and removed for later analysis. For the stomachs a total of up to 25 stomachs were taken across the various length categories per species per catch.

2.4 Zooplankton

The various planktonic size components were sampled at 71 fixed plankton stations along the various transects using two ringnets of different mesh: 270 µm (ichtyoplankton and macro-zooplankton) and 80 µm (zooplankton). The two ringnets were fixed to a frame which enabled them to be deployed simultaneously. Both nets had flowmeters (General Oceanics mechanical flowmeters with standard rotor, model 2030R) mounted in the centre of the aperture of the net and a mini-CTD (SAIV) was attached to the bridle. Position, date, time, seabed depth, sampled depth (from CTD attached to net) and flowmeter reading were recorded. Nets were washed down on hauling and samples were transferred from the terminal mesh grid. When possible, samples from the 270 µm mesh were transferred into jars and immediately analysed under a binocular microscope before the full sample was preserved in 4% buffered formaldehyde. If immediate analysis was not possible, samples were transferred into 1 lb glass jars and preserved before analysis on a later day during the survey. Ichthyoplankton (eggs and larvae) and macrozooplankton from the 270 µm samples were counted and, in the case of clupeid larvae, measured and raised using flow meter derived sample volumes. Samples from the 80 µm mesh were transferred into jars and preserved with 4% buffered formaldehyde for later analysis using a zooscan in the lab.

At a subset of 18 prime stations two water sample were taken and fixed on lugol, one for phytoplankton analysis back in the lab and one for micro-zooplankton analysis. In addition, this year at 40 stations surface samples of zooplankton were taken using the new CALPS (Cefas Autonomous Litter and Plankton Sampler). For an hour at each of these stations a sample was taken using an 80 µm mesh net to be compared with the vertical casts.

2.5 Oceanography

Physical, chemical and biological properties of the water column were investigated using different platforms of observations (Ferrybox, CTD, remote sensing) and by collecting of discrete water samples at the subsurface.

The Ferrybox provided continuous measurements in real time at the subsurface of different variables including temperature, salinity, fluorescence and dissolved oxygen concentration. Daily and weekly maps of chlorophyll concentration (OC5 algorithm), sea surface temperature and frontal systems were downloaded from Neodaas (www.neodaas.ac.uk). The Ferrybox, was connected to a flow cytometer, which performed hourly measurements of the size and abundance of pico- and nanoplankton populations. A pCO2 analyser carried out continuous measurements of the dissolved carbon dioxide in water and air during the whole survey.

Vertical profiles of temperature, salinity, fluorescence, optical backscatter, dissolved oxygen and Photosynthetically Available Radiation (PAR) were collected at 39 sampling stations using an ESM2 profiler. At 18 of these stations, water samples were collected at the surface from the continuous water pump that supplies the Ferrybox, for analysis of salinity, dissolved inorganic nutrients (for this project), samples for flow cytometry and pigments analysis, as well as for analysis of phytoplankton and microzooplankton communities.

Surface samples for determination of Total Alkalinity (TA), dissolved inorganic nutrients and dissolved organic matter (for PML, Shelf Sea Biogeochemistry project), and samples for dissolved oxygen analysis were collected from a Niskin bottle connected to the hydrowire of the ESM2 logger.

Samples for analysis of dissolved oxygen concentration, salinity and chlorophyll will be used for calibrating the sensors on the ESM2 profiler and on the Ferrybox.

A summary of the samples collected and of the CTD casts carried out during the survey is given in Table 1.

Table 1. Samples collected during the survey and number of vertical casts carried out.

	Total
Salinity	21
Dissolved oxygen	24
TA/DIC	13
Dissolved inorganic nutrients (PML)	13
Dissolved organic nutrients (PML)	13
Dissolved inorganic nutrients (Cefas)	18
Chlorophyll/Pigments analysis	38
Flow Cytometry	38
Phytoplankton	18
Microzooplankton	18
CTD casts with ESM2	39

2.6 Top predators

Effort-related surveys were made for top predators daily during all daylight hours whenever the ship was moving on or between transects. This year, two different but complimentary approaches were taken to record birds and marine mammals. On the Bridge wing of one side of the vessel (selected as appropriate to minimise sun glare), two experienced JNCC-accredited European Seabirds At Sea (ESAS) surveyors employed an effort-based distance sampling straight-line transect survey following strict ESAS methodology, whilst on the other Bridge wing, a single volunteer MARINElife surveyor employed an adapted and slightly simplified version of this methodology. As a result, a 90° bow-to-beam scan area was surveyed by the ESAS team continuously during daylight hours, including all transit cross-lines, and with the additional coverage provided by the MARINElife surveyor, a 180° scan area was surveyed almost continually throughout the entire survey. Furthermore, observations were conducted during the net-retrieval stage of each trawl to identify species of birds associated with the fishing activity of the survey vessel. All species of birds (both seabirds and terrestrial migrants) were recorded, along with all sightings of marine mammals.

ESAS methodology aims to achieve an assessment of the numbers and distribution of animals in a designated quantifiable area by employing a sampling method so that numbers can be extrapolated into the entirety of the study zone. ESAS methodology is an internationally recognised sampling method conforming to internationally accepted standards enabling data to be compared with surveys elsewhere. It is recommended that ESAS surveys only occur in sea state 4 or less, although the effects of environmental conditions on surveyability are very vessel dependent. Fortunately, the weather conditions during the entire 2015 Peltic survey rarely reached sea state 5 or above, facilitating almost constant useable data gathering.

Special attention was given to gathering data on Balearic Shearwaters, as the waters off south west England are considered an increasingly important habitat for this globally critically endangered seabird.

3. Preliminary results

3.1. Pelagic Ichthyofauna

After removing the off-transect data a total of ~1400 nautical miles of acoustic sampling units were collected for further analysis (Fig. 3). A total of 23 successful trawls were made (Fig. 3). The trawls were evenly spread across the survey area, providing a suitable source of species and length data to partition the acoustic data.

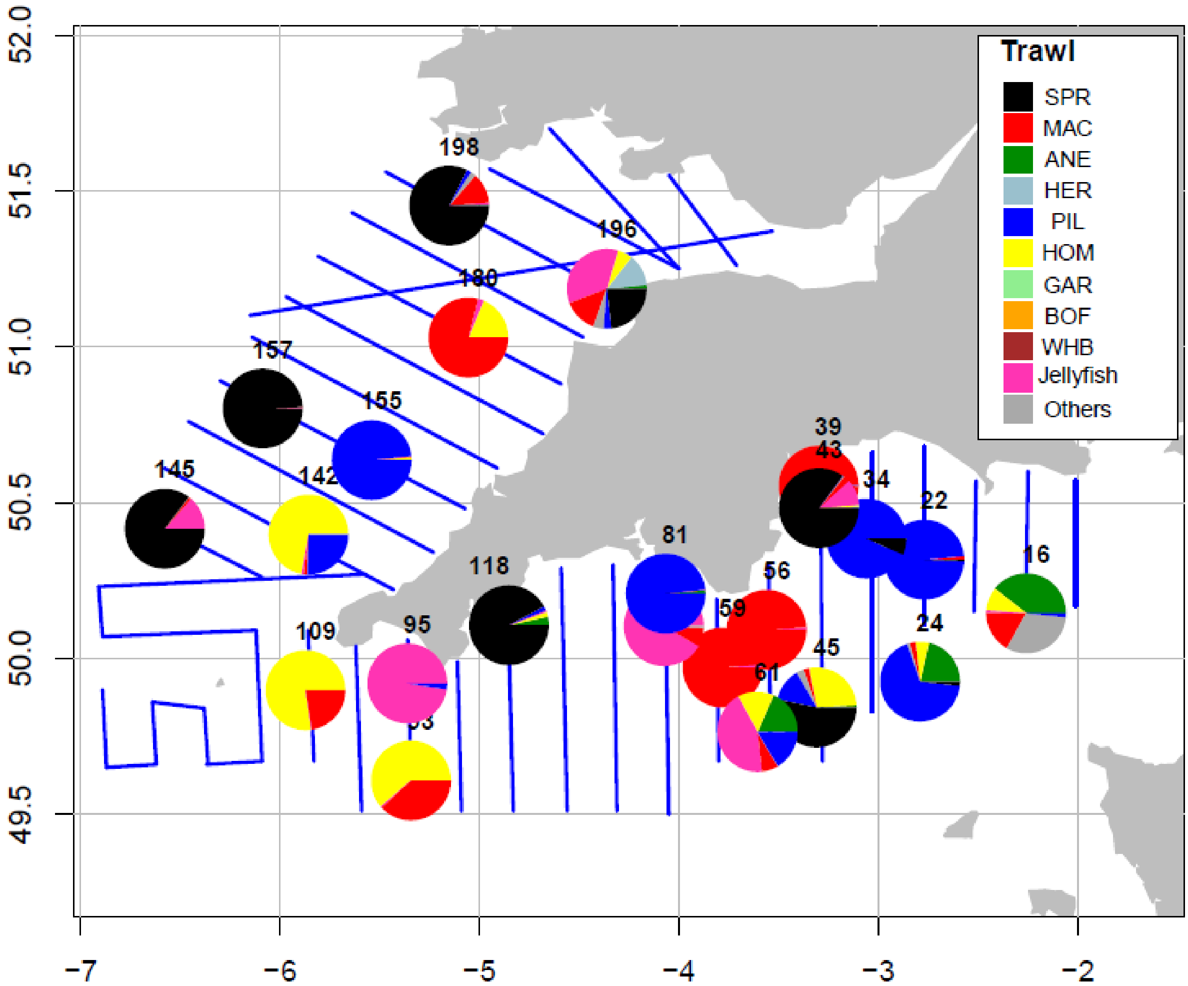


Figure 3. Overview map and detail of the survey area. Acoustic transects (blue lines) and trawl catches (pies) with relative catch composition by key species. Three letter codes: SPR=sprat, MAC=mackerel, ANE=anchovy, HER=herring, PIL=sardine, HOM= horse mackerel, GAR=garfish, BOF=Boarfish, WHB=Blue whiting.

Several trawls included jellyfish of at least three species. Sprat (*Sprattus sprattus*) dominated the inshore waters of England, both in the English Channel and in the Bristol Channel. However sprat in the Bristol Channel consisted nearly entirely of small specimens, whereas those from the Lyme Bay area were more mature (fig. 4). Some very high densities of sprat were encountered in Lyme Bay. For the first time sprat were found in deeper waters around the Isles of Scilly and large offshore aggregations mixed with sardine in the Bristol Channel.

Sardines (*Sardina pilchardus*) were much more widespread than in previous years according to the trawl stations (fig. 3), with specimens found in most hauls, including around the Isles of Scilly and offshore in the Bristol Channel (fig. 3 and 4). This year for the first time large spawning aggregations were observed in the acoustic data of the western channel (Fig 4).

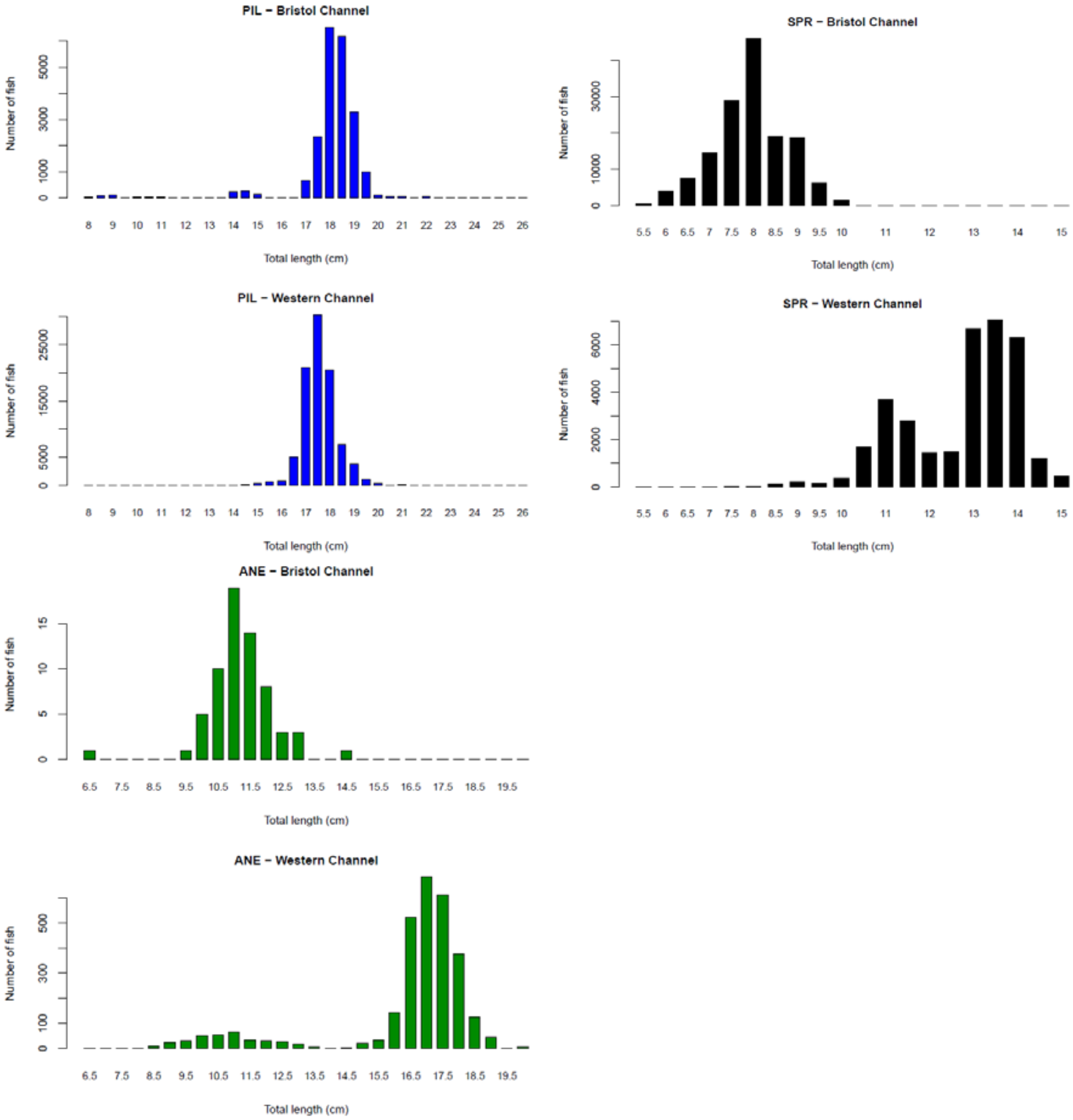


Figure 4. Trawl-caught numbers by length of sardine (*Sardina pilchardus*) (top left) sprat (*Sprattus sprattus*) (top right) and anchovy (*Engraulis encrasicolus*) by subarea. Please note that these numbers were not yet raised by the acoustic data.

Mackerel (*Scomber scombrus*) observations appeared to be in line with those in 2012 and 2014 when only small numbers of juvenile mackerel were found. None of the very large mackerel schools as seen in 2013 were observed in the western channel this year despite the large overlap in timing of the surveys.

This year, anchovy appeared in larger numbers than in previous years but again only in the Lyme Bay trawl stations (Fig 3, 5). However three length classes could be identified in the catches with good numbers of large fish. Horse mackerel (*Trachurus trachurus*) and herring (*Clupea harengus*) were found in the study area (fig. 3) although generally not in dense schools, but mixed in with other small pelagic species. Herring typically displayed a more coastal distribution whereas horse mackerel were found pretty much across the entire study.

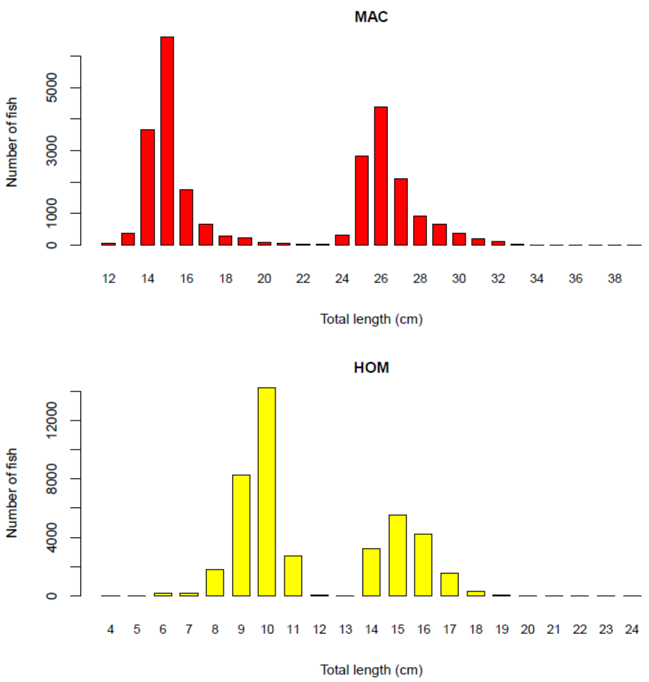


Figure 5. Trawl caught numbers by length of mackerel and horse mackerel for survey.

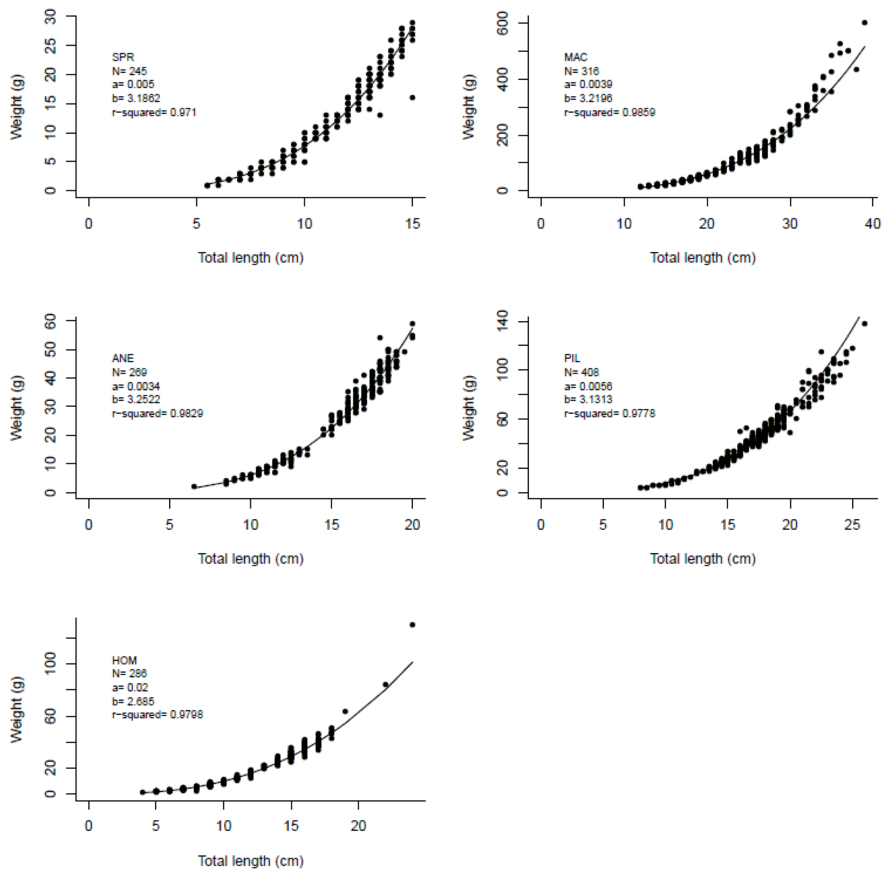


Figure 6. Length weight relationships of dominant pelagic species across the survey area.

3.2. Plankton data

Zooplankton samples were collected at 70 stations with the two ringnets. Whilst water samples were taken from 39 stations, only a subset of 18 "key" stations will be further analysed to extract micro-zooplankton. Onboard ichthyoplankton processing revealed that the bulk of eggs were sardine, with small numbers of sprat, lemon sole and sandsol making up the remaining categories. Most abundant were sardine eggs and larvae and “unidentified clupeid” larvae the vast majority of which were thought to comprise of sardine as few other clupeid species are spawning at this time of year. Sardine eggs were patchily distributed predominantly in the western part of the English Channel with smaller numbers in the Isles of Scilly. This year for the first time small numbers of eggs were found in the Bristol Channel. A detailed size based (zooscan) and taxonomic analysis of the zooplankton will be undertaken on return to the laboratory.

3.3. Oceanographic data

3.3.1. Temperature and salinity

With temperatures up to 16°C, surface waters of the Western English Channel were warmer than surrounding waters of the Celtic and Irish Seas (Figures 7 and 8). The average, minimum and maximum temperatures recorded at the 39 sampling stations during this survey (Table 2) were comparable with temperatures recorded during the survey in 2013 (Cend20_13); however, they were lower than temperatures measured in 2014 (Cend20_14). Particularly, the maximum temperature recorded in 2015 (15.95°C) was approximately 2°C lower than the maximum temperature measured in 2014 (18.14°C). Salinity of surface water at the different sampling stations was similar except for the inner stations in the Bristol Channel, which had a lower salinity as result of increased freshwater influence from the river Severn. The salinity range was comparable with the other three surveys (Table 2).

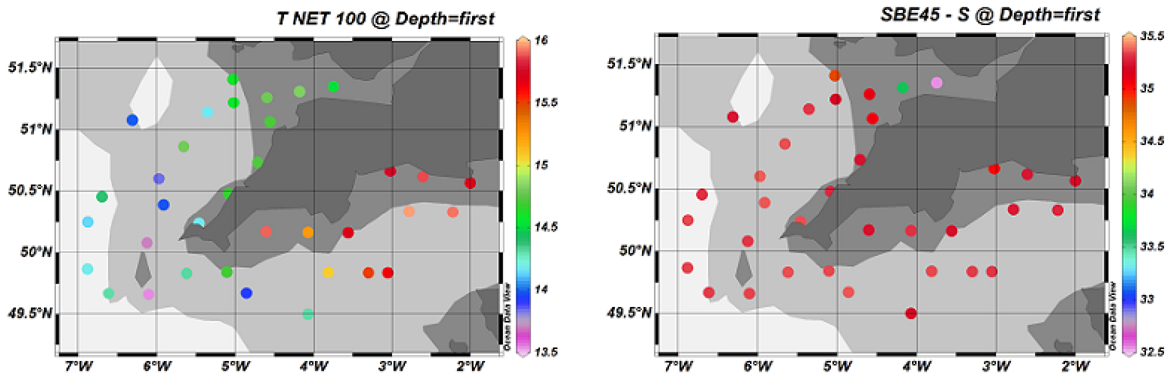


Figure 7. Temperature (T Net 100, °C) and salinity (SBE45) at 4 m depth measured by the Ferrybox at the 39 oceanographycal sampling stations between 3rd October and 19th October.

Remote sensing images (Figure 7) showed that a patch of slightly cooler water (approximately 14°C (Figures 7 and 8) was located south of Eddystone Bay and the Isles of Scilly south to the France coast. During the course of the survey the location of this patch of cooler water did not change, likely as result of the calm weather conditions and sea state. A similar patch of cooler water was also clearly visible in the remote sensing images from the 2014 survey, althought in 2014 it extended westward during the course of the survey.

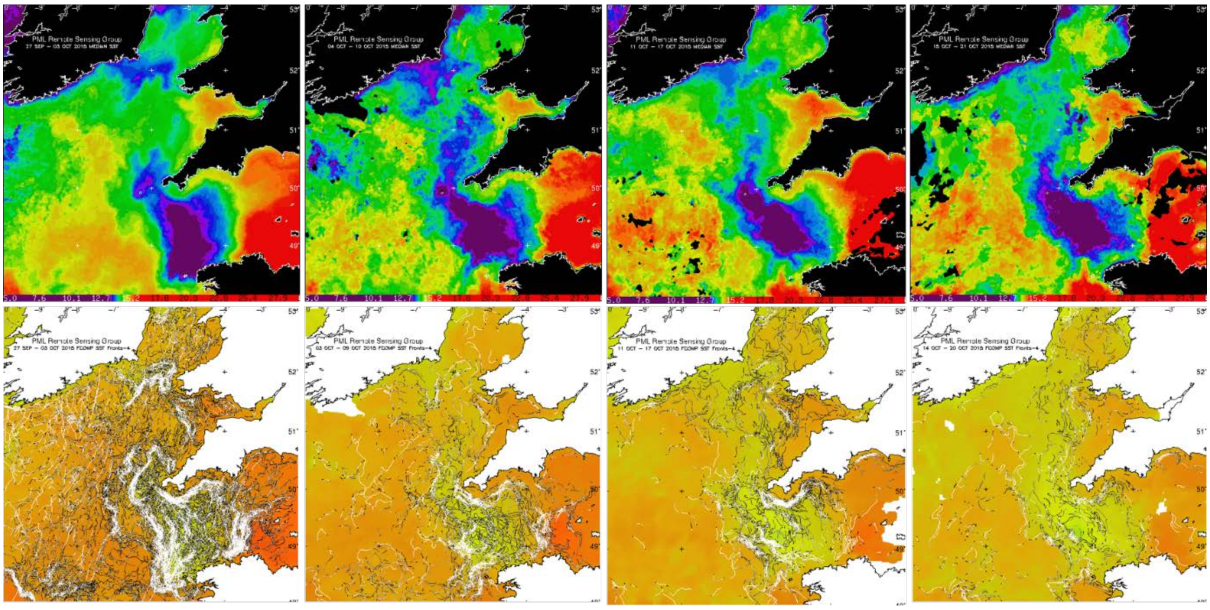


Figure 8. Composite surface maps for the periods 27 September - 3 October, 4 – 10 October, 11 – 17 October and 14-20 October 2015 of temperature (upper row of images) and thermal frontal systems (lower row) from Neodaas.co.uk.

The northern, eastern and western boundaries between the cool water patch and the warmer waters of the English Channel and the Celtic Sea was marked by a series of frontal systems (Figure 7), clearly visible particularly in the composite image for the week 27 September – 3 October. The frontal systems were present throughout the survey although they became weaker over time (Figure 7).

Table 2. Average, minimum and maximum values at 4 m depth of temperature, salinity and fluorescence, measured by the Ferrybox at the 39 oceanographycal sampling stations, during surveys in 2015 (Cend22_15), 2014 (Cend20_14) and 2013 (Cend20_13).

Survey	**Average**	**Minimum**	**Maximum**
Cend22_15 – Temperature (°C)	14.72	13.53	15.95
Cend22_15 – Salinity	35.14	32.53	35.14
Cend22_15 – Fluorescence	1.17	0.46	2.32
Cend20_14 – Temperature (°C)	15.98	14.62	18.14
Cend20_14 – Salinity	35.09	33.33	35.37
Cend20_14 – Fluorescence	0.19	0.08	0.44
Cend20_13 – Temperature (°C)	14.91	13.65	16.15
Cend20_13 – Salinity	35.28	33.36	35.61

Vertical profiles of temperature and salinity (carried out with a SAIV Mini CTD mounted on the zooplankton sampling nets) were plotted using the software Ocean Data View (ODW). Surface maps from CTD measurements (Figure 7) showed a temperature distribution similar to the one observed from the satellite-derived maps. The surface maps of the Western English Channel (Figure 10) show the presence of a gradient from cooler and saltier waters towards the Scilly Isle to warmer and less salty waters in Lyme Bay. Stations in the Bristol Channel showed a similar gradient (warm and less salty waters in the inner Bristol Channel, cooler and saltier waters in the outer Channel; Figure 10), although waters in the Bristol Channel were not as warm as in Lyme Bay (16.33 and 18.08 °C respectively; Table 2).

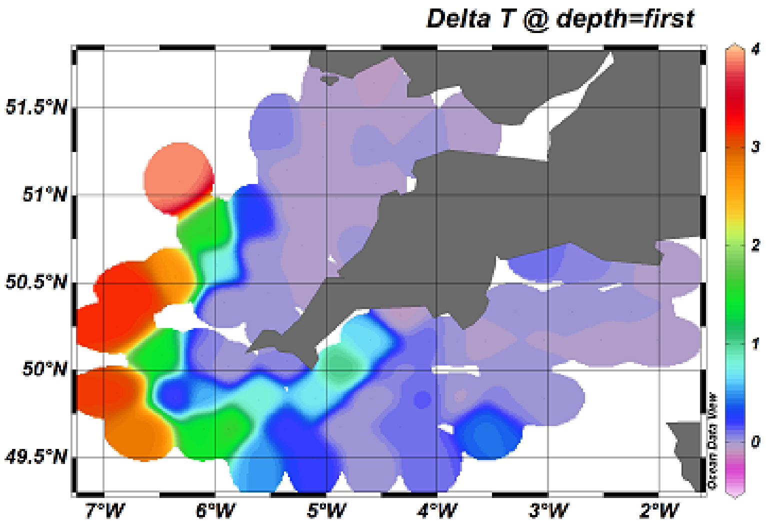


Figure 9. Values of ΔT (surface temperature – bottom temperature; °C) at the 69 sampling stations, as measured by the SAIV MiniCTD. The water column is considered stratified when ΔT > 0.5 (°C).

3.3.2. Chlorophyll and fluorescence

Higher levels of chlorophyll concentration were observed offshore, south of Edddystone Bay and around the Scilly Isles (Figure 10), corresponding with the frontal systems around the cool patch of water in the Western English Channel. In these frontal systems, nutrient-rich waters are mixed with nutrient-depleted surface waters leading to an observed increase in phytoplankton biomass.

Chlorophyll concentration was higher south of Lyme Bay and off the Scilly Isles, as shown by the Ferrybox raw fluorescence (Figure 11). Remote sensing images also indicated high level of chlorophyll concentration in Bristol Channel. However, this observation was not supported by the Ferrybox fluorescence measurements which were generally low (compare Figure 4 and 5). This was likely due to the higher level of suspended solids in the inner Bristol Channel affecting the reliability of the remote sensing algorithm for calculating chlorophyll concentration.

Remote sensed images (Figure 10) shows that the autumn bloom was well developed during the week before the survey (27 September - 3 October); however high level of fluorescence were recorded throughout the survey in different areas. On average, fluorescence measurements at the different sampling stations, recorded by the Ferrybox during this survey, were 6 time higher than average fluorescence measured during the previous year survey (Cend20_14).

Analysis of phytoplankton samples at the inverted microscope, and of samples for HPLC and flow cytometry in the laboratory will provide details of the pico-, nano- and phytoplankton community as well as their abundance and pigment composition.

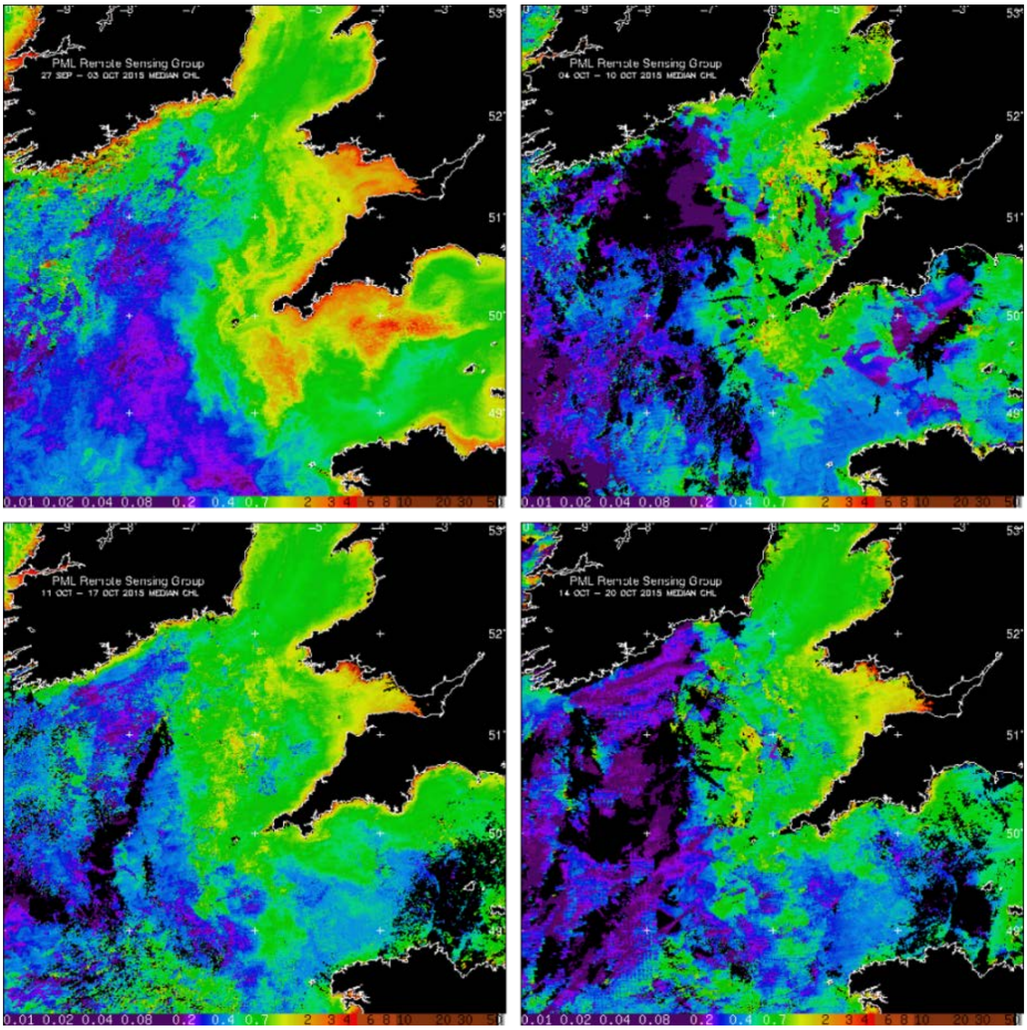


Figure 10. Composite surface maps for the periods 27 September - 3 October, 4 – 10 October, 11 – 17 October and 14-20 October 2015 of surface chlorophyll from Neodaas.co.uk.

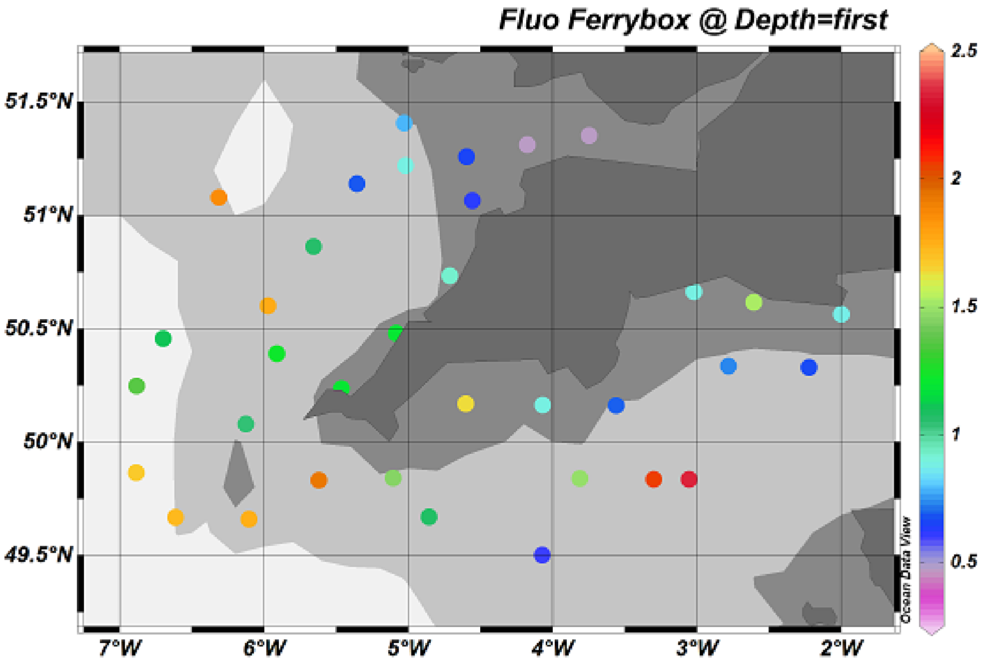


Figure 11. Fluorescence values at 4 m depth, at 18 sampling stations, as recorded by the Ferrybox.

3.4. Marine Mammals and birds

This year, as in 2014, all transects were run in daylight, and with more sea time in the survey area and better weather, almost complete coverage was achieved in all sections of the survey. Visibility during effort surveys was generally good to excellent, and rain was infrequent and fog absent.

In total, there were 170 sightings (96 in 2014) of seven cetacean species (same as in 2014), with significantly more individual animals counted (1790 compared to 1520 in 2014).

The most abundant cetacean species encountered throughout was Common Dolphin *Delphinus delphis* with 129 (76 in 2014) sightings of 1,650 animals (1520 in 2014), chiefly but not exclusively in deeper waters (>50m) in the west and northwest of the survey area. The White-beaked Dolphin *Lagenorhynchus albirostris* were encountered in the western section of Lyme Bay as in previous years; Long-finned Pilot Whales *Globicephala melas* were found south of Plymouth and all nine Fin Whale *Balaenoptera physalus* sightings (22 confirmed individuals) were located to the north west of the Cornwall and Devon coasts. Rorqual whale encounters where the animals were too distant to see their dorsal fins were logged as Unidentified rorqual sp., although they were all presumed to be Fin Whale. A single sighting of two animals at approximately 3 km distance from the vessel whose distinctly different blows were seen well and photographed, were thought to be humpback whales. However as no diagnostic views were obtained these were logged as unidentified baleen whales.

Detailed results of the bird observations were not available at the time of writing and only a brief summary is provided here. A total of 50 species of birds were recorded during the survey. A notable observation included a flock of at least 115 Storm Petrels *Hydrobates pelagicus,* feeding in the RV Endeavour’s wake during net retrieval operations, south of Portland Bill, Dorset.

Some evidence of visible migration was noted, particularly along the Dorset coast, with a steady stream of Meadow Pipits Anthus pratensis overhead. A Richard’s Pipit Anthus richardi and an Alpine Swift Apus melba seen off south Devon and south Dorset respectively were both vagrant individuals presumably blown off course by the easterly airflow which dominated the weather for most of the survey period.

Unexpectedly high numbers of Balearic Shearwaters, *Puffinus mauretanicus*, chiefly in the Bristol Channel in 2013 (79) and 2014 (205) provided an important focus again for 2015. This species is the UKs only critically endangered seabird, having declined by ~95% since 1970s. UK waters are at the edge of their non-breeding range however, distinct northward shifts in range have been noted in recent years so it is likely that the UK will become increasingly important. This year a minimum of 90 specimens were counted (subject to analysis of the two datasets recorded), the majority of which in the same general area to the west of Lundy Island in the Bristol Channel, as was the case in the previous two years. Behaviours noted include shallow plunge diving, surface pecking and active searching, particularly around feeding groups of Common Dolphin and occasionally investigating the RV Endeavour’s wake during net retrievals. These data will be further analysed as part of a Defra funded project to establish the importance of the Bristol Channel as an important feeding area, and will be used to inform future conservation measures.

4. Summary

The fourth autumn survey in the Peltic survey provided the first opportunity to conduct the acoustic transects in daylight only, as opposed to the 24 hour regimes in 2012 and 2013. The motivation was that in previous years at least one of the species (sprat) was observed to disappear at the top of the echograms at dusk raising concerns about under-sampling. Whilst this new sampling requires more survey time, this was compensated by the fact that 3 days of survey time were freed up by being able to mob and demob in the southwest reducing the steaming time significantly. Whilst the 16 trawl hauls fell below the number aimed, all provided good and representative catches. Pending completion of the acoustic data processing, preliminary results suggested that numbers of sprat, sardine and anchovy were all up from previous two years. Mackerel quantities appeared more in line with 2012 not showing any of the large schools observed in 2013. High numbers of sardine eggs were found and larvae numbers were down suggesting that the survey took place earlier in the autumn spawning season. Despite the large temporal overlap with the 2013 survey physical conditions were different: top temperatures were higher and strong frontal features existed in several areas of the survey whilst chlorophyll values were lower than last year.

Annex 5f: IHLS

1 International herring larvae surveys

1.1 Review of larvae surveys in 2015

1.1.1 North Sea

The main spawning grounds of North Sea autumn spawning herring are monitored annually in the International herring larvae surveys. They are treated as four sub areas (Orkney/Shetlands, Buchan, Central North Sea and Southern North Sea). The first two sub areas should be sampled twice, the last two sub areas three times during the spawning season in different half month intervals (Table 5e.1). The standard gear is a GULF III or GULF VII sampler and stations are approximately 10 nautical miles apart.

The abundance of newly hatched larvae (less than 10 mm total length; 11 mm for the Southern North Sea) is used as the basis for the index calculation. To estimate larval abundance, the mean number of larvae per square meter as obtained from the ichthyoplankton hauls is raised to rectangles of 30x30 nautical miles and the corresponding surface area. These values are summed up within the given sub area and provide the larval abundance per sub area for one interval.

However, since the middle of the 1990s, survey participation and effort is too low to monitor the whole spawning season. In the last two decades, almost only the Netherlands and Germany participated in the herring larvae surveys.

The herring larvae sampling period is still in progress at the time of the WGIPS meeting in January. So far, five units and time periods out of ten were covered in the 2015/16 period, as given below.

Table 5e.1: Areas and time periods covered during the 2015/2016 herring larvae surveys:

Area / Period	1-15 September	16-30 September	1-15 October
Orkney / Shetland	--	Germany	
Buchan	--	Netherlands	
Central North Sea	--	Netherlands	--
	16-31 December	1-15 January	16-31 January
Southern North Sea	Netherlands	Germany	Netherlands

For most of the herring larvae surveys in the North Sea, sample examination and larvae measurements have not yet been completed; therefore, it is not possible to give an overview on the final survey results. Figure 5e.1 shows the herring larvae distribution as obtained by the German survey in the Orkney/Shetlands and the Buchan area in the second half of September 2015.

As in previous years, the available information will be summarized and presented at the Herring Assessment Working Group (HAWG) meeting in March 2016.

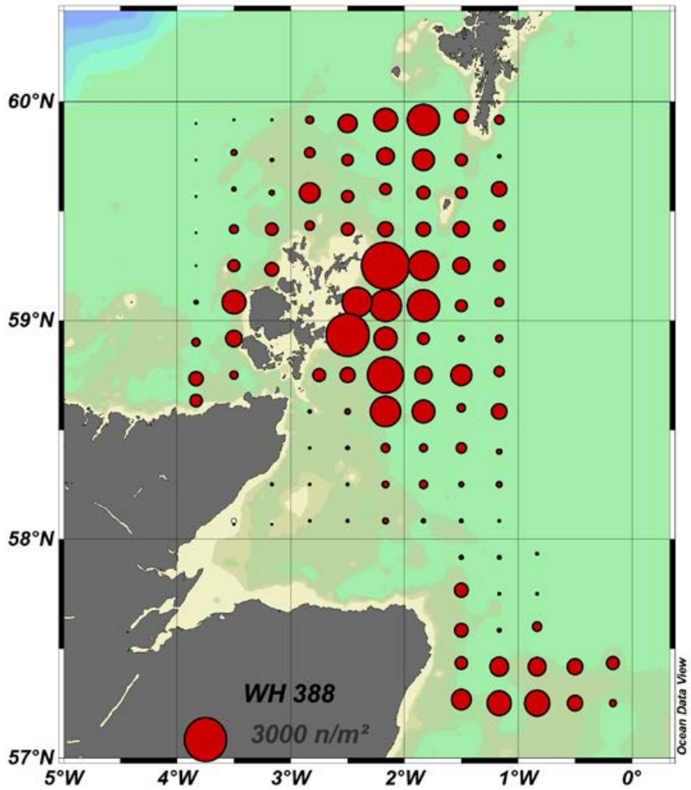


Figure 5e.1: Abundance of herring larvae per square metre (all sizes, n/m²), as obtained by the German survey in the Orkney/Shetlands and Buchan area (second half of September 2015). The symbol size is equal to 3 000 larvae/m². WH 388 refers to the national cruise number.

1.2 Coordination of herring larvae surveys in the North Sea in 2016

At the time of the WGIPS meeting, only the participation of the Netherlands and Germany is confirmed for the next herring larvae survey period in the North Sea. Due to limitations in available ship time, none of the areas will be covered neither in the first half of September nor in October. Sampling will be done in the second half of September by Germany in the Orkney/Shetland area and by the Netherlands in the Buchan area and the Central North Sea. The whole spawning activity of Downs herring will be monitored in three surveys from the middle of December 2016 to the end of January 2017. A preliminary timetable for the next sampling period is presented as follows:

Table 3.2.1: Areas and time periods for the 2016 herring larvae surveys:

Area / Period	1-15 September	16-30 September	1-15 October
Orkney / Shetland	--	Germany	
Buchan	--	Netherlands	
Central North Sea	--	Netherlands	--
	16-31 December	**1-15 January**	**16-31 January**
Southern North Sea	Netherlands	Germany	Netherlands

1.2.1 Irish Sea

Herring larvae surveys of the northern Irish Sea (ICES area VIIaN) have been carried out by the Agri-Food and Biosciences Institute (AFBI), formerly the Department of Agriculture and Rural Development for Northern Ireland (DARD), in November each year since 1993. The surveys have been carried out onboard the RV “Corystes” since 2005, and prior to that on the smaller RV “Lough Foyle”.

Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea (Figure 3.1.3.1). Larvae are sampled using a Gulf-VII high-speed plankton sampler with 280 μm net. Mean catch-rates (nos.m-2) are calculated over stations to give separate indices of abundance for the NE and NW Irish Sea. Larval production rates (standardized to a larva of 6 mm), and birth date distributions, are computed based on the mean density of larvae by length class.

A growth-rate of 0.35 mm day-1 and instantaneous mortality of 0.14 day-1 are assumed based on estimates made in 1993–1997.

The 2015 survey was conducted in fair to good weather conditions. The spatial distribution of herring larvae was similar to previous years, with high abundances to the north of the Isle of Man and in the Douglas bank area. Evidence of a more southerly dispersal of larvae was provided by the relatively high abundances of larvae in the southern stations. A number of larvae were encountered in the vicinity of the Mourne spawning grounds off the Northern Irish coast.

The point estimate of production in the north-eastern Irish Sea for 2015 (2.06 x 1012 larvae) was an increase from last year but still below the time series mean (Figure 3.1.3.2). The advanced stage of development of many of the larvae suggested earlier hatching and possible good growth rates of larvae. The index is used as an indicator of spawning-stock biomass in the assessment of Irish Sea herring by the Herring Assessment Working Group (HAWG).

The 2016 survey is scheduled to take place Oct 31st- 6th November.

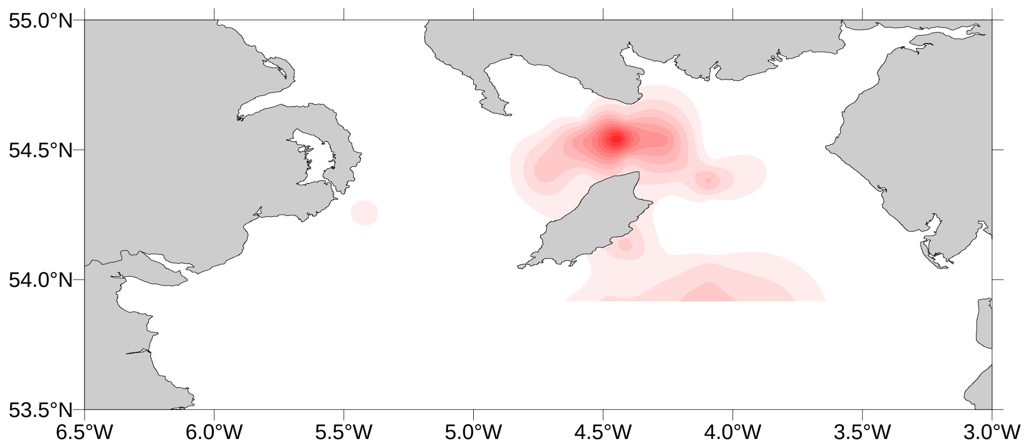


Figure 1.2.1.1: Estimates of larval herring abundance in the Northern Irish Sea in 2015. Intensity of shading is proportional to larva abundance.

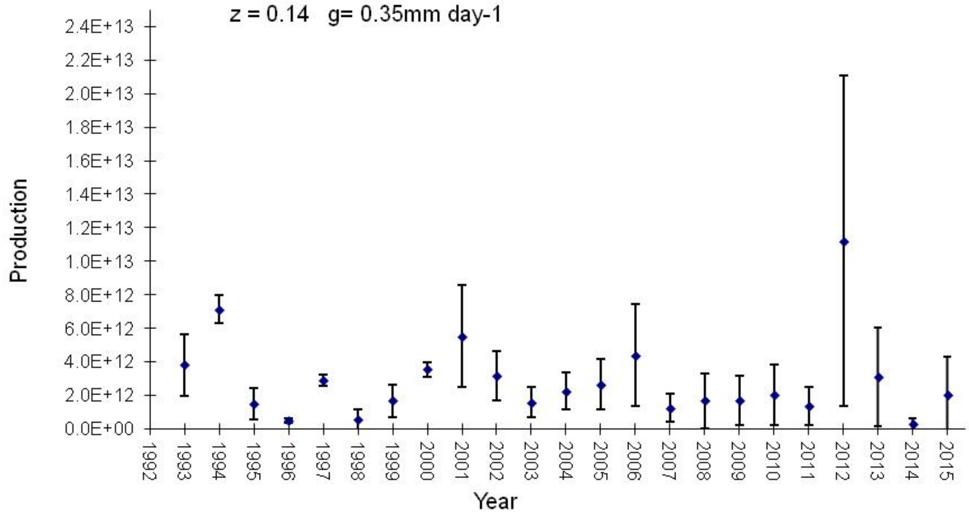


Figure 1.2.1.2: Estimates of larval herring production in the NE Irish Sea from 1993 to 2015. Error bars denote 1 standard error (calculated from coefficients of variation of the estimates of abundance, but not including uncertainty in growth or mortality).

Annex 6: survey planning

IBWSS

Four vessels representing the Faroe Islands, the Netherlands (EU), Ireland (EU) and Norway are scheduled to participate in the 2016 blue whiting spawning stock survey.

Survey timing and design were discussed during the 2015 IBWSS post-cruise and 2016 WGIPS meetings. The group decided that in 2016, the survey design should follow the principle of the one used during the three previous surveys. The focus will still be on a good coverage of the shelf slope in survey areas 2 and 3 (Figure A6.1.). However, this year area 2 will be covered by longitudinal transects perpendicular to the slope

The design is based on variable transect spacing, ranging from 30 nmi in areas containing less dense aggregation (areas 1 and 5), to 20 nmi in the core survey area (area 2, 3 and 4) (Figure A6.1.). The western borders of the transects in area 3 are set to 12°W in order to cover potential blue whiting aggregations extending further from the continental slope into the Rockall Trough. Transects are drawn systematically with a random start location.

The aim is to have three vessels surveying on their transects in area 3 at the same time. That way, the core survey area 3 can be covered synoptically by several vessels with similar temporal progression.

It was decided that the Dutch and Irish vessels would start the survey in the southern areas. 3–4 days after beginning their individual surveys, these vessels will be joint by the Norwegian vessel progressing northwards. Once the Norwegian vessel has finished surveying area 3 and 5, it will continue northwards into the Faroese-Shetland channel, area 4, and continue coverage in a northeastern direction. The Faroese vessel will primarily survey area 4 (Faroese/Shetland) and join the other vessels in the north of area 3 once they are present there towards the end of the survey period. The Rockall area will be covered by the Irish, Dutch and Norwegian vessels, starting in the south, progressing northward. Survey extension in terms of coverage (51–61ºN) will be in line with the previous year to ensure containment of the stock and survey timing will also remain fixed as in previous years.

Key will be to achieve coverage of area 3 in a consistent temporal progression between vessels. It is therefore very important that all vessels covering the core Hebrides area are present on station in the north of area 2 (just north of Porcupine Bank) on 24–25 March 2016. Nonetheless, if some vessels are found to lag behind others, the 20 n.m. transect spacing will allow for adaptation of the survey design without great loss of coverage. For instance, this may mean either skipping or extending some of the horizontal transects to catch up or keep pace with the other vessels. Biological sampling should be carried out following methods normally applied to sampling acoustic registrations.

If registrations of blue whiting marks are continuing at the end of any planned transects, the length of these transects should be extended until no more marks are registered for a distance of 3 n.m. (or 20 minutes at normal survey speed). The transect at the outer western boarder can be cut off, if no registration of blue whiting for 5 n.m.

Preliminary cruise tracks for the 2016 survey are presented in. Survey coordinator in 2016, Ebba Mortensen (Faroe Islands) has been tasked with coordinating contact between participants prior to and during the survey. Detailed cruise lines for each ship will be circulated by the coordinator to the group by the end of January 2016.

As the survey is planned with inter-vessel cooperation in mind it is vitally important that participants stick to the planned transect positioning.

Participants are also required to use the logbook system for recording course changes, CTD stations and fishing operations. The survey will be carried out according to survey procedures described in the ICES WGIPS Manual for Acoustic Surveys.

Table A6.1. Individual vessel dates for the active surveying period in the 2016 International Blue Whiting Spawning stock Survey (IBWSS).

SHIP	NATION	ACTIVE SURVEYING TIME (DAYS)	DEFINITIVE SURVEYING DATES
Celtic Explorer	Ireland (EU)	16	19.3.2016 – 8.4.2016
Hired vessel	Norway	14	21.3.2016 – 6.4.2016
Tridens	Netherlands (EU)	17	21.3.2016 – 8.4.2016
Magnus Heinason	Faroes	11	30.3.2016 –13.4.2016

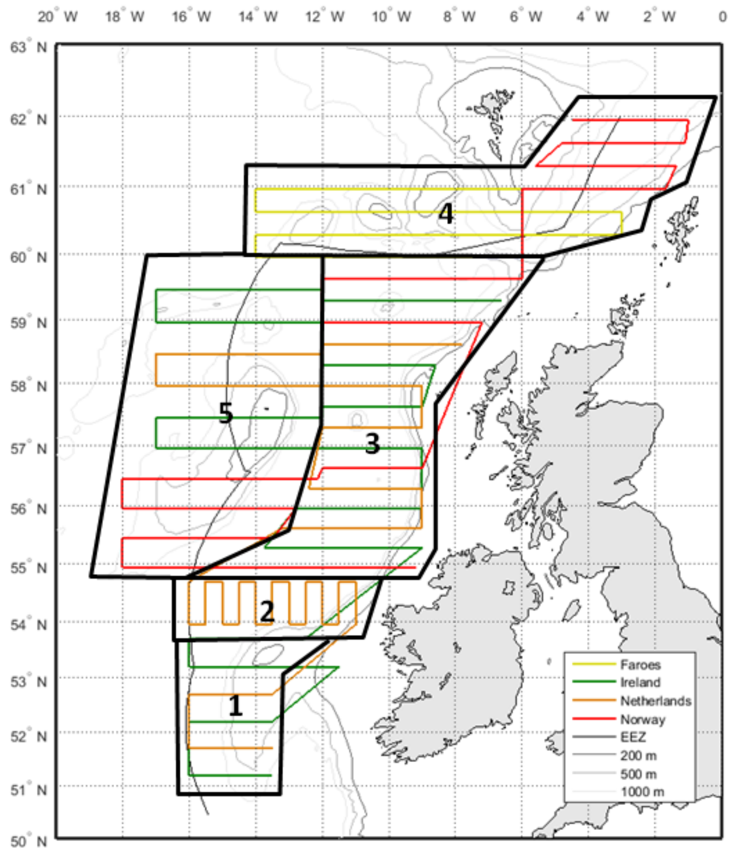


Figure A6.1. Planned survey tracks for the combined 2016 International Blue Whiting Spawning stock Survey (IBWSS).

IESNS

Denmark (EU-coordinator), Faroe Islands, Iceland, Russia and Norway will participate in the IESNS survey in April-June 2016. Ships and preliminary dates are given in Table A6.2. Survey days exclude time for: hydrographic cross sections, coverage outside the IESNS area and crew change. As in the two previous years, the plan is to use a stratified systematic transect design with random starting points. The suggested transects in each stratum are shown in Figure A6.2. Compared with last year, more survey effort is put into stratum 1 and 3. In addition, Norway will cower two rows of transects across the Norwegian Sea (between Iceland and Norway) in order to collect plankton data from this "cross section". Norway will be the survey coordinator during the cruise. A post-cruise meeting is suggested to be held on 21–23 June 2016 in IJmuiden, The Netherlands.

Table A6.2. Individual vessel dates for the active surveying period in the 2016 IESNS.

Ship	Nation	Survey days*	Preliminary dates
Dana	Denmark (EU)	20	27 Apr – 26 May
Magnus Heinason	Faroes	11	5 May- 17 May
Árni Friðriksson	Iceland	17	2 May – 23 May
Johan Hjort	Norway	30	2 May – 8 June
Fridtjof Nansen	Russia	25	15 May – 10 June

*estimated effective survey days in the IESNS area

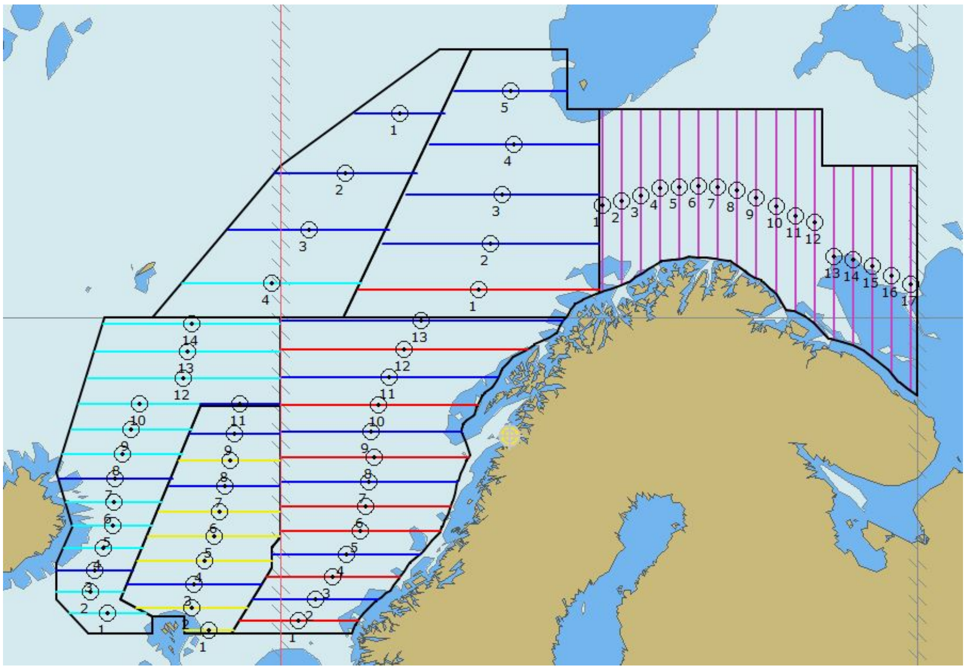


Figure A6.2. Suggested transects for the IESNS survey in 2016. Colours represent the different vessels/nations (yellow: FO, light blue: IS, dark blue: NO, red: EU, purple: RU).

IESSNS

The main priority for IESSNS is standardized trawling in the surface for mackerel at predetermined locations. In addition will there be acoustic recordings down to 500 m targeting herring and blue whiting. In 2016 will the following countries participate in IESSNS; Norway with two vessels in the period 1-31 July, Island with one vessel in the period 1-31 July, Faroese with one vessel in the period 1-18 July and Greenland with one vessel in the period 24 July-7 August. The can be minor adjustment to the periods. Covered area will generally be the same as the last years (fig a). As in 2015, the survey area is divided into different strata. There is a variable effort for the different strata, which is correlated with expected abundance. It is random positions and equal distance between stations within each stratum. Highest effort will be in southern region of Iceland, Faroese waters and in the central Norwegian Sea. It is a challenge to coordinate the survey to minimize the possibility for double counting of fish. This is especially the case for Iceland, which survey around the island. To account for this, Iceland will survey clockwise around the island starting in the northwestern region. Norway and Faroese will start in the south and move northwards with east-west transects. The vessels will to some degree overlap transects this year. The survey in Greenlandic waters has not been planned in detail yet, due to uncertainty regarding the number of days for the survey.

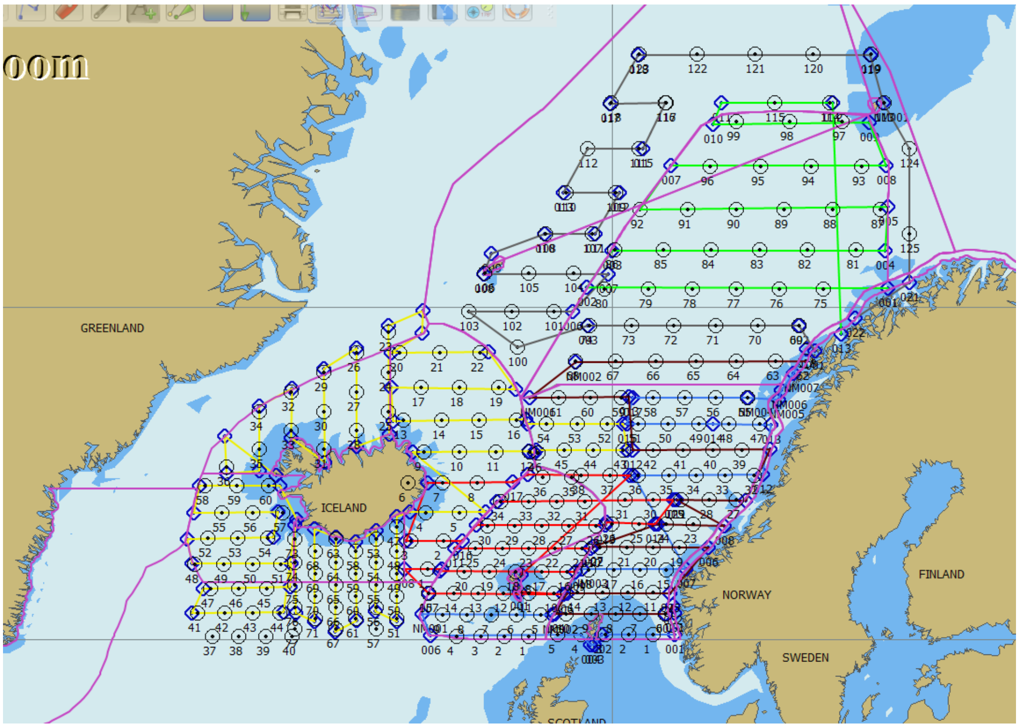


Figure A6.3. Map of the planned stations and transects of IESSNS 2016. NB: Coverage for the Greenland vessel is not included in the figure.

HERAS

Norway, Denmark, Germany, Netherlands, Scotland and Ireland will participate in the 2016 HERAS and MSHAS surveys. Ships and preliminary dates are given in Table A6.3. During WKEVAL 2015, several areas requiring standardization among participating nations were identified. With the move away from rectangle based estimation, it was necessary to establish a new set of survey strata for the HERAS survey area while maintaining historical geographical coverage. Inshore extension was maintained at the 20m contour for shallow waters regions of the Baltic and southeastern North Sea and the 30m contour for all other areas where applicable. The Norwegian survey is bounded a set distance from shore (5 Nautical mile) due to operational reasons as the 30 m contour is not practical due to the steep coastal topography. The 200 m contour marks the lower depth limit of the survey at the shelf edge and in the northern boundary. The preliminary strata for 2016 are displayed in Figure A6.4.

The survey design will be standardized across participants and will follow best practice with transect planning. The main body of the survey will utilize systematic parallel transect lines with randomized starting points and with transects running perpendicular to lines of bathymetry. Zig-zag transects will be used in instances where parallel lines are not practical due to operational reasons, such as bays and inlets, and will be stratified accordingly.

The survey effort, e.g. transect spacing, will be allocated among strata based on the observed abundance and variance in the survey over the last 10 years. Strata will be surveyed at three levels of effort; high, medium and low as indicated by the size of the black circles in Figure A6.4. The aim is to choose transect spacing to maintain or improve the precision of the survey. Survey effort should also ensure adequate coverage of the North Sea sprat stock, which requires that the southern boundary of the survey area be kept at 52°N.

The final design of strata and allocation of transects will be confirmed over the coming months in discussion with participants. The survey design and the allocation of survey area and transects to vessels/nations must also consider the specialist skills required to adequately cover the areas where stock splitting is carried out based on biological samples. In all strata to the west of 4°W there is a requirement to collect photographs of herring and otoliths and to carry out analysis of otolith shape and body morphometry to prepare for splitting the acoustic index into 6aN and 6aS stock components. This sampling has been carried out by Scotland and Ireland since 2010 and it was recommended in the February 2015 benchmark of the Malin Shelf herring stocks that these efforts be continued (ICES 2015).

To the East of 2°E and North of 56°N, in the areas covered by Denmark and Norway in previous years, there is a requirement to be able to split the survey abundance into North Sea Autumn spawning herring and Western Baltic spring-spawning herring. Denmark does this based on otolith shape analysis and provides stock discrimination on the individual fish level, whereas Norway uses a vertebrae count method that provides information only at the group level. In future, these methods should be calibrated and preferably one method agreed on as the standard for the survey. The chosen method must provide stock information at the individual fish level.

Analysis and reporting

A post-cruise meeting will be held in Bergen on 14–17 November 2016. The post-cruise meeting will allow the group to evaluate survey data, discuss issues arising from the surveys and produce the combined survey estimate. The group is still anticipating the new database structure, which is being developed by ICES. In the interim the group will continue to use the data format agreed at WKEVAL and modified during the 2015 survey analysis for delivery of disaggregated data. Survey data are to be uploaded to an agreed SharePoint location in the modified WKEVAL format no later than **31 October 2016**.

Table A6.3. Periods, areas and rectangles to be covered in the 2016 acoustic survey.

Vessel	Available days for actual survey	Period available
Celtic Explorer (IRE)	20 forMSHAS, 20 for BFAS	16 June – 30 June and 4 July – 30 July
Scotia (SCO)	19	26 June – 15 July
Johan Hjort (NOR)	17	27 June – 14 July
Dana (DEN)	14	22 June – 5 July
Tridens (NED)	17	27 June – 1 July, 4 – 9 July, 11 – 16 July, 18– 22 July
Solea (GER)	21	29 June – 19 July

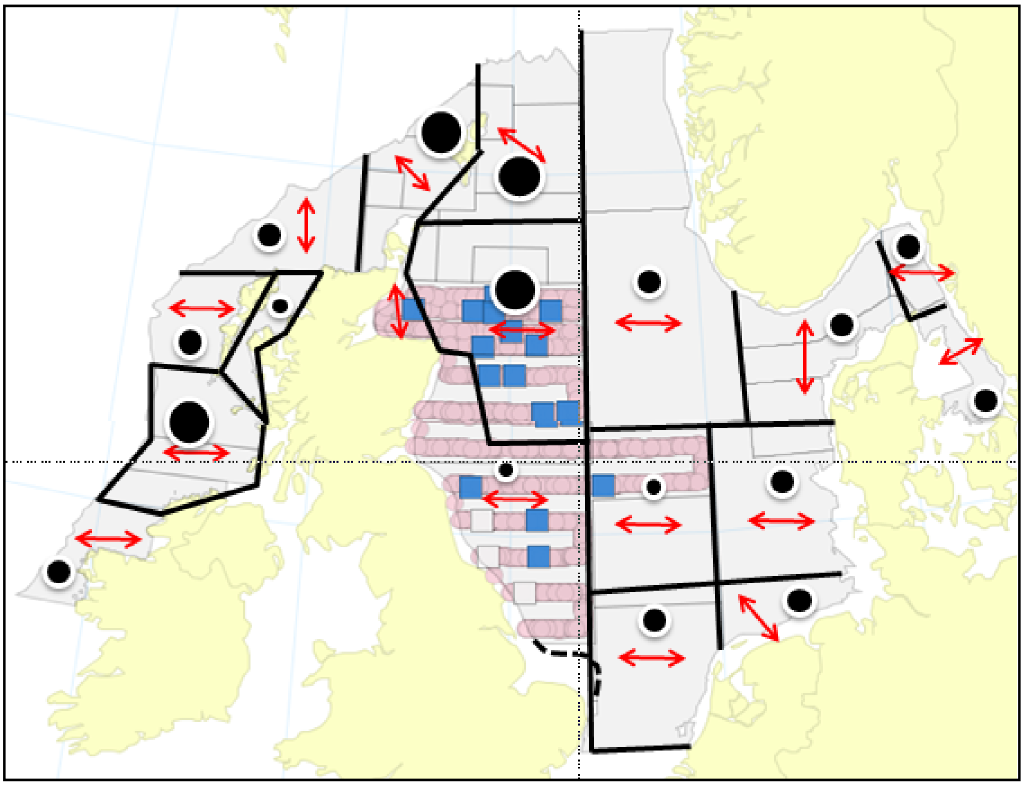


Figure A6.4. Preliminary strata for the HERAS 2016 survey overlaid on strata used in the StoX analysis of the 2015 survey. Red arrows indicate suggested optimal transect direction and black circles indicate relative survey effort allocation among strata. With high, low and medium effort levels assigned based on previous abundance and variance observed during the survey.

BFAS

The boarfish acoustic survey 2016 will be carried out on board the RV *Celtic Explorer* as a continuation of the Malin Shelf herring survey. This new survey program will run concurrently over a 6-week period from northern Scotland to northern Biscay. The survey will be broken into three 2-week legs for logistical purposes. Survey timing for the boarfish component will be the same as in previous years, commencing on the 10 July and running over 21 days until the 31 July. Having the survey on board the *Celtic Explorer* will allow for detailed hydrographic and behaviour studies to be undertaken centred on boarfish spawning behaviour. In addition, marine mammal and seabird surveys will be undertaken.

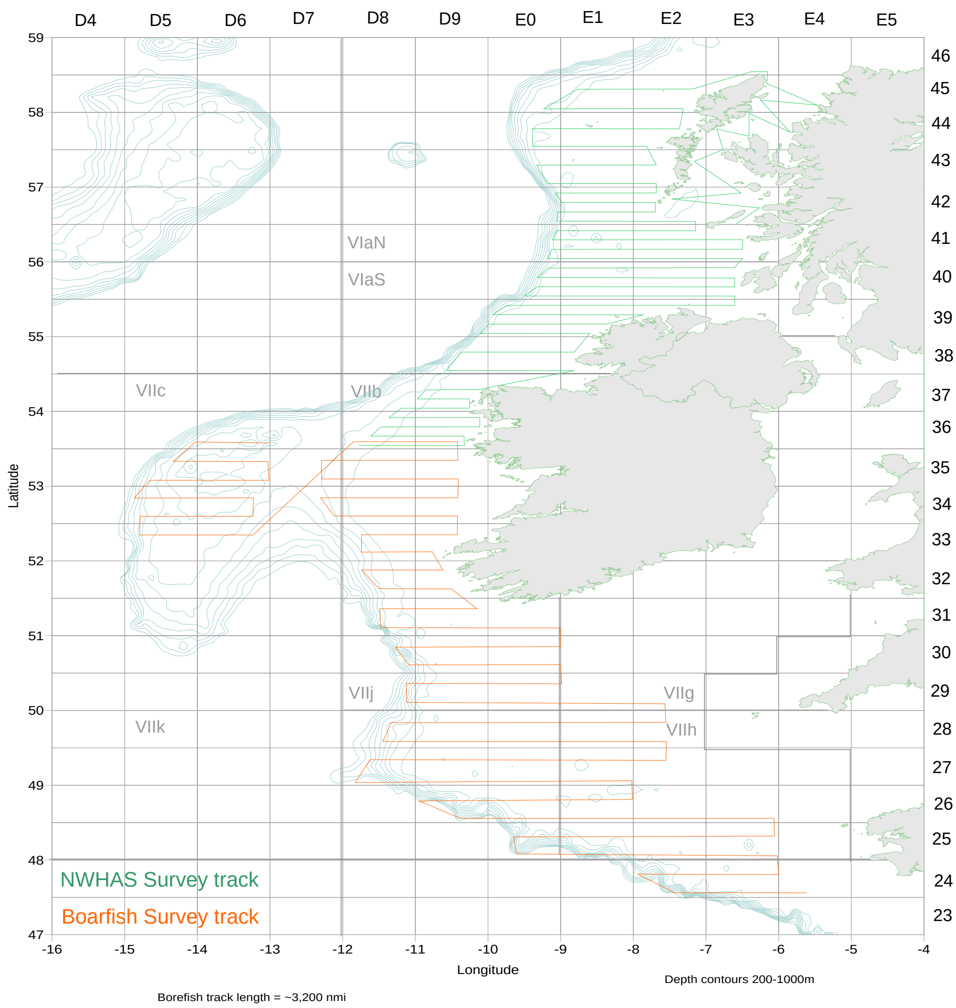


Figure A6.5. Map of the planned coverage by the Malin shelf herring acoustic survey (green) and the boarfish acoustic survey (orange).

CSHAS

The Celtic Sea acoustic survey 2016 will be carried out on board the RV *Celtic Explorer* beginning on the 6 October and running for 21 days. Survey design has been modified to ensure the surveys capacity to track the stock effectively while retaining core geographical coverage. A working document was provided to the HAWG 2016 detailing the changes in survey design and the reasoning behind these changes. Hydrographic, seabird and marine mammals survey will be undertaken in continuation of established programs.

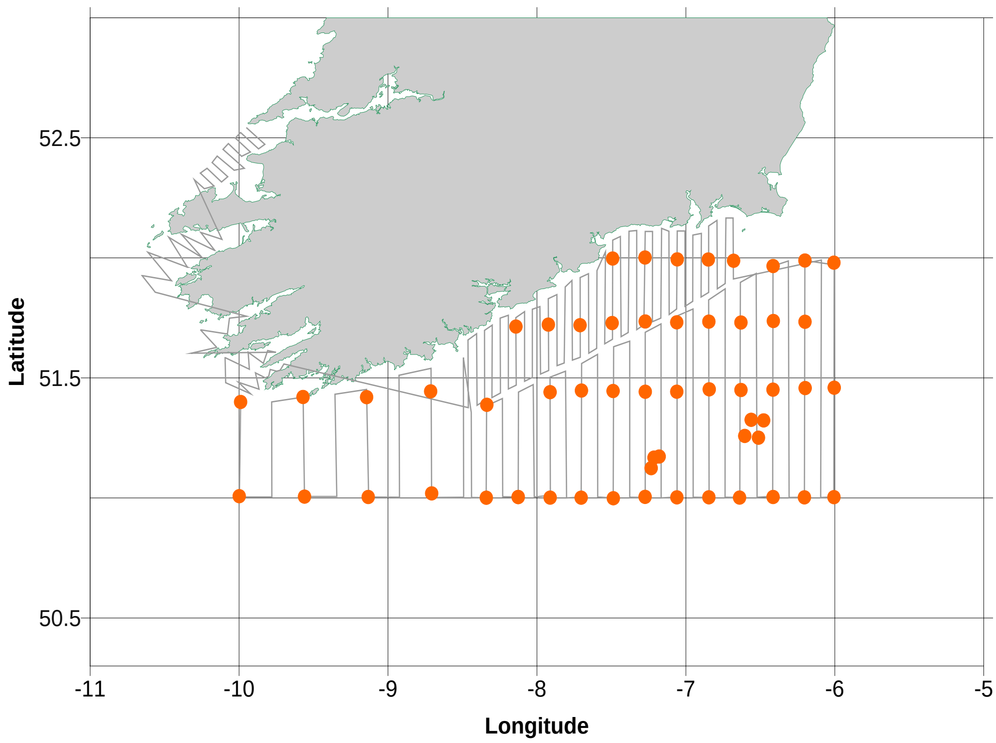


Figure A6.6. Map of the planned coverage by the Malin shelf herring acoustic survey (green) and the boarfish acoustic survey (orange).

ISAS

The 2016 Irish Sea acoustic survey (ISAS) will be carried out on board the RV *Corystes* between August 30 and September 15. Figure A6.7. shows the plan and acoustic tracks for cruise C03516. The survey design of systematic, parallel transects covers approximately 620 nmi and will be divided into two parts, transects around the periphery of the Irish Sea is randomized within +/- 4 nmi of a baseline position each year with spacing set between 8–10 nmi. Transect spacing is reduced to 2 nmi in strata around the Isle of Man to improve precision of estimates of adult herring biomass.

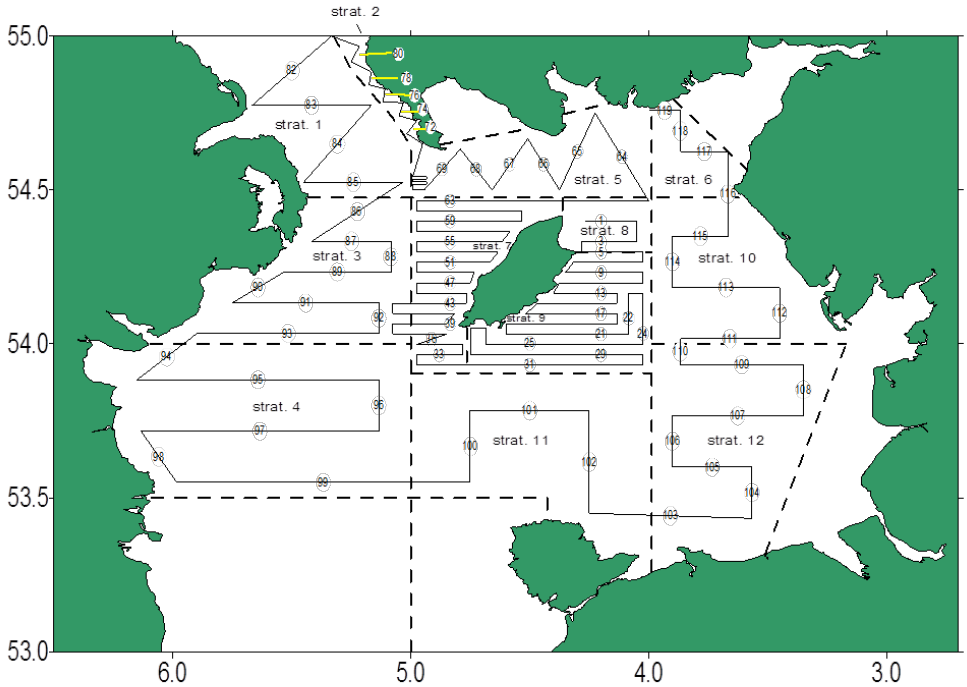


Figure A6.7. Map of Irish Sea and North Channel showing proposed coverage for the 2016 herring acoustic survey C03516.

GERAS

The GERAS acoustic survey 2016 will be carried out on board the RV *Solea* from September 30 until October 20. The plan for cruise SB726 and acoustic transects to be followed follow the design adopted for the previous years but may be subject to change regarding recent difficulties in attaining all required permits from Swedish authorities and short-term notices of specific area closures in the Swedish survey area in preceding years.

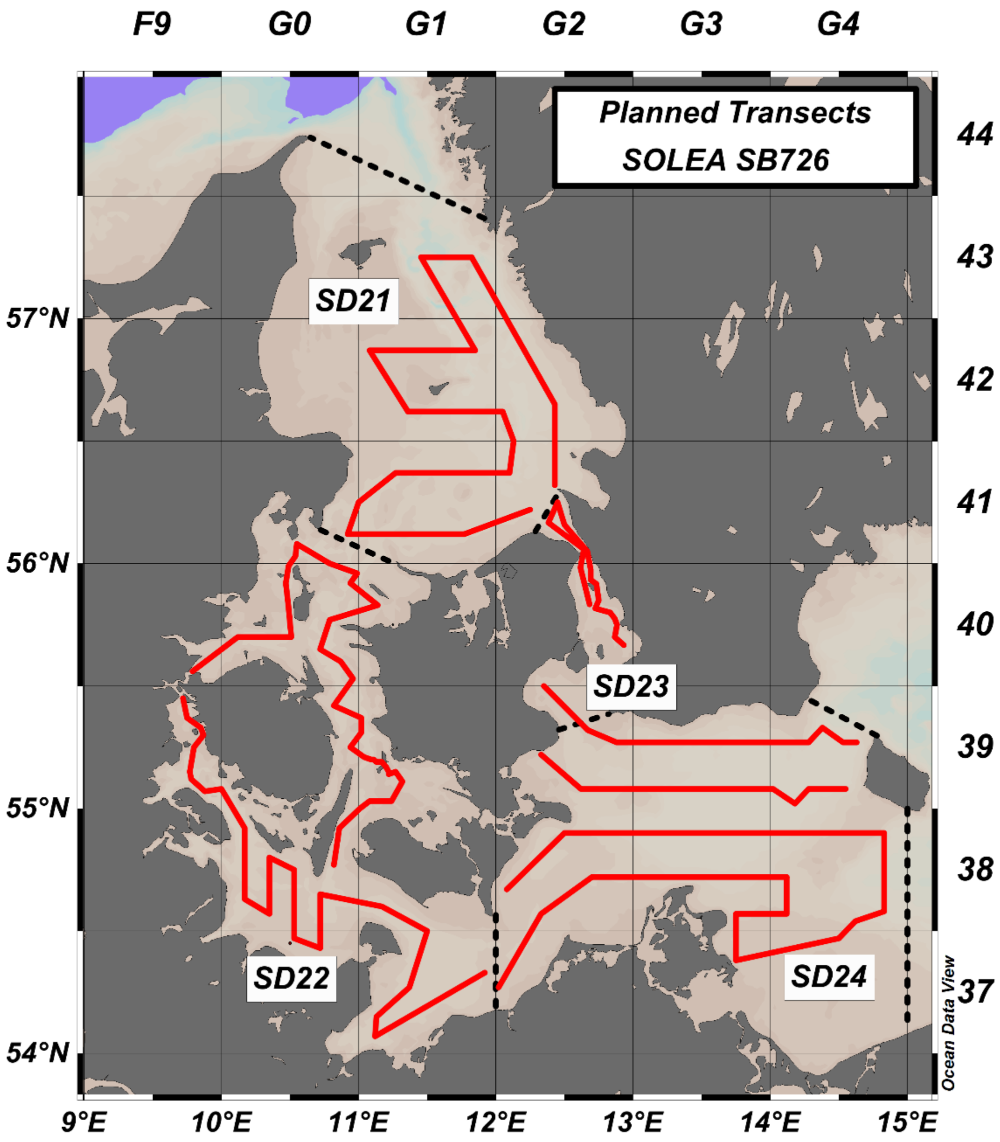


Figure A6.8. Map of the planned coverage and acoustic transects for the German Acoustic Autumn Survey (GERAS) in 2016.

PELTIC

The 5th (and last under project POSEIDON) of the PELTIC surveys in the SW of British waters is scheduled to take place between 3 and 20 October. It is two days shorter than previous surveys and as a result the Isles of Scilly region is likely to have to be dropped. Inconsistent coverage of this region in previous surveys due to poor weather conditions, and low abundance of the key pelagic species makes this area of low priority. The survey protocol will otherwise be the same as in the last two years: a series of 10 nmi spaced transects will be run during daylight in conjunction with surface oceanographic measurements and marine mammal and bird observations. Pelagic hauls will be made to ground-truth the acoustic marks and collect biological information on the dominant pelagic fish species in the area: sprat, sardine, mackerel, anchovy, horse mackerel and herring. At night a regular grid of Zooplankton and CTD stations will be sampled. Where possible, regular communications with the CSAS survey will be maintained to coordinate coverage in the Celtic Sea.

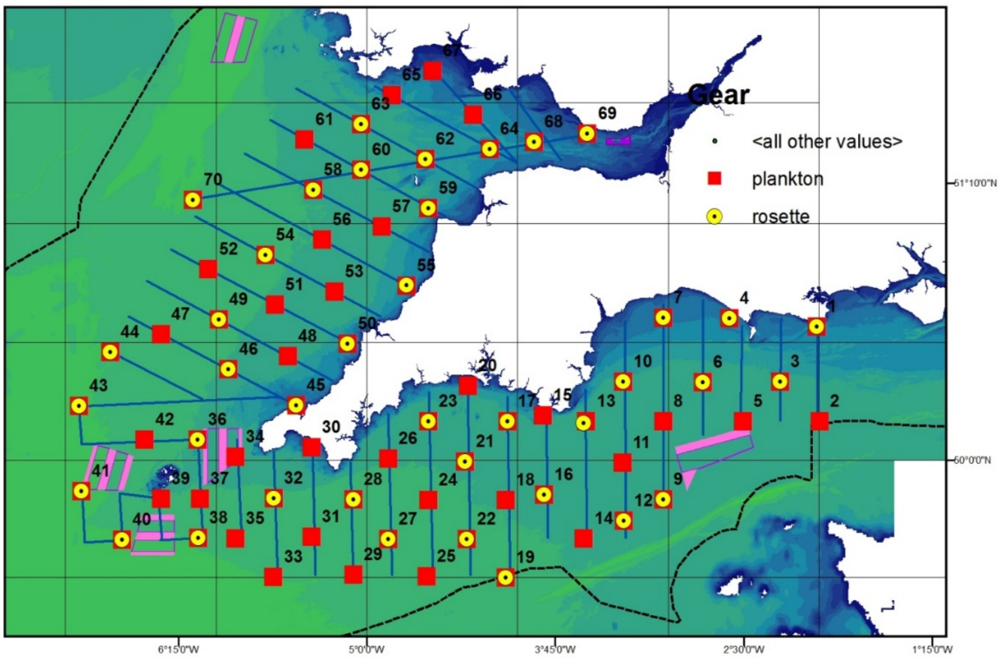


Figure A6.9. Figure Map of the acoustic transects (blue) and plankton (red) and hydrographic (yellow) stations of PELTIC 2016. Isles of Scilly transects (west) will not be covered.

References

ICES. 2015. Report of the Benchmark Workshop on West of Scotland Herring (WKWEST), 2-6 February, Dublin, Ireland. ICES CM 2015\ACOM:34. 299 pp.

Annex 7: auxiliary ecosystem monitoring technology

Zooplankton sampling

There are various types of gear used for sampling zooplankton. Mochness or zooplankton trawls are expensive and time consuming but get a representative sample of all species. Mochness are able to get samples at specific depths, due to opening and closing of codends mechanically while in the water. WP2 is a small net which is hauled vertically from 200 m or 400 m to the surface (Figure A7.1). It does not provide vertical information and the largest zooplankton are able to avoid the gear. However, it is quick, cheap and easy to handle. Sampling takes around 15 min and can be done simultaneously as operating a CTD. The normal procedure is to first remove jellyfish and other large particles before the sample is split into two equal parts. One part is stored on formalin and used for species identification, while the other part is used for biomass estimation. The procedure for biomass estimation is to sieve the samples through cups with varying meshes to split the sample into 3 different size groups; 180–1000 µm, 1000–2000 µm, > 2000 µm. The samples are then dried before the weight is recorded (see also Figure A7.2). There is an increasing demand for a better understanding of zooplankton and its interactions with other parts of ecosystems. Integrated assessment gets increased focus and ecosystem based management will probably be more important in the coming years. A fishery targeting zooplankton is under development in several areas. Increased sampling of zooplankton is therefore encouraged.

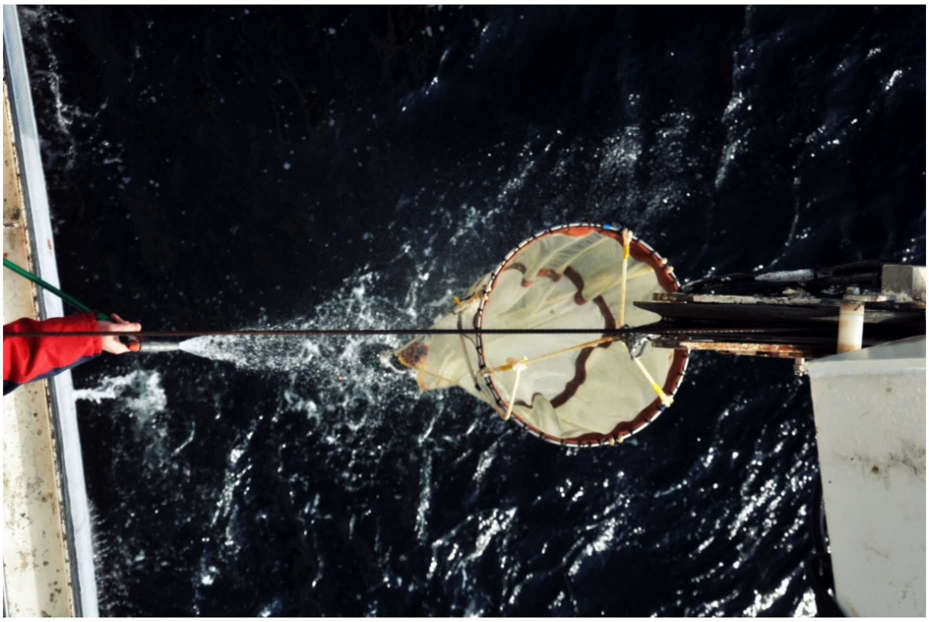


Figure A7.1. WP2 net being hauled to the surface from 200 m.

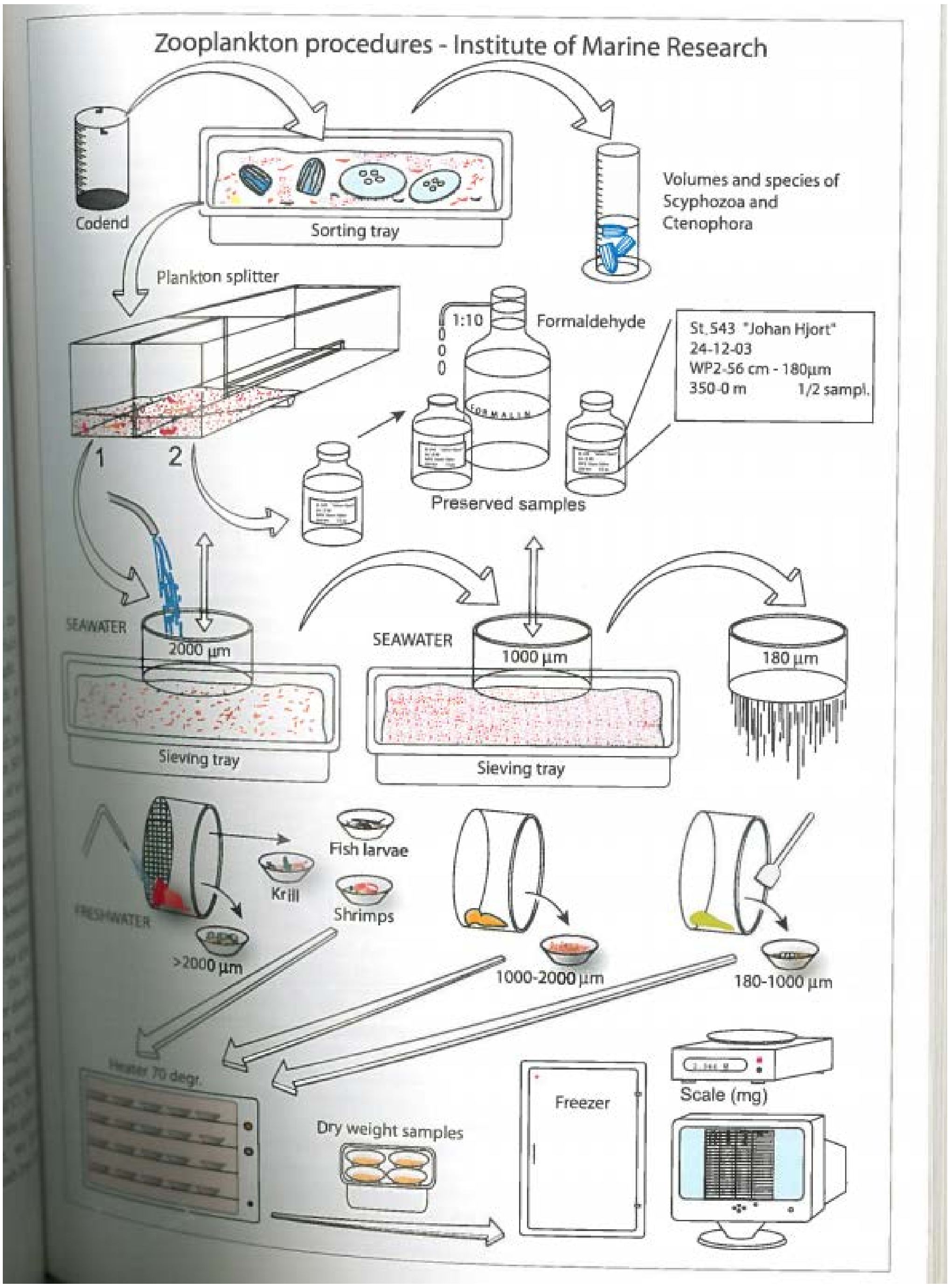


Fig A7.2. Schematic overview of the procedure for handling the zooplankton samples obtained with WP2.

<u>Multibeam data</u>

Fish schools on echograms offer a range of descriptive features which can be used to classify species or groups. Traditionally, the identification of acoustically detected fish schools during surveys has been dependent on a combination of biological sampling and (subjective) inspection of acoustic data by experts. However, it is often very difficult to distinguish between fish species with similar acoustic properties. This can lead to the incorrect allocation of acoustic energy sampled during surveys and consequently affect accuracy of abundance estimates. Therefore supplementary sources of information are required to help improve discrimination. When acoustic data are coupled with the morphological properties of fish schools and their geographical distribution it can improve discrimination success rates. Previously such information was only available as two-dimensional echograms, however, with recently acquired new quantitative multibeam echosounder (MBES) technology we are now able to visualize schools in 3D.

To date no study has investigated the 3D structure of three key pelagic species (herring, sprat and Norway pout), which are commonly encountered during North Sea acoustic surveys. Using multibeam data we can better characterize schools and improve species classification. Discriminant function analysis can then be developed to help distinguish species. These additional sources of information will be particularly useful in mixed species assemblages. It also allows us to study the behaviour and interaction of these species, which is an important step towards ecosystem based surveys and management.

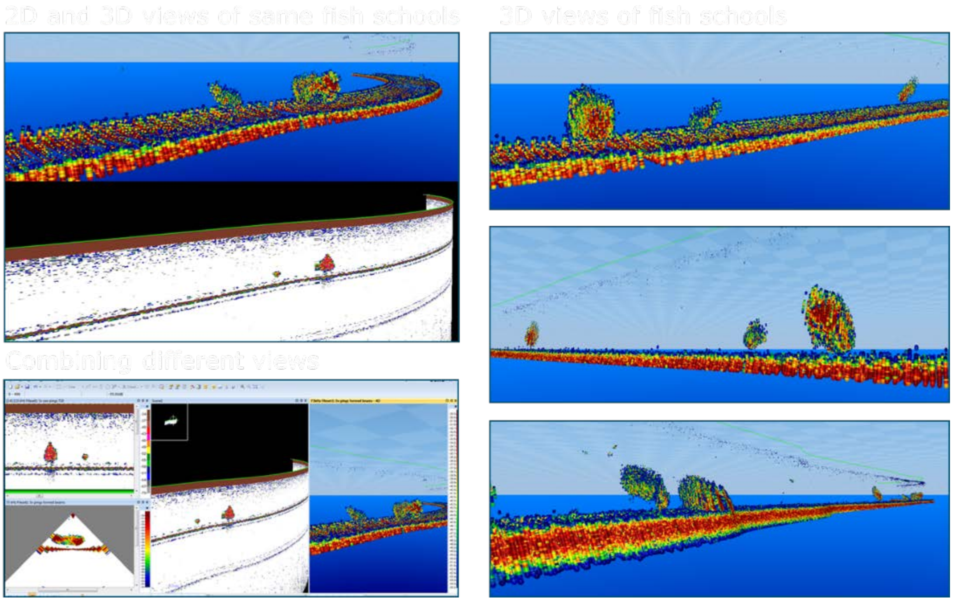


Figure A7.3. Example 3D reconstructions of herring schools from ME70 multibeam data.

Integrated ecosystem monitoring

Trawl surveys provide a platform to collect additional data across the North Sea with little extra effort making them a good basis for more ecosystem focused surveys. In 2016, the Netherlands aim to explore the use of acoustic equipment on board RV Tridens to collect additional data on seabed types and pelagics during trawl surveys and to assess the value such data adds to the trawl survey and at what extra analytical costs. Aside from the methodological development the project aims to explore the spatial connectivity of seabed type, benthos, benthic, demersal and pelagic fish and plankton.

The Beam Trawl Survey (BTS) will serve as the trial trawl survey for the collection of the additional acoustic data. As the BTS follows the herring acoustic survey within a reasonably short space of time, no additional calibration of acoustic equipment will be needed. Manuals on the set-up of the acoustic equipment for recording acoustic data will be provided to the BTS personnel and allow data to be collected during the 4 week survey. Analysis of EK60 (pelagics and plankton) and ME70 (seabed, techniques to be developed) data will commence following the survey. As it will not be possible to ground-truth the acoustic data, we will use a combination of existing identification algorithms (taking advantage of multifrequency backscatter) and thresholding to group scattering targets (i.e. swimbladderedvs.non-swimbladdered fish, separate plankton into broad zooplankton groups). As the acoustic data will not be collected along-transects as is usual with acoustic surveys, specific methods developed for analysis of acoustic data from trawl/fishing vessel surveys will be applied to allow acoustic data and trawl survey data to be linked (van der Kooij *et al*., 2015). Geostatistical methods will be applied to quantify the links between seabed types, benthic biomass, abundance/biomass of benthic/demersal fish and relative abundance of pelagic fish groups. The project will thus not only develop methods for surveys and multi-trophic level data analysis but also provide ecological insights into ecosystem connections across trophic levels.

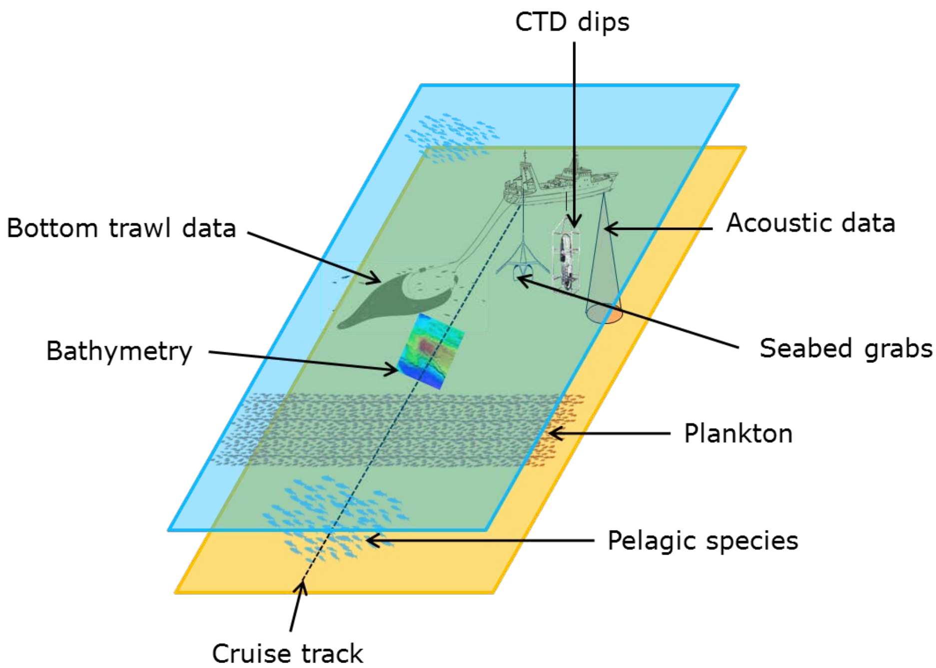


Figure A7.4. Schematic showing the various types of data that can be collected during trawl surveys performing acoustic operations.

<u>Alternative ground-truthing methods</u>

Acoustic surveys rely on ‘ground-truthing’ techniques to verify acoustic observations. Typically this is achieved through trawling. Fernandes *et al*. (accepted) describe several alternative tools for obtaining ‘ground-truth’ information; handline and small video cameras. Here, we mention only the deployment of a small video camera (Figure A7.4.) into schools of mackerel, which provided species identification, and, fish tilt distributions. Furthermore, the video camera was deployed as part of a ‘mini lander’ (Figure A7.5.) onto rocky seabed where trawling is not possible: this approach successfully identified Norway pout, suggested it was the dominant scatterer on this type of seabed. These techniques complement traditional trawling methods and also provide insights into fish behaviour (i.e. orientation).

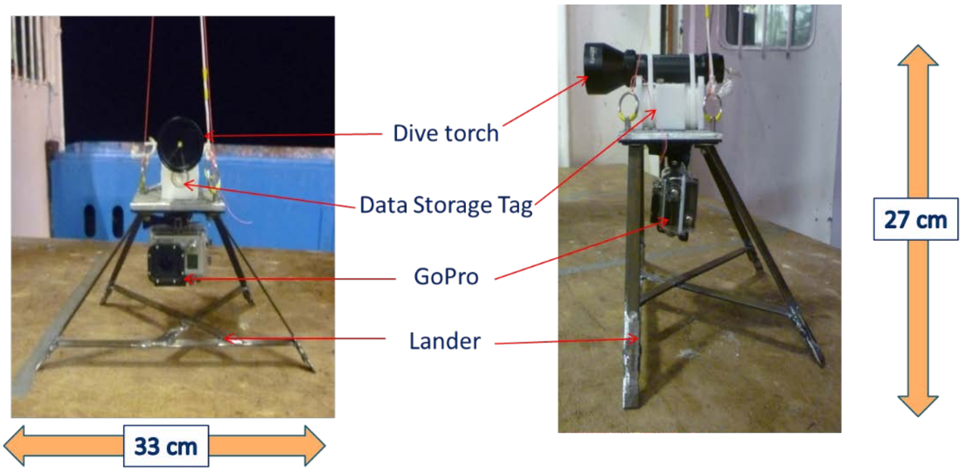


Figure A7.5. Image of the lander, showing the major components.

Jellyfish monitoring

Jellyfish occur in large quantities especially in the inner Danish waters during the HERAS survey period. Jellyfish can be seen as competitors to pelagic fish by consuming large amount of ichthyoplankton and zooplankton. Furthermore jellyfish can predate on herring by eating egg and larvae. Therefore a correlation between the abundance of jellyfish and herring has been hypothesized.

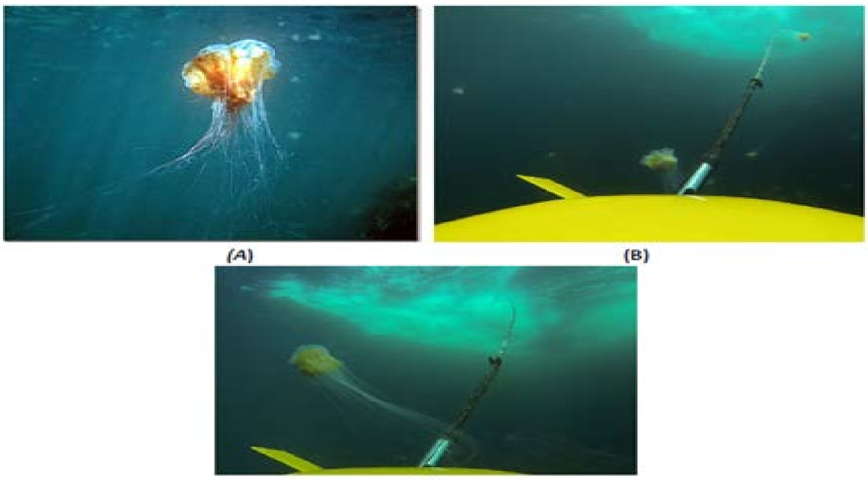
Jellyfish are seen in the trawl catches with up to 31% of the total catch in weight (2014) but very variant from year to year presumably correlated to the water temperature in spring. The concentration of jellyfish in the catches is increasing going from the western part of the survey area (6˚E) to the eastern part (12˚E) of the survey area. Concentrations of jellyfish can also be seen at the echosounders as dispersed layers.

The amount of jellyfish in the trawl catches is not a reliable quantitative measurement for the concentration of jellyfish neither is the appearance on the echosounders as little is known on the catchability in the trawls or the acoustical reflection.

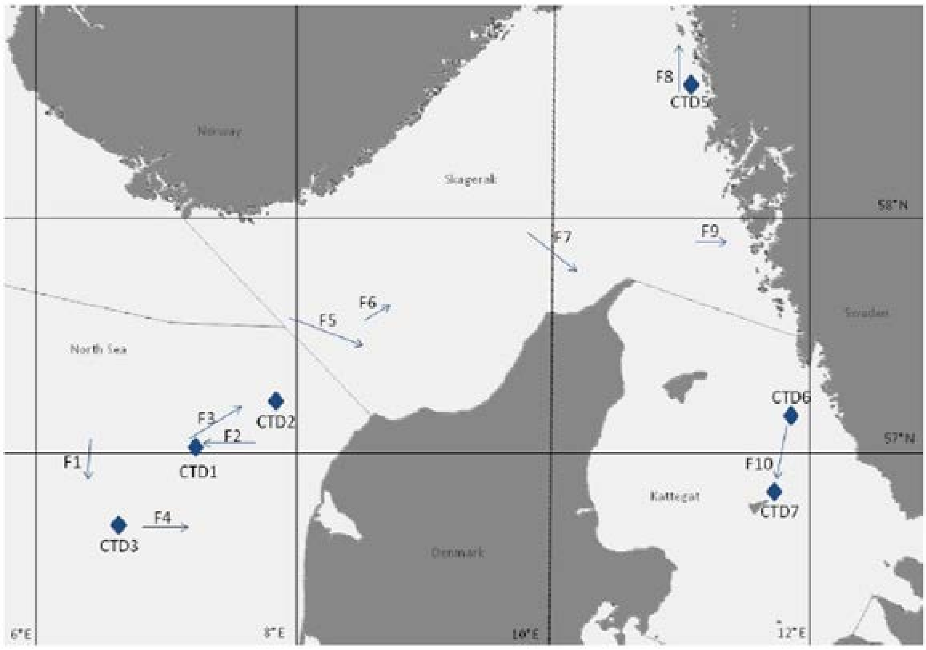
DTU-Aqua therefore haw looked at visual counting as a solution for quantifying the concentration of jellyfish. A GoPro camera (Hero3) was mounted on our towed body for echosounders.

The towed body is towed from the foredeck of the vessel along the side of vessel outside the bove wave. At operation the vessel are sailing with 10 knots and the towed body will be stable in a depth of 3–5 metres depth.

The first tests were conducted in 2014 and gave remarkably good pictures.



During the first years test the jellyfish were counted manually from the movie sections and 10 test of 1 hour was conducted, see figure below.



The jellyfish in the area is dominated by two species, *Cyanea capillata* and *Ayrelia aurita*. The 10 test in 2014 showed differences in distribution of jellyfish over the survey area and between two dominant species, see figure below.

During the 2015 survey the methodology has been developed further. A computer program for automatically counting of jellyfish has been developed. This program can furthermore distinguish between the two dominant species as they have different colour.

The future work with the jellyfish monitoring will be:

1) Produce a standard camera system that is easy to mount on the towfish (as the GoPros are) and that can run for multiple hours without battery and data storage issues;
2) Refine the automatic counting software to speed up the processing of data;
3) Set this as a routine on board of the vessel. This is extremely easy to do given the very little amount of time and expertise that is needed to place the camera on the towfish;
4) Have a dedicated computer on board to deal with the process of heavy footage files;
5) Correlated the video/presence of jellyfish with other data easily available on board: CTD data and so forth, to have a deep and complete understanding of the causes for the presence/absence of these organisms

References

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van der Kooij, J., Fässler, S.M.M., Stephens, D., Readdt, L., Scott, B.E., and Roel, B.A. 2015. Opportunistically recorded acoustic data support Northeast Atlantic mackerel expansion theory. ICES Journal of Marine Science, doi: 10.1093/icesjms/fsv243

Annex 8: StoX comparison (IESNS, IBWSS)

Re-estimation of abundance from acoustic pelagic surveys using the new open source software StoX

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Introduction

Estimation of abundance at age from acoustic fish surveys involves many steps, like interpretation of echograms, assignment of fish samples to acoustic values (NASC) and translating acoustic values into fish density. Various software tools are normally used in this process, and with time new tools often replace older tools. When such transitions occur, it is advantageous to re-estimate historic abundances from the survey since the methods may be different in the new tool. Ideally, the entire time series is re-calculated. However, it may be difficult to obtain old data in the required format.

The software Beam (Totland and Godø 2001) has been used for many years to estimate abundance from various acoustic surveys in the North-East Atlantic. Beam was developed at IMR, Norway in 1999. There are now many good reasons to start using a newer tool: Beam only works with an old version of SAS, few persons are able to run the program and an ad-hoc square based (non-statistical) design is assumed. A new tool called StoX has been developed at IMR, Norway, and the idea is that this tool will replace Beam from 2016 onwards. A detailed description og StoX is given below.

The objective in this work is to present new abundance estimates from StoX as far back as possible for some international acoustic surveys, and then compare these estimates with the existing old Beam estimates.

Surveys

Currently two blue whiting surveys and two herring surveys have been re-estimated with StoX:

- IESNS in the Norwegian Sea: abundance of both blue whiting and Norwegian spring-spawning herring. Data in the required format is available from 2008 onwards (from the NAPES database).
- IESNS in the Barents Sea: abundance of (mostly juvenile) Norwegian spring-spawning herring. Data in the required format is available from 2009 onwards (from the NAPES database).

- IBWSS west of the British Isles: abundance of (mostly adult) blue whiting. Data in the required format is available from 2004 onwards (from the NAPES database).

The latest cruise reports from these surveys can be found as working documents in the latest WGWIDE report (ICES 2015).

StoX

StoX is open source software developed at IMR, Norway to calculate survey estimates from acoustic and swept area surveys. Both the software, examples and documentation can be found here: http://www.imr.no/forskning/prosjekter/stox/nb-no. The program is a stand-alone application build with Java for easy sharing and further development in cooperation with other institutes. The underlying high resolution data matrix structure ensures future implementations of e.g. depth dependent target strength and high resolution length and species information collected with camera systems. Despite this complexity, the execution of an index calculation can easily be governed from user interface and an interactive GIS module, or by accessing the Java function library and parameter set using external software like R. Accessing StoX from external software may be an efficient way to process time series or to perform boot-strapping on one dataset, where for each run, the content of the parameter dataset is altered. Various statistical survey design models can be implemented in the R-library, however, in the current version of StoX the stratified transect design model developed by Jolly and Hampton (1990) is implemented. When new statistical methods are implemented it is regarded essential that expert specification demands, documentation and statistical rigorousness is available.

A problem with using StoX on old data is when surveys were not planned and conducted according to a standard statistical design, with pre-defined strata and acoustic transects. This applies to most of the surveys re-estimated in this work. The data must then be “forced” into the required design, i.e. transects and strata are defined in retrospect. These choices are shown as figures, and issues in specific years/cruises are written in the figure texts.

Results

IESNS in the Barents Sea (only Norwegian spring-spawning herring)

Results from StoX is shown in Table 1-7. Figure 1 shows internal consistency by age step for the StoX estimates and the old Beam estimates, Figure 2-4 show the StoX estimates together with the old estimates and Figure 5-11 show how transects were tagged in StoX.

IESNS in the Norwegian Sea, Norwegian spring-spawning herring

Results from StoX is shown in Table 8-15. Figure 12 shows internal consistency by age step for the StoX estimates and the old Beam estimates, Figure 13-27 show the StoX estimates together with the old estimates and Figure 28-35 show how transects were tagged in StoX.

IBWSS (only blue whiting)

Results from StoX is shown in Table 16-27. Figure 36 shows internal consistency by age step for the StoX estimates and the old Beam estimates, Figure 37-49 show the StoX estimates together with the old estimates and Figure 50-60 show how transects were tagged in StoX.

IESNS in the Norwegian Sea, Blue whiting

Results from StoX is shown in Table 27-34. Figure 61 shows internal consistency by age step for the StoX estimates and the old Beam estimates, Figure 62-72 show the StoX estimates together with the old estimates and Figure 73-80 show how transects were tagged in StoX.

References

ICES. 2015. Report of the working group on widely distributed stocks (WGWIDE). ICES CM 2015 ACOM:15.

Jolly, G. M., and I. Hampton. 1990. A stratified random transect design for acoustic surveys of fish stocks. Can.J. Fish. Aquat. Sci. 47: 1282-1291.

Table 1. IESNS in the Barents Sea. StoX estimates of Norwegian spring-spawning herring for 2009.

LenGrp	age 1	2	3	4	Number (1E3)	Biomass (1E3kg)	Mean W (g)
10-11	71557	-	-	-	71557	529.5	7.40
12-13	71557	-	-	-	71557	815.8	11.40
13-14	71557	-	-	-	71557	1030.4	14.40
14-15	71557	-	-	-	71557	1273.7	17.80
16-17	-	71557	-	-	71557	1617.2	22.60
17-18	-	71557	-	-	71557	2046.5	28.60
18-19	-	143115	71557	-	214672	7513.5	35.00
20-21	-	-	71557	-	71557	3463.4	48.40
21-22	-	-	71557	-	71557	3763.9	52.60
27-28	-	-	-	71557	71557	8400.8	117.40
TSN(1000)	286230	286230	214672	71557	858690	-	-
TSB(1000 kg)	3649.4	8529.7	9874.9	8400.8	-	30454.9	-
Mean length (cm)	12.63	17.37	19.83	27.50	-	-	-
Mean weight (g)	12.75	29.80	46.00	117.40	-	-	35.47

Table 2. IESNS in the Barents Sea. StoX estimates of Norwegian spring-spawning herring for 2010.

LenGrp	age 1	2	Number (1E3)	Biomass (1E3kg)	Mean W (g)
9-10	332472	-	332472	1745.5	5.25
10-11	867671	-	867671	6264.6	7.22
11-12	1889415	-	1889415	15007.4	7.94
12-13	1532615	-	1532615	16875.8	11.01
13-14	332472	-	332472	4920.6	14.80
14-15	166236	166236	332472	6450.0	19.40
15-16	-	202727	202727	4581.6	22.60
16-17	-	664944	664944	16922.8	25.45
18-19	-	202727	202727	6892.7	34.00
19-20	-	129745	129745	5189.8	40.00
TSN(1000)	5120882	1366379	6487261	-	-
TSB(1000 kg)	47656.4	37194.3	-	84850.7	-
Mean length (cm)	11.50	16.25	-	-	-
Mean weight (g)	9.31	27.22	-	-	13.08

Table 3. IESNS in the Barents Sea. StoX estimates of Norwegian spring-spawning herring from for 2011.

LenGrp	age 1	2	3	Number (1E3)	Biomass (1E3kg)	Mean W (g)
9-10	29523	-	-	29523	130.9	4.43
10-11	217654	-	-	217654	1340.4	6.16
11-12	788047	-	-	788047	6062.1	7.69
12-13	33935	-	-	33935	330.9	9.75
13-14	9841	19682	-	29523	441.9	14.97
14-15	-	249650	-	249650	4367.6	17.49
15-16	-	838968	-	838968	17706.0	21.10
16-17	-	1362074	-	1362074	33594.0	24.66
17-18	-	1021927	-	1021927	28721.6	28.11
18-19	-	270491	-	270491	9178.7	33.93
19-20	-	39364	9841	49205	2030.2	41.26
20-21	-	-	9841	9841	474.3	48.20
21-22	-	-	9841	9841	551.1	56.00
24-25	-	-	9841	9841	836.5	85.00
TSN(1000)	1079000	3802156	39364	4920521	-	-
TSB(1000 kg)	7989.2	95473.2	2303.8	-	105766.2	-
Mean length (cm)	10.97	16.35	21.25	-	-	-
Mean weight (g)	7.40	25.11	58.53	-	-	21.49

Table 4. IESNS in the Barents Sea. StoX estimates of Norwegian spring-spawning herring for 2012.

LenGrp	age 1	2	Number (1E3)	Biomass (1E3kg)	Mean W (g)
9-10	76228	-	76228	411.6	5.40
10-11	259176	-	259176	1860.0	7.18
11-12	121965	-	121965	1112.9	9.13
12-13	15246	-	15246	182.9	12.00
14-15	76228	-	76228	1494.1	19.60
15-16	167702	-	167702	3750.4	22.36
16-17	106719	-	106719	2759.5	25.86
17-18	45737	-	45737	1494.1	32.67
18-19	15246	-	15246	655.6	43.00
23-24	-	15246	15246	1265.4	83.00
TSN(1000)	884247	15246	899492	-	-
TSB(1000 kg)	13721.1	1265.4	-	14986.5	-
Mean length (cm)	12.91	23.50	-	-	-
Mean weight (g)	15.52	83.00	-	-	16.66

Table 5. IESNS in the Barents Sea. StoX estimates of Norwegian spring-spawning herring for 2013.

LenGrp	age 1	2	3	4	Number (1E3)	Biomass (1E3kg)	Mean W (g)
11-12	132112	-	-	-	132112	1224.2	9.27
16-17	-	616521	-	-	616521	16809.0	27.26
17-18	-	616521	-	-	616521	19570.1	31.74
18-19	-	616521	44037	-	660558	23665.6	35.83
19-20	-	88074	-	-	88074	3509.8	39.85
20-21	-	44037	88074	-	132112	6794.9	51.43
22-23	-	-	88074	-	88074	5729.2	65.05
23-24	-	-	44037	-	44037	3487.7	79.20
25-26	-	-	-	44037	44037	4562.3	103.60
26-27	-	-	-	44037	44037	5460.6	124.00
TSN(1000)	132112	1981674	264223	88074	2466083	-	-
TSB(1000 kg)	1224.2	63946.4	15620.0	10022.9	-	90813.5	-
Mean length (cm)	11.33	17.36	21.08	26.00	-	-	-
Mean weight (g)	9.27	32.27	59.12	113.80	-	-	36.83

Table 6. IESNS in the Barents Sea. StoX estimates of Norwegian spring-spawning herring for 2014.

LenGrp	age 1	2	3	4	5	Number (1E3)	Biomass (1E3kg)	Mean W (g)
8-9	492709	-	-	-	-	492709	1601.3	3.25
9-10	273852	-	-	-	-	273852	1287.1	4.70
10-11	496076	-	-	-	-	496076	3047.3	6.14
11-12	667795	-	-	-	-	667795	5368.0	8.04
12-13	770489	-	-	-	-	770489	8048.9	10.45
13-14	799670	-	-	-	-	799670	10768.0	13.47
14-15	167406	230184	-	-	-	397590	6947.4	17.47
15-16	58923	196410	-	-	-	255333	5303.1	20.77
16-17	-	1029751	-	-	-	1029751	26244.7	25.49
17-18	-	682105	-	-	-	682105	20345.9	29.83
18-19	-	554438	-	-	-	554438	19042.8	34.35
19-20	-	321446	21430	-	-	342876	13790.1	40.22
20-21	-	40853	61280	-	-	102133	4973.9	48.70
21-22	-	-	317343	-	-	317343	18046.2	56.87
22-23	-	-	368409	-	-	368409	23534.9	63.88
23-24	-	-	547143	-	-	547143	40335.4	73.72
24-25	-	-	306400	21886	-	328286	27284.9	83.11
25-26	-	-	131314	65657	-	196971	18099.5	91.89
26-27	-	-	43771	-	-	43771	4760.1	108.75
27-28	-	-	-	21886	21886	43771	4738.3	108.25
28-29	-	-	-	21886	-	21886	2768.5	126.50
29-30	-	-	-	-	21886	21886	3042.1	139.00
TSN(1000)	3726921	3055187	1797091	131314	43771	8754285	-	-
TSB(1000 kg)	34145.6	88554.6	128239.4	13065.8	5372.9	-	269378.4	-
Mean length (cm)	11.47	16.97	22.96	25.83	28.00	-	-	-
Mean weight (g)	9.16	28.99	71.36	99.50	122.75	-	-	30.77

Table 7. IESNS in the Barents Sea. StoX estimates of Norwegian spring-spawning herring for 2015.

LenGrp	age 1	2	3	4	Number (1E3)	Biomass (1E3kg)	Mean W (g)
9-10	66085	-	-	-	66085	396.5	6.00
11-12	66085	-	-	-	66085	561.7	8.50
12-13	198255	-	-	-	198255	2279.9	11.50
13-14	-	1359051	-	-	1359051	20725.5	15.25
14-15	-	1005641	-	-	1005641	17455.0	17.36
15-16	-	850485	-	-	850485	19196.7	22.57
16-17	-	1505866	-	-	1505866	42343.5	28.12
17-18	-	1509295	-	-	1509295	49124.0	32.55
18-19	-	2241327	-	-	2241327	86851.4	38.75
19-20	-	2240227	320032	-	2560259	114611.6	44.77
20-21	-	758759	206934	-	965693	52423.3	54.29
21-22	-	-	345347	-	345347	21325.2	61.75
22-23	-	-	66085	-	66085	5055.5	76.50
23-24	-	-	279262	-	279262	23178.8	83.00
24-25	-	-	-	66085	66085	5253.8	79.50
25-26	-	-	-	66085	66085	7071.1	107.00
26-27	-	-	-	66085	66085	6806.8	103.00
TSN(1000)	330425	11470650	1217661	198255	13216990	-	-
TSB(1000 kg)	3238.2	375997.8	76292.8	19131.6	-	474660.3	-
Mean length (cm)	11.40	17.04	21.04	25.00	-	-	-
Mean weight (g)	9.80	32.78	62.66	96.50	-	-	35.91

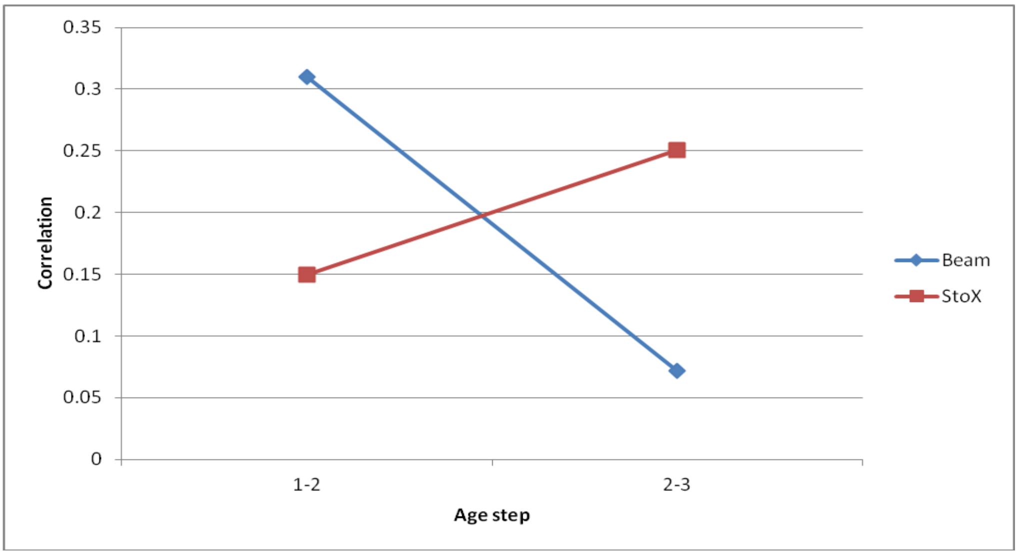

Figure 1. IESNS in the Barents Sea, Norwegian spring.spawning herring. Internal consistency (correlation between log-transformed abundance estimates for the same cohort at consecutive ages) by age step for the StoX estimates and the old Beam estimates.

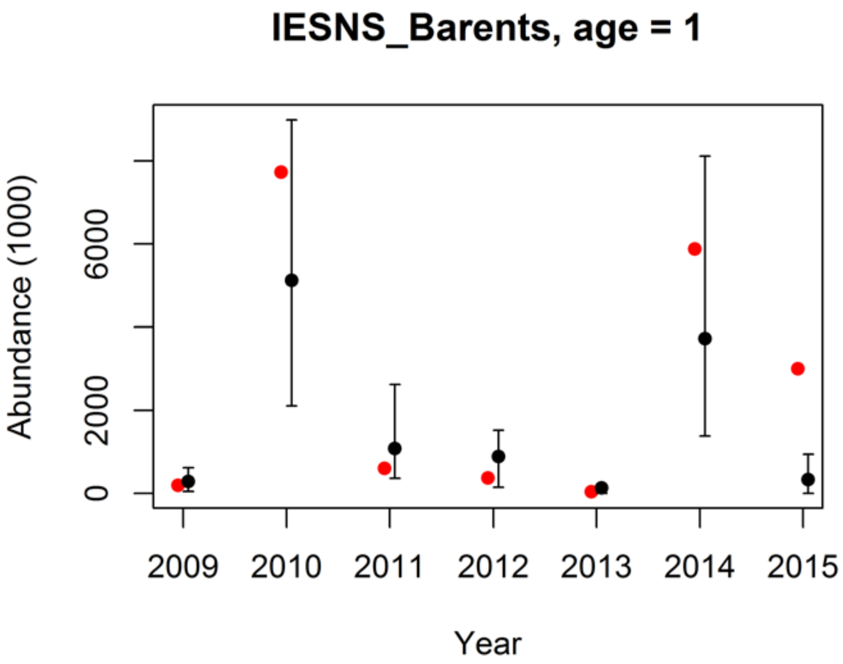

Figure 2. IESNS in the Barents Sea, Norwegian spring-spawning herring age 1. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

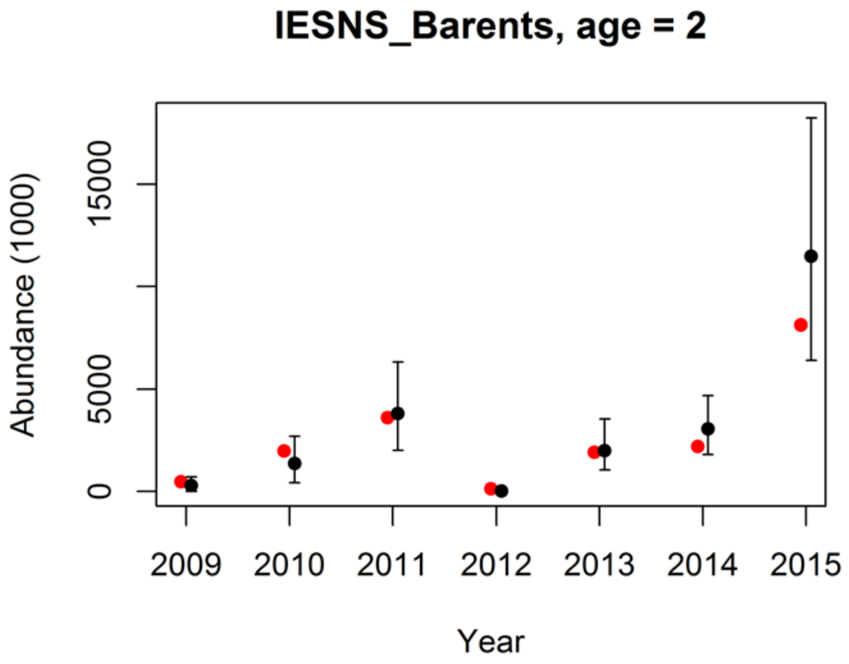

Figure 3. IESNS in the Barents Sea, Norwegian spring-spawning herring age 2. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

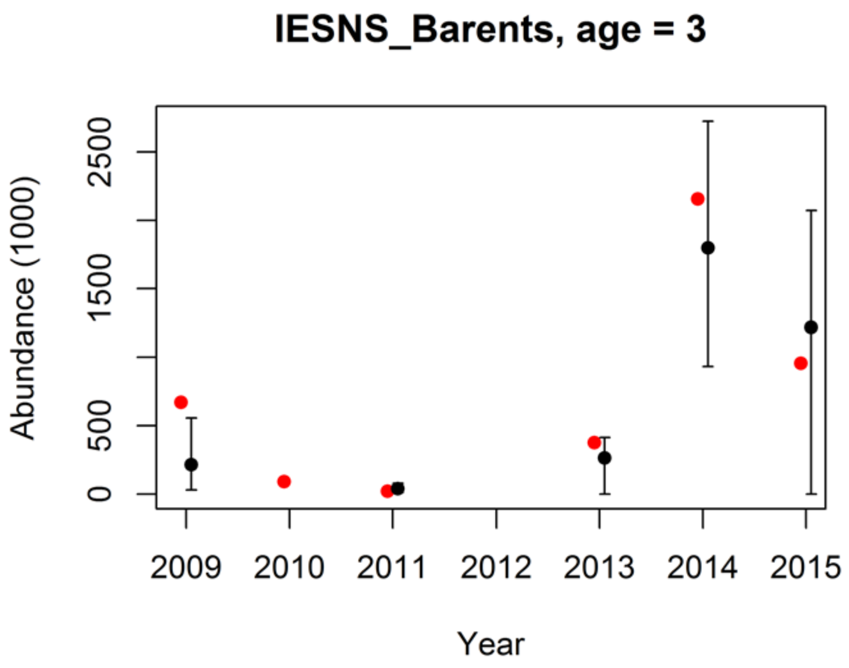

Figure 4. IESNS in the Barents Sea, Norwegian spring-spawning herring age 3. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

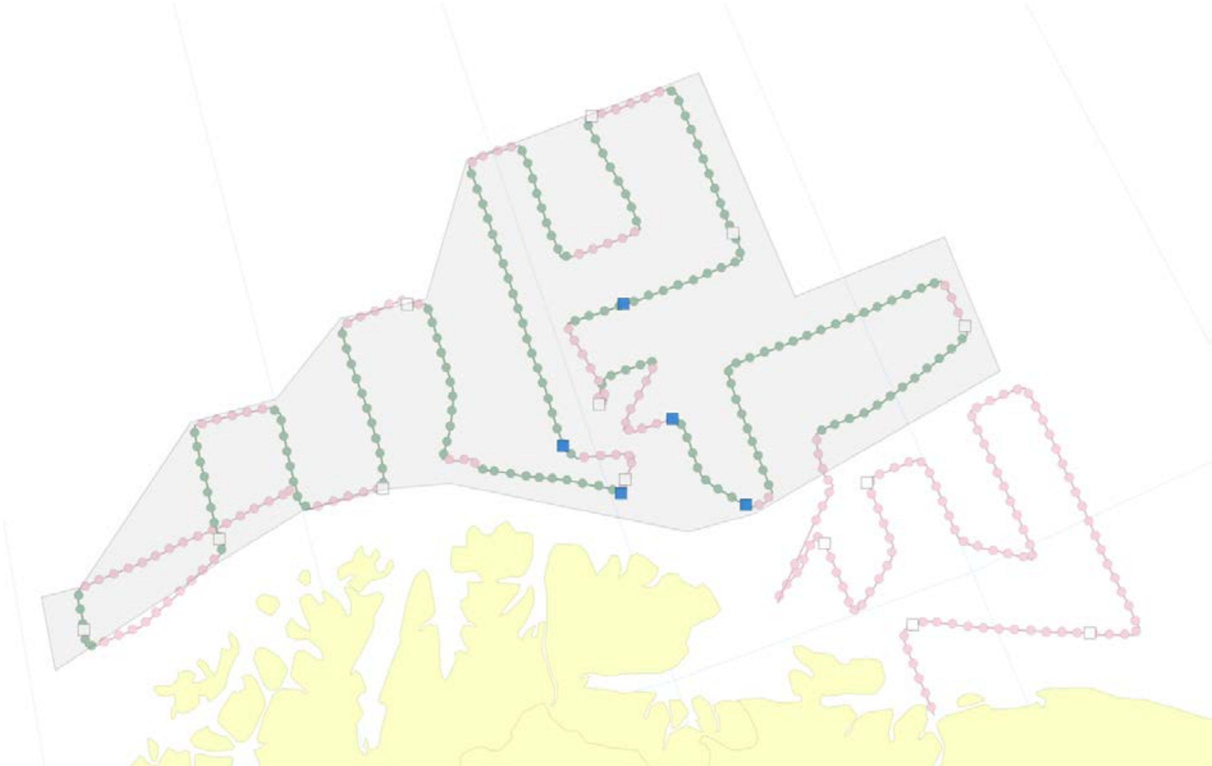

Figure 5. IESNS in the Barents Sea 2009. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

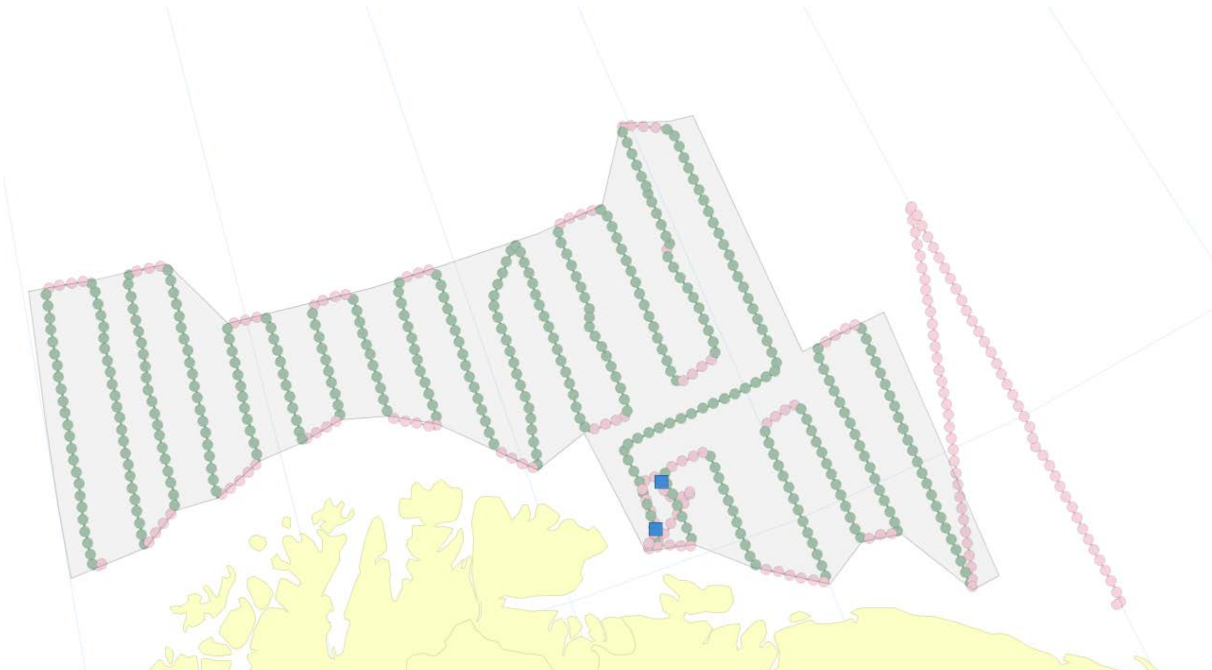

Figure 6. IESNS in the Barents Sea 2010. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX

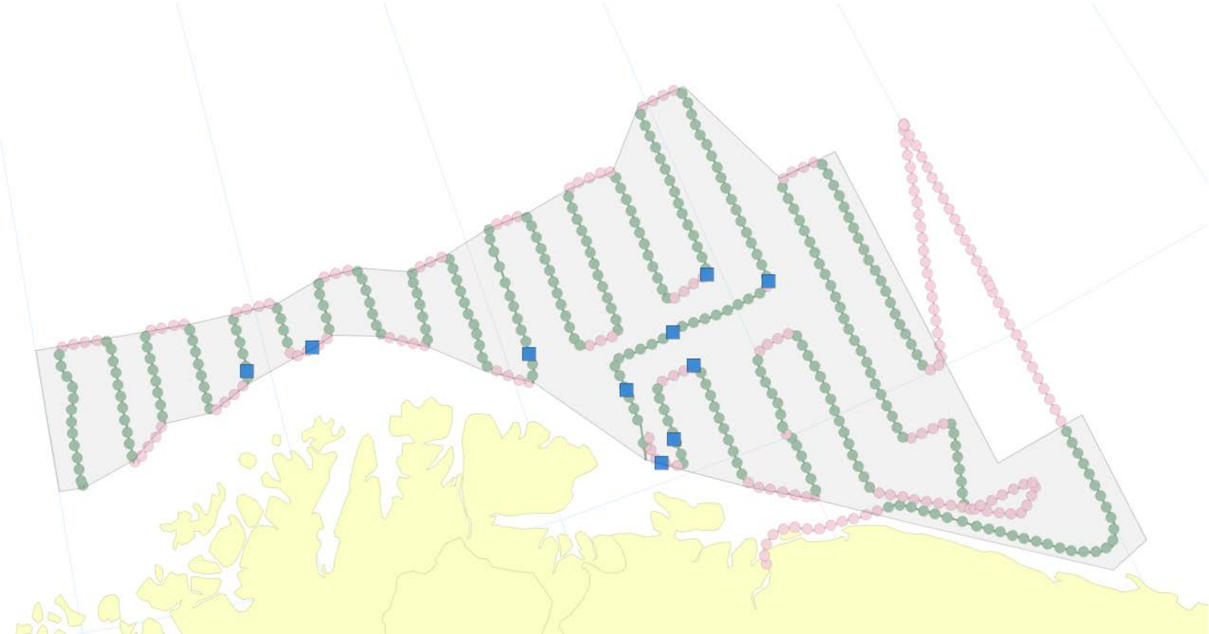

Figure 7. IESNS in the Barents Sea 2011. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX

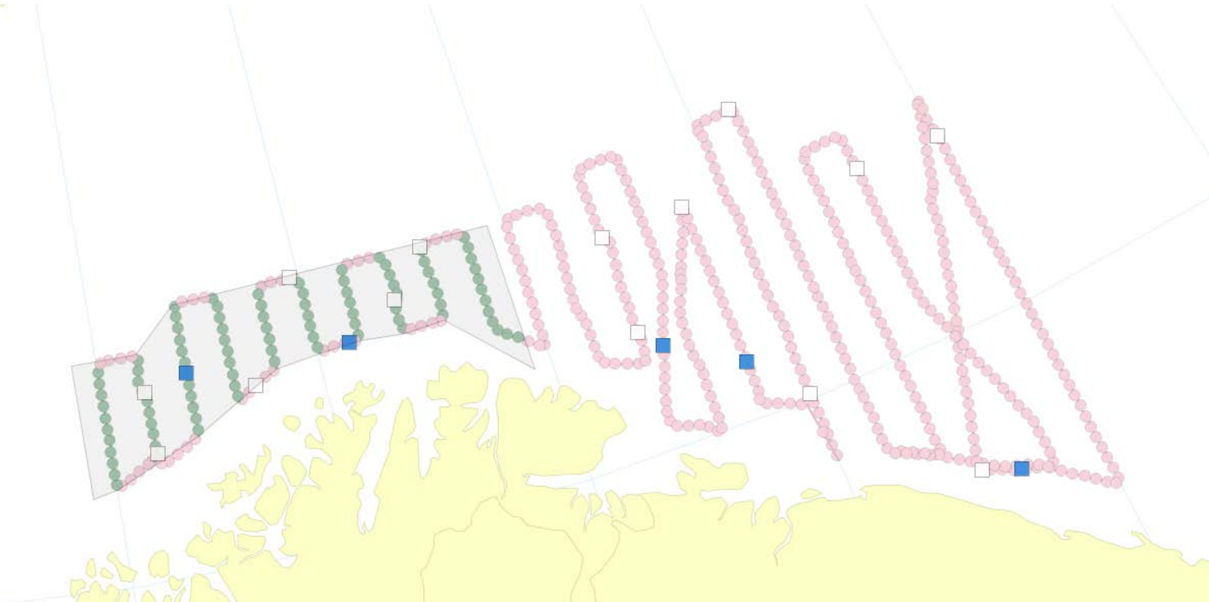

Figure 8. IESNS in the Barents Sea 2012. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX

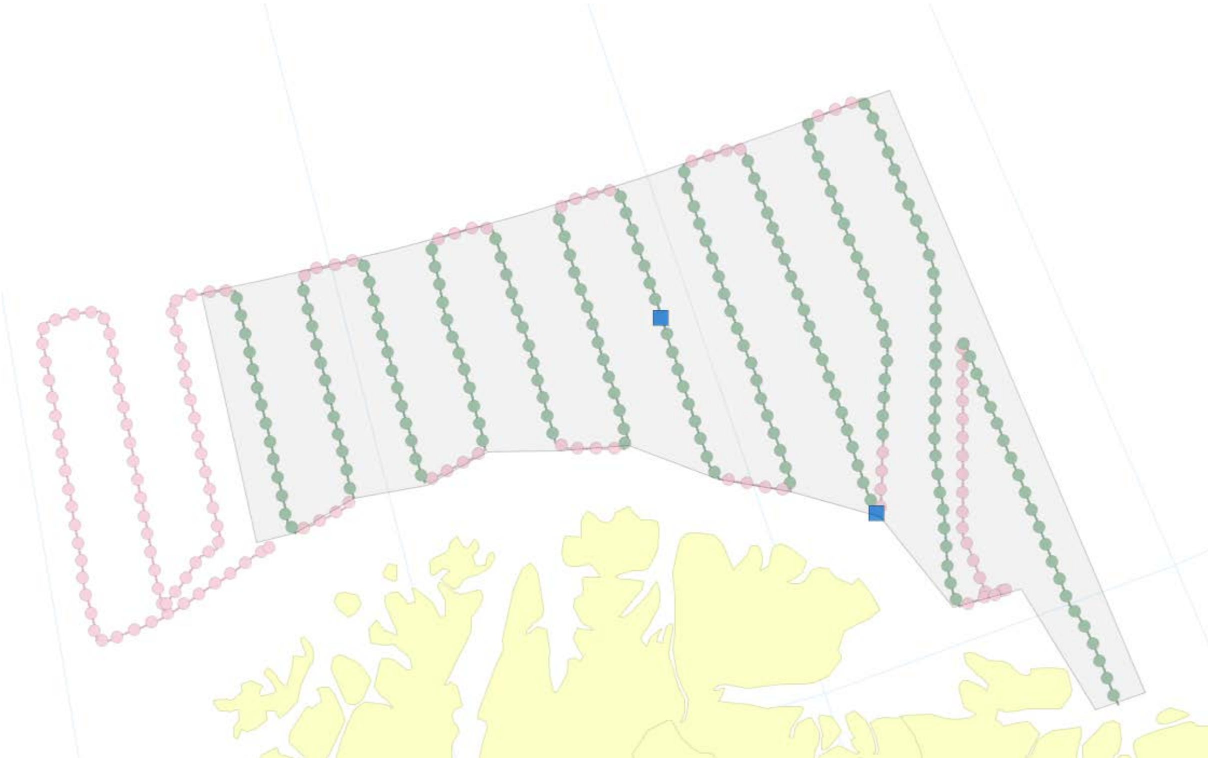

Figure 9. IESNS in the Barents Sea 2013. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX

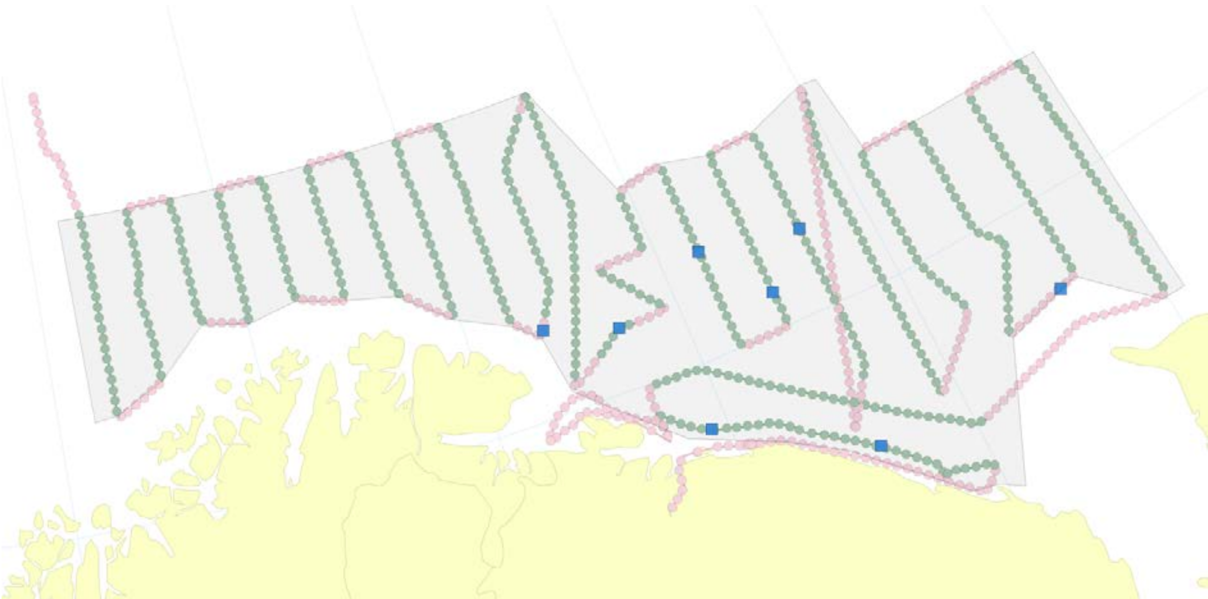

Figure 10. IESNS in the Barents Sea 2014. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX

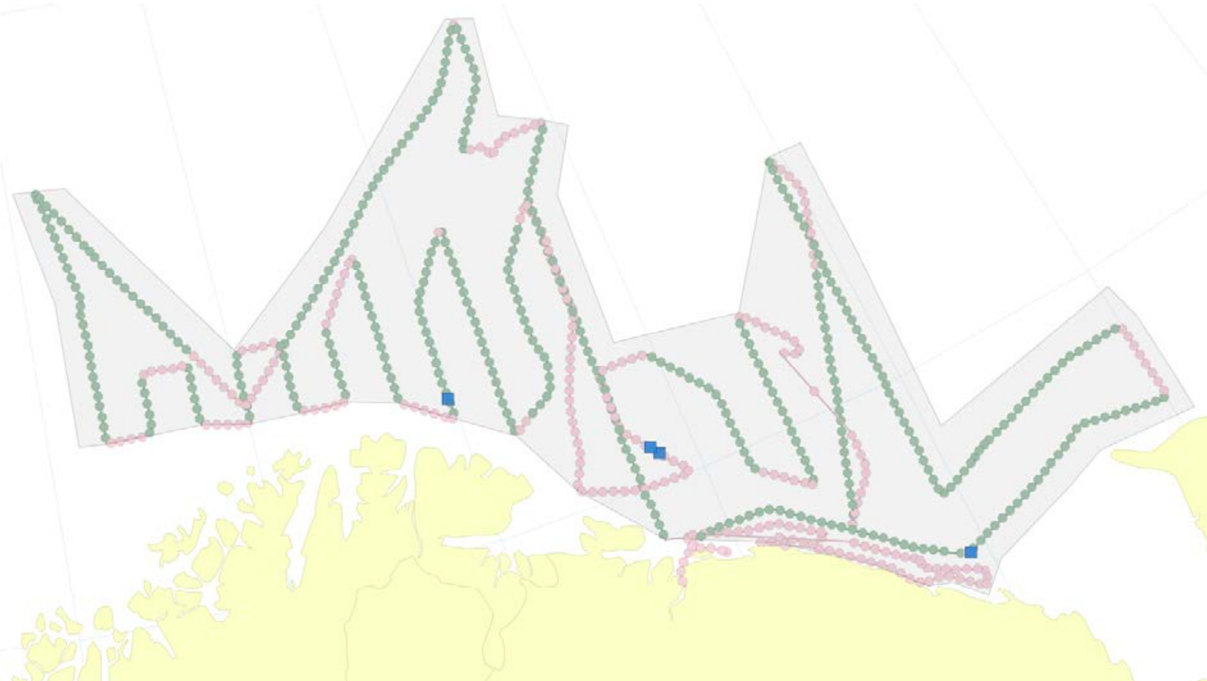

Figure 11. IESNS in the Barents Sea 2015. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX

Table 8. IESNS in the Norwegian Sea. StoX estimates of Norwegian spring-spawning herring for 2008.

LenGrp	age 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	971.1	21455	971.1	45.26
18-19	4660.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	94178	4660.1	49.48
19-20	12658.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	213343	12658.4	59.33
20-21	18319.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	286366	18319.9	63.97
21-22	13941.8	3664.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	224895	17606.6	78.29
22-23	15741.0	8797.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	288162	24538.6	85.16
23-24	13371.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	146709	13371.7	91.14
24-25	7282.5	14873.0	1160.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	212685	23316.2	109.63
25-26	3846.1	3915.6	56684.3	-	358.6	-	-	-	-	-	-	-	-	-	-	-	-	535133	64804.5	121.10
26-27	4196.8	17300.8	192324.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1595656	213821.9	134.00
27-28	-	12201.3	344426.0	11141.8	-	-	-	-	-	-	-	-	-	-	-	-	-	2487782	367769.1	147.83
28-29	-	3589.3	471654.6	83223.4	1942.3	-	-	-	-	-	-	-	-	-	-	-	-	3375830	560409.6	166.01
29-30	-	1932.8	501691.4	339358.0	39822.8	-	-	-	-	-	-	-	-	-	-	-	-	4888762	882805.0	180.58
30-31	-	11748.9	151788.8	509760.8	294209.0	11674.8	-	4998.4	-	3769.5	-	-	-	-	-	-	-	4970447	987950.3	198.76
31-32	-	-	26985.8	482932.0	1064772.7	31757.3	18432.1	12545.6	17941.5	-	-	1447.1	-	-	-	-	-	7728939	1656814.1	214.37
32-33	-	-	5007.5	194969.6	1314230.6	76121.3	38629.5	43428.3	5358.1	-	-	-	-	-	-	-	-	7250380	1677744.9	231.40
33-34	-	-	-	29541.4	539118.3	162796.5	133867.7	215609.2	80001.8	9575.7	-	-	-	-	-	-	-	4612448	1170510.7	253.77
34-35	-	-	-	-	81111.4	64525.5	246288.9	531351.8	217250.5	23238.5	3865.1	3563.4	-	1349.9	-	-	-	4243703	1172545.0	276.30
35-36	-	-	-	-	7762.4	32989.7	114748.1	397087.3	249659.9	47001.2	4216.1	12437.1	-	-	-	-	-	2951515	865901.7	293.38
36-37	-	-	-	-	-	-	63055.9	145269.9	170024.1	32294.6	10535.2	-	27077.0	37853.4	19380.3	-	-	1604696	505490.5	315.01
37-38	-	-	-	-	-	-	-	9527.1	47959.3	18328.6	21315.6	31653.8	41332.6	35603.0	12719.3	7918.4	-	674117	226357.6	335.78
38-39	-	-	-	-	-	-	-	-	5778.2	1296.2	6995.0	-	16145.4	29793.4	7410.0	10858.9	-	227012	78277.0	344.81
39-40	-	-	-	-	-	-	-	-	-	-	-	-	6329.9	-	4764.5	-	-	29810	11094.4	372.17
40-41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	687.3	1576	687.3	436.09
TSN(1000)	1240242	631389	10809290	8270930	14827041	1513234	2256742	4847634	2734452	449201	149393	151300	270278	309150	131471	50819	23031	48665597	-	-
TSB(1000 kg)	94018.2	78024.2	1751723.4	1650927.0	3343328.0	379865.2	615022.1	1359817.6	793973.2	135504.3	46927.0	49101.5	90884.9	104599.7	44274.1	18777.3	1658.4	-	10558426.2	-
Mean length (cm)	21.27	25.47	28.12	30.40	31.76	32.95	34.02	34.28	34.75	35.01	36.48	36.10	37.10	36.85	36.91	37.61	18.85	-	-	-
Mean weight (g)	75.81	123.58	162.06	199.61	225.49	251.03	272.53	280.51	290.36	301.66	314.12	324.53	336.26	338.35	336.76	369.49	72.01	-	-	216.96

Table 9. IESNS in the Norwegian Sea. StoX estimates of Norwegian spring-spawning herring for 2009.

LenGrp	age 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	613.2	14955	613.2	41.00
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2076.3	41527	2076.3	50.00
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1869.4	36655	1869.4	51.00
20-21	2304.9	-	4729.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	104752	7034.6	67.15
21-22	-	6523.2	2940.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	130108	9463.8	72.74
22-23	4805.1	19284.1	9424.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	419659	33513.2	79.86
23-24	-	23294.0	15198.8	6762.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	491417	45255.6	92.09
24-25	-	24444.3	5828.0	7085.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	364467	37358.0	102.50
25-26	6367.5	14824.2	9729.7	10653.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	340282	41575.1	122.18
26-27	-	23827.1	43898.5	5491.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	548089	73217.0	133.59
27-28	-	43156.9	61351.0	88762.8	217.1	-	-	-	-	-	-	-	-	-	-	-	-	-	1298335	193487.8	149.03
28-29	-	34181.9	39592.5	319342.7	15979.7	-	-	-	-	-	-	-	-	-	-	-	-	-	2503398	409096.8	163.42
29-30	-	12539.5	27300.6	506013.1	15692.0	-	-	-	-	-	-	-	-	-	-	-	-	-	3146776	561545.2	178.45
30-31	-	-	50540.1	520765.0	204358.9	36498.5	8324.3	-	-	-	-	-	-	-	-	-	-	-	4161991	820486.7	197.14
31-32	-	-	22995.7	494186.3	437261.2	170413.0	16903.1	57831.2	19216.3	-	-	-	-	-	-	-	-	-	5617052	1218806.8	216.98
32-33	-	-	10078.2	250320.7	693239.4	587659.4	122459.7	27952.7	-	-	-	13988.8	-	-	-	-	-	-	7207061	1705698.9	236.67
33-34	-	-	10322.6	106201.3	490750.1	879462.0	188280.8	41862.9	30941.0	21739.6	-	-	-	-	-	-	-	-	6998704	1769560.3	252.84
34-35	-	-	2495.5	7527.8	206441.1	613007.0	149589.3	77425.8	169881.9	96057.1	13354.3	-	500.8	-	-	-	-	-	4927270	1336280.5	271.20
35-36	-	-	-	10488.0	16698.8	89069.1	90148.1	128049.7	308605.6	185452.2	13802.8	6349.6	-	1078.5	-	-	-	-	2858572	849742.2	297.26
36-37	-	-	-	-	-	18647.2	9835.3	66267.4	163010.9	97251.7	19853.2	17057.9	15305.9	3346.1	13087.8	-	-	-	1326223	423663.3	319.45
37-38	-	-	-	-	-	-	-	5399.5	34787.7	24610.5	10229.0	14445.1	24096.4	7860.0	19760.0	6117.3	4051.2	-	448101	151356.7	337.77
38-39	-	-	-	-	-	-	-	-	-	-	3303.0	7821.2	-	6878.9	8914.3	4085.4	-	-	82383	31002.8	376.33
39-40	-	-	-	-	-	-	-	-	-	-	-	-	-	5009.4	-	-	-	-	12828	5009.4	390.49
41-42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1457	-	-
TSN(1000)	144057	1668550	2159326	12300011	8994405	9527172	2146686	1434534	2466410	1410522	188443	193347	123212	66990	122784	28968	12052	94593	43082062	-	-
TSB(1000 kg)	13477.4	202075.2	316425.4	2333601.4	2080638.2	2394756.2	585540.6	404789.0	726443.4	425111.1	60542.3	59662.5	39903.0	24172.9	41762.2	10202.6	4051.2	4558.9	-	9727713.5	-
Mean length (cm)	22.97	25.17	27.12	29.88	32.09	32.97	33.42	33.97	34.84	34.96	35.58	35.24	36.57	37.38	36.85	37.38	37.00	18.86	-	-	-
Mean weight (g)	93.56	121.11	146.54	189.72	231.33	251.36	272.76	282.17	294.53	301.39	321.28	308.58	323.86	360.84	340.13	352.20	336.13	48.95	-	-	225.80

Table 10. IESNS in the Norwegian Sea. StoX estimates of Norwegian spring-spawning herring for 2010.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
10-11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17025	17025	136.2	8.00
11-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48144	48144	433.3	9.00
12-13	127406	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	127406	1508.5	11.84
13-14	72949	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72949	1097.2	15.04
14-15	34050	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34050	629.9	18.50
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9245	9245	-	-
18-19	-	25928	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25928	1158.1	44.67
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9245	9245	-	-
20-21	-	23760	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23760	1473.1	62.00
21-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	48642	48642	3550.9	73.00
22-23	-	47519	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47519	4144.7	87.22
23-24	-	9019	99944	-	-	-	-	-	-	-	-	-	-	-	-	-	-	108963	10719.8	98.38
24-25	-	-	100010	66673	-	-	-	-	-	-	-	-	-	-	-	-	-	166683	17696.5	106.17
25-26	-	-	48519	189738	-	-	-	-	-	-	-	-	-	-	-	-	-	238258	29445.6	123.59
26-27	-	-	158210	192147	-	-	-	8484	-	-	-	-	-	-	-	-	-	358842	47906.1	133.50
27-28	-	-	37030	452724	48273	-	-	-	-	-	-	-	-	-	-	-	-	538026	80539.0	149.69
28-29	-	-	56714	420370	163826	90864	-	-	-	-	-	-	-	-	-	-	-	731774	120159.9	164.20
29-30	-	-	-	310514	475260	614814	-	-	-	-	-	-	-	-	-	-	-	1400589	256969.6	183.47
30-31	-	-	41929	361871	683828	1965701	59070	-	-	-	-	-	-	-	-	-	-	3112399	612789.9	196.89
31-32	-	-	-	320188	224748	2822513	878324	201700	-	-	-	-	-	-	-	-	-	4447473	956923.6	215.16
32-33	-	18592	-	9954	132299	1766878	2147049	1174009	28057	-	-	30170	-	-	-	-	-	5307008	1257769.7	237.00
33-34	-	-	-	9566	24286	853936	2098026	1475916	95671	73024	119092	14947	-	-	-	-	-	4764464	1213800.6	254.76
34-35	-	-	-	-	13561	235901	505089	2036336	429284	313438	229762	119422	-	-	-	-	-	3882792	1069330.2	275.40
35-36	-	-	-	-	14468	-	297371	679240	209749	383838	355910	200394	9043	-	-	21204	-	2171217	648147.5	298.52
36-37	-	-	-	-	-	-	3347	21966	105854	100835	205017	197553	54810	63178	8368	8368	-	769295	241919.2	314.47
37-38	-	-	-	-	-	-	-	3201	-	11203	73622	16005	15414	7411	-	4801	-	131658	44375.6	337.05
38-39	-	-	-	-	-	-	-	-	-	-	-	-	6113	1223	-	14672	-	22008	8223.4	373.65
39-40	-	-	-	-	-	-	-	-	-	-	-	-	4891	-	-	-	-	4891	1833.0	374.80
43-44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1831	1831	-	-
TSN(1000)	234405	124818	542356	2333746	1780549	8350607	5988276	5600851	868615	882338	983403	578492	90270	71812	8368	49045	134134	28622083	-	-
TSB(1000 kg)	3235.6	12018.5	71239.1	390893.8	348937.7	1800129.8	1482565.7	1473762.4	252332.2	257941.0	289565.7	174039.1	29059.0	23509.8	2942.2	16389.2	4120.4	-	6632681.0	-
Mean length (cm)	12.81	22.68	25.82	28.44	30.12	31.32	32.70	33.43	34.45	34.70	34.89	35.01	36.40	36.14	36.00	36.26	16.11	-	-	-
Mean weight (g)	13.80	96.29	131.35	167.50	195.97	215.57	247.58	263.13	290.50	292.34	294.45	300.85	321.91	327.38	351.60	334.17	36.20	-	-	231.90

Table 11. IESNS in the Norwegian Sea. StoX estimates of Norwegian spring-spawning herring for 2011.

LenGrp	age 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	344.1	8823	344.1	39.00
17-18	-	-	2160.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	59801	2160.2	36.12
18-19	4386.4	388.6	-	-	254.3	-	254.3	-	-	-	-	-	-	-	-	-	-	-	111404	5283.6	47.43
19-20	10150.0	1180.7	-	-	-	879.5	-	-	-	-	-	-	-	-	-	-	-	-	236189	12210.2	51.70
20-21	29744.3	-	-	-	1839.2	-	-	-	-	-	-	-	-	-	-	-	-	-	539076	31583.5	58.59
21-22	6617.6	-	-	-	-	-	-	3195.6	-	-	-	-	-	-	-	-	-	-	151872	9813.2	64.61
22-23	6130.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	77825	6130.1	78.77
23-24	-	3973.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	44952	3973.5	88.39
24-25	6893.8	4697.2	362.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	112988	11953.6	105.80
25-26	-	30132.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	259710	30132.2	116.02
26-27	129.9	19509.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	151299	19639.5	129.81
27-28	12793.4	11965.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	168022	24758.9	147.35
28-29	-	9245.5	40136.3	3994.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	323266	53376.5	165.12
29-30	372.8	10790.2	70313.2	75654.4	1988.1	-	-	-	-	-	-	-	-	-	-	-	-	-	875146	159118.8	181.82
30-31	3729.1	32101.8	70233.0	180930.7	42019.5	75567.4	5953.5	6562.4	-	-	-	-	-	-	-	-	-	-	2075411	417097.5	200.97
31-32	-	18674.1	53934.8	319983.2	110662.1	304379.9	2326.3	3580.0	12913.5	-	2381.2	-	-	-	-	-	-	-	3773754	828835.0	219.63
32-33	11607.6	4313.2	28389.1	110991.2	232546.2	805518.1	190154.4	61007.8	-	1481.3	-	2910.1	-	-	-	-	-	-	6114542	1448919.1	236.96
33-34	-	1443.9	15504.2	41433.1	85781.9	714909.7	365401.4	322143.9	75468.0	51610.1	9191.7	1848.5	-	-	-	-	-	-	6558851	1684736.3	256.86
34-35	-	-	7664.3	26003.2	91396.8	257504.9	467412.4	464182.8	38769.7	34665.8	15903.6	-	-	-	-	-	-	-	5147468	1403503.5	272.66
35-36	-	-	-	4340.3	13765.3	146298.1	166958.7	242260.8	72482.1	84594.1	86804.5	9899.8	-	-	-	-	-	-	2833231	827403.9	292.04
36-37	-	-	-	-	16921.8	-	24516.4	49313.6	34081.1	75356.0	74643.4	23990.4	10120.6	2322.4	3401.7	1053.4	-	-	1004091	315720.8	314.43
37-38	-	-	-	-	-	-	-	3047.3	5024.1	12915.4	17651.5	29691.8	1086.8	1707.5	-	-	1211.0	-	216656	72335.3	333.87
38-39	-	-	-	-	-	-	-	-	-	-	7071.8	15036.9	-	3078.5	-	-	-	-	70559	25187.2	356.97
39-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1102.4	2818	1102.4	391.20
TSN(1000)	1205267	977041	1528237	3607203	2563544	9419779	4541633	4298276	824757	891879	712374	260875	36620	22074	10421	2977	3158	11641	30917757	-	-
TSB(1000 kg)	92555.1	148415.9	288697.8	763330.8	597175.2	2305057.6	1222977.4	1155294.4	238738.6	260622.7	213647.6	83377.5	11207.5	7108.3	3401.7	1053.4	1211.0	1446.5	-	7395319.0	-
Mean length (cm)	21.59	26.98	29.62	31.01	32.16	32.61	33.63	33.83	34.25	34.86	35.45	36.31	36.16	37.11	36.00	36.00	37.00	21.95	-	-	-
Mean weight (g)	76.79	151.90	188.91	211.61	232.95	244.70	269.28	268.78	289.47	292.22	299.91	319.61	306.05	322.02	326.43	353.80	383.40	124.26	-	-	239.19

Table 12. IESNS in the Norwegian Sea. StoX estimates of Norwegian spring-spawning herring for 2012.

LenGrp	age 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
17-18	729.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20842	729.5	35.00
18-19	3437.4	635.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93878	4072.9	43.38
19-20	6054.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	119335	6054.7	50.74
20-21	4626.0	1514.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	104779	6140.1	58.60
21-22	3768.7	5679.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	127751	9447.8	73.95
22-23	1143.0	10659.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	139437	11802.4	84.64
23-24	-	25060.7	893.3	-	-	-	-	-	-	-	-	-	-	-	-	-	277576	25954.0	93.50
24-25	-	33643.7	348.3	-	-	-	-	-	-	-	-	-	-	-	-	-	322930	33992.0	105.26
25-26	-	57175.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	486307	57175.1	117.57
26-27	1769.6	81828.6	957.4	-	-	-	-	-	-	-	-	-	-	-	-	-	647877	84555.6	130.51
27-28	-	56595.2	4489.5	1059.0	-	-	-	-	-	-	-	-	-	-	-	-	425280	62143.7	146.12
28-29	-	50760.9	7947.8	-	1856.7	-	-	-	-	-	-	-	-	-	-	-	375567	60565.5	161.26
29-30	-	25928.8	17523.0	4603.4	-	-	-	-	-	-	-	-	-	-	-	-	264435	48055.2	181.73
30-31	-	16146.4	18932.4	9169.4	14183.1	8939.6	1537.9	-	-	-	-	-	-	-	-	-	334338	68908.8	206.11
31-32	-	2690.9	16483.8	34285.0	50560.9	42311.2	22871.2	-	2942.6	-	3568.6	-	-	-	-	-	784621	175714.2	223.95
32-33	-	3303.2	9780.3	73152.8	175743.5	198126.4	129962.6	16375.0	6126.9	-	-	5199.3	-	-	-	-	2539928	617769.9	243.22
33-34	-	-	1617.8	25503.0	112349.6	264527.9	475568.0	134065.3	54910.8	4177.1	5708.2	1764.3	-	-	-	-	4139641	1080192.1	260.94
34-35	-	-	-	6142.8	33692.5	99334.2	367848.7	269045.1	265287.8	14619.5	12432.8	13616.4	3897.3	-	-	-	3883879	1085917.3	279.60
35-36	-	-	-	1014.5	7816.7	47143.7	115676.6	130095.0	190015.9	41368.6	73762.0	24167.1	17286.5	674.3	361.0	-	2176631	649382.1	298.34
36-37	-	-	-	-	680.9	194.2	16823.0	18054.8	62940.7	26163.6	64161.0	37733.2	18461.3	2343.3	567.7	-	775997	248123.6	319.75
37-38	-	-	-	-	-	-	176.0	3686.5	22230.7	3650.4	26508.9	12672.2	5266.3	388.3	7696.4	-	243777	82275.7	337.50
38-39	-	-	-	-	-	-	-	-	-	-	2345.6	3016.5	4801.3	-	3997.9	-	39753	14161.3	356.23
39-40	-	-	-	-	-	-	-	1231.1	-	1006.4	-	-	-	-	-	-	6013	2237.5	372.08
40-41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	506	-	-
TSN(1000)	378279	2895150	412189	669705	1645805	2559844	4225765	2025800	2096821	297571	606981	314658	154825	10990	36188	506	18331080	-	-
TSB(1000 kg)	21528.8	371621.7	78973.6	154929.9	396884.0	660577.2	1130464.0	572552.8	604455.5	90985.7	188487.0	98169.0	49712.6	3405.9	12623.0	-	-	4435370.7	-
Mean length (cm)	19.81	25.85	29.69	31.97	32.48	33.02	33.58	34.11	34.53	35.17	35.42	35.35	35.75	35.89	37.20	40.00	-	-	-
Mean weight (g)	56.91	128.36	191.60	231.34	241.15	258.05	267.52	282.63	288.27	305.76	310.53	311.99	321.09	309.90	348.82	-	-	-	241.97

Table 13. IESNS in the Norwegian Sea. StoX estimates of Norwegian spring-spawning herring for 2013.

LenGrp	age 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
17-18	331.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8968	331.8	37.00
18-19	428.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10201	428.4	42.00
19-20	2370.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	46052	2370.2	51.47
20-21	1658.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28137	1658.9	58.96
21-22	1662.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23927	1662.9	69.50
22-23	774.8	2730.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42479	3504.8	82.51
23-24	4412.9	3453.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	85002	7866.8	92.55
24-25	3116.8	17703.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	194289	20820.5	107.16
25-26	-	21564.3	4231.5	-	-	-	-	-	-	-	-	-	-	-	-	-	223421	25795.8	115.46
26-27	-	8717.2	24675.0	-	-	-	-	-	-	-	-	-	-	-	-	-	254808	33392.2	131.05
27-28	-	9183.2	61742.5	-	-	-	-	-	-	-	-	-	-	-	-	-	474535	70925.7	149.46
28-29	-	25695.1	93356.4	-	2824.3	-	-	-	-	-	-	-	-	-	-	-	755850	121875.8	161.24
29-30	-	6406.2	149704.3	15946.8	11164.7	1546.3	-	-	-	-	-	-	-	-	-	-	1014978	184768.4	182.04
30-31	-	4150.5	169856.5	7125.0	5000.9	15716.0	8889.8	2668.2	-	-	-	-	-	-	-	-	1070700	213406.9	199.32
31-32	-	-	171800.9	18840.3	18010.6	12446.6	7063.1	-	2966.9	775.3	737.6	-	-	-	-	-	1062672	232641.3	218.92
32-33	-	1444.3	49710.6	21759.0	76688.6	108766.0	60603.4	44810.9	16302.0	1597.7	1035.4	-	-	-	-	-	1552750	382718.0	246.48
33-34	-	-	11282.3	15971.0	116081.5	184220.2	222294.1	214310.4	96539.1	23929.4	-	10652.7	-	-	-	-	3381431	895280.7	264.76
34-35	-	-	8018.4	14116.5	57845.3	160095.9	398822.3	534850.2	199151.2	129357.9	18101.3	-	945.7	-	-	-	5447147	1521304.8	279.28
35-36	-	-	-	4919.0	15303.3	49311.1	128794.9	412721.9	343369.7	236363.9	50982.5	44691.0	8038.3	1456.8	-	-	4373096	1295952.4	296.35
36-37	-	-	-	-	-	2776.9	18116.9	94669.3	130691.2	137003.4	99842.7	96933.4	15271.8	9922.2	4083.9	-	1921351	609311.8	317.13
37-38	-	-	-	-	-	-	2037.8	10567.7	13434.2	25508.4	35718.4	81170.6	13603.4	4445.3	-	-	562255	186485.8	331.67
38-39	-	-	-	-	-	-	-	-	1639.0	4980.1	5120.3	24593.9	10770.0	3287.1	4405.2	-	156471	54795.7	350.20
39-40	-	-	-	-	-	-	-	-	-	-	5351.8	1086.1	377.2	-	-	-	17512	6815.1	389.17
40-41	-	-	-	-	-	-	-	-	-	-	-	-	14109.4	-	-	-	36178	14109.4	390.00
41-42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3098	-	-
TSN(1000)	205169	776243	3955370	433663	1210519	2035612	3069553	4651596	2766998	1873351	692071	804883	185911	58053	25220	3098	22747311	-	-
TSB(1000 kg)	14756.9	101048.5	744378.3	98677.4	302919.1	534879.1	846622.3	1314598.6	804093.3	559516.2	216890.1	259127.7	63115.9	19111.5	8489.1	-	-	5888224.2	-
Mean length (cm)	21.31	26.04	29.58	31.72	32.76	33.23	33.87	34.32	34.66	35.02	35.81	36.18	37.19	36.47	36.99	41.00	-	-	-
Mean weight (g)	71.93	130.18	188.19	227.54	250.24	262.76	275.81	282.61	290.60	298.67	313.39	321.94	339.50	329.21	336.60	-	-	-	258.89

Table 14. IESNS in the Norwegian Sea. StoX estimates of Norwegian spring-spawning herring for 2014.

LenGrp	age 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
14-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	546	-	-
15-16	-	90.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4200	90.2	21.48
17-18	-	-	39.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1091	39.3	36.00
18-19	-	432.2	197.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14494	630.0	43.47
19-20	-	-	3923.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70301	3923.8	55.81
20-21	-	-	8453.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	132177	8453.7	63.96
21-22	-	-	8540.0	5558.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	192920	14098.8	73.08
22-23	-	-	10784.6	9439.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	240912	20224.3	83.95
23-24	-	-	2130.1	26364.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	295399	28494.6	96.46
24-25	-	-	2168.4	19256.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	191675	21424.7	111.78
25-26	-	-	-	32643.9	294.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	274617	32938.3	119.94
26-27	-	-	921.2	15858.5	1852.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	136695	18632.2	136.30
27-28	-	-	1380.8	20666.7	9938.0	515.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	215692	32500.8	150.68
28-29	-	-	-	4746.1	36561.7	16004.2	7903.8	-	-	-	-	-	-	-	-	-	-	-	-	-	380498	65215.8	171.40
29-30	-	-	-	1661.4	22716.0	59250.1	10342.8	3268.1	-	-	-	1642.5	-	334.4	3777.1	-	-	-	-	-	540451	102992.4	190.57
30-31	-	-	-	5418.3	40278.4	121712.8	13636.0	11899.7	6117.1	1263.8	-	-	-	-	-	-	-	-	-	-	966025	200326.1	207.37
31-32	-	-	-	1142.2	14113.4	94092.5	31475.8	5215.6	11088.8	14919.4	2924.6	2712.7	2177.3	-	5414.1	-	-	-	-	-	832684	185276.3	222.51
32-33	-	-	-	-	14011.6	187748.8	37288.0	6740.8	39749.6	16500.8	4558.7	1838.7	-	-	-	-	-	-	-	-	1239989	308437.0	248.74
33-34	-	-	-	-	12305.2	92381.2	50489.8	72329.2	206062.3	70233.8	50747.8	5765.3	1215.2	-	-	-	-	-	-	-	2040303	561529.8	275.22
34-35	1123.7	-	-	-	4169.9	64137.4	28983.3	131921.2	281936.8	274353.6	289790.8	32529.1	34026.6	4643.3	-	-	-	-	-	-	3966993	1147615.6	289.29
35-36	1066.7	871.3	-	-	-	5220.2	5950.4	60137.7	191555.8	188437.7	321875.7	158074.8	84994.3	16640.1	3188.9	1157.0	1892.2	-	-	-	3426588	1041062.8	303.82
36-37	-	-	-	-	-	518.3	-	7115.6	42762.9	106400.7	148754.4	120584.5	94612.6	54475.4	4630.4	8044.2	412.4	-	-	-	1833300	588311.5	320.90
37-38	-	-	-	739.3	-	-	-	-	2695.4	6556.0	22206.3	19016.9	11614.0	20411.6	2026.2	33200.6	201.4	-	-	-	354318	118667.9	334.92
38-39	-	-	-	-	-	1056.4	-	-	-	-	6003.4	-	9651.7	16101.6	718.0	16796.6	648.9	-	-	-	144939	50976.8	351.71
39-40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3207.3	-	-	8280	3207.3	387.33
41-42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	219.7	-	542	219.7	404.95
TSN(1000)	7811	17398	517240	1230825	797812	2790288	748816	1065277	2681452	2284660	2842071	1119251	777977	349807	76368	180003	9205	8280	542	546	17505629	-	-
TSB(1000 kg)	2190.4	1393.7	38539.8	143495.5	156241.2	642637.1	186069.9	298628.0	781968.8	678666.0	846861.8	342164.3	238291.6	112606.5	19754.8	59198.4	3154.9	3207.3	219.7	-	-	4555289.6	-
Mean length (cm)	34.48	20.45	21.34	24.74	29.67	31.54	32.04	33.83	34.10	34.50	34.90	35.36	35.52	36.30	32.81	37.22	35.81	39.00	41.00	14.50	-	-	-
Mean weight (g)	280.42	80.11	74.51	116.58	195.84	230.31	248.49	280.33	291.62	297.05	297.97	305.71	306.30	321.91	258.68	328.88	342.73	387.33	404.95	-	-	-	260.23

Table 15. IESNS in the Norwegian Sea. StoX estimates of Norwegian spring-spawning herring for 2015.

LenGrp	age 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
19-20	5931	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5931	332.2	56.00
20-21	21406	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	21406	1412.8	66.00
21-22	41121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	41121	2959.4	71.97
22-23	106088	17134	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	123222	9967.1	80.89
23-24	33485	82469	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	115954	10773.0	92.91
24-25	154451	58395	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	212846	22108.9	103.87
25-26	18337	125122	51774	-	-	-	-	-	-	-	-	-	-	-	-	-	-	195232	24410.5	125.03
26-27	-	64822	151786	-	-	-	-	-	-	-	-	-	-	-	-	-	-	216608	29438.7	135.91
27-28	4611	8065	288241	4611	-	-	-	-	-	-	-	-	-	-	-	-	-	305529	46098.0	150.88
28-29	-	55361	125982	15848	36330	27012	3455	-	-	-	-	-	-	-	-	-	-	263988	44415.2	168.25
29-30	-	47041	224733	51198	193801	76765	-	4092	-	-	-	-	-	-	-	-	-	597632	109219.1	182.75
30-31	-	-	211148	177667	178667	166060	36312	-	-	10894	-	-	-	-	-	-	-	780748	157041.9	201.14
31-32	-	-	114088	174013	247013	155225	38806	69851	34926	73714	-	-	-	-	-	-	-	907635	200828.1	221.27
32-33	-	-	116290	156833	485530	55735	18578	60466	35464	46981	15117	-	-	-	-	-	-	990994	241182.7	243.37
33-34	-	9211	14966	291709	1311080	106414	68533	163051	66349	61328	2303	3454	7116	-	-	-	-	2105514	559205.0	265.59
34-35	-	-	-	197098	786403	212908	362232	922079	801085	786721	68094	45529	13855	12390	-	-	-	4208395	1196600.7	284.34
35-36	-	-	-	107448	251737	542451	453142	1403486	927453	1866425	205716	109280	55759	11550	-	-	-	5934444	1774454.7	299.01
36-37	-	-	-	-	57180	56168	168173	503217	524094	1099346	299967	301740	132077	34891	14017	18641	-	3209510	1006573.7	313.62
37-38	-	-	-	-	-	-	4672	51701	94849	357641	96090	268812	38540	91345	2336	-	-	1005986	338207.8	336.20
38-39	-	-	-	-	-	-	5757	-	14557	46975	24060	57964	4296	6633	-	-	-	160242	56792.8	354.42
39-40	-	-	-	-	-	-	-	-	24710	-	816	816	10614	2449	-	-	-	39406	13744.3	348.79
44-45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	695	695	-	-
TSN(1000)	385431	467620	1299007	1176425	3547742	1398738	1159659	3177943	2523487	4350024	712163	787595	262258	159258	16352	18641	695	21443038	-	-
TSB(1000 kg)	34941.3	61142.5	231893.8	287412.1	907372.7	368558.8	339561.4	930431.2	752769.3	1312560.7	222327.3	251604.8	81361.5	52475.6	5228.1	6125.5	-	-	5845766.5	-
Mean length (cm)	23.07	25.75	28.85	32.43	32.96	33.34	34.57	34.83	35.05	35.28	35.67	36.32	35.99	36.61	36.14	36.00	44.00	-	-	-
Mean weight (g)	90.66	130.75	178.52	244.31	255.76	263.49	292.81	292.78	298.31	301.74	312.19	319.46	310.23	329.50	319.72	328.60	-	-	-	272.63

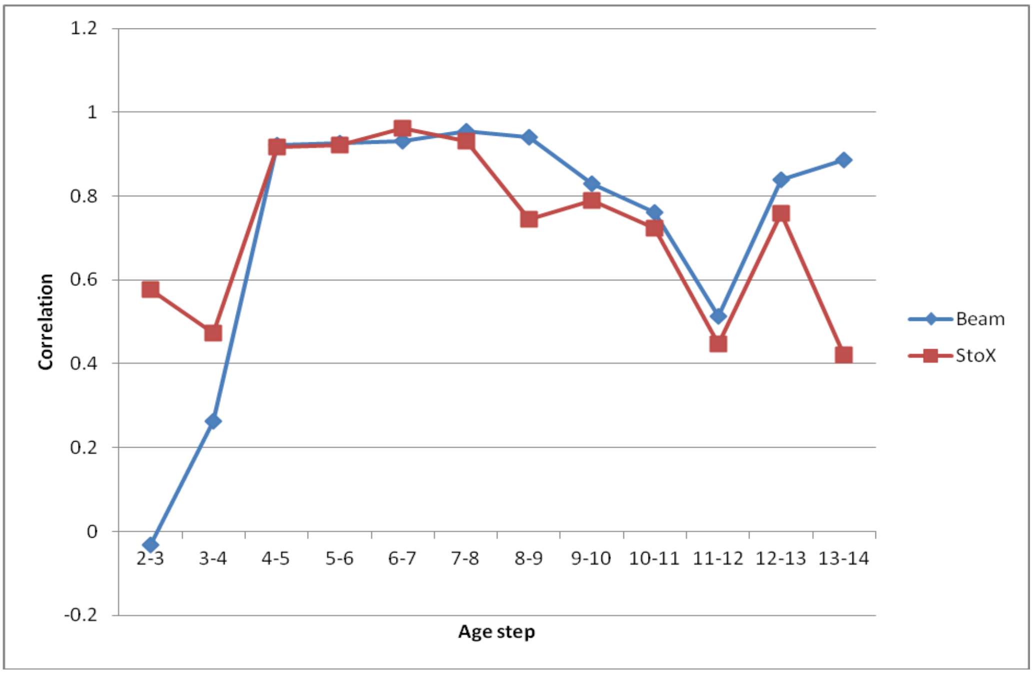

Figure 12. IESNS in the Norwegian Sea, Norwegian spring-spawning herring. Internal consistency (correlation between log-transformed abundance estimates for the same cohort at consecutive ages) by age step for the StoX estimates and the old Beam estimates.

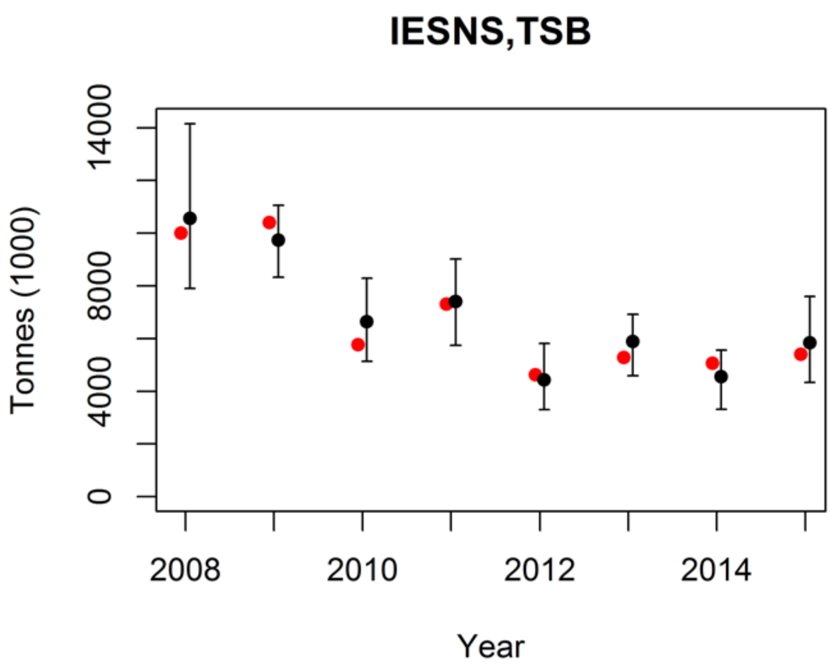

Figure 13. IESNS in the Norwegian Sea, total stock biomass of Norwegian spring-spawning herring. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

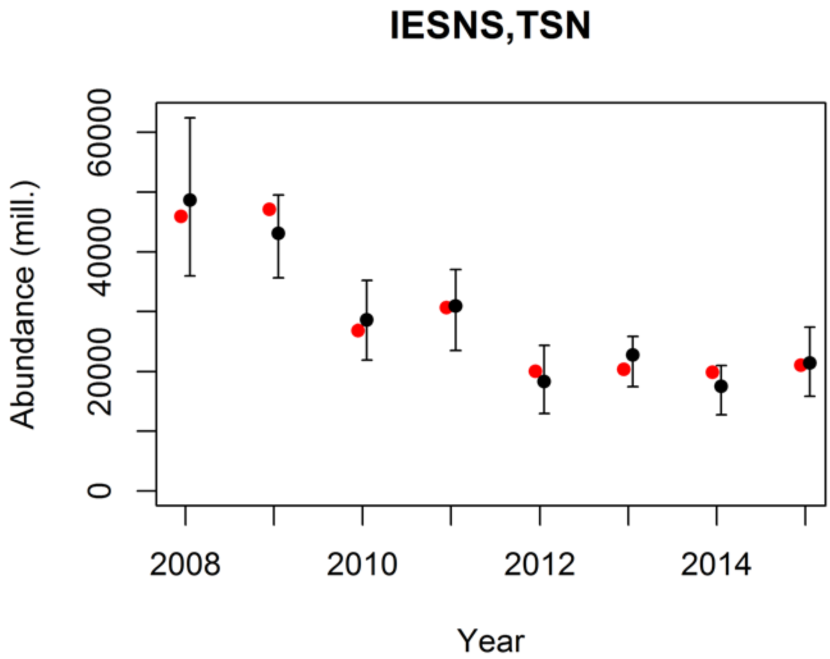

Figure 14. IESNS in the Norwegian Sea, total stock number of Norwegian spring-spawning herring. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

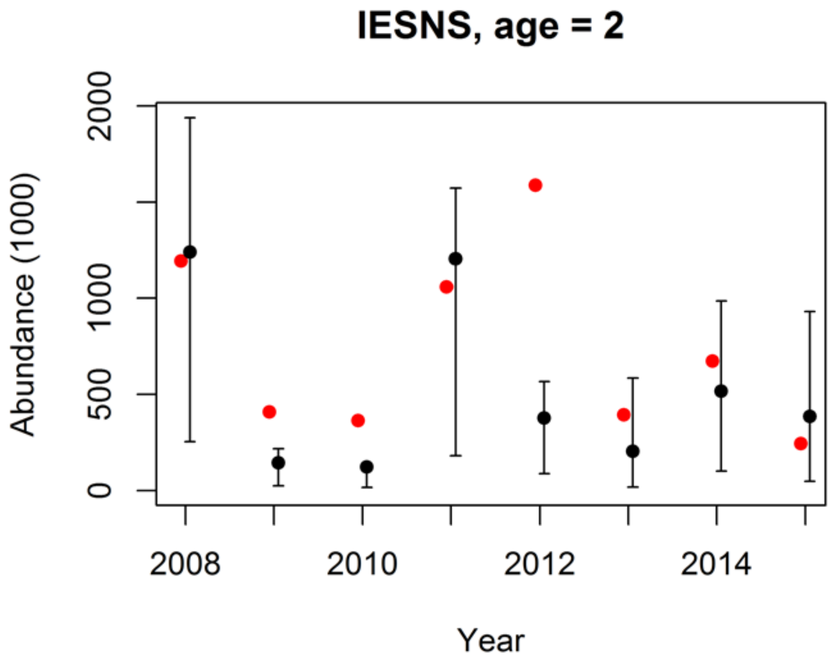

Figure 15. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 2. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

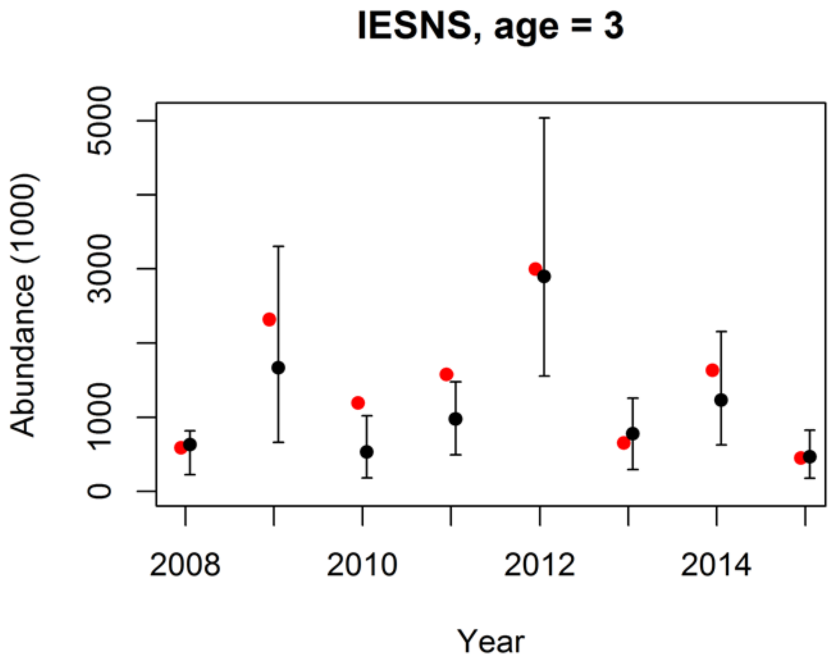

Figure 16. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 3. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

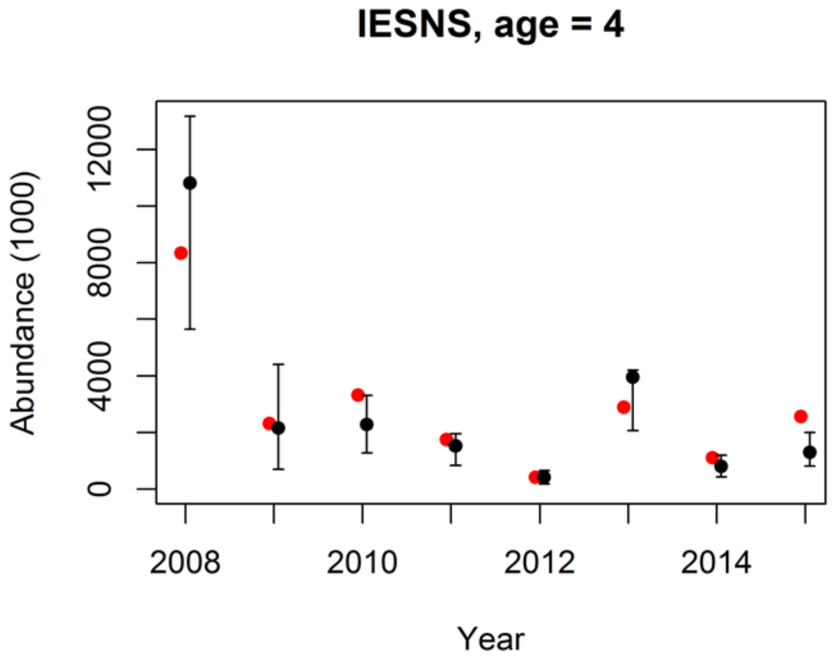

Figure 17. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 4. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

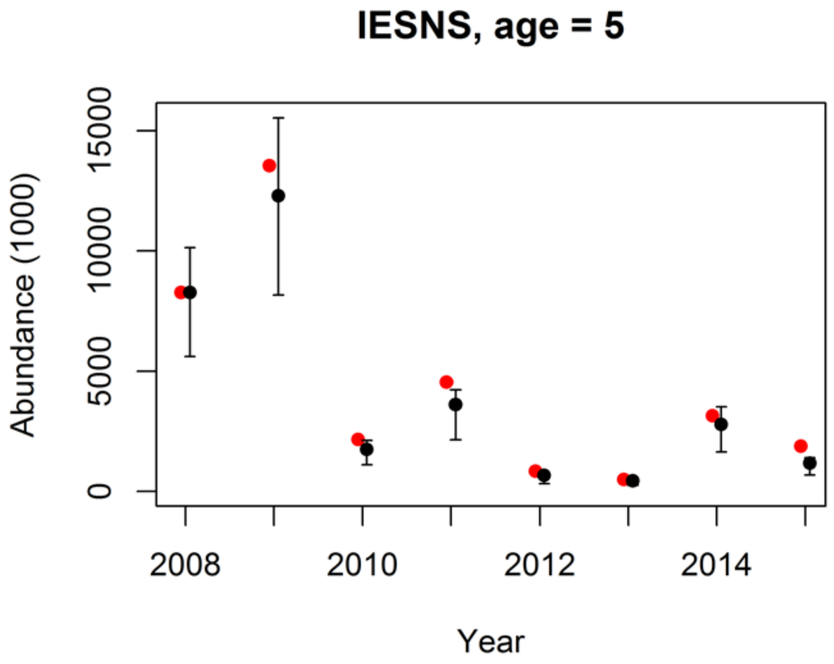

Figure 18. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 5. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

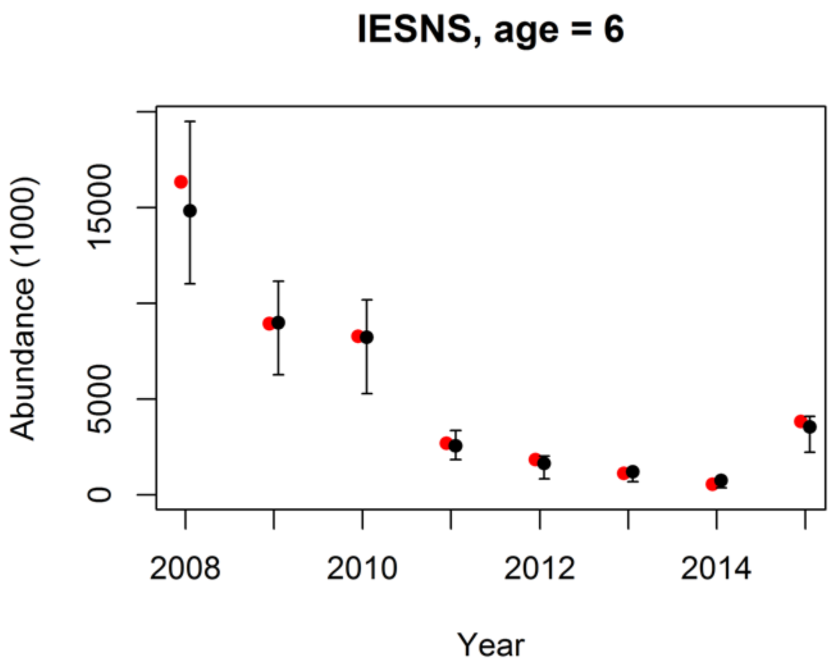

Figure 19. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 6. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

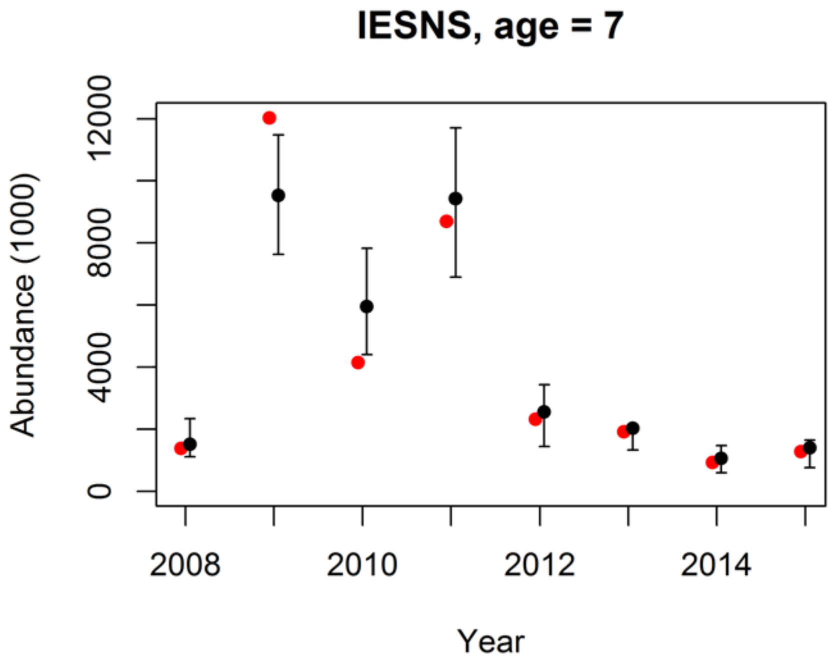

Figure 20. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 7. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

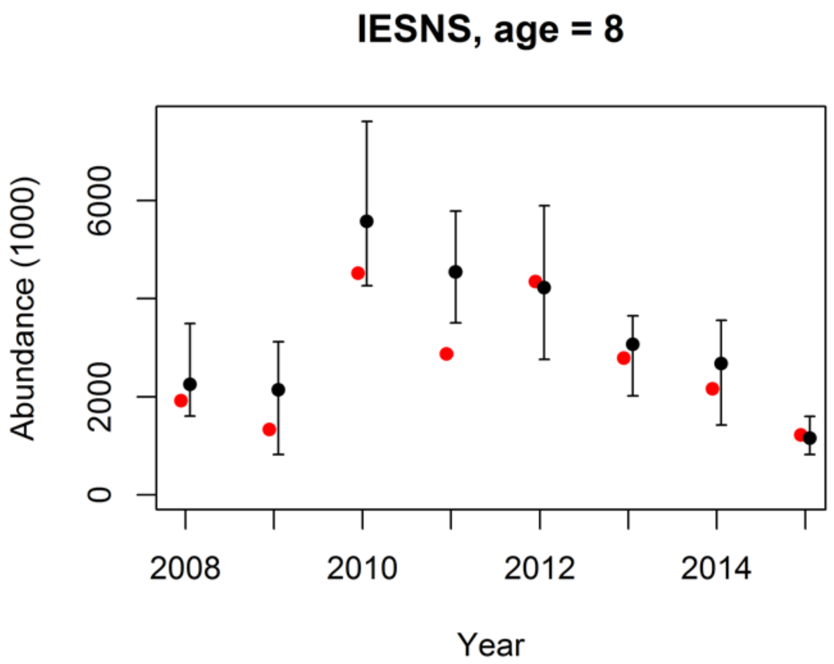

Figure 21. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 8. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

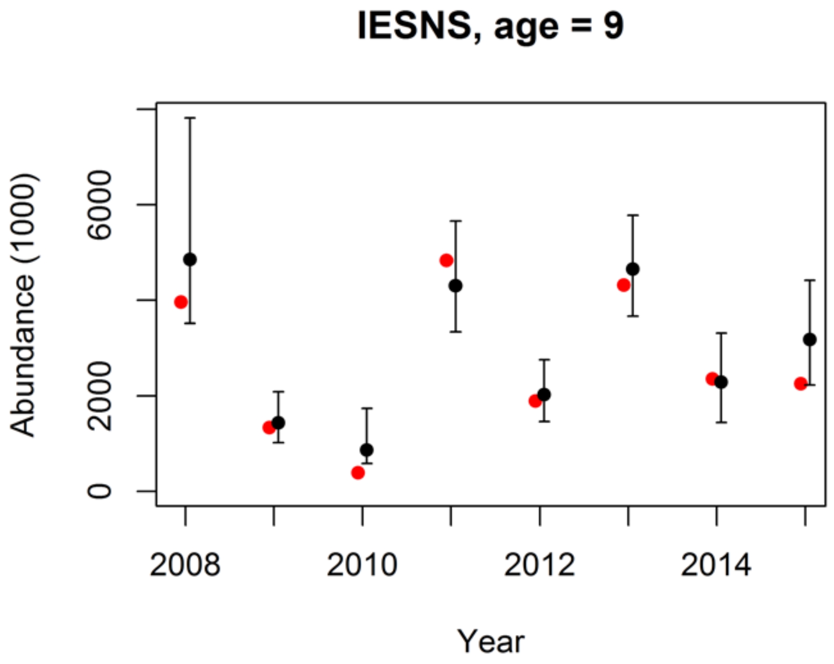

Figure 22. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 9. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

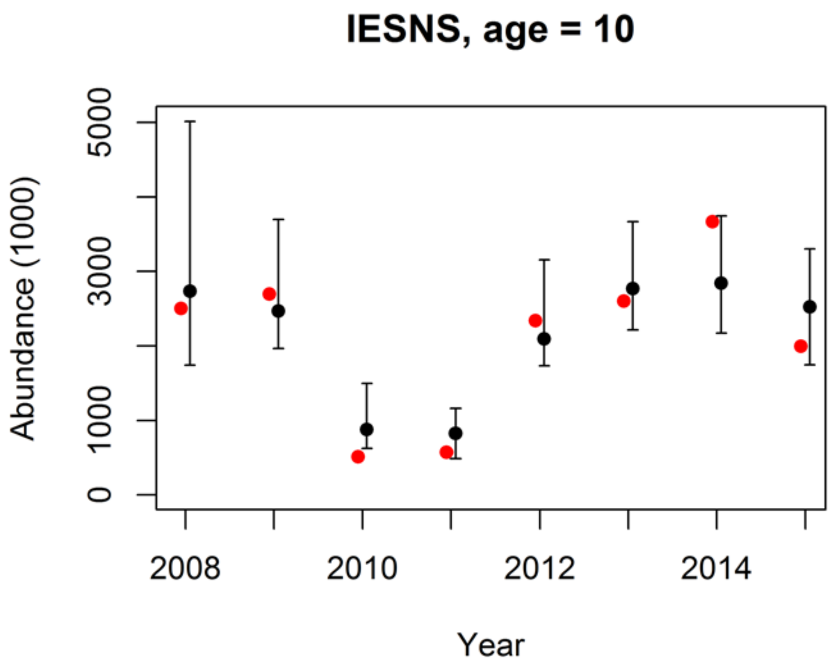

Figure 23. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 10. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

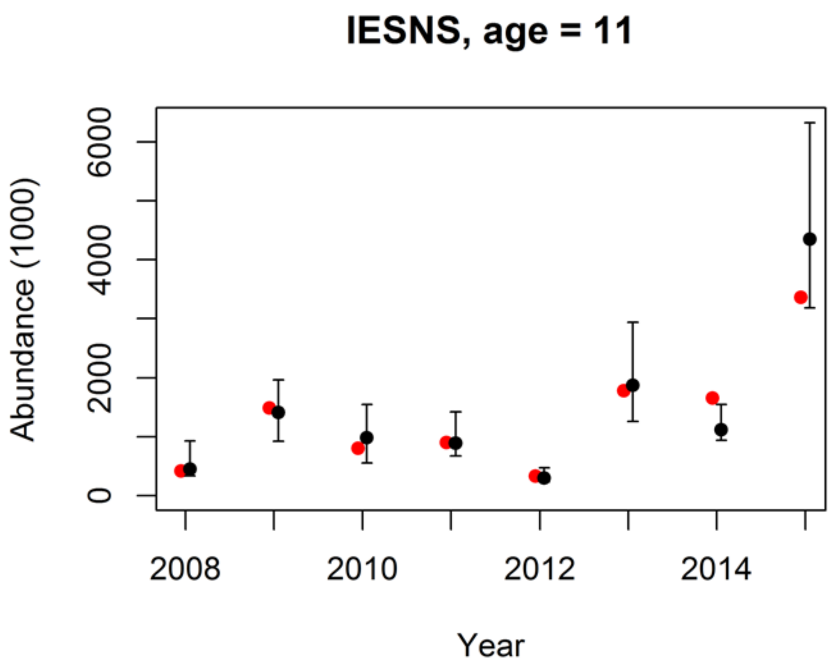

Figure 24. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 11. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

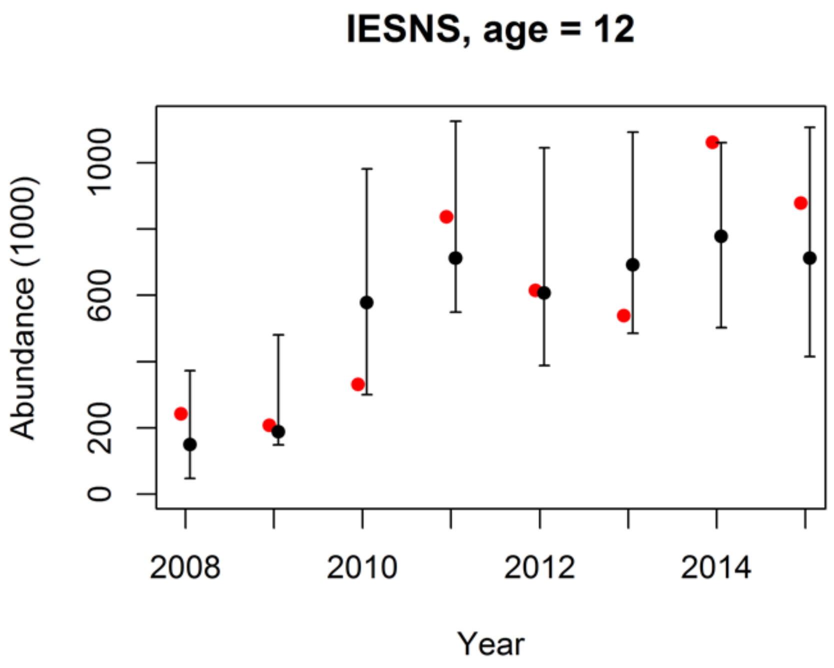

Figure 25. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 12. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

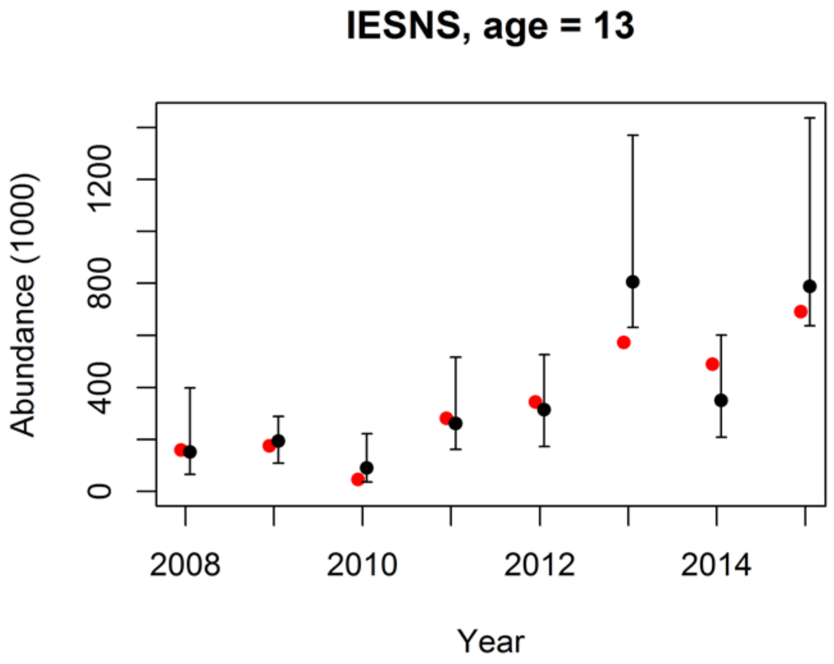

Figure 26. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 13. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

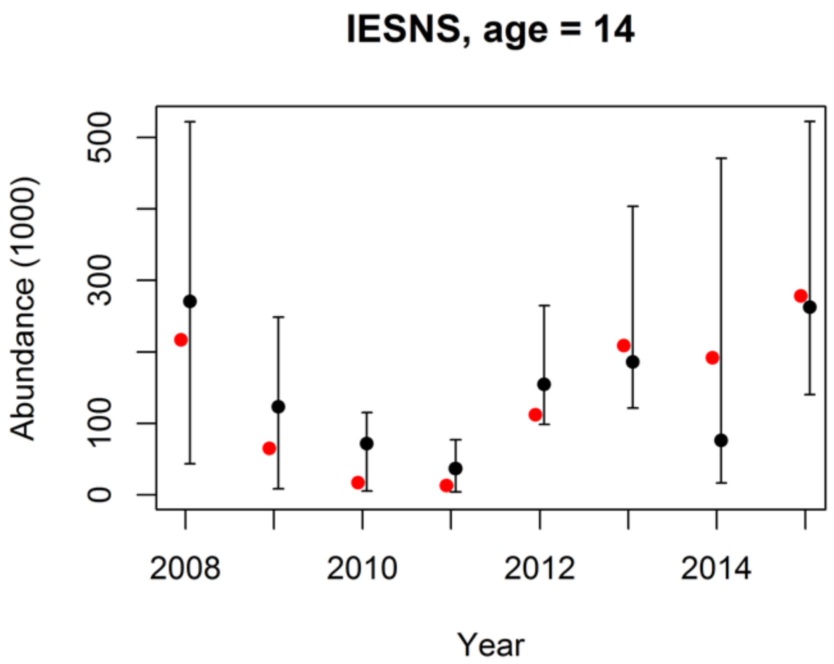

Figure 27. IESNS in the Norwegian Sea, Norwegian spring-spawning herring age 14. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

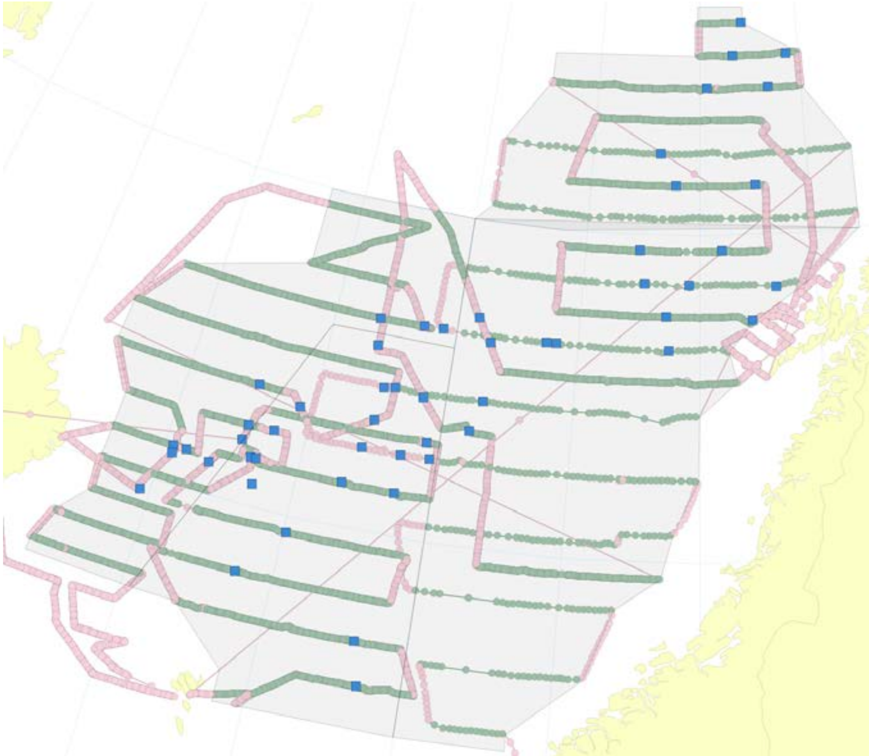

Figure 28. IESNS in the Norwegian Sea 2008, Norwegian spring-spawning herring. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

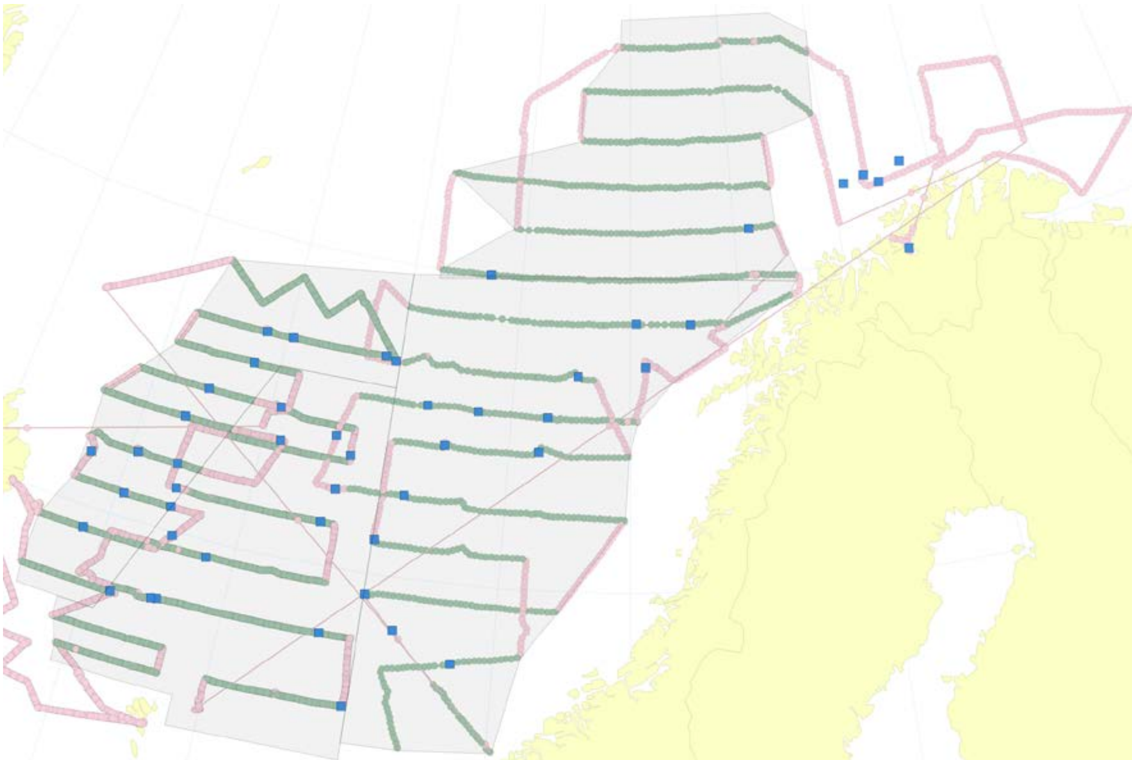

Figure 29. IESNS in the Norwegian Sea 2009, Norwegian spring-spawning herring. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

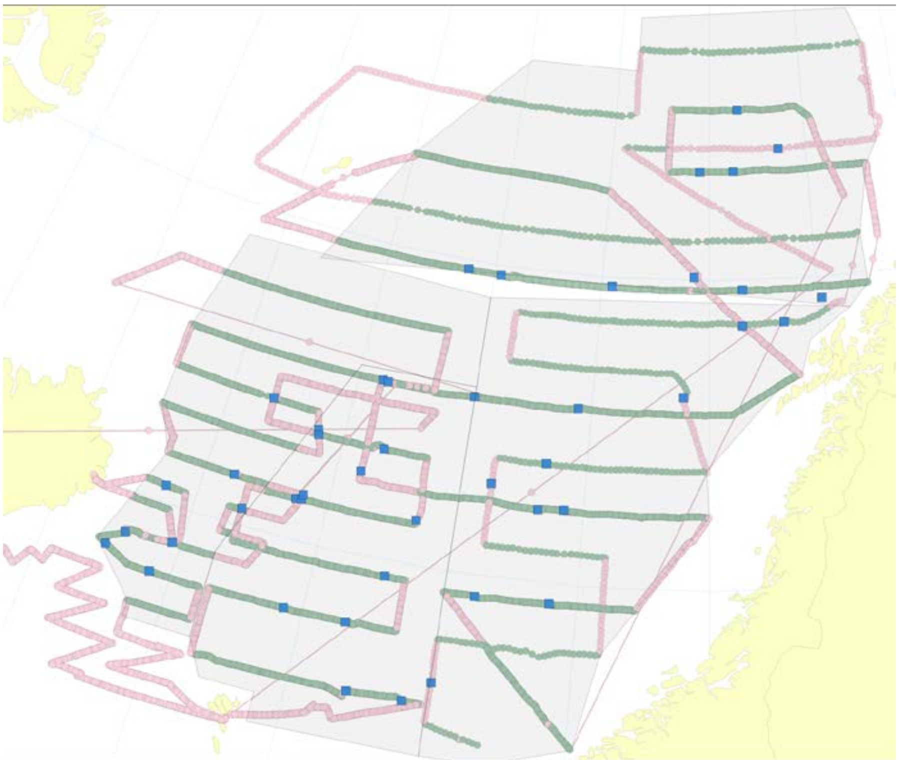

Figure 30. IESNS in the Norwegian Sea 2010, Norwegian spring-spawning herring. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

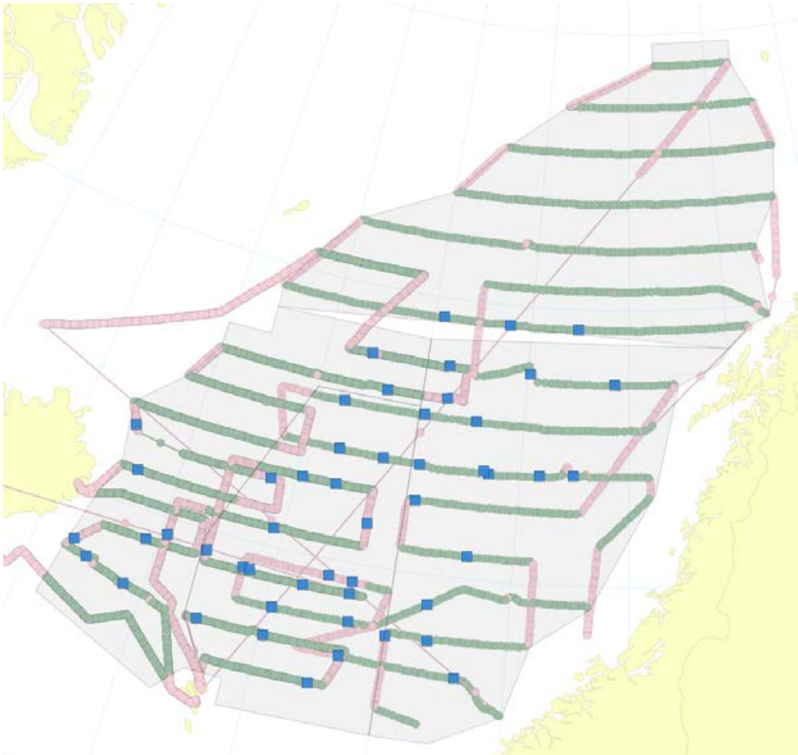

Figure 31. IESNS in the Norwegian Sea 2011, Norwegian spring-spawning herring. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

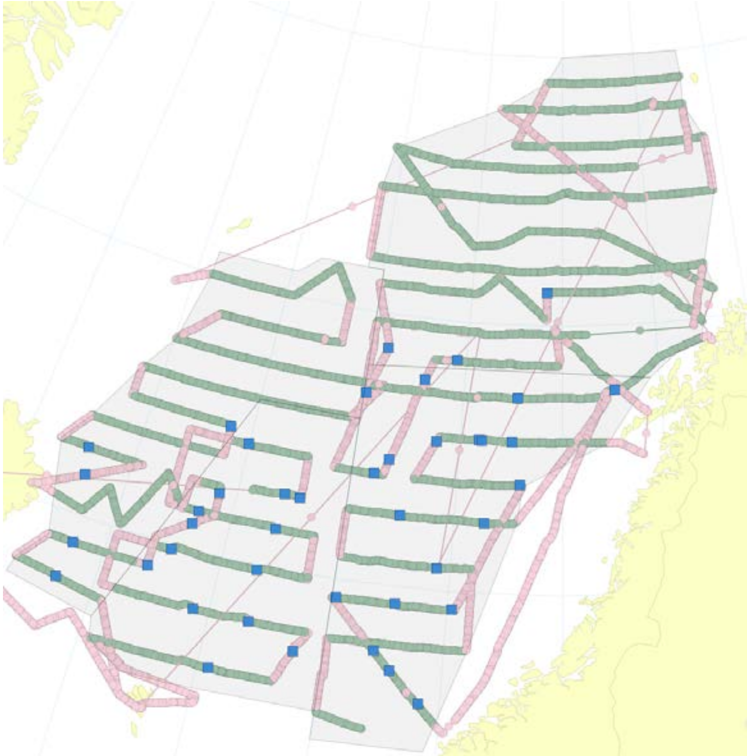

Figure 32. IESNS in the Norwegian Sea 2012, Norwegian spring-spawning herring. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

Figure 33. IESNS in the Norwegian Sea 2013, Norwegian spring-spawning herring. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

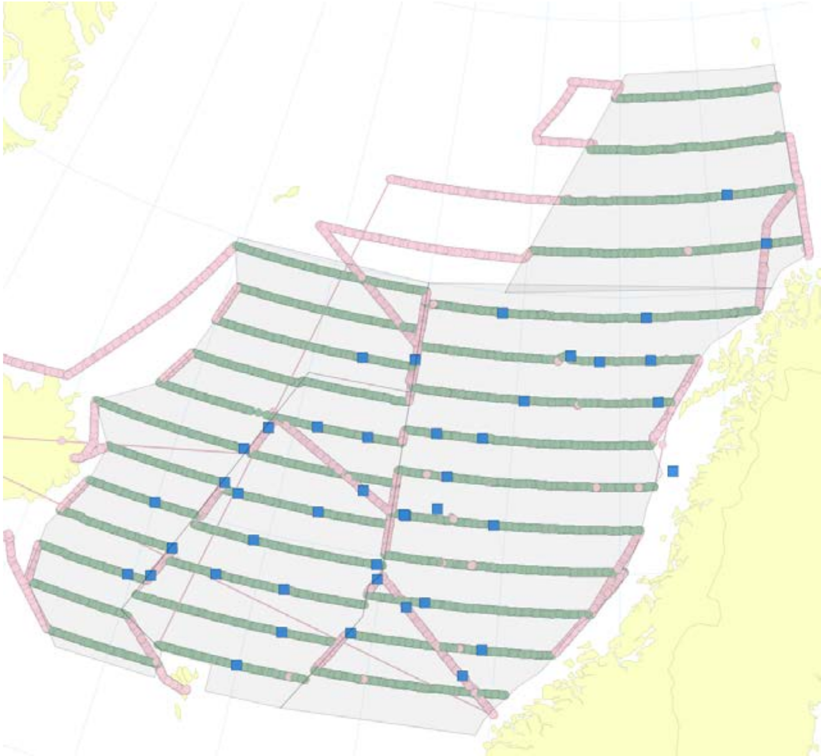

Figure 34. IESNS in the Norwegian Sea 2014, Norwegian spring-spawning herring. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

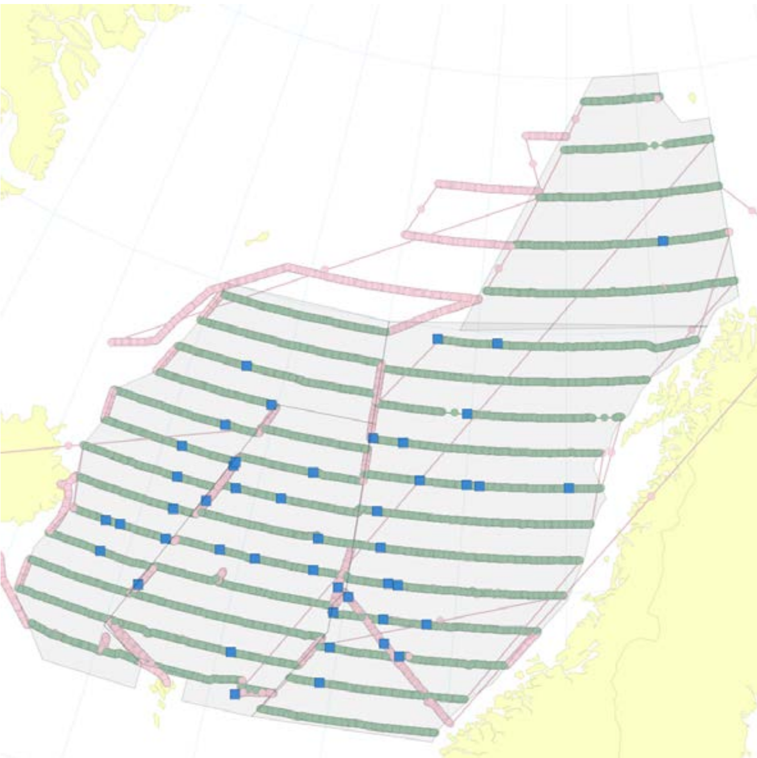

Figure 35. IESNS in the Norwegian Sea 2015, Norwegian spring-spawning herring. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

Table 16. IBWSS. StoX estimates of blue whiting for 2004.

LenGrp	age 1	2	3	4	5	6	7	8	9	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
14-15	31097	-	-	-	-	-	-	-	-	-	31097	375.6	12.08
15-16	51305	-	-	-	-	-	-	-	-	-	51305	960.1	18.71
16-17	135677	-	-	-	-	-	-	-	-	-	135677	3050.0	22.48
17-18	251108	-	-	-	-	-	-	-	-	-	251108	6390.0	25.45
18-19	273154	-	-	-	-	-	-	-	-	-	273154	8356.0	30.59
19-20	71722	140514	-	-	-	-	-	-	-	-	212236	7674.8	36.16
20-21	79088	325935	-	-	-	-	-	-	-	-	405023	16481.9	40.69
21-22	27299	599728	57226	-	-	-	-	-	-	-	684252	32826.7	47.97
22-23	8334	889620	313169	139478	-	-	-	-	-	-	1350600	76161.0	56.39
23-24	146965	1411262	1235896	771997	11250	-	-	-	-	-	3577370	219376.5	61.32
24-25	21282	1235895	2698389	2622419	357090	30799	-	-	-	-	6965874	470810.2	67.59
25-26	-	582979	4243952	3253288	317861	-	20042	-	-	-	8418121	622766.2	73.98
26-27	-	181279	2518421	2483260	1093069	10021	-	30063	-	-	6316113	518155.4	82.04
27-28	-	79256	998340	3117020	719509	284049	-	36122	20042	-	5254337	479026.6	91.17
28-29	-	54340	642333	1480243	927771	129827	79341	312767	34660	-	3661282	378166.0	103.29
29-30	-	36928	78085	827124	779344	194857	170908	55391	20042	-	2162679	241136.8	111.50
30-31	-	-	190004	230054	380480	259747	293557	66482	-	-	1420324	177011.0	124.63
31-32	-	-	38523	190949	337829	106065	201099	26815	-	-	901280	123508.8	137.04
32-33	-	-	17989	18597	128492	39569	170241	44083	-	-	418970	64892.7	154.89
33-34	-	-	-	-	25961	11172	58859	21047	31881	-	148919	24255.7	162.88
34-35	-	-	29946	-	-	-	-	-	-	-	29946	3248.3	108.47
35-36	-	-	-	-	-	20042	-	-	19925	-	39967	8143.4	203.75
36-37	-	-	-	-	39851	-	-	-	-	-	39851	9584.1	240.50
37-38	-	-	-	-	-	-	-	-	27477	-	27477	7123.0	259.24
38-39	-	-	-	-	-	-	-	-	-	10021	10021	2234.6	223.00
39-40	-	-	-	-	-	-	-	-	10021	-	10021	3166.6	316.00
TSN(1000)	1097031	5537735	13062272	15134428	5118507	1086148	994045	592770	164047	10021	42797005	-	-
TSB(1000 kg)	37849.2	344522.0	999837.0	1260464.6	512393.7	125059.7	127660.8	67377.6	27482.8	2234.6	-	3504882.0	-
Mean length (cm)	18.63	23.26	25.39	26.17	27.85	29.06	30.48	28.93	32.17	38.00	-	-	-
Mean weight (g)	34.50	62.21	76.54	83.28	100.11	115.14	128.43	113.67	167.53	223.00	-	-	81.90

Table 17. IBWSS. StoX estimates of blue whiting for 2005.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
14-15	34764	-	-	-	-	-	-	-	-	-	-	-	34764	479.6	13.80
15-16	235377	-	-	-	-	-	-	-	-	-	-	-	235377	3836.8	16.30
16-17	631539	-	-	-	-	-	-	-	-	-	-	-	631539	12520.8	19.83
17-18	574175	-	-	-	-	-	-	-	-	-	-	-	574175	13406.1	23.35
18-19	392366	18142	-	-	-	-	-	-	-	-	-	-	410508	11869.1	28.91
19-20	162611	109049	-	-	-	-	-	-	-	-	-	-	271660	9352.5	34.43
20-21	65024	412801	-	-	-	3907	-	-	-	-	-	-	481732	18659.6	38.73
21-22	5521	218111	85101	-	-	-	-	-	-	-	-	-	308733	14167.5	45.89
22-23	21422	211099	332012	24257	-	-	-	-	-	-	-	-	588790	31341.4	53.23
23-24	-	218318	833280	159712	47498	-	-	-	-	-	-	-	1258808	76651.3	60.89
24-25	6057	140499	1312065	784234	447531	-	-	-	-	-	-	-	2690387	184386.0	68.54
25-26	-	84742	1686087	2000887	970020	135033	-	-	-	-	-	-	4876770	363302.5	74.50
26-27	-	-	879520	2323460	2110228	294866	-	-	-	-	-	-	5608073	460684.5	82.15
27-28	-	-	338913	1210367	1638092	303108	10722	-	-	-	-	-	3501203	321556.5	91.84
28-29	-	-	89933	839554	1325258	440697	90900	29991	-	-	-	-	2816332	289892.3	102.93
29-30	-	-	43780	331252	1188843	516617	84545	11702	-	-	-	-	2176738	248838.5	114.32
30-31	-	-	-	68363	468555	502726	19037	43218	10077	-	-	-	1111976	142386.7	128.05
31-32	-	-	-	15919	247470	497000	112691	10264	21225	-	-	-	904568	129618.9	143.29
32-33	-	-	-	21645	22499	114033	107887	9679	21645	-	-	-	297389	47959.4	161.27
33-34	-	-	-	-	23150	72182	74191	73910	-	-	-	-	243432	42079.1	172.86
34-35	-	-	-	-	-	29803	93811	28634	12386	12386	3474	-	180494	34190.2	189.43
35-36	-	-	-	-	-	-	21813	14677	12875	-	-	-	49365	10498.1	212.66
36-37	-	-	-	-	11268	10675	-	40268	-	-	-	-	62210	14474.6	232.67
37-38	-	-	-	-	-	-	16574	2376	4653	-	-	-	23603	5804.8	245.93
38-39	-	-	-	-	-	3361	-	8797	8652	-	-	-	20811	5899.8	283.50
39-40	-	-	-	-	-	899	-	6214	14941	-	-	-	22054	6752.9	306.20
40-41	-	-	-	-	-	-	-	-	18882	2376	-	-	21258	8196.4	385.56
41-42	-	-	-	-	-	-	-	-	3554	-	-	-	3554	1219.2	343.00
43-44	-	-	-	-	-	-	-	-	-	-	4960	-	4960	2996.1	604.00
46-47	-	-	-	-	-	-	-	-	-	-	-	27383	27383	-	-
TSN(1000)	2128855	1412762	5600691	7779650	8500412	2924907	632170	279730	128889	14762	8435	27383	29438646	-	-
TSB(1000 kg)	52228.6	69702.7	402214.5	658602.9	803256.3	346067.4	95117.2	49073.0	30032.0	3039.1	3687.5	-	-	2513021.3	-
Mean length (cm)	16.97	21.59	24.74	26.18	27.23	29.06	31.45	32.79	35.08	35.18	39.59	46.00	-	-	-
Mean weight (g)	24.53	49.34	71.82	84.66	94.50	118.32	150.46	175.43	233.01	205.87	437.18	-	-	-	85.44

Table 18. IBWSS. StoX estimates of blue whiting for 2006.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	13	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	177574	-	-	-	-	-	-	-	-	-	-	177574	2933.1	16.52
16-17	711525	-	-	-	-	-	-	-	-	-	-	711525	13589.7	19.10
17-18	796296	-	-	-	-	-	-	-	-	-	-	796296	18476.5	23.20
18-19	565525	30055	-	-	-	-	-	-	-	-	-	595580	15907.6	26.71
19-20	216669	155953	-	-	-	-	-	-	-	-	-	372622	12478.1	33.49
20-21	6864	324244	-	-	-	-	-	-	-	-	-	331108	13953.4	42.14
21-22	17448	273164	36080	-	-	-	-	-	-	-	-	326693	15662.8	47.94
22-23	19723	289028	155897	-	-	-	-	-	-	-	-	464649	27000.7	58.11
23-24	-	351742	546246	193510	-	-	-	-	-	-	-	1091498	70400.7	64.50
24-25	-	391249	1702082	880419	45215	47689	-	-	-	-	-	3066654	217727.6	71.00
25-26	496	294974	3980579	2024951	285857	61624	-	-	-	-	-	6648481	515137.9	77.48
26-27	-	111820	2644544	2138882	538073	263672	-	-	-	-	-	5696992	485436.1	85.21
27-28	-	-	1356258	3018829	951853	230156	-	-	-	-	-	5557096	525472.3	94.56
28-29	-	-	227529	2087664	883557	339101	-	-	-	-	-	3537850	382761.3	108.19
29-30	-	-	193830	907030	889506	345216	38156	-	10451	-	-	2384189	289397.4	121.38
30-31	-	-	-	245341	511847	261583	83569	11388	-	-	-	1113729	152798.5	137.20
31-32	-	-	14879	141943	288358	343283	153604	14368	-	-	-	956435	149550.8	156.36
32-33	-	-	-	21734	212585	204604	102522	50462	-	-	-	591906	103076.6	174.14
33-34	-	-	-	16566	28671	174288	108164	-	-	-	-	327689	67950.5	207.36
34-35	-	-	-	-	64228	180631	76831	-	6166	-	-	327856	79255.1	241.74
35-36	-	-	-	-	13516	98336	103825	41435	41435	-	-	298548	76928.4	257.68
36-37	-	-	-	-	-	84844	115354	-	21211	-	-	221409	64921.6	293.22
37-38	-	-	-	-	-	82100	109466	109466	28023	-	-	329055	104443.7	317.40
38-39	-	-	-	-	-	-	31445	94335	31445	-	-	157225	55028.7	350.00
39-40	-	-	-	-	-	-	-	30749	-	30749	-	61499	23830.7	387.50
40-41	-	-	-	-	-	-	-	-	28940	-	-	28940	12299.7	425.00
41-42	-	-	-	-	-	-	-	-	30749	-	-	30749	13222.2	430.00
42-43	-	-	-	-	-	-	-	-	-	-	7941	7941	2676.1	337.00
TSN(1000)	2512120	2222231	10857924	11676869	4713266	2717127	922937	352204	198421	30749	7941	36211788	-	-
TSB(1000 kg)	59350.6	131965.9	866732.0	1105285.9	545479.2	412793.3	207969.4	105721.3	62198.0	12146.0	2676.1	-	3512317.6	-
Mean length (cm)	17.29	22.66	25.59	26.90	28.50	30.30	33.61	36.08	37.28	39.50	42.00	-	-	-
Mean weight (g)	23.63	59.38	79.82	94.66	115.73	151.92	225.33	300.17	313.46	395.00	337.00	-	-	96.99

Table 19. IBWSS. StoX estimates of blue whiting for 2007.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	Number (1E3)	Biomass (1E3kg)	Mean W (g)
16-17	10233	-	-	-	-	-	-	-	-	-	-	-	10233	248.5	24.28
17-18	47267	-	-	-	-	-	-	-	-	-	-	-	47267	1452.7	30.73
18-19	102390	9752	-	-	-	-	-	-	-	-	-	-	112143	3826.8	34.12
19-20	135334	-	-	-	-	-	-	-	-	-	-	-	135334	5581.9	41.25
20-21	129752	19504	-	-	-	-	-	-	-	-	-	-	149256	6899.7	46.23
21-22	43238	107787	27681	27681	-	-	-	-	-	-	-	-	206387	10261.9	49.72
22-23	-	140223	165585	43851	-	-	-	-	-	-	-	-	349659	20179.0	57.71
23-24	-	203871	311028	87769	9634	-	-	-	-	-	-	-	612302	40818.2	66.66
24-25	-	114604	835255	407200	71103	8726	-	-	-	-	-	-	1436888	110099.9	76.62
25-26	-	108079	1514986	1461520	336690	18401	5332	-	-	-	-	-	3445008	289223.0	83.95
26-27	-	1702	1380802	2662914	1146285	262381	55617	-	-	-	-	-	5509700	493921.8	89.65
27-28	-	-	614273	3243093	1908814	619932	56608	-	-	-	-	-	6442721	629733.4	97.74
28-29	-	-	295318	2206111	1765297	538971	155762	49776	-	-	-	-	5011235	539706.7	107.70
29-30	-	-	38520	696802	1406848	697294	130298	132629	-	-	-	-	3102392	380254.1	122.57
30-31	-	-	36408	210118	1055621	325289	130543	44087	10388	-	-	-	1812453	256119.5	141.31
31-32	-	-	10269	150911	404262	239023	185916	48260	3591	-	-	-	1042232	163439.7	156.82
32-33	-	-	-	22773	201426	183809	225830	64020	28059	-	-	-	725918	131869.0	181.66
33-34	-	-	10613	23481	98212	119786	50572	60732	17046	11740	3913	-	396095	78792.1	198.92
34-35	-	-	-	-	14628	51022	80062	28988	44680	-	-	-	219381	48802.3	222.45
35-36	-	-	-	-	13150	66753	16765	23643	12193	11889	-	-	144393	35946.7	248.95
36-37	-	-	-	-	-	-	16457	-	7073	23239	-	3537	50305	14294.8	284.16
37-38	-	-	-	-	-	18433	-	3537	-	-	-	-	21970	5829.6	265.34
38-39	-	-	-	-	4876	-	-	-	-	3770	-	3770	12416	3979.5	320.51
39-40	-	-	-	-	-	4876	-	-	-	3537	-	-	8413	2752.2	327.15
TSN(1000)	468214	705524	5240739	11244224	8436848	3154696	1109762	455673	123031	54174	3913	7307	31004103	-	-
TSB(1000 kg)	18981.3	47283.6	449847.2	1101632.5	960958.4	406473.7	171771.9	71978.3	26318.4	15582.2	821.8	2383.7	-	3274032.9	-
Mean length (cm)	19.22	23.09	25.62	27.03	28.33	29.22	30.59	31.04	33.43	35.50	33.00	37.53	-	-	-
Mean weight (g)	40.54	67.02	85.84	97.97	113.90	128.85	154.78	157.96	213.92	287.63	210.00	326.24	-	-	105.60

Table 20. IBWSS. StoX estimates of blue whiting for 2008.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	13	Number (1E3)	Biomass (1E3kg)	Mean W (g)
16-17	1640	-	-	-	-	-	-	-	-	-	-	-	1640	34.4	21.00
17-18	15696	-	-	-	-	-	-	-	-	-	-	-	15696	420.1	26.76
18-19	31714	2784	-	-	-	-	-	-	-	-	-	-	34499	1119.1	32.44
19-20	88635	68672	-	-	-	-	-	-	-	-	-	-	157307	5578.2	35.46
20-21	84864	86785	-	-	-	-	-	-	-	-	-	-	171649	7292.4	42.48
21-22	102364	123760	3107	-	-	-	6245	-	-	-	-	-	235475	11820.5	50.20
22-23	12469	71806	30614	-	-	-	-	-	-	-	-	-	114889	7501.7	65.29
23-24	-	80548	26378	33255	-	-	-	-	-	-	-	-	140181	9522.3	67.93
24-25	-	52650	141618	149635	-	10432	-	-	-	-	-	-	354336	26506.9	74.81
25-26	-	35990	351981	643043	131436	9778	-	-	-	-	-	-	1172229	97381.7	83.07
26-27	-	-	477080	1866275	537447	90508	21278	-	-	-	-	-	2992588	273666.5	91.45
27-28	-	-	289824	1903755	1628460	581797	112862	24232	-	-	-	-	4540930	456441.9	100.52
28-29	-	-	104723	1441426	1928852	729473	232566	123473	2464	-	-	-	4562976	506254.7	110.95
29-30	-	-	11625	421903	1417522	974571	251415	223210	-	5227	-	-	3305473	405261.5	122.60
30-31	-	-	14176	104849	701985	579372	386908	128197	62119	-	48375	10968	2036950	280646.3	137.78
31-32	-	-	-	62071	208861	362898	260141	112883	30102	67701	25204	-	1129861	174288.8	154.26
32-33	-	-	-	-	101467	279109	145897	170280	50191	10176	10251	-	767370	131993.6	172.01
33-34	-	-	-	11014	65919	150267	104783	84870	29719	43891	2615	-	493078	92810.1	188.23
34-35	-	-	-	5003	-	55107	73013	100559	19267	2623	-	-	255570	54307.0	212.49
35-36	-	-	-	-	-	13293	70335	21936	29023	36310	-	-	170898	39243.0	229.63
36-37	-	-	-	-	-	19670	25700	24155	14704	-	-	-	84229	21517.6	255.47
37-38	-	-	-	-	-	-	-	-	17032	11167	11167	-	39366	10181.9	258.64
38-39	-	-	-	-	-	12752	10382	8741	-	2283	-	-	34157	10862.3	318.01
39-40	-	-	-	-	-	-	3615	5255	9850	-	4494	-	23214	7555.1	325.46
40-41	-	-	-	-	-	-	-	-	4308	-	-	-	4308	1773.2	411.60
41-42	-	-	-	-	-	-	9564	-	-	2724	-	-	12288	5331.8	433.92
TSN(1000)	337383	522994	1451127	6642229	6721950	3869029	1714702	1027791	268778	182101	102107	10968	22851157	-	-
TSB(1000 kg)	14946.0	28677.9	133114.3	673663.3	763354.9	497621.5	256753.1	161398.2	54280.2	36432.2	17530.0	1541.0	-	2639312.5	-
Mean length (cm)	19.84	21.69	26.05	27.13	28.36	29.43	30.54	31.09	33.01	33.09	31.92	30.25	-	-	-
Mean weight (g)	44.30	54.83	91.73	101.42	113.56	128.62	149.74	157.03	201.95	200.07	171.68	140.50	-	-	115.50

Table 21. IBWSS. StoX estimates of blue whiting for 2009.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	369	369	-	-
16-17	1140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1140	20.5	18.00
17-18	18677	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18677	477.4	25.56
18-19	40655	479	-	-	-	-	-	-	-	-	-	-	-	-	-	41134	1294.0	31.46
19-20	88991	2334	-	-	-	-	-	-	-	-	-	-	-	-	-	91325	3401.8	37.25
20-21	64516	13368	-	-	-	-	-	-	-	-	-	-	-	-	-	77884	3277.8	42.09
21-22	34376	20086	-	-	-	-	-	-	-	-	-	-	-	-	-	54462	2722.1	49.98
22-23	5960	72985	2980	-	-	-	-	-	-	-	-	-	-	-	-	81924	4922.9	60.09
23-24	20361	86279	16663	2337	-	-	-	-	-	-	-	-	-	-	-	125639	8049.7	64.07
24-25	-	84067	52235	1329	8275	-	-	-	-	-	-	-	-	-	-	145906	10584.0	72.54
25-26	-	30247	81006	53792	22326	15991	-	-	-	-	-	-	-	-	-	203362	16342.4	80.36
26-27	-	15062	99436	121696	92067	8374	-	-	-	-	-	-	-	-	-	336634	31937.9	94.87
27-28	-	1800	84837	321330	495120	189977	27287	13378	-	-	-	-	-	-	-	1133728	117201.7	103.38
28-29	-	1984	6418	488594	1057604	471766	127831	24346	5426	-	-	-	-	-	-	2183970	247345.9	113.26
29-30	-	-	16068	191228	1214329	765271	307531	64129	2921	-	-	-	-	-	-	2561477	324121.4	126.54
30-31	-	-	-	70515	524159	1021851	391088	73893	16982	1555	-	-	-	-	-	2100043	288869.8	137.55
31-32	-	-	-	20467	234628	571086	293233	88975	11100	6102	-	-	-	-	-	1225591	186938.8	152.53
32-33	-	-	-	8543	67366	261416	224871	88543	13485	10216	-	-	-	-	-	674441	113841.8	168.79
33-34	-	-	-	3138	8420	83465	160943	114475	12553	3138	2287	-	-	-	-	388420	73293.9	188.70
34-35	-	-	-	8667	14621	41917	43614	29076	43759	10771	3249	-	-	-	-	195674	40755.2	208.28
35-36	-	-	-	-	-	12937	40453	32488	78033	4762	1587	3175	-	-	-	173434	39085.5	225.36
36-37	-	-	-	-	-	2949	16291	31304	33985	29162	25971	3265	1632	-	-	144561	35717.3	247.07
37-38	-	-	-	-	-	10284	1469	1357	11027	11228	11545	8340	-	-	-	55250	15244.0	275.91
38-39	-	-	-	-	-	-	905	16035	4834	-	8088	1611	-	-	-	31474	9048.1	287.48
39-40	-	-	-	-	-	-	-	8940	16176	-	13187	-	-	-	-	38303	12099.9	315.90
40-41	-	-	-	-	-	-	-	-	-	3466	8088	-	-	5199	-	16754	5715.5	341.14
41-42	-	-	-	-	-	-	-	-	-	8088	-	-	2000	-	-	10088	4148.1	411.19
42-43	-	-	-	-	-	-	-	-	-	-	-	-	-	4000	-	4000	1421.8	355.50
44-45	-	-	-	-	-	-	-	-	-	-	-	-	2000	-	-	2000	803.9	402.00
TSN(1000)	274676	328690	359643	1291636	3738915	3457285	1635516	586939	250283	88489	74003	16391	5632	9199	369	12117664	-	-
TSB(1000 kg)	11488.0	21969.0	32212.9	144594.0	456652.7	474780.1	248919.5	103545.8	53707.3	21200.3	20196.6	3891.1	2302.9	3223.3	-	-	1598683.4	-
Mean length (cm)	19.61	23.29	25.83	27.95	28.82	29.90	30.76	32.02	34.43	35.44	37.16	36.56	40.62	40.96	15.00	-	-	-
Mean weight (g)	41.82	66.84	89.57	111.95	122.14	137.33	152.20	176.42	214.59	239.58	272.92	237.40	408.89	350.39	-	-	-	131.93

Table 22. IBWSS. StoX estimates of blue whiting for 2011.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
11-12	-	1730	-	-	-	-	-	-	-	-	-	-	-	1730	15.6	9.00
12-13	-	-	-	-	-	-	-	-	-	-	-	-	1730	1730	-	-
13-14	-	3459	-	-	-	-	-	-	-	-	-	-	-	3459	45.3	13.10
14-15	-	-	-	-	-	-	-	-	-	-	-	-	1730	1730	-	-
15-16	-	-	-	-	-	-	-	-	-	-	-	-	1730	1730	-	-
16-17	-	11291	-	-	-	-	-	-	-	-	-	-	-	11291	311.3	27.57
17-18	-	15257	-	-	-	-	-	-	-	-	-	-	-	15257	446.7	29.28
18-19	70969	27610	1352	-	-	-	-	-	-	-	-	-	-	99932	3283.0	32.85
19-20	143479	141460	3931	-	-	-	-	-	-	-	-	-	-	288870	11248.4	38.94
20-21	9801	243135	10971	-	-	-	-	-	-	-	-	-	-	263907	12535.7	47.50
21-22	26273	274841	20259	1394	-	-	-	-	-	-	-	-	-	322767	17834.2	55.25
22-23	23714	199015	50211	3563	-	-	-	-	-	-	-	-	-	276502	17149.7	62.02
23-24	17175	93476	42023	8238	1494	-	-	-	-	-	-	-	-	162405	11430.7	70.38
24-25	-	93724	82008	13126	-	-	-	-	-	-	-	-	-	188857	15269.2	80.85
25-26	20444	174248	109582	18716	2324	-	-	-	-	-	-	-	-	325314	27028.9	83.09
26-27	-	68229	136485	90195	2333	2333	-	-	-	-	-	-	-	299576	28587.2	95.43
27-28	-	2484	248820	91915	65393	-	8174	-	-	-	-	-	-	416787	43874.1	105.27
28-29	-	10969	249408	200594	58956	62686	1967	38782	-	-	-	-	-	623362	75101.4	120.48
29-30	-	-	136852	246246	157660	143336	120376	163280	101311	28946	-	-	-	1098007	145782.9	132.77
30-31	-	-	43136	184195	290860	404391	552599	262058	162756	7287	-	-	-	1907282	276596.5	145.02
31-32	-	-	-	42529	232224	468443	478133	738605	178076	26300	-	-	-	2164310	342245.8	158.13
32-33	-	-	-	22148	149523	337170	471872	475549	263056	44478	-	-	-	1763795	302737.9	171.64
33-34	-	-	-	5075	66675	153798	310650	403221	289653	12850	-	-	-	1241923	231337.1	186.27
34-35	-	-	-	2011	11745	74958	107056	230444	140367	40849	-	-	-	607429	123477.9	203.28
35-36	-	-	-	-	3391	32140	54975	71390	85056	43593	1850	-	-	292396	65467.7	223.90
36-37	-	-	-	-	-	14715	49163	14715	39523	15809	-	7905	-	141829	34218.6	241.27
37-38	-	-	-	-	-	18172	6422	12844	21929	2966	-	-	-	62332	16237.6	260.50
38-39	-	-	-	-	-	-	-	-	-	9208	-	-	-	9208	2734.9	297.00
39-40	-	-	-	-	-	-	-	11050	7096	7096	-	14192	-	39433	11783.0	298.81
40-41	-	-	-	-	-	-	8789	-	8789	-	8789	-	-	26366	9562.0	362.67
TSN(1000)	311855	1360928	1135038	929943	1042578	1712141	2170176	2421938	1297613	239381	10639	22096	5189	12659515	-	-
TSB(1000 kg)	13465.4	83293.9	115041.1	117446.2	152514.8	276612.3	362664.9	413649.9	235772.3	45476.1	3849.0	6557.2	-	-	1826343.2	-
Mean length (cm)	20.09	22.01	26.73	28.71	30.57	31.46	31.78	32.00	32.60	33.43	39.13	38.09	13.67	-	-	-
Mean weight (g)	43.18	61.20	101.35	126.29	146.29	161.56	167.11	170.79	181.70	189.97	361.78	296.76	-	-	-	144.33

Table 23. IBWSS. StoX estimates of blue whiting for 2012.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	13	Number (1E3)	Biomass (1E3kg)	Mean W (g)
13-14	13012	-	-	-	-	-	-	-	-	-	-	-	-	13012	154.5	11.88
14-15	8040	6285	-	-	-	-	-	-	-	-	-	-	-	14325	206.7	14.43
15-16	60230	22866	22383	-	-	-	-	-	-	-	-	-	-	105479	2247.2	21.31
16-17	103549	112148	45827	-	-	-	-	-	-	-	-	-	-	261524	6379.7	24.39
17-18	241761	176026	45508	-	-	-	-	-	-	-	-	-	-	463295	13401.8	28.93
18-19	291837	171016	41560	-	-	-	-	-	-	-	-	-	-	504412	17888.4	35.46
19-20	212446	169976	46640	-	-	-	-	-	-	-	-	-	-	429061	17513.3	40.82
20-21	132470	118940	11918	7945	-	-	-	-	-	-	-	-	-	271273	12546.2	46.25
21-22	53737	98012	27887	2060	-	-	-	-	-	-	-	-	-	181695	10025.8	55.18
22-23	13490	103119	62969	-	-	-	-	-	-	-	-	-	-	179577	11804.9	65.74
23-24	6240	170527	352810	42485	1404	-	-	-	-	-	-	-	-	573466	43512.9	75.88
24-25	4214	205950	957178	71961	8088	-	-	-	-	-	-	-	-	1247391	101481.2	81.35
25-26	-	214655	1695909	51852	-	-	-	6170	-	-	-	-	-	1968586	174020.4	88.40
26-27	-	104842	1435324	100741	6081	-	-	-	-	-	-	-	-	1646988	157671.6	95.73
27-28	-	89259	1015527	127968	13593	4800	2400	-	-	-	-	-	-	1253547	131973.9	105.28
28-29	-	27128	494085	179841	70902	8308	-	27549	-	-	-	-	-	807813	93664.3	115.95
29-30	-	27528	119881	209089	94841	107955	168546	80998	21090	21141	-	-	-	851069	116660.4	137.08
30-31	-	-	42379	105344	152773	305569	298840	113101	92137	88901	5389	-	-	1204435	178892.7	148.53
31-32	-	-	9985	57961	95880	382138	467044	362610	307074	111735	14679	-	-	1809106	286440.4	158.33
32-33	-	-	36046	50629	107404	267571	500764	350266	244630	141880	19280	301	-	1718770	295796.7	172.10
33-34	-	-	-	14269	11404	207974	332391	376963	249666	207860	5707	-	1053	1407286	260561.2	185.15
34-35	-	-	-	-	29969	85438	243254	168672	174973	190170	451	14380	-	907308	182880.6	201.56
35-36	-	-	-	-	-	22313	151958	162328	110402	71783	27915	8881	-	555581	123101.7	221.57
36-37	-	-	-	-	3987	14181	57502	86260	21721	55755	12054	301	-	251761	60548.2	240.50
37-38	-	-	-	-	-	5041	8769	21178	29230	23384	8769	14615	301	111287	28504.9	256.14
38-39	-	-	-	-	-	7687	-	21926	1537	11286	-	-	-	42436	12187.1	287.19
39-40	-	-	-	-	-	-	-	7328	-	-	-	21400	-	28728	9241.0	321.67
40-41	-	-	-	-	-	-	-	-	3567	-	-	5206	-	8773	3069.1	349.84
41-42	-	-	-	-	-	657	-	-	-	2081	2081	150	-	4968	1865.3	375.44
43-44	-	-	-	-	-	-	-	-	-	-	-	2378	-	2378	1032.0	434.00
TSN(1000)	1141026	1818277	6463815	1022143	596326	1419633	2231469	1785349	1256027	925975	96326	67612	1354	18825332	-	-
TSB(1000 kg)	41392.3	114962.4	595562.2	121708.3	88571.1	238780.4	393015.3	327341.9	225468.2	170869.8	18960.9	18381.4	259.9	-	2355274.0	-
Mean length (cm)	18.23	21.67	25.53	27.98	30.44	31.66	32.20	32.68	32.68	33.13	33.98	37.38	34.17	-	-	-
Mean weight (g)	36.28	63.23	92.14	119.07	148.53	168.20	176.12	183.35	179.51	184.53	196.84	271.86	192.00	-	-	125.11

Table 24. IBWSS. StoX estimates of blue whiting for 2013.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	Number (1E3)	Biomass (1E3kg)	Mean W (g)
17-18	63020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	63020	1848.4	29.33
18-19	83968	33302	-	-	-	-	-	-	-	-	-	-	-	-	-	117270	3961.0	33.78
19-20	244920	67568	-	-	-	-	-	-	-	-	-	-	-	-	-	312487	12974.4	41.52
20-21	117119	191096	27897	-	-	-	-	-	-	-	-	-	-	-	-	336113	16474.4	49.01
21-22	50865	235066	43947	11180	-	-	-	-	-	-	-	-	-	-	-	341057	19583.4	57.42
22-23	17103	407612	375243	-	-	-	-	-	-	-	-	-	-	-	-	799958	51477.4	64.35
23-24	-	251047	1203788	30226	-	-	-	-	-	-	-	-	-	-	-	1485061	107432.3	72.34
24-25	9499	124010	1456739	87073	-	-	-	-	-	-	-	-	-	-	-	1677321	135221.2	80.62
25-26	-	34882	1015376	427766	5498	-	25207	-	-	-	-	-	-	-	-	1508729	135274.1	89.66
26-27	-	1751	898741	773687	199376	-	4411	-	-	-	-	-	-	-	-	1877966	176129.3	93.79
27-28	-	-	547242	1665317	432916	63563	-	5812	-	-	-	-	-	-	-	2714849	277233.0	102.12
28-29	-	-	377681	1840129	509007	57989	-	-	16145	-	-	-	-	-	-	2800952	316855.9	113.12
29-30	-	-	220774	1324129	394389	173328	34060	31476	-	-	-	-	-	-	-	2178155	268676.3	123.35
30-31	-	-	10712	655236	566651	184495	129724	69038	55354	129791	15376	4562	-	-	-	1820939	255305.9	140.21
31-32	-	-	5294	225603	390984	301202	225998	144284	97907	208834	34436	-	-	-	-	1634542	255143.9	156.10
32-33	-	-	-	106760	216331	98072	242671	322254	162628	221676	68873	14941	-	-	-	1454206	252470.2	173.61
33-34	-	-	-	41371	133925	196661	184504	258105	112965	258627	45376	-	-	-	-	1231534	234360.1	190.30
34-35	-	-	-	3021	61674	79424	261079	194697	177388	196591	26611	24171	18128	-	-	1042785	210326.2	201.70
35-36	-	-	-	5020	-	60969	82595	149651	164933	196419	69145	8988	2996	14979	5992	761686	170533.5	223.89
36-37	-	-	-	-	3096	43349	54260	153146	48805	68850	18578	22854	-	-	-	412938	96710.9	234.20
37-38	-	-	-	-	19077	11787	27685	9083	54438	50873	20208	8411	-	-	-	201562	50015.4	248.14
38-39	-	-	-	-	-	5142	15427	24930	16709	16011	2571	-	2571	-	-	83360	24586.8	294.95
39-40	-	-	-	-	-	3535	14139	19582	7070	7070	3535	-	-	-	-	54930	16470.8	299.85
40-41	-	-	-	-	-	-	4102	12323	7738	-	7628	-	-	-	-	31791	11035.5	347.13
41-42	-	-	-	-	-	-	-	-	3328	1664	-	-	-	-	-	4991	1928.0	386.27
42-43	-	-	-	-	-	-	-	-	2007	-	-	-	-	-	-	2007	792.8	395.00
43-44	-	-	-	-	-	-	-	-	-	-	-	-	-	4496	-	4496	2400.9	534.00
44-45	-	-	-	-	-	-	-	1972	-	-	-	-	-	-	-	1972	1045.1	530.00
45-46	-	-	-	-	-	-	-	-	-	1972	-	-	-	-	-	1972	938.7	476.00
TSN(1000)	586494	1346334	6183433	7196519	2932923	1279515	1305861	1396353	927413	1358376	312338	83927	23695	19475	5992	24958648	-	-
TSB(1000 kg)	25825.4	82484.7	530535.3	809019.4	392085.2	213729.2	237814.7	274150.2	185760.9	261954.9	64857.0	17174.9	4865.3	5438.7	1509.9	-	3107205.7	-
Mean length (cm)	19.42	21.94	24.98	28.01	29.53	31.45	32.69	33.42	33.67	33.32	33.94	34.58	34.69	37.08	35.00	-	-	-
Mean weight (g)	44.03	61.27	85.80	112.42	133.68	167.04	182.11	196.33	200.30	192.84	207.65	204.64	205.33	279.26	252.00	-	-	124.49

Table 25. IBWSS. StoX estimates of blue whiting for 2014.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15241	15241	274.3	18.00
16-17	261494	12031	-	-	-	-	-	-	-	-	-	-	-	-	-	-	273525	6282.7	22.97
17-18	750050	32667	-	-	-	-	-	-	-	-	-	-	-	-	-	-	782718	20594.2	26.31
18-19	1083632	168785	2496	-	-	-	-	-	-	-	-	-	-	-	-	-	1254913	34128.5	27.20
19-20	1267144	248024	16304	-	-	-	-	-	-	-	-	-	-	-	-	-	1531472	34654.4	22.63
20-21	568664	137544	40716	-	-	-	-	-	-	-	-	-	-	-	-	-	746924	18051.5	24.17
21-22	213188	78098	190680	-	-	-	-	-	-	-	-	-	-	-	-	-	481966	14986.9	31.10
22-23	27614	96534	340892	65233	16308	-	-	-	-	-	-	-	-	-	-	-	546581	26444.8	48.38
23-24	-	106294	371339	256319	-	-	-	-	-	-	-	-	-	-	-	-	733952	46376.6	63.19
24-25	11107	294938	952090	939138	336066	25789	-	-	-	-	-	-	-	-	-	-	2559129	179675.2	70.21
25-26	-	226108	1295757	2173453	1613477	77175	41208	-	-	-	-	-	-	-	-	-	5427179	416924.3	76.82
26-27	-	89995	988800	2101358	3101984	76837	-	-	-	-	-	-	-	-	-	-	6358973	522975.3	82.24
27-28	-	-	700937	1678123	1957170	264716	-	-	-	-	-	-	-	-	-	-	4600945	426089.6	92.61
28-29	-	-	180156	705368	1589335	483813	9453	-	-	-	-	-	-	-	-	-	2968124	312701.8	105.35
29-30	-	-	106201	205083	879659	603393	93329	-	-	-	-	-	-	-	-	-	1887665	214860.5	113.82
30-31	-	-	27730	187073	403115	494079	184330	47111	-	35420	43837	68631	-	-	-	-	1491326	189402.0	127.00
31-32	-	-	-	66548	162165	381882	168482	58262	193611	153951	97413	36142	-	6612	-	-	1325068	182612.7	137.81
32-33	-	-	12804	36380	17852	123840	97167	213571	241270	87041	176256	109528	8587	2862	-	-	1127159	168211.5	149.23
33-34	-	-	12269	6311	103145	120537	50279	159890	178027	145298	126793	81041	14891	5956	-	-	1004439	161128.3	160.42
34-35	-	-	-	-	21767	30019	62136	14996	92971	98991	159301	75033	2996	37328	15009	-	610548	116291.6	190.47
35-36	-	-	-	-	-	55914	22083	59265	99775	131727	96023	50452	3146	-	3146	-	521532	105071.1	201.47
36-37	-	-	-	-	-	11890	23291	11645	61240	70063	56071	40171	23732	23732	-	-	321834	72053.2	223.88
37-38	-	-	-	-	-	3923	20035	-	24140	21425	32186	-	16074	5352	2676	-	125810	31852.8	253.18
38-39	-	-	-	-	-	-	-	12023	3072	-	16686	11869	-	-	-	-	43649	13271.7	304.05
39-40	-	-	-	-	-	-	-	-	-	24209	7395	-	-	-	-	-	31604	9968.1	315.41
40-41	-	-	-	-	-	-	-	-	-	-	-	1549	-	-	-	-	1549	494.8	319.50
42-43	-	-	-	-	-	-	-	-	4455	-	-	3923	4455	-	-	-	12833	4447.3	346.56
43-44	-	-	-	-	-	-	-	-	-	4455	-	-	-	3923	-	-	8378	2336.0	278.83
44-45	-	-	-	-	-	-	-	-	-	-	-	-	-	3820	-	-	3820	1990.4	521.00
45-46	-	-	-	-	-	-	-	-	-	-	-	-	3820	-	-	-	3820	2605.4	682.00
TSN(1000)	4182893	1491019	5239171	8420388	10202045	2753804	771791	576763	898560	772581	811961	478340	77702	89585	20832	15241	36802677	-	-
TSB(1000 kg)	91780.5	66153.7	335667.4	709507.3	986652.9	362889.1	107784.3	87007.2	163165.7	127472.6	167541.7	90009.8	20896.3	15431.5	4523.1	274.3	-	3336757.4	-
Mean length (cm)	18.68	22.00	25.19	26.14	26.97	29.50	31.21	32.74	33.16	33.59	33.53	33.24	35.96	35.40	34.67	15.50	-	-	-
Mean weight (g)	21.94	44.37	64.07	84.26	96.71	131.78	139.65	150.85	181.59	165.00	206.34	188.17	268.93	172.26	217.13	18.00	-	-	90.67

Table 26. IBWSS. StoX estimates of blue whiting for 2015.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	13	15	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
11-12	1015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1015	11.2	11.00
13-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15791	15791	170.5	10.80
14-15	49676	-	-	-	-	-	-	-	-	-	-	-	-	-	-	49676	704.8	14.19
15-16	115834	6530	-	-	-	-	-	-	-	-	-	-	-	-	-	122364	2113.3	17.27
16-17	370762	23454	-	-	-	-	-	-	-	-	-	-	-	-	-	394216	8187.8	20.77
17-18	692337	128811	-	-	-	-	-	-	-	-	-	-	-	-	-	821148	21651.9	26.37
18-19	789340	123505	-	7806	-	-	-	-	-	-	-	-	-	-	-	920651	28396.1	30.84
19-20	732539	128340	-	-	-	-	-	-	-	-	-	-	-	-	-	860879	31069.9	36.09
20-21	370324	117128	-	-	-	-	-	-	-	-	-	-	-	-	-	487452	21605.6	44.32
21-22	105131	234633	43145	-	-	-	-	-	-	-	-	-	-	-	-	382910	20057.2	52.38
22-23	28326	730196	103704	-	-	-	-	-	-	-	-	-	-	-	-	862227	52297.4	60.65
23-24	-	1327064	364178	36304	-	-	-	-	-	-	-	-	-	-	-	1727545	115335.3	66.76
24-25	-	1227478	312443	104767	40793	-	-	-	-	-	-	-	-	-	-	1685481	126222.9	74.89
25-26	-	402563	416249	409273	96057	8049	-	-	-	-	-	-	-	-	-	1332191	112376.2	84.35
26-27	-	75781	383883	840346	260676	14666	-	-	-	-	-	-	-	-	-	1575353	144029.2	91.43
27-28	-	38234	169190	867247	416867	65373	-	-	-	-	-	-	-	-	-	1556911	153961.6	98.89
28-29	-	1326	69095	622446	281760	36645	-	-	-	-	-	-	-	-	-	1011271	109309.7	108.09
29-30	-	-	10996	425759	259547	79993	22872	-	-	-	-	-	-	-	-	799167	98236.2	122.92
30-31	-	-	-	157017	206891	41027	-	1326	1326	-	-	-	-	-	-	407587	57041.7	139.95
31-32	-	-	-	106331	86866	37652	12199	5778	11555	20957	-	24279	2889	-	-	308505	48938.9	158.63
32-33	-	-	-	34090	46058	52738	5617	26218	62884	30892	32089	20103	3233	-	-	313923	58557.7	186.54
33-34	-	-	-	-	49438	23934	57046	40565	13062	22390	22859	-	5594	-	-	234887	45821.3	195.08
34-35	-	-	15510	18875	30883	44730	42346	6292	22020	17370	33099	6647	-	-	-	237772	54684.4	229.99
35-36	-	-	-	-	13730	28911	4332	11393	22834	14850	19986	-	28482	5696	-	150214	35164.1	234.09
36-37	-	-	-	-	2827	17953	5654	13377	46603	5654	-	8485	5654	-	-	106207	26783.8	252.19
37-38	-	-	-	-	-	10450	9474	-	19412	8239	2935	-	1326	-	-	51837	13862.1	267.42
38-39	-	-	-	-	-	2516	13592	-	-	10063	-	-	3022	-	-	29193	8662.9	296.75
39-40	-	-	-	-	-	-	-	-	3354	1171	-	-	-	-	-	4526	1191.8	263.33
41-42	-	-	-	-	-	-	-	-	3354	-	-	-	-	-	-	3354	1130.4	337.00
42-43	-	-	-	-	-	-	-	3354	-	-	3948	-	-	-	-	7302	3429.6	469.68
45-46	-	-	-	-	-	-	-	-	-	-	-	3354	-	-	-	3354	1559.8	465.00
TSN(1000)	3255286	4565042	1888395	3630261	1792393	464636	173132	108302	206406	131586	114916	62868	50200	5696	15791	16464910	-	-
TSB(1000 kg)	101838.7	304911.1	158222.2	371033.4	205030.2	75405.4	37205.8	24580.1	46214.3	28171.6	24853.2	12057.1	11228.3	1643.4	170.5	-	1402565.2	-
Mean length (cm)	18.17	22.96	24.99	27.37	28.35	30.81	33.48	33.76	34.41	33.91	33.98	33.33	34.94	35.25	13.30	-	-	-
Mean weight (g)	31.28	66.79	83.79	102.21	114.39	162.29	214.90	226.96	223.90	214.09	216.27	191.78	223.67	288.50	10.80	-	-	85.19

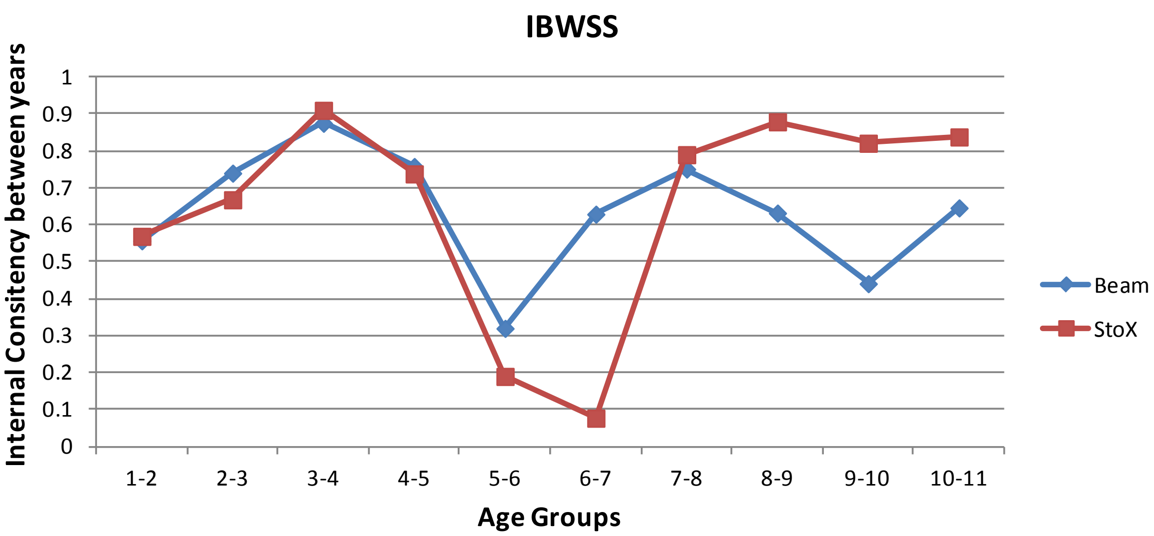

Figure 36. IBWSS. Blue whiting. Internal consistency between age groups one year compared to the one year older group the year after in the IBWSS time series.

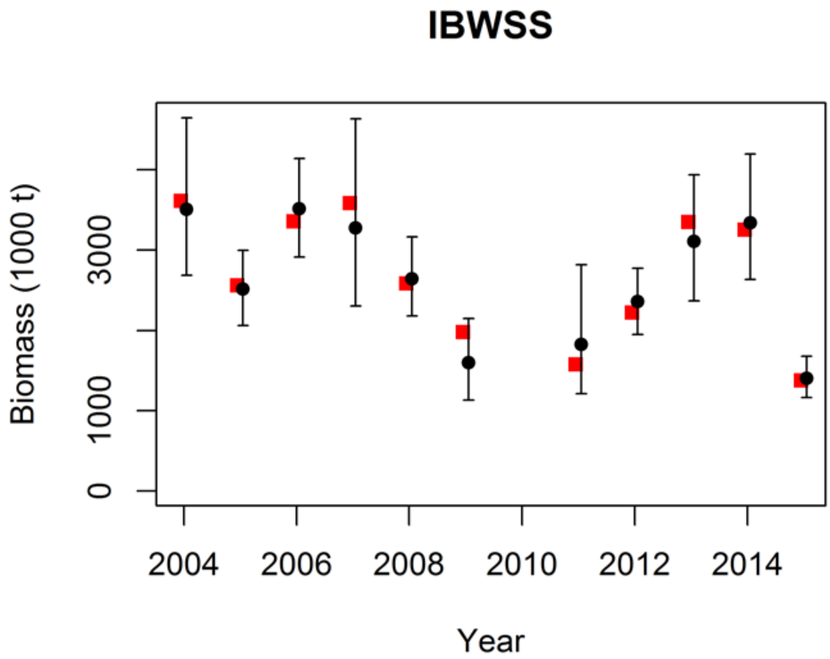

Figure 37. IBWSS. Blue whiting, estimate of total biomass. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red squares are the old estimates (from Beam).

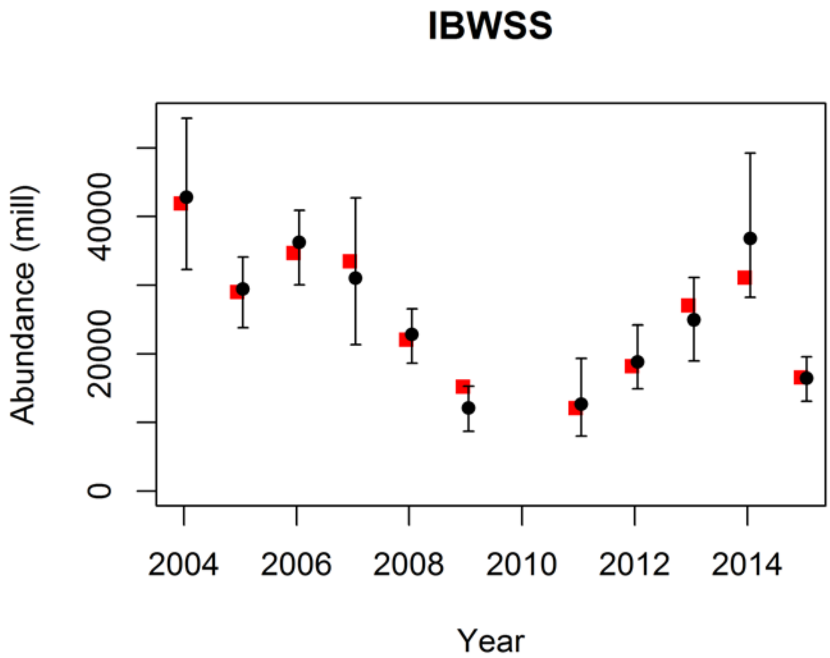

Figure 38. IBWSS. Blue whiting, estimate of total abundance. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red squares are the old estimates (from Beam).

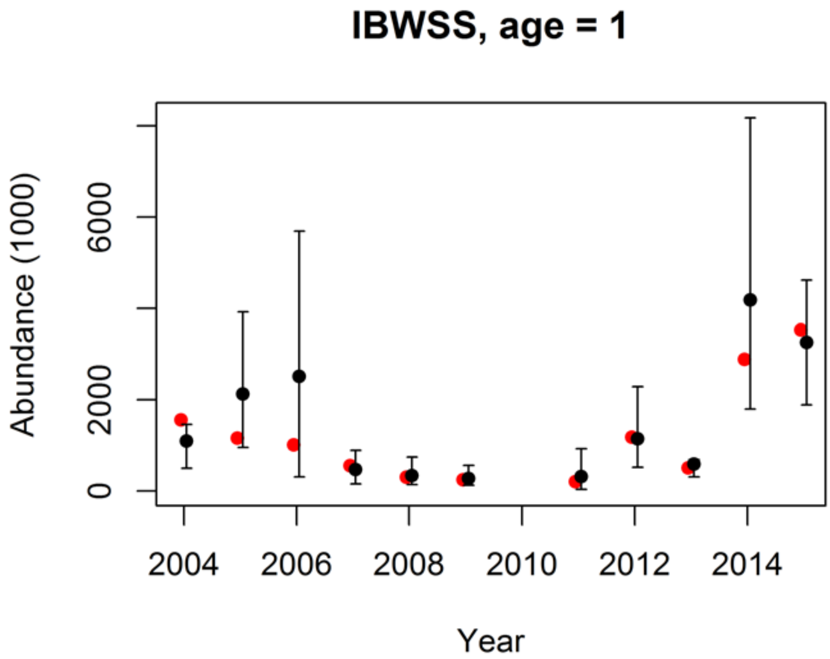

Figure 39. IBWSS. Blue whiting age 1. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

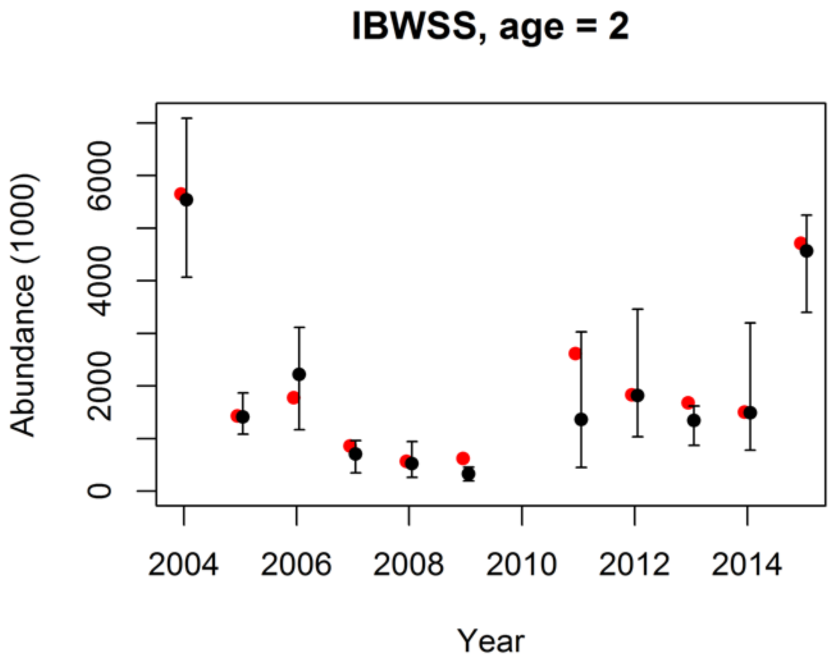

Figure 40. IBWSS. Blue whiting age 2. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

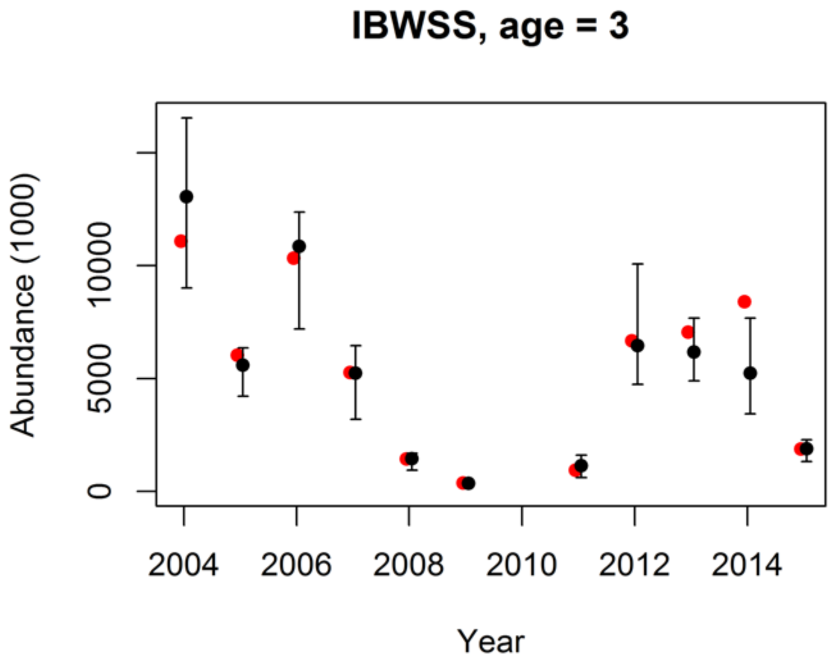

Figure 41. IBWSS. Blue whiting age 3. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

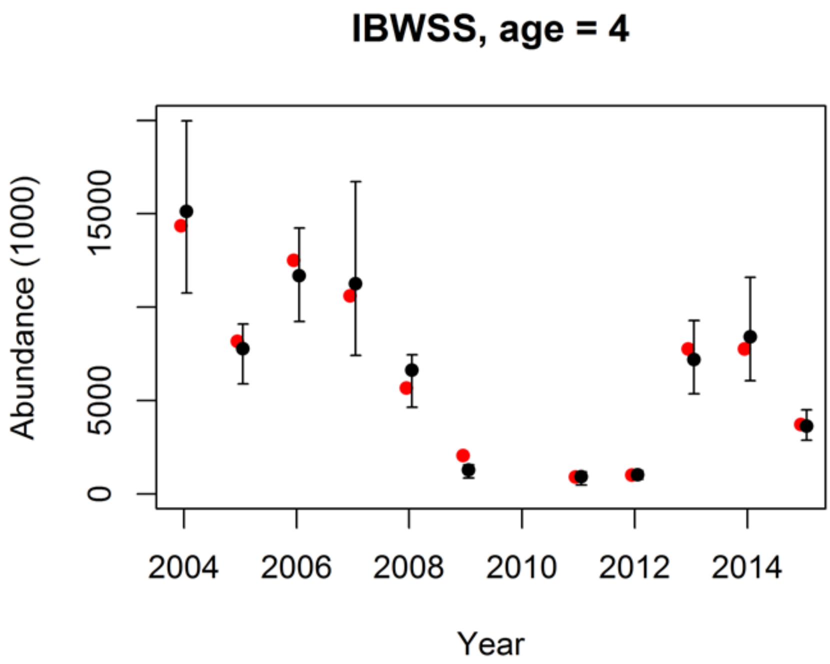

Figure 42. IBWSS. Blue whiting age 4. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

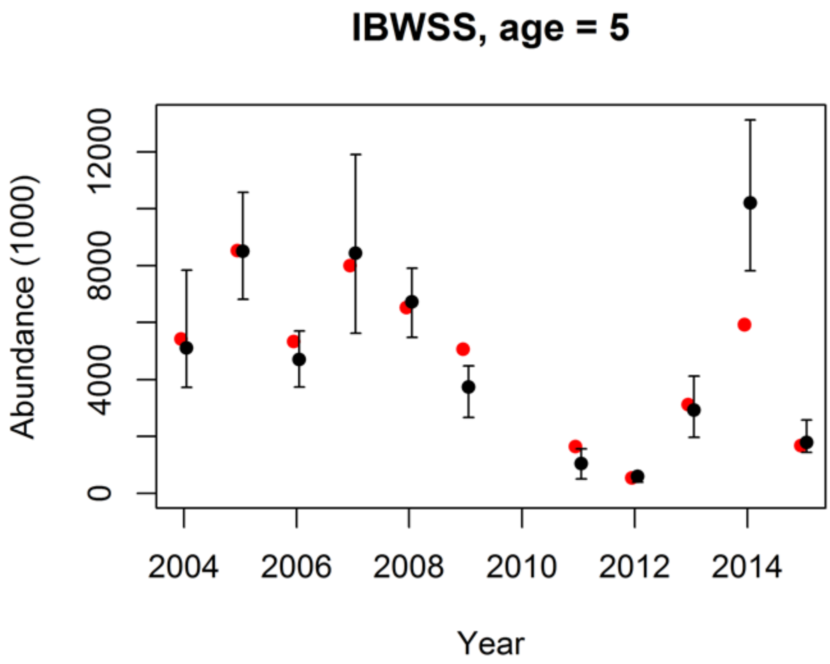

Figure 43. IBWSS. Blue whiting age 5. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

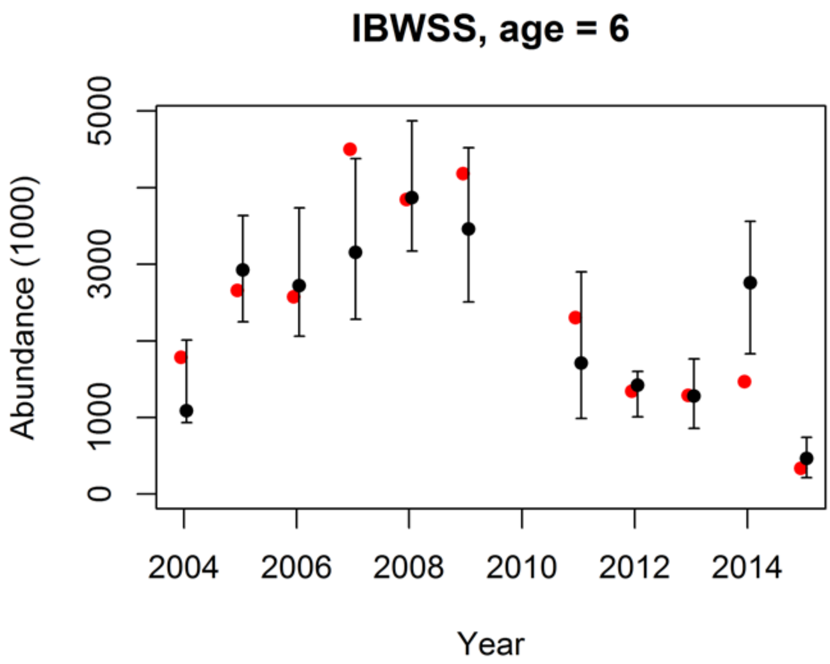

Figure 44. IBWSS. Blue whiting age 6. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

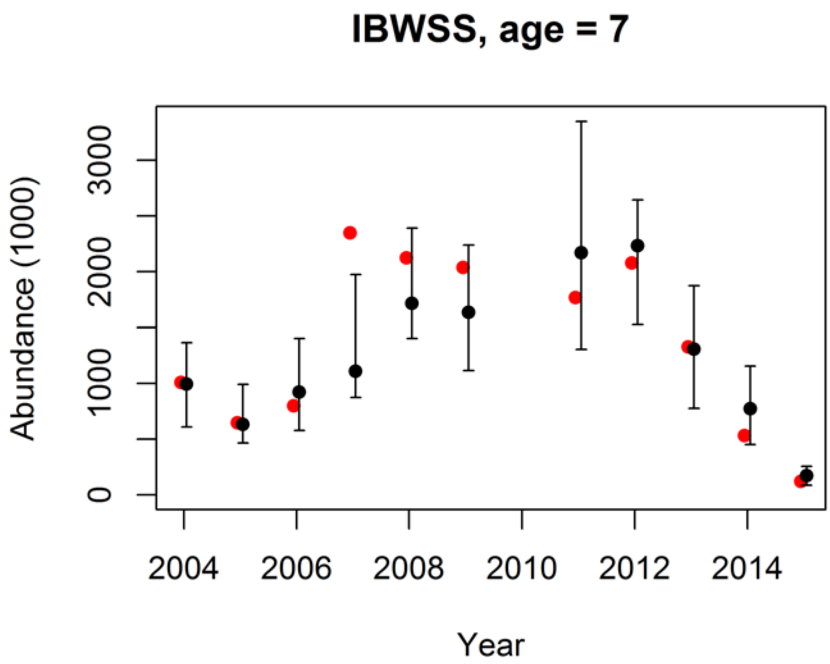

Figure 45. IBWSS. Blue whiting age 7. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

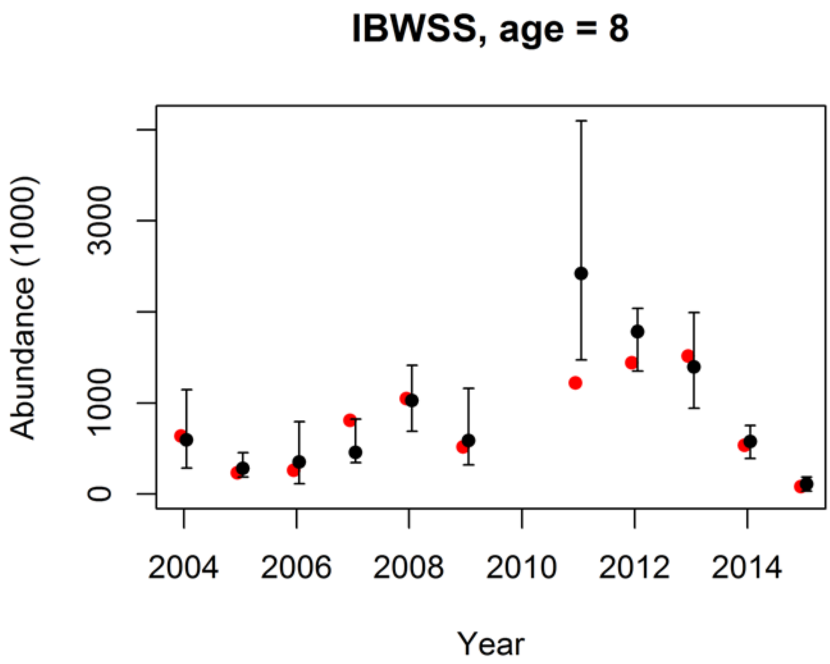

Figure 46. IBWSS. Blue whiting age 8. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

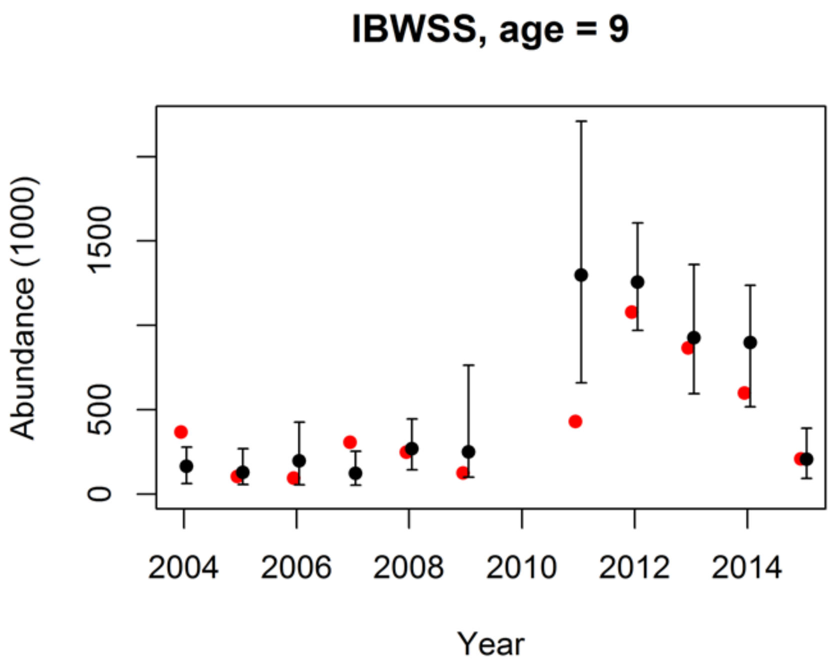

Figure 47. IBWSS. Blue whiting age 9. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

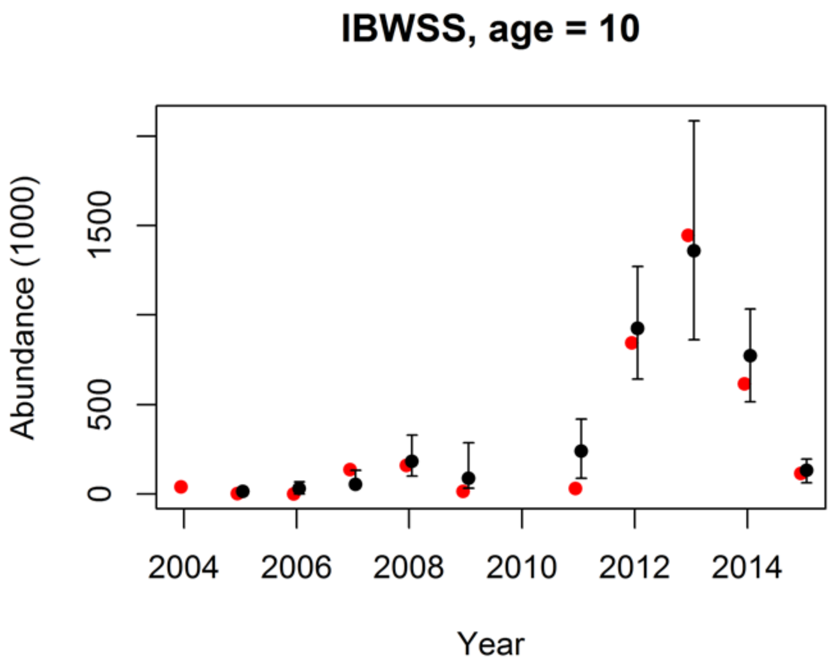

Figure 48. IBWSS. Blue whiting age 10. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

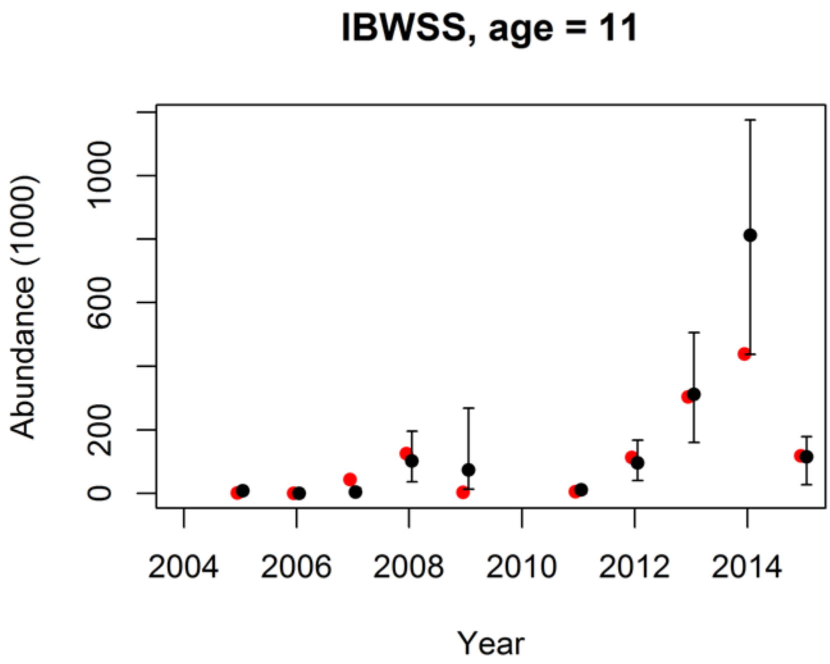

Figure 49. IBWSS. Blue whiting age 11. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

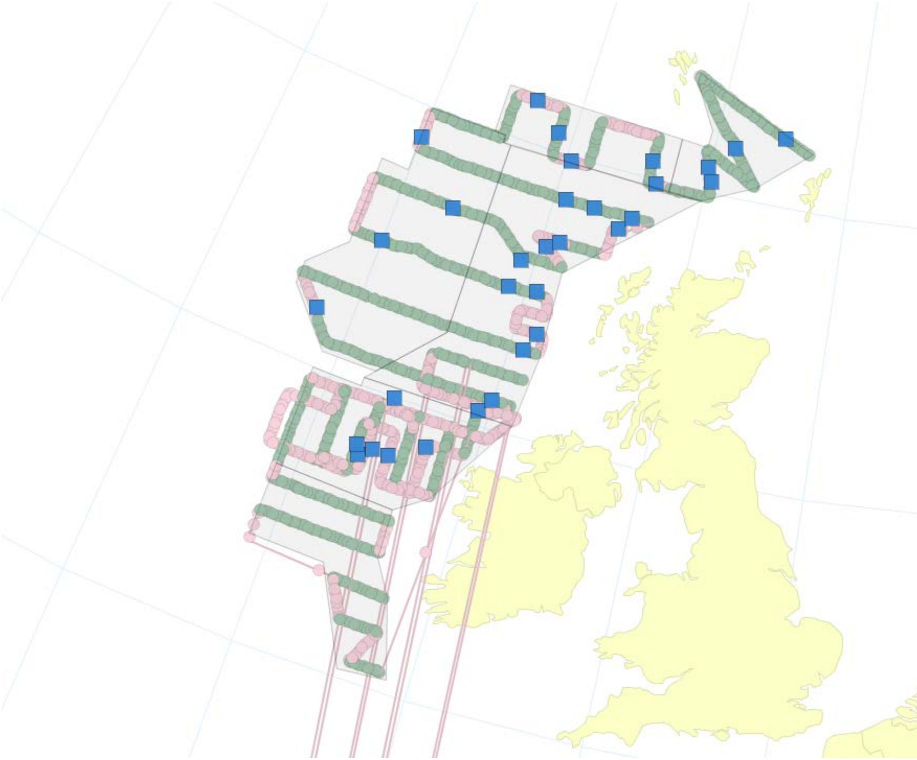

Figure 50. IBWSS 2004. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

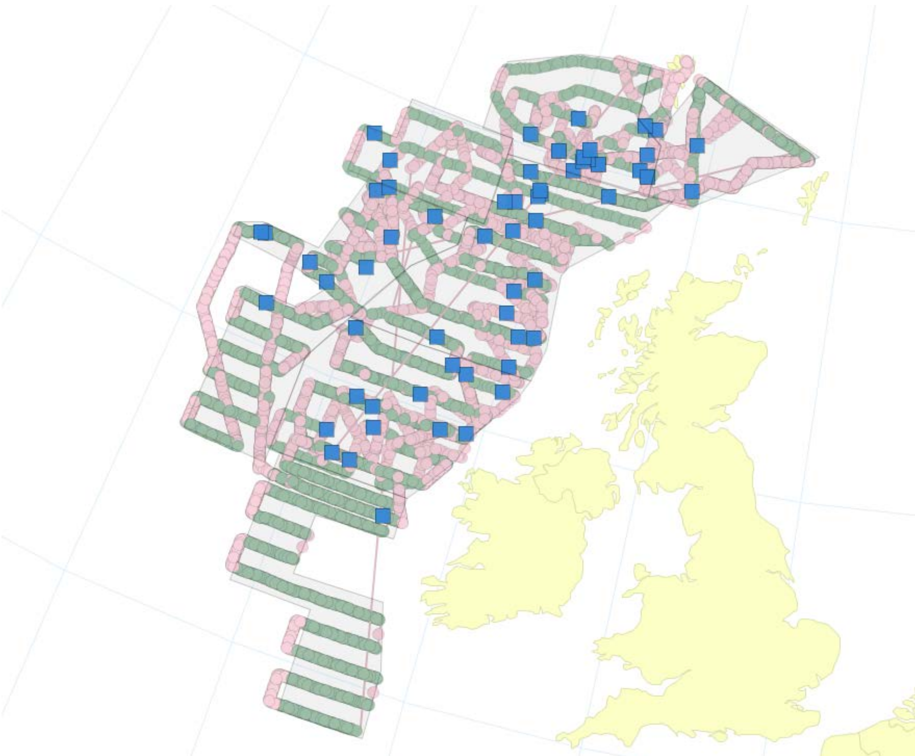

Figure 51. IBWSS 2005. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

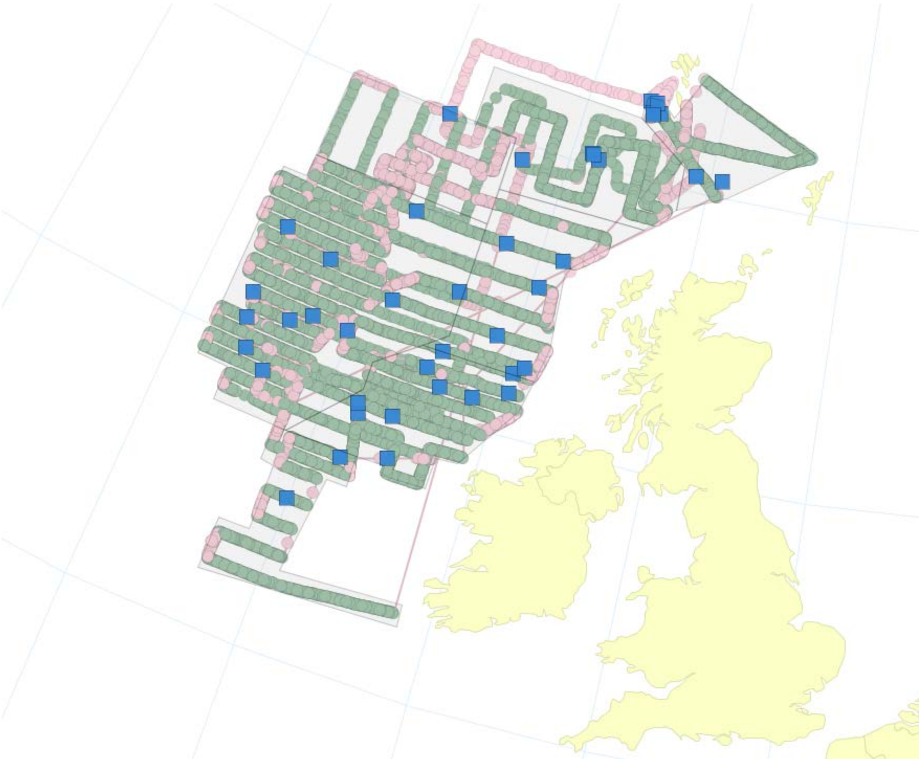

Figure 52. IBWSS 2006. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

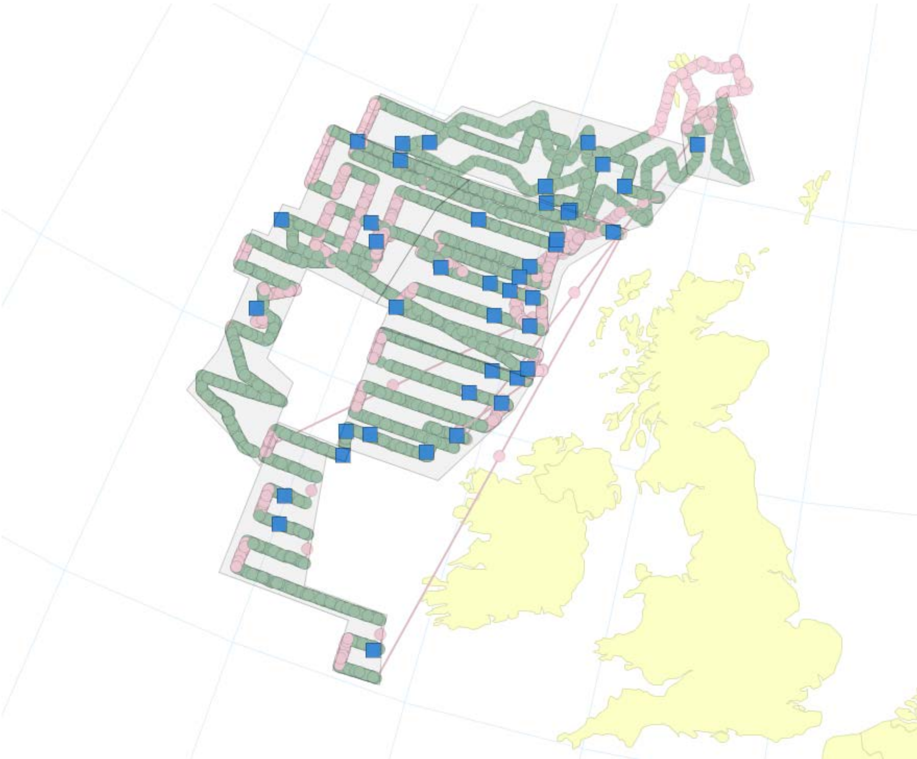

Figure 53. IBWSS 2007. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

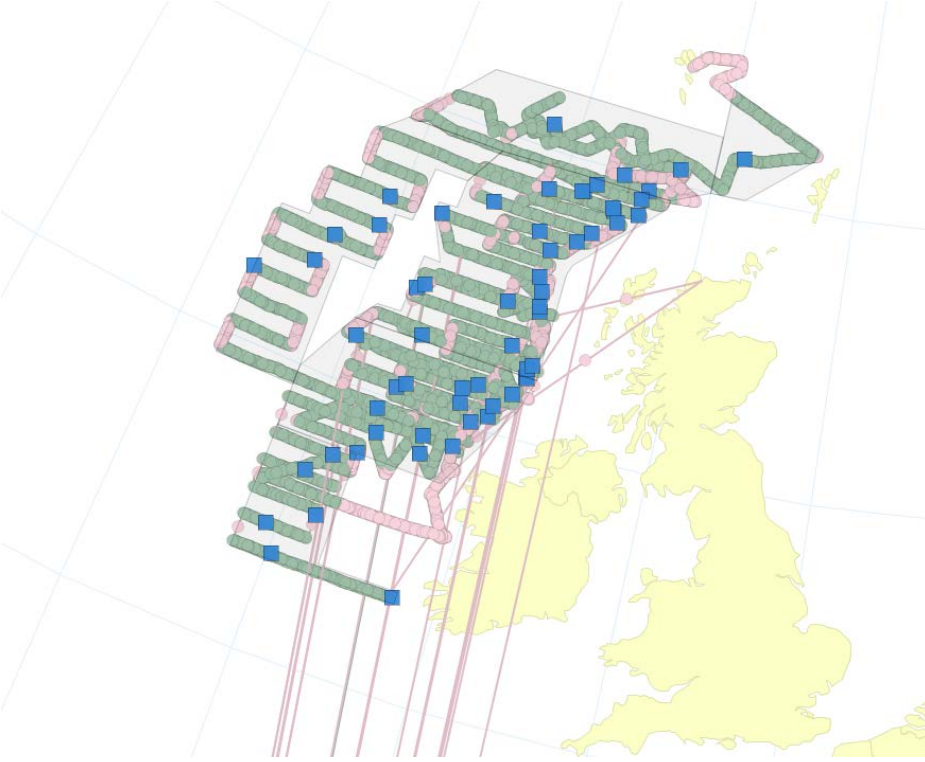

Figure 54. IBWSS 2008. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

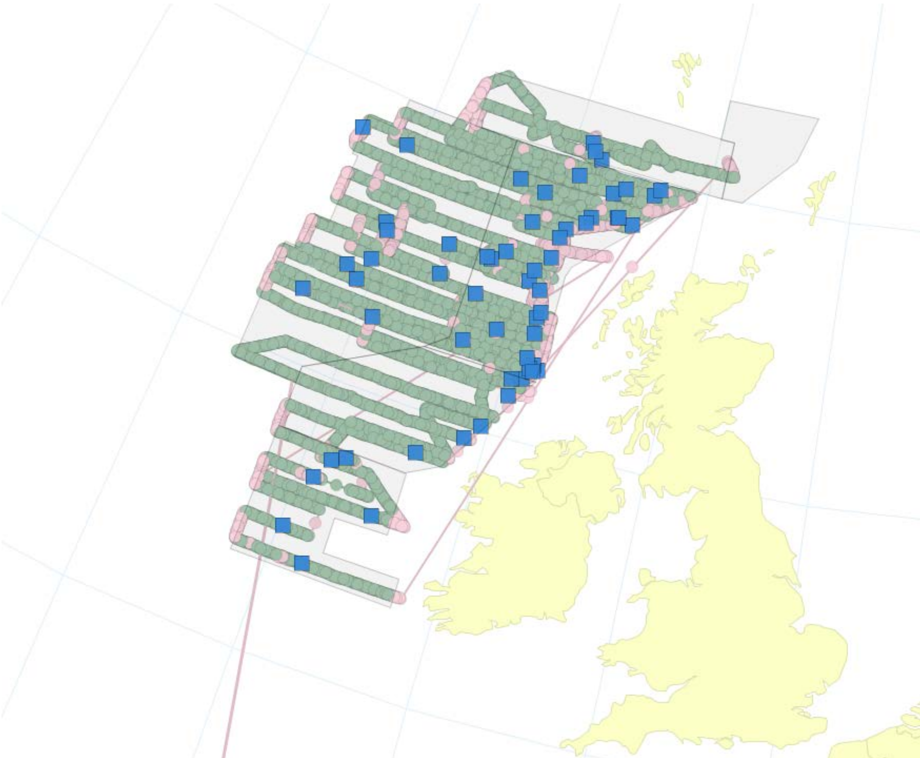

Figure 55. IBWSS 2009. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

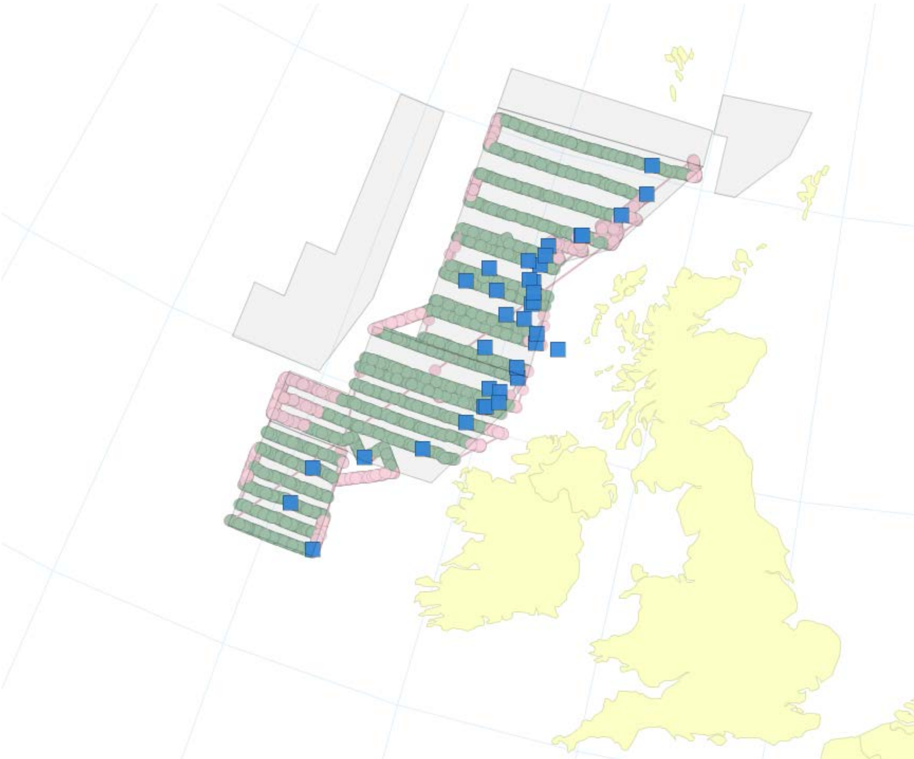

Figure 56. IBWSS 2011. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

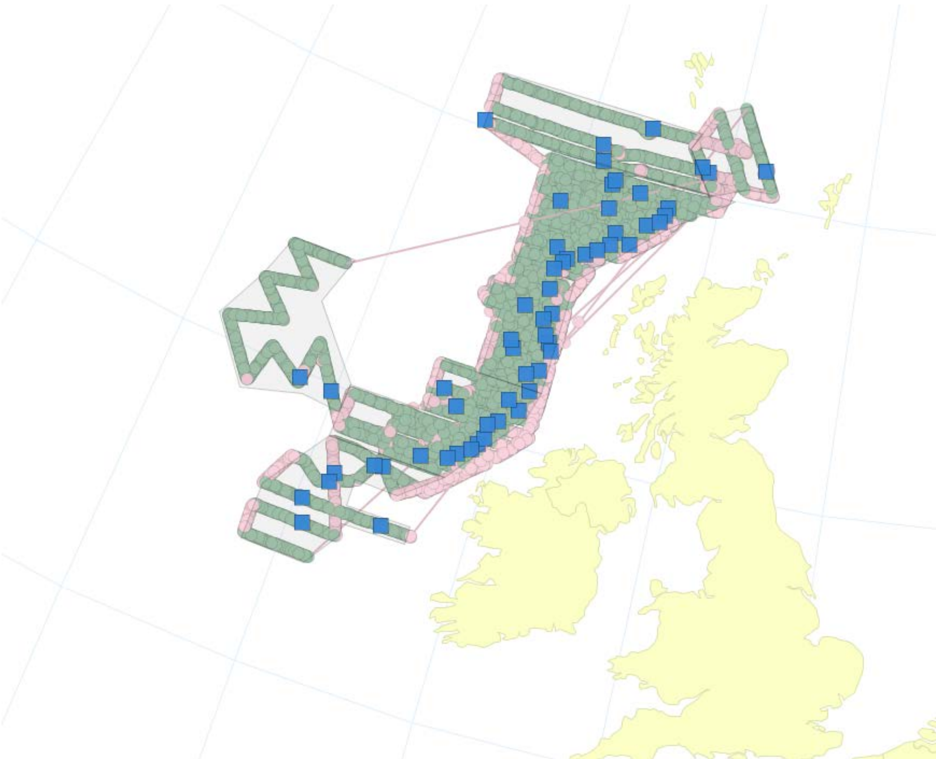

Figure 57. IBWSS 2012. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

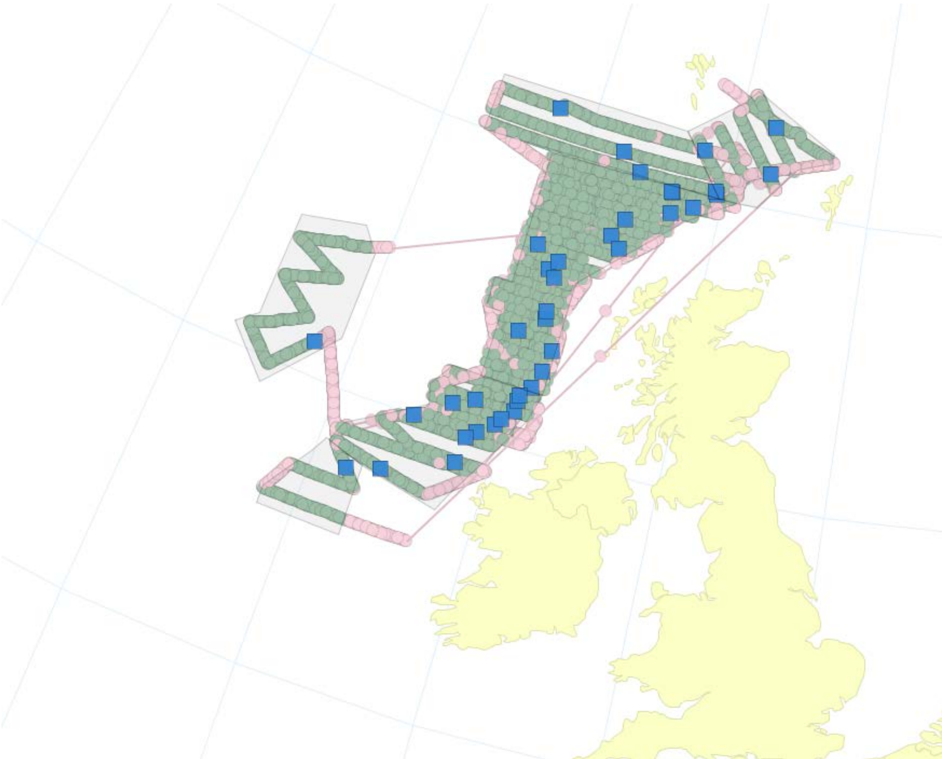

Figure 58. IBWSS 2013. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

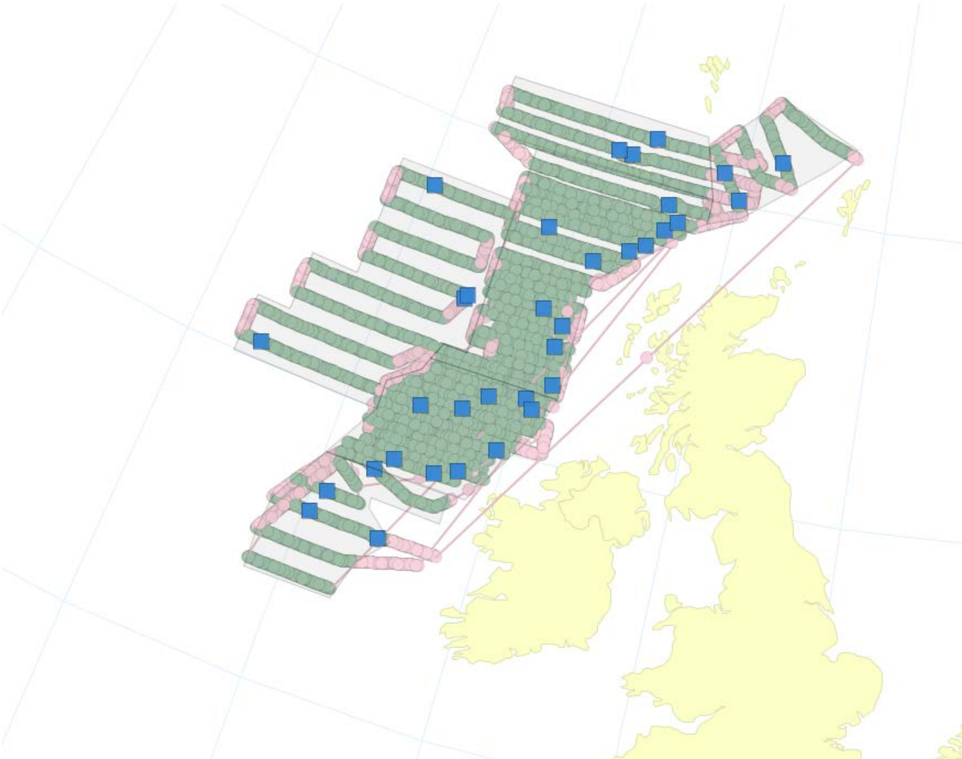

Figure 59. IBWSS 2014. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

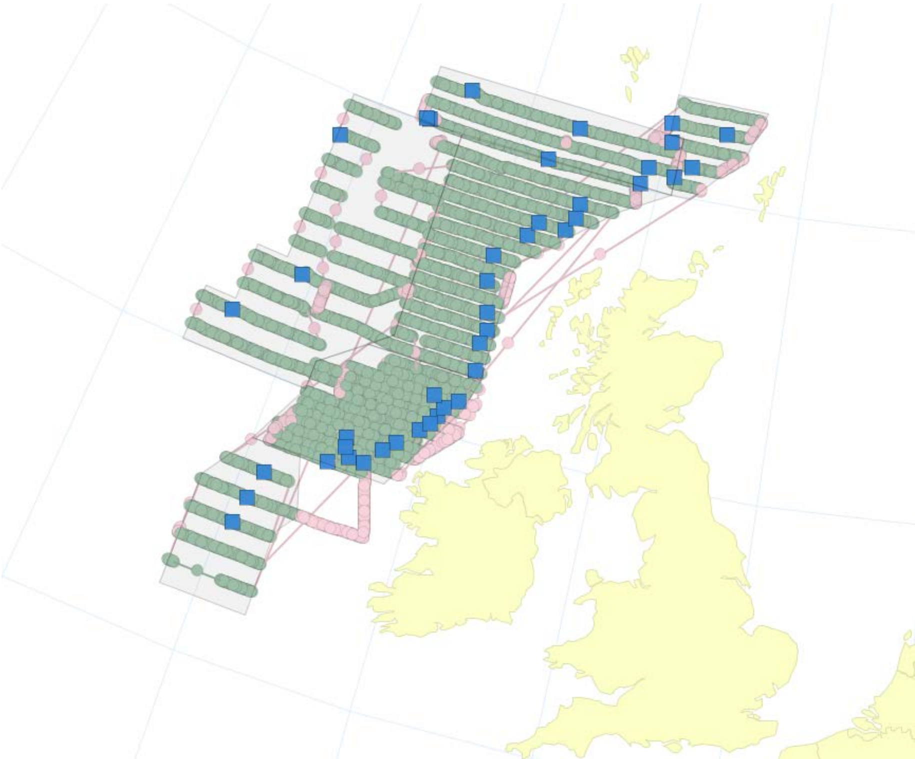

Figure 60. IBWSS 2015. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

Table 27. IESNS. StoX estimates of blue whiting for 2008.

	age												
LenGrp	1	2	3	4	5	6	7	8	9	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
18-19	-	-	-	-	-	-	-	-	-	1413	1413	52.3	37.00
19-20	-	-	-	-	-	-	-	-	-	7736	7736	324.9	42.00
20-21	17050	2741	-	-	-	-	-	-	-	-	19791	979.0	49.47
21-22	7729	-	-	-	-	-	-	-	-	-	7729	402.5	52.08
22-23	-	6692	-	-	-	-	-	-	-	-	6692	429.1	64.12
23-24	-	3596	-	-	-	-	-	-	-	-	3596	263.2	73.20
24-25	-	4045	6768	2940	-	-	-	-	-	-	13752	1170.9	85.14
25-26	-	-	36502	38100	13418	-	-	-	-	-	88021	8303.8	94.34
26-27	-	-	102725	154857	26348	10951	-	-	-	-	294881	32113.2	108.90
27-28	-	-	103108	268053	89374	41680	5627	2251	-	-	510092	60770.1	119.14
28-29	-	-	25292	419433	97535	41422	10711	1188	-	-	595581	79226.7	133.02
29-30	-	-	19082	204099	151520	37888	20351	1210	-	-	434150	63768.6	146.88
30-31	-	-	-	43331	114486	39226	13357	7212	-	-	217612	34790.0	159.87
31-32	-	-	-	17742	33271	58860	16038	4365	-	-	130276	22859.9	175.47
32-33	-	-	-	7492	19414	33378	9194	5614	-	-	75093	15128.1	201.46
33-34	-	-	-	2389	2389	13622	5962	3944	1195	-	29502	6427.3	217.86
34-35	-	-	-	-	5250	2118	7279	-	-	-	14646	3905.7	266.67
35-36	-	-	-	-	-	5256	-	2628	-	-	7883	1875.8	237.94
36-37	-	-	-	-	-	-	-	-	-	2166	2166	249.1	115.00
37-38	-	-	-	3628	-	-	3628	-	-	-	7257	2381.5	328.18
38-39	-	-	-	-	-	2576	-	-	-	-	2576	734.1	284.94
40-41	-	-	-	-	-	-	-	-	-	5199	5199	2313.5	445.00
41-42	-	-	-	-	-	-	-	-	-	2599	2599	1221.7	470.00
45-46	-	-	-	-	-	-	-	-	-	5199	5199	3015.3	580.00
TSN(1000)	24778	17074	293477	1162064	553006	286977	92146	28412	1195	24313	2483442	-	-
TSB(1000 kg)	1187.7	1240.0	33982.7	153961.8	77837.8	45389.2	16469.9	5208.1	252.2	7176.9	-	342706.4	-
Mean length (cm)	20.57	22.47	26.73	27.97	28.85	29.83	30.67	31.11	33.00	33.07	-	-	-
Mean weight (g)	47.93	72.63	115.79	132.49	140.75	158.16	178.74	183.31	211.10	295.19	-	-	138.00

Table 28. IESNS. StoX estimates of blue whiting for 2009.

	age											
LenGrp	1	2	3	4	5	6	7	8	9	Number (1E3)	Biomass (1E3kg)	Mean W (g)
22-23	6254	-	-	-	-	-	-	-	-	6254	385.5	61.65
24-25	-	4460	13380	-	-	-	-	-	-	17840	1437.4	80.57
25-26	-	3063	9270	-	-	-	-	-	-	12334	1136.8	92.17
26-27	-	-	19392	67498	13564	-	-	-	-	100454	10402.7	103.56
27-28	-	-	-	138341	89091	24353	-	-	-	251785	27285.1	108.37
28-29	-	-	2334	74599	353411	43407	16005	-	-	489755	61919.5	126.43
29-30	-	-	2597	105250	385986	141483	13091	6926	1731	657064	90193.5	137.27
30-31	720	-	2159	44997	257088	244417	40484	10639	1439	601943	92437.9	153.57
31-32	-	-	-	19902	84270	228145	26255	3061	-	361633	60942.8	168.52
32-33	-	-	-	22056	27221	63654	88319	2944	1403	205596	36583.8	177.94
33-34	-	-	-	-	18839	24557	9285	13964	22000	88645	18021.8	203.30
34-35	-	-	-	-	-	-	3257	21017	1629	25903	5431.3	209.67
35-36	-	-	-	-	-	-	-	-	9110	9110	2230.2	244.81
37-38	-	-	-	-	-	-	-	8019	-	8019	2023.6	252.35
TSN(1000)	6973	7523	49132	472644	1229470	770015	196696	66571	37312	2836337	-	-
TSB(1000 kg)	508.6	651.4	4908.4	64895.4	166389.1	119390.9	33156.4	13253.2	7278.6	-	410432.0	-
Mean length (cm)	22.88	24.61	25.85	28.20	29.03	30.20	31.08	32.89	33.23	-	-	-
Mean weight (g)	72.93	86.59	99.90	137.30	135.33	155.05	168.57	199.08	195.07	-	-	144.70

Table 29. IESNS. StoX estimates of blue whiting for 2010.

	age												
LenGrp	2	3	4	5	6	7	8	9	10	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
22-23	-	-	-	-	-	-	-	-	-	4188	4188	284.6	67.95
23-24	43708	-	-	-	-	-	-	-	-	-	43708	3201.4	73.25
24-25	71427	7246	-	-	-	-	-	-	-	-	78673	6853.8	87.12
25-26	131912	49567	-	-	-	-	-	-	-	-	181479	18038.9	99.40
26-27	32793	23245	9236	-	-	-	-	-	-	-	65274	7282.9	111.57
27-28	-	11690	-	1917	4606	1535	-	-	-	-	19749	2547.7	129.01
28-29	-	-	9414	15831	12689	-	-	-	1156	-	39090	5321.2	136.13
29-30	-	-	7618	42104	8350	1287	1287	-	-	-	60645	8601.6	141.83
30-31	-	-	1604	71654	27108	7928	6383	-	-	-	114677	18110.4	157.93
31-32	-	-	2267	39192	39790	16134	2719	-	-	-	100101	17216.1	171.99
32-33	-	-	-	7300	55783	1483	13525	-	-	-	78091	15922.4	203.89
33-34	-	-	-	-	29024	9484	11203	-	-	-	49711	10301.5	207.23
34-35	-	-	-	4336	7824	16001	9711	8725	-	-	46597	9548.3	204.91
35-36	-	-	-	-	-	3554	1950	7800	-	-	13304	3355.8	252.24
36-37	-	-	-	-	-	-	1950	3900	-	-	5850	1644.3	281.07
37-38	-	-	-	-	-	-	-	-	-	1950	1950	465.1	238.50
TSN(1000)	279840	91748	30138	182334	185174	57407	48727	20425	1156	6138	903087	-	-
TSB(1000 kg)	26478.8	9329.6	3893.8	27412.9	33637.7	11097.6	11246.0	4683.5	166.5	749.7	-	128696.0	-
Mean length (cm)	24.55	25.43	28.00	30.01	31.32	32.27	32.65	34.76	28.50	26.81	-	-	-
Mean weight (g)	94.62	101.69	129.20	150.34	181.65	193.32	230.79	229.31	144.00	122.13	-	-	142.51

Table 30. IESNS. StoX estimates of blue whiting for 2011.

LenGrp	age 1	2	4	5	6	7	8	9	10	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
18-19	-	-	-	-	-	-	-	-	-	9034	9034	-	-
19-20	16952	36023	-	-	-	-	-	-	-	-	52975	2000.3	37.76
20-21	66917	125432	-	-	-	-	-	-	-	-	192349	8829.8	45.91
21-22	209687	90463	-	-	-	-	-	-	-	-	300150	16264.7	54.19
22-23	416487	64519	-	-	-	-	-	-	-	-	481007	30588.3	63.59
23-24	429871	27797	-	-	-	-	-	-	-	-	457668	34140.9	74.60
24-25	332251	9856	-	-	-	-	-	-	-	-	342107	28765.9	84.08
25-26	115728	-	-	-	-	-	-	-	-	-	115728	10691.0	92.38
26-27	24985	-	-	-	-	-	-	-	-	-	24985	2678.0	107.18
27-28	-	-	8822	-	-	-	-	-	-	-	8822	1013.2	114.84
28-29	-	-	7592	2761	3451	-	-	3422	-	-	17226	2091.5	121.41
29-30	-	-	11843	6357	37834	19789	5562	-	-	-	81385	12642.8	155.35
30-31	-	-	-	8609	24604	87448	9266	31850	-	-	161775	26726.7	165.21
31-32	-	-	-	9793	25616	86420	59280	10492	-	-	191601	34342.8	179.24
32-33	-	-	-	14428	12439	83605	14428	-	-	-	124900	25781.1	206.41
33-34	-	-	-	4130	-	50811	22755	25406	-	-	103101	23404.0	227.00
34-35	-	-	-	4050	13275	44257	-	11251	-	-	72833	17774.7	244.05
35-36	-	-	2085	15835	-	2633	-	31670	15067	-	67290	18176.6	270.12
TSN(1000)	1612879	354089	30342	65961	117219	374963	111291	114091	15067	9034	2804936	-	-
TSB(1000 kg)	115831.5	18127.5	4560.0	14195.7	19417.9	74131.7	21269.2	25049.2	3329.8	-	-	295912.4	-
Mean length (cm)	22.76	21.08	28.97	32.27	30.66	31.75	31.70	32.53	35.00	18.25	-	-	-
Mean weight (g)	71.82	51.19	150.29	215.21	165.65	197.70	191.11	219.56	221.00	-	-	-	105.84

Table 31. IESNS. StoX estimates of blue whiting for 2012.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	36282	-	-	-	-	-	-	-	-	36282	737.6	20.33
16-17	262780	164690	-	-	-	-	-	-	-	-	427470	9658.1	22.59
17-18	1089964	490922	-	-	-	-	-	-	-	-	1580886	44190.8	27.95
18-19	1582685	717869	-	-	-	-	-	-	-	-	2300553	74451.4	32.36
19-20	1895425	592630	-	-	-	-	-	-	-	-	2488055	95925.7	38.55
20-21	1731588	377110	-	-	-	-	-	-	-	-	2108698	94979.5	45.04
21-22	1409176	326736	-	-	-	-	-	-	-	-	1735912	92826.4	53.47
22-23	1012085	252841	1344	-	-	-	-	-	-	-	1266270	77738.8	61.39
23-24	298873	252880	9290	-	-	-	-	-	-	-	561043	40506.4	72.20
24-25	154096	1868	44732	-	-	-	-	-	-	-	200696	16157.4	80.51
25-26	27630	15508	84743	15933	-	-	-	-	-	-	143813	13746.1	95.58
26-27	11697	35508	112369	5268	-	-	-	-	-	-	164842	17742.2	107.63
27-28	-	-	219845	6995	-	-	-	-	-	-	226840	26807.8	118.18
28-29	-	-	66616	45268	-	-	-	-	-	-	111884	15551.5	139.00
29-30	-	-	29242	68071	6074	3037	7593	1519	-	-	115536	16756.4	145.03
30-31	-	-	12737	48281	25948	32096	14705	8403	2101	-	144271	24005.2	166.39
31-32	-	-	5632	1519	101124	69576	9111	8669	-	-	195631	33322.4	170.33
32-33	-	-	-	4711	21890	84515	46620	-	-	-	157737	29845.3	189.21
33-34	-	-	-	-	45916	114281	62451	3853	-	-	226502	47763.6	210.87
34-35	-	-	-	-	74429	62539	201088	18959	-	-	357014	89602.6	250.98
35-36	-	-	-	-	-	43210	96895	5433	-	-	145538	38999.1	267.96
36-37	-	-	-	-	-	137444	23394	11697	-	-	172535	48715.2	282.35
37-38	-	-	-	3563	-	29242	-	65798	-	-	98603	27620.6	280.12
38-39	-	-	-	-	-	3436	-	-	-	-	3436	1285.2	374.00
39-40	-	-	-	-	-	-	5848	11697	-	-	17545	5597.0	319.00
40-41	-	-	-	-	-	-	-	-	-	5848	5848	2047.0	350.00
TSN(1000)	9475999	3264842	586551	199609	275381	579377	467706	136028	2101	5848	14993442	-	-
TSB(1000 kg)	413448.1	138429.3	66407.7	30714.4	52648.3	131475.3	116440.7	34634.7	334.0	2047.0	-	986579.4	-
Mean length (cm)	19.77	19.50	26.69	28.94	32.27	33.77	34.07	35.62	30.50	40.00	-	-	-
Mean weight (g)	43.63	42.40	113.22	153.87	191.18	226.93	248.96	254.61	159.00	350.00	-	-	65.80

Table 32. IESNS. StoX estimates of blue whiting for 2013.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7481	7481	329.2	44.00
20-21	32390	52250	14707	-	-	-	-	-	-	-	-	-	-	-	-	-	99346	4648.4	46.79
21-22	109480	284407	25317	-	-	-	-	-	-	-	-	-	-	-	-	-	419205	23313.1	55.61
22-23	144985	860215	212231	-	-	-	-	-	-	-	-	-	-	-	-	-	1217431	77113.9	63.34
23-24	148638	1555759	262300	-	-	-	-	-	-	-	-	-	-	-	-	-	1966697	142115.8	72.26
24-25	8157	1590916	399864	4640	-	-	-	-	-	-	-	-	-	-	-	-	2003578	162936.4	81.32
25-26	10067	1221652	276978	-	-	-	-	-	-	-	-	-	-	-	-	-	1508697	138025.7	91.49
26-27	-	712667	163863	1170	-	-	-	-	-	-	-	-	-	-	-	-	877700	91058.9	103.75
27-28	-	199478	120000	32602	799	-	-	-	-	-	-	-	-	-	-	-	352878	41570.7	117.80
28-29	-	53661	88397	84959	-	378	-	-	-	-	-	-	-	-	-	-	227395	30321.6	133.34
29-30	-	13255	75175	39758	10675	1620	-	1255	365	-	-	-	-	-	-	-	142102	21456.4	150.99
30-31	-	-	77023	7266	73869	7254	5566	-	6800	7027	1700	-	-	-	-	-	186505	31464.9	168.71
31-32	-	-	19883	36181	51705	38649	19620	49193	23595	1244	4510	-	1244	-	-	-	245826	46894.0	190.76
32-33	-	-	2554	25661	53237	29065	53069	27941	19216	13135	5928	1642	821	-	-	-	232268	48207.1	207.55
33-34	-	-	3005	-	3826	60652	50800	51173	13764	5808	6389	4646	-	581	-	-	200643	45760.8	228.07
34-35	-	-	-	768	4408	27967	28767	22444	21589	37233	3842	3073	3842	1537	-	-	155470	37988.6	244.35
35-36	-	-	-	-	6230	17638	19750	24307	24456	1841	5523	3068	-	-	-	-	102814	27950.3	271.85
36-37	-	-	-	-	-	705	22899	23376	-	-	2820	-	-	-	705	-	50504	14902.9	295.08
37-38	-	-	-	-	-	-	404	-	9666	808	808	-	-	-	-	-	11687	3677.4	314.66
38-39	-	-	-	-	-	-	521	5388	10039	3346	-	-	-	260	-	-	19555	6854.2	350.50
39-40	-	-	-	-	-	-	-	-	-	2791	-	-	-	-	-	-	2791	1151.2	412.44
40-41	-	-	-	-	-	-	-	-	-	2791	-	-	-	-	-	-	2791	1263.8	452.79
41-42	-	-	-	-	-	3432	-	-	-	-	-	-	-	-	-	-	3432	1442.5	420.29
44-45	-	-	-	-	-	-	-	-	-	2308	-	-	-	-	-	-	2308	993.3	430.40
TSN(1000)	453717	6544260	1741299	233005	204748	187359	201397	205077	129490	78334	31520	12430	5907	2378	705	7481	10039106	-	-
TSB(1000 kg)	29183.6	529147.3	166181.2	36167.4	39744.7	42480.2	46829.9	48359.3	31853.8	19228.3	7137.6	2831.9	1314.3	486.2	166.4	329.2	-	1001441.1	-
Mean length (cm)	22.20	24.11	25.08	29.04	31.06	32.93	33.32	33.42	33.75	34.25	33.48	33.85	33.22	34.53	36.00	19.25	-	-	-
Mean weight (g)	64.32	80.86	95.44	155.22	194.12	226.73	232.53	235.81	245.99	245.47	226.45	227.83	222.51	204.46	236.00	44.00	-	-	99.75

Table 33. IESNS. StoX estimates of blue whiting for 2014.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	13	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	811	811	-	-
16-17	-	7947	-	-	-	-	-	-	-	-	-	-	-	-	7947	212.3	26.71
17-18	59929	80694	-	-	-	-	-	-	-	-	-	-	-	-	140623	3751.8	26.68
18-19	446983	252674	4671	-	-	-	-	-	-	-	-	-	-	-	704328	24178.3	34.33
19-20	947671	547483	5000	-	-	-	-	-	-	-	-	-	-	-	1500154	60635.4	40.42
20-21	1216992	567949	3480	-	-	-	-	-	-	-	-	-	-	-	1788421	83986.3	46.96
21-22	848054	284241	5256	-	-	-	-	-	-	-	-	-	-	-	1137552	61123.0	53.73
22-23	333236	109146	9516	3172	-	-	-	-	-	-	-	-	-	-	455069	28003.3	61.54
23-24	24344	63857	124601	21763	-	-	-	-	-	-	-	-	-	-	234564	16832.8	71.76
24-25	3368	47534	303758	45143	-	-	-	-	-	-	-	-	-	-	399803	33296.3	83.28
25-26	-	29145	390688	100206	11150	-	-	-	-	-	-	-	-	-	531189	49678.2	93.52
26-27	-	41490	542499	144135	22865	1649	-	-	-	-	-	-	-	-	752638	77278.0	102.68
27-28	-	15143	504490	123620	29811	-	-	-	-	-	-	-	-	-	673064	77397.6	114.99
28-29	-	955	337516	121351	34330	-	-	-	-	-	-	-	-	-	494152	62059.7	125.59
29-30	12570	-	124427	109169	27774	7496	-	-	-	-	-	-	-	-	281436	40589.0	144.22
30-31	-	-	18628	42743	46109	9157	6073	1526	7066	-	-	-	-	-	131302	21035.2	160.20
31-32	-	-	-	58528	11672	24794	14034	6276	7556	1889	-	-	-	-	124749	20905.5	167.58
32-33	-	-	-	19378	45261	22783	12947	6276	50191	25428	12947	-	-	-	195211	37559.5	192.40
33-34	-	-	-	-	-	5022	17720	23260	45926	-	-	35439	4554	-	131921	28157.6	213.44
34-35	-	-	-	1092	2185	3714	6827	28173	3201	19817	3714	4642	-	-	73364	16749.9	228.31
35-36	-	-	-	-	-	-	9286	13024	13170	1869	1869	8206	-	-	47425	11847.5	249.82
36-37	-	-	-	-	850	850	-	1700	2740	30710	2740	913	-	-	40505	10382.4	256.32
37-38	-	-	-	-	-	-	-	-	-	3378	-	-	-	-	3378	810.7	240.00
38-39	-	-	-	-	-	-	811	811	878	-	-	-	-	-	2500	659.2	263.71
TSN(1000)	3893147	2048259	2374527	790300	232007	75466	67698	81046	130728	83091	21270	49201	4554	811	9852105	-	-
TSB(1000 kg)	181324.5	100975.6	241990.3	98243.6	35449.2	13303.1	14217.4	16310.7	30192.7	19994.2	4558.7	9708.8	860.7	-	-	767129.6	-
Mean length (cm)	20.03	20.23	26.18	27.46	29.24	31.38	32.63	33.62	32.74	34.24	33.52	33.54	33.10	15.50	-	-	-
Mean weight (g)	46.58	49.30	101.91	124.31	152.79	176.28	210.01	201.25	230.96	240.63	214.32	197.33	189.00	-	-	-	77.87

Table 34. IESNS. StoX estimates of blue whiting for 2015.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
14-15	7566	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7566	111.6	14.75
15-16	24887	5621	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30508	591.2	19.38
16-17	253865	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	253865	6102.7	24.04
17-18	1165669	4844	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1170513	34073.2	29.11
18-19	2535036	22864	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2557900	85503.8	33.43
19-20	2683548	41606	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2725154	105603.5	38.75
20-21	1302702	65079	-	-	13075	-	-	-	-	-	-	-	-	-	-	-	1380856	61070.9	44.23
21-22	475913	82474	14098	-	-	-	-	-	-	-	-	-	-	-	-	-	572485	29493.3	51.52
22-23	91326	394624	20539	2284	-	-	-	-	-	-	-	-	-	-	-	-	508772	32288.5	63.46
23-24	11986	730652	70353	2125	-	-	-	-	-	-	-	-	-	-	-	-	815117	60258.5	73.93
24-25	10674	674603	175282	18490	-	-	-	-	-	-	-	-	-	-	-	-	879049	73294.6	83.38
25-26	-	484543	145918	17431	23349	-	-	-	-	-	-	-	-	-	-	-	671241	62826.9	93.60
26-27	-	217575	273064	66777	14676	-	-	-	-	-	-	-	-	-	-	-	572093	60998.3	106.62
27-28	-	33079	191831	167299	51230	-	-	-	-	-	-	-	-	-	-	-	443440	54957.6	123.93
28-29	-	-	136003	175759	63103	5609	-	-	-	-	-	-	-	-	-	-	380474	51610.3	135.65
29-30	-	25885	60335	168088	38597	13023	2737	-	2876	-	-	-	-	-	-	-	311542	46432.6	149.04
30-31	-	10205	41899	53152	42611	63853	13835	-	-	6072	-	-	1012	-	-	-	232640	38047.0	163.54
31-32	-	2600	4978	56878	28357	27264	-	11058	732	6267	11226	1464	-	-	-	-	150824	27283.6	180.90
32-33	-	-	-	31231	2748	41350	-	5496	15388	37429	7201	4453	-	-	-	-	145294	28505.3	196.19
33-34	-	-	-	19298	26091	23200	7395	18866	15643	5013	877	6136	877	-	-	-	123394	27051.9	219.23
34-35	-	-	-	2098	21448	9333	20591	27377	4930	16995	18986	7347	-	-	-	-	129105	30136.0	233.42
35-36	-	-	-	-	7052	-	22463	12051	9014	4313	19368	3659	1308	654	1962	-	81842	20044.2	244.91
36-37	-	-	2607	-	-	4468	12921	6702	8936	9682	3401	-	-	-	-	-	48718	12633.2	259.32
37-38	-	-	-	-	-	-	2649	9627	-	-	6902	2275	-	-	2684	-	24137	7010.6	290.45
38-39	-	-	-	-	-	-	-	-	-	2303	-	-	-	-	-	-	2303	631.0	274.00
39-40	-	-	-	-	-	-	-	-	572	-	-	-	-	-	-	-	572	156.2	273.00
40-41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2362	2362	802.9	340.00
TSN(1000)	8563172	2796256	1136908	780908	332337	188099	82592	91177	58091	88072	67960	25333	3197	654	4646	2362	14221764	-	-
TSB(1000 kg)	318567.7	222219.8	125369.4	109614.5	51032.5	34162.3	19203.3	20583.7	12665.0	19071.0	15498.4	6380.3	765.1	152.4	1431.0	802.9	-	957519.3	-
Mean length (cm)	18.84	23.75	26.12	28.47	29.03	31.38	33.91	34.09	33.66	33.14	34.20	33.87	32.97	35.00	36.30	40.00	-	-	-
Mean weight (g)	37.20	79.47	110.27	140.37	153.56	181.62	232.51	225.76	218.02	216.54	228.05	251.85	239.37	233.00	308.03	340.00	-	-	67.33

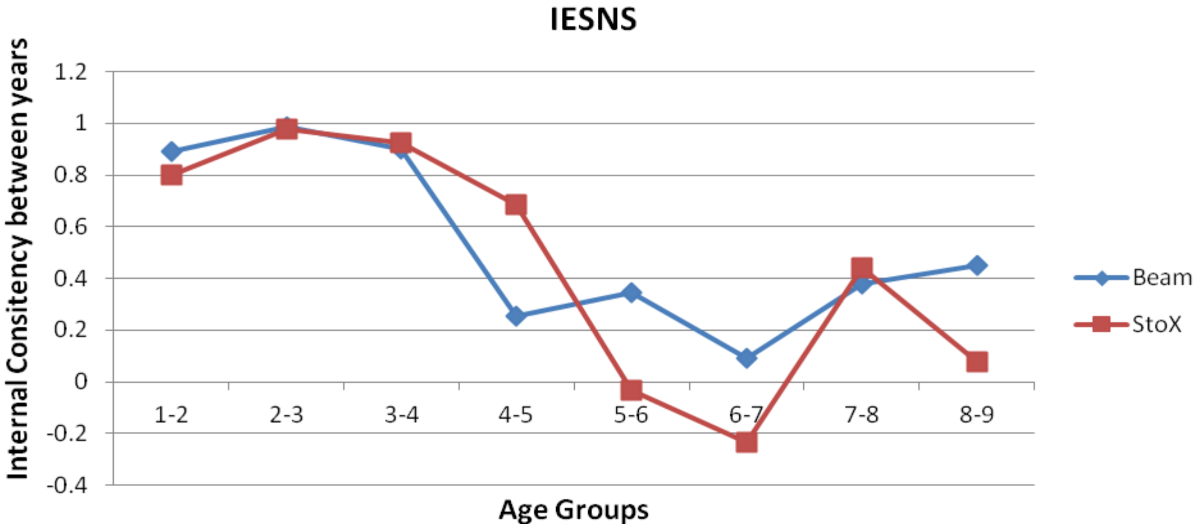

Figure 61. IESNS. Blue whiting. Internal consistency between age groups one year compared to the one year older group the year after in the IBWSS time series.

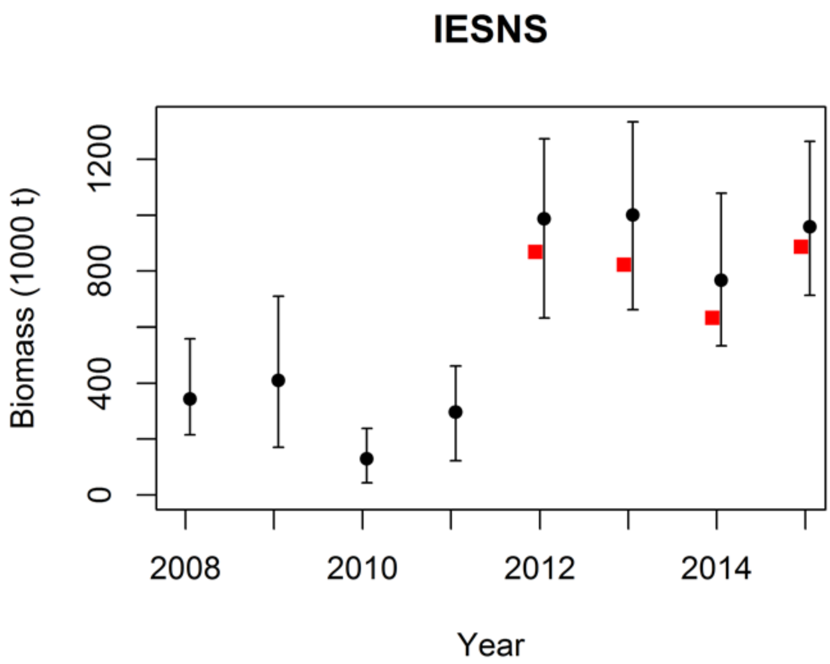

Figure 62. IESNS. Blue whiting, estimate of total biomass. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red squares are the old estimates (from Beam).

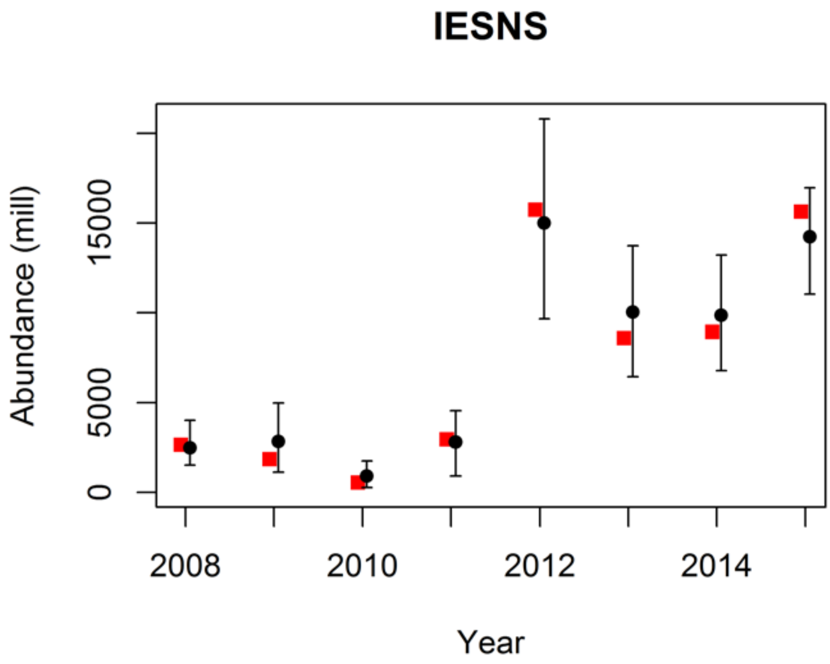

Figure 63. IESNS. Blue whiting, estimate of total abundance. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red squares are the old estimates (from Beam).

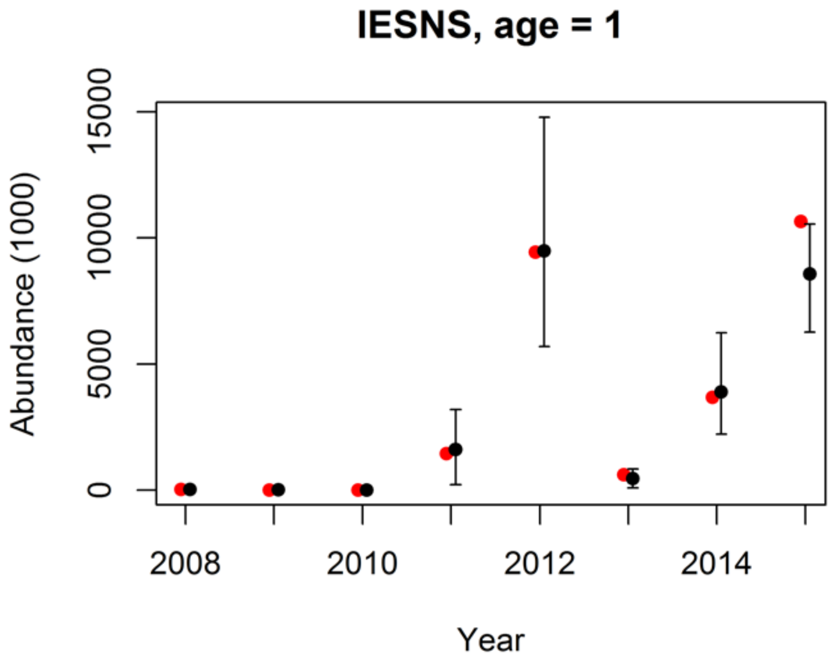

Figure 64. IESNS. Blue whiting age 1. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

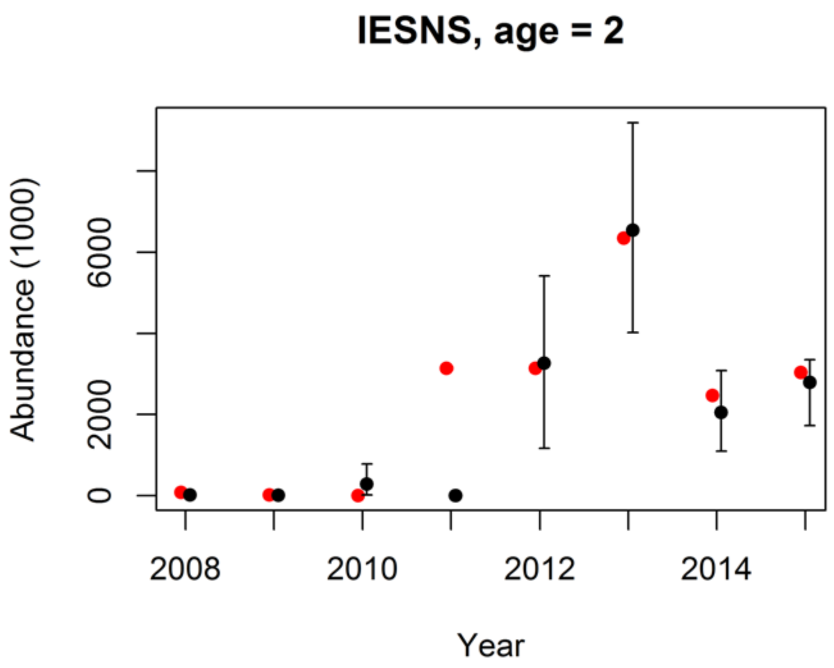

Figure 65. IESNS. Blue whiting age 2. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

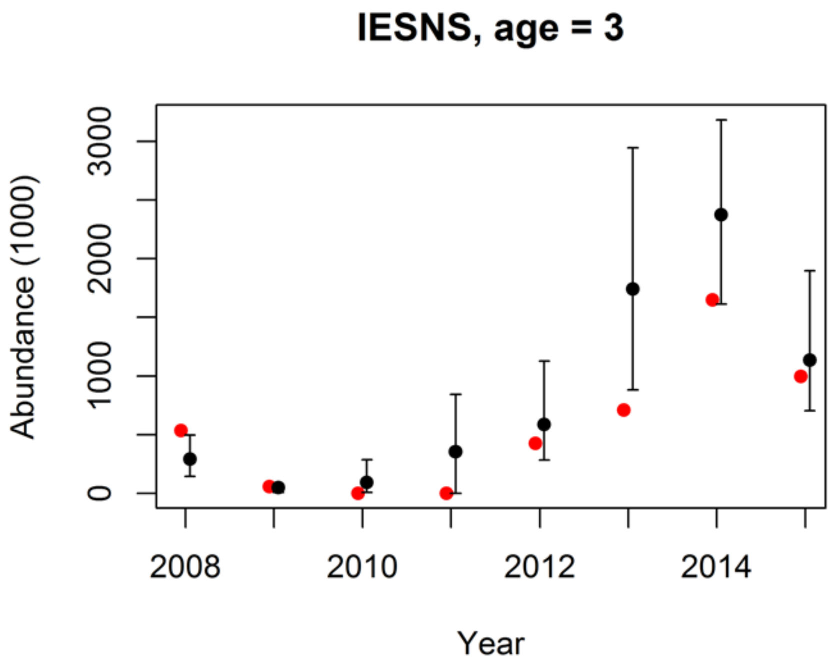

Figure 66. IESNS. Blue whiting age 3. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

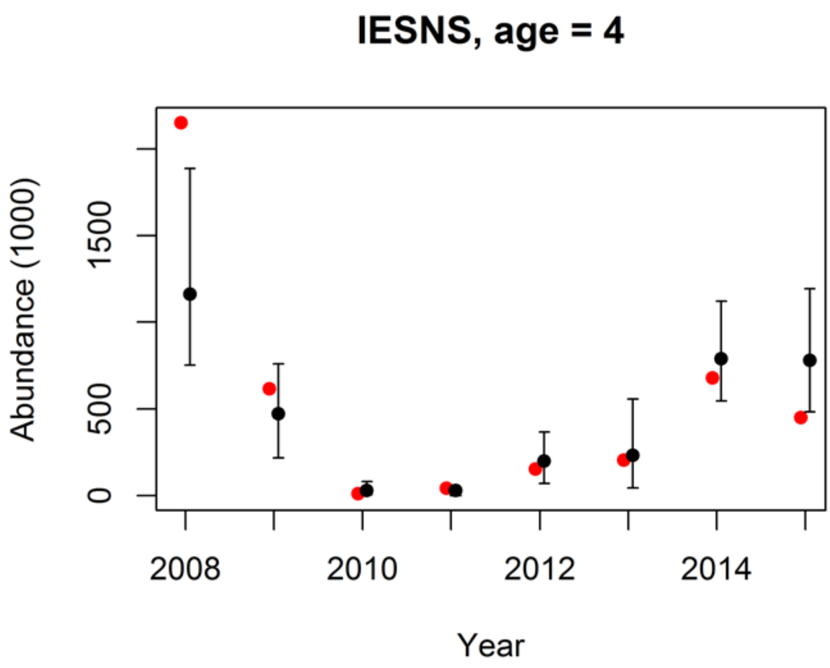

Figure 67. IESNS. Blue whiting age 4. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

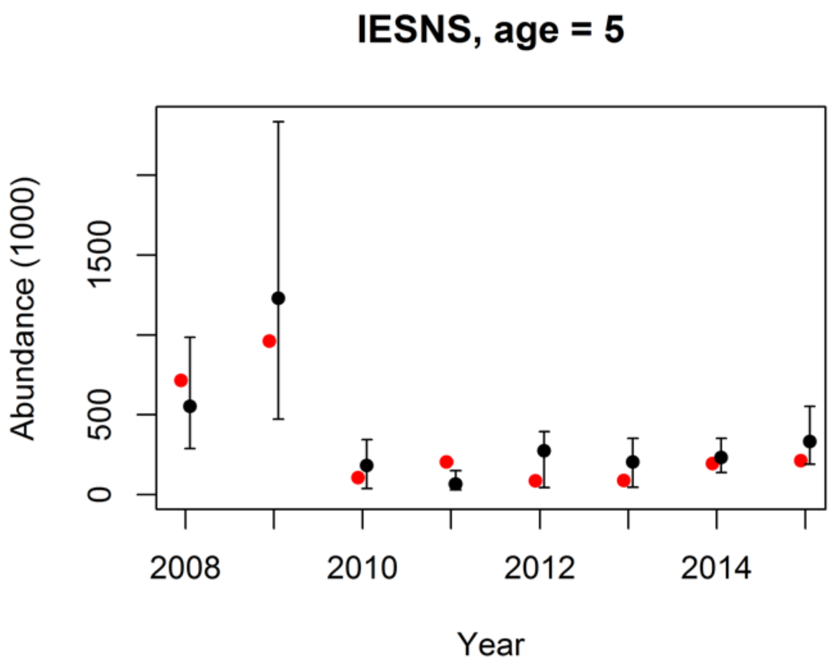

Figure 68. IESNS. Blue whiting age 5. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

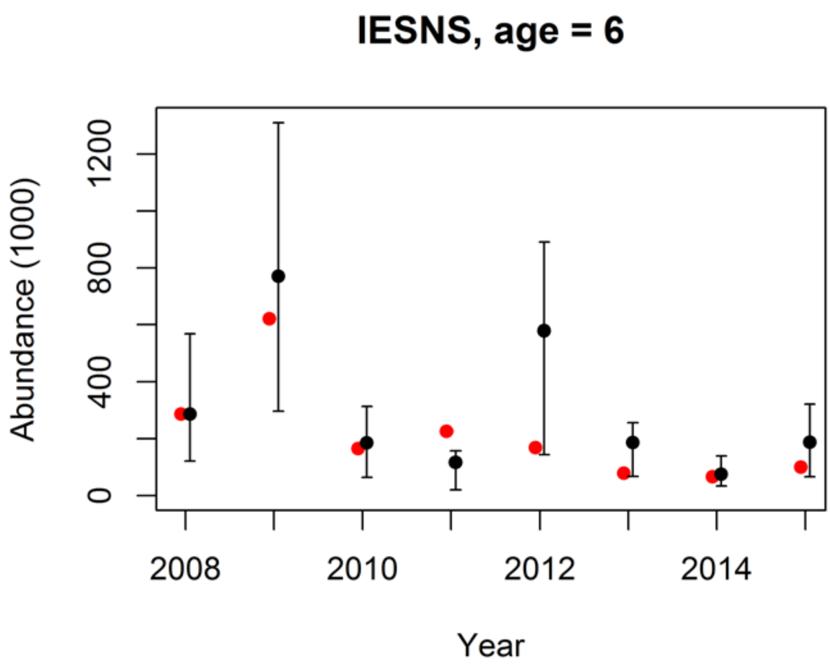

Figure 69. IESNS. Blue whiting age 6. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

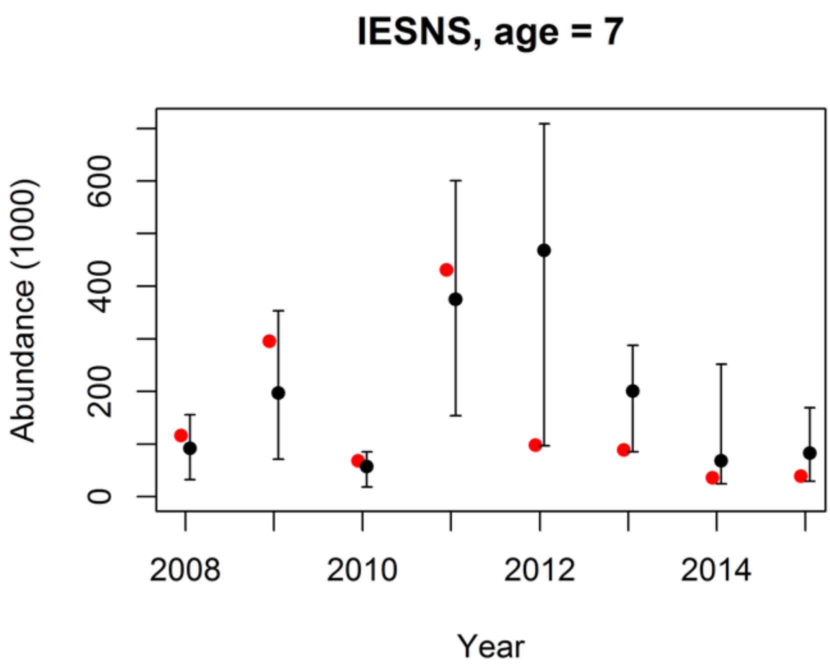

Figure 70. IESNS. Blue whiting age 7. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

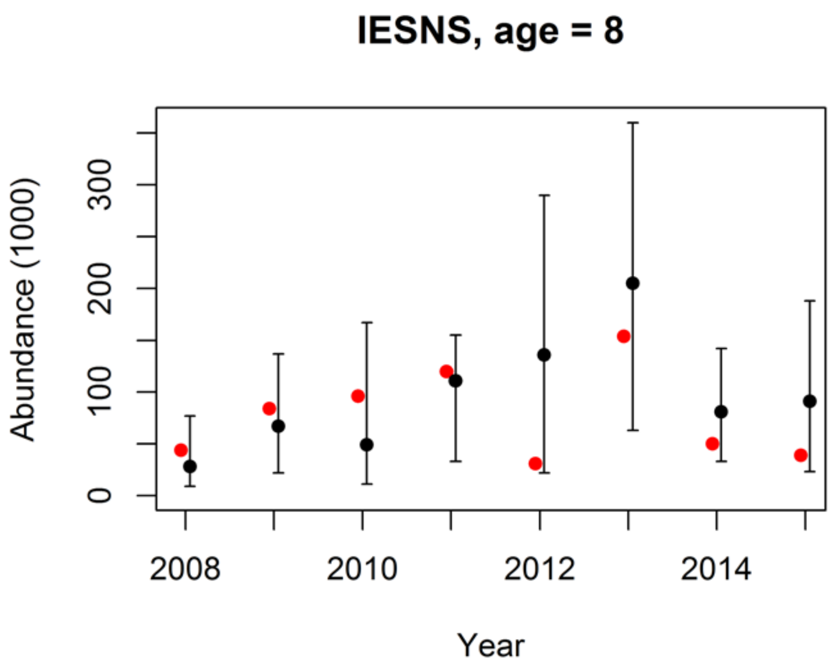

Figure 71. IESNS. Blue whiting age 8. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

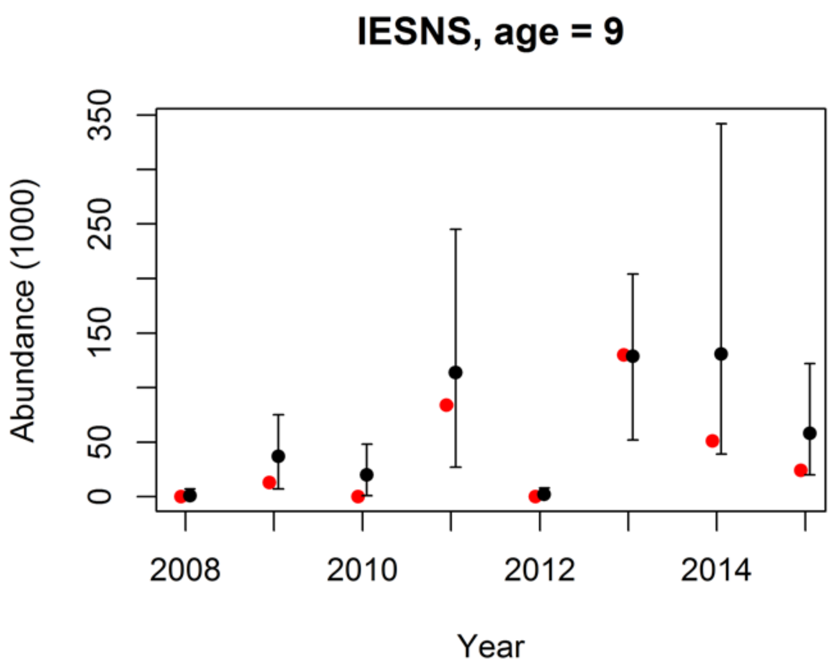

Figure 72. IESNS. Blue whiting age 9. The black dots and error bands are StoX estimates with 95 % confidence intervals while the red dots are the old estimates (from Beam).

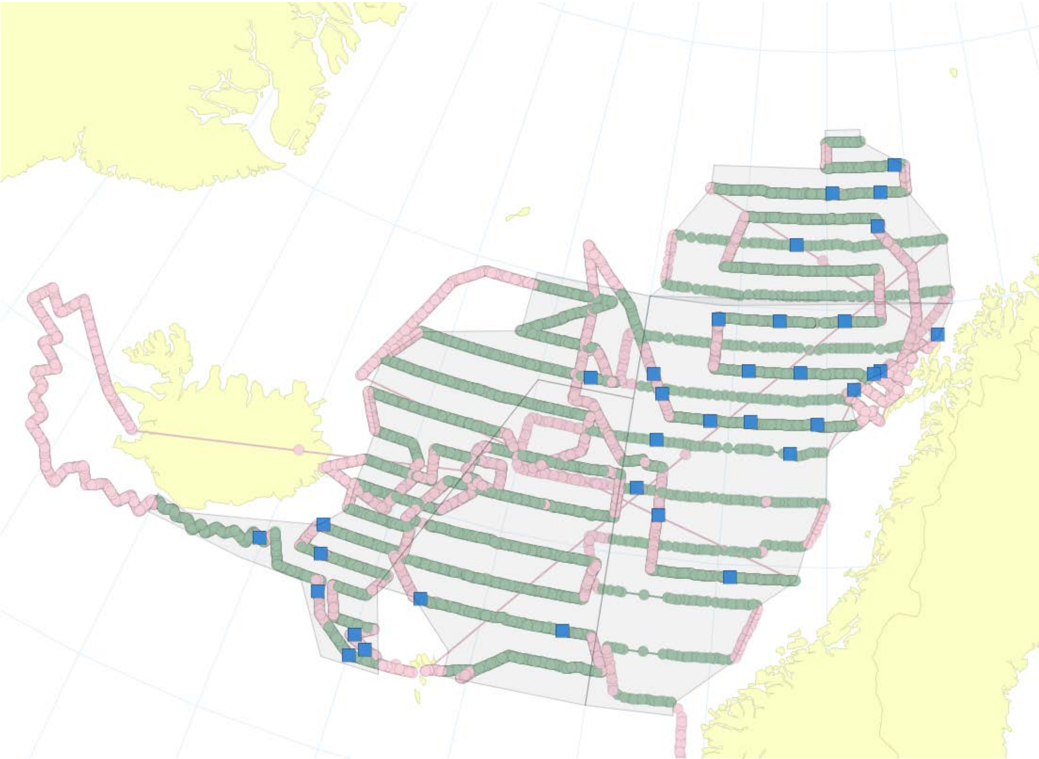

Figure 73. IESNS, blue whiting 2008. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

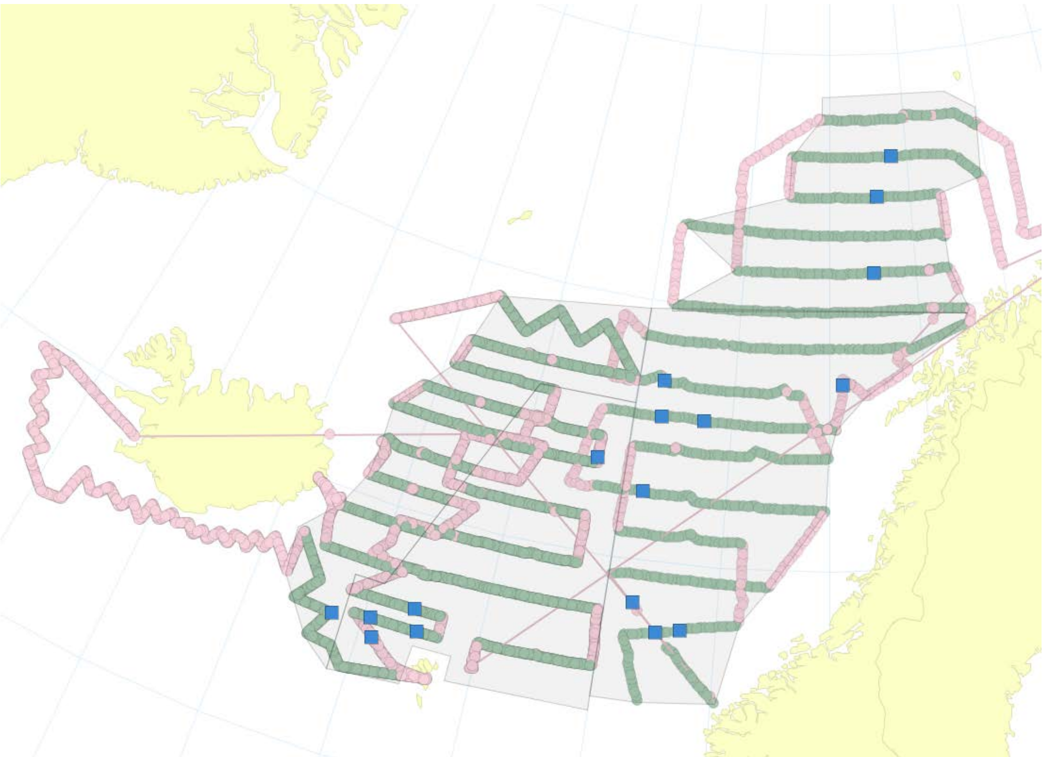

Figure 74. IESNS, blue whiting 2009. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

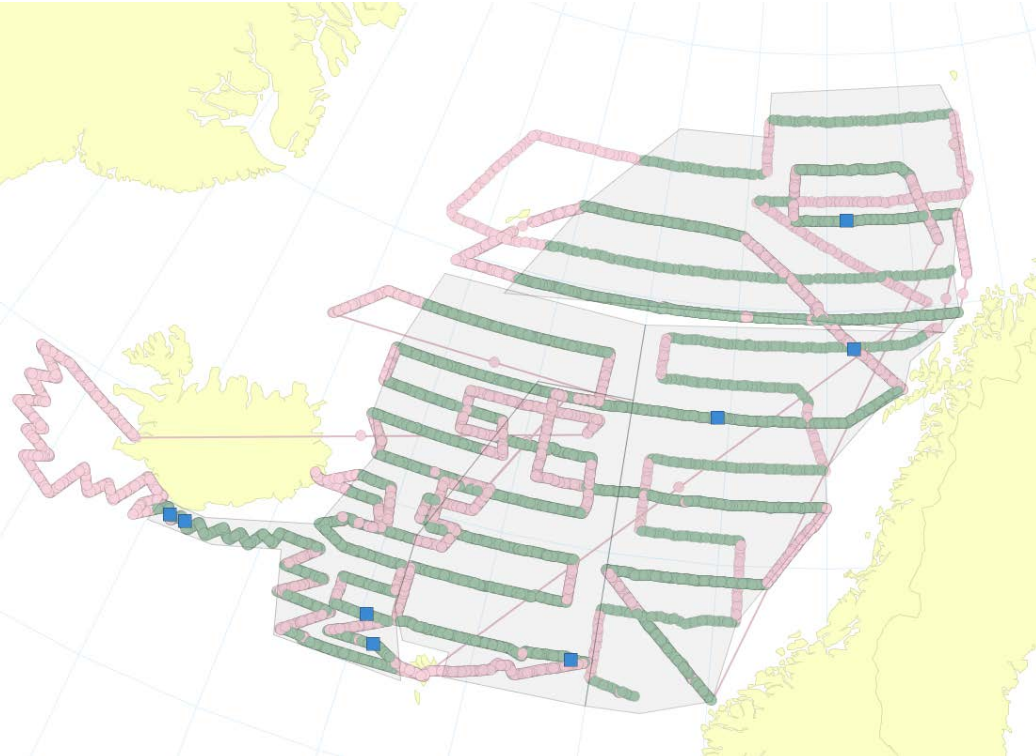

Figure 75. IESNS, blue whiting 2010. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

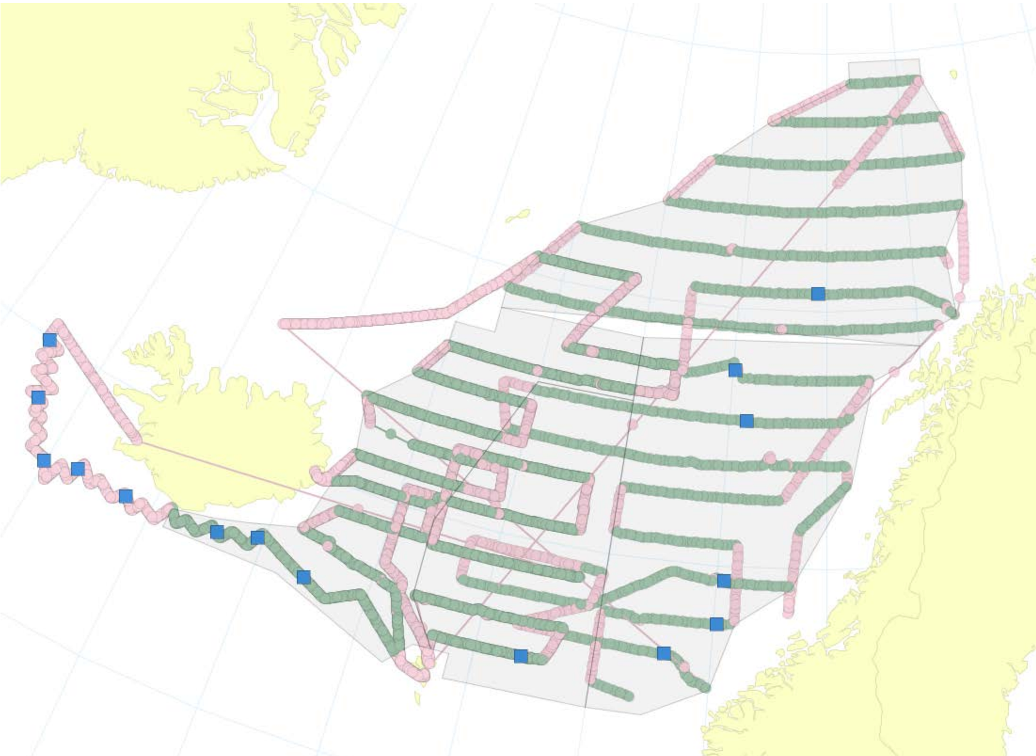

Figure 76. IESNS, blue whiting 2011. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

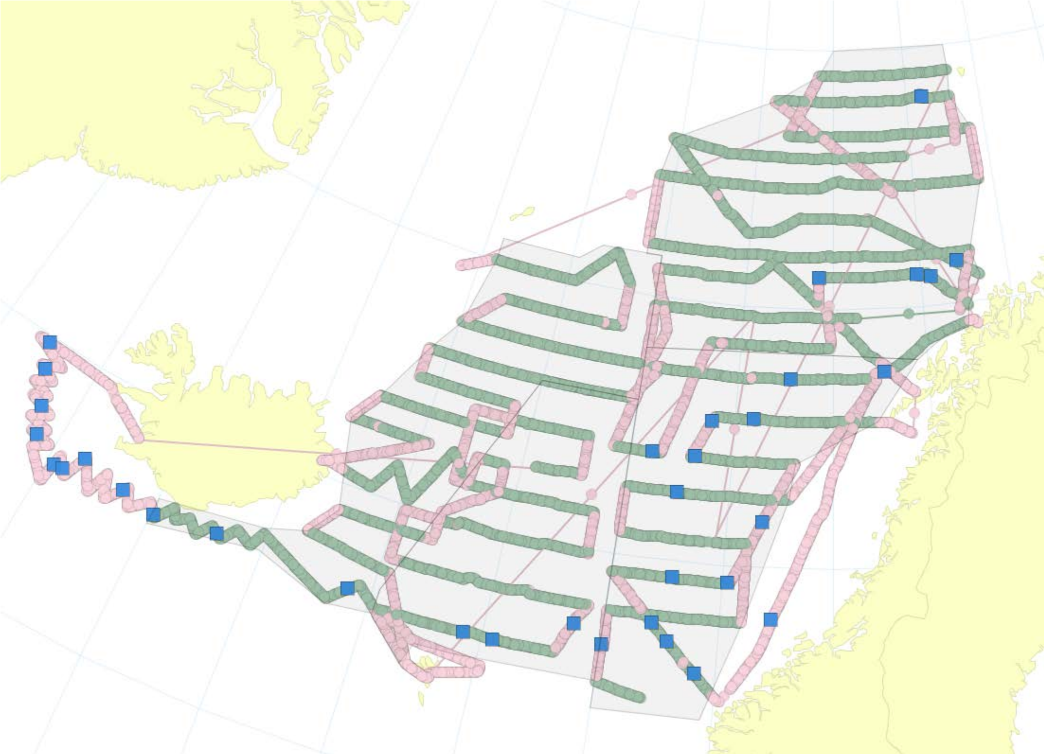

Figure 77. IESNS, blue whiting 2012. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

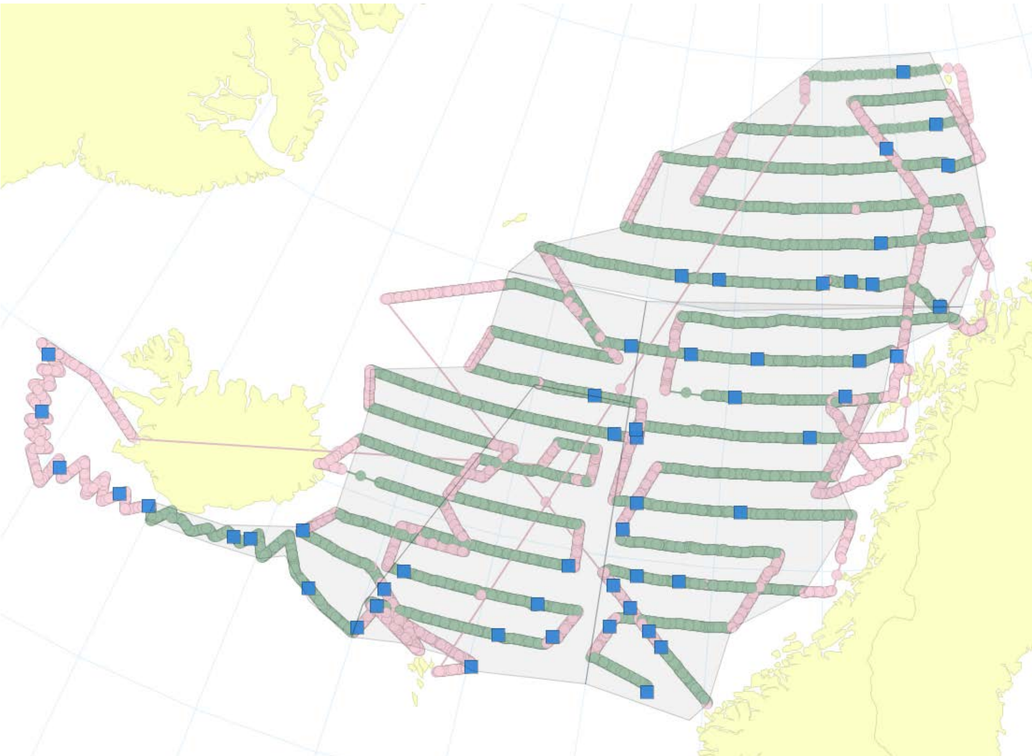

Figure 78. IESNS, blue whiting 2013. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

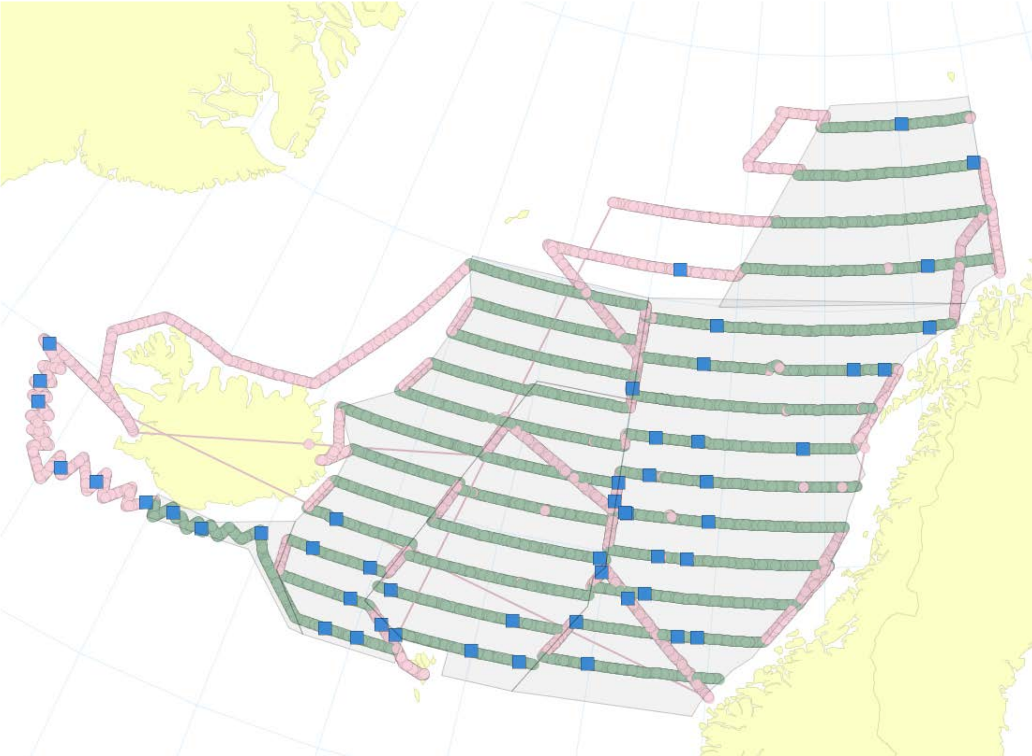

Figure 79. IESNS, blue whiting 2014. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

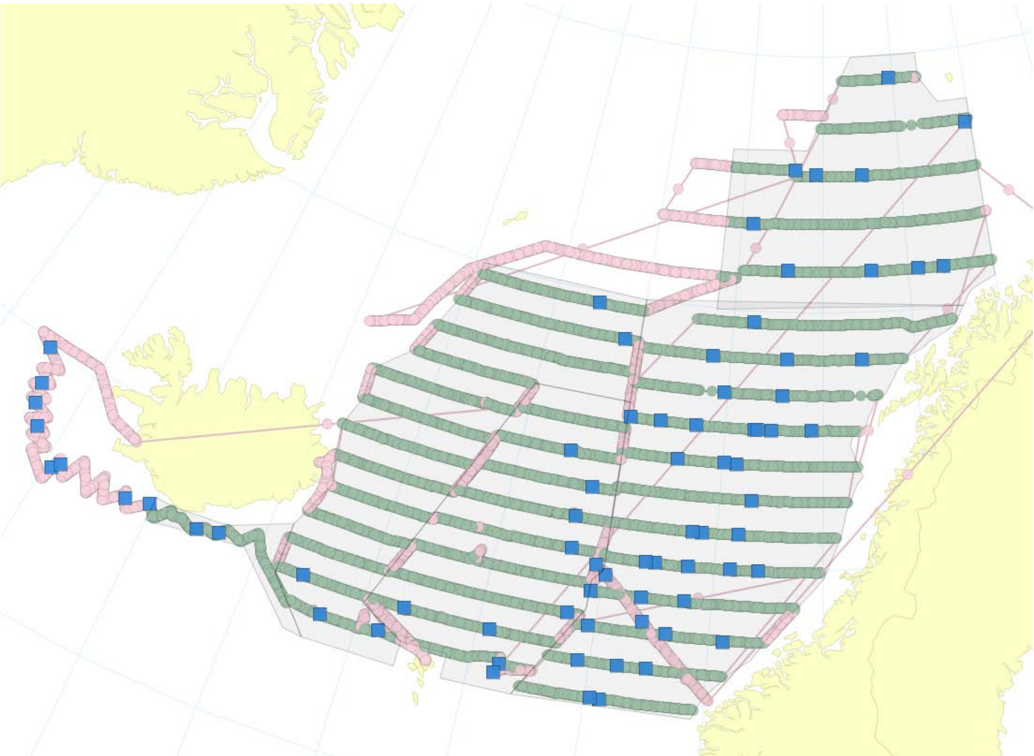

Figure 80. IESNS, blue whiting 2015. Green dots: edsus defined as transects in StoX. Blue squares: trawl stations used in StoX.

Annex 9: Sensitivity analysis HERAS 2015. Effect of changing the estimation tool to StoX for the 2015 HERAS.

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INTRODUCTION

The HERAS survey group is currently undergoing a process of review and transition initiated in 2015, whereby the group is migrating to a new acoustic database and common abundance calculation tool (StoX). At the 2015 WGIPS meeting it was decided to use StoX to calculate the global abundance for HERAS data collected in 2015 (ICES, 2015a). This was in part due to the FishFrame acoustic database no longer being a realistic tool for use.

Abundance estimation for the HERAS survey was previously carried out independently and at a national level by each survey participant for their own individual survey data. These data, aggregated by age and stock (NSAS, WBSS) were then combined within FishFrame to produce 'global' estimates of abundance. Since 2007, WGIPS had been using FishFrame as the standard computational tool and database for storing aggregated national data from the HERAS survey. The need for a change of this approach came about through both the need to standardise abundance estimation procedures across nations and also due to the fact that DTU-Aqua, who previously hosted and maintained FishFrame, no longer had the resources to continue doing that into the future.

At the same time, IMR has started development of StoX (www.imr.no/forskning/prosjekter/stox), which provided a suitable survey abundance estimation tool with a range of advantages: it can be universally applied, is open source, documented, reviewable and accessible to all, and offers functionalities that were not previously available when using FishFrame to collate the global estimates, such as utilising disaggregated data and uncertainty estimation.

At the WKEVAL workshop, the initial groundwork was laid for changing to using StoX as the main analysis tool. The outcomes of that workshop are documented fully elsewhere (ICES, 2015b) but in short the following was achieved:

(1) Agreement on common reporting format of data for the analysis. This was in particular challenging for the trawl data as for example each nation was using different ways of stratifying sampling and storing information regarding raising factors.

(2) Agreement to apply a statistically sound survey design. This means to be more stringent in how the survey design is interpreted and applied in all parts of the survey area, including to follow transects as planned, and no inclusion of off-transect tracks in the analysis . It was also agreed to move towards a survey design designed to provide estimates by predefined strata rather than the ICES rectangle based stratification methods presently applied. This will enable more robust uncertainty estimation and is a method easily implemented in StoX.

One of the primary objectives of WKEVAL was to retrospectively recalculate HERAS abundance using the StoX application as a sensitivity analysis with existing methods. However, the task of reformatting data for the period 2012-2014 was underestimated prior to the WK. The reformatting of the data for this period has meanwhile been completed. The importance of this exercise is recognised by the group but due to other outstanding work tasks will have to be rescheduled for a later date.

Similar review exercises have been carried out for other coordinated survey groups within WGIPS (IBWSS, IESSNS, IESNS) moving to StoX and overall estimates of biomass and abundance are considered comparable. Historically these survey groups used a common software package (BEAM) to calculate global abundance making the transition to StoX, and comparative exercises a more straightforward process. It is important to note that the situation for HERAS is more complicated. HERAS used a two-step process to calculating abundance; first at a national level and then at a global level within FishFrame.

At the time of the 2015 HERAS post-cruise meeting, the survey had already been carried out and therefore still followed an ICES rectangle based design. As it was not possible given the state and accessibility of FishFrame to carry out a “business as usual” analysis, the 2015 data were analysed in each national institute using national calculation procedures and programmes and also analysed (based on the same input data as far as possible) in StoX.

As a sensitivity analysis, it was decided to compare 2015 HERAS StoX outputs from each nations’ survey area using settings that had been agreed by all to the outputs using individual national calculation procedures in order to show possible effects of shifting from using one method to the other.

For each nation a detailed comparison was carried out on the estimates of the main indices used in assessments. Where possible the comparisons were made to the level of each stock the data from a nation contributed to and focussed on mean length and weight at age, abundance at age and maturity.

The comparisons presented here used the national components from the larger StoX output for the combined survey and the nationally provided estimates, which were those that would in the past have gone into FishFrame.

Note that this comparison does not compare ”like for like” as different expert decisions were invariably made on a national level, such as survey stratification, inclusion of inter-transect and off-transect survey tracks, and different groupings and allocations of trawls to transects. It does however demonstrate the effect of the change in analysis methods that were previously done at the national level, and gives an indication as to the likely size of this effect at the collated level and ultimately on the indices provided to the stock assessments.

METHODS

National estimation

The national estimates were produced following the procedures described in detail in the report from the WKEVAL workshop in 2015 (ICES 2015b) and in the survey manual (ICES, 2015c). The underlying basic principle for all national survey estimates is the use of estimation with a rectangular grid method described in detail in Simmonds and MacLennan (2005) where the grid unit is the ICES statistical rectangles.

The contribution by each national survey area to the total abundance of each stock was calculated based on the nationally produced estimates.

StoX estimation

StoX is open source software developed at IMR, Norway to calculate survey estimates from acoustic and swept-area surveys (www.imr.no/forskning/prosjekter/stox). The program is a stand-alone application built with Java for ease of sharing and further development in cooperation with other institutes. The underlying high-resolution data matrix structure ensures that future implementations of e.g. depth dependent target strength and high-resolution length and species information collected with camera systems can be accommodated. Despite this complexity, the execution of an index calculation can easily be governed from a user interface and an interactive GIS module, or by accessing the Java function library and parameter set using external software like R. Various statistical survey design models can be implemented in the R-library, however, in the current version of StoX the stratified transect design model developed by Jolly and Hampton (1990) is implemented.

StoX has been tested alongside existing abundance calculation tools during the 2014 and 2015 IESNS, IBWSS, IESSNS surveys and the Norwegian acoustic sandeel and cod surveys and has been adopted as the primary method used to calculate abundance in the future. One of the advantages of using StoX is the ability to retrace the steps used in estimating abundance for each run performed. This includes the allocation of hauls used during the analysis, something that is not possible for all the national methods used for the HERAS survey up till now.

During the HERAS 2015 post-cruise meeting (Dublin, January 2016), a common StoX project setup for the 2015 surveys was agreed upon. Decisions on analysis strata, transect assignment and haul assignments was suggested by each nation for their survey area and was discussed amongst all participants. A final version for each area was then agreed on and used in the analysis to produce the HERAS 2015 estimates. The strata adopted for analysing the HERAS 2015 survey in StoX are shown in Figure 1 and the detailed allocation of EDSU’s to transects within strata is shown for each national survey chapter.

StoX uncertainty estimation

The uncertainty surrounding the estimates of abundance at age was estimated using bootstrapping with 500 replicate simulations in the R model implemented in StoX.

The point estimate of abundance at age from the StoX estimation was subtracted from the mean of the bootstrapped replicates to provide an estimate of the bias. The calculated bias was then subtracted from the StoX point estimate of the mean abundance to produce the bias corrected mean abundances. The 90% bootstrapped confidence intervals were bias corrected in a similar manner by subtracting the bias from the 5% and 95% quantiles.

Due to the time consuming task of running the bootstrapping model, uncertainty was estimated for total numbers at age only for each survey area, but not for combinations of numbers at age and maturity or lengths and weights.

Uncertainty estimates are not readily available for national estimates, so the StoX estimates with associated uncertainty were compared to the national point estimates only.

RESULTS

Danish survey

The area covered by Denmark can be seen in Figure 2. The Danish survey provides input to the estimates of Western Baltic Spring spawning herring (WBSS) and North Sea autumn spawning herring (NSAS) as well as sprat in IIIa and sprat in the North Sea. Herring NASC and Sprat NASC are partitioned from a general category of “mixed fish” NASC based entirely on trawl composition. In StoX this step was done for each EDSU in a separate project before using the resulting outputs in the abundance estimation project. For the national method this step was carried out per sub-strata following a national spreadsheet based procedure. There is therefore in all likelihood differences at the input data level in terms of NASC, but the difference in the resolution achievable in the two methods made direct comparisons difficult.

During the post cruise meeting it was agreed that it was not appropriate to include the entire survey track in the estimate as done in the national analysis. Inter-transects especially along the coast but also at the strata boundaries should be excluded as should detours from transects (for trawling operations in particular). The inclusion of such sections of track violates the statistical assumptions in the survey design. This difference in the inclusion of acoustic samples between the two methods is also likely to introduce differences in the results between the two methods.

Herring is split into two stocks (WBSS and NSAS) in the Danish area based on otolith shape analysis and the Danish data provides stock membership information at the individual fish level. Sprat is divided into the two stocks based solely on geography and the area is split along the ICES area boundary between IIIa and IVa. In this comparison herring was compared at the stock level for the whole Danish area, but sprat was compared for the area total as the national estimate was only readily available at this level.

Large discrepancies were seen between the abundance calculated in StoX and the national method for WBSS, NSAS and sprat (Figure 3). This was particularly pronounced for the most abundant age group, which was age 1 for all stocks. For both herring stocks the national estimate was twice that estimated by StoX and even higher in the case of sprat. For older ages the StoX estimate was similar to or higher than the national estimate. For NSAS herring the national estimate has no abundance of age 4 fish, although this age class is represented in the biological data (although only by one fish).

For age 1 the national estimates were significantly different from the StoX estimate for all ages and for sprat this was also the case for older ages.

Some discrepancies are also seen in mean weight for all three categories/stocks (Figure 4). A straight average of available biodata for each stock and age combination is displayed for information and is generally seen to be intermediate of the two estimates. The most extreme difference is seen in WBSS at age 6. The averages from the biological input data seem the most realistic given the trajectory of change from one age to the next.

Similar discrepancies as found in the mean weight were apparent in the mean lengths at age also (Figure 5).

It is a bit unclear what contributes most to these discrepancies. Clearly there are quite big differences in the analysis in terms of the acoustic input data and the stratification and haul assignment used, and the results should be expected to differ. However, the differences in the biological parameters raises concerns, how the stratification scheme used to collect data and how data is weighed in the national analysis, could contribute to this.

German survey

The area covered by the German survey can be seen in Figure 6. The German survey provides input to the estimate for NSAS herring and North Sea sprat.

The German acoustic data was partitioned to species level using the splitNASC function in StoX and the resulting herring and sprat NASCs were used in the StoX analysis. For the national calculations the NASC was partitioned at the rectangle level using a national spreadsheet method. There is likely to be some differences in the acoustic input data for the two methods resulting from this, but comparisons indicate that this difference is minor (Figure 7).

The survey design was intended to ensure adequate coverage at the rectangle level. However, the new strata used in the StoX analysis required some adjustment to transects, and parts of the cruise track that was included in the national analysis was excluded in the StoX analysis (Figure 6). The decisions regarding which EDSU to include in transects in the StoX analysis were taken at the HERAS post cruise meeting in plenary. Some differences in results should be expected due to this.

The abundances estimated for sprat were in good agreement between the two methods (Figure 8). For NSAS herring the estimates for age one were comparable, but for age 0 the national method estimated a significantly higher abundance, well outside the confidence interval for the StoX estimate (Figure 8). The national NSAS result did not have any age 2 fish, but the StoX analysis did. There was one age 2 fish in the biotic input file, so the national results should probably have had some.

Mean weights estimated with StoX were in very good agreement for all ages for both sprat and NSAS herring (Figure 9). The small difference observed for age 4 sprats is likely due to a sparsity of individual observations at this age. Where the national method will reflect a weighted average at this age, the StoX method is based on a random pick of one individual from a small and possibly diverse pool of individuals.

The two methods produced almost identical mean lengths for all ages for both NSAS herring and sprat (Figure 10).

The comparison between StoX and the German national method revealed some differences in the overall number of fish, especially for age 0 NSAS herring.

It is likely that this is largely an effect of the difference in size of the strata between the two methods. Herring is distributed in highly clustered aggregations both spatially and in terms of age structure in the German survey area with enormous hauls of small herring in some areas while the number of herring caught in other areas can be very small (10’s of larger fish rather than millions). In the national method, the effect of haul composition is confined to a smaller area, the ICES rectangle, whereas in the StoX method this area is much larger (se German strata in Figure 6). In both StoX and the national method equal weight is given to each haul when combining them and large differences in numbers caught and size distribution between hauls will skew the overall size, and therefore age distribution, between the two methods.

It is important that this is taken into consideration when planning the next survey both in terms of how trawling is allocated within the strata, and how the hauls are allocated to transects and combined.

There does not seem to be a similar issue with sprat. This is probably because sprat is more widely distributed across the survey area and spatially more uniformly distributed in terms of age distribution.

Dutch survey

The area covered by the Dutch survey can be seen in Figure 11. The Dutch survey provides input to the estimates of NSAS herring as well as North Sea sprat. Herring NASC and Sprat NASC are partitioned during the acoustic scrutiny process and the acoustic input data is therefore identical between the two methods. The largest discrepancy between the methods is the inclusion of inter-transects in the national analysis. These have been excluded in the StoX analysis after agreement during the post cruise meeting (Figure 11).

Overall there was good agreement between the abundance at age and maturity for both NSAS herring and sprat (Figure 12). There was some difference in the mature 2 wr abundance for both sprat and NSAS herring. This was the category with the highest abundance in both stocks, and probably a scaling issue given the exclusion of parts of the survey track in the StoX analysis. The numbers at age from the national estimates were well within the estimated 90% confidence interval for the StoX estimates for both NSAS and sprat (Figure 13).

The two methods produced almost identical mean lengths for all ages and maturities for both sprat and NSAS herring (Figures 14 and 15).

Scottish survey

The area covered by the Scottish survey can be seen in Figure 16. The Scottish survey provides input to the estimate for NSAS herring only.

Scottish acoustic data are scrutinised to species level and acoustic input data is identical between the two methods. Inter-transects at strata borders (but not bordering coast lines) had been included in the National analysis (Figure 16). It was agreed at the post cruise meeting to exclude all inter-transects in the StoX analysis. Small differences in results are expected due to this.

Overall there was good agreement between the abundance at age and maturity for NSAS herring (Figure 17). There was some difference in the abundance of the most abundant age groups (2 mature, 3 mature, 5 and 6 mature). This is likely a scaling issue given the exclusion of parts of the survey track in the StoX analysis. The uncertainties surrounding the Scottish StoX estimates were relatively small and the national estimates were well within the 90% bootstrapped confidence interval (Figure 18).

Mean weights estimated with StoX was in good agreement for all ages and maturities (Figure 19). The small differences observed for a few of the older ages in NSAS herring is likely due to a sparsity of individuals sampled in these categories (7 and 8 wr). Where the national method will reflect a weighted average at these ages, the StoX method is based on a random pick of one individual from a small and possibly diverse pool of individuals.

The two methods produced almost identical mean lengths for all ages and maturities for NSAS herring (Figure 20).

Norwegian survey

The area covered by the Norwegian survey can be seen in Figure 21. The Norwegian survey provides input to the estimate for both NSAS and WBSS herring. Norwegian acoustic data are scrutinised to species level and all inter-transects has been excluded both in the national spreadsheet method and in the StoX analysis. The acoustic input data is identical between the two methods.

Overall there was good agreement between the abundance at age and maturity for WBSS and NSAS herring for the two methods (Figure 22). There was some difference in the abundance of some of the age groups (2 immature, 4-8 mature). This might be caused by differences in the method of calculation (by strata in StoX as compared to by ICES rectangle in the national method), the inclusion of L-W measured only individuals also in Stox where the national method only uses aged individuals, and StoX taking into account the length of the aged individuals when assigning an age and maturity stage of non-aged individuals. In addition the survey area might be slightly different between the two methods, and last unfortunately there is also a risk of errors in the national method (as it is a large Excel sheet with a large amount of sheets and equations). The uncertainties associated with the StoX estimates on abundance at age could only be estimated for total herring as the stock discrimination method used by Norway does not provide stock membership at the individual fish level. The levels were relatively small and the national estimates were contained well within the limits (Figure 23).

Mean weights estimated with StoX was in good agreement for the most abundant age groups (1-2 wr, Figure 24). There are some small differences observed for some of the older ages. This might be due to a sparsity of individual observations in these categories. Where the national method will reflect an average at these ages, the StoX method is based on a random pick of one individual from a small and possibly diverse pool of individuals (but within the correct length group). Other differences mentioned to affect abundance between the two methods might also influence mean weight.

The two methods produced almost identical mean lengths for nearly all ages and maturities for both NSAS and WBSS herring (Figure 25). The differences observed might be explained by the inclusion of individuals with just length and weight observations in StoX, whereas only aged individuals were included in the national method.

The results could be further improved if individuals could be assigned to stock (NSAS or WBSS) instead of using the vertebrae count method (group level).

Irish survey

The area covered by the Irish survey is shown in Figure 26. The Irish survey provides input for the Malin Shelf herring stocks only. Although there was only a 1% difference in the total herring biomass estimated by the national method compared to the StoX method (449 kt and 454 kt respectively), there were greater differences in the abundances at age (Figure 27). However, the national abundance by age estimates were all contained within the uncertainty levels surrounding the StoX estimates. A number of reasons explain these differences to varying degrees.

Strata: The national method has traditionally used ICES statistical rectangles as strata but for 2015 the greater flexibility of the StoX program was utilised to post-stratify transects into more appropriate strata based on herring distribution and survey effort.

Inter-transects: Similar to the Scottish survey in the North Sea, inter-transects (running south to north) between seven transects bordering ICES area IVa West were included in the national estimate but excluded from the StoX estimate following group discussions.

Haul Allocations: Haul allocations were based on proximity in the national method. The final StoX haul allocation scheme was mostly proximity based but included some minor manual alterations. However, a number of different haul allocation schemes were tested in StoX and the majority converged to very similar biomass estimates.

Number of Hauls: Eight hauls included in the analysis (both methods) contained herring. Agreement between the methods would likely improve if more herring hauls were available. The relatively low number of herring hauls was mainly attributable to the availability of fishable marks (SSB of 430 kt MSHAS vs. 2300 kt NSAS).

Mixed Schools: Perhaps the greatest difference resulted from the treatment of mixed species schools. The procedures for producing species specific NASC values for the Irish national method and the StoX input files were not easily comparable and will be improved in 2016.

Effect on individual stock indices

North Sea autumn spawning herring

The global estimates of NSAS herring is collated with inputs from the Danish, German, Norwegian, Dutch and Scottish surveys. The contribution from each survey to the total stock abundance and biomass is listed in Table 1. The most significant contributions come from the Scottish (26% of TSN and 41% of TSB), Dutch (37% of TSN and 36% of TSB) and Norwegian (19% of TSN and 19% of TSB) survey areas. The comparisons showed very good agreement between the results from the two methods for all of these surveys and the effect on the overall indices of changing to StoX would therefore be expected to be minor.

The Danish and German survey contributes with a minor amount and the influence of the discrepancies demonstrated in those surveys will not significantly affect the assessment of North Sea autumn spawning herring (DK: 11% of TSN and 3% of TSB and GER: 6% of TSN and 1% of TSB).

The discrepancies are mainly detected in the ages 0 and 1 from both of these surveys. The discrepancies observed here will therefore not affect the assessment of North Sea herring as age 0 is not used in the assessment and age 1 wr is given very little weight.

Western Baltic Spring Spawning herring

The global estimates for WBSS herring is collated from only the Norwegian and Danish surveys. Although the Norwegian survey showed good agreement in the estimates for WBSS, the Danish contribution to the overall estimates is significant for WBSS (~80% of TSN and 48% of TSB, Table 2). Figure 28 show that effect on the global estimates of abundances, maturity, mean weight and mean length at age of the Danish discrepancies are largely confined to the abundance at age 1 and the pattern in age distribution is retained between the two methods, just less pronounced in the StoX analysis.

Malin Shelf and VIaN herring

Only the Irish survey is contributing to the estimates of these two stocks this year. Based on the uncertainties estimated with StoX, the national and StoX calculated values are not significantly different, but there is larger discrepancies between these values than is achieved in the other directly comparable surveys (NOR, SCO and NL). Planning in 2016 should take into account the effect of allocating enough hauls and improving the splitting of mixed species NASCs for StoX input files. It is unlikely that the differences will affect the outcomes of the assessment in 2016. First of all the survey index is in general notoriously noisy (WKWEST 2015) and secondly, both the national and the StoX method are estimating an overall similar trend in the stock both in terms of the dominant ages and in the total numbers and biomass.

Sprat in North Sea

The global estimates of sprat in the North Sea is dominated by contributions from the German (66% of TSN and 59% of TSB) and Dutch survey areas (30% of TSN and 38% of TSB). Both of these surveys showed very good agreement between the national estimates and the StoX estimates for sprat, and the changeover to StoX should have a negligible effect. As the Danish contribution is very small, it is unlikely that the discrepancies observed in this survey will have any detectable influence.

Sprat in IIIa

The overall estimates for sprat in IIIa comes entirely from the Danish survey and are as such affected by the change over to the StoX method. The two methods provided significantly different abundances especially for age 1. The overall trends in abundance compared both to the time series and in terms of the relative abundance of each age group were comparable (This report, Annex 4c).

CONCLUSIONS

The effect of changing from one analysis method to another was investigated. The nationally calculated total abundances at age and maturity, which is what would previously have been collated to global estimates in the FishFrame database, were contrasted to the number at age and maturity calculated independently for each nation in the StoX software using the same settings that were then used to calculate the overall abundances.

It was shown that estimates from the StoX calculations for most areas and ages were very close to the national estimates and that for all but a few the nationally calculated point estimates were well contained within the uncertainty surrounding the StoX calculated estimates. The largest discrepancies were found in the German and Danish results, which was not surprising given that these StoX analyses diverged the furthest from the national methods and stratifications. For the German data the discrepancies were only an issue for North Sea herring. As the German contribution to the overall estimate of this stock is very small overall and the contribution is mainly of ages with no or little impact on the assessment (ages 0 and 1wr) this was not considered to have affected the North Sea herring estimates. For the Danish data, the discrepancies were seen in sprat, North Sea herring and Western Baltic spring spawning herring and especially in the abundance of age 1. The overall effect is considered to be small considering the uncertainties associated with this type of data and the fact that the overall patterns and trends were preserved.

The Dutch, Scottish and Norwegian surveys already use designs, haul allocations and acoustic scrutiny methods that are comparable between the national methods and StoX, and the difference in switching to StoX for the analysis is negligible.

Using StoX for analysis is transparent, the results are reproducible and readily facilitates uncertainty estimation. It offers an opportunity to fully standardise the calculation methods used within the HERAS group to estimate abundance and can be used to highlight issues associated for example with the design of the overall survey or individual survey strata.

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Table 1. Contribution by national surveys to overall abundance estimate of North Sea autumn spawning herring from HERAS 2015. Values are from national estimates.

NSAS	TSN (mill)	TSN % of total	TSB (kt)	TSB % of total
SCO	6797	26%	1213	41%
DK	2950	11%	103	3%
NL	9786	37%	1065	36%
GER	1588	6%	20	1%
NOR	5088	19%	556	19%
TOTAL	26209		2958	

Table 2. Contribution by national surveys to overall abundance estimate of Western Baltic spring spawning herring from HERAS 2015. Values are from national estimates.

WBSS	TSN (mill)	TSN %	TSB (kt)	TSB %
DK	4874	79%	180	48%
NOR	1282	21%	198	52%
TOTAL	6156		378	

Table 3. Contribution by national surveys to overall abundance estimate of sprat in the North Sea from HERAS 2015. Values are from national estimates.

Sprat NS	TSN (mill)	TSN %	TSB (kt)	TSB %
DK	2963	4%	21	3%
GER	43497	66%	444	59%
NL	19523	30%	287	38%
TOTAL	65983		752	

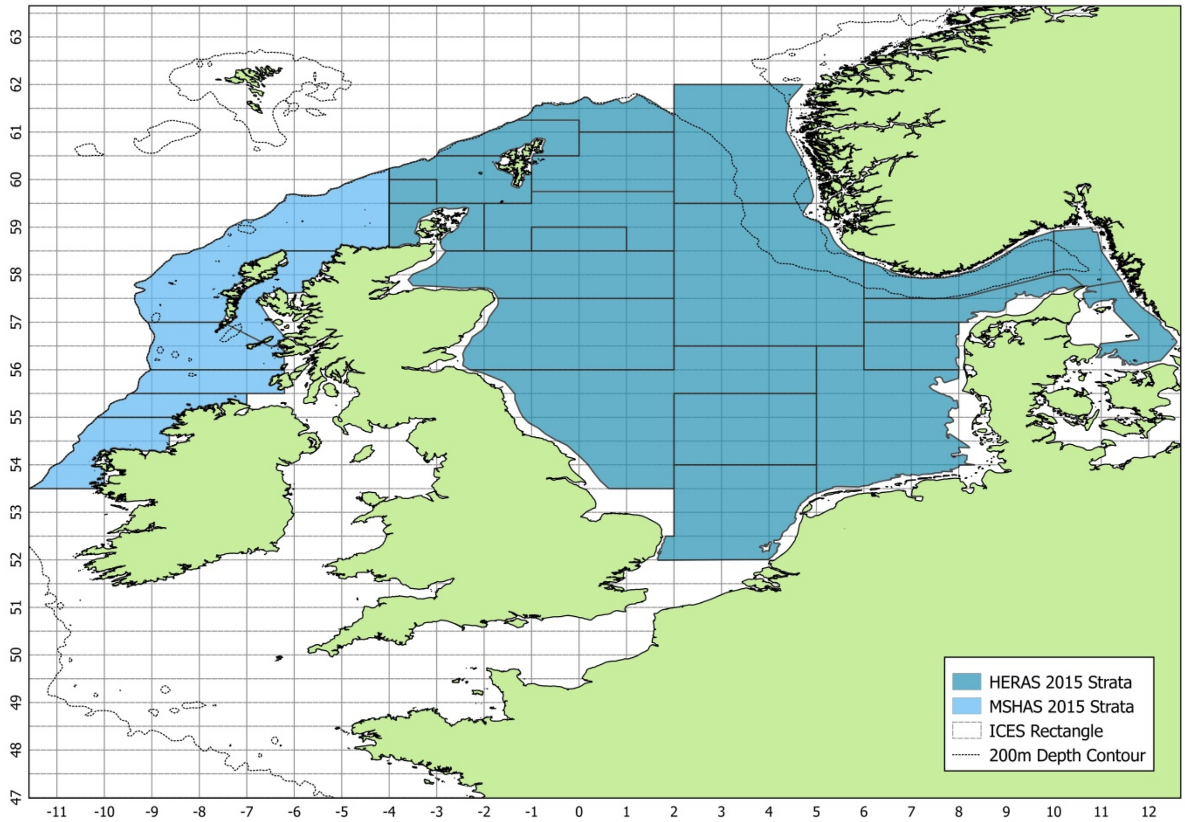


Figure 1. Strata used in the StoX analysis of the HERAS 2015 survey.

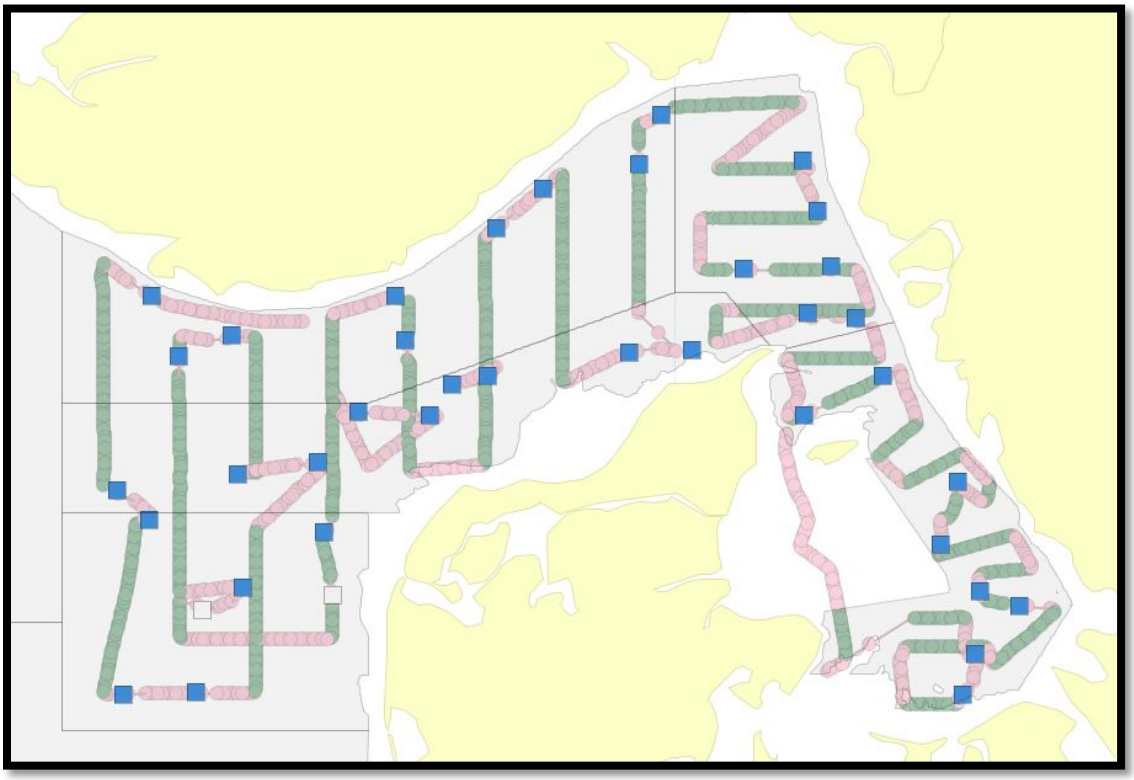


Figure 2. Danish survey track. Pink locations are acoustic EDSU's included in the nationally estimated abundance. Green locations are EDSU's included in StoX estimate. Blue squares are locations of trawl hauls used in the analysis. Shaded area represents strata used in StoX and is the area the mean density per transect within strata is extrapolated to for calculating the total abundance for each strata.

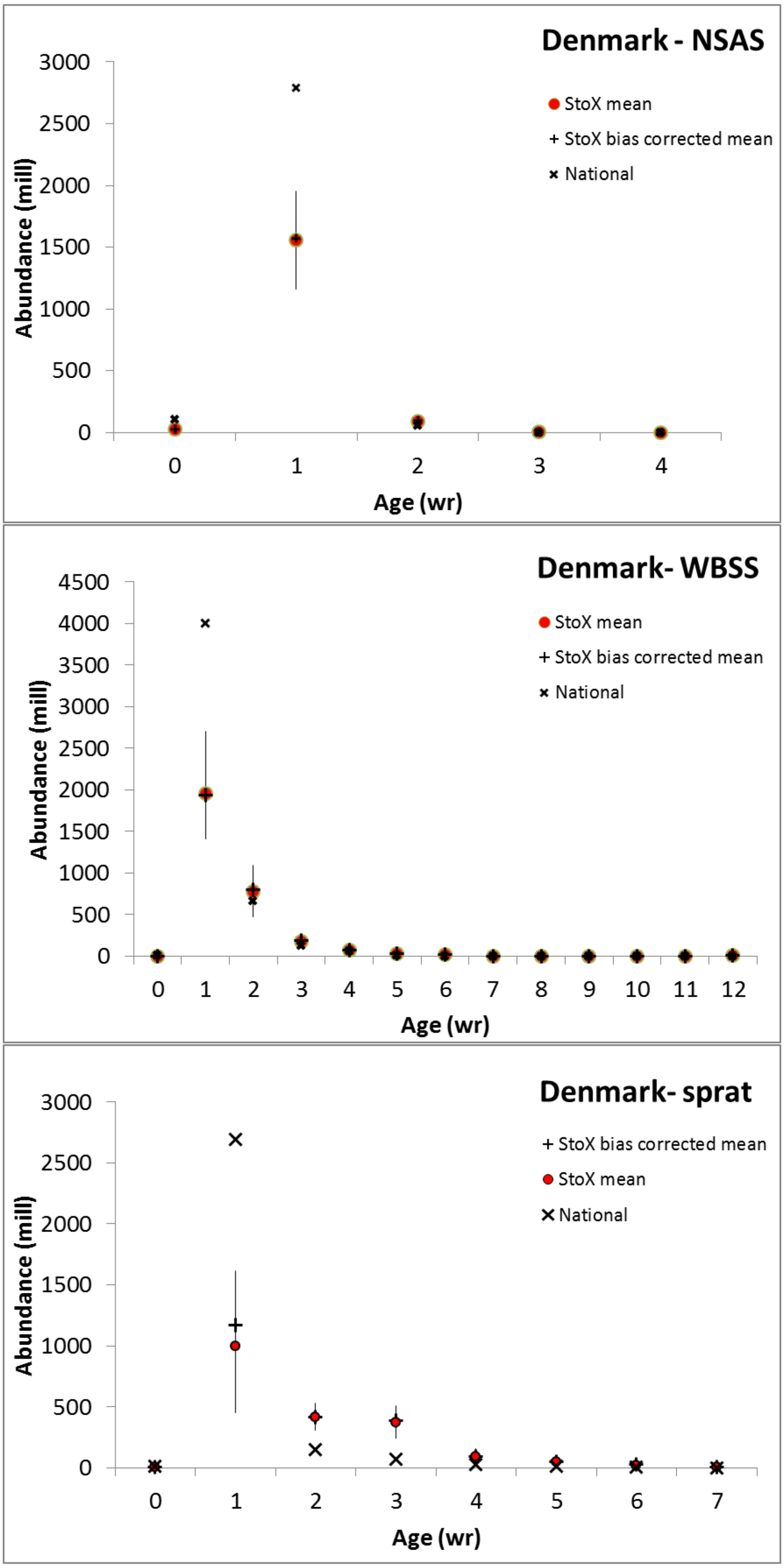


Figure 3. Abundance at age estimated with both methods in the Danish area for WBSS, NSAS and sprats. Error bars represent the bias corrected 90% bootstrapped confidence interval for the StoX estimated mean.

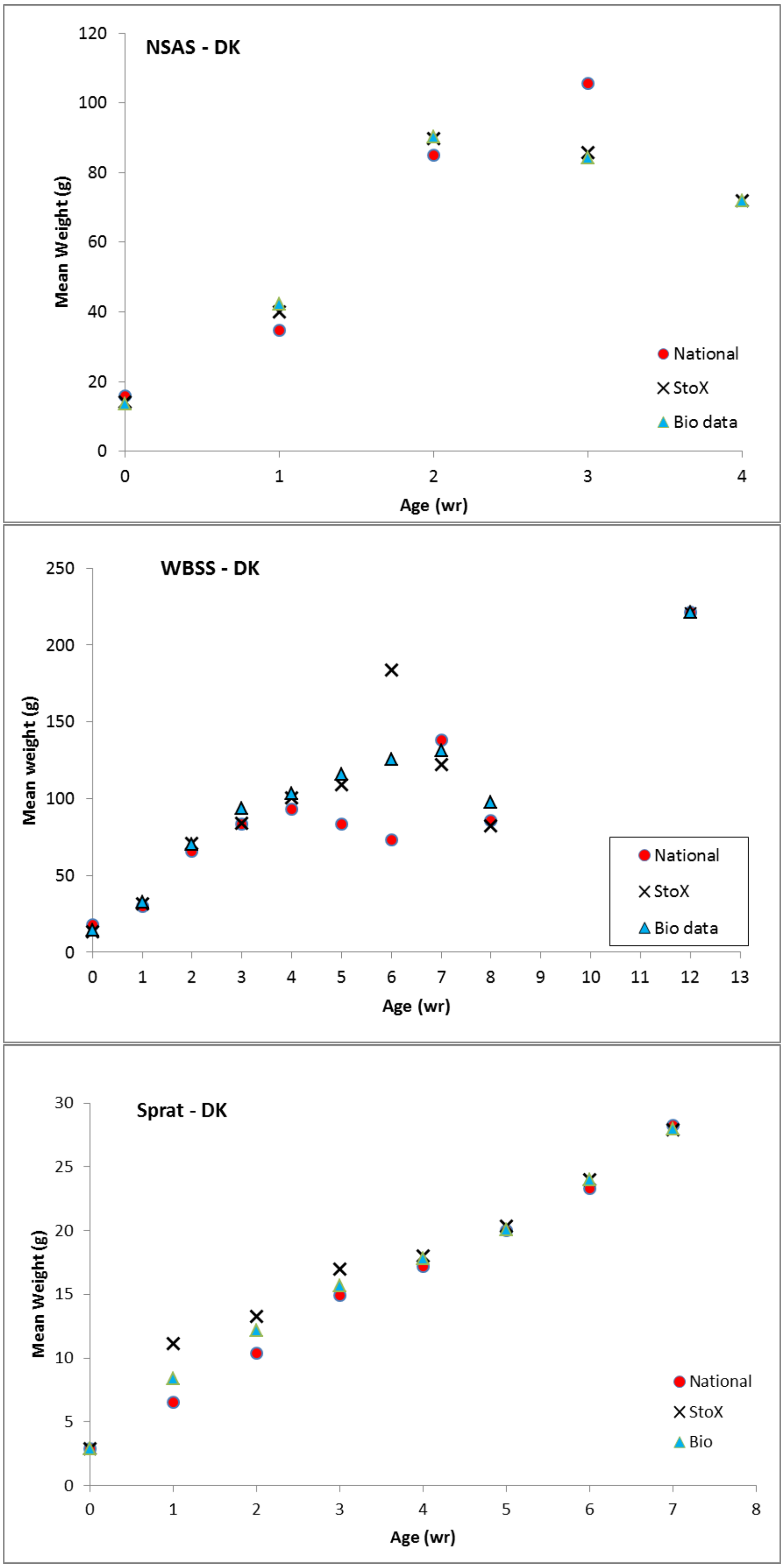


Figure 4. Estimated mean weights at age for the two herring stocks and sprat in the Danish national analysis, StoX analysis and straight averages of unraised biological data.

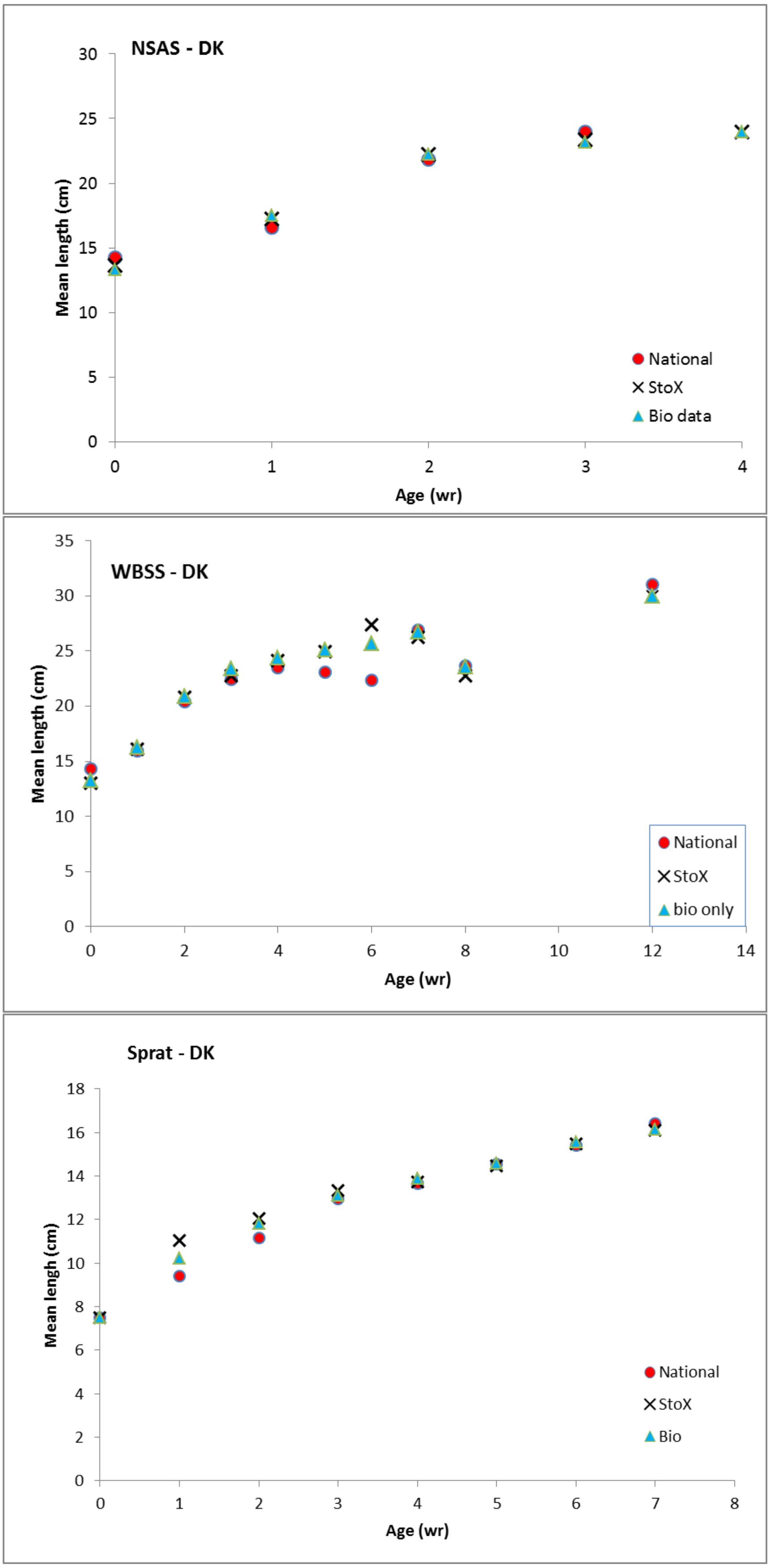


Figure 5. Estimated mean length at age for the two herring stocks and sprat in the Danish national analysis and StoX analysis. Average weight at age calculated from bio data included for information.

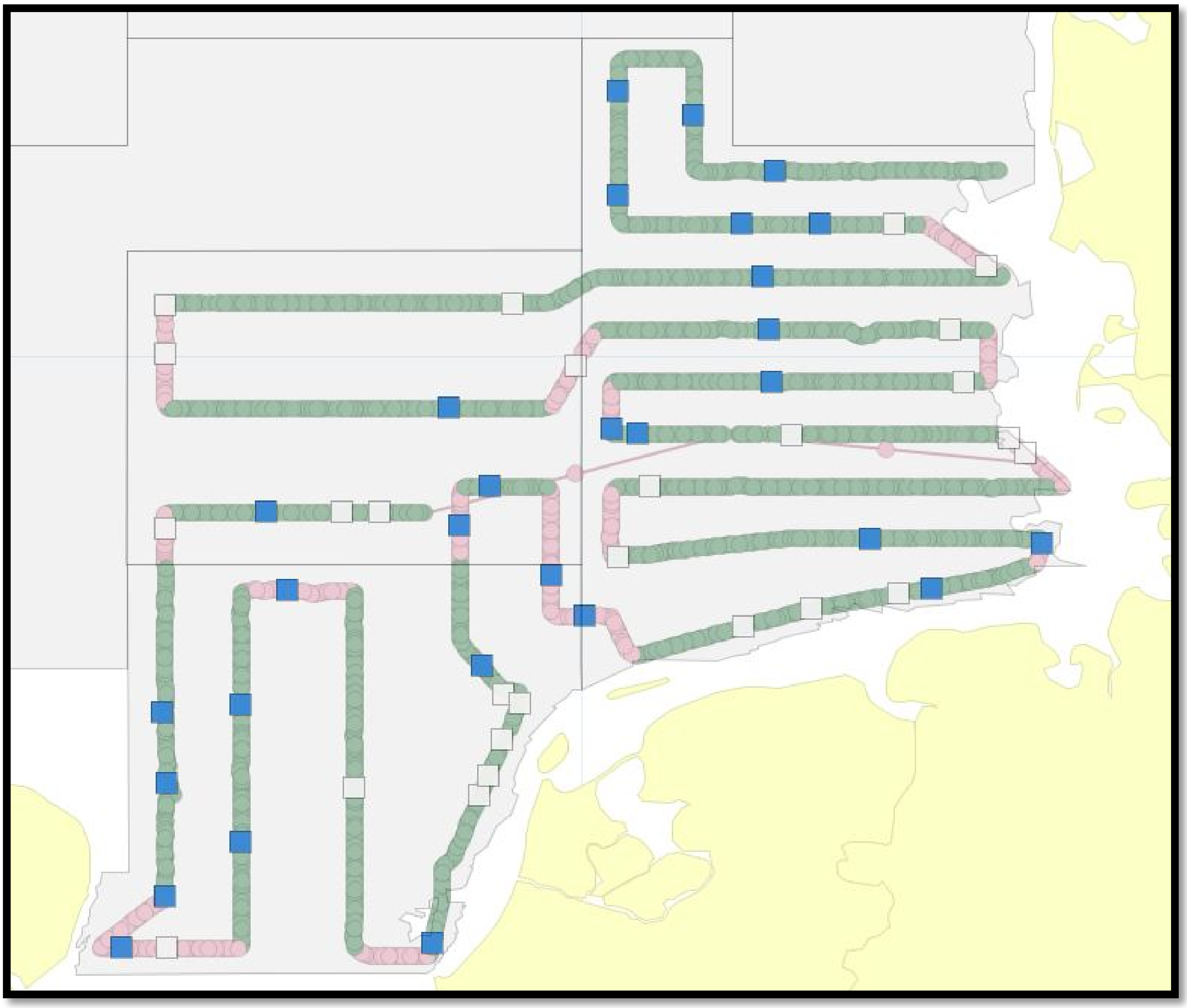


Figure 6. Area surveyed by Germany and survey track. Pink locations are acoustic EDSU's included in national estimated abundance but excluded in the StoX estimate. Green locations – EDSU's included in both estimates. Blue squares are locations of trawl hauls used in the analysis. Shaded area represents strata used in StoX and is the area the mean density per transect within strata is extrapolated to for calculating the total abundance for each strata.

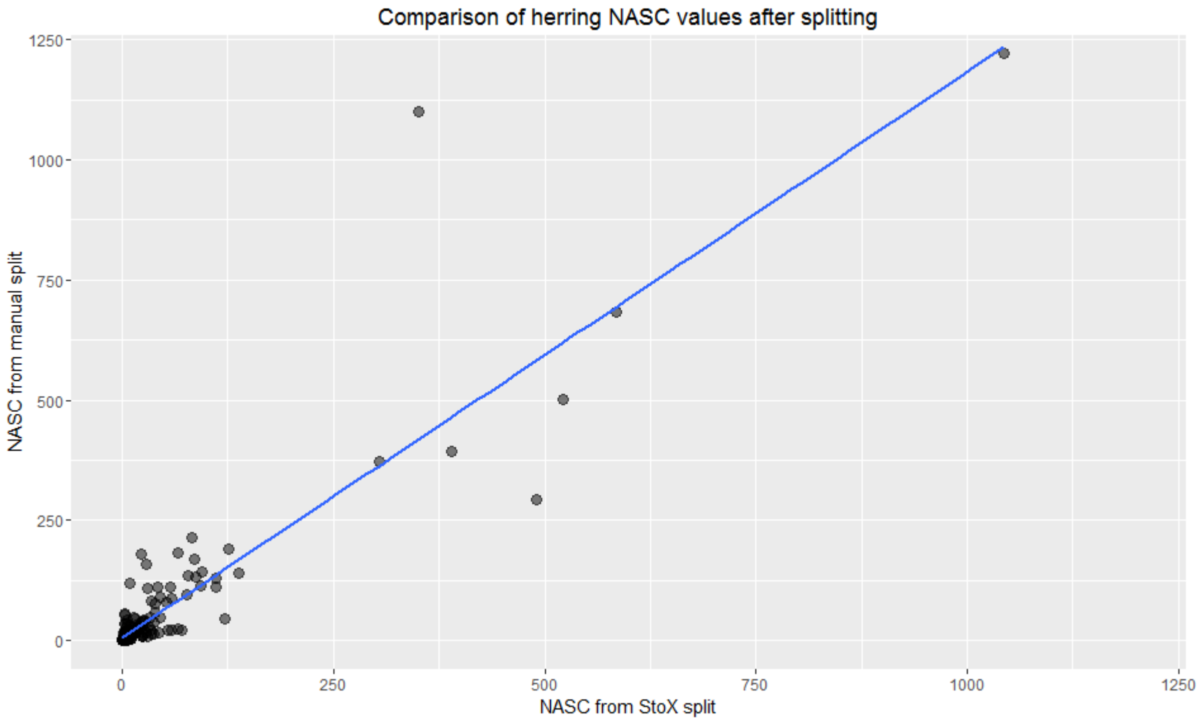


Figure 7. Comparison of partitioned NASC allocated to herring from the national calculation and from the splitNASC function in StoX for German acoustic data. The comparison is carried out at the EDSU level and the partitioned NASC for herring for each EDSU with splitting results from both methods available (n=271) are plotted against each other (Stox splitNASC = 549 EDSUs with HER, Manual split NASC = 271 EDSUs with HER).

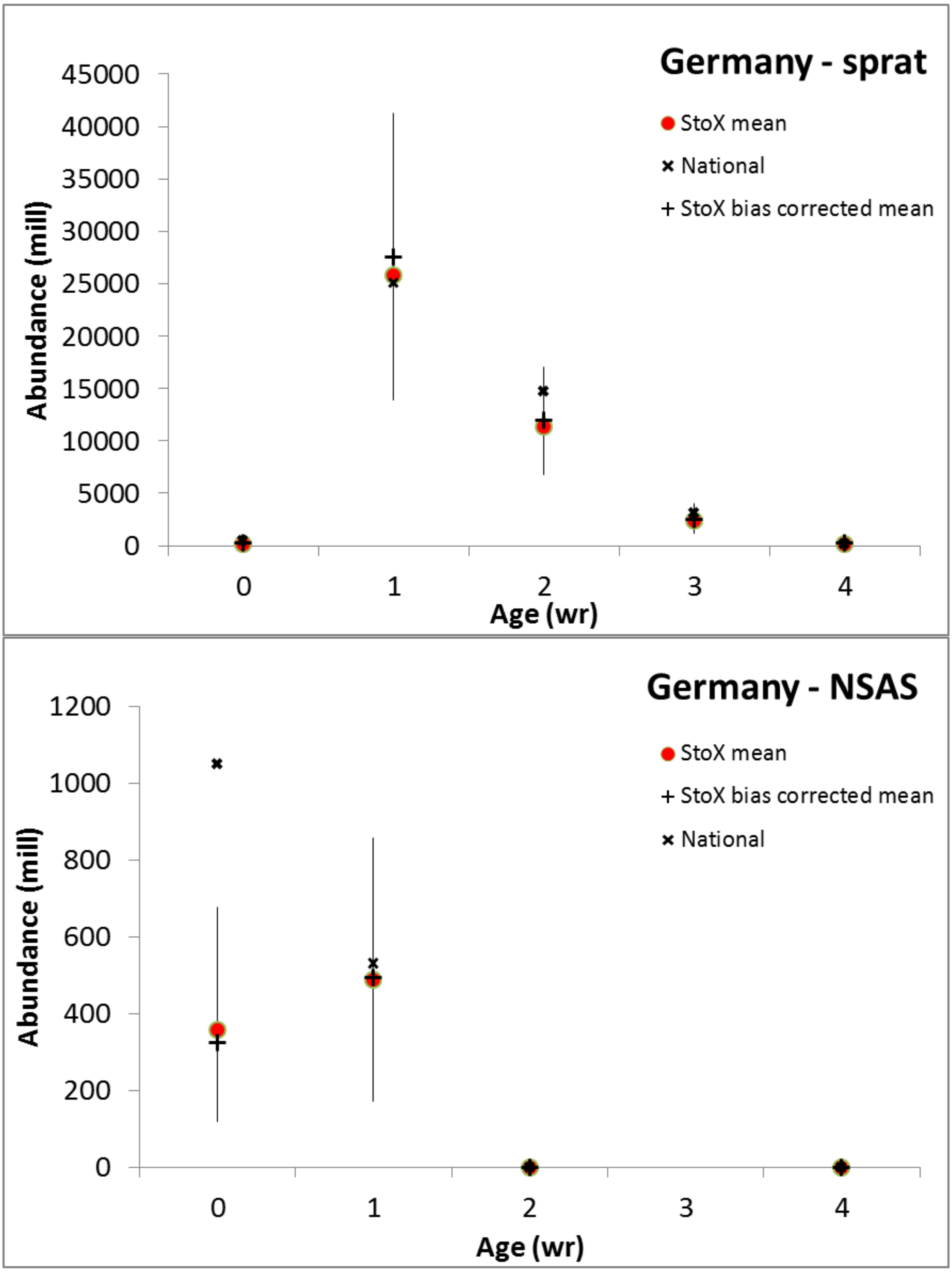


Figure 8. Abundance at age estimated with both methods in the German area for NSAS and Sprat. Error bars represent the bias corrected 90% bootstrapped confidence interval for the StoX estimated mean.

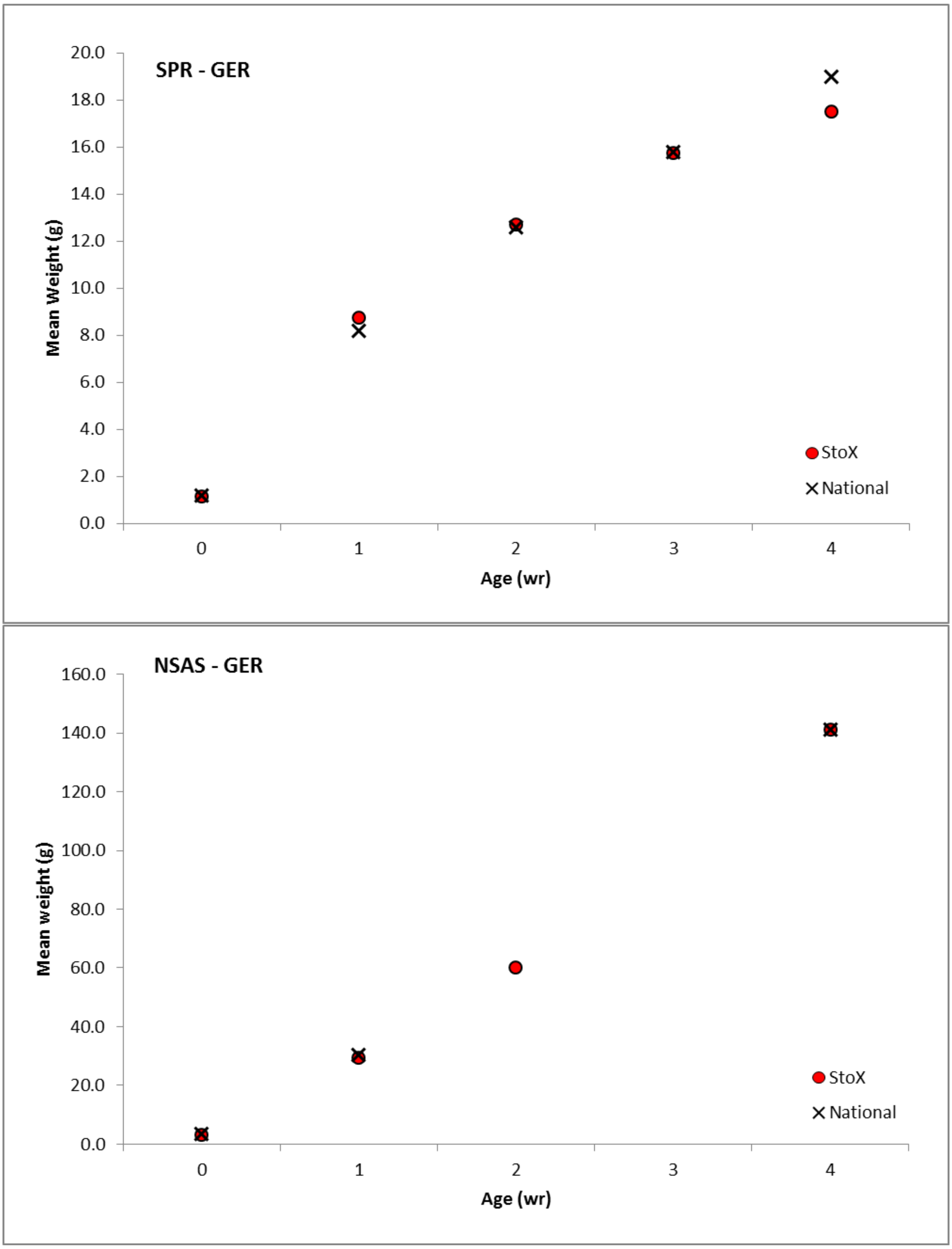


Figure 9. Estimated mean weights at age for NSAS and sprat in German national analysis and StoX analysis.

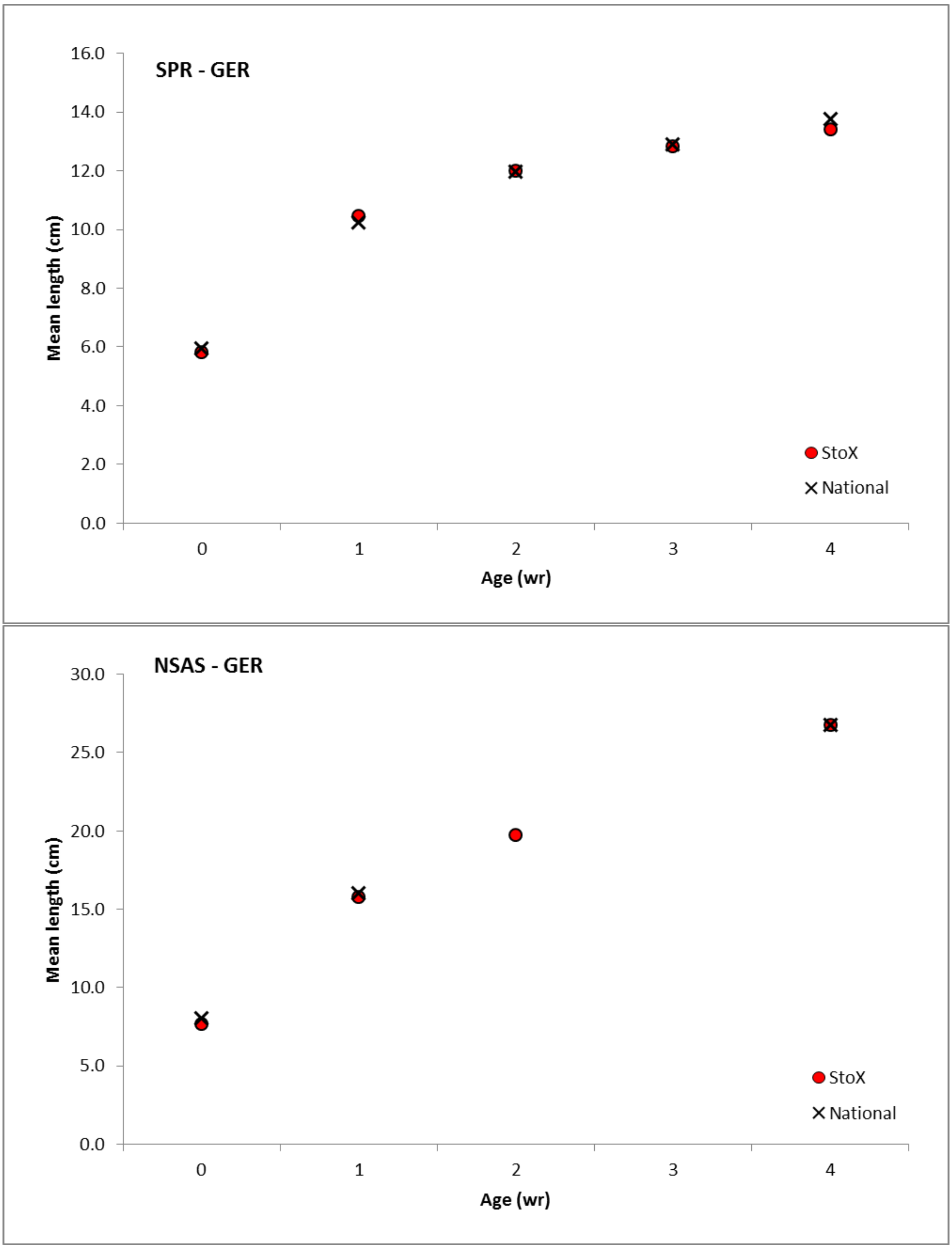


Figure 10. Estimated mean length at age for NSAS herring from German national analysis and StoX analysis.

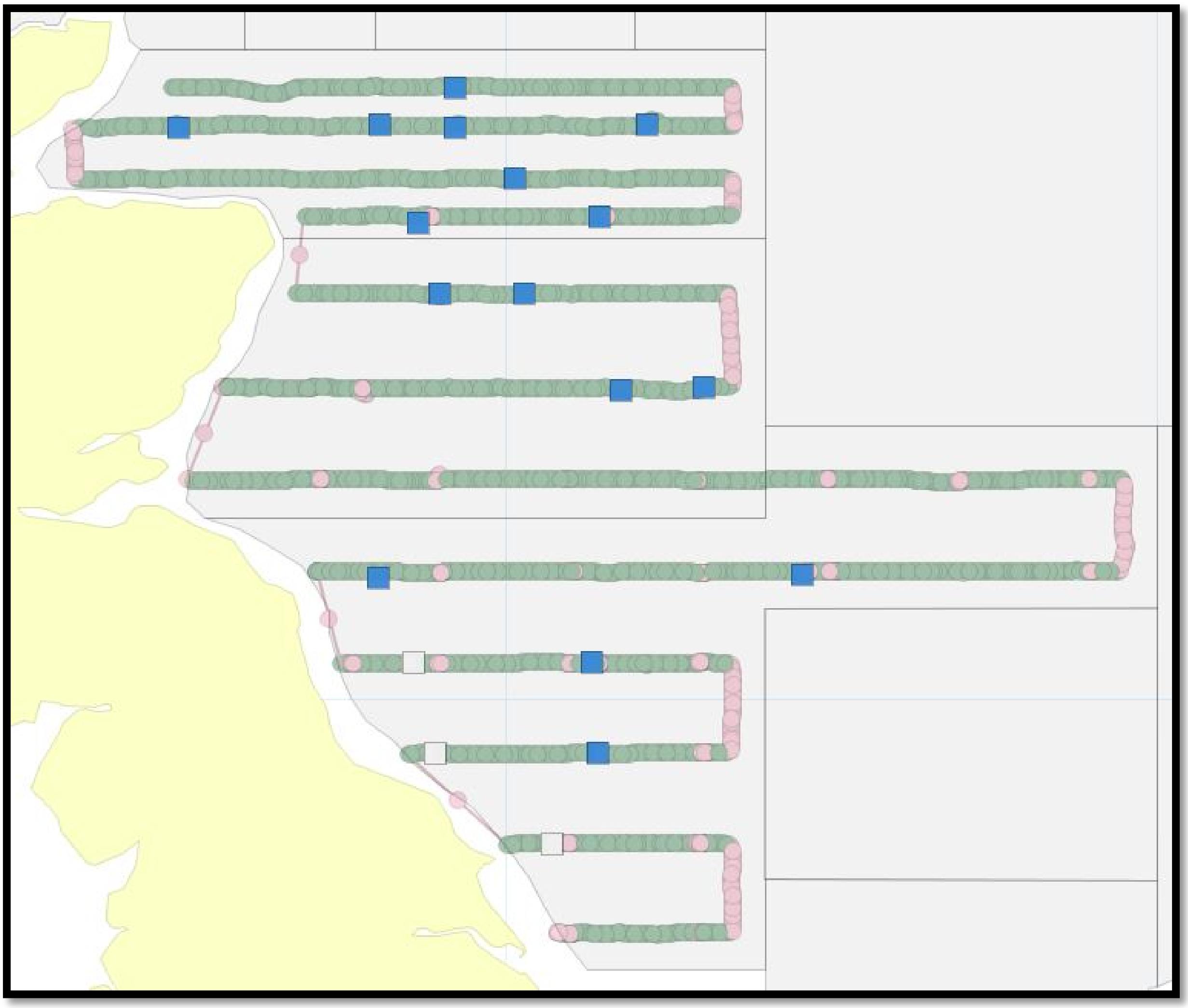


Figure 11. Dutch survey area and track. Pink locations are Acoustic EDSU's included in national estimated abundance but excluded in the StoX estimate. Green locations – EDSU's included in both estimates. Blue squares are locations of trawl hauls used in the analysis. Shaded area represents strata used in StoX and is the area the mean density per transect within strata is extrapolated to for calculating the total abundance for each strata.

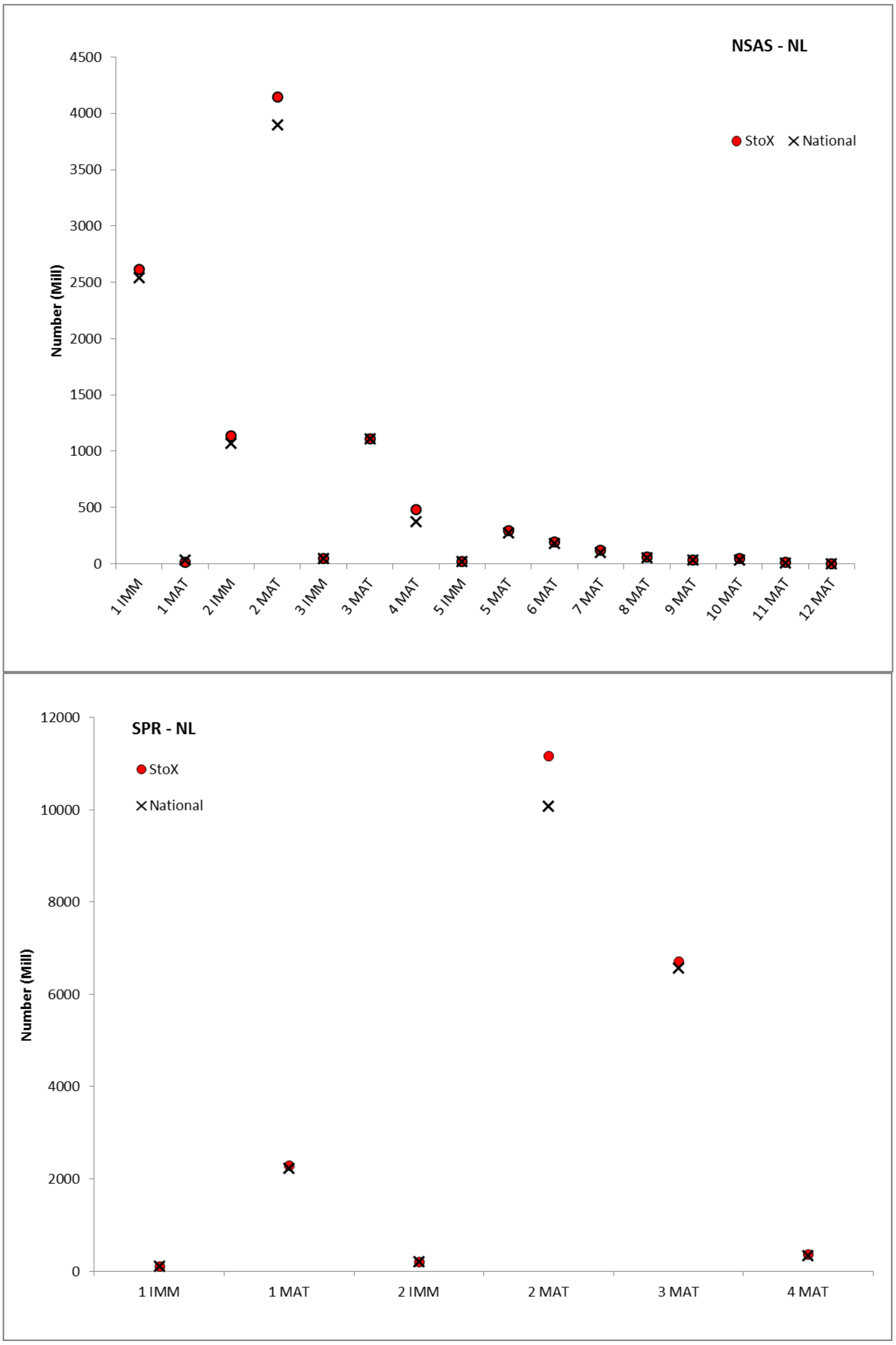


Figure 12. Abundance at age and maturity estimated with both methods in the Dutch area for NSAS and sprat.

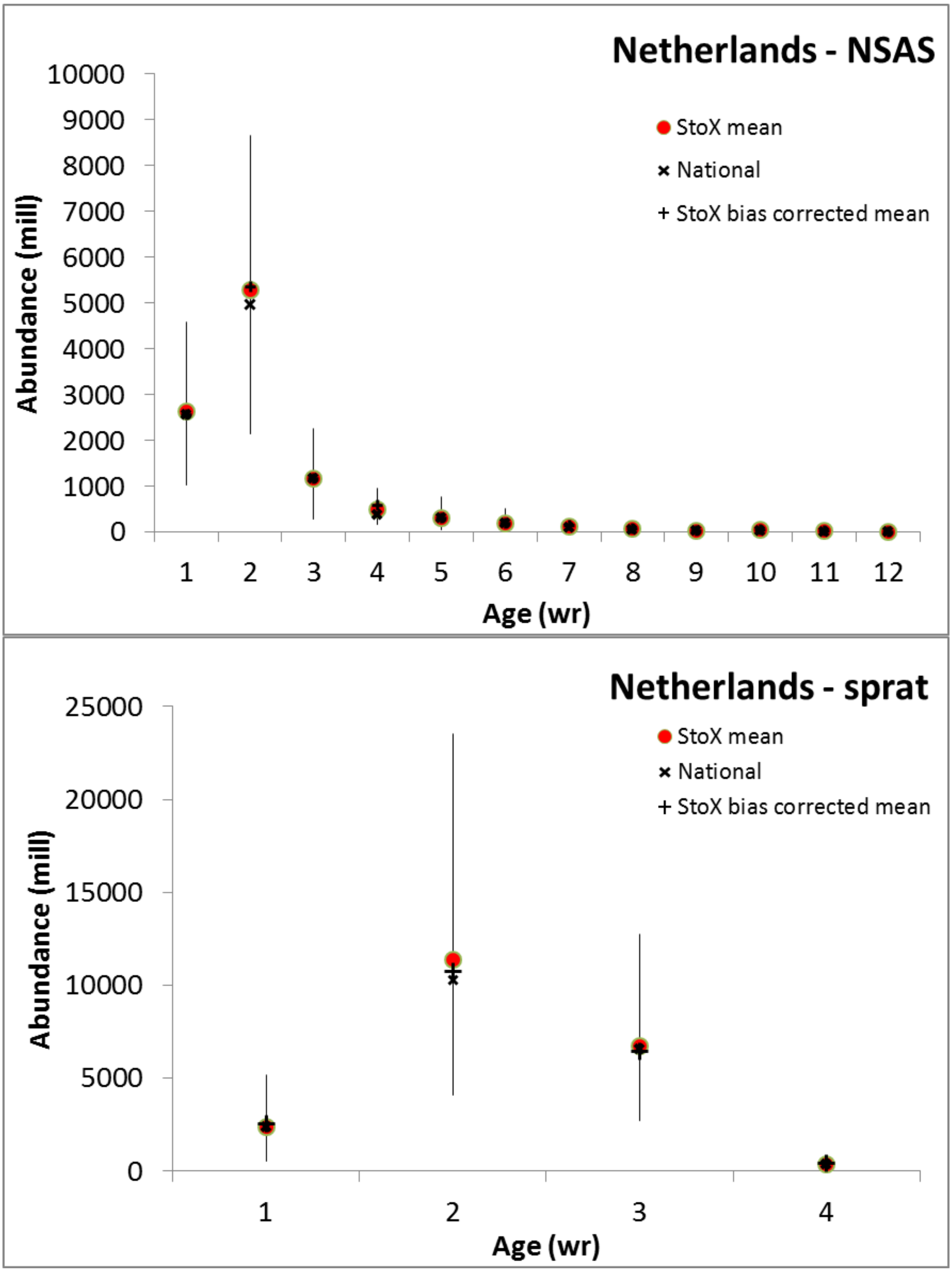


Figure 13. Abundance at age estimated with both methods in the Dutch area for NSAS and Sprat. Error bars represent the bias corrected 90% bootstrapped confidence interval for the StoX estimated mean.

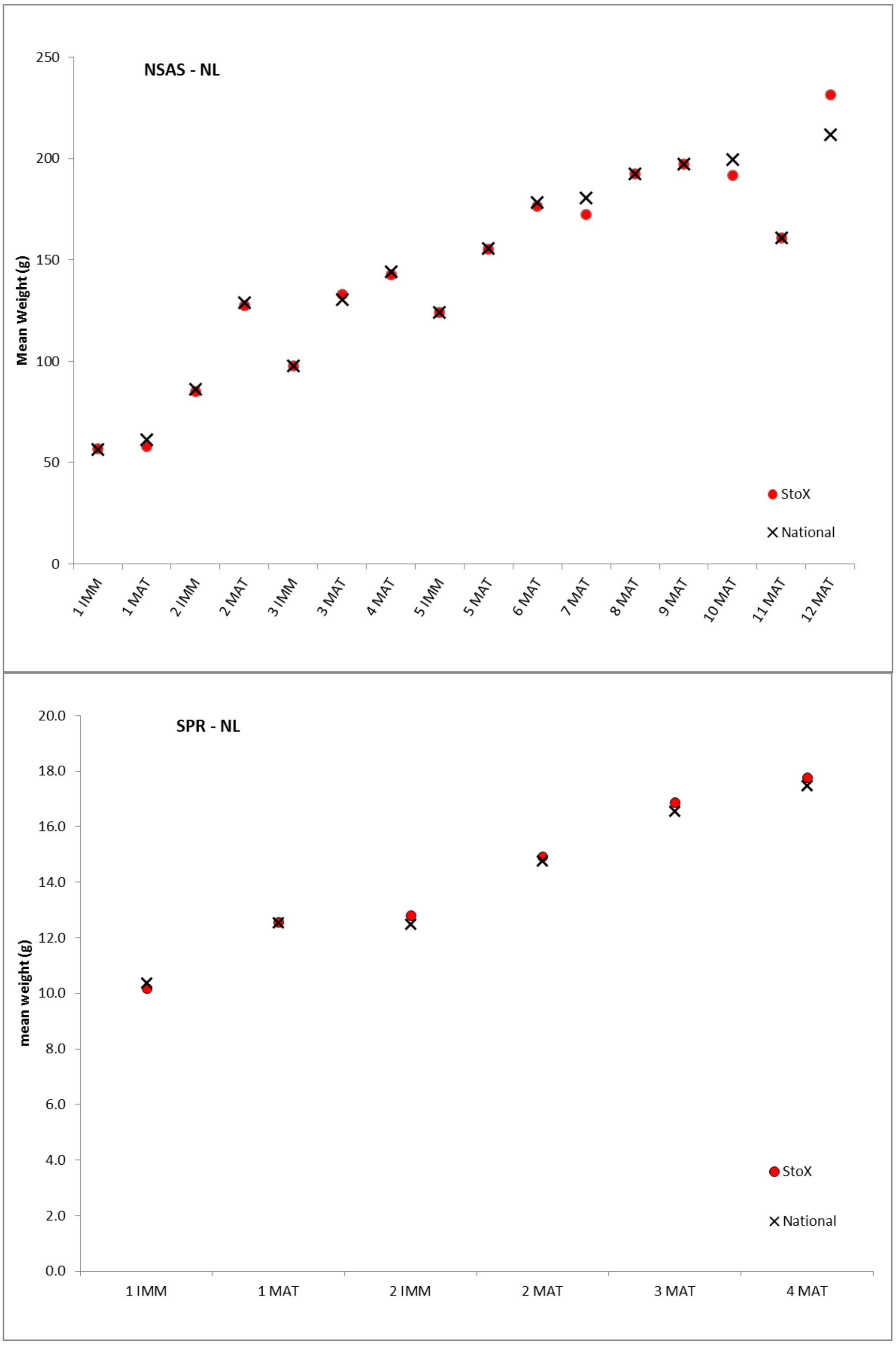


Figure 14. Estimated mean weights at age for the two herring stocks and sprat in Dutch national analysis and StoX analysis.

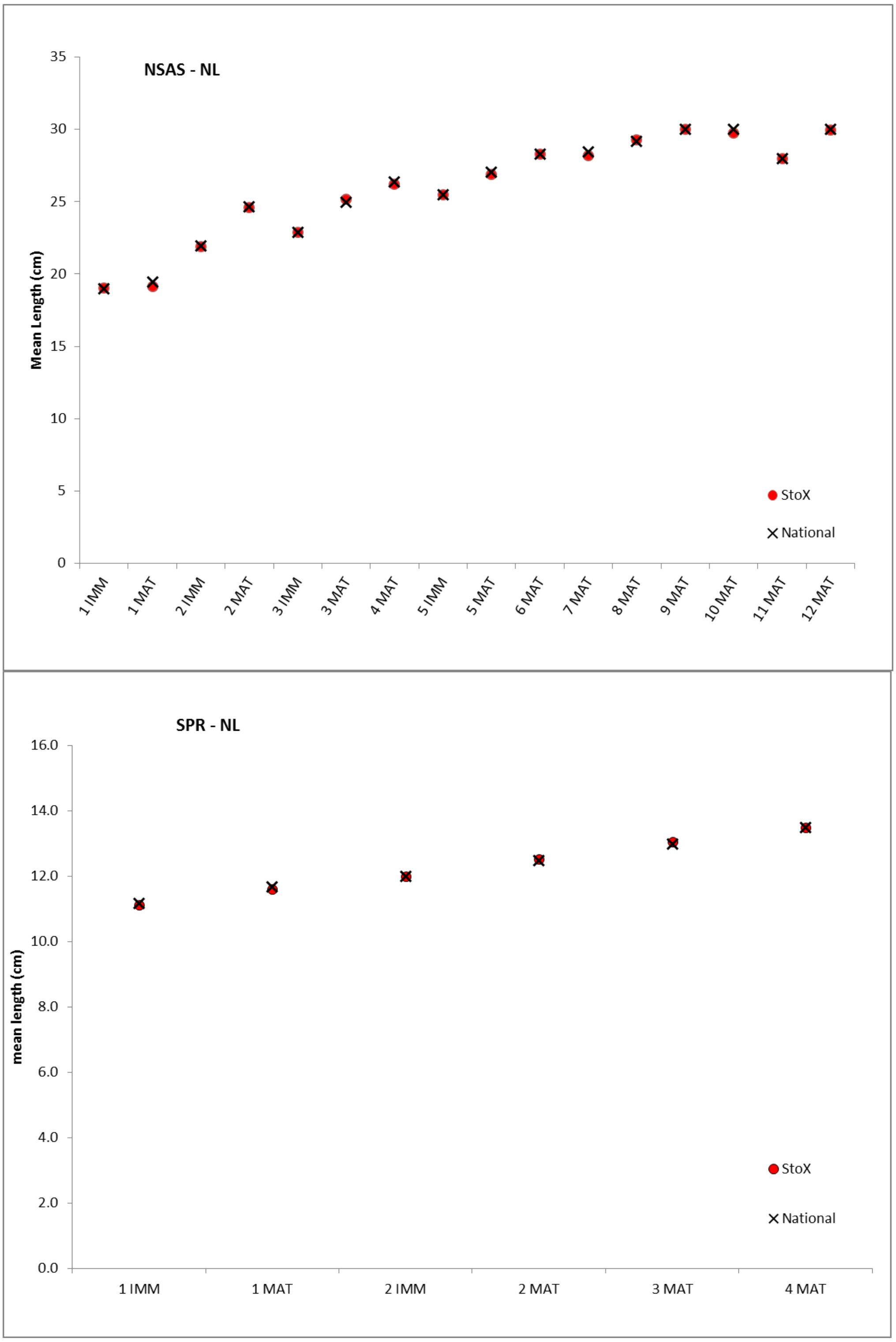


Figure 15. Estimated mean length at age for the two herring stocks and sprat in Dutch national analysis and StoX analysis.

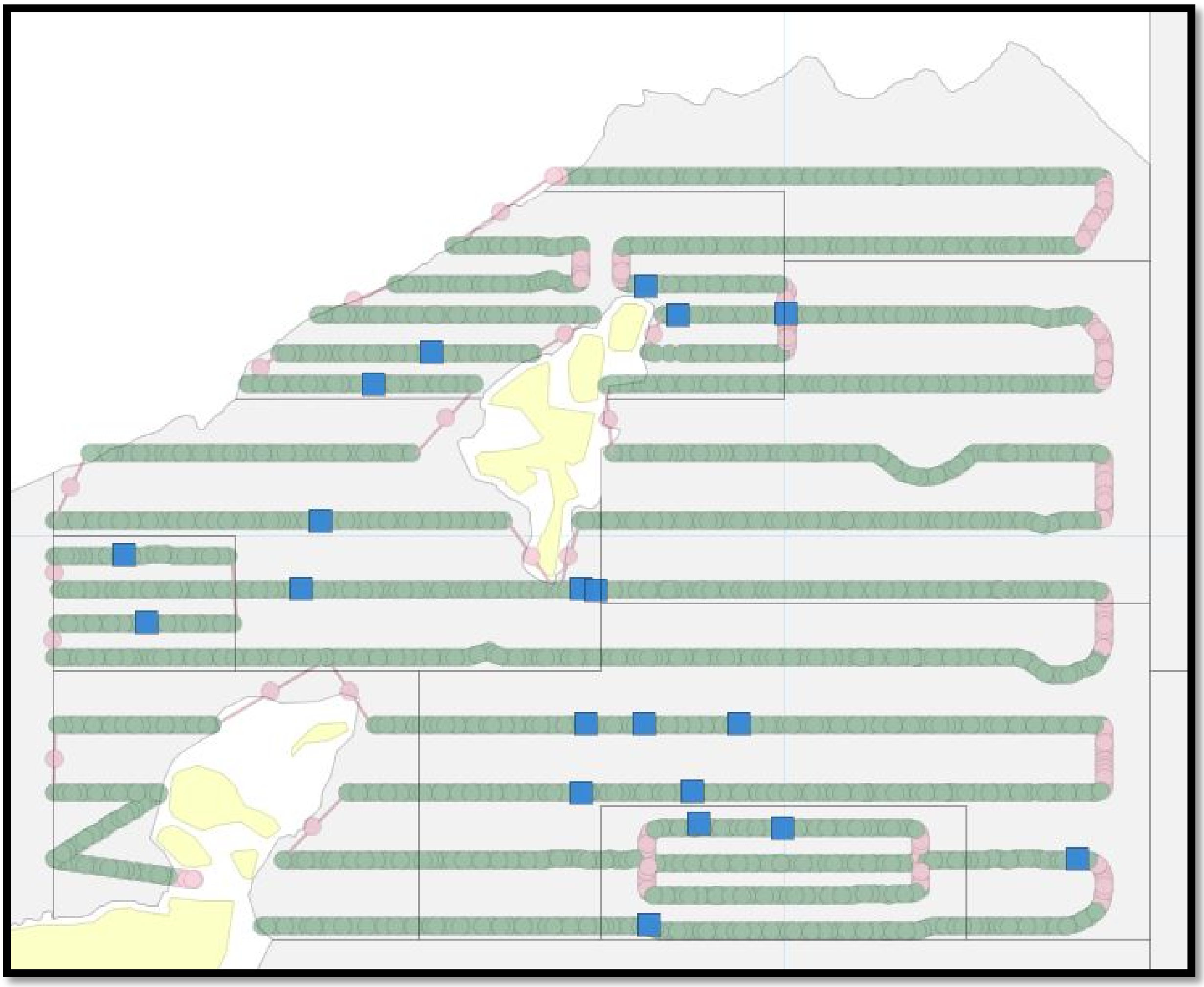


Figure 16. Scottish area and survey track. Pink locations are acoustic EDSU's included in national estimated abundance but excluded in the StoX estimate. Green locations – EDSU's included in both estimates. Blue squares are locations of trawl hauls used in the analysis. Shaded area represents strata used in StoX and is the area the mean density per transect within strata is extrapolated to for calculating the total abundance for each strata.

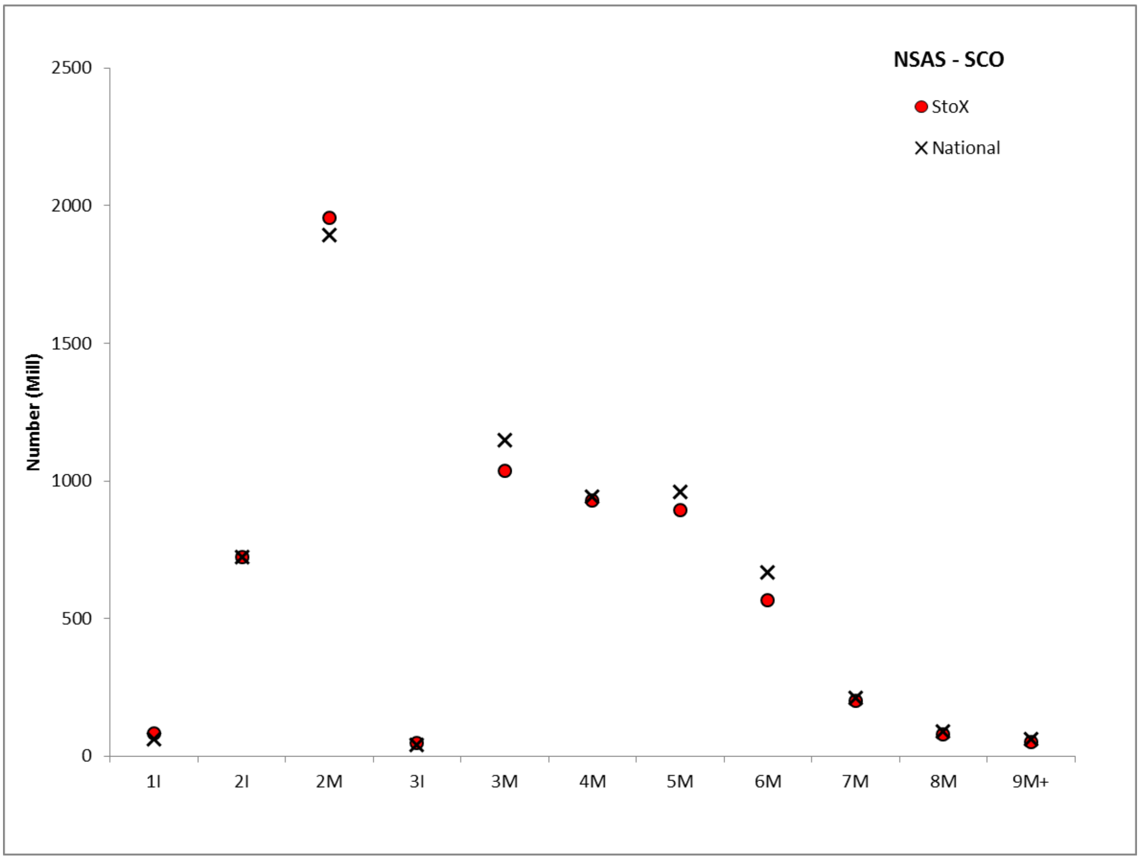


Figure 17. Abundance at age and maturity estimated with each method in the Scottish area for NSAS.

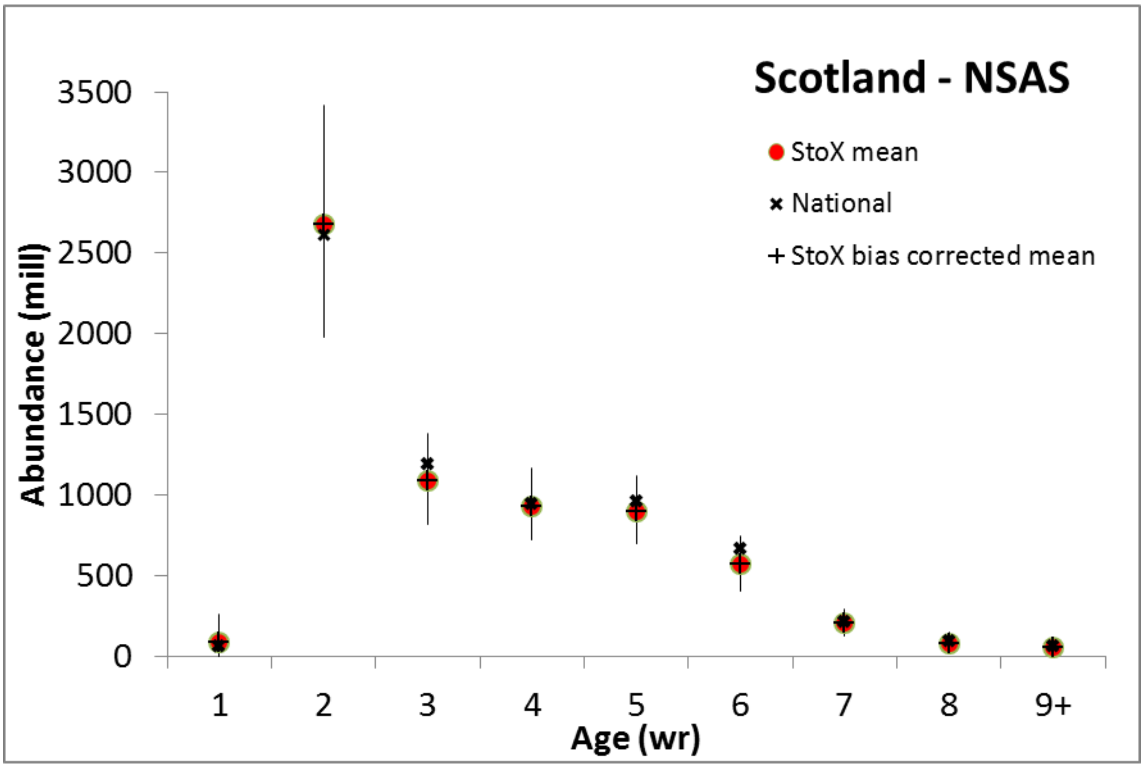


Figure 18. Abundance at age estimated with both methods in the Scottish area for NSAS. Error bars represent the bias corrected 90% bootstrapped confidence interval for the StoX estimated mean.

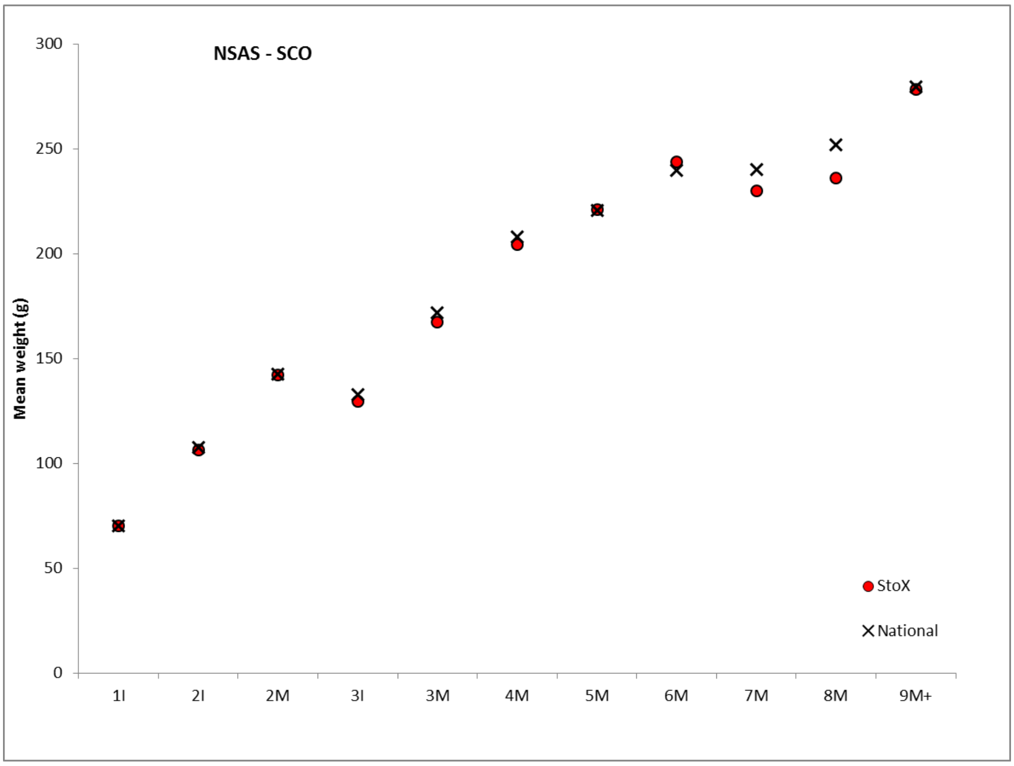


Figure 19. Estimated mean weights at age for NSAS in Scottish national analysis and StoX analysis.

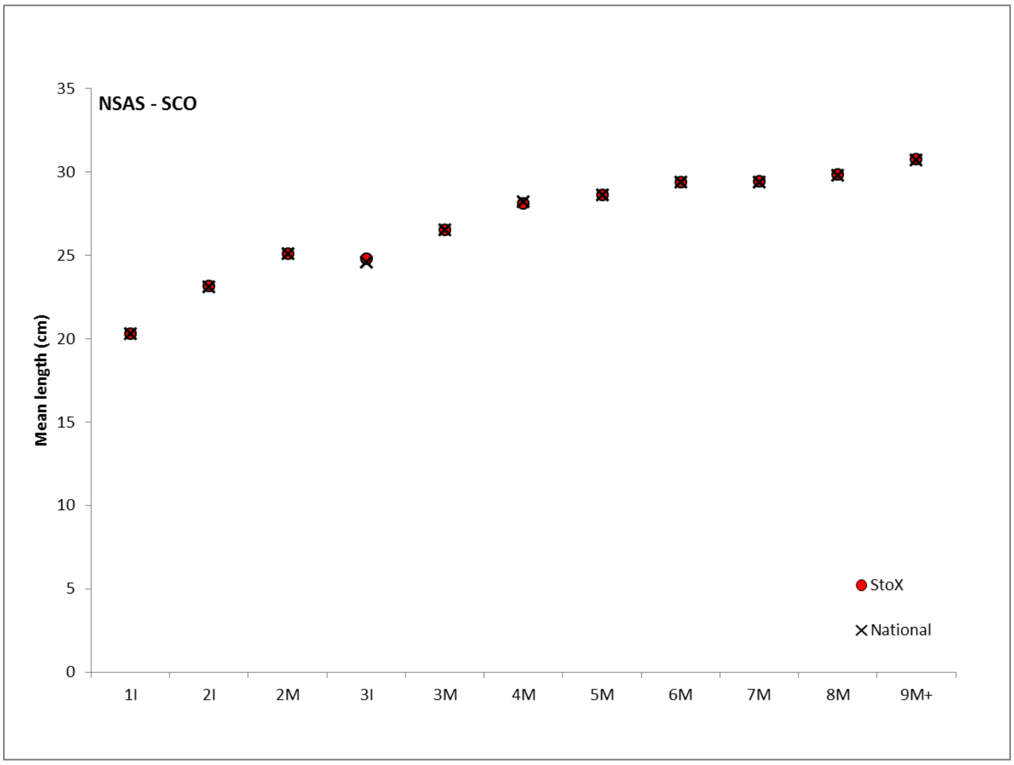


Figure 20. Estimated mean length at age for NSAS herring in Scottish national analysis and StoX analysis.

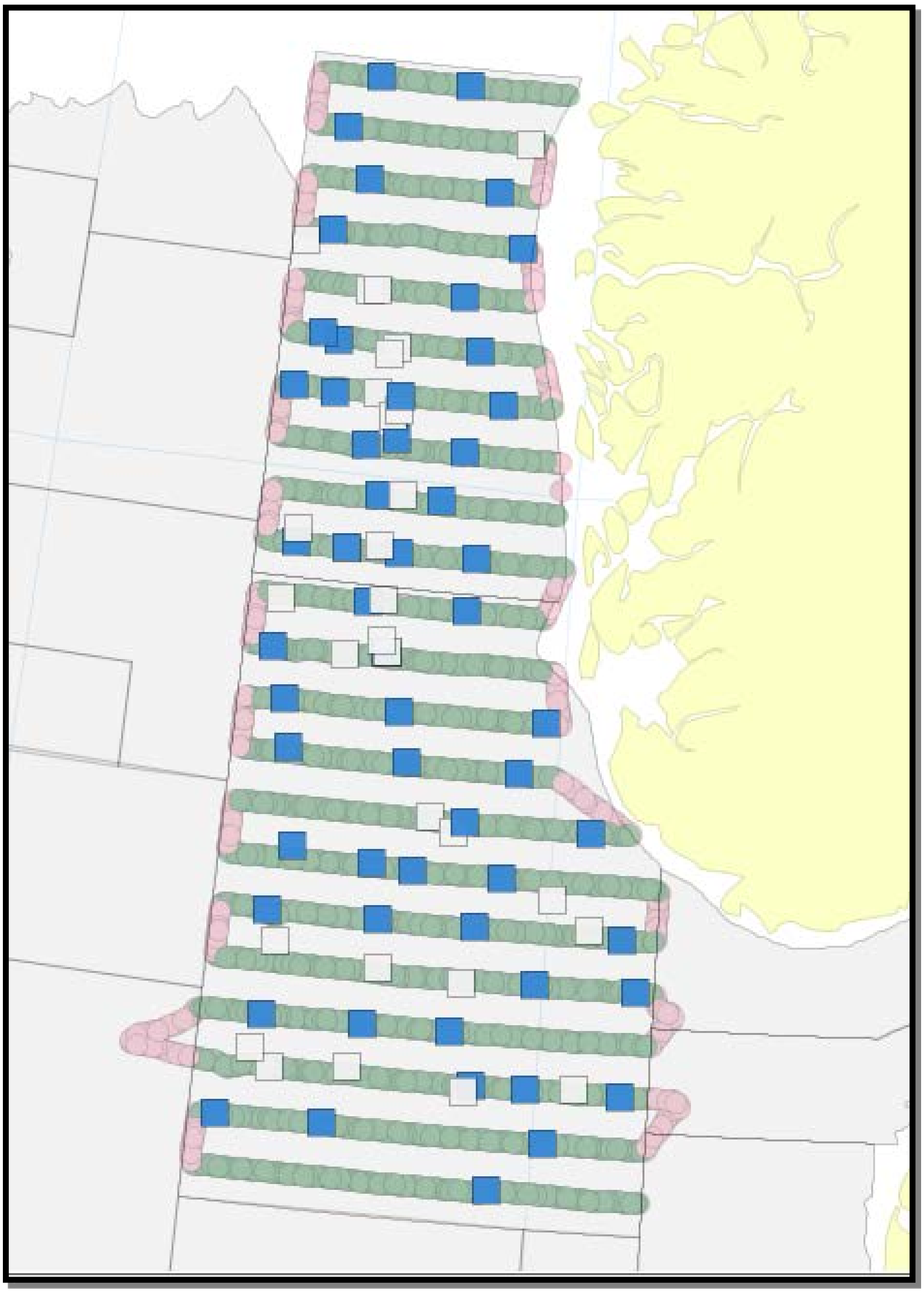


Figure 21. Norwegian area and survey track. Pink locations are acoustic EDSU's excluded both in national estimated abundance and in the StoX estimate. Green locations – EDSU's included in both estimates. Blue squares are locations of trawl hauls used in the analysis. Shaded area represents strata used in StoX and is the area the mean density per transect within strata is extrapolated to for calculating the total abundance for each strata.

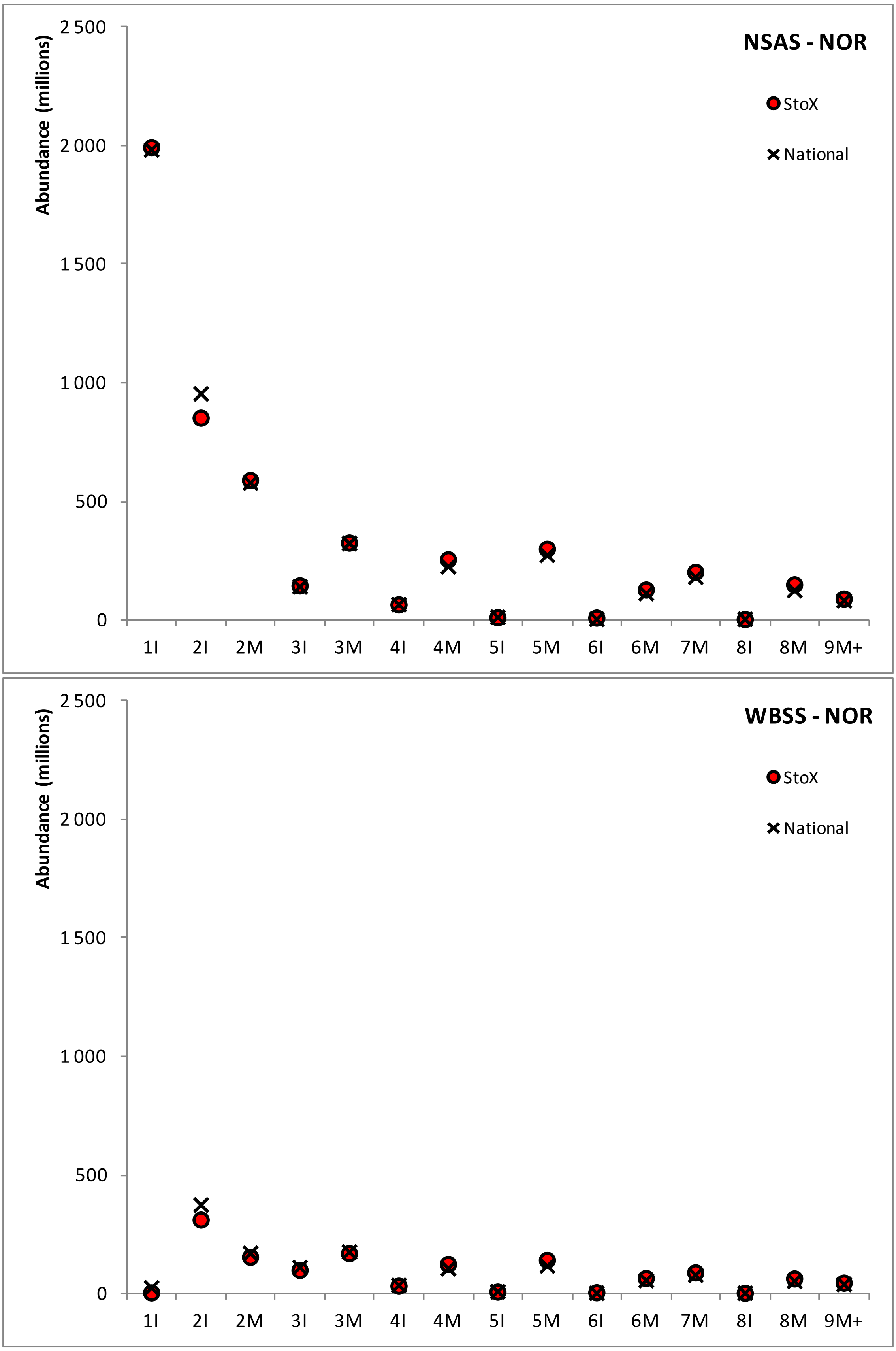


Figure 22. Abundance at age and maturity estimated with each method in the Norwegian area NSAS, and WBSS.

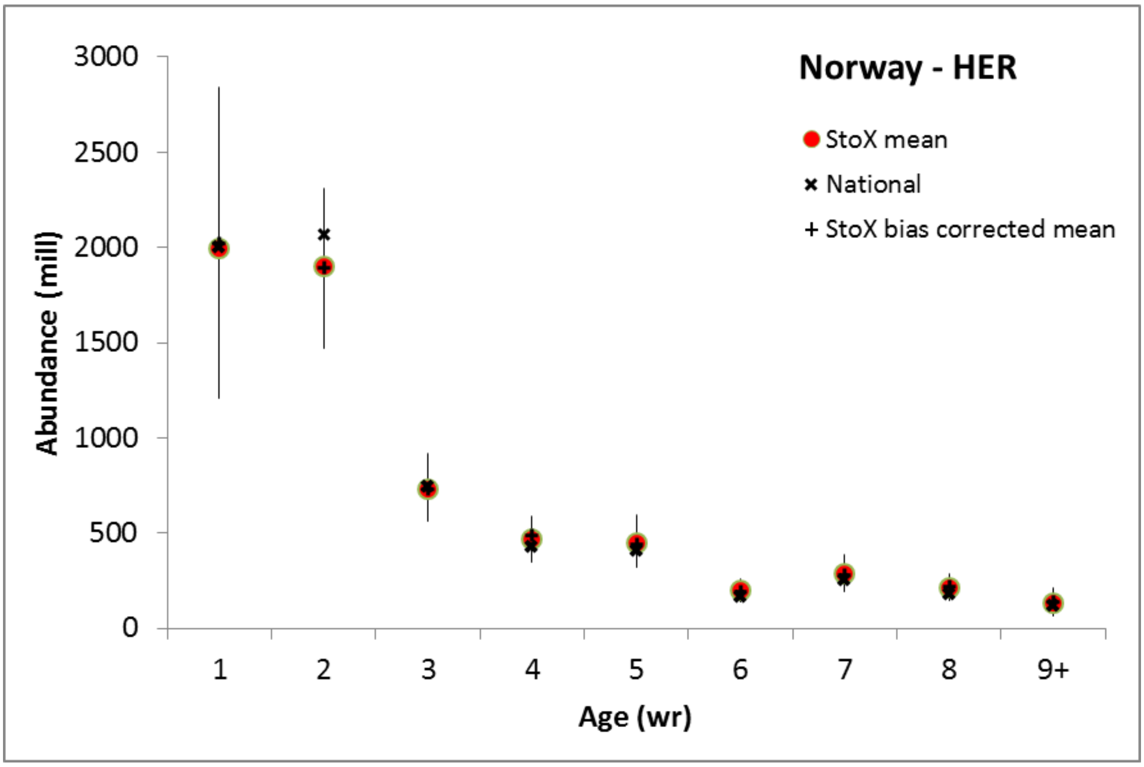


Figure 23. Total abundance at age estimated with both methods in the Norwegian area for both WBSS and NSAS combined. Error bars represent the bias corrected 90% bootstrapped confidence interval for the StoX estimated mean.

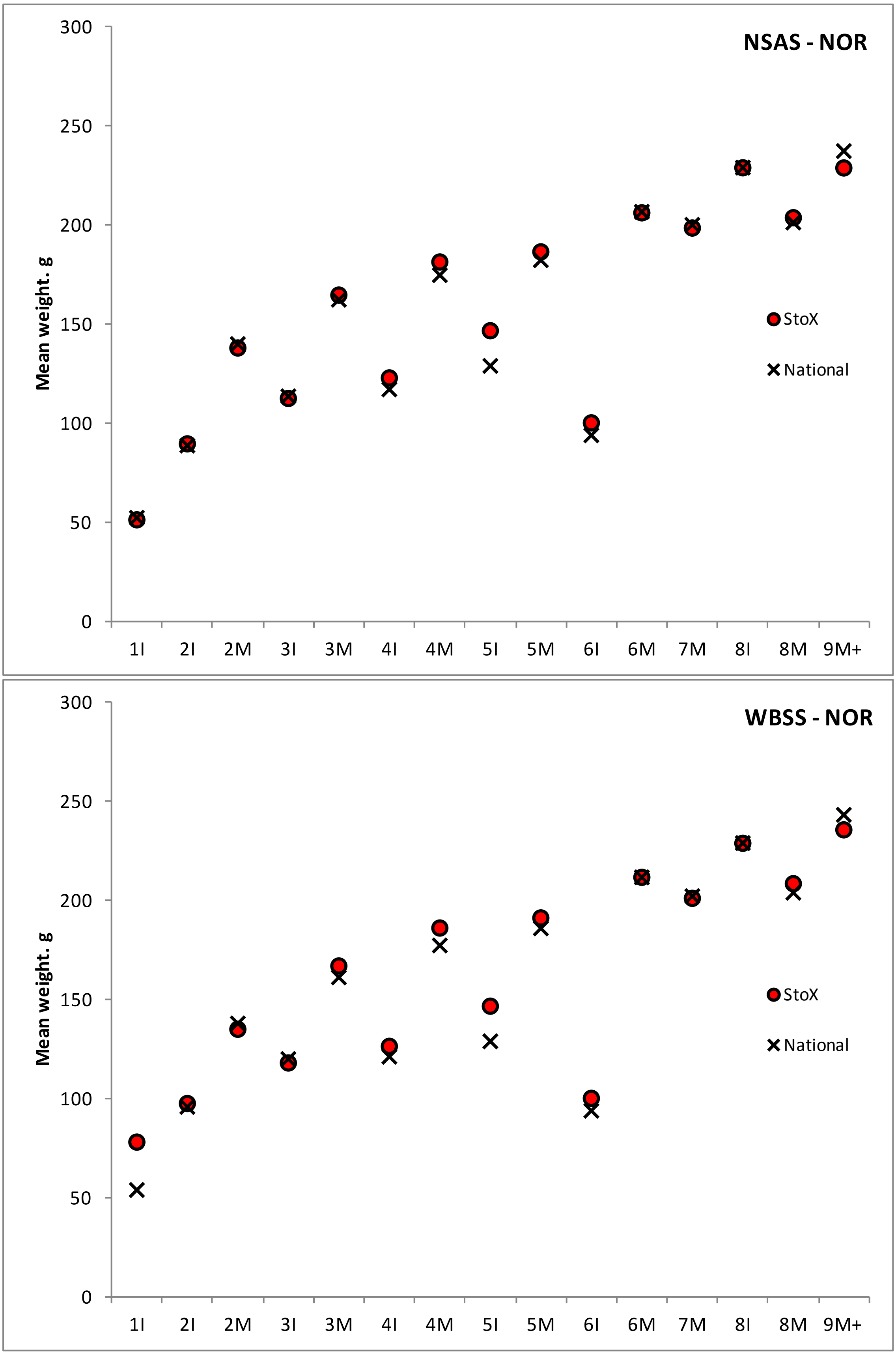
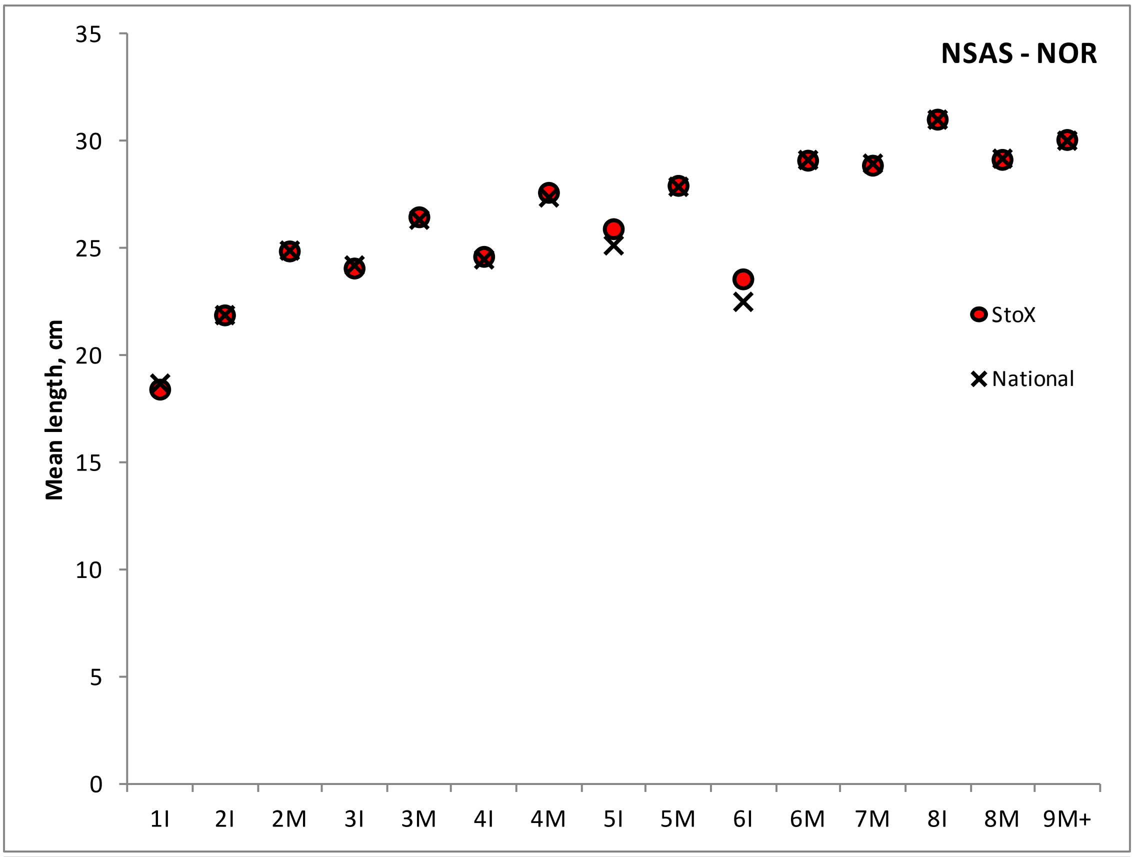


Figure 24. Estimated mean weights at age for NSAS and WBSS in Norwegian national analysis and StoX analysis.



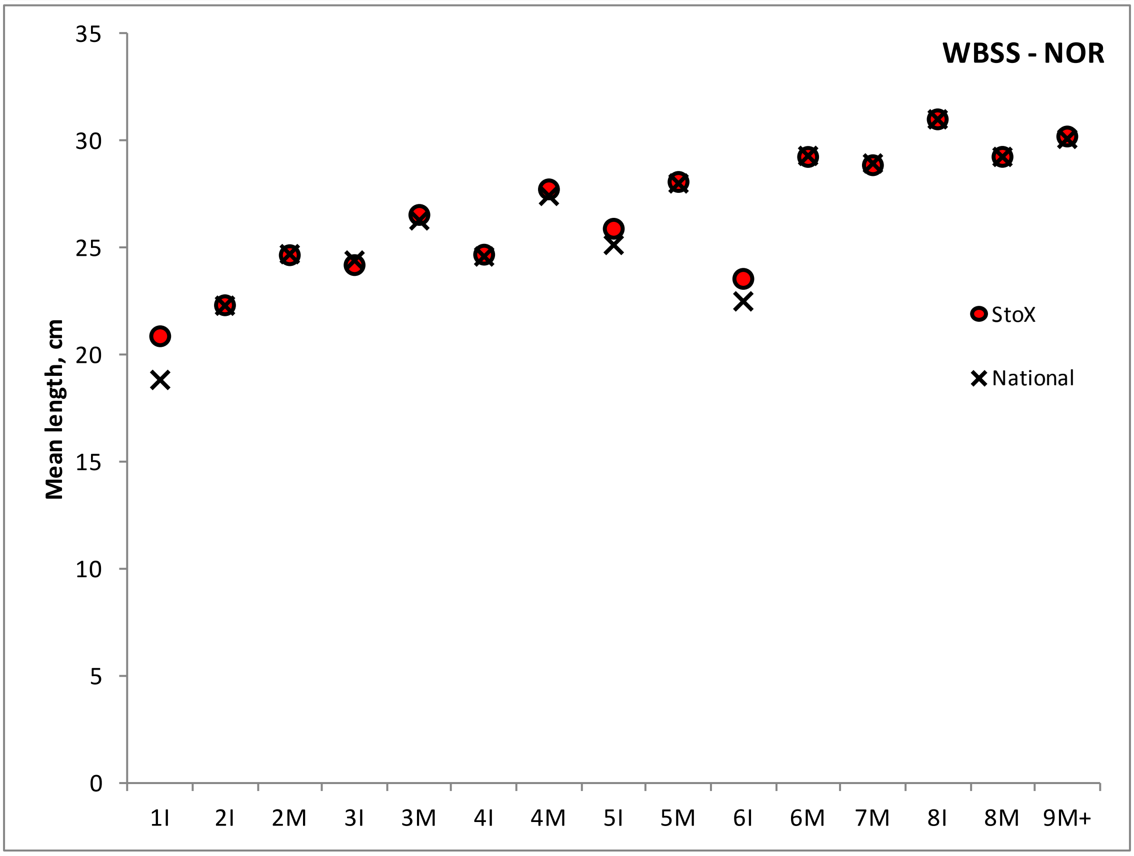


Figure 25. Estimated mean length at age for WBSS and NSAS herring in Norwegian national analysis and StoX analysis.

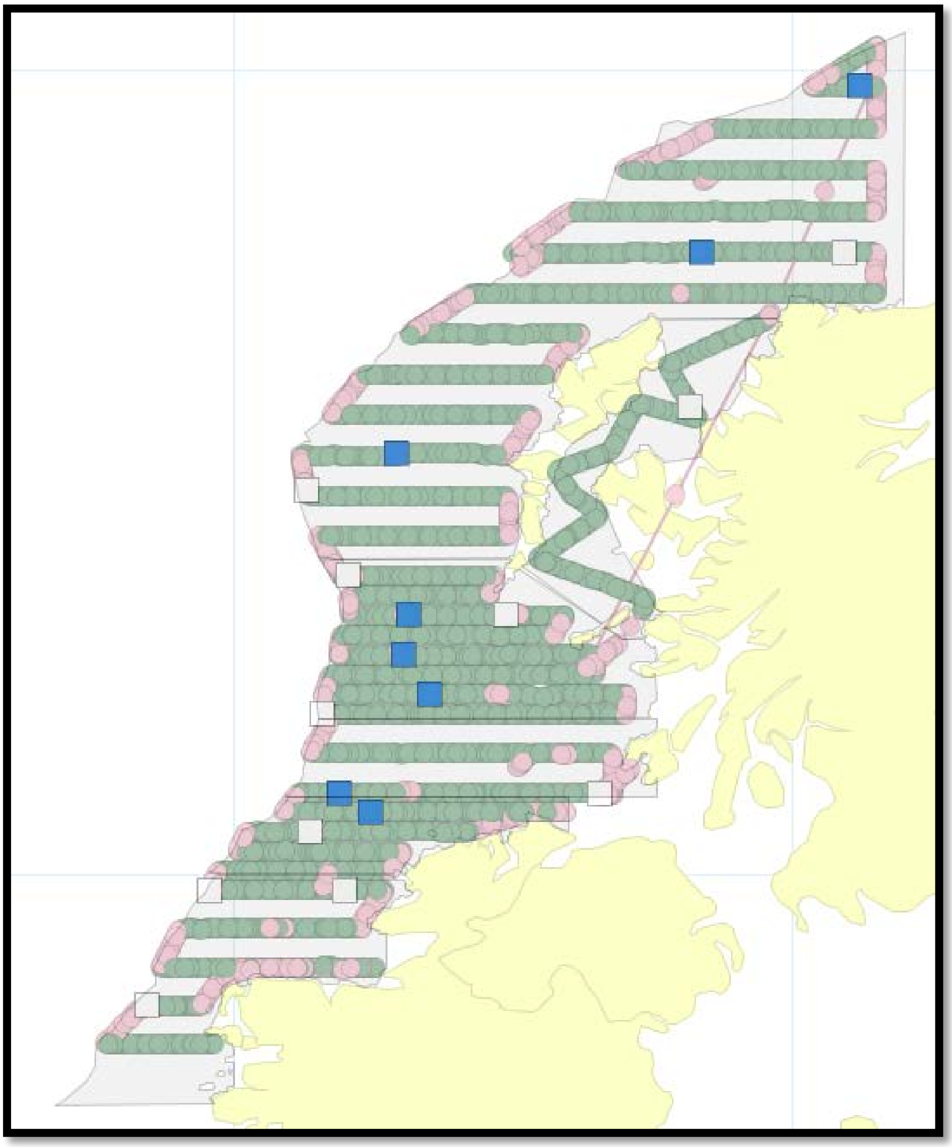


Figure 26. Irish area and survey track. Pink locations are acoustic EDSU's excluded both in national estimated abundance and in the StoX estimate. Green locations – EDSU's included in both estimates. Blue squares are locations of trawl hauls used in the analysis. Shaded area represents strata used in StoX and is the area the mean density per transect within strata is extrapolated to for calculating the total abundance for each strata.

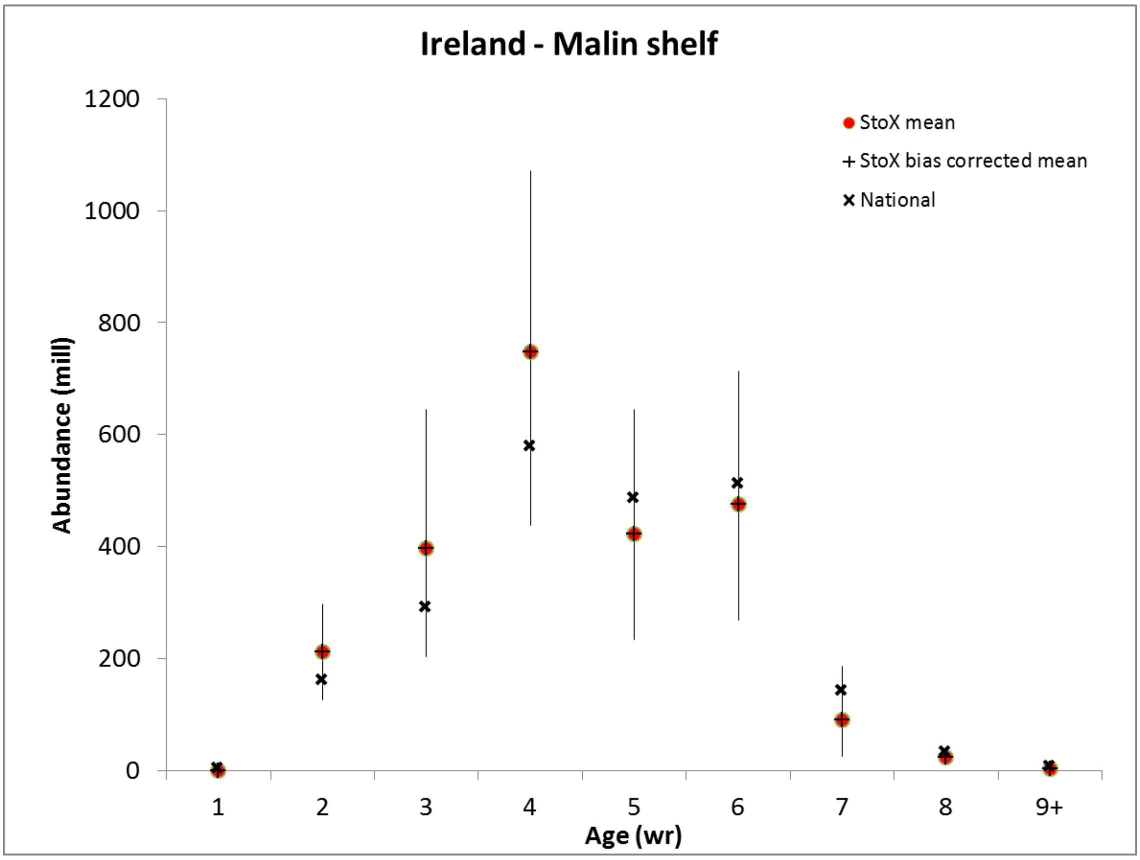


Figure 27. Total abundance at age estimated with both methods in the Irish survey area. Error bars represent the bias corrected 90% bootstrapped confidence interval for the StoX estimated mean.

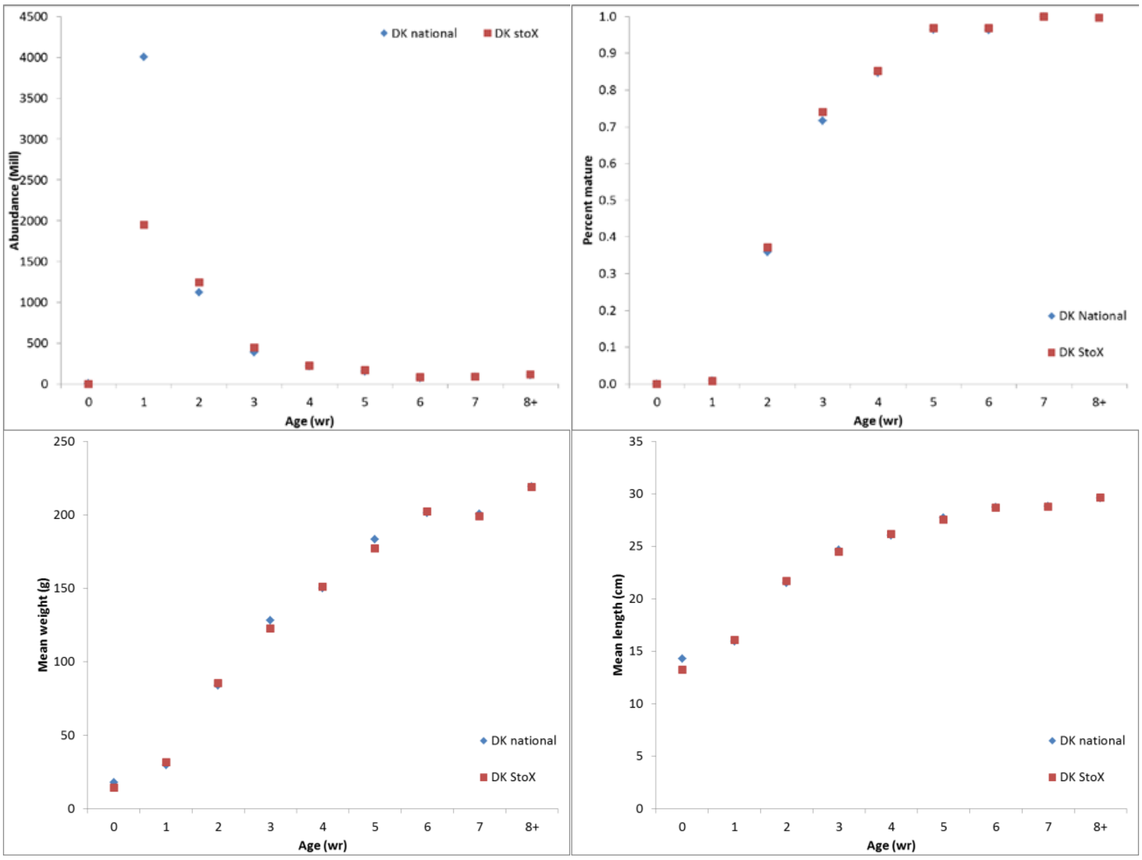


Figure 28. Global estimates for WBSS collated from Norwegian StoX data and either Danish StoX data (blue) or Danish national data (red).

Annex 10: Answers to "Recommendations to WGIPS"

Nr	From	Recommendation	Answer
66	WKIELD	1. WKIELD recommends creating an overview of the egg and larval development scales (with descriptions of the different stages) which are used in the ichthyoplankton surveys.	1) IHLS focuses on newly hatched herring larvae, regardless of the developmental stage (e.g. pre-flexion, yolk-sac). All measurements are done according to length.
67		2. WKIELD recommends creating a table of flowmeter types used and position of the flowmeter in the inlet in the various ichthyoplankton surveys.	2) Hydrobios electronic flowmeter. Inner flow measured at center of the mouth opening of the conus, outer flow on the frame of the sampler.
73		8. All ichthyoplankton survey groups should provide WGALES with a list of possible outputs needed for the WGs.	8) None. All indices (LAI, SCAI) are calculated prior to or at HAWG.
74		9. The appropriate grid for the distribution maps as output of the ICES Eggs and Larvae database needs to be defined by WGALES, based on recommendations from the ichthyoplankton groups.	9) Typical distance between two IHLS stations is 10 nautical miles.
196	HAWG	Issue: Improvement of baseline for splitting of herring stocks in the Malin Shelf survey How to address: UK and Ireland to cooperate with each other to secure samples of spawning fish in each spawning component. Stocks: Herring in Divisions VIaN, VIaS, VIIb,c	UK and Ireland both secured samples of spawning herring from the 2015/2016 spawning season. Unfortunately no morphometrical data were collected from the UK samples, only genetics. The institutes will continue to collaborate to collect these samples.

198	WKWEST	Issue: The **acoustics surveys**. The combined VIaN and VIaS, VIIb,c assessment (WKWEST) utilizes two acoustic time-series to calibrate the SAM assessment model. The first index is based on the traditional survey that extends from 1991–2008 when the expanded (into VIaS) Malin survey began and continues to date. The approach adopted by the benchmark work-shop for the assessment was to use the two time-series as independent indices with the first index stopping in 2007 and the second commencing in 2008. However, the newer time-series is basically the old geographical coverage expanded to the south. For the sake of consistency, it is recommended that between now and the next benchmark an analysis is undertaken whereby the first time-series is extended from 2008 to present using the overlapping coverage and the expanded coverage initiated in 2009 be considered as a new index for the assessment. This would provide a consistent index from 1991 to 2014 or the present.	WGIPS is unsure what analysis is being requested. WGIPS reports both the entire Malin Shelf Herring Acoustic Survey estimate (VIaN, VIaS, and VIIbc) and the West of Scotland estimate (VIaN only) annually. The first time-series, known as the West of Scotland Herring Acoustic Survey (1991 – 2007), is directly comparable to the West of Scotland estimate that is still reported each year, i.e. the VIaN portion of the new Malin Shelf Herring Acoustic Survey (2008 – Present).
199	WKWEST	Issue: **IBTS** The Scottish IBTS survey in area VIa is conducted in both the 1st and 3rd quarters of the year and changed in 2010 from sampling on an ICES statistical rectangle basis (as used in the North Sea IBTS) to a stratified random design. Although it was suggested that the implications of this on the index were likely minimal the WKWEST felt it more appropriate to break the time-series into two periods and use only the earlier time-series in the assessment models. The more recent IBTS survey series could be considered for use by	wrongly addressed to WGIPS

		HAWG after more years of data are available and/or a determination is made on combining of the two into a single continuous time-series. The Scottish survey does not extend southward far enough to encompass all fish in the area. However, there is a Republic of Ireland survey that does extend further south and these data will be investigated to see if they can be used in conjunction with the Scottish data to provide a more complete coverage, especially of fish spawn-ing in VIaS, VIIb,c.	
227	WGWIDE	The International Ecosystem Survey in Nordic Seas and adjacent waters in July-August (IESSNS) is an expansion of the Norwegian Sea summer survey (Stock Annex), however the coverage and main focus has changed. In the latest years, mackerel has been the main target of the survey, but the survey gives useful information of the blue whiting and NSS herring stocks in this period. This survey started in 2009. The working group discussed the necessity of having more than one survey giving information to the blue whiting assessment and a subgroup of members from IESSNS participating countries decided that the survey from 2016 also should include blue whiting as target species. It may also be valuable to the NSS herring assessment to use information from IESSNS survey, and WGWIDE recommends to include NSS herring as target species from 2016.	During IESSNS it has been recorded echosounder data, but the practice has varied between years and countries. In the first years, from 2007 to 2013, it was recorded acoustic data down to 500 m which was scrutinized with respect to herring and blue whiting. The biological sampling for verification of acoustic backscattering and age determination of blue whiting was in this period limited, but some biological sampling was done. The introduction of the Multpelt 832 with 400 m dynema warp limited the possibility to trawl deeper than 150-200 m. In 2014 and 2015, Norway only recorded acoustic data down to 100 m as to maximized ping rate and increase the focus on acoustic registration of mackerel. In this period, acoustic data were scrutinized for herring but not for blue whiting.

			Due to the need for more fishery-independent dataseries for herring and blue whiting as input to the assessment, it is requested to also focus on herring and blue whiting during IESSNS 2016 and forward. In addition to stations with trawl hauls for mackerel, the vessels will follow predefined transects with 40-55 nmi spacing. The exception is in the northern region towards Svalbard where herring and blue whiting are expected to be absent. In this area the Norwegian vessels will not follow transects but go straight from transect to transect. The coverage will be extended north of Iceland into Greenland waters with the aim of covering NSS-herring feeding in that area. The vessels will record data from several acoustic frequencies and have the possibility to trawl at acoustic registrations. The number of frequencies will depend on which commercial vessels are hired for the survey. Sampling of acoustic data in southern Greenland waters is not decided yet, as the vessel hired for the survey not necessarily have the possibility to record and store acoustic data. It is possible that the survey not will cover part of the herring stock northwest of Jan Mayen. However, last year's result indicated that the centre of gravity for herring in July has moved southwards towards Iceland. It is planned to purchase 1000 m dynema warps before the survey so it will be possible to do deep

			trawl hauls (300-400 m depth) for adult blue whiting. In general the participating countries have extended the survey period with a couple of days compared to last year, to account for extra time needed to obtain trawl samples of blue whiting.
239 241	WGBIOP	2. Initiation of Sprat biological data collection (standard parameters: length, weight, maturity, age) 4. WGBIOP requests WGIPS to collect and prepare gonad samples from the 2016 herring and sprat surveys for the workshop on maturity staging of herring and sprat (WKMSHS2). WGBIOP endorses the recommendation of WGIPS to have a maturity staging workshop for sprat.	Sprat biological data are already standardly collected during HERAS surveys. From all the HERAS survey participants (IRL, SCO, NO, NL, GE, DK), only Scotland can guarantee to collect samples during the 2016 survey. Ireland and Denmark will not have the required staff to perform any additional sampling. The other participants (Norway, Netherlands, and Germany) can collect samples if they manage to get additional staff at short notice before the survey, hence sampling from these countries is still uncertain. Potential samples that can be collected would be: SCO: adult herring NO: adult herring NL: juvenile and adult herring and sprat GE: juvenile herring and sprat WGBIOP still needs to inform regarding how many fish at each stage per species are require for a successful workshop.