WORKING GROUP OF INTERNATIONAL PELAGIC SURVEYS (WGIPS)

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Contents

i Executive summary

The Working Group of International Pelagic Surveys (WGIPS) coordinates, implements, and reports on acoustic surveys for pelagic fish species. 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 2020 surveys.

WGIPS 2020 discussed the results from two workshops held in 2019; WKSCRUT2 (Workshop on Scrutinizing of Acoustic data from the International Ecosystem Summer Survey in Nordic Seas (IESSNS)) and WKHASS (Workshop on Herring Acoustic Spawning Surveys). Procedures agreed at WKSCRUT2 were accepted at WGIPS and individual participant surveys will incorporate these to ensure harmony in echogram scrutiny across the relevant surveys in the IESSNS. WKHASS looked at three herring industry acoustic surveys (conducted in 6aN, 6aS/7b, c and 7a) and decided that while each survey gives robust estimates of abundance, there is still improvements needed in survey design and protocols for each. It was recommended that the 7a survey in the Irish Sea is included in the SISP 9 Manual for International Pelagic Surveys, ICES Acoustic Surveys database should host data from the spawning surveys, and that estimations should be compared with standard StoX (open source software for survey analyses) methods.

The group agreed that scrutinisation procedures, including the use of biological samples, need to be scientifically reviewed periodically for all acoustic surveys covered by WGIPS. A set of technical procedures also need to be agreed for each survey and kept updated in the SISP 9 manual.

A day session with presentations was held at WGIPS in 2020 to assess auxiliary pelagic ecosystem surveying techniques currently used on surveys coordinated by WGIPS.

WGIPS held a subgroup meeting of International Blue Whiting Spawning Survey (IBWSS) participants to discuss scrutiny procedures and reporting of mesopelagics from surveys, in response to a recommendation from the Workshop on Developing Mesopelagic Methods (WKMESOMeth). Participants agreed to begin providing acoustic data and to develop biological sampling capacity over time within existing constraints. Outcomes will be reviewed by WGIPS in 2021. WGIPS also held a subgroup to discuss the recommendation from the Working Group on Widely Distributed Stocks (WGWIDE) to undertake a feasibility study to extend the swept area survey for mackerel in the summer, south of 60°N. To progress this complex request WGIPS responded to WGWIDE by suggesting a workshop be initiated for 2021, to include participants from WGIPS, WGWIDE, and other experts.

It was agreed that using the StoX survey analysis software and the ICES database as common tools for all surveys coordinated within WGIPS will be encouraged.

All WGIPS surveys were completed as planned in 2019. Results and coordination plans for the 2020 individual and multinational pelagic acoustic surveys in Northeast Atlantic waters are presented in this report.

ii Expert group information

Expert group name	Working Group of International Pelagic Surveys (WGIPS)
Expert group cycle	Multiannual fixed term
Year cycle started	2019
Reporting year in cycle	2/3
Chair(s)	Bram Couperus, Netherlands
	Michael O'Malley, Ireland
Meeting venue(s) and dates	13 – 17 January, 2020, Bergen, Norway (25 participants)

1 Terms of Reference

ToR	Description	Background	Science plan codes	Duration	Expected Deliverables
a (ACOM)	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.	a) Advisory Requirements b) Requirements from other EGs	3.2, 5.2	years 1–3	Survey reports containing indices of stock biomass and abundance at age, spatial distributions of stocks and hydrographic conditions. HAWG WGWIDE
b(ACOM)	Coordinate the timing, area and effort allocation and methodologies for individual and multinational acoustic surveys on pelagic resources in the Northeast Atlantic waters covered (Multinational surveys: IBWSS, IESNS, IESSNS, HERAS, and individual surveys: CSHAS, ISAS, PELTIC, GERAS, WESPAS, industry coordinated surveys, CAPS).	a) Science Requirements b) Advisory Requirements c) Requirements from other EGs	3.1	years 1–3	Cruise plans for international and individual surveys. HAWG WGWIDE
c (SCICOM)	Adopt standardized analysis methodology and data storage format utilizing the ICES acoustic database repository for all acoustically derived abundance estimates of WGIPS coordinated surveys	a) Science Requirements b) Advisory Requirements	3.2	years 1–3	Progress on the adaption of standardized analysis methodology and data storage format utilizing the ICES pelagic acoustic database repository for WGIPS coordinated surveys.
d (ACOM)	Periodically review and update the WGIPS acoustic survey manual to address and maintain monitoring requirements for pelagic ecosystem surveys	a) Science requirements b) Advisory requirements	3.1	years 1–3	Updated WGIPS survey manual.
e (ACOM)	Review the work, and report of workshops organised by WGIPS and develop formal ICES recommendations. This should include SISP updates and adopting changes to survey coordination	a) Science requirements b) Advisory requirements	3.1	years 1–3	

	where deemed appropriate.				
f (ACOM)	Review and evaluate survey designs across all WGIPS coordinated surveys to ensure the integrity of survey deliverables, including acoustic surveys on spawning aggregations.	a) Science requirements b) Advisory Requirements c) Requirements from other EGs	3.1, 3.3	years 1–3	Optimize and harmonise sampling designs and precision estimates for the different surveys to ensure survey quality. HAWG WGWIDE
g(ACOM)	Assess and compare scrutinisation procedures employed for the analysis of raw acoustic data from WGIPS coordinated surveys	a) Science requirements b) Advisory requirements	3.2, 3.3, 4.2	year 1	Documented standardised scrutinisation recommendations; Update of survey manual to address and maintain monitoring requirements for pelagic ecosystem surveys.
h (SCICOM)	Collaborate with groups wishing to utilize available time-series from WGIPS coordinated surveys.	a) Science requirements	3.2	Years 1-3	Facilitate testing and developing forecast models provided by WGS2D and other groups.
i (SCICOM)	Assess developing pelagic ecosystem surveying technology (e.g. optical technology, multi-beam and wideband acoustics) to: (i) achieve monitoring of different ecosystem components, and/or (ii) give input to the development of ecosystem indicators from surveys covered by WGIPS, (iii) continue to support the development of tools to improve the accuracy and precision of survey estimates.	a) Science Requirements b) Advisory Requirements c) Requirements from other EGs	3.1, 3.3, 4.1	years 1–3	Update ecosystem metrics that are collected by WGIPS coordinated surveys; and protocols/recommendations for practical implementation of new technologies.

2 Summary of Work Plan

Year 1	General meeting, preceded by 3 post-cruise meetings which collate data of multinational surveys. 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 standardize scrutinisation procedures for the International Ecosystem Summer Survey in the Norwegian Sea (IESSNS) covered by the WG (WKSCRUT). Inter-sessional work on the review and updates for the WGIPS acoustic manual, followed by a session during the annual meeting to review and provide possible updates for the WGIPS acoustic survey manual. Harmonize changes amongst the different surveys. Develop survey design protocols for acoustic surveys on spawning aggregations for inclusion in the survey manual. Session (mini symposium) to assess auxiliary pelagic ecosystem surveying technology focusing on methods currently used to monitor different ecosystem components across WGIPS coordinated surveys. Session on the future and development of databases (more specifically the ICES acoustic database and the PGNAPES database)
Year 2	General meeting, preceded by 3 post-cruise meetings which collate data of multinational surveys. Session to review and evaluate survey designs across all WGIPS coordinated surveys done in Year 2, and coordinate planning and discuss designs for surveys taking place in Year 3. Inter-sessional work on the review and updates for the WGIPS acoustic manual, followed by a session during the annual meeting to review and provide possible updates for the WGIPS acoustic survey manual. Harmonize changes amongst the different surveys. Develop survey design protocols for acoustic surveys on spawning aggregations for inclusion in the survey manual. Session to assess progress in the implementation of auxiliary pelagic ecosystem surveying technology and methodology (e.g. optical technology, multi-beam and wideband acoustics) for monitoring components of the wider ecosystem in surveys covered by WGIPS. Session on the future and development of databases (more specifically the ICES acoustic database and the PGNAPES database).
Year 3	General meeting, preceded by 3 post-cruise meetings which collate data of multinational surveys. Session to review and evaluate survey designs across all WGIPS coordinated surveys done in Year 3. Inter-sessional work on the review and updates for the WGIPS acoustic manual, followed by a session during the annual meeting to review and provide possible updates for the WGIPS acoustic survey manual. Harmonize changes amongst the different surveys. Develop survey design protocols for acoustic surveys on spawning aggregations for inclusion in the survey manual. Session to assess progress in the implementation of auxiliary pelagic ecosystem surveying technology and methodology (e.g. optical technology, multi-beam and wideband acoustics) for monitoring components of the wider ecosystem in surveys covered by WGIPS. Session on the future and development of databases (more specifically the ICES acoustic database and the PGNAPES database).

3 Supporting Information

Priority	The Group has a very high priority as its members have expertise in design and implementation of acoustic-trawl surveys, including sampling of additional ecosystem parameters. It will therefore directly contribute to the implementation of integrated pelagic ecosystem monitoring programmes in the ICES area. The Group's core task is the standardisation, planning, coordination, implementation, and reporting of acoustic surveys for the main pelagic fish species including herring, sprat, blue whiting, mackerel, and boarfish in Northeast Atlantic waters. The work provides essential data in the form of survey indices to WGWIDE and HAWG in the aim to perform integrated ecosystem assessment.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 20–25 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	WGWIDE, HAWG
Linkages to other committees or groups	There is a very close working relationship with other groups in EOSG, especially relevant links to WGACEGG, WGALES, WGBIFS, WGFAST, WGFTFB, WGISDAA, WGISUR, WGMEGS, WGTC, WGINOR, WGINOSE, WGIAB, WKEVAL, WKMSMAC2, WKSCRUT, WKSUREQ
Linkages to other organizations	EU H2020 project 'AtlantOS'

4 List of Outcomes and Achievements in this delivery period

Indices for the stocks of herring, sprat, mackerel, boarfish, and blue whiting in Northeast Atlantic waters from annual ecosystem surveys are used as fishery-independent data for analytical assessment purposes in HAWG and WGWIDE. The following outcomes and achievements were obtained during this delivery period:

- 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 pro-portion, 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 6.a/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 3.a 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 7.a), autumn spawning herring, numbers, biomass, distribution maturity proportion, mean weight, and length-at-age from the Irish Sea Acoustic Survey (ISAS).
- Irish Sea (area 7.a N), Industry spawning survey of herring biomass and distribution (ISSS)
- 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 Western European Shelf Pelagic Acoustic Survey (WESPAS)
- Celtic Sea herring numbers, biomass, maturity proportion, mean weight, and length-at-age, from the Celtic Sea herring Acoustic Survey (CSHAS)
- 6.a herring numbers, biomass, maturity proportion, mean weight, and length-at-age, from the industry surveys in 6.a.N and 6.a.S
- Blue whiting numbers, biomass, maturity proportion, mean weight, and length-at-age, from PELACUS

Other ecosystem survey-derived operational products:

- Horse Mackerel numbers, biomass, maturity proportion, mean weight, and length-at-age, from WESPAS
- Zooplankton distribution based on dry weight samples from the IESNS, IESSNS and WESPAS surveys.
- Recorded observations of marine mammals during the IESSNS, CSHAS and WESPAS.
- Recorded observations of seabird abundance and distribution during CSHAS, IBWSS and WESPAS surveys

Other outcomes and achievements:

- Comments and input to development of the ICES Acoustic database;
- Overview of new and currently applied auxiliary pelagic ecosystem sampling technologies, including session on ecosystem technologies
- collection of genetic samples on board HERAS/WESPAS surveys for splitting of stocks
- 2020 survey plans (see Annex 16 for 2020 survey plans);
- Contribution to ICES Annual Science Conference
- Contribution to the Topic Group on Collecting Quality Underwater Acoustic Data in Inclement Weather (TGQUAD)
- Continued adoption of a common survey evaluation tool (StoX) across the surveys coordinated within WGIPS and transition to the use of the ICES acoustic database repository
- Continued development of common code to aid survey planning, formatting, quality check, and plot data from acoustic surveys. Continued used of the WGIPS GitHub repository initiated https://github.com/ices-eg/WGIPS
- Workshop on echogram scrutiny on the IESSNS (WKSCRUT2)
- Workshop on survey design for the acoustic surveys on spawning aggregations of herring (WKHASS)
- Contribution to WKMESOMeth; constructed protocol for testing acoustic and sampling of mesopelagics on IBWSS 2020

5 Progress Report on ToRs and work plan

Progress by ToR:

a) Results of different ecosystem surveys conducted in 2019 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.

b) Timing, planning, and methods applied for individual (CSHAS, BFAS, ISAS, ISSS, PELTIC, GERAS and 6a Industry surveys) and coordinated multinational (IBWSS, IESNS, IESSNS, HERAS) surveys were discussed and evaluated.

c) A number of WGIPS coordinated and individual acoustic surveys have already made it into the ICES Acoustic Trawl survey database e.g. HERAS, CSHAS, WESPAS, PELTIC IBWSS (IRL and NED) and 6.aN Industry survey (6.aSPAWN). Under this TOR, the group will keep following the progress for the rest of the surveys coordinated by WGIPS. In 2019, WKHASS recommended that the Irish Sea surveys be uploaded to the ICES DB.
There are on-going compatibility issues with the .xml files that are extracted from both the ICES DB and PGNAPES databases. StoX currently cannot handle .xml files from both databases when combined in one project. It would be preferable if files from either database could be used in the StoX project for the IBWSS, IESNS and IESSNS. It is also important that there is one agreed procedure going forward for all participants of these internationally coordinated surveys. At the IBWSS post-cruise meeting in Galway in 2019 and again at the WGIPS meeting in 2020, it was agreed that all participating countries would upload to the ICES database and the PGNAPES database in 2020. Therefore both .xml formats can be used within two StoX projects at the post-cruise meetings in 2020. A comparison can be made between the StoX projects using both formats. There is support within all members of the group that participate in the international surveys to use the ICES database in the future, however, there is still concern about how hydrographic data is stored in and processed from this database. There is also concern about the extra time needed to produce data in the format for the ICES database, which is new to some participants.

Table 1. Progress of adopting the ICES DB and StoX for the individual surveys with the following columns:

Survey	Database (ICES or other)	Abundance estimation software (StoX or other)
Herring Acoustic Survey (HERAS)	Biological and acoustic files in ICES DB	StoX
Malin Shelf Acoustic Survey (MSAS)	Biological and acoustic files in ICES DB	StoX
West of Scotland acoustic survey (WoS)	Biological and acoustic files in ICES DB	StoX
6.a/7.b/c Industry herring acoustic survey(6.aSPAWN)	6.a.N and 6.a.S biological and acoustic files in ICES DB from 2018.	StoX
GERAS	Access database/Preparation of uploading files to ICES DB	GERIBAS II
ISSS	National SQL database	R-scripts
ISAS	National SQL database	R-scripts

WESPAS	Biological and acoustic files in ICES DB	StoX
PELTIC	Biological and acoustic files in ICES DB	EchoR, StoX
IBWSS	PGNAPES & ICES Database	StoX
IESSNS	PGNAPES	StoX
IESNS	PGNAPES & ICES Database	StoX
CSHAS	Biological and acoustic files in ICES DB	StoX

d) The SISP manual will be updated inter-sessionally. Outstanding tasks have been allocated to relevant WGIPS members. Additions to the manual as a result of WKSCRUT2 will be made in 2020. The recommendation from WKHASS in 2019 is that the spawning survey for herring in 7.a should be added to the manual in 2020.

e) WGIPS 2020 discussed the results from the 2 workshops held in 2019 (WKSCRUT2 and WKHASS). Recommendations from both workshops were agreed and will be progressed in 2020. The manual SISP 9 will be updated inter-sessionally to reflect the results from both workshops. It was agreed by the group that scrutinisation procedures need to be scientifically reviewed periodically within WGIPS for all acoustic surveys.

f) The WKHASS workshop in 2019 specifically dealt with issues of survey design on the spawning surveys on herring in 6.a and 7.a. WKHASS recommended that the spawning survey on herring in the Irish Sea (7.a) should be included in the SISP 9 manual. The spawning surveys in 6.a. are still undergoing design changes and require further work. WKHASS recommended that the ICES Acoustic trawl surveys database hosts acoustic and biological data from the herring acoustic spawning surveys in 6a and 7a. WKHASS also recommends that estimations of biomass and abundance is compared with the WGIPS standard StoX methods, where in-house methods are currently used.

g) A workshop on acoustic scrutinising procedures for the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) was recommended by the WGIPS in 2019 and held in Bergen 17-18 Sep. 2019. Participants (13) from all nations participating in the IESSNS attended the workshop. The IESSNS targets mackerel, herring and blue whiting during their summer feeding migration in the Nordic Seas. However, mackerel is estimated by standardized swept-area trawl method while herring and blue whiting are estimated using standard acoustic methods. Hence the scrutinising of herring and blue whiting were the main focus of the workshop. The group defined three areas with typical and common acoustic backscatter features within the total survey area covered by IESSNS: The Irminger Sea including East Greenland and West Iceland, the Norwegian Sea and adjacent areas including Iceland Sea and the area around the Faroes, and shelf areas. Further, two general procedures were also presented; the first was how to separate herring from plankton (the "threshold" method and the "200 kHz" method), and the second how to deal with the acoustic backscatter in the upper layers in years when strong year-classes of blue whiting occur in the survey area (that resemble small herring schools). Several examples were analysed in the report and showed that all participants used the same general procedure during the scrutinising process. However, some minor adjustments were done by individual participants to ensure that a common identical procedure was followed by the whole group, as shown by the examples in the report.

h) The IBWSS facilitates testing and developing forecast models provided by WGS2D (blue whiting spawning habitat forecast). Isidora Katara (CEFAS) presented results from work on species distribution models and essential fish habitat in European waters and has proposed collaborating in the future with WGIPS and specifically the acoustic data held on the ICES DB.

i) Increasingly, complimentary data outside of the more traditional sources such as CTD and supplementary biological data are collected. Visual abundance surveys for marine mammals and seabirds are becoming increasingly common, as are zooplankton sampling (dry weight), in-trawl optics and broadband acoustic and sonar data. Annually, the group report these additional data sources within the Ecosystem index overview table. Currently such additional data sources are collected in a somewhat ad hoc fashion by national institutes. To provide meaningful on-going ecosystem metrics a more coordinated approach is required within the group. The first part of this process is to identify the end user and specific requirements. For this to be achieved successfully then support from outside this group is required to:

- Determine the final end user group, what is the (primary) use of these data?
- prioritise data types and metrics
- determine protocols and methods to provide a coordinated collection program
- define metadata standards and a data repository for these data
- identification of the costs, where applicable, and potential funding sources
- determine feedback process from final end user group

The group recognises their unique position to be able to provide ecosystem data sources alongside more traditional survey outputs and are willing to engage in a structured collection process. To this end, the group looks forward to future engagement with other expert groups.

6 Recommendations issued to WGIPS from other Working Groups

Recommendations issued to WGIPS from other working groups in 2019

Recommendation	Addressed to
ID 67 WKMESOMeth recommends that relevant survey groups within WGIPS (IBWSS, IESSNS, IESNS) are allocated time during WGIPS annual meetings in 2020-2021 to develop protocols for reporting of mesopelagic fish abundance.	WGIPS
ID 67 Reply: Annex 18	

Recommendation	Addressed to
ID 129 WGWIDE recommends undertaking feasibility study with regard to surveys conducted in summer south of 60N to potentially extend swept area coverage outside the southern boundary of the current IESSNS-survey. Annex	WGIPS
ID 129 Reply: Annex 19	

7 Cooperation with Advisory Structures

HAWG

Indices for the stocks of herring and sprat in North-east Atlantic waters from annual ecosystem surveys are used as fishery-independent data for analytical assessment purposes in HAWG. Communication between HAWG and WGIPS is strengthened through overlap in memberships of the two groups as well as the delivery of survey summary reports from WGIPS to stock assessors and the return of these to WGIPS with comments from stock assessors.

WGWIDE

Indices for the stocks of herring, mackerel, boarfish, and blue whiting in North-east Atlantic waters from annual ecosystem surveys are used as fishery-independent data for analytical assessment purposes in WGWIDE.

WKREO

The group considered the preliminary results of Workshop on the Realigning of the Ecosystem Observation Steering Group (WKREO). This group reviewed the current tasks of the multi-annual data collection expert groups, develop options for reorganizing Ecosystem Observation Steering Group (EOSG's) expert groups that can effectively conduct the essential tasks and evaluate different reorganisation options for EOSG to identify the potential for issues.

WKREO proposes to realign the EG's on data collection from the current situation – with groups covering specific techniques – towards regional data collection groups that look at specific ecosystems.

WGIPS supports this proposal as in general a greater ecosystem perspective is required. It is in line with the WGIPS recommendation from 2019 to requests guidance from SCICOM to identify ecosystem metrics that can be routinely collected during surveys coordinated by the group. However - in contrast to the expectations as expressed by WKREO in its preliminary report – WGIPS does not expect the proposed scheme will lead to less meetings as international acoustic surveys will require the same planning and coordination as before.

ICES Acoustic Trawl Survey Data Portal

Since 2015 the ICES Data Centre has been developing ICES Acoustic Trawl Survey database and portal http://acoustic.ices.dk as part of the AtlantOS project (2015-2019). WGIPS have been involved in the development by giving input to the data structure and workflow, amongst others through several survey-specific and general work-shops, i.e. the Workshop on Evaluating Current National Abundance Estimation Methods for HERAS Surveys (WKEVAL) and the Workshop on the Review of the ICES acoustic-trawl survey database design (WKIACTDB). Additional input came from the yearly WGIPS and survey post-cruise meetings.

The Acoustic Trawl Survey Data Portal is now in production being maintained and several WGIPS coordinated surveys are now actively using the database i.e. HERAS, CSHAS, WESPAS, CLYDAS, 6aSPAWN and partly IBWSS and IESNS. More is expected to come.

8 Revisions to the Work Plan

WGIPS recommends support is provided by the ICES data centre at the WGIPS meeting in 2021 to start using the ICES Transparent Assessment Framework (ICES TAF) for documenting and archiving the estimation process of indices from the coordinated surveys.

To facilitate the adoption of the ICES TAF for documenting the survey estimates, WGIPS asks if ICES could provide support with training in the system during the next WGIPS meeting (January 2021, Belfast) and suggests 1/2 day be set aside for a demonstration and hands-on support to those surveys that are ready to start this process.

Background:

Many of the surveys coordinated in WGIPS have already adopted the ICES Acoustic Trawl Survey database for data storage (http://www.ices.dk/marine-data/data-portals/Pages/acoustic.aspx) and the StoX software (https://www.hi.no/hi/forskning/prosjekter/stox) for the estimation process. This makes it an easy step to adopt ICES TAF to fully document all data processing steps from version control of the data extracted from the database to the production of estimates in StoX and any additional data processing performed on data to deliver the final index to the assessment. WGIPS has been discussing the need for a practical, secure and future proof way to archive the final agreed StoX projects from each survey and scripting the full estimation process including StoX estimation on the ICES TAF would address this.

Although not all surveys will be ready to go onto the ICES TAF immediately it would be helpful to get the process started with the aim to get as many of the surveys onto the ICES TAF during the next WGIPS reporting period (2022 - 2024).

Annex 1: List of participants

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Annex 2: Resolutions

There are no resolutions put forward by WGIPS in 2020, however, in response to a recommendation (129) from WGWIDE, WGIPS requests that a workshop be held in 2021 do deal with the complex issues raised in this recommendation. WGIPS awaits a response from WGWIDE for this request.

Annex 3: 2019 IBWSS Survey Summary Table and Survey Report

Document 3a: IBWSS 2019 survey summary table

Survey Summary table WGIPS 2020	
Name of the survey (abbreviation):	International blue whiting spawning stock survey (IBWSS)
Target Species:	Blue whiting
Survey dates:	18 March – 11 April 2019
Summary:	
The International Blue Whiting Spawning stock survey was carried out over 24 days and thus slightly more than the recommended 21 day time window agreed by the group. Weather conditions were mixed with both good and bad periods. All vessels experienced poor weather conditions at some point during the survey, resulting in slower transect speeds.The total area surveyed was comparable but lower than in 2018. Corresponding acoustic sampling effort (transect miles) increased. Reduced area coverage can be accounted by the lack of blue whiting in western peripheral areas (stratum 5-Rockall). Acoustic sampling increased due to the presence of the RV Miguel Oliver and her coverage of the Porcupine sea bight. Coverage in the sea bight can be considered a new extension of the total survey area and is necessary to contain the stock in its southern boundary. The survey in 2019 shows an increase in total stock biomass of 4% with a corresponding decrease in total abundance of 9% when compared to the 2018 estimate. The estimated uncertainty around the total stock biomass was higher than last year, CV=0.17 compared to 0.13. The stock biomass within the survey area was dominated by 4, 5 and 6-year-old fish contributing 82% of total stock biomass. The proportion of immature fish (1 year old) in the 2018 estimate represent 0.7% of the TSB and 2.9% of TSN, which is much lower than last year. Survey effort, timing and area coverage were comparable to previous years and the same vessel and sampling equipment (transducers and trawl) were used.	
	Description
Survey design	Stratified systematic parallel design (15 - 35 nmi spacing) with randomised start point. Adaptive surveying was used in border areas to the west where blue whiting spawning concentrations disappear. Zigzag design in stratum 2 (the northern slope of Porcupine)
Index Calculation method	StoX (via the PGNAPES database)

Random/systematic error issues	NA, outside of those already described in literature for standardised acoustic surveys
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	Yes, in poor weather conditions three of the four vessels use a drop keel and minimum integration is at 12 m
Extinction (shadowing)	Some issues on the shelf break but considered minor
Blind zone	NA, blue whiting distributed in deeper layers
Dead zone	Some issues on the shelf break but considered minor
Allocation of backscatter to species	Directed trawling for verification and species composition purposes and age structure.
Target strength	TS = 20 log10 (L) - 65.2 Pedersen et al. 2011
Calibration	All survey frequencies were calibrated and results were within recommended tolerances
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	The 2019 estimate of abundance is considered as robust. Good stock containment was achieved for both core and peripheral strata.
Stock ID and mixing issues	*No issues*
Measures of uncertainty (CV)	Estimated uncertainty around the total stock biomass was higher than last year, CV=0.17 compared to 0.13.
Biological sampling	Sampling levels was considered representative and well distributed across strata, in line with previous years.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*

Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

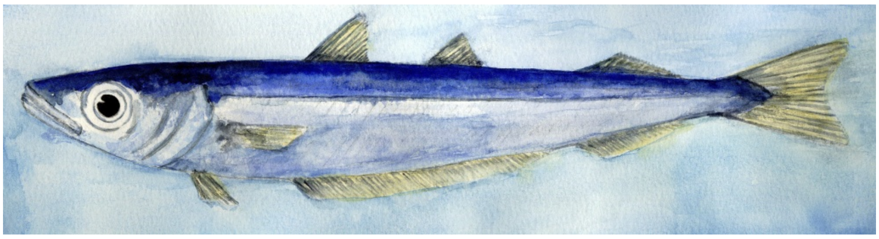
Document 3b: IBWSS 2019 survey report

Please see the report on the next page.

Working Document

Working Group on International Pelagic Surveys
Bergen, Norway, January 2020

Working Group on Widely Distributed Stocks
Tenerife, Spain, August 2019



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS) SPRING 2019

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Material and methods

Survey planning and Coordination

Coordination of the survey was initiated at the meeting of the Working Group on International Pelagic Surveys (WGIPS) in January 2019 and continued by correspondence until the start of the survey. During the survey effort was refined and adjusted by the survey coordinator (Norway) using real time observations. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Celtic Explorer	Marine Institute, Ireland	28/3 – 11/4
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	29/3 – 08/4
Tridens	Wageningen Marine Research, the Netherlands	19/3 – 02/4
Kings Bay	Institute of Marine Research, Norway	25/3 – 07/4
Miguel Oliver	Spanish Institute of Oceanography, Spain	18/3 – 21/3

The survey design was based on methods described in ICES Manual for International Pelagic Surveys (ICES, 2015). Overall weather conditions were mixed with periods of poor and good weather. All vessels experienced some downtime due to poor weather conditions. The entire survey was completed in 26 days, above the 21-day target threshold. However, the survey start was delayed by almost one week compared to 2018 and included additional effort by the Spanish survey in the Porcupine Sea bight.

Cruise tracks and survey strata are shown in Figure 1. Trawl stations for each participant vessel are shown in Figure 2 and CTD stations in Figure 3. All vessels worked in a northerly direction with the exception of the Faroes (Figure 4). Communication between vessels occurred daily via email to the coordinator (Norway) exchanging up to date information on blue whiting distribution, echograms, fleet activity and biological information.

Sampling equipment

Vessels employed a midwater trawl for biological sampling, the properties of which are given in Table 1. Acoustic equipment for data collection and processing are presented in Table 2. Survey abundance estimates are based on acoustic data collected from calibrated scientific echo sounders using an operating frequency of 38 kHz. All transducers were calibrated using a standardised sphere calibration (Demer et al. 2015) prior, during or directly after the survey. Acoustic settings by vessel are summarised in Table 2.

Biological sampling

All components of the trawl haul catch were sorted and weighed; fish and other taxa were identified to species level. The level of biological sampling by vessel is shown in Table 3.

Hydrographic sampling

Hydrographic sampling (vertical CTD casts) was carried out by each vessel at predetermined locations (Figure 3 and Table 3). Depth was capped at a maximum depth of 1000 m in open water. Not all pre-planned CTD stations were undertaken due to weather restrictions.

Plankton sampling

Plankton sampling by way of vertical WP2 casts were carried out by the Magnus Heinason (FO) to a depth of 200 m (Table 3).

Acoustic data processing

Echogram scrutinisation was carried out by experienced personnel, with the aid of trawl composition information. Post-processing software and procedures differed among the vessels;

On Celtic Explorer, acoustic data were backed up every 24 hrs and scrutinised using EchoView (V 9.0) post-processing software for the previous days work. Data was partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species (daylight only) and blue whiting.

On Magnus Heinason, acoustic data were scrutinised every 24 hrs on board using EchoView (V 9.0) post processing software. Data were partitioned into the following categories: plankton (<200 m depth layer), pearlside and mesopelagic species, blue whiting and krill (krill/mesopelagics). Partitioning of data into the above categories was based on trawl samples and acoustic characteristics on the echograms.

On Tridens, acoustic data were backed up continuously and scrutinised every 24 hrs using the Large Scale Survey System LSSS (2.5.0) post-processing software. Blue whiting were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

On Kings Bay, the acoustic recordings were scrutinized using LSSS (V. 2.5.0) once or twice per day. Data was partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

On Miguel Oliver, acoustic data were scrutinised every 24 hrs on board using EchoView (V 9.0) post processing software. Data were partitioned into the following categories: Müeller's pearlside, blue whiting and mesopelagic layer (mainly composed by krill and other mesopelagic fish species). Partitioning of data into the above categories was based on trawl samples and acoustic characteristics on the echograms.

Acoustic data analysis

Acoustic data were analysed using the StoX software package (V 2.7), as the standard adopted for WGIPS coordinated surveys. A description of StoX can be found here: http://www.imr.no/forskning /prosjekter/stox/nb-no. Estimation of abundance from acoustic surveys with StoX is carried out according to the stratified transect design model developed by Jolly and Hampton (1990). Baseline survey strata, established in 2017, were adjusted based on survey effort and observations in 2018 (Figure 1). The strata and transects used are shown in Figure 1 and 5. Length and weight data from trawl samples were equally weighted and applied across all transects within a given stratum (Figure 5).

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) is used:

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

In StoX a super-individual table is produced where abundance is linked to population parameters including age, length, weight, sex, maturity etc. This table is used to split the total abundance estimate by any combination of population parameters. The StoX project folder for 2019 is available on request.

Estimate of relative sampling error

For the baseline run, StoX estimates the number of individuals by length group which are further grouped into population characteristics such as numbers at age and sex.

A total length distribution is calculated, by transect, using all the trawl stations assigned to the individual transects. Conversion from NASC (by transect) to mean density by length group by stratum uses the calculated length distribution and a standard target strength equation with user defined parameters. Thereafter, the mean density by stratum is estimated by using a standard weighted mean function, where each transect density is weighted by transect distance. The number of individuals by stratum is given as the product of stratum area and area density.

The bootstrap procedure to estimate the coefficient of variance (RStoX V1.11) randomly replaces transects and trawl stations within a stratum on each successive run. The output of all the runs is stored in a RData-file, which is used to calculate the relative sampling error.

Results

Distribution of blue whiting

In total 7,610 nmi (nautical miles) of survey transects were completed across six strata, relating to an overall geographical coverage of 121,397 nmi² (Figure 1, Tables 3). The acoustic sampling effort area increased in 2019 to include the Porcupine sea bight area. Otherwise area coverage was comparable to 2018 (Table 7). The stock was considered well contained within core and peripheral abundance areas (Rockall Bank and south Porcupine Bank). The distribution of blue whiting as observed during the survey is shown in Figures 6 and 7.

The bulk of the stock in 2019 was located in the 3 strata that covers the shelf edge area (Strata 1, 2 and 3) accounting for 95% of total biomass (Table 4). The Rockall Trough area alone (strata 3) accounted for 61% of the overall survey estimate; this is at a similar level to the two previous years. The Porcupine Bank (strata 2) increased by 57% and contained 21% of the stock compared to 13% in 2018. The three strata outside the core shelf edge area (stratum 4, 5, and 6) collectively decreased from around 12% in 2018 to 5% in 2019 (Table 4). The Rockall and Hatton Bank area (strata 5) contributed just 0.7% of the overall biomass of blue whiting in 2019, down from 4% in 2018. A decrease in salinity and temperature observed in 2017 persists through 2018 and 2019 (see next section).

The two northernmost strata (South Faroes (strata 4) and Shetland Channel (strata 6) accounted for the remaining 4.1% of the biomass (Table 4).

The highest s_A value (98,698 m²/nmi² - sampling unit: one nautical mile) observed in the survey in 2019 was recorded by FV *Kings Bay* on the northern slope of Porcupine Bank in strata 2 (Figure 8a). An example of a typical high density layer of blue whiting observed in the Rockall Trough strata is shown in Figure 8b. A weak layer of blue whiting from the Rockall Bank strata is shown in Figure 8c. Juvenile blue whiting were mainly observed in the northern stratum (South Faroes and Faroe – Shetland Channel) and an example echogram is shown in Figure 8d. High density blue whiting registrations were observed in the Porcupine Sea bight by the RV *Miguel Oliver* (Figure 8e & 8f).

The vertical distribution of blue whiting observed in 2019 did not extend deeper than 750 m as observed in 2018. However, schools in the Porcupine sea bight were observed down to a depth of 600 m.

Stock size

The estimated total biomass of blue whiting for the 2019 international survey was 4.2 million tonnes, representing an abundance of 36.9×10^9 individuals (Table 4). Spawning stock was estimated at 4.17 million tonnes and 35.8×10^9 individuals (Table 5).

Stock composition

Individuals of ages 1 to 13 years were observed during the survey.

The main contribution (82%) to the spawning stock biomass were the age groups 4, 5 and 6 with the five year olds (2014 year-class) being most abundant (47%), followed by the 2015 year-class (24%) and 2013 year-class (11%) (Table 5).

The highest mean weights of blue whiting were caught in the northern part of the Rockall Trough stratum 3 (Figures 9 and 10). Highest mean weight in 2019 was in strata 3 representing 121g.

Five year olds (the 2014 year-class) were dominant in all strata with the exception of strata 4 (south Faroes) and strata 6 (Faroe/Shetland Channel), where 1 year olds ranked highest (Figure 12). The proportion of 1 and 2-year-old fish was low in the total estimate in 2019 (Figure 13).

An uncertainty estimate at age based on a comparison of the abundance estimates was calculated for IBWSS for years 2017, 2018 and 2019 using StoX (Figure 11). By comparing the estimates of young year classes from 2017 to 2019 it appears that good cohort tracking is achieved in the survey for some year classes. For example, the relative abundance of two year olds in 2016 (2014-year class) was high; the strong abundance of this cohort is also seen in 2017 as three year olds, in 2018 as four year olds, and in 2019 as five year olds. Similarly, the 2015 year-class were picked up as two year olds in 2017, and subsequently the three and four year olds in 2018 and 2019 respectively are relatively strong. The CV of the abundant age groups 3 to 6 was below 0.25 in 2019 (Figure 11).

The CV of the total estimate of both biomass and abundance were 0.17, which is higher than last year (0.125) and slightly higher than the years before when the CV varied around 0.16.

The survey time series (2004-2019) of TSN and TSB are presented in Figures 14 and 15 respectively and Table 6.

Hydrography

A total of 118 CTD casts were undertaken over the course of the survey (Table 1). Horizontal plots of temperature and salinity at depths of 50 m, 100 m, 200 m and 500 m as derived from vertical CTD casts are displayed in Figures 16-19 respectively. A decrease in salinity and temperature observed in 2017 persists through 2018 and 2019. This is thought to limit the western extent of the blue whiting spawning distribution on the Rockall and Hatton Bank areas (Hátún *et al.* 2009).

Concluding remarks

Main results

- Weather conditions were mixed with both good and bad periods. All vessels experienced poor weather conditions at some point during the survey, resulting in slower transect speeds.
- The total area surveyed was comparable but lower than in 2018. Corresponding acoustic sampling effort (transect miles) increased. Reduced area coverage can be accounted by the lack of blue whiting in western peripheral areas (stratum 5- Rockall). Acoustic sampling increased due to the presence of the RV *Miguel Oliver* and her coverage of the Porcupine sea bight. Coverage in the sea bight can be considered a new extension of the total survey area and is necessary to contain the stock in its southern boundary.
- Overall, biological sampling saw an increased number of measured fish but a lower number of aged individuals compared to 2018.
- The International Blue Whiting Spawning Stock Survey 2019 shows an increase in total stock biomass of 4% with a corresponding decrease in total abundance of 9% when compared to the 2018 estimate.
- The survey was carried out over 26 days, above the 21-day time window target. These additional days can be accounted for the by the delayed start of the RV *Celtic Explorer* compared to previous years.
- Estimated uncertainty around the total stock biomass was higher than last year, CV=0.17 compared to 0.13.
- The stock biomass within the survey area was dominated by 4, 5 and 6-year-old fish contributing 82% of total stock biomass.
- There was no evidence of blue whiting below 750 m
- Immature fish (1-year-old) represent 0.7% of the TSB and 2.9% of TSN.

Interpretation of the results

- The group considers the 2019 estimate of abundance as robust. Good stock containment was achieved for both core and peripheral strata. Sampling effort (biological and acoustic), was comparable to previous years.
- Total stock biomass observed in 2019 is the highest in the overall time series (2004-present). Representing an increase in TSB of 4% compared to 2018 (4.0 mt and 4.2 mt respectively). The 2014-year class (5 year old fish) accounts for approximately 46% of the TSB and almost 2 million tons. This year class is the largest observed in the survey time series.
- The bulk of SSB was distributed from the northern edge of the Porcupine Bank and continued northwards through the Rockall Trough and up to the Hebrides.
- The Northern migratory stock and the Porcupine sea bight; Spatio-temporal survey data and biological data from trawl hauls (RV *Tridens* and RV *Miguel Oliver*) were comparable in terms of length cohorts. The eastward extension of the survey area is necessary to contain the northern stock. Comparative analysis of age readings is required.

Recommendations

- The group recommends that coverage in the western Rockall/Hatton Bank (stratum 5) should be carried out based on real time observations. That is, effort should not be expended where no aggregations are evident and transects are terminated when no blue whiting is observed for 15 nmi consistent 'clear water' miles. This applies to peripheral regions to the west of the Rockall and Hatton Bank areas.

- To facilitate the process of calculating global biomass the group requires that all data be made available at least 72 hours in advance of the meeting start date.
- The group recommends that the process of producing output reporting tables, figures and maps from StoX outputs files is standardised through scripting routines and developed by WGIPS for wider use.
- To facilitate the above process, we request that StoX developers look into the possibility of fixing the format of output tables of biomass and abundance to aid this process. Currently zero values in biomass and abundance tables (age and lengths) are omitted.
- Current XML file formats generated from ICES or PGNAPES data repositories are not cross compatible for combined use in StoX due to differences in formatting. As the group diverges from using PGNAPES as the sole data repository to using the ICES acoustic database members need to be clear during the planning phase on which repository they intend to use going forward. This issue requires attention during WGIPS in 2020 so as not to disrupt the process of global abundance estimation in 2020.
- It is recommended that all participants produce files types in both ICES and PGNAPES file formats for the 2020 post cruise meeting to facilitate cross compatibility testing within StoX.

Achievements

- The Porcupine sea bight was covered synoptically, in close temporal progression by two survey vessels.
- Acoustic sampling effort (track miles), trawling effort and biological metrics of blue whiting were comparable to 2018.

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Table 1. Country and vessel specific details, IBWSS March-April 2019.

	Celtic Explorer	Magnus Heinason	Tridens	Kings Bay	Miguel Oliver
Trawl dimensions					
Circumference (m)	768	640	860	832	752
Vertical opening (m)	50	42-45	30-70	45	30
Mesh size in codend (mm)	20	40	40	40	20
Typical towing speed (kn)	3.5-4.0	3.2-3.6	3.5-4.0	3.5-4.0	3.5-4.0
Plankton sampling	-	16	-	-	
Sampling net	-	WP2 plankton net	-	-	
Standard sampling depth (m)	-	200	-	-	
Hydrographic sampling					
CTD Unit	SBE911	SBE911	SBE911	SBE25	SBE25
Standard sampling depth (m)	1000	1000	1000	900	520

Table 2. Acoustic instruments and settings for the primary frequency, IBWSS March-April 2019.

	Celtic Explorer	Magnus Heinason	Tridens	Kings Bay	Miguel Oliver
Echo sounder	Simrad EK 60	Simrad EK60	Simrad EK 60	Simrad EK 80	Simrad EK 60
Frequency (kHz)	**38**, 18, 120, 200	**38**, 200	18, **38**, 70, 120, 200, 333	18, **38**, 70	**38**, 18, 70, 120, 200
Primary transducer	ES 38B	ES 38B	ES 38B	ES 38B	ES 38B
Transducer installation	Drop keel	Hull	Drop keel	Drop keel	Hull
Transducer depth (m)	8.7	3	8	8.5	6.5
Upper integration limit (m)	15	7	15	15	15
Absorption coeff. (dB/km)	9.9	10.1	9.5	9.59	9.2
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	2.43	2.43	2.43
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	23	21.9
2-way beam angle (dB)	-20.6	-20.8	-20.6	-20.7	-20.6
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.85	25.64	26.52	24.06	24.68
s_A correction (dB)	-0.64	-0.66	-0.76	0.008	-0.54
3 dB beam width (dg)					
alongship:	6.87	7.02	6.79	7.0	6.90
athw. ship:	6.91	7.00	6.81	7.0	7.10
Maximum range (m)	750	750	750	750	1000
Post processing software	Echoview	Echoview	LSSS	LSSS	Echoview

Table 3. Survey effort by vessel, IBWSS March-April 2019.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton sampling WP2-net	Aged fish	Length-measured fish
Celtic Explorer	28/3-11/4	2282	7	24	-	350	3001
Magnus Heinason	29/3-8/4	1400	6	19	17	300	668
Kings Bay	25/3- 7/4	2185	11	27	-	330	1,091
Tridens	19/3-2/4	1473	10	28	-	798	800
Miguel Oliver	18/3-21/3	270	4	20	-	160	668
Total	28/3-11/4	7610	38	118	17	1938	6228

Table 4. Abundance and biomass estimates of blue whiting by strata in 2019 and 2018. IBWSS March-April 2019.

		2019				2018				Difference 2019-2018	
Strata	Name	TSB (10^3 t)	TSN (10^9)	% TSB	% TSN	TSB (10^3 t)	TSN (10^9)	% TSB	% TSN	TSB	TSN
1	Porcupine Bank	870	8,350	20.7	22.6	534	5,519	13.2	13.6	57%	66%
2	N Porcupine Bank	572	5,692	13.6	15.4	521	5,599	12.9	13.8	6%	12%
3	Rockall Trough	2,555	21,116	60.9	57.2	2,475	24,708	61.4	60.9	-1%	-6%
4	South Faroes	125	1,039	3.0	2.8	164	1,604	4.1	4.0	-27%	-29%
5	Rockall Bank	29	272	0.7	0.7	179	1,835	4.4	4.5	-85%	-84%
6	Faroe/Shetland Ch.	47	448	1.1	1.2	162	1,336	4.0	3.3	-72%	-63%
	Total	4,198	36,918	100	100	4,035	40,602	100	100	4%	-9%

Table 5. Survey stock estimate of blue whiting, IBWSS March-April 2019.

					Age in years (year class)					Number	Biomass	Mean	Prop
Length	1	2	3	4	5	6	7	8	9	10+		weight	Mature
(cm)	2018	2017	2016	2015	2014	2013	2012	2011	2010		(10^6)	(10^6 kg)	(g)	
16-17	11										11	0.3	28	0
17-18	50										50	1.6	31	0
18-19	184										184	6.1	33	50
19-20	233										233	8.2	35	16
20-21	291										291	13.5	46	23
21-22	173										173	8.8	51	21
22-23	82	19	4								104	6.5	62	46
23-24	81	89	2								172	11.6	67	59
24-25	35	380	113								528	38.3	73	95
25-26		475	467	281	638	101					1,962	164.0	84	100
26-27		146	948	2,125	2,069	209					5,497	506.0	92	100
27-28		43	1,038	2,589	3,514	574					7,759	787.1	101	100
28-29		14	421	2,348	4,765	406	31	7			7,991	889.8	111	100
29-30		3	182	921	2,853	666	28		7		4,660	579.3	124	100
30-31			150	862	1,651	669	103	37			3,473	480.0	138	100
31-32				380	758	257	170				1,564	244.7	156	100
32-33			144	63	442	79	40	195		18	982	181.9	185	100
33-34				20	97	336	47	114			614	113.2	184	100
34-35					109	86	26	42		5	269	57.5	214	100
35-36					68	2		65		2	137	32.6	238	100
36-37							15		74	12	101	21.8	215	100
37-38						22		41	11	6	80	21.9	274	100
38-39					14	18		13			46	10.0	218	100
39-40							24				24	7.7	316	100
40-41											0		-	100
41-42						8					8	3.1	372	100
43-44									6		6	2.4	397	100
TSN(mill)	1,129	1,169	3,468	9,590	16,979	3,434	484	513	99	144	36,918			
TSB(1000 t)	51.7	94.4	358.2	1,025.1	1,962.1	463.3	81.4	131.4	20.6	38.2	4,197.6			
Mean length(cm)	20.1	25.0	27.1	27.9	28.4	29.5	31.7	33.4	36.2					
Mean weight(g)	46	81	103	107	116	135	168	256	209					
% Mature	8	99	98	100	100	100	100	100	100	100				
SSB (1000kg)	4.3	93.4	349.5	1024.5	1961.4	463.3	81.4	131.4	20.6	38.2	4168.0			
SSN (mill)	93	1156	3384	9584	16973	3434	484	513	99	144	35862.1			

Table 6. Time series of StoX abundance estimates of blue whiting (millions) by age in the IBWSS. Total biomass in last column (1000 t).

Year	Age 1	2	3	4	5	6	7	8	9	10+	TSB
2004	1,097	5,538	13,062	15,134	5,119	1,086	994	593	164		3,505
2005	2,129	1,413	5,601	7,780	8,500	2,925	632	280	129	23	2,513
2006	2,512	2,222	10,858	11,677	4,713	2,717	923	352	198	31	3,512
2007	468	706	5,241	11,244	8,437	3,155	1,110	456	123	58	3,274
2008	337	523	1,451	6,642	6,722	3,869	1,715	1,028	269	284	2,639
2009	275	329	360	1,292	3,739	3,457	1,636	587	250	162	1,599
2010*											
2011	312	1,361	1,135	930	1,043	1,712	2,170	2,422	1,298	250	1,826
2012	1,141	1,818	6,464	1,022	596	1,420	2,231	1,785	1,256	1,022	2,355
2013	586	1,346	6,183	7,197	2,933	1,280	1,306	1,396	927	1,670	3,107
2014	4,183	1,491	5,239	8,420	10,202	2,754	772	577	899	1,585	3,337
2015	3,255	4,565	1,888	3,630	1,792	465	173	108	206	247	1,403
2016	2,745	7,893	10,164	6,274	4,687	1,539	413	133	235	256	2,873
2017	275	2,180	15,939	10,196	3,621	1,711	900	75	66	144	3,135
2018	836	628	6,615	21,490	7,692	2,187	755	188	72	144	4,035
2019	1,129	1,169	3,468	9,590	16,979	3,434	484	513	99	144	4,198

*Survey discarded.

Table 7. Survey effort in the IBWSS.

Survey effort	Survey area (nmi²)	Transect n. miles (nmi)	Trawls	CTDs	Plankton	Bio sampling (WHB) Measured	Aged
2004	149 000		76	196			
2005	172 000	12 385	111	248	-	29 935	4 623
2006	170 000	10 393	95	201	-	7 211	2 731
2007	135 000	6 455	52	92		5 367	2 037
2008	127 000	9 173	68	161	-	10 045	3 636
2009	133 900	9 798	78	160	-	11 460	3 265
2010	109 320	9 015	62	174	-	8 057	2 617
2011	68 851	6 470	52	140	16	3 810	1 794
2012	88 746	8 629	69	150	47	8 597	3 194
2013	87 895	7 456	44	130	21	7 044	3 004
2014	125 319	8 231	52	167	59	7 728	3 292
2015	123 840	7 436	48	139	39	8 037	2 423
2016*	134 429	6 257	45	110	47	5 390	2 441
2017	135 085	6 105	46	100	33	5 269	2 477
2018	128, 030	7 296	49	101	45	5 315	2 619
2019	121, 397	7, 610	38	118	17	6 228	1 938

* End of Russian participation.

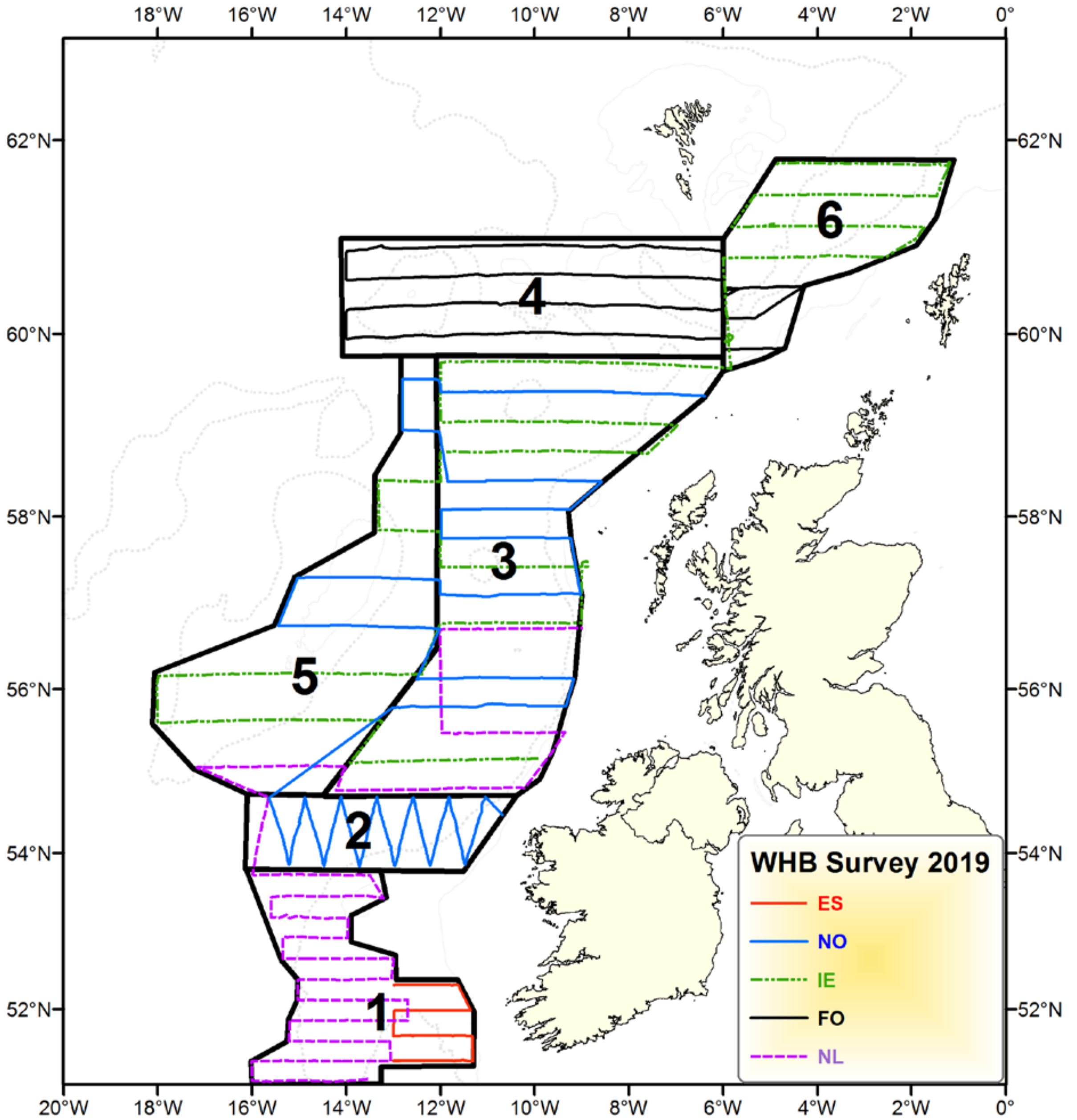


Figure 1. Strata and cruise tracks for the individual vessels (country) during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2019.

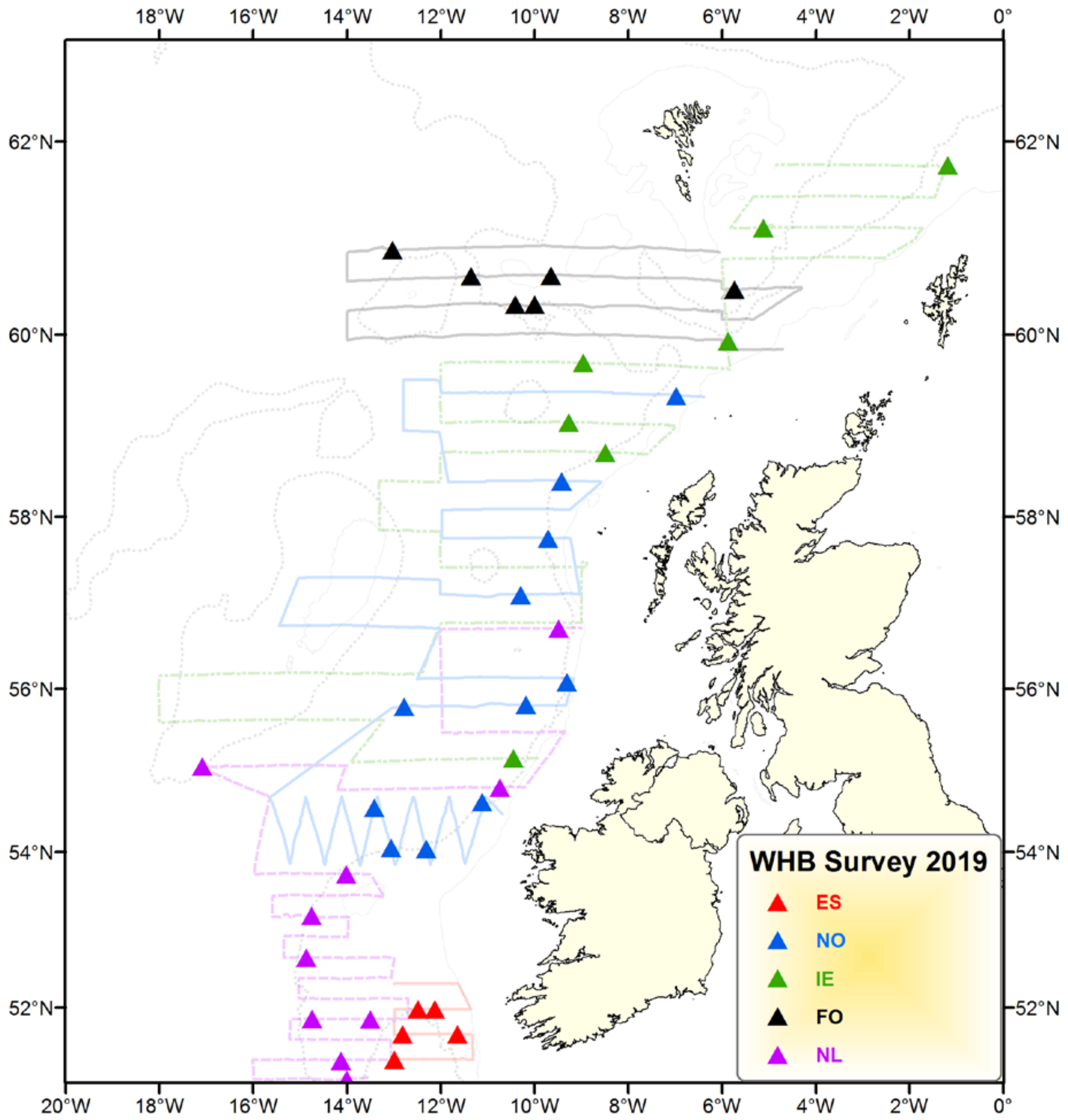


Figure 2. Vessel cruise tracks and trawl stations of the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2019. IE: Ireland (RV *Celtic Explorer*); FO: Faroe Islands (RV *Magnus Heinason*); NL: Netherlands (RV *Tridens*); NO: Norway (FV *Kings Bay*); ES: Spain (RV *Miguel Oliver*).

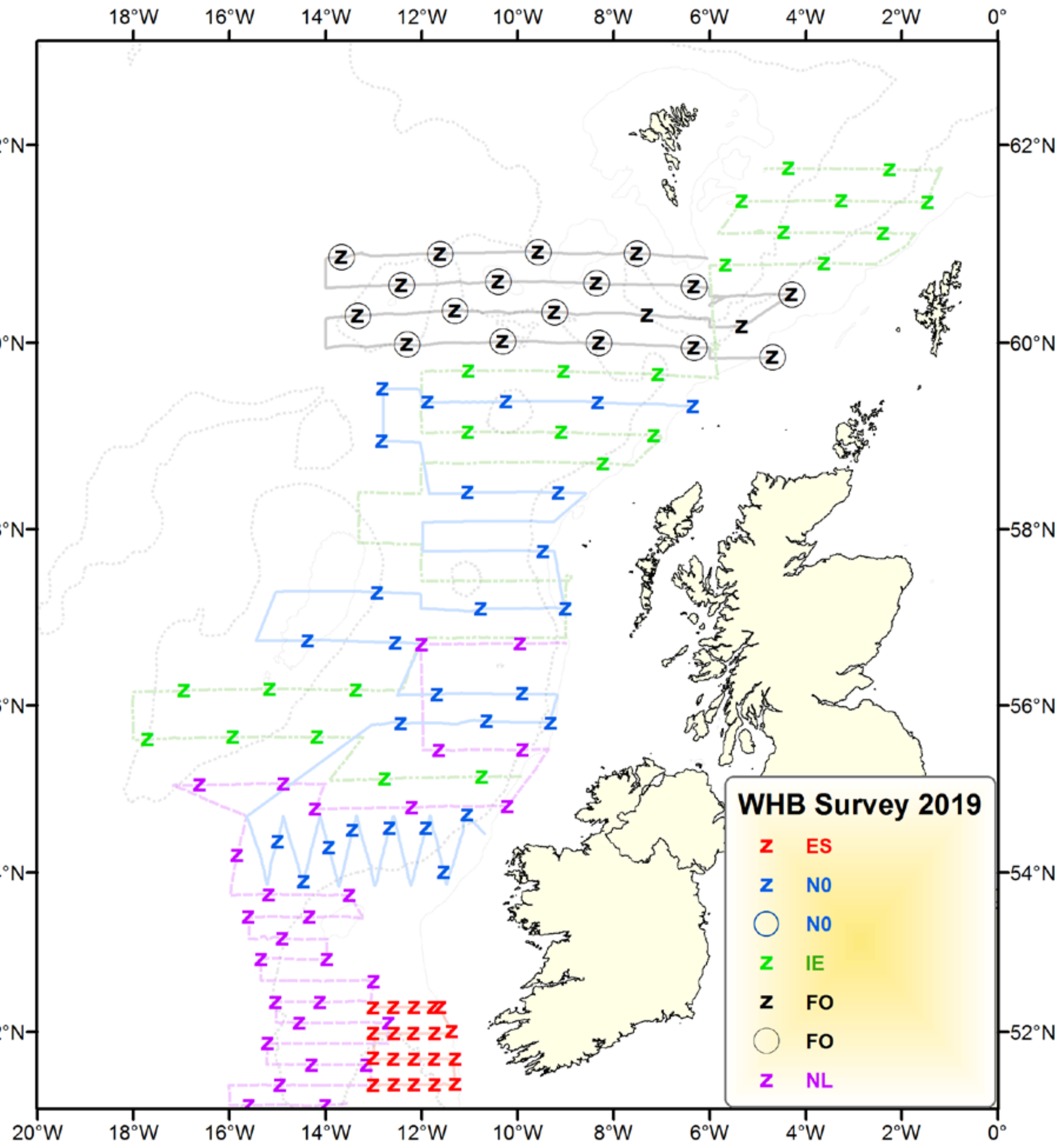


Figure 3. Vessel cruise tracks with hydrographic CTD stations (z) and WP2 plankton net samples (circles) during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2019. Colour coded by vessel.

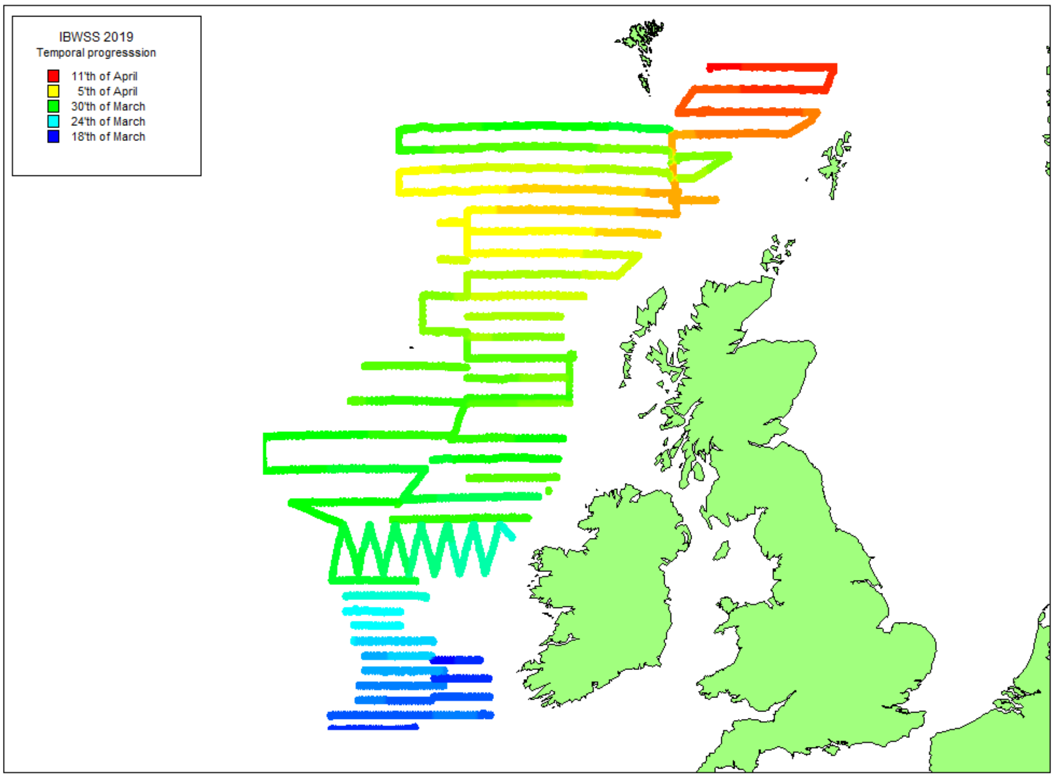


Figure 4. Temporal progression for the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2019.

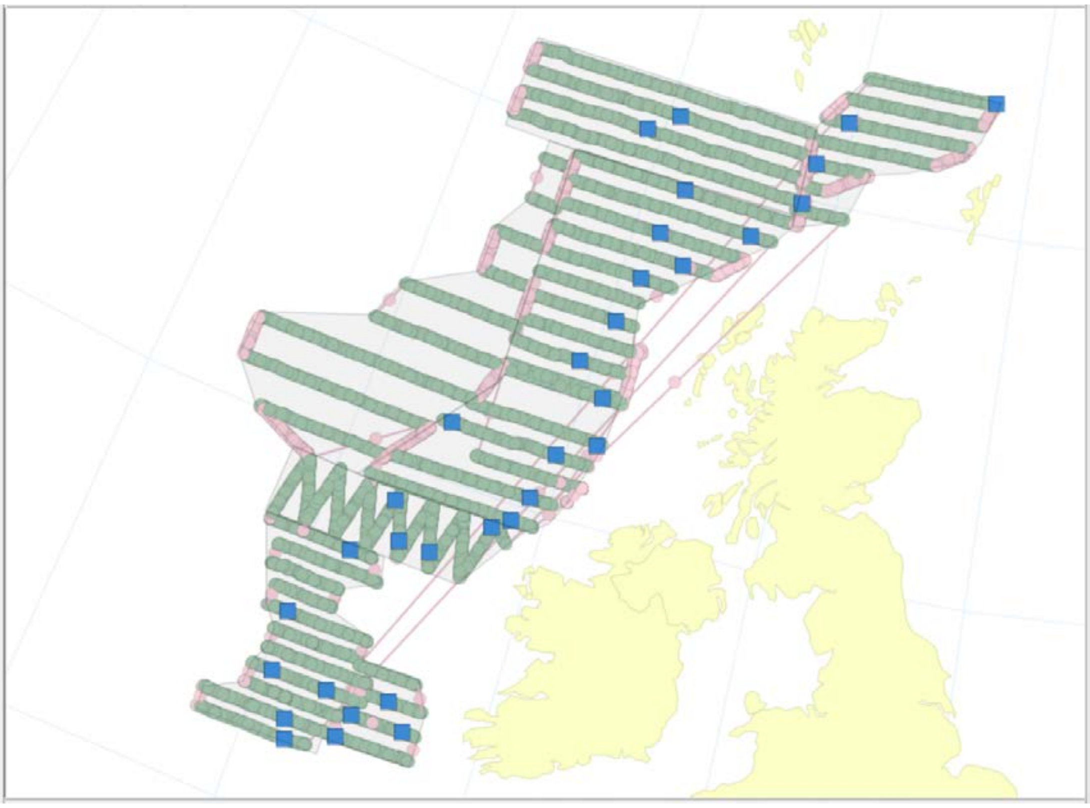


Figure 5. Tagged acoustic transects (green circles) with associated trawl stations containing blue whiting (blue squares) used in the StoX abundance estimation. IBWSS March-April 2019.

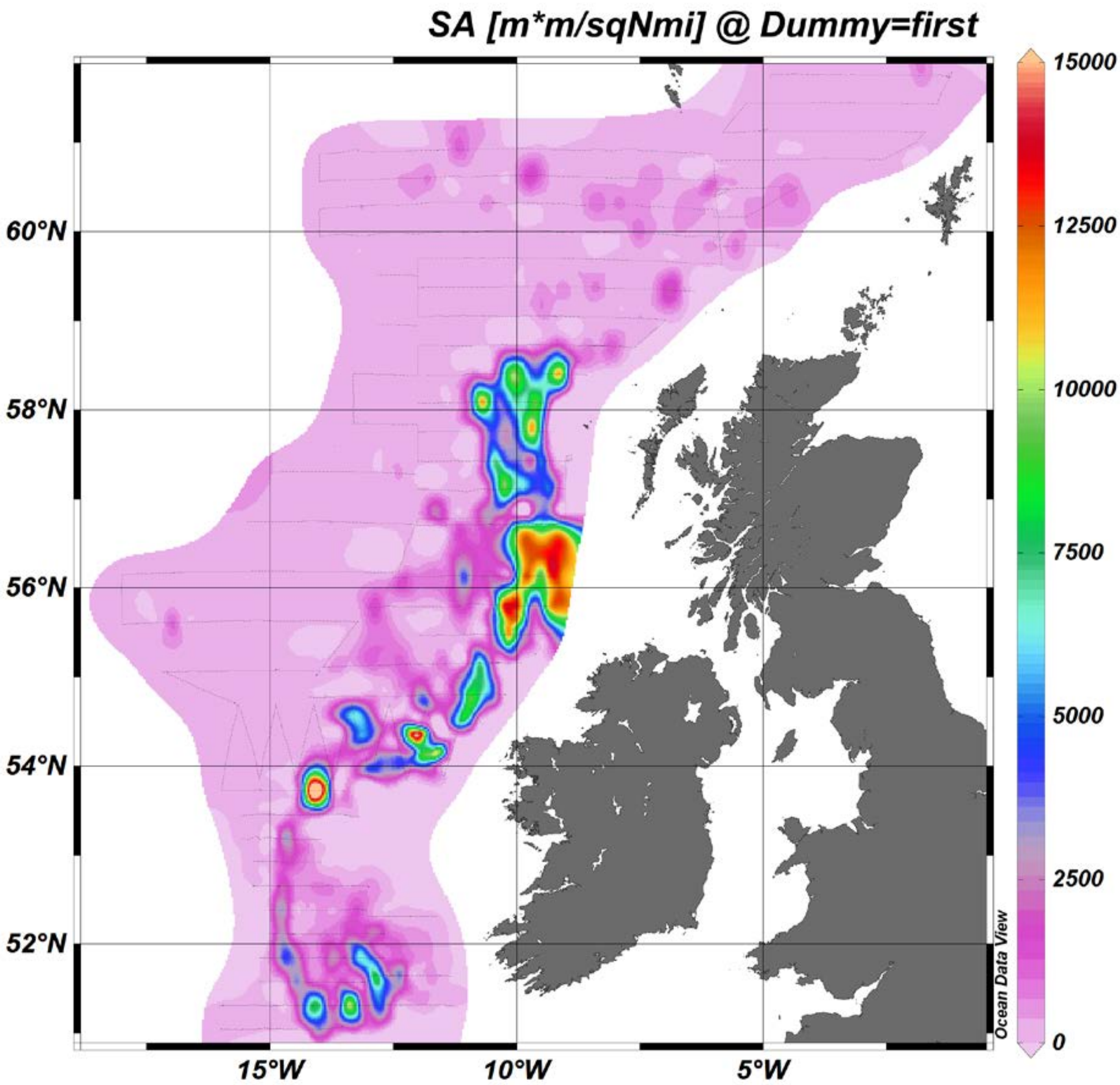


Figure 6. Map of acoustic density (s_A m^2/nmi^2) of blue whiting during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2019.

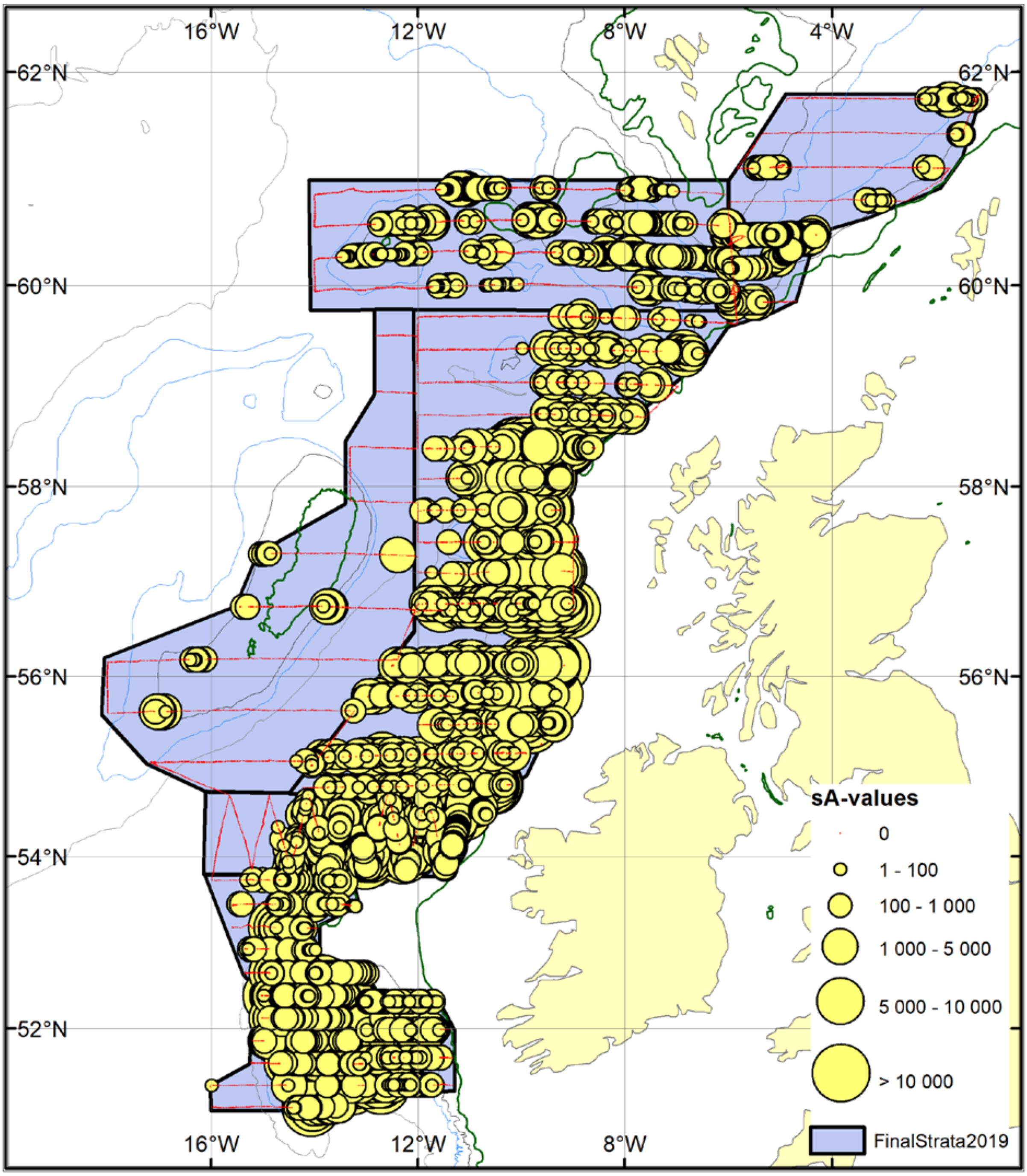
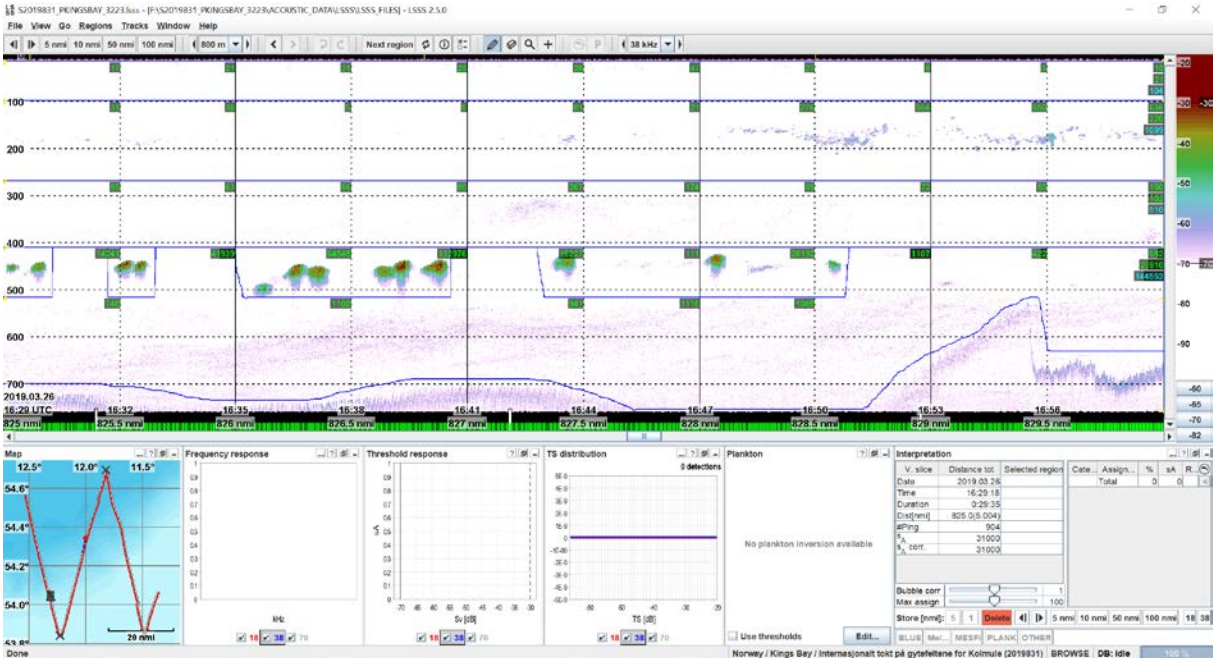
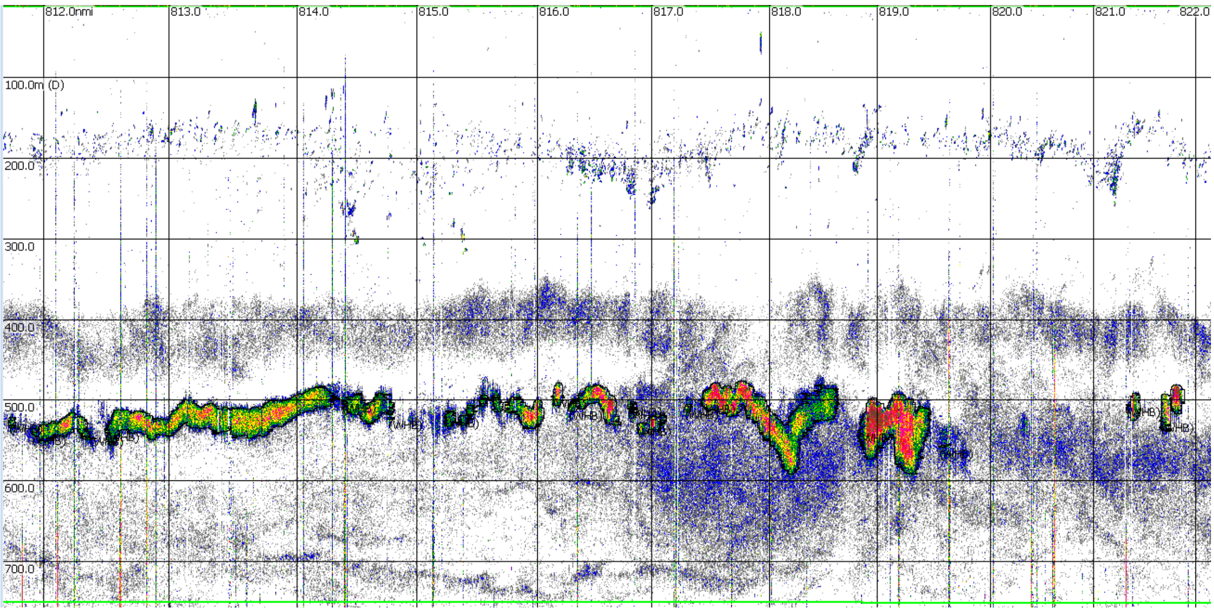


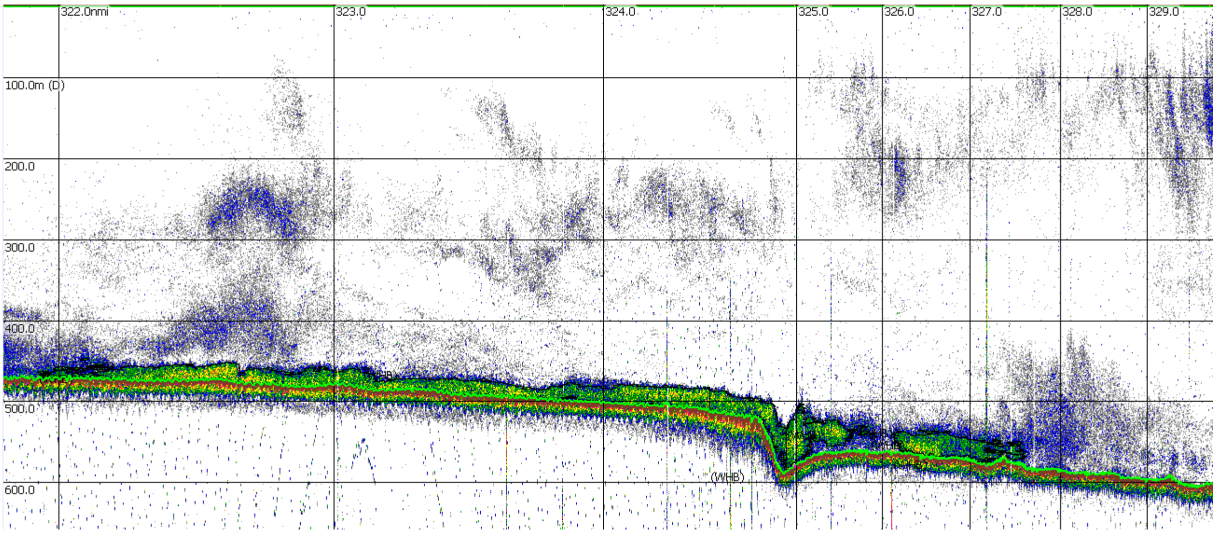
Figure 7. Map of acoustic density (s_A m^2/nmi^2) of blue whiting by 1 nmi (circle scaled by acoustic density). IBWSS March-April 2019.



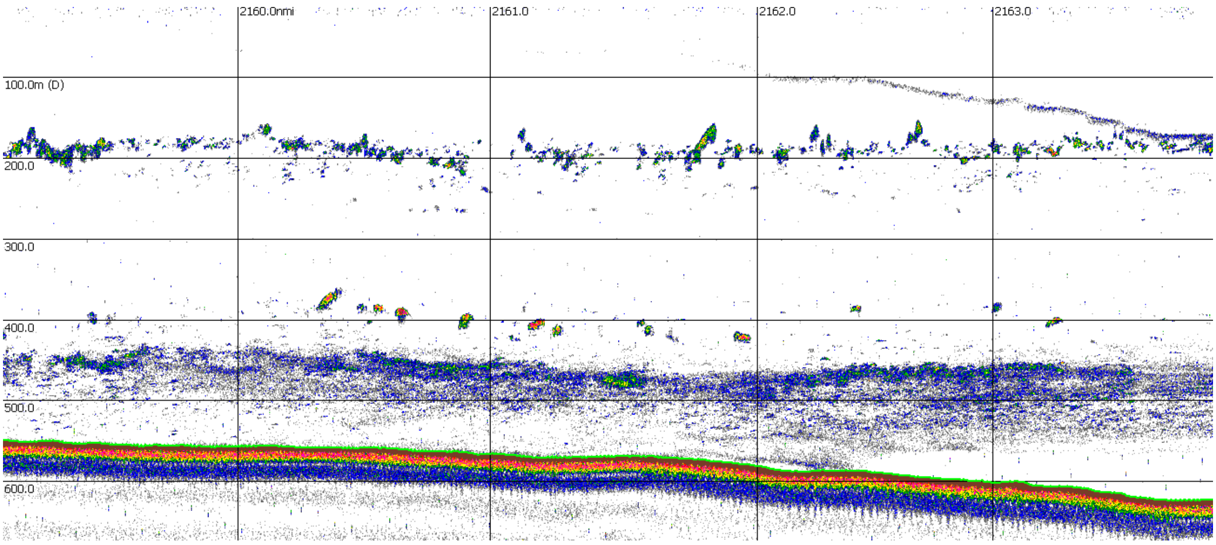
a) High density blue whiting registrations recorded on western Porcupine Bank area (strata 2) FV *Kings Bay*, Norway.



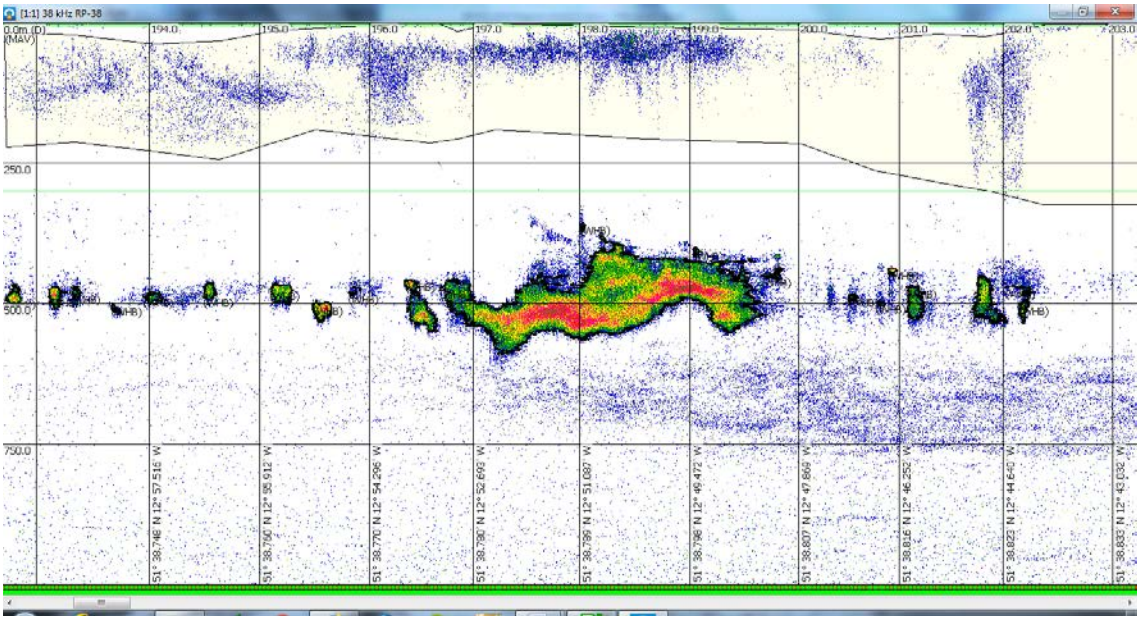
b) High density blue whiting layer per 1 nmi log interval at 500- 600 m recorded by the RV *Celtic Explorer* in the Rockall Trough area (strata 3).



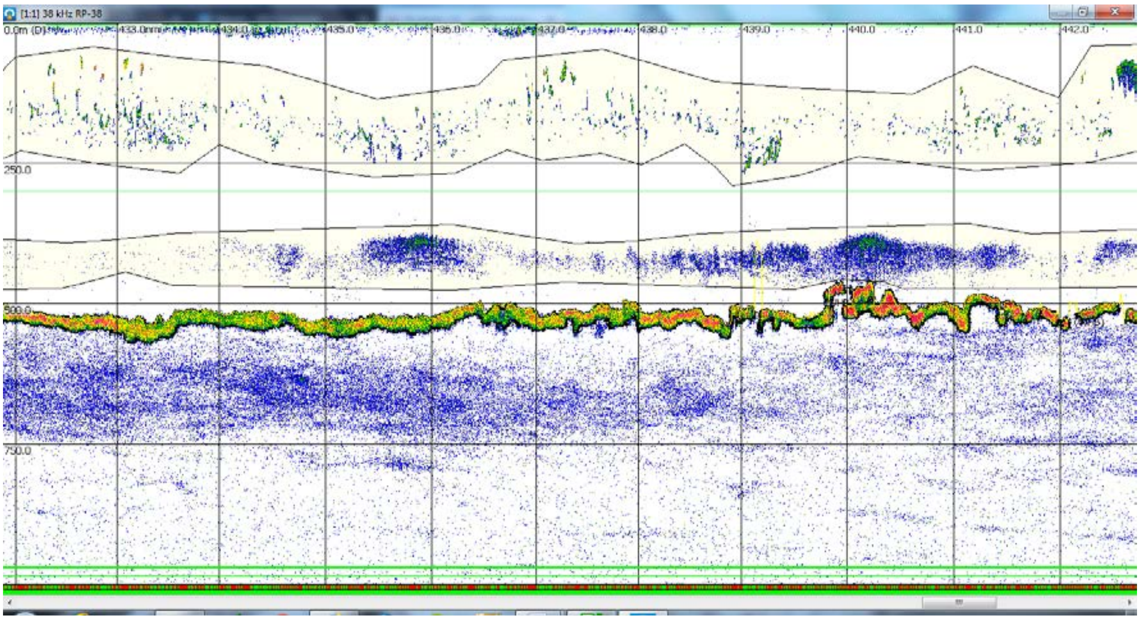
c) Low density blue whiting layer per 1nmi log interval close to the bottom at 450 – 550 m recorded by the RV *Celtic Explorer* in the Rockall Bank area (strata 5).



d) Juvenile and adult blue whiting marks per 1nmi log interval at 400 m depth. A layer of mesopelagic fish is also evident at 150 – 200 m. Recorded by the RV *Celtic Explorer* in the Faroe – Shetland channel area (strata 6).



e) High density blue whiting schools-like at 500- 600 m recorded by the RV *Miguel Oliver* at night in the Porcupine Sea bight area (stratum 7).



f). High density day time blue whiting layer at 500- 600m recorded by the RV *Miguel Oliver* the Porcupine Sea bight area (stratum 7).

Figure 8. Echograms of interest encountered during the IBWSS, March-April 2019. Vertical banding represents 1 nmi acoustic sampling intervals (EDSU), vertical binning at 50 m intervals. All echograms presented at 38 kHz.

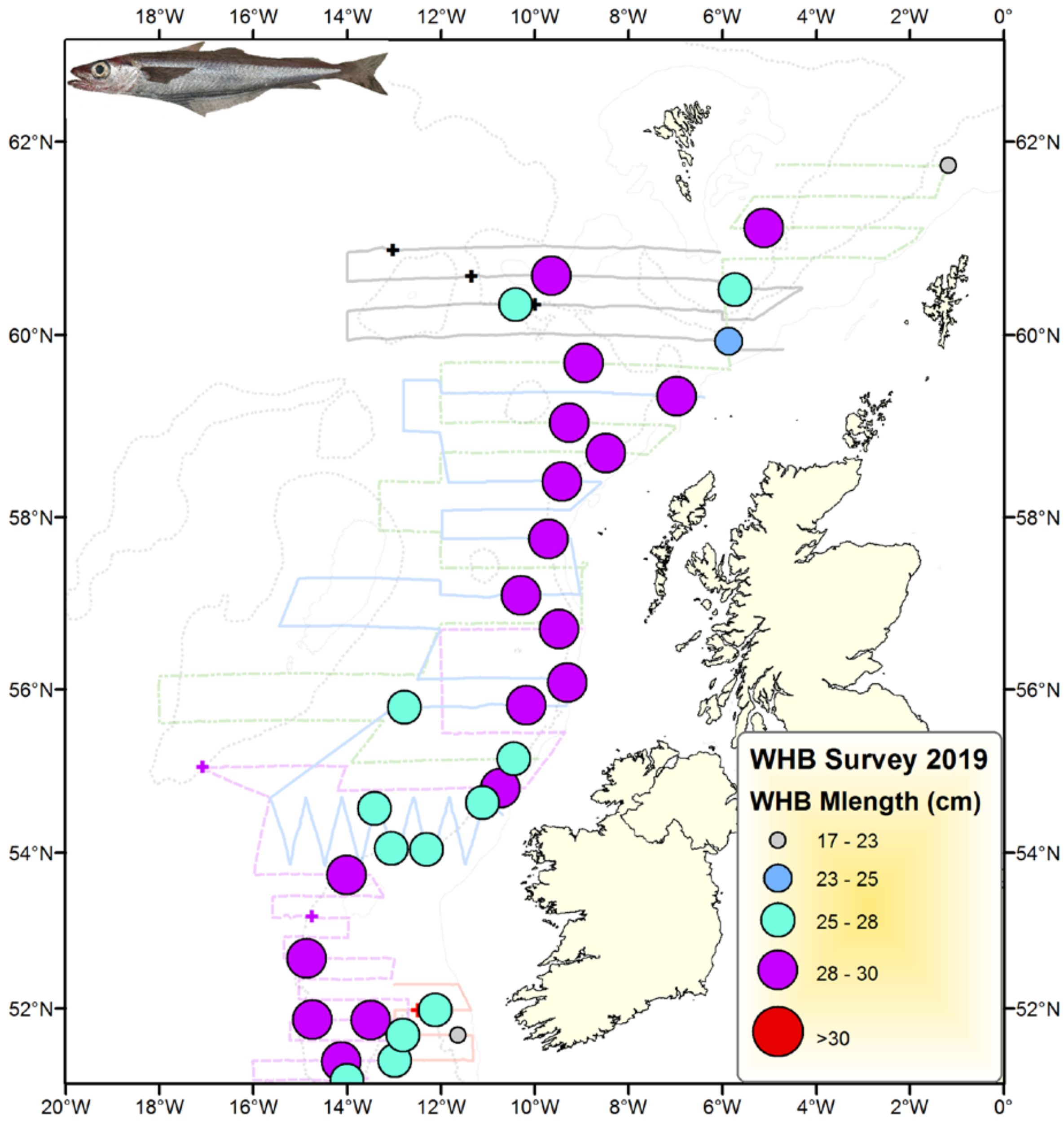


Figure 9. Combined mean length of blue whiting from trawl catches by vessel, IBWSS in March- April 2019. Crosses indicate hauls with zero blue whiting catches.

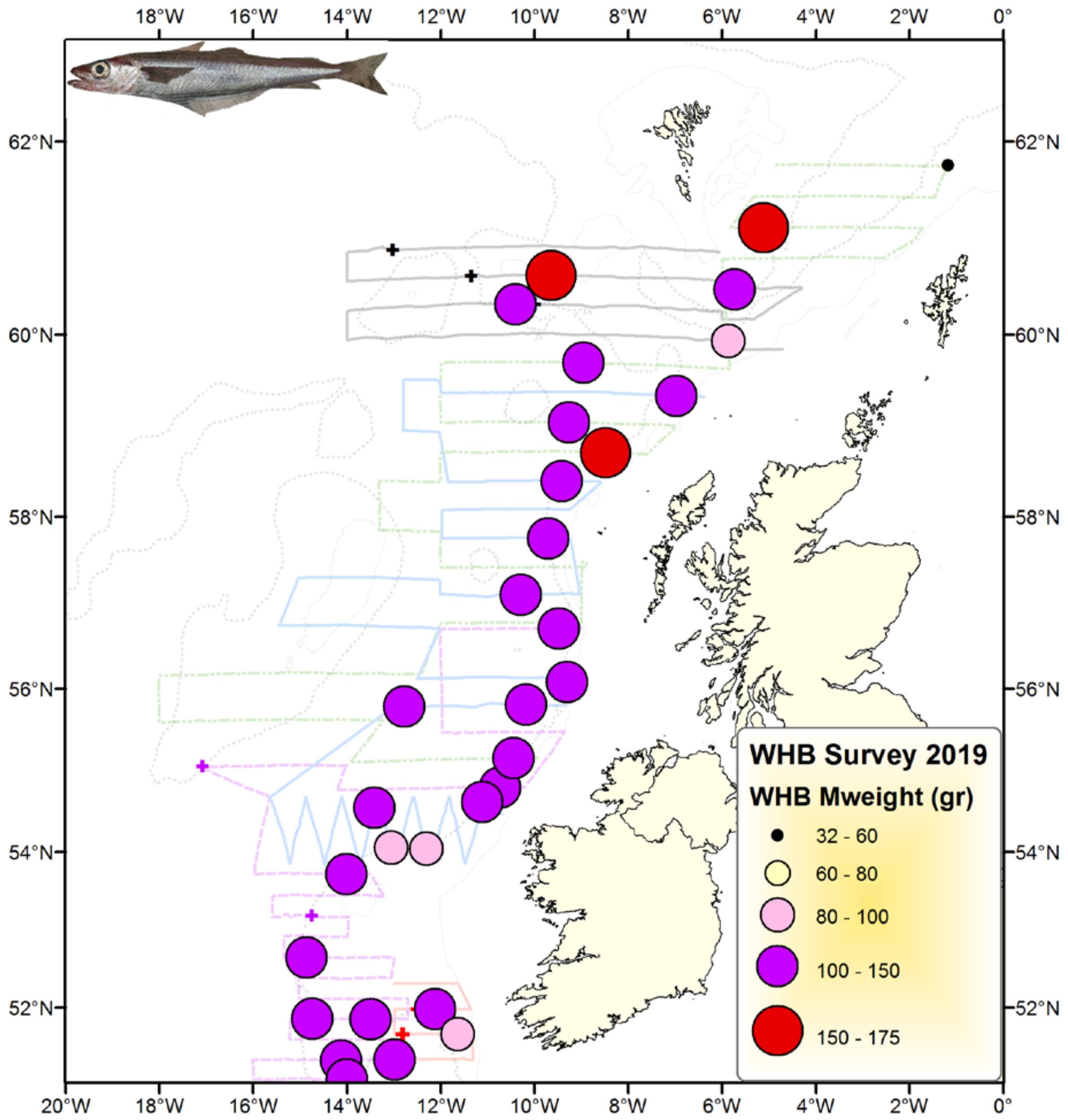


Figure 10. Combined mean weight of blue whiting from trawl catches, IBWSS March- April 2019. Crosses indicate hauls with zero blue whiting catches.

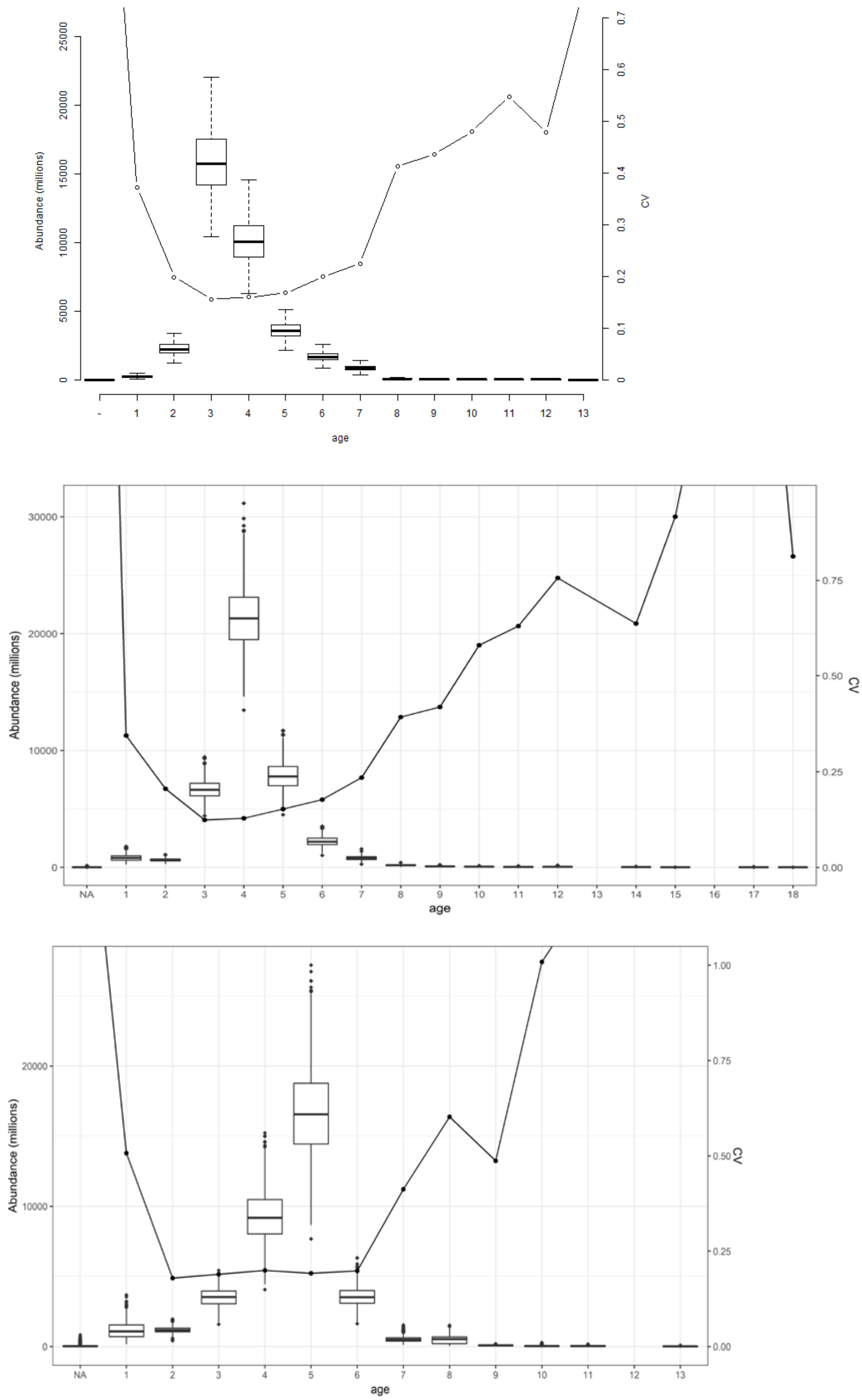


Figure 11. Blue whiting bootstrap abundance (millions) by age (left axis) and associated CVs (right axis) in 2017 (top panel), 2018 (middle panel) and 2019 (lower panel). From StoX.

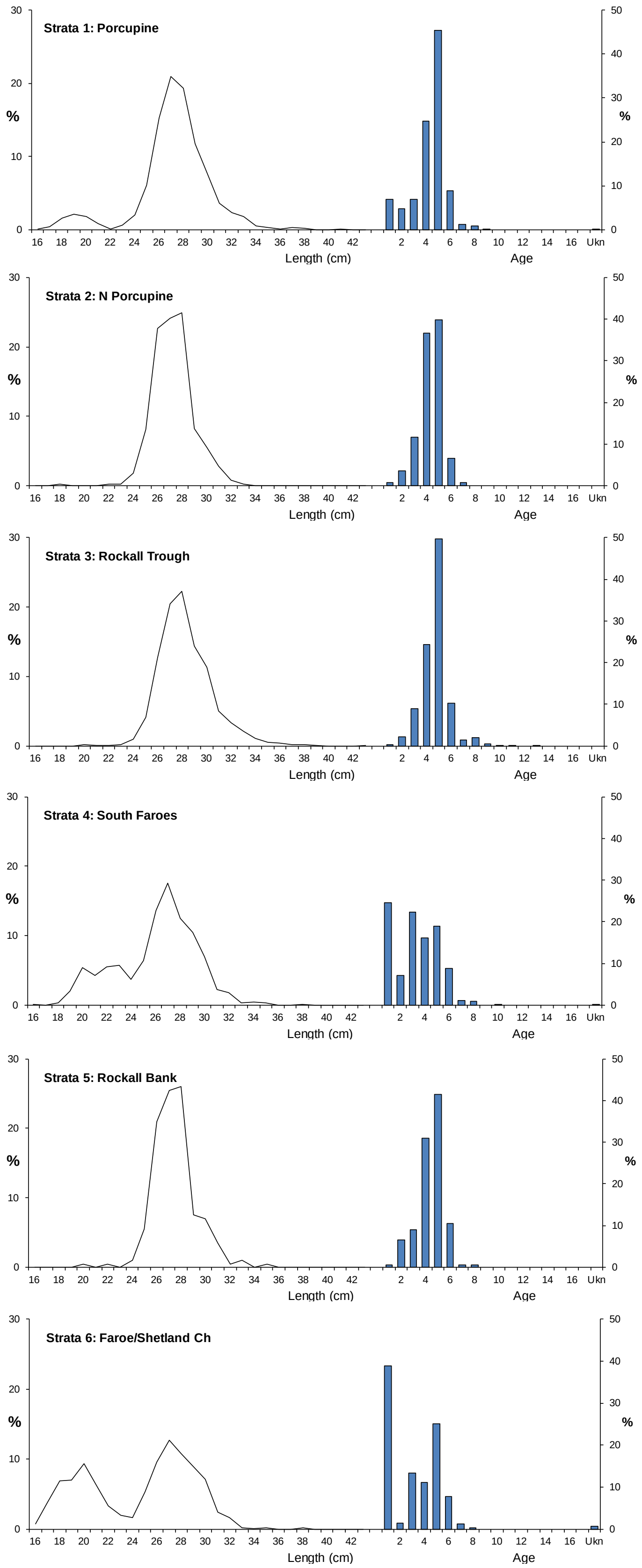


Figure 12. Length and age distribution (numbers) of blue whiting by survey strata. March-April 2019.

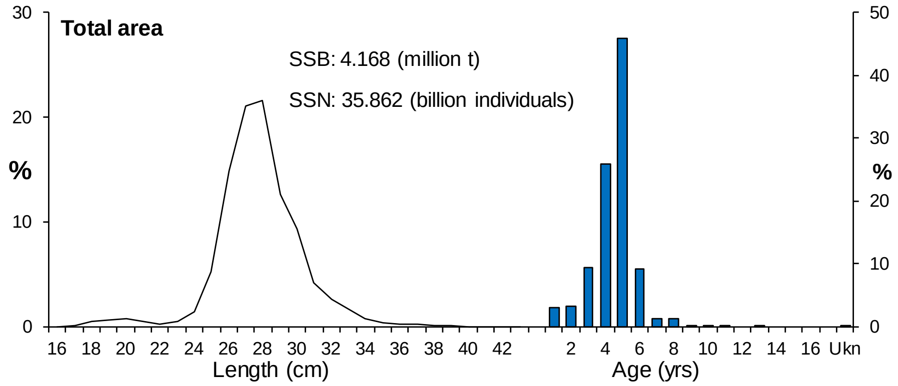


Figure 13. Length and age distribution (numbers) of total stock of blue whiting. March-April 2019.

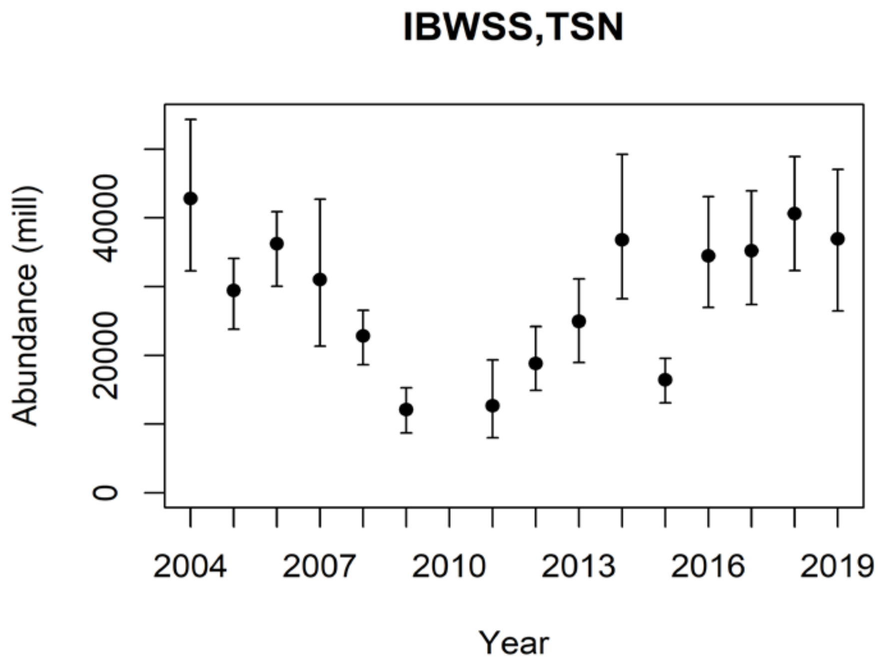


Figure 14. Time series of StoX survey indices of blue whiting abundance, 2004-2019, excluding 2010 due to data problems.

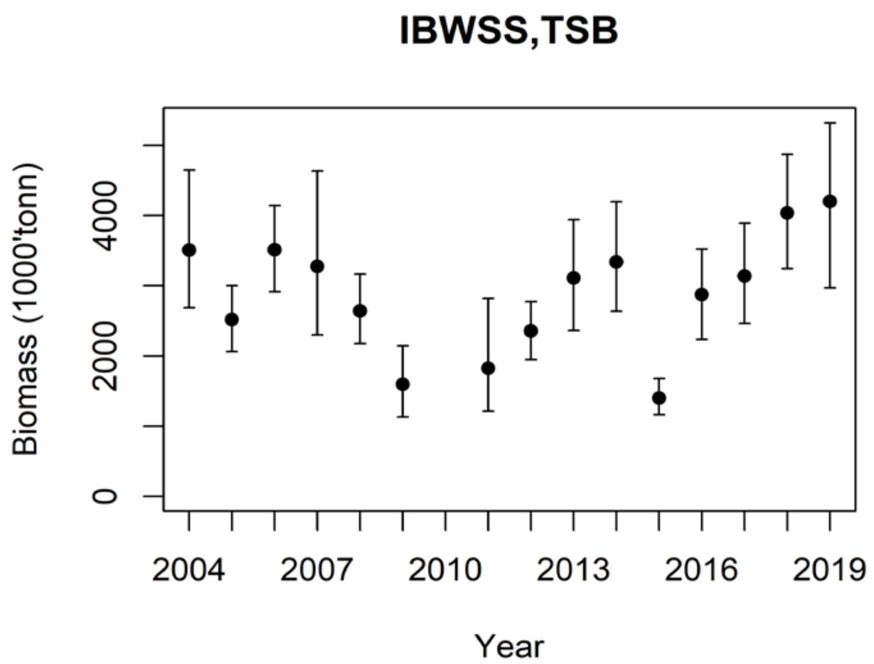


Figure 15. Time series of StoX survey indices of blue whiting biomass, 2004-2019, excluding 2010 due to data problems.

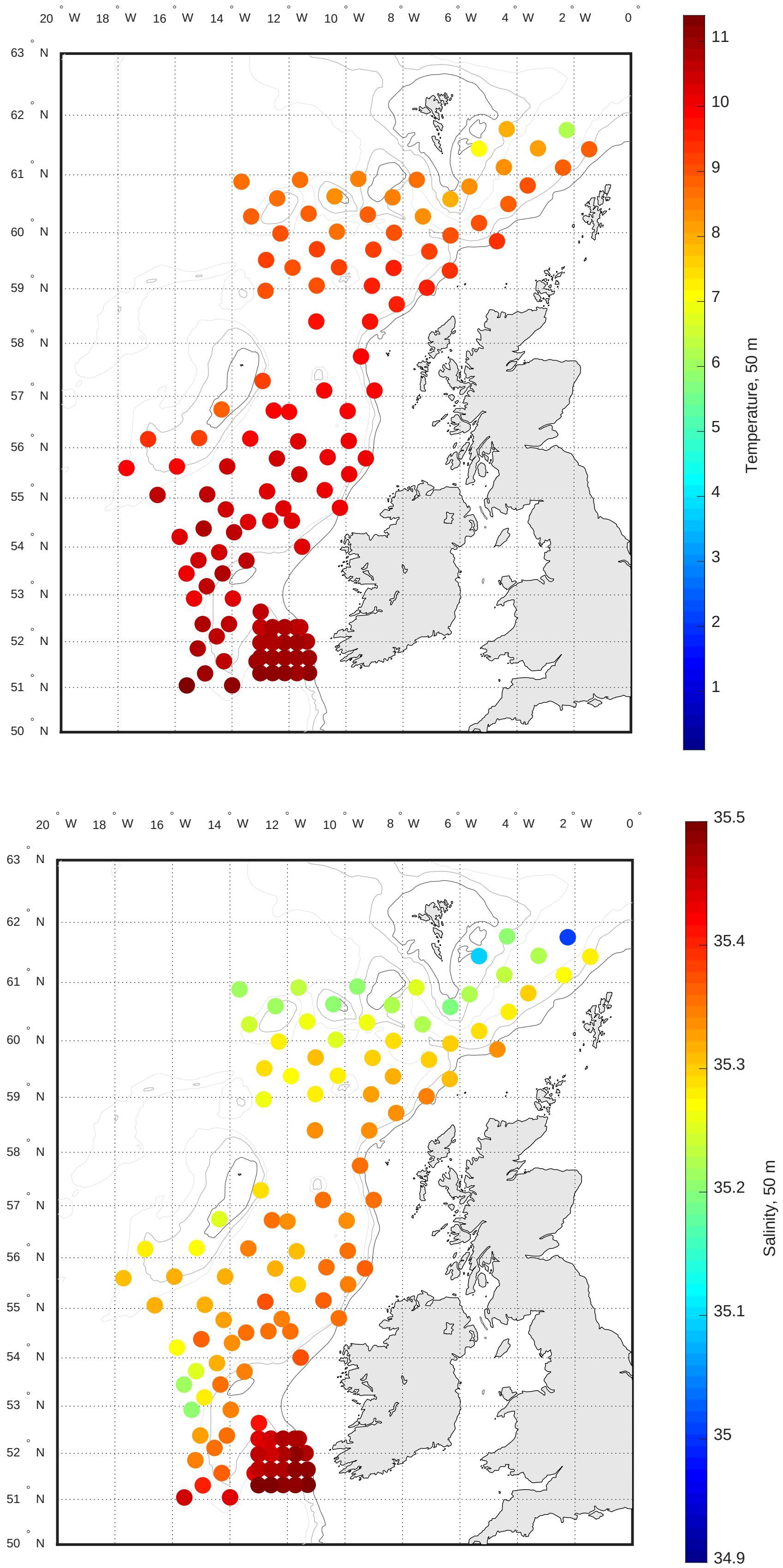


Figure 16. Horizontal temperature (top panel) and salinity (bottom panel) at 50 m subsurface as derived from vertical CTD casts. IBWSS March-April 2019.

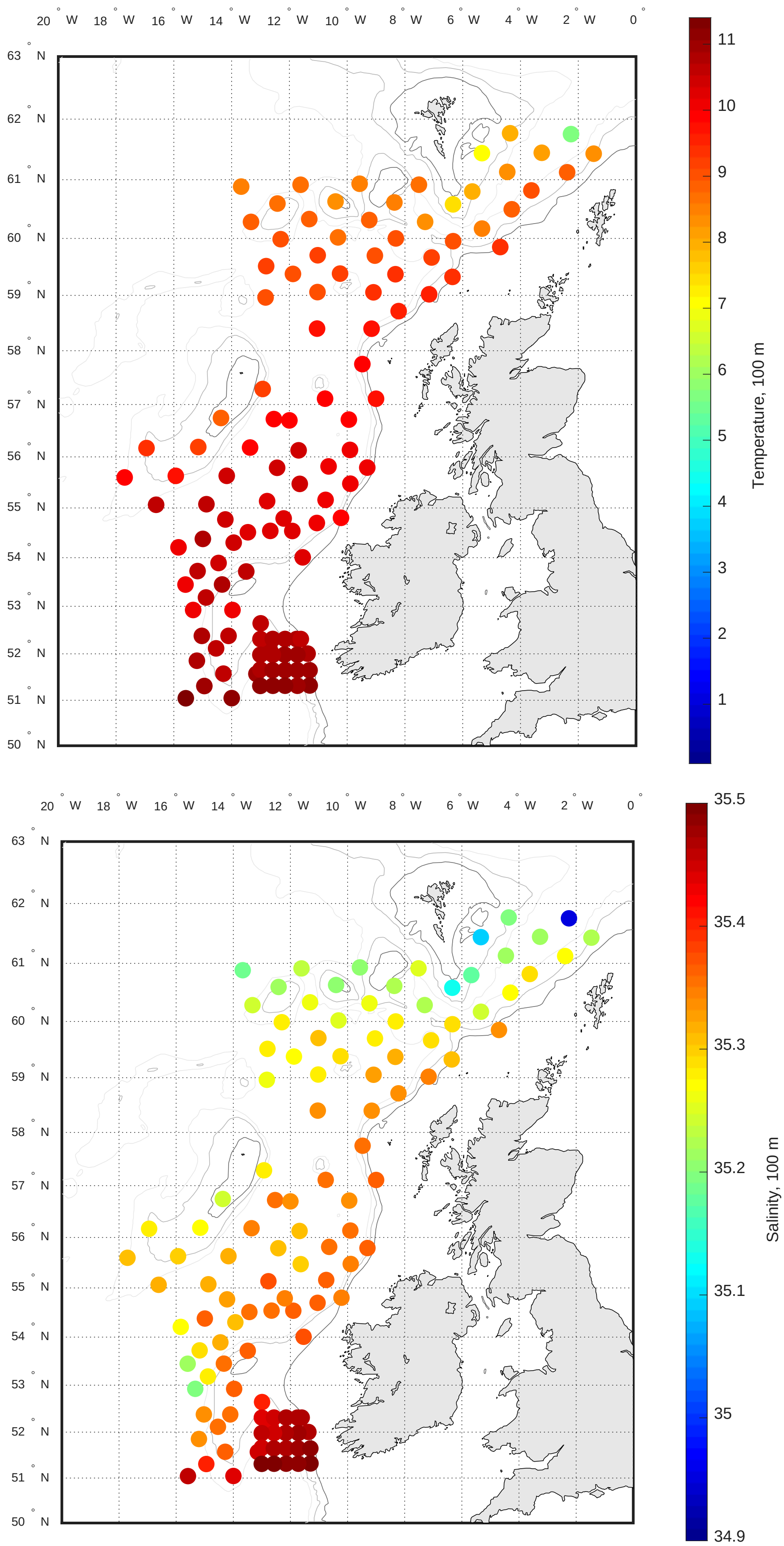


Figure 17. Horizontal temperature (top panel) and salinity (bottom panel) at 100 m subsurface as derived from vertical CTD casts. IBWSS March-April 2019.

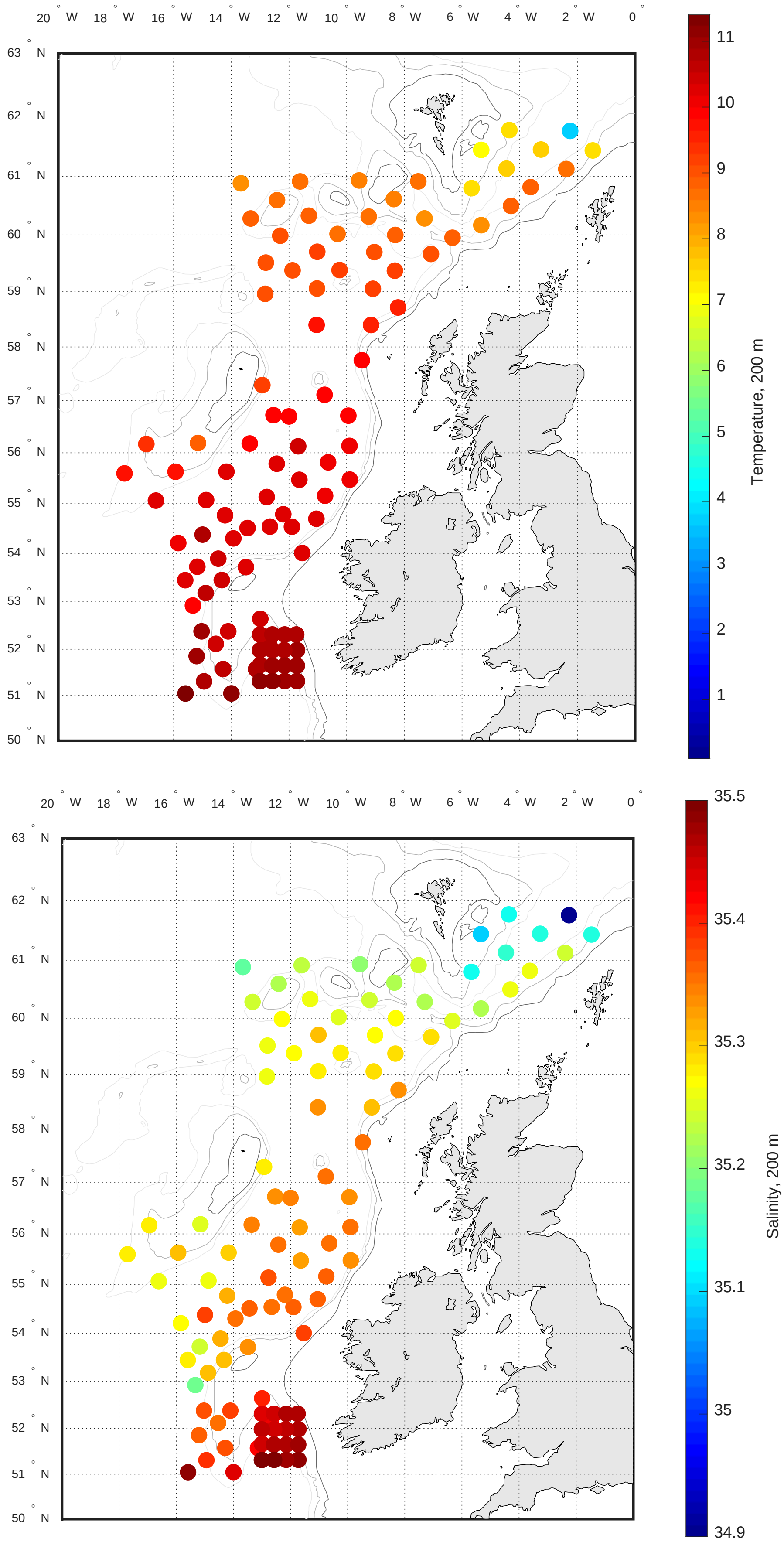


Figure 18. Horizontal temperature (top panel) and salinity (bottom panel) at 200 m subsurface as derived from vertical CTD casts. IBWSS March-April 2019.

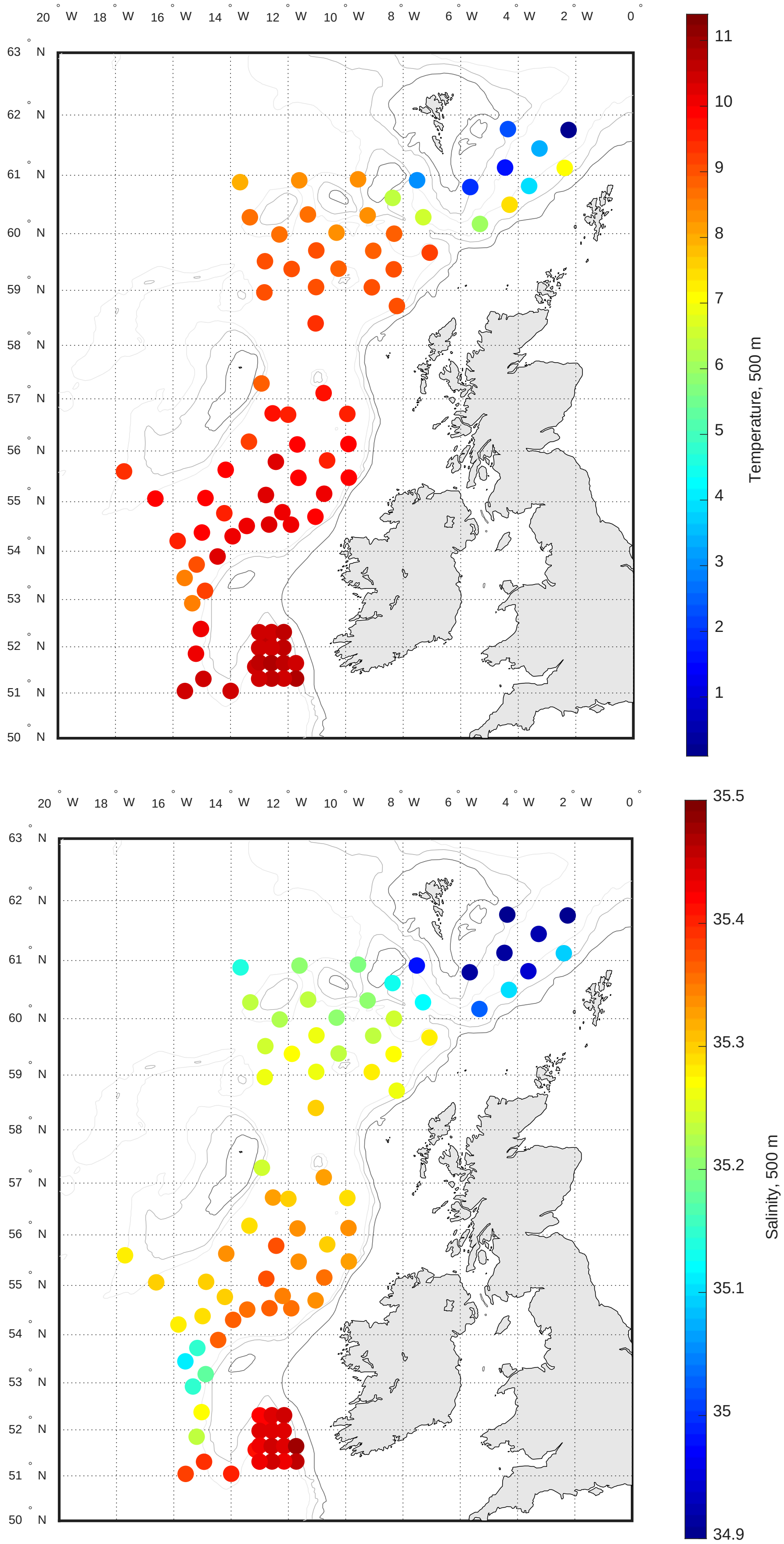


Figure 19. Horizontal temperature (top panel) and salinity (bottom panel) at 500 m subsurface as derived from vertical CTD casts. IBWSS March-April 2019.

Annex 4: 2019 IESNS Survey Summary Table and Survey Report

Document 4a: IESNS 2019 survey summary table

Survey Summary table WGIPS 2020	
Name of the survey (abbreviation):	International Ecosystem Survey in the Nordic Seas (IESNS)
Target Species:	Norwegian spring-spawning herring
Survey dates:	29 April – 19 June

Summary:

Survey effort, timing and area coverage in 2019 were comparable to previous years.

The zero-line was not fully reached in the north western part of the distribution area of the adult NSS herring in 2019. However, based on the zero-line reached south and east of this area, the vast majority of the NSS herring stock is believed to be contained within the survey area. It is therefore recommended that the results from IESNS 2019 can be used for assessment purpose. The herring was primarily (~2/3) distributed in the south western Norwegian Sea, but a third of the biomass was distributed between 69°N and 72°N and this was still primarily the 2013 year class, but also the 2014 and 2016 year classes were numerous. This year the amount of herring in the eastern part of the Barents Sea was significant. As in previous years the size and age of herring were found to increase towards west and south in the Norwegian Sea. Correspondingly, it was mainly older herring that appeared in the southwestern areas. The 2013 year class was observed across most of the survey area.

The total estimate of herring in the Norwegian Sea from the 2019 survey was 19.7 billion in number and the biomass 4.87 million tonnes. This estimate is 0.17 million tonnes (3 %) decrease from the 2018 survey estimate. The biomass estimate decreased from 2009 to 2012, and has since then been rather stable at 4.2 to 5.9 million tonnes, with the lowest abundance occurring in 2017.

Six year old herring (year class 2013) dominated both in terms of number and biomass (24 %). Its number at age 6 is higher than for the 2009 year class at same age, but only half the size of the large 2004 year class, which puts the size of the 2013 year class into perspective. The large 2004 year class, which has dominated the stock together with the 2002 year class, has contributed significantly to the biomass of older age-groups. Herring aged 12-15 years old thus comprised 19% of the numbers and 25% of the biomass. In the Barents Sea, herring was distributed widely in the area and in large concentrations in the eastern part of the survey area, where the zero line concentration was not reached. Herring at age 3 was dominating (17 billions, mean length 22.1 cm and mean weight 67 g). This is the second highest observation of age 3 herring in the Barents Sea since the start of this survey in 1991, only slightly lower than the estimate in 1994 (the strong 1991 year class).

	Description
Survey design	Stratified systematic parallel transects design with randomised starting point of the southernmost transect within each strata.

Index Calculation method	StoX (via the PGNAPES database)
Random/systematic error issues	N/A
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	No problems due to bad weather for acoustic recordings
Extinction (shadowing)	N/A
Blind zone	Upper 8-12 m not covered by acoustics.
Dead zone	N/A
Allocation of backscatter to species	Standard TS for herring and blue whiting
Target strength	Blue whiting: TS = 20 log(L) – 65.2 dB (ICES 2012) Herring: TS = 20.0 log(L) – 71.9 dB The target strength for blue whiting was first applied in 2012
Calibration	OK
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	Time series: Considered to have covered the adult stock adequately 2019 survey: the entire stock during its migration on the feeding grounds, the adults in the Norwegian Sea and adjacent waters
Stock ID and mixing issues	Yes, some mixing of herring might have occurred in some of the fringe regions: Southeastern Icelandic zone all herring west of 14 W were excluded from the index calculations (being Icelandic sumer-spawners). In the Faroe zone all herring north of 62 N was allocated to NSSH. In the EU zone/NO zone in the southeast the herring of autumn-spawning type was excluded fom the stock index calculations (south of 62 N).
Measures of uncertainty (CV)	The estimated survey uncertainty for the main age groups in the sestimate was around 0.25
Biological sampling	Sampling levels was considered representative. In the recent years there have been concerns regarding age reading of herring, because the age distributions from the different participants have showed differences within the same strata. A scale and otolith exchange has been ongoing for some period, where scales and otoliths for the same fish have been sampled. On basis of that work, a workshop was planned

	in the spring 2018 to discuss the results. This workshop was postponed and has not yet been undertaken.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

Document 4b: IESNS 2019 survey report

Please see the report on the next page.

Working Document to

Working Group on International Pelagic Surveys (WGIPS)
Bergen, Norway, 13 - 17 January 2020
and
Working Group on Widely distributed Stocks (WGWIDE)
Santa Cruz, Tenerife, Spain, 28 August - 3 September 2019

INTERNATIONAL ECOSYSTEM SURVEY IN NORDIC SEA (IESNS) in May – June 2019

Post-cruise meeting, Reykjavik, Iceland, 18-20 June 2019

Are Salthaug[2], Erling Kåre Stenevik[2], Åge Høines[2], Valantine Anthonypillai[2], Kjell Arne Mork[2], Cecilie Thorsen Broms[2], Øystein Skagseth[2], Evgeny Sentyabov[4]
RV G.O. Sars

Karl-Johan Stæhr[3], Serdar Sakinan[6], Mathias Kloppmann[8], Sven Kupschus[9]
RV Dana

Guðmundur J. Óskarsson[7], Hildur Pétursdóttir[7]
RV Árni Friðriksson

Eydna í Homrum[5], Ebba Mortensen[5], Leon Smith[5]
RV Magnus Heinason

Pavel Krevoshey[10]
RV Vilnyus

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[6] Wageningen Marine Research, IJmuiden, The Netherlands
[7] Marine and Freshwater Research Institute, Reykjavik, Iceland
[8] vTI-SF, Hamburg, Germany
[9] Cefas, Lowestoft, UK
[10] PINRO, Murmansk, Russia

Introduction

In May-June 2019, five research vessels; R/V Dana, Denmark (joined survey by Denmark, Germany, Ireland, The Netherlands, Sweden and UK), R/V Magnus Heinason, Faroe Islands, R/V Árni Friðriksson, Iceland, R/V G.O. Sars, Norway and R/V Vilnyus, Russia participated in the International ecosystem survey in the Nordic Seas (IESNS). 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 Faroes, 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 represents analyses of data from this International survey in 2019 that are stored in the PGNAPES database and supported by national survey reports from each survey (Dana: Staehr, Sakinan, Kloppmann, Kupschus 2019, Magnus Heinason: Homrum et al, FAMRI 1918-2019, Árni Friðriksson: Óskarsson et al. 2019).

Material and methods

Coordination of the survey was done during the WGIPS meeting in January 2019 and by correspondence. Planning of the acoustic transects and hydrographic stations and plankton stations were carried out by using the recently developed survey planner function in the r-package Rstox version 1.11 (see www.imr.no/forskning/prosjekter/stox). The survey planner function generates the survey plan (transect lines) in a cartesian coordinate system, and transforms the positions to the geographical coordinate system (longitude, latitude) using the azimuthal equal distance projection, which ensures that distances, and also equal coverage, if the method used is designed with this prerequisite, are preserved in the transformation. Figure 1 shows the planned acoustic transects and hydrographic and plankton stations in each stratum. Only parallel transects were used this year, however, the transects now follow great circles instead of a constant latitude as before, so they appear bended in a Mercator projection. 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	02/5-31/5
G.O. Sars	Institute of Marine Research, Bergen, Norway	29/4-03/6
Vilnyus	PINRO, Russia	03/6-19/6
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	02/5- 14/5
Árni Friðriksson	Marine and Freshwater Research Institute, Iceland	08/5-19/5

Figure 2 shows the cruise tracks, Figure 3a the hydrographic and plankton stations and Figure 3b the pelagic 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. The temporal progression of the survey is shown in Figure 4.

In general, the weather condition did not affect the survey even if there were some days that were not favourable and prevented for example WP2 and Multinet sampling at some stations. 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	Vilnyus
Echo sounder	Simrad EK 60	Simrad EK 80	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	ES38B	ES38B	ES38B
Transducer installation	Towed body	Drop keel	Drop keel	Hull	Hull
Transducer depth (m)	5	8.5	8	3	4.5
Upper integration limit (m)	5	15	15	7	10
Absorption coeff. (dB/km)	10	10.1	10	10.1	10
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	1.573	2.43	2.425	2.425	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	-20.7	-20.81	-20.8	-20.6
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.32	26.07	24.36	25.64	25.76
s_A correction (dB)	-0.56	-0.15	-0.58	-0.66	-0.64
3 dB beam width (dg)					
alongship:	6.8	6.48	7.28	7.02	7.09
athw. ship:	6.8	6.22	7.23	7.00	7.01
Maximum range (m)	500	500	500	500	500
Post processing software	LSSS1	LSSS	LSSS	Sonardata Echoview 9.1	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 2009), and “Notes from acoustic Scrutinizing workshop in relation to the IESNS”, Reykjavík 3.-5. March 2015 (Annex 4 in ICES 2015).

Generally, acoustic recordings were scrutinized 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	Vilnyus
Circumference (m)		496	832	640	500
Vertical opening (m)	25-35	25-30	30–35	45–55	50
Mesh size in codend (mm)	16	24	40	40	16
Typical towing speed (kn)	3.5-4.0	3.0–4.5	3.6–4.5	3.0–3.5	3.3–4.5

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, blue whiting and mackerel were sexed, aged, and measured for length and weight, and their maturity status was estimated using established methods. For the Norwegian, Icelandic and Faroese vessel, a smaller subsample of stomachs was sampled for further analyses on land. An additional sample of 70–300 fish was measured for length.

Acoustic data were analysed using the StoX software package which has been used for some years now for WGIPS coordinated surveys. A description of StoX can be found here: www.imr.no/forskning/prosjekter/stox. Estimation of abundance from acoustic surveys with StoX is carried out according to the stratified transect design model developed by Jolly and Hampton (1990). This method requires pre-defined strata, and the survey area was therefore split into 6 strata with pre-defined acoustic transects as agreed during the WGIPS in January 2019. Within each stratum, parallel transects with equal distances 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. The strata and transects used in StoX are shown in Figure 1. All trawl stations within a given stratum with catches of the target species (either blue whiting or herring) were assigned to all transects within the stratum, and the length distributions were weighted equally within the stratum. The following target strength (TS)-to-fish length (L) relationships were used:

Blue whiting: TS = 20 log(L) – 65.2 dB (ICES 2012)

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).

The hydrographical and plankton stations by survey are shown in Figure 3a. Most vessels collected hydrographical data using a SBE 911 CTD. Maximum sampling depth was 1000 m. 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 to the surface or from the bottom whenever bottom depth was less than 200 m. All samples were split in two and one half was preserved in formalin while the other half was dried and weighed. The samples for dry weight were size fractionated before drying by sieving the samples through 2000 µm and 1000 µm sieves, giving the size fractions 180/200 – 1000 µm, 1000 – 2000 µm, and > 2000 µm. Data are presented as g total dry weight per m^2. For the zooplankton distribution map, all stations are presented. For the time series, stations in the Norwegian Sea delimited to east of 14°W and west of 20°E have been included. The zooplankton data were interpolated using objective analysis utilizing a Gaussian correlation function to obtain a time-series for four different areas. The results are given as inter-annual indexes of zooplankton abundance in May. This method was introduced at WGINOR in 2015 (ICES, 2016) and the results match the former used average index. It has been noted that the Djedy net applied by the Russian vessel in the Barents Sea seems to be less effective in catching zooplankton in comparison to WPII 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.

Results and Discussion

Hydrography

The temperature for selected depths in the Norwegian Sea is shown in Figure 5. The temperature distributions in the ocean, averaged over selected depth intervals; 0-50 m, 50-200 m, and 200-500 m, are shown in Figures 6-8. The temperatures in the surface layer (0-50 m) ranged from below 0°C in the Greenland Sea to 9°C in the southern part of the Norwegian Sea (Figure 6). The Arctic front was encountered south of 65°N east of Iceland extending eastwards towards about 2° West where it turned northeastwards to 65°N and then almost straight northwards. This front was well-defined at 200-500 m depth while shallower it was unclear. Further to west at about 8° West another front runs northward to Jan Mayen, the Jan Mayen Front, that was distinct 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 69° N in the surface layer.

Relative to a 23 years long-term mean, from 1995 to 2017, the temperatures at 0-50 m and 50-200 m over the western Norwegian Sea, roughly west of the 0 meridian, were higher in 2019 compared to the long-term mean (Figures 6-7). Relative warmest water was in the south- and northwestern Norwegian Sea where the temperatures in some regions were 1.0 °C higher than the mean. In the eastern area of the Norwegian Sea, the temperatures were instead lower than normal, where temperatures in few areas were 0.5 °C lower than the mean. At 200-500 m depth, both higher and lower temperatures than the long-term mean can be observed in whole region.

The temperature, salinity and potential density in the upper 800 m at the Svinøy section in May 2019 are shown in Figure 9. Atlantic water is lying over the colder and fresher intermediate layer and reach down to 500 m at the shelf edge and shallower westward. The warmest water is located near the shelf edge where the core of the inflowing Atlantic Water is located. Westward, temperature and salinity are reduced due to mixing with colder and less saline water. Relative to a long-term mean, from 1978 to 2007, the temperatures in 2019 were substantial higher in the western part (west of 2.5° E) where temperatures were 3.0 °C higher than the mean between 200 m and 400 m depth. In the eastern part the temperatures were in general lower than long-term mean.

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 local air-sea heat flux in addition influence the upper layer and it is found that it can explain about half of the year to year variability of the ocean heat content in the Norwegian Sea.

Zooplankton

The zooplankton biomass (g dry weight m^{-2}) in the upper 200 m is shown in Figure 10. Sampling stations were evenly spread over the area, covering Atlantic water, Arctic water, and the Arctic frontal zone. The Svinøy transect was not included in this survey but covered in a separate survey. The highest zooplankton biomasses were not concentrated in a specific area but spread over several locations covering the entire sampling area, except from the southernmost part and especially the area south-east of Iceland which contained low biomasses. High biomasses were found in an area around Lofoten/Vesterålen and north and northwest of that area, and in the Norwegian Sea basin.

Figure 11 shows the zooplankton index given for the sampling area (delimited to east of 14°W and west of 20°E). To examine regional difference in the biomass, the total area were divided into 4 subareas 1) Southern Norwegian Sea including the Norwegian Sea Basin, 2) The Northern Norwegian Sea including the Lofoten Basin, 3) Jan Mayen Arctic front, and 4) East of Iceland. The mean index of subarea 1 and 2 is also given. The zooplankton biomass index for the Norwegian Sea and nearby areas was in 2019 10.8 g dry weight m^{-2}, which is an increase from last year. A similar increase was observed in all sub-areas, except from East of Iceland.

The zooplankton biomass index for the Norwegian Sea in May has been estimated since 1995. For the period 1995-2002 the plankton index was relatively high even if varying between years. From 2003-2006, the index decreased continuously and was at lower levels for several years, but since 2010 there has been an increasing trend. For the period 2003-2019 the mean was 7.9 g, compared to 11.5 for the period 1995-2002. This general pattern applies more or less to all the different sub-areas within the Norwegian Sea. In 2019 the biomass index for the Norwegian Sea was comparable to the high-biomass period. The zooplankton biomass at the Jan Mayen Arctic front was high until 2007 but has since then been at the same level as the Norwegian Sea. The zooplankton biomass East of Iceland was in general higher compared with the other sub-areas until 2015.

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 zooplankton stocks. Timing effects, as match/mismatch with the phytoplankton bloom, can also affect the zooplankton abundance. It is also worth noting that the period with lower zooplankton biomass coincides with lower-than-average heat contents in the Norwegian Sea (ICES 2019). More ecological and environmental research to reveal inter-annual variations and long-term trends in zooplankton abundance are recommended. Quantitative research 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.

Norwegian spring-spawning herring

The zero-line was not fully reached in the north western part of the distribution area of the adult NSS herring. However, based on the zero-line reached south and east of this area, the vast majority of the NSS herring stock is believed to be contained within the survey area. It is therefore recommended that the results from IESNS 2019 can be used for assessment purpose. The herring was primarily (~2/3) distributed in the south western Norwegian Sea (Figure 12) but a third of the biomass was distributed between 69°N and 72°N and this was still primarily the 2013 year class but also the 2014 and 2016 year classes were numerous. This year the amount of herring in the eastern part of the Barents Sea was significant.

As in previous years the size and age of herring were found to increase towards west and south in the Norwegian Sea (Figure 13). Correspondingly, it was mainly older herring that appeared in the southwestern areas. The 2013 year class (age 6) was observed across most of the survey area.

Six year old herring (year class 2013) dominated both in terms of number and biomass (24 %) on basis of the StoX estimations for the Norwegian Sea (Table 2). Its number at age 6 (Table 2) is higher than for the 2009 year class at same age, but only half the size of the large 2004 year class (Figure 14), which puts the size of the 2013 year class into perspective. The large 2004 year class, which has dominated the stock together with the 2002 year class, has contributed significantly to the biomass of older age-groups (see paragraph on issues with age determination below). Herring aged 12-15 years old thus comprised 19% of the numbers and 25% of the biomass. Uncertainty estimates for number at age based on bootstrapping within StoX are shown in Figure 15.

The total estimate of herring in the Norwegian Sea from the 2019 survey was 19.7 billion in number and the biomass 4.87 million tonnes. This estimate is 0.17 million tonnes (3 %) decrease from the 2018 survey estimate. The biomass estimate decreased significantly from 2009 to 2012, and has since then been rather stable at 4.2 to 5.9 million tonnes with similar confidence interval (Figure 16), with the lowest abundance occurring in 2017. Although there is only little change in total abundance and biomass, there is a gradual shift in age and size composition with the 2013 and 2014 year classes becoming more dominant than the old 2004 year class. The 2016 year class had started to enter the Norwegian Sea.

In the Barents Sea, herring was distributed widely in the area and in large concentrations in the eastern part of the survey area, where the zero line concentration was not reached. The abundance estimates of herring by age and length in the Barents Sea (Stratum 6) are shown in Table 3. The herring at age 3 was in the highest number (17 billions, mean length 22.1 cm and mean weight 67 g). This is the second largest observation of age 3 herring in the Barents Sea since the start of this survey in 1991, only slightly lower than the estimate in 1994 (the strong 1991 year class). Age 2 herring was also in significant amount (2.3 billions, mean length 16.7 cm and mean weight 28.5 g). The abundance of age 1 herring was low (0.1 billions, mean length 12.0 and mean weight 11.2 g). The survey estimates of age 1, 2 and 3 from the period 1991-2019 are shown in Figure 17. The year class from 2016 was also relatively numerous at age 1 in 2017 and the 5th largest on record as 2 year olds in 2018. This gives good indications that the 2016 year class is a good year class, which will probably recruit to the adult stocks over the coming two-three years. The zero-line was not fully covered to north and east, but the main aggregations were more southerly distributed and probably most of the juvenile herring was covered by the survey.

In the last 5 years there have been concerns regarding age reading of herring, because the age distributions from the different participants have showed differences – particularly older specimens appear to have uncertain ages. A scale and otolith exchange has been ongoing for some period, where scales and otoliths for the same fish have been sampled. On basis of that work, a workshop was planned in the spring 2018 to discuss the results. This workshop was postponed indeterminately. The survey group emphasizes the necessity of having this workshop before next year's survey takes place.

With respect to age-reading concerns in the recent years, the comparison between the nations in this year's survey showed a similar difference as observed in recent years (Figure 21). For example, the 2004 year class was in higher proportion by the Norwegian readers than the Faroese and the Icelandic readers in Stratum 3 and 4, which had higher proportions of the 2005 and 2006 year classes. These three year classes are in the plus group in the analytical assessment (age 12+).

In the IESNS survey in 2019 there was good agreement in the acoustic scrutinizing results between any neighbouring vessels.

Blue whiting

The spatial distribution of blue whiting in 2019 was similar to the years before, with the highest abundance estimates in the southern and eastern part of the Norwegian Sea, along the Norwegian continental slope. The main concentrations were observed in connections with the continental slopes of Norway and along the Scotland – Iceland ridge (Figure 18). Blue whiting was distributed similar as last year and not as far west into the Norwegian Sea as in the years before. The largest fish were found in the western and northern part of the survey area (Figure 19). It should be noted that the spatial survey design was not intended to cover the whole blue whiting stock during this period.

The total biomass index of blue whiting registered during the IESNS survey in 2019 was 0.53 million tonnes, which is a 6 % increase from the biomass estimate in 2018 (0.50). The abundance index for 2019 was 6.2 billion, which is 41 % higher than in 2018. The main reason for this is the incoming 2018 year class. Ages 4, 1 and 5 are dominating the acoustic estimate (71 % of the biomass and 80% by number). Uncertainty estimates for numbers at age based on bootstrapping with StoX are shown in Figure 20.

In this year's IESNS survey, one-year old blue whiting was more numerous as compared to IESNS 2017 and 2018. The survey group compared age and length distributions by vessel and strata (Figure 22 and 23) and no clear differences were found.

Mackerel

Trawl catches of mackerel is shown in Figure 24. This shows that mackerel was present in the southern part of the Norwegian Sea in the beginning of May. No further quantitative information can be drawn from these data as this survey is not designed to monitor mackerel.

Vertical profile across the Norwegian Sea

Two "transects" were carried out by G.O. Sars across the southern part of the Norwegian Sea (Figure 25). Herring was distributed mainly to the west of 2 - 3° W, in the temperature range 0 - 4 °C. The largest aggregations of older herring were observed acoustically between 6 and 10° W in the high-gradient thermal zone near the border of the cold East Icelandic Current in a layer from 150 to 400 m. The blue whiting, as in previous years, was distributed in Atlantic waters, preferring a layer between 300 and 400 m. Its schools were registered mainly in areas with high temperature gradients from the "warm side" of the frontal zone between the Atlantic and Arctic waters and in the bottom layer above the shelf and continental the slope of Norway. Some blue whiting were observed in the southwestern area to south from Faroe-Iceland Ridge in layer 350-450 m under temperature 6-7 °C.

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General recommendations and comments

Recommendation	Adressed to
1. Continue the methodological research in distinguishing between Herring and blue whiting in the interpretation of echograms.	WGIPS
2. It is recommended that a workshop based on the ongoing otolith and scale exchange will take place before next year's IESNS survey.	WGBIOP, WGWIDE
3. It is recommended that the WGIPS meeting in 2020 includes a workshop on how to deal with stock components of herring in the IESNS-survey.	WGIPS
4. It is recommended that the WGIPS meeting in 2020 discusses whether cruise-planning with zig-zag transects in some strata is a possibility for the IESNS survey in order to optimise survey coverage.	WGIPS
5. It is recommended that the WGIPS meeting in 2020 discusses the possible implementation of sonar observations in IESNS and other acoustic surveys.	WGIPS

Next year's post-cruise meeting

We will aim for next meeting in Copenhagen 16-18 June 2020. The final decision will be made at the next WGIPS meeting.

Concluding remarks

- The sea temperature in 2019 at 0-200 m depth was above long-term mean (1995-2017) in the western and central Norwegian Sea but below the mean in the eastern and southern areas of the Norwegian Sea.
- The 2019 index of meso-zooplankton biomass in the Norwegian Sea and adjoining waters increased a bit from last year and is comparable to the mean of the earlier high-biomass period, but is still relatively low in the westernmost areas.
- The total biomass estimate of NSSH in herring in the Norwegian Sea was 4.87 million tonnes, which is a 3 % decrease from the 2018 survey estimate. The survey followed the pre-planned protocol and the survey group recommends using the abundance estimates in the analytical assessment.
- The 2013 year class dominated in the survey indices both in numbers and biomass (24 %). Despite relatively high number at age 6 of this year class, it is half the size of the large 2004 year class at the same age.
- The estimated number at age 3 (2016 year class) of NSSH in the Barents Sea in 2019 was the highest observed since 1994. Although uncertainty around the estimates are high, this indicates that the 2016 year class will recruit strongly to the adult stock over the next two-three years.
- The biomass of blue whiting measured in the 2019 survey increased by 6 % from last year's survey and 41 % in terms of numbers.
- Ages 4, 1 and 5 (2015, 2018 and 2014 year classes) of blue whiting are dominating the acoustic estimate (71 % of the biomass and 80 % by numbers).

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Tables

Table 1. Survey effort by vessel for the International ecosystem survey in the Nordic Seas in May - June 2018.

Data for Vilnyus will be updated for final report in August 2019.

Vessel	Effective survey period	Effective acoustic cruise track (nm)	Trawl stations	Ctd stations	Aged fish (HER)	Length fish (HER)	Plankton stations
Dana	06/05-26/05	2058	20	38	473	1559	38
Magnus Heinason	2/5-12/5	1496	12	19	349	554	19
Árni Fridriksson	8/5-19/5	2320	13	35	914	2515	34
G.O.Sars	01/5-31/5	4887	53	55	564	1680	54
Vilnyus	03/6-19/6	2770	17	45	556	2955	45
Total		**10761**	**98**	**147**	**2300**	**6308**	**145**

Table 2. IESNS 2019 in the Norwegian Sea. Estimates of abundance, mean weight and mean length of Norwegian spring-spawning herring.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
16-17	-	-	-	24512	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24512	713.3	29.10
17-18	-	55317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	55317	2012.6	36.38
18-19	6030	18091	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24121	978.7	40.58
19-20	-	4923	4923	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9846	537.9	54.63
20-21	-	19696	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19696	1288.0	65.39
21-22	-	19967	54564	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74531	5233.6	70.22
22-23	-	27108	275402	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	302510	24142.4	79.81
23-24	-	-	640302	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	640302	59839.0	93.45
24-25	-	-	592054	7461	-	-	-	-	-	-	-	-	-	-	-	-	-	-	599515	61842.0	103.15
25-26	-	19111	290836	23889	-	-	-	-	-	-	-	-	-	-	-	-	-	-	333836	39115.4	117.17
26-27	-	-	401494	3375	3375	-	-	-	-	-	-	-	-	-	-	-	-	-	408244	54944.1	134.59
27-28	-	3180	177549	80370	85869	3180	6361	-	-	-	-	-	-	-	-	-	-	-	356510	54080.0	151.69
28-29	-	-	143631	118774	217920	141779	13128	-	18379	13128	-	-	-	-	-	-	-	-	666739	115694.5	173.52
29-30	-	-	5557	205671	456082	392370	66183	2364	33091	7091	7091	-	-	-	-	-	-	-	1175500	220984.3	187.99
30-31	-	-	9045	153768	409969	488625	177890	69347	106231	15075	3015	-	9045	-	-	-	-	-	1442012	299482.5	207.68
31-32	-	-	-	21795	539092	780021	99941	76904	108269	86403	49970	-	-	-	-	-	-	-	1762397	394334.4	223.75
32-33	-	-	-	5894	263760	1499818	198994	152871	23574	67810	42406	5894	36986	-	-	-	-	-	2298006	562165.2	244.63
33-34	-	-	-	45209	110186	931985	274370	223970	60198	21066	1289	-	-	-	-	-	-	-	1668273	437728.9	262.38
34-35	-	-	-	-	40303	307932	302795	233985	123268	215323	30847	55462	53724	28961	6806	-	-	-	1399405	404735.9	289.22
35-36	-	-	-	-	28359	196578	70759	331745	208858	309430	198001	198257	200157	174175	44490	35448	-	-	1996256	620313.0	310.74
36-37	-	-	-	-	3566	33763	13372	72161	198850	350525	261806	224979	548152	264010	254163	2674	-	-	2228021	723676.3	324.81
37-38	-	-	-	-	11522	9048	22708	44157	41219	198577	206531	147545	404944	371497	261547	54879	5027	-	1779201	615561.3	345.98
38-39	-	-	-	-	-	-	8613	-	-	10179	3915	51722	108650	82144	90090	18009	-	-	373323	137998.6	369.65
39-40	-	-	-	-	-	-	-	-	-	-	-	-	19045	17102	3420	33866	-	-	73433	28858.9	393.00
40-41	-	-	-	-	-	-	-	-	-	-	-	2750	-	-	-	5499	-	-	8249	3737.3	453.06
41-42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8306	8306	3584.1	431.50
TSN(1000)	6030	167393	2595359	690716	2170003	4785101	1255113	1207504	921939	1294606	804871	686609	1380702	937888	660516	150376	5027	8306	19728061	-	-
TSB(1000 kg)	253.3	10528.0	288485.2	124080.6	461558.3	1146871.7	322436.5	342043.3	258763.5	394139.7	254213.4	224025.6	453514.2	312166.5	222575.8	52598.7	1743.5	3584.1	-	4873582.1	-
Mean length (cm)	18.00	20.09	24.60	28.68	30.49	31.90	32.62	33.81	33.73	34.98	35.47	36.04	36.22	36.45	36.76	37.27	37.00	41.00	-	-	-
Mean weight (g)	42.00	62.89	111.15	179.64	212.70	239.68	256.90	283.26	280.67	304.45	315.84	326.28	328.47	332.84	336.97	349.78	346.85	431.50	-	-	247.04

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Table 3. IESNS 2019 in the Barents Sea. Estimates of abundance, mean weight and mean length of Norwegian spring-spawning herring.

LenGrp	age 1	2	3	4	Number (1E3)	Biomass (1E3kg)	Mean W (g)
11-12	44590	-	-	-	44590	412.5	9.25
12-13	57958	38639	-	-	96596	1197.8	12.40
13-14	9441	28323	-	-	37764	561.7	14.88
14-15	-	146810	-	-	146810	2695.4	18.36
15-16	-	464859	-	-	464859	10005.3	21.52
16-17	-	594723	11894	-	606617	15673.9	25.84
17-18	-	419589	18243	-	437832	12967.7	29.62
18-19	-	330068	123076	-	453145	16237.7	35.83
19-20	-	198315	637012	-	835328	35684.7	42.72
20-21	-	84062	1921406	-	2005468	100276.4	50.00
21-22	-	-	3692469	-	3692469	215843.3	58.46
22-23	-	-	5473191	-	5473191	377116.2	68.90
23-24	-	-	4352376	22827	4375204	342148.5	78.20
24-25	-	-	956706	-	956706	86193.3	90.09
25-26	-	-	122087	-	122087	12114.0	99.23
26-27	-	-	6381	-	6381	638.1	100.00
TSN(1000)	111989	2305387	17314842	22827	19755046	-	-
TSB(1000 kg)	1252.1	65629.6	1161355.4	1529.4	-	1229766.6	-
Mean length (cm)	11.99	16.72	22.05	23.00	-	-	-
Mean weight (g)	11.18	28.47	67.07	67.00	-	-	62.25

Table 4. IESNS 2019 in the Norwegian Sea. Estimates of abundance, mean weight and mean length of blue whiting.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
15-16	-	-	-	-	-	-	-	-	-	-	-	1414	1414	-	-
16-17	201748	-	-	-	-	-	-	-	-	-	-	-	201748	4521.1	22.41
17-18	401046	-	-	-	-	-	-	-	-	-	-	-	401046	10793.4	26.91
18-19	728972	-	-	-	-	-	-	-	-	-	-	-	728972	24964.6	34.25
19-20	928754	-	-	-	-	-	-	-	-	-	-	-	928754	36072.1	38.84
20-21	522045	1388	-	-	-	-	-	-	-	-	-	-	523433	24431.9	46.68
21-22	220569	-	-	-	-	-	-	-	-	-	-	-	220569	12334.4	55.92
22-23	99456	-	-	13369	-	-	-	-	-	-	-	-	112825	7075.0	62.71
23-24	38055	6732	-	-	-	-	-	-	-	-	-	-	44787	3167.4	70.72
24-25	-	36494	61170	18643	4460	-	-	-	-	-	-	-	120766	10226.7	84.68
25-26	12528	61556	87524	86038	11008	-	-	-	-	-	-	-	258654	25551.0	98.78
26-27	-	109246	146840	177200	41030	9914	-	4265	-	-	-	-	488496	53790.1	110.11
27-28	3427	-	225124	245039	152288	32593	1940	-	2397	-	-	-	662808	83509.6	125.99
28-29	-	-	25770	274957	216755	66846	4182	1835	-	-	-	-	590344	83894.2	142.11
29-30	-	-	37072	121687	270425	75085	17977	-	-	-	-	-	522247	79843.0	152.88
30-31	-	-	47156	41705	104185	39331	6605	3642	-	-	-	-	242625	40925.2	168.68
31-32	-	-	-	33566	21461	29717	1989	32377	-	-	-	-	119110	21843.1	183.39
32-33	-	-	-	-	8489	6589	4237	2909	970	-	997	-	24191	4666.4	192.90
33-34	-	-	-	-	-	10386	1888	-	-	3944	-	-	16218	3382.1	208.54
34-35	-	-	-	-	-	-	-	-	4543	-	-	-	4543	1065.6	234.58
35-36	-	-	-	-	1058	2115	-	-	-	-	-	-	3173	928.0	292.47
36-37	-	-	-	-	-	-	-	5123	2115	-	-	-	7239	1912.6	264.22
TSN(1000)	3156598	215417	630655	1012205	831158	272577	38819	50152	10025	3944	997	1414	6223961	-	-
TSB(1000 kg)	123807.7	22738.5	74785.7	131456.3	122102.7	41704.6	6033.0	9147.8	2094.0	826.0	201.2	-	-	534897.5	-
Mean length (cm)	18.86	25.28	26.70	27.46	28.57	29.22	29.75	31.17	32.92	33.00	32.00	15.00	-	-	-
Mean weight (g)	39.22	105.56	118.58	129.87	146.91	153.00	155.41	182.40	208.87	209.46	201.75	-	-	-	85.96

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Figures

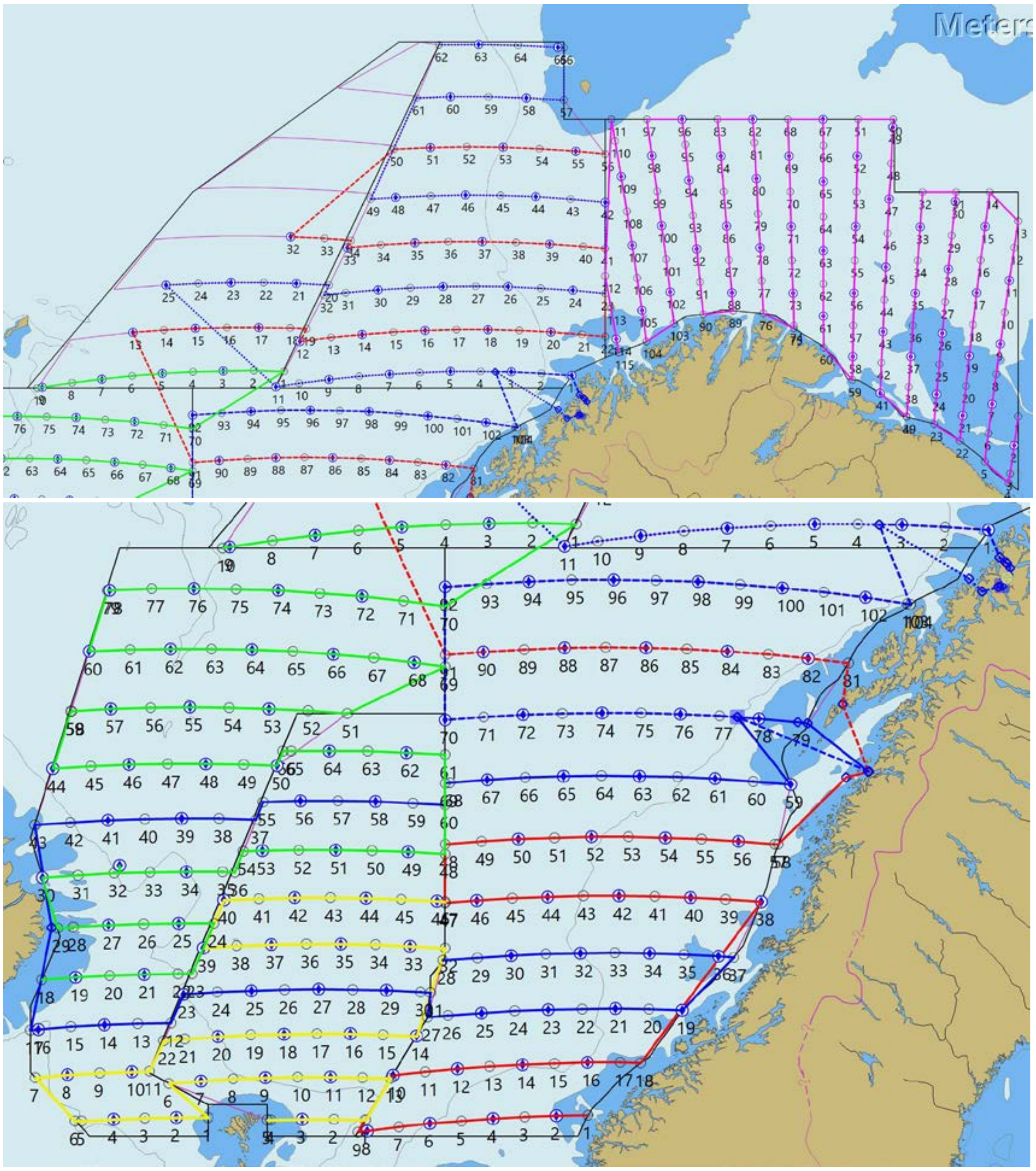

Figure 1. The pre-planned strata and transects for the IESNS survey in 2019 (red: EU, dark blue: Norway, yellow: Faroes Islands, violet: Russia, green: Iceland). Hydrographic stations and plankton stations are shown as blue circles with diamonds. All the transects have numbered waypoints for each 30 nautical mile and at the ends.

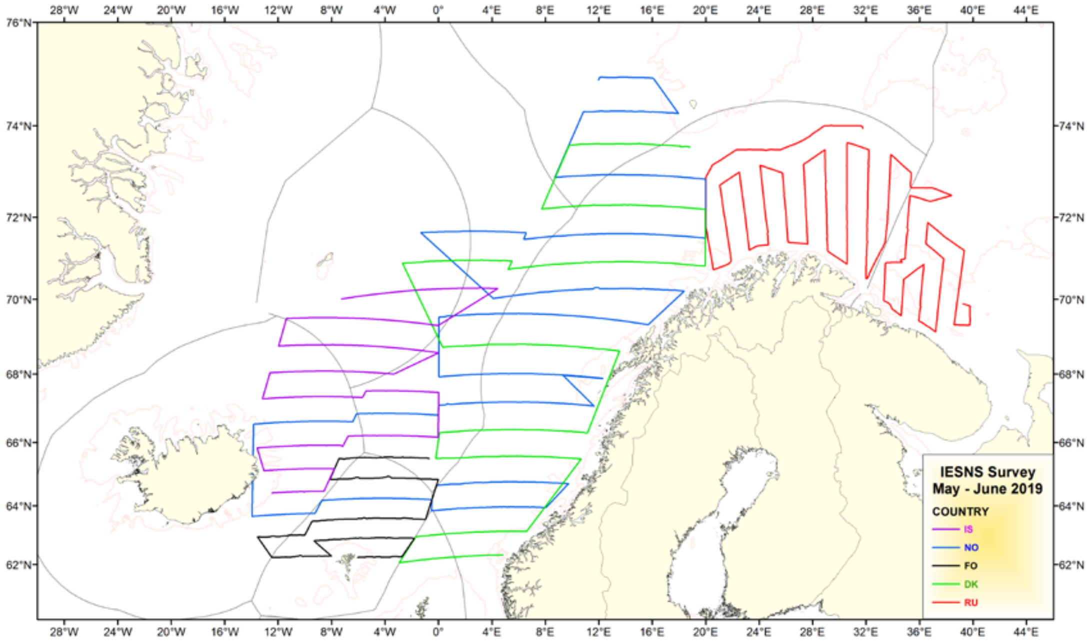

Figure 2. Cruise tracks for the IESNS survey in May 2019.

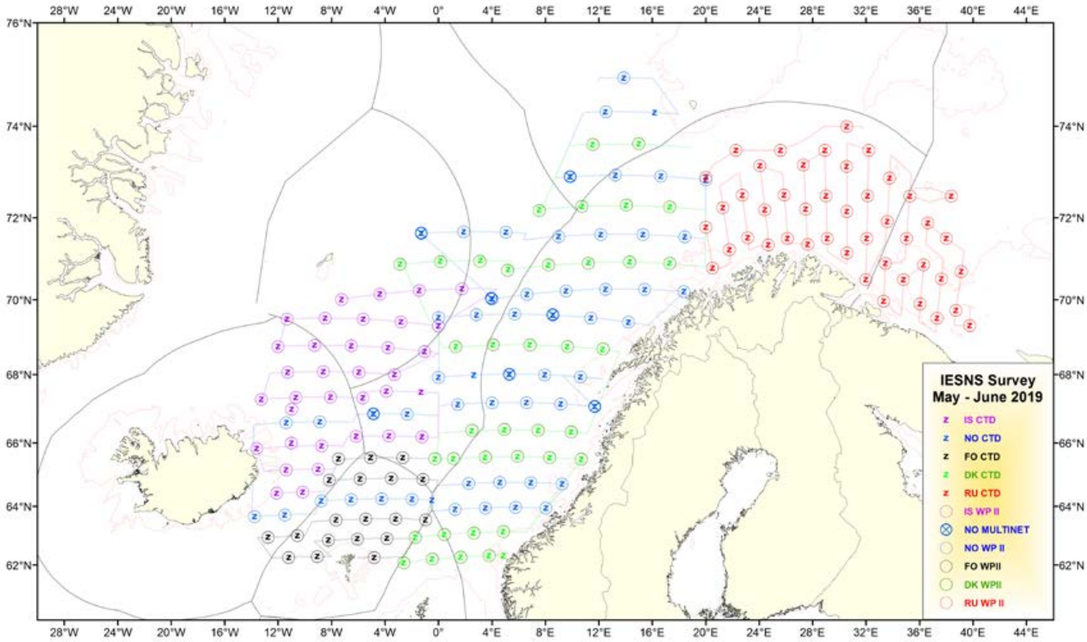

Figure 3a. IESNS survey in May 2019: location of hydrographic and plankton stations.

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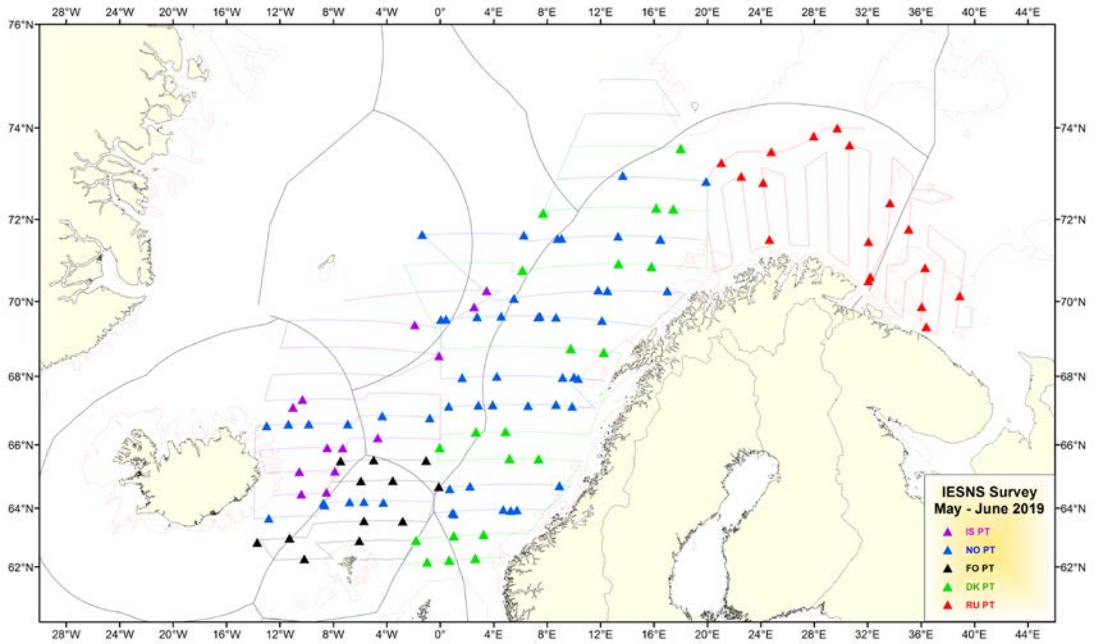

Figure 3b. IESNS survey in May 2019: location of pelagic trawl stations.

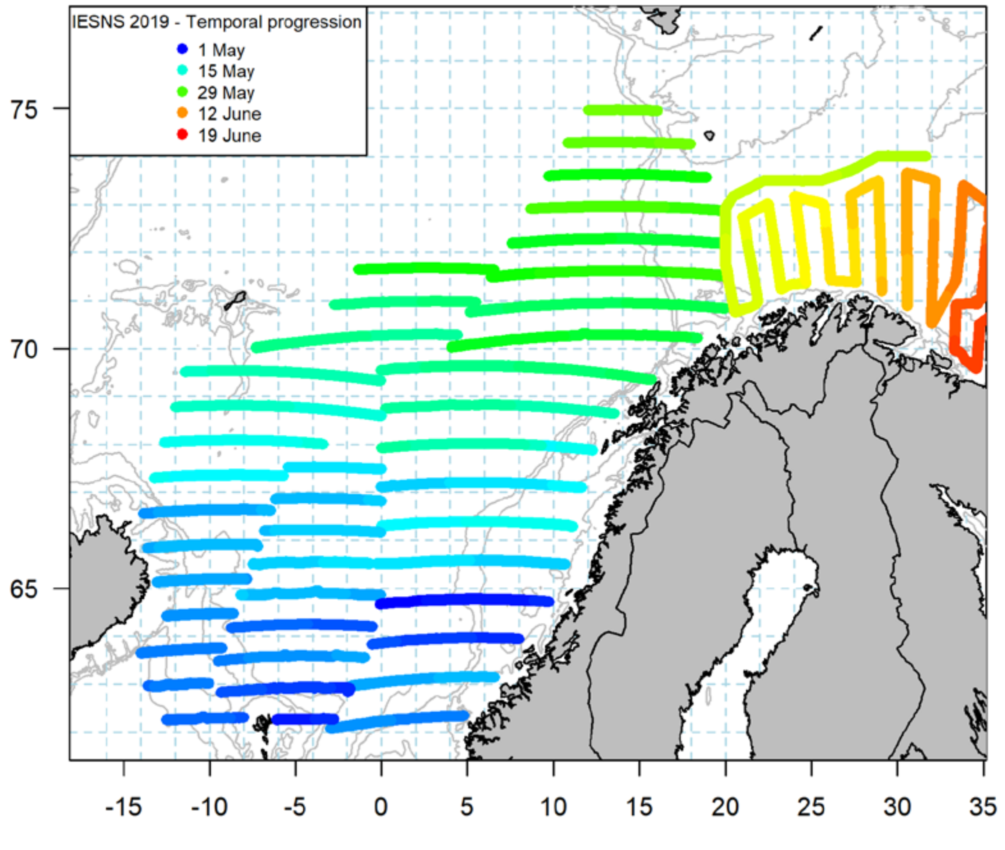

Figure 4. Temporal progression IESNS in May-June 2019.

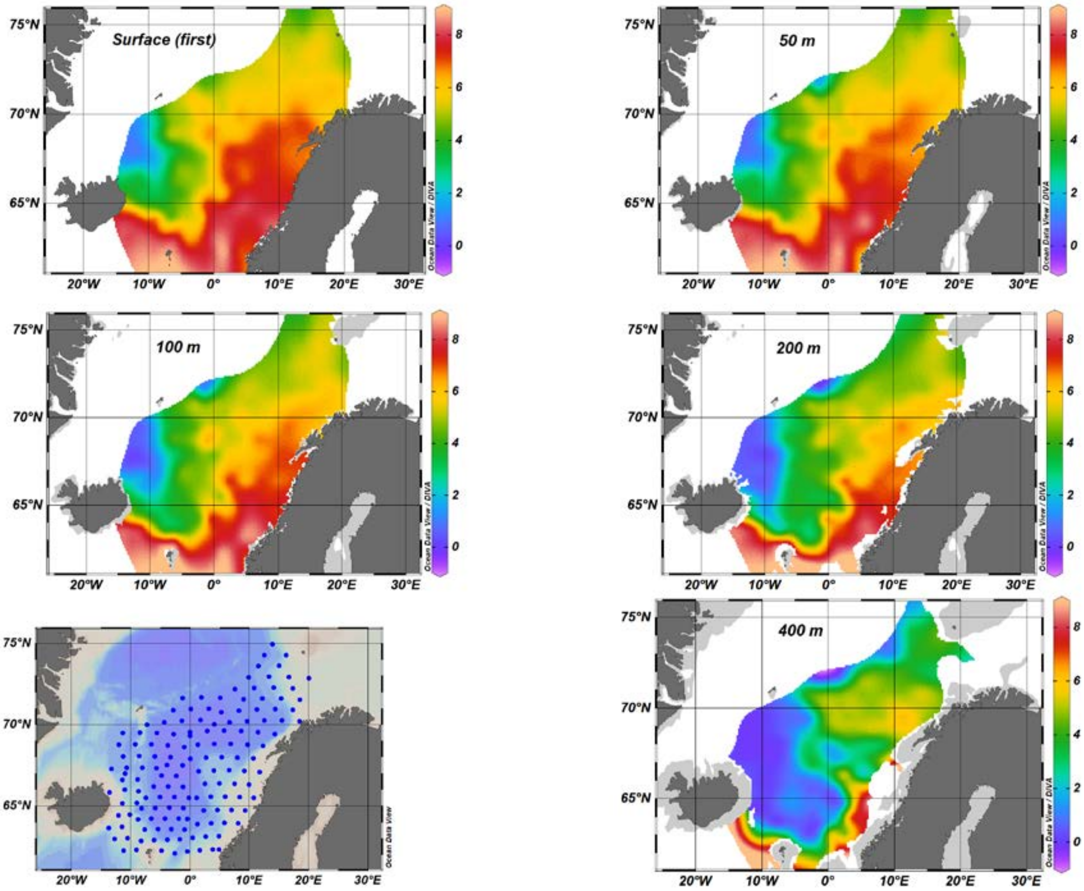

Figure 5. The horizontal distribution of temperatures (°C) at surface, 50m, 100m, 200m and 400m depth in IESNS in May-June 2019.

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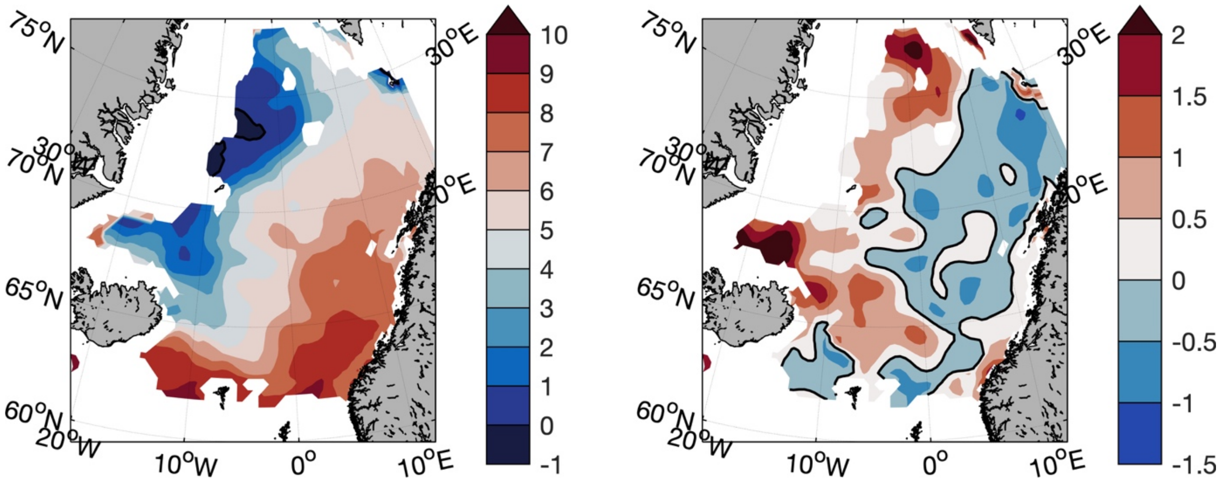

Figure 6. Temperature (left) and temperature anomaly (right) averaged over 0-50 m depth in May 2019. Anomaly is relative to the 1995-2017 mean.

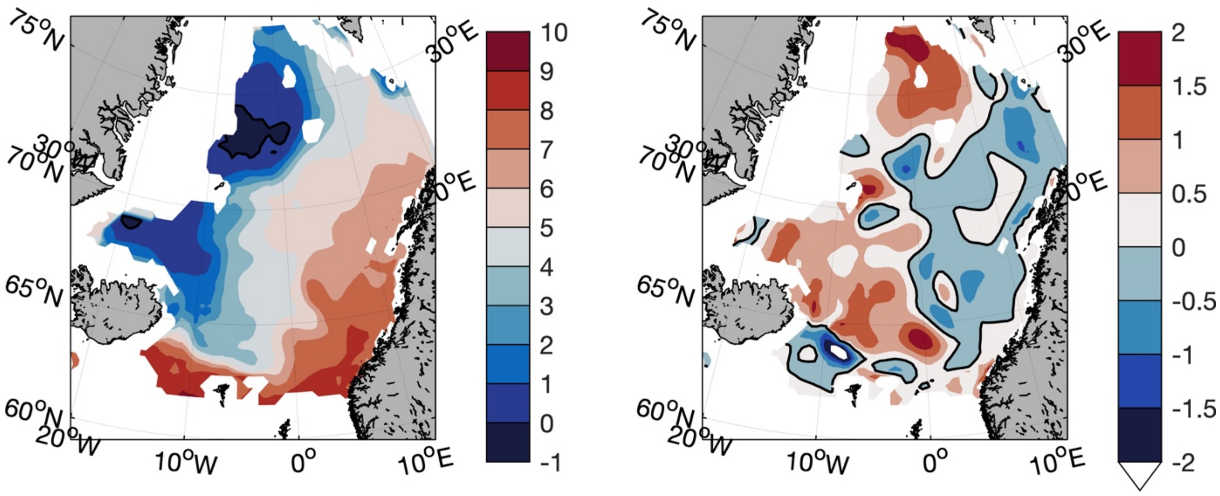

Figure 7. Temperature (left) and temperature anomaly (right) averaged over 50-200 m depth in May 2019. Anomaly is relative to the 1995-2017 mean.

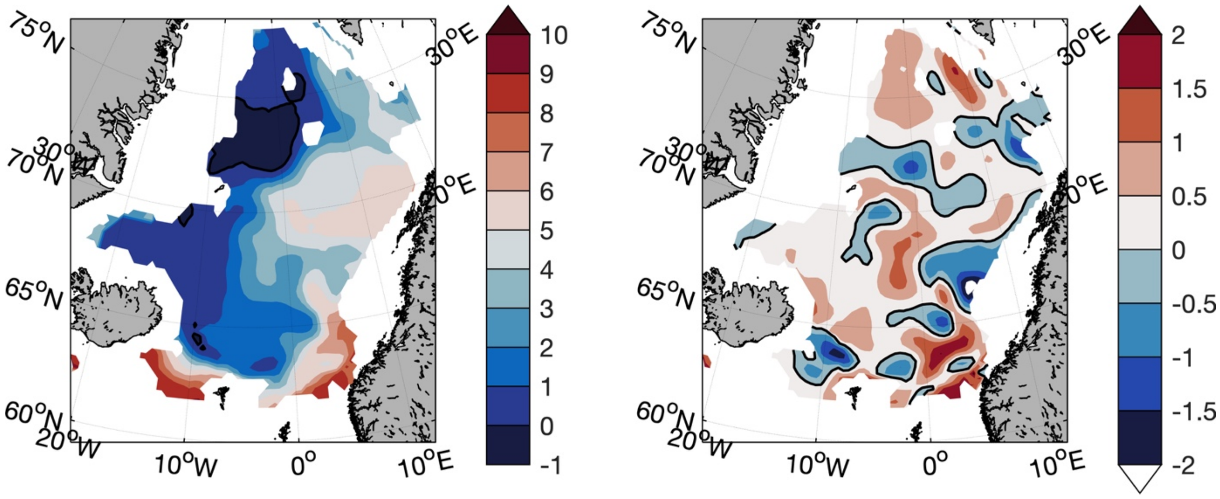

Figure 8. Temperature (left) and temperature anomaly (right) averaged over 200-500 m depth in May 2019. Anomaly is relative to the 1995-2017 mean.

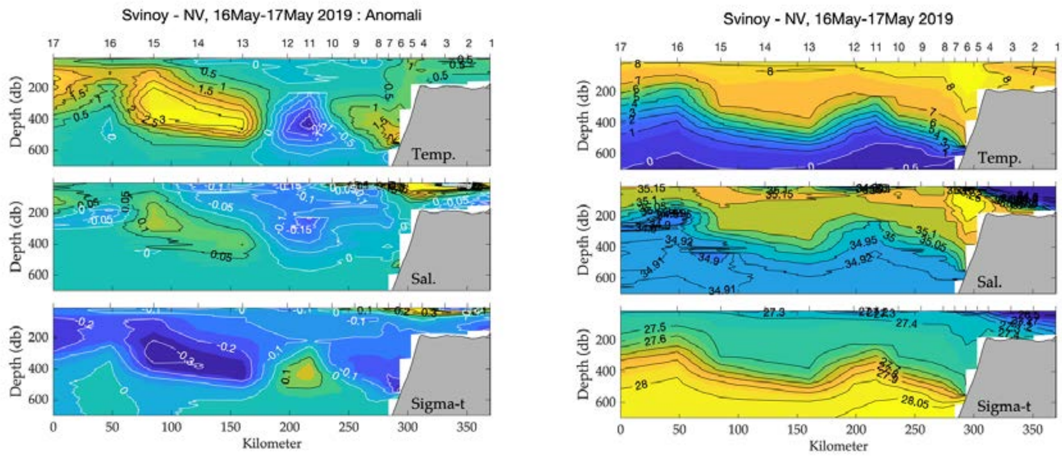

Figure 9. Temperature, salinity and potential density (sigma-t) (left figures) and anomalies (right figures) in the Svinøy section, May 2019. Anomalies are relative to a 30 years long-term mean (1978-2007).

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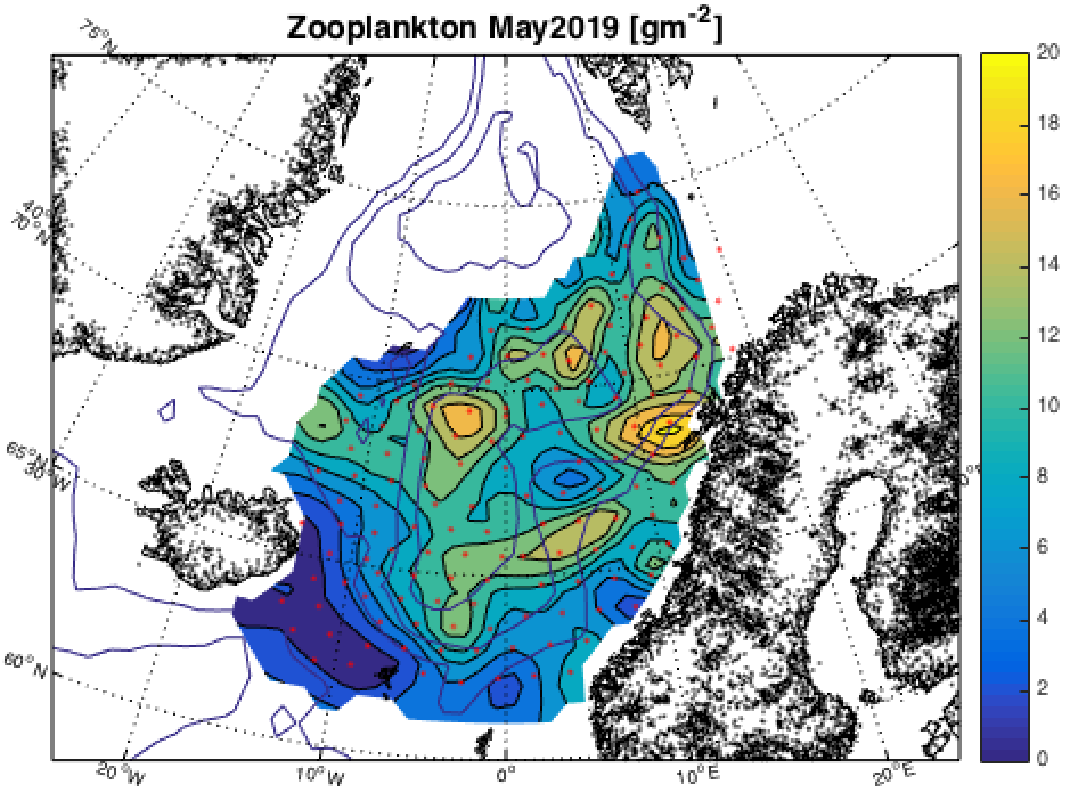

Figure 10. Representation of zooplankton biomass (g dry weight m^{-2}; at 0-200 m depth) in May 2019.

Figure 11. Indices of zooplankton dry weight (g m^{-2}) sampled by WP2 in May in (a) the different areas in and near Norwegian Sea from 1997 to 2019 as derived from interpolation using objective analysis utilizing a Gaussian correlation function (see details on methods and areas in ICES 2016).

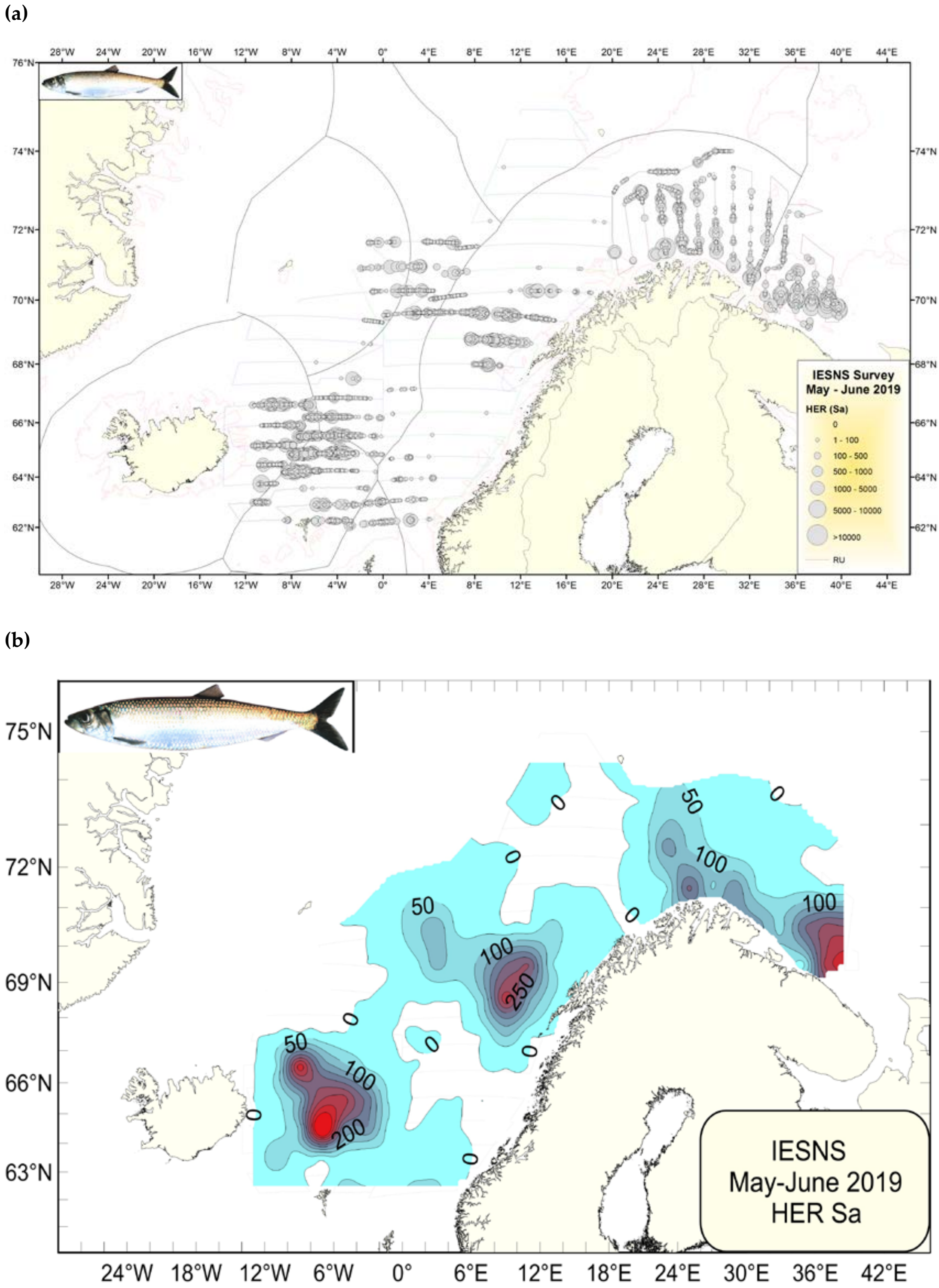

Figure 12. Distribution of Norwegian spring-spawning herring as measured during the IESNS survey in May 2019 in terms of NASC values (m^2/nm^2) (a) averaged for every 1 nautical mile and (b) represented by a contour plot.

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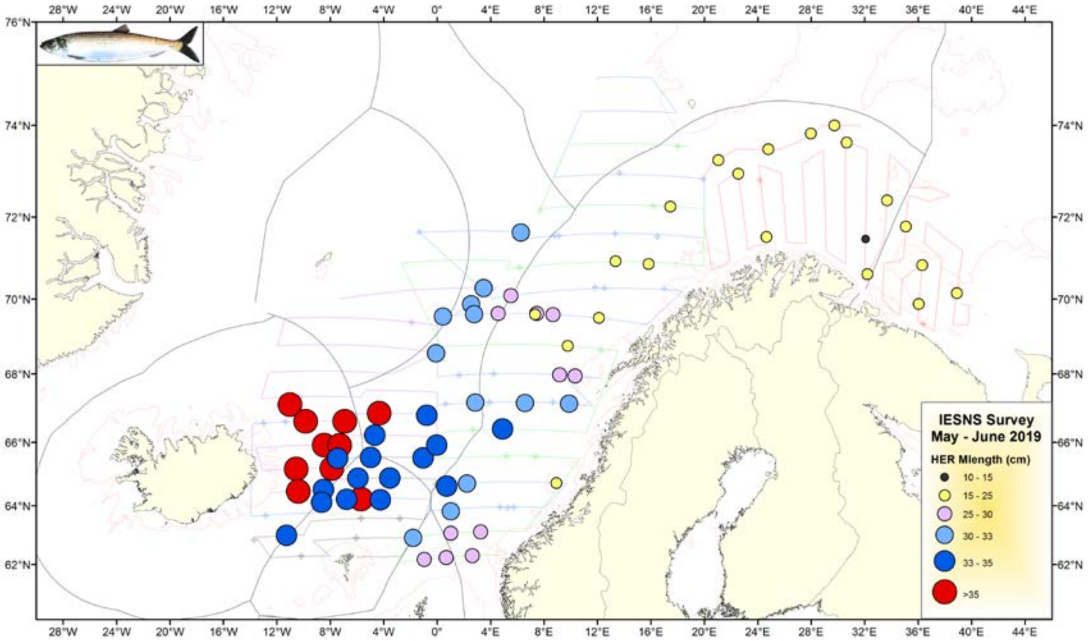

Figure 13. Mean length of Norwegian spring-spawning herring in all hauls in May 2019.

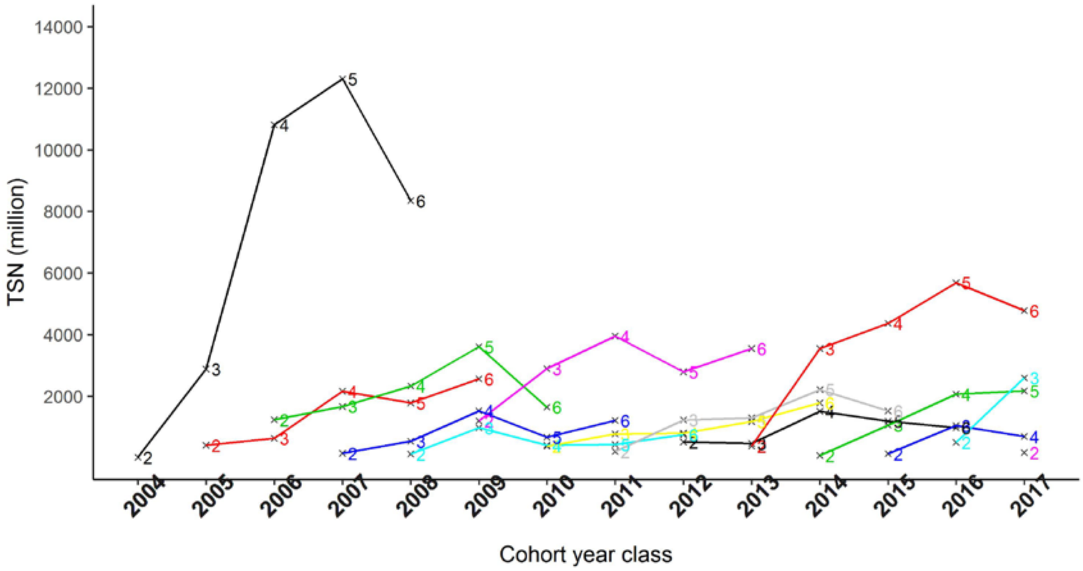

Figure 14. Tracking of the Total Stock Number (TSN, in millions) of Norwegian spring-spawning herring for each cohort since 2004 from age 2 to age 6. From 2008, stock is estimated using the StoX software. Prior to 2008, stock was estimated using BEAM.

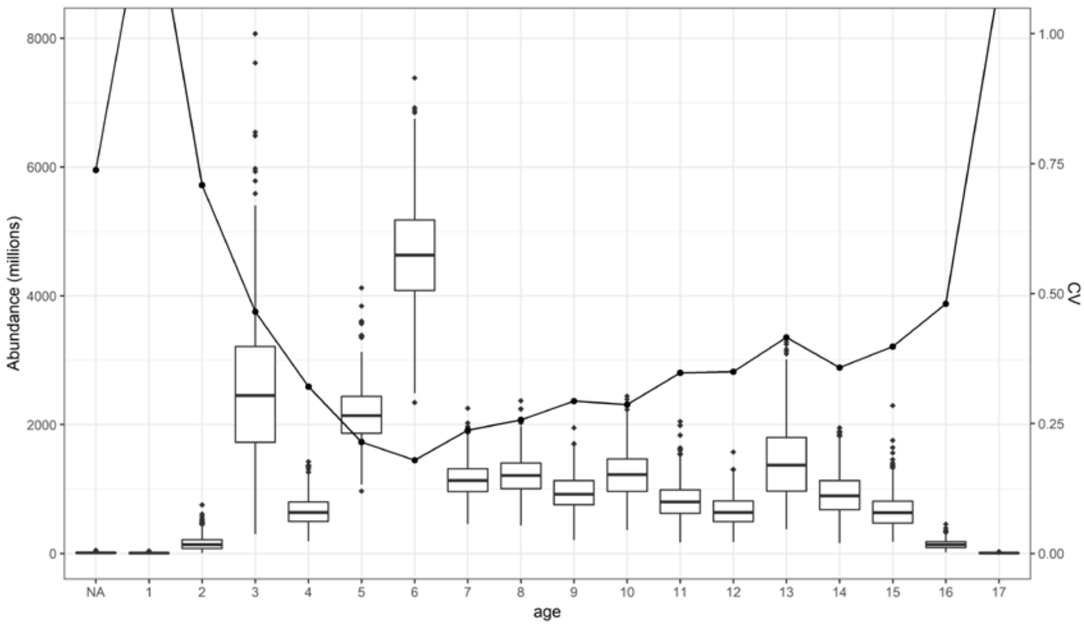

Figure 15. Norwegian spring-spawning herring in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 500 replicates using the StoX software.

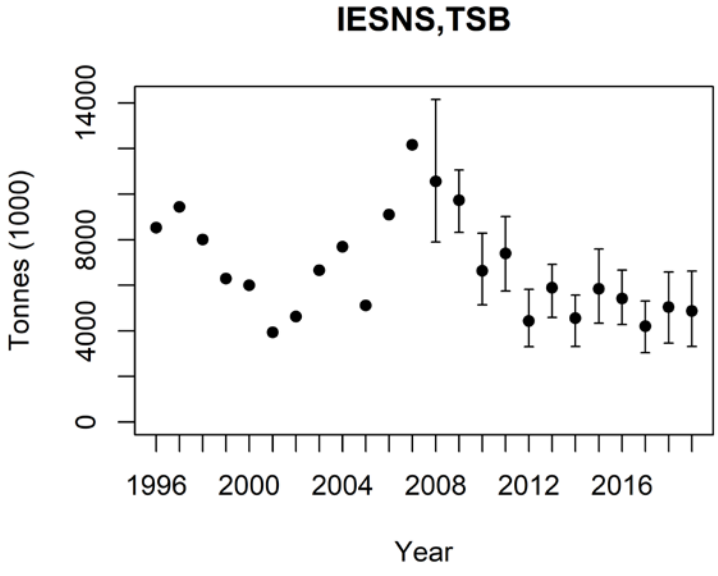

Figure 16. The annual biomass index of Norwegian-spring spawning herring in the IESNS survey (Barents Sea, east of 20°E, is excluded) from 1996 to 2019 as estimated using BEAM (1996-2007; calculated on basis of rectangles) and as estimated with the software StoX (2008-2019; with 90% confidence interval; calculated on basis of standard stratified transect design).

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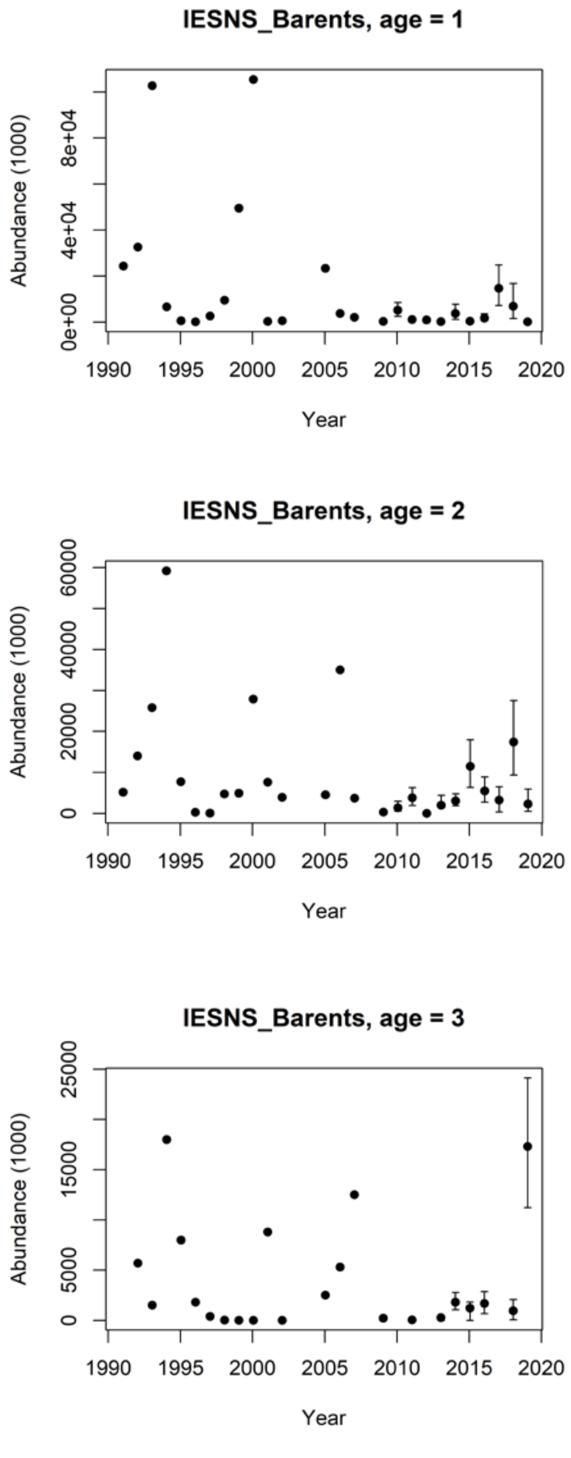
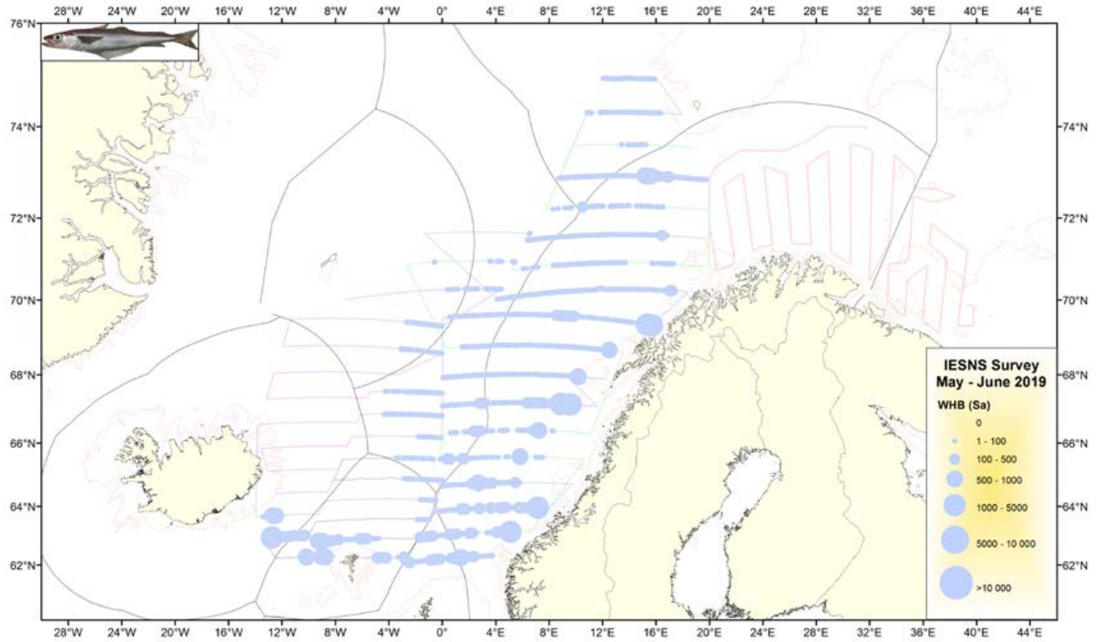


Figure 17. Numbers at age 1-3 herring in the Barents Sea in April-June. From 2009 onwards StoX has been used and the error bars indicates 90% confidence intervals.

(a)



(b)

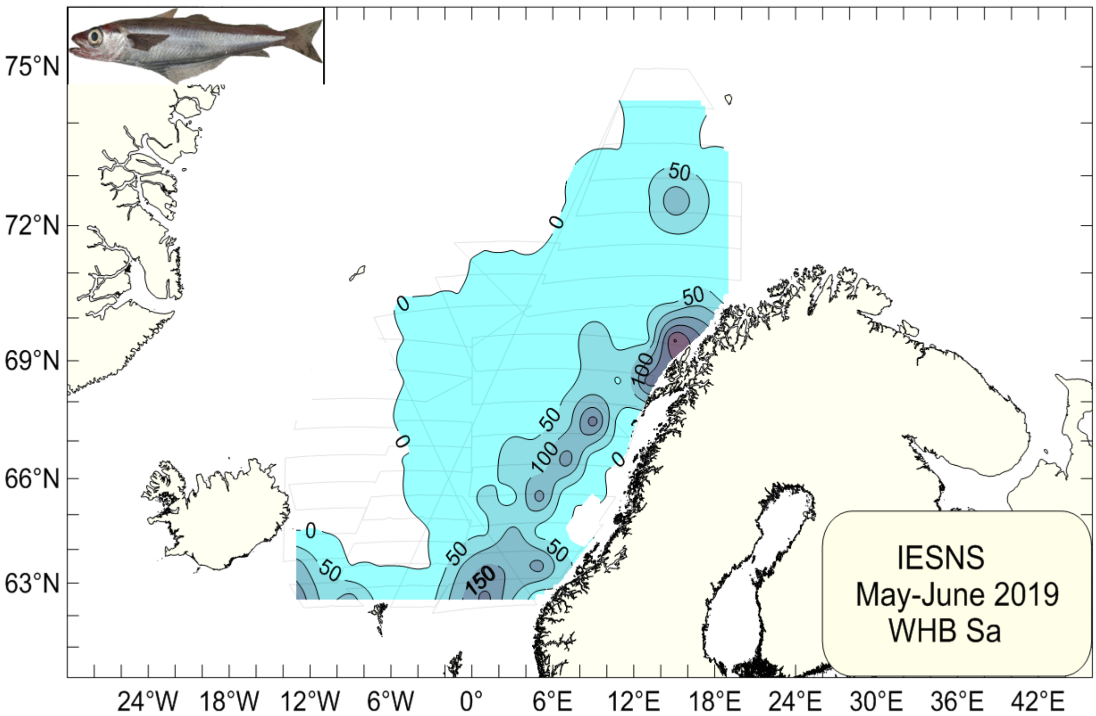


Figure 18. Distribution of blue whiting as measured during the IESNS survey in May 2019 in terms of NASC values (m²/nm²) (a) averaged for every 1 nautical mile and (b) represented by a contour plot. Note that the coverage in the Barents Sea is not included in b.

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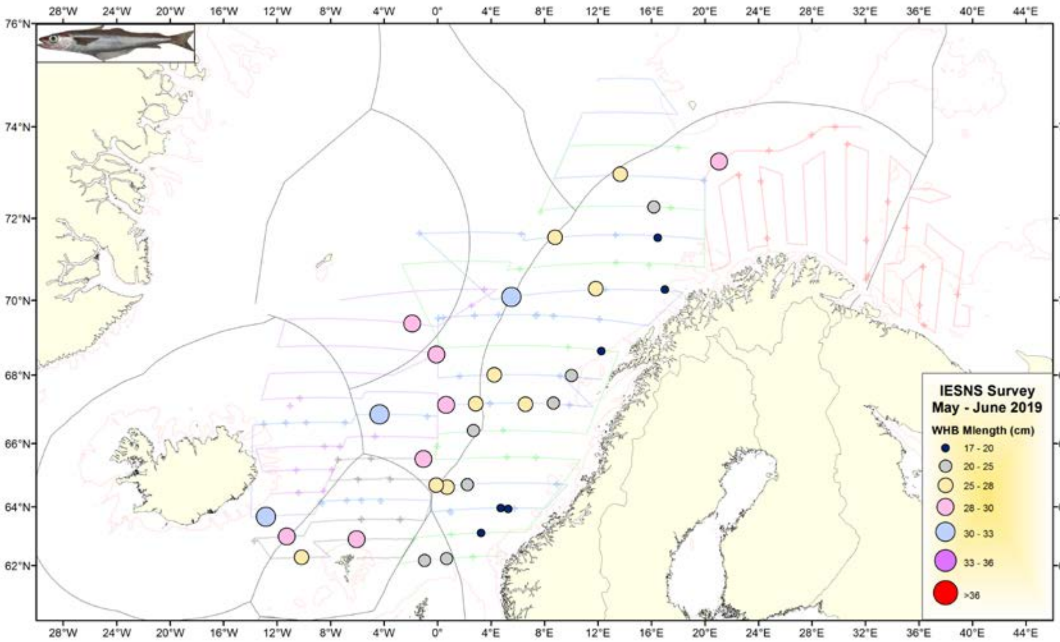

Figure 19. Mean length of blue whiting in all hauls in IESNS 2019.

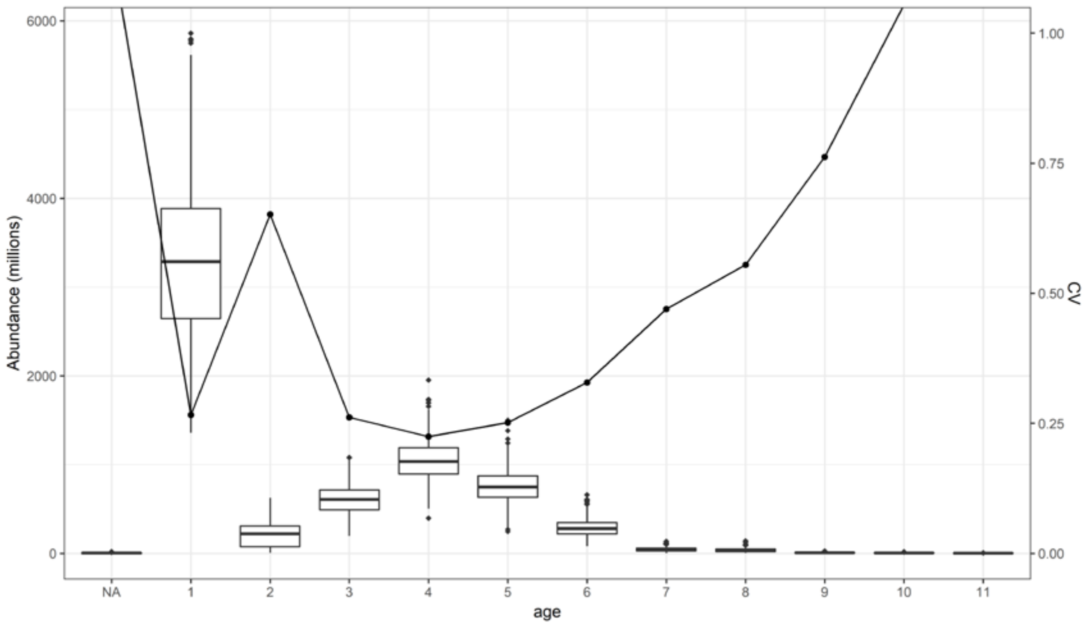

Figure 20. Blue whiting in the Norwegian Sea: R boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 500 replicates using the StoX software.

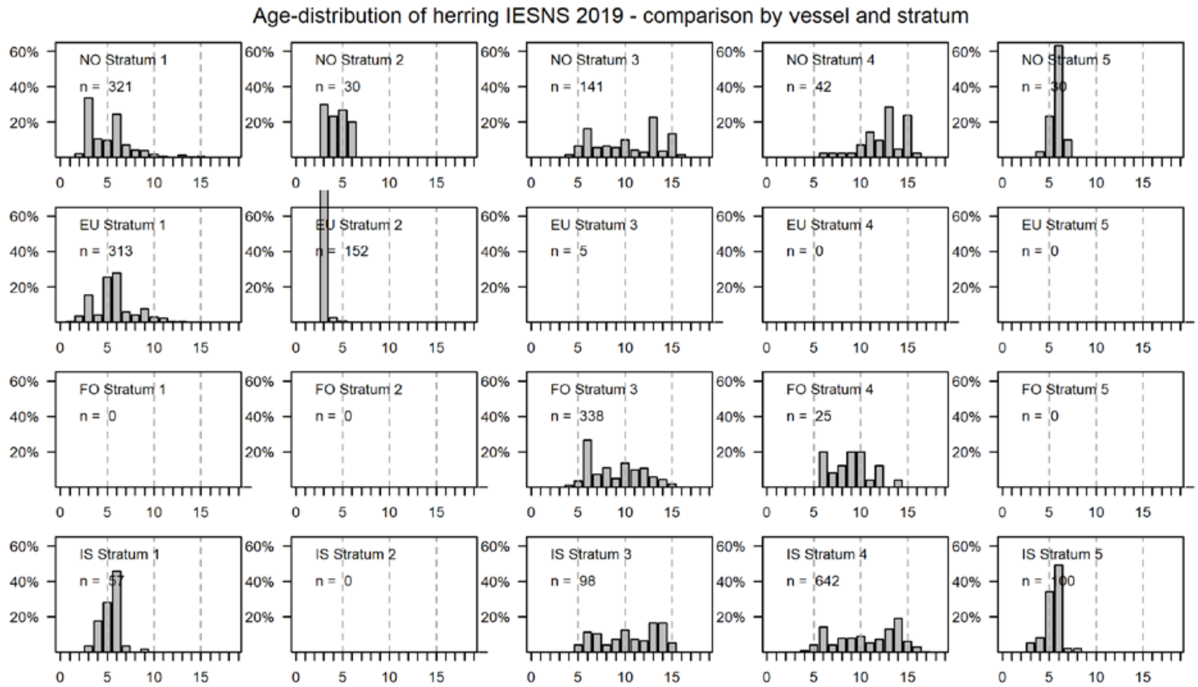

Figure 21. Comparison of the age distributions of NSS-herring by stratum and country in IESNS 2019. The strata are shown in Figure 3.

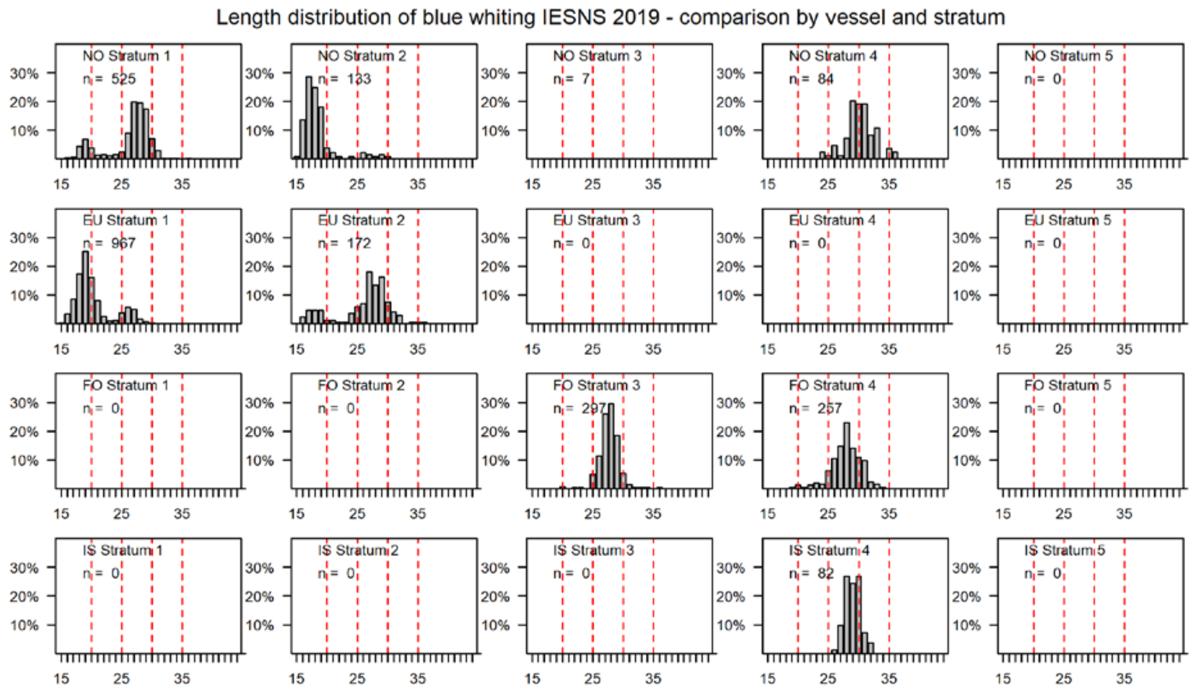

Figure 22. Comparison of the length distributions of blue whiting by stratum and country in IESNS 2019. The strata are shown in Figure 3.

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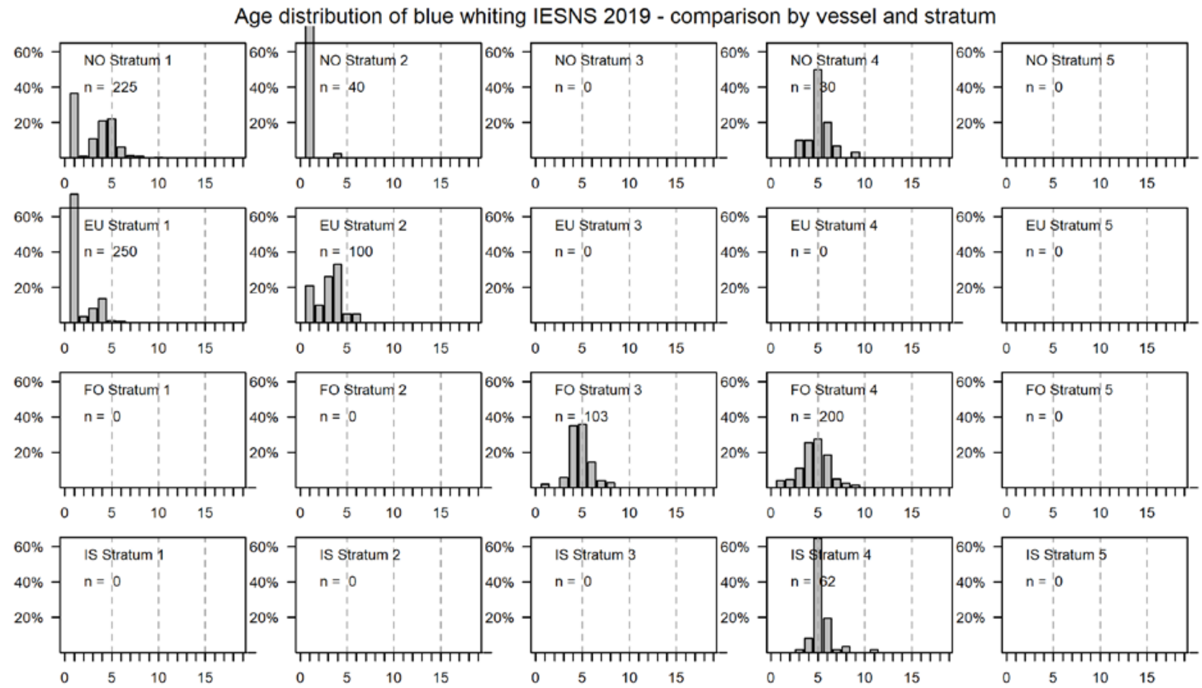

Figure 23. Comparison of the age distributions of blue whiting by stratum and country in IESNS 2019. The strata are shown in Figure 3.

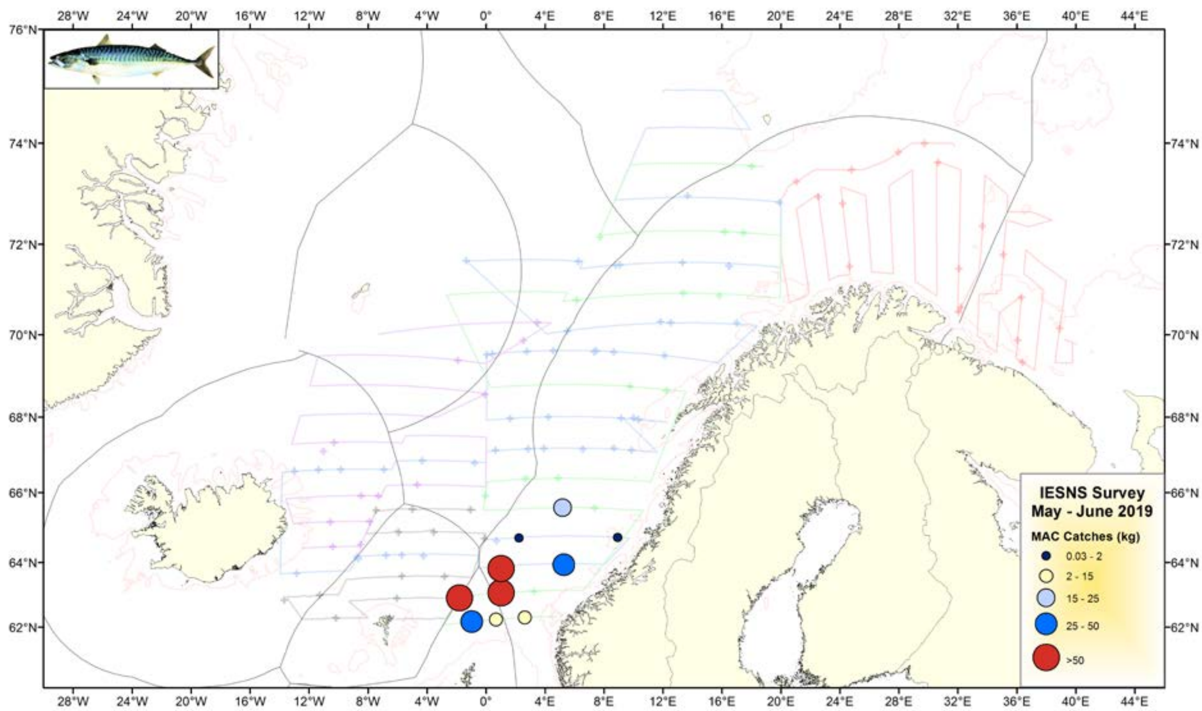

Figure 24. Pelagic trawl catches of mackerel in IESNS 2019.

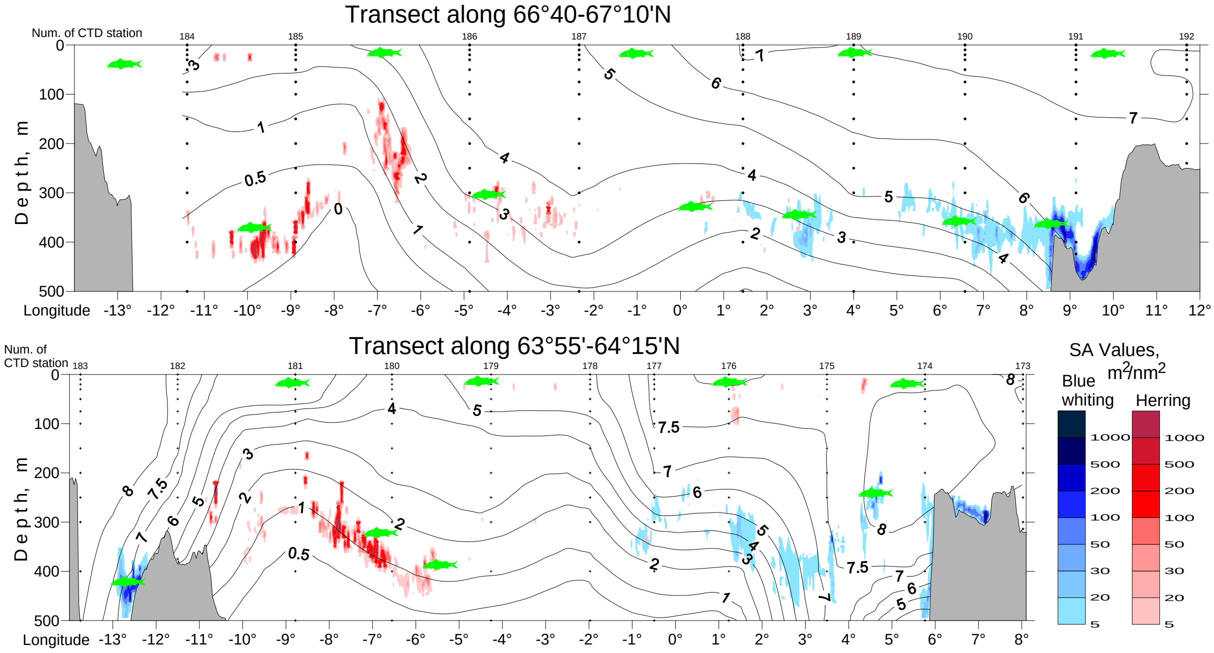

Figure 25. Acoustic values of NSS-herring (red) and blue whiting (blue), location of trawl stations (green fish) and temperature profile (black lines) along two transects across the whole Norwegian Sea in May 2019, covered by "G.O. Sars".

Annex 5: 2019 HERAS Survey Summary Table and Survey Report

Document 5a: HERAS 2019 survey summary table

Survey Summary table WGIPS 2020	
Name of the survey (abbreviation):	HERAS
Target Species:	Herring and sprat
Survey dates:	25 June – 24 July 2019
Summary:	
The 2019 survey covered planned strata and survey effort, timing and coverage were mainly comparable to previous years and all main aggregations of sprat and herring are considered to have been sampled sufficiently. The Dutch and German areas were not covered in full in strata 81 and 131. This is due to a lack of time due to engine problems for the Dutch component and adverse weather conditions for the German component. This did not affect the StoX analysis and subsequent abundance estimation significantly. The lack of data in strata 131 was handled by redefining the strata in StoX. The impact of the few missing southern transects in strata 81 was considered minor. Comprehensive trawling was carried out over the course of the survey providing good confidence in school recognition and supporting biological data for age stratified abundance estimation of the target species in almost all strata. In Strata 1 however, no samples of herring were secured and biological composition of the biomass was assumed from the closest hauls in the neighbouring strata 121. With the very low stock size now in the western area it is getting more difficult to secured catches in this area and potentially affects the accuracy of the stock composition estimates for West of Scotland and Malin Shelf herring. Distribution of herring in the North Sea area is similar to that seen in 2017 and 2018 though it did not extend as far south as in the years prior to 2017. Abundance of NSAS herring was slightly lower compared to recent surveys in the North Sea area. Particularly the abundance of age 2 winter ring herring was very low this year and the maturity level of this age class is still low although it is higher than in 2018. The WBSS herring abundance estimate was 23% lower than last year's estimate, and among the lowest estimates of the time series.	

In the Malin Shelf area herring was found in all but the Minch strata. There was an increase in herring distributed south of 56°N in 2019 compared to recent years. There was still herring found in the traditional areas to the north and west of the Outer Hebrides (north of 56°N). In the Malin Shelf area abundance was lower than last year, one of the lowest levels in the time series. The estimate of uncertainty for the Malin Shelf area is high (CV = 0.42); the low number of herring marks recorded on transects along with the low number of biological samples obtained is most likely contributing to this.

Sprat was also encountered within the expected areas. Abundance estimates in the North Sea and Div. 3.a were both high above the long-term average.

The estimates derived from the 2019 survey are considered to be valid for most stocks and consistent with those in each time series. Some caution advised for Malin Shelf herring stock composition due to the very low number of biological samples secured in the area.

	Description
Survey design	Stratified systematic parallel design with randomised starting point within each stratum.
Index Calculation method	StoX (via ICES database) is used to provide indices of abundance. StoX calculated abundances in strata covered by Norway (strata11 and 141) are split by proportion WBSS and NSAS following the Norwegian national method that has been used for the whole time series before being combined with StoX calculated abundances from all other strata.
Random/systematic error issues	No specific issues for this survey outside of those described for standardised acoustic surveys.
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	2019: OK Not generally an issue. During severe weather survey effort was paused in most strata until conditions improved.
Extinction (shadowing)	2019: OK Target species not thought to aggregate in dense enough schools to produce extinction effects.

Blind zone	2019: OK Target species typically not found in large quantities this close to the surface in this area (herring and sprat). It could be a problem in the Norwegian strata where small feeding schools are found high in the water column and when surveying 24h (NOR, DK). This has been consistent throughout the time series and should thus not be a problem for the indices.
Dead zone	2019: OK Target species (herring and sprat) typically not distributed tight to seabed, and thus not a problem.
Allocation of backscatter to species	2019: OK Species composition verified by directed trawling. Allocation of backscatter to species mainly using multifrequency algorithms in LSSS and Echoview.
Target strength	2019: OK Standard agreed (TS = 20 log L - 71.2 dB herring and sprat)
Calibration	2019: OK Survey frequencies calibrated during survey according to SISP and results within recommended tolerances.
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	2019: OK Other surveys often see NSAS herring slightly north of our survey area, but only small amounts assumed not to influence our indices

	significantly. This is evaluated annually by data from the other surveys.
Stock ID and mixing issues	2019: OK WBSS and NSAS herring mix in the North Sea and Skagerrak-Kattegat, and the stocks are split east of 2°E and north of 56°N. Some WoS and Norwegian spring spawning herring might also be found the North Sea. Work is progressing to develop practical methods for assigning each individual to the correct stock that can be standardised across the survey area.
Measures of uncertainty (CV)	MSHAS – 0.42
Biological sampling	2019: OK The number of trawl stations, and herring and sprat measured and aged are considered sufficient and at a similar level as earlier years.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

Document 5b: HERAS 2019 survey report

Please see the report on the next page.

The 2019 ICES Coordinated Acoustic Survey in the Skagerrak and Kattegat, the North Sea, West of Scotland and the Malin Shelf area

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[2] Wageningen Marine Research, IJmuiden, The Netherlands
[3] Marine Institute, Galway, Ireland
[4] Thünen Institute of Sea Fisheries, Bremerhaven, Germany
[5] Institute of Marine Research, Bergen, Norway
[6] DTU-Aqua, Hirtshals, Denmark

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 lower than previous year at 1.9 million tonnes (2018: 2.3) due to a decrease in the number of fish (2018: 12,315 mill. fish, 2019: 10,295). The spawning stock is dominated by fish of age 5 and 6 wr, which is in accordance with the strong year classes in previous years surveys.

The 2019 estimate of Western Baltic spring-spawning herring 3+ group is 74,000 tonnes and 574 million. This is a decrease of 31 and 23%, respectively, compared to the 2018 estimates of 107,000 tonnes and 745 million fish.

The West of Scotland estimate (6.a.N) of SSB is 76 000 tonnes and 406 million individuals, a large decrease compared to the 152 000 tonnes and 875 million herring estimate in 2018.

The 2019 SSB estimate for the Malin Shelf area (6.a and 7.b, c combined) is 128,000 tonnes and 740 million individuals. This is lower than the 2018 estimates (159,000 tonnes and 925 million herring). There was less herring found in the northern strata (to the north and west of the Outer Hebrides) in 2019 compared to recent years, however, there was more herring distributed south of 56°N in 2019; this resulted in a higher estimate for the Malin Shelf combined area compared to the West of Scotland.

There was a sprat benchmark in November 2018 (ICES 2018), resulting in the two sprat stocks in the North Sea and Skagerrak-Kattegat being merged into one. For consistency, the survey results are presented separately in this report for these two areas.

The total abundance of North Sea sprat (Subarea 4) in 2019 was estimated at 124,999 million individuals and the biomass at 892,000 tonnes (Table 5.10). This is about the same level as last year, the highest and second highest in the time series in terms of abundance and biomass respectively, and high above the long-term average of the time series, in terms of both abundance (130% above) and biomass (91%). The stock is dominated by 0- and 2-year-old sprat (70% in numbers). The estimate includes 0-gr sprat (35% in numbers, and 6% in biomass), which only occasionally is observed in the HERAS survey.

In Div. 3.a, the sprat abundance in 2019 is estimated at 2,645 million individuals and the biomass at 38,400 tonnes. This is the second highest estimate of the time series in terms of biomass, and well above the long-term average both in terms of abundance (52%) and biomass (39%). The stock is dominated by 2-year-old sprat.

1 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 2019 herring acoustic surveys.

VESSEL	PERIOD	CONTRIBUTING TO STOCKS	STRATA
Celtic Explorer (IRL) EIGB	4 – 24 July	MSHAS, WoS	2, 3, 4, 5, 6
Scotia (SCO) MXHR6	27 June – 19 July	MSHAS,WoS, NSAS, Sprat NS	1, 91 (north of 58°30'N), 111, 121
Johan Hjort (NOR) LDGJ	29 June – 16 July	NSAS, WBSS, Sprat NS	11, 141
Tridens (NED) PBVO	1 – 18 July	NSAS, Sprat NS	81, 91 (south of 58°30'N), 101
Solea (GER) DBFH	28 June – 18 July	NSAS, Sprat NS	51, 61, 71, 131
Dana (DEN) OXBH	25 June – 09 July	NSAS, WBSS, Sprat NS, Sprat 3.a	21, 31, 41, 42, 151, 152

2 Methods

Survey design and acoustic data collection

The acoustic surveys were carried out and analysed in accordance with the ICES survey manual for International Pelagic Surveys (ICES 2015) using Simrad EK60 and EK80 echosounders with transducers mounted either on the hull, drop keel or in towed bodies. Only data gathered at 38kHz was used for the analysis. Data collected at other frequencies was used for target discrimination. Echo integration and further data analyses were carried out using either LSSS (Large Scale Survey System), Myriax Echoview or Ev2Akubio software. The survey tracks were selected to cover the whole area with sampling intensities based on the herring densities of previous years. Transect spacing between 10 and 30 nautical miles were used in various parts of the area according to perceived abundance and variance from previous years' surveys (Table 5.18). The survey was designed to be analysed using StoX (StoX 2015, Johnsen et al 2019) with an internal agreed strata system (Figure 5.1-5.2).

A total of 9607.3 n.mi of track covered during the survey was used in the acoustic analysis, achieving good coverage of the entire survey area. The transect distance had to be increased slightly from the planned 15 nm due to time constraints in the two Norwegian strata (11, 141). Trawling effort was adequate to achieve good resolution of length distribution and biological parameters in all strata.

Scrutiny of acoustic data

In the Dutch, Irish, Norwegian and Scottish survey, scrutiny of hydroacoustic data during post-processing is taken to species level and corresponding disaggregated data are uploaded to the ICES database. In the German survey area, clupeids usually do not occur in monospecific schools but in comparatively clearly distinguishable aggregations. Accordingly, post-processing of hydroacoustic data is based on an aggregated CLU category. In the Danish survey it is only distinguished between fish and no fish in the post-processing of hydroacoustic data. A corresponding MIX category is allocated to all fish-echo traces and disaggregation of hydroacoustic data is based on total catch composition on a stratum level. All disaggregation steps of mixed acoustic categories are conducted using a Split-NASC project/module in the StoX software (StoX 2015, Johnsen et al 2019).

For both splitting/disaggregating of hydroacoustic data as well as further analyses of disaggregated data (stock estimates), the following target strengths were used for clupeids (ICES, 2015):

Herring, sprat, sardine, anchovy $TS = 20 \log L - 71.2$ dB

Data analysis

The 2019 disaggregated biological and acoustic data were delivered to the acoustic survey database[1] held at the ICES data centre and the data was analysed using the StoX analysis software (StoX 2015, Johnsen et al 2019).

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 5.1). The data were combined to provide estimates of the North Sea autumn spawning herring, Western Baltic spring-spawning herring, West of Scotland (6.a.N) herring and Malin Shelf herring stocks (6.a.N-S and 7.b-c) as well as sprat in the North Sea and 3.a.

1 https://www.ices.dk/marine-data/data-portals/Pages/acoustic.aspx

3 Stock definitions

North Sea Autumn Spawning herring (NSAS)

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 71, 81, 91, 101, 111, 121 in Figure 5.1). East of 2°E and north of 56°N [56.5°N between 2-6°E], in strata 11, 141, 151, 152, 41, 42, 31 and 21, herring is split into North Sea autumn spawners and Western Baltic spring spawners (Figure 5.1). In strata 11 and 141 this is based on analysis of number of vertebrae and in strata 21, 31, 41, 42, 151 and 152 is based on otolith shape analysis.

Western Baltic spring spawning herring (WBSS)

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 mentioned above. The stock splitting methodologies are only applied within strata 11, 21, 31, 41, 42, 141, 151 and 152 (Figure 5.1).

Malin Shelf Herring (MSHAS)

Includes all herring in the stock complex located in ICES areas 6.a and 7.b, c. 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 1 - 6 in Figure 5.1). The survey targets herring of 6.a.N and 6.a.S spawning origin in mixed feeding aggregations on the Malin Shelf. Work is in progress to split the abundance and biomass estimates by spawning origin (6.a.N vs 6.a.S). The differentiation between 6.a herring and North Sea herring across the 4°W line of longitude is purely based on geography.

West of Scotland herring (6.a.N)

This is a subset of the Malin Shelf herring abundance\biomass estimate based purely on geographical location (strata 1 - 4 in Figure 5.1). All herring recorded north of the 56°N line of latitude are reported as West of Scotland (6.a.N). This distinction is kept to maintain a comparable time series of herring abundance to the West of Scotland. The area North of the 56°N line of latitude has been covered annually since 1991 whereas the extended area (MSHAS index) has only been covered since 2008.

North Sea and Div. 3a sprat

The sprat benchmark in November 2018 (ICES 2018) decided that sprat in these two areas should be assessed as one stock from now. In this survey report, the results are still presented separately for these two areas for consistency. The indices should be summed for use in the sprat assessment.

All sprat recorded in the North Sea geographical area (ICES Subarea 4) are included in the North Sea sprat survey estimate. Sprat is however very rarely recorded in the northern part (strata 11, 91, 111, 121 and 141 in Figure 5.1).

Sprat in 3.a. All sprat in strata 21, 31, 41 and 42 are included in this index.

The border between ICES Div. 3.a and Subarea 4 was revised in 2015. The new border has been used for index calculation since 2015, but prior to this the old border was used to delineate the stocks.

4 Acoustic Survey Results for 2019

The survey strata used for the analysis are shown in Figure 5.1. The area covered during the national acoustic surveys is given in Figure 5.2, and magnitudes of acoustic herring and sprat detections (nautical area scattering coefficients) for 5 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, sprat in the North Sea and Div. 3.a) 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.

Herring

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

The estimate of **North Sea** autumn spawning herring spawning stock biomass has decreased by 18% from 2.3 million tonnes in 2018 to 1.9 million tonnes this year (Table 5.6, Figure 5.11).

The abundance of mature fish has decreased from 12 315 million in 2018 to 10 295 this year (Table 5.2). The mean weight of mature fish is similar to last year at 186.4 g and the decrease in biomass follows directly from a decrease in numbers. The 2012- and 2013- year classes (age 5 and 6 winter ring now) continues to be stronger than the long-term average and accounts for 46% of the stock in this year's survey. The 2014-year class (4 wr in 2019) continues to be well below average and this year the 2016-yearclass (2-wr in 2019) is also emerging very weak at the lowest recorded level in the time series (28% of the long-term average).

The abundance of immature fish in the stock has decreased by 25% since last year from 20 290 million in 2018 to 15 265 million this year. This is mainly due to the low number of 2 wr fish this year and the continued relatively low maturity level of the 2 wr fish (Table 5.6, Figure 5.5).

Maturity of 2 winter ringers was at an all-time low in 2018 at 37%. This year the proportion mature at 2 winter rings were higher at 59%, but still low when compared to the long term picture. Maturities for ages 3 and above were comparable to the long-term average, with 97% of 3 winter ringers and 99% or higher maturity for all ages 4 and above. 100% maturity was achieved by age 5 (Table 5.2). Since 2015 observed maturities is reported for all age groups, previously maturity was fixed at 100% for ages above 4 wr.

The distribution of adult herring in the North Sea is still concentrated in the areas east and north of Scotland (Figure 5.3). The distribution was similar to that seen in 2017 and 2018 and does not extend as far south as was the norm in the years prior to 2017. Juvenile herring were seen primarily in the usual distribution in the south eastern parts of the North Sea and in Kattegat.

The 2019 estimate of **Western Baltic** spring-spawning herring 3+ group is 74 000 tonnes and 574 million herring (Table 5.3). This is below the average after 2008 (716 million herring). The 2018 estimate was 745 million, whereas the 2017 estimate was the highest level observed since 2008 (1353 million) and comparable to the stock size prior to the low levels observed after 2008. The stock is dominated by 1 and 2 winter ring fish (Table 5.7, Figure 5.6). The numbers of older herring (3+ group) in the stock is below the recent average level but comprise an average proportion of the total stock compared to recent period (36% as compared to an average of 37% for 2009 to 2018). In 2017, mean weights at age were significantly increased for ages 1-3 winter ringers (up by an average of 20%) but returned to old levels in 2018 and 2019.

The **Malin Shelf** herring estimate of SSB is 128 000 tonnes and 740 million individuals (Table 5.4), a decrease compared to the 159 000 tonnes and 925 million herring estimate in 2018. The estimate is the second lowest in the time series (Table 5.9, Figure 5.14). In 2019, 59% of the biomass was observed north of 56°N (the geographic area included in the West of Scotland (6.a.N) index). This is not typical for the time series; generally, the vast majority of herring are found north of 56°N. For instance, in 2018, 96% of the biomass was observed north of 56°N. The **West of Scotland** (6.a.N) estimate of SSB is 76 000 tonnes and 406 million individuals (Table 5.4), a large decrease compared to the 152 000 tonnes and 875 million herring estimate in 2018. Long-term indices of abundance per age class for West of Scotland herring are provided in Table 5.8 and Figure 5.7. In 2018, the biomass of herring in 6.a.S and 7.b, c was 7 000 tonnes.

There was a decrease in the 2019 estimates for the **Malin Shelf and West of Scotland** (6.a.N) compared to 2018, and the estimates since 2016 are the lowest in the time series. The distribution of herring schools was similar to 2017 with more herring distributed south of 56°N line of latitude (Figure 5.3a). There were some strong herring marks found to the west and northwest of the Outer Hebrides and around St. Kilda in 2019 again. In 2018, large aggregations of juvenile herring were observed around the Northern end of the Hebrides, around the Butt of Lewis and the North Minch. In 2019, juvenile herring were mainly found south of 56°N and to the west of the Hebrides, but in much lower numbers compared to 2018 (Figures 5.3 and 5.17). Herring has in the past been found in high densities to the east of the 4°W line in association with a specific bathymetric feature and the occurrence of these herring west of the line in some years has the ability to strongly influence the annual estimate of abundance of the Malin Shelf/West of Scotland estimates. There is some evidence that this was the case in 2019 again. It appears that the increase in the 2017 and 2018 estimates compared to 2016 were a result of a greater spread in the distribution of herring rather than distributions occurring around the 4°W line.

The 2012- and 2013-year classes (age 5 and 6 winter rings in 2019) are still strong in the stock and comprised 29% of total abundance and 35% of the biomass. The stock is otherwise dominated by 2- and 3 winter ringers (2015 and 2016 year classes), making up 50% of the abundance and 41% of the biomass. Age disaggregated survey abundance indices for Malin Shelf herring since 2008 are given in Table 5.9 and Figure 5.8.

Sprat in the North Sea and Div. 3.a

In the North Sea, sprat data were available from strata 51, 61, 71, 81, 91, 101, 131, 141 and 151 (Table 5.17). In 2015-2018, no sprat were observed in the northern part of the North Sea in strata 11, 111, 121, 141 and 152. In 2019, small amounts of sprat were observed in the most south-eastern part of stratum 141. Sprat were found in the entire stratum 101 in 2018, whereas in 2015-2017 they were mostly found in coastal areas and in 2019 more offshore. In 2014, no sprat were found in this part of the survey, and the coastal distribution of sprat probably explains some of the high variability in abundances between years. In strata 51, 61 and 71, sprat as in previous years were distributed throughout the whole survey area. Highest sprat densities were measured in the southwestern (stratum 81) and southern part of the survey area (51 and 61). Sprat concentrated in the southern part of the North Sea, with the highest abundances and biomass in an area below 56° 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 Div. 3.a in terms of abundance and biomass per stratum is shown in Table 5.17. The NASC values attributed to sprat in the survey are shown in Figure 5.4.

The total abundance of North Sea sprat (Subarea 4) in 2019 was estimated at 124 999 million individuals and the biomass at 880 000 tonnes (Table 5.10). This is at the same level as the historic high in the time series (2016) in terms of abundance and the second highest in terms of biomass. Compared to the 2016 estimate, abundance and biomass is 0.3% higher and 21% lower, respectively (Table 5.11, Figure 5.9). The stock was dominated by 1- and 2-year-old sprat (92% of biomass), and 49% of the sprat were found to be mature (Table 5.10). The 2019, as the 2014-2016 and 2018, sprat biomass estimates are all well above the long-term average for the survey time series, whereas the 2017 estimate is 24% lower (Table 5.11).

An age-disaggregated time-series of North Sea sprat abundance and biomass (ICES Subarea 4), 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 Div. 3.a, sprat in stratum 21 dominated the estimate, but very small amounts were also found in the Skagerrak area (stratum 151), as in 2014-2017. In 2018 and 2013, sprat were only found in the Kattegat (stratum 21). The abundance is estimated at 2 645 million individuals, 23% less than the 3 438 million individuals in 2018 (Tables 5.12-5.13). The biomass was 15% higher than in 2018, at 38 400 tonnes. 2-year-old sprat dominate the stock (57% 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 Div. 3.a are given in Table 5.13 and Figure 5.10. The sprat distribution in the North Sea and Div. 3.a in terms of abundance and biomass per stratum is shown in Table 5.17. The NASC values attributed to sprat in the survey are shown in Figure 5.4.

5 Quality considerations

The 2019 HERAS global survey estimates of abundance were calculated using StoX (StoX 2015, Johnsen et al 2019), with input files (XML) mostly generated via the ICES Acoustic database[2]. The delivery of disaggregated acoustic and biological data to the group continues to be considered an improvement to the survey analysis as it allows a level of transparency and discussion on data collection and standardisation issues not readily achieved before.

Scrutiny of acoustic data

In the Dutch, Irish, Norwegian and Scottish survey, scrutiny of hydroacoustic data during post-processing is taken to species level. Based on scattering characteristics of echotraces as well as catch composition of corresponding targeted trawl catches, a robust allocation of e.g. herring and sprat to echoes originating from detected fish schools and aggregations is feasible. Accordingly, the acoustic categories HER (herring) and SPR (sprat) are allocated to these echotraces and corresponding NASC values are exported from integration results.

In the German survey area, clupeids mostly occur in mixed schools of "typical" appearance that based on hydroacoustic characteristics and corresponding catch composition from trawl haul does not allow allocation of a distinct species category to echotraces. However, clupeid schools in the area are comparatively clearly distinguishable and an allocation of a general aggregated CLU (clupeid) category is feasible. After post-processing, acoustic and biological data from trawl hauls (catch composition, length distribution) are then used in StoX software in a Split-NASC project to partition the general CLU category into HER, SPR and, depending on occurrence and abundance, ANE (anchovy). In 2019, rather atypical or unclear echotraces were recorded in coastal areas of the southern German Bight and along the Dutch coast. Trawl hauls targeting these echotraces yielded a mixture of mostly horse mackerel (*Trachurus trachurus*) and sardines (*Sardine pilchardus*) as well as small contributions of sprat. Since these echotraces accordingly also represented mixed species schools or at least no clear clupeid signal, the aggregated acoustic category MIX was also utilized during post-processing and integration of German acoustic data in 2019. This category then was also split into HOM (horse mackerel), PIL (sardine) and SPR in the StoX Split-NASC project. To account for the rather punctual occurrence of sardines in clupeid aggregations in some strata, that when including PIL into the general CLU category from NASC-splitting would lead to an over-weighting of PIL in the whole stratum, another aggregated category UNK (category names mandatory from ICES DB) was used in the corresponding sections of acoustic transects that then was split into HER, SPR and PIL in the Split-NASC project. NASC values for all relevant acoustic categories resulting from the split-NASC were combined in a following step. This approach is considered to give a robust estimate of the disaggregated, species-specific NASC distribution in the German survey area.

In the Danish survey scrutiny 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 on stratum level. This approach is not compatible with best practice anymore and it should be possible to use modern acoustics species discrimination techniques to apply a more specific allocation. At WGIPS 2017 a scrutiny exercise with all participants was carried out for Danish data, and there was general agreement that it is possible to standardise Danish scrutiny methods to align with those used by other participants in most of the area. However, in the deepest part of the area covered by Denmark (strata 41 and 152) fish does not tend to school even in daytime and herring is found mixed with other species in layers. The group notices that issues such as different catchability of species, height of trawl compared to thickness of the water column sampled and the validity of the TS values for some of the less studied species all add to the uncertainty in partitioning the

2 https://www.ices.dk/marine-data/data-portals/Pages/acoustic.aspx

echoes and this method should only be used when there is no other alternative, i.e. when species level scrutiny is not possible due to herring an sprat occurring in truly inseparable mixed aggregations.

Stock splitting methods

At present two different methods are used within the survey to assign herring in the splitting area (otolith microstructure: strata 21, 31, 41, 42, 151, 152, vertebrae count: 11, 141) 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. Ideally, the method should be standardised across the surveys to use one common method for all splitting between the two stocks.

Recently Germany has also conducted analysis of otoliths to deduct stock membership of herring in the southern area. Only very small amounts of spring spawners have been found during this exercise (2 in 2015, 1 in 2016, 3 in 2017, 1 in 2018).

The method used by Norway does not provide stock information at the individual fish level and it is therefore not possible at the present, 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.

An ICES workshop to address this issue and to provide guidance on data collection and analysis of this survey was carried out in November 2017 (WKSIDAC: ICES 2017b). Although progress was made towards unifying the methods in this workshop the practical guidance aspect was deferred to recommending a further workshop on this topic.

6.a.N and 6.a.S: Work has been ongoing for several years to split the Malin Shelf herring survey into 6.a.N and 6.a.S 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 presently being investigated to facilitate this split.

It should also be mentioned that Norwegian spring spawning herring is occasionally encountered in very small quantities in the most northern part of the survey area and this should be considered in a future splitting scenario.

Biological sampling

Comprehensive trawling was carried out over the course of the survey providing good confidence in school recognition and supporting biological data for age stratified abundance estimation of the target species in almost all strata. In Strata 1 however, no samples of herring were secured and biological composition of the biomass was assumed from the closest hauls in the neighbouring strata 121. With the very low stock size now in the western area it is getting more difficult to secured catches in this area and this potentially affects the accuracy of the stock composition estimates for West of Scotland and Malin Shelf herring. In the remainder of the survey area for this stock only two biological samples were secured. These reflected well though the distribution and occurrence of significant aggregations in strata 2 – 6.

Maturity

Since the 2015 survey no assumptions have been made about expected full maturity above a certain age and those actually observed in the surveys are reported in this report. In the past (prior to 2015), 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.

From 2017 the proportion mature at age of WBSS is not reported. Due to the timing of the survey in relation to the spawning time of this spring spawning stock it would be erroneous to calculate SSB based on observations at this time of the year.

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 allows for an estimate of survey uncertainty. However, until such time as issues with the stock splitting methodology mentioned above is fully addressed, the StoX software cannot be used to fully complete the estimation of abundance of each stock and therefore uncertainty estimation is not possible at the present.

Stock containment

Due to time constraints, strata 42, 81 and 131 were not fully covered. In strata 42 and 81, the herring and sprat distribution is traditionally similar within the strata, and the transects fulfilled thus were assumed to be representative for the entire strata and no strata adjustments were done. In strata 131, there is typically an increase in the clupeid density from north to south, and this stratum was therefore adjusted to the area covered by the transects (see Figure 5.2) to avoid overestimation.

The last few years, herring has been observed in the most northern HERAS transects, indicating that North Sea herring is now distributed further north than the area covered by the HERAS survey. Other surveys covering the area north of the HERAS area have also detected small amounts of herring in recent years. To ensure containment of North Sea herring in the northern part of the HERAS survey we suggest using data from summer surveys covering the most northern part of the North Sea and areas further north. In particular, the Norwegian acoustic saithe survey (NORACU) where the first part co-occurs with the Norwegian part of HERAS, and the second part covers the area between 59-62°N and 1°W to 2°E. NORACU allocate herring for the acoustics, but since herring is not the target species there are no targeted hauls. The trawl hauls targeting saithe though occasionally have good samples of herring, and this survey thus can be used to add an exploratory stratum North of the northern boundary of if the HERAS to monitor the containments (or lack thereof) of North Sea herring.

EK80 vs EK60

During this survey, three vessels used the EK80 system in Continuous Wave mode (CW, i.e. narrow band): RV Solea from Germany, RV Johan Hjort from Norway and Tridens II from the Netherlands. The EK80 CW is the successor of the EK60 which was used routinely for acoustic surveys since the 2000s. The system has been introduced in 2015 commercially and underwent careful scrutiny by various institutes. Research showed that the results from the EK60 and the EK80 CW are comparable (Demer et al. 2017, ICES 2017a, MacAulay et al 2018, Sakinan and Berges 2020). Macaulay et al. (2018) investigated in depth the performances of the EK60 and the EK80 CW. This was done using ping to ping data collected in 2016 by FRV Tridens II and FRV G.O. SARS (Norway) during the IBWSS survey (Blue Whiting). This work shows that the magnitude of variability between the two systems are smaller than the stochastic variation expected from echosounders. Further investigations have been carried out from the data collected by FRV Tridens II during the HERAS 2017 and 2018 surveys (Sakinan and Berges 2020) and resulted similarly without significant differences. WMR (Netherlands) subsequently decided to switch to using the EK80 in 2019 and in the future years. However, it is important to keep monitoring thoroughly the quality of the results produced by the EK80 system while the system is increasingly being used by more countries (three out of six countries in the

HERAS survey in 2019). In addition, despite being available in the market since 2015, the EK80 and associated software still undergo bug fixes (e.g. a bug in the calibration software was fixed in December 2019[3]). The Performance of each system used during this survey was evaluated by considering the consistency of the calibration using the standard spheres method (Demer et al. 2015, Foote et al. 1987). The rms error during the calibration trials is small (< 1dB) and the S_a correction is minor for all systems.

3 https://www.simrad.online/ek80/swrn/ek80_swrn_current_en_a4.pdf

6 Further improvements to survey

1) Efforts to further standardise the HERAS survey should continue. Scrutinisation in the Danish survey should be reviewed and where possible brought into line with the procedures used by the rest of the survey group.
2) Continue monitoring of stock containment to the North of stratum 111. This informs one on whether it is necessary to expand the survey area further north.
3) Provide Sardine and anchovy occurrence at the south of the survey coverage.
4) Norwegian data from 2015 onwards will be uploaded to the ICES database by the end of 2019.
5) Extensive test check on the national data to be performed prior to the post-cruise meeting in 2020.

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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 2019. Mean weights, mean length and fraction mature by age winter ring.

Age (ring)	Numbers	Biomass	Maturity	Weight(g)	Length (cm)
0	4,573	15	0.00	3.3	7.7
1	10,146	384	0.01	37.8	16.6
2	1,303	137	0.59	105.1	22.8
3	2,345	339	0.97	144.5	25.2
4	1,212	196	0.99	161.8	26.1
5	3,506	718	1.00	204.8	27.8
6	1,657	374	1.00	225.8	28.6
7	395	95	1.00	240.3	29.3
8	252	65	1.00	258.0	30.1
9+	172	44	1.00	255.8	30.1
Immature	15,265	448		29.3	14.1
Mature	10,295	1,919		186.4	27.0
Total	25,560	2,366	0.40	92.6	19.3

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 2019. Numbers, biomass, mean weights and mean length and by winter ring.

Age (ring)	Numbers	Biomass	Weight (g)	Length (cm)
0	2	0	4.0	8.5
1	418	15	35.8	16.9
2	591	49	82.7	21.7
3	315	32	102.1	23.2
4	109	15	139.6	25.4
5	67	12	170.8	26.9
6	52	9	178.6	27.4
7	19	3	187.5	27.9
8+	13	3	221.8	29.8
3+	574	74	129.6	24.7
Total	1,585	138	87.2	21.5

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 2019. Mean weights, mean lengths and fraction mature by winter ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0.0	0.00	0.0	0.0
1	3	0.3	0.00	98.1	22.2
2	50	5.8	0.36	117.0	23.4
3	77	11.6	0.95	149.8	25.4
4	41	7.4	1.00	179.0	27.0
5	137	26.8	1.00	195.8	27.8
6	86	17.6	1.00	205.4	28.2
7	14	3.1	1.00	216.9	29.0
8	16	3.6	1.00	223.5	29.3
9+	20	4.3	1.00	218.1	28.9
Immature	39	4		114.3	23.1
Mature	406	76		187.7	27.4
Total	445	81	0.91	181.3	27.0

Table 5.5. Total numbers (millions) and biomass (thousands of tonnes) of Malin Shelf herring (6.a.N-S, 7.b,c) June-July 2019. Mean weights, mean lengths and fraction mature by winter ring.

Age (ring)	Numbers	Biomass	Maturity	Weight (g)	Length (cm)
0	0	0.0	0.00	0.0	0.0
1	24	1.7	0.00	69.4	20.0
2	231	27.0	0.43	116.7	23.2
3	225	33.9	0.90	151.0	25.2
4	123	20.9	1.00	170.4	26.4
5	169	32.8	1.00	194.0	27.6
6	95	19.3	1.00	202.3	28.0
7	14	3.1	1.00	216.9	29.0
8	17	3.8	1.00	223.0	29.3
9+	21	4.6	1.00	216.7	29.0
Immature	180	19		105.0	22.5
Mature	740	128		173.3	26.5
Total	920	147	0.80	159.9	25.7

Table 5.6. Estimates of North Sea autumn spawners (millions) at age and SSB from acoustic surveys, 1986–2019. For 1986 the estimates are the sum of those from the Div. 4.a summer survey, the Div. 4.b autumn survey, and the Div. 4.c, 7.d winter survey. The 1987 to 2019 estimates are from summer surveys in Div. 4.a-c and 3.a 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
2016	9,034	12,011	5,832	1,273	822	909	395	220	146	51,686	2,648
2017	3,054	1,761	6,095	3,142	787	365	298	153	140	30,055	1,943
2018	9,938	4,254	1,692	5,150	2,440	719	529	293	111	32,606	2,337
2019	10,146	1,303	2,345	1,212	3,506	1,657	395	252	172	25,560	1,919

Table 5.7. Numbers at age (millions) of Western Baltic spring spawning herring at age (winter rings) from acoustic surveys 1992 to 2019. 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
2016	425	255	381	99	40	40	12	28	1,483	600
2017	696	424	661	401	94	53	52	92	2,474	1,353
2018	106	224	271	175	169	50	35	44	1,075	745
2019	418	591	315	109	67	52	19	13	1,585	574

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 2019. In 1997 the survey was carried out one month early in June as opposed to July when all the other surveys were carried out. A revision of the period 1991 to 2007 was carried out in 2010 and is incorporated in this table Hatfield and Simmonds 2010.

Year/Age	1	2	3	4	5	6	7	8	9+	SSB:
1993	2	579	690	689	565	900	296	158	161	845
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	576	803	329	95	61	77	78	115	370
1997	792	642	286	167	66	50	16	29	24	175
1998	1,222	795	667	471	179	79	28	14	37	376
1999	534	322	1,388	432	308	139	87	28	35	460
2000	448	316	337	900	393	248	200	95	65	445
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	223
2006	112	835	388	285	582	415	227	22	59	472
2007	0	126	294	203	145	347	243	164	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
2016	0	30	108	88	112	79	62	6	1	88
2017	0	22	324	144	97	109	44	18	5	139
2018	964	323	92	331	153	51	72	27	13	152
2019	3	50	77	41	137	86	14	16	20	76

Table 5.9. Numbers at age (winter rings, millions) and SSB (thousands of tonnes) of the Malin Shelf acoustic survey (6.a.N-S, 7.b,c) time series from 2008 to 2019. This table was been revised in 2015, details can be found in Lusseau et al 2015.

Year/Age	1	2	3	4	5	6	7	8	9+	SSB:
2008	50	267	996	720	363	331	744	386	274	845
2009	773	265	274	444	380	225	193	500	456	592
2010	133	375	374	242	173	146	102	100	297	370
2011	63	257	900	485	213	228	205	113	264	498
2012	796	548	832	517	249	115	111	57	105	434
2013	0	209	434	672	195	71	61	29	37	284
2014	1012	278	242	502	534	148	33	19	13	280
2015	0	212	397	747	423	476	90	24	2	430
2016	0	30	108	88	112	79	62	6	1	88
2017	0	25	339	155	106	110	47	13	5	145
2018	1289	447	106	343	153	52	72	27	13	159
2019	24	231	225	123	169	95	14	17	21	128

Table 5.10. Sprat in the North Sea (ICES Subarea 4): Abundance, biomass, mean weight and mean length by age and maturity (i = immature, m = mature) from the summer 2019 North Sea acoustic survey (HERAS).

Age	Abundance (million)	Biomass (1000 t)	Mean weight (g)	Mean length (cm)
0i	574	0.2	0.4	4.8
1i	62 537	150.9	2.4	6.8
1m	30 966	261.7	8.5	10.5
2i	204	1.4	6.9	9.7
2m	26 308	391.8	14.9	12.3
3i	43	0.3	6.7	10.3
3m	4 168	70.9	17	12.9
4m	194	3.2	16.4	13.3
5m	6	0.1	14.7	13.0
Immature	**63 358**	**152.8**	**2.4**	**6.8**
Mature	**61 641**	**727.6**	**11.8**	**11.4**
Total	**124 999**	**880.4**	**7.0**	**9.1**

Table 5.11. Sprat in the North Sea (ICES Subarea 4): Time-series of abundance and biomass as obtained from the summer North Sea acoustic survey (HERAS) time series 2000-2019. 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
2019	574	93 503	26 512	4 410	**124 999**	0	413	393	74	**880**
2018	3 409	107 083	9 061	588	**120 141**	1	717	106	10	**834**
2017	2 941	38 124	3 518	1 374	**45 956**	2	280	48	24	**354**
2016	24 792	58 599	33 318	7 880	**124 588**	24	500	453	141	**1118**
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 ICES Div. 3.a: Abundance, biomass, mean weight and length by age and maturity from the summer 2019 North Sea acoustic survey (HERAS).

Age	Abundance (million)	Biomass (tonnes)	Mean weight (g)	Mean length (cm)
0i	0.7	2	3.0	7.5
0m				
1i	35.1	308	8.8	10.2
1m	236.4	2 345	9.9	10.4
2i	59.3	606	10.2	10.7
2m	1 448.7	19 168	13.2	11.9
3m+	865.1	15 992	18.5	13.6
Immature	95.1	916	9.6	10.5
Mature	2 550.3	37 505	14.7	12.3
Total	2 645.3	38 421	14.5	12.3

Table 5.13. Sprat in ICES Div. 3.a: Time-series of sprat abundance and biomass as obtained from the summer North Sea acoustic survey (HERAS) time series 2006-2019.

	Abundance (million)					Biomass (1000 t)				
Year/Age	0	1	2	3+	Sum	0	1	2	3+	Sum
2019	0.7	271.5	1 508.0	865.1	2 645.3	0.0	2.7	19.8	16.0	38.4
2018	98.2	2 096.9	1 051.6	191.0	3 437.7	0.3	17.7	11.7	3.7	33.4
2017	0.0	10.9	146.3	90.5	247.7	0.0	0.1	2.3	1.7	4.1
2016	0.0	5.4	671.2	280.0	956.5	0.0	0.0	8.7	4.8	13.5
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	1 451.9	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 stratum, last year and present survey. Stratum numbers correspond to numbering in Figure 5.1.

	2018				2019			
Strat.	Abundance (mill)	Biomass (kt)	Mean weight (g)	% Mature	Abundance (mill)	Biomass (kt)	Mean weight (g)	% Mature
11	327	69	211.2	96	169	32	188.9	0.91
21	841	6.9	8.2	0.5	1306	15.9	12.2	0.01
31	193	8.7	45.1	2.9	785	40.7	51.9	0.01
41	60	5.6	92.9	5.3	326	28.7	87.9	0.20
42	84	6.2	73.8	2.8	466	31.1	66.7	0.09
51	4158	23.7	5.7	0.0	1925	5.0	2.6	0.00
61	2326	17.7	7.6	0.0	1365	3.7	2.7	0.00
71	395	4.7	11.9	0.0	5	0.1	13.9	0.00
81	4475	197.7	44.2	0.3	48	2.4	50.8	0.20
91	7850	864.1	110.1	53	3300	473.8	143.6	0.93
101	337	7.9	23.4	0.0	299	10.5	35.2	0.00
111	6546	1373.9	209.9	97	5326	1129.8	212.1	1.00
121	1279	268.0	209.6	99	1536	275.7	179.4	1.00
131	3080	106.8	34.7	0.0	454	6.5	14.4	0.01
141	229	34	147.5	60	7820	285	36.5	0.00
151	319	11.6	36.3	0.3	240	10.1	41.9	0.06
152	108	9.7	89.9	13	192	16.2	84.7	0.16

Table 5.15. Western Baltic spring spawning herring. Total abundance, biomass and mean weight by stratum. Stratum numbers correspond to numbering in Figure 5.1.

	2018			2019		
Stratum	Abundance (mill)	Biomass (kt)	Mean weight (g)	Abundance (mill)	Biomass (kt)	Mean weight (g)
11	16	2	204.4	87	14	164.2
21	67	4.4	64.8	471	23.6	50.2
31	211	18.0	85.3	202	13.0	64.3
41	102	10.6	104.4	204	21.0	102.9
42	63	5.2	81.3	124	11.0	88.6
141	67	8	154.5	246	35	144.2
151	92	3.9	42.3	102	6.2	60.8
152	129	15.1	116.3	148	13.7	92.6

Table 5.16. Malin shelf and 6.a.N herring. Total abundance, biomass, mean weight and percent mature by stratum. Stratum numbers correspond to numbering in Figure 5.1. The 6.a.N herring geographic subset is comprised of strata marked with *.

	2018					2019				
Stratum	Abundance (mill)	Biomass (kt)	CV	Mean weight (g)	% Mature	Abundance (mill)	Biomass (kt)	CV	Mean weight (g)	% Mature
1*	1218	82.8		68.0	0.16	299	57.7		193.1	1.00
2*	332	2.5		7.5	0.00	0	0.0		-	-
3*	522	96.8		185.5	0.98	136	21.6		158.2	0.74
4*	247	36.1		146.3	0.71	10	1.4		140.2	0.72
5	478	34.9		73.0	0.10	408	57.1		140.0	0.70
6	0	0.0		-	-	67	9.4		139.6	0.71

Table 5.17. Sprat in the North Sea and Div. 3.a. Total abundance, biomass, mean weight and percent mature by stratum. Stratum numbers correspond to numbering in Figure 5.1.

		2018				2019			
ICES area	Stratum	Abundance (mill)	Biomass (t)	Mean Weight (g)	% Mature	Abundance (mill)	Biomass (t)	Mean Weight (g)	% Mature
Div. 3.a	21	3 438	33 409	9.7	93%	2 532	36 630	14.5	96%
	31	0	0	-	-	0	0	-	-
	41	0	0	-	-	0	0	-	-
	42*	0	0	-	-	113	1 791	15.8	100%
North Sea	11	0	0	-	-	0	0	-	-
	51	62 624	457 761	7.3	65%	21 315	140 678	6.6	54%
	61	41 663	272 339	6.5	64%	18 521	108 888	5.9	38%
	71	3 441	32 623	9.5	89%	4 717	44 675	9.5	98%
	81	1 821	13 430	7.4	80%	67 486	459 089	6.9	38%
	91	3 885	2 276	4.5	9%	502	4 310	8.6	100%
	101	5 669	42 816	7.6	100%	330	2 311	7.0	100%
	111	0	0	-	-	0	0	-	-
	121	0	0	-	-	0	0	-	-
	131	1 022	11 650	11.4	100%	11 834	116 028	9.8	91%
	141	0	0	-	-	265	4 028	15.2	84%
	151	16	235	14.3	99%	29	384	13.3	100%
	152*	0	0	-	-	0	0	-	-

* New strata from 2017, 42 and 152 was part of strata 41 and 151, respectively, in 2016

Table 5.18. Length of track used in analysis, number of fish ages used in estimates and transect spacing for each stratum in the 2018 and 2019 survey. Number of ages cannot be summed for all strata to give total number of ages for the survey as haul information may have been used in more than one stratum.

	2018				2019			
Stratum	Total transect length (nmi.)	Herring ages	Sprat ages	Transect spacing (nmi.)	Total transect length (nmi.)	Herring ages	Sprat ages	Transect spacing (nmi.)
1	589	723	-	15	481	222		15
2	184	33	-	-	154	122	-	-
3	292	778	-	15	302	122	-	15
4	265	170	-	15	261	130	-	15
5	256	150	-	15	360	130	-	15
6	188	0	-	15	196	130	-	15
11	715	500	-	15-18.75	959	520	-	15
51	600	603	676	25	599	432	1018	25
61	243	327	338	23	244	253	415	23
71	303	184	343	17.5	317	192	166	17.5
81	477	239	88	30	447	309	188	~40
91	1609	1195	22	15	1645	1244	107	15
101	95	40	21	15	62	65	47	15
111	701	965	-	15	849	1252	-	15
121	431	578	-	15	484	619	-	15
131	610	276	345	30	367	234	436	30
141	1106	450	-	15-24	990	588	58	18.75
21	151	481	391	13	177	858	471	13
31	147	355	-	10	146	394	-	10
41	155	826	-	17.5	140	911	-	17.5
42	85	489	-	17.5	62	469	64	17.5
151	341	956	71	15	307	473	146	15
152	73	550	-	15	59	356	-	15

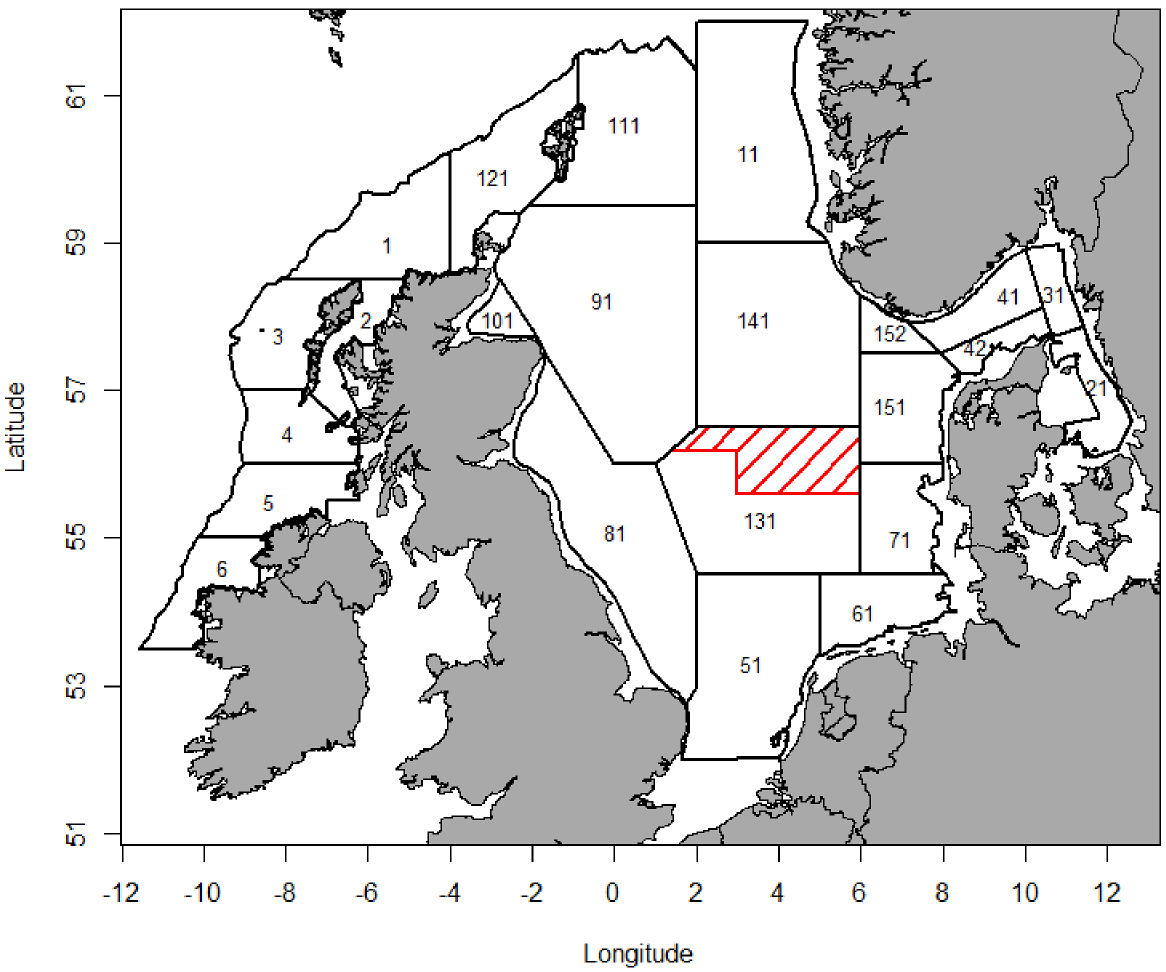

Figure 5.1. Strata used in the HERAS survey 2019. The area shaded in red in strata 131 was not included in the analysis this year as it was not surveyed.

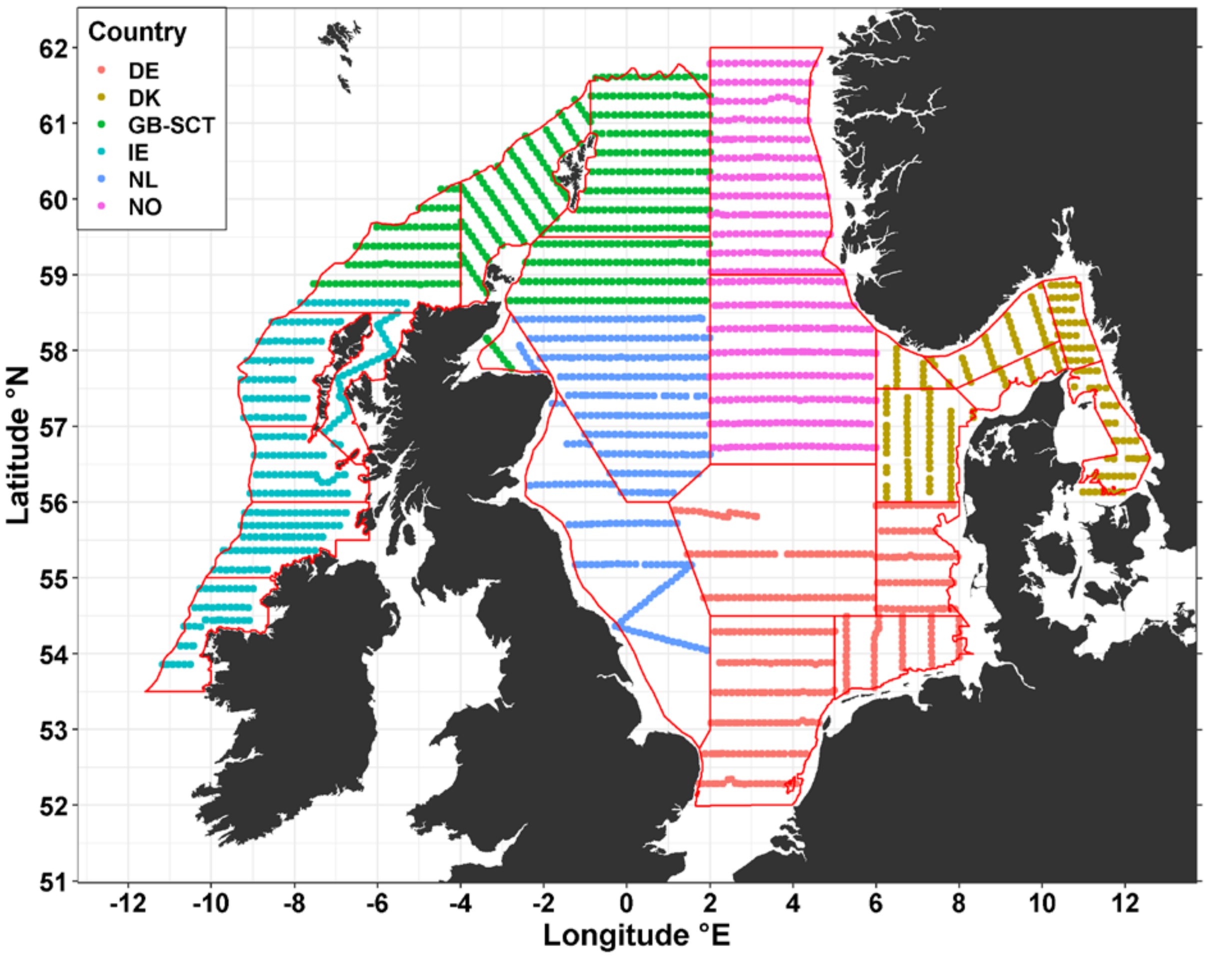

Figure 5.2. Survey area coverage in the HERAS survey in 2019 and individual vessel tracks by nation.

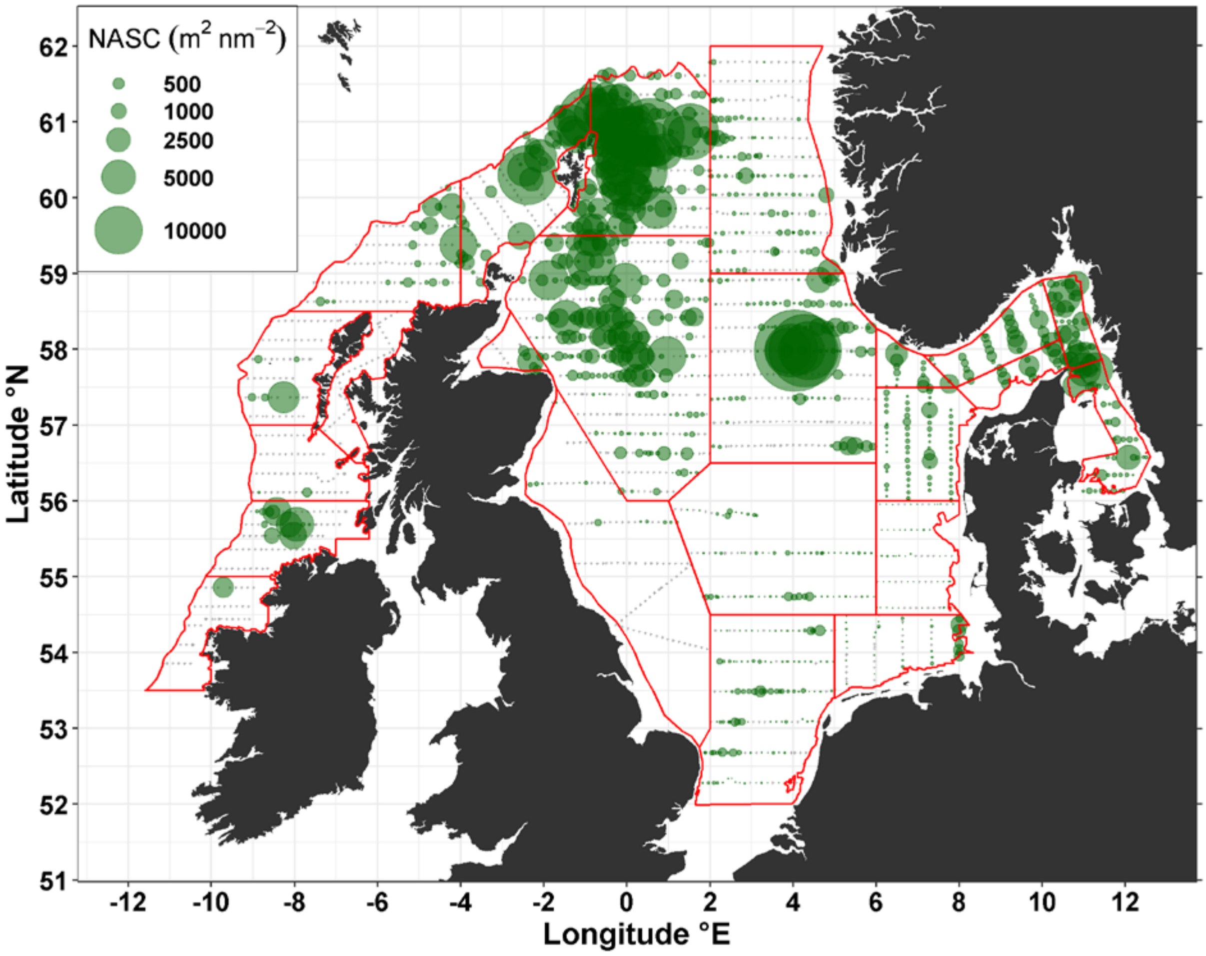

Figure 5.3. Distribution of NASC attributed to herring in HERAS in 2019. Acoustic intervals represented by light grey dot with green circles representing size and location of herring aggregations. NASC values are resampled at 5 nmi. intervals along the cruise track. The red lines show the strata system.

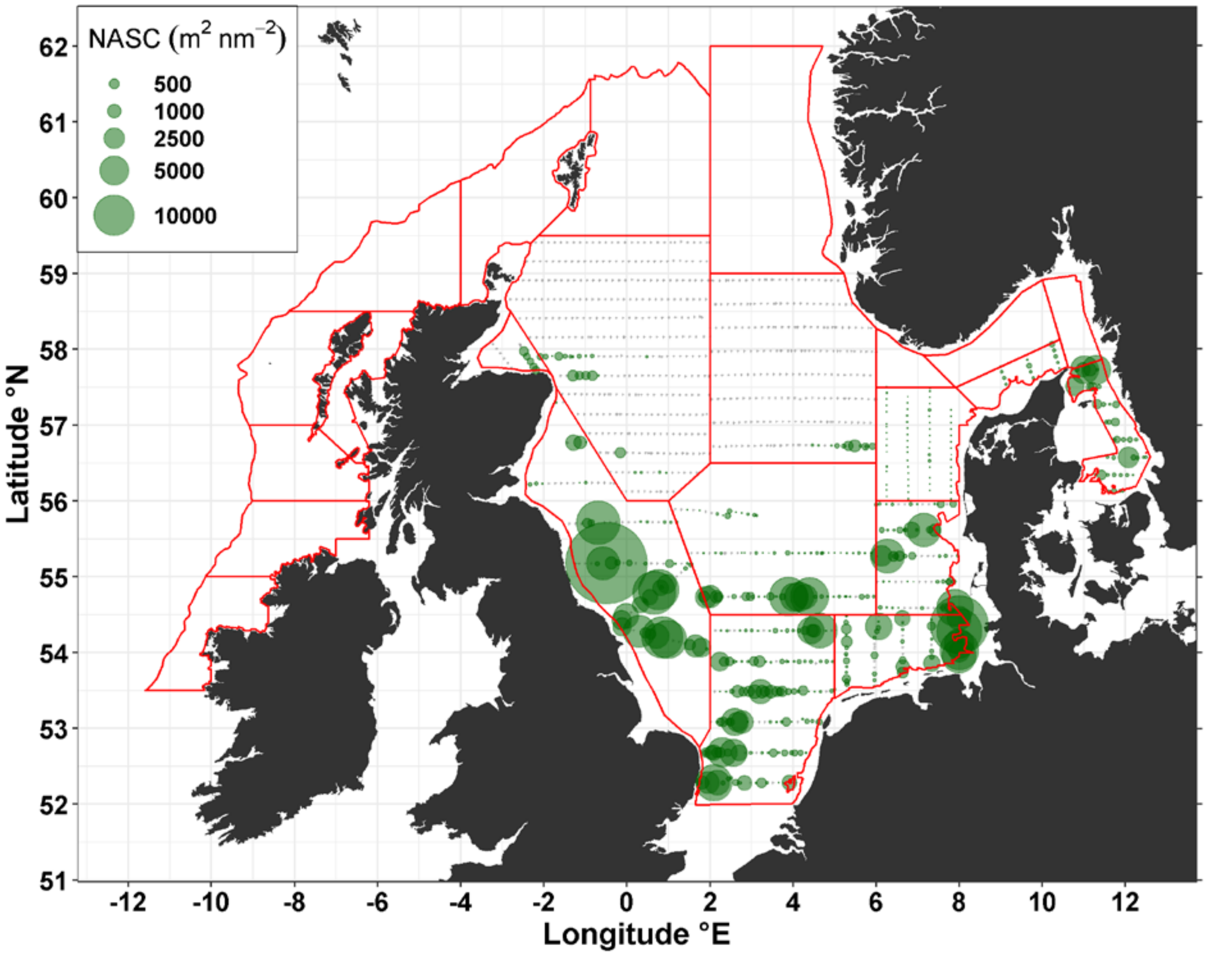

Figure 5.4. Distribution of NASC attributed to sprat in HERAS in 2019. Acoustic intervals represented by light grey dot with green circles representing size and location of sprat aggregations. NASC values are resampled at 5 nmi. intervals along the cruise track. The red lines show the strata system.

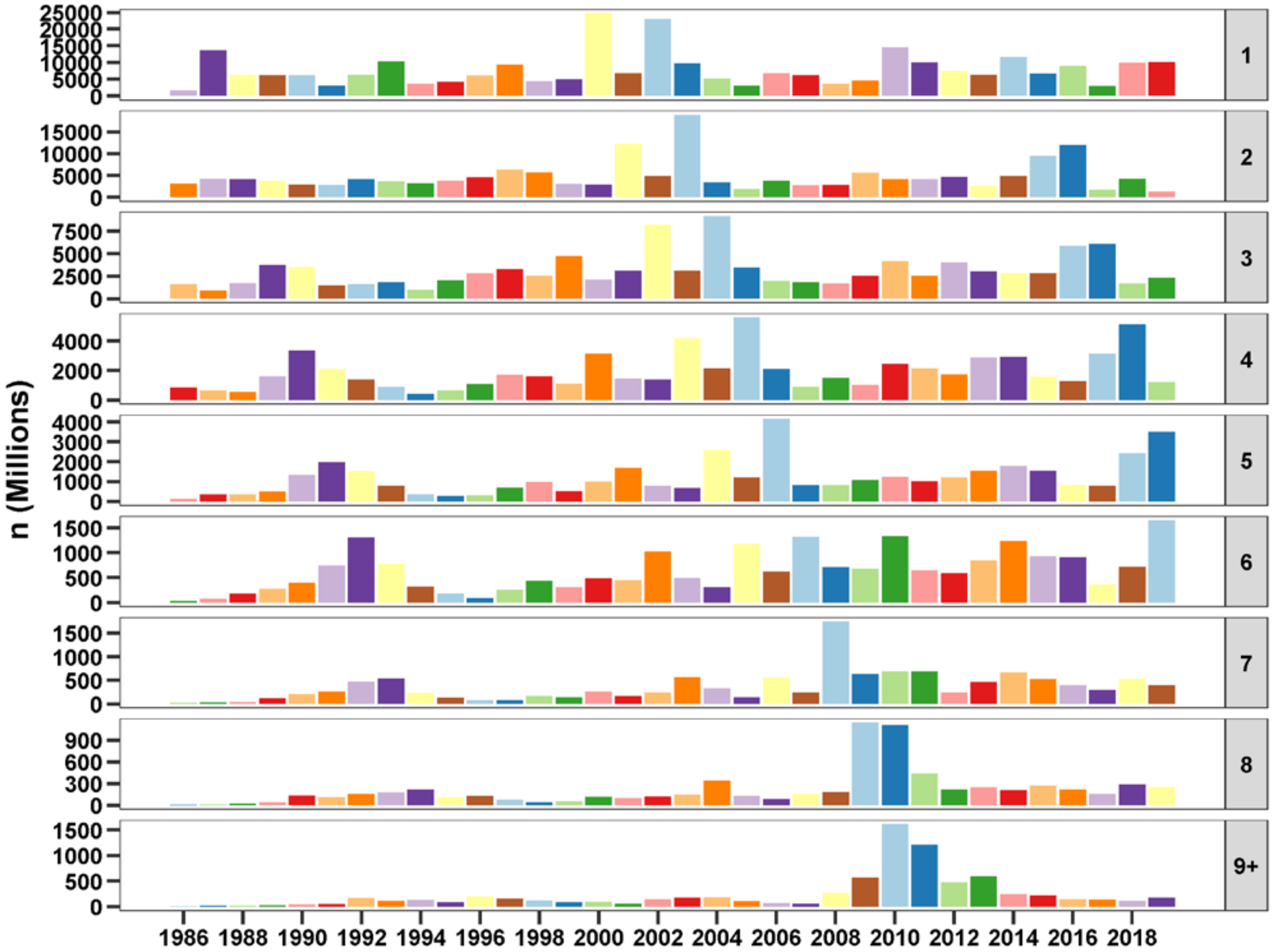

Figure 5.5. North Sea autumn spawning Herring: HERAS indices (millions) by age (winter rings, panels) and year from the acoustic surveys 1986-2019. Note diverging scales of abundance between ages.

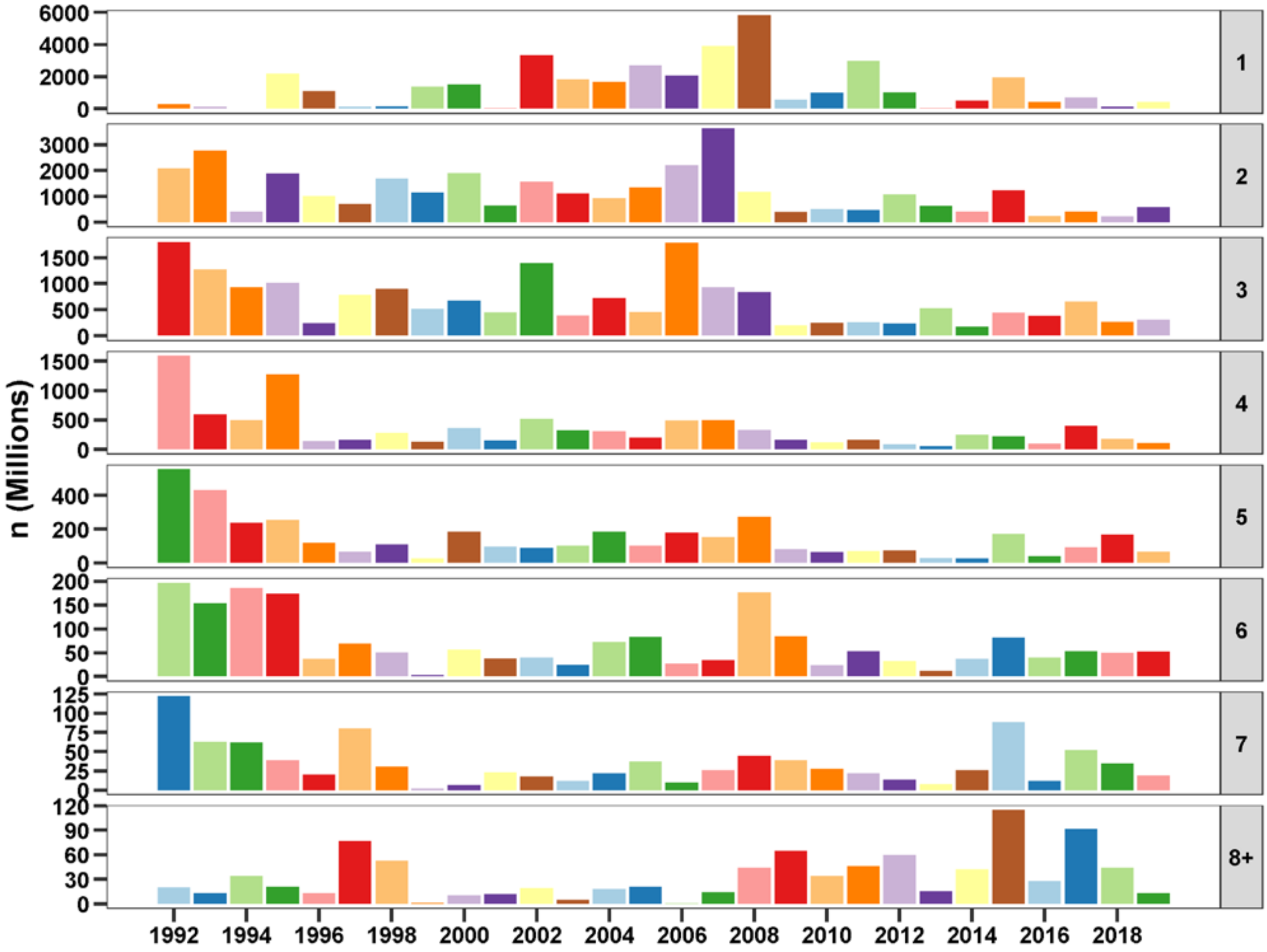

Figure 5.6. Western Baltic spring spawning Herring: HERAS indices (millions) by age (winter rings, panels) and year from the acoustic surveys 1992-2019. Note diverging scales of abundance between ages.

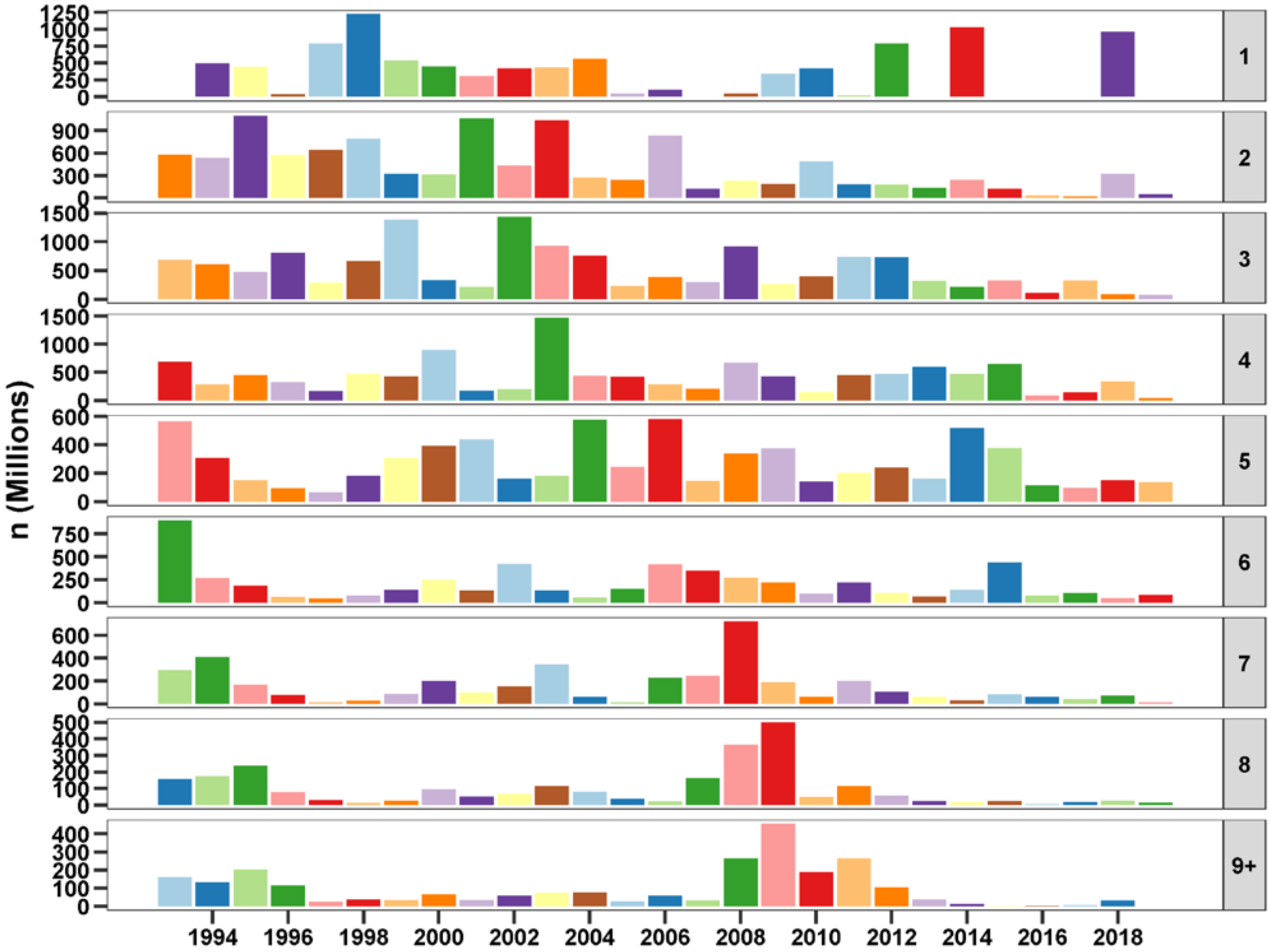

Figure 5.7. West of Scotland (6.a.N) autumn spawning herring: HERAS indices (millions) by age (winter rings, panels) and year from the acoustic surveys 1993-2019.

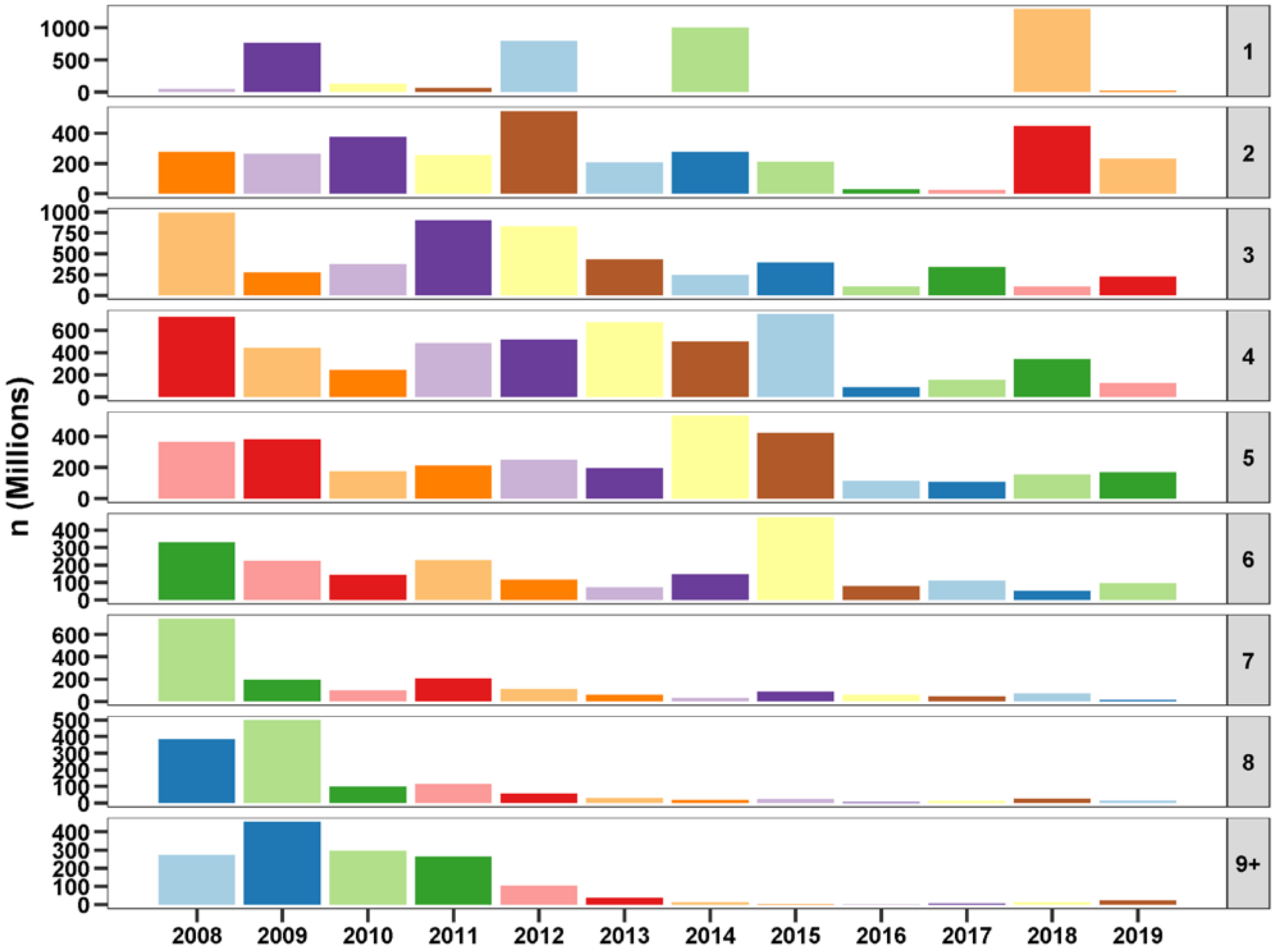

Figure 5.8. Malin Shelf Herring (6.a.N-S, 7.b,c): HERAS indices (millions) by age (winter rings, panels) and year from the acoustic surveys 2008-2019.

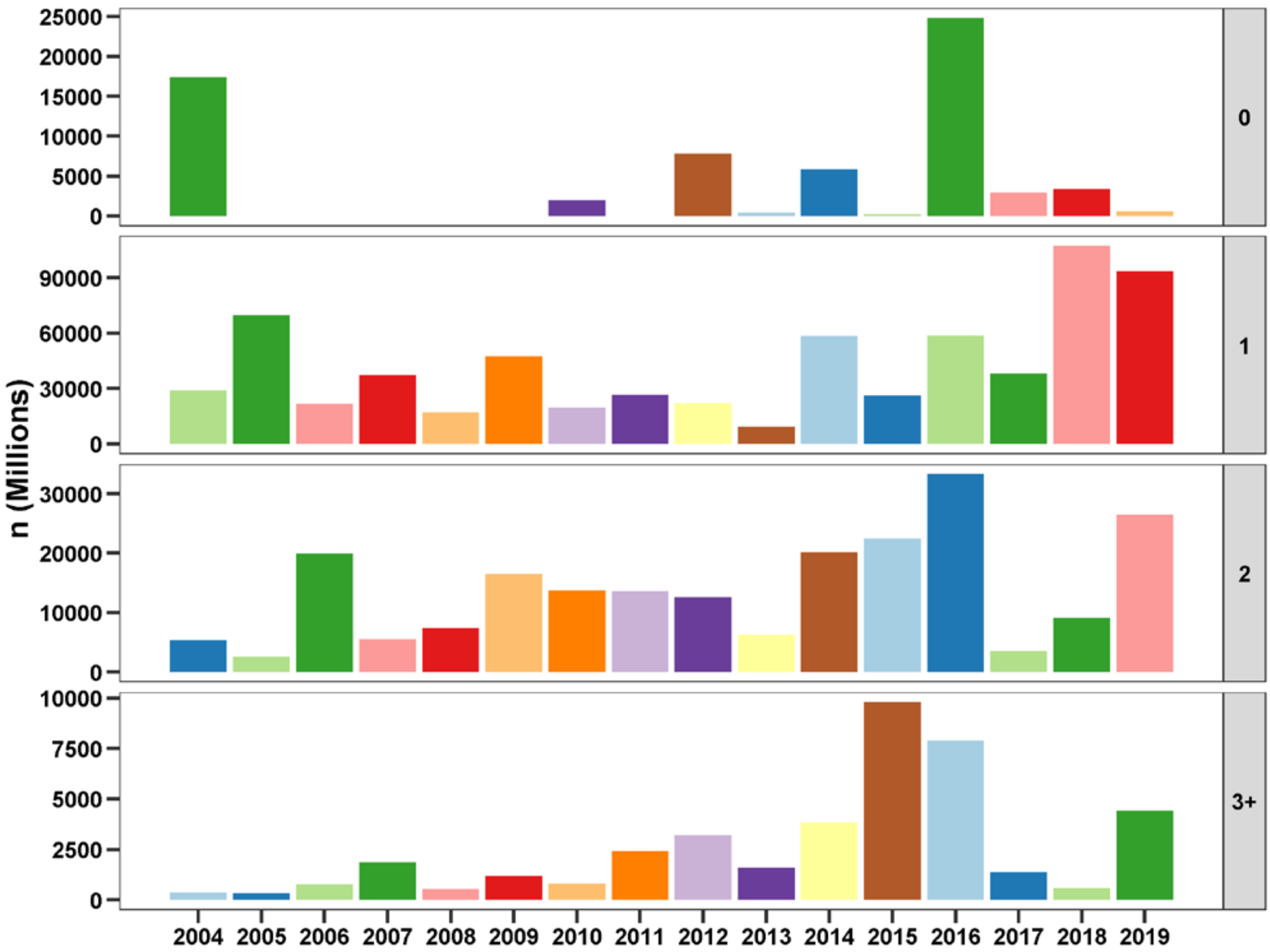

Figure 5.9. North Sea Sprat (ICES Subarea 4): HERAS indices (millions) by age (winter rings, panels) and year from the acoustic surveys 2004-2019. Note diverging scales of abundance between ages.

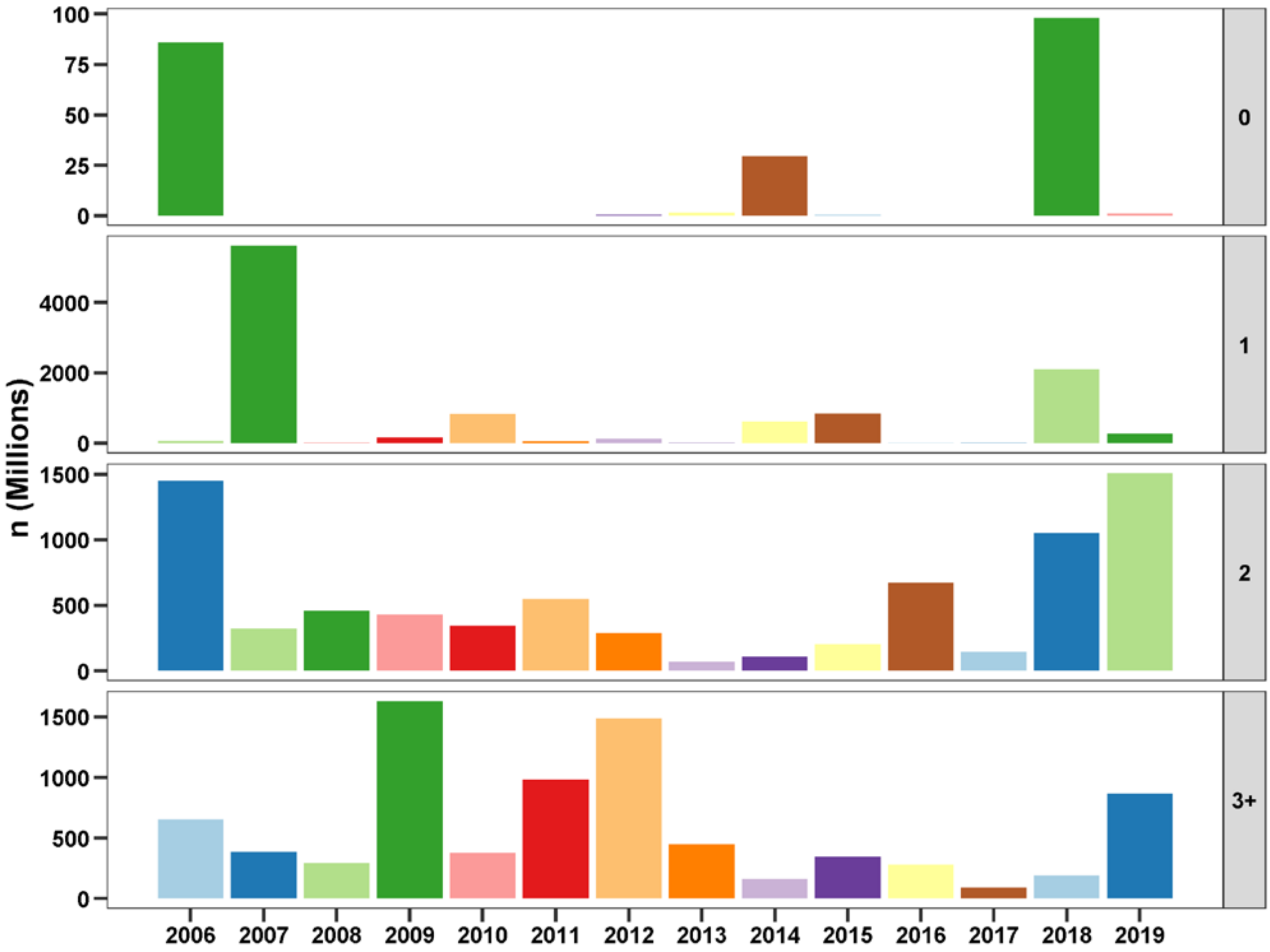

Figure 5.10. Sprat in Div. 3.a: HERAS indices (millions) by age (winter rings, panels) and year from the acoustic surveys 2006-2019. Note diverging scales of abundance between ages.

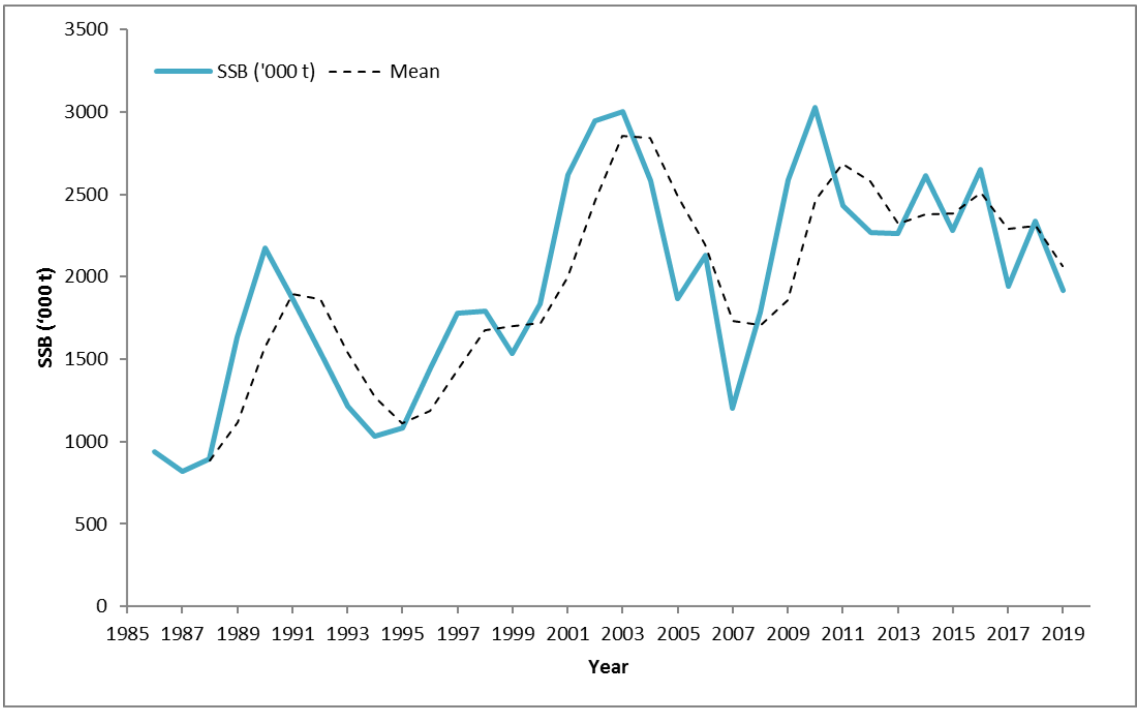

Figure 5.11. Time series of SSB of North Sea autumn spawning herring with three year running mean.

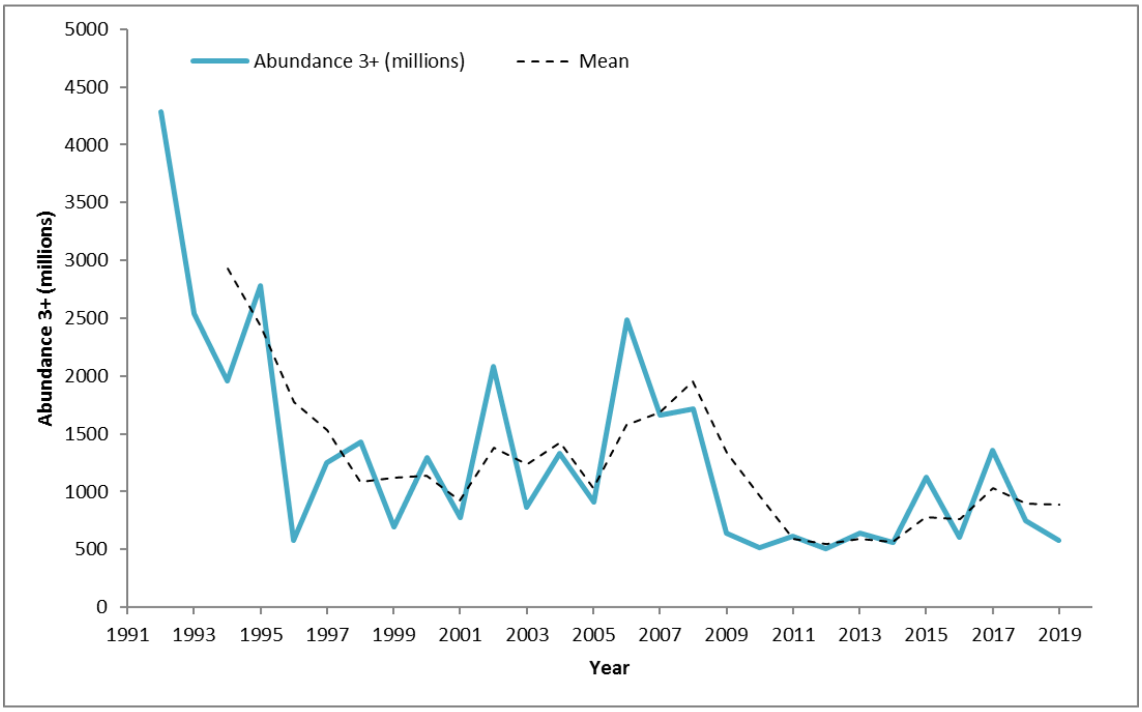

Figure 5.12. Time series of 3+ abundance of Western Baltic spring-spawning herring with three year running mean.

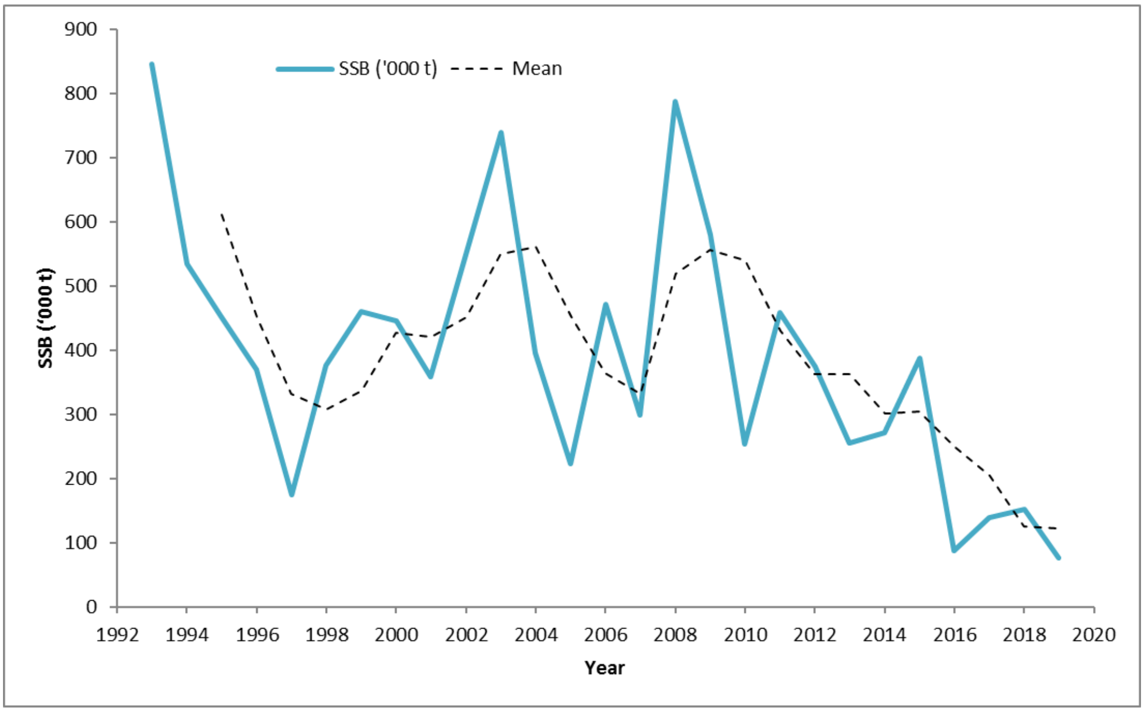

Figure 5.13. Time series of SSB of West of Scotland herring (geographical subset of Malin Shelf herring) with three year running mean.

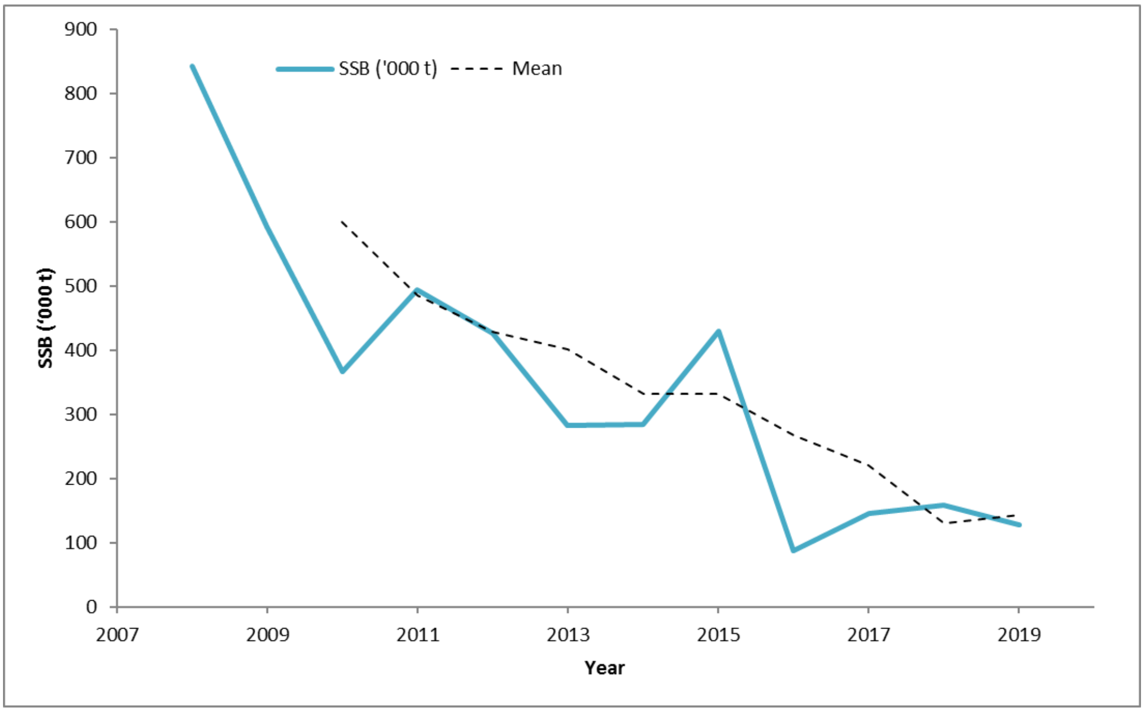

Figure 5.14. Time series of SSB of Malin Shelf herring with three year running mean.

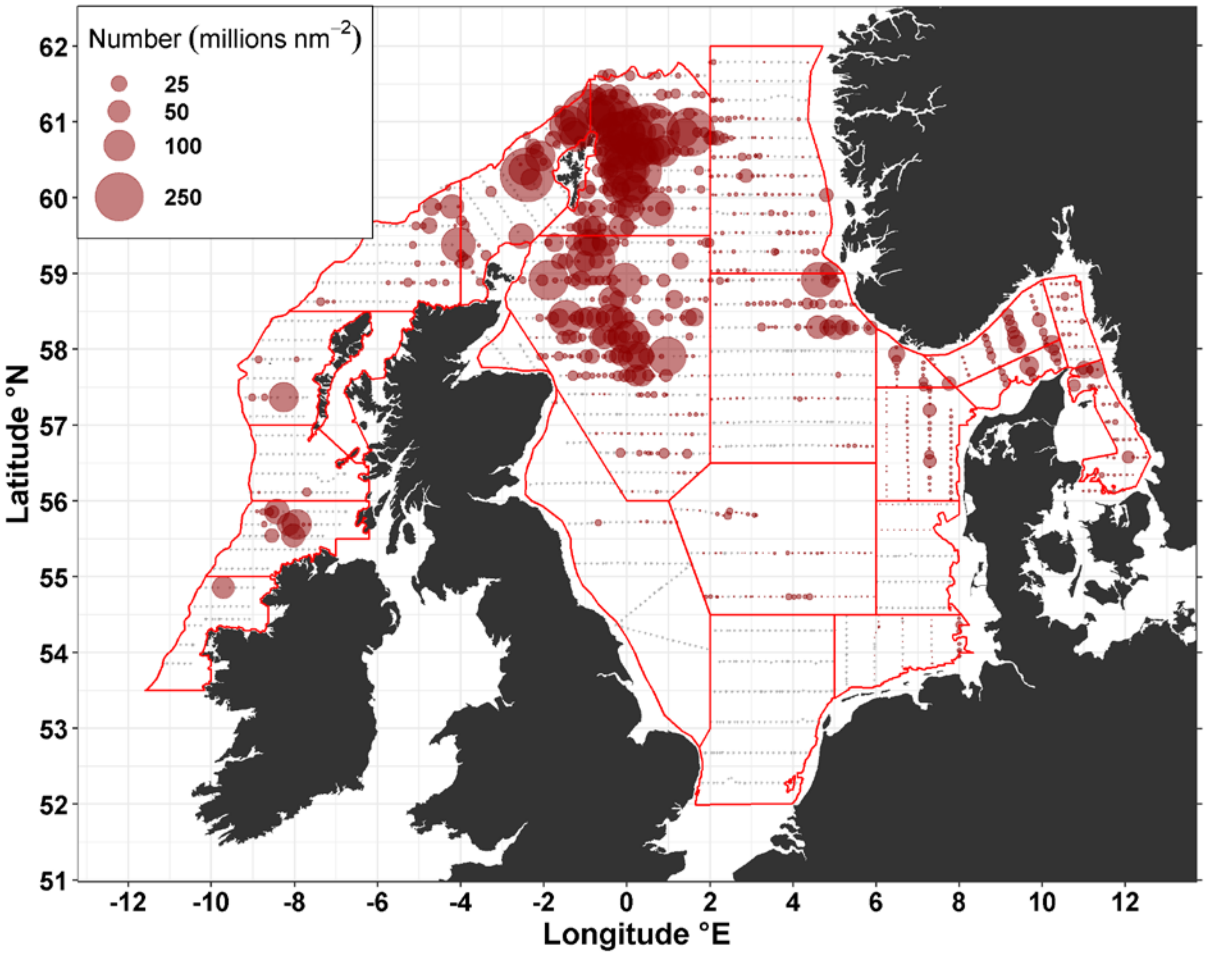

Figure 5.16. Distribution of mature herring in 2019 (n in millions). The NASC values per interval within each stratum were split into mature and immature following the proportion mature for the stratum.

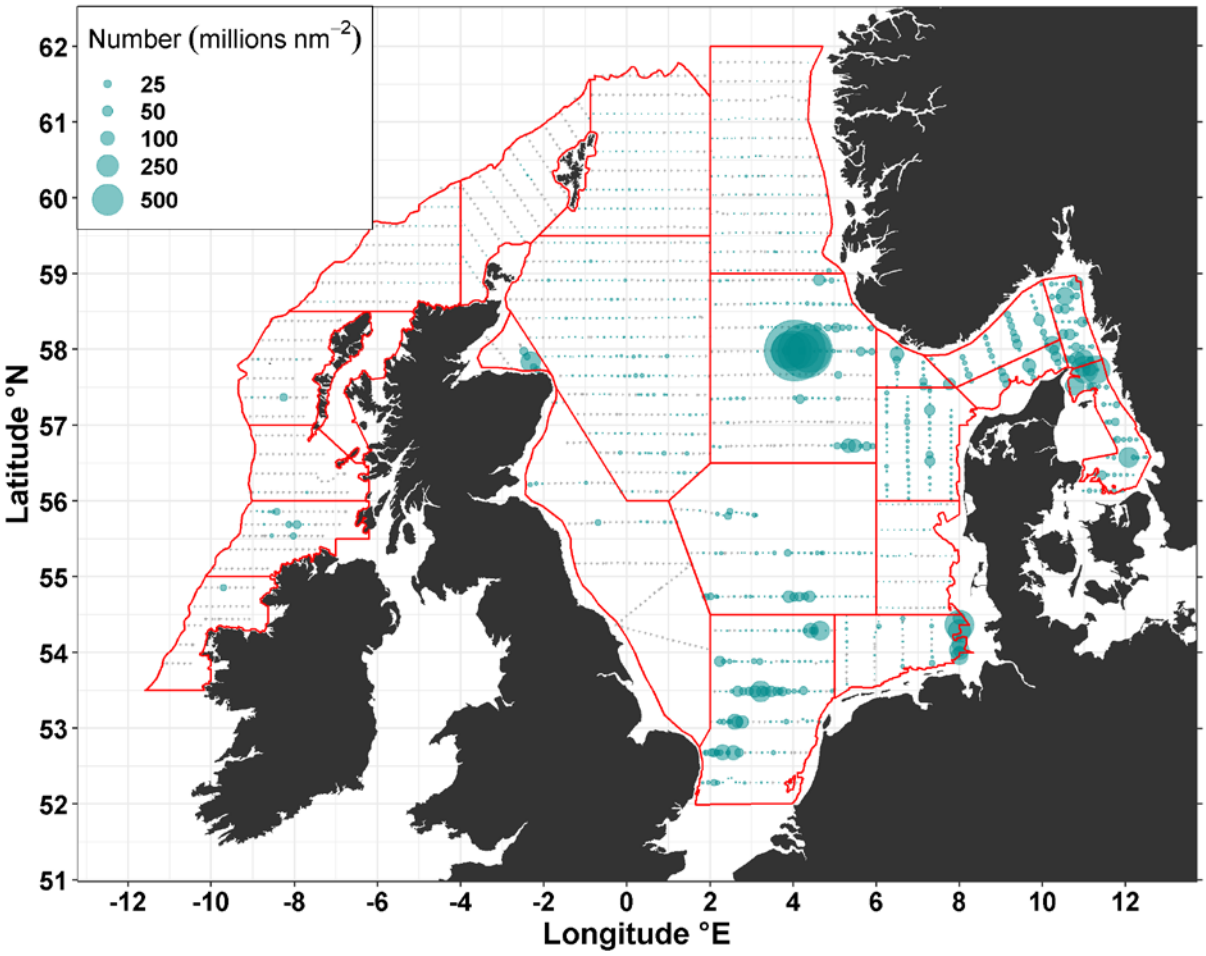

Figure 5.17. Distribution of immature herring in 2019 (n in millions). The NASC values per interval within each stratum were split into mature and immature following the calculated proportion mature for the stratum.

Annex 6: 2019 IESSNS Survey Summary Table and Survey Report

Document 6a: IESSNS 2019 survey summary table

Survey Summary table WGIPS 2020	
Name of the survey (abbreviation):	International Ecosystem Summer Survey in the Nordic Seas (IESSNS)
Target Species:	NEA mackerel
Survey dates:	28 June – 5 August
Summary:	

The International Ecosystem Summer Survey in the Nordic Seas (IESSNS) was performed within approximately 5 weeks from June 28th to August 5th in 2019 using six vessels from Norway (2), Iceland (1), Faroe Islands (1), Greenland (1) and Denmark (1). Survey effort, timing and area coverage in 2019 were comparable to previous years.

The mackerel index increased by 85% for biomass and 56 % for abundance (numbers of individuals) compared to the 2018 index. In 2019, the most abundant year classes were 2011, 2010, 2016, 2014 and 2013, respectively. Overall, the cohort internal consistency remained good and was similar to 2018.

The survey coverage area was 2.9 million km2 which is similar as in 2017 and 2018. Furthermore, 0.3 million km2 was surveyed in the North Sea. Distribution zero boundaries were found in majority of the survey area with a notable exception of high mackerel abundance at the survey boundary southwest of Faroe Island and in the northern Norwegian Sea. The mackerel were more north-easterly distributed in 2019, compared to the period from 2012 to 2018. This was specifically apparent in Greenland waters, where the catch was the lowest for the time series.

The total number of Norwegian spring-spawning herring (NSSH) recorded during IESSNS 2019 was 15.2 billion and the total biomass index was 4.78 million tonnes, which is slightly higher compared to 2018. The herring stock is dominated by 6-year old herring (year class 2013) in terms of numbers and biomass. This year class is now distributed in all areas with herring in the survey compared to last year when it was mainly found in the north-eastern part. It contributes 23% and 22% to the total biomass and total abundance, respectively.

The total biomass of blue whiting registered during IESSNS 2019 was 2.0 million tons, which is the same compared to 2018. The stock estimate in number for 2019 is 16.2 billion compared to 16.3 billion of age groups 1+ in 2018. The age group five is dominating the estimate (36% and 30% of the biomass and by numbers, respectively). A good sign of recruiting year class (0-group) was also seen in the survey this year.

As in previous years, the spatio-temporal overlap between mackerel and NSSH was highest in the southern and south-western parts of the Norwegian Sea. There was practically no overlap between mackerel and NSSH in the central part of the Norwegian Sea, whereas we had some overlap between mackerel and herring in the northern part of the Norwegian Sea. Herring distribution was mostly

limited to the area east and north of Iceland and the southern Norwegian Sea. However, NSSH was also found in the central northern part for the first time in many years, dominated by the 2013- and 2016- year classes.	
	Description
Survey design	Swept-area systematic trawl survey with a random starting point and fixed spacing between stations in each stratum. Eight permanent and two dynamic strata. Each stratum has a random starting point and fixed spacing between stations. Permanent strata are constant between years and cover the core mackerel distribution area in the Norwegian Sea and in the Icelandic EEZ. The dynamic zones are located at westward and northward mackerel distribution range periphery. Effort varies between strata. A combination of spatial variance in mackerel abundance, in years 2010-2014, and available survey time determines effort. Effort increases as spatial variability in abundance increases.
Index Calculation method	Age-segregated swept-area trawl index is calculated using stratified approach. StoX (via the PGNAPES database)
Random/systematic error issues	N/A
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	No problems due to bad weather for a acoustic recordings
Extinction (shadowing)	N/A
Blind zone	Upper 8-12 m not covered by acoustics. No attempts made to correct for loss of herring in the blind zone.
Dead zone	N/A
Allocation of backscatter to species	Only allocated backscatter identified as herring or blue whiting using standard TS for herring and blue whiting
Target strength	Blue whiting: TS = 20 log(L) – 65.2 dB (ICES 2012) Herring: TS = 20.0 log(L) – 71.9 dB
Calibration	OK

Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	Considered to have covered the adult spawning stock adequately
Stock ID and mixing issues	N/A for mackerel Yes for NSS herring (adults): Concern of similar mixing issues as for the IESNS in May, with uncertainty whether the Icelandic summer-spawning herring southeast of Iceland and the autumn-spawning herring types in the south (east of the Faroes) and southeast (around Shetland).
Measures of uncertainty (CV)	The estimated survey uncertainty for the main age groups in the estimate was around 0.2-0.25
Biological sampling	Sampling levels was considered representative.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

Document 6b: IESSNS 2019 survey report

Please see the report on the next page.

Working Document to

ICES Working Group on Widely Distributed Stocks (WGWIDE, No. 5)
Spanish Institute of Oceanography (IOE), Santa Cruz, Tenerife, Canary Islands 28. August – 3. September 2019

Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 28th June – 5th August 2019

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Contents

1 Executive summary

The International Ecosystem Summer Survey in the Nordic Seas (IESSNS) was performed within approximately 5 weeks from June 28th to August 5th in 2019 using six vessels from Norway (2), Iceland (1), Faroe Islands (1), Greenland (1) and Denmark (1). The main objective is to provide annual age-segregated abundance index, with an uncertainty estimate, for northeast Atlantic mackerel (*Scomber scombrus*). The index is used as a tuning series in stock assessment according to conclusions from the 2017 ICES mackerel benchmark. A standardised pelagic swept area trawl method is used to obtain the abundance index and to study the spatial distribution of mackerel in relation to other abundant pelagic fish stocks and to environmental factors in the Nordic Seas, as has been done annually since 2010. Another aim is to construct a new time series for blue whiting (*Micromesistius poutassou*) abundance index and for Norwegian spring-spawning herring (NSSH) (*Clupea harengus*) abundance index. This is obtained by utilizing standardized acoustic methods to estimate their abundance in combination with biological trawling on acoustic registrations.

The mackerel index increased by 85% for biomass and 56 % for abundance (numbers of individuals) compared to the 2018 index. In 2019, the most abundant year classes were 2011, 2010, 2016, 2014 and 2013, respectively. Overall, the cohort internal consistency remained good and was similar to 2018.

The survey coverage area was 2.9 million km^2 which is similar as in 2017 and 2018. Furthermore, 0.3 million km^2 was surveyed in the North Sea. Distribution zero boundaries were found in majority of the survey area with a notable exception of high mackerel abundance at the survey boundary south-west of Faroe Island and in the northern Norwegian Sea. The mackerel were more north-easterly distributed in 2019, compared to the period from 2012 to 2018. This was specifically apparent in Greenland waters, where the catch was the lowest for the time series.

The total number of Norwegian spring-spawning herring (NSSH) recorded during IESSNS 2019 was 15.2 billion and the total biomass index was 4.78 million tonnes, which is slightly higher compared to 2018. The herring stock is dominated by 6-year old herring (year class 2013) in terms of numbers and biomass. This year class is now distributed in all areas with herring in the survey compared to last year when it was mainly found in the north-eastern part. It contributes 23% and 22% to the total biomass and total abundance, respectively.

The total biomass of blue whiting registered during IESSNS 2019 was 2.0 million tons, which is the same compared to 2018. The stock estimate in number for 2019 is 16.2 billion compared to 16.3 billion of age groups 1+ in 2018. The age group five is dominating the estimate (36% and 30% of the biomass and by numbers, respectively). A good sign of recruiting year class (0-group) was also seen in the survey this year.

As in previous years, the spatio-temporal overlap between mackerel and NSSH was highest in the southern and south-western parts of the Norwegian Sea. There was practically no overlap between mackerel and NSSH in the central part of the Norwegian Sea, whereas we had some overlap between mackerel and herring in the northern part of the Norwegian Sea. Herring distribution was mostly limited to the area east and north of Iceland and the southern Norwegian Sea. However, NSSH was also found in the central northern part for the first time in many years, dominated by the 2013- and 2016- year classes.

Other fish species also monitored are lumpfish (*Cyclopterus lumpus*) and Atlantic salmon (*Salmo salar*). Lumpfish was caught at 73% of surface trawl stations distributed across the surveyed area from Cape Farwell, Greenland, to western part of the Barents Sea. Abundance was greater north of latitude 66 °N compared to southern areas. A total of 58 North Atlantic salmon were caught, mainly in central and northern part of the Norwegian Sea. More salmon was caught in western regions compared to previous years.

Sea surface temperature (SST) was 1-2°C warmer in Icelandic and Greenland waters in July 2019 compared to the long-term average (20-year mean), but similar to the long-term average in eastern part of the

Norwegian Sea. This contrasts with the situation in 2018 when SST was 1-2°C colder than the average in Icelandic and Greenland waters. The SST in the entire Norwegian Sea in July 2019 was similar to July 2018.

The overall average zooplankton index in 2019 declined substantially compared to 2018. In 2019, the index decreased in both Greenland and Icelandic waters, whereas the index increased in the Norwegian Sea compared to 2018.

2 Introduction

During approximately five weeks of survey in 2019 (28th of June to 3rd of August), six vessels; the M/V "Kings Bay" and M/V "Vendla" from Norway, and M/V "Finnur Fridi" operating from Faroe Islands, the R/V "Árni Friðriksson" from Iceland, the M/V "Eros" operating in Greenland waters and M/V "Ceton" operating in the North Sea by Danish scientists, participated in the International Ecosystem Summer Survey in the Nordic Seas (IESSNS).

The main aim of the coordinated IESSNS have been to collect data on abundance, distribution, migration and ecology of Northeast Atlantic mackerel (*Scomber scombrus*) during its summer feeding migration phase in Nordic Seas, used as tuning series in stock assessment of mackerel at the annual meeting of ICES working group of widely distributed stocks (WGWIDE). Since 2016, systematic acoustic abundance estimation of both Norwegian spring-spawning herring (*Clupea harengus*) and blue whiting (*Micromesistius poutassou*) have also been conducted. This objective was initiated to provide an additional abundance index for these two stocks because the current indices used in the stock assessments by ICES have shown some unexplained fluctuations (ICES 2016). It was considered that a relatively small increase in survey effort would accommodate a full acoustic coverage of the adult fraction (spawning stock biomass (SSB)) of both species during their summer feeding distribution in the Nordic Seas (Utne et al. 2012; Trenkel et al. 2014; Pampoulie et al. 2015). The pelagic trawl survey was initiated by Norway in the Norwegian Sea in the beginning of the 1990s. Faroe Islands and Iceland have participated in the joint mackerel-ecosystem survey since 2009, Greenland since 2013 and Denmark for the first time in 2018.

Opportunistic whale observations were conducted onboard the Norwegian vessels Kings Bay and Vendla, and the Icelandic R/V Arni Fridriksson, predominantly from the bridge. The major objectives were to collect data on distribution, aggregation and behaviour of marine mammals in relation to potential prey species and the physical environment.

Swept-area abundance indices of mackerel from IESSNS have been used for tuning in the analytical assessment by ICES WGWIDE, since the benchmark assessment in 2014 (ICES 2014). In the benchmark process in 2017 methodological and statistical changes were made to calculation of the index (ICES 2017).

The North Sea was included in the survey area again in 2019, following the recommendations of WGWIDE. This was done by scientists from DTU Aqua, Denmark. The commercial fishing vessels "Ceton S205" was used, and in total 38 stations (CTD and fishing with the pelagic Multipelt 832 trawl) were successfully conducted. No problems applying the IESSNS methods were encountered. Area coverage, however, was restricted to the northern part of the North Sea at water depths deeper than 50 m and no plankton samples were taken (see Appendix 1 for comparison with 2018 results).

3 Material and methods

Coordination of the IESSNS 2019 was done during WGWIDE 2018 meeting in August-September 2018 in Torshavn, Faroe Islands, and at the WGIPS meeting in January 2019 in Santa Cruz, Tenerife, Canary Islands, and by correspondence in spring and summer 2019. The participating vessels together with their effective survey periods are listed in Table 1.

Overall, the weather conditions were calm with good survey conditions for all six vessels for oceanographic monitoring, plankton sampling, acoustic registrations and pelagic trawling. There were sporadic windy periods in Greenland waters. The weather was good and calm for the two Norwegian vessels and the Icelandic and Faroese vessels operating in the central and northern part of the Norwegian Sea and in Icelandic and Faroese waters The chartered vessel Ceton encountered some bad weather in the North Sea, without influencing the swept area trawling.

During the IESSNS, the special designed pelagic trawl, Multpelt 832, has now been applied by all participating vessels since 2012. 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 (Valdemarsen et al. 2014). 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 in February 2014, were considered and implemented during the IESSNS survey in July-August 2014 and in the surveys thereafter. Furthermore, recommendations and requests resulting from of the mackerel benchmark in January-February 2017 (ICES 2017), were carefully considered and implemented during the IESSNS survey in July-August 2017. In 2018, the Faroese and Icelandic vessels employed new, redesigned cod-ends with the capacity to hold 50 tonnes. This was done to avoid the cod-end from bursting during hauling of large catches as occurred at three stations in the 2017 IESSNS.

Table 1. Survey effort by each of the five vessels during the IESSNS 2019. The number of predetermined ("fixed") trawl stations being part of the swept-area stations for mackerel in the IESSNS are shown after the total number of trawl stations.

Vessel	Effective survey period	Length of cruise track (nmi)	Total trawl stations/ Fixed stations	CTD stations	Plankton stations
Árni Friðriksson	3/7-29/7	5500	69/61	61	60
Finnur Fríði	28/6- 12/7	3150	47/40	42	41
Eros	19/7-3/8	2881	27/27	27	27
Ceton	2/7-12/7	1870	38/38	38	-
Vendla	4/7-5/8	5933	91/66	71	71
Kings Bay	4/7-5/8	5639	88/77	76	76
Total	28/6-5/8	24873	360/309	315	275

3.1 Hydrography and Zooplankton

The hydrographical and plankton stations by all vessels combined are shown in Figure 1. Árni Friðriksson was equipped with a SEABIRD CTD sensor with a water rosette that was applied during the entire cruise. Finnur Fríði was equipped with a mini SEABIRD SBE 25+ CTD sensor, Kings Bay and Vendla were both equipped with SAIV CTD sensors. Eros used a SEABIRD 19+V2 CTD sensor. Ceton used a Seabird SeaCat 4 CTD. 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.

Zooplankton was sampled with a WP2-net on 5 of 6 vessels, Ceton did not take any plankton samples. Mesh sizes were 180 µm (Kings Bay and Vendla) and 200 µm (Árni Friðriksson, Finnur Fríði and Eros). 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 2014a).

Not all planned CTD and plankton stations were taken due to bad weather. The number of stations taken by the different vessels is provided in Table 1.

3.2 Trawl sampling

All vessels used the standardized Multpelt 832 pelagic trawl (ICES 2013a; Valdemarsen et al. 2014; Nøttestad et al. 2016) for trawling, both for fixed surface stations and for trawling at greater depths to confirm acoustic registrations. Standardization of trawl deployment was emphasised during the survey as in previous years (ICES 2013a; ICES 2014b). Effective trawl width (actually door spread) and trawl depth was monitored live by scientific personnel and/or the captain and stored on various sensors on the trawl doors, headrope and ground rope of the Multpelt 832 trawl. The properties of the Multpelt 832 trawl and rigging on each vessel is reported in Table 2.

Trawl catch was sorted to the highest taxonomical level possible, usually to species for fish, and total weight per species recorded. The processing of trawl catch varied between nations as the Norwegian, Icelandic and Greenlandic vessels sorted the whole catch to species but the Faroese vessel sub-sampled the catch before sorting. Sub-sample size ranged from 60 kg (if it was clean catch of either herring or mackerel) to 100 kg (if it was a mixture of herring and mackerel). The biological sampling protocol for trawl catch varied between nations in number of specimens sampled per station (Table 3).

Table 2. Trawl settings and operation details during the international mackerel survey in the Nordic Seas from 28th June to 5th August 2019. The column for influence indicates observed differences between vessels likely to influence performance. Influence is categorized as 0 (no influence) and + (some influence).

Properties	**Kings Bay**	**Árni Friðriksson**	**Vendla**	**Ceton**	**Finnur Fríði**	**Eros**	**Influ-ence**
Trawl producer	Egersund Trawl AS	Hampiðjan new 2017 trawl	Egersund Trawl AS	Egersund Trawl AS	Vónin	Hampiðjan	0
Warp in front of doors	Dynex–34 mm	Dynex-34 mm	Dynex -34 mm	Dynex	Dynema – 30 mm	Dynex-34 mm	+
Warp length during towing	350	350	350	350	350-360	340-347	0
Difference in warp length port/starb. (m)	2-10	16	2-10	10	0-10	10-20	0
Weight at the lower wing ends (kg)	2×400	2×400 kg	2×400	2×400	2×400	2×500	0
Setback (m)	6	14	6	6	6	6	+
Type of trawl door	Seaflex 7.5 m² adjustable hatches	Jupiter	Seaflex 7.5 m² adjustable hatches	Thybron type 15	Injector F-15	T-20vf Flipper	0
Weight of trawl door (kg)	1700	2200	1700	1970	2000	2000	+
Area trawl door (m²)	7.5 with 25% hatches (effective 6.5)	6	7.5 with 25% hatches (effective 6.5)	7	6	7 with 50% hatches (effective 6.5)	+
Towing speed (knots) mean (min-max)	4.8 (4.3-5.3)	4.9 (4.1-5.2)	4.5 (3.8-5.6)	4.8 (4.8-5.5)	4.5 (3.8-5.3)	4.9 (4.1-5.9)	+
Trawl height (m) mean (min-max)	28-40	35.3 (27.4-41.0)	28-37	32 (25-41)	42.7	-	+
Door distance (m) mean (min-max)	115-120	103 (91 - 116)	118-126	119 (114-128)	102.8	118 (113-121)	+
Trawl width (m)*	66.8	60.4	67.3	67.4	58.5	66.5	+
Turn radius (degrees)	5-10	5	5-12	5-10	5-10 BB turn	6-8 SB turn	+
Fish lock front of cod-end	Yes	Yes	Yes	Yes	Yes	Yes	+
Trawl door depth (port, starboard, m) (min-max)	5-15, 7-18	4-21, 4-17	6-22, 8-23	4-28	3-12, 4-19	(11.4-11)	+
Headline depth (m)	0-1	0	0-1	0	0	0-1	+
Float arrangements on the headline	Kite with fender buoy +2 buoys on each wingtip	Kite + 2 buoys on wings	Kite with fender buoy +2 buoys on each wingtip	Kite with fender buoy + 2 buoys on each wingtip	Kite + 1 buoy on each wingtips	Kite + 1 buoy on each wingtips	+
Weighing of catch	All weighted	All weighted	All weighted	All weighted	All weighed	All weighted	+

* calculated from door distance

Table 3. Protocol of biological sampling during the IESSNS 2019. Numbers denote the maximum number of individuals sampled for each species for the different determinations.

	Species	Faroes	Greenland	Iceland	Norway	Denmark
Length measurements	Mackerel	100	100/50*	150	100	≥ 75 (as appropriate)
	Herring	100	100/50*	200	100	
	Blue whiting	100	100/50*	100	100	
	Lumpfish	10	All	all	all	all
	Salmon	all	All	all	all	-
	Other fish sp.	100	25/25	50	25	As appropriate
Weight, sex and maturity determination	Mackerel	25	25	50	25	***
	Herring	25	25	50	25	0
	Blue whiting	50	25	50	25	0
	Lumpfish	10		1^	25	0
	Salmon	1		0	25	0
	Other fish sp.	0	0	0	0	0
Otoliths/scales collected	Mackerel	25	25	25	25	***
	Herring	25	25	50	25	0
	Blue whiting	50	25	50	25	0
	Lumpfish	0	0	1	0	0
	Salmon	1	0	0	0	0
	Other fish sp.	0	0	0	0	0
Fat content	Mackerel Herring Blue whiting	0 0 0	50 0 50	10** 10** 10	0 0 0	0 0 0
Stomach sampling	Mackerel	5	20	10**	10	***
	Herring	5	20	10**	10	0
	Blue whiting	5	20	10	10	0
	Other fish sp.	1	0	0	10	0
Tissue for genotyping	Mackerel	0	0	0	0	0
	Herring	0	0	0	0	0

*Length measurements / weighed individuals
**Sampled at every third station
*** One fish per cm-group from each station was weighed, aged, stomachs were sampled from each second station.
^All live lumpfish were tagged and released, only otoliths taken from fish which were dead when brought aboard

Underwater camera observations during trawling

M/V “Kings Bay” and M/V “Vendla” employed an underwater video camera (GoPro HD Hero 4 and 5 Black Edition, www.gopro.com) to observe mackerel aggregation, swimming behaviour and possible escapement from the cod end and through meshes. The camera was put in a waterproof box which tolerated pressure down to approximately 100 m depth. No light source was employed with cameras; hence, recordings were limited to day light hours. Some recordings were also taken during nighttime when there was midnight sun and good underwater visibility. Video recordings were collected at 65 trawl stations. The camera was attached on the trawl in the transition between 200 mm and 400 mm meshes.

3.3 Marine mammals

Opportunistic observations of marine mammals were conducted by trained scientific personnel and crew members from the bridge between 4th July and 6th August 2019 onboard M/V “Kings Bay” and M/V “Vendla”, respectively. Opportunistic marine mammal observations were also done on R/V Árni Friðriksson from the bridge between 3rd and 29th July 2019 by crew members and by one student between 3rd July and 15th July.

3.4 Lumpfish tagging

Lumpfish caught during the survey by vessels R/V “Árni Friðriksson” and M/V “Eros” were tagged with Peterson disc tags and released. When the catch was brought aboard, any lumpfish caught were transferred to a tank with flow-through sea water. After the catch of other species had been processed, all live lumpfish larger than ~15 cm were tagged. The tags consisted of a plastic disc secured with a titanium pin which was inserted through the rear of the dorsal hump. Contact details of Biopol (www.biopol.is) were printed on the tag. The fish were returned to the tank until all fish were tagged. The fish were then released, and the time of release was noted which was used to estimate the latitude and longitude of the release location.

3.5 Acoustics

Multifrequency echosounder

The acoustic equipment onboard Kings Bay and Vendla were calibrated 3rd July 2019 for 18, 38 and 200 kHz. Árni Friðriksson was calibrated in May 2019 for the frequencies 18, 38, 120 and 200 kHz. Finnur Fríði was calibrated on 27th June 2019 for 38 kHz. Calibration of the acoustic equipment onboard Eros was done after the cruise on the 5th of August. All frequencies were calibrated successfully. Ceton did not conduct any acoustic data collection because no calibrated equipment was available. All the other 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.

Acoustic recordings were scrutinized to herring and blue whiting on daily basis using the post-processing software (LSSS or Echoview, see Table 4 for details of the acoustic settings by vessel). Acoustic measurements were not conducted onboard Ceton in the North Sea. 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.

To estimate the abundance from the allocated NASC-values the following target strengths (TS) relationships were 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

Table 4. Acoustic instruments and settings for the primary frequency (38 kHz) during IESSNS 2019.

	M/V Kings Bay	R/V Árni Friðriksson	M/V Vendla	M/V Finnur Fríði	M/V Ceton *	Eros
Echo sounder	Simrad EK80	Simrad EK 60	Simrad EK 60	Simrad EK 60	Simrad ES 80	Simrad EK80
Frequency (kHz)	18, 38, 70, 120, 200	18, 38, 120, 200	18, 38, 70, 120, 200	38,120, 200	38	18, 38, 70, 120, 200
Primary transducer	ES38B	ES38B	ES38B	ES38B		ES38B
Transducer installation	Drop keel	Drop keel	Drop keel	Hull		Hull
Transducer depth (m)	9	8	9	8		8
Upper integration limit (m)	15	15	15	Not used		15
Absorption coeff. (dB/km)	9.6	10.0	9.1	9.8		9.3
Pulse length (ms)	1.024	1.024	1.024	1.024		1.024
Band width (kHz)	2.43	2.43	2.43	2.43		2.43
Transmitter power (W)	2000	2000	2000	2000		2000
Angle sensitivity (dB)	21.90	21.9	21.90	21.9		21.9
2-way beam angle (dB)	-20.7	-20.81	-20.6	-20.3		-20.7
TS Transducer gain (dB)	24.33	24.36	24.56	26.67		25.63
s_A correction (dB)	-0.58	-0.58	-0.69	-0.58		-0.6
alongship:	7.01	7.28	7.03	7.16		6.86
athw. ship:	7.00	7.23	7.09	7.22		7.05
Maximum range (m)	500	500	500	500		750 for 18 and 38 kHz 500 for 70, 120 and 200 kHz
Post processing software	LSSS v.2.5.1	LSSS v.2.3.0	LSSS v.2.5.1	Sonardata Echoview 10.x		LSSS v.2.5.1

* No acoustic data collection

Multibeam sonar

M/V Kings Bay was equipped with the Simrad fisheries sonar SH90 (frequency range: 111.5-115.5 kHz), with a scientific output incorporated which allow the storing of the beam data for post-processing. M/V Vendla was equipped with the Simrad fisheries sonar SX93 (frequency range: 20-30 kHz). Acoustic multibeam sonar data was stored continuously onboard Kings Bay and Vendla for the entire survey.

Cruise tracks

The six participating vessels followed predetermined survey lines with predetermined surface trawl stations (Figure 1). Calculations of the mackerel index are based on swept area approach with the survey area split into 13 strata, permanent and dynamic strata (Figure 2). Distance between predetermined surface trawl stations is constant within stratum but variable between strata and ranged from 35-90 nmi. The survey design using different strata is done to allow the calculation of abundance indices with uncertainty estimates, both overall and from each stratum in the software program StoX (see Salthaug et al. 2017). Temporal survey progression by vessel along the cruise tracks in July-August 2019 is shown in Figure 3. The cruising speed was between 10-12 knots if the weather permitted otherwise the cruising speed was adapted to the weather situation.

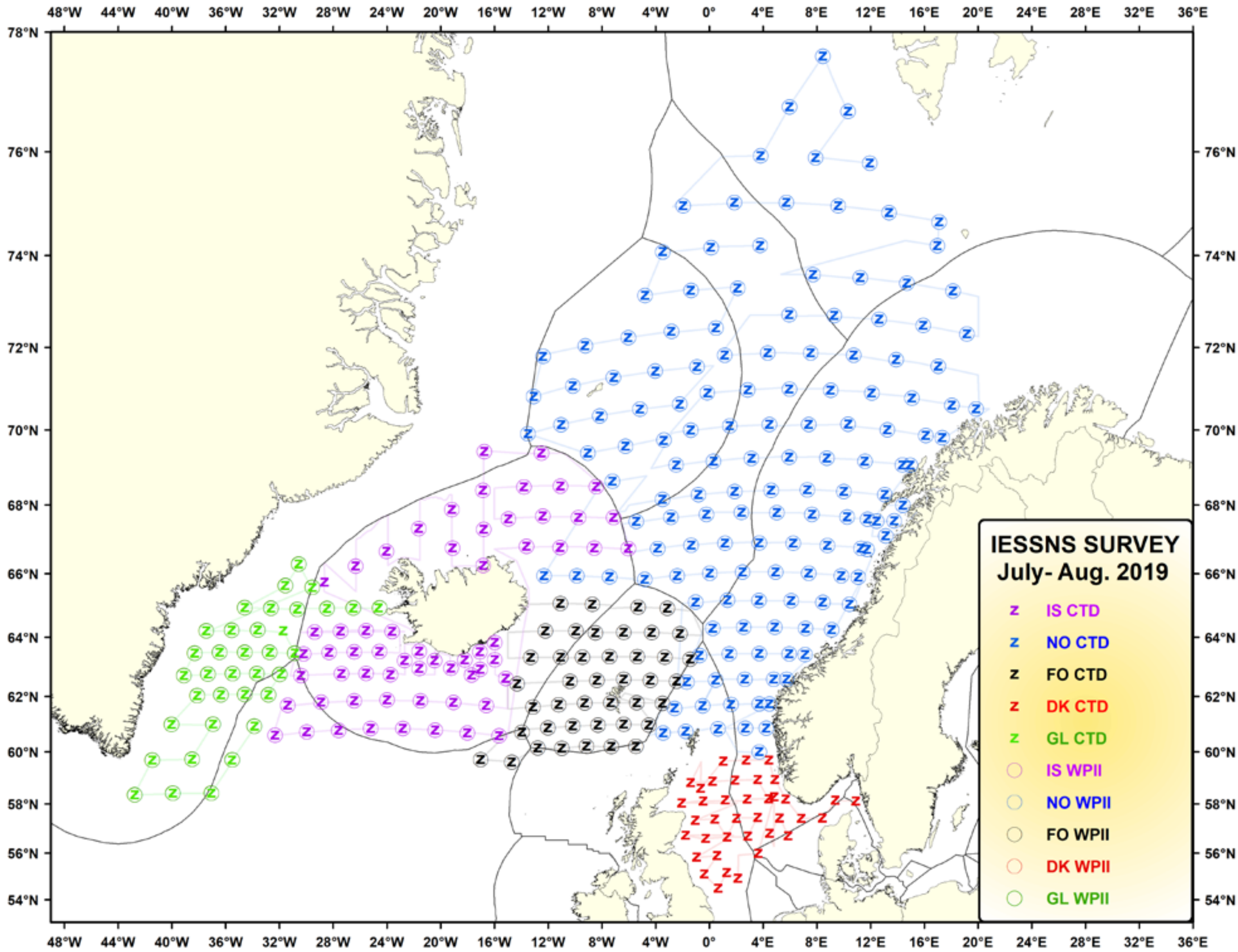


Figure 1. Fixed predetermined trawl stations (shown for CTD and WP2) included in the IESSNS 28th June – 5th August 2019. At each station a 30 min surface trawl haul, a CTD station (0-500 m) and WP2 plankton net samples (0-200 m depth) was performed. The colour codes, Árni Friðriksson (purple), Finnur Fríði (black), Kings Bay and Vendla (blue), Eros (green) and Ceton (red).

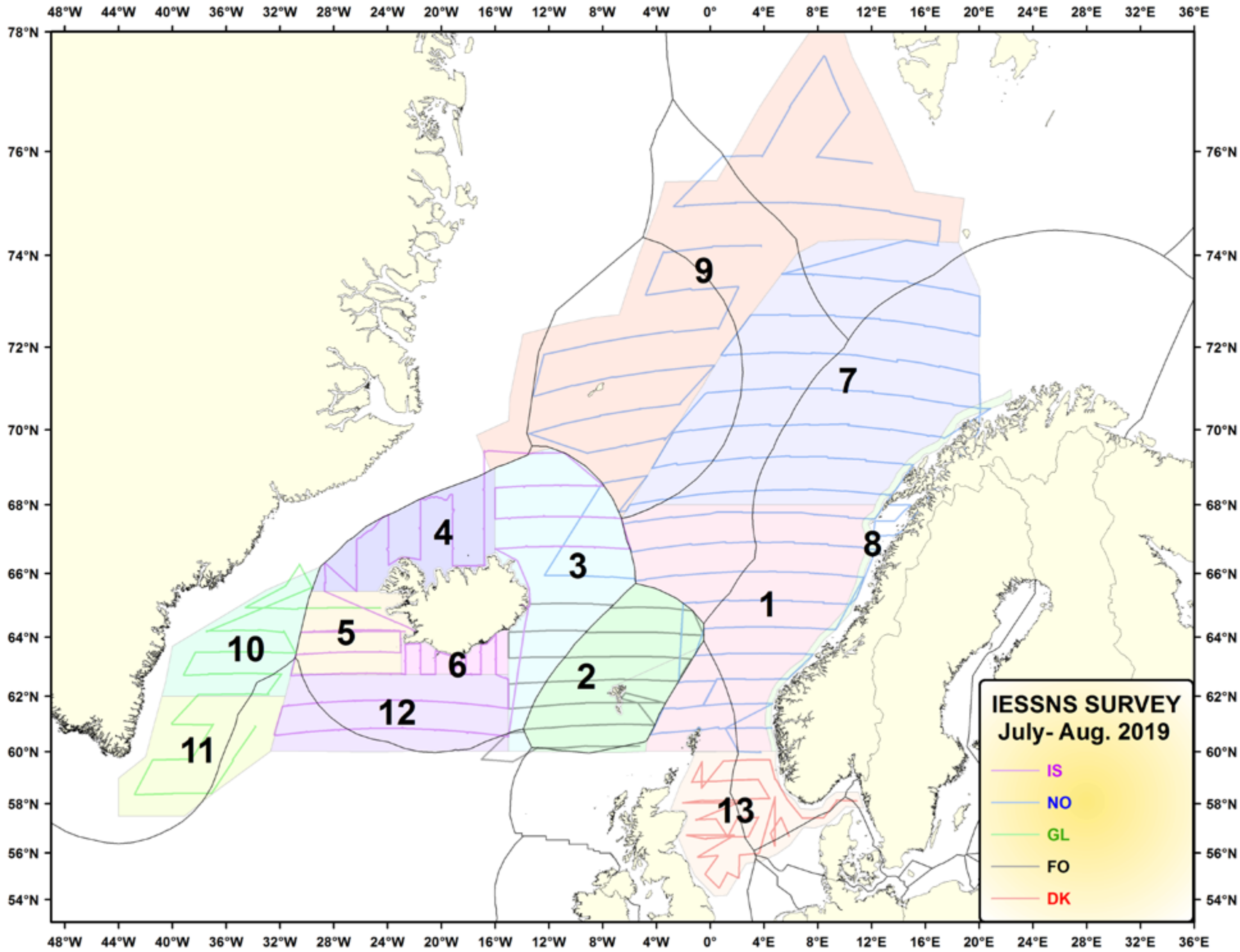


Figure 2. Permanent and dynamic strata used in StoX for IESSNS 2019. The dynamic strata are: 4, 9 and 11.

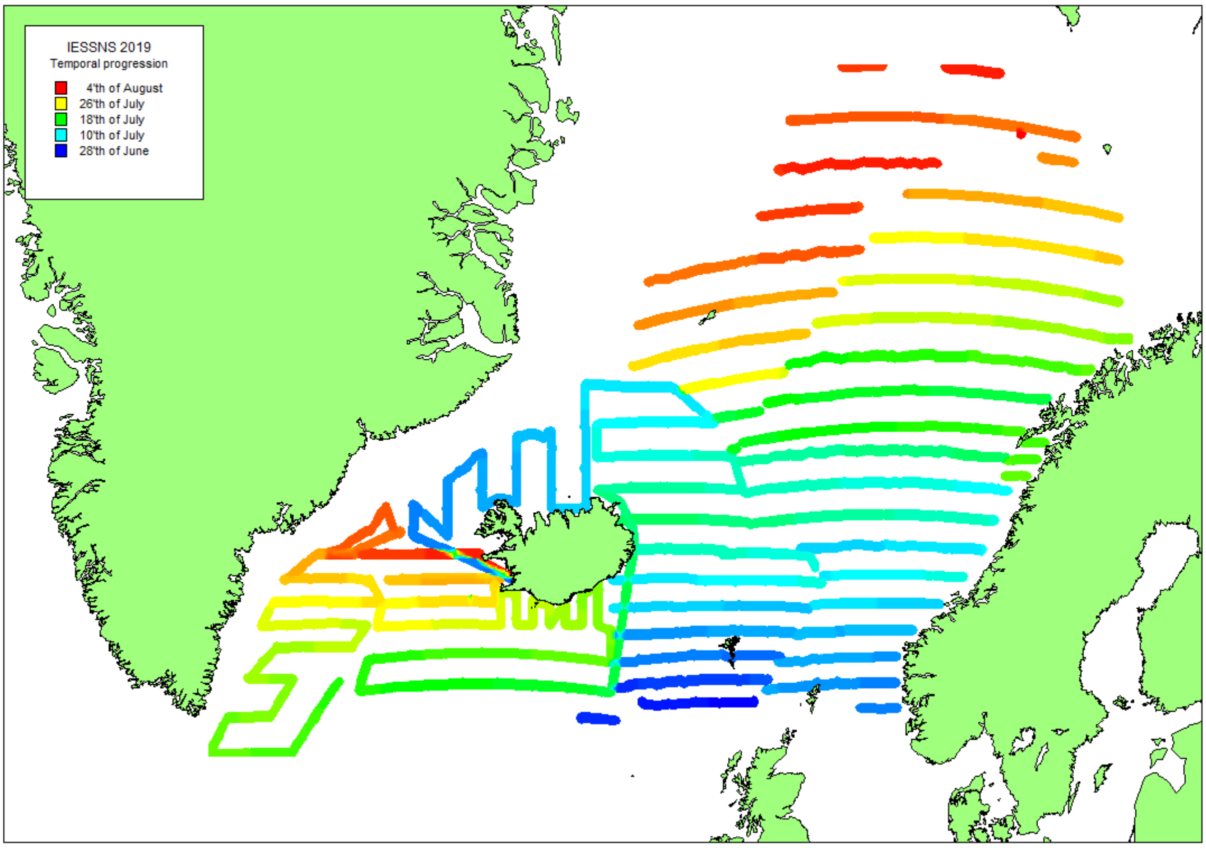


Figure 3. Temporal survey progression by vessel along the cruise tracks during IESSNS 2019: blue represents effective survey start (28th of June) progressing to red representing the effective end of the survey (4th of August). Ceton is not included in the survey progression map for the North Sea, due to no acoustic recordings.

3.6 StoX

StoX is open source software developed at IMR, Norway to calculate survey estimates from acoustic and swept area surveys. The software, with examples and documentation, can be found at: http://www.imr.no/forskning/prosjekter/stox/nb-no. The program is a stand-alone application built 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. 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. Mackerel, herring and blue whiting indices were calculated using the StoX software package (version 2.7).

3.7 Swept area index and biomass estimation

The swept area age segregated index is calculated separately for each stratum (see stratum definition in Figure 2). Individual stratum estimates are added together to get the total estimate for the whole survey area which is approximately defined by the area between 57°N and 78°N and 44°W and 20°E in 2019.

Average density (Mac_D; kg km^{-2}) is calculated for each trawl haul with the following formula;

Mac_D = h * d * c

where h (km) is the horizontal opening of the trawl, d is distance trawled (km) and c is the total mackerel catch (kg). The horizontal opening of the trawl is vessel specific, and the average value across all hauls is calculated based on door spread (Table 5 and Table 6).

Table 5. Descriptive statistics for trawl door spread, vertical trawl opening and tow speed for each vessel. Number of trawl stations used in calculations is also reported. Horizontal trawl opening was calculated using average vessel values for trawl door spread and tow speed (details in Table 6).

	Finnur Fríði	RV Árni Friðriksson	Kings Bay	Vendla	Eros	Ceton
Trawl doors horizontal spread (m)						
Number of stations	39	60	68	57	27	38
Mean	102.8	103	119	126	119	119
max	111	116	120	130	127	128
min	97	91	115	117	113	114
st. dev.	3.3	6.7	1.5	4.2	3.1	4.9
Vertical trawl opening (m)						
Number of stations	40	61	68	57	27	38
Mean	42.7	35.3	37.8	34.2	34.7	32
max	47	41.0	40	36	39.0	41
min	35	27.4	30	28	31.5	25
st. dev.	2.5	2.5	3.6	2.6	2.0	4.5
Horizontal trawl opening (m)						
mean	58.5	60.4	66.8	67.3	66.5	67.4
Speed (over ground, nmi)						
Number of stations	42	61	68	57	27	38
mean	4.45	4.9	4.6	4.2	4.9	4.8
max	5.3	5.2	5.3	5.6	5.9	5.5
min	3.8	4.1	4.3	3.8	4.1	4.1
st. dev.	0.41	0.2	0.41	0.7	0.3	0.3

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 flume tank simulations in 2013 (Hirtshals, Denmark) where formulas were developed from 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 * Door spread (m) + 13.094

Towing speed 5.0 knots: Horizontal opening (m) = 0.3959 * Door spread (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. In 2017, the towing speed range was extended from 5.0 to 5.2.

	Towing speed							
Door spread(m)	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2
100	57.2	57.7	58.2	58.7	59.2	59.7	60.2	60.7
101	57.6	58.1	58.6	59.1	59.6	60.1	60.6	61.1
102	58.1	58.6	59.0	59.5	60.0	60.5	61.0	61.4

103	58.5	59.0	59.5	59.9	60.4	60.9	61.3	61.8
104	59.0	59.4	59.9	60.3	60.8	61.3	61.7	62.2
105	59.4	59.9	60.3	60.8	61.2	61.7	62.1	62.6
106	59.8	60.3	60.7	61.2	61.6	62.1	62.5	62.9
107	60.3	60.7	61.2	61.6	62.0	62.5	62.9	63.3
108	60.7	61.1	61.6	62.0	62.4	62.9	63.3	63.7
109	61.2	61.6	62.0	62.4	62.8	63.2	63.7	64.1
110	61.6	62.0	62.4	62.8	63.2	63.6	64.1	64.5
111	62.0	62.4	62.8	63.2	63.6	64.0	64.4	64.8
112	62.5	62.9	63.3	63.7	64.0	64.4	64.8	65.2
113	62.9	63.3	63.7	64.1	64.4	64.8	65.2	65.6
114	63.4	63.7	64.1	64.5	64.9	65.2	65.6	66.0
115	63.8	64.2	64.5	64.9	65.3	65.6	66.0	66.3
116	64.3	64.6	65.0	65.3	65.7	66.0	66.4	66.7
117	64.7	65.0	65.4	65.7	66.1	66.4	66.8	67.1
118	65.1	65.5	65.8	66.1	66.5	66.8	67.1	67.5
119	65.6	65.9	66.2	66.6	66.9	67.2	67.5	67.9
120	66.0	66.3	66.6	67.0	67.3	67.6	67.9	68.2

4 Results and discussion

4.1 Hydrography

Satellite measurements of sea surface temperature (SST) in the eastern part of the Norwegian Sea in July 2019 was similar to the average for July 1990-2009 based on SST anomaly plot (Figure 4). Surface temperature in the western part of the Norwegian Sea in July 2019 was slightly higher (1°C) compared to the average (Figure 4). The SST situation in the entire Norwegian Sea in July 2019 is very similar to July 2018. In Icelandic and Greenland waters, on the other hand, the SST was 1-2°C warmer than the average in July 2019 (Figure 4). This contrasts with the situation in 2018 when SST was 1-2°C colder than the average in Icelandic and Greenland waters. Sea Surface Temperature in July 2019 was most like the situation in July 2010 and partly in July 2012, whereas quite different than most other years for the time series from 2010 to 2019.

It must be mentioned that the NOAA 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 *in situ* features of SSTs between years (Figures 5-8). However, since the anomaly is based on the average for the whole month of July, it should give representative results of the surface temperature.

The upper layer (< 20 m depth) was 1.0-2.0°C warmer in 2019 compared to 2018 in most of Icelandic and Greenland waters (Figure 5). The temperature in the upper layer was higher than 8°C in most of the surveyed area, except along the north-western fringes of the surveyed areas north of Iceland, west of Jan Mayen and Svalbard where it was lower. In the deeper layers (50 m and deeper; Figure 6-8), the hydrographical features in the area were similar to the last four years (2014-2018). At all depths there were a clear signal from the cold East Icelandic Current, which originates from the East Greenland Current.

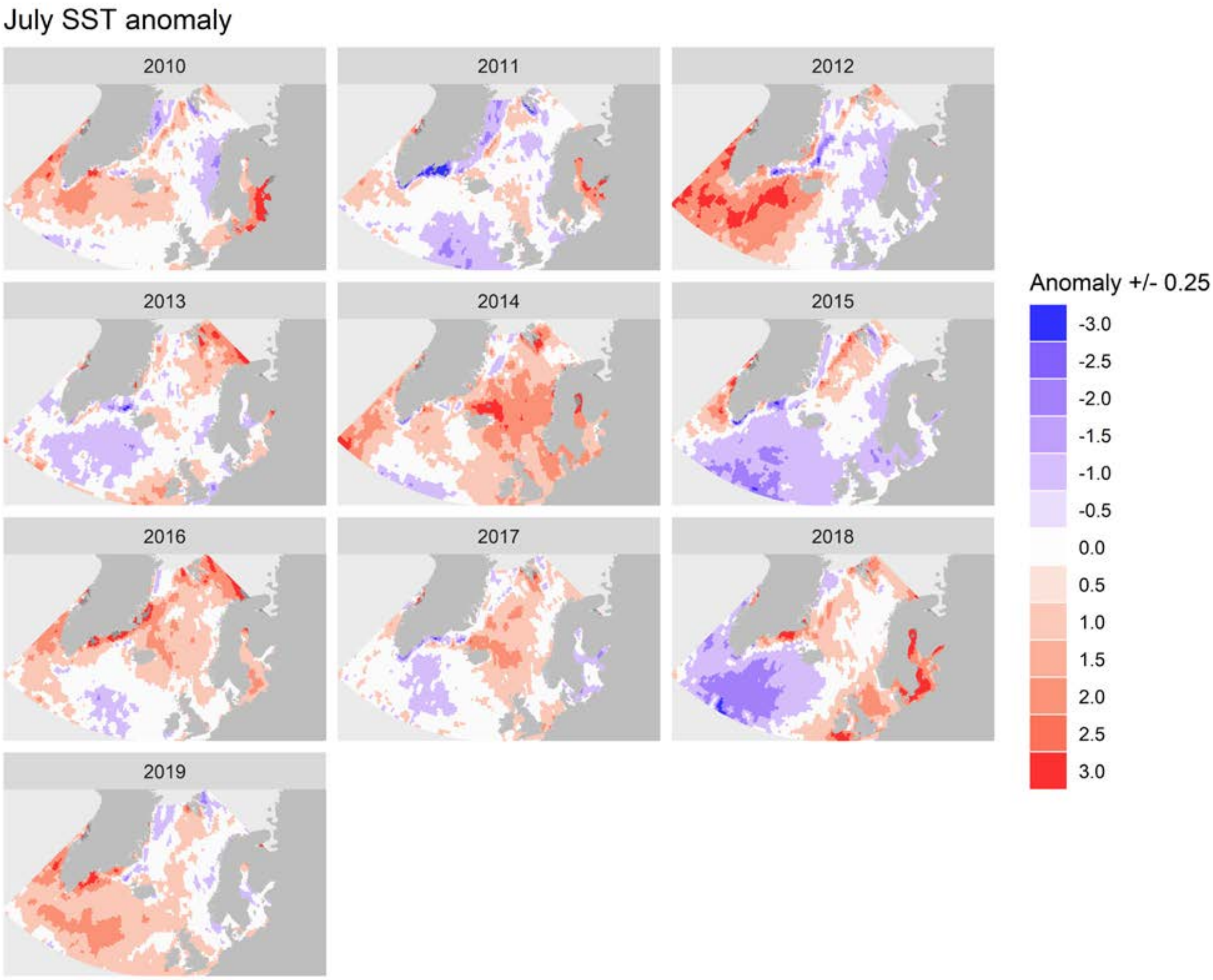


Figure 4. Annual sea surface temperature anomaly (°C) in Northeast Atlantic for the month of July from 2010 to 2019 showing warm and cold conditions in comparison to the average for July 1990-2009. Based on monthly averages of daily Optimum Interpolation Sea Surface Temperature (OISST, AVHRR-only, Banzon et al. 2016, https://www.ncdc.noaa.gov/oisst).

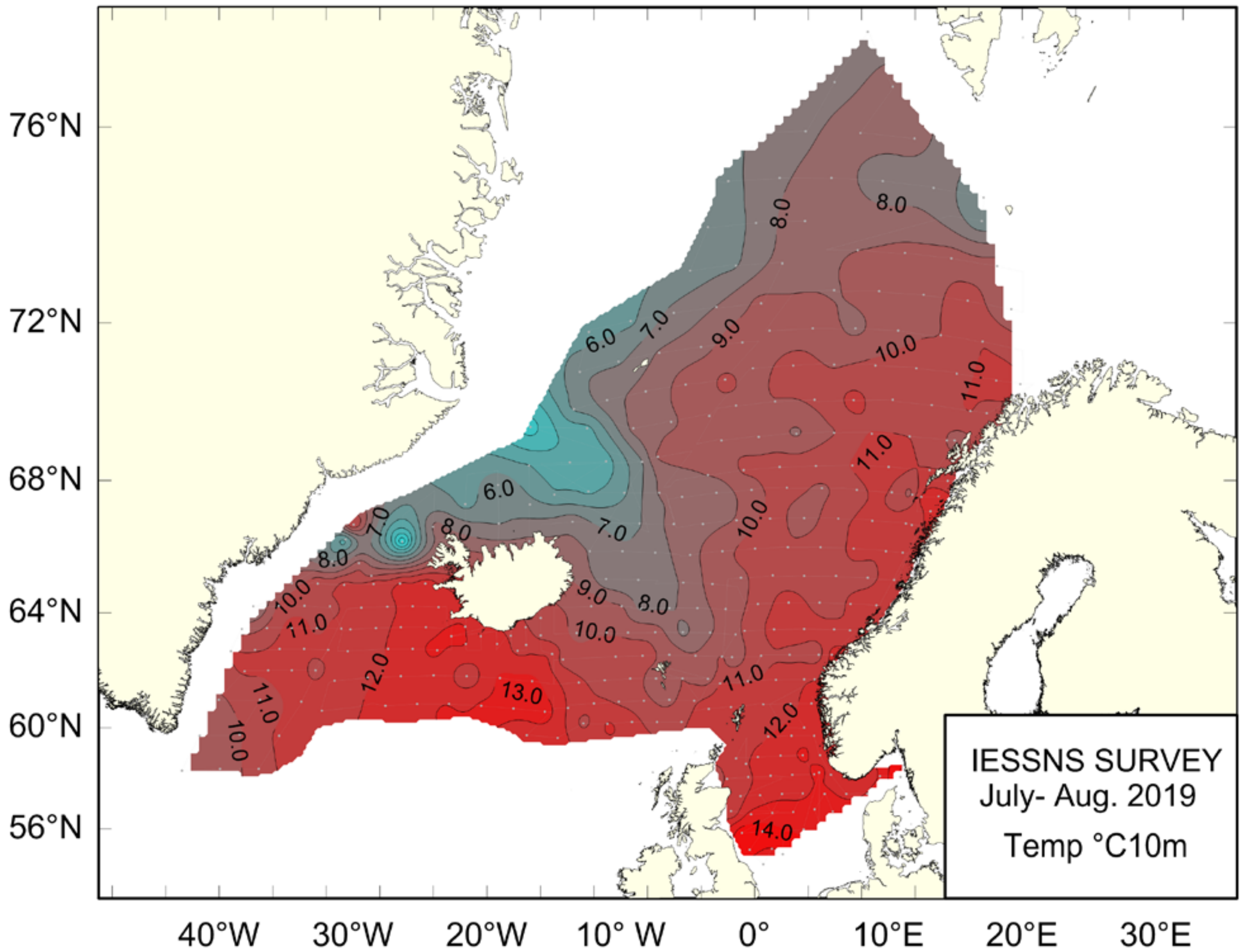


Figure 5. Temperature (°C) at 10 m depth in Nordic Seas and the North Sea in July-August 2019.

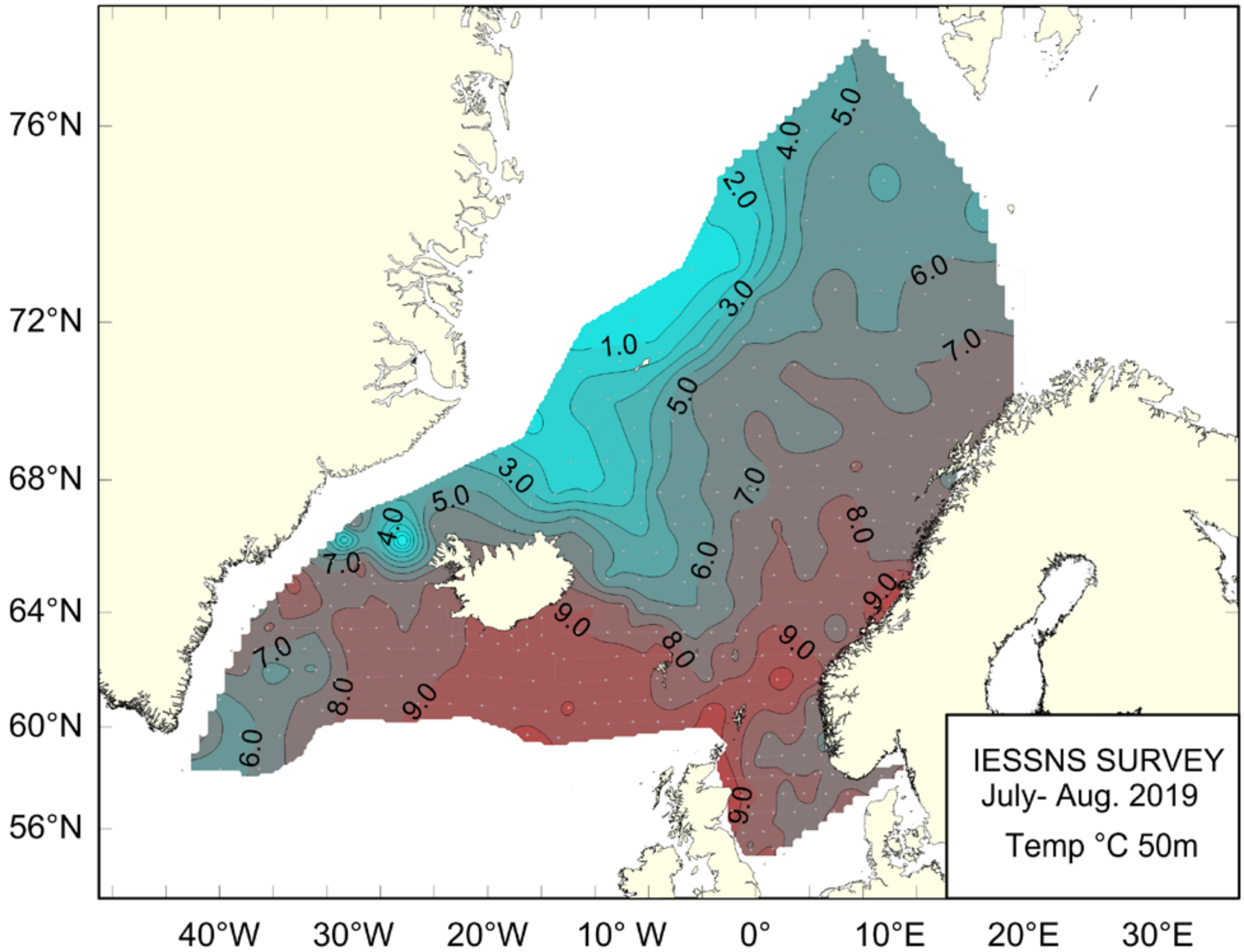


Figure 6. Temperature (°C) at 50 m depth Nordic Seas and the North Sea in July-August 2019.

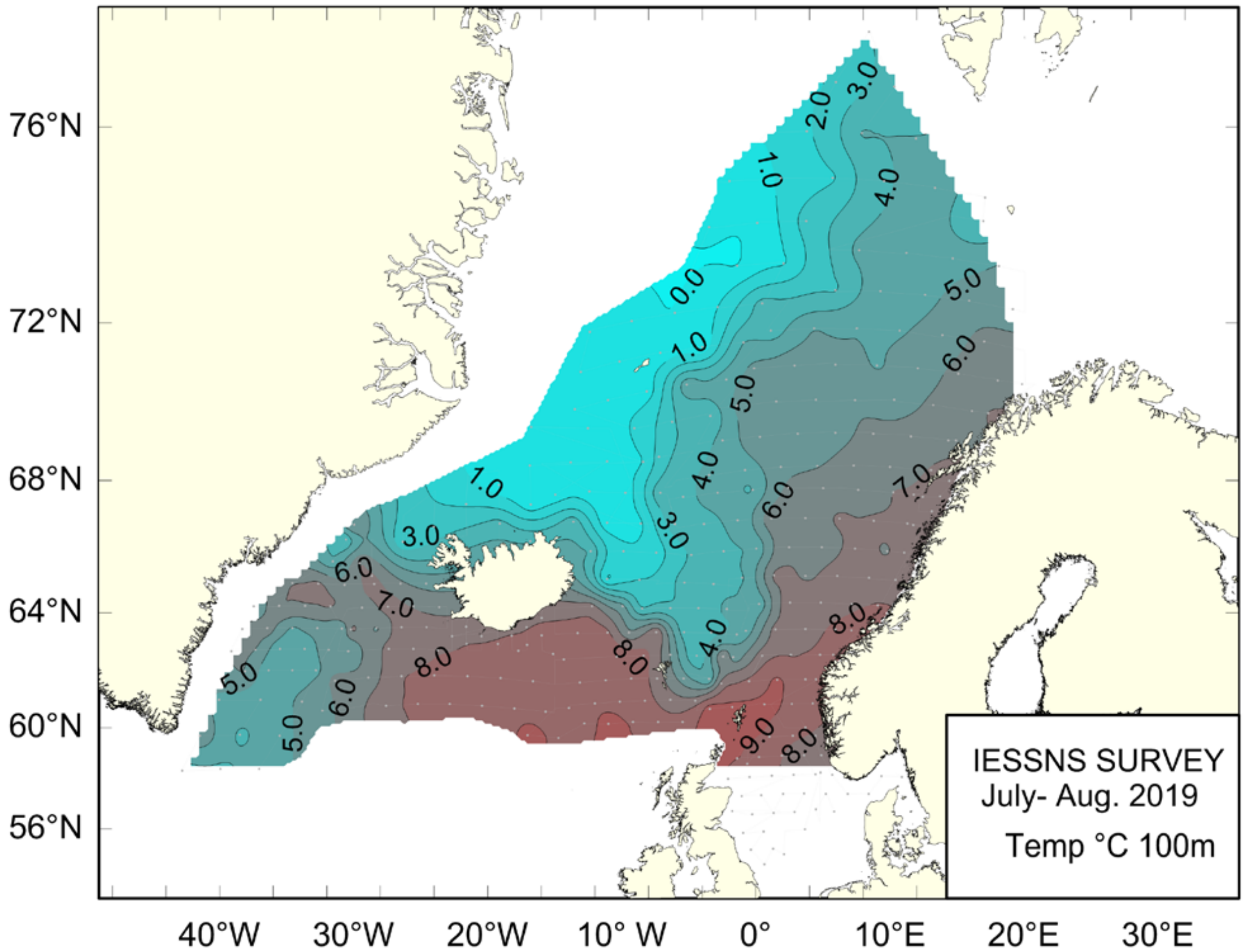


Figure 7. Temperature (°C) at 100 m depth in Nordic Seas and the North Sea in July-August 2019.

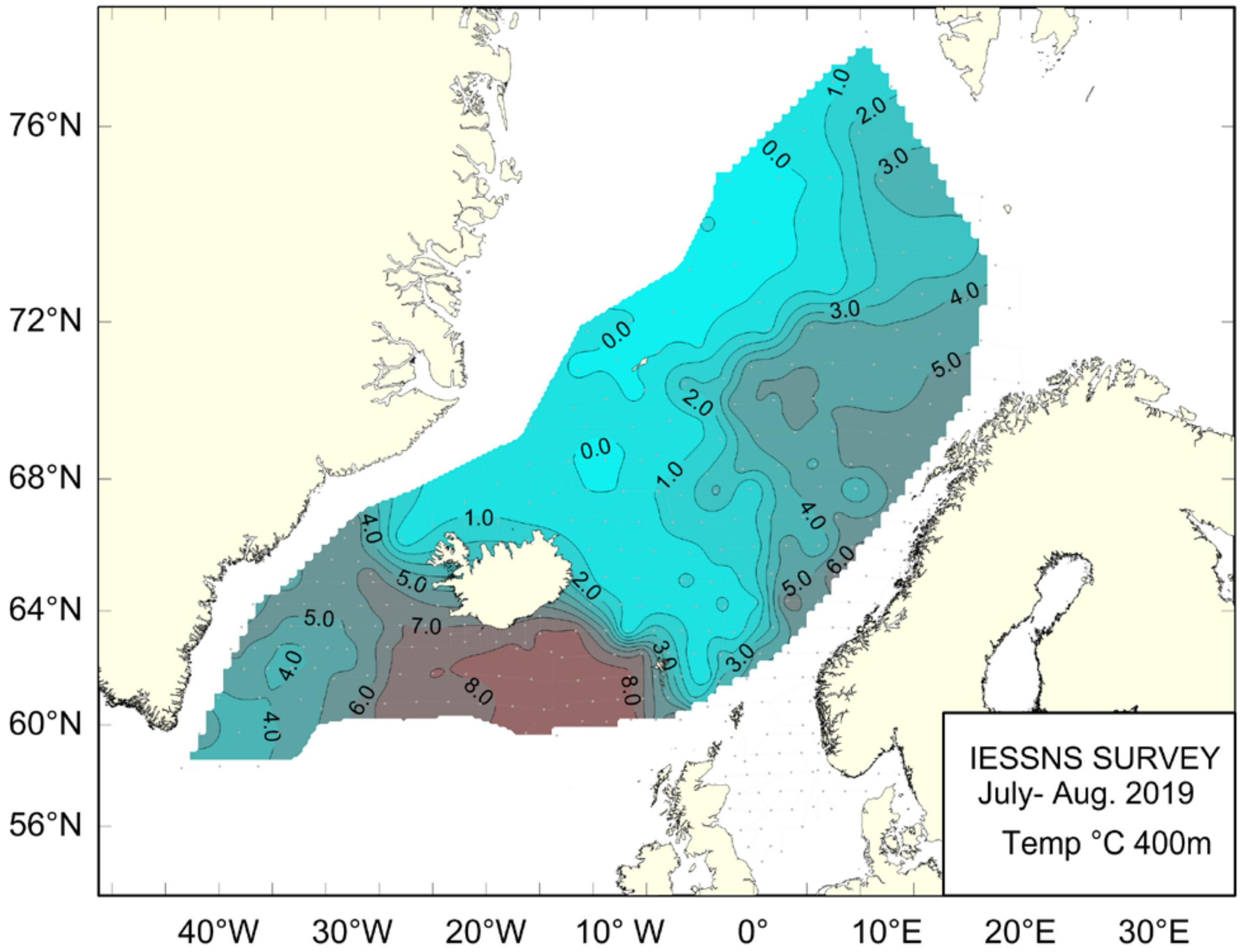
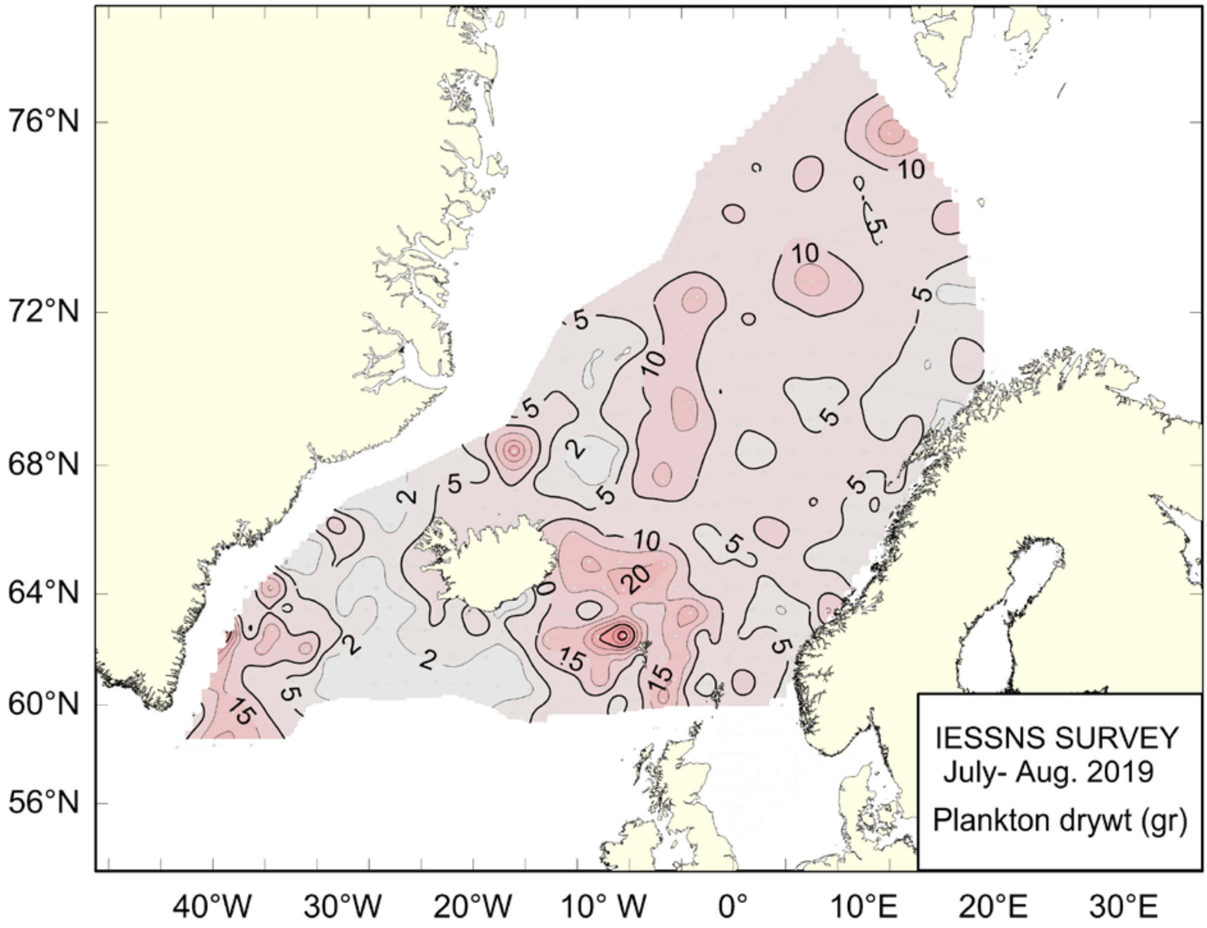


Figure 8. Temperature (°C) at 400 m depth in Nordic Seas and the North Sea in July-August 2019.

4.2 Zooplankton

Average zooplankton index for the survey area declined quite substantially from 2019 compared to both 2017 and 2018. Zooplankton biomass varied between areas and was highest in Greenland waters (Figure 9a). In 2019, the average had decreased in Greenland (10.1 g m^{-2}; n=27) and Icelandic waters (7.0 g m^{-2}; n=60), while it had increased in the Norwegian Sea (8.7 g m^{-2}; n=173) compared to 2018. There was a sharp decline by more than 30% of zooplankton in Greenland waters (eastward of longitude 30 °W) compared to both 2017 and 2018. There was also a decline in Icelandic waters from 2018 to 2019. This relatively short time-series show much more pronounced fluctuations and year-to-year variability (cyclical patterns) in Icelandic and Greenlandic waters compared to the Norwegian Sea. This might in part be explained by both more homogeneous oceanographic conditions in the area defined as Norwegian Sea. Zooplankton in Iceland and Greenland waters are highly variable from year to year and statistically correlated (r=0.83). These plankton indices, however, needs to be treated with some care due as it is only a snapshot of the standing stock biomass, not of the actual production in the area, which complicates spatio-temporal comparisons.


IESSNS SURVEY
July- Aug. 2019
Plankton drywt (gr)
76°N
72°N
68°N
64°N
60°N
56°N
40°W
30°W
20°W
10° W
0°
10°E
20°E
30°E

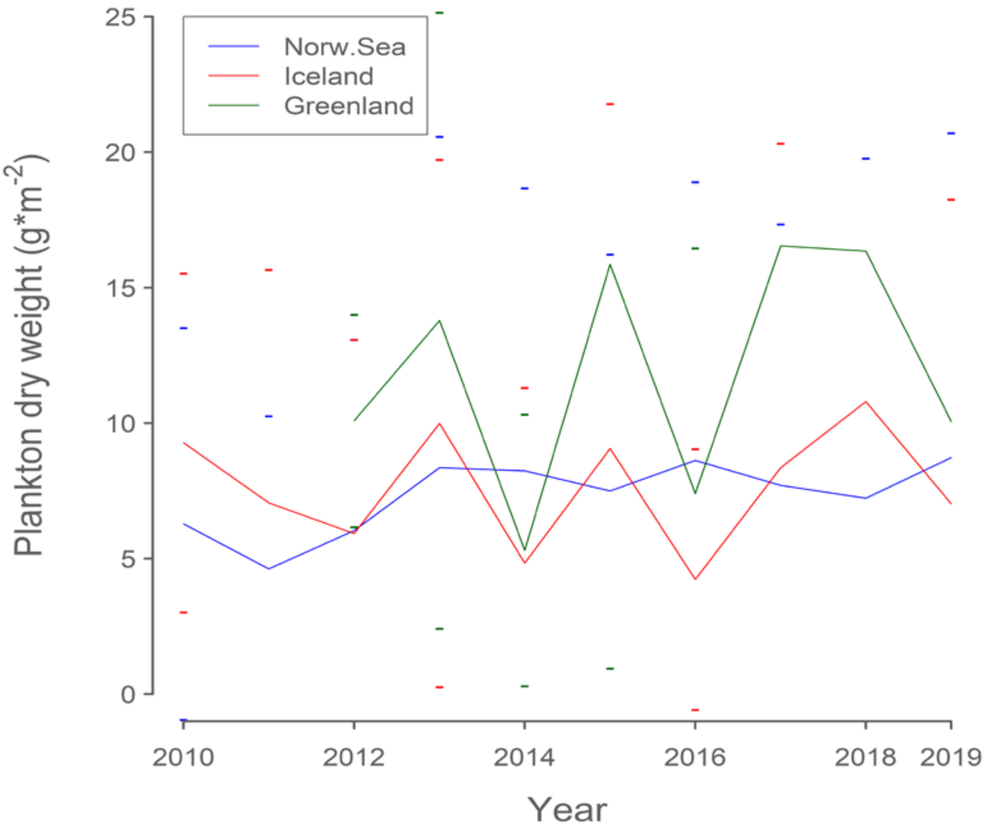


Figure 9. Zooplankton biomass indices (g dw/m², 0-200 m) (a) in Nordic Seas in July-August 2019 and (b) time-series of mean zooplankton biomass for three subareas within the survey range: Norwegian Sea (between 14°W-17°E & north of 61°N), Icelandic waters (14°W-30°W) and Greenlandic waters (west of 30°W).

4.3 Mackerel

The mackerel biomass index i.e. catch rates by trawl station (kg/km²) measured at predetermined surface trawl stations is presented in Figure 10 together with the mean catch rates per 1*2° rectangles. The map shows large variations in trawl catch rates throughout the survey area from zero to 52 tonnes/km² (mean = 3.9). High density areas were found in the northern Norwegian Sea, south-east of Iceland, between Iceland and the Faroe Island, as well as south west of the Faroe Islands. The mackerel were more north-easterly distributed in 2019, compared to the years between 2012 and 2018 (Figure 11 & 12). This was apparent in Greenland waters, where the catch was the lowest in the time series.

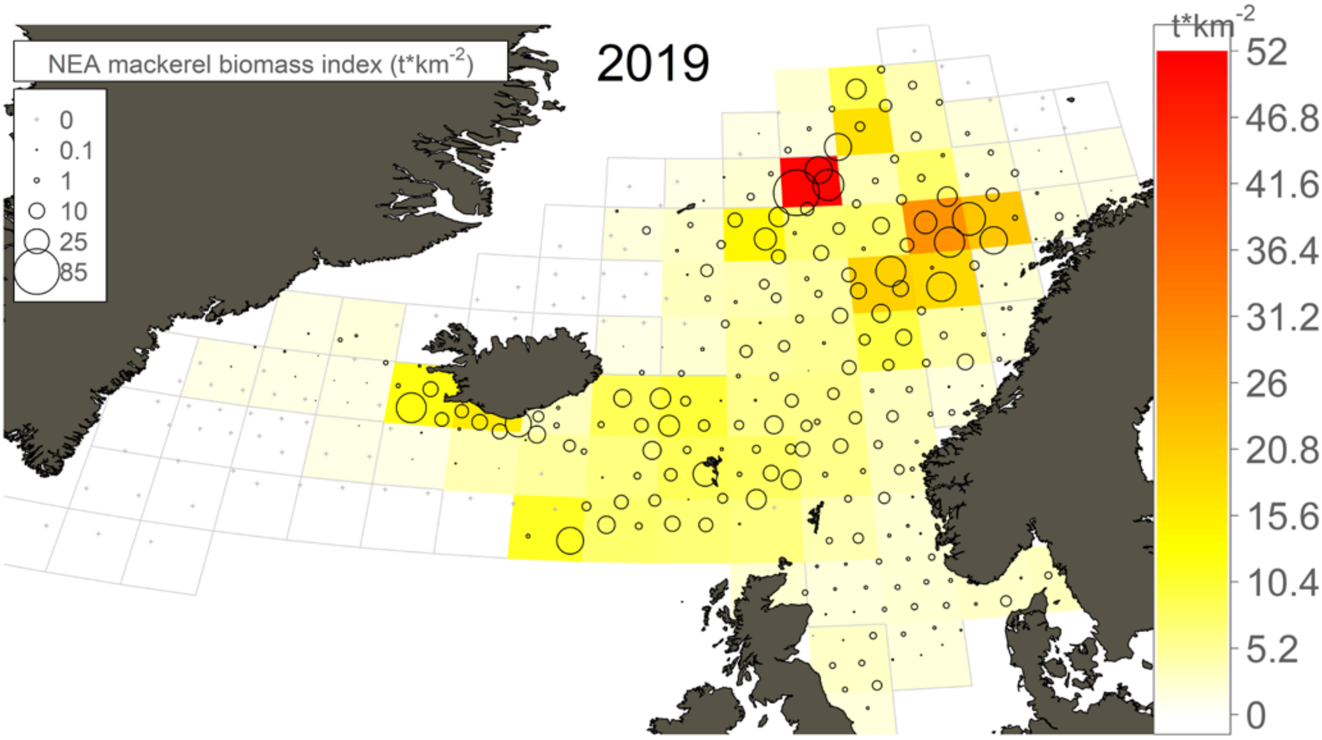


Figure 10. Mackerel catch rates by Multpelt 832 pelagic trawl haul at predetermined surface trawl stations (circle areas represent catch rates in kg/km²) overlaid on mean catch rates per standardized rectangles (2° lat. x 4° lon.).

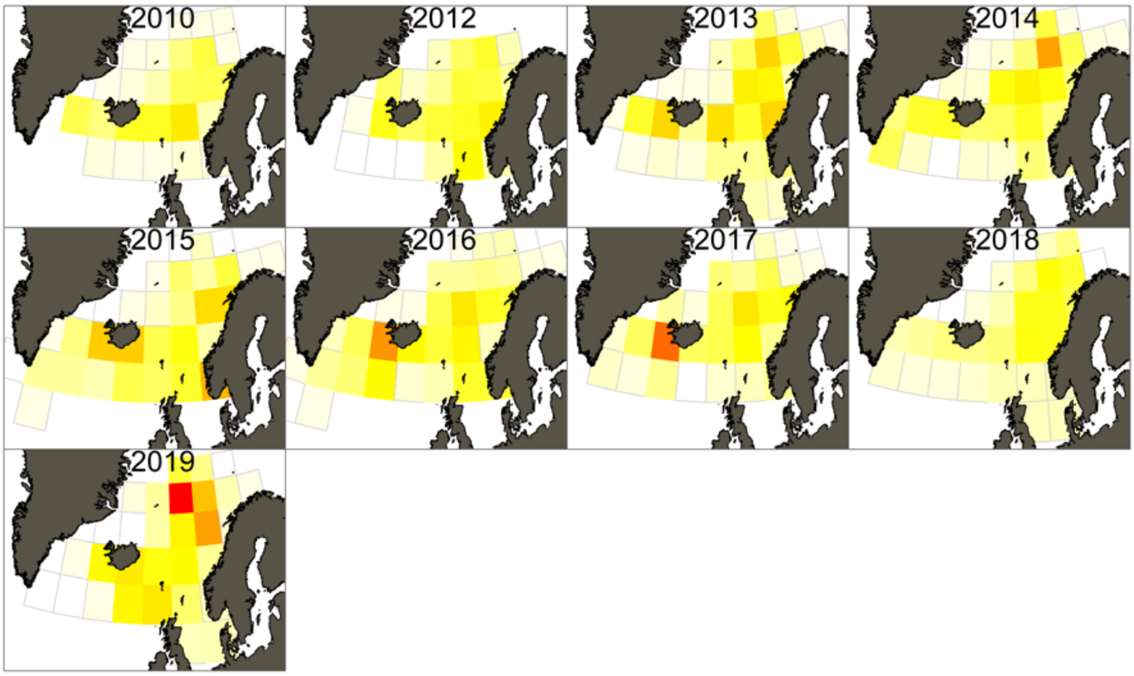


Figure 11. Annual distribution of mackerel proxied by the absolute distribution of mean mackerel catch rates per standardized rectangles (4° lat. x 8° lon.), from Multpelt 832 pelagic trawl hauls at predetermined surface trawl stations. Color scale goes from white (= 0) to red (= maximum value for the highest year).

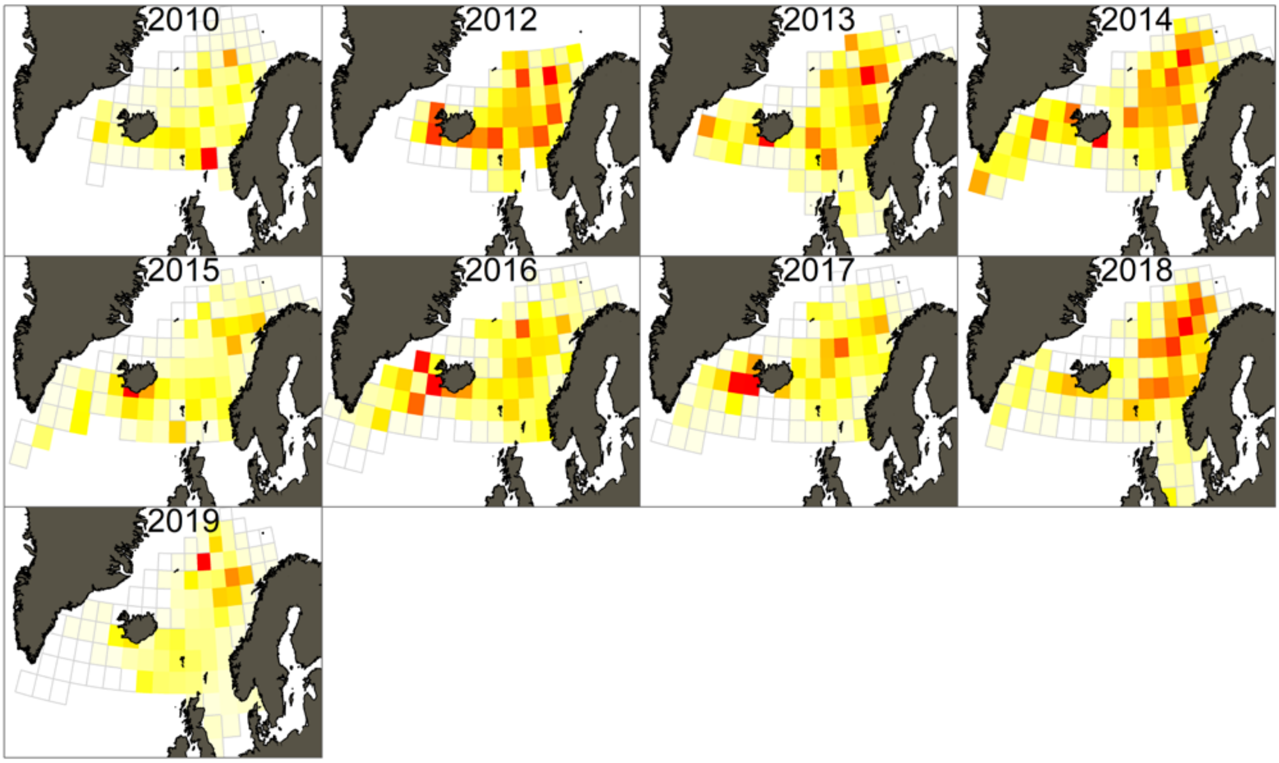


Figure 12. Annual distribution of mackerel proxied by the relative distribution of mean mackerel catch rates per standardized rectangles (2° lat. x 4° lon.), from Multpelt 832 pelagic trawl hauls at predetermined surface trawl stations. Color scale goes from white (= 0) to red (= maximum value for the given year).

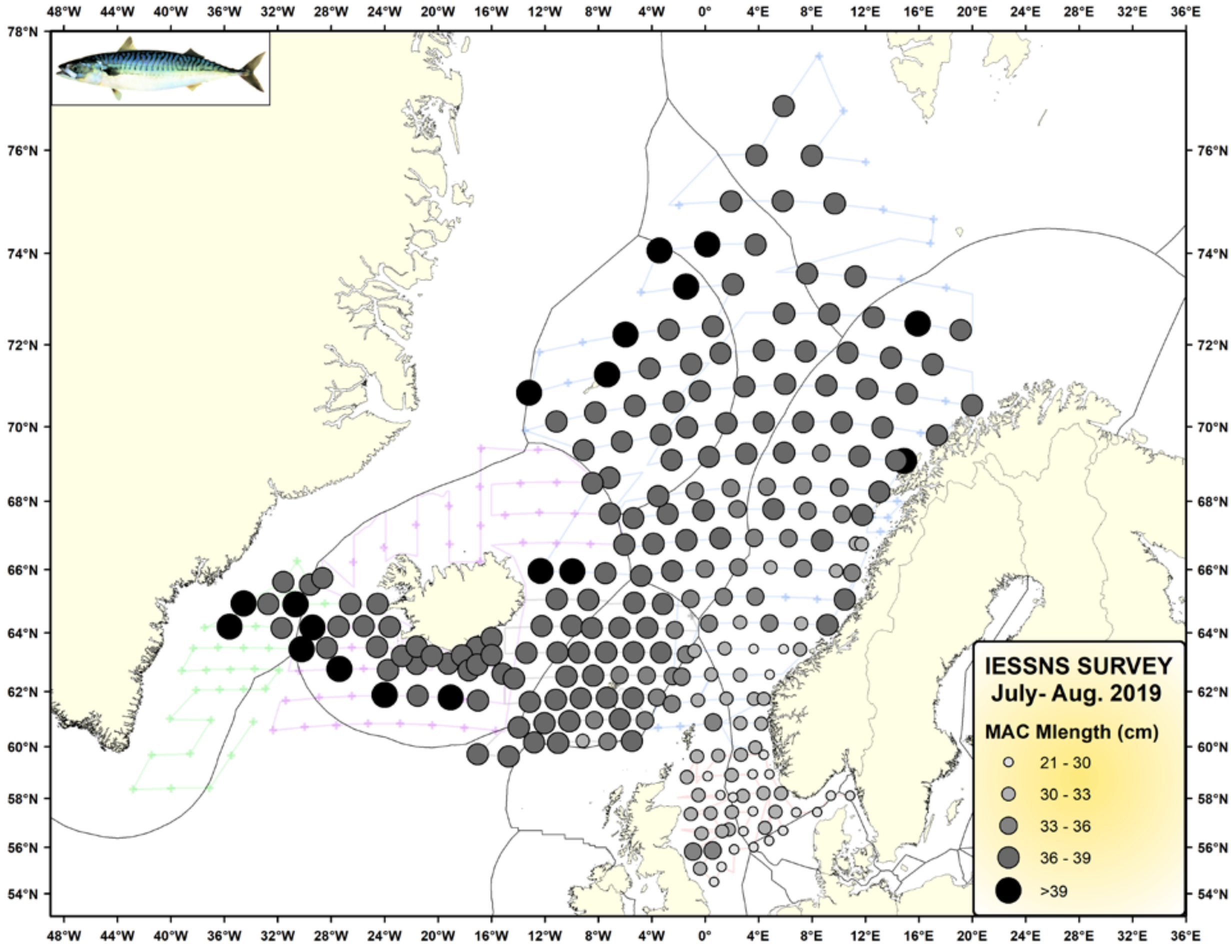


Figure 13. Average length of mackerel at predetermined surface trawl stations during IESSNS 2019.

Mackerel caught in the pelagic trawl hauls onboard the six vessels varied from 25.2 to 41.0 cm in length, with an average of 35.0 cm. Individuals in length range 30–37 cm dominated in numbers and biomass. The mackerel weight (g) varied between 192 to 641 g with an average of 422 g. Mackerel length distribution followed the same pattern as previous years in the Norwegian Sea, with increasing size towards the distribution boundaries in the north and the north-west. In the west (Iceland-Greenland waters), the largest mackerel were again found towards south and west, however, with the restricted western distribution this does appear slightly different (Figure 13). The spatial distribution and overlap between the major pelagic fish species (mackerel, herring, blue whiting, salmon (*Salmo salar*), lumpfish) in 2019 according to the catches are shown in Figure 14.

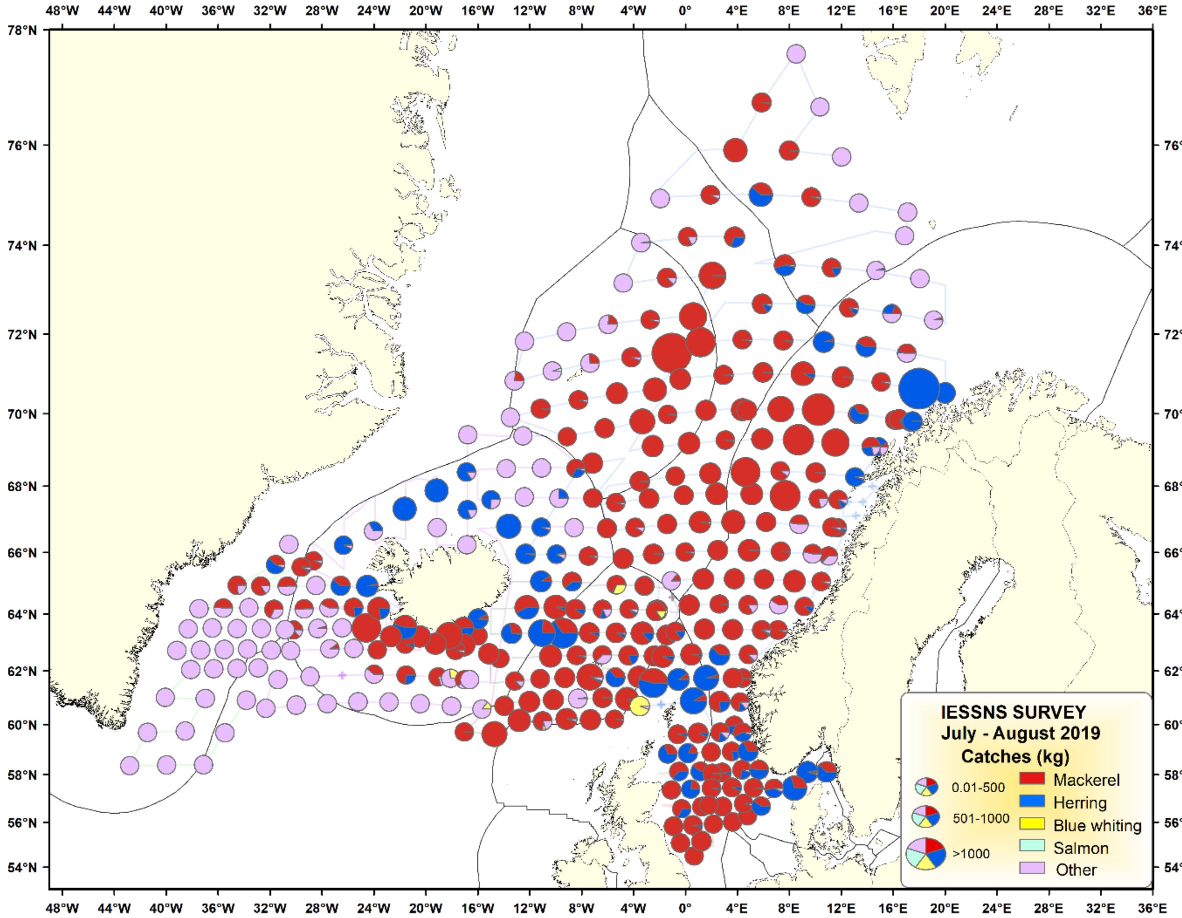


Figure 14. Distribution and spatial overlap between various pelagic fish species (mackerel, herring, blue whiting, salmon, lumpfish (other)) in 2019 at all surface trawl stations. Vessel tracks are shown as continuous lines.

Swept area analyses from standardized pelagic trawling with Multpelt 832

The swept area estimates of mackerel biomass from the 2019 IESSNS were based on abundance of mackerel per stratum (see strata definition in Figure 2) and calculated in StoX. Mackerel biomass index and abundance index was the highest in the time series that started in 2010 (Table 7, Figure 15). Comparing the 2019 estimate to the 2018 estimate shows a 56 % increase in abundance and 85 % increase in biomass. The survey coverage area (excl. the North Sea, 0.3 million km^2) was 2.9 million km^2 in 2019, which is similar to 2018 and 2017. The most abundant year classes were 2011, 2010, 2016, 2014 and 2013 (Figure 16). Mackerel of age 2 and to some extent also age 3 are not completely recruited to the survey (Figure 18, bottom). Therefore, the results suggest that the incoming 2016- and 2017- year classes are large. Variance in age index estimation is provided in Figure 17.

The internal consistency plot for age-disaggregated year classes is similar to last year (Figure 18, top). There is a strong internal consistency for ages 1 to 5 years ($0.83 < r < 0.93$), it is poor ($0.13 < r < 0.31$) between age 5 and 6 as well as 7 and 8, and it is a fair/good internal consistency for ages 5 to 11 years ($0.58 < r < 0.81$).

Mackerel index calculations from the catch in the North Sea (stratum 13 in Figure 2) were excluded from the index calculations presented in the current chapter to facilitate comparison to previous years and because the 2017 mackerel benchmark stipulated that trawl stations south of latitude 60 °N be excluded from index calculations (ICES 2017). Results from the mackerel index calculations for the North Sea are presented in Appendix 1.

The indices used for NEA mackerel stock assessment in WGIWIDE are the number-at-age indices for age 3 to 11 year (Table 7).

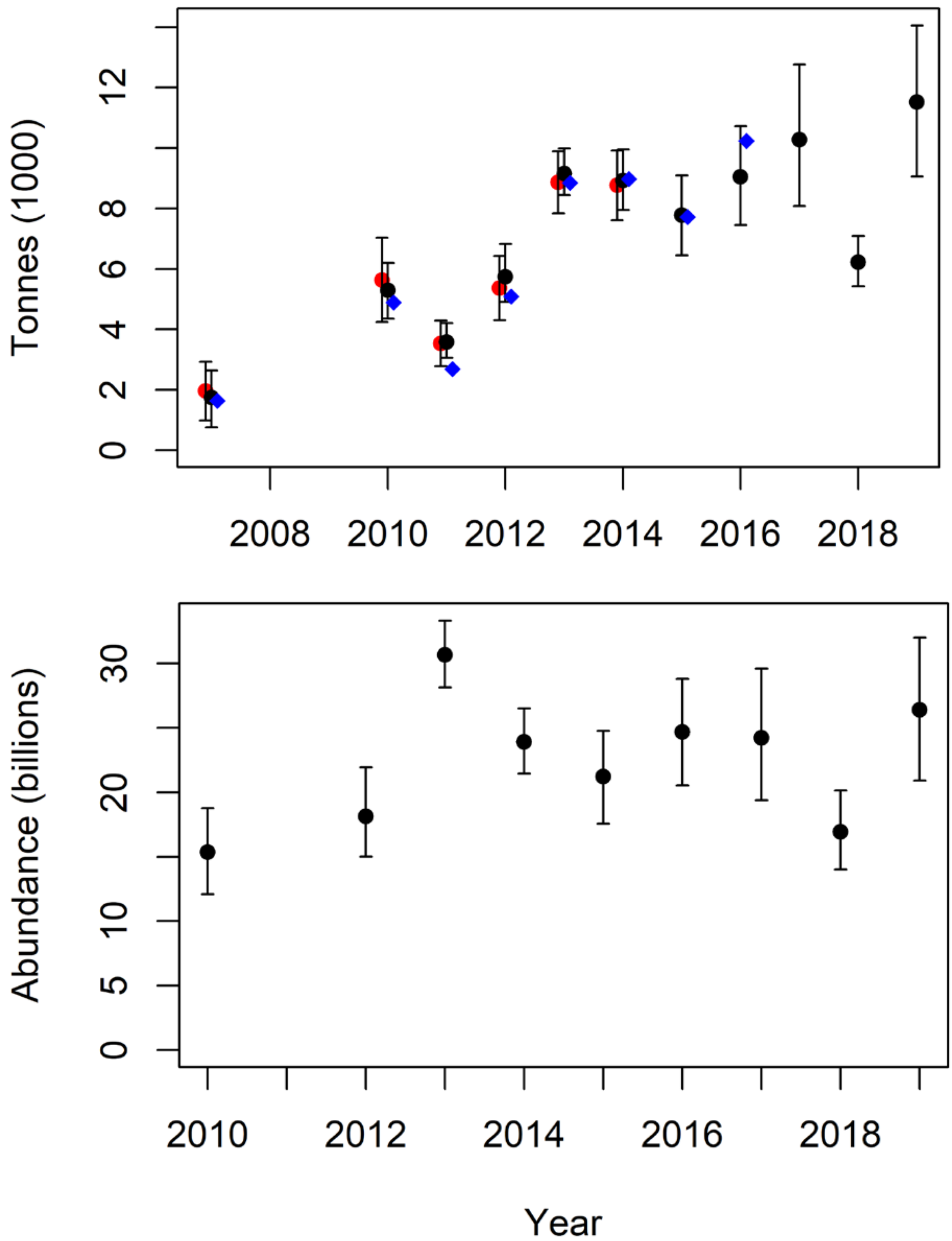


Figure 15. Estimated total stock biomass (TSB) of mackerel from StoX (black dots), Nøttestad et al. (2016) (red dots) and IESSNS cruise reports (blue diamonds) (top) and estimated total stock numbers (TSN) of mackerel from StoX (black dots) (bottom), The error bars represent approximate 90 % confidence intervals.

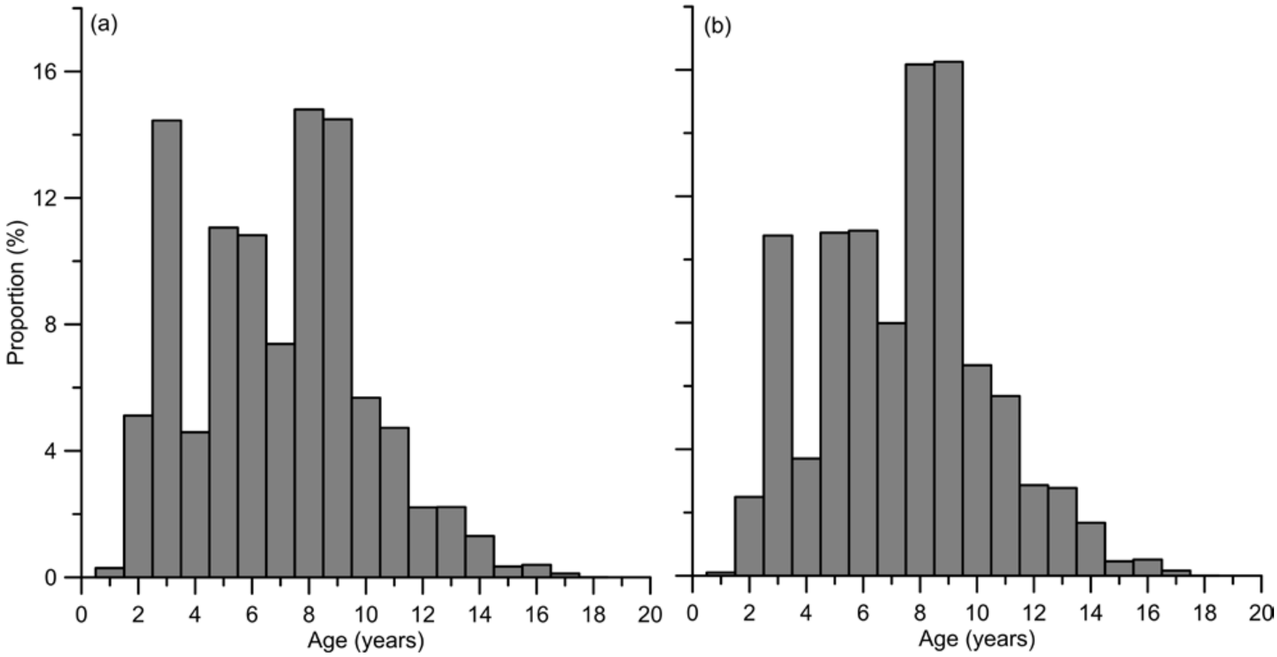


Figure 16. Age distribution in proportion represented as a) % in numbers and b) % in biomass of Northeast Atlantic mackerel in 2019.

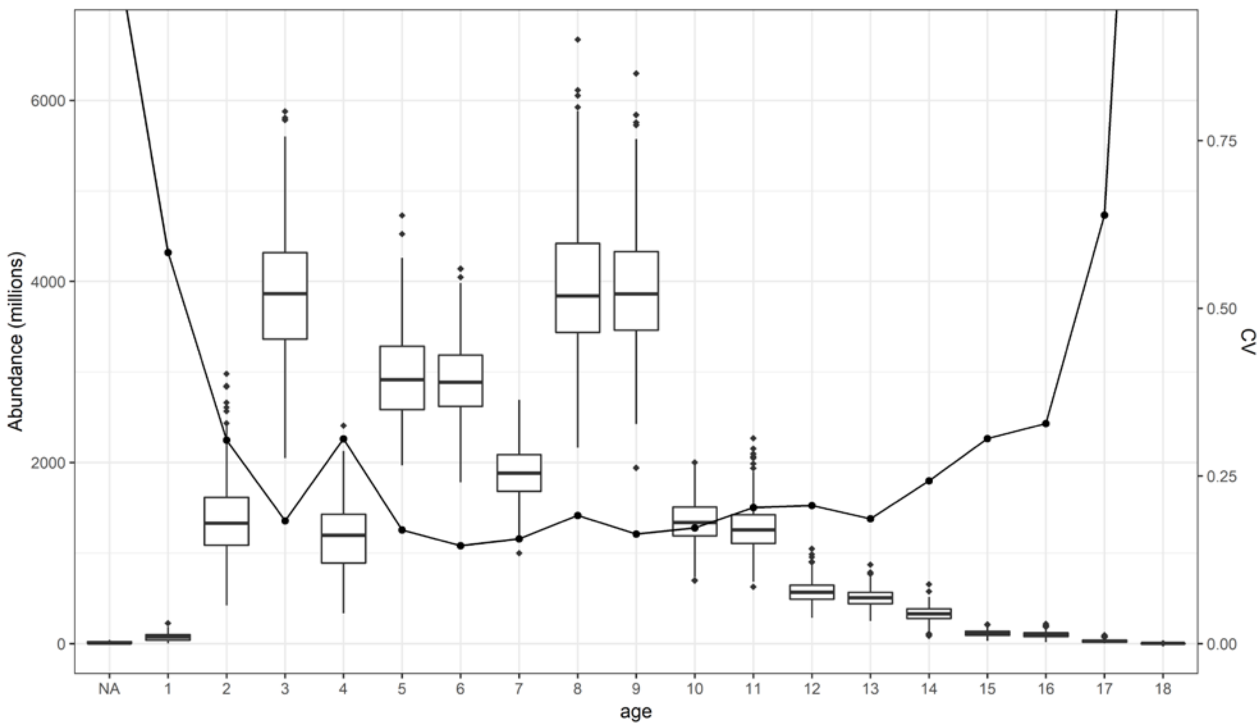


Figure 17. Number by age for mackerel. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 500 replicates using the StoX software.

Table 7. a-c) Time series of the IESSNS showing (a) age-disaggregated abundance indices of mackerel (billions), (b) mean weight (g) per age and (c) estimated biomass at age (million tonnes) from 2007 to 2019. d) Output from StoX

a)

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)	Tot N
2007	1.33	1.86	0.90	0.24	1.00	0.16	0.06	0.04	0.03	0.01	0.01	0.00	0.01	0.00	5.65
2010	0.03	2.80	1.52	4.02	3.06	1.35	0.53	0.39	0.20	0.05	0.03	0.02	0.01	0.01	13.99
2011	0.21	0.26	0.87	1.11	1.64	1.22	0.57	0.28	0.12	0.07	0.06	0.02	0.01	0.00	6.42
2012	0.50	4.99	1.22	2.11	1.82	2.42	1.64	0.65	0.34	0.12	0.07	0.02	0.01	0.01	15.91
2013	0.06	7.78	8.99	2.14	2.91	2.87	2.68	1.27	0.45	0.19	0.16	0.04	0.01	0.02	29.57
2014	0.01	0.58	7.80	5.14	2.61	2.62	2.67	1.69	0.74	0.36	0.09	0.05	0.02	0.00	24.37
2015	1.20	0.83	2.41	5.77	4.56	1.94	1.83	1.04	0.62	0.32	0.08	0.07	0.04	0.02	20.72
2016	<0.01	4.98	1.37	2.64	5.24	4.37	1.89	1.66	1.11	0.75	0.45	0.20	0.07	0.07	24.81
2017	0.86	0.12	3.56	1.95	3.32	4.68	4.65	1.75	1.94	0.63	0.51	0.12	0.08	0.04	24.22
2018	2.18	2.50	0.50	2.38	1.20	1.41	2.33	1.79	1.05	0.50	0.56	0.29	0.14	0.09	16.92
2019	0.08	1.35	3.81	1.21	2.92	2.86	1.95	3.91	3.82	1.50	1.25	0.58	0.59	0.57	26.4

b)

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)
2007	133	233	323	390	472	532	536	585	591	640	727	656	685	671
2010	133	212	290	353	388	438	512	527	548	580	645	683	665	596
2011	133	278	318	371	412	440	502	537	564	541	570	632	622	612
2012	112	188	286	347	397	414	437	458	488	523	514	615	509	677
2013	96	184	259	326	374	399	428	445	486	523	499	547	677	607
2014	228	275	288	335	402	433	459	477	488	533	603	544	537	569
2015	128	290	333	342	386	449	463	479	488	505	559	568	583	466
2016	95	231	324	360	371	394	440	458	479	488	494	523	511	664
2017	86	292	330	373	431	437	462	487	536	534	542	574	589	626
2018	67	229	330	390	420	449	458	477	486	515	534	543	575	643
2019	153	212	325	352	428	440	472	477	490	511	524	564	545	579

c)

Year\Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14(+)	Tot B
2007	0.18	0.43	0.29	0.09	0.47	0.09	0.03	0.02	0.02	0.01	0.01	0.00	0.01	0.00	1.64
2010	0.00	0.59	0.44	1.42	1.19	0.59	0.27	0.20	0.11	0.03	0.02	0.01	0.01	0.00	4.89
2011	0.03	0.07	0.28	0.41	0.67	0.54	0.29	0.15	0.07	0.04	0.03	0.01	0.01	0.00	2.69
2012	0.06	0.94	0.35	0.73	0.72	1.00	0.72	0.30	0.17	0.06	0.03	0.01	0.00	0.00	5.09
2013	0.01	1.43	2.32	0.70	1.09	1.15	1.15	0.56	0.22	0.10	0.08	0.02	0.01	0.01	8.85
2014	0.00	0.16	2.24	1.72	1.05	1.14	1.23	0.80	0.36	0.19	0.05	0.03	0.01	0.00	8.98
2015	0.15	0.24	0.80	1.97	1.76	0.87	0.85	0.50	0.30	0.16	0.04	0.04	0.02	0.01	7.72
2016	<0.01	1.15	0.45	0.95	1.95	1.72	0.83	0.76	0.53	0.37	0.22	0.10	0.04	0.04	9.11
2017	0.07	0.03	1.18	0.73	1.43	2.04	2.15	0.86	1.04	0.33	0.28	0.07	0.05	0.03	10.29
2018	0.15	0.57	0.16	0.93	0.50	0.63	1.07	0.85	0.51	0.26	0.30	0.16	0.08	0.05	6.22
2019	0.01	0.29	1.24	0.43	1.25	1.26	0.92	1.86	1.87	0.77	0.65	0.33	0.32	0.32	11.52

Table 7d) Estimates of abundance, mean weight and mean length of mackerel based on calculation in StoX for IESSNS 2019.

LenGrp (age)	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)
18-19	45.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1335	60.6	45.42
19-20	55.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2296	126.9	55.27
20-21	60.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3428	206.7	60.31
21-22	-	69.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	575	39.9	69.27
22-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	91.0	74	6.8	91.00
23-24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.6	555	55.9	100.58
24-25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	114.9	1142	131.2	114.88
25-26	145.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22012	3208.5	145.76
26-27	156.9	161.6	155.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65967	10477.9	158.84
27-28	159.0	175.1	189.7	175.1	165.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	290352	50983.2	175.59
28-29	201.5	194.7	195.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	374768	73101.1	195.06
29-30	-	217.2	214.2	226.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	393319	85397.0	217.12
30-31	-	241.4	247.9	249.7	251.3	266.0	-	-	255.9	-	-	-	-	-	-	-	-	-	-	609333	149809.7	245.86
31-32	-	266.6	274.8	291.6	292.5	-	-	285.3	278.6	-	-	-	-	-	-	-	-	-	-	967693	269885.1	278.90
32-33	-	313.0	306.2	325.5	290.7	290.4	314.5	-	-	-	-	-	-	-	-	-	-	-	-	1237341	382196.0	308.89
33-34	-	312.3	339.2	338.0	327.4	327.7	-	-	-	-	-	-	-	-	-	-	-	-	-	1066369	359974.7	337.57
34-35	-	320.0	375.4	379.4	366.9	359.1	-	424.3	390.9	-	-	-	-	-	-	-	-	-	-	1291109	483425.5	374.43
35-36	-	412.0	418.3	411.0	409.7	406.6	400.6	423.9	423.5	387.3	359.7	-	379.6	-	-	-	-	-	-	2777412	1143483.2	411.71
36-37	-	-	362.2	443.3	444.7	437.7	443.2	445.5	452.2	455.2	456.9	429.4	428.0	-	-	-	-	-	-	4638338	2061271.9	444.40
37-38	-	-	487.1	475.7	474.0	480.4	468.7	477.2	475.9	474.9	480.0	468.6	455.4	460.0	492.1	442.5	-	-	-	5599575	2664028.8	475.76
38-39	-	-	508.8	504.0	516.9	506.6	520.3	499.1	512.1	516.5	509.4	528.2	511.3	527.3	494.4	487.8	-	-	-	3751183	1915605.3	510.67
39-40	-	-	528.0	588.5	551.4	589.5	547.5	545.4	554.4	543.9	534.8	552.5	520.8	540.0	561.8	535.5	546.0	-	-	2050873	1115916.2	544.12
40-41	-	-	-	584.0	533.7	641.9	567.3	607.9	576.9	576.4	586.5	599.8	554.4	586.3	579.3	572.7	591.7	-	-	847185	490784.8	579.31
41-42	-	-	650.0	-	-	745.9	686.6	542.0	605.4	630.8	619.6	612.1	639.3	625.1	604.9	682.9	-	-	-	335134	209209.4	624.26
42-43	-	-	-	-	756.1	-	655.1	-	659.7	665.2	697.5	710.4	657.9	699.5	685.8	663.3	-	-	-	67784	45665.2	673.69
43-44	-	-	-	-	-	802.0	772.0	-	-	-	725.6	663.1	699.5	713.3	708.0	-	-	606.4	-	6667	4717.5	707.59
44-45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	707.7	471	333.4	707.66
45-46	-	-	-	-	-	-	-	-	-	-	-	-	688.0	-	833.3	-	-	-	-	860	648.1	753.97
TSN(1000)	77213	1350193	3814661	1211770	2920591	2856932	1948653	3906891	3824410	1499778	1248160	584066	586585	344601	90489	104106	31589	219	2243	26403151	-	-
TSB(1000 kg)	11778.9	286752.2	1239274.6	426846.0	1249678.7	1257274.0	920393.4	1862667.6	1872447.6	767051.0	654542.4	329619.0	319405.9	192633.1	52432.8	58693.2	18600.1	132.9	527.3	-	11520750.7	-
Mean length (cm)	25.83	28.89	32.69	33.35	35.76	36.17	37.02	37.18	37.45	38.11	38.56	39.34	39.43	39.31	40.06	39.66	39.94	43.08	28.22	-	-	-
Mean weight (g)	152.55	212.38	324.87	352.25	427.89	440.08	472.32	476.76	489.60	511.44	524.41	564.35	544.52	559.00	579.44	563.79	588.81	606.42	235.06	-	-	436.34

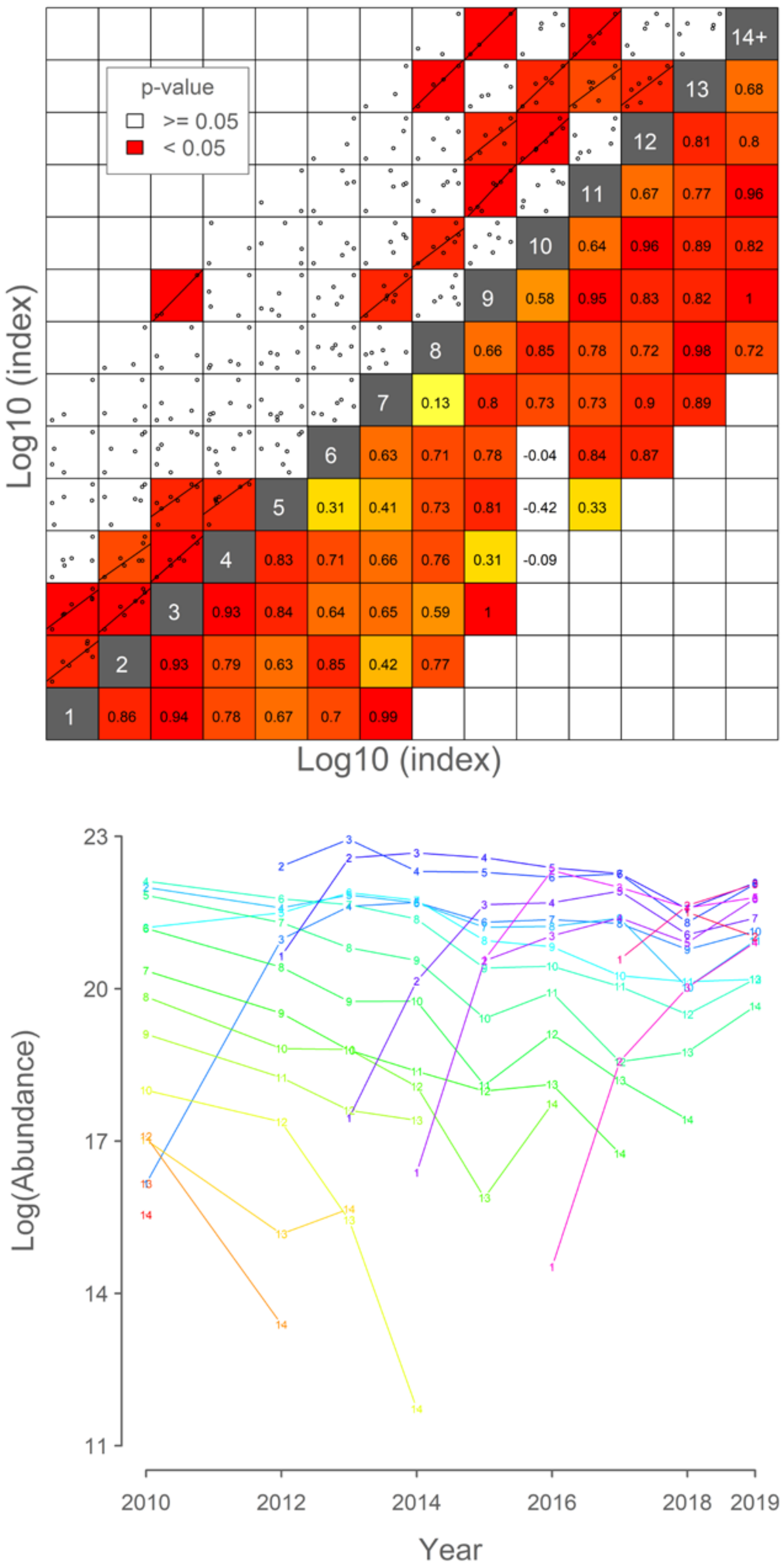


Figure 18. Diagnostics of the of mackerel density index from 2012 to 2019. Internal consistency (top), Ages indicated by white numbers in grey diagonal cells. Statistically significant positive correlations (*p<0.05*) are indicated by regression lines and red cells in upper left half. Correlation coefficients (r) are given in the lower right half. Catch curves (bottom). Each cohort is marked by a uniquely coloured line that connects the estimates indicated by the respective ages.

Distribution zero boundaries were found in majority of survey area with a notable exception of high mackerel abundance at the survey boundary south-west of Faroe Island. Low densities were found in a single location at the north-western boundary west of Jan-Mayen, and high densities towards the Fram Strait west of Svalbard.

The mackerel appeared more patchily distributed within the survey area and more northerly and north-westerly distributed in 2019 compared to in 2017 and 2018. This difference in distribution primarily consists of a marked biomass decline in the west and a marked increase in the north and northwest. Furthermore, there was also a westward shift in distribution within the Norwegian Sea.

The marked decrease in the western areas since 2017 may have several causes, importantly; it reflects that the 2017 estimate was driven by few exceptionally large catches. Statistical methods that account for trawl catch distributions with over-dispersion has successfully been applied to mackerel trawl data before (Jansen et al. 2015; Nikolioudakis et al. 2019). In 2019 there were practically no mackerel in Greenland waters during the survey. The marked increase of mackerel in the Norwegian Sea, could partly be explained by improved feeding conditions from average estimates in the Norwegian Sea in 2019 compared to previous years and more mackerel migrating into the surveyed area compared to in 2018. Furthermore, there are indications that there has been strong recruitment during the last two years from 2016-2017, based on results from the mackerel recruitment index used in the assessment. Both vertical and horizontal distribution and patchiness and avoidance behaviour of mackerel may have affected the catch rates and catchability from the swept area trawling in surface waters differently in 2018 compared to 2019 and 2017. There are indications from results at Rockall bank and other areas at the IBTS surveys, that a larger fraction of the mackerel stock may have been distributed south of our survey coverage at 60°N in July-August 2018 compared to in July-August 2019. This also indicate that it would be beneficial to have an additional future survey participation by other countries covering the southwestern waters south of 60°N. We see a strong year effect for all age groups in the results from 2019 compared to 2018. However, the biomass and abundance indices of mackerel in 2019 were much more in line with the results from 2017.

As in previous years, the spatio-temporal overlap between mackerel and NSSH was highest in the southern and south-western parts of the Norwegian Sea. There was practically no overlap between NEA mackerel and NSSH in the central part of the Norwegian Sea, whereas we had some overlap between mackerel and herring in the northern part of the Norwegian Sea. Herring distribution was mostly limited to the area east and north of Iceland and the southern Norwegian Sea. However, NSSH was also found in the central northern part for the first time in many years, dominated by the 2013- and 2016- year classes.

The swept-area estimate was, as in previous years, based on the standard swept area method using the average horizontal trawl opening by each participating vessel (ranging 58.5-67.4m; Table 5), assuming that a constant fraction of the mackerel inside the horizontal trawl opening are caught. Further, that if mackerel is distributed below the depth of the trawl (footrope), this fraction is assumed constant from year to year.

Results from the survey expansion southward into the North Sea is analysed separately from the traditional survey grounds north of latitude 60°N as per stipulations from the 2017 mackerel benchmark meeting (ICES 2017). We have now available IESSNS survey data from 2018 and 2019 for the North Sea.

This year's survey was well synchronized in time and was conducted over a relatively short period (5 weeks) given the large spatial coverage of around 3 million km^2 (Figure 1). This was in line with recommendations put forward in 2016 that the survey period should be around four weeks with mid-point around 20. July. The main argument for this time period, was 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.

4.4 Norwegian spring-spawning herring

Norwegian spring-spawning herring (NSSH) was recorded in the southern (north of the Faroes and east and north of Iceland) and north-eastern part of the Norwegian Sea basin (Figure 19). The fish in the northeast consisted of young adults (mainly 3- and 6- year olds) while the fish further southwest are a range of age groups, mainly from 6 to 14 years old. Herring registrations south of 62°N in the eastern part were allocated to a different stock, North Sea herring while the herring closer to the Faroes south of 62°N were Faroese autumn spawners. Also, herring to the west in Icelandic waters (west of 14°W south of Iceland and west of 24°W north of Iceland, not shown on the map) were allocated to a different stock, Icelandic summer-spawners. The abundance of NSSH in the eastern and north-eastern part of the area surveyed were lower and consisted mainly of younger and smaller fish than in the western part. The 0-boundary of the distribution of the adult part of NSSH was considered to be reached in all directions. However, the second most abundant year class in the survey estimate, the 2016- year class (3- year olds) are not fully covered in this survey. Most of this young year class is still located in the Barents Sea based on results from the ecosystem surveys in the Barents Sea.

The NSSH stock is dominated by 6-year old herring (year class 2013) in terms of numbers and biomass (Table 8). This year class is now distributed in all areas with herring in the survey compared to last year when it was mainly found in the north-eastern part. It contributes 23% and 22% to the total biomass and total abundance, respectively. The total number of herring recorded in the Norwegian Sea was 15.2 billion and the total biomass index was 4.78 million tonnes in 2019, in comparison to 13.6 billion and a total biomass index of 4.46 million tonnes in 2018. This means that the biomass index was slightly higher in 2019 than in 2018. Number by age, with uncertainty estimates, for NSSH is shown in Figure 20. The group considered the acoustic biomass estimate of herring to be of good quality in the 2019 IESSNS as in the previous survey years.

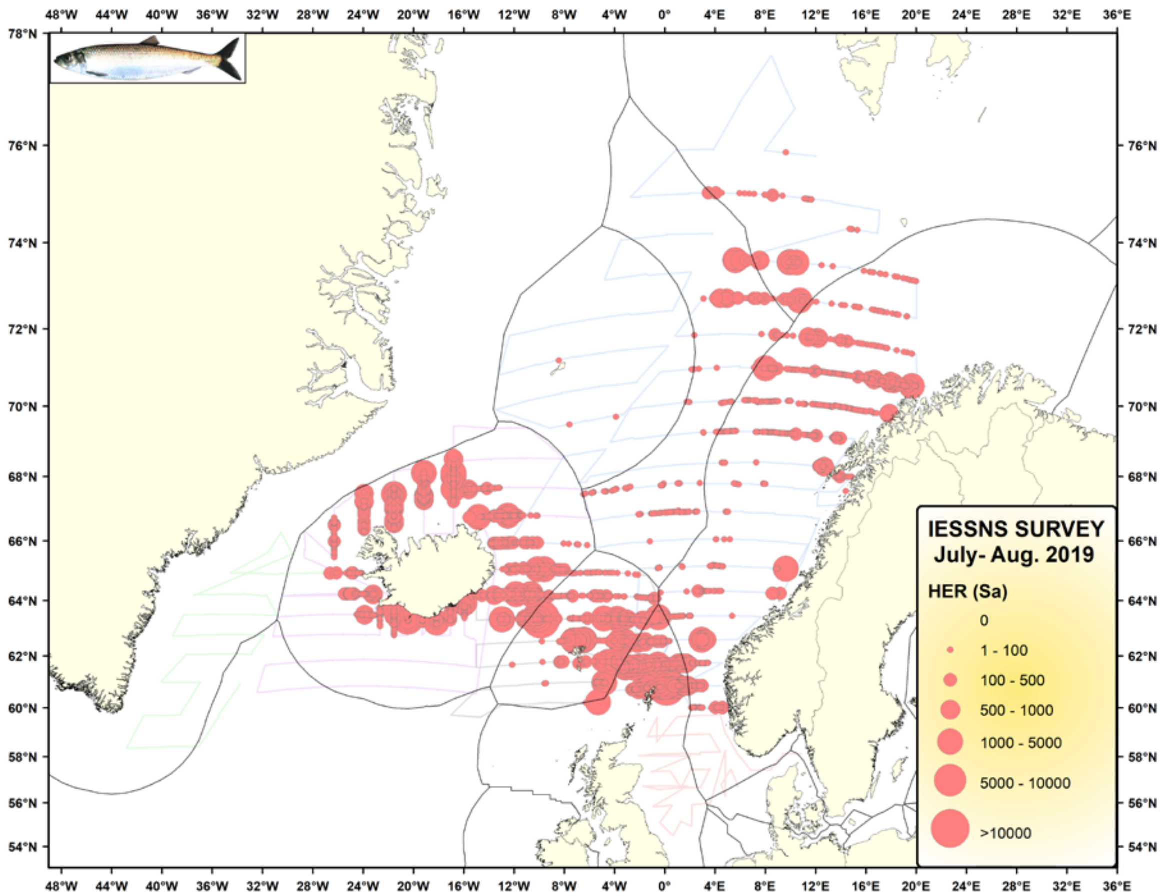


Figure 19. The sA/Nautical Area Scattering Coefficient (NASC) values of herring along the cruise tracks in 2019. Values north of 62ºN, and east of 14ºW, are considered to be Norwegian spring-spawning herring. South and west of this area the herring observed are other stocks, *i.e.* Faroese autumn spawners, North Sea herring and Icelandic summer spawning herring.

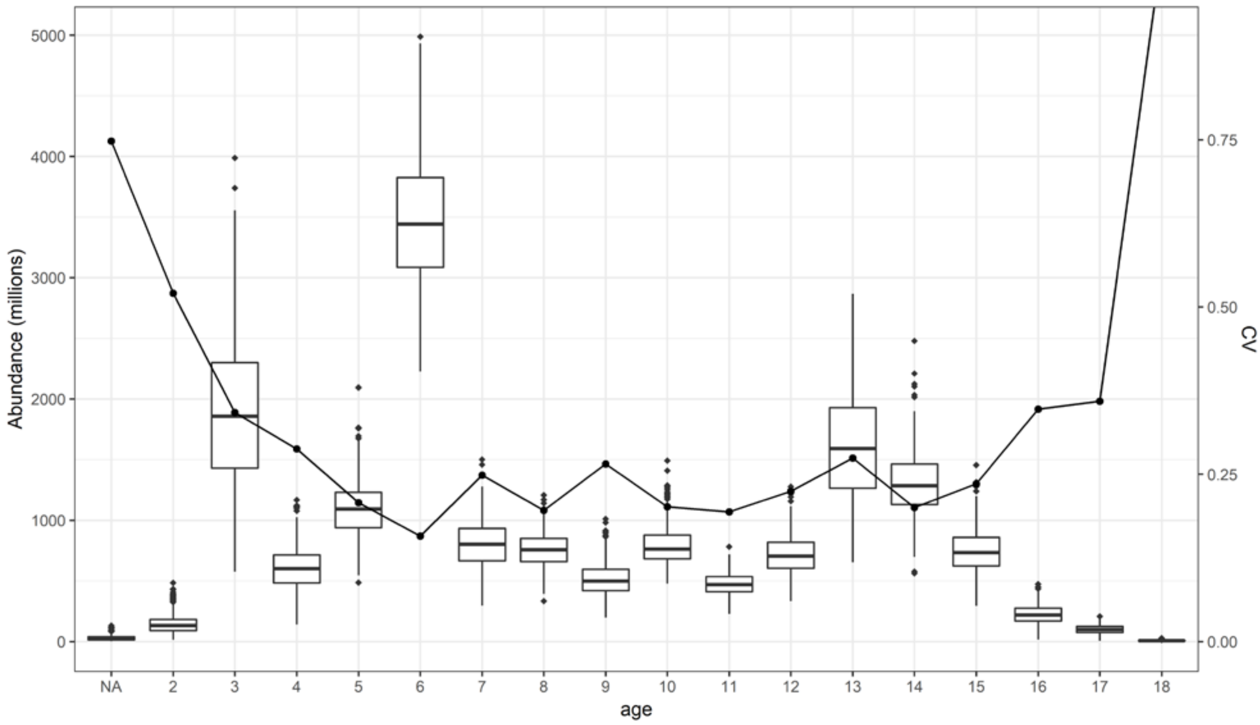


Figure 20. Number by age for Norwegian spring-spawning herring during IESSNS 2019. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 500 replicates using the StoX software.

Table 8. Estimates of abundance, mean weight and mean length of Norwegian spring-spawning herring based on calculation in StoX for IESSNS 2019.

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)
14-15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1893	1893	45.4	24.00
15-16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16-17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17-18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1893	1893	68.1	36.00
18-19	11828	15977	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27805	1119.9	40.28
19-20	6860	6860	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13721	699.8	51.00
20-21	20818	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20818	1311.5	63.00
21-22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19762	19762	1665.9	84.30
22-23	44947	4731	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	49678	4951.3	99.67
23-24	23089	-	5772	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28861	2978.4	103.20
24-25	20818	26495	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47313	5859.2	123.84
25-26	24221	206376	9634	-	8808	-	-	-	-	-	-	-	-	-	-	-	-	-	249040	36659.0	147.20
26-27	-	420933	49037	21019	6433	-	-	-	-	-	-	-	-	-	-	-	-	-	497422	81005.6	162.85
27-28	-	518195	87141	13858	41574	3465	11319	-	-	-	-	-	-	-	-	-	-	-	675552	121158.7	179.35
28-29	-	376825	54678	59549	76814	11652	11652	2913	-	-	-	-	-	-	-	-	-	-	594082	120467.3	202.78
29-30	-	119725	71307	52850	125882	51911	-	78021	10263	16420	11146	-	-	-	-	-	-	-	537525	125525.3	233.52
30-31	-	91309	116543	254855	74004	38696	54681	12879	25538	11039	-	5520	21283	-	-	-	-	-	706348	179615.4	254.29
31-32	-	44136	131284	356156	427881	12239	10158	20316	20877	25676	49793	201390	-	10158	-	-	-	-	1310064	366915.2	280.07
32-33	-	25564	25442	229417	1297150	56852	62946	37773	62953	-	-	104911	-	-	-	-	-	-	1903010	571454.1	300.29
33-34	-	12427	33420	50212	1035752	215875	72592	30266	14503	17788	-	17788	-	-	-	-	-	-	1500623	477060.2	317.91
34-35	-	-	6145	24940	337328	352310	138168	36308	18744	-	20285	30240	-	-	-	-	-	-	964468	324725.7	336.69
35-36	-	-	-	4326	43394	74490	210462	180324	236500	66665	253222	148104	140479	48253	-	12978	-	-	1419196	511294.8	360.27
36-37	-	-	-	-	-	41430	111055	76055	119294	102076	229777	670420	348972	145974	86442	6950	-	-	1938443	729270.4	376.21
37-38	-	-	-	-	-	-	19015	40381	107311	179345	169450	419279	397974	303175	73501	52682	-	-	1762115	701554.4	398.13
38-39	-	-	-	-	-	-	-	3488	84472	43980	16075	122152	240545	233647	37842	8647	6976	-	797825	338056.4	423.72
39-40	-	-	-	-	-	-	-	1598	-	-	-	4869	83485	16253	15179	18974	-	-	140358	64743.4	461.28
40-41	-	-	-	-	-	-	-	-	-	-	-	-	-	11446	11446	-	-	-	22891	11647.0	508.80
TSN(1000)	152581	1869554	590404	1067181	3475021	858919	702048	520323	700455	462990	749748	1724672	1232738	768907	224410	100231	6976	23547	15230704	-	-
TSB(1000 kg)	15035.9	344119.4	136410.1	289293.0	1039849.0	275970.4	233783.4	173825.2	254428.6	168740.1	276301.0	635219.1	485525.1	312828.8	93800.0	39752.0	3192.1	1779.4	-	4779852.4	-
Mean length (cm)	22.42	27.33	29.53	31.00	32.30	33.40	34.03	33.86	35.28	35.75	35.59	35.55	36.77	37.05	37.14	37.20	38.00	20.20	-	-	-
Mean weight (g)	98.54	184.06	231.05	271.08	299.24	321.30	333.00	334.07	363.23	364.46	368.53	368.31	393.86	406.85	417.99	396.61	457.55	75.57	-	-	313.83

4.5 Blue whiting

Blue whiting was distributed throughout the entire survey area with exception of the area north of Iceland influenced by the cold East Icelandic Current and in the East Greenland area. The highest sA-values were observed in the eastern and southern part of the Norwegian Sea, along the Norwegian continental slope, around the Faroe Islands as well as south of Iceland and the distribution in 2019 is similar to the 2018 distribution. The main concentrations of older fish were observed in connection with the continental slopes, both in the eastern and the southern part of the Norwegian Sea (Figure 21). The largest fish were found in the central and northern part of the survey area.

The total biomass of blue whiting registered during IESSNS 2019 was 2.0 million tons (Table 9), which is the same compared to 2018. The stock estimate in number for 2019 is 16.2 billion compared to 16.3 billion of age groups 1+ in 2018. The age group five is dominating the estimate (36% and 30% of the biomass and by numbers, respectively). A good sign of recruiting year class (0-group) was also seen in the survey this year.

Number by age, with uncertainty estimates, for blue whiting during IESSNS 2019 is shown in Figure 22.

The group considered the acoustic biomass estimate of blue whiting to be of good quality in the 2019 IESSNS as in the previous survey years.

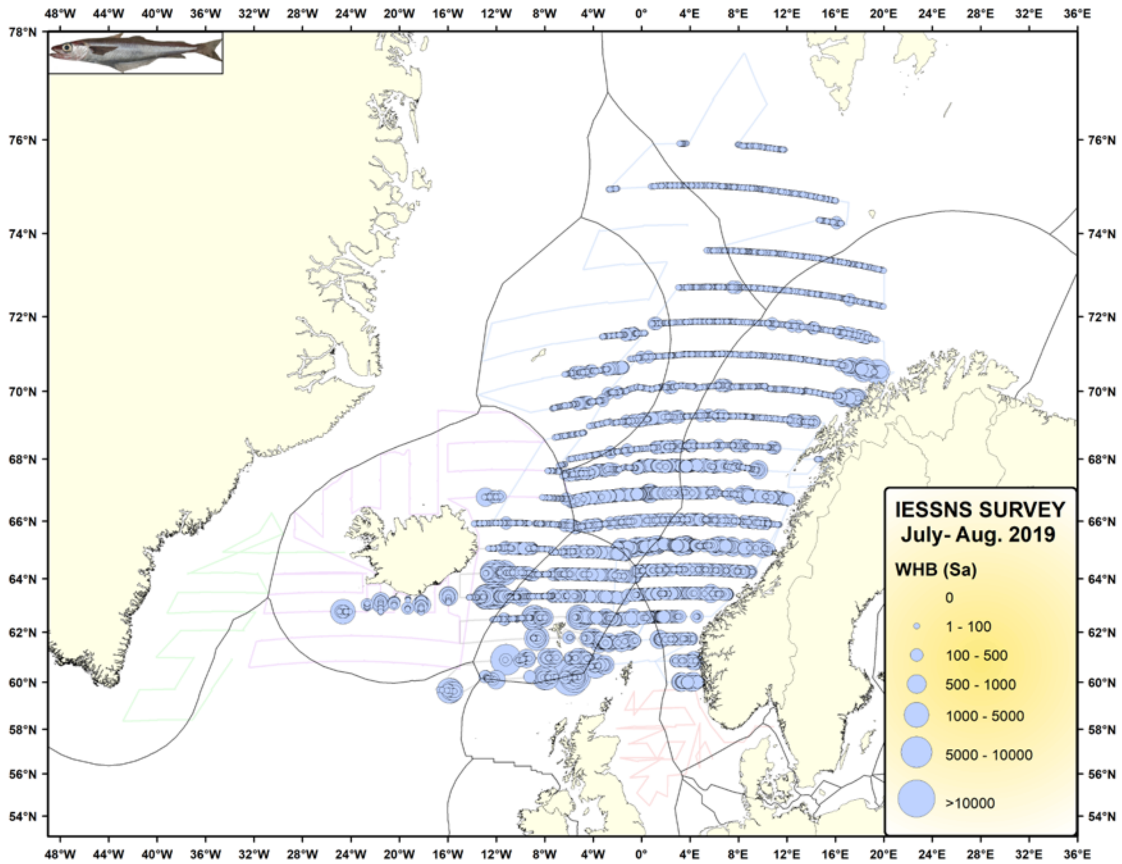


Figure 21. The sA/Nautical Area Scattering Coefficient (NASC) values of blue whiting along the cruise tracks in IESSNS 2019.

Table 9. Estimates of abundance, mean weight and mean length of blue whiting based on calculation in StoX for IESSNS 2019.

LenGrp	age 0	1	2	3	4	5	6	7	8	9	10	Unknown	Number (1E3)	Biomass (1E3kg)	Mean W (g)
9-10	-	-	-	-	-	-	-	-	-	-	-	41290	41290	-	-
10-11	179782	-	-	-	-	-	-	-	-	-	-	-	179782	1078.7	6.00
11-12	245276	-	-	-	-	-	-	-	-	-	-	-	245276	2136.9	8.71
12-13	742161	-	-	-	-	-	-	-	-	-	-	-	742161	7639.2	10.29
13-14	419538	-	-	-	-	-	-	-	-	-	-	-	419538	6041.0	14.40
14-15	431653	-	-	-	-	-	-	-	-	-	-	-	431653	7593.6	17.59
15-16	122387	-	-	-	-	-	-	-	-	-	-	-	122387	2697.5	22.04
16-17	12091	-	-	-	-	-	-	-	-	-	-	-	12091	290.2	24.00
17-18	-	-	-	-	-	-	-	-	-	-	-	3807	3807	83.8	22.00
18-19	-	13326	-	-	-	-	-	-	-	-	-	-	13326	342.7	25.71
19-20	-	58448	-	-	-	-	-	-	-	-	-	-	58448	2069.4	35.41
20-21	-	45689	81842	-	-	-	-	-	-	-	-	-	127531	6116.0	47.96
21-22	-	96286	249072	-	-	-	-	-	-	-	-	-	345358	20098.2	58.20
22-23	-	183118	363974	-	-	-	-	-	-	-	-	-	547092	36303.9	66.36
23-24	-	161561	443693	6176	-	-	-	-	-	-	-	-	611431	45728.6	74.79
24-25	-	63431	220678	-	19330	38660	-	-	-	-	-	-	342098	29877.7	87.34
25-26	-	315	238986	201293	197353	135844	6442	-	-	-	-	-	780234	77108.6	98.83
26-27	-	17527	73113	660792	687115	534868	81213	-	79485	-	-	-	2134114	231058.0	108.27
27-28	-	-	180484	567017	1286928	1341078	150141	37237	72998	-	-	-	3635883	428875.5	117.96
28-29	-	-	50015	461404	976222	1272180	305664	55484	31523	-	-	-	3152492	415762.7	131.88
29-30	-	-	22264	230403	667792	1007146	259856	33174	-	2160	-	-	2222795	324328.9	145.91
30-31	-	-	8736	49959	407292	670400	138264	9181	3768	654	-	-	1288253	211455.6	164.14
31-32	-	-	-	2295	81907	304294	92257	22691	21262	-	-	-	524705	94821.9	180.71
32-33	-	-	-	-	16676	80874	55580	8605	10445	-	6453	-	178633	35779.9	200.30
33-34	-	-	-	-	5926	47431	11451	36124	-	-	-	-	100932	21537.6	213.39
34-35	-	-	-	-	1261	1261	38534	6271	-	-	-	-	47327	10867.8	229.63
35-36	-	-	-	-	-	315	5611	-	6012	2004	2004	-	15945	4219.0	264.59
36-37	-	-	-	-	-	-	5510	-	-	-	-	-	5510	1816.8	329.71
37-38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38-39	-	-	-	-	-	-	-	-	-	-	-	1904	1904	552.1	290.00
39-40	-	-	-	-	-	-	-	-	3607	-	-	-	3607	1222.7	339.00
TSN(1000)	2152887	639702	1932857	2179339	4347802	5434350	1150524	208766	229101	4817	8457	47001	18335603	-	-
TSB(1000 kg)	27477.1	41410.4	160751.9	263617.9	563266.3	734895.2	172044.0	32177.7	28457.9	938.6	1831.4	635.8	-	2027504.3	-
Mean length (cm)	12.79	22.16	23.76	27.23	27.90	28.38	29.12	29.79	28.13	31.63	32.96	11.17	-	-	-
Mean weight (g)	12.76	64.73	83.17	120.96	129.55	135.23	149.54	154.13	124.22	194.83	216.54	111.33	-	-	110.83

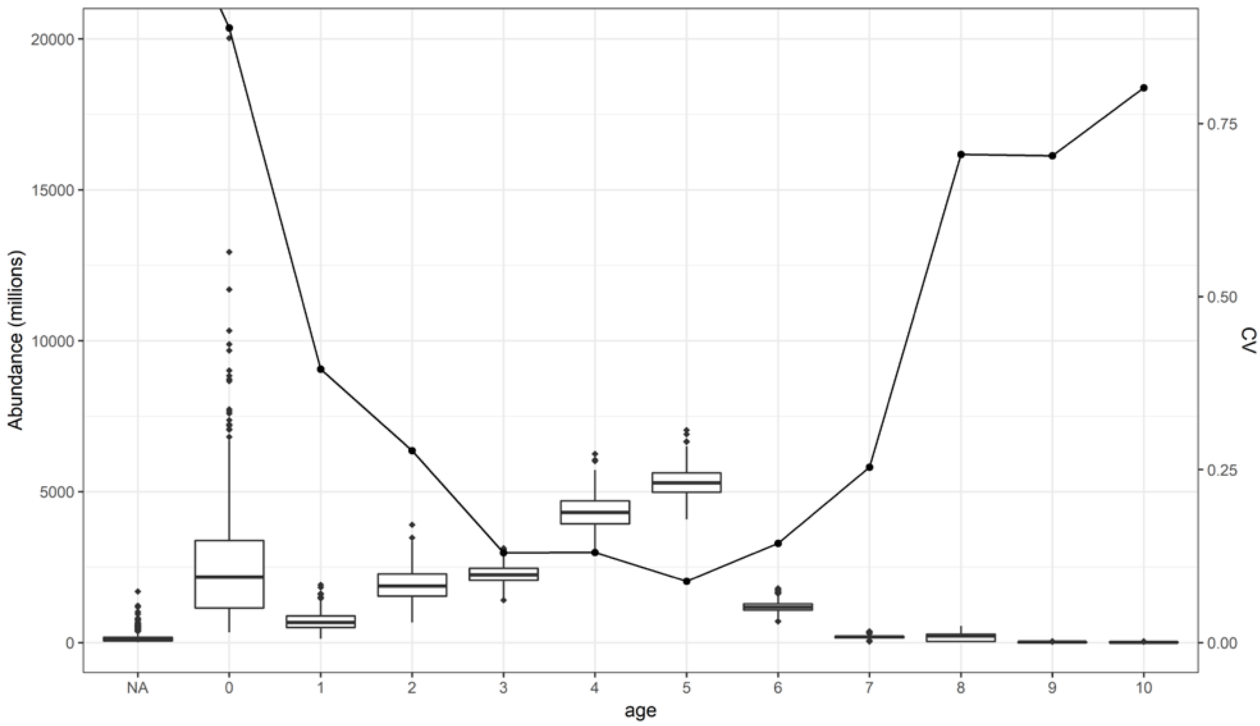


Figure 22. Number by age with uncertainty for blue whiting during IESSNS 2019. Boxplot of abundance and relative standard error (CV) obtained by bootstrapping with 500 replicates using the StoX software.

4.6 Other species

Lumpfish (*Cyclopterus lumpus*)

Lumpfish was caught in approximately 73% of trawl stations across the six vessels (Figure 23) and where lumpfish was caught, 98% of the catches were ≤10kg. Lumpfish was distributed across the entire survey area, from west of Cape Farwell in Greenland in the southwest to the central Barents Sea in the northeast part of the covered area. Of note, total trawl catch at each trawl station were processed on board R/V "Árni Friðriksson", M/V "Kings Bay", M/V "Vendla" and M/V "Eros", whereas a subsample of 50 kg to 200 kg was processed onboard M/V "Finnur Fríði" in Faroese waters. Therefore, small catches (<10 kg) of lumpfish might be missing from the survey track of M/V "Finnur Fríði" (black crosses in Figure 23). However, it is unlikely that larger catches of lumpfish would have gone unnoticed by crew during sub-sampling of catch.

Abundance was greatest north of 66°N, and lower south of 65°N south of Iceland, in Faroese waters and northern UK waters. The zero line was not hit to the north, northwest and southwest of the survey so it is likely that the distribution of lumpfish extends beyond the survey coverage. The length of lumpfish caught varied from 5 to 51 cm with a bimodal distribution with the left peak (5-20 cm) likely corresponding to 1-group lumpfish and the right peak consisting of a mixture of age groups (Figure 24). For fish ≥20 cm in which sex was determined, the males exhibited a unimodal distribution with a peak around 25-27 cm. The females also exhibited a unimodal distribution but with a peak around 27-30 cm which was positively skewed. Aboard the Norwegian vessels, the ratio of males to females was approximately 1:1. Generally, the mean length and mean weight of the lumpfish was highest in the coastal waters and along the shelf edges in southwest, west, and northwest, and lowest in the central Norwegian Sea.

A total of 472 fish (217 by R/V "Árni Friðriksson" and 255 by M/V "Eros") between 13 and 46 cm were tagged during the survey (Figure 25).

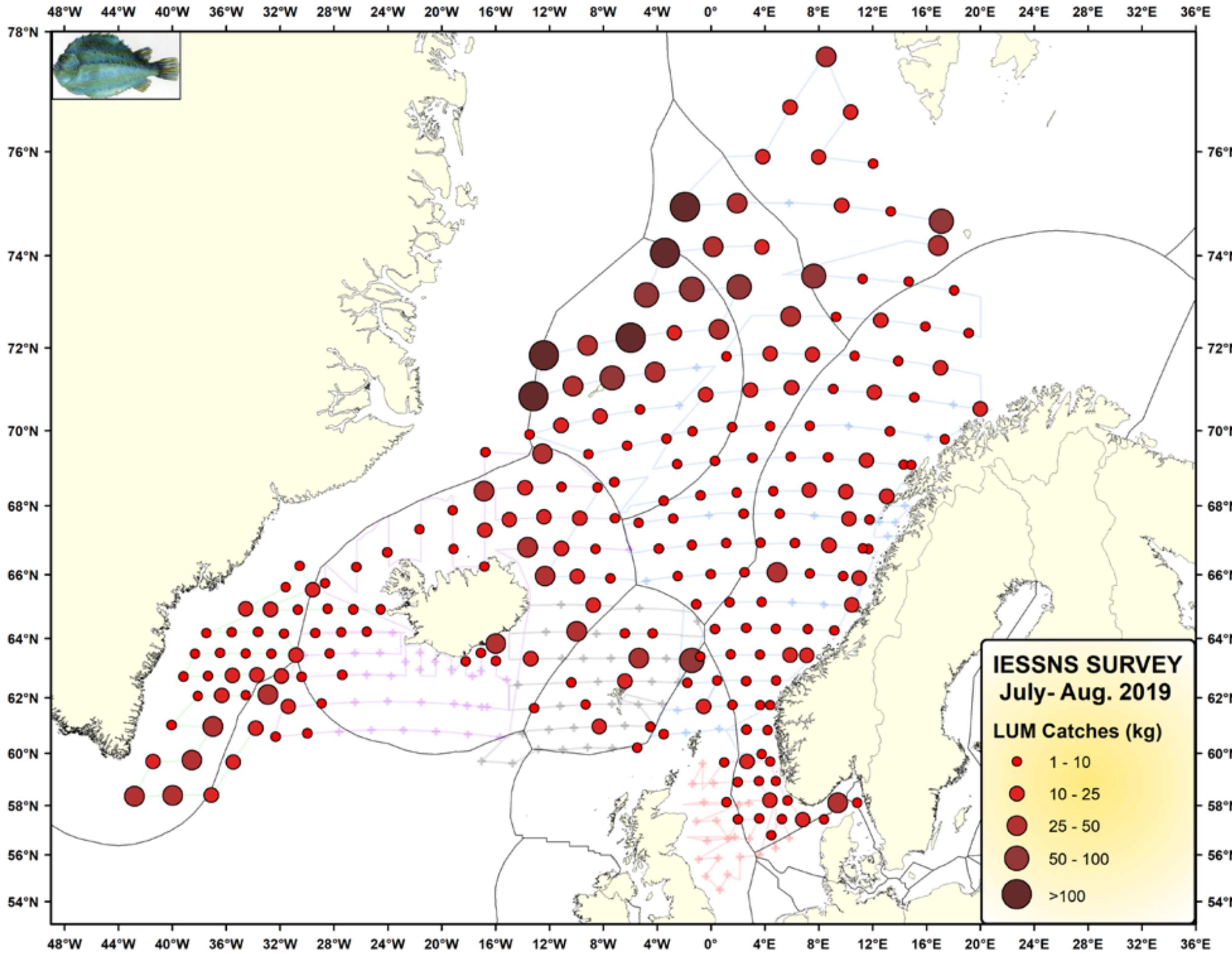


Figure 23. Lumpfish catches at surface trawl stations during IESSNS 2019.

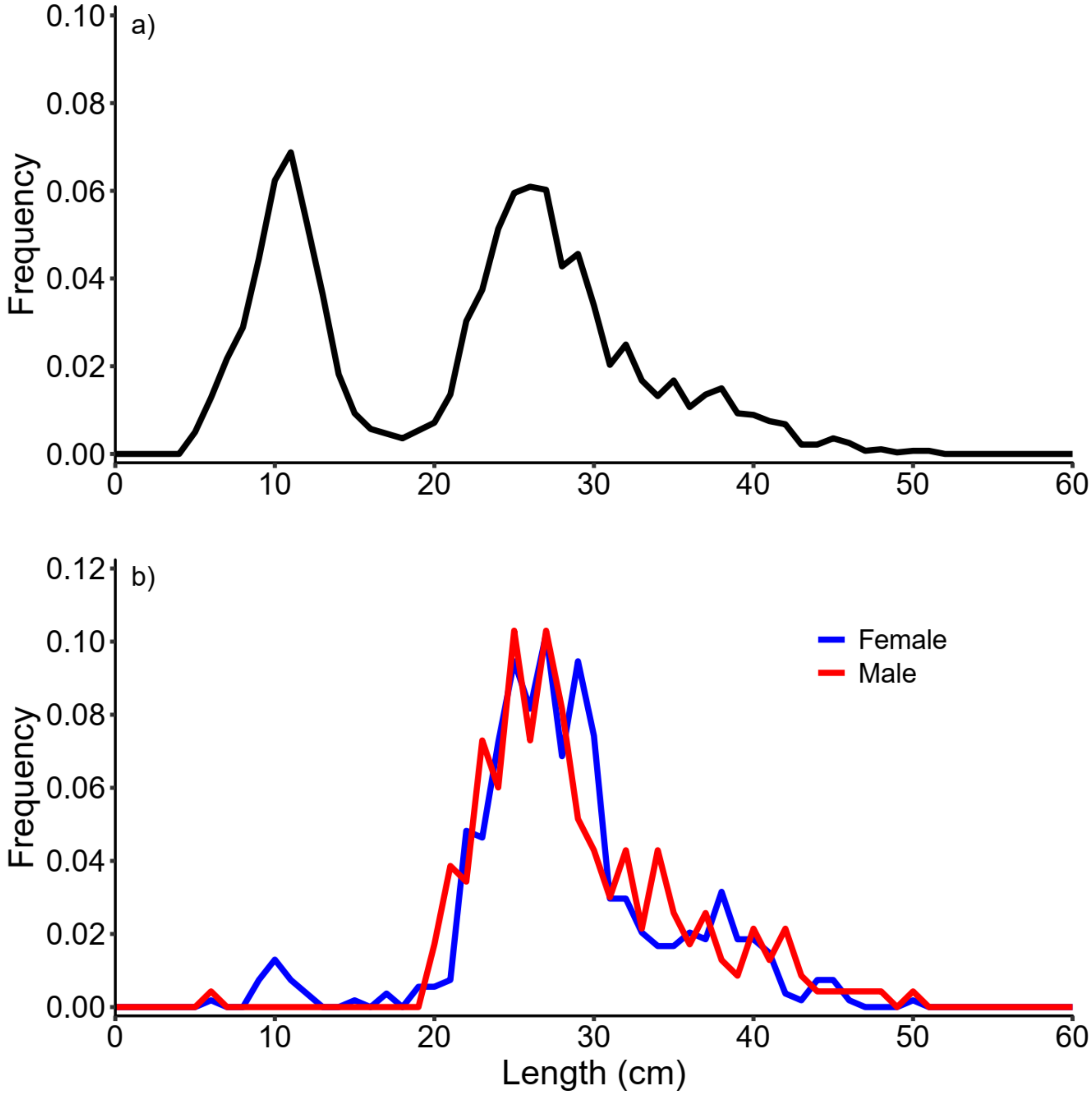


Figure 24. Length distribution of a) all lumpfish caught during the survey and b) length distribution of fish in which sex was determined.

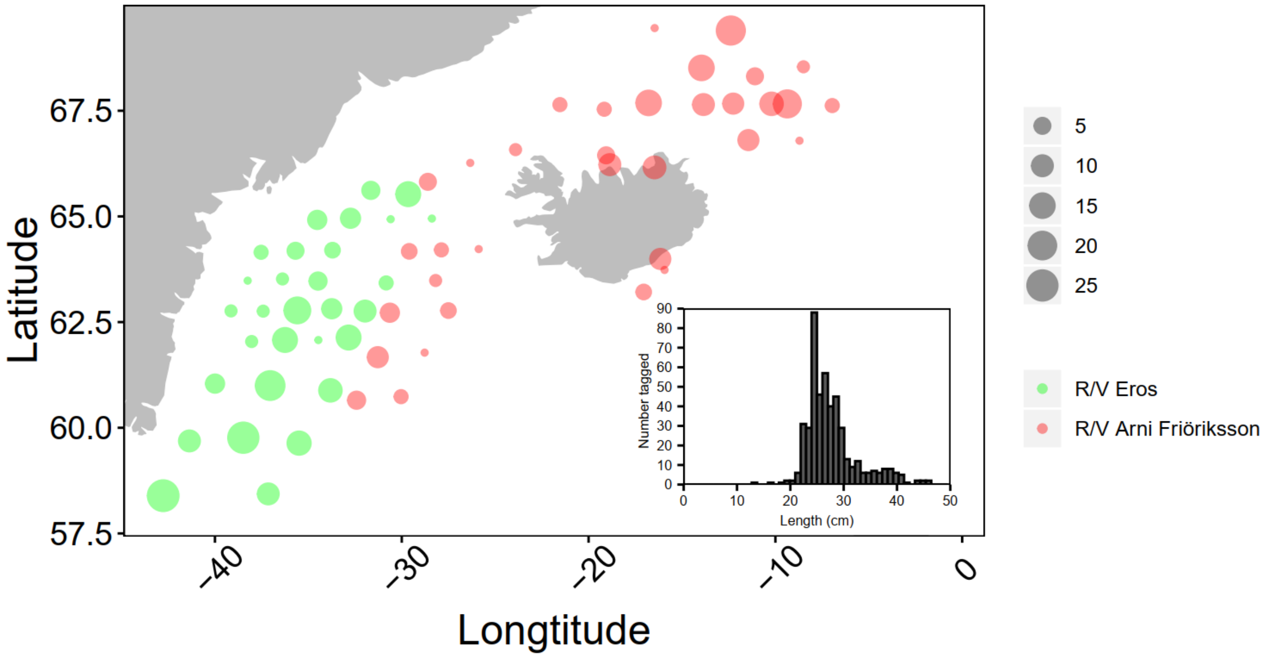


Figure 25. Number tagged, and release location, of lumpfish. Insert shows the length distribution of the tagged fish.

Salmon (*Salmo salar*)

A total of 58 North Atlantic salmon were caught in 37 stations both in coastal and offshore areas from 62°N to 74°N in the upper 30 m of the water column during IESSNS 2019 (Figure 24). The salmon ranged from 0.08 kg to 2.5 kg in weight, dominated by postsmolt weighing 80-200 grams. The length of the salmon ranged from 20 cm to 62 cm, with a large majority of the salmon <30 cm in length. The general impression was that postsmolt was distributed more westerly in 2019 compared to in 2017 and 2018.

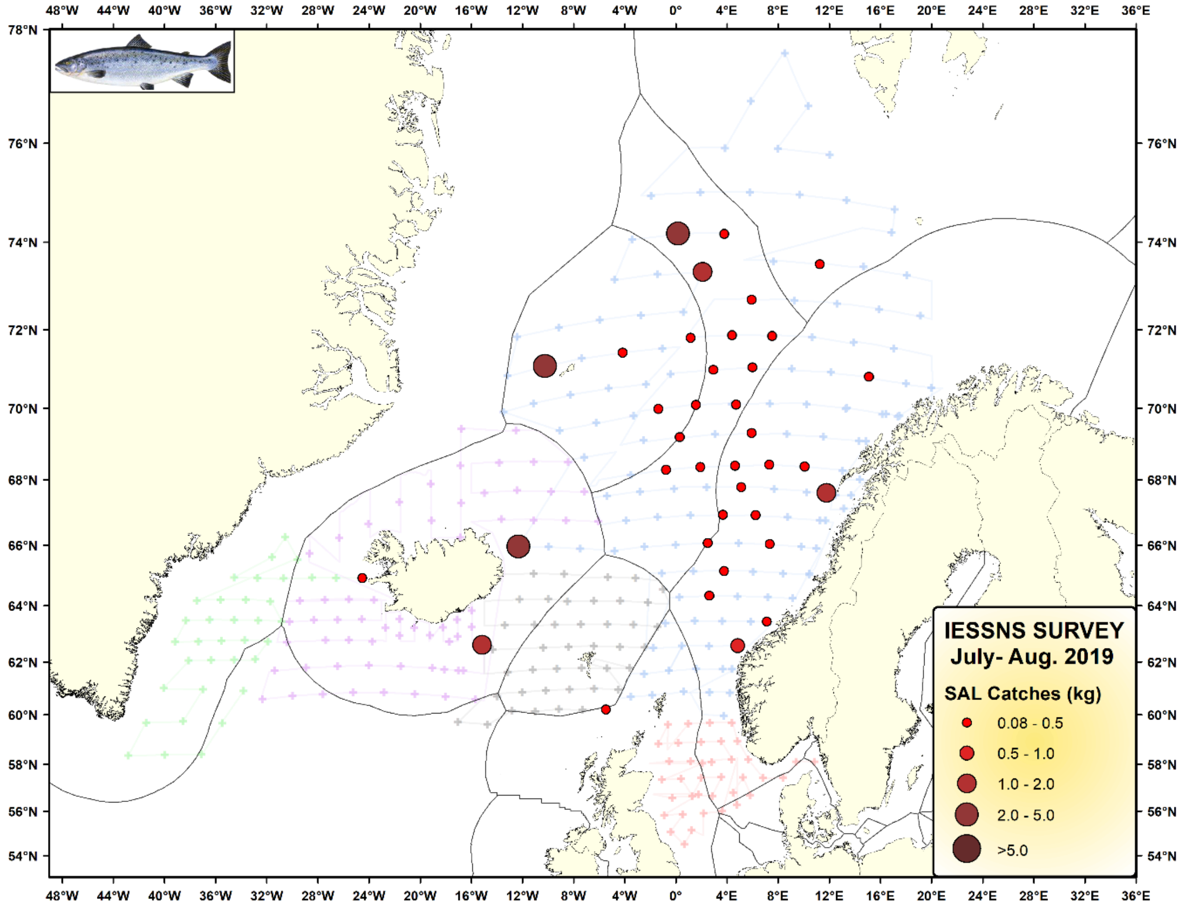


Figure 26. Catches of salmon at surface trawl stations during IESSNS 2019.

Capelin (*Mallotus villosus*)

Capelin was caught in the surface trawl on 29 stations along the cold front in SE Greenland, Denmark Strait, North of Iceland, West and North of Jan Mayen and at the entrance to the Barents Sea around Bear Island (Figure 27).

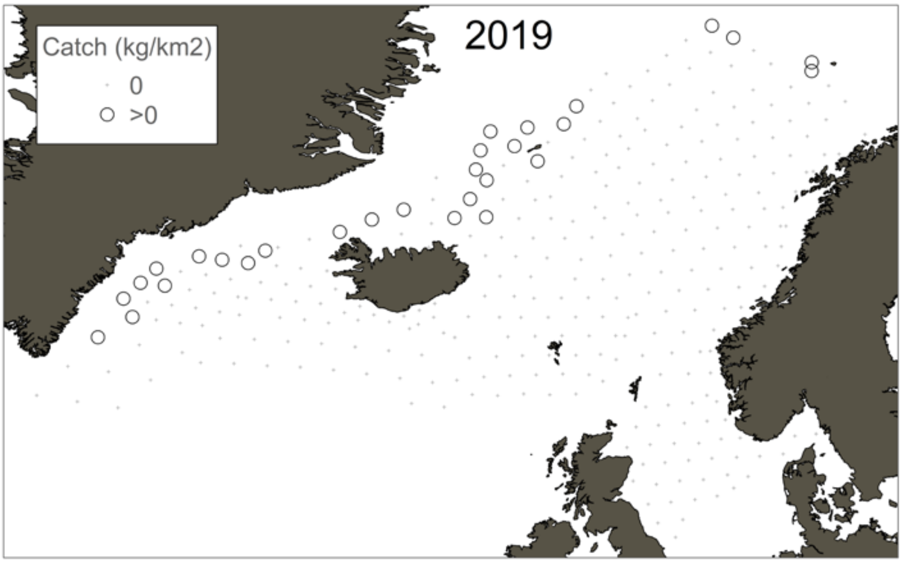


Figure 27. Presence of capelin in surface trawl stations during the IESSNS survey 2019.

4.7 Marine Mammals

Opportunistic whale observations were done by M/V "Kings Bay" and M/V "Vendla" from Norway in addition to R/V "Árni Friðriksson" from Iceland in 2019 (Figure 28). Overall, 521 marine mammals of 10 different species were observed, which was a reduction from 600+ in 2018 and 700+ in 2017 observed individuals. This could partly be explained by reduced observation effort on R/V "Árni Friðriksson" as in 2017 dedicated whale observers were onboard which was not the case in 2018 and 2019. Kings Bay had several days with fog and very reduced visibility in the north-western region (Jan Mayen area), possibly influencing the low number of marine mammals observed on this vessel during IESSNS 2019. Vendla experienced mainly good to excellent visibility during the entire survey period except for some limited periods between Bear Island and Svalbard, while Arni Fridriksson had occasional periods with fog north of Iceland. The species that was observed included; fin whales (*Balaenoptera physalus*), minke whales (*Balaenoptera acutorostrata*), humpback whales (*Megaptera novaeangliae*), blue whales (*Balaenoptera musculus*), sei whales (*Balaenoptera borealis*) pilot whales (*Globicephala sp.*), killer whales (*Orcinus orca*), sperm whales (*Physeter macrocephalus*), white beaked dolphins (*Lagenorhynchus albirostris*) and harbour porpoise (*Phocoena phocoena*). The dominant number of marine mammal observations were along the continental shelf between the north-eastern part of the Norwegian Sea and western part of the Barents Sea. Fin whales (n=63, group size = 1-4) and humpback whales (n=73, group size = 1-10) dominated among the large whale species, and they were particularly abundant from Norwegian coast outside Finnmark stretching north/northwest via Bear Island to southwest of Svalbard. Killer whales (n=55, group size = 1-10) dominated in the southern and eastern part of the Norwegian Sea, mostly overlapping and feeding on mackerel. White beaked dolphins (n=78, group size = 1-15) were present in the northern part of the Norwegian Sea. There were more observations made of marine mammals in the central Norwegian Sea in 2019 compared to previous years.

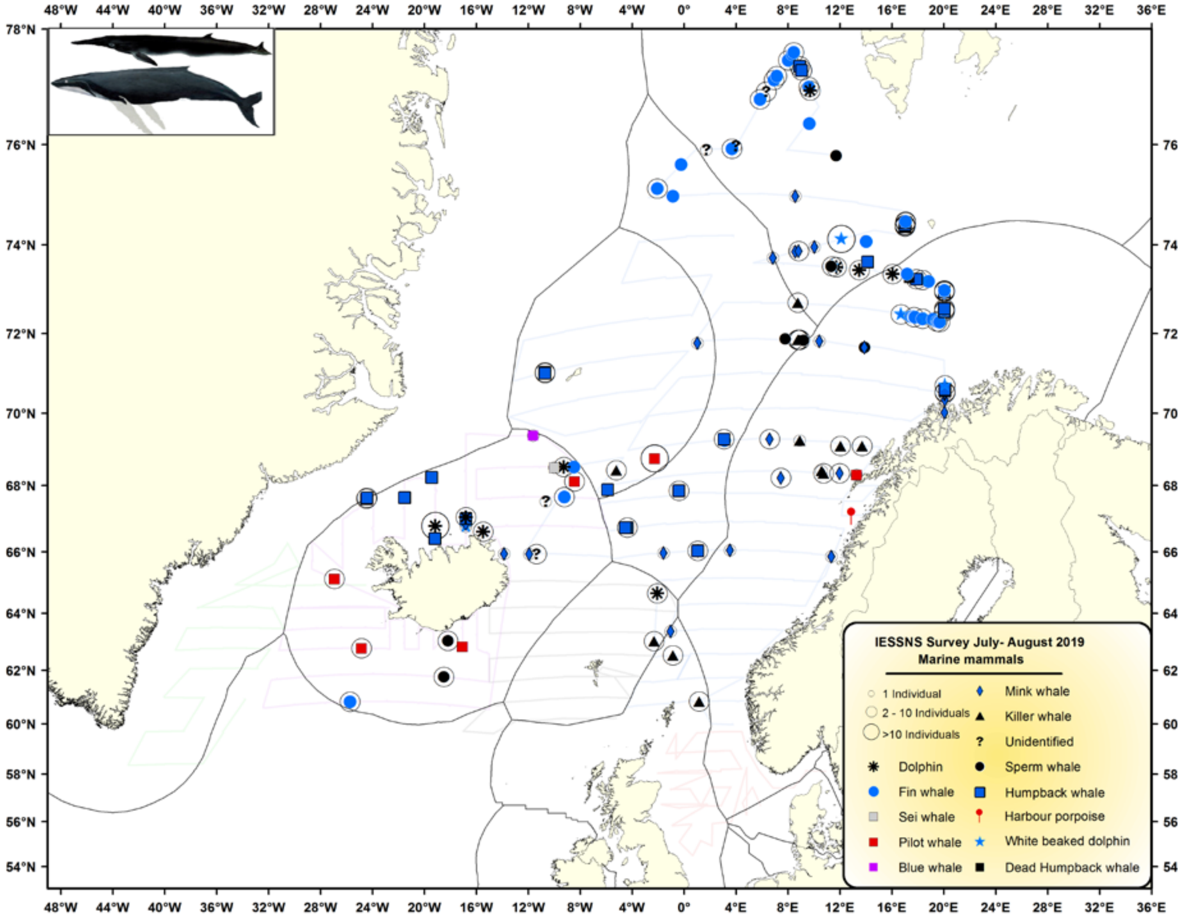


Figure 28. Overview of all marine mammals sighted during IESSNS 2019.

5 Recommendations

Recommendation	To whom
WGIPS recommends that the IESSNS extension to the North Sea should continue for establishing a time series suitable for assessing the part of the NE Atlantic Mackerel stock in the North Sea. The surveys conducted by Denmark in 2018 and 2019 have demonstrated that the IESSNS methodology works also for the northern North Sea (i.e. north and west from Doggerbank) and the Skagerrak for the area is deeper than 50 m. The survey provides essential fishery-independent information on the stock during its feeding migration in summer and WGIPS recommends that the Danish survey should continue as a regular annual survey.	WGWIDE, RCG NANSEA

6 Action points for survey participants

Action points
The guidelines for trawl performance should be revised to reflect realistic manoeuvring of the Multpelt832 trawl.
Criteria and guidelines should be established for discarding substandard trawl stations using live monitoring of headline, footrope and trawl door vertical depth, and horizontal distance between trawl doors. As predetermined surface trawl station, discarded hauls should be repeated until performance is satisfactory.
Explicit guideline for incomplete trawl hauls is to repeat the station or exclude it from future analysis. It is not acceptable to visually estimate mackerel catch, it must be hauled onboard and weighted. If predetermined trawl hauls are not satisfactory according to criteria the station will be excluded from mackerel index calculations, i.e. treated as it does not exist, but not as a zero mackerel catch station.
Tagging of lumpfish should be initiated or continue on all vessels.
We recommend that observers collect sighting information of marine mammals and birds on all vessels.

7 Survey participants

M/V "Vendla":

Leif Nøttestad (International coordinator and cruise leader), Institute of Marine Research, Bergen, Norway
Sindre Vatnehol (cruise leader), Institute of Marine Research, Bergen, Norway
Valantine Anthonypillai, Institute of Marine Research, Bergen, Norway
Benjamin Marum, Institute of Marine Research, Bergen, Norway
Thassya Christina dos Santos Schmidt, Institute of Marine Research, Bergen, Norway
Christine Djønne, Institute of Marine Research, Bergen, Norway
Frøydis Tousgaard Rist Bogetveit, Institute of Marine Research, Bergen, Norway
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Kåre Tveit, Institute of Marine Research, Bergen, Norway
Vilde Regine Bjørdal, Institute of Marine Research, Bergen, Norway
Inger Henriksen, Institute of Marine Research, Bergen, Norway

M/V "Kings Bay":

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Arne Johannes Holmin (cruise leader), Institute of Marine Research, Bergen, Norway
Lage Drivenes, Institute of Marine Research, Bergen, Norway
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Adam Custer, Institute of Marine Research, Bergen, Norway
Maik Tiedemann, Institute of Marine Research, Bergen, Norway
Penny Lee Liebig, Institute of Marine Research, Bergen, Norway
Stine Karlson, Institute of Marine Research, Bergen, Norway
Susanne Tonheim, Institute of Marine Research, Bergen, Norway

R/V "Árni Friðriksson":

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Agnes Eydal, Marine Research Institute, Reykjavík, Iceland
Anna Heiða Ólafsdóttir, Marine Research Institute, Reykjavík, Iceland
Arnþór B. Kristjánsson, Marine Research Institute, Reykjavík, Iceland
Björn Sigurðarson, Marine Research Institute, Reykjavík, Iceland
Emil Sölvi Ágústsson, University of Iceland, Reykjavík, Iceland
Freyr Arnaldsson, Marine Research Institute, Reykjavík, Iceland
James Kennedy, Marine Research Institute, Reykjavík, Iceland
Jóhann Gíslason, Marine Research Institute, Reykjavík, Iceland
Páll B. Valgeirsson, Marine Research Institute, Reykjavík, Iceland
Ragnhildur Ólafsdóttir, Marine Research Institute, Reykjavík, Iceland
Sigurlína Gunnarsdóttir, Marine Research Institute, Reykjavík, Iceland
Sólrún Sigurgeirsdóttir, Marine Research Institute, Reykjavík, Iceland
Tomas Didrikas, Marine Research Institute, Reykjavík, Iceland

M/V "Finnur Fríði":

Eydna í Homrum, Faroe Marine Research Institute, Torshavn, Faroe

Leon Smith, Faroe Marine Research Institute, Torshavn, Faroe
Poul Vestergaard, Faroe Marine Research Institute, Torshavn, Faroe
Páll Mohr Joensen, Faroe Marine Research Institute, Torshavn, Faroe

M/V "Eros":
On-board cruise leader: Søren L. Post, Greenland Institute of Natural Resources, Nuuk, Greenland
Jørgen Sethsen, Greenland Institute of Natural Resources, Nuuk, Greenland
Mette Svantemann, Greenland Institute of Natural Resources, Nuuk, Greenland
Malou Platou, Greenland Institute of Natural Resources, Nuuk, Greenland
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1 Appendix 1:

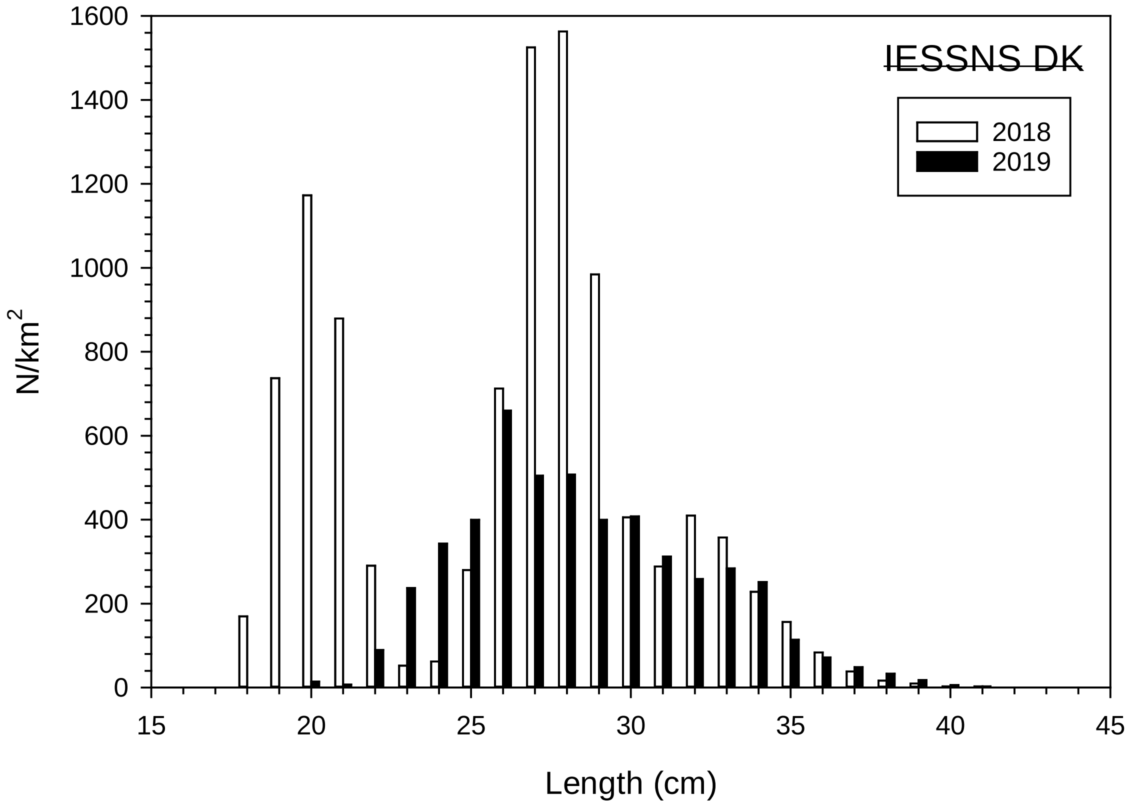
Denmark joined the IESSNS in 2018 for the first time extending the original survey area into the North Sea. The commercial fishing vessels "Ceton S205" was used, and in total 39 stations (CTD and fishing with the pelagic Multipelt 832 trawl) had successfully been conducted. No problems applying the IESSNS methods were encountered. Area coverage, however, was restricted to the northern part of the North Sea at water depths larger 50 m and no plankton samples were taken.

Denmark joined the IESSNS again in 2019 using the same vessel. 38 station were taken (PT and CTD, no plankton and no appropriate acoustic equipment available). The locations of stations differed slightly from the previous year focussing on the area north and west of Doggerbank and extended into the eastern Skagerrak.

Average mackerel catch in 20019 was lower than in 2018 (1009 compared to 1743 kg/km2). The length and age composition indicate a relative low amount of small (< 25 cm) individuals (Tab. A.1) whereas the abundance of older (≥ age 6) mackerel was higher in 2019 than in 2018 (Fig. A.1.), and the mean individual weight increased from 204 in 2018 to 220 g in 2019.

Table A1. StoX estimate of age segregated and length segregated mackerel index for the North Sea in 2019. Also provided is average length and weight per age class.

LenGrp	age 1	2	3	4	5	6	7	8	9	10	11	12	Number (1E3)	Biomass (1E3kg)	Mean W (g)
18-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19-20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-21	2314	-	-	-	-	-	-	-	-	-	-	-	2314	149.0	64.36
21-22	1469	-	-	-	-	-	-	-	-	-	-	-	1469	111.8	76.09
22-23	13171	-	-	-	-	-	-	-	-	-	-	-	13171	1133.7	86.08
23-24	33414	745	-	-	-	-	-	-	-	-	-	-	34159	3096.2	90.64
24-25	50228	-	-	-	-	-	-	-	-	-	-	-	50228	5557.8	110.65
25-26	62325	209	-	-	-	-	-	-	-	-	-	-	62534	8172.5	130.69
26-27	88071	17616	-	-	-	-	-	-	-	-	-	-	105686	14967.0	141.62
27-28	66712	24203	674	-	-	-	-	-	-	-	-	-	91588	15526.3	169.52
28-29	24663	81243	-	-	-	-	-	-	-	-	-	-	105906	20070.9	189.52
29-30	3405	90274	2644	-	-	-	-	-	-	-	-	-	96323	19671.7	204.23
30-31	759	54156	45081	346	-	-	-	-	-	-	-	-	100342	24027.1	239.45
31-32	-	27383	25019	27464	-	-	-	-	-	-	-	-	79865	21511.4	269.35
32-33	-	4929	42869	16616	400	-	-	-	-	-	-	-	64814	17876.5	275.81
33-34	-	6714	22531	34224	7627	-	-	-	-	-	-	-	71097	21182.0	297.93
34-35	-	-	9371	22922	15351	15109	-	113	-	-	-	-	62866	20863.7	331.88
35-36	-	-	965	7597	11034	5520	3715	1054	-	-	-	-	29885	10414.4	348.48
36-37	-	-	-	978	6236	3733	3227	2409	1527	-	-	-	18110	6920.1	382.11
37-38	-	-	-	-	713	4068	3654	2651	1369	-	-	-	12455	5191.8	416.85
38-39	-	-	-	-	-	658	2329	2498	1012	1166	-	-	7662	3461.5	451.77
39-40	-	-	-	-	-	261	-	1463	1082	725	-	466	3996	1957.4	489.81
40-41	-	-	-	-	-	-	-	442	404	462	10	19	1337	696.8	521.08
41-42	-	-	-	-	-	-	-	490	129	97	13	13	742	458.7	618.09
42-43	-	-	-	-	-	-	-	-	-	-	64	-	64	42.8	672.00
43-44	-	-	-	-	-	-	-	-	-	80	-	-	80	51.2	638.00
TSN(1000)	346531	307470	149154	110147	41361	29349	12925	11119	5522	2530	87	499	1016695	-	-
TSB(1000 kg)	46889.3	63754.6	40510.5	33331.5	14102.1	10336.8	5369.5	4753.4	2485.9	1270.9	55.9	251.9	-	223112.3	-
Mean length (cm)	25.40	28.88	31.45	32.72	34.43	34.99	36.36	37.35	37.63	38.93	41.61	39.09	-	-	-
Mean weight (g)	135.31	207.35	271.60	302.61	340.95	352.20	415.44	427.52	450.16	502.30	639.96	505.26	-	-	219.45



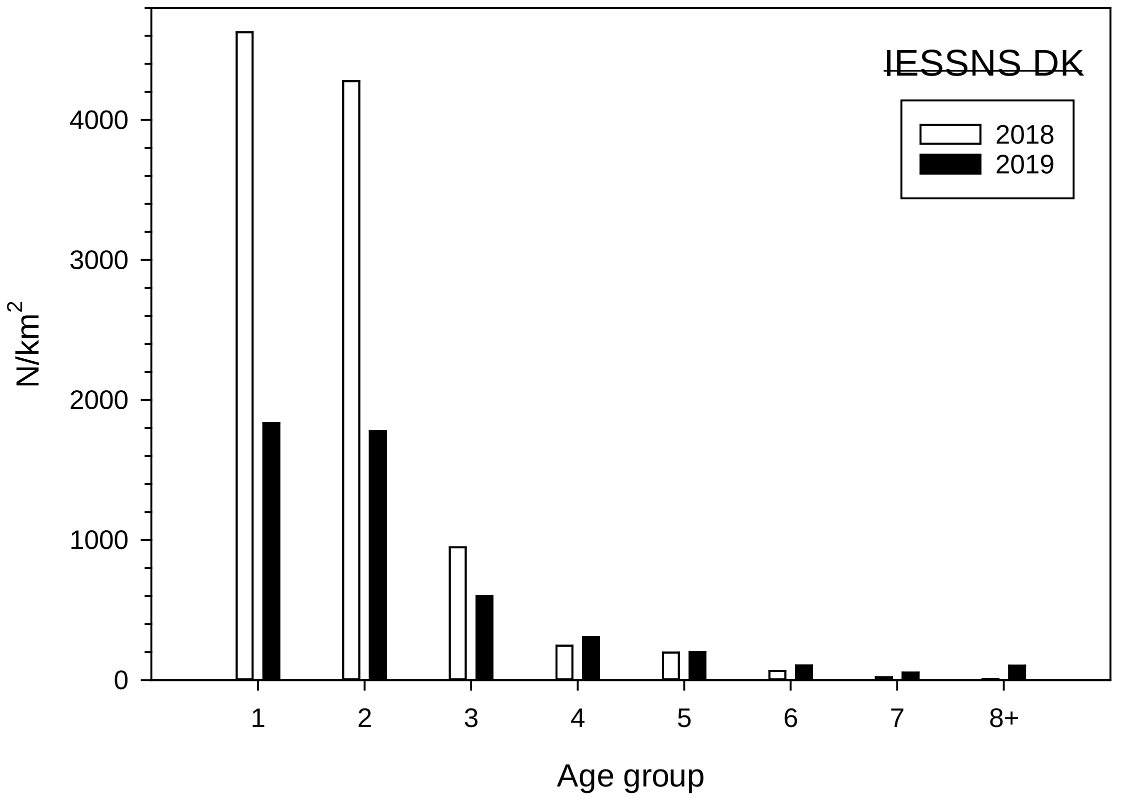


Fig. A1. Comparison of length and age distribution of mackerel in the North Sea 2018 and 2019.

2 Annex 2:

The mackerel index is calculated on all valid surface stations. That means, that invalid and potential extra surface stations and deeper stations need to be excluded. Below is the exclusion list used when calculating the mackerel abundance index for IESSNS 2019.

Table A2-1: Trawl station exclusion list for IESSNS 2019 for calculating the mackerel abundance index.

Vessel	Country	Exclusion list	
		Cruise	Stations
Kings Bay	Norway	2019837	29,38,47,52,55,70,74,77,79,81,82,86,92,98
Vendla	Norway	2019838	37,41,49,52,57,64,67,70,73,76,77,78,83,86,88,89,90,91,93,97,100,104,109,112,113
Árni Friðriksson	Iceland	A8-2019	342,344,347,361,365,366,375,383
Finnur Fríði	Faroe Islands	1952	9, 33,50,73,82,1081,1084 *
Eros	Greenland	CH-2019-01	87
Ceton	EU (Denmark)		North Sea data were not used in the combined index in IESSNS 2019

* Observe that in PGNAPES and the national database station numbers are 4-digit numbers preceeded by 1952 (e.g. ‘19520009’)

Annex 7: 2019 GERAS Survey Summary Table and Survey Report

Document 7a: GERAS 2019 survey summary table

Survey Summary Table WGIPS 2020	
Name of the survey (abbreviation):	GERAS / BIAS (GER) (FRV "Solea" SB768)
Target Species:	Herring (*Clupea harengus*, Western Baltic Spring Spawning Herring WBSSH; Central Baltic Herring CBH), Sprat (*Sprattus sprattus*) Anchovy (*Engraulis encrasicolus*), Sardine (*Sardina pilchardus*)
Survey dates:	01-21 Oct 2019
Summary:	
The objectives of the survey were carried out successfully and largely as planned in all of the covered ICES Subdivisions. Only in SD 21 (Kattegat), the two northernmost statistical rectangles had to be omitted due to a loss of survey time from adverse weather conditions requiring a temporal interruption of survey operations earlier. Neither the interruption nor the reduction of the surveyed area are considered to affect quality or quantity of acoustic estimates. Altogether, 1124 nautical miles of hydroacoustic transects (plus 103 nmi night and daytime transects for comparison) were covered. For species allocation and identification as well as to collect biological data for an age stratified abundance estimation of the target species herring and sprat, altogether 45 fishery hauls were conducted. Vertical hydrography profiles were measured on 76 stations. In roughly half of all sampled rectangles, mean NASC values per nautical mile were either comparable with or higher than the values measured in 2018, and lower in the remaining rectangles. Compared to the long-time survey mean however, mean NASC values in the large majority of rectangles covered were distinctly lower. On ICES subdivision scale, mean NASC values were overall lower than in the previous year in subdivision 21, slightly higher in SD 22, distinctly lower in SD 23 and almost identical to 2018 in SD 24. After excluding the Central Baltic Herring fraction from the estimates via the Separation Function, the present Western Spring Spawning Herring biomass estimate represents the lowest recorded value in the whole time series since 1993.	
	Description
Survey design	Stratified systematic (parallel where applicable) design. Start point not randomized. ICES statistical rectangles used as strata for all ICES subdivisions

Index Calculation method	GERIBAS II Software. Index based on mean NASC per ICES statistical rectangle.
Random/systematic error issues	Survey design and transects restricted by area topography. No fully systematic coverage of survey area possible. Indications of large herring aggregations outside the surveyed transects/time period were registered.
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	Bubble sweep down due to adverse weather conditions occurred and required interruption of survey operations (SD 24). Due to the continuation of the survey in improved conditions, this is not considered to affect integration results.
Extinction (shadowing)	No particular issues as targets are scattered in loose aggregations in most of the surveyed areas during the survey operations.
Blind zone	Due to the night-time distribution of clupeids also in surface layers, registrations of clupeids occur in the blind zone but are not quantified (integration start depth 10 m). In some parts of the survey area, the blind zone exclusion exceeds more than half of the total water column.
Dead zone	No particular issue as clupeids are mostly distributed pelagically and away from seafloor during night-time survey operations.
Allocation of backscatter to species	Directed trawling. Mixed species category applied throughout survey. Species allocations and splitting of NASC values based on combined trawl haul composition per ICES statistical rectangle.
Target strength	Clupeids: TS = 20 log10 (L) - 71.2 Gadids: TS = 20 log10 (L) - 67.5 Mackerel: TS = 20 log10 (L) – 84.9 see SISP Survey manual (ICES, 2017). Clupeid TS allocated to other species included in analysis (see above).
Calibration	All survey frequencies calibrated and results within recommended tolerances (Demer et al., 2015).
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	Time series: It is assumed that WBSSH (primary target species) is contained within the survey area. An unquantified but assumedly low degree of mixing of WBSSH and CBH (Central Baltic Herring) can occur outside of the survey area (east of SD 24). Due to transects often determined by topography/bathymetry, aggregations of WBSSH in shallower areas not sampled by the survey may have been missed. 2019 survey: Survey area not fully covered as planned resulting from a loss of survey time due to bad weather. Two rectangles in the nortern survey area of the Kattegat (SD 21) were omitted, that

	are not part of the standard area of the GERAS-Index for HAWG. Accordingly, this is not considered to have reduced stock containment and was also addressed in the analysis.
Stock ID and mixing issues	Time series: WBSSH and CBH mix at varying degrees in different parts of the survey area (especially in SD 24). Separation of stocks is achieved through application of an age-growth based stock separation function (SF) (Gröhsler et al. 2013). 2019 survey: The present results support the continued applicability of the SF despite occurrence of some CBH in the GERAS baseline samples of WBSSH in SDs 21 and 23. CBH were identified in herring samples from throughout the survey area, but only in SD 24 contributed significantly to the overall herring abundance (ca. 25%). Mean weights became distinctly more typical for the growth pattern of WBSSH after removal of CBH, and a conspicuous peak in abundance of year class 5 (very weak year class for WBSSH) also vanished through removal of CBH by the SF (strong 2014 year class of CBH).
Measures of uncertainty (CV)	none
Biological sampling	Time series: Based on survey design restrictions, comprehensive sampling is not feasible in all statistical rectangles surveyed. Biological information from neighboring rectangles is used for generating estimates in these cases. This mostly applies to rectangles with low abundance. 2019 survey: Biological information for ICES statistical rectangles 37G4 (SD 24), 39G2 (SD 23), 39F9, 40F9 (SD 22) used/amended from neighbouring rectangles.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

Document 7b: GERAS 2019 survey report

Please see the report on the next page.

Federal Research Institute for Rural Areas, Forestry and Fisheries

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Survey Report FRV "Solea" SB768

German Acoustic Autumn Survey (GERAS)

01 – 21 October 2019

Matthias Schaber[1] & Tomas Gröhsler[2]

1 INTRODUCTION

1.1 Background

The cruise was part of an international hydroacoustic survey providing information on stock parameters of small pelagics in the Baltic Sea, coordinated by the ICES Working Group of International Pelagic Surveys (WGIPS) and the ICES Baltic International Fish Survey Working Group (WGBIFS). Further WGBIFS contributors to the Baltic survey are national fisheries research institutes of Sweden, Poland, Finland, Latvia, Estonia and Lithuania. FRV "Solea" participated for the 32nd time. The survey area covered the western Baltic Sea including Kattegat, Belt Sea, Sound and Arkona Sea (ICES Subdivisions (SD) 21, 22, 23 and 24).

1.2 Objectives

The survey has the main objective to annually assess the clupeid 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).

The following objectives were planned for SB768:

- Hydroacoustic measurements for the assessment of small pelagics in the Kattegat and western Baltic Sea including Belt Sea, Sound and Arkona Sea (ICES Subdivisions 21, 22, 23 and 24)
- (Pelagic) trawling according to hydroacoustic registrations
- Hydrographic measurements on hydroacoustic transects and after each fishery haul
- Identification and recording of species- and length-composition of trawl catches
- Collection of biological samples of herring, sprat and additionally European anchovy and cod for further analyses
- Parallel survey with RV "Clupea" (CLU338) on the regular transect in Subdivision 23 to compare day- and nighttime clupeid distribution and catchability.

1.3 Survey summary

The objectives of the survey were carried out successfully and largely as planned in all of the covered ICES Subdivisions. Only in SD 21 (Kattegat), the two northernmost statistical rectangles had to be omitted due to a loss of survey time from adverse weather conditions requiring a temporal interruption of survey operations earlier. Neither the interruption nor the reduction of the surveyed area are considered to affect quality or quantity of acoustic estimates.

Altogether, 1124 nautical miles of hydroacoustic transects (plus 103 nmi night and daytime transects for comparison) were covered. For species allocation and identification as well as to collect biological data for an age stratified abundance estimation of the target species herring and sprat, altogether 45 fishery hauls were conducted. Vertical hydrography profiles were measured on 76 stations.

In roughly half of all sampled rectangles, mean NASC values per nautical mile were either comparable with or higher than the values measured in 2018, and lower in the remaining rectangles. Compared to the long-time survey mean however, mean NASC values in the large majority of rectangles covered were distinctly lower. On ICES subdivision scale, mean NASC values were overall lower than in the previous year in subdivision 21, slightly higher in SD 22, distinctly lower in SD 23 and almost identical to 2018 in SD 24.

2 SURVEY DESCRIPTION & METHODS APPLIED

2.1 Cruise narrative

The 768th cruise of FRV "Solea" represents the 32nd subsequent GERAS survey. Equipment of the vessel as well as calibration of echosounders took place on October 1st, embarkation of scientific crew and beginning of survey was scheduled for the following day, when FRV "Solea" left Kiel harbor in the afternoon. The hydroacoustic survey operations commenced October 2nd in SD 22 (Kiel Bight).

Generally, survey operations were conducted during nighttime to account for the more pelagic distribution of clupeids during that time. Weather conditions at the beginning of the survey required to start survey operations in the westerly survey area of the comparatively sheltered western Baltic SD 22. Several scheduled changes of scientific crew during SB768 (exceptional case in 2019) required interruption of survey operations in SD 22 to enter Rostock-Warnemünde port for the first exchange of the chief scientist on October 7th. Afterwards, survey operations commenced in SD 22 (finished on October 8th) and continued in SD 24. There, adverse weather conditions required a one day interruption of survey work on October 11th. After conditions improved, the survey commenced in SD 24, where 2 out of 3 transect sections (SD 24 south, SD north) were finished before FRV "Solea" entered Copenhagen port for another exchange of the chief scientist on October 14th. In late afternoon of October 15th, FRV "Solea" left Copenhagen port to commence survey operations in SD 23, where after accomplishing the regular night time transect another parallel run of that transect was accomplished the following day together with FRV "Clupea" to collect hydroacoustic data (both vessels) and biological samples (FRV "Clupea") for a comparison of day-night distributions and catchability of herring in the Sound. Afterwards, SD 21 was covered with a reduced sampling effort (the two northernmost rectangles had to be omitted) due to the previous loss of survey time (crew change, weather conditions). After accomplishing SD 21 on October 18th, the remaining transect in SD 24 (SD24 middle) was covered on October 19th accomplishing survey operations in all ICES Subdivisions. The scientific survey program was finished on October 20th, 05:40 AM. Afterwards, FRV "Solea" steamed to Marienehe port, where the survey ended on October 21st.

Altogether, the following survey schedule was accomplished:

Belt Sea	(SD 22)	02. - 07.10.
Arkona Sea	(SD 24)	08. - 13.10. & 19.10.
Sound	(SD 23)	15.10. & 18.10. (Additional fishery haul)
Kattegat	(SD 21)	16. - 18.10.
Sound	(SD 23) (day)	16.10. (Parallel survey with FRV "Clupea")

Total survey time	16 nights (+ 1 day comparison in SD 23), excl. 1 day loss (bad weather)
Fishery hauls	45
CTD-casts	76
Hydroacoustic transects	1124 nmi (+ 103 nmi transects for comparison)

2.2 Survey design

ICES statistical rectangles were used as strata for all Subdivisions (ICES, 2017). The area was limited by the 10 m depth line. The survey area in the Western Baltic Sea is characterized 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, the covered regular cruise track length was 1124 nautical miles (2018: 1211 nmi) (Figure 1).

2.3 Acoustic data collection

All acoustic investigations were performed during night time to account for the more pelagic distribution of clupeids during that time. Hydroacoustic data were recorded with a Simrad EK80 scientific echosounder with hull-mounted 38, 70, 120 and 200 kHz transducers at a standard ship speed of 10 kn. Post-processing and analysis of hydroacoustic data were conducted with Echoview 10 software (Echoview Software Pty Ltd, 2019). Mean volume back scattering values (S_v) were integrated over 1 nmi intervals from 10 m below the surface to ca. 0.5 m over the seafloor. Interferences from surface turbulence, bottom structures and scattering layers were removed from the echogram. The transducer settings applied were in accordance with the specifications provided in ICES (2015, 2017).

2.4 Calibration

All transducers (38, 70, 120 and 200 kHz) were calibrated prior to the beginning of the survey in acceptable weather conditions from an anchored vessel in Strande Bay/Kiel Bight (54°25.35 N, 10°12.29 E). Overall calibration results were considered good based on calculated RMS values. Resulting transducer parameters were applied for consecutive data-collection and post-processing of hydroacoustic survey data. Calibration results for the 38 kHz transducer are given in Table 1.

2.5 Biological data – trawl hauls

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 netsonde indicated large catches. To validate and allocate echorecordings, altogether 45 fishery hauls were conducted (Figure 1). 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).

2.6 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. Altogether, 76 CTD-profiles were measured (Figure 8).

2.7 Data analysis

All data analyses were conducted using GERIBAS II software (Arivis, 2014) and Microsoft Office.

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
Clupeids	= 20 log L (cm) - 71.2	ICES (1983)
Gadids	= 20 log L (cm) - 67.5	Foote et al. (1986)
Scomber scombrus	= 20 log L (cm) - 84.9	ICES (2017)

All other species that were included in the analysis based on their contribution to the catches per rectangle were allocated the clupeid TS (see table above).

The total number of fish (total N) in one rectangle was estimated as the product of the mean Nautical Area Scattering Coefficient (NASC; S_A) and the rectangle area, divided by the corresponding mean cross section σ. The total number was separated into the categories mentioned above and further into herring and sprat according to the mean catch composition.

All calculations performed were in accordance with the guidelines in the "SISP Manual of International Baltic Acoustic Surveys (IBAS)" (ICES, 2017).

Some hauls with very low catches in terms of numbers and biomass as well as hauls conducted with unclear fishing gear were rendered invalid for further analyses. Based on survey design restrictions, comprehensive sampling is not feasible in all statistical rectangles surveyed. Biological information from neighboring rectangles is used for generating estimates in these cases. This mostly applies to rectangles with low abundance as well as to rectangles where low catch hauls and invalid hauls need to be omitted.

Stock splitting / Application of the separation function (SF):

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 from baseline samples of WBSSH and CBH in 2011-2018 support the applicability of the SF (Oeberst et al., 2013; WD Oeberst et al., 2014, 2015, 2016, 2017; WD Gröhsler and Schaber, 2018, 2019).

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 since 2005 excludes CBH 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 RESULTS

3.1 Hydroacoustic data (M. Schaber)

Figure 2 depicts the spatial distribution of mean NASC values (5 nmi intervals) measured on the hydroacoustic transects covered in 2019. In general, the majority of these NASC measurements can be allocated to clupeids. In 13 out of 25 rectangles surveyed, mean NASC values were comparable (7) or (partly significantly) higher (6) than those recorded in 2018. However, in 20 out of 25 rectangles, mean NASC levels recorded were well below the long-term survey average. On ICES subdivision scale, mean NASC values were slightly lower than in the previous year in subdivision 21, slightly higher in SD 22, distinctly lower in SD 23 and almost identical to 2018 in SD 24.

In SD 21, overall NASC values measured were lower than those measured in the previous year. Only in one rectangle (41G0), mean NASC per 1 nmi EDSU was almost tenfold higher than the one measured in 2018, driving the overall only slightly lower mean NASC in this subdivision as compared to 2018. This rectangle however only contained a short section of transect. Aggregations were mostly patchy along the cruisetrack, with highest NASC levels measured in the southern parts of the Kattegat.

In SD 22, mean overall NASC values recorded were comparable or higher than in 2018 in 8 out of 11 rectangles surveyed. Lower values were measured in 3 rectangles. In some rectangles, the increase in NASC measured was significant, but often originated from rather unusual aggregations of fishes in rectangles containing only short transect sections or in an area that usually is characterized by very low NASC levels. In comparison to the long-term survey mean, all but 2 rectangles in SD 22 again showed decreased NASC values. No clear aggregation or area of increased NASC measurements was evident, but highest measurements origin from distinct aggregations of (most likely) anchovies in the area north of the Little Belt.

As in the previous years, the large aggregations of big herring that usually could be observed in SD 23 in the Sound were not present in autumn 2019. Mean NASC values were again distinctly lower than the levels measured in 2018 in the relevant rectangles. They also were well below the long-term survey mean. Only in the southern part of the Sound, NASC levels were above the 2018 measurements (rectangle 39G2). A daytime replicate hydroacoustic measurement of the inner Sound parallel with FRV “Clupea” (hydroacoustics and fishing operations) showed differing but consistent distribution patterns with somewhat increased NASC values as compared to the regular nighttime transect coverage (Figure 3). This comparison will be fully evaluated in later steps.

In SD 24, mean NASC values were comparable to or higher than the levels measured in 2018 in 7 out of 9 rectangles. While an eightfold increase was measured in the southernmost transect parts of 37G4, NASC levels measured in the Kadetrinne area west of Fischland-Darß-Zingst (37G2) and northern Arkona Basin along the Swedish coast (39G3) were distinctly lower than in 2018. The former however had shown a fourfold increase in 2018 and is characterized as an area with usually rather low NASC measurements. As in the years before, somewhat notable aggregations were detected around Rügen Island.

3.2 Biological data (T. Gröhsler)

Fishery hauls according to ICES Subdivision (Figures 1 & 4):

SD	Hauls (n)
21	8 (incl. 1 invalid haul)
22	16
23	4
24	17

Altogether, 1 165 individual herring, 792 sprat, 318 European anchovies and 5 sardines were frozen for further investigations (e.g. determining sex, maturity, age). Results of catch compositions by Subdivision are presented in Tables 2-5. Altogether, 34 different species were recorded. Herring were caught in 42, sprat in 38 hauls. SD 23, which is typically characterized by the highest mean herring catch rates per station (kg 0.5 h^{-1}), showed the lowest values ever recorded (during nighttime hauls). In contrast to 2018, when sardines (*Sardina pilchardus*) only appeared in catches from SD 22 and SD 23, this species was caught in SD 21 and SD 23 in 2019. As in previous years, anchovy (*Engraulis encrasicolus*) were present in the whole survey area, albeit in a higher frequency of occurrence compared to 2018 (26 of 58 day- and nighttime hauls in 2018, 36 of 45 nighttime hauls in 2019). A map depicting clupeid catches per haul is shown in Figure 4.

Altogether, the following fish species were sampled and processed:

Species	Length measurements (n)	Prevalence (n of hauls)
Aphia minuta	307	21
Clupea harengus	5737	42
Ctenolabrus rupestris	3	3
Engraulis encrasicolus	1181	36
Eutrigla gurnardus	6	4
Gadus morhua	60	14
Gasterosteus aculeatus	452	23
Limanda limanda	72	14
Merlangius merlangus	274	30
Mullus surmuletus	3	3
Platichthys flesus	22	12
Pomatoschistus minutus	138	12
Sardina pilchardus	5	3
Scomber scombrus	125	11
Sprattus sprattus	4266	38
Syngnathus typhle	301	3
Trachinus draco	703	18
Trachurus trachurus	1	37
Others	42	-

Figures 5 and 6 show relative length-frequency distributions of herring and sprat in ICES subdivisions 21, 22, 23 and 24 for the years 2018 and 2019. Compared to results from the previous survey in 2018, the following conclusions for **herring** can be drawn (Figure 5):

- Catches in SD 21 showed a bimodal distribution with modes at 15.25-15.75 cm and 18.75 cm. This is in contrast to 2018, when a multimodal distribution showed modes at 11.75 cm, 15.25-15.75 cm and 21.2.5-21.75 cm.
- Catches in SD 22 were dominated in the last two years by the incoming year class (ca. ≤15 cm) with a mode at 12.75-13.25 cm.
- As in the years 2016-2018, larger herring (>20 cm) were almost absent from night time catches conducted in SD 23 in 2019. Catches in 2019 showed – quite similar to the results in SD 21 - a bimodal distribution with modes at 14.25 cm and 18.75 cm. This is in contrast to 2018, when the catches were only dominated by the contribution of the incoming year class (ca. ≤15 cm), showing a mode at 13.25 cm.
- Catches in SD 24 showed in both years a similar bimodal distribution with modes at 13.25-13.75 cm and 17.75-18.25 cm accompanied by the almost absence of herring larger than ca. 23 cm.

Relative length-frequency distributions of **sprat** in the years 2018 and 2019 (Figure 6) can be characterized as follows:

- In SD 21 catches of the incoming year class (ca. ≤10 cm) were virtually absent in both years. In The catches were dominated by the contribution of larger sprat in both years.
- Catches in SD 22 were dominated in 2019 by the contribution of the incoming year class (ca. ≤10 cm). This is contrast to the results in 2018, where the contribution of larger sprat (>10 cm) was highest.
- In SD 23, the catches showed a bimodal distribution with a higher contribution of the incoming year class (ca. ≤10 cm, mode at 8.75 cm) compared to amount of older sprat (mode at 12.15 cm). This is in contrast to the results in 2018 where almost exclusively the incoming year class (ca. ≤10 cm) contributed to the catches.
- In SD 24, the bimodal sprat length-frequency distribution was characterized by a similar contribution of the incoming year class (ca. ≤10 cm) and older sprat in both years. The catches were dominated by the contribution of larger sprat (>10 cm) in 2018 and in 2019.
- Altogether, the present contribution of the incoming year class (ca. ≤10 cm) seemed to be higher than the lower one in 2018.

For abundance and biomass estimates, the following considerations and calculation steps were included in the analysis:

<u>Fish species considered:</u>

Transparent goby	(*Aphia minuta*)
Herring	(*Clupea harengus*)
European anchovy	(*Engraulis encrasicolus*)
Cod	(*Gadus morhua*)
Three-spined stickleback	(*Gasterosteus aculeatus*)
Haddock	(*Melanogrammus aeglefinus*)
Whiting	(*Merlangius merlangus*)
Mackerel	(*Scomber scombrus*)
Sprat	(*Sprattus sprattus*)
Greater weever	(*Trachinus draco*)
Horse mackerel	(*Trachurus trachurus*)

Exclusion of trawl hauls with very low catches:

Haul No.	Rectangle	Subdivision (SD)
2, 11	38G0	22
4, 7	40G0	22
14, 15	37G1	22
18	38G2	24
32	41G2	23
37	42G1	21
45	39G2	24

Exclusion of trawl hauls due to net damage:

Haul No.	Rectangle	Subdivision (SD)
39	42G2	21

Inclusion of hauls with low catches:

Despite low catches 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 the following rectangles:

Haul No.	Rectangle	Subdivision (SD)
5	41G0	22
6	40G1	22
8, 9	39G0	22
10	39G1	22
12	37G0	22
17	37G2	24
27	39G4	24
40	42G2	21

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

Rectangle/SD to be filled	with Haul No.	of Rectangle/SD
39F9/22	8 and 9	39G0/22
40F9/22	3	40G0/22
39G2/23	29	39G2/24
37G4/24	20 and 23	38G4/24

3.3 Stock Splitting / Application of the Separation Function

The age-length distribution of herring in SDs 21, 22 and SD 23 in 2019 indicated some contribution of fish of CBH origin. This also included the SD 23 area of ICES rectangle 39G2, since biological samples of that rectangle were also used to raise the corresponding mean NASC values in the SD 24 area of the rectangle. Accordingly, the SF was applied all areas (SDs 21-24) in 2019.

The applicability of the SF, which is normally checked by analyzing the growth parameters based on baseline samples of WBSSH in SDs 21 and 23, could not be tested in 2019 due some degree of mixing of CBH/WBSSH in SDs 21 and 23.

3.4 Biomass and abundance estimates

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.

3.4.1 Herring incl. Central Baltic Herring (CBH)

The herring stock in Subdivisions 21-24 was estimated to be 3.3 x 10^9 fish (Table 7) or 89.6 x 10^3 tonnes (Table 9). For the included area of Subdivisions 22-24 the number of herring was calculated to be 3.1 x 10^9 fish or 81.7 x 10^3 tonnes.

3.4.2 Herring excl. Central Baltic Herring (CBH)

Estimated numbers of herring excluding CBH in SDs 21-24 by age group and SD/rectangle for 2019 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 summarized in Table 15.

Gradual removal of the CBH fraction by SD (total survey area) yielded the following results:

Numbers (millions)	Total	excluding CBH in SD:			
	incl. CBH	24 & 39G2/23	24 & 22	24 & 22 & 23	21-24
SDs 21-24	3264.7	2448.3	2436.8	2434.2	2419.2
Percent of Total	100.0%	75.0%	74.6%	74.6%	74.1%
Difference		-25.0%	-0.5%	-0.1%	-0.6%
Biomass (t)	Total	excluding CBH in SD:			
	incl. CBH	24 & 39G2/23	24 & 22	24 & 22 & 23	21-24
SDs 21-24	89624.0	56993	55992	55886	55093
Percent of Total	100.0%	63.6%	62.5%	62.4%	61.5%
Difference		-36.4%	-1.8%	-0.2%	-1.4%

A removal of the CBH fraction in SDs 21-24 from the herring HAWG-GERAS index of the standard area (excluding 43G1/43G2 in SD 21 and 37G3/37G4 in SD 24) in 2019 also resulted in biomass reductions of 36 % with corresponding reductions in numbers of 24 % (2018: -20 % and -11 %, respectively; Figure 7; survey indices time series depicted in Figure 8).

3.4.3 Sprat

The estimated sprat stock in Subdivisions 21-24 was 4.5x 10^9 fish (Table 10) or 51.0 x 10^3 tonnes (Table 12). For the included area of Subdivisions 22-24 the number of sprat was calculated to be 4.2 x 10^9 fish or 45.6 x 10^3 tonnes. The overall abundance estimate in 2019 was dominated by the new incoming year class (Figure 6 and Table 10).

3.5 Hydrography

Vertical profiles of temperature, salinity and oxygen concentration were measured with a SeaBird SBE CTD-probe on a station grid covering the whole survey area. Hydrography measurements were either conducted directly after a trawl haul or, in case of no fishing activity, in regular intervals along the cruise track. Altogether, 76 CTD casts were conducted during this survey (Figure 9).

Surface temperatures ranged from ca. 11°C in the northeastern Arkona Basin (SD 24) and ca. 13 °C in the Kattegat area (SD 21) to > 14°C in the southwestern coastal areas of SD 22. Bottom temperatures were similar in most parts of Subdivisions 21, 22 and 23, but more variable due to strong thermohaline layering in some parts of SD 24 (eastern central Arkona) and SD 22 (inner Mecklenburg Bight). While bottom temperatures in the central and eastern Arkona Sea exceeded surface temperatures (maximum temperatures > 15 °C), lowest bottom temperatures were recorded in the inner Mecklenburg Bight at around 11-12 °C. Overall lowest temperatures of ca. 8 °C were recorded in the northeastern Arkona Sea in intermediate layers.

As usual due to the hydrographic nature of the western Baltic Sea, surface salinities showed a large gradient (from ca. 7.5 PSU in the eastern Arkona Sea to > 25 PSU in the Kattegat). As in the previous year, surface salinity in the western parts of the survey area (SD 22) was comparatively high at levels of ca. 20 PSU. Salinity near the seafloor ranged from 8 PSU in the Arkona Sea to ca. 34 PSU in the Kattegat. Especially in the Sound (SD 23), a very strong stratification with steep salinity gradients was observed.

Surface waters were well oxygenated throughout the survey area. Near the seafloor, local oxygen depletion was measured in the southwestern coastal area of SD 22 between the Little Belt and Kiel Bight.

4 DISCUSSION

Compared to 2018, the present estimates of herring **incl. CBH** show an increase in stock biomass, whereas abundance values decreased (ICES rectangles 43G1 and 43G2 in SD21 removed from 2018 results for comparison):

Herring (incl. CBH)	Difference compared to 2018	
Area	Numbers (%)	Biomass (%)
Subdivisions 21-24	-11	+8

This present decrease of 11 % in numbers was mainly driven by distinctly lower numbers in SD 21 (-74 %) and SD 23 (-82 %) as compared to 2018, together with higher numbers in SD 24 (+48 %). The increase in total biomass of 8 % was mainly driven by a presently very high contribution of age group 5 (+179 %).

Compared to 2018, the present estimates of herring **excl. CBH** now show a significant decrease in stock biomass and abundance values (ICES rectangles 43G1 and 43G2 in SD21 removed from 2018 results for comparison):

Herring (excl. CBH)	Difference compared to 2018	
Area	Numbers (%)	Biomass (%)
Subdivisions 21-24	-26	-16

The application of the Separation Function to remove CBH from the index calculation yields robust results, even though the actual applicability of the SF could not be tested in 2019 due to a lack of “clean” baseline samples from SDs 21 and 23. However, several issues were resolved and results corroborated after applying the SF and removing CBH from the samples from all areas (SD 21-24) in 2019: Mean weights of different age groups that prior to removal showed somewhat untypical growth pattern for WBSSH became distinctly more realistic for older age groups after removing the CBH fraction. Additionally, a conspicuous peak of abundance of 5 year old herring that otherwise could not be explained vanished after removing the CBH fraction. The 2014 year class represents only a weak year class in the WBSSH assessment (ICES, 2019a). The assumption of this peak originating from CBH is realistic, since latest assessment results for CBH show a very strong (strongest in the time series) 2014 year class (ICES, 2019b).

The present Western Spring Spawning Herring biomass estimate represents the lowest recorded value in the whole time series since 1993 (Figure 8).

Prior to 2016, high numbers of large herring were usually and regularly recorded in SD 23 (the Sound), which is considered an important transition and aggregation area for the WBSSH stock during its spawning migration (Nielsen, 1996). In 2019, for the fourth consecutive year, those fishes were absent. This virtual complete absence could, as in the previous years, be explained by a possibly delayed immigration of WBSSH from the feeding areas in the Skagerrak. The exceptionally low numbers of large and older herring 2016-2019 could also be explained by the very low recruitment, which was recorded through the N20 larval survey index during the last years. The sustained downward trend in recruitment could explain the further disappearance of older herring in time. The strong correlation of the N20 index with the 1-age group of the GERAS index (Polte et al., 2019) supports this assumption. Methodological biases leading to the low numbers observed can again not be ruled out, but at least in terms of overall acoustic detections of clupeids seem unlikely. Possible shifts in distribution of herring aggregations towards shallower areas would be undetected by the current survey and cannot be disregarded. During the 2019 initial parallel survey of the inner Sound transect with FRV “Solea” and FRV “Clupea” (day and night comparison based on registrations and catches from the regular sampling the night before), different (compared to the night) but consistent (amongst vessels) NASC measurements were made. The difference was observed spatially as well as in terms of somewhat higher NASC levels recorded, albeit the latter does not seem significant based on a preliminary scrutinisation of data. Length-Frequency-Distributions from herring catches made in two daytime hauls from FRV “Clupea” in the Sound (not included in the 2019 analysis, not shown here) show modes at ca. 14, 18 and 24 cm, as opposed to only two modes at 14 and 18 cm in the regular nighttime hauls conducted with FRV “Solea”. Accordingly, the fraction of larger herring present in the daytime hauls was not recorded during the regular survey the night before. FRV “Clupea” also conducted a trial hydroacoustic trawl survey in the Sound covering also shallow water areas on east-west transects. Final analysis of both parallel and trial surveys is pending.

Migrations of herring out of the sound can be 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 2019, no such migration could be assumed since no older and bigger herring were detected in corresponding areas of the adjacent SD 24, nor was there an indication of according hydrographic conditions driving herring out of the Sound.

5 SURVEY PARTICIPANTS

Name	Function	Institute
Dr. M. Schaber (15.-21.10.)	Cruise Leader (Hydroacoustics, Hydrography)	TI-SF
M. Bleil (02.-07.10.)	Cruise Leader (Hydroacoustics, Hydrography)	TI-OF
Dr. A. Velasco (07.-14.10.)	Cruise Leader (Hydrography)	TI-OF
D. Andersen (15.-21.10.)	Fishery biology	DTU Aqua (DK)
M. Koth	Fishery biology	TI-OF
L. S. Lundgaard (02.-14.10.)	Fishery biology	DTU Aqua (DK)
S. Niemann	Fishery biology	TI-OF
S. Winning	Fishery biology, Hydroacoustics	TI-SF

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7 FIGURES

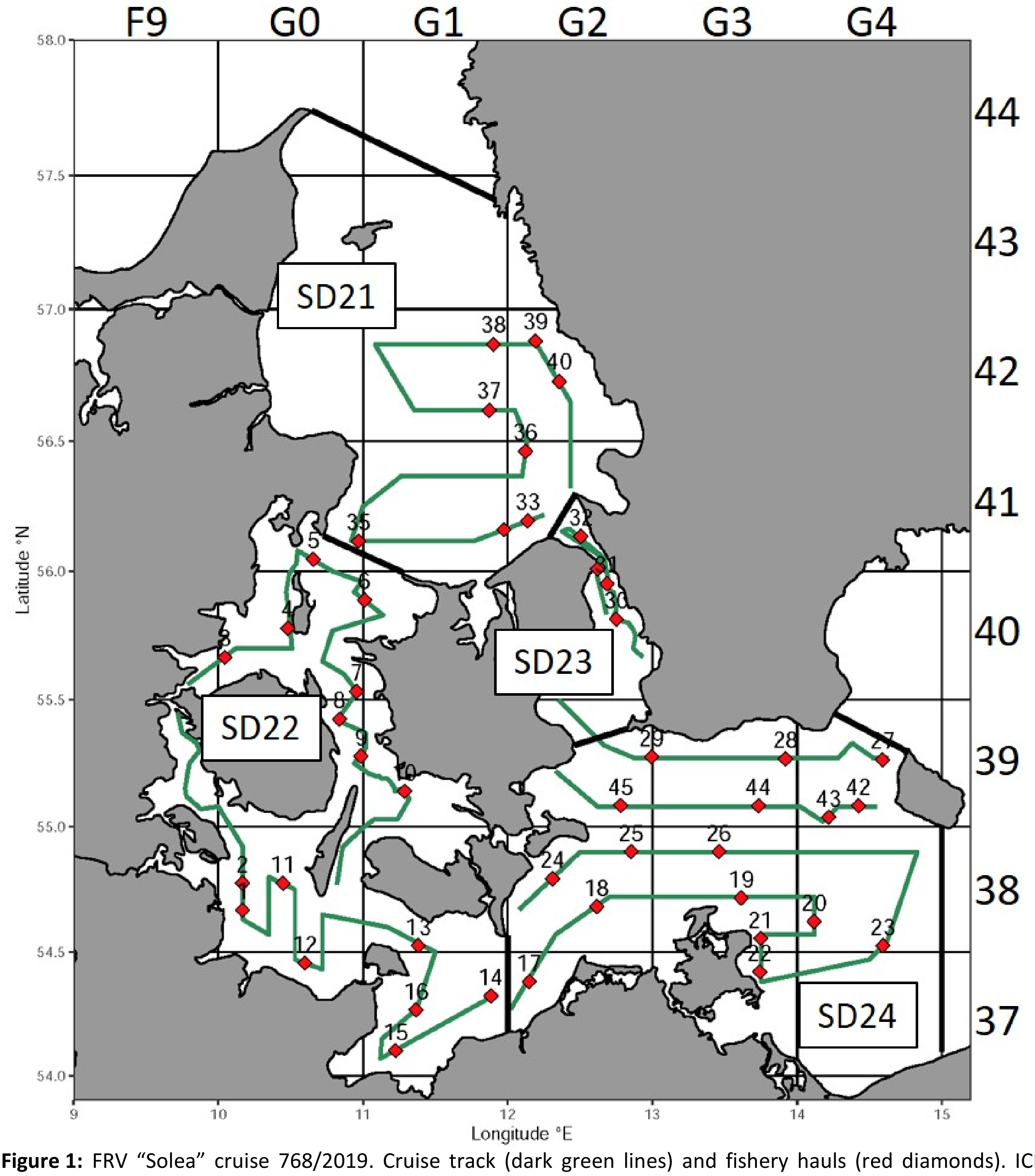


Figure 1: FRV “Solea” cruise 768/2019. Cruise track (dark green lines) and fishery hauls (red diamonds). ICES statistical rectangles are indicated in the top and right axis. Thick black lines separate ICES subdivisions (SD).

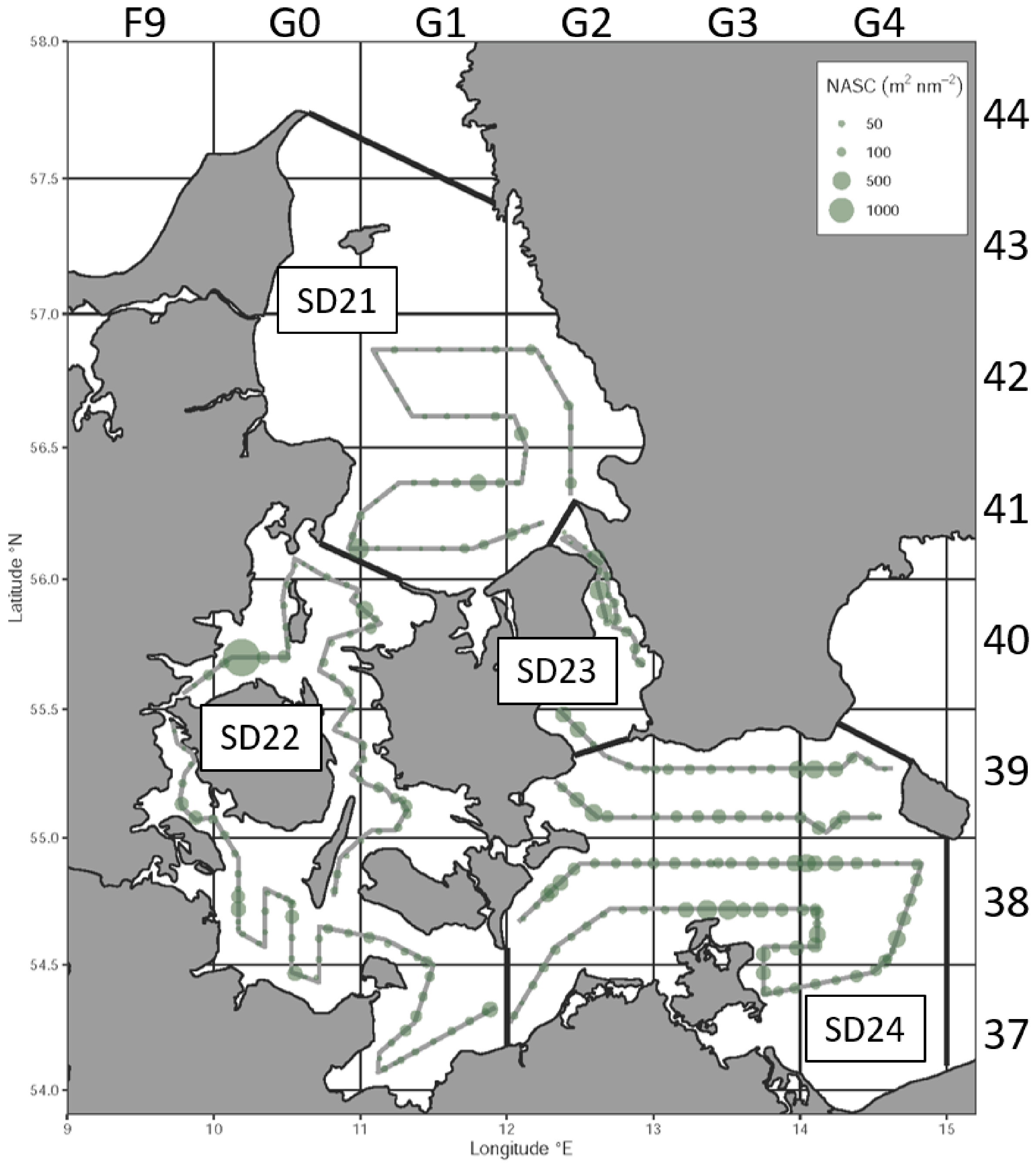


Figure 2: FRV "Solea" cruise 768/2019. Cruise track (thin grey lines) and mean NASC (5 nmi intervals, dots). ICES statistical rectangles are indicated in the top and right axis. Thick black lines separate ICES subdivisions (SD).

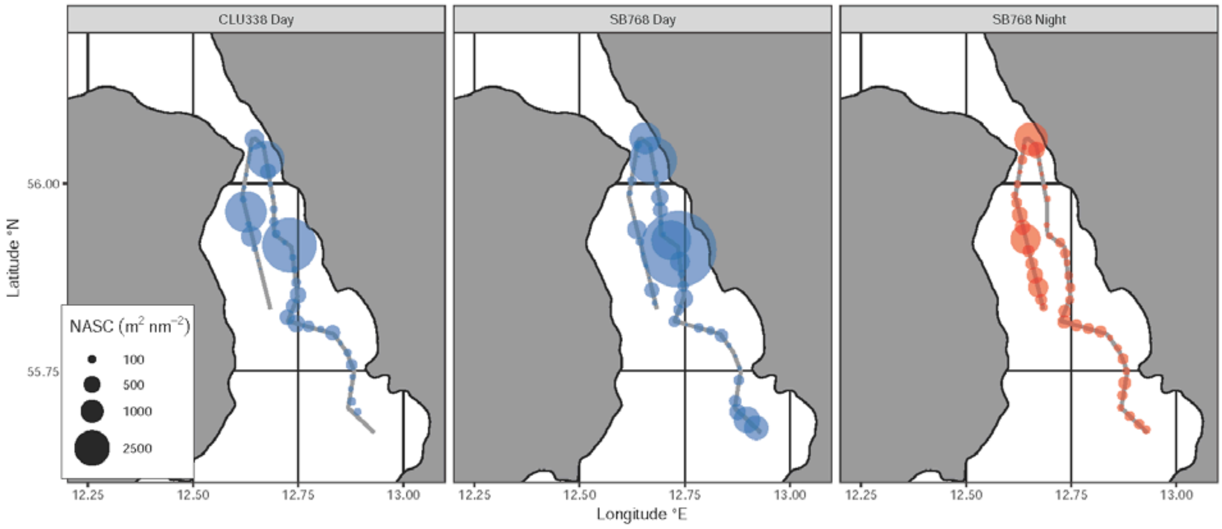


Figure 3: FRV "Solea" cruise 768/2019 and FRV "Clupea" cruise 338/2019: Comparison of clupeid distribution and abundance in the inner Sound (SD 23) 15.-16.10.2019. Cruise tracks (thin grey lines) and mean NASC (1 nmi intervals, dots) measured during daytime (blue dots, left and middle panel) and nighttime (red dots, right panel).

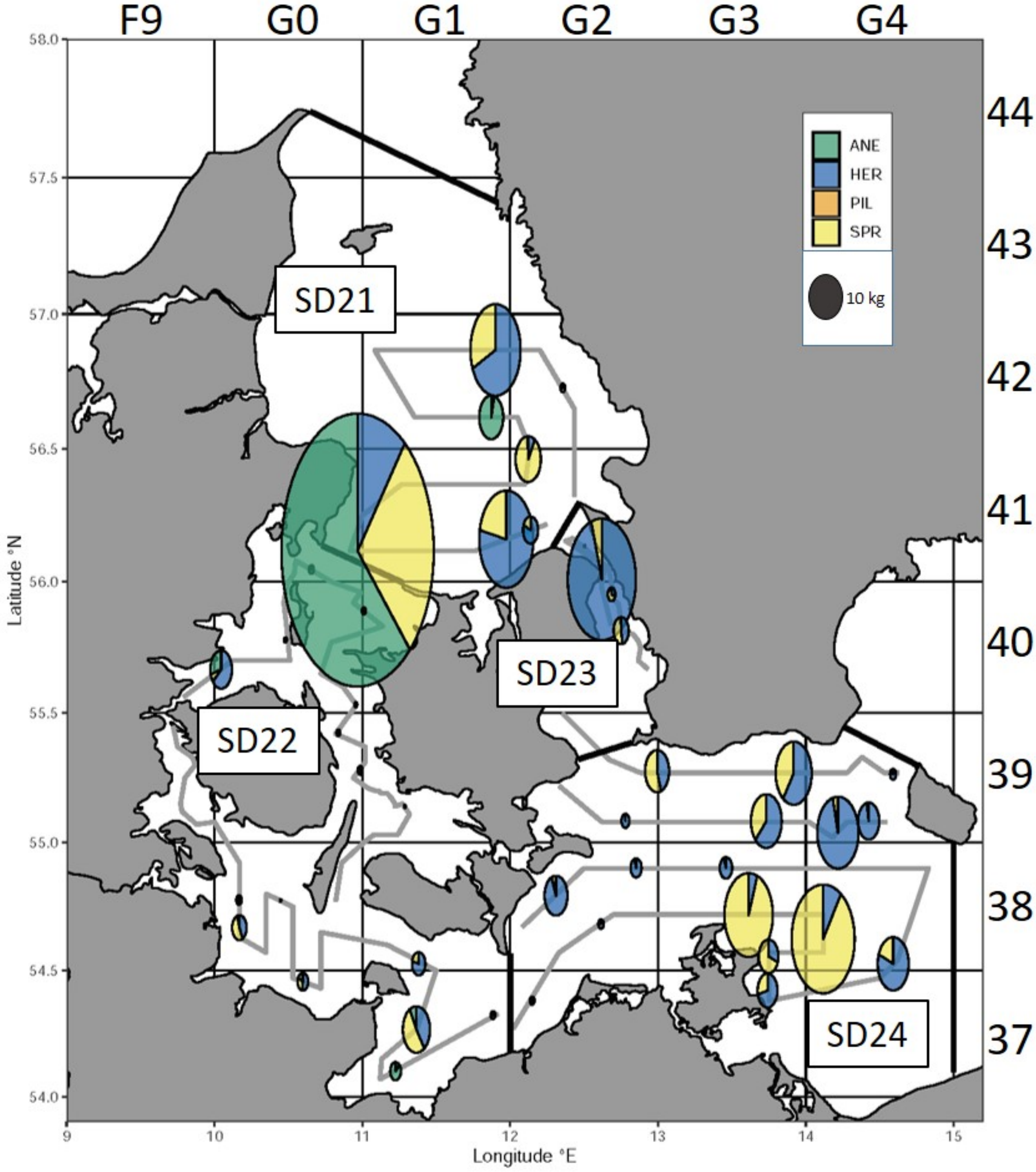


Figure 4: FRV "Solea" cruise 768/2019. Clupeid catch per haul (kg $30min^{-1}$). ANE = European anchovy (*Engraulis encrasicolus*), HER = Herring (*Clupea harengus*), PIL = Sardine (*Sardina pilchardus*), SPR = Sprat (*Sprattus sprattus*). ICES statistical rectangles are indicated in the top and right axis. Thick black lines separate ICES subdivisions (SD). Thin grey lines indicate cruise track.

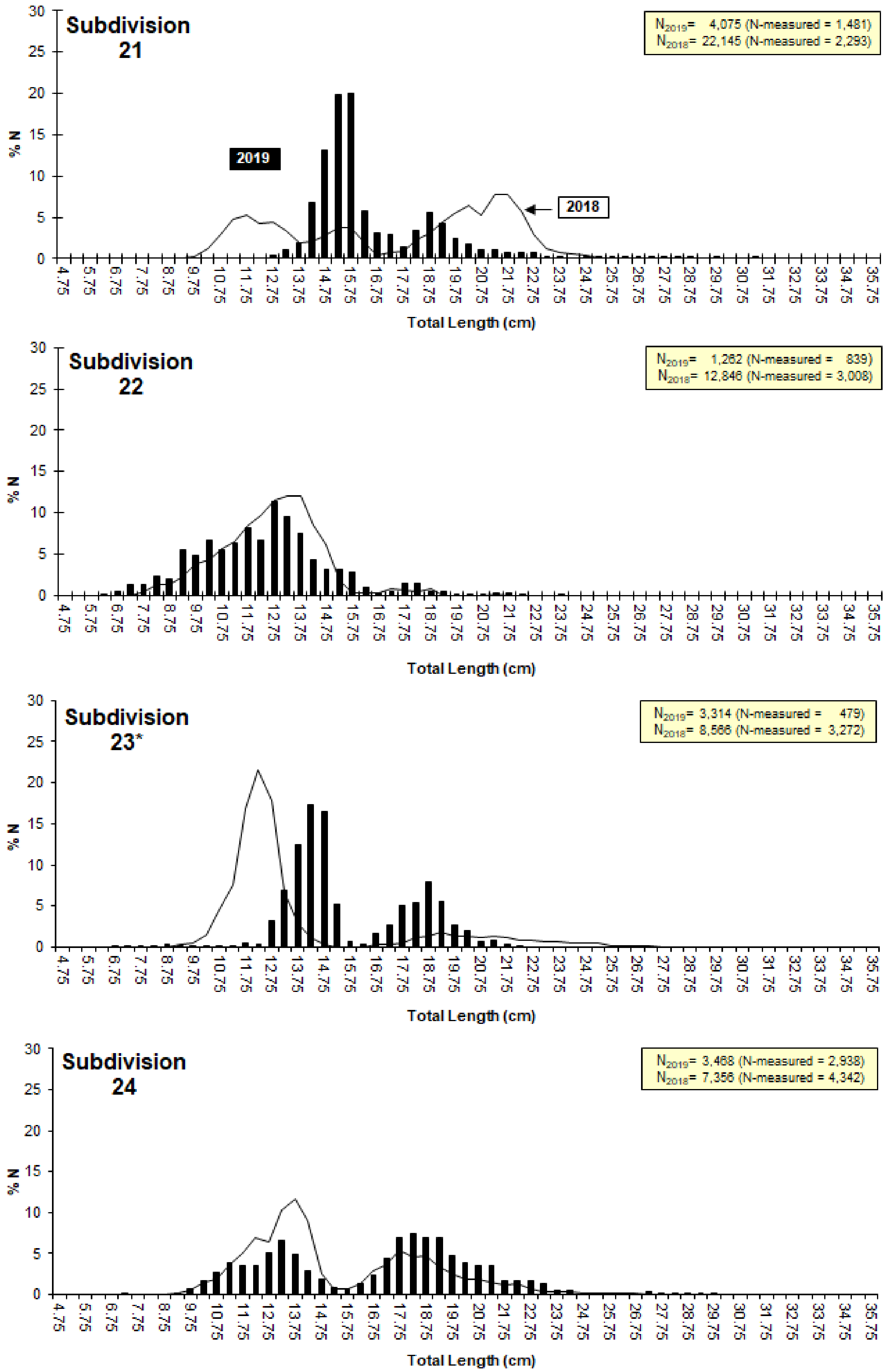


Figure 5: FRV “Solea” cruise 768/2019. Herring (Clupea harengus) length-frequency distribution (bars) compared to the previous year (cruise 754/2018, lines). In 2018, daytime comparison hauls conducted in SD 23 were included.

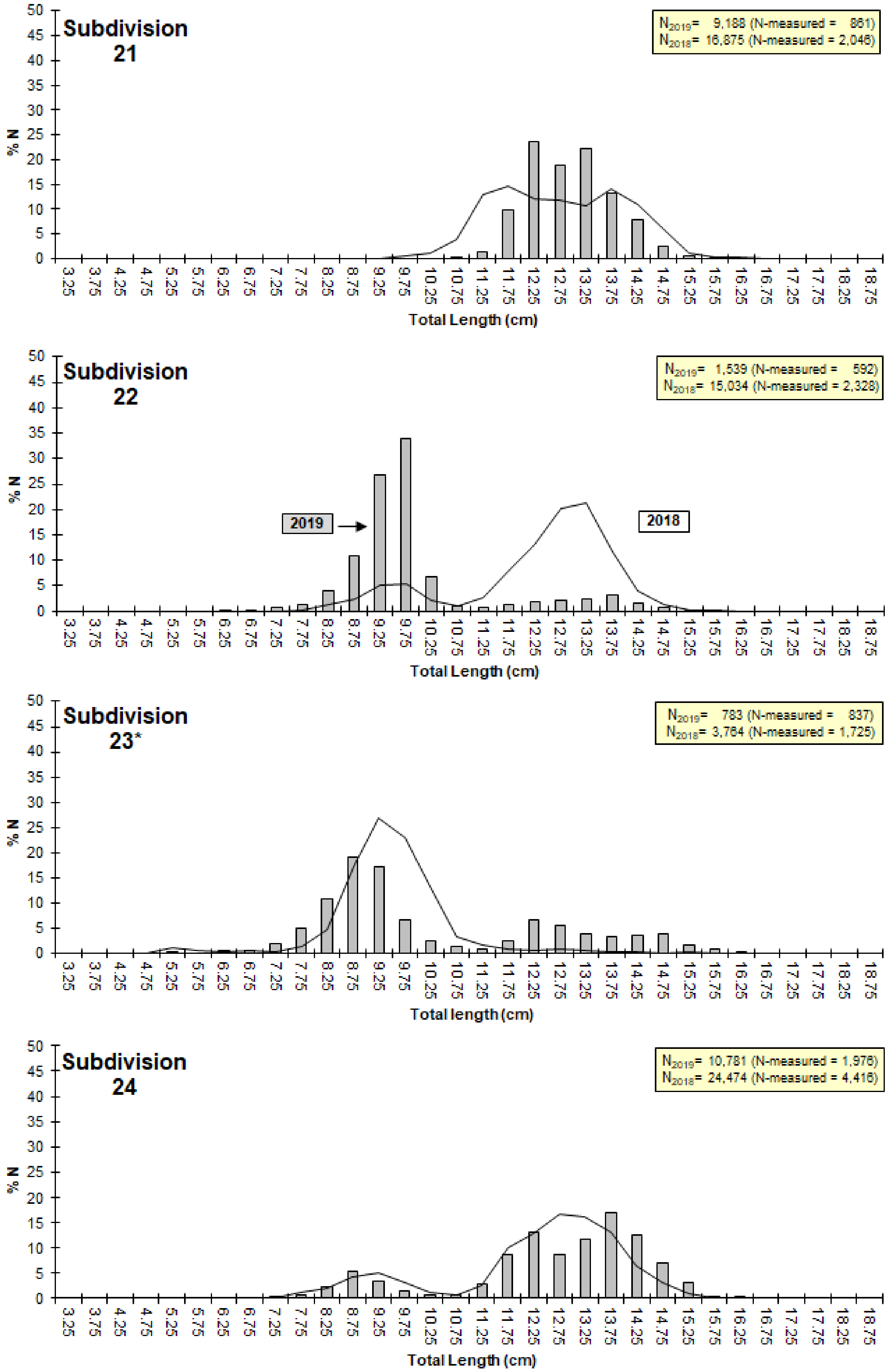


Figure 6: FRV "Solea" cruise 768/2019. Sprat (*Sprattus sprattus*) length-frequency distribution (bars) compared to the previous year (cruise 754/2018, lines). In 2018, daytime comparison hauls conducted in SD 23 were included.

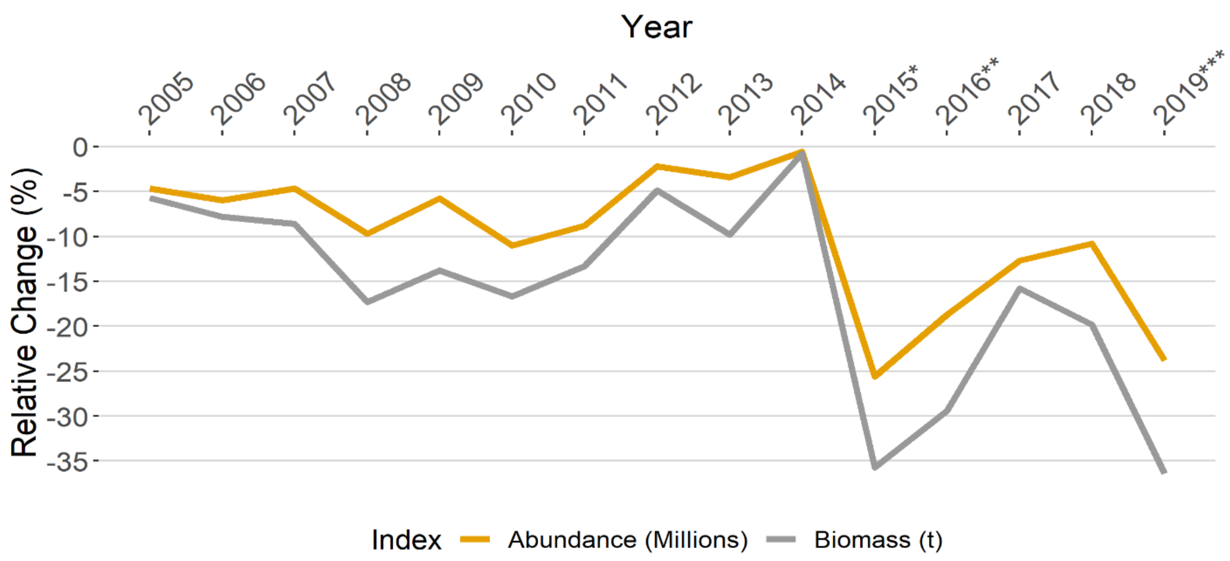


Figure 7: Relative changes in abundance and biomass of Western Baltic Spring Spawning herring in ICES Subdivisions 21-24 (2005-2019) after application of the stock Separation Function (SF, Gröhsler et al., 2013) to the abundance and biomass index generated from German acoustic survey data (GERAS). **2015 excl. of CBH in SD 22 and SD 24 and mature herring (stages ≥6) in SD 23;**2016 excl. of CBH in SD 22 and SD 24; ***2019 excl. of CBH in SDs 21-24.*

Figure 8: Time series of GERAS survey indices for Western Baltic Spring Spawning Herring (WBSSH) age groups 0-8+. A) Abundance and B) Biomass of herring in ICES Subdivisions 21 (Southern Kattegat, ICES statistical rectangles 41G0 - 42G2) – 24 (excl. ICES statistical rectangles 37G3 & 37G4). Blue line (until 2005): WBSSH including Central Baltic Herring fraction; Red line (from 2005): WBSSH after application of Separation Function (SF).

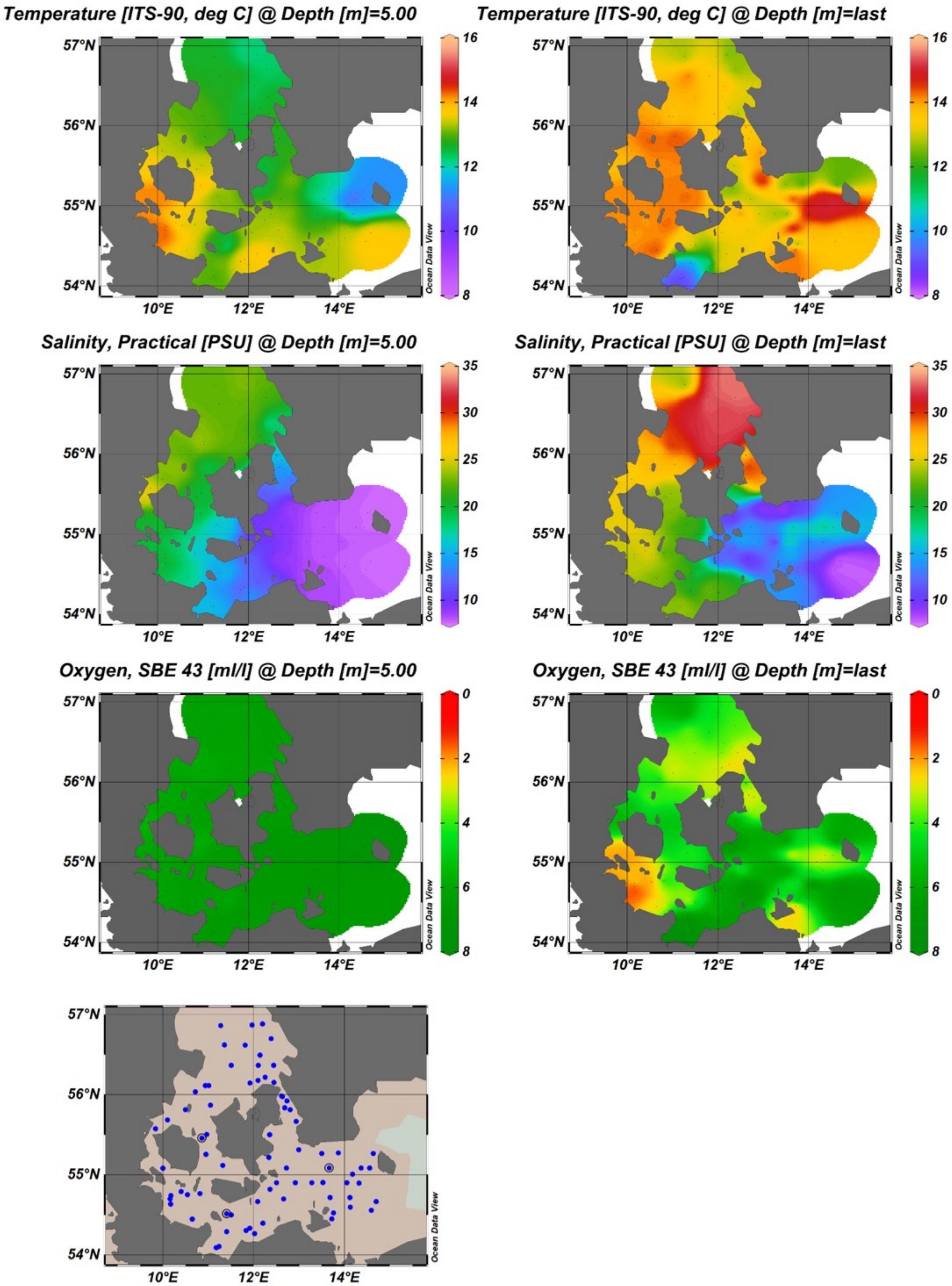


Figure 9: FRV "Solea" cruise 768/2019: Hydrography. CTD stations are depicted as blue dots in the area map (lower panel). Temperature (°C, top panels), salinity (PSU, middle panels and oxygen concentration (ml/l, lower panels) near the surface (left) and near the seafloor (right).

8 TABLES

Table 1: FRV “Solea” cruise 768/2019: Simrad EK80 calibration report (38 kHz Transducer).

Date:	01.10.2019		
Calibration Site:	Strande Bay/Kiel Bight (54°25.35 N, 10°12.29 E)		
Transceiver Type:	WBT		
Software Version:	EK80 1.12.2.0		
Reference Target:	Tungsten (WC-Co) 38.1 mm		
Transducer:	ES38-7 Serial No. 147		
Frequency:	38000 Hz	Beamtype:	Split/Narrow
Gain:	26.66 dB	Equivalent Beam Angle:	-20.7 dB
Beamwidth Athw.:	6.35 deg	Beamwidth Along.:	6.27 deg
Offset Athw.:	0.33 deg	Offset Along.:	-0.26 deg
Depth:	4.20 m		
Pulse Duration:	1.024 ms		
Power:	2000 W		
TS Detection:			
Min. Value:	-50.0 dB	Min. Spacing:	0.0
Max. Gain Comp.:	3.0 dB	Min. Echolength:	0.8
Max. Echolength:	1.8		
Environment:			
Absorption Coeff.:	0.005349	Sound Velocity:	1487.1 m/s
Temperature:	14.4 °C	Salinity:	19.7 PSU
Calibration results:			
Transducer Gain:	26.76 dB	SaCorrection:	-0.14 dB
Beamwidth Athw.:	6.35 deg	Beamwidth Along.:	6.27 deg
Offset Athw.:	0.33 deg	Offset Along.:	-0.26 deg
RMS-Error:	0.13		

Table 2: FRV "Solea" cruise 768/2019: Catch composition (kg 0.5 h^{-1}) by haul in SD 21.

Haul No.	33	34	35	36	37	38	39	40	Total
Species / ICES Rectangle	41G2	41G1	41G0	41G2	42G1	42G1	42G2	42G2	
APHIA MINUTA					+		0.22	0.05	**0.27**
CARCINUS							0.01		**0.01**
CLUPEA HARENGUS	3.37	41.85	45.23	0.95	0.17	31.50		0.11	**123.18**
ENGRAULIS ENCRASICOLUS		0.03	263.68	0.05	10.14	0.07			**273.97**
EUTRIGLA GURNARDUS	0.07			0.04					**0.11**
GASTEROSTEUS ACULEATUS								+	**+**
LIMANDA LIMANDA	0.09	0.15							**0.24**
LOLIGO	0.08	0.03	0.03	0.03	0.22	0.01	0.15	0.02	**0.57**
MERLANGIUS MERLANGUS	0.03	0.09		+	0.08	0.05		0.10	**0.35**
MULLUS SURMULETUS	+	0.01							**0.01**
POMATOSCHISTUS MINUTUS	+								**+**
SARDINA PILCHARDUS			0.12						**0.12**
SCOMBER SCOMBRUS		2.95	0.90	0.08	3.26	0.89			**8.08**
SEPIOLA		+							**+**
SPRATTUS SPRATTUS	0.79	11.74	115.88	9.64	0.25	14.48		0.28	**153.06**
TRACHINUS DRACO	2.87	10.62	0.15	0.17	0.55	22.10	0.04	0.11	**36.61**
TRACHURUS TRACHURUS	1.47	0.23	0.21	0.04	0.07	0.06		+	**2.08**
Total	**8.77**	**67.70**	**426.20**	**11.00**	**14.74**	**69.16**	**0.42**	**0.67**	**598.66**
Medusae	1.58	3.02	1.60	1.65	1.71	0.86	4.85	9.90	25.16

+ = < 0.01 kg Haul 39 not valid

Table 3: FRV "Solea" cruise 768/2019: Catch composition (kg 0.5 h^{-1}) by haul in SD 22.

Haul No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Species / ICES Rectangle	38G0	38G0	40G0	40G0	41G0	40G1	40G0	39G0	39G0	39G1	38G0	37G0	38G1
ALLOTEUTHIS					+								
APHIA MINUTA	+	+	0.01	+	+		0.01	+	+	+		+	
BELONE BELONE										0.05			
CLUPEA HARENGUS	1.60	0.23	5.46		0.04	0.02	0.11	0.14	0.10		0.02	1.06	2.61
CRANGON CRANGON							+					+	
CTENOLABRUS RUPESTRIS					+		+						
ENGRAULIS ENCRASICOLUS	0.17	0.01	2.46	0.15	0.38	0.05	0.01	0.07	0.28	0.04	0.02	0.35	0.01
GADUS MORHUA	0.01												
GASTEROSTEUS ACULEATUS	0.71	0.38		+				+		1.70	0.01		+
GOBIUS NIGER	0.02												
LIMANDA LIMANDA	2.29	0.29		0.13	0.08		0.01	0.05	0.03			1.53	1.07
LOLIGO				+		+	0.01	+					
LUMPENUS LAMPRETAEFORMIS	0.02												
MERLANGIUS MERLANGUS	0.04	0.05	0.06		0.01		0.01	0.02			0.04	0.35	0.12
MULLUS SURMULETUS					0.01								
PLATICHTHYS FLESUS	0.12												
PLEURONECTES PLATESSA	0.52												
POMATOSCHISTUS MINUTUS	0.01												
SCOMBER SCOMBRUS					0.13	0.01			0.99		0.18		
SEPIOLA					+								
SPRATTUS SPRATTUS	2.02	0.28	0.60			0.21	0.02	0.02	0.08	0.01		0.59	0.69
SYNGNATHUS				+									
SYNGNATHUS TYPHLE				+	+					+			
TRACHINUS DRACO			0.06	0.02	0.38	0.09	0.25	0.01					
TRACHURUS TRACHURUS			0.08	0.01	0.02	0.05	0.13	0.12	0.09	0.09	+	0.24	0.17
TRISOPTERUS MINUTUS				+									
Total	**7.53**	**1.24**	**8.73**	**0.31**	**1.05**	**0.43**	**0.56**	**0.43**	**1.57**	**1.89**	**0.27**	**4.12**	**4.67**
Medusae	33.53	64.40	17.76	41.95	21.78	14.98	15.93	26.10	12.98	4.81	34.56	34.72	15.30

Haul No.	14	15	16	Total
Species / ICES Rectangle	37G1	37G1	37G1	
ALLOTEUTHIS				**+**
APHIA MINUTA				**0.02**
BELONE BELONE				**0.05**
CLUPEA HARENGUS	0.29	0.24	5.42	**17.34**
CRANGON CRANGON				**+**
CTENOLABRUS RUPESTRIS			0.01	**0.01**
ENGRAULIS ENCRASICOLUS	0.04	1.83	1.12	**6.99**
GADUS MORHUA				**0.01**
GASTEROSTEUS ACULEATUS		0.01	0.04	**2.85**
GOBIUS NIGER				**0.02**
LIMANDA LIMANDA			0.11	**5.59**
LOLIGO				**0.01**
LUMPENUS LAMPRETAEFORMIS				**0.02**
MERLANGIUS MERLANGUS		0.01	0.01	**0.72**
MULLUS SURMULETUS				**0.01**
PLATICHTHYS FLESUS			0.37	**0.49**
PLEURONECTES PLATESSA				**0.52**
POMATOSCHISTUS MINUTUS		+		**0.01**
SCOMBER SCOMBRUS				**1.31**
SEPIOLA				**+**
SPRATTUS SPRATTUS	0.03	0.03	6.94	**11.52**
SYNGNATHUS				**+**
SYNGNATHUS TYPHLE				**+**
TRACHINUS DRACO				**0.81**
TRACHURUS TRACHURUS	0.06	0.10	0.36	**1.52**
TRISOPTERUS MINUTUS				**0.00**
Total	**0.42**	**2.22**	**14.38**	**49.82**
Medusae	12.46	17.71	12.79	381.77

+ = < 0.01 kg

Table 4: FRV "Solea" cruise 768/2019: Catch composition (kg 0.5 h^{-1}) by haul in SD 23.

Haul No.	30	31	32	41	Total
Species / ICES Rectangle	40G2	40G2	41G2	41G2	
APHIA MINUTA	0.02	0.00	0.00		**0.02**
CLUPEA HARENGUS	2.00	0.31	0.03	80.66	**83.00**
CRANGON CRANGON		+			**+**
ENGRAULIS ENCRASICOLUS	0.04	0.03		0.02	**0.09**
EUTRIGLA GURNARDUS		0.07		0.42	**0.49**
GADUS MORHUA	15.53	11.24	2.08	7.35	**36.20**
GASTEROSTEUS ACULEATUS	+		+		**+**
LIMANDA LIMANDA			0.03	0.40	**0.43**
LOLIGO	0.03	0.15	0.07	0.03	**0.28**
MELANOGRAMMUS AEGLEFINUS		8.09			**8.09**
MERLANGIUS MERLANGUS	0.11	0.01		1.96	**2.08**
MYSIDACEA		+			**+**
POMATOSCHISTUS MINUTUS	+				**+**
SARDINA PILCHARDUS	0.01			0.01	**0.02**
SCOPHTHALMUS RHOMBUS	0.39			0.21	**0.60**
SEPIOLA		0.02	0.01	0.01	**0.04**
SPRATTUS SPRATTUS	2.16	0.71		4.26	**7.13**
SYMPHODUS MELOPS				0.05	**0.05**
TRACHINUS DRACO	0.02	0.03	0.06	0.01	**0.12**
TRACHURUS TRACHURUS	0.09	0.08	0.02	0.28	**0.47**
Total	**20.40**	**20.74**	**2.30**	**95.67**	**139.11**
Medusae	2.04	1.99	3.45	0.38	**7.86**

+ = < 0.01 kg

Table 5: FRV "Solea" cruise 768/2019: Catch composition (kg 0.5 h^{-1}) by haul in SD 24.

Haul No.	17	18	19	20	21	22	23	24	25	26	27	28	29
Species / ICES Rectangle	37G2	38G2	38G3	38G4	38G3	37G3	38G4	38G2	38G2	38G3	39G4	39G3	39G2
APHIA MINUTA			+					+	+				
CLUPEA HARENGUS	0.13	0.52	2.49	6.95	2.14	5.11	14.13	8.99	2.07	2.63	0.68	14.26	4.69
CRANGON CRANGON			+		+								
CYCLOPTERUS LUMPUS	0.24												
ENGRAULIS ENCRASICOLUS	0.25	0.02	0.07		0.02	+	0.03	0.10	0.04	0.01			
GADUS MORHUA		0.02			3.75	9.27	0.47					7.23	
GASTEROSTEUS ACULEATUS	0.01	+	+					0.18	0.06	0.17	0.01		+
MERLANGIUS MERLANGUS	0.01		10.04		1.61	5.44		0.08	+	0.19		1.55	0.38
PLATICHTHYS FLESUS		0.58	0.83		0.10		0.27		0.35	0.17	0.51		
PLEURONECTES PLATESSA													
POMATOSCHISTUS MINUTUS			0.02		+					+			+
SCOMBER SCOMBRUS			1.05										
SPRATTUS SPRATTUS	0.02		40.36	65.76	4.84	2.06	3.33	0.52	0.07	0.17		9.48	5.83
TRACHURUS TRACHURUS	0.06	0.02	0.01		0.01	0.01	+	0.02	0.02	0.01	0.01		
Total	**0.72**	**1.16**	**54.87**	**72.71**	**12.47**	**21.89**	**18.23**	**9.89**	**2.61**	**3.35**	**1.21**	**32.52**	**10.90**
Medusae	12.22	17.35	12.32	27.58	11.21	3.84	18.03	19.17	4.15	10.77	6.97	3.16	7.36

Haul No.	42	43	44	45	Total
Species / ICES Rectangle	39G4	39G4	39G3	39G2	
APHIA MINUTA			0.01	0.01	**0.02**
CLUPEA HARENGUS	7.96	29.86	10.86	1.15	**114.62**
CRANGON CRANGON		+	+		**+**
CYCLOPTERUS LUMPUS					**0.24**
ENGRAULIS ENCRASICOLUS	0.09		0.02	0.02	**0.67**
GADUS MORHUA	0.30	+	0.42	0.04	**21.50**
GASTEROSTEUS ACULEATUS		+	+	0.09	**0.52**
MERLANGIUS MERLANGUS			1.85		**21.15**
PLATICHTHYS FLESUS		0.17	0.57	0.87	**4.42**
PLEURONECTES PLATESSA			0.30		**0.30**
POMATOSCHISTUS MINUTUS	+	0.03	0.02	+	**0.07**
SCOMBER SCOMBRUS	0.30				**1.35**
SPRATTUS SPRATTUS	0.16	1.26	6.45	0.02	**140.33**
TRACHURUS TRACHURUS	0.01			0.01	**0.19**
Total	**8.82**	**31.32**	**20.50**	**2.21**	**305.38**
Medusae	6.80	0.83	5.15	9.47	**176.37**

+ = < 0.01 kg

Table 6: FRV "Solea", cruise 768/2019. 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	339.8	1.703	215.69	6.28	26.40	13.55	56.94
21	41G1	946.8	84.8	3.339	240.46	45.44	35.14	109.26	84.50
21	41G2	432.3	56.2	1.834	132.47	11.85	50.15	15.69	66.44
21	42G1	884.2	26.5	3.233	72.48	56.18	30.37	40.72	22.01
21	42G2	606.8	93.1	0.526	1074.01	1.50	8.00	16.11	85.92
21	Total	2,978.2			1735.11			195.33	315.81
22	37G0	209.9	107.6	1.518	148.78	20.27	14.86	30.16	22.12
22	37G1	723.3	90.9	0.976	673.65	28.34	58.98	190.90	397.30
22	38G0	735.3	87.8	0.833	775.02	20.03	26.26	155.23	203.53
22	38G1	173.2	93.1	1.472	109.54	60.81	20.95	66.61	22.94
22	39F9	159.3	121.2	0.934	206.71	7.61	6.72	15.74	13.90
22	39G0	201.7	58.5	0.934	126.33	7.61	6.72	9.62	8.49
22	39G1	250.0	96.3	0.288	835.94	0.00	0.22	0.00	1.85
22	40F9	51.3	97.0	1.590	31.30	49.48	10.24	15.49	3.21
22	40G0	538.1	245.0	1.590	829.15	49.48	10.24	410.26	84.93
22	40G1	174.5	185.1	1.230	262.60	2.44	34.15	6.40	89.67
22	41G0	173.1	28.3	2.207	22.20	1.59	0.00	0.35	0.00
22	Total	3,389.7			4021.22			900.76	847.94
23	39G2	130.9	278.5	1.016	358.82	13.72	86.00	49.22	308.58
23	40G2	164.0	230.2	3.417	110.49	13.12	63.32	14.49	69.96
23	41G2	72.3	112.0	2.499	32.40	90.68	7.29	29.38	2.36
23	Total	367.2			501.71			93.09	380.90
24	37G2	192.4	80.4	0.955	161.98	8.96	1.49	14.51	2.42
24	37G3	167.7	199.6	4.300	77.84	34.56	56.09	26.90	43.66
24	37G4	875.1	162.2	2.181	650.81	34.41	65.28	223.91	424.86
24	38G2	832.9	126.8	1.375	768.09	67.57	9.61	519.02	73.83
24	38G3	865.7	274.8	1.771	1343.28	24.00	59.05	322.34	793.27
24	38G4	1034.8	250.0	2.181	1186.15	34.41	65.28	408.10	774.33
24	39G2	406.1	166.7	1.016	666.31	13.72	86.00	91.40	573.02
24	39G3	765.0	152.1	2.581	450.82	42.98	54.79	193.76	247.00
24	39G4	524.8	251.6	3.448	382.95	71.96	6.68	275.58	25.57
24	Total	5,664.5			5,688.23			2075.52	2957.96
22-24	Total	9,421.4			10,211.16			3069.37	4186.80
21-24	Total	12,399.6			11,946.27			3264.70	4502.61

Table 7: FRV "Solea", cruise 768/2019. 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	11.16	1.71	0.23	0.21	0.12	0.11	0.01			13.55
21	41G1	21.38	56.89	14.73	6.94	2.47	5.24	1.60			109.25
21	41G2	8.31	5.34	0.89	0.51	0.13	0.40	0.12			15.70
21	42G1	38.05	2.11	0.08	0.30	0.11	0.06				40.71
21	42G2	2.35	10.64	0.65	0.92	0.34	0.90	0.32			16.12
21	Total	81.25	76.69	16.58	8.88	3.17	6.71	2.05	0.00	0.00	195.33
22	37G0	21.77	7.22		0.37	0.24	0.56				30.16
22	37G1	190.90									190.90
22	38G0	137.41	10.67	1.72	1.24	2.85	0.77	0.57			155.23
22	38G1	62.17	2.64	0.37	0.65	0.41		0.37			66.61
22	39F9	8.66	3.33	0.98	2.14	0.52	0.10				15.73
22	39G0	5.29	2.04	0.60	1.31	0.32	0.06				9.62
22	39G1										0.00
22	40F9	14.41	0.95		0.03	0.01	0.08				15.48
22	40G0	381.77	25.15		0.79	0.31	2.25				410.27
22	40G1	6.40									6.40
22	41G0		0.30		0.02		0.02				0.34
22	Total	828.78	52.30	3.67	6.55	4.66	3.84	0.94	0.00	0.00	900.74
23	39G2	30.69	2.37	3.53	2.51	2.67	5.85	0.90	0.60	0.09	49.21
23	40G2	11.19	2.44	0.41	0.13	0.16	0.09			0.06	14.48
23	41G2	19.06	7.39	1.44	0.47	0.56	0.46				29.38
23	Total	60.94	12.20	5.38	3.11	3.39	6.40	0.90	0.60	0.15	93.07
24	37G2	9.67	0.81	0.48	0.97	0.48	1.61	0.48			14.50
24	37G3	5.73	1.29	4.44	3.56	3.09	5.71	1.80	0.82	0.45	26.89
24	37G4	69.58	20.20	28.74	25.15	24.37	42.64	7.19	4.82	1.24	223.93
24	38G2	376.21	26.93	22.87	21.00	23.24	41.23	3.12	4.40	0.04	519.04
24	38G3	190.53	13.85	25.57	17.61	21.70	41.12	5.56	5.06	1.34	322.34
24	38G4	126.81	36.82	52.39	45.83	44.42	77.71	13.10	8.78	2.25	408.11
24	39G2	57.00	4.41	6.56	4.66	4.96	10.86	1.68	1.11	0.16	91.40
24	39G3	70.08	11.52	25.70	17.91	19.06	39.06	5.59	4.01	0.83	193.76
24	39G4	15.31	12.40	46.16	41.49	46.19	70.53	27.01	10.94	5.54	275.57
24	Total	920.92	128.23	212.91	178.18	187.51	330.47	65.53	39.94	11.85	2 075.54
22-24	Total	1 810.64	192.73	221.96	187.84	195.56	340.71	67.37	40.54	12.00	3 069.35
21-24	Total	1 891.89	269.42	238.54	196.72	198.73	347.42	69.42	40.54	12.00	3 264.68

Table 8: FRV "Solea", cruise 768/2019. 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	23.60	40.19	56.50	41.37	36.85	46.03	45.79			26.84
21	41G1	22.78	47.55	67.23	68.49	85.25	69.22	88.90			49.18
21	41G2	21.69	44.95	58.01	49.15	37.05	46.35	45.79			33.49
21	42G1	21.93	35.06	33.80	30.38	34.74	40.22				22.76
21	42G2	32.80	42.11	39.10	40.27	32.80	44.99	45.79			40.56
21	Total	22.67	46.11	65.32	62.53	74.06	63.97	79.44			40.15
22	37G0	19.09	35.26		36.07	34.47	36.46				23.61
22	37G1	10.20									10.20
22	38G0	7.69	39.61	55.50	54.90	50.61	40.61	53.50			11.91
22	38G1	13.07	39.10	53.50	58.08	53.46	0.00	53.50			15.24
22	39F9	9.31	43.23	71.00	66.81	65.67	38.94				30.21
22	39G0	9.31	43.23	71.00	66.81	65.67	38.94				30.24
22	39G1										0.00
22	40F9	17.10	36.98		37.19	34.47	38.69				18.48
22	40G0	17.10	36.98		37.19	34.47	38.69				18.49
22	40G1	18.42									18.42
22	41G0		38.94		38.94	0.00	38.94				38.94
22	Total	13.58	38.04	61.97	58.16	51.64	38.76	53.50			15.87
23	39G2	14.48	33.34	41.48	39.20	39.35	40.55	49.87	45.42	59.30	24.14
23	40G2	10.69	40.10	41.78	43.82	41.22	36.89			61.00	17.53
23	41G2	17.49	39.43	42.92	43.00	41.16	37.89				25.43
23	Total	14.73	38.38	41.89	39.97	39.74	40.31	49.87	45.42	59.98	23.52
24	37G2	11.79	32.89	37.88	42.87	42.87	41.87	42.87			21.31
24	37G3	9.07	34.37	52.95	54.79	52.99	46.22	62.20	57.02	70.50	42.56
24	37G4	13.77	33.37	42.11	41.37	40.84	40.55	66.41	45.88	63.18	32.98
24	38G2	9.42	33.59	34.90	33.42	35.19	36.32	36.58	37.55	64.05	16.46
24	38G3	11.04	33.63	43.37	41.62	42.69	40.97	55.21	46.96	70.94	23.77
24	38G4	13.77	33.37	42.11	41.37	40.84	40.55	66.41	45.88	63.18	32.97
24	39G2	14.48	33.34	41.48	39.20	39.35	40.55	49.87	45.42	59.30	24.14
24	39G3	15.96	33.35	44.11	41.84	42.24	42.23	57.01	48.27	61.01	33.05
24	39G4	16.64	34.57	52.86	64.14	73.48	68.36	110.97	70.81	75.03	66.00
24	Total	11.64	33.56	44.26	46.03	48.70	46.31	80.89	52.38	69.67	31.46
22-24	Total	12.63	35.08	44.49	46.35	48.62	46.11	80.10	52.28	69.55	26.64
21-24	Total	13.06	38.22	45.94	47.08	49.02	46.46	80.08	52.28	69.55	27.45

Table 9: FRV "Solea", cruise 768/2019. 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	263.4	68.7	13.0	8.7	4.4	5.1	0.5			363.7
21	41G1	487.0	2 705.1	990.3	475.3	210.6	362.7	142.2			5 373.3
21	41G2	180.2	240.0	51.6	25.1	4.8	18.5	5.5			525.8
21	42G1	834.4	74.0	2.7	9.1	3.8	2.4				926.5
21	42G2	77.1	448.1	25.4	37.1	11.2	40.5	14.7			653.9
21	Total	1 842.2	3 535.9	1 083.1	555.2	234.8	429.2	162.8	0.0	0.0	7 843.2
22	37G0	415.6	254.6		13.4	8.3	20.4				712.2
22	37G1	1 947.2									1 947.2
22	38G0	1 056.7	422.6	95.5	68.1	144.2	31.3	30.5			1 848.9
22	38G1	812.6	103.2	19.8	37.8	21.9		19.8			1 015.0
22	39F9	80.6	144.0	69.6	143.0	34.2	3.9				475.2
22	39G0	49.3	88.2	42.6	87.5	21.0	2.3				290.9
22	39G1										0.0
22	40F9	246.4	35.1		1.1	0.3	3.1				286.1
22	40G0	6 528.3	930.1		29.4	10.7	87.1				7 585.4
22	40G1	117.9									117.9
22	41G0		11.7		0.8		0.8				13.2
22	Total	11 254.5	1 989.5	227.4	381.0	240.6	148.9	50.28	0.00	0.0	14 292.0
23	39G2	444.4	79.0	146.4	98.4	105.1	237.2	44.9	27.25	5.3	1 188.0
23	40G2	119.6	97.8	17.1	5.7	6.6	3.3			3.7	253.9
23	41G2	333.4	291.4	61.8	20.2	23.1	17.4				747.2
23	Total	897.4	468.3	225.4	124.3	134.7	258.0	44.9	27.3	9.0	2 189.1
24	37G2	114.0	26.6	18.2	41.6	20.6	67.4	20.6			309.0
24	37G3	52.0	44.3	235.1	195.1	163.7	263.9	112.0	46.8	31.7	1 144.6
24	37G4	958.1	674.1	1 210.2	1 040.5	995.3	1 729.1	477.5	221.1	78.3	7 384.2
24	38G2	3 543.9	904.6	798.2	701.8	817.8	1 497.5	114.1	165.2	2.6	8 545.7
24	38G3	2 103.5	465.8	1 109.0	732.9	926.4	1 684.7	307.0	237.6	95.1	7 661.8
24	38G4	1 746.2	1 228.7	2 206.1	1 896.0	1 814.1	3 151.1	870.0	402.8	142.2	13 457.2
24	39G2	825.4	147.0	272.1	182.7	195.2	440.4	83.8	50.4	9.5	2 206.4
24	39G3	1 118.5	384.2	1 133.6	749.4	805.1	1 649.5	318.7	193.6	50.6	6 403.1
24	39G4	254.8	428.7	2 440.0	2 661.2	3 394.0	4 821.4	2 997.3	774.7	415.7	18 187.7
24	Total	10 716.2	4 304.0	9 422.6	8 201.0	9 132.2	15 305.0	5 300.9	2 092.2	825.7	65 299.7
22-24	Total	22 868.0	6 761.7	9 875.3	8 706.3	9 507.5	15 711.8	5 396.0	2 119.5	834.7	81 780.8
21-24	Total	24 710.2	10 297.6	10 958.4	9 261.5	9 742.3	16 141.0	5 558.9	2 119.5	834.7	89 624.0

Table 10: FRV "Solea", cruise 768/2019. Numbers (millions) of sprat by age and area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total
21	41G0		25.17	24.71	5.10	1.92		0.03			56.93
21	41G1		27.33	41.41	8.52	7.00		0.23			84.49
21	41G2		28.27	29.20	5.75	3.10		0.12			66.44
21	42G1		3.76	11.45	3.46	3.18		0.17			22.02
21	42G2		37.58	39.23	7.85	1.26					85.92
21	Total	0.00	122.11	146.00	30.68	16.46	0.00	0.55	0.00	0.00	315.80
22	37G0	0.67	4.81	9.39	3.36	3.29	0.60				22.12
22	37G1	395.81	1.49								397.30
22	38G0	84.79	53.66	38.99	12.28	10.94	2.87				203.53
22	38G1	12.58	2.24	5.02	1.37	1.51	0.22				22.94
22	39F9	5.79	1.07	4.19	1.24	1.26	0.35				13.90
22	39G0	3.54	0.65	2.56	0.76	0.77	0.21				8.49
22	39G1	1.85									1.85
22	40F9	1.95	0.92	0.21	0.07	0.05	0.01				3.21
22	40G0	51.70	24.42	5.44	1.94	1.22	0.22				84.94
22	40G1	8.72	44.17	21.92	7.23	6.66	0.96				89.66
22	41G0										0.00
22	Total	567.40	133.43	87.72	28.25	25.70	5.44	0.00	0.00	0.00	847.94
23	39G2	289.70	8.78	3.02	3.21	2.88	0.90	0.10			308.59
23	40G2	68.20	0.82	0.53	0.19	0.13	0.06	0.02	0.01		69.96
23	41G2	0.10	0.59	0.77	0.44	0.25	0.10	0.07	0.04	0.01	2.37
23	Total	358.00	10.19	4.32	3.84	3.26	1.06	0.19	0.05	0.01	380.92
24	37G2			0.36	0.85	1.21					2.42
24	37G3	13.73	15.71	4.41	4.41	4.33	1.02	0.05			43.66
24	37G4	13.28	50.48	68.27	115.61	132.47	32.35	9.57	2.84		424.87
24	38G2	72.11	0.63	0.33	0.39	0.22	0.14	0.02			73.84
24	38G3	92.53	362.59	97.43	109.05	101.10	26.62	3.80	0.14		793.26
24	38G4	24.21	92.00	124.42	210.70	241.43	58.96	17.44	5.18		774.34
24	39G2	537.95	16.30	5.60	5.96	5.35	1.66	0.19			573.01
24	39G3		24.18	40.43	72.69	82.24	19.99	6.41	1.06		247.00
24	39G4	0.30	3.84	3.99	6.63	7.48	2.36	0.80	0.17		25.57
24	Total	754.11	565.73	345.24	526.29	575.83	143.10	38.28	9.39	0.00	2,957.97
22-24	Total	1,679.51	709.35	437.28	558.38	604.79	149.60	38.47	9.44	0.01	4,186.83
21-24	Total	1,679.51	831.46	583.28	589.06	621.25	149.60	39.02	9.44	0.01	4,502.63

Table 11: FRV "Solea", cruise 768/2019. 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		14.89	17.50	18.20	20.25		22.73			16.51
21	41G1		15.28	18.42	19.30	20.85		22.73			17.71
21	41G2		14.86	17.80	19.06	21.07		22.73			16.82
21	42G1		15.28	19.69	20.68	22.02		22.73			19.45
21	42G2		15.76	16.95	17.47	19.81					16.52
21	Total		15.25	17.84	18.76	20.97		22.73			17.10
22	37G0	4.96	15.66	18.30	18.44	18.78	18.43				17.42
22	37G1	6.09	9.11								6.10
22	38G0	5.25	14.05	17.08	17.36	17.88	18.96				11.44
22	38G1	5.99	15.83	17.63	18.09	18.11	18.43				11.14
22	39F9	3.07	17.61	17.87	18.17	18.00	18.15				11.73
22	39G0	3.07	17.61	17.87	18.17	18.00	18.15				11.73
22	39G1	3.98									3.98
22	40F9	6.69	13.47	16.19	17.17	17.94	18.99				9.68
22	40G0	6.69	13.47	16.19	17.17	17.94	18.99				9.68
22	40G1	9.37	12.39	17.28	18.56	19.07	18.99				14.35
22	41G0										
22	Total	6.01	13.47	17.30	17.87	18.33	18.80				9.20
23	39G2	4.44	10.4	13.93	14.69	14.68	14.65	16.91			4.94
23	40G2	5.03	12.59	15.73	18.03	20.71	23.00	21.15	18.89		5.28
23	41G2	5.28	14.17	16.36	18.69	19.88	22.93	22.29	21.60	24.71	16.74
23	Total	4.55	10.79	14.58	15.31	15.32	15.90	19.34	21.06	24.71	5.08
24	37G2			15.74	15.74	15.74					15.74
24	37G3	5.06	11.59	13.37	13.99	13.98	14.30	17.45			10.27
24	37G4	6.67	12.15	15.18	15.94	16.38	16.60	17.80	20.78		15.34
24	38G2	5.34	7.34	15.10	15.20	15.77	15.06	16.91			5.50
24	38G3	5.66	11.17	13.62	14.47	14.75	15.01	17.43	19.70		11.90
24	38G4	6.67	12.15	15.18	15.94	16.38	16.60	17.80	20.78		15.34
24	39G2	4.44	10.40	13.93	14.69	14.68	14.65	16.91			4.94
24	39G3		12.16	15.26	16.06	16.41	16.74	17.85	19.70		15.78
24	39G4	5.11	11.48	15.12	16.29	16.78	16.92	17.83	19.70		15.53
24	Total	4.80	11.45	14.71	15.63	16.07	16.29	17.77	20.62		12.12
22-24	Total	5.15	11.82	15.23	15.74	16.16	16.38	17.77	20.66	24.71	10.89
21-24	Total	5.15	12.32	15.88	15.90	16.29	16.38	17.84	20.66	24.71	11.32

Table 12: FRV "Solea", cruise 768/2019. 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		374.9	432.5	92.8	38.9		0.7			939.9
21	41G1		417.6	762.9	164.3	146.1		5.3			1,496.2
21	41G2		420.1	519.6	109.7	65.4		2.7			1,117.5
21	42G1		57.4	225.4	71.5	70.1		3.8			428.1
21	42G2		592.3	665.0	137.2	25.0					1,419.5
21	Total	0.0	1,862.2	2,605.4	575.5	345.5	0.0	12.6	0.0	0.0	5,401.1
22	37G0	3.3	75.3	171.9	61.9	61.8	11.1				385.3
22	37G1	2,410.0	13.6								2,423.6
22	38G0	445.3	753.7	666.1	213.1	195.6	54.5				2,328.3
22	38G1	75.3	35.4	88.4	24.8	27.4	4.1				255.4
22	39F9	17.8	18.8	74.9	22.5	22.7	6.3				163.0
22	39G0	10.9	11.5	45.8	13.7	13.9	3.9				99.6
22	39G1	7.4									7.4
22	40F9	13.1	12.4	3.3	1.3	0.8	0.2				31.1
22	40G0	346.0	329.0	88.0	33.4	21.8	4.1				822.3
22	40G1	81.7	547.1	378.8	134.3	127.1	18.2				1,287.1
22	41G0										0.0
22	Total	3,410.6	1,796.8	1,517.2	505.0	471.1	102.4	0.0	0.0	0.0	7,803.0
23	39G2	1,285.4	91.3	42.0	47.1	42.3	13.1	1.7			1,523.0
23	40G2	342.9	10.4	8.3	3.4	2.6	1.3	0.5	0.3		369.6
23	41G2	0.5	8.3	12.6	8.1	5.0	2.3	1.5	0.9	0.2	39.5
23	Total	1,628.7	110.0	63.0	58.7	50.0	16.7	3.7	1.2	0.2	1,932.2
24	37G2			5.7	13.3	19.0					38.1
24	37G3	69.5	182.1	58.9	61.7	60.6	14.6	0.9	0.0		448.3
24	37G4	88.6	613.4	1,036.6	1,843.3	2,169.4	537.1	170.2	59.1		6,517.6
24	38G2	384.9	4.6	4.9	6.0	3.5	2.1	0.3			406.3
24	38G3	524.0	4,049.3	1,327.3	1,577.7	1,491.5	399.5	66.3	2.8		9,438.4
24	38G4	161.5	1,117.9	1,889.2	3,359.6	3,953.8	978.8	310.3	107.7		11,878.6
24	39G2	2,386.9	169.6	78.1	87.5	78.6	24.4	3.2			2,828.2
24	39G3		294.1	617.2	1,167.1	1,349.5	334.5	114.3	21.0		3,897.7
24	39G4	1.5	44.2	60.3	108.0	125.5	39.9	14.3	3.4		397.0
24	Total	3,616.9	6,475.1	5,078.1	8,224.2	9,251.4	2,330.8	679.9	193.9	0.0	35,850.1
22-24	Total	8,656.3	8,381.9	6,658.3	8,787.9	9,772.4	2,449.9	683.5	195.1	0.2	45,585.3
21-24	Total	8,656.3	10,244.1	9,263.7	9,363.4	10,117.9	2,449.9	696.1	195.1	0.2	50,986.5

Table 13: FRV "Solea", cruise 768/2019. Numbers (m) of herring excl. CBH in SDs 21-24 by age/W-rings & area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total	
21	41G0	11.16	1.71	0.17	0.05						13.09	
21	41G1	21.38	56.89	14.23	4.14	1.33	0.78	0.52			99.27	
21	41G2	8.31	5.34	0.82	0.14						14.61	**excl. CBH**
21	42G1	38.05	2.11								40.16	
21	42G2	2.35	10.64	0.32							13.30	
21	Total	81.25	76.68	15.53	4.33	1.33	0.78	0.52	0.00	0.00	180.42	
22	37G0	21.77	7.22								28.99	
22	37G1	190.90									190.90	
22	38G0	137.42	10.67	1.72	0.77						150.57	
22	38G1	62.17	2.64	0.37	0.49						65.68	
22	39F9	8.66	3.33	0.98	2.03						15.01	
22	39G0	5.29	2.04	0.60	1.24						9.17	**excl. CBH**
22	39G1										0.00	
22	40F9	14.42	0.95								15.36	
22	40G0	381.82	25.10								406.92	
22	40G1	6.40									6.40	
22	41G0		0.30								0.30	
22	Total	828.85	52.25	3.68	4.53	0.00	0.00	0.00	0.00	0.00	889.31	
23	39G2	30.69	2.37	1.80	0.27	0.09					35.22	
23	40G2	11.19	2.44	0.16	0.04						13.83	**excl. CBH**
23	41G2	19.06	7.39	0.78	0.11						27.34	
23	Total	60.94	12.21	2.73	0.42	0.09	0.00	0.00	0.00	0.00	76.39	
24	37G2	9.67	0.81	0.16							10.64	
24	37G3	5.73	1.29	3.66	1.64	0.61	0.12	0.20			13.25	
24	37G4	69.58	20.20	13.21	4.42	1.31	0.50	0.91			110.13	
24	38G2	376.21	26.93	4.10	0.34						407.58	
24	38G3	190.53	13.85	15.14	2.12	1.85	0.31	0.34		0.16	224.30	**excl. CBH**
24	38G4	126.81	36.82	24.08	8.05	2.40	0.90	1.66			200.72	
24	39G2	57.00	4.41	3.35	0.51	0.16					65.43	
24	39G3	70.08	11.52	16.80	3.57	0.64	0.31	0.33	0.10	0.03	103.38	
24	39G4	15.31	12.40	37.38	23.85	17.77	15.19	13.95	1.44	0.41	137.70	
24	Total	920.92	128.23	117.88	44.50	24.74	17.33	17.39	1.54	0.60	1,273.13	
22-24	Total	1,810.70	192.68	124.29	49.46	24.83	17.33	17.39	1.54	0.60	2,238.83	
21-24	Total	1,891.96	269.36	139.82	53.79	26.16	18.11	17.91	1.54	0.60	2,419.25	

Table 14: FRV "Solea", cruise 768/2019. Mean weight (g) of herring excl. CBH in SDs 21-24 by age/W-rings & area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total	
21	41G0	22.98	39.51	63.28	67.12						25.82	
21	41G1	22.30	46.64	66.64	83.24	124.92	180.70	179.85			48.59	
21	41G2	21.20	44.11	58.40	62.67						32.06	excl. CBH
21	42G1	21.37	34.66								22.07	
21	42G2	32.77	41.64	44.77							40.15	
21	Total	22.15	45.28	65.73	82.37	124.92	180.70	179.85			39.08	
22	37G0	18.28	35.66								22.61	
22	37G1	9.86									9.86	
22	38G0	7.40	39.36	61.33	69.50						10.60	
22	38G1	12.69	39.92	54.00	69.50						14.44	
22	39F9	8.90	42.17	69.50	69.50						28.47	
22	39G0	8.90	42.17	69.50	69.50						28.47	excl. CBH
22	39G1											
22	40F9	16.26	36.73								17.52	
22	40G0	16.26	36.73								17.52	
22	40G1	17.40									17.40	
22	41G0		38.38								38.38	
22	Total	12.98	37.85	64.12	69.50						14.94	
23	39G2	14.54	35.63	50.08	68.48	74.13					18.34	
23	40G2	10.42	40.46	50.55	56.89						16.32	excl. CBH
23	41G2	17.33	39.83	49.34	56.80						24.48	
23	Total	14.66	39.14	49.90	64.25	74.13					20.17	
24	37G2	11.57	35.80	48.00							13.96	
24	37G3	8.89	37.00	56.78	68.64	83.60	90.83	96.20			37.75	
24	37G4	13.79	35.72	53.14	69.98	89.45	137.08	172.95			27.56	
24	38G2	9.26	36.04	43.73	60.89						11.42	
24	38G3	10.92	36.01	50.41	76.44	86.26	89.66	92.33		100.33	16.67	excl. CBH
24	38G4	13.79	35.72	53.14	69.98	89.45	137.08	172.95			27.56	
24	39G2	14.54	35.63	50.08	68.48	74.13					18.35	
24	39G3	15.96	35.62	50.02	64.56	85.35	117.30	147.76	175.75	100.33	26.70	
24	39G4	16.58	36.99	56.99	80.48	117.41	151.20	158.55	168.18	100.33	84.53	
24	Total	11.55	35.94	53.26	75.34	108.94	147.93	158.46	168.67	100.33	26.09	
22-24	Total	12.31	36.66	53.50	74.71	108.82	147.93	158.46	168.67	100.33	21.46	
21-24	Total	12.73	39.12	54.86	75.33	109.64	149.34	159.08	168.67	100.33	22.77	

Table 15: FRV "Solea", cruise 768/2018. Total biomass (t) of herring excl. CBH in SDs 21-24 by age/W-rings & area.

Sub-division	Rectangle/ W-rings	0	1	2	3	4	5	6	7	8+	Total	
21	41G0	256.6	67.5	10.5	3.4						338.0	
21	41G1	476.7	2,653.3	948.4	344.3	166.7	140.7	93.8			4,823.7	
21	41G2	176.1	235.5	47.6	9.0						468.2	excl. CBH
21	42G1	813.1	73.0								886.1	
21	42G2	77.0	443.0	14.1							534.1	
21	Total	1,799.5	3,472.3	1,020.6	356.6	166.7	140.7	93.8	0.0	0.0	7,050.1	
22	37G0	397.9	257.5								655.5	
22	37G1	1,881.5									1,881.5	
22	38G0	1,016.8	419.8	105.7	53.2						1,595.5	
22	38G1	788.9	105.4	20.0	34.3						948.5	
22	39F9	77.1	140.5	68.4	141.3						427.3	
22	39G0	47.1	85.9	41.8	86.4						261.1	excl. CBH
22	39G1										0.0	
22	40F9	234.4	34.8								269.2	
22	40G0	6,207.1	921.9								7,129.0	
22	40G1	111.4									111.4	
22	41G0		11.6								11.6	
22	Total	10,762.1	1,977.5	235.8	315.16	0.0	0.0	0.00	0.00	0.0	13,290.6	
23	39G2	446.2	84.4	90.1	18.5	6.7					646.0	
23	40G2	116.6	98.9	7.8	2.5						225.8	excl. CBH
23	41G2	330.3	294.4	38.3	6.3						669.2	
23	Total	893.1	477.7	136.3	27.2	6.7	0.0	0.0	0.0	0.0	1,541.0	
24	37G2	111.9	29.0	7.7							148.6	
24	37G3	50.9	47.7	207.8	112.6	51.0	10.9	19.2			500.2	
24	37G4	959.5	721.5	702.0	309.3	117.2	68.5	157.4			3,035.4	
24	38G2	3,483.7	970.6	179.3	20.7						4,654.3	
24	38G3	2,080.6	498.7	763.2	162.1	159.6	27.8	31.4		16.1	3,739.4	excl. CBH
24	38G4	1,748.7	1,315.2	1,279.6	563.3	214.7	123.4	287.1			5,532.0	
24	39G2	828.8	157.1	167.8	34.9	11.9					1,200.5	
24	39G3	1,118.5	410.3	840.3	230.5	54.6	36.4	48.8	17.6	3.0	2,760.0	
24	39G4	253.8	458.7	2,130.3	1,919.5	2,086.4	2,296.7	2,211.8	242.2	41.1	11,640.5	
24	Total	10,636.4	4,608.9	6,278.0	3,352.8	2,695.3	2,563.7	2,755.6	259.8	60.2	33,210.8	
22-24	Total	22,291.6	7,064.2	6,650.1	3,695.2	2,702.0	2,563.7	2,755.6	259.8	60.2	48,042.4	
21-24	Total	24,091.1	10,536.5	7,670.7	4,051.8	2,868.7	2,704.3	2,849.5	259.8	60.2	55,092.5	

Annex 8: 2019 ISAS Survey Summary Table and Survey Report

Document 8a: ISAS 2019 survey summary table

Survey Summary table WGIPS 2020	
Name of the survey (abbreviation):	**Irish Sea Acoustic Survey (ISAS)**
Target Species:	**Herring**
Survey dates:	**28th August – 13th September 2019**
Summary:	
The survey started on the peripheral Irish Sea transects to the west of the Solway Firth at 05:15 on the 28th August and continued to completion on 13th September. Sea conditions were variable during the survey; adverse weather between the 29th and 31th Aug. and 09th and 11th Sept. resulted and in temporary cessations of the survey. Targets were identified by aimed midwater trawls, 30 successful tows were completed in 2019, which is consistant with fishing intensity for survey over time series. Trawling intensity provides good confidence in school recognition and supporting biological data for age stratified abundance estimation of target species (herring and sprat). Herring was fairly widely distributed within mixed schools at low abundance throughout the Irish Sea area, and within fewer localised high abundance schools. The bulk of 1+ herring targets in 2019 were observed west of the Isle of Man and off the Mull of Galloway on the Scottish coast. Cohorts, ages 0 -9 are visible within the survey. The major contribution of age to the total estimates in the 2019 survey is from age 1 accounting for 47% of total estimates by number. It is perceived that the pervelance of 0gp and 1 year old emerging year classes (~28% age 0, 47% age 1) will recruit to the SSB over the next 1-2 years.	

	Description
Survey design	The survey design of systematic, parallel transects covers approximately 620 nm. 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 and transect spacing is reduced to 2 nm in strata around the Isle of Man to improve precision of estimates of adult herring biomass. Survey design and methodology adheres to the methods laid out in the WGIPS acoustic survey manual.

Index Calculation method	Weighted mean TS is applied to the NASC value to give numbers per square nautical mile – further decomposed by age class according to length frequencies in relevant target identified trawls and survey age-length key.
Random/systematic error issues	NA
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	Sea conditions were variable during the survey; particularly poor weather between the 29th and 31th Aug. and 09th and 11th Sept. resulted and in temporary cessations of the survey in order to eliminate potential sweep down.
Extinction (shadowing)	No perceived issues. Majority of target schools in mid to lower water column. For schools on or just above sea bed, negligible affects discerned.
Blind zone	Sub surface zone of 8 m applied. Majority of target schools in survey within mid to lower water column.
Dead zone	NA
Allocation of backscatter to species	Directed trawling, with 30 successful trawls completed during the course of this survey.
Target strength	Herring, sprat and horse mackerel: TS = 20log(L) -71.2 db Mackerel: TS = 20log(L) -84.9 db Gadoids: TS = 20log(L) -67.5 db
Calibration	The hull mounted Simrad EK60 acoustic system with 38 kHz split-beam was calibrated on the 27th August off Laxey on the east coast of the Isle of Man. Conditions were good and results within parameters.
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	Time series: Complete coverage 2019 survey: Complete coverage
Stock ID and mixing issues	Time series: Winter hatched fish, of which the majority are thought to be of Celtic Sea origin, are present in the pre-spawning aggrega-

	tions sampled in the Irish Sea during the acoustic survey. The presence of these winter hatched fish has implications for the estimates of 1-ringer+ biomass and SSB 2019 survey: No additional issues
Measures of uncertainty (CV)	CV of biomass and numbers at age
Biological sampling	2019 Survey: The biological sampling is deamed to be appropriate for the stock and area. Sampling is in line with historic levels. Biological samples are not available at the time of WGIPS to update biological data. Ages (age-length-key) and maturity data for 2018 are used for initial biomass estimates and population age structure.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

Document 8b: ISAS 2019 survey report

Please see the report on the next page.

Survey report for RV Corystes

26th August – 13th September 2019

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

Gavin McNeill (SIC)
Peter McCorriston
Ian McCausland
Jim McArdle
Gary Heaney
Jessica Graham
Gary Littler

2.2 Narrative

The vessel departed Belfast at 22:00 on the 26th August and proceeded to the east coast of the Isle of Man for acoustic calibration off Laxey on the 27th August. The survey started on the peripheral Irish Sea transects to the west of the Solway Firth at 05:15 on the 28th August and continued to the completion of transect 108 off Liverpool Bay on the 29st August. A tempory break in the survey followed due to bad wather, during this time, the ship made way to the northeast of the Isle of Man and awaited recommencement of the survey at the start of transect 1 on the 31st August at 12:00 and end on transect 81 to the northwest of the Mull of Galloway 03rd Sept. A mid cruise break to facilitate crew and scientific staff changes took place overnight on the 4th Sept. The survey recommenced 5th Sept at 12:00 on the western Irish Sea peripheral transects working south along the Northern Ireland coast, additional survey transects in the vicinity of Rig Bank and Slieve Na Griddle were conducted on 05th and 6th Sept. respectively. The final set of transects for the first phase of the survey ended on transect 107 on 09th Sept and a further set of transects around the Isle of Man were conducted. Sea conditions were variable during the survey; particularly poor weather between the 29th and 31th Aug. and 09th and 11th Sept. resulted and in temporary cessations of the survey.

2.3 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 27th 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 2019 survey with 30 successful trawls completed Figure 5B.2. Table 5B.2 gives the positions, catch composition and mean length by species for these trawl hauls. Thirty-one hauls contained herring to be used in the analysis. The length frequency distributions of these hauls are illustrated in Figure 5B.3. 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 $W = 0.00234 *L^{3.383}$ (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). Age-length key for herring (Table 5B.3) from which otoliths were removed at sea during the Irish Sea 2018 survey have been included in this report as otoliths from the 2019 survey are still being analyised. Age-length data will be updated for the 2019 survey upon completion of their analysis.

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.4. The highest abundance of herring was to the west of the Isle of Man and off the Mull of Galloway on the Scottish coast.

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 ~28% age 0, 47% age 1, ~13% age 2, ~4% age 3, ~6% age 4 and 2% age 5+.

4. DISCUSSION

The herring stock estimate in the survey area (Irish Sea/North Channel) was estimated to be 68,789t The major contribution of ages to the total estimates is from age 1 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 bulk of 1+ herring targets in 2019 were observed west of the Isle of Man and off the Mull of Galloway on the Scottish coast (western side of stratum 7 and southern end stratum 2 respectively; Figure 5B.1), 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.3). The estimate of herring SSB of 34,500t is within the observed range for the time series and the biomass estimate of 64,840t for 1+ ringers for 2019 also remains within the observed range since 2011. Whilst herring 1+ ringers biomass estimates are higher than observed in 2018, the herring SSB estimates are comparatively lower in the 2019 survey. The survey estimates are influenced by the timing of the spawning migration. The highest proportion of the 1+ biomass estimates were to the west of the Isle of Man (strata 7), and northwest of the Isle of Man, south of the Mull of Galloway (strata 2) which is indicative of a later migration into the Irish Sea.

Sprat and 0-group herring were distributed around the periphery of the Irish Sea, with the most abundance of 0-group herring in the eastern side and in areas along the northern Irish coast to the west.

Results of a successive acoustic survey conducted later in September confirmed similar biomass estimates to the main acoustic survey and to those observed in the last few years. The survey results are within the rage of what has been observed historically.

TABLES AND FIGURES

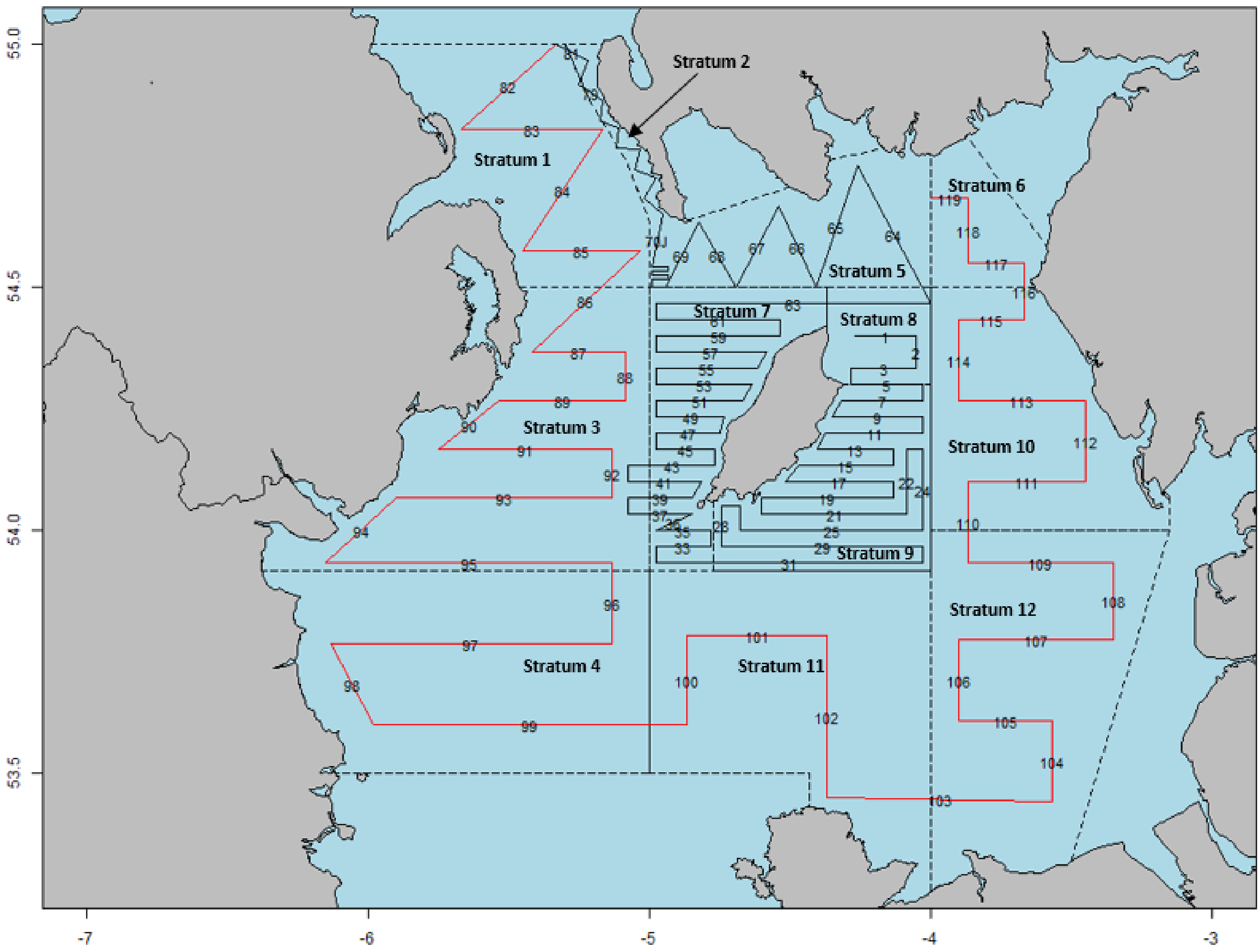


Figure 5B.1: Acoustic survey tracks for the 2019 Irish Sea acoustic survey. Survey design of systematic, parallel transects covers approximately 620 nm

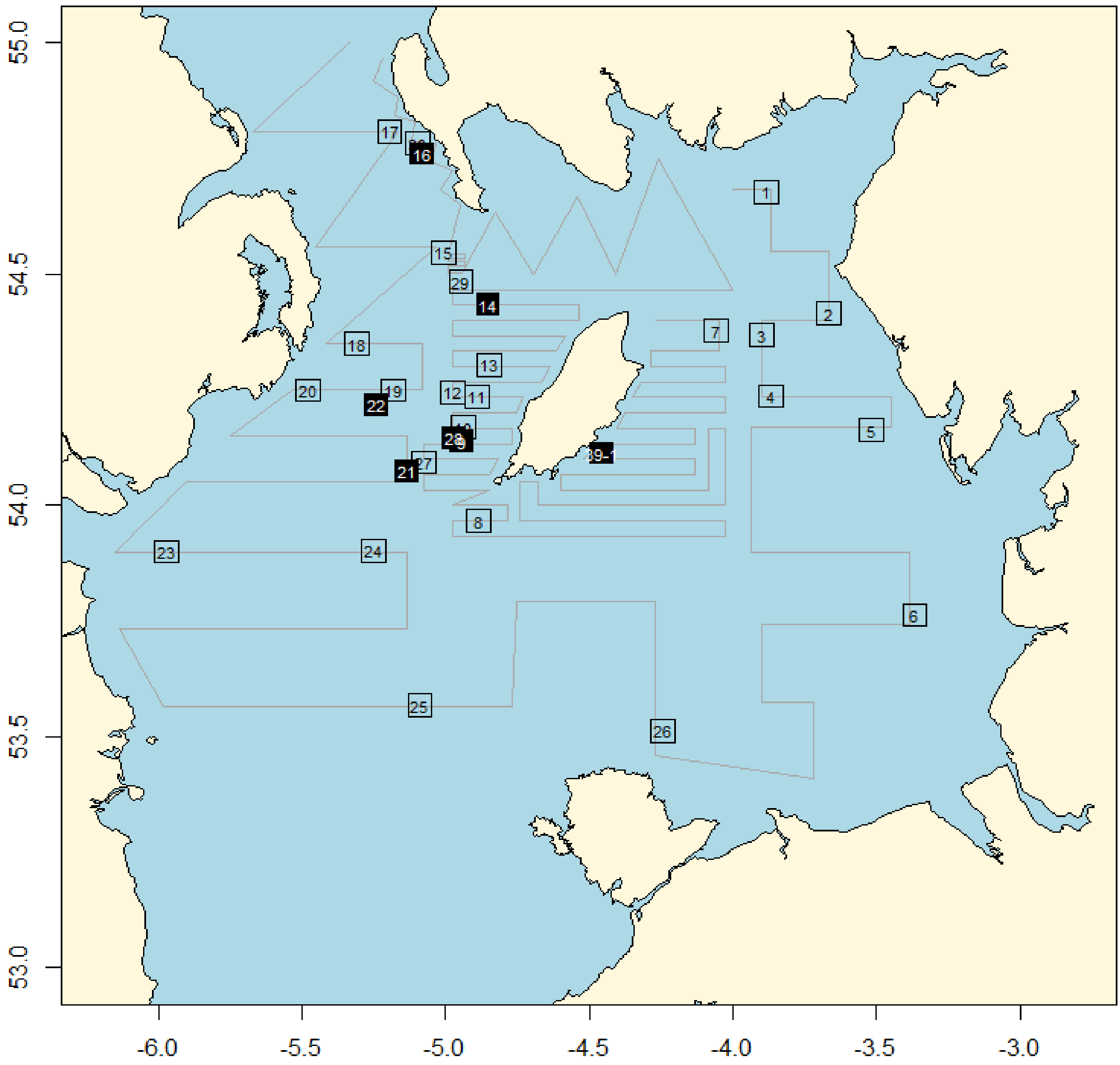
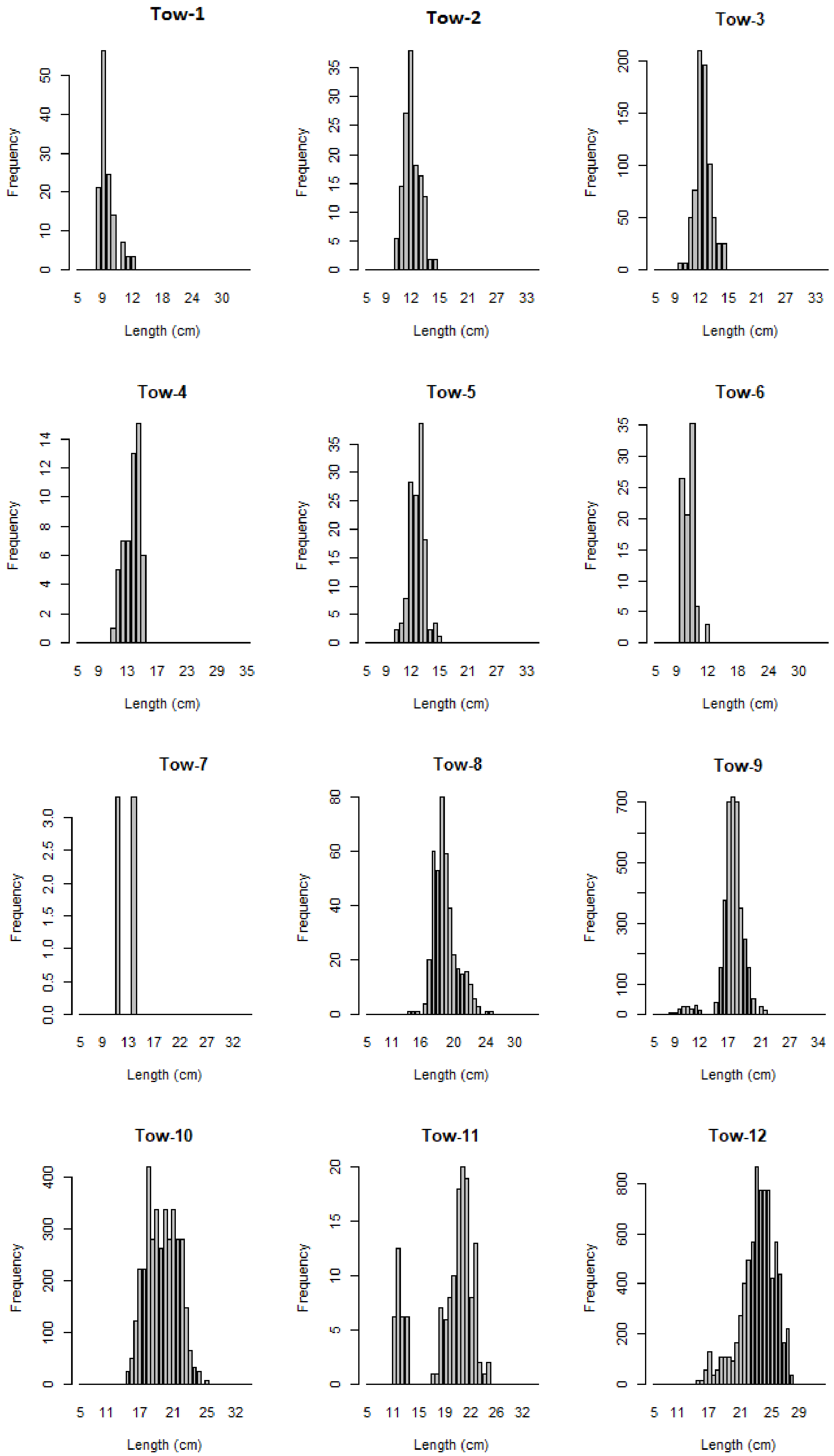
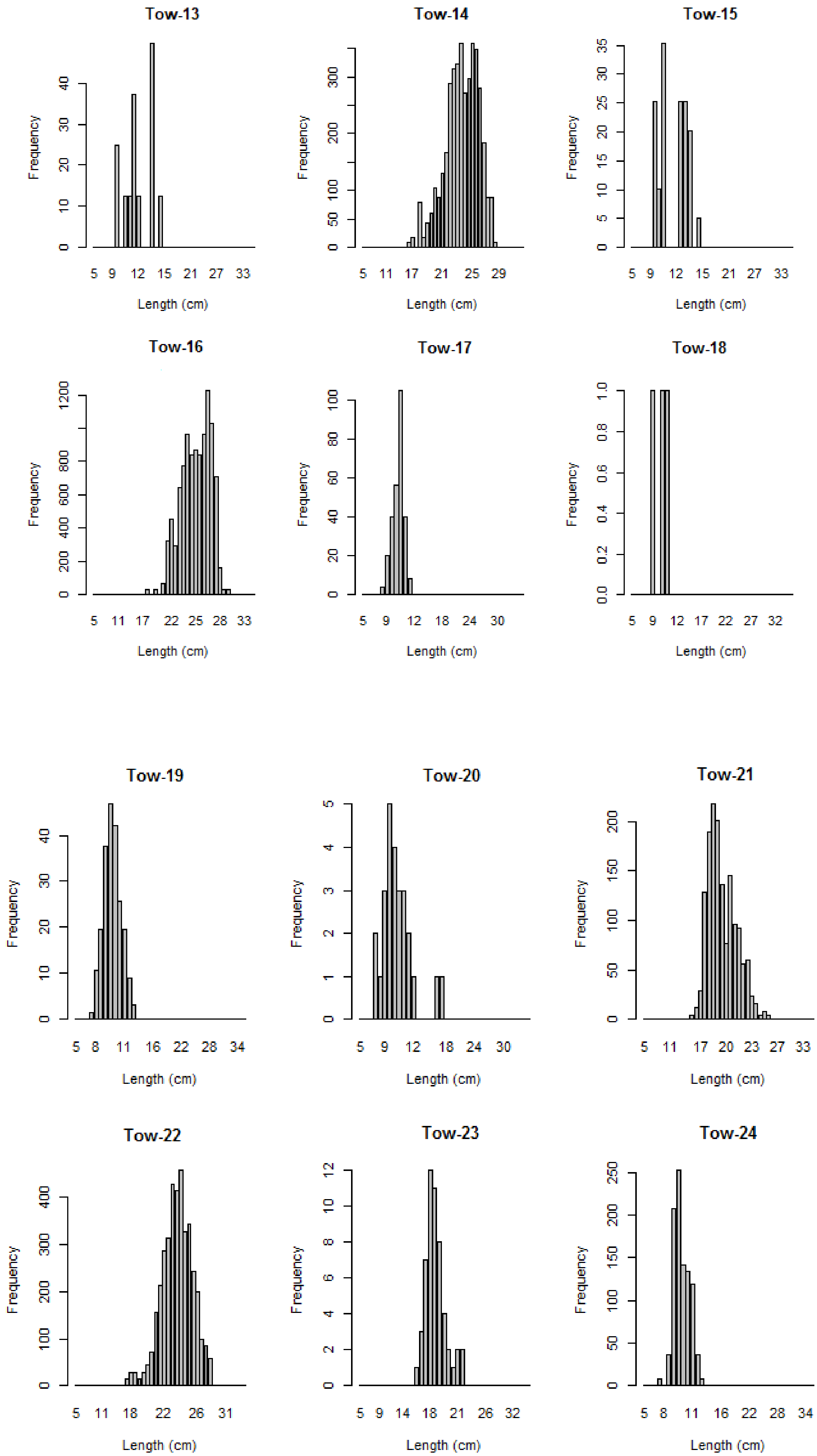


Figure 5B.2 Acoustic survey tracks with trawl positions of the 2019 Irish Sea and North Channel survey on RV "Corystes". Filled squares indicate trawls in which significant numbers of herring were caught or trawls with a high proportion of herring, while open squares indicate trawls with few or no herring.

Herring Length Frequency (%)

Cruise 35 Herring Acoustic




Tow-13
Tow-14
Tow-15
Tow-16
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Tow-18
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Tow-20
Tow-21
Tow-22
Tow-23
Tow-24
Frequency
Length (cm)

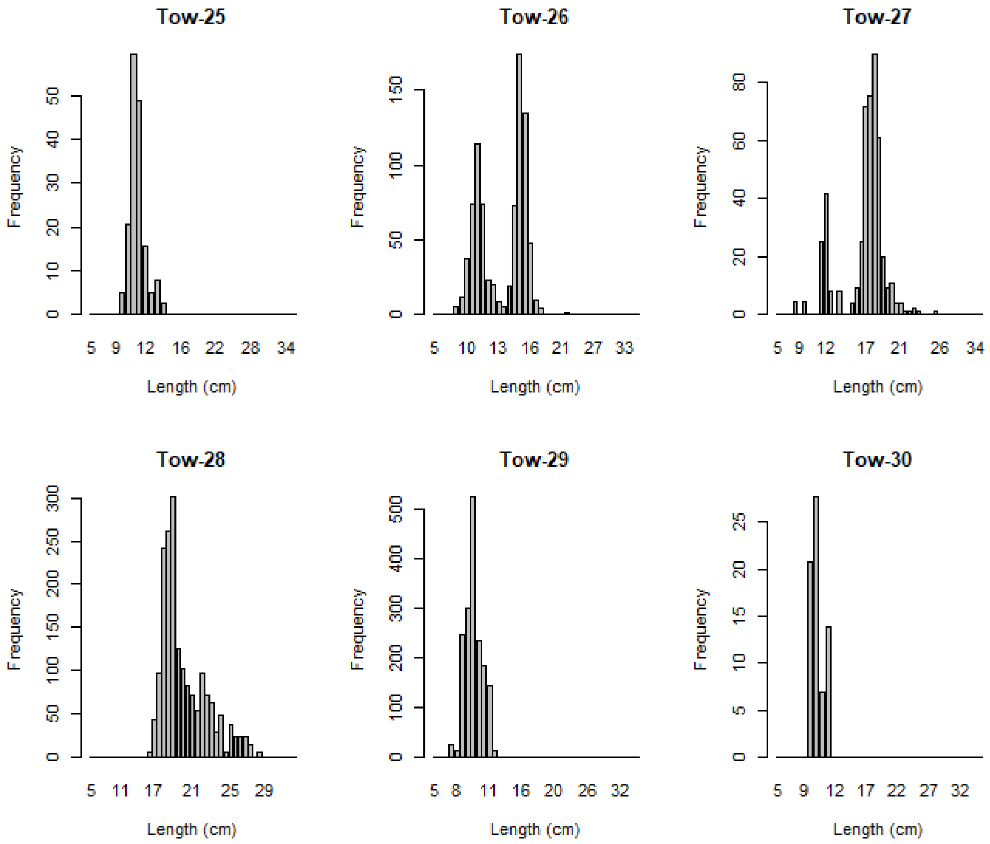


Figure 5B.3: Percentage length compositions of herring in each trawl sample in the September 2019 Irish Sea and North Channel acoustic survey on RV "Corystes".

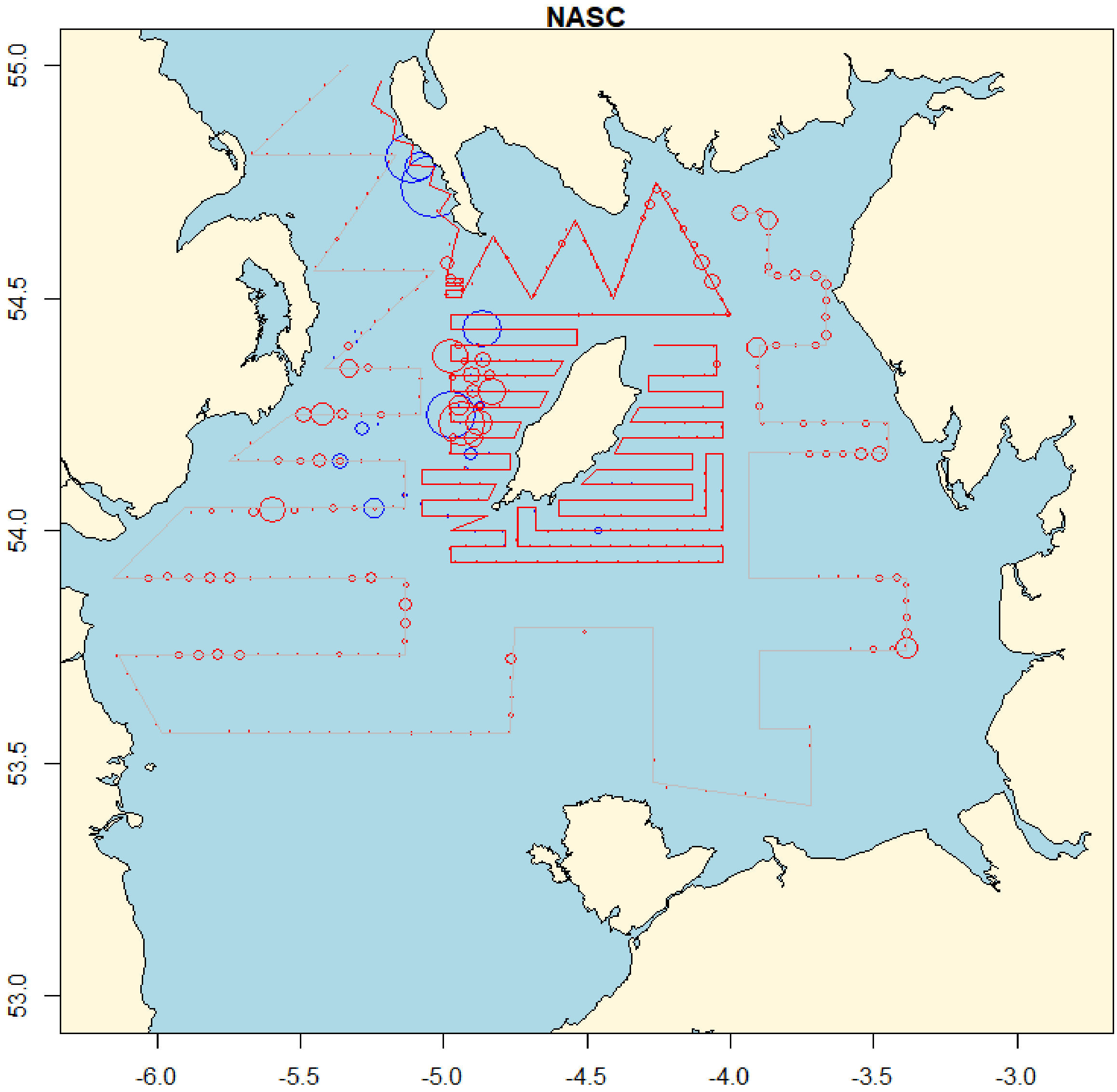


Figure 5B.4: Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values (size of elipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2019 acoustic survey on RV "Corystes". (a) Open blue circles are for herring NASC values (maximum value was 12136) and (b) open red circles are for clupeoid mix NASC, which include juvenile herring and sprat (maximum value was 8703).

Table 5B.1: Simrad EK60 and analysis settings used on the 2018 and 2019 Irish Sea and North Channel herring acoustic survey on RV "Corystes"

TRANSCEIVER MENU		
Year	2018	2019
Frequency	38 kHz	38 kHz
Sound speed	1481.7m.s^{-1}	1511.8m.s^{-1}
Max. Power	2000 W	2000 W
Default Transducer Sv gain	26.36 dB	26.74dB
Athw. Beam Angle	7.02 deg	7.04 deg
Athw. Offset Angle	-0.03 deg	0.00 deg
Along. Beam Angle	6.95 deg	6.98 deg
Along. Offset Angle	0.18 deg	0.12 deg
Calibration details		
TS of sphere	-33.6 dB	-33.6 dB
Range to sphere in calibration	11.5m	11.5 m
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, August/September 2019.

		Shooting details.						Total catch	percentage composition of fish by weight							Mean length (cm)	
Tow	Date	Time	Lat.		Long.		Depth (m)	kg.	sprat	herring	mackerel	scad	anchovy	whiting	other fish	sprat	herring
1	28/08/2019	06:11	54	40.645	3	53.033	26.16	80	95.3	0.8	3.3	0.0	0.0	0.0	0.0	8.2	10.8
2	28/08/2019	13:05	54	24.922	3	39.956	21.6	68	77.3	2.3	19.7	0.0	0.2	0.1	0.2	9.4	12.1
3	28/08/2019	15:26	54	22.127	3	54.052	37.07	35	69.9	27.0	4.3	0.0	0.0	0.0	0.0	9.6	13.3
4	28/08/2019	17:31	54	14.201	3	52.14	19.06	37	97.6	2.4	0.0	0.0	0.0	0.0	0.0	8.2	13.4
5	29/08/2019	05:54	54	9.79	3	31.072	19.28	50	91.9	3.4	4.5	0.0	0.6	0.0	0.0	9.5	12.4
6	29/08/2019	13:39	53	45.766	3	22	18.6	204	99.6	0.3	0.0	0.0	0.1	0.1	0.0	9.4	10.8
7	31/08/2019	13:59	54	22.689	4	3.386	37	182	98.5	0.1	1.3	0.0	0.0	0.0	0.0	9.8	12.8
8	01/09/2019	20:05	53	57.9698	4	53.0378	62	32	27.8	68.4	2.5	0.0	0.0	0.1	0.0	12.3	19.9
9	02/09/2019	03:03	54	8.288	4	56.67	74	165	0.0	98.9	0.3	0.0	0.0	0.8	0.1		17.7
10	02/09/2019	05:03	54	10.133	4	56.16	69.2	249	5.3	94.4	0.1	0.0	0.0	0.2	0.0	11.1	20.4
11	02/09/2019	08:22	54	14.1334	4	53.3537	68.35	342	96.6	2.6	0.9	0.0	0.0	0.0	0.0	9.6	20.5
12	03/09/2019	09:54	54	14.7222	4	58.4781	93	897	0.0	99.2	0.0	0.0	0.0	0.7	0.1		22.2
13	03/09/2019	13:14	54	18.233	4	50.782	50	402	99.1	0.5	0.4	0.0	0.0	0.1	0.0	9.7	11.5
14	02/09/2019	23:45	54	26.045	4	51.027	54	684	0.0	72.3	0.3	0.0	0.0	0.0	27.4		22.9
15	03/09/2019	06:01	54	32.8	4	4.8	52.1	133	93.1	1.2	5.8	0.0	0.0	0.0	0.0	9.3	11.9
16	03/09/2019	19:02	54	45.598	5	4.78	30.87	1500	0.0	100.0	0.0	0.0	0.0	0.0	0.0		25.5
17	05/09/2019	15:44	54	48.545	5	11.675	104.47	96	97.0	1.9	0.9	0.0	0.0	0.0	0.3	8.7	10.2
18	06/09/2019	09:19	54	20.9837	5	18.4613	68.9	96	99.9	0.0	0.2	0.0	0.0	0.0	0.0	8.4	10.1
19	06/09/2019	11:50	54	14.942	5	11.015	106	32	95.0	3.7	0.8	0.0	0.0	0.0	0.0	8.4	10.3
20	06/09/2019	14:12	54	14.933	5	28.753	41.6	181	98.9	0.3	0.5	0.0	0.0	0.0	0.0	9.5	10.3
21	06/09/2019	19:41	54	4.4232	5	8.0344	95	95	0.0	94.0	0.0	0.0	0.0	0.0	6.5		20.4
22	06/09/2019	22:32	54	13.0443	5	14.3573	99	572	0.0	78.7	0.0	0.0	0.0	0.0	21.3		23.1
23	07/09/2019	10:06	53	53.998	5	58.2288	34.5	64	88.9	4.3	6.0	0.0	0.0	0.0	0.8	9.5	19.2
24	07/09/2019	14:03	53	54.119	5	15.098	94	212	96.9	2.6	0.2	0.0	0.0	0.0	0.0	8.6	10.6
25	08/09/2019	08:03	53	34.0556	5	5.3459	74.2	77	96.1	2.1	1.3	0.0	0.1	0.0	0.0	8.9	12.1
26	08/09/2019	15:25	53	30.766	4	14.601	42.8	42	62.7	35.2	2.7	0.0	0.0	0.0	0.0	8.8	14.5
27	12/09/2019	15:30	54	5.597	5	4.409	84	148	87.2	12.3	0.0	0.0	0.0	0.1	0.4	9.0	18.2
28	12/09/2019	18:20	54	8.689	4	58.204	68.04	125	0.0	100.0	0.0	0.0	0.0	0.0	0.0		22.5
29	13/09/2019	09:06	54	28.9967	4	56.7611	95	107	90.4	8.7	0.8	0.0	0.0	0.0	0.0	9.0	13.3
30	13/09/2019	20:39	54	46.9844	5	5.8436	41	105	97.7	0.4	0.0	0.0	0.0	0.0	1.9	7.8	10.1

Table 5B.3: Preliminary age-length key for herring from which otoliths were removed at sea during the Irish Sea/North Channel survey 2018. 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+	Total
6.5	1	0	0	0	0	0	0	0	0	1
7	2	0	0	0	0	0	0	0	0	2
7.5	1	0	0	0	0	0	0	0	0	1
8	1	0	0	0	0	0	0	0	0	1
8.5	4	0	0	0	0	0	0	0	0	4
9	3	0	0	0	0	0	0	0	0	3
9.5	8	0	0	0	0	0	0	0	0	8
10	10	0	0	0	0	0	0	0	0	10
10.5	7	0	0	0	0	0	0	0	0	7
11	5	0	0	0	0	0	0	0	0	5
11.5	6	0	0	0	0	0	0	0	0	6
12	9	0	0	0	0	0	0	0	0	9
12.5	7	0	0	0	0	0	0	0	0	7
13	7	0	0	0	0	0	0	0	0	7
13.5	6	0	0	0	0	0	0	0	0	6
14	4	0	0	0	0	0	0	0	0	4
14.5	3	0	0	0	0	0	0	0	0	3
15	5	0	0	0	0	0	0	0	0	5
15.5	0	1	0	0	0	0	0	0	0	1
16	0	1	0	0	0	0	0	0	0	1
16.5	0	0	0	0	0	0	0	0	0	0
17	0	2	0	0	0	0	0	0	0	2
17.5	0	5	0	0	0	0	0	0	0	5
18	0	5	0	0	0	0	0	0	0	5
18.5	0	5	2	0	0	0	0	0	0	7
19	0	10	0	0	0	0	0	0	0	10
19.5	0	11	3	0	0	0	0	0	0	14
20	0	8	0	0	0	0	0	0	0	8
20.5	0	12	0	2	0	0	0	0	0	14
21	0	9	6	0	0	0	0	0	0	15
21.5	0	9	14	1	0	0	0	0	0	24
22	0	6	13	0	0	0	0	0	0	19
22.5	0	3	8	1	0	0	0	0	0	12
23	0	1	18	1	0	0	0	0	0	20
23.5	0	1	22	16	2	0	0	0	0	41
24	0	0	15	16	1	0	0	0	0	32
24.5	0	0	5	23	3	0	0	0	0	31
25	0	2	6	22	6	1	1	0	0	38
25.5	0	1	2	19	14	1	2	0	0	39
26	0	0	1	8	10	3	4	1	0	27
26.5	0	1	0	2	14	1	3	1	1	23
27	0	0	0	5	5	1	5	1	5	22
27.5	0	0	0	1	6	2	7	1	3	20
28	0	0	0	0	1	2	4	1	5	13
28.5	0	0	0	0	1	1	1	1	4	8
29	0	0	0	0	0	0	0	0	1	1
Total	89	93	115	117	63	12	27	6	19	541

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 2019.

Stratum	No. sprat	Biomass sprat	No. Her	Biomass Her
1	1727521	5626	46147	2290
2	5973	17	267633	19116
3	8443940	27275	308290	19933
4	2992090	8515	28868	255
5	3818464	11054	24252	176
6	4206009	15142	30784	361
7	1154494	5782	289082	18501
8	145143	509	232	3
9	244917	930	18775	2095
10	6710501	24698	131970	1713
11	4646886	11056	100220	1657
12	6663860	26294	51011	668
13	0	0	2130	233
14	0	0	30239	1787
Totals	40759800	136898	1329633	68789

Annex 9: 2019 ISSS Survey Summary Table and Survey Report

Document 9a: ISSS 2019 survey summary table

<table>
<tr><td colspan="2">Survey Summary table WGIPS 2020</td></tr>
<tr><td>Name of the survey (abbreviation):</td><td>Irish Sea Acoustic Spawning Survey (ISSS)</td></tr>
<tr><td>Target Species:</td><td>Herring</td></tr>
<tr><td>Survey dates:</td><td>28th September – 30th September 2019</td></tr>
<tr><td colspan="2">Summary:</td></tr>
<tr><td colspan="2">A commercial chartered fishing vessel started the survey on Isle of Man grid on transect 1 on 28st September and continued through to the end of transect 82 on the 30th September 2019 .Sea conditions were reasonably good during the survey; no weather induced down time was recorded. Targets were identified by aimed midwater trawls, 1 successful tow was completed in 2019, which is consistant with fishing intensity for survey over time series, providing confidence in school recognition and supporting biological data for age stratified abundance estimation of target species (herring).

High abundance schools of Herring were locally distributed. The bulk of 1+ herring targets in 2019 were observed west of the Isle of Man and off the Mull of Galloway on the Scottish coast.

Cohorts, ages 0 -9 are visible within the survey. The major contribution of age to the total estimates in the 2019 survey is from age 1 accounting for 49% of total estimates by number. It is perceived that the pervelance of 1 and 2 year old emerging year classes (~49% age 0, 21% age 1) will recruit to the SSB over the next 1-2 years.</td></tr>
<tr><td></td><td>Description</td></tr>
<tr><td>Survey design</td><td>The survey design of systematic, parallel transects covers approximately 620 nm. The position of the set of transect with spacing is reduced to 2 nm in strata around the Isle of Man. Survey design and methodology adheres to the repeats the methods laid out in the WGIPS acoustic survey manual.</td></tr>
<tr><td>Index Calculation method</td><td>Weighted mean TS is applied to the NASC value to give numbers per square nautical mile – further decomposed by age class according to length frequencies in relevant target identified trawls and survey age-length key.</td></tr>
</table>

Random/systematic error issues	NA
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	Sea conditions were reasonably good during the survey; no weather induced down time was recorded.
Extinction (shadowing)	No perceived issues. Majority of target schools in mid to lower water column. For schools on or just above sea bed, negligible affects discerned.
Blind zone	Sub surface zone of 8 m applied. Majority of target schools in survey within mid to lower water column.
Dead zone	NA
Allocation of backscatter to species	One dediacetd trawl was conducted.
Target strength	Herring, sprat and horse mackerel: TS = 20log(L) -71.2 db Mackerel: TS = 20log(L) -84.9 db Gadoids: TS = 20log(L) -67.5 db
Calibration	The hull mounted Simrad EK60 acoustic system with 38 kHz split-beam was calibrated on the 15th September in Brodick bay off the Isle of Arran, in the Firth of Clyde, Scotland Conditions were good and the calibration results satisfactory. All procedures were according to those defined in the survey manual.
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	Time series:The survey is focused on spawning aggregations with 75% coverage of main ISAS. 2019 survey: As in previous years, complete coverage.
Stock ID and mixing issues	Time series: Designed to generate an SSB index constituted from herring on or around the Irish Sea spawning ground to reduced stock mixing issues. 2019 survey: No additional issues
Measures of uncertainty (CV)	CV of biomass and numbers at age

Biological sampling	2019 Survey: The biological sampling uses biological sampling for the main Irish Sea acoutiscs survey and is deamed to be appropriate for the stock and area. The sampling levels are in line with historic levels. Biological samples are not available at the time of WGIPS to update biological data. Ages (age-length-key) and maturity data for 2018 are used for initial biomass estimates and population age structure.

Document 9b: ISSS 2019 survey report

Please see the report on the next page.

Survey report for FV Havilah

28th September – 30th September 2019

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 Irish Sea commercial survey conducted in the autumn.

2. SURVEY DESCRIPTION & METHODS

2.1 Personnel

Peter McCorriston (SIC)
Ian McCausland
Gary Heaney

2.2 Narrative

The vessel departed Belfast at 2100 on the 27th September and proceeded to the east coast of the Isle of Man The survey starting on transect 1 to the northeast of The Isle of Man on the 28th September proceeding through to the end of transect 81 on the 30th September, with the ship returning to Belfast at 00:00 on the 01st October. Sea conditions were reasonably good during the survey enabling full completion of survey grid without disruption.

Survey design

The survey design of systematic, parallel transects covers approximately 640 nm (Figure 5B.1). Transect spacing is set to 2 nm in strata around the Isle of Man where adult herring were expected to be most abundant but also to have a very patchy distribution with relatively low probability of encounter. The survey design is based on information on herring distribution in autumn obtained from previous surveys, and from patterns in the commercial fishery showing a concentration of herring in Manx waters at this time. 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 15th September in Brodick bay off the Isle of Arran, in the Firth of Clyde, Scotland. 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 was collected 24hrs a day at 38 kHz 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 is 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 Data analysis

EDSUs were defined by 15 minute intervals which represented 2.5 nm per EDSU, assuming a survey speed of 11 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 2019 survey with 30 successful trawls completed Figure 5B.2. Table 5B.2 gives the positions, catch composition and mean length by species for these trawl hauls and Table 5B.3 shows positions, catch composition and mean length by species for a further haul completed during the commercial survey. The length frequency distributions of these hauls are illustrated in Figure 5B.3 for the main survey and Figure 5B.4 for the commercial survey. Length frequency distributions reflect the general juvenile/adult herring distributions within the sampling area. The preliminary age length key (Table 5B.4) 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) and for herring only are presented in Figure 5B.5. The highest abundance of herring was to the east of the Isle of Man and along the south west coast of the Isle of Man

3.3 Biomass estimates

The estimated biomass and number of herring and sprat by strata are given in Table 5B.5. The total herring SSB estimate comprises is 36.41t

4. DISCUSSION

The herring stock estimate for the Irish Sea commercial survey area was estimated to be 55.22t The major contribution of ages to the total estimates is from ages 0 fish by number and weight. The herring were distributed within a few distinct high abundance areas to the southwest and southeast of the Isle of Man. The bulk of 1+ herring targets in 2018 were observed in the southwestern corner of stratum 7 and southwestern corner of stratum 9. Figure 5B.5, shows a further, fairly scattered, lower abundance observed throughout the remainder of the Irish Sea survey area. The length frequencies generated from these trawls highlight the spatial heterogeneous nature of herring age groups in the Irish Sea (Figure 5B.3 & 5B.4). The estimate of herring SSB of 36.409t and biomass estimate of 54,898t for 1+ ringers for 2018 commercial acoustic survey remain within range for the time series. The survey estimates are influenced by the timing of the spawning migration.

5 TABLES AND FIGURES

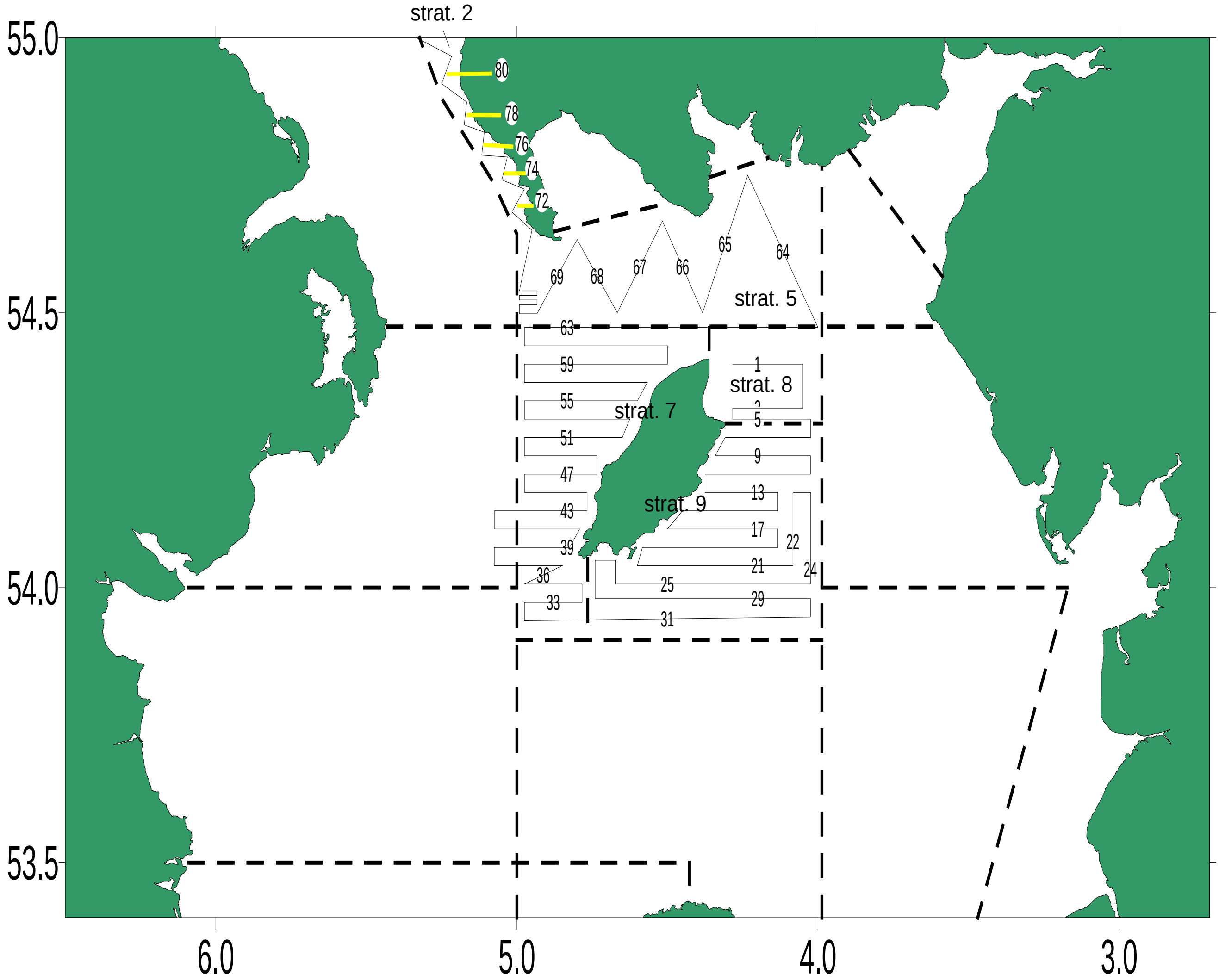


Figure 5B.1: Acoustic survey tracks for the 2019 Irish Sea acoustic survey. Survey design of systematic, parallel transects covers approximately 620

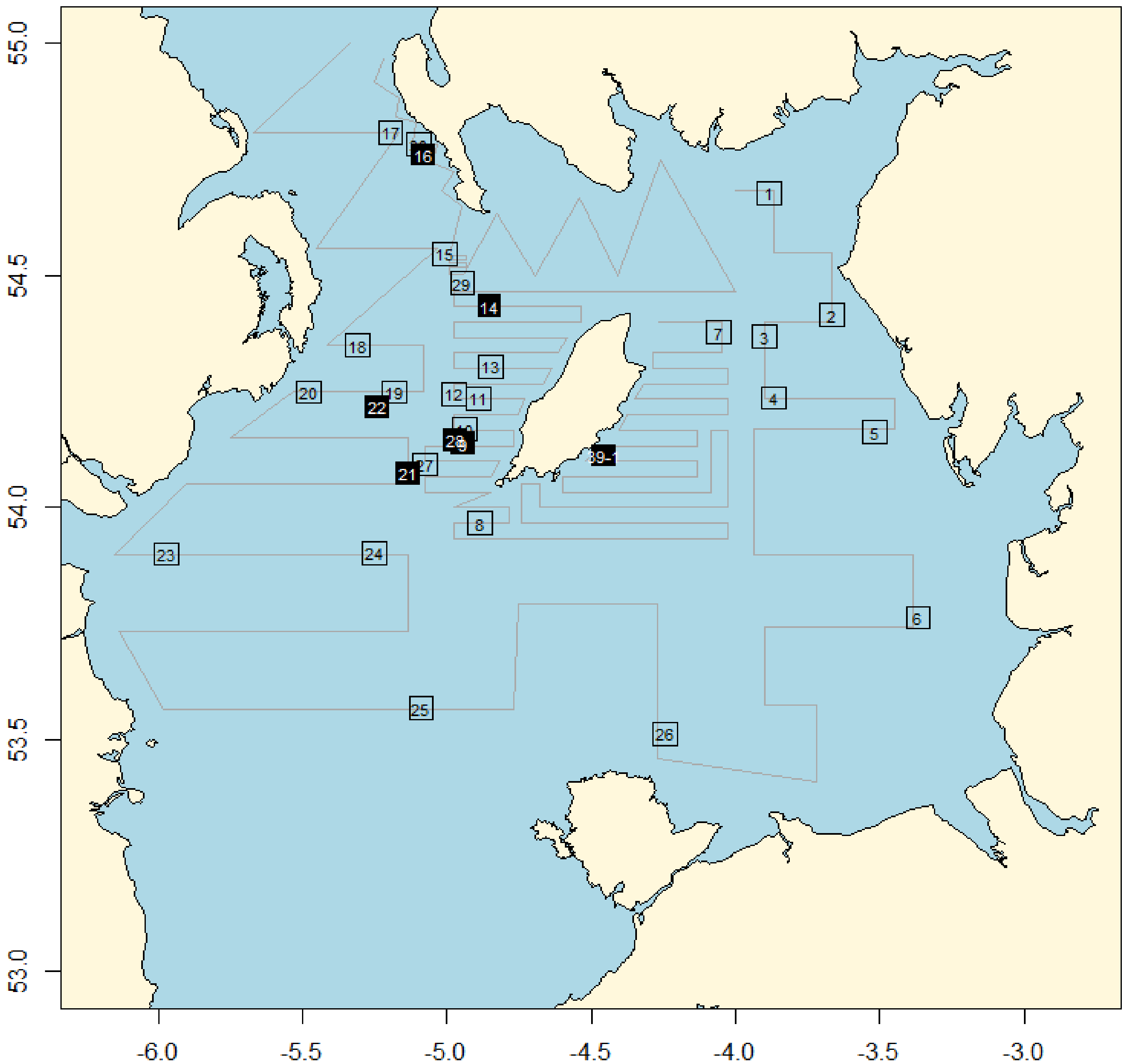
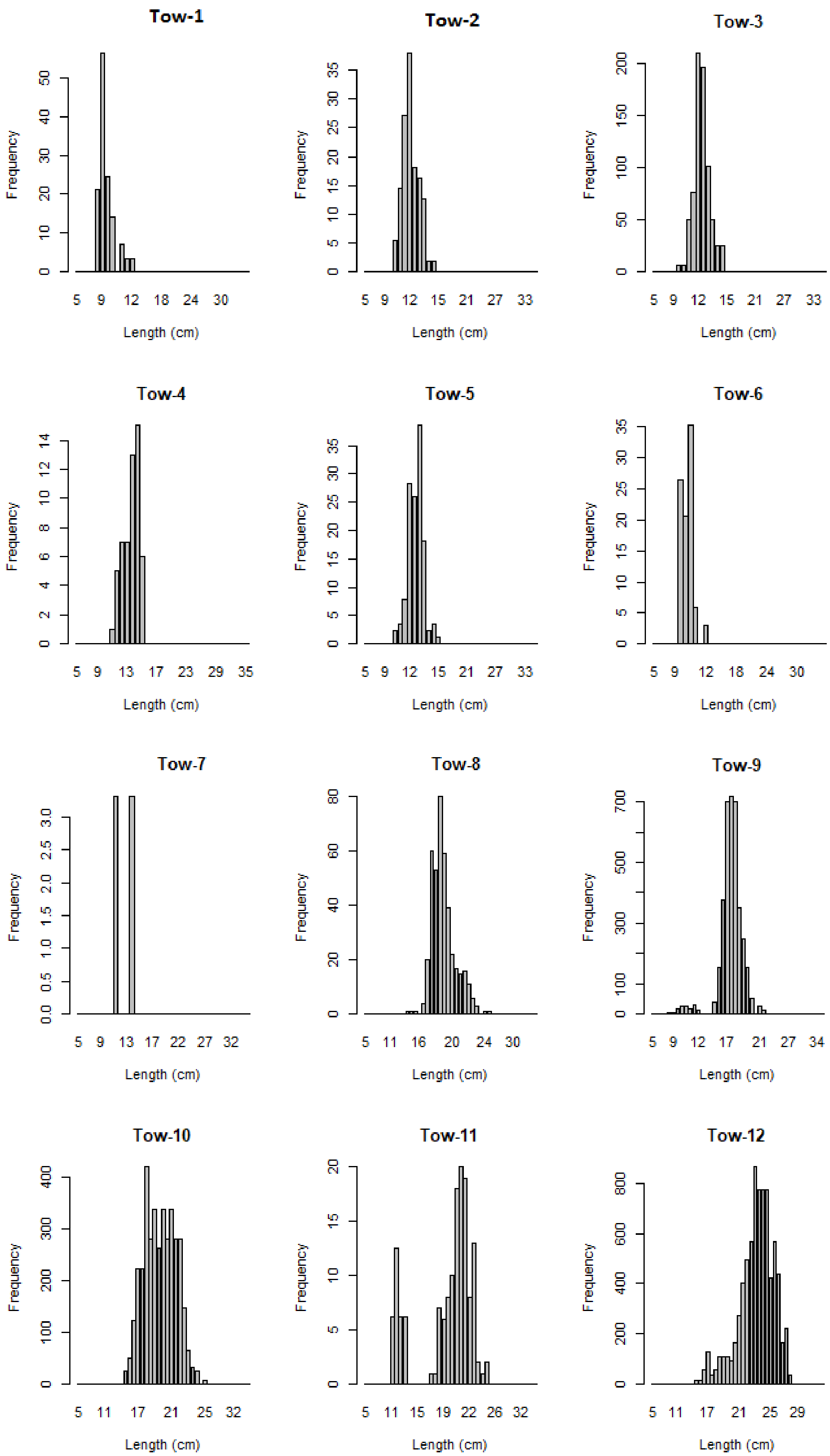
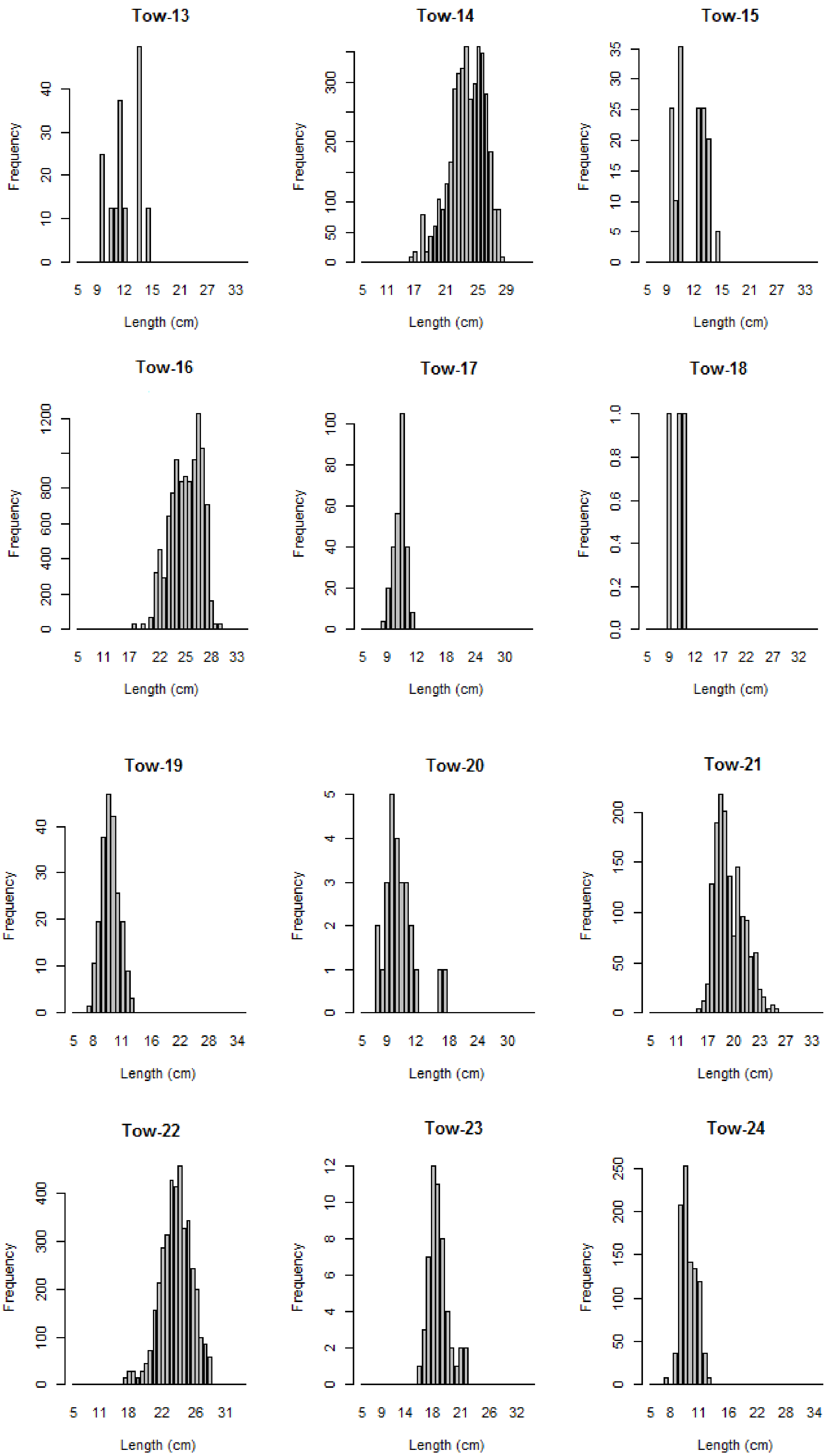


Figure 5B.2 Acoustic survey tracks with trawl positions of the 2019 Irish Sea and North Channel survey on RV "Corystes" and 2019 Irish Sea and North Channel commercial survey on FV "Haviliah" . Filled squares indicate trawls in which significant numbers of herring were caught or trawls with a high proportion of herring, while open squares indicate trawls with few or no herring.


Tow-1
Frequency
Length (cm)
5 9 12 18 24 30
Tow-2
Frequency
Length (cm)
5 9 12 15 21 27 33
Tow-3
Frequency
Length (cm)
5 9 12 15 21 27 33
Tow-4
Frequency
Length (cm)
5 9 13 17 23 29 35
Tow-5
Frequency
Length (cm)
5 9 12 15 21 27 33
Tow-6
Frequency
Length (cm)
5 9 12 18 24 30
Tow-7
Frequency
Length (cm)
5 9 13 17 22 27 32
Tow-8
Frequency
Length (cm)
5 11 16 20 24 30
Tow-9
Frequency
Length (cm)
5 9 12 17 21 27 34
Tow-10
Frequency
Length (cm)
5 11 17 21 25 32
Tow-11
Frequency
Length (cm)
5 11 15 19 22 26 32
Tow-12
Frequency
Length (cm)
5 11 17 21 25 29


Tow-13
Frequency
Length (cm)
5 9 12 15 21 27 33
Tow-14
Frequency
Length (cm)
5 11 17 21 25 29
Tow-15
Frequency
Length (cm)
5 9 12 15 21 27 33
Tow-16
Frequency
Length (cm)
5 11 17 22 25 28 33
Tow-17
Frequency
Length (cm)
5 9 12 18 24 30
Tow-18
Frequency
Length (cm)
5 9 12 17 22 27 32
Tow-19
Frequency
Length (cm)
5 8 11 16 22 28 34
Tow-20
Frequency
Length (cm)
5 9 12 18 24 30
Tow-21
Frequency
Length (cm)
5 11 17 20 23 27 33
Tow-22
Frequency
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Frequency
Length (cm)
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Tow-24
Frequency
Length (cm)
5 8 11 16 22 28 34

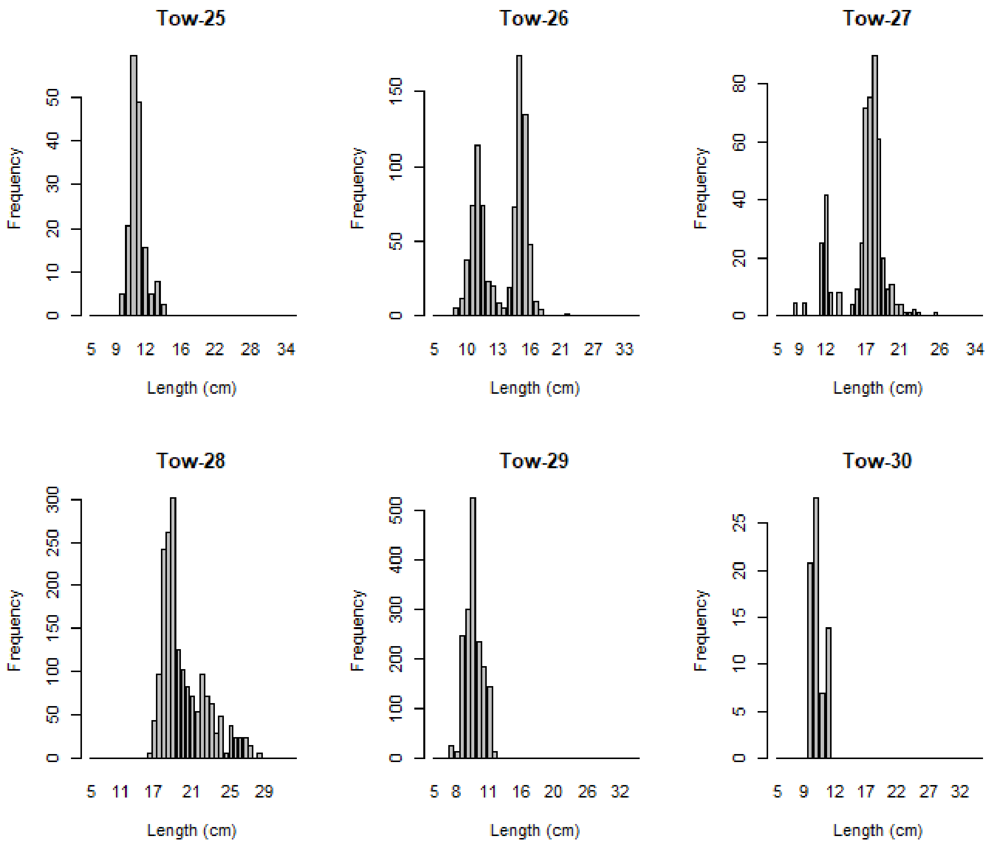

Figure 5B.3: Percentage length compositions of herring in each trawl sample in the September 2019 Irish Sea and North Channel acoustic survey on RV "Corystes".

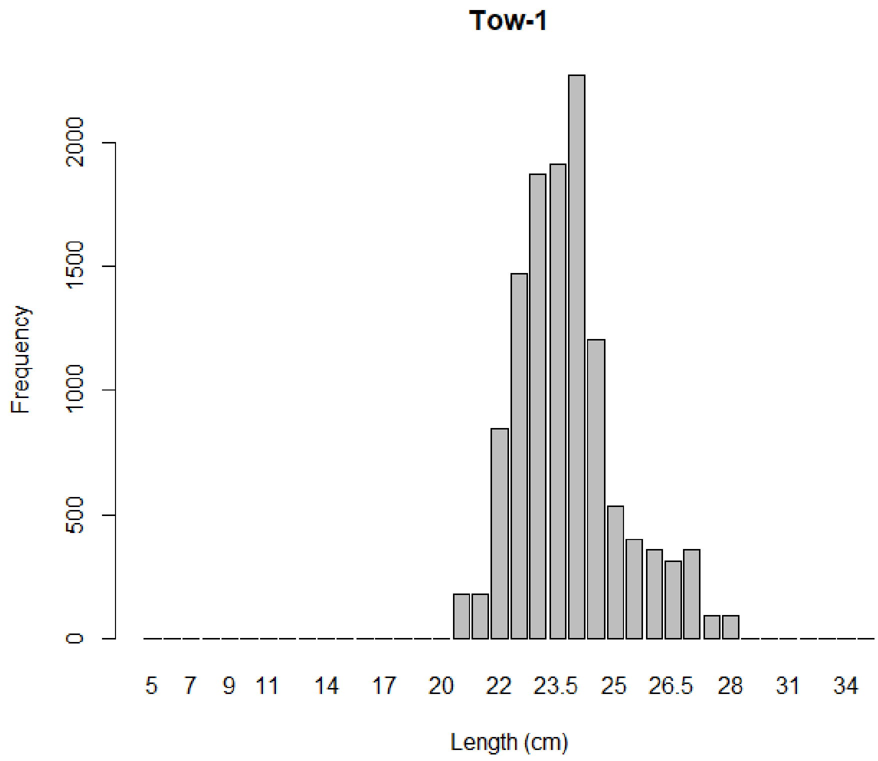

Figure 5B.4: **Percentage length compositions of herring in each trawl sample in the 2019 Irish Sea and North Channel commercial acoustic survey on the FV "Havilah".**

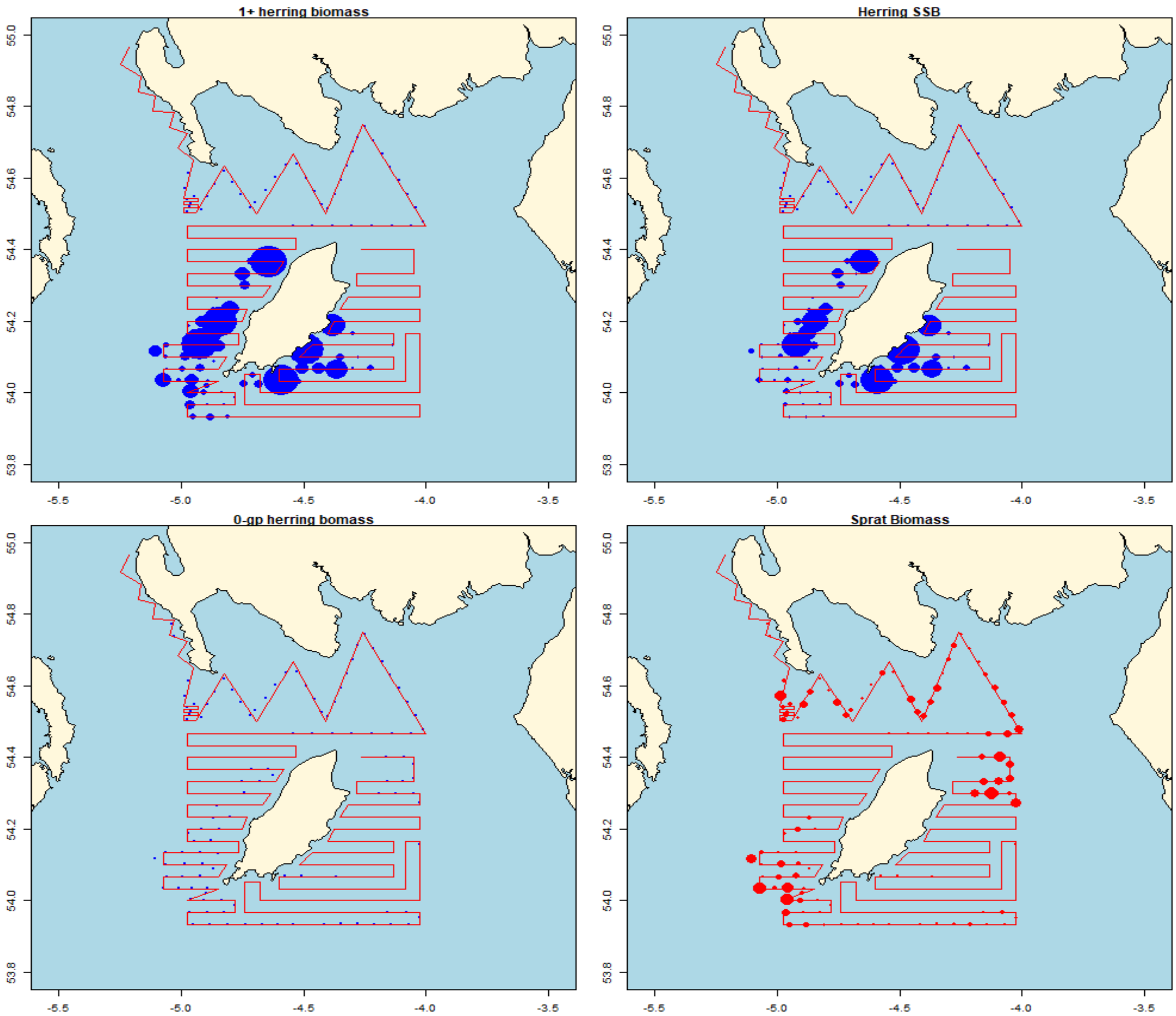

Figure 5B.5: Map of the Irish Sea and North Channel with a post plot showing the distribution of NASC values (size of elipses is proportional to square root of the NASC value per 15-minute interval) obtained during the 2019 commercial acoustic survey on FV "Haviliah". (a) Solid blue circles are for herring NASC values (maximum value was 7365) and (b) solid red circles are for clupeoid mix NASC, which include juvenile herring and sprat (maximum value was 4015).

Table 5B.1: Simrad EK60 and analysis settings used on the 2018 and 2019 Irish Sea and North Channel herring acoustic survey on FV "Havilah".

TRANSCEIVER MENU		
Year	2018	2019
Frequency	38 kHz	38 kHz
Sound speed	1503.4m.s^{-1}	1510.8 m.s^{-1}
Max. Power	2000 W	2000 W
Default Transducer Sv gain	27.03dB	26.96 dB
Athw. Beam Angle Athw. Offset Angle Along. Beam Angle Along. Offset Angle	6.99 deg -0.01 deg 6.97 deg -0.02 deg	6.96 deg -0.03 deg 6.95 deg 0.01 deg
Calibration details		
TS of sphere	-33.6 dB	-33.6 dB
Range to sphere in calibration	11.5m	11.5m
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, August/September 2019

		Shooting details.						Total catch	percentage composition of fish by weight							Mean length (cm)	
Tow	Date	Time	Lat.		Long.		Depth (m)	kg.	sprat	herring	mackerel	scad	anchovy	whiting	other fish	sprat	herring
1	28/08/2019	06:11	54	40.645	3	53.033	26.16	80	95.3	0.8	3.3	0.0	0.0	0.0	0.0	8.2	10.8
2	28/08/2019	13:05	54	24.922	3	39.956	21.6	68	77.3	2.3	19.7	0.0	0.2	0.1	0.2	9.4	12.1
3	28/08/2019	15:26	54	22.127	3	54.052	37.07	35	69.9	27.0	4.3	0.0	0.0	0.0	0.0	9.6	13.3
4	28/08/2019	17:31	54	14.201	3	52.14	19.06	37	97.6	2.4	0.0	0.0	0.0	0.0	0.0	8.2	13.4
5	29/08/2019	05:54	54	9.79	3	31.072	19.28	50	91.9	3.4	4.5	0.0	0.6	0.0	0.0	9.5	12.4
6	29/08/2019	13:39	53	45.766	3	22	18.6	204	99.6	0.3	0.0	0.0	0.1	0.1	0.0	9.4	10.8
7	31/08/2019	13:59	54	22.689	4	3.386	37	182	98.5	0.1	1.3	0.0	0.0	0.0	0.0	9.8	12.8
8	01/09/2019	20:05	53	57.9698	4	53.0378	62	32	27.8	68.4	2.5	0.0	0.0	0.1	0.0	12.3	19.9
9	02/09/2019	03:03	54	8.288	4	56.67	74	165	0.0	98.9	0.3	0.0	0.0	0.8	0.1		17.7
10	02/09/2019	05:03	54	10.133	4	56.16	69.2	249	5.3	94.4	0.1	0.0	0.0	0.2	0.0	11.1	20.4
11	02/09/2019	08:22	54	14.1334	4	53.3537	68.35	342	96.6	2.6	0.9	0.0	0.0	0.0	0.0	9.6	20.5
12	03/09/2019	09:54	54	14.7222	4	58.4781	93	897	0.0	99.2	0.0	0.0	0.0	0.7	0.1		22.2
13	03/09/2019	13:14	54	18.233	4	50.782	50	402	99.1	0.5	0.4	0.0	0.0	0.1	0.0	9.7	11.5
14	02/09/2019	23:45	54	26.045	4	51.027	54	684	0.0	72.3	0.3	0.0	0.0	0.0	27.4		22.9
15	03/09/2019	06:01	54	32.8	4	4.8	52.1	133	93.1	1.2	5.8	0.0	0.0	0.0	0.0	9.3	11.9
16	03/09/2019	19:02	54	45.598	5	4.78	30.87	1500	0.0	100.0	0.0	0.0	0.0	0.0	0.0		25.5
17	05/09/2019	15:44	54	48.545	5	11.675	104.47	96	97.0	1.9	0.9	0.0	0.0	0.0	0.3	8.7	10.2
18	06/09/2019	09:19	54	20.9837	5	18.4613	68.9	96	99.9	0.0	0.2	0.0	0.0	0.0	0.0	8.4	10.1
19	06/09/2019	11:50	54	14.942	5	11.015	106	32	95.0	3.7	0.8	0.0	0.0	0.0	0.0	8.4	10.3
20	06/09/2019	14:12	54	14.933	5	28.753	41.6	181	98.9	0.3	0.5	0.0	0.0	0.0	0.0	9.5	10.3
21	06/09/2019	19:41	54	4.4232	5	8.0344	95	95	0.0	94.0	0.0	0.0	0.0	0.0	6.5		20.4
22	06/09/2019	22:32	54	13.0443	5	14.3573	99	572	0.0	78.7	0.0	0.0	0.0	0.0	21.3		23.1
23	07/09/2019	10:06	53	53.998	5	58.2288	34.5	64	88.9	4.3	6.0	0.0	0.0	0.0	0.8	9.5	19.2
24	07/09/2019	14:03	53	54.119	5	15.098	94	212	96.9	2.6	0.2	0.0	0.0	0.0	0.0	8.6	10.6
25	08/09/2019	08:03	53	34.0556	5	5.3459	74.2	77	96.1	2.1	1.3	0.0	0.1	0.0	0.0	8.9	12.1
26	08/09/2019	15:25	53	30.766	4	14.601	42.8	42	62.7	35.2	2.7	0.0	0.0	0.0	0.0	8.8	14.5
27	12/09/2019	15:30	54	5.597	5	4.409	84	148	87.2	12.3	0.0	0.0	0.0	0.1	0.4	9.0	18.2
28	12/09/2019	18:20	54	8.689	4	58.204	68.04	125	0.0	100.0	0.0	0.0	0.0	0.0	0.0		22.5
29	13/09/2019	09:06	54	28.9967	4	56.7611	95	107	90.4	8.7	0.8	0.0	0.0	0.0	0.0	9.0	13.3
30	13/09/2019	20:39	54	46.9844	5	5.8436	41	105	97.7	0.4	0.0	0.0	0.0	0.0	1.9	7.8	10.1

Table 5B.3: Catch composition and position of hauls undertaken by the FV Haviliah during the Irish Sea/North Channel commercial survey, September 2019.

		Shooting details.						Total catch	percentage composition of fish by weight							Mean length (cm)	
Tow	Date	Time	Lat.		Long.		Depth (m)	kg.	sprat	herring	mackerel	scad	anchovy	whiting	other fish	sprat	herring
1	28/09/2019	20:00	54	6.76	4	27.22	36.5	2000	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1

Table 5B.4: Preliminary age-length key for herring from which otoliths were removed at sea during the Irish Sea/North Channel survey 2018. 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+	TOTAL
6.5	1	0	0	0	0	0	0	0	0	1
7	2	0	0	0	0	0	0	0	0	2
7.5	1	0	0	0	0	0	0	0	0	1
8	1	0	0	0	0	0	0	0	0	1
8.5	4	0	0	0	0	0	0	0	0	4
9	3	0	0	0	0	0	0	0	0	3
9.5	8	0	0	0	0	0	0	0	0	8
10	10	0	0	0	0	0	0	0	0	10
10.5	7	0	0	0	0	0	0	0	0	7
11	5	0	0	0	0	0	0	0	0	5
11.5	6	0	0	0	0	0	0	0	0	6
12	9	0	0	0	0	0	0	0	0	9
12.5	7	0	0	0	0	0	0	0	0	7
13	7	0	0	0	0	0	0	0	0	7
13.5	6	0	0	0	0	0	0	0	0	6
14	4	0	0	0	0	0	0	0	0	4
14.5	3	0	0	0	0	0	0	0	0	3
15	5	0	0	0	0	0	0	0	0	5
15.5	0	1	0	0	0	0	0	0	0	1
16	0	1	0	0	0	0	0	0	0	1
16.5	0	0	0	0	0	0	0	0	0	0
17	0	2	0	0	0	0	0	0	0	2
17.5	0	5	0	0	0	0	0	0	0	5
18	0	5	0	0	0	0	0	0	0	5
18.5	0	5	2	0	0	0	0	0	0	7
19	0	10	0	0	0	0	0	0	0	10
19.5	0	11	3	0	0	0	0	0	0	14
20	0	8	0	0	0	0	0	0	0	8
20.5	0	12	0	2	0	0	0	0	0	14
21	0	9	6	0	0	0	0	0	0	15
21.5	0	9	14	1	0	0	0	0	0	24
22	0	6	13	0	0	0	0	0	0	19
22.5	0	3	8	1	0	0	0	0	0	12
23	0	1	18	1	0	0	0	0	0	20
23.5	0	1	22	16	2	0	0	0	0	41
24	0	0	15	16	1	0	0	0	0	32
24.5	0	0	5	23	3	0	0	0	0	31
25	0	2	6	22	6	1	1	0	0	38
25.5	0	1	2	19	14	1	2	0	0	39
26	0	0	1	8	10	3	4	1	0	27
26.5	0	1	0	2	14	1	3	1	1	23
27	0	0	0	5	5	1	5	1	5	22
27.5	0	0	0	1	6	2	7	1	3	20
28	0	0	0	0	1	2	4	1	5	13
28.5	0	0	0	0	1	1	1	1	4	8
29	0	0	0	0	0	0	0	0	1	1
TOTAL	89	93	115	117	63	12	27	6	19	541

Table 5B.5: Acoustic survey estimates of biomass (t) and numbers ('000) of herring and sprat by survey stratum from the AFBI commercial acoustic surveys in 2019.

Stratum	No. sprat	Biomass sprat	No. Her	Biomass Her
2	13355.17	37.09	63.76	0.43
3	543839.95	2744.59	77472.86	4049.18
5	4634987.76	13022.97	44763.81	278.62
7	778908.08	3930.90	479148.52	32101.37
8	1584613.11	6016.34	229.65	3.04
9	269451.42	1023.03	198110.02	22137.57
Total	7825155.5	26774.92	799788.6	58570.2

Annex 10: 2019 CSHAS Survey Summary Table

Survey Summary table WGIPS 2020	
Name of the survey (abbreviation):	Celtic Sea Herring Acoustic Survey (CSHAS) 2019
Target Species:	Herring and sprat
Survey dates:	06 October – 26 October, 2019
Summary:	**Cruise Report Link: http://hdl.handle.net/10793/1494**

The objectives of the survey were carried out successfully and as planned with no time lost due to weather. The broad scale survey used a laddered approach generating 2 independent estimates for the wider area. High intensity adaptive surveys were carried close inshore and on historic offshore abundance areas. Comprehensive trawling was undertaken across the survey area and the stock was considered contained within the survey area. The normal co-occurring fishery was closed before the survey due to the high occurrence of juvenile fish landed. The size composition of early fishery landings and survey samples were comparable. During the survey, mature fish were encountered in very low numbers contributing 0.4% of the total biomass. The presence of 0-group herring found during the 2018 survey, did not appear as (1-group fish) in the numbers expected during this year's survey.

Sprat were distributed widely across the survey area, following a similar pattern of distribution to previous years. Standing stock biomass increased from observations in 2018 (60,608 t, 2018; 49,000 t) and is comparable within the medium term times series.

Broad scale surveys yielded historically low herring biomass (Pass 1: 2,244.5 t (CV abundance: 55%) and Pass 2: 1,766 t (CV abundance: 56%)). Of the total standing stock biomass, 99.6% was composed of immature fish relating to 99.9% of total abundance. Dominant age classes within the stock were 0, 1 and 2 winter rings respectively.

Standing stock within the survey time series remains at low levels.

	Description
Survey design	Stratified systematic parallel design with randomised starting point within each stratum.
Index Calculation method	StoX (via ICES database) is used to provide indices of abundance.
Random/systematic error issues	Stock aggregated in localised inshore area that was also the focus of high intensity fishing effort. This has the effect of dispersing schools making accurate acoustic measurement difficult. This is more pronounced due to the current low standing stock biomass at this time.
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*

Bubble sweep down	NA, good weather dominated the survey
Extinction (shadowing)	ADZ presented more of an issue for the adaptive surveys
Blind zone	NA
Dead zone	High intensity surveys carried out on herring aggregations within <0.5m of the seabed and in the ADZ
Allocation of backscatter to species	Directed trawling for verification purposes
Target strength	Recommended values for target species
Calibration	All survey frequencies calibrated and results within recommended tolerances
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	It's believed that the bulk of the stock was contained during the survey
Stock ID and mixing issues	NA
Measures of uncertainty (CV)	Pass 1: 2,244.5 t (CV abundance: 55%), Pass 2: 1,766 t (CV abundance: 56%
Biological sampling	Comprehensive directed trawling carried out
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	To be answered by Assessment Working Group
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	To be answered by Assessment Working Group

Annex 11: 2019 WESPAS Survey Summary Table

Survey Summary table WGIPS 2020	
Name of the survey (abbreviation):	WESPAS / MSHAS (IRL)
Target Species:	Herring, boarfish, horse mackerel
Survey dates:	13 June – 29 July, 2019
Summary:	**Cruise Report Link: http://hdl.handle.net/10793/1462**

The objectives of the survey were carried out successfully and as planned. Good weather conditions dominated during the survey allowing for extended marine mammal and seabird survey effort. No weather induced downtime was recorded. Comprehensive trawling was carried out over the course of the survey (n=45) providing good confidence in school recognition and supporting biological data for age stratified abundance estimation of target species (herring, boarfish, horse mackerel).

Herring were distributed further south in 2019 compared to 2017 and 2018. TSB Malin Shelf herring biomass was 47% lower than in 2018. Dominant year classes: 2 and 3-wr fish representing 59% of the TSB. Boarfish distribution similar to previous years. The number of schools and acoustic density was slightly lower than in 2018.The 2019 survey estimate was -4% in biomass and -8% in abundance for comparable survey effort in 2018. Main age cohorts are visible within the survey. The presence of immature 1-2-year-old fish in 2019, highest in the time series. Potentially these emerging year classes will recruit to the SSB over the next 1-2 years. Horse mackerel were distributed in comparable regions along the Irish west coast and in the Celtic Sea for comparable survey effort. Geographical distribution was thus comparable to previous surveys but the number and acoustic density of aggregations was slightly lower than in 2018 but comparable overall to the as yet short time series (excluding 2017). Poor cohort tracking remains an issue between years.

Survey effort, timing and area coverage were comparable to previous years and the same vessel and sampling equipment (transducers and trawl) were used.

	Description
Survey design	Stratified systematic parallel design with randomised starting point within each stratum.
Index Calculation method	StoX (via ICES database) is used to provide indices of abundance.
Random/systematic error issues	NA, outside of those already described in literature for standardised acoustic surveys
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	NA, good weather dominated the survey

Extinction (shadowing)	Some shelf slope areas
Blind zone	Some shelf slope areas
Dead zone	Some shelf slope areas
Allocation of backscatter to species	Directed trawling for verification purposes
Target strength	Herring TS = 20log10(L) – 71.2 (38 kHz) Boarfish TS = 20log10(L) – 66.2 (38 kHz) Horse Mackerel TS = 20log10(L) – 67.5 (38 kHz)
Calibration	All survey frequencies calibrated and results within recommended tolerances
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	Herring; yes in line with co-occurring survey effort. Boarfish and horse mackerel; no, temporal alignment remains an issue in the southern boundary (Fra: PELGAS) and no survey coverage in the western Channel area.
Stock ID and mixing issues	Malin Shelf herring consists of mixed herring from 6aN, 6aS/7b,c and other areas
Measures of uncertainty (CV)	Malin Shelf Herring = 0.42 Boarfish = 0.25 Horse Mackerel = 0.34
Biological sampling	Comprehensive directed trawling carried out for boarfish and horse mackerel. The estimate of uncertainty for the Malin Shelf area is high (CV = 0.42); the low number of herring marks recorded on transects along with the low number of biological samples obtained is most likely contributing to this.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

Annex 12: 2019 PELTIC Survey Summary Table and Survey Report

Document 12a: PELTIC 2019 survey summary table

Survey Summary Table WGIPS 2020	
Name of the survey (abbreviation):	PELTIC19
Target Species:	Sprat, sardine, anchovy, horse mackerel, mackerel, herring
Survey dates:	1-28 Octcober 2019
Summary:	
Peltic19 constituted the 8th autumn survey on small pelagic fish and their ecosystem in the waters of the western English Channel and eastern Celtic Sea. The survey started in the Bristol Channel working into the English Channel. This year, for the third year running, the survey was extended beyond the area covered between 2012 and 2016, which focussed solely on the Mackerel Box. The extended survey coverage included the French waters of western Channel (ICES 7e). Despite the persistent westerly weather conditions, and resulting down time, the survey was successfully completed. In total just under 1800 nautical miles of acoustic sampling units were collected and supplemented with 38 valid trawls which provided details on species composition and biological information. The (preliminary) results indicated that sprat was found to be more widespread than in recent years although total biomass for survey area was comparable to 2018. The biomass in Lyme Bay, which is relevant to the stock assessment, was up from 2018, from 17,091 t to 23,443 t. As observed in recent years, sardine was widespread in the survey area, including north of the Cornish Peninsula. Sardine egg distribution reflected that of the adults, including the presence of the highest densities, by some margin, in the Eddystone Bay. Sardine biomass for the whole was estimated at 239,478 t, up from 157,936t. The recent trend in anchovy expansion in the survey area continued. Biomass, at 11,880 t was more comparable to the long term mean, after last year high value. For the first time, large numbers of juvenile anchovy (4-7 cm) were found in a surface layer along the French coast. Details on biomass and distribution of herring, blue whiting, horse mackerel, mackerel and boarfish were also provided. Atlantic bluefin tuna were again observed in large numbers across the survey area. Oceanographic conditions in October were comparable to the average values of the time series.	

	Description
Survey design	Systematic stratified parallel (5-10 and 15 nmi), perpendicular to bathymetry
Index Calculation method	StoX and EchoR

Random/systematic error issues	None
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	No major issue, despite adverse weather conditions as survey was suspended during stormy conditions. Where possible, sailing direction was modified to reduce effect. Occasional noise was removed during processing so not thought to affect results.
Extinction (shadowing)	Not an issue (school backscatter explored *in situ* for high values >20,000 NASC).
Blind zone	*Time-series*: survey daylight only to avoid effects of diurnal vertical migration. High pingrate (0.5 s-1) also ensures that surface fish schools just below nearfield are captured acoustically at 10 knots. *2019*: juvenile anchovy schools at surface in French waters may be undersampled. Negligible impact on estimates as majority of schools were comfortably within the sampling range; in addition anchovy thought to belong to Bay of Biscay stock
Dead zone	0.5m; no known issue for target species
Allocation of backscatter to species	Echotypes which are allocated to trawls based on combination of nearest distance of acoustic data to trawl and expertise
Target strength	Recommended (-71.2 clupeids, -66.2 boarfish; -68.9 horse mackerel; -67.4 gadoids); Mackerel processed at 200 kHz using b20 of 84.03
Calibration	On drift at 0.512 amd 0.256 μs for 38, 120 and 200 kHz; on-axis calibration performed for 333 kHz at 0.512 μs in post-procssing software. Results comfortably within recommended parameters. Post-survey, details of a **bug in EK80 calibration software** were identified which, when applied to EK60 data, affected the NASC values recorded. At the time of writing, new values are calculated and while details are not known, the PELTIC results presented are under-estimates.
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	*Time series*: **sardine** extends into Bay of Biscay which is covered by JUVENA survey (AZTI); bulk of biomass in western English Channel; a small component of the sardine extends east into Channel and southern North Sea but the quantities are thought to be small; **sprat** questions remain about the link of Lyme Bay sprat to other populations in Channel and beyond although seemingly isolated in autumn. Sprat in Celtic Sea not captured as extending further west (covered by MI, Ireland during CSHAS) *2019 survey*: as above

Stock ID and mixing issues	*Time series:* genetic work in progress on sardine, sprat and anchovy. Sardine is single stock although some question about autumn and spring spawners; anchovy also. Sprat in Lyme Bay show little discrimintation from those in Celtic Sea, the North Sea and Skaggerak. *2019 survey*: for the first time significant numbers of midwater schools, consisting of anchovy larvae, were observed in French near-shore waters of the western Channel. Samples are being genityped to identify which stock these belong to but the absence of spawning in the English Channel suggests these are Bay of Biscay anchovy.
Measures of uncertainty (CV)	Biomass CV: Sprat (0.33), Sardine (0.19), anchovy (0.25)
Biological sampling	*Time series*: good *2019 survey*: probably oversampling as station based rather than stratum based
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

Document 12b: PELTIC 2019 survey report

Please see the report on the next page.

RESEARCH VESSEL SURVEY REPORT

RV CEFAS ENDEAVOUR
Survey: C END 15 - 2019.

STAFF:

Name	Role	Name	Role
Part 1		**Part 2**	
Jeroen van der Kooij	SIC/acoustics	**Joana Silva**	SIC/fish
Joana Silva	2IC/fish	**Fabio Campanella**	2IC/acoustics
Oliver Twigge	Hydro	**Oliver Twigge**	Hydro
Marc Whybrow	Tech	**Marc Whybrow**	Tech
Richard Humphreys	Fish Lead	**Richard Humphreys**	Fish Lead
Matt Eade	Fish	**Sam Barnett**	Fish
Sam Barnett	Fish	**Allen Searle**	Fish
Fabio Campanella	Acoustics	**Sílvia Rodriguez-Clíment**	Acoustics
James Pettigrew	Plankton	**Hayden Close**	Plankton
Nevena Almeida	Plankton	**Hannah Lloyd-Hartley**	Plankton
James Scott	PhD (UEA)	**James Scott**	PhD (UEA)
Chris Brodie	PhD (Uni Salford)	**Chris Brodie**	PhD (Uni Salford)
Roweena Patel	PhD (Uni Reading)	**Roweena Patel**	PhD (Uni Reading)
Nuala Campbell	ML observer	**Nuala Campbell**	ML observer
Camille Burton	ML observer	**Camille Burton**	ML observer

DURATION: 1st – 28th October (28 days)

LOCATION: Western Channel and Celtic Sea (ICES Divisions 7.d, e, f, g, Fig 1)

Centre for Environment Fisheries & Aquaculture Science

Cefas

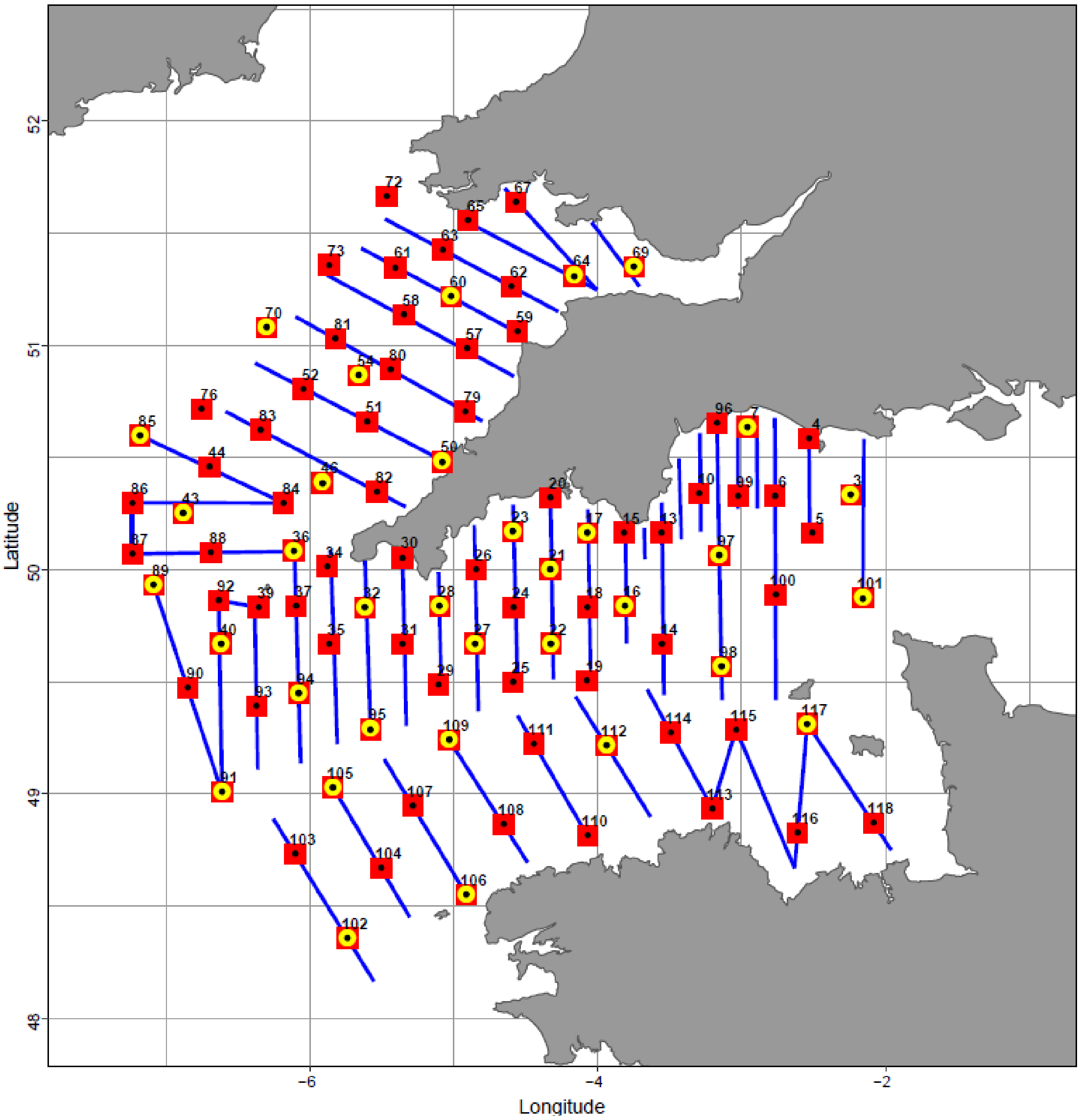

Figure 1. Overview of the planned survey area, with the acoustic transect (blue lines), plankton stations (red squares) and hydrographic stations (yellow circles).

AIMS:

1. To carry out the eighth annual multidisciplinary pelagic survey of the western Channel and Celtic Sea to estimate the biomass of-, and gain insight into the population of the small pelagic fish community including sprat (*Sprattus sprattus)*, sardine (*Sardina pilchardus*), mackerel (*Scomber scombrus*) , anchovy (*Engraulis encrasicolus*), horse mackerel (*Trachurus trachurus*), boarfish (*Capros aper*) and blue whiting (*Micromesistius poutassou*).

   a. To carry out a fisheries acoustic survey during daylight hours only, using four operating frequencies (38, 120, 200 and 333 kHz) to map and quantify the small pelagic species community.
   b. To trawl for small pelagic species using a 20x40m herring (mid-water) trawl in order to obtain information on:
      - Species and size composition of acoustic marks
      - Age-composition and distribution, for small pelagic species
      - Length weight and maturity information of pelagic species
      - Stomach contents of selected species

2. To collect biological data (size, weight, age and maturity) on a range of data-limited fish species, including European seabass (*Dicentrarchus labrax*), black seabream (*Spondyliosoma cantharus*), striped red mullet (*Mullus surmuletus*), garfish (*Belone belone* and *B*. *svetovidovi*), saury pike (*Scomberesox saurus*).

3. To collect plankton samples using two ring-nets with 80 µm, and 270 µm mesh sizes at fixed stations. Carried out at night by vertical haul and samples will be processed onboard:
    a. Ichthyoplankton (eggs and larvae, 270 µm) of pelagic species will be identified, counted and (in case of clupeids) staged and measured onboard to identify spawning areas.
    b. Zooplankton (80 µm) will be stored for further analysis back in the lab.

4. Water column sampling. At fixed stations along the acoustic transect, a CTD (either an ESM2 profiler or a Seabird mounted on a Rosette sampler) will be deployed to obtain measurements of environmental properties within the water column. Water column profile and water samples will provide information on chlorophyll concentration, dissolved oxygen, salinity, temperature, turbidity, and dissolved inorganic nutrients concentration as well as the relevant QA/QC samples for calibration of the equipment. Water samples will be collected and fixed on board for analysis post-survey. Samples for analysis of the phytoplankton and microzooplankton communities will also be collected at the subsurface at fixed sampling stations.

5. Seabirds and Marine Mammals. Locations, species, numbers and activities observed will be recorded continuously during daylight hours by Marinelife observers located on the bridge.

6. Ferrybox Continuous CTD/Thermo-salinograph. Continuously collect oceanographic data at 4 m depth during steaming, including chlorophyll concentration (from calibrated fluorescence).

7. To carry out hourly measurements of the phytoplankton functional groups using an online flow-cytometer, connected to the Ferrybox; in collaboration with project JERICHO NEXT.

8. To further trial the continuous Plankton Image Analyser (PIA, James Scott, PhD).

9. To collect and process samples of environmental DNA and assess method as monitoring tool for pelagic fish, cetaceans and diversity (Chris Brodie, PhD).

10. To collect stomach contents of small pelagic fish (e.g. anchovy and sardine) for onboard and post-survey analysis (Roweena Patel, PhD).

11. To collect small pelagic fish stomachs for a study on proliferation of microplastics through food webs. Not completed and replaced with #10

12. To collect a zooplankton sample using the 200 µm mesh ring-net at the West Gabbard2 SmartBuoy, for the Lifeform project (Defra) as part of the UK monitoring network of zooplankton. Not completed due to time constraints.

13. To collect and freeze sardine specimens at three different locations: eastern English Channel, Western English Channel and Bristol Channel for genetic and otolith morphometric study (Ana Verissimo, CIBIO, Portugal)

14. To collect 15 tissue samples of sardine for each ICES rectangle for a Portuguese study to integrate genetic analysis into fisheries biology and assessment (Ana Rita Vieira, MARE, University of Lisbon, Portugal)

NARRATIVE:

All staff joined the RV Cefas Endeavour in Swansea docks by 16:00 on the 30th of September. Inductions were held at 16:00 followed by the presurvey debrief at 18:00. Given the incremental weather conditions forecasted, the captain suggested conducting the echosounder calibration in port the following morning (1st of October) before sailing: while the available water depth was shallow at 12 m, the relatively sheltered position and lack of tide led us to consider it. As planned, staff involved with the calibration were ready at 5:30 to make final preparations but a range of circumstances delayed the actual calibration attempt until 9:00 BST. With the pilot due at 10:00, the calibration had to be aborted. The RV sailed out of Swansea at 10:00 and commenced the inner most transect of the Bristol Channel, after which shakedown tows for the plankton nets and rosette/CTD were conducted, both preceded by relevant toolbox talks. At 16:00, after the toolbox talk, the trawl was deployed for a shakedown tow. Overnight, a series of plankton and rosette stations were conducted. At approximately 7:00 BST on Wednesday 2nd of October favourable conditions meant that a second calibration of the echosounders was attempted. A sheltered location at northern end of transect 10, along the western tip of the Pembrokeshire coast was used, which had sufficient water depth, but strong tides. The calibration, conducted on the drift was completed at 9:45 (38, 120 and 200 kHz at 0.512 and the 38 at 0.256) by which point the RV needed to leave the area for planned fire practise, which affected the acoustic sampling of the northern parts of transects 10 and 9. The survey had commenced properly which, as per protocol, involved running acoustic transects during the day at 10 knots, while simultaneously collecting continuous sub-surface oceanographic data with the Ferrybox. Two Marinelife observers recorded qualitative and quantitative information on the top predators on transect. At night, a series plankton and rosette stations was sampled. Late afternoon on Thursday the 3rd of October, the RV sought shelter (daylight required) on the east side of Lundy from Storm Lorenzo which was due to arrive at night. No night time surveying was conducted. Approximately 24 hours later, in the afternoon of Friday the 4th of October, the RV sailed to explore conditions and resumed survey work. For the next few days, the survey progressed westwards under fresh but workable conditions. On the 7th of October, the pelagic trawl was damaged during a fishing operation on transect 15. While the true extent of the damage was not known until later, as a precautionary measure it was decided to rig the spare trawl. Although trawling operations could resume later in the afternoon, few fish schools appeared on the echosounder and therefore no further tows were conducted. Acoustic monitoring was continued as were the overnight primary stations sampling for zooplankton and CTDs. Several plankton stations had to be repeated over the first few weeks due to incidental damage to either the plankton nets (ringnet) or their codend. The next few days, the RV moved away from the Bristol Channel to sample the transects around the Isle of Scilly with weather conditions remaining fresh (25 knots of wind). Transect #18 had to be surveyed straight into the swell (east to west) leading to relatively poor acoustic data quality and reduced vessel speed. However, as very few fish schools were observed and no uplift of weather was expected work was continued. By the 11th of October, the Isles of Scilly transect had been completed and surveying of the Cornish waters in the western Channel commenced. Calmer weather on the 12th October (fair winds of 6 knots) led us to pick the exposed western most transects on the French side of the western Channel and associated prime stations overnight. At the (inshore) start of Transect 47 a series of surface schools were observed on the echosounder which comprised of post-larval anchovy (3.5-7 cm in length). These same schools were later observed inshore of the adjacent transects to the east.

Overnight, the RV steamed to Falmouth for a scheduled crew change on Monday the 14th of October, which was completed by 18:00 BST. Overnight, the vessel steamed from Falmouth to Lyme Bay to use the continued calm conditions to survey this important area for sprat. Most of the Lyme Bay transects were completed by the afternoon of the 17th under very good conditions (5-8 knots of wind, calm seas). While on occasion the wind picked up in the afternoon, daytime conditions remained very favourable and swell remained negligible, ensuring excellent data quality. After scientific staff change in the afternoon of the 17th of October by small boat transfer in Weymouth, the RV steamed back to French waters to survey the eastern-most transects. Due to adverse weather conditions, no trawling operations could be conducted on the 18th of October, but few fish schools were seen on the echograms so this was no major issue. Vastly improved conditions led the RV to commence transect 41, at the southern end, working its way back to Lyme Bay to complete the outstanding transects during the next couple of days. After completion, for the remainder of the survey, the RV resumed some of the western transects in the western Channel, working eastwards including transects in French waters. During this period, it became apparent that the inflow into the ferrybox (surface oceanographic sampler) was reduced which was likely caused by biofouling. The final two weeks of the survey was conducted without the autopilot working which meant that manual steering was required during the remainder of the survey. This did not adversely affect the quality of the data collected. Fair conditions changed to increasing south-westerly winds towards the end of the survey which reduced night time sampling opportunities of primary stations and several oceanographic and meso-zooplankton stations were not completed. The survey was interrupted due to weather in the early afternoon on the 26th of October, when the vessel steamed into Lyme Bay to shelter. The next morning the survey was resumed and final transects and stations in the Eddystone Bay were completed. On the 28th of October five scientific staff disembarked via small boat transfer in Weymouth after which the RV commenced its transit back to Lowestoft where, after collection of a sample at Dungeness, she docked at 20:00 BST on the 29th of October.

RESULTS:

NOTE: In December 2019, Simrad released the latest EK80 software (v 1.12.4). In the associated release note (https://www.simrad.online/ek80/swrn/ek80_swrn_current_en_a4.pdf), details were provided of a bug discovered in the calibration software of previous versions. The bug affected the Sa correction and as a consequence the biomass estimates originally calculated during the 2019 PELTIC survey and those in 2018 were affected. In this version of the survey report, corrected biomass values are provided.

Pelagic Ichthyofauna

After removing the off-transect data a total of 1800 nautical miles of acoustic sampling units were collected for further analysis (Figure 2). These included several transects in the eastern Channel, which was sampled for the first time this year. A total of 38 valid trawls were made with the mid-water trawl, providing a suitable source of species and length data to partition the acoustic data. The trawl was changed over early on in the survey due to gear damage; although the same make and model as the original trawl, the lighter material used caused some temporary issues with the headline sensor deployment. However, these were fixed by adding a firmer floatation line on the headline. General patters of fish distribution were similar to those observed for the time series and included, for the third year running, the French waters of the western English Channel.

Sprat (*Sprattus sprattus*) was widespread in most of the survey area with the typical presence of two core areas, one in the Bristol Channel, including the coastal waters in the west, and the other in English waters of the western Channel (Lyme bay, Figure 3). Medium sized fish (mode of 8-9 cm) dominated all main areas. As in previous years, the smallest fish were found in the Bristol Channel and the largest (mode of 11.5 cm) in Lyme Bay, although high numbers of age-0 sprat in Lyme Bay suggested a decent recruitment. Preliminary biomass estimate of the sprat population in English waters of western Channel Bay was 36,789 t, a 69% increase from 21,772 t in 2018. Sprat was also found in French waters although further east than in previous years (Figure 3). Sprat biomass for the total area was 111,073 t and comparable to 106,431 in 2018.

Sardine (*Sardina pilchardus*) distribution was comparable to previous years with the bulk of biomass found in the English Channel (Figure 4). The apparent trend of increasing numbers of sardine north of the Cornish Peninsula continued. Northern waters of the English Channel again host the largest size-range of sardines with the largest fish also extending to the waters around the Isles of Scilly. In French waters, most sardines were smaller than 14 cm. Area 7 sardine is the most abundant small pelagic fish in the area with a total biomass for 2019 estimated of the consistently sampled area to be 374,617 t, which was more than double compared to last year's estimate of 145,514 t.

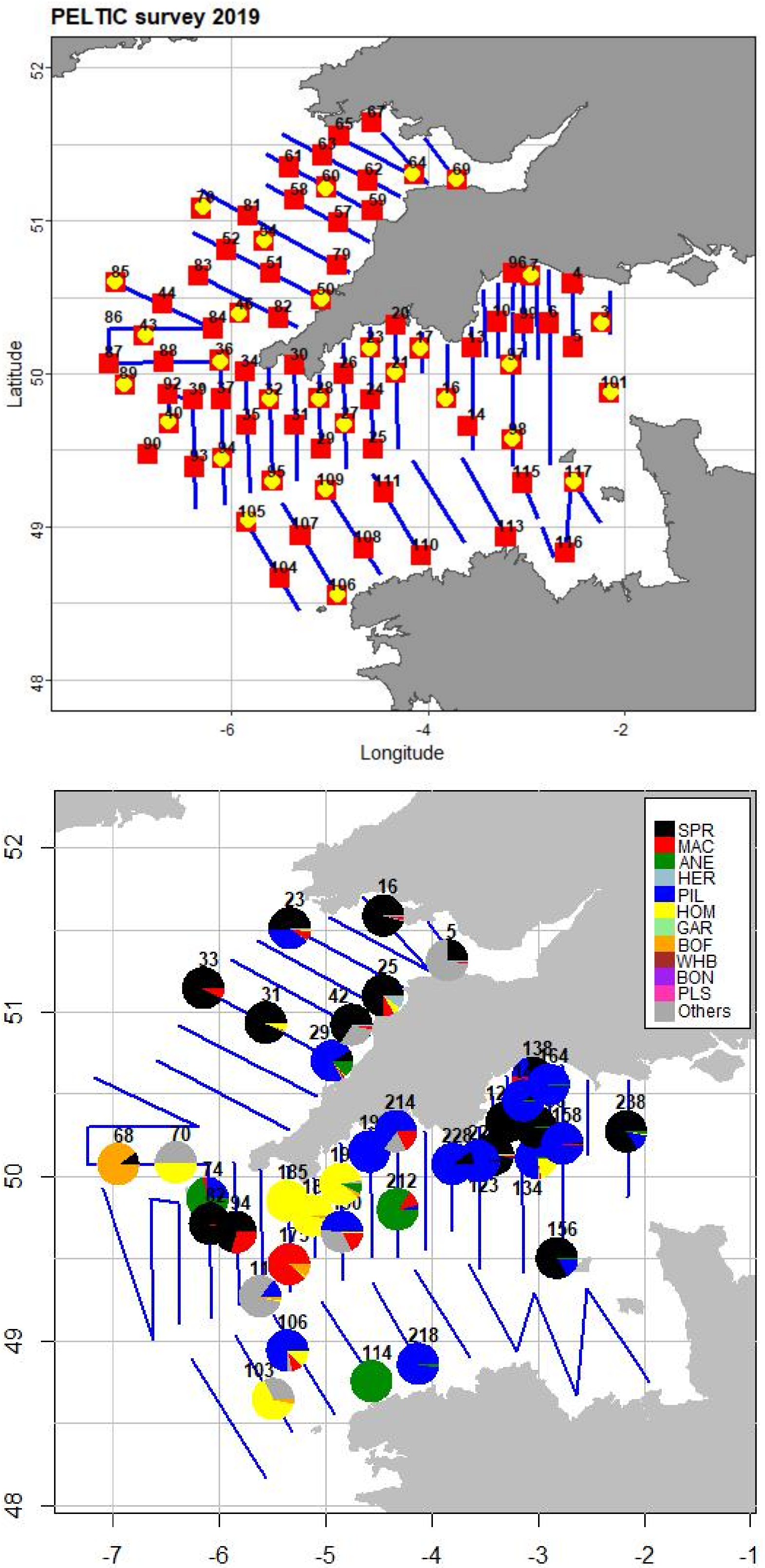

Figure 2. Overview map and detail of the PELTIC19 survey area. Top: Acoustic transects (blue lines) and prime stations completed. Bottom: Trawl stations (pies) with relative catch composition by key species. Three letter codes: SPR=sprat, MAC=mackerel, ANE=anchovy, HER=herring, PIL=sardine, HOM= horse mackerel, GAR=garfish, BOF=Boarfish, WHB=Blue whiting, BON=Atlantic bonito, PLS=pearlside.

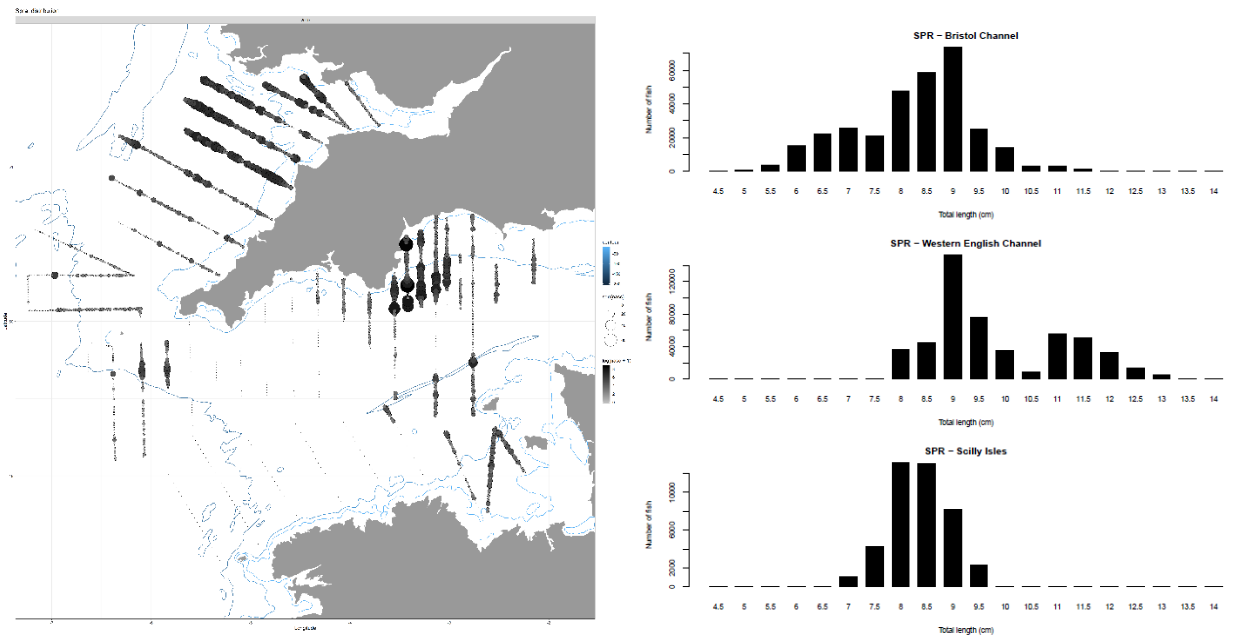

Figure 3. Relative acoustic sprat density distribution (NASC, left) and trawl-based length frequency histogram for sprat in some of the subareas of the Peltic survey (right).

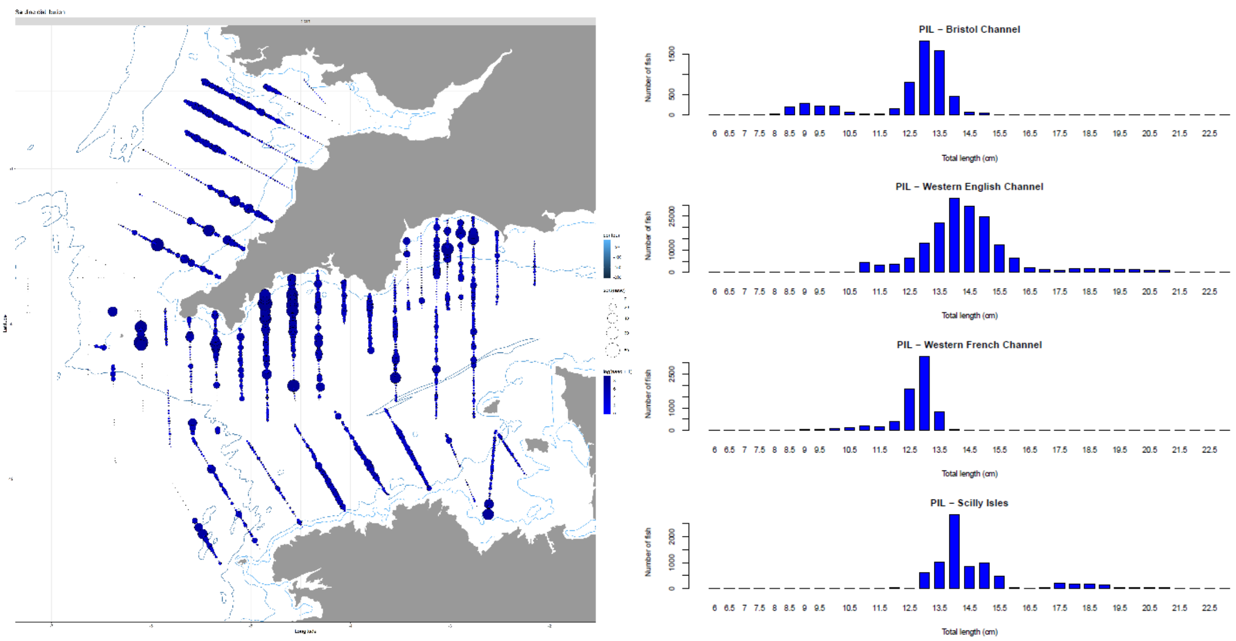

Figure 4. Relative acoustic sardine density distribution (NASC, left) and trawl-based length frequency histogram for sardine in each of the subareas of the Peltic survey. Please note that bubble size has not been standardised between species.

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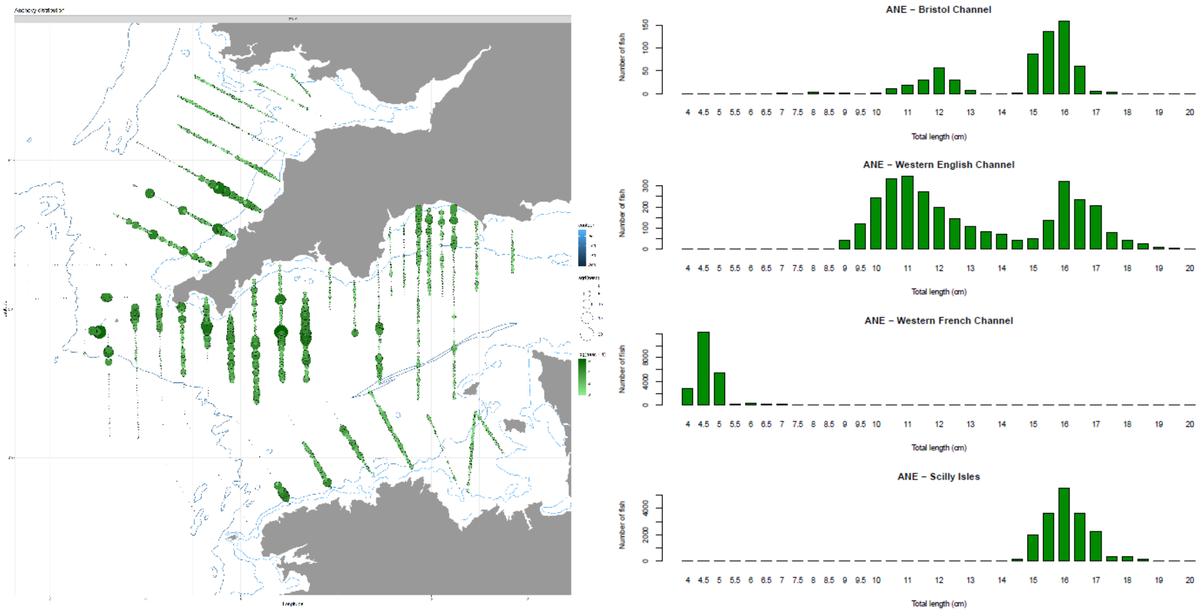

Figure 5. Relative acoustic anchovy density distribution (NASC, left) and trawl-based length frequency histogram for anchovy in each of the subareas of the Peltic survey. Please note that bubble size has not been standardised between species.

Anchovy (*Engraulis encrasicolus*) distribution in 2019 confirmed the expected trend of northwards expansion with increased anchovy biomass in the Bristol Channel, an area not inhabited by anchovy in the first years of the survey series. Similar length frequency modes on both sides of the Cornish Peninsula (11-12 and 16 cm, Fig. 5) suggested that the majority of these fish are from the same population. Particularly notable was the presence of juvenile anchovy in small surface schools on the French side (Fig. 6). This has not been observed in previous years. Genetic samples will confirm which stock they belong to but it is speculated that these are fish originating in the Bay of Biscay. Total anchovy biomass in the survey area was estimated at 14,874 t, which was up from 2018 (10,096 t for the same area).

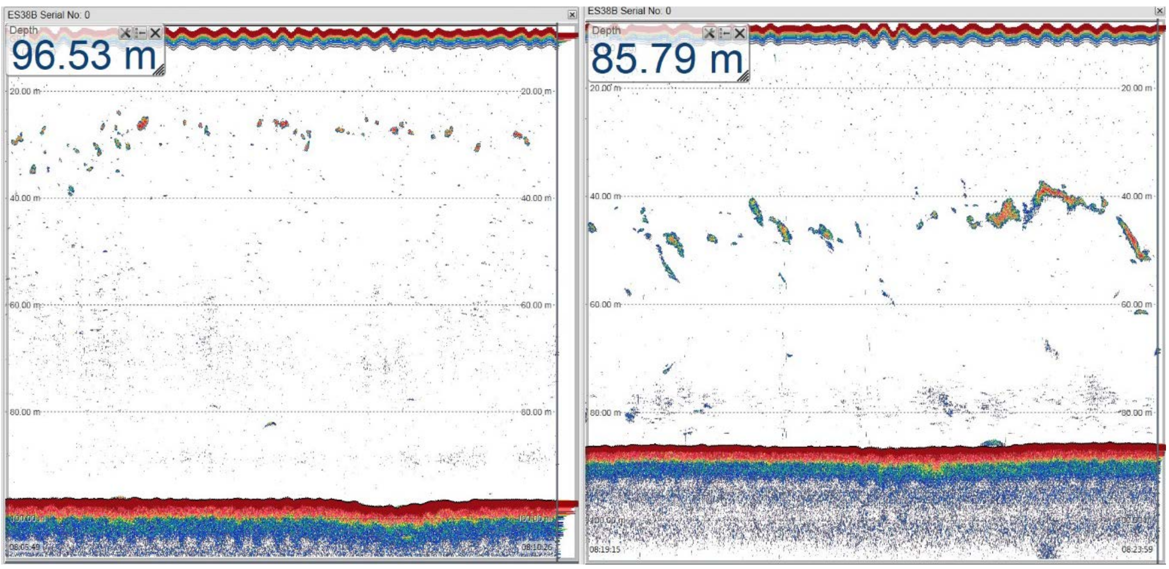

Figure 6. Two example daytime echograms (38 kHz, -70dB gain) of layer of surface schools in near-shore French waters, comprised of juvenile (4-6 cm) anchovy.

Following last year's large apparent recruitment pulse of juvenile **herring (*Clupea harengus*)**, combined acoustic and trawl information suggested that 2019 was more in line with the usual observations. Horse mackerel and mackerel were again distributed throughout the survey area, largely consisting of young-of-the-year specimens (Horse mackerel: modes between 6-8 cm, mackerel 15-19 cm). Larger horse mackerel (mode at 22 cm) were caught in French waters and larger mackerel (mode at 28 cm) in English waters of the western Channel.

Zooplankton

Samples of mesozooplankton and ichthyoplankton communities were collected at 79 stations using 80 and 270 micron ringnets, respectively. This was fewer than planned and was due to weather conditions. Several stations in the central English Channel and on the French side were missed due to adverse weather conditions. Preliminary results on the distribution of sardine eggs suggested a similar distribution as found in previous years with spawning areas on both side of the Cornish Peninsula but highest densities in the western Channel (Figure 7). Plankton samples were again collected in the southern half of the English Channel. Information on size and taxonomic group of zooplankton samples collected at the same stations, will be obtained by Zooscan processing back in the lab.

For the duration of the survey, the Plankton Image Analyser (PIA) was run to collect images of zooplankton organisms, which will be processed and analysed at PML.

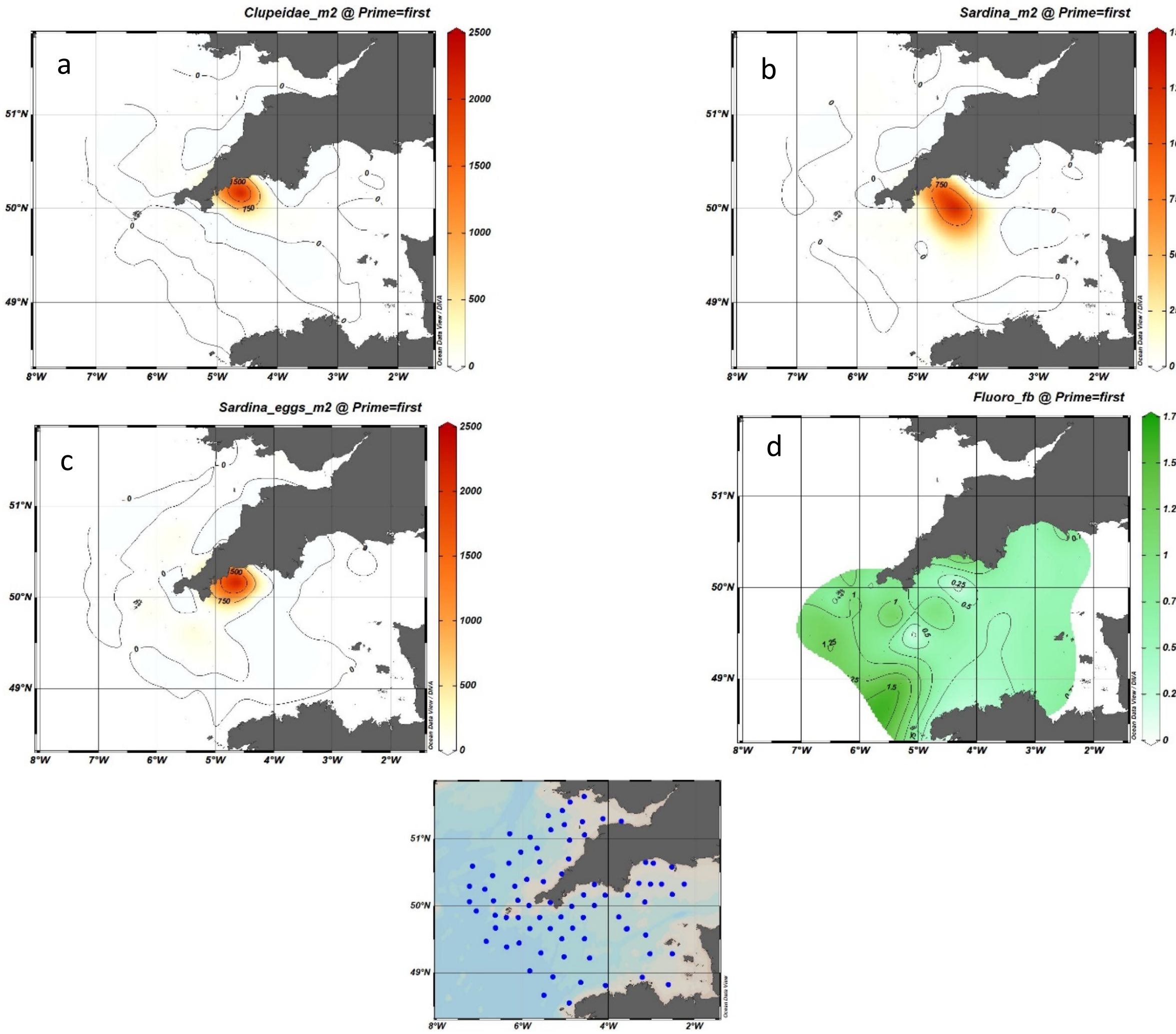

Figure 7. Distribution of fish larvae (total Clupeidae and Sardine; a, b) and eggs at the sampling stations (c), determined from samples collected with the 270 µm ring net and analysed on board; subsurface fluorescence concentration recorded by the Ferrybox (d). Note that the larvae are separated by those confirmed to be sardine (Sardina) and those that could not be further distinguished to species (Clupeidae), the vast majority was considered to also be sardine.

Physical Oceanography

Temperature and salinity of the water column at the 79 zooplankton sampling stations was measured with a SAIV MiniCTD profiler, and, at 33 of these (water stations), a SeaBird CTD, mounted on the Rosette sampler, was also deployed. Total number of stations sampled was lower than planned which was due to adverse weather conditions. The SeaBird CTD was equipped with PAR, oxygen, turbidity and fluorescence sensors and allowed for live measurements of environmental variables along the water column. At 30 of these water stations, water samples were collected for analysis of phytoplankton and microzooplankton communities, dissolved oxygen, salinity, phytoplankton pigments (including chlorophyll-a) and dissolved inorganic nutrients (nitrate, nitrite, ammonium, phosphate, silicate). To collect the water samples, 12 Niskin bottles attached to the Rosette, were used, except during 6 sampling events when sea state was too rough, and samples were collected from the flow-through of the FerryBox.

Water samples were collected at water stations and during trawls, then filtered for determination and quantification of eDNA in the water.

Water at the subsurface (4 m) was continuously monitored by the FerryBox, which recorded different environmental variables, including temperature, salinity, fluorescence, turbidity, and oxygen. Furthermore, a flow cytometer, connected to the FerryBox, carried out measurements of abundance and size of the phytoplankton community every hour, while the PIA (Plankton Image Analyzer) provided continuous monitoring of the mesozooplankton population. Due to issues with the water inflow, neither Ferrybox nor Flowcytometer managed to provide continuous coverage.

Table 1. Number of samples collected during Cend15_19 and number of profiles carried out.

	Total
Salinity	30
Dissolved oxygen (triplicates)	16
Chlorophyll/Pigments analysis (HPLC - duplicates)	31
Inorganic nutrients	30
Phytoplankton	30
Microzooplankton	30
Mesozooplankton (80 µm)	79
Mesozooplankton (270 µm)	79
eDNA samples	?
CTD profiles with Rosette	33
CTD profiles with ESM2	6
CTD profiles with RBR	8
CTD profiles with SAIV MiniCTD	83

As per previous years, sea surface temperature was highest in the Bristol Channel and then just off the Western French Channel near St Brieuc. Maximum temperature from this survey was 17.2°C, this is warmer by more than 0.5 °C compared to previous two years and more closely resembles the maximum of the 2016 survey. As is a common observation during the PELTIC survey series, the lowest surface temperatures were recorded at the mouth of the western English Channel (Fig. 8, 9). Although the lowest surface temperature recorded this year was, at 13.5°C, warmer than that in 2018 and comparable to years before then. Lowest bottom temperatures were taken at the most westly stations advancing into the Celtic Sea.

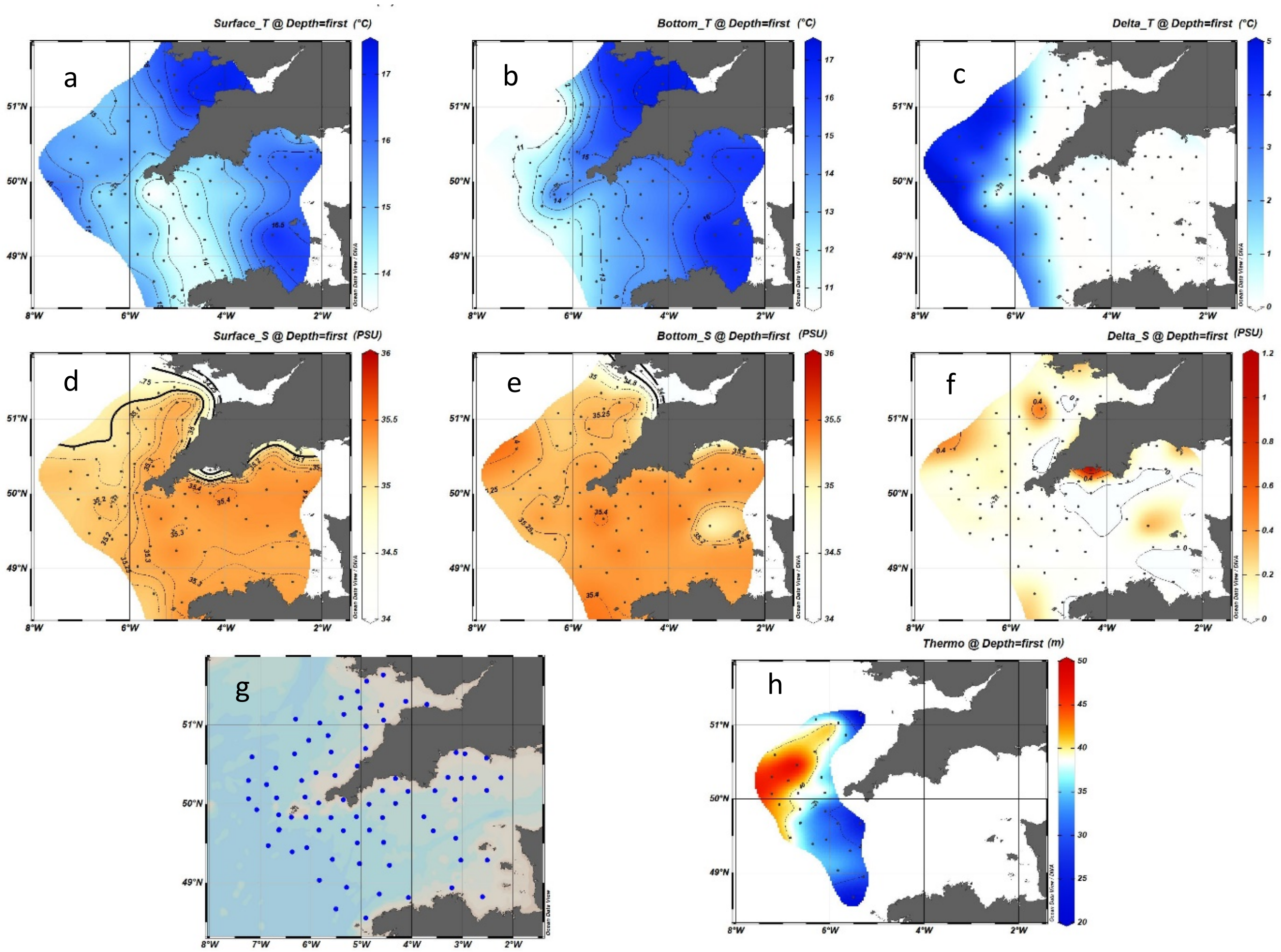

Figure 8. Temperature (a-c, T, °C) and salinity (d-f S) distribution at the surface (a, d) and bottom (b, e) as recorded by the SAIV MiniCTD at the 79 sampling stations (g). The difference in temperature (c, Delta_T) and salinity (f, Delta_S) between surface and bottom is also given, together with depth of the thermocline (h, Thermo), at the stratified stations (Delta_T > 0.5 °C).

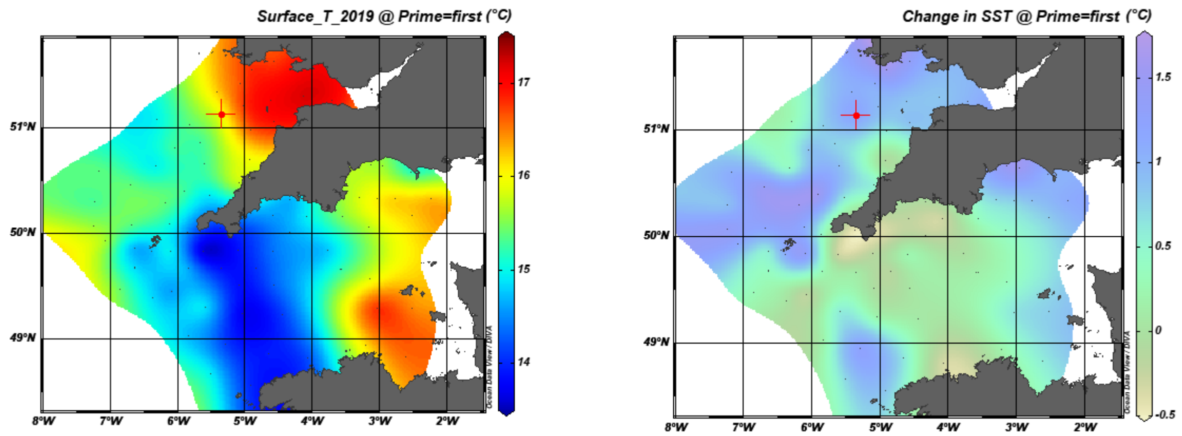

Figure 9. Sea surface temperatures recorded this survey (left) and difference in sea surface temperatures recorded from last year 2018 (right).

Table 2. Summary statistics (minimum, maximum, mean, standard deviation, and number of observations) of temperature and salinity measurements, recorded by the SAIV MiniCTD at the sampling stations. Column titles are the same as in Figure 2.

	Surface_T	Bottom_T	Surface_S	Bottom_S	Delta_T	Delta_S	Thermo
Min	13.51	10.55	31.81	31.85	0	0	21
Max	17.23	17.23	35.39	35.44	4.74	1.16	48
Mean	15.29	14.28	35.12	35.19	1.04	0.09	36.3
StDev	0.93	1.88	0.46	0.43	1.54	0.16	6.6
Number	79	79	79	79	79	79	28

Offshore stations in the Bristol Channel and in the Western approaches, west of Lizard Point, were seasonally thermally stratified (Delta_T > 0.5 °C; Figure 8). While a series of storms with strong wave activity throughout October was thought to have accelerated the mixing, the picture is similar to previous years. Coastal stations in the English and French side of the Channel were vertically mixed (Figure 8). The difference between surface and bottom temperatures was highest at offshore stations in the Celtic Sea and up to 4.74 °C (Table 2). Thermoclines with the deepest initial start of the stratification, >30m, were found at offshore stations (off the Bristol Channel). Those with shallower stratification were more coastal and typically associated with the cooler sea surface temperatures off Western France (minimum of 11m, Table 2 and Figure 8). The strength of stratification was similar to that of previous years between 4.9°C and 4.3°C. Unusually low salinity values were recorded (31.89; Table 2 and Figure 8) in the Bristol Channel and were thought to be due to increased rainfall towards the end of September. This result was confirmed by the value recorded by the Ferrybox (31.70), but this will be validated after calibration of sensors. Salinity remained low throughout Bristol Channel, and was also lower in Lyme Bay and the Bay of Sein, France. Highest salinity values were recorded offshore of Lizard Point (35.39; Table 2 and Figure 8) and south west corners of the Celtic Sea. Surface distribution of chlorophyll concentration was estimated by fluorometers on the Ferrybox and on the SeaBird profiler mounted on the Rosette sampler. Remote sensed images of ocean colour from MODIS (algorithm OC3) from Neodaas.co.uk (PML) were consulted to obtain a synoptic view of the study area, but were of limited use due to cloud cover throughout the survey.

Observer data: Birds, marine mammals and large pelagic fish

For the whole survey, two volunteer MARINElife surveyors, stationed on the bridge in a central position, employed an effort-based 300m box methodology for recording birds (an adapted version of ESAS methodology) with an additional 180° scan area surveyed along each transect line, as used on the majority of MARINElife's year-round surveys. During survey transects, all species of birds (both seabirds and terrestrial migrants) were recorded, along with all sightings of marine mammals and large pelagic fish. . Approximately 3,025km of transect line was sampled during the full course of the survey. This year, very little (incidental) data were collected during the deployment of the fishing net, during the net-retrieval phase or during transits between transects.

The diversity of birds was far fewer than in 2018, which almost certainly reflected the team being less experienced- and competent bird observers than previous years, although other factors may have been at play too. A total of 2,679 sightings of 14,151 birds (44% of the 2018 total), from 21 species (51% of the 2018 total) were recorded throughout the duration of the survey. As in all previous surveys, the Gannet was the highest recorded species. It was a very poor year for shearwater sightings, with no Balearics shearwaters recorded. It should, be noted that there were only five sightings in UK waters in 2018, with none in Lyme Bay and only a further nine sightings in French waters.

Table 3. Cetacean species recorded by MARINElife surveyors on effort during Peltic survey 2018:

Species	Scientific Name	# sightings	# animals
Minke Whale	*Balaenoptera acutorostrata*	2	3
Common Bottlenose Dolphin	*Tursiops truncatus*	3	51
Short-beaked Common Dolphin	*Delphinus delphis*	236	967
White-beaked Dolphin	*Lagenorhynchus albirostris*	1	3
Harbour Porpoise	*Phocoena phocoena*	2	3
	Total:	244	1,026

The MARINElife observers recorded a total of 244 cetacean encounters, totalling approximately 1,026 animals from 5 species. Compared with 2018 there were more sightings (44%), but of fewer individuals (-66%) and species (three less). Encouragingly, White-beaked Dolphins were seen in Lyme Bay. For only the second time in the time series, no Fin Whales were seen although this is likely due to poor visibility (heavy fog) while surveying the hotspot for this species (Celtic Deep). Very few Harbour Porpoises were seen despite the reasonably good viewing conditions. Short-beaked common dolphin *Delphinus delphis* was again by far the most frequently recorded species, with 236 sightings; 86 more than in 2018) of nearly 1,000 animals (2000 less than 2018) (Table 3). These inter annual differences may indicate that there were fewer bigger groups. Common Dolphins were widely distributed (Figure 4) although there were no sightings within the 12 nautical mile limit off west Cornwall and the most easterly transects off the north coast of France. One group of 3 White-beaked Dolphin *Lagenorhynchus albirostris* were seen this year, in Lyme Bay. Of the three Common Bottlenose Dolphin *Tursiops truncatus* sightings, two were north and west of Land's End, Cornwall whilst the third was north west of Ushant.

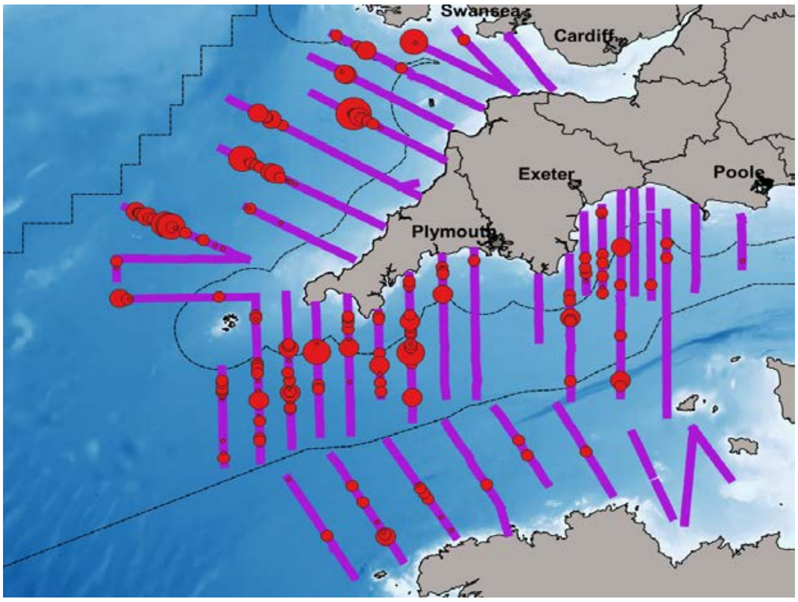

Figure 4: Distribution of all Common dolphin sightings (red circles) in 2019, scaled to abundance. Abundance categories (small to large circles): 1, 2-5, 6-10, 11-20, 20-25. Purple lines show survey effort

In addition to birds and cetaceans, there were three sightings of Atlantic Grey Seal *Halichoerus grypus* and four other unidentified seals. Sightings of tuna were down on those in 2018 at 11 different sightings across the survey area.

Weather was particularly difficult for surveying and there were a few days within the survey, particularly part 1, where the team were faced with storms.

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Summary

Peltic19 constituted the 8th autumn survey on small pelagic fish and their ecosystem in the waters of the western English Channel and eastern Celtic Sea. The survey commenced on the 1st of October and ran for 28 effective survey days, starting in the Bristol Channel working into the English Channel. This year, for the third year running, the survey was extended beyond the area covered between 2012 and 2016, which had focussed solely on the Mackerel Box. The extended survey coverage included the French waters of western Channel (ICES 7e). Despite the persistent westerly weather conditions, and resulting down time, the pelagic fish objectives of the survey were successfully completed. In total just under 1800 nautical miles of acoustic sampling units were collected and supplemented with 38 valid trawls which provided details on species composition and biological information. The weather conditions did impact the number of zooplankton and oceanographic stations sampled at night with some stations in the central English Channel missing. The (preliminary) results indicated that sprat was found to be more widespread than in recent years although biomass for survey area was comparable to 2018. The biomass in Lyme Bay, which is relevant to the stock assessment of sprat in 7de, was up from 2018, to 36,789[1] t. As observed in recent years, sardine was widespread in the survey area, including north of the Cornish Peninsula. Sardine egg distribution reflected that of the adults, including the presence of the highest densities, by some margin, in the Eddystone Bay. Sardine biomass for the whole was estimated at 374,619 t, significantly up from 2018. The recent trend in anchovy expansion in the survey area continued. Biomass, at 14,974 t was up from last year. For the first time, large numbers of juvenile anchovy (4-7 cm) were found in a surface layer along the French coast. Details on biomass and distribution of herring, blue whiting, horse mackerel, mackerel and boarfish were also calculated. As in recent years, Atlantic bluefin tuna were observed across the survey area although the number of sightings was down significantly from 2018. Oceanographic conditions in October were back to more usual values of the time series after last year's hot conditions.

Jeroen van der Kooij and Jo Silva
Scientists In Charge
21/02/2019

SEEN IN DRAFT

Master:
Senior Fishing Mate:

INITIALLED:

DISTRIBUTION:

[1] Biomass values presented are those recalculated and corrected following the announcement of a software bug in the fisheries acoustic calibration software: https://www.simrad.online/ek80/swrn/ek80_swrn_current_en_a4.pdf

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Annex 13: 2019 6aSPAWN Survey Summary Table and Survey Report

Document 13a: 6aSPAWN 2019 survey summary table

Survey Summary table WGIPS 2020	
Name of the survey (abbreviation):	6a7bc herring industry survey (6aSPAWN)
Target Species:	Herring
Survey dates:	1st – 23rd September 2019 (6aN) 1st – 17th December 2019 (6aS,7b)
Summary:	

2019 was the fourth industry-led survey of herring in 6a/7bc. Three industry vessels were used for acoustic surveys in 6aN and one in 6aS/7b. Two vessels used in 6aN were each equipped with a calibrated Simrad EK80 transceiver. FV Pathway used the ship's hull-mounted transducer, while FV Dirk Dirk deployed a towed body transducer. The industry vessels were proven to be very stable platforms for acoustic surveys. The acoustic survey vessels were deployed in sequence, covering four known pre-spawning/ spawning areas. Timing was planned to coincide with the known spawning period, but the presence of adult herring marks was notably lower than in previous years and only one biological sample contained spawning-ready fish. Sea state was variable but at no time bad enough to prevent the collection of good quality acoustic data during the survey by FV Pathway. Technical difficulties with the towed body transducer on FV Dirk Dirk followed by a malfunctioning hull transducer and significant disruption due to poor weather resulted in the Dirk Dirk data only being fit only to use as information on acoustic mark identification and fish distribution. No biomass calculations were possible.

The main distribution of acoustic marks that could be confidently identified as herring was concentrated in survey Area 3 (North Minch) in the same locations as previously recorded. No spawning marks were seen in Area 2 (East of Cape Wrath), where significant spawning marks have been seen in the past. Similar to 2018, a notable feature of the 2019 was a predominance in Area 5 (East side of Isle of Lewis) of young herring mixed with sprat. Horse mackerel were also recorded again, often in close proximity with herring marks and mixed diffuse aggregations of sprat. Mackerel were found in abundance distributed throughout the area, being caught in every survey haul. An aggregation of blue whiting that were close to spawning was located off Stornoway. Total biomass estimates of herring recorded during the survey in 6aN was 76, 000 t. The lack of abundance of herring during and after the acoustic survey periods resulted in the decision to curtain commercial fishing of the monitoring quota by Scottish vessels. In total, only 37% of the allocated monitoring quota was utilised in 2019.

An acoustic survey of Atlantic herring *Clupea harengus* was conducted in ICES areas 6aS/7b in Dec 2019 using the research vessel RV *Celtic Voyager* and the fishing vessel MFV *Ros Ard* SO745 http://hdl.handle.net/10793/1498. This survey is the fourth in a time series that is hoped will be developed into a long-term index of spawning/pre-spawning herring in 6aS/7b. The survey design is based on the predicted distribution of this winter spawning herring in this area. Poor weather negatively impacted the survey in 2019, resulting in fewer transect miles completed and fewer strata areas covered than planned. In total, approximately 600nmi of cruise track was completed using 96 transects. This resulted in a total area coverage of approximately 606 nmi², a significant reduction compared to recent years. Parallel transect spacing was set at 3.5nmi for the Donegal Bay strata. Tightly spaced zig-zag transects were used in a relatively small area in Lough Swilly. A Simrad ES-120 7CD (120 kHz)

split-beam echosounder was used to collect acoustic raw data. The transducer was mounted on a towed body from the *Celtic Voyager* in Donegal Bay and was pole mounted from the *Ros Ard* in Lough Swilly. Very strong herring marks were evident in Lough Swilly in deepest part of the channel. The herring marks continued for many miles in the upper Swilly, an area where boats in the monitoring fishery had also concentrated effort. There were some herring marks in discreet areas around Drumanoo Head, Bruckless Bay and Inver Bay in the Donegal Bay Strata. Biological samples from the monitoring fishery of herring were used to augment the samples from the survey. Herring samples were taken from boats fishing in Lough Swilly and Inver Bay as close spatially and temporally as possible to the survey in these areas. Herring were dominated overall by 1- and 2-wr fish, (52% of the overall numbers) followed by relatively strong 3- and 5-wr cohorts. The total stock biomass (TSB) estimate of herring for the combined 6aS/7b area was 25,289 tonnes (Lough Swilly = 19,697 tonnes, Donegal Bay = 5,591 tonnes). This is considered to be a minimum estimate of herring in the 6aS/7b survey area at the time of the survey, and a significant decrease on the previous 3 years surveys. The reduction in the survey area completed as a consequence of the poor weather resulted in the survey not containing the stock in 2019. However, the overall CV estimate on biomass and abundance for the survey area completed is low (~0.17) in 2019. This is driven by the improved survey design in Lough Swilly, with reduced transect spacing and increased transect miles in this strata. The CV for the Donegal Bay strata is relatively high (0.63), this is mostly caused by the over-reliance on a few acoustic marks of herring in Bruckless and Inver Bays in particular and many transects with little or no herring marks. The survey in 2019 had to be altered due to weather, requiring a change in design and approach. However, the template of focusing on discreet areas was generally successful and may provide a template for future designs, particularly when reduced effort is necessary during poor weather or resource limits.	
	Description
Survey design	6aN - Stratified systematic parallel design (2-4 nmi spacing) with randomised start point. All vessel surveyed all strata in sequence with 10 day lag. 6aS - Stratified systematic parallel design (3.5 nmi spacing) with randomised start point. High intensity zig/zag transects in Lough Swilly
Index Calculation method	6aN and 6aS - StoX (via the ICES acoustic database)
Random/systematic error issues	NA, outside of those already described in literature for standardised acoustic surveys
Specific survey error issues (acoustic)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Bubble sweep down	6aN- Not an issue in FV Pathway 2019 due to fair weather conditions and stabilty of boat aided by filling fish tanks with water. Poor weather issues for FV Dirk Dirk combined with broken towed body transducer comprised the survey. 6aS – not an issue with towed body or pole mounted system used in 2019
Extinction (shadowing)	6aN- Occurred on few occasions when very dense sprat schools were detected. Can occur with spawning aggregations, but these were not recorded in 2019. Dense schools on rocky outcroppings can be subject to side lobes, but these were not classified as herring. 6aS – may be an issue with hyper-aggregating schools, particularly in Lough Swilly
Blind zone	6aN and 6aS - NA, herring and other schools at significant depth

Dead zone	6aN and 6aS - Dense herring schools tight to the bottom in a few places making delineation more difficult, but detailed school by school scrutiny and checking too place to resolve any issues.
Allocation of backscatter to species	6aN - Directed trawling for verification and species composition purposes and age structure. Insufficient in some areas so nearest sample allocated. 6aS – Directed trawling on marks during survey, samples also used from the monitoring fishery taking place at same time and in same areas as the survey
Target strength	TS = 20log10(L) – 71.2 (38 kHz) TS = 20log10(L) – 76 (120 kHz)
Calibration	6aN - 38kHz calibrated on all vessels 6aS – 120kHz calibrated on 17/12/2019
Specific survey error issues (biological)	*There are some bias considerations that apply to acoustic-trawl surveys only, and the respective SISP should outline how these are evaluated:*
Stock containment	6aN- The 2019 estimate of abundance from FV Pathway is considered a reliable estimate of herring present during the survey. Limited number of spawning samples and presence of spawning marks raises question about timing or whether fish were not there to be seen. Extended observations by other vessels outside the survey period, indicate that abundance was lower rather than timing was wrong. 6aS - The survey did not contain the herring stock in 6aS/7b in 2019, however, the core areas of Lough Swilly and Donegal Bay were covered and containment most likely achieved for these areas. There was hyper-aggregating behaviour and shallow distribution (<15m) of herring in Lough Swilly in paticular. These fish were primarily in the middle of the channel in Lough Swilly, with little or no marks of fish observed in the shallow edges of the Lough. The new survey deign in Lough Swilly (tighter and more intense zig/zag transects) alleviated the concern that the stock was not contained in this area. The improvements to the survey design adapted following WKHASS (ICES 2020) workshop have improved the survey in the Lough Swilly strata. The improved methods need to be adapted in other areas for surveys in future years. The over-reliance of the estimate on few areas of high herring density led to the high CV on the estimates of abundance and biomass in the Donegal Bay strata. This could be improved in the future with better survey design in these areas. Additional areas off the west Mayo and Galway coasts were covered by this survey in searching mode again in 2019. These included a number of grounds that were known to have spawning in the past including areas around the Bills of Achill and Clare Island, however, no herring aggregations were located in these areas. Spawning is known to occur outside of the areas covered by the survey in 2019, but the lack of occurrence of herring marks in the areas searched suggest that herring were in low numbers in these areas, even though containment was most likely not achieved in 2019. There were substantial areas not covered by the survey in 2019, including areas where herring have been observed by the fleet (e.g. Lough Foyle).
Stock ID and mixing issues	No issues – both surveys are conducted at times and in areas when both 6aN and 6aS stocks are expected to be geographically separated
Measures of uncertainty (CV)	6aN- CV of biomass used for estimate of spawning biomass in each strata ranged from 0.3 to 0.6, with mean 0.42 on biomass estimate 6aS – 0.17

Biological sampling	6aN - Biological data to allocate to acoustic marks identified as herring was satisfactory in 2019. 6aS - Biological data to allocate to acoustic marks identified as herring was satisfactory in 2019.
Were any concerns raised during the meeting regarding the fitness of the survey for use in the assessment either for the whole times series or for individual years? (please specify)	*To be answered by Assessment Working Group*
Did the Survey Summary Table contain adequate information to allow for evaluation of the quality of the survey for use in assessment? Please identify shortfalls	*To be answered by Assessment Working Group*

Document 13b: 6aSPAWN 2019 survey report

Please see the report on the next page.

THE 2019 INDUSTRY–SCIENCE ACOUSTIC SURVEY OF HERRING IN THE WESTERN BRITISH ISLES (ICES DIV 6A, 7B,C)

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Contents

Executive summary

2019 was the fourth industry-led survey of herring in 6a/7bc. Industry and scientific institutions from Scotland, Ireland, Northern Ireland, Netherlands, and England successfully carried out scientific surveys with the aim to improve the knowledge base for the herring spawning components in 6aN and 6aS, 7bc, and submit relevant data to ICES to assist in assessing the herring stocks and contribute to establishing a rebuilding plan.

Following agreement on a scientific monitoring fishery TAC of 5 800 t (4 170 t in 6aN and 1 630 t in 6aS/7bc) (EU 2018/120), the scientific survey was designed based on ICES advice, and experience from 2016-18 on the timing, location and number of samples required to collect assessment-relevant data from the monitoring fishery (ICES 2016a).

Three industry vessels were used for acoustic surveys in 6aN and one in 6aS/7b. Two vessels used in 6aN were each equipped with a calibrated Simrad EK80 transceiver. FV Pathway used the ship's hull-mounted transducer, while FV Dirk Dirk deployed a towed body transducer. A different industry vessel was dedicated to taking samples for morphological and genetic analyses in 6aN, and another directed to searching and fishing in specific areas so as to maintain comparability with previous commercial catch data. In 6aS/7b biological, genetic and morphometric samples for were collected by numerous inshore vessels.

In 6aN, the acoustic survey vessels were deployed in sequence, covering four known pre-spawning/ spawning areas. Timing was planned to coincide with the known spawning period, but the presence of adult herring marks was notably lower than in previous years and only one biological sample contained spawning-ready fish. Technical difficulties with the towed body transducer on FV Dirk Dirk followed by a malfunctioning hull transducer and significant disruption due to poor weather resulted in the Dirk Dirk data only being fit only to use as information on acoustic mark identification and fish distribution. No biomass calculations were possible.

The lack of abundance of herring resulted in the decision to curtain commercial fishing of the monitoring quota by Scottish vessels. In total, only 37% of the allocated monitoring quota was utilised in 2019.

The main distribution of acoustic marks that could be confidently identified as herring was concentrated in survey Area 3 (North Minch) in the same locations as previously recorded. No spawning marks were seen in Area 2 (East of Cape Wrath), where significant spawning marks have been seen in the past. Similar to 2018, a notable feature of the 2019 was a predominance in Area 5 (East side of Lewis) of young herring mixed with sprat. Horse mackerel were also recorded again, often in close proximity with herring marks

and mixed diffuse aggregations of sprat. Mackerel were found in abundance distributed throughout the area, being caught in every survey haul. An aggregation of blue whiting (which were close to spawning) was located off Stornoway. Total biomass estimates of herring recorded during the survey in 6aN was 76, 000 t.

Coinciding with the 2019 International Herring Acoustic Survey, a one-off 10-day acoustic survey was carried out by FV Grateful in July. The first objective was to undertake a detailed survey of the Minch to address the question whether the limited coverage in the Minch by the International Survey might be missing herring aggregations outside of the survey track. The second objective was to try and identify the species responsible for strong acoustic marks associated with outcroppings on rocky ground. The acoustic survey did not record any herring marks, and trawl samples found very few herring that were mixed in with catches dominated by other species. Drop-camera work was successful in identifying that the acoustic marks on rocky ground are most likely produced by juvenile gadoid species and zooplankton concentrations. However, some uncertainty still remains regarding possible avoidance by herring, which we hope to address in future work.

In 6aS/7b herring were distributed similar to 2016, 2017 and 2018. Herring were again found close inshore with the overall distribution dominated by aggregations of herring in a few discrete areas. Poor weather negatively impacted the survey, and a significant part of the planned survey area was missed, therefore containment of the stock was not achieved in 2019. However, the core areas of Donegal Bay and Lough Swilly were surveyed, both areas important to the monitoring fishery. Total biomass estimates of herring recorded during the survey in 6aS/7b was 10 506 t. The inshore distribution of herring generally makes containment of the stock difficult in this area, however, the improved survey design in Lough Swilly resulted in a much lower measure of uncertainty (CV), compared to previous years. Horse mackerel were distributed mainly in an area to the north and west the Stags of Broadhaven, Co. Mayo.

With provision made for monitoring fishery quota 3 480 t (6aN) and 1 360 t (6aS/7bc) in 2020 (EU 2020/123), plans are underway for a fifth survey in 2020, taking into account the recommendations of ICES WKHASS (2020) and WGIPS (ICES 2020a).

1 Rationale, aim and objectives

1.1 Rationale

During the ICES benchmark workshop on herring west of the British Isles (ICES 2015a), the stock assessments of 6aN herring and 6aS/7bc herring (Figure 1.1) were merged into one combined assessment. The reason for this is that the summer acoustic surveys and fishery occur at a time when the northern and southern components are mixed, and the baseline morphometric information required to separate the two components was found to be unreliable due to evidence of changes over time. The consequence is that since 2015, ICES has advised a zero TAC, and recommended that a rebuilding plan be developed (ICES 2017a). The ICES HAWG also stated in its March 2015 report that there is a clear need to determine the relative stock sizes (ICES 2015b).

Under the auspices of the Pelagic Advisory Council, this situation catalysed fishing industry associations representing Scottish, English, Dutch, Irish and German fishery interests to set about providing the much needed evidence required to establish reliable stock assessments for the separate stocks, and develop a rebuilding plan.

In response to the STECF 2015 autumn plenary recommendation that it would be beneficial to maintain an uninterrupted time series of fishery-dependent catch data, and a subsequent special request (to ICES) by the European Commission, ICES provided advice on methods for undertaking a scientific monitoring fishery for the purpose of obtaining relevant data for assessment (ICES 2016a). In particular, the advice referred to collection of data necessary to determine the identity and structure of the two stocks, collected in a way that (i) satisfies standard length, age, and reproductive monitoring purposes by EU Member States for ICES, and (ii) ensures that sufficient spawning-specific samples are available for morphometric and genetic analyses as agreed by the Pelagic Advisory Council monitoring scheme 2016 (Pelagic Advisory Council, 2016).

This advice, and a resulting EU Council regulation (EU 2016/0203) that made provision for a scientific monitoring TAC of 5 800 tonnes (4 170 t in 6aN and 1 630 t in 6aS, 7bc) were the enablers for the industry-led survey to take place. EU Council regulation (EU 2019/124) made the same provision, enabling the fourth survey to take place.

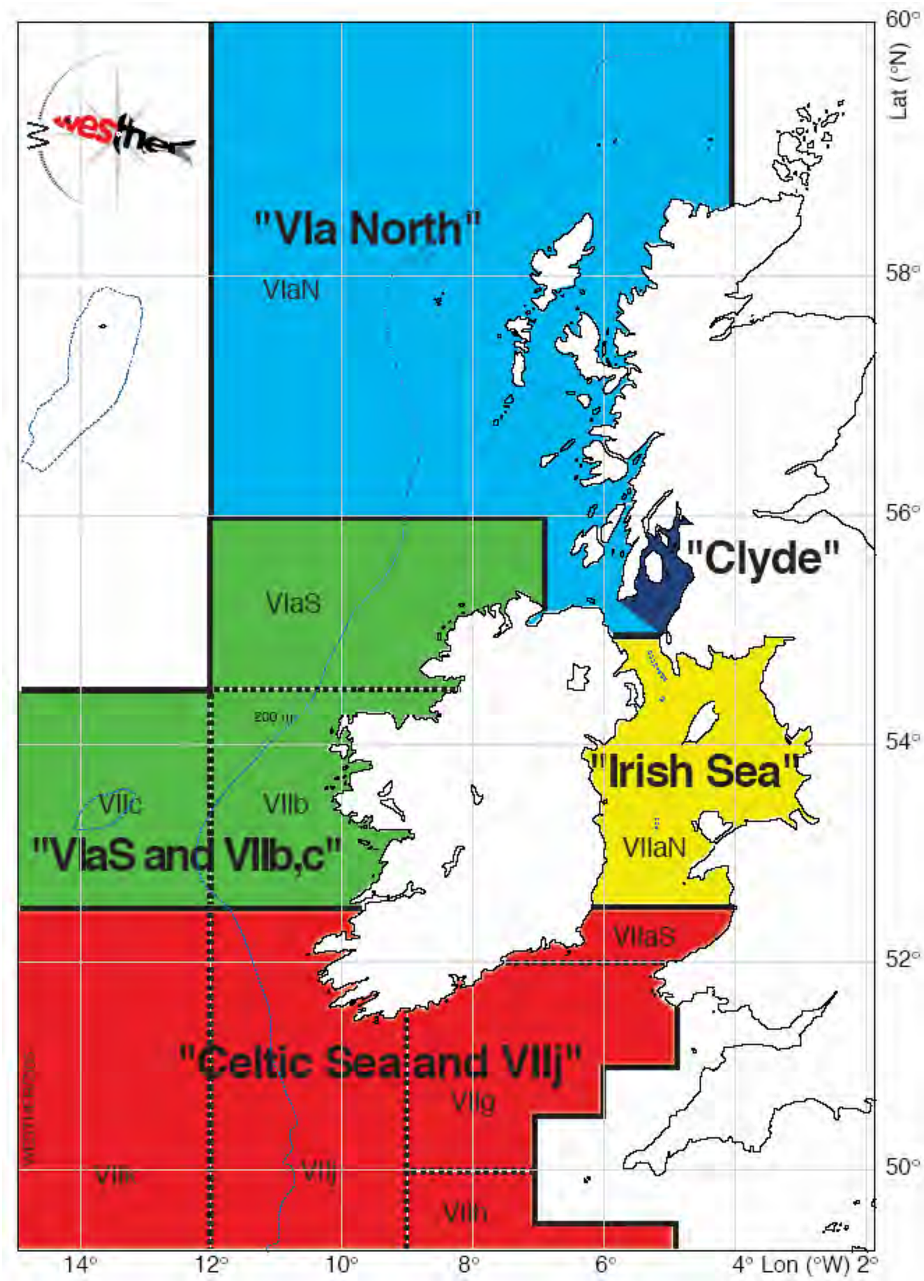


Figure 1.1. Herring stock assessment areas.

1.2 Overall Aim

To improve the knowledge base for the spawning components of herring in 6aN and 6aS/7b, and submit relevant data to ICES to assist in assessing the herring stocks and contribute to establishing a rebuilding plan.

1.3 Objectives

In this report, only information on the methods and results pertaining to objective 1 are documented. A full survey report is available on request.

1. **Abundance estimation**: Collect acoustic data and information on the size and age of herring and use it to generate an age-disaggregated acoustic estimate of the biomass of pre-spawning/ spawning components of herring in 6aN and 6aS/7bc ('Western herring').
2. **Stock identity separation:** Collect morphometric and genetic data to distinguish whether the 6aN stocks are different from the stocks in 6aS, 7bc.
3. **Age composition of the commercial catch:** Collect catch-at-age data from the monitoring fishery to provide continuous fishery-dependent time series required for assessment.
4. **Rationale for continued monitoring:** Use the results of the surveys as evidence for consideration and design of a scientific monitoring fishery in 2019.
5. **Evidence for a rebuilding plan:** Use the results of the surveys to contribute to the scientific basis for development of a rebuilding plan for Western herring.

Coinciding with the 2019 International Herring Acoustic Survey, a one-off 10-day acoustic survey was carried out by FV Grateful in July. The objectives addressed the questions whether the limited coverage in the Minch by the International Survey might be missing herring aggregations outside of the survey track, and whether the species responsible for strong acoustic marks associated with outcroppings on rocky ground were herring or not.

2 Material and methods

2.1 Research plan

The overall research plan involves the planning, implementation and analysis & reporting stages outlined in Figure 2.1.

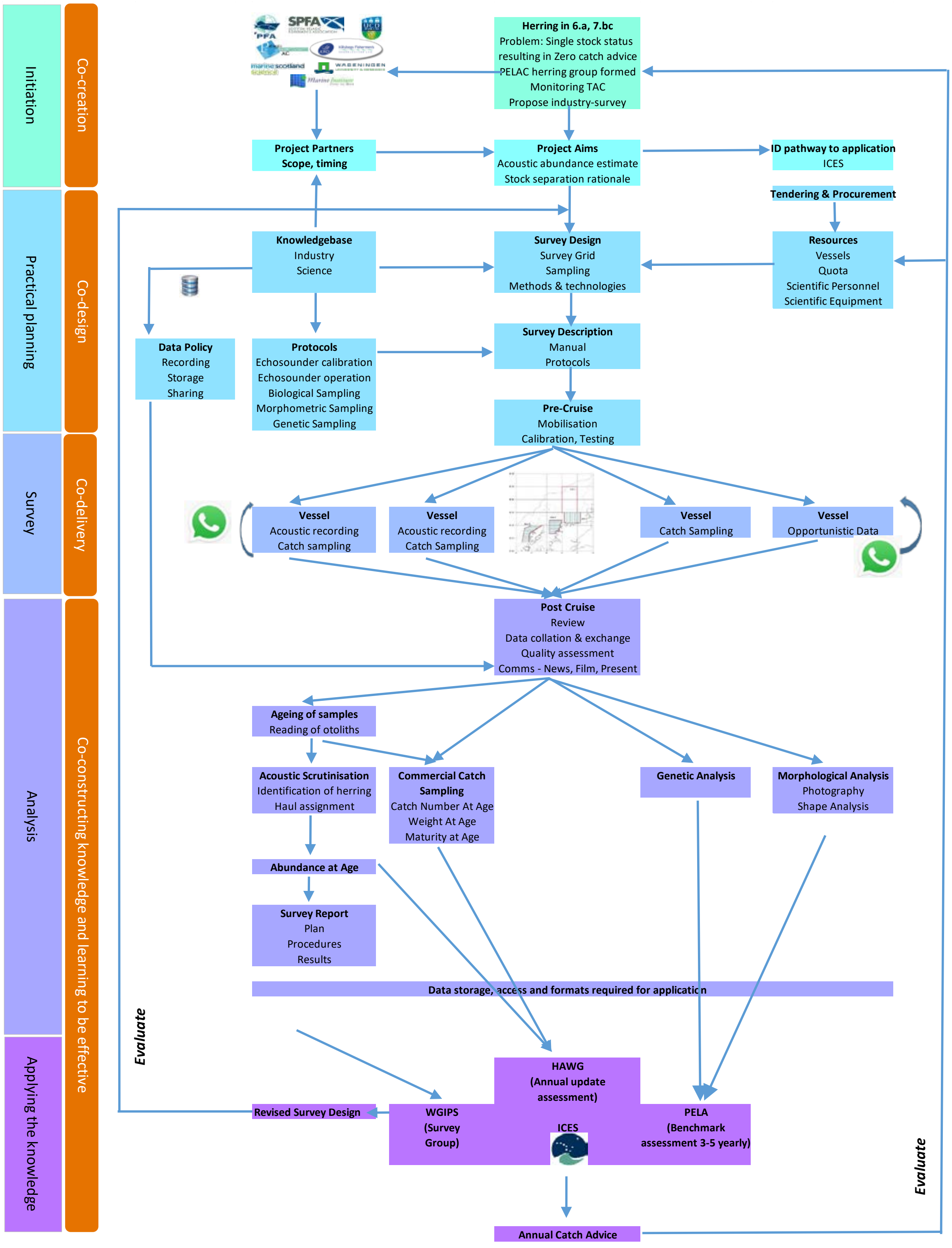


Figure 2.1. Overview of the planning, implementation and analysis stages in the Western herring surveys.

2.1.1 Specific survey objectives

Specific objectives for the field survey followed objectives 1-3, described in section 1.3. Each of the vessels involved were assigned specific objectives and provided with a vessel-specific sailing plan and survey protocol manuals (example available on request). Sections 2.2 to 2.4 describe the survey methods in detail.

2.1.2 Survey areas

Utilising ICES advice on the monitoring fishery (ICES 2016a) together with the experience from previous surveys, a review of spawning areas and timing (Mackinson 2017) and discussions with fishing skippers during the planning meeting (16 May 2019), five areas were selected for surveying in 6aN (Figure 2.2). The areas coincided with the geographic distribution of known active herring spawning areas (Figure 2.3, and observed in previous surveys) and records of commercial catches (Figure 2.4). Areas 2-4 are considered to be active spawning areas and Area 1 a pre-spawning aggregation area that contains an unknown mixture of stocks of Western and North Sea herring, where a large proportion of catches has been taken in recent years (ICES 2015a). Area 5 was a added in 2018 based on evidence from 2017 and local creel fishermen of herring on the east side of the North Minch. Systematic acoustic surveys (see section 2.2) were conducted only in areas 2-5 in 6aN, but ad-hoc acoustic data was recorded by other vessels also.

In 6aS/7b, the acoustic survey area (Figure 2.5) collected data from known spawning areas (Figure 2.6). Spawning time in this area is variable, generally between October and February (Table 2.1).

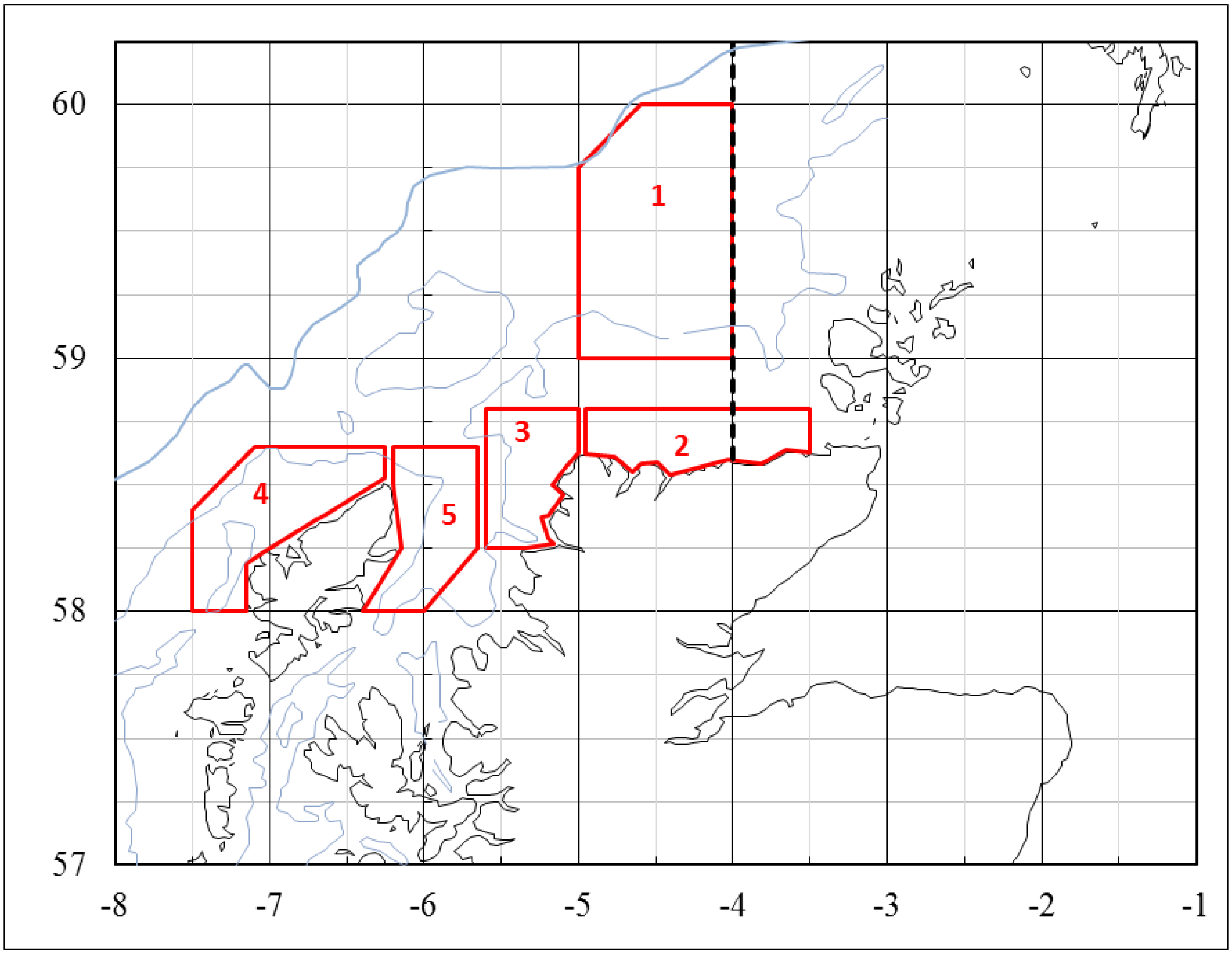


Figure 2.2. Planned survey areas used in the 6aNorth surveys. Area 1- North pre-spawning mixing area, Area 2 -East of cape Wrath, Area 3 – The Minch, Area 4 – Outer Hebrides, Area 5 – east Minch.

1 Pre-spawning mixed area (47E5 and 48E5)
2 East of Cape Wrath (46E5)
3 West of Cape Wrath (46E4)
4 Butt of Lewis /west of Hebrides (45E2)
5 North Donegal (39E2 and 39E1)
6 West Donegal (38E1)

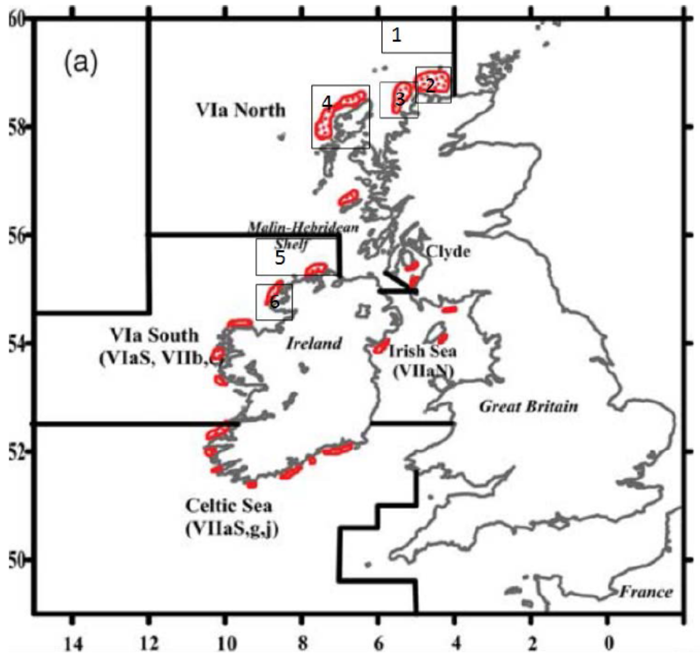


Figure 2.3. Spawning areas for herring in ICES subareas 6 and 7, with currently active spawning areas and pre-spawning aggregation areas for each stock indicated by black rectangles. Used in ICES 2016, redrawn from Geffen *et al.* (2011).

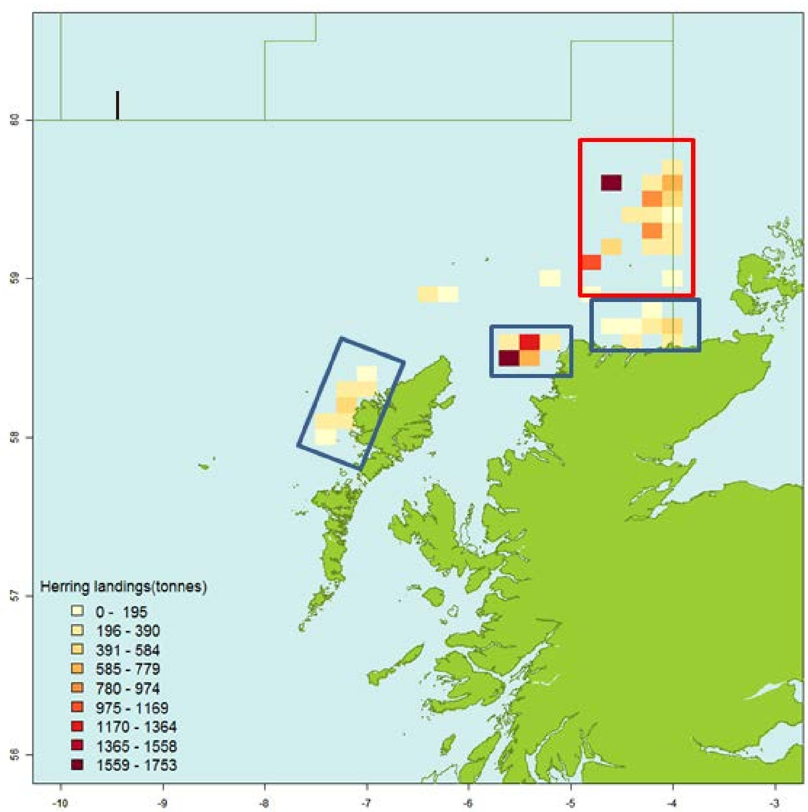


Figure 2.4. Distribution of commercial catches reported in 6aN in 2011.

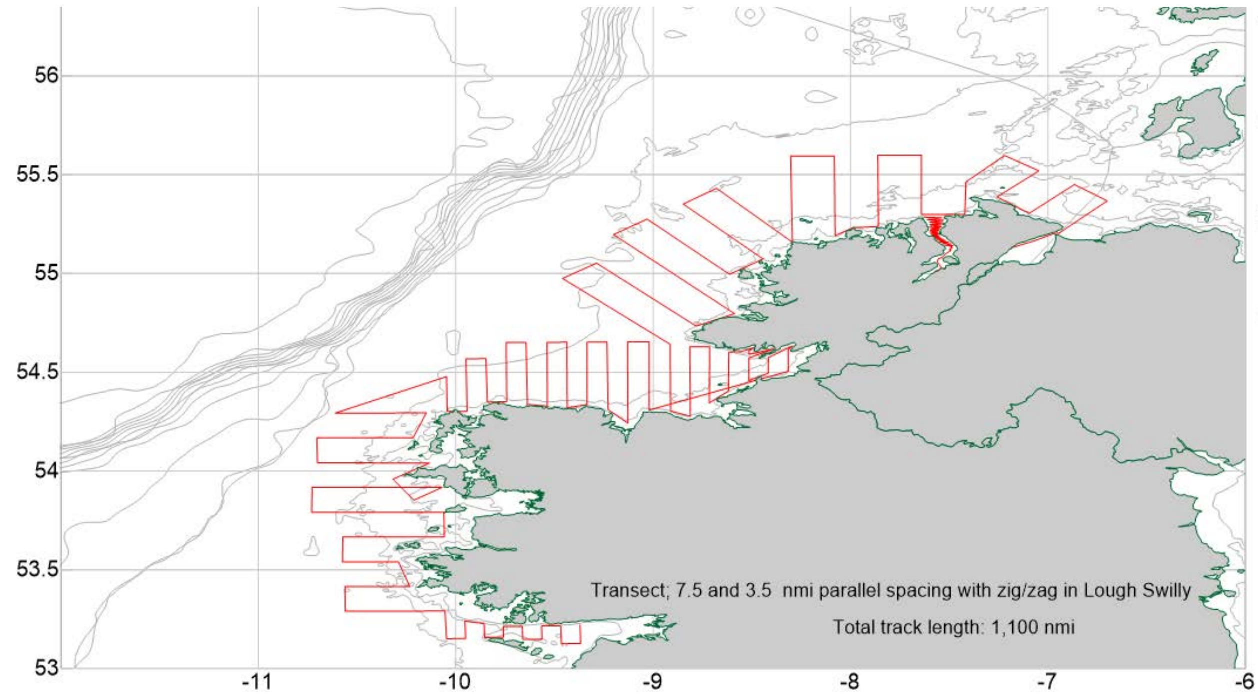


Figure 2.5. Planned acoustic survey area and transects for 6aS/7b, in 2019. Acoustic survey area for 6aS and 7b. Transect spacing: 7.5nmi (3nmi in Donegal Bay, zig/zag in Lough Swilly, in/out in smaller bays. The total planned transect length was 1100nmi (start 53˚13N and 9.22˚W) with progress from south to north. The survey design allows for some intense surveys in areas where fish are observed and also in areas known to contain herring from information from the fleet (e.g. Lough Swilly, Lough Foyle and Inver Bay).

Table 2.1. Spawning areas, spawning grounds and spawning beds in 6aS/7bc. Area (km²) and depth (m) refer to individual spawning beds (from O'Sullivan, 2013).

Spawning Area	Spawning Ground	Spawning Bed	Depth (m)	Area (Sq Km)	Activity
North Donegal	Malin Head	Inishtrahull	45	121.58	November
		Malin Head North	90	39.06	November
	Limeburner	Limeburner	30	33.28	November
		The Bananas	58	169.17	Nov and Feb
	Tory	Malin Head Northwest	70-90	47.42	Nov and Feb
West Donegal	The Blowers	The Blowers	30	3.96	Oct/Nov
		Stags	20	0.89	Nov/Dec
	Aran Mor	Aran Mor 1	43	32.35	Oct/Nov
		The Quarry	70-80	11.84	October
	Rosbeg 1	Rosbeg 1.1	32-36	0.13	Oct/Nov
	Rosbeg 2	Rosbeg 2.1	43	44.06	October
	Glen Head	Glen Bay	32-36	24.17	Nov/Dec
		Malinmore Head 1	18	6.31	November
		Malinmore Head 2	90	1.59	Jan/Feb
Donegal Bay	Killybegs	Killybegs 1	20	1.01	Dec/Jan
	Lennadoon	Lennadoon 1	32-42	101.92	Jan/Feb
		Killala Bay	25	3.05	January
	Downpatrick	Downpatrick West	32	23.66	November
		Downpatrick/Ceide Fields	34-45	97.05	Dec/Jan
Mayo	The Stags	The Stags 1	36	0.89	November
	Blackrock	Blackrock 1	36	7.74	Oct/Nov
	Clare Island	The Bills	36	29.83	November
		Clare Island 1	32	3.07	Oct/Nov
		Clare Island 2	36	1.58	Oct/Nov
		South Clare Island 1	45	3.71	December
		South Clare Island 2	~40-45	2.01	Nov/Dec
	Lecky Rock	Davillaun/Lecky Rock	20	3.63	Sept/Oct

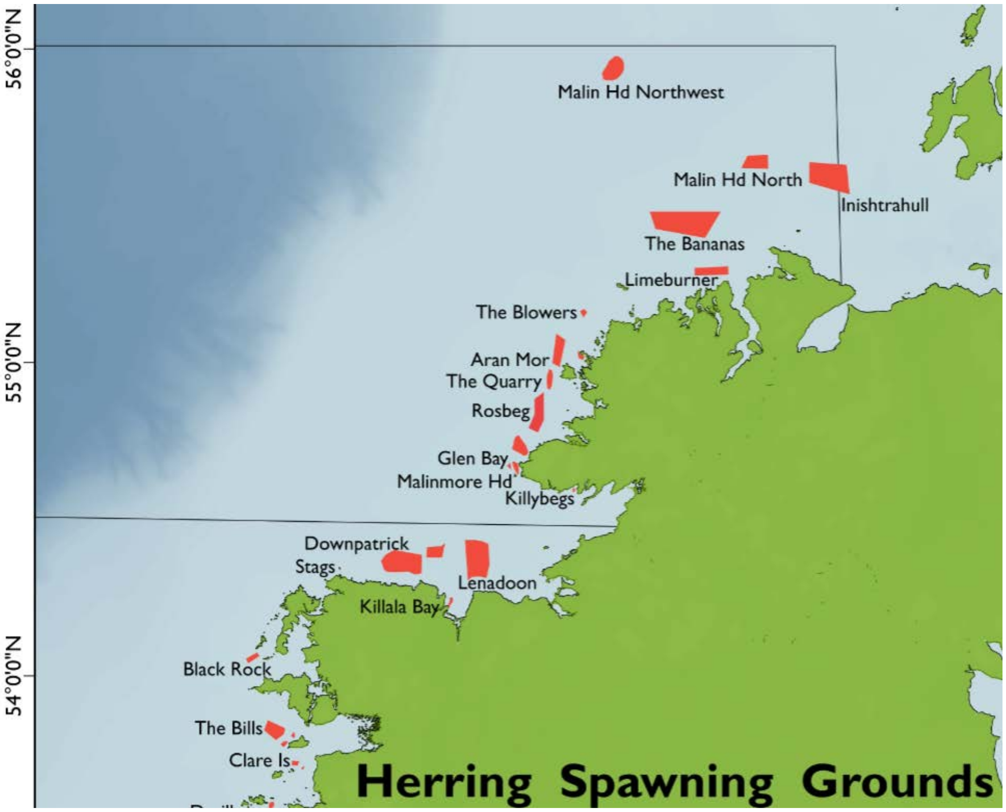


Figure 2.6. Herring Spawning grounds in 6aS/7b,c (from O'Sullivan, 2013).

2.1.3 Timing, vessels and areas for each of the survey vessels (Table 2.2).

Area	Acoustics vessel	Start	End	Duration	Timing and area coverage	Sun 01-Sep	Mon 02-Sep	Tue 03-Sep	Wed 04-Sep	Thu 05-Sep	Fri 06-Sep	Sat 07-Sep	Sun 08-Sep	Mon 09-Sep	Tue 10-Sep	Wed 11-Sep	Thu 12-Sep	Fri 13-Sep	Sat 14-Sep	Sun 15-Sep	Mon 16-Sep	Tue 17-Sep	Wed 18-Sep	Thu 19-Sep	Fri 20-Sep	Sat 21-Sep	Sun 22-Sep	Mon 23-Sep
Minch	**Grateful**	**12-Jul**	22-Jul	11	**Minch**																							
Area 4	**Pathway**	**01-Sep**	02-Sep	2	**Area 4**																							
Area 5		03-Sep	04-Sep	**2**	**Area 5**																							
Area 3		05-Sep	07-Sep	**3**	**Area 3**																							
Area 2		09-Sep	**12-Sep**	**4**	**Area 2**																							
Area 4	**Dirk Dirk**	**13-Sep**	14-Sep	2	**Area 4**																							
Area 5		15-Sep	16-Sep	**2**	**Area 5**																							
Area 3		17-Sep	19-Sep	**3**	**Area 3**																							
Area 2		20-Sep	**23-Sep**	**4**	**Area 2**																							

	Area 2	Area 3	Area 4	Area 5	TOTAL
Spacing (nmi)	2	2	4	4	
Duration (d)	2.3	2.2	1.9	1.4	**7.7**
Length (nmi)	320	301	260	197	**1079**

Table 2.2a. Deployment in 6aN. Sequencing shown for vessels undertaking acoustic survey work. Vessels deployed for catch sampling only have flexible period of operation covering known spawning timing.

Table 2.2b. Deployment in 6aS/7b

Area	Earliest survey date	End date	Calibration	Acoustic Survey distance (nm), one coverage	Vessel and type (Refrigerated Sea Water (RSW) or Freezer)	Flag	Homeport	Vessel#	Role	Skipper
Donegal Bay	01-Dec	10 Dec	N/A	600nmi	RV *Celtic Voyager*	IRL	Galway		Acoustic and catch sampling	Colin McBrearty and Philip Baugh
Loch Swilly	17 Dec	17 Dec	Loch Swilly	33nmi focus on Loch Swilly	MFV *Ros Ard*	IRL	Burtonport	SO745	Acoustic and catch sampling	Edward Gallagher

2.1.4 FV Grateful Minches survey – July 2019.

The objectives were:

1. **Undertake a detailed acoustic survey of the Minch** comprising (a) typical transect survey (10nmi spacing in North Minch, 7.5nmi South Minch (b) Fishing scouting search in likely herring areas. The ships Simrad EK80 echosounder (38kHz) was calibrated and used to record acoustic data.
2. **Identify acoustic marks on hard (untrawlable) ground.** A specially designed rig with a go-pro camera and light source was used to film acoustic marks while the vessels drifted over the target.

Figure 2.7. Minches Survey plan. 10nmi spacing (blue lines) used in North Minch and 7.nmi spacing (purple) in the south. Stars show camera drop locations where acoustic marks on rocky ground were found.

2.2 Abundance estimation

2.2.1 Acoustic survey design

The purpose of the acoustic surveys was to estimate the minimum spawning biomass of adult herring and spawning ready herring within the boundaries of the survey areas.

Acoustic surveys were conducted in survey areas 2-5 (6aN) and in 6aS/7b, each designed on regularly spaced parallel transects (Figure 2.2 & 2.5), or zig-zags in the shallow waters. Transect direction was assigned perpendicular to the narrowest dimension of the survey area to maximise precision of the estimation by having many short transects rather than a few long ones. In 6aN each vessel surveyed each of the areas in sequence, the second vessel starting when the first was finishing, giving a 10-day lag (Table 2.2a) between the replicate surveys. The survey dates in each area aimed to cover the peak time of spawning and were decided based on records of known spawning times and advice of fishermen familiar in working the areas.

Sufficient time was factored in to the planning to provide opportunity for the survey areas to be adapted according to the situation observed, such as changes to the survey boundary to ensure full coverage of fish aggregations, or undertaking finer scale observations in high density locations. Table 2.3 summarises the design and equipment for each area, and notes any adaptations to the original planned survey transects.

2.2.2 Equipment specifications and calibration

See Table 2.3 for specification.

The standard calibration procedure described in Demer et al. (2015: http://courses.washington.edu/fish538/resources/CRR326_Calibration.pdf) was used to calibrate each of the echosounders deployed on each of the vessels. Echomaster Marine successfully performed the calibration of Pathway and Grateful, stern on to the breakwater in Peterhead at the slack of a high tide (22m under transducer) in calm conditions.

Dirk Dirk deployed a towed body transducer operating (38, 120, 200 Khz) for a Simrad EK80 transceiver. Calibration was undertaken at sea in Scapa Flow immediately prior to the survey.

Calibration of the EK60 120kHz transducer on the MFV *Ros Ard* was carried out in Lough Swilly at the end of the survey on 17/12/2019. A chain clump was dropped off the stern of the vessel to assist in keeping the vessel in position. Water depth was approximately 25m at the calibration site. This calibration was carried out using standard methodology as described by Foote et al (1987). Standard LOBE calibration (SIMRAD 2003) was carried out and the successful calibration was made possible by good conditions in the deep water. There was minimal interference from biota in the water column.

Figure 2.8. Towed-body mounted 38 and 120 kHz transducers and the RV *Celtic Voyager*, left, and the pole mounted 120 kHz on the FV *Ros Ard*, right. The 120 kHz echosounder was calibrated in Lough Swilly on 17/12/2019.

2.2.3 Acoustic survey protocols

Surveys in 6aN were conducted in daylight hours only, 05:00 to 19:00 UTC/GMT. At the beginning of the next day, the survey restarted and continued from the position it ended on the day before. This maintained continuity in the coverage and avoided the possibility of double counting herring schools, which can occur if the survey does not continually progress in the same direction.

Surveys in 6aS/7b were continuous over 24 hours due to the limited daylight in December and scale of coverage planned. Survey speed was 8 - 10 knots, reducing as needed in poor weather. The RV *Celtic Explorer* used the towed body system (38 and 120 kHz) and the MFV *Ros Ard* used the pole mounted 120 kHz system only. The 120 kHz echosounder was the same system for both surveys. The 120 kHz was used for working up the estimates for the survey in 2019. The 38 kHz was not used to work up estimates in 2019.

To maximise data quality, Refrigerated Sea Water (RSW) vessels took on board ballast water to aid stability of the vessel and minimise cavitation. The vessels proved to be very stable platforms in all the conditions experienced and at no time was the quality of acoustic data compromised. All other acoustic equipment was turned off to eliminate interference with the EK80. Only during fishing operations were other acoustic instruments used. A motion reference unit was installed to compensate for heave, pitch and roll.

Raw acoustic data were recorded and stored on the ships PC and backed up each day on a portable hard disk drive for later processing.

Survey log sheets were used to record haul position and other events relevant to aiding in the interpretation of the acoustic data.

2.2.4 Fishing operations for scientific samples

During the acoustic surveys, selected fish marks were targeted with a fishing operation (Figure 2.9) to capture fish for the purposes of:

(i) Confirming the species identity of acoustic marks, particularly those suspected to be herring or to confirm that they were definitely not herring.

(ii) Collecting samples for biological analysis.

The fishing operations of RSW vessels were directed to take a catch of the smallest possible size sufficient for biological sampling. The operation for freezer trawlers was either a targeted biological sample or a typical commercial catch.

Each surveying vessel was granted a derogation to discard fish that were not retained for biological sampling and to retain any catches of herring, up to the maximum specified quota taken either during or outside the survey period.

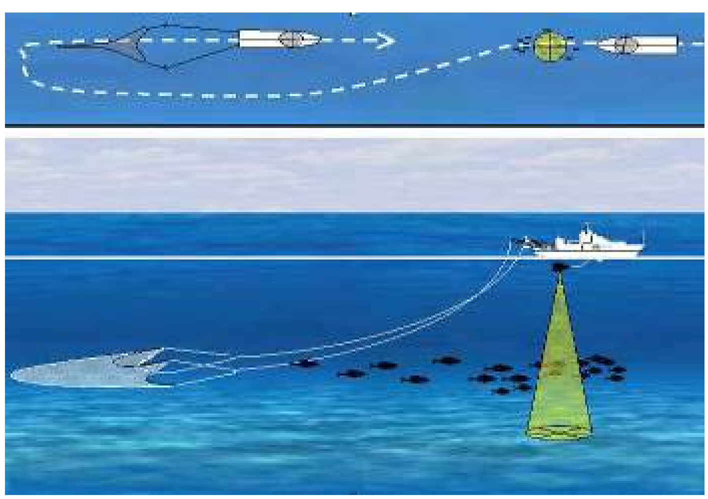


Figure 2.9. Schematic description of fishing operation to collect a biological catch sample during an acoustic survey.

Table 2.3. Acoustic survey summary

Area surveyed	Vessel	Transducer and Frequency	Echo-sounder	Power Pulse duration Ping interval	Environment	Calibration Location/ date, supplier	Survey area changes
Minches (July 2019)	Grateful (FR249)	Hull mounted split beam ES38B (38kHhz), draft ~5.5m With heave compensation. ES200-7C (200kHz) split beam [not used]	SIMRAD EK80	**@38kHhz** Power: 2000W Pulse duration: 1.024ms Pulse form: Continuous wave Ping interval = 0.5 sec	Temp = 10C, Salinity =35ppt, Sound speed 1491.5 m/s	Peterhead breakwater 9 Jul, Echomaster Marine	
4,5,3,2	Pathway (PD 165)	Hull mounted split beam ES38B (38kHz), draft ~5m With heave compensation. ES200-7C (200kHz) split beam [not used]	SIMRAD EK80	**@38kHz** Power: 2000W Pulse duration: 1.024ms Pulse form: Continuous wave Ping interval = 0.5 sec	Temp = 10C, Salinity =35ppt, Sound speed 1491.5 m/s	Peterhead breakwater 28 Aug, Echomaster Marine	
5,3,2	Dirk Dirk (KW172)	Hull mounted split beam ES38B (38kHz), draft ~5m Other frequencies used 120, 200 kHz	SIMRAD EK80	**@38kHz** Power: 2000W Pulse duration: 1.024ms Pulse form: Continuous wave Ping interval = 0.5 sec	Temp = 10C, Salinity =35ppt, Sound speed 1491.5 m/s	Scapa Flow Benoit Berges (WMR)	Weather meant unable to survey area 4.
6aS and 7b	Celtic Voyager and Ros Ard	Towed body mounted split beam ES38B (38kHz) and ES120 (120kHz). Pole mounted ES 120 7CD (120 kHz)	SIMRAD EK60 (120 kHz only used for estimates)	Power: 300W (120 kHz); Pulse duration: 1.024ms Ping interval = 0.33 Hz	Temp = 10˚C, Salinity =35ppt, Sound speed 1493.89 m/s	Lough Swilly, Co. Donegal 17th December 2019	Additional transects in area around Bills of Achill, Donegal Bay and Clare island.

2.2.5 Biological sampling

The purpose of the biological sampling was to (i) provide data on the relative abundance of each length and age class of herring, which is needed to make age-disaggregated acoustic abundance estimates, (ii) determine the maturation state of herring and indicate the location and timing of spawning, (iii) for genetic analysis (which are not reported here).

2.2.5.1 *Haul information*

Haul data were recorded using the same template for all surveys, 1 sheet per haul. Information was recorded on the date, time, fishing position, depth, gear, catch composition, total weight of catch and weight of the sub sample taken for length frequency and biological sampling. To aid in scrutinisation, screen captures (Figure 2.10) were taken during the haul operation; identifying first the targeted mark and later the marks covered while trawling. Comments about the marks were written on the haul sheet, as well as whether or not the herring were spawning (based on “running” eggs and sperm upon capture) and whether any catch remaining after biological sampling was retained or discarded.

2.2.5.2 *Catch sampling*

The catch sampling procedure was as follows:

- Weight of the catch of all species, or where the catch was too large, 3-5 randomly mixed baskets were taken as a sample of the catch and weighed.
- The catch sample was sorted and the total weight of each species recorded.
- One full basket (or 2 half) of herring was weighed (approx. 30kg). This subsample was used to determine lengths, weight, age and for genetic samples. (see below). (Figure 2.11)

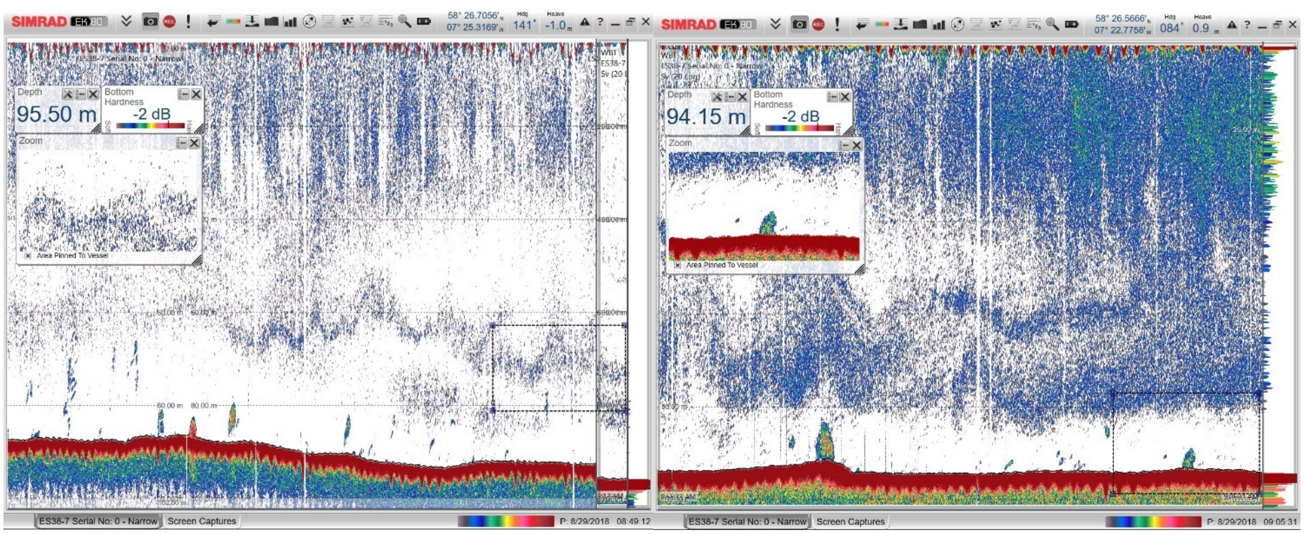


Figure 2.10. Example screen shots of targeted marks (first panel) and those trawled on.

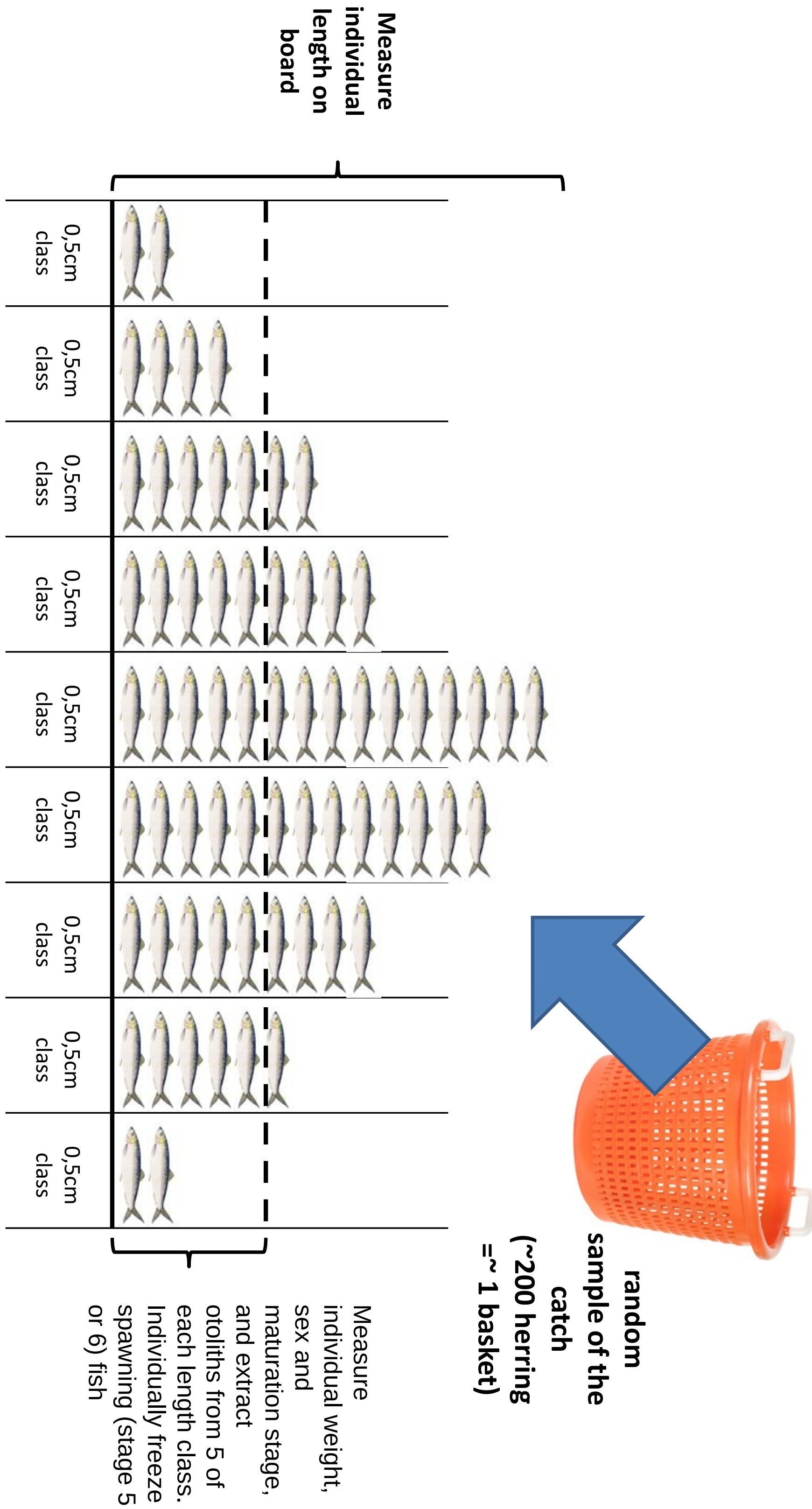


Figure 2.11. Illustration of the required catch sampling procedure.

2.2.5.3 *Length measurements*

The length of all the herring in the subsample was measured and recorded to the nearest half centimetre below (e.g. if the fish was 24.7cm then it was recorded as 24.5cm). This data is used to determine a length frequency distribution of the catch and subsequently to apply an age-disaggregated estimate of biomass. Additional biological measures (next section) were recorded from five fish within each half centimetre length class.

2.2.5.4 *Whole weight, Sex, Maturity stage, Otolith, Genetics*

Each fish from was assigned an ID number so that subsequent genetic samples can be cross-referenced to biological data.

In addition to the length, the following information was recorded for each fish.

- Weight in g
- Sex
- Maturity stage from 1-9 based on the classification in the Scottish and Irish sampling (MSS manual 2011) or on the ICES 6 point scale (ICES 2011) for the Dutch-collected samples. All maturity estimates were later converted to the ICES scale.
- Otoliths were extracted for age determination at the lab. Standard procedures for age determination from the growth rings on the otoliths (ear bones) of herring were used to determine the age of fish sampled (ICES 2005). This age data was used to create an age-length key (ALK).
- If the fish was from a spawning haul (see 2.2.5.1), it was bagged, labelled and frozen for later genetic analysis.

2.2.6 Acoustic Analysis methods

2.2.6.1 *Echogram scrutinisation – partitioning to species*

Scrutinising echograms involves identifying fish marks and assigning them to species, and ensuring that any non-fish acoustic signals are not included as fish (e.g. bottom signals).

Assigning fish marks to species is a heuristic process that relies upon (i) evidence from the targeted hauls made during the survey (Figure 2.10), (ii) prior experience of ‘experts’ (fishermen and acoustic scientists) based on their knowledge of what was caught when certain types of fish marks were fished upon in the area in previous surveys occurring around the same time, and (ii) knowledge of fish behavior.

While it’s impossible to be 100% confident when assigning fish marks to species, following some agreed guidelines for classification of marks greatly improves the consistency in the way that acoustic data from different surveys are scrutinized, and hence in the quality and comparability of the biomass estimates.

Acoustic fish marks were classified in to the following categories (See examples in Figure 2.12):

- **Herring** – confident that the marks were herring based on either evidence from a targeted haul or proximity and similarity to other schools known to be herring.
- **Maybe herring** – aggregations/ collections of marks within reasonable vicinity of definite herring marks (approx. 10nm radius) and shape and appearance similar to definite herring marks but often associated with hard ground where identity cannot be confirmed by trawling.
- **Possibly herring** – Marks that look like herring, but possibly isolated individual marks and found in areas beyond the immediate vicinity of confirmed herring marks.
- **Cap-hugging marks** – from 2016-2018, significant marks have been observed on rocky outcroppings that are not possible to trawl (see examples in 2019 report). Despite consulting acousticians and fishermen, the expert knowledge on these marks was inconclusive, hence they were classified separately. In July 2019, FV Grateful sought to identify these marks with a drop-down camera, the evidence from which suggests that they are not herring, but more likely Norway pout, juvenile gadoids and zooplankton concentrations. However, there is a need to verify this for the September surveys, and some uncertainty still remains regarding possible avoidance by herring, which we hope to address in future work. It is important to note that where marks on the sides of steep slopes of outcropping occurred, they were excluded from the analysis because of the possibility of being registration of acoustic side lobes.
- **Sprat** – confident that the marks were sprat based on either evidence from a targeted haul or proximity and similarity to other schools known to be sprat. A lot of very dense discrete schools close to the surface are believed to be sprat. Targeted hauls generally have low success rate due to fish going through the net and difficulties in fishing close to the surface. Sprat schools tend to be sharp streak-like marks that are very dense. They can also occur in mixed
- **Unclassified –** confident that the marks were not herring or sprat based on either evidence from a targeted haul or proximity and similarity to other schools known to not be herring, or characteristics atypical of herring schools.
- **Horse mackerel –** a lot of horse mackerel marks were observed through 6aS/7b and are routinely found in 6aN. They can be difficult to identify and require trawl verification because they look a lot like herring marks, although they are

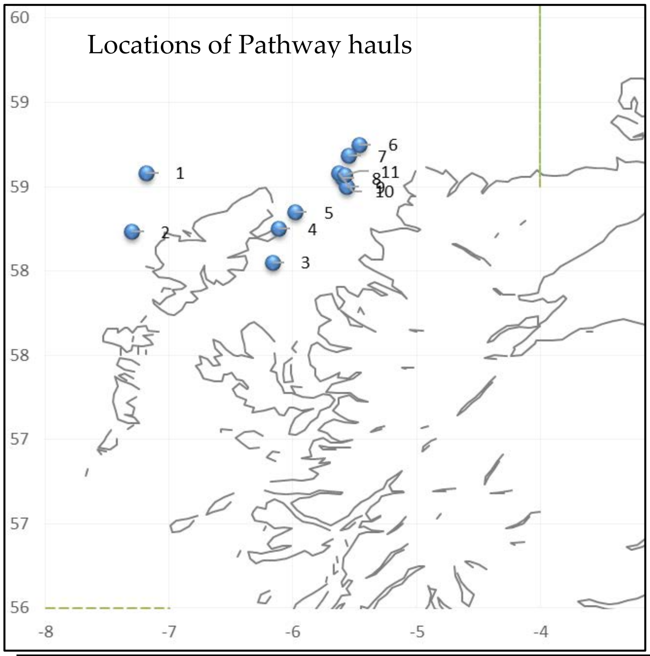
generally more amorphous in shape and form more extended layer-like aggregations near the bottom.

- **Mackerel** – The difference in frequency response from 38 to 200 KHz (stronger) makes mackerel easier to identify. They tend to be found in layers (can be at different depths) and are ubiquitous in 6aN with some mackerel caught in most hauls.

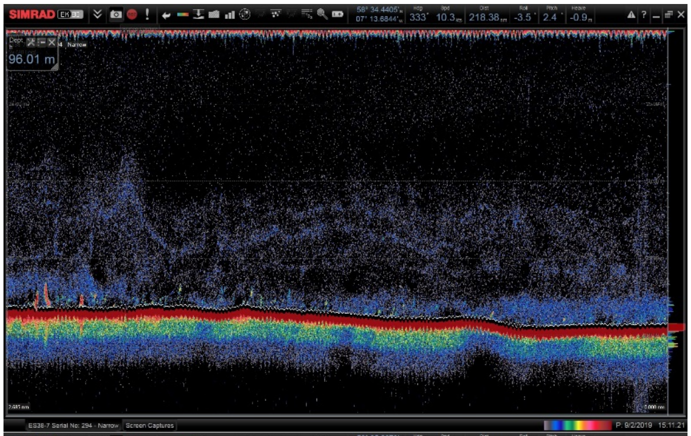
How strongly the acoustic marks are displayed on the screen (backscatter threshold) can have a bearing on the interpreters classification of the acoustic marks and their selection using school detection algorithms. While it is desirable to be consistent in the setting of this parameter, in practice the setting is determined largely by the need to filter out fish schools from other acoustic signals that create noisy backscatter data. Other methods used to help distinguish herring marks from other fish and organisms causing backscatter included looking at the 'frequency response' (i.e. how the backscatter properties look at different acoustic frequencies), and the application of filters (Figure 2.13). Great attention was given to comparing and discussing the types of marks recorded and validated by trawls from all of the vessels involved in the surveys. In the end, every school was manually scrutinised thereafter to ensure that it was appropriately classified and delineated based on the available information.

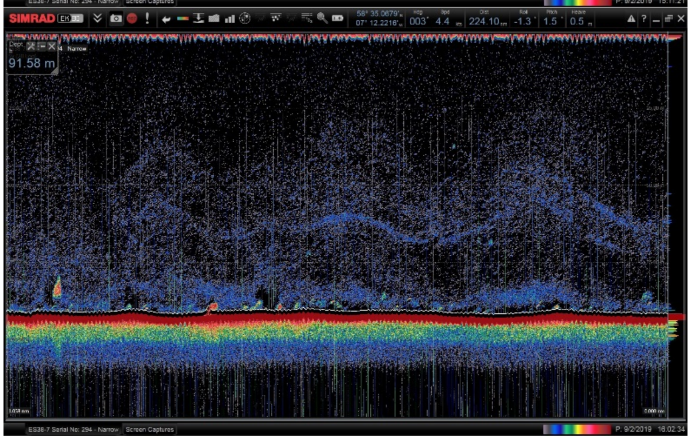
As in 2018, in 2019, the diversity of acoustic marks (Figure 2.12) and the availability of trawls samples with which to verify them, made the classification of marks and assignment of herring biological sample data to acoustic transects (Table 3.5, Figure 2.15) particularly challenging.

<u>6aN acoustic marks recorded by Pathway</u>

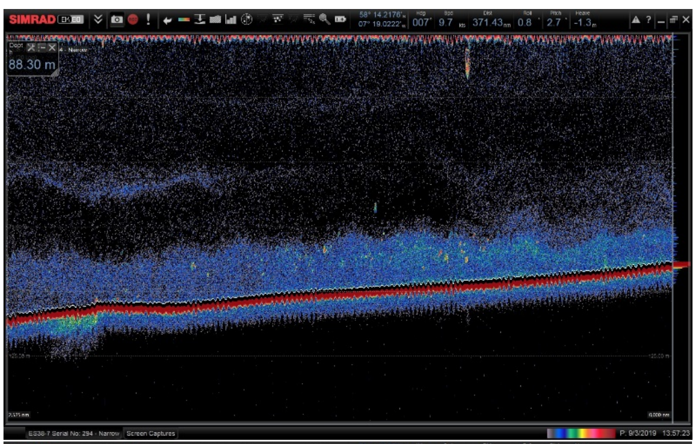


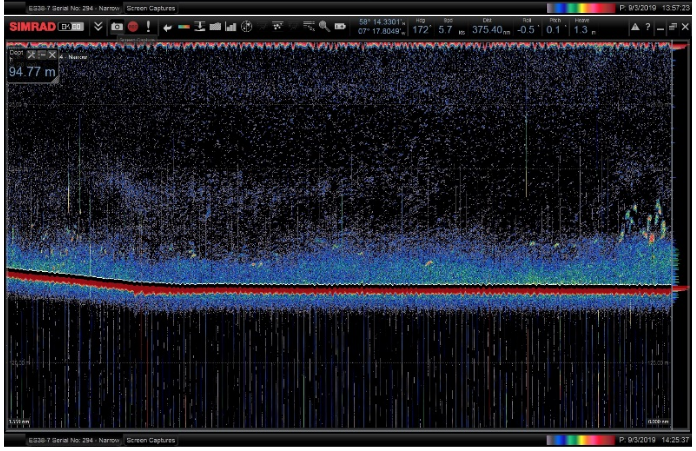
Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
1	0%	0%	24%	76%	0%	0%	0%
2	1%	0%	18%	5%	15%	62%	0%
3	12%	0%	9%	0%	0%	79%	0%
4	3%	9%	3%	0%	3%	0%	83%
5	79%	7%	4%	0%	4%	0%	5%
6	2%	0%	98%	0%	0%	0%	0%
7	95%	0%	4%	0%	0%	1%	0%
8	1%	0%	20%	0%	26%	53%	0%
9	1%	0%	31%	0%	28%	40%	0%
10	81%	16%	3%	0%	0%	0%	0%
11	80%	12%	5%	0%	2%	0%	0%



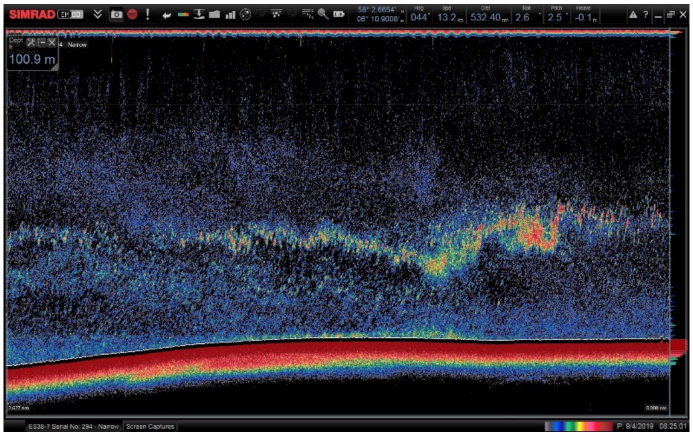


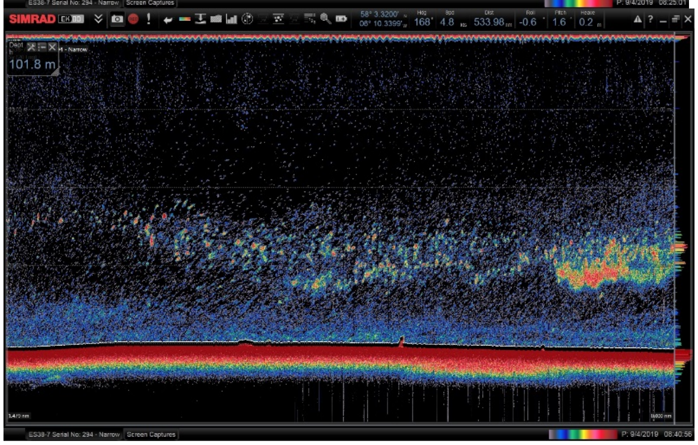
Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
1	0%	0%	24%	76%	0%	0%	0%



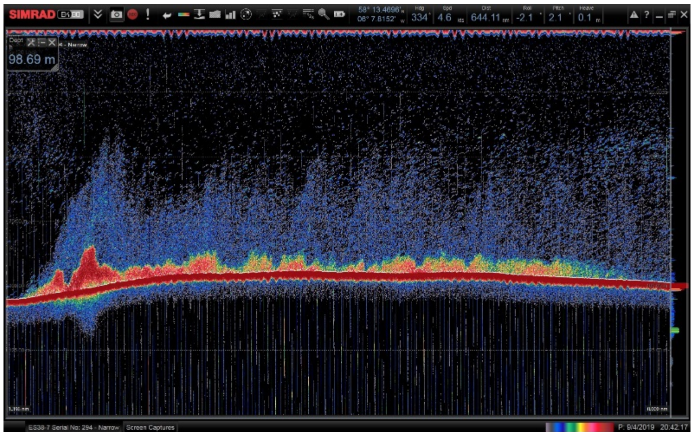


Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
2	1%	0%	18%	5%	15%	62%	0%

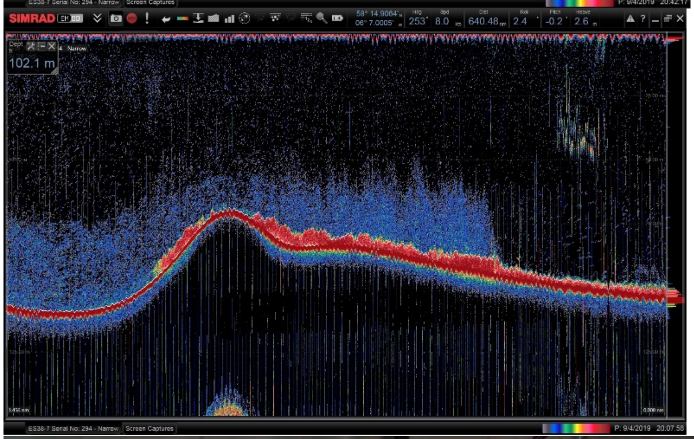


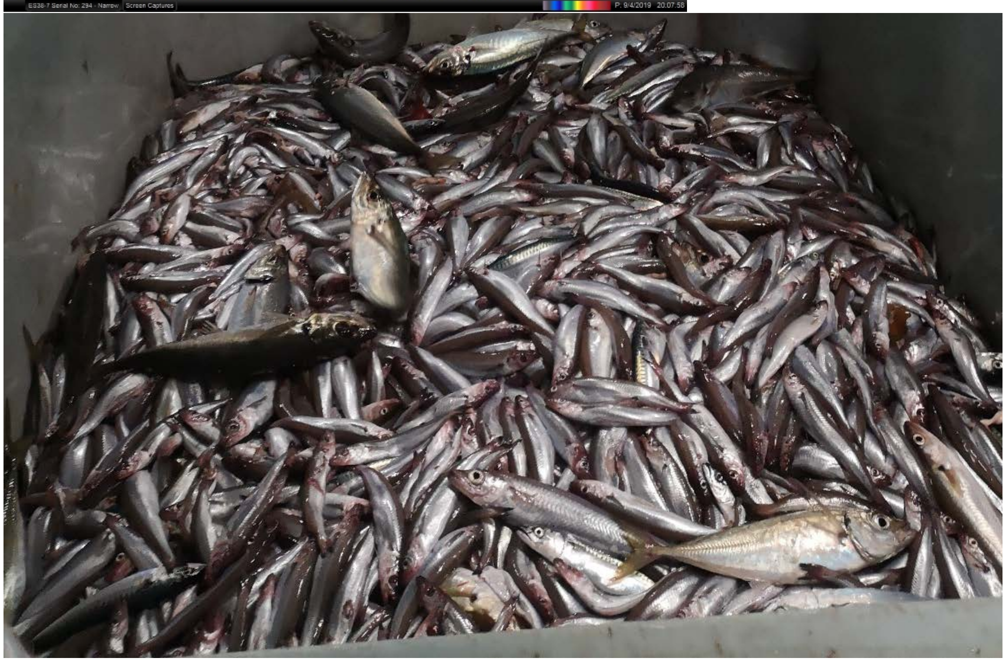


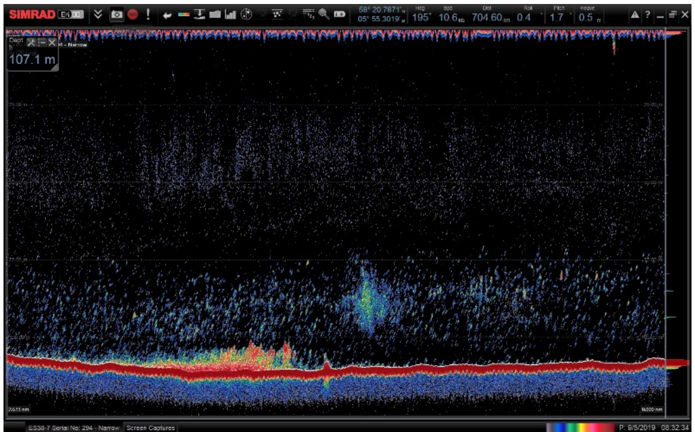
Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
3	12%	0%	9%	0%	0%	79%	0%

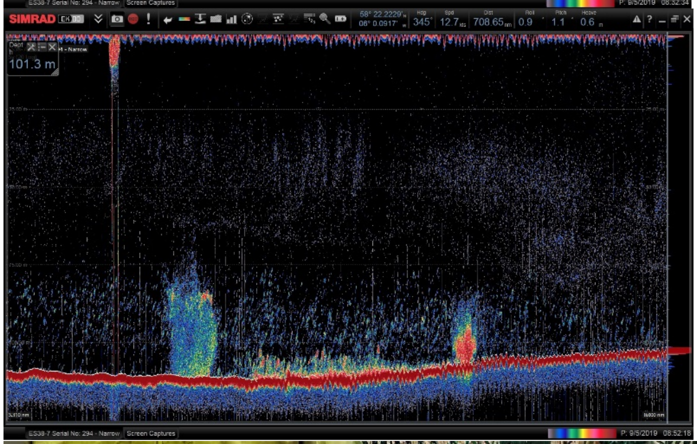


Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
4	3%	9%	3%	0%	3%	0%	83%

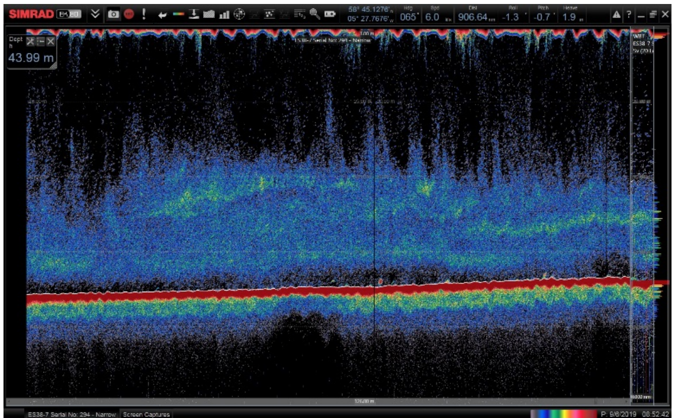




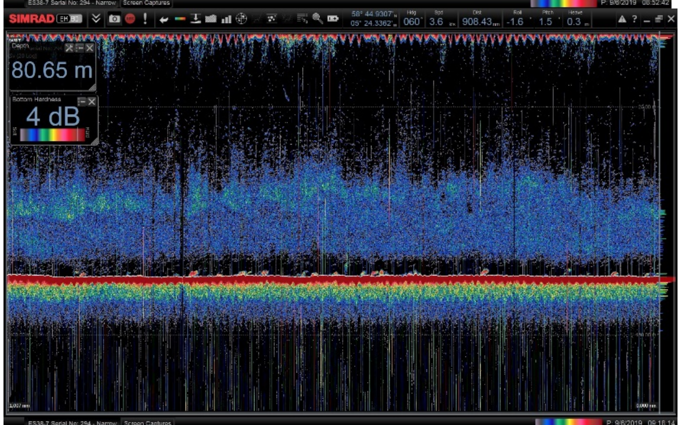


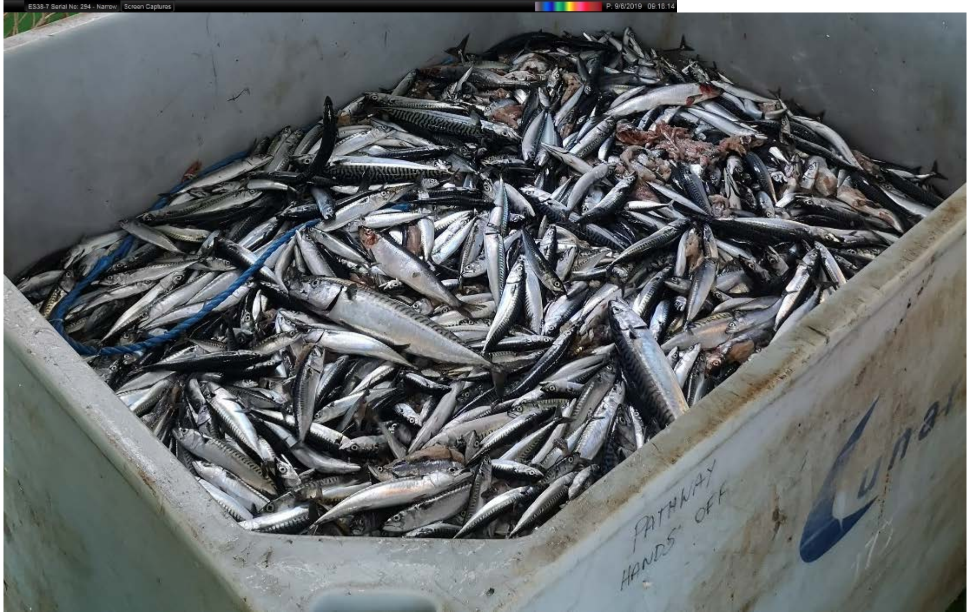


Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
5	79%	7%	4%	0%	4%	0%	5%

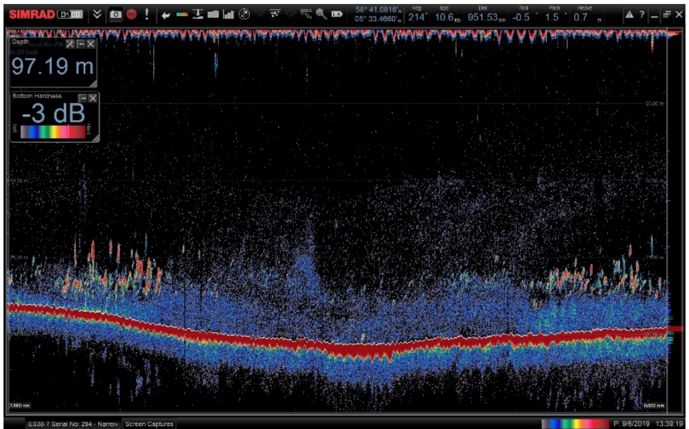


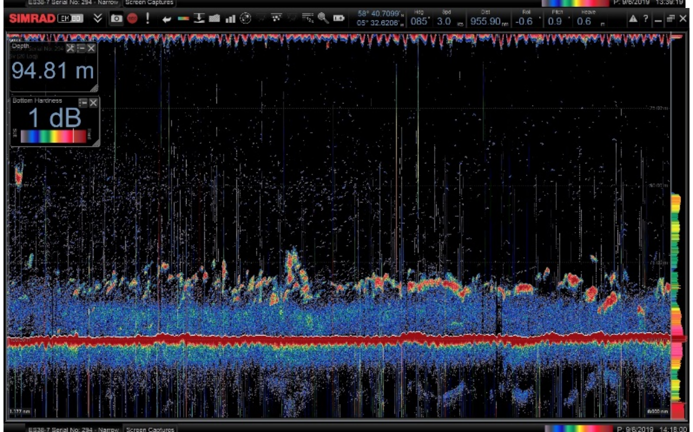
Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
6	2%	0%	98%	0%	0%	0%	0%

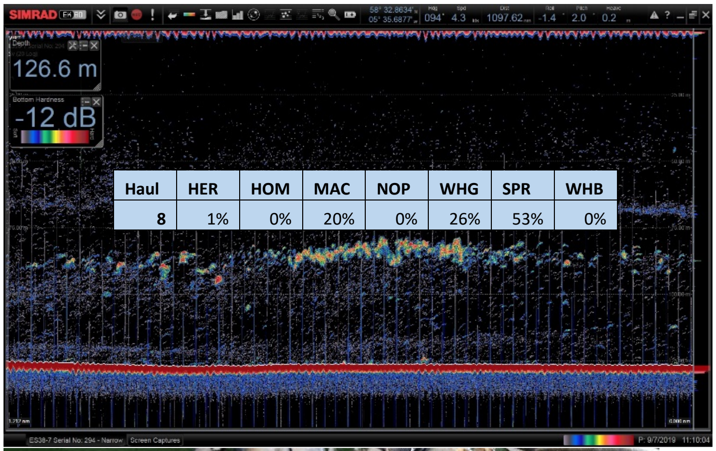




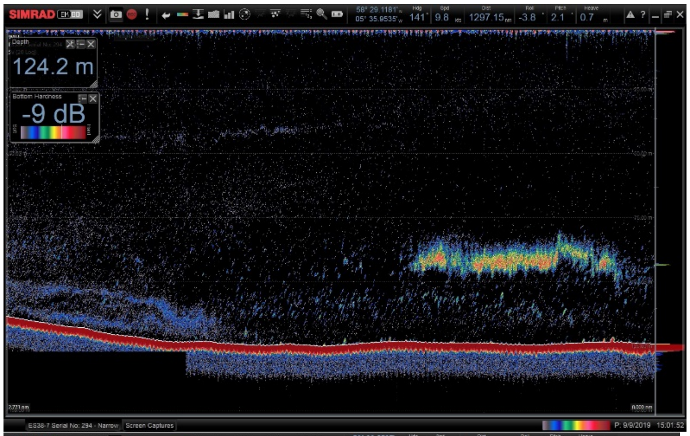
Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
7	95%	0%	4%	0%	0%	1%	0%



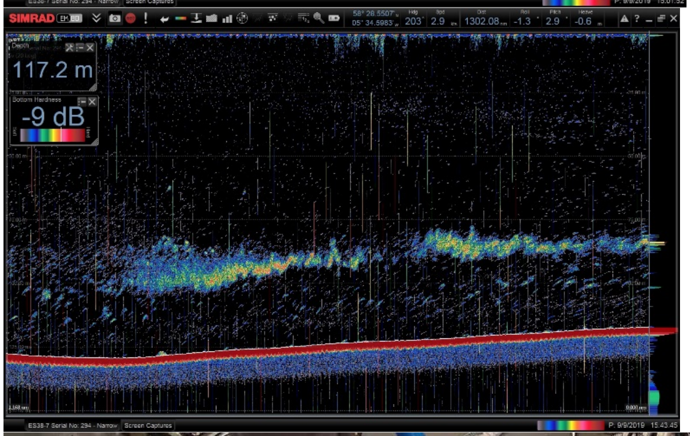


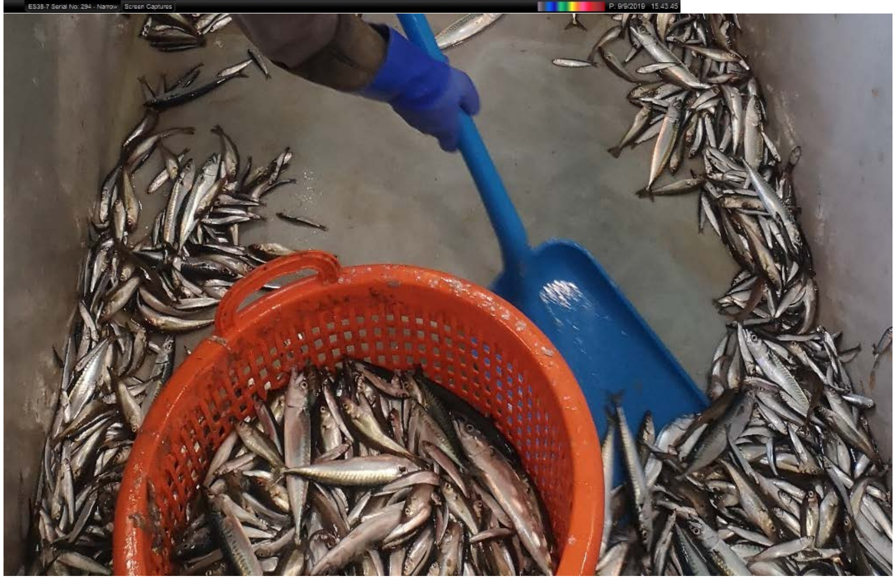


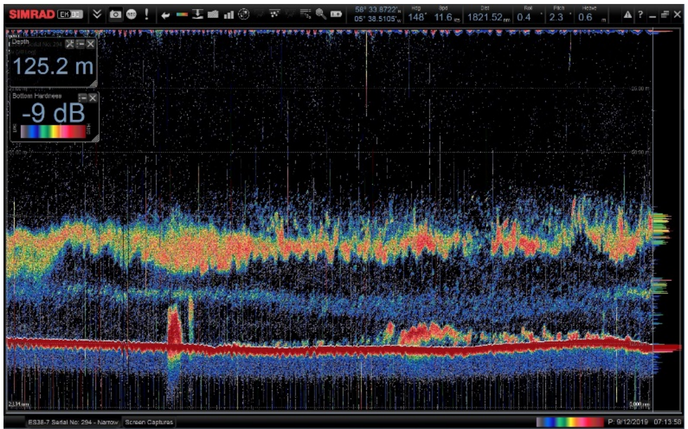
Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
8	1%	0%	20%	0%	26%	53%	0%

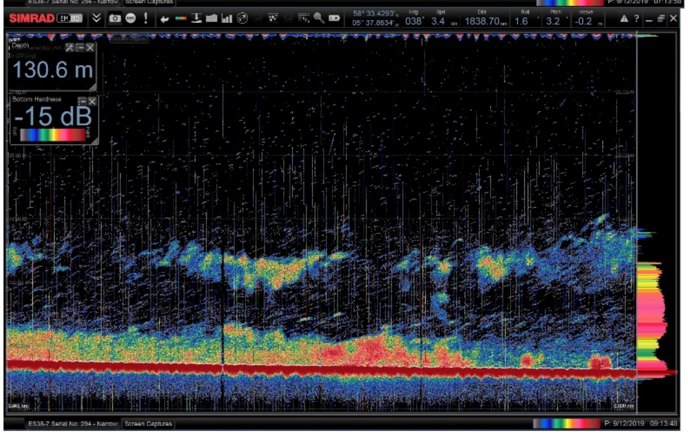


Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
9	1%	0%	31%	0%	28%	40%	0%



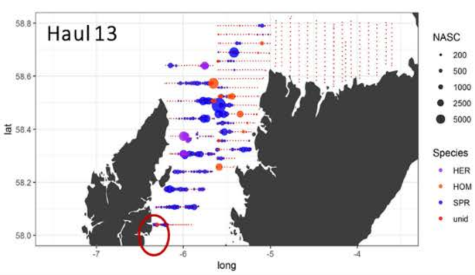


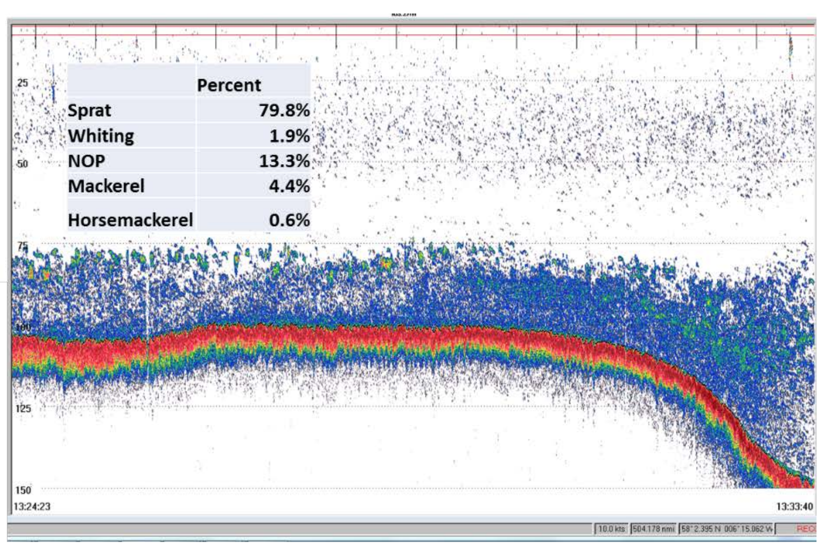


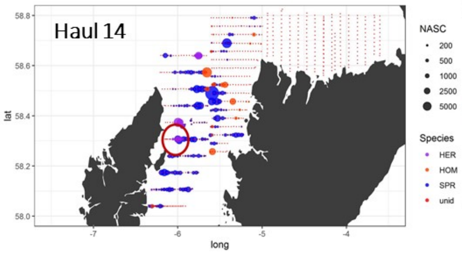


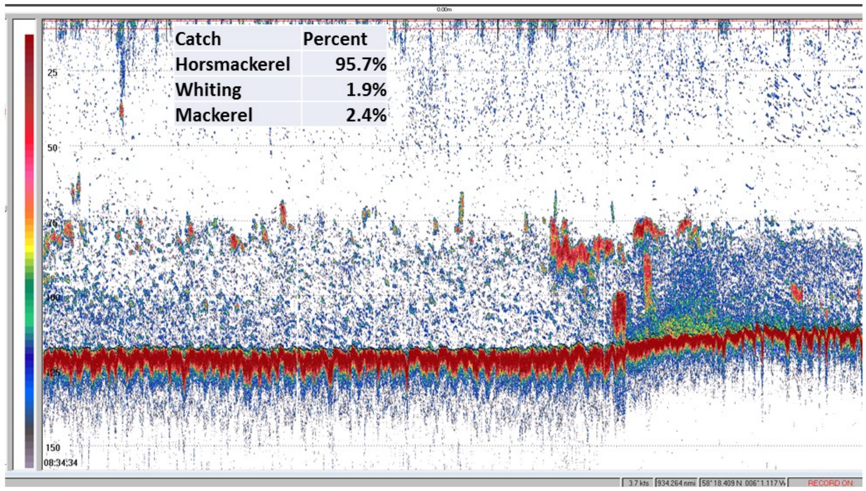
Haul	HER	HOM	MAC	NOP	WHG	SPR	WHB
10	81%	16%	3%	0%	0%	0%	0%

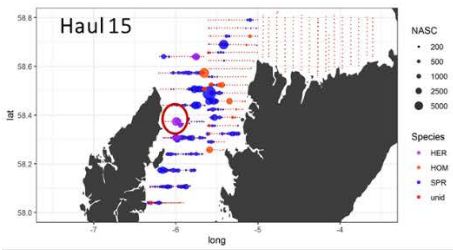
6aN acoustic marks of Juvenile herring recorded by Dirk Dirk

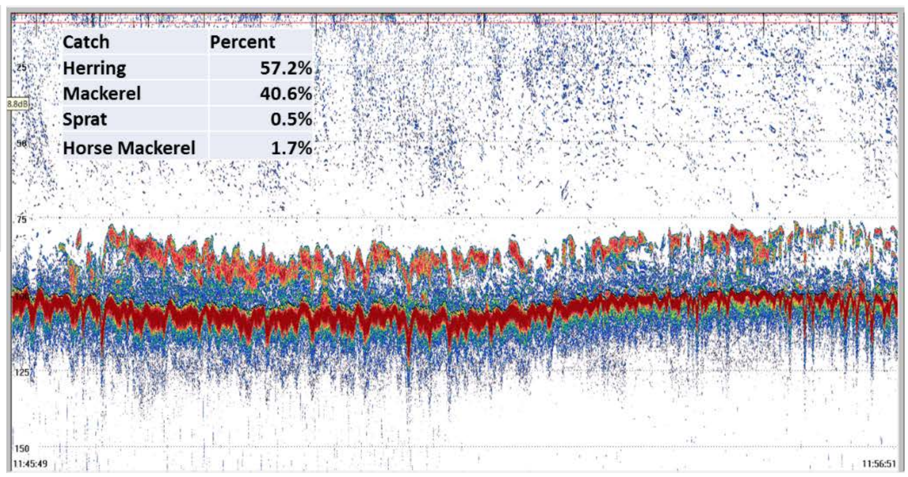


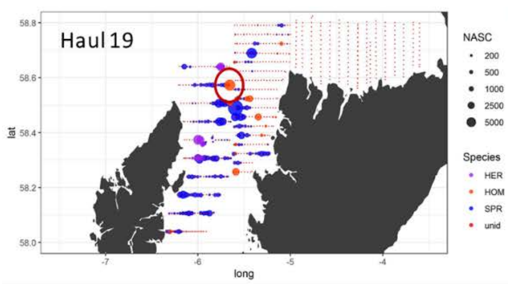


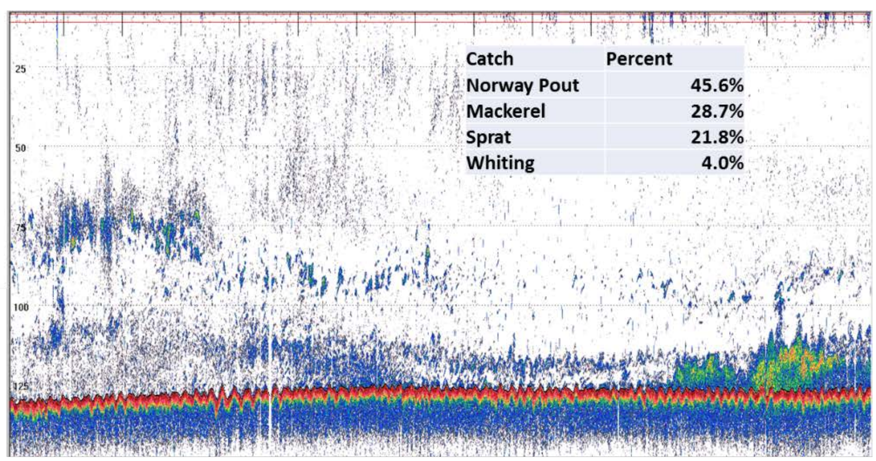

Haul 14
NASC
200
500
1000
2500
5000
Species
HER
HOM
SPR
unid
lat
long

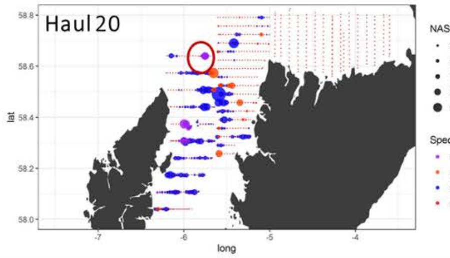

Catch Percent
Horsmackerel 95.7%
Whiting 1.9%
Mackerel 2.4%

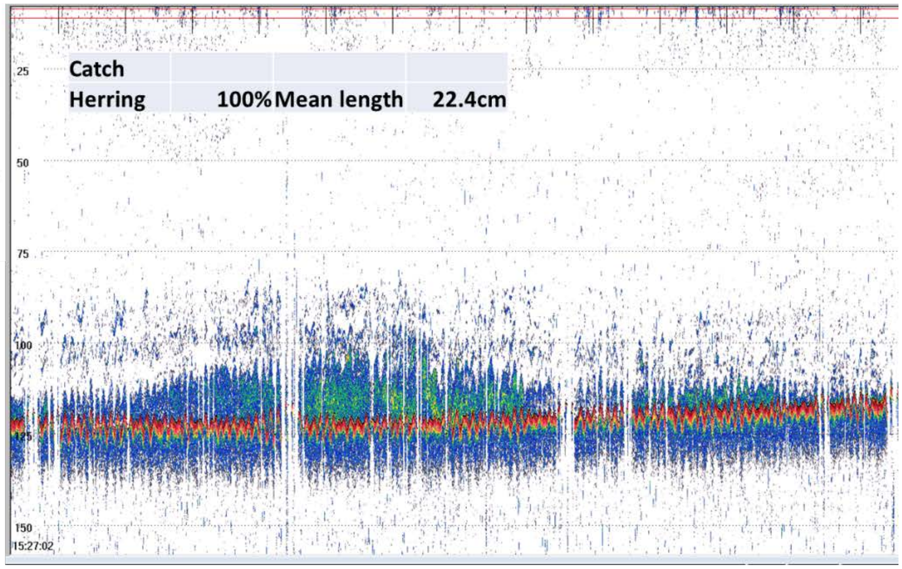

Haul 15
NASC
200
500
1000
2500
5000
Species
HER
HOM
SPR
unid
lat
long

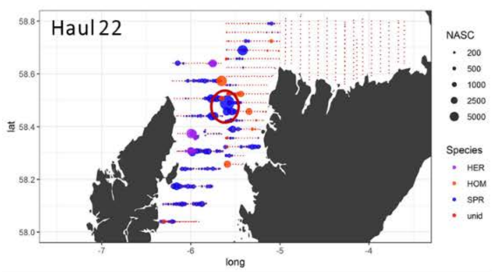

Catch Percent
Herring 57.2%
Mackerel 40.6%
Sprat 0.5%
Horse Mackerel 1.7%
11:45:49
11:56:51

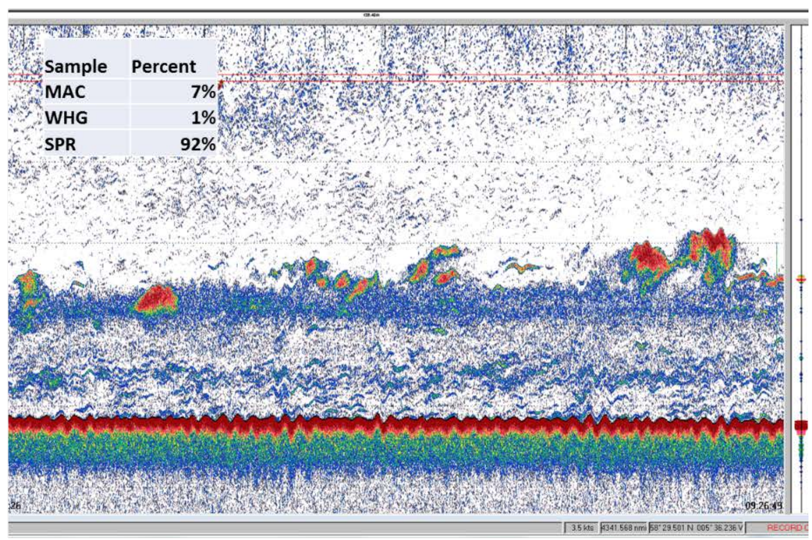

Haul 19
NASC
200
500
1000
2500
5000
Species
HER
HOM
SPR
unid
lat
long

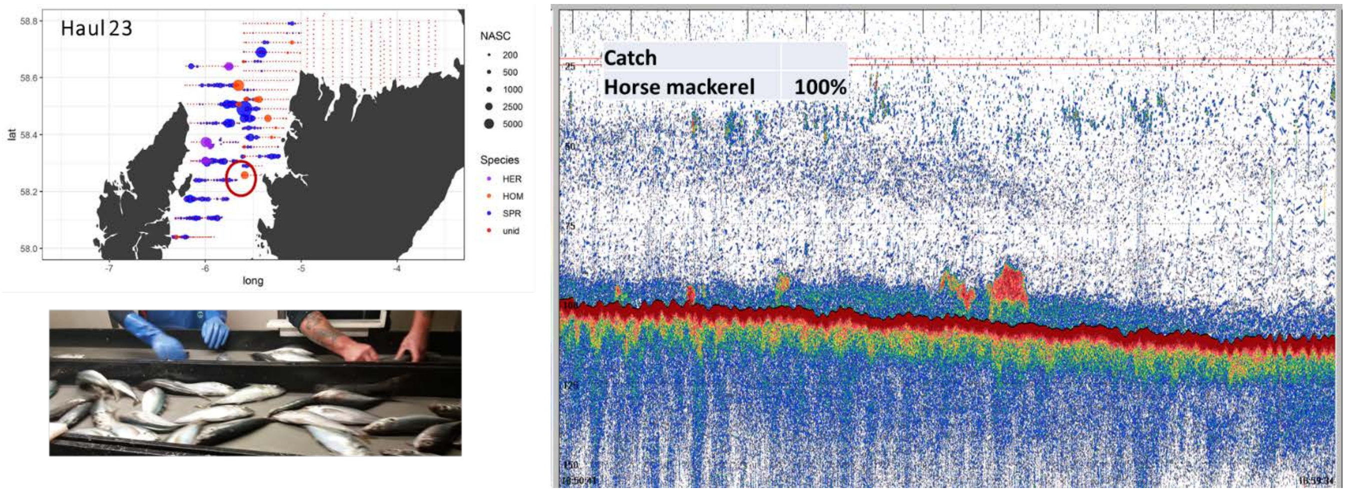

Catch Percent
Norway Pout 45.6%
Mackerel 28.7%
Sprat 21.8%
Whiting 4.0%


Haul 20
NASC
200
500
1000
2500
5000
Species
HER
HOM
SPR
unid
lat
long

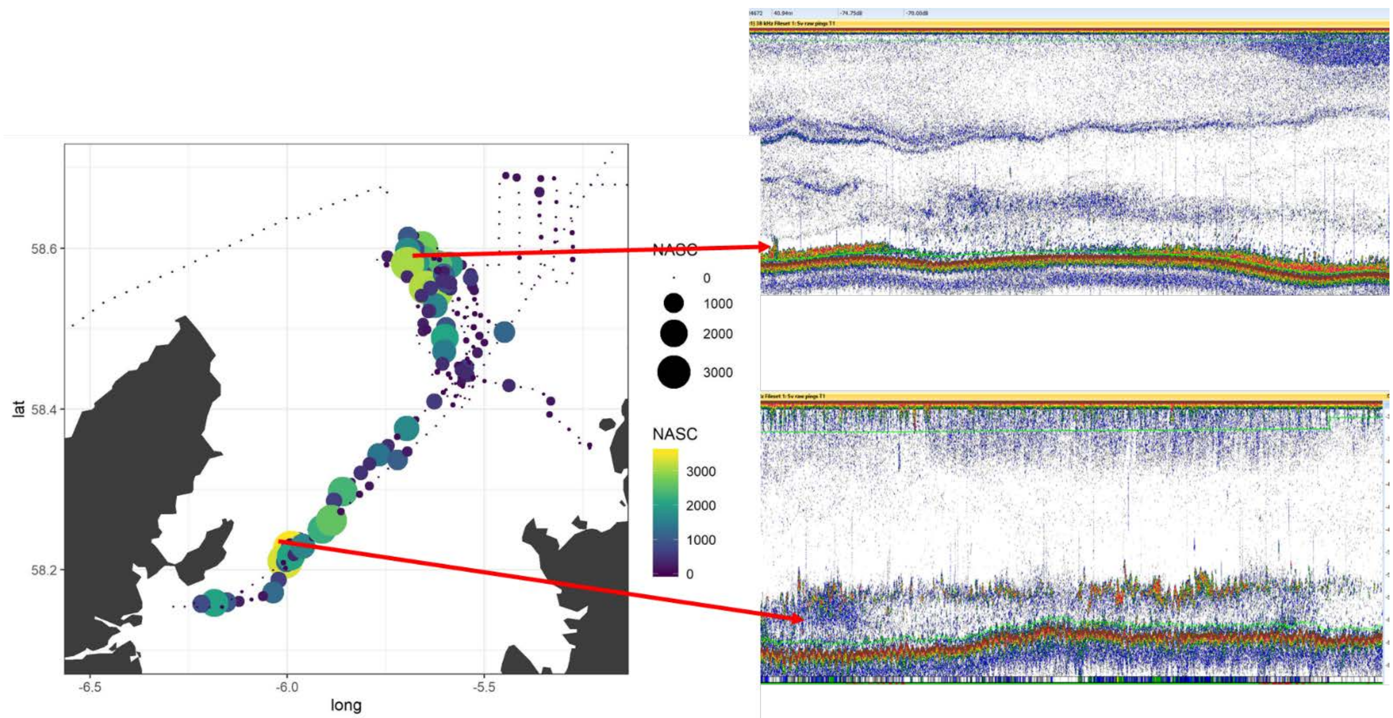

Catch
Herring 100% Mean length 22.4cm
25
50
75
100
150
15:27:02

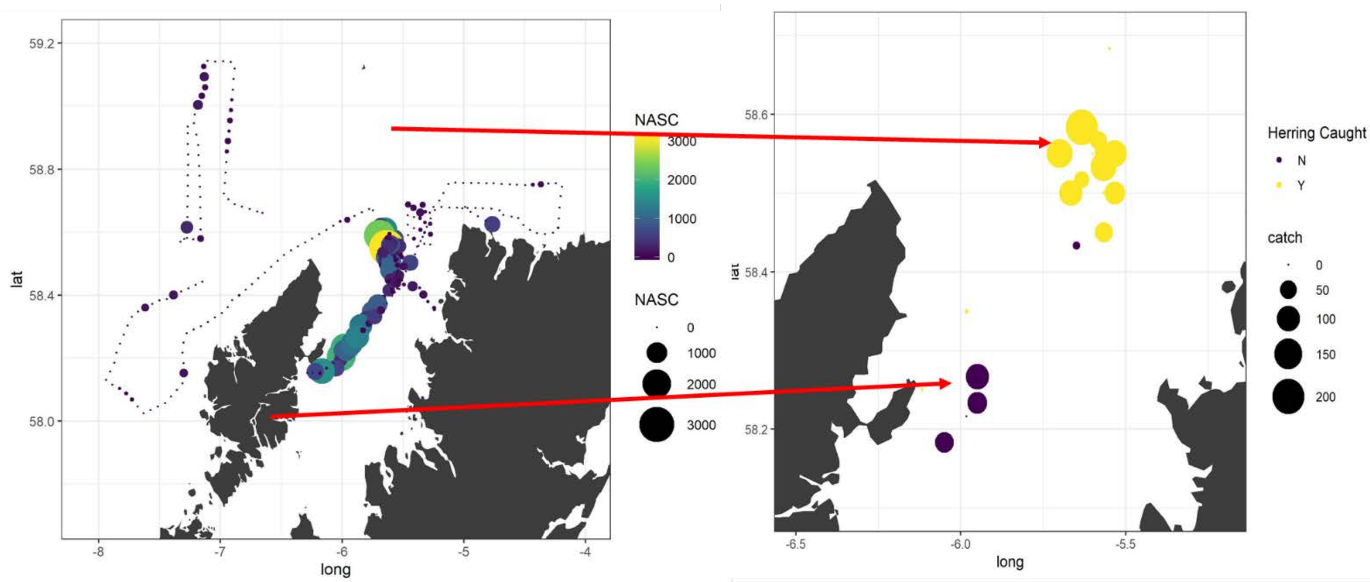

Haul 22
NASC
200
500
1000
2500
5000
Species
HER
HOM
SPR
unid
lat
long


Sample Percent
MAC 7%
WHG 1%
SPR 92%

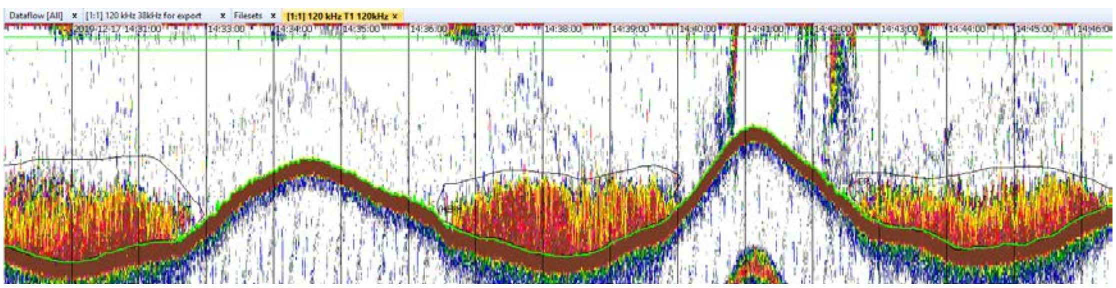


<u>6aN acoustic marks recorded by Wiron</u>

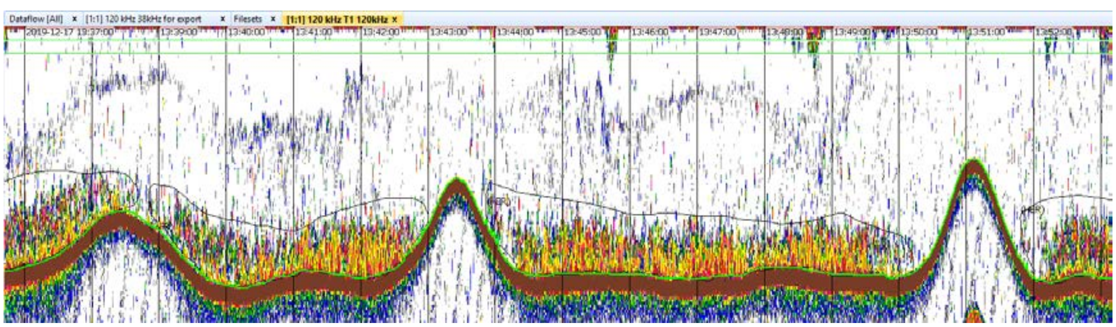




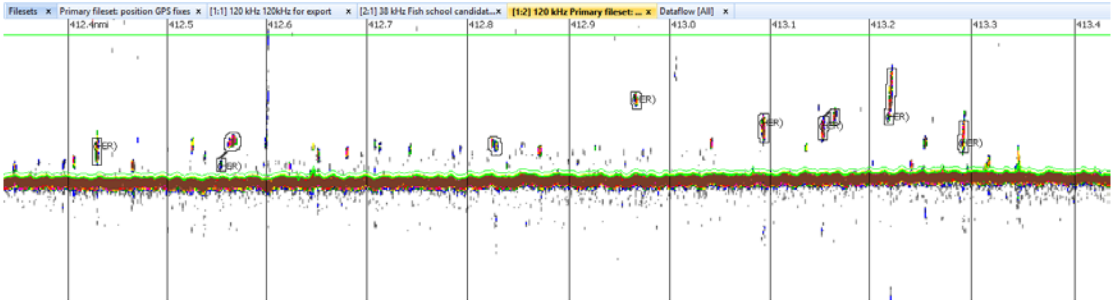
<u>6aS/7b acoustic marks recorded by *Celtic Voyager/Ros Ard*</u>



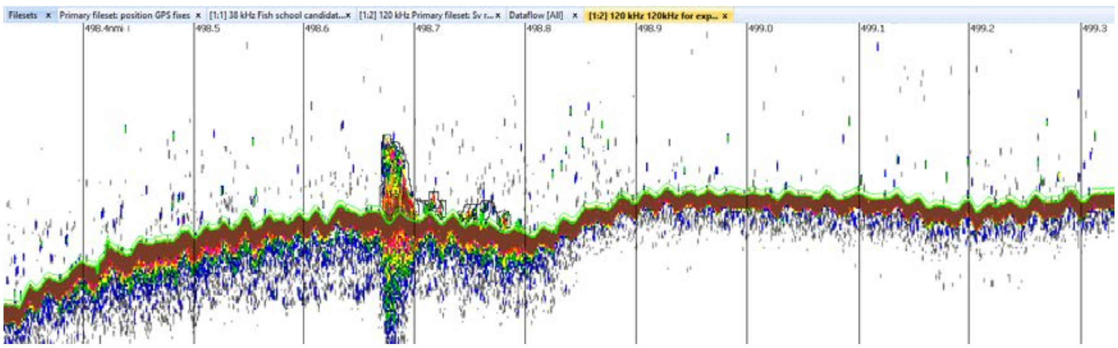
6aS/7b industry acoustic survey on 17/12/2019: Series of herring marks (120 kHz) in Lough Swilly, Co. Donegal (ICES area 6aS). Water depth max ~ 18m approximately.



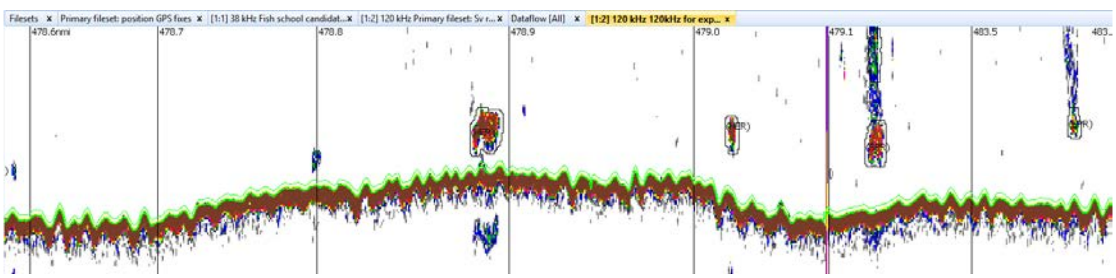
6aS/7b industry acoustic survey on 17/12/2019: Series of herring marks (120 kHz) in Lough Swilly (ICES area 6aS). Water depth max ~ 20m approximately.



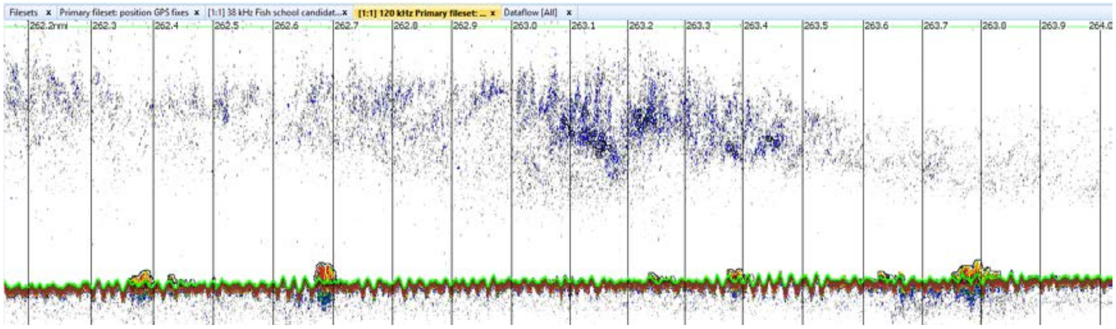
6aS/7b industry acoustic survey in 04/12/2019: Haul 7 - series of herring marks (120 kHz) in Donegal Bay (ICES area 7b). Water depth ~ 30m approximately.



6aS/7b industry acoustic survey on 04/12/2019: Herring mark (120 kHz) at Drumanoo Head (ICES area 6aS). Water depth max ~ 30m approximately.



6aS/7b industry acoustic survey on 06/12/2019: Haul 8 - sprat and herring mix (120 kHz) in Donegal Bay (ICES area 7b). Water depth ~ 30 m approximately.



6aS/7b industry acoustic survey on 03/12/2019: Horse mackerel marks (120 kHz) north and east of the Stags of Broadhaven area (ICES area 6aS). Water depth ~ 90m approximately.

Figure 2.12. Examples of acoustic marks and their identification.

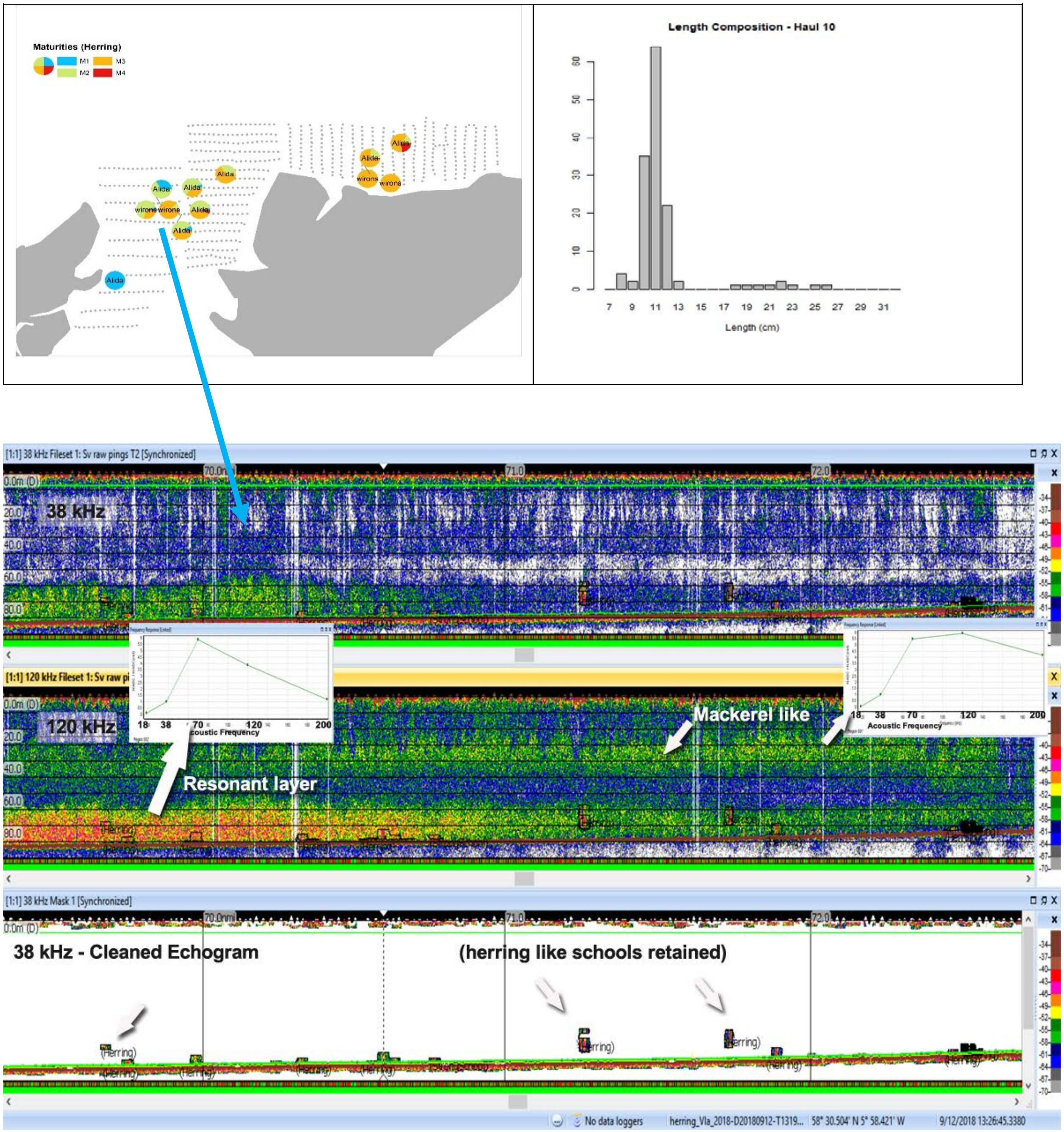


Figure 2.13. Example of analysis of acoustic properties to help classify schools in 6aN from Alida acoustic data in 2018.

2.2.6.2 *Age disaggregated abundance estimation*

The process for estimating abundance and biomass from the acoustic data is shown in Figure 2.14, with additional description given below.

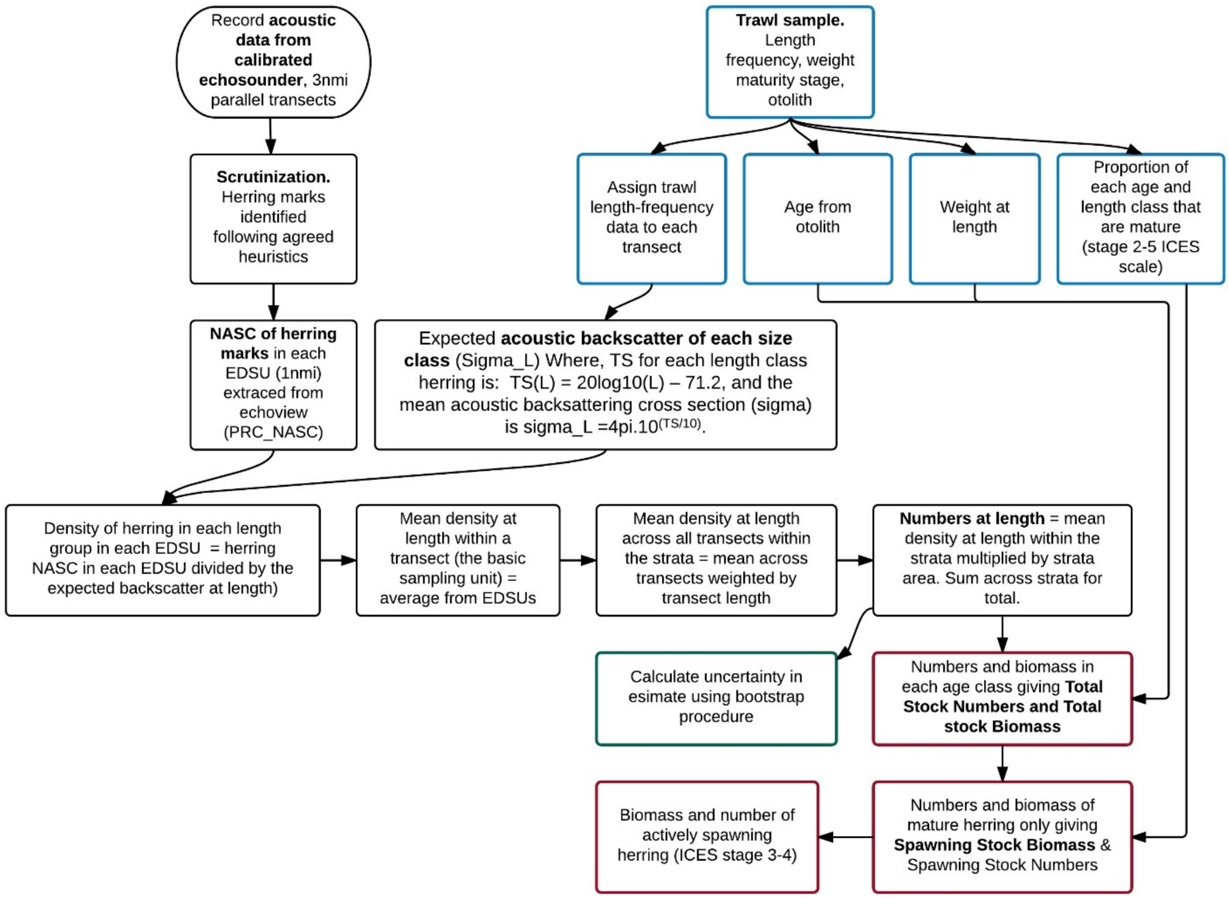


Figure 2.14. Flow diagram of the analysis methods to estimate abundance and biomass. Blue boxes – biological data; black boxes – treatment of acoustic data; red boxes- derived abundances indices; green box – uncertainty estimates

The StoX software (http://www.imr.no/forskning/prosjekter/stox/nb-no) was used to calculate the age disaggregated acoustic abundance estimates. StoX is an open source software developed at IMR, Norway to calculate survey estimates from acoustic and swept area surveys. The program is a stand-alone application built in Java for easy sharing and further development in cooperation with other institutes, and is now routinely used to derive abundance estimates from WGIPS coordinated surveys. Documentation and user guides are available from the website. Estimation of abundance from acoustic surveys with StoX is carried out according to the stratified transect design model developed by Jolly and Hampton (1990).

Following scrutinisation of the echograms and export of the Nautical Area Scattering Coefficient assigned to herring marks for each 1nm cell (PRC_NASC from Echoview software), the calculation of age disaggregated abundance was as follows:

1. **Define survey strata.** In 6aN, each of the 4 areas surveyed was assigned as a strata. In 6aS/7b only 2 strata were defined in 2019, (i) Lough Swilly, using zig-zag transects, where the boundaries of the strata was delineated approximately 250m either side of the centre line of the deepest part of the Lough Swilly channel in approximately 10 – 20m water depth. (ii) Donegal bay using parallel transects with 3.5 nmi spacing including shallow inshore areas of Bruckless Bay and Inver Bay. The reduction in area covered compared to other years was a direct result of poor weather.

2. **Assigning herring length data from trawls to acoustic transects.** For each transect within each survey strata, the length distribution of herring associated with the transect was determined as the un-weighted mean of all trawls allocated to the respective transects (e.g. Figure 2.15).

   Technical difficulties with the towed body transducer on FV Dirk Dirk followed by a malfunctioning hull transducer and significant disruption due to poor weather resulted in the Dirk Dirk data only being fit only to use as information on acoustic mark identification and fish distribution. No biomass calculations were possible, hence only acoustic data from Pathway were used in subsequent analyses. Difficulties in getting sufficient representative biological survey samples to allocate to the echograms necessitated borrowing sample data from adjacent areas hauls that were considered representative based on their time, location, catch composition and comparison with the identified acoustic marks (see Figure 2.15, Table 3.3).

3. **Expected backscattering cross section of fish in each length group.** The mean acoustic backscattering cross-section "sigma" (σ_{bs}) for each length group of herring was calculated from the length frequency data assigned to each transect using the target strength-length relationships for herring recommended by the ICES Working Group on International Pelagic Surveys. Where, the target strength (TS) relationship used to calculate the mean acoustic backscattering cross-sections for herring is:

   $$TS = 20\log10\,(L) - 71.2 \quad \text{[at 38 kHz]}\ \textit{for herring}$$

   $$TS = 20\log10\,(L) - 67.5 \quad \text{[at 38 kHz]}\ \textit{for horse mackerel}$$

   $$TS = 20\log10\,(L) - 76\ \text{dB} \quad \text{[at 120 kHz]}\ \textit{for herring}$$

   and the mean acoustic backscattering cross section is:

   $$\sigma_{sp} = 4\pi . 10^{(TS/10)}$$

4. **The average density of herring in each length class on a single transect** was calculated by dividing the Nautical Area Scattering Coefficient (NASC - the area

backscattering coefficient for a particular integration region in areal units (m^2/nmi^2), within each Elementary Distance Sampling Unit (EDSU, here =1nmi or 0.5nmi) on each transect by the length-specific σ_{bs} (acoustic fish backscatter) assigned to the transect, then averaging over the EDSUs.

5. **Numbers of herring in a single stratum & total numbers.** For each length group, a weighted average (weighted by transect length) of the mean density of herring in each transect is multiplied by the area of the stratum. Total numbers at length is the sum for each stratum.
6. **The numbers and biomass per age & maturity class.** Trawl data on the relationship between length, age and maturity stage were used to partition the numbers at length to estimates of numbers and biomass in each age class and maturity stage. The 9 point maturity stage classification used in the Scottish and Irish sampling (MSS manual 2011) was converted to the ICES 6 point scale prior to analysis (Table 2.4) (ICES 2011).
7. **Estimate of the relative sampling error.** Within StoX a bootstrap procedure was used to estimate the coefficient of variance (CV) of the estimate of numbers at length. The procedure randomly selects transects within a stratum in every n bootstrap iteration (n =1000 check). For each selected transect, biological information from trawl stations that were assigned to the transect are randomly sampled and used as input to estimate fish abundance in the stratum in that particular bootstrap iteration. Each bootstrap iteration follows the same estimation procedures as used in StoX and described above (using the combination of mean acoustic density per transect and associated biological information, to estimate fish numbers at length in each stratum). This procedure was not performed for the 6aN survey this year because of difficulties in getting stox programme to work.
8. **Choosing the best estimate from replicates**. In the 6aN, where replicate acoustic surveys were conducted for each stratum, the maximum biomass estimate of these was chosen as the best estimate.

Acoustic data were recorded on hard-drives at sea and uploaded to network facilities back at the laboratory. The acoustic metadata and cleaned post-processed EV files are stored using Marine Scotland Science data base following established procedures. 6aS/7b raw and processed data are stored at the Marine Institute, Ireland. Estimates of NASC values from the surveys are stored in the ICES acoustic database.

13

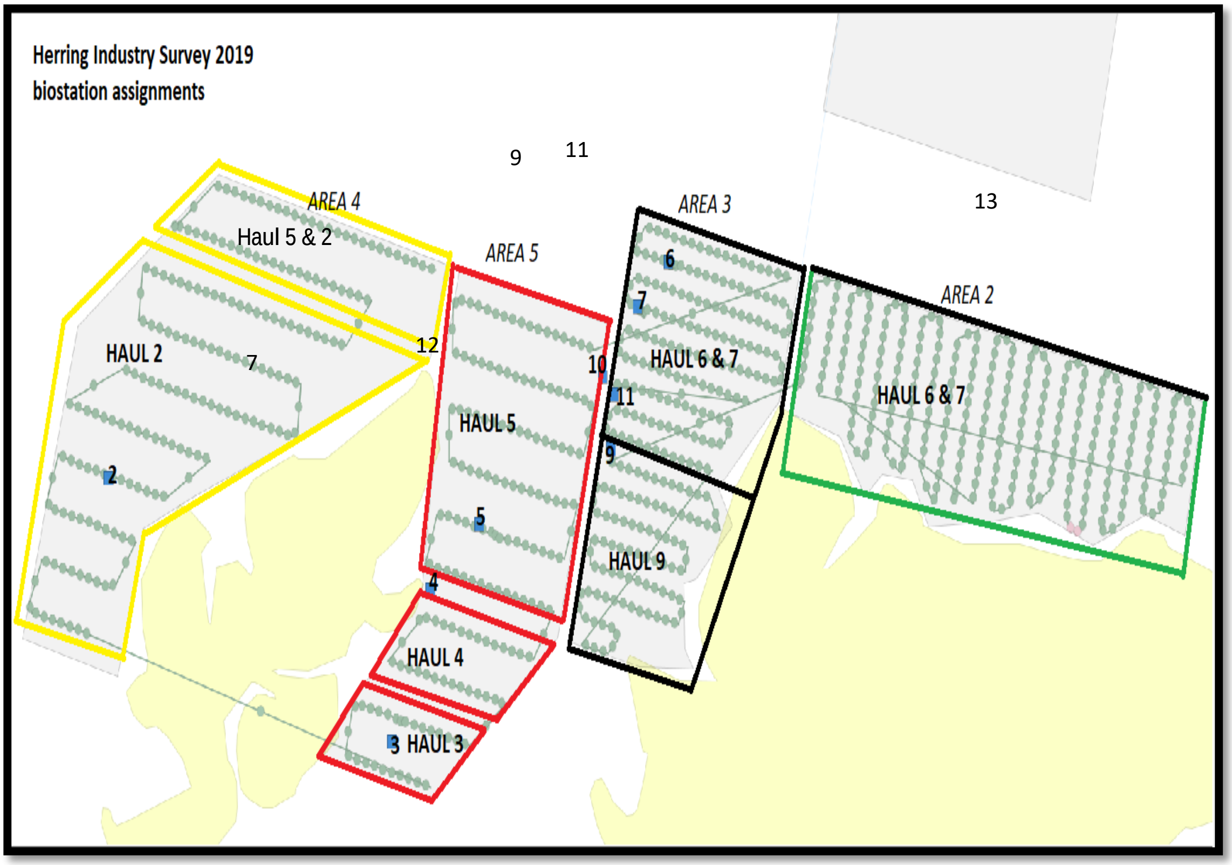


Figure 2.15a. Pathway acoustic survey in 6aN – marking haul numbers for biological data assignment. **Note:** The information from two hauls (hauls 10 and 11) were not used in the analysis, as these are commercial hauls taken at the end of the survey, a whole week after the area was surveyed.

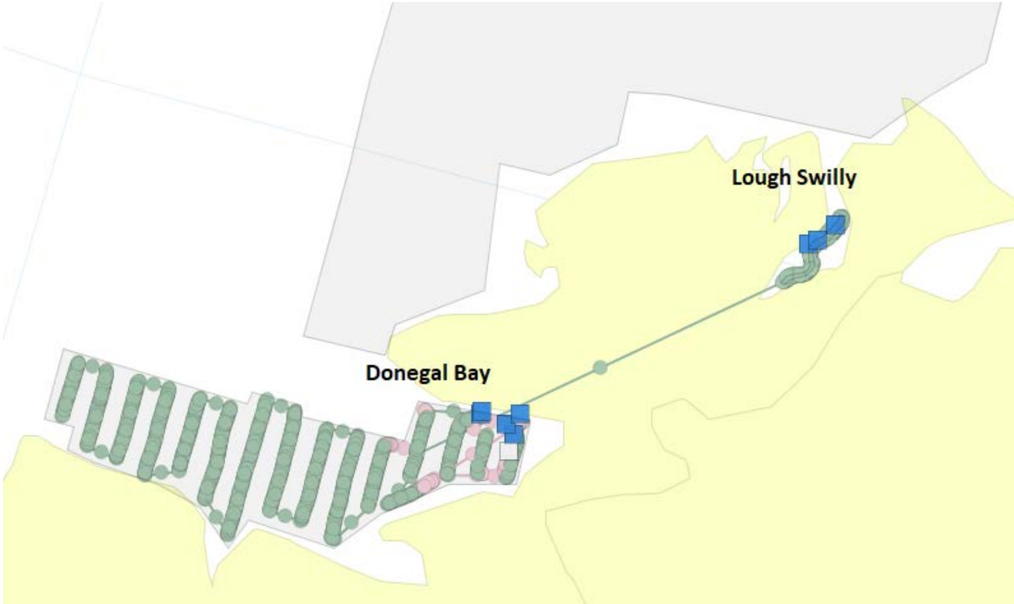


Figure 2.15b. 6aS/7b industry acoustic survey in 2019: StoX strata delineated for the 2 scrutiny areas for herring (Lough Swilly and Donegal Bay). The haul samples stations where herring were obtained for length frequency analysis are also shown as blue squares.

Table 2.4. Translation of Marine Scotland 9 point maturity scale to ICES 6 point scale

NINE POINT MATURITY SCALE (MARINE SCOTLAND MANUAL)	EQUIVALENT ICES SCALE STAGE
1 Immature virgin	1 (Immature)
2 Immature	1 (Immature)
3 Early maturing	2 (Mature – but not included in spawning category))
4 Maturing	2 (Mature – but not included in spawning category)
5 Spawning prepared	3 (Mature – included in spawning category)
6 Spawning	3 (Mature – included in spawning category)
7 Spent	4 (Mature – Spent – included in spawning category)
8 Recovering/resting	5 (Mature – resting - not included in spawning category)
9 Abnormal	6 (Abnormal – not included in Mature or spawning categories)

3 Results

3.1 Sampling summary

3.1.1 Sampling statistics 6aN

The survey vessels covered four different areas between 2019-09-02 and the 2019-10-06 (Figure 3.1), making a total of 57 hauls, of which 24 were taken in survey mode and 33 during commercial fisheries in 6aN. Dirk Dirk took 12 hauls in the North Sea during its trip.

Within ICES area 6aN, herring were sampled from 26 hauls, resulting in biological information collected from a total of 1687 herring (Table 3.1). 370 spawning herring were found in 8 out of the 57 hauls. Details on the sampling per trip are shown Figure 3.2.

Length distributions of herring indicated a larger spread of sizes overall than previously recorded, with smaller fish found again in survey area 5 and in also in other areas, but in lower numbers (Figure 3.3, 3.4).

All maturity data were converted into a common six point scale, in which stage 1 is immature, stage 2 is ripening, stage 3 is spawning and stage 4 is spent or resting. Although sample sizes are too few to glean good information on the timing of spawning, mature herring close to or spawning were detected from 6th September, with the highest proportion of mature fish around the 3rd week of September. (Figure 3.5).

Maps of the July acoustic survey in the Minches with relative acoustic density, and locations of sampling hauls are shown in Figure 3.6. The acoustic survey did not record any herring marks, and trawl samples found very few herring that were mixed in with catches dominated by other species. Drop-camera work was successful in identifying that the acoustic marks on rocky ground are most likely produced by juvenile gadoid species and zooplankton concentrations (https://youtu.be/inW5bIjAun0). However, some uncertainty still remains regarding possible avoidance by herring, which we hope to address in future work.

Maps of the survey tracks for the September acoustic survey, relative acoustic density, and locations of hauls whose biological data was used in for the estimation of the biomass of herring in 6aN are shown in Figure 3.7, Table 3.2.

Table 3.1. Overview of biological sampling. 'Type' refers to the type of activity (S=survey, C=commercial). The variables starting with 'n' denote the number of fish measured for the specific variable. Area 'other' refers to an area NW of Isle of Lewis fished by Dirk Dirk, and for Pathway a single haul that falls within the boundary of Area 5 and 3.

```
variable   typehaul   vesselname2         area3   area4   area5   oth   (all)
---------- ---------- ------------------- ------- ------- ------- ----- -------
```

nage	C	Dirk Dirk (KW172)	90	0	0	150	240
nage	C	Pathway (PD165)	51	0	0	67	118
nage	C	Wiron5+6 (PH2200)	145	0	150	0	295
nage	C	(all)	286	0	150	217	653
nage	S	Dirk Dirk (KW172)	0	0	221	0	221
nage	S	Pathway (PD165)	85	34	162	0	281
nage	S	Research (LK62)	99	0	199	0	298
nage	S	(all)	184	34	582	0	800
nage	(all)	(all)	470	34	732	217	1453
ngen	C	Dirk Dirk (KW172)	200	0	0	25	225
ngen	C	Pathway (PD165)	0	0	0	0	0
ngen	C	Wiron5+6 (PH2200)	0	0	100	0	100
ngen	C	(all)	200	0	100	25	325
ngen	S	Dirk Dirk (KW172)	0	0	0	0	0
ngen	S	Pathway (PD165)	100	0	0	0	100
ngen	S	Research (LK62)	100	0	200	0	300
ngen	S	(all)	200	0	200	0	400
ngen	(all)	(all)	400	0	300	25	725
nlen	C	Dirk Dirk (KW172)	200	0	0	175	375
nlen	C	Pathway (PD165)	51	0	0	68	119
nlen	C	Wiron5+6 (PH2200)	145	0	187	0	332
nlen	C	(all)	396	0	187	243	826
nlen	S	Dirk Dirk (KW172)	0	0	221	0	221
nlen	S	Pathway (PD165)	139	37	162	0	338
nlen	S	Research (LK62)	100	0	202	0	302
nlen	S	(all)	239	37	585	0	861
nlen	(all)	(all)	635	37	772	243	1687
nmat	C	Dirk Dirk (KW172)	200	0	0	175	375
nmat	C	Pathway (PD165)	51	0	0	59	110
nmat	C	Wiron5+6 (PH2200)	145	0	187	0	332
nmat	C	(all)	396	0	187	234	817
nmat	S	Dirk Dirk (KW172)	0	0	121	0	121
nmat	S	Pathway (PD165)	120	14	104	0	238
nmat	S	Research (LK62)	100	0	143	0	243
nmat	S	(all)	220	14	368	0	602
nmat	(all)	(all)	616	14	555	234	1419
nmorph	C	Dirk Dirk (KW172)	0	0	0	0	0
nmorph	C	Pathway (PD165)	0	0	0	0	0
nmorph	C	Wiron5+6 (PH2200)	0	0	0	0	0
nmorph	C	(all)	0	0	0	0	0
nmorph	S	Dirk Dirk (KW172)	0	0	0	0	0
nmorph	S	Pathway (PD165)	0	0	0	0	0
nmorph	S	Research (LK62)	0	0	0	0	0
nmorph	S	(all)	0	0	0	0	0
nmorph	(all)	(all)	0	0	0	0	0
nsex	C	Dirk Dirk (KW172)	200	0	0	175	375
nsex	C	Pathway (PD165)	51	0	0	68	119
nsex	C	Wiron5+6 (PH2200)	145	0	187	0	332
nsex	C	(all)	396	0	187	243	826
nsex	S	Dirk Dirk (KW172)	0	0	121	0	121
nsex	S	Pathway (PD165)	139	37	162	0	338
nsex	S	Research (LK62)	100	0	202	0	302
nsex	S	(all)	239	37	485	0	761
nsex	(all)	(all)	635	37	672	243	1587
nwgt	C	Dirk Dirk (KW172)	200	0	0	175	375
nwgt	C	Pathway (PD165)	51	0	0	68	119
nwgt	C	Wiron5+6 (PH2200)	145	0	187	0	332
nwgt	C	(all)	396	0	187	243	826
nwgt	S	Dirk Dirk (KW172)	0	0	221	0	221
nwgt	S	Pathway (PD165)	139	37	162	0	338
nwgt	S	Research (LK62)	100	0	202	0	302
nwgt	S	(all)	239	37	585	0	861
nwgt	(all)	(all)	635	37	772	243	1687

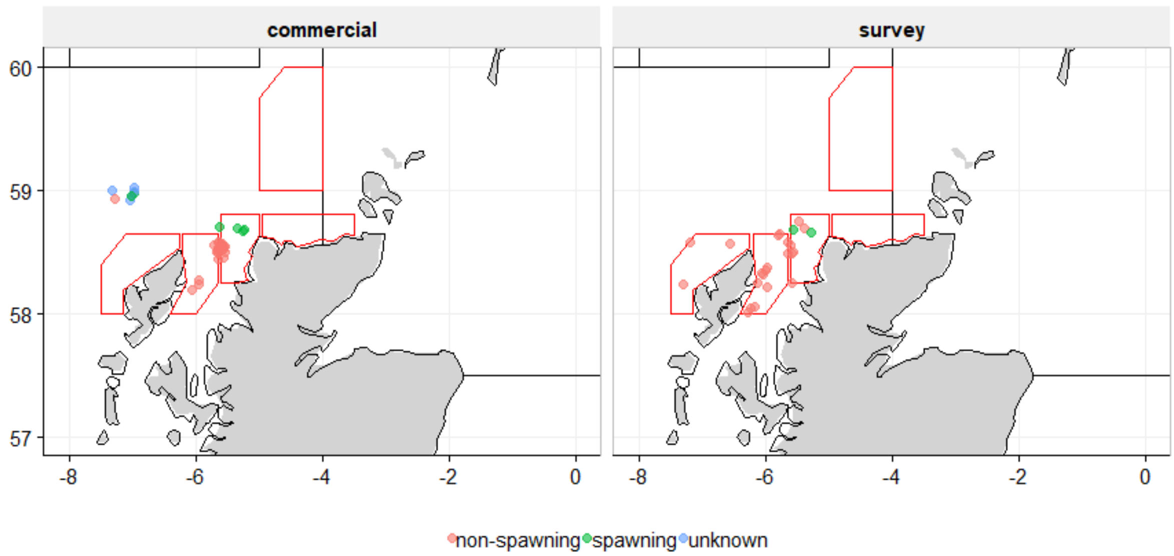
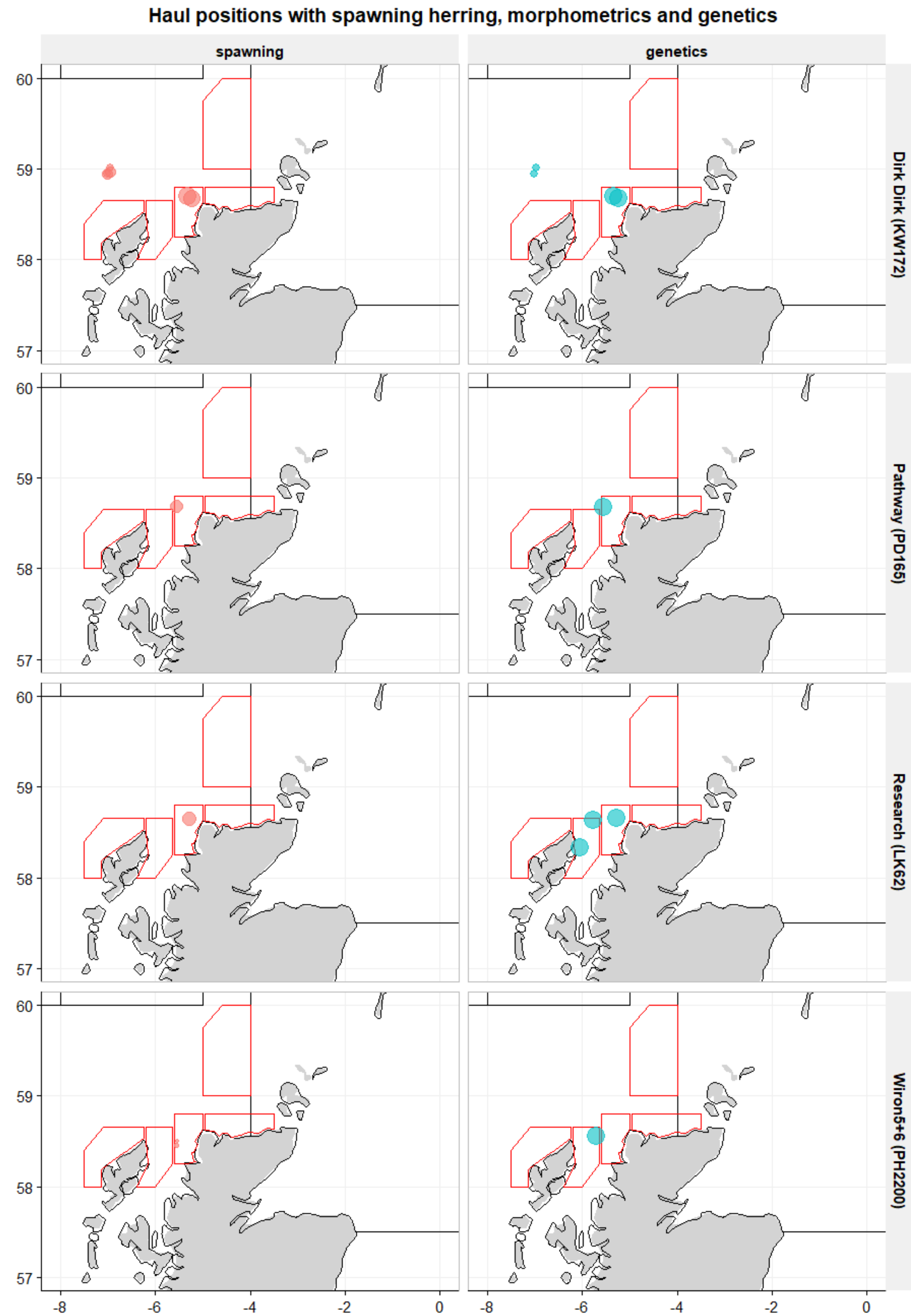


Figure 3.1. Spatial distribution of commercial hauls (C) and survey hauls (S) with spawning and non-spawning herring



Haul positions with spawning herring, morphometrics and genetics
spawning
genetics
Dirk Dirk (KW172)
Pathway (PD165)
Research (LK62)
Wiron5+6 (PH2200)
60
59
58
57
-8
-6
-4
-2
0

Figure 3.2. Spatial distribution of hauls with number of spawning herring and number of morphometric samples and genetic samples.

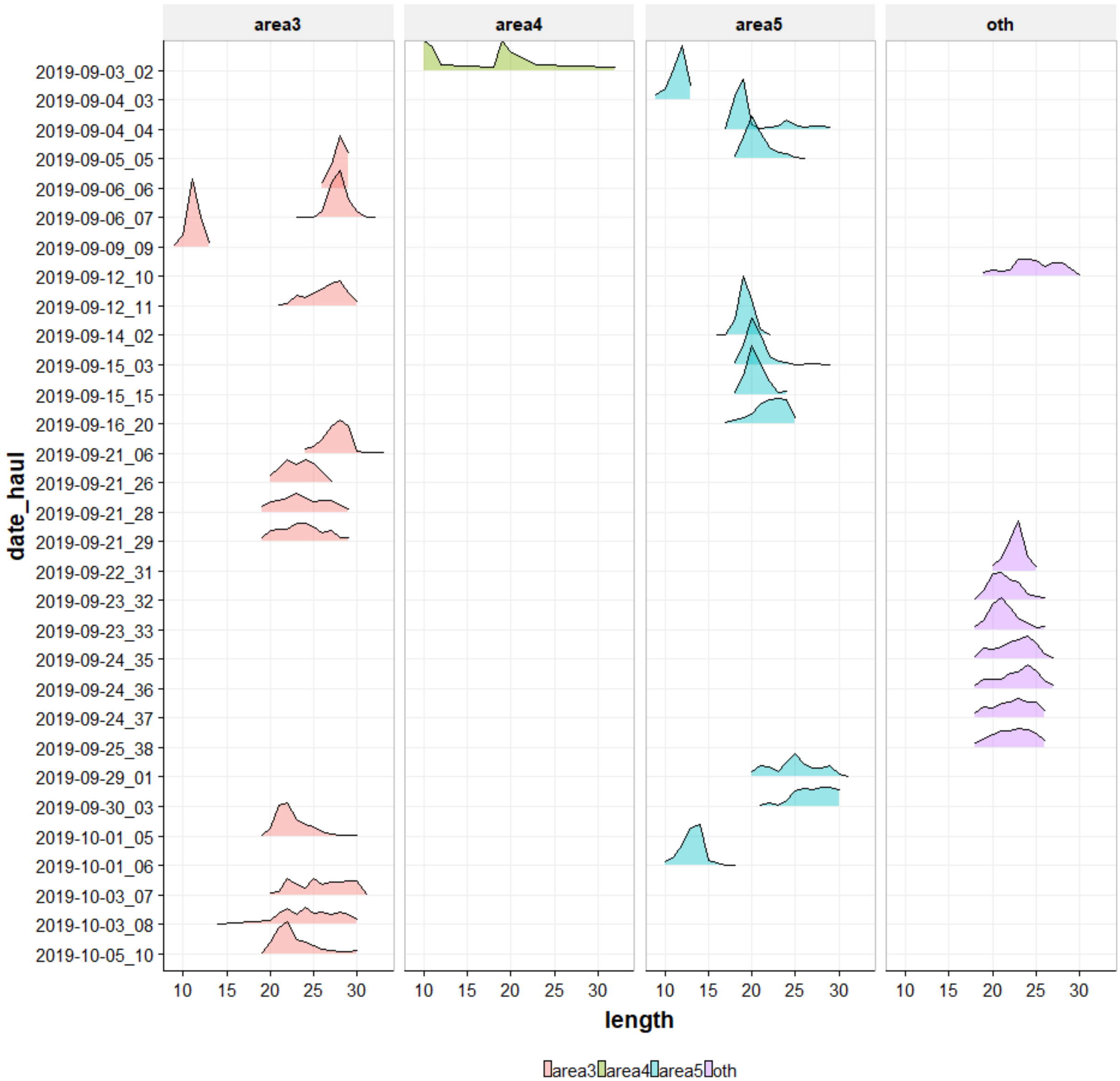


Figure 3.3. Relative length frequencies of herring by date and survey area. 'Other' refers to an area to NW of Isle of Lewis fished by Dirk Dirk, and for Pathway a single haul that falls within the boundary of Area 5 and 3.

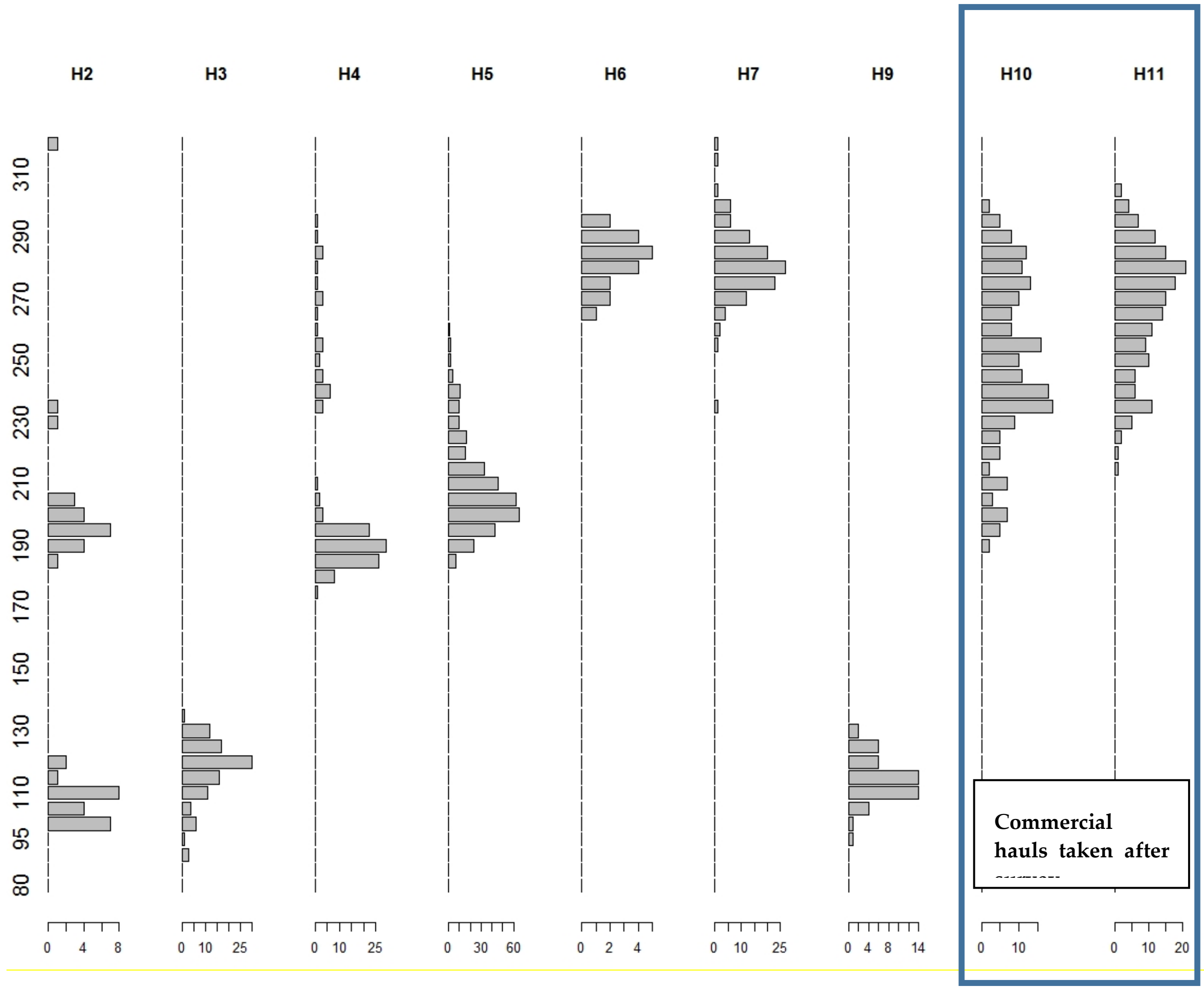


Figure 3.4. Pathway 2019 survey. Length-frequency distributions of herring in each haul caught during and after the survey.

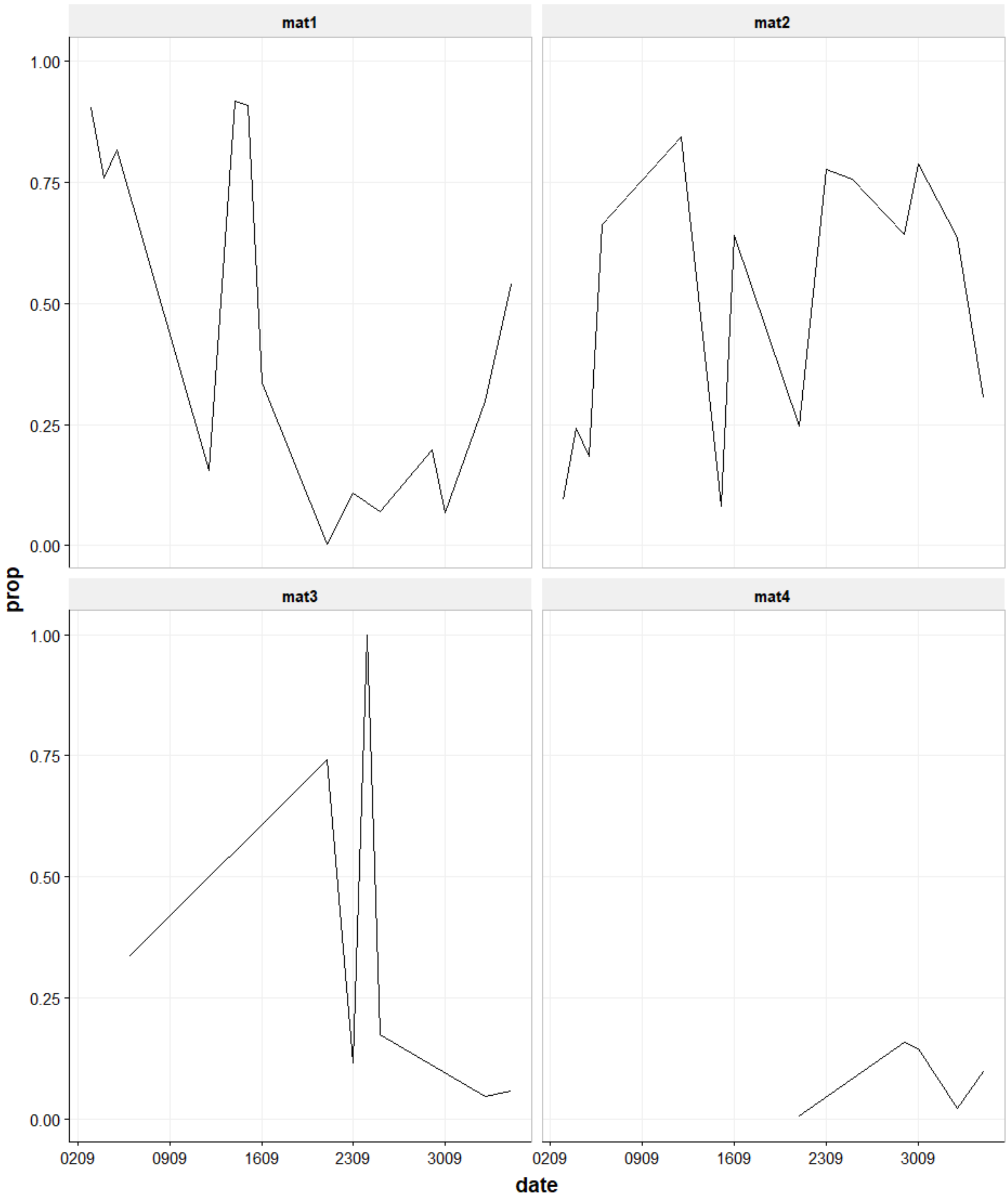


Figure 3.5. Proportion of maturity stage by date. Maturity stage 3 refers to spawning herring.

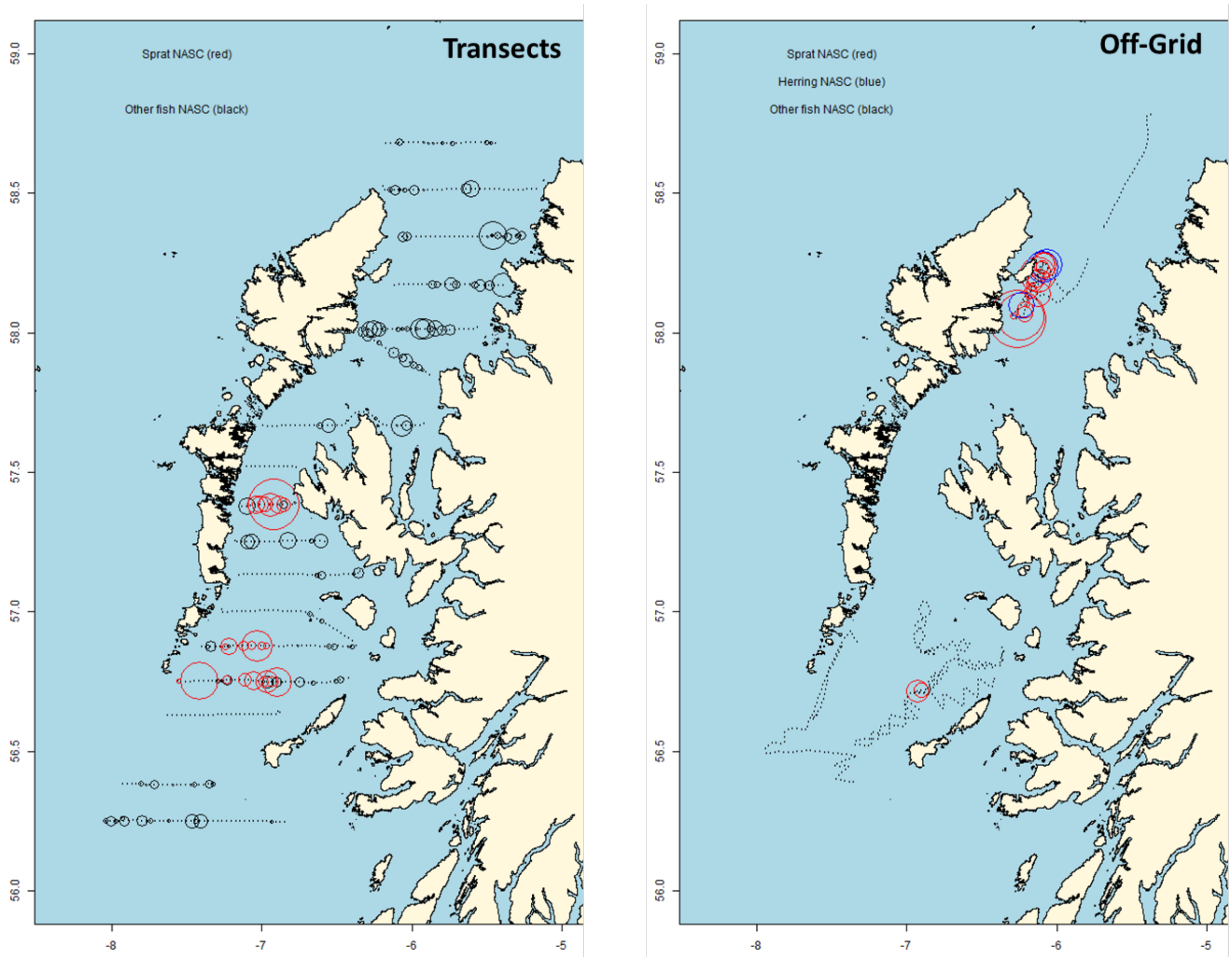


Figure 3.6. Relative acoustic densities (NASC m²/mn²) and trawl haul details for Grateful.

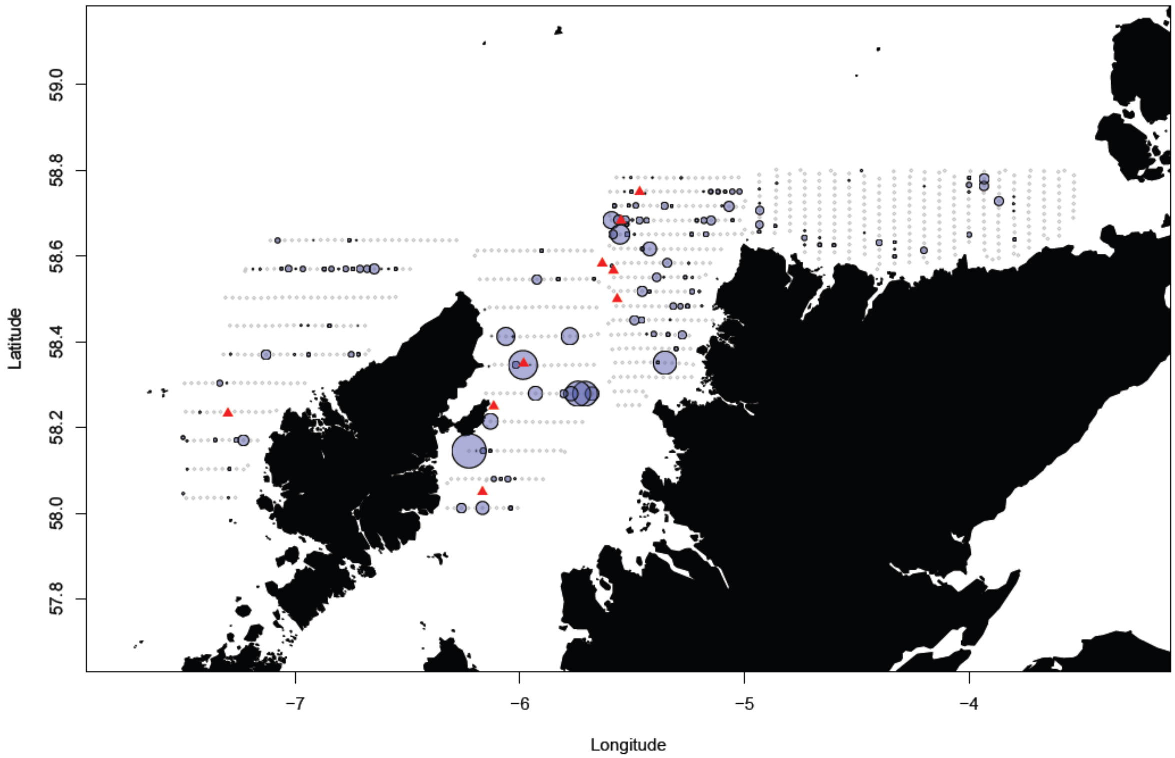


Figure 3.7a. Relative acoustic densities (blue bubbles) (NASC m²/mn²) and trawl haul locations (red triangles) for Pathway.

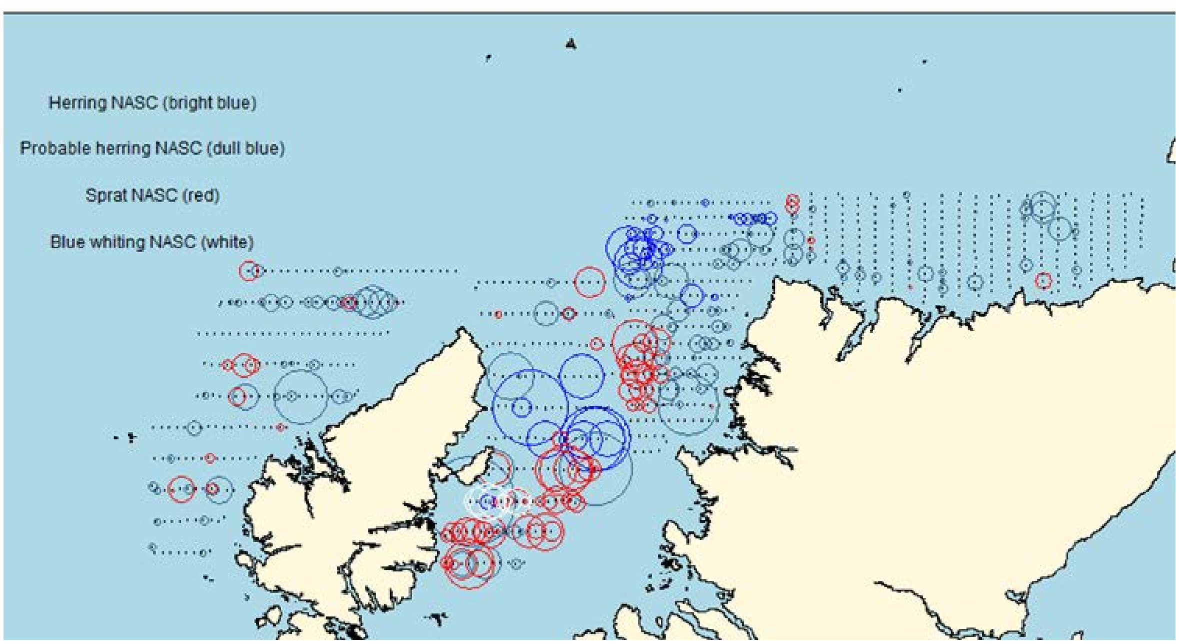


Figure 3.7b. Relative acoustic densities (NASC m²/mn²) of all fish marks for Pathway.

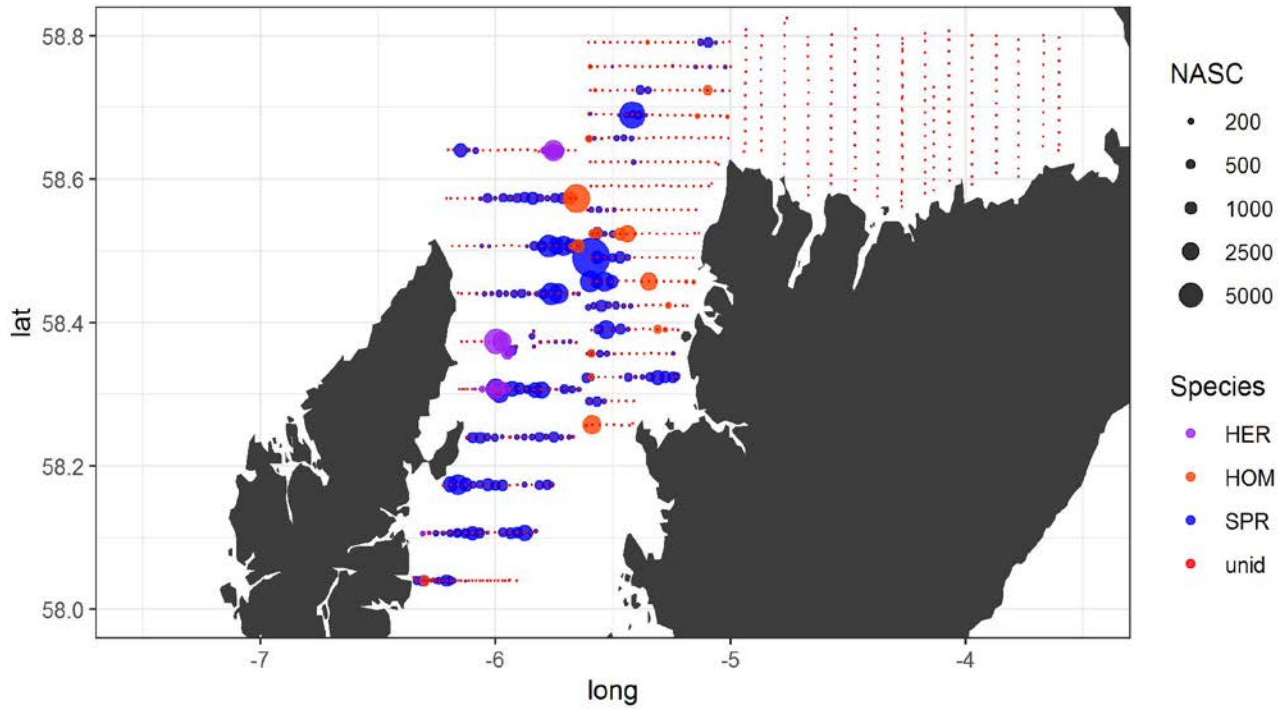


Figure 3.7c. Relative acoustic densities (NASC m²/mn²) of all fish marks for Dirk Dirk.

Table 3.2. Haul information and catch composition for hauls relevant to the analysis of the acoustic surveys in 6aN.

			Position			Catch (kg)							
Vessel	**Haul no.**	**Date-Time**	**North**	**West**	**Used in analysis area**	**HER**	**HOM**	**MAC**	**NOP**	**WHG**	**HAD**	**SPR**	**WHB**
Pathway	**1**	02/09/2019 15:45	58°35'	07°11'		0	0	6	19	0	0	0	0
	2	03/09/2019 14:20	58°14'	07°18'	Applied to all transect in southern strata of Area 4 and combined with haul 5 in northern part of Area 4.	1	0	40	11	33	0	140	0
	3	04/09/2019 08:39	58°03'	06°10'	Applied to all transect in southern strata of Area 5.	5	0	4	0	0	0	34	0
	4	04/09/2019 20:26	58°15'	06°07'	Applied to mid-section of Area 5	6	19	7	0	6	0	0	186
	5	05/09/2019 09:14	58°21'	05°59'	Haul 5 & 2 applied to northern strata of Area 4. Haul 5 applied to northern strata of Area 5.	714	65	39	0	39	0	0	43
	6	06/09/2019 08:50	58°45'	05°28'	Haul 6 & 7 applied to all transects in area 2 due to proximity and presence of larger mature fish typical of area 2. Also applied to northern strata of Area 3.	4	0	246	0	0	0	0	0
	7	06/09/2019 14:05	58°41'	05°33'	Haul 6 &7 applied to all transects in area 2 (as above) and to northern strata of Area 3.	236	0	11	0	0	0	3	0
	8	07/09/2019 11:07	58°33'	05°36'		0	0	6	0	8	0	16	0
	9	09/09/2019 15:30	58°30'	05°34'	Applied to southern strata of Area 3 due to temporal proximity.	0	0	23	0	21	0	30	0
	10	12/09/2019 08:43	58°35'	05°38'	**Commercial haul. Not applied to acoustic analysis.**	161290	32258	6452	0	0	0	0	0
	11	12/09/2019 12:02	58°34'	05°35'	**Commercial haul. Not applied to acoustic analysis.**	39877	6135	2454	0	920	613	0	0

3.1.2 Sampling statistics 6aS/7bc

Approximately 600nmi of transects were completed successfully using 96 transects (81 in Lough Swilly). A full survey report can be found in O'Malley et al 2020. This resulted in a total area coverage of approximately 606 nmi², a significant reduction compared to previous surveys. There were 3 tows carried out during the survey with 2 containing herring. A total of six samples were obtained from commercial tows on herring during the fishery. The monitoring fishery was being conducted on smaller boats in the same areas and close to the same time as the survey. Biological samples from some of these vessels were used to augment the samples from the survey. Samples were taken from Lough Swilly and Inver Bay as close spatially and temporally as possible to the survey in these areas.

Maps of the survey tracks, relative acoustic density, and locations of hauls that were used to determine biological parameters for the estimation of the biomass of herring in 6aS, 7b are shown in Figure 3.7-3.10, Table 3.9 & 3.10.

The location of survey hauls and samples from the fishery is shown in Figure 3.7. The fishery in 6aS/7b began in mid-November and continued throughout the survey period. Most of the fishing activity, particularly in November/early December was inshore in shallow water.

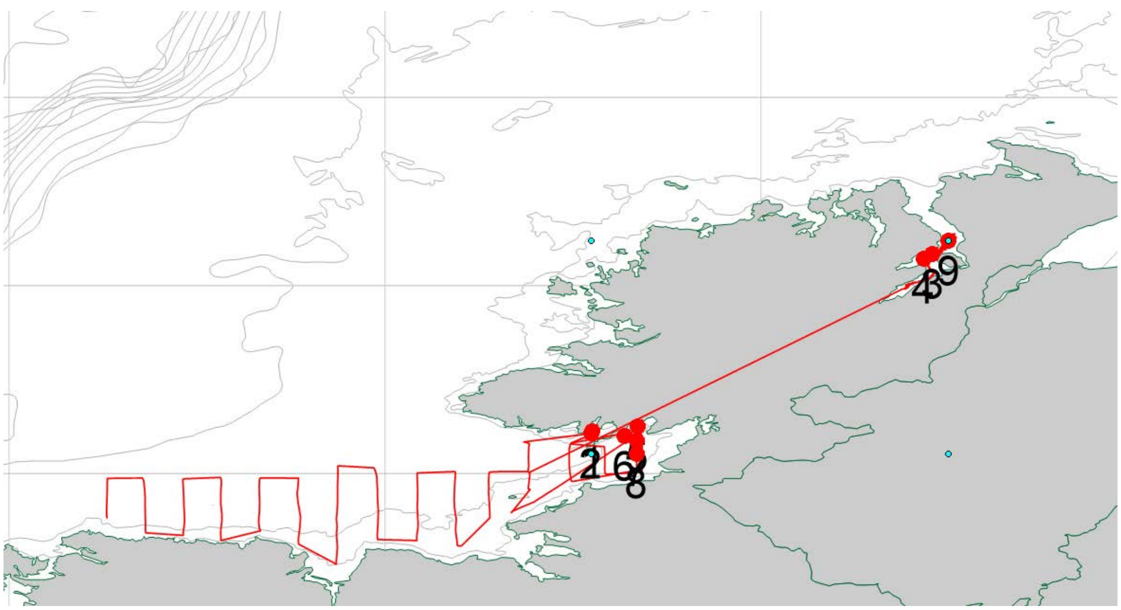


Figure 3.7. 6aS/7b industry acoustic survey in 2019: Distribution of biological samples obtained in 6aS/7b - all samples were inshore from both the survey and the monitoring fishery taking place at the same time.

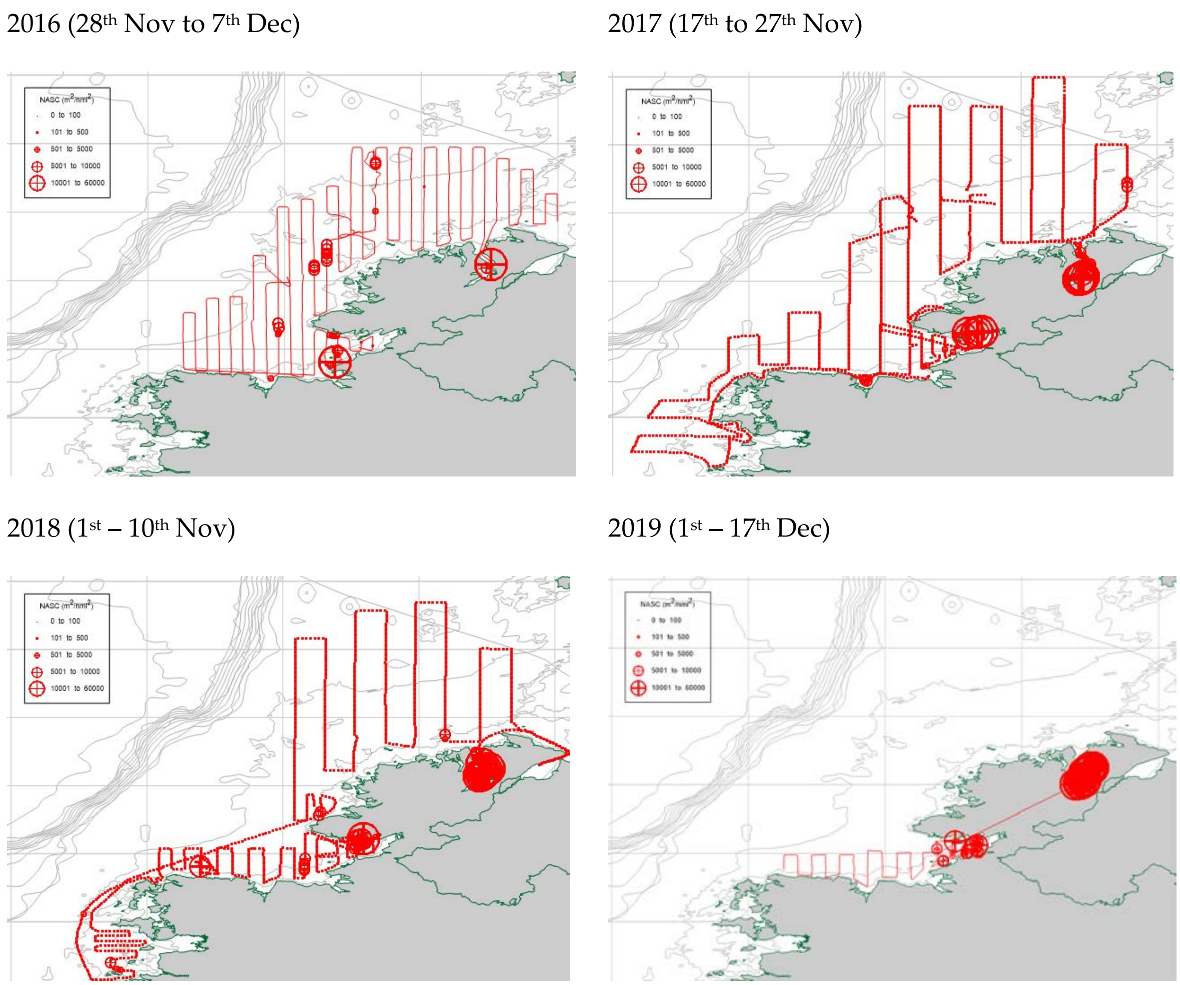


Figure 3.8a. 6aS/7b industry acoustic survey in 2016, 2017, 2018 and 2019: distribution of NASC allocated to herring. Area covered in 2019 was significantly reduced compared to other years due to poor weather.

Table 9. 6aS/7b industry acoustic survey in 2019: details and number of biological samples from the hauls used in the survey estimates.

Haul No	Date	Target Species	Location	Fish (measured lengths)	Weight,	Age, maturity, sex
1	25/11/2019	*Clupea harengus*	Drumanoo Head	319	77	77
2	25/11/2019	*Clupea harengus*	Drumanoo Head	313	77	77
3	27/11/2019	*Clupea harengus*	Lough Swilly	255	91	91
4	27/11/2019	*Clupea harengus*	Lough Swilly	372	81	81
5	18/12/2019	*Clupea harengus*	Inver Bay	182	66	66
6	18/12/2019	*Clupea harengus*	Inver Bay	304	93	93
7	04/12/2019	*Clupea harengus*	Inver Bay	520	150	50
7	04/12/2019	*Sprattus sprattus*	Inver Bay	312	100	NA
7	04/12/2019	*Trachurus trachurus*	Inver Bay	65	65	NA
8	06/12/2019	*Sprattus sprattus*	Inver Bay	373	100	NA
9	17/12/2019	*Clupea harengus*	Lough Swilly	665	150	55

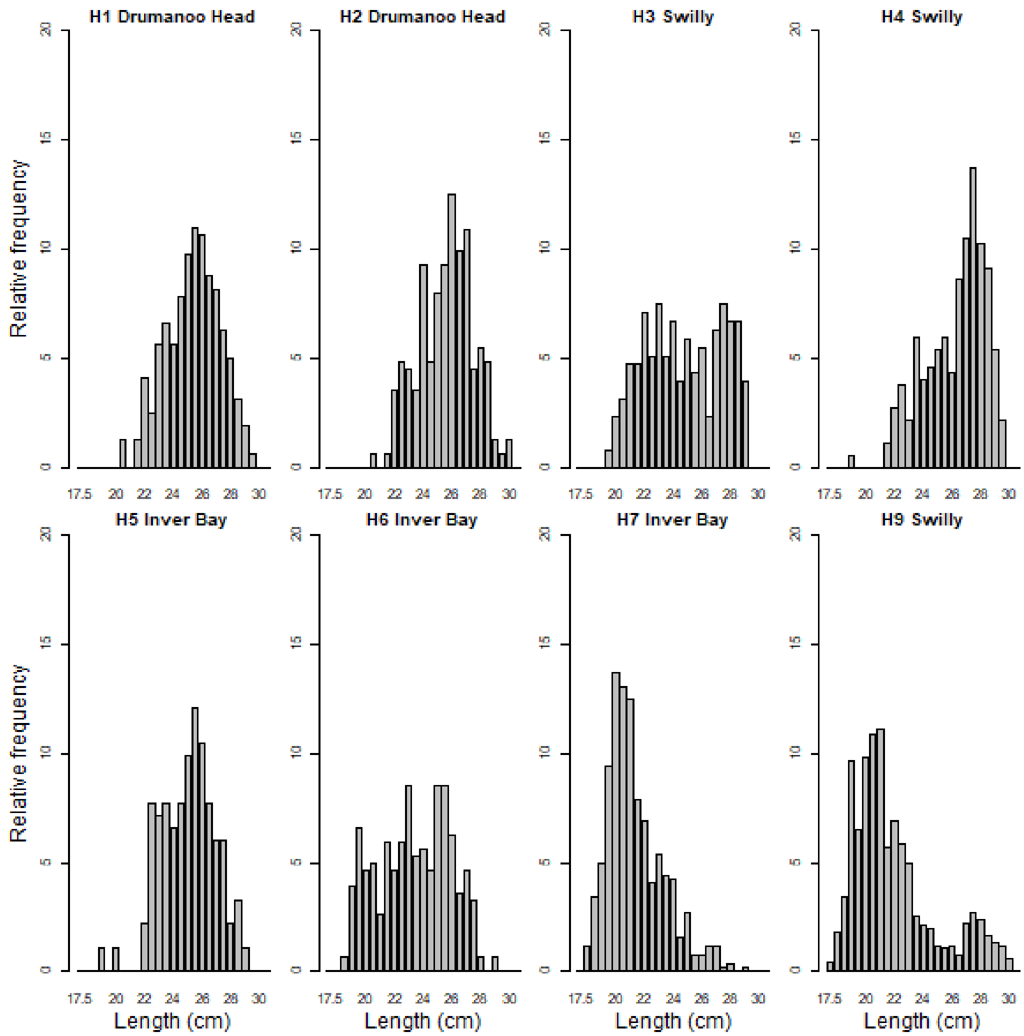


Figure 3.9a. 6aS/7b industry acoustic survey in 2019: relative length (cm) frequency distributions of herring in each haul that contained herring.

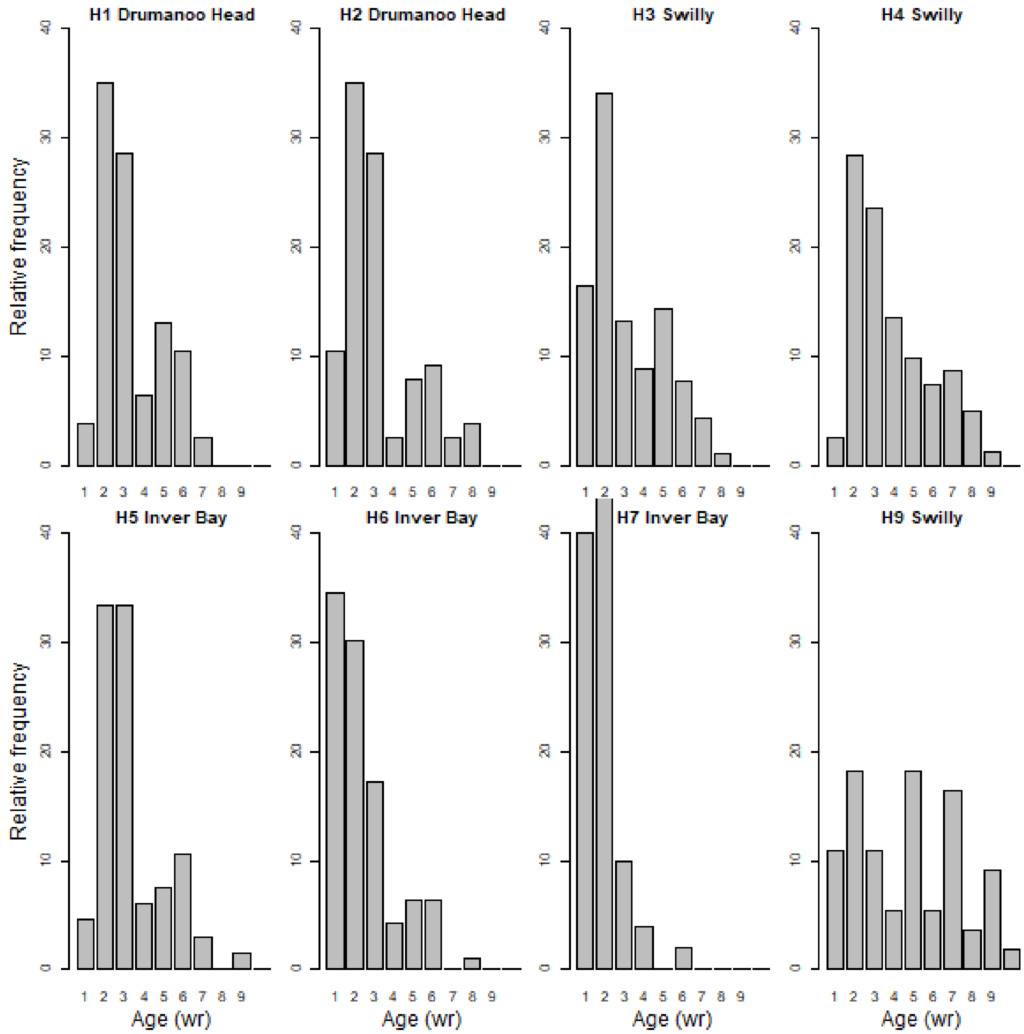


Figure 3.9b. 6aS/7b industry acoustic survey in 2019: relative age (-wr) frequency distributions of herring in each haul.

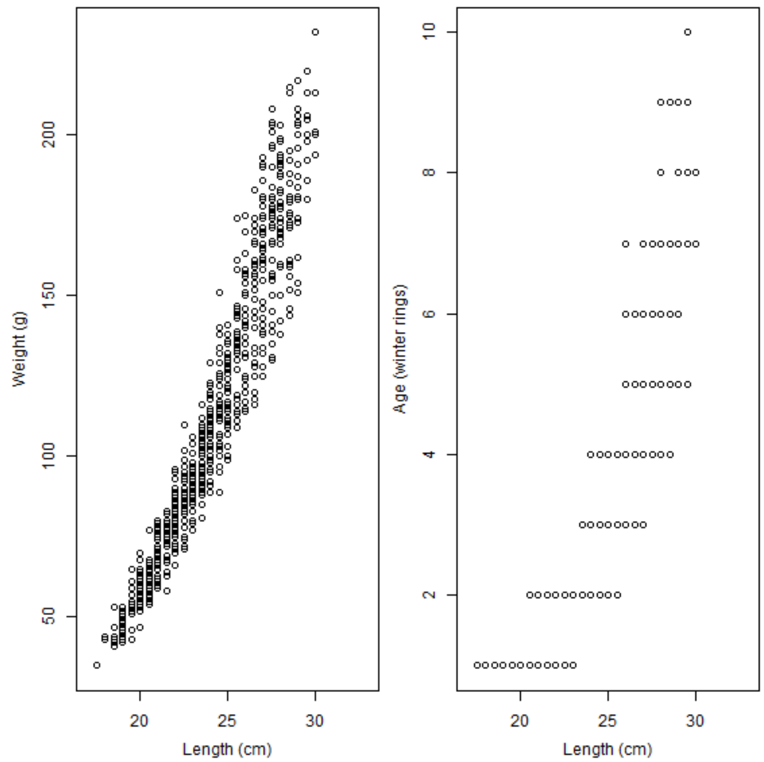


Figure 3.10. 6aS/7b industry acoustic survey in 2019: weight at length and age at length of herring.

The 1- and 2-wr age class of herring constituted ~ 52% of the overall numbers, (1-wr ~ 25% and 2-wr ~26%) followed by 15% at 3-wr, and 11% at 5-wr, 8% at 4-wr (Table 3.10a). Maturity at age for 6aS/7b herring is shown in Table 3.10b. 74% of 1-wr herring were immature, and 10% of 2-wr herring were immature. Maturity scales used for herring are shown in Table 2.4.

Table 3.10a. 6aS/7b industry acoustic survey in 2019: relative age (wr) distribution for 6aS/7b herring in 2019.

Age (winter rings)	*Relative age distribution (%) Herring*
1	**25.36**
2	**26.35**
3	**14.66**
4	**8.31**
5	**11.42**
6	**6.67**
7	**4.70**
8	**1.00**
9	**1.35**
10	**0.16**

Table 3.10b. 6aS/7b industry acoustic survey in 2019: Maturity at age for 6aS/7bc herring in 2019.

Age (winter rings)	*Immature (%)*	*Mature (%)*
1	73.6	26.4
2	10.2	89.8
3	2.3	97.7
4	0	100
5	0	100
6	0	100
7	1.5	98.5
8	0	100
9	0	100
10	0	100

3.2 Abundance estimation

Biological data were used to estimate the abundance and biomass of herring in each strata according to length, age and maturity stage.

3.2.1 6aN (Tables 3.11 to 3.13)

A summary table for each vessel's coverage of their entire surveyed area (Table 3.11) and breakdown for each area (Table 3.12) is followed by a summary of the maximum biomass recorded in each of the surveyed areas, including the CV of the biomass estimate (Table 3.13). CVs on biomass estimates are highest where the biomass estimates are derived from few concentrated marks occurring over a limited number of transects, and lower where marks are more evenly spread across the area. CVs on abundance at age are generally poor across all ages, reflecting relatively low sample sizes.

Table 3.11a. Combined results for all strata covered by Pathway in 2019. (Figures in bold are weighted averages based on the numbers in each age group.)

Age (wr)	Numbers (mill)	Biomass (kt)	Maturity	Mean Weight (g)	Mean Length (cm)
0	263	2.7	0.00	10.4	11.3
1	131	1.5	0.00	11.3	11.7
2	449	31.5	0.01	70.2	19.9
3	156	16.9	0.60	108.2	22.5
4	22	3.8	1.00	177.9	26.5
5	74	15.9	1.00	215.0	28.1
6	15	3.4	1.00	230.6	29.1
7	0	0.1	1.00	256.0	32.0
8	1	0.3	1.00	262.3	30.7
9+	0	0.0			
Immature	902	41		**45.7**	**16.3**
Mature	209	35		**167.0**	**25.6**
Total	1112	76	**0.19**	**68.5**	**18.1**

Table 3.12. Summary for each survey area covered by Pathway in 2019. (Note: that values for each survey area are based on the weighted averages of the abundance, mean weight and % mature arising from the combination of biological data from the hauls assigned to each strata, and thus, as average for the whole Area may not be immediately intuitive).

Survey area	**Abundance (mill)**	**Biomass (kt)**	**Mean weight (g)**	**% Mature**
Area 2	27	5.8	216.7	1.00
Area 3	261	17.4	66.7	0.27
Area 4	186	9.2	49.7	0.07
Area 5	638	43.7	68.6	0.15

Table 3.13. Summary CV estimates for survey areas in 2019.

Ton by stratum

Stratum	Ton.5%	Ton.50%	Ton.95%	Ton.mean	Ton.sd	Ton.cv
Strata2	3184.28	5517.41	8724.87	5696.21	1717.15	0.30
Strata3	1922.98	16069.91	23172.01	15290.22	5647.26	0.37
Strata4	2891.38	7468.95	13803.57	7809.90	3424.76	0.44
Strata5	1604.84	29917.60	64832.13	30126.76	20816.81	0.69

Total number by stratum (mill)

Stratum	Ab.Sum.5%	Ab.Sum.50%	Ab.Sum.95%	Ab.Sum.mean	Ab.Sum.sd	Ab.Sum.cv
Strata2	14816015	25735627	4.1E+07	26620210	8028425	0.30
Strata3	53639457	204365060	3.5E+08	193263354	100902377	0.52
Strata4	40720773	155614410	3.2E+08	159953401	86247225	0.54
Strata5	87482930	412840276	9.1E+08	436857725	265391215	0.61

Ton by survey

Ton.5%	Ton.50%	Ton.95%	Ton.mean	Ton.sd	Ton.cv
22566.3	56001.61	95522.54	57004.6	23944.15	0.42

Total number by survey (mill)

Ab.Sum.5%	Ab.Sum.50%	Ab.Sum.95%	Ab.Sum.mean	Ab.Sum.sd	Ab.Sum.cv
2.09E+08	7.76E+08	1.377E+09	7.9E+08	376734112	0.48

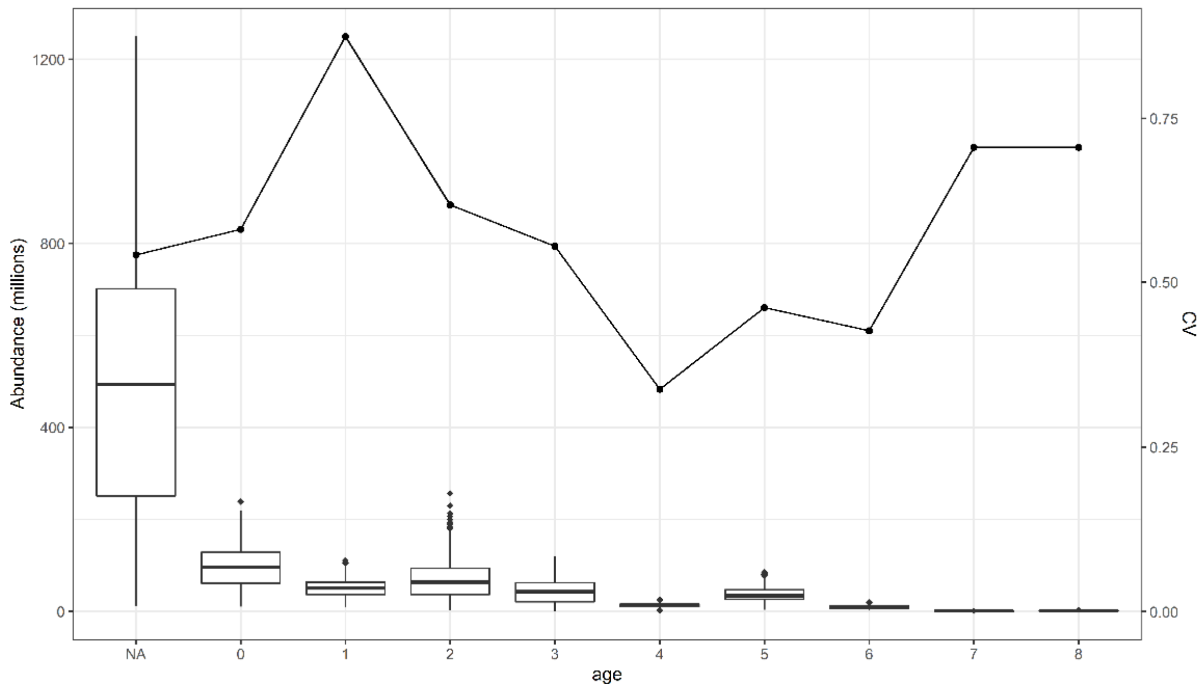


Figure 3.11. CV by age for Pathway

3.2.2 6aS/7b herring (Table 3.15 to 3.17)

The estimated total stock biomass (TSB), number at age (TSN), numbers at length class and mean weight of herring found in the 2 survey strata areas is shown in Tables 3.15 – 3.16. The transects in Lough Swilly were conducted in a zig-zag pattern due to the shallow nature of the habitat, therefore for estimation purposes, Lough Swilly was treated as a separate strata within StoX. There was only one other stratum in 2019, Donegal Bay (parallel transects with 3.5nmi. spacing). The combined estimated numbers at age and biomass at age over the entire survey area is also shown in Table 3.17. The TSB estimate of herring for the combined 6aS/7b area was 25,289 tonnes (Lough Swilly = 19,697 tonnes, Donegal Bay = 5,591 tonnes). The time series of age disaggregated herring data for the Industry acoustic survey is shown in table 9 and 10.

Table 3.15. 6aS/7b industry acoustic survey in 2019: age-disaggregated estimate of herring in survey Lough Swilly area. The estimated TSB for the Lough Swilly strata = 19,697 tonnes.

Variable: Abundance
EstLayer: 1
Stratum: Swilly
SpecCat: Clupea harengus
specialstage: TOTAL

LenGrp	age 1	2	3	4	5	6	7	8	9	10	Number (1E3)	Biomass (1E3kg)	Mean W (g)
17.5-18.0	249	-	-	-	-	-	-	-	-	-	249	8.7	35.00
18.0-18.5	996	-	-	-	-	-	-	-	-	-	996	42.8	43.00
18.5-19.0	1909	-	-	-	-	-	-	-	-	-	1909	80.4	42.13
19.0-19.5	5610	-	-	-	-	-	-	-	-	-	5610	250.9	44.73
19.5-20.0	4003	-	-	-	-	-	-	-	-	-	4003	213.9	53.44
20.0-20.5	6695	-	-	-	-	-	-	-	-	-	6695	369.5	55.20
20.5-21.0	7709	-	-	-	-	-	-	-	-	-	7709	447.0	57.99
21.0-21.5	8131	610	-	-	-	-	-	-	-	-	8741	577.0	66.01
21.5-22.0	5406	940	-	-	-	-	-	-	-	-	6346	416.8	65.69
22.0-22.5	1243	7956	-	-	-	-	-	-	-	-	9199	741.4	80.59
22.5-23.0	-	8129	-	-	-	-	-	-	-	-	8129	718.7	88.41
23.0-23.5	1876	6164	-	-	-	-	-	-	-	-	8040	707.1	87.95
23.5-24.0	-	6914	576	-	-	-	-	-	-	-	7490	784.6	104.75
24.0-24.5	-	6607	461	-	-	-	-	-	-	-	7068	770.1	108.96
24.5-25.0	-	2739	3028	-	-	-	-	-	-	-	5767	697.3	120.92
25.0-25.5	-	1600	4000	1280	-	-	-	-	-	-	6879	866.5	125.95
25.5-26.0	-	-	4826	1401	-	-	-	-	-	-	6227	863.7	138.70
26.0-26.5	-	-	2076	2875	639	-	479	-	-	-	6069	865.2	142.55
26.5-27.0	-	-	751	1954	2104	1653	-	-	-	-	6463	1038.2	160.65
27.0-27.5	-	-	750	3299	3149	2849	450	-	-	-	10496	1804.2	171.89
27.5-28.0	-	-	-	2545	8834	749	1048	-	-	-	13176	2238.7	169.91
28.0-28.5	-	-	-	1950	3749	3149	1200	150	450	-	10648	1940.4	182.24
28.5-29.0	-	-	-	466	2643	2643	3887	-	-	-	9639	1683.4	174.65
29.0-29.5	-	-	-	-	302	754	1508	1206	2111	-	5880	1138.0	193.54
29.5-30.0	-	-	-	-	-	-	810	463	231	347	1851	366.1	197.75
30.0-30.5	-	-	-	-	-	-	249	83	-	-	332	67.2	202.25
TSN(1000)	43826	41660	16468	15770	21419	11797	9630	1902	2792	347	165611	-	-
TSB(1000 kg)	2560.5	3968.2	2191.2	2544.0	3642.4	2113.5	1696.0	374.2	545.5	62.5	-	19697.9	-
Mean length (cm)	20.34	23.07	25.26	26.71	27.52	27.69	28.34	29.09	28.88	29.50	-	-	-
Mean weight (g)	58.42	95.25	133.06	161.32	170.05	179.16	176.11	196.73	195.38	180.00	-	-	118.94

Table 3.16. 6aS/7b industry acoustic survey in 2019: age-disaggregated estimate of herring in survey Donegal Bay area. The estimated TSB for the Donegal Bay strata = 5,591 tonnes.

Variable: Abundance
EstLayer: 1
Stratum: Donegal Bay
SpecCat: Clupea harengus
specialstage: TOTAL

LenGrp	age 1	2	3	4	5	6	7	8	9	Number (1E3)	Biomass (1E3kg)	Mean W (g)
17.5-18.0	-	-	-	-	-	-	-	-	-	-	-	-
18.0-18.5	115	-	-	-	-	-	-	-	-	115	5.0	43.17
18.5-19.0	410	-	-	-	-	-	-	-	-	410	17.6	42.80
19.0-19.5	1001	-	-	-	-	-	-	-	-	1001	45.6	45.55
19.5-20.0	1594	-	-	-	-	-	-	-	-	1594	90.7	56.93
20.0-20.5	1928	-	-	-	-	-	-	-	-	1928	114.4	59.32
20.5-21.0	1938	45	-	-	-	-	-	-	-	1983	125.7	63.43
21.0-21.5	1361	209	-	-	-	-	-	-	-	1571	109.0	69.39
21.5-22.0	825	1025	-	-	-	-	-	-	-	1850	136.2	73.62
22.0-22.5	823	1427	-	-	-	-	-	-	-	2251	178.6	79.38
22.5-23.0	556	1897	-	-	-	-	-	-	-	2454	205.3	83.69
23.0-23.5	251	2761	-	-	-	-	-	-	-	3012	276.8	91.90
23.5-24.0	-	3310	-	-	-	-	-	-	-	3310	328.4	99.22
24.0-24.5	-	1719	860	96	-	-	-	-	-	2675	289.3	108.17
24.5-25.0	-	1580	1271	103	-	-	-	-	-	2954	338.1	114.44
25.0-25.5	-	677	3319	-	-	-	-	-	-	3996	476.7	119.30
25.5-26.0	-	461	3758	248	-	-	-	-	-	4467	601.1	134.57
26.0-26.5	-	-	3681	-	-	106	-	-	-	3787	534.7	141.20
26.5-27.0	-	-	1891	550	653	103	-	-	-	3198	479.9	150.06
27.0-27.5	-	-	343	514	1199	377	-	-	-	2433	387.3	159.20
27.5-28.0	-	-	-	430	1147	538	-	-	-	2114	364.3	172.29
28.0-28.5	-	-	-	200	100	900	100	-	-	1300	228.1	175.51
28.5-29.0	-	-	-	-	-	538	115	-	115	768	136.3	177.55
29.0-29.5	-	-	-	-	35	-	277	69	-	381	69.3	181.55
29.5-30.0	-	-	-	-	63	-	-	63	-	126	25.5	202.50
30.0-30.5	-	-	-	-	-	-	-	127	-	127	27.5	216.00
TSN(1000)	10803	15112	15122	2141	3197	2561	493	260	115	49804	-	-
TSB(1000 kg)	682.8	1454.1	2004.0	325.5	537.0	426.4	93.1	51.1	17.5	-	5591.5	-
Mean length (cm)	20.44	23.25	25.50	26.64	27.18	27.71	28.68	29.61	28.50	-	-	-
Mean weight (g)	63.21	96.22	132.52	152.05	167.95	166.48	189.01	196.77	152.00	-	-	112.27

Table 3.17. 6aS/7b industry acoustic survey in 2019: age-disaggregated estimate of herring in total survey area. The total estimated TSB for the entire survey area = 25,289 tonnes.

Variable: Abundance
EstLayer: 1
Stratum: TOTAL
SpecCat: Clupea harengus
specialstage: TOTAL

LenGrp	age 1	2	3	4	5	6	7	8	9	10	Number (1E3)	Biomass (1E3kg)	Mean W (g)
17.5-18.0	249	-	-	-	-	-	-	-	-	-	249	8.7	35.00
18.0-18.5	1111	-	-	-	-	-	-	-	-	-	1111	47.8	43.02
18.5-19.0	2320	-	-	-	-	-	-	-	-	-	2320	98.0	42.25
19.0-19.5	6610	-	-	-	-	-	-	-	-	-	6610	296.5	44.85
19.5-20.0	5596	-	-	-	-	-	-	-	-	-	5596	304.7	54.44
20.0-20.5	8623	-	-	-	-	-	-	-	-	-	8623	483.9	56.12
20.5-21.0	9647	45	-	-	-	-	-	-	-	-	9691	572.8	59.10
21.0-21.5	9492	819	-	-	-	-	-	-	-	-	10312	686.0	66.53
21.5-22.0	6231	1965	-	-	-	-	-	-	-	-	8196	553.0	67.48
22.0-22.5	2067	9383	-	-	-	-	-	-	-	-	11450	920.1	80.36
22.5-23.0	556	10027	-	-	-	-	-	-	-	-	10583	924.1	87.32
23.0-23.5	2127	8925	-	-	-	-	-	-	-	-	11052	983.9	89.03
23.5-24.0	-	10224	576	-	-	-	-	-	-	-	10800	1113.0	103.06
24.0-24.5	-	8327	1321	96	-	-	-	-	-	-	9743	1059.4	108.74
24.5-25.0	-	4319	4299	103	-	-	-	-	-	-	8721	1035.4	118.73
25.0-25.5	-	2277	7318	1280	-	-	-	-	-	-	10875	1343.2	123.51
25.5-26.0	-	461	8584	1649	-	-	-	-	-	-	10694	1464.8	136.98
26.0-26.5	-	-	5757	2875	639	106	479	-	-	-	9856	1399.9	142.03
26.5-27.0	-	-	2643	2504	2757	1756	-	-	-	-	9661	1518.1	157.15
27.0-27.5	-	-	1092	3813	4348	3226	450	-	-	-	12929	2191.5	169.50
27.5-28.0	-	-	-	2975	9980	1286	1048	-	-	-	15290	2602.9	170.24
28.0-28.5	-	-	-	2150	3849	4049	1300	150	450	-	11947	2168.5	181.51
28.5-29.0	-	-	-	466	2643	3180	4002	-	115	-	10407	1819.7	174.86
29.0-29.5	-	-	-	-	336	754	1785	1275	2111	-	6261	1207.2	192.81
29.5-30.0	-	-	-	-	63	-	810	526	231	347	1977	391.6	198.05
30.0-30.5	-	-	-	-	-	-	249	210	-	-	459	94.7	206.06
TSN(1000)	54629	56772	31590	17911	24616	14358	10123	2162	2907	347	215414	-	-
TSB(1000 kg)	3243.3	5422.3	4195.2	2869.5	4179.4	2539.9	1789.1	425.3	563.0	62.5	-	25289.5	-
Mean length (cm)	20.36	23.12	25.38	26.70	27.47	27.70	28.35	29.15	28.87	29.50	-	-	-
Mean weight (g)	59.37	95.51	132.80	160.21	169.78	176.90	176.74	196.73	193.66	180.00	-	-	117.40

The results of the uncertainty estimates (CV) for abundance and biomass of herring in 6aS/7b are shown in Table 3.18. The CV for the survey overall is low (0.17), and the lowest in the time-series so far. The CV estimates on biomass and abundance are high for the Donegal Bay strata (~0.63), but low for the Lough Swilly strata (0.13) for the survey in 2019. The biomass is dominated by herring from Lough Swilly, and as a consequence the CV for the survey overall is low. The survey design in Lough Swilly has improved in 2019 compared to 2016-2018, with increased intensity of survey transects. The ICES workshop on herring acoustic surveys on spawning fish (WKHASS) held in 2019 (ICES 2020) investigated some of these issues and results from the workshop suggested that an increased transect intensity would improve the CV in such circumstances when herring are tightly aggregated. For herring in Donegal Bay, the high CV is mostly caused by the over-reliance on a few strong acoustic marks and many transects with little or no herring marks in the strata. The survey design in the bays (Inver, Bruckless, etc.) in the Donegal Bay strata needs to be improved further as evidenced from these results.

Table 3.18. 6aS/7b industry acoustic survey in 2019: uncertainty estimates of herring (with CV) by weight and number for the Donegal Bay and Lough Swilly (Swilly) and the total survey area.

```
[1] "Ton by stratum"
       Stratum     Ton.5%    Ton.50%   Ton.95%  Ton.mean    Ton.sd    Ton.cv
1: Donegal Bay   837.1315  5373.484 12567.48  5778.208 3639.277 0.6298280
2:      Swilly 15541.1950 19544.850 24210.39 19611.442 2576.146 0.1313593
[1] "Total number by stratum (mill)"
       Stratum Ab.Sum.5% Ab.Sum.50% Ab.Sum.95% Ab.Sum.mean Ab.Sum.sd Ab.Sum.cv
1: Donegal Bay   7663853   48447483  111002564    51165466  31204139 0.6098672
2:      Swilly 130287631  167697674  215107011   169344170  26011458 0.1536011
[1] "Ton by survey"
     Ton.5%  Ton.50%  Ton.95% Ton.mean   Ton.sd    Ton.cv
1: 18129.55 25103.58 33026.11 25354.98 4523.639 0.1784122
[1] "Total number by survey (mill)"
   Ab.Sum.5% Ab.Sum.50% Ab.Sum.95% Ab.Sum.mean Ab.Sum.sd Ab.Sum.cv
1: 161795140  217976474  285697115   220202643  37588416 0.1706992
```

The survey did not contain the herring stock in 6aS/7b in 2019, however, the core areas of Lough Swilly and Donegal Bay were covered and containment most likely achieved for these areas. There was hyper-aggregating behaviour and shallow distribution (<15m) of herring in Lough Swilly in particular. These fish were primarily in the middle of the channel in Lough Swilly, with little or no marks of fish observed in the shallow edges of the Lough. The new survey deign in Lough Swilly (tighter and more intense zig/zag transects) alleviated the concern that the stock was not contained in this area. The improvements to the survey design adapted following WKHASS workshop have improved the survey in the Lough Swilly strata. The improved methods need to be adapted in other areas for surveys in future years. The over-reliance of the estimate on few areas of high herring density led to the high CV on the estimates of abundance and biomass in the Donegal Bay strata. This could be improved in the future with better survey design in these areas. Additional areas off the west Mayo and Galway coasts were covered by this survey in searching mode again in 2019. These included a number of grounds that were known to have spawning in the past including areas around the Bills of Achill and Clare Island, however, no herring aggregations were located in these areas. Spawning is known to occur outside of the areas covered by the survey in 2019, but the lack of occurrence of herring marks in the areas searched suggest that herring were in low numbers in these areas, even though containment was most likely not achieved in 2019. There were substantial areas not covered by the survey in 2019, including areas where herring have been observed by the fleet (e.g. Lough Foyle).

4 Achievements and Recommendations

4.1 Abundance estimation –acoustics

4.1.1 Recommendations for data users

4.1.1.1 *6aN*

The 2019 acoustic surveys in the three strata surveyed in 6aN are considered to

- Have contained a significant part of the area where herring spawn in 6aN.
- Provide a reliable estimate of
  - the minimum biomass of mature herring at age observed in survey areas 5,4,3,2 during the survey period.
- Does not provide a reliable estimate of
  - the biomass of immature herring because (i) small herring passed easily through the trawl net (ii) mixing with sprat means they may have been underestimated.
  - the minimum spawning biomass, because many fish sampled in 2019 were still in the maturing stage, and because in area 2 in particular the lack of any biological samples meant that biological data had to be inferred from another survey area.

The acoustic survey in has particular value in relation to

- Monitoring the age structure and providing an index of abundance and biomass of herring in 6aN in known spawning areas (see ICES WKHASS 2020).
- Monitoring and changes in the timing of spawning and distribution at this time of year and mapping in detail the spawning locations in 6aN, which is useful in relation to marine spatial planning considerations.
- Promoting a positive example of industry-science and developing industry's skills to assess pelagic stocks.
- Source of comparison of trends of abundance with the MALIN Shelf/ WoS herring acoustic survey.

4.1.1.2 *6aS/7bc*

- The 2019 TSB estimate of 25,289 tonnes is considered to be a minimum estimate of herring in the 6aS/7b survey area at the time of the survey; all areas were not covered in 2019 because of poor weather, and therefore the stock was not contained in the survey area.
- The majority of herring marks were observed inshore in shallow areas, particularly in upper Lough Swilly. The stock appears to have been largely contained by the survey design in this strata, an improvement on previous years. However there is still a concern regarding containment inshore in areas not covered by the survey
- The monitoring fishery is conducted in the same areas/times as the survey, therefore the sampling is considered representative of the surveyed biomass.
- The survey estimation of biomass and abundance is normally conducted by integrating backscatter with the 38 kHz echosounder, however, it was only possible to conduct the full survey using the 120 kHz echosounder in 2019. The Swilly survey had to be organised in short time, and the pole-mounted system with the relatively smaller 120 kHz transducer was the only option available.
- The target strength to length relationship used (Edwards and Armstrong, 1984) comes from empirical work done on caged herring in a Scottish sea loch; it is considered to be suitable for inshore herring in Irish waters.
- It is reasonable to consider the herring surveyed were 6aS/7b fish due to the inshore distribution and proximity to the spawning grounds.
- The survey results reflected the monitoring fishery occurring at the same time.
- Cohort tracking - there appears to be good cohort tracking in the survey over the 4-year time-series
- The survey in 2019 was conducted ~ 4 weeks later than in 2018. This was due to vessel availability. The survey began after the fishery started in 2019. The fish were in Lough Swilly in large numbers before the beginning of the survey.
- There is a need to reduce uncertainty of estimate further through better survey design, particularly in the Donegal Bay strata (Inver, Bruckless Bays, etc.). The CV would be reduced with more intense transects particularly when schools are hyper-aggregating in inshore areas. The improved design in Lough Swilly in 2019 was instigated following the workshop held in 2019 (WKHASS; ICES 2020). A similar design that deals with the inshore behaviour in Donegal Bay during this time could overcome this issue. It is hoped that an improved survey design will be used in 2020.

4.1.2 Recommendations for future surveys from WGIPS

4.1.2.1 *6aN*

- Continue to ensure that future surveys follow standard protocols whereby all fish recordings (even of non-commercial size) encountered on the echogram be sampled regularly. This is paramount to improve analysis of the acoustic data and accuracy of the estimated abundance and stock composition for different species in the survey area.
- Maintain the strategy to try and provide continuous coverage in key areas.
- Based on outcomes of WKHASS, seek to focus future surveys on survey area 3 and 2, which are most likely to provide the best candidates for indices of abundance. And for surveys in 2020 to provide the flexibility and opportunity to search more widely in 6aN over and extend period consistent with pre/ spawning in the area.
- If the scientific TAC is considered to put the stock at risk based on stock trends observed from the HERAS acoustic survey in July or during industry surveys in September, give a reasoned justification to recommend that alternative payment options for industry participation. This evidence is outwith the continued need to establish a re-building plan where scientific TAC is adjusted according to changes in stock size.
- Early planning of ways to handle any sample discard issues without compromising the methodology an acoustic survey. Consider different options for different vessel roles.
- Continue to ensure that industry vessels are equipped with nets appropriate for taking small samples for biological analysis.
- Notify creel fishermen of survey transects in advance.

4.1.2.2 *6aS/7bc*

- Survey in 2020 and beyond – funding of the survey is currently uncertain, but there are plans at the Marine Institute to move toward an industry/science partnership survey that involves smaller vessels and concentrates on core inshore areas only. Results from 2016-2019 have shown that the vast majority of herring is distributed inshore in discreet areas during the survey in Nov/Dec.
- The new design in Lough Swilly resulted in a lower measure of uncertainty (CV) for the Swilly strata in 2019. It is important that the uncertainty for other inshore areas is also improved with future survey designs, following recommendations from WKHASS (ICES, 2020).

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Skippers and crew of the Grateful, Pathway, Research, Dirk Dirk, Wiron 5&6, Celtic Voyager, Ros Ard.

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P&O Maritime, Galway

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Appendices

Appendix 1. 120 kHz calibration results for RV Ros Ard 17/12/2019

```
Calibration  Version   2.1.0.12

Date:  17.Dec.2019

Comments:
  NW Herring 2019 Calibration lough Swilly 2019/12/17 120kHz

Reference Target:
  TS                    -39.48 dB       Min. Distance         15.00 m
  TS Deviation             5.0 dB       Max. Distance         20.00 m

Transducer:  ES120-7CD  Serial No.   120
  Frequency             120000 Hz       Beamtype                Split
  Gain                   26.00 dB       Two Way Beam Angle   -20.7 dB
  Athw. Angle Sens.         23.00       Along. Angle Sens.      23.00
  Athw. Beam Angle       7.00 deg       Along. Beam Angle    7.00 deg
  Athw. Offset Angle     0.00 deg       Along. Offset Angle  0.00 deg
  SaCorrection            0.00 dB       Depth                 1.00  m

Transceiver:  GPT 120 kHz 009072034686 2-1 ES120-7CD
  Pulse Duration         1.024 ms       Sample Interval     0.191   m
  Power                    300  W       Receiver Bandwidth   3.03 kHz

Sounder Type:
  EK60 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.  37.4 dB/km       Sound Velocity     1493.9 m/s

Beam Model results:
  Transducer Gain    = 26.95 dB       SaCorrection        = -0.34 dB
  Athw. Beam Angle   = 6.44 deg       Along. Beam Angle   = 6.43 deg
  Athw. Offset Angle = 0.01 deg       Along. Offset Angle= 0.10 deg

Data deviation from beam model:
  RMS =    0.26 dB
  Max =    1.64 dB  No. =   257  Athw. =  2.1 deg  Along = -1.7 deg
  Min =   -1.36 dB  No. =    27  Athw. = -1.5 deg  Along = -4.6 deg

Data deviation from polynomial model:
  RMS =    0.21 dB
  Max =    1.43 dB  No. =   257  Athw. =  2.1 deg  Along = -1.7 deg
  Min =   -1.08 dB  No. =    27  Athw. = -1.5 deg  Along = -4.6 deg
```

Annex 14: 2019 PELACUS Survey Report

PELACUS – IBWSS is part of the internationally co-ordinated IBWSS.
Results from PELACUS - IBWSS is incorporated into IBWSS and can be found in Annex 3a and 3b.

Annex 15: Ecosystem Index Overview Table

	IBWSS					IESNS					HERAS						IESSNS			Western Baltic	CSHAS	WESPAS	Irish Sea	Pelagic
Participating countries																								
✓																								
Data type																								
fish																								
Organism collection	✓	✓				✓	✓				✓					✓	✓	✓		✓				
Stomach sampling	✓	✓				✓	✓				(✓)						✓	✓						✓
Additional biological data (of non-target species)	✓	✓	✓	✓		✓	✓		✓		✓	✓		✓		✓	✓	✓		✓	✓	✓	✓	✓
Disease/parasite registration											✓				✓									
Genetic information												✓										✓		
Lipid content											(✓)													
Omnidirectional sonar observations of pelagic fish	✓		✓			✓					✓	✓					✓				✓	✓		
Tagging																								
Bioactive material																								
Scientific multibeam echosounder for 3D fish school shapes/schools observations in surface 'dead zone'																	✓							

Multifrequency echosounder data for species identification, abundance and biomass estimation (number of frequencies)	5	2	4	2		6	2				4	4	2		3/5	4	5	2		4	4	4	2	4
Physical/chemical oceanography																								
Continuous underway measurements	✓	✓	✓	✓		✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Station measurements	✓	✓	✓	✓		✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Water movement						✓					✓													
Nutrients						✓					✓											(✓)		✓
Biological oceanography																								
Microbiological sampling																						(✓)		
Phytoplankton sampling						✓			✓					✓	✓									✓
Zooplankton samples	✓	✓	✓			✓	✓		✓					✓	✓		✓	✓				✓		✓
Multifrequency echosounder data for zooplankton identification & abundance estimation (number of high frequencies >=38 kHz)	4		1	1		5					2	3	1		2/3	1	4			1	3	3	1	3
	IBWSS					IESNS					HERAS						IESSNS			Western Baltic	CSHAS	WESPAS	Irish Sea	Peltic
Participating countries																								

Charismatic megafauna																								
Visual observations			✓	(✓)		✓					(✓)	✓				(✓)	✓				✓	✓	✓	✓
Towed hydrophones																						✓	✓	
Seabird observations																								
Species counts			✓									✓									✓	✓		✓
Abundance survey (ESAS)			✓									✓									✓	✓		✓
Habitat description																								
Camera observations			✓									✓					✓	(✓)			✓	✓		
Sidescan sonar						✓																		
Bathymetric multibeam echosounder			✓			✓						✓									✓	✓		
Physical ground samples																								
Pollution																								
Litter			✓	✓		✓			✓			✓		✓	✓	✓				✓	✓	✓		✓
Pollution in water column																								
Pollution in sediments																								
Pollution in organisms																								
Environmental conditions																								
Weather condition/sea state	✓	✓	✓	✓		✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓

Annex 16: WGIPS Survey Plans 2020

IBWSS

Four vessels representing the Faroe Islands, the Netherlands (EU), Ireland (EU) and Norway are scheduled to participate in the 2020 blue whiting spawning stock survey. In addition, Spain will participate with 5 days of survey time, at the start time of the core survey, investigating the Porcupine Sea bight.

Survey timing and design were discussed during the 2019 IBWSS post-cruise and 2020 WGIPS meetings. The group decided that in 2020, the survey design should follow the principle of the one used during the last survey. The zig-zag design in stratum 2 will also be continued and the focus will still be on a good coverage of the shelf slope in survey areas 2 and 3 (Figure A16.1.)

The design is based on variable transect spacing, ranging from 30 nm in areas containing less dense aggregation (areas 1 and 5), to 15-20 nm in the core survey area (area 2, 3 and 4) (Figure A16.1.). 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.

The Irish and the Dutch vessels will start the survey in the southern areas. More or less at the same time the Norwegian vessel will start in stratum 2 (the zig-zag stratum). This will then ensure the progression of all three vessels northwards at the same time in stratum 3 (the core area). 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 three vessels when they progress northwards. 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) around 28th of March 2020. 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 5 n.m. (or 30 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 2019 survey are presented. Detailed cruise lines for each ship are uploaded on the WGIPS sharepoint (/2020 Meeting docs/Working documents/IBWSS 2020 Post Cruise).

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 A16.1. Individual vessel dates for the active surveying period in the 2020 International Blue Whiting Spawning stock Survey (IBWSS).

Ship	nation	active surveying time (days)	definitive surveying dates
Celtic Explorer	Ireland (EU)	16	23.3.2020 – 8.4.2020
Kings Bay	Norway	14	23.3.2020 – 5.4.2020
Tridens	Netherlands (EU)	14	24.3.2020 – 6.4.2020
Magnus Heinason	Faroes	10	27.3.2020 –7.4.2020
Miguel Oliver	Spain	5	20.3.2020-25.3.2020

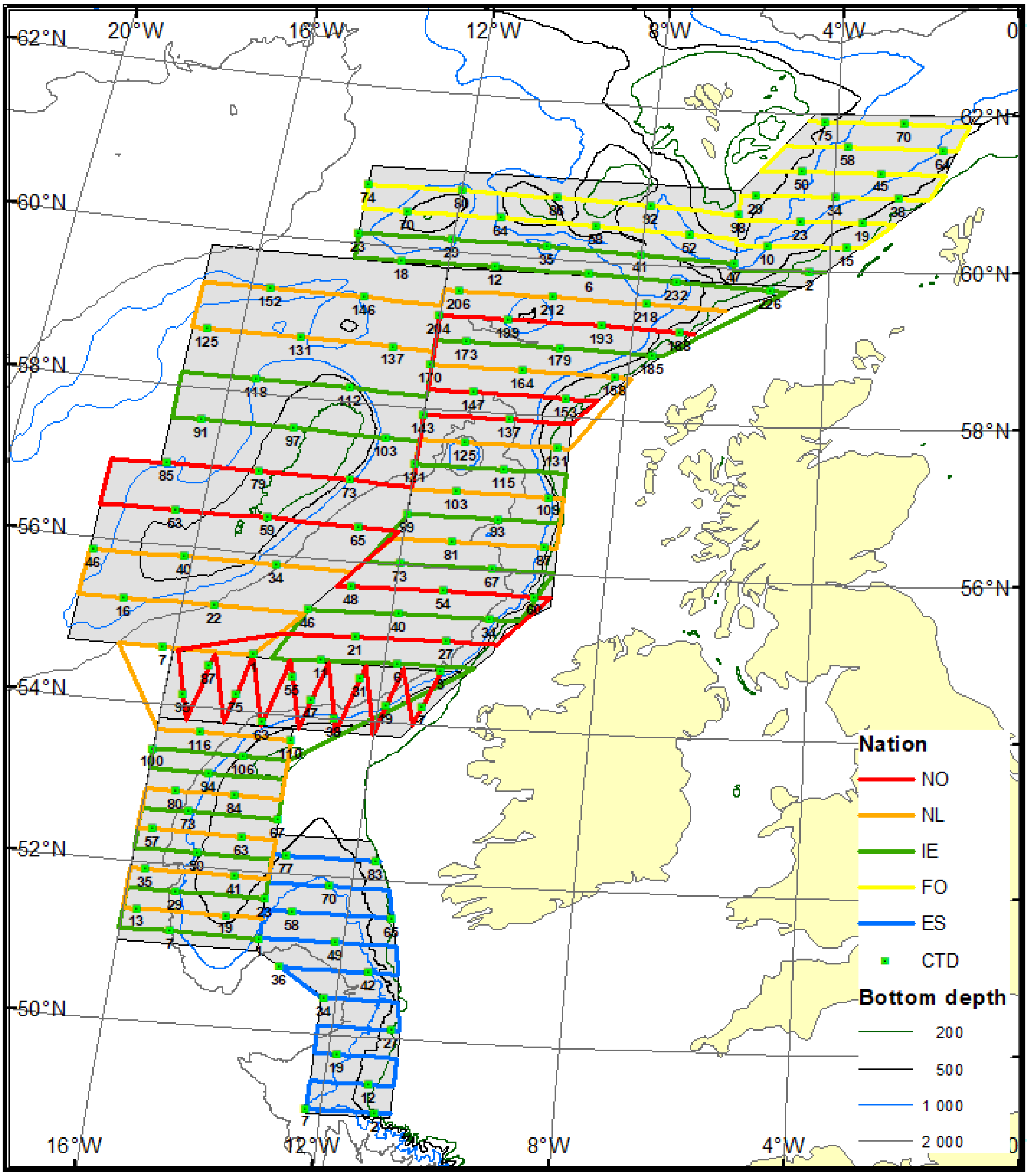


Figure A16.1. Planned survey tracks for the combined 2020 International Blue Whiting Spawning stock Survey (IBWSS).

IESNS

Denmark (EU-coordinator), Faroe Islands, Iceland, Russia and Norway will participate in the IESNS survey in April-June 2020. Ships and preliminary dates are given in Table A16.2. Survey days exclude time for: hydrographic cross sections, coverage outside the IESNS area and crew change. As in the five 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 A16.2. The survey planning function in Rstox was used to generate the transects. Norway will cower two rows of transects across the Norwegian Sea (between Iceland and Norway) in order to collect plankton data from this "cross-basin section". Norway will be the survey coordinator during the cruise. A post-cruise meeting is suggested to be held 16-18 June 2020 at the Faroese representation in Copenhagen.

Table A16.2. Individual vessel dates for the active surveying period in the 2020 IESNS (preliminary).

Ship	Nation	Dates (harbour to harbour)	Effective survey days	Crew change
Dana	Denmark (EU)	1 May – 27 May	17	11-12 May, Bodø
Magnus Heinason	Faroe Islands	30 Apr – 12 May	10	
Árni Friðriksson	Iceland	4 May – 23 May	16	
G.O. Sars	Norway	1 May – 3 June	29	19-20 May, Tromsø
Atlantniro	Russia	15 May – 10 June	25	

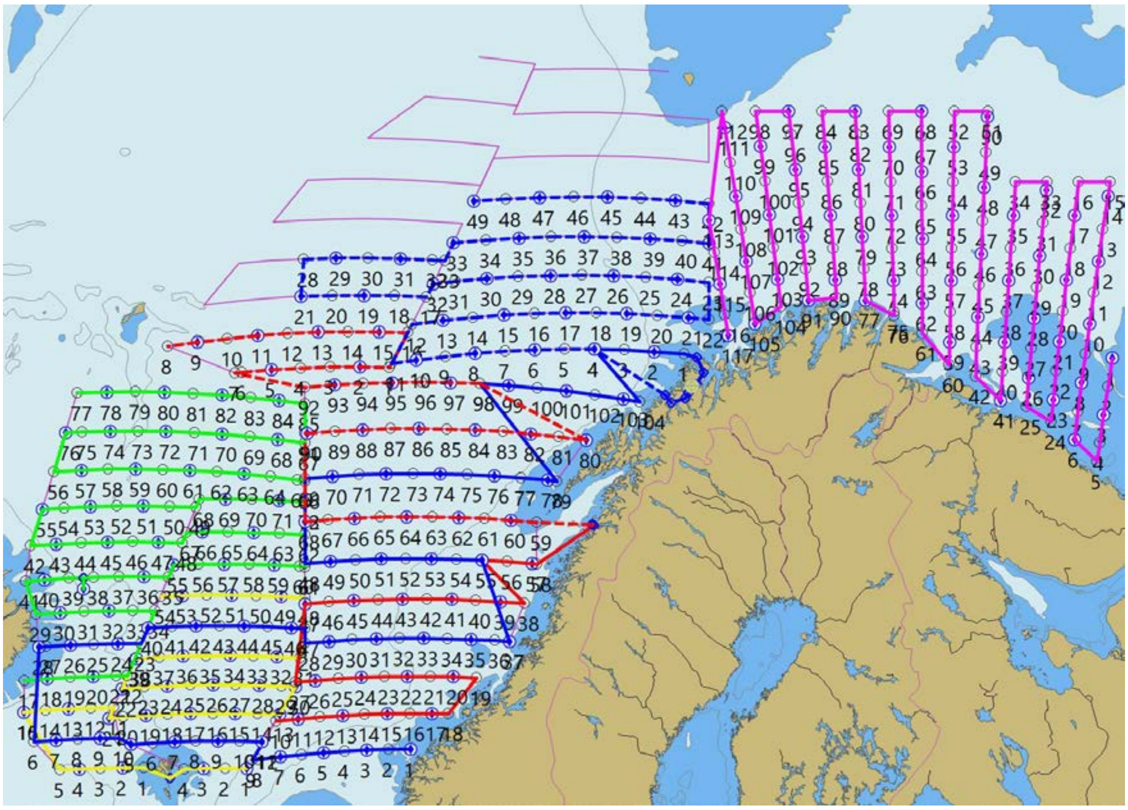


Figure A16.2. Suggested cruise tracks and transects for the IESNS survey in 2020. Colors represent the different vessels/nations (yellow: FO, green: IS, dark blue: NO, red: EU, purple: RU). Suggested CTD stations are shown as blue circles with a diamond inside (the numbered positions are transect points for each 30 nautical mile).

IESSNS

The International Ecosystem Summer Survey in the Nordic Seas (IESSNS) main priority is standardized surface swept-area trawling for mackerel at predetermined locations. Additionally, abundance indices of Norwegian spring-spawning herring and blue whiting will be obtained using standard acoustics methods, from surface to 500 m depth. Stratified random survey design is used to predetermine the acoustic survey transect locations. Location of the first transect and the first station, in each stratum, is randomized and all other transect/stations are located at a fixed distance from the first transect/station.

There are eleven strata and effort varies between them, from 40 nmi to 80 nmi between stations (Figure A16.3). Effort is higher in stratum with greater abundance and higher expected variability in abundance. In general, each country surveys its exclusive economic zone (EEZ) and international waters are split between participants. In 2020, six vessels from five countries (Norway, Iceland, Faroe Islands, Greenland, and Denmark) participate in the survey. Survey coverage is similar to 2019 or around 3 million km^2.

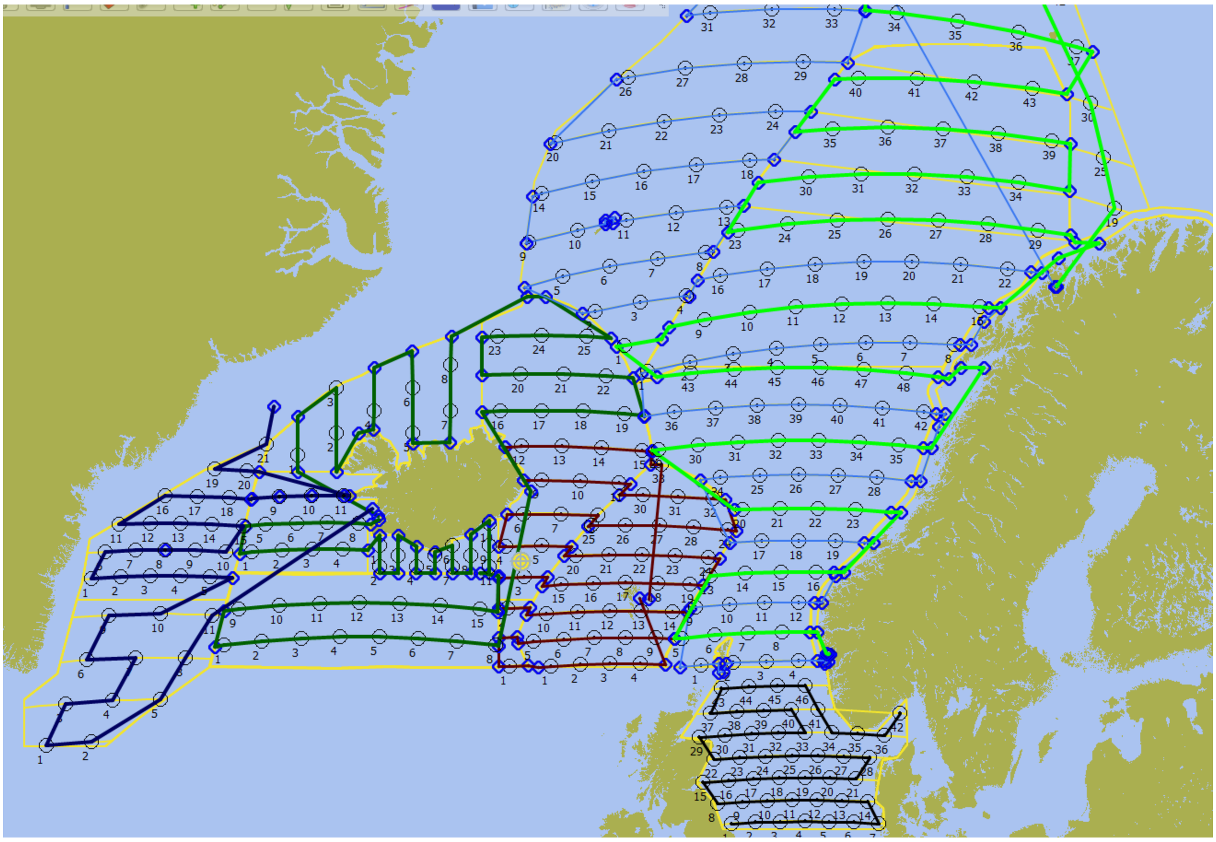


Figure A16.3. Preliminary surface stations (open circles) and transects (yellow, blue, brown and green = Norway with 2 vessels, turquoise = Faroe Islands, red = Iceland, black = Greenland) for IESSNS from 1. July to 4. August 2020. Strata boundaries delineated with yellow lines.

HERAS

Norway, Denmark, Germany, Netherlands, Scotland and Ireland will participate in the 2020 HERAS and MSHAS surveys. Ships, preliminary dates and preliminary strata allocations are given in Table A16.3 below. Inshore extension is to be maintained at the 20-m contour for shallow waters regions of the Baltic and south eastern North Sea, and the 30-m contour for all other areas where applicable. The Norwegian survey is bounded a set distance from shore (5 n.mi) 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 northwestern boundary. The strata for 2020 are displayed in Figure A16.4 below.

The survey design has been standardised across participants and will follow best practice in terms of transect planning. The main body of the survey will utilise systematic parallel transect lines with randomised starting points and with transects running perpendicular to lines of bathymetry. Zig-zag transects are used in instances where parallel lines are not practical due to operational reasons, such as bays and inlets, or to better utilise survey time, and are stratified accordingly (Strata 2 and 81).

The survey effort, i.e. transect spacing, will be maintained at similar level to 2019. Survey effort should also ensure adequate coverage of the North Sea sprat stock, which requires the southern boundary of the survey area to 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 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 tissue samples for genetic analysis as well as photographs of herring and otoliths, and to carry out analysis of otolith shape and body morphometry to prepare for splitting the acoustic index into 6.aN and 6.aS 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 traditionally covered by Denmark and Norway, 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 vertebral count method that provides information only at the strata level. A workshop to standardise the method to one that will provide stock information at the individual fish level was held in Galway in November 2017 (WKSIDAC). This is work in progress, as there is a need for more samples to agree on adequate methods. Additional sampling on the 2020 survey should be continued for this work, and there might be requests for both collection of otoliths for shape analysis and genetic samples from the survey.

Analysis and reporting

A post-cruise meeting will be held in ICES, Copenhagen, Denmark, 16-20 November 2020. The post-cruise meeting will allow the group to evaluate survey data, discuss issues arising from the surveys and produce the combined survey estimate. Data uploaded to the ICES acoustic database for the 2016-2018 survey is not complete in all cases. This should be rectified in time for the 2020 post cruise meeting. Survey data for the 2020 survey is to be uploaded to the ICES Acoustic database in the agreed format no later than **31 October 2020.**

Table A16.3. Time periods, areas and rectangles to be covered in the 2020 acoustic survey.

Vessel	Available days for survey	Period available	Strata to cover
Celtic Explorer (IRE)	19	01 – 20 July	2, 3, 4, 5, 6

Scotia (SCO)	18	28 June – 20 July	1, 91 (north of 58°30’N), 111, 121
Johan Hjort (NOR)	16	27 June – 14 July	11, 141
Dana (DEN)	13	23 June – 08 July	21, 31, 41, 42, 151, 152
Tridens (NED)	12	29 June – 17 July	81, 91 (south of 58°30’N), 101
Solea (GER)	19	29 June – 19 July	51, 61, 71, 131

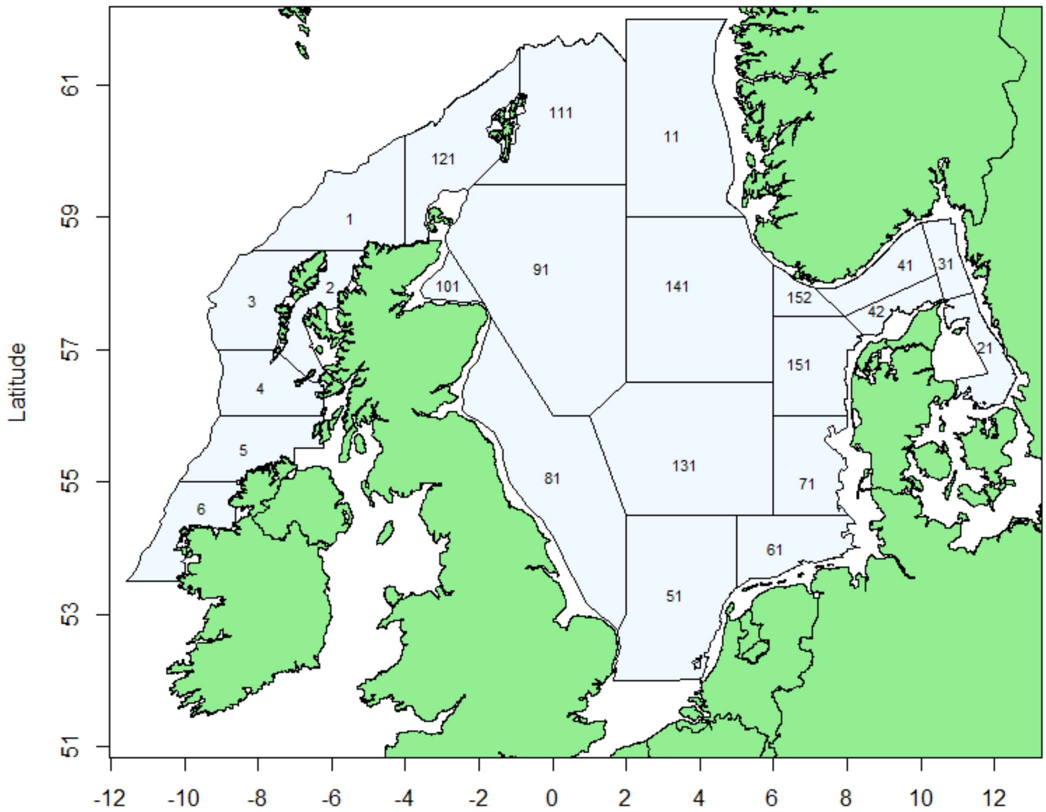


Figure A16.4. Strata for the HERAS 2020 survey.

WESPAS

The 2020 WESPAS (Western European Shelf Pelagic Acoustic Survey) will be carried out on board the RV *Celtic Explorer*. The survey will begin in Northern Biscay on the 06 June and work progressively northwards over 42 days ending on the 17 July to the north of Scotland (A16.5). The survey will be broken into two 3-week legs, with a 1-day break to facilitate a crew change.

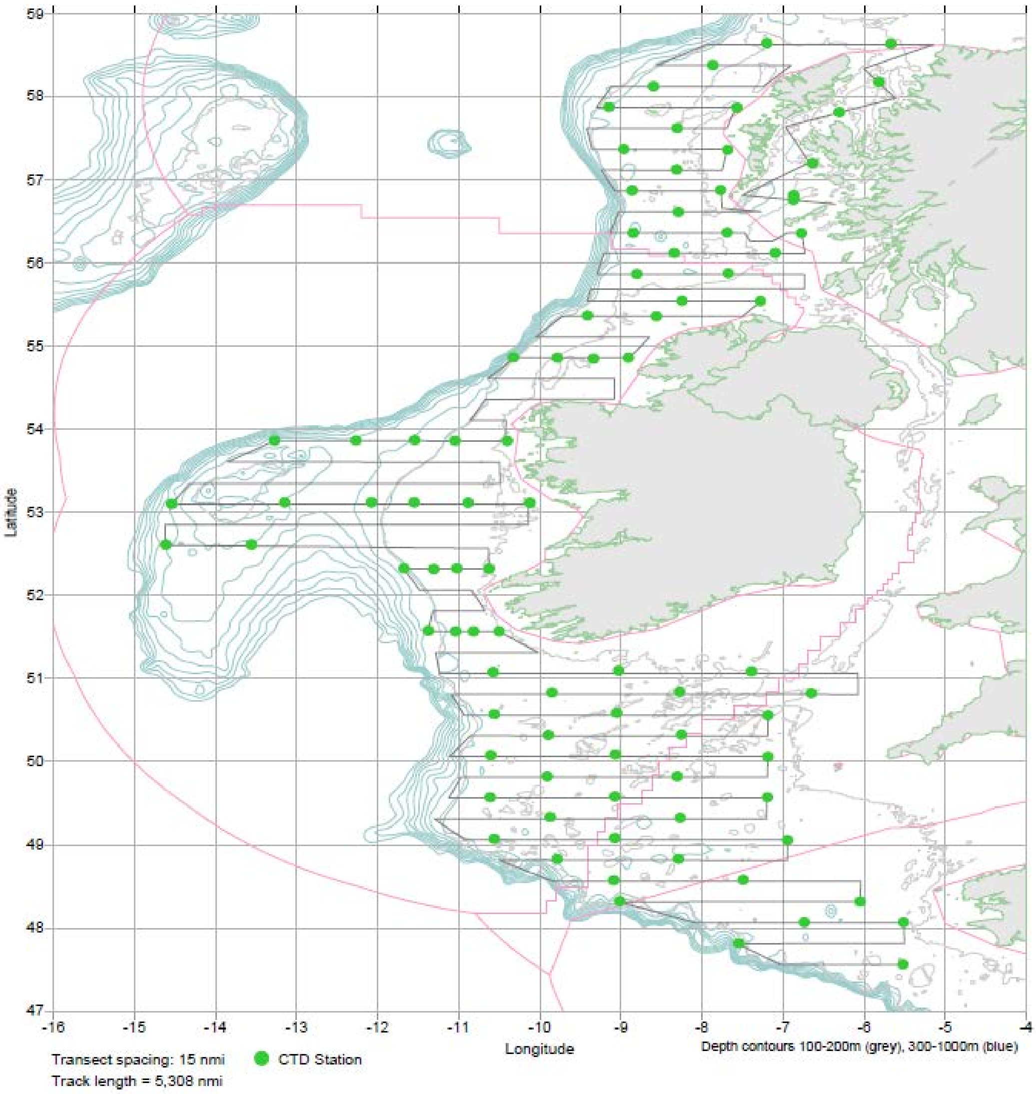


Figure A16.5. Proposed survey design and hydrographic station layout, WESPAS 2020.

CSHAS

The 2020 Celtic Sea acoustic survey will be carried out on board the RV *Celtic Explorer* from the 06 – 26 October (21 days). Survey design utilises a laddered broad scale survey (A16.6) and focused adaptive high resolution site surveys.

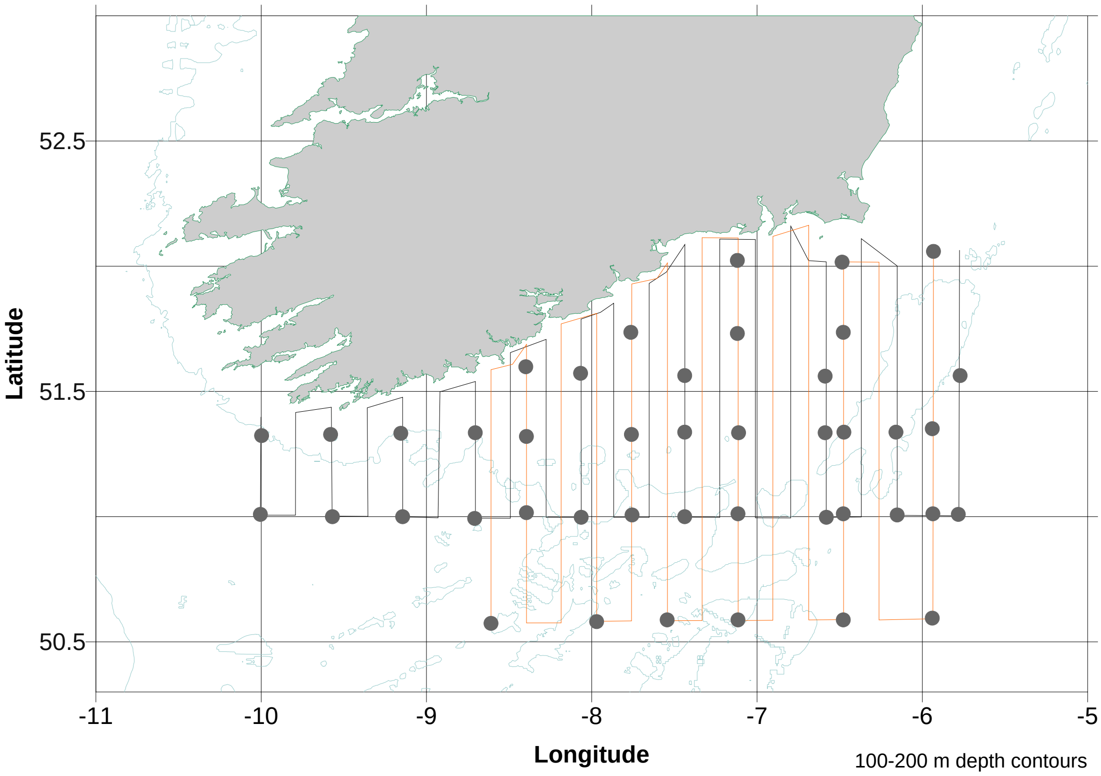


Figure A16.6. Proposed laddered survey design and hydrographic station layout, CSHAS 2020.

ISAS

The 2020 Irish Sea acoustic survey (ISAS) will be carried out onboard the RV *Corystes* between August 26th and September 14th 2020. Figure A16.7 shows the plan and acoustic tracks for cruise C03520. The survey design of systematic, parallel transects covers approximately 620 nm and will be divided into two parts, transects around the periphery of the Irish Sea is randomized within +/- 4 nm of a baseline position each year with spacing set between 8-10 nm. Transect spacing is reduced to 2 nm in strata around the Isle of Man to improve precision of estimates of adult herring biomass.

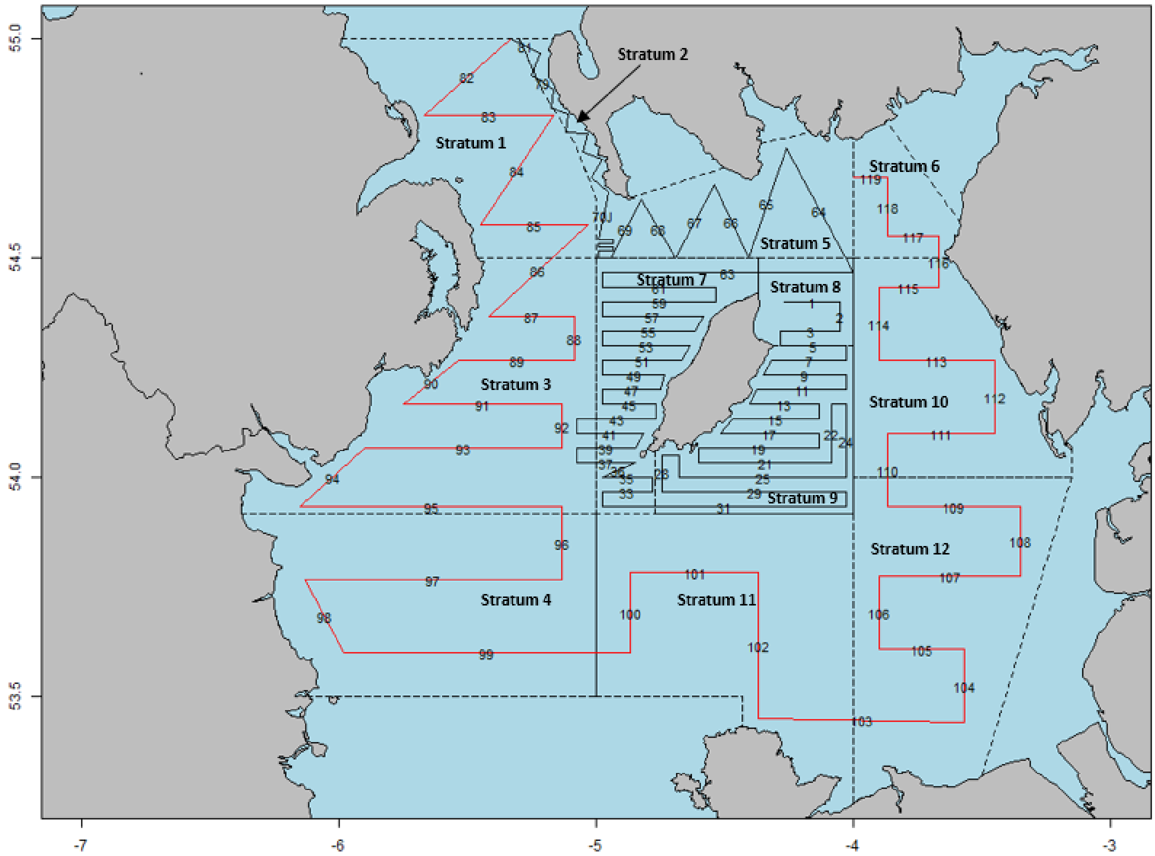


Figure A16.7. Map of Irish Sea and North Channel showing proposed coverage for the 2020 herring acoustic survey C03520.

ISSS

The 2020 Irish Sea commercial acoustic survey (ISSS) will be carried out on board the FV Haviliah between September 14th and October 10th. Figure A16.8 shows the plan and acoustic tracks for cruise HA3920. The survey design of systematic, parallel transects. Transect spacing is set to 2 nm in strata around the Isle of Man where adult herring were expected to be most abundant but also to have a very patchy distribution with relatively low probability of encounter. The survey design is based on information on herring distribution in autumn obtained from previous surveys, and from patterns in the commercial fishery showing a concentration of herring in Manx waters at this time. Survey design and methodology adheres to the methods laid out in the WGIPS acoustic survey manual.

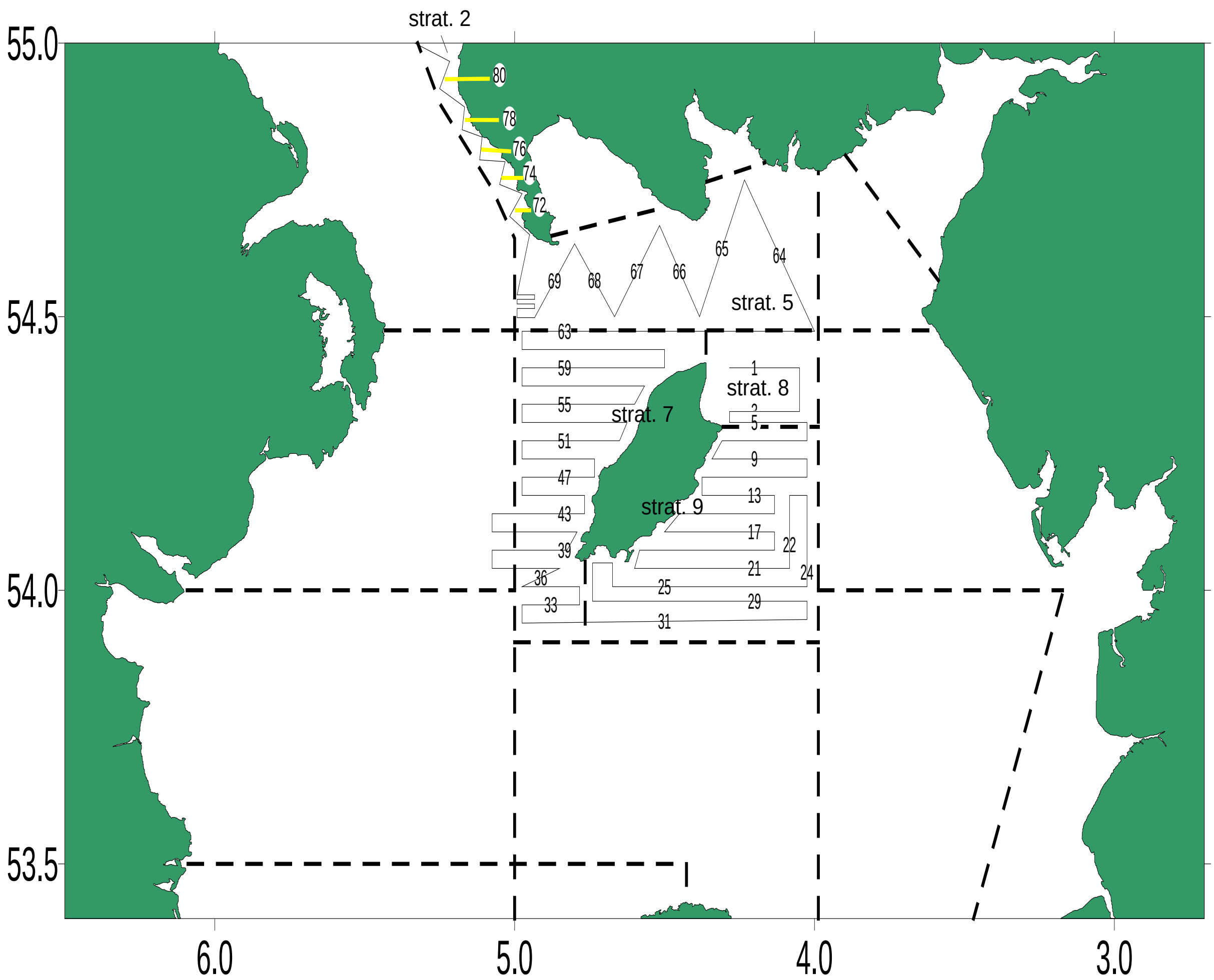


Figure A16.8. Map of Irish Sea and North Channel showing proposed coverage for the 2020 herring commercial acoustic survey HA3920.

GERAS

The GERAS acoustic survey 2020 will be carried out on board FRV *"Solea"* from October 2nd until October 22nd. The plan for cruise SB783 and acoustic transects to be followed follow the design adopted for the previous years (figure A16.9) 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.

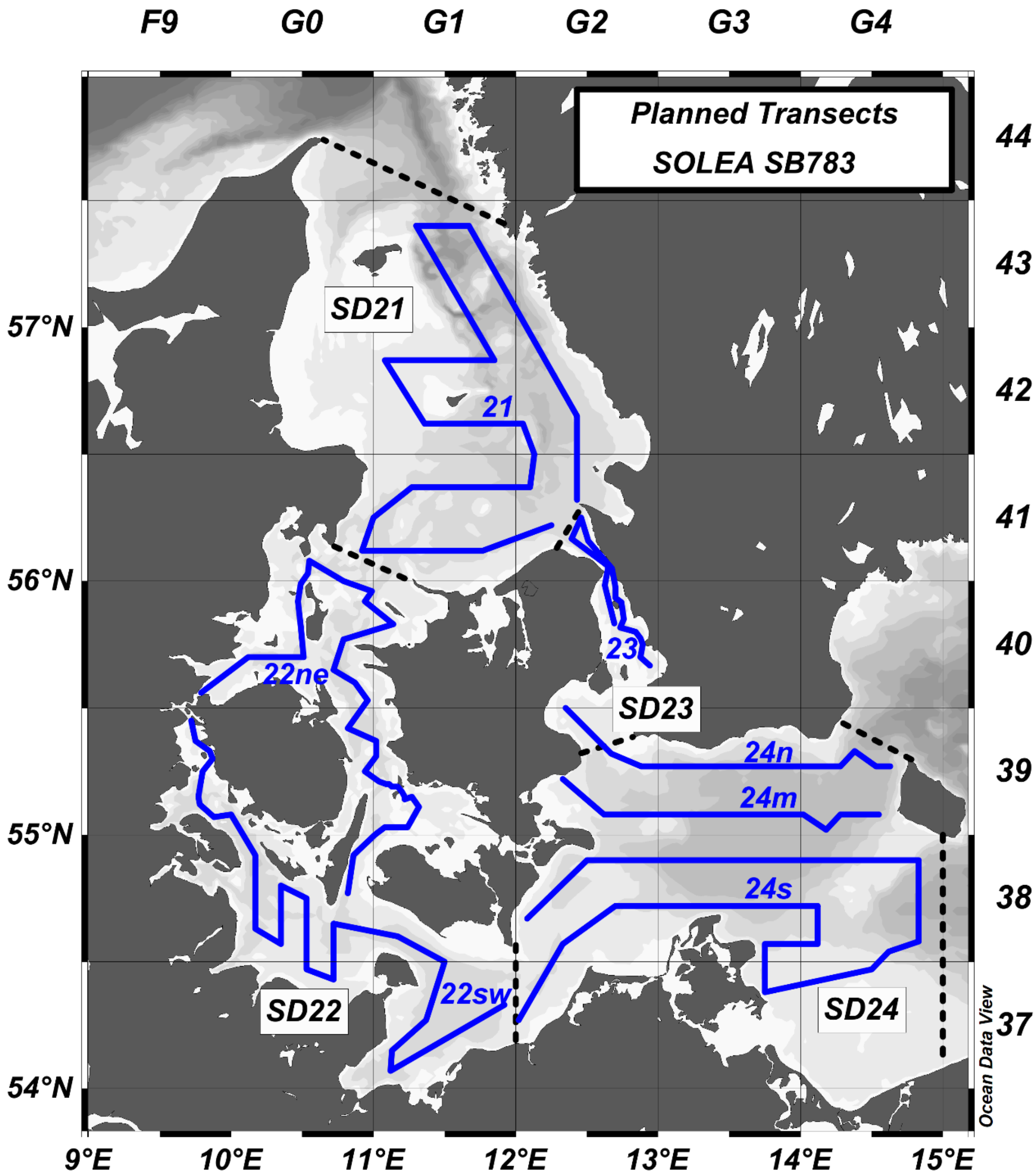


Figure A16.9. Map of the planned coverage in ICES Subdivisions (SD) 21-24 and acoustic transects (blue, transect ID indicated) for the German Acoustic Autumn Survey (GERAS) in 2020 (cruise SB783).

PELTIC

The 2020 PELTIC survey (Pelagic ecosystem survey in the Western Channel and eastern Celtic Sea) is scheduled to be carried out onboard the RV *Cefas Endeavour* from the 30th September to the 30th October. As in the last three years, French waters of the western Channel are scheduled to be covered. A possible extension further north is also being discussed which would extend the survey by several days.

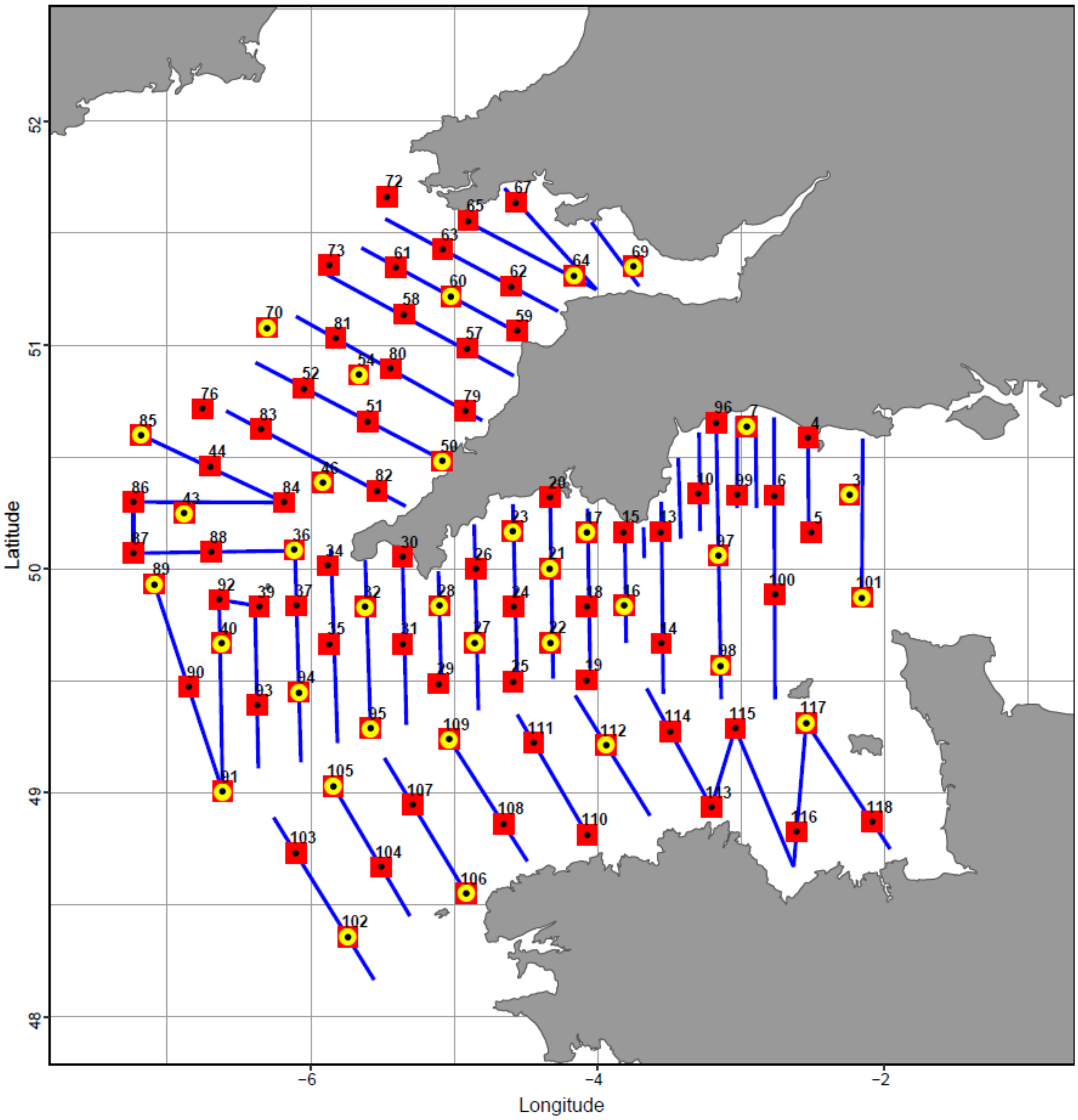


Figure A16.10. Overview of the planned survey area, with the acoustic transect (blue lines), plankton stations (red squares) and hydrographic stations (yellow circles)., PELTIC 2019.

Industry Survey in 6.a.N

Important considerations

1. Approaching benchmark, so need to see what is the best we can take from the acoustic surveys and make sure 2020 adds to that. Aim is to create a survey index useful for assessment.
2. Recommendations from ICES WKHASS 2020 and WGIPS 2020 used to guide where to focus effort and how to address outstanding information gaps.
3. Cutting the cloth to suit: The available monitoring quota in 2020 has been reduced to 3,840 t in 6aN. If five vessels are assigned to the work this give 680 t each with 80 t contingency. If survey time per vessel is pro-rated based on previous years, this gives 8 days per vessel.

Proposal

- In 2020, we again propose to re-distribute some of the acoustic survey effort currently deployed in Aug/Sept to the beginning of July to coincide with the part of the International Herring Survey (HERAS) that surveys the Malin Shelf region. In coordination with the HERAS planning group, 1 industry vessel from Scotland would undertake ~8 days acoustic survey work aimed at addressing specific objectives relevant to the acoustic assessment of herring stocks in the region. (Details below)
- The remaining two Scottish vessels along with Dutch vessels would undertake the spawning survey in Sept, where acoustic survey effort would focus on the key spawning areas (survey Area 3 and Area 2, Figure 1). The reduced acoustic survey grid would allow for ad-hoc searching in other areas to see if fish spawning elsewhere in 6aN that we haven't surveyed. Vessels would be staggered in time with flexible start dates aimed at covering the main time close to and during spawning.
- Time/ cost permitting we would do additional drop-camera work targeted suspected herring marks on hard ground and to investigate camera avoidance. This would bring better confidence and validation to classification of acoustic data in 6aN (and elsewhere).

DETAILS

Part 1: 8-16 July (in tandem with HERAS survey)

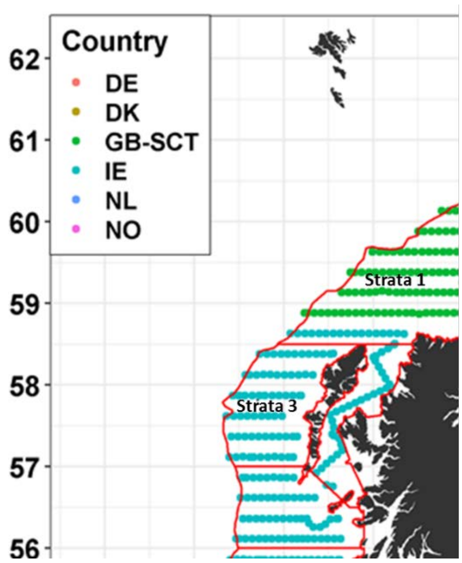
Objectives

1. Test effect of transect spacing on estimates of acoustic density on Malin shelf. Perform Undertake 1 strata with finer spacing or undertake to cover two strata with industry vessel interlacing parallel transects with survey vessel. [resource/time constraints need to be further considered].

   Following statistical analysis to determine what transect spacing would be achievable without compromising the quality of the data (as indicated by a high survey coefficient of variation), the current design of the HERAS survey in the Malin shelf and 6a areas is based on a 15nmi spacing. A test of the implications of transect spacing on estimates of acoustic density could be undertaken by having an industry vessel survey in-between the official survey transects of one or more complete strata (in terms of StoX analysis strata) at the same time as the scientific survey vessel . During such a test it would be necessary to conduct a vessel inter-calibration, where vessels attempt to record the same fish marks to ensure they see the same thing. The inter-calibration exercise would be beneficial to the industry by providing information to quantify the performance and quality of the acoustic data recorded by a commercial vessel side-by-side a scientific research vessel.
2. Increase chances of obtaining biological samples to determine age structure of herring stock

3. Test mackerel surface trawling [this is request to address a request from WGWIDE on feasibility of mackerel swept area survey south of 60°N]

<u>**Deployment**</u>
Vessel: Charisma
Dates: 8 days between 7/8 to 16 July
Staff: Steve Mackinson + Shaun Fraser (NAFC) + 1 x SFF
Role: Acoustic /trawl



Part 2: ~29 Aug-25 Sept (as before – Industry spawning survey)

Objectives

1. Acoustic surveys and Scouting (Ocean star and Alida)
2. Genetic sampling and Scouting (Chris Andra)
3. Scouting and Catch sampling in Area 1 (Freezer trawler)

<u>**Deployment**</u>

Vessel: Ocean star
Dates: 8-10 days between 29 Aug and 7 Sept
Staff: Steve Mackinson +Steve O'Connel
Role: Acoustic/trawl

Vessel: Chris Andra
Dates: ~13-23 September, but may need to be adjusted earlier, so keep time window open
Staff: Katie Brigden + 1
Role: genetic/ morpho sampling

Vessel: Alida?
Dates: ~13-23 September
Staff: Serdar Sakinan + 1
Role: ?

Vessel: <u>Wirons ?</u>
Dates: ~12 August, Scouting in 6a then Irish Sea fishing. September back in 6a for sampling.
Staff: ?
Role: ?

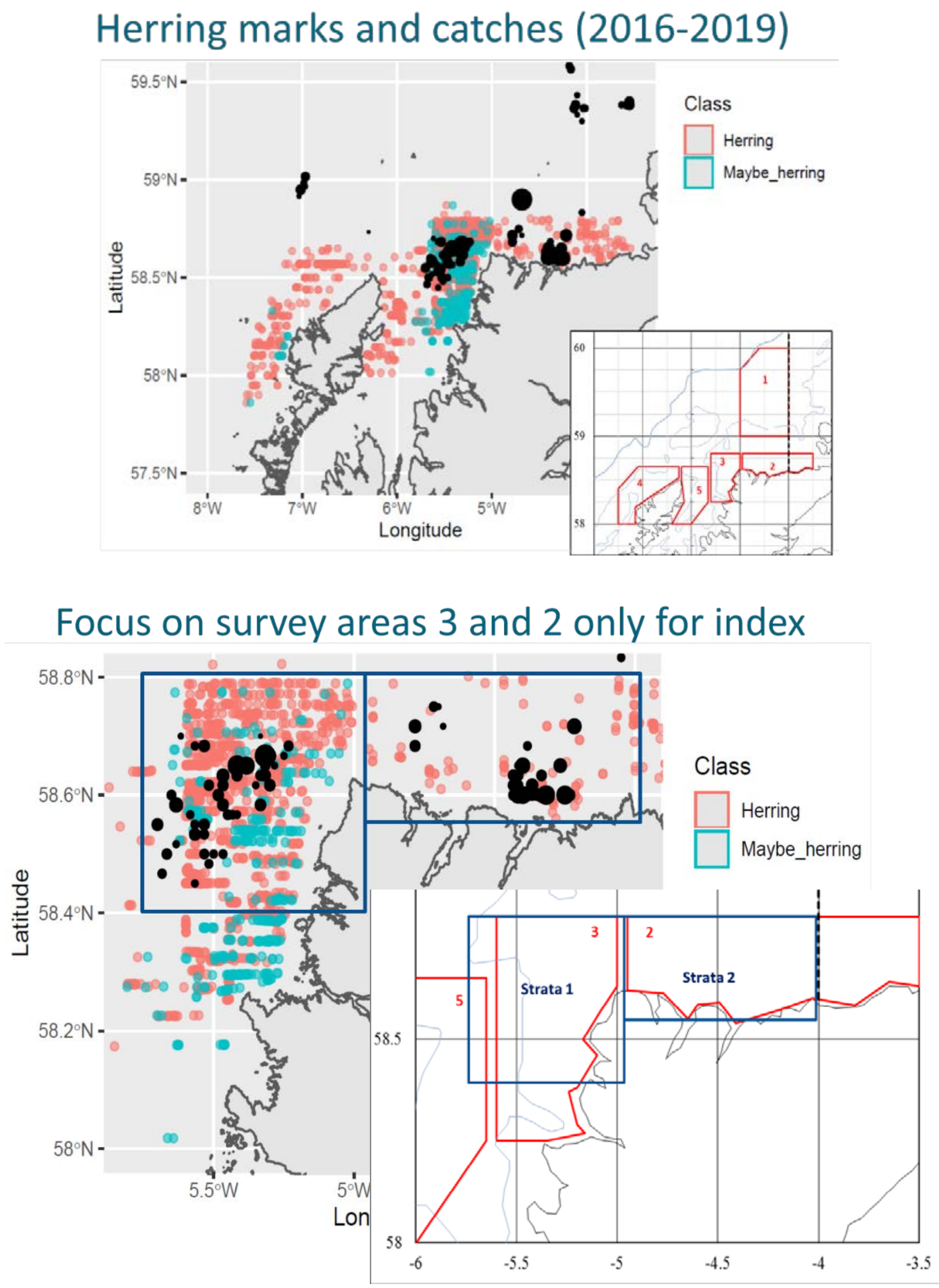


Figure A16.11. Top panel: herring marks and catches in survey areas. Bottom panel: focus on area 2 & 3.

Industry Survey in 6.a.S

The proposed survey design will deviate from the previous design to include a flexible and targeted approach to strata from 2020 onwards. The plan is to increase transect effort in core areas (e.g. A16.12). The entire survey area will be divided up into numerous smaller strata, concentrating on areas where herring are known to occur in pre-spawning aggregations. This will require a more mobile echo-sounder (e.g. SIMRAD WBAT 38 kHz) that can be deployed easily from smaller vessels (10 -15m length) with minimal mob and de-mob time. It is hoped that many vessels can be involved in the survey with this approach, each surveying for 1-2 days covering all areas. The advantage will be that the survey design can be reactive to information coming from the fleet, poor weather can largely be avoided, and thereby improving the consistency of results and reducing bias. All core inshore areas can be completed by using this approach. Information and expertise from inshore vessels will be considered in the survey design. It is hoped that increased participation in the survey by the fleet that is actively fishing for herring in these areas will result in a more robust estimate of the stock. If the stock expands in areas or time in the future, the flexible approach can react to it, by adapting the survey design to include this information.

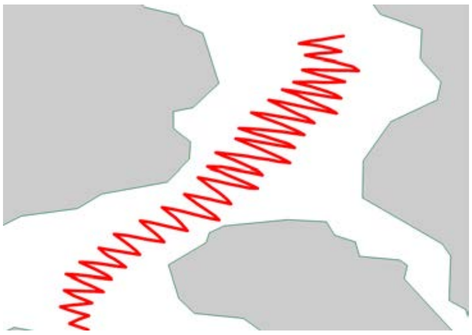


Figure A16.12. 6aS/7b industry acoustic survey: Example of intense zig/zag survey design in Lough Swilly. This more intense transect approach will be repeated in other areas, including Bruckless Bay and Inver Bay in 2020.

Annex 17: StoX re-calculations

*Please see the report on the next page.

Re-calculating abundance estimates from WGIPS coordinated surveys with the most recent version of Stox and Rstox

Are Salthaug, Sindre Vatnehol, Espen Johnsen, Åge Høines, Leif Nøttestad, Erling Kåre Stenevik, Aril Slotte

The purpose of this work is to (1) ensure that Stox project used to calculate official abundance estimates from international pelagic surveys still works, meaning that they are possible to run and that the original estimates can be reproduced, and (2) present boostrap means as a better alternative than baseline estimates for use in ICES stock assessments.

Background

Abundance estimates from most WGIPS coordinated surveys are currently being calculated with the software Stox[1, a]. An important scientific principle behind Stox is reproducibility; estimates from a survey should be easy to re-calculate at a later stage and these new estimates should be equal to the original estimates. Large differences indicate errors in software or data in the old or in the new run. As part of the introduction of Stox in 2015-2016, historic time series of acoustic abundance estimates from the International Ecosystem Survey in the Nordic Seas (IESNS) and the International Blue Whiting Spawning Survey (IBWSS) were re-calculated with Stox, and the results were presented at WGIPS in 2016[2]. From 2016 onwards, Stox has been used to estimate abundance on the IESNS and IBWSS post-cruise meetings. At the benchmark assessment of mackerel in 2017, swept-area estimates (of mackerel) from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) were re-calculated and presented at WKWIDE 2017[3]. From 2017 onwards Stox has been used to calculate these IESSNS swept area estimates. Acoustic IESSNS estimates of herring and blue whiting have been calculated with Stox from 2016 onwards. Though not an international cruise, abundance estimates from the Norwegian acoustic survey on the spawning grounds of Norwegian spring-spawning herring (here abbreviated NORHERSS) are used in the ICES stock assessment of Norwegian-spring spawning herring and Stox is used to calculate the estimates. Results from this cruise is therefore also included in this document.

The current version of Stox (2.7) and Rstox (1.11) have been preceeded by many earlier versions; software errors have been corrected and methods have been improved. Input data may have been updated and the tool used to generate Stox input data from the PGNAPES database, the PGNAPES client (current version 1.5) have gone through som updates and bug fixes. These factors, among others, may lead to problems when trying to run old Stox projects in the newest version of Stox and they may also lead to differences in results (estimated abundance). However, the magnitude of such differences is important: large differences are serious while small should be viewed as acceptable (and expected due to the software updates etc).

Methods

[a]Johnsen et al. 2019. StoX: An open source software for marine survey analyses. Methods Ecol Evol. 2019;10:1523–1528.

An overview of the different cruise time series with belonging Stox projects is given in Table 1. The new stox runs used the same settings (tagging, removal of stations, assignments etc) as in the original projects but sometimes minor technical changes had to be done, like replacing capital letters with lower case letters in species names. In addition, the boostrap part of the projects (R and R report) were changed to 1000 replicates, and also to include reports of total stock numbers and total stock biomass. More specifically, these changes were done in the project.xml file and a new project was created that used this file and input data as decribed below. The new 86 projects will be made available somewhere on a share point.

The original stox projects that have been used to estimate the official survey abundance estimates were mostly downloaded from the ICES share point system (https://community.ices.dk/) as they have been put here after recalculations and post-cruise meetings, mostly on the WGIPS share point but also and the WKWIDE 2017 site (re-calculations of IESSNS swept-area of mackerel 2007-2016). Some exceptions are IBWSS 2015 (blue whiting), IESSNS 2015 (herring and blue whiting) and IESNS 2019 (blue whiting); these projects had to be obtained from private PCs as they had not been put on the ICES share point, however, the baseline estimates in the projects where checked against the tables in reports (post-cruise and WGIPS). Input data (biotic xml and acoustic xml) from before 2017 where downloaded with the most recent PGNAPES client (version 1.5) and from 2017 onwards the input data from the original stox projects were used. There were some exceptions to this as well: in projects where Norwegian/IMR input files have been used these were not replaced (e.g in all the IESSNS swept area projects before 2017[3]), in IESNS 2016 in the Norwegian Sea (herring and blue whiting) the orginal Icelandic acoustic file had to be used and in IESNS 2009 in the Barents Sea (herring) the original biotic file had to be used, to make the projects run.

Results

Point estimates and uncertainty of abundance from all the re-run stox projects are shown in Table 2 and Figure 1-160. In 24 % of the rows in Table 2 there are differences between the old and new baseline estimate (more than 0.001 %). Most of the differences are, however, small: only 10 % of the differences are above 1 %, and 0.2 % of the differences are above 10 %. Visually, the differences between old baseline, new baseline, and the mean of the boostrap appears rather small and the old baseline estimates are all inside the confidence intervals of the new runs (Figure 1-160).

Discussion

It is now possible to run all the old IESNS, IESSNS, IBWSS and NORHERSS Stox projects in Stox version 2.7. However, some of the estimates from the new runs are not equal to those from the original runs, though most of the differences are very small. There are many possible reasons for these differences, and finding all of them, which in theory should be possible, is beyond the scope of this work. One common reason is that the impute function (distributing individuals with missing age into age groups based on length) has been changed in newer version of Stox. If this is the case the total stock number should be equal but the numbers per age different. Another reason might be that unofficial beta versions of stox was used in the original run, this happened some times in 2015 and 2016, i.e. a human error. In one project, IESSNS swept-area in 2017 (mackerel) the biotic input files had a mix of lower case and capital letters for the species name, and this affected the impute function so that the numbers at age (but not the total number) changed slightly in the new run. Other reasons may be changes in the input data and other software changes in the Stox code.

Abundance estimates from surveys are normally a central input to fish stock assessments, were they usually are treated as relative indices of abundance. These point estimates are normally kept constant from year to year except for addition of numbers from the most recent survey. With more focus on reproducibility, like in the present work with Stox, this will likely change. Ideally, the survey estimates should be reproduced in each new stock assessment to ensure that the latest software is used and to reduce the likelihood of errors. With this procedure, it is also easy to implement (and check the sensitivity of) new settings and assumptions in the survey calculations like for example depth dependent target strength. Moreover, the uncertainty in the estimate can be used directly in the stock assessment via bootstrap. This is for example done with Rstox in the ICES stock assessment of Norwegian spring-spawning herring were the assessment model XSAM is used.

Till now the point estimates from Stox used in the ICES stock assessments of Norwegian spring-spawning herring, Northeast Atlantic mackerel and blue whiting have been from the baseline report. In our opinion, the mean from boostrap replicats should be used instead. The reason for this is that the baseline estimates are not calculated deterministically but via a stochastic step, namely the impute function. Therefore, a given baseline estimate can be viewed as one possible outcome among others. The mean of 1000 boostrap replicates is thus expected to be a more robust estimate, and this mean should therefore be used instead of the baseline estimate. This position is also supported by statistical experts.

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11. ICES. 2018b. Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 30th of June – 6th of August 2018. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE 2018). 39 pp.

12. ICES. 2018c. International blue whiting spawning stock survey (IBWSS) spring 2018. WD to Working Group on International Pelagic Surveys (WGIPS 2019) and Working Group on Widely Distributed Stocks (WGWIDE 2018). 29 pp.

13. ICES. 2019a. International Ecosystem Survey in Nordic Sea (IESNS) in May-June 2019. Working Document to the Working Group on International Pelagic Surveys (WGIPS 2020) and Working Group on Widely Distributed Stocks (WGWIDE 2019). 33 pp.

14. ICES. 2019b. Cruise report from the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) 28th of June – 5th of August 2019. Working Document to ICES Working Group on Widely Distributed Stocks (WGWIDE 2019). 51 pp.

15. ICES. 2019c. International blue whiting spawning stock survey (IBWSS) spring 2019. Working Document to the Working Group on International Pelagic Surveys (WGIPS 2020) and Working Group on Widely Distributed Stocks (WGWIDE 2019). 32 pp.

16. https://datasetexplorer.hi.no/apps/datasetexplorer/v2/navigation Stox process file and input data can be downloaded for each year under 'Surveytimeserie's and 'Norwegian Sea NOR Norwegian spring-spawning herring acoustic abundance index in Feb-Mar'. Running Stox using these files should produce the original baseline results.

17. WGIPS share point https://community.ices.dk/ExpertGroups/wgips/_layouts/15/start.aspx#/ Stox projects are put here after post cruise meetings (working documents/post-cruise meeting). Estimates are available in baseline report in the output folder of a given Stox project.

Table 1. Overview of the different cruise time series of available Stox projects that have been re-run in this work (86 projects in total). Cruise abbreviations: IESNS = the International Ecosystem Survey in the Nordic Seas, IBWSS=the International Blue Whiting Spawning Stock Survey, IESSNS= the International Ecosystem Summer Survey in the Nordic Seas, NORHERSS=the Norwegian spring-spawning herring survey on the spawning grounds.

cruise	area	species	survey type	year range
IESNS	Norwegian Sea	herring	acoustic	2008-2019
IESNS	Norwegian Sea	blue whiting	acoustic	2008-2019
IESNS	Barents Sea	herring	acoustic	2009-2019
IBWSS	Celtic Seas	Blue whiting	acoustic	2004-2019
IESSNS	Nordic Seas	mackerel	swep-area	2007,2010-2019
IESSNS	Nordic Seas	herring	acoustic	2016-2019
IESSNS	Nordic Seas	blue whiting	acoustic	2016-2019
NORHERSS	Norwegian coast	herring	acoustic	1988-1989, 1994-1996,1998-2000,2005-2008,2015-2019

Table 2. Stox estimates of abundance by cruise, area, species and age (and three other groups/categories; Unknown category, Number which is total stock number and total biomass). Abundance is number in thousands for all categories except biomass which is in tons. *Basline_old* is the baseline estimates from the orginal stox run taken from *source_old* where the source number corresponds to the list of sources above in the text. *Baseline* is the baseline estimates from the new current run with stox version 2.7, and results from boostrap with 1000 replicates with Rstox are given as the 5th percentile (p5%), the median, the 95th percentile (p95%) and the mean. Cruise abbreviations: IESNS = the International Ecosystem Survey in the Nordic Seas, IBWSS= the International Blue Whiting Spawning Stock Survey, IESSNS= the International Ecosystem Summer Survey in the Nordic Seas, NORHERSS=the Norwegian spring-spawning herring survey on the spawning grounds.

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESNS	Norwegian_Sea	herring	2008	2	1240242	1240242	380030	1151733	2230061	1213468	2
IESNS	Norwegian_Sea	herring	2008	3	631389	631389	330793	636719	1023176	655420	2
IESNS	Norwegian_Sea	herring	2008	4	10809290	10809290	7057166	10720879	15872360	10996879	2
IESNS	Norwegian_Sea	herring	2008	5	8270930	8270930	5696515	8348017	11455716	8405955	2
IESNS	Norwegian_Sea	herring	2008	6	14827041	14827041	10204823	14706056	19826334	14798182	2
IESNS	Norwegian_Sea	herring	2008	7	1513234	1513234	1034624	1523781	2130637	1543200	2
IESNS	Norwegian_Sea	herring	2008	8	2256742	2256742	1552695	2214747	2972571	2232299	2
IESNS	Norwegian_Sea	herring	2008	9	4847634	4847634	3631385	4859635	6274200	4889538	2
IESNS	Norwegian_Sea	herring	2008	10	2734452	2734452	1941990	2741054	3724794	2790219	2
IESNS	Norwegian_Sea	herring	2008	11	449201	449201	322398	495918	740102	510618	2
IESNS	Norwegian_Sea	herring	2008	12	149393	149393	49342	142764	259969	148000	2
IESNS	Norwegian_Sea	herring	2008	13	151300	151300	62817	170016	285824	172379	2
IESNS	Norwegian_Sea	herring	2008	14	270278	270278	71542	245833	415560	243524	2
IESNS	Norwegian_Sea	herring	2008	15	309150	309150	78791	281848	519958	290515	2
IESNS	Norwegian_Sea	herring	2008	16	131471	131471	39032	171947	328466	170842	2
IESNS	Norwegian_Sea	herring	2008	17	50819	50819	5677	63197	132466	66879	2
IESNS	Norwegian_Sea	herring	2008	Unknown	23031	23031	5948	33766	223482	58823	2
IESNS	Norwegian_Sea	herring	2008	Number	48665597	48665597	36697868	49449370	61907057	49186740	2
IESNS	Norwegian_Sea	herring	2008	Biomass	10558426.2	10556767.8	8096457	10700008	13316437	10654765	2
IESNS	Norwegian_Sea	herring	2009	2	144057	144057	18004	123371	308348	137405	2
IESNS	Norwegian_Sea	herring	2009	3	1668550	1668550	763454	1671037	3525066	1816568	2
IESNS	Norwegian_Sea	herring	2009	4	2159326	2159326	770323	1966575	4810668	2280164	2
IESNS	Norwegian_Sea	herring	2009	5	12300011	12300011	8244812	11897729	16524037	12118108	2
IESNS	Norwegian_Sea	herring	2009	6	8994405	8994405	6375403	8501442	11088654	8598804	2
IESNS	Norwegian_Sea	herring	2009	7	9527172	9527172	7762924	9651710	12002762	9734634	2
IESNS	Norwegian_Sea	herring	2009	8	2146686	2146686	928463	2053830	3288303	2053702	2
IESNS	Norwegian_Sea	herring	2009	9	1434534	1434534	964885	1436805	1922739	1433183	2
IESNS	Norwegian_Sea	herring	2009	10	2466410	2466410	1758496	2589051	3485656	2607817	2
IESNS	Norwegian_Sea	herring	2009	11	1410522	1410522	860079	1374095	1908303	1374603	2
IESNS	Norwegian_Sea	herring	2009	12	188443	188443	145371	231662	350843	237035	2
IESNS	Norwegian_Sea	herring	2009	13	193347	193347	97926	193041	311266	197829	2
IESNS	Norwegian_Sea	herring	2009	14	123212	123212	8550	115002	239733	111600	2
IESNS	Norwegian_Sea	herring	2009	15	66990	66990	26280	69876	124228	71077	2
IESNS	Norwegian_Sea	herring	2009	16	122784	122784	71683	129799	227402	138024	2
IESNS	Norwegian_Sea	herring	2009	17	28968	28968	4120	24614	51104	26143	2
IESNS	Norwegian_Sea	herring	2009	18	12052	12052	0	10119	38631	12799	2
IESNS	Norwegian_Sea	herring	2009	Unknown	94593	94593	26397	88834	248362	107136	2

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESNS	Norwegian_Sea	herring	2009	Number	43082062	43082062	36697868	42798528	61907057	49186740	2
IESNS	Norwegian_Sea	herring	2009	Biomass	9727713.5	9727713.5	8096457	9675161	13316437	10654765	2
IESNS	Norwegian_Sea	herring	2010	1	234405	234405	0	218114	633511	231134	2
IESNS	Norwegian_Sea	herring	2010	2	124818	124818	25362	107380	248304	119433	2
IESNS	Norwegian_Sea	herring	2010	3	542356	542356	201504	534974	1048137	572157	2
IESNS	Norwegian_Sea	herring	2010	4	2333746	2333746	1541474	2221422	3245946	2296388	2
IESNS	Norwegian_Sea	herring	2010	5	1780549	1780549	1215090	1818699	2474816	1828294	2
IESNS	Norwegian_Sea	herring	2010	6	8350607	8350607	6093890	8328553	10829266	8395055	2
IESNS	Norwegian_Sea	herring	2010	7	5988276	5988276	4655680	5858997	7447616	5918257	2
IESNS	Norwegian_Sea	herring	2010	8	5600851	5600851	4187664	5645470	7391670	5675590	2
IESNS	Norwegian_Sea	herring	2010	9	868615	868615	516102	908226	1375811	923433	2
IESNS	Norwegian_Sea	herring	2010	10	882338	882338	583682	884651	1215644	888494	2
IESNS	Norwegian_Sea	herring	2010	11	983403	983403	546430	990585	1448630	1001826	2
IESNS	Norwegian_Sea	herring	2010	12	578492	578492	276486	551054	818114	549700	2
IESNS	Norwegian_Sea	herring	2010	13	90270	90270	21074	83587	171672	88580	2
IESNS	Norwegian_Sea	herring	2010	14	71812	71812	9548	39668	83552	42159	2
IESNS	Norwegian_Sea	herring	2010	15	8368	8368	0	7837	25901	8919	2
IESNS	Norwegian_Sea	herring	2010	16	49045	49045	0	52857	109126	53155	2
IESNS	Norwegian_Sea	herring	2010	Unknown	134134	134134	28605	157797	407059	179112	2
IESNS	Norwegian_Sea	herring	2010	Number	28622083	28622083	22794241	28780026	35128489	28771687	2
IESNS	Norwegian_Sea	herring	2010	Biomass	6632681	6632681	5286779	6646141	8166931	6649348	2
IESNS	Norwegian_Sea	herring	2011	2	1205267	1205084	218859	1008639	2391376	1109895	2
IESNS	Norwegian_Sea	herring	2011	3	977041	973878	458100	896927	1471556	921193	2
IESNS	Norwegian_Sea	herring	2011	4	1528237	1527024	1099303	1642298	2304673	1662924	2
IESNS	Norwegian_Sea	herring	2011	5	3607203	3606287	2572259	3576214	4681756	3591552	2
IESNS	Norwegian_Sea	herring	2011	6	2563544	2561689	1970285	2582762	3273190	2604930	2
IESNS	Norwegian_Sea	herring	2011	7	9419779	9415282	7044601	9310076	11626580	9303097	2
IESNS	Norwegian_Sea	herring	2011	8	4541633	4537075	3333625	4371645	5482774	4389919	2
IESNS	Norwegian_Sea	herring	2011	9	4298276	4292329	3200803	4238932	5414125	4257292	2
IESNS	Norwegian_Sea	herring	2011	10	824757	822671	511540	762425	1085692	770570	2
IESNS	Norwegian_Sea	herring	2011	11	891879	888803	594716	952157	1308372	955543	2
IESNS	Norwegian_Sea	herring	2011	12	712374	710296	491101	730797	978061	732165	2
IESNS	Norwegian_Sea	herring	2011	13	260875	259836	146057	266182	404729	269124	2
IESNS	Norwegian_Sea	herring	2011	14	36620	36558	4404	27591	59452	29143	2
IESNS	Norwegian_Sea	herring	2011	15	22074	21851	0	17456	40273	17921	2
IESNS	Norwegian_Sea	herring	2011	16	10421	10315	0	6162	19160	6763	2
IESNS	Norwegian_Sea	herring	2011	17	2977	2947	0	3777	14181	4803	2
IESNS	Norwegian_Sea	herring	2011	18	3158	3126	0	2101	11244	3097	2
IESNS	Norwegian_Sea	herring	2011	Unknown	11641	11613	4797	72785	322565	100714	2
IESNS	Norwegian_Sea	herring	2011	Number	30917757	30886665	24410601	30640390	36925396	30730644	2
IESNS	Norwegian_Sea	herring	2011	Biomass	7395319	7386787.8	5923571	7300279	8812099	7335703	2
IESNS	Norwegian_Sea	herring	2012	2	378279	384721	85843	360479	838714	395568	2
IESNS	Norwegian_Sea	herring	2012	3	2895150	2937210	1453602	2859232	4819796	2942358	2
IESNS	Norwegian_Sea	herring	2012	4	412189	417287	192656	390052	682941	409525	2
IESNS	Norwegian_Sea	herring	2012	5	669705	675581	386062	653361	980424	667538	2
IESNS	Norwegian_Sea	herring	2012	6	1645805	1658496	1102712	1703299	2455813	1735763	2
IESNS	Norwegian_Sea	herring	2012	7	2559844	2574016	1767446	2568952	3709324	2632561	2
IESNS	Norwegian_Sea	herring	2012	8	4225765	4248605	3066895	4287336	5682756	4327970	2
IESNS	Norwegian_Sea	herring	2012	9	2025800	2032347	1428569	1886450	2358820	1883515	2
IESNS	Norwegian_Sea	herring	2012	10	2096821	2102219	1546201	2139175	2769441	2148364	2
IESNS	Norwegian_Sea	herring	2012	11	297571	298303	208990	291939	395548	297067	2
IESNS	Norwegian_Sea	herring	2012	12	606981	608176	352714	600889	838556	604044	2
IESNS	Norwegian_Sea	herring	2012	13	314658	315515	146270	305001	443923	303022	2
IESNS	Norwegian_Sea	herring	2012	14	154825	154825	70731	138222	210626	139266	2
IESNS	Norwegian_Sea	herring	2012	15	10990	10990	2135	13064	33893	14945	2
IESNS	Norwegian_Sea	herring	2012	16	36188	36188	5901	24601	51528	26193	2
IESNS	Norwegian_Sea	herring	2012	Unknown	506	506	0	990	53444	11813	2
IESNS	Norwegian_Sea	herring	2012	Number	18331080	18454986	13568897	18585617	23508466	18539512	2
IESNS	Norwegian_Sea	herring	2012	Biomass	4435370.7	4459853.9	3369884	4465740	5578215	4476317	2
IESNS	Norwegian_Sea	herring	2013	2	205169	194431	26686	141946	585604	200622	2
IESNS	Norwegian_Sea	herring	2013	3	776243	708385	375871	691213	1167183	718241	2
IESNS	Norwegian_Sea	herring	2013	4	3955370	3609864	2533980	3521773	4658291	3554846	2
IESNS	Norwegian_Sea	herring	2013	5	433663	402025	264422	418681	613187	425124	2
IESNS	Norwegian_Sea	herring	2013	6	1210519	1147780	758084	1133000	1654188	1160803	2
IESNS	Norwegian_Sea	herring	2013	7	2035612	1943977	1429695	1836316	2346990	1858704	2
IESNS	Norwegian_Sea	herring	2013	8	3069553	2946906	2070448	2853878	3845541	2904769	2
IESNS	Norwegian_Sea	herring	2013	9	4651596	4478190	3549481	4434927	5391461	4449298	2
IESNS	Norwegian_Sea	herring	2013	10	2766998	2716913	2111885	2740102	3544914	2772404	2
IESNS	Norwegian_Sea	herring	2013	11	1873351	1859459	1201577	1839550	2693031	1864735	2
IESNS	Norwegian_Sea	herring	2013	12	692071	687171	381640	663287	1014149	677521	2
IESNS	Norwegian_Sea	herring	2013	13	804883	803693	487290	772029	1156824	790486	2
IESNS	Norwegian_Sea	herring	2013	14	185911	186439	93407	211209	390933	222300	2
IESNS	Norwegian_Sea	herring	2013	15	58053	58133	24024	71291	135792	74809	2
IESNS	Norwegian_Sea	herring	2013	16	25220	25220	4963	24153	57297	26604	2
IESNS	Norwegian_Sea	herring	2013	Unknown	3098	3098	0	6863	72867	21198	2
IESNS	Norwegian_Sea	herring	2013	Number	22747311	21771685	18068708	21643527	25561747	21722465	2

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESNS	Norwegian_Sea	herring	2013	Biomass	5888224.2	5666883.3	4642435	5631655	6759235	5653313	2
IESNS	Norwegian_Sea	herring	2014	0	7811	7811	1752	6527	16058	7372	2
IESNS	Norwegian_Sea	herring	2014	1	17398	17398	1042	12723	31319	13363	2
IESNS	Norwegian_Sea	herring	2014	2	517240	517240	152944	479139	970427	515309	2
IESNS	Norwegian_Sea	herring	2014	3	1230825	1230825	628260	1192860	2063385	1257791	2
IESNS	Norwegian_Sea	herring	2014	4	797812	797812	412104	770323	1187118	783770	2
IESNS	Norwegian_Sea	herring	2014	5	2790288	2790288	1673688	2755840	4022322	2788475	2
IESNS	Norwegian_Sea	herring	2014	6	748816	748816	382283	688478	1124888	714920	2
IESNS	Norwegian_Sea	herring	2014	7	1065277	1065277	668793	1100335	1616813	1118027	2
IESNS	Norwegian_Sea	herring	2014	8	2681452	2681452	1583971	2596496	3748328	2634121	2
IESNS	Norwegian_Sea	herring	2014	9	2284660	2284660	1410118	2199598	3270888	2268107	2
IESNS	Norwegian_Sea	herring	2014	10	2842071	2842071	1897484	2786041	3785029	2805772	2
IESNS	Norwegian_Sea	herring	2014	11	1119251	1119251	821871	1114167	1418249	1117519	2
IESNS	Norwegian_Sea	herring	2014	12	777977	777977	485579	696824	939927	703363	2
IESNS	Norwegian_Sea	herring	2014	13	349807	349807	189096	336914	492154	336629	2
IESNS	Norwegian_Sea	herring	2014	14	76368	76368	25434	68295	131996	71622	2
IESNS	Norwegian_Sea	herring	2014	15	180003	180003	22542	215956	400214	194598	2
IESNS	Norwegian_Sea	herring	2014	16	9205	9205	3948	8771	16901	9494	2
IESNS	Norwegian_Sea	herring	2014	17	8280	8280	0	6953	22038	7053	2
IESNS	Norwegian_Sea	herring	2014	18	542	542	0	511	1468	523	2
IESNS	Norwegian_Sea	herring	2014	Unknown	546	546	0	565	10483	2043	2
IESNS	Norwegian_Sea	herring	2014	Number	17505629	17505629	12417373	17323098	22487945	17349872	2
IESNS	Norwegian_Sea	herring	2014	Biomass	4555289.6	4555289.7	3204044	4492173	5823383	4503629	2
IESNS	Norwegian_Sea	herring	2015	2	385431	385431	37173	373131	906248	391345	2
IESNS	Norwegian_Sea	herring	2015	3	467620	467620	186241	398258	762943	431682	2
IESNS	Norwegian_Sea	herring	2015	4	1299007	1299007	892449	1294359	1845270	1316057	2
IESNS	Norwegian_Sea	herring	2015	5	1176425	1176425	737694	1119760	1561378	1132135	2
IESNS	Norwegian_Sea	herring	2015	6	3547742	3547742	2586858	3507420	4575567	3534560	2
IESNS	Norwegian_Sea	herring	2015	7	1398738	1398738	894448	1298657	1743179	1309324	2
IESNS	Norwegian_Sea	herring	2015	8	1159659	1159659	833890	1175101	1632669	1191093	2
IESNS	Norwegian_Sea	herring	2015	9	3177943	3177943	2331993	3112447	4120395	3155723	2
IESNS	Norwegian_Sea	herring	2015	10	2523487	2523487	1944626	2507764	3208435	2526197	2
IESNS	Norwegian_Sea	herring	2015	11	4350024	4350024	3168062	4382594	5878064	4457335	2
IESNS	Norwegian_Sea	herring	2015	12	712163	712163	423359	677716	982339	686686	2
IESNS	Norwegian_Sea	herring	2015	13	787595	787595	524903	805620	1135785	815894	2
IESNS	Norwegian_Sea	herring	2015	14	262258	262258	148316	288834	452792	290182	2
IESNS	Norwegian_Sea	herring	2015	15	159258	159258	74236	164841	274366	168861	2
IESNS	Norwegian_Sea	herring	2015	16	16352	16352	5069	18360	38265	19498	2
IESNS	Norwegian_Sea	herring	2015	18	18641	18641	0	23401	61164	23066	2
IESNS	Norwegian_Sea	herring	2015	Unknown	695	695	0	642	2498	824	2
IESNS	Norwegian_Sea	herring	2015	Number	21443038	21443038	17211191	21382118	26203775	21450462	2
IESNS	Norwegian_Sea	herring	2015	Biomass	5845766.5	5845766.5	4634619	5818199	7205495	5851095	2
IESNS	Norwegian_Sea	herring	2016	2	74913	74913	16566	68221	157732	75165	4
IESNS	Norwegian_Sea	herring	2016	3	3548714	3548714	1551820	3484018	5795914	3549947	4
IESNS	Norwegian_Sea	herring	2016	4	1507991	1507991	870546	1481663	2403456	1537674	4
IESNS	Norwegian_Sea	herring	2016	5	2215377	2215377	1382832	2170103	3367762	2228756	4
IESNS	Norwegian_Sea	herring	2016	6	1778853	1778853	1040808	1675306	2692388	1748544	4
IESNS	Norwegian_Sea	herring	2016	7	2682543	2682543	1759130	2542894	3794073	2630911	4
IESNS	Norwegian_Sea	herring	2016	8	928550	928550	527985	937220	1362682	938008	4
IESNS	Norwegian_Sea	herring	2016	9	1143238	1143238	766569	1075369	1486177	1091985	4
IESNS	Norwegian_Sea	herring	2016	10	1769566	1769566	1386533	1794693	2278022	1806165	4
IESNS	Norwegian_Sea	herring	2016	11	1851338	1851338	1346668	1876441	2416047	1882028	4
IESNS	Norwegian_Sea	herring	2016	12	2877275	2877275	2105542	2856263	3595787	2853163	4
IESNS	Norwegian_Sea	herring	2016	13	929365	929365	705043	925796	1176013	933767	4
IESNS	Norwegian_Sea	herring	2016	14	439216	439216	294183	434032	598097	435648	4
IESNS	Norwegian_Sea	herring	2016	15	67344	67344	26426	67985	113514	68381	4
IESNS	Norwegian_Sea	herring	2016	16	67051	67051	9879	56791	118835	59759	4
IESNS	Norwegian_Sea	herring	2016	17	2074	2074	0	1668	6002	2036	4
IESNS	Norwegian_Sea	herring	2016	Unknown	5658	5658	684	6632	24123	9043	4
IESNS	Norwegian_Sea	herring	2016	Number	21889065	21889065	16304669	21512531	28049938	21850979	4
IESNS	Norwegian_Sea	herring	2016	Biomass	5419410.5	5419410.5	4099902	5333587	6859184	5407861	4
IESNS	Norwegian_Sea	herring	2017	1	10739	10739	0	8283	24970	9815	10
IESNS	Norwegian_Sea	herring	2017	2	132104	132104	1921	130666	261248	131156	10
IESNS	Norwegian_Sea	herring	2017	3	1062516	1062516	115881	949204	1676575	948174	10
IESNS	Norwegian_Sea	herring	2017	4	4362511	4362511	1746459	4312001	6766840	4295016	10
IESNS	Norwegian_Sea	herring	2017	5	1192292	1192292	562335	1153024	2011205	1198442	10
IESNS	Norwegian_Sea	herring	2017	6	1521880	1521880	863567	1520651	2248323	1542978	10
IESNS	Norwegian_Sea	herring	2017	7	874451	874451	432031	808997	1256054	825664	10
IESNS	Norwegian_Sea	herring	2017	8	1452815	1452815	764670	1386112	2110581	1413952	10
IESNS	Norwegian_Sea	herring	2017	9	326509	326509	186800	312461	471077	317197	10
IESNS	Norwegian_Sea	herring	2017	10	726950	726950	416106	727107	1116076	737738	10
IESNS	Norwegian_Sea	herring	2017	11	974924	974924	636256	999248	1394313	1007776	10
IESNS	Norwegian_Sea	herring	2017	12	1784745	1784745	990704	1734826	2566568	1741419	10
IESNS	Norwegian_Sea	herring	2017	13	2229068	2229068	1427328	2216192	3067494	2229967	10
IESNS	Norwegian_Sea	herring	2017	14	537932	537932	275262	498837	766428	506557	10
IESNS	Norwegian_Sea	herring	2017	15	201072	201072	94454	195736	321532	200331	10

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESNS	Norwegian_Sea	herring	2017	16	27091	27091	3716	23473	65098	28107	10
IESNS	Norwegian_Sea	herring	2017	18	9630	9630	0	9352	22211	8938	10
IESNS	Norwegian_Sea	herring	2017	Unknown	14093	14093	912	13262	40524	15363	10
IESNS	Norwegian_Sea	herring	2017	Number	17441322	17441322	10813346	17238681	23202921	17158589	10
IESNS	Norwegian_Sea	herring	2017	Biomass	4202777.1	4202777.1	2716665	4148259	5587214	4151892	10
IESNS	Norwegian_Sea	herring	2018	2	500232	500232	131914	459309	1012953	495771	10
IESNS	Norwegian_Sea	herring	2018	3	1052226	1052226	287751	899770	2031850	1003659	10
IESNS	Norwegian_Sea	herring	2018	4	2063214	2063214	1192056	1964983	2761418	1968044	10
IESNS	Norwegian_Sea	herring	2018	5	5686387	5686387	3713359	5521809	7812474	5663579	10
IESNS	Norwegian_Sea	herring	2018	6	973329	973329	651083	953139	1359720	970015	10
IESNS	Norwegian_Sea	herring	2018	7	1433588	1433588	934926	1393199	1985530	1408506	10
IESNS	Norwegian_Sea	herring	2018	8	560950	560950	378323	562310	789983	568622	10
IESNS	Norwegian_Sea	herring	2018	9	1328201	1328201	836580	1271479	1775868	1279411	10
IESNS	Norwegian_Sea	herring	2018	10	337692	337692	219873	346075	518836	353823	10
IESNS	Norwegian_Sea	herring	2018	11	688827	688827	445864	674434	908272	674647	10
IESNS	Norwegian_Sea	herring	2018	12	1564688	1564688	1025372	1549667	2126648	1563538	10
IESNS	Norwegian_Sea	herring	2018	13	1477836	1477836	862907	1436627	2134216	1464196	10
IESNS	Norwegian_Sea	herring	2018	14	1528668	1528668	978178	1476275	2041455	1498051	10
IESNS	Norwegian_Sea	herring	2018	15	257783	257783	146127	265415	424111	272742	10
IESNS	Norwegian_Sea	herring	2018	16	193815	193815	107163	189370	295559	194496	10
IESNS	Norwegian_Sea	herring	2018	17	36423	36423	7097	31477	62276	32628	10
IESNS	Norwegian_Sea	herring	2018	Unknown			0	299	2416	700	10
IESNS	Norwegian_Sea	herring	2018	Number	19683857	19683857	13543069	19261691	25182909	19412428	10
IESNS	Norwegian_Sea	herring	2018	Biomass	5041660.7	5041660.7	3470603	4948520	6535430	4987032	10
IESNS	Norwegian_Sea	herring	2019	1	6030	6030	0	1737	16092	4253	13
IESNS	Norwegian_Sea	herring	2019	2	167393	167393	19945	136325	365389	156651	13
IESNS	Norwegian_Sea	herring	2019	3	2595359	2595359	880801	2511561	4891923	2625352	13
IESNS	Norwegian_Sea	herring	2019	4	690716	690716	356783	661677	1083657	679561	13
IESNS	Norwegian_Sea	herring	2019	5	2170003	2170003	1424929	2161317	2986304	2187431	13
IESNS	Norwegian_Sea	herring	2019	6	4785101	4785101	3357535	4612455	6017484	4656014	13
IESNS	Norwegian_Sea	herring	2019	7	1255113	1255113	714324	1140903	1648481	1158391	13
IESNS	Norwegian_Sea	herring	2019	8	1207504	1207504	745596	1217230	1781801	1222625	13
IESNS	Norwegian_Sea	herring	2019	9	921939	921939	521146	928966	1437963	952365	13
IESNS	Norwegian_Sea	herring	2019	10	1294606	1294606	716536	1211112	1823516	1231739	13
IESNS	Norwegian_Sea	herring	2019	11	804871	804871	435031	796095	1329869	823072	13
IESNS	Norwegian_Sea	herring	2019	12	686609	686609	329031	631686	1054395	654887	13
IESNS	Norwegian_Sea	herring	2019	13	1380702	1380702	613053	1351064	2466605	1406015	13
IESNS	Norwegian_Sea	herring	2019	14	937888	937888	441973	898271	1469827	916909	13
IESNS	Norwegian_Sea	herring	2019	15	660516	660516	304566	620282	1079790	655758	13
IESNS	Norwegian_Sea	herring	2019	16	150376	150376	51804	133930	259196	141695	13
IESNS	Norwegian_Sea	herring	2019	17	5027	5027	0	3265	14281	4556	13
IESNS	Norwegian_Sea	herring	2019	Unknown	8306	8306	570	8874	22910	10019	13
IESNS	Norwegian_Sea	herring	2019	Number	19728061	19728061	13657032	19332538	25622289	19487293	13
IESNS	Norwegian_Sea	herring	2019	Biomass	4873582.1	4873582.1	3301011	4763405	6569553	4804924	13
IESNS	Barents_Sea	herring	2009	1	286230	286230	44209	273659	698428	312316	2
IESNS	Barents_Sea	herring	2009	2	286230	286230	0	253994	746491	295767	2
IESNS	Barents_Sea	herring	2009	3	214672	214672	56554	203745	524415	232683	2
IESNS	Barents_Sea	herring	2009	4	71557	71557	0	55750	172672	60183	2
IESNS	Barents_Sea	herring	2009	Number	858690	858690	344668	846497	1611133	900949	2
IESNS	Barents_Sea	herring	2009	Biomass	30454.9	30454.9	12986	29401	51031	30446	2
IESNS	Barents_Sea	herring	2010	1	5120882	5120882	1874991	4830412	9359323	5118250	2
IESNS	Barents_Sea	herring	2010	2	1366379	1366379	397506	1214943	2829056	1382935	2
IESNS	Barents_Sea	herring	2010	Number	6487261	6487261	2505369	6249618	11856625	6501185	2
IESNS	Barents_Sea	herring	2010	Biomass	84850.7	84850.7	31592	79889	157029	85160	2
IESNS	Barents_Sea	herring	2011	1	1079000	1079000	367805	985029	2585941	1186567	2
IESNS	Barents_Sea	herring	2011	2	3802156	3802156	1944487	3768033	6384780	3916617	2
IESNS	Barents_Sea	herring	2011	3	39364	39364	11788	37981	80323	40994	2
IESNS	Barents_Sea	herring	2011	Number	4920521	4920521	2574437	4879011	8472548	5144177	2
IESNS	Barents_Sea	herring	2011	Biomass	105766.2	105766.2	54633	105177	177633	109608	2
IESNS	Barents_Sea	herring	2012	1	884247	884247	163100	729875	1481495	771580	2
IESNS	Barents_Sea	herring	2012	2	15246	15246	0	9904	123971	27970	2
IESNS	Barents_Sea	herring	2012	Number	899492	899492	183583	775497	1503603	799550	2
IESNS	Barents_Sea	herring	2012	Biomass	14986.5	14986.5	3720	15078	28648	15689	2
IESNS	Barents_Sea	herring	2013	1	132112	132112	0	120699	203392	105482	2
IESNS	Barents_Sea	herring	2013	2	1981674	1981674	1223622	2094894	3506366	2190520	2
IESNS	Barents_Sea	herring	2013	3	264223	264223	0	241398	406783	210964	2
IESNS	Barents_Sea	herring	2013	4	88074	88074	0	80466	135594	70321	2
IESNS	Barents_Sea	herring	2013	Number	2466083	2466083	1462259	2547966	3839729	2577287	2
IESNS	Barents_Sea	herring	2013	Biomass	90813.5	90813.5	50203	87559	134551	89419	2
IESNS	Barents_Sea	herring	2014	1	3726921	3726921	1485127	3533426	7435491	3874552	2
IESNS	Barents_Sea	herring	2014	2	3055187	3055187	1577286	2984874	4956740	3110065	2
IESNS	Barents_Sea	herring	2014	3	1797091	1797091	840795	1692883	2739109	1728460	2
IESNS	Barents_Sea	herring	2014	4	131314	131314	21641	124290	261511	126818	2
IESNS	Barents_Sea	herring	2014	5	43771	43771	0	40485	94968	43406	2
IESNS	Barents_Sea	herring	2014	Number	8754285	8754285	4770572	8737552	13477645	8883301	2
IESNS	Barents_Sea	herring	2014	Biomass	269378.4	269378.4	147128	259910	389523	266275	2

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESNS	Barents_Sea	herring	2015	1	330425	330425	0	314614	926657	335532	2
IESNS	Barents_Sea	herring	2015	2	11470650	11470650	6222644	11395340	18975128	11758491	2
IESNS	Barents_Sea	herring	2015	3	1217661	1217661	0	1149314	2171245	1182519	2
IESNS	Barents_Sea	herring	2015	4	198255	198255	0	198124	514966	205919	2
IESNS	Barents_Sea	herring	2015	Number	13216990	13216990	7603790	13233268	20736815	13482462	2
IESNS	Barents_Sea	herring	2015	Biomass	474660.3	474660.3	287082	471551	683017	475564	2
IESNS	Barents_Sea	herring	2016	1	1677338	1677338	396951	1508106	3842845	1778679	4
IESNS	Barents_Sea	herring	2016	2	5462758	5462758	2462738	5340482	9726259	5618829	4
IESNS	Barents_Sea	herring	2016	3	1668104	1668104	0	1499140	3122460	1568307	4
IESNS	Barents_Sea	herring	2016	4	103306	103306	0	94947	276272	100686	4
IESNS	Barents_Sea	herring	2016	5	41643	41643	0	39476	98338	38375	4
IESNS	Barents_Sea	herring	2016	Number	8953148	8953148	4487577	8780251	14598207	9104877	4
IESNS	Barents_Sea	herring	2016	Biomass	278025.2	278025.2	144608	267157	431182	274268	4
IESNS	Barents_Sea	herring	2017	1	14657837	14657837	7229149	14076856	23829370	14608852	4
IESNS	Barents_Sea	herring	2017	2	3265555	3265555	346173	3144216	6740548	3079460	4
IESNS	Barents_Sea	herring	2017	Number	17923392	17923392	9622479	17541052	26249148	17688312	4
IESNS	Barents_Sea	herring	2017	Biomass	275726.4	275726.4	139179	267233	407031	268754	4
IESNS	Barents_Sea	herring	2018	1	6865924	6865924	1474761	6326360	16328919	7347639	4
IESNS	Barents_Sea	herring	2018	2	17403628	17403628	8212735	16814635	27471101	17422411	4
IESNS	Barents_Sea	herring	2018	3	943215	943215	102890	753234	1876840	826939	4
IESNS	Barents_Sea	herring	2018	4	9227	9227	0	7959	26707	8896	4
IESNS	Barents_Sea	herring	2018	Unknown	520041	520041	0	468293	1713064	568994	4
IESNS	Barents_Sea	herring	2018	Number	25742035	25742035	13031195	25691716	41654829	26174880	4
IESNS	Barents_Sea	herring	2018	Biomass	709168.2	709168.2	372219	675345	1036043	688655	4
IESNS	Barents_Sea	herring	2019	1	111989	111989	9365	96790	308627	114227	4
IESNS	Barents_Sea	herring	2019	2	2305387	2305387	460038	2161443	4772482	2367279	4
IESNS	Barents_Sea	herring	2019	3	17314842	17314842	10308447	17125508	25696462	17480889	4
IESNS	Barents_Sea	herring	2019	4	22827	22827	0	42345	120114	44296	4
IESNS	Barents_Sea	herring	2019	Unknown			0	0	8321	963	4
IESNS	Barents_Sea	herring	2019	Number	19755046	19755046	11945854	19641731	29099583	20007653	4
IESNS	Barents_Sea	herring	2019	Biomass	1229766.6	1229766.6	744977	1221498	1815791	1246809	4
NORHERSS	Norwegian_Coast	herring	1988	3	374603	374603	187204	384320	617867	392072	16
NORHERSS	Norwegian_Coast	herring	1988	4	298904	298904	165460	297656	473138	307046	16
NORHERSS	Norwegian_Coast	herring	1988	5	8065648	8065648	5219990	8038745	10819126	8014938	16
NORHERSS	Norwegian_Coast	herring	1988	6	85867	85867	41698	79515	127310	81218	16
NORHERSS	Norwegian_Coast	herring	1988	7	32920	32920	3552	30936	65629	32817	16
NORHERSS	Norwegian_Coast	herring	1988	8	10981	10981	0	10218	33470	11553	16
NORHERSS	Norwegian_Coast	herring	1988	9	37539	37539	3593	33686	74089	36378	16
NORHERSS	Norwegian_Coast	herring	1988	10	21962	21962	0	20249	47864	22201	16
NORHERSS	Norwegian_Coast	herring	1988	11	41457	41457	7243	42895	89706	44905	16
NORHERSS	Norwegian_Coast	herring	1988	Number	8969880	8969880	5842768	8954564	12065118	8943129	16
NORHERSS	Norwegian_Coast	herring	1988	Biomass	1630917.2	1630917.2	1063273	1619586	2180321	1621459	16
NORHERSS	Norwegian_Coast	herring	1989	1	235	235	0	208	722	248	16
NORHERSS	Norwegian_Coast	herring	1989	2	164495	164495	30732	140005	362297	161159	16
NORHERSS	Norwegian_Coast	herring	1989	3	16513	16513	5078	15540	29435	16190	16
NORHERSS	Norwegian_Coast	herring	1989	4	335657	335657	166425	330045	532293	337708	16
NORHERSS	Norwegian_Coast	herring	1989	5	88606	88606	43420	90527	140228	90920	16
NORHERSS	Norwegian_Coast	herring	1989	6	3995251	3995251	2686787	3886346	5500114	3972899	16
NORHERSS	Norwegian_Coast	herring	1989	7	105868	105868	45349	96321	171734	101207	16
NORHERSS	Norwegian_Coast	herring	1989	8	11701	11701	0	10732	27571	11539	16
NORHERSS	Norwegian_Coast	herring	1989	9	7801	7801	0	4167	11534	4202	16
NORHERSS	Norwegian_Coast	herring	1989	10	58507	58507	20913	52084	98493	54817	16
NORHERSS	Norwegian_Coast	herring	1989	12	3900	3900	0	4030	9475	3752	16
NORHERSS	Norwegian_Coast	herring	1989	13	39004	39004	17643	40167	73929	42362	16
NORHERSS	Norwegian_Coast	herring	1989	15	3900	3900	0	4054	12671	4341	16
NORHERSS	Norwegian_Coast	herring	1989	16	3900	3900	0	4096	13660	4523	16
NORHERSS	Norwegian_Coast	herring	1989	Unknown	3900	3900	0	4723	26049	7490	16
NORHERSS	Norwegian_Coast	herring	1989	Number	4839239	4839239	3265342	4724794	6733624	4813359	16
NORHERSS	Norwegian_Coast	herring	1989	Biomass	1175408.7	1175408.7	789165	1144296	1623385	1168828	16
NORHERSS	Norwegian_Coast	herring	1994	2	43035	43035	867	32170	81408	37094	16
NORHERSS	Norwegian_Coast	herring	1994	3	99459	99459	38831	92355	183574	99663	16
NORHERSS	Norwegian_Coast	herring	1994	4	48250	48250	20455	44835	82897	47576	16
NORHERSS	Norwegian_Coast	herring	1994	5	851470	851470	591599	838749	1138379	848448	16
NORHERSS	Norwegian_Coast	herring	1994	6	480073	480073	326384	475693	672135	483091	16
NORHERSS	Norwegian_Coast	herring	1994	7	72866	72866	33913	61216	91242	62049	16
NORHERSS	Norwegian_Coast	herring	1994	8	15483	15483	2653	12169	24606	12612	16
NORHERSS	Norwegian_Coast	herring	1994	9	152495	152495	97130	139801	206346	144215	16
NORHERSS	Norwegian_Coast	herring	1994	10	43216	43216	27174	47160	79016	48968	16
NORHERSS	Norwegian_Coast	herring	1994	11	1838205	1838205	1370589	1814948	2337449	1835719	16
NORHERSS	Norwegian_Coast	herring	1994	12	3079	3079	0	3964	10634	3955	16
NORHERSS	Norwegian_Coast	herring	1994	13	3310	3310	0	3867	8782	3554	16
NORHERSS	Norwegian_Coast	herring	1994	Unknown	18268	18268	0	28962	112853	38166	16
NORHERSS	Norwegian_Coast	herring	1994	Number	3669209	3669209	2724303	3617896	4702421	3665109	16
NORHERSS	Norwegian_Coast	herring	1994	Biomass	1215058.9	1215058.9	888798	1197006	1561870	1206832	16
NORHERSS	Norwegian_Coast	herring	1995	1	507539	507539	0	484341	2161668	636233	16
NORHERSS	Norwegian_Coast	herring	1995	2	4003	4003	0	3017	12351	4097	16

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
NORHERSS	Norwegian_Coast	herring	1995	3	408581	408581	229542	427024	749194	449647	16
NORHERSS	Norwegian_Coast	herring	1995	4	4643084	4643084	3299564	4596202	6354352	4679231	16
NORHERSS	Norwegian_Coast	herring	1995	5	3185730	3185730	2547983	3160227	4020784	3210783	16
NORHERSS	Norwegian_Coast	herring	1995	6	1986023	1986023	1547022	1945290	2409139	1957337	16
NORHERSS	Norwegian_Coast	herring	1995	7	291659	291659	209961	289188	420888	299326	16
NORHERSS	Norwegian_Coast	herring	1995	8	17916	17916	0	18136	39639	19884	16
NORHERSS	Norwegian_Coast	herring	1995	10	140866	140866	57600	103622	162340	106357	16
NORHERSS	Norwegian_Coast	herring	1995	11	75676	75676	30226	54457	82789	55177	16
NORHERSS	Norwegian_Coast	herring	1995	12	2299029	2299029	1802614	2310822	2873463	2326927	16
NORHERSS	Norwegian_Coast	herring	1995	Number	13560106	13560106	11067521	13581883	16890617	13745000	16
NORHERSS	Norwegian_Coast	herring	1995	Biomass	2858038	2858038	2425797	2855370	3335054	2859587	16
NORHERSS	Norwegian_Coast	herring	1996	2	126068	126068	42979	107543	244244	119277	16
NORHERSS	Norwegian_Coast	herring	1996	3	147208	147208	76321	173346	339589	185781	16
NORHERSS	Norwegian_Coast	herring	1996	4	1884513	1884513	1088771	1888669	3155015	1975895	16
NORHERSS	Norwegian_Coast	herring	1996	5	7922920	7922920	4857226	7733939	11705407	7960380	16
NORHERSS	Norwegian_Coast	herring	1996	6	2383905	2383905	1548367	2288218	3223118	2326141	16
NORHERSS	Norwegian_Coast	herring	1996	7	886705	886705	556622	861981	1257872	874826	16
NORHERSS	Norwegian_Coast	herring	1996	8	314150	314150	142236	283449	522740	301068	16
NORHERSS	Norwegian_Coast	herring	1996	10	389	389	0	355	936	359	16
NORHERSS	Norwegian_Coast	herring	1996	11	121028	121028	56291	133378	231596	136298	16
NORHERSS	Norwegian_Coast	herring	1996	13	1829538	1829538	1043729	1734318	2598170	1760216	16
NORHERSS	Norwegian_Coast	herring	1996	Unknown			0	0	20758	4340	16
NORHERSS	Norwegian_Coast	herring	1996	Number	15616423	15616423	10125740	15170338	22066764	15644581	16
NORHERSS	Norwegian_Coast	herring	1996	Biomass	3381603.4	3381603.4	2213357	3279270	4669042	3366374	16
NORHERSS	Norwegian_Coast	herring	1998	2	40987	40987	2602	38925	138369	50666	16
NORHERSS	Norwegian_Coast	herring	1998	3	329831	329831	14783	267413	718735	307775	16
NORHERSS	Norwegian_Coast	herring	1998	4	983651	983651	479227	928703	1586992	978064	16
NORHERSS	Norwegian_Coast	herring	1998	5	3012034	3012034	1535995	2893185	4636555	2981739	16
NORHERSS	Norwegian_Coast	herring	1998	6	13088884	13088884	5694200	12422115	22131658	12858939	16
NORHERSS	Norwegian_Coast	herring	1998	7	8213665	8213665	4493063	7956151	12545704	8132505	16
NORHERSS	Norwegian_Coast	herring	1998	8	1908962	1908962	1010107	1804456	2813443	1851284	16
NORHERSS	Norwegian_Coast	herring	1998	9	587757	587757	378239	584833	830782	591926	16
NORHERSS	Norwegian_Coast	herring	1998	10	193781	193781	79849	161347	256671	162774	16
NORHERSS	Norwegian_Coast	herring	1998	11	34864	34864	0	39864	109332	42583	16
NORHERSS	Norwegian_Coast	herring	1998	13	359341	359341	136197	322283	535499	328924	16
NORHERSS	Norwegian_Coast	herring	1998	15	1408141	1408141	784549	1325014	2214373	1392925	16
NORHERSS	Norwegian_Coast	herring	1998	17	7212	7212	0	6797	20257	6870	16
NORHERSS	Norwegian_Coast	herring	1998	Unknown			0	0	102112	18207	16
NORHERSS	Norwegian_Coast	herring	1998	Number	30169108	30169108	15426310	28919428	47358397	29705181	16
NORHERSS	Norwegian_Coast	herring	1998	Biomass	7007526.7	7007526.7	3578517	6731421	10859458	6885806	16
NORHERSS	Norwegian_Coast	herring	1999	2	118883	118883	49928	109653	194567	113558	16
NORHERSS	Norwegian_Coast	herring	1999	3	1572361	1572361	942736	1499928	2231668	1529550	16
NORHERSS	Norwegian_Coast	herring	1999	4	378798	378798	254725	364901	502387	369419	16
NORHERSS	Norwegian_Coast	herring	1999	5	1365583	1365583	1025840	1334992	1729706	1350906	16
NORHERSS	Norwegian_Coast	herring	1999	6	2593077	2593077	1950640	2614464	3531812	2668571	16
NORHERSS	Norwegian_Coast	herring	1999	7	9355607	9355607	6291672	8982433	13190210	9333845	16
NORHERSS	Norwegian_Coast	herring	1999	8	6979046	6979046	5216720	6864097	9190913	7004171	16
NORHERSS	Norwegian_Coast	herring	1999	9	1631781	1631781	1174273	1632283	2288890	1665868	16
NORHERSS	Norwegian_Coast	herring	1999	10	494530	494530	333358	503825	706796	510596	16
NORHERSS	Norwegian_Coast	herring	1999	11	124101	124101	62660	122776	227500	130058	16
NORHERSS	Norwegian_Coast	herring	1999	12	187	187	0	147	463	164	16
NORHERSS	Norwegian_Coast	herring	1999	14	360483	360483	173625	331217	617325	352611	16
NORHERSS	Norwegian_Coast	herring	1999	16	359027	359027	189078	360085	604714	372757	16
NORHERSS	Norwegian_Coast	herring	1999	Unknown	29003	29003	689	23615	122137	35830	16
NORHERSS	Norwegian_Coast	herring	1999	Number	25362467	25362467	19106206	25041151	32986783	25437902	16
NORHERSS	Norwegian_Coast	herring	1999	Biomass	6234984.5	6234984.5	4577282	6154397	8260858	6262260	16
NORHERSS	Norwegian_Coast	herring	2000	2	1398568	1398568	296025	1178395	3437398	1394284	16
NORHERSS	Norwegian_Coast	herring	2000	3	671937	671937	153484	607095	1495561	691093	16
NORHERSS	Norwegian_Coast	herring	2000	4	2617324	2617324	1248570	2488459	4504185	2599618	16
NORHERSS	Norwegian_Coast	herring	2000	5	103424	103424	49454	100767	190762	108615	16
NORHERSS	Norwegian_Coast	herring	2000	6	485147	485147	298031	460249	711496	477074	16
NORHERSS	Norwegian_Coast	herring	2000	7	1138801	1138801	805664	1126319	1524513	1144213	16
NORHERSS	Norwegian_Coast	herring	2000	8	4193036	4193036	3074297	4218317	5751852	4281628	16
NORHERSS	Norwegian_Coast	herring	2000	9	2863510	2863510	2003148	2770403	3858813	2837595	16
NORHERSS	Norwegian_Coast	herring	2000	10	547462	547462	339165	478176	697683	493352	16
NORHERSS	Norwegian_Coast	herring	2000	11	47948	47948	20858	45960	92034	50150	16
NORHERSS	Norwegian_Coast	herring	2000	12	1837	1837	0	1683	5791	1950	16
NORHERSS	Norwegian_Coast	herring	2000	14	15041	15041	0	7420	17589	7460	16
NORHERSS	Norwegian_Coast	herring	2000	15	99873	99873	57328	100378	168825	105505	16
NORHERSS	Norwegian_Coast	herring	2000	17	116966	116966	59672	112880	212667	122090	16
NORHERSS	Norwegian_Coast	herring	2000	Unknown			0	0	0	46	16
NORHERSS	Norwegian_Coast	herring	2000	Number	14300871	14300871	9765184	13954366	20093828	14314673	16
NORHERSS	Norwegian_Coast	herring	2000	Biomass	3283461.7	3283461.7	2346906	3225409	4355640	3285175	16
NORHERSS	Norwegian_Coast	herring	2005	2	38710	38710	0	36859	99570	37596	16
NORHERSS	Norwegian_Coast	herring	2005	3	269681	269681	102532	227107	398430	237569	16
NORHERSS	Norwegian_Coast	herring	2005	4	661637	661637	413492	640853	977767	660630	16

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
NORHERSS	Norwegian_Coast	herring	2005	5	2085539	2085539	1282587	2076363	3111773	2127853	16
NORHERSS	Norwegian_Coast	herring	2005	6	5871410	5871410	3686326	5874336	8422084	5946610	16
NORHERSS	Norwegian_Coast	herring	2005	7	8223283	8223283	5652141	8273309	11419113	8328377	16
NORHERSS	Norwegian_Coast	herring	2005	8	659511	659511	296472	605479	993003	613433	16
NORHERSS	Norwegian_Coast	herring	2005	9	456577	456577	320443	472993	780388	503070	16
NORHERSS	Norwegian_Coast	herring	2005	10	182739	182739	51317	147906	282488	155705	16
NORHERSS	Norwegian_Coast	herring	2005	11	112893	112893	33277	85548	175086	91719	16
NORHERSS	Norwegian_Coast	herring	2005	12	557309	557309	344330	559769	860406	576236	16
NORHERSS	Norwegian_Coast	herring	2005	13	1138024	1138024	644436	1103227	1798314	1151649	16
NORHERSS	Norwegian_Coast	herring	2005	14	595067	595067	335287	557213	929454	586966	16
NORHERSS	Norwegian_Coast	herring	2005	20	6452	6452	0	6285	26969	8877	16
NORHERSS	Norwegian_Coast	herring	2005	Unknown			0	0	0	53	16
NORHERSS	Norwegian_Coast	herring	2005	Number	20858830	20858830	14146642	20873265	28592225	21026341	16
NORHERSS	Norwegian_Coast	herring	2005	Biomass	5222861.2	5222861.2	3532955	5197887	7149636	5260441	16
NORHERSS	Norwegian_Coast	herring	2006	2	26695	26695	10284	24454	46424	25605	16
NORHERSS	Norwegian_Coast	herring	2006	3	98241	98241	45905	83854	154865	90084	16
NORHERSS	Norwegian_Coast	herring	2006	4	6072690	6072690	4448210	6054977	7833927	6053546	16
NORHERSS	Norwegian_Coast	herring	2006	5	478146	478146	376313	540036	753880	548490	16
NORHERSS	Norwegian_Coast	herring	2006	6	911876	911876	567041	874775	1227520	882279	16
NORHERSS	Norwegian_Coast	herring	2006	7	3291329	3291329	2525084	3308673	4351654	3362226	16
NORHERSS	Norwegian_Coast	herring	2006	8	3289662	3289662	2414935	3270583	4387033	3310961	16
NORHERSS	Norwegian_Coast	herring	2006	9	122018	122018	48441	106903	178805	110252	16
NORHERSS	Norwegian_Coast	herring	2006	10	66601	66601	39573	84308	133933	85840	16
NORHERSS	Norwegian_Coast	herring	2006	11	25483	25483	0	12015	71321	20491	16
NORHERSS	Norwegian_Coast	herring	2006	12	71580	71580	37362	84436	157876	89350	16
NORHERSS	Norwegian_Coast	herring	2006	13	53875	53875	19904	54033	105140	57938	16
NORHERSS	Norwegian_Coast	herring	2006	14	265282	265282	126416	224162	438869	246147	16
NORHERSS	Norwegian_Coast	herring	2006	15	62525	62525	14756	57636	131365	62666	16
NORHERSS	Norwegian_Coast	herring	2006	Unknown			0	0	29288	4927	16
NORHERSS	Norwegian_Coast	herring	2006	Number	14836002	14836002	11320309	14910304	18514209	14950800	16
NORHERSS	Norwegian_Coast	herring	2006	Biomass	3391648.3	3391648.3	2579405	3418085	4256061	3430949	16
NORHERSS	Norwegian_Coast	herring	2007	2	31722	31722	0	30433	84096	33288	16
NORHERSS	Norwegian_Coast	herring	2007	3	368581	368581	16235	345923	930835	367476	16
NORHERSS	Norwegian_Coast	herring	2007	4	1593660	1593660	1154810	1606153	2144776	1618426	16
NORHERSS	Norwegian_Coast	herring	2007	5	12174763	12174763	9687952	12359761	15284599	12396596	16
NORHERSS	Norwegian_Coast	herring	2007	6	621927	621927	465411	781849	1301383	815189	16
NORHERSS	Norwegian_Coast	herring	2007	7	645698	645698	403497	644699	939645	655379	16
NORHERSS	Norwegian_Coast	herring	2007	8	2841703	2841703	2079880	2891651	4048926	2955626	16
NORHERSS	Norwegian_Coast	herring	2007	9	3258378	3258378	2365580	3159573	4200063	3204945	16
NORHERSS	Norwegian_Coast	herring	2007	10	136725	136725	43052	135306	260162	140650	16
NORHERSS	Norwegian_Coast	herring	2007	11	222747	222747	119701	220085	365869	228063	16
NORHERSS	Norwegian_Coast	herring	2007	12	33861	33861	8626	36215	86716	39932	16
NORHERSS	Norwegian_Coast	herring	2007	13	179146	179146	83935	192630	371294	204153	16
NORHERSS	Norwegian_Coast	herring	2007	14	261921	261921	130717	270393	474146	284268	16
NORHERSS	Norwegian_Coast	herring	2007	15	502737	502737	231066	410946	643705	419716	16
NORHERSS	Norwegian_Coast	herring	2007	16	51039	51039	11846	47746	95784	49938	16
NORHERSS	Norwegian_Coast	herring	2007	Unknown	4398	4398	2736	9657	34697	13210	16
NORHERSS	Norwegian_Coast	herring	2007	Number	22929006	22929006	18679442	23150624	28959383	23426855	16
NORHERSS	Norwegian_Coast	herring	2007	Biomass	5238000.6	5238000.6	4220754	5298457	6666856	5350278	16
NORHERSS	Norwegian_Coast	herring	2008	2	15219	15219	0	14034	38905	14854	16
NORHERSS	Norwegian_Coast	herring	2008	3	70221	70221	0	29421	155884	47952	16
NORHERSS	Norwegian_Coast	herring	2008	4	2448546	2448546	738324	2339161	5420012	2563593	16
NORHERSS	Norwegian_Coast	herring	2008	5	2699061	2699061	1563719	2771677	4331705	2824377	16
NORHERSS	Norwegian_Coast	herring	2008	6	9059833	9059833	5017944	8848352	13451534	8882331	16
NORHERSS	Norwegian_Coast	herring	2008	7	529763	529763	251578	482226	914112	522322	16
NORHERSS	Norwegian_Coast	herring	2008	8	475526	475526	213670	445427	800604	470538	16
NORHERSS	Norwegian_Coast	herring	2008	9	1598607	1598607	825018	1527569	2474659	1565829	16
NORHERSS	Norwegian_Coast	herring	2008	10	1599856	1599856	776506	1482673	2608964	1567151	16
NORHERSS	Norwegian_Coast	herring	2008	11	153492	153492	63663	151810	291327	161219	16
NORHERSS	Norwegian_Coast	herring	2008	12	104334	104334	27536	88302	220723	101520	16
NORHERSS	Norwegian_Coast	herring	2008	13	49269	49269	0	37426	118829	46450	16
NORHERSS	Norwegian_Coast	herring	2008	14	137960	137960	32203	119190	248480	127950	16
NORHERSS	Norwegian_Coast	herring	2008	15	64875	64875	9505	60368	165549	70091	16
NORHERSS	Norwegian_Coast	herring	2008	16	87318	87318	17199	58512	137672	65585	16
NORHERSS	Norwegian_Coast	herring	2008	Unknown			0	17027	267326	58023	16
NORHERSS	Norwegian_Coast	herring	2008	Number	19093880	19093880	10632369	18894607	29681178	19089786	16
NORHERSS	Norwegian_Coast	herring	2008	Biomass	4580640.6	4580640.6	2588010	4510741	6919009	4552764	16
NORHERSS	Norwegian_Coast	herring	2015	2	229895	229895	56431	190290	395248	203557	16
NORHERSS	Norwegian_Coast	herring	2015	3	516235	516235	162278	487127	1115938	533303	16
NORHERSS	Norwegian_Coast	herring	2015	4	2748085	2748085	1217538	2718992	4605681	2754395	16
NORHERSS	Norwegian_Coast	herring	2015	5	768041	768041	511440	733052	1012552	744426	16
NORHERSS	Norwegian_Coast	herring	2015	6	3223010	3223010	2507371	3245102	4094964	3267249	16
NORHERSS	Norwegian_Coast	herring	2015	7	377138	377138	235900	378116	560965	388274	16
NORHERSS	Norwegian_Coast	herring	2015	8	649971	649971	385115	685590	1032310	691904	16
NORHERSS	Norwegian_Coast	herring	2015	9	2868220	2868220	1956852	2692989	3503765	2714587	16
NORHERSS	Norwegian_Coast	herring	2015	10	720429	720429	527697	775462	1069177	783995	16

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
NORHERSS	Norwegian_Coast	herring	2015	11	7250984	7341463	5618100	7215774	8854996	7222302	16
NORHERSS	Norwegian_Coast	herring	2015	12	335833	335833	157307	359681	611244	366743	16
NORHERSS	Norwegian_Coast	herring	2015	13	1732512	1642034	1224761	1640490	2157825	1657531	16
NORHERSS	Norwegian_Coast	herring	2015	14	50017	50017	421	47484	114667	51448	16
NORHERSS	Norwegian_Coast	herring	2015	15	219675	219675	100994	228225	346808	228312	16
NORHERSS	Norwegian_Coast	herring	2015	16	8949	8949	0	9873	21407	8965	16
NORHERSS	Norwegian_Coast	herring	2015	Unknown	13182	13182	0	20679	140856	45295	16
NORHERSS	Norwegian_Coast	herring	2015	Number	21712177	21712177	17302671	21614303	26028404	21662286	16
NORHERSS	Norwegian_Coast	herring	2015	Biomass	6390470.2	6390470.2	5117446	6370117	7578889	6365278	16
NORHERSS	Norwegian_Coast	herring	2016	2	16937	16937	3800	15437	42703	18092	16
NORHERSS	Norwegian_Coast	herring	2016	3	217629	208241	59489	176427	398687	196815	16
NORHERSS	Norwegian_Coast	herring	2016	4	253307	258712	63712	211864	476180	236517	16
NORHERSS	Norwegian_Coast	herring	2016	5	538935	564248	288826	547032	1037654	594404	16
NORHERSS	Norwegian_Coast	herring	2016	6	403892	403678	154591	341649	676339	364706	16
NORHERSS	Norwegian_Coast	herring	2016	7	2288422	2352311	636733	2078644	3857757	2118691	16
NORHERSS	Norwegian_Coast	herring	2016	8	242103	241604	84200	221366	462687	239661	16
NORHERSS	Norwegian_Coast	herring	2016	9	569128	562569	189280	491575	940934	513983	16
NORHERSS	Norwegian_Coast	herring	2016	10	2791968	2855373	830345	2890246	5304987	2930342	16
NORHERSS	Norwegian_Coast	herring	2016	11	681097	642762	310374	620792	1122039	651919	16
NORHERSS	Norwegian_Coast	herring	2016	12	4144213	4064483	1500702	3956465	6747990	3995097	16
NORHERSS	Norwegian_Coast	herring	2016	13	197053	192433	88998	187000	351374	199071	16
NORHERSS	Norwegian_Coast	herring	2016	14	981624	991829	355160	808544	1382389	824234	16
NORHERSS	Norwegian_Coast	herring	2016	15	15921	13236	631	16326	41278	16658	16
NORHERSS	Norwegian_Coast	herring	2016	16	83121	56796	21482	60934	158617	70704	16
NORHERSS	Norwegian_Coast	herring	2016	17	7266	7197	771	8590	19547	9170	16
NORHERSS	Norwegian_Coast	herring	2016	18	414	621	0	417	1216	456	16
NORHERSS	Norwegian_Coast	herring	2016	Unknown	130	130	51	150	6630	1263	16
NORHERSS	Norwegian_Coast	herring	2016	Number	13433160	13433160	5062322	12856832	22243902	12981784	16
NORHERSS	Norwegian_Coast	herring	2016	Biomass	4338176.1	4338176.1	1577779	4137932	7194743	4182420	16
NORHERSS	Norwegian_Coast	herring	2017	2	13165	13165	0	11328	65545	19196	16
NORHERSS	Norwegian_Coast	herring	2017	3	95049	95049	39068	99982	219945	109815	16
NORHERSS	Norwegian_Coast	herring	2017	4	1077991	1077991	733929	1059336	1483555	1076003	16
NORHERSS	Norwegian_Coast	herring	2017	5	665786	665786	501114	633777	801453	641482	16
NORHERSS	Norwegian_Coast	herring	2017	6	867735	867735	692799	875739	1079764	879922	16
NORHERSS	Norwegian_Coast	herring	2017	7	410941	410941	315073	424233	550960	427930	16
NORHERSS	Norwegian_Coast	herring	2017	8	1375673	1375673	1036982	1319739	1632246	1325902	16
NORHERSS	Norwegian_Coast	herring	2017	9	176430	176430	127142	180089	245285	181060	16
NORHERSS	Norwegian_Coast	herring	2017	10	231406	231406	133378	201680	293412	206482	16
NORHERSS	Norwegian_Coast	herring	2017	11	1902667	1902667	1659792	2013408	2421349	2025743	16
NORHERSS	Norwegian_Coast	herring	2017	12	295443	295443	215404	300309	404215	302581	16
NORHERSS	Norwegian_Coast	herring	2017	13	2600282	2600282	2121369	2520234	3045740	2542459	16
NORHERSS	Norwegian_Coast	herring	2017	14	74042	74042	46604	78219	123059	80449	16
NORHERSS	Norwegian_Coast	herring	2017	15	632564	632564	528495	655116	802631	658616	16
NORHERSS	Norwegian_Coast	herring	2017	16	18628	18628	0	10331	27631	11646	16
NORHERSS	Norwegian_Coast	herring	2017	17	29738	29738	11995	32450	65453	34768	16
NORHERSS	Norwegian_Coast	herring	2017	18	8366	8366	0	12368	35980	13143	16
NORHERSS	Norwegian_Coast	herring	2017	19	3527	3527	0	3655	9265	4083	16
NORHERSS	Norwegian_Coast	herring	2017	20	4536	4536	0	5401	16176	5764	16
NORHERSS	Norwegian_Coast	herring	2017	Unknown	2169	2169	0	2357	10444	3391	16
NORHERSS	Norwegian_Coast	herring	2017	Number	10486138	10486138	9104057	10502786	12049921	10550433	16
NORHERSS	Norwegian_Coast	herring	2017	Biomass	3295270.6	3295270.6	2864927	3296628	3773236	3313719	16
NORHERSS	Norwegian_Coast	herring	2018	2	94541	94541	1533	83406	338073	104108	16
NORHERSS	Norwegian_Coast	herring	2018	3	144885	144885	76857	140228	236886	146013	16
NORHERSS	Norwegian_Coast	herring	2018	4	1779400	1779400	1044634	1678273	2497134	1720376	16
NORHERSS	Norwegian_Coast	herring	2018	5	2780101	2780101	2045788	2719396	3662908	2771072	16
NORHERSS	Norwegian_Coast	herring	2018	6	484534	484534	345684	454027	588389	458932	16
NORHERSS	Norwegian_Coast	herring	2018	7	823669	823669	678532	842068	1015605	845170	16
NORHERSS	Norwegian_Coast	herring	2018	8	621727	621727	459313	635062	844917	638922	16
NORHERSS	Norwegian_Coast	herring	2018	9	1082522	1082522	910174	1088213	1296514	1094825	16
NORHERSS	Norwegian_Coast	herring	2018	10	463356	463356	343341	440030	559442	443656	16
NORHERSS	Norwegian_Coast	herring	2018	11	378203	378203	282072	369600	465325	369778	16
NORHERSS	Norwegian_Coast	herring	2018	12	1188265	1188265	956668	1153984	1375292	1159382	16
NORHERSS	Norwegian_Coast	herring	2018	13	360205	360205	257086	365792	491495	368475	16
NORHERSS	Norwegian_Coast	herring	2018	14	1524375	1524375	1253121	1536180	1821635	1537967	16
NORHERSS	Norwegian_Coast	herring	2018	15	44641	44641	26923	49957	77487	50936	16
NORHERSS	Norwegian_Coast	herring	2018	16	251498	251498	209695	273871	349348	275722	16
NORHERSS	Norwegian_Coast	herring	2018	17	2934	2934	0	3470	8848	3407	16
NORHERSS	Norwegian_Coast	herring	2018	18	11404	11404	1217	9394	22535	10215	16
NORHERSS	Norwegian_Coast	herring	2018	20	10977	10977	0	12116	31706	13799	16
NORHERSS	Norwegian_Coast	herring	2018	Unknown			0	0	5036	721	16
NORHERSS	Norwegian_Coast	herring	2018	Number	12047235	12047235	10553316	11987377	13483114	12013478	16
NORHERSS	Norwegian_Coast	herring	2018	Biomass	3260157.1	3260157.1	2871636	3251178	3638698	3262189	16
NORHERSS	Norwegian_Coast	herring	2019	1	109567	109567	0	85792	191025	78294	16
NORHERSS	Norwegian_Coast	herring	2019	2	1769	1769	0	1744	5098	1929	16
NORHERSS	Norwegian_Coast	herring	2019	3	359512	359512	121955	339749	729235	371893	16
NORHERSS	Norwegian_Coast	herring	2019	4	304367	304367	215391	304827	422086	310330	16

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
NORHERSS	Norwegian_Coast	herring	2019	5	939122	939122	706366	925684	1221209	940479	16
NORHERSS	Norwegian_Coast	herring	2019	6	3655271	3655271	2594949	3749029	5087757	3778448	16
NORHERSS	Norwegian_Coast	herring	2019	7	798791	798791	507845	730231	1092340	754480	16
NORHERSS	Norwegian_Coast	herring	2019	8	895597	895597	712987	873346	1062003	878695	16
NORHERSS	Norwegian_Coast	herring	2019	9	644377	644377	477809	648382	882018	660436	16
NORHERSS	Norwegian_Coast	herring	2019	10	1033758	1033758	841139	1045317	1303783	1053579	16
NORHERSS	Norwegian_Coast	herring	2019	11	739795	739795	537875	726672	955631	736299	16
NORHERSS	Norwegian_Coast	herring	2019	12	394548	394548	287022	401565	565151	411588	16
NORHERSS	Norwegian_Coast	herring	2019	13	1844663	1844663	1375702	1776724	2359603	1807464	16
NORHERSS	Norwegian_Coast	herring	2019	14	208732	208732	101501	178643	275948	182404	16
NORHERSS	Norwegian_Coast	herring	2019	15	1873599	1873599	1429157	1804979	2262457	1819283	16
NORHERSS	Norwegian_Coast	herring	2019	16	52400	52400	7954	47389	88639	47969	16
NORHERSS	Norwegian_Coast	herring	2019	17	264850	264850	174360	272820	412092	280896	16
NORHERSS	Norwegian_Coast	herring	2019	18	3238	3238	0	4367	17023	5437	16
NORHERSS	Norwegian_Coast	herring	2019	19	7037	7037	0	8617	18805	8306	16
NORHERSS	Norwegian_Coast	herring	2019	Unknown	7988	7988	2544	11218	132003	38030	16
NORHERSS	Norwegian_Coast	herring	2019	Number	14138984	14138984	11765046	14138482	16726125	14166239	16
NORHERSS	Norwegian_Coast	herring	2019	Biomass	4249454.3	4249454.2	3552068	4233678	5021139	4250191	16
IESSNS	Nordic_Seas	mackerel	2007	1	1531829	1550499	101689	1498829	2924844	1455917	3
IESSNS	Nordic_Seas	mackerel	2007	2	2190530	2203523	593895	2110367	3725985	2155522	3
IESSNS	Nordic_Seas	mackerel	2007	3	937118	958191	429445	957670	1528762	960856	3
IESSNS	Nordic_Seas	mackerel	2007	4	205816	239141	74412	261948	563792	270038	3
IESSNS	Nordic_Seas	mackerel	2007	5	1040356	1072659	471503	1024437	1473450	1007236	3
IESSNS	Nordic_Seas	mackerel	2007	6	147816	150058	67145	154781	256156	153182	3
IESSNS	Nordic_Seas	mackerel	2007	7	44695	51027	29162	52995	89484	55240	3
IESSNS	Nordic_Seas	mackerel	2007	8	35127	40566	25493	37537	52267	38287	3
IESSNS	Nordic_Seas	mackerel	2007	9	23826	25756	13740	26841	54448	29509	3
IESSNS	Nordic_Seas	mackerel	2007	10	9034	12962	5214	12395	22236	12911	3
IESSNS	Nordic_Seas	mackerel	2007	11	10180	10392	2878	9782	17762	10071	3
IESSNS	Nordic_Seas	mackerel	2007	12	2969	5065	1106	5321	13707	6151	3
IESSNS	Nordic_Seas	mackerel	2007	13	6325	2084	916	2479	7509	2976	3
IESSNS	Nordic_Seas	mackerel	2007	14	554	4881	92	309	989	576	3
IESSNS	Nordic_Seas	mackerel	2007	15	1727	2293	985	2469	7532	2992	3
IESSNS	Nordic_Seas	mackerel	2007	16	45	45	0	45	151	63	3
IESSNS	Nordic_Seas	mackerel	2007				0	0	96870	19403	3
IESSNS	Nordic_Seas	mackerel	2007	Number	6187946	6329142	2327886	6079082	10574522	6180929	3
IESSNS	Nordic_Seas	mackerel	2007	Biomass	1748592.6	1801954.1	785031	1780132	2728182	1762542	3
IESSNS	Nordic_Seas	mackerel	2010	1	10423	10423	360	7677	20696	8523	3
IESSNS	Nordic_Seas	mackerel	2010	2	3575099	3575009	1088435	3493325	6098260	3508743	3
IESSNS	Nordic_Seas	mackerel	2010	3	1617005	1617005	1341288	1670006	2004301	1670276	3
IESSNS	Nordic_Seas	mackerel	2010	4	4035646	4034471	3374779	4015215	4786639	4034005	3
IESSNS	Nordic_Seas	mackerel	2010	5	3059146	3055606	2515552	3097218	3757629	3116250	3
IESSNS	Nordic_Seas	mackerel	2010	6	1591100	1588534	1249283	1506931	1819670	1518146	3
IESSNS	Nordic_Seas	mackerel	2010	7	691936	690319	475234	689300	894418	688335	3
IESSNS	Nordic_Seas	mackerel	2010	8	413253	412393	249011	401370	547353	402623	3
IESSNS	Nordic_Seas	mackerel	2010	9	198106	198106	127231	196585	297477	203826	3
IESSNS	Nordic_Seas	mackerel	2010	10	65803	65687	40815	65573	94164	66105	3
IESSNS	Nordic_Seas	mackerel	2010	11	24747	24747	13273	26863	46647	27960	3
IESSNS	Nordic_Seas	mackerel	2010	12	26511	26457	12004	24318	41070	25192	3
IESSNS	Nordic_Seas	mackerel	2010	13	10419	10419	3122	11032	20388	11287	3
IESSNS	Nordic_Seas	mackerel	2010	14	5656	5567	1102	6167	12586	6355	3
IESSNS	Nordic_Seas	mackerel	2010	15	25	25	0	43	597	151	3
IESSNS	Nordic_Seas	mackerel	2010	Unknown	26963	26963	1263	26963	54656	27038	3
IESSNS	Nordic_Seas	mackerel	2010	Number	15351836	15341731	11996581	15268373	18958194	15314815	3
IESSNS	Nordic_Seas	mackerel	2010	Biomass	5292728.7	5288671.4	4383650	5260445	6175309	5274578	3
IESSNS	Nordic_Seas	mackerel	2011	1	377302	377302	122938	380848	712280	394217	3
IESSNS	Nordic_Seas	mackerel	2011	2	850968	850968	428429	910648	1396323	904969	3
IESSNS	Nordic_Seas	mackerel	2011	3	1889267	1889267	1194671	1917138	2732389	1927006	3
IESSNS	Nordic_Seas	mackerel	2011	4	1447260	1447260	1179190	1416751	1666518	1421006	3
IESSNS	Nordic_Seas	mackerel	2011	5	2303217	2303217	1792454	2309678	2814921	2309615	3
IESSNS	Nordic_Seas	mackerel	2011	6	1340399	1340399	978123	1302293	1640858	1305421	3
IESSNS	Nordic_Seas	mackerel	2011	7	760416	760416	561061	738866	950374	742321	3
IESSNS	Nordic_Seas	mackerel	2011	8	286638	286638	233968	301729	387658	305015	3
IESSNS	Nordic_Seas	mackerel	2011	9	158528	158528	102939	158678	218192	158662	3
IESSNS	Nordic_Seas	mackerel	2011	10	164637	164637	54870	164418	264973	155426	3
IESSNS	Nordic_Seas	mackerel	2011	11	25226	25226	10383	22660	36268	23046	3
IESSNS	Nordic_Seas	mackerel	2011	12	13583	13583	7180	15515	31477	17088	3
IESSNS	Nordic_Seas	mackerel	2011	13	10588	10588	1373	9641	24281	10856	3
IESSNS	Nordic_Seas	mackerel	2011	14	2844	2844	0	7265	22838	8917	3
IESSNS	Nordic_Seas	mackerel	2011	Unknown	219975	219975	24443	219884	441856	225620	3
IESSNS	Nordic_Seas	mackerel	2011	Number	9850848	9850848	8426867	9887662	11557459	9909184	3
IESSNS	Nordic_Seas	mackerel	2011	Biomass	3581326.7	3581326.7	3186076	3577914	4021293	3593711	3
IESSNS	Nordic_Seas	mackerel	2012	1	921318	947022	366092	921480	1417432	909008	3
IESSNS	Nordic_Seas	mackerel	2012	2	5420720	5412164	3977375	5445590	7115600	5494990	3
IESSNS	Nordic_Seas	mackerel	2012	3	1283247	1242189	1089884	1250128	1403487	1248019	3
IESSNS	Nordic_Seas	mackerel	2012	4	2383260	2444941	2126159	2409247	2740892	2417735	3

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESSNS	Nordic_Seas	mackerel	2012	5	2164365	2113792	1799149	2127379	2464835	2130344	3
IESSNS	Nordic_Seas	mackerel	2012	6	2850847	2884494	2243061	2852513	3569522	2877433	3
IESSNS	Nordic_Seas	mackerel	2012	7	1783942	1792843	1350069	1792021	2270046	1801547	3
IESSNS	Nordic_Seas	mackerel	2012	8	740361	715555	524765	736234	991446	742036	3
IESSNS	Nordic_Seas	mackerel	2012	9	299490	290000	234089	303491	402179	308985	3
IESSNS	Nordic_Seas	mackerel	2012	10	149282	123824	81893	123297	183767	126948	3
IESSNS	Nordic_Seas	mackerel	2012	11	84344	91429	44635	77856	111460	78148	3
IESSNS	Nordic_Seas	mackerel	2012	12	35209	43340	10571	30950	55672	31410	3
IESSNS	Nordic_Seas	mackerel	2012	13	3880	16556	409	5056	16607	6295	3
IESSNS	Nordic_Seas	mackerel	2012	14	652	965	0	279	4766	1262	3
IESSNS	Nordic_Seas	mackerel	2012	15	1227	3031	0	325	4921	1210	3
IESSNS	Nordic_Seas	mackerel	2012	16	86	86	0	107	2121	475	3
IESSNS	Nordic_Seas	mackerel	2012	Unknown	1924	1924	0	3847	44121	12178	3
IESSNS	Nordic_Seas	mackerel	2012	Number	18124153	18124153	16461771	18200842	19803469	18188023	3
IESSNS	Nordic_Seas	mackerel	2012	Biomass	5747307.9	5752043.1	5105597	5756749	6442029	5756213	3
IESSNS	Nordic_Seas	mackerel	2013	1	38 081	38081	13937	29153	54785	31518	3
IESSNS	Nordic_Seas	mackerel	2013	2	6385831	6385831	4919002	6441254	7959411	6454753	3
IESSNS	Nordic_Seas	mackerel	2013	3	9201746	9201746	8393410	9252938	10174014	9259327	3
IESSNS	Nordic_Seas	mackerel	2013	4	2456618	2456618	1977549	2440411	2888723	2429501	3
IESSNS	Nordic_Seas	mackerel	2013	5	3073772	3073772	2557411	3060270	3614556	3072698	3
IESSNS	Nordic_Seas	mackerel	2013	6	3218990	3218990	2757346	3101967	3437688	3101216	3
IESSNS	Nordic_Seas	mackerel	2013	7	2540444	2540444	2063962	2587728	3132935	2594353	3
IESSNS	Nordic_Seas	mackerel	2013	8	1087937	1087937	886969	1128953	1379256	1130267	3
IESSNS	Nordic_Seas	mackerel	2013	9	377406	377406	312449	374005	435695	374132	3
IESSNS	Nordic_Seas	mackerel	2013	10	144695	144695	109016	146668	195226	149284	3
IESSNS	Nordic_Seas	mackerel	2013	11	146826	146826	73002	147205	215494	144193	3
IESSNS	Nordic_Seas	mackerel	2013	12	44186	44186	20571	43522	64639	42696	3
IESSNS	Nordic_Seas	mackerel	2013	13	5100	5100	2602	6752	15177	7429	3
IESSNS	Nordic_Seas	mackerel	2013	14	6335	6335	545	3091	9176	3699	3
IESSNS	Nordic_Seas	mackerel	2013	15	15070	15070	5633	13605	25659	14534	3
IESSNS	Nordic_Seas	mackerel	2013	Unknown	31999	31999	17851	40782	64520	41343	3
IESSNS	Nordic_Seas	mackerel	2013	Number	28775038	28775038	26820025	28828898	30958520	28850942	3
IESSNS	Nordic_Seas	mackerel	2013	Biomass	8796529.6	8796529.6	8182546	8791554	9514294	8805919	3
IESSNS	Nordic_Seas	mackerel	2014	1	13011	13011	0	10790	16764	8453	3
IESSNS	Nordic_Seas	mackerel	2014	2	564120	564120	419263	524818	686071	537406	3
IESSNS	Nordic_Seas	mackerel	2014	3	7034162	7034162	6043514	7057353	8012769	7045930	3
IESSNS	Nordic_Seas	mackerel	2014	4	4896456	4896456	4358874	4902826	5497086	4909046	3
IESSNS	Nordic_Seas	mackerel	2014	5	2659443	2659443	2389615	2684458	3007541	2693451	3
IESSNS	Nordic_Seas	mackerel	2014	6	2630617	2630617	2337391	2673706	3054107	2676076	3
IESSNS	Nordic_Seas	mackerel	2014	7	2768227	2768227	2445238	2782660	3125552	2786049	3
IESSNS	Nordic_Seas	mackerel	2014	8	1910160	1910160	1638123	1838178	2077414	1849112	3
IESSNS	Nordic_Seas	mackerel	2014	9	849010	849010	647918	844845	1068908	848405	3
IESSNS	Nordic_Seas	mackerel	2014	10	379745	379745	286320	375969	477938	376919	3
IESSNS	Nordic_Seas	mackerel	2014	11	95304	95304	63333	111075	159473	110556	3
IESSNS	Nordic_Seas	mackerel	2014	12	70775	70775	31283	65303	103815	66008	3
IESSNS	Nordic_Seas	mackerel	2014	13	36295	36295	9536	23723	47642	25184	3
IESSNS	Nordic_Seas	mackerel	2014	14	124	124	0	810	9354	2651	3
IESSNS	Nordic_Seas	mackerel	2014	15	3983	3983	0	1034	6038	1757	3
IESSNS	Nordic_Seas	mackerel	2014	Unknown	3398	3398	124	4674	23221	8469	3
IESSNS	Nordic_Seas	mackerel	2014	Number	23914831	23914831	22346883	23915036	25631027	23945471	3
IESSNS	Nordic_Seas	mackerel	2014	Biomass	8925765.9	8925765.9	8311625	8920208	9601661	8930525	3
IESSNS	Nordic_Seas	mackerel	2015	1	861607	860885	399404	815618	1466497	862416	3
IESSNS	Nordic_Seas	mackerel	2015	2	841100	827104	522096	836423	1223027	850678	3
IESSNS	Nordic_Seas	mackerel	2015	3	2539963	2543365	1890965	2397461	3053471	2430849	3
IESSNS	Nordic_Seas	mackerel	2015	4	6409324	6374611	4944530	6397226	8192369	6458124	3
IESSNS	Nordic_Seas	mackerel	2015	5	4802298	4782516	3813438	4757207	5901169	4811449	3
IESSNS	Nordic_Seas	mackerel	2015	6	1795564	1794791	1429599	1818196	2249779	1831931	3
IESSNS	Nordic_Seas	mackerel	2015	7	1628872	1602818	1242399	1578985	1949839	1588956	3
IESSNS	Nordic_Seas	mackerel	2015	8	1254859	1250432	847991	1207321	1576990	1208712	3
IESSNS	Nordic_Seas	mackerel	2015	9	727691	691113	437632	690568	969308	701263	3
IESSNS	Nordic_Seas	mackerel	2015	10	270562	255801	161095	261262	372755	262661	3
IESSNS	Nordic_Seas	mackerel	2015	11	72410	70676	31930	59586	102541	62665	3
IESSNS	Nordic_Seas	mackerel	2015	12	64719	62614	19897	42841	73709	44218	3
IESSNS	Nordic_Seas	mackerel	2015	13	7907	7971	2962	7348	14155	7801	3
IESSNS	Nordic_Seas	mackerel	2015				0	0	13984	1584	3
IESSNS	Nordic_Seas	mackerel	2015	Number	21276875	21124697	17123849	20940060	25653093	21123307	3
IESSNS	Nordic_Seas	mackerel	2015	Biomass	7811638.3	7746729.5	6318559	7669220	9385887	7737644	3
IESSNS	Nordic_Seas	mackerel	2016	1	2027	2042	0	1567	4005	1740	3
IESSNS	Nordic_Seas	mackerel	2016	2	4982298	5045565	3648933	4945543	6475454	4979151	3
IESSNS	Nordic_Seas	mackerel	2016	3	1374705	1396303	1068291	1409169	1812511	1422859	3
IESSNS	Nordic_Seas	mackerel	2016	4	2635033	2662812	2014401	2613749	3482144	2672138	3
IESSNS	Nordic_Seas	mackerel	2016	5	5243607	5307254	4044273	5237995	6585136	5239687	3
IESSNS	Nordic_Seas	mackerel	2016	6	4368491	4401080	3162758	4360286	5685006	4391489	3
IESSNS	Nordic_Seas	mackerel	2016	7	1893026	1889979	1308863	1864769	2464750	1875887	3
IESSNS	Nordic_Seas	mackerel	2016	8	1658839	1652072	1236146	1670710	2197882	1685233	3
IESSNS	Nordic_Seas	mackerel	2016	9	1107866	1097942	831186	1119168	1457829	1127705	3

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESSNS	Nordic_Seas	mackerel	2016	10	754993	737295	538498	727807	909055	731095	3
IESSNS	Nordic_Seas	mackerel	2016	11	450100	426843	264659	389894	529468	392864	3
IESSNS	Nordic_Seas	mackerel	2016	12	198619	191670	150608	209741	280461	212366	3
IESSNS	Nordic_Seas	mackerel	2016	13	73737	73540	35509	67140	105577	68484	3
IESSNS	Nordic_Seas	mackerel	2016	14	50216	48520	23201	46483	74761	47336	3
IESSNS	Nordic_Seas	mackerel	2016	15	15069	14835	5811	17092	37118	18819	3
IESSNS	Nordic_Seas	mackerel	2016	16	148	147	0	108	363	127	3
IESSNS	Nordic_Seas	mackerel	2016	17	343	362	0	409	1051	403	3
IESSNS	Nordic_Seas	mackerel	2016	24	1488	1352	0	766	2702	911	3
IESSNS	Nordic_Seas	mackerel	2016	Unknown	2196	2212	597	2514	37767	6683	3
IESSNS	Nordic_Seas	mackerel	2016	Number	24812801	24951823	20176516	24711401	29787914	24874977	3
IESSNS	Nordic_Seas	mackerel	2016	Biomass	9114166.5	9144533.8	7278872	9044353	11012053	9114265	3
IESSNS	Nordic_Seas	mackerel	2017	1	863057	868173	495291	875533	1253032	872609	17
IESSNS	Nordic_Seas	mackerel	2017	2	115762	112921	62223	103818	154563	105637	17
IESSNS	Nordic_Seas	mackerel	2017	3	3561851	3483803	2811550	3512983	4306843	3523182	17
IESSNS	Nordic_Seas	mackerel	2017	4	1953029	1988819	1253573	2021558	2788764	2003124	17
IESSNS	Nordic_Seas	mackerel	2017	5	3317114	3337234	2658918	3446794	4328363	3475672	17
IESSNS	Nordic_Seas	mackerel	2017	6	4679214	4514860	3732850	4543747	5418589	4573485	17
IESSNS	Nordic_Seas	mackerel	2017	7	4652563	4625242	3413725	4657152	6099018	4706082	17
IESSNS	Nordic_Seas	mackerel	2017	8	1754433	1841291	1251599	1750462	2360361	1763878	17
IESSNS	Nordic_Seas	mackerel	2017	9	1944414	2009411	1237706	1955912	2841109	1982509	17
IESSNS	Nordic_Seas	mackerel	2017	10	626220	648952	468497	653388	876775	658833	17
IESSNS	Nordic_Seas	mackerel	2017	11	507395	544124	367606	525869	723442	533387	17
IESSNS	Nordic_Seas	mackerel	2017	12	115061	121099	76416	120412	185474	125004	17
IESSNS	Nordic_Seas	mackerel	2017	13	79737	85955	47186	84721	135174	86818	17
IESSNS	Nordic_Seas	mackerel	2017	14	18890	10645	343	8644	35608	12413	17
IESSNS	Nordic_Seas	mackerel	2017	15	8382	12711	2372	8725	18201	9347	17
IESSNS	Nordic_Seas	mackerel	2017	16	15514	7396	9	5124	13210	5714	17
IESSNS	Nordic_Seas	mackerel	2017	Unknown	7187	7187	3649	7789	12850	8639	17
IESSNS	Nordic_Seas	mackerel	2017	Number	24219824	24219824	20038216	24301698	29069054	24446333	17
IESSNS	Nordic_Seas	mackerel	2017	Biomass	10285252.5	10276828.5	8396665	10313693	12513396	10387898	17
IESSNS	Nordic_Seas	mackerel	2018	1	2183264	2183264	578203	2009492	4145357	2127733	17
IESSNS	Nordic_Seas	mackerel	2018	2	2500448	2500448	1670956	2452831	3396543	2491781	17
IESSNS	Nordic_Seas	mackerel	2018	3	496241	496241	338626	485546	647721	486863	17
IESSNS	Nordic_Seas	mackerel	2018	4	2382609	2382609	1788702	2385055	2989680	2379735	17
IESSNS	Nordic_Seas	mackerel	2018	5	1199685	1199685	944532	1226295	1502877	1227472	17
IESSNS	Nordic_Seas	mackerel	2018	6	1407577	1407577	1177917	1421450	1663900	1421451	17
IESSNS	Nordic_Seas	mackerel	2018	7	2328858	2328858	1941784	2266555	2622134	2281571	17
IESSNS	Nordic_Seas	mackerel	2018	8	1786228	1786228	1574399	1840243	2107792	1844249	17
IESSNS	Nordic_Seas	mackerel	2018	9	1049119	1049119	848606	1043624	1250367	1042749	17
IESSNS	Nordic_Seas	mackerel	2018	10	498939	498939	402171	500669	619815	504494	17
IESSNS	Nordic_Seas	mackerel	2018	11	557175	557175	422688	534108	663318	537058	17
IESSNS	Nordic_Seas	mackerel	2018	12	292540	292540	211280	299632	391420	300817	17
IESSNS	Nordic_Seas	mackerel	2018	13	138932	138932	94823	137314	188977	139220	17
IESSNS	Nordic_Seas	mackerel	2018	14	36874	36874	23807	42633	64162	43044	17
IESSNS	Nordic_Seas	mackerel	2018	15	29530	29530	15282	33018	53417	33724	17
IESSNS	Nordic_Seas	mackerel	2018	16	7666	7666	2501	8768	17672	9336	17
IESSNS	Nordic_Seas	mackerel	2018	17	7766	7766	0	7811	19972	7964	17
IESSNS	Nordic_Seas	mackerel	2018	18	205	205	0	32	582	141	17
IESSNS	Nordic_Seas	mackerel	2018	19	3909	3909	0	813	7060	1969	17
IESSNS	Nordic_Seas	mackerel	2018	20	26	26	0	19	63	29	17
IESSNS	Nordic_Seas	mackerel	2018	Unknown	12069	12069	0	12447	59951	20224	17
IESSNS	Nordic_Seas	mackerel	2018	Number	16919660	16919660	14199514	16827946	19942455	16901625	17
IESSNS	Nordic_Seas	mackerel	2018	Biomass	6223589.2	6223589.2	5453987	6228813	7052677	6237732	17
IESSNS	Nordic_Seas	mackerel	2019	1	77213	77213	8836	70282	136175	69548	17
IESSNS	Nordic_Seas	mackerel	2019	2	1350193	1350193	704677	1309455	2046117	1341816	17
IESSNS	Nordic_Seas	mackerel	2019	3	3814661	3814661	2668675	3801295	4929186	3798988	17
IESSNS	Nordic_Seas	mackerel	2019	4	1211770	1211770	595758	1177872	1764678	1169916	17
IESSNS	Nordic_Seas	mackerel	2019	5	2920591	2920591	2179043	2869535	3806718	2927755	17
IESSNS	Nordic_Seas	mackerel	2019	6	2856932	2856932	2271454	2875242	3618680	2899360	17
IESSNS	Nordic_Seas	mackerel	2019	7	1948653	1948653	1395904	1880624	2348020	1879220	17
IESSNS	Nordic_Seas	mackerel	2019	8	3906891	3906891	2746475	3829963	5275572	3923877	17
IESSNS	Nordic_Seas	mackerel	2019	9	3824410	3824410	2942720	3838995	5014079	3894140	17
IESSNS	Nordic_Seas	mackerel	2019	10	1499778	1499778	973382	1326926	1742541	1339754	17
IESSNS	Nordic_Seas	mackerel	2019	11	1248160	1248160	900818	1252209	1717970	1273700	17
IESSNS	Nordic_Seas	mackerel	2019	12	584066	584066	393813	562914	765422	570865	17
IESSNS	Nordic_Seas	mackerel	2019	13	586585	586585	355456	505148	668673	507965	17
IESSNS	Nordic_Seas	mackerel	2019	14	344601	344601	202970	329158	461393	331061	17
IESSNS	Nordic_Seas	mackerel	2019	15	90489	90489	62834	113011	175040	115289	17
IESSNS	Nordic_Seas	mackerel	2019	16	104106	104106	47934	96727	158273	99723	17
IESSNS	Nordic_Seas	mackerel	2019	17	31589	31589	2197	25762	58357	27524	17
IESSNS	Nordic_Seas	mackerel	2019	18	219	219	0	36	788	151	17
IESSNS	Nordic_Seas	mackerel	2019	Unknown	2243	2243	928	3468	32473	10119	17
IESSNS	Nordic_Seas	mackerel	2019	Number	26403151	26403151	20784288	26062911	32006761	26180770	17
IESSNS	Nordic_Seas	mackerel	2019	Biomass	11520750.7	11520750.7	8949427	11338221	14085895	11418142	17
IESSNS	Nordic_Seas	herring	2016	1	39602	40590	0	28421	121609	37579	5

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESSNS	Nordic_Seas	herring	2016	2	137975	145775	16171	95686	297364	119222	5
IESSNS	Nordic_Seas	herring	2016	3	758893	752168	349580	706908	1275295	746972	5
IESSNS	Nordic_Seas	herring	2016	4	646757	604252	280560	557151	926807	576551	5
IESSNS	Nordic_Seas	herring	2016	5	1629678	1637071	807923	1589184	2571976	1621662	5
IESSNS	Nordic_Seas	herring	2016	6	1638955	1559166	769577	1646249	2483804	1636143	5
IESSNS	Nordic_Seas	herring	2016	7	1988599	2010407	989857	1950481	2947132	1967394	5
IESSNS	Nordic_Seas	herring	2016	8	1526332	1614020	730042	1548996	2570940	1588353	5
IESSNS	Nordic_Seas	herring	2016	9	1263851	1189518	650246	1227741	1983146	1274482	5
IESSNS	Nordic_Seas	herring	2016	10	1954476	2023396	1179158	1974001	2887131	2001063	5
IESSNS	Nordic_Seas	herring	2016	11	2186711	2151187	1248921	2104836	3316669	2163836	5
IESSNS	Nordic_Seas	herring	2016	12	4195684	4129803	2258205	3980566	6143698	4062834	5
IESSNS	Nordic_Seas	herring	2016	13	1460213	1542821	731455	1359555	2344508	1405472	5
IESSNS	Nordic_Seas	herring	2016	14	488298	496959	286417	475484	753357	493333	5
IESSNS	Nordic_Seas	herring	2016	15	186294	190852	83054	172789	300332	178434	5
IESSNS	Nordic_Seas	herring	2016	16	92895	107056	35898	96970	197672	104828	5
IESSNS	Nordic_Seas	herring	2016	Unknown	89547	84613	10313	72383	192905	82619	5
IESSNS	Nordic_Seas	herring	2016	Number	20284760	20279653	11472489	19866057	28710490	20060776	5
IESSNS	Nordic_Seas	herring	2016	Biomass	6751488.9	6752934.5	3827233	6598343	9692100	6676486	5
IESSNS	Nordic_Seas	herring	2017	1	1216376	1216376	113021	1023126	3004179	1231637	8
IESSNS	Nordic_Seas	herring	2017	2	247662	247662	60258	226152	496208	239707	8
IESSNS	Nordic_Seas	herring	2017	3	1284763	1284763	412304	1189621	2632073	1317748	8
IESSNS	Nordic_Seas	herring	2017	4	4585786	4585786	2117679	4485994	7714488	4652506	8
IESSNS	Nordic_Seas	herring	2017	5	1055603	1055603	570064	1002606	1464703	1002650	8
IESSNS	Nordic_Seas	herring	2017	6	1188440	1188440	665214	1176679	1770531	1183643	8
IESSNS	Nordic_Seas	herring	2017	7	815767	815767	429080	781210	1208148	795372	8
IESSNS	Nordic_Seas	herring	2017	8	1794067	1794067	996918	1693933	2466594	1716290	8
IESSNS	Nordic_Seas	herring	2017	9	1022146	1022146	505279	967621	1604765	1004499	8
IESSNS	Nordic_Seas	herring	2017	10	1131359	1131359	694109	1083045	1630749	1115228	8
IESSNS	Nordic_Seas	herring	2017	11	1652800	1652800	990304	1616475	2499552	1657392	8
IESSNS	Nordic_Seas	herring	2017	12	1401088	1401088	863448	1360367	1996913	1381174	8
IESSNS	Nordic_Seas	herring	2017	13	2211822	2211822	1401462	2100641	3046210	2144877	8
IESSNS	Nordic_Seas	herring	2017	14	294441	294441	166852	303800	533997	321377	8
IESSNS	Nordic_Seas	herring	2017	15	166662	166662	71961	148659	242734	151931	8
IESSNS	Nordic_Seas	herring	2017	16	5248	5248	566	5595	10703	5697	8
IESSNS	Nordic_Seas	herring	2017	17	34075	34075	619	24116	59891	26578	8
IESSNS	Nordic_Seas	herring	2017	21	5199	5199	0	5390	26424	8047	8
IESSNS	Nordic_Seas	herring	2017	Unknown	496081	496081	104	424101	1679348	551632	8
IESSNS	Nordic_Seas	herring	2017	Number	20609383	20609383	13596514	20637686	27375901	20507985	8
IESSNS	Nordic_Seas	herring	2017	Biomass	5884923.3	5884923.3	3867547	5834900	7657879	5821218	8
IESSNS	Nordic_Seas	herring	2018	2	577075	577075	101872	466419	1478405	586564	11
IESSNS	Nordic_Seas	herring	2018	3	722390	722390	164465	593194	1381797	656386	11
IESSNS	Nordic_Seas	herring	2018	4	878987	878987	398257	824788	1490642	864250	11
IESSNS	Nordic_Seas	herring	2018	5	3077925	3077925	1551987	2975743	4832088	3053988	11
IESSNS	Nordic_Seas	herring	2018	6	931162	931162	517475	892679	1402243	924162	11
IESSNS	Nordic_Seas	herring	2018	7	1264097	1264097	627830	1144957	1827552	1171618	11
IESSNS	Nordic_Seas	herring	2018	8	733881	733881	453544	729534	1071509	745558	11
IESSNS	Nordic_Seas	herring	2018	9	947728	947728	618173	968998	1365114	971017	11
IESSNS	Nordic_Seas	herring	2018	10	1070466	1070466	720596	1064681	1464073	1077687	11
IESSNS	Nordic_Seas	herring	2018	11	693602	693602	431871	649626	949736	662951	11
IESSNS	Nordic_Seas	herring	2018	12	1035918	1035918	753751	1068933	1434630	1077700	11
IESSNS	Nordic_Seas	herring	2018	13	966461	966461	548075	822308	1153777	837106	11
IESSNS	Nordic_Seas	herring	2018	14	508707	508707	319547	504433	753280	516332	11
IESSNS	Nordic_Seas	herring	2018	15	224140	224140	106689	210585	355660	217685	11
IESSNS	Nordic_Seas	herring	2018	16	47942	47942	17097	42398	82118	45221	11
IESSNS	Nordic_Seas	herring	2018	17	7053	7053	0	6235	19612	7888	11
IESSNS	Nordic_Seas	herring	2018	18	1860	1860	0	1971	4835	1914	11
IESSNS	Nordic_Seas	herring	2018	Unknown	3435	3435	145	5708	95248	19913	11
IESSNS	Nordic_Seas	herring	2018	Number	13692829	13692829	8897732	13215157	18773554	13437938	11
IESSNS	Nordic_Seas	herring	2018	Biomass	4465385.1	4465385.1	3055287	4339926	5896282	4378509	11
IESSNS	Nordic_Seas	herring	2019	2	152581	152581	46454	129860	289888	142681	14
IESSNS	Nordic_Seas	herring	2019	3	1869554	1869554	939941	1852325	3138923	1910086	14
IESSNS	Nordic_Seas	herring	2019	4	590404	590404	343341	604616	923315	615793	14
IESSNS	Nordic_Seas	herring	2019	5	1067181	1067181	740790	1090430	1493139	1100514	14
IESSNS	Nordic_Seas	herring	2019	6	3475021	3475021	2632466	3460485	4404250	3487013	14
IESSNS	Nordic_Seas	herring	2019	7	858919	858919	506258	805025	1167507	814079	14
IESSNS	Nordic_Seas	herring	2019	8	702048	702048	524335	742797	1006104	750854	14
IESSNS	Nordic_Seas	herring	2019	9	520323	520323	318384	495324	748500	510387	14
IESSNS	Nordic_Seas	herring	2019	10	700455	700455	552981	757356	1078473	780498	14
IESSNS	Nordic_Seas	herring	2019	11	462990	462990	313162	464311	646110	470207	14
IESSNS	Nordic_Seas	herring	2019	12	749748	749748	460603	705458	994007	716736	14
IESSNS	Nordic_Seas	herring	2019	13	1724672	1724672	902456	1567991	2322500	1597354	14
IESSNS	Nordic_Seas	herring	2019	14	1232738	1232738	885496	1268266	1740655	1283947	14
IESSNS	Nordic_Seas	herring	2019	15	768907	768907	481461	722697	1065740	738504	14
IESSNS	Nordic_Seas	herring	2019	16	224410	224410	94397	217594	343006	220058	14
IESSNS	Nordic_Seas	herring	2019	17	100231	100231	47161	96456	156852	98567	14
IESSNS	Nordic_Seas	herring	2019	18	6976	6976	0	4292	13147	4550	14

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESSNS	Nordic_Seas	herring	2019	Unknown	23547	23547	3541	24298	71809	29245	14
IESSNS	Nordic_Seas	herring	2019	Number	15230704	15230704	12579706	15241529	18069008	15271072	14
IESSNS	Nordic_Seas	herring	2019	Biomass	4779852.4	4779852.4	3985308	4783655	5671364	4794466	14
IESNS	Norwegian_Sea	blue_whiting	2008	1	24778	24663	0	12677	51790	17725	2
IESNS	Norwegian_Sea	blue_whiting	2008	2	17074	16863	3239	17717	58847	22510	2
IESNS	Norwegian_Sea	blue_whiting	2008	3	293477	291564	166775	289040	509585	308302	2
IESNS	Norwegian_Sea	blue_whiting	2008	4	1162064	1157731	714208	1140420	1752602	1177823	2
IESNS	Norwegian_Sea	blue_whiting	2008	5	553006	546917	228388	543140	1051009	574461	2
IESNS	Norwegian_Sea	blue_whiting	2008	6	286977	283071	106668	261113	535057	280931	2
IESNS	Norwegian_Sea	blue_whiting	2008	7	92146	91190	32772	83655	163114	89179	2
IESNS	Norwegian_Sea	blue_whiting	2008	8	28412	27965	6962	26766	69308	31281	2
IESNS	Norwegian_Sea	blue_whiting	2008	9	1195	1169	0	970	6515	1933	2
IESNS	Norwegian_Sea	blue_whiting	2008	Unknown	24313	24313	3318	23625	76189	29912	2
IESNS	Norwegian_Sea	blue_whiting	2008	Number	2483442	2465446	1383723	2460484	3961810	2534057	2
IESNS	Norwegian_Sea	blue_whiting	2008	Biomass	342706.4	340252.1	193165	337227	539653	346695	2
IESNS	Norwegian_Sea	blue_whiting	2009	1	6973	6973	0	4565	15459	5737	2
IESNS	Norwegian_Sea	blue_whiting	2009	2	7523	7523	908	7084	16530	7766	2
IESNS	Norwegian_Sea	blue_whiting	2009	3	49132	49132	22329	47649	87420	50106	2
IESNS	Norwegian_Sea	blue_whiting	2009	4	472644	472644	237853	436320	704409	447900	2
IESNS	Norwegian_Sea	blue_whiting	2009	5	1229470	1229470	500141	1261134	2233616	1292036	2
IESNS	Norwegian_Sea	blue_whiting	2009	6	770015	770015	306431	740810	1308684	762504	2
IESNS	Norwegian_Sea	blue_whiting	2009	7	196696	196696	94353	201340	352150	211443	2
IESNS	Norwegian_Sea	blue_whiting	2009	8	66571	66571	25115	63117	113246	65411	2
IESNS	Norwegian_Sea	blue_whiting	2009	9	37312	37312	4961	33330	85788	38523	2
IESNS	Norwegian_Sea	blue_whiting	2009	Unknown			0	0	6754	1238	2
IESNS	Norwegian_Sea	blue_whiting	2009	Number	2836337	2836337	1265917	2812799	4782816	2882664	2
IESNS	Norwegian_Sea	blue_whiting	2009	Biomass	410432	410432	200865	406214	672897	416108	2
IESNS	Norwegian_Sea	blue_whiting	2010	2	279840	279840	12179	242744	927860	324790	2
IESNS	Norwegian_Sea	blue_whiting	2010	3	91748	91748	9283	91792	263571	110441	2
IESNS	Norwegian_Sea	blue_whiting	2010	4	30138	30138	4740	27786	72721	32359	2
IESNS	Norwegian_Sea	blue_whiting	2010	5	182334	182334	29224	158329	402029	178957	2
IESNS	Norwegian_Sea	blue_whiting	2010	6	185174	185174	74265	169131	313506	179591	2
IESNS	Norwegian_Sea	blue_whiting	2010	7	57407	57407	24652	50614	87765	52951	2
IESNS	Norwegian_Sea	blue_whiting	2010	8	48727	48727	9673	48726	98554	49054	2
IESNS	Norwegian_Sea	blue_whiting	2010	9	20425	20425	77	13716	43784	17165	2
IESNS	Norwegian_Sea	blue_whiting	2010	10	1156	1156	0	2025	6046	2317	2
IESNS	Norwegian_Sea	blue_whiting	2010	Unknown	6138	6138	1262	5817	15894	6759	2
IESNS	Norwegian_Sea	blue_whiting	2010	Number	903087	903087	321616	893222	1761030	954384	2
IESNS	Norwegian_Sea	blue_whiting	2010	Biomass	128696	128696	54066	126062	230470	133075	2
IESNS	Norwegian_Sea	blue_whiting	2011	1	1612879	1612879	225453	1582892	3178174	1563387	2
IESNS	Norwegian_Sea	blue_whiting	2011	2	354089	354089	0	311719	896090	327088	2
IESNS	Norwegian_Sea	blue_whiting	2011	4	30342	30342	9687	36168	83354	39634	2
IESNS	Norwegian_Sea	blue_whiting	2011	5	65961	65961	16675	63285	146035	68139	2
IESNS	Norwegian_Sea	blue_whiting	2011	6	117219	117219	25180	80600	212900	96025	2
IESNS	Norwegian_Sea	blue_whiting	2011	7	374963	374963	199145	391670	651778	402064	2
IESNS	Norwegian_Sea	blue_whiting	2011	8	111291	111291	51234	103213	208614	112197	2
IESNS	Norwegian_Sea	blue_whiting	2011	9	114091	114091	34654	97999	189310	102731	2
IESNS	Norwegian_Sea	blue_whiting	2011	10	15067	15067	0	12143	29099	12208	2
IESNS	Norwegian_Sea	blue_whiting	2011	Unknown	9034	9034	0	8100	31930	10111	2
IESNS	Norwegian_Sea	blue_whiting	2011	Number	2804936	2804936	953783	2731023	4909822	2733584	2
IESNS	Norwegian_Sea	blue_whiting	2011	Biomass	295912.4	295912.4	131155	280688	484668	291522	2
IESNS	Norwegian_Sea	blue_whiting	2012	1	9475999	9475999	5852377	9640742	14110374	9711838	2
IESNS	Norwegian_Sea	blue_whiting	2012	2	3264842	3264842	1125870	3148710	5364817	3184305	2
IESNS	Norwegian_Sea	blue_whiting	2012	3	586551	586551	235699	568244	998348	590234	2
IESNS	Norwegian_Sea	blue_whiting	2012	4	199609	199609	65937	208937	385451	212774	2
IESNS	Norwegian_Sea	blue_whiting	2012	5	275381	275381	17935	232134	563540	252295	2
IESNS	Norwegian_Sea	blue_whiting	2012	6	579377	579377	43065	456915	1093599	509249	2
IESNS	Norwegian_Sea	blue_whiting	2012	7	467706	467706	52779	408037	818161	424470	2
IESNS	Norwegian_Sea	blue_whiting	2012	8	136028	136028	11786	109451	245347	116832	2
IESNS	Norwegian_Sea	blue_whiting	2012	9	2101	2101	0	1949	9637	2686	2
IESNS	Norwegian_Sea	blue_whiting	2012	10	5848	5848	0	869	20031	5572	2
IESNS	Norwegian_Sea	blue_whiting	2012	Unknown			0	0	55166	10618	2
IESNS	Norwegian_Sea	blue_whiting	2012	Number	14993442	14993442	10062677	14962185	20200243	15020872	2
IESNS	Norwegian_Sea	blue_whiting	2012	Biomass	986579.4	986579.4	595123	940948	1342241	950871	2
IESNS	Norwegian_Sea	blue_whiting	2013	1	453717	453717	139626	347464	760918	377972	2
IESNS	Norwegian_Sea	blue_whiting	2013	2	6544260	6544260	4099759	6232268	9414790	6413787	2
IESNS	Norwegian_Sea	blue_whiting	2013	3	1741299	1741299	910134	1678869	2731852	1745168	2
IESNS	Norwegian_Sea	blue_whiting	2013	4	233005	233005	34609	199292	464901	217234	2
IESNS	Norwegian_Sea	blue_whiting	2013	5	204748	204748	29026	139153	478950	187339	2
IESNS	Norwegian_Sea	blue_whiting	2013	6	187359	187359	44468	156379	334824	168550	2
IESNS	Norwegian_Sea	blue_whiting	2013	7	201397	201397	50430	166273	362677	181825	2
IESNS	Norwegian_Sea	blue_whiting	2013	8	205077	205077	42275	173350	454892	197528	2
IESNS	Norwegian_Sea	blue_whiting	2013	9	129490	129490	32809	118081	253394	126951	2
IESNS	Norwegian_Sea	blue_whiting	2013	10	78334	78334	19138	69327	149500	74964	2
IESNS	Norwegian_Sea	blue_whiting	2013	11	31520	31520	9438	31725	69132	35326	2
IESNS	Norwegian_Sea	blue_whiting	2013	12	12430	12430	1978	9934	28784	11991	2

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESNS	Norwegian_Sea	blue_whiting	2013	13	5907	5907	1422	5350	15708	6733	2
IESNS	Norwegian_Sea	blue_whiting	2013	14	2378	2378	0	1200	6583	2414	2
IESNS	Norwegian_Sea	blue_whiting	2013	16	705	705	0	497	3783	1685	2
IESNS	Norwegian_Sea	blue_whiting	2013	Unknown	7481	7481	0	8230	23190	9530	2
IESNS	Norwegian_Sea	blue_whiting	2013	Number	10039106	10039106	6486847	9605791	13779204	9758997	2
IESNS	Norwegian_Sea	blue_whiting	2013	Biomass	1001441.1	1001441.1	628439	957963	1320995	968792	2
IESNS	Norwegian_Sea	blue_whiting	2014	1	3893147	3936709	2193047	3839836	6435838	4059358	2
IESNS	Norwegian_Sea	blue_whiting	2014	2	2048259	2029761	1069457	1976149	3121922	2007346	2
IESNS	Norwegian_Sea	blue_whiting	2014	3	2374527	2421708	1474768	2278123	3453013	2361807	2
IESNS	Norwegian_Sea	blue_whiting	2014	4	790300	778486	461948	751785	1193427	776926	2
IESNS	Norwegian_Sea	blue_whiting	2014	5	232007	205687	106489	208924	356224	216207	2
IESNS	Norwegian_Sea	blue_whiting	2014	6	75466	63721	26774	68819	141213	73601	2
IESNS	Norwegian_Sea	blue_whiting	2014	7	67698	91183	18861	74616	193086	85848	2
IESNS	Norwegian_Sea	blue_whiting	2014	8	81046	73570	36313	70284	119262	73012	2
IESNS	Norwegian_Sea	blue_whiting	2014	9	130728	133245	34018	98764	236568	113530	2
IESNS	Norwegian_Sea	blue_whiting	2014	10	83091	83010	8052	65380	172488	73211	2
IESNS	Norwegian_Sea	blue_whiting	2014	11	21270	18630	2239	18609	45853	20190	2
IESNS	Norwegian_Sea	blue_whiting	2014	12	49201	47122	5984	27751	80929	33831	2
IESNS	Norwegian_Sea	blue_whiting	2014	13	4554	5429	0	4721	14680	5111	2
IESNS	Norwegian_Sea	blue_whiting	2014	Unknown	811	811	0	1151	7789	2026	2
IESNS	Norwegian_Sea	blue_whiting	2014	Number	9852105	9889072	6316282	9686973	14430868	9902006	2
IESNS	Norwegian_Sea	blue_whiting	2014	Biomass	767129.6	764615	465300	743664	1088161	756754	2
IESNS	Norwegian_Sea	blue_whiting	2015	1	8563172	8563172	6089471	8381298	11765277	8572784	2
IESNS	Norwegian_Sea	blue_whiting	2015	2	2796256	2796256	1920326	2733881	3819325	2755084	2
IESNS	Norwegian_Sea	blue_whiting	2015	3	1136908	1136908	675245	1115018	1760323	1153096	2
IESNS	Norwegian_Sea	blue_whiting	2015	4	780908	780908	401218	707499	1122443	738437	2
IESNS	Norwegian_Sea	blue_whiting	2015	5	332337	332337	146110	310478	545158	322295	2
IESNS	Norwegian_Sea	blue_whiting	2015	6	188099	188099	45175	176215	364035	178757	2
IESNS	Norwegian_Sea	blue_whiting	2015	7	82592	82592	24581	76251	147762	77089	2
IESNS	Norwegian_Sea	blue_whiting	2015	8	91177	91177	23032	76599	162152	79649	2
IESNS	Norwegian_Sea	blue_whiting	2015	9	58091	58091	17009	45753	101626	50471	2
IESNS	Norwegian_Sea	blue_whiting	2015	10	88072	88072	29355	80579	169501	84292	2
IESNS	Norwegian_Sea	blue_whiting	2015	11	67960	67960	19484	62752	140713	66297	2
IESNS	Norwegian_Sea	blue_whiting	2015	12	25333	25333	2823	16867	44126	19840	2
IESNS	Norwegian_Sea	blue_whiting	2015	13	3197	3197	0	3252	10102	4028	2
IESNS	Norwegian_Sea	blue_whiting	2015	14	654	654	0	819	4255	1215	2
IESNS	Norwegian_Sea	blue_whiting	2015	15	4646	4646	0	2770	11467	3582	2
IESNS	Norwegian_Sea	blue_whiting	2015	Unknown	2362	2362	0	1770	10379	3035	2
IESNS	Norwegian_Sea	blue_whiting	2015	Number	14221764	14221764	10338518	13803187	18934324	14109951	2
IESNS	Norwegian_Sea	blue_whiting	2015	Biomass	957519.3	957519.3	638572	921129	1301034	938252	2
IESNS	Norwegian_Sea	blue_whiting	2016	1	4223151	4223151	2818507	4164144	6170455	4284534	4
IESNS	Norwegian_Sea	blue_whiting	2016	2	8089138	8089138	6118731	8000556	10394756	8068772	4
IESNS	Norwegian_Sea	blue_whiting	2016	3	4212548	4212548	3121559	4109401	5479677	4185799	4
IESNS	Norwegian_Sea	blue_whiting	2016	4	1517342	1517342	885863	1380939	1881620	1381087	4
IESNS	Norwegian_Sea	blue_whiting	2016	5	919948	919948	506445	919886	1420878	930413	4
IESNS	Norwegian_Sea	blue_whiting	2016	6	408690	408690	207158	430755	721168	445458	4
IESNS	Norwegian_Sea	blue_whiting	2016	7	258168	258168	100897	233013	455331	250706	4
IESNS	Norwegian_Sea	blue_whiting	2016	8	162151	162151	40479	131873	298554	144889	4
IESNS	Norwegian_Sea	blue_whiting	2016	9	58301	58301	8897	59811	140933	65099	4
IESNS	Norwegian_Sea	blue_whiting	2016	10	33507	33507	8843	31221	69673	34537	4
IESNS	Norwegian_Sea	blue_whiting	2016	11	29323	29323	2619	30856	91997	36586	4
IESNS	Norwegian_Sea	blue_whiting	2016	12	15777	15777	0	7253	33087	10330	4
IESNS	Norwegian_Sea	blue_whiting	2016	13	3865	3865	0	2244	9914	3190	4
IESNS	Norwegian_Sea	blue_whiting	2016	14	5801	5801	0	2816	17486	4696	4
IESNS	Norwegian_Sea	blue_whiting	2016	15	5783	5783	0	4160	13061	4594	4
IESNS	Norwegian_Sea	blue_whiting	2016	16	6246	6246	0	3956	16607	5303	4
IESNS	Norwegian_Sea	blue_whiting	2016	17	1928	1928	0	2208	8206	2664	4
IESNS	Norwegian_Sea	blue_whiting	2016	Unknown	2283	2283	0	2729	22373	5819	4
IESNS	Norwegian_Sea	blue_whiting	2016	Number	19953948	19953948	15552073	19727811	24983880	19864476	4
IESNS	Norwegian_Sea	blue_whiting	2016	Biomass	1547881	1547881	1167888	1507630	1906420	1521071	4
IESNS	Norwegian_Sea	blue_whiting	2017	1	1236334	1236334	730918	1200135	1816896	1222673	10
IESNS	Norwegian_Sea	blue_whiting	2017	2	2087065	2087065	1550657	2073913	2710732	2092486	10
IESNS	Norwegian_Sea	blue_whiting	2017	3	4202809	4202809	3264603	4247609	5370076	4267880	10
IESNS	Norwegian_Sea	blue_whiting	2017	4	1266000	1266000	870973	1201087	1603838	1219461	10
IESNS	Norwegian_Sea	blue_whiting	2017	5	389308	389308	237232	368839	571464	384068	10
IESNS	Norwegian_Sea	blue_whiting	2017	6	172518	172518	88943	157065	271737	166288	10
IESNS	Norwegian_Sea	blue_whiting	2017	7	120238	120238	39888	115179	197277	117030	10
IESNS	Norwegian_Sea	blue_whiting	2017	8	46531	46531	12076	37605	86389	42264	10
IESNS	Norwegian_Sea	blue_whiting	2017	9	22432	22432	0	21697	63714	24252	10
IESNS	Norwegian_Sea	blue_whiting	2017	10	55739	55739	9463	47557	122030	54234	10
IESNS	Norwegian_Sea	blue_whiting	2017	11	27750	27750	5456	25307	67035	29118	10
IESNS	Norwegian_Sea	blue_whiting	2017	12	22807	22807	2076	17981	53216	21057	10
IESNS	Norwegian_Sea	blue_whiting	2017	13	32000	32000	0	25416	81112	28977	10
IESNS	Norwegian_Sea	blue_whiting	2017	14	10706	10706	0	9111	27738	9957	10
IESNS	Norwegian_Sea	blue_whiting	2017	Unknown			0	0	745	100	10
IESNS	Norwegian_Sea	blue_whiting	2017	Number	9692236	9692236	7484948	9667906	12048262	9679844	10

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESNS	Norwegian_Sea	blue_whiting	2017	Biomass	927644.5	927644.5	714059	914167	1154391	921577	10
IESNS	Norwegian_Sea	blue_whiting	2018	1	440951	440951	205982	414239	768563	447501	10
IESNS	Norwegian_Sea	blue_whiting	2018	2	1491186	1491186	902238	1422822	2097941	1452275	10
IESNS	Norwegian_Sea	blue_whiting	2018	3	802935	802935	559689	802480	1134631	820195	10
IESNS	Norwegian_Sea	blue_whiting	2018	4	1189624	1189624	833320	1185370	1607436	1203445	10
IESNS	Norwegian_Sea	blue_whiting	2018	5	370205	370205	268501	362695	476037	367432	10
IESNS	Norwegian_Sea	blue_whiting	2018	6	88991	88991	60452	92018	132185	93716	10
IESNS	Norwegian_Sea	blue_whiting	2018	7	46520	46520	18116	38560	82647	42741	10
IESNS	Norwegian_Sea	blue_whiting	2018	8	7050	7050	2010	6812	17183	7750	10
IESNS	Norwegian_Sea	blue_whiting	2018	9	9747	9747	2902	8278	15516	8582	10
IESNS	Norwegian_Sea	blue_whiting	2018	10	1439	1439	0	967	5197	1528	10
IESNS	Norwegian_Sea	blue_whiting	2018	11	1119	1119	0	1118	3193	1275	10
IESNS	Norwegian_Sea	blue_whiting	2018	12	4802	4802	0	2209	7838	2611	10
IESNS	Norwegian_Sea	blue_whiting	2018	13	763	763	0	879	3321	1056	10
IESNS	Norwegian_Sea	blue_whiting	2018	Unknown	849	849	0	673	2147	899	10
IESNS	Norwegian_Sea	blue_whiting	2018	Number	4456182	4456182	3259584	4422093	5812511	4451006	10
IESNS	Norwegian_Sea	blue_whiting	2018	Biomass	500652.6	500652.6	370886	495526	644448	499737	10
IESNS	Norwegian_Sea	blue_whiting	2019	1	3156598	3156598	1880467	3198589	4845865	3258566	13
IESNS	Norwegian_Sea	blue_whiting	2019	2	215417	215417	31515	217932	419470	208222	13
IESNS	Norwegian_Sea	blue_whiting	2019	3	630655	630655	372957	607347	891193	614925	13
IESNS	Norwegian_Sea	blue_whiting	2019	4	1012205	1012205	685714	1044475	1450369		13
IESNS	Norwegian_Sea	blue_whiting	2019	5	831158	831158	460206	757990	1075232	762176	13
IESNS	Norwegian_Sea	blue_whiting	2019	6	272577	272577	146612	282656	436304	288915	13
IESNS	Norwegian_Sea	blue_whiting	2019	7	38819	38819	17729	42465	82935	45289	13
IESNS	Norwegian_Sea	blue_whiting	2019	8	50152	50152	8636	34311	69594	35765	13
IESNS	Norwegian_Sea	blue_whiting	2019	9	10025	10025	0	6576	18813	7591	13
IESNS	Norwegian_Sea	blue_whiting	2019	10	3944	3944	0	3202	10037	3543	13
IESNS	Norwegian_Sea	blue_whiting	2019	11	997	997	0	846	3115	1042	13
IESNS	Norwegian_Sea	blue_whiting	2019	Unknown	1414	1414	0	1767	8986	2770	13
IESNS	Norwegian_Sea	blue_whiting	2019	Number	6223961	6223961	4473018	6231680	8420847	6277130	13
IESNS	Norwegian_Sea	blue_whiting	2019	Biomass	534897.5	534897.5	374446	524463	715417	530578	13
IESSNS	Nordic_Seas	blue_whiting	2016	0	3868857	3868857	48416	3524698	9343782	4019236	5
IESSNS	Nordic_Seas	blue_whiting	2016	1	5610095	5608840	4169238	5759858	7459133	5781359	5
IESSNS	Nordic_Seas	blue_whiting	2016	2	11372252	11366662	9506349	11247262	13822954	11423496	5
IESSNS	Nordic_Seas	blue_whiting	2016	3	4294911	4372593	3392029	4306112	5331038	4324155	5
IESSNS	Nordic_Seas	blue_whiting	2016	4	2588479	2554240	1345320	2419236	3093717	2352781	5
IESSNS	Nordic_Seas	blue_whiting	2016	5	1138166	1132116	659130	1180343	1809384	1190459	5
IESSNS	Nordic_Seas	blue_whiting	2016	6	322770	322770	139164	364583	556178	350920	5
IESSNS	Nordic_Seas	blue_whiting	2016	7	208789	178240	35130	157670	273049	157524	5
IESSNS	Nordic_Seas	blue_whiting	2016	8	176709	176709	58599	156575	277347	159537	5
IESSNS	Nordic_Seas	blue_whiting	2016	9	8008	8008	0	6317	19217	6666	5
IESSNS	Nordic_Seas	blue_whiting	2016	10	104714	104714	25804	82884	148338	84730	5
IESSNS	Nordic_Seas	blue_whiting	2016	11	34650	34650	0	29711	77443	30349	5
IESSNS	Nordic_Seas	blue_whiting	2016	12	17052	17052	6427	19832	40982	21228	5
IESSNS	Nordic_Seas	blue_whiting	2016	13	68327	68327	0	56334	122320	59800	5
IESSNS	Nordic_Seas	blue_whiting	2016	14	5726	5726	0	4887	11086	4497	5
IESSNS	Nordic_Seas	blue_whiting	2016	16	2863	2863	0	3396	11300	4110	5
IESSNS	Nordic_Seas	blue_whiting	2016	Unknown			0	44611	1588795	335677	5
IESSNS	Nordic_Seas	blue_whiting	2016	Number	29822369	29822369	26086681	30099680	34982267	30306523	5
IESSNS	Nordic_Seas	blue_whiting	2016	Biomass	2283006.7	2282873.6	2013866	2277483	2499957	2268883	5
IESSNS	Nordic_Seas	blue_whiting	2017	0	23137203	23137203	293766	21998177	39175828	20546812	8
IESSNS	Nordic_Seas	blue_whiting	2017	1	2558261	2558261	1047607	2372927	3919343	2423248	8
IESSNS	Nordic_Seas	blue_whiting	2017	2	5764440	5764440	4450996	5844651	7556019	5901432	8
IESSNS	Nordic_Seas	blue_whiting	2017	3	10302753	10302753	7996391	10000690	12413632	10065607	8
IESSNS	Nordic_Seas	blue_whiting	2017	4	2300636	2300636	1550316	2163887	2830592	2171895	8
IESSNS	Nordic_Seas	blue_whiting	2017	5	573437	573437	324715	616779	967764	625782	8
IESSNS	Nordic_Seas	blue_whiting	2017	6	249991	249991	70923	230658	450763	237764	8
IESSNS	Nordic_Seas	blue_whiting	2017	7	18129	18129	0	15092	40320	15156	8
IESSNS	Nordic_Seas	blue_whiting	2017	8	24668	24668	0	24017	85725	28596	8
IESSNS	Nordic_Seas	blue_whiting	2017	10	24693	24693	0	12029	52142	17089	8
IESSNS	Nordic_Seas	blue_whiting	2017	Unknown	442138	442138	19445	382620	2974502	666742	8
IESSNS	Nordic_Seas	blue_whiting	2017	Number	45396350	45396350	20539728	43645328	67768885	42700123	8
IESSNS	Nordic_Seas	blue_whiting	2017	Biomass	2703566	2703566	2045098	2589254	3331517	2617544	8
IESSNS	Nordic_Seas	blue_whiting	2018	1	914663	914663	523783	871984	1305102	892787	11
IESSNS	Nordic_Seas	blue_whiting	2018	2	1165301	1165301	906691	1189834	1565867	1208255	11
IESSNS	Nordic_Seas	blue_whiting	2018	3	3251822	3251822	2657279	3174567	3820161	3197945	11
IESSNS	Nordic_Seas	blue_whiting	2018	4	6349676	6349676	5239830	6404379	7747848	6434475	11
IESSNS	Nordic_Seas	blue_whiting	2018	5	3150656	3150656	2373961	3054859	3775706	3070294	11
IESSNS	Nordic_Seas	blue_whiting	2018	6	900253	900253	622067	935576	1296831	938234	11
IESSNS	Nordic_Seas	blue_whiting	2018	7	384842	384842	218152	366706	542454	371109	11
IESSNS	Nordic_Seas	blue_whiting	2018	8	100330	100330	57819	104318	168985	107414	11
IESSNS	Nordic_Seas	blue_whiting	2018	9	51755	51755	8552	44145	96426	46642	11
IESSNS	Nordic_Seas	blue_whiting	2018	10	10101	10101	0	5226	19928	6442	11
IESSNS	Nordic_Seas	blue_whiting	2018	11	2026	2026	0	2123	6394	2165	11
IESSNS	Nordic_Seas	blue_whiting	2018	12	11743	11743	340	14390	45282	17698	11
IESSNS	Nordic_Seas	blue_whiting	2018	13	8190	8190	0	5735	19788	6608	11

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IESSNS	Nordic_Seas	blue_whiting	2018	14	5164	5164	0	857	15061	3170	11
IESSNS	Nordic_Seas	blue_whiting	2018	15	3383	3383	0	4001	23772	6813	11
IESSNS	Nordic_Seas	blue_whiting	2018	Unknown	11016	11016	2769	11853	30081	13708	11
IESSNS	Nordic_Seas	blue_whiting	2018	Number	16320922	16320922	13715347	16322028	18996701	16323758	11
IESSNS	Nordic_Seas	blue_whiting	2018	Biomass	2038664.9	2038664.9	1718085	2036015	2370205	2038723	11
IESSNS	Nordic_Seas	blue_whiting	2019	0	2152887	2152887	0	2096986	6554360	2470795	14
IESSNS	Nordic_Seas	blue_whiting	2019	1	639702	639702	321341	665055	1195105	703658	14
IESSNS	Nordic_Seas	blue_whiting	2019	2	1932857	1932857	1127053	1868080	2826024	1905909	14
IESSNS	Nordic_Seas	blue_whiting	2019	3	2179339	2179339	1807967	2236156	2753803	2254076	14
IESSNS	Nordic_Seas	blue_whiting	2019	4	4347802	4347802	3438766	4293423	5291441	4316811	14
IESSNS	Nordic_Seas	blue_whiting	2019	5	5434350	5434350	4578050	5290815	6161875	5317880	14
IESSNS	Nordic_Seas	blue_whiting	2019	6	1150524	1150524	929890	1162228	1458308	1174020	14
IESSNS	Nordic_Seas	blue_whiting	2019	7	208766	208766	107057	180105	257518	181040	14
IESSNS	Nordic_Seas	blue_whiting	2019	8	229101	229101	19962	219863	365906	186394	14
IESSNS	Nordic_Seas	blue_whiting	2019	9	4817	4817	280	8247	20114	8988	14
IESSNS	Nordic_Seas	blue_whiting	2019	10	8457	8457	0	7336	23493	9077	14
IESSNS	Nordic_Seas	blue_whiting	2019	Unknown	47001	47001	19039	100932	535320	163245	14
IESSNS	Nordic_Seas	blue_whiting	2019	Number	18335603	18335603	15084717	18258311	23689080	18691893	14
IESSNS	Nordic_Seas	blue_whiting	2019	Biomass	2027504.3	2027504.3	1750036	2018973	2319006	2023303	14
IBWSS	Celtic_Seas	blue_whiting	2004	1	1097031	1097031	604555	1097164	1601720	1101874	2
IBWSS	Celtic_Seas	blue_whiting	2004	2	5537735	5537735	4211961	5749855	7947464	5847068	2
IBWSS	Celtic_Seas	blue_whiting	2004	3	13062272	13062272	9857807	12994390	17405389	13249737	2
IBWSS	Celtic_Seas	blue_whiting	2004	4	15134428	15134428	10755628	14884232	20904959	15253709	2
IBWSS	Celtic_Seas	blue_whiting	2004	5	5118507	5118507	3501414	5122101	7059432	5182431	2
IBWSS	Celtic_Seas	blue_whiting	2004	6	1086148	1086148	794902	1173057	1667156	1190520	2
IBWSS	Celtic_Seas	blue_whiting	2004	7	994045	994045	461756	778860	1144048	786111	2
IBWSS	Celtic_Seas	blue_whiting	2004	8	592770	592770	215483	543547	913554	552046	2
IBWSS	Celtic_Seas	blue_whiting	2004	9	164047	164047	35912	171726	315790	172720	2
IBWSS	Celtic_Seas	blue_whiting	2004	Unknown	10021	10021	0	31058	135406	44909	2
IBWSS	Celtic_Seas	blue_whiting	2004	Number	42797005	42797005	33462394	42768289	55152890	43381125	2
IBWSS	Celtic_Seas	blue_whiting	2004	Biomass	3504882	3504882	2686976	3499381	4564110	3548843	2
IBWSS	Celtic_Seas	blue_whiting	2005	1	2128855	2128855	803751	1885542	3994373	2058095	2
IBWSS	Celtic_Seas	blue_whiting	2005	2	1412762	1412762	1006511	1408512	1956891	1435903	2
IBWSS	Celtic_Seas	blue_whiting	2005	3	5600691	5600691	4530732	5597912	6715452	5624900	2
IBWSS	Celtic_Seas	blue_whiting	2005	4	7779650	7779650	6256767	7641712	9082638	7653877	2
IBWSS	Celtic_Seas	blue_whiting	2005	5	8500412	8500412	6740100	8412092	10362768	8470386	2
IBWSS	Celtic_Seas	blue_whiting	2005	6	2924907	2924907	2056932	2747976	3436512	2753270	2
IBWSS	Celtic_Seas	blue_whiting	2005	7	632170	632170	427553	627477	872436	634429	2
IBWSS	Celtic_Seas	blue_whiting	2005	8	279730	279730	145641	268962	412480	272979	2
IBWSS	Celtic_Seas	blue_whiting	2005	9	128889	128889	47258	116669	212453	121832	2
IBWSS	Celtic_Seas	blue_whiting	2005	10	14762	14762	0	9681	25973	10637	2
IBWSS	Celtic_Seas	blue_whiting	2005	11	8435	8435	1419	7828	21064	9107	2
IBWSS	Celtic_Seas	blue_whiting	2005	Unknown	27383	27383	0	27217	77808	27804	2
IBWSS	Celtic_Seas	blue_whiting	2005	Number	29438646	29438646	23448297	28915351	34906913	29073218	2
IBWSS	Celtic_Seas	blue_whiting	2005	Biomass	2513021	2513021	2026916	2472792	2960264	2481827	2
IBWSS	Celtic_Seas	blue_whiting	2006	1	2512120	2512120	406928	2350304	6432786	2651432	2
IBWSS	Celtic_Seas	blue_whiting	2006	2	2222231	2223901	1200208	2130256	3809346	2267582	2
IBWSS	Celtic_Seas	blue_whiting	2006	3	10857924	10880761	7973388	10970364	15003450	11169702	2
IBWSS	Celtic_Seas	blue_whiting	2006	4	11676869	11695111	9529524	11801293	15127731	12034060	2
IBWSS	Celtic_Seas	blue_whiting	2006	5	4713266	4717002	3544970	4359841	5696064	4458157	2
IBWSS	Celtic_Seas	blue_whiting	2006	6	2717127	2719074	2000306	2675934	3498340	2692623	2
IBWSS	Celtic_Seas	blue_whiting	2006	7	922937	923038	617465	848725	1182990	868440	2
IBWSS	Celtic_Seas	blue_whiting	2006	8	352204	352204	109577	338169	584417	338866	2
IBWSS	Celtic_Seas	blue_whiting	2006	9	198421	198421	76839	194425	350999	200433	2
IBWSS	Celtic_Seas	blue_whiting	2006	10	30749	30749	0	29226	73478	28456	2
IBWSS	Celtic_Seas	blue_whiting	2006	13	7941	7941	0	7941	22915	8465	2
IBWSS	Celtic_Seas	blue_whiting	2006	Unknown			0	0	163608	24153	2
IBWSS	Celtic_Seas	blue_whiting	2006	Number	36211788	36260321	28991900	36313554	46164107	36742369	2
IBWSS	Celtic_Seas	blue_whiting	2006	Biomass	3512318	3516591	2842508	3466217	4344573	3521650	2
IBWSS	Celtic_Seas	blue_whiting	2007	1	468214	468214	179869	431000	907099	474539	2
IBWSS	Celtic_Seas	blue_whiting	2007	2	705524	705524	487792	731144	1030531	740353	2
IBWSS	Celtic_Seas	blue_whiting	2007	3	5240739	5240739	4148050	5216857	6715821	5304591	2
IBWSS	Celtic_Seas	blue_whiting	2007	4	11244224	11244224	9205102	11474972	14022865	11493808	2
IBWSS	Celtic_Seas	blue_whiting	2007	5	8436848	8436848	6844332	8379791	10032819	8393329	2
IBWSS	Celtic_Seas	blue_whiting	2007	6	3154696	3154696	2398589	3098857	3923713	3127669	2
IBWSS	Celtic_Seas	blue_whiting	2007	7	1109762	1109762	778515	1134890	1520420	1139952	2
IBWSS	Celtic_Seas	blue_whiting	2007	8	455673	455673	289931	471224	684430	478532	2
IBWSS	Celtic_Seas	blue_whiting	2007	9	123031	123031	51085	102037	170049	104159	2
IBWSS	Celtic_Seas	blue_whiting	2007	10	54174	54174	23594	50354	102793	55505	2
IBWSS	Celtic_Seas	blue_whiting	2007	11	3913	3913	0	4820	16118	5522	2
IBWSS	Celtic_Seas	blue_whiting	2007	12	7307	7307	0	6424	21710	7868	2
IBWSS	Celtic_Seas	blue_whiting	2007	Unknown			0	0	11964	2395	2
IBWSS	Celtic_Seas	blue_whiting	2007	Number	31004103	31004103	25842650	31331407	36710220	31328224	2
IBWSS	Celtic_Seas	blue_whiting	2007	Biomass	3274033	3274033	2752049	3325126	3908505	3318605	2
IBWSS	Celtic_Seas	blue_whiting	2008	1	337383	337490	111491	275129	578709	312483	2
IBWSS	Celtic_Seas	blue_whiting	2008	2	522994	523658	274415	464215	825106	499321	2

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IBWSS	Celtic_Seas	blue_whiting	2008	3	1451127	1454845	1060157	1483299	1976475	1497688	2
IBWSS	Celtic_Seas	blue_whiting	2008	4	6642229	6660986	4956384	6460986	8351840	6537836	2
IBWSS	Celtic_Seas	blue_whiting	2008	5	6721950	6746519	5452079	6787830	8156397	6775019	2
IBWSS	Celtic_Seas	blue_whiting	2008	6	3869029	3882109	3105340	3884503	4636974	3860216	2
IBWSS	Celtic_Seas	blue_whiting	2008	7	1714702	1719485	1417140	1798189	2198029	1801645	2
IBWSS	Celtic_Seas	blue_whiting	2008	8	1027791	1029235	720302	987190	1291065	996755	2
IBWSS	Celtic_Seas	blue_whiting	2008	9	268778	269460	131693	244122	362335	244706	2
IBWSS	Celtic_Seas	blue_whiting	2008	10	182101	182274	93530	168794	264760	172300	2
IBWSS	Celtic_Seas	blue_whiting	2008	11	102107	102194	36236	102879	194411	107666	2
IBWSS	Celtic_Seas	blue_whiting	2008	13	10968	11052	0	15573	44715	16531	2
IBWSS	Celtic_Seas	blue_whiting	2008	Unknown			0	0	0	1068	2
IBWSS	Celtic_Seas	blue_whiting	2008	Number	22851157	22919307	18734830	22840141	26941613	22823233	2
IBWSS	Celtic_Seas	blue_whiting	2008	Biomass	2639313	2646969	2161147	2632112	3114136	2637746	2
IBWSS	Celtic_Seas	blue_whiting	2009	1	274676	274701	107223	259940	514674	277416	2
IBWSS	Celtic_Seas	blue_whiting	2009	2	328690	328795	199751	337896	523490	348052	2
IBWSS	Celtic_Seas	blue_whiting	2009	3	359643	359713	214740	356143	534128	362488	2
IBWSS	Celtic_Seas	blue_whiting	2009	4	1291636	1291844	901519	1298412	1805959	1322757	2
IBWSS	Celtic_Seas	blue_whiting	2009	5	3738915	3739462	2828830	3706840	4787229	3743845	2
IBWSS	Celtic_Seas	blue_whiting	2009	6	3457285	3457785	2549725	3550735	4905536	3617732	2
IBWSS	Celtic_Seas	blue_whiting	2009	7	1635516	1635758	1054889	1606183	2217230	1618926	2
IBWSS	Celtic_Seas	blue_whiting	2009	8	586939	587009	300171	519076	834192	531430	2
IBWSS	Celtic_Seas	blue_whiting	2009	9	250283	250307	98914	191479	400468	220150	2
IBWSS	Celtic_Seas	blue_whiting	2009	10	88489	88494	27469	69749	148603	76939	2
IBWSS	Celtic_Seas	blue_whiting	2009	11	74003	74008	11182	47960	126205	58391	2
IBWSS	Celtic_Seas	blue_whiting	2009	12	16391	16394	4973	15564	29031	16137	2
IBWSS	Celtic_Seas	blue_whiting	2009	13	5632	5633	0	6689	16218	7102	2
IBWSS	Celtic_Seas	blue_whiting	2009	14	9199	9201	0	7575	19026	8197	2
IBWSS	Celtic_Seas	blue_whiting	2009	Unknown	369	369	0	352	1674	574	2
IBWSS	Celtic_Seas	blue_whiting	2009	Number	12117664	12119472	8930909	12117082	15864020	12210134	2
IBWSS	Celtic_Seas	blue_whiting	2009	Biomass	1598683	1598919	1154792	1590731	2044161	1589739	2
IBWSS	Celtic_Seas	blue_whiting	2011	1	311855	311955	40382	291998	912133	351161	2
IBWSS	Celtic_Seas	blue_whiting	2011	2	1360928	1361322	454746	1278802	2908661	1412178	2
IBWSS	Celtic_Seas	blue_whiting	2011	3	1135038	1135279	659957	1126308	1843208	1166296	2
IBWSS	Celtic_Seas	blue_whiting	2011	4	929943	930170	534306	875541	1390545	906425	2
IBWSS	Celtic_Seas	blue_whiting	2011	5	1042578	1042878	544697	984392	1604561	1018263	2
IBWSS	Celtic_Seas	blue_whiting	2011	6	1712141	1712625	1019773	1769253	2825209	1830963	2
IBWSS	Celtic_Seas	blue_whiting	2011	7	2170176	2170811	1305626	2081306	3299854	2164605	2
IBWSS	Celtic_Seas	blue_whiting	2011	8	2421938	2422649	1397132	2298313	3801799	2450208	2
IBWSS	Celtic_Seas	blue_whiting	2011	9	1297613	1297997	669491	1267341	2256540	1343337	2
IBWSS	Celtic_Seas	blue_whiting	2011	10	239381	239455	72607	191122	376428	207556	2
IBWSS	Celtic_Seas	blue_whiting	2011	11	10639	10642	0	9644	24049	9905	2
IBWSS	Celtic_Seas	blue_whiting	2011	12	22096	22103	0	17036	45045	19362	2
IBWSS	Celtic_Seas	blue_whiting	2011	Unknown	5189	5189	0	8570	29555	11300	2
IBWSS	Celtic_Seas	blue_whiting	2011	Number	12659515	12663075	8329020	12294540	19130974	12891557	2
IBWSS	Celtic_Seas	blue_whiting	2011	Biomass	1826343	1826863	1187378	1768816	2710404	1847744	2
IBWSS	Celtic_Seas	blue_whiting	2012	1	1141026	1139589	572819	1169312	2000987	1211866	2
IBWSS	Celtic_Seas	blue_whiting	2012	2	1818277	1816248	1077405	1745685	2940031	1849818	2
IBWSS	Celtic_Seas	blue_whiting	2012	3	6463815	6454499	5038681	6548635	9029246	6689453	2
IBWSS	Celtic_Seas	blue_whiting	2012	4	1022143	1020649	812895	1013755	1231019	1016152	2
IBWSS	Celtic_Seas	blue_whiting	2012	5	596326	595053	441462	587324	738737	589437	2
IBWSS	Celtic_Seas	blue_whiting	2012	6	1419633	1414541	1050367	1341337	1658097	1346298	2
IBWSS	Celtic_Seas	blue_whiting	2012	7	2231469	2220411	1560252	2099425	2671534	2103985	2
IBWSS	Celtic_Seas	blue_whiting	2012	8	1785349	1777066	1348492	1691584	2088036	1702233	2
IBWSS	Celtic_Seas	blue_whiting	2012	9	1256027	1249293	975014	1266710	1548231	1268364	2
IBWSS	Celtic_Seas	blue_whiting	2012	10	925975	920757	672798	949493	1212426	947237	2
IBWSS	Celtic_Seas	blue_whiting	2012	11	96326	95999	42269	102082	156871	100807	2
IBWSS	Celtic_Seas	blue_whiting	2012	12	67612	67013	24164	61367	99349	61592	2
IBWSS	Celtic_Seas	blue_whiting	2012	13	1354	1317	14	841	3651	1245	2
IBWSS	Celtic_Seas	blue_whiting	2012	Unknown			0	0	7582	993	2
IBWSS	Celtic_Seas	blue_whiting	2012	Number	18825332	18772434	15880291	18765707	22605632	18889481	2
IBWSS	Celtic_Seas	blue_whiting	2012	Biomass	2355274	2347488	2011028	2337015	2673525	2337807	2
IBWSS	Celtic_Seas	blue_whiting	2013	1	586494	581549	342994	571973	852450	581698	2
IBWSS	Celtic_Seas	blue_whiting	2013	2	1346334	1337251	973317	1351419	1798996	1360384	2
IBWSS	Celtic_Seas	blue_whiting	2013	3	6183433	6174972	4690498	6279887	8093577	6322397	2
IBWSS	Celtic_Seas	blue_whiting	2013	4	7196519	7210986	5215762	7138924	9397751	7162001	2
IBWSS	Celtic_Seas	blue_whiting	2013	5	2932923	2937694	2259158	2922148	3748473	2945632	2
IBWSS	Celtic_Seas	blue_whiting	2013	6	1279515	1282194	908320	1251152	1622263	1258248	2
IBWSS	Celtic_Seas	blue_whiting	2013	7	1305861	1308107	762743	1299049	1824940	1298241	2
IBWSS	Celtic_Seas	blue_whiting	2013	8	1396353	1398112	960084	1370158	1813080	1377052	2
IBWSS	Celtic_Seas	blue_whiting	2013	9	927413	928650	610740	896391	1254076	910904	2
IBWSS	Celtic_Seas	blue_whiting	2013	10	1358376	1360546	895497	1399437	1993712	1419082	2
IBWSS	Celtic_Seas	blue_whiting	2013	11	312338	313067	188885	319423	482690	324852	2
IBWSS	Celtic_Seas	blue_whiting	2013	12	83927	84032	34380	77484	129515	79043	2
IBWSS	Celtic_Seas	blue_whiting	2013	13	23695	23719	3721	23158	49144	24197	2
IBWSS	Celtic_Seas	blue_whiting	2013	14	19475	19495	0	14469	34592	15418	2
IBWSS	Celtic_Seas	blue_whiting	2013	16	5992	5998	0	6375	21150	7515	2

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IBWSS	Celtic_Seas	blue_whiting	2013	Unknown			0	0	0	124	2
IBWSS	Celtic_Seas	blue_whiting	2013	Number	24958648	24966373	20031600	24998595	30658134	25086789	2
IBWSS	Celtic_Seas	blue_whiting	2013	Biomass	3107206	3109591	2518618	3107277	3788712	3108808	2
IBWSS	Celtic_Seas	blue_whiting	2014	1	4182893	4182893	1968264	4045963	7541448	4329937	2
IBWSS	Celtic_Seas	blue_whiting	2014	2	1491019	1491019	935341	1466532	2258054	1512024	2
IBWSS	Celtic_Seas	blue_whiting	2014	3	5239171	5239171	3820452	5037639	6862365	5161783	2
IBWSS	Celtic_Seas	blue_whiting	2014	4	8420388	8420388	6602926	8696482	10865773	8653071	2
IBWSS	Celtic_Seas	blue_whiting	2014	5	10202045	10202045	7648384	10030068	12649764	10047027	2
IBWSS	Celtic_Seas	blue_whiting	2014	6	2753804	2753804	1655462	2577497	4107026	2698054	2
IBWSS	Celtic_Seas	blue_whiting	2014	7	771791	771791	408315	670707	1028933	689292	2
IBWSS	Celtic_Seas	blue_whiting	2014	8	576763	576763	355041	552158	779461	559339	2
IBWSS	Celtic_Seas	blue_whiting	2014	9	898560	898560	474220	833575	1242113	842011	2
IBWSS	Celtic_Seas	blue_whiting	2014	10	772581	772581	510639	746812	1003103	751082	2
IBWSS	Celtic_Seas	blue_whiting	2014	11	811961	811961	528283	814660	1158094	820318	2
IBWSS	Celtic_Seas	blue_whiting	2014	12	478340	478340	314891	488688	711370	494865	2
IBWSS	Celtic_Seas	blue_whiting	2014	13	77702	77702	27736	68017	124895	71218	2
IBWSS	Celtic_Seas	blue_whiting	2014	14	89585	89585	45692	91478	162413	96102	2
IBWSS	Celtic_Seas	blue_whiting	2014	15	20832	20832	3558	19255	42839	20653	2
IBWSS	Celtic_Seas	blue_whiting	2014	Unknown	15241	15241	0	15241	55591	20768	2
IBWSS	Celtic_Seas	blue_whiting	2014	Number	36802677	36802677	30762019	36893078	42639346	36767545	2
IBWSS	Celtic_Seas	blue_whiting	2014	Biomass	3336757	3760508	3037222	3735516	4439113	3743154	2
IBWSS	Celtic_Seas	blue_whiting	2015	1	3255286	3255286	2085843	3216730	4752102	3287158	2
IBWSS	Celtic_Seas	blue_whiting	2015	2	4565042	4569645	3577033	4680319	5897172	4691393	2
IBWSS	Celtic_Seas	blue_whiting	2015	3	1888395	1891463	1418246	1820249	2249288	1827156	2
IBWSS	Celtic_Seas	blue_whiting	2015	4	3630261	3641426	2778958	3572317	4539602	3613603	2
IBWSS	Celtic_Seas	blue_whiting	2015	5	1792393	1797081	1426102	1853003	2336480	1864777	2
IBWSS	Celtic_Seas	blue_whiting	2015	6	464636	465744	227387	461574	669433	445834	2
IBWSS	Celtic_Seas	blue_whiting	2015	7	173132	173899	72660	158657	262000	161444	2
IBWSS	Celtic_Seas	blue_whiting	2015	8	108302	108302	28621	114646	194326	112814	2
IBWSS	Celtic_Seas	blue_whiting	2015	9	206406	206491	98838	214307	355433	218722	2
IBWSS	Celtic_Seas	blue_whiting	2015	10	131586	131586	58477	116185	187548	118705	2
IBWSS	Celtic_Seas	blue_whiting	2015	11	114916	114916	35820	92344	168751	96553	2
IBWSS	Celtic_Seas	blue_whiting	2015	12	62868	62954	11683	69538	124003	64120	2
IBWSS	Celtic_Seas	blue_whiting	2015	13	50200	50200	11045	54269	110689	56183	2
IBWSS	Celtic_Seas	blue_whiting	2015	15	5696	5696	0	4907	24100	7996	2
IBWSS	Celtic_Seas	blue_whiting	2015	Unknown	15791	15791	0	14237	39775	16100	2
IBWSS	Celtic_Seas	blue_whiting	2015	Number	16464910	16490479	13519174	16462574	19994910	16582558	2
IBWSS	Celtic_Seas	blue_whiting	2015	Biomass	1402565	1405137	1167386	1396793	1658568	1405138	2
IBWSS	Celtic_Seas	blue_whiting	2016	1	2744709	2744709	2161868	2770002	3522271	2794521	6
IBWSS	Celtic_Seas	blue_whiting	2016	2	7893483	7893483	5590778	7719674	11945015	8050456	6
IBWSS	Celtic_Seas	blue_whiting	2016	3	10163628	10163628	7994222	10029981	12626254	10105761	6
IBWSS	Celtic_Seas	blue_whiting	2016	4	6273974	6273974	4819229	6200156	7869136	6255837	6
IBWSS	Celtic_Seas	blue_whiting	2016	5	4686728	4686728	3359329	4593799	5983526	4634353	6
IBWSS	Celtic_Seas	blue_whiting	2016	6	1539168	1539168	1060727	1487609	2132871	1527810	6
IBWSS	Celtic_Seas	blue_whiting	2016	7	412879	412879	254877	440668	682865	451073	6
IBWSS	Celtic_Seas	blue_whiting	2016	8	133304	133304	49094	105137	172515	106621	6
IBWSS	Celtic_Seas	blue_whiting	2016	9	234771	234771	85170	206447	372283	214038	6
IBWSS	Celtic_Seas	blue_whiting	2016	10	137892	137892	30088	125208	238524	125490	6
IBWSS	Celtic_Seas	blue_whiting	2016	11	118583	118583	49898	111938	188859	114341	6
IBWSS	Celtic_Seas	blue_whiting	2016	12	64772	64772	19844	60117	129154	66854	6
IBWSS	Celtic_Seas	blue_whiting	2016	13	7779	7779	0	8842	18422	7801	6
IBWSS	Celtic_Seas	blue_whiting	2016	16	8751	8751	0	8746	22010	8648	6
IBWSS	Celtic_Seas	blue_whiting	2016	17	23071	23071	0	21594	52051	20753	6
IBWSS	Celtic_Seas	blue_whiting	2016	Unknown	3266	3266	0	3754	34711	9000	6
IBWSS	Celtic_Seas	blue_whiting	2016	Number	34446759	34446759	27733318	34243090	41641123	34493356	6
IBWSS	Celtic_Seas	blue_whiting	2016	Biomass	2872728.2	2872728	2299475	2841637	3448719	2860151	6
IBWSS	Celtic_Seas	blue_whiting	2017	1	275153	262408	136235	251325	479578	273704	9
IBWSS	Celtic_Seas	blue_whiting	2017	2	2180092	2248222	1709368	2247931	2942711	2281835	9
IBWSS	Celtic_Seas	blue_whiting	2017	3	15938611	15682137	12350585	15679064	19491750	15800611	9
IBWSS	Celtic_Seas	blue_whiting	2017	4	10195580	10175821	8093317	10050047	12267320	10116063	9
IBWSS	Celtic_Seas	blue_whiting	2017	5	3621484	3761730	2951268	3655683	4523011	3693065	9
IBWSS	Celtic_Seas	blue_whiting	2017	6	1710772	1792776	1245586	1695065	2199416	1714349	9
IBWSS	Celtic_Seas	blue_whiting	2017	7	900096	921383	586924	878265	1266189	892488	9
IBWSS	Celtic_Seas	blue_whiting	2017	8	74749	76217	36409	81276	135981	83198	9
IBWSS	Celtic_Seas	blue_whiting	2017	9	65580	83787	24930	67935	133120	71704	9
IBWSS	Celtic_Seas	blue_whiting	2017	10	72322	54115	18292	56338	103846	57474	9
IBWSS	Celtic_Seas	blue_whiting	2017	11	79042	54885	10154	63972	135803	68056	9
IBWSS	Celtic_Seas	blue_whiting	2017	12	41307	41307	12791	44842	90480	46433	9
IBWSS	Celtic_Seas	blue_whiting	2017	13	23172	23172	0	19044	48985	20718	9
IBWSS	Celtic_Seas	blue_whiting	2017	Unknown			0	0	24391	6640	9
IBWSS	Celtic_Seas	blue_whiting	2017	Number	35177961	35177961	28600143	35212499	41795134	35126338	9
IBWSS	Celtic_Seas	blue_whiting	2017	Biomass	3134934	3134817	2557874	3116401	3740211	3128990	9
IBWSS	Celtic_Seas	blue_whiting	2018	1	836283	836283	411537	793253	1327547	820952	12
IBWSS	Celtic_Seas	blue_whiting	2018	2	627685	627685	423298	638658	857618	637990	12
IBWSS	Celtic_Seas	blue_whiting	2018	3	6615259	6615259	5334670	6630138	8036972	6666595	12
IBWSS	Celtic_Seas	blue_whiting	2018	4	21490424	21490424	16835508	21300017	25768231	21298805	12

cruise	area	species	year	age/group	baseline_old	baseline	p5%	median	p95%	mean	source_old
IBWSS	Celtic_Seas	blue_whiting	2018	5	7692044	7692044	6008087	7774587	9838746	7822740	12
IBWSS	Celtic_Seas	blue_whiting	2018	6	2187289	2187289	1631844	2187644	2904628	2224208	12
IBWSS	Celtic_Seas	blue_whiting	2018	7	755106	755106	518022	779048	1129786	794315	12
IBWSS	Celtic_Seas	blue_whiting	2018	8	187524	187524	73082	185976	315066	189165	12
IBWSS	Celtic_Seas	blue_whiting	2018	9	72479	72479	34105	79415	150552	84104	12
IBWSS	Celtic_Seas	blue_whiting	2018	10	46484	46484	5038	49299	105884	51965	12
IBWSS	Celtic_Seas	blue_whiting	2018	11	33411	33411	4324	27626	66556	30550	12
IBWSS	Celtic_Seas	blue_whiting	2018	12	27059	27059	0	34520	76294	33759	12
IBWSS	Celtic_Seas	blue_whiting	2018	14	19864	19864	2428	19718	44212	21017	12
IBWSS	Celtic_Seas	blue_whiting	2018	15	5539	5539	0	3377	11668	4328	12
IBWSS	Celtic_Seas	blue_whiting	2018	17	1845	1845	0	1737	6036	2553	12
IBWSS	Celtic_Seas	blue_whiting	2018	18	3340	3340	0	3243	7961	3281	12
IBWSS	Celtic_Seas	blue_whiting	2018	Unknown			0	0	6252	1561	12
IBWSS	Celtic_Seas	blue_whiting	2018	Number	40601635	40601635	32296625	40631875	48929876	40687887	12
IBWSS	Celtic_Seas	blue_whiting	2018	Biomass	4034502	4034502	3241576	4026715	4871566	4045373	12
IBWSS	Celtic_Seas	blue_whiting	2019	1	1128742	1128742	446949	1073471	2376937	1183531	15
IBWSS	Celtic_Seas	blue_whiting	2019	2	1168854	1168854	875929	1167766	1555807	1184873	15
IBWSS	Celtic_Seas	blue_whiting	2019	3	3468328	3468328	2460954	3519491	4636373	3516048	15
IBWSS	Celtic_Seas	blue_whiting	2019	4	9589656	9589656	6488513	9174744	12488644	9292286	15
IBWSS	Celtic_Seas	blue_whiting	2019	5	16978576	16978576	11691957	16552013	22124735	16666998	15
IBWSS	Celtic_Seas	blue_whiting	2019	6	3434000	3434000	2442370	3514514	4794002	3559463	15
IBWSS	Celtic_Seas	blue_whiting	2019	7	483911	483911	248252	490751	954684	528119	15
IBWSS	Celtic_Seas	blue_whiting	2019	8	512840	512840	99998	516116	1070555	501833	15
IBWSS	Celtic_Seas	blue_whiting	2019	9	98649	98649	16133	77208	138142	76143	15
IBWSS	Celtic_Seas	blue_whiting	2019	10	24937	24937	1634	22655	74799	29403	15
IBWSS	Celtic_Seas	blue_whiting	2019	11	12380	12380	0	17057	81143	22772	15
IBWSS	Celtic_Seas	blue_whiting	2019	13	5569	5569	0	7017	37856	10144	15
IBWSS	Celtic_Seas	blue_whiting	2019	Unknown	11073	11073	6036	23038	230046	55286	15
IBWSS	Celtic_Seas	blue_whiting	2019	Number	36917514	36917514	26437479	36676964	47051034	36626898	15
IBWSS	Celtic_Seas	blue_whiting	2019	Biomass	4197615	4197615	2967700	4148839	5317291	4152060	15

Figures

Old and new baseline estimates and mean of 1000 boostrap replicates per age/group (SumMean).

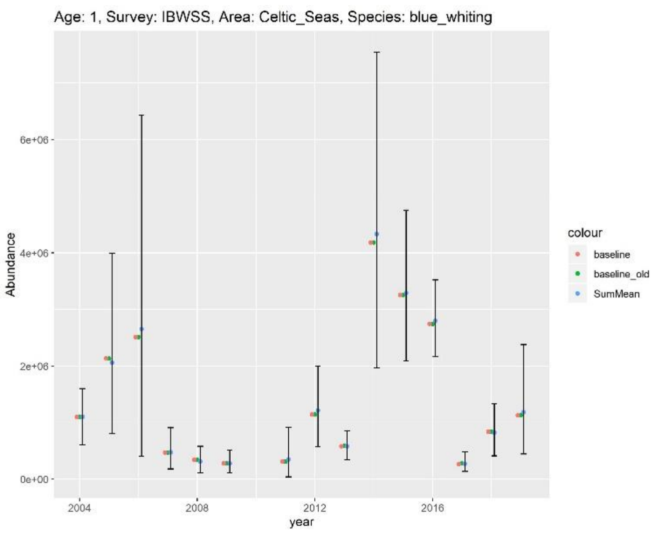


Figure 1

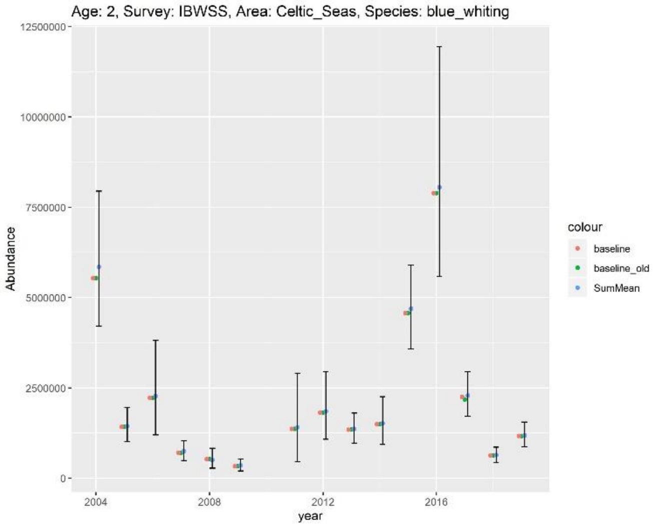


Figure 2

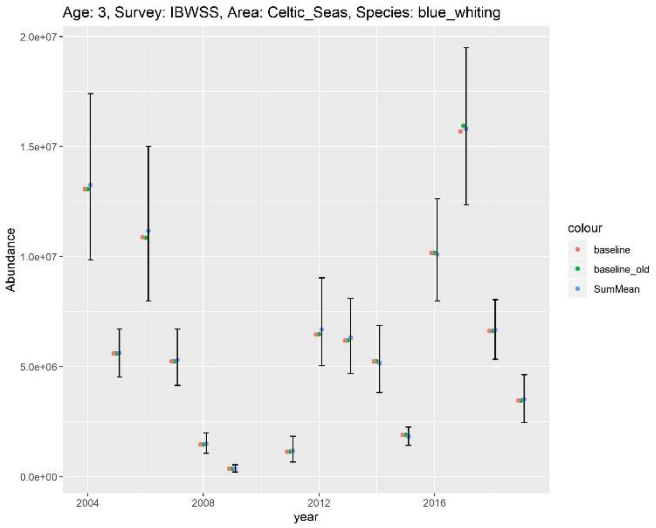
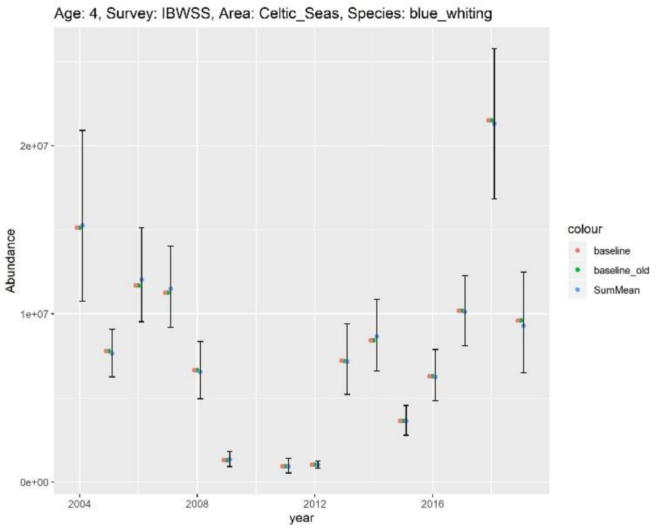


Figure 3



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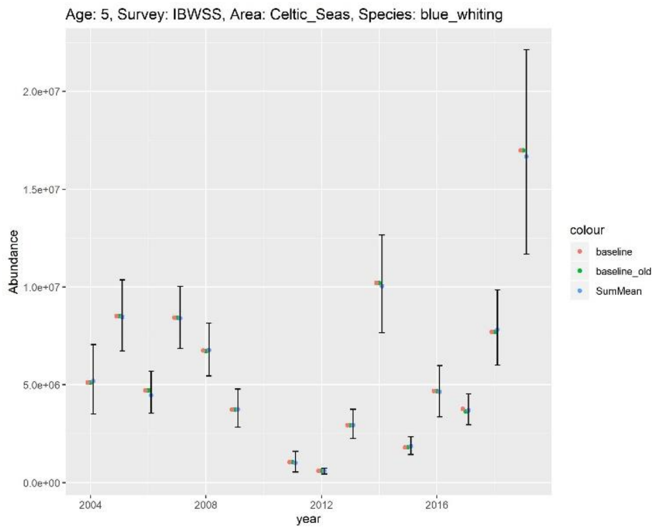

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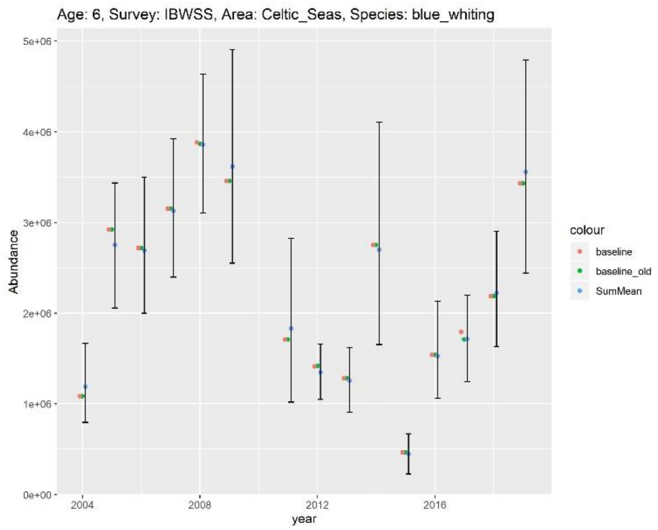

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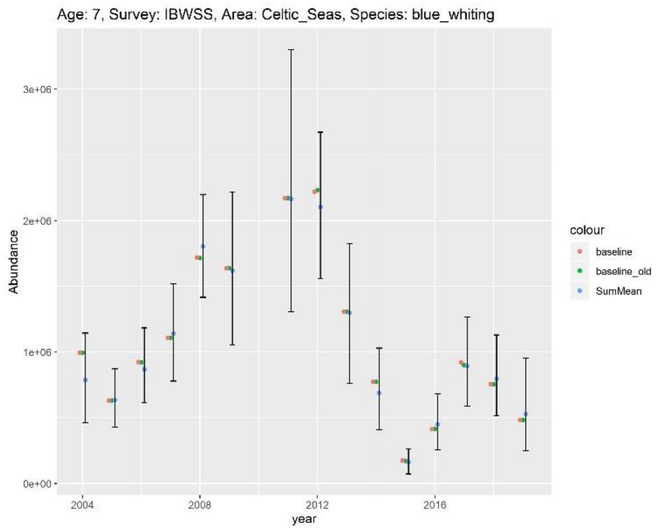

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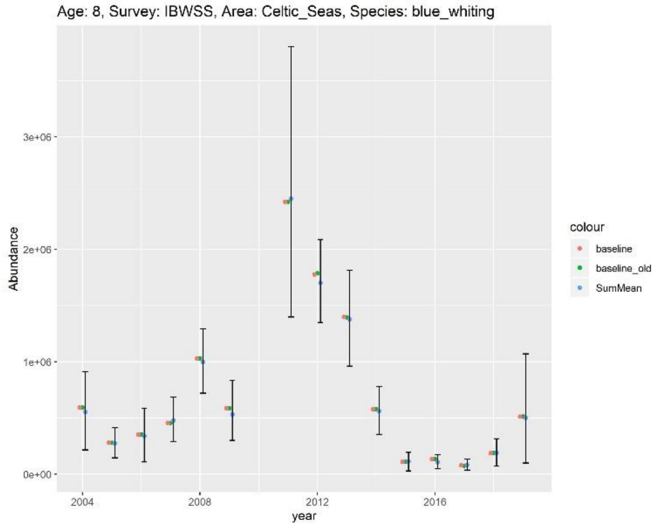


Figure 8

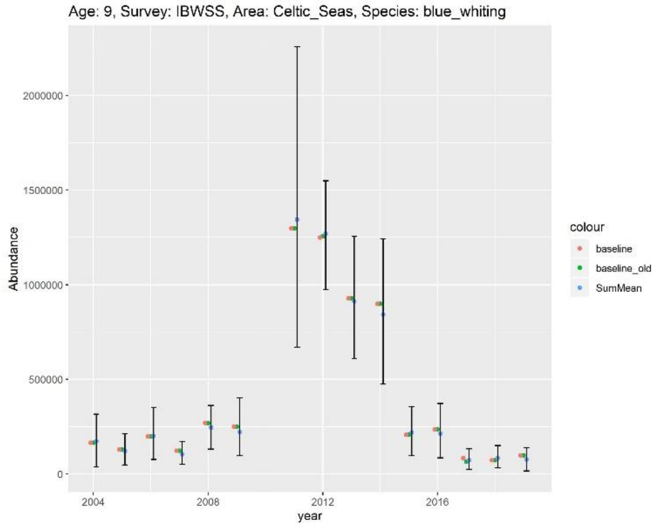


Figure 9

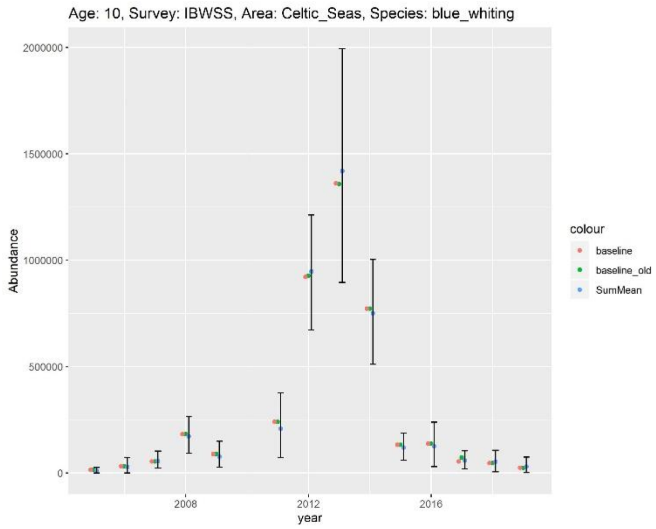
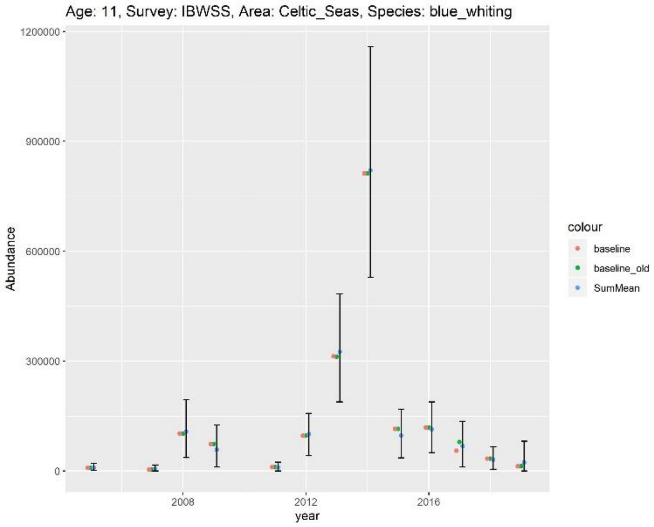


Figure 10



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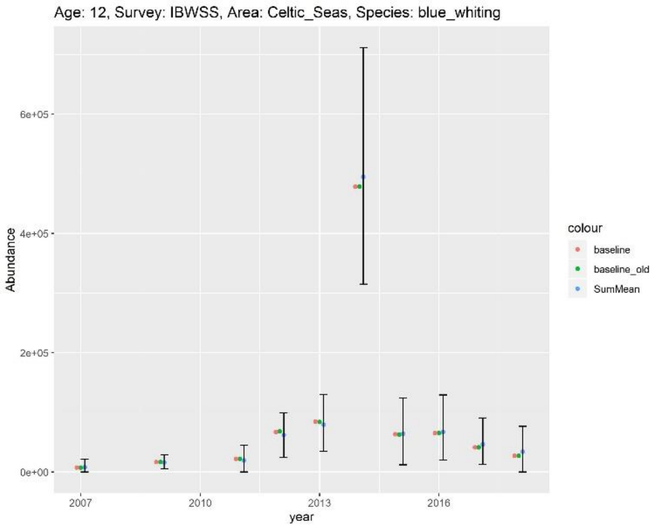


Figure 12

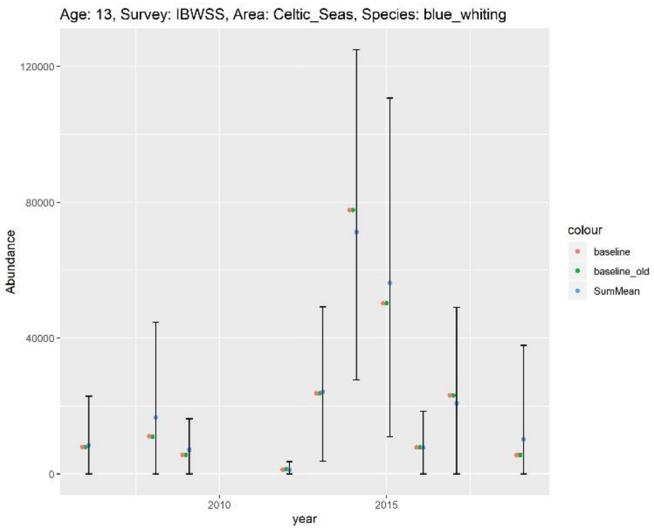


Figure 13

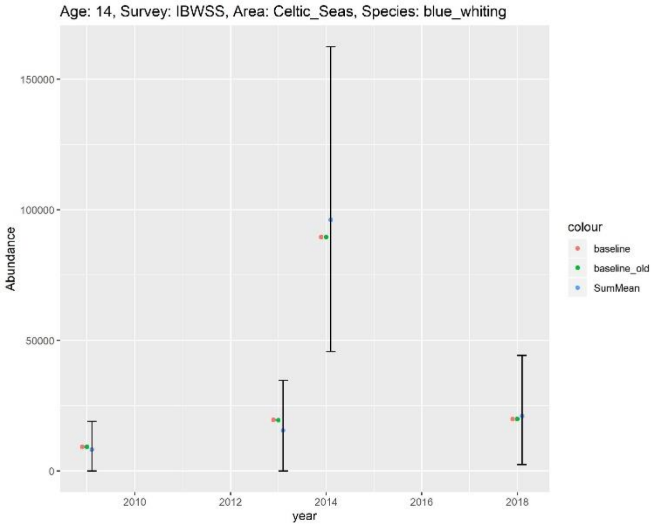


Figure 14

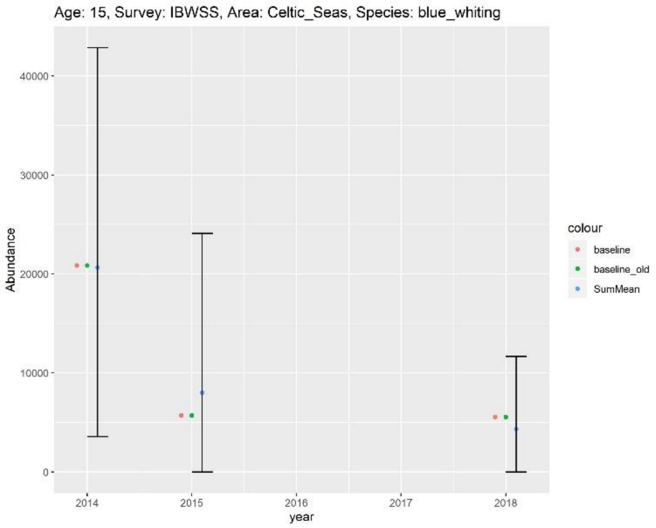


Figure 15

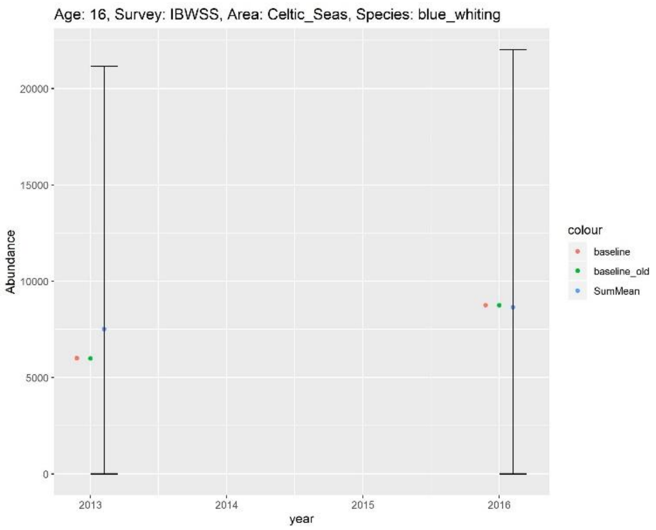
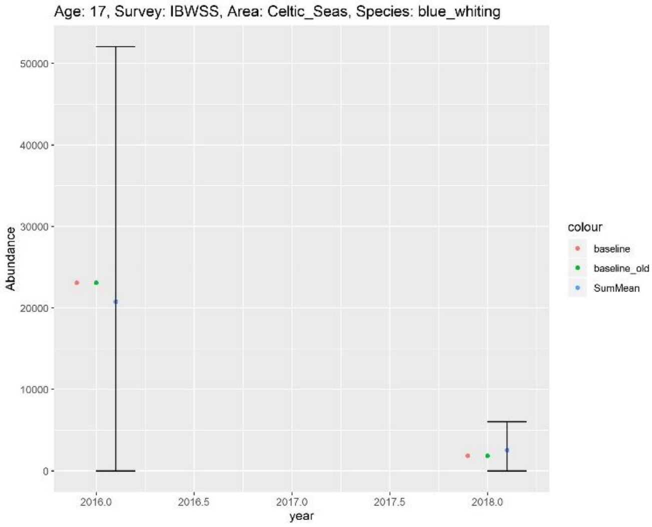


Figure 16



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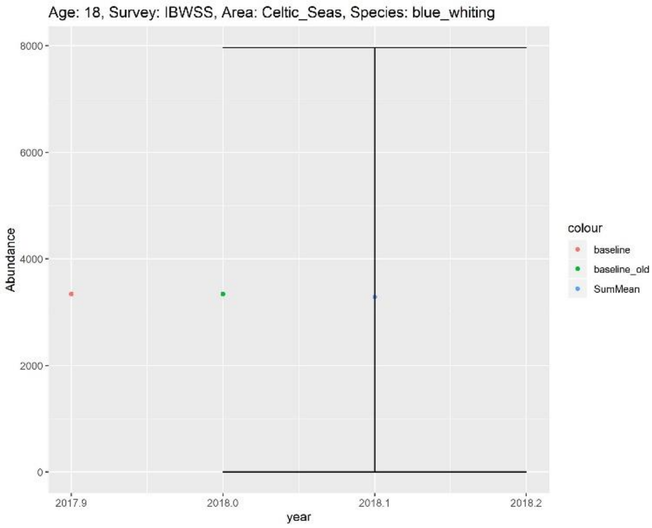

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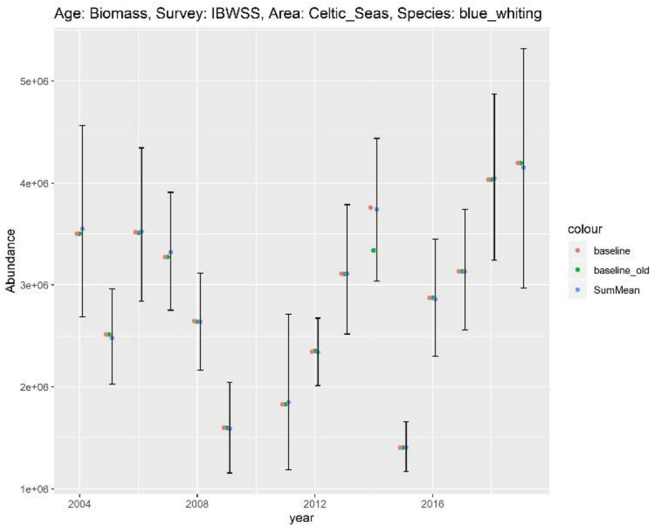

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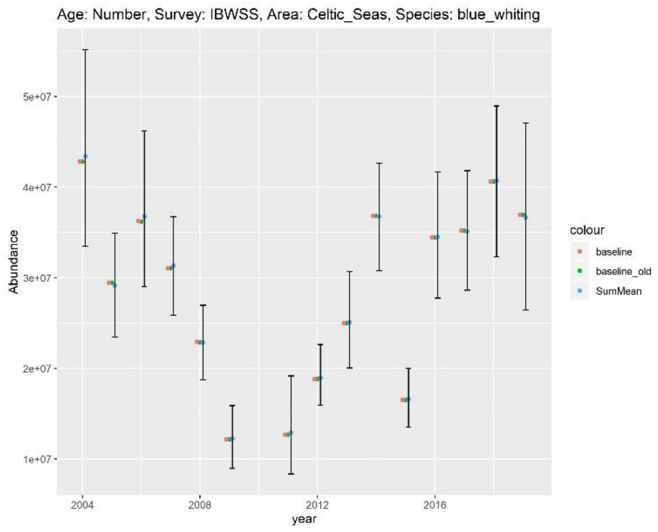
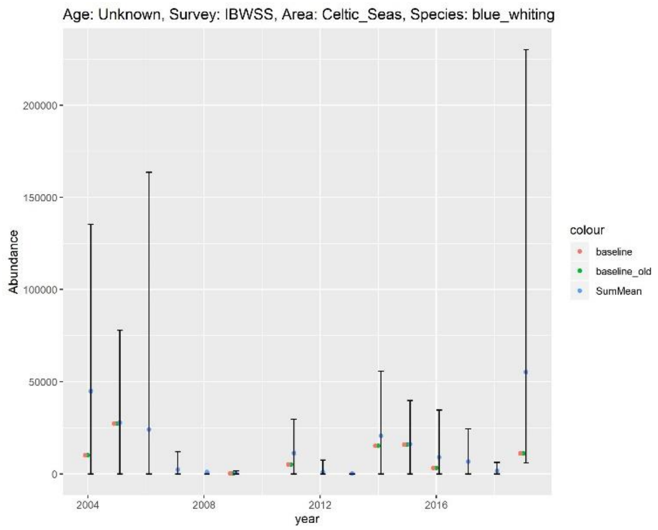


Figure 20



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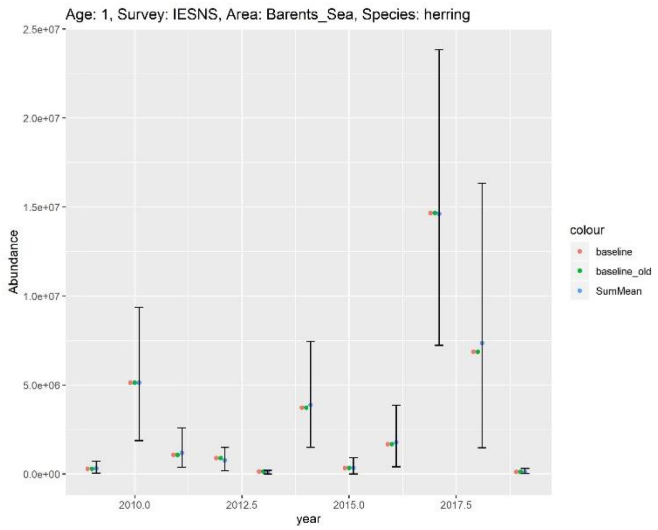
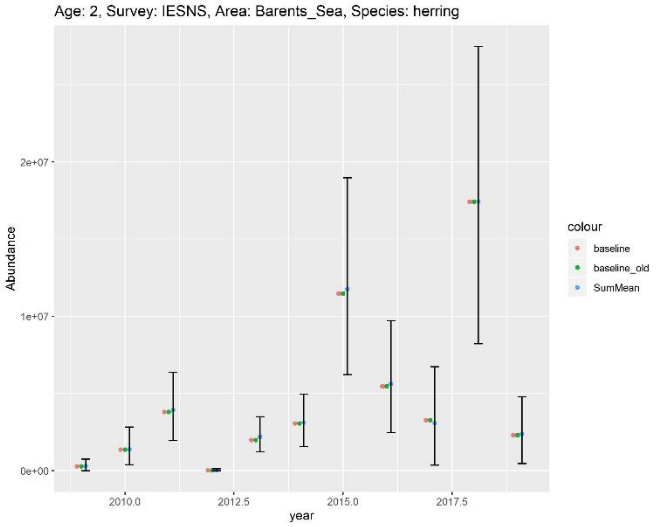


Figure 22



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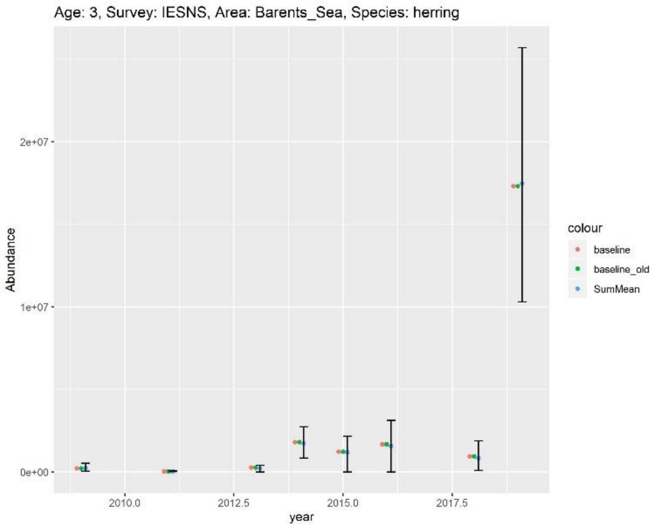

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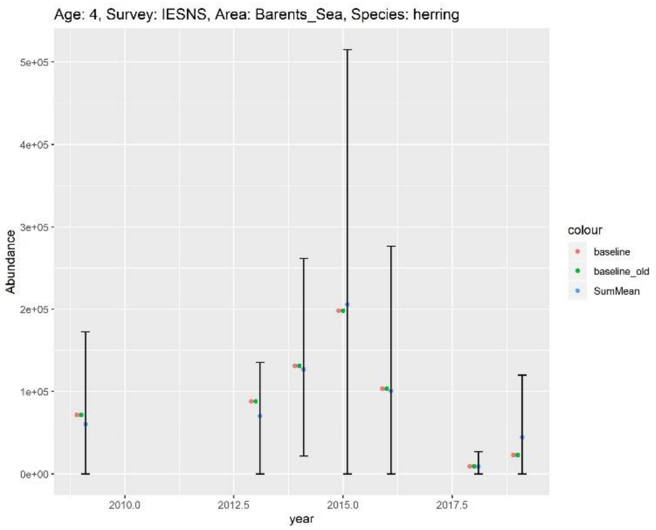

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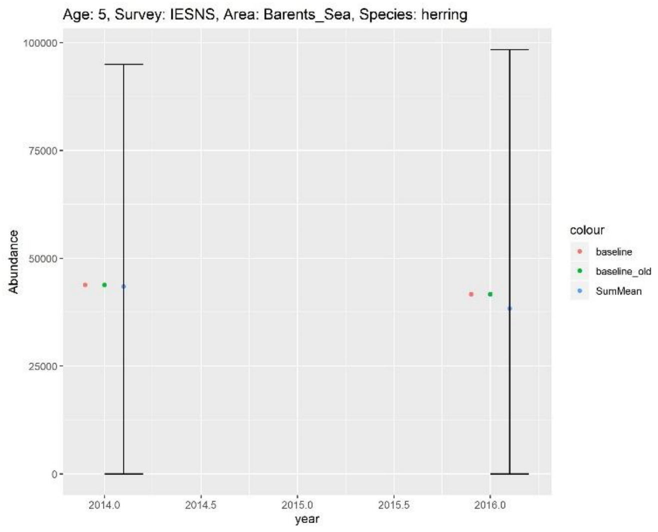

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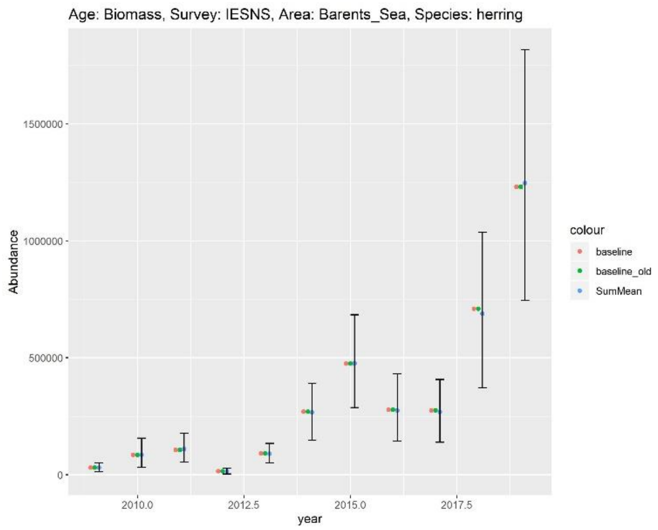

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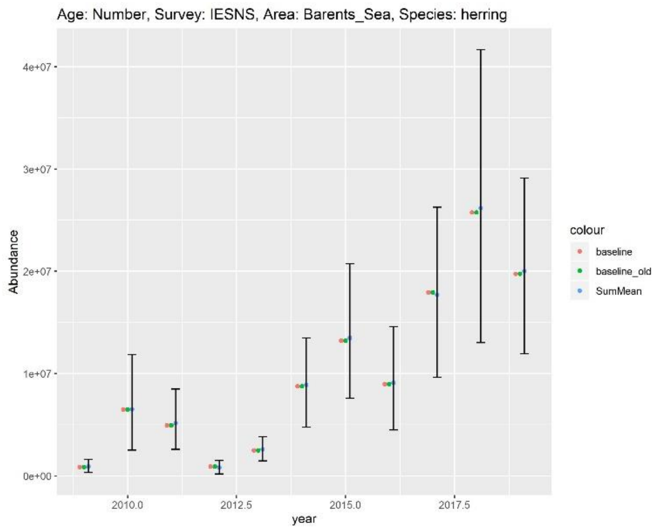

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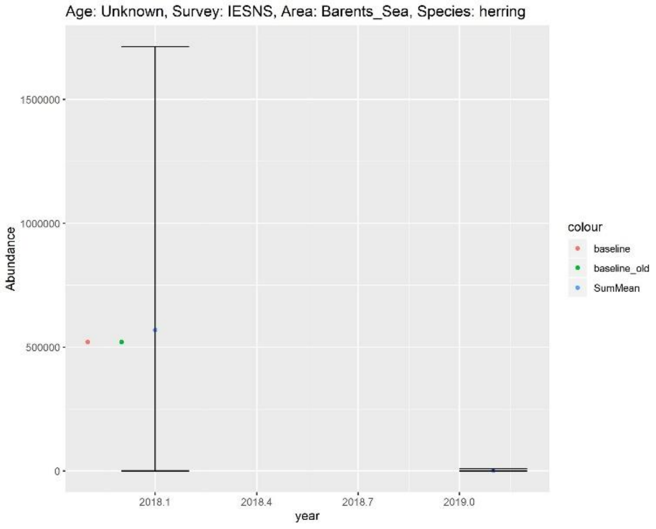

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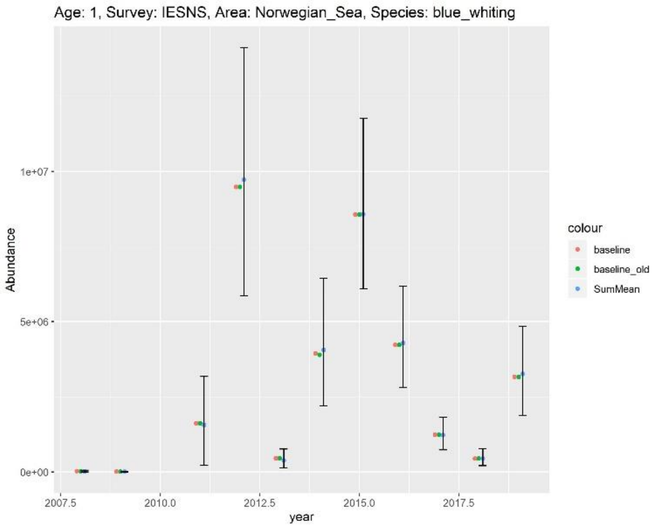
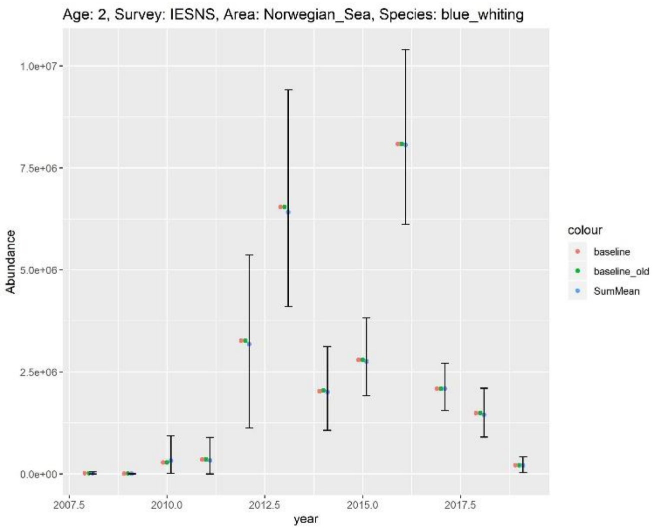


Figure 30



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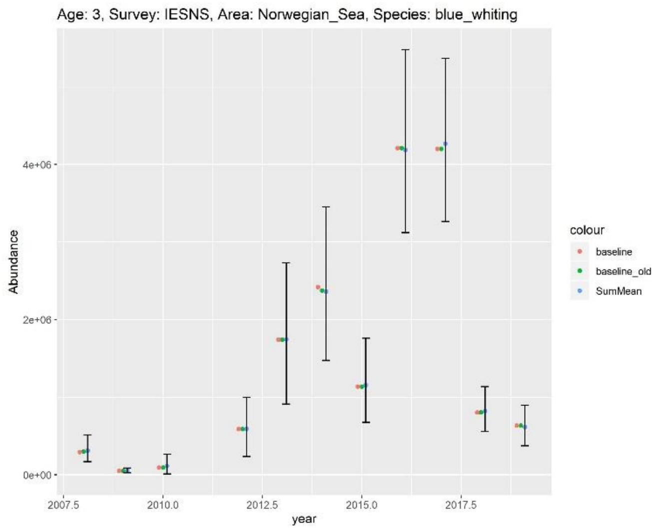

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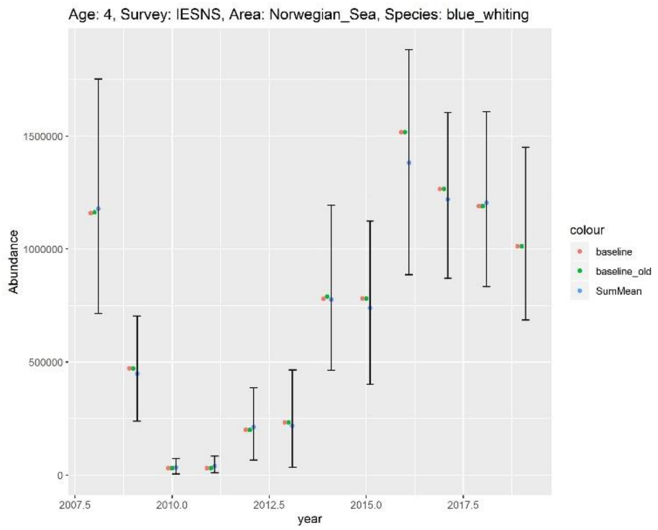

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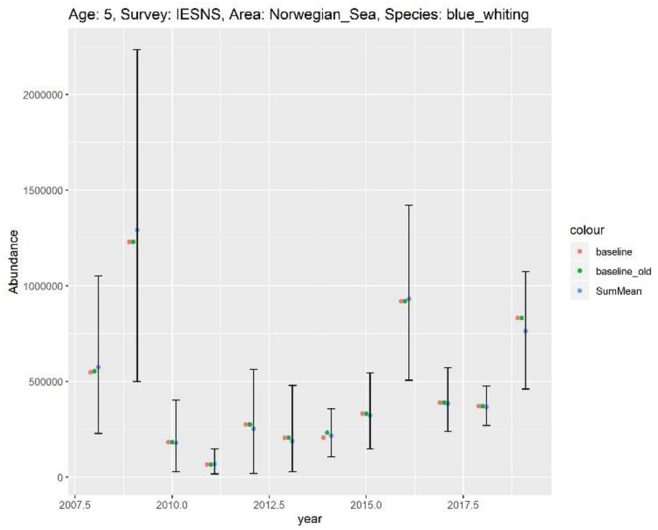

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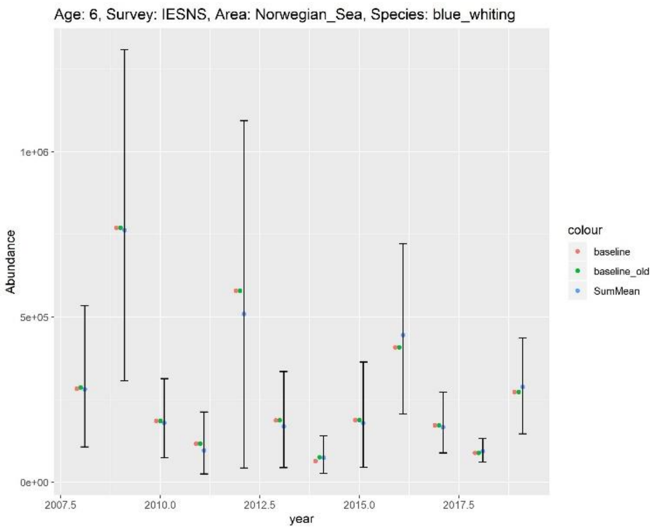

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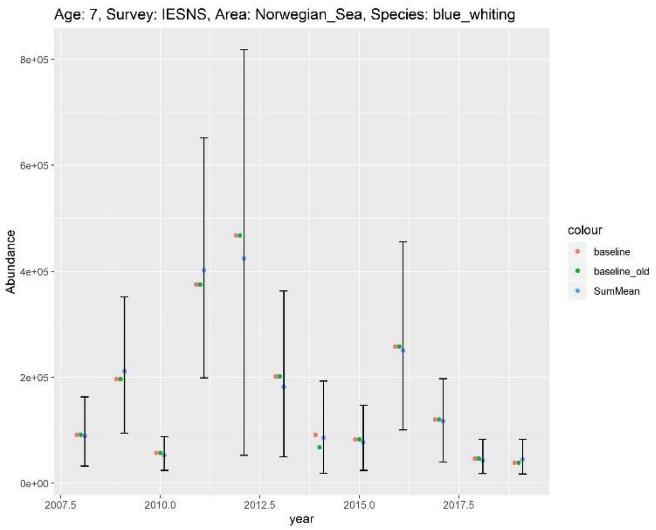

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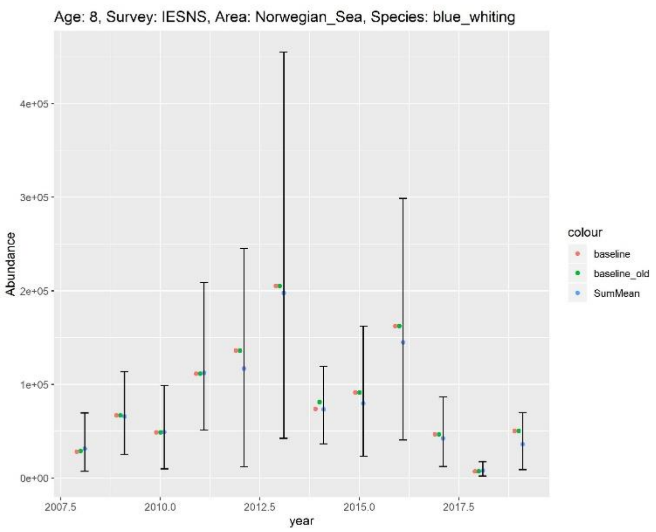

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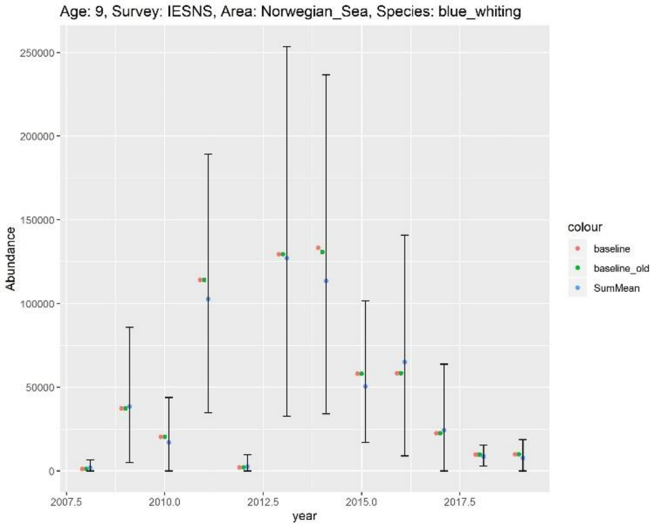

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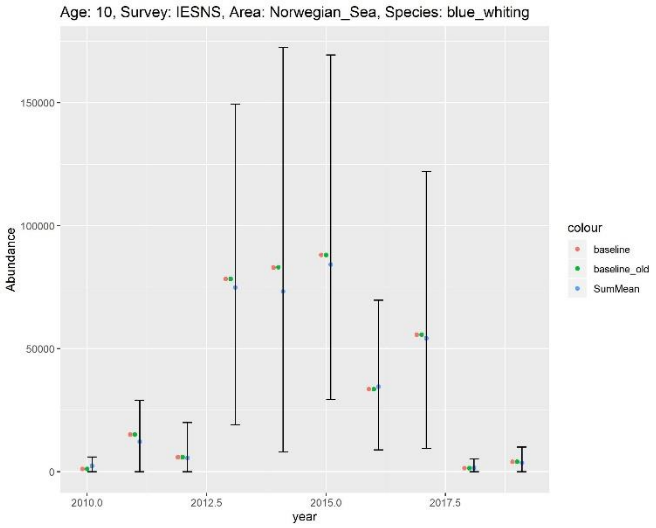

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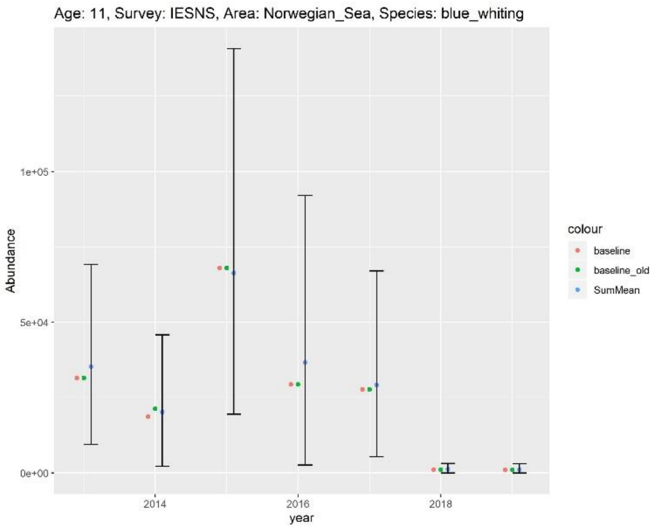

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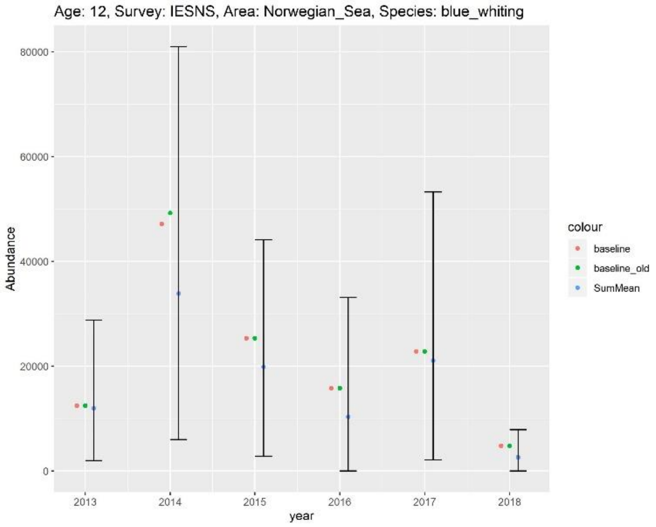

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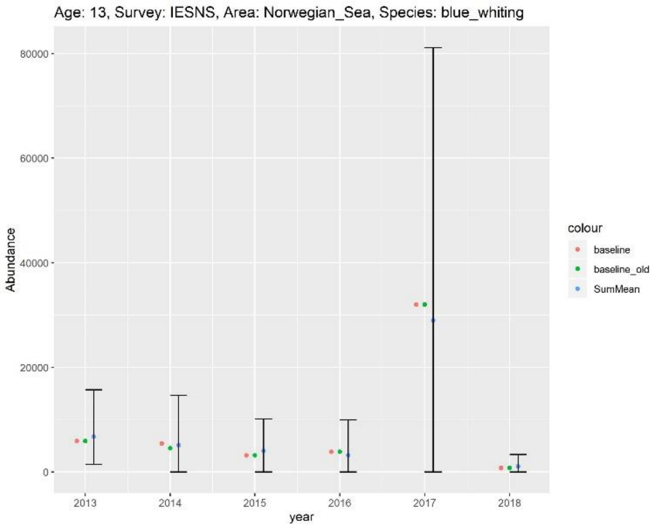

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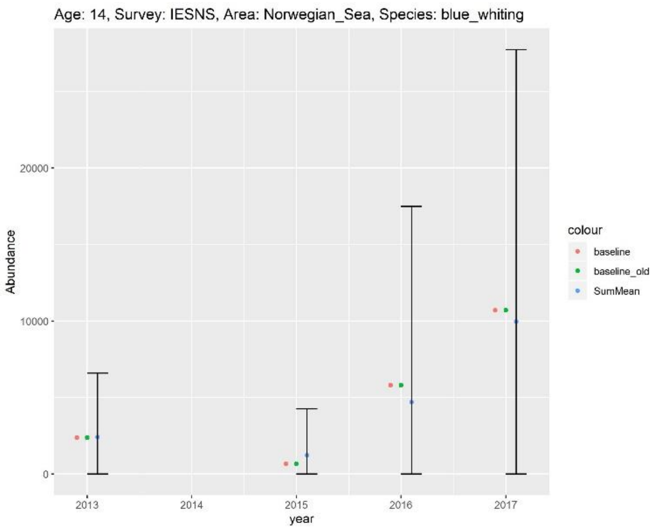

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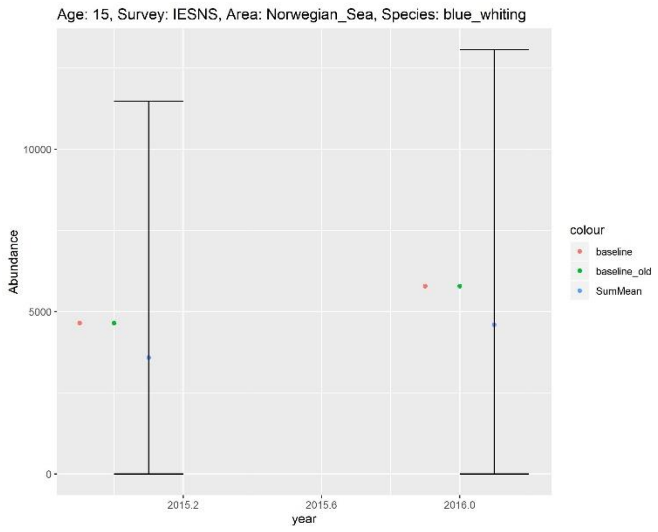

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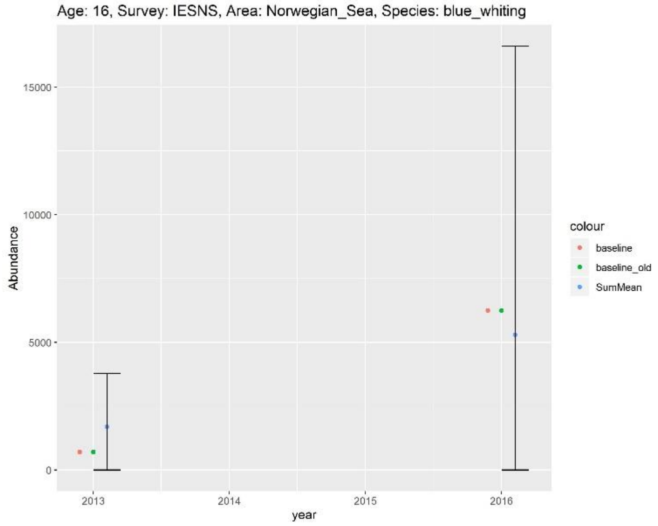

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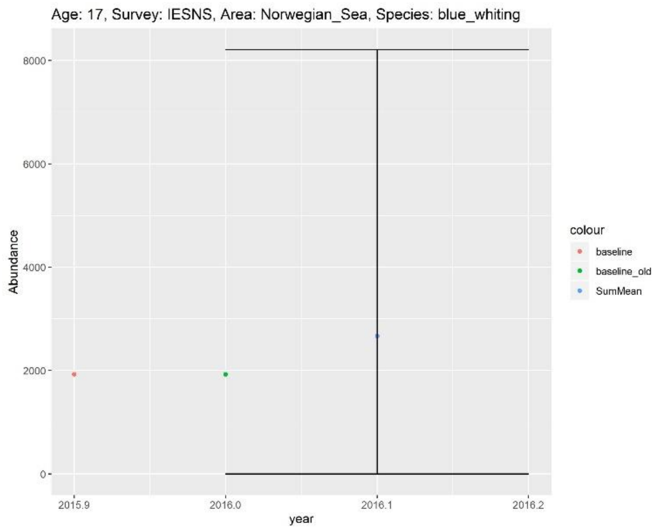

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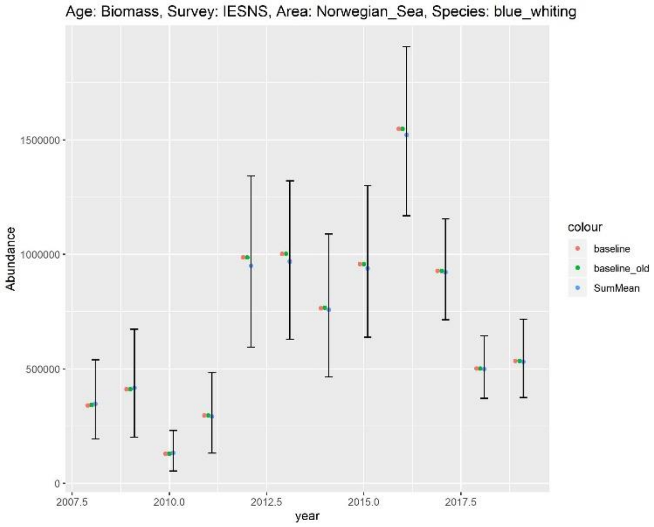

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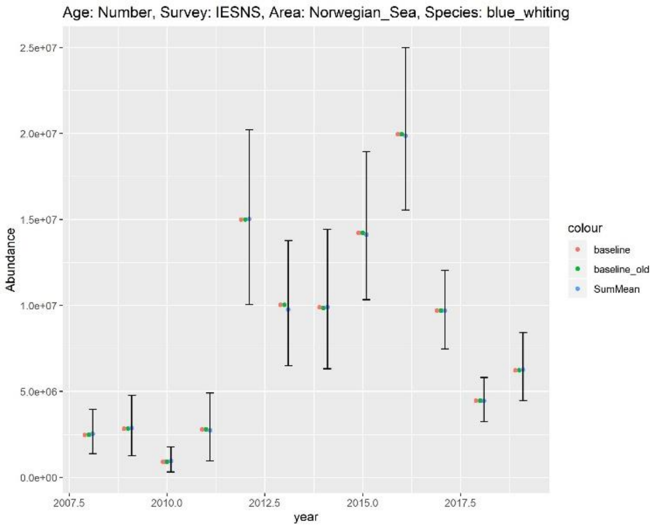

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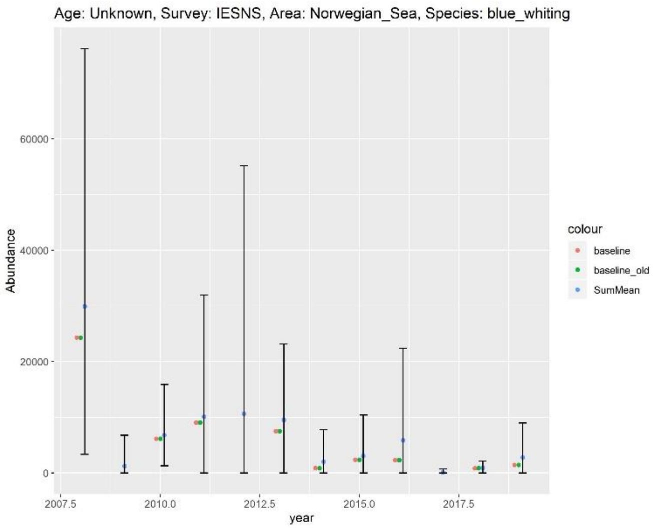

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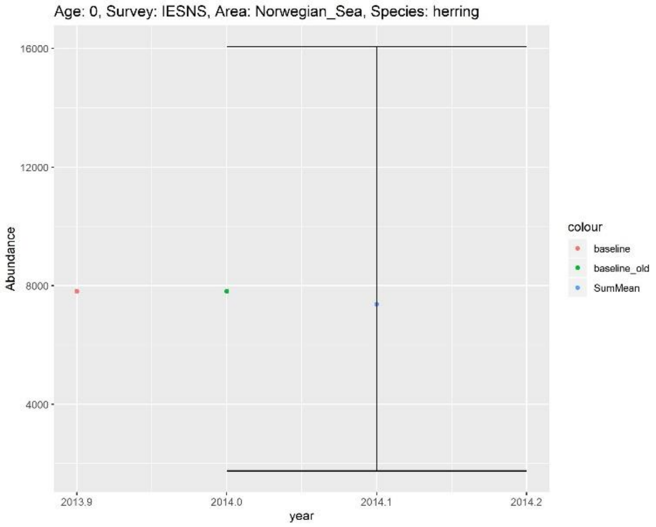

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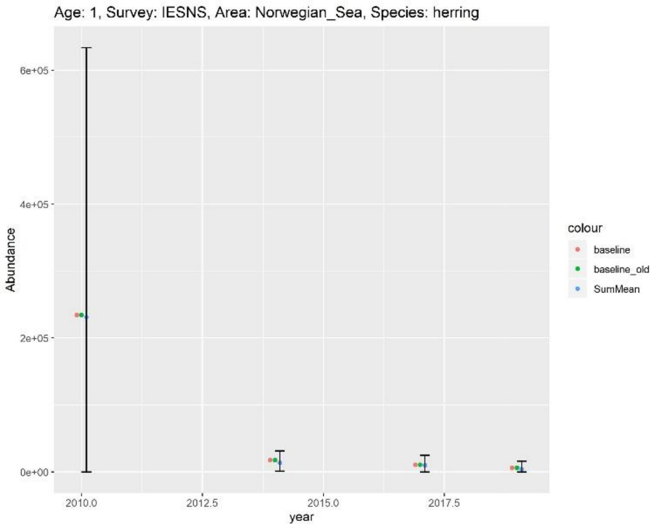

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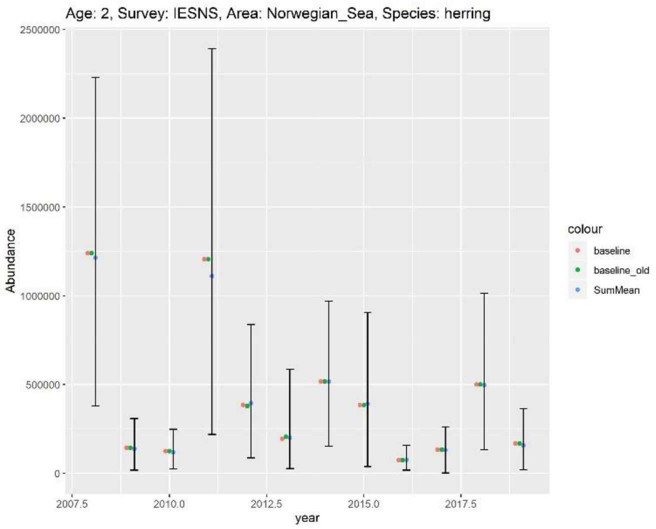
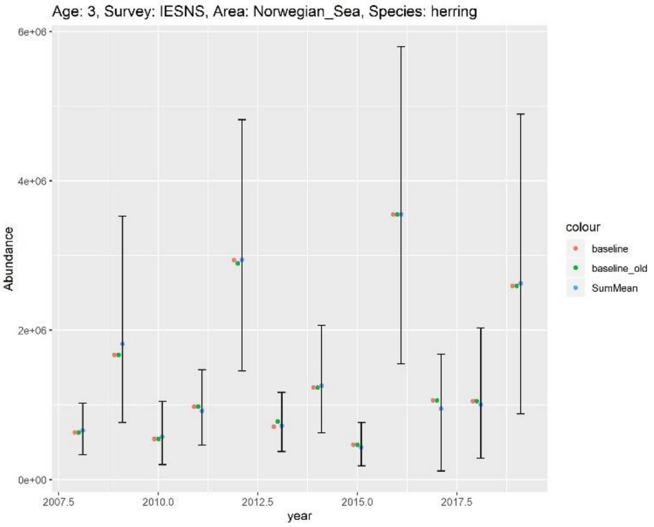


Figure 52



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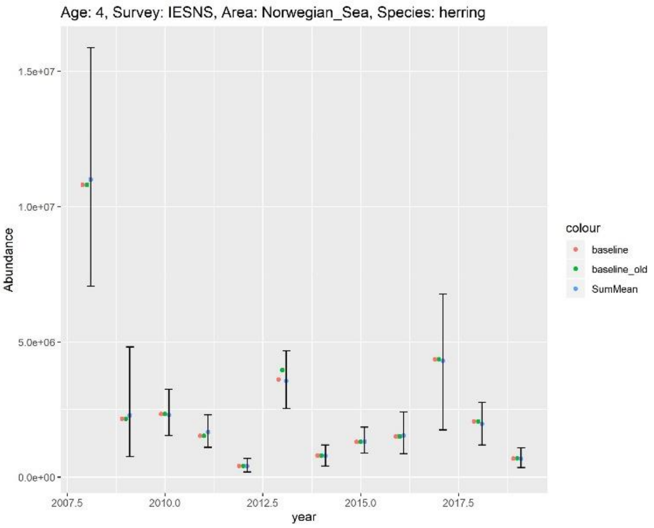

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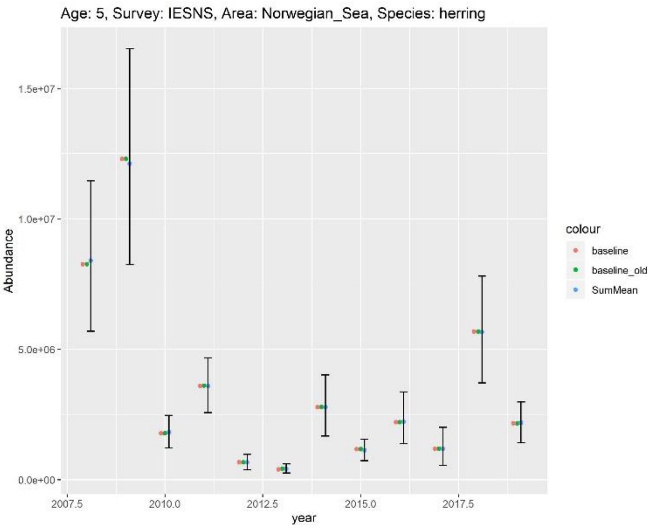

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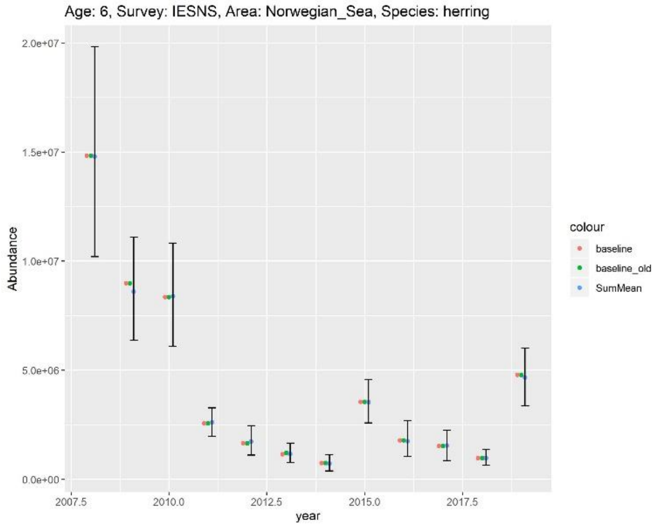

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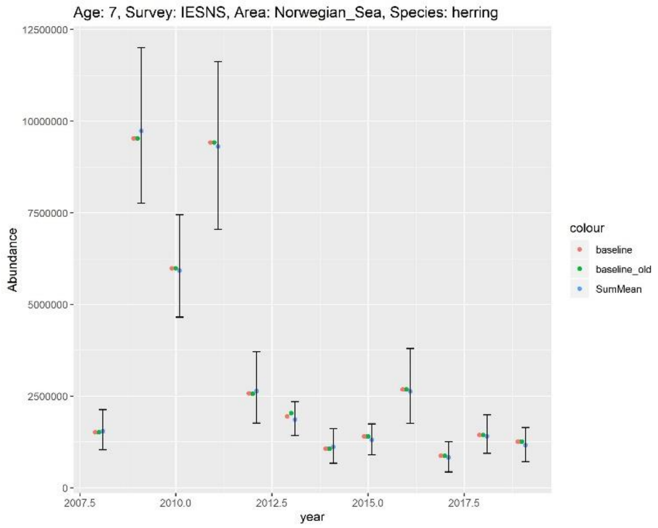

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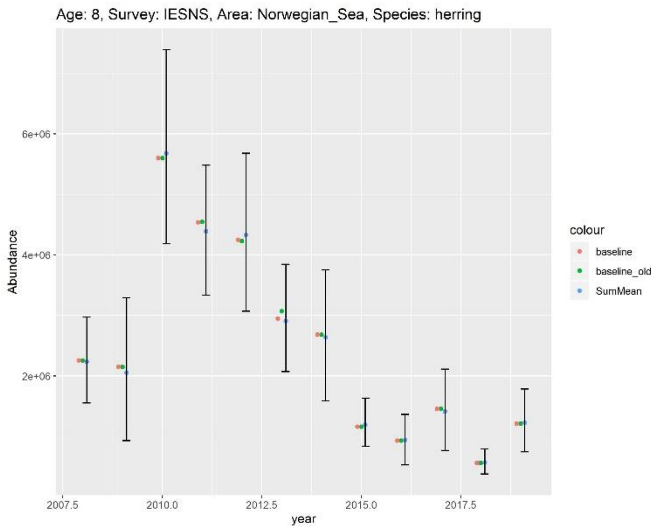

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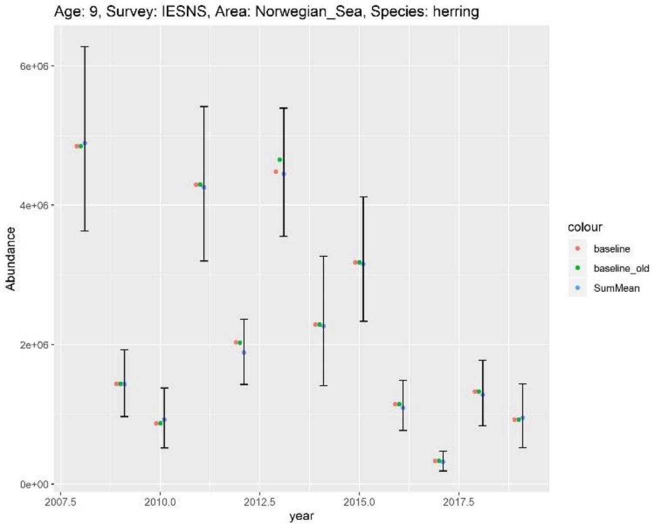

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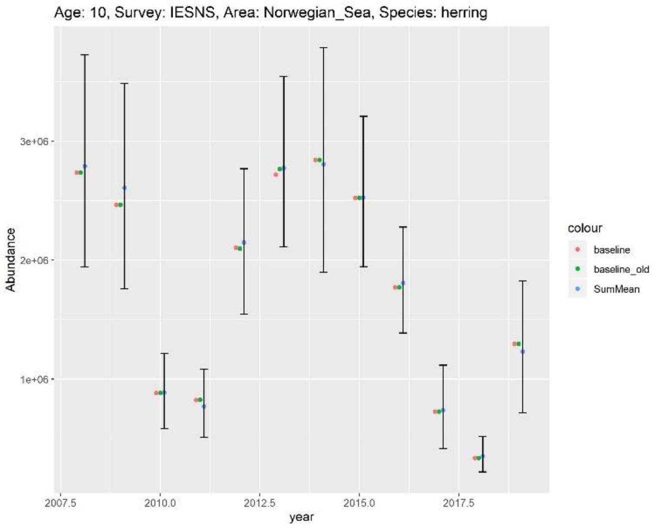

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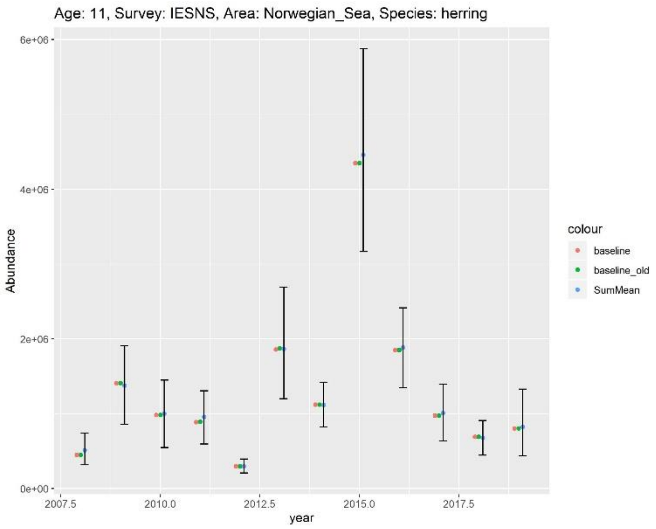

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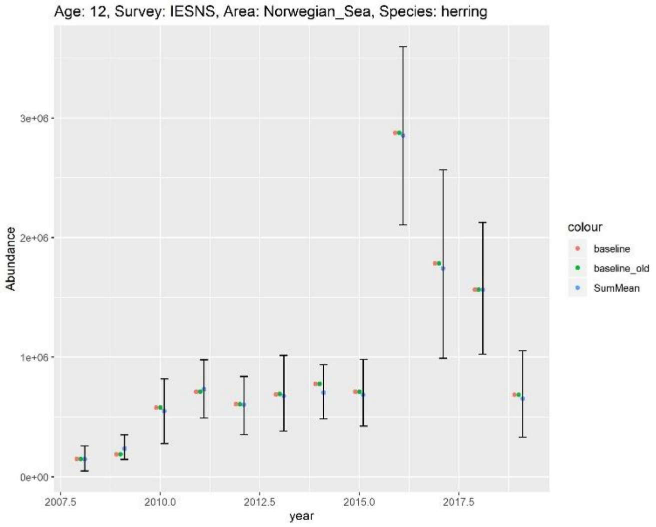

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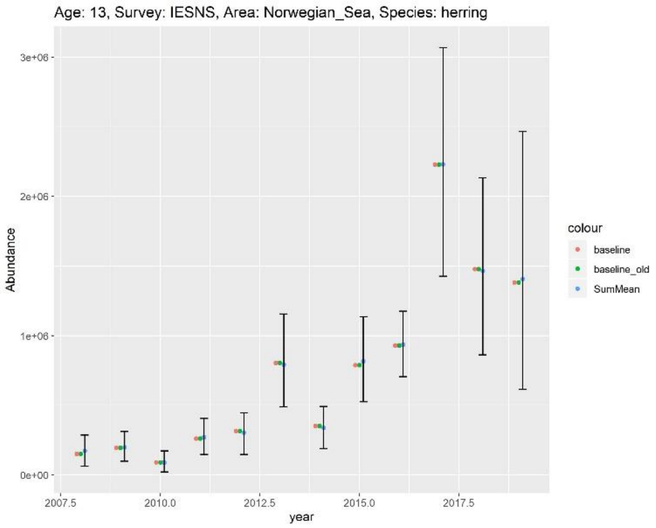

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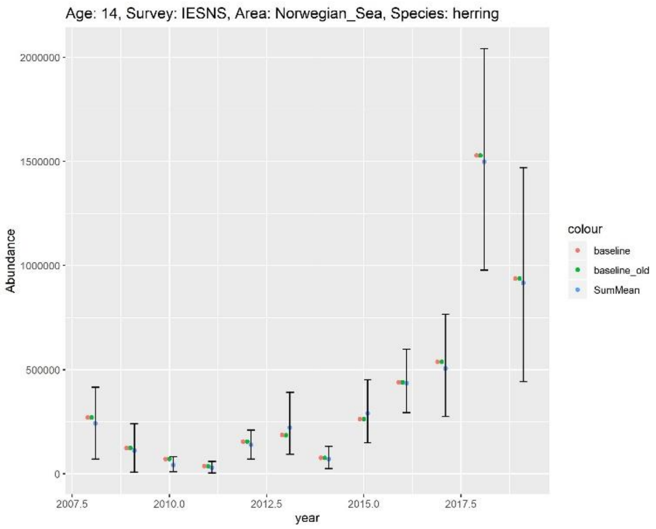

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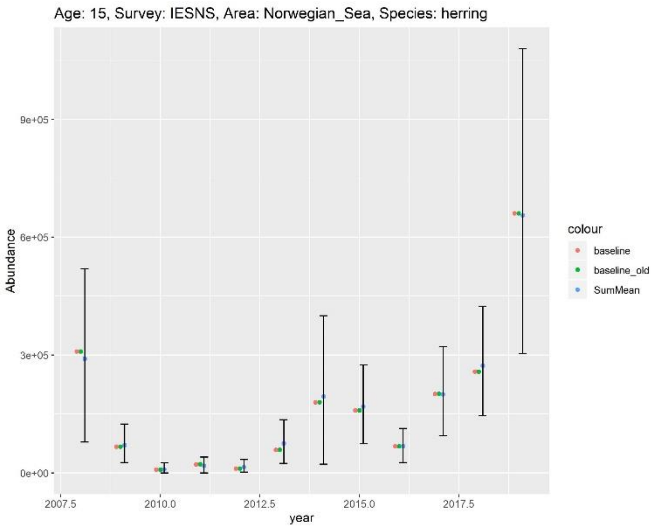

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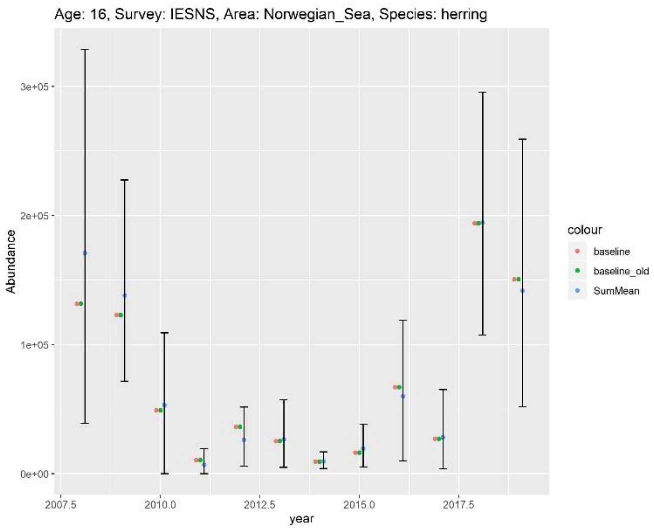

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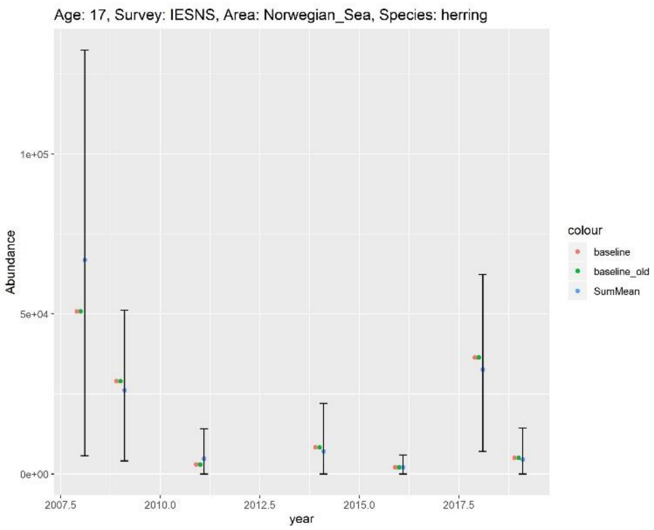

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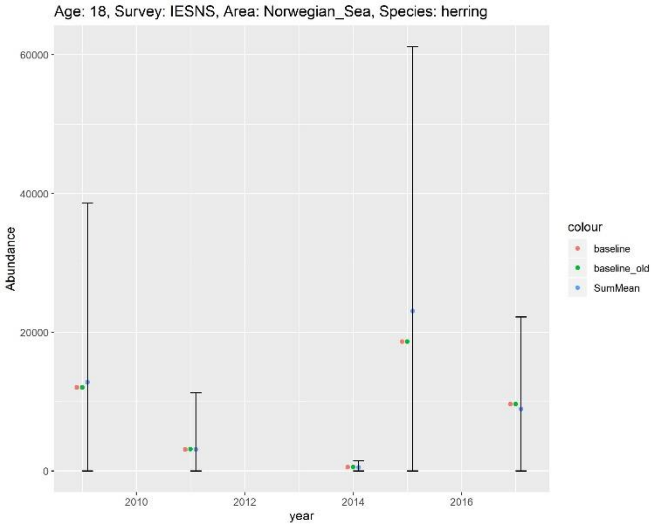

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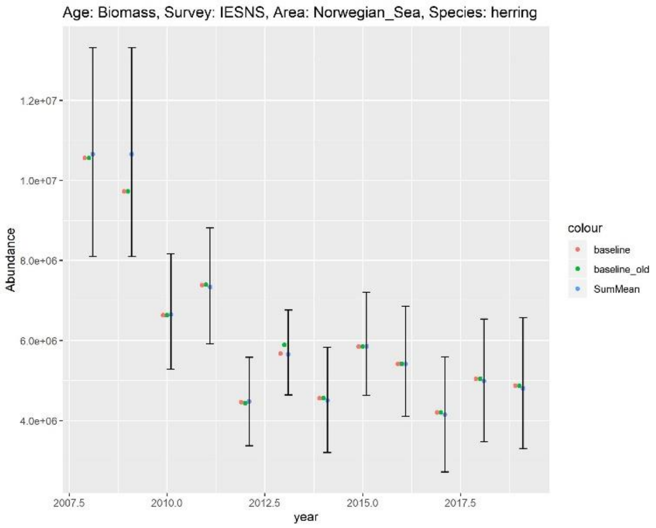

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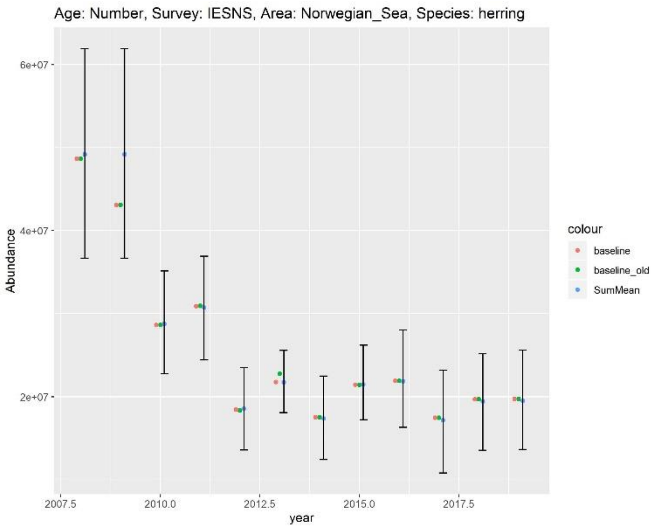

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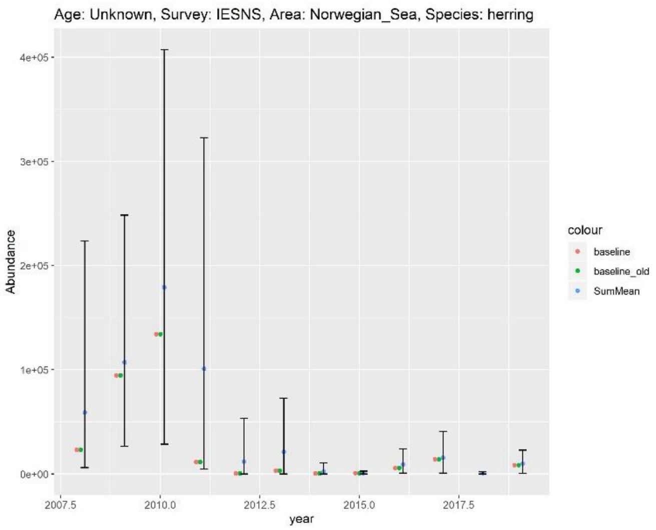

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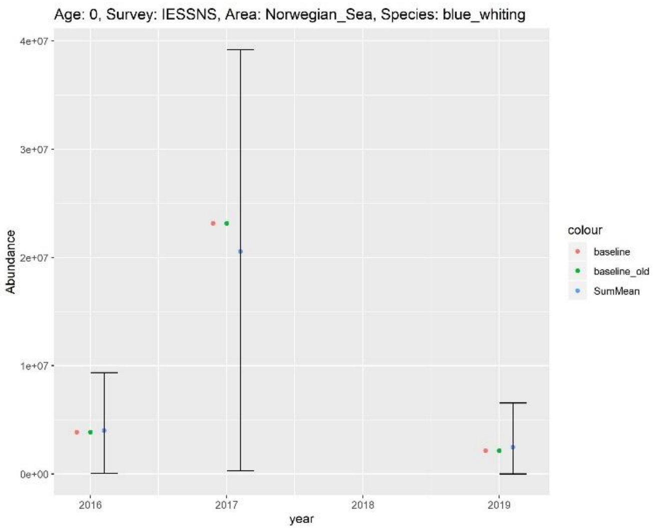

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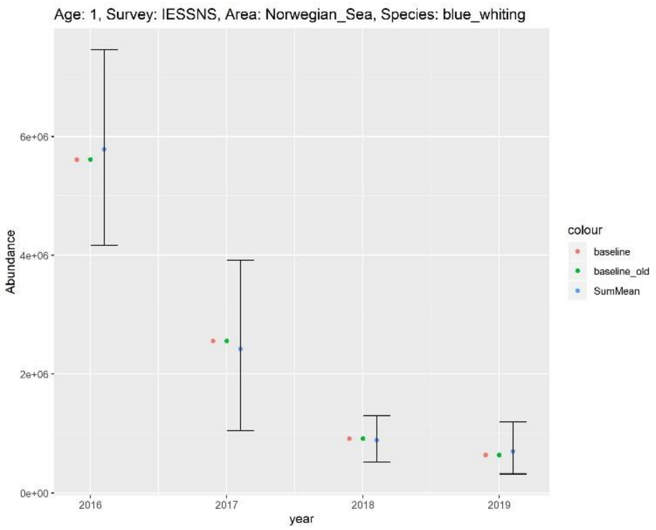

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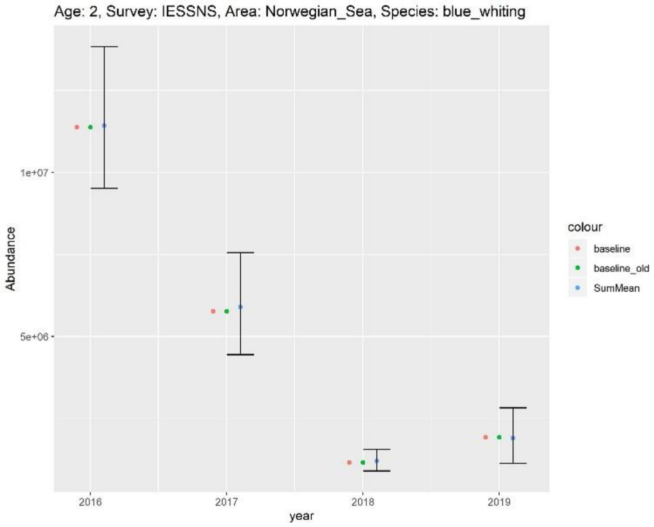

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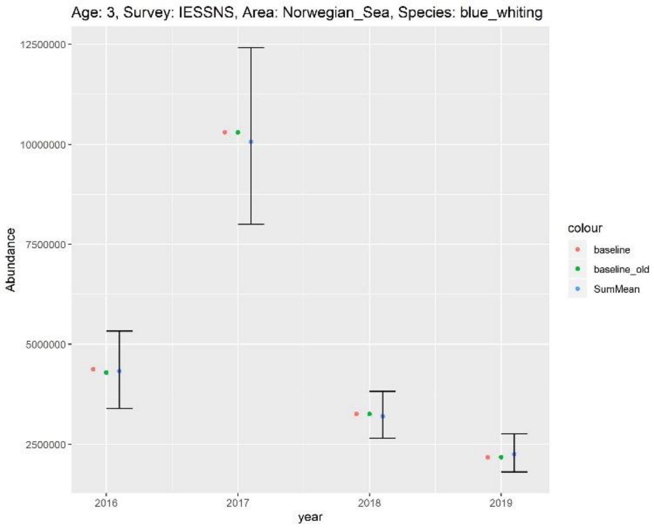

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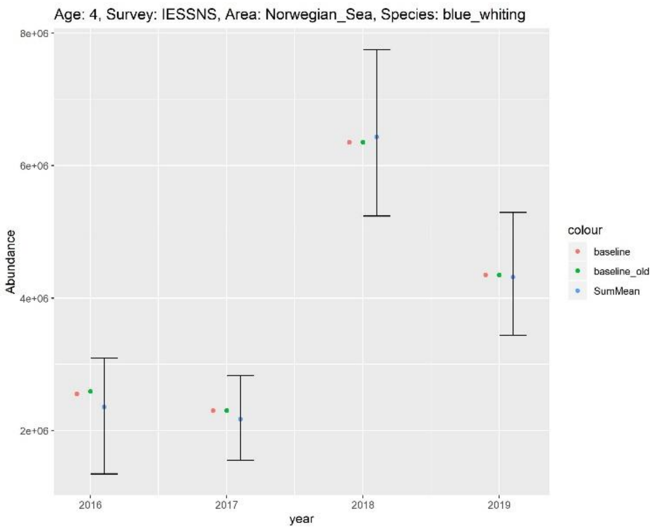

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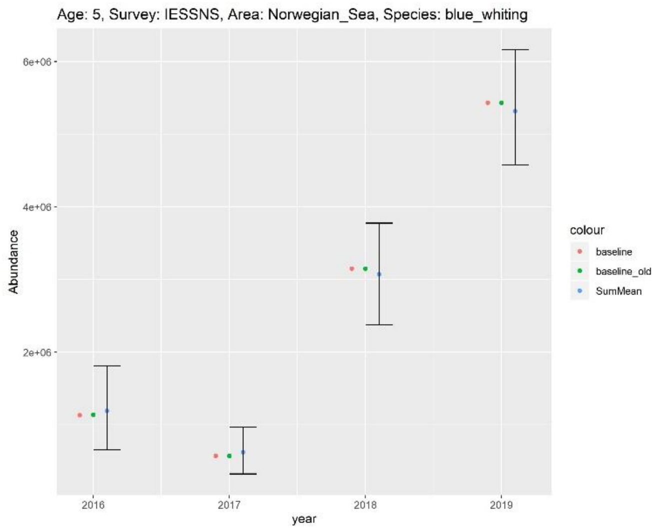

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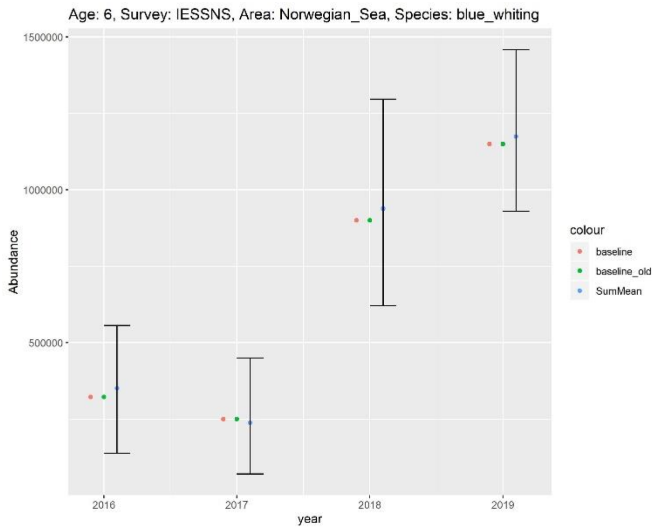

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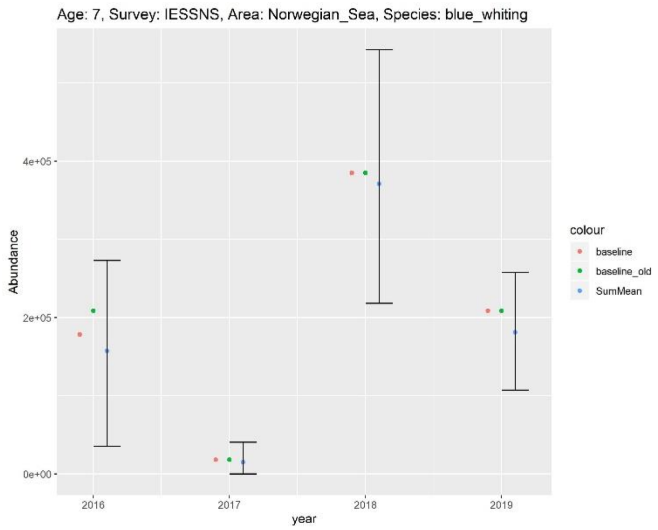

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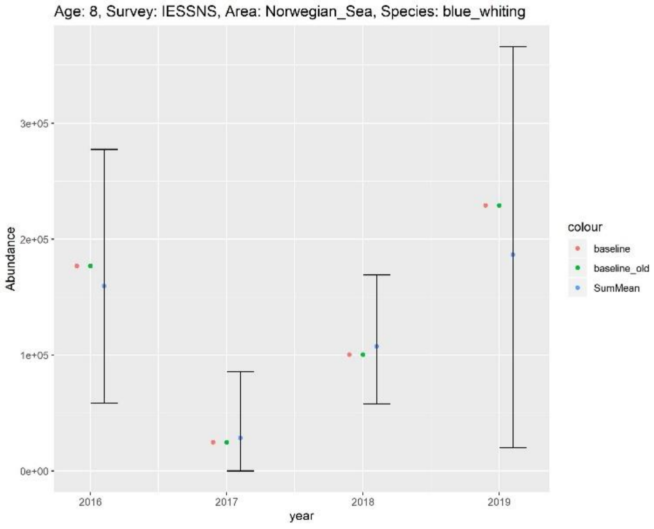

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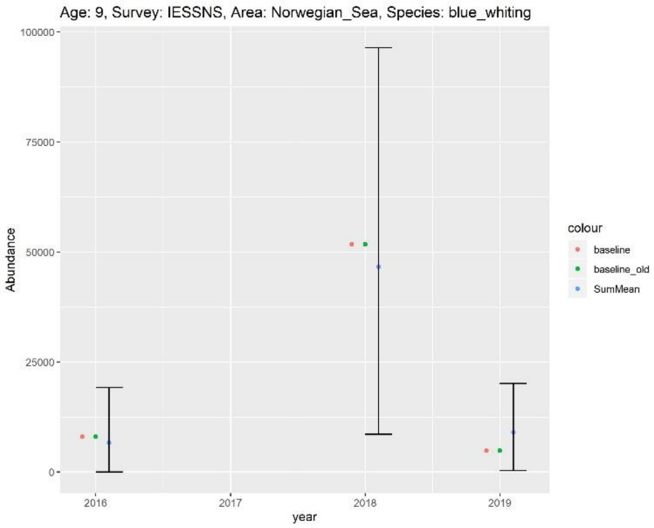

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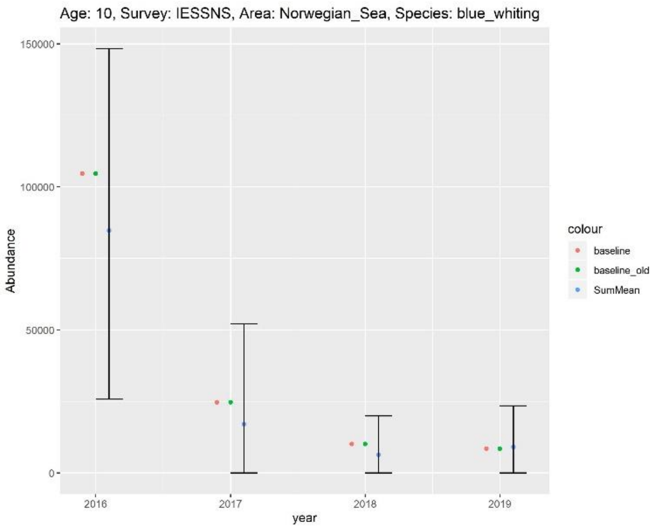

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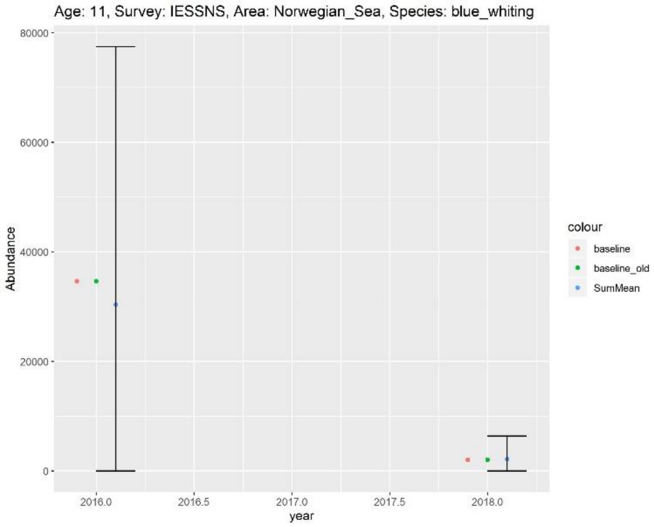

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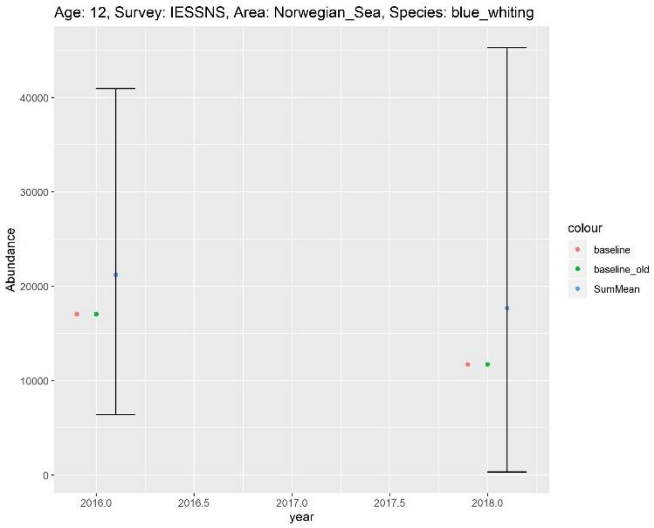

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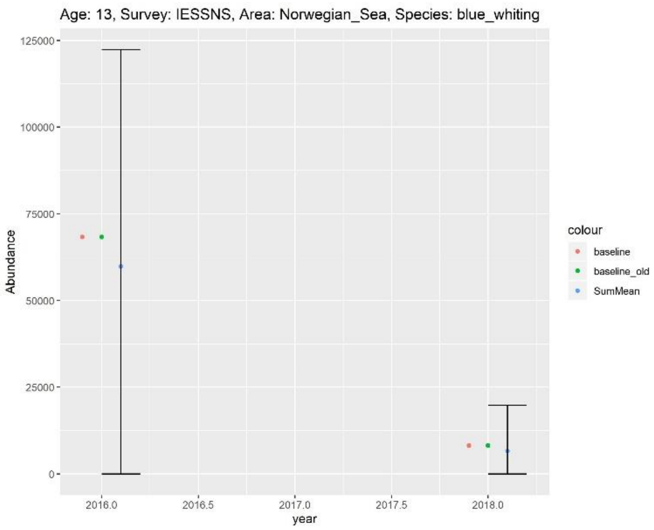

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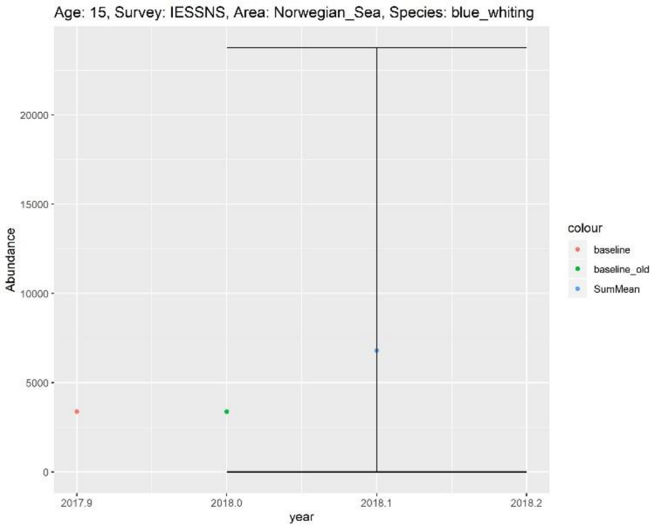
Figure 86



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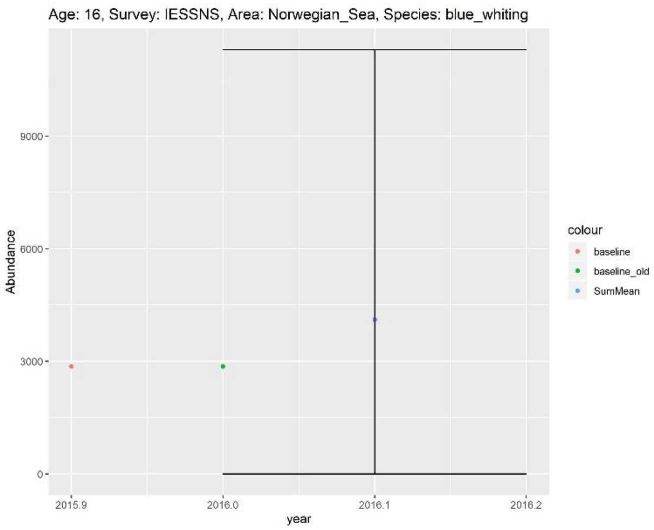

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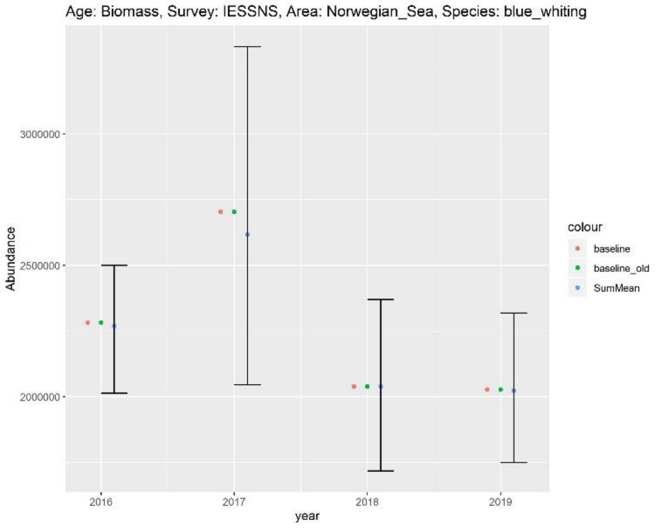

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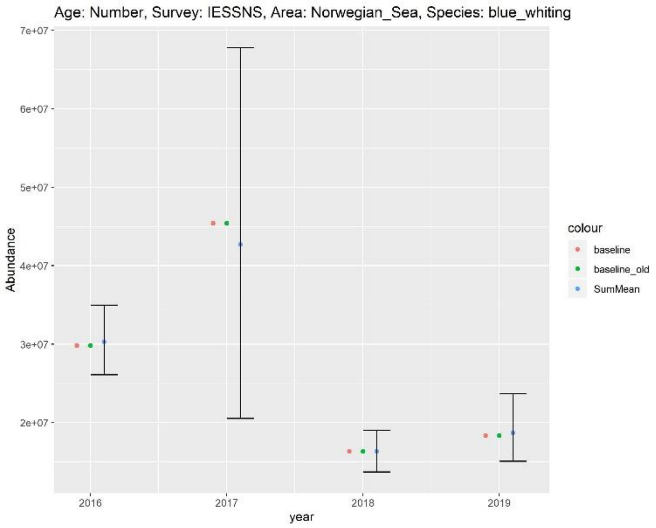

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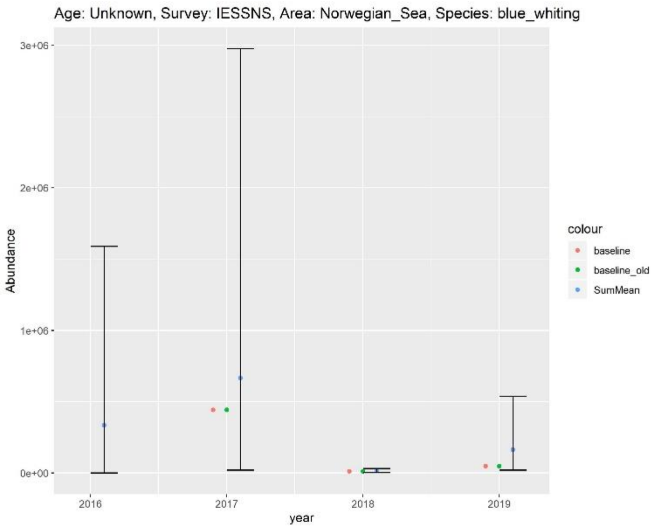

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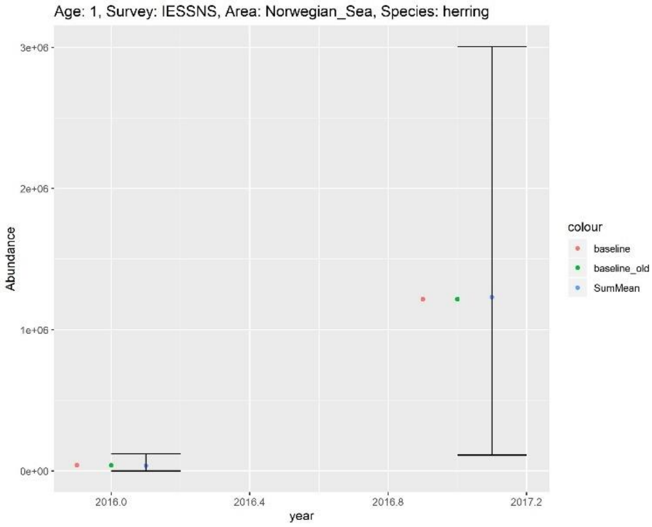

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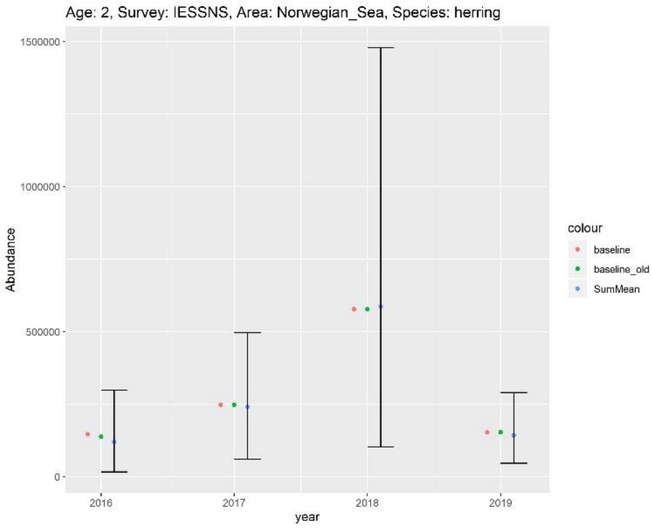

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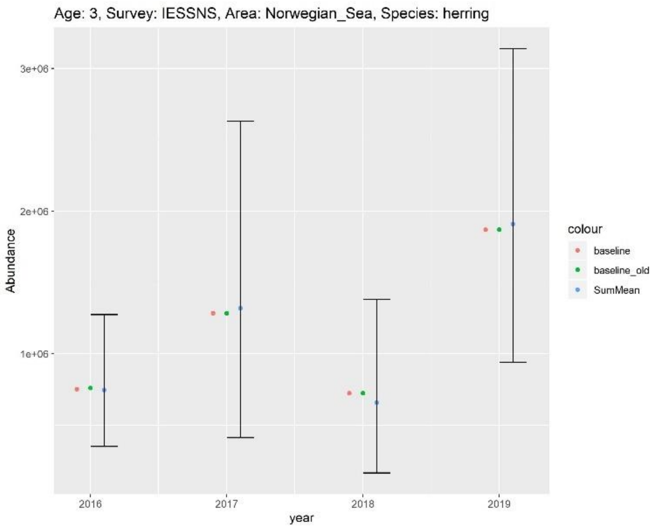

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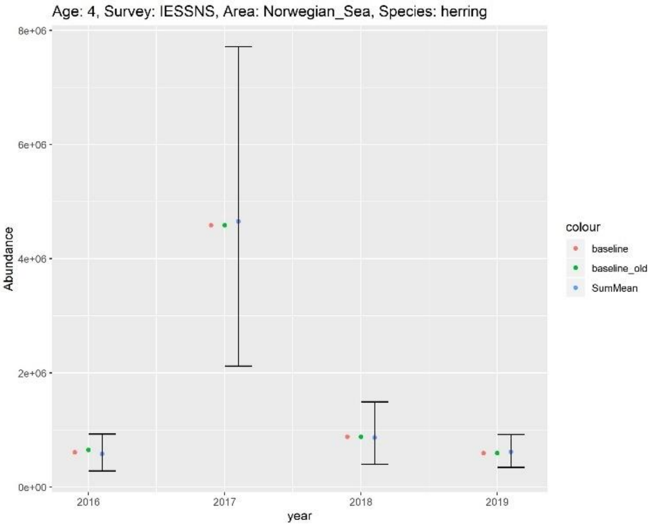

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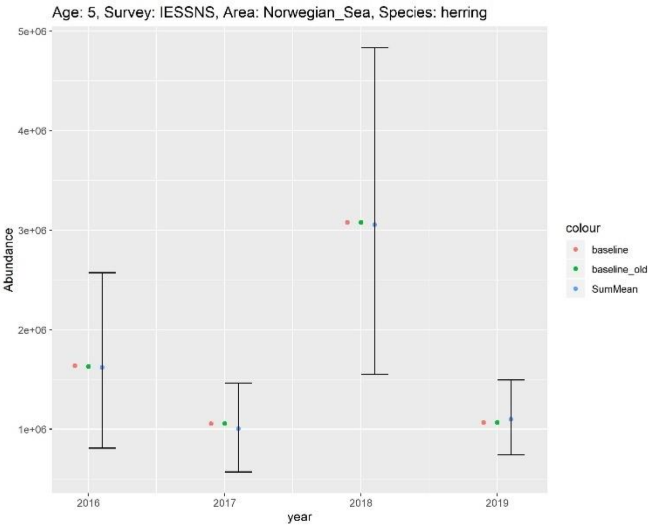

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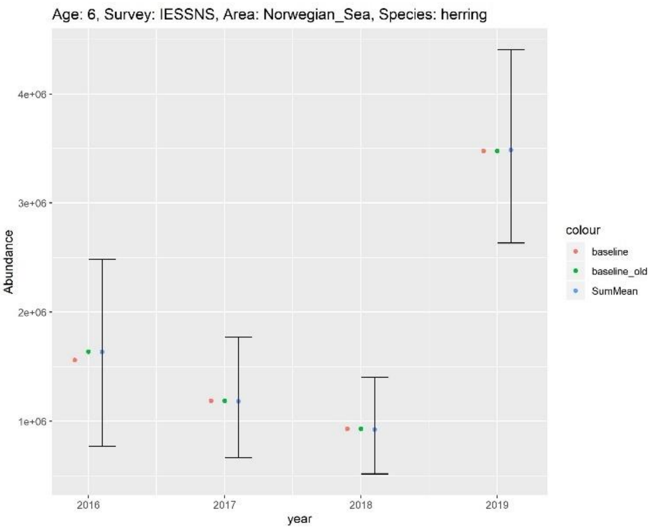

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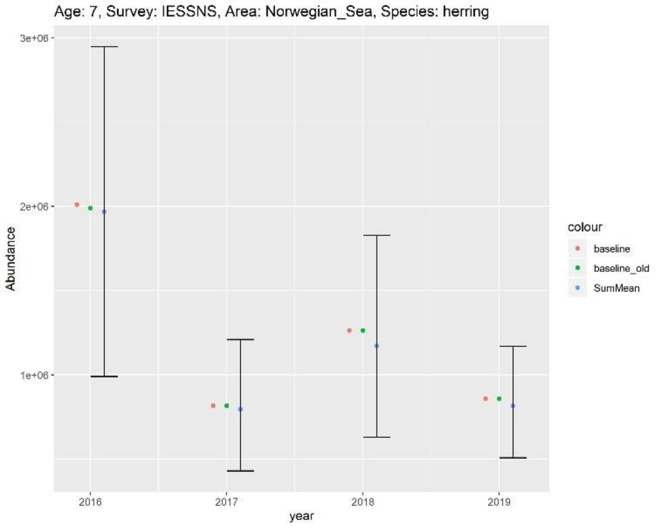

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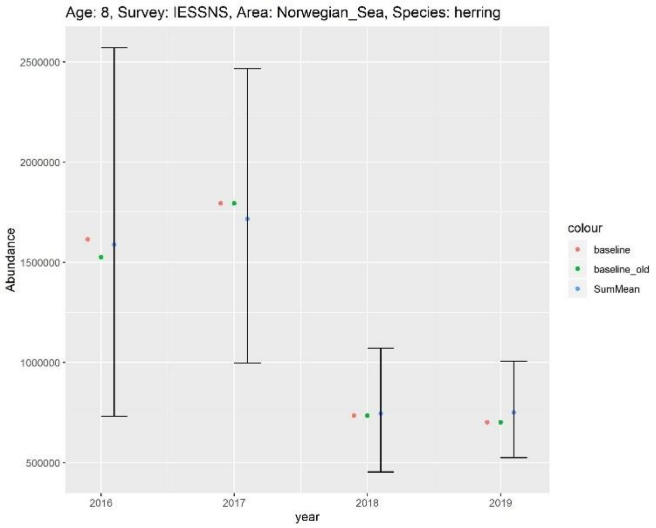

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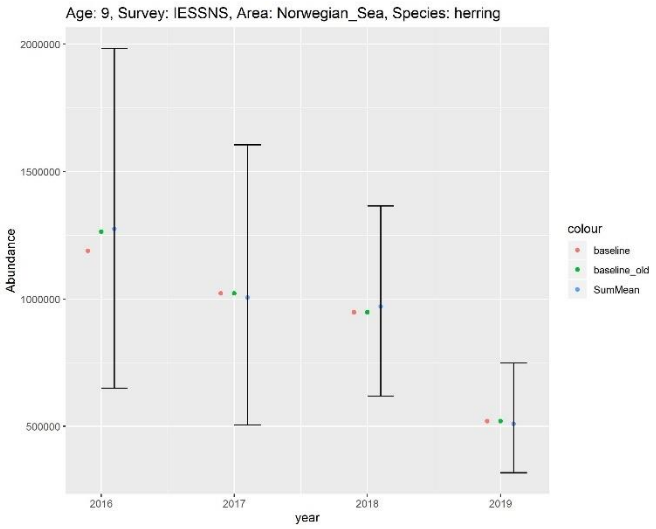

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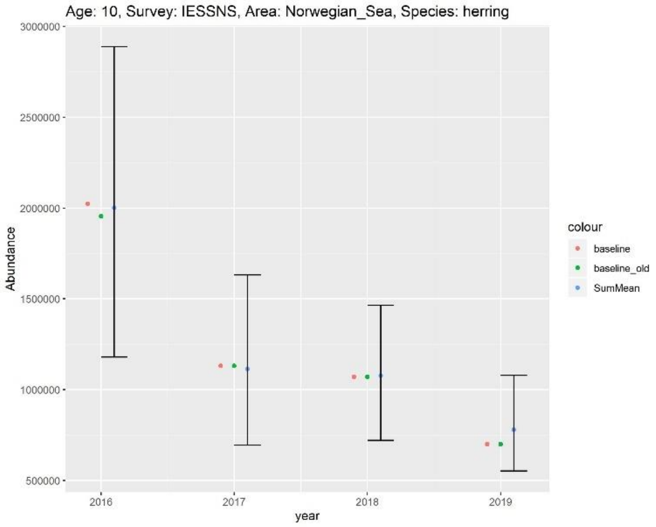

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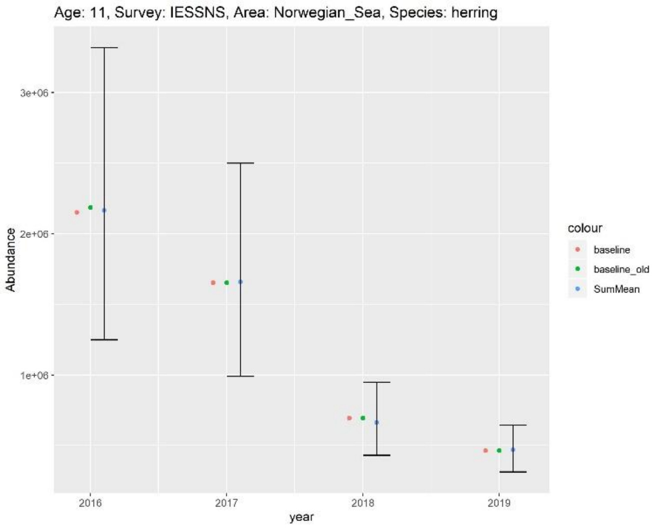

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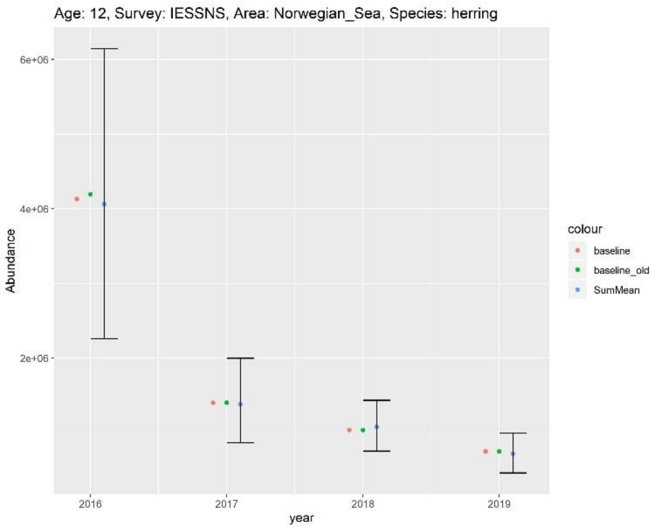

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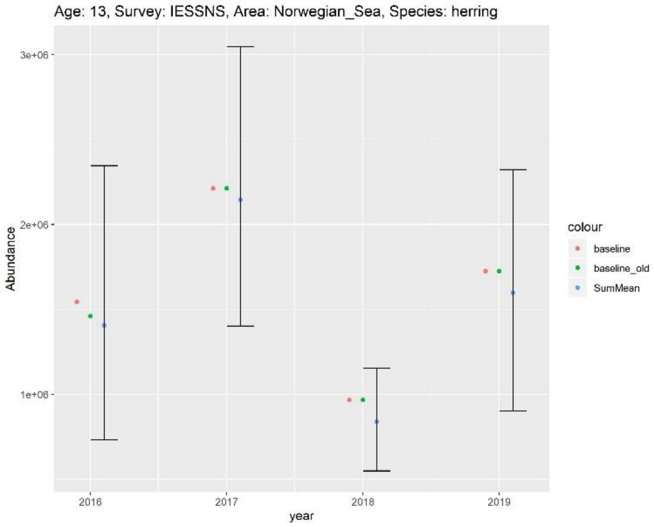

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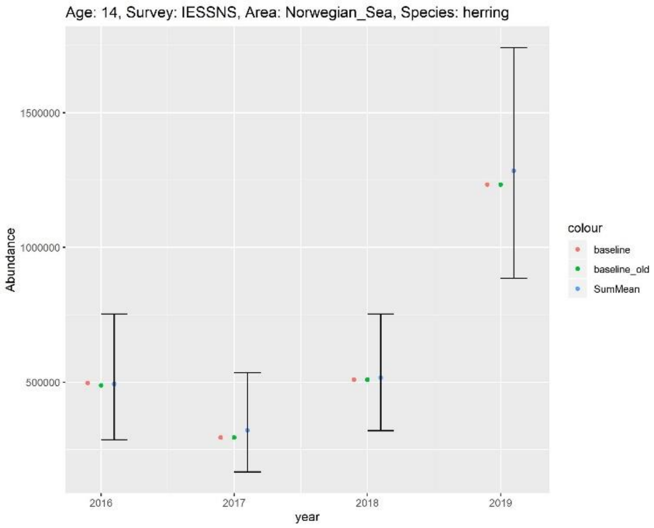

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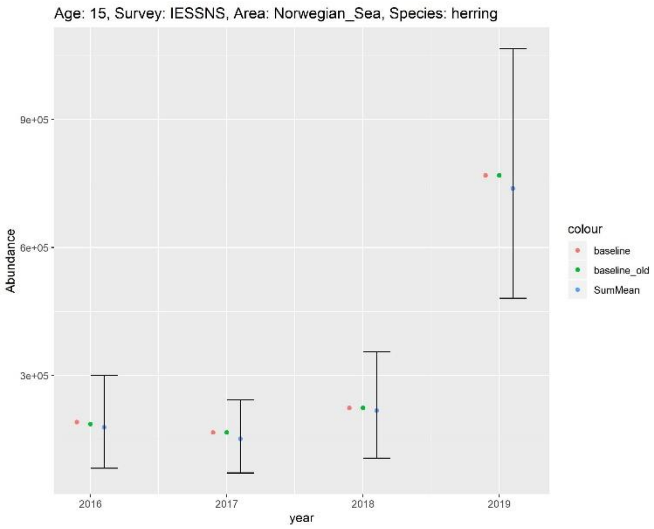

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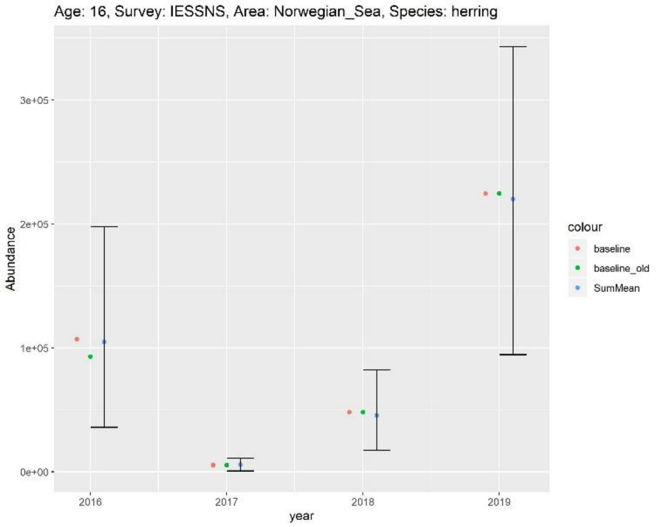

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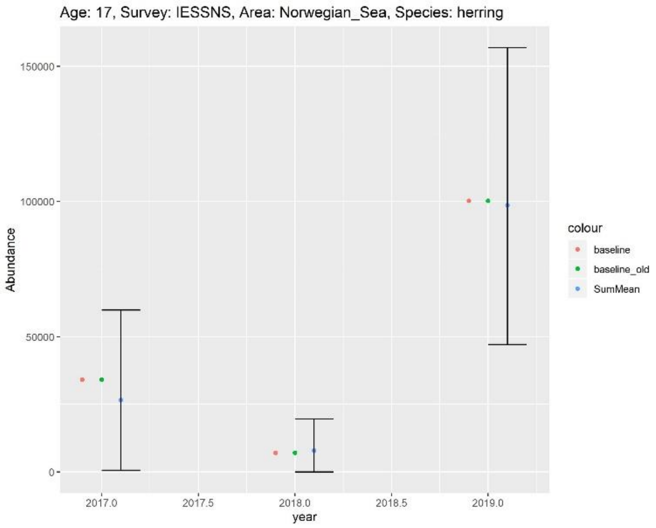

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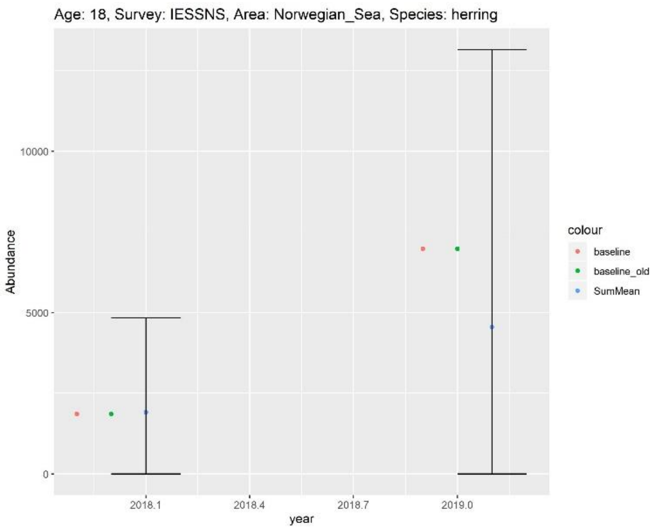

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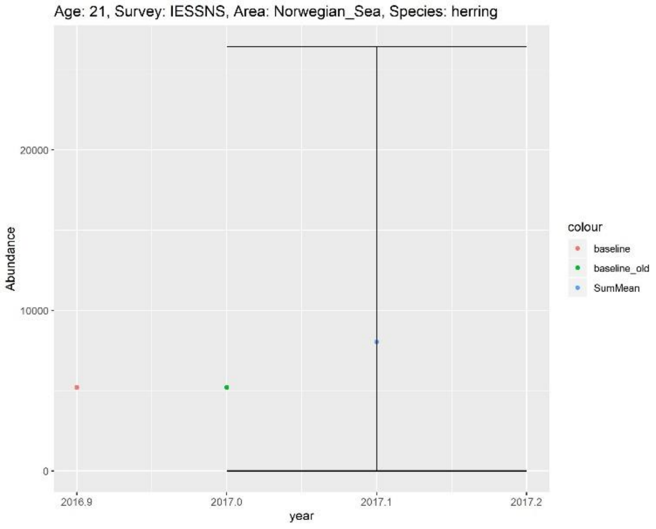

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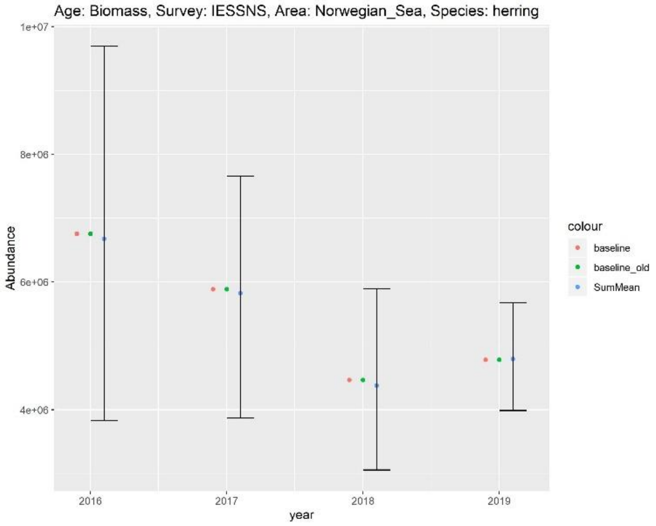

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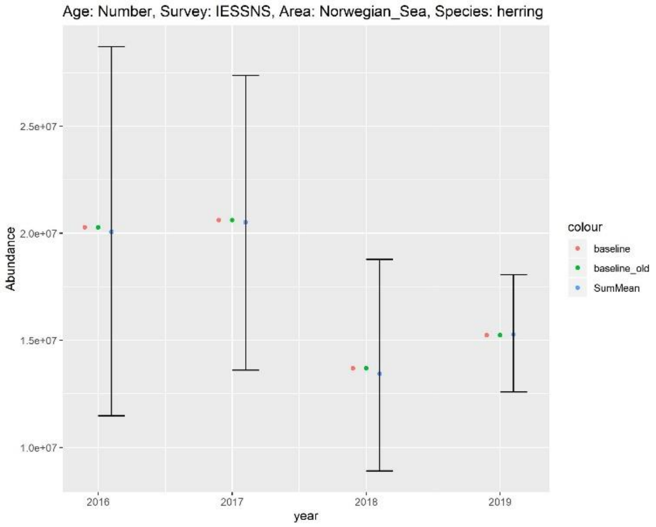

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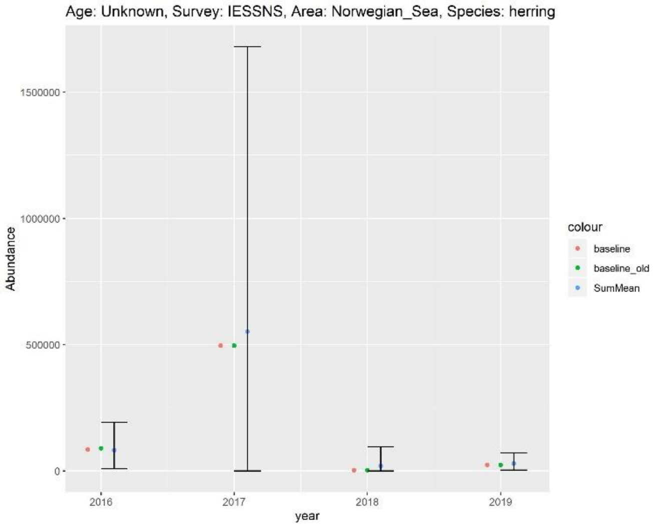

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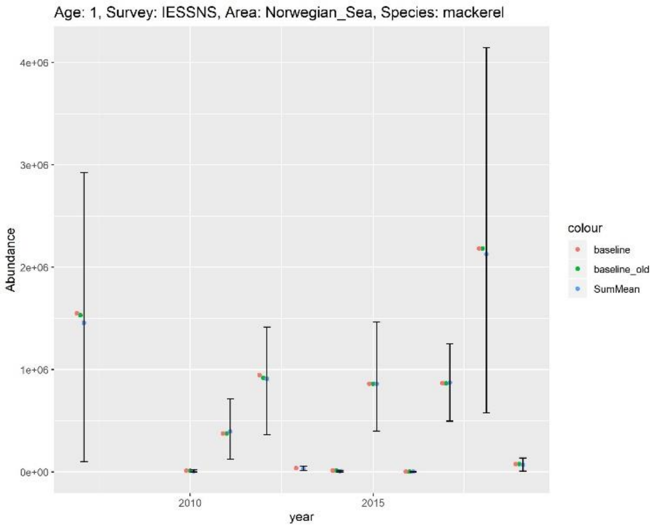

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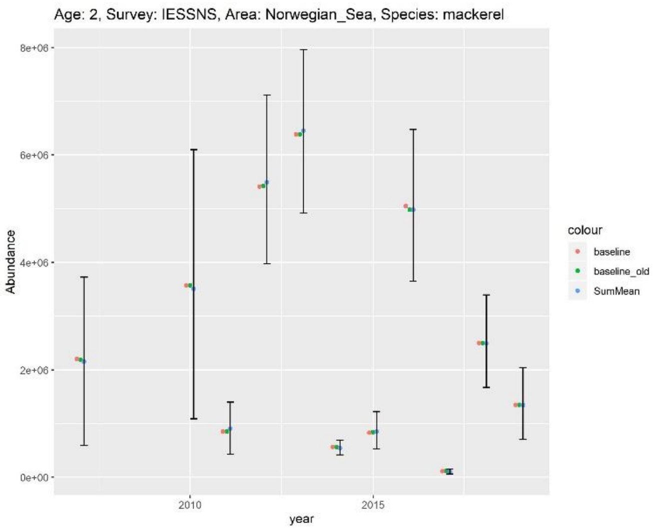

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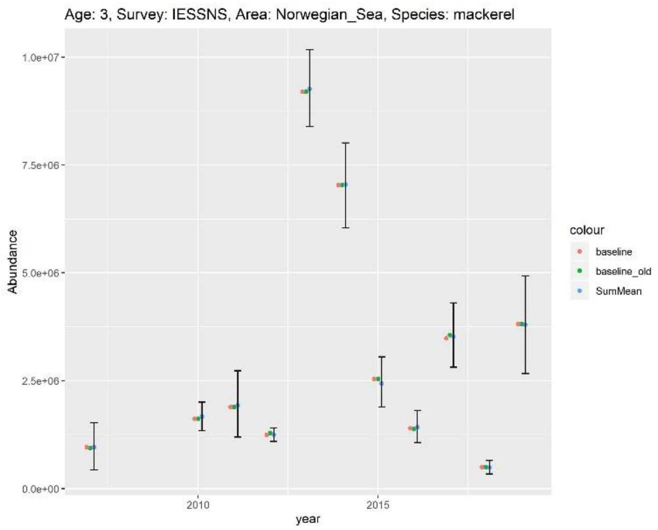

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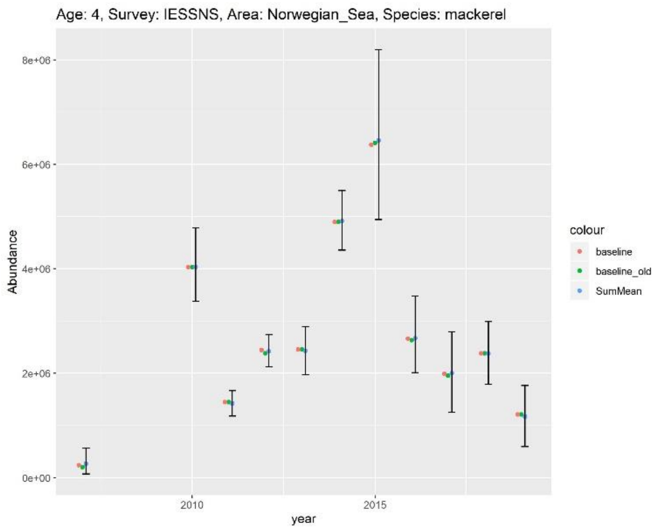

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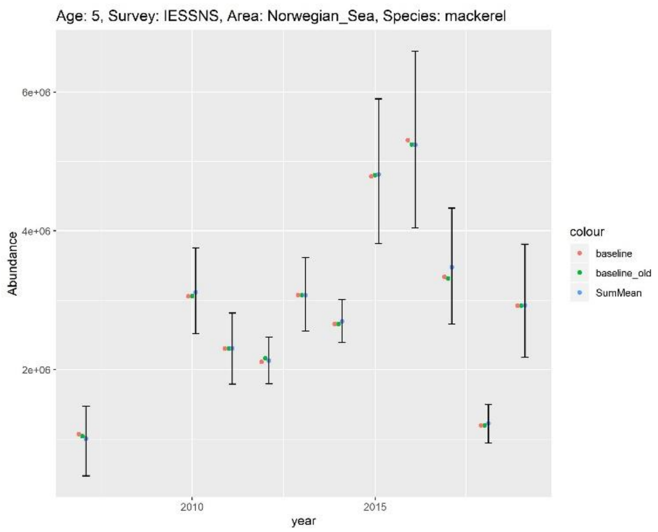

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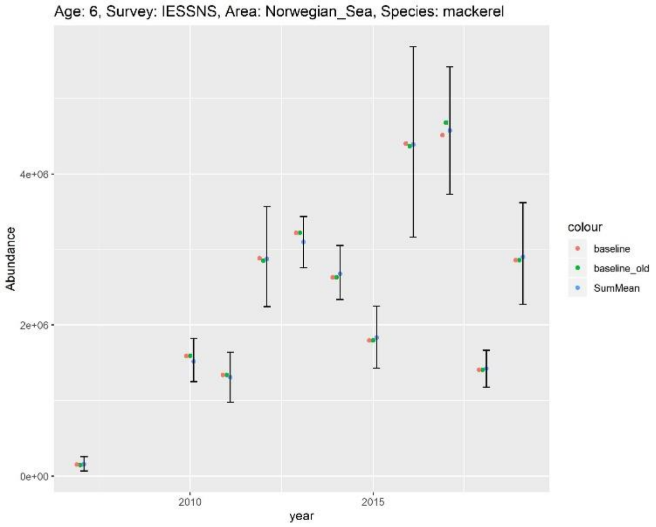

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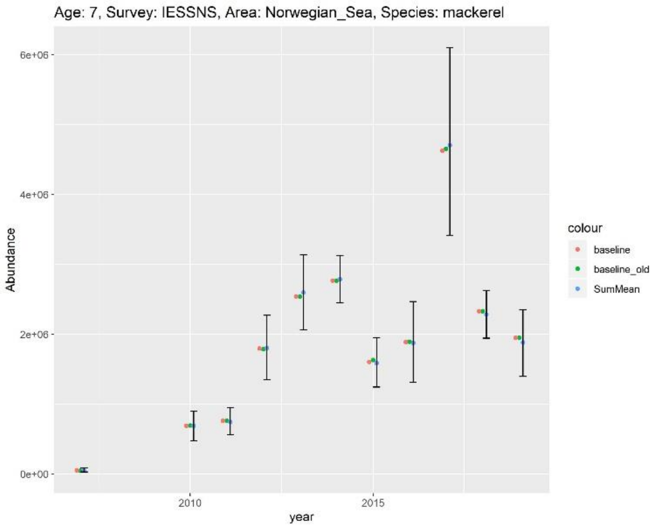

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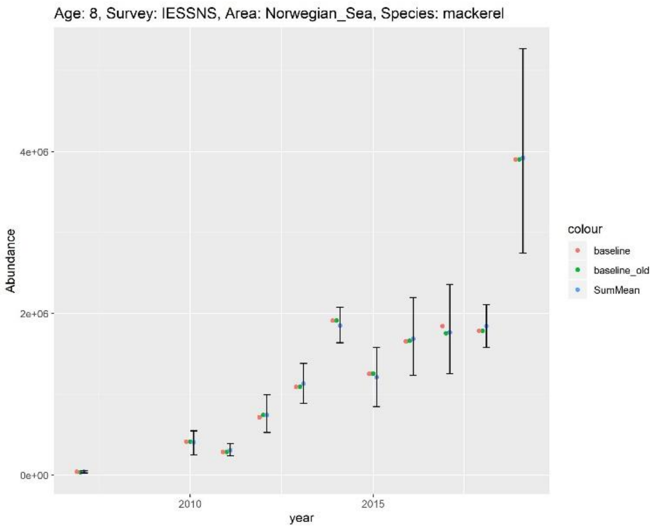

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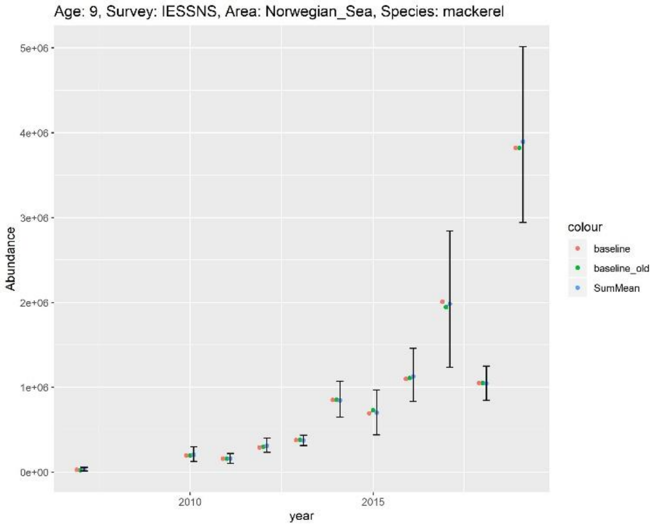

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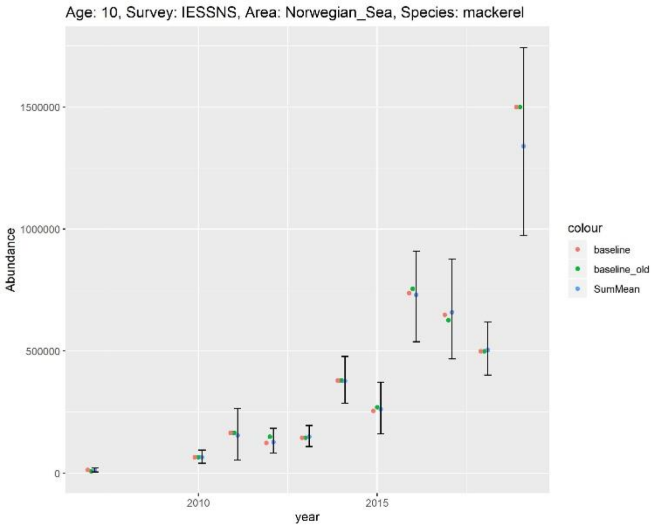

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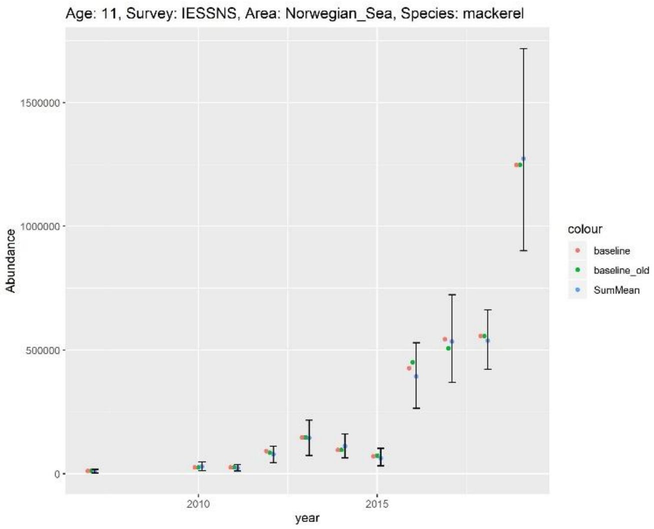

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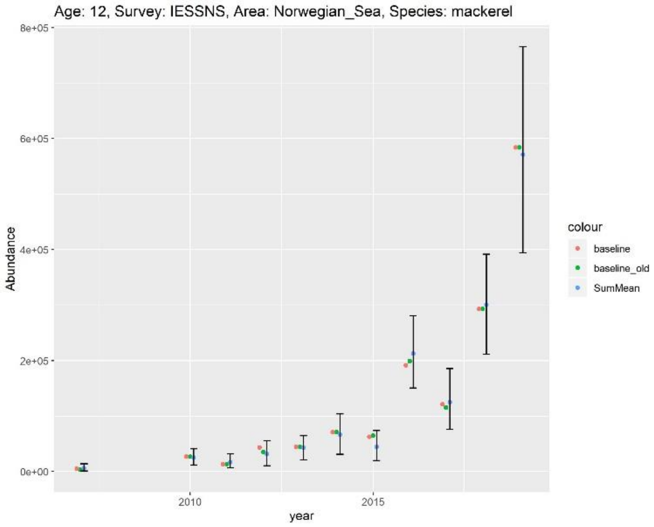

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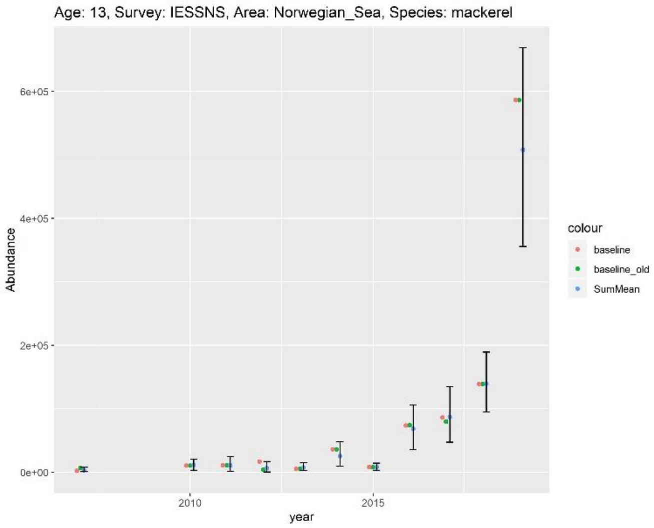

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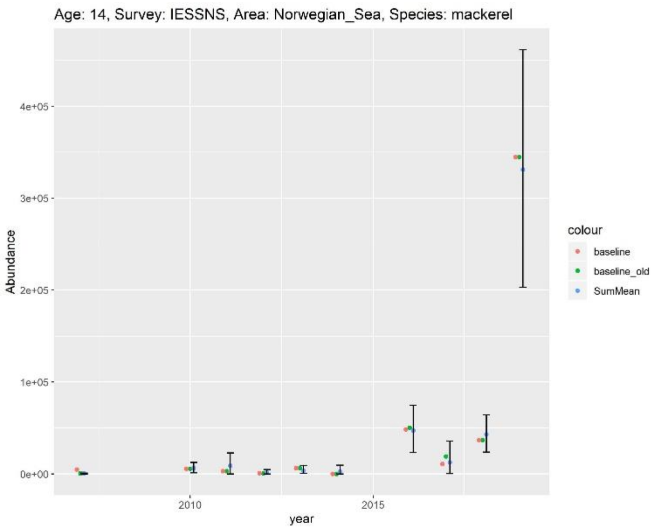
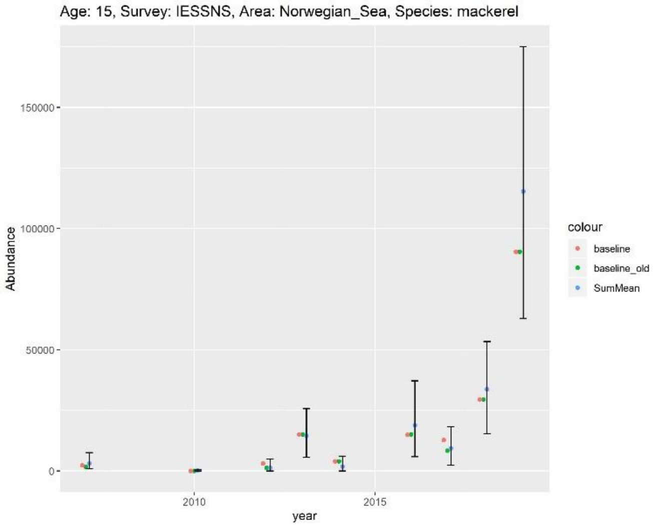


Figure 127



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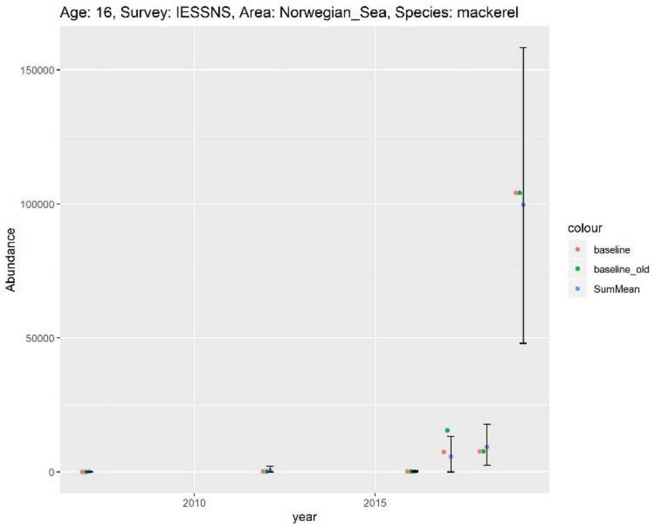

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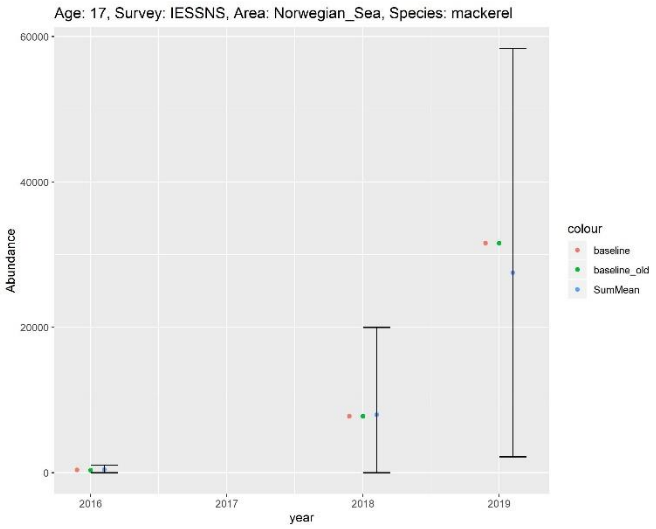

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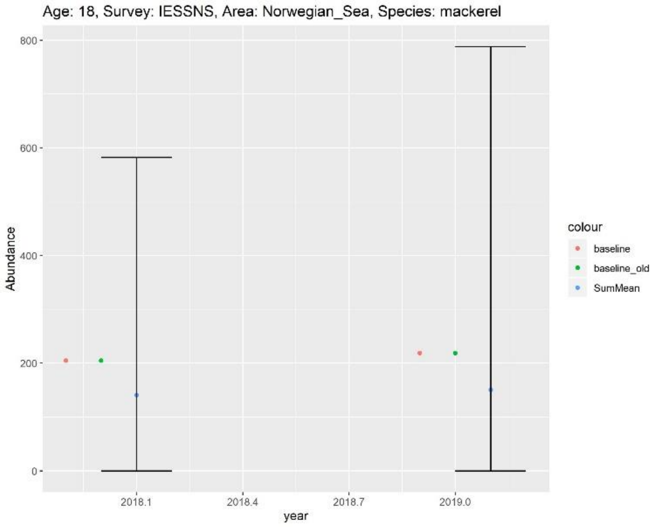

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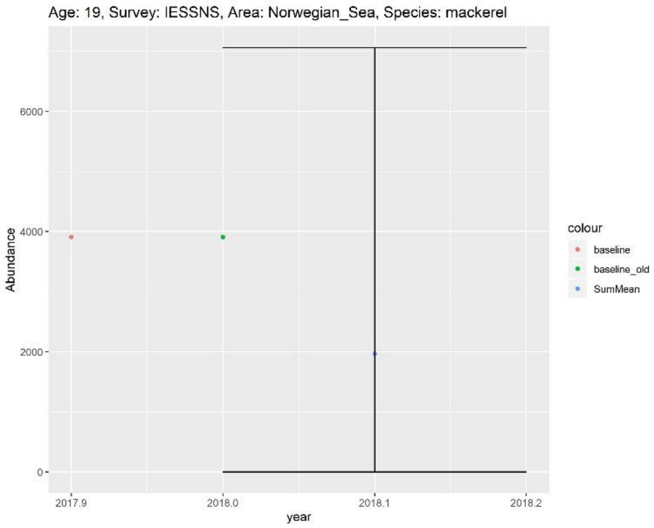

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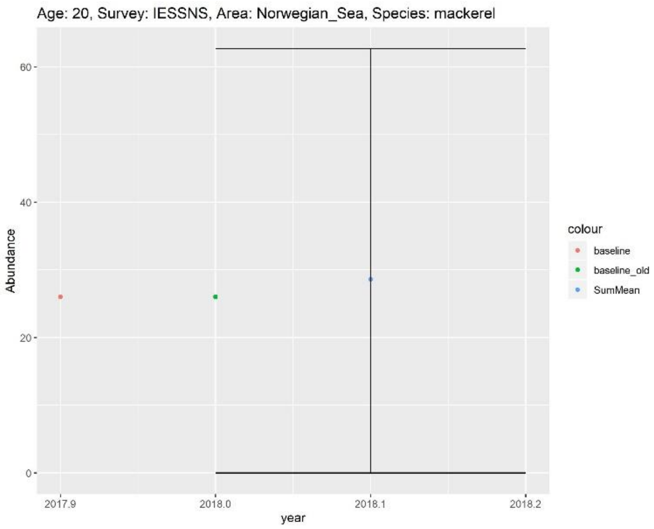

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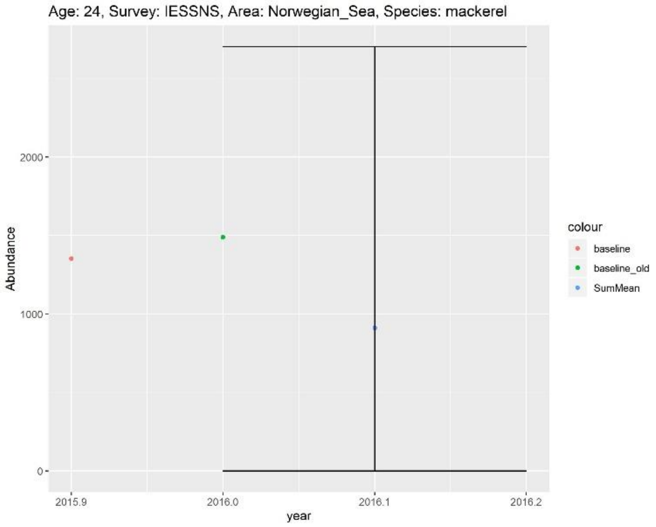

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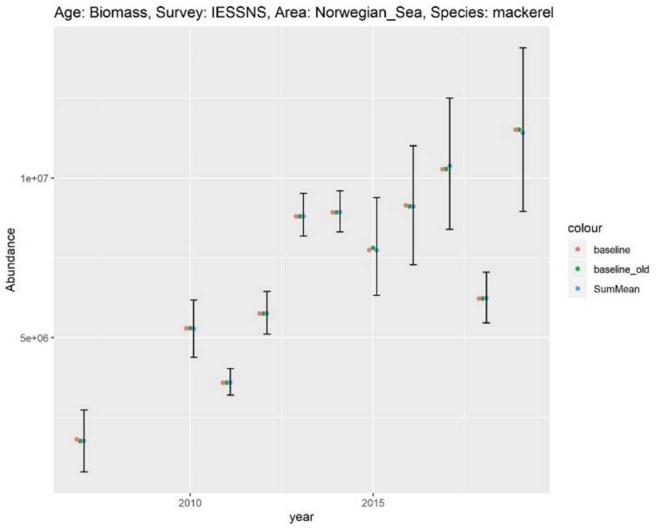

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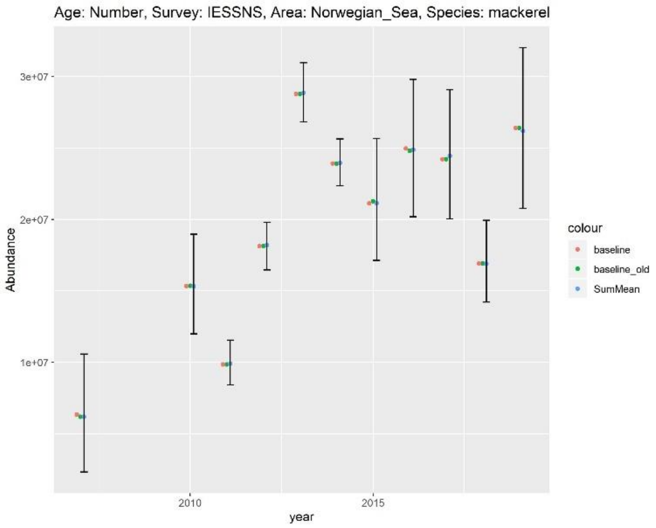

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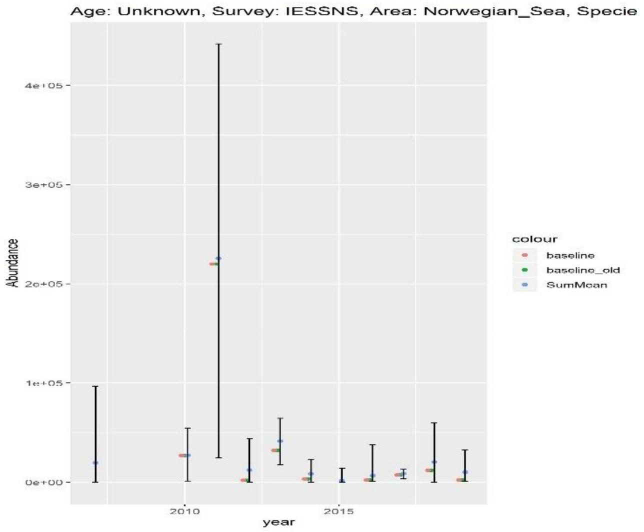
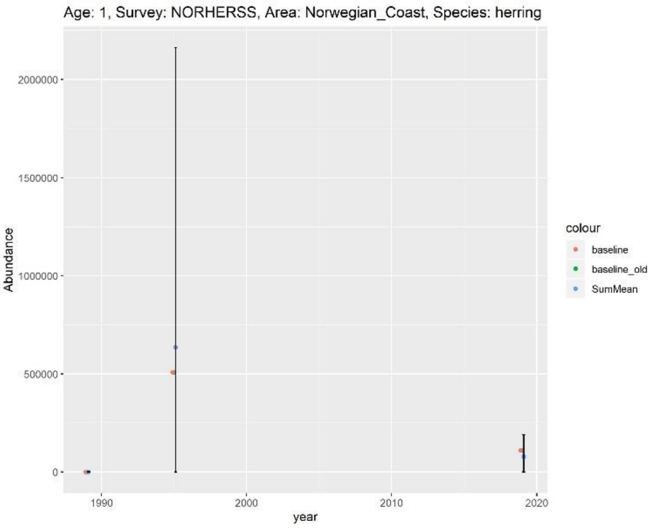


Figure 137 (mackerel)



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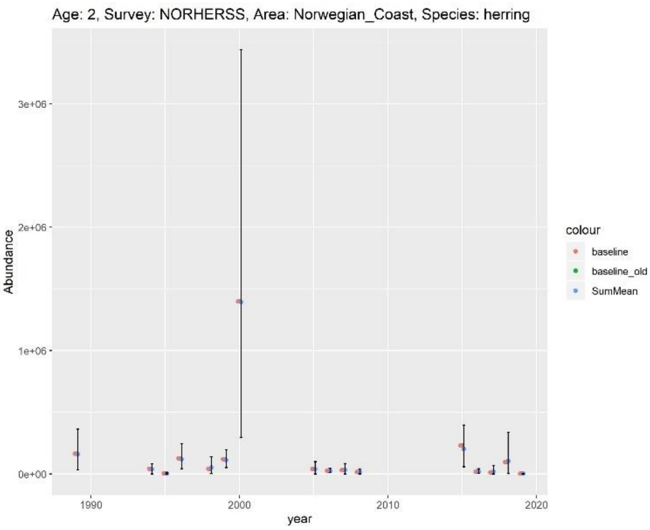

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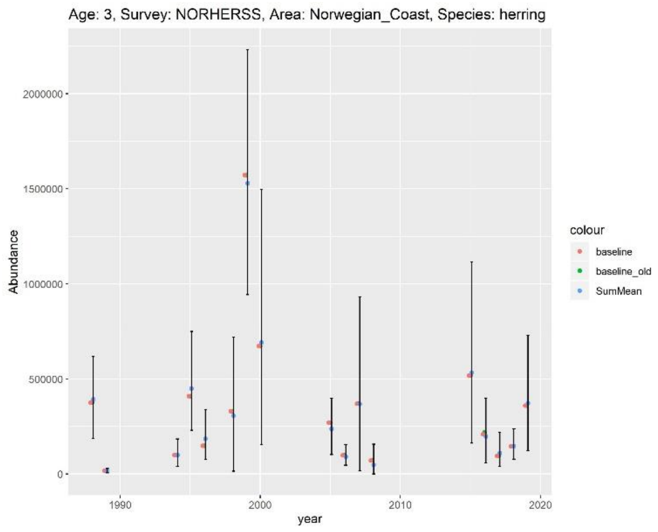

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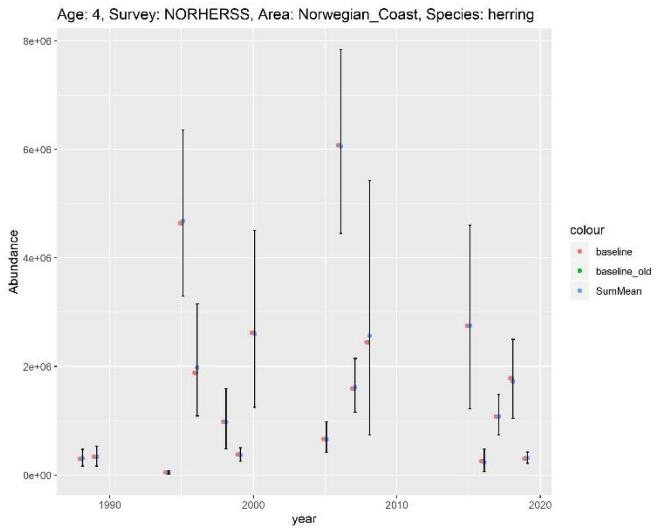

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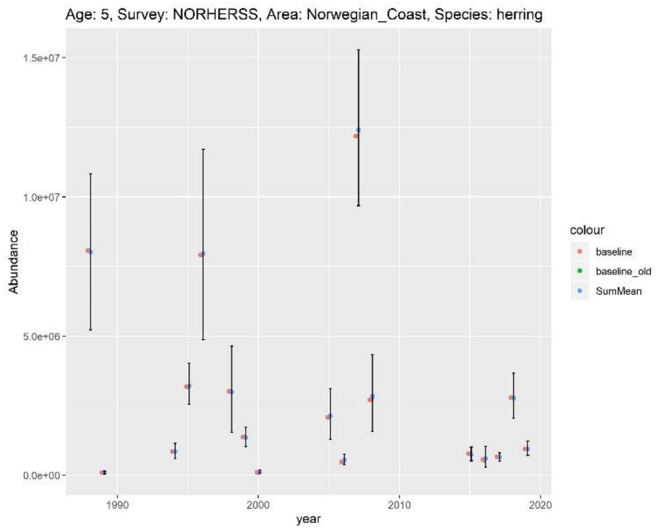

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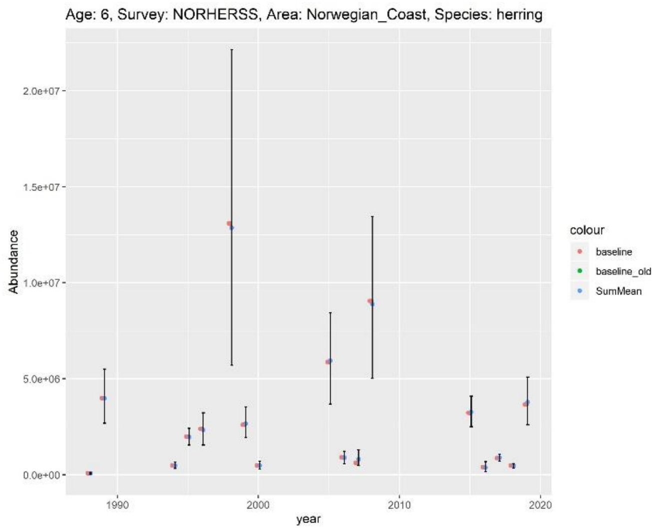

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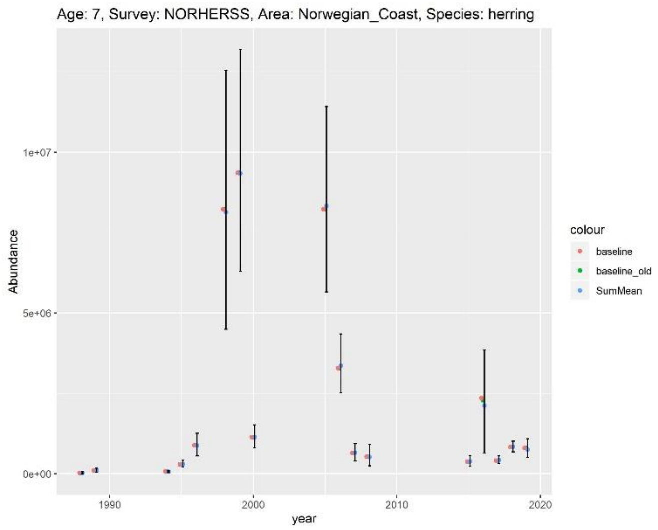

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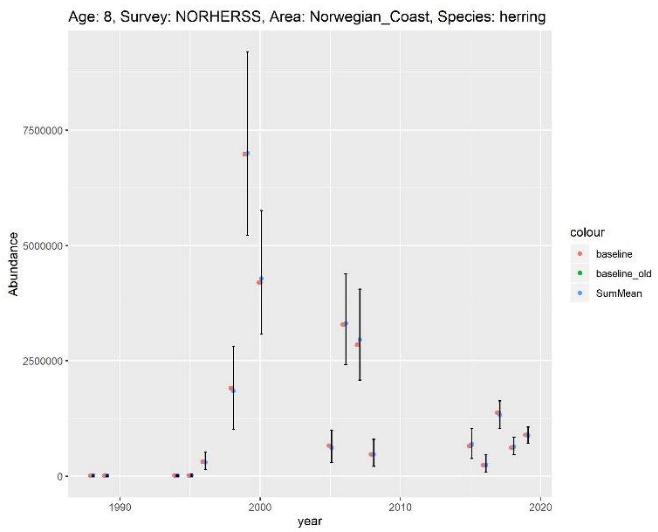

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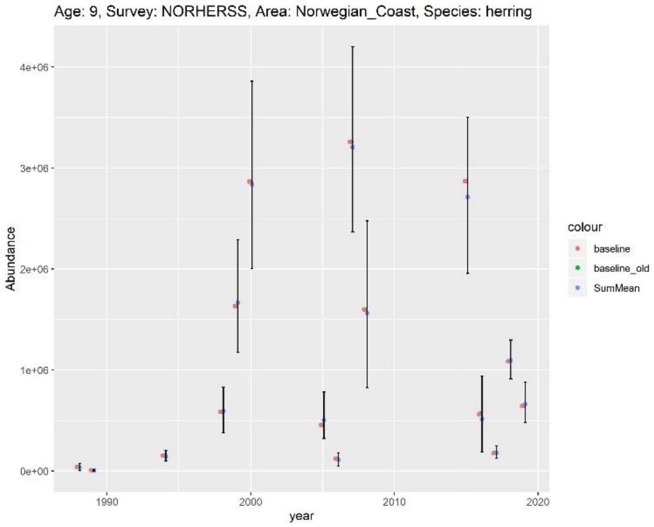

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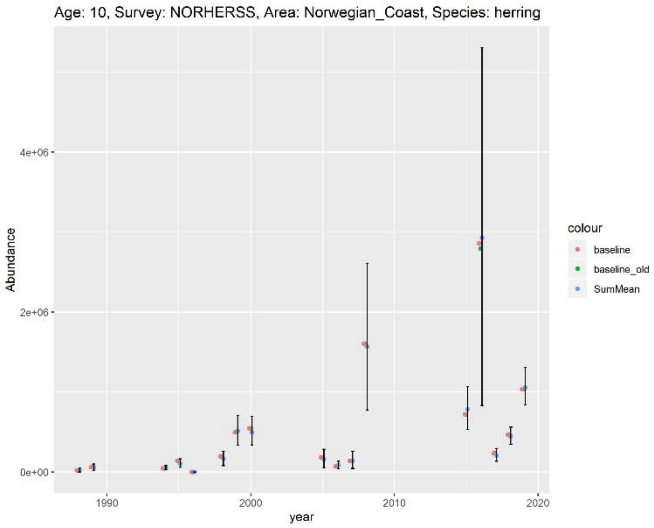

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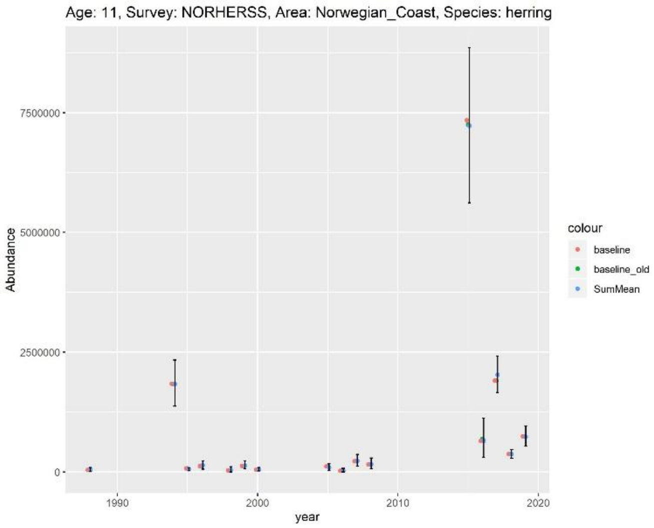

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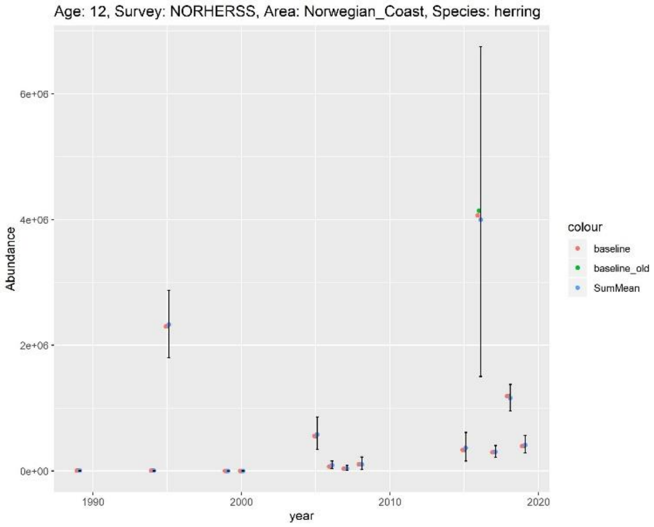

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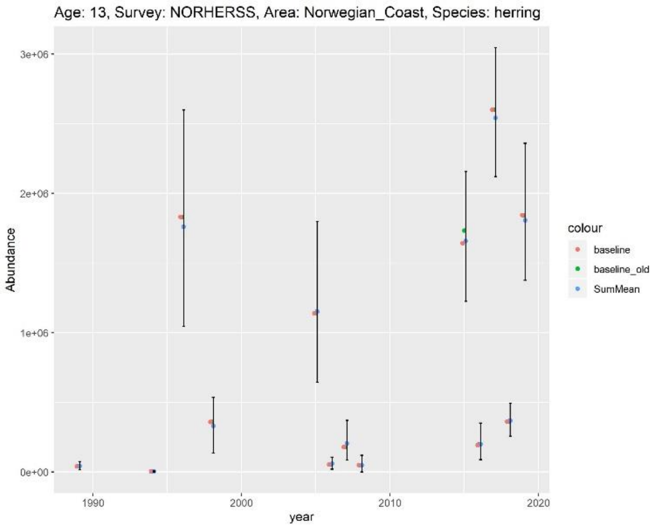

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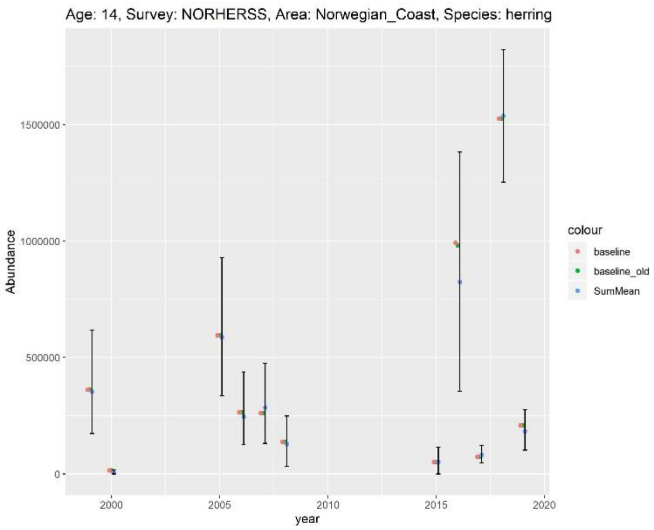

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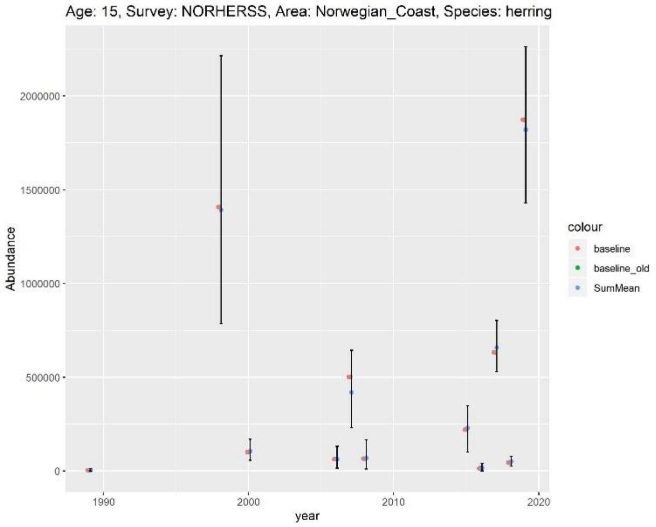

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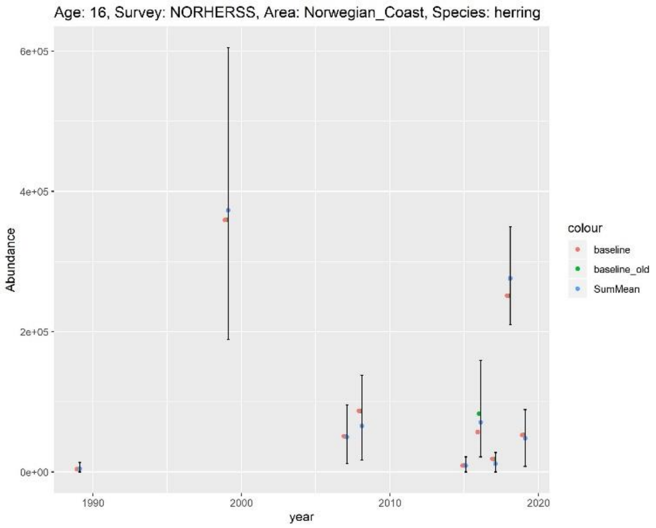

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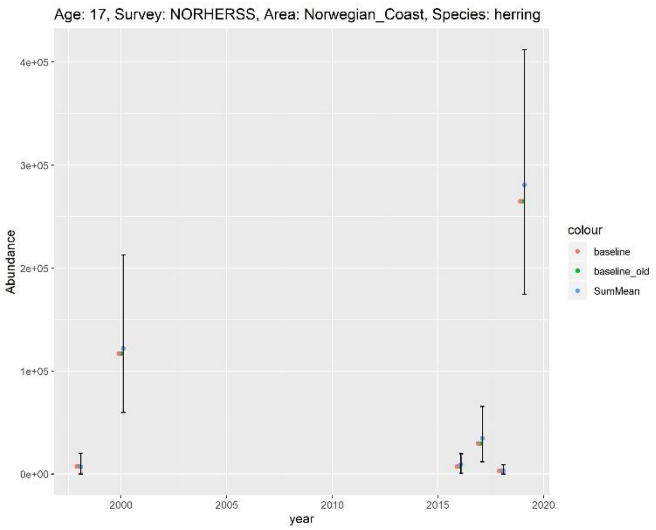

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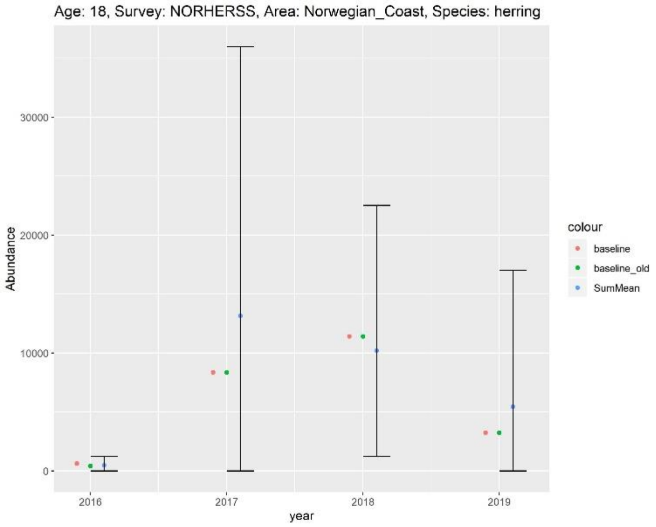

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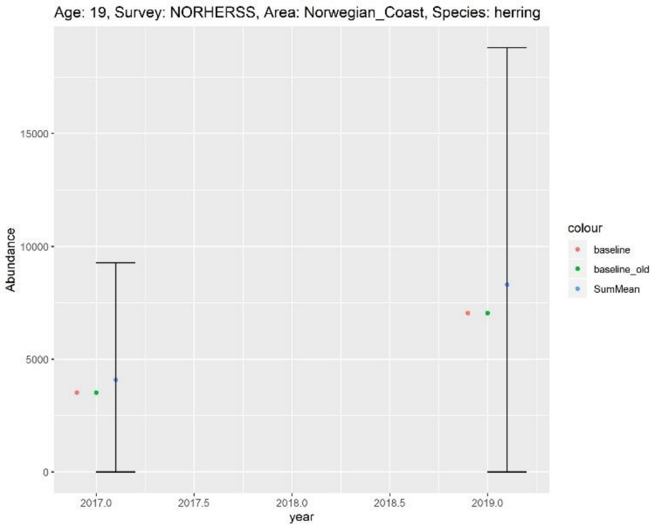

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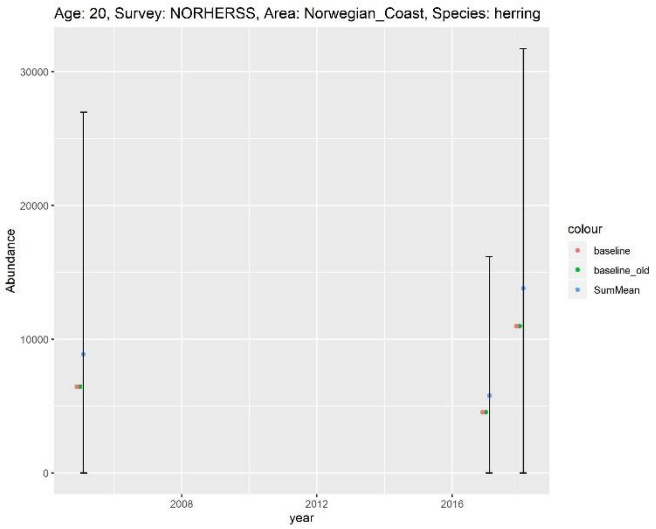

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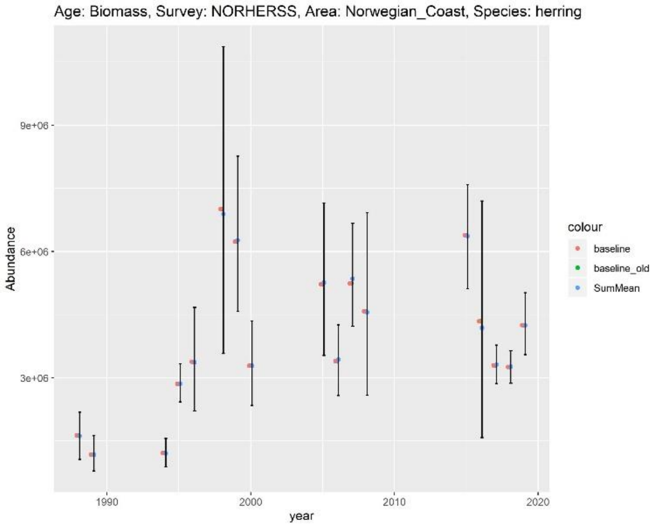

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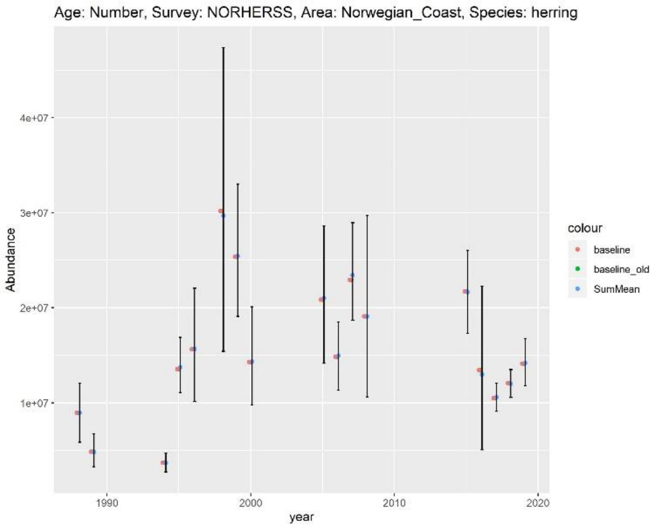

Figure 159

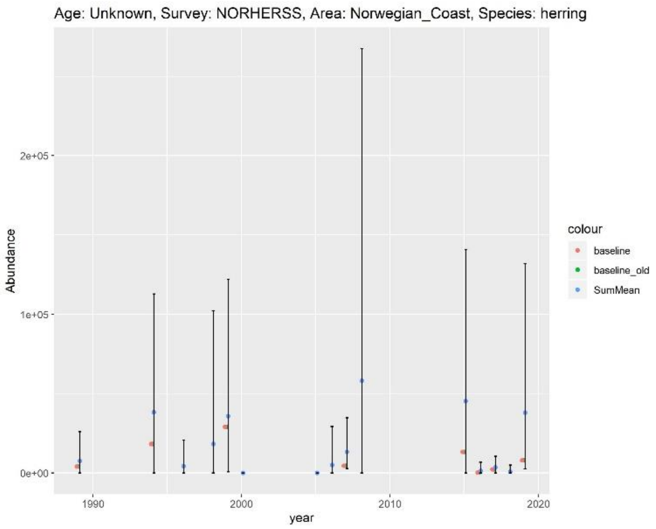

Figure 160

Annex 18: Response to Recommendation 67 from WKMESOMeth

*Please see the response on the next page.

Recommendation response from WKMESOMeth

That relevant survey groups within WGIPS (**IBWSS, IESSNS, IESNS**) are allocated time during WGIPS annual meetings in 2020-2021 to develop protocols for reporting of mesopelagic fish abundance

Response

A subgroup made up of IBWSS participants (NO, FO, NL, IE, ES) met during the WGIPS meeting (January, 2020) to discuss the formulation of scrutiny procedures to harmonise the reporting of mesopelagic acoustic density during future surveys. This exercise was carried out in response to a recommendation received by the group from WKMESOMeth (ICES, 2019).The IBWSS survey participants agreed to begin the process of providing acoustic data and biological data, where applicable, using harmonised echo-integration criteria developed here. Some members (IRL, NL) showed interest in developing biological sampling capacity over time given existing constraints.

Other survey groups within WGIPS are asked to provide data and/or feedback on the feasibility and limitations of providing data going forward, where applicable, relative to the sampling environment and the behaviour of targets within the survey area.

Within IBWSS, echogram scrutinisation criteria should adhere to the following as a minimum;

Daylight observations

Restricting echo-integration to daylight only, allows for the categorisation of defined schools and aggregations occurring at depth (50-300m). Approaching sunset, schools and aggregations begin to migrate to surface waters and are joined by migratory components coming from the deeper DSL as part of the diel vertical migration (DVM) cycle. During the hours of darkness, target classification in the epipelagic zone (0-200 m) is considered too complex due to the dispersion of targets, range effects (surface blind zone) and outside the scope of routine surveys.

Depth defined integration

The collection of acoustic data during routine survey operations is constrained by the core purpose of the survey. It is agreed that new data provision, acoustic or biological, is limited to what is achievable given existing restraints.

During the IBWSS survey, acoustic data are routinely collected down to depths of 750 m using a ping rate of 1 ping per sec^{-1} (ICES, 2015). The existing depth range is thought to represent but not likely fully contain the vertical distribution of the highest densities of mesopelagic targets described here. Data collection down to 1,000 m is achievable with a ping rate of between 1 -1.5 pings per sec^{-1} using an EK60 in narrowband mode. Multifrequency data (18, 38, 70, 120* kHz), where feasible, will aid species discrimination using multi-frequency and decibel (dB) differencing to characterize species backscatter. For EK80 broadband systems testing is required to determine the most effective configuration.

Biologically, the most commonly encountered schools occur in the upper water column from 80-300m (Figure 1). Schools within this zone are often distinct from the surface plankton, from high density blue whiting aggregations (350-650m) and from the deep scattering layer (>350m). Aggregations are not considered to be composed of single species or taxa. However, previous exploratory trawling on these aggregations during IBWSS surveys has shown these aggregations to contain higher proportions of *Maurolicus muelleri*, *Benthosema glaciale* and Atlantic krill *(Meganyctiphanes norvegica)* amongst others.

Upper water column targets are of higher acoustic density and more readily available for directed trawl sampling than more species complex and diffuse deeper zone of the DSL. Using directed trawling to identify species composition will provide the biological metrics required to estimate abundance and will enhance current knowledge in regards to species distribution and behaviour.

Classification of target species/aggregations

Echo-integration on defined, high density schools and aggregations in upper waters are considered less challenging as compared to deeper, diffuse multi-layers present in the DSL. Trawl sampling in upper depths (50-300m) is less time consuming than deep layer sampling and is therefore more achievable during routine surveying operations.

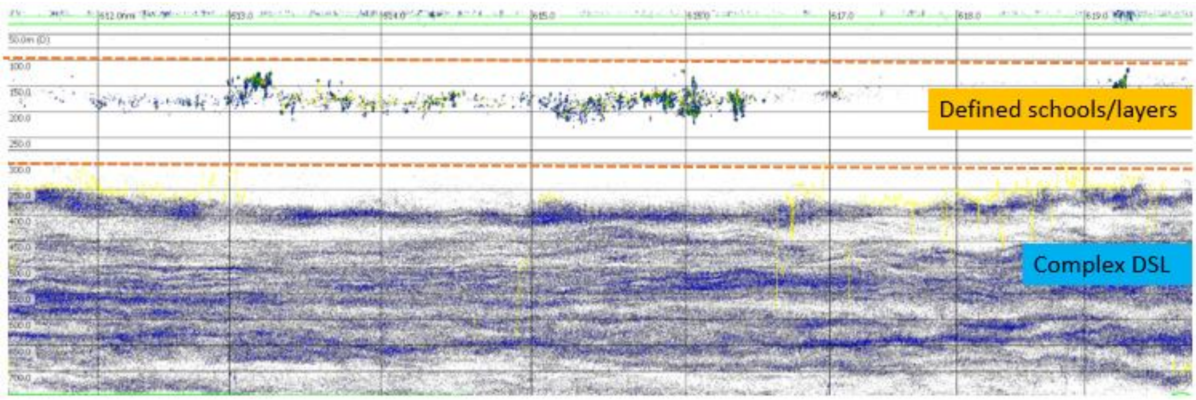

Figure 1. Example echogram (38 kHz) of common upper mesopelagic schools/aggregations observed during the IBWSS survey. Vertical depth bins (50m), linear sampling unit 1 nmi.

Species composition through directed trawling

Where opportunities exist, and the appropriate sampling gear is available, directed trawling to groundtruth species composition of insonified targets should be carried out. By defining species composition and gathering species specific metrics such as length and weight these data can be used to determine acoustic abundance estimates. Directed trawling will also build capacity in school/aggregation identification, species composition and acoustic characteristics of schools to increase the quality of future outputs.

Echo-integration and reporting

Currently, two different database vocabularies exist, the information of which are provided below. Differences between these reporting structures means that data sources from individual databases cannot currently be combined, for example within StoX, for abundance estimation. Work is underway within WGIPS to address cross compatibility issues. As part of the MEESO and SUMMER projects the agreed data repository is the ICES acoustic database.

ICES acoustic database vocabularies, containing mesopelagic reporting categories can be found here: https://vocab.ices.dk/?ref=1458

PGNAPES reporting vocabularies: FAO/ASFIS codes (3 letter species codes).

In addition to reporting of trawl identified school composition. It was also agreed the importance of reporting 'unidentified' mesopelagic backscatter.

Table 1. WGIPS coordinated surveys by nation and agreement to report mesopelagic acoustic categories (Ac) and biological data from directed trawling (Bd), commencing in 2020.

Nation	IBWSS	IESSNS	IESNS
Faroes	Ac	Ac	Ac
Norway	Ac		Ac
Netherlands	Ac	-	-
Ireland	Ac / Bd	-	-
Spain	Ac	-	-
Russia	-	-	
Iceland	-		
Denmark	-		
Greenland	-		-
ICES DB format	Yes		

Update and review

A review exercise will be conducted during the 2021 WGIPS meeting to review the data and findings of the 2020 survey and refine the protocol. If considered useful, a WK focusing on the scrutinisation of mesopelagics during WGIPS coordinated surveys will be proposed to include the expertise developed within the MEESO and SUMMER projects. Once agreed, the protocol will be included as part of the WGIPS survey manual (ICES, 2015) and will undergo the current periodic review process.

Summary

Minimum echo-integration criteria relating to mesopelagic sampling during the IBWSS:

- Report acoustic max depth and ping rate
- Daylight only allocation- excluding during active vertical migration period (dawn and dusk) and during the hours of darkness.
- Depth restricted from 50 to 300 m, below the surface plankton layer and above the DSL.
- Restricted to clear and distinct schools and aggregations occurring in open ocean.
- Species specific integration should only be carried out when supporting biological information is available from directed trawling on insonified targets using a suitable sampling gear.

References

ICES. 2019. Workshop on The Development of Practical Survey Methods for Measurements and Monitoring in the Mesopelagic Zone (WKMESOMeth). ICES Scientific Reports. 1:43. 47 pp. http://doi.org/10.17895/ices.pub.5537

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

Annex 19: Response to Recommendation 129 from WGWIDE

*Please see the response on the next page.

Recommendation 129 from WGWIDE

It is recommended to undertake feasibility study with regard to surveys conducted in summer south of 60N to potentially extend swept area coverage outside the southern boundary of the current IESSNS-survey.

Response

A sub group met during the WGIPS meeting to discuss the request to undertake a feasibility study with regard to extending the swept area coverage for mackerel in the summer (IESSNS) south of 60˚N. The sub group included representatives of the HERAS, WESPAS and ISSNS surveys and members of WGWIDE.

The sub group interpreted the request as asking for a feasibility study to determine two things: Firstly whether it is possible to use existing acoustic surveys conducted in July to extend the coverage of the swept area survey, secondly whether there is scientific value in doing so. The acoustic surveys in question are HERAS (Scotland) and WESPAS (Ireland) that target herring in ICES area 6a in July annually from the coast to the 200m depth contour.

The first point is relatively easily answered. The two existing surveys are already stretched in terms of available time to meet their objectives. Adding additional trawl effort with a different gear would compromise the main objectives of these surveys. Additionally, there are operational difficulties using the MULTPELT trawl on these research vessels, because they may have insufficient power to operate the net properly. It is possible that under exceptional circumstances in some years there could be time for a few experimental hauls using a modified version of gear that is currently rigged for the herring survey, but WGIPS questions the merit in such an exercise unless carried out as part of a larger feasibility study outside of the existing surveys. WGIPS suggests that WGWIDE could contact the pelagic industry which might be better able to carry out comparable surface tows given both the availability of fishing vessels at this time, and their suitability for deploying surface gear.

On the second point, experience from the HERAS and WESPAS surveys raises doubts about the validity of estimating mackerel abundance from a survey focussing on the top 30-40 m of the water column throughout the area south of 60˚N. During these surveys in the summer mackerel is regularly caught in trawl hauls (figures 4-5 and table 1) and the distribution of mackerel can be widespread in some years and at all depths throughout the survey area. This is evident from trawl hauls and echosounder data from these surveys (figures 1-3). Although it is uncertain how reliably mackerel is available for detection by acoustic methods in these survey areas during this time of the year, some observations are worth noting.

When mackerel is encountered in aggregations dense enough to be detected acoustically, they are encountered at variable depths in this area. Although they are occasionally encountered close to the surface (figure 1) they are more frequently observed in midwater or close to the bottom (figures 2-5 and table 1).

This raises questions about the value of an index of abundance from this area based only on the density of mackerel observed in trawls at the surface especially if the proportion of mackerel in the surface compared to the rest of the water column varies between years.

This concern could be substantiated or alleviated with a more thorough analysis of existing data sources but this is beyond the scope of the WGIPS meeting and it is suggested instead that a workshop be scheduled to properly address these questions.

WGIPS suggest that the following data sources could be analysed and results presented at the workshop with emphasis on investigating the depths that mackerel are found at in the area covered over several years:

a) Acoustic multi-frequency data is available from the two acoustic surveys (HERAS and WESPAS) and could be re-scrutinised for mackerel using tested algorithms (e.g. Korneliussen et al. 2010).

b) Provide details of location, depth and magnitude of catches of mackerel from the two acoustic surveys (HERAS and WESPAS) over recent years

c) As mackerel can be caught incidentally while hauling, camera recordings of trawls where existing, could be scrutinised to verify depth of capture

d) Hydrographic data collected during the summer could be analysed to investigate the hypothesis that the reason mackerel is not restricted to surface waters in the area south of 60˚N is the lack of a strong thermocline in the potentially better mixed shelf waters

WGIPS welcomes thoughts from WGWIDE on this proposal and suggests that one way forward is that a workshop be initiated for 2021, to include participants from WGIPS, WGWIDE and other experts. The points raised above should be developed into ToRs for the workshop.

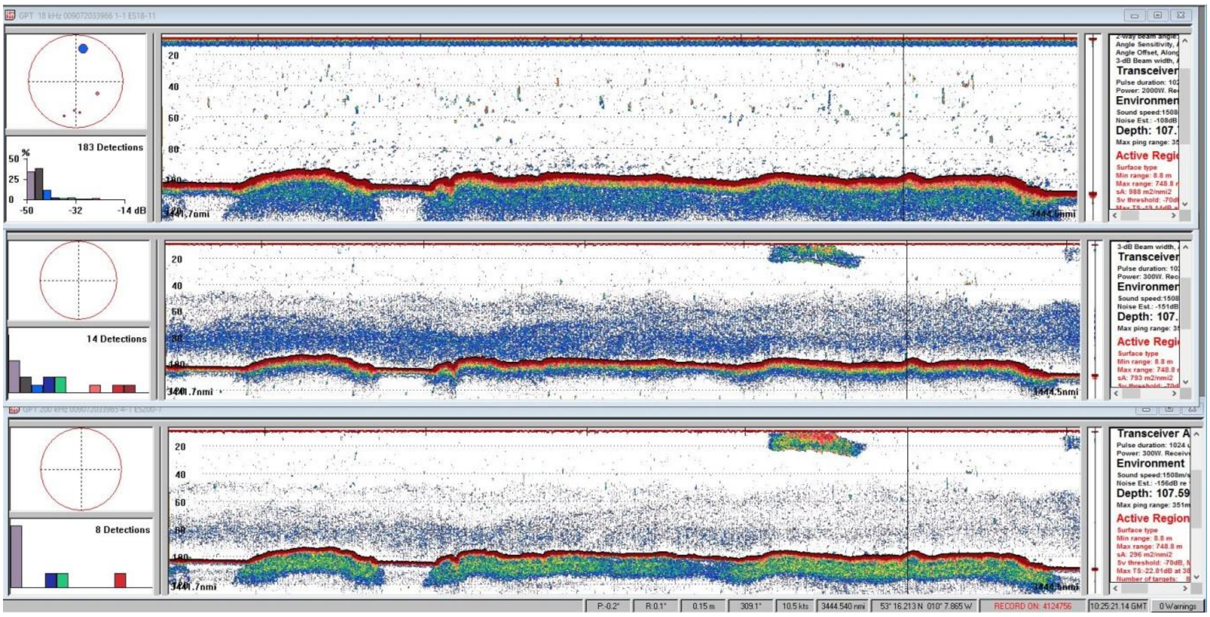

Figure 1. Mackerel close to the surface on 18 (top), 120 (middle) and 200 kHz (bottom) during WESPAS 2019

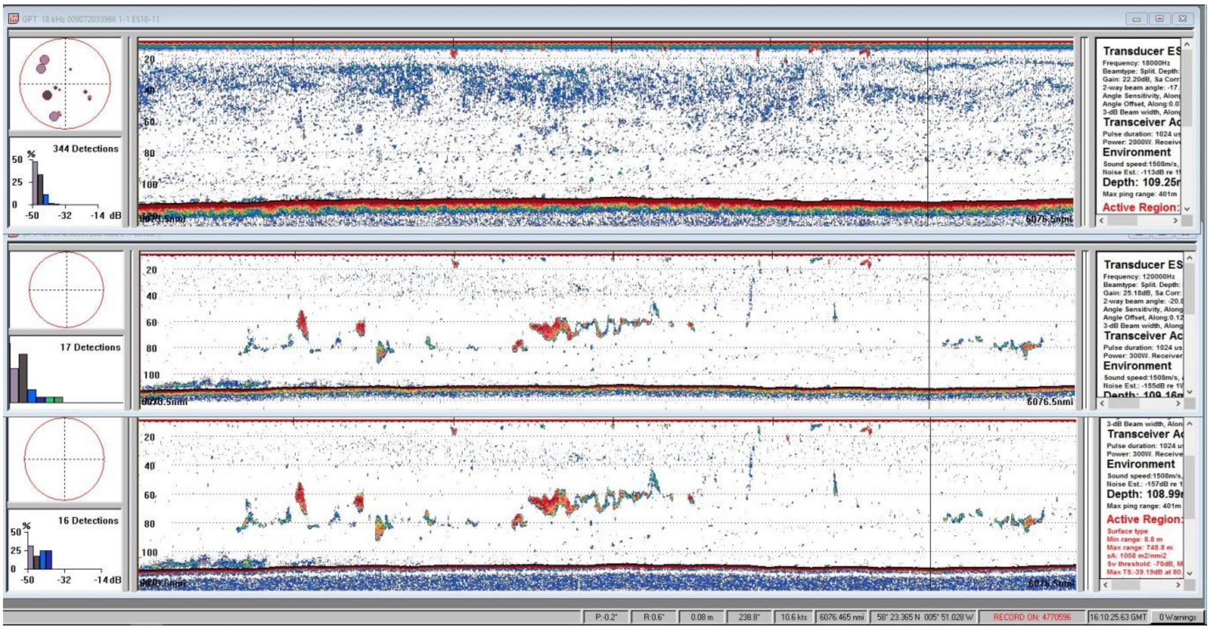

Figure 2: Mackerel marks on 18 (top), 120 (middle) and 200 kHz (bottom) in a layer at 60-80m in 120m deep water during WESPAS 2019.

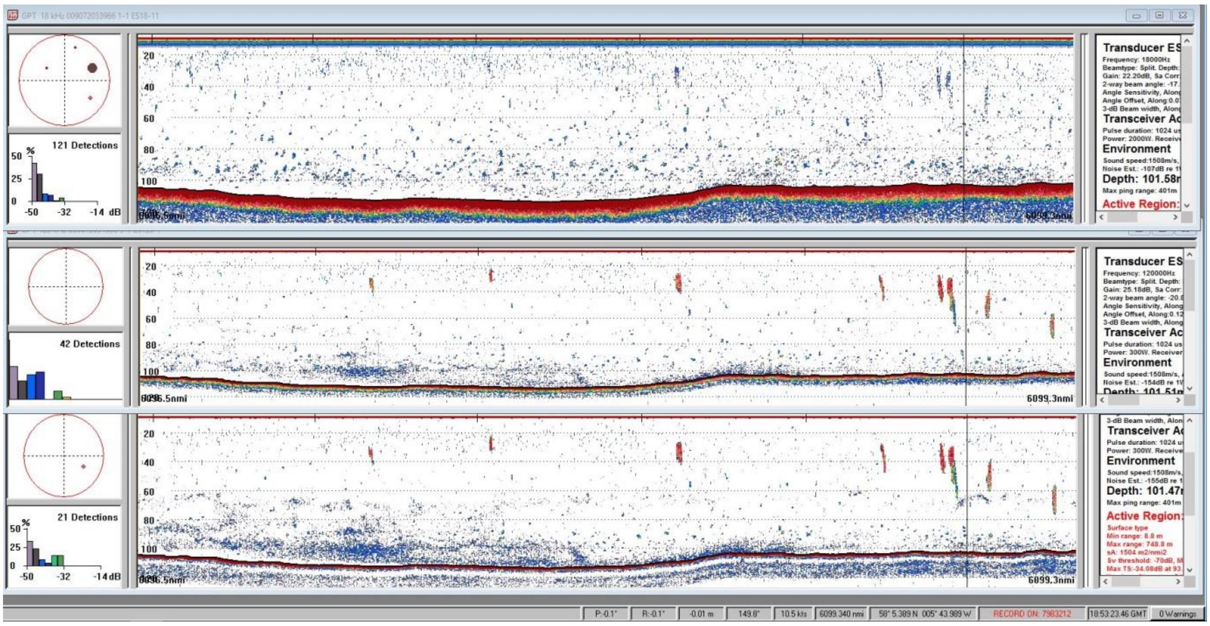

Figure 3. Mackerel marks on 18 (top), 120 (middle) and 200 kHz (bottom) in a layer at 60-80m in 100m deep water during WESPAS 2019.

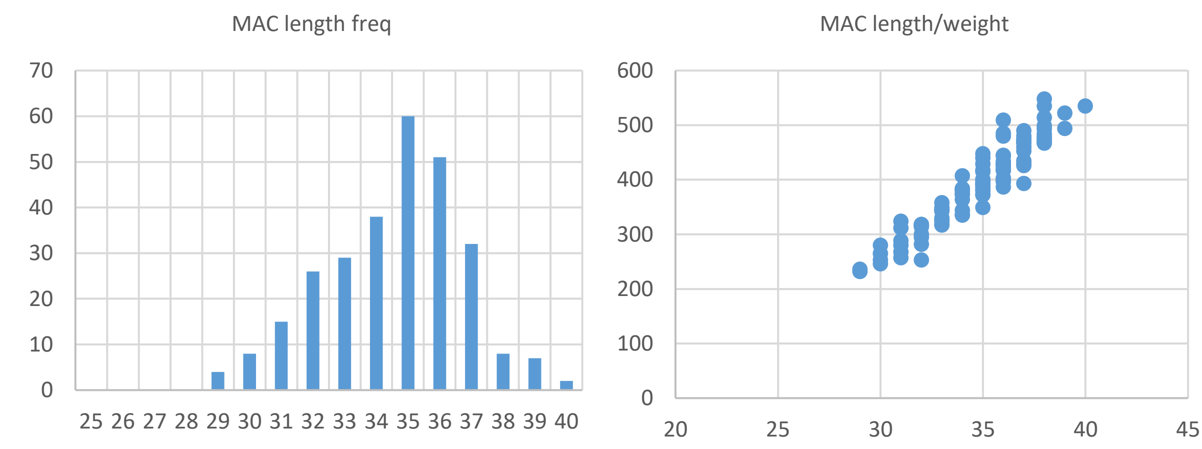

Figure 4. Example biological data from WESPAS 2019 (Haul 36, 180m deep) (1000kg 85% MAC)

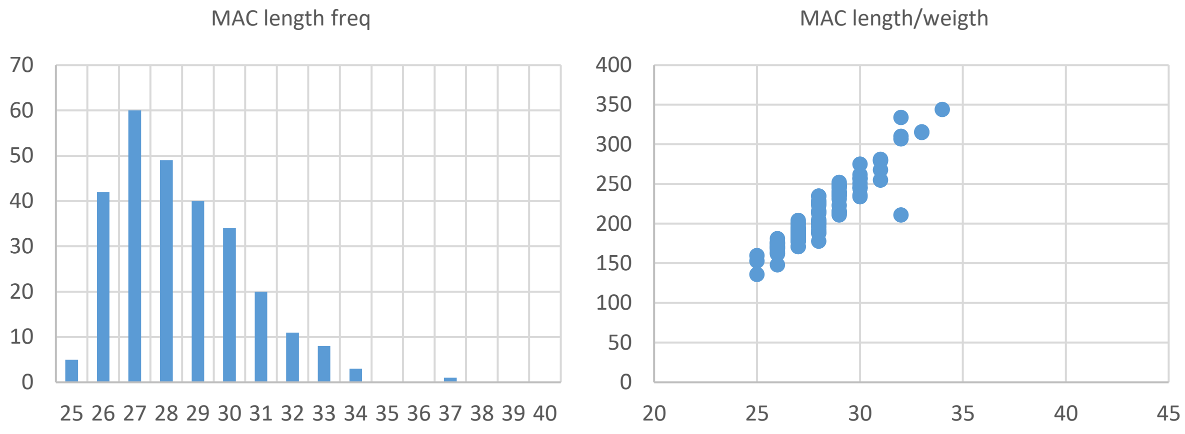

Figure 5. Example biological data from WESPAS 2019 (Haul 38, 170m deep) (200kg 45% MAC)

Table 1. Examples of mackerel catches in 6a during HERAS 2019.

Haul	Date/Time	Lat.	Long.	Haul duration (min)	Water depth	Gear and position	Mackerel catch weight (kg)	MIN (cm)	MAX (cm)	Weighted Mean length (cm)
183	11/07/2019 14:25	60.859	-0.484	24	114	PT160 Bottom	379.5	25	43	30.3
185	12/07/2019 08:31	60.638	-1.611	32	100	PT160 Bottom	249.4	26	37	31.8
186	12/07/2019 15:36	60.531	-2.072	26	126	PT160 Bottom	1432.0	26	36	30.3
189	14/07/2019 09:54	60.127	-4.109	29	155	PT160 Bottom	138.3	29	40	34.9
190	14/07/2019 15:36	59.879	-4.542	25	133	PT160 Bottom	96.4	30	41	34.9

Annex 20: References

ICES. 2019. Workshop on the Development of Practical Survey Methods for Measurements and Monitoring in the Mesopelagic Zone (WKMESOMeth). ICES Scientific Reports. 1:43. 47 pp. http://doi.org/10.17895/ices.pub.5537

ICES. 2020. ICES Workshop on Scrutinizing of Acoustic Data from the IESSNS survey (WKSCRUT2). ICES Scientific Reports. 2:13. 32 pp. http://doi.org/10.17895/ices.pub.5959