WORKING GROUP FOR THE CELTIC SEAS ECOREGION (WGCSE)

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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Editors

Mathieu Lundy • Sofie Nimmegeers

Authors

Gianfranco Anastasi • Paul Bouch • Paul Coleman • Helen Dobby • Mickael Drogou • Simon Fischer • Andrzej Jaworski • Ruth Kelly • Vladimir Khlivnoi • Vladimir Laptikhovsky • Claire Moore • Sara-Jane Moore • Marianne Robert • Pia Schuchert • Bart Vanelslander • Rui Catarino • Jennifer Doyle • Timothy Earl • Ailsa Ellis • Niall Fallon • Chris Firmin • Samuel Hardman • Kieran Hyder • Mathieu Lundy • Sofie Nimmegeers • David Stokes • Jonathan White • Elisa Barreto • Mikel Aristegui

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Contents

i Executive summary

The Working Group for the Celtic Seas Ecoregion (WGCSE) performs stock assessments on demersal stocks in Rockall, West of Scotland, Irish Sea, West of Ireland, Western English Channel, Bristol Channel, Celtic Sea and Southwest of Ireland. In this report the group pro-vides updated fisheries data and assessments for twelve Nephrops stocks, five sole and plaice stocks, four cod and whiting stocks, three haddock stocks, two each of megrim and seabass, one anglerfish, one saithe and one pollack stock. For most of the stocks advice is drafted in May, but for Nephrops, anglerfish and Rockall megrim it is not issued until autumn to take account of the 2021 survey information. Due to the COVID-19 pandemic, the 2020 survey information could not be included for anglerfish and Rockall megrim. The advice for whg.27.7b-ce-k was delayed until autumn after an error was identified in the data raising procedure during the working group in May. At the IBPCSWhiting in September, the catch data input files were revised, followed by an update of the SAM assessment and the reference points. For a number of stocks (ple.27.7bc, sol.27.7bc, bss.27.6a7bj, cod.27.6a, cod.27.6b, nep.27.6aoutFU and nep.27.7outFU), no new advice was provided this year. In 2019 advice for pok.27.7-10 was requested for the first time and was postponed until a benchmark work-shop can take place. Since the last Working Group meeting, 3 stocks have gone through a benchmark procedure; ple.27.7h-k, meg.27.6b and whg.27.6a the results of which were pre-sented to the group. Analytical assessments using age-structured models were conducted for 12 of the 22 demersal fish stocks. A surplus-production model and a Depletion-Corrected Average Catch model, without age or length structure, was used to assess lez.27.4a6a and pol.27.67 respectively. The state of the 8 fish stocks for which no analytical assessment could be performed was inferred from examination of catch/landings data or the use of a survey index or biomass index as indicator of stock development. UWTV survey based assessments were conducted for 10 nephrops stocks. Overall the stock status across the ecoregion is very similar to that presented last year. Of the 32 stocks assessed this year, 21 were fished below FMSY, 5 stocks were fished above FMSY and 6 stocks had unknown status relative to FMSY; 17 were above MSY Btrigger, and 8 were below MSY Btrigger, with 7 unknown relative to Btrigger..

ii Expert group information

Expert group name	Working Group for the Celtic Seas Ecoregion (WGCSE)
Expert group cycle	Annual
Year cycle started	2021
Reporting year in cycle	1/1
Chairs	Sofie Nimmegeers, Belgium
	Mathieu Lundy, Northern Ireland
Meeting venue and dates	5–14 May 2021, Online meeting (27 participants)
	20-21 September 2021, web conference (15 participants)

1 Introduction

1.1 Terms of reference

1.1.1 Generic ToRs for Regional and Species Working Groups

2020/2/FRSG01 The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA and WGNAS.

The working group should focus on:

a) Consider and comment on Ecosystem and Fisheries overviews where available;

b) For the aim of providing input for the Fisheries Overviews, consider and comment on the following for the fisheries relevant to the working group:

   i) descriptions of ecosystem impacts on fisheries

   ii) descriptions of developments and recent changes to the fisheries

   iii) mixed fisheries considerations, and

   iv) emerging issues of relevance for management of the fisheries;

c) Conduct an assessment on the stock(s) to be addressed in 2021 using the method (assessment, forecast or trends indicators) as described in the stock annex and produce a **brief** report of the work carried out regarding the stock, providing summaries of the following where relevant:

   i) Input data and examination of data quality; in the event of missing or inconsistent survey or catch information refer to the ACOM document for dealing with COVID-19 pandemic disruption and the linked template that formulates how deviations from the stock annex are to be reported.

   ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;

   iii) For relevant stocks (i.e., all stocks with catches in the NEAFC Regulatory Area), estimate the percentage of the total catch that has been taken in the NEAFC Regulatory Area in 2020.

   iv) Estimate MSY reference points or proxies for the category 3 and 4 stocks

   v) Evaluate spawning stock biomass, total stock biomass, fishing mortality, catches (projected landings and discards) using the method described in the stock annex;

      a. for category 1 and 2 stocks, in addition to the other relevant model diagnostics, the recommendations and decision tree formulated by WKFORBIAS (see Annex 2 of https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WKFORBIAS_2019.pdf) should be considered as guidance to determine whether an assessment remains sufficiently robust for providing advice.

b. b. If the assessment is deemed no longer suitable as basis for advice, consider whether it is possible and feasible to resolve the issue through an interbenchmark. If this is not possible, consider providing advice using an appropriate Category 2 to 5 approach.;

vi) The state of the stocks against relevant reference points;

Consistent with ACOM's 2020 decision, the basis for Fpa should be Fp.05.

a. 1. Where Fp.05 for the current set of reference points is reported in the relevant benchmark report, replace the value and basis of Fpa with the information relevant for Fp.05

b. 2. Where Fp.05 for the current set of reference points is not reported in the relevant benchmark report, compute the Fp.05 that is consistent with the current set of reference points and use as Fpa. A review/audit of the computations will be organized.

c. 3. Where Fp.05 for the current set of reference points is not reported and cannot be computed, retain the existing basis for Fpa.

vii) Catch scenarios for the year(s) beyond the terminal year of the data for the stocks for which ICES has been requested to provide advice on fishing opportunities;

viii) Historical and analytical performance of the assessment and catch options with a succinct description of associated quality issues. For the analytical performance of category 1 and 2 age-structured assessments, report the mean Mohn's rho (assessment retrospective bias analysis) values for time series of recruitment, spawning stock biomass, and fishing mortality rate. The WG report should include a plot of this retrospective analysis. The values should be calculated in accordance with the "Guidance for completing ToR viii) of the Generic ToRs for Regional and Species Working Groups - Retrospective bias in assessment" and reported using the ICES application for this purpose.

d) Produce a first draft of the advice on the stocks under considerations according to ACOM guidelines.

i. In the section 'Basis for the assessment' under input data match the survey names with the relevant "SurveyCode" listed ICES survey naming convention *(restricted access)* and add the "SurveyCode" to the advice sheet.

e) Review progress on benchmark issues and processes of relevance to the Expert Group.
i) update the benchmark issues lists for the individual stocks;
ii) review progress on benchmark issues and identify potential benchmarks to be initiated in 2022 for conclusion in 2023;
iii) determine the prioritization score for benchmarks proposed for 2022–2023;
iv) as necessary, document generic issues to be addressed by the Benchmark Oversight Group (BOG)

f) Prepare the data calls for the next year's update assessment and for planned data evaluation workshops;

g) Identify research needs of relevance to the work of the Expert Group.

h) Review and update information regarding operational issues and research priorities on the Fisheries Resources Steering Group SharePoint site.

i) If not completed in 2020, complete the audit spread sheet 'Monitor and alert for changes in ecosystem/fisheries productivity' for the new assessments and data used for the stocks. Also note in the benchmark report how productivity, species interactions, habitat and distributional changes, including those related to climate-change, could be considered in the advice.

Information of the stocks to be considered by each Expert Group is available here.

1.1.2 Specific ToRs

WGCSE – Working Group for the Celtic Seas Ecoregion

2020/2/FRSG09 The Working Group for the Celtic Seas Ecoregion (WGCSE), chaired by Mathieu Lundy, UK and Sofie Nimmegeers, Belgium will meet in Ghent, Belgium or virtually tbc. 5–14 May 2021 and by correspondence September / October 2021 to:

a) Address generic ToRs for Regional and Species Working Groups;

b) Report on reopened advice as appropriate;

The assessments will be carried out on the basis of the stock annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates specified in the 2020 ICES data call.

WGCSE will report by 25 May 2021 for the attention of ACOM, and by 1 October 2021 for *Nephrops* stocks, anglerfish and megrim in Rockall. Concerning ToR b) the group will report on the ACOM guidelines on reopening procedure of the advice before October and will report on reopened advice before October.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Dates to be added for reopening procedure and clarify if ToR on reopening is needed

Defer for further discussion and post revision on Resolutions Forum for approval (to be addressed by SG Chair, EG Chair, ACOM or SCICOM chair and Secretariat)

1.2 Participation

Due to the COVID-19 pandemic, all ICES assessment physical meetings were suspended and held remotely. Nevertheless, an adequate participation could be achieved with representation of the different institutes that are generally involved.

1.3 Methods

The type of final assessments presented at the WG are summarised as follows:

Category 1 age-based assessments and forecasts were conducted for bss.27.4bc7ad–h, cod.27.7.e–k, had.27.6.b, had.27.7.a, had.27.7.b–k, ple.27.7.a, sol.27.7.a, sol.27.7.e, sol.27.7.fg, whg.27.6.a (this stock was benchmarked in 2021 (WKNSEA, (ICES, 2021a)) and, as a result, the stock was changed from category 5 to category 1), whg.27.7.a and whg.27.7.b–ce–k;

Category 1 Bayesian surplus production model for lez.27.4.a6.a;

Category 1: UWTV survey based assessments and advice were used for nep.fu.11, nep.fu.12, nep.fu.13, nep.fu.14, nep.fu.15, nep.fu.16, nep.fu.17, nep.fu.19, nep.fu.2021 and nep.fu.22. Fisheries data were updated at the May meeting and survey data were updated in the autumn;

Category 2: Lez.27.6b was benchmarked in 2021 (WKMSYSPICT, (ICES, 2021b)) and, as a result, the stock was changed from category 3 to category 2. The stock has a SPICT assessment to determine stock status and a short-term catch forecast for lez.27.6b;

Category 3: Catch-at-age based assessments with caveats i.e. used for trends only and without forecasts for ple.27.7.e;

Category 3: SPICT used to provide biomass trend for ple.27.7fg;

Category 3: Analysis of the trends in survey data are used as the basis for advice for anf.27.3a46, cod 27.7.a;

Category 3: ple.27.7h-k was benchmarked in 2021 (WKWEST, (ICES, 2021c)) and, as a result, trends from combined biomass index and length-based indicator are now used as the basis for advice;

Category 4: Depletion corrected average catch was used for pol.27.67;

Category 5 & 6: sol.27.7h-k and whg.27.6.b;

For the stocks for which a full analytical assessment was possible, the WG used either Extended Survivor's Analysis (XSA), Age-Structured Assessment Program (ASAP) or state space assessment model (SAM). These approaches and procedures for using them are discussed in further detail in the relevant stock annexes.

1.4 Data issues

Data were generally submitted in a timely fashion through the InterCatch database for landings and discards data, and through the accessions database for other sources of data.

1.5 Transparent Assessment Framework (TAF)

TAF is a new framework, currently in development, to organize all ICES stock assessments. Using a standard sequence of R scripts, it makes the data, analysis, and results available online, and documents how the data were pre-processed. Among the key benefits of this structured and open approach are improved quality assurance and peer review of ICES stock assessments. Furthermore, a fully scripted TAF assessment is easy to update and rerun later, with a new year of data. A number of assessments are being scripted in standard TAF scripts. See http://taf.ices.dk for more information.

The following stocks have their 2021 assessment on TAF: cod.27.7a, had.27.7a, nep.fu.2021, nep.fu.22, ple.27.7e, sol.27.7a, sol.27.7e and sol.27.7fg. Overall, the 2021 update for most of the stocks is not yet completed.

1.6 Internal auditing and external reviews

As in previous years the WG carried out its own internal audit process using the standard ICES template. Given the workload of many of the scientists at WGCSE (sometimes with one scientist responsible for two or more stocks), many of the reports were not finalized until after the WG meeting. Audits were therefore typically carried out by correspondence after the WG and not completed for some stocks.

All stocks for which advice was provided in June and October 2021 were audited by the WG and audit reports were produced for most of these. Issues discovered during the audit process were corrected in the WG report.

1.7 Generic ToR e: WGCSE recommendations for stocks to be benchmarked

In 2022 WKNSCS is scheduled to benchmark ple.27.7fg and cod.27.7a. For those stocks the focus is to examine alternative assessment models to XSA (e.g. A4A, ASAP, SAM, CASAL), explore the impact of all available tuning fleets, reconsider available life-history and catch data.

WGCSE recommend that pol.27.67 and pok.27.7-10 should be benchmarked together. Currently, both stocks are categorized as category 4 data-limited and the DCAC method is applied to provide advice. As the DCAC method only uses long time-series of official landings, it may not reflect recent stock fluctuations or changes in the fisheries, smoothed by the length of the time-series. So new computations of DCAC are always very close to the previous year's results, even if recruitment or SSB highly fluctuate. Therefore, it is relevant to explore new assessment models. Furthermore, this is the first year advice was provided for the pok.27.7-10 stock.

At-sea observer sampling for discards remains sparse for had.27.6b, which leads to uncertainty in fishery selectivity patterns and catch estimates data used in the assessment. The assessment model used (FLXSA) assumes catch is measured with no uncertainty and so does not account for this sampling issue. The estimates of SSB are consistently being overestimated and F is consistently being underestimated, therefore it is recommended to address this in a benchmark.

There is a joint recommendation with the Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE) to evaluate the stock identity of the Atlantic seabass stocks. The Working Groups recognized the complexity and considered that a stock identity workshop might be convened to allow relevant experts to consider relevant studies (data storage tags, conventional tags, genetics, otolith microchemistry and larval dispersion models) and advise whether the existing stock boundaries remain appropriate. This work should be proceeding towards a benchmark in the next stage. The aim should be to explore and peer-review all available information on recreational catches. There is also a need for information on recruitment trends in other areas, as it cannot be assumed that the Solent index will in the long term represent overall recruitment patterns throughout areas 4 and 7. Estimates of discards are available only from the early 2000s, but do not cover all fisheries, are imprecise, and are only included for some fleets in the assessment. Discard rates are expected to increase in the short term as fishers adjust to take account of the management measures, such as the increase in minimum conservation reference size from 36 cm to 42 cm. The difference in perception between the modelled discards and the observed, should also be addressed. The benchmark should evaluate if sampling is currently sufficient to support continued application of Stock Synthesis fitting selection parameters to fishery composition data.

The assessment of ple.27.7a indicates that recruitment and fishing mortality have both been decreasing in recent years, and the average age of catches has been increasing. An increasing amount of the stock is contained within the modelled plusgroup (41% in the last five years is age 8+) and this is forecast to increase. Consequently, the assessment and forecast have increased uncertainty and a pattern of retrospective downscaling of SSB is seen in the recent history of the assessment. This demographic change might cause problems for fitting the model, and is therefore proposed to tackle in an InterBenchmark Protocol by extending the age within the assessment, although issue may arise with historic data.

Further details are given in the stock sections.

Every year a prioritization exercise for the stocks that need to be benchmarked is done. The sum of the weighting scores (1-5) for each of the 5 criteria will determine the urgency for a benchmark. Those criteria are related to the quality of the previous assessments, the opportunity to improve the assessment, the management importance, the perceived stock status and the time since the previous benchmark.

To have an overview of this information, an issue list is requested for every stock.

1.8 Specific ToRs

1.8.1 c(ii): Estimation of MSY proxy reference points for category 3 and 4 stocks

The Terms of reference contained a list of six stocks for which proxy reference points should be considered. The Working Group addressed this Tor as follows.

Category 3 stocks:

For ple.27.7e, an age-based assessments is performed, although only used as relative indicator of stock status. Most of the reference points were estimated using the package EqSim, and the method of WKMSYREF4 at WGCSE 2017. The extra data available at this year's Working Group did not warrant recalculation of the reference points.

For ple.27.7h-k, the length based indicator (LBI)-estimated values of the ratio $L_{mean}/L_{F=M}$ are used to estimate exploitation status relative to the proxy MSY reference point

For ple.27.7fg , a SPiCT assessment using survey and lpue data, combined with a hind-cast of discards was used to estimate the stock status relative to reference points.

For anf.27.3a46, which was benchmarked in 2018, none of the DL approaches for estimating proxy reference points were entirely satisfactory.

Lez.27.6b was benchmarked in 2021 and, as a result, the stock was changed from category 3 to category 2.

Category 4 stocks:

For pol.27.67 and pok.27.7-10, no reference points are defined.

1.8.2 c(viii): Calculation of Mohn's Rho

Through this additional ToR, the working group was requested to report the assessment bias statistic Mohn's rho for each of the category 1 stocks. The Mohn's rho statistic that compares estimates from assessments with recent years of data removed to estimates from the current assessment is the standard tool for retrospective analysis. For the following stocks the Mohn's rho data were uploaded to the "Retro-bias-2021" SharePoint: bss.27.4bc7ad–h, cod.27.6.a, had.27.7.a, had.27.7.b-k, whg.27.7.bc-ek, cod.27.7.e-k, whg.27.7.a, whg.27.6.a, ple.27.7.a, sol.27.7.a, sol.27.7.e and sol.27.7.fg.

The assessments of Nephrops stocks do not revise the perception of previous years, and so there is no retrospective assessment.

The guidance on calculating Mohn's Rho seems unclear about whether the SSB for the intermediate year should be used for the calculation of rho in XSA and ASAP models. Some members considered that the SSB in the final data year was a consequence of the known numbers and catch in the year before and should therefore be included, while others took the view that the SSB in the final data year depends on a recruitment assumption for the final data year where the recruitment has some proportion mature. Furthermore, this SSB also depends on the assumed stock weights at age in the final data year. In the latter case, the SSB in the final data year is not directly derived from the assessment model and should therefore be excluded from the Mohn's rho calculation.

The workshop on catch forecast from biased assessments (WKFORBIAS, (ICES, 2020)) took place in November 2019 and was tasked to quantify the extent and possible causes for retrospective bias. For the stock assessments that do show strong retrospective patterns, the first step was to identify what constitutes a strong retrospective pattern then a set of recommendations and a decision tree was developed to help experts determine a course of action.

The updated Inter-Benchmark assessment of whg.27.7.bc-ek (IBPCSWhiting, (ICES, 2021d)) shows an increase in retrospective bias compared to the previous year's assessment, with Mohn's Rho values close to the acceptable limit of 0.2 (SSB: 0.18%), therefore this should be examined further.

There is some evidence of a retrospective pattern for bss.27.4bc7ad–h as the Mohn's Rho value for SSB and F are close to the tolerance threshold. The model is sensitive to the recent change in selectivity due to management measures where a block change in the selectivity and retention parameter estimates where introduced for data proceeding 2015.

Adding an additional year of data to the cod.27.7e–k assessment resulted in Mohn's Rho values of -0.19 for F and 0.25 for SSB. This may be due to the variability of cod recruitment over years, the strong dependency of the fishery to recruitment (not well estimated by the survey) and the unexpected disappearance of fish of older age. Despite the high values of the Mohn's rho coefficient and the uncertainties in the estimates of the most recent year, the assessment has been validated (the stock is maintained in category 1), and the output are used to provide the short-term forecast. This decision follows the guidelines provide by WKFORBIAS. Despite the uncertainties in the estimates of the most recent years, SSB and F are estimated well below biological references points.

With a Mohn's Rho value for SSB of 0.51, there is a profound retrospective pattern for had.27.6b. As the SSB is well above MSY Btrigger, Bpa, and Blim, the assessment has been validated, and the output are used to provide the short-term forecast.

1.9 References

ICES. 2020. Workshop on Catch Forecast from Biased Assessments (WKFORBIAS; outputs from 2019 meeting). ICES Scientific Reports. 2:28. 38 pp. http://doi.org/10.17895/ices.pub.5997

ICES. 2021a. Benchmark Workshop on North Sea Stocks (WKNSEA). ICES Scientific Reports, 3:25. 756 pp. https://doi.org/10.17895/ices.pub.7922

ICES. 2021b. Benchmark Workshop on the development of MSY advice for category 3 stocks using Surplus Production Model in Continuous Time; SPiCT (WKMSYSPiCT). ICES Scientific Reports. 3:20. 316 pp. https://doi.org/10.17895/ices.pub.7919.

ICES. 2021c. Benchmark Workshop on selected stocks in the Western Waters in 2021 (WKWEST). ICES Scientific Reports. 3:31. 504 pp. https://doi.org/10.17895/ices.pub.8137.

ICES. 2021d Inter-Benchmark Protocol on Celtic Seas Whiting (IBPCSWhiting)

2 Anglerfish (*Lophius budegassa, Lophius piscatorius*) in subareas 4 and 6 and in Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat)

Assessment in 2021

The last benchmark for this stock was carried out in February 2018 (ICES, 2018) where it was agreed to provide advice on the basis of the procedure for category 3.2.0 of ICES RGLIFE data-limited stock (DLS) methods as set out in the stock annex. However, in 2020, the Scottish component of the SIAMISS survey (covering the northern North Sea, the north of Division 6a and Division 6b) was cancelled due to the COVID-19 pandemic. While the Irish part of the survey did go-ahead (covering the southern part of Division 6a), historical densities and stock trends suggest that extrapolation of this component of the survey to the wider stock area would be inappropriate. The lack of survey data in 2020 therefore implies that advice cannot be given exactly according to the procedures set out in the Stock Annex. The advice provided this year is based on the framework for category 3 stocks, but with the 2020 index value treated as missing. The PA buffer is not applied since it was applied in 2019.

ICES advice applicable to 2020 and 2021

ICES advice for 2020

ICES advises that when the precautionary approach is applied, catches in 2020 should be no more than 22 056 tonnes.

ICES advice for 2021

ICES advises that when the precautionary approach is applied, catches in 2021 should be no more than 17 645 tonnes.

2.1 General

Stock description and management units

The anglerfish stock on the Northern Shelf is considered to occur in Division 3.a (Skagerrak and Kattegat), Subarea 4 (the North Sea) and Subarea 6 (West of Scotland plus Rockall). Anglerfish in the North Sea and Skagerrak/Kattegat were considered by this Working Group for the first time in 1999. In 2004 the WGNSDS considered the stock structure of anglerfish on a wider European scale, and found no conclusive evidence to indicate an extension of the stock area northwards to include Division 2.a. In 2013, Division 2.a was removed from WGCSE ToR.

Management applicable to 2020 and 2021

Council Regulation (EU) 2020/123 of 27 January 2020 fixing for 2020 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters.

Species	**Anglerfish** **Lophiidae**	**Zone:**	**Union waters of 2.a and 4** **(ANF/2AC4-C)**
Belgium	498(1)		
Denmark	1098(1)		
Germany	536(1)		
France	102(1)		
The Netherlands	377(1)		
Sweden	13(1)		
United Kingdom	11 461(1)		
Union	14 085(1)		
TAC	14 085		Precautionary TAC

(1) Special condition: of which up to 10% may be fished in: 6; Union and international waters of 5b; international waters of 12 and 14 (ANF/*56-14).

Species	Anglerfish Lophiidae	Zone:	Norwegian waters of 4 (ANF/04-N.)
Belgium	51	Precautionary TAC	
Denmark	1305		
Germany	21	Article 3 of Regulation (EC) No 847/96 shall not apply	
The Netherlands	18		
United Kingdom	305	Article 4 of Regulation (EC) No 847/96 shall not apply	
Union	1700		
TAC	Not relevant		

Species	Anglerfish Lophiidae	Zone:	6; Union and international waters of 5.b; international waters of 12 and 14 (ANF/56-14)
Belgium	286(1)		
Germany	327(1)		
Spain	307		
France	3525(1)		
Ireland	797		
The Netherlands	276(1)		
United Kingdom	2453(1)		
Union	7971		
TAC	7971		Precautionary TAC

(1) Special condition: of which up to 5 % may be fished in: Union waters of 2a and 4 (ANF/*2AC4C).

According to the 'agreed record', the following TACs have been agreed between the EU and UK for 2021. The allocations are as per the EU-UK Trade and Cooperation Agreement (TCA).

ICES areas	TAC	UK allocation	EU allocation
UK & EU waters of 4; UK waters of 2a.	11 972	10 327[1,2]	1 645[1,2]
6; UK & international waters of 5b; international waters of 12 & 14	6 377	2 488[3]	3 889[3]

1: Special condition: of which up to 30% may be fished in UK, EU and international waters of 6a north of 58'30''.

2: Special condition: of which up to 10% may be fished in UK waters fo 6a south of 58'30''; Union and international waters of 5b; International waters of 12 and 14.

3: Special condition: of which up to 20% may be fished in UK and EU waters of 2a and 4.

Species	Anglerfish Lophiidae	Zone:	Norwegian waters of 4 (ANF/04-N.)
Belgium	37	Precautionary TAC Article 3 of Regulation (EC) No 847/96 shall not apply Article 4 of Regulation (EC) No 847/96 shall not apply	
Denmark	935		
Germany	15		
The Netherlands	13		
Union	1000		
TAC	Not relevant		

Management of Northern Shelf anglerfish is based on separate TACs for the North Sea Subarea 4 and West of Scotland Subarea 6. There is no TAC for Skagerrak and Kattegat Division 3.a. Table 4.1 summarises the ICES advice and actual management applicable for Northern Shelf anglerfish for 2003 onwards.

Although there is no minimum landing size for this species, there is an EU minimum weight of 500 g for marketing purposes (EC Regulation 2406/96).

Fishery description

A more detailed description of the fisheries can be found in the Stock Annex. The official national landings as reported to ICES are given in Table 4.2 and the breakdown by country in Tables 4.3–4.5. Minor revisions were made to tables in 2020 with updates from the ICES official and historical nominal catch statistics for 2018 and the addition of the preliminary catch statistics values for 2019. Total officially reported landings of anglerfish from the Northern Shelf are shown in Figure 4.1.

Trends in nominal international fishing effort in the North Sea and Eastern Channel and the West of Scotland collated by STECF for the Evaluation of Fishing Effort Regimes in European Waters are shown in Figure 4.2. Since 2014, there have been slight increases in TR effort in both the North Sea and West of Scotland, with effort across all gears in the North Sea stable or reducing since 2012 and in the West of Scotland increasing from 2014 driven by marked increases in trawl fisheries.

The fishery in 2020

Official landings in 2020 for subareas 6 and 4 were 18 197 t (6434 t and 11 763 t respectively), giving a 17.5% undershoot of the combined TAC of 22 056 t (81% and 83% TAC uptake respectively). In Subarea 6 Belgium (0%), the Netherlands (0%) and France (37%) had noticeably low uptakes. Belgium was also observed to significantly undertake their quota in Subarea 4 (44%). Denmark (58%) and Germany (65%) both decreased their Subarea 4 uptakes in comparison to 2019, while the United Kingdom increased its uptake (70%). The UK exceeded its quota in Subarea 6 (by 52%), a decrease of 24% compared to 2019. Over quota landings by individual states are most likely due to countries obtaining additional quota from other EU member states, or carrying forward unutilised quota from 2019 and using a flexibility allowance whereby 10% of Subarea 4 TAC can be utilised to reattribute landings from Subarea 6.

Uptake of EC quota in 2020, based on the preliminary officially reported landings, was as follows:

	TAC 6	Lan-dings 6	Uptake (%)	TAC 4 (Norwegian)	TAC 2.a & 4	TAC 2.a & 4(total)	Landings 4	Uptake (%)
Belgium	286	-	0%	51	498	549	243	44%
Denmark	-	-	-	1305	1098	2403	1398	58%
France	3525	1304	35%	-	102	102	127	124%
Germany	327	229	70%	21	536	557	361	65%
Ireland	797	900	113%	-	-	-	-	-
Netherlands	276	-	0%	18	377	395	285	72%
Norway	-	0.9	-	-	-	-	997	-
Russia	-	-	-	-	-	-	-	-
Spain	307	264	86%	-	-	-	-	-
Sweden	-	-	-	-	13	13	72	553%
UK (total)	2453	3731	152%	305	11461	11766	8282	70%
Total Union TAC	7971	6434	81%	1 700	14085	15785	11765	75%

Based on data submitted to ICES, the fishery was principally prosecuted by vessels using demersal trawls (Table 4.6), targeting either white fish (72% of total landings by weight) or *Nephrops* (5%). Alongside these fleets there was also a significant gillnet fishery (18%), as well as an assortment of other gears in which small quantities of anglerfish are caught as bycatch. The latter have been grouped here as miscellaneous gears (5%). Gillnets accounted for slightly smaller proportion of total landings across gear types in 2020 in comparison to 2019.

UK (Scottish) vessels accounted for the majority of reported anglerfish landings from the combined Northern Shelf area, taking approximately 63% of the landings overall. Scottish, Danish and Norwegian vessels took 60%, 18% and 10%, respectively, of the North Sea (Divisions 4.a–4.c) landings. Scottish, Irish and French vessels took 46%, 19% and 17%, respectively, of the West Coast (Subarea 6) landings..

Landings in Division 3.a are not regulated: Table 4.5 shows the official landings which fluctuated between 400–500 t from 2005–2015, but have more than doubled since then. Official landings in 2020 were 888 t, slightly lower than 2019.

2.2 Data

Landings

National landings data as reported to ICES and Working Group estimates of total landings are given in Table 4.2. The working group procedures used to determine the total international landings numbers and weights-at-length are documented in the stock annex. It is acknowledged that throughout the landings time-series, there have consistently been differences between the total official landings and the landings as estimated by the WG. This is likely due to differences in the data provided to the WG by national scientists and administrators.

Due to restrictive TACs, the likelihood of misreporting and underreporting of anglerfish landings in the past is considered to have been high, particularly during the period 2003–2005. During the benchmark at WKROUND (ICES, 2013), it was agreed that recent landings are likely to be more accurate from 2006 due to, i) less restrictive TACs, ii) the introduction of buyers and sellers legislation in the UK and Ireland and iii) the offshore gillnet fishery for anglerfish historically conducted by Spanish flagged vessels and thought to under-report landings, being much reduced. Anecdotal reports from fisheries offices and catch sampling staff suggest that towards the end of 2016 and into 2017 the high abundance of anglerfish on the grounds, and the restrictive quota were leading to an increase in suspected misreporting, discarding and black landings. There was no new information in 2021 to suggest that these suspected practices continued into 2018 and 2019, and the lower quota uptake during these years may indicate that the incentives for this behaviour are no longer prevalent. During the period 2005–2010, landings data were not provided to the Working Group by some of the major nations exploiting the fishery; however the recent data call for the WKAngler benchmark (2018) has meant that WG estimates of subarea 6 and 4 landings have now been calculated for this period.

Discards

Prior to the recent WKAngler benchmark (2018) discard estimates have only been available within InterCatch since 2012. Following the WKAngler data call discard information are now available for some fleets since 2002; however, discard information from UK (Scotland) is not available before 2008. The discard estimates that are available from other nations for the 2002–2007 period are substantially higher than the later UK (Scottish) rates. Given that these (non-Scottish) fleets represent proportionally less of the landings, the discards pre-2008 are considered to be non-representative of the overall fishery (WKAngler 2018).

The breakdown of landings and discards by main gear group and area for 2019 and 2020 is given in Table 4.6. Landings and discards over time are shown in Figure 4.15. Discard data indicate that discarding in this fishery is relatively low due to high market value and no MCRS. Overall discarding was 1.6% of total catch in 2020, consistent with the estimate for 2018. Demersal TR2 trawlers had the highest discard rate due to more restrictive quota share, 8.1% in 2019, slightly less than the value for 2019 (12.7%), but a substantial reduction from 2017 (20.9%) and 2016 (43.9%). In comparison TR1 trawlers, gillnets and miscellaneous gear types typically tend to have much lower discard rates (<2%).

Figures 4.3 (a–c) show the percentage of landed weight by fleet, country and area. Length–frequency samples for catch in 2021 were submitted by Belgium, Denmark, France, Germany, Ireland, Norway, UK (England & Wales) and the UK (Scotland). There was good coverage of both the demersal TR1 and TR2 fleets in Subarea 4 and Division 6.a. There were no samples from UK-flagged gillnet vessels (operating in Subarea 4) which alone accounted for approximately 12% of all landings (Figure 4.3a).

Length compositions

There is now a time-series of commercial catch-at-length data for 2002–2020 (12.7). The spread of lengths in the landings distributions are wider during the period 2012–2014 after which the distributions are steeper and unimodal. In 2015 the strong 2013 cohort entered the fishery producing a markedly different catch composition of lengths with the bulk of landings being between 30 and 50 cm in length with steep tails either side. Discard rates are lower from 2015 onwards however the landings of <30 cm fish were also lower, suggesting this reduction could be a combination of catch composition and the increase in quota availability. The distribution of lengths in the landings in 2019 and 2020 has a wider spread to its peak than in recent years likely due to contribution of the 2014 cohort which are now larger individuals.

Biological

An anglerfish ageing exchange was held in 2011 to investigate the possibility of the collation of an international landings-at-age dataset of hard structure age readings, however little agreement was found between methods or readers. This was acknowledged in the findings of the WKROUND report on current assessment and issues with data and assessment of this stock (ICES, 2013). Further to this, discussions at WKAngler established that few countries are actively reading anglerfish hard structures, although they continue to be collected, processed and stored. It is unlikely that any developments in regards to an agreed reading criterion will be made in the near future.

Research vessel surveys

The SIAMISS (Scottish Irish Anglerfish Megrim Industry Science Survey) is a dedicated anglerfish survey. It covers much of the known distribution of the northern shelf anglerfish (ICES divisions 4a, 6a and 6b), with the exception of the central and southern parts of Subarea 4 and the Skagerrak and Kattegat (Division 3a). The survey area has been stratified based on knowledge from fishermen with sampling effort within each stratum allocated roughly according to its expected biomass. Given the large spatial coverage of the survey, it is typically carried out by multiple vessels including commercial fishing vessels and both Irish and Scottish research vessels using a standard gear. Abundance and biomass estimates are worked up on the basis of swept-area and account for herding by the trawl doors and sweeps, ii) escapes under the footrope and iii) anglerfish abundance and biomass in the southern part of Division 6a not covered in 2005, 2008 and 2010. Further details regarding the survey design and work up can be found in the stock annex and working document for 2021 (see Barreto *et al*., 2021).

The survey began in 2005 and is carried out on an annual basis (usually in spring, but sometimes in November). In 2020, however, the Scottish component of the SIAMISS survey (covering the northern North Sea, the north of divisions 6a and 6b) was cancelled due to the COVID-19 pandemic. While the Irish part of the survey did go-ahead (covering the southern part of Division 6a), historical densities and stock trends suggest that extrapolation of this component of the survey to the wider stock area would be inappropriate. Therefore, there is no abundance/biomass estimate from SIAMISS for 2020. In 2021 the anglerfish multi-vessel survey took place from 8th to 29th of April and involved two vessels: FRV Scotia – surveying Division 4a, Division 6a North of 58°N, and Rockall (6b) and the Irish Marine Institute research vessel FRV Celtic Explorer, surveying Division 6a South of 58°N. One haul with the duration of 60 minutes was made at each sampling station (n=137).

Figures 4.16 and 4.17 show the 2021 survey haul locations and mean numbers and weight per km^2 caught at these locations. Larger numbers of anglerfish were caught along the shelf-edge below 58°N, with large weights of fish being caught at the same locations and also at Rockall, indicating that the fish at Rockall are larger than those caught on the shelf-edge.

Estimated total population numbers and biomass at length by area from the most recent survey in 2021 are shown in Figure 4.7 which show a much higher proportion of large fish at Rockall than in divisions 6a and 4a. In terms of numbers, area 4a has by far the highest value, when compared with areas 6a and 6b. Comparison of numbers-at-length and weight-at-length over time for all areas combined show a downward pattern, with both numbers and biomass decreasing, when compared with recent years. (Figure 4.8).

A time-series of total biomass is given in Table 4.7 and Figure 4.5. The total biomass estimate for the Northern Shelf in 2021, the most recent survey year was 48 355 t a decrease of 19% compared to 2019, the lowest value since 2013. A large proportion of total population numbers consisted of individuals <30 cm in 2021, suggesting reasonably strong recruitment.

The breakdown of total numbers and biomass by area (Table 4.8 and Figure 4.6) shows that Division 6b has lower estimated population numbers with less variability over time than in either division 6a or 4a. Division 4a consistently has the highest total biomass of the three areas and shows similar temporal trends to Division 6a.

Estimates of the ratio of survey biomass between subareas 4 and 6 have fluctuated around 1:1, (time-series average of 48% in Subarea 4, Table 4.7). The proportion of biomass in Subarea 4 had been steadily increasing since 2013; however, 2017 saw a slight decrease followed by a marked decline in 2018 to a time-series low of 37% (Figure 4.10). 2021 has seen an increase in the proportion of biomass in Subarea 4 moving back towards a 1:1 split.

Additional survey indices were developed during the WKAngler 2018 benchmark after revisiting the anglerfish abundance of several surveys within the stock area (ICES, 2018). Mean weight per hour for both the SCW-IBTS Q1 and Q4 surveys declined in 2018 following time-series highs in 2017 and 2016 respectively (Figure 4.13) which reflects the SIAMISS-Q2 biomass trend (Figure 4.6).. Although the SIAMISS-Q2 biomass time-series for Division 6.b shows less year to year fluctuation than the Rockall index the increasing trend and magnitude of change for the 2005–2020 period are very similar. In Subarea 4 the NS-IBTS-Q1 and Q3 indices show declining mean weights per hour for the recent five years across all length groupings (Figure 4.14). This contradicts the SIAMISS-Q2 biomass series which continued to increase until 2017 before a marked decline in 2018.

2.3 Historical stock development

There has been no analytic assessment of Northern Shelf anglerfish since 2003, due to a combination of unreliable commercial data, landings misreporting, uncertain effort data and poor catchability of anglerfish in traditional research surveys. The Scottish Irish anglerfish and megrim industry science survey (SIAMISS-Q2) initiated by Marine Scotland Science in 2005, along with official logbook data and tally-book data schemes have addressed some of these issues, providing valuable information to fishery managers as well as minimum absolute abundance and biomass estimates annually. Since 2012 assessment has followed the ICES RGLIFE data-limited stock (DLS) 3.2.0 method of survey based indicative trends (ICES, 2012).

At the benchmark in 2018, it was agreed to use SIAMISS-Q2 survey as an indicator of historical stock development. During the first half of the time-series, the biomass index for the stock fluctuated around 40 kt. Between 2011 and 2017, the total biomass increased significantly (more than doubled) due to very strong recruitment which is first observed in the survey length frequency data in 2013 and can continue to be clearly tracked through these data until 2017. Between 2017 and 2021, the estimated total stock biomass decreased by greater than 40%.

Figure 4.11 and Table 4.9 shows mean standardised harvest rate (calculated as catch/survey index) by both weight and number of individuals. Whilst there are no reference levels to relate these harvest rates to, trends can still be useful. In terms of biomass, the harvest rate has shown an increasing trend since 2015 and in 2019 and 2020 are estimated to be some of the highest values of the time-series. The harvest rate in number has shown a more gradual increase over this time.

The marked fall in harvest rate by number from 2013–2014 is likely due to the influx of the substantial 2013 year class (i.e. large increase in survey numbers) and not a change in fishing behaviour. It may be more appropriate to use a harvest rate which is measured over a given length range of commercially exploitable fish.

2.4 Application of the advice rule

Due to the lack of SIAMISS survey data in 2020, the procedure for the provision of advice as documented in the Stock Annex cannot be followed exactly. Instead, the framework for category 3 stocks is applied with the 2020 index value treated as missing. The index is estimated to have decreased by more than 20% and thus the uncertainty cap was applied. The precautionary buffer was last applied in 2019 and its application has, therefore, not been considered again. The advised catch for 2022 is lower than the 2021 advice because of the decrease in the index ratio.

Index A (2020–2021; 2020 not available)	**49 355 t**	
Index B (2017 - 2019)		74 710 t
Index ratio (A/B)		0.65
Uncertainty cap	Applied	0.8
Advised catch for 2020		17 645 t
Precautionary buffer	Not applied	
Catch advice **		14 116 t
% Advice change ^		-20%

*** The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.**

**** [Advised catch for 2021] × [uncertainty cap].**

^ Advice value for 2022 relative to the advice value for 2021.

2.5 Biological reference points

Precautionary approach reference points.

	Type	Value	Technical basis
Precautionary approach	B_{lim}	Not defined	There is currently no biological basis for defining B_{lim}
	B_{pa}	Not defined	
	F_{lim}	Not defined	There is currently no biological basis for defining F_{lim}
	F_{pa}	0.30	$F_{35\%SPR}$ = 0.30. This fishing mortality corresponds to 35% of the unfished SSB/R. It is considered to be an approximation of F_{MSY}.
Targets	F_y	Not defined	

(unchanged since 1998).

One suggested method for future assessment is a *Nephrops*-like harvest-ratio approach which creates a catch-options table based on a range of harvest ratios. However to date no MSY reference points have been determined for Northern shelf anglerfish despite further exploration (Holah, H., 2017). Limited data, dome-shaped selectivity and uncertain life-history parameters continue to be inhibiting factors. Previous attempts to determine suitable harvesting rates, based on a yield-per-recruit analysis, estimated F_{MAX} to be 0.19 (ICES, 2004). The southern Celtic Sea/Bay of Biscay stock has recently been benchmarked and an F_{MSY} of 0.28 was adopted (ICES, 2018a). In the case of *Nephrops* the technical basis for MSY $B_{trigger}$ is the bias-adjusted lowest observed UWTV survey estimate of abundance, however for anglerfish, whilst abundances from SIAMISS-Q2 were initially intended to be an absolute measure of abundance they are now considered to be only a relative index so this may not be appropriate.

2.6 Management plans

ICES is aware of the multiannual management plan (MAP) which has been adopted by the EU for this stock (EU, 2019) and which ICES considers to be precautionary. There is no agreed shared management plan with the UK for this stock, and ICES provides advice according to ICES precautionary approach.

2.7 Uncertainties and bias in assessment and forecast

The WGCSE has previously attempted assessments of the anglerfish stock(s) within its remit using a number of different approaches. As yet none have proved entirely satisfactory. The catch-at-length analysis used in previous years appears to have addressed a number of the suspected problems with the data due to the rapid development of the fishery, and has also provided a satisfactory fit to the catch-at-length distribution data. However, since 2003, the WG has been unable to present an analytic assessment due to the lack of reliable fishery and insufficient survey information, and in addition it is not known to what extent the dynamic pool assumptions of the traditional assessment model are valid for anglerfish. A catch-at-age model was presented to two benchmark working groups (WKFLAT 2012 and WKROUND 2013) but was not accepted due to concerns over age reading. The SPiCT and ASPIC surplus production models were explored at the WKAngler benchmark (2018) and whilst the models converged, the models were unstable and the uncertainty was large. This is most likely due to the lack of contrast in the catch data.

Commercial data

For a number of years the WG has expressed concerns over the quality of the commercial catch-at-length data because of:

- Accuracy of landings statistics due to species and area misreporting (historically an issue between 1998–2005 and anecdotally again in 2016).
- Lack of information on total catch and catch composition of gillnetters operating on the continental slope to the northwest of the British Isles (See the stock annex for further details of this fishery).

Survey data

There are still several factors which make the survey estimates likely to be underestimates or minimum estimates. Firstly, although experiments have been carried out to estimate escapes from under the footrope, and a model applied to account for this component of catchability, the estimates of smaller anglerfish still look to be underestimated (Figure 4.7). This could be due to either a net selectivity issue, or an availability [to the trawl] issue, as it is known that younger fish occur in shallower water (Hislop *et al*., 2001), or both. Secondly, the area considered is not complete, as the survey does not cover some of Division 4.a and none of 4.b or 4.c. However, numbers are thought to be low in these areas. A comparison of mean length in the commercial catch (Figure 4.12) and in the SIAMISS-Q2 and NS-IBTS surveys suggests that the selectivity of the commercial fleet and the angler SIAMISS-Q2 survey gear are similar (before the survey estimation procedure of corrections is applied).

Biological information

Knowledge of the biology of anglerfish has improved, with some basic biological parameters suitable for use in future assessments, such as mean weight-at-length in the stock, now available from the industry–science survey data. Difficulties still remain in finding mature females. A further discussion of the biology can be found in the stock annex.

Life-history parameters of the anglerfish species *Lophius piscatorius* and *Lophius Budegassa* in the Northeast Atlantic were reviewed at the WKAngler benchmark (2018) with appropriate ranges of natural mortality (M) discussed and new approaches to estimating age from mixture modelling of length distributions presented (see WKAngler 2018 report for further details).

Stock structure

Currently, anglerfish on the Northern Shelf are split into Subarea 6 (including 5.b (EC), 7 and 14) and the North Sea (and 2.a (EC)) for management purposes. However, genetic studies have found no evidence of separate stocks over these two regions (including Rockall) and particle-tracking studies have indicated interchange of larvae between the two areas (Hislop *et al*., 2001). So, at previous WGs, assessments have been made for the whole Northern Shelf area combined. In fact, both microsatellite DNA analysis (O'Sullivan *et al*., 2005) and particle tracking studies carried out as part of EC 98/096 (Anon, 2001) also suggested that anglerfish from further south (Subarea 7) could also be part of the same stock.

At present, the stock is assessed for the two anglerfish species *L. piscatorius* and *L. budegassa* combined despite differing life-history characteristics and overlap in spatial distribution. This has been the case due to the black anglerfish (*L. Budegassa*) proportionally representing only around 10% of the estimated stock biomass from the SIAMISS-Q2 survey and that the Scottish fleet land the two species for sale combined as "monkfish". Given that the proportion of black anglerfish has been as high as 28% in Division 6.a and that the Scottish market sampling programme records to species level, a splitting out of black anglerfish in this stock may be a consideration for a future benchmark.

2.8 Recommendations for next Benchmark

This stock was last benchmarked in February 2018 at WKAngler. The recommendations to be carried forward following WKAngler are the following tasks:

- Investigate length-based stock assessment using, for example, the SS3 approach applied to southern anglerfish stocks.
- Investigate growth models appropriate for anglerfish subareas 4 and 6.
- Investigate an age-aggregated production/depletion model.
- Determine the best way to incorporate *Lophius budegassa* into assessment and advice.

The WKAngler data call led to the compilation of commercial sampling data (length, age, weight) previously held internationally, to construct a historical catch-at-length dataset for 2002 to present. At this stage, the focus is currently to utilise this more complete dataset to develop a suitable assessment model for this stock.

2.9 Management considerations

Up to and including 2011, ICES provided qualitative advice regarding the future exploitation of 'data-limited' stocks where there was either limited knowledge of their biology or a lack of data on their exploitation. However, in response to a strong interest from advice recipients to base advice on the information available, ICES developed the data-limited stocks (DLS) approach framework, for which anglerfish is a category 3 data-limited stock. This requires considering the application of an uncertainty cap and/or precautionary buffer to a survey adjusted *status quo* catch at each annual advice draft.

The two TACs in this area do not match the stock unit. One TAC area covers Subarea 4 and Division 2.a (EC); the second covers Division 5.b (EC) and subareas 6, 12, and 14. There is no TAC for Division 3.a and landings from this area have increased significantly in recent years. As a result of this mismatch, there is a potential for catches to exceed advice. There is no TAC for the Norwegian fishery in Subarea 4.

The TACs in subareas 4 (including Norwegian waters) and 6 until 2010 were split 67:33%, since 2011 they have been split 64:36%. In 2018, 10% of the TAC for 4 and 2.a could be taken from Division 5.b, or subareas 6, 7 and 9. Over the survey time-series, the stock has been fairly evenly distributed between 4:6, the split has fluctuated around 50:50 (47% on average) (Table 4.7 and Figure 4.10) however in 2018 there was a significant decrease to 38% increasing to 40% in 2019 and 47% in 2021. Note that the North Sea is only partially surveyed: however, the area covered does encompass most of the distribution of anglerfish.

Ideally, the management of the fishery should be based on a specific plan, or harvest control rule, after an evaluation of various stakeholder-led suggestions of alternative options. This still needs to be pursued in consultation with stakeholders such as the North Western Waters Advisory Council.

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Table 4.1. ICES advice and actual management applicable for Northern Shelf anglerfish for 2003 onwards.

YEAR	Catch corresponding to advice	BASIS	WEST OF SCOTLAND (Sub-area 6)		NORTH SEA (Subarea 4)	
			TAC[4)]	WGCSE landings	TAC[5)]	WGCSE landings
2003	<6700[1)^]	Reduce F below F_{pa}	3180	3068	7000	8714
2004	<8800[2)^]	Reduce F below F_{pa} [2)]	3180	3130	7000	8532
2005	-	No effort increase[2)]	4686	3747	10 314	9696
2006	-	No effort increase[2)]	4686	3491	10 314	9564
2007	-	No effort increase[2)]	5155	4476	11 345	9823
2008	-	No effort increase[3)]	5155	4847	11 345	10 732
2009	-	No effort increase[3)]	5567	5192	11 345	9781
2010	-	No effort increase[3)]	5567	3912	11 345	7900
2011	-	Decrease effort	5456	4693	9643	7920
2012	-	Reduce catches	5183	4372	9161	6412
2013	-	Decrease catches by 20%[2)]	4924	4727	8703	6306
2014	10 231	Decrease catches by 20%[2)]	4432	5880	7833	8165
2015	14 702	Increase landings by 20%[2)]	5313	5008[(7)]	9390	10 243
2016	≤ 18 435	Increase recent advised catch by no more than 20%[2)]	6375	5966	11267	12 854
2017	≤ 22 007	Precautionary approach	7650	6460	13521	14 508
2018	≤ 26 408	Precautionary approach	9180	6356	16225	14 280
2019	≤ 31 690	Precautionary approach	11453	7912	20237	12674
2020	≤ 22 056	Precautionary approach	7971	6 601	14085	11 582
2021	≤ 17 645	Precautionary approach	6 377		11 972	

All values raised to nearest tonne.

^ Landings advice

1) Advice for Division 3.a, Subarea 4 and Subarea 6.a combined.

2) Advice for Division 3.a, Subarea 4 and Subarea 6 combined.

3) Advice for Division 2.a, Division 3.a, Subarea 4 and Subarea 6 combined.

4) TAC applies to 5.b(EC), 6, 7 and 14.

5) TAC applies to 2.a & 4 (EC).

(7)Landings including raised discards.

Although there is no minimum landing size for this species, there is an EU minimum weight of 500 g for marketing purposes (EC Regulation 2406/96).

An additional quota of 1500 t was also available for EU vessels fishing in the Norwegian zone of Subarea 4 in 2011–2018 which was increased to 1700 t in 2018.

Table 4.2. Anglerfish on the Northern Shelf (3.a, 4 & 6). Total official landings by area (tonnes).

	3.a	4.a	4.b	4.c	6.a	6.b	4	6	Total (3.A, 4,6)	WG Landings	WG Discards
1973	140	2085	575	41	9221	127	2701	9348	12189	-	-
1974	202	2737	1171	39	3217	435	3947	3652	7801	-	-
1975	291	2887	1864	59	3122	76	4810	3198	8299	-	-
1976	641	3624	1252	49	3383	72	4925	3455	9021	-	-
1977	643	3264	1278	54	3457	78	4596	3535	8774	-	-
1978	509	3111	1260	72	3117	103	4443	3220	8172	-	-
1979	687	2972	1578	112	2745	29	4662	2774	8123	-	-
1980	652	3450	1374	175	2634	200	4999	2834	8485	-	-
1981	549	2472	752	132	1387	331	3356	1718	5623	-	-
1982	529	2214	654	99	3154	454	2967	3608	7104	-	-
1983	506	2465	1540	181	3417	433	4186	3850	8542	-	-
1984	568	3874	1803	188	3935	707	5865	4642	11075	-	-
1985	578	4569	1798	77	4043	1013	6444	5056	12078	-	-
1986	524	5594	1762	47	3090	1326	7403	4416	12343	-	-
1987	589	7705	1768	66	3955	1294	9539	5249	15377	-	-
1988	347	7737	2061	95	6003	1730	9893	7733	17973	-	-
1989	334	7868	2121	86	5729	313	10075	6042	16451	-	-
1990	570	8387	2177	34	5615	822	10598	6437	17605	-	-
1991	595	9235	2522	26	5061	923	11790	5984	18369	17441	-
1992	938	10209	3053	39	5479	1089	13301	6568	20807	21872	-
1993	843	12309	3143	66	5553	681	15519	6234	22596	23971	-
1994	811	14505	3445	210	5273	909	18162	6182	25155	25057	-
1995	823	17891	2627	402	6354	958	20920	7312	29055	28913	-
1996	702	25176	1847	304	6408	602	27327	7010	35039	35100	-

	3.a	4.a	4.b	4.c	6.a	6.b	4	6	Total (3.A, 4,6)	WG Landings	WG Discards
1997	776	23425	2172	160	5330	990	25757	6320	32853	32728	-
1998	626	16859	2088	78	4506	1313	19026	5819	25471	25293	-
1999	660	13344	1517	24	4284	1401	14885	5685	21230	21854	-
2000	602	12338	1617	31	3311	1074	13986	4385	18973	19682	-
2001	621	12861	1832	21	2660	1309	14714	3969	19304	19157	-
2002	667	11048	1244	21	2280	718	12313	2998	15978	15067	-
2003	478	8523	847	20	2493	643	9390	3136	13004	12008	-
2004	519	8987	851	15	2453	671	9853	3124	13496	11976	-
2005	458	8424	688	5	3019	958	9117	3982	13557	13728	-
2006	426	10340	683	3	2785	915	11026	3700	15152	13292	-
2007	433	10632	749	4	3353	1261	11384	4613	16430	14564	490
2008	486	11038	769	5	3373	1246	11813	4619	16918	15878	903
2009	478	10067	651	8	2984	1820	10726	4804	16008	15372	38
2010	433	8190	615	11	3040	1606	8815	4645	13895	12136	69
2011	405	7760	764	8	2871	1871	8532	4742	13679	12902	95
2012	423	6459	714	4	2835	1831	7177	4666	12266	11143	590
2013	407	6393	546	5	2667	2123	6944	4790	12141	11375	687
2014	440	7633	820	27	2610	1754	8481	4365	13286	14406	448
2015	478	9690	985	16	3290	1723	10691	5013	16182	15663	395
2016	586	11680	1196	11	4638	1423	12887	6060	19533	19412	981
2017	742	13620	1107	7	5024	1504	14733	6528	22023	21719	756
2018	914	13438	823	11	4369	1932	14274	6303	21487	21572	326
2019*	1028	11170	1299	28	5022	2632	12498	7654	21180	21551	513
2020*	886	10674	1066	24	4749	1685	11763	6434	19064	19 072	316

***Preliminary.**

Table 4.3. Anglerfish in Subarea 6. Nominal landings (t) as officially reported to ICES.

Division 6.a (West of Scotland)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*
Belgium	3	2	9	6	5	-	5	2	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Denmark	1	3	4	5	10	4	1	2	1	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Faroe Is.	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3	2	1	2	4	1	-	-	-	+	1	-	-	-	-
France	1910	2308	2467	2382	2648	2899	2058	1634	1814	1132	943	739	1212	1191	1396	1314	1764	1746	1513	1206	1168	1166	1114	1098	1107	1734	1882	1287	1256	1281
Germany	1	2	60	67	77	35	72	137	50	39	11	3	27	39	39	1	-	54	79	79	59	63	48	85	63	81	79	127	94	8
Ireland	250	403	428	303	720	717	625	749	617	515	475	304	322	219	356	392	470	295	328	510	488	346	336	410	446	581	579	596	897	698
NL	-	-	-	-	-	-	27	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Norway	6	14	8	6	4	4	1	3	1	3	2	1	+	+	1	1	1	2	+	2	1	+	1	1	1	1	1	2	2	1
Spain	7	11	8	1	37	33	63	86	53	82	70	101	196	110	83	76	3	174	185	197	138	69	123	54	30	178	173	218	298	232
UK(E,W&NI)	270	351	223	370	320	201	156	119	60	44	40	32	31	30	20	24	42	5	12	3	-	12	6	-	-	-	-	-	-	-
UK(Scot.)	2613	2385	2346	2133	2533	2515	2322	1773	1688	1496	1119	1100	705	862	1127	974	1071	1096	864	1040	-	1179	1038	-	-	-	-	-	-	-
UK (total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1016			962	1643	2062	2311	2139	2475	2529
Total	5061	5479	5553	5273	6354	6408	5330	4506	4284	3311	2660	2280	2493	2453	3024	2785	3353	3373	2984	3040	2871	2835	2667	2610	3290	4638	5024	4369	5022	4749

Unallocated	296	2638	3816	2766	5112	11148	7506	5234	3799	3114	2068	187	2	16	-8	-74	145	332	190	56	62	91	115	1595	68	-58	12	42	298	-6
As used by WG	5357	8117	9369	8039	11466	17556	12836	9740	8083	6425	4728	2467	2495	2469	3016	2711	3498	3705	3174	3096	2933	2926	2782	4205	3358	4580	5036	4411	5320	4743

*Preliminary.

Table 4.3. Continued. Anglerfish in Subarea 6. Nominal landings (t) as officially reported to ICES.

Division 6.b (Rockall)/ *Preliminary.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*
Faroe Is.	-	2	-	-	-	15	4	2	2	-	1	-	-	-	-	-	-	1	4	8	-	5	-	1	+	+	+	-	-	-
France	-	-	29	-	-	-	1	1	-	48	192	43	191	175	293	224	327	327	339	168	508	456	663	148	219	-	-	-	17	23
Germany	-	-	103	73	83	78	177	132	144	119	67	35	64	66	77	72	222	93	132	87	90	79	88	66	139	177	167	266	340	221
Ireland	272	417	96	135	133	90	139	130	75	81	134	51	26	13	35	53	70	76	91	107	108	235	237	162	156	160	214	282	365	202
Norway	18	10	17	24	14	11	4	6	5	11	5	3	6	5	4	6	7	5	9	12	7	5	9	3	6	11	4	1	1	2
Portugal	-	-	-	132	128	-	91	413	429	20	18	8	4	19	63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Russia	-	-	-	-	-	-	-	-	-	-	1	-	-	2	4	1	1	35	-	-	-	-	-	1	2	-	2	-	1	3
Spain	333	263	178	214	296	196	171	252	291	149	327	128	59	43	34	36	12	85	57	32	29	36	-	27	119	56	118	43	60	32
UK(E,W&NI)	99	173	76	50	105	144	247	188	111	272	197	133	133	54	93	46	-	1	48	15	-	120	395	-	-	-	-	-	-	-
UK(Scot)	201	224	182	281	199	68	156	189	344	374	367	317	160	294	355	477	-	624	1141	1177	-	895	732	-	-	-	-	-	-	-
UK (total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	622	-	-	-	1129			1347	1081	1018	999	1340	1848	1202

Total	923	1089	681	909	958	602	990	1313	1401	1074	1309	718	643	671	958	915	1261	1246	1820	1606	1871	1831	2123	1754	1723	1423	1504	1932	2632	1685
Unallocated	-	-	-	-132	-128	0	-91	-413	-9	17	-178	-210	-70	-10	-227	-136	-282	-104	198	-791	-111	-385	-178	-80	-74	-37	-80	12	-140	115
As used by WG	923	1089	681	777	830	602	899	900	1392	1091	1131	508	573	661	731	779	979	1142	2018	815	1760	1446	1945	1674	1649	1386	1424	1944	2492	1800

Table 4.3. Continued. Anglerfish in Subarea 6. Nominal landings (t) as officially reported to ICES.

Subarea 6 (West of Scotland and Rockall)

^ indicates landings assigned to subarea 6 but not to a division. /*Preliminary.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*
Belgium	3	2	9	6	5	-	5	2	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-
Denmark	1	3	4	5	10	4	1	2	1	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Faroe Is.	-	2	-	-	-	15	4	2	2	-	1	-	-	2	2	3	2	2	6	12	1	5	-	1	+	1	+	-	-	-
France	1910	2308	2496	2382	2648	2899	2059	1635	1814	1180	1135	782	1403	1366	1689^	1537	2090	2073	1852	1374	1676	1622	1777	1246	1326	1734	1882	1287	1274	1304
Germany	1	2	163	140	160	113	249	269	194	158	78	38	91	105	116	73	222	146	211	166	149	142	136	151	201	258	246	394	435	229
Ireland	522	820	524	438	853	807	764	879	692	596	609	355	348	232	391	445	540	371	419	617	596	581	572	572	602	741	793	878	1262	899
Nether-	-	-	-	-	-	-	27	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Norway	24	24	25	30	18	15	5	9	6	14	7	4	6	5	5	7	8	7	9	14	7	6	10	4	8	12	5	4	2	1
Portugal	-	-	-	132	128	-	91	413	429	20	18	8	4	19	63	-	-	-	-	-	-	-	-	-	-	-		-	-	-
Russia	-	-	-	-	-	-	-	-	-	-	1	-	-	2	4	1	1	35	-	-	-	-	-	1	2	-	2	-	1	3
Spain	340	274	186	215	333	229	234	338	344	231	397	229	255	153	117^	112	15	259	242	229	167	105	123	81	149	234	290	261	358	264
UK(E,W&NI)	369	524	299	420	425	345	403	307	171	316	237	165	164	84	113	70	188	6	60	-	-	132	401	-	-	-	-	-	-	-
UK(Scot)	2814	2609	2528	2414	2732	2583	2478	1962	2032	1870	1486	1417	865	1156	1482	1451	1546	1720	2005	-	-	2073	1770	-	-	-	-	-	-	-
UK (total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2234	2145	2205	2171	2310	2724	3080	3310	3479	4322	3731

Total	5984	6568	6234	6182	7312	7010	6320	5819	5685	4385	3969	2998	3136	3124	3982	3700	4613	4619	4804	4645	4742	4666	4790	4365	5013	6060	6528	6303	7654	6434
Unallocated	296	2638	3816	2634	4984	11148	7415	4821	3790	3131	1890	-22	-68	6	-235	-209	-137	228	388	-733	-49	-294	-63	1515	-5	-94	-68	53	158	109
As used by WG	6280	9206	10050	8816	12296	18158	13735	10640	9475	7516	5859	2976	3068	3130	3747	3491	4476	4847	5192	3912	4693	4372	4727	5880	5008	5966	6460	6356	7812	6543

Table 4.4. Nominal landings (t) of Anglerfish in the North Sea, as officially reported to ICES.

Northern North Sea (4.a)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020
BE	2	9	3	3	2	8	4	1	5	12	-	8	1	-	-	-	-	-	-	-	-	-	+	-	-	-	1	-	-	-
DK	1245	1265	946	1157	732	1239	1155	1024	1128	1087	1289	1308	1523	1538	1379	1311	961	1071	1134	1143	841	821	854	801	962	1506	2002	1790	1668	1058
Faroes	1	-	10	18	20	-	15	10	6	-	2	-	3	11	22	2	-	-	4	-	-	-	-	-	-	-	-	-	1	-
FR	124	151	69	28	18	7	7	3	18	8	9	8	8	8	4	7	13	13	20	23	20	14	15	27	26	35	91	141	185	124
GB	71	68	100	84	613	292	601	873	454	182	95	95	65	20	84	173	186	344	216	124	46	265	274	321	286	208	523	462	547	
NL	23	44	78	38	13	25	12	-	15	12	3	8	9	38	13	14	14	12	5	8	5	5	-	16	-	21	28	68	68	40
NO	587	635	1224	1318	657	821	672	954	1219	1182	1212	928	769	999	880	1006	831	860	859	791	494	485	545	524	406	610	840	1230	1269	954
ES	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-		-	-
SE	14	7	7	7	2	1	2	8	8	78	44	56	8	6	5	5	20	67	-	-	-	-	-	-	6	4	8	12	17	59
UK (E, W&NI)	129	143	160	169	176	439	2174	668	781	218	183	98	104	83	34	99	303	13	320	371	-	248	550	-	-	-	-	-	-	-
UK (Scot.)	7039	7887	9712	11683	15658	22344	18783	13318	9710	9559	10024	8539	6033	6284	6003	7722	8304	8658	7509	5730	-	4622	4154	-	-	-	-	-	-	-
UK (total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6353	4870	4704	5943	8005	9296	10127	9735	7415	8092

Total	9235	10209	12309	14505	17891	25176	23425	16859	13344	12338	12861	11048	8523	8987	8424	10340	10632	11038	10067	8190	7760	6459	6393	7633	9690	11680	13620	13438	11170	11739

*Preliminary.

Table 4.4. Continued. Nominal landings (t) of Anglerfish in the North Sea, as officially reported to ICES.

Central North Sea (4.b)

* Preliminary

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*
Belgium	357	538	558	713	579	287	336	371	270	449	579	435	180	260	207	138	179	181	134	124	111	131	135	213	196	251	168	155	248	239
Denmark	345	421	346	350	295	225	334	432	368	260	251	255	191	274	237	276	173	237	248	194	286	301	192	334	369	584	565	411	534	339
Faroes	-	-	2	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
France	-	1	-	2	-	-	-	-	-	-	-	-	-	+	-	+	+	-	3	6	2	+-	+-	1	+	+	-	+	-	2
Germany	4	2	13	15	10	9	18	19	9	14	9	17	11	11	9	14	12	22	17	21	17	10	10	17	23	18	14	26	27	16
Ireland	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Netherlands	285	356	467	510	335	159	237	223	141	141	123	62	42	25	31	33	61	58	36	46	53	61	41	72	88	120	166	111	309	226
Norway	17	4	3	11	15	29	6	13	17	9	15	10	12	22	16	12	24	15	21	10	11	11	26	8	9	16	41	36	22	42
Spain	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Sweden	-	-	-	3	2	1	3	3	4	3	2	9	2	1	4	4	6	9	-	-	-	-	-	-	3	7	10	12	19	14
UK(E, W&NI)	669	998	1285	1277	919	662	664	603	364	423	475	236	167	120	96	108	-	105	85	88	-	85	70	-	-	-	-	-	-	-
UK (Scotland)	845	733	469	564	472	475	574	424	344	318	378	210	241	138	88	98	-	142	108	125	-	115	72	-	-	-	-	-	-	-
UK (total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	293	-	-	-	284	200	142	175	297	201	143	72	139	189

Total	2522	3053	3143	3445	2627	1847	2172	2088	1517	1617	1832	1244	847	851	688	683	749	769	651	615	764	714	546	820	985	1196	1107	823	1299	1066

Table 4.4. Continued. Nominal landings (t) of Anglerfish in the North Sea as officially reported to ICES.

Southern North Sea (4.c)

*** Preliminary.**

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*
Belgium	13	12	34	37	26	28	17	17	11	15	15	16	9	5	4	3	3	4	6	7	6	2	2	4	5	2	1	1	1	2
Denmark	2	+	-	+	+	+	+	+	+	+	+	+	+	+		+	+	-	-	+	+	+	-	-	-	+	-	+	-	-
France	-	-	-	-	-	-	-	10	-	+	-	+	-	-	-	+	+	-	1	1	1	+	+	1	+	1	+	+	-	-
Germany	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-	+	-	+	+	+	+	+	+	-	+
Netherlands	5	10	14	20	15	17	11	15	10	15	6	5	1	-	1	-	1	1	-	2	1	1	1	19	10	8	5	8	26	19
Norway	-	-	-	-	+	-	-	-	+	-		-	+	-	-	+	-	-	1	-	-	-	-	1	+	-	-	1	-	-
UK(E&W&NI)	6	17	18	136	361	256	131	36	3	1	-	-	10	3	-	+	-	+	1	1	-	-	1	-	-	-	-	-	-	-
UK (Scot-land)	+	+	+	17	+	3	1	+	+	+	-	-	-	7	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (Total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-+	-+	+	1	1	1	+	1	2	1	1	+	1	1	1
Total	26	39	66	210	402	304	160	78	24	31	21	21	20	15	5	3	4	5	8	11	8	4	5	27	16	11	7	11	28	22

Table 4.4. Continued. Nominal landings (t) of Anglerfish in the North Sea as officially reported to ICES.

Subarea 4 (North Sea)

***Preliminary./ ^ indicates landings assigned to Subarea 4 but not to a division.**

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*
Belgium	372	559	595	753	607	323	357	389	286	476	594	459	190	265	211	141	181	185	140	131	116	133	137	217	200	253	169	156	249	243
Denmark	1599	1686	1293	1509	1027	1464	1489	1456	1496	1347	1540	1563	171	181	161	1587	1134	1308	1382	133	112	112	104	113	1331	2090	2567	2201	2202	1398
Faroes	1	-	12	18	20	-	15	10	6	-	2	10	3	11	22	2	-	-	4	-	-	-	-	-	-	-	-	-	-	-
France	124	152	69	30	18	7	7	13	18	8	9	8	8	8	4	7	14	13	23	30	24	15	15	30	26	36	91	142	186	127
Germany	**75**	**70**	**113**	**99**	**623**	**301**	**619**	**892**	**463**	**196**	**104**	**112**	**76**	**31**	**93**	**187**	**198**	**367**	**233**	**145**	**63**	**275**	**284**	**339**	**309**	**226**	**537**	**488**	**575**	**361**
Ireland	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Netherlands	313	410	559	568	363	201	260	238	166	168	132	75	52	63	45	47	76	71	41	56	59	67	42	108	98	148	199	187	404	285
Norway	604	639	1227	1329	672	850	678	967	1236	1191	1227	938	781	102	896	1018	855	875	881	802	505	496	572	533	415	626	881	1267	1291	955
Sweden	14	7	7	10	4	2	5	11	12	81	46	65	10	7	9	10	26	76	-	-	-	-	-	-	10	11	18	25	35	72
UK(E&W&NI	804	1158	1463	1582	1456	1357	2969	1307	1148	642	658	334	281	206	130	207	425	118	406	460	-	333	621	-	-	-	-	-	-	-
UK (Scot-	7884	8620	1018	1226	1613	2282	1935	1374	1005	9877	1040	8749	627	642	609	7820	8476	8800	7617	585	-	473	422	-	-	-	-	-	-	-
UK (Total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	663	506	484	612	8303	9498	1027	9808	7555	8282
Total	11790	13301	15519	18162	20920	27327	25757	19026	14885	13986	14714	12313	9390	9853	9117	11026	11384	11813	10726	8815	8532	7177	6944	8481	10691	12887	14733	14274	12499	11763
Unallocated	-1224	-1573	-2441	-2732	-5126	-11087	-7540	-4999	-3166	-2422	-2037	-600	-676	-1330	579	-1462	-1561	-1081	-945	-915	-612	-765	-638	-316	-448	-33	-225	6	175	-182
WG estimate	10566	11728	13078	15430	15794	16240	18217	14027	11719	11564	12677	11713	8714	8523	9696	9564	9823	10732	9781	7900	7920	6412	6306	8165	10243	12854	14508	14280	12674	11581

Table 4.5. Nominal landings (t) of Anglerfish in Division 3.a, as officially reported to ICES.

***Preliminary.**

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*
Belgium	15	48	34	21	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Denmark	493	658	565	459	312	367	550	415	362	377	375	369	215	311	274	227	255	287	344	270	251	307	298	309	336	389	526	597	692	600
France	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	1	-	-	-
Germany	-	-	1	+	-	1	1	1	2	1	-	1	-	1	1	2	1	1	1	1	2	1	1	-	1	2	1-	2	1	1
Netherlands	-	-	-	-	-	-	-	-	-	-	-	-	3	4	4	3	1	3	-	5	-	-	-	4	9	17	16	16	46	66
Norway	64	170	154	263	440	309	186	177	260	197	200	242	189	130	100	139	132	144	134	158	153	115	108	127	90	124	118	204	189	129
Sweden	23	62	89	68	36	25	39	33	36	27	46	55	71	73	79	54	44	51	-	-	-	-	-	-	42	53	81	95	100	71
UK (Total)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Total	595	938	843	811	823	702	776	626	660	602	621	458	426	433	486	478	433	405	423	407	440	478	586	742	914	1028	866	458	426	433
Unallocated	-	-	-	-	-	-	-	-	-	-	-	-174	-189	-168	-187	-79	-109	-116	-63	-65	-78	-66	5	9	22	35	22	-174	-189	-168
As used by WG	-	-	-	-	-	-	-	-	-	-	-	284	237	265	299	399	324	289	360	342	362	412	591	751	936	1063	888	284	237	265

Table 4.6. Breakdown of WG estimates of commercial catches for 2019 and 2020 by main gear group and area.

2019	**3.a**		**4**		**6.a**		**6.b**		**Total**		**% of Total**	
Fleet	**Landings**	**Discards**	**Landings**	**Discards**	**Landings**	**Discards**	**Landings**	**Discards**	**Landings**	**Discards**	**Landings**	**Discards**
Demersal trawl	163	1	8781	145	5000	103	1246	16	15190	264	70	51
Nephrops trawl	654	10	241	59	42	68	0	0	937	138	4	26
Gillnets	181	2	2828	64	108	4	1199	15	4316	85	20	17
Other/Not specified	63	1	824	19	170	4	48	1	1105	26	5	5
Total	1061	47	12674	244	5320	179	2493	32	21548	513	100	100
2020												
Fleet	**Landings**	**Discards**	**Landings**	**Discards**	**Landings**	**Discards**	**Landings**	**Discards**	**Landings**	**Discards**	**Landings**	**Discards**
Demersal trawl	151	5	8296	86	4521	80	920	6	13888	178	73	56
Nephrops trawl	538	14	257	55	41	4	0	0	837	73	4	23
Gillnets	119	3	2434	40	32	1	817	5	3402	49	18	16
Other/Not specified	80	2	595	10	208	4	62	0	945	16	5	5
Total	888	22	11522	177	4763	88	1799	11	19072	316	100	100

Table 4.7. Total biomass estimates with confidence intervals and relative standard errors from the 2005–2021 SIAMISS-Q2 surveys.

Year	Number of hauls	Number measured	Biomass (t)	Confidence Interval		RSE	Percentage Biomass in subarea 4
2005			38.617	23.479	53.755	20.0	48.27%
2006			40.985	34.478	47.492	8.1	53.49%
2007	156	1569	50.392	43.676	57.108	6.8	56.62%
2008	167	2219	53.546	42.421	64.671	10.6	55.51%
2009	206	1643	38.060	32.987	43.133	6.8	44.82%
2010	168	1280	42.279	30.429	54.129	14.3	51.90%
2011	153	1037	33.254	24.846	41.662	12.9	44.96%
2012	169	1461	36.325	29.704	42.946	9.3	41.59%
2013	93	984	38.395	31.020	45.770	9.8	37.04%
2014	106	1568	52.884	42.769	62.999	5.2	40.25%
2015	117	2198	67.915	58.782	77.047	6.9	43.66%
2016	108	2025	77.946	66.831	89.060	7.275	56.39%
2017	153	3265	87.896	74.222	101.569	7.937	53.47%
2018	142	2714	77.661	66.258	89.064	7.491	37.80%
2019	128	1860	58.575	46.189	70.962	10.789	40.49%
2021	137	1524	48.355	37.233	59.476	11.734	46.71%

Table 4.8. Abundance and biomass estimates from the 2005–2021 SIAMISS-Q2 surveys by ICES subareas and divisions.

Year	Month	Numbers (millions)					Biomass (kt)				
		IVa	VIa	VIb	VI	Total	IVa	VIa	VIb	VI	Total
2005	November	11.168	10.866	1.800	12.666	23.834	18.642	14.096	5.879	19.975	38.617
2006	November	12.844	10.459	3.174	13.633	26.477	21.921	12.175	6.889	19.064	40.985
2007	November	15.304	7.956	4.000	11.956	27.26	28.534	11.072	10.786	21.858	50.392
2008	April	12.613	7.718	3.952	11.67	24.283	29.721	14.383	9.442	23.825	53.546
2009	April	8.279	5.144	3.688	8.832	17.111	17.058	8.150	12.852	21.002	38.060
2010	April	7.366	5.161	3.131	8.292	15.658	21.944	11.59	8.745	20.335	42.279
2011	April	5.150	6.057	3.669	9.726	14.876	14.949	9.330	8.974	18.304	33.253
2012	Abril	5.432	4.961	5.135	10.096	15.528	15.106	9.213	12.005	21.218	36.325
2013	October	8.470	8.461	4.885	13.346	21.816	14.369	10.801	13.626	24.427	38.796
2014	April	17.553	16.096	6.488	22.584	40.136	21.284	16.633	14.967	31.60	52.884
2015	April	18.266	28.604	5.496	34.100	52.366	29.653	24.047	14.215	38.262	67.915
2016	April	21.648	14.383	4.538	18.922	40.569	43.956	18.273	15.717	33.99	77.946
2017	April	23.691	16.332	4.360	20.683	44.374	46.995	29.297	11.604	40.901	87.896
2018	April	11.819	13.528	6.240	19.768	31.586	29.353	22.350	25.958	48.308	77.661
2019	April/May	14.606	21.032	3.592	24.624	39.231	23.719	18.864	15.992	34.856	58.575
2021	April	17.371	8.608	3.048	11.656	29.027	22.587	12.74	13.027	25.767	48.355

Table 4.9. Northern Shelf anglerfish mean standardised harvest rates of catch numbers and biomass 2008–2021.

Year	Mean standardised harvest rate – Number	Mean standardised harvest rate – Biomass
2007	1.019557	0.962803
2008	1.396944	1.010032
2009	1.117361	1.304825
2010	1.307811	0.930318
2011	1.08548	1.259594
2012	1.28022	1.041019
2013	1.058155	1.001878
2014	0.727179	0.938519
2015	0.62145	0.761601
2016	0.861419	0.842697
2017	0.760659	0.824041
2018	0.908121	0.908698
2019	0.855643	1.213976
2020	0.8597116	1.1520000

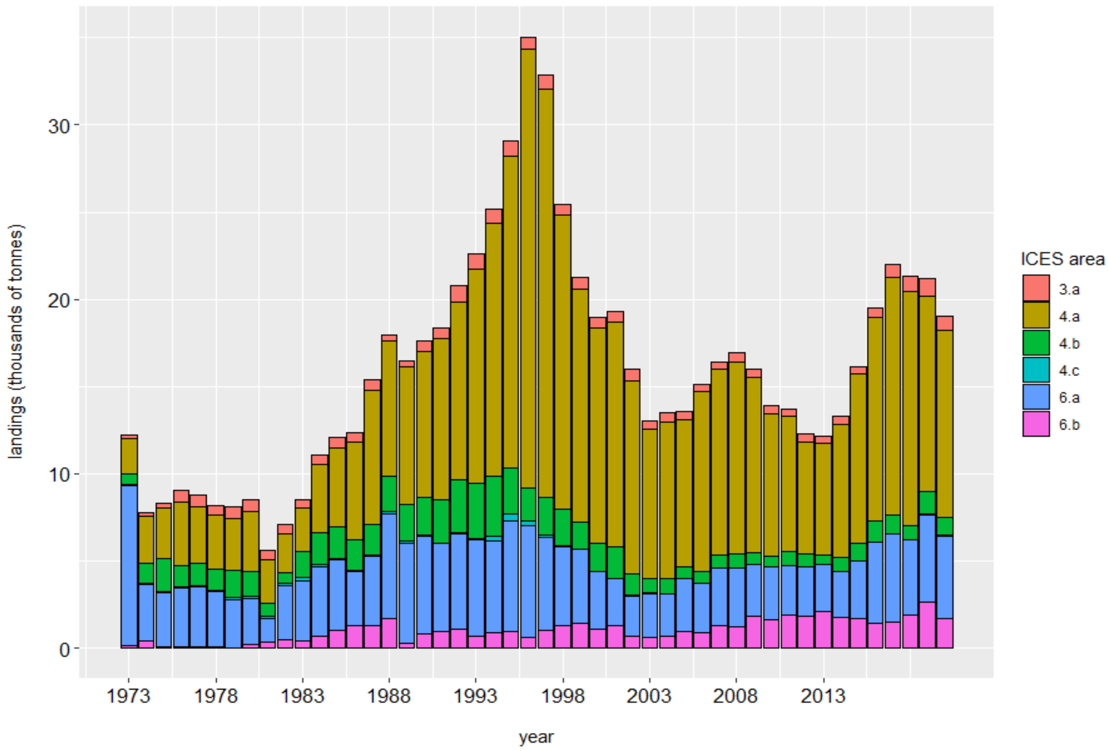

Figure 4.1. Northern Shelf anglerfish. Officially reported landings by ICES area (1973–2020).

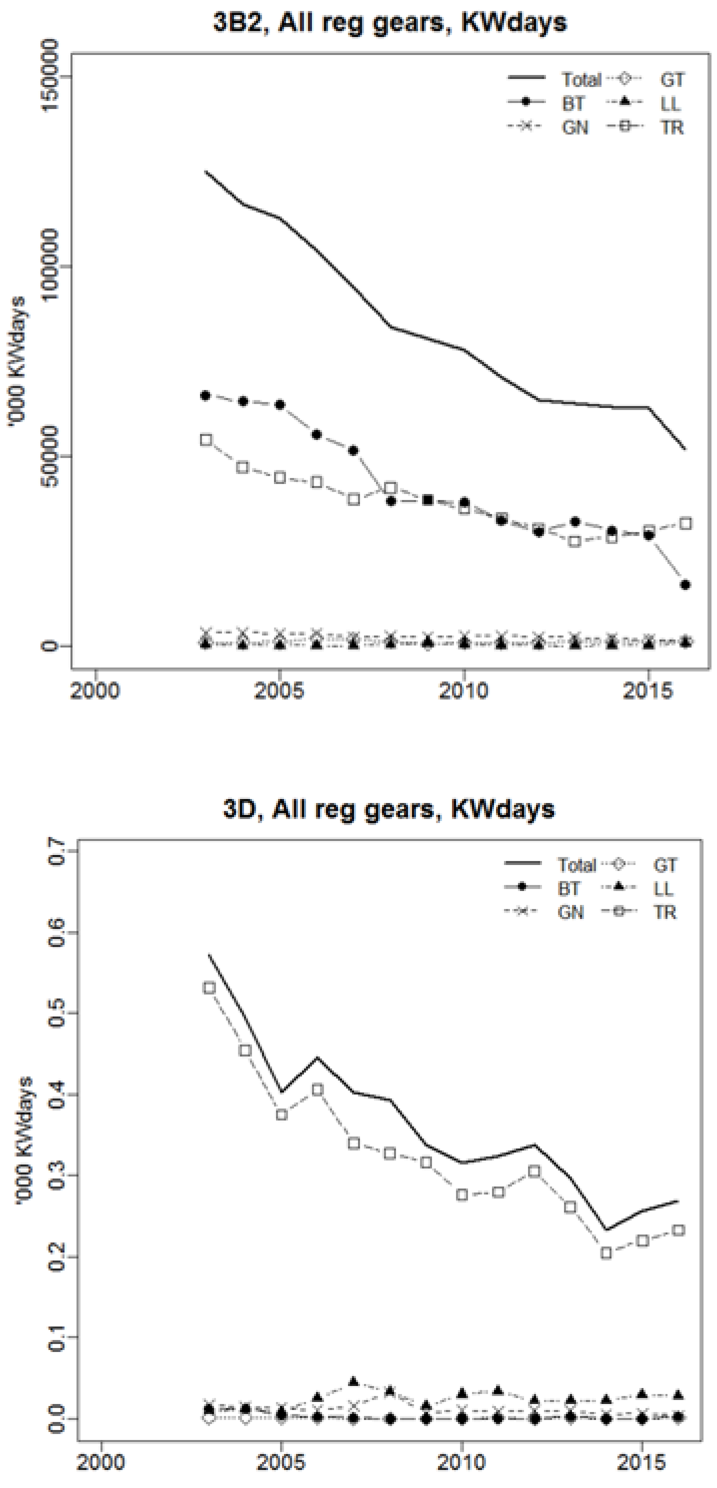

Figure 4.2. Trends in nominal international fishing effort (kW*days at sea) in North Sea and II (EU) (left) and West of Scotland (right) collated by STECF for the Evaluation of Fishing Effort Regimes in European Waters (STECF, 2017).

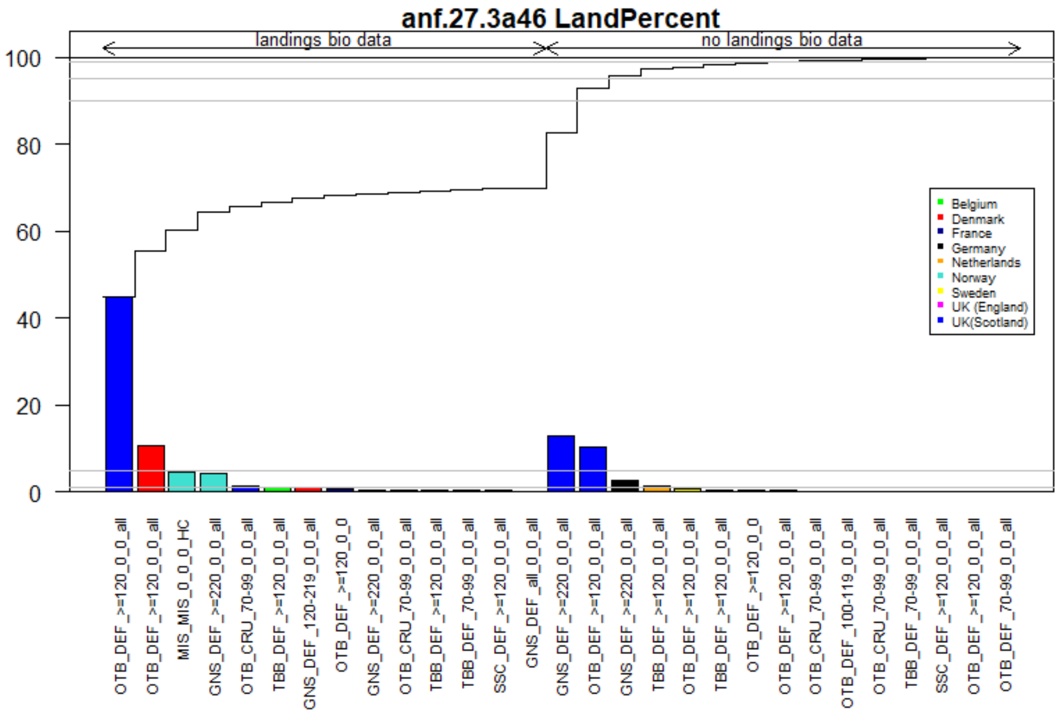

Figure 4.3a. Percentage of total landings weight by fleet and country in 2020; Subarea 4.

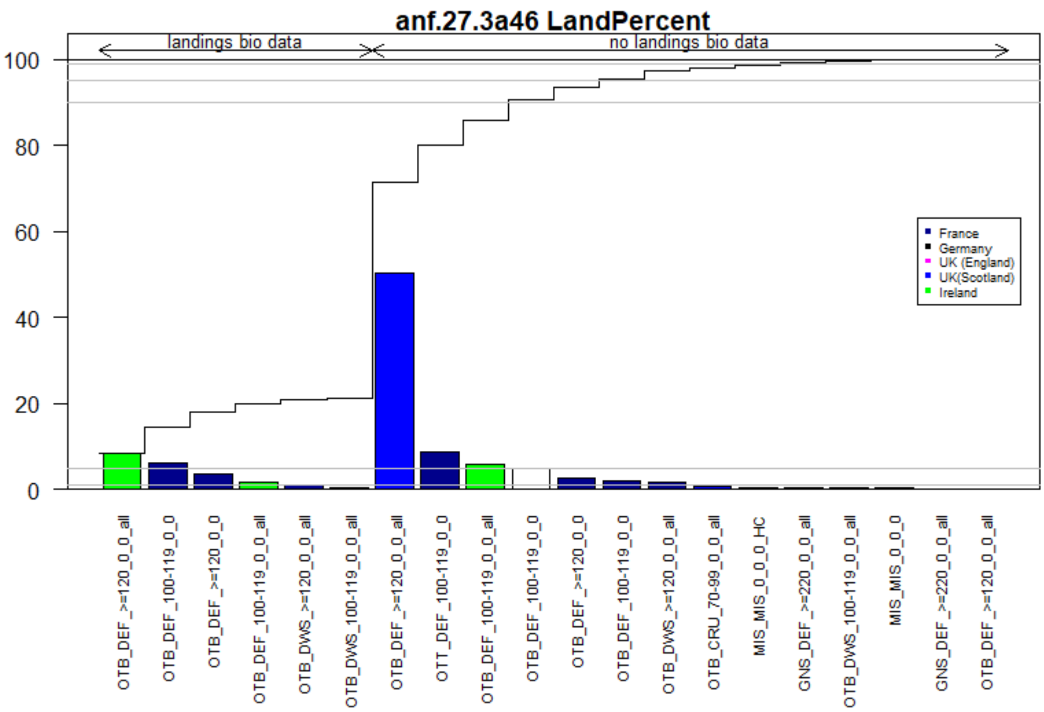

Figure 4.3b. Percentage of total landings weight by fleet and country in 2020; Division 6.a.

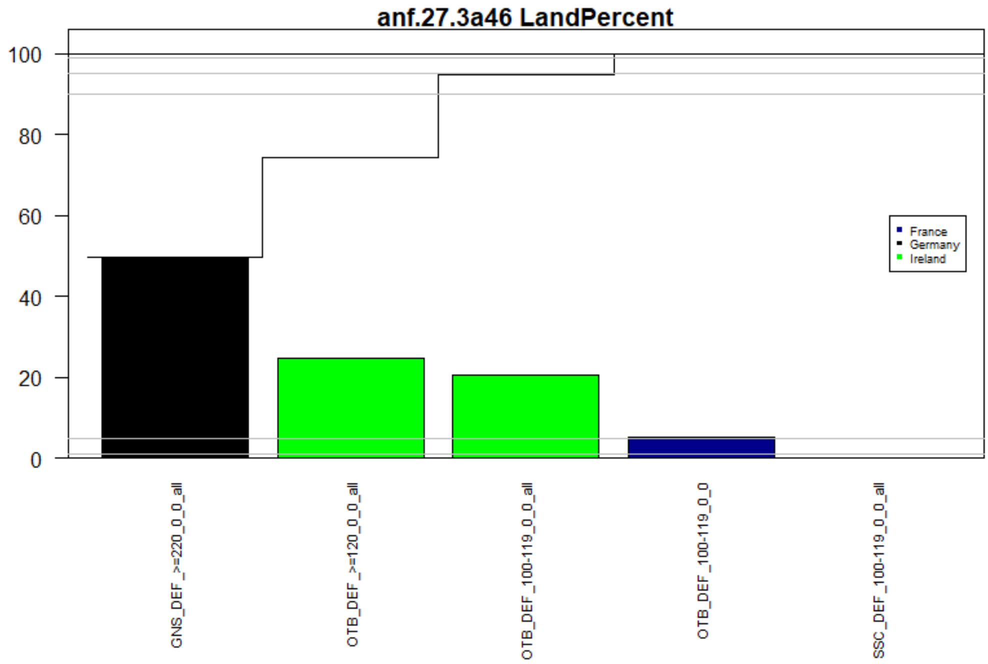

Figure 4.3c. Percentage of landings weight by fleet and country in 2020; Division 6.b.

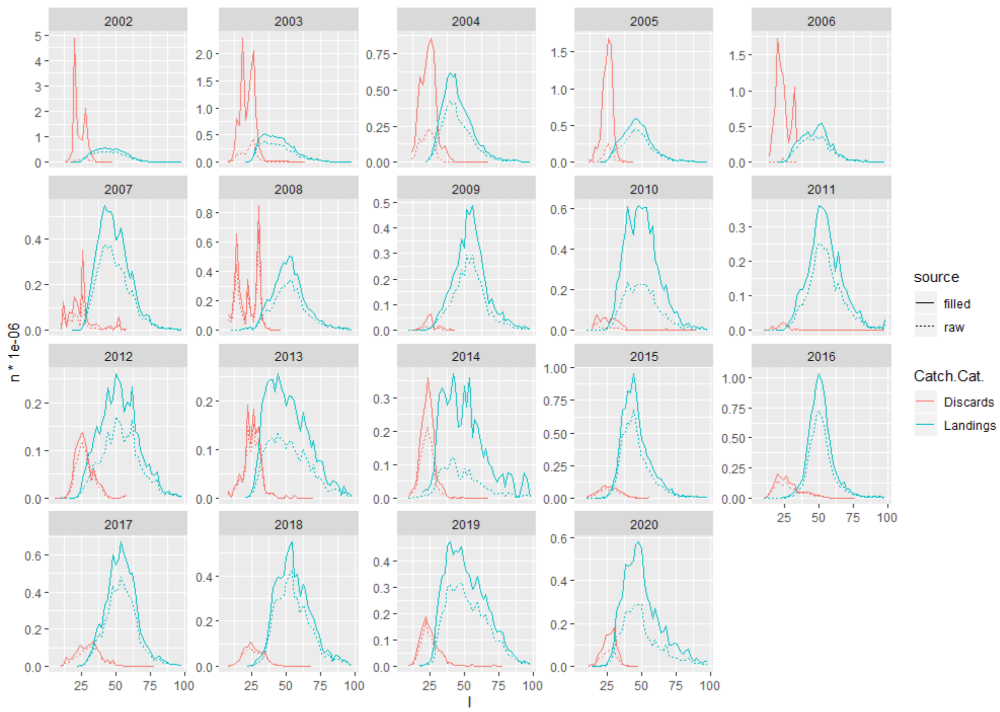

Figure 4.4. WGCSE Landed numbers ('00 thousands) at-length (cm) 2002–2019.

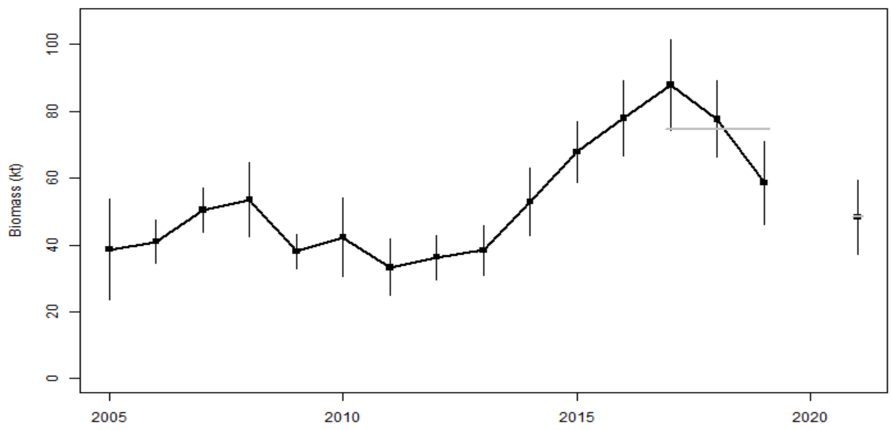

Figure 4.5. SIAMISS-Q2 estimates of total biomass, with confidence intervals, for subareas 4 and 6 combined, 2005–2021.

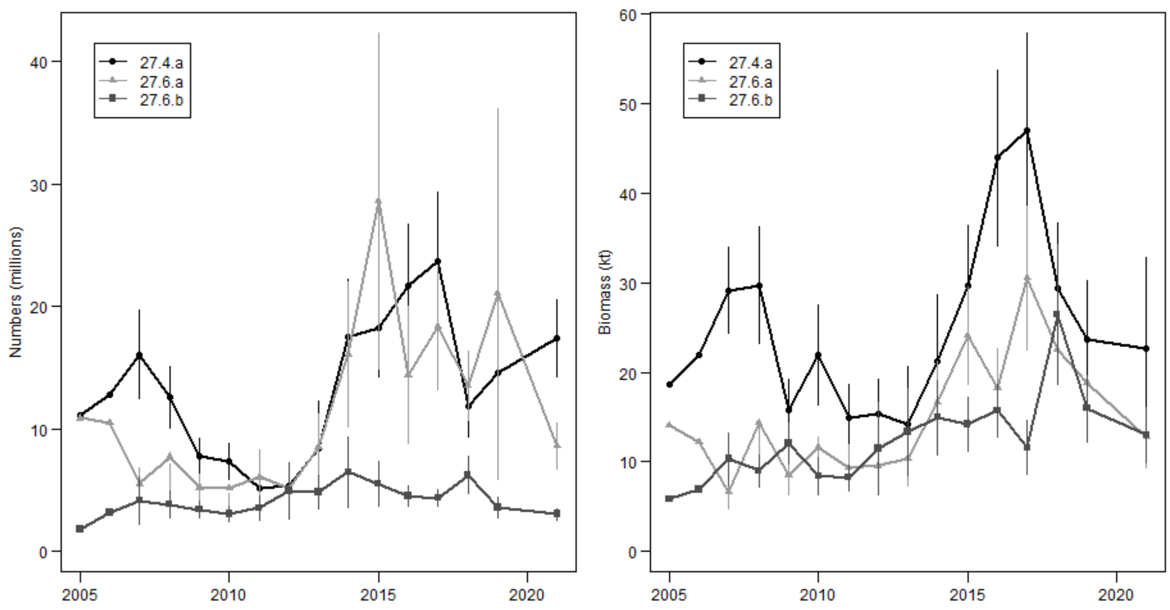

Figure 4.6. SIAMISS-Q2 estimates of total abundance (left) and biomass (right) of anglerfish for the Northern Shelf 2005–2021 provided for ICES Subarea 4a (circles black line), Division 6.a (triangles grey line) and Division 6.b (square black line).

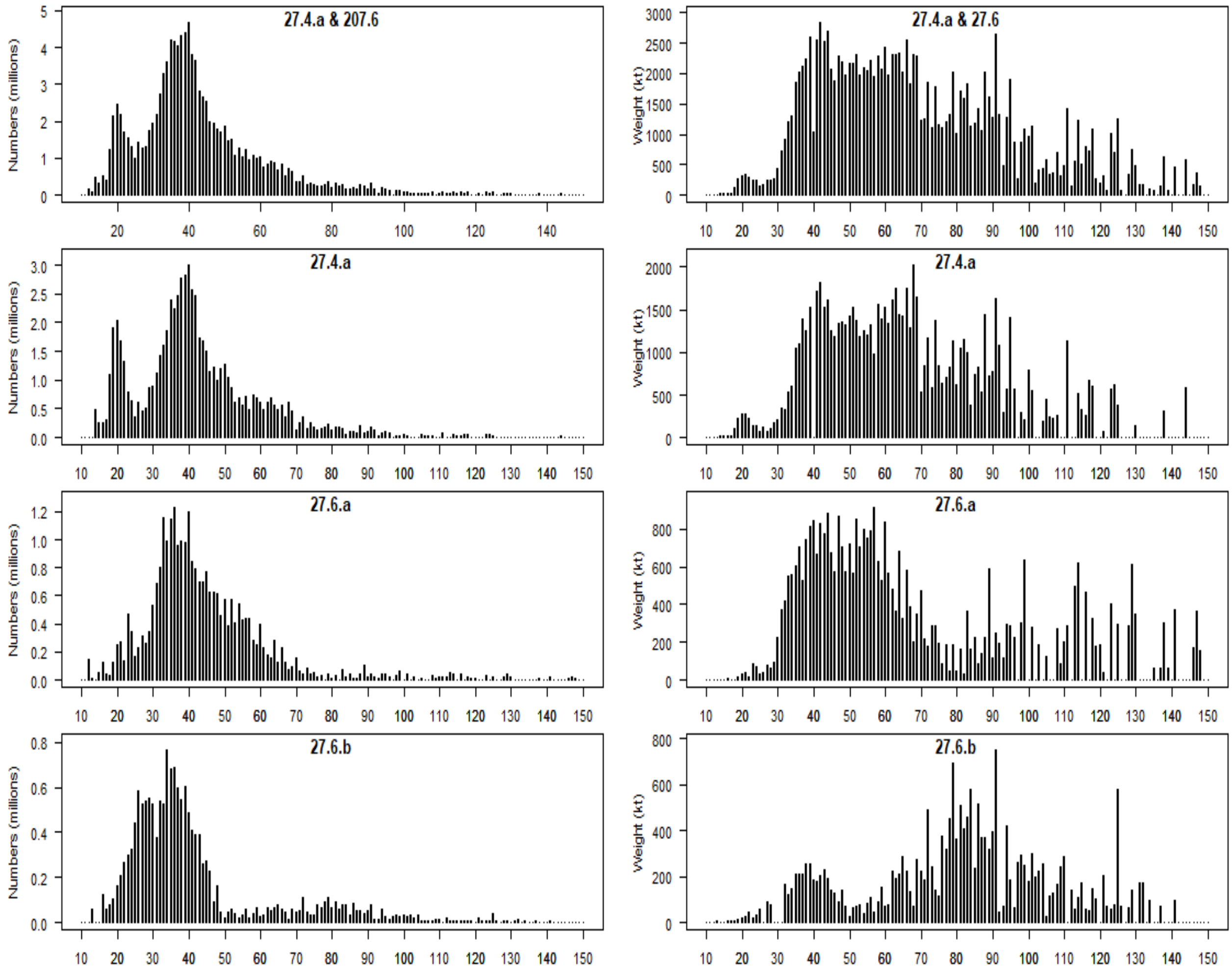

Figure 4.7. SIAMISS-Q2 estimates of total numbers (millions) at-length (cm) for subareas 4.a–c and 6.a–b, 2021.

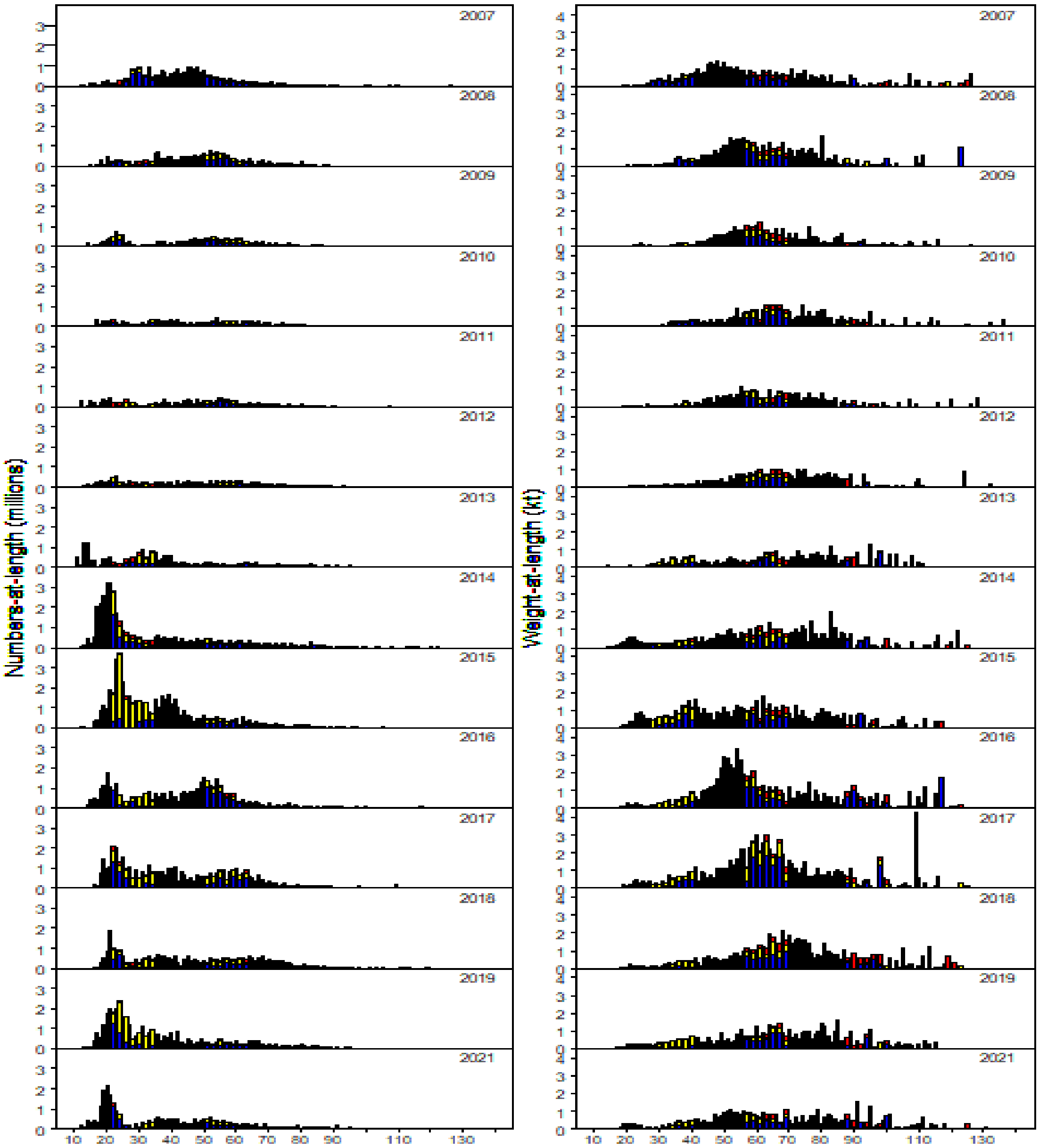

Figure 4.8. SIAMISS-Q2 estimates of total numbers (millions) at-length (cm) (left) and estimates of total biomass (kt) at-length (cm) (right) for subareas 4.a (blue)–c and 6.a (yellow)–b (red) combined, 2007–2021.

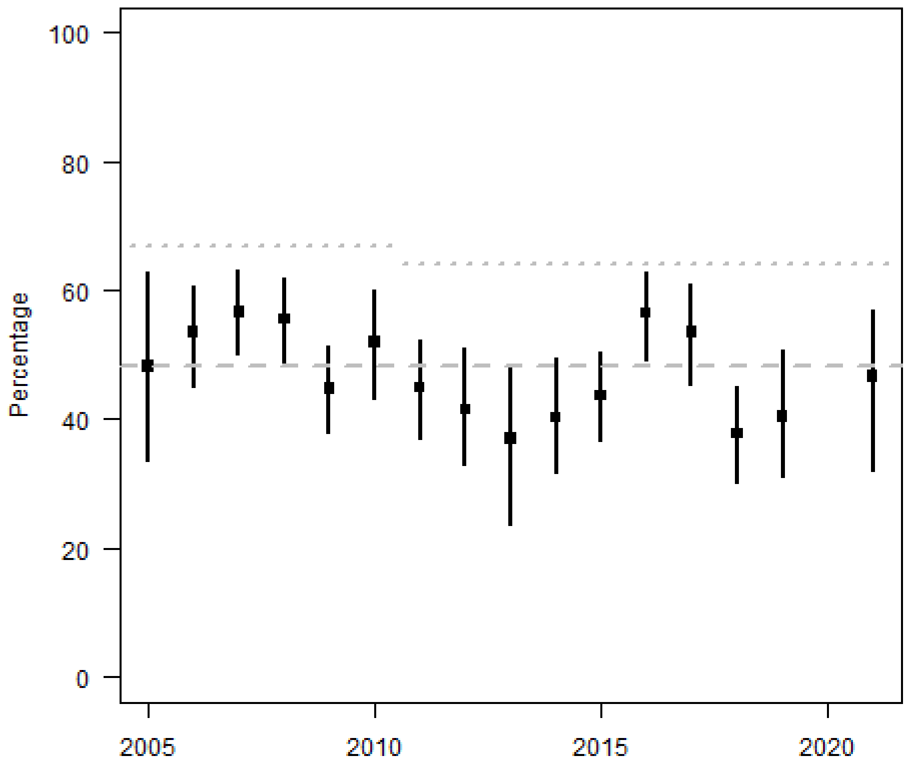

Figure 4.10. Percentage of SIAMISS-Q2 total biomass, with confidence intervals, estimated to be in subareas 4.a–c compared with subareas 4.a–c and 6.a–b combined. The full grey line represents the average of these percentages over the time-series (2005–2021) (48%). The dotted grey lines represent the percentage of TAC allocated for subareas 4.a–c compared to the total of the TAC for subareas 4.a–c and 6.a–b, (67% in 2005–2010, 64% in 2011–2021).

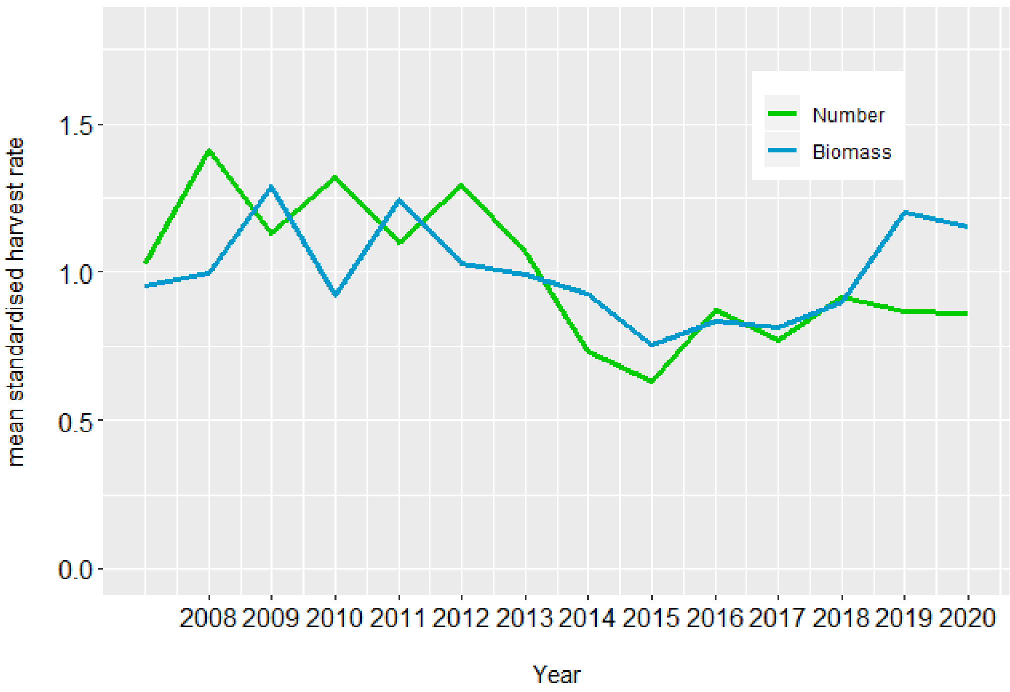

Figure 4.11. Northern Shelf anglerfish harvest rate 2008–2019 (mean standardised WG catch total numbers of biomass / SIAMISS-Q2 total numbers or biomass). Due to the Covid-19 pandemic the SIAMISS-Q" survey did not take place in 2020. Data for 2020 has therefore been interpolated using a mean of 2019 and 2021 values.

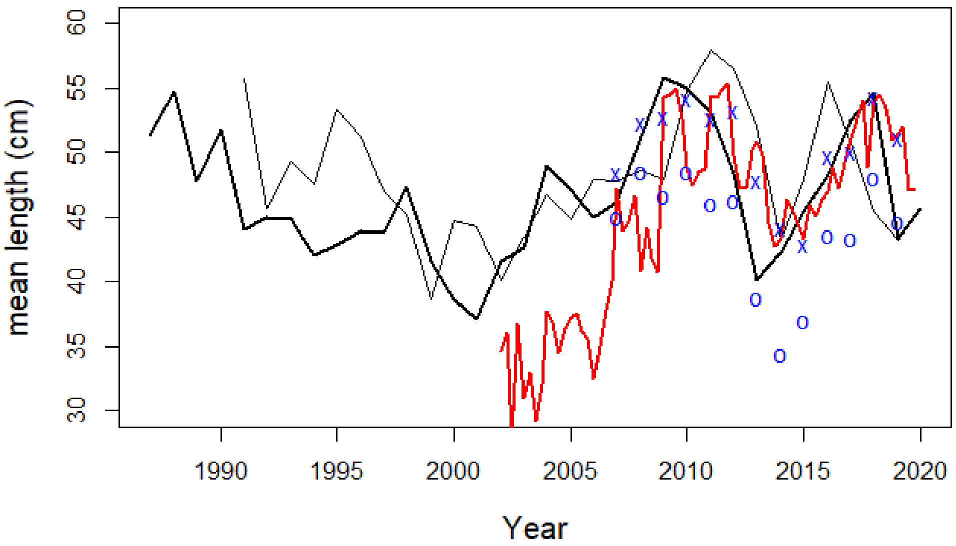

Figure 4.12. Mean length for NS-IBTS-Q1 (black bold), NS-IBTS-Q3 (black), commercial catch WKAnglerfish InterCatch estimation (red), and SIAMISS-Q2 raw catches (blue crosses) and after survey estimation procedure of corrections for footrope escapes, herding etc. (blue open circles) (see Reid *et al.*, 2007).

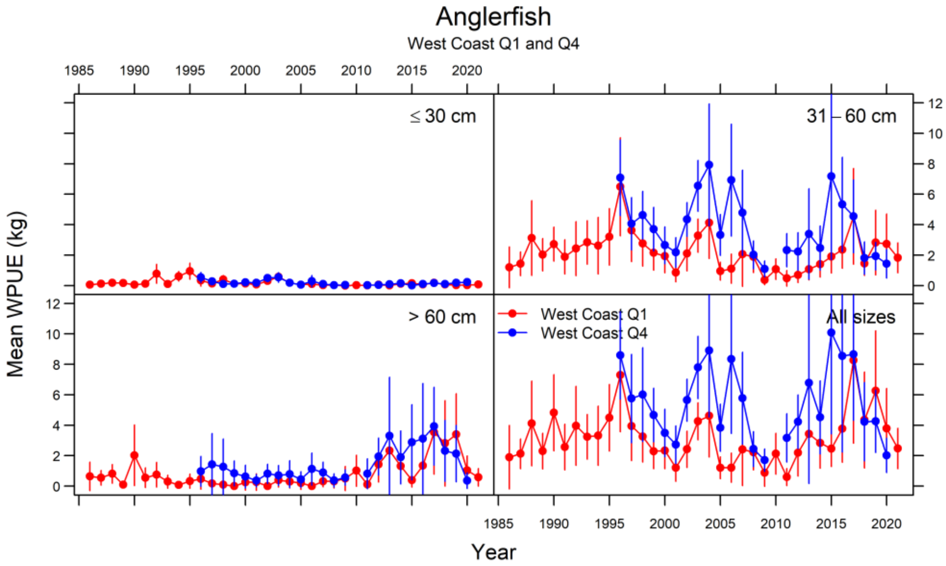

Figure 4.13. Survey indices of mean weight (g) per hour from SWC-IBTS-Q1 (blue) in 6.a, SWC-IBTS-Q4 (red) in 6.a and Rockall (red) in 6.b.

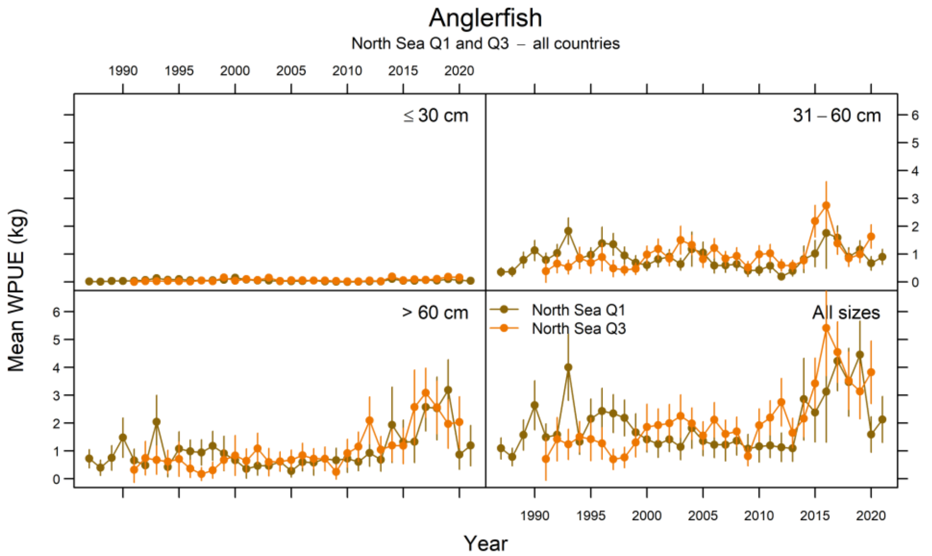

Figure 4.14. Survey indices of mean weight (g) per hour from NS-IBTS-Q1 (brown) and NS-IBTS-Q3 (orange).

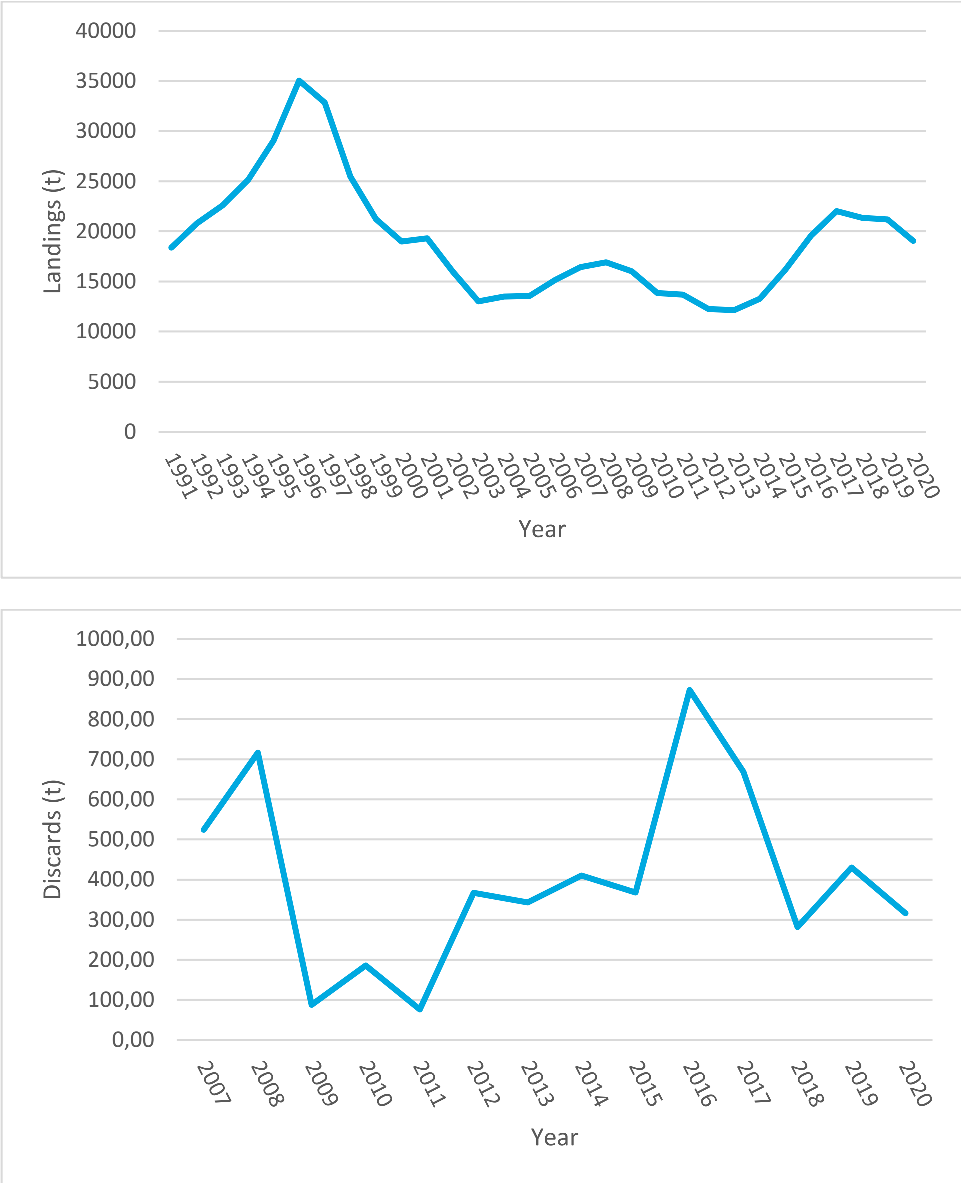

Figure 4.15. ICES landings of anglerfish 1991–2019 (top) and ICES discards of anglerfish 2007–2019 (bottom) in subareas 4 and 6 and in Division 3.a.

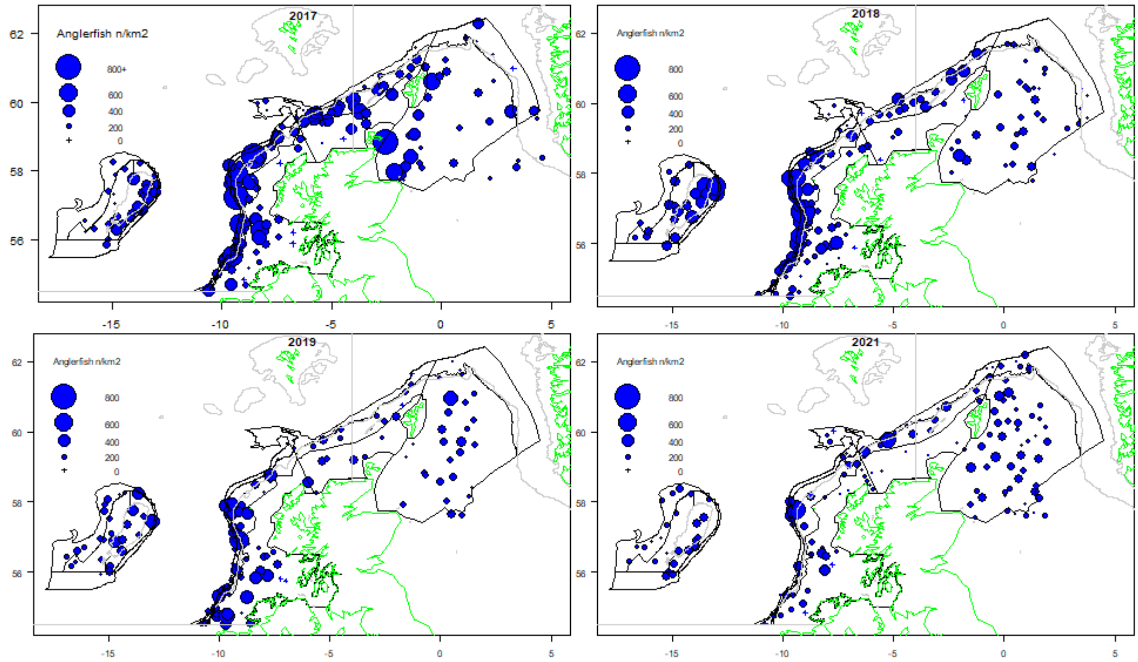

Figure 4.16. Numbers of anglerfish per km² observed by SIAMISS surveys 2017–2021.

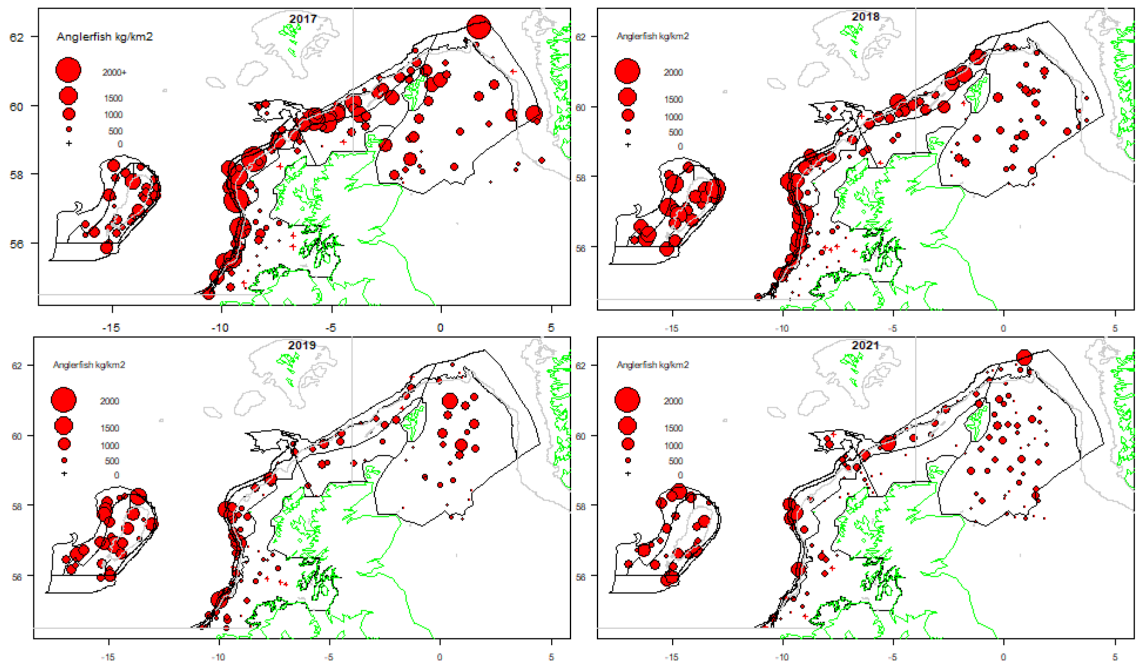

Figure 4.17. Weight of anglerfish(kg) per km² observed by SIAMISS surveys 2017–2021.

5 Cod in Division 6.a

5.1 Introduction

The last benchmark for this stock was carried out in February 2020 (ICES, 2020). This resulted in a change of assessment method (TSA to SAM), inclusion of revised catch data from 2003 onwards and updated biological parameters.

The assessment presented here contains a deviation from the catch estimation process as agreed at the benchmark and documented in the Stock Annex:

Processed UK VMS data have not been submitted in accordance with the ICES VMS data call deadline and hence were not available ahead of WGCSE. Furthermore, data access issues between UK administrations mean that raw UK VMS data are not directly available for the estimation of Scottish area misreported landings. This applies to data from both 2019 and 2020. Therefore, instead of using these data to estimate area misreported landings (as agreed at WKDEM, ICES, 2020a), the WG has again had to make use of estimates provided by Marine Scotland Compliance (which were used by the WG prior to the 2020 benchmark). These estimates are used for both 2019 and 2020 landings data.

5.2 General

5.2.1 Advice

This stock has had zero catch advice since 2004. In recent years, this advice has typically been issued on a biennial basis. In 2020 biennial advice (for zero catch) was provided on the basis of the MSY approach and hence no new advice sheet is provided this year.

5.2.2 Stock definition and the management unit

The assessment unit is Division 6.a although the latest evidence from genetic, tagging and otolith chemistry studies suggest that cod to the west of Scotland comprise of at least four subpopulations that remain geographically separate throughout the year. Some of these appear to be coastal groups with a tendency towards year-round residency, although there is some exchange between the southern inshore groups and the Irish Sea. Genetic studies have found no significant differentiation between cod sampled in the north of 6a in depths > 100 m and samples from Shetland in Division 4. Similarly, historic tag – recapture results also indicate some west to east movement across 4°W. This subpopulation region accounts for most of the cod landed in 6a since 2010 (ICES, 2020a, WD 4.1).

A recent workshop on cod stock ID (WKNSCODID; ICES, 2020b) in the North Sea was convened to agree potential stock boundaries for cod within the North Sea. The main conclusion was of separate Viking (northeast N Sea) and Dogger (remaining N Sea) genetic populations (with boundaries agreed), with the northern offshore component of Division 6a considered likely to be part of the latter. A process for developing a spatial assessment for North Sea cod and potentially including the northern part of Division 6a is underway and will conclude in 2023. As yet, no discussion has taken place on potential boundaries of stocks within Division 6.a.

The management unit is ICES Divisions 6.a plus EU and international waters of Division 5.b to the east of 12°00′W. Prior to 2009, the TAC was set for ICES Subareas 6, 12 and 14 plus Subdivision 5.b.1.

Recent management

The minimum conservation reference size of cod for human consumption in this area is 35 cm.

From 2012 to 2018 the TAC for cod in Division 6.a was set to zero with allowance for a bycatch of cod to be landed provided that it does not comprise more than 1.5% of the live weight of the total catch retained on board per fishing trip. From 2015, this provision was not allowed for catches subject to the landing obligation.

With the full implementation of the landing obligation in 2019 for fisheries catching cod, a bycatch TAC of 1735 t was set to allow mixed fisheries with a bycatch of cod to continue. In 2020, this TAC has been reduced to 1279 t. A breakdown of these TACs by country can be found below.

Due to a lack of agreement in UK-EU negotiations, no agreed TAC for 2021 was available at the time of writing, although the bycatch quota published by the UK government was 892 t and the interim by-catch TAC published by the EU was 321 t.

TAC for 2015–2018

Species:	Cod *Gadus morhua*	**Zone:**	VIa; Union and international waters of Vb east of 12° 00′ W (COD/5BE6A)
Belgium	0		
Germany	0		
France	0		
Ireland	0		
United Kingdom	0		
Union	0		
TAC	0 (1)		Analytical TAC

(1) By-catch of cod in the area covered by this TAC may be landed provided that it does not comprise more than 1,5 % of the live weight of the total catch retained on board per fishing trip. This provision shall not apply for catches subject to the landing obligation.

TAC 2019

Species:	Cod *Gadus morhua*	**Zone:**	6a; Union and international waters of 5b east of 12° 00′ W (COD/5BE6A)
Belgium	3 (1)		
Germany	26 (1)		
France	275 (1)		
Ireland	385 (1)		
United Kingdom	1 046 (1)		
Union	1 735 (1)		
TAC	1 735 (1)		Analytical TAC Article 8 of this Regulation applies

(1) Exclusively for by-catches of cod in fisheries for other species. No directed fisheries for cod are permitted under this quota.

TAC 2020

Species:	Cod *Gadus morhua*	**Zone:**	6a; Union and international waters of 5b east of 12°00′ W (COD/5BE6A)
Belgium	2 (1)	Analytical TAC	
Germany	19 (1)	Article 8 of this Regulation applies	
France	203 (1)	Article 3 of Regulation (EC) No 847/96 shall not apply	
Ireland	284 (1)	Article 4 of Regulation (EC) No 847/96 shall not apply	
United Kingdom	771 (1)		
Union	1 279 (1)		
TAC	1 279 (1)		

(1) Exclusively for by-catches of cod in fisheries for other species. No directed fisheries for cod are permitted under this quota.

Technical measures applicable to the West of Scotland, including those associated with the cod recovery plan in force up to 2008 (Council Regulation No. 423/2004), the cod long-term management plan in force from 2009 (Council Regulation No. 1342/2008) were amended by Council Regulation No. 1243/2012. The management plan was further amended in 2016 by Council Regulation (EU) 2016/2094 to cover the transitional period in which preparations are ongoing towards multiannual plans for multi-species fisheries. In 2018 the cod management plan was discontinued. Cod in Division 6.a is not included as a named target species in the multiannual plan for Western Waters (Council Regulation (EU) 2019/472).

5.2.3 The fishery in 2020

The table of official landings statistics is given in Table 5.1 and Figure 5.1. Official landings declined in 2020 (983 t) compared to 2019 (1486 t) which had the highest value since 2002. In 2020, over 75% of the official landings were reported by UK vessels, approximately 15% by France with smaller amounts declared by Norway, Ireland and Spain. The majority of reported cod landings in Division 6.a are now taken in the far north of the area. In 2020, officially reported BMS (below minimum size) landings of cod in Division 6.a amounted to less than two tonnes.

Due to restrictive TACs, seasonal/spatial closures of the fishery, and effort restrictions based on bycatch composition, the likelihood of misreporting and underreporting of cod in the past is considered to have been high. Underreporting is considered to have been reduced to low levels following the introduction of legislation in Ireland and the UK in 2006. However, area misreporting of cod landings from Division 6.a into Division 4.a (i.e. caught in Division 6.a, but declared in Division 4.a) and to a lesser extent Division 5.b, by the Scottish fleet is now believed to occur. The UK legislation introduced in 2006 is also believed to be responsible for a significant increase in discards starting in 2006. Following the full implementation of the landing obligation (2019 onwards) for fisheries catching cod and the availability of a bycatch TAC rather than a 1.5% bycatch allowance, discard rates were much reduced in 2019 and 2020 (although area misreporting continues to occur).

5.3 Data

Catch data

Area-misreported landings by the Scottish fleet are considered to represent a considerable proportion of the total landings. One of the main focuses of the 2020 benchmark was deriving an objective approach for estimating area misreported landings based on an analysis of VMS data linked to daily logbook landings (WD 4.4, ICES, 2020a) rather than using estimates provided by Marine Scotland Compliance (MS-C) based on fishery observations and expert judgement (as used by the WG prior to the 2020 benchmark). However, UK VMS data for 2019 and 2020 have not been submitted in accordance with the VMS data call deadline and hence were not available prior to WGCSE. Therefore, as last year, the WG had to revert to making use of area misreported landings estimates provided by MS-C. Figure 5.2 and Table 5.2 shows the time-series of estimates of area misreported landings (which come from the UKS large mesh demersal trawl fleet) alongside reported landings for Division 6.a. Total estimated area misreported Division 6.a cod landings in 2020 are 332 t. This represents a decline since 2019, although the proportion relative to total landings remains similar (26 %). These landings are largely reported into Division 4.a, but assumed to actually be taken in Division 6.a.

The landings uploaded into InterCatch are shown in Figure 5.3 by métier and country, and discard proportions by weight shown in Figure 5.4. As in previous years, catch sampling is available for the main Scottish and Irish fleets. In addition, an estimate of total discards is available for the Spanish OTB_DEF_100-119 fleet. The French OTB_DEF≥120 métier is the largest métier with unsampled landings and represents ~ 7.5% of the total landings in 2020.

It can be seen that landings by Scottish trawl ≥120 mm dominate. This fleet also has the highest total discards although the discard rate in the *Nephrops* trawl fleet (OTB_CRU_70-99) is much greater (over 95%) (Figure 5.4).

Following an analysis of Scottish catch sampling data conducted at WKDEM (ICES, 2020a), it was agreed that for the purposes of allocated age compositions and discard rates, the area-misreported landings should be considered as 'sampled' landings and treated as part of the Scottish demersal trawl fleet. This is in contrast to previous assessment WGs where the area-misreported component was considered unsampled and were assumed to have zero discards and landings age compositions consistent with the total sampled landings (i.e. all countries).

Discard proportions and landings and discard age distributions were assigned within InterCatch to unsampled fleets on the same basis where possible (and as described in the Stock Annex). Raised discards are shown in Figure 5.5 and estimated total catch by métier in Figure 5.6. The final mix of numbers-at-age from sampled and unsampled landings, and sampled and raised (unsampled) discards is given in Figure 5.7. An extremely small amount (< 3 t) of below minimum size (BMS) landings was also reported, but is not shown. The assumptions about unsampled landings and raised discards have little impact on the final catch numbers-at-age as the unsampled fleets make only a minor contribution to the fishery compared to the sampled (Scottish) fleets.

Sampling levels (number of trips) by country are given below and compared to 2019. A limited number of Northern Irish samples are also available in 2020. Sampling of the Scottish OTB_DEF landings has been quite poor in the recent past. The small sample sizes (which include a few very large fish with high raising factors) can result in a very high sum of products (SOP, landings-at-age x weight-at-age) for this fleet in *some years*.

		Scotland			Ireland
	Year	Demersal trawl (OTB_DEF)	*Nephrops* trawl (OTB_CRU)	Total	Total
2019	Landings	19	1	20	21
	Observer	22	18	40	28
2020	Landings	9	1	10	24
	Observer	10	4	14	5

In 2020, fishery sampling was disrupted by the COVID-19 pandemic. Sampling of both landings and discards from the main fleet (Scottish OTB_DEF) reduced to around half the number of trips in previous years. While the number of samples was lower for this fleet, samples were available from both sources (landings and discards) for all quarters with the exception of quarter 2. The most significant impact of the reduced sampling was on the number of samples and seasonal coverage of discard samples from the *Nephrops* trawl fleet. The number of samples from this fleet was around 25% of typical levels and only occurred in the first quarter of the year.

The WG estimates of total landings and discards are given in Table 5.2 and shown in Figure 5.9. The total discard proportion by weight is shown in Figure 5.10, and while this has increased somewhat in 2020 (20%) compared to 2019 (9%), it remains well below the previous 3-year average. (2016–2018) when the discard proportion was estimated to be in excess of 70% of the total catch.

In contrast to the period 2006 to 2018 when there was substantial high-grading and discarding occurring (to some degree) over all age classes, in 2019 and 2020, discarding is mostly limited to ages 1 and 2 (and to a lesser degree age 3) (Figure 5.11 and 5.12).

Age-compositions and weights-at-age

Raised landings numbers-at-age and discard numbers-at-age are given in Tables 5.3 and 5.5 respectively and total catch numbers-at-age in Table 5.7.

Annual mean weights-at-age in landings, discards and catch are given in Tables 5.4, 5.6 and 5.8. Figure 5.13 shows the mean weights-at-age in the landings and discards. The mean weight of age two and three fish in the landings increased since the mid-2000s in line with the increase in high-grading which occurred at these ages. Other age classes show fluctuations with a long-term downward trend particularly for ages 5 and above. Values at older age are noisy, particularly in recent years (most likely due to low sampling levels). Mean weight-at-age in the discards shows no real trend between 2006 and 2018. In 2020, there is a decline in mean weight-at-age in both the landings and discards at age 1. While the 2020 estimates remain well within historical values (and are not extreme), the lower discard mean weight could potentially be due to the lack of discard samples from quarter 2 onwards (i.e. after individuals have grown) from the *Nephrops* fleet which is typically the most important fleet for age 1 discards. (See above for COVID-19 samples disruption). The reason for the decline in mean weight-at-age 1 in the landings is harder to explain and potentially is noise related to low sample sizes or increased retention of smaller fish (due to the LO).

Biological data

Given the trends in observed mean weights, WKDEM proposed the use of a temporally varying natural mortality would be more appropriate. The catch weights show high interannual variability (Figure 5.14) and therefore it was agreed to use smoothed catch weights as stock weights and then use these with the Lorenzen (1996) function with the 'natural' parameters to obtain natural mortality (WD 4.3, ICES, 2020a). The smoothing means that any biases in catch weights related to lack of sampling are likely to have only limited impact on stock weights and natural mortality.

To derive the stock weights, a GAM is fitted to mean catch weights-at-age (Figure 5.14). Refitting the GAM each year results in typically minor revisions to stock weights used to estimate SSB between assessment years (and also natural mortality, WD 4.3, ICES, 2020a). However, this year, there is more substantial revision to stock weights-at-age 4 as the fitted GAM has become more 'wiggly' and estimated an increasing trend in stock weights in recent years. Given that this also has an impact on the natural mortality estimates a sensitivity analysis was conducted comparing the assessment results using the WGCSE 2020 stock weights and natural mortality and the new stock weights and natural mortality. The differences were extremely minor and are not discussed further.

The catch mean weight-at-age 2 in 2019 remains a substantial outlier. At WGCSE 2020, the sampling data for 2019 were scrutinized in detail and the estimate could not be attributed to a particularly anomalous or influential sample and therefore the data point was considered valid (See ICES, 2020 for further details).

At all ages there is a general downward trend in catch weights (and hence stock weights) over time although with an apparent recent increase at ages 3 and 4. This results in increases in natural mortality, although at most ages the scale of this increase is very small (Figure 5.15). Stock weights and natural mortality are given in Tables 5.9 and 5.10.

The maturity ogive was also updated at WKDEM. An analysis of Scottish survey data (following the approach advocated by ICES, 2008) indicated a proportion of individuals at age 1 to be mature, but no temporal trend in maturity. A new ogive was therefore used for the full time-series (WD 4.2, ICES, 2020a).

Age	1	2	3	4	5	6	7+
WGCSE 2019	0	0.52	0.86	1.0	1.0	1.0	1.0
WKDEM/WGCSE 2020 onwards	0.27	0.53	0.48	0.91	0.97	0.99	1.0

Survey data

All available survey data are given in Table 5.11, with the data used in the assessment highlighted in bold. Survey descriptions are given in the stock annex. Since the inter-benchmark in 2019 (IBPCod6.a), the assessment makes use of three quarter four surveys (one of which is no longer current) and two quarter one surveys (one of which is discontinued). Survey indices for the two current Scottish surveys (UK-SCOWCGFS- Q1 and UK-SCOWCGFS- Q4) are provided with an estimate of variance.

The cpue by survey haul for recent years for the two Scottish surveys (UK-SCOWCGFS- Q1 and UK-SCOWCGFS- Q4) are shown in Figure 5.16. Both surveys show mostly zero returns over latitudes between 56 degrees N and 58.5 degrees N. This pattern has been consistent in surveys since 2007. The Scottish surveys have highest catch rates to the north of 59 degrees N, in and around the closed area although these seem to have reduced in recent years (coincidental with a reduction in the size of the area closed to fishing, Figure 5.16). South of 56 degrees N, the Q1 surveys catch mostly young cod in the Clyde region. Occasional very large hauls associated with apparent aggregations of older cod (typically age 3 and above) have a significant impact on the survey indices and their variance estimates. In 2017, the indices for age four, five and six cod in the quarter one survey show particularly high uncertainty due to a single very large haul (Figure 5.16) of large cod with most other stations having very low or zero values. In 2018 (in the same survey), there were no large hauls and therefore the estimated variance is low. In 2019, the quarter one survey shows very low catch rates of ages > 1 across the survey area, but relatively high catch rates (compared to recent years) of age 1 fish.

The quarter four survey estimates also have substantial uncertainty. This is particularly apparent in the 2018 survey with two hauls catching large numbers of individuals aged 4 to 6 and very low catches elsewhere, resulting in CVs of around 60% for these ages in this year.

A series of inshore and offshore Scottish industry–science surveys, known as the West Coast Demersal Fish (WCDF) project were conducted between December 2013 and November 2014. The initiative, funded by the Scottish Government and the European Fisheries Fund, was a joint venture between Marine Scotland Science and the Scottish Fishermen's Federation with the aim of improving the understanding of the current state of demersal stocks to the West of Scotland. The surveys show a broadly similar distribution to the UK-SCOWCGFS- Q1 and UK-SCOWCGFS-Q4 with bigger fish and increased abundance inside the Windsock compared to outside. Biomass estimates from these surveys and from the SIAMISS (anglerfish survey) were presented to WKDEM, but were considered too uncertain to provide useful information for the stock assessment.

5.4 Stock assessment

This assessment uses a SAM run as outlined in the stock annex. Exploratory analysis of the input catch and survey data are also carried out.

Data screening

Log catch (landings + discards) numbers-at-age over time (Figure 5.17) show good tracking of strong and weak cohorts historically. These signals become less apparent and more noisy after 2010, potentially due to low sampling levels and/or ageing errors. There is however, a clear indication of increasing numbers of older fish appearing in the catch since this time, which would be consistent with a reduction in fishing mortality. Catch curves from commercial catch-at-age data are also shown in Figure 5.17. Although the data are noisy, there is some evidence of a flattening off of the catch curves in recent years compared to those of the cohorts spawned in the late 1990s. A plot of log catch curve gradients derived from commercial catch data over different age ranges is shown in Figure 5.18. Here too there is some evidence of a decreasing mortality in recent years. (Note that these exploratory catch data plots are based on reported landings and discards and will be influenced in part by underreporting of landings in the 1990s and early 2000s).

Figure 5.19 shows the mean standardised catch-at-age by proportion (number). It shows good tracking of the strong cohorts as recently as the 2005 year class which shows well up to age 4. More recently the data become rather noisy since 2018, the proportion of the catch-at-age at age four and above are very high. These observations are not supported consistently by above average values at younger ages of the same cohort. Potentially this could be associated with a slight change in the distribution of the fishery and access to a previously closed area where a significant proportion of the older fish are located (Figure 5.16), however recent VMS data area unavailable and hence this hypothesis cannot be substantiated.

Figure 5.20 shows the log mean standardised indices from the ScoGFS-WIBTS-Q1 survey by year and by cohort. The early part of the time-series appears to track the cohorts relatively well with no obvious year effects. However, in later years the indices become noisier and there is some evidence of year effects in the survey. The survey ended in 2010. Figure 5.21 shows log catch curves for the ScoGFS-WIBTS-Q1 survey. It shows a strong "hook" at the younger ages (lower catchability), with abundance-at-age two often higher than at-age one. In later years, survey abundance also shows increases from age 2 to age 3 in the same year class and the survey's ability to track recent cohorts seems poor relative to the 1990s and early 2000s. The survey scatterplots (Figure 5.22) show some consistency in the estimates of year-class strength across age classes (particularly the younger, adjacent ages), although less so at older ages. There is no trend in the log catch curve gradients derived from this survey that would be consistent with a change in mortality (Figure 5.23) for any of the age ranges considered.

Figure 5.24 shows the log mean standardised indices by cohort and year from the ScoGFS-WIBTS-Q4 survey. The survey shows reasonable tracking of cohorts at ages one to three and no particular evidence of year effects. This is also evident in the survey scatterplots which show reasonable correlation at younger ages (Figure 5.25). This survey catches very few fish at ages five and above.

Figure 5.26 shows the log mean standardised indices by cohort and year from the IRGFS-WIBTS-Q4. The log mean standardised indices plot shows consistent signals at ages 1 and 2 with no obvious year effects. The scatterplots (Figure 5.28) also show reasonable consistency between ages one and two, but the tracking at older ages is less strong. The data cover too few age classes sufficiently well to give an indication of trend in mortality through catch curve gradients (Figure 5.27).

Figure 5.29 shows log mean standardised indices by cohort and year from the UK-SCOWCGFS-Q1. There is little evidence of successful tracking of cohorts and some evidence of survey year effects (2015, 2017 and 2019, particularly for older ages). There appeared to be a general increase in the catch rates of older ages over time to 2017 (four and above), but no equivalent increase in the catch rates of younger ages (from the same cohort). These declined significantly in 2018 and

2019, although there has been an increase in the catch rate of age one in 2019 which is tracked in 2020 at age 2.

The log catch curves from the UK-SCOWCGFS- Q1 are also very noisy (Figure 5.30) and typically do not show a decline as the cohort ages. The survey scatterplots show that even the catch rates of successive age classes (within the same cohort) are only weakly related (Figure 5.31).

Figure 5.32 shows log mean standardised indices by cohort and year from the UK-SCOWCGFS-Q4. There is some evidence of cohort tracking, but this is not consistent over time or ages and this is also apparent in the survey scatterplots shown in Figure 5.34. Figure 5.33 shows the log catch curves from the UK-SCOWCGFS-Q4 which are noisy and difficult to interpret given the short time-series and missing year of survey data.

Overall, information on mortality trends from all survey-series (including the ScoGFS-WIBTS-Q1) appears to be fairly poor due to the generally high variability and large CVs (ranging from 30% to 75% depending on age-class) for the two current Scottish surveys.

Figure 5.35 shows a comparison (between surveys) of log mean standardised survey indices at age over time (mean standardised over the common year range of all three surveys). The two quarter four surveys show some consistency over time at age two while the two Scottish surveys show some consistency of trends at age three. At older ages (in the Scottish surveys), there appears to be a divergence in the trend in recent years.

The inter-benchmark in 2019 agreed that all five surveys should be included in the final assessment (and this was followed at WKDEM in 2020), the basis being that the additional surveys show reasonable internal consistency and in addition, some between survey consistency. It was considered that the Irish survey could provide an additional indicator of year-class strength and could be useful as it covers the period during which there is a break in the Scottish survey indices. The lack of spatial coverage of this survey (only the southern part of Division 6.a) was deemed less important given the index is only being used to provide information on the younger ages.

Final assessment

The SAM configuration file for the final assessment model run is given in Table 5.12. To summarise the main features:

- Fishing mortality at ages 4 and above are assumed equal (See # Coupling of the fishing mortality states, Table 5.12).
- Survey catchabilities are mostly freely estimated for each age with the exception of the two oldest ages (i.e. no survey catchability plateau assumed). The exception to this is the WIBTS.Q1 for which all catchabilities are independently estimated.
- Catch observation variance parameters are allowed to differ for age 1 and age 7+ while other age groups are coupled (# Coupling of the variance parameters for the observations). To allow for greater uncertainty in the catch data for 2006 onwards (when the fishery changes from being a landings fishery to largely discards), the estimated catch observation error standard deviation is doubled for 2006 onwards (based on inspection of the one step ahead residuals).
- Survey observation variance parameters differ between surveys but are coupled for all age groups within a survey.
- Recruitment is modelled as a random walk.
- A catch scaling factor is estimated for 1995–2006 when underreporting of landings was considered significant.
- Fishing mortality across ages is modelled with AR(1) and process variance parameters coupled across all ages with the exception of age 1. Process variance in stock numbers-at-age were assumed coupled with the exception of age 1 (the age at recruitment).

Input data are derived as agreed at the 2020 benchmark with the exception of the use of Marine Scotland Compliance estimates of area-misreported landings for 2019 and 2020 rather than using VMS data. As highlighted in Section 5.1, processed UK VMS data were not submitted in accordance with the ICES VMS data call deadline and hence were not available ahead of WGCSE. Furthermore, data access issues between UK administrations mean that raw UK VMS data are not directly available to MSS scientists for the estimation of Scottish area misreported landings. This applies to data from both 2019 and 2020. Therefore, instead of using these data to estimate area misreported landings (as agreed at WKDEM, ICES, 2020a), the WG has again had to make use of estimates provided by MS-C (which were used by the WGs prior to the 2020 benchmark). These estimates are used for both 2019 and 2020 landings data. A comparison of VMS estimates and MS-C estimates carried out at WKDEM suggested VMS estimates were generally lower but with no obvious linear relationship between the two.

The fits of the model to observations (catch and survey indices on a log scale) are shown in Figures 5.36 to 5.41. The fits to the survey data appear better at younger ages while the model appears to follow the catch data better at ages 2 and above (age 1 observations are likely to be noisier due to uncertain discard estimates).

The standardised one step ahead residuals are shown in Figure 5.42. There is some evidence of negative residuals at lower ages and positive residuals at higher ages in the catch in the final year, a pattern which is reversed in the Scottish survey residuals in those years, and could potentially be associated with changing selectivity. However, there are no major outliers in the residuals most lying within ±2. There are a few patterns apparent in the (discontinued) survey residuals which are rather similar to those observed in previous TSA assessments (ICES, 2019a & b) and at WKDEM (ICES, 2020): most notably some evidence of a tendency to more positive residuals in the latter half of the WCIBTS.Q1 (at age 1) and WCIBTS.Q4 (at age 2) and some year effects in most of the surveys (years with mostly positive or mostly negative residuals).

The model runs which leave out each survey index in turn are shown in Figure 5.43. With the exception of the period when total catches are excluded from the assessment (catch-scaling factor estimated for 1995–2006), the estimates of SSB and recruitment are relatively robust to the exclusion of the different survey-series. Excluding the early Scottish Q4 survey (WCIBTS.Q4) results in higher estimates of SSB, recruitment and catch than the baseline run during this period (when catches area excluded) and excluding the early Scottish Q1 survey much lower estimates. When the WCIBTS.Q4 is excluded, estimates of meanF are lower than the baseline during the first part of this period (to 2000) and higher than the baseline after 2000 while excluding the WCIBTS.Q1 shows the opposite effect. The relative magnitude of the changes when each of these surveys are excluded suggests the WCIBTS.Q1 to be much more influential in the overall assessment of stock trends.

When either the SCO.Q1 or SCO.Q4 survey series (the two current Scottish indices) are excluded there is a downward revision in the estimate of fishing mortality in the final year (although still within the confidence bounds of the estimate) while excluding the Irish survey index appears to have little impact on the assessment results.

The retrospective analysis is shown in Figure 5.44. Although the Mohn's rho value for F is within the bounds advised by WKFORBIAS (ICES, 2020c), two of the peels lie outside the confidence intervals of the final assessment run. There appears to be a tendency to overestimate F when the underlying fishing mortality starts declining, although there are both upward and downward revisions apparent which could be due to the very noisy data in recent years. The estimates of mean F appear to be substantially more noisy than SSB. The Mohn's rho values (as %) are as follows:

SSB	Mean F	Recruitment
-9.0	17	47.0

Both the recruitment and SSB Mohn's rho include the intermediate year in each assessment peel (as there is an intermediate year survey included in the assessment and hence SSB and R estimates available for this year). The high Mohn's rho in recruitment is mostly due to the downward revision of the 2020 recruitment estimate (~ half the previous estimate) with other years showing less significant revisions.

Final parameter estimates from the SAM run are given in Table 5.13. Table 5.14 gives the SAM population numbers-at-age and Table 5.15 the estimated F-at-age. A full summary output is given in Table 5.16 (including model estimates of catch and catch scaling parameters).

Stock status

The summary plot including reference points is shown in Figure 5.45 and the stock–recruitment estimates are shown in Figure 5.46. The estimated SSB shows a steady downward trend until 2006, an increase to 2016 and then a further decline since then. Recruitment has been very low since 2001, and is extremely poor in 2016–2018 and also in 2021. Although fishing mortality declined between 2009 and 2016 to below F_{lim}, it has shown an increase since then and is estimated to be above F_{lim} in 2020. It is not known whether, and to what extent, this increase is associated with the discontinuation of the days-at-sea regulation in 2017, which was part of the cod recovery plan.

Estimated SSB in the final year is well below B_{lim} (= ~14 000 tonnes). Mean F is well above F_{MSY} and has been fluctuating around F_{lim} since 2013. Although the latest assessment shows a flattening off of F since 2013, there has been a clear decrease in mean F since 2009. The decline in mean F is proportionately similar (~ 50%) to the decline in STECF effort (large and small mesh demersal/crustacean trawl from both regulated and unregulated fleets), although the mean F does not start to decline until several years after the effort.

5.5 Short-term stock projections

Although no new advice is being issued in 2021 (for 2022), a short-term forecast is required to provide advice on best estimates of catch (in 2022) for zero TAC advice stocks (the 'EU-Technical Service request'). Forecasting in SAM takes the form of short-term stochastic projections. A total of 1000 samples are generated from the estimated distribution of survivors. These replicates are then simulated forward according to model and forecast assumptions (see below), using the usual exponential decay equations, but also incorporating the stochastic survival process (using the estimated survival standard deviation) and subject to different catch-options scenarios.

The same approach as last year is followed for the short-term forecast. For the recruitment assumptions we use an approach similar to the previous deterministic forecast (in terms of year ranges, etc). Recruitment in the intermediate year (2021) is taken as the SAM estimate (median from a normal distribution about the assessment estimate). Estimates of recruitment for subsequent years were resampled from 2011–2020 to reflect recent low recruitments.

Fishing mortality in the intermediate year (2021) was taken as a three-year average over 2018 to 2020 as an estimate of F status quo (given that there is no particular trend in mean F).

Cod in Division 6a has been fully under the landings obligation since 2019 when a bycatch TAC of 1735 t was set to allow mixed fisheries with a cod bycatch to continue (in contrast to a 0 t TAC with 1.5% bycatch regulation in previous years). In 2020, the bycatch TAC was reduced to 1279 t.

These increases in TAC (and the introduction of the LO) appear to have resulted in a significant change in discarding practices in 2019 and 2020. In the forecast for 2021 and 2022, total catch is partitioned into landings and discards on the basis of the discard proportions-at-age averaged over 2019 and 2020 (rather than the more typical 3-year average) on the assumption that this behaviour will continue. Note that in the advice issued in 2019 for 2020, no partition was provided due to uncertainty regarding how the fishery would respond to the changes in TAC.

In 2019, there was a clear reduction in the mean weight-at-age in the discards which was assumed to be due to the change in discarding practices (reduced high-grading). However, this appears not to persist in 2020 (except for age 1) and hence the 2019 values may just be the result of variability in the sampling data rather than a systematic change. Nevertheless, for consistency with the landings/discard partition, two-year (2019 and 2020) mean weights were also used in the forecast.

Variable	Value	Notes
$F_{ages\ 2–5}$ (2021)	0.75	Average F = (2018–2020)
SSB (2022)	2963	Tonnes; short-term forecast.
$R_{age\ 1}$ (2021)	1615	Thousands; Median recruitment estimated in the assessment in 2020.
$R_{age\ 1}$ (2022)	4028	Thousands; Median recruitment resampled from the years 2010–2019
$R_{age\ 1}$ (2023)	2416	Thousands; Median recruitment resampled from the years 2010–2019
Total catch (2021)	1693	Tonnes; short-term forecast.
Projected landings (2020)	1015	Tonnes; short-term forecast assuming 2019 discard pattern
Projected discards (2020)	678	Tonnes; short-term forecast assuming 2019 discard pattern

Under the forecast assumption of status quo F, landings in 2021 are predicted to be 1015 t and discards to be 678 t. The SSB in 2022 is forecast to be 2963 t which is well below $B_{lim.}$ This value (2963 t) is significantly lower than that forecast for 2022 from the assessment carried out in 2020 (4064 t) under fishing at F_{lim} (=0.73), similar to this year's 2021 intermediate year assumption. This appears to be largely the result of the reduction in estimated recruitment for 2020 (from 5181 thousand in 2020 assessment to 2412 thousand in 2021 assessment).

The forecast under different catch scenarios for 2022 is shown in Table 5.17. Note that the values that appear in the catch scenarios, are medians from the distributions that result from the stochastic forecast.

The forecast stock trajectory under the agreed advice for 2022 (biennial zero catch advice) shows an increase in SSB in 2022 (Figure 5.47). Figure 5.48 shows the contribution by recruitment year to SSB in 2023 and catch in 2022 (when fished at F_{MSY}). The assumption regarding recruitment in 2022 and 2023 contribute approximately 22% and 4% respectively to the forecast SSB in 2023 while the 2022 recruitment makes up just over 3.5% of the 2022 catch. (Figure 5.48).

5.5.1 Reference points

Both MSY and precautionary reference points were reconsidered at WKDEM in February 2020 in accordance with ICES guidelines and are shown below (weights in tonnes). The estimate of F_{MSY} is derived from simulation based on segmented regression stock–recruitment only as both the Ricker and Beverton-Holt stock–recruitment relationships suggest peaks well outside the range of observed values. As in the estimates derived at IBPCOD.6A, yield is defined as catch above MCRS (estimated by assuming a historical discard rate prior to high-grading).

	WKMSYREF4	IBPCod.6a	WKDEM 2020	Rationale (WKDEM; ICES 2020a)
B_{lim}	14 000	14 000	14 376	Tonnes; SSB consistent with high probability of above average recruitment (SSB in 1992 as estimated by WKDEM)
B_{pa}	20 000	20 000	20 126	Tonnes; 1.4 x B_{lim}
F_{lim}	0.82	0.77	0.73	F with 50% probability of SSB<Blim
F_{pa}	0.59	0.55	0.57^	Fp.05; the F that leads to SSB ≥ Blim with 95% probability with ICES AR^
F_{MSY}	0.167	0.29	0.30	Based on simulation using a segmented regression stock–recruitment relationship (EqSim)
MSY $B_{trigger}$	20 000	20 000	20 126	B_{pa}
F_{MSY} upper	0.254	0.41	0.49	F at 95 % MSY (above F_{MSY})
F_{MSY} lower	0.108	0.20	0.18	F at 95 % MSY (below F_{MSY})

^ Updated at WGCSE 2021 following updated guidance on fishing opportunities (ICES, 2021b). Fp.05 value derived at WKDEM 2020.

5.5.2 Management plans

Technical measures applicable to the West of Scotland, including those associated with the cod recovery plan in force up to 2008 (Council Regulation No. 423/2004), the cod long-term management plan in force from 2009 (Council Regulation No. 1342/2008) were amended by Council Regulation No. 1243/2012. The management plan was further amended in 2016 by Council Regulation (EU) 2016/2094 to cover the transitional period in which preparations are ongoing towards multiannual plans for multispecies fisheries. In 2018, the cod management plan was discontinued. Cod in Division 6.a is not included as a named target species in the multiannual plan for Western Waters i.e. only considered as a bycatch species (Council Regulation (EU) 2019/472).

5.6 Quality of the assessment

Figure 5.49 shows a comparison between this year's and previous year's assessments. The revised estimates of recruitment and SSB compared to pre-2020 assessments are largely the result of the inclusion of the updated historical catch data at WKDEM (ICES, 2020a). The benchmark changes to the assessment have had only minor impact on the perception of the stock.

Landings

Since the early 1990s the most significant problem with the assessment of this stock is with commercial data. Incorrect reporting of landings, species, quantity and management area, is known to have occurred. Scottish landings (from 2006) are adjusted to include estimates of misreporting (in an attempt to reduce bias in the assessment) and in the five years, 2014–2018, area-misreported landings accounted for over 50% of the total landings although that has reduced to around 25% in more recent years. The misreporting estimates for 2019 and 2020 have been provided by Marine Scotland Compliance based on intelligence and consideration of VMS data (i.e. vessel activity) due to a lack of access to UK VMS data for these years (See Sections 5.1 and 5.3).

Estimates for earlier years are derived from VMS data analysis conducted at WKDEM (ICES, 2020a) and these are somewhat higher than MS-C estimates for those years.

Discards

Although discards have reduced significantly in recent years (2019 and 2020) due to the LO, over the last five years discarding accounts for over 70% of the total catch. Despite an increase in sampling levels, discard estimates are still very uncertain (approximate CV = 50% for Scottish large mesh demersal fleet in 2017) contributing to uncertainty in the estimates of mean F.

In 2020, discard sampling, and to a lesser extent landings sampling, was disrupted due to the COVID-19 pandemic, with the most significant impact on the number of samples and seasonal coverage of discard samples from the *Nephrops* trawl fleet. The number of samples from this fleet was around 25% of typical levels and only occurred in the first quarter of the year. There is therefore likely greater uncertainty (than usual) in estimates of catch numbers-at-age one (given the importance of this fleet to those estimates) and hence potentially increased uncertainty in estimates of recruitment in 2020.

Lower mean weights-at-age one in discards may also be attributed to lack of samples from quarter 2 onwards (i.e. after individuals have grown) from the *Nephrops* fleet. However, given that stock mean weights are GAM smoothed and mean weights in forecast are averaged, any unusual values are likely to have limited influence on the assessment and forecast.

Biological factors

Cod consumption by seals (derived from diet composition studies and seal abundance estimates) is estimated to be 7632 tonnes (95% CI: 3542–13 937) in 2010 (Hammond and Wilson, 2016) compared to a TSB estimate of just under 6000 tonnes from the SAM assessment, and it has been suggested that seals may be impairing the recovery of this stock. However, there is uncertainty as to whether the seals are actually exploiting the same population as the fishery. Seal foraging mostly occurs on the continental shelf (Russell *et al.*, 2017) including rocky areas which are unsuitable for trawl fishing and are not surveyed on RV trips, while most of the cod landings are taken along the continental shelf edge in the north of Division 6a (STECF, 2016) and thus the seals and fishery are largely operating in different areas. Given the complex stock structure and the presence of coastal cod populations, it is clear there is potential for the seals and fishery to be exploiting different substocks.

The final SAM assessment assumes natural mortality to be a function of stock weight-at-age (Lorenzen, 1996) which are in turn derived from smoothed catch weights-at-age. Natural mortality clearly remains a major source of uncertainty in this assessment and incorrect assumptions regarding its trend and magnitude can have a significant impact on estimates of stock status.

Stock structure

Stock structure is complex and at least four subpopulations are known to occur within this area. The stock assessment therefore represents an assessment of multiple substocks with the northern component accounting for most of the landings since the mid-2000s. The survey distribution plots show that there is an almost complete absence of cod on the shelf in Division 6.a with the majority of the landings and stock concentrated in an area in the north of the region (around the closed area) bordering Division 4.a. It may be more appropriate to consider this component of the stock as part of the North Sea stock (or at least the northwest component of this stock) as proposed by WKNSEA (ICES, 2021a).

Assessment method

The benchmark agreed on the final SAM model configuration by comparing model residuals, AIC and retrospective patterns. There remain some patterns in the residuals particularly in the later surveys which are very noisy and the various sensitivity analyses conducted at WKDEM had little impact on these. Other assessment models also display similar problems. The retrospective analysis in the SAM shows overestimation of fishing mortality during the initial years of decline in mean F (although not persistent across all years of the retrospective analysis), which may suggest the model reacts slowly to changes in fishing mortality. However, there is also both under- and over-estimation in recent years which may be a reflection of extremely noisy data with the assessment struggling to pick up the trend.

The input data for this cod assessment are particularly uncertain (both survey indices and commercial data) and as a result, the data can be interpreted in different ways by different assessment methods. The assessment presented by Cook (2019) and a number of exploratory assessments presented at WKDEM show a stock which by 2016 had recovered to levels consistent with those of the 1990s (although with a subsequent decline since then) while the SAM assessment shows little sign of SSB recovery. In this respect the SAM assessment is very similar to the previous TSA and exploratory a4a assessments considered at the benchmark (ICES, 2020a). The key differences between the Cook (2019) model and the ICES assessment appears to be in the estimates of fishery selectivity and survey catchability and these result in substantial differences in stock trends. An extensive discussion on the plausibility of the estimates can be found in Section 4.3 of ICES (2020a).

Given these model uncertainties, estimates of uncertainty from the final SAM assessment are therefore unlikely to adequately reflect the true uncertainty in the estimates of stock biomass and fishing mortality for this stock.

5.6.1 Recommendation for next Benchmark

problem	solution	expertise necessary[1]	suggested time
Stock identity – multiple substocks within 6a and linkage with northern N Sea	Evaluate a possible merge between northern North Sea and 6.a cod stocks. Or as an alternative, split area 6.a in two areas North and South.	Scientists from MSS andMI	Next benchmark although would need collaboration with WGNSSK.
Noisy survey data	Explore modelled indices using e.g. delta-logN approach and also modelled ALKs.	Scientists from MSS	Ahead of next benchmark.
Fishery selectivity pattern	Flat-topped & dome-shaped selectivity pattern both plausible – modelling the main fleets separately may help. Implement multifleet SAM assessment.	Scientists from MSS	Fleet-disaggregated data now available in InterCatch for 2003 onwards. Exploratory assessment to be put together ahead of next benchmark.
Assessment model uncertainty – different models with the same assumptions result in quite different stock status	Application of a multiple model approach.	Scientists from MSS	Could be explored as part of WKENSEMBLE. In preparation for next benchmark.

[1] **MSS = Marine Scotland Science; MI = Marine Institute Ireland.**

5.6.2 Management considerations

The fisheries for cod have been fully under the landing obligation from 2019 onwards. In the past they have been managed by a combination of landings limits, area closures and technical measures. The measures taken thus far have not recovered the stock. Although fishing mortality declined between 2009 and 2016, it has shown an increase since then. It is not known whether, and to what extent, this increase is associated with the discontinuation of the days-at-sea regulation in 2017, which was part of the cod recovery plan.

Cod are known to form aggregations, so it is still possible to find areas of high cod density at low stock abundance (as apparent in the Scottish Q1 survey in particular). This can lead to high caches in localized areas, generating high fishing mortality even with low fishing effort. The impact of this could potentially be reduced by the use of temporary spatial closures.

The fishing opportunities regulation explicitly made the stock a bycatch species from 2012 to 2018. Allowing landings up to 1.5% of the live weight of the total catch can cause a perverse incentive for vessels to increase catches of other species and does not inhibit the catch of cod.

Although the UK 'Buyers and Sellers' and Irish 'Sales Notes' legislation is considered to have reduced underreporting from 2006, discard data showed increased discards at ages one and two, and a change in discard practices such that fish are discarded at older ages from 2006–2018 (i.e. such that the discards were largely high-grading). With the full implementation of the landing obligation in 2019 for fisheries catching cod, a bycatch TAC of 1735 t was set to allow mixed fisheries with a bycatch of cod to continue. The fishery has responded to this by reducing discards, particularly at higher ages. The forecast assumes that in 2020 and 2021, this discarding behaviour will continue. The bycatch TAC has been reduced to 1279 t in 2020.

Estimates of area misreporting (landings believed to be taken in Division 6.a and reported elsewhere) from imply ICES landings estimates which are in excess of TAC. Area misreported landings accounted for over 60% of the total landings in 2018 and although there has been a proportionate reduction in 2019 due to the increase in reported landings, the tonnage of area-misreported landings remains significant. Measures to reduce area misreporting should be introduced.

Cod is taken in mixed demersal fisheries, and in Division 6.a is a bycatch species. To greatly reduce cod catch would likely result in having to greatly reduce harvesting of other stocks such as haddock, whiting and anglerfish. It is also important the bycatch from the *Nephrops* fleet is closely monitored (including discard observations). In 2019, large trawl gear vessels targeting finfish are responsible for almost 90% of cod catches in Division 6.a, the *Nephrops* fleet take approximately 4% and the remainder are taken by other gears, including longliners and gillnets.

A report by the Sea Mammal Research unit (Hammond and Harris, 2006) gives estimates of cod consumed by grey seals to the west of Scotland. Although highly uncertain, the estimates suggest predation mortality on cod is significant and this may impair the ability of the cod stock to recover, but data are limited (Cook *et al.*, 2015).

5.7 References

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Table 5.1. Cod.27.6a. ICES official catch statistics.

Country	Belgium	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Netherlands	Norway	Spain	UK (E, W, N.I.)	UK (Scotland)	UK	Official BMS landings	Total
1985	48	-	-	7411	66	-	2564	-	204	28	260	8032	-		18613
1986	88	-	-	5096	53	-	1704	-	174	-	160	4251	-		11526
1987	33	4	-	5044	12	-	2442	-	77	-	444	11143	-		19199
1988	44	1	11	7669	25	-	2551	-	186	-	230	8465	-		19182
1989	28	3	26	3640	281	-	1642	-	207	85	278	9236	-		15426
1990	-	2	-	2220	586	-	1200	-	150	-	230	7389	-		11777
1991	6	2	-	2503	60	-	761	-	40	-	511	6751	-		10634
1992	-	3	-	1957	5	-	761	-	171	-	577	5543	-		9017
1993	22	2	-	3047	94	-	645	-	72	-	524	6069	-		10475
1994	1	+	-	2488	100	-	825	-	51	-	419	5247	-		9131
1995	2	4	-	2533	18	-	1054	-	61	16	450	5522	-		9660
1996	+	2	-	2253	63	-	1286	-	137	+	457	5382	-		9580
1997	11	-	-	956	5	-	708	2	36	6	779	4489	-		6992
1998	1	-	-	714	6	-	478	1	36	42	474	3919	-		5671
1999	+	+	-	842	8	-	223	-	79	45	381	2711	-		4289
2000	+	-	-	236	6	-	357	-	114	14	280	2057	-		3064
2001	2	-	-	391	4	-	319	-	39	3	138	1544	-		2440
2002	+	-	-	208	+	-	210	-	88	11	195	1519	-		2231
2003	-	-	-	172	+	-	120	-	45	3	79	879	-		1298
2004	-	-	2	91	-	-	34	-	10	-	46	413	-		596
2005	-	-	-	107	-	-	28	-	17	-	25	243	-		420

Country	Belgium	Denmark	Faroe Islands	France	Germany	Greenland	Ireland	Netherlands	Norway	Spain	UK (E, W, N.I.)	UK (Scotland)	UK	Official BMS landings	Total
2006	-	-	1	108	2	-	18	-	30	-	14	318	-		491
2007	-	-	12	92	2	-	70	-	30	-	21	260	-		487
2008	-	-	1	82	1	-	58	-	65	-	6	232	-		445
2009	-	-		74	-	-	24	-	18	-	14	104	-		234
2010	-	-	-	60	-	-	49	-	21	-	4	115	-		249
2011	-	-	-	49	-	-	41	-	8	-	3	107	-		208
2012	-	-	-	4	-	-	18	-	2	-	2	135	-		161
2013	-	-	-	3	-	-	14	-	24	-	1	130	-		172
2014	-	-	-	5	-	-	12	-	13	-	9	121	-		160
2015	-	-	-	11	-	-	17	-	59	-	-	-	168		256
2016	-	11	-	86	-	1	28	-	39	-	-	-	183		348
2017	-	1	-	119	-	-	19	-	14	-	-	-	200		352
2018	-	+	+	101	-	-	12	-	37	-	-	-	210		360
2019*	-	-	-	144	-	-	40	-	47	31	-	-	1225	+	1486
2020*				140		3	65		4	32			738	2	983

*** Preliminary.**

+ < 0.5 tonnes.

Table 5.2. Cod.27.6a. Landings (reported into 6a and area misreported), discards, BMS and catch (tonnes) estimates, as used by the WG (caton from InterCatch).

Year	Landings		Discards	BMS	Catch
	reported	misreported			
1981	23865		303		24168
1982	21511		571		22082
1983	21305		197		21503
1984	21272		329		21601
1985	18607		963		19570
1986	11820		263		12083
1987	18971		2388		21358
1988	20413		368		20781
1989	17169		2076		19246
1990	12175		571		12746
1991	10927		622		11549
1992	9086		1779		10865
1993	10314		139		10453
1994	8928		661		9588
1995	9439		141		9580
1996	9427		63		9489
1997	7034		499		7533
1998	5714		538		6252
1999	4201		69		4270
2000	2977		821		3798
2001	2347		92		2439
2002	2243		480		2722
2003	1292		60		1353
2004	573		78		651
2005	516		54		570
2006	470	34	461		965
2007	485	30	1651		2166
2008	460	102	1037		1598
2009	231	54	1287		1572
2010	239	119	1575		1933
2011	211	130	3867		4208
2012	162	65	1914		2141
2013	172	93	1870		2136
2014	161	234	3369		3764
2015	258	270	2498		3026
2016	336	272	1499		2108
2017	355	320	3519		4195
2018	378	613	2429		3419
2019	1489	571	204		2264
2020	941	332	307	2.5	1583

Table 5.3. Cod.27.6a. Landings-at-age (thousands). Values for 2006 onwards include an adjustment for area misreporting.

	1	2	3	4	5	6	7+
1978	723	1761	999	695	286	97	75
1979	929	1612	2125	682	342	134	69
1980	1195	3294	2001	796	191	77	37
1981	461	7016	3220	904	182	29	20
1982	1827	1673	3206	1189	367	111	33
1983	2335	4515	1118	1400	468	148	60
1984	2143	2360	2564	448	555	185	59
1985	1355	5069	1269	1091	140	167	79
1986	792	1486	2055	411	191	40	30
1987	7873	4837	988	905	137	56	26
1988	1008	8336	2193	278	210	39	20
1989	2017	1082	3858	709	113	69	33
1990	513	4024	432	924	170	23	11
1991	1518	1728	1805	188	266	70	23
1992	1407	1868	575	720	69	58	24
1993	328	3596	1050	131	183	24	36
1994	942	1207	1545	280	56	51	20
1995	753	2750	700	630	70	15	11
1996	341	2331	1210	247	204	31	13
1997	1414	1067	989	281	66	62	7
1998	310	3318	293	174	57	16	9
1999	132	884	1047	64	48	24	9
2000	765	532	211	231	15	12	13
2001	96	1241	155	63	52	3	4
2002	337	340	522	41	13	14	4
2003	53	487	93	120	7	2	2
2004	45	99	90	12	27	3	1
2005	37	124	46	40	7	6	0
2006	18	97	78	23	14	2	1
2007	7	170	53	28	2	3	2
2008	0	20	106	21	13	1	2
2009	1	9	10	40	6	1	0
2010	6	80	26	20	11	1	1
2011	0	29	51	18	4	6	1
2012	1	1	18	24	3	2	2
2013	0	8	7	39	9	2	1
2014	0	5	73	34	25	2	0
2015	0	44	40	29	21	19	1
2016	1	17	82	52	17	9	11
2017	0	13	52	47	46	13	3
2018	2	10	28	78	51	32	11
2019	9	21	129	89	142	57	13
2020	7	75	9	55	44	53	30

Table 5.4. Cod.27.6a. Mean weight-at-age in landings (kg).

	1	2	3	4	5	6	7+
1978	0.63	1.373	3.389	5.262	7.096	8.686	9.857
1979	0.693	1.373	2.828	4.853	6.433	7.784	9.636
1980	0.624	1.375	3.002	5.277	7.422	8.251	9.331
1981	0.55	1.166	2.839	4.923	7.518	9.314	10.328
1982	0.692	1.468	2.737	4.749	6.113	7.227	9.856
1983	0.583	1.265	2.995	4.398	6.305	8.084	9.744
1984	0.735	1.402	3.168	5.375	6.601	8.606	10.35
1985	0.628	1.183	2.597	4.892	6.872	8.344	9.766
1986	0.71	1.211	2.785	4.655	6.336	8.283	9.441
1987	0.531	1.312	2.783	4.574	6.161	7.989	10.062
1988	0.806	1.182	2.886	5.145	6.993	8.204	9.803
1989	0.704	1.298	2.425	4.737	7.027	7.52	9.594
1990	0.613	1.275	2.815	4.314	7.021	9.027	11.671
1991	0.64	1.095	2.618	4.346	6.475	8.134	10.076
1992	0.686	1.293	2.607	4.268	6.19	7.844	10.598
1993	0.775	1.316	2.94	4.646	6.244	7.802	8.409
1994	0.644	1.292	2.899	4.71	6.389	8.423	8.409
1995	0.606	1.148	2.857	4.956	6.771	8.539	9.505
1996	0.667	1.221	2.738	5.056	6.892	8.088	10.759
1997	0.595	1.21	2.571	4.805	6.952	7.821	9.63
1998	0.605	1.061	2.264	4.506	6.104	8.017	9.612
1999	0.691	1.039	2.194	4.688	6.486	8.252	9.439
2000	0.689	1.261	2.457	4.126	6.666	7.917	8.392
2001	0.654	0.988	2.679	4.568	5.86	7.741	9.386
2002	0.668	1.14	2.33	4.841	6.175	7.192	9.548
2003	0.659	1.046	2.272	3.82	5.932	8.022	8.681
2004	0.605	1.026	2.191	4.398	6.033	8.242	9.84
2005	0.75	1.109	2.425	3.969	4.775	6.616	10.214
2006	0.659	1.176	2.239	3.813	6.16	7.759	11.041
2007	0.728	1.127	2.592	4.322	6.503	7.738	8.83
2008	0.556	1.157	3.067	4.843	6.283	7.964	8.487
2009	0.974	2.038	2.861	4.781	6.004	8.327	9.137
2010	0.936	1.468	2.918	4.064	5.785	9.158	10.275
2011	0	1.804	2.811	4.51	5.842	6.528	9.837
2012	0.661	1.797	3.118	5.331	6.428	7.617	8.695
2013	0.957	1.368	2.933	4.075	6.135	7.144	9.842
2014	1.028	1.6	2.097	3.051	4.693	5.503	7.207
2015	0.914	2.406	2.958	3.844	5.455	5.558	9.158
2016	0.713	1.429	2.367	3.917	5.137	6.596	7.622
2017	0.902	1.229	2.063	4.533	5.616	5.081	9.243
2018	0.871	1.686	2.761	4.163	5.427	6.427	8.575
2019	0.857	1.159	2.962	4.242	5.461	7.045	8.841
2020	0.618	1.310	2.308	4.763	5.957	6.362	6.448

Table 5.5. Cod.27.6a. Discard numbers-at-age (thousands).

	1	2	3	4	5	6	7+
1978	412	26	0	0	0	0	0
1979	16	81	0	0	0	0	0
1980	1171	0	0	0	0	0	0
1981	54	907	0	0	0	0	0
1982	1808	8	0	0	0	0	0
1983	843	25	0	0	0	0	0
1984	1088	11	0	0	0	0	0
1985	5188	114	0	0	0	0	0
1986	970	14	0	0	0	0	0
1987	14358	12	0	0	0	0	0
1988	231	1059	2	0	0	0	0
1989	6243	6	0	0	0	0	0
1990	4181	41	0	0	0	0	0
1991	2518	14	2	0	0	0	0
1992	7385	143	3	0	0	0	0
1993	279	84	1	0	0	0	0
1994	2743	6	0	0	0	0	0
1995	625	56	0	0	0	0	0
1996	191	50	0	0	0	0	0
1997	1521	34	0	0	0	0	0
1998	790	972	0	0	0	0	0
1999	230	5	0	0	0	0	0
2000	2882	33	0	0	0	0	0
2001	176	115	0	0	0	0	0
2002	1051	199	0	0	0	0	0
2003	124	27	7	0	0	0	0
2004	238	23	0	0	0	0	0
2005	127	22	0	0	0	0	0
2006	1058	45	25	2	3	1	0
2007	283	1321	46	35	2	3	0
2008	64	151	416	3	1	0	0
2009	590	157	116	146	8	7	0
2010	410	810	150	17	7	0	0
2011	303	579	1255	102	1	4	0
2012	1029	180	605	78	0	0	0
2013	2175	346	220	167	24	0	3
2014	913	948	644	116	45	2	0
2015	264	571	620	72	18	2	0
2016	1253	377	189	94	13	0	0
2017	240	429	912	223	43	5	0
2018	87	447	206	300	54	18	6
2019	248	112	49	6	1	0	0
2020	304	173	16	10	0	0	0

Table 5.6. Cod.27.6a. Mean weight-at-age in discards (kg).

	1	2	3	4	5	6	7+
1978	0.37	0.321					
1979	0.276	0.43					
1980	0.361						
1981	0.135	0.326					
1982	0.314	0.392					
1983	0.223	0.374					
1984	0.298	0.435					
1985	0.178	0.346					
1986	0.267	0.305					
1987	0.166	0.37					
1988	0.296	0.283					
1989	0.332	0.59					
1990	0.132	0.454					
1991	0.245	0.351					
1992	0.22	1.03	2.382				
1993	0.239	0.812	3.723				
1994	0.24	0.365					
1995	0.203	0.256					
1996	0.226	0.389					
1997	0.321	0.328					
1998	0.23	0.367	0.59				
1999	0.294	0.299					
2000	0.28	0.421					
2001	0.248	0.417					
2002	0.263	1.021					
2003	0.311	0.6	0.388				
2004	0.261	0.576					
2005	0.242	0.483	0.803				
2006	0.276	1.346	2.786	3.501	6.242	5.581	11.151
2007	0.196	0.948	3.014	4.457	4.985	10.635	
2008	0.224	0.999	2.049	3.853	5.216		
2009	0.264	1.333	2.296	3.834	6.051	6.985	9.119
2010	0.273	1.274	2.268	3.218	3.245		
2011	0.266	1.072	2.213	2.993	4.891	4.168	
2012	0.142	1.118	2.179	3.222			
2013	0.125	1.155	2.11	3.05	5.029		6.269
2014	0.15	1.21	2.39	3.066	3.998	4.349	
2015	0.404	1.063	2.33	3.428	4.414	6.103	
2016	0.205	1.096	2.212	3.759	4.435		
2017	0.262	1.048	2.183	3.473	4.397	7.714	
2018	0.217	1.046	2.219	3.649	5.3	4.98	2.117
2019	0.226	0.548	1.397	2.318	3.516		
2020	0.167	0.922	3.199	4.763			

Table 5.7. Cod.27.6a. Total catch-at-age (thousands).

	1	2	3	4	5	6	7+
1978	1135	1787	999	695	286	97	75
1979	945	1693	2125	682	342	134	69
1980	2366	3294	2001	796	191	77	37
1981	515	7923	3220	904	182	29	20
1982	3635	1681	3206	1189	367	111	33
1983	3178	4540	1118	1400	468	148	60
1984	3231	2371	2564	448	555	185	59
1985	6543	5183	1269	1091	140	167	79
1986	1762	1500	2055	411	191	40	30
1987	22231	4849	988	905	137	56	26
1988	1239	9395	2195	278	210	39	20
1989	8260	1088	3858	709	113	69	33
1990	4694	4065	432	924	170	23	11
1991	4036	1742	1807	188	266	70	23
1992	8792	2011	578	720	69	58	24
1993	607	3680	1051	131	183	24	36
1994	3685	1213	1545	280	56	51	20
1995	1378	2806	700	630	70	15	11
1996	532	2381	1210	247	204	31	13
1997	2935	1101	989	281	66	62	7
1998	1100	4290	293	174	57	16	9
1999	362	889	1047	64	48	24	9
2000	3647	565	211	231	15	12	13
2001	272	1356	155	63	52	3	4
2002	1388	539	522	41	13	14	4
2003	176	514	100	120	7	2	2
2004	282	122	90	12	27	3	1
2005	163	146	46	40	7	6	0
2006	1076	143	104	25	17	3	1
2007	290	1492	100	64	5	6	2
2008	64	171	522	24	15	1	2
2009	591	166	126	186	14	8	1
2010	416	889	175	37	17	1	1
2011	303	608	1307	120	5	10	1
2012	1030	181	623	101	3	2	2
2013	2175	355	228	206	33	2	4
2014	913	953	717	149	70	4	0
2015	264	615	660	102	39	21	1
2016	1254	394	271	146	30	9	11
2017	240	442	963	270	89	18	3
2018	88	457	235	378	105	49	16
2019	256	132	178	95	142	57	13
2020	311	248	26	65	44	53	30

Table 5.8. Cod.27.6a. Mean weight-at-age (kg) in total catch.

	1	2	3	4	5	6	7+
1978	0.536	1.358	3.389	5.262	7.096	8.686	9.857
1979	0.686	1.328	2.828	4.853	6.433	7.784	9.636
1980	0.494	1.375	3.002	5.277	7.422	8.251	9.331
1981	0.506	1.07	2.839	4.923	7.518	9.314	10.328
1982	0.504	1.463	2.737	4.749	6.113	7.227	9.856
1983	0.488	1.26	2.995	4.398	6.305	8.084	9.744
1984	0.588	1.398	3.168	5.375	6.601	8.606	10.35
1985	0.271	1.165	2.597	4.892	6.872	8.344	9.766
1986	0.466	1.203	2.785	4.655	6.336	8.283	9.441
1987	0.295	1.31	2.783	4.574	6.161	7.989	10.062
1988	0.711	1.081	2.883	5.145	6.993	8.204	9.803
1989	0.423	1.294	2.425	4.737	7.027	7.52	9.594
1990	0.185	1.267	2.815	4.314	7.021	9.027	11.671
1991	0.394	1.089	2.615	4.346	6.475	8.134	10.076
1992	0.295	1.274	2.606	4.268	6.19	7.844	10.598
1993	0.529	1.304	2.941	4.646	6.244	7.802	8.409
1994	0.343	1.287	2.899	4.71	6.389	8.423	8.409
1995	0.423	1.13	2.857	4.956	6.771	8.539	9.505
1996	0.509	1.204	2.738	5.056	6.892	8.088	10.759
1997	0.453	1.183	2.571	4.805	6.952	7.821	9.63
1998	0.336	0.904	2.264	4.506	6.104	8.017	9.612
1999	0.439	1.035	2.194	4.688	6.486	8.252	9.439
2000	0.366	1.212	2.457	4.126	6.666	7.917	8.392
2001	0.391	0.94	2.679	4.568	5.86	7.741	9.386
2002	0.361	1.096	2.33	4.841	6.175	7.192	9.548
2003	0.415	1.023	2.14	3.82	5.932	8.022	8.681
2004	0.316	0.943	2.191	4.398	6.033	8.242	9.84
2005	0.356	1.014	2.425	3.969	4.775	6.616	10.214
2006	0.282	1.23	2.373	3.789	6.175	7.002	11.046
2007	0.209	0.969	2.788	4.397	5.726	9.174	8.83
2008	0.224	1.018	2.256	4.715	6.189	7.964	8.487
2009	0.266	1.372	2.342	4.039	6.03	7.222	9.111
2010	0.282	1.291	2.363	3.683	4.784	9.158	10.275
2011	0.266	1.107	2.237	3.221	5.722	5.507	9.837
2012	0.142	1.12	2.205	3.713	6.428	7.617	8.695
2013	0.125	1.16	2.137	3.243	5.336	7.144	7.145
2014	0.15	1.212	2.36	3.063	4.245	4.984	7.207
2015	0.405	1.159	2.368	3.548	4.964	5.612	9.158
2016	0.206	1.11	2.259	3.815	4.834	6.596	7.622
2017	0.263	1.053	2.177	3.656	5.032	5.746	9.243
2018	0.229	1.06	2.285	3.755	5.362	5.909	6.304
2019	0.248	0.644	2.532	4.112	5.450	7.045	8.841
2020	0.178	1.039	2.873	4.763	5.957	6.362	6.448

Table 5.9. Cod.27.6a. Mean weight-at-age (kg) in stock.

	1	2	3	4	5	6	7
1981	0.496	1.262	2.899	4.844	6.884	8.390	10.102
1982	0.488	1.256	2.882	4.844	6.850	8.370	10.079
1983	0.480	1.250	2.865	4.841	6.815	8.350	10.055
1984	0.473	1.244	2.848	4.830	6.781	8.330	10.032
1985	0.465	1.238	2.830	4.807	6.746	8.311	10.009
1986	0.457	1.232	2.811	4.773	6.712	8.291	9.986
1987	0.450	1.225	2.793	4.731	6.677	8.272	9.962
1988	0.442	1.219	2.774	4.685	6.642	8.252	9.938
1989	0.434	1.213	2.755	4.644	6.606	8.232	9.912
1990	0.427	1.207	2.736	4.616	6.570	8.211	9.885
1991	0.419	1.201	2.716	4.605	6.532	8.188	9.857
1992	0.411	1.195	2.695	4.614	6.494	8.164	9.827
1993	0.404	1.188	2.671	4.638	6.455	8.139	9.795
1994	0.396	1.182	2.646	4.669	6.415	8.111	9.763
1995	0.388	1.176	2.618	4.696	6.374	8.080	9.730
1996	0.380	1.170	2.588	4.709	6.332	8.047	9.697
1997	0.373	1.164	2.556	4.698	6.288	8.009	9.662
1998	0.365	1.158	2.524	4.663	6.243	7.969	9.626
1999	0.357	1.152	2.493	4.605	6.197	7.924	9.588
2000	0.350	1.145	2.464	4.533	6.149	7.875	9.548
2001	0.342	1.139	2.438	4.456	6.101	7.822	9.505
2002	0.334	1.133	2.415	4.383	6.051	7.766	9.459
2003	0.327	1.127	2.394	4.319	6.001	7.704	9.408
2004	0.319	1.121	2.376	4.264	5.950	7.639	9.353
2005	0.311	1.115	2.361	4.210	5.899	7.569	9.290
2006	0.304	1.108	2.348	4.150	5.848	7.493	9.221
2007	0.296	1.102	2.337	4.075	5.797	7.412	9.144
2008	0.288	1.096	2.328	3.980	5.745	7.326	9.059
2009	0.281	1.090	2.321	3.867	5.693	7.234	8.965
2010	0.273	1.084	2.316	3.745	5.641	7.138	8.864
2011	0.265	1.078	2.315	3.628	5.590	7.037	8.756
2012	0.258	1.072	2.316	3.533	5.538	6.933	8.643
2013	0.250	1.065	2.322	3.477	5.487	6.828	8.525
2014	0.242	1.059	2.332	3.471	5.437	6.722	8.402
2015	0.235	1.053	2.346	3.520	5.386	6.616	8.277
2016	0.227	1.047	2.364	3.622	5.337	6.512	8.149
2017	0.219	1.041	2.386	3.769	5.288	6.408	8.020
2018	0.212	1.035	2.411	3.950	5.239	6.306	7.888
2019	0.204	1.028	2.437	4.151	5.191	6.204	7.756
2020	0.196	1.022	2.465	4.361	5.143	6.103	7.624

Table 5.10. Cod.27.6a. Natural mortality.

	1	2	3	4	5	6	7
1981	0.496	0.378	0.297	0.256	0.231	0.218	0.207
1982	0.498	0.379	0.298	0.256	0.232	0.219	0.207
1983	0.501	0.379	0.298	0.256	0.232	0.219	0.207
1984	0.503	0.380	0.299	0.256	0.232	0.219	0.207
1985	0.505	0.380	0.299	0.257	0.233	0.219	0.207
1986	0.508	0.381	0.300	0.257	0.233	0.219	0.208
1987	0.510	0.382	0.300	0.258	0.233	0.219	0.208
1988	0.513	0.382	0.301	0.259	0.234	0.219	0.208
1989	0.515	0.383	0.302	0.259	0.234	0.220	0.208
1990	0.518	0.383	0.302	0.260	0.234	0.220	0.208
1991	0.521	0.384	0.303	0.260	0.235	0.220	0.208
1992	0.524	0.384	0.304	0.260	0.235	0.220	0.209
1993	0.527	0.385	0.304	0.259	0.236	0.220	0.209
1994	0.529	0.386	0.305	0.259	0.236	0.221	0.209
1995	0.532	0.386	0.306	0.258	0.237	0.221	0.209
1996	0.536	0.387	0.307	0.258	0.237	0.221	0.209
1997	0.539	0.387	0.308	0.258	0.237	0.221	0.210
1998	0.542	0.388	0.309	0.259	0.238	0.222	0.210
1999	0.545	0.388	0.310	0.260	0.238	0.222	0.210
2000	0.549	0.389	0.312	0.261	0.239	0.222	0.210
2001	0.552	0.390	0.313	0.262	0.240	0.223	0.211
2002	0.556	0.390	0.313	0.264	0.240	0.223	0.211
2003	0.560	0.391	0.314	0.265	0.241	0.224	0.211
2004	0.564	0.392	0.315	0.266	0.241	0.224	0.212
2005	0.568	0.392	0.315	0.267	0.242	0.225	0.212
2006	0.572	0.393	0.316	0.268	0.242	0.226	0.212
2007	0.576	0.393	0.316	0.269	0.243	0.226	0.213
2008	0.580	0.394	0.317	0.271	0.244	0.227	0.214
2009	0.585	0.395	0.317	0.273	0.244	0.228	0.214
2010	0.590	0.395	0.317	0.276	0.245	0.229	0.215
2011	0.595	0.396	0.317	0.278	0.246	0.230	0.216
2012	0.600	0.397	0.317	0.281	0.246	0.231	0.217
2013	0.605	0.397	0.317	0.282	0.247	0.232	0.217
2014	0.610	0.398	0.317	0.282	0.248	0.233	0.218
2015	0.616	0.399	0.316	0.281	0.248	0.234	0.219
2016	0.622	0.399	0.315	0.279	0.249	0.235	0.220
2017	0.628	0.400	0.314	0.275	0.250	0.236	0.221
2018	0.635	0.401	0.314	0.272	0.250	0.237	0.222
2019	0.642	0.401	0.313	0.268	0.251	0.238	0.223
2020	0.649	0.402	0.312	0.264	0.252	0.240	0.225

Table 5.11. Cod.27.6a. Survey data made available to the WG. Data used in update assessment are highlighted in bold. For the Scottish surveys, numbers are standardised to catch rate per ten hours. For the Irish surveys, effort is given as minutes towed and numbers are in units.

ScoGFS- WIBTS- Q1: **Scottish west coast groundfish survey (ages 1–6 used)**

Effort (Hrs)	1	2	3	4	5	6	7	
10	**1.5**	**23.7**	**8.6**	**13.6**	**3.9**	**2.5**	1.2	1985
10	**1.5**	**6.9**	**26.8**	**5.6**	**7.3**	**2.5**	1.9	1986
10	**57.4**	**16.2**	**15.3**	**22.8**	**3.0**	**2.8**	0.0	1987
10	**0.0**	**64.9**	**14.2**	**3.4**	**2.1**	**0.7**	0.2	1988
10	**4.5**	**7.2**	**45.1**	**8.6**	**1.9**	**0.5**	0.8	1989
10	**2.0**	**24.6**	**4.1**	**14.7**	**4.2**	**1.6**	0.8	1990
10	**4.8**	**5.4**	**17.4**	**5.2**	**13.4**	**2.8**	0.5	1991
10	**7.3**	**11.5**	**5.4**	**7.6**	**3.4**	**2.3**	0.5	1992
10	**1.7**	**38.2**	**12.7**	**1.7**	**1.4**	**1.1**	0.0	1993
10	**13.6**	**14.7**	**25.1**	**5.8**	**1.0**	**0.0**	0.0	1994
10	**6.4**	**23.8**	**14.0**	**16.5**	**1.2**	**1.9**	0.7	1995
10	**2.8**	**20.9**	**24.1**	**4.1**	**2.8**	**1.3**	0.0	1996
10	**11.1**	**7.7**	**11.6**	**7.9**	**4.2**	**4.7**	1.0	1997
10	**2.8**	**30.9**	**5.3**	**8.7**	**3.7**	**0.6**	2.0	1998
10	**1.5**	**8.2**	**8.2**	**1.4**	**3.2**	**0.5**	0.5	1999
10	**13.3**	**5.4**	**6.9**	**1.3**	**0.0**	**0.4**	0.0	2000
10	**2.7**	**18.4**	**5.7**	**13.2**	**19.5**	**1.1**	1.6	2001
10	**5.3**	**4.3**	**10.6**	**2.6**	**0.5**	**3.0**	0.0	2002
10	**2.7**	**16.7**	**2.0**	**4.7**	**1.8**	**0.7**	0.4	2003
10	**5.7**	**3.0**	**5.6**	**2.3**	**1.7**	**0.0**	0.0	2004
10	**1.3**	**1.5**	**1.2**	**0**	**0**	**0.4**	0	2005
10	**2.2**	**1.9**	**1.1**	**0.3**	**0**	**0**	0.3	2006
10	**2.1**	**18.8**	**3.4**	**1.2**	**0**	**0.6**	0	2007
10	**0.8**	**2.1**	**44.2**	**6.3**	**0.8**	**0**	0	2008
10	**1.8**	**2.6**	**2.3**	**0.4**	**0**	**0**	0	2009
10	**4.6**	**16.2**	**3.7**	**1.0**	**0.7**	**0**	0	2010

Table 5.11. Continued. Cod.27.6a. Survey data made available to the WG. For the Scottish surveys, numbers are standardised to catch rate per ten hours. For the Irish surveys, effort is given as minutes towed and numbers are in units.

UK-SCOWCGFS-Q1 (index) (ages 1–6 used)

Effort (Hrs)	1	2	3	4	5	6	7	8
10	**0.52**	**32.95**	**21.07**	**0.93**	**0.98**	**0.74**	0.00	2011
10	**13.99**	**27.30**	**22.72**	**4.58**	**3.50**	**2.20**	4.20	2012
10	**20.03**	**40.26**	**26.38**	**36.95**	**7.76**	**0.30**	0.00	2013
10	**11.40**	**41.73**	**13.44**	**5.12**	**4.31**	**0.75**	0.00	2014
10	**8.16**	**36.40**	**70.70**	**37.74**	**23.25**	**13.00**	2.47	2015
10	**4.73**	**56.07**	**65.41**	**44.56**	**5.67**	**2.36**	2.29	2016
10	**2.92**	**33.49**	**50.58**	**49.58**	**156.64**	**10.71**	24.89	2017
10	**1.728**	**20.375**	**7.199**	**19.765**	**9.98**	**2.261**	1.092	2018
10	**9.924**	**4.173**	**6.888**	**2.031**	**3.181**	**0.318**	0.318	2019
10	**14.433**	**28.978**	**11.516**	**9.782**	**1.176**	**0.646**	0.0	2020
10	**1.175**	**12.137**	**22.988**	**2.946**	**2.519**	**1.236**	0.0	2021

UK-SCOWCGFS-Q1 (variance)

Effort (Hrs)	1	2	3	4	5	6	7	8
10	**0.09**	**78.37**	**24.06**	**0.22**	**0.49**	**0.30**	0.00	2011
10	**44.18**	**120.08**	**33.73**	**2.31**	**8.34**	**4.83**	13.02	2012
10	**118.35**	**151.04**	**136.89**	**240.05**	**6.47**	**0.09**	0.00	2013
10	**20.17**	**383.27**	**12.23**	**3.04**	**5.47**	**0.28**	0.00	2014
10	**14.35**	**112.82**	**1264.73**	**602.27**	**289.82**	**98.91**	5.48	2015
10	**1.81**	**214.42**	**607.48**	**319.21**	**5.02**	**1.60**	1.85	2016
10	**1.43**	**155.67**	**498.57**	**1061.90**	**20475.95**	**84.79**	287.62	2017
10	**1**	**24.03**	**2.21**	**20.09**	**7.46**	**0.5**	0.25	2018
10	**6.79**	**2.03**	**6.12**	**0.6**	**1.98**	**0.1**	0	2019
10	**121.47**	**65.29**	**14.48**	**24.01**	**0.46**	**0.22**	0	2020
10	**1.03**	**10.19**	**31.36**	**1.35**	**0.92**	**0.37**	0.13	2021

Table 5.11. Continued. Cod.27.6a. Survey data made available to the WG. For the Scottish surveys, numbers are standardised to catch rate per ten hours. For the Irish surveys, effort is given as minutes towed and numbers are in units.

IreGFS	**Irish groundfish survey**				
1993	2002				
Effort (Hrs)	0	1	2	3	
1849	0.0	312.0	49.0	13.0	1993
1610	20.0	999.0	56.0	13.0	1994
1826	78.0	169.0	142.0	69.0	1995
1765	0.0	214.0	89.0	18.0	1996
1581	6.0	565.0	31.0	10.0	1997
1639	0.0	83.0	53.0	6.0	1998
1564	0.0	24.0	14.0	3.0	1999
1556	0.0	124.0	4.0	1.0	2000
755	3.0	82.0	28.0	2.0	2001
798	0.0	50.6	2.2	1.2	2002

ScoGFS-WIBTS-Q4: **Quarter 4 Scottish ground fish survey (ages 1–4 used)**

1996	**2010**									
Effort (Hrs)	0	1	2	3	4	5	6	7	8	
10	0	**0.7**	**14.4**	**5**	**3**	1.1	0.5	0	0	1996
10	1	**10.9**	**2.4**	**1.4**	**1.4**	1.4	0.2	0	0	1997
10	+	**14.8**	**9.7**	**1.1**	**0**	0	0	0	0	1998
10	2	**4**	**6**	**9.2**	**0.5**	0	0	0	0	1999
10	0	**15.8**	**2.6**	**0.4**	**0.4**	0	0	0	0	2000
10	1	**1.7**	**7.3**	**1.7**	**0.3**	0	0	0	0	2001
10	1	**10.4**	**2.8**	**6.8**	**0.6**	0	0	0	0	2002
10	1	**1.5**	**11.3**	**2.9**	**0.6**	0	0	0	0	2003
10	0	**5.1**	**3.8**	**1.4**	**0**	0.7	0	0	0	2004
10	+	**2.1**	**3**	**0**	**0.6**	0.3	0	0	0	2005
10	0	**16.9**	**5.9**	**1.4**	**0.7**	0	0	0	0	2006
10	0	**12**	**20**	**1.3**	**0.5**	0	0.3	0	0	2007
10	2	**7.7**	**5**	**7**	**1**	0	0	0	0	2008
10	2	**14.2**	**3.8**	**1.2**	**1.2**	0.3	0	0	0	2009
10	na	na	na	na	na	na	na	na	na	2010

Table 5.11. Cont. Cod.27.6a. Survey data made available to the WG. For the Scottish surveys, numbers are standardised to catch rate per ten hours. For the Irish surveys, effort is given as minutes towed and numbers are in units.

UK-SCOWCGFS-Q4 (index) (ages 1–6 used)

Effort (Hrs)	0	1	2	3	4	5	6	7	8	
10	0.60	**9.71**	**31.54**	**10.88**	**0.93**	**1.70**	**2.38**	0.00	0.00	2011
10	0.75	**19.78**	**7.12**	**15.43**	**13.60**	**1.02**	**0.68**	0.34	0.00	2012
Survey not completed due to mechanical issues										2013
10	1.67	**23.65**	**28.06**	**15.63**	**5.57**	**6.63**	**1.37**	0.00	0.00	2014
10	3.64	**28.17**	**52.53**	**34.22**	**10.58**	**4.24**	**5.27**	1.18	0.59	2015
10	0.374	**6.162**	**34.941**	**45.443**	**118.92**	**14.893**	**5.773**	3.176	0	2016
10	2.127	**10.024**	**6.221**	**24.427**	**10.881**	**8.538**	**0.767**	0.511	0	2017
10	0	**4.569**	**15.945**	**4.809**	**39.902**	**29.022**	**10.887**	0.829	0	2018
10	0.351	**17.65**	**1.402**	**3.246**	**3.457**	**1.814**	**0.627**	0.363	0	2019
10	0.601	**15.988**	**24.873**	**3.472**	**4.936**	**1.35**	**0.783**	0.392	0	2020

UK-SCOWCGFS-Q4 (variance)

Effort (Hrs)	0	1	2	3	4	5	6	7	8	
10	0.21	**31.08**	**38.07**	**5.78**	**0.19**	**1.56**	**4.79**	0.00	0.00	2011
10	0.14	**41.72**	**2.79**	**11.37**	**48.79**	**1.05**	**0.46**	0.12	0.00	2012
Survey not completed due to mechanical issues										2013
10	0.68	**132.97**	**56.62**	**44.17**	**3.87**	**4.79**	**0.39**	0.00	0.00	2014
10	5.55	**98.78**	**316.23**	**51.22**	**8.60**	**4.43**	**4.61**	0.34	0.12	2015
10	0.14	**7.394**	**419.36**	**716.38**	**7654.82**	**118.64**	**24.30**	6.08	0	2016
10	3.215	**11.252**	**3.816**	**76.154**	**14.262**	**8.928**	**0.207**	0.063	0	2017
10	0	**3.71**	**28.22**	**8.46**	**532.1**	**271.49**	**44.45**	0.39	0	2018
10	0.03	**88.63**	**0.43**	**1.86**	**2.6**	**0.67**	**0.39**	0.13	0	2019
10	0.36	**14.8**	**16.12**	**1.84**	**6.76**	**0.71**	**0.61**	0.15	0	2020

Table 5.11. Continued. Cod.27.6a. Survey data made available to the WG. For the Scottish surveys, numbers are standardised to catch rate per ten hours. For the Irish surveys, effort is given as minutes towed and numbers are in units.

IRGFS-WIBTS-Q4 Irish West Coast groundfish. (ages 1–3 used)

Effort (Hrs)	0	1	2	3	4	
1127	0	**10**	**11**	**0**	0	2003
1200	0	**24**	**10**	**1**	0	2004
960	63	**13**	**7**	**0**	2	2005
1510	0	**95**	**12**	**0**	0	2006
1173	0	**161**	**12**	**0**	1	2007
1135	0	**23**	**24**	**4**	0	2008
1378	1	**75**	**4**	**5**	0	2009
1291	0	**70**	**31**	**4**	3	2010
1287	1	**26**	**26**	**4**	0	2011
1230	0	**74**	**7**	**3**	0	2012
1295	0	**92**	**11**	**0**	0	2013
1200	0	**113**	**20**	**2**	0	2014
1213	0	**15**	**11**	**3**	0	2015
962	0	**27**	**23**	**2**	0	2016
1196	0	**2**	**17**	**7**	2	2017
966	1	**21**	**3**	**0**	1	2018
1291	0	36	1	0	0	2019
805	6	4	6	2	0	2020

Table 5.12. Cod.27.6a. SAM configuration file.

```
# Where a matrix is specified rows corresponds to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive
#
$minAge
# The minimium age class in the assessment
 1

$maxAge
# The maximum age class in the assessment
 7

$maxAgePlusGroup
# Is last age group considered a plus group for each fleet (1 yes, or 0 no).
 1 0 0 0 0 0

$keyLogFsta
# Coupling of the fishing mortality states (nomally only first row is used).
  0  1  2  3  3  3  3
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1

$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, 2 AR(1), 3 separable AR(1).
 2

$keyLogFpar
# Coupling of the survey catchability parameters (normally first row is not used, as that is covered by fishing mortality).
 -1 -1 -1 -1 -1 -1 -1
  0  1  2  3  4  5 -1
  6  7  7 -1 -1 -1 -1
  8  9 10 10 -1 -1 -1
 11 12 13 14 15 15 -1
 16 17 18 19 20 20 -1

$keyQpow
# Density dependent catchability power parameters (if any).
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1

$keyVarF
# Coupling of process variance parameters for log(F)-process (normally only first row is used)
  0  1  1  1  1  1  1
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1
```

```
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1

$keyVarLogN
# Coupling of process variance parameters for log(N)-process
 0 1 1 1 1 1 1

$keyVarObs
# Coupling of the variance parameters for the observations.
  0  1  1  1  1  1  2
  3  3  3  3  3  3 -1
  4  4  4 -1 -1 -1 -1
  5  5  5  5 -1 -1 -1
  6  6  6  6  6  6 -1
  7  7  7  7  7  7 -1

$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"
 "ID" "ID" "ID" "ID" "ID" "ID"

$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#1-2 2-3 3-4 4-5 5-6 6-7
 NA  NA  NA  NA  NA  NA
 NA  NA  NA  NA  NA  -1
 NA  NA  -1  -1  -1  -1
 NA  NA  NA  -1  -1  -1
 NA  NA  NA  NA  NA  -1
 NA  NA  NA  NA  NA  -1

$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, 2 for Beverton–-Holt, and 3 piece-wise constant).
 0

$noScaledYears
# Number of years where catch scaling is applied.
 12

$keyScaledYears
# A vector of the years where catch scaling is applied.
 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006

$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).
0  0  0  0  0  0  0
1  1  1  1  1  1  1
2  2  2  2  2  2  2
3  3  3  3  3  3  3
4  4  4  4  4  4  4
5  5  5  5  5  5  5
```

```
 6   6   6   6   6   6   6
 7   7   7   7   7   7   7
 8   8   8   8   8   8   8
 9   9   9   9   9   9   9
10  10  10  10  10  10  10
11  11  11  11  11  11  11

$fbarRange
# lowest and highest age included in Fbar
 2 5

$keyBiomassTreat
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, 2 FSB index, 3 total catch, 4 total landings and 5 TSB index).
 -1 -1 -1 -1 -1 -1

$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN" "LN" "LN" "LN"

$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).
 0

$fracMixF
# The fraction of t(3) distribution used in logF increment distribution
 0

$fracMixN
# The fraction of t(3) distribution used in logN increment distribution
 0

$fracMixObs
# A vector with same length as number of fleets, where each element is the fraction of t(3) distribution used in the distribution of that fleet
 0 0 0 0 0 0

$constRecBreaks
# Vector of break years between which recruitment is at constant level. The break year is included in the left interval. (This option is only used in combination with stock–recruitment code 3)
```

Table 5.13. Cod.27.6a. SAM estimated model parameters.

	par	sd(par)	exp(par)	Low	High
logFpar_0	-9.82838	0.15859	0.00005	0.00004	0.00007
logFpar_1	-7.97542	0.15230	0.00034	0.00025	0.00047
logFpar_2	-7.09473	0.15240	0.00083	0.00061	0.00113
logFpar_3	-6.64948	0.15455	0.00129	0.00095	0.00176
logFpar_4	-6.17985	0.16636	0.00207	0.00148	0.00289
logFpar_5	-5.77522	0.17565	0.00310	0.00218	0.00441
logFpar_6	-11.05502	0.20677	0.00002	0.00001	0.00002
logFpar_7	-11.37316	0.16734	0.00001	0.00001	0.00002
logFpar_8	-8.22207	0.23173	0.00027	0.00017	0.00043
logFpar_9	-7.17275	0.23217	0.00077	0.00048	0.00122
logFpar_10	-6.87532	0.18451	0.00103	0.00071	0.00149
logFpar_11	-8.46820	0.22338	0.00021	0.00013	0.00033
logFpar_12	-6.28431	0.16495	0.00187	0.00134	0.00259
logFpar_13	-5.83587	0.16360	0.00292	0.00211	0.00405
logFpar_14	-5.41641	0.20294	0.00444	0.00296	0.00667
logFpar_15	-4.88943	0.21227	0.00753	0.00492	0.01151
logFpar_16	-6.90009	0.19471	0.00101	0.00068	0.00149
logFpar_17	-6.11951	0.15086	0.00220	0.00163	0.00297
logFpar_18	-5.48184	0.16282	0.00416	0.00300	0.00576
logFpar_19	-4.66324	0.21101	0.00944	0.00619	0.01439
logFpar_20	-4.07536	0.23803	0.01699	0.01055	0.02734
logSdLogFsta_0	-2.27513	0.74424	0.10278	0.02320	0.45537
logSdLogFsta_1	-2.38938	0.21184	0.09169	0.06002	0.14006
logSdLogN_0	-0.12670	0.12396	0.88099	0.68755	1.12887
logSdLogN_1	-2.47967	0.49691	0.08377	0.03101	0.22631
logSdLogObs_0	-0.54009	0.13328	0.58270	0.44635	0.76069
logSdLogObs_1	-1.51040	0.07983	0.22082	0.18824	0.25905
logSdLogObs_2	-0.80877	0.13058	0.44541	0.34303	0.57834
logSdLogObs_3	-0.35391	0.06673	0.70194	0.61424	0.80216

logSdLogObs_4	-0.18393	0.10989	0.83199	0.66784	1.03650
logSdLogObs_5	-0.24961	0.11157	0.77910	0.62328	0.97388
logSdLogObs_6	0.45361	0.09198	1.57398	1.30950	1.89188
logSdLogObs_7	0.27542	0.10930	1.31708	1.05847	1.63888
itrans_rho_0	0.96687	0.41743	2.62969	1.14112	6.06007
logScale_0	0.02857	0.15291	1.02898	0.75787	1.39707
logScale_1	-0.15797	0.17361	0.85388	0.60340	1.20834
logScale_2	-0.10377	0.18557	0.90144	0.62195	1.30652
logScale_3	0.13513	0.19131	1.14469	0.78076	1.67824
logScale_4	0.19002	0.19435	1.20927	0.81981	1.78376
logScale_5	0.36608	0.19780	1.44208	0.97092	2.14187
logScale_6	0.70997	0.20186	2.03393	1.35831	3.04560
logScale_7	0.60880	0.20047	1.83823	1.23104	2.74491
logScale_8	1.12448	0.19632	3.07863	2.07892	4.55907
logScale_9	1.36950	0.18722	3.93340	2.70491	5.71983
logScale_10	1.20292	0.17757	3.32983	2.33447	4.74958
logScale_11	0.69269	0.23513	1.99909	1.24912	3.19933

Table 5.14. Cod.27.6a. SAM estimates of population numbers-at-age (thousands).

	1	2	3	4	5	6	7
1981	10730	19538	7001	1983	475	63	51
1982	24180	5338	7795	2594	727	183	44
1983	14158	11850	2218	2781	896	258	82
1984	24072	6605	4628	774	878	293	111
1985	10611	11376	2447	1466	228	255	121
1986	21463	4720	4105	746	379	64	102
1987	43214	10227	1762	1300	214	108	49
1988	7331	19009	3716	537	351	61	45
1989	21484	3146	6287	1137	155	99	32
1990	7985	9493	1076	1731	320	44	37
1991	11755	3393	3328	351	490	101	25
1992	21811	5021	1090	1006	109	139	38
1993	7867	9526	1697	309	289	34	54
1994	13868	3508	3299	491	91	85	27
1995	10236	6035	1246	1008	140	27	33
1996	4230	4484	1934	366	295	42	18
1997	17060	1831	1414	514	106	87	17
1998	5443	7420	550	370	144	30	30
1999	4309	2219	2172	141	105	43	18
2000	14632	1807	645	564	39	30	18
2001	4145	6084	561	174	161	11	14
2002	6995	1705	1869	150	45	43	7
2003	2311	2819	497	501	41	12	13
2004	3248	913	796	120	130	11	7
2005	2222	1277	263	197	30	32	4
2006	7256	894	410	62	46	7	9
2007	2470	3073	295	106	13	11	4
2008	1772	995	1070	75	25	3	3
2009	5475	739	348	263	16	6	2

2010	6397	2357	269	84	54	3	2
2011	2416	2793	891	68	18	13	1
2012	4136	1064	1138	235	15	4	3
2013	7440	1813	478	374	61	4	2
2014	6313	3329	792	170	112	18	2
2015	5842	2839	1528	282	55	38	6
2016	2181	2727	1313	577	93	19	16
2017	1933	969	1316	516	195	33	12
2018	912	883	423	494	169	64	15
2019	4028	387	385	150	147	53	25
2020	2412	1777	173	137	44	44	23
2021	1614	1034	810	64	40	13	20

***2021 values are SAM-derived projections of population numbers.**

Table 5.15. Cod.27.6a. SAM estimates for fishing mortality-at-age.

	1	2	3	4	5	6	7
1981	0.219	0.516	0.688	0.752	0.752	0.752	0.752
1982	0.229	0.531	0.722	0.812	0.812	0.812	0.812
1983	0.247	0.569	0.779	0.894	0.894	0.894	0.894
1984	0.265	0.609	0.845	0.986	0.986	0.986	0.986
1985	0.285	0.646	0.896	1.057	1.057	1.057	1.057
1986	0.279	0.626	0.861	1.007	1.007	1.007	1.007
1987	0.300	0.665	0.898	1.030	1.030	1.030	1.030
1988	0.312	0.689	0.910	1.016	1.016	1.016	1.016
1989	0.320	0.704	0.934	1.031	1.031	1.031	1.031
1990	0.314	0.683	0.875	0.957	0.957	0.957	0.957
1991	0.321	0.713	0.912	0.977	0.977	0.977	0.977
1992	0.312	0.705	0.921	0.975	0.975	0.975	0.975
1993	0.298	0.691	0.917	0.976	0.976	0.976	0.976
1994	0.295	0.691	0.912	0.976	0.976	0.976	0.976
1995	0.303	0.728	0.943	0.977	0.977	0.977	0.977
1996	0.314	0.770	0.993	0.999	0.999	0.999	0.999
1997	0.327	0.812	1.031	1.010	1.010	1.010	1.010
1998	0.336	0.831	1.037	1.000	1.000	1.000	1.000
1999	0.335	0.823	1.030	1.015	1.015	1.015	1.015
2000	0.334	0.805	1.013	1.025	1.025	1.025	1.025
2001	0.339	0.810	1.025	1.059	1.059	1.059	1.059
2002	0.349	0.825	1.039	1.069	1.069	1.069	1.069
2003	0.356	0.835	1.080	1.105	1.105	1.105	1.105
2004	0.349	0.811	1.099	1.162	1.162	1.162	1.162
2005	0.328	0.759	1.101	1.203	1.203	1.203	1.203
2006	0.304	0.701	1.068	1.213	1.213	1.213	1.213
2007	0.285	0.656	1.047	1.201	1.201	1.201	1.201
2008	0.271	0.624	1.053	1.226	1.226	1.226	1.226
2009	0.264	0.607	1.081	1.296	1.296	1.296	1.296

2010	0.248	0.563	1.026	1.232	1.232	1.232	1.232
2011	0.233	0.523	0.976	1.195	1.195	1.195	1.195
2012	0.210	0.458	0.840	1.044	1.044	1.044	1.044
2013	0.197	0.423	0.760	0.950	0.950	0.950	0.950
2014	0.187	0.397	0.703	0.867	0.867	0.867	0.867
2015	0.178	0.376	0.656	0.818	0.818	0.818	0.818
2016	0.176	0.369	0.637	0.804	0.804	0.804	0.804
2017	0.186	0.394	0.679	0.867	0.867	0.867	0.867
2018	0.191	0.409	0.711	0.929	0.929	0.929	0.929
2019	0.190	0.408	0.719	0.975	0.975	0.975	0.975
2020	0.183	0.388	0.688	0.961	0.961	0.961	0.961

Table 5.16. Cod.27.6a. SAM summary table. ('Catch' refers to model estimate).

Year	Recruitment Age 1			SSB			TSB			Catch			Estimated catch scaling factor	Fishing mortality Ages 2-5		
	Value	Low	High	Value	Low	High	Value	Low	High	Value	Low	High		Value	Low	High
1981	10730	7725	14905	43283	37585	49845	64189	55679	73999	23547	19276	28765		0.68	0.58	0.79
1982	24180	17915	32637	42496	37310	48402	60499	53355	68599	23637	20152	27726		0.72	0.64	0.81
1983	14158	10516	19062	35778	31677	40410	50519	44847	56909	20941	18137	24178		0.78	0.70	0.88
1984	24072	17917	32341	30417	27011	34252	46022	40747	51979	21335	18388	24753		0.86	0.77	0.96
1985	10611	7918	14218	25407	22593	28572	37851	33486	42785	16367	14111	18983		0.91	0.82	1.02
1986	21463	15589	29550	21989	19416	24904	34827	30421	39870	14238	12186	16635		0.88	0.79	0.98
1987	43214	31093	60060	24080	21320	27197	45840	39114	53723	15726	13371	18496		0.91	0.81	1.01
1988	7331	5385	9980	26692	23049	30910	42518	36224	49906	19010	15924	22693		0.91	0.82	1.01
1989	21484	15857	29108	24972	21628	28833	37901	33002	43526	16269	13705	19312		0.93	0.83	1.03
1990	7985	5792	11006	19319	17019	21931	28624	25167	32555	12781	10900	14988		0.87	0.78	0.97
1991	11755	8706	15873	16182	14275	18343	23929	21120	27112	10464	8968	12209		0.90	0.80	1.00
1992	21811	16130	29494	14300	12712	16088	24762	21521	28493	9251	7972	10734		0.89	0.80	1.00
1993	7867	5671	10912	14315	12401	16524	23138	19770	27080	10986	9248	13050		0.89	0.79	1.01
1994	13868	9679	19871	14092	11750	16901	22200	18351	26856	10075	8411	12069		0.89	0.78	1.02
1995	10236	7010	14948	13096	10250	16733	20505	15945	26370	9452	7352	12151	1.029	0.91	0.79	1.04
1996	4230	2838	6303	11009	8292	14616	15965	12003	21234	8388	6214	11324	0.854	0.94	0.82	1.08
1997	17060	11386	25560	9366	6934	12650	16049	11775	21875	7113	5135	9854	0.901	0.97	0.84	1.11
1998	5443	3593	8244	9144	6622	12628	15123	10885	21010	6102	4305	8649	1.145	0.97	0.84	1.11
1999	4309	2832	6556	7727	5555	10747	11325	8174	15690	5300	3736	7519	1.209	0.97	0.85	1.11
2000	14632	9599	22303	6684	4815	9279	11982	8556	16781	4828	3374	6909	1.442	0.97	0.84	1.11
2001	4145	2708	6344	6995	4989	9808	11689	8300	16462	5064	3501	7326	2.034	0.99	0.86	1.13

Year	Recruitment Age 1			SSB			TSB			Catch			Estimated catch scaling factor	Fishing mortality Ages 2-5		
	Value	Low	High	Value	Low	High	Value	Low	High	Value	Low	High		Value	Low	High
2002	6995	4591	10659	6438	4625	8960	10117	7298	14025	4776	3303	6905	1.838	1.00	0.87	1.15
2003	2311	1535	3478	5242	3836	7164	7752	5678	10583	3662	2576	5206	3.079	1.03	0.90	1.19
2004	3248	2203	4789	3659	2745	4878	5383	4064	7131	2582	1861	3581	3.933	1.06	0.92	1.22
2005	2222	1487	3320	2629	2026	3411	4021	3111	5199	1877	1391	2533	3.330	1.07	0.92	1.23
2006	7256	4933	10673	2495	1993	3124	4813	3767	6149	1867	1408	2475	1.999	1.05	0.91	1.21
2007	2470	1642	3715	3112	2450	3953	5432	4219	6994	2205	1663	2924		1.03	0.89	1.18
2008	1772	1201	2614	3124	2443	3995	4589	3630	5801	2212	1664	2942		1.03	0.90	1.19
2009	5475	3825	7836	2544	2088	3100	4317	3539	5265	1920	1509	2444		1.07	0.92	1.24
2010	6397	4531	9031	2930	2421	3546	5581	4549	6846	2157	1654	2813		1.01	0.88	1.17
2011	2416	1674	3488	3797	3115	4629	6160	5047	7518	2505	1954	3211		0.97	0.83	1.14
2012	4136	2936	5828	3842	3159	4673	5813	4825	7003	2298	1811	2914		0.85	0.72	0.99
2013	7440	5255	10534	3945	3320	4687	6582	5501	7875	2076	1676	2571		0.77	0.66	0.91
2014	6313	4475	8904	4984	4171	5956	8237	6843	9914	2622	2064	3331		0.71	0.60	0.84
2015	5842	4107	8310	6246	5195	7509	9541	7950	11451	3443	2713	4369		0.67	0.56	0.80
2016	2181	1540	3088	6702	5579	8051	9292	7756	11132	3480	2781	4355		0.65	0.54	0.79
2017	1933	1359	2749	6173	5094	7480	7854	6522	9460	3221	2587	4010		0.70	0.59	0.83
2018	912	618	1346	4488	3663	5498	5489	4530	6649	2479	1994	3082		0.75	0.62	0.89
2019	4028	2779	5840	2988	2422	3688	4064	3354	4924	1764	1429	2179		0.77	0.63	0.95
2020	2412	1424	4086	2630	2109	3281	3987	3191	4982	1514	1217	1883		0.75	0.59	0.96
2021	1614	344	7587	2893	2160	3873	4092	2983	5614							

Table 5.17. Cod.27.6a. Catch scenarios based on the SAM assessment and assuming F status quo in the intermediate year. Units are tonnes (SSB, landings, discards and catch) or thousands(recruitment).

Variable	Value	Notes
$F_{ages\ 2–5}$ (2021)	0.75	Average F = (2018–2020)
SSB (2022)	2963	Tonnes; short-term forecast.
$R_{age\ 1}$ (2021)	1615	Thousands; Median recruitment estimated in the assessment in 2020.
$R_{age\ 1}$ (2022)	4028	Thousands; Median recruitment resampled from the years 2010–2019
$R_{age\ 1}$ (2023)	2416	Thousands; Median recruitment resampled from the years 2010–2019
Total catch (2021)	1693	Tonnes; short-term forecast.
Projected landings (2020)	1015	Tonnes; short-term forecast assuming 2019 discard pattern
Projected discards (2020)	678	Tonnes; short-term forecast assuming 2019 discard pattern

Catch options

Basis	Total catch (2022)	Projected landings (2022)	Projected discards (2022)	F_{total} (2022)	$F_{projected\ landings}$ (2022)	$F_{projected\ discards}$ (2022)	SSB (2023)	% SSB change *	% TAC change ^
ICES advice basis									
MSY approach: F = 0	0	0	0	0	0	0	5040	70%	-100
Other scenarios									
F_{MSY} × SSB(2022)/MSY $B_{trigger}$	141	99	42	0.044	0.034	0.01	4870	64%	
$F_{MSY\ lower}$: $F_{MSY\ lower}$ × SSB(2022) / MSY $B_{trigger}$	85	60	25	0.027	0.02	0.007	4936	67%	
$F_{MSY\ upper}$: $F_{MSY\ upper}$ × SSB(2022) / MSY $B_{trigger}$	227	159	68	0.072	0.055	0.017	4768	61%	
F = $F_{MSY\ lower}$	534	373	161	0.18	0.136	0.044	4404	49%	
F = F_{MSY}	841	584	257	0.3	0.23	0.073	4037	36%	
F = F_{pa}	1413	970	443	0.57	0.43	0.139	3354	13.2%	
F = $F_{MSY\ upper}$	1258	868	390	0.49	0.37	0.12	3538	19.40%	
F = F_{sq}	1729	1177	552	0.75	0.57	0.184	2976	0.44%	
F = F_{lim}	1691	1152	539	0.73	0.55	0.179	3021	1.96%	
SSB(2023)=SSB(2022)	1741	1185	556	0.76	0.57	0.187	2963	0.00%	
SSB(2023)=1.2 x SSB(2022)	1243	858	385	0.48	0.36	0.118	3556	20%	
SSB(2023)=1.4 x SSB(2022)	750	522	228	0.26	0.199	0.064	4148	40%	
F = F_{sq} x 0.69	1319	908	411	0.52	0.39	0.127	3466	17.0%	
F = F_{sq} x 1.66	2362	1578	784	1.25	0.95	0.31	2213	-25%	
SSB(2023) = B_{lim} **									
SSB(2023) = B_{pa} = MSY $B_{trigger}$ **									

*** SSB 2023 relative to SSB 2022.**

**** The B_{lim}, B_{pa}, and MSY $B_{trigger}$ options were left blank because B_{lim}, B_{pa}, and MSY $B_{trigger}$ cannot be achieved in 2023, even with zero catches.**

^ Total catch in 2022 relative to TAC in 2021 cannot be provided because the 2021 TAC is not yet available.

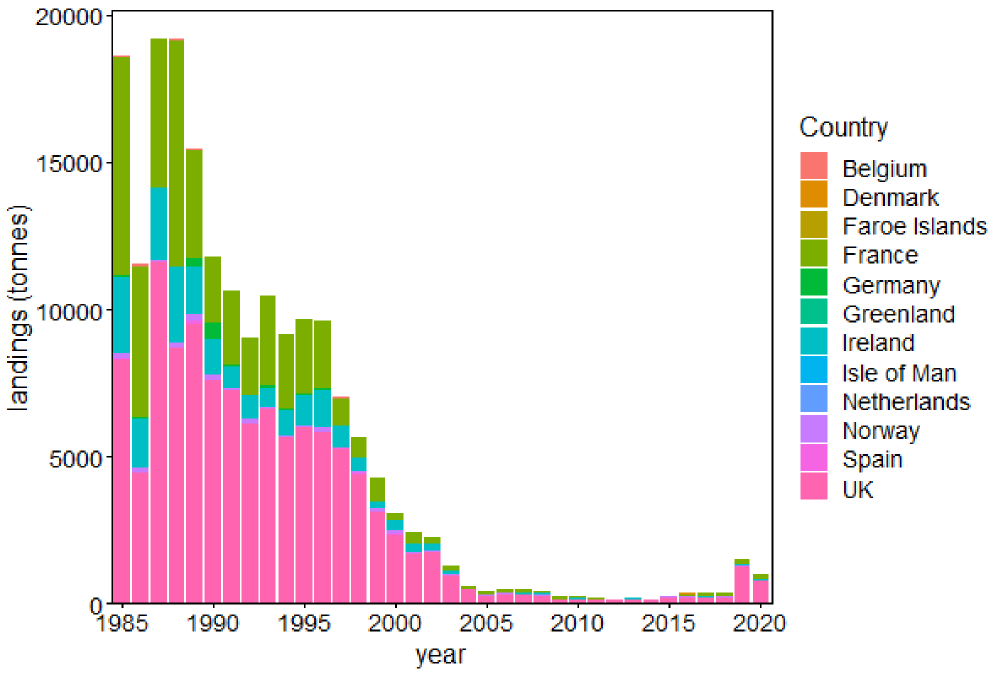

Figure 5.1. Cod.27.6a. ICES official landings by country.

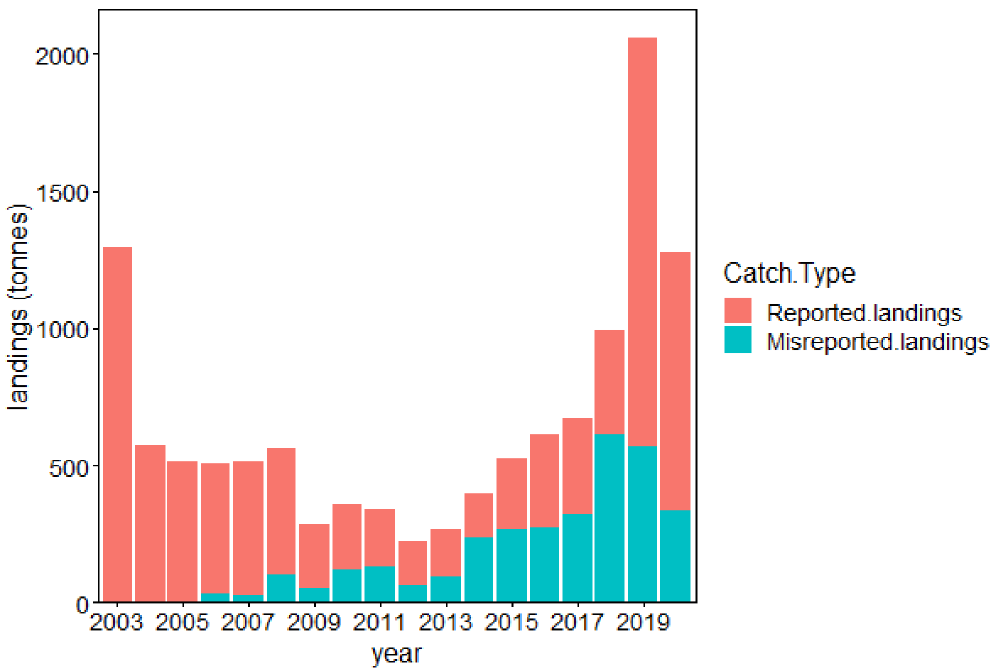

Figure 5.2. Cod.27.6a. ICES estimates of reported (red) and area misreported landings (blue) of cod caught in ICES Division 6.a.

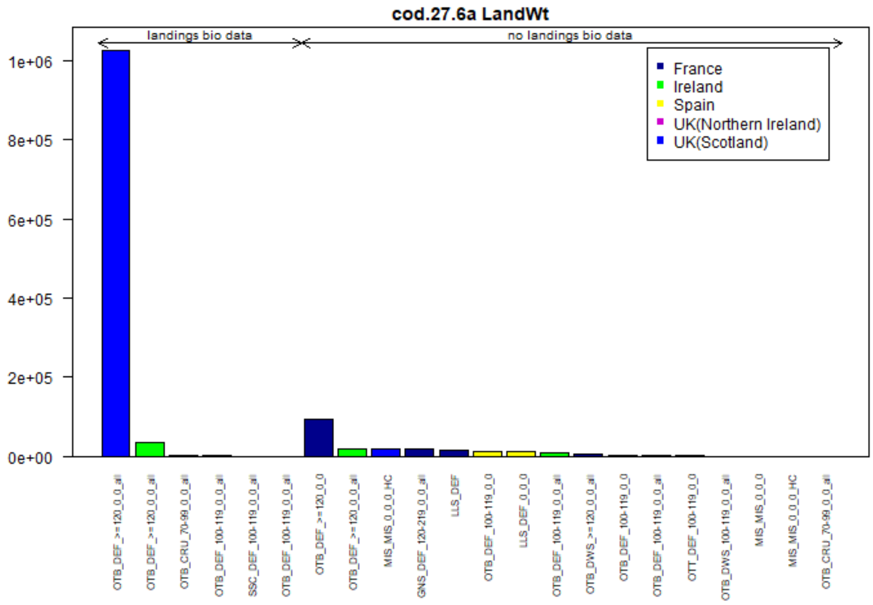

Figure 5.3. Cod.27.6a. Amounts landed by métier (kg) in 2020 as submitted to InterCatch.

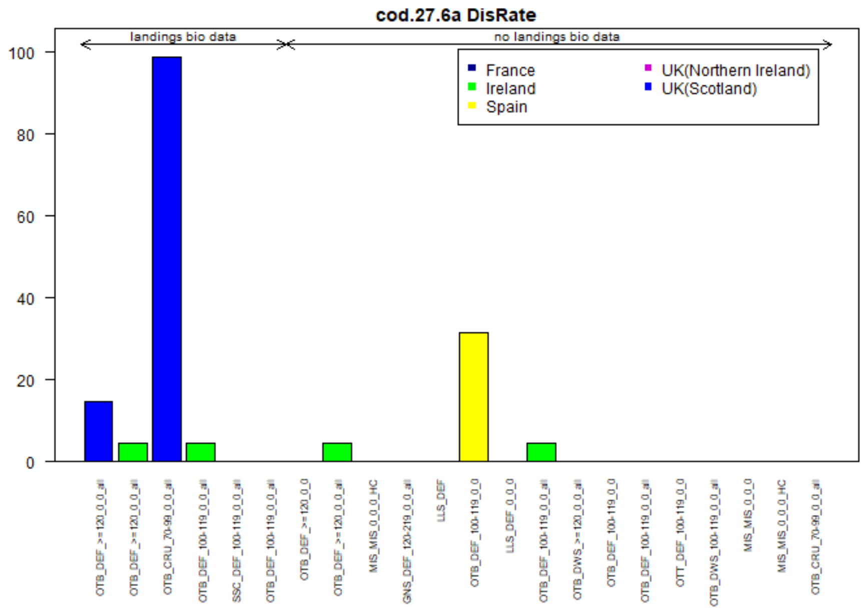

Figure 5.4. Cod.27.6a. Discard rates by weight by métier in 2020 as submitted to InterCatch.

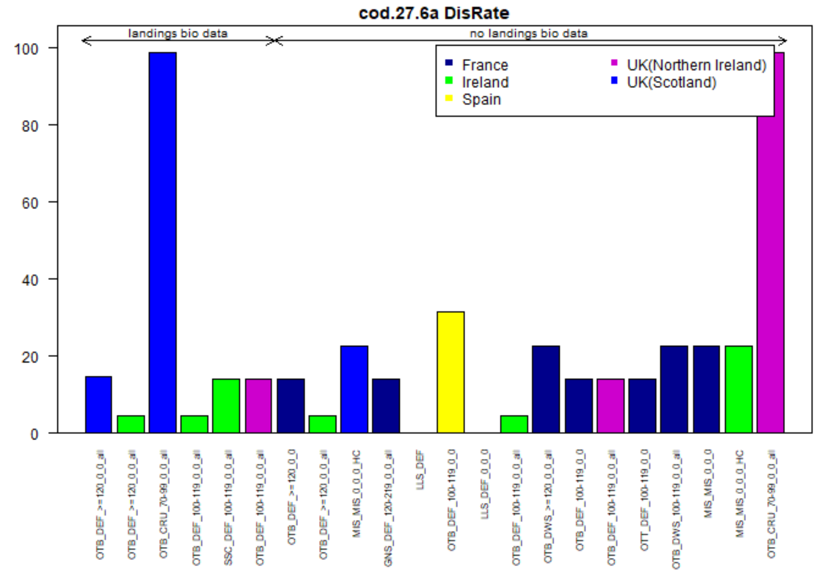

Figure 5.5. Cod.27.6a. Discard rates after allocations within InterCatch.

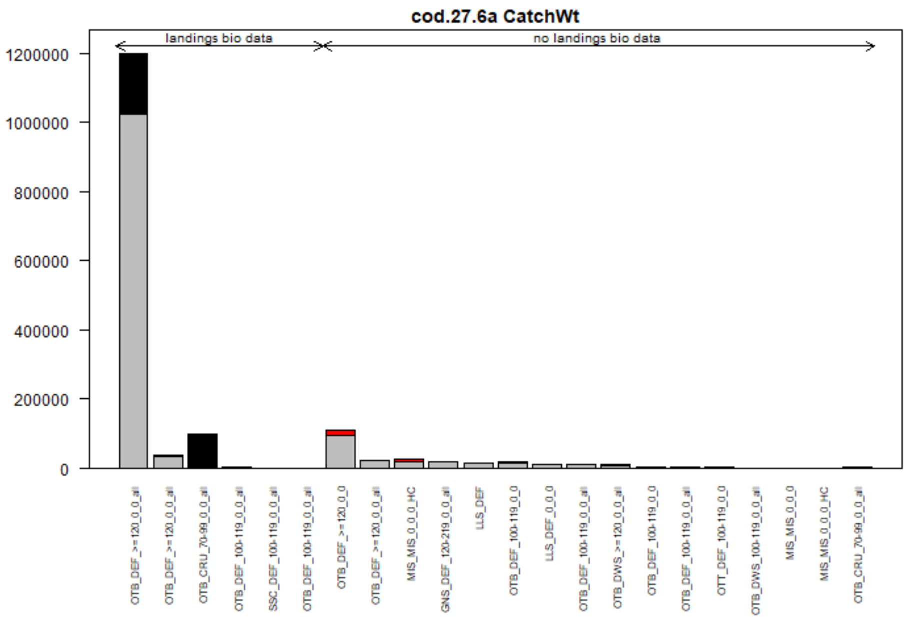

Figure 5.6. Cod.27.6a. Landings (grey), imported (black) and raised (red, but so small so not visible) discards of all fleets after allocations within InterCatch.

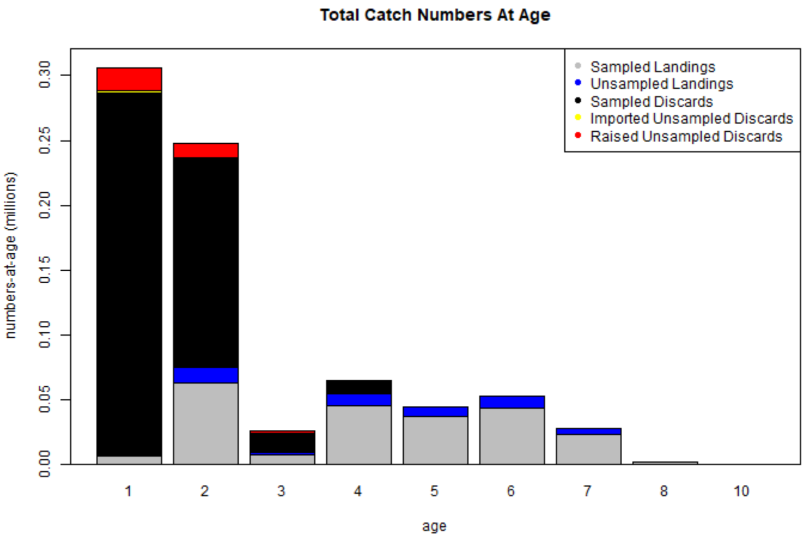

Figure 5.7. Cod.27.6a. Catch numbers-at-age by sampled and unsampled landings and sampled and raised (unsampled) discards, after allocations within InterCatch.

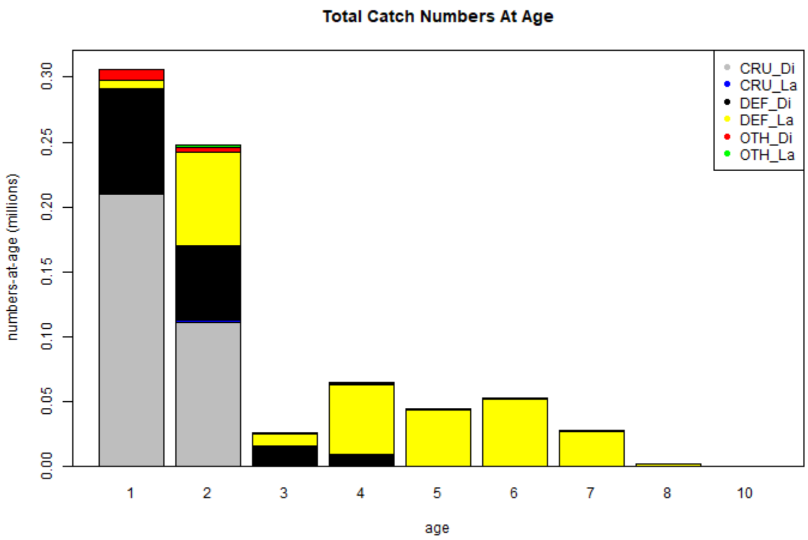

Figure 5.8. Cod.27.6a. Catch numbers-at-age by fleet/ catch category after allocations within InterCatch.

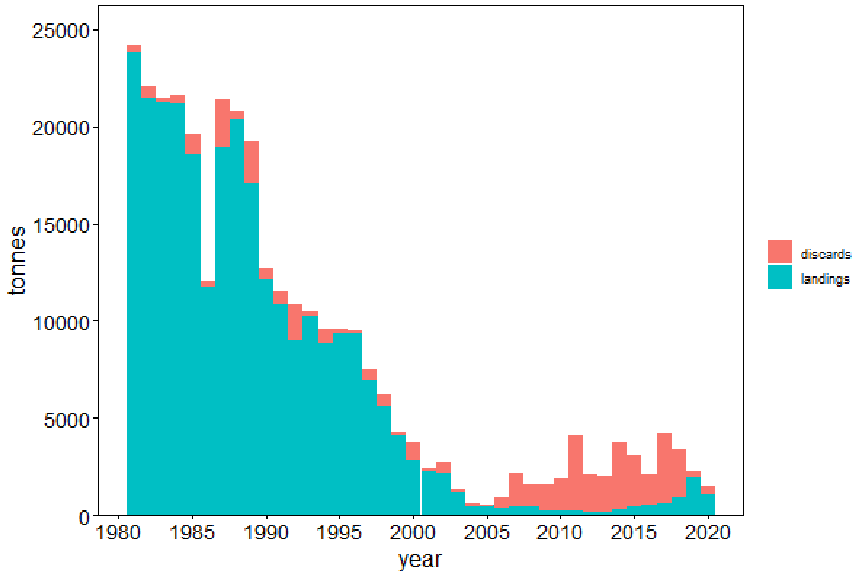

Figure 5.9. Cod.27.6a. Landings and discards estimates by weight, as used by the WG.

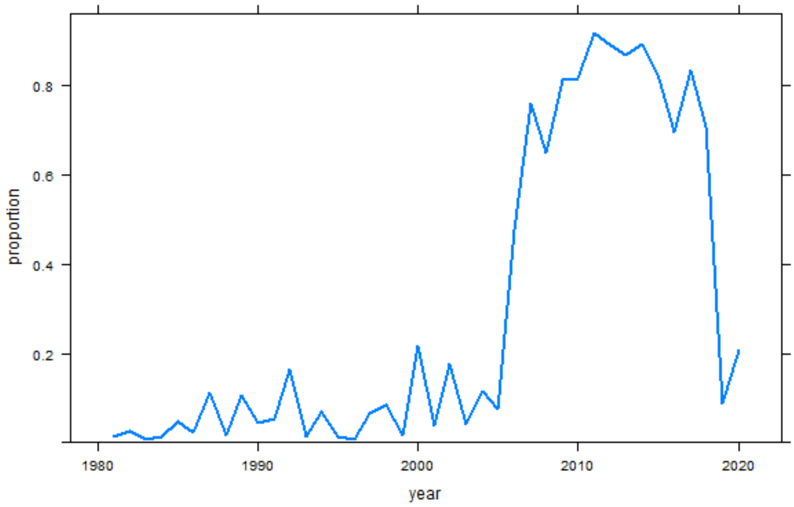

Figure 5.10. Cod.27.6a. Discard proportion (of total catch) by weight.

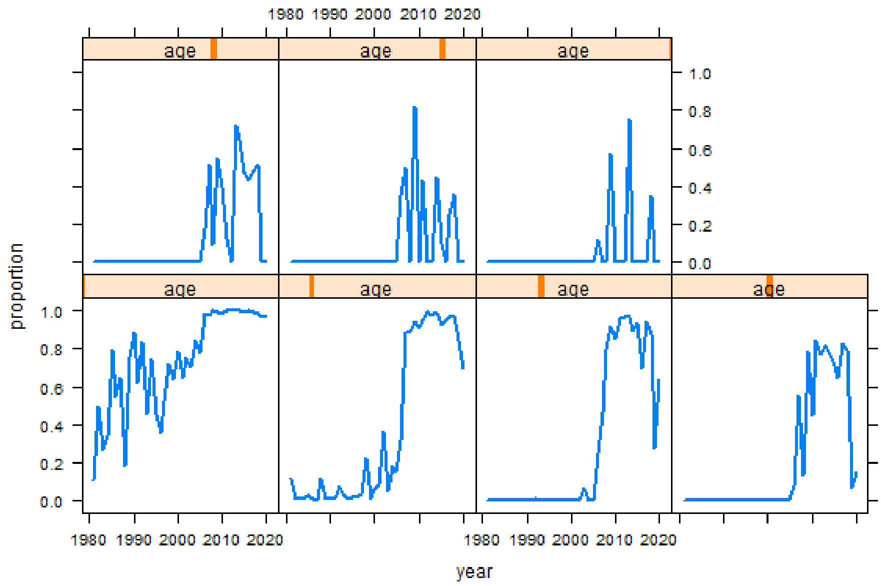

Figure 5.11. Cod.27.6a. Discard proportion by number by age.

Figure 5.12. Cod.27.6a. Catch-at-age in numbers by year. Red: discards, blue: landings.

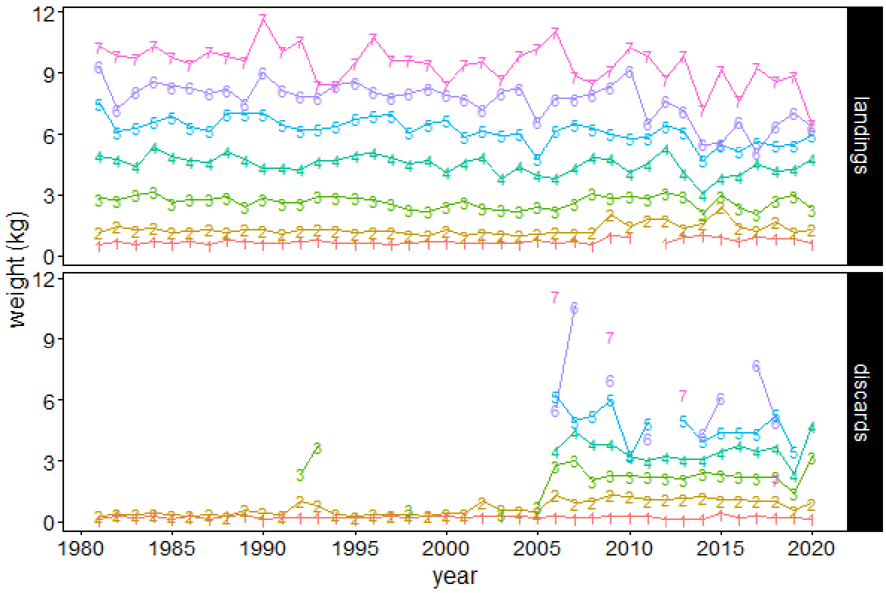

Figure 5.13. Cod.27.6a. Mean weights-at-age in landings and discards.

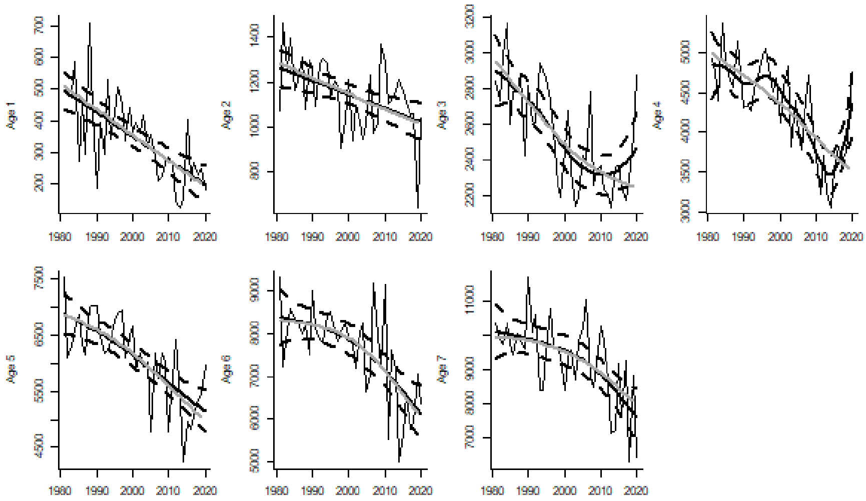

Figure 5.14. Cod.27.6a. Smoothed trends in weight-at-age estimated with a GAM (thick black line) together with the 95% confidence interval (dashed lines) fitted to catch mean weights-at-age (thin black line). Thick grey line shows smoothed trend from WGCSE 2020 (i.e. one less datapoint).

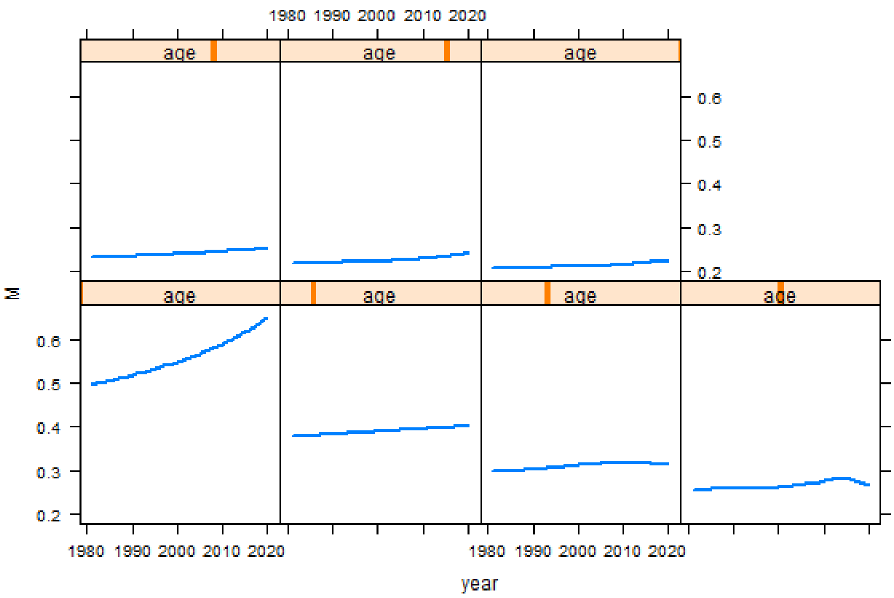

Figure 5.15. Cod.27.6a. Natural mortality-at-age based on stock weight-at-age and mortality–weight relationship (Lorenzen, 1996). (Age 1 bottom left, Age 7+ top right).

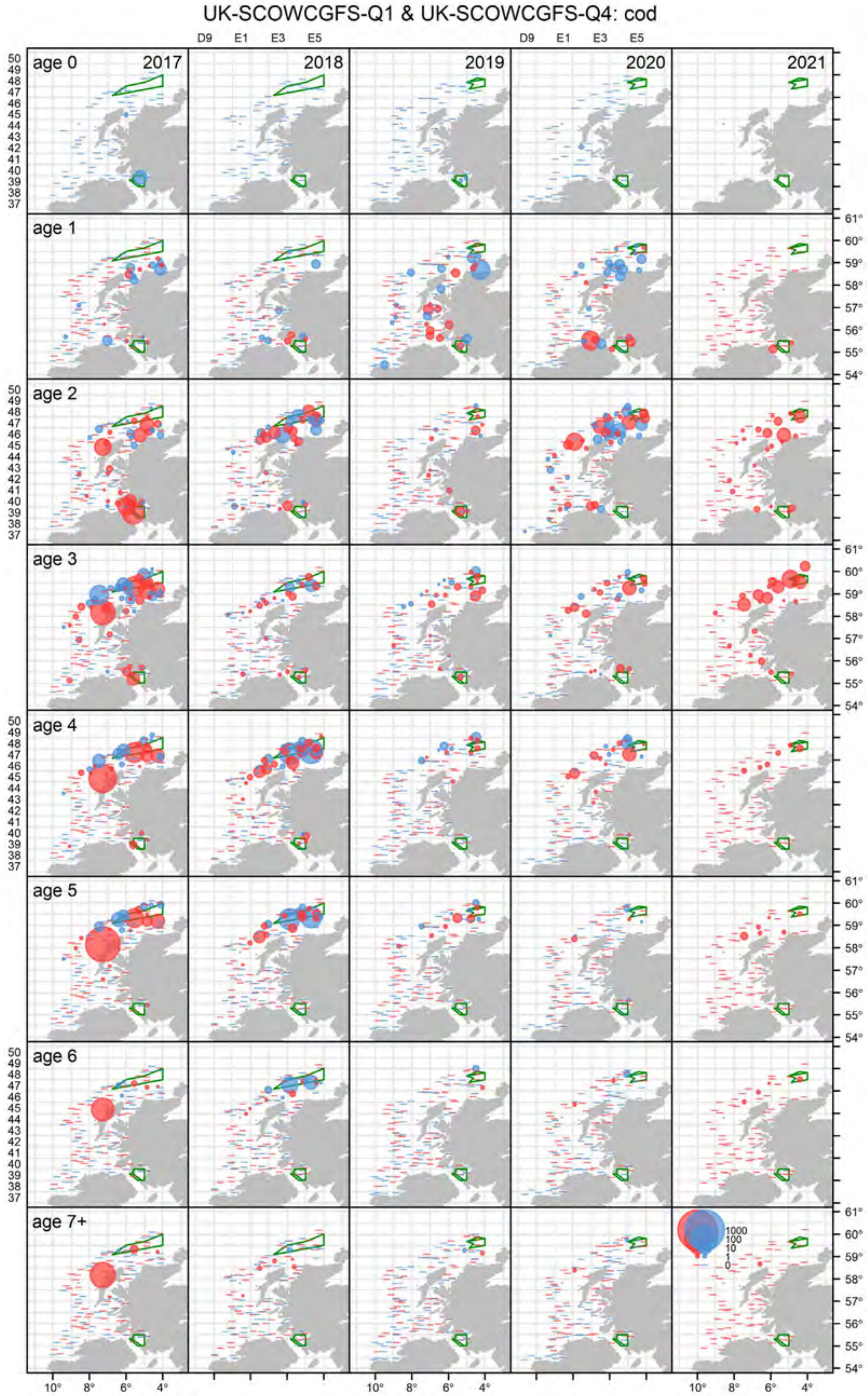

Figure 5.16. Cod.27.6a. Cpue numbers for fish aged at 1+ per tow resulting from Scottish quarter one survey (UK-SCOWCGFS-Q1) in red and (UK-SCOWCGFS-Q4) in blue. Numbers are standardised to 30 minutes towing. Green polygons are areas closed to fishing.

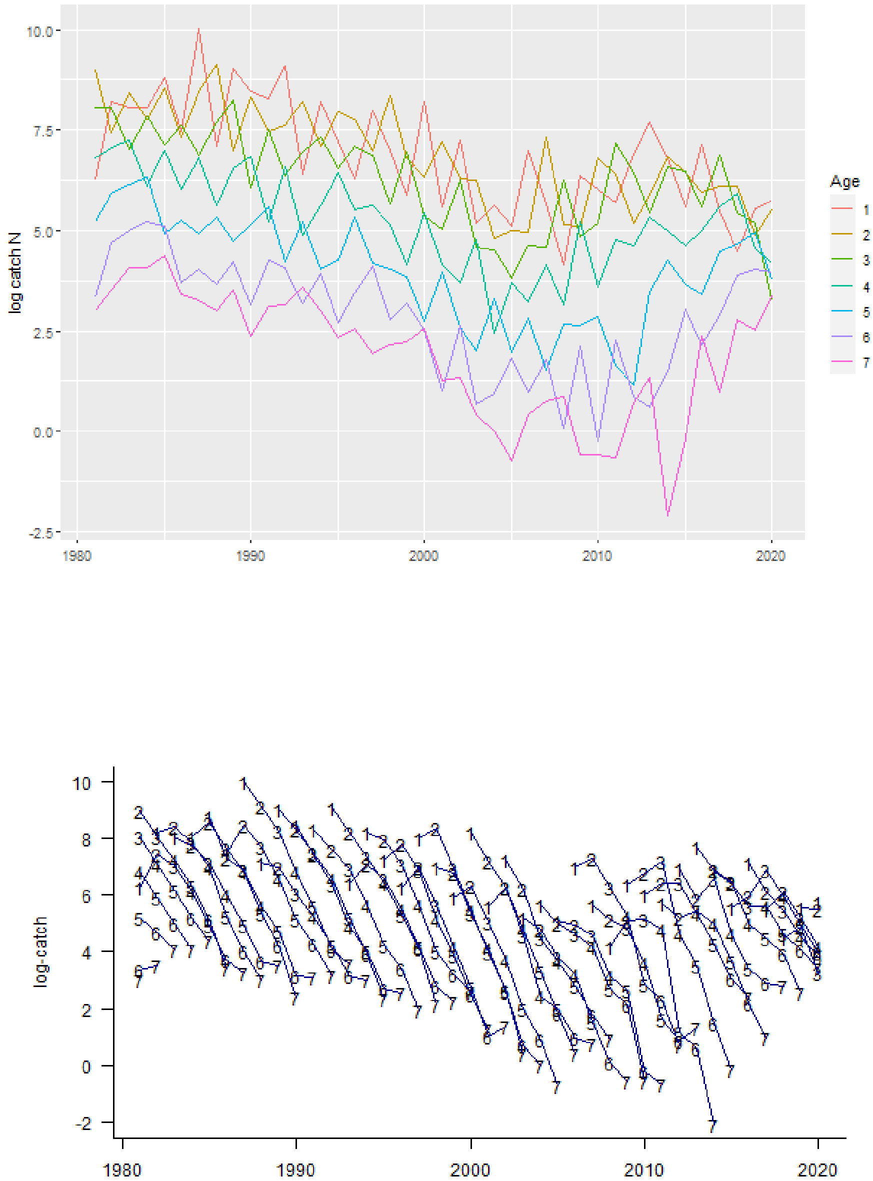

Figure 5.17. Cod.27.6a. Log catch numbers-at-age (upper) and catch curves (lower) from commercial catch-at-age data.

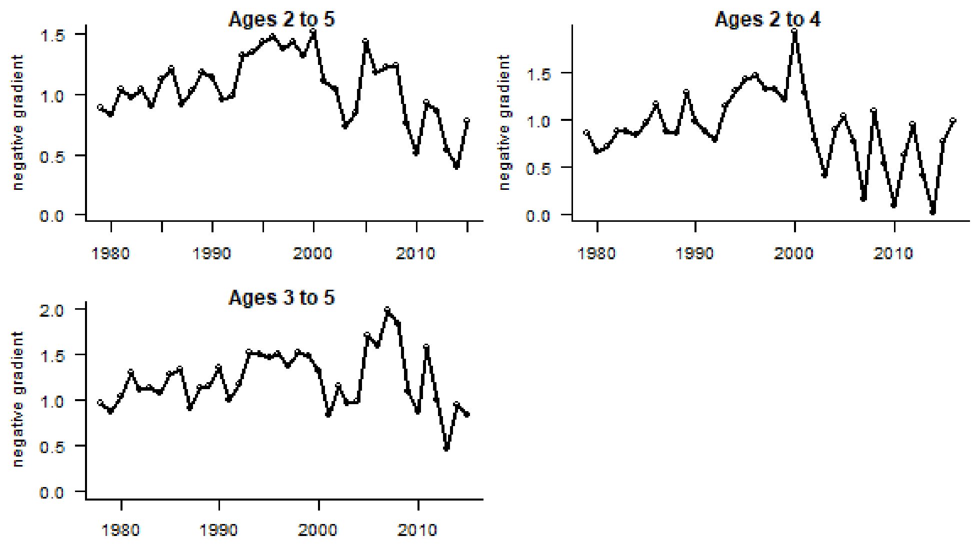

Figure 5.18. Cod.27.6a. Log catch (landings + discards) curve gradient plot using WG commercial catch-at-age data over different age ranges.

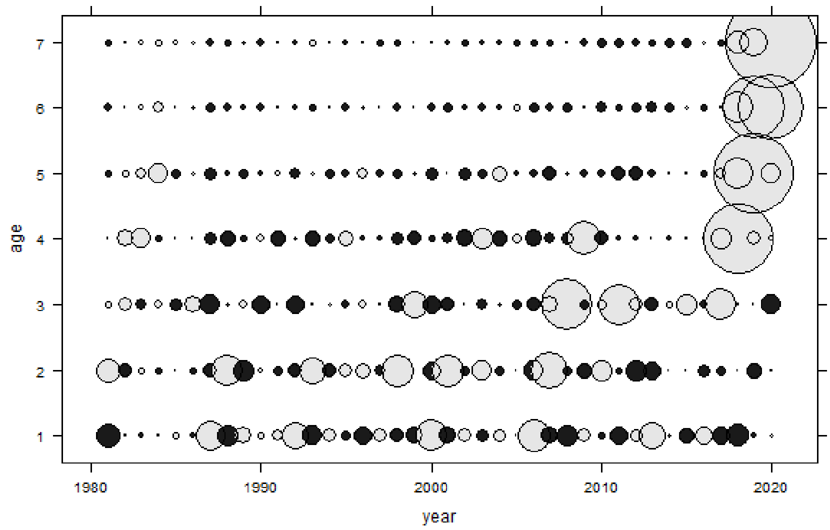

Figure 5.19. Cod.27.6a. Mean standardised catch-at-age proportions by number.

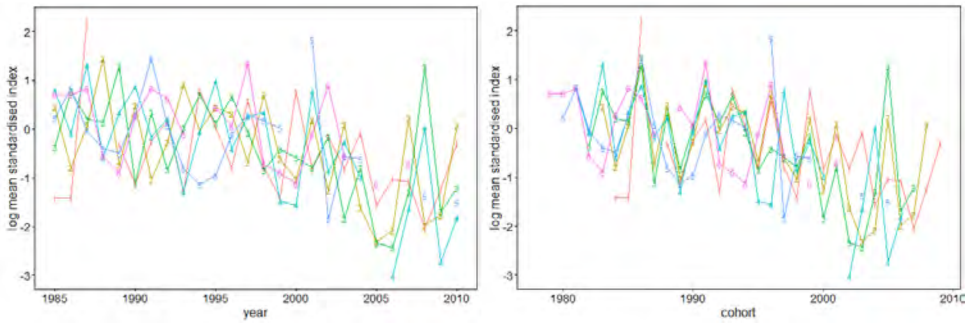

Figure 5.20. Cod.27.6a. Log mean standardised index values -by year- (left) and cohort (right) from Scottish quarter one ground fish survey (ScoGFS-WIBTS-Q1); ages 1–6. Survey finished in 2010.

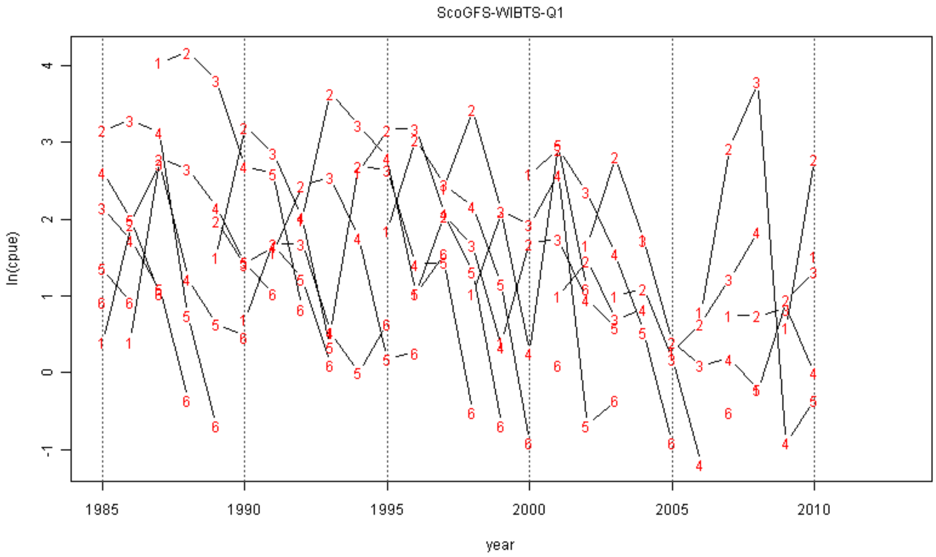

Figure 5.21. Cod.27.6a. Log catch curves from Scottish quarter one ground fish survey (ScoGFS-WIBTS-Q1); ages 1–6. Survey finished in 2010.

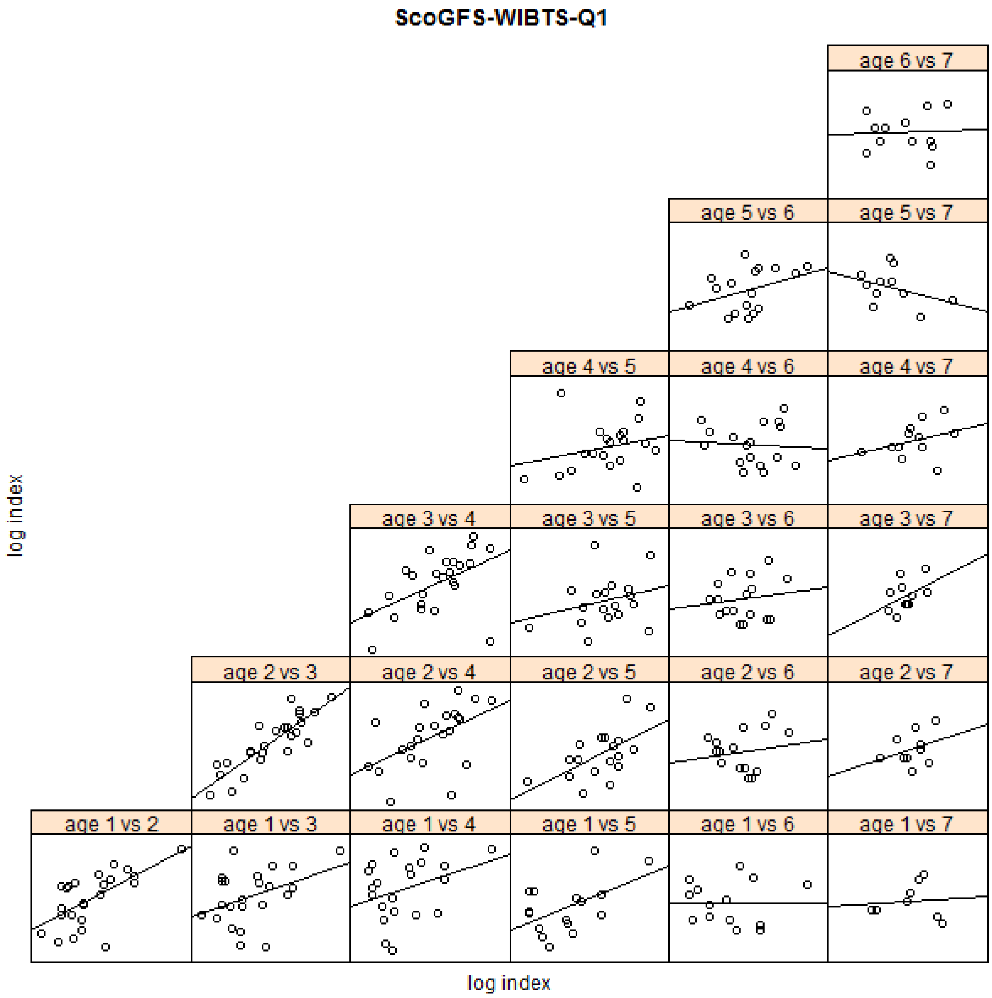

Figure 5.22. Cod.27.6a. Within-survey correlations for the Scottish quarter one ground fish survey (ScoGFS-WIBTS-Q1), comparing index values at different ages for the same cohorts. The straight line in a linear regression. Survey finished in 2010.

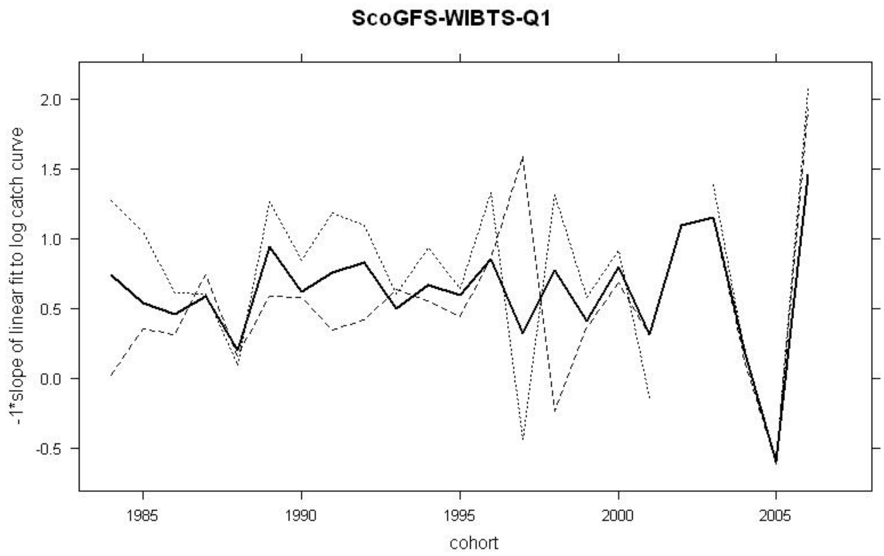

Figure 5.23. Cod.27.6a. Log catch curve gradient plot using ScoGFS-WIBTS-Q1 index data. Solid line shows time-series of gradient of linear fit to curve over the age range 2–5, dashed line over the ages 2–4 and dotted line over the ages 3–5. Last cohort shown was at-age 5 in 2010, the last year of the ScoGFS-WIBTS-Q1 survey.

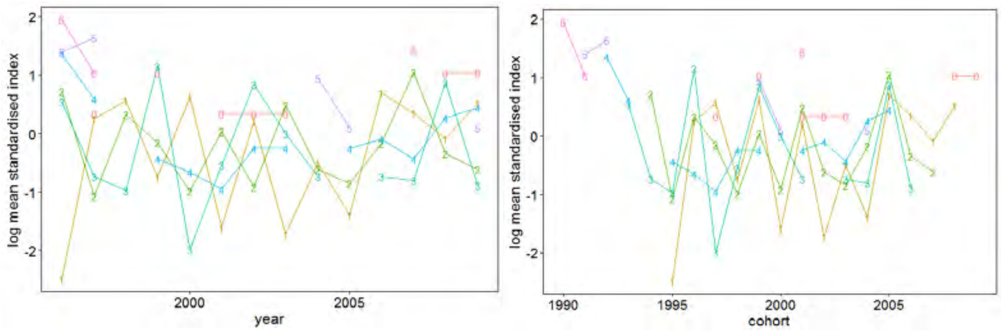

Figure 5.24. Cod in Division6a. Log mean standardised index values by year (left) and cohort (right) from ScoGFS-WIBTS-Q4.

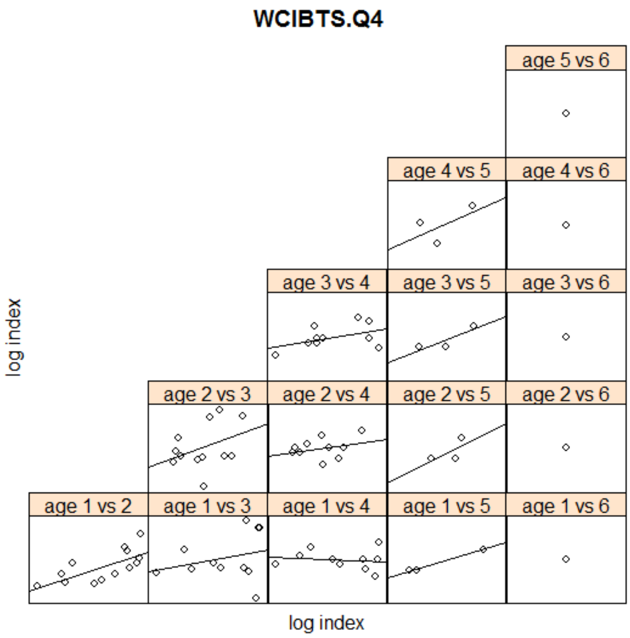

Figure 5.25. Cod.27.6a. Within survey correlations for ScoGFS-WIBTS-Q4 survey, comparing index values at different ages for the same cohorts. The solid line is a linear regression. Insufficient age 6 fish are caught to enable scatterplots to be constructed.

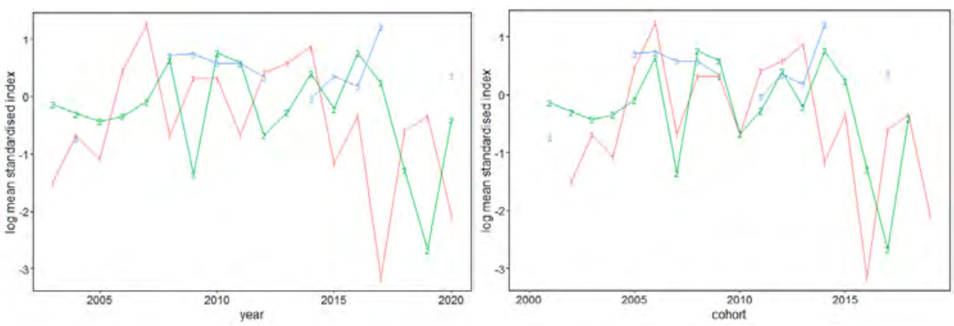

Figure 5.26. Cod.27.6a. Log mean standardised index values -by year (left) and cohort (right) from Irish quarter four ground fish survey (IRGFS-WIBTS-Q4); ages 1–3. Survey started in 2003.

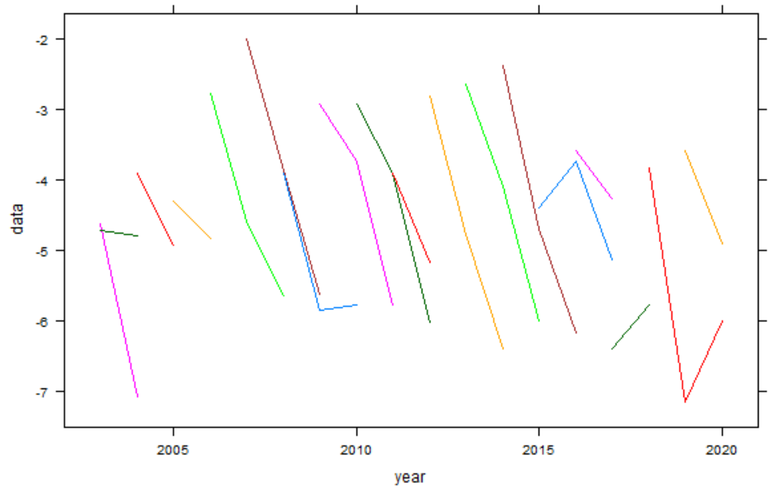

Figure 5.27. Cod.27.6a. Log catch curves from Irish quarter four ground fish survey (IRGFS-WIBTS-Q4); ages 1–3. Survey started in 2003.

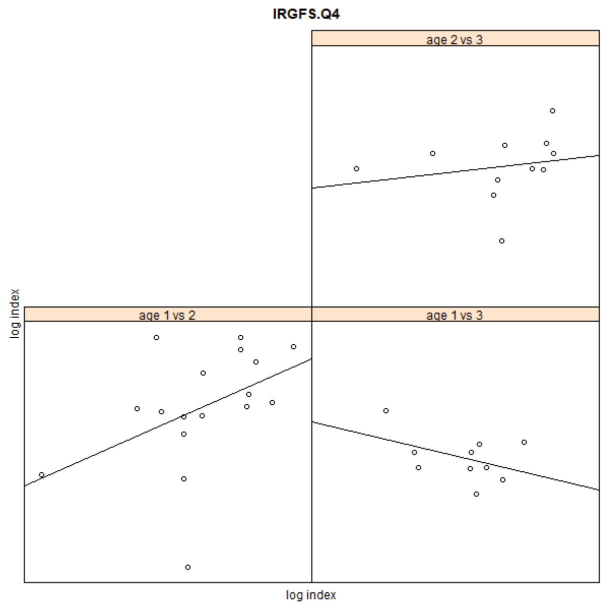

Figure 5.28. Cod.27.6a. Within-survey correlations for the Irish quarter four ground fish survey (IRGFS-WIBTS-Q4), comparing index values at different ages for the same cohorts. The straight line is a linear regression.

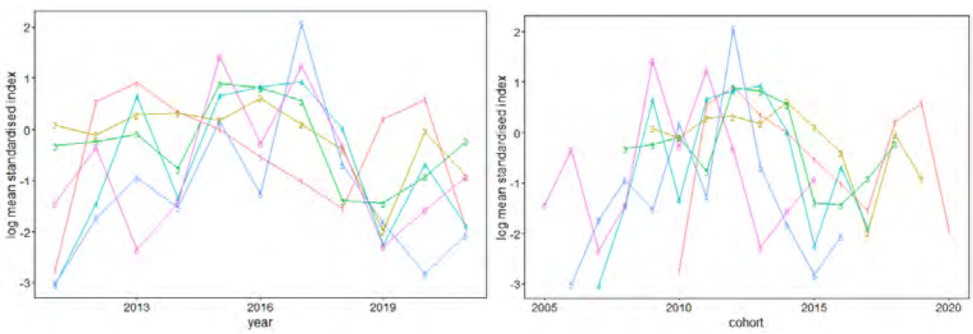

Figure 5.29. Cod.27.6a. Log mean standardised index values -by year (left) and cohort (right) - from Scottish quarter one ground fish survey UK-SCOWCGFS-Q1; ages 1–6.

Figure 5.30. Cod.27.6a. Log catch curves from new Scottish quarter one ground fish survey (UK-SCOWCGFS-Q1); ages 1–7. Survey started in 2011.

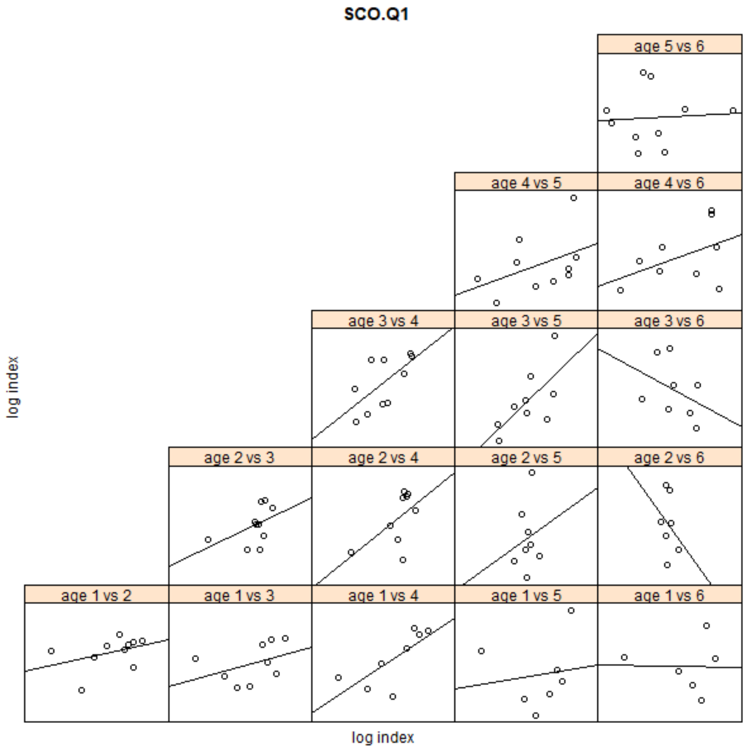

Figure 5.31. Cod.27.6a. Within survey scatterplots from new Scottish quarter one ground fish survey (UK-SCOWCGFS-Q1), comparing index values at different ages for the same cohorts. The straight line in a linear regression.

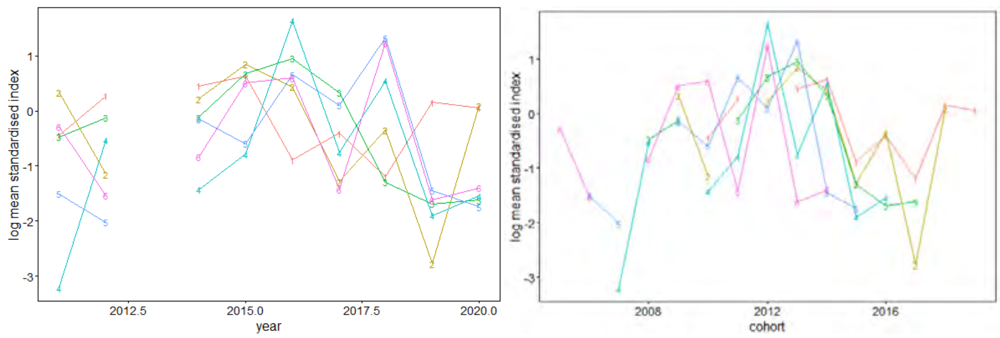

Figure 5.32. Cod.27.6a. Log mean standardised index values by year (left) and cohort (right) from Scottish quarter four ground fish survey UK-SCOWCGFS-Q4); ages 1–6.

Figure 5.33. Cod.27.6a. Log catch curves from new Scottish quarter four ground fish survey (UK-SCOWCGFS-Q4).

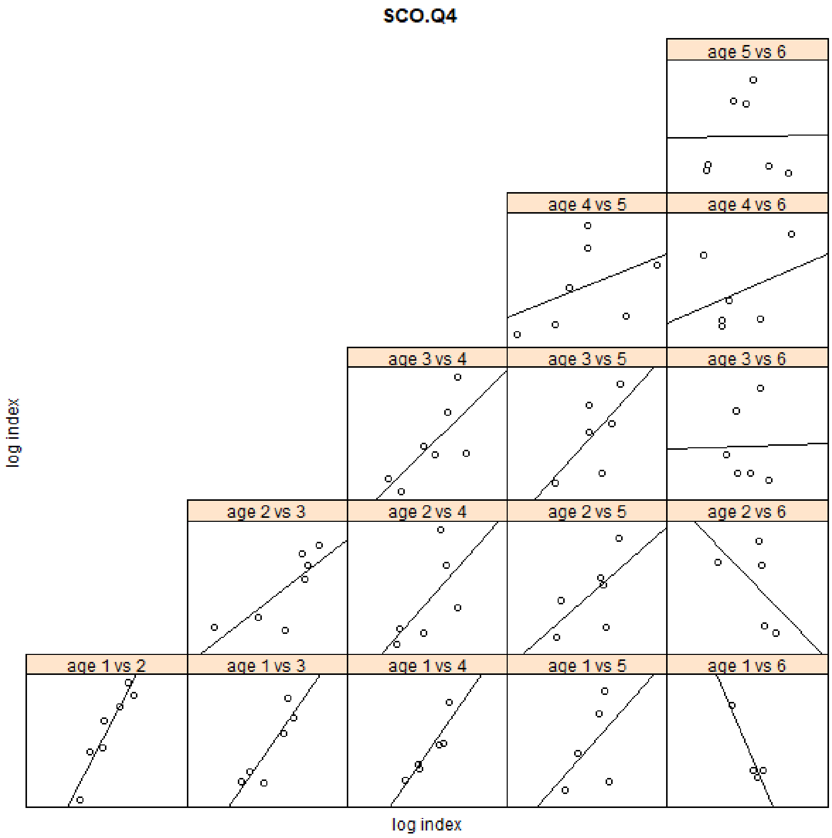

Figure 5.34. Cod.27.6a. Within survey scatterplots from new Scottish quarter four ground fish survey (UK-SCOWCGFS-Q4), comparing index values at different ages for the same cohorts. The straight line in a linear regression.

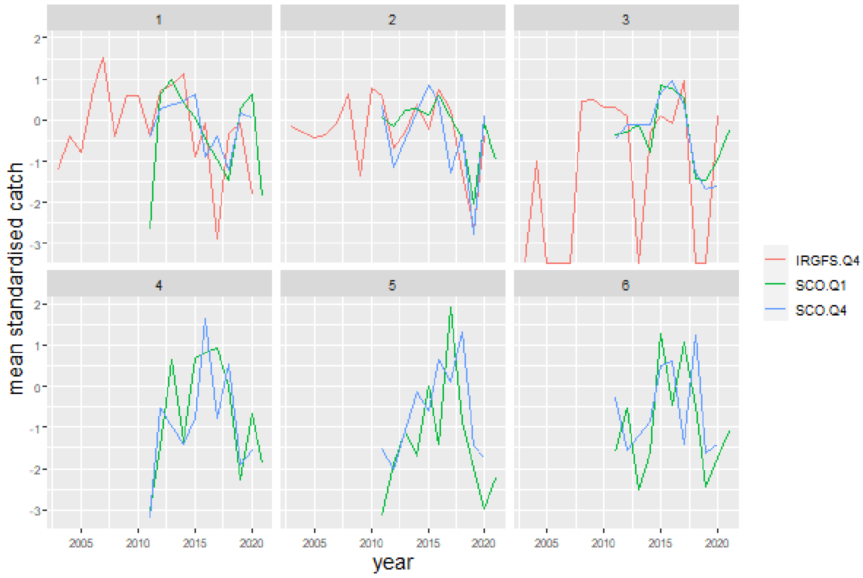

Figure 5.35. Cod.27.6a. Comparison of survey indices by age. Irish Q4 survey (IRGFS.Q4) is compared to the current Scottish surveys (SCO.Q1=UK-SCOWCGFS-Q1 & SCO.Q4=UK-SCOWCGFS-Q4). Values are mean standardised over the time period in common (2011–2020).

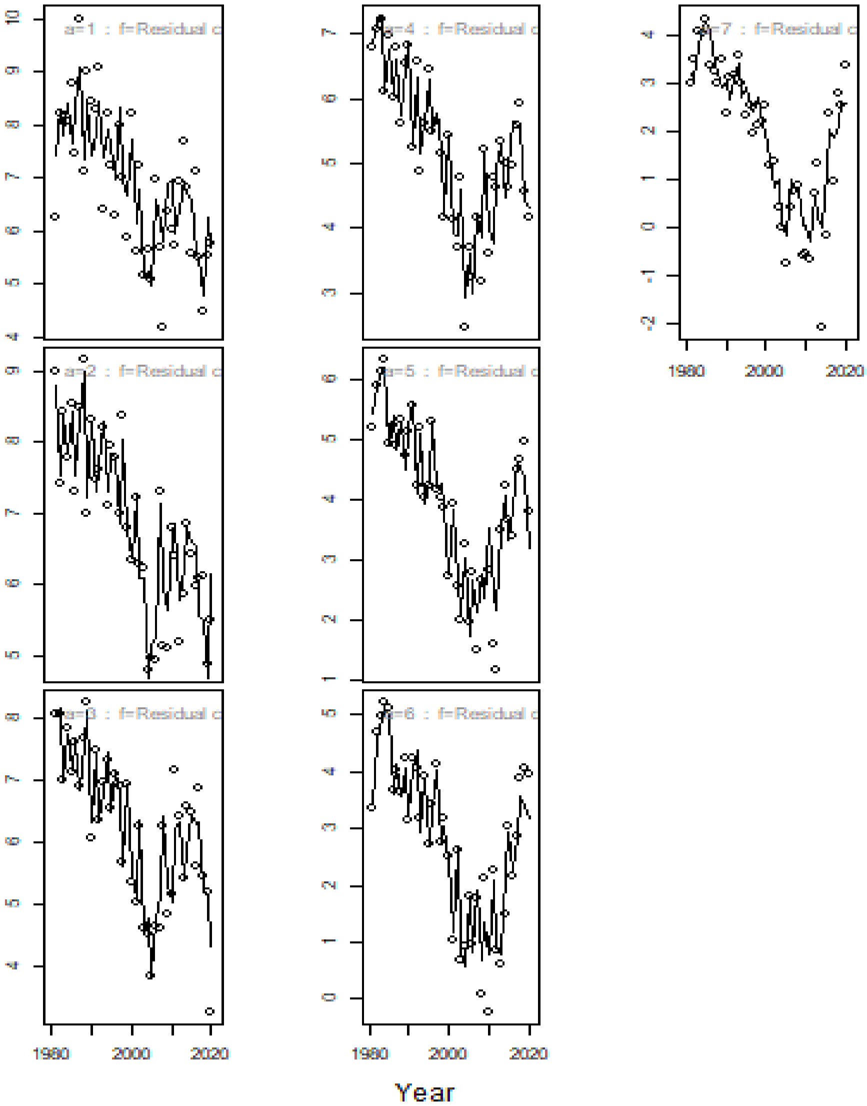

Figure 5.36. Cod.27.6a. SAM final run. Comparison of model estimated and observed log catch numbers-at-age.

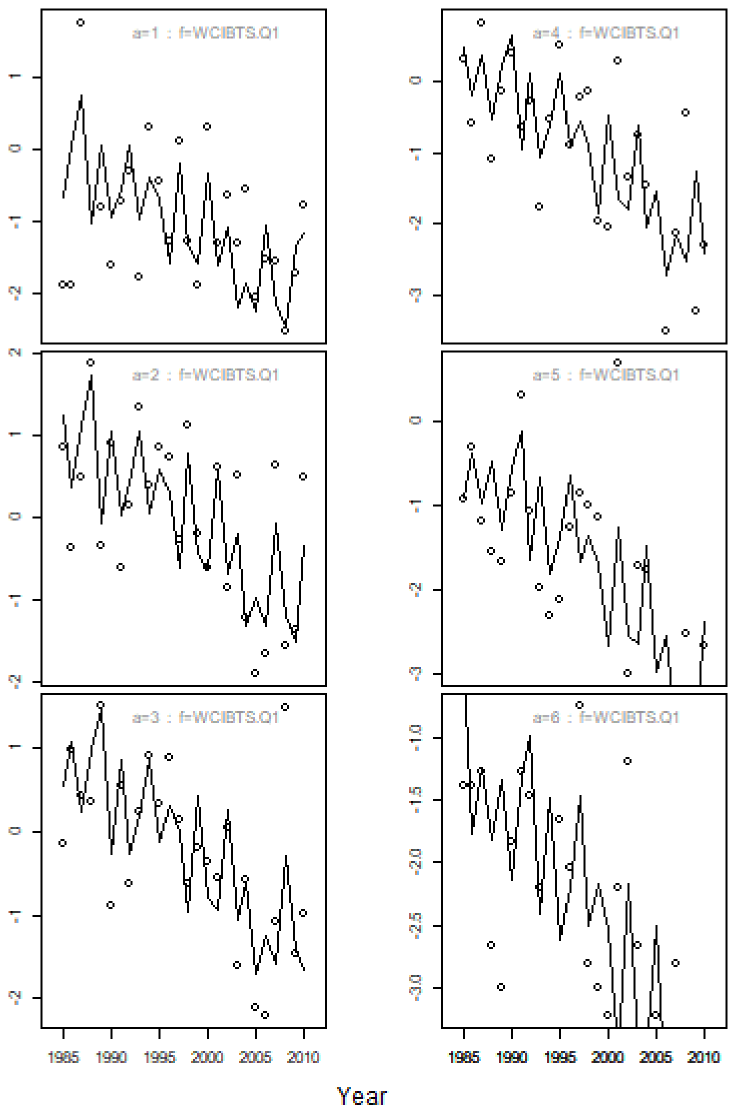

Figure 5.37. Cod.27.6a. SAM final run. Comparison of model estimated and observed log index-at-age (ScoGFS-WIBTS-Q1).

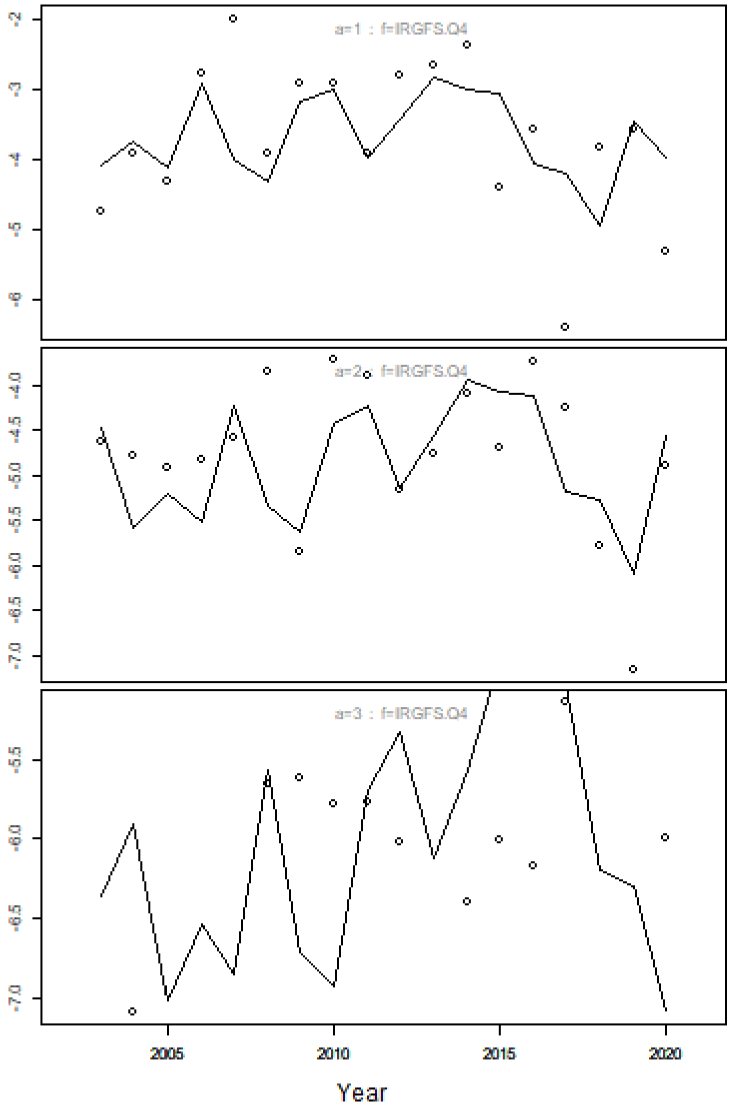

Figure 5.38. Cod.27.6a. SAM final run. Comparison of model estimated and observed log index-at-age (IRGFS-WIBTS-Q4).

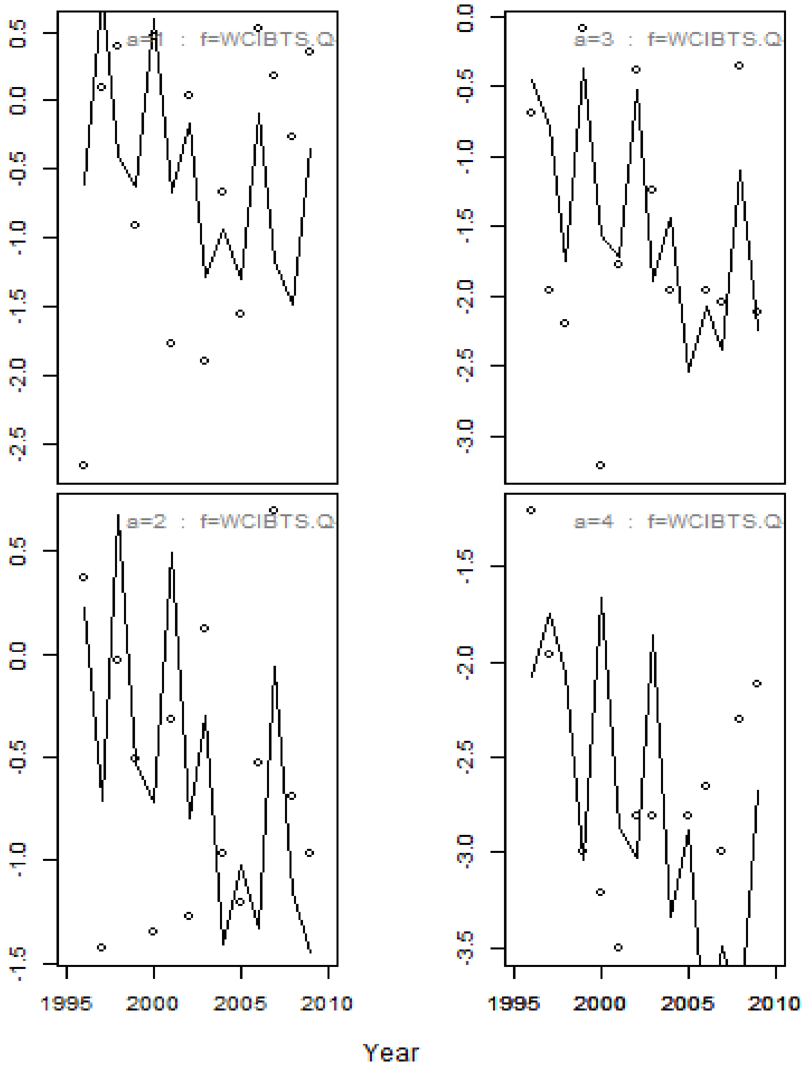

Figure 5.39. Cod.27.6a. SAM final run. Comparison of model estimated and observed log index-at-age (ScoGFS-WIBTS-Q4).

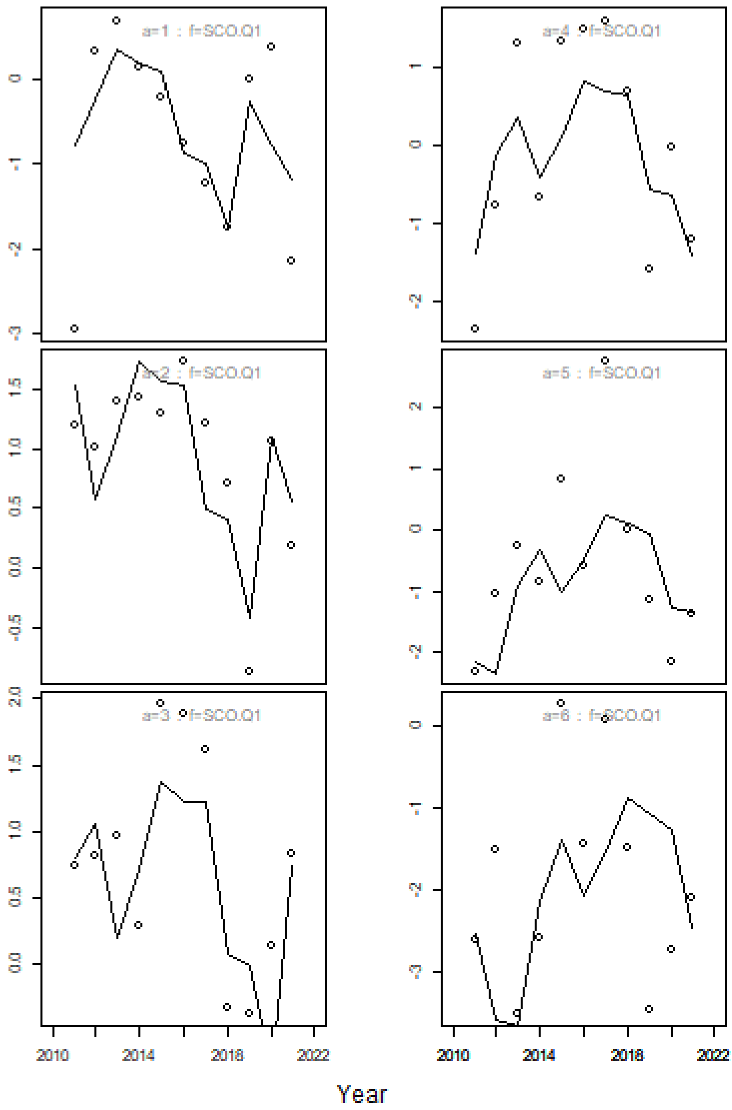

Figure 5.40. Cod.27.6a. SAM final run. Comparison of model estimated and observed log index-at-age (UK-SCOWCGFS-Q1).

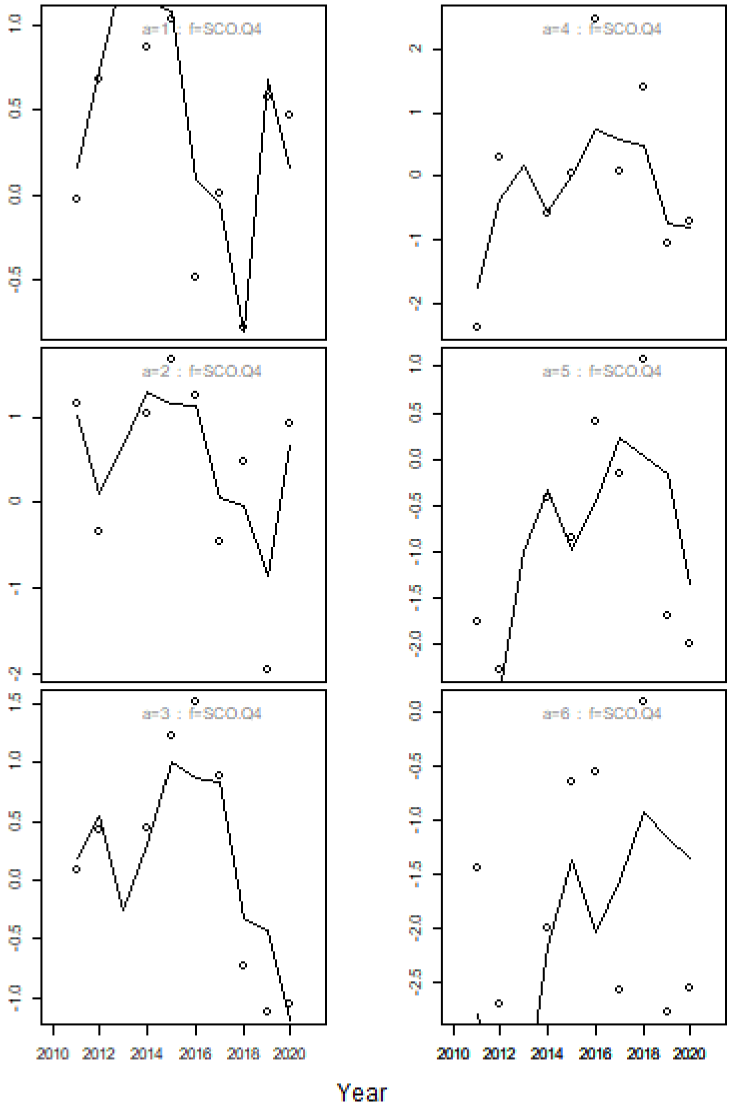

Figure 5.41. Cod.27.6a. SAM final run. Comparison of model estimated and observed log index-at-age (UK-SCOWCGFS-Q4).

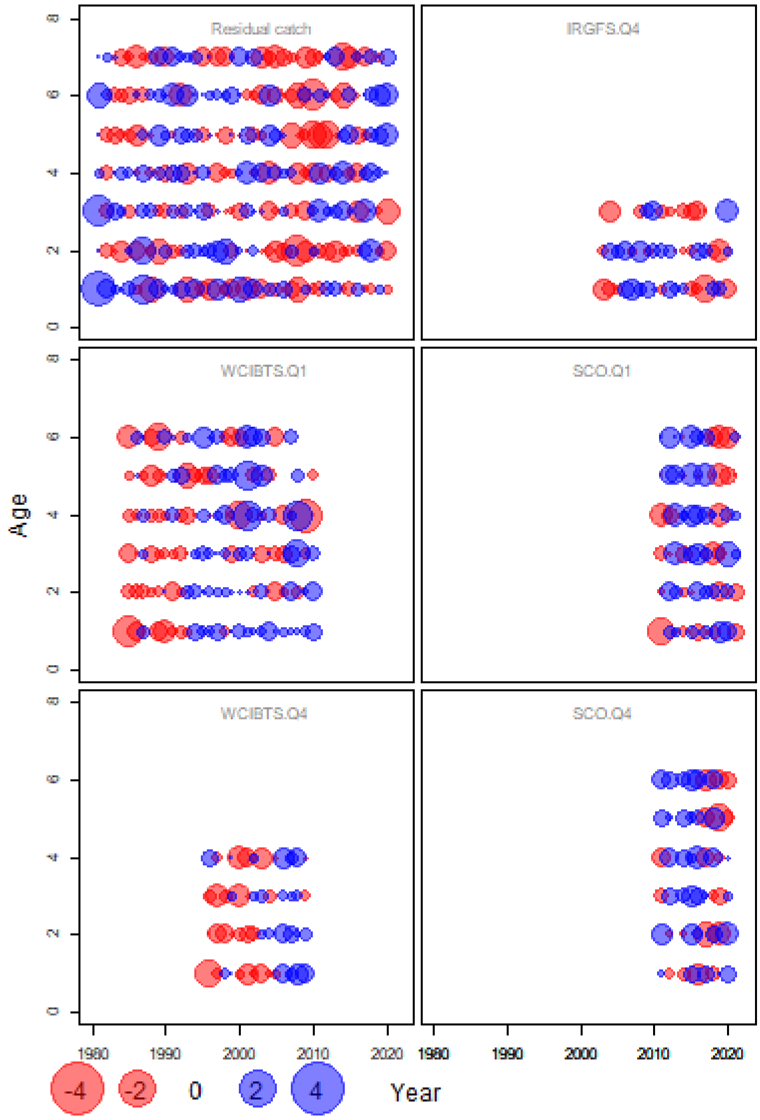

Figure 5.42. Cod.27.6a. SAM final run. One step ahead residuals for catch-at-age data and survey indices.

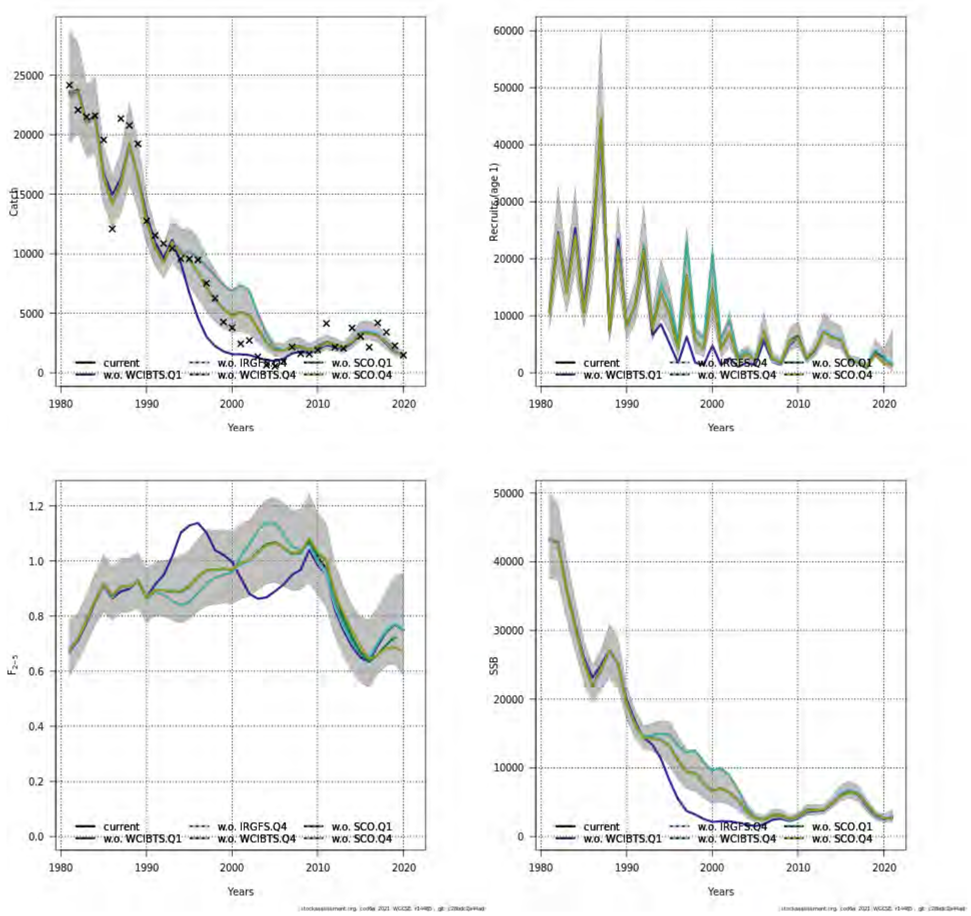

Figure 5.43. Cod.27.6a. SAM final run. Leave one out sensitivity analysis.

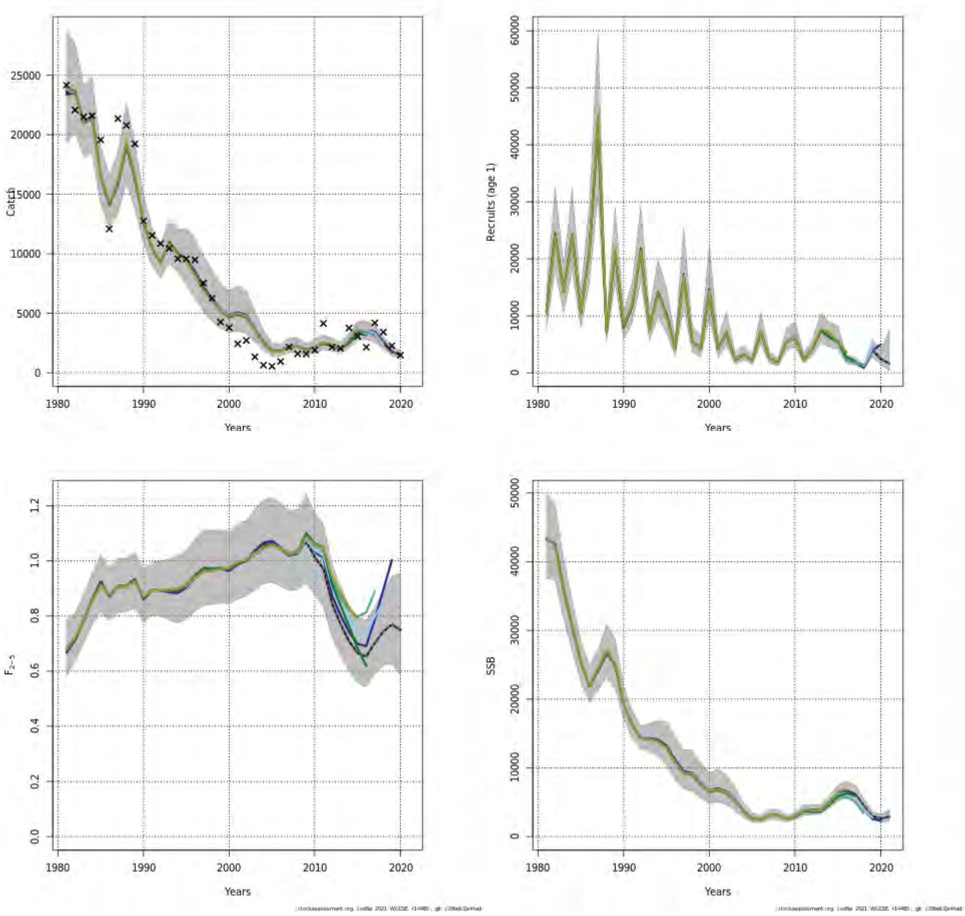

Figure 5.44. Cod.27.6a. Retrospective plots of final SAM run.

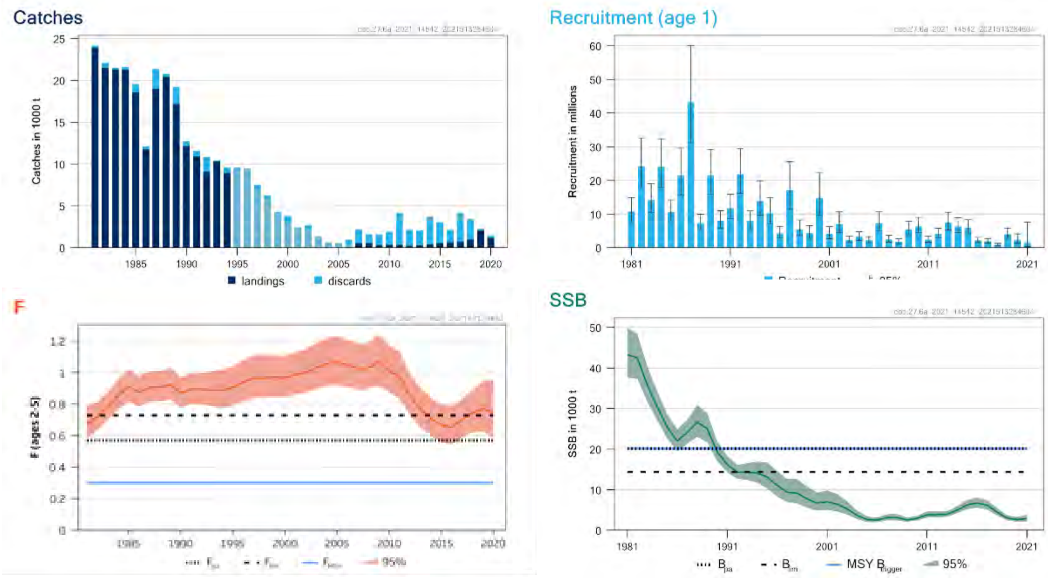

Figure 5.45. Cod.27.6a. Summary of the stock assessment. ICES estimated landings and discards shown in the upper left panel (catches from 1995–2006 (unshaded) are excluded from the assessment). Shaded areas (F and SSB) and error bars (recruitment) correspond to 95% confidence intervals.

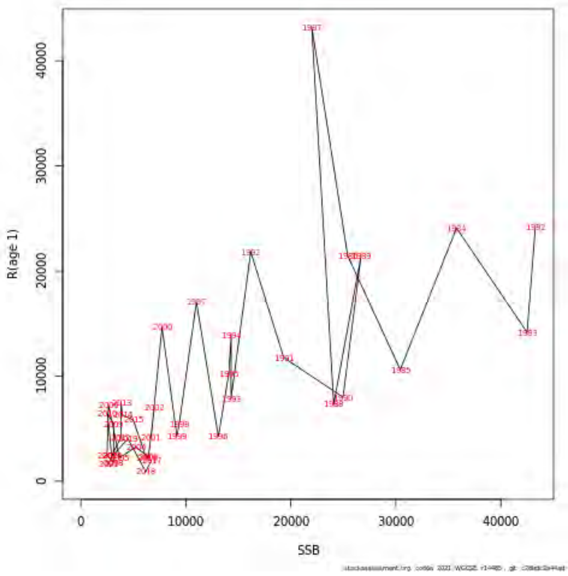

Figure 5.46. Cod.27.6a. SAM final run. Stock–recruit relationship. Numbers indicate recruitment year.

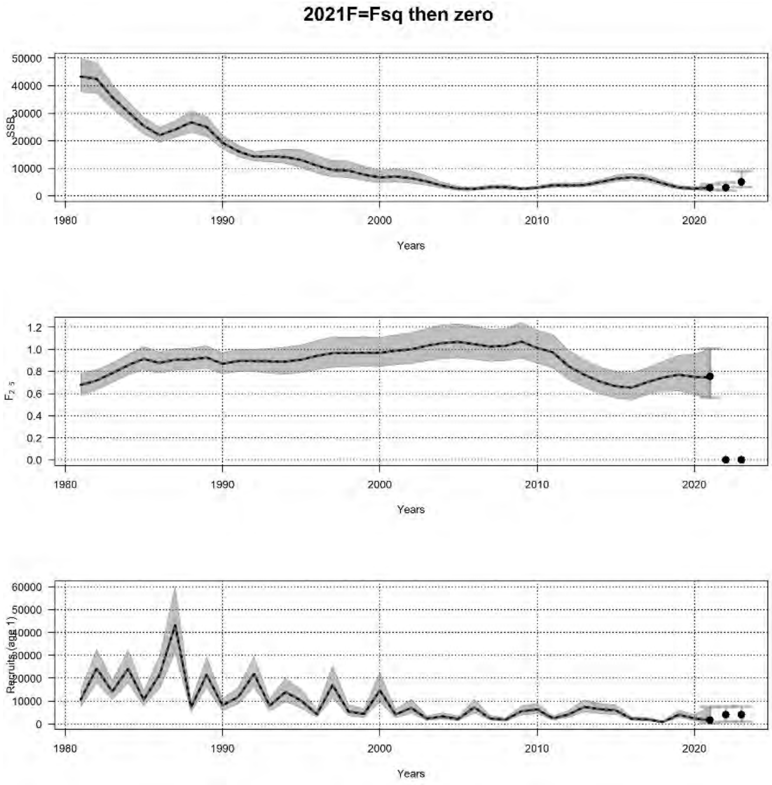

Figure 5.47. Cod.27.6a. SAM forecast assuming Fsq in the intermediate year followed by zero catch (the proposed advice) in subsequent years.

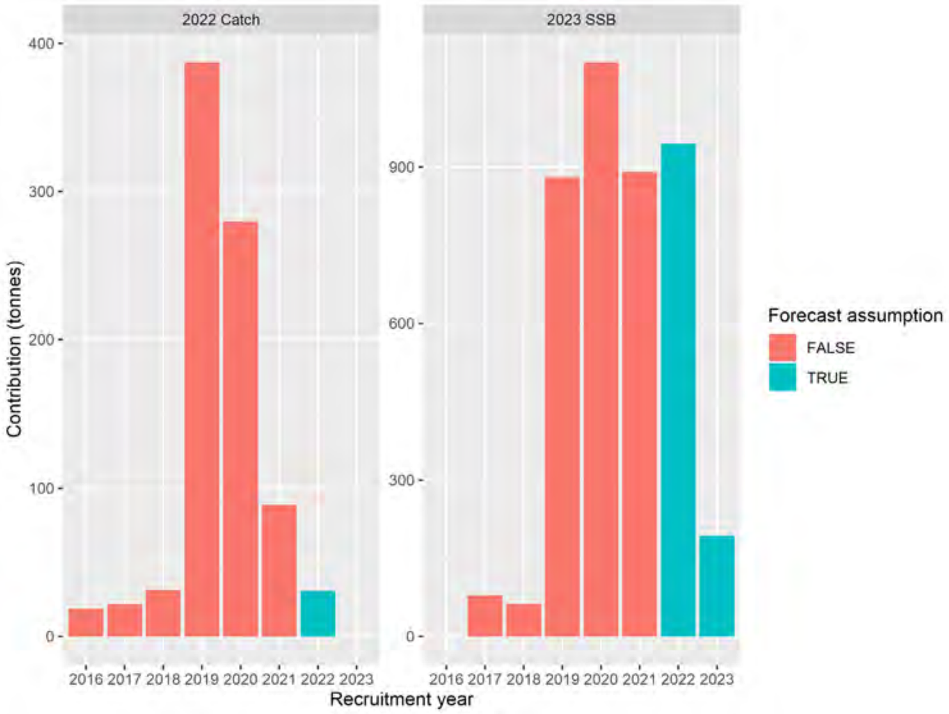

Figure 5.48. Cod.27.6a. Percentage contribution to landings yield in 2021 and SSB in 2022 by recruitment year (not year class). Blue ('TRUE') indicates forecast assumption rather than an assessment model estimate.

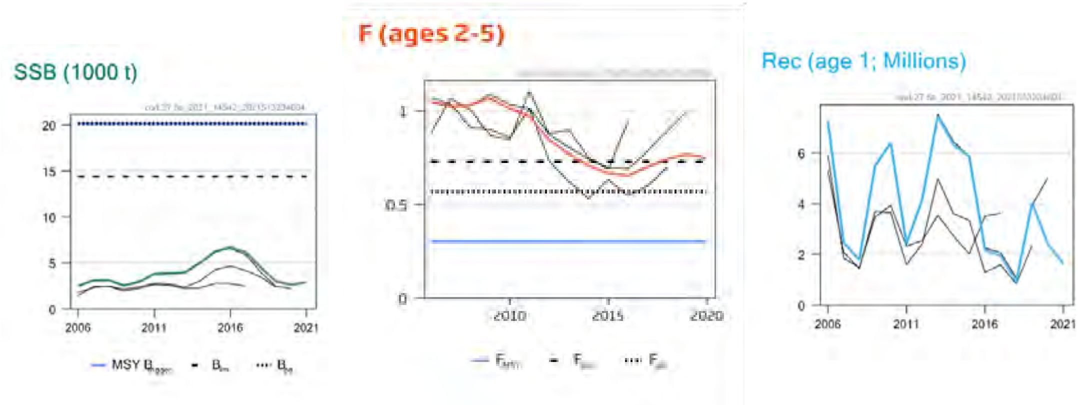

Figure 5.49. Cod.27.6a. Comparison of historical assessments.

4 Cod (*Gadus morhua*) in Division 6.b (Rockall)

Assessment in 2020

In 2020, the updated assessment and advice followed the agreed procedures for category 6.2.0 of ICES RGLIFE data-limited stock (DLS) advice rules (ICES, 2017a) as set out in the stock annex. For stocks without information on abundance or exploitation, ICES considers that a precautionary reduction of catches should be implemented unless there is ancillary information clearly indicating that the current level of exploitation is appropriate for the stock.

New survey information indicates increased catch rates since 2018 and stable landings per unit of effort since 2016 indicate that the current level of exploitation is appropriate for this stock. A precautionary buffer was therefore not applied.

ICES advice applicable in 2021–2023

ICES advises that when the precautionary approach is applied, catches should be no more than 14 tonnes in each of the years 2021, 2022, and 2023.

Previous advice for this stock is included below.

ICES advice applicable in 2018–2020

ICES advises that when the precautionary approach is applied, catches should be no more than 14 tonnes in each of the years 2018, 2019, and 2020. ICES cannot quantify the corresponding landings.

ICES advice applicable in 2016–2017

ICES advises that when the precautionary approach is applied, landings should be no more than 17 tonnes in each of the years 2016 and 2017. ICES cannot quantify the corresponding total catches.

4.1 Data

Official landings data for cod in 6.b are shown by nation in Table 4.1 and Figure 4.1. Total reported landings were 39.35 tonnes in 2020. There were no updates to landings from previous years. In the past, official landings have shown very high interannual variation and it is not known whether these are a true reflection of removals.

Landings data have been uploaded to InterCatch for 2020. In addition, some landings age compositions and discard data were also uploaded to InterCatch. Data uploaded to InterCatch for 2020 are shown below.

Country	Discards (t)	Landings (t)
Ireland		13.3
Norway		0.95
UK (Scotland)	0.16	25.1
Grand Total		39.35

In recent years, only limited discard data have been submitted to InterCatch for this stock. Discarded weight has been submitted for the Scottish demersal otter trawl fleet for the years 2014–2020; however, there is high interannual variability in the estimated discard rate for this fleet (0%, 34.90%, 18.94%, 1.96% and 4.59%, 0.04%). Discard information has also been provided by Ireland in 2016, 2017 and 2019 for the demersal otter trawl fleet with 100–119 mm mesh size (2.25%, 3.68% and 17.39%), although no discard information was submitted in 2018 or 2020.

Commercial lpue data

Irish and Scottish landings, effort and lpue are presented in Figures 4.2 and 4.3 and Tables 4.2 and 4.3. Figure 4.2 shows a large decline in the Irish lpue between 1995 and 2003 followed by relatively stable values at a level much lower than at the start of the time-series. In 2017, there was a large increase in effort for this fleet exceeding the previous time-series maximum. This fell in 2018 but rose again in 2019 to a new high, exceeding the 2017 effort level. In 2020 effort fell slightly but remained above the 2017 level. The recording of hours fished data in the log sheets is not mandatory for the Scottish fleet and consequently the data are incomplete. Scottish otter-trawl fleet data are therefore in units of kg/kWday. The Scottish time-series is much shorter and relatively noisier than the Irish time series. Whilst there were marked increases in lpue in 2015 and 2016, given the magnitude of increase it seems unlikely to be completely attributable to an increase in stock size (an almost five-fold increase over two years). Between 2016 and 2019, lpue for the Scottish fleet has fluctuated without trend. 2020 has seen a sharp decrease in lpue and a slight decrease in effort.

4.2 References

ICES. 2017a. Advice basis. *In* Report of the ICES Advisory Committee, 2017. ICES Advice 2017, Book 1, Section 1.2.

Table 4.1. Cod in Division 6.b (Rockall). Official catch statistics.

Country	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Faroe Islands	18	-	1	-	31	5	-	-	-	1	-	-	-	-	-	-	-
France	9	17	5	7	2	-	-	-	-	-	-	-	-	-	-	-	+
Germany	-	3	-	-	3	-	-	126	2	-	-	-	10	22	3	11	1
Ireland	-	-	-	-	-	-	400	236	235	472	280	477	436	153	227	148	119
Norway	373	202	95	130	195	148	119	312	199	199	120	92	91	55	52	85	152
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-
Russia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7
Spain	241	1200	1219	808	1345	-	64	70	-	-	-	2	5	1	6	4	3
UK (E&W and NI)	161	114	93	69	56	131	8	23	26	103	25	90	23	20	32	22	4
UK (Scotland)	221	437	187	284	254	265	758	829	714	322	236	370	210	706	341	389	286
UK	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1023	1973	1600	1298	1886	549	1349	1596	1176	1097	661	1031	775	962	661	659	572

Table 4.1. Continued. Cod in Division 6.b (Rockall). Official catch statistics.

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018*	2019*	2020*
Faroe Islands	-	-	-	-	-	-	-	-	3	5	-	-	-	-	-	-	-	-	-	-
France	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Germany	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	40	18	11	7	12	23	24	41	20	6	12	1	2	6	5	15	17	14	10	14
Norway	89	28	25	23	7	7	12	12	25	27	49	11	3	+	18	11	3	1	5	1
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Russia	26	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Spain	1	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E&W and NI)	2	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (Scotland)	176	67	57	45	43	29	26	41	48	23	37	11	9	-	-	-	-	-	-	-
UK	-	-	-	-	-	-	-	-	-	-	-	-	-	10	18	37	38	49	51	27
Total	334	115	102	75	62	58	62	94	97	61	98	23	14	15	41	62	58	64	66	42

* **Preliminary.**

Table 4.2. Cod in 6.b. Landings, effort and lpue data from the Irish otter-trawl fleet.

Year	Landings tonnes	Effort '000s Hrs	Lpue Kg/Hr
1995	414.9	9.1	45.39
1996	402	7.2	55.68
1997	130.5	7.2	18.2
1998	207.1	7.3	28.23
1999	137.8	8.79	15.88
2000	101.1	9.9	10.23
2001	33.3	7.2	4.6
2002	16.2	2.6	6.18
2003	9.9	4.5	2.18
2004	6.9	2.2	3.08
2005	8.8	3.3	2.68
2006	22.2	5.9	3.76
2007	24.2	6.6	3.68
2008	41.6	9.9	4.21
2009	21.7	4.4	4.97
2010	7.5	3.3	2.3
2011	10.2	2.5	4.01
2012	1	3.2	0.31
2013	1.8	3.8	0.46
2014	5.6	4.2	1.34
2015	5.1	4.7	1.07
2016	16.4	6.2	2.65
2017	17.3	14.9	1.16
2018	13.3	11.8	1.13
2019	9.5	17.2	0.55
2020	13.3	15.1	0.88

Table 4.3. Cod in 6.b. Landings, effort and lpue data from the Scottish TR1 fleet.

Year	lnds(t)	eff(kwdays)	Lpue(kg/kwday)
2003	64.09	2504466	0.0256
2004	39.76	1842103	0.0216
2005	42.98	1217357	0.0353
2006	28.25	1011354	0.0279
2007	25.98	1060551	0.0245
2008	40.29	1124197	0.0358
2009	47.76	1631239	0.0293
2010	22.65	1744452	0.0130
2011	36.54	1565753	0.0233
2012	10.78	901552	0.0120
2013	9.09	532767	0.0171
2014	9.70	668665	0.0145
2015	19.92	563098	0.0354
2016	34.01	514486	0.0661
2017	37.71	794571	0.0475
2018	49.25	794017	0.062
2019	51.63	1078714	0.046
2020	25.10	978909	0.027

Table 4.4. Cod in 6.b. Survey data made available to the WG: Scottish Q3 ground fish survey ((Rock-WIBTS-Q3)). Catch rates are given as number per 10 hours.

Year	Effort (10 Hours)	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
2011	10	0	0	0	0	0	0	0	0	0	0
2012	10	0	0	0	0	0	0	0	0	0	0
2013	10	0	0.493	0.493	0	0	0	0	0	0.403	0
2014	10	0	0.279	0.894	0	0	0	0	0	0	0
2015	10	0	0	0.922	0.307	0	0	0	0	0	0.307
2016	10	0	0	0.269	0.538	0.538	0	0	0.269	0	0
2017	10	0	0	0	0	0.922	1.062	0	0	0	0
2018	10	0	0	0.307	0.614	0.307	0.307	0	0	0	0
2019	10	0	1,249	0.453	0.969	0.094	0	0	0	0	0

Data for 2020 not available.

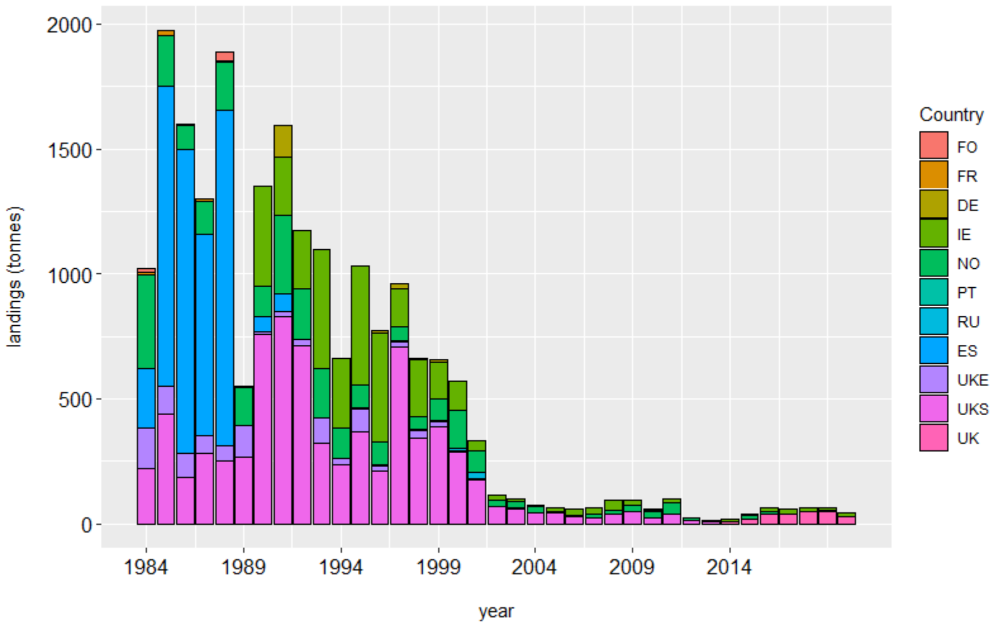

Figure 4.1. Cod in Division 6.b. Total of official catch by nation. Values for 2020 are provisional.

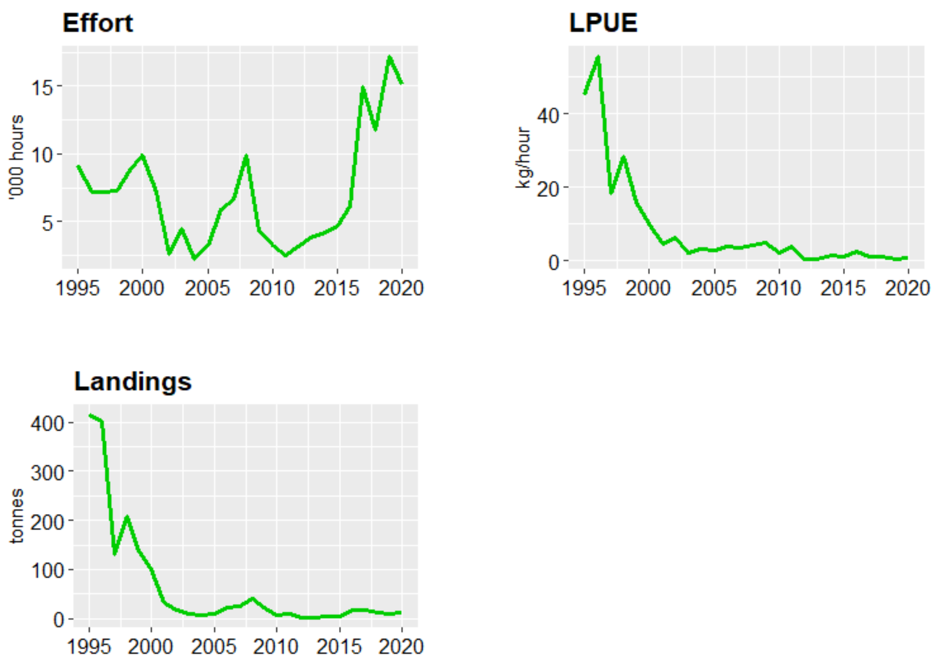

Figure 4.2. Cod in Division 6.b. Landings, effort and lpue (kg/hr) from the Irish Otter-trawl fleet 1995–2020.

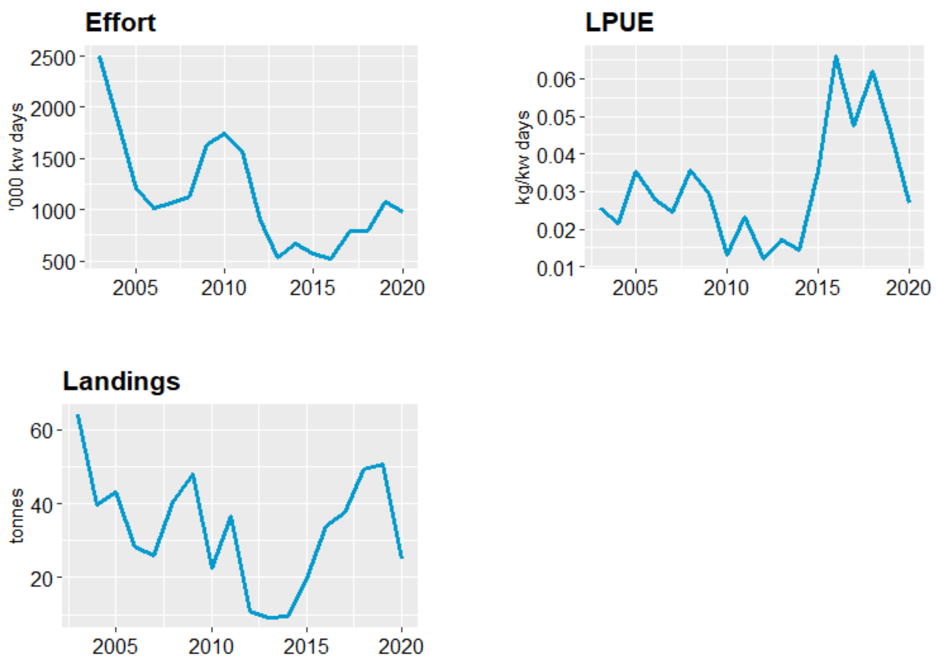

Figure 4.3. Cod in Division 6.b. Landings, effort and LPUE (Kg/kWday) from the Scottish TR1 fleet 2003–2020.

5 Cod in 7.a (Irish Sea)

Situated between Ireland and Great Britain the Irish Sea (7.a) is connected by to the Celtic Sea (7.g) at its southern extreme by the St George's Channel and in north is linked to sea region West of Scotland (6.a) by the Northern Channel. The average depth is 50 m but the area is contrasted between a deeper channel, in the west, and shallower bays in the east. The channel has a maximum depth exceeding 275 m whilst the eastern bays have depths less than 50 m. Distinct habitat patches result from a combination of bathymetry, topographical features and hydrography. The sea bed of the eastern Irish Sea is dominated by fine sediment plains with some small areas of areas of mud habitat, the fine sediments graduate to more coarse material in central areas. A large well-defined deep-water mud basin is located in the northwestern region in close to the Northern Irish and Irish coast.

Irish Sea fisheries are predominantly demersal trawling and seining with demersal trawling for *Nephrops* dominating effort with vessels using mesh in the range 70–99 mm. Effort using fishing gear with ≥100 mm mesh sizes is currently at a low level compared to historic activity, a considerable decline in effort was observed between 2003 and 2007 and has continued. The species composition of catches by vessels in using ≥100 mm mesh consists of primarily haddock, with lower quantities of hake. At present there is no commercial towed gear fishery for cod permitted. Beam trawls are operating within the Irish Sea with mesh sizes in the range 80–119 mm, targeting sole, plaice, and rays. A seasonal pelagic and gillnet herring fishery operates in late summer–early autumn in the pre- and post-spawning period. Dredge fisheries target king and queen scallops, with king scallops in coastal areas with the queen scallop fishery operating in the central area south of the Isle of Man, to a lesser extent queen scallops are also targeted using trawl nets, during the late summer when swimming activity is most pronounced.

Type of assessment

An ICES category 3 assessment based on a biomass trend was used since 2019 as the full analytical assessment, benchmarked at ICES WKIrish3 (ICES, 2017a), did result in a very strong retrospective pattern making the outcomes highly uncertain.

ICES advice applicable to 2020 and 2021

ICES advised on the basis of the MSY and precautionary approaches that there should be no directed fisheries, and bycatch and discards should be minimized in 2017. A TAC based on the MSY approach was advised for 2018 and 2019 and an approach based on the 2 over 3 rule was applied since 2020.

5.1 General

Stock description and management units

The stock and the management unit are both ICES Division 7.a (Irish Sea).

Management applicable to 2020

TACs and quotas set for 2020

Zone 7a (COD/07A)	Analytical TAC	Weight tonnes	Landed
	Belgium	3	9.5
	France	9	0
	Ireland	170	147
	The Netherlands	1	0
	United Kingdom	74	95.6
	EU	257	252.1
	TAC	257	

Management of this cod fishery is by TAC, days-at-sea limits and technical measures. Technical regulations in force in the Irish Sea, including those associated with the cod recovery plan since 2000, are described in Section 5. 2.

Fishery in 2020

The reported landings in 2020 were 252.1 t, remaining below the TAC of 257 t, however the agreed TAC was considerably higher than the TAC advised by WGCSE (116 t). Since 2009, Irish landings of cod reported from ICES rectangles immediately north of the Irish Sea/Celtic Sea boundary (ICES rectangles 33E2 and 33E3) have been reallocated into the Celtic Sea as they represent a combination of inaccurate area reporting and catches of cod considered by ICES to be part of the Celtic Sea stock (ICES, 2009). The amount of Irish landings transferred from 7.a to 7.e–k by year is shown below. Total landings for this stock in 2020 were 181.1 t after this re-allocation and total catches in the area were 206 t.

Year	Tonnes
2004	108
2005	54
2006	103
2007	527
2008	558
2009	193
2010	143
2011	147
2012	130
2013	75
2014	24
2015	39
2016	40
2017	19
2018	20
2019	37
2020	71

The total quota uptake for most countries was less than the TAC advice, while landings by UK vessels have realised 129% of TAC in 2020 (Table 5.2), while the uptake of the TAC allocation after re-allocating the ICES rectangles 33E2 and 33E3 in Ireland was low at 44.6% (Table 5.2). The majority of landings was taken by the TR1 fleet, followed by bycatch in *Nephrops* trawlers. Landings and discards by métier and country can be seen in Table 5.3. Total uptake of cod TAC was 70.5%.

A Fishery–Science Partnership Survey (FSP) was repeated in the western Irish Sea in spring 2020 and 2021 in the western Irish Sea using semi-pelagic gear on commercial vessels. This survey attempts to address the lack of sampling opportunities created by the diminishing TAC for cod in the Irish Sea and the resulting significant reduction of a directed whitefish fleet targeting cod.

InterCatch procedure

Since 2013 international landings and discards-at-age are uploaded into InterCatch. Discards are raised for unreported strata and métiers to estimate total discards-at-age.

Landings

The input data on fishery landings and age compositions are split into four periods:

1. 1968–1990. Landings in this period, provided to ICES by stock coordinators from all countries, are assumed to be un-biased and are used directly as the input data to stock assessments.
2. 1991–1999. TAC reductions in this period caused substantial misreporting of cod landings into several major ports in one country, mainly species misreporting. Landings into these ports were estimated based on observations of cod landings by different fleet sectors during regular port visits. For other national landings, the WG figures provided to ICES stock coordinators were used.
3. 2000–2005. Cod recovery measures were considered to have caused significant problems with estimation of landings. The ICES WG landings data provided by stock coordinators for all countries are considered uncertain and estimated within an assessment model. Observations of misreported landings were available for 2000, 2001, 2002 and 2005. However, they have generally not been used to correct the reported landings but have been used to evaluate model estimates in those years.
4. Since 2006. The introduction of the UK buyers and sellers legislation is considered to have reduced the bias in the landings data but the level to which this has occurred is unknown. Consequently, comparisons were made between the fit of the model to recorded landings under an assumption of bias and unbiased information.
5. 2020. The Covid-19 pandemic made the collection of observer data onboard vessels impossible for Q2–Q4, making the estimation of discard data and the establishment of age structure in catches impossible for most of the year. Age structure of the stock is available from Q1 observer data and the 3 surveys, FSP, and Q1 and Q4 groundfish surveys.

The annual numbers-at-age caught and the mean weights-at-age in landings (applied to the total catch) by age are given in Tables 5.4 and 7.5; however, data from 2020 are excluded due to limited discard and port sampling during the COVID-19 pandemic. While previous years' surveys and commercial data showed an improvement in age structure, which resulted from very low fishing pressure since 2013 and a relatively strong 2013 cohort, this cohort has by now disappeared from the fishery.

Discards data

The Cod 7.a Stock Annex and WKIrish3 (ICES, 2017 a, b) benchmark report gives details on historic raising to total national and international discards.

Biological data
Natural mortality
Natural mortality has been revised in WKIrish2 (ICES, 2016). M-at-age calculated following Lorenzen (1996) was considered a better representation of the natural mortality than M=0.2. Natural mortality was kept constant throughout years.

Maturity
Maturity ogive has been revised in WKIrish2 (ICES, 2016). Each year the smoother is applied to the full time-series of raw data and values are accordingly updated. Updated values after application of the smoother are in Table 5.7. Please refer to the stock annex for further information.

Survey data used for advice
Please refer to the stock annex for a description of the surveys and survey data.

Survey	Ages	Years	
NIGFS-WIBTS-Q1 (G7144)	Biomass only	1993	2021

5.2 Historical stock development

Trend-based analysis in Category 3 using 2 over 3 rule.

The advice of the stock is now based on a trend-based assessment using a relative biomass and harvest index.

Deviations from Stock Annex
The assessment did not follow the stock annex as the model provided too great a retrospective pattern in 2019. A trend-based assessment has been used since 2019.

Final assessment
A trend-based analysis was used to assess the stock status.

The NIGFS-Q1 (G7144) survey (1993–2021) was used to generate a biomass trend by using biomass/nautical miles (Table 5.8 a). The total biomass in weight rather than age classes was used to enable the inclusion of the latest survey in Q1 2021. This was then standardised to the mean and the average of the last two years was divided by the mean of the preceding three to generate the index of change. The rate of change (resulting from the 2 over 3 rule) (Figure 5.1, Table 5.9) was 0.62, suggesting that the biomass is continuing to drop.

The biomass index is largely based on ages 1–4; including the current year gives a good indication of the SSB development from 2021 to 2022.

A harvest rate indicator was constructed using the ratio of total catches to biomass index which was then standardised to the mean; this is used for informative reasons only.

Final assessment: long-term trends
The harvest rate indicator has been constantly declining since 2013 and saw a slight increase since 2018 due to the landings increase in response to the higher TAC (Figure 5.1, Table 5.9) which coincided with a decline in the biomass index.

The biomass index is back to the pre-2011 level, showing that the impact of the strong year-class group has by now disappeared from the stock. The biomass index takes into account fish ages 1 to 4. Not all constitute to the SSB in the current year, but the index largely follows the commercial exploitation pattern of the year +1 and is therefore considered an appropriate index for exploitable biomass in the next year.

5.3 Short-term predictions

No short-term forecast was carried out.

5.4 Biological reference points

No reference points available at the current time.

5.5 Management plans

The Irish Sea cod management plan, as described in Council Regulation (EC) 1342/2008 was evaluated independently by ICES in 2009 using the approach adopted in AGCREMP 2008 and found to be not consistent with the ICES Precautionary Approach (WGCSE 2009).

5.6 Uncertainties and bias in assessment

Surveys

The Irish Sea has relatively good survey coverage. The surveys in general give consistent signals of fish abundance-at-age.

Stock structure and migrations

Stock structure and migrations have been in full discussed in the WKIrish2 report (ICES, 2016).

A tagging study of Irish Sea cod began in 2016 in part to address these issues. Up to January 2019, 4238 cod were caught and tagged aboard chartered commercial fishing vessel using semi-pelagic fishing gear, FSP survey, shore angling competitions and others. Up to January 2019, 138 tagged cod were returned. The project relies on collaboration with the fishing industry to provide the data to develop a better understanding of the current behaviour, biology and stock status of Irish Sea cod. Most recent results suggest a stronger migratory behaviour of Irish Sea cod into the Celtic Sea, indicating that up to 18% of mature fish might leave the Irish Sea (Report citation). This will have considerable impacts on the future management and assessment of the stock, but additional research is necessary.

5.7 Management considerations

A number of emergency and cod recovery plan measures have been introduced since 2000 to conserve Irish Sea cod. These include a spawning closure since 2000 and effort control since 2003. There have also been several vessel decommissioning schemes. As it has not been possible to provide analytical catch forecasts in recent years, the TAC has been reduced by 15–20% annually since 2006 and by 25% since 2009. An MSY approach was used to set TAC in 2018 and 2019, which was followed by a precautionary advice since 2020.

5.8 Future Issues and considerations

Cod in the Irish Sea and the Celtic Sea are in a highly exploited state and show historically a very steep age-profile.

Under the current highly exploited status it seems that recruitment rather than fishing pressure is driving stock trends.

The recent years show that a single, above average, cohort (the 2013 year class), can have a considerable impact on the SSB. However, as those fish seemed to disappear at age 3 or 4, this resulted in the strong retrospective downwards revisions of SSB.

It is essential to further the understanding of the stock structure to improve future management, which includes the further investigation of migration and natural mortality in the Irish Sea. It might be necessary for a combined approach to manage the stocks in 7A and 7E–G, in the light of the recent tagging study results.

5.9 References

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Table 5.1. Nominal landings (t) of COD in Division 7.a as officially reported to ICES and figures used by ICES from 2000.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019[1]	2020[1]
Belgium	60	283	318	183	104	115	60	67	26	19	21	36	23	13	9	12	3	5.1	1.9	10.3	9.5
France	53	74	116	151	29	35	18[2]	17[2]	3	12	1	3	1	<1	<1	<1	<1	<1	<1	<1	0
Ireland	455	751	1,111	594	380	220	275	608	618[2]	323[2]	289	275	193	160	148	137	84.2	53.4	104.6	129	75.9
Netherlands	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (England, Wales & NI)	799	885	1,134	505[3]	646[3]	594[3]	5892[3]	423	5432	3872	282	169	109	107	79	50	35.5	41.4	113.3	195	95.4
UK (Isle of Man)	11	1	7	7	5	n/a	n/a	n/a	22	12	1	1	<1	<1	<1	<1	<1	3	<1	<1	<1
UK (Scotland)	38	32	29	23	15	3	6	2	12	12	-	-	-	-	-	-	-	<1	<1	-	<1
Total	1,417	2,026	2,715	1,477	1,179	967	948	1,117	1224	754	594	485	326	281	236	199	122.83	103.15	234.9	334.4	252.1
Unallocated	-143	226	-20	-192	-107	-57	-108	-415	-563	-286	-130	-117	-128	-75	-33	-38	-40.5	-19.4	-20	-36.7	-71
Total as used by WG	1274[4]	2252[4]	2695[4]	1285[4]	1072[4]	910[4]	840[4]	702[4]	661[4]	468[4]	464[4]	368	198	206	213	161	82	83.75	214.9	297.7	181.1

[1]Preliminary. [2]Revised. n/a = not available [3] includes sample-based estimates of landings into three ports [4] based on official data only.

Table 5.2. a)–c) Cod in 7a. Working Group figures for annual landings and TAC uptake since 2000.

a)

Year	Total	TAC	% uptake
2000	1273	2100	61
2001	2251	2100	107
2002	2695	3200	84
2003	1285	1950	66
2004	1072	2150	50
2005	910	2150	42
2006	840	1828	46
2007	702	1462	48
2008	662	1199	55
2009	468	899	52
2010	465	674	69
2011	368	506	73
2012	198	380	52
2013	206	285	72
2014	213	182	117
2015	161	146	110

Year	**Total**	**TAC**	**% uptake**
2016	82	146	56
2017	84	146	57
2018	215	695	31
2019	298	807	37
2020	181	257	70

b)

2009	UK	Ireland	France	Belgium	Netherlands	Total
Landings	391	55	3	19	0	498
TAC	259	592	33	12	3	899
% uptake	151%	9%	9%	160%	0%	

2010	UK	Ireland	France	Belgium	Netherlands	Total
Landings	292	151	1	21	0	465
TAC	194	444	25	9	2	674
% uptake	150%	34%	4%	233%	0%	

2011	UK	Ireland	France	Belgium	Netherlands	Total
Landings	170	160	3	36	0	369
TAC	146	333	19	7	2	506
% uptake	117%	48%	16%	533%	0%	

2012	UK	Ireland	France	Belgium	Netherlands	Total
Landings	112	63	0	23	0	198
TAC	109	251	14	5	1	380
% uptake	103%	25%	0%	460%	0%	

2013	UK	Ireland	France	Belgium	Netherlands	Total
Landings	107	85	1	13	0	206
TAC	82	188	10	4	1	285
% uptake	130%	45%	10%	325%	0%	

2014	UK	Ireland	France	Belgium	Netherlands	Total
Landings	79	124	0	9	0	213
TAC	52	120	7	2	2	182
% uptake	153%	103%	0%	455%	0%	

2015	UK	Ireland	France	Belgium	Netherlands	Total
Landings	50	99	0	12	0	161
TAC	42	97	5	2	0	146
% uptake	119%	102%	0%	600%	NA	

2016	UK	Ireland	France	Belgium	Netherlands	Total
Landings	35	44	0.4	3	0	82
TAC	42	97	5	2	0	146
% uptake	83%	45%	8%	150%	0%	

2017	UK	Ireland	France	Belgium	Netherlands	Total
Landings	41	38	0.2	5	0	84
TAC	42	97	5	2	0	146
% uptake	98%	39%	4%	250%	0%	

2018	UK	Ireland	France	Belgium	Netherlands	Total
Landings	128.5	84.6	0.05	1.9	0	214.9
TAC	200	459	25	9	2	695
% uptake	64%	18%	<1%	<1%	0%	31%

2019	UK	Ireland	France	Belgium	Netherlands	Total
Landings	193.9	90	0.2	10.2	0	294.6
TAC	233	530	30	11	3	807
% uptake	83%	17%	<1%	93%	0%	36.5%
2020	**UK**	**Ireland**	**France**	**Belgium**	**Netherlands**	**Total**
Landings	95.6	75.9	0	9.5	0	181.1
TAC	74	170	9	3	1	257
% uptake	129%	45%	0%	317%	0%	70%

Table 5.3. Landings and discard proportions by métier.

Catch (2020)	Landings				
206 tonnes	otter trawls		mid-water trawl	beam trawls	other gear types
	Nephrops directed 25%	demersal fish directed 40%	17%	18%	<1%
	181 tonnes				
	Discards				
	otter trawls		mid-water trawl	beam trawls	other gear types
	54% *Nephrops* directed	1% demersal fish directed	<1%	45%	<1%
	25 tonnes				

Table 5.4. Cod in 7a. Total catch numbers-at-age (thousands).

	0	1	2	3	4	5	6+
1968	17	439	1563	1003	456	177	30
1969	20	969	1481	1050	269	186	113
1970	22	1810	1385	352	204	163	71
1971	22	2835	2022	904	144	67	51
1972	26	900	3267	824	250	58	59
1973	27	2377	1091	1783	430	173	81
1974	16	601	3559	557	494	131	74
1975	26	1810	642	1407	294	249	117
1976	27	1247	3007	363	500	61	104
1977	31	946	511	1233	163	218	71
1978	40	855	1092	310	311	39	65
1979	44	1948	1288	608	127	164	71
1980	25	2636	2797	729	243	49	55
1981	38	1457	3635	1448	244	99	47
1982	46	538	2284	1455	557	102	79
1983	47	1011	932	751	499	154	46
1984	37	1733	1195	439	240	161	75
1985	34	1360	2105	703	158	84	77

	0	1	2	3	4	5	6+
1986	49	1180	2248	699	203	64	65
1987	47	4522	1793	841	252	75	43
1988	43	2971	4734	702	263	71	38
1989	41	754	2163	1886	231	86	37
1990	38	869	1075	545	372	70	30
1991	47	2169	1408	442	127	98	22
1992	37	1529	1243	664	132	42	49
1993	39	388	2907	403	119	16	13
1994	40	916	569	848	68	20	10
1995	43	678	1283	180	163	7	6
1996	88	447	1113	700	38	39	6
1997	5	651	1149.5	501	213	17	16
1998	0	231	1928	335	80	28	8
1999	141	236	843	871	66	21	7
2000	62	1107	176	107	50	4	1
2001	7	403	841	53	13	9	2
2002	0	238	564	405	7	2	3
2003	50	121	472	109	36	1	0

	0	1	2	3	4	5	6+
2004	50	161	134	174	22	6	3
2005	50	118	256	78	34	5	1
2006	50	89	174	128	17	8	3
2007	16	216	210	56	11	1	0
2008	6	77	169	87	9	3	0
2009	329	60	57	66	17	3	0
2010	49	220	188	16	7.5	2	1
2011	10	54	106	36	2	1	1
2012	8	84	135	145	10	0	0
2013	36	37	59	30	9	2	0
2014	1	41	86	26	5	1	0
2015	0	37	80	26	4	1	0
2016	0	11	25	30	2	1	0
2017	0	12	28	16	3	0	0
2018	256	95	27	36	2	2	1
2019	0	60	68	12	9	1	2
2020	0	108	50	20	4	2	1

Table 5.5. Mean weights-at-age in the landings (used for whole stock and catch). *wean weight-at-age in landings only available for Q1, hence considerably lower than previous years and not included.

	0	1	2	3	4	5	6+
1968	0.1	0.61	1.66	3.33	5.09	6.19	6.86
1969	0.1	0.61	1.66	3.33	5.09	6.19	7.26
1970	0.1	0.61	1.66	3.33	5.09	6.19	7.17
1971	0.1	0.61	1.66	3.33	5.09	6.19	7.12
1972	0.1	0.61	1.66	3.33	5.09	6.19	7.28
1973	0.1	0.61	1.66	3.33	5.09	6.19	7.16
1974	0.1	0.61	1.66	3.33	5.09	6.19	7.34
1975	0.1	0.61	1.66	3.33	5.09	6.19	7.05
1976	0.1	0.61	1.66	3.33	5.09	6.19	7.13
1977	0.1	0.61	1.66	3.33	5.09	6.19	7.63
1978	0.1	0.61	1.66	3.33	5.09	6.19	7.19
1979	0.1	0.61	1.66	3.33	5.09	6.19	7.48
1980	0.1	0.61	1.66	3.33	5.09	6.19	6.87
1981	0.1	0.61	1.66	3.33	5.09	6.19	7.55
1982	0.1	1.01	1.52	3.49	5.57	7.59	9.11
1983	0.1	1	1.84	3.99	5.96	7.97	9.97
1984	0.1	0.68	1.81	3.81	5.87	7.48	10.05

	0	1	2	3	4	5	6+
1985	0.1	0.78	2.02	4.24	5.83	7.5	9.04
1986	0.1	0.81	1.83	3.86	5.86	7.39	8.78
1987	0.1	0.71	2.16	3.91	6.41	7.82	10.32
1988	0.1	0.61	1.56	3.76	5.67	8.02	9.88
1989	0.1	0.94	1.85	3.22	5.41	6.57	9.47
1990	0.1	0.84	1.94	3.57	5.28	7.53	9.4
1991	0.1	0.86	1.64	3.54	5.42	6.39	9.11
1992	0.1	0.81	1.96	3.99	5.98	6.92	8.67
1993	0.1	0.85	1.71	3.67	5.68	7.37	10.17
1994	0.1	0.8	1.92	3.61	6.08	7.68	8.57
1995	0.1	0.9	1.84	4.00	5.79	8.45	9.14
1996	0.1	0.98	1.63	3.26	5.3	7.72	9.79
1997	0.1	0.85	1.94	3.62	5.29	6.12	9.4
1998	0.1	0.93	1.65	3.73	5.37	7.03	9.35
1999	0.1	0.85	1.62	3.18	5.51	7.52	10.25
2000	0.1	0.85	1.99	3.57	5.14	7.15	8.39
2001	0.1	0.99	1.82	4.15	5.61	7.33	9.51
2002	0.1	0.94	1.84	3.44	5.73	7.71	10.01

	0	1	2	3	4	5	6+
2003	0.1	1.21	1.66	3.29	5.43	10.2	11.09
2004	0.1	1.11	2.2	3.63	6.51	7.64	8.61
2005	0.1	0.91	1.94	3.51	5.32	7.74	8.89
2006	0.1	0.83	1.84	3.67	4.71	6.39	7.84
2007	0.1	0.83	1.85	3.78	5.35	7.99	10.04
2008	0.1	0.89	1.59	3.54	6.00	7.57	9.46
2009	0.1	1.1	2.01	3.46	5.31	7.1	6.82
2010	0.1	1.26	2.29	3.93	6.34	7.33	9.64
2011	0.1	0.95	1.88	3.75	5.54	6.75	9.04
2012	0.1	0.93	1.88	3.37	5.34	7.60	8.56
2013	0.1	0.97	2.32	4.06	5.54	7.43	10.79
2014	0.1	0.88	2.26	4.49	7.00	8.75	9.41
2015	0.1	0.83	1.79	3.69	6.49	8.55	9.95
2016	0.1	0.95	1.58	3.1	5.01	10.66	8.136
2017	0.1	0.70	1.82	3.82	5.85	7.62	9.74
2018	0.1	0.43	1.69	3.64	5.56	8.58	8.70
2019	NA	0.44	2.13	4.25	6.14	6.79	9.00
2020*							

Table 5.6. Cod in 7.a. Estimates of numbers discarded (a) and the discarded proportions (b) from 1968–2019. Data are total numbers ('000 fish) discarded at-age, estimated from numbers per sampled trip raised to total fishing effort by each country supplying data (UK, Ireland and Belgium) Please refer to WKIrish3 (ICES, 2017a) documents.

a)

Year	0	1	2	3	4	5	6+
1968	17.81	74.71	0	0	0	0	0
1969	20.85	87.45	0	0	0	0	0
1970	22.13	92.83	0	0	0	0	0
1971	22.94	96.2	0	0	0	0	0
1972	26.51	111.18	0	0	0	0	0
1973	27.17	113.96	0	0	0	0	0
1974	16.94	71.04	0	0	0	0	0
1975	26.38	110.62	0	0	0	0	0
1976	26.77	112.28	0	0	0	0	0
1977	31.05	130.23	0	0	0	0	0
1978	39.96	167.57	0	0	0	0	0
1979	44.35	185.98	0	0	0	0	0
1980	24.6	103.16	0	0	0	0	0
1981	37.67	157.97	0	0	0	0	0
1982	46.04	193.1	0	0	0	0	0
1983	46.98	197.05	0	0	0	0	0
1984	37.3	156.45	0	0	0	0	0
1985	33.89	142.12	0	0	0	0	0
1986	49.15	206.15	0	0	0	0	0
1987	47.38	198.69	0	0	0	0	0
1988	42.59	178.64	0	0	0	0	0
1989	41.03	172.09	0	0	0	0	0

Year	0	1	2	3	4	5	6+
1990	37.85	158.74	0	0	0	0	0
1991	46.64	195.61	0	0	0	0	0
1992	36.74	154.1	0	0	0	0	0
1993	39.4	165.24	0	0	0	0	0
1994	39.92	167.44	0	0	0	0	0
1995	42.97	180.2	0	0	0	0	0
1996	87.95	128.79	0	0	0	0	0
1997	5.28	127.79	0.5	0	0	0	0
1998	0	27.47	2	0	0	0	0
1999	141.42	165.79	0	0	0	0	0
2000	62.36	817.69	0	0	0	0	0
2001	7.22	65.15	0	0	0	0	0
2002	0	42.49	0	0	0	0	0
2003	50.43	75.68	32.62	15.83	1.25	0.13	0
2004	50.43	92.78	32.81	15.83	1.25	0.13	0
2005	50.43	76.34	32.36	15.83	1.25	0.13	0
2006	50.43	75.08	32	15.83	1.25	0.13	0
2007	16	167	4.60	0	0	0	0
2008	5.50	63.40	3.40	0	0	0	0
2009	329.30	39.80	4.40	0.1	0	0	0
2010	48.70	180	60.30	1.4	0.5	0.1	0
2011	9.70	42.70	0.90	0	0	0	0
2012	7.50	79.90	100.20	112.9	5.9	0.2	0
2013	36.10	31	26.50	11	2	0.5	0
2014	1.09	34.66	41.93	10.3	1.53	0.1	0

Year	0	1	2	3	4	5	6+
2015	0	37.30	45.80	6.8	1.3	0.3	0
2016	0	9.84	14.15	13.45	0.91	0.74	0
2017	0.43	9.85	7.88	8.10	0.57	0.10	0.10
2018	255.50	72.19	8.89	4.88	0.12	0.22	0
2019	0	39.2	0.4	0	0	0	0
2020*	NA						

b)

Year	0	1	2	3	4	5	6+
1968	1	0.17	0	0	0	0	0
1969	1	0.09	0	0	0	0	0
1970	1	0.05	0	0	0	0	0
1971	1	0.03	0	0	0	0	0
1972	1	0.12	0	0	0	0	0
1973	1	0.05	0	0	0	0	0
1974	1	0.12	0	0	0	0	0
1975	1	0.06	0	0	0	0	0
1976	1	0.09	0	0	0	0	0
1977	1	0.14	0	0	0	0	0
1978	1	0.20	0	0	0	0	0
1979	1	0.10	0	0	0	0	0
1980	1	0.04	0	0	0	0	0
1981	1	0.11	0	0	0	0	0

Year	0	1	2	3	4	5	6+
1982	1	0.36	0	0	0	0	0
1983	1	0.19	0	0	0	0	0
1984	1	0.09	0	0	0	0	0
1985	1	0.10	0	0	0	0	0
1986	1	0.17	0	0	0	0	0
1987	1	0.04	0	0	0	0	0
1988	1	0.06	0	0	0	0	0
1989	1	0.23	0	0	0	0	0
1990	1	0.18	0	0	0	0	0
1991	1	0.09	0	0	0	0	0
1992	1	0.10	0	0	0	0	0
1993	1	0.43	0	0	0	0	0
1994	1	0.18	0	0	0	0	0
1995	1	0.27	0	0	0	0	0
1996	1	0.29	0	0	0	0	0
1997	1	0.20	0	0	0	0	0
1998	NA	0.12	0	0	0	0	0
1999	1	0.70	0	0	0	0	0
2000	1	0.74	0	0	0	0	0
2001	1	0.16	0	0	0	0	0
2002	NA	0.18	0	0	0	0	0
2003	1	0.63	0.07	0.15	0.03	0.12	NA
2004	1	0.58	0.25	0.09	0.06	0.022	0

Year	0	1	2	3	4	5	6+
2005	1	0.65	0.13	0.20	0.04	0.03	0
2006	1	0.84	0.18	0.12	0.07	0.02	0
2007	1	0.77	0.02	0	0	0	NA
2008	1	0.82	0.02	0	0	0	NA
2009	1	0.67	0.08	0	0	0	NA
2010	1	0.82	0.32	0.06	0.07	0.05	0
2011	1	0.80	0.01	0	0	0	0
2012	1	0.95	0.74	0.78	0.60	1	NA
2013	1	0.84	0.45	0.37	0.22	0.34	NA
2014	1	0.85	0.49	0.39	0.28	0.09	NA
2015	NA	1	0.57	0.26	0.30	0.23	NA
2016	NA	0.91	0.58	0.45	0.40	0.62	0
2017	1	0.80	0.28	0.51	0.20	0.21	0.49
2018	1	0.76	0.33	0.13	0.05	0.10	0
2019	NA	0.65	<0.01	0	0	0	0
2020*				0	0	0	0

NA= not available.

***Data for 2020 are unavailable due to restricted discard sampling during COVID-19.**

Table 5.7. Maturity ogive updated for 2019. Prior to 1995 maturity was considered constant.

	1	2	3+
1996	0	0.16813	1
1997	0	0.227979	1
1998	0	0.286251	1
1999	0	0.343219	1
2000	0	0.399177	1
2001	0	0.454318	1
2002	0	0.50882	1
2003	0	0.562596	1
2004	0	0.613574	1
2005	0	0.645098	1
2006	0	0.666656	1
2007	0	0.679903	1
2008	0	0.688753	1
2009	0	0.696175	1
2010	0	0.703207	1
2011	0	0.707172	1
2012	0	0.705993	1
2013	0	0.703562	1
2014	0	0.704858	1
2015	0	0.712319	1
2016	0	0.718405	1
2017	0	0.724183	1
2018	0	0.729912	1
2019	0	0.735728	1
2020	0	0.74193	1

Table 5.8. Survey catch numbers-at-age and c.v.

Northern Irish Groundfish Q1

year	c.v.	1	2	3	4
1993	0.78	138.12	648.76	44.60	10.42
1994	0.34	1380.43	109.71	120.27	8.45
1995	0.68	700.73	386.15	20.03	10.78
1996	0.42	1106.13	329.28	111.67	1.39
1997	0.64	537.30	415.84	66.72	21.39
1998	0.84	169.36	769.23	56.87	11.98
1999	0.86	49.50	253.08	241.87	15.29
2000	0.65	629.60	101.053	34.58	33.01
2001	0.89	406.68	561.44	18.44	5.78
2002	0.64	662.16	253.31	333.54	0
2003	0.54	73.87	1079.20	104.05	32.70
2004	0.75	216.96	171.96	88.62	5.38
2005	0.76	63.53	225.07	29.41	27.96
2006	0.63	169.99	130.75	58.30	2.52
2007	0.95	164.35	124.39	30.60	5.15
2008	0.90	40.66	217.15	13.02	5.17
2009	0.76	144.00	59.00	33.00	9.00

year	c.v.	1	2	3	4
2010	0.82	1022.12	208.96	14.66	2.26
2011	0.49	353.98	414.69	46.01	2.26
2012	0.81	161.90	222.82	99.27	14.25
2013	0.81	276.59	213.68	60.08	1.49
2014	0.63	314.41	222.80	53.29	13.66
2015	0.84	78.96	719.35	69.19	8.56
2016	1.06	349.20	175.00	148.30	10.70
2017	0.77	69.8	445.20	57.80	12.60
2018	1.26	138.1	50.50	62.60	0
2019	0.88	214.9	171.6	27.8	14.7
2020	0.977	78.5	145.4	39.4	0

Northern Irish Groundfish Quarter 4.

year	c.v.	0	1	2
1991	0.57	1109.37	50.06	47.60
1992	0.71	553.23	146.44	0.76
1993	0.45	1672.49	25.44	10.44
1994	0.38	1206.80	33.32	0
1995	0.60	486.65	50.15	6.54
1996	0.82	1322.20	97.19	0
1997	0.55	376.51	163.9	5.72
1998	0.75	58.47	32.48	9.49
1999	0.68	301.64	2.03	0
2000	0.72	506.79	109.91	0
2001	0.55	487.89	37.68	12.53
2002	0.86	161.45	29.4	0
2003	0.76	578.97	23.71	0
2004	0.82	706.13	107.72	17.28
2005	0.73	130.20	1.47	6.58
2006	1.22	86.99	0	2.98
2007	0.62	17.28	17.28	0
2008	1.09	213.62	6.1	0

year	c.v.	0	1	2
2009	0.83	171.80	2.98	0
2010	0.82	92.48	53.86	3.05
2011	0.75	107.05	1.69	6.37
2012	0.72	321.82	32.79	20.33
2013	0.78	41.67	79.95	20.66
2014	0.78	0	55.35	39.15
2015	0.57	224.27	0	55.42
2016	0.83	14.98	0	181.79
2017	0.68	429.50	44.60	10.60
2018	1.42	68.50	112.60	0
2019	1.27	39.7	54.1	0
2020	1.39	7.2	68.8	0

UK FSP

year	2	3	4	5	6+
2005	0.43	1.41	0.99	0.08	0.03
2006	0.54	2.81	0.43	0.10	0.01
2007	0.61	1.32	0.59	0.06	0.06
2008	0.22	0.82	0.15	0.08	0.02
2009	0.17	1.15	0.38	0.10	0.02
2010	0.74	0.45	0.47	0.13	0.02
2011	0.41	1.68	0.14	0.10	0.04
2012	0.36	2.30	0.80	0.07	0.02
2013	0.84	1.88	1.35	0.37	0.06
2014					
2015	0.60	2.04	1.17	0.26	0.05
2016	1.00	6.39	1.43	0.41	0.03
2017	3.06	2.85	3.84	1.01	0.23
2018	0.43	3.73	0.61	0.63	0.15
2019	1.30	0.75	0.83	0.12	0.19
2020	0.77	2.64	0.13	0.18	0.08

Table 5.9. Relative Biomass, Harvest rate landings and discards as used for the advice.

Year	Biomass index	Landings	Discards	Harvest Rate/ Fishing pressure
1968		8541	1285	
1969		7991	1898	
1970		6426	708	
1971		9246	363	
1972		9234	1546	
1973		11819	1222	
1974		10251	1749	
1975		9863	857	
1976		10247	381	
1977		8054	201	
1978		5662	0	
1979		7548	0	
1980		10599	0	
1981		13958	0	
1982		13381	313	
1983		10015	372	
1984		8383	2	
1985		10483	61	

Year	Biomass index	Landings	Discards	Harvest Rate/ Fishing pressure
1986		9852	154	
1987		12894	128	
1988		14168	109	
1989		12751	202	
1990		7379	159	
1991		7095	163	
1992		7735	98	
1993	1.40	7555	155	2.9
1994	1.06	5402	142	2.8
1995	0.90	4587	166	2.8
1996	1.33	4964	140	2.0
1997	1.25	5859	120	2.5
1998	1.56	5318	29	1.81
1999	1.50	4784	159	1.74
2000	0.87	1274	699	1.20
2001	1.30	2252	64	0.94
2002	2.7	2695	46	0.53
2003	2.2	1285	215	0.36

Year	Biomass index	Landings	Discards	Harvest Rate/ Fishing pressure
2004	0.81	1072	254	0.86
2005	0.93	910	204	0.63
2006	0.49	840	185	1.11
2007	0.46	702	145	0.97
2008	0.45	662	61	0.85
2009	0.36	466	88	0.81
2010	0.53	464	386	0.84
2011	0.77	365	48	0.28
2012	0.76	198	678	0.60
2013	0.84	206	152	0.22
2014	0.92	213	184	0.23
2015	1.67	161	147	0.097
2016	1.08	82	60	0.070
2017	0.92	84	59	0.082
2018	0.41	215	42	0.33
2019	0.68	295	7	0.23
2020	0.44	181	25	0.25
2021	0.40			

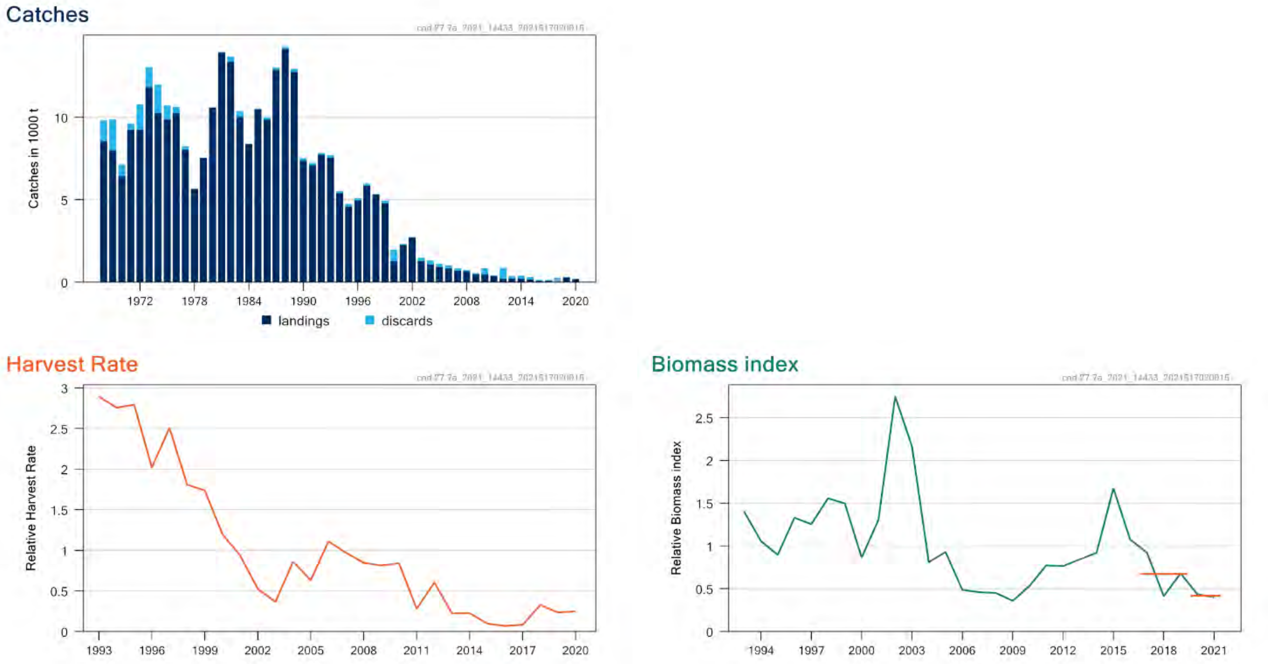


Figure 5.1. Total catches, harvest rate as an indicator for fishing pressure and biomass index as used for the advice. The two red lines indicate the 2 over 3 rule values.

6 Cod in divisions 7.e–k (eastern English Channel and southern Celtic Seas)

Full analytical assessment

This stock has been benchmarked at WKCELTIC 2020. XSA was replace by SAM as the assessment model. Time-series of data were updated since 2004 as well as the tuning series. The first ten years of data (1970–1979) were removed from the assessment time-series of catches, because of inconsistency in cohort tracking information. Data, assessment and forecast procedure are detailed in the stock annex.

Latest ICES advices in 2019 and 2020

2019; ”*For Cod in divisions 7.e–k, ICES advises that when the MSY approach is applied, there should be zero catch in 2020.*”
2020; ”*For Cod in divisions 7.e–k, ICES advises that when the MSY approach is applied, there should be zero catch in 2021.*”

6.1 General

6.2 Stock description and management units

The TAC is set for ICES Areas 7.b–c, 7.e–k, 8, 8, 10, and CECAF 34.1.1(1), excluding 7.d. This is representative of the stock area as the cod population in 7.d is more relevant to the North Sea population. However, landings from 7.bc are not included in the assessment area.

Management applicable in 2020 and 2021

TAC 2020 (Council regulation 2019/124)

Species:	Cod *Gadus morhua*	Zone:	7b, 7c, 7e-k, 8, 9 and 10: Union waters of CECAF 34.1.1 (COD/7XAD34)
Belgium	18 (1)	Analytical TAC	
France	294 (1)	Article 8 of this Regulation applies	
Ireland	461 (1)	Article 3 of Regulation (EC) No 847/96 shall not apply	
The Netherlands	0 (1)	Article 4 of Regulation (EC) No 847/96 shall not apply	
United Kingdom	32 (1)		
Union	805 (1)		
TAC	805 (1)		

(1) Exclusively for by-catches of cod in fisheries for other species. No directed fisheries for cod are permitted under this quota.

Preliminary TAC 2021 (Council regulation 2019/92)

Species:	Cod *Gadus morhua*	Zone:	7b, 7c, 7e-k, 8, 9 and 10; Union waters of CECAF 34.1.1 (COD/7XAD34)
Belgium	5 (1)	Analytical TAC	
France	74 (1)	Article 3 of Regulation (EC) No 847/96 shall not apply	
Ireland	115 (1)	Article 4 of Regulation (EC) No 847/96 shall not apply	
Netherlands	0 (1)	Article 7(1) of this Regulation applies	
Union	194 (1)	Article 9 of this Regulation applies	
United Kingdom	8 (1)		
TAC	202 (1)		

(1) Exclusively for by-catches of cod in fisheries for other species. No directed fisheries for cod are permitted under this quota.

Since 2005, ICES rectangles 30E4, 31E4, and 32E3 have been closed during the first quarter (Council Regulations 27/2005, 51/2006, and 41/2007, 40/2008, and 43/2009).

Technical measures applied to this stock are a minimum mesh size (MMS) for beam and otter trawlers in Subarea 7 and a minimum landing size (MLS) of 35 cm.

Fishery

Landings data used by the WG are summarised in Table 6.1, and the Figure 6.1 provides historical landings by countries. In 2020, the catches are 1152 t.

TAC was undershot in previous years, but in 2020 an overshoot of the agreed TAC was observed for almost all nations. Cod is no longer a target species, but a bycatch in haddock and whiting dedicated fisheries.

Given the rapid growth of cod in this area, discards are mostly composed of one and two-year old fish. Since 2011, quotas were not restricted and the discard rate has been stable around 10–15%. However, following the recent TAC reductions, TAC is now restrictive for most of the countries. Discards estimate for 2020 is 231 t. It corresponds to a discards rate of 20%, which is around the average of recent years.

Cod is mainly caught in area 27.7.g, followed by areas 27.7.h, 27.7.e and 27.7.j respectively. No landings are reported in 27.7.k and few in 27.7.j2 (Figure 6.2).

France is fishing in all areas but most of its landings are taking in 27.7.g. Ireland and Belgium are fishing in 27.7.g and UK in 27.7.e. For each country, landings distribution in the Celtic Sea is similar to previous years.

In Celtic Sea, cod is mainly caught by OTB_DEF_100-119_0_0_all métiers (50% of the landings), followed by OTB_DEF_70–99_0_0_all, OTB_CRU_100–119_0_0_all and seine SCC_DEF_100–119_0_0_all. Beamers (i.e. TBB_DEF_70–99_0_0_all) also contribute to cod landings (Figure 6.3).

Discards rate in weight varies among métiers depending on gear, mesh size range and targeted species (Figure 6.4).

The group advises to follow métier definition specified in the Appendix 2 of the ICES data call to reduce the number of métier upload in InterCatch. Métier which contribute to less than 1% of the landings should be included in the MIS_MIS_0_0_0_HC métier.

Information from the industry

In recent years, yields have been very low and cod is no longer targeted by French vessels and catches represent a very low number of individuals per tow.

The recent regulatory changes in the Celtic Sea since 2019 (Reg UE 2034/2018 which introduces many new selective devices since 01/07/2019 and article 13 Reg UE 123/2020) significantly modifies (1) the size structure of species catches by improving selectivity (2) vessel strategy in order to respect different catch composition thresholds.

6.3 Data

InterCatch procedure

Since 2013, international landings and discards data are uploaded in InterCatch. An updated data tile series, from 2004 to 2019, was provided as part of the WKCELTIC 2020. Discards are raised for unreported strata to estimate total discards in weight. During WKCELTIC effort were made to streamlining data compilation procedures for fishery-dependent data of the three main gadoids species (cod, haddock and whiting).

Unsampled strata of landings and discards (number-at-age) are filled in using an allocation procedure. Information on national and international assumptions made by data providers and submitters at the national level and allocation grouping used in IC are available on SharePoint (R script). To ensure the consistency of data processing at international level, the same rules are applied each year for the allocation procedure: fill unsampled strata using as much as possible the same métier and quarter, regardless of area and country. Unsampled BMS landings and Logbook Registered Discards are filled in using discards data employing as much as possible the same métier and quarter, regardless of area and country.

The impact of the Covid-19 pandemic on the fishery cannot be quantitatively determined but may be assumed to have reduced fishing effort in quarter 2 of 2020. Sampling levels were reduced in quarters 2, 3 and 4 for almost all nations, leading to less data (discards ration and sampled age structure) uploaded in IC in 2021 compared to previous years.

UK did not collect data for the stock from Q2 and Q3, and the trips sampled in Q1 and Q4 had zero discards for cod. More generalisations across gear and countries have been applied in 2021 than in previous years.

However, the percentage of sampled versus raised data as well as the distribution of sampled data over the quarters were considered satisfactory (Figure 6.5).

Season	Source	PerC
1	Imported	0.196
2	Imported	0.444
3	Imported	0.204
4	Imported	0.157

Catches

Age distribution of 2020 catches (i.e. landings and discards) is illustrated in the Figure 6.10 and Table 6.2. It is noticeable that this stock has always been composed of few age classes, even though Celtic Sea cod can live up to ten years. While the catch was mainly composed of age 2 over the period 2005–2008, the strong 2009 year class has contributed strongly to the catch at older ages in recent years: 63% in number in 2012 at age 3, 36% at age 4 in 2013 (Table 8.2.a and 8.2.b). In 2014, high recruitment has been observed resulting in an increasing proportion of age 1 fish in the landings (53%), age 2 accounts for 22% of the landings. In 2015, landings are dominated by fish of age 2, in 2016 landings are dominated by fish of age 3 and in 2017 landings was mostly composed by cod of age 2. In 2018, 20% of the landings was fish of age 1, 35% of fish of age 2 and 31% of fish of age 3. In 2019, more than 50% of the catches are Age 1 fish, and less than 30% of the catches are made of age superior to 2. In 2020, 36% of the catches are Age 1 fish, and 58% of the catches (in number) are made of age 2.

Discards

The landings/discards pattern is known to be strongly variable between fleets and years due to métier, recruitment intensity, TACs constraints and mixed fisheries concerns.

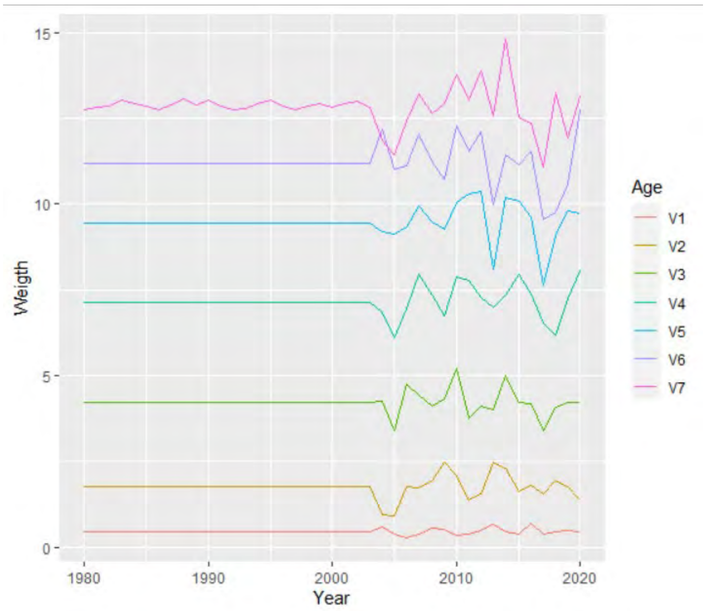
In 2009, age 1 individuals (30–45 cm, Mahé *et al*., 2016) were mainly discarded. In 2010, most of them were landed. In 2011, ages 1 and 2 represents respectively 51% and 46% of the total discards in numbers for all fleets. Due to the low TAC relative to the high magnitude of recruitment in 2009 and 2010, all countries had unusually high discard rates in 2011, generally 70% by weight was made up of fish above the minimum landing size (MLS, i.e. 35 cm for Celtic Sea cod). The high-graded fish from the French fishery have been added to the landings in 2003–2011. In 2014, total amount of discards was 740 t (639 t imported + 101 t raised), giving a discard rate of 19%. This discards rate was higher than the average 10% and mostly consisted of undersized fish from the strong 2013 year class (fish of age 1 in 2014). In 2015, the total amount of discard was 565 t (250 t sampled and uploaded in InterCatch and 309 t resulting from the raising procedures), giving a discard rate by weight of 12%, which is considered the usual discard rate for this species in the mixed fisheries. High-grading in 2015 (discards of fish above Minimum conservation size) was low. In 2016, the total amount of discards was 220 t (154 t sampled and uploaded in InterCatch and 52 t resulting from the raising procedures), giving a discard rate by weight of 6.3%. In 2017, the total amount of discards was 117 t (47 t sampled and uploaded in InterCatch and 62 t resulting from the raising procedures), giving a discard rate by weight of 5%, which is considered lower than average. They are mainly composed of age 1 fish (Figure 6.10).

In recent years, due to quota constraints at vessels levels, length distribution of discards for the UK fleet have shown high-grading pattern (cod being a non-target species). However, this fleet has little contribution to both, landings and discards quantities and this was no more reported in 2017. In 2019, discards are mostly composed of fish of 1 year, as in 2018 (Figure 6.10).

Biological

Catch numbers-at-age, catch weights-at-age and stock weights-at-age are given respectively in Tables 6.2, 6.3 and 6.4.

Temporal trends in stock and catch were scrutinized at WGCSE 2021, to ensure that reduce sampling due to Covid-19 pandemic did not impact catch weight. No important issues were reported.



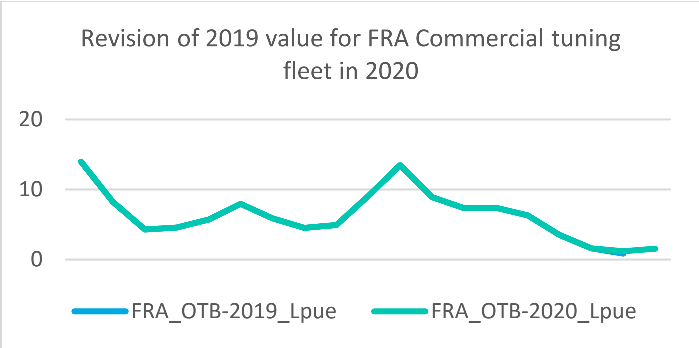
Biological parameters are described in the stock annex and has been updated at WKCELTIC 2020. Celtic Sea cod are very fast growing and early maturing compared with more northern cod stocks.

Commercial LPUE

Tables 6.5 a–c gather the values of landings, fishing effort and LPUE dataseries for the French (a), Irish (b) and UK fleets (c). Figures 6.6 a-c illustrate the trends of LPUE and effort by country.

A general decrease in the LPUE trend is observed in almost all series between 1990 and 2004, where the TAC began to be constraining. From that point, the LPUE seemed to stabilize, or even to increase if high-grading is taken into account. The strong 2009 year class resulted in an increase of LPUE for all fleets between 2010 and 2012. Different features are observed in the effort time-series. The métiers showing the highest levels of cod directed effort have decreased significantly in the last 5–10 years until 2010. Since then, effort has gone up again until 2013 following the increased of TAC possibilities.

Since 2013, French fishing effort and LPUE have decreased (Figure 6.6a). Effort of Irish fleet targeting gadoids (i.e. Otter trawl 27.7.g) remains at a high level as a consequence of mixed fisheries interaction with increased whiting and haddock fisheries opportunities (Figure 6.6b). In the meantime, the Spawning–Stock Biomass (SSB) is low, as such LPUE is decreasing since 2013. In 2018, Otter trawl Irish 27.7.g LPUE has increased. Effort of the UK trawl fleet in 27.7.e–k shows a decreasing trend (down to zero in 2016) and increases since then, while beam trawl effort in 27.7.e–k relatively stable in recent years (Figure 6.6c). Minor revision of FRA commercial fleet from 0.84 to 1.18 in 2019 was made, which is believed to have very little impact on assessment results.



The impact of the Covid-19 pandemic on the fishery cannot be quantitatively determined but a slight reduction of fishing effort of the main fleets in 2020 was observed for all country. As, a result in 2020, LPUE of Irish otter trawls in 7.g and UK trawls in 7.ek are decreasing, while French otter trawl LPUE remain stable.

Remark: The UK English and Welsh effort data are only reliable for vessels over 12 metres registered length, and therefore has always been provided to working groups for vessels greater than 12 metres. The fleet of over 12 meter vessels has been declining gradually over the years, until in 2016 no effort recorded from this fleet. The zero figures provided for 2016 have been checked and are correct (Figure 6.6c).

Surveys and commercial tuning fleet

Two ongoing surveys, both part of the DCF, IBTS Q4 (EVHOE-WIBTS-Q4; IGFS-WIBTS-Q4) are combined and modelled to produce a single index using VAST modelling (see details in the stock annex and WKCELTIC 2020 report).

In 2017 and 2018, the French EVHOE survey was not conducted due to technical difficulties at the beginning of the survey. The Irish survey covered additional stations normally undertaken by the EVHOE survey.

Commercial tuning index based on French OTB and OTT fleet is provided. The calculation of the commercial tuning series was updated at WKCELIC 2020 to better account for changes in fleet behaviour along the years (see details in the stock annex and WKCELTIC 2020 report). LPUE is decreasing since 2012.

The historical time-series of commercial tuning index (OTDEF French fleet for quarter 2, 3 and 4), and the survey index are shown in Table 6.6.

Data issues

No important issues were reported this year. Catch sampling of the fisheries was reduced in 2020 due to Covid-19, which may result in a higher uncertainty associated with discard estimates and age structure of the catch. However, this is considered to have had minimal impact on the perception of the stock status.

Remark: When for a métier/strata landings are upload annually, there are not information available in InterCatch to split the annual landings into quarterly landings and therefore the associated age composition and mean weight-at-age. As a result, when extracting quarter 1 versus quarter 2, 3 and, 4 data to inform on mean weight of the stock and the catch for the assessment, these data are not used.

6.4 Stock assessment

Model used: SAM (stockassessment.org).

Final update assessment (XSA)

The final assessment was run with the same settings as established by WKCELTIC 2020 and described in the stock annex. Discards are included in the assessment. (sotcokassessment.org, Cod_7ek_WGCSE2020).

Residuals and diagnostics do not highlight any problem regarding the input data and model fit (Figures 6.7 and 6.8). Outputs from the assessment are reported in Tables 6.7–6.10 and in Figures 6.7–6.11.

The comparison of runs with and without tuning indices indicates is shown in Figure 6.12b. The information contains in both indices are consistent.

In 2021, the assessment shows an upward revision in F (Figure 6.12a), associated with downward revision in SSB and recruitment in recent years.

Mohn's rho analysis (i.e. a measure of the relative difference between an estimate from an assessment with a truncated time-series and an estimate of the same quantity from an assessment using the full time-series) resulted in values of -19% for $F_{bar\ (2–5)}$, 25% for SSB and 34% for recruitment.

The retrospective bias in assessment when an additional year of data are incorporated may be due to the variability of cod recruitment over years, the strong dependency of the fishery to recruitment (not well estimated by the survey) and the unexpected disappearance of fish of older age.

Despite the high values of the Mohn's rho coefficient and the uncertainties in the estimates of the most recent year, the assessment has been validated (the stock is maintained in category 1), and the output are used to provide the short-term forecast. This decision follows the guidelines provide by WGBIAS (decision tree). Despite the uncertainties in the estimates of the most recent years, SSB and F are estimated well below biological references points.

The conclusions of the very recent benchmark were that given the recruitment driven dynamics of the stock and the low stock size reducing.

State of the stock

Table 6.7 and 6.8 summarise the estimated fishing mortality-at-age and the stock numbers-at-age, respectively. The stock summary is reported in Table 6.9 and Figure 6.11.

Catches are around 5000 t since 2000 (Figure 6.11), with some higher catches following strong recruitments. Reliable discard estimates are available since 2004 and range between 134 and 3749 t depending on the interplay between recruitment dynamics and TAC constraints.

Recruitment has been highly variable over time with occasional very high recruitment followed by period of low recruitments. Since 2012, recruitment has been very weak with the exception of the 2014 year class, which is above average (Table 6.9 and Figure 6.11). Recruitment estimated in 2017 is remarkably low but around the median in 2019.

Spawning–stock biomass (SSB) has been fluctuating around B_{pa} since 2004, except from 2011 to 2013 (as the consequence of a very good recruitment year) and is below B_{lim} since 2017 (Table 6.9 and Figure 6.11, ICES, 2012).

Fishing mortality has been above F_{MSY} for the entire time-series, fluctuating between F_{lim} and F_{pa}. Fishing mortality increased up to above F_{lim} in recent years (Table 6.9 and Figure 6.11).

6.5 Short-term projections

Assumptions made for the short-term projections are described in Table 6.12 and followed the stock annex.

The advice from last year was based on a catch constraint. The agreed TAC for 2021 was not available at WGCSE 2021. As such, F status quo was used as an assumption of F in 2021 to reflect recent fishing pressure. It assumed that the catches in 2021 would be the sum of landings of 1609 tonnes and average discards over the last three years (272 tonnes), i.e. 1881 tonnes. It seems relatively high; however, it is worth noting that the model has a tendency to overestimate catches in recent years.

Recruitment values of 2021 and 2022 are slightly different in the stochastic forecast, because random resampling of a distribution may lead to different median estimates. The recruitment Age 1 fish) values are 1526 in 2021 and 1488 in 2022.

SSB is predicted to be 1354 t in 2022 which would still be below B_{lim} (4200 t) (Table 6.11).

ICES provides zero-catch advice for this stock in 2022, because the median SSB remains below B_{lim} by 2023 under all catch scenarios (Table 6.12 and Table 6.13).

In the ICES advice framework, this would result in advised catches of between 79 tonnes (at F_{MSY} lower × SSB2022/MSY $B_{trigger}$) and 134 tonnes (at F_{MSY} × SSB2022/MSY $B_{trigger}$), but the median SSB would remain below B_{lim} by 2023.

The assumed recruitment in 2022 and 2023 used in the forecast would constitute a significant part of the projected SSB in 2023 (67%), (Figure 6.14 and Table 6.14).

6.6 Medium-term projection

No medium-term projections were carried out.

6.7 Biological reference points

The reference points have been estimated using the agreed ICES guidelines, see Table 6.11 (ICES, 2016). F_{pa} was set to $F_{p0.5}$; the F that leads to SSB ≥ B_{lim} with 95% probability at the last benchmark in 2020.

6.8 Management plans

The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to demersal stocks including cod in ICES divisions 7.e–k.

6.9 Uncertainties and bias in assessment and forecast

The stock was benchmarked in 2020 (ICES, 2020a). The model was changed to a stochastic state–space assessment model (SAM). Maturity and natural mortality information was updated, discards were included in the assessment, catch (landings and discards) time-series were reviewed and updated from 2004 to 2018, commercial tuning series were reviewed and included as biomass index, and survey indices were updated to a single modelled time-series using a vector-autoregressive spatio-temporal model (VAST). The F-pattern shows less variability across the time-series and higher estimates in most recent years than the previous assessment. Fishing mortality is observed to be sensitive to the addition of an extra year of data.

However, despite this uncertainty, it is quite clear that the cod stock is well below SBB limits and well above F target. Given that situation and the recommendations of WKBIAS, the last benchmark and WGCSE 2021 validated the proposed assessment model and its use for prediction.

6.10 Recommendations for future developments

There is room for development of a modelled commercial tuning fleet instead of the current method based on catch thresholds. Indeed, despite the work performed to improve the commercial tuning fleet, it is never easy to account for changes in fisheries targeting behaviours. Indeed, in recent years cod is not targeted anymore by most of the fisheries.

Even if the survey index combined two surveys, it is based on few fish. Further work and sensitivity analysis on the VAST assumptions might also be performed and documented in the future to ensure that the model will converge for all ages and show low retrospective patterns.

6.11 Management considerations

The strong retrospective pattern implies that the current F estimates might be uncertain. Forecasts are sensitive to the assumption on recruitment as the landings are usually composed of a high proportion of age 2 fish (and age 1 for discards).

The recent technical measures introduced in the Celtic Sea, increase in the mesh size of the square mesh panels and raised lines are expected to reduce catches of Celtic Sea cod and improved the selection pattern. Impact of this measure should be monitored.

Additionally, mixed-fisheries issues could be responsible for maintaining F at high level, as other gadoids fishing opportunities are higher. In this context, cod is no longer a target species but can be considered as by catch in the fleet targeting haddock, whiting and *Nephrops*.

Historical information on management consideration can be found in the stock annex.

6.12 References

ICES. 2012. Report of the Working Group on the Celtic Seas Ecoregion (WGCSE), 9–18 May 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:12.

ICES. 2016. Report of the Workshop to consider FMSY ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13–16 October 2015, Brest, France. ICES CM 2015/ACOM:58. 187 pp.

Table 6.1. Cod in divisions 7.e–k. History of official commercial landings presented by country and used by the Working Group. All weights are in tonnes.

Year	Belgium	France	Ireland	UK	Others	Total	Discard estimates	Landings taken or reported in rectangles 33E2 and 33E3 *
1971	NA	NA	NA	NA	NA	5782	NA	NA
1972	NA	NA	NA	NA	NA	4737	NA	NA
1973	NA	NA	NA	NA	NA	4015	NA	NA
1974	NA	NA	NA	NA	NA	2898	NA	NA
1975	NA	NA	NA	NA	NA	3993	NA	NA
1976	NA	NA	NA	NA	NA	4818	NA	NA
1977	NA	NA	NA	NA	NA	3059	NA	NA
1978	NA	NA	NA	NA	NA	3647	NA	NA
1979	NA	NA	NA	NA	NA	4650	NA	NA
1980	NA	NA	NA	NA	NA	7243	NA	NA
1981	NA	NA	NA	NA	NA	10597	NA	NA
1982	NA	NA	NA	NA	NA	8766	NA	NA
1983	NA	NA	NA	NA	NA	9641	NA	NA
1984	NA	NA	NA	NA	NA	6631	NA	NA
1985	NA	NA	NA	NA	NA	8317	NA	NA
1986	NA	NA	NA	NA	NA	10475	NA	NA
1987	NA	NA	NA	NA	NA	10228	NA	NA

Year	Belgium	France	Ireland	UK	Others	Total	Discard estimates	Landings taken or reported in rectangles 33E2 and 33E3 *
1988	554	13863	1480	1292	2	17191	NA	NA
1989	910	15801	1860	1223	15	19809	NA	NA
1990	621	9383	1241	1346	158	12749	NA	NA
1991	303	6260	1659	1094	20	9336	NA	NA
1992	195	7120	1212	1207	13	9747	NA	NA
1993	391	8317	766	945	6	10425	NA	NA
1994	398	7692	1616	906	8	10620	NA	NA
1995	400	8321	1946	1034	8	11709	NA	NA
1996	552	8981	1982	1166	0	12681	NA	NA
1997	694	8662	1513	1166	0	12035	NA	NA
1998	528	8096	1718	1089	0	11431	NA	NA
1999	326	5488	1883	897	0	8594	NA	NA
2000	208	4281	1302	744	0	6535	NA	NA
2001	347	6033	1091	838	0	8309	NA	NA
2002	555	7368	694	618	0	9235	NA	NA
2003	136	5222	517	346	0	6221	NA	NA
2004	153	2934	657	281	1	4027	543	108
2005	186	2127	855	309	1	3478	1426	54

Year	Belgium	France	Ireland	UK	Others	Total	Discard estimates	Landings taken or reported in rectangles 33E2 and 33E3 *
2006	101	2431	995	371	3	3902	2118	103
2007	107	3113	1208	411	3	4842	1248	527
2008	65	2994	1222	295	1	4577	306	558
2009	48	3020	847	267	5	4187	1229	193
2010	52	2449	1030	296	3	3831	3040	143
2011	123	4808	1010	427	7	6376	3749	147
2012	290	6900	1539	706	8	9443	2341	85
2013	202	5051	1470	548	3	7273	562	76
2014	141	2715	1189	466	0	4512	1569	24
2015	121	3373	1109	422	3	5028	483	39
2016	97	2579	881	365	1	3924	525	40
2017	82	1578	623	188	0	2471	134	19
2018	49	611	706	130	0	1496	316	20
2019**	43	369	554	84	NA	1051	300	37
2020**	18	371	487	44	2	922	231	71

***Included in Ireland landings estimates. Landings in the south of Division 7.a (33E2 and 33E3) are included in the assessment and are considered to be part of the stock.**

Table 6.2. Cod in divisions 7e–k. Catch number-at-age (in thousands). Number-at-age 1 and 2 before 2004 are estimated by the assessment model.

Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7+	Year
NA	NA	285	175	52	55	14	1980
NA	NA	811	153	41	20	12	1981
NA	NA	888	169	36	19	5	1982
NA	NA	540	424	77	21	11	1983
NA	NA	134	97	94	22	5	1984
NA	NA	465	61	40	47	15	1985
NA	NA	673	254	30	31	17	1986
NA	NA	448	250	62	20	15	1987
NA	NA	320	133	46	21	8	1988
NA	NA	2483	149	77	18	11	1989
NA	NA	1006	663	79	21	16	1990
NA	NA	229	330	203	48	14	1991
NA	NA	329	64	70	53	17	1992
NA	NA	928	79	24	19	16	1993
NA	NA	1199	258	27	10	17	1994
NA	NA	310	284	73	13	5	1995
NA	NA	1199	134	95	43	4	1996
NA	NA	951	297	48	22	6	1997
NA	NA	641	254	99	36	8	1998
NA	NA	756	158	59	36	14	1999
NA	NA	419	169	44	17	14	2000
NA	NA	136	98	70	19	19	2001
NA	NA	883	64	33	12	11	2002
NA	NA	827	217	15	9	7	2003
873	1077	229	189	65	5	6	2004
2875	2080	182	93	47	19	8	2005
7477	1052	295	17	25	13	9	2006
3556	1302	355	79	10	8	11	2007
467	885	403	122	27	4	6	2008
2212	421	424	120	47	11	4	2009
9794	618	151	107	46	14	5	2010
2325	4905	423	49	34	13	4	2011
746	1860	1757	117	18	14	11	2012
388	383	581	516	55	16	7	2013
4708	415	83	132	149	8	2	2014
242	2272	137	26	47	37	7	2015
624	195	707	33	7	17	16	2016
159	561	57	166	24	5	15	2017
902	172	137	14	38	5	2	2018
944	247	29	26	4	11	2	2019
342	548	36	3	2	2	2	2020

Table 6.3. Cod in divisions 7e–k. Catch weight (in kg) at age.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7+
1980	0.457	1.756	4.217	7.147	9.454	11.179	12.73800
1981	0.457	1.756	4.217	7.147	9.454	11.179	12.82433
1982	0.457	1.756	4.217	7.147	9.454	11.179	12.84160
1983	0.457	1.756	4.217	7.147	9.454	11.179	13.04373
1984	0.457	1.756	4.217	7.147	9.454	11.179	12.94520
1985	0.457	1.756	4.217	7.147	9.454	11.179	12.85860
1986	0.457	1.756	4.217	7.147	9.454	11.179	12.73800
1987	0.457	1.756	4.217	7.147	9.454	11.179	12.87613
1988	0.457	1.756	4.217	7.147	9.454	11.179	13.06075
1989	0.457	1.756	4.217	7.147	9.454	11.179	12.90245
1990	0.457	1.756	4.217	7.147	9.454	11.179	13.02887
1991	0.457	1.756	4.217	7.147	9.454	11.179	12.84900
1992	0.457	1.756	4.217	7.147	9.454	11.179	12.76847
1993	0.457	1.756	4.217	7.147	9.454	11.179	12.80275
1994	0.457	1.756	4.217	7.147	9.454	11.179	12.92082
1995	0.457	1.756	4.217	7.147	9.454	11.179	13.04880
1996	0.457	1.756	4.217	7.147	9.454	11.179	12.86750
1997	0.457	1.756	4.217	7.147	9.454	11.179	12.73800
1998	0.457	1.756	4.217	7.147	9.454	11.179	12.86750
1999	0.457	1.756	4.217	7.147	9.454	11.179	12.92300
2000	0.457	1.756	4.217	7.147	9.454	11.179	12.81200
2001	0.457	1.756	4.217	7.147	9.454	11.179	12.94226
2002	0.457	1.756	4.217	7.147	9.454	11.179	12.99664
2003	0.457	1.756	4.217	7.147	9.454	11.179	12.81200
2004	0.585	0.939	4.268	6.849	9.207	12.192	11.86933
2005	0.388	0.899	3.412	6.107	9.138	11.017	11.43300
2006	0.285	1.780	4.758	6.971	9.341	11.119	12.42300
2007	0.362	1.738	4.412	7.943	9.953	12.043	13.20200
2008	0.541	1.925	4.105	7.337	9.483	11.220	12.64783
2009	0.510	2.457	4.324	6.740	9.252	10.707	12.93800
2010	0.330	2.078	5.223	7.863	10.056	12.290	13.78180
2011	0.358	1.381	3.740	7.774	10.314	11.531	13.02500
2012	0.488	1.532	4.108	7.276	10.386	12.096	13.87391
2013	0.655	2.471	4.019	6.976	8.088	9.991	12.55800
2014	0.448	2.281	4.988	7.353	10.180	11.432	14.80600
2015	0.367	1.608	4.230	7.952	10.087	11.147	12.53600
2016	0.706	1.787	4.175	7.386	9.619	11.556	12.35400
2017	0.393	1.532	3.414	6.517	7.630	9.563	11.09620
2018	0.444	1.927	4.076	6.160	9.081	9.780	13.23200
2019	0.465	1.774	4.203	7.223	9.815	10.576	11.95100
2020	0.455	1.369	4.233	8.058	9.731	12.757	13.13100

Table 6.4. Cod in divisions 7e–k. Stock weight-at-age =1st quarter values.

year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7+
1980	0.370	1.421	3.936	6.901	9.324	11.107	13.574000
1981	0.370	1.421	3.936	6.901	9.324	11.107	13.578000
1982	0.370	1.421	3.936	6.901	9.324	11.107	13.578800
1983	0.370	1.421	3.936	6.901	9.324	11.107	13.626820
1984	0.370	1.421	3.936	6.901	9.324	11.107	13.583600
1985	0.370	1.421	3.936	6.901	9.324	11.107	13.607930
1986	0.370	1.421	3.936	6.901	9.324	11.107	13.574000
1987	0.370	1.421	3.936	6.901	9.324	11.107	13.580400
1988	0.370	1.421	3.936	6.901	9.324	11.107	13.695250
1989	0.370	1.421	3.936	6.901	9.324	11.107	13.620270
1990	0.370	1.421	3.936	6.901	9.324	11.107	13.640620
1991	0.370	1.421	3.936	6.901	9.324	11.107	13.579140
1992	0.370	1.421	3.936	6.901	9.324	11.107	13.575410
1993	0.370	1.421	3.936	6.901	9.324	11.107	13.577000
1994	0.370	1.421	3.936	6.901	9.324	11.107	13.582470
1995	0.370	1.421	3.936	6.901	9.324	11.107	13.588400
1996	0.370	1.421	3.936	6.901	9.324	11.107	13.580000
1997	0.370	1.421	3.936	6.901	9.324	11.107	13.574000
1998	0.370	1.421	3.936	6.901	9.324	11.107	13.580000
1999	0.370	1.421	3.936	6.901	9.324	11.107	13.582570
2000	0.370	1.421	3.936	6.901	9.324	11.107	13.577430
2001	0.370	1.421	3.936	6.901	9.324	11.107	13.605840
2002	0.370	1.421	3.936	6.901	9.324	11.107	13.624640
2003	0.370	1.421	3.936	6.901	9.324	11.107	13.577430
2004	0.356	0.830	4.035	6.101	9.324	13.784	9.952167
2005	0.320	0.830	4.035	6.101	9.324	11.135	15.169000
2006	0.267	1.516	4.370	6.325	9.350	11.081	12.688000
2007	0.290	1.453	3.916	8.101	10.658	11.413	15.827000
2008	0.344	1.623	4.027	7.200	8.941	10.916	12.550670
2009	0.399	1.914	3.880	6.404	8.898	10.507	13.964000
2010	0.286	1.597	4.874	7.466	9.852	11.254	13.545200
2011	0.324	1.030	3.478	8.051	10.251	11.355	15.493000
2012	0.410	1.289	3.641	6.979	9.704	12.111	15.844000
2013	0.440	1.774	3.746	6.854	7.334	9.330	12.844000
2014	0.363	1.762	4.109	6.762	10.082	11.634	15.360000
2015	0.428	1.202	4.326	8.210	10.337	11.508	14.311000
2016	0.618	1.542	3.622	7.110	10.048	11.707	13.416000
2017	0.335	1.337	3.313	6.189	7.249	9.651	10.962330
2018	0.376	1.617	3.675	5.655	8.508	9.223	12.240000
2019	0.366	1.509	3.821	7.254	9.725	10.795	11.486000
2020	0.420	1.200	3.705	8.174	10.286	13.407	13.634000

Table 6.5a. Cod in divisions 7e–k. LPUE for French OT-DEF fleets. Units: landings in tonnes, effort in 000s hours fished and LPUE in kg/hour fished. This series is used to tune the assessment model.

Effort	Landings	Year
264146	3692073	2002
240535	1978251	2003
214247	918840	2004
156961	714850	2005
125245	712566	2006
150288	1193033	2007
138626	814340	2008
143812	647808	2009
143730	705691	2010
258383	2332986	2011
252110	3393990	2012
190886	1696287	2013
151518	1113363	2014
185791	1374691	2015
178399	1122665	2016
137849	483571	2017
102586	163178	2018
114838	136473	2019
96907	149412	2020

Table 6.5b. Cod in divisions 7e–k. Time-series of landings, effort and LPUE for the Irish fleets. Units: landings in tonnes live weight, effort in 000s hours fished and LPUE in kg/hour fished.

	Otter_trawl_27.7j			Beam_trawl_27.7j			Scottish_seiner_27.7j			Gillnet_27.7j		
NA	Landings	Effort	lpue	Landings	Effort	lpue	Landings	Effort	lpue	Landings	Effort	lpue
1995	339,3	93,2	3,6	0,0	0,2	0,2	75,5	5,3	14,4	178,8	21,3	8,4
1996	326,4	70,2	4,6	8,7	1,4	6,3	124,5	8,2	15,3	65,0	5,2	12,4
1997	352,7	82,7	4,3	3,4	1,7	2,0	115,8	10,7	10,8	45,5	8,3	5,5
1998	262,7	89,1	2,9	19,1	5,2	3,7	103,4	6,6	15,6	59,1	16,0	3,7
1999	76,7	40,5	1,9	27,5	7,4	3,7	9,6	1,4	6,8	24,6	8,7	2,8
2000	95,5	63,9	1,5	21,2	6,9	3,1	24,4	3,5	7,0	13,8	7,0	2,0
2001	148,5	67,4	2,2	10,7	3,0	3,6	31,3	4,4	7,1	14,8	6,6	2,3
2002	150,0	90,4	1,7	5,4	3,1	1,7	24,6	8,9	2,8	12,3	8,1	1,5
2003	73,6	107,4	0,7	8,8	9,0	1,0	12,0	7,9	1,5	6,3	11,2	0,6
2004	36,1	88,3	0,4	2,5	2,2	1,2	10,3	8,1	1,3	4,2	6,1	0,7
2005	37,8	71,3	0,5	4,7	2,4	2,0	17,5	5,8	3,0	3,4	6,1	0,6
2006	39,6	64,5	0,6	2,0	1,5	1,3	15,6	5,3	2,9	7,2	7,3	1,0
2007	35,9	78,3	0,5	7,8	2,4	3,3	9,8	3,5	2,8	6,5	10,5	0,6
2008	33,1	66,7	0,5	2,6	1,1	2,3	9,5	2,8	3,3	6,5	7,9	0,8
2009	26,6	73,0	0,4	4,7	2,8	1,7	8,9	3,3	2,7	8,0	10,9	0,7
2010	52,5	85,7	0,6	1,7	1,0	1,7	17,0	4,4	3,9	8,4	9,4	0,9
2011	57,7	62,8	0,9	1,7	0,6	2,7	21,6	4,6	4,7	16,8	8,0	2,1
2012	62,8	65,6	1,0	0,4	0,3	1,5	29,8	5,4	5,6	25,2	8,3	3,0
2013	66,1	61,3	1,1	1,8	0,6	3,3	32,5	6,6	4,9	15,4	9,8	1,6
2014	51,6	53,9	1,0	1,2	0,6	1,9	52,6	7,4	7,1	9,7	12,2	0,8
2015	63,6	46,9	1,4	0,6	0,1	6,3	38,2	5,3	7,2	18,1	14,2	1,3
2016	48,5	50,7	1,0	0,3	0,2	1,5	25,2	5,3	4,7	15,8	17,1	0,9
2017	41,3	56,4	0,7	0,0	0,0	10,0	24,0	5,3	4,5	10,4	18,0	0,6
2018	42,3	52,1	0,8	0,2	0,1	2,4	28,5	6,4	4,5	5,9	16,8	0,4
2019	30,4	53,4	0,6	0,2	0,1	1,7	18,1	7,3	2,5	5,5	14,5	0,4
2020	26,72	44,11	0,61	0,07	0,02	2,92	17,16	5,53	3,10	13,80	13,52	1,02

	Otter_trawl_27.7g			Beam_trawl_27.7g			Scottish_seiner_27.7g			Gillnet_27.7g		
NA	Landings	Effort	lpue	Landings	Effort	lpue	Landings	Effort	lpue	Landings	Effort	lpue
1995	429,8	63,3	6,8	85,8	20,7	4,1	111,3	6,4	17,3	114,9	6,3	18,1
1996	569,2	60,0	9,5	112,5	26,7	4,2	164,9	9,7	16,9	338,9	6,2	54,8
1997	401,9	65,0	6,2	131,5	28,1	4,7	215,2	16,1	13,4	52,8	1,9	27,7
1998	450,5	72,3	6,2	166,8	35,2	4,7	264,1	14,9	17,7	87,3	3,4	25,4
1999	300,7	51,5	5,8	190,6	40,8	4,7	64,6	8,0	8,1	200,4	8,4	23,9
2000	279,4	60,6	4,6	180,6	36,8	4,9	106,0	9,9	10,8	151,7	10,1	15,0
2001	358,5	69,4	5,2	101,2	39,5	2,6	115,0	16,3	7,0	115,8	8,8	13,2
2002	212,9	77,2	2,8	57,9	31,5	1,8	71,0	20,9	3,4	31,0	6,4	4,8
2003	167,2	86,8	1,9	56,8	49,2	1,2	35,6	20,1	1,8	31,3	11,1	2,8
2004	190,2	97,1	2,0	74,3	54,9	1,4	54,4	18,4	3,0	62,0	13,5	4,6
2005	292,5	124,7	2,3	118,9	49,6	2,4	64,4	14,6	4,4	77,9	10,9	7,2
2006	379,4	118,0	3,2	128,6	60,5	2,1	91,0	14,8	6,2	63,7	7,8	8,1
2007	316,1	135,4	2,3	96,2	55,8	1,7	58,5	15,8	3,7	85,4	9,4	9,1
2008	344,9	125,4	2,7	85,4	37,2	2,3	55,6	11,6	4,8	88,0	14,1	6,2
2009	405,9	137,1	3,0	74,4	37,9	2,0	34,6	8,2	4,2	81,1	13,8	5,9
2010	524,8	140,8	3,7	94,7	40,2	2,4	54,3	9,7	5,6	76,0	14,0	5,4
2011	438,4	120,3	3,6	82,5	35,3	2,3	46,7	11,0	4,2	76,6	11,3	6,7
2012	780,7	127,7	6,1	161,9	40,3	4,0	111,5	14,1	7,9	129,1	15,4	8,4
2013	721,4	118,2	6,1	195,8	38,5	5,1	111,3	13,2	8,5	92,5	14,4	6,4
2014	600,1	127,3	4,7	142,9	37,8	3,8	110,5	12,5	8,9	59,2	14,1	4,2
2015	526,3	132,7	4,0	160,1	37,8	4,2	59,2	9,3	6,4	48,7	12,5	3,9
2016	418,1	148,2	2,8	106,8	39,6	2,7	51,1	10,4	4,9	47,1	13,6	3,5
2017	361,4	136,1	2,7	46,4	35,2	1,3	42,1	9,7	4,3	22,4	14,8	1,5
2018	387,6	108,2	3,6	72,6	37,4	1,9	61,1	9,7	6,3	16,7	14,0	1,2
2019	244,8	103,9	2,4	71,9	34,1	2,1	50,9	14,3	3,6	21,9	16,0	1,4
2020	184,36	89,91	2,05	55,00	29,14	1,89	51,51	13,59	3,79	20,08	15,02	1,34

Table 6.5c. Cod in divisions 7e–k. Time-series of landings, effort and LPUE for the UK fleets. Units: landings in tonnes, effort in days fished and LPUE in kg/day.

	Beam_trawl_27.7ek		Trawl_27.7ek		Trawl_27.7e	
YEAR	**Lands..t.**	**Effort..Days.**	**Lands..t..1**	**Effort..Days..1**	**Lands..t..2**	**Effort..Days..2**
1983	25.55	2853	40.93	2573	20.60	1871
1984	128.75	8427	235.68	8092	76.42	5618
1985	145.39	7706	250.67	7186	63.97	5411
1986	165.76	6651	232.19	6174	78.31	4425
1987	248.91	8060	210.36	5446	88.49	3701
1988	249.21	9487	262.68	5645	151.35	4265
1989	231.24	10071	177.12	5997	96.00	4607
1990	309.07	10477	305.78	6661	119.41	4423
1991	256.19	9017	242.33	5938	83.60	4004
1992	256.33	8183	231.85	6494	80.76	4108
1993	221.79	9511	183.05	5055	42.88	3761
1994	179.13	13925	78.23	4426	41.25	3423
1995	241.35	15076	115.05	4405	55.09	3294
1996	304.22	15748	120.46	4476	59.21	2589
1997	303.67	16373	150.01	5088	79.81	3011
1998	266.15	15574	119.56	4729	62.50	2699
1999	257.43	15614	90.68	6638	46.81	2486
2000	188.07	16456	110.79	7054	52.59	2681
2001	257.24	17335	109.75	5875	59.05	2732
2002	132.13	16503	82.70	5657	34.11	2448
2003	108.77	18285	58.80	5120	24.48	2273
2004	96.93	18250	44.06	5273	15.05	2334
2005	103.60	17157	41.13	5047	17.38	1762
2006	91.88	15412	55.43	5314	13.54	1699
2007	111.28	15085	49.65	5679	21.61	1917
2008	71.38	13734	49.34	4686	24.26	1750
2009	67.27	12170	27.56	4928	12.56	1847

	Beam_trawl_27.7ek		Trawl_27.7ek		Trawl_27.7e	
YEAR	Lands..t.	Effort..Days.	Lands..t..1	Effort..Days..1	Lands..t..2	Effort..Days..2
2010	65.62	12150	31.13	5185	15.27	2213
2011	99.03	13205	47.73	4354	26.00	1931
2012	165.63	13411	79.03	4312	30.95	2068
2013	114.49	12950	37.30	2014	22.94	1587
2014	87.55	12807	17.07	1606	14.06	1440
2015	89.39	12769	16.68	1061	14.40	978
2016	73.81	13913	0.00	0	0.00	0
2017	35.49	14283	19.37	3718	9.33	2398
2018	24.41	13065	17.51	3233	5.34	1987
2019	18.03	12649	11.76	2660	3.64	1548
2020	10.21	12332	2.55	1481	1.74	1093

Table 6.6. Cod in divisions 7e–k. Time-series of survey indices scrutinized at WGCSE and used in the assessment.

Cod in Divisions 7e-k, tuning fleets, WGCSE20
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FR-OTDEF Q2+3+4 trawlers in 7e-k

2002	2020		
1	1	0.25	1
-1	-1		

Year	Effort	Landings
2002	264146	3692073
2003	240535	1978251
2004	214247	918840
2005	156961	714850
2006	125245	712566
2007	150288	1193033
2008	138626	814340
2009	143812	647808
2010	143730	705691
2011	258383	2332986
2012	252110	3393990
2013	190886	1696287
2014	151518	1113363
2015	185791	1374691
2016	178399	1122665
2017	137849	483571
2018	102586	163178
2019	114838	136473
2020	96907	149412

next table

IR-GFS FR-EVHOE Q4 combined indices - VAST Modelling

2003	2020	NA	NA
1	1	0.79	0.92
1	4	NA	NA

Year	Effort	Age 1	Age 2	Age 3	Age 4
2003	1	25.842	38.501	47.069	16.900
2004	1	36.603	33.908	15.445	18.271
2005	1	113.438	34.168	12.128	0.000
2006	1	73.798	41.585	8.476	0.000
2007	1	100.743	69.388	31.665	12.139
2008	1	30.298	69.419	29.354	10.293
2009	1	60.106	20.742	27.971	11.391
2010	1	513.638	61.244	5.803	7.259
2011	1	238.921	370.988	24.989	4.165
2012	1	20.399	117.429	153.831	25.015
2013	1	25.824	8.185	23.890	32.896
2014	1	302.771	29.828	13.954	20.775
2015	1	14.148	153.793	9.227	0.000
2016	1	131.751	22.476	107.008	17.903
2017	1	22.455	67.631	27.008	35.812
2018	1	37.867	9.080	12.352	11.255
2019	1	148.594	36.032	2.121	6.805
2020	1	54.791	104.103	2.893	0.978

Table6.7. Cod in divisions 7e–k. Final SAM fishing mortality-at-age.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7+	Fbar(mean 2–5)
1980	0.480	0.946	0.910	0.912	0.891	1.155	1.155	0.915
1981	0.472	0.929	0.892	0.888	0.862	1.112	1.112	0.893
1982	0.442	0.868	0.829	0.819	0.792	1.015	1.015	0.827
1983	0.454	0.892	0.853	0.840	0.810	1.033	1.033	0.849
1984	0.404	0.789	0.750	0.733	0.706	0.896	0.896	0.744
1985	0.408	0.797	0.759	0.739	0.710	0.896	0.896	0.751
1986	0.438	0.858	0.820	0.796	0.761	0.949	0.949	0.809
1987	0.449	0.881	0.844	0.817	0.781	0.964	0.964	0.831
1988	0.422	0.826	0.789	0.758	0.725	0.887	0.887	0.774
1989	0.447	0.877	0.840	0.799	0.761	0.920	0.920	0.819
1990	0.486	0.959	0.921	0.874	0.830	0.995	0.995	0.896
1991	0.521	1.031	0.996	0.945	0.901	1.072	1.072	0.968
1992	0.516	1.021	0.987	0.931	0.890	1.058	1.058	0.957
1993	0.506	1.000	0.965	0.905	0.864	1.023	1.023	0.933
1994	0.524	1.037	1.003	0.937	0.896	1.059	1.059	0.968
1995	0.510	1.008	0.974	0.908	0.869	1.022	1.022	0.940
1996	0.523	1.036	1.002	0.924	0.882	1.028	1.028	0.961
1997	0.512	1.011	0.977	0.890	0.838	0.964	0.964	0.929
1998	0.529	1.048	1.015	0.919	0.859	0.972	0.972	0.960
1999	0.537	1.064	1.030	0.927	0.863	0.963	0.963	0.971
2000	0.528	1.045	1.011	0.904	0.839	0.926	0.926	0.950
2001	0.541	1.071	1.040	0.930	0.866	0.948	0.948	0.977
2002	0.556	1.103	1.072	0.949	0.878	0.953	0.953	1.000
2003	0.542	1.074	1.045	0.918	0.846	0.914	0.914	0.971
2004	0.530	1.047	1.019	0.893	0.825	0.891	0.891	0.946
2005	0.554	1.095	1.071	0.934	0.867	0.941	0.941	0.992
2006	0.512	1.005	0.985	0.859	0.806	0.882	0.882	0.914
2007	0.502	0.986	0.974	0.854	0.808	0.894	0.894	0.905
2008	0.480	0.946	0.945	0.835	0.799	0.893	0.893	0.881
2009	0.478	0.946	0.954	0.848	0.819	0.926	0.926	0.892
2010	0.460	0.913	0.927	0.828	0.805	0.922	0.922	0.868
2011	0.451	0.899	0.914	0.815	0.793	0.914	0.914	0.855
2012	0.479	0.963	0.982	0.878	0.857	0.999	0.999	0.920
2013	0.502	1.021	1.048	0.940	0.922	1.081	1.081	0.983
2014	0.462	0.941	0.963	0.860	0.838	0.985	0.985	0.900
2015	0.472	0.967	0.993	0.884	0.858	1.017	1.017	0.925
2016	0.490	1.012	1.043	0.924	0.893	1.067	1.067	0.968
2017	0.573	1.196	1.242	1.104	1.061	1.272	1.272	1.151
2018	0.611	1.285	1.342	1.180	1.118	1.337	1.337	1.231
2019	0.630	1.335	1.410	1.240	1.163	1.395	1.395	1.287
2020	0.564	1.190	1.261	1.109	1.042	1.259	1.259	1.151
	NA	NA	NA	NA	NA	NA	NA	NA

Table 6.8. Cod in divisions 7e–k. Final SAM stock number-at-age.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7+
1980	16740	4799	672	301	91	73	21
1981	7657	6433	1340	232	93	29	22
1982	3551	2894	1872	396	76	33	12
1983	7917	1316	873	662	141	29	15
1984	9034	3111	369	262	216	50	12
1985	7623	3690	1038	144	102	84	22
1986	8227	3047	1206	392	62	45	34
1987	27431	3106	922	392	130	26	25
1988	13844	11259	893	309	118	45	16
1989	4611	5571	3758	347	123	43	21
1990	6289	1709	1688	1170	148	44	23
1991	16225	2297	451	499	351	62	21
1992	18451	5992	577	129	137	102	24
1993	9545	6839	1592	161	42	42	33
1994	20029	3336	1854	467	53	15	23
1995	16407	7403	814	504	145	18	10
1996	11876	5992	2000	270	153	51	8
1997	12548	4213	1535	566	102	45	14
1998	7725	4636	1089	425	187	45	17
1999	4133	2769	1189	296	123	65	21
2000	16020	1375	690	317	92	40	27
2001	14945	5987	327	188	99	33	25
2002	5272	5437	1542	97	59	29	19
2003	3263	1800	1222	381	30	19	14
2004	4292	1229	435	304	116	11	12
2005	8015	1794	280	139	94	40	9
2006	8455	2727	469	58	45	31	16
2007	6387	2809	743	147	20	16	17
2008	2164	2196	711	216	51	7	11
2009	5344	821	630	217	74	19	6
2010	24984	1981	248	189	78	25	8
2011	9366	9580	634	89	65	28	10
2012	1683	3579	2838	209	36	23	14
2013	2246	608	972	813	72	15	11
2014	12135	807	168	271	262	21	6
2015	1074	4849	243	49	91	83	9
2016	2398	399	1257	75	16	31	27
2017	620	849	116	300	28	6	17
2018	1526	205	181	26	69	8	4
2019	4056	471	37	33	7	17	3
2020	1488	1478	72	6	6	2	4

Table 6.9. Cod in divisions 7e–k. Final SAM summary table.

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(2–5)	Low	High	TSB	Low	High
1980	16740	7382	37959	10166	7770	13301	0.915	0.743	1.127	19682	13038	29711
1981	7657	3520	16656	12924	9800	17044	0.893	0.740	1.077	20332	14285	28937
1982	3551	1641	7684	13050	10436	16321	0.827	0.687	0.996	16772	13128	21426
1983	7917	3756	16689	10605	8764	12833	0.849	0.703	1.026	14635	11613	18443
1984	9034	4333	18835	8264	6675	10232	0.745	0.601	0.923	13742	10082	18732
1985	7623	3645	15942	9816	7868	12247	0.751	0.616	0.915	15334	11440	20554
1986	8227	3869	17493	10992	8874	13616	0.809	0.677	0.966	16360	12498	21416
1987	27431	13157	57192	10305	8421	12610	0.831	0.693	0.996	22739	15400	33574
1988	13844	6635	28885	15858	11475	21916	0.774	0.635	0.945	28586	19337	42260
1989	4611	2171	9790	22338	17131	29127	0.819	0.684	0.982	28721	21812	37819
1990	6289	2916	13566	17747	14362	21930	0.896	0.754	1.065	21656	17448	26880
1991	16225	7530	34959	11103	9271	13296	0.968	0.804	1.166	18732	13653	25699
1992	18451	8721	39037	10339	7803	13699	0.957	0.808	1.135	21242	14192	31793
1993	9545	4430	20564	13492	10192	17860	0.934	0.790	1.103	21932	15538	30958
1994	20029	9565	41940	13533	10796	16963	0.968	0.818	1.145	23635	17091	32686
1995	16407	7904	34057	13827	10571	18087	0.940	0.799	1.106	24961	17472	35660
1996	11876	5753	24513	15873	12444	20245	0.961	0.814	1.134	24735	18276	33475
1997	12548	6072	25933	14406	11651	17813	0.929	0.787	1.096	22226	16803	29400
1998	7725	3738	15965	12947	10443	16051	0.960	0.815	1.130	19135	14454	25333
1999	4133	2010	8501	10667	8710	13063	0.971	0.823	1.145	14333	11269	18232
2000	16020	8100	31685	7440	6210	8914	0.950	0.805	1.121	14456	10433	20032
2001	14945	7720	28933	8724	6516	11681	0.977	0.833	1.145	18258	12848	25945
2002	5272	2869	9688	11612	9317	14472	1.000	0.851	1.177	17541	13525	22748
2003	3263	2001	5323	9174	7736	10878	0.971	0.835	1.128	11895	9961	14203
2004	4292	2633	6996	5382	4625	6263	0.946	0.823	1.088	7502	6374	8830
2005	8015	5417	11860	4169	3627	4792	0.992	0.851	1.157	7498	6294	8932
2006	8455	5485	13033	5471	4648	6440	0.914	0.795	1.051	9774	8085	11815
2007	6387	4240	9622	6765	5747	7963	0.905	0.788	1.041	10699	8955	12782

Year	R(age 1)	Low	High	SSB	Low	High	Fbar(2–5)	Low	High	TSB	Low	High
2008	2164	1457	3214	6818	5814	7995	0.881	0.766	1.014	9403	7962	11104
2009	5344	3616	7897	5465	4659	6409	0.892	0.775	1.026	8491	7206	10006
2010	24984	17074	36559	5403	4645	6285	0.868	0.749	1.007	14088	11271	17610
2011	9366	6360	13791	9240	7737	11035	0.855	0.735	0.994	16967	13991	20577
2012	1683	1130	2506	14412	12030	17264	0.920	0.806	1.050	17947	15106	21322
2013	2246	1504	3355	10347	8756	12227	0.983	0.838	1.153	12087	10376	14080
2014	12135	8189	17982	6214	5309	7274	0.900	0.775	1.046	11322	9375	13673
2015	1074	716	1612	6552	5534	7756	0.925	0.800	1.070	9766	8018	11894
2016	2398	1599	3595	5981	4988	7173	0.968	0.831	1.128	8065	6815	9543
2017	620	407	943	3265	2752	3873	1.151	1.003	1.320	4021	3410	4742
2018	1526	1006	2314	1655	1420	1927	1.231	1.063	1.426	2428	2073	2842
2019	4056	2668	6165	1036	878	1224	1.287	1.044	1.587	2858	2222	3675
2020	1488	756	2929	1395	1066	1825	1.150	0.835	1.585	2854	2091	3897

Table 6.10a. Cod in divisions 7e–k. Table of model parameters.

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-6.910	0.049	0.001	0.001	0.001
logFpar_1	-3.154	0.162	0.043	0.031	0.059
logFpar_2	-2.234	0.156	0.107	0.078	0.146
logFpar_3	-1.939	0.157	0.144	0.105	0.197
logSdLogFsta_0	-2.313	0.394	0.099	0.045	0.218
logSdLogN_0	-0.024	0.132	0.976	0.749	1.272
logSdLogN_1	-1.756	0.293	0.173	0.096	0.311
logSdLogObs_0	-0.685	0.226	0.504	0.320	0.792
logSdLogObs_1	-1.049	0.244	0.350	0.215	0.571
logSdLogObs_2	-1.376	0.145	0.253	0.189	0.338
logSdLogObs_3	-1.900	0.231	0.150	0.094	0.237
logSdLogObs_4	-0.486	0.150	0.615	0.456	0.830
transfIRARdist_0	-0.950	0.472	0.387	0.150	0.994
itrans_rho_0	1.809	0.669	6.105	1.602	23.257

Table 6.10b. Cod in divisions 7e–k. Model fitting.

Model	log(L)	#par	AIC
Current	-209.68	14	447.37
Base	-209.68	14	447.37

Table 6.11. Cod division 7e–k. Short-term forecast assumption.

Variable	Value	Notes
F ages 2–5 (2021)	1.23	Fsq = Faverage (2018–2020)**.
SSB (2022)	1354	Fishing at Fsq; in tonnes.
Recruitment age 1 (2021, 2022)	1526, 1488	Median from resampled (2015–2020); in thousands*.
Total catch (2021)	1881	Fishing at Fsq, in tonnes.
Projected landings (2021)	1609	Short-term forecast assuming average 2018–2020 landings pattern; in tonnes.
Projected discards (2021)	272	Short-term forecast assuming average 2018–2020 discards pattern; in tonnes.

Table 6.12. Cod in divisions 7e–k. Reference points.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	5800	B_{pa}; in tonnes	ICES (2020a)
	F_{MSY}	0.29	Segmented regression with B_{lim} (EqSim)	ICES (2020a)
Precautionary approach	B_{lim}	4200	B_{loss}, lowest observed SSB from which there has been some recovery (2005) rounded value; in tonnes	ICES (2020a)
	B_{pa}	5800	B_{lim} × 1.4; in tonnes	ICES (2020a)
	F_{lim}	1.13	Segmented regression with B_{lim} (EqSim)	ICES (2020a)
	F_{pa}	0.77	$F_{p0.5}$; the F that leads to SSB ≥ B_{lim} with 95% probability	ICES (2020a)
Management plan	MAP MSY $B_{trigger}$	5800	MSY $B_{trigger}$; in tonnes	EU (2019), ICES (2020a)
	MAP B_{lim}	4200	B_{lim}; in tonnes	EU (2019), ICES (2020a)
	MAP F_{MSY}	0.29	F_{MSY}	EU (2019), ICES (2020a)
	MAP range F_{lower}	0.17	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with MSY	EU (2019), ICES (2020a)
	MAP range F_{upper}	0.41	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with MSY	EU (2019), ICES (2020a)

Table 6.13. Stochastic Short-term forecast.

F_{MSY}

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	fbarL:median	fbarL:low	fbarL:high	fbarD:median	fbarD:low	fbarD:high	Land:median	Land:low	Land:high	Discard:median	Discard:low	Discard:high
2020	1.150	0.840	1.580	1492	768	2891	1408	1086	1841	1794	1319	2460	1.063	0.776	1.463	0.087	0.064	0.117	1421	1049	1947	373	270	513
2021	1.231	0.854	1.778	1526	620	4056	1710	950	2929	1881	1195	2915	1.177	0.815	1.701	0.054	0.039	0.077	1609	1004	2562	272	191	353
2022	0.290	0.192	0.438	1488	620	4056	1354	561	2866	519	286	991	0.277	0.183	0.419	0.013	0.009	0.019	437	231	872	82	55	119
2023	0.290	0.184	0.457	1526	620	4056	2667	1180	5681	923	480	1857	0.277	0.176	0.437	0.013	0.008	0.020	831	419	1723	92	61	134

Basis for the advice F=0.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	fbarL:median	fbarL:low	fbarL:high	fbarD:median	fbarD:low	fbarD:high	Land:median	Land:low	Land:high	Discard:median	Discard:low	Discard:high
2020	1.150	0.840	1.580	1492	768	2891	1408	1086	1841	1794	1319	2460	1.063	0.776	1.463	0.087	0.064	0.117	1421	1049	1947	373	270	513
2021	1.231	0.854	1.778	1526	620	4056	1710	950	2929	1881	1195	2915	1.177	0.815	1.701	0.054	0.039	0.077	1609	1004	2562	272	191	353
2022	0.000	0.000	0.000	1488	620	4056	1354	561	2866	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0	0
2023	0.000	0.000	0.000	1526	620	4056	3449	1630	7168	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0	0

Other scenarios

F status quo then F_{MSY} HCR.

Year	fbar: median	fbar: low	fbar: high	rec: median	rec:low	rec:high	ssb: median	ssb:low	ssb:high	catch:median	catch:low	catch:high	fbarL:median	fbarL:low	fbarL:high	fbarD:median	fbarD:low	fbarD:high	Land:median	Land:low	Land:high	Discard: median	Discard: low	Discard: high
2020	1.150	0.840	1.580	1492	768	2891	1408	1086	1841	1794	1319	2460	1.063	0.776	1.463	0.087	0.064	0.117	1421	1049	1947	373	270	513
2021	1.231	0.854	1.778	1526	620	4056	1710	950	2929	1881	1195	2915	1.177	0.815	1.701	0.054	0.039	0.077	1609	1004	2562	272	191	353
2022	0.068	0.045	0.102	1488	620	4056	1354	561	2866	134	74	257	0.065	0.043	0.098	0.003	0.002	0.004	113	60	227	21	14	30
2023	0.290	0.184	0.457	1526	620	4056	3246	1512	6787	1092	565	2226	0.277	0.176	0.437	0.013	0.008	0.020	998	502	2086	94	63	140

F status quo then F_{MSY} lower HCR.

Year	fbar: median	fbar: low	fbar: high	rec: median	rec:low	rec:high	ssb: median	ssb:low	ssb:high	catch:median	catch:low	catch:high	fbarL:median	fbarL:low	fbarL:high	fbarD:median	fbarD:low	fbarD:high	Land:median	Land:low	Land:high	Discard: median	Discard: low	Discard: high
2020	1.150	0.840	1.580	1492	768	2891	1408	1086	1841	1794	1319	2460	1.063	0.776	1.463	0.087	0.064	0.117	1421	1049	1947	373	270	513
2021	1.231	0.854	1.778	1526	620	4056	1710	950	2929	1881	1195	2915	1.177	0.815	1.701	0.054	0.039	0.077	1609	1004	2562	272	191	353
2022	0.040	0.026	0.060	1488	620	4056	1354	561	2866	79	44	153	0.038	0.025	0.057	0.002	0.001	0.003	67	36	135	12	8	18
2023	0.290	0.184	0.457	1526	620	4056	3329	1560	6942	1116	577	2278	0.277	0.176	0.437	0.013	0.008	0.020	1021	513	2140	95	64	138

F status quo then F_{MSY} upper HCR.

Year	fbar: median	fbar: low	fbar: high	rec: median	rec:low	rec:high	ssb: median	ssb:low	ssb:high	catch:median	catch:low	catch:high	fbarL:median	fbarL:low	fbarL:high	fbarD:median	fbarD:low	fbarD:high	Land:median	Land:low	Land:high	Discard: median	Discard: low	Discard: high
2020	1.150	0.840	1.580	1492	768	2891	1408	1086	1841	1794	1319	2460	1.063	0.776	1.463	0.087	0.064	0.117	1421	1049	1947	373	270	513
2021	1.231	0.854	1.778	1526	620	4056	1710	950	2929	1881	1195	2915	1.177	0.815	1.701	0.054	0.039	0.077	1609	1004	2562	272	191	353
2022	0.096	0.063	0.144	1488	620	4056	1354	561	2866	186	103	359	0.091	0.060	0.138	0.005	0.003	0.006	158	84	317	28	19	42
2023	0.290	0.184	0.457	1526	620	4056	3167	1466	6638	1069	554	2176	0.277	0.176	0.437	0.013	0.008	0.020	975	490	2036	94	64	140

Stable SSB.

Year	fbar: median	fbar: low	fbar: high	rec: median	rec:low	rec:high	ssb: median	ssb:low	ssb:high	catch:median	catch:low	catch:high	fbarL:median	fbarL:low	fbarL:high	fbarD:median	fbarD:low	fbarD:high	Land:median	Land:low	Land:high	Discard: median	Discard: low	Discard: high
2020	1.150	0.840	1.580	1492	768	2891	1408	1086	1841	1794	1319	2460	1.063	0.776	1.463	0.087	0.064	0.117	1421	1049	1947	373	270	513
2021	1.231	0.854	1.778	1526	620	4056	1710	950	2929	1881	1195	2915	1.177	0.815	1.701	0.054	0.039	0.077	1609	1004	2562	272	191	353
2022	1.085	0.718	1.637	1488	620	4056	1354	561	2866	1426	768	2673	1.037	0.686	1.566	0.048	0.032	0.071	1174	601	2328	252	167	345
2023	1.113	0.709	1.751	1526	620	4056	1354	497	3201	1489	744	2917	1.064	0.677	1.675	0.049	0.032	0.076	1223	574	2570	266	170	347

F2021.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	fbarL:median	fbarL:low	fbarL:high	fbarD:median	fbarD:low	fbarD:high	Land:median	Land:low	Land:high	Discard:median	Discard:low	Discard:high
2020	1.150	0.840	1.580	1492	768	2891	1408	1086	1841	1794	1319	2460	1.063	0.776	1.463	0.087	0.064	0.117	1421	1049	1947	373	270	513
2021	1.231	0.854	1.778	1526	620	4056	1710	950	2929	1881	1195	2915	1.177	0.815	1.701	0.054	0.039	0.077	1609	1004	2562	272	191	353
2022	1.231	0.815	1.858	1488	620	4056	1354	561	2866	1536	823	2878	1.176	0.778	1.777	0.055	0.037	0.081	1261	643	2501	275	180	377
2023	1.231	0.782	1.940	1526	620	4056	1202	424	2919	1456	717	2868	1.177	0.746	1.856	0.054	0.036	0.084	1171	538	2503	285	179	365

F_{pa}.

Year	fbar:median	fbar:low	fbar:high	rec:median	rec:low	rec:high	ssb:median	ssb:low	ssb:high	catch:median	catch:low	catch:high	fbarL:median	fbarL:low	fbarL:high	fbarD:median	fbarD:low	fbarD:high	Land:median	Land:low	Land:high	Discard:median	Discard:low	Discard:high
2020	1.150	0.840	1.580	1492	768	2891	1408	1086	1841	1794	1319	2460	1.063	0.776	1.463	0.087	0.064	0.117	1421	1049	1947	373	270	513
2021	1.231	0.854	1.778	1526	620	4056	1710	950	2929	1881	1195	2915	1.177	0.815	1.701	0.054	0.039	0.077	1609	1004	2562	272	191	353
2022	0.770	0.510	1.162	1488	620	4056	1354	561	2866	1137	619	2142	0.736	0.487	1.112	0.034	0.023	0.050	943	491	1874	194	128	268
2023	0.770	0.489	1.213	1526	620	4056	1763	698	3988	1431	737	2801	0.736	0.467	1.161	0.034	0.022	0.052	1226	602	2525	205	135	276

F_{lim}.

Year	fbar: median	fbar: low	fbar: high	rec: median	rec:low	rec:high	ssb: median	ssb:low	ssb:high	catch:median	catch:low	catch:high	fbarL:median	fbarL:low	fbarL:high	fbarD:median	fbarD:low	fbarD:high	Land:median	Land:low	Land:high	Discard: median	Discard: low	Discard: high
2020	1.150	0.840	1.580	1492	768	2891	1408	1086	1841	1794	1319	2460	1.063	0.776	1.463	0.087	0.064	0.117	1421	1049	1947	373	270	513
2021	1.231	0.854	1.778	1526	620	4056	1710	950	2929	1881	1195	2915	1.177	0.815	1.701	0.054	0.039	0.077	1609	1004	2562	272	191	353
2022	1.130	0.748	1.705	1488	620	4056	1354	561	2866	1461	786	2740	1.080	0.714	1.631	0.050	0.034	0.074	1203	614	2383	258	172	357
2023	1.130	0.718	1.781	1526	620	4056	1306	472	3121	1468	731	2880	1.080	0.685	1.704	0.050	0.033	0.077	1200	559	2538	268	172	342

B_{lim} - Not archivable.

B_{pa}, Msy $B_{trigger}$, not archivable.

Table 6.14. Catch option table.

Basis	Total catch (2022)	Pro-jected landings (2022)	Pro-jected discards (2022)	Ftotal (2022)	Fpro-jected landings (2022)	Fpro-jected discards (2022)	SSB (2023)	% SSB change *
				ICES advice basis				
MSY and precau-tionary consider-ations: F = 0	0	0	0	0	0	0	3449	155
Other scenarios								
FMSY × S SB2022/ MSY Btrig ger	134	113	21	0.068	0.065	0.003	3246	140
FMSY low er × SSB2 022/MSY Btrigger	79	67	12	0.040	0.038	0.002	3329	146
FMSY up-per × SSB 2022/MS Y Btrigger	186	158	28	0.096	0.091	0.005	3167	134
F=FMSY	519	437	82	0.290	0.277	0.013	2667	97
F = 0	0	0	0	0	0	0	3449	155
F=Flim	1461	1203	258	1.130	1.080	0.05	1306	-4
F = Fpa	1137	943	194	0.770	0.736	0.034	1763	30
SSB2023 = Blim								
SSB2023 = Bpa = MSY Btrig ger								
F = F2021	1536	1261	275	1.231	1.176	0.055	1202	-11
SSB2022 =SSB202 3	1426	1174	252	1.085	1.037	0.048	1354	0

Table 6.15. Cod in divisions 7e–k. Forecast (a) yield in 2022 and (b) SSB in 2023.

recruitment	val	type	Prop	Age
2022	2.655970e-04	2022 Catch	14.4800330	1
2021	7.398342e-04	2022 Catch	40.3348889	2
2020	4.023381e-04	2022 Catch	21.9350013	3
2019	3.850629e-04	2022 Catch	20.9931735	4
2018	2.880126e-05	2022 Catch	1.5702105	5
2017	4.636939e-06	2022 Catch	0.2528005	6
2016	7.958578e-06	2022 Catch	0.4338923	7
2023	0.000000e+00	2023 SSB	0.0000000	1
2022	8.351603e+02	2023 SSB	25.2295711	2
2021	1.395051e+03	2023 SSB	42.1434374	3
2020	5.552465e+02	2023 SSB	16.7735813	4
2019	4.800388e+02	2023 SSB	14.5016150	5
2018	3.338672e+01	2023 SSB	1.0085878	6
2017	1.136100e+01	2023 SSB	0.3432073	7

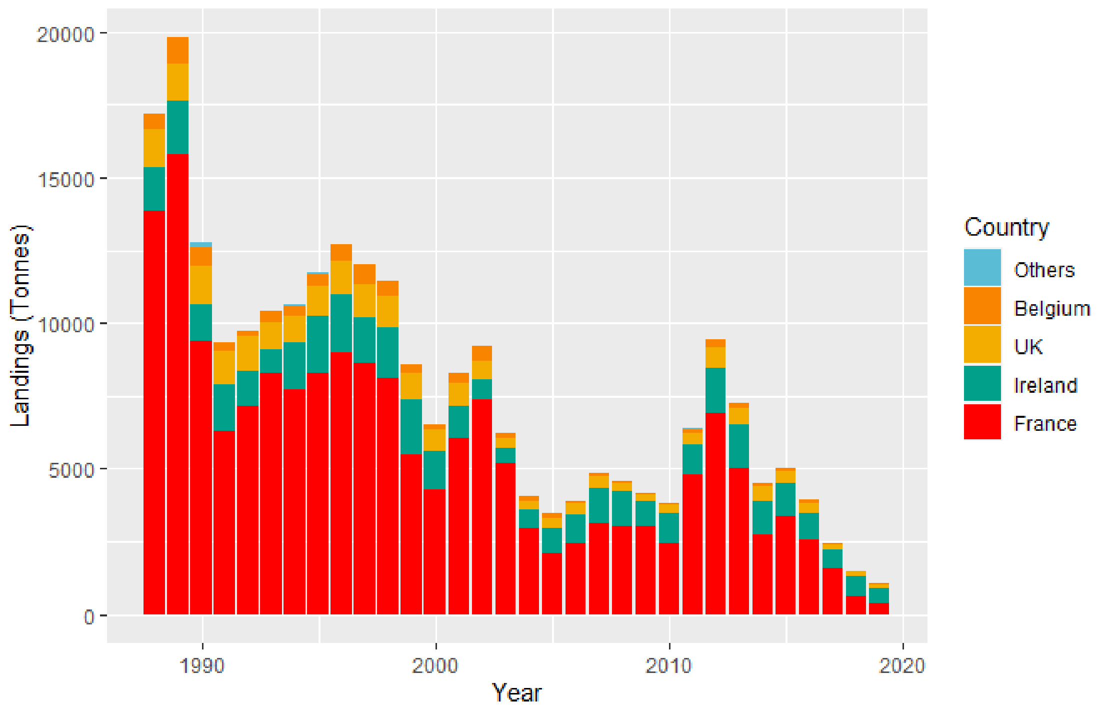


Figure 6.1. Cod in divisions 7e–k. Historical landings (in Tonnes) by country. Revised at WKCETIC 2020.

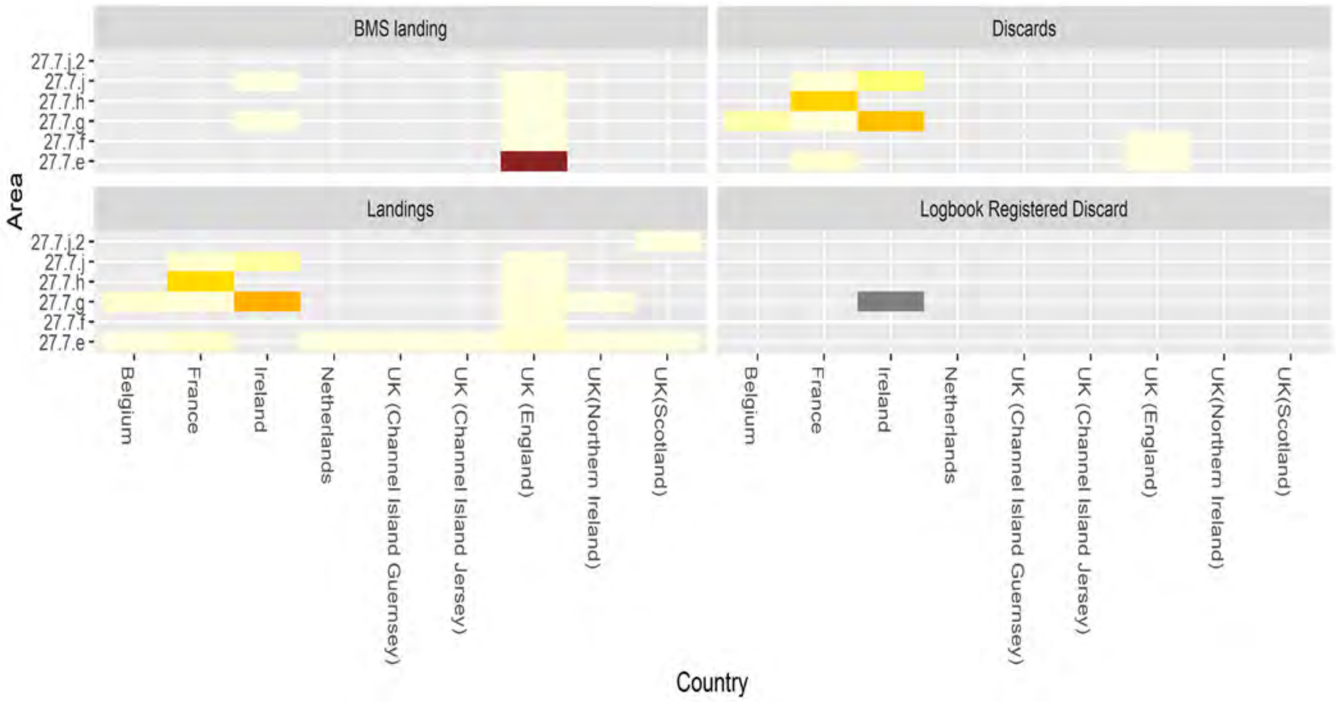


Figure 6.2. Cod in divisions 7e–k. Catches volume in Tonnes (i.e. landings and discards) by area and country.

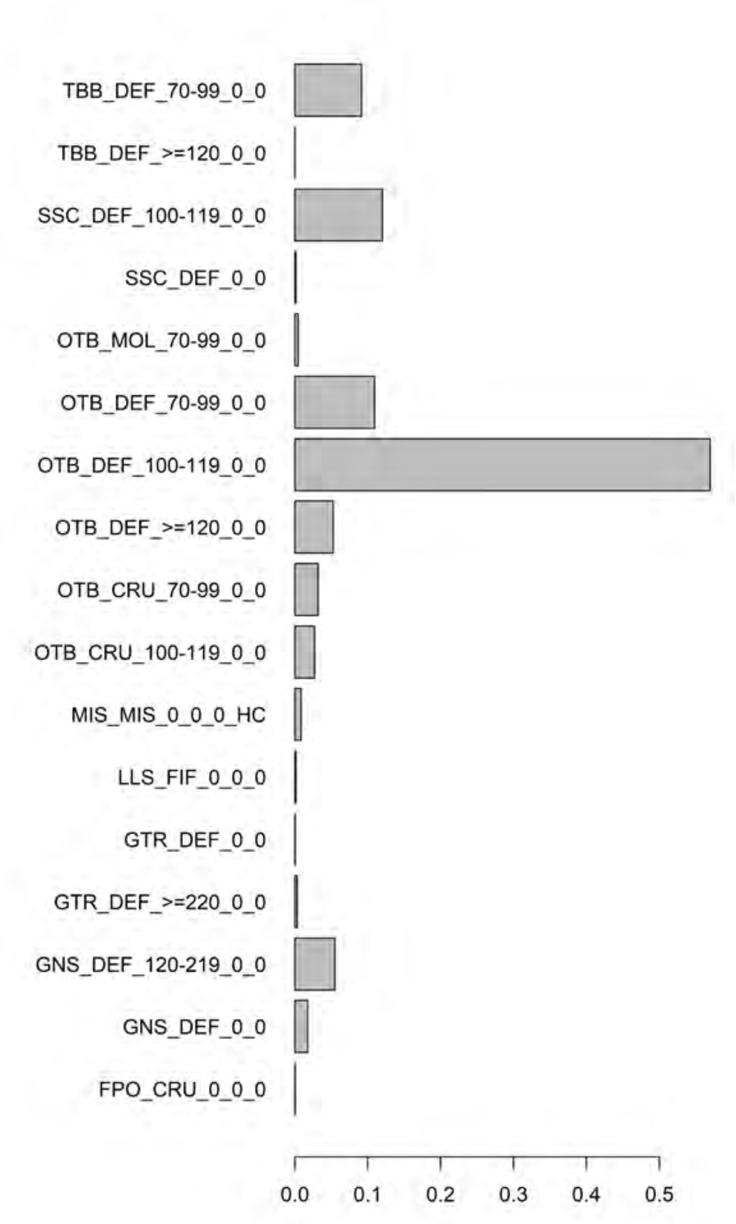


Figure 6.3. Cod in divisions 7e–k. Proportion of landings per métier (Level 6).

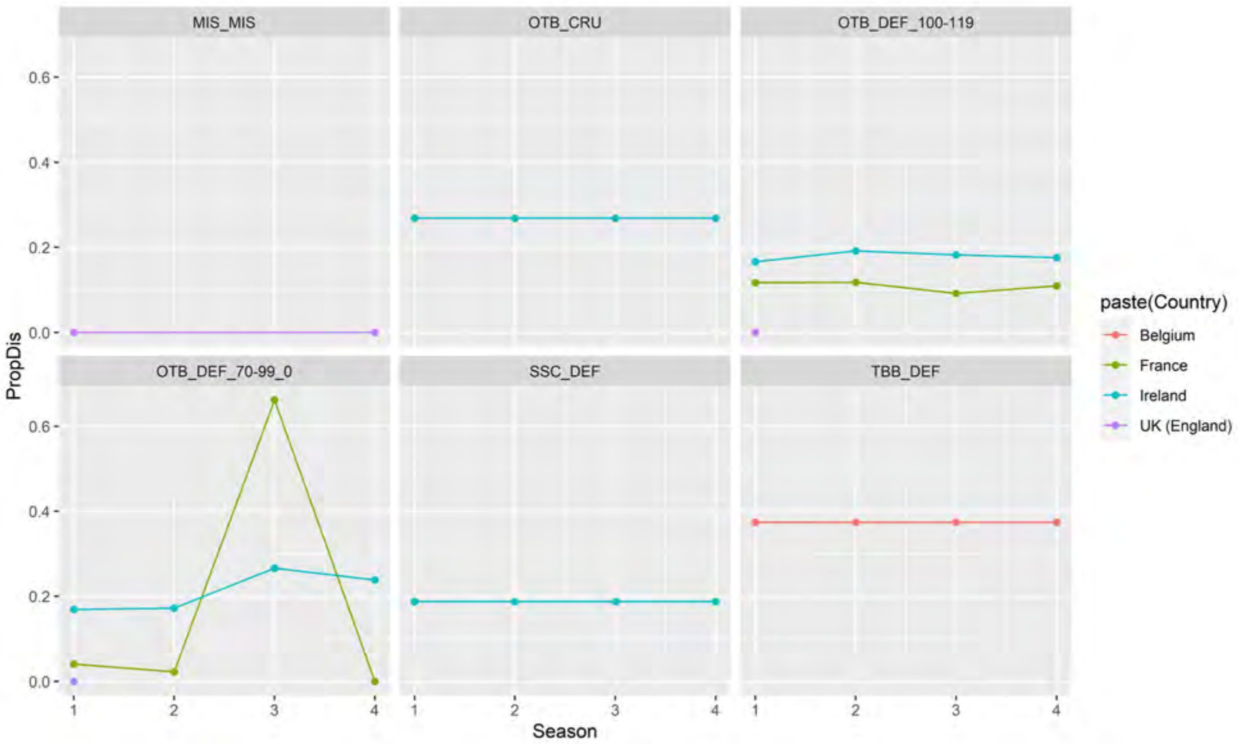


Figure 6.4. Cod in divisions 7e–k. Discard proportion per fleet and season.

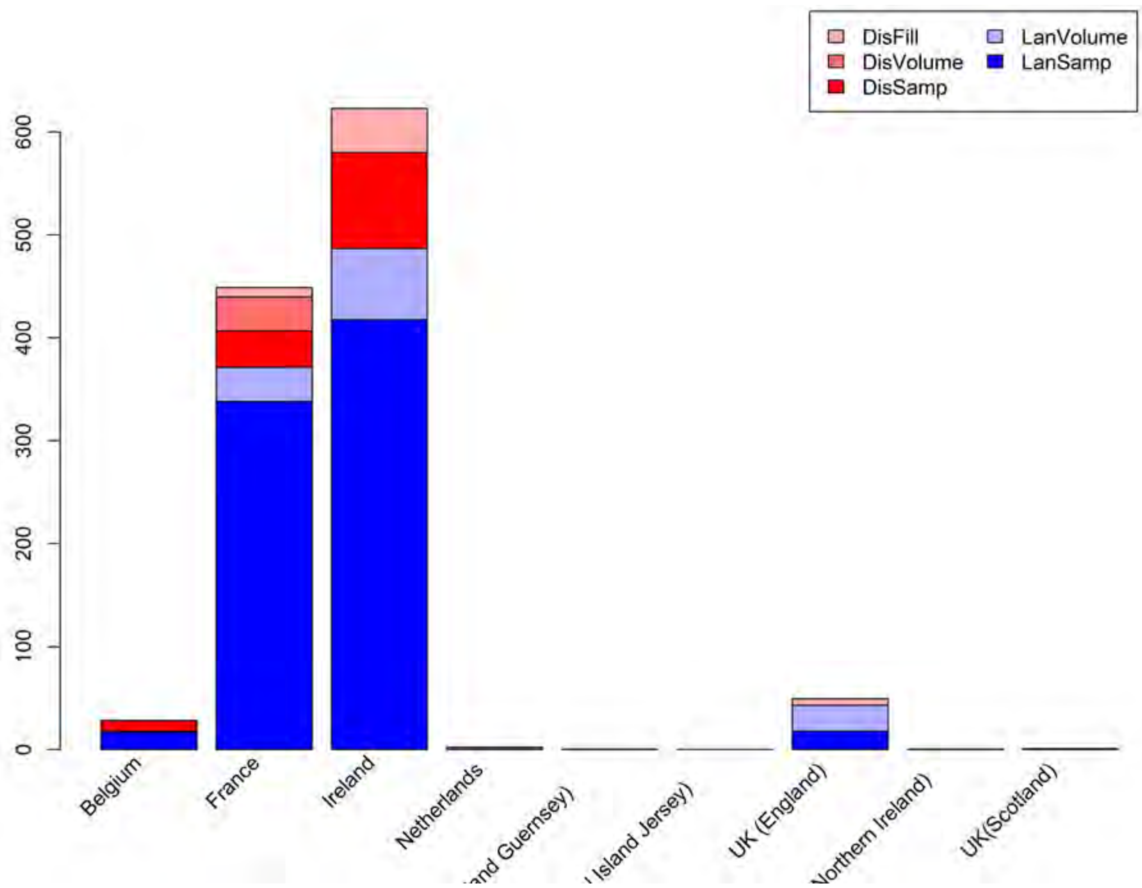


Figure 6.5. Cod in divisions 7e–k. Allocation procedure.

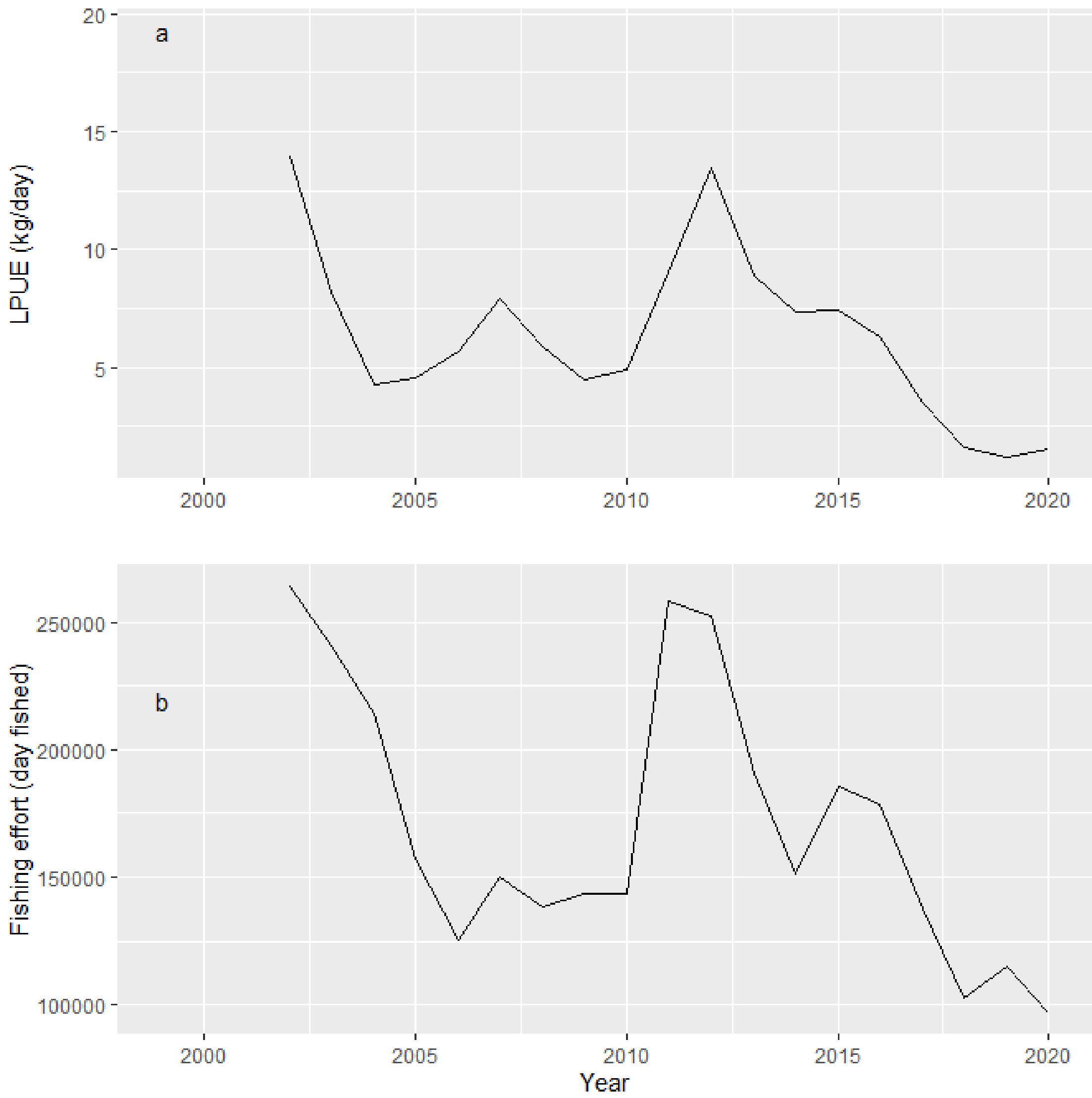


Figure 6.6a. Cod in divisions 7e–k. Time-series of (a) LPUE and (b) fishing effort for the French fleets. Units: LPUE in kg/day and fishing effort in days fished.

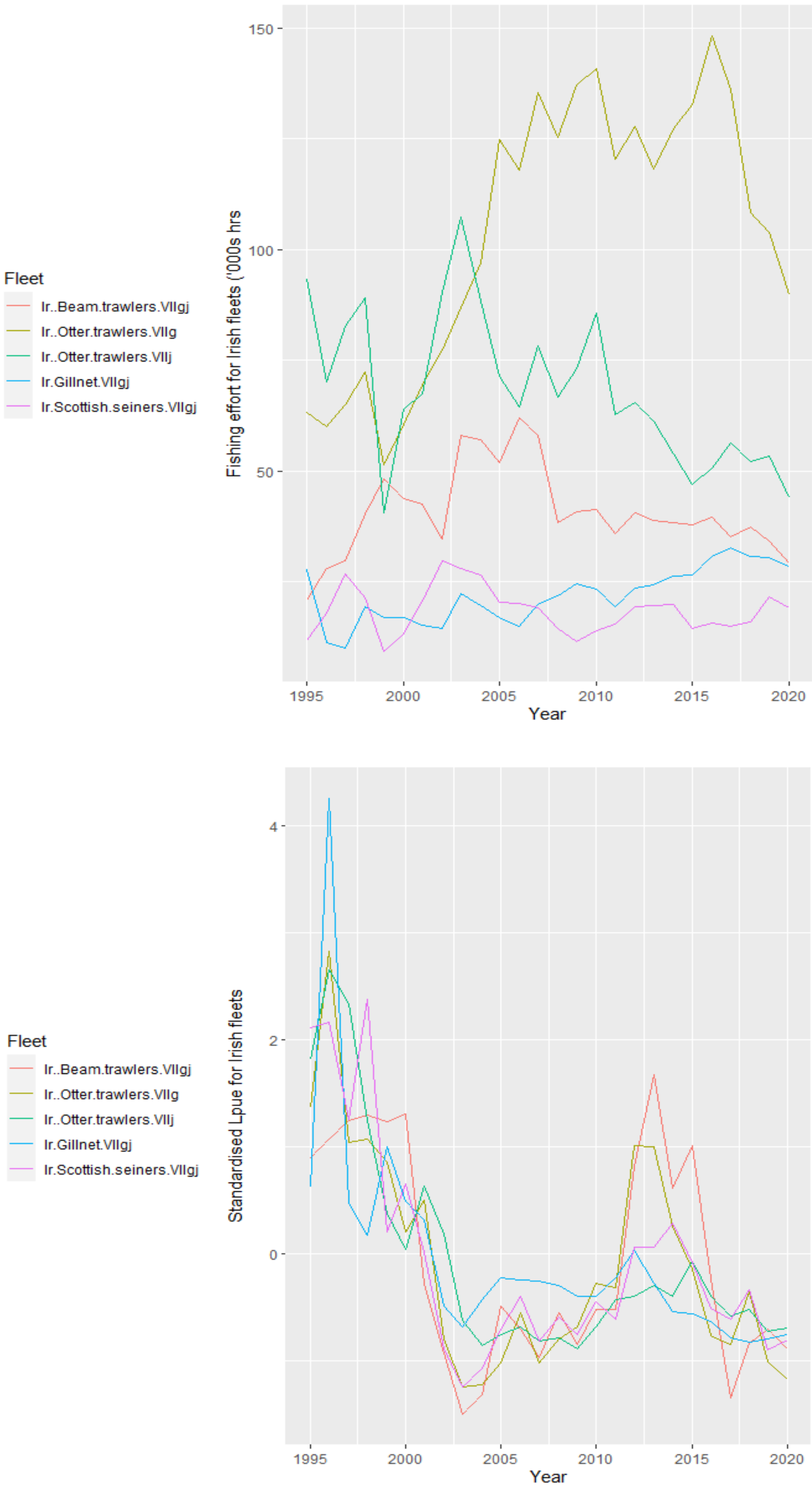


Figure 6.6b. Cod in divisions 7e–k. Time-series of (a) LPUE and (b) fishing effort for the Irish fleets. Units: LPUE in kg/day fished and Effort in 000s hours fished.

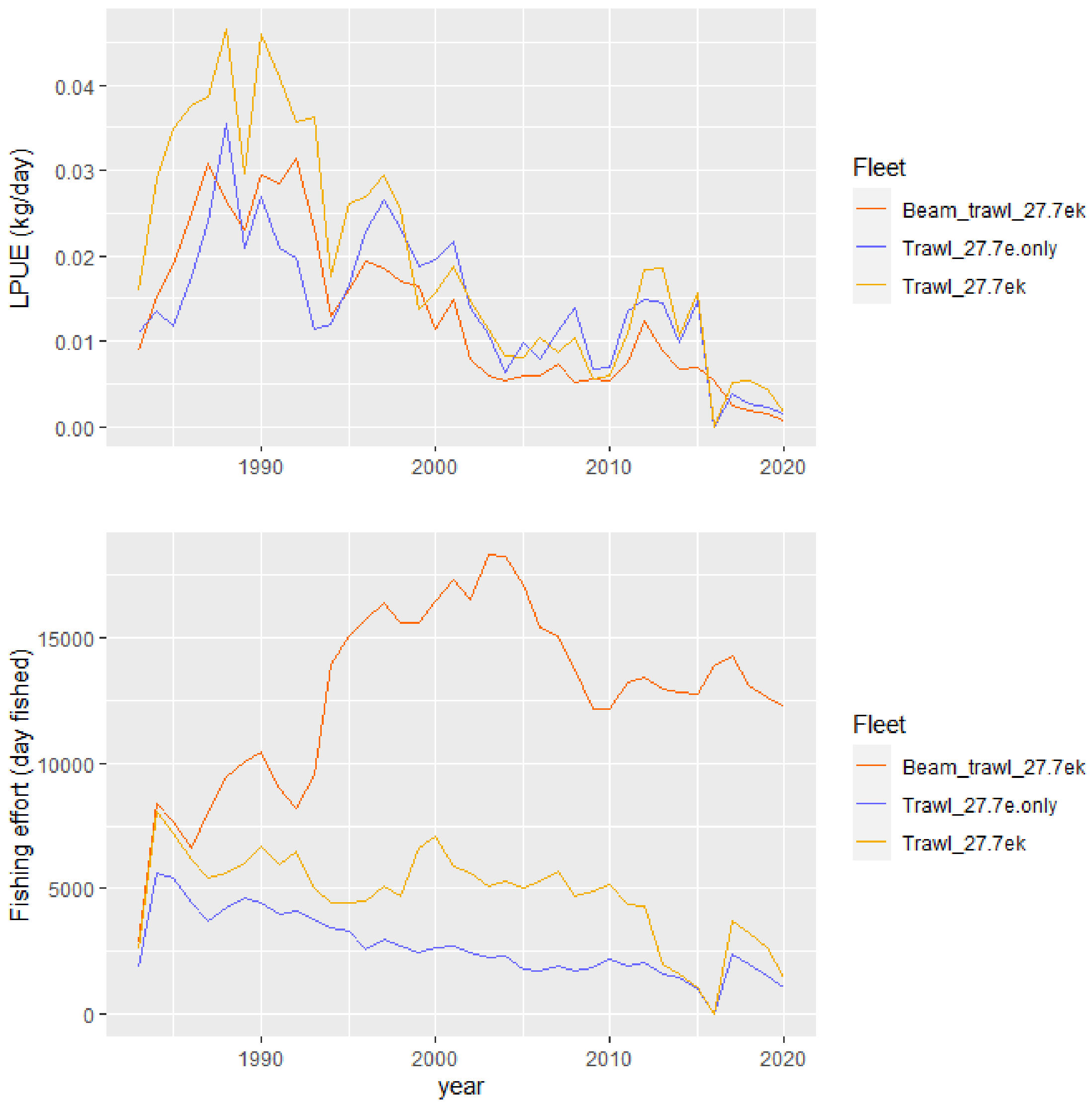


Figure 6.6c. Cod in divisions 7e–k. Time-series of LPUE and fishing effort for the UK fleets. Units: LPUE in kg/day and fishing effort in days fished.

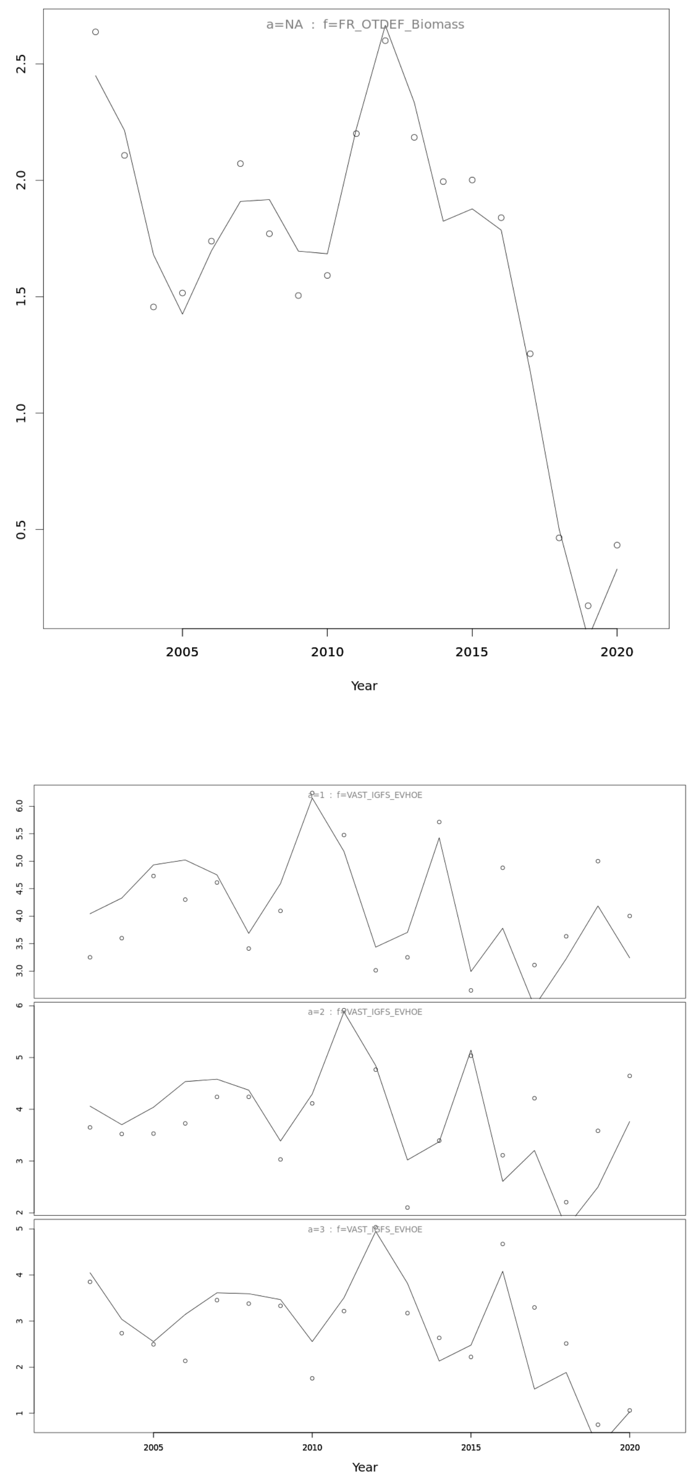
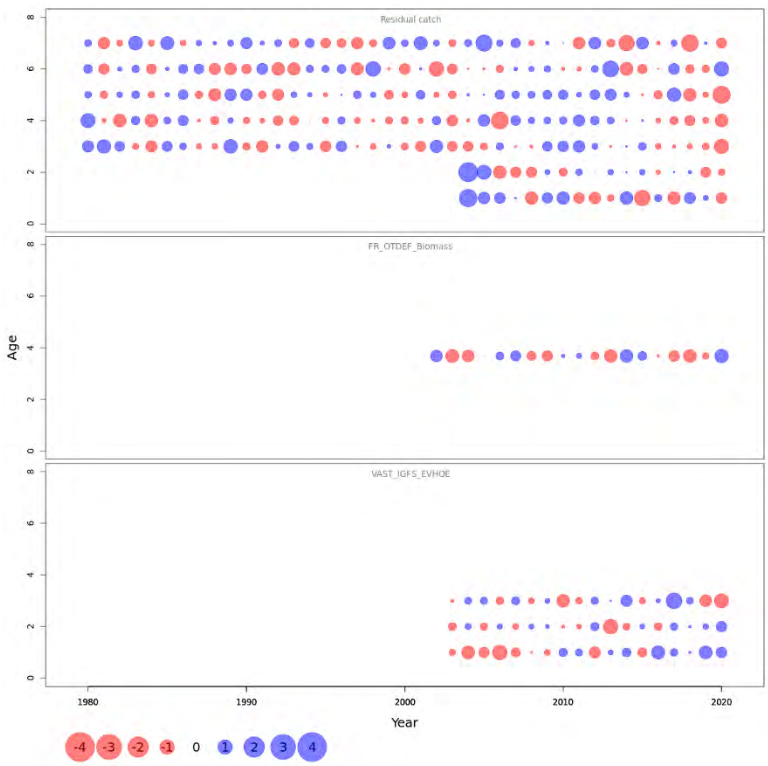


Figure 6.7. Cod in divisions 7e–k. Fits of the tuning indices used in the assessment. Commercial tuning fleet corresponds to French OTDEF Q2+3+4 as biomass index. The survey index is a combined index based on both French IR-GFS and FR-Evhoe Q4 data where mean number-at-age are modelled using VAST.



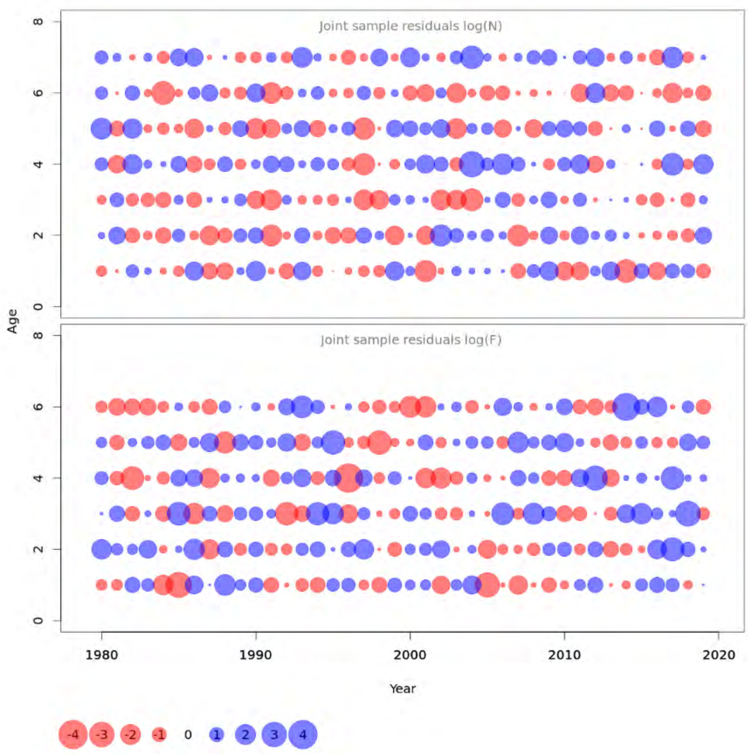


Figure 6.8. Cod in divisions 7e–k. Final assessment. Residuals.

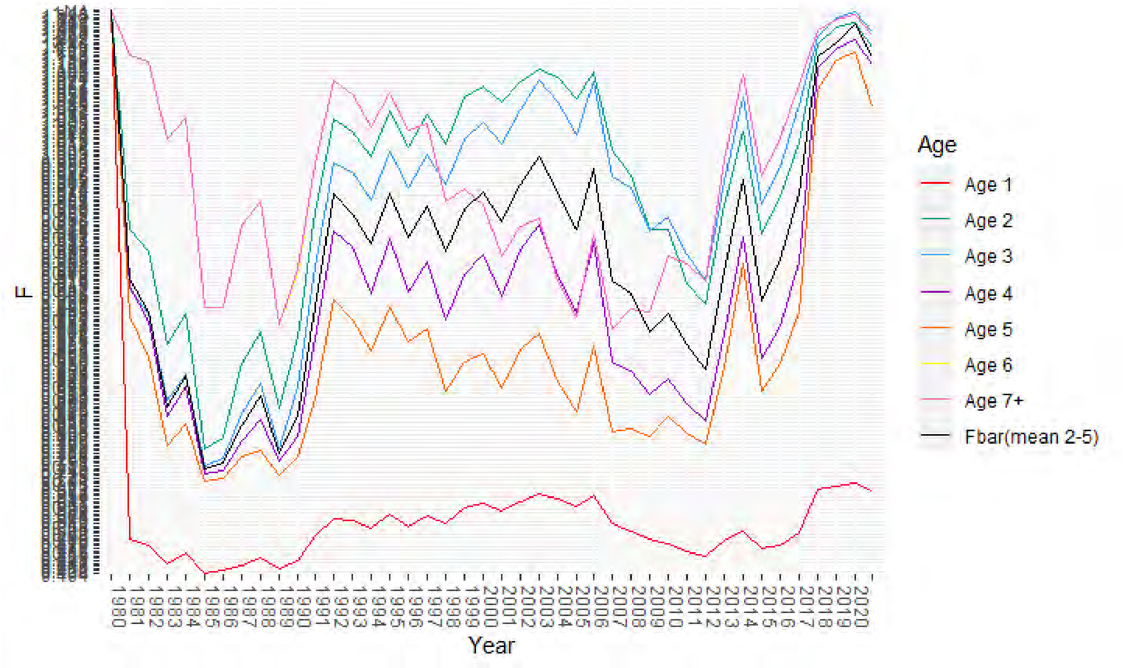


Figure 6.9. Cod in divisions 7e–k. Fishing mortality.

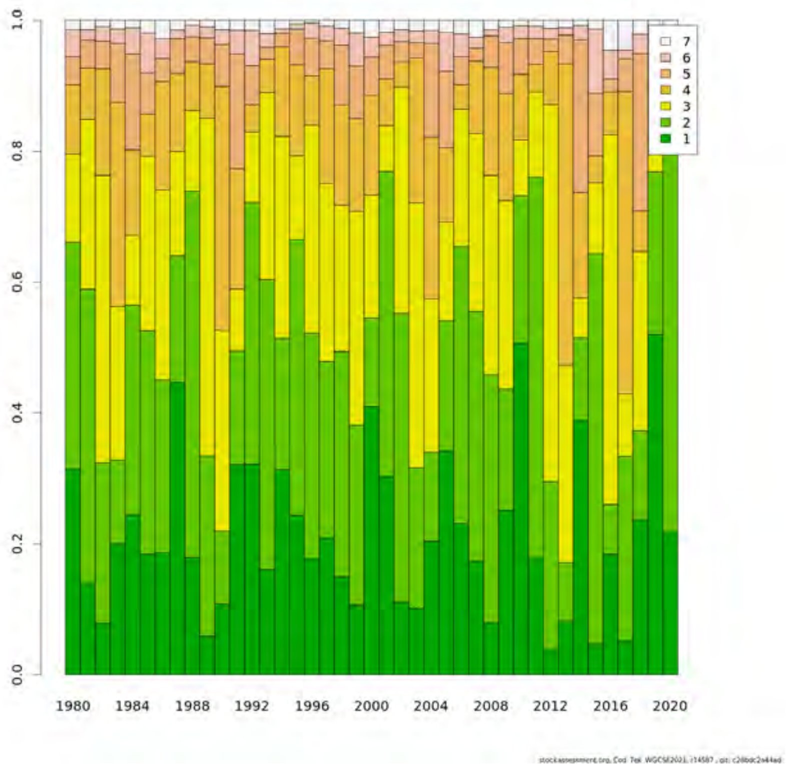
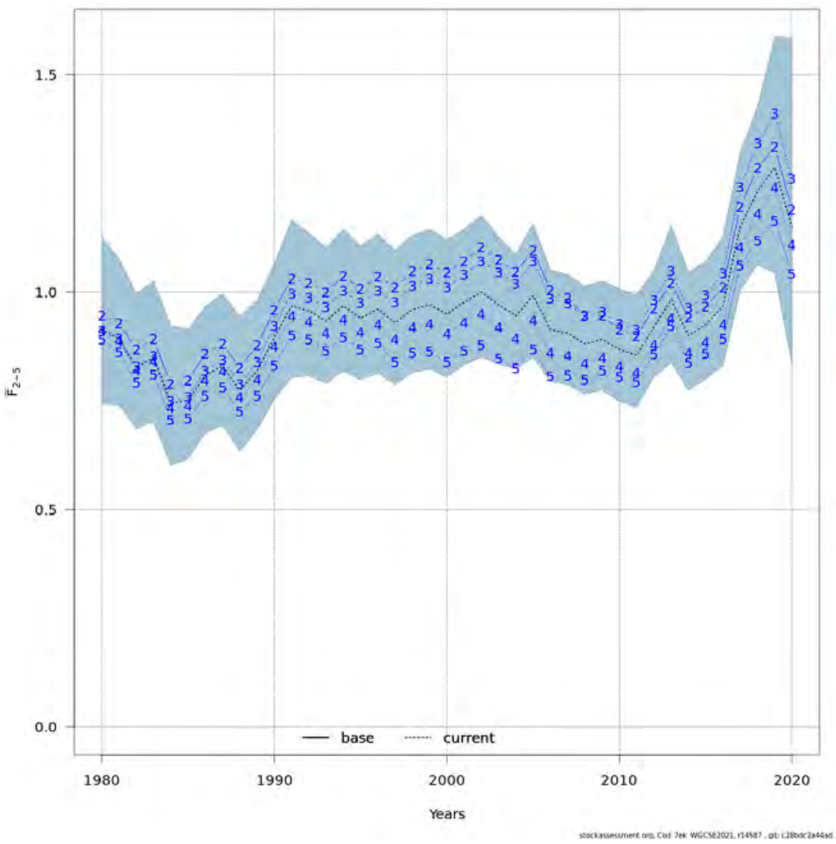
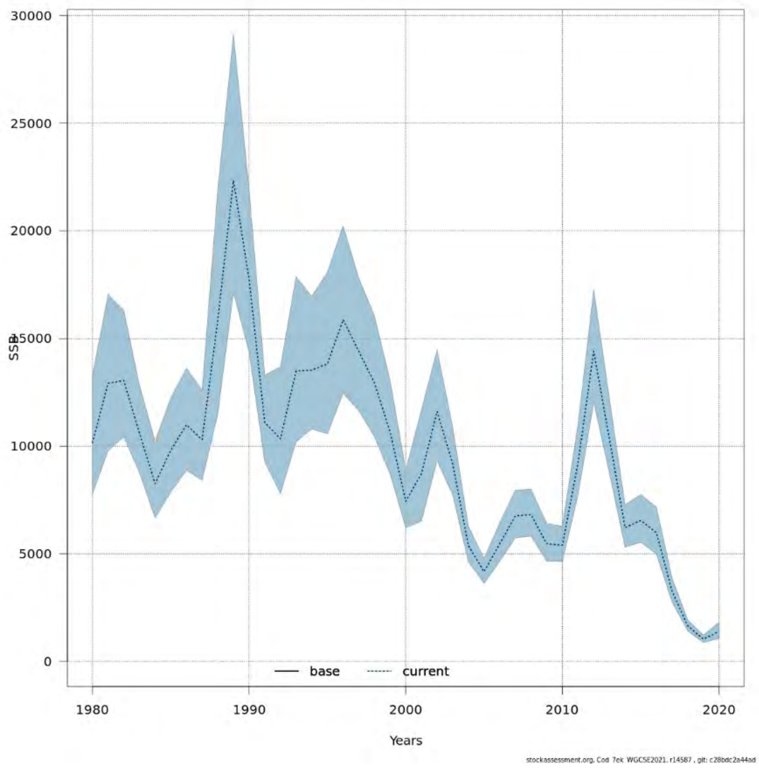
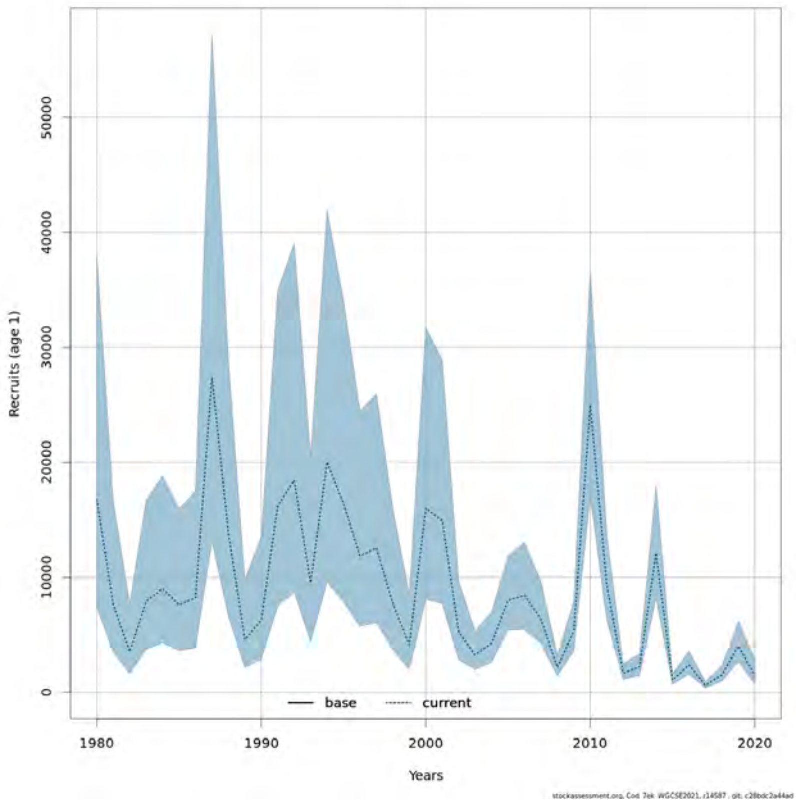


Figure 6.10. Cod in divisions 7e–k. Final SAM outputs. Catch proportion-at-age. Age 0 are not included in the assessment.


1.5
1.0
0.5
0.0
$\bar{F}_{2-5}$
base
current
1980
1990
2000
2010
2020
Years


30000
25000
20000
15000
10000
5000
0
SSB
base
current
1980
1990
2000
2010
2020
Years



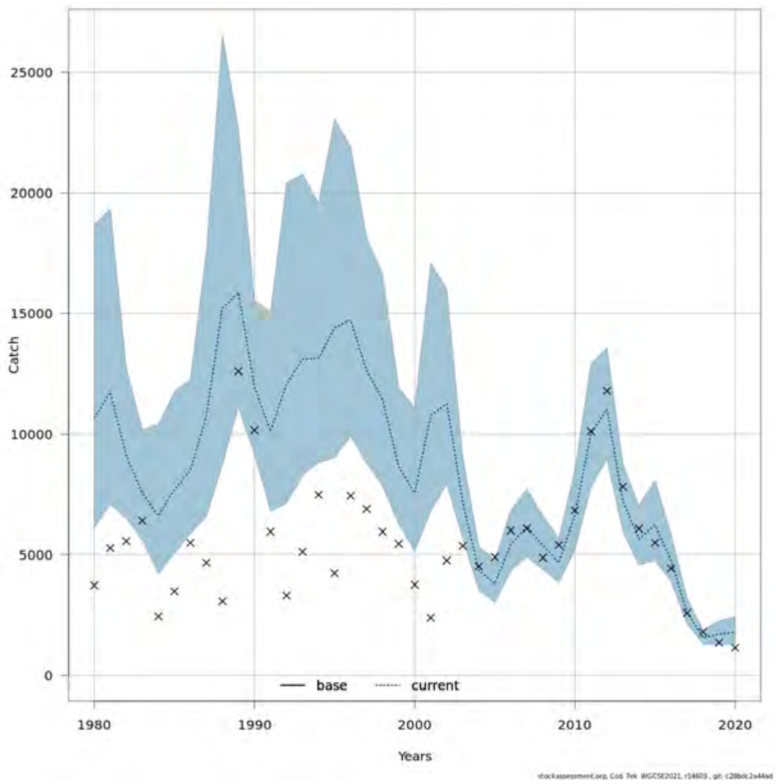
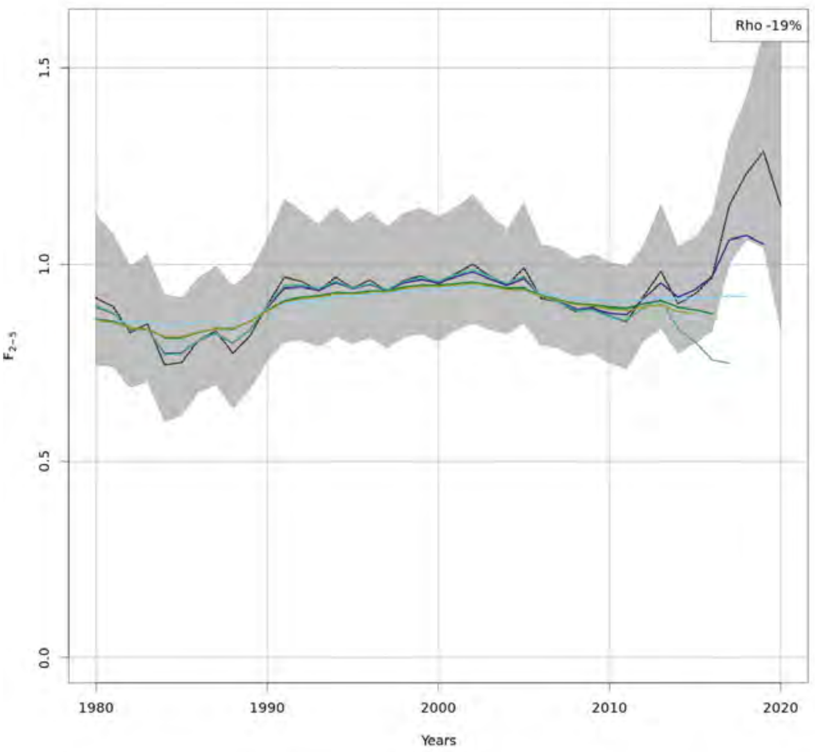
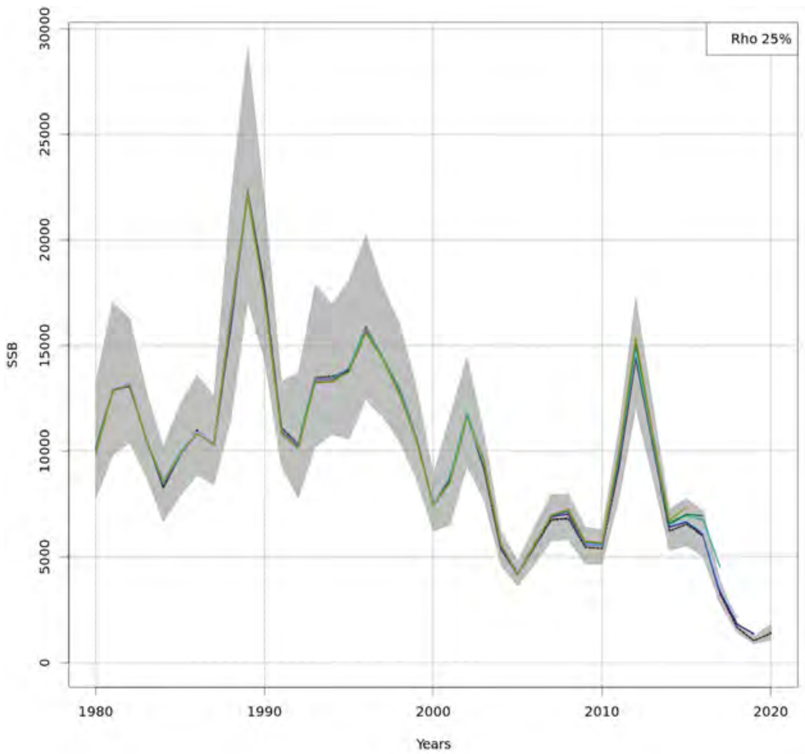


Figure 6.11. Cod in divisions 7e–k. Final SAM outputs. SSB, F, R and catches estimates.


Rho -19%
F_{2-5}
0.0
0.5
1.0
1.5
1980
1990
2000
2010
2020
Years


Rho 25%
SSB
0
5000
10000
15000
20000
25000
30000
1980
1990
2000
2010
2020
Years

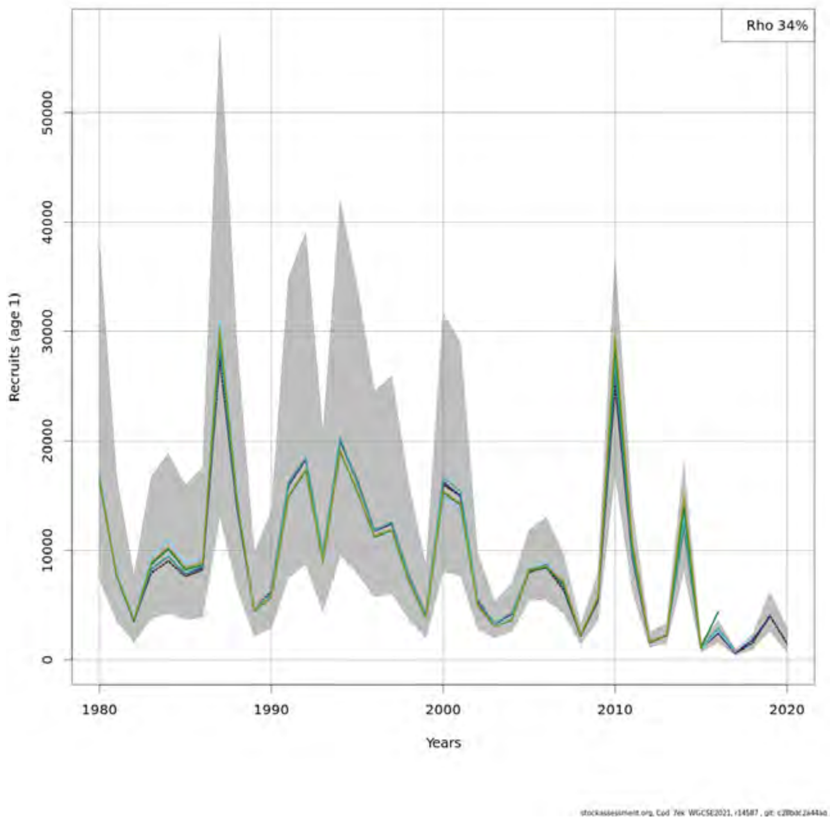
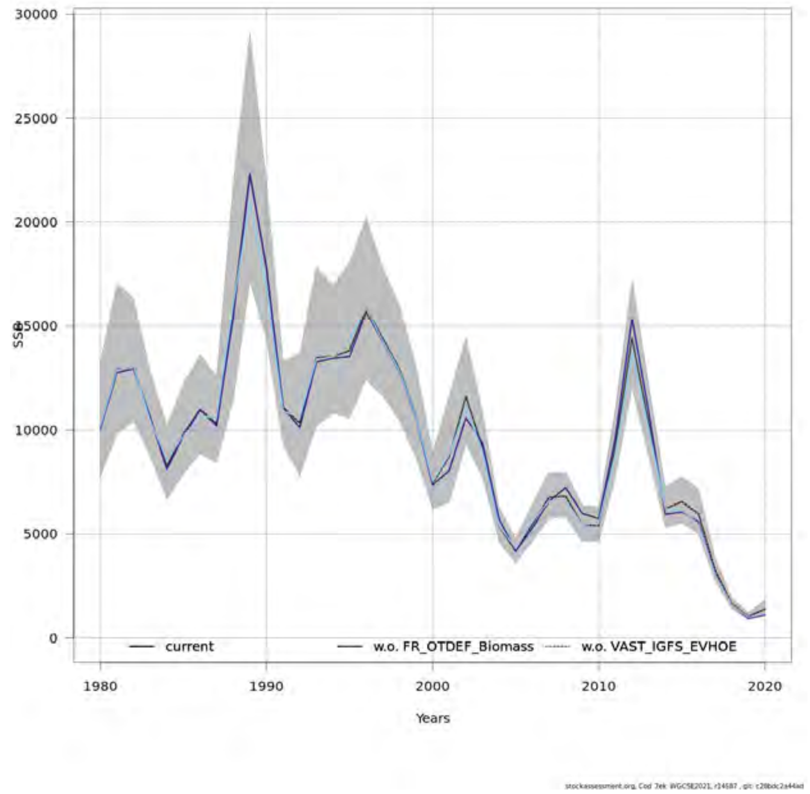


Figure 6.12a. Cod in divisions 7e–k. Final SAM. Retrospective plots.



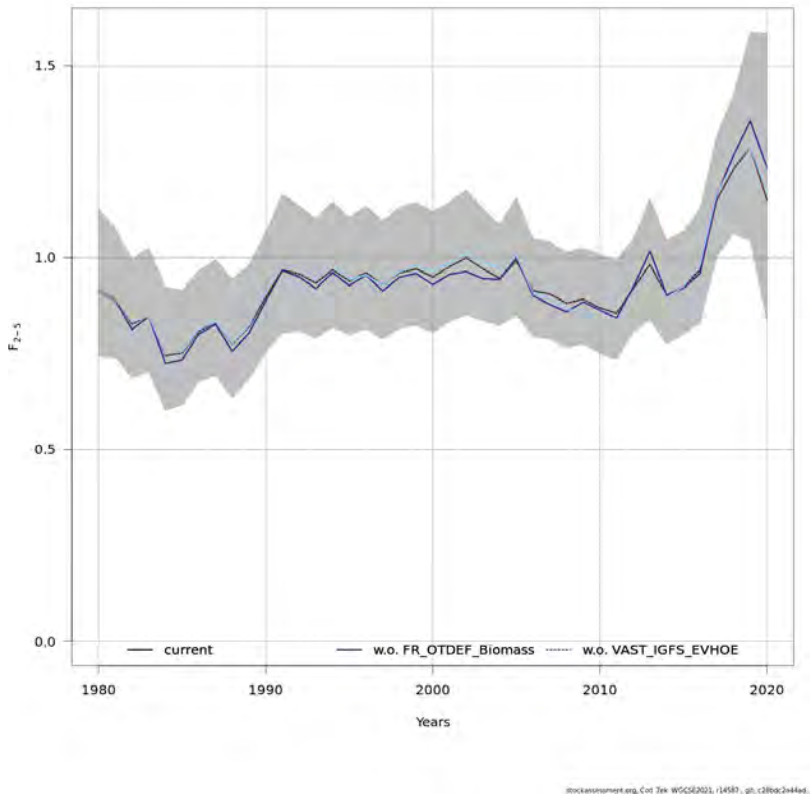


Figure 6.12b. Cod in divisions 7e–k. Final SAM. Comparison between runs (runs with the two tuning indices, with only the survey index and with only the commercial tuning index).

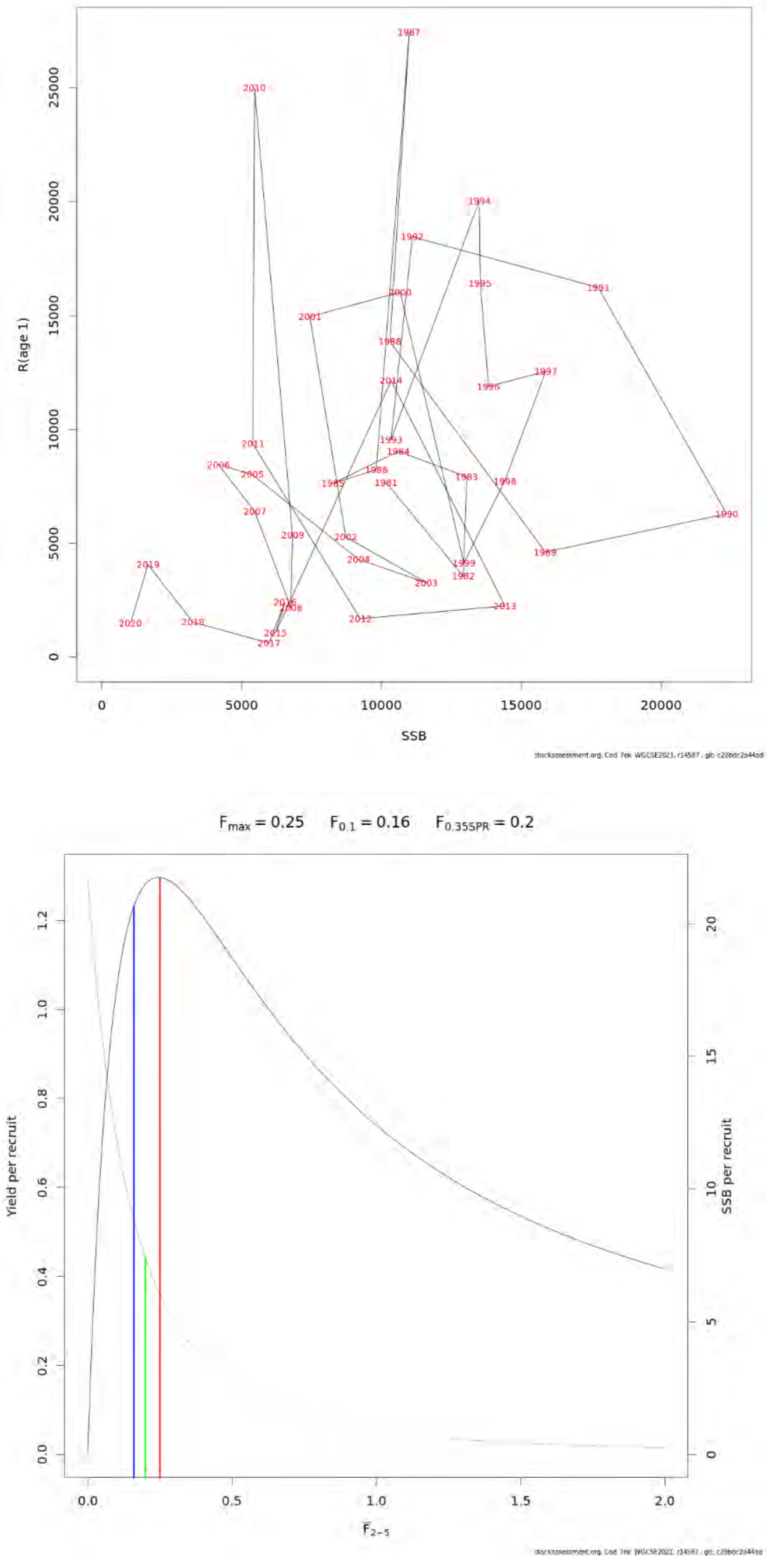


Figure 6.13. Cod in divisions 7e–k. Stock–recruitment plots and yield per recruit information.

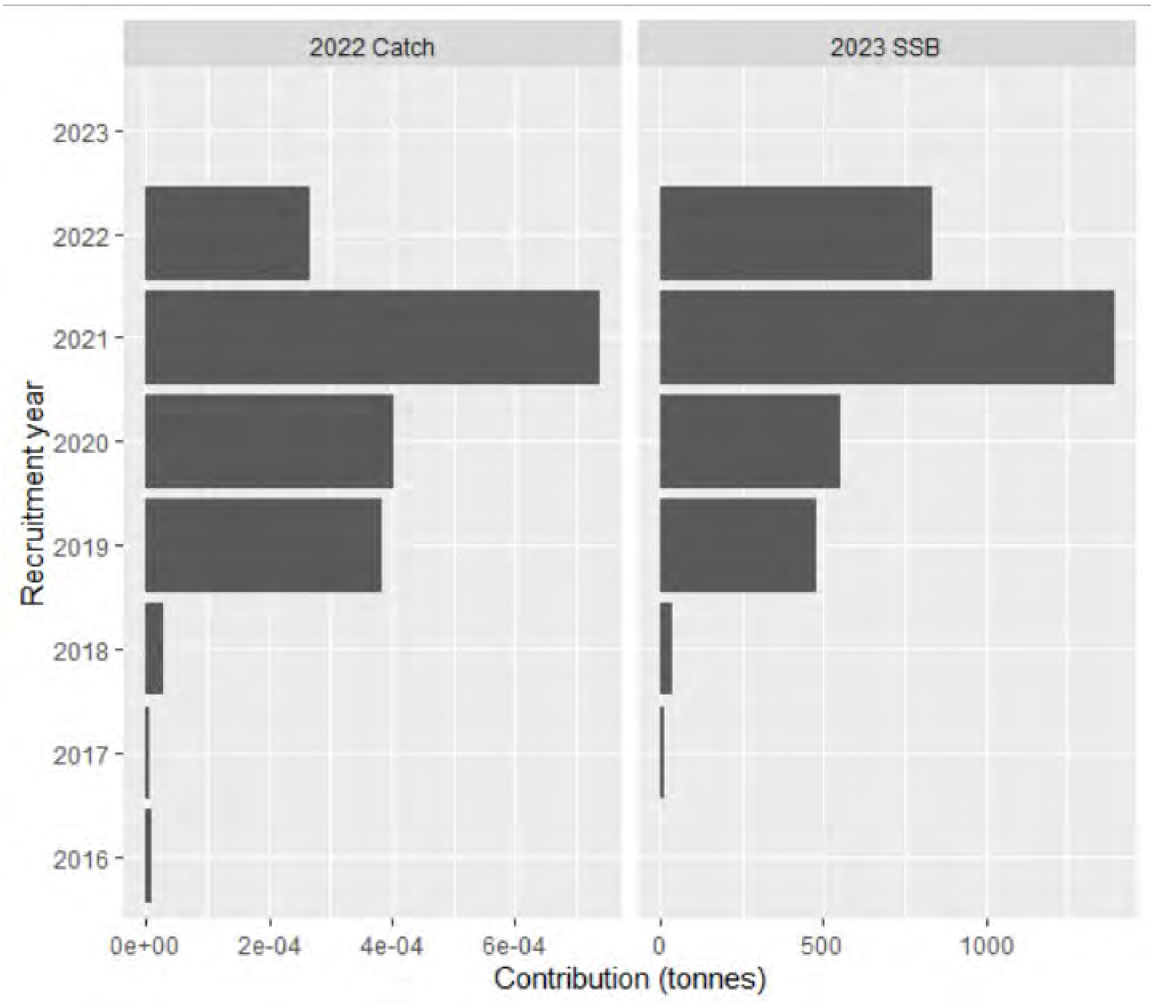


Figure 6.14. Cod in divisions 7e–k. Forecast (a) yield in 2022 and (b) SSB in 2023.

7 Haddock in Division 6.b (Rockall)

Type of assessment in 2021: Update assessment

The current assessment is an update of last year's assessment taking into account the recommendations of the benchmark conducted in 2019. The same approach has been used in the annual assessment since 2005 when on the recommendation of RGNSDS, adopted a new assessment approach, which allows modelling of the total catch (including discards) when no on-board observations were available (for details see the Stock Annex).

ICES advice applicable to 2021

ICES advice applicable to 2021 can be found here:

http://ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/had.27.6b.pdf

7.1 General

Stock description and management units

The haddock stock at Rockall is an entirely separate stock from that inhabiting the continental shelf of the British Isles. Since 2004, the EU TAC for haddock in 6.b has been included with divisions 12 and 14. For details of the earlier management units see the Stock Annex.

Management applicable to 2020 and 2021

The EU TAC for 6.b, 12 and 14 was set at 10 472 t in 2020.

Species:	Haddock *Melanogrammus aeglefinus*	**Zone:**	Union and international waters of 6b, 12 and 14 (HAD/6B1214)
Belgium	23	Analytical TAC	
Germany	28	Article 7(2) of this Regulation applies	
France	1 155		
Ireland	824		
United Kingdom	8 442		
Union	10 472		
TAC	10 472		

Agreed TAC for 2021 was not available.

The ICES advice, agreed TAC for EU waters, and WG estimates of landings during 2002–2020 are summarised below. All values are in tonnes.

YEAR	Predicted catch corresp. to advice	Predicted landings corresp. to advice#	BASIS	AGREED TAC [a]	WG LANDINGS
2002	< 1300		Reduce F below 0.2		3336
2003	-		Lowest possible F		6242
2004	-		Lowest possible F [b]	0702	6445
2005	-		Lowest possible F [b]	0702	5179
2006	-		Lowest possible F [b]	0597	2765
2007	< 7100		Reduce F below F_{PA} [b]	4615	3349
2008	< 10640		Keep F below F_{PA} [b]	6916	4221
2009		< 4300	No long-term gains in increasing F [b]	5879	3445
2010		< 3300	Little gain on the long-term yield by increasing F [b]	4997	3405
2011		<2700	Reduction in F is needed to keep SSB to above B_{PA} in 2012	3748	1903
2012		< 3300	MSY approach	3300	0710
2013	0	0	No directed fisheries, minimize bycatch and discards	0990	0826
2014	<1620	<0980	MSY approch	1210	1675
2015	<4310	<2930	MSY approch	2580	2445
2016	< 3932	< 3225	MSY approach	3225	2585
2017	≤ 4690	≤ 4130	MSY approach	4690	4610
2018	≤ 5163		MSY approach	5163	3868
2019	≤10469		MSY approach	10469	7786
2020	≤10472		MSY approach	10472	5212
2021	<6239		MSY approach	[c]	

[a] Prior to 2014, the TAC was set for divisions 6.a and 6.b (plus 5.b, 12 and 14) combined with restrictions on quantity that can be taken in 5.b and 6.a. The quantity shown here is the total area TAC minus the maximum amount which is allowed to be taken from 5.b and 6.a. In 2004, the EU TAC for Division 6 was split and the 6.b TAC for haddock was included with 12 and 14. This value is the TAC for 6.b, 12 and 14.

[b] Single-stock boundary and the exploitation of this stock should be conducted in the context of mixed fisheries, protecting stocks outside safe biological limits.

[C] Agreed TAC was not available.

The minimum landing size of haddock taken by EU vessels at Rockall is 30 cm. There is no minimum landing size for haddock taken by non-EU vessels within international waters.

In order to protect the pre-recruit stock, the International Waters component of the statistical rectangle 42D5 has been closed for fishing since 2001 and its EU component since 2002 (see the Stock Annex, Section A.3). The protected area (the whole rectangle) is referred to as Rockall Haddock Box. In order to protect cold-water corals, three further areas (North West Rockall, Logachev Mounds and West Rockall Mounds) were closed since January 2007 (see the Stock Annex, Section A.3). A new area to protect cold-water corals (Empress of British Banks) was established by the NEAFC in 2007 and 2012.

Since 2009 in NEAFC regulatory area, including international waters of Rockall, a discard ban was established.

Fishery in 2020

Russian fishery in 2020

The Russian haddock catch in Rockall declined from 5844 t in 2004 to 245 t in 2019. In 2019 The total haddock catch obtained by the Russian fleet at Rockall in 2020 amounted to 133 t. Other demersal fish species were caught in small numbers as bycatch.

Scottish fishery in 2020

Total Scottish haddock landings in 6b increased from 3418 t in 2018 to 6542 t in 2019. In 2020, the catch decreased to 4573 t (Table 4.3.1). Other important target species included anglerfish (*Lophius* spp.), ling, saithe and megrim. Scottish historical effort presented in Tables 4.3.2 and 4.3.3.

Irish fishery in 2020

Irish effort in Rockall declined during 2009–2015 and increased again since 2016. (Table 4.3.3).

Landings totalling 679 t haddock were reported from Irish otter trawlers in 2019 (decreased from 888 t in 2019; Table 4.3.1). Irish vessels used single otter trawls with a mesh size ranging from 100 to 120 mm together with a square mesh panel.

Norwegian fishery in 2020

Norwegian landings of haddock at Rockall have been relatively low over time. Total Norwegian landings of 13 t were reported in 2019 and 14 t in 2020, the lowest for the Norwegian time-series. Norwegian demersal fleet fishing on the Rockall Bank consisted mainly of longliners targeting mainly ling and tusk.

7.2 Data

Landings

Nominal landings as reported to ICES are given in Table 4.3.1, along with Working Group estimates of total estimated landings. Revisions to official catch statistics for previous years are also shown in Table 4.3.1.

Anecdotal evidence suggests that misreporting of haddock from Rockall has occurred historically (which may have led to discrepancies in assessment), but a quantitative estimation of the degree of misreporting is not possible.

International age composition and mean weight-at-age in the landings were compiled according to the methods described in the Stock Annex.

BMS landings

In 2016, Below Minimum Size (BMS) landings (subject EU landings obligation) were negligable at 0.4 t. In 2017 and 2018 BMS landings were not reflected in the catch statistic. 4 t of BMS landings were reported in 2019 and 2 t in 2020. The assessment includes BMS landings within total landings.

Discards

Haddock at Rockall have lower size-at-age than haddock from other areas (Blacker, 1971; Khlivnoy, 2006; Filina, Khlivnoy and Vinnichenko, 2009). This leads to discarding of smaller haddock. Historically, the discard rate was as high between 12 and 75% by weight according to the results of discards trips (see the Stock Annex). The methods used to reconstruct the historical time-series of discards is described in the Stock Annex.

For the 2017 assessment, discard numbers from 2010–2016 were estimated from sampling aboard Scottish and Irish vessels (Tables 4.3.4–4.3.6). The Russian fleets retain total catches onboard therefore; there is no need to calculate discards as per the Scottish and Irish fleets. In 2015, the discard rate was estimated at 38% and 52% by numbers on Scottish and Irish observer trips. In 2016, the level of discards has not changed significantly and was estimate at 11% and 56% by numbers on Scottish and Irish observer trips.

In 2017, the discard rate was also high and was estimated at 17% by numbers on Scottish and 39% on Irish observer trips. In 2018, discard rate was estimated at 32% by numbers on Scottish and 50% on Irish fleet. In 2020, discard rate decreased to 6% by Scottish information the lowest for the time-series (Tables 4.3.4–4.3.7). The number of samples for discards remain low. This leads to uncertainty in the discards assessment. Irish discards trips in 2020 showed high level of discards. That data are not sufficient to submit in assessment (Tables 4.3.5a). In 2020, night rate of discards was observed on Spanish fishery at Rockall. Assessment of discards in 2020 was done only on the basis of Scottish samples.

Biological

There was no change in biological parameters compared to the 2020 assessment (see the Stock Annex).

Surveys

The Scottish Rock-IBTS-Q3 survey is the only abundance index available for this stock (Figures 4.3.1–4.3.3). The survey is co-ordinated by IBTS and described further in the IBTS reports and Stock Annex.

The survey coverage has been extended in recent years (Figure 4.3.1). The 2020 indices were obtained from the same survey area as the previous year. During the benchmark in 2019, the number of different runs were conducted to explore the sensitivity of the assessment results and diagnostics to different survey indices. The correction to the survey data has little impact on the results of the stock assessment (Figure 3). In terms of diagnostics (Figures 4 and 5), the fit to the 2015 survey data at age 5 shows significant improvement in Run S1 compared to the baseline: in the baseline model run there is a large positive residual which is no longer apparent. The benchmark agreed that based on the model diagnostics, the 'standard' survey index with corrected ALK for ages 4–5 in 2015 should continue to be used in the assessment (Table 4.3.8).

Additional abundance and biomass estimates are calculated by the swept area method using three types of stratification of the survey area:

1. by geographic strata of 15' latitude wide and 15' longitude long (Figure 4.3.4);
2. by five bathymetric strata depending on depth: <150 m, 150–175 m, 176–200 m, 201–225 m and >225 m (Figure 4.3.5);

3. the whole survey area is taken for one strata without substratification (Figure 4.3.6).

All three methods show similar patterns (Figures 4.3.4–4.3.6).

In 2011, gear was changed on the Scottish survey and an analysis showed that there was no detectable difference on indices between the pre-2011 surveys and more recent surveys (IBTSWG 2012).

The Russian acoustic survey conducted in 2005, provided information on the size and biomass of the haddock stock both in the EU zone and in international waters. The acoustic survey yielded a biomass estimate of 60 000 t and an abundance estimate of 225.9 million (for details, see the Stock Annex). No such survey has been conducted in subsequent years.

Commercial Effort, Lpue and Cpue

Commercial effort series are available for Scottish trawlers, light trawlers, seiners, Irish otter trawlers and Russian trawlers fishing in Division 6.b. The effort data for these fleets are shown in Figure 4.3.7 and Tables 4.3.2–4.3.3. The Scottish fleet provided effort by hours from 1985 to 2008 (Table 4.3.2), from 2003 effort data were provided by Kwdays. (Table 4.3.3). Effort by the Scottish and Irish fleets has been relatively stable at a low level for the last three years.

Commercial Lpue for the Irish and Scottish fleets and cpue for the Russian fleet are shown in Figures 4.3.8–4.3.9. The WG decided that the commercial cpue and lpue data, which do not include discards, and have not been corrected for changes in fishing power despite known changes in vessel size, engine power, fish-finding technology and net design, were unsuitable for catch-at-age tuning.

7.3 Description of stock assessment approach

Model used:

The assessment is based on catch-at-age data and one survey index (Scottish Rock-IBTS-Q3) and conducted using the XSA method.

Software used:

The 2019 benchmark recommended that FLXSA software be used for the 2019 assessment as opposed to the previous software (XSA from Lowestoft suite of VPA programs) used from 2005 to 2018.

Model Options chosen:

Settings for the final XSA assessment did not change compared to the previous assessment (see the Stock Annex) and were as follows:

Assessment model: XSA

Tuning indices: one survey index (Scottish Rock-IBTS-Q3)

Time-series weights: none

Catchability dependent for ages <4

Regression type: C

Minimum number of points used for regression: 10

Q plateau: 5

Shrinkage stand. error: 1.0

Shrinkage age, year: 4 years, 3 ages

Minimum stand. error: 0.3

Plus group: 7+

F_{BAR}: 2–5

Input data types and characteristics:

There were no changes in data types and characteristics compared to the previous assessment:

Year range: 1991–2020

Age range: 1–7+

For tuning data, the following year and age ranges were used:

Year range: 1991–200

Age range: 1–6

Data screening

Figures 4.3.10 and 4.3.11 plus Table 4.3.9, show landings, discards and total catch by number and weight. Landings, discards and total catch-at-age by number are shown in Tables 4.3.10–4.3.12.

BMS landings of 4 t of haddock at Rockall were reported in 2019 and were included in the total landings. As the BMS landings were negligible, no negative affect was seen in the average weight of landings.

From 2012, the catch-at-age data were estimated by InterCatch, as it was recommended by a benchmark 2019. The two main fleets (UK(Scotland OTB_DEF_>=120 and Irish OTB_DEF_100–119) are t sampled for both landings and discards. Discard rate allocation to other unsampled fleets consisted of:

> Manually matching annual discards to available quarterly landings by country/fleet (where necessary);
>
> Using a weighted average discard rate for all unsampled fleets (weighted by CATON) with the exception of the Norwegian longline fleet and the Russian fleet for which discards are both assumed to be zero.

Landings age compositions were allocated to unsampled fleets using a weighted average of all sampled fleets (excluding the Russian fleet which retain all landings on board). The weighting algorithm used is 'Mean weight weighted by numbers-at-age or length'. Discards age compositions were allocated in a similar manner.

In 2019, a benchmark assessment was conducted on this stock. During the benchmark meeting, the discards data for 2010 were revised. The discards were calculated on average discards proportion of total catch but prior to the 2019 benchmark, the discards only for 2010 were calculated on that proportion applied to the landings (not total catch). The benchmark concluded that the previous method applied for 2010 was incorrect, as discards proportion is relative the total catch. Since 2019 in correct assessment, the discards for 2010 were calculated based on the discards numbers in 2009 at-age recalculated using the ratio between total landings in 2009 and 2010 (by numbers).

The resulting age compositions and mean weights-at-age show only minor differences to those compiled at previous assessment WG meetings (Figure 4.3.12).

Mean weights-at-age in total catch, landings, discards and stock are shown in Tables 4.3.13–4.3.16 and Figures 4.3.13-4.3.16.

Historically, stock weights-at-age have been assumed to be equal to the raw catch weights. In recent years, the number of sampled trips for both landings and discards has been low. This led to higher variability in the mean weight-at-age estimates. For this reason, the smoothed catch weights-at-age was applied by the WGCSE in recent years.

To mitigate against variability in the mean weight-at-age mean weights are assumed as five-year averages as per recommendations from the 2019 benchmark.

The mean weights-at-age in the total catch (including discards) are shown in Figure 4.3.14.

There were small landings of aged 1 haddock from 2010–2012 and very few aged 2–6 compared to historical values. Haddock aged 7 dominated landings. However, in 2013 both landings and discards of aged 1haddock significant increased. Discarded fish are, primarily ages 1 and2 (see Tables 4.3.1 and 4.3.2 in the Stock Annex). Figures of log catches by age show that these values are much less variable when discards are included (Figures 4.3.15–4.3.20). Data on catches, landings and discards-at-age are given in Tables 4.3.10–4.3.13.

The Scottish Rock-IBTS-Q3 was the only survey index available to the working group. Plots of log cpue by age, year and year class are shown in Figures 4.3.21–4.3.24.

Comparative scatterplots of log index at-age are shown in Figure 4.3.24. The survey shows relatively good internal consistency in tracking year-class strength through time.

Final update assessment

Final run

Settings for the final XSA assessment are shown in Section C of the Stock Annex. There have been no changes to assessment settings since 2013.

The diagnostics file of the final XSA run is given in Table 4.3.17 and Figure 4.3.25. Adjusted survey cpue against XSA population estimates are shown in Figures 4.3.26, 4.3.26. The analysis of residuals and retrospective analysis (Figures 4.3.25, 4.3.28) show that applying the chosen parameters for XSA (as in the Stock Annex) improves the residual patterns compared to other exploratory settings. However, the same trends are still apparent in the log catchability residuals. The results of the retrospective analysis conducted by the Working Group in 2002, 2003 and 2005 indicated that using shrinkage values of more than 0.5 improved the retrospective curves and showed convergence. In this year's analysis, only 30 years of data were available for the retrospective analysis (1991–2020), but a rrelatively good year-to-year consistency was obtained. The final XSA results are given in Tables 4.3.18–4.3.20.

Summary plots from the final XSA assessment are shown in Figure 4.3.29.

Comparison with previous assessments

The estimates from this year's assessment are reasonably consistent with the assessments carried out in previous years (Figure 4.3.30). In 2019, a benchmark assessment was conducted on this stock (ICES, 2019b). The new assessment resulted in the SSB being revised downwards by 33% in 2018 and by 12% in 2019 compared to last year's assessment. At the same time F for 2018 increased by 33%.

In addition, during the benchmark 2019 fishing mortality for 2010 was revised upward. Due to the revision of discard data for 2010. As a result, total catch was estimated close to 2009. The decline of SSB in 2010 with the same the catch gave increase F.

State of the stock

The stock summary relative to reference points is plotted in Figure 4.3.29.

The spawning–stock biomass (SSB) has increased from the lowest observed in 2014 and is estimated to be above MSY $B_{trigger}$ in 2016. Fishing mortality (F) has declined over time and is close by F_{MSY} in 2019. Recruitment during 2008–2012 is estimated to be extremely weak. Recruitment improved from 2013–2014, decreased again in 2015–2016, increased in 2017 and is still lower than the values estimated at the beginning of the time-series. The 2020 year class estimated from results of a survey showed high recruitment.

Additional indicators of state stock

The trawl survey-based assessment, Russian trawl-acoustic survey and the statistical catch-at-age analysis (StatCam analytical model) and state–space assessment model (SAM) were used as additional indicators for stock status.

Statistical catch-at-age analysis (SCAA)

For Statistical catch-at-age analysis, StatCam model was used (J. Brodziak, 2005). VPA and SCAA used identical survey and catch data. For StatCam runs, two scenarios were used: The first;non-parametric model, second; parametric model.

The StatCam model shows good conformity between observed and predicted survey index and catch biomass (Figures 4.3.31).

StatCam summary plots are shown in Figure 4.3.32.

Both Statistical catch-at-age analysis and VPA results show a similar tendency for the SSB dynamics. However, the assessment of the stock size depends on the choice of the model.

Results of stock assessment by SAM model (state–space assessment model)

The same input data were used for both runs of SAM and the VPA. The summary plots for SAM assessment are shown in Figure 4.3.33.

The SAM assessment and VPA results show a similar tendency in stock status. However, in recent years, the SSB assessed by SAM increased slowly compared to the VPA assessment.

The comparison of stock assessment results produced by different models

All that models results and trawl survey-based assessment show a similar tendency for SSB dynamics. However, there are variations in the interannual dynamics of the stock assessed by different models.

The SSB and TSB plots from the XSA, SCAA and SAM assessment are compared in Figure 4.3.34.

7.4 Short-term projections

Estimating year-class abundance

From 2007–2011, the abundance of age 0 individuals from the survey index were estimated to be extremely weak. Large levels of 0 age group were observed in 2012. Year classes (0 age groups) 2013 and 2014 were below average, but above levels 2008–2012 (Figure 4.3.35). No significant relationship between spawning biomass and recruitment was found. Poor year classes may be related to environmental factors including rising seawater temperatures in Rockall Bank, a reduction in zooplankton abundance (ephausiids and *Calanus finmarhicus*) and the negative impact of predation on eggs, larvae and food competition from the grey gurnard (Filina, Khlivnoy and Vinnichenko, 2009; Khlivnoy and Sentiabov, 2009). The 0 age group was overestimated in 2012 from survey data. This resulted in an uncertainty in the assessment as more than 70% of 0-group fish were caught during a single haul (Figure 4.3.2). From 2007–2016 the recruitment (age 1) assessed by VPA was below average for full the time-series 1991–2016 (Table 4.3.20).

In 2016 and 2017, a strong 0-group was observed. However, a considerable number of 0-group fish were caught during a single haul (Figure 4.3.2). This increased the uncertainty of forecasting recruitment as seen in 2012. The 0-group have decreased again in 2018–2019. The 2020 year class estimated from results of a survey showed high recruitment.

VPA abundance for age 1 has been highly correlated with age 0 indices from 1993–2015 (r^2=0.75), but from 2016–2019 this correlation declined (Figure 4.3.36). The recruitment (age 1) from 2013 was therefore estimated using RCT3 regression (Shepherd, 1997) relating survey indices to stock abundance. The recruitment in 2021 was estimated at 50 739 thousand.

For forecasting recruitment (age 1) in 2022 and thereafter, the WG recommended the same procedure as last year using the 25th percentile over the whole time-series.

Many definitions of how to compute the percentile are shown in literature (Thurstone L. L., 1922). The WG chose the simple rounding to the nearest integer and taking the value that corresponded to that rank of percentile. The rank of percentile was determined by the following equation:

$$n = \frac{P}{100} * N + \frac{1}{2}$$

P being the percentile value (P=28), and N the length of the time-series (N=27). The rank of 25th percentile for the recruitment was 8. The 7th lowest value of the time-series corresponds to a value number of 13 832 thousand in 2015.

The input data for the short-term forecast can be found in Table 4.3.21.

Catch

The assumed catch in 2021 of 6999 t is estimated based on three-year average of F.

Results of forecast of catch are shown in Tables 4.3.21–4.3.23.

Mean Weights and F pattern

In recent years, the number of sampled trips for both landings and discards has been low. This leads to higher variability in. Since 2015, to mitigate against this in the forecast, five-year averages for weight were used in the catch options (before three year mean values were used). Averages from the three last years of exploitation patterns and weight-at-age were used. Three last years' average is more appropriate compare to five-year average of exploitation patterns (Figure 4.3.37).

Partitioning of catch into landings and discards

An uncertainty in the assessment and forecast relates to discard estimates. The number of sampled discard trips over the last few years has been low. Since the discard ratio-at-age varies considerably from year to year a ten-year average discard proportion (2011–2020) was used for forecasting discards over the short term (Tables 4.3.7–4.3.10 and Figure 4.3.38).

STF results

Results obtained from the forecast are given in Tables 4.3.21–4.3.23.

Stock numbers of recruits and their source for recent year classes used in the predictions and the relative (%) contributions to landings and SSB (by weight) of these year classes are shown in Table 4.3.24.

The forecasted catch for 2022 is 6.6% lower than the 2021 advice, due to a decline in stock size compared to the previous assessment combined with a recent change in age composition of stock and the estimated fishery selectivity pattern, particularly in fish at older ages.

7.5 MSY evaluations and Biological reference points

ICES carried out an evaluation of MSY and PA reference points for this stock in 2019 WKROCK-MSE (ICES, 2019). The results are summarized below:

Frame-work	Reference point	Value	Technical basis	Source
MSY approach	MSY Btrigger	3712 tonnes	Bpa	ICES (2019)
	FMSY	0.168	Segmented regression with Bloss, the lowest observed spawning–stock biomass (EqSim).	ICES (2019)
Precautionary approach	Blim	2474 tonnes	Blim = Bloss, the lowest observed spawning–stock estimated in previous assessments.	ICES (2019)
	Bpa	3712 tonnes	Bpa = Blim × 1.4. This is considered to be the minimum SSB required to obtain a high probability (95%) of maintaining SSB above Blim	ICES (2019)
	Flim	1.06	Based on a 50% probability of being above Blim in a stochastic simulation with a segmented regression using breakpoint at Blim.	ICES (2019)
	Fpa	0.710	Fpa = Flim/1.5	ICES (2019)
Management plan	SSBmgt	3712 tonnes	Bpa	ICES (2019)
	Fmgt	0.168	Based on harvest control rule evaluations.	ICES (2019)
Management plan*	MAP MSY Btrigger	3712 tonnes	MSY Btrigger	
	MAP Blim	2474 tonnes	Blim	
	MAP FMSY	0.168	FMSY	
	MAP range Flower	0.105	Consistent with ranges provided by ICES (2016a), resulting in no more than 5% reduction in long-term yield compared with MSY.	ICES (2019)
	MAP range Fupper	0.27	Consistent with ranges provided by ICES (2016a), resulting in no more than 5% reduction in long-term yield compared with MSY.	ICES (2019)

7.6 Management plans

In 2011 and 2012 in accordance with the conclusions of the 2010–2011, Annual Meeting of the NEAFC, a delegation from the RF and EU considered a management plan. In light of ICES suggestions, the necessary adjustments required to draft a plan were considered. The revised proposal for a harvest control component of a long-term management plan for haddock at Rockall was forwarded to NEAFC for approval at the 2012 Annual Meeting. ICES was requested to evaluate the EU-Russia proposal for the harvest control component of the management plan for

Rockall haddock and to evaluate the proposal of protection of juvenile Rockall haddock. The management plan states total catch should not exceed the established TAC and includes measures to record and minimise discards.

ICES evaluated a new HCR proposal for Rockall haddock between RF and EU nations in August 2013 (ICES, 2013) and found that a maximum F of 0.2 was required in the HCR to ensure consistency with the precautionary approach, under the low recruitment conditions observed since 2004.

The NEAFC regulatory area (RA) established a ban on discards. Measures to reduce discards for the stock distribution area were required. The remainder of the management plan for this species is considered to be suitable and has been agreed by the Contracting Parties (NEAFC, 2015).

In 2017, NEAFC requested ICES to evaluate the harvest control component and to consider whether the plan is consistent with the precautionary approach required to provide sustainable harvesting of the stock.

In 2019, ICES evaluated the harvest control rules (HCRs) proposed for Rockall haddock and advised that they are considered precautionary in the short, medium, and long term under the assumption of intermediate levels of productivity.

The HCRs with TAC constraint rule (a) in the request are precautionary in the long term under all scenarios, except those with very low recruitment. If recruitment is low (as observed between 2007 and 2012) over a long time frame, without sporadic recruitment peaks, none of the HCRs are precautionary in the long term. TAC constraint rule (a) generally leads to lower probability of SSB < B_{lim} than the constraint rule (b), both in the short and long term.

7.7 Uncertainties and bias in assessment and forecast

The WG considers that the long-term trends in the XSA assessment and survey biomass estimates/indices are indicative of the general stock trends. The assessment has become uncertain in recent years as catch and sampling levels have declined to low levels. To mitigate against the three-year averages of exploitation patterns and five-year average catch weights and ten year mean discard proportions were used in the catch options for forecast.

7.8 Recommendation for next benchmark

In recent years, WGCSE have highlighted an increasing number of issues to be addressed when this stock is benchmarked.

1. The WG considers that a longer series of more accurate landings, discards (for non-Russian fleets) and survey data will be necessary to overcome these deficiencies.
2. There are concerns over the accuracy of landings statistics from Rockall in 90 years XX century.
3. Comparison of methods is required to test which discard rate is advisable.
4. In 1999 and 2011, the gear and tow duration were changed on the Scottish survey. Analysis showed that there was no detectable difference between the older and 2011 survey on haddock indices in neighbouring areas. There was no analysis of changes on the Scottish survey in 2009. Analysis of the impact of this on the stock assessment is needed.
5. The XSA assessment shows trends in catchability, even if reduced by weak shrinkage. Diagnostics give quite large standard errors on survivors' estimates (0.3–0.4) and there are often quite different values given by Scottish Rock-IBTS-Q3, F-shrinkage and P-shrinkage. During the 2019 benchmark, progress was made, however, further investigations are required.

6. The survey covers only part of the known distribution area and causes uncertainty in the assessment, therefore additional survey indices are required from the entire area of Rockall.
7. The relationship between the survey assessed 0-group and the recruitment-at-age 1 computed by VPA is required for the short-term forecast.
8. Quality control and standardisation between international age readers is required.

7.9 Management considerations

The new F_{MSY} estimate is consistent with the F in the management plan previously evaluated by ICES in 2013 (ICES, 2013). The stock appears to be recovering after a period of low recruitment, however recruitment is still unstable expansion of the fishery at Rockall should be avoided.

Haddock in 6b was not included under the EU landings obligation (EC, 2015). However, the discard rate remains at a high level. Since 2017 the basis for ICES advice was changed from landings advice to catch advice as a result this can result in excess of the TAC due to high discards rate. It would be beneficial to develop and introduce measures aimed at preventing discards of haddock into fisheries practice. Elaboration of such measures complies with recommendations under the UNGA Resolution 61/105 that urges states to take action to reduce or eliminate fish discards (UNGA Resolution 61/105, 2007, Chapter VIII, item 60).

7.10 References

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Table 4.3.1. Nominal catch (tonnes) of haddock in Division 6.b, 2000–2020, as officially reported to ICES.

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020[1]
Faroe Is-	n/a	n/a	-	-	-	-	2	2	16	-	42	2	53	-	<1	<1	-	-	-	-	-
France	5	2	-	1	-	-	-	-	-	-	-	<1	-	-	<1	-	-	-	-	8	2
Iceland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	824	357	206	169	19	105	41	338	721	352	169	123	31	105	94	190	362	500	433	888	679
Norway	152	70	49	60	32	33	123	84	36	71	65	40	48	121	41	66	63	26	16	13	14
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Russian Federation	2,154	630	1,630	4,237	5,844	4,708	2,154	1,282	1669	55	198	-	1	4	388	136	-	153	-	245	133
Spain	47	51	7	19	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E, W & NI)	36	-	-	56	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (Scotland)	2,470	1,205	1,145[3]	1,607	411[3]	332[3]	440[3]	1,643[3]	1,779[3]	2,951[3]	2,931[3]	1,738[3]	577[3]	596[3]	1,152[3]	2,052[3]	2,160[3]	3,930[3]	3,418	6,531	4,573
Total	5,688	2,315	3,037	6,148	6,306	5,178	2,765	3,349	4,221	3,429	3,405	1,903	710	826	1,675	2,445	2,585	4,610	3,868	7,685	5,401[6]
Unallocated catch	-357	-279	299	94	139	1	0	0	0	-192	0	0	0	0	0	0	0	0	0	93	102[6]
WG esti-	5,331	2,036	3,336	6.242	6,445	5,179	2,765	3,349	4,221	3,237	3,405	1,903	710	826	1,675	2,445	2,585	4,610	3,868	7,782	5,512[5]

[1]Preliminary.

[2]Included in Division 6.a.

[3]Includes Scotland, England, Wales and NI landings

[4]Includes the total Russian catch.

[5]Including BMS catch.

[6]without BMS landings

n/a = not available.

Table 4.3.2. Details of Scottish and Irish effort (in hours) from 1985–2015 (preliminary data, no data since 2016).

Year	Scottish fleet			Irish fleet
	SCOTRL*	SCOLTR*	SCOSEI*	IROTB*
1985	8421	3081	1677	-
1986	7465	4783	507	-
1987	8786	9737	402	-
1988	12450	5521	261	-
1989	10161	11946	1411	-
1990	3249	5335	4552	-
1991	2995	11464	6733	-
1992	2402	9623	3948	-
1993	1632	11540	1756	-
1994	2305	15543	399	-
1995	1789	13517	1383	9142
1996	1627	17324	952	7219
1997	563	16096	1061	7169
1998	1332	12263	456	7461
1999	11336	9424	456	8680
2000	12951	8586	80	9883
2001	7838	1037	42	7244
2002	8304	1100	0	2626
2003	15000	500	50	4618
2004	15200	300	50	2070
2005	7788	32	0	2693
2006	9990	231	0	5903
2007	4534	319	44	6589
2008	2497	1016	82	9740
2009	NA	NA	NA	4354
2010	NA	NA	NA	3280
2011	NA	NA	NA	2495
2012	NA	NA	NA	3291
2013	NA	NA	NA	2947
2014	NA	NA	NA	3159
2015	NA	NA	NA	3053
2016	NA	NA	NA	NA
2017	NA	NA	NA	NA
2018	NA	NA	NA	NA

SCOTRL* – Scottish Heavy Trawl, SCOLTR* – Scottish Light Trawl, SCOSEI* – Scottish Seine, IROTB* – Irish bottom otter trawl.

Table 4.3.3. Effort from the Scottish TR1 fleet and Irish otter-trawl fleet at Rockall (see the Section 4 Cod 6.b).

year	Scottish TR1 fleet effort(kwdays)	Irish otter-trawl fleet Effort '000s Hrs
2003	2504466	4.542
2004	1842103	2.233
2005	1217357	3.283
2006	1011354	5.9
2007	1060551	6.587
2008	1124197	9.898
2009	1631239	4.353
2010	1744452	3.28
2011	1565753	2.534
2012	901552	3.248
2013	532767	3.809
2014	668665	4.2
2015	563098	4.7
2016	514486	6.2
2017	794571	14.9
2018	NA	NA
2019	NA	NA

Table 4.3.4. Discards and retained catches of haddock (number per trip) by Irish discard trips in the Rockall area from 2007–2009 and 2011–2012.

Year	2007		2008		2009		2011		2012	
Length (cm)	Discards	Re-tained Catch	Discards	Re-tained Catch	Discards	Re-tained Catch	Discards	Re-tained Catch	Discards	Re-tained Catch
10	-	-	-	-	-	-	-	-	1	-
11	-	-	-	-	-	-	-	-	1	-
12	-	-	-	-	-	-	-	-	1	-
13	-	-	-	-	-	-	-	-	1	-
14	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-
19	1.3	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-
22	1.6	-	14.8	-	-	-	-	-	-	-
23	4.6	-	66.2	-	-	-	13.1	-	-	-
24	7.3	-	183.8	-	-	-	98.9	5.7	-	-
25	22.7	-	576.9	-	15.6	-	53.9	5.7	-	-
26	54.2	-	1424.9	-	30.4	-	75.3	11.4	-	-
27	104.6	-	3024.6	-	25.2	-	121.3	34.3	2	-
28	256.9	-	6274.7	-	228.2	-	96.4	108.5	-	-
29	386.5	7.9	7193.3	-	180.6	-	33.6	62.8	-	-
30	533.4	17.6	7813.5	13.9	573.2	9.9	73.9	5.7	3	2
31	462.6	47.2	7573.7	40.6	1338.1	9.9	28.6	17.1	6	3
32	298.8	88.3	4639.0	77.8	1762.8	57.8	46.9	125.3	7	4
33	227.3	99.4	3664.7	126.8	2256.5	235.9	20.7	92.4	9	5
34	120.8	139.2	2391.8	277.4	1496.5	397.3	16.0	196.8	7	7
35	78.3	118.8	1590.1	503.6	656.6	614.8	4.8	118.6	6	8

Year	2007		2008		2009		2011		2012	
Length (cm)	Discards	Re-tained Catch	Discards	Re-tained Catch	Discards	Re-tained Catch	Discards	Re-tained Catch	Discards	Re-tained Catch
36	27.4	187.0	871.7	580.5	423.5	567.1	0.3	340.4	2	6
37	26.1	139.8	280.3	640.9	66.9	526.8	0.0	235.8	1	11
38	24.3	142.7	78.3	581.9	57.4	421.4	0.0	632.2	-	8
39	3.4	162.5	206.6	443.0	23.1	346.9	4.8	312.7	-	11
40	8.7	119.4	37.5	535.6	-	281.4	-	158.9	-	9
41	1.3	133.8	5.2	310.7	-	197.9	-	203.4	-	12
42	4.6	133.1	5.2	334.7	-	155.7	-	348.1	-	13
43	3.2	109.3	-	333.5	-	195.1	-	225.4	-	11
44	-	118.6	-	291.1	-	201.7	-	305.4	-	13
45	-	97.9	-	253.6	-	149.9	-	226.0	-	10
>45 cm	-	574.5	0.0	1791.2	0.0	1001.7	-	2490.8	1	144
Total	2659.9	2436.9	47916.8	7136.8	9134.4	5371.3	688.6	6263.7	48.0	277.0
Discard rate, %	52.2		87.0		63.0		10.0		14.8	

Table 4.3.5. Length composition of Irish discards and landings of haddock (number) by results of Irish discard trips in the Rockall area in 2014–2015.

Year	2014		2015	
Length (cm)	Discards	Landings	Discards	Landings
15	-	-	-	-
16	-	-	-	-
17	-	-	-	-
18	-	-	-	-
19	-	-	-	-
20	508.86	-	-	-
21	1249.21	-	68.03	-
22	3757.56	-	136.45	-
23	9882.93	-	548.57	-
24	17742.15	-	2466.15	-
25	26690.88	-	5489.88	-
26	29456.22	206.22	8664.85	-
27	27737.04	1787.22	17011.27	-
28	28506.24	4605.52	23581.32	-
29	23556.01	5224.18	28730.09	-
30	22791.88	4261.83	33689.11	274.85
31	25734.19	4330.57	32838.74	742.11
32	25404.86	3436.96	33210.44	1044.45
33	17211.02	4880.48	25934.47	2308.78
34	8877.72	6392.74	17534.75	2666.09
35	4733.26	7217.61	7589.53	8300.60
36	2034.38	6324.00	4142.17	9702.36
37	918.99	5774.09	854.19	16628.69
38	77.02	4674.26	110.53	10636.86
39	153.20	3780.65	88.60	13495.35
40	0.00	4949.22	-	14787.16
41	39.00	4949.22	-	12808.21
42	51.67	7011.39	-	17425.77
43	12.67	4743.00	-	14732.19
44	12.67	4055.61	-	11488.91
45	25.34	2680.83	-	11186.57
>45 cm	290.53	30520.19	-	77254.68
Total	277455.52	121805.80	242689.10	225483.63
Discard rate, %	69.5		51.8	

Table 4.3.5a. Length composition of Irish discards and landings of haddock (number) by results of Irish discard trips in the Rockall area in 2020.

Year	**2020**	
Length (cm)	Discards	Landings
20	366.822	0
21	3.16	0
22	165.32	0
23	999.62	0
24	5040.62	0
25	9651.98	0
26	21392.66	0
27	35921.01	0
28	6665.29	0
29	64835.95	0
30	78568.49	0
31	79622.33	0
32	58216.09	0
33	47281.39	0
34	41409.76	0
35	27253.52	0
36	18987.2	0
37	7644.62	0
38	1590.68	0
39	2554.228	0
Total	570440.2	0

Table 4.3.6. Discards and retained catches of haddock (number per trip) by Scottish discard trips in the Rockall area in 2009 and 2011–2015.

Length (cm)	2009	2011		2012	2013*			2014*		2015*		
	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings
9	-	-	-	-	1.0	-	-		-	-	-	-
10	-	-	-	-	3.0	-	-		-	-	-	-
11	-	-	-	-	5.2	-	-		-	-	-	-
12	-	-	-	-	66.5	-	-		-	-	-	-
13	-	-	-	-	233.3	-	-		-	-	-	-
14	-	-	-	-	313.0	-	-		-	-	-	-
15	-	-	-	-	842.8	-	-		-	-	-	-
16	-	-	-	-	516.7	-	226		1493	-		-
17	-	-	-	-	247.3	-	0		7817	-	138	-
18	-	-	-	-	341.7	-	0		22709	-	957	-
19	-	-	-	-	81.5	-	135		39126	-	4591	-
20	-	-	-	-	4.7	-	39		37513	-	9278	-
21	-	-	-	-		-	357		25979	-	15194	-
22	-	-	-	-		-	1322		8774	-	16591	-
23	-	-	-	-	4.0	-	2201		14104	-	19529	-
24	-	-	-	-	23.0	-	3665		28818	-	42079	-
25	-	-	-	-	18.9	-	6643		64709	-	122065	-
26	-		3.8		36.4	-	6714		118616	-	206928	-
27	-		3.8		15.9	-	6424		164637	-	254254	-
28	24.2		17.4		22.6	-	5018		142534	-	305155	-
29	14.7		78.6		53.4	-	3599		121740	1422	342216	-
30	-		53.0		77.9	37.3	2326		78972	7965	330023	10543
31	5.3	26.4	17.4		126.6	76.1	1286	894	58592	25316	178402	31628
32	12.0	-	35.2	317.1	119.9	161.9	1181	2682	31670	30389	94018	84630

Length (cm)	2009	2011		2012	2013*			2014*		2015*		
	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings
33	20.1	47.1	28.0	463.7	160.4	464.8	643	6454	13957	33340	23867	195299
34	-	201.7	-	637.4	71.0	1093.8	208	18902	10246	52890	9191	271402
35	-	220.2	139.8	1171.2	25.6	1366.4	101	23579	3404	47790	-	328955
36	-	269.0	139.8	1709.7	42.0	1872.7	39	34036	-	60976	-	241848
37	-	296.5		1668.7	10.1	2164.3		35748	-	57701	-	277221
38	-	353.1	139.8	2032.6	17.5	1917.5		33986	-	57472	-	197661
39	-	193.2		1927.7		2393.7	39	27892	-	61971	-	256136
40	-	237.9	139.8	1233.5		2091.6		36058	-	45808	-	188271
41	-	131.7		1020.3	1.5	1876.3		23821	-	42575	-	189250
42	-	107.9		959.1		1247.9		18935	-	50824	-	123229
43	-	181.9		641.2	118.0	1416.8		23001	-	48330	-	150363
44	-	96.8	139.8	406.0	118.0	1288.2		20654	-	48019	-	108077
45	-	72.1		233.1		1326.8		22804	-	40359	-	75009
46	-	82.4	139.8	138.1	2.1	1252.9		22272	-	34162	-	78581
47	-	46.8		122.2	193.5	1023.0		22565	-	36909	-	39233
48	-	47.0	139.8	55.9		833.8		17565	-	33530	-	43136
49	-	33.3	1.0	49.9	194.5	711.7		18802	-	29220	-	48753
50	-	19.3	-	36.2	1.0	651.6		17499	-	28263	-	42833
51	-	8.9	-	37.5		410.3		12020	-	22682	-	50870
52	-	4.8	-	14.7		315.2		14866	-	23089	-	72142
53	-	5.1	-	20.5		206.1		12313	-	27292	-	40558
54	-	3.2	-	8.4		210.4		18722	-	34873	-	9895
55	-	2.3	-	5.4		98.8	26	11861	-	23816	-	34552
56	-	4.6	-	3.4		203.3		19573	-	18753	-	12660
57	-	2.7	-	1.6		408.4		14254	-	17896	-	9895
58	-	1.9	-	3.1		404.8		8962	-	16511	-	9506
59	-	1.7	-	9.1		87.8		6702	-	21930	-	7518

Length (cm)	2009		2011		2012		2013*		2014*		2015*	
	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings	Dis-cards	Land-ings
60	-	1.2	-			189.9		9813	-	20822	-	2765
61	-	1.7	-	2.7		190.7		5851	-	12248	-	
62	-	1.1	-	1.3		213.7		6436	-	20519	-	5531
63	-	0.5	-	2.4		210.2		4016	-	9150	-	
64	-	1.3	-			97.7		6675	-	7792	-	1166
65	-		-	1.1		45.1		5212	-	9321	-	
66	-		-	1.1		105.2		2314	-	13225	-	
67			-			45.0		3830		14393		
68			-	1.0		24.3		1649		9712		3154
69			-			63.1		1649		3359		
70			-	0.9		58.0		1915		4556		
71						47.9		665		2406		
72						42.2		1782		190		
73						20.1		1117		1102		2765
74						20.6		133		2181		
76						5.7						
77						8.6				71		
78				0.7		4.1				759		
82				0.6								
Total	76.3	2705.3	1216.8	14939.0	4110.5	29006.3	42218	600479	995410	1214092	1974476	3245035
Dis-card rate, %	2.7		7.5		12.4		6.6		45.0		37.8	

***Retained discards and landings.**

Table 4.3.7. Discards and retained catches of haddock (number) by Scottish and Irish discard trips in the Rockall area in 2013–2020.

Year	Country		Age						
			1	2	3	4	5	6	7+
2013	Scotland	Landings	116013	9886	1154	33064	4373	33020	3387
		Discards	4666330	28973	0	0	0	0	11791
	Ireland*	Landings	-	-	-	-	-	-	-
		Discards	55362	5189	9389	3816	31041	35875	0
	Ire-	Landings	-	-	-	-	-	-	-
		Discards	3061	2869	5192	2110	1716	1984	0
2014	Scotland	Landings	-	577684	2252	213	87220	18169	528556
		Discards	142263	853148	-	-	-	-	-
	Ireland	Landings	4188	58642	2353	1277	21085	7630	26631
		Discards	15651	261804	-	-	-	-	-
2015	Scotland	Landings	-	464407	2679182	1620	1171	24139	88332
		Discards	70129	1935829	45431	-	-	-	-
	Ireland	Landings	-	2277	159849	3767	3662	42685	13244
		Discards	-	149261	93428	-	-	-	-
2016	Scotland	Landings	127	580	1991	590	0	0	2891
		BMS	1271	356	51	-	-	-	-
		Discards	163346	153742	88894	402	-	-	-
	Ireland	Landings	-	27955	138593	278405	3345	2294	8634
		BMS	-	-	-	-	-	-	-
		Discards	23629	177594	287589	108446	-	-	-
2017	Scotland	Landings	340	955346	1401088	1606845	821574	2851	12316
		BMS	-	-	-	-	-	-	-
		Discards	747839	245953	1073	201	268	-	-
	Ireland	Landings	24	166140	75380	217982	125193	4364	9657
		BMS	-	-	-	-	-	-	-
		Discards	314743	43494	19349	12118	-	-	-
2018	Scotland	Landings	-	3116059	456039	2052985	533709	191175	8853
		BMS	-	-	-	-	-	-	-
		Discards	87472	2906183	2033	38342	458	431	-
	Ireland	Landings	-	33562.58	6180.39	4416.73	17015.94	13023.1	3205.62
		BMS	-	-	-	-	-	-	-
		Discards	219.48	42390.14	790.51	1315.76	-	-	-
2020	Scot-	Landins	11.77	1757.05	1044.52	2776.266	337.085	438.55	115.7
		BMS	2.41	10.12	3.25	0.002	0.015	-	-
		Dis-	193.749	215.7184	-	0.15358	-	-	-

*** Mesh size 110–119 mm.**

**** Mesh size 70–99 mm.**

Table 4.3.8. Haddock in 6.b. Tuning data available from the Scottish groundfish survey conducted in September. In bold, the data used in the assessment.

HADDOCK WGCSE 2020 ROCKALL
101
SCOGFS
1991–2020
1 1 0.66 0.75
0 6

1	14458	16398	4431	683	315	228	37	64	3
1	20336	**44912**	**14631**	**3150**	**647**	**127**	**200**	4	32
1	15220	**37959**	**15689**	**3716**	**1104**	**183**	**38**	73	21
1	23474	**13287**	**11399**	**4314**	**969**	**203**	**30**	12	4
1	16923	**16971**	**6648**	**5993**	**1935**	**483**	**200**	16	-1
1	33578	**19420**	**5903**	**1940**	**1317**	**325**	**69**	6	1
1	28897	**10693**	**2384**	**538**	**292**	**281**	**71**	9	1
1	-1	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	-1	-1
1	10178	**9969**	**2410**	**708**	**279**	**172**	**90**	64	32
1	-1	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	-1	-1
1	31813	**7455**	**521**	**284**	**154**	**39**	**14**	12	14
1	11704	**20925**	**2464**	**173**	**105**	**65**	**20**	10	15
1	2526	**10114**	**10927**	**1656**	**138**	**97**	**100**	26	6
1	-1	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	-1	-1
1	24452	**4082**	**920**	**1506**	**2107**	**231**	**33**	13	7
1	3570	**18715**	**2562**	**256**	**1402**	**1694**	**349**	16	6
1	558	**2671**	**6019**	**570**	**254**	**516**	**367**	28	2
1	85	**560**	**966**	**3813**	**182**	**41**	**282**	249	49
1	132	**139**	**323**	**488**	**1651**	**40**	**9**	54	17
1	-1	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	-1	-1
1	13	**17**	**96**	**22**	**42**	**88**	**607**	4	4
1	39619	**4**	**12**	**73**	**14**	**75**	**50**	635	9
1	6035	**14179**	**5**	**8**	**8**	**9**	**11**	23	166
1	3044	**7232**	**4692**	**5**	**0**	**13**	**0**	11	10
1	1997	**2908**	**5635**	**3357**	**0**	**0**	**16**	2	20
1	67096	**1576**	**1483**	**2064**	**1526**	**11**	**1**	5	2
1	30130	**29449**	**956**	**909**	**1389**	**663**	**5**	1	2
1	10008	**4170**	**10535**	**308**	**773**	**967**	**358**	0	0
1	5204	**5590**	**2700**	**3844**	**91**	**124**	**269**	126	13
1	44892	**2337**	**2537**	**596**	**1211**	**32**	**47**	44	29

Table 4.3.9. Haddock in 6.b. International landings, discards and total catch.

Year	Num (*1000)			Weight, tonnes		
	Landings	Discards	Total Catch[1]	Landings	Discards	Total Catch[1]
1991	12302	65832	78134	5655	13229	18884
1992	11418	55964	67383	5320	11873	17192
1993	8767	44656	53423	4784	9856	14639
1994	11400	46628	58028	5733	11027	16761
1995	11784	35467	47251	5587	9170	14758
1996	14066	41506	55572	7075	9356	16432
1997	9965	26980	36945	5166	5893	11059
1998	9034	47831	56865	4984	10863	15847
1999	12931	52881	65812	5358	11065	16423
2000	16000	26033	42033	5445	6611	12056
2001	5069	9222	14291	2020	1536	3556
2002	11168	21899	33067	3116	4153	7269
2003	24542	25087	49629	5967	5521	11488
2004	22706	3989	26695	6437	883	7321
2005	19505	1877	21382	5238	505	5742
2006	9605	1667	11273	2756	386	3142
2007	8936	12300	21236	3348	2242	5590
2008	10209	7603	17812	4221	2104	6325
2009	6709	4765	11474	3242	1556	4798
2010	5264	3242	8506	3404	907	4311
2011	3082	248	3331	1861	152	2013
2012	631	49	680	686	26	712
2013	829	5039	5868	889	1065	1954
2014	3114	1634	4748	1845	332	2177
2015	4327	2397	6724	2510	554	3064
2016	3733	1333	5068	2504	401	2905
2017	6629	1552	8181	4431	379	4810
2018	6985	3087	10072	3850	788	4638
2019	12772	1138	13926[2]	7782	303	8088[2]
2020	7601	518	8127[2]	5510	131	5643[2]

[1] **Landings and discards.**

[1] [5]**Including BMS catch is 4 tonnes (N=16*1000) in 2019 and 2 tonnes (N=8*1000) in 2020.**

Table 4. 3.10. Haddock in 6.b. International catch (landings and discards) numbers (*10³) at-age.

	Age						
Year	1	2	3	4	5	6	7
1991	21 186	33 847	15 189	5 341	1 704	346	522
1992	16 084	24 711	18 584	5 361	1 761	676	206
1993	11 178	19 375	15 494	4 938	1 617	461	359
1994	8 170	20 623	17 868	8 209	2 449	476	232
1995	2 749	9 831	21 584	9 756	2 464	787	79
1996	12 096	18 811	10 911	9 612	3 299	751	92
1997	9 957	10 535	5 388	4 098	5 002	1 758	206
1998	14 224	19 807	10 173	4 763	3 740	2 767	1 391
1999	17 282	21 949	12 203	5 499	3 419	2 684	2 776
2000	8 222	12 581	10 698	4 917	2 050	1 498	2 066
2001	7 669	2 013	1 699	821	1 041	477	570
2002	13 363	11 119	4 537	2 445	898	260	444
2003	6 576	23 606	14 568	2 065	1 286	927	602
2004	932	4 112	10 282	9 212	1 386	296	474
2005	1 061	3 723	7 420	8 124	753	109	193
2006	2 880	1 475	1 626	2 414	2 291	436	151
2007	1 489	9 829	3 630	1 514	2 227	1 827	720
2008	476	2 207	11 437	1 291	507	964	930
2009	223	707	1 237	8 046	495	263	504
2010	152	534	1 064	2 087	4 096	276	296
2011	4	59	75	183	181	2 579	249
2012	5	6	144	58	3	35	428
2013	4 896	98	101	86	39	84	565
2014	406	3 008	418	52	138	47	679
2015	80	2 973	3 387	104	7	61	112
2016	374	1 051	2 639	988	3	2	11
2017	1 194	1 670	1 802	2 191	1 207	58	59
2018	88	6373	504	2273	598	222	13
2019	288	1995	10866	67	560	90	60
2020	264	2202	1190	3392	364	518	180

Table 4.3.11. Haddock in 6.b. International landings numbers (*10³) at-age.

	Age						
Year	1	2	3	4	5	6	7
1991	87	6807	3011	1344	558	32	464
1992	86	3642	5623	964	580	364	160
1993	28	1919	4740	1157	489	144	290
1994	30	1160	5299	3665	1039	66	141
1995	1	146	5205	4791	1319	279	43
1996	2	5149	1861	4149	2347	473	85
1997	0	319	2102	2155	3658	1540	192
1998	4	392	1815	1340	1898	2284	1301
1999	245	2600	2994	1972	1228	1600	2291
2000	33	3446	5081	3006	1296	1176	1963
2001	402	994	1116	555	991	462	549
2002	657	2983	3998	2111	809	217	392
2003	920	8103	11010	1848	1189	879	593
2004	197	1765	9502	9119	1364	286	472
2005	887	2835	6866	7913	725	98	182
2006	2344	768	1290	2356	2269	428	150
2007	31	1220	2709	1074	1550	1634	719
2008	17	749	6191	1164	479	761	848
2009	5	11	244	5243	460	261	486
2010	0	71	196	352	4078	274	294
2011	2	23	71	177	181	2405	222
2012	0	0	134	51	0	35	410
2013	162	14	2	46	6	46	553
2014	226	1553	418	52	138	47	679
2015	9	820	3214	104	7	61	112
2016	127	612	2137	842	3	2	11
2017	7	1336	1783	2179	1207	58	59
2018	0	3418	502	2233	598	222	13
2019	10	1514	10556	59	484	90	60
2020	21	1936	1190	3392	364	518	180

Table 4.3.12. Haddock in 6.b. International discards numbers (*10³) at-age.

YEAR	AGE						
	1	2	3	4	5	6	7
1991	21099	27040	12178	3998	1146	313	58
1992	15998	21069	12961	4397	1181	312	46
1993	11151	17456	10755	3781	1128	317	69
1994	8140	19464	12570	4545	1409	410	91
1995*	2748	9685	16379	4965	1145	508	36
1996	12094	13662	9051	5463	952	278	7
1997*	9957	10216	3286	1944	1344	218	15
1998*	14220	19415	8357	3423	1842	483	91
1999*	17037	19348	9209	3526	2191	1084	485
2000*	8189	9136	5616	1912	755	322	103
2001*	7268	1019	583	266	50	15	21
2002	12706	8136	539	334	89	43	51
2003	5655	15503	3558	217	97	48	8
2004	735	2346	781	93	22	10	2
2005	174	888	554	210	28	11	11
2006	536	707	336	58	22	8	1
2007	1458	8609	921	440	678	193	0
2008	458	1458	5246	128	28	203	82
2009	218	696	993	2803	35	2	18
2010*	152	463	868	1736	19	2	2
2011*	2	36	4	6	0	174	27
2012*	5	6	10	7	3	0	18
2013*	4733	84	99	40	33	38	12
2014*	179	1454	0	0	0	0	0
2015*	71	2153	173	0	0	0	0
2016*	245	439	503	146	0	0	0
2017*	1187	334	20	12	0	0	0
2018*	88	2955	3	40	0	0	0
2019*	275	471	308	8	76	0	0
2020*	237	263	0.00	0.2	0	0	0

*** Data calculated using estimates from discard observer trips.**

Table 4.3.13. Haddock in 6.b. International catch (landings and discards) weights-at-age (kg).

YEAR	AGE						
	1	2	3	4	5	6	7
1991	0.142	0.240	0.291	0.378	0.469	0.414	0.681
1992	0.133	0.239	0.318	0.362	0.423	0.567	0.852
1993	0.137	0.238	0.335	0.400	0.493	0.503	0.882
1994	0.153	0.233	0.319	0.420	0.469	0.477	0.740
1995	0.118	0.222	0.309	0.401	0.501	0.460	0.870
1996	0.136	0.278	0.314	0.396	0.553	0.575	0.762
1997	0.136	0.240	0.322	0.381	0.512	0.634	0.940
1998	0.141	0.250	0.308	0.354	0.436	0.546	0.663
1999	0.138	0.208	0.272	0.334	0.379	0.483	0.619
2000	0.189	0.250	0.267	0.321	0.382	0.451	0.709
2001	0.133	0.264	0.326	0.447	0.427	0.520	0.683
2002	0.135	0.239	0.237	0.325	0.509	0.579	0.755
2003	0.153	0.203	0.256	0.349	0.384	0.424	0.604
2004	0.147	0.198	0.244	0.294	0.444	0.609	0.753
2005	0.114	0.197	0.235	0.311	0.459	0.600	1.062
2006	0.093	0.198	0.245	0.329	0.441	0.595	0.787
2007	0.114	0.186	0.265	0.294	0.386	0.496	0.578
2008	0.199	0.241	0.291	0.437	0.571	0.669	0.937
2009	0.248	0.288	0.339	0.391	0.668	0.513	1.012
2010	0.141	0.247	0.333	0.327	0.590	0.977	1.464
2011	0.198	0.280	0.596	0.449	0.695	0.603	0.748
2012	0.263	0.295	0.622	0.784	0.372	1.411	1.219
2013	0.211	0.368	0.236	0.704	0.423	0.827	1.261
2014	0.140	0.286	0.268	0.545	1.000	1.036	1.370
2015	0.104	0.254	0.601	0.354	1.178	0.948	1.439
2016	0.298	0.449	0.600	0.711	1.556	1.808	2.650
2017	0.219	0.430	0.586	0.691	0.944	0.780	1.270
2018	0.088	0.298	0.563	0.700	0.935	1.233	1.928
2019	0.180	0.434	0.581	0.771	1.030	1.440	1.683
2020	0.245	0.500	0.576	0.807	0.749	1.029	1.363

Table 4.3.14. Haddock in 6.b. International landings weights-at-age (kg).

YEAR	AGE						
	1	2	3	4	5	6	7
1991	0.302	0.402	0.444	0.592	0.724	0.963	0.704
1992	0.136	0.366	0.455	0.658	0.612	0.759	0.954
1993	0.305	0.402	0.503	0.701	0.830	0.820	0.972
1994	0.314	0.356	0.452	0.558	0.638	1.224	0.890
1995	0.377	0.311	0.414	0.479	0.640	0.699	1.236
1996	0.327	0.436	0.501	0.487	0.627	0.709	0.783
1997	0.300	0.315	0.401	0.444	0.564	0.661	0.973
1998	0.256	0.344	0.494	0.517	0.542	0.591	0.678
1999	0.085	0.177	0.326	0.417	0.495	0.595	0.662
2000	0.111	0.206	0.242	0.328	0.413	0.483	0.720
2001	0.094	0.281	0.344	0.497	0.427	0.522	0.690
2002	0.107	0.196	0.227	0.323	0.521	0.627	0.804
2003	0.100	0.164	0.246	0.350	0.387	0.423	0.606
2004	0.142	0.172	0.241	0.293	0.446	0.617	0.754
2005	0.103	0.184	0.230	0.310	0.461	0.614	1.095
2006	0.084	0.167	0.223	0.327	0.440	0.598	0.789
2007	0.096	0.238	0.275	0.322	0.449	0.521	0.578
2008	0.125	0.197	0.302	0.444	0.583	0.752	0.984
2009	0.300	0.346	0.420	0.416	0.692	0.512	1.031
2010	0.052	0.420	0.517	0.457	0.591	0.980	1.473
2011	0.214	0.329	0.613	0.454	0.694	0.594	0.780
2012	0.189	0.368	0.632	0.850	0.898	1.412	1.238
2013	0.510	0.554	0.713	0.972	1.361	0.948	1.267
2014	0.186	0.351	0.268	0.545	1.000	1.036	1.370
2015	0.107	0.327	0.615	0.354	1.178	0.948	1.439
2016	0.409	0.574	0.664	0.767	1.576	1.808	2.650
2017	0.173	0.460	0.587	0.692	0.944	0.780	1.270
2018	-1	0.332	0.564	0.705	0.935	1.235	1.928
2019	0.190	0.489	0.589	0.825	1.116	1.440	1.683
2020	0.298	0.531	0.576	0.807	0.749	1.029	1.363

Table 4.3.15. Haddock in 6.b. International discards weights-at-age (kg).

YEAR	AGE						
	1	2	3	4	5	6	7
1991	0.142	0.199	0.253	0.306	0.345	0.358	0.499
1992	0.133	0.217	0.258	0.298	0.330	0.342	0.499
1993	0.137	0.220	0.260	0.307	0.346	0.359	0.504
1994	0.153	0.226	0.263	0.308	0.345	0.356	0.508
1995	0.118	0.220	0.276	0.325	0.341	0.329	0.438
1996	0.136	0.218	0.276	0.326	0.370	0.348	0.515
1997	0.136	0.238	0.272	0.312	0.372	0.442	0.512
1998	0.141	0.248	0.267	0.291	0.327	0.336	0.451
1999	0.139	0.212	0.255	0.288	0.313	0.318	0.417
2000	0.189	0.267	0.289	0.311	0.330	0.334	0.484
2001	0.135	0.247	0.294	0.344	0.412	0.440	0.513
2002	0.137	0.254	0.308	0.335	0.398	0.338	0.382
2003	0.161	0.223	0.287	0.342	0.337	0.440	0.487
2004	0.148	0.218	0.282	0.343	0.324	0.371	0.449
2005	0.171	0.240	0.298	0.357	0.387	0.473	0.511
2006	0.132	0.233	0.334	0.420	0.495	0.435	0.423
2007	0.115	0.179	0.233	0.227	0.243	0.280	0.420
2008	0.202	0.264	0.279	0.370	0.351	0.358	0.446
2009	0.247	0.287	0.319	0.343	0.360	0.662	0.507
2010	0.141	0.220	0.292	0.301	0.322	0.534	0.250
2011	0.178	0.248	0.300	0.302	0.795	0.727	0.481
2012	0.263	0.295	0.488	0.319	0.339	0.733	0.797
2013	0.201	0.337	0.228	0.397	0.247	0.679	0.980
2014	0.082	0.218	-	-	-	-	-
2015	0.104	0.227	0.334	-	-	-	-
2016	0.240	0.276	0.325	0.393	-	-	-
2017	-	0.308	0.482	0.520	0.726	-	-
2018	0.088	0.258	0.361	0.422	0.479	0.536	-
2019	0.180	0.259	0.297	0.374	0.486	-	-
2020	0.054	0.2422	0.274	-	0.512	-	-

Table 4.3.16. Haddock 6.b. Stock weights-at-age (kg).

YEAR	AGE						
	1	2	3	4	5	6	7
1991	0.142	0.240	0.291	0.378	0.469	0.414	0.681
1992	0.133	0.239	0.318	0.362	0.423	0.567	0.852
1993	0.137	0.238	0.335	0.400	0.493	0.503	0.882
1994	0.153	0.233	0.319	0.420	0.469	0.477	0.740
1995	0.137	0.234	0.314	0.392	0.471	0.484	0.805
1996	0.136	0.242	0.319	0.396	0.488	0.516	0.821
1997	0.136	0.242	0.320	0.399	0.506	0.530	0.839
1998	0.137	0.245	0.314	0.390	0.494	0.538	0.795
1999	0.134	0.240	0.305	0.373	0.476	0.540	0.771
2000	0.148	0.245	0.297	0.357	0.452	0.538	0.739
2001	0.148	0.242	0.299	0.368	0.427	0.527	0.723
2002	0.147	0.242	0.282	0.356	0.426	0.516	0.686
2003	0.150	0.233	0.272	0.355	0.416	0.491	0.674
2004	0.151	0.231	0.266	0.347	0.429	0.517	0.701
2005	0.136	0.220	0.260	0.345	0.444	0.546	0.771
2006	0.128	0.207	0.243	0.322	0.447	0.561	0.792
2007	0.124	0.197	0.249	0.315	0.423	0.545	0.757
2008	0.134	0.204	0.256	0.333	0.460	0.594	0.823
2009	0.154	0.222	0.275	0.352	0.505	0.574	0.875
2010	0.159	0.232	0.295	0.355	0.531	0.650	0.956
2011	0.180	0.248	0.365	0.380	0.582	0.651	0.948
2012	0.210	0.270	0.436	0.477	0.579	0.834	1.076
2013	0.212	0.295	0.425	0.531	0.550	0.866	1.141
2014	0.191	0.295	0.411	0.562	0.616	0.971	1.212
2015	0.183	0.297	0.465	0.567	0.734	0.965	1.207
2016	0.203	0.330	0.465	0.619	0.906	1.206	1.588
2017	0.195	0.357	0.458	0.601	1.020	1.080	1.598
2018	0.170	0.343	0.524	0.600	1.123	1.161	1.731
2019	0.178	0.373	0.586	0.645	1.129	1.242	1.794
2020	0.206	0.422	0.581	0.736	1.043	1.258	1.779

Table 4.3.17. XSA diagnostics from the assessment of Haddock in 6.b. Final runs.

FLR	XSA	Diagnostics	06.05.2021	16:56:55							
CPUE	data	from	had.tun								
Catch	data	for	30	years.	1991	to	2020	Ages	1	to	7
	fleet	first	age	last	age	first	year	last	year	alpha	beta
1	SCOG	1	6	1991	2020	0.66	0.75				
	Time	series	weights	:							
	Tapere	time	weighting	not	applied						
Catcha	analys	:									
	Catcha	independent	of	size	for	ages	>	3			
	Catcha	independent	of	age	for	ages	>	4			
Termir	popula	estimation	:								
	Surviv	estimates	shrunk	towards	the	mean	F				
	of	the	final	4	years	or	the	3	oldest	ages.	
S.E.	of	the	mean	to	which	the	estima	are	shrunk	=	1
	Minimu	standard	error	for	population						
	estima	derived	from	each	fleet	=	0.3				
	prior	weighting	not	applied							
Regres	weights										
	year										
age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
all	1	1	1	1	1	1	1	1	1	1	
	Fishing	mortalities									
	year										
age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
1	0.012	0.004	0.17	0.017	0.006	0.061	0.019	0.005	0.013	0.02	
2	0.058	0.026	0.103	0.15	0.17	0.109	0.417	0.135	0.163	0.131	
3	0.232	0.195	0.708	0.834	0.251	0.224	0.276	0.212	0.359	0.138	
4	0.419	0.285	0.172	1.046	0.504	0.107	0.293	0.672	0.039	0.18	
5	0.228	0.009	0.313	0.455	0.35	0.023	0.185	0.121	0.34	0.308	
6	0.361	0.063	0.446	0.789	0.374	0.163	0.821	0.047	0.024	0.613	
7	0.361	0.063	0.446	0.789	0.374	0.163	0.821	0.047	0.024	0.613	

Table 4.3.17. Continued.

	XSA	population	number	(Thousand)							
	age										
year	1	2	3	4	5	6	7				
2011	340	1162	400	592	983	9401	901				
2012	1355	275	898	260	318	640	7731				
2013	34615	1105	219	605	160	258	1719				
2014	26176	23910	816	88	417	96	1356				
2015	13832	21064	16855	290	25	217	395				
2016	7016	11253	14556	10735	144	15	77				
2017	69342	5406	8262	9529	7895	115	115				
2018	18051	55692	2916	5133	5820	5371	316				
2019	24499	14699	39830	1931	2146	4224	2780				
2020	14947	19798	10230	22778	1520	1251	429				
	Estima	population	abundance	at	1st	Jan	2021				
	age										
year	1	2	3	4	5	6	7				
2021	-1.530	11999	14216	7299	15581	915	555				
	Fleet:	SCOGFS									
	Log	catchability	residuals.								
	year										
age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	-0.34	0.148	-0.041	-0.145	0.022	0.144	-0.28	NA	0.081	NA	-0.54
2	-0.48	0.33	0.259	-0.104	0.03	0.109	-0.42	NA	-0.34	NA	-0.7
3	-0.55	0.32	0.378	0.273	0.302	-0.07	-0.82	NA	-0.34	NA	-0.48
4	-0.23	0.547	0.445	0.453	0.768	-0.06	-1.2	NA	-0.39	NA	-0.77
5	-0.24	0.065	0.484	-0.472	0.841	-0.08	-0.81	NA	-0.49	NA	-0.54
6	0.022	0.21	-0.04	-0.149	0.152	-0.15	-0.41	NA	-0.21	NA	-0.48
	year										
age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	-0.21	-0.004	NA	0.341	-0.18	0.219	0.216	0.25	NA	0.219	-1.49
2	-0.72	0.106	NA	0.09	0.575	-0.34	0.151	0.335	NA	0.253	0.084
3	-0.9	-0.285	NA	-0.02	-0.12	0.367	-0.04	0.257	NA	0.228	0.396
4	-0.88	-0.594	NA	0.554	0.558	0.639	0.216	-0.07	NA	0.167	-0.2
5	-1.1	0.26	NA	-0.496	0.887	0.112	-0.22	-0.48	NA	0.264	1.077
6	-0.08	0.243	NA	0.085	0.266	-0.1	0.033	-0.46	NA	0.031	0.01
	year										
age	2013	2014	2015	2016	2017	2018	2019	2020			
1	0.379	0.185	0.175	0.367	0.201	0.167	0.1	0.014			
2	-1.52	0.325	0.547	0.186	0.626	0.154	0.371	0.084			
3	0.247	-1.158	0.722	0.477	0.387	0.453	0.14	-0.18			
4	-1.69	NA	NA	0.641	0.797	1.096	-0.51	-0.29			
5	-0.14	-0.632	NA	-0.036	0.17	0.806	-0.1	-1.13			
6	-0.33	NA	0.174	-0.055	-0.04	-0.16	-0.22	-0.33			

Table 4.3.17. Continued.

	Mean	log	catchability	and	standa	error	of	ages	with	catcha
	indepe	of	year	class	strengt	and	consta	w.r.t.	time	
	4	5	6							
Mean_	-2.38	-2.3752	-2.3752							
S.E_L	0.699	0.5944	0.2127							
	Regre:	statistics								
	Ages	with	q	depende	on	year	class	strength		
	slope	intercept								
Age	1	0.7093286	4.020833							
Age	2	0.7878025	3.640562							
Age	3	0.8563679	3.350391							
	Termir	year	survivor	and	F	summaries:				
	Age	1	Year	class	2019					
source										
	scaled	survivors	yrcls							
SCOG	0.687	12247	2019							
fshk	0.218	9558	2019							
nshk	0.095	17446	2019							
	Age	2	Year	class	2018					
source										
	scaled	survivors	yrcls							
SCOG	0.688	15814	2018							
fshk	0.312	8666	2018							
	Age	3	Year	class	2017					
source										
	scaled	survivors	yrcls							
SCOG	0.725	5937	2017							
fshk	0.275	3486	2017							
	Age	4	Year	class	2016					
source										
	scaled	survivors	yrcls							
SCOG	0.621	11642	2016							
fshk	0.379	9522	2016							
	Age	5	Year	class	2015					
source										
	scaled	survivors	yrcls							
SCOG	0.663	296	2015							
fshk	0.337	1802	2015							
	Age	6	Year	class	2014					
source										
	scaled	survivors	yrcls							
SCOG	0.858	398	2014							
fshk	0.142	2015	2014							

Table 4.3.18. Haddock in 6.b. Final XSA runs. Fishing mortality-at-age.

	age						
year	1	2	3	4	5	6	7
1991	0.241	0.612	0.903	0.953	0.472	0.72	0.72
1992	0.178	0.491	0.834	0.999	1.026	0.345	0.345
1993	0.107	0.338	0.665	0.55	1.001	0.849	0.849
1994	0.142	0.293	0.603	0.945	0.587	0.964	0.964
1995	0.051	0.254	0.571	0.802	0.859	0.376	0.376
1996	0.241	0.573	0.497	0.543	0.709	0.706	0.706
1997	0.167	0.342	0.315	0.35	0.612	1.113	1.113
1998	0.248	0.581	0.657	0.512	0.629	0.846	0.846
1999	0.501	0.754	0.899	0.95	0.881	1.462	1.462
2000	0.39	0.865	1.108	1.263	1.279	1.413	1.413
2001	0.115	0.154	0.257	0.211	1.067	1.335	1.335
2002	0.154	0.244	0.614	0.724	0.376	0.874	0.874
2003	0.169	0.446	0.583	0.637	1.149	0.858	0.858
2004	0.076	0.152	0.355	0.945	1.31	0.934	0.934
2005	0.085	0.483	0.448	0.531	0.171	0.301	0.301
2006	0.037	0.162	0.402	0.254	0.276	0.141	0.141
2007	0.135	0.172	0.754	0.827	0.395	0.37	0.37
2008	0.13	0.303	0.31	0.672	0.747	0.296	0.296
2009	0.171	0.291	0.277	0.375	0.596	1.214	1.214
2010	0.112	0.791	0.966	1.072	0.332	0.811	0.811
2011	0.012	0.058	0.232	0.419	0.228	0.361	0.361
2012	0.004	0.026	0.195	0.285	0.009	0.063	0.063
2013	0.17	0.103	0.708	0.172	0.313	0.446	0.446
2014	0.017	0.15	0.834	1.046	0.455	0.789	0.789
2015	0.006	0.17	0.251	0.504	0.35	0.374	0.374
2016	0.061	0.109	0.224	0.107	0.023	0.163	0.163
2017	0.019	0.417	0.276	0.293	0.185	0.821	0.821
2018	0.005	0.135	0.212	0.672	0.121	0.047	0.047
2019	0.013	0.163	0.359	0.039	0.34	0.024	0.024
2020	0.02	0.131	0.138	0.180	0.308	0.613	0.613

Table 4.3.19. Haddock in 6.b. Final XSA runs. Stock numbers (*10³) at-age.

	age						
year	1	2	3	4	5	6	7
1991	109360	81737	28239	9609	5009	744	1108
1992	109018	70367	36295	9376	3034	2559	775
1993	122000	74702	35253	12900	2826	891	683
1994	68239	89771	43630	14843	6094	850	408
1995	61263	48477	54837	19554	4724	2773	276
1996	62421	47670	30794	25366	7181	1638	198
1997	71666	40161	22008	15339	12071	2894	333
1998	71678	49666	23349	13143	8850	5357	2652
1999	48438	45815	22741	9911	6451	3862	3895
2000	28113	24020	17650	7577	3139	2188	2945
2001	77850	15577	8282	4771	1754	715	836
2002	103304	56799	10932	5243	3164	494	829
2003	46702	72487	36442	4845	2080	1778	1136
2004	14155	32287	37988	16654	2098	540	848
2005	14462	10745	22714	21798	5300	464	816
2006	87139	10881	5429	11883	10496	3658	1264
2007	13054	68738	7574	2973	7544	6521	2549
2008	4312	9340	47384	2916	1065	4161	3989
2009	1564	3100	5650	28447	1219	413	775
2010	1588	1079	1898	3507	16010	550	581
2011	340	1162	400	592	983	9401	901
2012	1355	275	898	260	318	640	7731
2013	34615	1105	219	605	160	258	1719
2014	26176	23910	816	88	417	96	1356
2015	13832	21064	16855	290	25	217	395
2016	7016	11253	14556	10735	144	15	77
2017	69342	5406	8262	9529	7895	115	115
2018	18051	55692	2916	5133	5820	5371	316
2019	24499	14699	39830	1931	2146	4224	2780
2020	14947	19798	10230	22778	1520	1251	429

Table 4.3.20. Haddock in 6.b. Final XSA run. Summary table.

	RECRUITS	TOTALBIO	TOTSPBIO	LANDINGS	Yield/SSB	Fbar(2-5)
1991	109360	50408	15262	5656	0.3706	0.7347
1992	109018	49647	18330	5321	0.2903	0.8377
1993	122000	53907	19413	4781	0.2463	0.6384
1994	68239	55074	23717	5732	0.2417	0.6069
1995	61263	48410	28673	5587	0.1949	0.6214
1996	62421	44344	24381	7072	0.2901	0.5803
1997	71666	40565	21100	5167	0.2449	0.4051
1998	71678	43808	21820	4986	0.2285	0.5948
1999	48438	36278	18792	5356	0.285	0.871
2000	28113	22765	12719	5445	0.4281	1.1289
2001	77850	21171	5957	2020	0.3391	0.4224
2002	103304	36055	7124	3118	0.4377	0.4896
2003	46702	38031	14136	5968	0.4222	0.7039
2004	14155	27253	17658	6434	0.3644	0.6905
2005	14462	20997	16666	5239	0.3143	0.408
2006	87139	26296	12890	2756	0.2138	0.2737
2007	13054	26588	11497	3347	0.2911	0.5371
2008	4312	21825	19346	4222	0.2182	0.5079
2009	1564	14027	13098	3241	0.2475	0.3845
2010	1588	11726	11223	3404	0.3033	0.7904
2011	340	8276	7926	1860	0.2346	0.2345
2012	1355	9913	9554	686	0.0718	0.1288
2013	34615	10353	2688	889	0.3309	0.3238
2014	26176	14432	2378	1845	0.7758	0.6212
2015	13832	17493	8706	2510	0.2883	0.3186
2016	7016	18831	13694	2504	0.1828	0.1158
2017	69342	33254	17871	4430	0.2479	0.2929
2018	18051	40098	17927	3850	0.2147	0.285
2019	24499	47087	37243	7778	0.2088	0.2252
2020	14947	38063	26630	5508	0.2068	0.189

Table 4.3.21. Haddock in 6.b. Detailed short-term forecast output.

MFDP version 1a

Run: MSY

Time and date: 06:33 05.2021

F_{bar} age range (Total): 2–5

F_{bar} age range Fleet 1: 2–5

Year:	**2020**	**F multiplier:**	**0.9965**	**Fleet1 HCFbar:**	**0.1847**	**Fleet1 Fbar:**	**0.0039**					
	Catch											
Age	F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0016	21	6	0.0183	246	60	14947	3079	0	0	0	0
2	0.1148	1935	1028	0.0157	265	73	19798	8355	0	0	0	0
3	0.1375	1194	688	0	0	0	10230	5944	10230	5944	10230	5944
4	0.1794	3400	2744	0	0	0	22778	16765	22778	16765	22778	16765
5	0.3069	366	274	0	0	0	1520	1585	1520	1585	1520	1585
6	0.6109	524	539	0	0	0	1251	1574	1251	1574	1251	1574
7	0.6109	180	245	0	0	0	429	763	429	763	429	763
Total		7620	5523		511	132	70953	38064	36208	26631	36208	26631

Year:	2021	F multiplier:	1	Fleet1 HCFbar:	0.1874	Fleet1 DFbar:	0.0458					
	Catch											
Age	F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0022	101	27	0.0105	480	93	50739	9356	0	0	0	0
2	0.0698	709	338	0.0732	743	204	11996	4553	0	0	0	0
3	0.2034	2345	1398	0.0329	379	139	14226	8018	14226	8018	14226	8018
4	0.2698	1552	1178	0.0272	156	69	7300	4822	7300	4822	7300	4822
5	0.2066	2586	2751	0.0497	622	351	15587	17116	15587	17116	15587	17116
6	0.2161	161	202	0.0119	9	5	916	1117	916	1117	916	1117
7	0.2241	136	242	0.0039	2	1	747	1320	747	1320	747	1320
Total		7589	6136		2392	863	101509	46302	38774	32393	38774	32393

Year:	2022	F multiplier:	0.718	Fleet1 HCFbar:	0.1346	Fleet1 DFbar:	0.0328					
	Catch											
Age	F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0016	20	5	0.0075	94	18	13832	2551	0	0	0	0
2	0.0501	1774	846	0.0526	1860	512	41017	15566	0	0	0	0
3	0.146	1039	619	0.0236	168	62	8513	4798	8513	4798	8513	4798
4	0.1937	1459	1108	0.0195	147	65	9196	6075	9196	6075	9196	6075
5	0.1483	547	582	0.0357	132	74	4441	4876	4441	4876	4441	4876
6	0.1552	1285	1616	0.0085	71	38	9876	12053	9876	12053	9876	12053
7	0.1609	146	260	0.0028	3	2	1083	1916	1083	1916	1083	1916
Total		6270	5036		2474	770	87958	47834	33109	29717	33109	29717

Year:	2023	F multiplier:	0.718	Fleet1 HCFbar:	0.1346	Fleet1 DFbar:	0.0328					
	Catch											
Age	F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0016	20	5	0.0075	94	18	13832	2551	0	0	0	0
2	0.0501	485	231	0.0526	509	140	11222	4259	0	0	0	0
3	0.146	3700	2205	0.0236	598	219	30305	17080	30305	17080	30305	17080
4	0.1937	933	708	0.0195	94	42	5882	3886	5882	3886	5882	3886
5	0.1483	749	797	0.0357	180	102	6083	6680	6083	6680	6083	6680
6	0.1552	393	495	0.0085	22	12	3025	3691	3025	3691	3025	3691
7	0.1609	1028	1828	0.0028	18	11	7618	13469	7618	13469	7618	13469
Total		7309	6271		1515	543	77967	51615	52913	44805	52913	44805

Input units are thousands and kg - output in tonnes.

Table 4.3.22. Haddock in 6.b. Input data for the short-term forecast.

Missing.

Table 4.3.23. Haddock in 6.b. Short-term forecast output.

MFDP version 1a								
Run: 3YMFmsy								
Time and date: 06:33 15.05.2021								
Fbar age range (Total) : 2-5								
Fbar age range Fleet 1 : 2-5								
2020								
		Catch	Landings		Discards			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield		
38064	26631	0.9965	0.1847	5523	0.0039	132		
2021								
		Catch	Landings		Discards			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield		
46302	32393	1	0.1874	6136	0.0458	863		
2022							2023	
		Catch	Landings		Discards			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	Biomass	SSB
47834	29717	0.71	0.1331	4985	0.0325	762	51690	44880
.	29717	0.7108	0.1332	4990	0.0325	763	51683	44873
.	29717	0.7116	0.1334	4995	0.0326	764	51675	44865
.	29717	0.7124	0.1335	5000	0.0326	765	51667	44858
.	29717	0.7132	0.1337	5005	0.0326	765	51660	44850
.	29717	0.714	0.1338	5010	0.0327	766	51652	44843
.	29717	0.7148	0.134	5016	0.0327	767	51645	44835
.	29717	0.7156	0.1341	5021	0.0327	768	51637	44828
.	29717	0.7164	0.1343	5026	0.0328	769	51630	44820
.	29717	0.7172	0.1344	5031	0.0328	769	51622	44813
.	29717	0.718	0.1346	5036	0.0328	770	51615	44805
.	29717	0.7188	0.1347	5042	0.0329	771	51607	44798
.	29717	0.7196	0.1349	5047	0.0329	772	51600	44790
.	29717	0.7204	0.135	5052	0.033	773	51592	44783
.	29717	0.7212	0.1352	5057	0.033	774	51585	44775
.	29717	0.722	0.1353	5062	0.033	774	51577	44768
.	29717	0.7228	0.1355	5067	0.0331	775	51570	44760
.	29717	0.7236	0.1356	5073	0.0331	776	51562	44753
.	29717	0.7244	0.1358	5078	0.0331	777	51555	44746
.	29717	0.7252	0.1359	5083	0.0332	778	51547	44738
.	29717	0.726	0.1361	5088	0.0332	778	51539	44731

Table 4.3.24. Haddock 6.b. Stock numbers of recruits and their source for recent year classes used in predictions, and the relative (%) contributions to landings and SSB (by weight) of these year classes.

Year-class			2017	2018	2019	2020	2021	
Stock No. (thousands)			18051	24499	14947	50739	13832	
of	1	year-olds						
Source			XSA	XSA	XSA	RCT3	Percentile 25	
F2017 = 0.31, F 2018=0.2:								
% in	2021	landings	17.1	27.3	14.5	5.8	-	35.2
% in	2022	landings	7.8	18.4	13.8	41.6	1.3	17.2
% in	2021	SSB	14.9	24.8	0.0	0.0	-	60.4
% in	2022	SSB	16.4	20.4	16.1	0.0	0.0	47.0
% in	2023	SSB	8.2	14.9	8.7	38.1	0.0	30.1
GM : geometric mean recruitment								

Haddock 6b : Year-class % contribution to

a) 2022 Catches

b) 2023 SSB

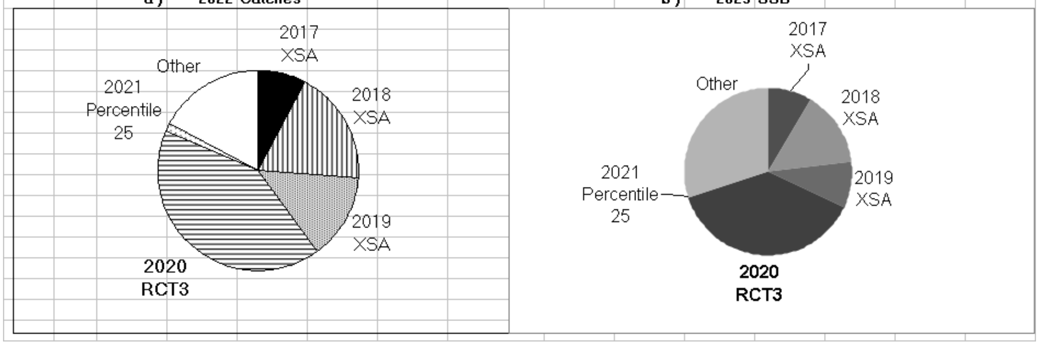


Figure 4.3.1. Distribution of haddock (catch N per 30 minutes) on the Rockall Bank from 2005–2019 from the Scottish trawl survey (Scottish Rock-IBTS-Q3).

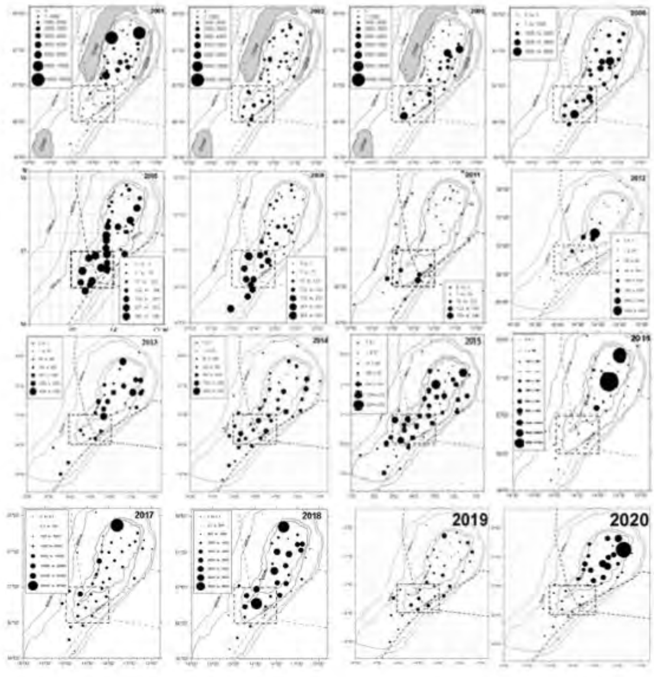


Figure 4.3.2. Haul pattern observed during bottom survey by RV 'Scotia' in September 2020.

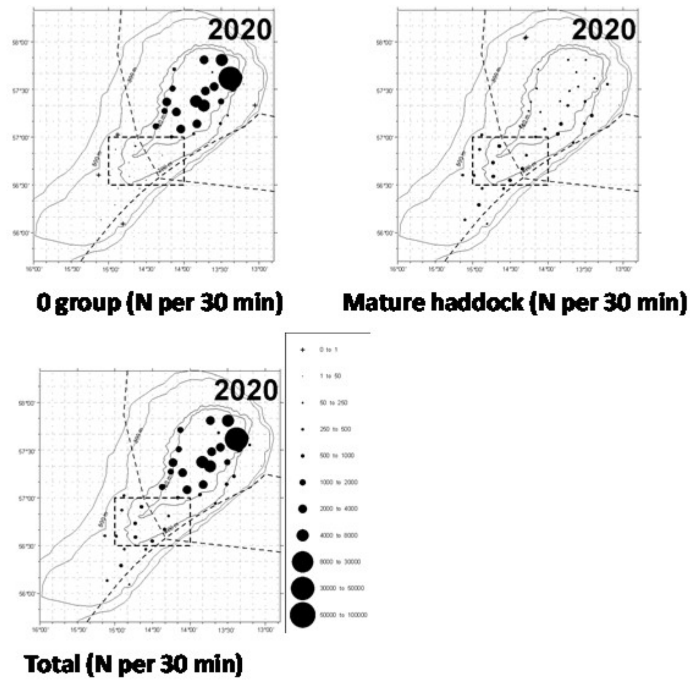


Figure 4.3.3. Distribution of 0-group, mature and total haddock (number per 30 minutes) on the Rockall Bank in 2019 from the Scottish trawl survey.

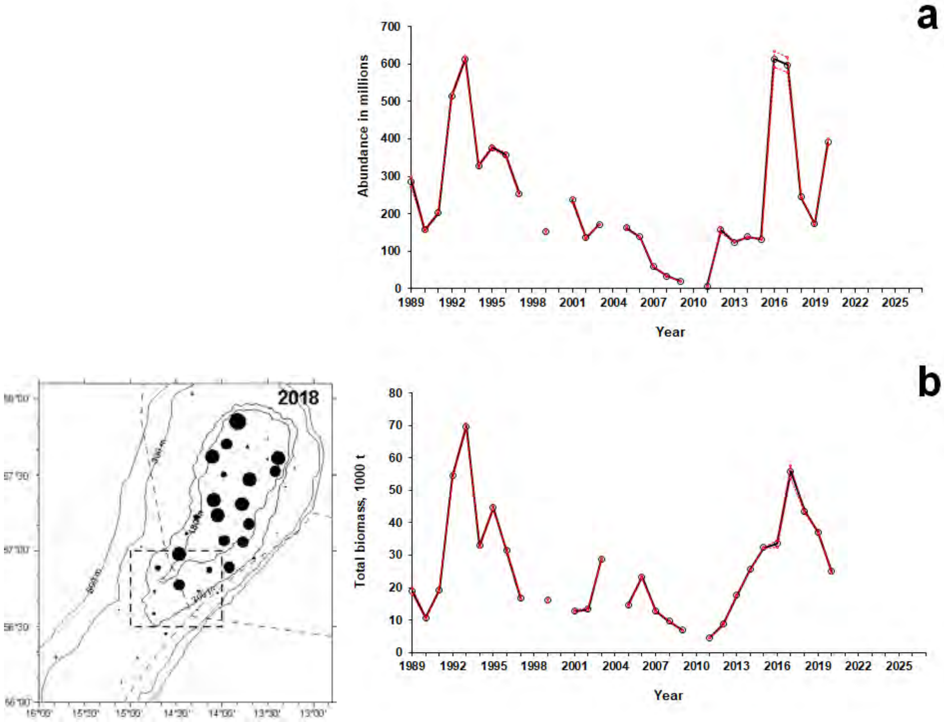


Figure 4.3.4. Abundance (a) and biomass (b) of haddock, assessed with the trawl survey method with geographical stratification based on rectangles of 15’ latitude and 15’ longitude by RV ‘Scotia’ survey. Red dashed line indicates the confidence interval with 0.95 reliability level.

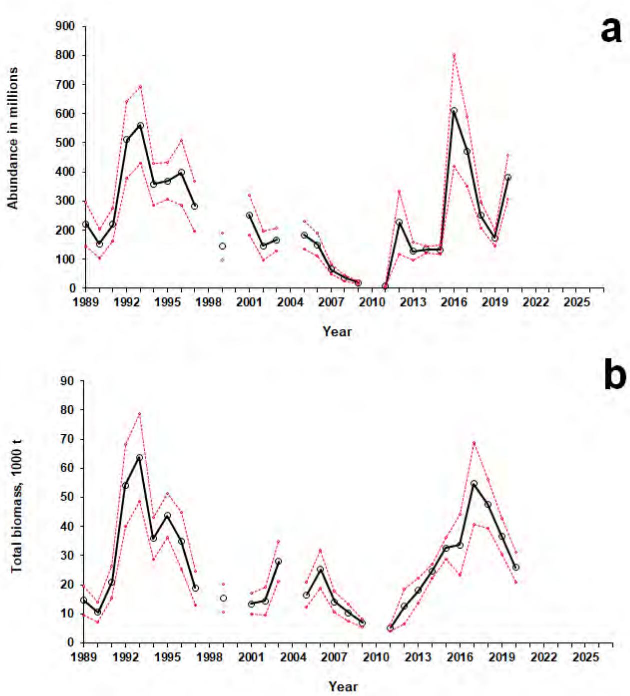


Figure 4.3.5. Abundance (a) and biomass (b) of haddock, assessed with the trawl survey method with geographical stratification based on bathymetry by RV ‘Scotia’ survey. Red dashed line indicates the confidence interval with 0.95 reliability level.

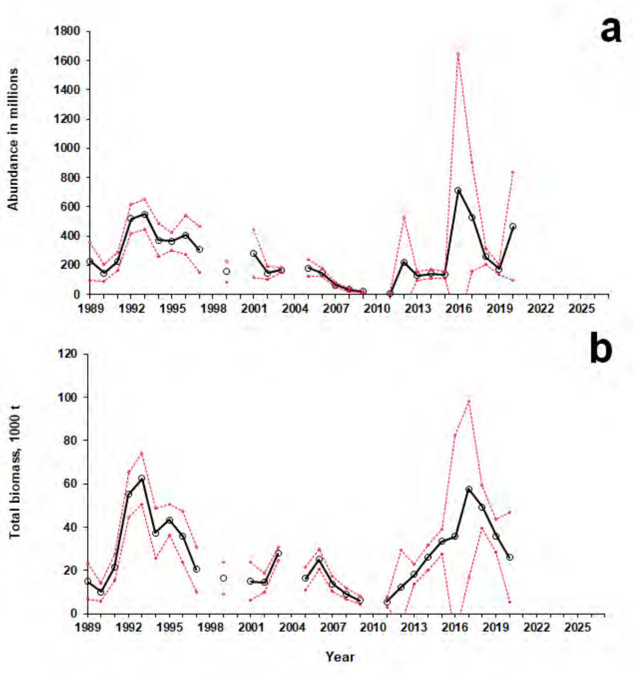


Figure 4.3.6. Abundance (a) and biomass (b) of haddock, assessed with the trawl survey method without geographical stratification by RV 'Scotia' survey. Red dashed line indicates the confidence interval with 0.95 reliability level.

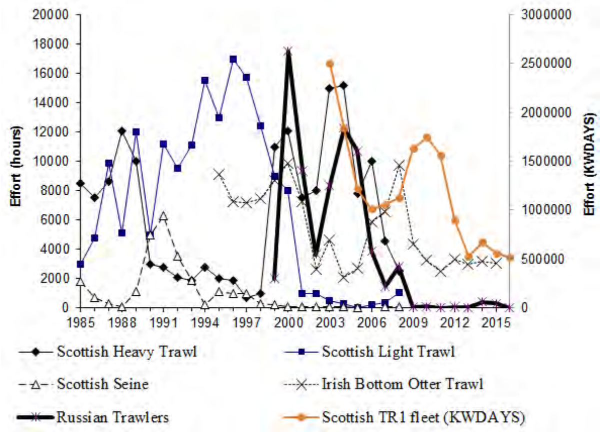


Figure 4.3.7. Rockall haddock in 6.b. Scottish, Irish effort from 1985–2016 and Russian effort from 1999–2016. Data for 2017–2019 are not available.

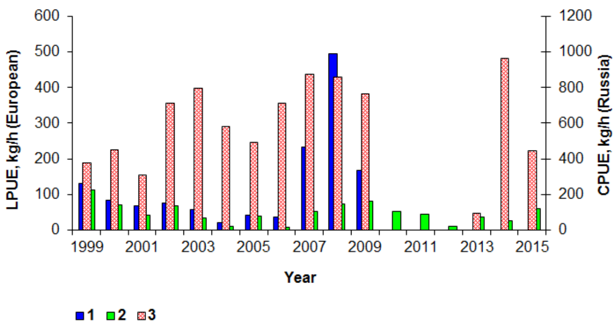


Figure 4.3.8. Lpue and cpue of the fleets fishing for Rockall haddock. Note that Scottish and Irish effort data may be unreliable as reporting is not mandatory (data from 2016–2019 are not available).

1 – Scottish lpue (all gears).

2 – Irish trawlers lpue.

3 – Cpue of Russian trawlers (BMRT type, tonnage class 10 from 1999–2007, and tonnage class 9 during 2008–2009 and 2013–2015).

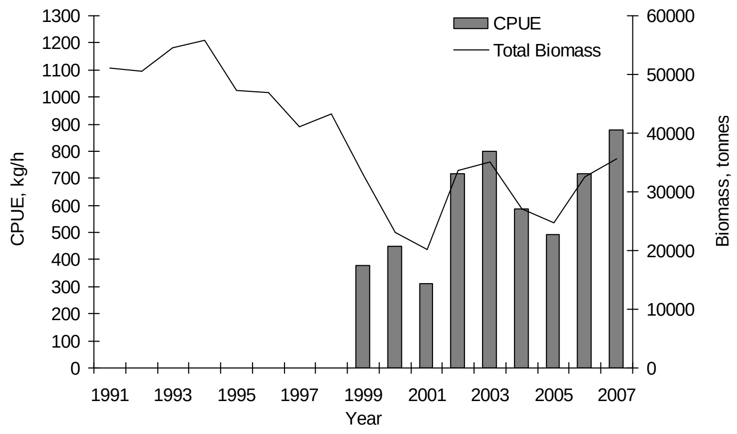


Figure 4.3.9. Dynamics of haddock total biomass (ICES, 2008a; ICES, 2008b) and directed fishing efficiency (t per a trawling hour) for tonnage class 10 vessels from 1999–2007.

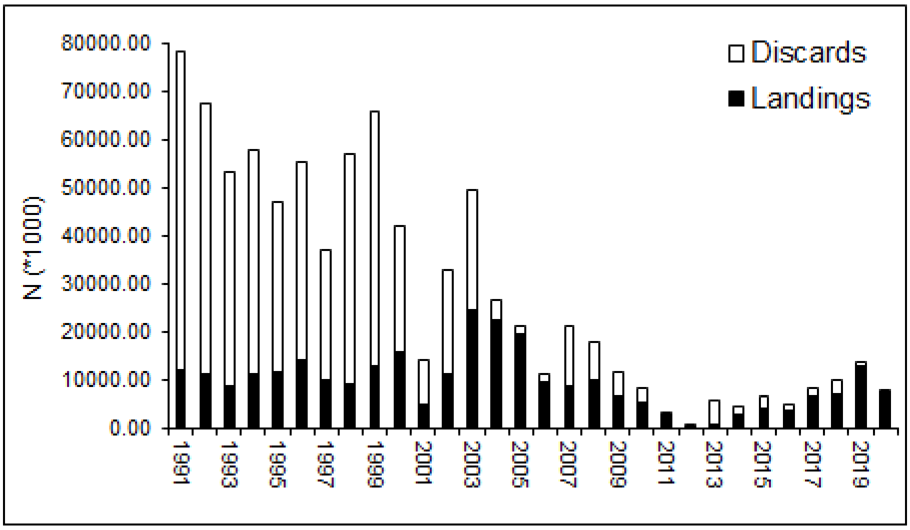


Figure 4.3.10. Time-series of total landings and discards of Rockall haddock ('000 individuals).

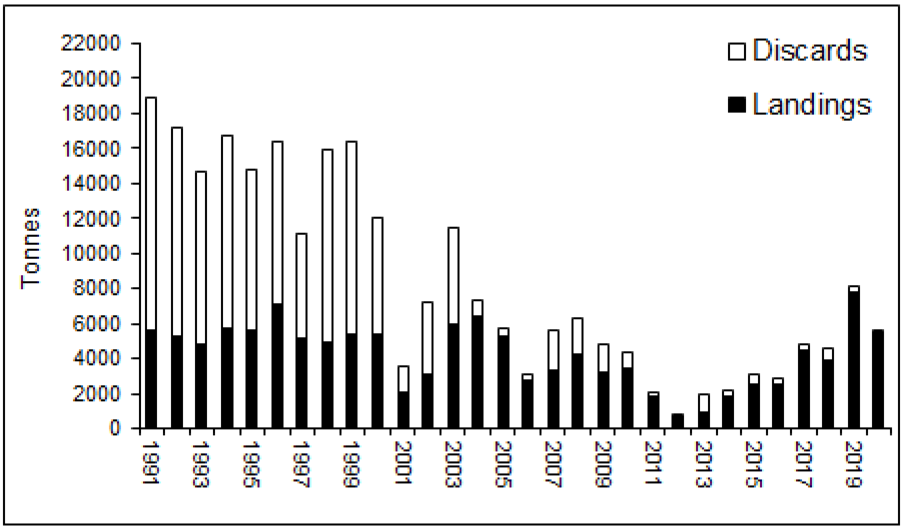


Figure 4.3.11. Time-series of total landings and discards of Rockall haddock (tonnes).

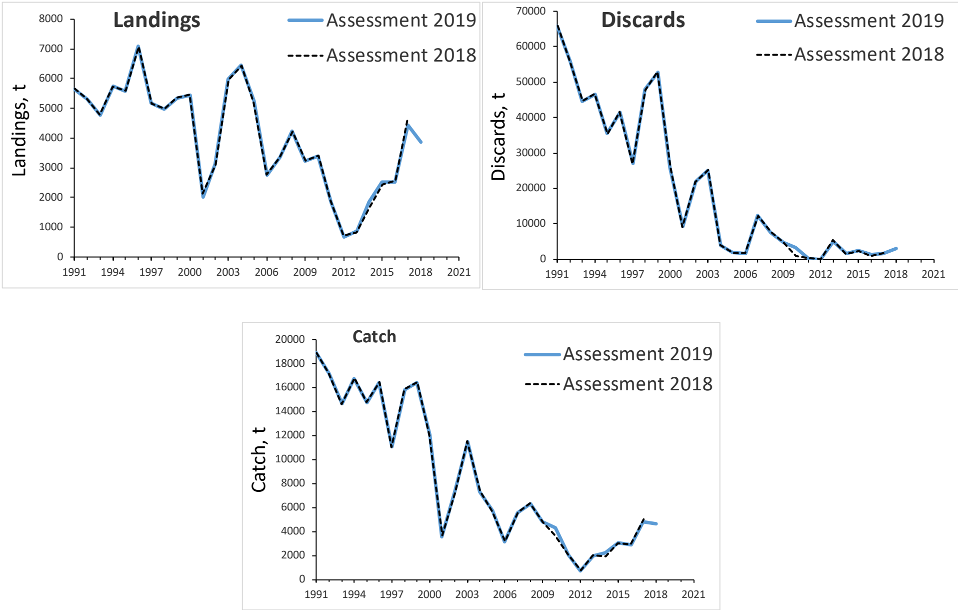


Figure 4.3.12. Comparison between assessment years 2018 and 2019; landings, discards and total catch of Rockall haddock.

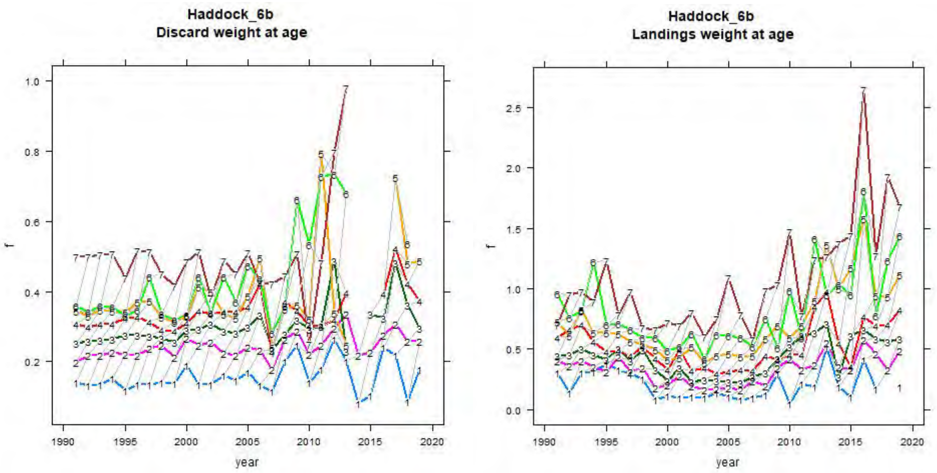


Figure 4.3.13. Haddock in 6.b. Mean weights-at-age in discards (left) and in landings (right).

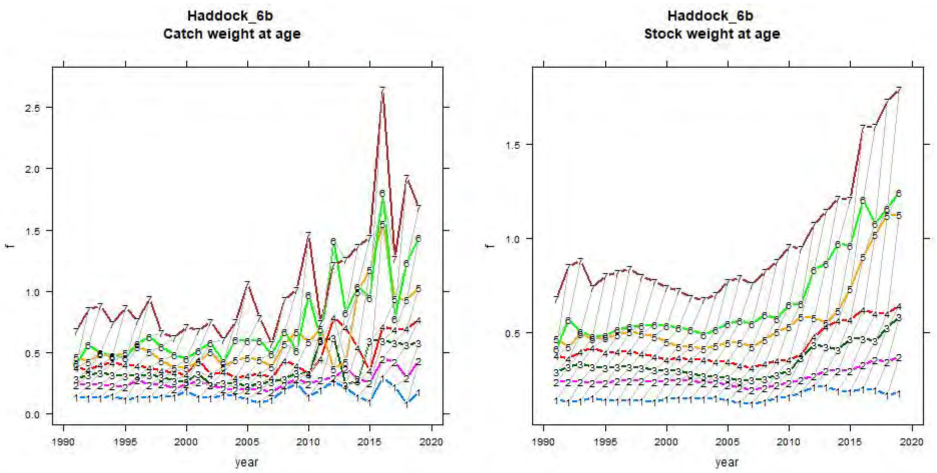


Figure 4.3.14. Haddock in 6.b. Mean weights-at-age in catch (left) and in stock (right).

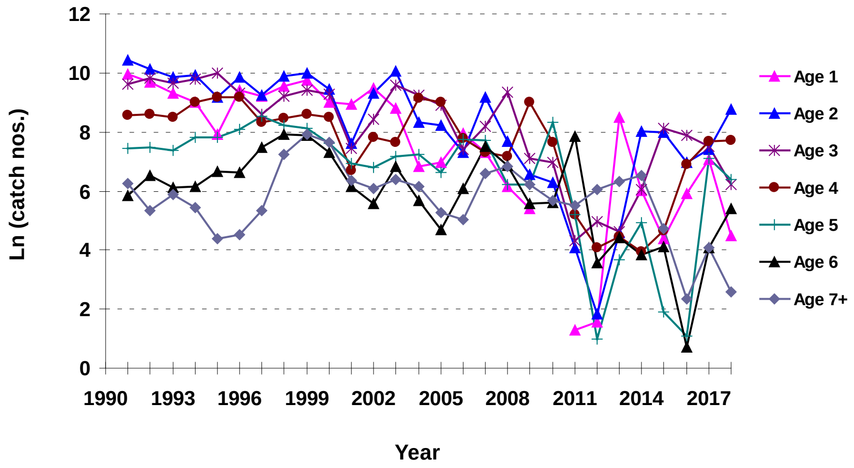


Figure 4.3.15. Haddock in 6.b. Log catch- (with discards in numbers) at-age by year.

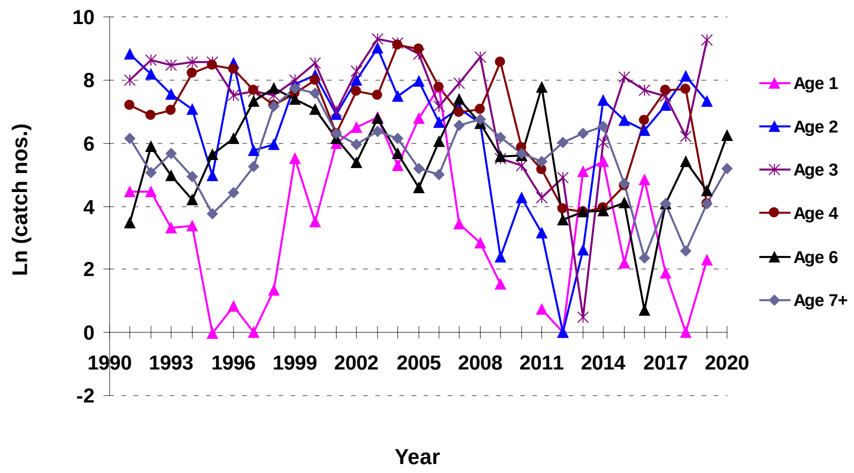


Figure 4.3.16. Haddock in 6.b. Log landings- (in numbers) at-age by year.

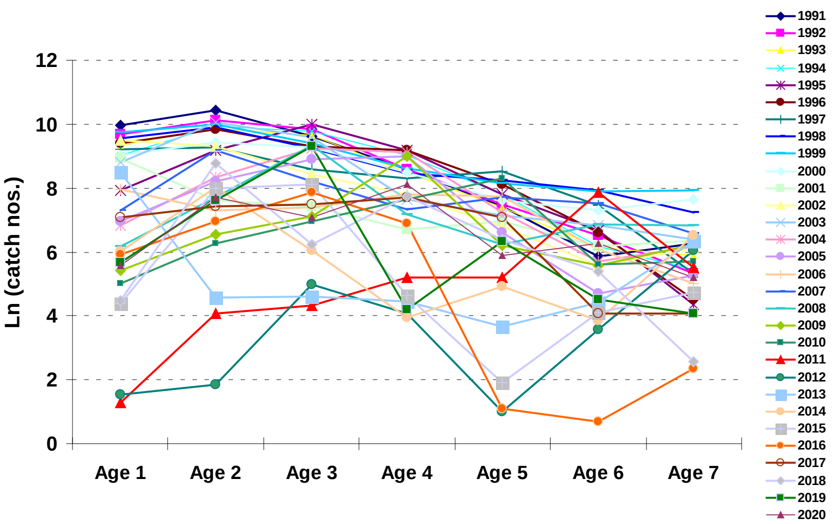


Figure 4.3.18. Haddock in 6.b. Catch curves (with registered discards).

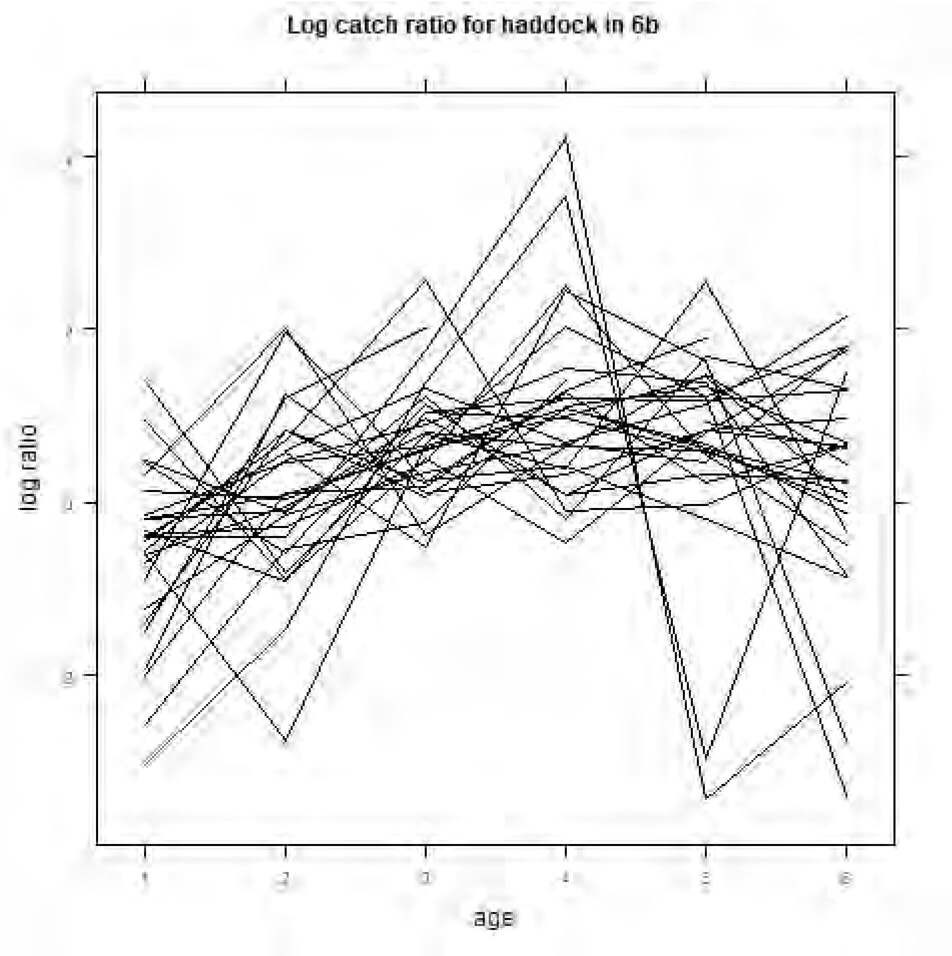


Figure 4.3.19. Haddock in 6.b. Catch curves (with registered discards).

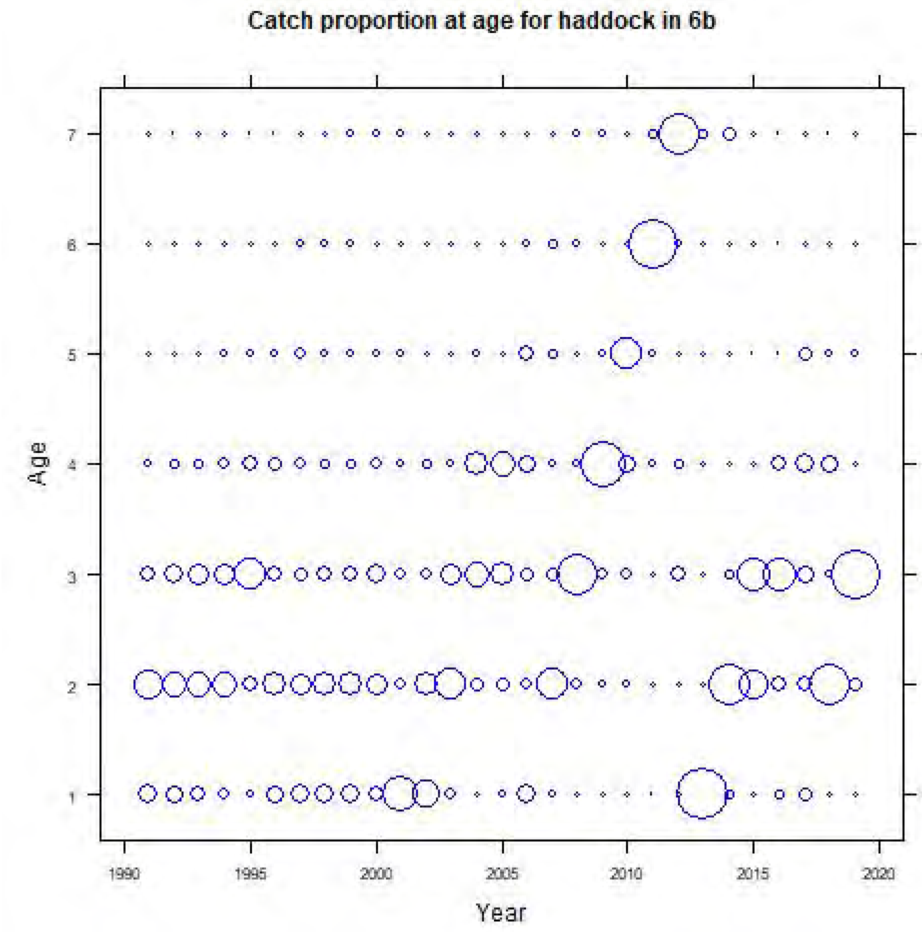


Figure 4.3.20. Haddock in 6.b. Relative catch proportion-at-age.

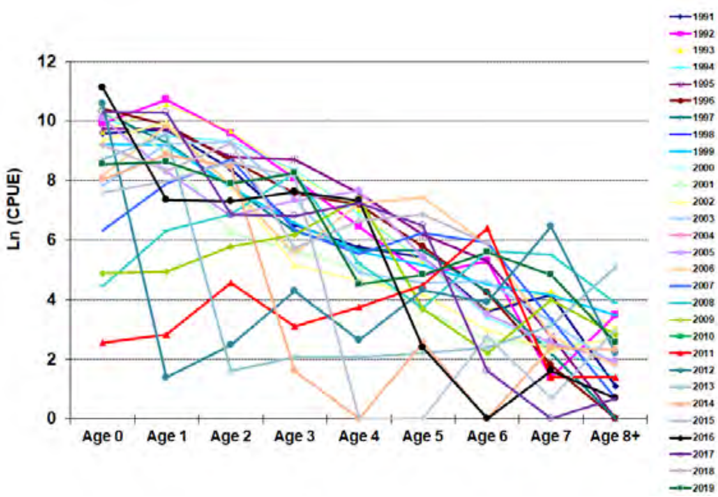


Figure 4.3.21. Haddock in 6.b. Log survey cpue-at-age by year.

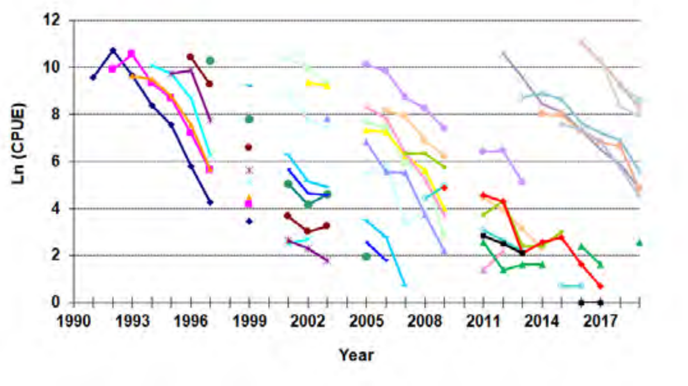


Figure 4.3.22. Haddock in 6.b. Final XSA run. Log survey cpue by year class.

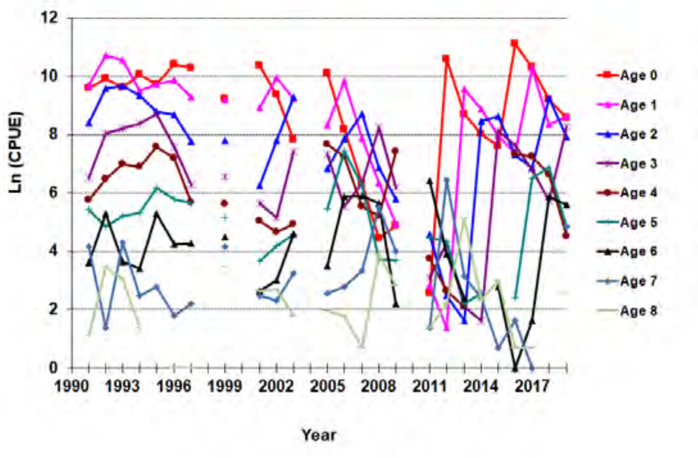


Figure 4.3.23. Haddock in 6.b. Log survey cpue-at-age.

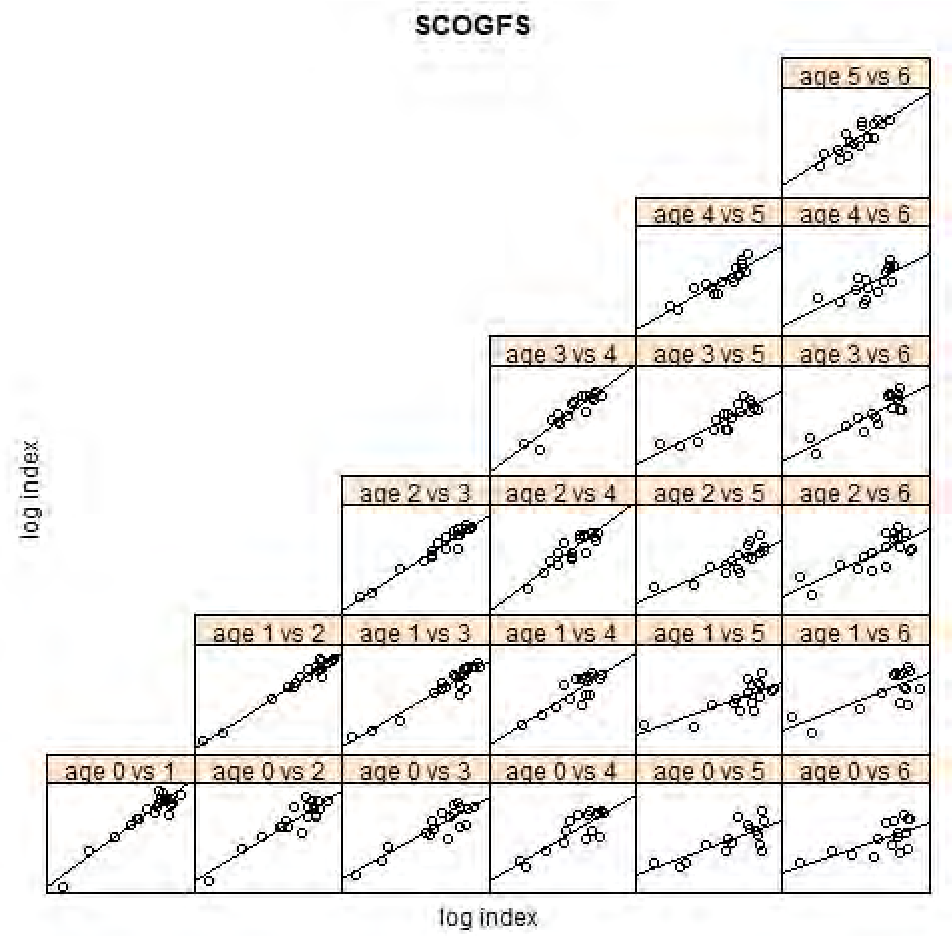


Figure 4.3.24. Haddock in 6.b. The analysis of survey data. Pairwise plots of age.

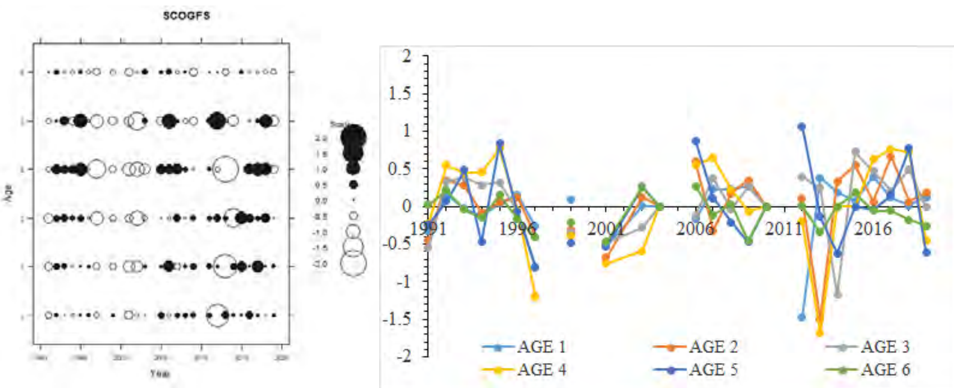


Figure 4.3.25. Haddock in 6.b. Log catchability residual plots (shrinkage 1.0, catchability dependent on stock size at-ages <4). Final XSA.

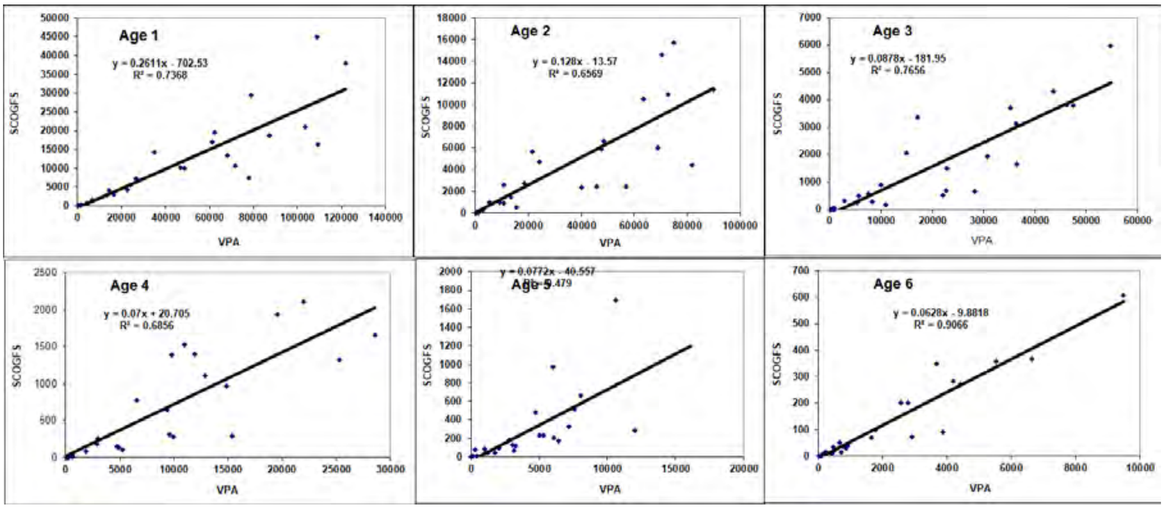


Figure 4.3.26. Haddock in 6.b. Adjusted Scottish groundfish survey cpue from the final XSA run plotted against VPA numbers- (shrinkage 1.0) at-age. Catchability dependent on stock size at-ages <4.

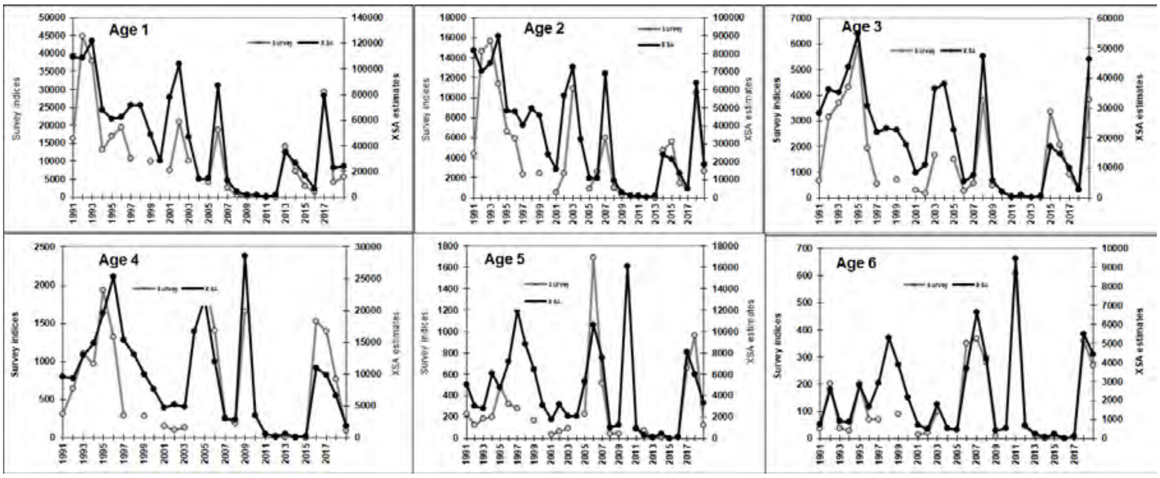


Figure 4.3.27. Haddock in 6.b. Survey indices and XSA estimates (shrinkage 1.0) at-age. Final XSA: catchability dependent on stock size at-ages <4.

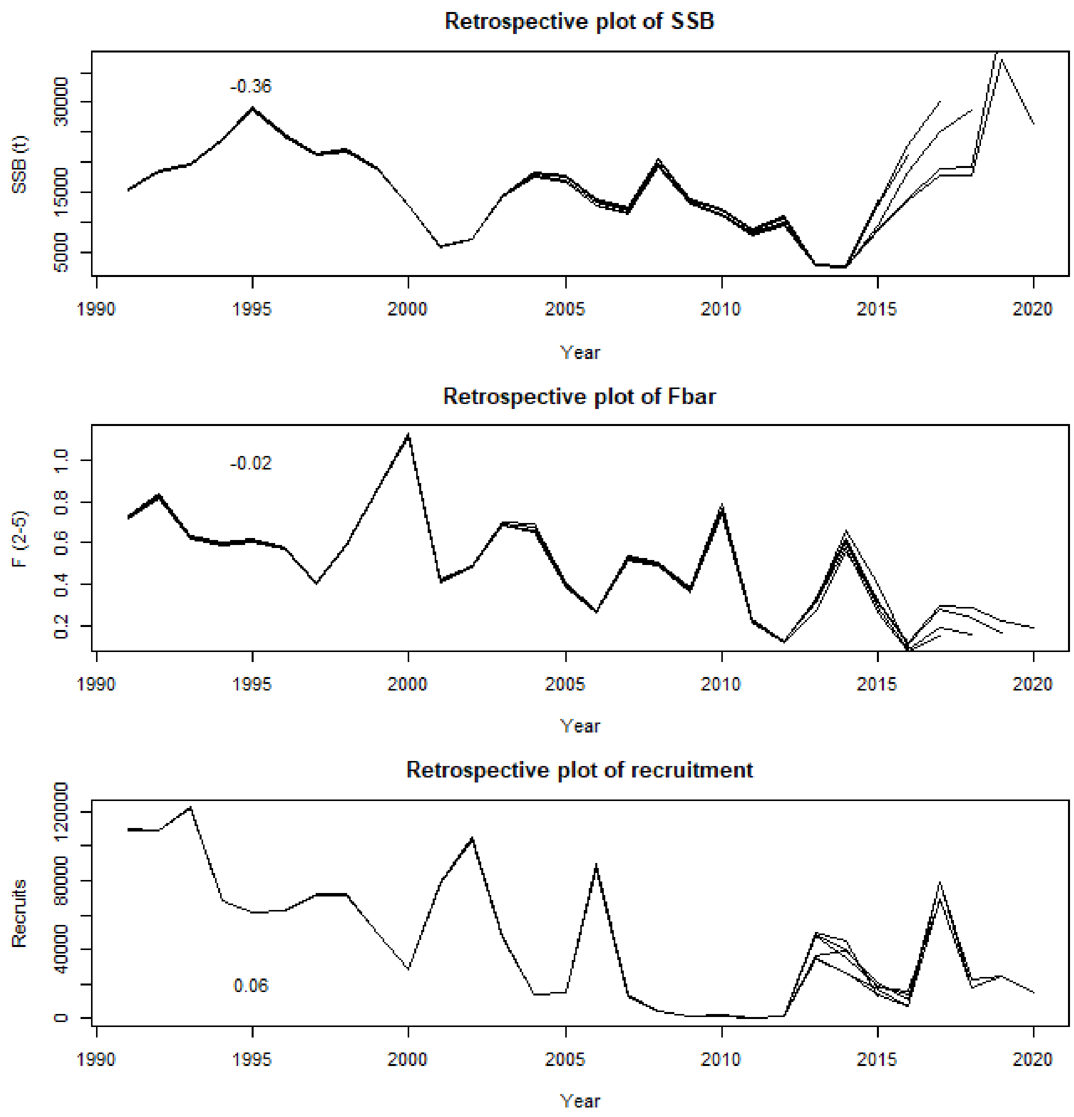


Figure 4.3.28. Haddock in 6.b. Retrospective analyses (F shrinkage 1.0) is implemented in the Mohns Rho.

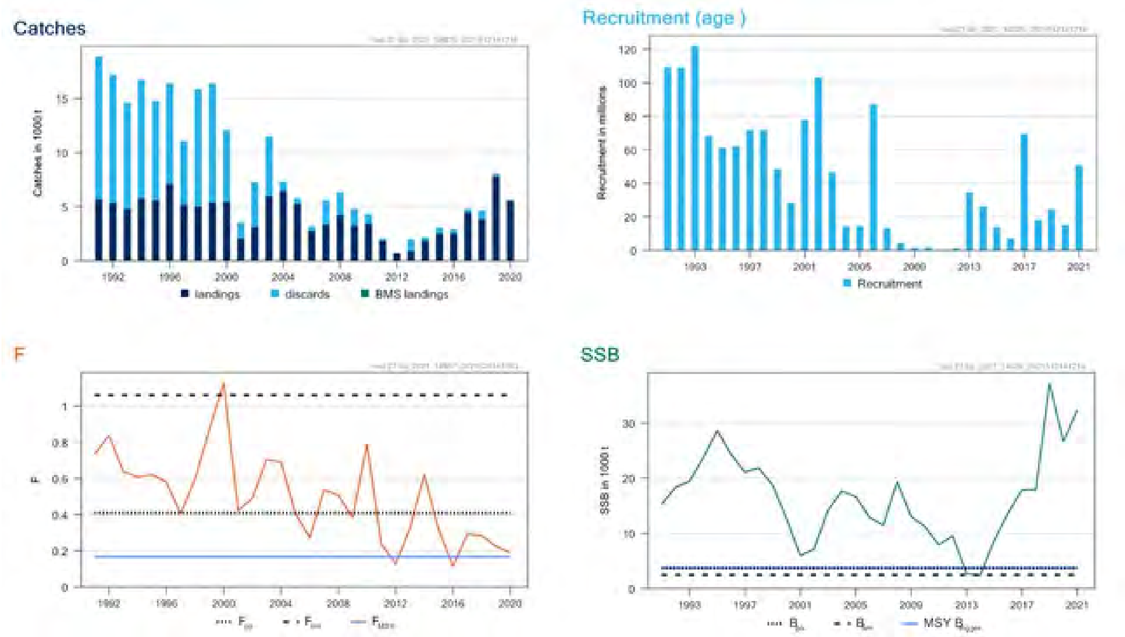


Figure 4.3.29. Haddock in 6.b. XSA assessment. Summary plots.

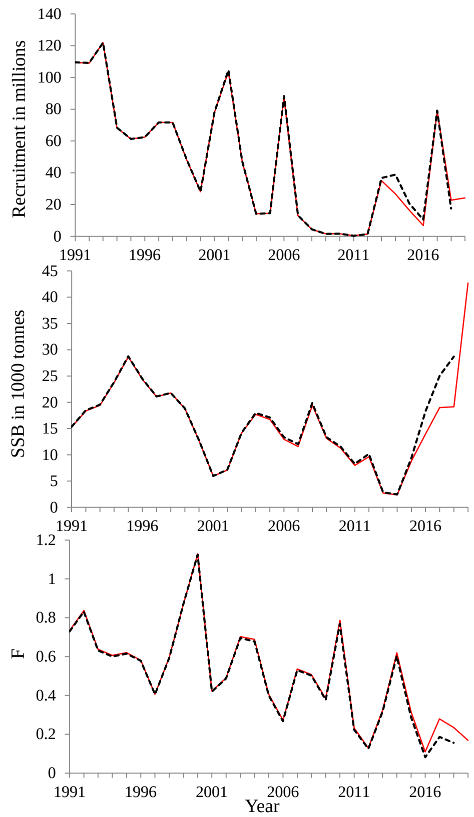


Figure 4.3.30. Haddock in 6.b. Comparison of the current final assessment 2020 (in red) with the previous one 2019 (in black). In the SSB plot, the solid blue line indicates B_{PA} and the dotted blue line refers to B_{lim}. In the fishing mortality plot, the solid blue line signifies F_{PA}.

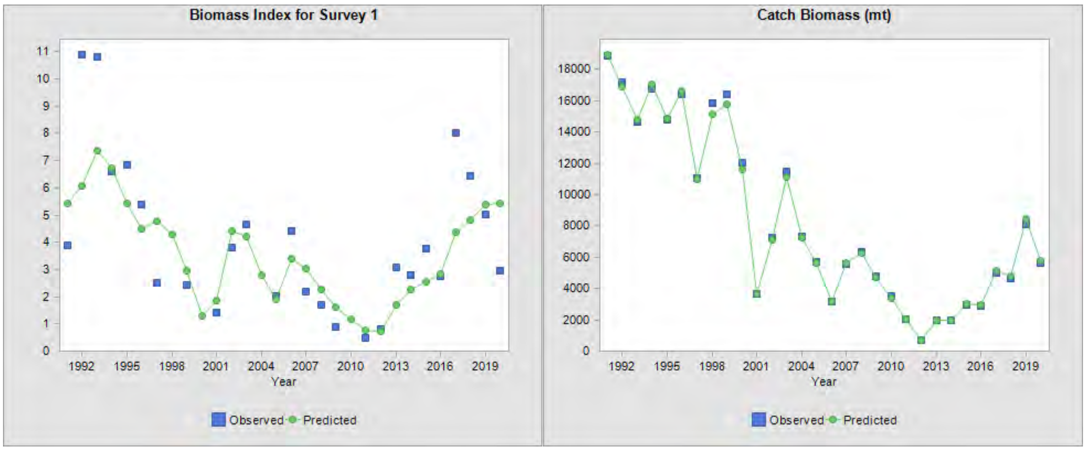


Figure 4.3.31. Haddock in 6.b. Comparison of observed and predicted survey and catch biomass derived from StatCam. The parametric model (scenario 1).

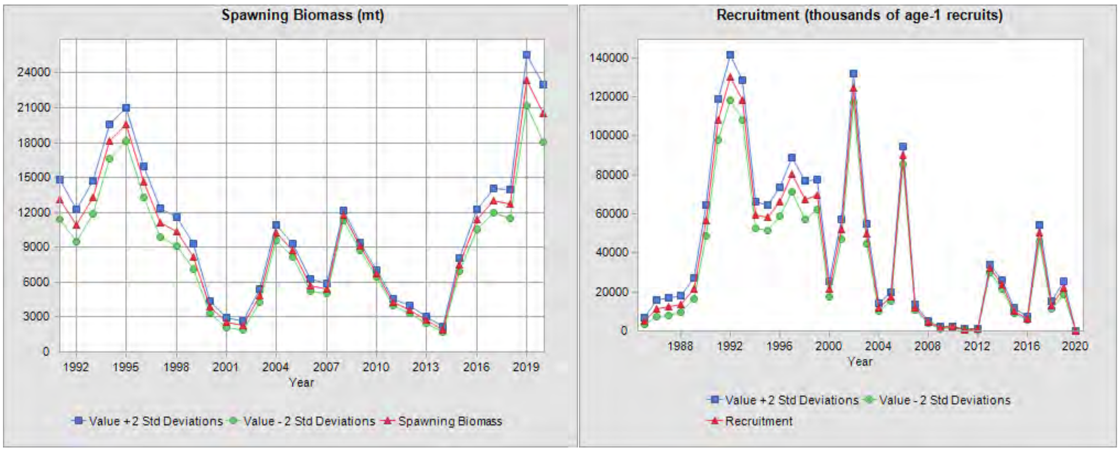


Figure 4.3.32. Haddock in 6.b. The SSB and recruitment by StatCam estimation. The parametric model (scenario 1).

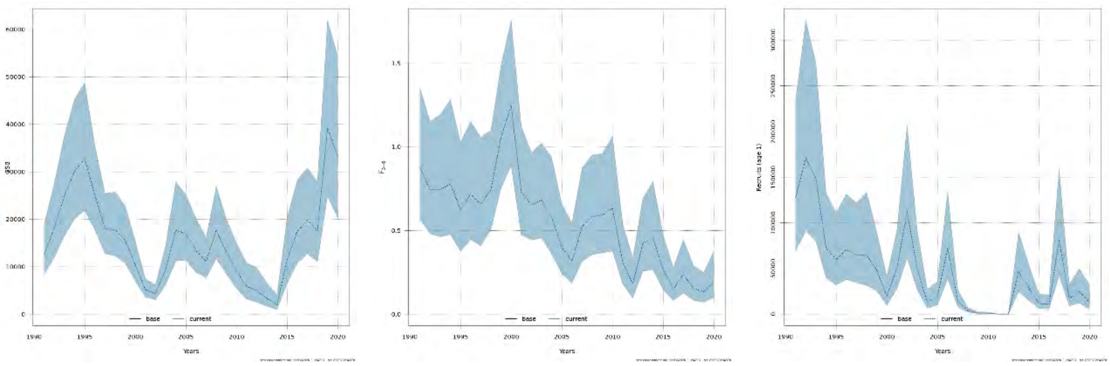


Figure 4.3.33. Haddock in 6.b. The SSB, fishing mortality and recruitment by SAM estimation.

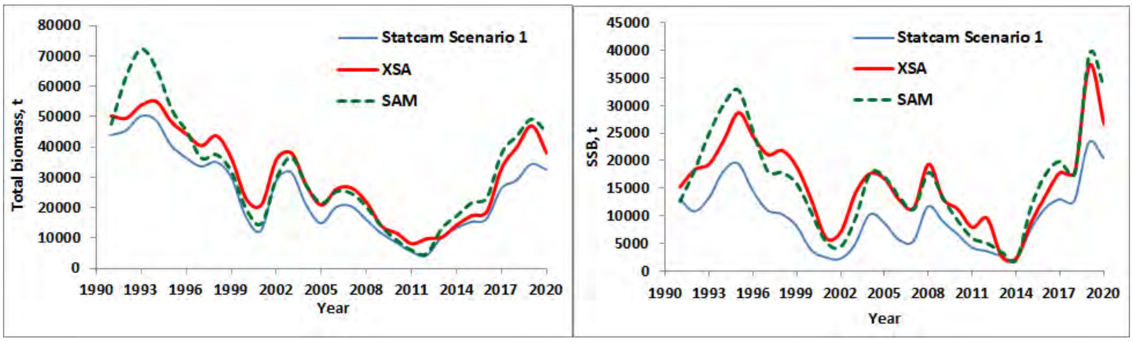


Figure 4.3.34. Haddock in 6.b. Comparison of the final XSA (VPA) assessment with the statistical catch-at-age model StatCam and SAM assessments.

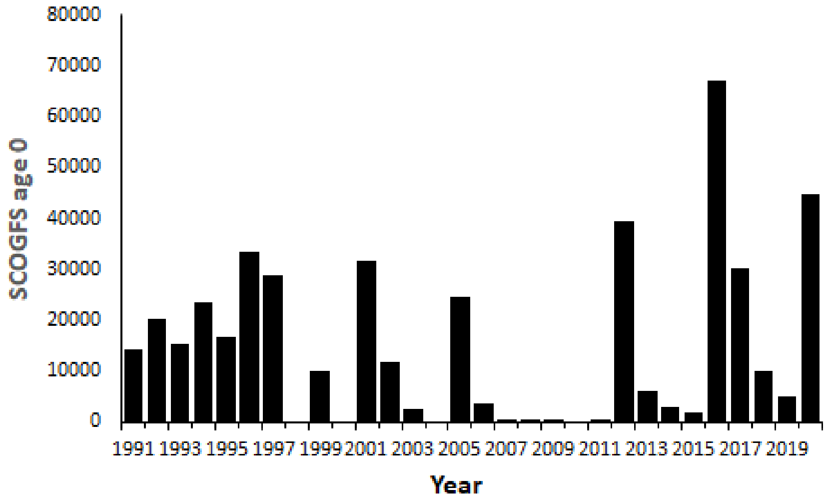


Figure 4.3.35. Haddock in 6.b. Scottish Groundfish survey indices of haddock abundance-at-age 0.

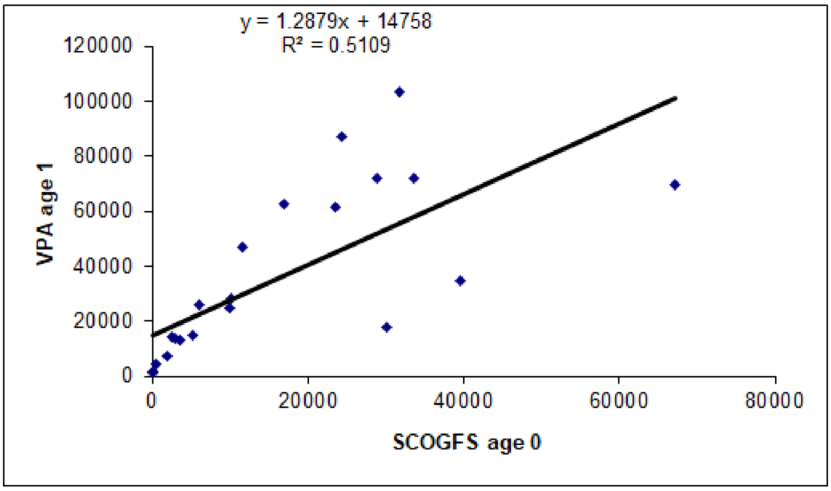


Figure 4.3.36. Haddock in 6.b. VPA numbers-at-age 1 from XSA plotted against Scottish Groundfish survey indices of haddock at-age 0.

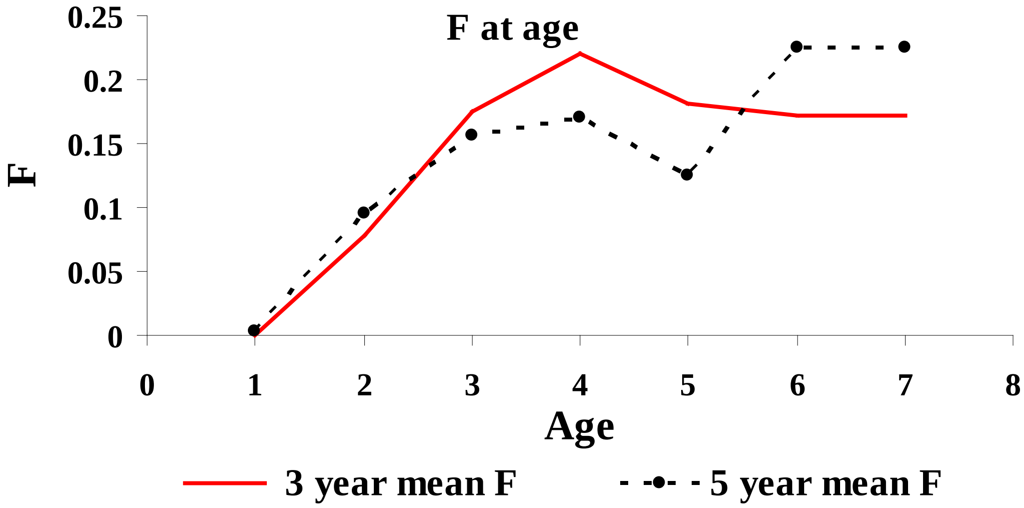


Figure 4.3.37. Haddock in Division 6.b. Three years (2018-2020) and five-year (2016–2020) averages of exploitation patterns.

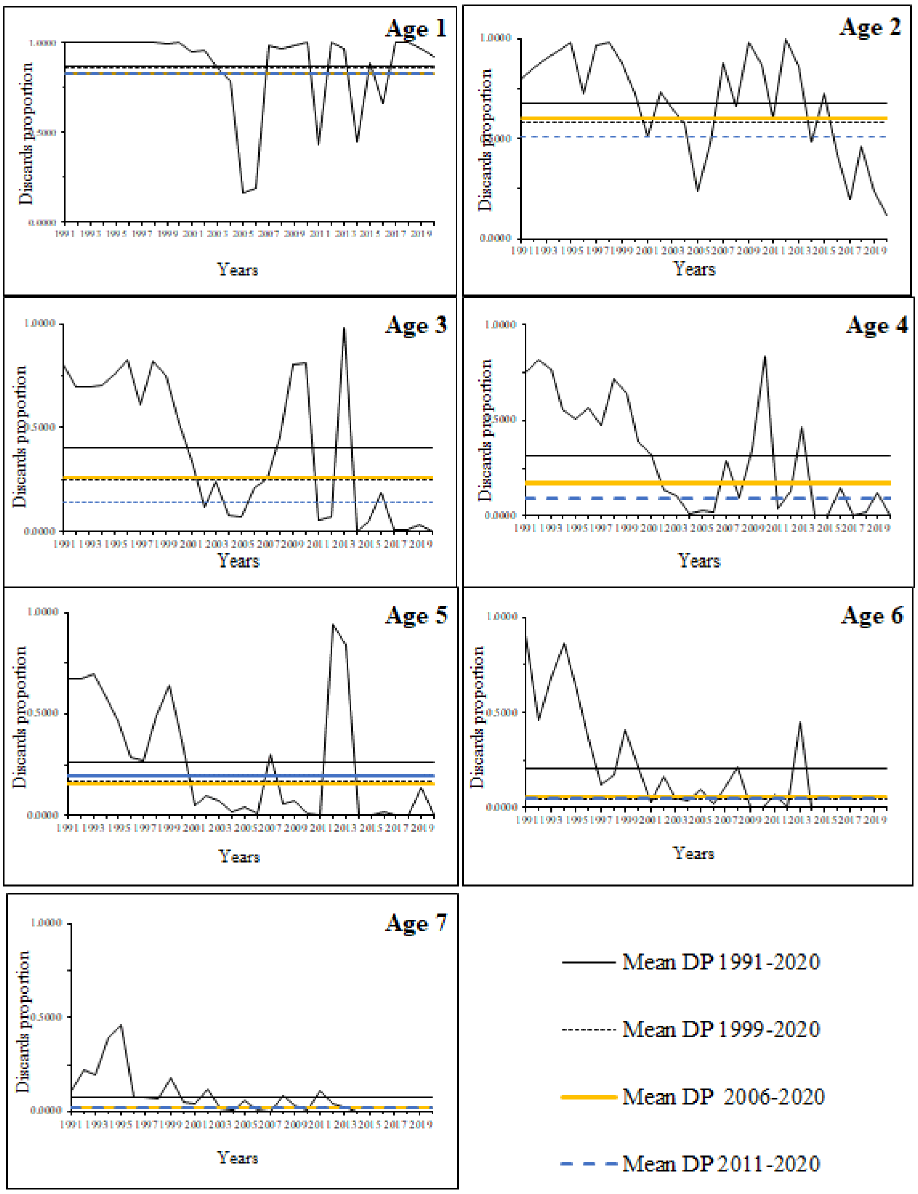


Figure 4.3.38. Haddock in Division 6.b. Discard proportion-at-age by year, and mean discard proportion-at-age for periods: 1991–2019, 1999–20198, 2006–2019 and 2010–2019.

8 Haddock in Divisions 7.b,c,e–k

Type of assessment in 2021

The Cetlic Sea haddock (27.7b,c,e–k) assessment was benchmarked in 2020, with discard and landings data reviewed and updated from 2005 onwards.

The 2021 SAM assessment was undertaken in the web tool: www.stockassessment.org. The procedure detailed in the Stock Annex 5, performed in the preceding year was followed, with adaptations to discard estimates, and landings and discard weights-at-age in 2020.

Owing to reduced sampling in 2020 discard estimates for some countries had to be estimated across international gear types, where in the past estimates were applied with specific reference to country and gear type observations. Estimated catch weights-at-age were found to be lower than the associated proceeding age groups caught in 2019. This was the case for landings and discard weights. In order to account for this, weights-at-age for 2020 were taken as the average weights-at-age seen from 2017 to 2019. Corresponding numbers-at-age in landings, discards, catch and resulting landings fractions were re-calculated based upon the total landings and discards weights.

Investigations were made into a number of different assessment approaches in order to offset the impacts of Covid-19 on 2020 sampling levels. These included:

Option 1 – SAM 2-year 2020 Forecast

Using the 2020 SAM assessment, produce advice from the SAM 2020 forecast extended by a year, to produces a 3-year forecast and advice for 2022 catch, with consistent interim year assumptions in 2020 and 2021.

Option 2 – Survey Based Category 3 assessment

Provide advice based on a Category 3, data limited survey-based approach, (two year mean / three year mean survey ratio, applied to the proceeding years catch advice) based upon the VAST standardised survey Irish and French autumn survey indices.

Option 3 – SAM 1-year 2021 Forecast – updating Survey data only

Run the 2020 SAM assessment and forecast incorporating an update to the 2020 VAST standardised Irish and French autumn survey indices only, with no inclusion of 2020 catch data.

Option 4 – SAM 1-year 2021 Forecast

Update all data, run the SAM assessment model with 2020 survey and catch data and forecast for 2021 catch following the standard approved stock assessment.

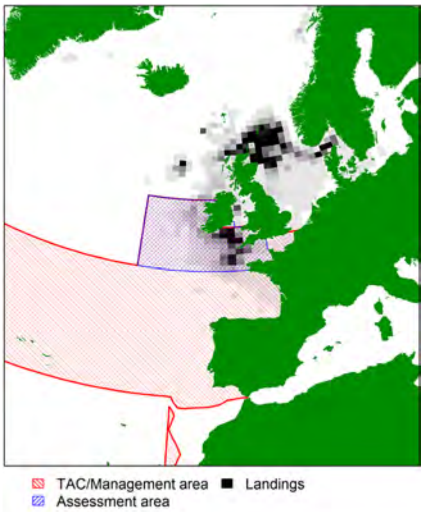
ICES advice applicable to 2021

Last year's full advice is available in the Report of the ICES Advisory Committee, 2020. ICES Advice 2020, had.27.7b–k. https://doi.org/10.17895/ices.advice.5897. The headline advice was as follows:

"ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 12 128 tonnes and 25 454 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (18 382 tonnes) can only be taken under conditions specified in the MAP, while the entire range is considered precautionary when applying the ICES advice rule".

8.1 General

Stock description and management units



The basis for the stock assessment area 7.b,c,e–k is described in detail in the stock annex.

Figure 8.4.1 shows the spatial distribution of international haddock landings in the NE Atlantic for 2016. It is clear from the figure that the stock extends into Area 8 and it could be argued that landings from 8 should be included in the stock area. In recent years these landings varied between 20 and 300 t which is up to 4% of the total landings in the stock area.

The TAC for haddock is set for the combined Areas 7.b–k, 8, 10 and 10 and EU waters of CECAF 34.1.1. This does not correspond to the stock assessment area (7.b–k).

2020 management (Council Regulation (EU) 2020/123)

Species:	Haddock *Melanogrammus aeglefinus*	**Zone:**	7b-k, 8, 9 and 10; Union waters of CECAF 34.1.1 (HAD/7X7A34)
Belgium	121	Analytical TAC	
France	7 239	Article 7(2) of this Regulation applies	
Ireland	2 413		
United Kingdom	1 086		
Union	10 859		
TAC	10 859		

2021 management (Council Regulation (EU) 2021/703)

An agreed EU TAC for only the first seven months of 2021 were agreed at time of writing:

Species:	Haddock *Melanogrammusaeglefinus*	Zone:	7b-k, 8, 9 and 10; Union waters of CECAF 34.1.1 (HAD/7X7A34)
Belgium	91	Analytical TAC	
France	5 441	Article 8(2) of this Regulation applies	
Ireland	1 814	Article 7(1) of this Regulation applies	
Union	7 346		
United Kingdom	pm		
TAC	pm		

Total area TAC is presented as "pm" owing to missing UK quota following BREXIT. The Advised EU TAC follows partial year ICES advice.

Since 2009, a separate TAC is set for 7.a haddock; previously a separate allocation for 7.a existed within the TAC for 7, 8, 9 and 10.

The 2020 EU Council Regulation included Article 13, "Remedial measures for cod and whiting in the Celtic Sea" which will impact the Celtic Sea haddock fishery as these three species occupy similar areas. Article 13 implements spatial and fishing gear restrictions in an effort to reduce fishing pressure on cod and whiting.

8.2 The fishery

The official landings reported to ICES and Working Group estimates of the landings and discards are given in Table 8.4.1. The historic landings are also shown in Figure 8.4.2.

Before 2002, the TAC was well in excess of the landings in the TAC area (Table 8.4.1a). The TAC appeared to become restrictive for France in 2003–2004 and Ireland in 2001–2003 and perhaps after (Table 8.4.1a and Figure 8.4.2b). (WGSSDS05 provided some qualitative evidence that misreporting was a problem). During 2005–2008 landings were well below the TAC. In 2009 and 2010 the total landings were still below the TAC, but the quota appeared to become restrictive again for Ireland and Belgium. Since 2011, the TAC has been close to the total landings and can be assumed to be restrictive for all countries.

Figure 8.4.2a gives a long-term overview of the landings of haddock. The time-series is characterized by a number of peaks with rapid increases in the landings, mostly followed by rapid decreases within a few years, suggesting the fishery was taking advantage of sporadic events of very high recruitment. During the 1960s and 1970s, three such peaks in landings occurred: the landings increased from less than 4000 t to 10 000 t or more. During the 1980s and early 1990s, landings were relatively stable around 2000–4000 t. During the mid-1990s the haddock landings increased again to over 10 000 t, mirroring increased landings in the Irish Sea in that period. Since the late 1990s the landings have varied between 7000 and 10 000 t and in 2012, the landings were the highest on record at more than 18 000 t.

The discard estimate for 2010 was the highest on record at 16 547 tonnes (Table 8.4.1b), this was mainly a consequence of the 2009 cohort entering the fishery.

Table 8.4.2 and Figure 8.4.3 show that Irish commercial lpue was relatively low between 2003 and 2007 after which it increased. Effort in the French gadoid fleet has declined considerably since the early 2000s as the result of a decommissioning scheme. The French and Irish 7.fgh fleets both showed an increase in lpue as the strong 2009 cohort entered the fishery. These data are presented for auxiliary information only; these fleets are not used directly in the assessment.

8.2.1 Information from the Industry

No updated information from industry was received.

8.3 Data

8.3.1 Landings and discard numbers-at-age

2020 sampling data were much reduced owing to COVID-19 pandemic restrictions, across all countries participating in the fishery and traditionally contributing sampling data. As a result, sampling was spread more than in previous years and among countries by fishing gear type, where in proceeding years a stronger element was applied to country-gear type.

The initial work-up of biological sample data did provide weights-at-age for 2020, however owing to the reduced sampling levels the weights-at-age produced suggested that age classes were reducing in weight relative to their proceeding year age-cohorts. To accommodate this, the 2020 weights-at-age were calculated as the mean weights seen from 2017 to 2019, and numbers-at-age recalculated through a Sum of Products procedure relative to their initially observed proportions.

The following descriptions apply to the re-estimated weights and numbers-at-age.

Discard and retained catch-at-age distributions are shown in Figure 7.4.4. Many of the discarded fish will be above the MLS, which is likely to be the result of restrictive quota.

Figures 8.4.5 and 8.4.6 show the available time-series of catch (discards and retained catch) and age distributions.

Sampled and un-sampled catch (landings and discards) by country are shown in Figure 8.4.7.

Landings numbers-at-age are given in Table 8.4.3a and discard numbers-at-age are given in Table 8.4.3b. Despite some uncertainty about the quality of the discard data, it is possible to track strong year classes in both the discards and the landings-at-age matrices. Discards account for a large proportion of the catch numbers up to age 3. Figure 8.4.6 shows the proportions-at-age that are discarded.

Figure 8.4.8 shows that the raw stock weights-at-age which are fairly noisy, a 3-year running average was applied to the stock weights used in the assessment. There appear to be cyclical trends in the weights-at-age that follow cohorts (rather than year-effects).

8.3.2 Biological

The assumptions of natural mortality and maturity are described in the stock annex. The maturity ogive used in the assessment is quite sharp, with 0.39% of 2-year olds and 91% of 3-year olds mature (stock annex).

8.3.3 Surveys and commercial tuning fleets

The available surveys and commercial tuning fleets are described in detail in the stock annex. One survey index is used in the assessment: the FR-IRL-IBTS index, which is a combined index from the French EVHOE Q4 WIBTS and Irish IGFS Q4 WIBTS surveys. This is standardised following the VAST procedure (stock annex).

The index data are given Table 8.4.4. The standardised indices are given by year in Figure 8.4.9 and by cohort in Figure 8.4.10. Figure 8.4.11 shows the scatterplot matrices of the log indices. These plots indicate that the internal consistency of the indices is robust.

8.4 Historical stock development

Model used: SAM

Software used: Stock Assessment.Org (https://www.stockassessment.org)

8.4.1 Data screening

The general approach to data screening and analysis was followed in addition to the data exploration tools available in the FLR package FLEDA. The results of the data screening are fully documented using R markdown and are available in the folder 'Data\Stock\had-7bce–k' on the ICES SharePoint.

8.4.2 Final update assessment

The final assessment was run with the same settings as established by WKCELTIC 2020 and described in the stock annex. While discards were combined with the landings and not supplied separately to the model, annual discard fractions were incorporated.

Figure 8.4.12 shows the residuals of that catch proportions-at-age. For age classes where discards dominate, the residuals are relatively large. There is no obvious pattern in the younger ages but the residuals in the middle of the time-series show a mostly positive evolution from the 2006 cohort. The strongest negativities residuals occur for the older age classes in 2006. Observed and assessment predicted catches are shown in Figure 8.4.13 and 8.4.14. The predicted catches were generally accurate while there was a tendency for under estimation from 2011–2018.

In the proportions-at-age residual plots of the survey (FRA-IRL-WIBTS_VAST) there are no consistent patterns (Figure 8.4.13). The observed and predicted index cpue values are shown in Figure 8.4.15. The assessment generally follows the survey index trends in age classes across the time-series.

The SAM assessment is shown in Figure 8.4.16, detailing catch, landings, SSB F and recruits with 95% confidence intervals.

8.4.3 State of the stock

Table 8.4.6 shows the estimated fishing mortality-at-age and Table 8.4.7 shows the stock numbers-at-age. The stock summary is given in Table 8.4.8.

The spawning–stock biomass (SSB) peaked in 2011 as the very strong 2009 year class matured; this cohort was followed by three years of below-average recruitment which led to a rapid decline in SSB after 2011. Recent recruitment has varied around the average, with a notable peak in 2009 and in 2018. SSB appears to have stabilised, while fishing mortality (F) has been above F_{MSY} for the entire time-series but shows a declining trend.

8.5 Short-term projections

Because recruitment of haddock is characterised by sporadic events, the assumed median recruitment for the intermediate years introduces significant uncertainty for the SSB estimate.

Short-term projections were performed in SAM as a stochastic process. Recruitment was estimated at 312 600 and 245 785 in 2021 and 2022 respectively, (medians 1993–2019; thousands). The short-term predictions are expected to give a reasonably reliable estimate of landings and discards in 2021 (assuming average F 2018–2020 and average discard patterns seen in 2018–2020).

Intermediate year assumptions are given in Table 8.4.9. The management options are given in Table 8.4.10.

8.6 MSY evaluations and biological reference points

ICES carried out and evaluation of MSY and PA reference points for this stock at WKCELTIC (ICES, 2020). The results are summarized below:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	12822	B_{pa}; in tonnes.	ICES (2020a)
	F_{MSY}	0.353	Based on simulation using a segmented regression stock–recruitment relationship (EqSim)	ICES (2020a)
Precautionary approach	B_{lim}	9227	Lowest observed SSB; in tonnes	ICES (2020a)
	B_{pa}	12822	B_{lim} combined with the assessment error; $B_{lim} \times \exp(1.645 \times \sigma)$; σ = 0.20 (default setting); in tonnes	ICES (2020a)
	F_{lim}	1.40	F with 50% probability of SSB < B_{lim}	ICES (2020a)
	F_{pa}	0.71	$F_{p0.5}$; the F that leads to SSB ≥ B_{lim} with 95% probability	ICES (2020a)
EU MAP	MAP MSY $B_{trigger}$	12822	MSY B_{pa}; in tonnes	EU (2019), ICES (2020a)
	MAP B_{lim}	9227	Lowest observed SSB; in tonnes	EU (2019), ICES (2020a)
	MAP F_{MSY}	0.353	F_{MSY}	EU (2019), ICES (2020a)
	MAP range F_{lower}	0.221	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with MSY	EU (2019), ICES (2020a)
	MAP range F_{upper}	0.521	Consistent with ranges resulting in no more than 5% reduction in long-term yield compared with MSY	EU (2019), ICES (2020a)

8.7 Management plans

The EU multiannual plan (MAP) for the Western Waters (EU, 2019), incorporating the stock haddock 7.b,c,e–k has been agreed. This MAP "establishing a multiannual plan for stocks fished in the Western Waters and adjacent waters, and for fisheries exploiting those stocks", under article 17 states that "It is appropriate to establish the target fishing mortality (F) that corresponds to the objective of reaching and maintaining MSY as ranges of values which are consistent with achieving MSY(F_{MSY}). Those ranges, based on best available scientific advice, are necessary in order to provide flexibility to take account of developments in the scientific advice, to contribute to the implementation of the landing obligation and to take into account the characteristics of mixed fisheries."

8.8 Uncertainties and bias in assessment and forecast

8.8.1 Landings

Sampling levels of the landed catch for recent years are considered to be sufficient to support current assessment approaches, although the assessment is contingent on the accuracy of the landings statistics. 2020 sampling levels were not appropriate to raise all national discards owing to COVID-19 pandemic affecting sampling, and international, gear level discard proportions were used. Weights-at-age resulting from data raising produced age which were not appropriate, with fish standardly "loosing" weight from age *x* to age *x*+1, which was considered not appropriate. In order to establish appropriate weights-at-age, average weights-at-age, from 2017 to 2019 were used.

8.8.2 Discards

Irish discards have been monitored since 1995. The number of trips sampled has varied considerably over time (between three and 62 trips per year). Sample numbers were particularly low in 1995, 1999–2002 and 2006. During the remaining years, the number of sampled trips was considered sufficient to give reliable estimates of discards.

French discard data exist from 2004 onwards but the data are not considered to be reliable before 2008. The time-series of French discards was reconstructed by assuming that 90% of one-year olds, 50% of two-year olds and 10% of three-year olds were discarded throughout the time-series. These proportions were estimated from the available discard and retained catch data provided by France. Discards were estimated for the early part of the time-series at WKROUND (2012) and retained by WKCELTIC up to 2004.

Although recent discard estimates are considered to be more reliable, the problem remains that the number of observer trips is very small compared to the total number of trips (typically <1% of all trips are sampled). The level of uncertainty owing to the small sample sizes is likely to be high but the cost of increasing discard coverage would be considerable. As mentioned sampling levels were considerably low in 2020.

8.8.3 Assessment bias

Figure 7.4.18a shows the retrospective of the ASAP analysis. The predicted catch shows little retrospective pattern, neither does the SSB estimate. The Recruitment however, has a relatively high Mohn's Rho at 19% owing primarily to the last of five data reductions. F shows variable tendencies with removal of data years; however, no overall pattern is discernible and the Mohn's Rho is low at 3%. The historical assessment (Figure 8.4.19) shows the agreement between the 2020 and 2021 assessments while the earlier ASAP assessment showed a more variable pattern of F and lower estimated of SSB in the recent past.

8.9 Forecast

The 2018 cohort accounts for over 77% the projected landings in 2020, with recruitment of this cohort estimated with a CV of 21%, which is reasonably precise and recruitment estimates have tended to be accurate in the past with little retrospective bias. The strong cohort was picked up by both the Irish and French quarter 4 surveys in 2018.

The 2018 GM recruitment assumption does not contribute much to the forecasted landings in 2020 (3% contribution), however it contributes 35% to the 2021 SSB estimate; this adds considerable uncertainty to the 2021 SSB forecast.

The large recruitment event seen in 2018 surveys is expected to contribute significantly to the realised 2019 catch and 2020 catch, (Figure 8.4.20, Tables 8.4.11 and 8.4.12).

8.10 Recommendation for next benchmark

8.10.1 Stock audit

The audit of the 2019 report did not raise any concerns.

8.10.2 Recommendations for future work

WGCSE recommend that cod, haddock and whiting in the Celtic Sea will be benchmarked together in 2019–2020. The focus of the benchmark will streamline data compilation procedures for fishery-dependent and survey data. This will give improved transparency and diagnostics surrounding commercial tuning fleets and surveys. The benchmark will also re-examine the assessment methods and diagnostics given the potential for changes in selectivity in the commercial fishery. The benchmark should also consider mixed fisheries and multispecies interactions as well as environmental drivers that may be impacting on growth and recruitment of all three species.

Catch data should continue to be monitored for indirect evidence of improved selection patterns due to the augmented TCMs in the Celtic Sea. Direct monitoring of escapement through SMPs would also be useful.

It would be desirable to include discards separately in the assessment model in order to specify greater precision for the discard numbers-at-age than for the landings numbers-at-age. However, WKROUND (2012) concluded that this resulted in undesirable residual patterns. The benchmark workshop did not have sufficient time to fully evaluate this problem.

It would be worth investigating the value of the commercial tuning fleet. If this fleet is to be retained it would be useful to apply a method of standardisation to account for possible changes in the fleet.

8.11 Management considerations

The stock size fluctuates strongly over the time. The size of the stock is determined to a large extent by recruitment, which has been erratic and in 2018 is shown to have been large. There is no discernible relationship between stock size and recruitment, as is the case with most haddock stocks.

Fishing mortality has been consistently above F_{MSY}, but this has not led to a decreasing trend in stock size, which suggests that the stock is robust to overfishing, however F has been increasing since 2015 and at current levels the SSB could quickly fall below MSY $B_{trigger}$ if recruitment were to be low for three or four years. Recent high 2018 recruitment is not yet appearing in the SSB estimates, which continues to fall.

The variable recruitment has also resulted in substantial short-term variability in TACs and high discards have occurred when a strong year class occurs, this is expected to be the case in 2019 and 2020 (Figure 8.4.19). Discarding of under-size as well as marketable fish is a serious problem for this stock, with approximately $^2/_3$ in catch numbers and almost half the catch weight has been discarded on average over the past decade. Alternative or complimentary approaches to managing such strong, recruit-driven fluctuations are required, especially with regard to the EU landings obligation.

The minimum landing size of haddock is 30 cm, which is approximately the same as the mean length of two-year old haddock in the Celtic sea. Because gadoids are caught in a mixed fishery, restrictive quota in recent years have led to increased discarding of marketable fish as well as already considerable discarding of undersized fish. Technical measures have been introduced to reduce discards of undersize gadoids (110 mm square-mesh panel in the *Nephrops* fisheries and 100 mm in the gadoid fisheries). It is not clear whether this is sufficient to reduce discard mortality of future cohorts. It is important that technical measures are fully implemented and their effectiveness in reducing discards and impact on commercial catches are monitored and evaluated.

8.12 References

EU. 2019. Regulation (EU) 2019/472 of the European Parliament and of the Council of 19 March 2019 establishing a multiannual plan for stocks fished in the Western Waters and adjacent waters, and for fisheries exploiting those stocks, amending Regulations (EU) 2016/1139 and (EU) 2018/973, and repealing Council Regulations (EC) No 811/2004, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007 and (EC) No 1300/2008.

COUNCIL REGULATION (EU) 2020/123 of 27 January 2020, fixing for 2020 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters.

COUNCIL REGULATION (EU) 2021/703 of 26 April 2021, amending Regulations (EU) 2021/91 and (EU) 2021/92 as regards certain fishing opportunities for 2021 in Union and non-Union waters.

ICES. 2016a. Report of the Workshop to consider FMSY ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13–16 October 2015, Brest, France. ICES CM 2015/ACOM:58. 187 pp.

ICES. 2016b. EU request to ICES to provide F_{MSY} ranges for selected stocks in ICES subareas 5 to 10. ICES Advice 2016 Book 5, ICES Special Request Advice, Published 5 February 2016.

Table 8.4.1.a. Haddock in 7.bc–ek. Official landings (quota uptake in brackets).

Year	BEL	ESP	FRA	IRL	UK*	Others	Total	TAC**
1994	123	0	2788	908	240	17	4076	
1995	189 (28%)	19	2964 (74%)	966 (72%)	266 (44%)	64	4468	6000
1996	133 (9%)	48	4527 (49%)	1468 (47%)	439 (31%)	38	6653	14000
1997	246 (16%)	54	6581 (71%)	2789 (90%)	569 (41%)	31	10270	14000
1998	142 (6%)	260	3674 (28%)	2788 (63%)	445 (22%)	52	7361	20000
1999	51 (2%)	88	2725 (19%)	2034 (42%)	278 (13%)	71	5247	22000
2000	90 (5%)	110	3088 (28%)	3066 (83%)	289 (17%)	13	6656	16600
2001	165 (12%)	646	4842 (61%)	3608 (135%)	422 (35%)	19	9702	12000
2002	132 (128%)		4348 (70%)	2188 (106%)	315 (34%)	106	7089	9300
2003	118 (130%)		5781 (106%)	1867 (103%)	393 (48%)	82	8241	8185
2004	136 (127%)		6130 (96%)	1715 (80%)	313 (33%)	159	8453	9600
2005	167 (130%)		4174 (54%)	2037 (80%)	292 (25%)	197	6867	11520
2006	99 (77%)		3191 (42%)	1874 (73%)	274 (24%)	183	5621	11520
2007	119 (93%)		4143 (54%)	1931 (75%)	385 (33%)	50	6628	11520
2008	109 (84%)		3638 (47%)	1800 (70%)	566 (49%)	121	6234	11579
2009	131 (102%)		5430 (70%)	2983 (116%)	716 (62%)	48	9308	11579
2010	170 (132%)		6240 (81%)	2609 (101%)	852 (74%)	128	9999	11579
2011	211 (143%)		8389 (95%)	3323 (112%)	1657 (124%)	129	13709	13316
2012	232 (125%)		11793 (106%)	4129 (112%)	1901 (114%)	166	18221	16645
2013	174 (111%)		8747 (93%)	2699 (86%)	1455 (103%)	23	13098	14148
2014	99 (94%)		6375 (101%)	2092 (99%)	785 (83%)	21	9372	9479
2015	118 (127%)		5679 (102%)	1657 (89%)	769 (92%)	6	8229	8342
2016	88 (109%)		4487 (93%)	1730 (107%)	692 (95%)	27	7024	7258
2017	110 (128%)		4885 (95%)	1677 (97%)	690 (89%)	12	7374	7751
2018	89 (116%)		4470 (97%)	1444 (94%)	583 (84%)	9	6595	6910
2019	90 (97%)		4259 (77%)	1323 (71%)	516 (62%)	74	6262	8329
2020	106 (88%)		3522 (49%)	2203 (91%)	543 (50%)	102	6476	10859

*** UK Includes Channel Islands.**

**** TAC Applied to subareas 7–10 from 1995 to 2008 and to 7b–k, 8, 9 and 10 from 2009 onwards.**

Table 8.4.1.b. Haddock in 7.bc–ek. ICES estimate of the landings (lan) and discards (dis).

Year	BEL Lan	ESP Lan	FRA Lan	IRL Lan	UK Lan	Others Lan	Total Lan	FRA Dis*	IRL Dis**	Others Dis***	Total Dis
1993							3348	505	594	109	1208
1994							4131	1116	594	176	1886
1995							4470	730	1221	267	2218
1996							6756	3170	713	426	4309
1997							10827	2129	502	253	2883
1998							7928	680	140	114	934
1999							4970	477	54	55	586
2000							7499	1587	727	189	2503
2001							9278	2234	743	441	3418
2002	134	85	3878	2070	301	21	6488	871	5651	552	7073
2003	116	82	5960	1731	362	41	8292	1835	6941	680	9456
2004	137	143	6336	1785	303	73	8777	1108	5156	486	6750
2005	165	197	4096	2026	282	21	6787	762	3933	496	5191
2006	98	185	3151	1883	262	14	5593	1061	1167	256	2484
2007	118	49	4073	2135	383	23	6781	1268	1241	230	2739
2008	109	121	4587	2032	545	61	7455	7608	2153	1427	11187
2009	131	47	5455	3271	703	1	9608	6064	2143	873	9080
2010	170	127	6267	2876	789	34	10262	11396	3246	1905	16547
2011	212	94	7365	3697	1511	0	12879	9320	2913	2145	14378
2012	232	105	11793	4608	1637	0	18376	7221	1678	1293	10191
2013	174	40	8622	3109	1480	0	13424	1103	727	255	2085
2014	99	3	6376	2529	848	0	9855	1793	992	392	3177
2015	118	0	5679	1978	766	4	8545	2798	2785	1110	6693
2016	88	0	4487	1713	692	26	7574				
2017	111	0.180	4896	2379	699	0	8086	4357	1597	2021	7975
2018	89	0	4446	1986	578	7	7109	2733	1133	1570	5436
2019	89	89	4548	2412	509	9	7656	1616	1445	200	3603
2020	102	176	3815	3193	546	27	7859	1450	1873	613	4260

*** For 1993–2007 fixed discard ratios were used to estimate French discards.**

**** For 1993–1994, the mean Irish discards over 1995–1999 were used.**

***** Estimated from the proportion of the landings of `Others' between 1993 and 2012.**

Table 8.4.2. Haddock in 7.bc–ek. Lpue (kg/hour fishing) of haddock and effort (hours fishing x 1000) for Irish Otter trawls in 7.bc, 7.fgh and 7.jk, the French demersal fleet in 7.bc–ek and effort only for the UK trawl fleets (excluding beam trawls) in 7.e–k (effort in fishing days).

	FR GAD 7ek effort	FR GAD 7ek lpue	IRL OTB 7bc effort	IRL OTB 7bc lpue	IRL OTB 7fgh effort	IRL OTB 7fgh lpue	IRL OTB 7jk effort	IRL OTB 7jk lpue	UK Trawl 7e–k effort
1983	NA	NA	NA	NA	NA	NA	NA	NA	51.5
1984	NA	NA	NA	NA	NA	NA	NA	NA	161.8
1985	NA	NA	NA	NA	NA	NA	NA	NA	143.7
1986	NA	NA	NA	NA	NA	NA	NA	NA	123.5
1987	NA	NA	NA	NA	NA	NA	NA	NA	108.9
1988	NA	NA	NA	NA	NA	NA	NA	NA	112.9
1989	NA	NA	NA	NA	NA	NA	NA	NA	119.9
1990	NA	NA	NA	NA	NA	NA	NA	NA	133.2
1991	NA	NA	NA	NA	NA	NA	NA	NA	118.8
1992	NA	NA	NA	NA	NA	NA	NA	NA	129.9
1993	NA	NA	NA	NA	NA	NA	NA	NA	101.1
1994	NA	NA	NA	NA	NA	NA	NA	NA	88.5
1995	NA	NA	78	5.77	64	1.48	106	2.20	88.1
1996	NA	NA	47	4.16	60	5.35	73	3.24	89.5
1997	NA	NA	63	4.36	65	5.83	92	8.23	101.8
1998	NA	NA	79	5.71	72	4.09	99	5.88	94.6
1999	NA	NA	77	5.27	51	2.35	52	3.53	132.8
2000	306	6.12	74	4.73	61	10.43	72	4.25	141.1
2001	333	10.57	78	4.30	69	8.69	81	7.41	117.5
2002	289	10.63	63	2.81	79	3.22	108	5.50	113.1
2003	264	15.15	81	2.09	87	3.26	123	3.88	102.4
2004	217	19.39	82	2.51	97	3.49	108	3.35	105.5
2005	175	14.67	69	2.45	127	4.53	93	3.70	100.9
2006	167	10.64	60	2.56	119	4.19	89	3.59	106.3
2007	160	14.97	60	3.31	136	4.01	103	3.66	113.6
2008	148	19.60	48	4.36	127	4.56	84	4.60	93.7

	FR GAD 7ek effort	FR GAD 7ek lpue	IRL OTB 7bc effort	IRL OTB 7bc lpue	IRL OTB 7fgh effort	IRL OTB 7fgh lpue	IRL OTB 7jk effort	IRL OTB 7jk lpue	UK Trawl 7e–k effort
2009	150	22.65	48	5.47	141	9.25	82	7.09	98.6
2010	131	30.83	54	4.36	144	7.33	101	5.15	103.7
2011	216	22.90	40	6.39	129	10.51	84	5.58	87.1
2012	188	45.03	44	4.93	135	13.17	84	6.58	86.2
2013	215	27.40	42	5.38	126	8.69	80	4.92	40.3
2014	203	19.81	46	5.22	142	5.11	77	3.91	32.1
2015	NA	NA	31	4.42	150	4.95	78	2.91	21.2
2016	NA	NA	39	2.41	164	4.94	83	3.09	NA
2017	NA	NA	36	2.25	151	5.10	92	2.43	NA
2018	NA	NA	46	2.19	125	5.33	93	1.70	NA
2019	NA	NA	32	2.42	127	5.86	93	1.73	NA
2020	NA	NA	34	2.80	98	11.2	84	1.86	NA

Table 8.4.3a. Haddock in 7.bc–ek. Landings numbers-at-age.

	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8
1993	0	491	3291	948	810	255	129	129	45
1994	0	1277	5223	674	302	94	24	35	16
1995	0	4275	1622	1327	270	245	46	0	0
1996	0	3693	15998	818	313	93	32	10	9
1997	0	1353	9645	5553	716	354	139	144	110
1998	0	167	3184	7403	1443	307	178	86	61
1999	0	476	654	1464	2425	307	18	19	6
2000	0	2197	2996	784	741	1250	205	35	28
2001	0	4297	8638	1131	303	317	321	54	39
2002	0	879	4274	3400	765	39	89	74	26
2003	0	703	8791	2160	1226	116	43	49	51
2004	0	125	5948	4663	928	589	51	12	20
2005	0	1075	1732	4230	1821	280	75	1	3
2006	0	839	3250	1034	2189	484	42	28	0
2007	0	404	4617	2916	737	1310	161	33	4
2008	0	1692	3268	3736	1046	286	414	91	50
2009	0	338	7111	2760	1890	577	228	234	38
2010	0	1757	5192	6031	1036	580	257	110	123
2011	0	100	12726	3607	3410	661	261	129	132
2012	0	82	1135	19931	2559	1795	323	109	108
2013	0	86	465	1899	10533	861	468	96	44
2014	0	277	854	467	1511	5585	368	219	40
2015	0	41	4881	632	309	928	2030	257	80
2016	0	62	310	5200	216	143	546	682	92
2017	0	58	2019	1071	3930	135	117	246	312
2018	0	70	714	2833	926	1653	42	64	150
2019	0	513	1566	1257	2678	529	762	41	110
2020	0	120	4318	1449	755	1381	260	175	30

Table 8.4.3b. Haddock in 7.bc–ek. Discard numbers-at-age.

	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8
1993	0	7617	2816	160	6	0	0	0	0
1994	0	15120	3069	170	5	0	0	0	0
1995	0	32830	1977	91	4	0	0	0	0
1996	0	20734	8976	187	9	0	0	0	0
1997	0	12613	10022	493	5	0	0	0	0
1998	0	3580	2348	445	5	0	0	0	0
1999	0	3742	1562	100	10	0	0	0	0
2000	0	29015	2521	64	3	0	0	0	0
2001	0	25234	6772	219	2	0	0	0	0
2002	0	21624	20729	249	7	0	0	0	0
2003	0	52412	11075	352	8	0	0	0	0
2004	0	11733	21598	1395	61	0	0	0	0
2005	0	30472	25291	6821	97	1	0	0	0
2006	0	20089	4529	11	10	4	1	0	0
2007	0	10748	8498	572	6	6	0	0	0
2008	0	34221	12620	1676	78	0	0	0	0
2009	0	21175	13989	592	64	0	0	0	0
2010	0	95699	19014	2742	34	1	0	0	0
2011	0	5881	58967	1675	262	16	1	0	1
2012	0	2732	5169	18518	153	55	2	0	0
2013	0	4076	2767	1372	4028	58	2	1	1
2014	0	20197	3315	507	631	732	4	1	0
2015	0	3590	18090	704	26	155	162	13	6
2016	0	27587	5222	8406	51	12	56	501	2
2017	0	3208	11913	1602	2121	31	2	4	3
2018	0	5287	5127	5306	491	215	0	2	2
2019	0	12878	2847	773	409	37	17	1	4
2020	0	2722	10938	597	28	25	1	1	0

Table 8.4.4. Haddock in 7.bc–ek. VAST survey data.

Year \Age	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0
2003	32208.0	179352.2	14994.4	1268.6	782.3	34.4	10.0	5.6
2004	107949.5	18508.7	23364.1	2372.7	670.0	378.5	404.5	6.1
2005	68193.0	31829.4	3829.3	5901.1	682.9	211.9	25.7	0.0
2006	33291.6	10898.1	7076.7	1642.3	1145.4	274.3	33.3	25.9
2007	258655.8	14205.7	3823.9	1943.6	538.1	717.9	70.1	11.8
2008	81907.5	55914.6	2513.1	614.5	614.6	259.7	372.3	115.8
2009	849687.7	19733.3	15997.8	720.9	324.9	254.2	185.4	102.0
2010	34042.4	295299.8	10574.9	4575.3	237.1	229.0	170.3	73.3
2011	20546.1	14197.3	74833.9	2304.9	1114.2	214.3	71.3	32.4
2012	7609.3	7283.1	4131.5	12745.4	656.6	520.1	67.6	38.3
2013	231859.2	3290.9	3124.0	1508.4	4052.3	335.3	174.6	42.8
2014	26908.5	55968.0	1387.7	888.2	698.9	1682.7	167.9	82.6
2015	121214.4	31566.6	17604.4	836.3	395.0	562.1	674.8	55.8
2016	19734.8	50020.4	12573.1	5989.8	441.2	216.8	506.3	186.7
2017	64807.1	7077.0	15076.0	2859.1	847.5	111.6	9.3	129.7
2018	258968.1	10070.6	1906.9	2958.6	1252.8	731.1	24.6	19.6
2019	94000.5	136030.0	4713.7	1201.8	1506.8	464.8	229.6	21.1
2020	27973.4	36212.7	56332.1	1229.6	589.6	1238.4	939.4	331.7

Table 8.4.6. Haddock in 7.bc–ek. Fishing mortality- (F) at-age.

	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8
1993	-	0.344	0.748	0.589	0.587	0.569	0.553	0.603	0.603
1994	-	0.327	0.702	0.547	0.536	0.515	0.500	0.545	0.545
1995	-	0.321	0.693	0.544	0.532	0.508	0.494	0.537	0.537
1996	-	0.307	0.675	0.540	0.532	0.507	0.494	0.535	0.535
1997	-	0.329	0.734	0.618	0.632	0.614	0.608	0.656	0.656
1998	-	0.319	0.723	0.621	0.658	0.654	0.656	0.703	0.703
1999	-	0.290	0.662	0.566	0.604	0.604	0.610	0.648	0.648
2000	-	0.325	0.761	0.656	0.708	0.717	0.729	0.756	0.756
2001	-	0.332	0.793	0.693	0.760	0.772	0.794	0.817	0.817
2002	-	0.316	0.772	0.676	0.754	0.775	0.807	0.831	0.831
2003	-	0.304	0.748	0.669	0.760	0.834	0.888	0.914	0.914
2004	-	0.314	0.773	0.688	0.772	0.854	0.904	0.903	0.903
2005	-	0.303	0.726	0.611	0.638	0.663	0.662	0.647	0.647
2006	-	0.252	0.591	0.486	0.493	0.505	0.501	0.514	0.514
2007	-	0.238	0.572	0.476	0.463	0.460	0.450	0.466	0.466
2008	-	0.244	0.607	0.528	0.510	0.500	0.495	0.532	0.532
2009	-	0.223	0.567	0.521	0.521	0.519	0.517	0.566	0.566
2010	-	0.201	0.523	0.505	0.522	0.539	0.551	0.622	0.622
2011	-	0.181	0.482	0.494	0.535	0.574	0.607	0.710	0.710
2012	-	0.170	0.459	0.491	0.547	0.606	0.654	0.788	0.788
2013	-	0.157	0.423	0.449	0.499	0.556	0.608	0.754	0.754
2014	-	0.143	0.393	0.421	0.460	0.517	0.573	0.729	0.729
2015	-	0.128	0.359	0.398	0.432	0.485	0.548	0.716	0.716
2016	-	0.127	0.358	0.409	0.444	0.492	0.554	0.728	0.728
2017	-	0.123	0.355	0.416	0.464	0.512	0.566	0.737	0.737
2018	-	0.111	0.329	0.392	0.434	0.480	0.526	0.688	0.688
2019	-	0.091	0.273	0.337	0.381	0.428	0.479	0.633	0.633
2020	-	0.073	0.221	0.276	0.315	0.354	0.394	0.521	0.521

Table 8.4.7. Haddock in 7.bc–ek. Stock numbers-at-age (start of year) (`1000).

	Age0	Age1	Age2	Age3	Age4	Age5	Age6	Age7	Age8
1993	136397	49566	13095	4495	1238	371	305	191	89
1994	393920	45451	17172	3463	1554	439	138	117	103
1995	475026	133420	15665	4771	1245	595	174	56	88
1996	165476	161391	46402	4344	1720	476	240	71	58
1997	59085	55624	59323	12740	1561	659	194	101	53
1998	89938	19624	19214	16609	4028	531	239	72	55
1999	359475	29994	6879	5268	5665	1282	181	83	43
2000	348984	122311	11031	1989	1888	2026	458	67	45
2001	485670	116979	42830	2879	636	614	651	146	36
2002	992452	162763	40154	10937	880	190	191	195	55
2003	234321	339800	58956	9948	3513	252	61	58	74
2004	350287	80379	118469	15568	3108	1045	69	17	36
2005	245785	115949	29658	30293	4754	889	269	16	14
2006	198128	81353	39497	7978	9790	1570	290	88	11
2007	699699	67205	30564	12013	3116	3847	616	119	38
2008	407920	230644	26079	9662	4508	1303	1604	263	70
2009	2343490	135690	86082	8080	3599	1738	554	662	132
2010	211788	789030	53847	27232	3063	1402	698	229	313
2011	89575	72026	306562	17679	9997	1255	551	272	207
2012	65390	29951	30848	103165	6672	3744	491	202	165
2013	623252	22561	12410	12069	37986	2516	1343	174	113
2014	221066	207945	9643	4523	5365	14560	989	491	93
2015	509791	76475	86636	3702	1823	2429	5745	386	192
2016	112634	174213	33962	33238	1489	760	1067	2225	194
2017	176925	37937	72325	13553	12883	586	308	423	791
2018	963380	56881	16726	27862	5639	5059	225	120	404
2019	312600	327660	24021	6988	11660	2352	2035	90	187
2020	136259	102741	147011	10020	3141	5197	1032	825	100

Table 8.4.8. Haddock in 7.bc–ek. Stock Summary: Estimated recruitment, spawning–stock biomass (SSB), and average fishing mortality.

Year	R(age 0)	Low	High	SSB	Low	High	Fbar(3–5)	Low	High	TSB	Low	High
1993	136397	67544	275440	9281	6211	13868	0.582	0.389	0.87	19732	13983	27846
1994	393920	247562	626806	10863	7556	15619	0.533	0.377	0.754	32027	23816	43069
1995	475026	299847	752549	11519	8204	16173	0.528	0.383	0.727	46517	35706	60602
1996	165476	105737	258966	20654	15379	27738	0.527	0.387	0.717	45205	36068	56656
1997	59085	37772	92422	25521	19450	33485	0.621	0.476	0.811	35065	27859	44134
1998	89938	57353	141035	19798	15523	25251	0.644	0.503	0.824	25801	20980	31731
1999	359475	230623	560318	13028	10447	16246	0.592	0.464	0.755	26458	21410	32696
2000	348984	224862	541620	11919	9820	14467	0.694	0.563	0.855	34560	27759	43026
2001	485670	318207	741264	18486	14201	24065	0.742	0.603	0.911	41924	33774	52039
2002	992452	660605	1490998	23448	18411	29864	0.735	0.598	0.903	62911	50725	78024
2003	234321	161008	341014	28255	22590	35342	0.754	0.61	0.933	74247	58986	93456
2004	350287	241554	507964	40708	32126	51581	0.771	0.609	0.977	64624	53378	78241
2005	245785	170790	353710	28512	23317	34865	0.637	0.508	0.799	55932	47151	66348
2006	198128	135778	289111	24196	20215	28961	0.495	0.381	0.643	45989	39220	53927
2007	699699	484583	1010309	22622	19212	26638	0.466	0.364	0.598	67304	54853	82580
2008	407920	284994	583869	21299	17931	25299	0.513	0.411	0.638	76333	63055	92408
2009	2343490	1618042	3394193	33115	27041	40554	0.52	0.419	0.646	192512	146310	253304
2010	211788	138406	324078	39553	33374	46876	0.522	0.422	0.645	181280	141751	231830
2011	89575	62988	127384	98240	77307	124842	0.535	0.432	0.661	123172	99516	152453

Year	R(age 0)	Low	High	SSB	Low	High	Fbar(3–5)	Low	High	TSB	Low	High
2012	65390	45120	94765	70734	56757	88153	0.548	0.439	0.683	81633	66751	99832
2013	623252	433410	896249	45241	36541	56012	0.501	0.403	0.623	87557	72083	106352
2014	221066	152482	320497	28814	23750	34958	0.466	0.375	0.58	76080	63596	91014
2015	509791	356527	728940	40673	33189	49844	0.438	0.351	0.547	95983	79284	116199
2016	112634	77069	164612	38415	31898	46262	0.448	0.357	0.564	79169	66354	94460
2017	176925	119845	261191	45702	37898	55115	0.464	0.362	0.594	68117	57631	80510
2018	963380	620509	1495708	36604	30288	44238	0.436	0.334	0.569	104214	80634	134689
2019	312600	185496	526798	34774	28559	42341	0.382	0.281	0.519	120198	90847	159033
2020	136259	61784	300508	71576	51403	99664	0.315	0.211	0.471	103808	76929	140079

Table 8.4.9. Haddock in divisions 7.b–k. Assumptions made for the interim year and in the forecast.

Variable	Value	Notes
F_{ages} 3–5 (2021)	0.315	Average F = (2018–2020) scaled to $F_{ages\ 3–5}$ in 2020
SSB (2022)	62 437	Short-term forecast; in tonnes
R_{age} 0 (2021, 2022)	312 600, 245 785	Median resampled (1993–2019); in thousands*
Total catch (2021)	15 291	Short-term forecast; in tonnes
Projected landings (2021)	10 616	Short-term forecast, assuming average 2018–2020 landing pattern; in tonnes
Projected discards (2021)	4675	Short-term forecast, assuming average 2018–2020 discard pattern; in tonnes

*** Random resampling of a distribution may lead to different median estimates.**

Table 8.4.10. Haddock in divisions 7.b–k. Assumptions made for the interim year and in the forecast.

Haddock in divisions 7.b–k. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2022)	Projected landings (2022)	Projected discards (2022)	F_{total} (2022)	$F_{projected\ landings}$ (2022)	$F_{projected\ discards}$ (2022)	SSB (2023)	% SSB change *	% advice change ^
ICES advice basis									
EU MAP ^^: F_{MSY}	15946	11885	4061	0.35	0.28	0.074	56747	-9.1	-13.3
F = MAP $F_{MSY\ lower}$	10570	7919	2651	0.22	0.174	0.047	62704	0.43	-12.8
F = MAP $F_{MSY\ upper}$	21988	16253	5735	0.52	0.41	0.110	50276	-19.5	-13.6
Other scenarios									
F = 0	0	0	0	0	0	0	74566	19.4	-100
F_{pa}	27740	20328	7412	0.71	0.56	0.149	44324	-29.0	51
F_{lim}	42885	30770	12115	1.400	1.11	0.30	28835	-53.8	133
$SSB_{2023} = B_{lim}$	65099	43929	21170	4.03	3.18	0.85	9227**	-85.2	254
$SSB_{2023} = B_{pa} =$ MSY $B_{trigger}$	60370	41496	18874	3.10	2.45	0.65	12822**	-79.5	228
$F = F_{2021}$	14464	10797	3667	0.32	0.25	0.07	58367	-6.52	-21.31
$SSB_{2023} = SSB_{2022}$	10818	8105	2713	0.227	0.179	0.048	62437	0.00	-41.1

*** SSB_{2023} forecast relative to SSB_{2022}.**

**** Numbers presented are estimations of the reference values.**

^ Advice values for 2022 relative to the corresponding 2021 values (MAP advice of 18 382, 12 128, and 25 454 tonnes, respectively; other values are relative to F_{MSY}).

^^ EU multiannual plan (MAP) for the Western Waters (EU, 2019).

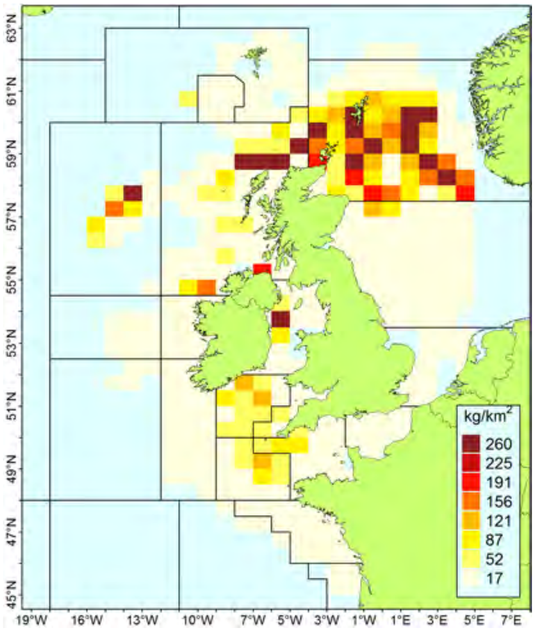


Figure 8.4.1. International haddock landings by ICES rectangle (all gears; 2016; data from https://stecf.jrc.ec.europa.eu/data-dissemination).

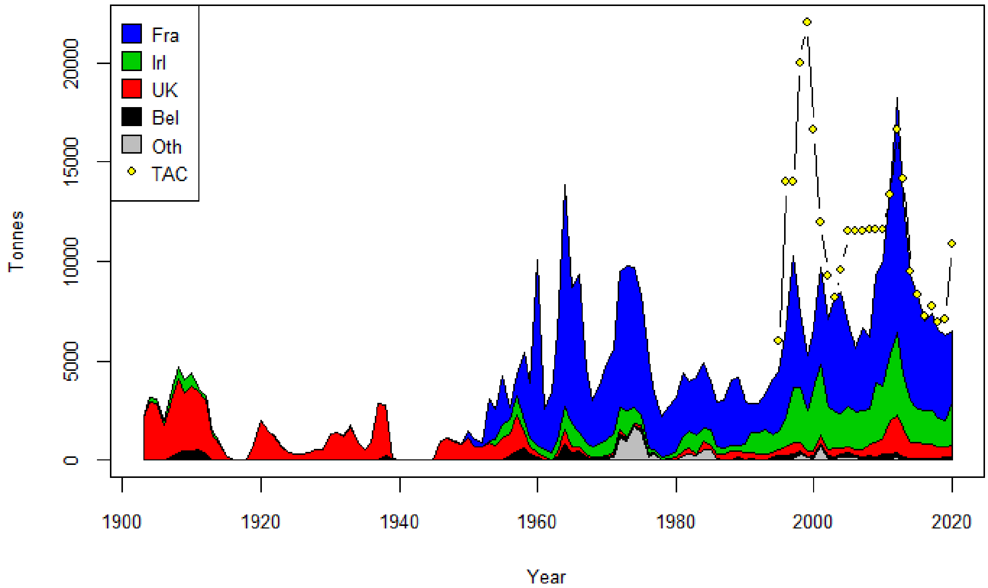


Figure 8.4.2a. Haddock in 7.bc–ek. Official Ices landings and TAC of haddock in 7.b–k.

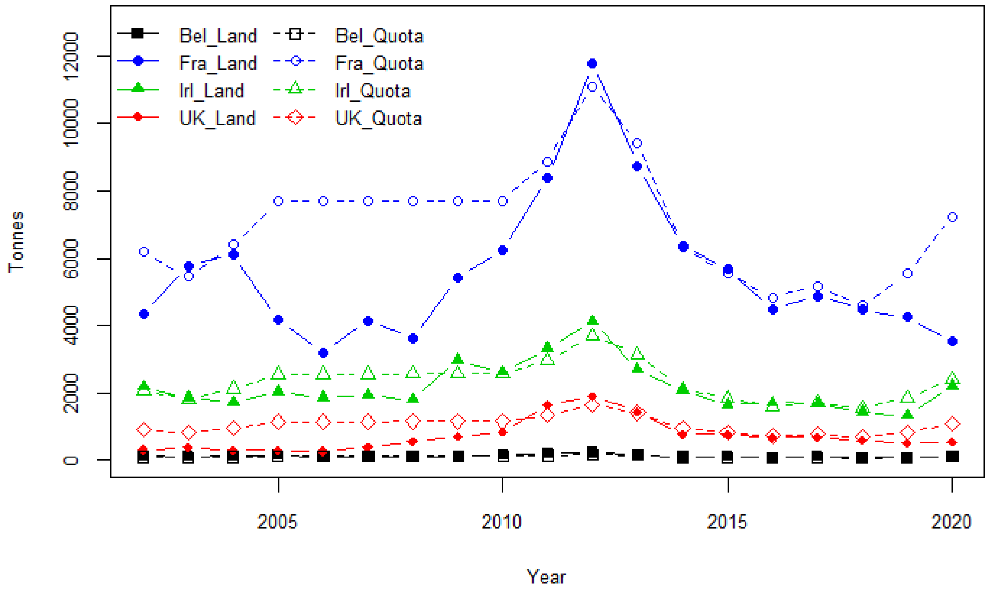


Figure 8.4.2b. Haddock in 7.bc–ek. Recent working group landings and quota by country.

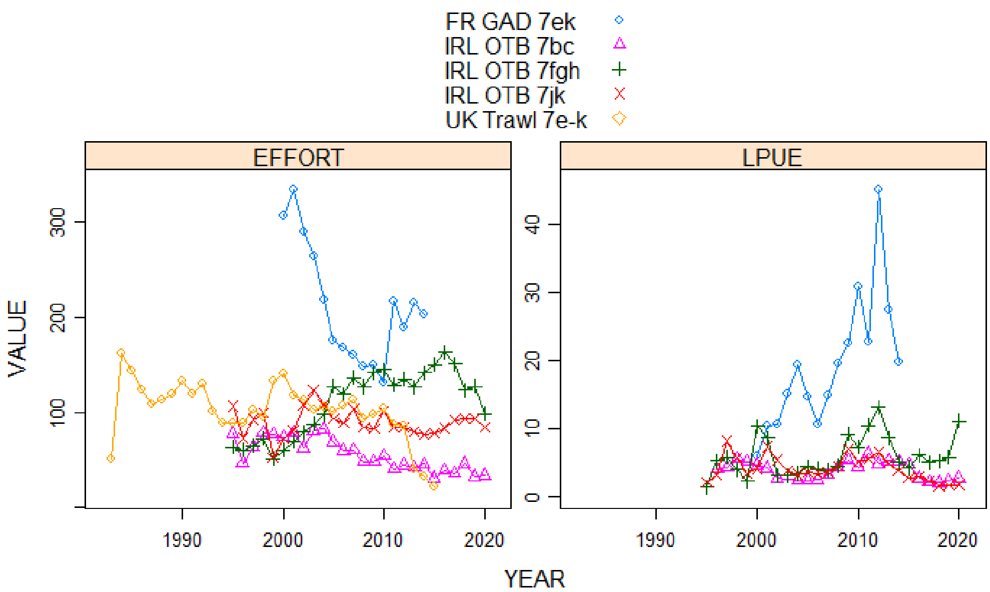


Figure 8.4.3. Haddock in 7.bc–ek. Effort ('1000h) of the Irish Otter trawl fleets, the French demersal otter trawl fleet and for UK trawl fleet (effort in fishing days, rescaled to other fleets) and lpue (kg/h) for the Irish and French fleets.

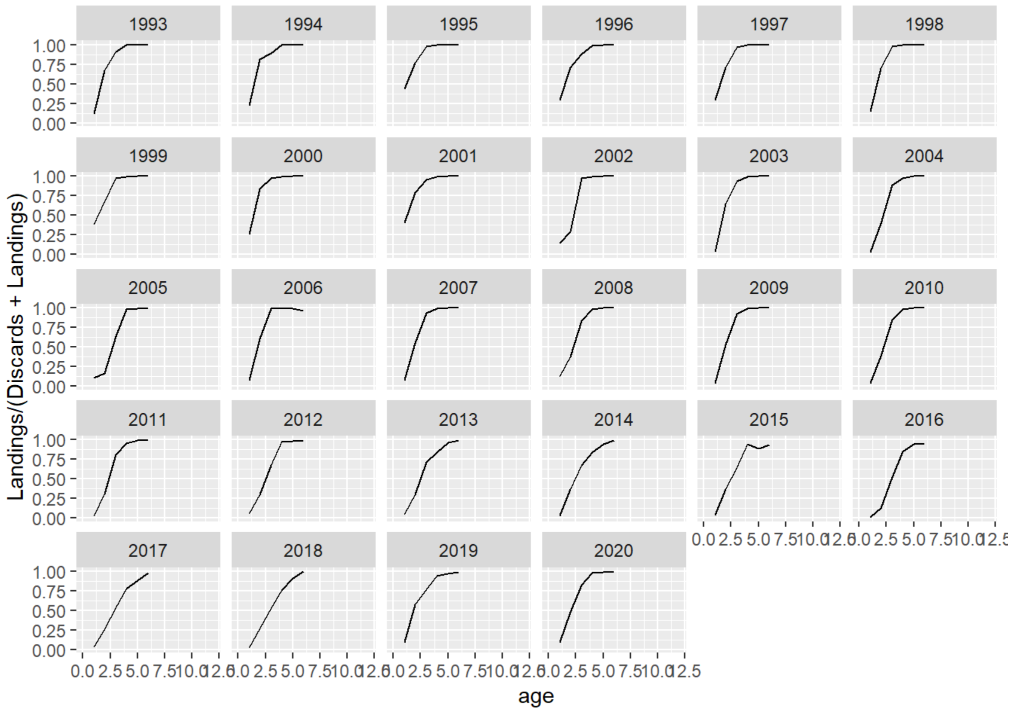


Figure 8.4.4 Proportional representation of landings relative to catch (discards + landings) by age, 1993–2020. 2020 estimates are based on average on 2017–2019 period.

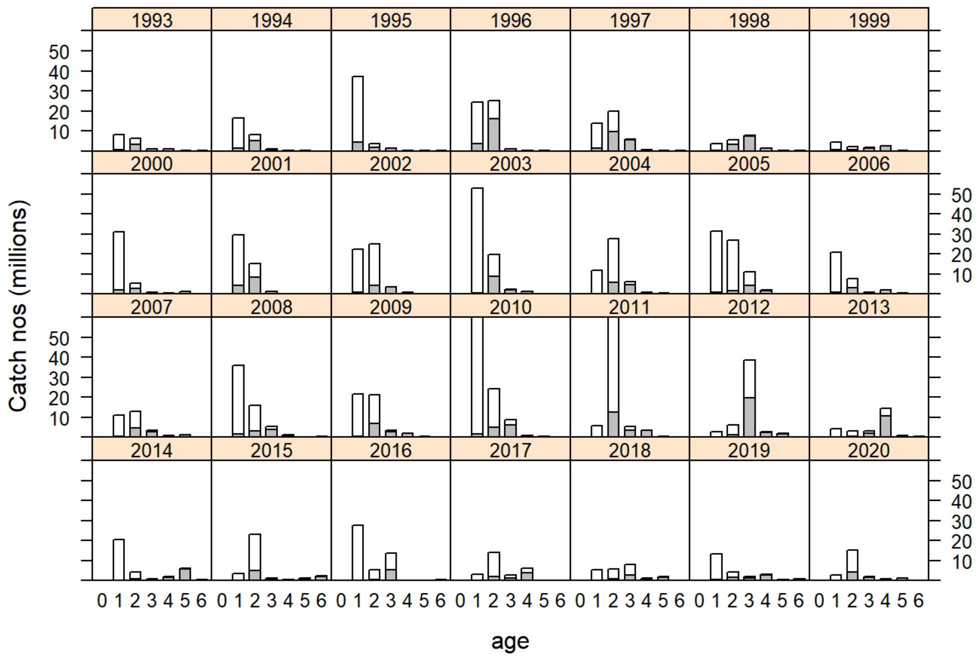


Figure 8.4.5. Haddock in 7.bc–ek. Discarding by number by age class (grey = landings, white = discards). 2020 estimates are recalculated based on mean catch weights from the 2017–2019 period.

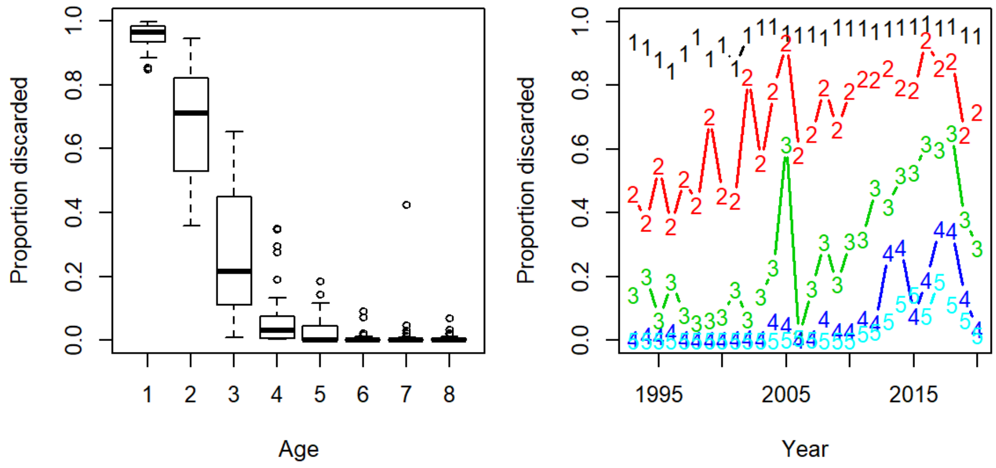


Figure 8.4.6. Haddock in 7.bc–ek. Proportion of discards by age (left) and year (right). 2020 estimates are recalculated based on mean catch weights from the 2017–2019 period.

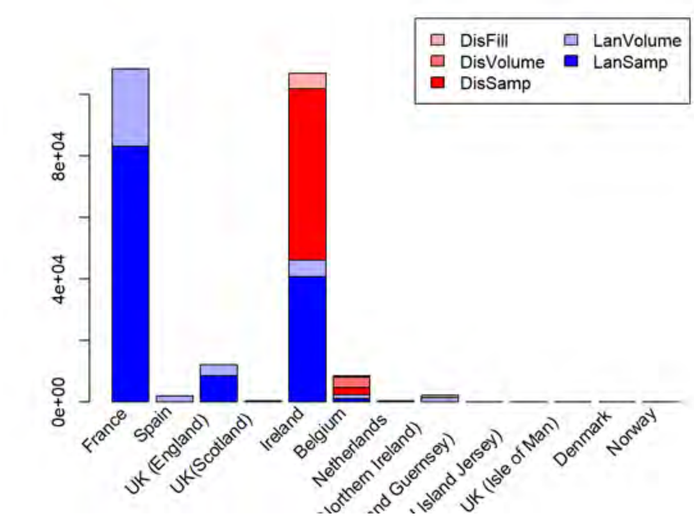


Figure 8.4.7. Haddock in 7bc–ek. Distribution sampled and unsampled the catches by country and gear.

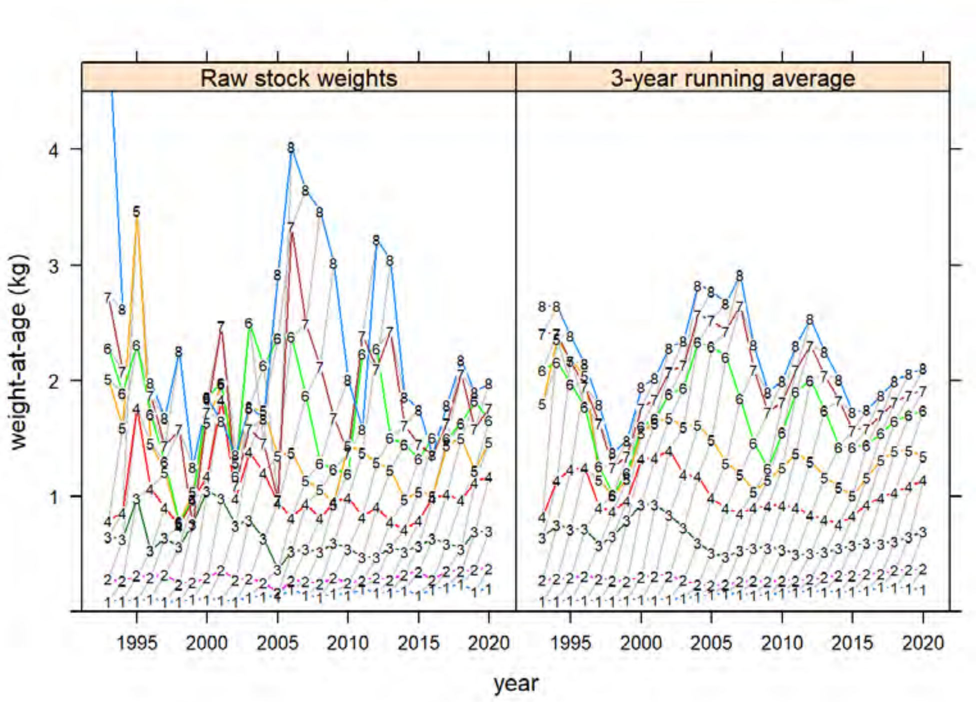


Figure 8.4.8. Haddock in 7.bc–ek. Raw stock weights-at-age (left) and the three-year running average stock weights (right).

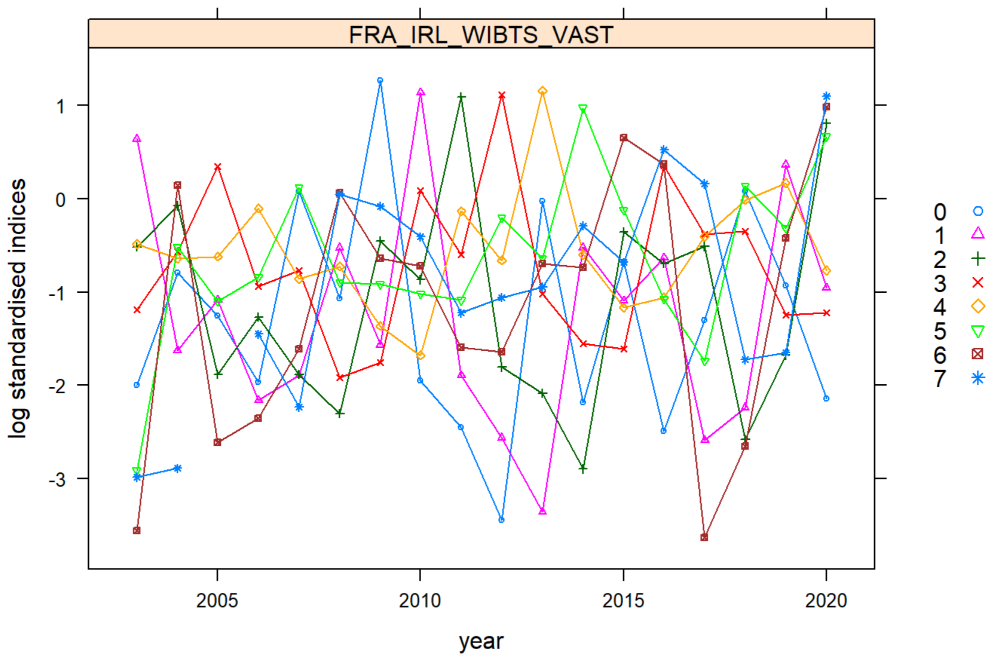


Figure 8.4.9. Haddock in 7.bc–ek. Log VAST standardised tuning fleets by year. The FRA-IRL-IBTS survey is the combined French EVHOE Q4 WIBTS and Irish IGFS Q4 WIBTS survey.

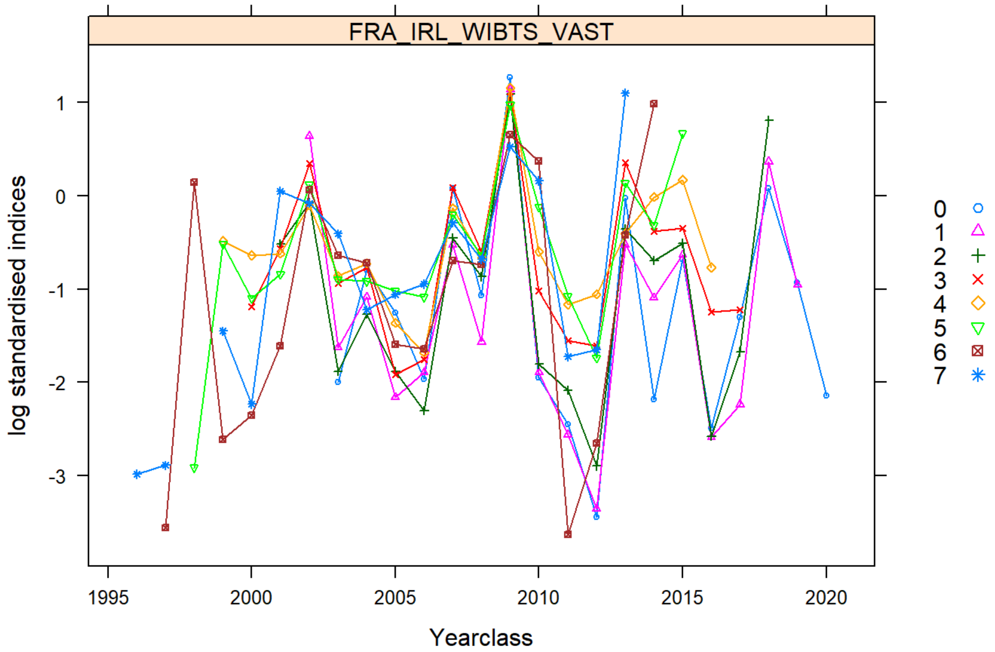


Figure 8.4.10. Haddock in 7.bc–ek. Log VAST standardised tuning fleets by cohort.

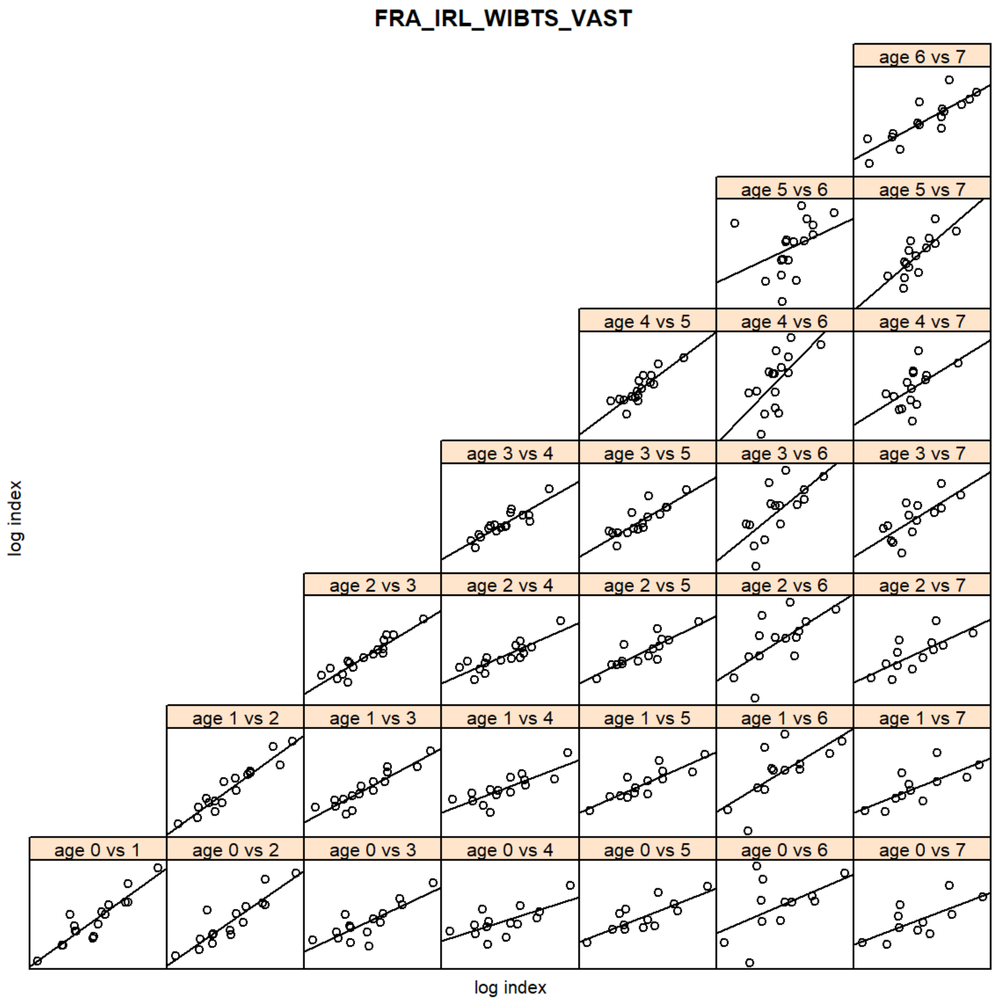


Figure 8.4.11. Haddock in 7.bc–ek. Scatterplot matrix of log indices of cohorts at different ages.

Figure 8.4.12. Haddock in 7.bc–ek. Residuals of the proportions-at-age in catch (upper) and survey (lower).

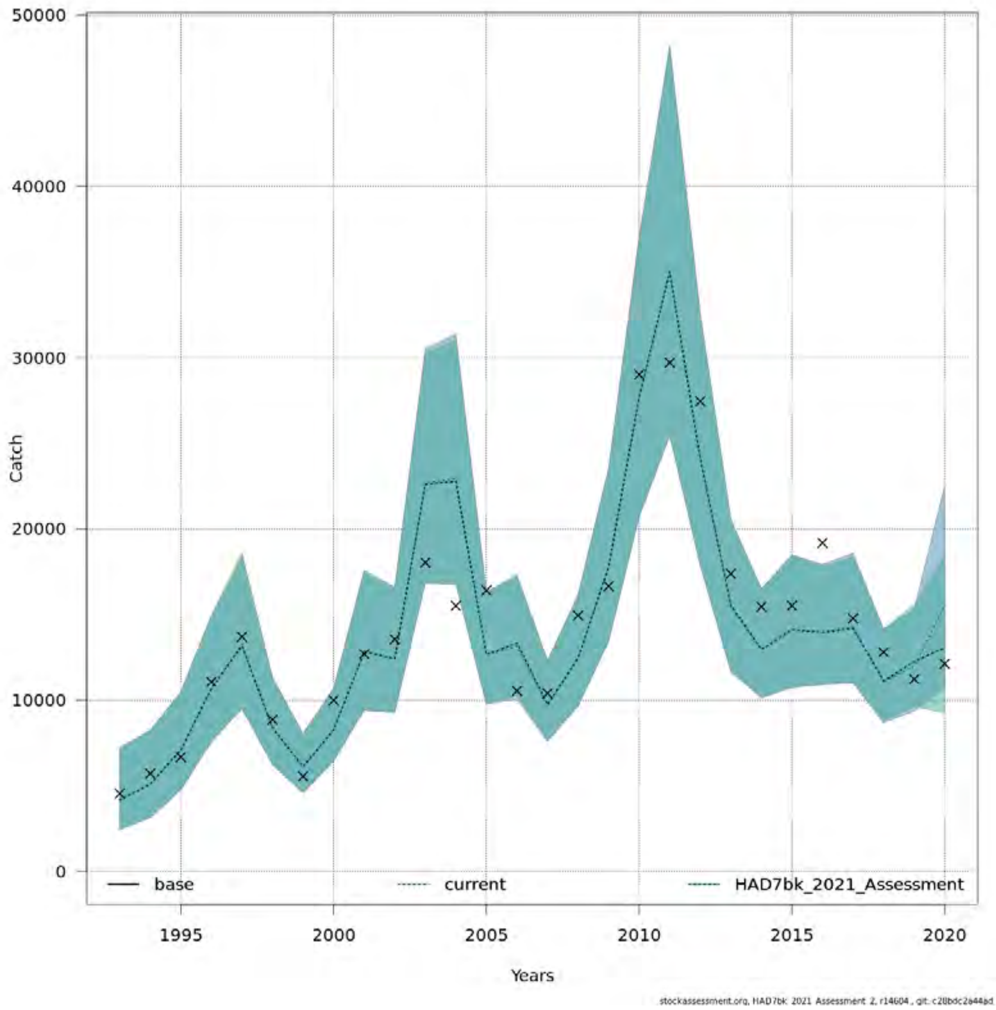


Figure 8.4.13. Haddock in 7.bc–ek. Observed (line) and predicted (x) catches.

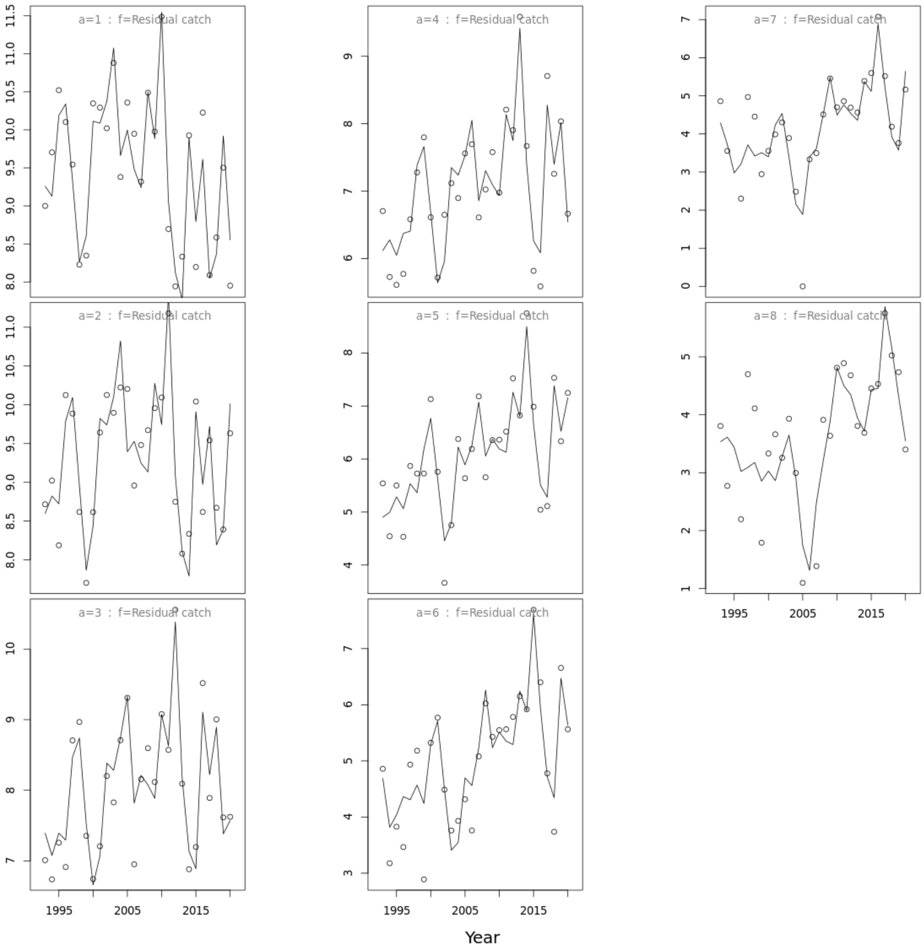


Figure 8.4.14. Haddock in 7.bc–ek. Observed and predicted (circles and line respectively) catch-at-age.

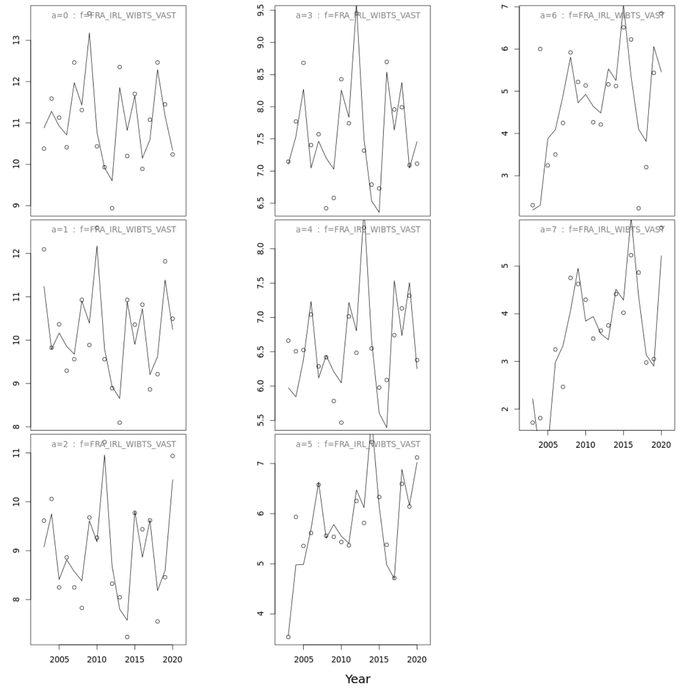


Figure 8.4.15. Haddock in 7.bc–ek. Observed and predicted (circles and line respectively) VAST survey indices.

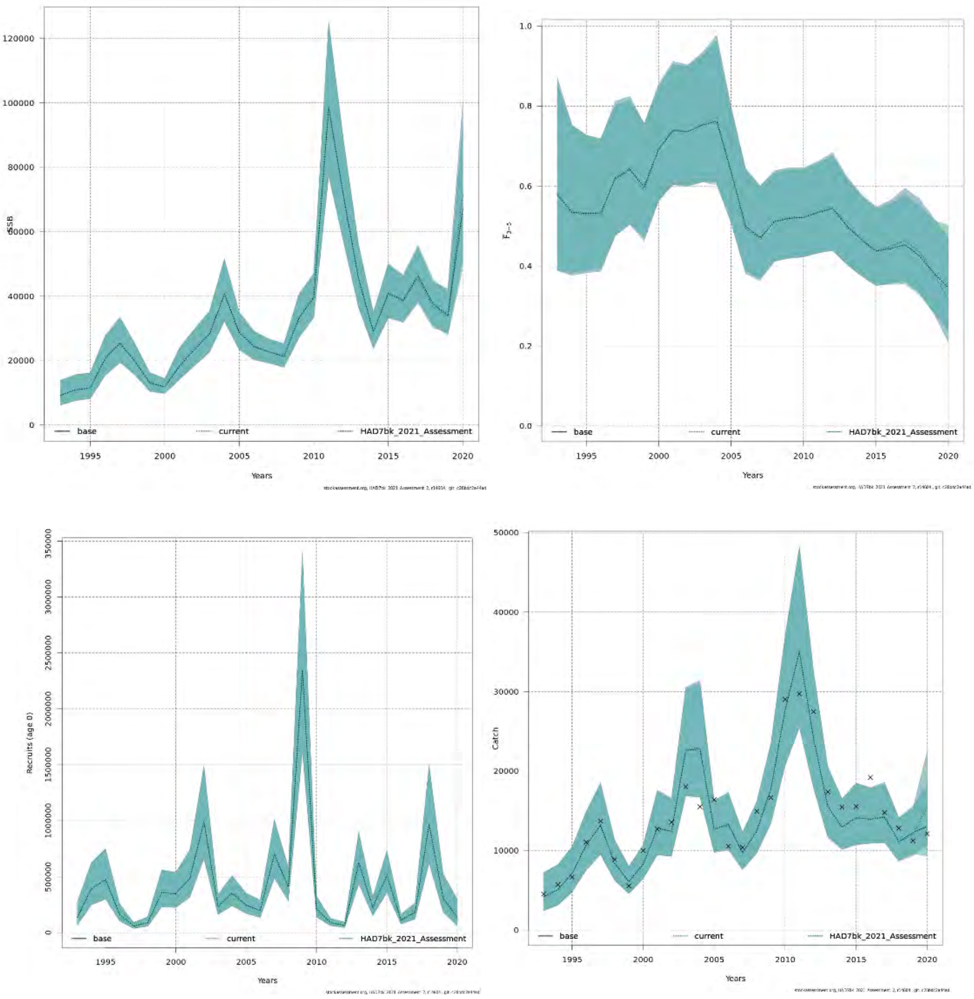


Figure 8.4.16. Haddock in 7.bc–ek. SAM assessment stock summary plots.

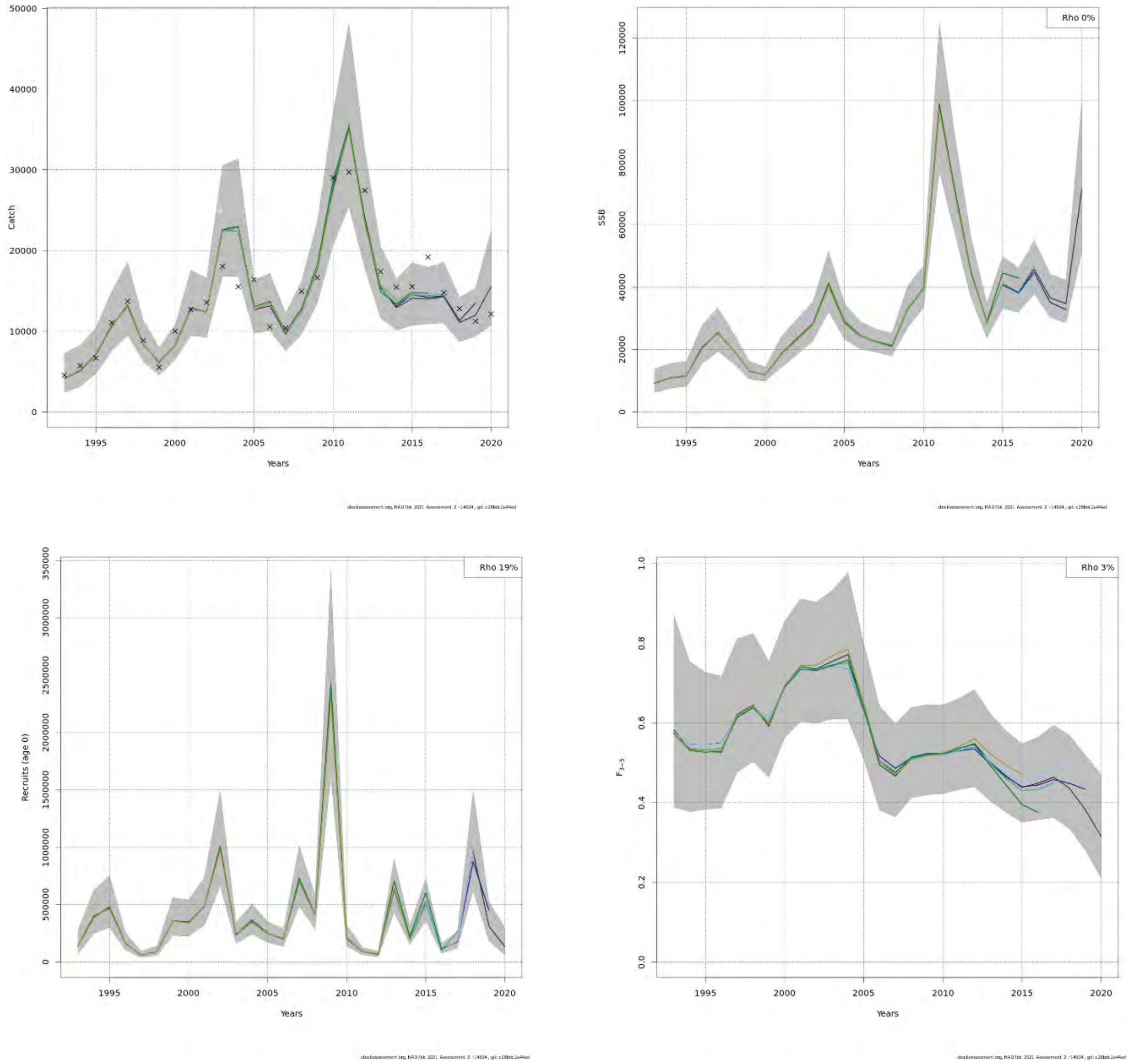


Figure 8.4.18a. Haddock in 7.bc–ek. Retrospective analysis of the final SAM assessment run. Catch (top left), SSB (top right), recruitment (bottom left) and F (bottom right).

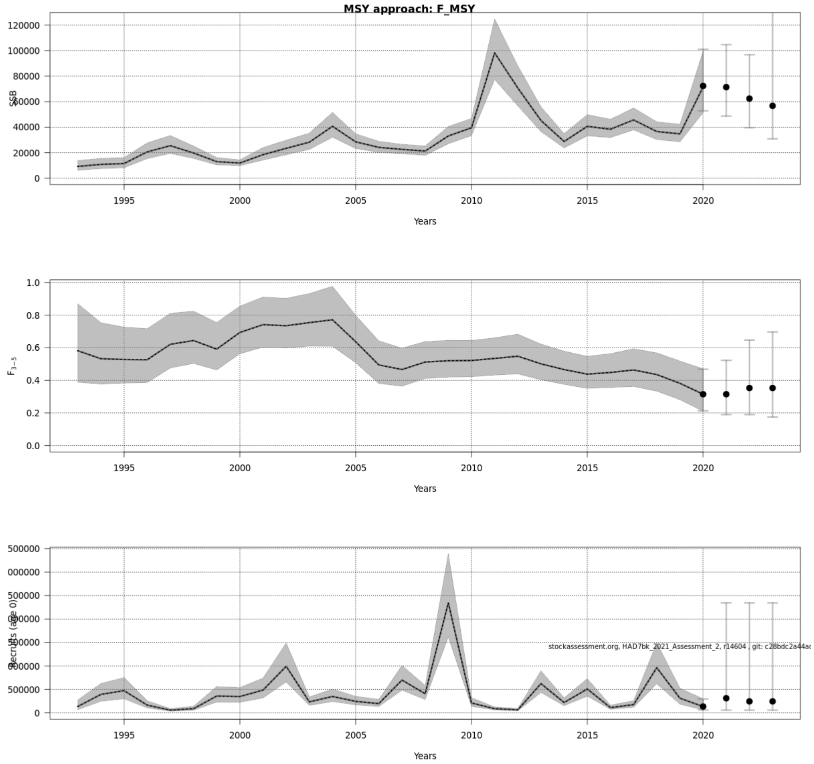


Figure 8.4.18b. Haddock in 7.bc–ek. Assessment and forecast of the final SAM run. SSB (top), and F (middle) and recruitment (bottom).

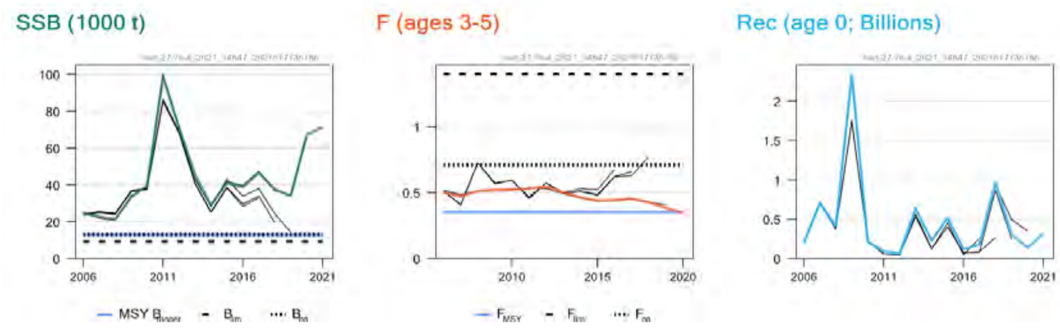


Figure 8.4.19. Haddock 7bc–ek. Historical assessment results (final-year recruitment and SSB assumptions included). The assessment was benchmarked in 2020, prior to which a different method (ASAP based) was applied.

9 Haddock (*Melanogrammus aeglefinus*) in Division7.a (Irish Sea)

Type of assessment

Age-structured assessment model using Age Structured Assessment Program (ASAP).

ICES advice applicable to 2021

ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 3371 tonnes.

ICES advice applicable to 2022

ICES advises that when the MSY approach is applied, catches in 2022 should be no more than 2761 tonnes.

9.1 General

Stock descriptions and management units

The stock and management units are both ICES Division 7.a (Irish Sea). Landing taken or reported by Irish vessels in the southern most rectangles of 7.a have been reassigned to the 7.b–k stock since 2003 because they are believed to be part of the Celtic Sea stock.

Management applicable to 2022

Management measures include TAC and effort restrictions as well as technical measures. Due to the bycatch of cod in the haddock fishery, the regulations affecting Irish Sea haddock remain linked to those implemented under the cod recovery plan. From 1st January 2019 all fleets catching haddock are subject to the landing obligation.

TAC regulations for 2020 are given below; TAC regulations for 2021 are not available at time of the report:

2020 management (Council Regulation (EU) 2020/123)

Species:	Haddock *Melanogrammus aeglefinus*	Zone:	7a (HAD/07A.)
Belgium	50	Analytical TAC	
France	228	Article 7(2) of this Regulation applies	
Ireland	1 366		
United Kingdom	1 512		
Union	3 156		
TAC	3 156		

The minimum landing size for haddock in the Irish Sea is 30 cm.

Landings obligation

Since 2017 the landings obligation has been applied to the stock. According to the delegate regulation (EC, 2015) vessels where more than 25% of their landings using trawls and seines in the reference years (2013 and 2014) and area were specified gadoids (cod, haddock, whiting and saithe) were covered by the Landings Obligation. This implies that all catches of haddock in the

Irish Sea by those vessels must be landed. From the 1st January 2019 all fleets catching haddock are subject to the landings obligation.

Fishery in 2020

The characteristics of the fishery are described in the stock annex.

The fishery in 2019 was prosecuted by a similar fleet and gears as in recent years, with directed fishing restricted during the cod closure under special conditions. The targeted whitefish fishery that developed during the 1990 using semi-pelagic trawls was in decline underwent but since 2014 there has been a slight increase in activity due to abundance of the haddock stock and increased fishing opportunity. However, this continues to be pursued by a small number of vessel (<15). A proportion of the TAC is taken as bycatch in the *Nephrops* fishery in a mixed fishery.

In 2020 the whitefish fishery was considerably impacted by the COVID-19 pandemic, resulting in lower fishing effort, which is represented in the landings and total catches.

In 2020, the uptake of TAC was 31%. The primary two nations exploiting the stock are the UK and Ireland. The UK used 79% of quota allocation whilst Ireland used 42%. ICES catch estimates are adjusted for reallocation of Irish landings from southern rectangles of 7.a to 7.g, as it is believed that these fish do not belong to the 7.a stock. Table 11.1 gives nominal landings of haddock from the Irish Sea (Division 7.a) as reported by each country to ICES since 1984.

9.2 Data

Sampling was considerably reduced in 2020 due to the COVID-19 pandemic. Discard and landings sampling were largely suspended for Quarters 2 to 4. The criteria for submitting samples to InterCatch was a minimum of one sample for every 4% of the landings. If that criteria was not met, sampled data were not submitted. As a result, landings only files was submitted to InterCatch for cod and haddock from Ireland. Generally, sampling levels for both port-based and at-sea sampling has been at a low level for. This has been due to limited access to processing facilities, the pattern and number of vessels fishing in the Irish Sea as well as some vessels landing into Northern Irish ports. These issues of low levels of sampling have been exasperated by Covid-19.

In Northern Ireland landings and discards sampling was only available for quarter 1. A fishers self-sampling program in the *Nephrops* fleet, normally used for *Nephrops* assessment, was used to estimated discard rates for quarters 3 and 4, while the quarter 1 discard rate was applied estimate for quarter 2. Discard rate per landed *Nephrops* was used to estimate discards in the *Nephrops* fleet.

Landings

Table 9.2 gives the long-term trend of nominal landings of haddock from the Irish Sea (Division 7.a) as reported to ICES since 1972, together with Working Group estimates. The 1993–2005 WG estimates includes sampled-based re-estimates of landings into the main Irish Sea ports. Sampled based evidence suggests that WG estimates are similar to reported landings since 2006. Following the benchmark (WKROUND 2013) the landings have been revised since 1993, and exclude landings from the southern rectangles in the Irish Sea as they not are believed to be part of this stock.

The methods for estimating quantities and composition of haddock landings from 7.a, used in previous years, are described in the stock annex (see Annex 2). The series of numbers-at-age in the international commercial catch is given in Table 9.3. Sampling levels were not considered adequate to derive catch age compositions in 2003. The composition for haddock landings in

2020 is purely based on the Q1. This was taken into account in the model (c.v of catch composition set to 0.175, catch effective sample size was set to 1. The time-series mean weight-at-age in the catch is given Table 9.4, the mean weight-at-age for 2020 was calculated as the mean of 2017–2019 due to growth of fish at age throughout the year being not available.

Discards

Discard data were updated for Northern Ireland, as Ireland only submitted landings data due to reduced sampling. Northern Ireland on-board observer data are only available for quarter 1.

While 2020 was an exceptional year, the following two paragraphs still hold true for the general haddock assessment and data.

Annual discard data were updated for Ireland and Northern Ireland. Historic discard numbers-at-age for the different sampled fleets are given in the stock annex (see Annex 2). Issues relating to the reliability and confidence in the data were addressed at the benchmark assessment for this stock (WKROUND 2013; WKIrish3 2017).

Methods for estimating quantities and composition of discards from UK (NI) and Irish *Nephrops* trawlers are described in the stock annex. Sampling levels have increased in recent years. The large estimates of discarding for *Nephrops* fleets observed by previous WG are still evident. A historic time-series of discard numbers-at-age was constructed at the benchmark. Discard rates are very variable between fleets.

Biological data

The derivation of biological parameters and variables is described in the stock annex (see Annex 2). Natural mortality-at-age was calculated using the methods proposed by Lorenzen (1996) at WKIrish2 (2016). The proportions mature-at-age was also recalculated at the benchmark, and based on the mean proportion observed during the NIGFS-WIBTS-Q1 survey with a smoother fitted that is updated annually.

There is evidence of trends in mean length-at-age over time (Figure 9.1), which needs to be reflected in the stock weights-at-age. Since 2001 the WG calculated stock weights by fitting a von Bertalanffy growth curve to survey estimates of mean length-at-age in March, described in the Stock Annex. The procedure was updated this year using NIGFS-WIBTS-Q1 (2020) and quarter one commercial landings data for 2020. The time-series of length–weight parameters indicate a reduction in expected weight-at-length since 1996, although this strength of this decline has reduced in recent years (see stock annex for historical data):

	Length–weight parameters		Expected weight-at-length	
Year	A	B	30 cm	40 cm
2006	0.00506	3.165	239	595
2007	0.00469	3.194	244	612
2008	0.00523	3.159	242	601
2009	0.00431	3.224	249	629
2010	0.00413	3.238	250	635
2011	0.00457	3.207	250	629
2012	0.00499	3.174	243	606
2013	0.00451	3.208	247	622
2014	0.00591	3.121	241	591
2015	0.00423	3.232	251	637
2016	0.00420	3.233	250	634
2017	0.004144	3.235	249	631
2018	0.006453	3.108	251	614
2019	0.004911	3.196	258	647
2020	0.005161	3.165	245	608

The following parameter estimates were obtained:

Mean LI_{yc} = 45.4 cm; K = 0.428; t_0 = -0.092

```
> Linf
[1] 58.94599
> K = -(2*log(r))/(agepsi-agephi)
Error: object 'agepsi' not found
> agepsi<-6
> K = -(2*log(r))/(agepsi-agephi)
> K
[1] 0.2755326
> t0 = agephi + (1/K)*log((Linf-lphi)/Linf)
> t0
[1] -0.170702
```

Year-class effects giving estimates of asymptotic length relative to the mean were as follows:

Year class	Effect	Year class	Effect
1990	0.949	2004	0.983
1991	0.979	2005	0.989
1992	0.954	2006	0.953
1993	1.045	2007	0.986
1994	1.092	2008	0.961
1995	1.018	2009	1.002
1996	1.049	2010	1.058
1997	0.968	2011	1.074
1998	1.024	2012	1.106
1999	1.004	2013	1.014
2000	0.995	2014	1.019
2001	0.971	2015	0.943
2002	0.971	2016	0.920
2003	0.998	2017	1.001
		2018	0.999
		2019	0.999
		2020	

The year-class effects show a smooth decline from the mid-1990s coinciding with the rapid growth of the stock and may represent density-dependent growth effects, although other environmental factors may contribute. There is evidence in a reversal of this trend in recent years. The resultant stock weights-at-age are given in Table 9.3. The weight-at-age in the stock shows a decreasing trend over time which appears to have reversed in recent years.

Surveys

The survey data considered in the assessment for this stock are given in Table 9.5. All survey series data for haddock available to the Working Group are described in the stock annex (see Annex 2). The following age-structured abundance indices were used in the assessment:

- UK (NI) groundfish survey (NIGFS) in March (age classes 1 to 4, years 1992–2020). Acronym NIGFS-WIBTS-Q1.
- UK (NI) groundfish survey (NIGFS) in October (age classes 0 to 3; years 1991 to 2020). Acronym NIGFS-WIBTS-Q4.
- UK (NI) Methot–Isaacs–Kidd (NI-MIK) net survey in June (age 0; years 1994–2019).
- UK Fishery Science Partnership (UKFspW) western Irish Sea roundfish survey (age classes 2 to 5, years 2004–2020, the survey was not conducted in 2014).

The relative log standardised indices for cohorts are plotted against time in Figure 9.2. Whilst ages 2 to 4 appear to show strong signal in the UKFspW the ability to detect the year class in age 5 haddock is less clear. The strong 2013 year class could be tracked in all indices, indicating that the different surveys are capturing the prominent year-class signals in this stock (Figure 9.2). Correlation between survey indices by age is positive for all surveys and show high consistency within each survey (Figure 9.3). The indices from the UKFspW survey in the western Irish Sea also show similar year-class signals to the other survey-series, but are noisy with strong year effects (Figure 9.2).

9.3 Assessment

The assessment presented is the single fleet ASAP model.

The missing MikNET recruitment survey for 2020 and low sampling levels were considered a likely problem for the 2021 assessment. A sensitivity analysis was run using the final 2020 assessment and comparing it to a run without the 2019 MikNet survey; the assessment was robust to the missing of a single survey year and it was concluded the missing year would have minimal impact on the outcome of the assessment.

The other data issue to consider was the 2020 catch-at-age composition. Due to the samples restricted largely to Q1, CV for age composition was set to 0.175 rather than 0.15 and sample size was set to 1. Sensitivity tests were carried out with the 2020 final model and increasing CV values for catch compositions from 0.15 to 0.175 in steps 0f 0.05 for year 2007–2019. The assessment model was largely robust to the changes, however in the end only a single year was affected.

Due to length at age sampling restricted to Q1, weight-at-age was taken as an average from 2017–2019 to account for growth throughout the year not being observed.

Hence the following model settings were applied in 2021.

ASAP was used for the assessment and model settings:

Option	Setting
Use likelihood constant	Yes
Mean F (F_{bar}) age range	2–4
Fleet selectivity block 1	Asymptotic
Fleet selectivity block 2	Age coefficients (age 0–5) (0.2;0.5;0.8;1;0.7;0.5)
Fleet selectivity block 3	Age coefficients (age 0–5) (0.3;0.6;0.7;0.7;0.4;0.2)
Fleet selectivity block 4	Age coefficients (age 0–5) (0.1;0.6;0.8;0.9;1.0;1.0)
Discards	Included in catch (not specified separately from landings)
Index units	4 (numbers)
Index month	NIGFS-Q1 (3); NIGFS-Q4 (10); NIMIK (7); UKFSPW(3)
Index selectivity linked to fleet	-1 (not linked)
Index age range	NIGFS-Q1 (1–4); NIGFS-Q4 (0–3); NIMIK (0); UKFSPW(2–5)
Index Selectivity (NIGFS-Q1)	Double logistic
Index Selectivity (NIGFS-Q4)	Asymptotic
Index Selectivity (NIMIK)	This survey was not available for 2020
Index Selectivity (UK-FSPW)	Asymptotic
Index CV & ESS (NIGFS-Q1)	Observed strata CV (lower limit 0.1); ESS = 50
Index CV & ESS (NIGFS-Q4)	Observed strata CV (lower limit 0.1); ESS = 50
Index CV & ESS (NIMIK)	Observed station CV (lower limit 0.1); ESS = 50; not used for 2020
Index CV & ESS (UK-FSPW)	CV = 0.7; ESS = 10
Phase for F-Mult in 1st year	1
Phase for F-Mult deviations	2
Phase for recruitment deviations	3
Phase for N in 1st Year	1
Phase for catchability in 1st Year	3
Phase for catchability deviations	-5 (Assume constant catchability in indices)
Phase for unexploited stock size	1
Phase for steepness	-5 (Do not fit stock–recruitment curve)
Catch total CV	1993–2000 (0.175); 2003–2006 (0.2); 2007– 2019 (0.15); 2020 (0.175)

Option	Setting
Catch effective sample size	1993–2000 (50); 2003–2006 (1); 2007–2019 (50); 2020 (1)
Lambda for recruit deviations	0 (freely estimated)
Lambda for total catch	1
Lambda for total discards	NA (discards included in catch)
Lambda for F-Mult in 1st year	0 (freely estimated)
Lambda for F-Mult deviations	0 (freely estimated)
Lambda for index	1 for both indices in the model
Lambda for index catchability	0 for all indices (freely estimated)
Lambda for catchability devs	NA (phase is negative)
Lambda N in 1st year deviations	0 (freely estimated)
Lambda devs initial steepness	0 (freely estimated)
Lambda devs unexpl stock size	0 (freely estimated)

Final update assessment

The final assessment was run with the same settings as established by WKIrish 2017 and described in the stock annex, with the addition of a new selectivity pattern 2013–2020, as applied in 2018 and with a lower starting value for selection of age 0 haddock in the final selectivity block. Due to COVID_19 at sea observations and market sampling was restricted to Quarter1 of 2020; increased self-sampling of the TR2 fleet was in place for Q3 and Q4. Hence the changes as described in the stock annex were followed. The MIKnet (recruitment) survey did not take place during 2020. Weights-at-ages were averaged across 2017–2019 to account for the fact that length–age observations were restricted to Q1. Discards were combined with the landings as catch in the model.

Figure 9.5 shows the predicted and observed catch. The catch information from 2007 to present is regarded as the most confident, during 2003–2006 it is regarded that catch and sampling information is of relatively lower quality due to lack of sampling opportunity. Before 2003, the catch series is regarded as of intermediate confidence. The model has close fit to the current observed catch 2011–present. Before this time, there is consistent over estimation of the catch 2000–2011 following a period of consistent underestimation of catch 1993–2000. Figure 9.6 shows the residuals of the catch proportions-at-age. For all ages there appears to good fit with no consistent pattern, however, there are some large deviations from observed and predicted for age 5 fish across the series. Figure 9.7 shows that the catch is dominated by fish <4 years, therefore the large residuals for fish of age 5 are likely to result from low sampling and small contribution of 5+ fish to the stock. The fishing pressure (F)-at-age is shown in Table 9.6.

The residuals of the index are shown in Figure 9.7. A good fit to the NI-MIK index is seen across the series, although some single year events are observed with a strong deviation in the last two years of the index. For the UKFsPW survey a poor fit to the 2009, 2017 and 2018 is evident. This suggests an inability of the model to track the large survey index values, this should be investigated further to explore the method of index calculation. During the most recent two years of the index, when the stock biomass has been high the UKFspW survey appears to tend of overestimated compared to the model fit. There is strong tracking of the both NIGFS-WIBTS-Q1 and NIGFS-WIBTS-Q4 index in general patterns, however, a general trend to under estimate the NIGFS-WIBTS-Q4 index by the model is observed whilst the NIGFS-WIBTS-Q1 shows an initial period of over estimation 1993–2000, followed by a period of under estimation 2002–2013.

Figure 9.9 shows the residuals of the survey proportions-at-age. For all indices there is close fit between the observed and model predicted fit for fish up to four years old. The largest deviations occur in five-year old fish in the UKFspW survey, which under reported five-year old fish prior to 2014.

Figure 9.10 shows the retrospective analysis. The predicted catch shows no obvious retrospective pattern, neither does the recruitment estimate or fishing pressure. However, the SSB has a tendency to be revised downwards. The historic widely splayed retrospective runs are caused by re-estimation of selectivity patterns with a short terminal selectivity blocks (four years) and the influence of decreasing UK-FspW tuning series length with each retro peel. The results of the assessment are given in Table 9.8.

Comparison with previous assessments

Figure 9.11 shows the comparison of the current assessment with previous ASAP and model. There is close agreement with the stock trends of the current assessment and the previous assessment. Mohn's Rho values were calculated for five retrospective runs 2020: 2015 for F_{bar} (0.07), SSB (-0.02) and recruitment (-.35).

State of the stock

Following a period of sustained decline, since 2008, SSB increased during 2010–2013. A short-term decline was observed in 2014, but was reversed, and since 2014 the SSB has increased markedly. The stock is characterized by highly variable recruitment. The model indicates above average recruitment for the 2009–2011 year class after below average recruitment for the 2007 and 2008 year classes. Recruitment in 2013 is amongst the highest observed in the time-series and has been followed by strong recruitment in 2014 and 2015. The current SSB has declined from the highest observed level and continued the decline in 2020.

The recruitment in 2020 was extremely low; without discard sampling of the TR2 fleet in Q3 and Q4, and absence of the MIKnet recruitment survey, the Q4 groundfish survey was the only source for recruitment. The Q4 groundfish indicates the lowest recruitment since 1995. The initial Q1 2021 groundfish survey results complement the finding of a low recruitment event.

9.4 Short-term projections

Short-term projections were performed using FLR libraries. Recruitment for 2021–2023 was estimated at (GM 1993–2019; 371 740 thousand). The F used in the forecast for 2021was derived as F_{sq}= $F_{average}$ (2017–2019), excluding the 2020 F as this is deemed to be non-representative for the fishery and due to low effort of the TR1 fleet during the COVID-19 pandemic.

Catches were split into landings and discards using the proportions of the catch that were discarded over the full the last three years. Input data for the short-term forecast are given in Table 9.7. The management options output is given in Table 9.9.

Estimates of the relative contribution of recent year classes to the 2022 landings and 2023 SSB are shown in Figure 9.12. As the very strong 2013 year class has moved through the fishery the contribution to landings in 2021 is comprised of mainly the 2017 cohort (51%), with the SSB in 2022 largely be dependent on a the 2018 cohort, comprising 78% of the biomass.

9.5 Biological reference points

MSY evaluations

In response to an EU special request to provide plausible and updated F_{MSY} ranges for Irish Sea haddock the management reference points for the stock were re-estimated (Table 9.10 ICES, 2018). The B_{lim} was set as the lowest SBB at which above recruitment in the upper quartile has been observed (2994 t). The S–R plot for Irish Sea haddock shows no obvious S–R relationship mainly because the recruitment is highly variable. B_{lim} was estimated as 4160 t. MSY $B_{trigger}$ is set to 4281 t as the stock has been fished at or below F_{MSY} for more than five years. F_{MSY} median point estimates is 0.28. The upper bound of the F_{MSY} range giving at least 95% of the maximum yield was estimated to 0.35 and the lower bound at 0.20. F_{lim} is estimated to be 0.50 as F with 50% probability of SSB <B_{lim}; F_{pa} as 0.41= $F_{p.05}$ the F that leads to SSB>B_{lim} with 95% probability; F_{lim} x exp(-1.645 x σ); σ = 0.20.

Yield and biomass-per-recruit

Not available for this stock, previous explorations are detailed in the stock annex.

9.6 Management plans

There is no specific management plan for haddock in the Irish Sea. The regulations affecting Irish Sea haddock remain linked to those implemented under the cod management plan due to potential for bycatch of cod in a fishery targeting haddock (Council Regulation (EC) 1342/2008).

9.7 Uncertainties and bias in assessment and forecast

Landings

Sampling levels of the landed catch for recent years are considered to be sufficient to support current assessment. Landing samples in 2020 have been considerably compromised due to COVID-19 restrictions; landing samples were limited to Q1. Reported samples for 2020 are however considered to be sufficient for the assessment. However, within the assessment there is relocation of reported landings in rectangles 33E2 and 33E3 which are not considered part of the stock. Historic misreporting estimates are considered in the assessment and accounted for, current misreporting is not considered to be a factor within the fishery.

Discards

Sampling levels of discarding at sea remains high. For Northern Irish vessels targeting haddock 27.0% of trips are observed and 2.7% of the main *Nephrops* targeted fishery trips observed.

In 2020, no observations on *Nephrops* vessels were made in Q2–Q4, however self-samples from the *Nephrops* fleet were increased throughout Q3–4.

Selectivity

A breakpoint in selectivity is applied in 2000, associated with management measures to reduce fishing mortality on cod. The model included three selectivity blocks in fishery-dependent data, reflecting bycatch and targeted fishery until the year 2000 (asymptotic). After 2007, a fleet selectivity pattern without targeted fishing of older fish (dome-shaped) is applied. During 2000–2007 a transition between a fully selected stock to a regime without targeted fishing of older fish is fitted. The use of current specified selectivity blocks may require review at annual at regular intervals. In the current assessment a new selectivity pattern for the fishery was added from 2013 onwards with full selection of fish older than three years. With advice and management for haddock or other species, it is possible that the character of the fishery may change. A retrospective analysis demonstrated a consistent historic downward revision of the perceived SSB trend, however, there is consistent estimation of F. The initial two years of the retrospective plot show significant deviations. This was considered due to the model having a selectivity block, beginning in 2007, with reduced selection for older fish and the introduction of the UKFspW, with an asymptotic selectivity pattern, starting in 2007. The short period to estimate the selectivity parameters for both the fishery and survey index are considered to contribute to the instability of the model during this time.

Surveys

The survey indices used in the model have spatial coverage of the assessment area. The combination of a recruitment index (NI-MIK), juvenile fish survey indices (NIGFS-WIBTS-Q1 & NIGFS-WIBTS-Q4) and the UKFspW survey aimed at older fish using commercial fishing gear means that the full age range of the stock is covered by survey information.

9.8 Recommendations for next benchmark assessment

This stock was benchmarked through the WKIrish process in 2016–2017.

9.9 References

EC. 2015. Commission Delegated Regulation (EU) 2015/2438 of 12 October 2015 establishing a discard plan for certain demersal fisheries in north-western waters.

Table 9.1. Landings (t) of HADDOCK in Division 7.a, 1984–present, as officially reported to ICES. (Working Group figures are given in Table 9.2).

Country	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Belgium	3	4	5	10	12	4	4	1	8	18
France	38	31	39	50	47	n/a	n/a	n/a	73	41
Ireland	199	341	275	797	363	215	80	254	251	252
Netherlands	-	-	-	-	-	-	-	-	-	-
UK(E&W)[1]	29	28	22	41	74	252	177	204	244	260
UK (Isle of Man)	2	5	4	3	3	3	5	14	13	19
UK (N. Ireland)	38	215	358	230	196	…	…	…	…	…
UK (Scotland)	78	104	23	156	52	86	316	143	114	140
Total	387	728	726	1,287	747	560	582	616	703	730

Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Belgium	22	32	34	55	104	53	22	68	44	20
France	22	58	105	74	86	n/a	49	184	72	146
Ireland	246	320	798	1,005	1,699	759	1,238	652	401	229
Netherlands	-	-	1	14	10	5	2	-	-	-
UK(E&W)[1]	301	294	463	717	1,023	1,479	1,061	1,238	551	248
UK (Isle of Man)	24	27	38	9	13	7	19	1	-	-
UK (N. Ireland)	…	…	…	…	…	…	…	…	…	…
UK (Scotland)	66	110	14	51	80	67	56	86	47	31
Total	681	841	1,453	1,925	3,015	2,370	2,447	2,229	1,115	674

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	15	22	23	30	15	7	9	16	13	6.2
France	20	36	20	11	6	3	2	8	3	.7
Ireland	296	139	184	477	319	388	333	434	561	492
Netherlands	-	-		-	-	-	-	-	-	-
UK (England & Wales)[1]	421	344	419	559	521	446	593	355	236	154
UK (Isle of Man)	-	-	-	-	1	1	-	-	<1	<.1
UK (N. Ireland)	…	…	…	…	…	…	…	…	…	…
UK (Scotland)	9	6	9	1	17	1	2			-
United Kingdom									236	154
Total	761	547	655	1078	879	846	939	813	813	654

Country	2014	2015	2016	2017	2018	2019*	2020*
Belgium	7	7	5	5	4	9	4
France	0	7	1	5	0	0	0
Ireland	541	507	632	114	949	1132	754
Netherlands	-	-		-	-	-	-
UK (England & Wales)[1]	-	-		-	-	-	-
UK (Isle of Man)	<1	<1		-	-	-	-
UK (N. Ireland)	...	-		-	-	-	-
UK (Scotland)	-	-		-	-	-	-
United Kingdom	426	634	825	1240	1580	1196	539
Total	974	1154	1463	2363	2532	2537	1296

*** Preliminary.**

[1] 1989–2015 Northern Ireland included with England and Wales.

n/a = not available.

Table 9.2. Haddock in 7.a. Total international landings of haddock from the Irish Sea, 1972–present as officially reported to ICES. Working Group figures, assuming 1972–1992 official landings to be correct, are also given. The 1993–2005 WG estimates include sampled-based estimates of landings at a number of Irish Sea ports. Sample-based evidence confirms more accurate catch reporting since 2006. Landings in tonnes live weight. Since 1993 the landings have been corrected to exclude catches from the southernmost rectangles, which are not considered part of this stock.

Year	Official landings	WG landings	ICES discards**	ICES catch	% Discard	Landings taken or reported in rectangles 33E2 and 33E3
1972	2204	2204				
1973	2169	2169				
1974	683	683				
1975	276	276				
1976	345	345				
1977	188	188				
1978	131	131				
1979	146	146				
1980	418	418				
1981	445	445				
1982	303	303				
1983	299	299				
1984	387	387				
1985	728	728				
1986	726	726				
1987	1287	1287				
1988	747	747				
1989	560	560				
1990	582	582				
1991	616	616				
1992	703	656				
1993	730	813				
1994	681	1042				
1995	841	1736	780	2516	31%	16
1996	1453	2981	709	3690	19%	33
1997	1925	3547	895	4442	20%	36

Year	Official landings	WG landings	ICES discards**	ICES catch	% Discard	Landings taken or reported in rectangles 33E2 and 33E3
1998	3015	4874	1015	5889	17%	28
1999	2370	4095	634	4729	13%	34
2000	2447	1357	802	2159	37%	11
2001	2229	2246	269	2515	11%	74
2002	1115	1817	387	2204	18%	82
2003	674	659	-	-	-	64
2004	761	1217	392	1609	24%	53
2005	547	666	551	1217	45%	35
2006	655	633	306	939	33%	26
2007	1078	886	722	1608	45%	222
2008	879	786	643	1429	45%	194
2009	846	581	579	1160	50%	285
2010	939	679	508	1187	43%	267
2011	813	446	307	753	41%	374
2012	n/a	343	599	942	64%	473
2013	654	254	283	537	53%	410
2014	953	518	488	1006	49%	444
2015	1154	833	652	1451	44%	322
2016	1463	1008	298	1306	23%	455
2017	2363	1662	333	1995	17%	715
2018	2532	1993	568	2561	22%	532
2019	2537	1778	672	2450	27%	759
2020	1296	7423	234	976	24%	554

Table 9.3. Haddock in 7.a: stock weights-at-age.

	Age					
	0	1	2	3	4	5
1993	0.02	0.095	0.42	1.043	1.759	2.563
1994	0.02	0.083	0.338	0.968	1.999	3.028
1995	0.02	0.085	0.347	0.785	1.708	3.219
1996	0.02	0.083	0.359	0.788	1.319	2.718
1997	0.022	0.07	0.357	0.863	1.435	2.391
1998	0.018	0.06	0.253	0.743	1.384	2.165
1999	0.016	0.057	0.226	0.561	1.294	2.262
2000	0.017	0.048	0.23	0.51	0.966	2.123
2001	0.018	0.051	0.201	0.548	0.93	1.822
2002	0.017	0.056	0.215	0.472	0.983	1.637
2003	0.017	0.05	0.229	0.485	0.798	1.52
2004	0.017	0.041	0.199	0.509	0.816	1.306
2005	0.018	0.031	0.165	0.459	0.902	1.347
2006	0.014	0.033	0.128	0.378	0.803	1.435
2007	0.019	0.034	0.136	0.299	0.68	1.402
2008	0.014	0.037	0.139	0.31	0.515	1.167
2009	0.025	0.042	0.153	0.326	0.563	0.98
2010	0.017	0.04	0.176	0.357	0.58	0.945
2011	0.018	0.052	0.167	0.407	0.624	0.937
2012	0.012	0.057	0.209	0.375	0.688	0.96
2013	0.023	0.059	0.233	0.491	0.673	1.115
2014	0.022	0.038	0.238	0.512	0.812	1.04
2015	0.017	0.046	0.153	0.577	0.97	1.371
2016	0.021	0.047	0.192	0.354	1.015	1.533
2017	0.022	0.054	0.137	0.347	0.809	1.476
2018	0.023	0.068	0.196	0.472	0.601	0.987
2019	0.024	0.066	0.121	0.480	0.636	1.04
2020*	0.023	0.063	0.151	0.433	0.682	1.168

***Average weights 2017–2019.**

Table 9.4. Haddock in 7.a: Catch numbers-at-age.

	Age					
	0	1	2	3	4	5
1993	790	1568	2066	19	1	1
1994	16857	821	258	922	3	2
1995	950	8079	1587	107	220	5
1996	15171	1380	5510	728	16	30
1997	347	8828	1528	2388	201	16
1998	4209	4642	10532	252	488	42
1999	4944	3200	3436	4773	25	57
2000	287	11118	1771	466	457	418
2001	7883	425	3246	1074	30	89
2002	2105	8229	789	2063	142	18
2003	2000	2000	400	800	50	25
2004	10797	2056	421	827	46	78
2005	6048	4342	1416	285	193	34
2006	5334	2971	656	524	63	51
2007	2282	3537	3371	671	60	47
2008	2158	4569	2052	837	242	36
2009	4327	2490	2021	629	121	36
2010	3933	4058	834	464	309	59
2011	5669	2324	942	239	97	52
2012	6235	2799	774	201	27	28
2013	4525	1162	558	156	41	17
2014	1392	3854	1265	189	17	10
2015	518	1915	3087	324	63	5
2016	512	1845	907	1079	109	108
2017	231	783	2234	829	1096	78
2018	56	1039	5325	2845	426	526
2019	415	5276	4528	604	1132	467
2020	0	3269	559	282	598	367

Table 9.5. Haddock in 7.a: Available tuning data.

```
IRISH SEA haddock, 2013 WG,ANON,COMBSEX,TUNING DATA(effort, nos-at-age)
101
NIGFS-WIBTS-Q1
1993 2020
1 1 0.21 0.25
0 5
```

1	**0**	**139**	**569**	**31**	**0**	**0**
1	0	644	58	183	0	0
1	0	24823	437	0.1	43	0
1	0	1065	3743	67	3	1.1
1	0	25118	474	1457	44	2.1
1	0	3913	8694	70	105	1.1
1	0	6058	680	2072	16	11.1
1	0	14028	1853	64	147	5
1	0	3277	6990	770	40	20.1
1	0	28755	842	1059	78	1.1
1	0	6966	14162	341	356	26.1
1	0	19945	2379	2206	45	35.1
1	0	24488	6454	406	234	15
1	0	13444	12721	2194	91	33.1
1	0	20918	11325	3661	240	27
1	0	7480	12009	2559	495	48.1
1	0	9345	3888	2877	163	42
1	0	17058	1765	524	239	27
1	0	17278	5543	299	67	50
1	0	13509	5266	1095	38	13
1	0	8245	5202	751	119	20
1	0	33807	2260	773	108	22
1	0	15495	22420	1297	407	44
1	0	14418	9109	5594	205	38
1	0	4321	18887	5524	323	33
1	0	7897	4683	7086	1709	1369
1	0	38570	6789	814	832	183
1	0	16709	28889	2571	260	257

```
NIGFS-WIBTS-Q4
1991 2020
1 1 0.83  0.88
0 4
```

1	36.127	0.716	3.965	0	0
1	2.042	151.766	1.171	0.959	0
1	15.289	101.536	0.753	0	0.045
1	1067.99	13.327	13.2	0.092	0.001
1	160.434	398.722	1.81	0.886	0.04
1	365.679	10.521	39.889	0.08	0.034
1	685.913	28.002	0.527	1.633	0.001
1	59.867	93.66	5.533	0.125	0.104
1	584.902	19.354	28.408	0.947	0
1	146.491	105.115	1.18	3.372	0
1	552.309	59.354	30.746	0.295	0.27
1	666.652	167.224	7.422	4.911	0.001
1	476.2	122.094	12.378	0.264	0.052
1	387.556	111.692	35.717	2.228	0.441
1	94.667	102.086	37.1	11.654	0.375
1	88.61	46.338	23.832	1.991	0.33
1	451.303	45.695	6.139	4.891	0.23
1	219.533	82.392	5.858	1.752	0.973
1	207.925	42.145	7.808	1.044	0.093
1	165.294	79.593	12.05	1.275	0
1	1004.22	8.279	1.531	0.179	0
1	339.218	311.607	68.768	3.016	0.423
1	455.385	81.189	108.663	2.309	0.362
1	99.046	154.865	52.207	4.273	0.281
1	191.946	42.885	90.324	15.934	6.202
1	690.663	167.338	12.891	16.507	2.003
1	21.174	179.518	169.383	8.19	0.58

```
NIMIK
1994 2020
1 1 0.38 0.47
0 0
```

1	**47000**
1	1700
1	47800
1	14500
1	2500
1	15400
1	1700
1	17100
1	1200
1	4250
1	25970
1	8250
1	40240
1	3820
1	6638
1	18540
1	4532
1	6606
1	9818
1	28325
1	12892
1	48463
1	1800
1	26900
1	30954
1	23942
1	NA

```
FSP Haddock: Tuning data
101
UKFspW
2005 2020
1 1 0.15 0.25
0 5
```

1	0	0	1.774	1.506	4.981	0.291
1	0	0.308	7.749	7.336	0.546	1.115
1	0	0.208	42.727	37.286	6.289	0.697
1	0	0	4.657	12.836	7.213	0.794
1	0	0	0.662	3.99	1.443	0.541
1	0	0.627	1.422	3.78	2.753	0.866
1	0	0.048	0.598	1.976	1.121	0.81
1	0	0.27	4.135	4.772	0.79	0.226
1	0	0.035	3.684	7.674	1.742	0.176
1	NA	NA	NA	NA	NA	NA
1	0	0.437	31.2	19.349	5.051	0.554
1	0	0	0	59.769	12.592	6.205
1	0	0	19.748	85.536	246.488	10.838
1	0	0	0	36.397	62.861	55.448
1	0	0.339	4.357	25.291	40.261	22.519
1	0	0	0	26.759	16.887	16.539

Table 9.6. Haddock in 7.a: F-at-age.

	Age					
	0	1	2	3	4	5
1993	0.023	0.227	0.614	0.698	0.704	0.705
1994	0.024	0.236	0.639	0.726	0.733	0.734
1995	0.031	0.312	0.846	0.961	0.970	0.971
1996	0.025	0.250	0.675	0.767	0.775	0.775
1997	0.031	0.312	0.844	0.959	0.968	0.969
1998	0.033	0.327	0.886	1.007	1.016	1.017
1999	0.048	0.483	1.308	1.486	1.500	1.501
2000	0.034	0.342	0.926	1.053	1.063	1.063
2001	0.124	0.422	0.753	0.803	0.562	0.401
2002	0.159	0.539	0.961	1.026	0.717	0.513
2003	0.128	0.435	0.776	0.828	0.579	0.414
2004	0.123	0.416	0.743	0.792	0.554	0.396
2005	0.100	0.341	0.609	0.649	0.454	0.325
2006	0.057	0.195	0.347	0.371	0.259	0.185
2007	0.095	0.324	0.578	0.616	0.431	0.308
2008	0.144	0.512	0.578	0.545	0.299	0.145
2009	0.111	0.393	0.444	0.419	0.230	0.112
2010	0.162	0.574	0.648	0.611	0.335	0.163
2011	0.085	0.302	0.341	0.322	0.176	0.086
2012	0.088	0.314	0.354	0.334	0.183	0.089
2013	0.009	0.064	0.112	0.107	0.112	0.112
2014	0.011	0.086	0.150	0.144	0.150	0.150
2015	0.010	0.077	0.134	0.128	0.134	0.134
2016	0.007	0.053	0.093	0.089	0.093	0.093
2017	0.009	0.068	0.118	0.113	0.118	0.118
2018	0.012	0.089	0.156	0.149	0.156	0.156
2019	0.011	0.094	0.166	0.162	0.166	0.166
2020	0.005	0.0453	0.077	0.075	0.077	0.077

Table 9.7. Forecast input data.

Variable	Value	Source	Notes
F ages 2–4 (2021)	0.138	ICES (2021a)	Fsq = $F_{average(2017-2019)}$
SSB (2022)	13 692	ICES (2021a)	Short-term forecast
R age 0 (2021 and 2022) (thousand)	371740	ICES (2021a)	Geometric mean (1993-2019)
Catch (2021)	1840	ICES (2021a)	Short-term forecast, fishing at F_{sq}
Wanted catch * (2021)	1 474	ICES (2021a)	Average discard rate (2018–2020)
Unwanted catch *(2021)	366	ICES (2021a)	Average discard rate (2018–2020)

*** "Wanted catch" is used to describe fish that would be landed in the absence of the EU landing obligation.**

Table 9.8. Haddock in Division 7.a. Assessment results. All weights are in tonnes. Low and high refer to 1 std confidence limits.

Year	Recruitment age 0			SSB			Landings	Discards*	F ages 2–4		
	Low	Value	High	Low	Value	High			Low	Value	High
1993	116903	153295	189686	1764	2414	3064	813	365	0.40	0.67	0.94
1994	426070	526461	626852	1485	2265	3044	1042	468	0.38	0.69	1.00
1995	38334	61815	85296	1544	2400	3256	1736	780	0.50	0.92	1.34
1996	1102367	1359186	1616005	3690	4902	6114	2981	709	0.47	0.74	1.00
1997	149582	209979	270376	2734	4092	5451	3547	895	0.55	0.92	1.28
1998	260607	342686	424765	6527	8253	9978	4874	1015	0.67	0.97	1.26
1999	545255	677318	809381	4194	5689	7184	4095	634	0.94	1.42	1.90
2000	63101	96885	130670	1842	2764	3686	1357	802	0.57	1.00	1.44
2001	560857	706607	852357	2788	3904	5019	2246	269	0.46	0.70	0.94
2002	91764	132890	174017	1947	2960	3974	1817	387	0.54	0.89	1.24
2003	312287	422798	533308	2407	3507	4606	1517	390	0.42	0.72	1.02
2004	503406	646316	789225	1586	2656	3727	1217	392	0.38	0.69	1.00
2005	387298	494514	601730	1569	2553	3537	666	551	0.31	0.57	0.83
2006	457052	566424	675796	2203	3298	4393	633	306	0.177	0.32	0.47
2007	171752	223615	275479	3092	4307	5521	886	722	0.34	0.54	0.74
2008	117321	157601	197881	3101	4422	5742	786	643	0.30	0.47	0.65
2009	261536	335500	409465	2473	3863	5253	581	579	0.22	0.36	0.51
2010	190919	250735	310550	2042	3355	4668	679	508	0.31	0.53	0.75
2011	237893	311522	385151	1783	3050	4317	446	307	0.161	0.28	0.40
2012	219290	302376	385463	2042	3349	4656	343	599	0.168	0.29	0.42
2013	1141541	1462138	1782735	2656	4277	5899	254	282	0.063	0.114	0.165
2014	489514	657405	825297	3950	5907	7863	518	488	0.088	0.151	0.21
2015	723221	971690	1220159	8825	12117	15409	833	652	0.080	0.134	0.187
2016	201808	293344	384880	11690	15967	20244	1008	298	0.055	0.091	0.127
2017	252647	371433	490218	14862	20302	25742	1662	333	0.070	0.116	0.163
2018	478139	721061	963984	14872	20646	26421	1993	568	0.087	0.149	0.21
2019	237606	438584	639563	11833	17184	22534	1778	672	0.091	0.165	0.24
2020	0	6914	33054	12740	17659	22578	742	234	0.029	0.066	0.102
2021		**371740			17423						

*** Discards estimates available since 2007, prior to 2007 discards estimates are based on limited sampling.**

****Geometric mean recruitment 1993–2019.**

Table 9.9. Haddock in Division 7.a. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2022)	Wanted catch* (2022)	Unwanted catch* (2022)	F_{total} (2022)	F_{wanted} (2022)	$F_{unwanted}$ (2022)	SSB (2023)	%SSB change **	%Advice change ^	%TAC change ^^^
ICES advice basis										
EU MAP ***: F_{MSY}	2761	2517	244	0.28	0.170	0.110	8681	-36.60	-18.096	
F = MAP $F_{MSY\ lower}$	2044	1863	181	0.20	0.121	0.079	9404	-31.32	-17.94^^	
F = MAP $F_{MSY\ upper}$	3346	3050	296	0.35	0.21	0.138	8094	-40.89	-18.23^^	
Other scenarios										
F = 0	0	0	0	00	0		11487	-16.104	-100	
F = F_{pa}	3819	3481	338	0.41	0.25	0.162	7622	-44.33	13.29	
F = F_{lim}	4481	4085	397	0.50	0.30	0.197	6966	-49.124	32.93	
F = F2021	1447	1319	128	0.138	0.083	0.054	10009	-26.90	-57.075	
SSB2023 = B_{lim}	8654	7885	769	1.34	0.81	0.53	2994	-78.133	156.72	
SSB2023 = B_{pa}	7388	6733	655	1.015	0.62	0.40	4160	-69.62	119.163	
SSB2023=MSY $B_{trigger}$	7260	6616	644	0.99	0.60	0.39	4281	-68.73	115.37	
SSB2023=SSB2022 #										

*** "Wanted" and "unwanted" catch are used to describe fish that would be landed and discarded in the absence of the EU landing obligation, based on discard rate estimates for 2018–2020.**

**** SSB 2023 relative to SSB 2022.**

***** EU multiannual plan (MAP) for the Western Waters (EU, 2019).**

^ Advice value for 2022 relative to the F_{MSY} advice value for 2021 (3371 tonnes).

^^ Advice value this year relative to the advice value last year for the MAP $F_{MSY\ lower}$ (2491 tonnes) and MAP $F_{MSY\ upper}$ (4092 tonnes).

^^^ TAC 2021 not available

 # SSB2023= SSB2022 cannot be achieved even with zero catches.

Table 9.10. Haddock in 7.a Management reference points.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	4281 tonnes	5th percentile of BMSY; Irish Sea haddock has been fished at, or below F_{MSY} for >five years.	ICES (2018a)
	F_{MSY}	0.28	Median point estimates of EqSim with segmented regression stock–recruitment relationship	ICES (2018a)
	$F_{MSYLower}$	0.20	F at 95% of MSY below F_{MSY}	ICES (2018a)
	$F_{MSYUpper}$	0.35	F at 95% of MSY above F_{MSY}	ICES (2018a)
Precautionary approach	B_{lim}	2994 tonnes	Lowest observed SSB with >75th percentile recruitment	ICES (2018a)
	B_{pa}	4160 tonnes	B_{lim} combined with the assessment error; $B_{lim} \times \exp(1.645 \times \sigma)$; $\sigma = 0.20$	ICES (2018a)
	F_{lim}	0.50	F with 50% probability of SSB <B_{lim}	ICES (2018a)
	F_{pa}	0.41	$F_{p0.05}$; the F that leads to SSB>B_{lim} with 95% probability	ICES (2018a)
Management plan	SSB_{MGT}	Not applicable		
	F_{MGT}	Not applicable		

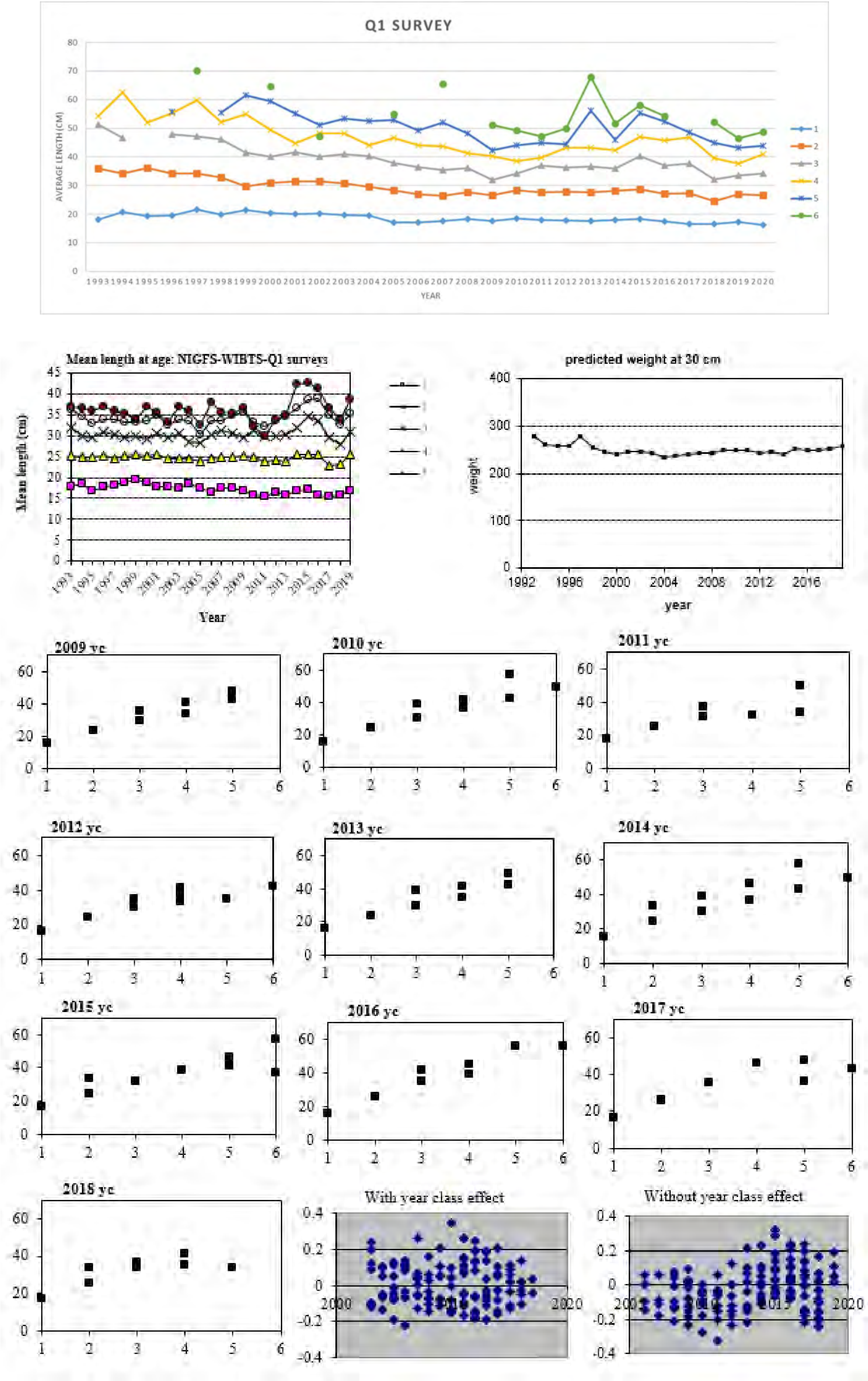


Figure 9.1. Haddock in 7.a: Growth of haddock in the Irish Sea. Top two panels: mean length-at-age in UK(NI) groundfish surveys in March (NIGFS-WIBTS-Q1), by year and age, and expected mean weight-at-length based on length–weight parameters from each survey. Lower panels: mean length-at-age from March surveys, and from Quarter 1 commercial landings at-age 3 and over, by year class. Lines are von Bertalanffy model fits with year-class effect included. Model residuals are shown for the fit without year-class effects, and for the fit with year-class effects.

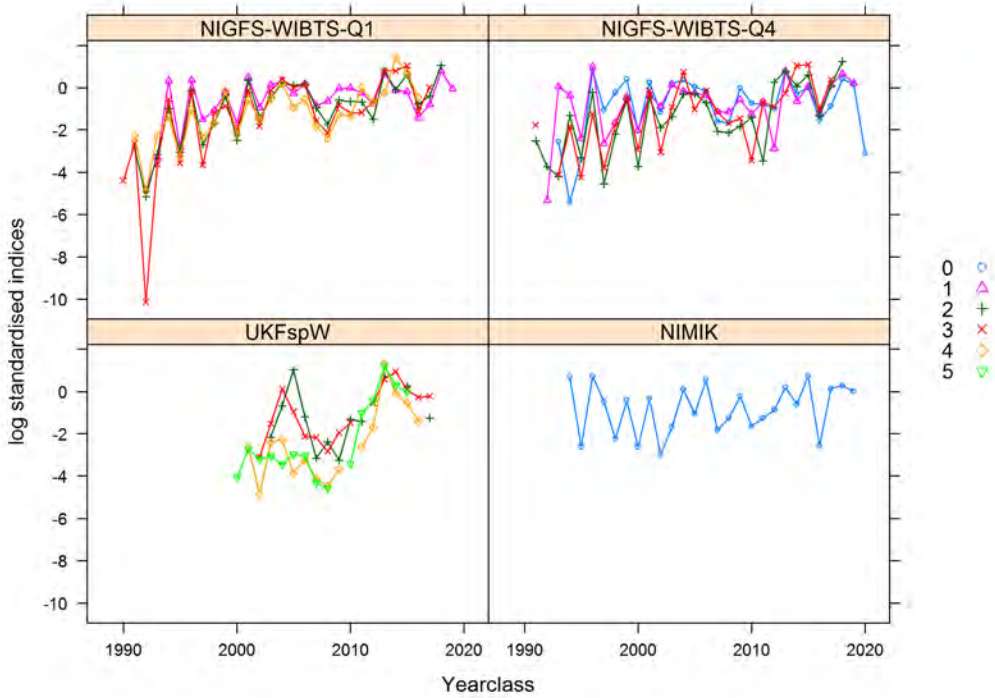
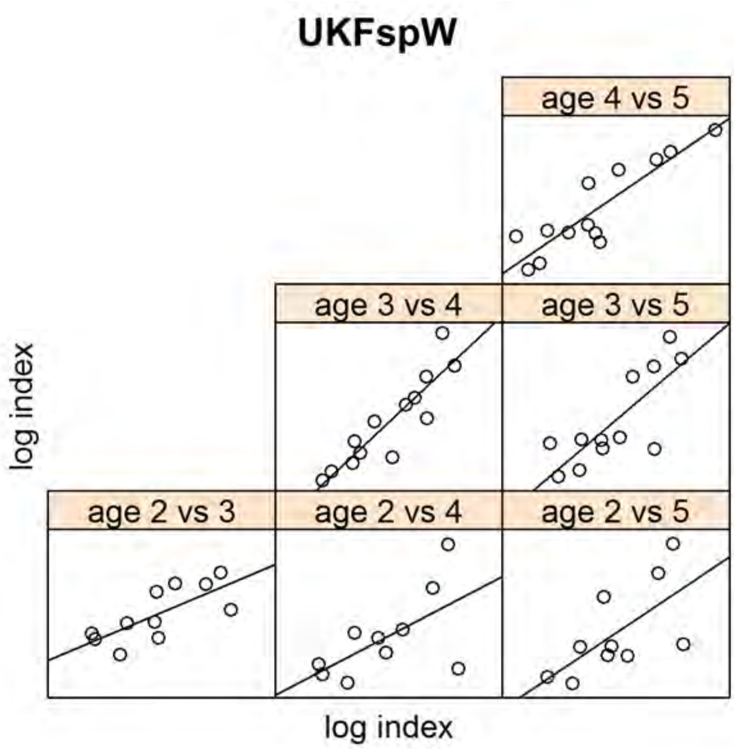


Figure 9.2. Haddock in 7.a: Trends in log-standardised survey indices.



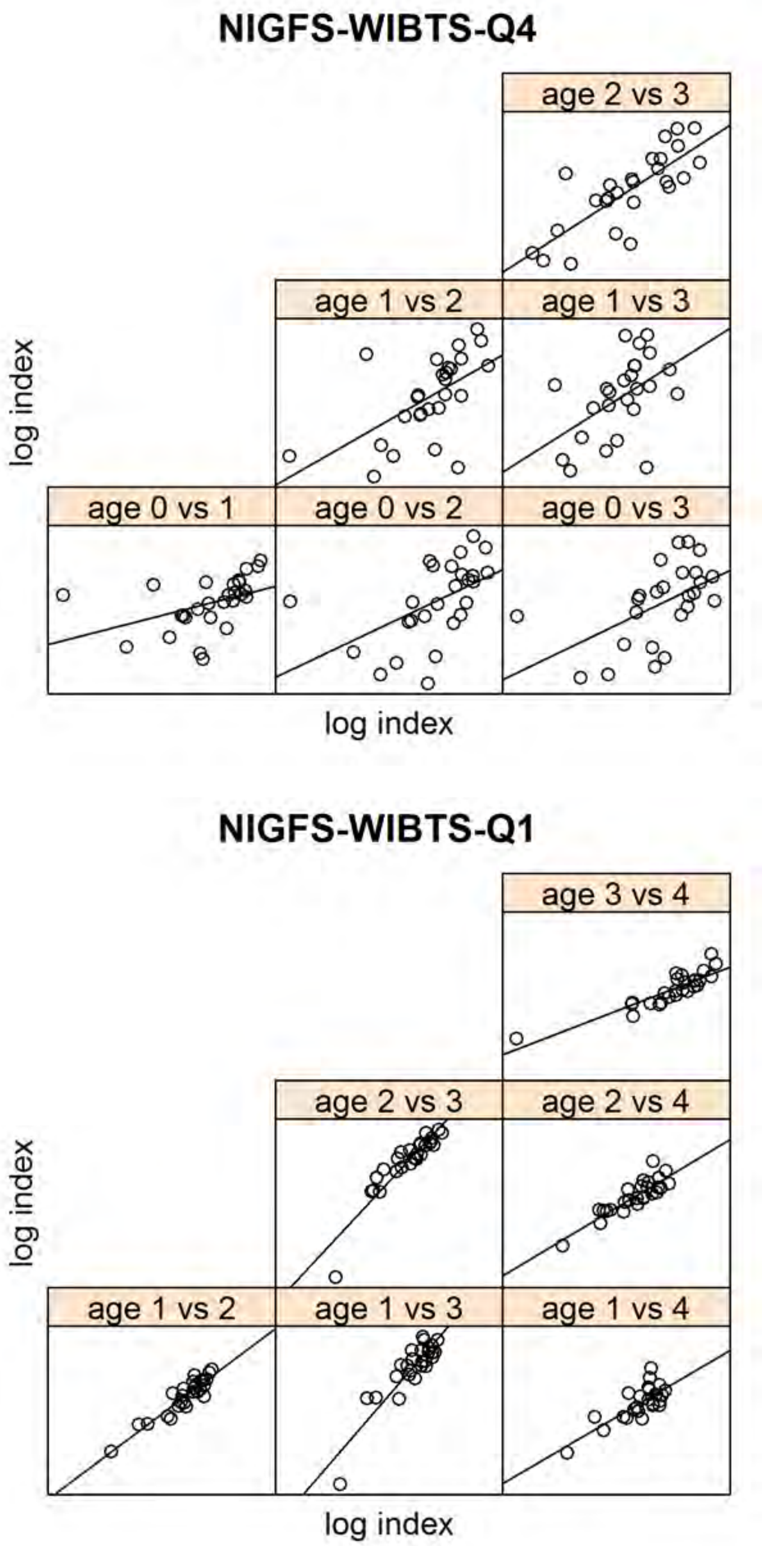


Figure 9.3. Haddock in 7.a: Scatterplot matrix of log indices of cohorts at different ages.

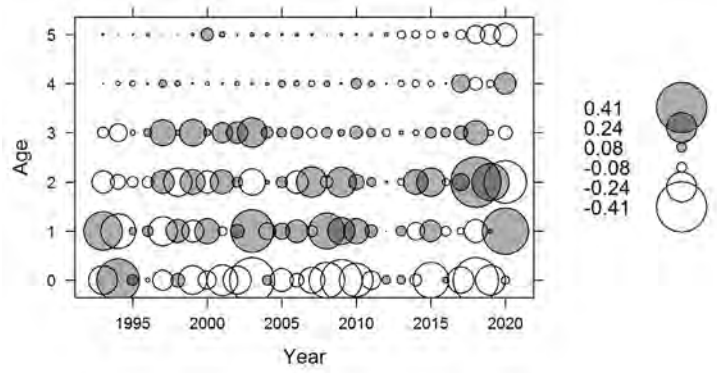


Figure 9.4. Residuals from fitted and observed catch age proportions.

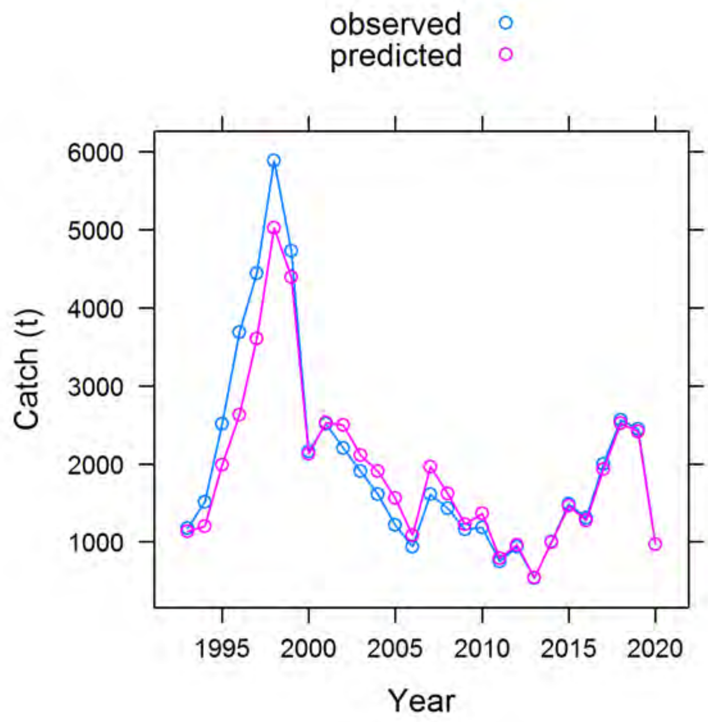


Figure 9.5. Fitted and observed catch from update assessment.

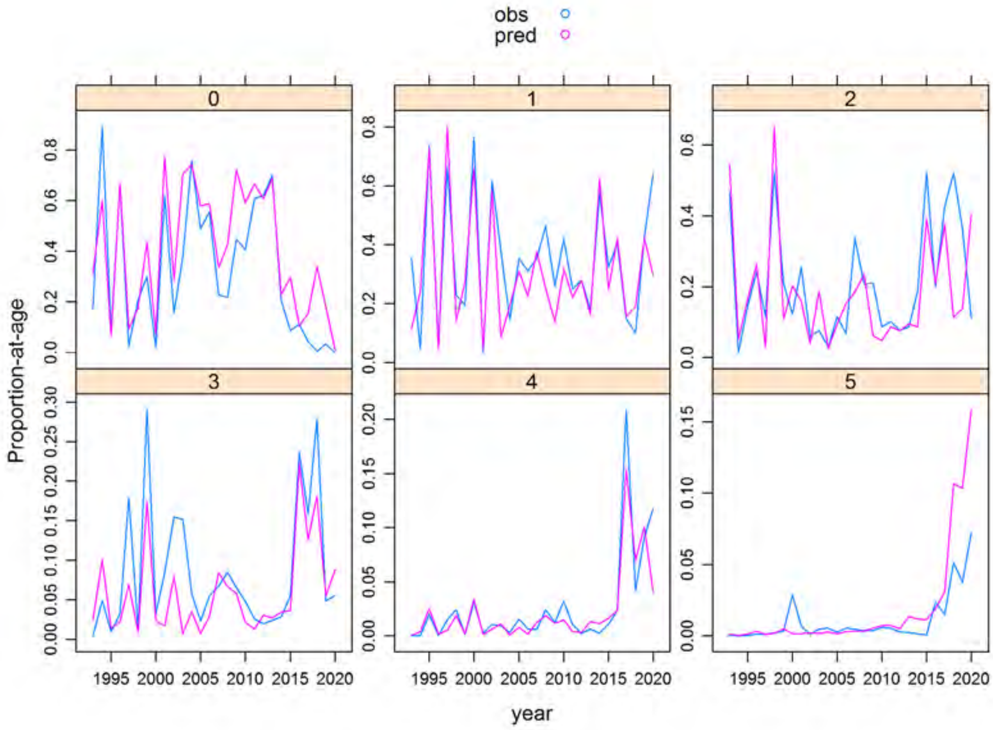


Figure 9.6. Fitted and observed catch age proportions from update assessment.

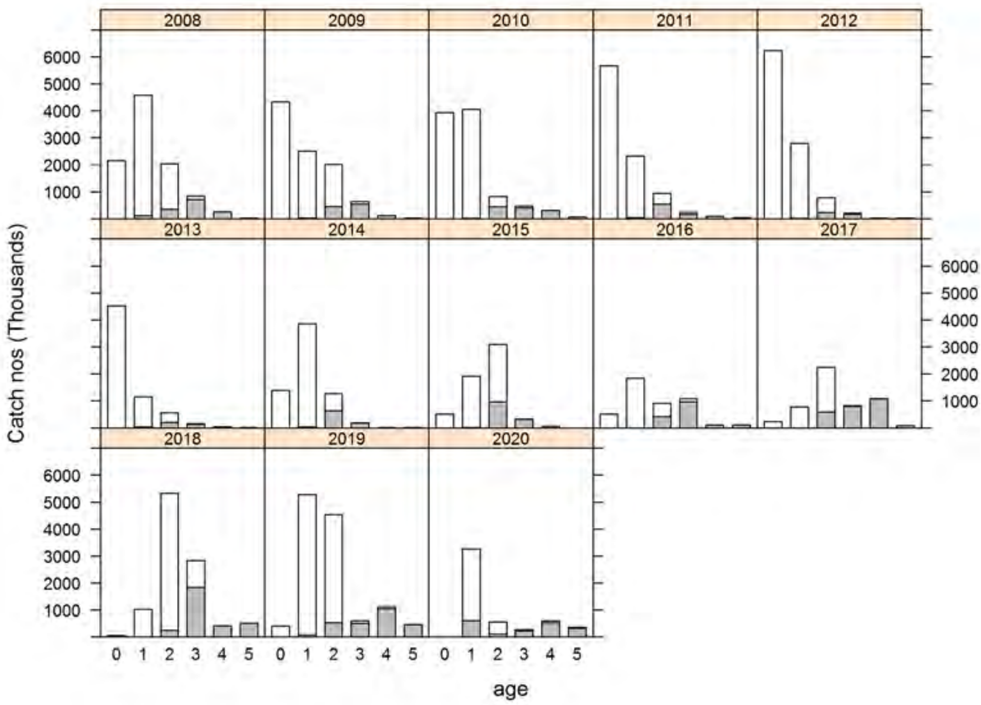


Figure 9.7. Observed catch numbers 2008–present.

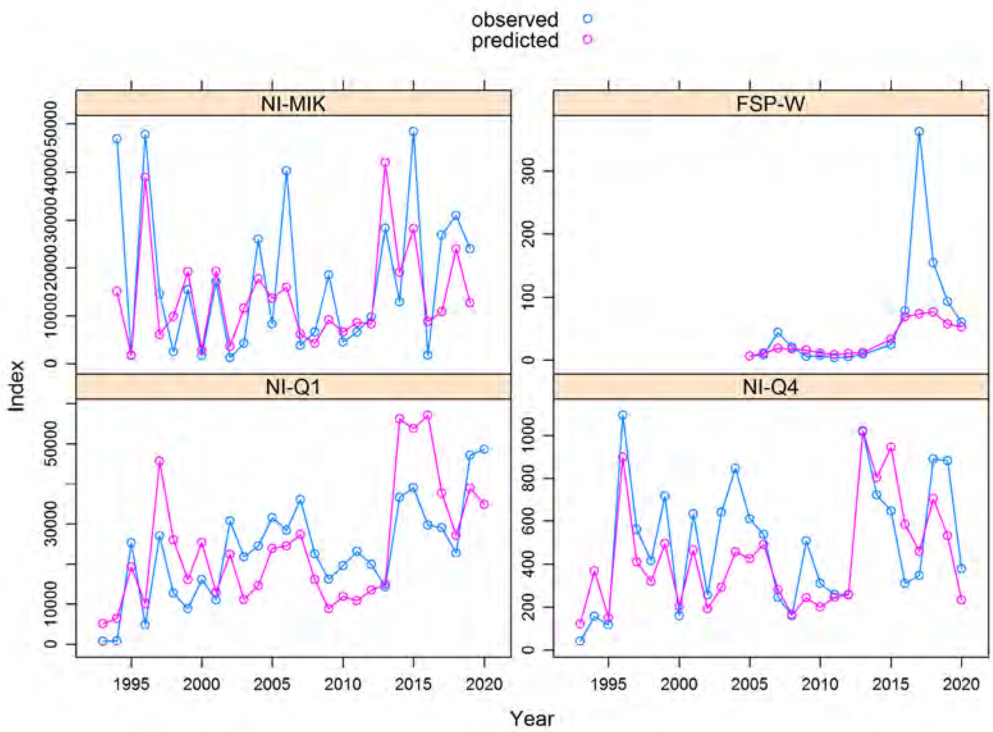


Figure 9.8. Fitted and observed index series from update assessment.

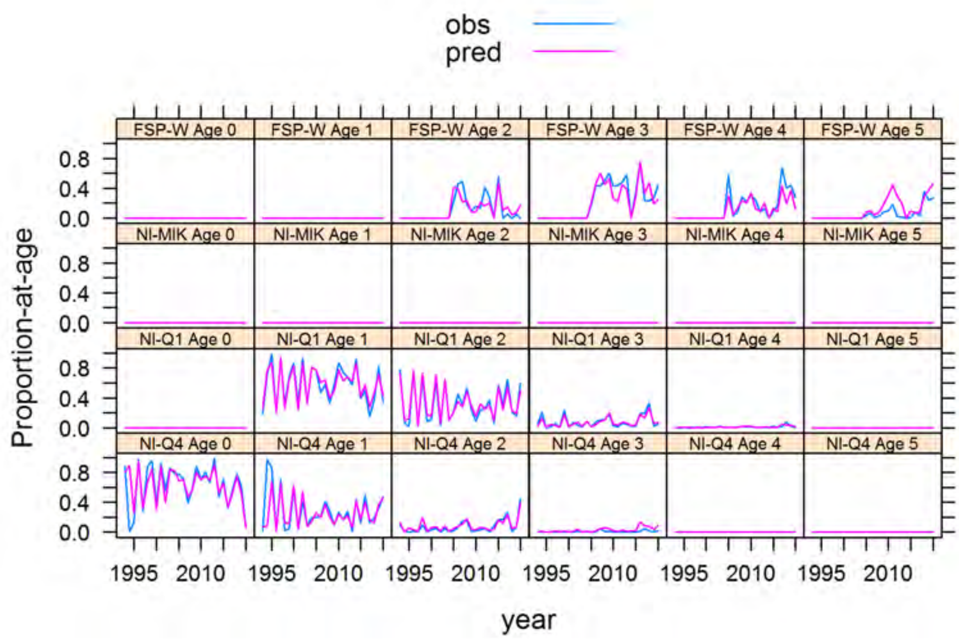


Figure 9.9. Fitted and observed index age proportions from update assessment.

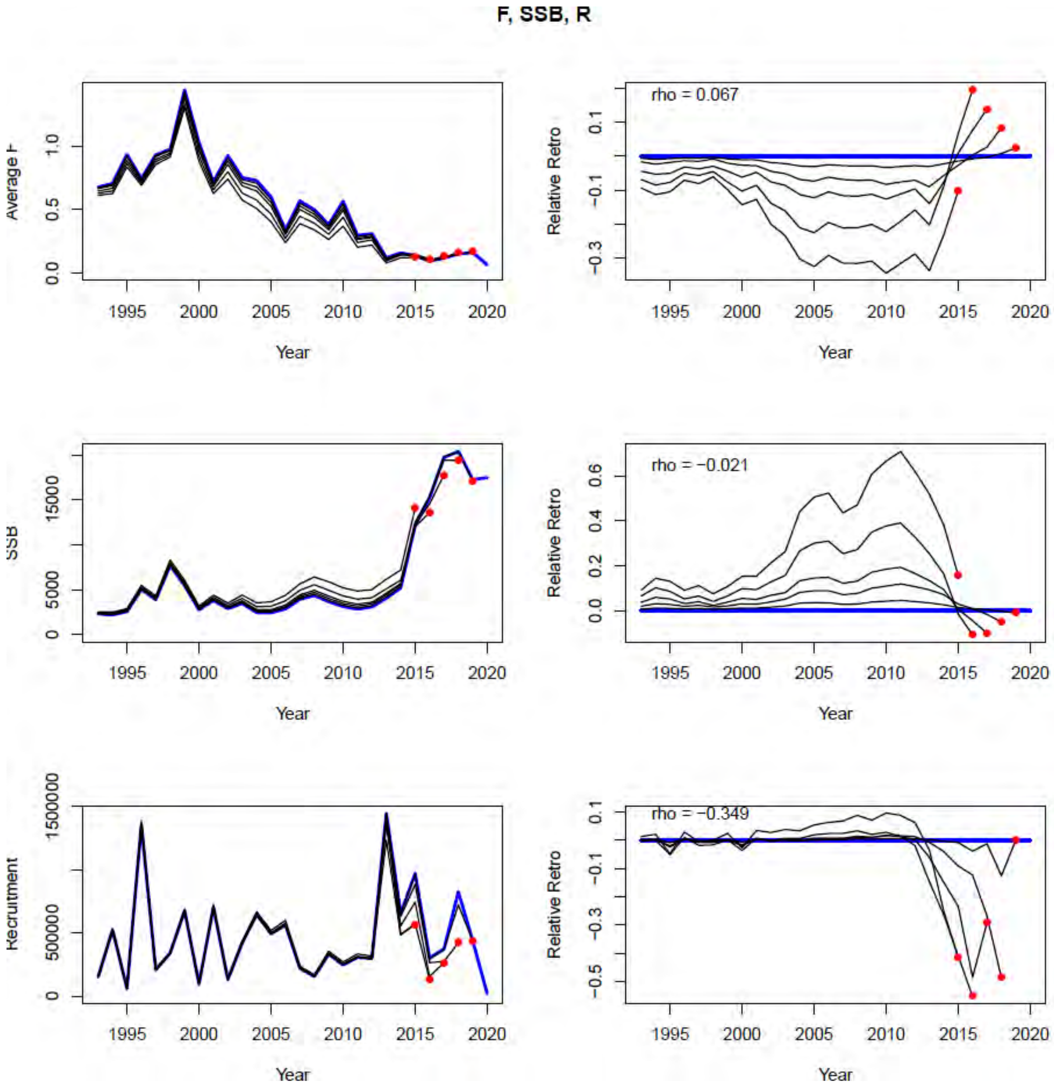


Figure 9.10. Retrospective plot the final update model.

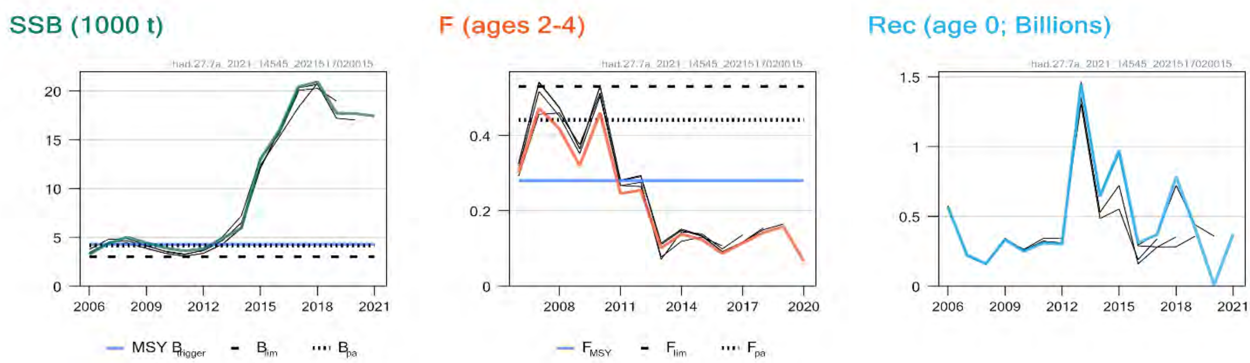


Figure 9.11. Haddock in Division7.a. Historical assessment results.

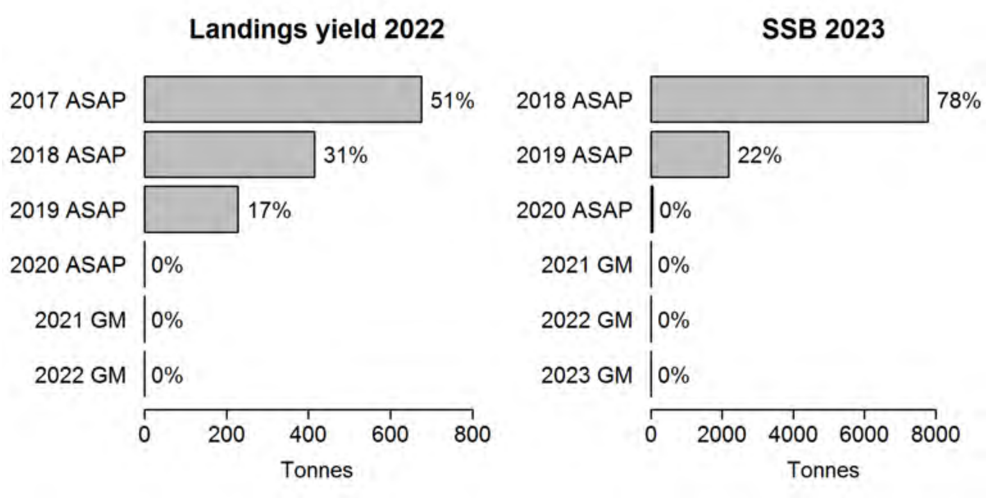


Figure 9.12. Haddock in 7a. Stock numbers of recruits and their source for recent year classes used in predictions, and the relative (%) contributions to landings and SSB (by weight) of these year classes.

10 Megrim (*Lepidorhombus* ssp.) in divisions 4.a and 6.a (northern North Sea, West of Scotland)

Type of assessment in 2021

Update of 2020 assessment with new landings and survey data. The model used to carry out the assessment is the Schaefer Surplus production process model in R and Winbugs.

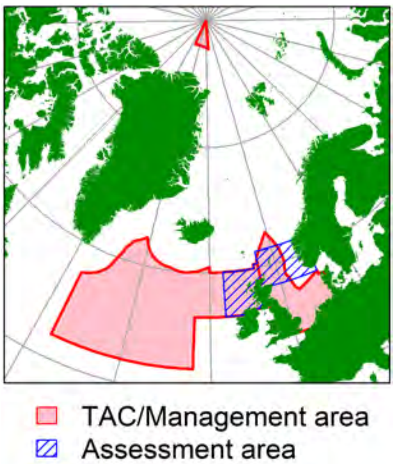
ICES advice applicable to 2021 and 2022

ICES advise that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2022 that correspond to the F ranges in the plan are between 5750 tonnes and 7350 tonnes.

10.1 General

Stock description and management units

Megrim stock structure is uncertain and historically the Working Group has considered megrim populations in 6.a and 6.b as separate stocks. The review group questioned the basis for this in 2004. Data collected during an EC study contract (98/096) on the 'Distribution and biology of anglerfish and megrim in the waters to the West of Scotland' showed significantly different growth parameters and significant population structure difference between megrim sampled in 6.a and 6.b (Anon, 2001). Spawning fish occur in both areas but whether these populations are reproductively isolated is not clear. As noted by WGNSDS (2008), megrim in 4.a has historically not been considered by ICES. Since 2009 data from 4 and 2.a are included in this report, but international catch and weight-at-age data for 4, prior 2006 were not available to the working group. Given that there is little evidence to suggest that megrim in 6.a and 4.a are separate stocks, based on a visual inspection of the spatial distribution of commercial landings and fishery-independent survey data, WKFLAT (2011) concluded that megrim in 6.a and 4.a should be considered as a single stock. This has subsequently been supported through recent genetic studies (MacDonald and Prieto, 2012) indicating that there is one stock consisting of divisions 4.a (northern North Sea) and 6.a (West of Scotland) and another separate stock in Division 6.b (Rockall).



Management area (red boxes) and assessment area (blue hatched boxes).

Species:	Megrims *Lepidorhombus* spp.	Zone:	Union waters of 2a and 4 (LEZ/2AC4-C)
Belgium	9	Analytical TAC	
Denmark	8	Article 7(2) of this Regulation applies	
Germany	8		
France	48		
The Netherlands	38		
United Kingdom	2 811		
Union	2 922		
TAC	2 922		

Species:	Megrims *Lepidorhombus* spp.	Zone:	Union and international waters of 5b; 6; international waters of 12 and 14 (LEZ/56-14)
Spain	671	Analytical TAC	
France	2 615 (1)	Article 7(2) of this Regulation applies	
Ireland	764		
United Kingdom	1 851 (1)		
Union	5 901		
TAC	5 901		

(1) Special condition: of which up to 5 % may be fished in: Union waters of 2a and 4 (LEZ/*2AC4C).

2020 TAC for 6, EC waters of 5.b and International waters of 12 and 14 (lower) and TAC for 4 and 2.a (upper).

The TAC value of 7300 Tonnes for 2021 is based on the ICES Catch Advice applicable to 2020 and 2021.

The uptake of the 2020 TAC for ICES Division 6 and EU waters of 5.b was 27%. The small uptake was mainly due to poor utilisation of quota by France and the UK, managing only 4.6 and 31.4% respectively. In Area 4 and 2.a, uptake of the TAC was 69%. The majority of available TAC (96%) is allocated to the UK, who take 85%.

Fishery in 2020

Impact of COVID-19

The impact of the Covid-19 pandemic on the fishery is difficult to quantify due to a mix of annual and quarterly data. Discard sampling levels present in InterCatch were reduced when compared to the previous year.

Biomass data from scientific tuning indices (IAMISS-Q2 (G1794), Sco-IBTS-Q1 (G1022), Sco-IBTS-Q3 (G2829), Sco-WIBTS-Q1 until 2010 (G1179), and Sco-WIBTS-Q4 until 2010 (G4299) were received. However, the SIAMISS-Q2 (G3745) survey was not completed in 2020. The impact to the assessment is considered to be negligible and discussed later in the report.

Landings

Catches of megrim comprise two species, *Lepidorhombus whiffiagonis* and *L. boscii*. Information available to the Working Group indicates that *L. boscii*, are a negligible proportion of the Scottish and Irish megrim catch (Kunzlik *et al*., 1995; Anon, 2001).

Commercial catches are dominated by female megrim, typically 90% of the total catch. The InterCatch catch estimate is 3529 tonnes, and the ICES landings estimate for 6.a and 4.a. is 3315 tonnes. The total ICES landings are well below the total TAC covering the fished areas of 4.a–6.a.

Official landings data for each country together with Working Group best estimates of landings from 6.a are shown in Table 10.2 and for 4.a in Table 10.3. To estimate ICES landings, we take InterCatch estimates and, if unavailable, we use official estimates.

There are often minor differences between official data and InterCatch for most countries. There were some minor discrepancies in 2019 and 2020.

Discards

Discard data were made available by Ireland, Scotland and France in Subdivision 6.a and Scotland, France and Denmark in Subdivision 4.a. Total discards were estimated to be 214 t or 6.4% by weight for the stock area in 2020, individual discard rates for Denmark, France, Ireland and Scotland were 1.3, 1.1, 24.6, and 5% by weight respectively. We assume no discards for Belgium, Netherlands, and Germany.

A linear decline in discards from 30 to 15% over time between 1985 and 2012 is assumed in the stock assessment. From 2013 onwards discard data have taken from InterCatch, there is no deviation from the agreed stock annex (see Annex 2).

Catch

A breakdown of 2020 catch by main gear type in InterCatch is given below:

Catch	Landings			Discards		
	Finfish trawls	*Nephrops* trawls	Other Gears	Finfish trawls	*Nephrops* trawls	Other Gears
3529 tonnes	99%	<1%	1%	89%	11%	0%
	3315 tonnes			214 tonnes		

Surveys

Indices from six fishery-independent surveys are used in the assessment. The surveys are outlined in Table 10.1 below and details can be viewed in the stock annex.

Table 10.1. Summary indices used for surplus production model.

NUMBER	SURVEY	NATIONALITY	AREA	TIME-SERIES	DEPTH RANGE (M)
1	SCO-IBTS-Q3 (G2829)	SCOTLAND	4.A	1987-PRESENT	<400 M
2	SCO-IBTS-Q1 (G1022)	SCOTLAND	4.A	1987-PRESENT	<400 M
3	SCOGFS-WIBTS-Q1 (G1179)	SCOTLAND	6.A	1986-2010	40-400
4	SCOGFS-WIBTS-Q4 (G4299)	SCOTLAND	6.A	1986-2010	50-300
5	SIAMISS-Q2 (G3745)	SCOTLAND	6.A*/4.A	2005-PRESENT	50-1050
6	SIAMISS-Q2 (G1794)	IRELAND	6.A*	2005-PRESENT	50-850

Figures 10.1 to 10.5 present the megrim biomass maps for the SIAMISS and IBTS surveys. The SIAMISS bubble plots show and increasing abundance over time throughout the area over the time-series. The abundance in 6.a was particularly high in 2013 and a similar high abundance occurred in 4.a in 2014 (Figure 10.1). Figures 10.2. (Sco-IBTS-Q3 (G2829) 4.a) and 10.3 (Sco-IBTS-Q1(G1022) 4.a) show the large increase in biomass over time in the northern North Sea. Biomass in the southern North Sea remains quite low.

Figures 10.4 (ScoGFS-WIBTS-Q1(G1179) 6.a) and 10.5 (ScoGFS-WIBTS-Q4(G4299) 6.a) also show an increase in biomass over the time-series. However, survey design and ground gear changed after 2010; this should be taken into account when interpreting the plots. Data were truncated from the time-series going into the assessment.

10.2 Estimation of survey cpue indices

Cpue trends of survey data

The data from the IBTS surveys exhibit a relatively large proportion of zeros, therefore the delta method of Stefánsson (1996) was used to generate indices. This method (delta-gamma model) comprises fitting two generalized linear models. The first model (binomial GLM) is used to obtain the proportion of non-zero tows, and is fit to the data coded as 1 or 0, if the tow contained a positive or zero cpue, respectively. The second model is fit to the positive only cpue data using a gamma or lognormal GLM.

At WGCSE 2017, it was discovered that previous delta-gamma cpue estimations had included the full time-series for the 6.a surveys, when fitting the model to those surveys. In 2020, these again generate a slightly different cpue index Figure 10.6. The truncated series was used in the 2021 assessment since fitting to the full series would be inappropriate.

The SIAMISS-Q2 survey (G3745) as described in Table 10.1, was not completed in 2020 following disruption due to the COVID-19 pandemic. To assess possible influence, the absence of the missing survey index may have on the assessment, a sensitivity analyses was conducted. Results suggest; impact to the assessment is considered negligible.

The biomass trend for the SIAMISS survey is shown in Figure 10.7. There is a weakly increasing trend over time with year effects evident in 6.a in 2013 and 2017. There is a noticeable upward trend in 6b in recent years; with 4a also displaying an increase in 2019. The biomass trends for the four IBTS surveys are shown in Figure 10.8.

Commercial cpue

Commercial cpue data have not been updated compared to last year and are not used in the assessment.

10.3 Stock assessment

The input data for the stock assessment are given in Table 10.4 this comprises of a time-series from all survey indices, and ICES catch estimates for this stock.

2021 Final run

The Pearson residual diagnostic plots for the final assessment are shown in Figure 10.9. The residuals for the two 6.a surveys and the SIAMISS survey are fairly randomly dispersed around zero. A trend in the residuals is evident for the two 4.a surveys, with increasing positive residuals in the last decade.

The prior and posterior distributions for the parameters in the final model fit, are shown in Figure 10.10. The priors are given in Table 10.5. The posterior distributions are similar to previous year's assessments. The posterior parameter estimates for the final assessment model are given in Table 10.6. These are similar to recent assessments.

Figure 10.11 shows the final model fits to the cpue series and the estimates of total biomass and harvest ratio. The fits to the 6.a and SIAMISS surveys are reasonable. The fits to the 4.a surveys show that the model is not fitting well to those surveys in recent years. This issue needs to be examined further in the next benchmark.

Figure 10.12 compares the assessment results of the model fitted to a cpue, generated using the full time-series of the 6.a surveys and a model with the truncated cpue series. This indicates that the impact of fitting the model to the full time-series of delta-gamma cpues for 6.a instead of the truncated time-series was minimal, mainly effecting the early part of the time-series.

The time-series of B/B_{MSY} and F/F_{MSY} landings and discards used in the final assessment are given in Table 10.7.

Comparison with previous assessments

Figure 10.13 compares the final assessment with those conducted by WGCSE at previous meetings. The 2021 assessment assesses the biomass estimate to be stable at the 2020 levels; prior to being revised down in recent years. Estimates of fishing mortality continue on an upward trend. There are also some deviations in the historic estimates of F and Biomass around 2000. These are linked to the use of the 6.a surveys to derive the delta-gamma cpues truncated in 2010.

To evaluate evidence of possible bias in the assessment population metrics, a Mohn's Rho analysis resulted in values of -0.03865 for F_{bar} and 0.038415 for biomass. ICES considers a value greater than 0.20 to be unacceptably high.

State of the stock

The state of the stock has not changed since last year. Fishing mortality has been below F_{MSY} for almost the full time-series and has an overall declining trend since the late 1990s. Biomass has consistently been above MSY $B_{trigger}$ and shows an increasing trend since 2005. The stock in 2021 is estimated to be 1.47 times B_{MSY}. The fishing mortality in 2020 is estimated to be have been 47% of F_{MSY}.

10.4 Short-term projections

Short-term projections have been updated according to the method set out in the stock annex. The basis for the catch options is given in Table 10.8.

The management option table is given in Table 10.9. Fishing at F_{MSY} in 2021 is projected to result in total catches of 7350 t (landings of 6888 t and discards of 462 t) and a Biomass of 1.34 times B_{MSY} in 2023.

10.5 Biological reference points

Precautionary approach reference points

F_{MSY}, B_{MSY} and the yield at MSY are all directly estimated in the model. It should be noted that these will vary when new survey and catch information is added. B_{pa} and B_{lim} are defined as 50%B_{MSY} and 30%B_{MSY} respectively. F_{lim} is defined as 1.7 F_{MSY} and is the F that drives the stock to B_{lim} assuming B_{lim}=30%B_{MSY}. The derivation is given below:

$P=rB(1-B/K)$

The surplus productivity associated with B_{lim} is:
$P_{lim}=rB_{lim}(1-B_{lim}/K)$
The corresponding F is:
$F_{lim}=rB_{lim}(1-B_{lim}/K)/B_{lim} = r(1-B_{lim}/K)$
$B_{lim}=0.3B_{MSY} = 0.3K/2$
$F_{lim} = r(1-0.3K/(2K)) = r(1-0.3/2) =0.85r$
$F_{MSY}=r/2$, let x denote the proportionality between F_{MSY} and F_{lim}
$xF_{MSY}=F_{lim}$
$x(r/2)=0.85r$
$x=2*0.85$
$x=1.7$

MSY reference points

In 2015, ICES provided precautionary F_{MSY} ranges that are derived to deliver no more than a 5% reduction in long-term yield compared with MSY. Details of this analysis are given in WKMSYREF3 (ICES, 2015) and the derivations are given below.

	MSY Flower[b)]	F_{MSY}[b)]	MSY F_{upper}[b)] with AR	MSY B[trigger]
Megrim in divisions 4.a and 6.a	0.39 × r [d)]	r/2 [d)]	r/2 [d)]	K [d)]

The stock has been fished below F_{MSY} for more than ten years, therefore, the WG considered it appropriate to set the MSY $B_{trigger} = B_{MSY}$ according to the ICES guidelines (ICES, 2017).

Uncertainties and bias in assessment and forecast

The model estimates of B and F to have large uncertainty. Despite this, there is a low probability that SSB is below MSY $B_{Trigger}$ and a high probability that F is below F_{MSY}.

The reference points are re-estimated within the assessment. The change between 2019 and 2020 reference points are consistent with previous years and results in a rescaling of relative stock status. However, in absolute terms, stock trends are consistent with those of previous years.

The biomass time-series from surveys has increasing uncertainty boundaries as the index increases. This results in uncertainty bounds in the model estimates; shows a contraction from the 2021 assessment.

Owing to incomplete discard data, historical discard rates (1985–2012) are assumed to have declined, from 30% at the beginning of the time-series, to an estimate of 15% in 2012. The evaluation of current stock status is robust to this assumption. Estimates since 2013 are based on observed discards.

Recommendation for next benchmark

This stock was subject to an inter-benchmark in 2012 (IBP-MEG, 2012). Due to incomplete age data, particularly for 4.a, a Bayesian state–space surplus production model was chosen as the final assessment model. Subsequent update assessments have highlighted a problem fitting to the 4.a surveys which needs to be examined in a future benchmark.

WGCSE recommends the following explorations:

- The SIAMISS survey should be merged into one continuous index. The length data for the index should also be examined.

- The ScoGFS-WIBTS-Q1/Q4 2011+: the ScoGFS-WIBTS-Q1/Q4 survey time-series should also be examined for re-introduction into the assessment as a new time-series. There may also be scope to integrate the IGFS.
- Available length and age-structured data should be compiled for this stock.
- Length or age-structured assessment models could be explored.

Once sufficient progress has been made on the points above, WGCSE will suggest a benchmark schedule.

Management considerations

Megrim is a bycatch species in the mixed demersal trawl in divisions 6.a and 4.a. Management measures for other species have constrained the fishery and reduced effort and fishing mortality on megrim. The general increase in mesh size in 6 and 4 since 2010 has also benefited the stock.

The TAC in 6 has not been fully utilised. However, the uptake rate is country specific, with some Member States reporting landings above their quota in the North Sea. Partial quota uptake by individual Member States may be linked to reduction in effort rather than reflective of a reduction in biomass. The TAC and assessment area are incompatible. There are two separate TAC areas covering ICES areas 6 and 4, whereas the assessment covers ICES divisions 6.a and 4.a combined. Due consideration of the inconsistency between management and assessment area is required when setting fishing opportunities for this stock and the separate 6.b Rockall stock. ICES (2013) have advised the EC that the TAC areas should be consistent with the assessment area and that ICES has no basis on how to split the catch advice so that it is consistent with the TAC areas.

10.6 References

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Table 10.2. Megrim in Subarea 6.a. Nominal catch (t) of Megrim West of Scotland, as officially reported to ICES and WG best estimates of landings. The shaded cells show updates in official data compared with last year.

Year	Belgium	France	Ireland	Netherlands	Spain	UK – Eng, Wales & N.Irl.	UK – Scotland	UK	Official Total	ICES landings
1990	0	398	317	0	91	25	1093	-	1924	2210
1991	1	455	260	0	48	167	1223	-	2154	2432
1992	0	504	317	0	25	392	887	-	2125	2549
1993	0	517	329	0	7	298	896	-	2047	2721
1994	1	408	304	0	1	327	866	-	1907	2693
1995	0	618	535	0	24	322	952	-	2451	3498
1996	0	462	460	0	22	156	944	-	2044	4054
1997	0	192	438	1	87	123	954	-	1795	3272
1998	0	172	433	0	111	65	841	-	1622	2705
1999	0	0	438	0	83	42	831	-	1394	2648
2000	0	135	417	0	98	20	754	-	1424	2247
2001	0	252	509	0	92	7	770	-	1630	2473
2002	0	79	280	0	89	14	643	-	1105	1828
2003	0	92	344	0	98	13	558	-	1105	1642
2004	0	50	278	0	45	17	469	-	859	1328
2005	0	48	156	0	69	10	269	-	552	561
2006	0	53	221	0	52			346	672	875
2007	0	104	191	0	5			667	967	1301
2008	0	92	172	0	149			874	1287	1545
2009	0	174	188	0	112			953	1427	1387
2010	0	271	318	0	288			822	1699	1698
2011	0	153	227	0	217			715	1312	1297
2012	0	140	214	0	142			590	1086	1132
2013	0	105	203	0	213			470	991	949
2014	0	126	246	0	57			465	894	948

Year	Belgium	France	Ireland	Netherlands	Spain	UK – Eng, Wales & N.Irl.	UK – Scotland	UK	Official Total	ICES landings
2015	0	140	311	0	140			520	1110	1110
2016	0	189	408	0	146			694	1437	1437
2017	0	132	336	0	313			579	1359	1359
2018	0	119	301	0	289			683	1392	1392
2019*	0	125	271	0	361			854	1605	1611
2020*	0	121	249	0	302			708	1382	1380

*** Preliminary official landings.**

Table 10.3. Megrim in Subarea 4 and 2.a. Nominal catch (t) of Megrim North Sea, as officially reported to ICES and WG best estimates of landings.

Country	Belgium	Denmark	France	Germany	Germany, Fed. Rep. of	Ireland	Netherlands	Norway	Spain	Sweden	UK – Eng, Wales & N.Irl.	UK – England & Wales	UK- N. Ireland	UK – Scotland	UK	Official total	ICES landings
1990	4	2	-	-	3	-	24	-	-	-	17	-	-	1126	-	1176	837
1991	3	1	-	6	-	-	28	-	-	-	9	-	-	1169	-	1216	878
1992	2	4	36	3	-	-	27	-	-	-	47	-	-	1372	-	1491	1025
1993	7	6	25	4	-	-	30	-	-	-	8	-	-	1736	-	1816	1081
1994	2	1	27	1	-	-	28	-	-	-	19	-	-	2000	-	2078	1207
1995	7	2	24	2	-	-	26	-	-	-	44	-	-	2193	-	2298	1172
1996	5	7	14	1	-	-	9	-	-	-	4	-	-	3221	-	3261	1199
1997	3	5	16	2	-	-	20	-	-	-	3	-	-	3091	-	3140	1584
1998	5	18	14	4	-	-	30	-	-	-	5	-	-	2628	-	2704	1548
1999	4	21	.	1	-	-	26	-	-	-	4	-	-	2121	-	2177	1111
2000	10	29	7	3	-	-	20	-	-	-	2	-	-	2044	-	2115	1247
2001	2	52	5	1	-	-	11	-	-	-	2	-	-	1854	-	1927	1098
2002	5	8	6	-	-	-	9	-	-	-	3	-	-	1675	-	1706	975
2003	3	11	11	2	-	1	7	<0.5	-	-	1	-	-	1235	-	1271	727
2004	-	7	9	2	-	-	11	<0.5	-	-	1	-	-	1130	-	1160	739
2005	-	1	3	4	-	-	19	<0.5	-	-	1	-	-	958	-	986	n/a
2006	0	3	4	1		0	6	1	0	0					1342	1357	1179
2007	0	11	18	4		0	1	1	0	0					1437	1472	1047
2008	0	31	20	1		0	1	4	0	0					1524	1581	1349

Country	Belgium	Denmark	France	Germany	Germany, Fed. Rep. of	Ireland	Netherlands	Norway	Spain	Sweden	UK – Eng, Wales & N.Irl.	UK – England & Wales	UK- N. Ireland	UK – Scotland	UK	Official total	ICES landings
2009	0	54	9	0		0	0	6	0	0					1474	1543	1484
2010	0	22	1	0		0	1	2	0	0					1440	1466	1499
2011	0	23	10	3		0	0	1	0	0					1394	1431	1421
2012	0	35	5	3		0	0	1	0	0					1397	1441	1458
2013	0	48	7	3		0	0	17	0	0					1690	1765	1788
2014	0	35	7	1		0	0	12	0	0					1475	1530	1551
2015	0	26	1437	0		0	0	8	0	0					1175	1217	1230
2016	0	46	13	2		0	2	21	0	0					1278	1362	1361
2017	0	0	36	0		0	0	29	0	0					1171	1235	1235
2018	0	0	66	0		0	0	0	0	0					1545	1611	1611
2019*	0	63	103	0		0	0	46	0	0					1374	1571	1585
2020*	0	40	80	0		0	0	54	0	0					1762	1950	1935

*** Preliminary official landings.**

Table 10.4 Time-series of megrim survey indices in ICES Area 6.a and Division 4 as used in the surplus production model.

year	sco.6.a.q1	sco.6.a.q4	sco.4.a.q1	sco.4.a.q3	monk.6.a	monk.4.a
1985	2.587277485	NA	NA	NA	NA	NA
1986	1.687998187	NA	1.251331172	NA	NA	NA
1987	1.370927849	NA	1.449766572	NA	NA	NA
1988	2.008519187	NA	1.68291766	NA	NA	NA
1989	1.161744375	NA	1.325875553	NA	NA	NA
1990	1.072563776	1.589121239	0.744397606	NA	NA	NA
1991	0.793239684	1.273655248	0.49356008	0.332513905	NA	NA
1992	0.958431742	1.885180977	0.644268506	0.321132671	NA	NA
1993	1.013121314	2.058297074	1.090323121	0.308721559	NA	NA
1994	1.589025993	3.246434856	0.265514852	0.387482494	NA	NA
1995	1.555854532	1.86283881	0	0.397889127	NA	NA
1996	1.939844315	1.946019601	0.510318402	0.613070372	NA	NA
1997	1.100463776	1.08114214	0.436281055	0.434069245	NA	NA
1998	1.094431565	1.89278891	0.815353163	0.23321597	NA	NA
1999	1.322173199	1.360191258	0.992708011	0.242461096	NA	NA
2000	1.1402973	1.185690184	0.856305846	0.259009868	NA	NA
2001	0.997603432	0.967749041	0.290991541	0.09238776	NA	NA
2002	0.760003661	1.857327481	1.239496921	0.358076071	NA	NA
2003	1.27176267	1.204997794	0.508135706	0.331439003	NA	NA
2004	1.244468536	1.063917875	0.2761797	0.475698572	NA	NA
2005	0.690390582	1.012592814	0.595130836	0.833015297	1660.37936	4753.223211
2006	0.916575585	1.120885129	0.784157908	0.953327086	2688.941957	3344.996789
2007	0.906749963	1.198995105	0.856059532	1.397526851	3380.35118	6347.543786
2008	1.253293602	0.956625811	1.590619874	1.208086764	2467.075926	7754.142821
2009	1.572726915	1.396689172	1.9640709	1.113488959	3830.667675	5946.946487
2010	1.170500809	NA	1.745054542	1.747809227	3312.129269	5394.945661
2011	NA	NA	1.937293368	1.643131358	2501.989739	4683.594176

year	sco.6.a.q1	sco.6.a.q4	sco.4.a.q1	sco.4.a.q3	monk.6.a	monk.4.a
2012	NA	NA	2.590647751	1.524713243	3450.807093	4839.467928
2013	NA	NA	2.693726908	1.480799224	6174.863646	6460.014881
2014	NA	NA	2.201796563	1.267149353	3033.072441	11970.29996
2015	NA	NA	2.991130975	1.310030592	2563.104873	4986.898965
2016	NA	NA	1.404269554	1.286342631	3027.648141	8207.786975
2017	NA	NA	1.820928571	1.026260339	6508.562836	10238.93712
2018	NA	NA	1.388613759	1.075230131	3364.16539	7154.307405
2019	NA	NA	0.648029069	0.966438403	2143.573456	7982.270745
2020	NA	NA	1.365189758	0.871031994	NA	NA

Table 10.5. ***Lepidorhombus whiffiagonis*** **in ICES areas 6.a and 4.a. Prior distributions on parameters.**

Parameter	Symbol	Prior distribution	Notes
Intrinsic rate of population growth	r	$\text{Uniform}(0.001, 2.0)$	
Carrying capacity	K	$\text{Uniform}(\ln(\max(C)), \ln\left(10 \times \sum_{t=1985}^{2010} C_t\right)$	From the maximum catch to ten times the cumulative catch across all years assuming uniform distribution on the logarithmic scale
Catchabilities	$\log(q_j)$	$\text{Uniform}(-11.0, 0.0)$	Uniformly distributed on log-scale. See catchability sensitivity in Section 2.2.3.1
Process error variance	$\frac{1}{\sigma_u^2}$	$\text{Gamma}(\text{shape} = 0.001, \text{rate} = 0.001)$	Gamma distributed on inverse variance (precision) scale
Measurement error variances	$\frac{1}{\sigma_{\varepsilon,j}^2}$	$\text{Gamma}(\text{shape} = 0.001, \text{rate} = 0.001)$	Gamma distributed on inverse variance (precision) scale
Proportion of *K* in 1985	a	$\text{Uniform}(0.01, 2.0)$	

Table 10.6. Parameter estimates for final assessment outputs.

Parameter	Estimates 2014	Estimates 2015	Estimates 2016	Estimates 2017	Estimates 2018	Estimates 2019	Estimates 2020	Estimates 2021
r.hat	0.55	0.51	0.51	0.51	0.47	0.50	0.51	0.52
K.hat	43134	47216	46840	42681	55129	44116	42625	41634
MSY	5660	5612	5362	5072	5362	5123	5101	5020
F_{MSY}	0.28	0.26	0.26	0.25	0.23	0.25	0.26	0.26
B_{MSY}	21567	23608	23420	21340	27565	22058	21313	20817
B	4109	42416	42356	37610	38057	37062	32660	32408
F	0.08	0.07	0.07	0.07	0.08	0.08	0.1	0.1
B_{lim}	6470	7082	7026	6402	8269	6617	6394	6245
B_{trig}	10783	11804	11710	10670	13782	11029	10656	10408

Table 10.7. Time-series of B/B_{MSY} and F/F_{MSY} estimates and landings and discards in tonnes for the final assessment.

Year	B/B_{MSY}	$B/B_{MSY\ High}$	$B/B_{MSY\ Low}$	Landings	Discards*	F/F_{MSY}	$F/F_{MSY\ High}$	$F/F_{MSY\ Low}$
1985	2.354	3.683	1.143	4499	1928	0.67	1.20	0.37
1986	1.647	2.275	1.034	2858	1193	0.53	0.84	0.32
1987	1.544	2.075	1.006	4614	1874	0.93	1.38	0.55
1988	1.441	2.038	0.914	5212	2061	1.14	1.74	0.65
1989	1.164	1.619	0.768	3451	1327	0.87	1.34	0.50
1990	1.063	1.465	0.716	3047	1140	0.82	1.28	0.46
1991	0.997	1.374	0.682	3310	1204	0.95	1.44	0.53
1992	1.055	1.478	0.701	3574	1263	0.97	1.49	0.53
1993	1.134	1.599	0.757	3802	1305	0.96	1.46	0.54
1994	1.246	1.793	0.825	3900	1300	0.90	1.36	0.48
1995	1.272	1.877	0.829	4670	1511	1.07	1.64	0.56
1996	1.229	1.853	0.788	5253	1649	1.27	1.99	0.62
1997	1.029	1.455	0.695	4856	1478	1.37	2.1	0.71
1998	0.986	1.415	0.658	4253	1254	1.22	1.85	0.62
1999	0.953	1.383	0.619	3759	1074	1.09	1.68	0.55
2000	0.891	1.305	0.578	3494	966	1.06	1.65	0.54
2001	0.824	1.168	0.55	3571	956	1.17	1.78	0.61
2002	0.846	1.227	0.536	2803	725	0.86	1.37	0.43
2003	0.882	1.315	0.561	2369	592	0.68	1.09	0.34
2004	0.884	1.279	0.584	2067	499	0.58	0.90	0.30
2005	0.884	1.184	0.617	1527	356	0.41	0.64	0.24
2006	1.007	1.342	0.692	2054	461	0.49	0.79	0.29
2007	1.152	1.548	0.796	2348	508	0.50	0.77	0.28
2008	1.283	1.707	0.909	2894	602	0.56	0.86	0.33
2009	1.403	1.861	0.971	2871	574	0.51	0.77	0.30
2010	1.416	1.864	0.992	3197	614	0.56	0.85	0.33
2011	1.455	1.94	1.036	3257	600	0.55	0.85	0.34

Year	B/B_{MSY}	$B/B_{MSY\ High}$	$B/B_{MSY\ Low}$	Landings	Discards*	F/F_{MSY}	$F/F_{MSY\ High}$	$F/F_{MSY\ Low}$
2012	1.575	2.129	1.128	2545	449	0.42	0.64	0.26
2013	1.783	2.495	1.23	2737	327	0.37	0.55	0.21
2014	1.792	2.464	1.251	2500	309	0.33	0.51	0.20
2015	1.664	2.165	1.209	2471	152	0.33	0.47	0.20
2016	1.753	2.318	1.266	2792	167	0.36	0.52	0.22
2017	1.899	2.745	1.361	2594	193	0.32	0.46	0.185
2018	1.693	2.241	1.202	3003	255	0.41	0.60	0.25
2019	1.556	2.017	1.1	3197	184	0.45	0.67	0.28
2020	1.563	2.09	1.069	3316	214	0.47	0.74	0.29
2021	1.465	2.068	0.966					

*** Discard estimates prior to 2013 are approximated, based on limited sampling information**

Table 10.8. Basis for the catch options.

Variable	Value	Source	Notes
$F_{(2020)}/F_{MSY}$	0.47	ICES (2018a)	F (average 2018–2020)
$B_{(2021)}/B_{MSY}$	1.56	ICES (2018a)	Fishing at F_{sq}
Catch (2020)	3529	ICES (2018a)	Fishing at F_{sq} ; in tonnes.
Landings (2020)	3302	ICES (2018a)	Assuming discard rate of 6.44% in total weight of catch (average 2018–2020)
Discards (2020)	227	ICES (2018a)	Assuming discard rate of 6.44% in total weight of catch (average 2018–2020)

Table 10.9. The management option table.

Basis	Total catch (2021)	Projected landings (2021)	Projected discards (2021)	Fishing mortality F2021/FMSY	Stock size B2022/BMSY	% B change *	Probability of Biomass2021 falling below MSY Btrigger	Probability of Biomass2021 falling below Blim	% TAC change ^	% Advice change ^^
ICES advice basis										
EU MAP ^^^: F_{MSY}	7350	6888	462	1	1.34	-14	0.079	0		1
F = MAP $F_{MSY\ lower}$	5750	5389	361	0.77	1.43	-9	0.042	0.001		1#
F = MAP $F_{MSY\ upper}$	7350	6888	543	1	1.35	-14	0.079	0		1#
Other scenarios										
F = 0	0	0	0	0	1.72	10	0.009	0.001		-100
$B_{2022} = B_{lim}$	27750	26007	1743	3.75	0.33	-79	0.98	0.49		280
$B_{2022} = B_{pa}$	13800	12933	867	1.86	1.02	-35	0.50	0.003		89
$SSB_{(2023)} = SSB_{(2022)}$	7950	7451	499	1.07	1.31	-16	0.101	0		9
$F = F_{2020}$	3529	3302	227	0.47	1.54	0	0	0		-60

* Biomass 2023 relative to biomass 2022.

^ The agreed TAC was not available.

^^ Advice value for 2022 relative to the advice value for 2021 (7300 tonnes).

^^^ EU multiannual plan (MAP) for the Western Waters (EU, 2019).

#Advice value this year relative to the advice value last year for the MAP $F_{MSY\ lower}$ (5700 tonnes) and MAP F_{MSY} upper (7300 tonnes).

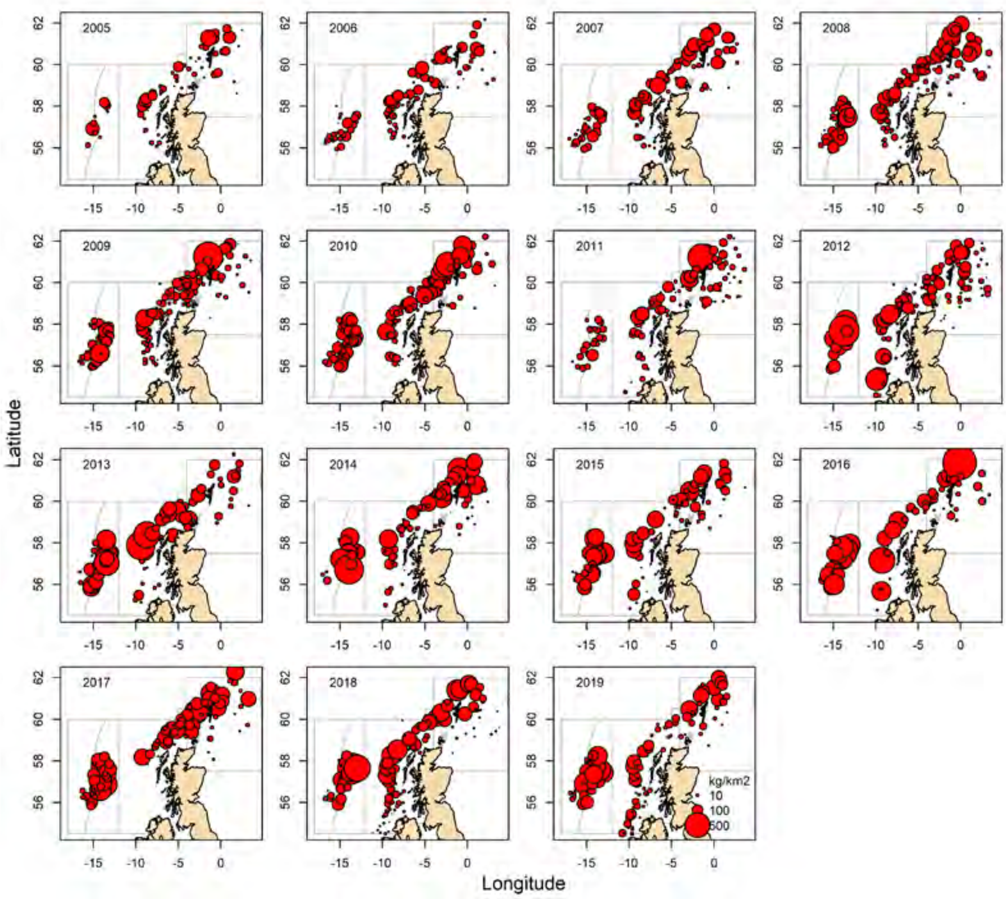


Figure 10.1. Maps of the northern continental shelf around the British Isles showing the biomass of megrim during the Scottish Irish Anglerfish and Megrim Industry Science Survey (SIAMISS) survey 2005–2019.

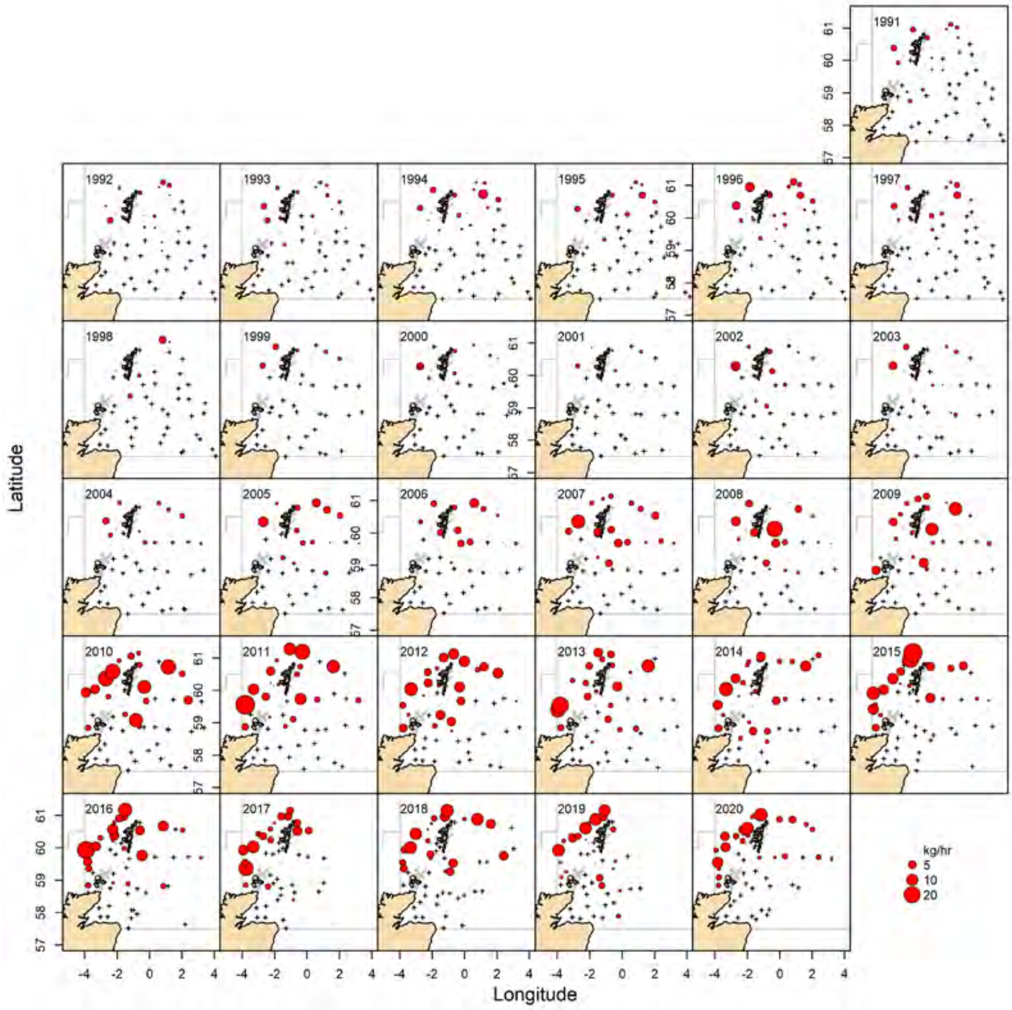


Figure 10.2. Sco-IBTS Q3 4.a 1991–present megrim biomass maps.

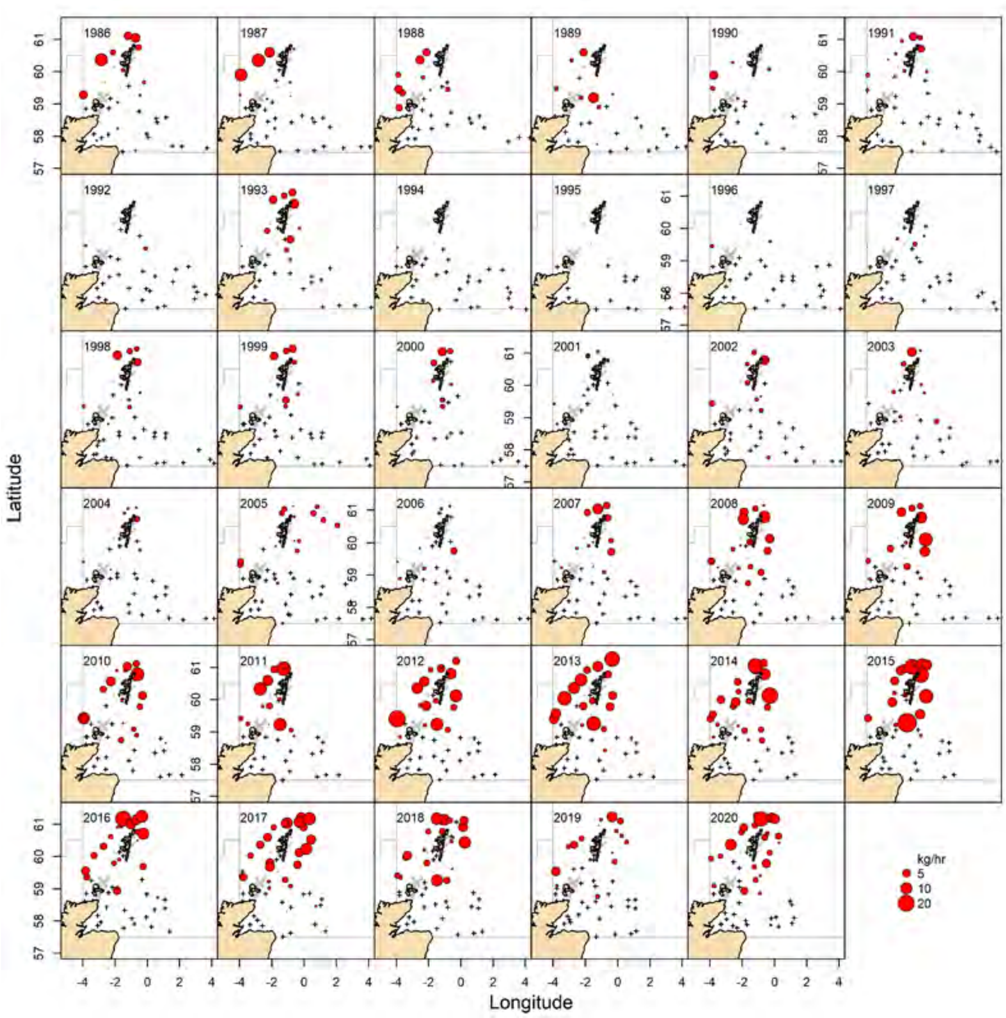


Figure 10.3. ScoIBTS Q1 4.a 1986–present megrim biomass maps.

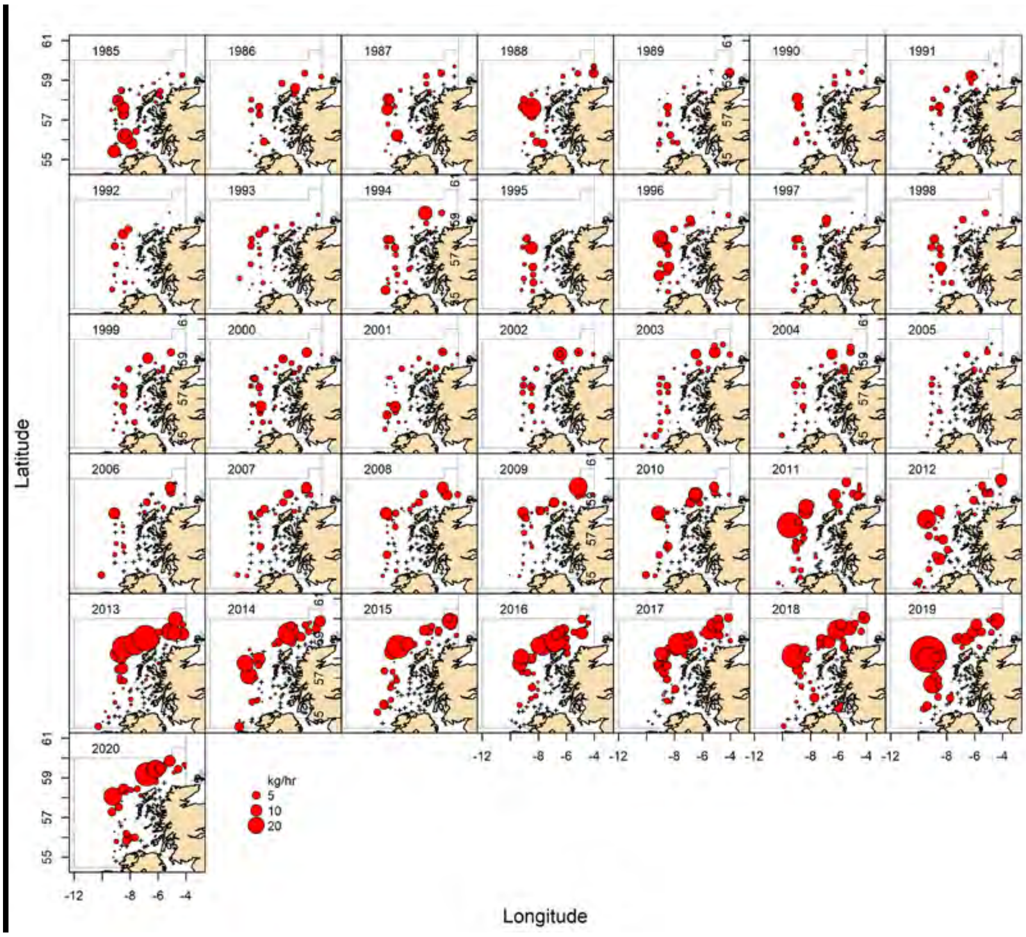


Figure 10.4 ScoGFS-WIBTS Q1 6.a megrim biomass maps.

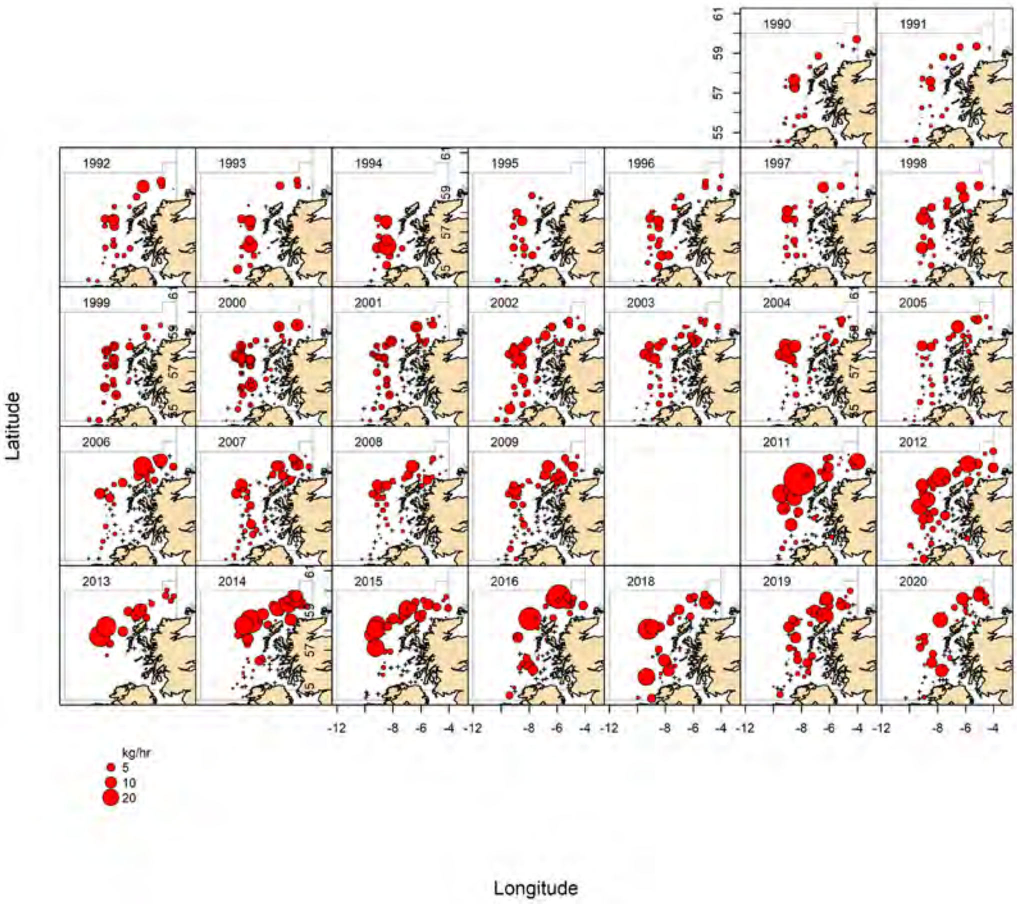


Figure 10.5 ScoGFS-WIBTS Q4 6.a megrim biomass maps.

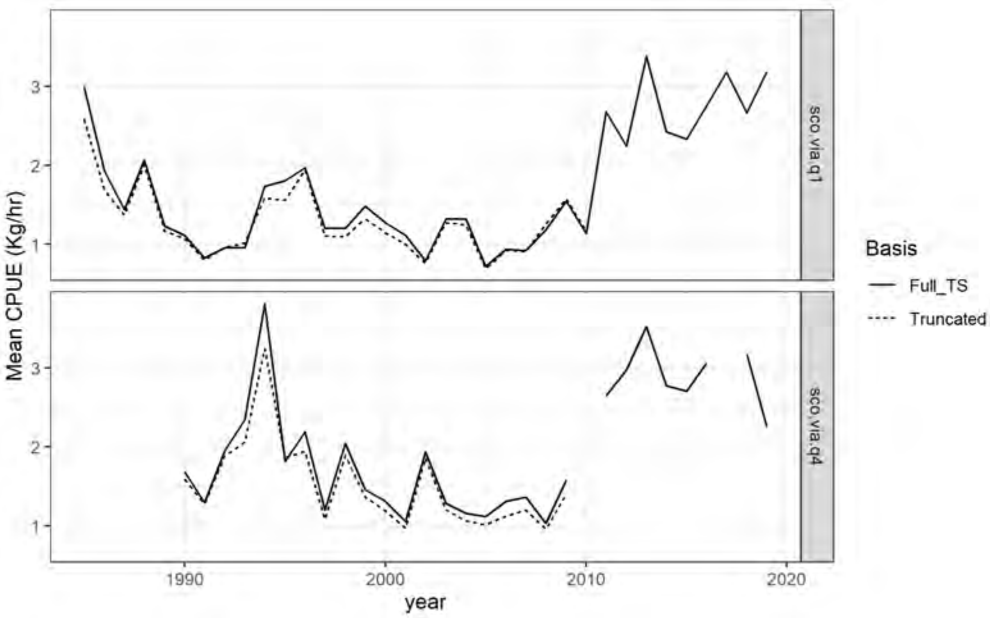


Figure 10.6. Comparison of the delta-gamma cpue estimates for the two 6.a Scottish IBTS surveys using the full time-series or truncating the series to 2010 after which the survey design and ground gear was changed.

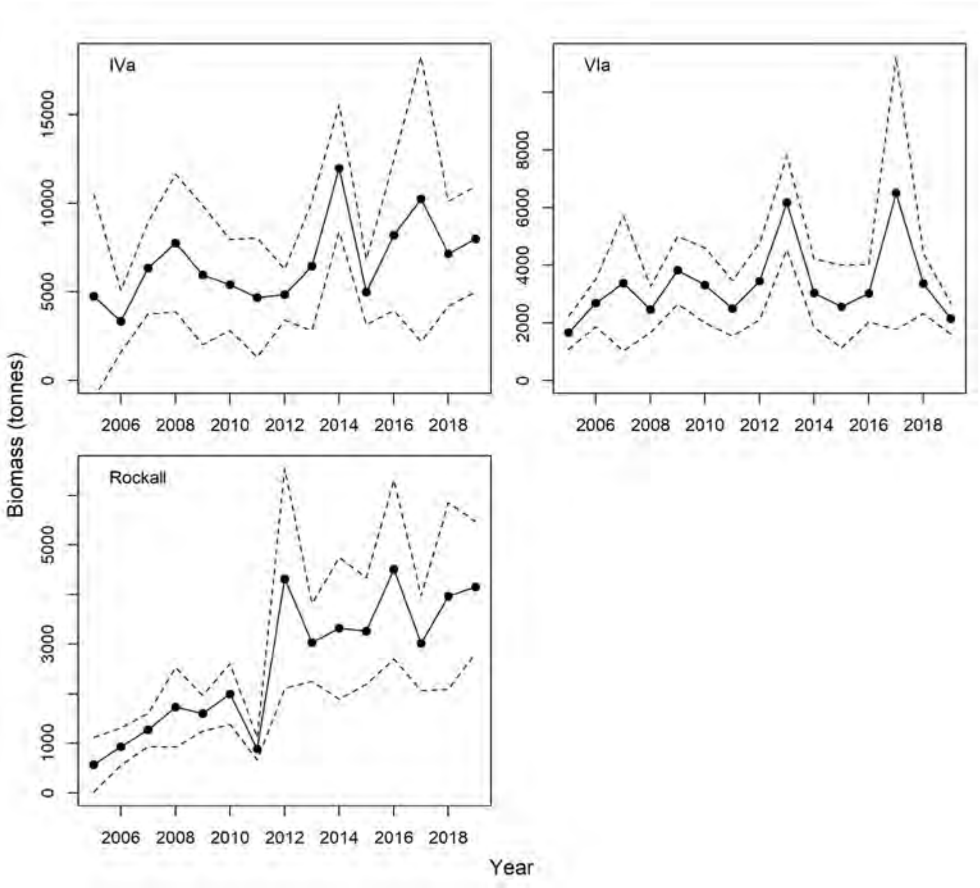


Figure 10.7. Megrim biomass estimates in ICES divisions 4, 6.a and 6.b from Scottish Irish Anglerfish and Megrim Industry Science Survey (SIAMISS) survey with 95%cls.

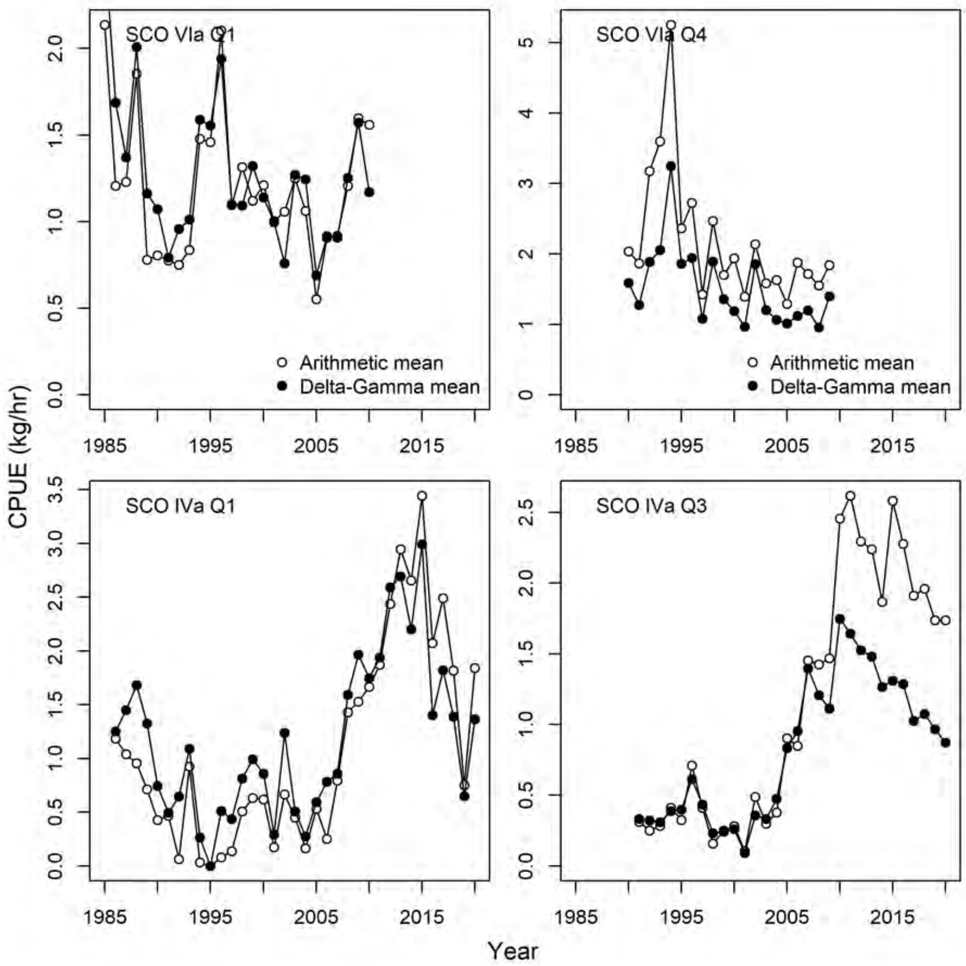


Figure 10.8. Megrim cpue estimates in ICES division 6.a Q1 top left panel and 6.a Q4.

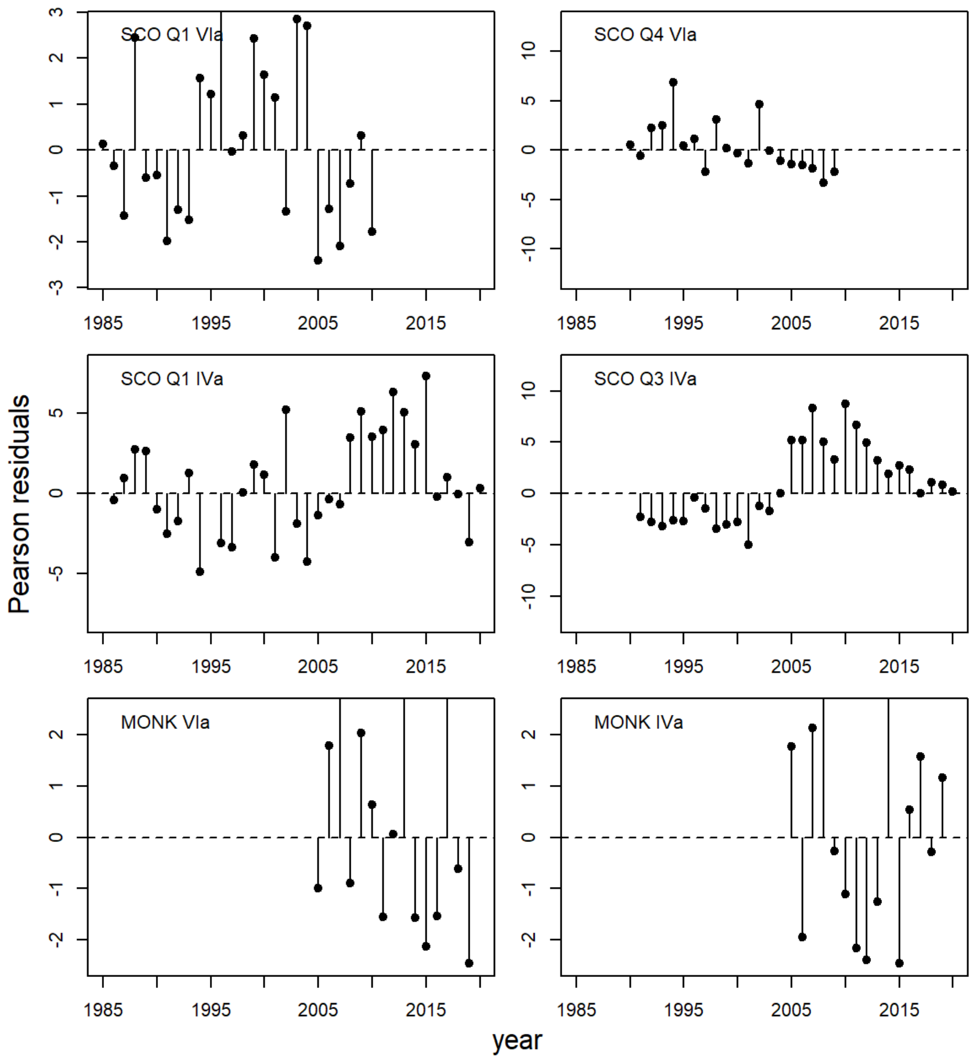


Figure 10.9. Pearson residuals for the six survey indices.

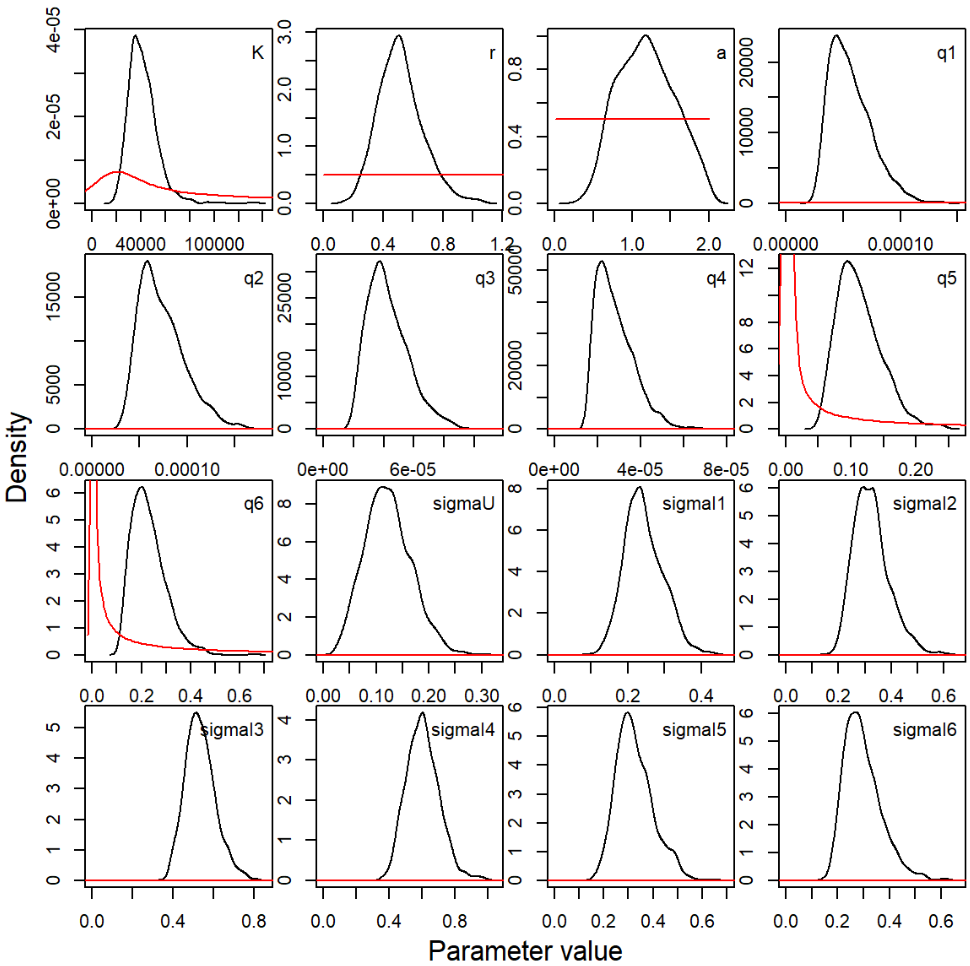


Figure 10.10. Prior (red line) and posterior distributions (black line) for the parameters in the model.

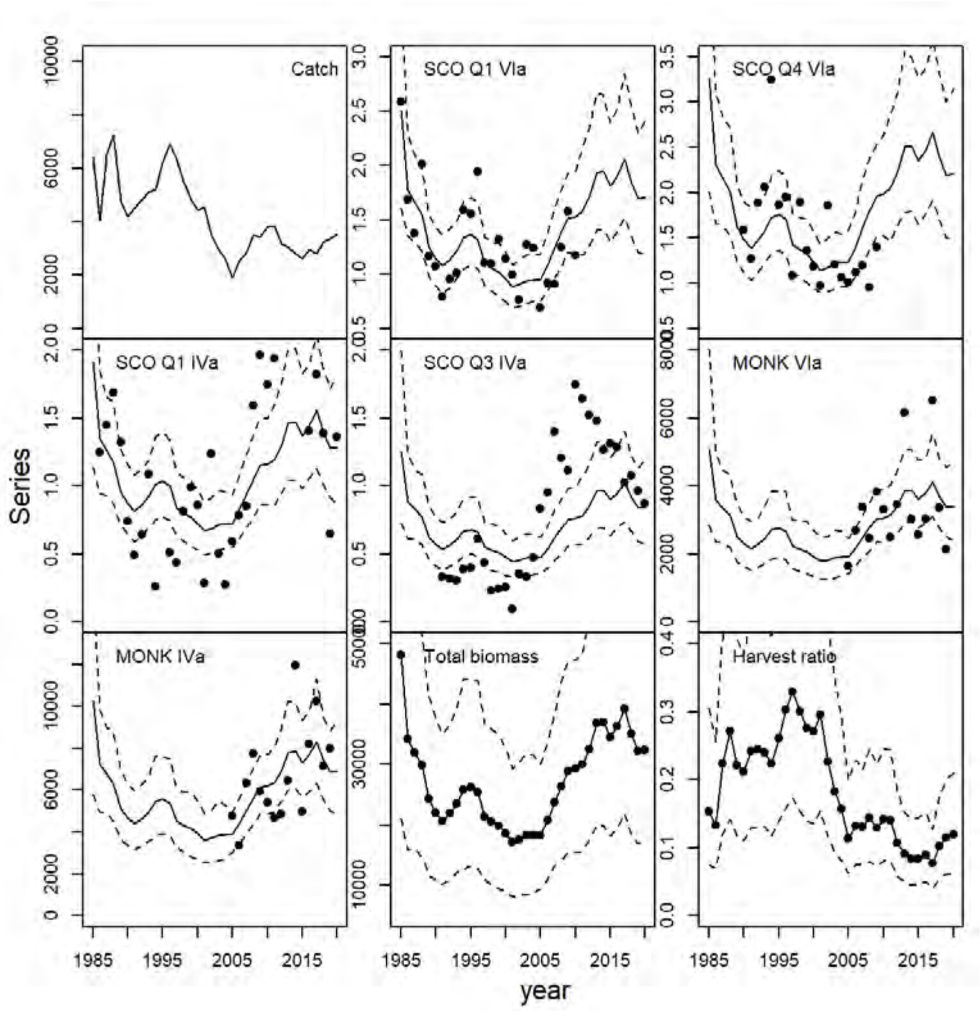


Figure 10.11. Time-series of catch and model estimates of total biomass and exploitation rate (median values are shown as solid lines and 95% confidence intervals shown as broken lines). The model fits to the various cpue series is also shown (observations dots, median fit solid line and 95% confidence intervals shown as broken lines).

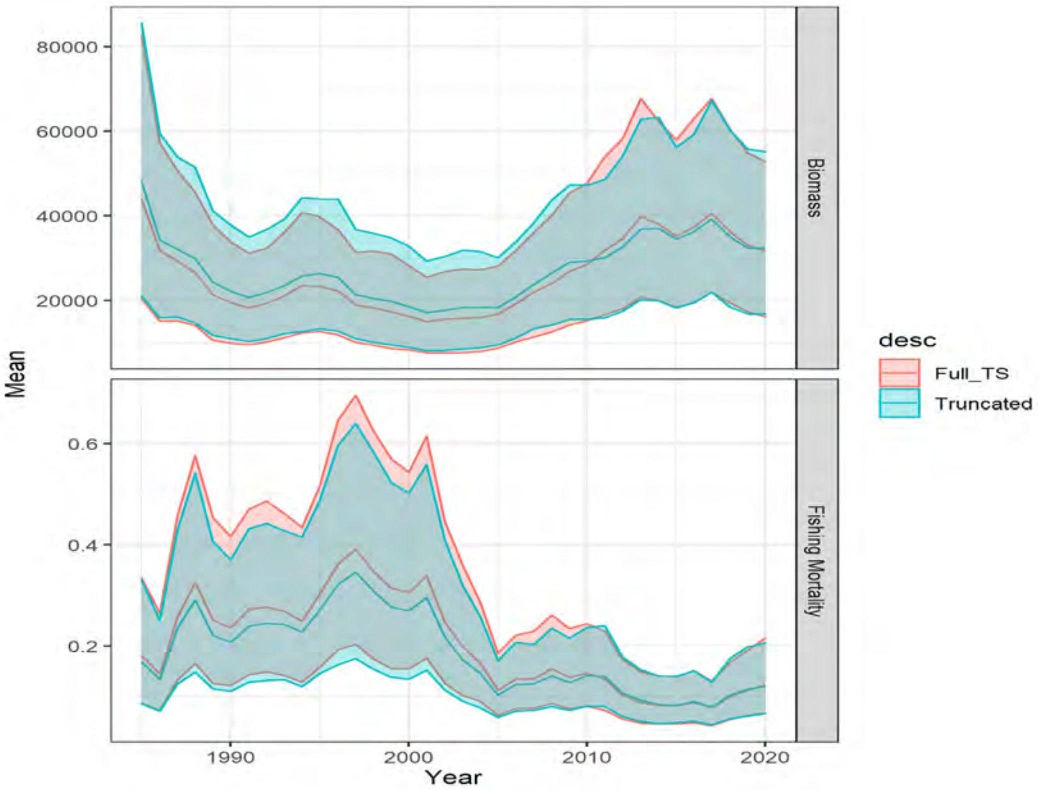


Figure 10.12. Comparison of assessment model results fitted to a cpue generated using the full time-series of the 6.a (red) and a truncated time-series (blue).

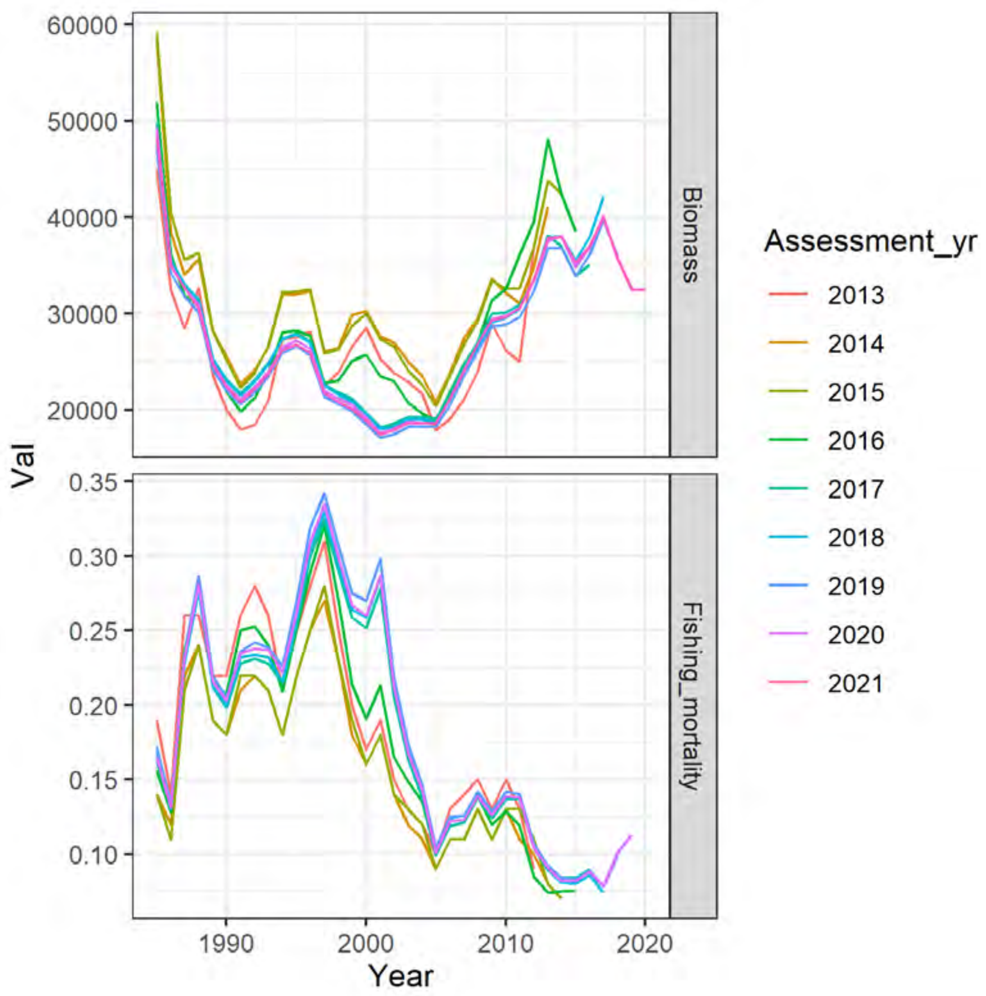


Figure 10.13. Comparison with previous assessments.

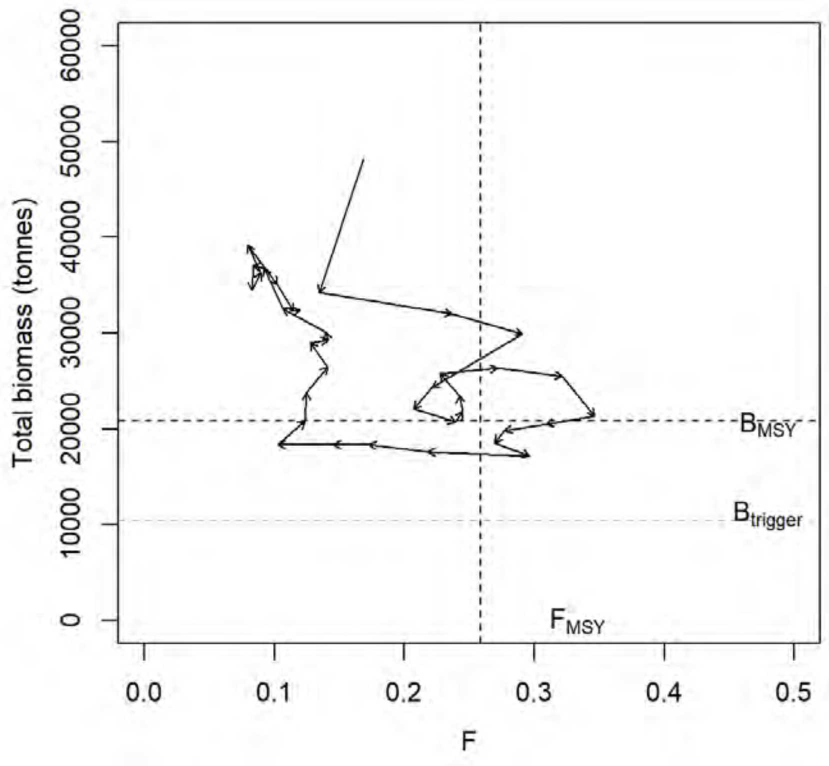


Figure 10.14. Kobe plot of stock status.

11 Megrim (*Lepidorhombus* spp.) in Division 6.b (Rockall)

Type of assessment in 2021

This stock was benchmarked in 2021 (ICES, 2021) and, as a result, the stock was changed from category 3 to category 2. The assessment, which is now based on Surplus Production in Continuous Time (SPiCT, Pedersen and Berg, 2017), includes revised assumptions and model priors. Reference points were also revised. These changes have resulted in a more reliable assessment and the methodology is appropriate to determine stock status and a short-term catch forecast.

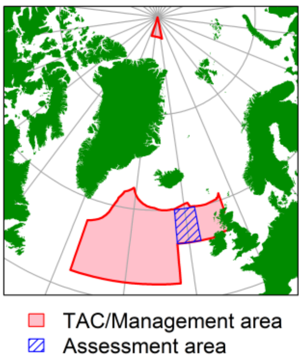
ICES advice applicable to 2022

ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2022 should be no more than 994 tonnes.

General

Stock description and management units

Megrim stock structure is uncertain. Data collected during an EC study contract (98/096) on the 'Distribution and biology of anglerfish and megrim in the waters to the west of Scotland,' showed significantly different growth parameters and significant population structure difference between megrim sampled in 6.a and 6.b (Gordon, 2001). Spawning fish occur in both areas but whether these populations are reproductively isolated is not clear. WKFLAT (2011) concluded that megrim in 6.b should continue to be considered as a separate stock until further information is available.



Management area (red box) and assessment area (blue hatched area).

TAC regulations for 2020 and 2021 are given below:

2020:

Species:	Megrims *Lepidorhombus* spp.		Zone:	Union and international waters of 5b; 6; international waters of 12 and 14 (LEZ/56-14)
Spain	671		Analytical TAC	
France	2 615	(1)	Article 7(2) of this Regulation applies	
Ireland	764			
United Kingdom	1 851	(1)		
Union	5 901			
TAC	5 901			

(1) Special condition: of which up to 5 % may be fished in: Union waters of 2a and 4 (LEZ/*2AC4C).

2021:

Species:	Megrims *Lepidorhombus* spp.		Zone:	6; United Kingdom and international waters of 5b; international waters of 12 and 14 (LEZ/56-14)
Spain	526	(1)	Analytical TAC	
France	2 053	(1)	Article 8(2) of this Regulation applies	
Ireland	600	(1)		
Union	3 179	(1)		
United Kingdom	2 046	(1)		
TAC	5 225			

(1) Special condition: of which up to 25 % may be fished in: United Kingdom and Union waters of 2a and 4 (LEZ/*2AC4C).

Fishery in 2020

Ireland had the highest catches in 2020 followed by the UK and Spain (Table 14.1). The majority of the landings and catches are from otter trawlers.

Landings			**Discards**		
Nephrops trawls	Other Gears	Finfish trawls	*Nephrops* trawls	Other Gears	Finfish trawls
0.00%	13%	87%	0.00%	0.00%	100%

Landings

Official landings data for each country together with Working Group best estimates of landings from 6.b are shown in Table 14.1 and Figure 14.1.

Catches of megrim comprise two species, *Lepidorhombus whiffiagonis* and *L. boscii*. Information available to the Working Group indicates that *L. boscii*, are a negligible proportion of the Scottish and Irish megrim catch (Kunzlik *et al.*, 1995; Anon, 2001). It is not clear to the WG whether landings of other countries are accurately partitioned by megrim species. Megrim are caught in association with anglerfish by some fleets and are area-misreported along with anglerfish. However, it is unknown whether misreporting from Division 6.b is an issue.

Discards

Discard data for 2020 were available for the UK and Spain in InterCatch. Total discard estimates were available from 2005–2020. To estimate catches prior to 2005, for the SPiCT analysis; a catch over landing ratio of 1.2 was used (derived from that observed ratio between 2017–2020). In 2020, discards represented approximately 6% of catch; increasing from 34 to 59 tonnes (Table 14.1 and Figure 14.1).

Surveys

In 2005, Scotland initiated a new industry–science partnership survey to provide an absolute abundance estimate for anglerfish. Sixteen years of survey data are available and these cover the main distribution of the anglerfish fishery. The survey is also considered to have greater spatial coverage for megrim, and as such was recommended by WKAGME (2008) as the main source of data of megrim relative biomass, for all megrim stocks in the Northern Shelf.

The survey index for 6.b is shown in Figure 14.2. Stock size is unknown for 2020 due to the absence of the SIAMISS-Q2 survey data in Subarea 6 and Division 4.a. The stock has displayed a largely increasing abundance and biomass trend since 2005. The area-stratified survey provides a minimum estimate of absolute biomass; survey catches are raised based on swept-area and weighted by area. The survey assumes that all megrim in the trawl path are retained e.g. q=1. Assuming full retention is overly optimistic, therefore the minimum estimate of stock biomass was provided.

Historical stock development

Prior to the benchmark in 2021, the stock was a category 3 stock that utilised a SPiCT assessment and the ratio of the mean of the last two SIAMISS-Q2 index values.

Final Assessment

Following on from the benchmark (ICES, 2021), the final assessment utilised a SPiCT model utilising the recommendations and developed settings. The catch data are shown in Figure 14.1 and combined the landings and discard estimates. The abundance index from the SIAMISS-Q2 survey is shown in Figure 14.2. Following on from the sensitivity and robustness testing at the benchmark the following prior settings were applied:

- Surplus production curve fixed (n=2)
- Intrinsic growth rate (r) 0.39 – modelled from FishLife
- An initial biomass depletion prior of 0.5
- Intermediate year catch – average of last 3 years catch

The output of the model can be seen in Figure 14.3. The residuals are all good with the exception of minor auto correlation in the catch time-series (Figure 14.4) but this has only changed slightly from the benchmark output, so is not regarded as an issue. Figure 14.5 shows the retrospective plots for the assessment, with good agreement with all the peels.

Final parameter estimates from the SAM run are given in Table 14.2.

State of the stock

The summary plots can be seen in Figure 14.3 and they show fishing pressure on the stock is below F_{MSY} and biomass is above MSY $B_{trigger}$ and B_{lim}.

Short-term projections

Short term projections were conducted using a 2021 catch that was the average of the preceding 3 years, and the assumptions are shown below:

Variable	Value	Notes
F (2021)/F_{MSY}	0.81	Status quo catch
B (2022)/B_{MSY}	1.25	Short term forecast (STF) with status quo catch
Catch (2021)	896	STF of catch under status quo catch; tonnes (average 2018-2020)

Four management scenarios were explored and the catch and relative reference points estimated for 2022. Adopting the MSY approach (using the 35th percentile of predicted catch under F=F_{MSY}) gave an estimated catch of 994 tonnes, a F/F_{MSY} of 0.91 and a B/B_{MSY} of 1.22.

Basis	Total catch (2022)	F_{2022}/F_{MSY}	B_{2023}/B_{MSY}	% Biomass change (2023 to 2022
MSY approach (35th percentile of predicted catch distribution under F = F_{MSY})	994	0.91	1.22	-2.68
F = F_{msy}	1105	1.00	1.22	-4.57
F = F_{2020} = Fsq	726	0.64	1.30	1.44
F = 0	0	0.0	1.44	12.9

MSY reference points

The MSY reference points are calculated based on the relative reference points estimated by the SPiCT model, so will change when the assessment is updated. The reference points are calculated as:

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	0.5 *	Relative value (B/BMSY) from the SPiCT assessment model. BMSY is estimated directly from the SPiCT model and changes when the assessment is updated.
	F_{MSY}	1 *	Relative value (F/FMSY) from the SPiCT assessment model. FMSY is estimated directly from the SPiCT model and changes when the assessment is updated.
Precautionary approach	B_{lim}	0.3 × B_{MSY}	Relative value (equilibrium yield at this biomass is 50% of MSY).
	F_{lim}	1.7 × F_{MSY}	Relative value (the F that drives the stock to B_{lim}).

Uncertainties and bias in assessment and forecast

Currently the assessment uses the SIAMISS survey to estimate biomass. It should be noted that the survey was specifically designed to catch anglerfish. While this is not an issue when the biomass index is presented in the relative context, in the case of megrim; the raised biomass calculation is based on full retention of megrim in the haul. The estimates are therefore considered as the minimum.

Recommendation for next Benchmark

This stock was subject to benchmark in 2021.

Management considerations

The TAC in 6 has not been fully utilised; the uptake rate is country-specific; partial quota by individual Member States may be an artefact of reduction in effort rather than reflective of a reduction in biomass. The TAC and assessment area are incompatible.

References

Gordon, J.D. 2001. (co-ordinator) Distribution and biology of anglerfish and megrim in waters to the west of Scotland. Final Report of EC DGXIV Study Contract 98/096 XX.

Kunzlik, P. A., A. W. Newton and A. W. Jermyn. 1995. Exploitation of monks (*Lophius* spp.) and megrims (*Lepidorhombus* spp.) by Scottish fishers in ICES Division VIa (West of Scotland). Final report EU FAR contract MA-2-520.

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Pedersen, M. W. and Berg, C. W. 2017. A stochastic surplus production model in continuous time. Fish Fish, 18: 226–243. doi:10.1111/faf.12174.

Table 14.1 Megrim in Subarea 6.b. Nominal catch (t) of Lez.27.6b, as officially reported to ICES and WG best estimates of landings (tonnes).

Year	France	Ireland	Spain	UK – Eng+Wales+N.Irl.	UK – England and Wales	UK – Scotland	UK	Official total	ICES landings	ICES Discards
1991	-	240	587	14	-	204	-	1045	1254	
1992	-	139	683	53	-	198	-	1073	1288	
1993	-	128	594	56	-	147	-	925	1110	
1994	-	176	574	38	-	258	-	1046	1255	
1995	-	117	520	27	-	152	-	816	979	
1996	-	124	515	92	-	112	-	843	1012	
1997	-	141	628	76	-	164	-	1009	1211	
1998	-	218	549	116	-	208	-	1091	1309	
1999	-	127	404	57	-	278	-	866	1039	
2000	4	167	427	57	-	309	-	964	1157	
2001	< 0.5	176	370	42	-	236	-	824	989	
2002	< 0.5	87	120	41	-	207	-	455	546	
2003		83	93	74	-	382	-	632	758	
2004		43	71	42	-	372	-	528	634	
2005		68	88	19	-	207	-	382	382	87
2006		95	59	9	-	181	-	344	344	75
2007		87	19	-	-		-	106	106	22
2008		68	84	-	1	141	-	294	294	59
2009		48	0	-	-	178	-	226	226	44
2010		47	0	-	-	-	92	139	139	26
2011		72	17	-	-	-	66	155	155	7
2012		120	15	-	-	-	89	224	224	21
2013		181	39	-	-	-	58	278	278	15
2014		230	18	-	-	-	95	343	343	15
2015		256	67	-	-	-	130	453	453	85
2016		272	27	-	-	-	106	405	405	145
2017		358	46	15	-	167	-	586	586	233
2018		438	61	-	-	-	263	763	764	203
2019	25	452	94	-	-	-	223	795	757	34
2020	41	467	112	-	-	-	246	866	861	59

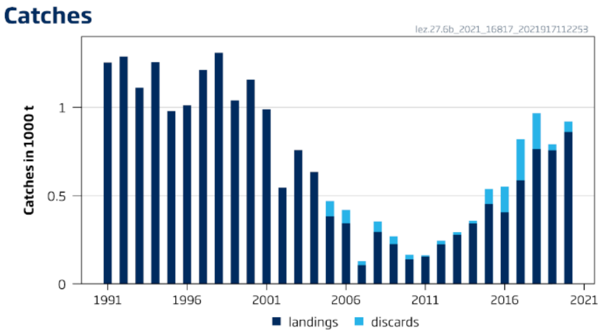

Figure 14.1. Lez.27.6b ICES estimated landings and discards

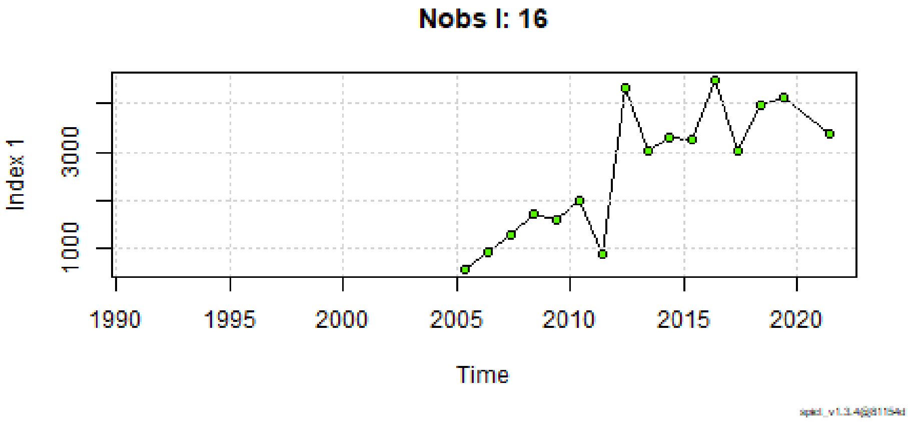

Figure 14.2. Survey data for lez.6b from SIAMISS (SCO-IV-VI-AMISS-Q2 [G1794])

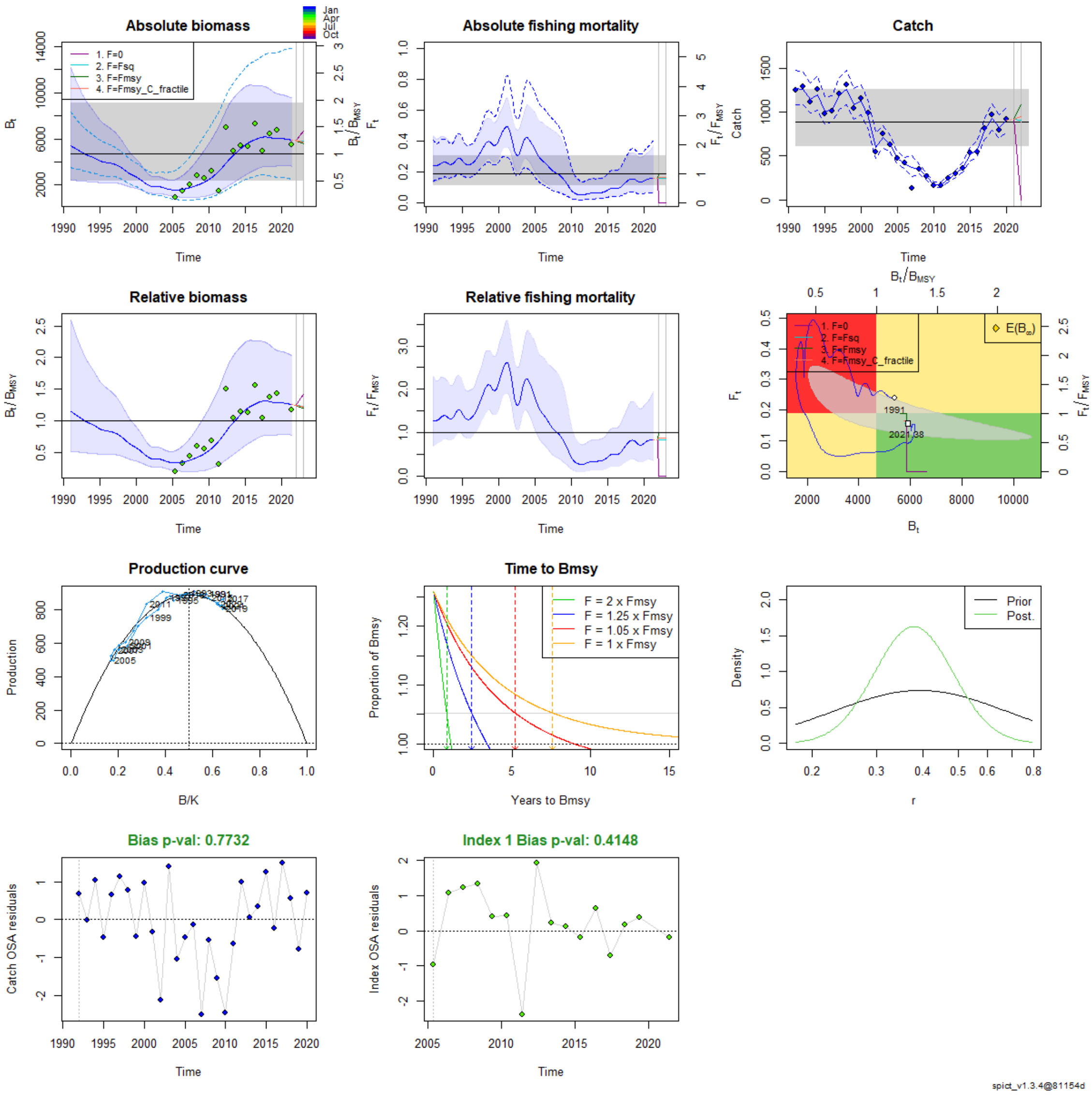

Figure 14.3. SPiCT model output for lez.27.6b. Top right: observed and fitted catch with 95 ci. Centre left: Biomass relative to B_{MSY}. Centre: F relative to F_{MSY}. Corresponding MSY quantities are shown in each plot as horizontal lines (0.5 B_{MSY} in the case of the relative biomass plot). Centre right Kobe plot of stock trajectory.

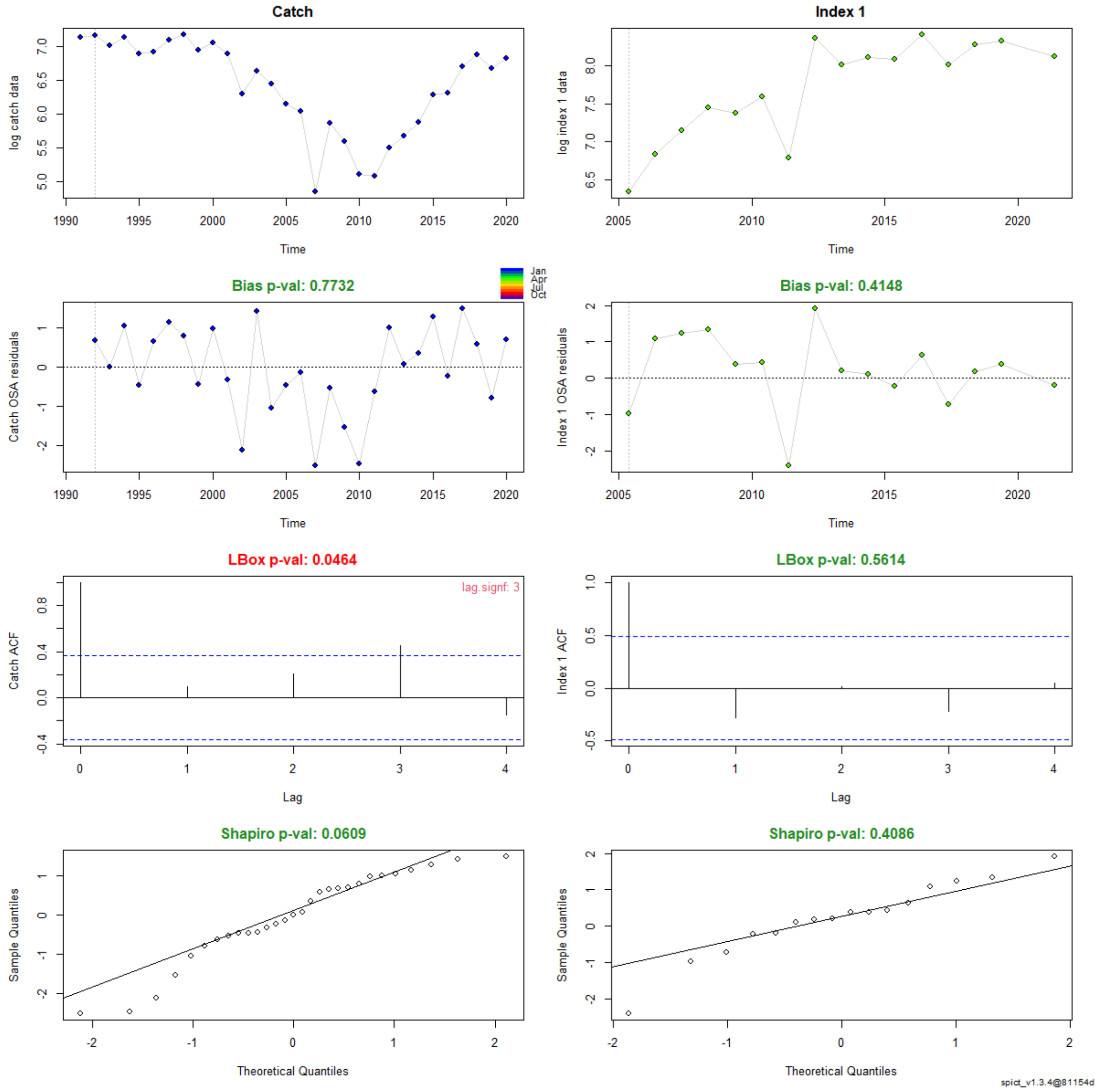

Figure 14.4. SPiCT model residual output for lez.27.6b

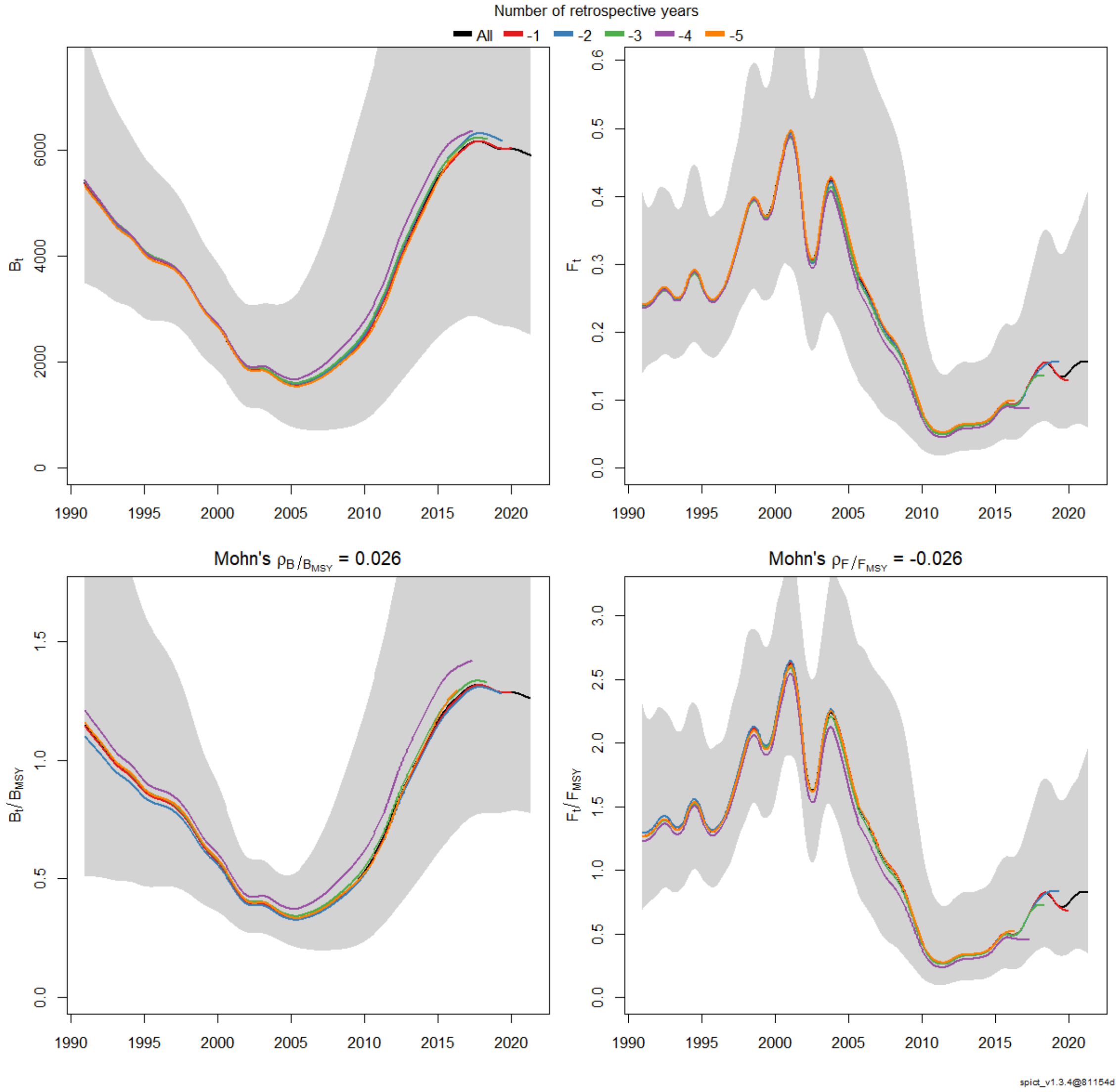

Figure 14.5. SPiCT model retrospectives for lez.27.6b

Table14.2. SPICT results for Lez.27.6b.

```
Model parameter estimates w 95% CI
            estimate        cilow        ciupp    log.est
 alpha     6.1973288    0.8029398 4.783283e+01  1.8241184
 beta      0.2963248    0.0732253 1.199155e+00 -1.2162990
 r         0.3785806    0.2339933 6.125102e-01 -0.9713262
 rc        0.3785806    0.2339933 6.125102e-01 -0.9713262
 rold      0.3785806    0.2339933 6.125102e-01 -0.9713262
 m       891.7289268  625.4168145 1.271441e+03  6.7931622
 K      9421.8127691 4863.0573656 1.825406e+04  9.1507828
 q         0.6149819    0.2626333 1.440041e+00 -0.4861625
 sdb       0.0530387    0.0070983 3.963047e-01 -2.9367329
 sdf       0.2798967    0.1834195 4.271201e-01 -1.2733348
 sdi       0.3286984    0.2254508 4.792294e-01 -1.1126145
 sdc       0.0829403    0.0270492 2.543183e-01 -2.4896337
 pp        0.9612999    0.7651192 9.947483e-01  3.2124433
 robfac   11.9595230    2.4226450 8.542805e+01  2.3942088

Deterministic reference points (Drp)
           estimate        cilow        ciupp   log.est
 Bmsyd 4710.9063845 2431.5286828 9127.0315340  8.457636
 Fmsyd    0.1892903    0.1169966    0.3062551 -1.664473
 MSYd   891.7289268  625.4168145 1271.4408382  6.793162
Stochastic reference points (Srp)
           estimate        cilow        ciupp   log.est rel.diff.Drp
 Bmsys 4689.5531018 2422.9015292 9076.6826588  8.453093 -0.004553373
 Fmsys    0.1885947    0.1165506    0.3051718 -1.668155 -0.003688382
 MSYs   884.4100935  622.9603480 1255.5874800  6.784921 -0.008275384

States w 95% CI (inp$msytype: s)
                    estimate        cilow        ciupp    log.est
 B_2021.38      5903.0663324 2515.2319273 13854.067192  8.6832272
 F_2021.38         0.1563457    0.0596583     0.409733 -1.8556858
 B_2021.38/Bmsy    1.2587695    0.7766337     2.040216  0.2301346
 F_2021.38/Fmsy    0.8290035    0.3488797     1.969868 -0.1875309

Predictions w 95% CI (inp$msytype: s)
                  prediction        cilow        ciupp    log.est
 B_2023.00      5773.2748912 2340.3566514 1.424172e+04  8.6609948
 F_2023.00         0.1563460    0.0475409 5.141695e-01 -1.8556839
 B_2023.00/Bmsy    1.2310928    0.7427571 2.040491e+00  0.2079022
 F_2023.00/Fmsy    0.8290051    0.2724668 2.522324e+00 -0.1875289
 Catch_2022.00   908.5001366  477.8066215 1.727420e+03  6.8117950
 E(B_inf)       5446.1786407           NA           NA  8.6026695
```

12 Norway lobster (*Nephrops norvegicus*) in Division 6.a, Functional Unit 11 (West of Scotland, North Minch)

Nephrops stocks have previously been identified by WGNEPH on the basis of population distribution, and defined as separate Functional Units. The Functional Units (FU) in ICES Division 6.a (of which there are three) are defined by the groupings of ICES statistical rectangles given in Table 14.1 and illustrated in Figure 14.1. The functional unit is the level at which the WG collates fishery data (quantities landed and discarded, fishing effort and length distributions) and at which it performs assessments.

Type of assessment in 2021

The assessment of North Minch *Nephrops* in 2021 is based on a combination of examining trends in fishery indicators and abundance estimated by underwater TV survey, both of which comprise an extensive dataseries for this FU. The assessment follows the process defined by the benchmark WG (WKNEPH 2009 and WKNEPH 2013) and is conducted annually according to standards set out by the Manual for the Nephrops Underwater TV Surveys TIMES 65 (Dobby H., et al, 2021). Further details on the assessment and catch options are provided in the stock annex.

ICES advice applicable to 2020

'ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 2604 tonnes and 3347 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit 11 is exploited sustainably, management should be implemented at the functional unit level.'

ICES advice applicable to 2021

'ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 3075 tonnes and 3953 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit 11 is exploited sustainably, management should be implemented at the functional unit level.'

12.1 General

Nominal landings as reported to ICES for divisions 6.a and 6.b are presented in Table 14.1.1. Total official landings from Division 6.a were 6943 tonnes in 2020, mostly reported by the UK with only 71 tonnes reported from Ireland. Table 14.1.2 and Figure 14.1.1 shows WG estimates of landings in Division 6.a broken down by FU. *Nephrops* landings are also made from outside the functional units, from statistical rectangles where small pockets of suitable sediment exist, although these are generally small amounts. In 2020, 151 tonnes of landings were reported from outside the FUs which is lower than the long-term average (Table 14.1.2). The main areas of activity outside FUs are the Stanton Bank (to the west of the South Minch) and areas of suitable sediment along the shelf edge and slope to the west of the Hebrides. There are no functional units in Division 6.b and only very small quantities of *Nephrops* are landed (Table 14.1.1(b)).

Stock description and management units

The North Minch (FU11) is located at the northern end of the west coast of Scotland (Figure 14.1). Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Within the North Minch functional unit these substrates are distributed according to prevailing hydrographic and bathymetric conditions. The area is characterised by numerous islands of varying size and sea lochs, which occur along the mainland coast. These topographical features create a diverse habitat with complex hydrography and a patchy distribution of soft sediments. Results from work on mapping the spatial extent of *Nephrops* habitat in the North Minch sea lochs indicate that the muddy habitat in these areas is only a very small proportion of the total *Nephrops* grounds in the North Minch (WKNEPH 2013).

Management applicable to 2020 and 2021

The management unit is Subarea 6 and EU and international waters of 5.b. The TAC for this area is 15 298 tonnes in 2021, down from 15 899 tonnes in 2020.

Since 2016, fisheries catching *Nephrops* in Division 6.a have been covered by the EU landing obligation (EU, 2015a). Creel fisheries are exempt from the landing obligation due to high survivability of discards. Dermersal trawlers using a codend between 80mm–110mm and within 12 miles of shore are also exempt from the landings obligation.

Ecosystem aspects

Details of the ecosystem aspects for this functional unit are provided in the stock annex if available.

Fishery description

Information on developments in the fishery was provided by Marine Scotland compliance officers.

In 2020 the fishery was described as generally very poor. In addition, it was reported that changes in regulations related to both Brexit and the COVID-19 pandemic made trade very difficult for those operating within the fishery.

In recent years the fishery starts steadily, with a good yield in the summer fishery from May to August. The fishery then tailes off in the Autumn. This is said to be a seasonal occurrence rather than being caused by bad weather. The majority of the Western Isles trawl fleet has tended to relocate to the east coast and to the fishing grounds in the Firth of Forth/Eyemouth/Shields for the winter months in recent years. Trawl activity in the winter months is generally at a relatively low level.

Activity in the *Nephrops* trawl sector was down in 2020 due to the COVID-19 pandemic and changes in regulations due to Brexit, however the creel sector remained constant. Prices for

Nephrops dropped by around 30% in Spring 2020 due to unstable EU markets and the COVID-19 pandemic but have since risen back to their previous value.

The largest part of the North Minch fleet is still based at Stornoway, numbering approximately 75 vessels in 2020. The majority of the Stornoway vessels (52) are below 10 m in length.

The fleet were targeting the same areas in the North Minch as previous years. The notable changes were that the trawl fleet stayed in the West coast when in previous years they would go to the East coast from September onward. The trawl fleet also lost most of their summer fishing due to the COVID-19 pandemic.

Very few vessels came from outside to fish in the area and activity in the area overall has been reduced in 2020.

Since 2009, vessels have been required to fit 120 mm square meshed panels, in accordance with the west coast emergency measures (Council Reg. (EU) 43/2009). Large SMPs (200 mm) are also widely used in the North Minch and have been mandatory for all TR2 vessels with power >112 kW fishing under the Scottish Conservation Credits scheme.

Further general information on the fishery can be found in the stock annex.

12.2 Data available

InterCatch

Data for 2020 were successfully uploaded into InterCatch prior to the 2021 WG meeting. In addition to uploading the 2020 catch data, total weight of landings data for 2017-2019 were updated following a review of Marine Scotland Science data holdings. Uploaded data were worked up in InterCatch to generate 2020 raised international length–frequency distributions. Uploaded data were worked up in InterCatch to generate 2020 raised international length–frequency distributions. Allocation schemes for any unsampled fleets are described in the stock annex. Data exploration in InterCatch has previously shown that outputs of raised data were very close to those generated by the previous method applied internally with differences being <0.1%. As such, InterCatch length–frequency outputs have been used in the stock assessment since 2012.

The COVID-19 pandemic resulted in a reduced sampling effort of commercial catches for FU11 in 2020. Discard sample data for FU11 were only available for Quarter one, and so InterCatch estimates of discard rates for Quarters two, three, and four in InterCatch were based on samples collected in Quarter one. Following download of data from InterCatch, alternate methods of 2020 discard estimation were thus considered. It was agreed at WGCSE that estimates of discard rates and size distributions for 2020 would be based on an averaging of discard samples across all Quarters from 2017-2019. Minimum and maximum discard rates over the same period were also examined to gain an appreciation of the plausible range of discarding that might occur. Assessment estimates affected by changes in discard rates are annotated below to reflect this; i.e. x (y/z), where x is the estimate based on the average discard rate 2017-2019, y is based on minimum discard rate, and z on maximum discard rate.

Commercial catch

Official catch statistics (landings) reported to ICES are shown in Tables 15.1.1(a) and 15.1.1(b); these relate to the whole of 6.a of which the North Minch is a part. Landings by gear category for FU11 provided by country have been reported since 1981 and are presented in Table 14.2.1. Landings from this fishery are usually only reported from Scotland; between 2012 and 2014 two tonnes of *Nephrops* landings were reported by Ireland and values between one and three tonnes have been reported since 2017. Total reported Scottish landings in 2020 were 1331 tonnes, consisting of 900 tonnes landed by trawlers targeting *Nephrops* (~68%), 414 tonnes landed by creel vessels (~31%) and 17 tonnes by other trawlers. In 2020 there were no reports of *Nephrops* landed in the below minimum size (or more properly minimum conservation reference size) category in accordance with the EU landing obligation (EU, 2015b).

Effort data

In 2015, WGCSE agreed that effort should be reported in kW days as this is likely to be more informative about changes in the actual fleet effort. Reported effort by Scottish trawlers targeting *Nephrops* (Métiers: OTB_CRU – Bottom Otter Trawls Targeting Crustaceans and OTT_CRU – Multirig Otter Trawls Targeting Crustaceans) has shown a decreasing trend since 2000 (Figure 14.2.1) but in 2012 the effort increased by 20% due to the influx of vessels from the North Sea during the first quarter of the year. Since then, effort has declined although there was a small increase in 2016.. The decline in effort observed in recent years continued in 2020, and may be attributed to poor fishing and the impact of the COVID-19 pandemic. Note that the year range in effort time-series (2000–2020) does not match with the more extensive year range available for landings, due to a lack of reliable effort data in the MSS in-house database. The effort is also slightly inconsistent with the landings data in that effort is provided for TR2 vessels while the '*Nephrops* trawl' landings additionally includes landings by large mesh trawlers targeting *Nephrops*.

Sampling levels

Length compositions of landings and discards are obtained during market and on-board observer sampling respectively. These sampling levels are shown in Table 14.2.2. Sampling effort in 2020 was lower than recent years due to disruptions to both the fishing industry and government sampling programmes attributable to the COVID-19 pandemic. Length compositions for the creel fishery are available for landings only as the small numbers of discards survive well and are not considered to be removed from the population.

Length compositions

Figure 14.2.2 shows a series of annual length–frequency distributions for the period 2000 to 2020. Catch (removals) length compositions are shown for each sex along with the mean length for both. In both sexes the mean sizes fluctuate over time and has generally remained stable since 2012. This parameter might be expected to reduce in size if overexploitation were taking place. The mean size of males and females have increased over the last two years. This change has most likely been effected by the increased proportion of the creel landings component in the catch.

Sex ratio

Males consistently make the largest contribution to the landings, although the proportion of males does vary between years (Figure 14.2.3(a)). This is likely due to the varying seasonal pattern in the fishery and associated relative catchability (due to different burrow emergence behaviour) of male and female *Nephrops.* Males are available throughout the year and the fishery is prosecuted in all quarters (although effort is usually reduced during the winter months when the weather is poor). Females are mainly taken in the summer when they emerge after egg hatching. The seasonal change in proportion of males to females is evident in Figure 14.2.3(b). In 2020 the normal temporal trend in sex ratios was observed where males dominate in quarters one and four but the ratio is more even (or often female dominated) in quarters two and three.

Mean weights

The mean weight in the landings (trawls and creels combined) shows substantial interannual variation (Figure 14.2.4 and Table 14.2.3) decreasing between 2010 and 2012, followed by an increase in 2013–2015 and a decrease again in 2016 and stable in 2017 followed by a slight increasing trend since. Given the relatively larger size of creel caught *Nephrops* (compared to trawl) the proportion of creel landings has a substantial effect on overall size composition. The increases in mean weight to 2010 (and also size, Figure 14.2.2) in particular are due to a higher proportion of creel landings. This can also be seen in 2020 and is again attributed to the higher proportions of creel landings in this year. Figure 14.2.5 shows the mean weight by sample and gear type over the period 2011–2020. There is no obvious trend in North Minch trawl-caught mean weights, however, a decrease in the mean weight of creel caught males is still obvious. The mean weight in the landings has a significant impact on the catch forecast. Due to the high interannual variability in mean weights it was considered more appropriate to use a full time-series average, from 1999 (first year with creel and trawl length distributions combined) until 2020 for producing the catch options.

Discarding

Discarding of undersized and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Discard rates fluctuate in this FU and averaged ~5.9% by number in the last three years (Table 14.2.4). In 2020, the discard rate increased to 5.7% by number (from 5.5% in 2019).

It is likely that some *Nephrops* survive the discarding process. An estimate of 25% (Charuau *et al*., 1982; Sangster *et al*., 1997; Wileman *et al*., 1999) survival is assumed for this FU in order to calculate removals (landings + dead discards) from the population. The discard survival rate for creel caught *Nephrops* has been shown to be high (ICES, 2013) and a value of 100% is used. The discard rate (adjusted for survival) which will be used in the provision of landings options for 2022 is 5.9% based on a three-year average of 2018–2020.

Abundance indices from UWTV surveys

Underwater TV surveys are available for this stock since 1994 (missing surveys in 1995 and 1997). The stock area for this FU was updated in 2013 to 2908 km^2 (see stock annex for further details). In 2020, due to the COVID-19 pandemic, the UWTV survey was carried out with a reduced scientific staffing, necessitating a reduced sampling schedule in some areas. In 2021, the sampling schedule resumed to what would be expected in a standard year.

In 2021, 50 valid stations were used in the final survey analysis (Table 14.2.5). Table 14.2.6 shows the basic analysis for the most recent TV survey conducted in FU11. At the 2012 SGNEPS meeting (ICES, 2012) it was decided that a CV (relative standard error) of <20% was an acceptable precision level for UWTV survey estimates of abundance. The CV for the most recent TV survey was 7.7%, lower than the precision level agreed (Table 14.2.6).

Figure 14.2.6 shows the distribution of stations in recent TV surveys (2016–2021), with the size of the symbols reflecting the *Nephrops* burrow density. Table 14.2.5 and Figure 14.2.7 show the time-series estimated abundance for the TV surveys, with 95% confidence intervals on annual estimates.

The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES, 2009; ICES, 2013). A number of potential biases were highlighted including those due to edge effects, species burrow misidentification and burrow occupancy. The cumulative relative to absolute conversion factor estimated for FU11 was 1.33 meaning that the TV survey is likely to overestimate *Nephrops* abundance by 33%.

12.3 Assessment

Comparison with previous assessments

The assessment follows the same procedure as last year and is based on a combination of examining trends in fishery indicators and underwater TV abundance estimates. Landings predictions are derived by applying a harvest rate to the UWTV survey estimate of abundance and assuming a length composition derived from recent fishery data (including data from both trawl and creel fisheries).

State of the stock

The assessment summary is provided in Table 14.2.4. The underwater TV survey is presented as the best available information on the North Minch *Nephrops* stock. The surveys provide a fishery-independent estimate of *Nephrops* abundance. At present, it is not possible to extract any length or age-structure information from the survey and therefore it only provides information on abundance over the area of the survey.

TV survey estimated stock abundance in 2021 was 1391 million individuals, a 3% decrease from the 2020 estimate. The stock is still well above the MSY $B_{trigger}$ value of 541 million, or the rounded value of 540 million individuals used in the provision of advice (Figure 14.2.7).

The calculated harvest rate in 2020 (dead removals/TV abundance = 3.1%) is below the F_{MSY} proxy for this stock (the value associated with high long-term yield and low risk depletion) of 10.8%.

12.4 Catch option table

Landings predictions at various harvest rates (based on principles established at WKNEPH (ICES, 2009)), including a selection of those equivalent to the per-recruit reference points, will be made on the basis of the 2021 UWTV survey conducted in June and presented in October 2021 for the provision of advice.

The table below shows the agreed inputs to the catch options table.

Input	Data	2021 assessment
Survey abundance (millions)	UWTV 2021	1391
Mean weight in wanted catch (g)	1999–2020	26.17
Mean weight in Unwatched catch (g)	1999–2020	11.07
Unwanted catch	average 2018–2020	5.9%*
Discards survival	Proportion by number	25%
Dead discard rate	average 2018–2020	4.5%

Due to the high interannual variability in mean weights it was considered more appropriate to use a full time-series average, from 1999 (first year with creel and trawl length distributions combined) until 2020 for producing the catch options.

*Based on mean discard rate (2017-2019) allocated to Quarters 2-4 of 2020; estimates of 8.8% and 4.3% were derived based on the maximum and minimum observed discard rates, respectively, for the same period

12.5 Reference points

New reference point F_{MSY} were derived for this stock at WKMSYRef4 (ICES, 2016). This was updated on the basis of an average of estimated F_{MSY} proxy harvest rates over a period of years, this corresponds more closely to the methodology for finfish. In cases where there is a clear trend in the values a five-year average was chosen. Similarly, the five-year average of the F at 95% of the YPR obtained at the F_{MSY} proxy reference point was proposed as the F_{MSY} lower bound and the five-year average of the F above F_{MAX} that leads to YPR of 95% of the maximum as the upper bound. Using an average value also has the advantage of reducing the effect of any unusually high or low estimates of the F_{MSY} proxy, which occasionally appear. For this stock, the F_{MSY} proxy has been revised from 10.9% to 10.8%.

WKFMSYRef4 did not update the MSY $B_{trigger}$ except for rounding to tens of millions. MSY $B_{trigger}$ has been defined as the lowest stock size from which the abundance has increased (ICES, 2013) and is calculated as 541 million individuals and rounded to 540 million for use as MSY $B_{trigger}$ in the advice. Full details are contained in the stock annex.

These reference points should remain under review by WGCSE and may be revised, should improve data become available.

Table 14.2.4 and Figure 14.5.1 show the harvest rates for FU11. From 2006–2009 there was a sustained period of high, above F_{MSY} proxy, harvest rates followed by two years of low harvest rates of around 6–7%. There was a sudden increase in 2012, following this the harvest rate declined and has remained below the F_{MSY} proxy. In 2019, the harvest rate has increased to 7.1%, but in 2020 has decreased to a historic low of 3.1%. It is likely that prior to 2006, the estimated harvest rates may not be representative due to underreporting of landings.

12.6 Management strategies

Scotland has recently established a network of regional Inshore Fisheries Groups (rIFGs), non-statutory bodies that aim to improve the management of Scotland's inshore fisheries out to six nautical miles, and to give commercial inshore fishermen a strong voice in wider marine management developments. The rIFGs will contribute to regional policies and initiatives relating to management and conservation of inshore fisheries, including impacts on the marine environment and the maintenance of sustainable fishing communities and measures designed to better conserve and sustainably exploit stocks of shellfish and sea fish (including salmon) in their local waters. Although no IFG proposals specific to the management of *Nephrops* fisheries have yet been adopted, some of the IFG management plans for the Scottish West Coast include spatial management of *Nephrops* fisheries and the introduction of creel limits.

On the 8th of February 2016, phase 1 of the fisheries management measures for inshore MPAs in Scottish waters came into force (SG, 2016). These measures relate to both NCMPA (Marine (Scotland) Act and the UK Marine and Coastal Access Act) and SACs (EC Habitats Directives – Council Directive 92/43/EEC) both of which have the aim of conserving biological diversity in Scottish waters and contribute to Scotland's MPA network (SG, 2017a). Although not specific to the management of the *Nephrops* fishery, they will influence spatial patterns of fishing for *Nephrops* where controls on the two main gear types, demersal trawls and creels are implemented on *Nephrops* habitat. Within the North Minch functional unit, two MPAs are covered by fisheries management measures. Specifically, the Wester Ross NCMPA where fishing activity is banned for demersal gears for vessels over 500 kW in power and banned in certain areas for vessels below 500 kW. North of the main *Nephrops* ground is the Loch Laxford SAC where demersal trawling is banned (SG, 2016). The areas of the SAC and NCMPA relative to the estimated *Nephrops* habitat within the North Minch functional unit are displayed in Figure 14.6.1.

12.7 Quality of assessment and forecast

The length and sex composition of the landings data is considered to be well-sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately. The reduced sampling effort in 2020 meant that discard sample data were only available for Quarter one, and it was agreed at WGCSE that estimates of discard rates and size distributions for Quarters 2-4 of 2020 would be adequately approximated for the purpose of forecasting by averaging of discard samples across all Quarters from 2017-2019. The length compositions from 1999 onwards, are derived from both creel and trawl samples. The creel fishery accounted for greater than 20% of landings from 2009 to 2011, decreasing gradually to 19% in 2019, before increasing in 2020 to 31%. This part of the fishery exhibits a length distribution composed of larger animals.

There were concerns over the accuracy of historical landings and effort data prior to 2006 when Buyers and Sellers legislation was introduced and the reliability began to improve. Because of this, the final assessment adopted is independent of historical landings data. Harvest rates since 2006 are also considered more reliable due to more accurate landings data reported under this legislation. Incorporation of creel length compositions (since the 2010 WG) has also improved estimates of harvest rates. Underwater TV surveys have been conducted for this stock since 1994, with a continual annual series available since 1998. The number of valid stations in the survey has remained relatively stable throughout the time period. Confidence intervals around the abundance estimates are relatively small for this functional unit. In the provision of catch options based on the absolute survey estimates additional uncertainties related to mean weight in the landings and the discard rates also arise. A three-year average (2018–2020) of discard rates (adjusted to account for some survival of discarded animals) has been used in the calculation of catch options.

The cumulative absolute conversion factor estimates for FU11 are largely based on expert opinion (see stock annex). The precision of these bias corrections cannot yet be characterised. The method to derive landings for the catch options is sensitive to the input dead discard rate and mean weight in landings and this introduces uncertainties in the catch forecasts. Precision estimates are needed for these forecast inputs.

The stock area was revised in 2013 (ICES, 2013) using integrated VMS-logbook data to more accurately estimate the spatial extent of *Nephrops* catches. Two other factors however, have the potential to increase the fished area further. Firstly, the inclusion of vessels smaller than 15 m would likely increase the fished area in some of the inshore locations and secondly, it is known that most of the sea lochs have areas of mud substrate and are typically fished by creel boats. In recent years, a number of TV surveys have taken place in the major North Minch sea lochs in an attempt to improve estimates of the ground area and *Nephrops* abundance. Work presented at the WKNEPH 2013 (ICES, 2013) showed that the total area of the sea lochs is 105 km^2, which is considerably smaller than the offshore VMS area estimated to be 2908 km^2. Therefore, it is unlikely that the exclusion of these inshore areas from the survey have an impact in the mean densities and overall abundance of *Nephrops* in the North Minch.

12.8 Recommendation for next benchmark

This stock was last benchmarked in 2013 (ICES, 2013). WGCSE will keep the stock under close review and recommend a future benchmark as required.

12.9 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level and management at the functional unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

Creel fishing takes place in this area but overall effort by this fleet in terms of creel numbers is not known, and measures to control numbers are not in place. There is a need to ensure that the combined effort from all forms of fishing is taken into account when managing this stock.

There is a bycatch of other species in the area of the North Minch and STECF estimates that discards of whiting and haddock are high in 6.a generally. It is important that efforts are made to ensure that unwanted bycatch is kept to a minimum in this fishery. Efforts to reduce discards and unwanted bycatches of cod include the implementation of large square meshed panels (SMPs) of 120 mm under the west coast emergency measures, and SMPs of 200 mm which were introduced under the Scottish Conservation Credits scheme.

12.10 References

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Table 14.1. ***Nephrops*** **functional units and descriptions by statistical rectangle.**

Functional Unit	Stock	Division	ICES Rectangles
11	North Minch	6.a	44–46 E3–E4
12	South Minch	6.a	41–43 E2–E4
13	Clyde	6.a	39–40 E4–E5

Table 14.1.1(a). Nominal landings (tonnes) of *Nephrops* in Division 6.a, 1980–2020, as officially reported to ICES.

	France	Ireland	Spain	UK-(Engl+Wales+N.Irl)	UK- Scotland	UK	TOTAL
1980	5	1	-	-	7422	-	7428
1981	5	26	-	-	9519	-	9550
1982	1	1	-	1	9000	-	9003
1983	1	1	-	11	10 706	-	10 719
1984	3	6	-	12	11 778	-	11 799
1985	1	1	28	9	12 449	-	12 488
1986	8	20	5	13	11 283	-	11 329
1987	6	128	11	15	11 203	-	11 363
1988	1	11	7	62	12 649	-	12 730
1989	-	9	2	25	10 949	-	10 985
1990	-	10	4	35	10 042	-	10 091
1991	-	1	-	37	10 458	-	10 496
1992	-	10	-	56	10 783	-	10 849
1993	-	7	-	191	11 178	-	11 376
1994	3	6	-	290	11 047	-	11 346
1995	4	9	3	346	12 527	-	12 889
1996	-	8	1	176	10 929	-	11 114
1997	-	5	15	133	11 104	-	11 257
1998	-	25	18	202	10 949	-	11 194
1999	-	136	40	256	11 078	-	11 510
2000	1	130	69	137	10 667	-	11 004
2001	9	115	30	139	10 568	-	10 861
2002	-	117	18	152	10 225	-	10 512
2003	-	145	12	81	10 450	-	10 688
2004	-	150	6	267	9941	-	10 364
2005	-	153	17	153	7616	-	7939
2006	-	133	1	255	13 419	-	13 808

	France	Ireland	Spain	UK-(Engl+Wales+N.Irl)	UK- Scotland	UK	TOTAL
2007	-	155	-	2088	14 120	-	16 363
2008	-	56	1	419	14 795	-	15 271
2009	-	53	-	1226	11 462	-	12 741
2010	-	45	1	1962	10 250	-	12 258
2011	-	38	-	2517	10 419	-	12 974
2012	-	28	-	2502	11 807	-	14 337
2013*	-	5	-	-	-	12866	12871
2014	-	51	-	-	-	12760	12811
2015	-	75	-	-	-	11653	11728
2016	-	107	0	-	-	14600	14707
2017	-	114	-	-	-	11442	11557
2018	-	65	0	-	-	8849	8914
2019	-	92	-	-	-	9 018*	9110
2020	-	71	-	538	6334	6872	6943

*** Includes 8.6 t landings reported by Isle of Man.**

Table 14.1.1(b). Nominal landings (tonnes) of *Nephrops* in Division 6.b, 1980–2018, as officially reported to ICES. There are no Functional Units in ICES Division 6.b but occasional small landings are made.

	France	Germany	Ireland	Spain	UK-(Engl+Wales+N.Irl)	UK- Scotland	TOTAL
1980	-	-	-	-	-	-	0
1981	-	-	-	-	-	-	0
1982	-	-	-	-	-	-	0
1983	-	-	-	-	-	-	0
1984	-	-	-	-	-	-	0
1985	-	-	-	-	-	-	0
1986	-	-	-	8	-	-	8
1987	-	-	-	18	11	-	29
1988	-	-	-	27	4	-	31
1989	-	-	-	14	-	-	14
1990	-	-	-	10	1	-	11
1991	-	-	-	30	-	-	30
1992	-	-	-	2	4	1	7
1993	-	-	-	2	6	9	17
1994	-	-	-	5	16	5	26
1995	1	-	-	2	26	1	30
1996	-	6	-	5	65	5	81
1997	-	-	1	3	88	23	115
1998	-	-	1	6	46	7	60
1999	-	-	-	5	2	5	12
2000	2	-	8	3	4	4	21
2001	1	-	1	14	2	7	25
2002	1	-	-	7	3	7	18
2003	-	-	1	5	6	18	30
2004	-	-	-	2	7	13	22
2005	3	-	1	1	5	7	17
2006	-	-	-	-	1	3	4

	France	Germany	Ireland	Spain	UK-(Engl+Wales+N.Irl)	UK- Scotland	TOTAL
2007	-	-	-	2	3	-	5
2008	-	-	-	-	-	-	0
2009	-	-	-	-	-	-	0
2010	-	-	-	-	-	-	0
2011	-	-	-	-	-	-	0
2012	-	-	-	-	-	-	0
2013	-	-	-	-	-	-	0
2014	-	-	-	-	-	-	0
2015	-	-	-	-	-	-	0
2016	-	-	-	-	-	0	0
2017	-	-	-	-	-	2	2
2018	-	-	-	-	-	0	0
2019	-	-	0	-	-	-	0
2020	-	-	0.5	-	-	-	-

Table 14.1.2. ***Nephrops*****, Total *Nephrops* landings (tonnes) by Functional Unit plus Other rectangles, 1981–2020.**

Year	FU11	FU12	FU13	Other	Total
1981	2861	3652	2968	39	9520
1982	2799	3552	2620	27	8998
1983	3197	3413	4076	34	10720
1984	4143	4300	3310	36	11789
1985	4060	4008	4286	104	12458
1986	3381	3484	4341	89	11295
1987	4084	3892	3009	257	11242
1988	4035	4473	3664	529	12701
1989	3205	4745	2812	212	10974
1990	2546	4430	2909	182	10067
1991	2793	4442	3038	255	10528
1992	3559	4237	2803	248	10847
1993	3193	4458	3343	344	11338
1994	3614	4414	2630	441	11099
1995	3655	4682	3987	460	12784
1996	2872	3995	4057	239	11163
1997	3046	4344	3621	243	11254
1998	2441	3730	4841	157	11169
1999	3257	4052	3752	438	11499
2000	3247	3953	3417	421	11038
2001	3259	3991	3182	420	10852
2002	3440	3305	3384	397	10526
2003	3269	3879	3173	433	10754
2004	3082	3869	2973	403	10327
2005	2949	3848	3395	254	10446
2006	4166	4633	4780	241	13820
2007	3978	5471	6660	420	16529
2008	3799	5356	5923	128	15206
2009	3496	4285	4779	185	12745

Year	FU11	FU12	FU13	Other	Total
2010	2413	3846	5843	569	12671
2011	2697	3702	6432	219	13050
2012	3542	3989	6687	435	14653
2013	3413	3776	5435	234	12858
2014	3257	3179	6207	53	12696
2015	3002	3400	5147	309	11858
2016	3529.4*	4402	6447	236	14614.4
2017	2491	3757	5403	250	11901
2018	1956	2540	4143	160	8799
2019	1979	2220	4683	173	9055
2020	1331	1976	3636	151	7094

***Includes below minimum size landed discards of 0.4 t.**

Table 14.2.1. ***Nephrops*****, North Minch (FU11), Nominal Landings of** ***Nephrops*****, 1981–2020.**

UK Scotland						**Other United Kingdom and Ireland**	**Total**
year	*Nephrops* trawl	other	creel	Below Minimum Size	Subtotal		
1981	2320	171	370	0	2861	0	2861
1982	2323	105	371	0	2799	0	2799
1983	2784	96	317	0	3197	0	3197
1984	3449	160	534	0	4143	0	4143
1985	3235	117	708	0	4060	0	4060
1986	2641	203	537	0	3381	0	3381
1987	3459	143	482	0	4084	0	4084
1988	3450	148	437	0	4035	0	4035
1989	2603	112	490	0	3205	0	3205
1990	1941	134	471	0	2546	0	2546
1991	2229	126	438	0	2793	0	2793
1992	2978	149	432	0	3559	0	3559
1993	2699	86	408	0	3193	0	3193
1994	2916	245	453	0	3614	0	3614
1995	2940	183	532	0	3655	0	3655
1996	2354	148	370	0	2872	0	2872
1997	2553	102	391	0	3046	0	3046
1998	2023	68	350	0	2441	0	2441
1999	2792	56	409	0	3257	0	3257
2000	2695	28	524	0	3247	0	3247
2001	2649	42	568	0	3259	0	3259
2002	2775	79	586	0	3440	0	3440
2003	2606	45	618	0	3269	0	3269
2004	2391	30	661	0	3082	0	3082
2005	2270	23	656	0	2949	0	2949
2006	3446	23	697	0	4166	0	4166

UK Scotland						Other United Kingdom and Ireland	Total
year	*Nephrops* trawl	other	creel	Below Minimum Size	Subtotal		
2007	3361	26	591	0	3978	0	3978
2008	3229	13	557	0	3799	0	3799
2009	2849	34	613	0	3496	0	3496
2010	1783	9	621	0	2413	0	2413
2011	2109	17	571	0	2697	0	2697
2012	2963	12	565	0	3540	2	3542
2013	2356	480	575	0	3411	2	3413
2014	2752	13	490	0	3255	2	3257
2015	2561	23	418	0	3002	0	3002
2016	3039	15	475	0.4	3529.4*	0	3529.4*
2017	2086	30	374	0	2489	1	2490
2018	1592	30	331	0	1950	3	1953
2019	1521	31	425	0	1975	2	1977
2020	900	17	414	0	1331	0	1331

***Below minimum size landings not rounded to show it was reported.**

Table 14.2.2. *Nephrops* Scottish sampling levels all FUs in 6.a (including N. Irish for Clyde).

***Number of trips expressed as number of hauls for discards.**

		2018		2019		2020	
FU		N trips*	N measured	N trips*	N measured	N trips*	N measured
North Minch	Landings	44	30 082	41	23 952	25	8 551
	Discards	48	4 136	35	3 658	4	443
South Minch	Landings	36	22 837	40	21 378	18	8 203
	Discards	29	2 547	25	1 578	7	673
Clyde	Landings	19	14 517	22	19 227	24	10 037
	N.Irish Landings	4	2 019				
	Discards	15	1 753	33	4 073	-	-

*** Number of trips expressed as number of hauls for discards.**

Table 14.2.3. ***Nephrops*** **mean weight in the landings (FU11–13).**

Year	FU11	FU12	FU13
1990	21.39	19.99	24.27
1991	25.35	21.74	20.65
1992	21.66	24.10	25.16
1993	20.79	21.26	29.44
1994	23.45	24.96	25.28
1995	22.24	21.96	19.24
1996	26.68	23.10	21.68
1997	21.71	23.37	24.21
1998	23.65	22.18	17.98
1999*	22.70	25.14	17.39
2000	24.19	27.30	19.96
2001	25.33	23.79	19.46
2002	25.93	26.83	16.35
2003	26.03	27.86	19.13
2004	25.16	27.37	18.80
2005	27.65	28.11	17.96
2006	24.52	26.24	19.27
2007	23.61	23.95	19.05
2008	23.90	23.91	16.59
2009	25.42	23.87	18.31
2010	29.39	25.86	21.21
2011	27.56	31.10	19.34
2012	23.43	29.17	21.83
2013	27.52	27.48	20.72
2014	27.96	29.91	20.79
2015	28.74	28.15	22.21
2016	25.76	24.76	17.70
2017	25.89	27.76	17.02
2018	27.39	27.27	16.14
2019	26.59	28.54	17.2
2020	31.06	36.58	18.96
Average**	26.17	27.32	17.45

***From 1999 onwards mean weights are shown for trawl and creels combined.**

**** Average for FU11 and FU12 (1999–2020); FU13 (2018–2020).**

Table 14.2.4. ***Nephrops*****, North Minch (FU11): Adjusted TV survey abundance, landings, discard rate (proportion by number) and estimated harvest rate.**

YEAR	LANDINGS IN NUMBERS (MILLIONS)	DISCARDS IN NUMBERS (MILLIONS)	REMOVALS IN NUMBERS (MILLIONS)**	ADJUSTED SURVEY VMS (MILLIONS)*	HARVEST RATE VMS	LANDINGS (TONNES)	DISCARDS (TONNES)	DISCARD RATE	DEAD DISCARD RATE	MEAN WEIGHT IN LANDINGS (g)	MEAN WEIGHT IN DISCARDS (g)
1999	144	28	165	794	20.7	3257	273	16.4	12.8	22.7	9.69
2000	134	10	142	1166	12.1	3247	100	6.9	5.2	24.19	10.08
2001	129	17	141	1092	13	3259	160	11.7	9.1	25.33	9.32
2002	133	28	154	1337	11.5	3440	277	17.6	13.8	25.93	9.78
2003	126	30	148	1751	8.5	3269	299	19.2	15.2	26.03	10
2004	122	18	136	1751	7.8	3082	202	13	10.1	25.16	11.02
2005	107	50	144	1540	9.4	2949	507	32	26.1	27.65	10.09
2006	170	74	225	1762	12.8	4166	757	30.3	24.6	24.52	10.27
2007	168	12	177	1206	14.7	3978	214	6.5	5	23.61	18.1
2008	159	19	173	1047	16.5	3799	194	10.5	8.1	23.9	10.36
2009	138	35	164	1195	13.7	3496	327	20.3	16	25.42	9.34
2010	82	12	91	1293	7	2413	128	12.4	9.6	29.39	10.98
2011	96	16	108	1726	6.3	2697	154	14.2	11	27.56	9.66
2012	151	21	167	891	18.7	3542	213	12.6	9.3	23.43	10.33
2013	122	24	140	1403	10	3413	364	16.4	12.8	27.52	15.18
2014	115	8	121	1251	9.6	3257	77	6.3	4.8	27.96	9.99
2015	103	15	114	1445	7.9	3002	143	12.6	9.8	28.74	9.66
2016	136	22	152	1422	10.7	3529***	266	14	10.9	25.76	12.05
2017	95	5	99	1050	9.4	2491	65	5.3	4	25.89	12.51
2018	72	5	75	1188	6.4	1956	59	6.6	5.1	27.39	11.46
2019	74	4	78	1232	6.3	1979	51	5.5	4.2	26.59	11.92
2020	43	3	45	1439	3.1	1331	31	5.7	4.3	31.06	11.84
2021				1391							
Average****									4.5	26.17	11.07

*** harvest rates previous to 2006 are unreliable.**

**** Removals numbers take the dead discard rate into account.**

***** Includes 0.4 tonnes of below minimum size landings.**

****** Dead discard average: 2018–2020; Mean weight in landings and discards average: 1999–2019.**

Table 14.2.5. ***Nephrops*, North Minch (FU11): Results of the 1994–2021 TV surveys (values adjusted for bias).**

YEARS	NUMBER OF VALID STATIONS	MEAN DENSITY (BURROWS/M²)	ABUNDANCE (SEDIMENT; MILLIONS)	95% CONFIDENCE INTERVAL (SEDIMENT; MILLIONS)	ABUNDANCE (VMS; MILLIONS)	95% CONFIDENCE INTERVAL (VMS; MILLIONS)
1994	41	0.29	500	74	820	122
1995				No Survey		
1996	38	0.19	330	47	541	76
1997				No Survey		
1998	38	0.31	547	77	898	127
1999	36	0.27	484	89	794	147
2000	39	0.40	711	82	1166	134
2001	56	0.38	666	81	1092	133
2002	37	0.46	815	91	1337	149
2003	41	0.60	1068	129	1751	211
2004	38	0.60	1068	107	1751	175
2005	41	0.53	939	100	1540	164
2006	30	0.61	1074	101	1762	165
2007	36	0.41	735	92	1206	150
2008	41	0.36	638	95	1047	157
2009	26	0.41	729	138	1195	227
2010	37	0.44	-	-	1293	231
2011	41	0.59	-	-	1726	226
2012	41	0.31	-	-	891	181
2013	41	0.48	-	-	1403	206
2014	44	0.43	-	-	1251	171
2015	41	0.50	-	-	1445	370
2016	39	0.49	-	-	1422	290
2017	42	0.36	-	-	1050	149
2018	44	0.40	-	-	1188	244
2019	47	0.42	-	-	1232	256
2020	33	0.49	-	-	1439	319

2021	50	0.48	-	-	1391	215

Table 14.2.6. ***Nephrops*, North Minch (FU11): Results of the 2021 TV survey.**

STRATUM	AREA (km^2)	NUMBER OF STATIONS	MEAN BURROW DENSITY (no./m^2)	OBSERVED VARIANCE	ABUNDANCE (MILLIONS)	STRATUM VARIANCE	PROPORTION OF TOTAL VARIANCE	SURVEY PRECISION LEVEL (CV)
2021 TV survey								
VMS	2908	50	0.478	0.068	1390.2	11605	1	
Total	2908	50			1390.2	11605	1	0.077

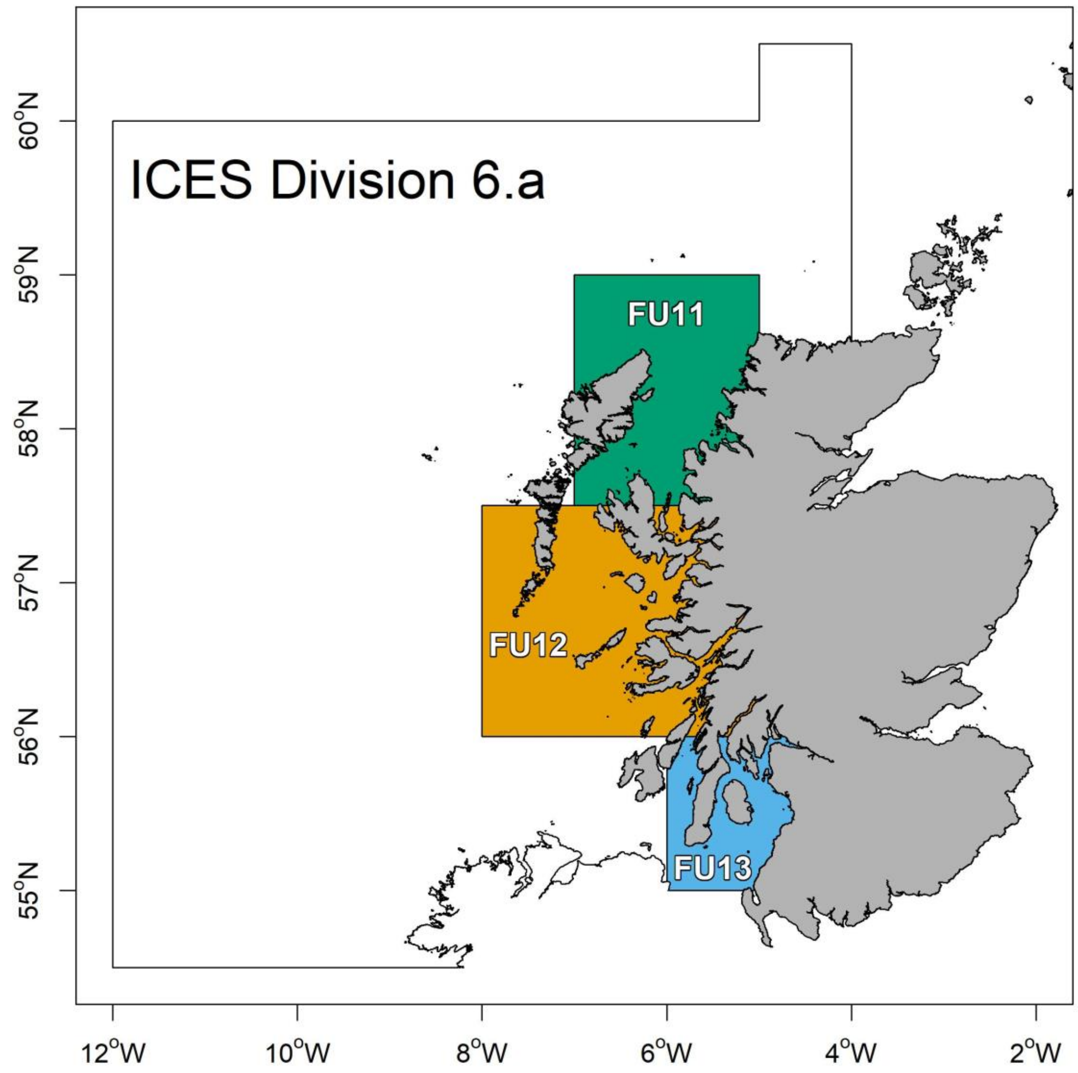

Figure 14.1. ***Nephrops*** **Functional Units in 6.a. North Minch (FU11), South Minch (FU12), Clyde (FU13).**

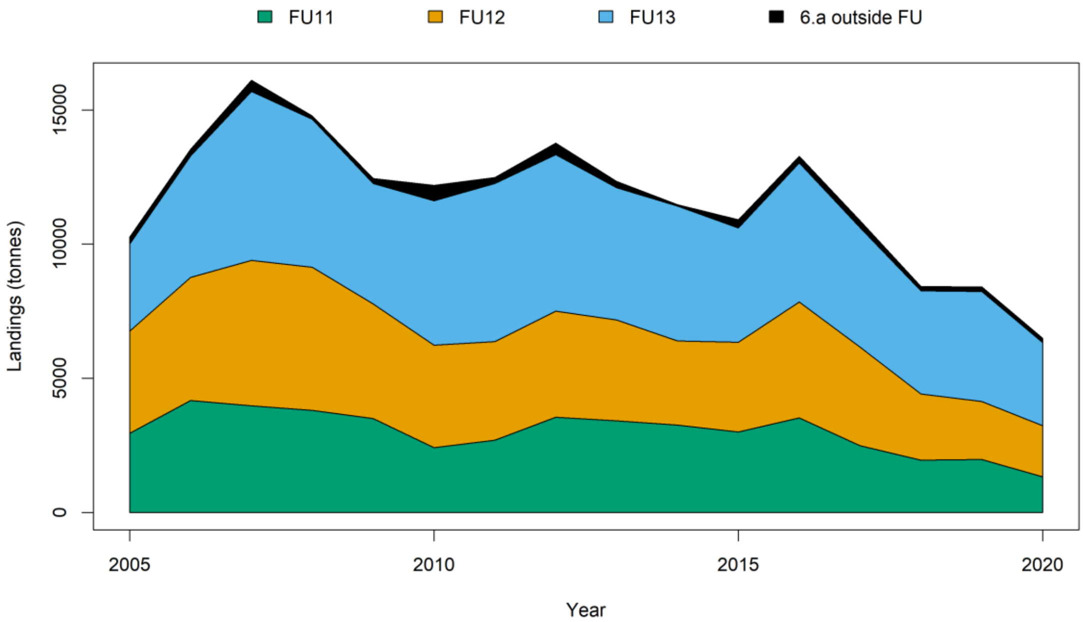

Figure 14.1.1. *Nephrops* in Division 6.a. Landings (tonnes) by functional unit (FU11, 12 &13) and from rectangles outside the functional units (6.a outside FU).

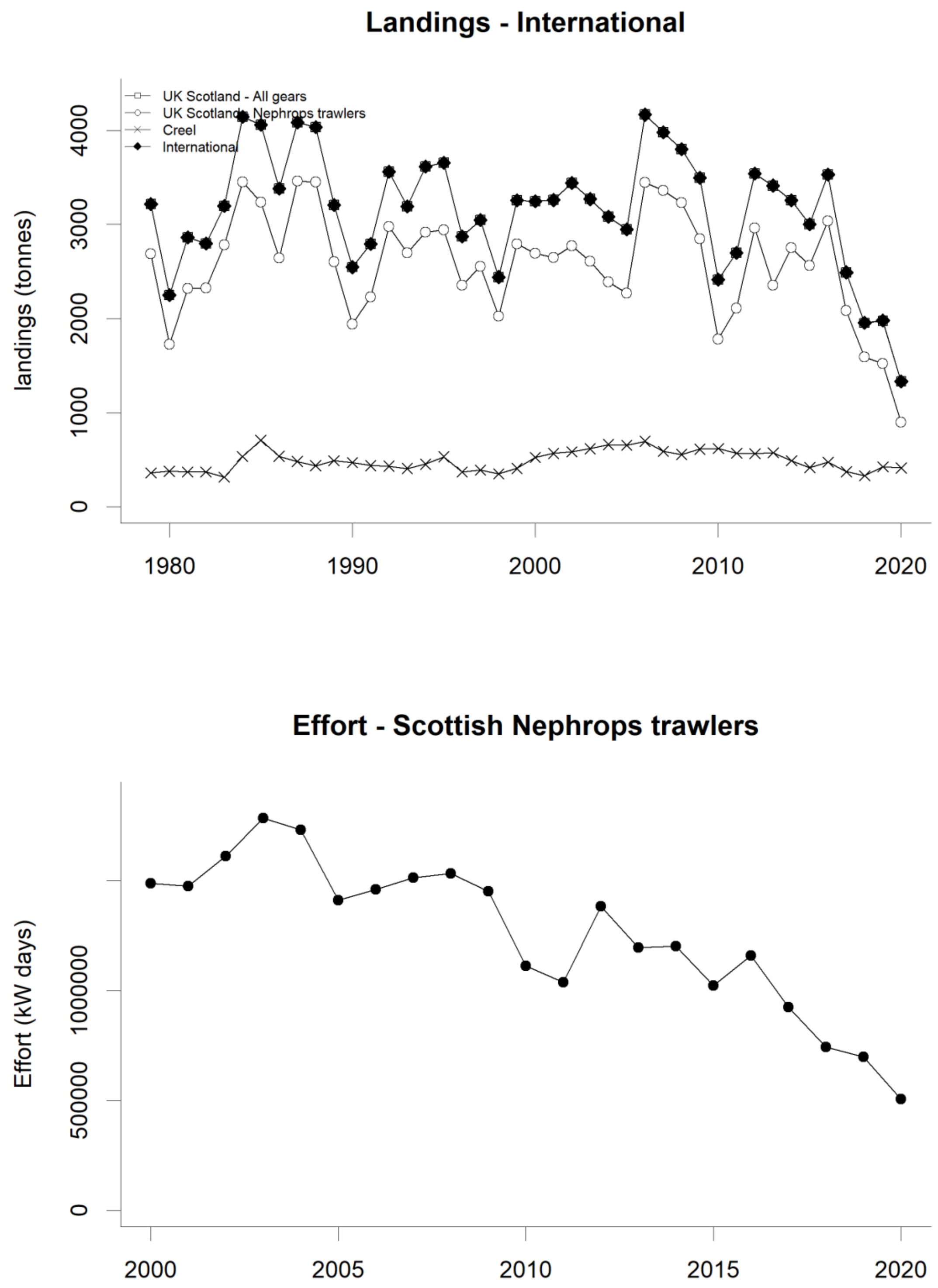

Figure 14.2.1. ***Nephrops*****, North Minch (FU11). Long-term landings and effort.**

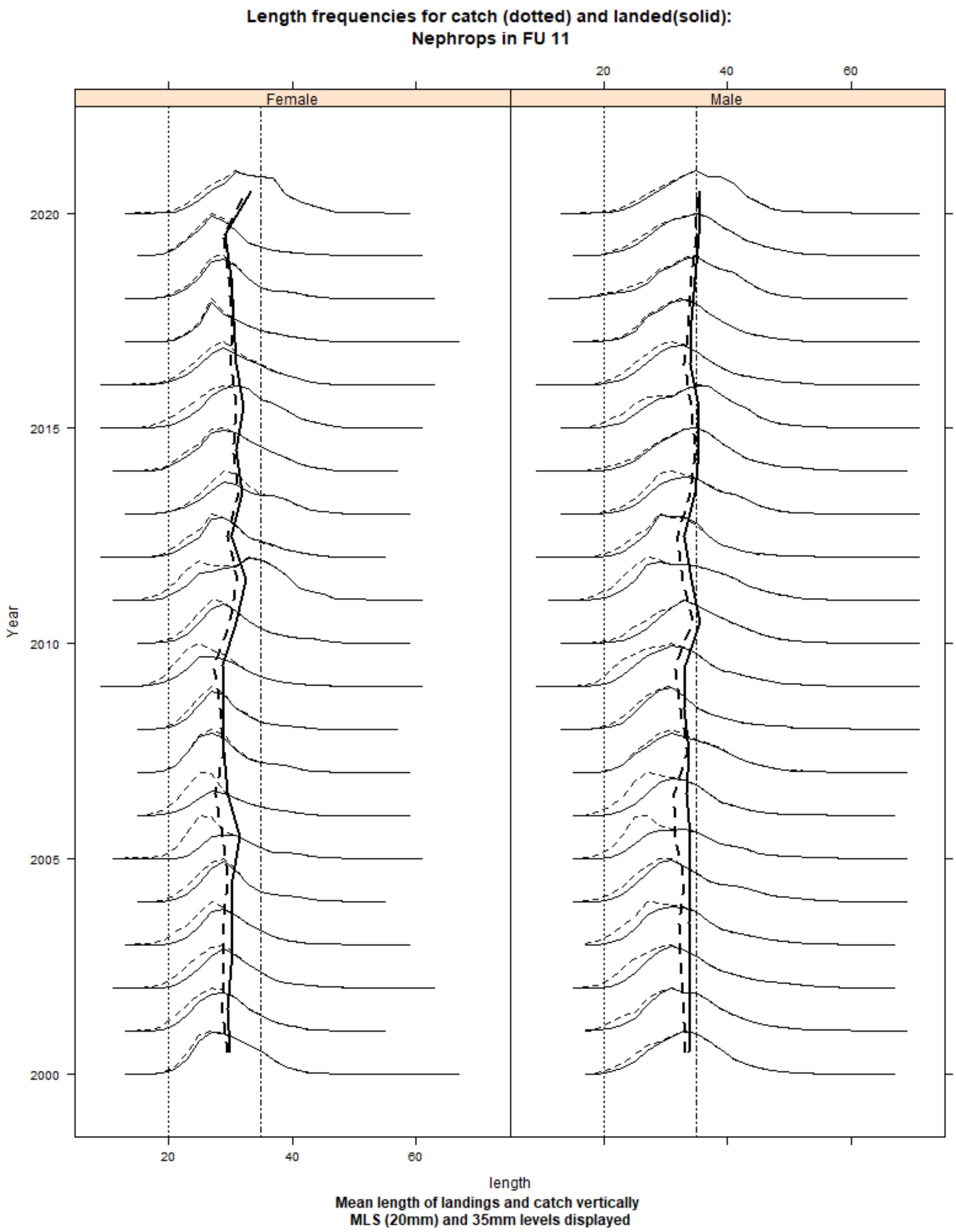

Figure 14.2.2. ***Nephrops*****, North Minch (FU11), Catch length–frequency distribution and mean sizes for *Nephrops* in the North Minch, 2000–2020.**

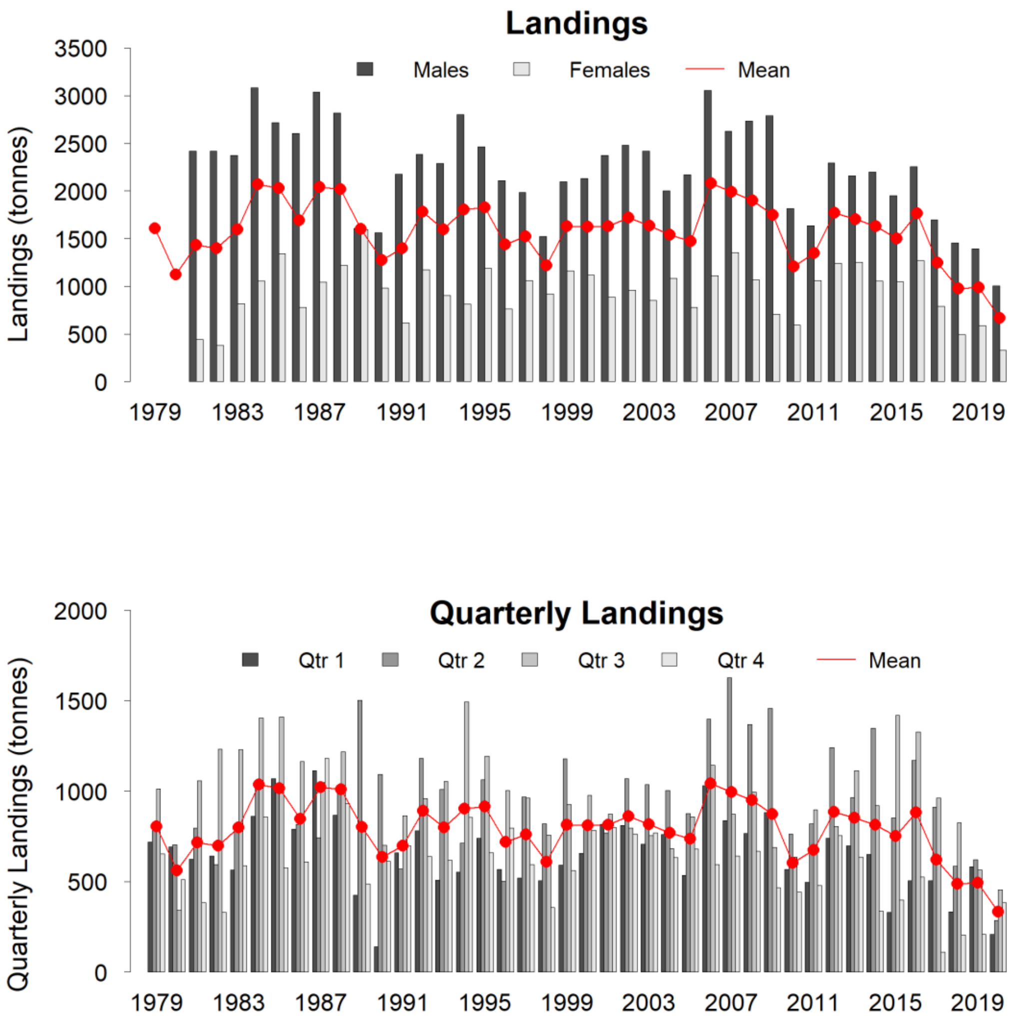

Figure 14.2.3 (a). ***Nephrops,*** **North Minch (FU11), Landings by quarter and sex from Scottish trawlers.**

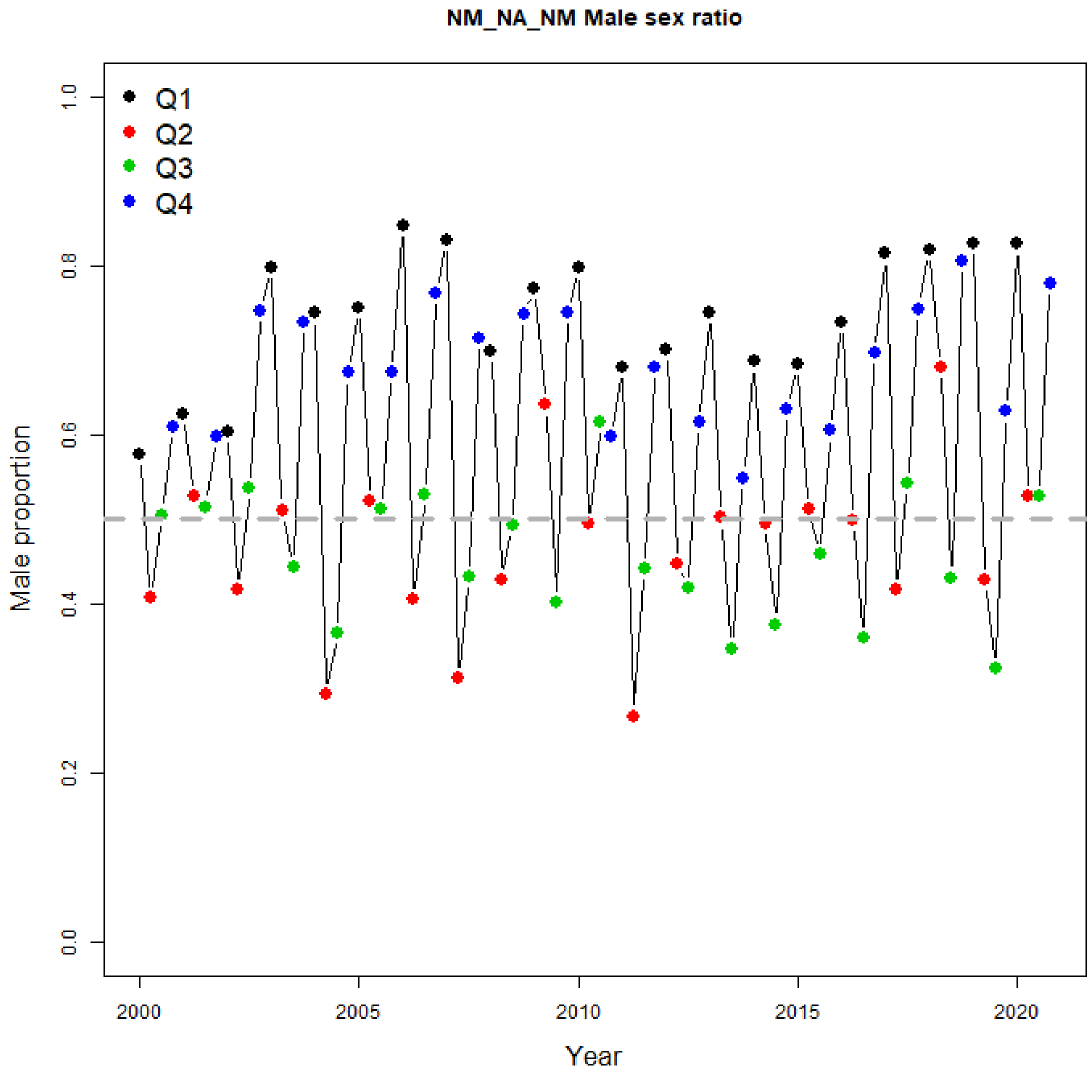

Figure 14.2.3 (b). ***Nephrops,*** **North Minch (FU11), Proportion of males by quarter (2000–2020).**

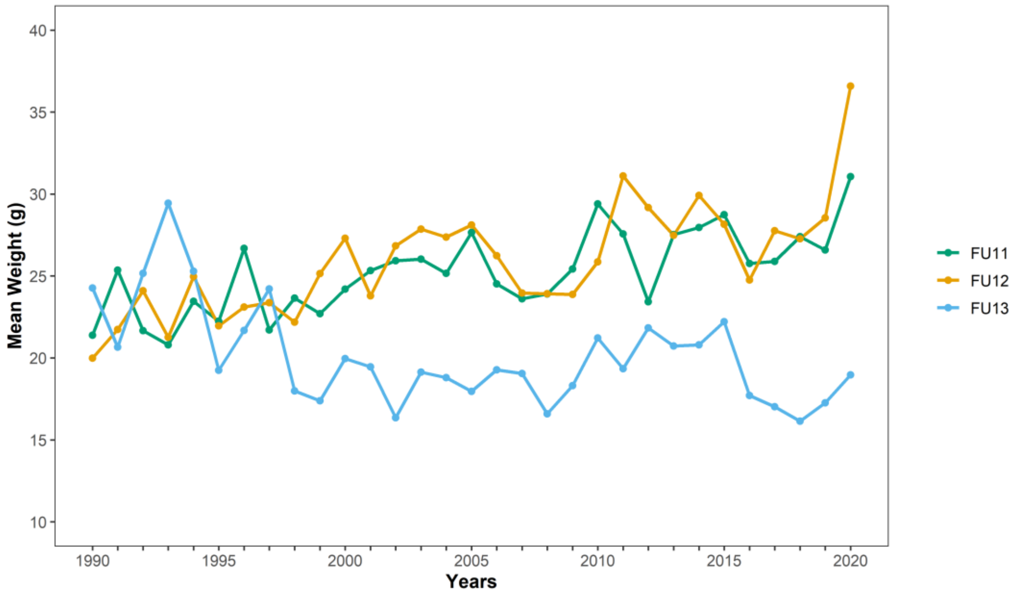

Figure 14.2.4. *Nephrops*, **(FU11 North Minch, FU12 South Minch and FU13 Clyde), mean weight in the landings from 1990–2020 (from Scottish market sampling data).**

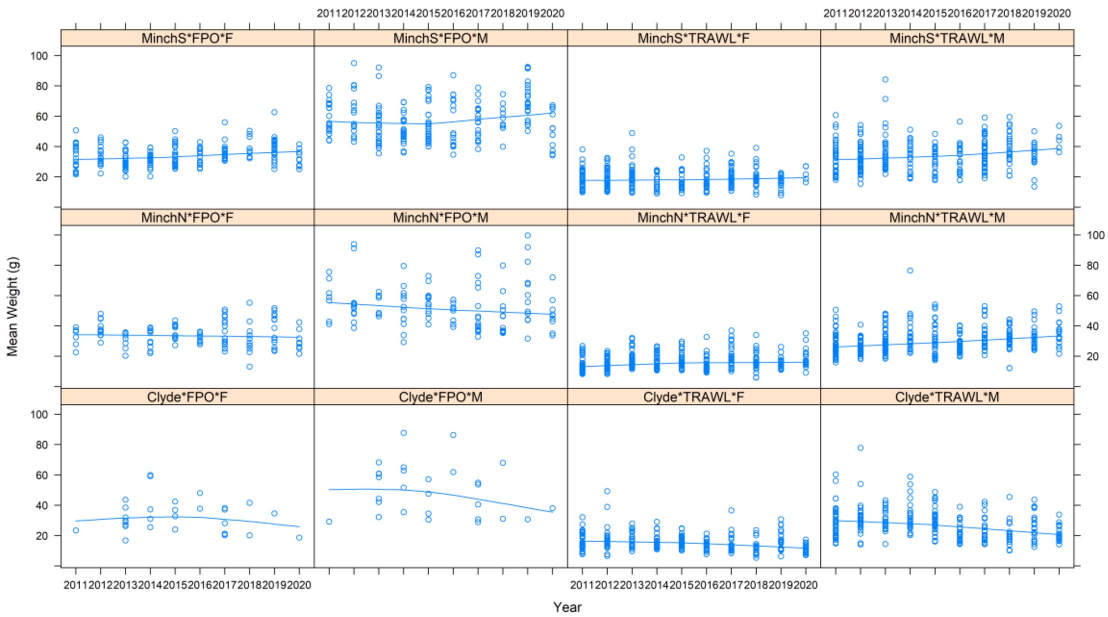

Figure 14.2.5. *Nephrops*, **(FU11 North Minch, FU12 South Minch, FU13 Clyde), mean weight in landings 2011–2020 by sample date, sex, métier and functional unit.**

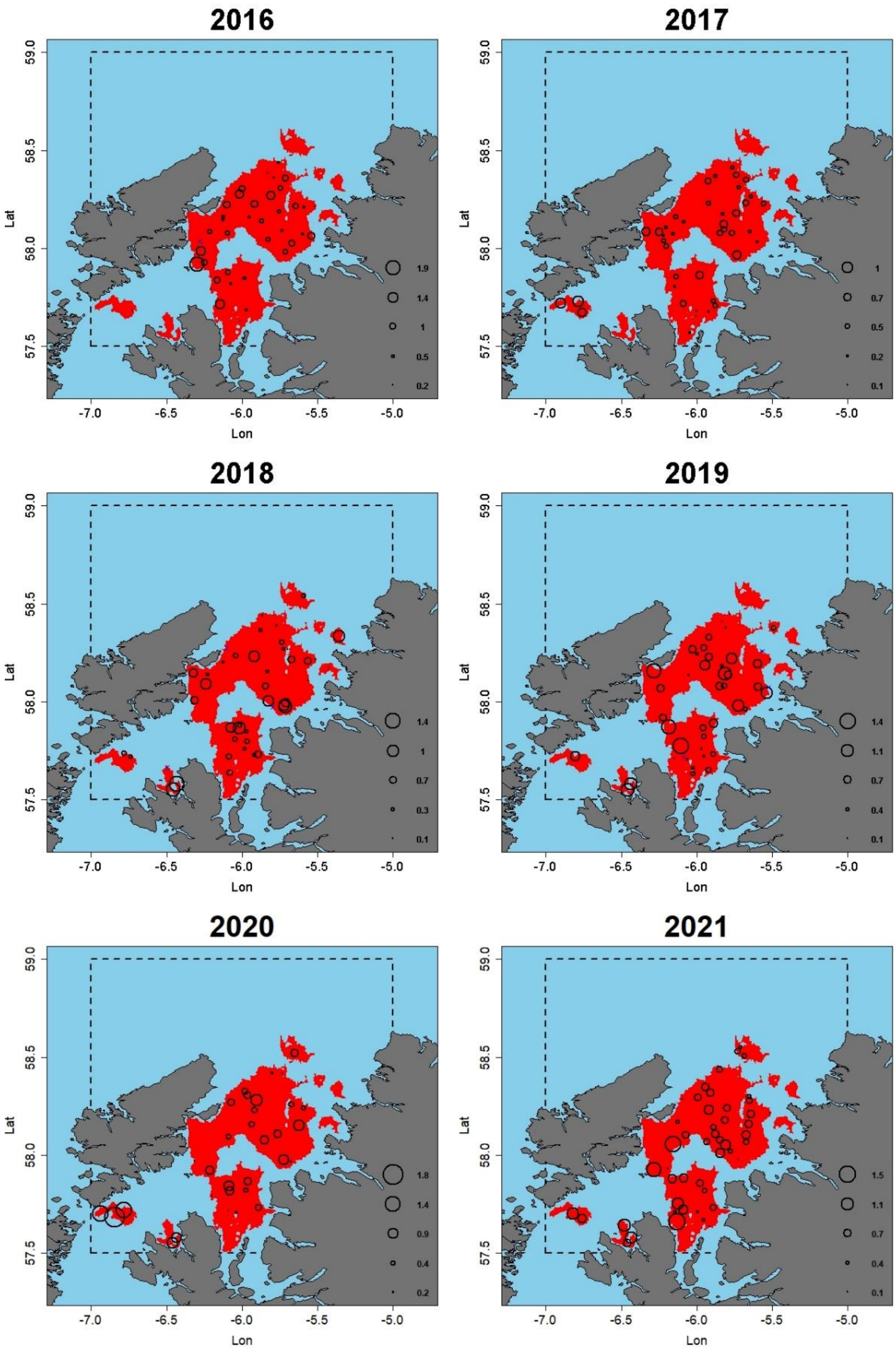

Figure 14.2.6. ***Nephrops*, North Minch (FU11), TV survey station distribution and relative density (burrows/m²), 2016–2021. Bubbles in these figures are all scaled the same. Crosses represent zero observations.**

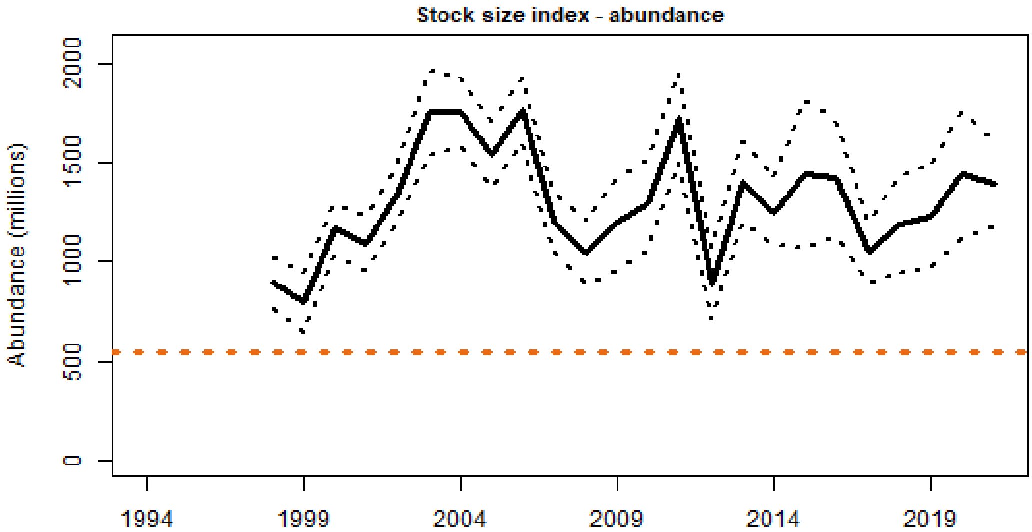

Figure 14.2.7. ***Nephrops*, North Minch (FU11), time-series of revised TV survey abundance estimates (adjusted for bias; solid black line), with 95% confidence intervals (dashed black lines), 1994–2021 (no survey in 1995 and 1997). The dashed red line is the rounded $B_{trigger}$ value of 540 million individuals.**

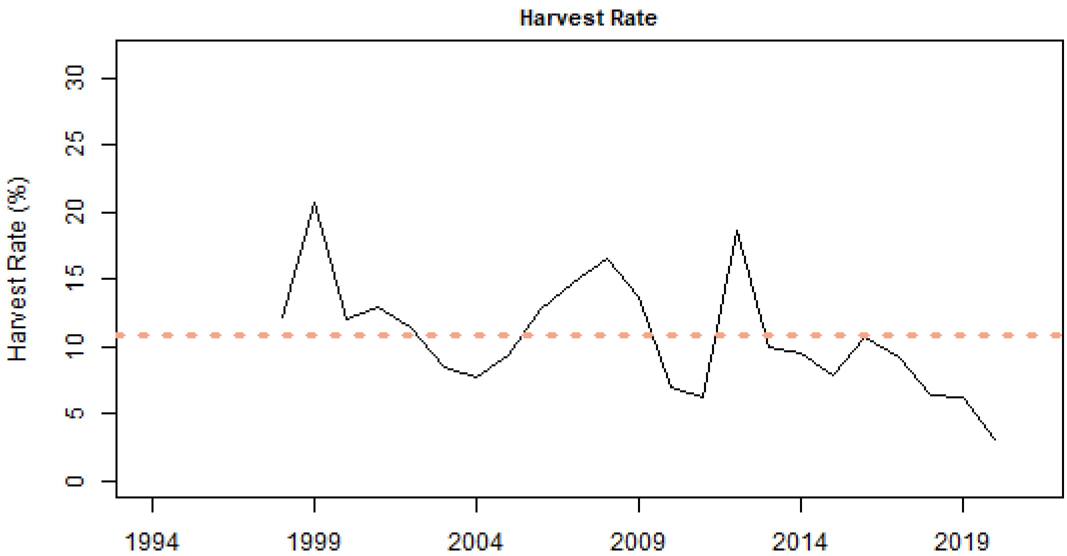

Figure 14.5.1. ***Nephrops*, North Minch (FU11), harvest rate, 1994–2020 (no survey data in 1995 and 1997). The red dashed and solid lines are the F_{MSY} proxy harvest rate (10.8%) and the harvest rate respectively. Harvest rates prior to 2006 are unreliable.**

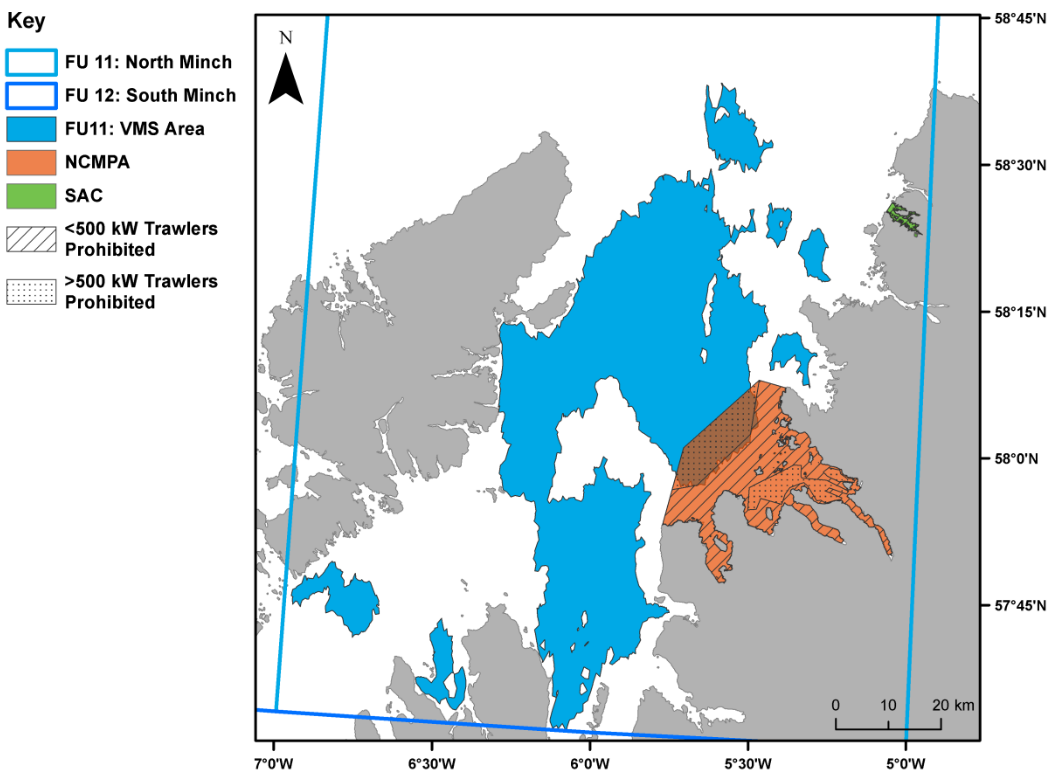

Figure 14.6.1. The area of *Nephrops* habitat (estimated from VMS data) within the North Minch (FU11) relative to the areas of the Nature Conservation MPA (NCMPA) and Special Area of Conservation (SAC) showing areas within these where demersal trawling is banned (hatched) and where it is permitted for vessels below 500 kW (clear; depending on gear type, see SG, 2016). Geographic Coordinate System: OSGB 1936, Datum: OSGB 1936, Projected Coordinate System: British National Grid. Coastline by Wessel and Smith (2016), MPA sites subsetted from NCMPA (SNH, 2015) and SAC (SNH, 2016) layers, management areas by SG (2017b) and functional units generated from merged ICES rectangles (ICES, 2017). Map and modified layers created using ArcGIS (ESRI, 2014).

13 Norway lobster (*Nephrops norvegicus*) in Division 6.a, Functional Unit 12 (West of Scotland, South Minch)

Type of assessment in 2021

The assessment and provision of advice through the use of the UWTV survey data and other commercial fishery data follow the process defined by the benchmark WG (WKNEPH, 2009; WKNEPH, 2013). Full details are provided in the stock annex.

ICES advice applicable to 2020

'ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 5671 tonnes and 7134 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit 12 is exploited sustainably, management should be implemented at the functional unit level.'

ICES advice applicable to 2021

'ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 4703 tonnes and 5916 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit 12 is exploited sustainably, management should be implemented at the functional unit level.'

13.1 General

Stock description

The South Minch (FU12) is located midway down the west coast of Scotland (North Minch report, section 15, figure 15.1). The area is characterised by numerous islands of varying size, and sea lochs occur along the mainland coast. These topographical features create a diverse habitat with complex hydrography and a patchy distribution of soft sediments. Further details are provided in the stock annex.

Management applicable to 2020 and 2021

Management is at the ICES subarea level as described at the beginning of Section 15 (FU11 North Minch report).

Ecosystem aspects

Details of the ecosystem aspects for this functional unit are provided in the stock annex where available.

Fishery description

Information on developments in the fishery was provided by Marine Scotland compliance officers. In 2020 the fishery was described as generally very poor. In addition, it was reported that changes in regulations related to both Brexit and the COVID-19 pandemic made trade very difficult for those operating within the fishery.

Two distinct fleets operate in the South Minch and the main ports are Oban and Mallaig. In Oban there are six local prawn trawlers and 48 Nephrops creelers (35 <10m vessels), while there are 15 Nephrops trawlers in Mallaig. There were no major changes to the fleets in 2020, but there was a comment that the overall size of the fleet is gradually decreasing over time.

Since 2009, vessels have been required to fit 120 mm square meshed panels, in accordance with the west coast emergency measures (Council Reg. (EU) 43/2009). Large SMPs (200 mm) are also widely used and were made mandatory for all TR2 vessels with power >112 kW fishing as part of the previous Scottish Conservation Credits scheme. Twin rig vessels tend to use a 200 mm square mesh panel with a 100 mm or larger mesh codend. These vessels do not catch bulk quantities and this leads to *Nephrops* of better average size and quality. A comment was noted in 2017 about the use of bungee cords to keep the meshes closed. This was investigated by Compliance officers but was deemed to be legal and was not reported as a problem in subsequent years.

There is very little fish bycatch landed due to the restrictions on cod, haddock and whiting (detailed in ICES, 2016a, ICES, 2016b and ICES, 2016c). Estimates of discard rates of haddock and whiting remain high (ICES, 2016d and ICES, 2017a). Haddock in areas 6a are now covered by the landings obligation in area.

Further general information on the fishery can be found in the stock annex.

13.2 Data available

InterCatch

Data for 2020 were successfully uploaded into InterCatch prior to the 2021 WG meeting. In addition to uploading the 2020 catch data, total weight of landings data for 2017-2019 were updated following a review of Marine Scotland Science data holdings. 2019 data were updated in InterCatch, and length distribution samples were re-raised according to the usual procedure. 2017 and 2018 data were updated in MSS stock objects, with changes of 2.9% and 0.01% to the respective landing weight values, and a change of ~2% to the 2017 harvest rate. Uploaded data were worked up in InterCatch to generate 2020 raised international length–frequency distributions. Allocation schemes for any unsampled fleets are described in the stock annex. Data exploration in InterCatch has previously shown that outputs of raised data were very close to those generated by the previous method applied internally with differences being <0.1%. As such, InterCatch length–frequency outputs have been used in the stock assessment since 2012.

The COVID-19 pandemic resulted in a reduced sampling effort of commercial catches for FU12 in 2020. Discard sample data for FU12 were only available for quarter one, and so InterCatch estimates of discard rates for quarters two, three, and four in InterCatch were based on samples collected in quarter one. Following download of data from InterCatch, alternate methods of 2020 discard estimation were thus considered. It was agreed at WGCSE that estimates of discard rates and size distributions for 2020 would be based on an averaging of discard samples across all quarters from 2017-2019. Minimum and maximum discard rates over the same period were also examined to gain an appreciation of the plausible range of discarding that might occur. Assessment estimates affected by changes in discard rates are annotated below to reflect this; i.e. x (y/z), where x is the estimate based on the average discard rate 2017-2019, y is based on minimum discard rate, and z on maximum discard rate.

Commercial catch

Official catch statistics (landings) reported to ICES are shown in Table 15.1.1 (see FU11 North Minch report, Section 15). These relate to the whole of 6.a of which the South Minch is a part. Landings for FU12 provided through national laboratories are presented in Table 16.2.1, broken down by country and by gear type. Landings from this fishery are predominantly reported from Scotland, with low levels reported from the rest of the UK and Ireland. Total reported Scottish landings in 2020 were 1899 tonnes (plus 8 tonnes from other UK vessels and 69 tonnes from Ireland), consisting of 1320 tonnes (69%) landed by Scottish *Nephrops* trawlers and 554 tonnes (29%) landed by Scottish creel vessels. The proportion of creel caught landings increased somewhat over the past decade, from 21% in 2011 to 29% in 2020.

Effort data

In 2015, WGCSE agreed that effort should be reported in kW days as this is likely to be more informative about changes in the actual fleet effort. Effort shows an overall decreasing trend since 2003 but there are peaks in 2008 and 2012, which can be attributed to visiting North Sea trawlers (Figure 16.2.1). The decline in effort observed in recent years continued in 2020, and may be attributed to poor fishing and the movement of vessels to the East coast of Scotland. Note that the effort time-series range (2000–2020) does not match with the more extensive year range available for landings due to a lack of reliable effort data in the Marine Scotland Science in-house database. The effort is also slightly inconsistent with the landings data in that effort is provided for TR2 vessels while the '*Nephrops* trawl' landings additionally includes landings by large mesh trawlers targeting *Nephrops*.

Sampling levels

Length compositions of landings and discards are obtained during market sampling and on-board observer sampling respectively. These sampling levels are shown in Table 15.2.2 (see FU11 North Minch report, Section 15). Sampling effort in 2020 was lower than recent years due to disruptions to both the fishing industry and government sampling programmes attributable to the COVID-19 pandemic. Length compositions for the creel fishery are available for landings only as the small numbers of discards survive well. Therefore these animals are not considered to be removed from the population and hence a value of 100% survival is assumed (ICES, 2013).

Length compositions

Figure 16.2.2 shows a series of annual length–frequency distributions from 2000 onwards and appears fairly stable over the time-series. Catch (removals) length compositions are shown for each sex along with the mean size for both. The mean size of males and females have increased over the last two years. This change has most likely been effected by the increased proportion of the creel landings component in the catch.

Sex ratio

The sex ratio in the South Minch in 2020 shows considerable divergence from that observed in recent years, although males still made the largest contribution to the annual landings. In recent years, males have been available to the fishery throughout the year while females were mainly caught in the summer when they emerge from the burrow after egg hatching. This seasonal change could be observed in the quarterly sex ratios, with males dominating the catch in quarters one and four, and a more even sex ratio observed in quarters two and three. However, in 2020, all quarterly sex ratios were majority male (Figure 16.2.3) due to the decreased number of samples which were available for the year. This metric is used as an indicator, whereby increasing proportions of females in the catch might signal an effect of acute overfishing. In this case, however, the unusual sex ratios are known to be due to poor sampling, and not a cause for concern to management.

Mean weights

The mean weight in the landings (Figures 15.2.4 and 15.2.5; see FU11 North Minch report, Table 15.2.3) have fluctuated at a high level since 2011 (in comparison to values for 2006 to 2010). Seasonal variability (and occasional outliers) in mean weights is seen in the individual sample estimates. There appears to be a small increase in the mean weight of the males for the trawl caught *Nephrops* and also, for the females caught by creels (Figure 15.2.5). The annual estimate of mean weight in the landings has an effect on the catch forecast. Over the time-series, there is a general increasing trend in mean weights in the landings, and the mean weight in 2020 is the highest in the time series. This can be explained by the increasing proportion of creel samples (which tend to catch and land larger *Nephrops*).

Discarding

Discarding of undersized and unwanted *Nephrops* occurs in this fishery. Discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Discarding rates in this FU have varied considerably over the years, ranging from as low as 3% to over 25%. In 2020, the discarding rate was 7.8% based on observed discard rates for Quarter 1 and mean discard rates based on 2017-2019 data for Quarters 2-4 (2.1% based on minimum observed quarter discard rate between 2017-2019 and 28.6% based on maximum quarterly discard rate). The rate based on the three year mean represents an increase on 2019 (4.9%). The low levels of discarding in recent years may be explained by poor fishing and a gradually decreasing fleet (Table 16.2.2).

Studies (Charuau *et al*., 1982; Sangster *et al*., 1997; Wileman *et al*., 1999) suggest that some *Nephrops* survive the discarding process, an estimate of 25% survival is assumed for this FU in order to calculate removals (landings + dead discards) from the population. The discard survival rate for creel caught *Nephrops* has been shown to be high (ICES, 2013) and a value of 100% is assumed. The discard rate (adjusted to account for survival) which will be used in the forecast was estimated by taking a three-year average 2018–2020, amounting to 4.3% (2.9%/9.8%).

Abundance indices from UWTV surveys

An underwater TV survey of the stock is conducted annually according to standards set out by the Manual for the Nephrops Underwater TV Surveys (Dobby H., et al, 2021). Surveys use a stratified random approach, and have been carried out for this stock since 1995. TV surveys are targeted at known areas of mud, sandy mud and muddy sand in which *Nephrops* construct burrows. The numbers of valid stations used in the final analysis in each year are shown in Table

16.2.3. On average, 36 stations have been considered valid each year, and raised to a stock area of 5072 km^2 (derived from BGS sediment data). In 2021, 41 valid stations were used in the final survey analysis (Table 16.2.3).

TV survey abundance estimates from 1995–2021 are shown in Table 16.2.3 and Figure 16.2.4. They show that the *Nephrops* population in the South Minch experienced several years of high abundance in the early mid-2000s. Aside from this, it has fluctuated without obvious trend over the time period covered by the survey (Figure 16.2.4). The 2021 abundance represents a 33.8% decrease in relation to 2020.

Table 16.2.4 shows a more detailed summary of the results from the three most recent TV surveys conducted in FU12. The table includes estimates of abundance and variability in each of the strata adopted in the stratified random approach. Mean burrow density decreased in 2021, in comparison to the 2020 survey, in all strata apart from Mud. Densities are generally lower in the western parts of the area towards the Outer Hebrides and higher in the inshore areas to the south west of Skye (Figure 16.2.5). The CV for the 2021 TV survey (Table 16.2.4) is lower than the 20% precision level agreed by WGNEPS (2019; 12.6%).

The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES, 2009; ICES, 2013), WGNEPS (ICES, 2018a), WKNEPS (ICES, 2018b) and (Leocádio *et al*., 2018). A number of potential biases were highlighted including those due to edge effects, species burrow misidentification and burrow occupancy. The cumulative relative to absolute conversion factor estimated for FU12 was 1.32 meaning that the TV survey is likely to overestimate *Nephrops* abundance by 32%.

13.3 Assessment

Comparison with previous assessments

The assessment follows the same procedure as last year and is based on a combination of examining trends in fishery indicators and underwater TV abundance estimates. The process was defined by the benchmark WG and is described in the stock annex.

State of the stock

The underwater TV survey is presented as the best available information on the South Minch (FU12) *Nephrops* stock. The details of the 2021 survey are shown in Table 16.2.4, and compared with the 2019 and 2020 outcomes. At present, it is not possible to extract any length or age structure information from the survey and therefore it provides information on abundance over the area of the survey.

TV survey estimated stock abundance in 2021 was 1272 million individuals, above the MSY $B_{trigger}$ value of 1016 million, or the rounded value of 1020 million used for the provision of advice.

The calculated harvest rate in 2020 (dead removals/TV abundance = 3%; 2.8%/3.6%) was below the F_{MSY} proxy for this stock (the value associated with high long-term yield and low risk depletion) of 11.7%.

13.4 Catch scenarios table

Landings predictions and catch options at various harvest rates (based on principles established at WKNEPH (ICES, 2009), are made on the basis of the 2021 UWTV survey conducted in June. These were presented at WGCSE NEPH in October 2021 for the provision of advice.

Catch scenarios table inputs and historical estimates of mean weight in landings and harvest rates are presented in Table 16.2.2 and summarised below. The calculation of catch scenarios for the South Minch follows the procedure outlined in the stock annex.

Given the variability in mean weights it was considered more appropriate to use a full time-series average, from 1999 (first year with creel and trawl length distributions combined) until 2020.

The table below shows the agreed inputs to the catch scenario table.

Input	Data	2021 assessment
Survey abundance (millions)	UWTV 2021	1272
Mean weight in projected landings (g)	1999–2020	27.32
Mean weight in projected discards (g)	1999–2020	10.13
Dead projected discards	2018–2020	4.3%*
Discard survival rate	Proportion by number (assumed)	25%**

* Based on mean discard rate (2017-2019) allocated to Quarters 2-4 of 2020; estimates of 9.8% and 2.9% were derived based on the maximum and minimum observed discard rates, respectively, for the same period

** Discard survival in the creel fishery is assumed to be 100%, as outlined in the stock annex.

13.5 Reference points

New reference points were derived for this stock at WKMSYRef4 (ICES, 2016e). These are updated on the basis of an average of estimated F_{MSY} proxy harvest rates over a period of years which corresponds more closely to the methodology for finfish. In cases where there is a clear trend in the values, a five-year average was chosen. Similarly, the five-year average of the F at 95% of the YPR obtained at the F_{MSY} proxy reference point was proposed as the F_{MSY} lower bound and the five-year average of the F above F_{MAX} that leads to YPR of 95% of the maximum as the upper bound. Using an average value also has the advantage of reducing the effect of any unusually high or low estimates of the F_{MSY} proxy, which occasionally appear. For this stock, the F_{MSY} proxy has been revised from 12.3% to 11.7%.

For *Nephrops* stocks, MSY $B_{trigger}$ has been defined as the lowest stock size from which the abundance has increased and is calculated as 1016 million individuals (in 2010). This value was rounded to 1020 million, in the advice from WKMSYRef4 on MSY $B_{trigger}$. Full details are contained in the stock annex.

These should remain under review by WGCSE and may be revised should improved data become available.

Table 16.2.2 and Figure 16.5.1 show the harvest rates for FU12. The harvest rate has fluctuated over the time-series and has been below the F_{MSY} proxy since 2013. The increase in 2016, compared to the 2013–2015 harvest rates, was due to relatively increased landings compared to abundance. The harvest rate more than halved in 2018 compared to 2017, and has continued to decrease through 2020 to a new historical low (3%; 2.8%/3.6%).

It is likely that prior to 2006, the harvest rates are underestimates due to under-reported landings.

13.6 Management strategies

Scotland has established a network of regional Inshore Fisheries Groups (rIFGs), non-statutory bodies that aim to improve the management of Scotland's inshore fisheries out to six nautical miles, and to give commercial inshore fishermen a strong voice in wider marine management developments. The rIFGs will contribute to regional policies and initiatives relating to management and conservation of inshore fisheries, including impacts on the marine environment and the maintenance of sustainable fishing communities and measures designed to better conserve and sustainably exploit stocks of shellfish and sea fish (including salmon) in their local waters. Although no IFG proposals specific to the management of *Nephrops* fisheries have yet been adopted, some of the IFG management plans for the Scottish West Coast include spatial management of *Nephrops* fisheries and the introduction of creel limits.

On the 8th of February 2016, phase 1 of the fisheries management measures for inshore MPAs in Scottish waters came into force (SG, 2016). These measures relate to both Nature Conservation MPAs (NCMPAs; Marine (Scotland) Act and the UK Marine and Coastal Access Act) and Special Areas of Conservation (SACs; EC Habitats Directives – Council Directive 92/43/EEC) both of which have the aim of conserving biological diversity in Scottish waters and contribute to Scotland's MPA network (SG, 2017a). Although not specific to the management of the *Nephrops* fishery, they will influence spatial patterns of fishing for *Nephrops* where controls on the two main gear types, demersal trawls and creels, are implemented on *Nephrops* habitat. There are seven protected areas within the South Minch functional unit with fisheries management measures. MPAs on the main areas of *Nephrops* habitat include the Loch Sunart to the Sound of Jura NCMPA where demersal trawling is banned in some areas, i.e. zoned, and seasonal closures implemented in others, Loch Sunart NCMPA/SAC, where demersal trawling is banned and creeling is zoned, the East of Mingulay SAC, demersal trawling banned and creeling zoned, and the Trenish Isles SAC, demersal trawling banned. Another area is the Loch Duich, Long and Alsh NCMPA/SAC, covering some patches of muddy sediment, where demersal trawling is banned or temporally closed in other areas that extend beyond the MPA onto muddy sediment. Other areas include the Loch Creran SAC/NCMPA, demersal trawling banned and creeling zoned, and the Firth of Lorn SAC, which has the same management as the Loch Sunart to the Sound of Jura NCMPA. For the Firth of Lorn and Loch Creran, management was in place prior to 2016 (SG, 2016). An additional NCMPA, at Loch Carron, was designated using emergence powers in 2017 (SG, 2017b). The areas of the SACs and NCMPAs relative to the estimated *Nephrops* habitat within the South Minch functional unit are displayed in Figure 16.6.1.

13.7 Quality of assessment and forecast

The length and sex composition of the landings data is considered to be adequately sampled, sampling levels have remained relatively consistent over the past two years (see Section 16.2), with the exception of quarter 2 of 2020 where sampling efforts were disrupted by the COVID-19 pandemic. Discard sampling has been conducted for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the trawl fishery adequately. The reduced sampling effort in 2020 meant that discard sample data were only available for Quarter one, and it was agreed at WGCSE that estimates of discard rates and size distributions for Quarters 2-4 of 2020 would be adequately approximated for the purpose of forecasting by averaging of discard samples across all Quarters from 2017-2019. The landings length compositions from 1999 onwards are derived from both creel and trawl samples. The creel fishery, which accounts for an increasing proportion of the landings in recent years (~27-29% in the past two years) and increasingly operates over similar areas to trawling, exhibits a length composition composed of larger animals.

There are concerns over the accuracy of historical landings and effort data prior to 2006 when Buyers and Sellers legislation was introduced and the reliability began to improve. Because of this, the final assessment adopted is independent of official statistics. Harvest rates since 2006 are also considered more reliable due to more accurate landings data reported under new legislation. Incorporation of creel length compositions has also improved estimates of harvest rates.

Underwater TV surveys have been conducted for this stock every year since 1995. The number of valid stations in the survey has remained relatively stable throughout the time period. The survey is targeted at known areas of mud, sandy mud and muddy sand within the South Minch.

The variance of density estimates in the South Minch is relatively high, particularly in the sandy mud strata, resulting in large confidence intervals and a greater uncertainty on the abundance estimates than in other FUs. This makes it difficult to determine which population changes are significant. Although the CV's have been smaller in recent years.

There is a need to explore options to implement further stratification for the South Minch survey area. In the provision of catch options based on the absolute survey estimates, additional uncertainties related to mean weight in the landings and the discard rates also arise. A three-year average (i.e. 2018–2020 for the 2021 assessment) of discard rates (adjusted to account for some survival of discarded animals) has been used in the calculation of catch options.

The cumulative relative to absolute conversion factor estimates for FU12 are largely based on expert opinion. The precision of these bias corrections cannot yet be characterised. The landings derived in the forecast (catch options table) are sensitive to the input dead discard rate and mean weights in landings, and this introduces uncertainties in the catch forecasts. Precision estimates are needed for these forecast inputs.

The overall area of the ground is estimated from the available BGS contoured sediment data and at present is considered to be a minimum estimate. Work is underway to improve the area estimation. VMS data linked to landings (from queries of the Scottish FIN database) suggest no major differences between areas fished and the mud sediment maps. Two other factors however, are likely to increase the estimate of ground area available for *Nephrops* and *Nephrops* directed fishing. Firstly, the inclusion of vessels smaller than 15 m would likely increase the fished area in some of the inshore locations and secondly, it is known that most of the sea lochs have areas of mud substrate and are typically fished by creel boats. In recent years, limited TV surveys have taken place in some of the sea lochs and attempts are being made to utilise these data to improve estimates of mud area and *Nephrops* abundance in the South Minch.

13.8 Recommendation for next benchmark

This stock was last benchmarked in 2009. WGCSE will keep the stock under close review and recommend future benchmark as required.

13.9 Management considerations

ICES and STECF have repeatedly advised that management should be at a smaller scale than the ICES division level. Management at the functional unit level could provide controls to ensure effort and catch were in line with resources available.

Creel fishing takes place in this area but overall effort in terms of creel numbers is not known and measures to control numbers are not in place. There is a need to ensure that the combined effort from all forms of fishing is taken into account when managing this stock.

There is a bycatch of other species in the area of the South Minch and estimated discards of whiting and haddock by the TR2 fleet are high in area 6.a generally. It is important that efforts continue to ensure that unwanted bycatch is kept to a minimum in this fishery.

13.10 References

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Table 16.2.1. *Nephrops*, South Minch (FU12), ICES estimates of landings of *Nephrops*, 1981–2019.

UK SCOTLAND						**OTHER UK**	**IRELAND**	**TOTAL**
YEAR	*NEPHROPS* TRAWL	OTHER	CREEL	BELOW MINIMUM SIZE	SUB TOTAL			
1981	2966	254	432	0	3652	0	0	3652
1982	2925	206	421	0	3552	0	0	3552
1983	2595	362	456	0	3413	0	0	3413
1984	3229	477	594	0	4300	0	0	4300
1985	3096	424	488	0	4008	0	0	4008
1986	2694	288	502	0	3484	0	0	3484
1987	2928	418	546	0	3892	0	0	3892
1988	3544	364	555	0	4463	10	0	4473
1989	3846	338	561	0	4745	0	0	4745
1990	3732	263	435	0	4430	0	0	4430
1991	3596	342	503	0	4441	1	0	4442
1992	3478	209	549	0	4236	1	0	4237
1993	3609	194	650	0	4453	5	0	4458
1994	3742	264	405	0	4411	3	0	4414
1995	3443	717	508	0	4668	14	0	4682
1996	3108	417	469	0	3994	1	0	3995
1997	3518	329	493	0	4340	3	1	4344
1998	2851	340	538	0	3729	0	1	3730
1999	3165	359	514	0	4038	0	14	4052
2000	2940	311	700	0	3951	0	2	3953
2001	2823	391	768	0	3982	0	9	3991
2002	2234	314	743	0	3291	0	14	3305
2003	2812	203	858	0	3873	0	6	3879
2004	2864	105	879	0	3848	0	21	3869
2005	2812	46	955	0	3813	1	34	3848
2006	3570	97	922	0	4589	9	35	4633
2007	4437	21	959	0	5417	19	35	5471

UK SCOTLAND						OTHER UK	IRELAND	TOTAL
YEAR	*NEPHROPS* TRAWL	OTHER	CREEL	BELOW MINIMUM SIZE	SUB TOTAL			
2008	4433	12	896	0	5341	2	13	5356
2009	3346	24	900	0	4270	4	11	4285
2010	2836	19	969	0	3824	16	6	3846
2011	2876	11	783	0	3670	23	9	3702
2012	3159	32	773	0	3964	19	6	3989
2013	2490	543	729	0	3762	13	1	3776
2014	2490	3	637	0	3130	32	17	3179
2015	2662	18	665	0	3345	22	33	3400
2016	3450	22	838	0	4310	33	59	4402
2017	2833	60	775	0	3668	23	66	3757
2018	1693	86	682	0	2461	45	34	2540
2019	1493	39	621	0	2153	29	38	2220
2020	1320	25	554	0	1899	8	69	1976

Table 16.2.2. ***Nephrops*****, South Minch (FU12): Adjusted TV survey abundance, landings, discard rate proportion by number) and estimated harvest rate.**

YEAR	LANDINGS NUMBER (MILLIONS)	DISCARDS NUMBER (MILLIONS)	REMOVALS NUMBER (MILLIONS)**	ADJUSTED SURVEY (MILLIONS)	HARVEST RATE*	LANDINGS (TONNES)	DISCARDS (TONNES)	DISCARD RATE (%)	DEAD DISCARD RATE (%)	MEAN WEIGHT IN LANDINGS (g)	MEAN WEIGHT IN DISCARDS (g)
1999	161	29	183	1086	16.9	4052	206	15.4	12	25.14	7
2000	145	33	170	1854	9.2	3953	284	18.7	14.7	27.3	8.5
2001	168	65	216	2037	10.6	3991	591	27.9	22.5	23.79	9.11
2002	123	26	143	1899	7.5	3305	247	17.6	13.8	26.83	9.37
2003	139	38	168	2157	7.8	3879	381	21.3	16.9	27.86	10.1
2004	141	44	175	2558	6.8	3869	454	23.8	19	27.37	10.26
2005	137	49	174	2208	7.9	3848	452	26.5	21.2	28.11	9.17
2006	177	30	199	1845	10.8	4633	324	14.3	11.1	26.24	10.97
2007	228	66	278	1016	27.3	5471	903	22.4	17.8	23.95	13.73
2008	224	74	279	1608	17.4	5356	605	24.7	19.8	23.91	8.23
2009	179	26	199	1542	12.9	4285	216	12.5	9.6	23.87	8.44
2010	149	12	158	2076	7.6	3846	133	7.7	5.9	25.86	10.76
2011	118	11	126	1945	6.5	3702	92	8.2	6.3	31.1	8.78
2012	133	16	145	919	15.8	3989	145	10.8	8.3	29.17	9.05
2013	136	4	140	1718	8.1	3776	50	3.1	2.4	27.48	11.31
2014	105	19	120	2073	5.8	3179	233	15.6	12.1	29.91	12.04
2015	120	10	128	1998	6.4	3400	121	7.7	5.9	28.15	12.04
2016	177	31	201	2118	9.5	4402	365	14.9	11.6	24.76	11.74
2017 ^	131	13	140	1384	10.1	3757	108	9.4	7	27.76	8.29
2018 ^	91	4	94	1946	4.8	2540	54	4.5	3.4	27.27	12.74
2019 ^	79	4	83	2362	3.5	2220	46	4.9	3.7	28.54	11.22
2020	54	5	57	1927	3	1976	46	7.8	6	36.58	9.95
Average***									4.7	26.87	10.14

*** Harvest rates previous to 2006 are unreliable.**

**** Removals numbers take the dead discard rate into account.**

***** Dead discard average: 2018–2020; Mean weight in landings and discards average: 1999–2020.**

^ Values updated in 2021 due to minor revisions in landings data.

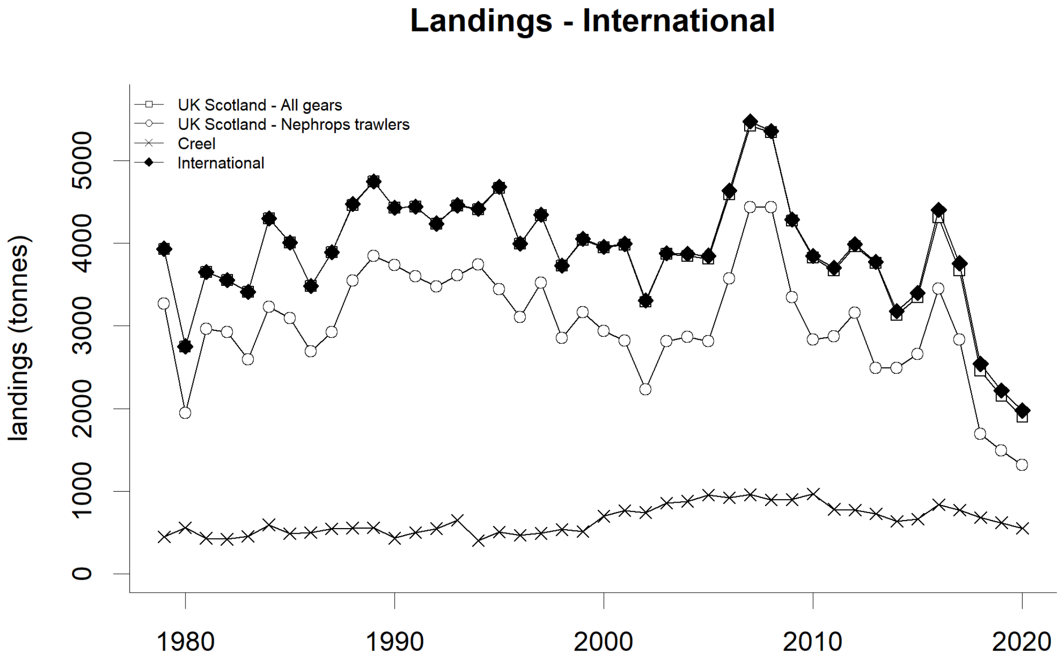
Table 16.2.3. ***Nephrops*****, South Minch (FU12): Results of the 1995–2021 TV surveys (adjusted for bias).**

YEAR	NUMBER OF VALID STATIONS	MEAN DENSITY (BURROWS/m²)	ABUNDANCE (MILLIONS)	95% CONFIDENCE INTERVAL (MILLIONS)
1995	33	0.227	1152	251
1996	21	0.288	1473	530
1997	36	0.212	1086	185
1998	38	0.288	1452	232
1999	37	0.212	1086	260
2000	41	0.364	1854	348
2001	47	0.402	2037	459
2002	31	0.371	1899	567
2003	25	0.424	2157	756
2004	38	0.508	2558	473
2005	33	0.432	2208	740
2006	36	0.364	1845	598
2007	39	0.197	1016	155
2008	33	0.318	1608	415
2009	25	0.303	1542	634
2010	34	0.409	2076	665
2011	36	0.383	1945	778
2012	38	0.182	919	185
2013	38	0.339	1718	365
2014	36	0.409	2073	530
2015	35	0.394	1998	514
2016	37	0.417	2118	440
2017	41	0.273	1384	282
2018	39	0.383	1946	371
2019	40	0.466	2362	578
2020	40	0.38	1927	517

YEAR	NUMBER OF VALID STATIONS	MEAN DENSITY (BURROWS/m²)	ABUNDANCE (MILLIONS)	95% CONFIDENCE INTERVAL (MILLIONS)
2021	41	0.251	1272	339

Table 16.2.4. ***Nephrops*** **South Minch (FU12). Results by stratum of the 2018–2020 TV surveys. Note that stratification was based on a series of sediment strata (M – Mud, SM – Sandy mud, MS – Muddy sand).**

STRATUM	AREA (km^2)	NUMBER OF STATIONS	MEAN BURROW DENSITY (no./m^2)	OBSERVED VARIANCE	ABUNDANCE (MILLIONS)	STRATUM VARIANCE	PROPORTION OF TOTAL VARIANCE	SURVEY PRECISION LEVEL (CV)
2019 TV Suvey								
M	303	2	0.466	0.001	141.2	65	0.001	
SM	2741	20	0.494	0.162	1352.7	61024	0.73	
MS	2028	18	0.428	0.099	867.9	22546	0.27	
Total	5071	40			2361.7	83635		0.121
2020 TV Suvey								
M	303	2	0.193	0.008	58.6	381	0.006	
SM	2741	20	0.474	0.148	1299.7	55679	0.834	
MS	2028	18	0.281	0.047	569.2	10685	0.16	
Total	5071	40			1927.4	66745		0.131
2021 TV Suvey								
M	303	3	0.402	0.084	121.7	2564	0.089	
SM	2741	17	0.261	0.046	716.9	20574	0.716	
MS	2028	21	0.214	0.029	433	5580	0.194	
Total	5071	41			1271.6	28719	0.999	0.126



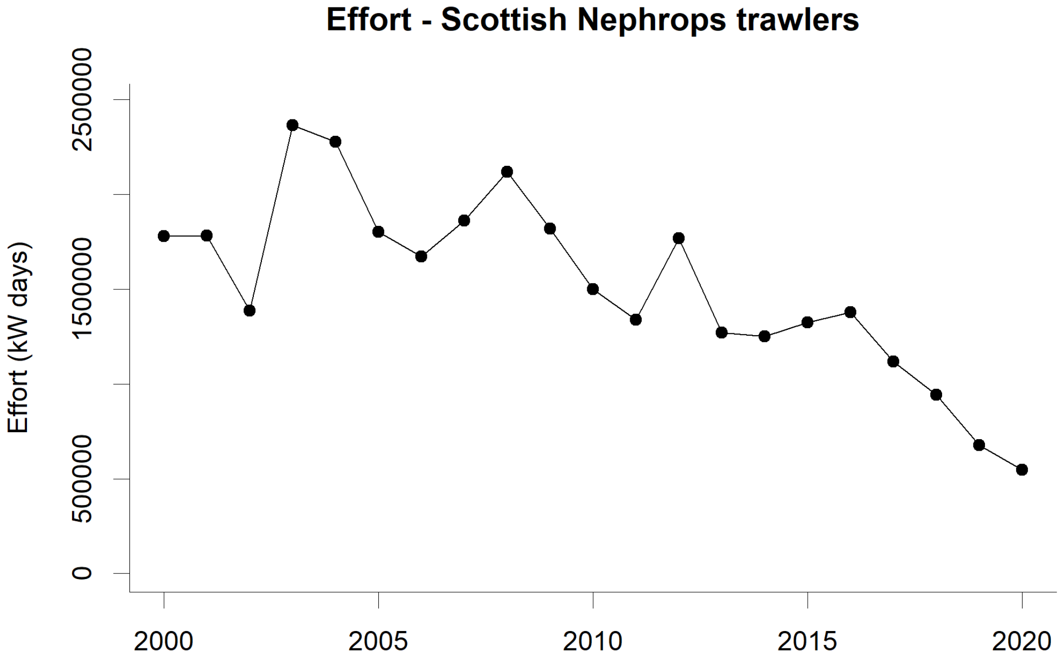


Figure 16.2.1. ***Nephrops*****, South Minch (FU12). Long-term landings and effort.**

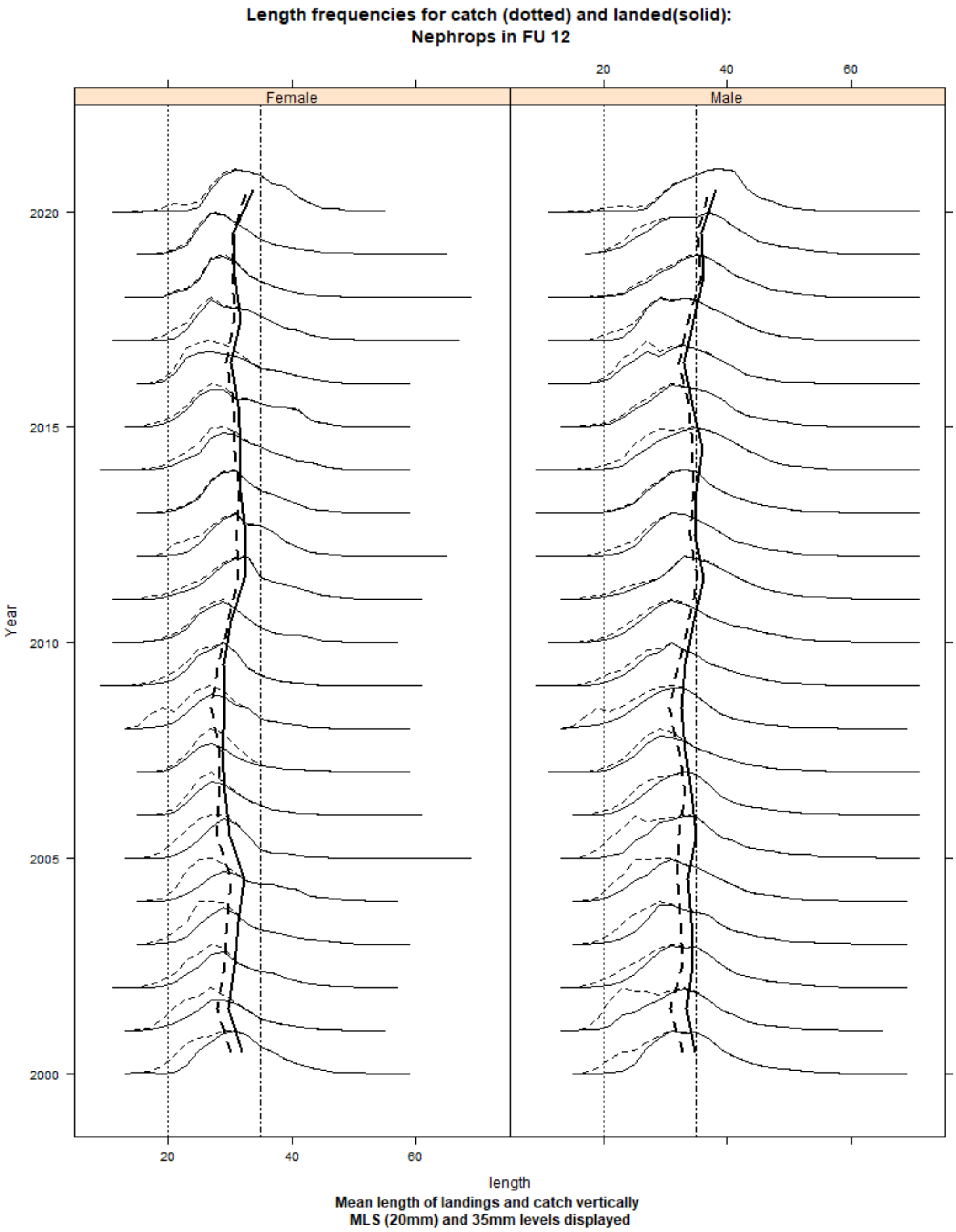
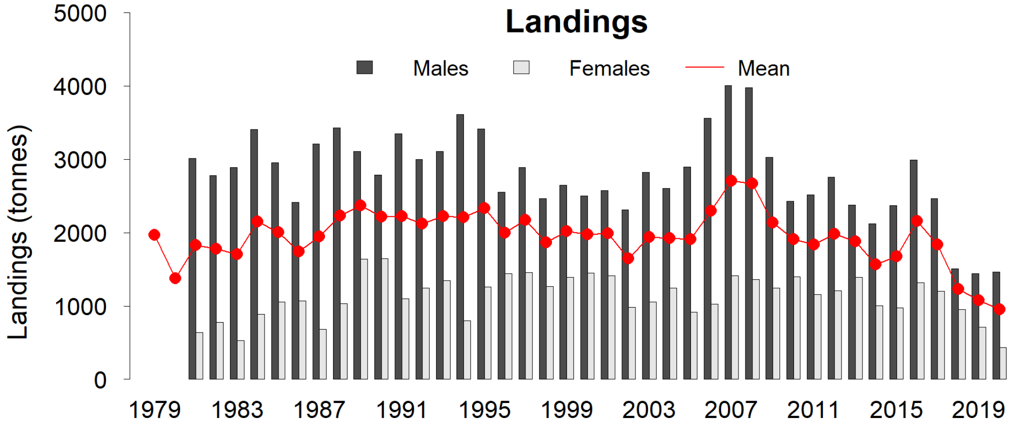


Figure 16.2.2. ***Nephrops*****. South Minch (FU12). Catch length–frequency distribution and mean size in catches (dotted) and landings (solid) for** ***Nephrops*** **in the North Minch, 2000–2020. Vertical lines are minimum conservation reference size (20 mm) and 35 mm.**



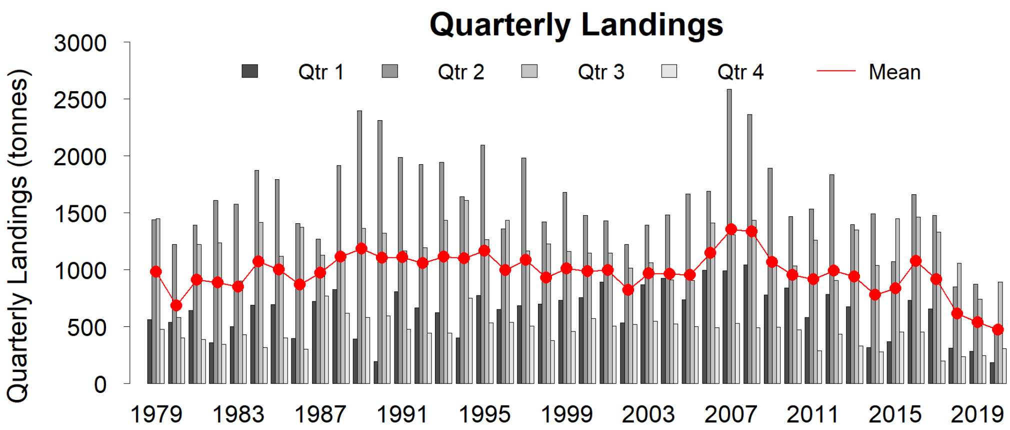


Figure 16.2.3. (a) ***Nephrops,*** **South Minch (FU12). Landings by sex and quarter from Scottish trawlers.**

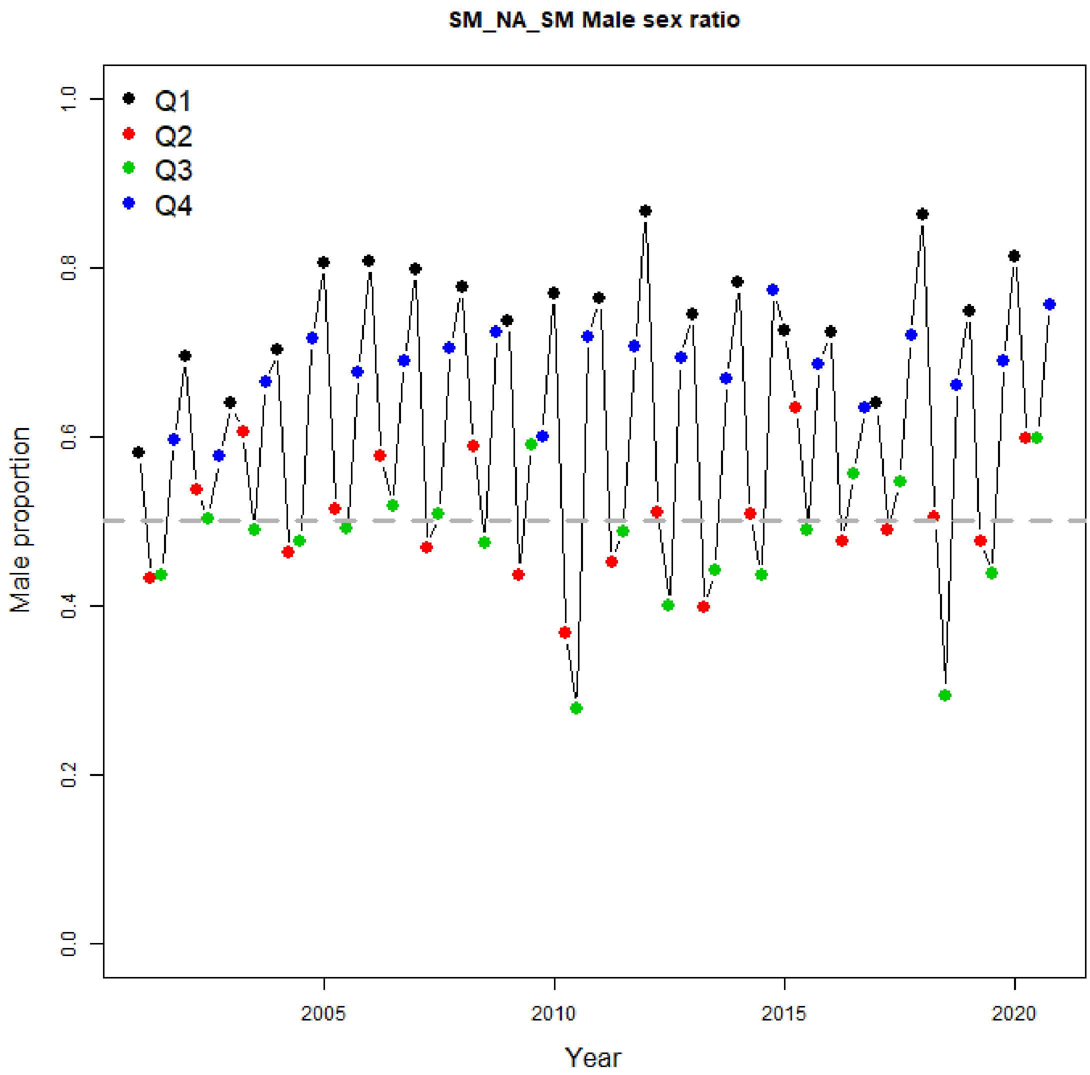


Figure 16.2.3 (b) ***Nephrops,*** **South Minch (FU12), Proportion of males by quarter (2000–2020).**

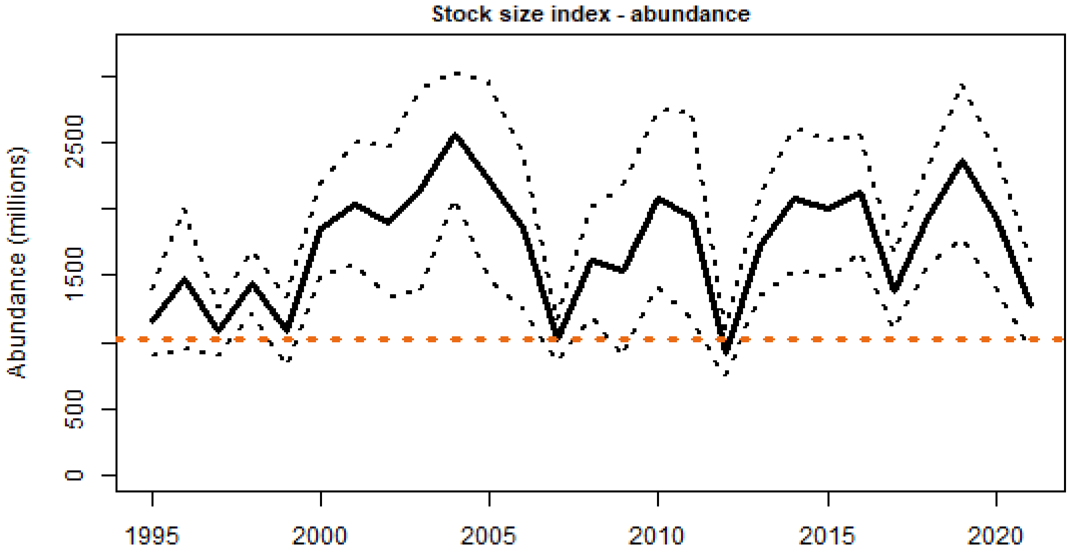


Figure 16.2.4. ***Nephrops*, South Minch (FU12), Time-series of TV survey abundance estimate (adjusted for bias, solid black line), with 95% confidence intervals (dashed black lines), 1995–2020. The dashed red line is the rounded $B_{trigger}$ value of 1020 million individuals.**

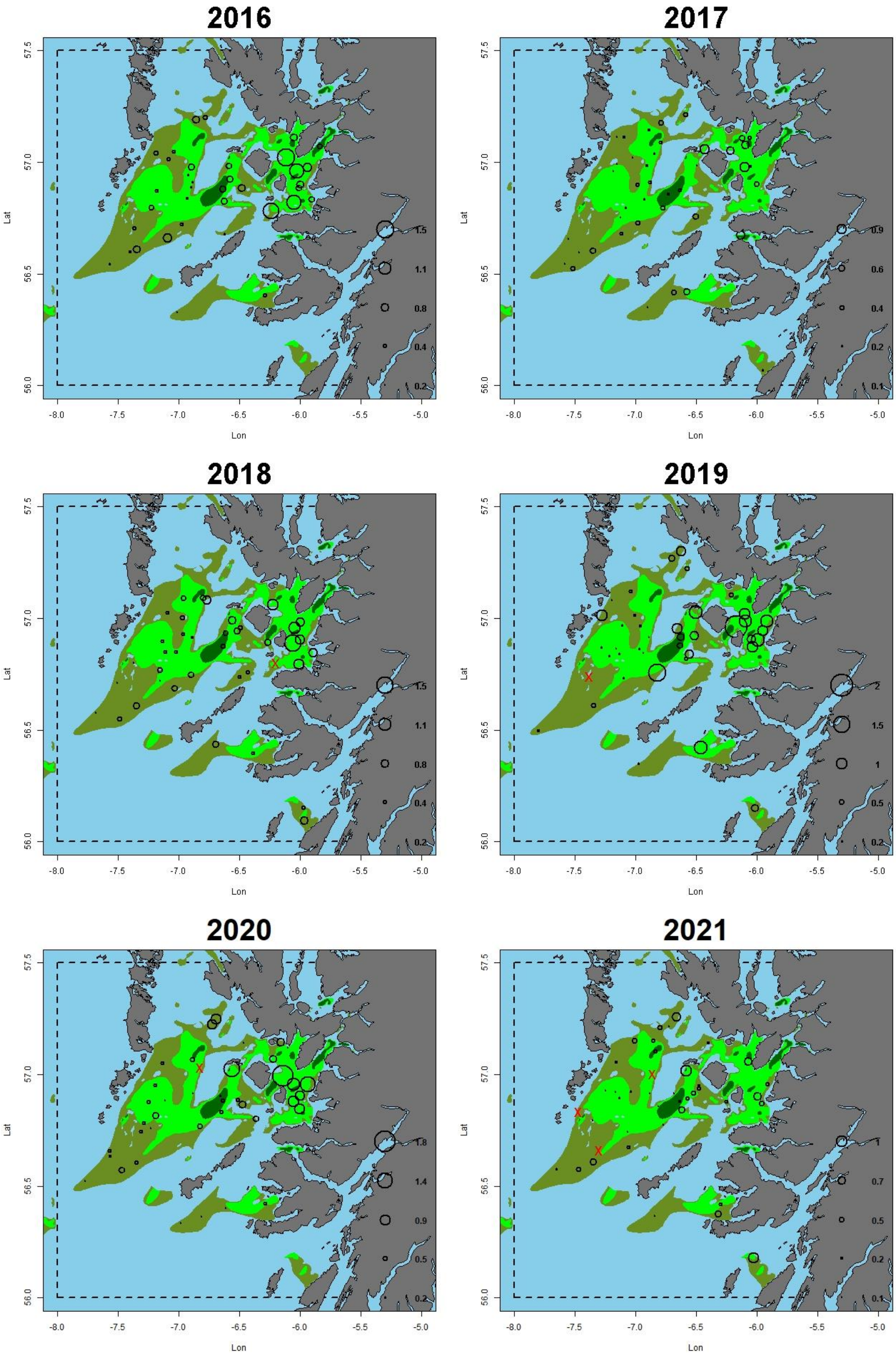


Figure 16.2.5. ***Nephrops*, South Minch (FU12), TV survey station distribution and relative density (burrows/m²), 2016–2021. Shaded green and brown areas represent areas of suitable sediment for *Nephrops*. Bubbles in this figure are all scaled the same. Red crosses represent zero observations.**

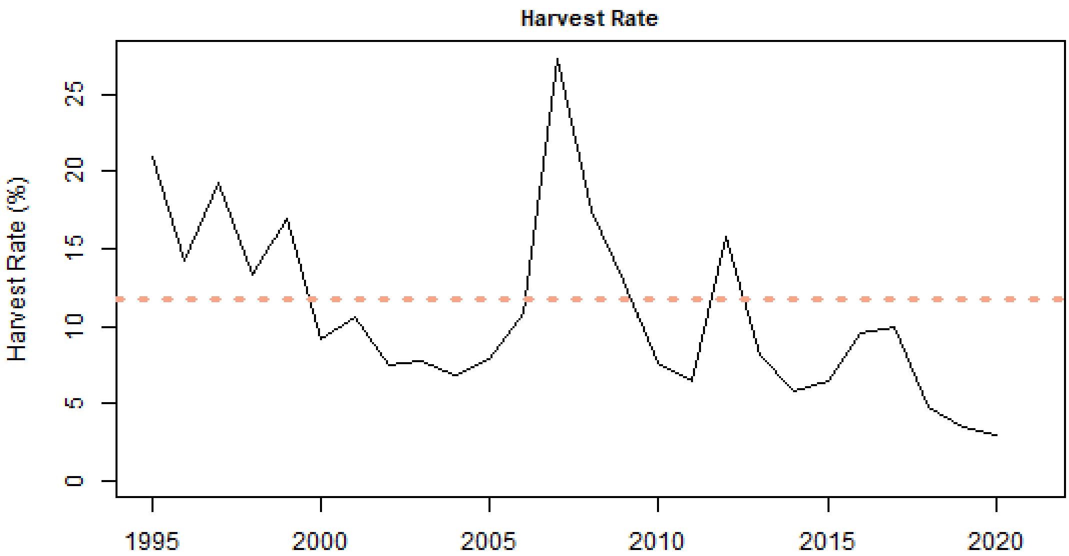


Figure 16.5.1. ***Nephrops*, South Minch (FU12), harvest rate, 1995–2020. The dashed and solid lines are the F_{MSY} proxy harvest rate (11.7%) and the harvest rate respectively. Harvest rates prior to 2006 are unreliable.**

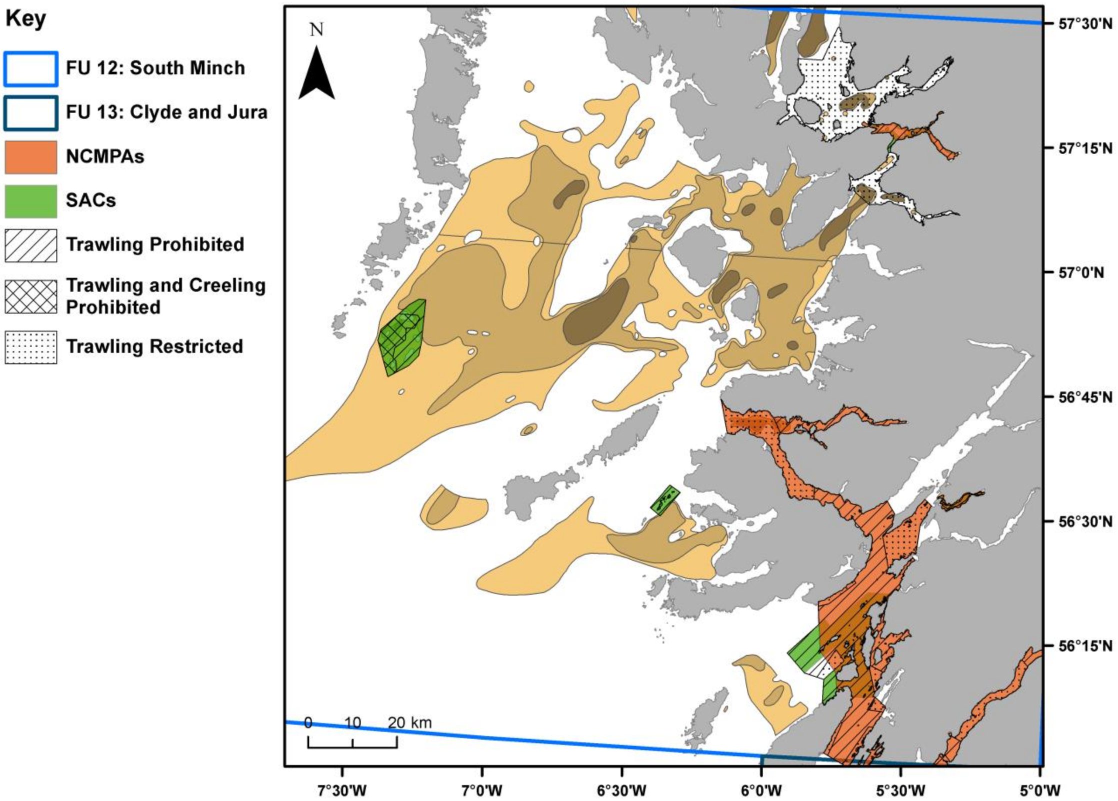


Figure 16.6.1. The area of *Nephrops* habitat (Mud, Muddy Sand and Sandy Mud) within the South Minch (FU12) relative to the areas of the Nature Conservation MPAs (NCMPAs) and Special Area of Conservations (SACs) with fisheries management measures. Areas where demersal trawling is prohibited, restricted (i.e. vessel size restrictions or seasonal closures) and where creeling is prohibited are displayed. For more detailed information see SG (2016). Geographic Coordinate System: OSGB 1936, Datum: OSGB 1936, Projected Coordinate System: British National Grid. Coastline by Wessel and Smith (2016), MPA sites subsetted from NCMPA (SNH, 2015) and SAC (SNH, 2016) layers, management areas from SG (2017c) and functional units generated from merged ICES rectangles (ICES, 2017b). Map and modified layers created using ArcGIS (ESRI, 2014).

14 Norway lobster (*Nephrops norvegicus*) in Division 6.a, Functional Unit 13 (West of Scotland, the Firth of Clyde and Sound of Jura)

Type of assessment in 2021

The assessment and provision of advice through the use of the UWTV survey data and other commercial fishery data follows the process defined by the benchmark WG (WKNEPH, 2009; WKNEPH, 2013). Full details are provided in the stock annex.

ICES advice applicable to 2020

'ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 3924 tonnes and 5861 tonnes (3428–5227 tonnes for the Firth of Clyde and 496–634 tonnes for the Sound of Jura). The entire range is considered precautionary when applying the ICES advice rule.

To ensure that Nephrops stocks are exploited sustainably, management of Nephrops should be implemented at the functional unit level. In this particular functional unit (FU), additional measures should be implemented to ensure that landings taken in each subarea (the Firth of Clyde and the Sound of Jura) are in line with the advice.'

ICES advice applicable to 2021

'ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 3638 tonnes and 5425 tonnes (3142–4791 tonnes for the Firth of Clyde and 496–634 tonnes for the Sound of Jura), assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that Nephrops stocks are exploited sustainably, management of Nephrops should be implemented at the functional unit level. In this particular functional unit (FU), additional measures should be implemented to ensure that landings taken in each subarea (the Firth of Clyde and the Sound of Jura) are in line with the advice.'

14.1 General

Stock description

The Clyde functional unit (FU13) is located in the southern waters off the west coast of Scotland (FU11 report, Section 12, Figure 15.1). It is comprised of two distinct patches in the Firth of Clyde and the Sound of Jura, to the east and west of the Mull of Kintyre respectively. The hydrography of the two subareas differs, with the Sound of Jura characterised by stronger tidal currents and the Firth of Clyde exhibiting features of a lower energy environment with a shallow entrance sill. Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Within the two distinct patches, these substrates are distributed according to prevailing hydrographic and bathymetric conditions. The available area of suitable sediment is smaller in the Sound of Jura, occupying only the deepest parts of the Sound, while in the Firth of Clyde these sediments predominate. Further details are provided in the stock annex.

Management applicable to 2020 and 2021

Management is at the ICES Subarea level as described at the beginning of Section 12 (FU11 North Minch report).

Ecosystem aspects

Details of the ecosystem aspects for this functional unit are provided in the stock annex where available.

Fishery description

Information on developments in the fishery was provided by Marine Scotland fishery compliance officers.

There are 30 vessels including 8 20 m trawlers and a small number of creelers fishing out of Ayr. All trawlers use 80 mm single or twin rigs with square mesh panels (SMP) of at least 120 mm, in accordance with west coast emergency measures conditions (Council Reg. (EU) 43/2009). Under the Scottish Conservation Credits scheme, vessels with power >112 kW are required to use a 200 mm SMP.

The activity of Northern Irish vessels was not perceived to be high since 2017, when compared to previous years. Many vessels have moved to other areas where there was better fishing, some travelling as far away as Eyemouth, and vessels fishing in FU13 did not land locally instead going back to their home port because of better fuel and market prices.

Mobile gear is banned in the Inshore Clyde from Friday night to Sunday night as are vessels greater than 21 m in length. Most creel boats operating in the Clyde have two crew members and operate around 1000 creels. Creeling activity now takes place quite widely in the northern parts of the Firth operating on some of the same grounds but often taking place during the weekend trawling ban.

In terms of the influence of Marine Protected Area (MPA) management measures on the fishery it was stated that the South Arran Nature Conservation MPA (NCMPA) removed a large sea area for *Nephrops* trawlers to operate over. Trawlers which would have operated in this area were displaced to areas where they would not have targeted previously, or where they would have only operated in poor weather conditions. However, it also allowed creelers to move into the areas were trawling was banned. There have been recent reports of increases in creel numbers in this area and this has resulted in gear conflict within the creel sector. The small area of the Upper Loch Fyne NCMPA closed to trawlers was reported to have had little affect. Further general information on the fishery can be found in the stock annex.

14.2 Data available

InterCatch

Data for 2020 were successfully uploaded into InterCatch prior to the 2021 WG meeting. In addition to uploading the 2020 catch data, total weight of landings data for 2017-2019 were updated following a review of Marine Scotland Science data holdings. 2019 data were updated in InterCatch, and length distribution samples were re-raised according to the usual procedure. 2017 and 2018 data were updated in MSS stock objects, with changes of 3.5% and 0.04% to the respective landing weight values, and changes of <3% to harvest rates. Uploaded data were worked up in InterCatch to generate 2020 raised international landings length–frequency distributions. Data exploration in InterCatch has previously shown that outputs of raised data were very close to those generated by the previous method applied internally with differences being <0.1%. As such, InterCatch length–frequency outputs have been used in the stock assessment since 2012.

The COVID-19 pandemic resulted in a reduced sampling effort of commercial catches for FU13 in 2020. There were no discards samples collected for FU13 in 2020, thus alternate methods of estimating discards were explored. It was agreed at WGCSE that estimates of discard rates and size distributions for 2020 would be based on an averaging of discard samples across all quarters from 2017-2019. Minimum and maximum discard rates over the same period were also examined to gain an appreciation of the plausible range of discarding that might occur. Assessment estimates affected by changes in discard rates are annotated below to reflect this; i.e. x (y/z), where x is the estimate based on the average discard rate 2017-2019, y is based on minimum discard rate, and z on maximum discard rate.

Commercial catch

Official catch statistics (landings) reported to ICES are shown in Table 15.1.1 (see FU11 North Minch report, Section 12). These relate to the whole of area 6.a of which the FU13 is a part. Landings statistics for FU13 provided through national laboratories are presented in Table 17.1.1, broken down by country and by gear type. Landings from this fishery are predominantly reported from Scotland, although Northern Ireland contributed 528 tonnes in 2020. Total reported Scottish landings in 2020 were 3104 tonnes (plus 532 tonnes from other UK vessels i.e. Northern Ireland and England), consisting of 2869 tonnes landed by trawlers (92.4%) and 225 tonnes (7.2%) landed by Scottish creel vessels. Scottish creel landings have generally increased in the most recent years, from approximately 3% in 2012 to just over 6% of total landings in 2020.

Statistical rectangle 40E4 covers parts of both the Firth of Clyde and the Sound of Jura. Table 17.2.1 shows the split in landings between the two subareas comprising FU13. Historically the allocation of landings to the two components of FU13 was carried out by the fishery office and required them to have detailed knowledge of where vessels have been fishing within 40E4. The apparent sudden decline in landings from the Sound of Jura in 2001 is not considered to be associated with a sudden change in fishing practices and is thought more likely to be due to changes in fishery office recording practices. For this reason, the landings split is considered unreliable in recent years and the commercial landings data are now presented for the combined Firth of Clyde and Sound of Jura. Given the relative magnitudes of the fisheries (Clyde likely to be much bigger), the commercial data are likely to be more representative of the Clyde.

Effort data

In 2015, WGCSE agreed that effort should be reported in kW days, as this is likely to be more informative about changes in the actual fleet effort. Effort shows an overall decreasing trend but was stable through 2010 to 2012 (Figure 17.2.1). Effort increased in 2016 in comparison to 2015, but has been on a generally decreasing trend since then. Note that the effort time-series range (2000–2020) does not match with the more extensive year range available for landings due to a lack of reliable effort data in the Marine Scotland Science in-house database. The effort is also slightly inconsistent with the landings data in that effort is provided for TR2 vessels while the '*Nephrops* trawl' landings additionally includes landings by large mesh trawlers targeting *Nephrops*.

Sampling levels

Length compositions of landings and discards are obtained during market and on-board observer sampling respectively. These sampling levels are shown in Table 15.2.2 (see FU11 North Minch report, Section 12). Sampling effort decreased in 2020 compared to 2019, mainly due to the COVID-19 pandemic (see "InterCatch", above).

Sampling of landings length compositions in the Sound of Jura is more infrequent but samples have been included in the FU13 raising procedure when available. Length compositions for the creel fishery are available for landings only. This is because survival in the animals that are discarded (although little quantitative information exists) is assumed to be high (ICES, 2013). Therefore these animals are not considered to be removed from the population and a value of 100% survival is used in the assessment (ICES, 2013).

Length compositions

Although assessments based on detailed catch analysis are not currently carried out, examination of length compositions can provide a preliminary indication of exploitation effects. Figure 17.2.2 shows a series of annual Clyde length–frequency distributions for the period 2000 to 2020. Catch (removals) length compositions are shown for each sex along with the mean size for both. The mean sizes of both sexes have fluctuated around relatively small ranges since 2015. The mean size of females in the catch has remained relatively stable over the past three to four years, whereas the mean size of males has shown an increase. This change has most likely been effected by the increased proportion of the creel landings component in the catch.

Sex ratio

Sex ratio in the Clyde shows some variation but males generally make the largest contribution to the annual landings (Figure 17.2.3(a)). This occurs because males are available throughout the year and the fishery takes place in all quarters, although effort is generally reduced during winter because of poor weather. Females on the other hand are mainly taken in summer when they emerge after egg hatching. The seasonal change in proportion of males to females is evident in Figure 17.2.3(b) where males typically dominate in quarters one and four but the ratio is generally more even in quarters two and three. In 2016, males dominated in all quarters, but this was within the normal range of variation which is seen for this stock over the time-series. The pattern was again fairly typical between 2017 and 2019, but in 2020 all quarterly sex ratios were majority male (Figure 17.2.3) due to the decreased number of samples which were available for the year. This metric is used as an indicator, whereby increasing proportions of females in the catch might signal an effect of acute overfishing. In this case, however, the atypical sex ratios observed in 2020 are is due to poor sampling, and not a cause for concern to management.

Mean weights

The mean weights in the landings have fluctuated in this FU over the time-series. The decreasing trend in mean weight which began in 2015 was followed by an increase in 2019 and 2020. Mean weight for FU13 is generally lower than other areas over the time-series (Table 15.2.3). There is a trend of increasing mean weights in the samples of landings for creel catches, noticeable for both sexes, but particularly for males in the early years of the time-series. However, this has declined in recent years, although sampling levels are low, particularly in the early and most recent years of the time-series. Given the seasonal variation present in other FUs it is not possible to state with any certainty that this trend is real (Figures 15.2.4 and 15.2.5; see FU11 North Minch report, Section 12).

Discarding

Discarding of undersized and unwanted *Nephrops* occurs in the Clyde fishery, and discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Discard rates have been high in this FU and have averaged around 25% by number in this FU since 1999. Since 2010, discard rates have been estimated to be substantially lower than the long term average and in 2018, were at the lowest rate in the time-series at only 2.5% (Table 17.2.2). The discard rate in FU13 increased substantially in 2019 to 19.1%. Due to an absence of discard sampling in 2020, a discard rate of 10.7% was calculated based on a mean rate across all quarters 2017-2019, and allocated to all quarters in 2020. Minimum and maximum discard rates of 8.5% and 12.5%, respectively, were recorded over the same period. The discard rate (adjusted to account for survival) which will be used in the forecast was estimated by taking a three-year average 2018–2020, amounting to 8.3% (6.5%/9.7%).

Studies (Charuau *et al*., 1982; Sangster *et al*., 1997; Wileman *et al*., 1999) suggest that some *Nephrops* survive the discarding process. An estimate of 25% survival is assumed for this FU in order to calculate removals (landings + dead discards) from the population. The discard survival rate for creel caught *Nephrops* has been shown to be high (ICES, 2013) and a value of 100% is used.

Abundance indices from UWTV surveys

An underwater TV survey of the stock is conducted annually according to standards set out by the Manual for the Nephrops Underwater TV Surveys (Dobby H., et al., 2021). Surveys have been carried out in both subareas since 1995 although the Sound of Jura has been surveyed more infrequently. Underwater television surveys of *Nephrops* burrow distributions avoid the problems associated with traditional trawl surveys that arise from variability of burrow emergence of *Nephrops*. TV surveys are targeted at known areas of mud, sandy mud and muddy sand in which *Nephrops* construct burrows. Full details of the UWTV approach can be found in the stock annex and the report of WKNEPH in 2009 (ICES, 2009). On average, 37 stations have been considered valid each year for the Firth of Clyde and 11 for the Sound of Jura. These are then raised to the estimated ground area available for *Nephrops*; in total 2080 km^2 based on contoured superficial sediment information (British Geological Surveys).

In 2021, 41 valid stations were used in the final survey analysis for the Firth of Clyde (Table 17.2.3) and 12 stations for the Sound of Jura (Table 17.2.4). Table 17.2.5 shows a detailed breakdown of information from the most recent TV surveys conducted in the Firth of Clyde. This includes estimates of abundance and variability of each of the strata adopted in the stratified random approach. Details for the Sound of Jura are shown in Table 17.2.6. A CV (relative standard error) of <20% is considered an acceptable precision level for UWTV survey estimates of abundance (SGNEPS, ICES, 2012). CVs for the three most recent TV surveys in Firth of Clyde and Sound of Jura are lower than the precision level agreed.

Figure 17.2.4 shows the distribution of stations in recent TV surveys (2016–2021) across FU13 (the two distinct subareas can be clearly seen) with the size of the symbols proportional to the *Nephrops* burrow density. Table 17.2.3 and Figure 17.2.5 show the time-series estimated abundance for the TV surveys in the Firth of Clyde, with 95% confidence intervals on annual estimates. Similar information for the Sound of Jura is shown in Table 17.2.4 and Figure 17.2.6. Most surveys have detected generally higher densities in the southern part of the Clyde.

The TV survey estimates of abundance for *Nephrops* in the Firth of Clyde suggest that the population increased until the mid-2000s implying a sustained period of increased recruitment. Following this, abundance has fluctuated around the values previously observed in the early 2000s. In 2021, the abundance decreased slightly but was well within recently observed ranges (Figure 17.2.5).

There is not a continuous time-series of abundance in the Sound of Jura and in some years (particularly 2002 and 2006) estimates are associated with large confidence intervals. Abundance has fluctuated with no obvious trend. In 2013, the abundance was at the second lowest point in the time-series. The abundance appears to have been relatively stable since 2017 (Figure 17.2.6).

The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES, 2009; ICES, 2013). A number of potential biases were highlighted including those due to edge effects, species burrow misidentification and burrow occupancy. The cumulative relative to absolute conversion factor estimated for FU13 was 1.19 meaning that the TV survey is likely to overestimate *Nephrops* abundance by 19%.

14.3 Assessment

Comparison with previous assessments

The assessment in 2021 is based on a combination of examining trends in fishery indicators and underwater TV, using an extensive dataseries for the Firth of Clyde component of FU13 and a more limited time-series of UWTV data from the Sound of Jura subarea. The assessment in 2021 follows that of previous years (since 2015) in that the commercial data for Clyde and Sound of Jura have been combined, because of concerns regarding the accuracy of the landings data. There are also no discard samples and limited market samples available for the Sound of Jura. Therefore, the harvest rate and catches for the two areas are presented as a combined total. *Nephrops* abundance will continue to be monitored separately, with a TV survey being conducted in both subareas where logistically possible.

State of the stock

The underwater TV surveys are presented as the best available information on the stocks of *Nephrops* in the two subareas of FU13. The surveys provide fishery-independent estimates of *Nephrops* abundance. At present, it is not possible to extract any length or age-structure information from the survey and it therefore only provides information on abundance over the area of the survey.

TV survey estimated stock abundance for the Firth of Clyde in 2021 was 1414 million individuals, a 27.1% decrease from the 2020 estimate but still well above the $B_{trigger}$ value of 580 million. The abundance estimate for the Sound of Jura in 2021 was 310 million individuals, a 2.5% decrease from the 2019 estimate, again above the $B_{trigger}$ value of 160 million.

A harvest rate could not be directly calculated for the whole FU in 2020 due to the lack of an abundance estimate for Sound of Jura, and so an interpolated value for 2020 Sound of Jura abundance (average of 2019 and 2021) was used. The resulting harvest rate for the FU13 in 2020 (dead removals for both subareas/Firth of Clyde and Sound of Jura TV abundance = 9.4%) was below the F_{MSY} proxy value (the value associated with high long-term yield and low risk depletion) for the Clyde (15.1%), and the Sound of Jura (12.0%). Note the F_{MSY} proxy values for this stock were revised in October 2015 at WKMSYRef4 (ICES, 2016b).

14.4 Catch option table

Landings predictions and catch options at various harvest rates (based on principles established at WKNEPH (ICES, 2009)), will be made for Firth of Clyde and Sound of Jura on the basis of the 2021 UWTV survey conducted in June. These will be presented in October 2021 for the provision of advice.

Catch scenario table inputs and historical estimates of mean weight in landings and harvest rates are presented in Table 17.2.2 and summarised below. The calculation of catch options for the Firth of Clyde follows the procedure outlined in the stock annex.

The table below shows the agreed inputs to the catch scenarios table for FU13.

Input	Data	2021 assessment
Survey abundance (millions)	UWTV 2021	1414 Clyde; 310 SoJ
Mean weight in projected landings (g)	2018–2020	17.45
Mean weight in projected discards (g)	2018–2020	8.06
Projected discards	Average 2018–2020 (proportion by number; combined for Firth of Clyde and Sound of Jura)	10.8%
Discards survival	Proportion by number (assumed)	25%
Dead projected discards	2018–2020	8.3%*

*Based on mean discard rate (2017-2019) allocated to all Quarters of 2020; estimates of 9.7% and 6.5% were derived based on the maximum and minimum observed discard rates, respectively, for the same period

14.5 Reference points

F_{MSY} proxy for this stock was revised in October 2015 at WKMSYRef4 (ICES, 2016a; ICES, 2016b). These were updated on the basis of an average of estimated F_{MSY} proxy harvest rates over a period of years, which corresponds more closely to the methodology for finfish. In cases where there is a clear trend in the values a five-year average was chosen. Similarly, the five-year average of the F at 95% of the YPR obtained at the F_{MSY} proxy reference point was proposed as the F_{MSY} lower bound and the five year average of the F above F_{MAX} that leads to YPR of 95% of the maximum as the upper bound. Using an average value also has the advantage of reducing the effect of any unusually high or low estimates of the F_{MSY} proxy, which occasionally appear. For this functional unit the F_{MSY} proxy has been revised to 15.1% for the Clyde and 12.0% for the Sound of Jura respectively.

For *Nephrops* stocks, MSY $B_{trigger}$ has been defined as the lowest stock size from which the abundance has increased and is calculated as 579 million individuals for the Firth of Clyde. The advice from WKMSYRef4 (ICES, 2016b) rounded this value to give an MSY $B_{trigger}$ of 580 million.

MSY $B_{trigger}$ was not previously proposed for FU13 (SJ) as there were few points in the survey series (due to missing years). WKMSYRef4 stated that the survey series is now considered to be of sufficient length to allow the B_{loss} (abundance in 1995) to be proposed as the MSY $B_{trigger}$. This results in a value of 160 million (ICES, 2016b). Full details are contained in the stock annex.

These should remain under review by WGCSE and may be revised should improved data become available.

Table 17.2.2 and Figure 17.4.1 show the estimated harvest rates over this period. The harvest rate was calculated from the total dead removals for both subareas divided by the combined abundance for the Firth of Clyde TV survey and the Sound of Jura. This does result in some years were the harvest rate is not calculable as we do not have a full time-series of TV surveys for the Sound of Jura. The combined harvest rate peaked in 2007 at 43.0% before declining to around the F_{MSY} level for the Clyde in 2010–2011. The harvest rate has fluctuated since then and increased in

2019 to 14.2% from 11.1% in 2018 (both below F_{MSY}). It is unlikely that prior to 2006, the estimated harvest rates are representative of actual harvest rates due to underreporting of landings.

14.6 Management strategies

Scotland has recently established a network of regional Inshore Fisheries Groups (rIFGs), non-statutory bodies that aim to improve the management of Scotland's inshore fisheries out to six nautical miles, and to give commercial inshore fishers a strong voice in wider marine management developments. The rIFGs will contribute to regional policies and initiatives relating to management and conservation of inshore fisheries, including impacts on the marine environment and the maintenance of sustainable fishing communities and measures designed to better conserve and sustainably exploit stocks of shellfish and sea fish (including salmon) in their local waters. Although no IFG proposals specific to the management of *Nephrops* fisheries have yet been adopted, some of the IFG management plans for the Scottish West Coast include spatial management of *Nephrops* fisheries and the introduction of creel limits.

A weekend ban on mobile gear was introduced in the Clyde in 1986 under a Scottish Statutory Instrument. Mobile gear is banned in the Inshore Clyde from Friday night to Sunday night, as are vessels greater than 21 m in length.

On the 8th of February 2016, phase 1 of the fisheries management measures for inshore MPAs in Scottish waters came into force (SG, 2016). These measures relate to both NCMPA (Marine (Scotland) Act and the UK Marine and Coastal Access Act) and Special Areas of Conservation (EC Habitats Directives – Council Directive 92/43/EEC) both of which have the aim of conserving biological diversity in Scottish waters and along with other protected sites make up Scotland's MPA network (SG, 2017a). Although not specific to the management of the *Nephrops* fishery they will influence spatial patterns of fishing for *Nephrops* where controls on the two main gear types, demersal trawls and creels, are implemented on *Nephrops* habitat. There are three NCMPAs within the Clyde functional unit. The MPA, which extends onto the main patch of *Nephrops* habitat, is the South Arran NCMPA, within the Firth of Clyde subarea, where a complete ban on demersal vessels greater than 120 gross tonnage has been implemented. Partial closures (i.e. zoned management) for demersal trawlers smaller than this size and creelers are also in place. For Loch Sween, north of the main habitat area in the Sound of Jura subarea, demersal trawling by vessels is banned. However, for trawlers smaller than 75 gross tonnage, temporal closures are in place over some of the area. For the Upper Loch Fyne and Loch Goil NCMPA, just north of the main habitat area in Firth of Clyde subarea, demersal trawling by vessels greater than 75 gross tones is banned and the activity of vessels below this is zoned. Creeling activity is also zoned (SG, 2016). The areas of the NCMPAs relative to the estimated *Nephrops* habitat within the Clyde functional unit are presented in Figure 17.6.1.

14.7 Quality of assessment and forecast

There are concerns over the accuracy of historical landings and effort data and because of this the final assessment adopted is independent of official statistics. Harvest rates since 2006 are also considered more reliable due to more accurate landings data reported under new legislation.

One of the main issues for this FU is the problem of not being able to split the landings between the Sound of Jura and Firth of Clyde. This means that we are unable to provide harvest rates for the two subareas separately. What is currently provided is not actually a harvest rate for either subarea; but is likely more representative of the Firth of Clyde. This has an impact on the quality of the assessment but not on the forecast.

In recent years, the length and sex composition of the landings data are considered to be well sampled. However, in 2018 sampling levels fell below this normal standard. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in the Firth of Clyde subarea fishery since 1990, and is considered to represent the fishery adequately. There are few samples available from the Sound of Jura and these have been included in the FU13 raising procedure.

Discard sampling in 2020 was impacted by the COVID-19 pandemic, with no samples collected in Functional Unit 13. Estimates of discard rates for all quarters in the assessment were based on mean discard rates across all quarters from 2017-2019 (see "InterCatch", above). This change is considered to have had minimal impact on the quality of the assessment because discard rates have been consistently low in recent years.

Underwater TV surveys have been conducted for this stock every year since 1995. The number of valid stations in the survey has remained relatively stable throughout the period. Confidence intervals around the abundance estimates are stable throughout the series and relatively low compared with other FUs in area 6.a. In the provision of catch scenarios based on the absolute survey estimates additional uncertainties related to mean weight in the landings and the discard rates also arise. A three-year average (2018–2020) of discard rate (adjusted to account for some survival of discarded animals) has been used in the calculation of catch advice.

The cumulative relative to absolute conversion factor estimates for FU13 component is largely based on expert opinion (see stock annex). The precision of these bias corrections cannot yet be characterised. The method to derive landings for the catch options is sensitive to the input dead discard rate and mean weight in landings and this introduces uncertainties in the catch forecasts. Precision estimates are needed for these forecast inputs.

The overall area of the ground is estimated from the available BGS contoured sediment data and at present is considered to be a minimum estimate. VMS data, recently made available and linked to landings (from queries of the Scottish FIN database) suggest no major differences between areas fished and the mud sediment maps. The inclusion of vessels smaller than 15 m would likely increase the fished area in some of the inshore locations, while in the Clyde the non-estimated sea loch areas are relatively small.

14.8 Recommendation for next benchmark

This stock was last benchmarked in 2009 (ICES, 2009). WGCSE recommends that the issue concerning the split of landings between Sound of Jura and the Firth of Clyde be examined when this stock is next proposed for benchmark process.

14.9 Management considerations

ICES and STECF have repeatedly advised that management should be at a smaller scale than the ICES division level. Management at the Functional Unit level could provide controls to ensure effort and catch were in line with resources available. In this FU, the two subareas imply that additional controls may be required to ensure that the landings taken in each subarea are in line with the landings advice.

Creel fishing takes place in part of this area although the relative scale of the fishery is smaller than in the Minches. Overall effort in terms of creel numbers is not known, and measures to control numbers are not in place. There is a need to ensure that the combined effort from all forms of fishing is taken into account when managing this stock.

There is a bycatch of other species in the area of the Firth of Clyde and estimated discards of whiting and haddock by the TR2 fleet are generally high in area 6.a. It is important that efforts continue to ensure that unwanted bycatch is kept to a minimum in this fishery. Current efforts to reduce discards and unwanted bycatches of cod include the implementation of large square meshed panels (SMPs) of 120 mm under the west coast emergency measures, and SMPs of 200 mm implemented as part of the previous Scottish Conservation Credits scheme. A seasonal closure (early spring) in the southwest part of the Firth of Clyde is in place to protect spawning cod although *Nephrops* vessels are derogated to fish in those parts where mud sediments are distributed.

14.10 References

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Table 17.1.1. ***Nephrops,*** **Clyde and Sound of Jura (FU13), ICES estimates of landings of** ***Nephrops*****, 1981–2020.**

UK SCOTLAND						OTHER UK	IRELAND	TOTAL**
YEAR	*NEPHROPS* TRAWL	OTHER	CREEL	BELOW MINIMUM SIZE	SUB TOTAL			
1981	2498	404	66	0	2968	0	0	2968
1982	2372	169	79	0	2620	0	0	2620
1983	3889	121	52	0	4062	14	0	4076
1984	3070	153	77	0	3300	10	0	3310
1985	3921	293	65	0	4279	7	0	4286
1986	4073	176	79	0	4328	13	0	4341
1987	2860	82	64	0	3006	3	0	3009
1988	3507	107	43	0	3657	7	0	3664
1989	2577	184	35	0	2796	16	0	2812
1990	2731	121	23	0	2875	34	0	2909
1991	2844	145	26	0	3015	23	0	3038
1992	2530	247	9	0	2786	17	0	2803
1993	3200	110	5	0	3315	28	0	3343
1994	2503	50	28	0	2581	49	0	2630
1995	3766	131	26	0	3923	64	0	3987
1996	3880	108	27	0	4015	42	0	4057
1997	3486	46	26	0	3558	63	0	3621
1998	4540	79	39	0	4658	183	0	4841
1999	3476	29	37	0	3542	210	0	3752
2000	3142	63	75	0	3280	137	0	3417
2001	2890	65	95	0	3050	132	0	3182
2002	3075	53	105	0	3233	151	0	3384
2003	2954	20	119	0	3093	80	0	3173
2004	2619	8	88	0	2715	258	0	2973
2005	3148	5	94	0	3247	148	0	3395
2006	4356	1	179	0	4536	244	0	4780

UK SCOTLAND						OTHER UK	IRELAND	TOTAL**
YEAR	*NEPHROPS* TRAWL	OTHER	CREEL	BELOW MINIMUM SIZE	SUB TOTAL			
2007	6069	4	221	0	6294	366	0	6660
2008	5320	3	184	0	5507	416	0	5923
2009	4304	1	191	0	4496	283	0	4779
2010	5162	5	211	0	5378	465	0	5843
2011	5664	9	219	0	5892	540	0	6432
2012	5617	4	203	0	5824	863	0	6687
2013	4708	4	212	0	4924	511	0	5435
2014	4770	1	258	0	5029	1178	0	6207
2015	4035	8	206	0	4249	898	0	5147
2016	4922	6	267	0	5195	1252	4	6447
2017	4195	3	263	0	4461	942	1	5403
2018	3574	13	253	0	3840	303	0	4143
2019	3834	3	265	0	4102	581	0	4683
2020	2869	10	225	0	3104	532		3636

Table 17.2.1. *Nephrops,* Clyde (FU13), ICES estimated landings of *Nephrops*, in each of the subareas (Firth of Clyde and Sound of Jura 1981–2020).

YEAR	UK LANDINGS		
	FIRTH OF CLYDE	SOUND OF JURA	ALL SUBAREAS
1981	2277	691	2968
1982	1983	637	2620
1983	3395	681	4076
1984	2600	710	3310
1985	3561	725	4286
1986	3228	1113	4341
1987	2408	601	3009
1988	3509	155	3664
1989	2595	217	2812
1990	2592	317	2909
1991	2654	384	3038
1992	2383	420	2803
1993	2766	577	3343
1994	2095	535	2630
1995	3692	295	3987
1996	3671	386	4057
1997	3135	486	3621
1998	4373	468	4841
1999	3423	329	3752
2000	3229	188	3417
2001	2979	203	3182
2002	3350	34	3384
2003	3154	19	3173
2004	2965	8	2973
2005	3388	7	3395
2006	4768	12	4780
2007	6580	80	6660

YEAR	UK LANDINGS		
	FIRTH OF CLYDE	SOUND OF JURA	ALL SUBAREAS
2008	5845	78	5923
2009	4688	91	4779
2010	5782	61	5843
2011	6363	69	6432
2012	6634	53	6687
2013	NA	NA	5435
2014	NA	NA	6207
2015	NA	NA	5147
2016	NA	NA	6447
2017	NA	NA	5403
2018	NA	NA	4143
2019	NA	NA	4683
2020	NA	NA	3636

Table 17.2.2. *Nephrops*, Clyde (FU13): Firth of Clyde and Sound of Jura combined. Adjusted TV survey abundance (Firth of Clyde subarea), landings, discard rate (proportion by number) and estimated harvest rate. The harvest rate was calculated from the total (dead) removals in number for both subareas divided by the combined abundance from both TV surveys.

YEAR	LANDINGS IN NUMBERS (MILLIONS)	DISCARD IN NUMBERS (MILLIONS)	REMOVALS IN NUMBERS (MILLIONS)**	ADJUSTED SURVEY CLYDE (MILLIONS)	ADJUSTED SURVEY JURA (MILLIONS)	COMBINED HARVEST RATE*	LANDINGS (TONNES)	DISCARDS (TONNES)	DEAD DISCARDS (TONNES)	DISCARD RATE (%)	DEAD DISCARD RATE (%)	MEAN WEIGHT IN LANDINGS (gr)	MEAN WEIGHT IN DISCARDS (gr)
1995	207	82	269	579	160	36.40	3987	619	464	28.4	22.90	19.24	7.54
1996	187	61	233	935	171	21.07	4057	635	476	24.7	19.70	21.68	10.35
1997	150	70	202	1198	NA	NA	3621	598	448	32	26.10	24.21	8.50
1998	269	187	409	1262	NA	NA	4841	1292	969	41	34.20	17.98	6.92
1999	216	93	286	930	NA	NA	3752	566	424	30.2	24.50	17.39	6.05
2000	171	48	207	1411	NA	NA	3417	470	352	22	17.40	19.96	9.75
2001	164	82	225	1486	272	12.80	3182	677	508	33.5	27.40	19.46	8.23
2002	207	50	245	1571	398	12.44	3384	406	305	19.5	15.40	16.35	8.12
2003	166	134	266	1817	260	12.81	3173	1247	935	44.7	37.70	19.13	9.31
2004	158	168	284	1970	NA	NA	2973	1435	1076	51.5	44.30	18.80	8.54
2005	189	69	241	1959	303	10.65	3395	611	458	26.8	21.60	17.96	8.81
2006	248	55	290	1851	430	12.71	4780	515	386	18.2	14.30	19.27	9.31
2007	350	387	640	1233	255	43.01	6660	2566	1924	52.5	45.30	19.05	6.64
2008	357	207	512	1769	NA	NA	5923	1433	1075	36.6	30.30	16.59	6.94
2009	261	169	388	1499	251	22.17	4779	1390	1043	39.3	32.70	18.31	8.23
2010	276	55	317	1750	376	14.91	5843	536	402	16.7	13.10	21.21	9.68
2011	333	74	388	2165	312	15.66	6432	568	426	18.2	14.30	19.34	7.65

YEAR	LANDINGS IN NUMBERS (MILLIONS)	DISCARD IN NUMBERS (MILLIONS)	REMOVALS IN NUMBERS (MILLIONS)**	ADJUSTED SURVEY CLYDE (MILLIONS)	ADJUSTED SURVEY JURA (MILLIONS)	COMBINED HARVEST RATE*	LANDINGS (TONNES)	DISCARDS (TONNES)	DEAD DISCARDS (TONNES)	DISCARD RATE (%)	DEAD DISCARD RATE (%)	MEAN WEIGHT IN LANDINGS (gr)	MEAN WEIGHT IN DISCARDS (gr)
2012	306	93	376	1421	371	20.98	6687	1066	800	23.4	18.60	21.83	11.42
2013	262	62	309	1990	198	14.12	5435	454	341	19	15.00	20.72	7.37
2014	295	78	353	1328	231	22.64	6207	696	522	20.9	16.60	20.79	8.92
2015	232	54	273	1820	376	12.43	5147	401	301	18.9	14.80	22.21	7.43
2016	364	69	416	1946	422	17.57	6447	636	477	15.9	12.40	17.70	9.21
2017 ^	316	32	340	1568	306	18.1	5403	275	199	9.5	7.1	17.02	8.55
2018 ^	268	7	273	2193	275	11.1	4143	68	51	2.5	1.9	16.14	9.79
2019 ^	271	64	319	2083	318	13.3	4683	435	326	19.1	15	17.26	6.81
2020	195	23	212	1941	NA	9.4	3636	177	133	10.7	8.3	18.96	7.57
2021	-	-	-	1414	310	-	-	-	-	-	-	-	-
Average***											8.3	17.45	8.06

*** Harvest rates previous to 2006 are unreliable.**

**** Removals numbers take the dead discard rate into account.**

***** Dead discard average: 2018–2020; Mean weight in landings and discard average: 2018–2020.**

^ Values updated in 2021 due to minor revisions in landings data.

Table 17.2.3. ***Nephrops*****, Clyde (FU13): Firth of Clyde subarea. Results of the 1995–2021 TV surveys (values adjusted for bias).**

YEAR	NUMBER OF VALID STATIONS	MEAN DENSITY (BURROWS / m²)	ABUNDANCE (MILLIONS)	95% CONFIDENCE INTERVAL (MILLIONS)
1995	29	0.277	579	176
1996	38	0.454	935	242
1997	31	0.571	1198	262
1998	38	0.605	1262	213
1999	39	0.445	930	289
2000	40	0.681	1411	246
2001	39	0.714	1486	268
2002	36	0.756	1571	288
2003	37	0.874	1817	292
2004	32	0.95	1970	367
2005	44	0.941	1959	287
2006	43	0.882	1851	257
2007	40	0.597	1233	218
2008	38	0.849	1769	291
2009	39	0.723	1499	210
2010	37	0.84	1750	327
2011	40	1.041	2165	305
2012	37	0.681	1421	227
2013	34	0.956	1990	246
2014	35	0.639	1328	237
2015	37	0.875	1820	351
2016	37	0.935	1946	249
2017	38	0.754	1568	239
2018	40	1.055	2193	297
2019	38	1.002	2083	381
2020	28	0.933	1941	297
2021	41	0.68	1414	211

Table 17.2.4. *Nephrops*, Clyde (FU13): Sound of Jura subarea. Results of the 1995–2021 TV surveys (values adjusted for bias).

YEAR	NUMBER OF VALID STATIONS	MEAN DENSITY (BURROWS / m²)	ABUNDANCE (millions)	95% CONFIDENCE INTERVAL (millions)
1995	7	0.42	160	58
1996	10	0.45	171	26
1997	no surveys			
1998				
1999				
2000				
2001	13	0.71	272	76
2002	9	1.04	398	167
2003	12	0.68	260	68
2004	no survey			
2005	11	0.79	303	84
2006	10	1.13	430	134
2007	10	0.67	255	58
2008	no survey			
2009	12	0.66	251	68
2010	12	0.98	376	39
2011	12	0.82	312	73
2012	12	0.98	371	61
2013	9	0.52	198	35
2014	9	0.61	231	90
2015	12	0.98	376	127
2016	12	1.11	422	42
2017	12	0.80	306	71
2018	12	0.72	275	53
2019	12	0.832	318	61
2020	no survey			

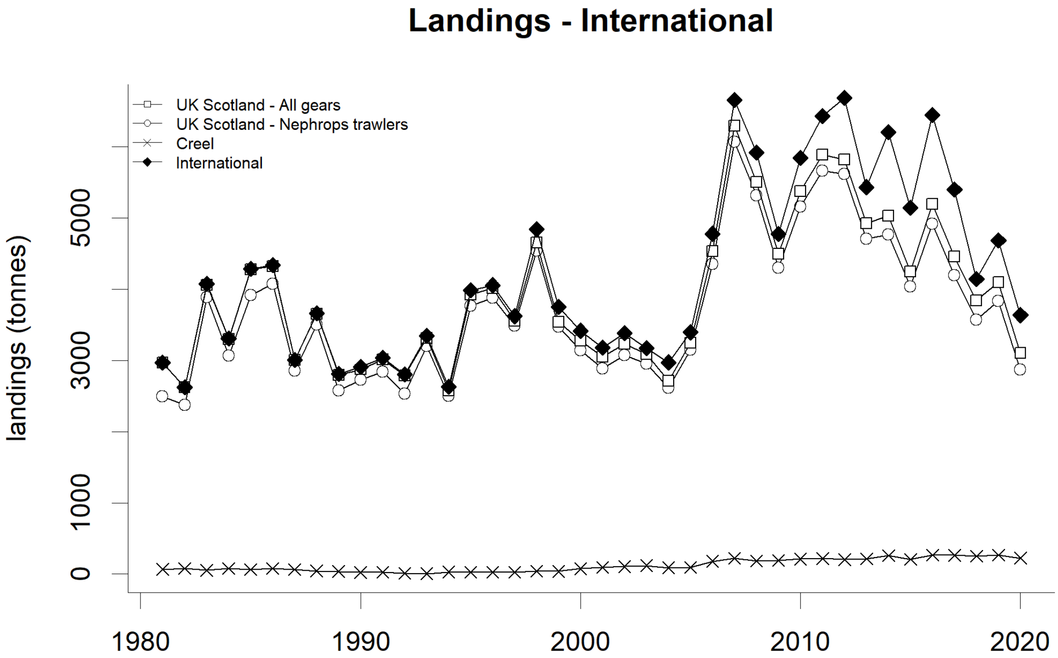
YEAR	NUMBER OF VALID STATIONS	MEAN DENSITY (BURROWS / m²)	ABUNDANCE (millions)	95% CONFIDENCE INTERVAL (millions)
2021	12	0.812	310	98

Table 17.2.5. ***Nephrops*****, Clyde (FU13): Firth of Clyde subarea. Results by stratum of the 2019–2021 TV surveys. Note that stratification was based on a series of sediment strata (M – Mud, SM – Sandy mud, MS – Muddy sand).**

STRATUM	AREA (km²)	NUMBER OF STATIONS	MEAN BURROW DENSITY (no./m²)	OBSERVED VARIANCE	ABUNDANCE (MILLIONS)	STRATUM VARIANCE	PROPORTION OF TOTAL VARIANCE	SURVEY PRECISION LEVEL (CV)
2019 TV survey								
M	716.8	14	0.841	0.096	602.8	3517	0.097	
SM	698.6	11	1.329	0.458	928.1	20296	0.559	
MS	664.6	13	0.831	0.367	552.4	12467	0.344	
Total	2080	38			2083.3	36279	1	0.09
2020 TV survey								
M	716.8	10	1.084	0.058	777	2983	0.095	
SM	698.6	9	1.294	0.246	904.3	13364	0.428	
MS	664.6	9	0.946	0.304	628.4	14895	0.477	
Total	2080	28			2309.7	31242	1	0.076
2021 TV survey								
M	716.8	16	0.718	0.078	514.3	2486	0.223	
SM	698.6	13	0.843	0.089	588.8	3354	0.301	
MS	664.6	12	0.469	0.144	311.3	5309	0.476	
Total	2080	41			1414.4	11149	1	0.072

Table 17.2.6. *Nephrops*, Clyde (FU13): Sound of Jura subarea. Results by stratum of the 2018, 2019, and 2021 TV surveys. Note that stratification was based on a series of sediment strata.

STRATUM	AREA (km2)	NUMBER OF STATIONS	MEAN BURROW DENSITY (no./m2)	OBSERVED VARIANCE	ABUNDANCE (MILLIONS)	STRATUM VARIANCE	PROPORTION OF TOTAL VARIANCE	SURVEY PRECISION LEVEL SURVEY (RSE)
2018 TV survey								
M	90	3	0.739	0.019	66.6	52	0.075	
SM	150	4	0.691	0.008	103.7	43	0.062	
MS	142	5	0.734	0.148	104.3	598	0.863	
Total	382	12			274.5	693	1	0.10
2019 TV survey								
M	90	2	0.689	0.088	62	357	0.389	
SM	150	4	0.878	0.023	131.8	128	0.139	
MS	142	6	0.874	0.129	124.1	434	0.472	
Total	382	12			317.9	919	1	0.101
2021 TV survey								
M	90	1	0.387	0.044	34.8	355	0.148	
SM	150	5	0.845	0.254	126.8	1140	0.474	
MS	142	6	1.046	0.27	148.6	909	0.378	
Total	382	12			310.2	2404	1	0.157



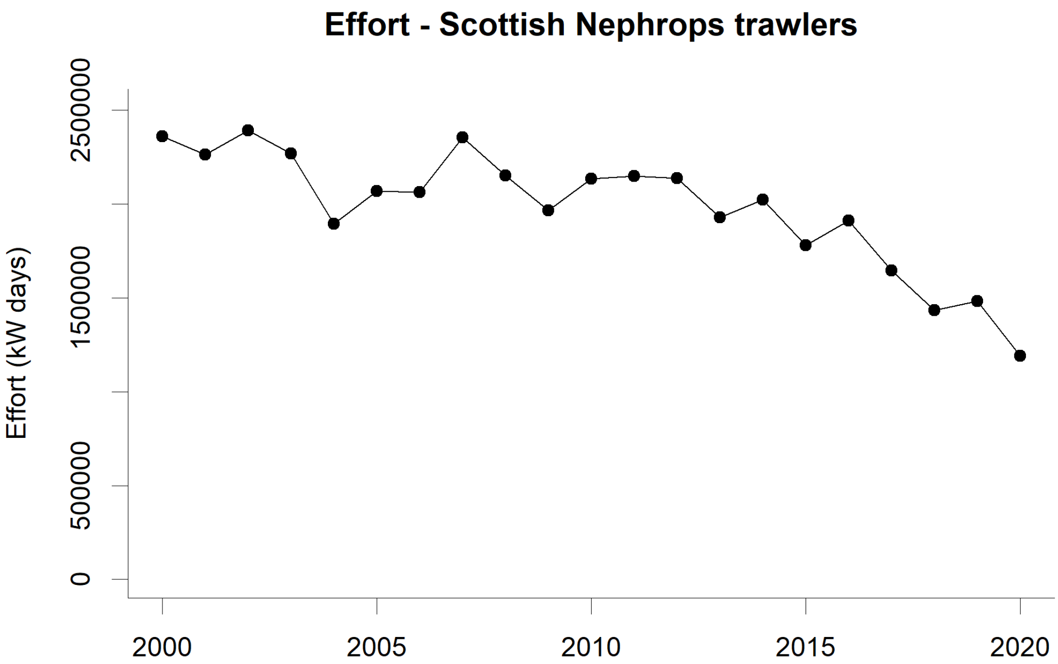


Figure 17.2.1. ***Nephrops*, Clyde (FU13). Long-term landings and effort.**

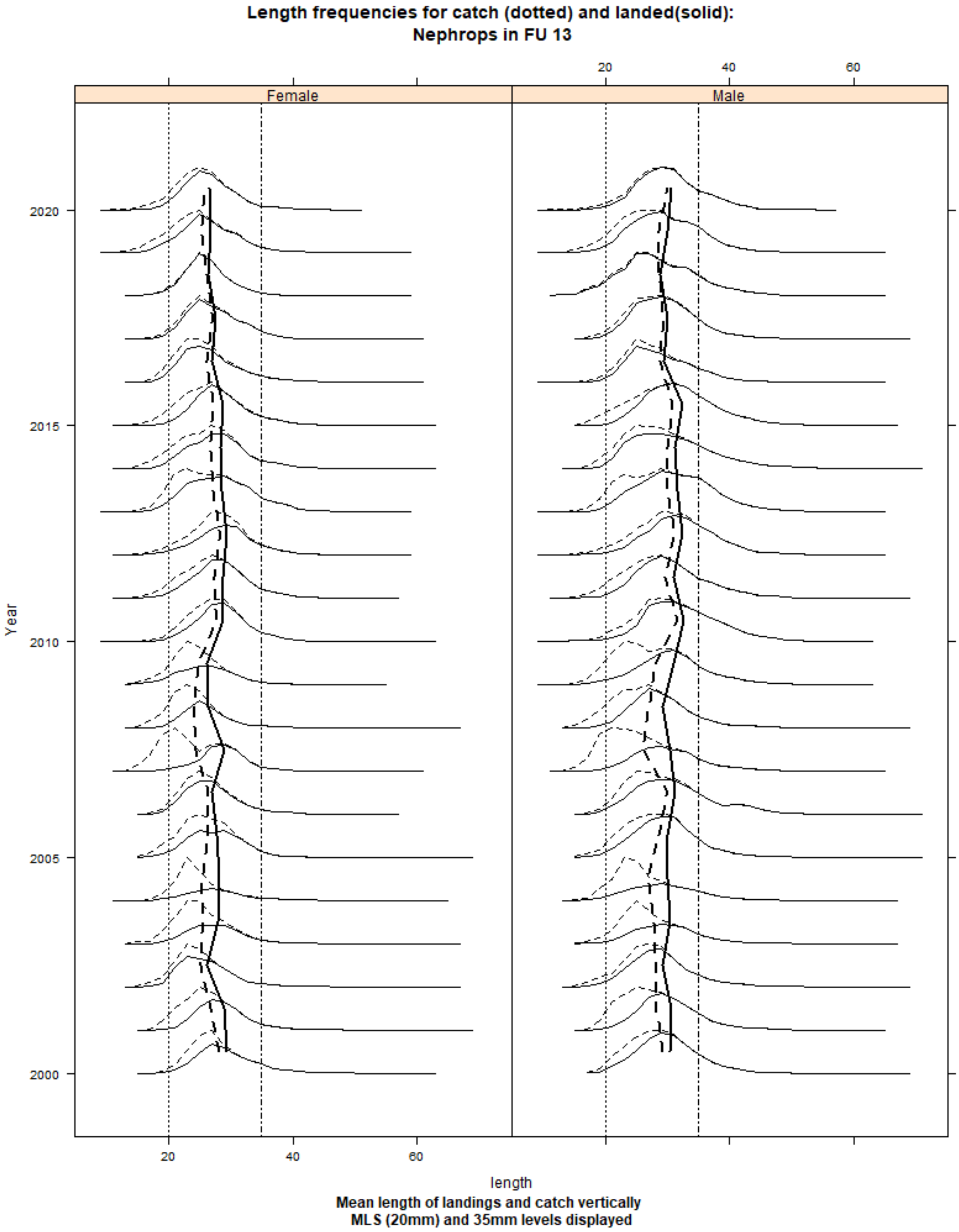


Figure 17.2.2. ***Nephrops,*** **Clyde (FU13). Catch length–frequency distribution and mean size in catches (dotted) and landings (solid) for *Nephrops*, 2000–2020. Vertical lines are minimum conservation reference size (25 mm) and 35 mm.**

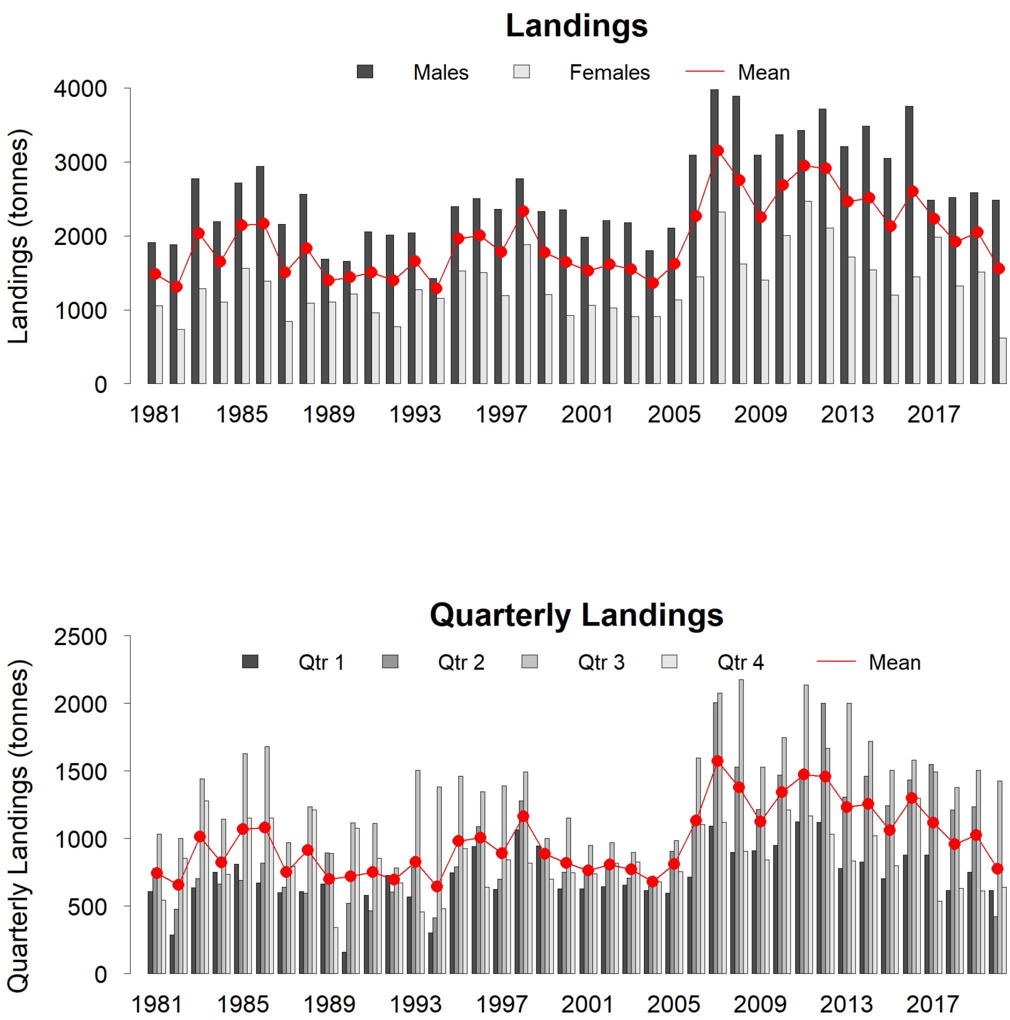


Figure 17.2.3. (a) *Nephrops*, Clyde (FU13). Landings by quarter and sex from Scottish trawlers.

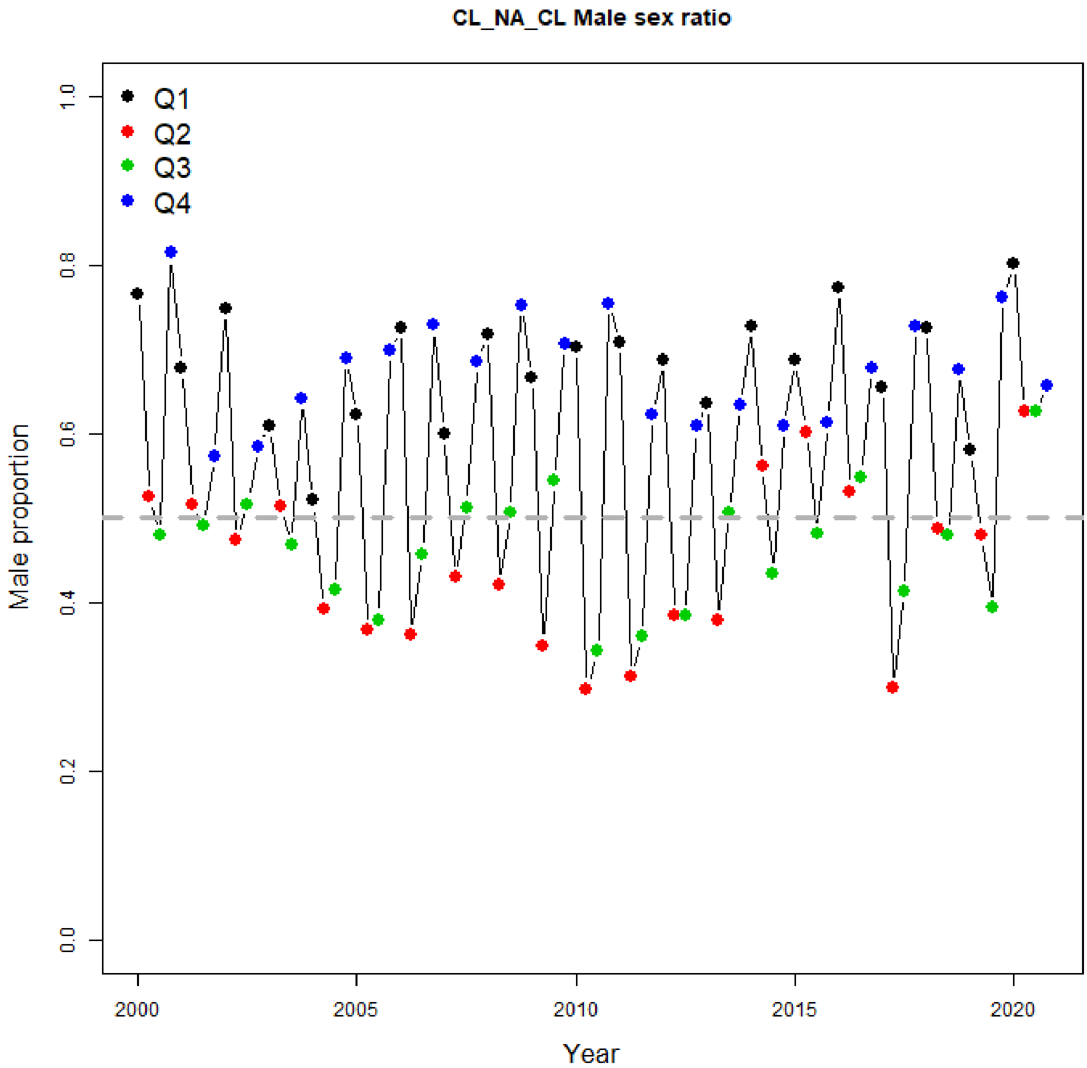


Figure 17.2.3. (b) ***Nephrops,*** **Clyde (FU13), Proportion of males by quarter (2000–2020).**

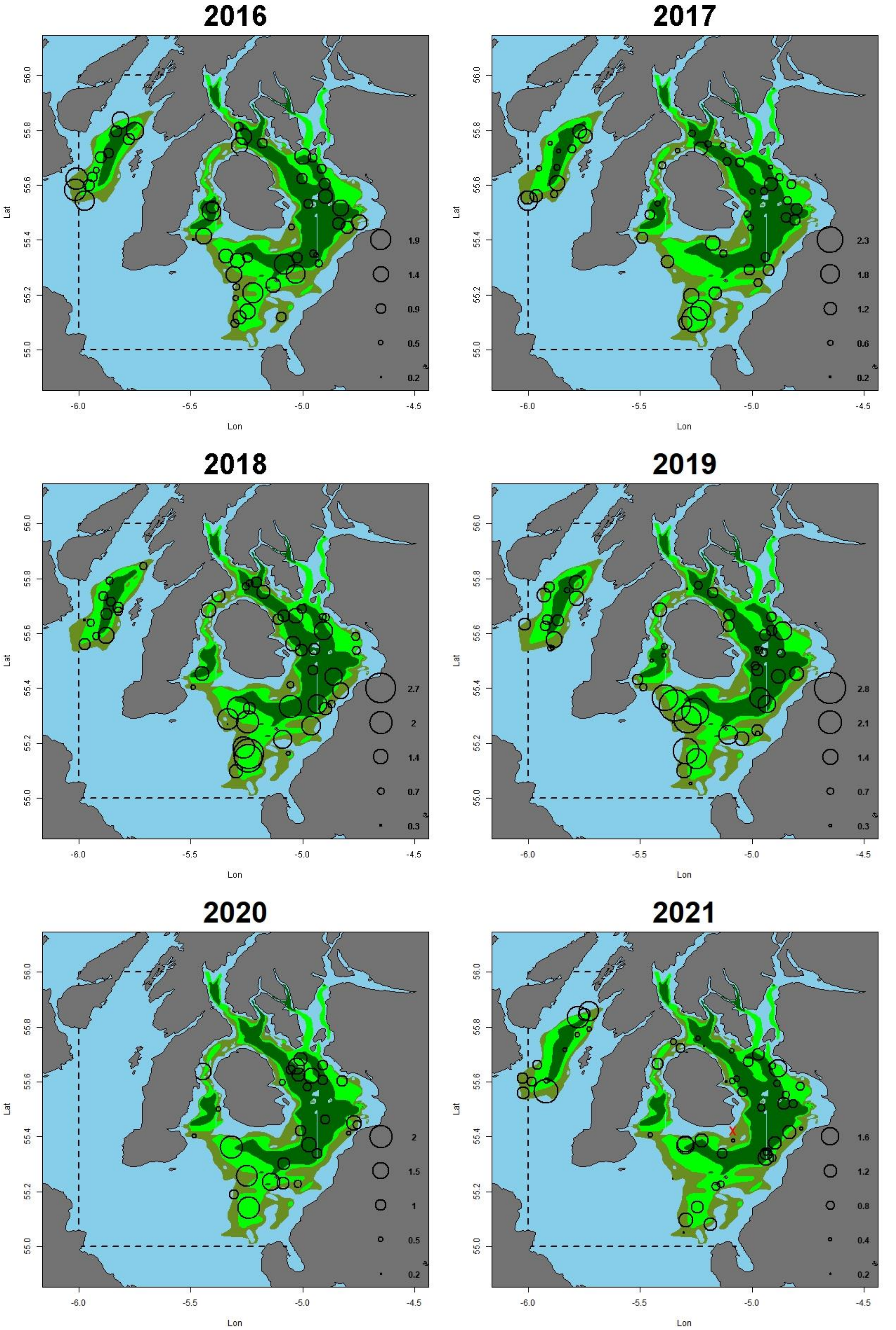


Figure 17.2.4. ***Nephrops*, Clyde (FU13), TV survey station distribution and relative density (burrows/m²) for Firth of Clyde and Sound of Jura subareas, 2016–2021. Sound of Jura located to the east. Shaded green and brown areas represent areas of suitable sediment for *Nephrops*. Bubbles scaled the same. Red crosses represent zero observations.**

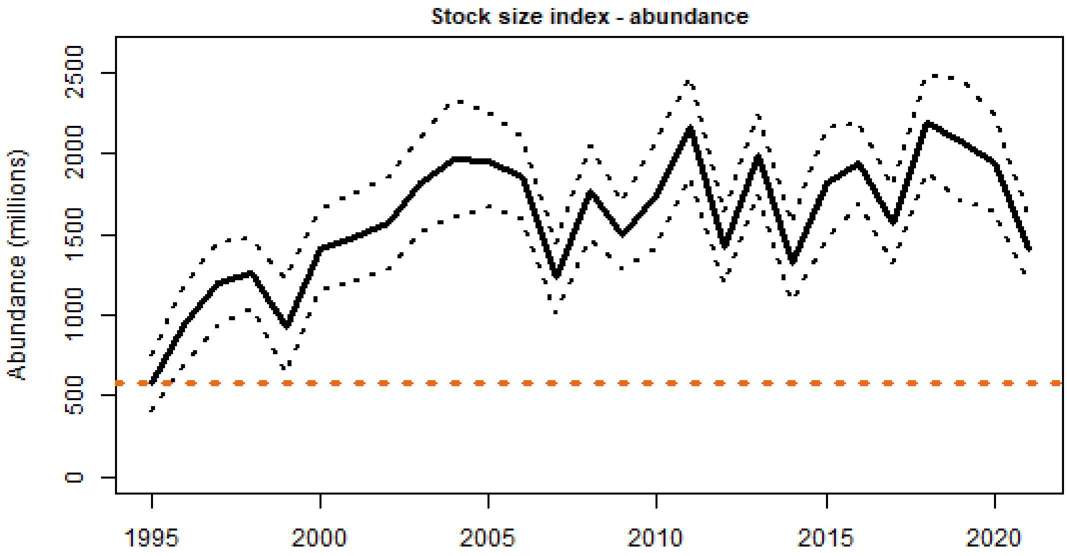


Figure 17.2.5. ***Nephrops*, Clyde (FU13): Firth of Clyde subarea. Time-series of revised TV survey abundance estimates (adjusted for bias, solid black line), with 95% confidence intervals (dotted black lines), 1995–2021. The dashed red line is the rounded $B_{trigger}$ value of 580 million individuals.**

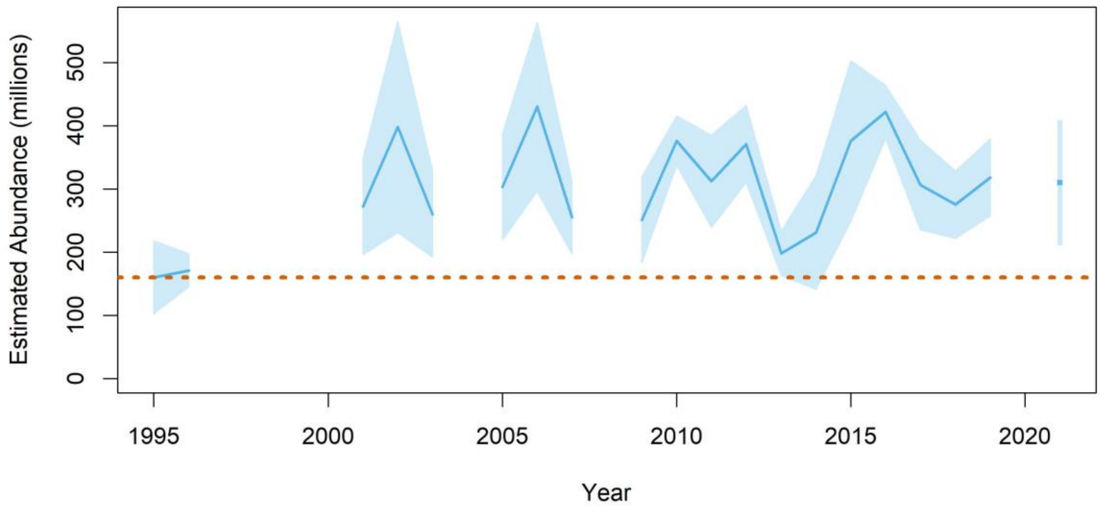


Figure 17.2.6. ***Nephrops*, Clyde (FU13): Sound of Jura subarea. Time-series of TV survey abundance estimates (adjusted for bias, solid blue line) with 95% confidence intervals (light blue polygons), 1995–2020. The dashed orange line is the rounded $B_{trigger}$ value of 160 million individuals.**

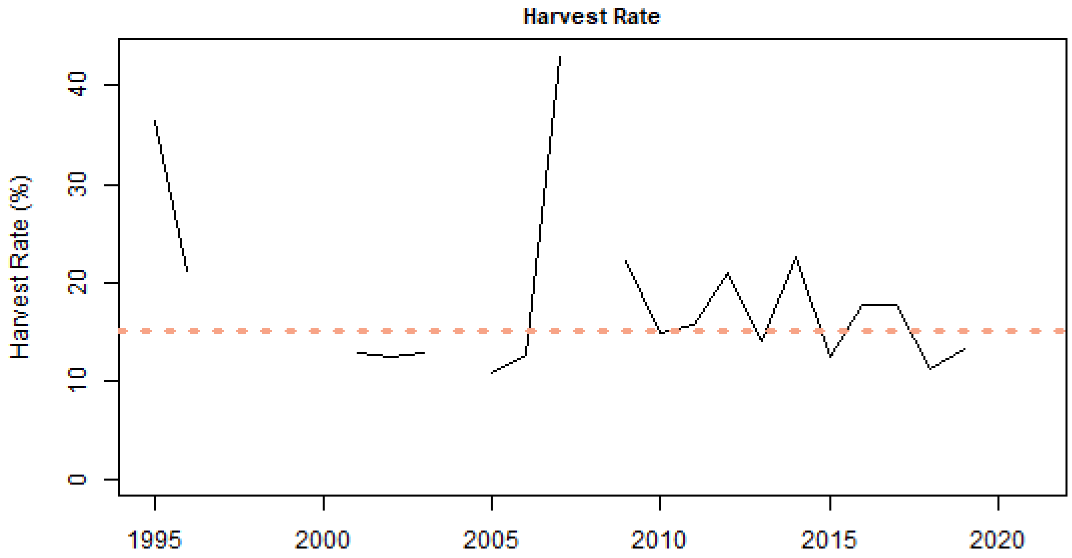


Figure 17.4.1. Clyde (FU13) *Nephrops* harvest rate, 1995–20120. The harvest rate is calculated by dead removals (both subareas combined)/TV abundances (both subareas combined). The dashed and solid lines are the F_{MSY} proxy harvest rate (for the Firth of Clyde 15.1%) and the harvest rate respectively. Harvest rates prior to 2006 are unreliable.

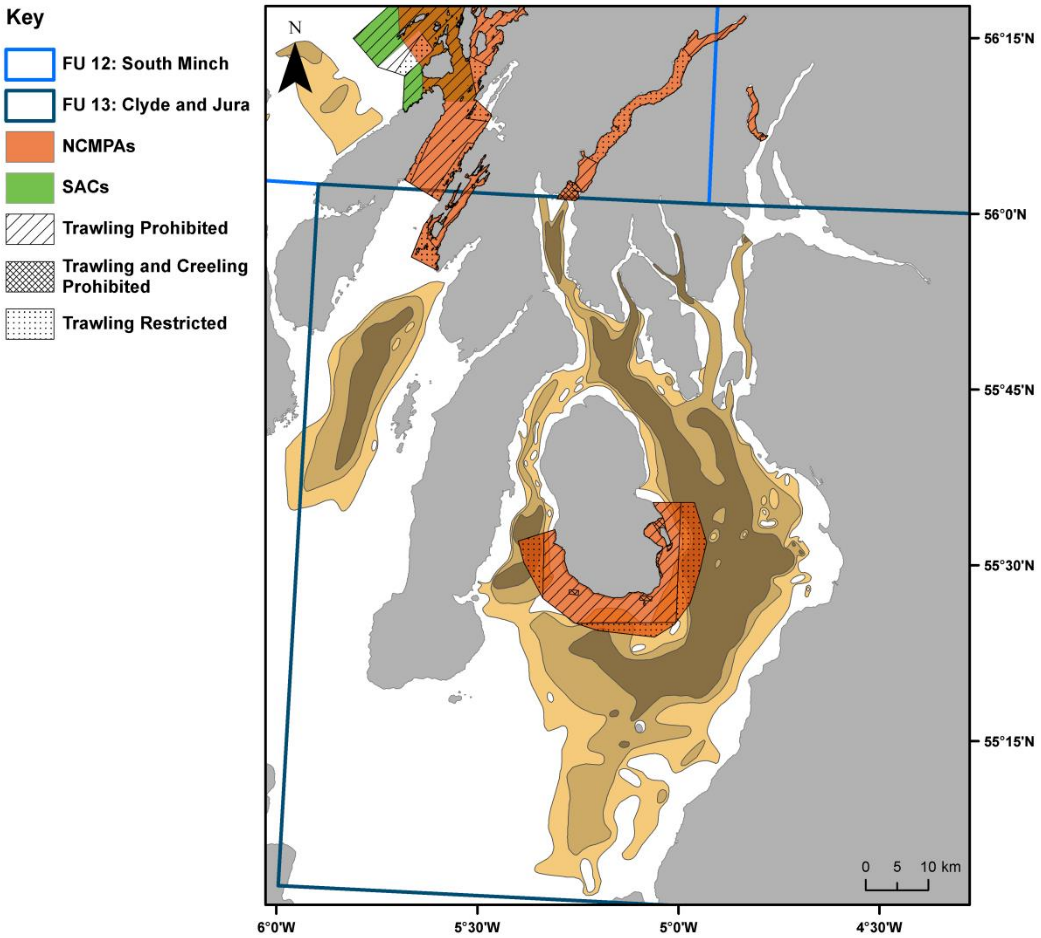


Figure 17.6.1. The area of *Nephrops* habitat (Mud, Muddy Sand and Sandy Mud) within the Clyde functional unit (FU13) relative to the areas of the Nature Conservation MPAs (NCMPAs) which fisheries management measures. Areas where demersal trawling is prohibited, restricted (i.e. vessel size restrictions or seasonal closures) and where creeling is prohibited are displayed. For more detailed information see SG (2016). Geographic Coordinate System: OSGB 1936, Datum: OSGB 1936, Projected Coordinate System: British National Grid. Coastline by Wessel and Smith (2016), MPA sites subsetted from NCMPA (SNH, 2015) and SAC (SNH, 2016) layers, management areas by SG (2017b) and functional units generated from merged ICES rectangles (ICES, 2017). Map and modified layers created using ArcGIS (ESRI, 2014).

15 *Nephrops* in Division 7.a (Irish Sea East, FU14)

15.1 *Nephrops* Subarea 7 general section

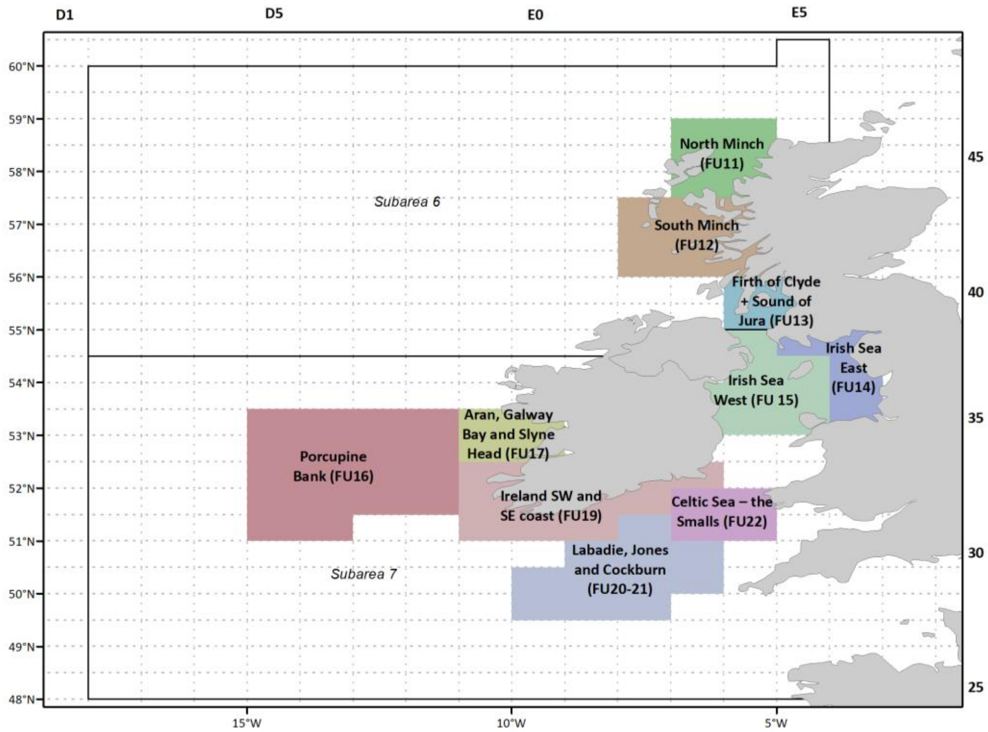
Stock description and management units

A TAC is in place for ICES Area 7 which does not correspond to the assessment units. As *Nephrops* are limited to muddy habitats the distribution of suitable sediment defines the species distribution and the stocks are therefore assessed as eight separate Functional Units. There are also some smaller catches from areas outside these Functional Units. The ICES statistical rectangles covered by the Functional Units in ICES Area 7 are listed in the table below.

FU no.	Name	ICES divisions	ICES Statistical rectangles
14	Irish Sea East	7a	35–38E6; 38E5
15	Irish Sea West	7a	35E3, 36E3; 35–37 E4–E5; 38E4
16	Porcupine Bank	7b,c,j,k	31–35 D5–D6; 32–35 D7–D8
17	Aran Grounds	7b	34–35 D9–E0
18*	Northwest Irish Coast	7b	36–37 D9; 37E0–E1
19	Southeast and southwest Irish Coast	7a,g,j	31–33 D9–E0; 31E1; 32E1–E2; 33E2–E3
20-21	Labadie, Jones and Cockburn bank	7g,h	28 EO–E2; 29 E0–E3; 30E1–E3; 31E2
22	Smalls Ground	7g	31–32 E3–E4

*** Landings from FU18 are reported to other statistical rectangles outside FUs as these are minimal. WGCSE will monitor FU18 landings in case of any fishery developments.**

Nephrops Functional Units in Subarea 7 (FU 14–22). The TAC covers all of Subarea 7. (Note: Functional Units in Subarea 6 (FU 11–13) also shown):



Landings Obligation

From 2019, on the West Coast and around Ireland **(FU 11–22),** any vessels catching Nephrops had to land all *Nephrops*. High survival exemptions exist for creel caught Nephrops. *De minimis* exemptions apply to *Nephrops* vessels, for Subarea 7 allowing them to discard *Nephrops*, as long as they made up no more than 5% of the catch.

Minimum Conservation Reference Size (Minimum landing size)

Under the Landing Obligation, minimum landings sizes have been abolished. Instead a Minimum Conservation Reference Size (MCRS) for each species has been introduced. Unless exempt, *Nephrops* below the MCRS must be landed and may be sold but cannot go for human consumption. In most cases, the MCRS is the same as old MLS, being 25 mm carapace length (or over 85 mm total length) around Ireland (FUs 16–22); the MCRS is 20 mm CL (>70 mm TL) on the West coast (6.a, FUs 11–13) and the Irish Sea (7a, FUs 14–15).

The MCRS implemented for the Irish Sea at 20 mm CL is less than the rest of the ICES Area 7 (set at 25 mm CL) and applies to the Irish and UK fleets. A more restrictive regulation is adopted by the French Producers' Organisations (35 mm CL or 115 mm TL) to all French trawlers.

Management applicable in 2019 and 2020

The TAC is currently set for the whole Area 7 with a special condition for Porcupine Bank (FU 16). The TAC for 2020 was 16 815 t, this represented a decrease of 15% in relation to 2019 with 19 784 t. The TAC area includes a number of *Nephrops* stocks showing different levels of exploitation. A single TAC covering a number of distinct stocks allows the possibility of unrestricted catches being taken from a heavily exploited stock when advice suggests they should be limited.

Details of all regulations including effort controls in place are provided in the stock annex for all functional units under this subarea.

TAC in 2020

Council Regulation (EU) 2020/123 of 27 January 2020 fixing for 2020 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters

Species:	**Norway lobster** *Nephrops norvegicus*	**Zone:**	**7** **(NEP/07.)**
Spain	1 089 (1)		Analytical TAC
France	4 089 (1)		
Ireland	6 201 (1)		
United Kingdom	5 516 (1)		
Union	16 815 (1)		
TAC	16 815 (1)		

(1) Special condition: within the limits of the abovementioned quotas, no more than the quantities given below may be taken in the following zone:

	Functional Unit 16 of ICES Subarea 7 (NEP/*07U16):
Spain	795
France	498
Ireland	957
United Kingdom	387
Union	2 637

TAC in 2019

Council Regulation (EU) 2019/124 of 30 January 2019 fixing for 2019 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters.

Species:	**Norway lobster** *Nephrops norvegicus*	**Zone:**	**7** **(NEP/07.)**
Spain	1 187 (1)		
France	4 811 (1)		
Ireland	7 296 (1)		
United Kingdom	6 490 (1)		
Union	19 784 (1)		Analytical TAC
TAC	19 784 (1)		Article 13(1) of this Regulation applies

(1) Special condition: within the limits of the abovementioned quotas, no more than the quantities given below may be taken in the following zone:

	Functional Unit 16 of ICES Subarea 7 (NEP/*07U16):
Spain	798
France	500
Ireland	959
United Kingdom	388
Union	2 645

Landings area 7

Table below gives the summary of reported landings by Functional Unit for ICES Area 7.

Year	FU 14 - Irish Sea East	FU 15 - Irish Sea West	FU 16 - Porcupine Bank	FU 17 - Aran Grounds	*FU 18 - Ireland Northwest Coast	FU 19 - Ireland Southwest and Southeast coast	FU 20–21 - Labadie, Jones, Cockburn	FU 22 - Smalls Grounds	FUs 20+21+22 - All Celtic Sea FUs combined	Other statistical rectangles Outside FUs	Total Landings ICES Subarea 7	TAC for 7
1978	961	7,296	1,744	481						249	10,731	
1979	900	8,948	2,269	452						237	12,806	
1980	730	4,578	2,925	442						205	8,880	
1981	829	7,249	3,381	414						382	12,255	
1982	869	9,315	4,289	210						234	14,917	
1983	763	9,448	3,426	131					3,667	174	17,609	
1984	602	7,760	3,571	324					3,653	187	16,097	
1985	498	6,901	3,919	207					3,599	194	15,318	
1986	671	9,978	2,591	147					2,638	113	16,138	
1987	449	9,753	2,499	62					3,409	107	16,279	24,700
1988	462	8,586	2,375	828					3,165	140	15,556	24,700

Year	FU 14 - Irish Sea East	FU 15 - Irish Sea West	FU 16 - Porcupine Bank	FU 17 - Aran Grounds	*FU 18 - Ireland Northwest Coast	FU 19 - Ireland Southwest and Southeast coast	FU 20–21 - Labadie, Jones, Cockburn	FU 22 - Smalls Grounds	FUs 20+21+22 - All Celtic Sea FUs combined	Other statistical rectangles Outside FUs	Total Landings ICES Subarea 7	TAC for 7
1989	401	8,128	2,115	347		899			4,005	134	16,029	26,000
1990	563	8,300	1,895	519		754			4,290	102	16,423	26,000
1991	747	9,554	1,640	410		1077			3,295	169	16,892	26,000
1992	427	7,541	2,015	374		888			4,165	409	15,819	20,000
1993	515	8,102	1,857	372	10	905	3,466	1,182		455	16,864	20,000
1994	447	7,606	2,512	729	126	390	4,202	941		570	17,523	20,000
1995	584	7,796	2,936	867	26	695	3,536	1081		397	17,917	23,000
1996	475	7,247	2,230	528	46	888	2,822	937		623	15,796	23,000
1997	566	9,971	2,409	841	15	756	2,038	944		340	17,880	23,000
1998	388	9,128	2,155	1,410	78	827	1,713	835		514	17,048	23,000
1999	624	10,786	2,289	1,140	16	579	1,152	1,775		322	18,683	23,000
2000	567	8,370	910	880	9	696	1,778	2,890		243	16,343	21,000
2001	532	7,441	1,222	913	2	815	1,833	2,938		368	16,064	18,900

Year	FU 14 - Irish Sea East	FU 15 - Irish Sea West	FU 16 - Porcupine Bank	FU 17 - Aran Grounds	*FU 18 - Ireland Northwest Coast	FU 19 - Ireland Southwest and Southeast coast	FU 20–21 - Labadie, Jones, Cockburn	FU 22 - Smalls Grounds	FUs 20+21+22 - All Celtic Sea FUs combined	Other statistical rectangles Outside FUs	Total Landings ICES Subarea 7	TAC for 7
2002	577	6,793	1,327	1,154	14	1,318	2,674	1,993		243	16,093	17,790
2003	376	7,052	1,064	933	16	1,239	2,953	2,065		186	15,884	17,790
2004	472	7,266	1,406	525	22	1,074	2,443	1,828		161	15,197	17,450
2005	570	6,529	2,197	778	15	712	2,469	2,533		180	15,983	19,544
2006	628	7,535	2,185	637	14	741	2,523	1,761		270	16,294	21,498
2007	959	8,424	2,074	913	3	957	2,419	2,950		206	18,905	25,153
2008	726	10,482	1,000	1,057	1	851	2,980	3,090		322	20,509	25,153
2009	693	9,166	879	626	10	868	3,145	2,185		316	17,888	24,650
2010	583	8,929	922	939	7	687	1,793	2,714		359	16,933	22,432
2011	561	10,159	1,278	659	13	643	1,237	1,636		110	16,296	21,759
2012	531	10,527	1,258	1,246	28	849	1,189	2,618		325	18,571	21,759
2013	495	8,672	1,141	1,295	0	794	1,387	2,257		194	16,235	23,605
2014	679	8,613	1,189	766	0	468	1,836	2,526		174	16,251	20,989

Year	FU 14 - Irish Sea East	FU 15 - Irish Sea West	FU 16 - Porcupine Bank	FU 17 - Aran Grounds	*FU 18 - Ireland Northwest Coast	FU 19 - Ireland Southwest and Southeast coast	FU 20–21 - Labadie, Jones, Cockburn	FU 22 - Smalls Grounds	FUs 20+21+22 - All Celtic Sea FUs combined	Other statistical rectangles Outside FUs	Total Landings ICES Subarea 7	TAC for 7
2015	378	8,632	1,394	370	0	507	2 116	2,350		80	15,827	21,619
2016	237	7,327	2,154	641	0	590	2 453	3,329		118	16,849	23,348
2017	265	6,149	2,632	295	0	420	1,849	3,560		137	15,307	25,356
2018	263	5,756	2,751	536	0	238	1,803	1,974		200	13,521	29,091
2019	270	7,590	2,251	167	0	249	2,723	2,083		216	15,549	19,784
2020	232	6,115	1,877	222	0	249	413	1,475		304	10,887	16,815
Average	560	8,174	2,097	623	17	738	2,248	2,088	3,589	255	15,927	22,291

***Landings from FU18 are reported to other statistical rectangles outside FUs as these are minimal since 2013. WGCSE will monitor FU18 landings in case of any fishery developments.**

Nephrops FU14 section

Type of assessment in 2021

This stock was interbenchmarked in September 2015 (ICES, 2015) and the assessment and provision of advice through the use of the UWTV survey data and other commercial fishery data follows the process defined by the interbenchmark process and described in the stock annex (updated at WGCSE 2020). The UWTV survey undertaken in summer 2021 forms the basis of advice for this stock.

ICES advice applicable to 2021

"ICES advises that when the MSY approach is applied, catches in 2022 should be no more than 835 tonnes, assuming recent discard rates.

To ensure that the stock in Functional Unit 14 is exploited sustainably, management should be implemented at the Functional Unit level.

ICES notes the existence of a management plan, developed and adopted by some of the relevant management authorities for this stock. ICES considers this plan to be precautionary when implemented at the Functional Unit level."

ICES advice applicable to 2020

"ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 871 tonnes and 1053 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule.

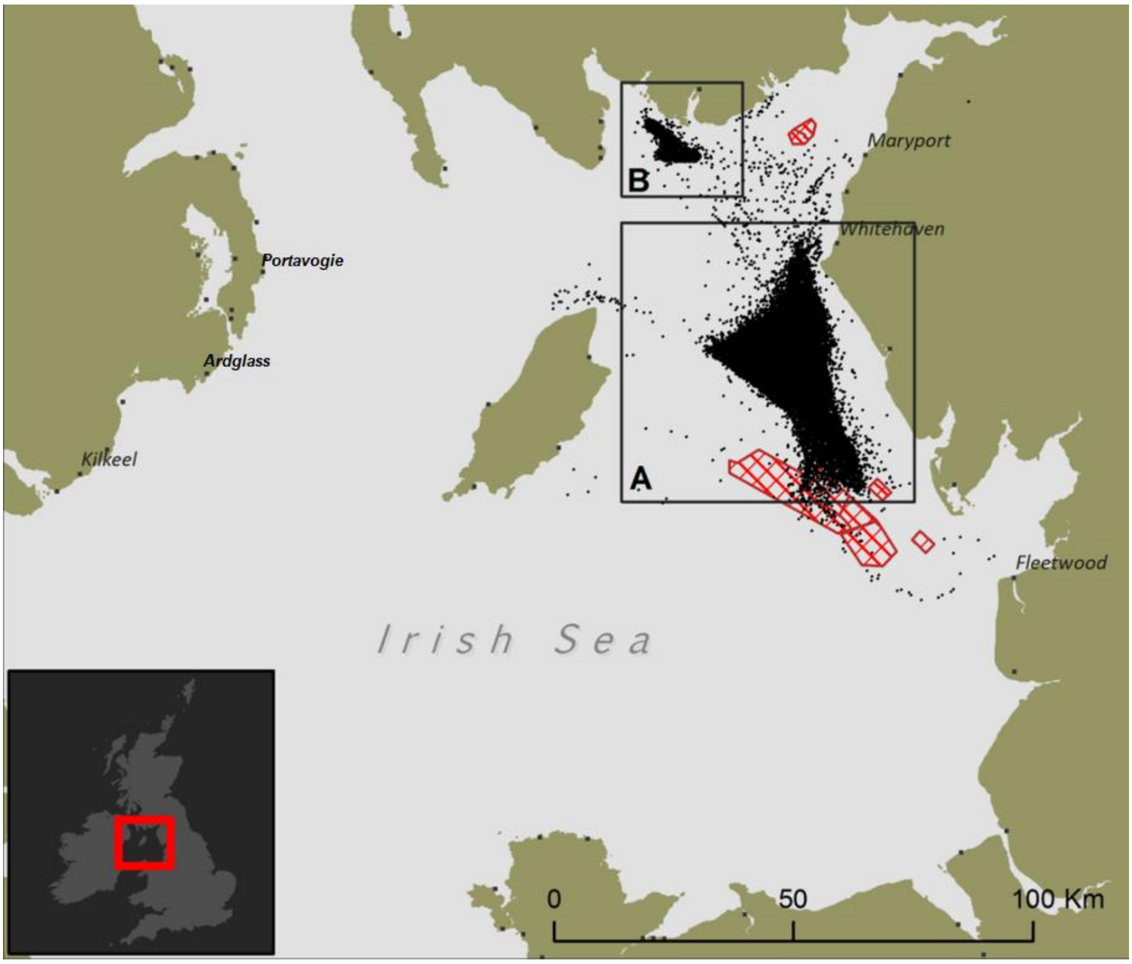
To ensure that the stock in Functional Unit 14 is exploited sustainably, management should be implemented at the functional unit (FU) level."

15.2 General

Stock description and management units

The Irish Sea East *Nephrops* stock (FU14) is in ICES Subarea 7 and comprises ICES rectangles: 38E5, 38E6, 37E6, 36E6, 35E6.

In FU14 *Nephrops* are caught on two spatially discrete grounds. Most of the fishery takes place on the main ground located between the West coast of England and Isle of Man, additionally there is also fishing activity in a small inshore ground known as Wigtown Bay.



East Irish Sea fishing grounds: A= Main fishing ground; B= Wigtown bay area. Windfarms represented by red polygons. (Source: ICES, 2015).

Main landing ports: Kilkeel, Portavogie, Ardglass, Whitehaven, Maryport

Fishery in 2020

The Eastern Irish Sea *Nephrops* fishery is dominated by UK activity, representing on average 90% of the reported annual international landings (2000–2020). This is a relatively small fishery compared to other FUs in the TAC area. Landings have been generally declining over the past ten years (Table 3.8.2), with an isolated high of 679 tonnes in 2014 and a low of 232 tonnes in 2020. The main fleets targeting *Nephrops* include directed single-rig and twin-rig otter trawlers operating out of ports in UK (NI), UK (E) and Republic of Ireland.

Being a summer (April to September) fishery, it is likely to have been impacted by the COVID-19 pandemic, with less catch than usual taken as a result. As in previous years, in 2020, the UK fleet still accounted for the largest proportion (90%) of landings in tonnes, however UK (NI) increased its portion from by 41% to 71% and UK (E) dropped by 55% to 19%. The majority of remaining landings were from Republic of Ireland, its portion increasing from 3% to 8%.

A more detailed historical fishery description is provided in the stock annex.

Information from stakeholders

No additional information was provided.

15.3 Data

InterCatch

Data for 2020 were successfully uploaded into InterCatch prior the 2021 WG meeting. The uploaded data were not worked up in InterCatch in 2021 due to no sampling activity in the fishery during 2020. Raised international length–frequency distributions, and derived catch and discard length frequencies for 2017 - 2019 were again used in the 2021 assessment. The allocation procedure was for English landings raised with English samples, Northern Irish landings raised with Northern Irish samples and all other remaining landings with pooled English and Northern Irish samples.

Landings

Official landings as reported to ICES from FU14 are presented in Table 3.8.1.

There are reported landings for this functional unit since 1973 with a minimum and maximum of 178.7 t (in 1974) and 960.5 t (in 1978) respectively. Between 1987 and 2006 landings from FU14 appeared relatively stable fluctuating around a long-term average of about 550 t. The introduction of the Buyers and Sellers legislation in 2006 by the UK precludes direct comparison with previous years as reported levels are considered to have significantly improved. Over the period 2007–2020, landings have declined considerably from the peak year of 2007 (959 t); landings in 2020 were the lowest in the period (232 t). There were no reported discards in 2020 and discarding (15 t) has been estimated based on 2017 – 2019 rates.

Effort

Following discussions at WGCSE, it was concluded that effort should be reported in the WGCSE report in kWdays, and lpue should be reported in kg/kWdays in the knowledge that the trend is likely to be a biased underestimate because it is not adjusted for efficiency or behavioural changes. Effort calculations are likely to have been unreliable prior the introduction of the Buyers and Sellers legislation in 2006 by the UK and improvement in landings reporting.

Total UK and Irish targeted effort (70-99mm mesh with >30% *Nephrops* by weight) and lpue is reported in Table 3.8.3 and Figure 3.8.2. There has been a general decline in targeted effort across the available time-series and is now around the lowest recorded levels (although 2014 did see a small rise in effort compared to 2013).

Within the UK targeted métier, there are significant differences between sub-fleets and changes in fleet composition may therefore unduly influence catch rate metrics. These issues need to be examined further.

Sampling Levels

Sampling levels, data aggregating and raising procedures were reviewed by IBPNeph 2015, documented in the stock annex, and examined further at WGCSE 2018. Recent sampling levels have fluctuated; prior to 2016 sample data have only been available from landings into England, however since 2016 samples have also been available from landings into Northern Ireland. In 2020, there was no sampling activity from the fishery due to impact of the Covid-19 pandemic.

Commercial length–frequency distributions

The raised catch length distributions are shown in Figure 3.8.3. The mean sizes for both sexes from 2008 fluctuate considerably. For 2020, the mean size of individual *Nephrops* was estimated from the average of 2017-2019 values to be slightly lower than in 2019 and 2020 but higher than the record low of 2016.

Length composition

Between 2010 and 2012, sampling levels are considered insufficient to reliably characterise the length composition of extractions. Increased sampling levels from 2013 onwards have allowed for length compositions to be constructed. For 2013 and 2014, a full revision was done through an interbenchmark process (ICES, 2015; described in the stock annex). Data aggregating and raising procedures from 2015 to 2017 were conducted according to benchmark procedures (ICES, 2005) and referred in the stock annex. These were revised during WGCSE 2018 to account for Northern Irish sampling data since 2016 and are described further in the stock annex. No sampling activity was possible during 2020 due to the effects of COVID-19 pandemic and length composition data from 2017 to 2019 were again used to generate mean sizes.

Updated historical trends in length distributions and proportion discarded are shown in Figure 3.8.3 and Table 3.8.4. Discard selection curve estimates for the East Irish Sea shows a L50= 23.54 and a L25=24.77 mm CL (Figure 3.8.4), which shows a selectivity at higher sizes compared with FU15.

Mature females are mainly caught in the non-berried state between moulting, (which reaches its peak in May) and spawning (which is at its peak in September). Females mature at about 23 mm carapace length. (Thomas and José Figueiredo, 1965).

Sex ratio

The catch sex ratio by year is shown in Figure 3.8.5. The ratio is quite variable but average sex ratio is 56% male (1999–2019), the sex ratio for 2019 being slightly above this (62%). Sex ratio was not estimated in 2020.

Mean weight explorations

The annual mean weight estimate for landings and discards is provided in Table 3.8.4 and in Figure 3.8.6. There is a substantial difference between the mean weights prior to 2011 and after 2013 (the gap being where sampling was too low to be reliable). Since 2016, NI sampling has been included and the mean weight of NI samples is considerably lower than for English sampling (e.g. for 2017-2019, mean weight of landings from English sampling was 30.9 g compared to 15.2 in Northern Irish sampling). As a result, comparison with years prior to 2016 is not practical. Mean weights over the previous four years (2016–2019) have been variable without trend though mean weights were not estimated for 2020 due to no sampling.

Discarding

Discard selection was revised at the IBP process in 2015 (ICES, 2015) and described in the stock annex. Figure 3.8.4 shows a single discard ogive fitted by pooling all years (2003–2014) and mesh sizes. Final discard selection for the East Irish Sea shows a L50= 23.54 and a L25=24.77 mm CL (Figure 4.3.4), which shows a selectivity at higher sizes compared with FU15. Due to high inter-annual variation in mean sizes of both landings and discards, the discard ogive was not updated using 2015 to 2019 data.

Table 3.8.5 gives raised international landings and discard weight and numbers by year.

At IBPNeph (ICES, 2015), it was agreed that the discard survival rate should be updated from 0% to 10%. Although there are no direct survivability studies available for this area, it is expected that the survivability of discarded animals should be similar to the fishery in FU15 where fishing practices are similar and both are largely spring/summer fisheries and animals discarded are exposed to warmer temperatures before being returned to the sea.

Abundance indices from UWTV surveys

In August of 2007–2021 the UK and the Republic of Ireland carried out an underwater TV survey of the *Nephrops* grounds in the eastern Irish Sea. The survey is of a fixed grid design and is carried out using the same protocols used in UWTV surveys in the western Irish Sea (ICES, 2007; ICES, 2014). The survey stations used in 2021 are presented in Figure 3.8.7.

Due to the construction of the windfarm in the southern part of the ground the survey area was reviewed at IBP 2015 but the protocols and standardised process to run the survey were not modified (see stock annex and IBP 2015 report ICES, 2015). The new survey area (based on a co-kriging model) is shown in Figure 3.8.8. The boundary used to define the ground limits for absolute abundance runs close to the outer survey stations.

Ground	Area Km²	Source
Main ground 2008–2010	1032.75	WGCSE 2008
Main ground 2011–2019	1019.79	IBP 2015 – ICES, 2015
Wigtown Bay	67.21	IBP 2015 – ICES, 2015

Wigtown Bay in relation to Main ground = 6.6% * (increase from 1.9% prior to the windfarm construction).

Abundance indexes were revised back to 2011, the year where the effect of effort displacement is clearly visible due to the windfarm construction. Final updated abundance burrow density estimates are presented in Table 3.8.6 and visualised in Figure 3.8.9 where the geospatial model was updated using the new area based on the co-kriging approach (1019.79 km²) and the extrapolation to Wigtown Bay using 6.6%.

The abundance estimates for 2021 (393 million) is an decrease of 21% compared to the 2020 figure of 496 million (Figure 3.8.10) and 18% lower than the 2008–2020 average. The surveys show a clear spatial distribution pattern, with highest densities in the centre of the patch and more variable in the areas further north and south. The grounds are fairly well delineated by consistently low-density ground to the west (Figure 3.8.9), however the 2021 results demonstrated some higher densities to the east, suggesting this boundary may need further investigation. CVs over the entire time-series (Table 3.8.6) are within the accepted precision level of 20% (ICES, 2012).

The use of the UWTV surveys for the provision of *Nephrops* management advice was extensively reviewed by WKNEPH (2009). A number of potential factors were highlighted including those due to edge effects; species burrow misidentification and burrow occupancy. Using the same process adopted at WKNEPH, a cumulative absolute conversion factor for this FU was predicted to be 1.2 for FU14 (see stock annex) which means the TV survey is likely to overestimate *Nephrops* abundance by 20%. The burrow abundances shown in Table 3.8.5 and Figure 3.8.9 have been adjusted using this conversion factor since 2008.

In 2021, a new survey camera system was implemented using high-resolution stills-based footage, generally resulting in improved picture and burrow definition. Comparison of the old and new systems in Functional Unit 16 has shown no significant difference in density estimates and previous assumptions relating to correction factors are still applied.

15.4 Assessment

Comparison with previous assessments

WGCSE 2021 carried out an UWTV based assessment for this stock, using the 2021 UWTV survey, however uses the same three-year average (2017–2019) for weights and discarding rates as the 2020 assessment. due to no sampling from the fishery in 2020. The methods used were otherwise in line with WKNEPH (ICES, 2009) and the approach taken for other *Nephrops* stocks in 6 and 7 by WGCSE. This approach was interbenchmarked at IBPNeph (ICES, 2015) and is described in the stock annex.

State of the stock

UWTV abundance estimates suggest that the stock size has fluctuated between abundance values of 350 and 694 million *Nephrops*. The 2021 estimate (393 million) decreased by 21% in relation to 2020 and is above the MSY $B_{trigger}$ (350 million).

Table 3.8.5 and Figure 3.8.11 summarise the abundance estimated including the confidence intervals and the harvest ratios (% dead removed / UWTV abundance) which have been above the F_{MSY} proxy.

15.5 Catch scenarios table

Catch scenarios table inputs and historical estimates of mean weight in landings and harvest ratios are presented in Table 3.8.5 and summarised below. The calculation of catch options for the FU14 follows the procedure outlined in the stock annex. The basis for the catch options:

Variable	Value	Notes
Stock abundance (2021)	393	Number of individuals (millions); UWTV 2021
Mean weight in projected landings	20.43	Average 2017–2019 in grammes
Mean weight in projected discards	9.23	Average 2017–2019 in grammes
Projected discards	12.27%	Percentage by number; average 2017–2019
Discards survival*	10%	Percentage by number
Dead projected discards	11.18%	Percentage by number; average 2017–2019

***Only applied in scenarios where discarding is allowed.**

15.6 Reference points

Reference points were defined for this stock at the IBPNeph (ICES, 2015) and proposals for F_{MSY} ranges made by WKMSYRef4 (ICES, 2016a; 2016b).

Based on the fact that some biological parameters are poorly known; inconsistent biological sampling; uncertainties about the stability of the stock over the reference period and uncertainties about the variability of recruitment it is expected that a combined sex $F_{0.1}$ is a suitable F_{MSY} proxy for this stock. This corresponds to a harvest rate of 11% and this value is expected to deliver high long-term yield with a low probability of recruitment overfishing. These calculations assume that the UWTV survey has knife-edge selectivity at 17 mm and that the supplied length frequencies represented the population in equilibrium. Currently this fishery is being harvested at 2.92% (Fsq_2018–2020 = 2.92%; F2020 = 2.58%), and historically the available data show a maximum harvest rate of 8.2% in 2008 which is below the F_{MSY} proxy.

At the IBPNeph, a MSY $B_{trigger}$ was defined for this stock. According with this definition, $B_{trigger}$ was set for FU14 as 350 million, corresponding to the lowest observed abundance estimate from the UWTV time-series, which occurred in 2009.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	350 million individuals	The lowest observed abundance estimate from the UWTV survey time-series.	ICES (2015)
	F_{MSY}	11% harvest rate	F_{MSY} proxy equivalent to $F_{0.1}$ for combined sexes.	ICES (2015)
	F_{MSY} lower	9.1% harvest rate	Average of the F at 95 % of the YPR obtained at the F_{MSY} proxy reference point	ICES (2016b)
	F_{MSY} upper	11% harvest rate	Average of the F above F_{MAX} that leads to YPR of 95 % of the maximum; capped at F_{MSY}	ICES (2016b)

15.7 Management strategies

There are no explicit management strategies for this stock.

The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to Norway lobster (*Nephrops norvegicus*) by functional unit in ICES Subarea 7 and also demersal stocks. The plan specifies conditions for setting fishing opportunities, depending on stock status and making use of the F_{MSY} ranges.

15.8 Quality of assessment and forecast

The quality of landings data has improved since 2012, but concerns over the accuracy of earlier years limits the period we can be confident about regarding trends in lpue and landings.

Underwater TV surveys have been conducted annually for this stock since 2007. The quality of the data from the first survey and the limited number of valid stations in the survey limits the number of useable surveys to 2008–2021.

In 2021, the survey camera system and reviewing method changed. Previous assumptions relating to correction factors are still applied. Comparison of the old and new systems in Functional Unit 16 has shown no significant difference in density estimates.

The revised algorithm used to derive distance covered by the sledge is considered as significantly more robust than the previous algorithm.

The IBP 2015 managed to address key points:

- Revisions to the area of the *Nephrops* grounds based on new available data: VMS, UWTV data and sediment information.
- A review of fishery data and raising procedures.
- Review of Reference points: F_{MSY} proxies and MSY $B_{trigger}$.

After this revision the quality of the assessment improved. Although there are still specific uncertainties and assumptions that need to be examined further for the East Irish Sea before less conservative F_{MSY} proxies could be considered.

There are several key uncertainties and bias sources in the method proposed (these are discussed further in ICES, 2009a). Various agreed procedures have been put in place to ensure the quality and consistency of the survey estimates following the recommendations of several ICES groups (ICES, 2007; ICES, 2008; ICES, 2009b). Taking explicit note of the likely biases in the surveys may at least provide an estimate of absolute abundance that is more accurate but no more precise (ICES, 2009a).

The cumulative absolute conversion factor estimates for FU14 are largely based on expert opinion. However, these were based on experience on other grounds and relatively limited experience on these grounds which would make this less reliable. The precision of these cannot yet be characterised. Ultimately there still remains a degree of subjectivity in the production of UWTV abundance estimates.

The effect of this assumption on realised harvest rates has not been investigated but remains a key uncertainty.

15.9 Recommendation for next benchmark

This stock was last benchmarked by IBPNeph (ICES, 2015). WGCSE will keep the stock under close review and recommend future benchmark as required.

At IBP 2015, it was mentioned that there are specific uncertainties and assumptions that need to be examined further for the East Irish Sea before less conservative F_{MSY} proxies could be considered.

- More accurate mapping of the spatial extent of the grounds and fisheries, this includes having positional data for <12 metre vessels and more survey data in Wigtown Bay area to better define this ground. Station grid was extended to Wigtown Bay in 2016.
- For now the total abundance estimate for FU14 is based on the abundance estimates of the geospatial model for the main ground plus adding the area of Wigtown Bay. As this area is becoming a more significant fishing patch it is worth to consider the use of a separate geospatial model in this ground. This should be explored in a future benchmark work.
- Improvement of spatial coverage and sampling of landings and discards, this includes increasing the sampling levels to cover Northern Irish vessels. Northern Irish sampling has been included in the assessment since 2018
- Area specific length–weight and maturity data to validate the parameters used for this FU.
- Better knowledge of the difference in growth and population structure across the area.
- If following the current advice, the recommended catches are taken, then the stock may decrease to well below MSY $B_{trigger}$ in the short term. The basis for setting MSY $B_{trigger}$ is currently from recent history may be too high, it could also be due to recent low recruitment (transitory issue) or that the F_{MSY} is too high. As such, the $MSY_{trigger}$ reference point needs to be looked into. It was noted that the basis for MSY $B_{trigger}$ was the recent history and that the value may be too high.
- Advice is compiled for ADGNEPH in October. Lagged (one year) TV survey gives good correlation with lpue, could this be used to calculate harvest rate rather than the in-year ratio?

15.10 Management considerations

ICES and STECF have repeatedly advised that management should be at a smaller scale than the ICES division level. Management at the Functional Unit level could allow effort and catch to be controlled in line with the scale of the resource.

There are no explicit recruitment indices.

The UWTV survey data allow for the provision of catch options and also to adopt the MSY approach. The UWTV surveys are conducted annually and a benchmark process has been adopted in 2015. In the past this stock has only been assessed biannually. These data provide the opportunity to reassess this stock more reliably on an annual basis.

15.11 References

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Table 3.8.1. Irish Sea: Landings (tonnes) by FU, 2000–2020; 2019* and 2020* refers to preliminary landings data. In 2012 and 2013 landings outside FU for Area 7a were not provided, so have been calculated from ICES official landings for 7a minus the FU areas.

YEAR	FU14	FU15	OTHER	TOTAL
2000	567	8370	1	8938
2001	532	7441	3	7976
2002	577	6793	1	7371
2003	376	7052	3	7431
2004	472	7267	25	7764
2005	570	6554	103	7227
2006	628	7561	52	8241
2007	959	8491	83	9533
2008	676	1050	122	11306
2009	708	9198	57	9963
2010	582	8963	23	9568
2011	561	10162	61	10784
2012	531	10527	208	11266
2013	495	8672	89	9256
2014	679	8613	NA	9292
2015	378	8632	NA	9010
2016	237	7327	9	7564
2017	265	6149	0	6414
2018	268	5756	0	6024
2019*	270	7590	4	7864
2020*	232	6115	7	6354

Table 3.8.2. Irish Sea East (FU14): Landings (tonnes) by country of landing and total discards, 2000–2019.

Year	Rep. Of Ireland	UK	Other Countries	Total Landings	Discards
2000	114	451	2	567	80
2001	26	506	0	532	42
2002	203	373	1	577	42
2003	69	306	1	376	11
2004	62	409	1	472	28
2005	34	536	0	570	33
2006	34	594	0	628	22
2007	86	873	0	959	47
2008	29	652	0	681	37
2009	16	692	0	708	6
2010	45	538	0	583	9
2011	31	530	0	561	0
2012	53	478	0	531	0
2013	35	460	0	495	38
2014	31	648	0	679	35
2015	88	290	0	378	18
2016	21	216	0	237	20
2017	7	258	0	265	28
2018	5	263	0	263	9
2019	9	260	0	270	15
2020	23	209	0	232	15*

*** Based on 2017-2019 discard rates**

Table 3.8.3. Irish Sea East (FU14): Effort data for the UK and Irish trawl *Nephrops* directed fleet.

	UK direct fleet			**Irish direct fleet**		
YEAR	EFFORT (KW DAYS)	LANDINGS (TONNES)	LPUE	EFFORT (KW DAYS)	LANDINGS (TONNES)	LPUE
2006	343,249	577.2	1.7	6,932	18.3	2.8
2007	443,319	854.4	1.9	25,309	79.2	3.1
2008	366,696	628.9	1.7	8,136	14.9	1.9
2009	354,210	680.1	1.9	5,516	13.1	2.5
2010	296,097	527.3	1.8	13,496	44.6	3.3
2011	252,607	525.7	2.1	8,955	29.7	3.6
2012	215,851	452.4	2.1	21,224	52.8	2.6
2013	210,108	445.1	2.1	11,304	35.5	3.1
2014	279,606	636.8	2.3	10,259	28.5	2.8
2015	132,751	275.7	2.1	27,128	83.7	3.1
2016	109,449	214.9	2.0	9,496	21.2	2.2
2017	101,657	252.4	2.5	2,620	6.7	2.6
2018	113,740	245.8	2.2	3,042	5.2	1.7
2019	94,606	248.1	2.6	3,591	8.7	2.4
2020	61,747	203.1	3.3	7,660	22.9	3.0

Table 3.8.4. Irish Sea East (FU14): Mean size (CL) and weight combined by sex for total annual landings and discards and proportion discarded.

Year	Mean CL (mm) Landings	Mean CL (mm) Discards	Mean Weight (g) Landings	Mean Weight (g) Discards	Proportion discarded
2000	29.83	22.32	19.05	7.52	0.26
2001	30.59	22.74	20.87	7.97	0.17
2002	30.64	23.75	22.41	8.98	0.15
2003	33.69	22.43	29.12	7.62	0.10
2004	31.01	22.24	21.93	7.57	0.15
2005	30.74	23.16	21.48	8.44	0.13
2006	32.36	22.75	25.07	7.98	0.10
2007	31.81	21.92	23.94	7.33	0.14
2008	31.07	23.14	22.88	8.49	0.13
2009	35.57	23.21	36.49	8.58	0.04
2010*					
2011*					
2012*					
2013	30.14	22.43	19.94	7.87	0.16
2014	31.01	24.34	22.37	9.60	0.11
2015	32.05	22.57	25.19	7.82	0.13
2016 **	27.39	23.11	15.82	8.38	0.14
2017	29.05	24.07	18.97	9.50	0.18
2018	30.58	24.46	21.39	9.78	0.07
2019	29.49	22.90	20.93	8.40	0.12
2020 ***	29.71	23.81	20.43	9.23	0.12

*** Values for 2010, 2011 and 2012 are not reliable due to poor sampling.**

**** Values for 2016 revised at WGCSE 2018 due to inclusion of Northern Irish sampling in 2016 and 2017.**

***** Values for 2020 are based on 2017-2019 averages**

Table 3.8.5. Irish Sea East (FU14): Sumary table for forecast inputs (current used shaded in blue) and historical estimates of raised landings and discards, mean weight in landings and harvest rate.

Year	Landings in number millions	Total discards in number millions	Removals in number millions	Dead Discard Rate number %	Discard Rate number %	UWTV abundance estimate millions	95% Confidence Interval	Harvest rate %	Landings tonnes	Total discards* tonnes	Mean weight in landings gramme	Mean weight in discards gramme
2000	30	11	40	24.4	26.4				567	80	19.05	7.52
2001	26	5	31	15.5	17.0				532	42	20.87	7.97
2002	26	5	30	14.1	15.4				577	42	22.41	8.98
2003	13	1	14	9.0	9.9				376	11	29.39	7.64
2004	22	4	25	13.5	14.8				472	28	21.93	7.57
2005	275	4	30	11.8	13.0				570	33	21.48	8.44
2006	25	3	28	9.2	10.1				628	22	25.07	7.98
2007	40	6	46	12.5	13.8				959	47	23.94	7.33
2008	30	4	34	11.6	12.7	408	63	8.2	676	37	22.88	8.49
2009	19	1	20	3.3	3.7	350	76	5.7	707	6	36.49	8.58
2010						422	103		582			
2011						449	99		561			
2012						694	99		531			
2013	25	5	30	15.0	16.4	487	82	6.0	495	39	19.94	7.87
2014	30	4	34	9.8	10.8	449	92	7.5	679	32	22.37	9.60
2015	15	2	17	11.9	13.0	591	86	2.9	378	18	25.19	7.82
2016*	15	2	17	12.4	13.6	430	106	4.0	237	20	15.82	8.38
2017	14	3	17	16.2	17.6	580	89	2.9	265	29	18.97	9.50
2018	12	1	13	6.3	6.9	514	118	2.6	263	9	21.39	9.78
2019	13	2	14	11.1	12.2	399	69	3.6	270	15	20.93	8.40
2020 **	11	2	11	11.2	12.3	496	84	2.6	232	15	20.43	9.23

Note: Abundance is adjusted by using a cumulative absolute conversion factor of 1.2. Abundance (millions) including Wigtown Bay (1.9% 2008–2010; 6.6% 2011–2019). Due to poor sampling no estimates for 2010–2012.

*** Values for 2016 revised at WGCSE 2018 due to inclusion of Northern Irish sampling in 2016 and 2017.**

**** Removals for 2020 calculated using 2020 landings and unweighted average of mean weights from 2017-2019**

Table 3.8.6. ***Nephrops*****, Irish Sea East (FU14): Results of the 2008–2020 TV surveys (values adjusted for bias).**

Year	No valid stations	Mean Kriged density (no./m²)	Abundance (millions) including Wigtown Bay (1.9% 2008–2010)	Abundance (millions) including Wigtown Bay (6.6% 2011–2018)	95% CI	CV
2007			Unreliable data			
2008	32	0.38	408		63	
2009	32	0.33	350		76	
2010	26	0.4	422		103	
2011	26	0.41		449	99	11.2%
2012	26	0.64		694	99	7.3%
2013	31	0.45		487	82	8.5%
2014	34	0.41		449	92	10.4%
2015	42	0.54		591	86	7.4%
2016	48	0.40		430	106	12.6%
2017	45	0.53		580	89	7.8%
2018	46	0.47		514	118	11.7%
2019	41	0.37		399	69	9.3%
2020	43	0.46		496	84	8.6%
2021	44	0.36		393	78	10.1%

Note: Abundance is adjusted by using a cumulative absolute conversion factor of 1.2. Abundance (millions) including Wigtown Bay (1.9% 2008–2010; 6.6% 2011–2020).

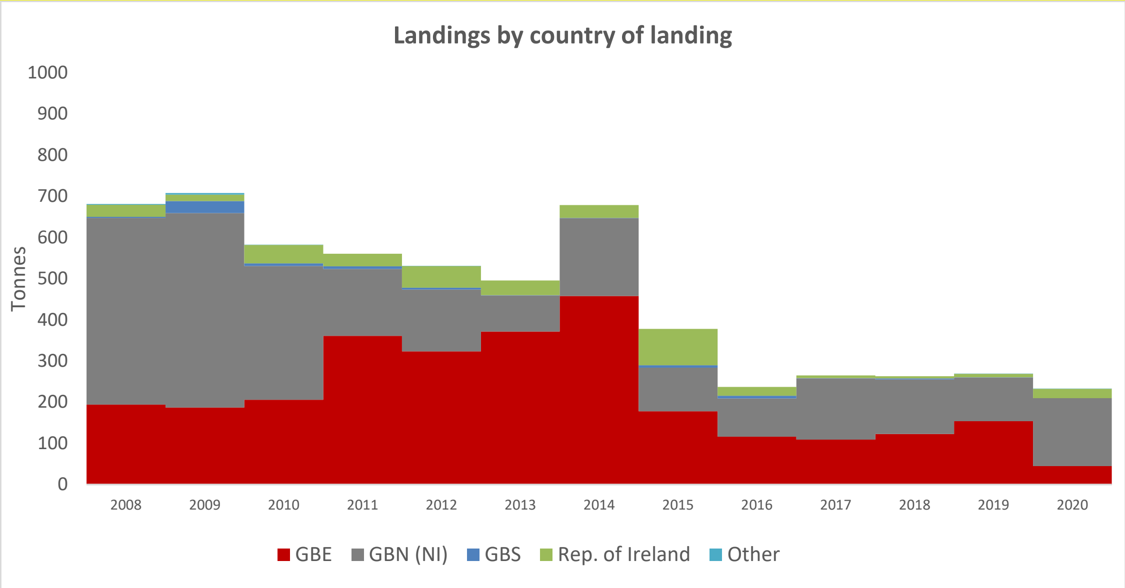


Figure 3.8.1. Irish Sea East (FU14): Landings in tonnes by country. GBE=England; GBN=Northern Ireland; GBS=Scotland; Rep. of Ireland=Republic of Ireland.

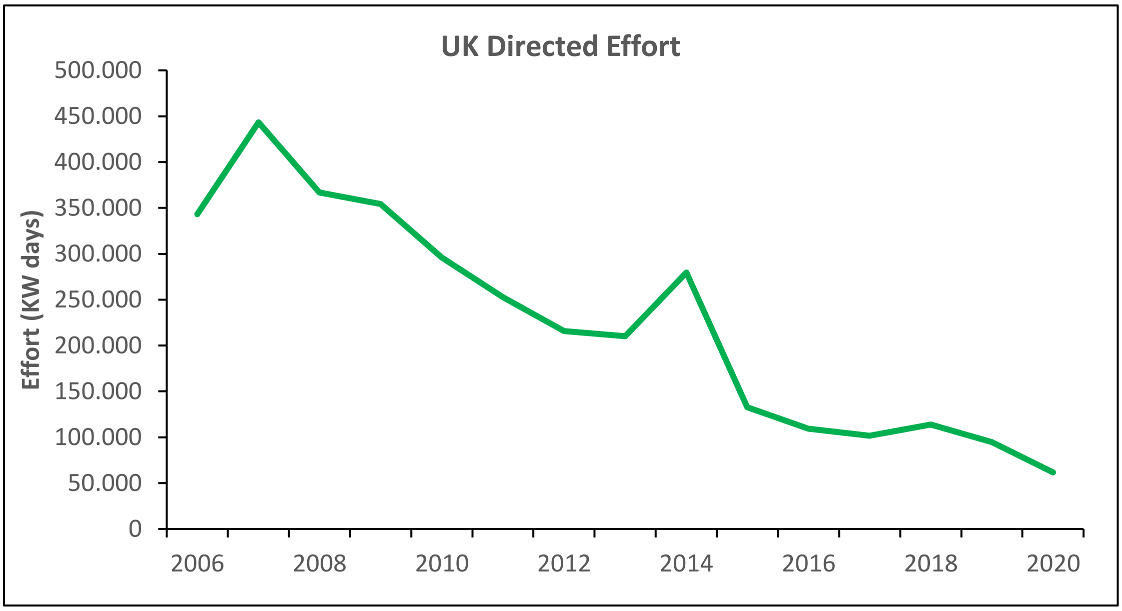


Figure 3.8.2. Irish Sea East (FU14): Effort data (KW days) for UK directed *Nephrops* fleet.

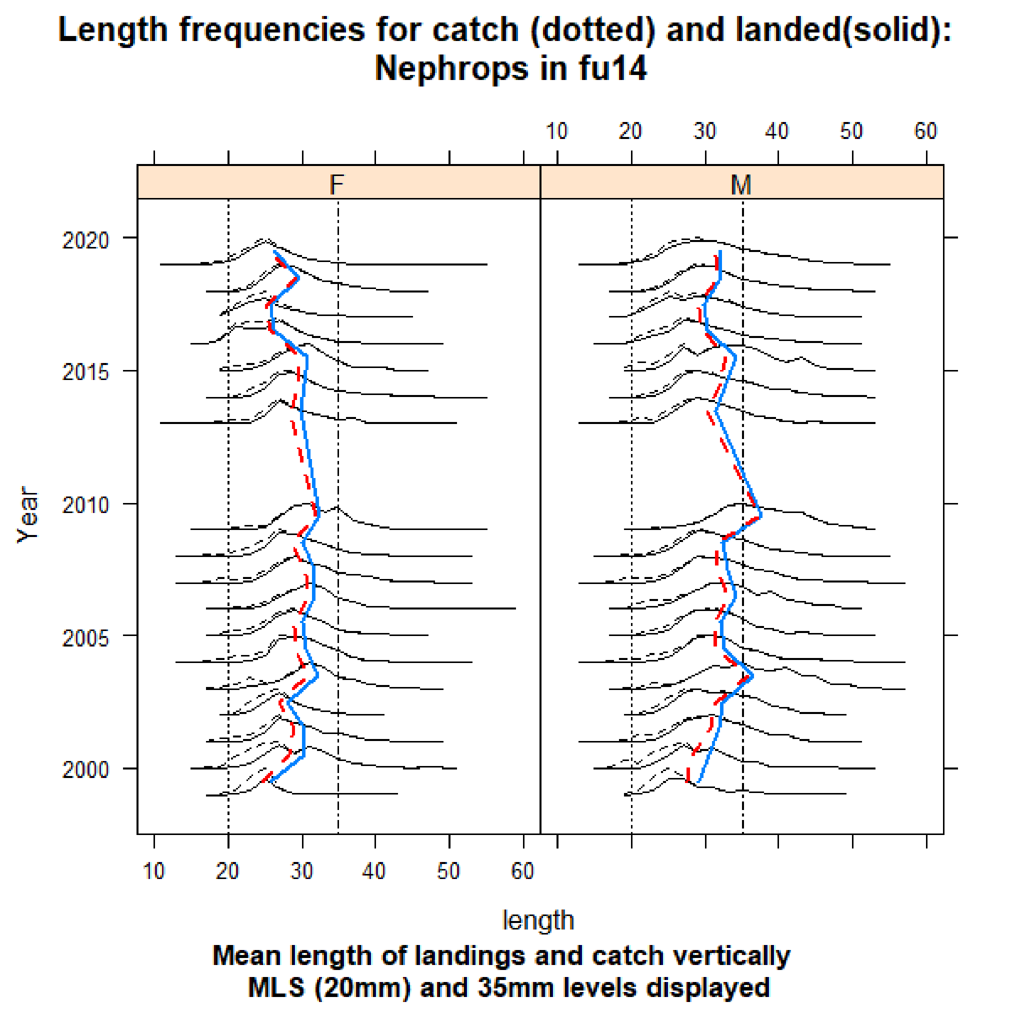


Figure 3.8.3. Irish Sea East (FU14): Length distribution of landings (solid lines) and catch (dotted lines), 2000–2020. Length frequencies for 2010–2012 are based in very poor sampling so not reliable. No sampling was carried out in 2020. Figure shows a vertical display of MLS (20 mm CL) and 35 mm CL levels.

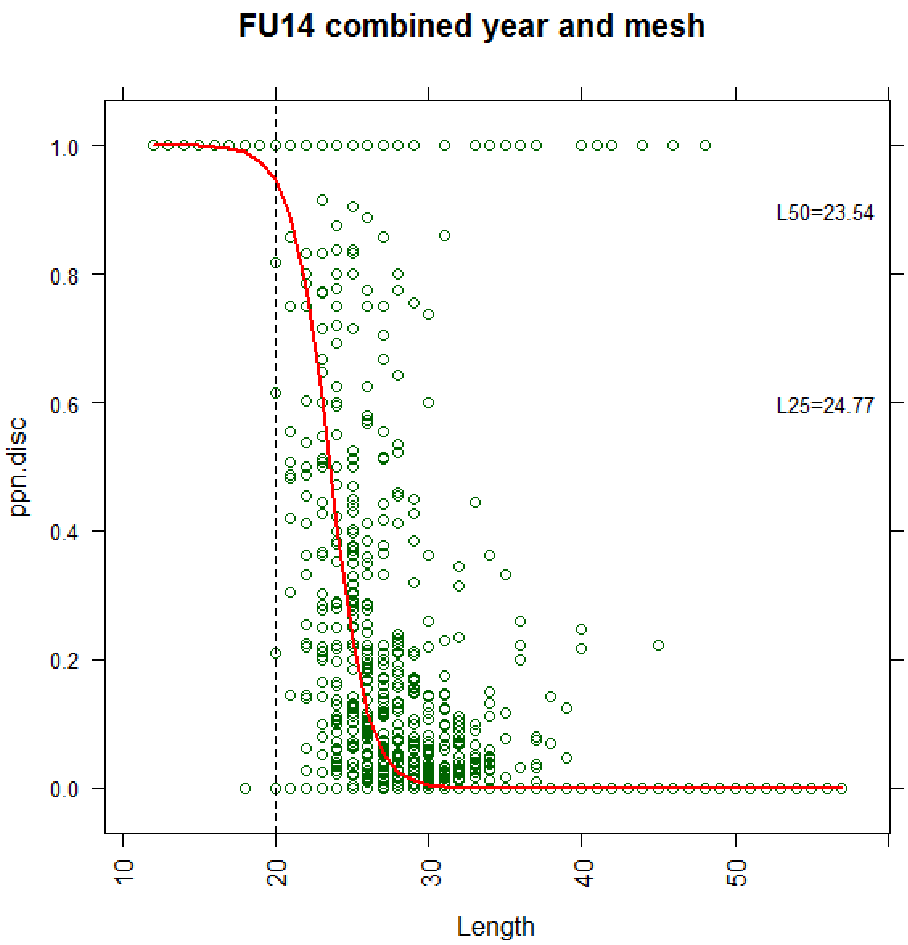


Figure 3.8.4. Irish Sea East (FU14): Final discard ogive pooled for all years (2003–2014) and mesh sizes. L50=23.54 and L25=24.77, (IBPNeph 2015).

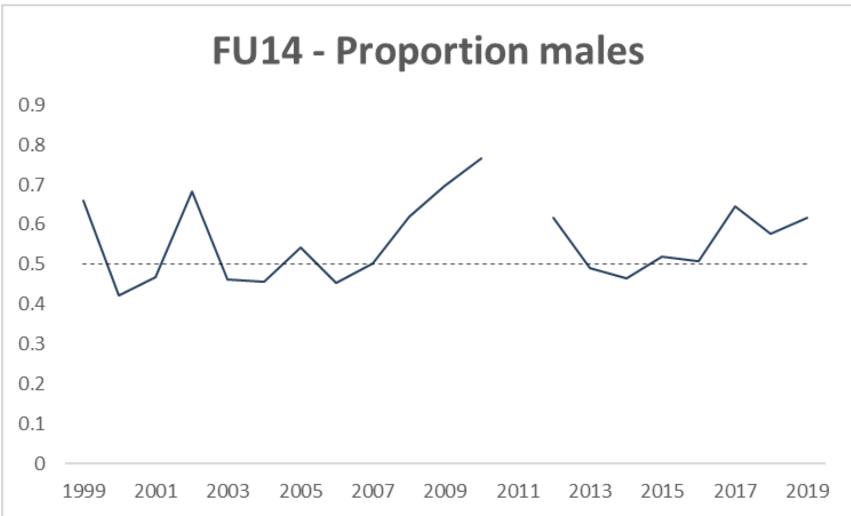


Figure 3.8.5. Irish Sea East (FU14): Proportion of males in catch since 1999. Between 2010 and 2012 due to poor sampling levels estimates of sex ratio are not reliable. No sampling was carried out in 2020

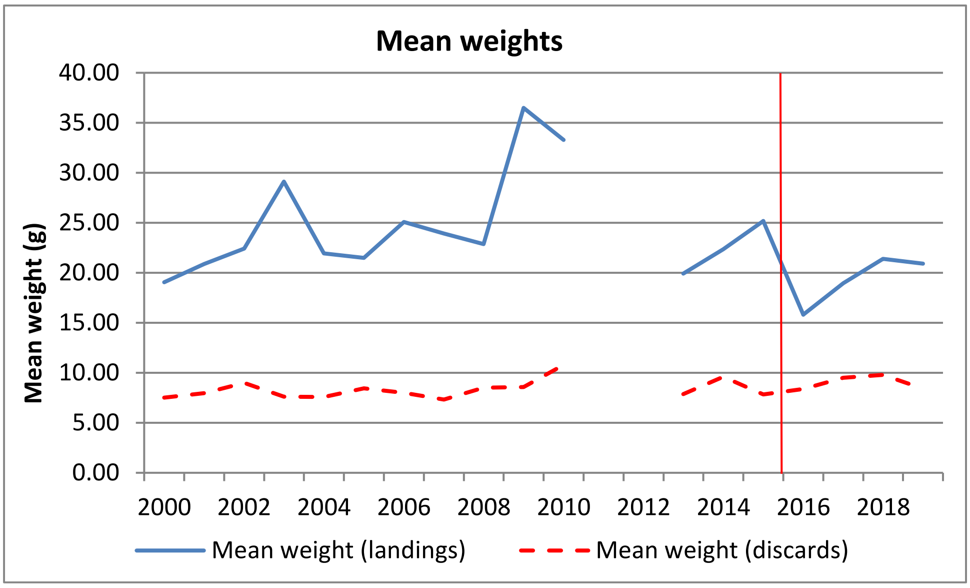


Figure 3.8.6. Irish Sea East (FU14): Mean weight (g) combined by sex for total annual landings and discards. Values for 2010, 2011 and 2012 are not reliable due to poor sampling. NI sampling included from 2016. Average of 2017-2019 sampling used for 2020

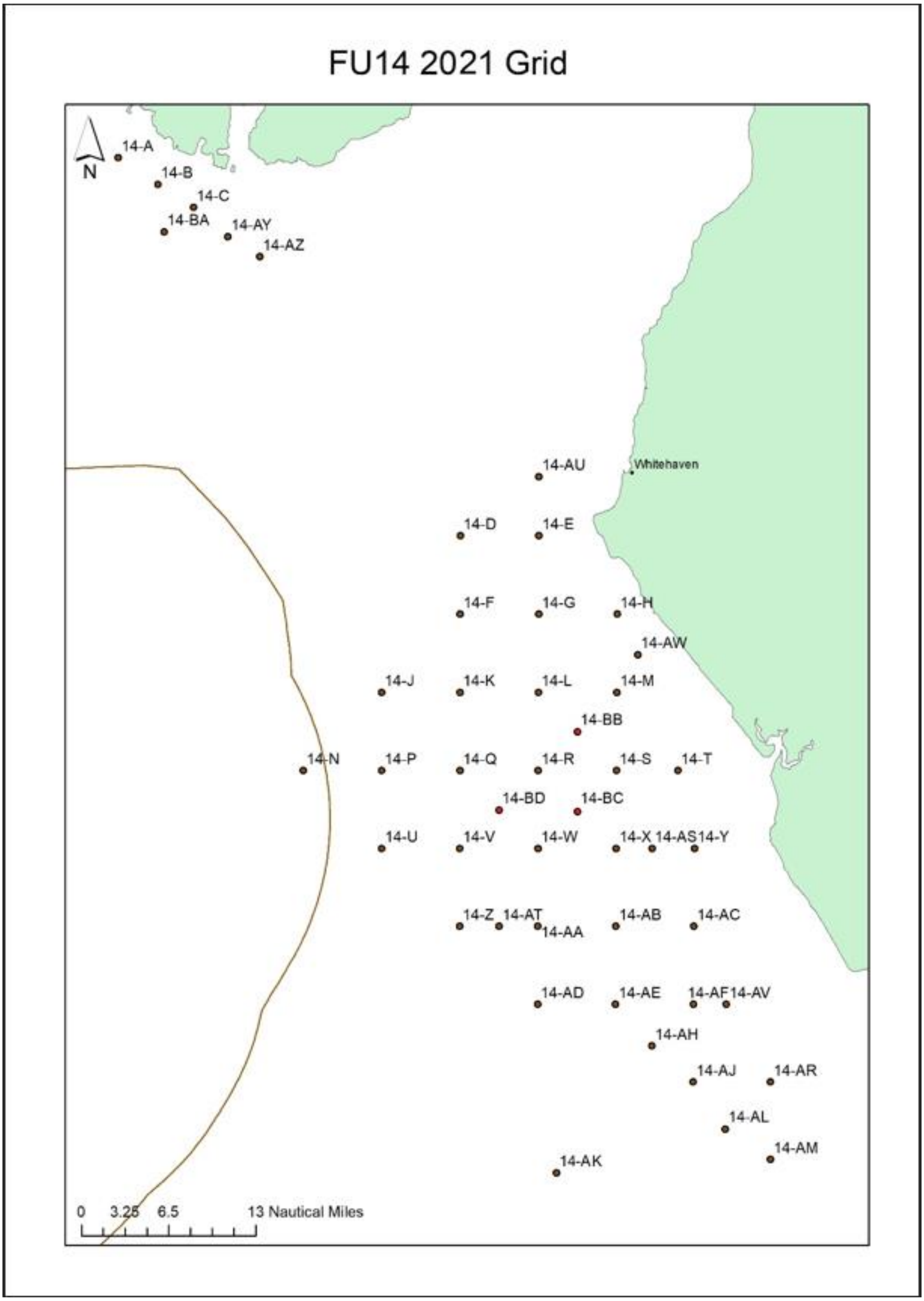


Figure 3.8.7. Irish Sea East (FU14): UWTV Survey stations for 2021 (Note: 14-BB, 14-BC, 14-BD were not completed this year).

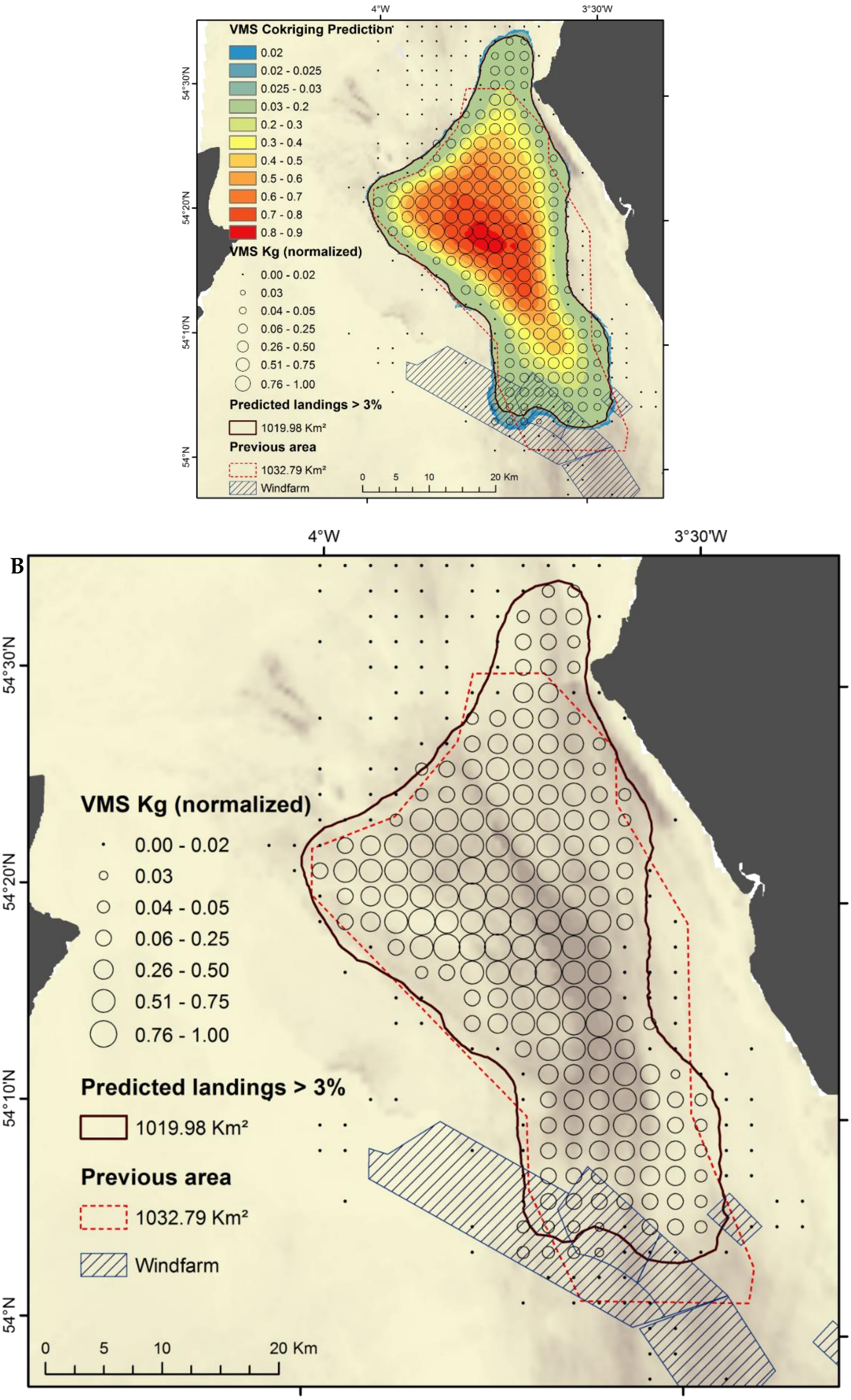
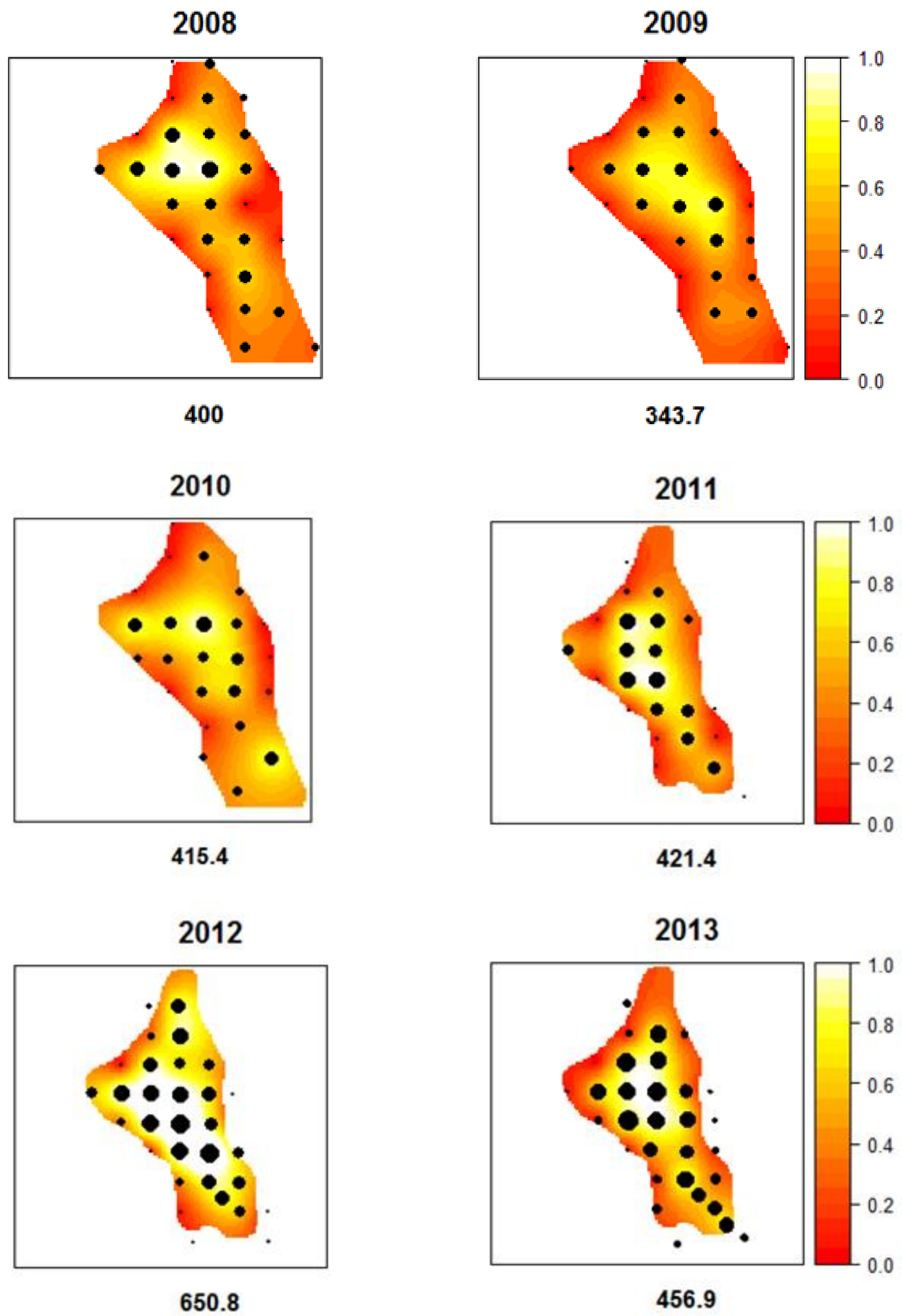
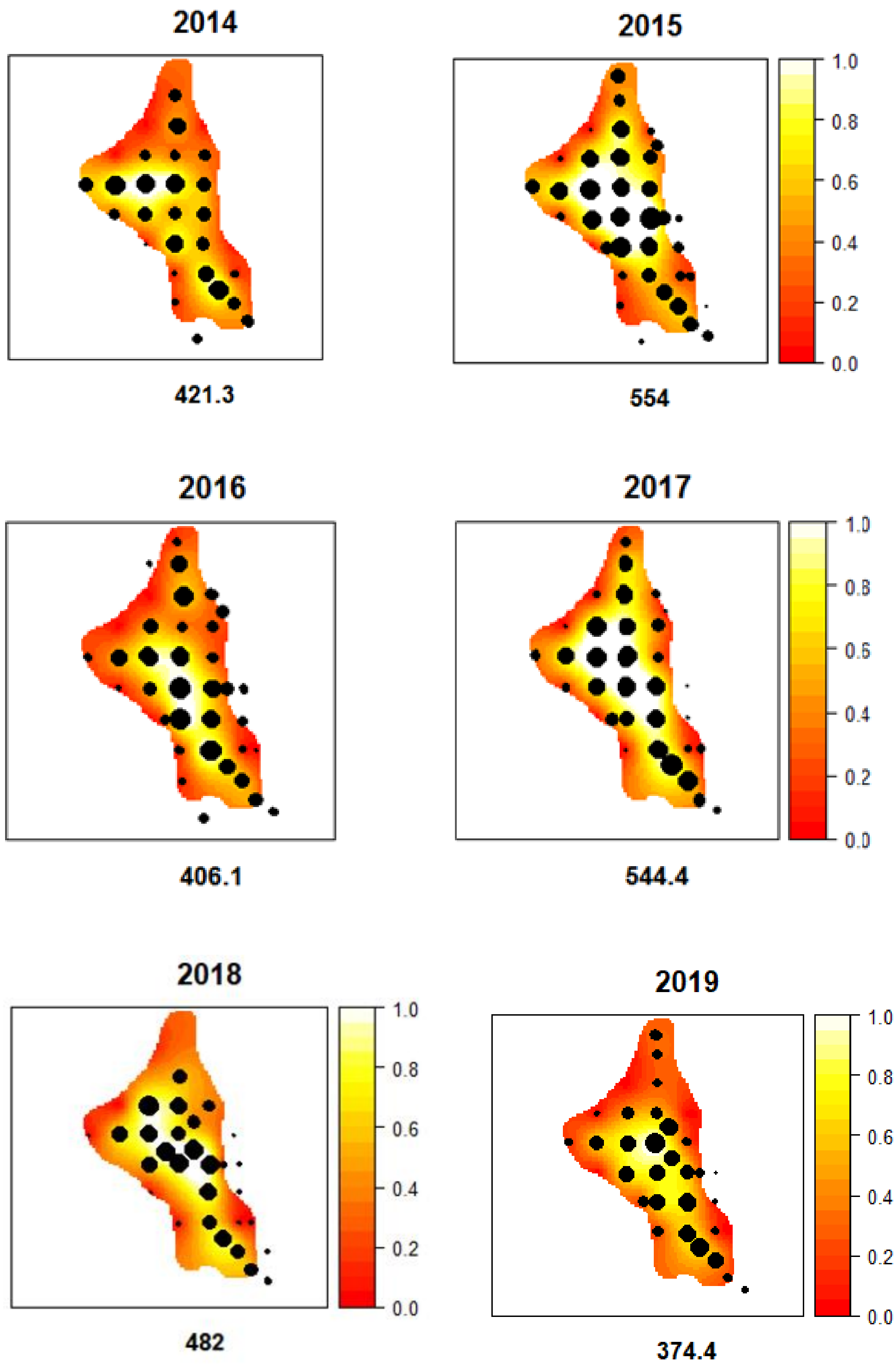


Figure 3.8.8. Irish Sea East (FU14): Co-kriging approach. Interpolation result of VMS (cut off 3%), survey density (2013–2015) data and mud distribution. A - model output; B - final polygon.


2008
400
2009
343.7
1.0
0.8
0.6
0.4
0.2
0.0
2010
415.4
2011
421.4
1.0
0.8
0.6
0.4
0.2
0.0
2012
650.8
2013
456.9
1.0
0.8
0.6
0.4
0.2
0.0


2014
421.3
2015
554
1.0
0.8
0.6
0.4
0.2
0.0
2016
406.1
2017
544.4
1.0
0.8
0.6
0.4
0.2
0.0
2018
482
1.0
0.8
0.6
0.4
0.2
0.0
2019
374.4
1.0
0.8
0.6
0.4
0.2
0.0

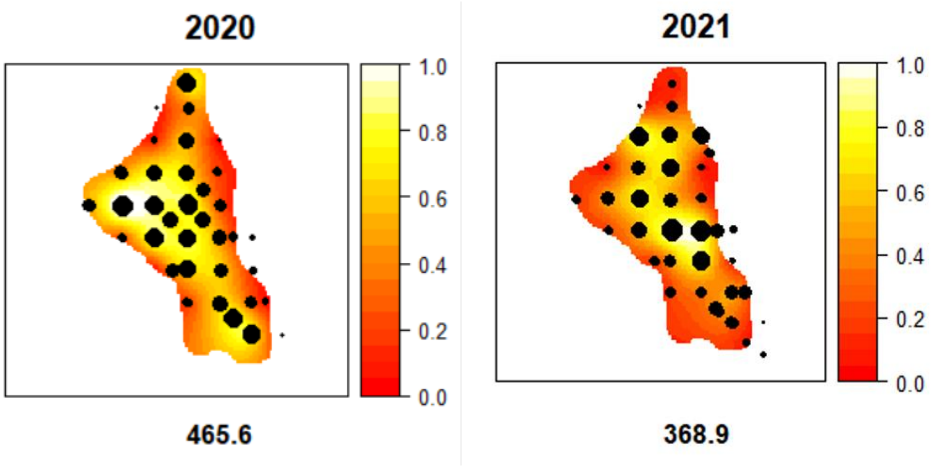


Figure 3.8.9. Irish Sea East (FU14): Burrow density estimates from the UWTV Survey 2008–2020 (individuals / m².) Abundance estimates (millions) given at the bottom of each plot are adjusted with the cumulative absolute conversion factor (but does not contain the additional area for Wigtown Bay). Area of ground = 1032.75 Km² for 2008–2010 and 1019.79 Km² for 2011–2020.

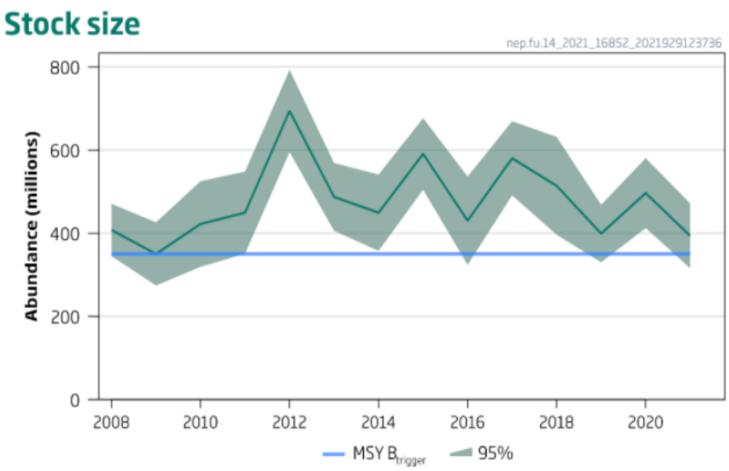


Figure 3.8.10. Irish Sea East (FU14): Burrow density estimates from the UWTV Survey 2008–2020. $B_{trigger}$ set as 350 million (orange dashed line).

Figure 3.8.11. Irish Sea East (FU14): Harvest Rate (% dead removed/UWTV abundance). The dashed and solid lines are F_{MSY} proxy (11%) and the harvest rate respectively. Between 2010 and 2012 due to poor sampling levels harvest rate estimates are not reliable.

16 Norway lobster (*Nephrops norvgicus*) in Division 7.a, Functional Unit 15 (Irish Sea, West)

Type of assessment

The assessment and provision of advice through the use of the UWTV survey data and other commercial fishery data follows the general process defined by WK*NEPH* (2009) described in the stock annex. The TV survey is due to be repeated in summer 2021 and the new survey will form the basis of advice for this stock in autumn.

ICES advice applicable to 2021

"ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 7965 tonnes and 11691 tonnes, assuming recent discarding rates. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit (FU) 15 is exploited sustainably, management should be implemented at the functional unit level."

16.1 General

Stock description and management units

The Irish Sea West (FU15) is comprised of ICES rectangles 35E3–E5, 36E3–E5, 37E3–E5 and 38E4 within 7a. It is included in ICES Area 7 together with the Irish Sea East (FU14), Porcupine Bank (FU16), Aran Grounds (FU17) northwest Irish Coast (FU18), southeast and southwest Irish Coast (FU19), NW Labadie, Baltimore and Galley, and Jones and Cockburn (FU20-21) and the Smalls (FU22).

A TAC is in place for ICES Area 7 which does not correspond to the assessment units. As *Nephrops* are limited to muddy habitats the distribution of suitable sediment defines the species distribution and the stocks are therefore assessed as seven separate Functional Units. The TAC for Area 7 is shown in the tables section.

Fishery description

The FU 15 *Nephrops* fishery first developed in the late 1950s. The environment in the Western Irish Sea is very suitable for *Nephrops*, with a large mud patch and a gyre that retains the larvae over the mud patch, thus ensuring good recruitment. The ground can be characterized as an area of very high densities of small *Nephrops*. Northern Ireland and Ireland are the main countries involved in the FU15 *Nephrops* fishery.

The fishery in 2019

The *Nephrops* fishery in the Irish Sea west is economically the most important in ICES Division 7.a and is mainly prosecuted by vessels from UK (Northern Ireland) and Ireland. Working Group landings from FU15 are presented in Table 16.1 and Figure 16.1. Total declared international *Nephrops* landings reported from FU15 in 2020 was 6115 t, which was a decrease increase from 2019 but considered likely to reflect behavioural change due to COVID-19 pandemic (Table 16.1). There has been a trend for Irish, since 2012, and more recently Northern Irish vessels to switch to multi (quad) rig trawls. Provisional data suggest a ~30% increase in *Nephrops* catch rates and a reduction in fish bycatch of ~30% due to the lower headline height. Since March 2012, it is mandatory for all Irish vessels to use specified species selective gears. Similar conditions have been introduced in October 2012 for the UK (Northern Ireland) vessels. In 2019 there was small increase in LPUE in 2019 for Northern Irish vessels whereas the LPUE for Irish vessels remained stable (Table 16.2).

Further general information on the fishery can be found in the stock annex.

Information from stakeholders

No information from stakeholders.

16.2 Data

Commercial size composition data for landings and discards were provided by Northern Ireland and Ireland. Other biological data used in the assessment were as listed in the stock annex compiled by the Benchmark meeting WK*NEPH* (2009).

InterCatch

Data were available in InterCatch and used to derive assessment input data.

Landings

Working Group landings from FU15 are presented in Table 16.1 and Figure 19.1. Total declared international *Nephrops* landings reported from FU15 in 2019 was 6115 t. Landings are derived primarily from Ireland and Northern Ireland. In 2020 there was significant impact of COVID-19 on the behaviour of fishers due to movement and social restrictions as well as market changes due to changing levels of demand.

Effort

Effort by the UK fleet remained relatively stable since 2002 following a steady decline from the early 1990s. There was a further marginal reduction in effort and lpue time-series for Ireland (Table 16.3) compared to 2016, with effort at the lowest reported value in the series. In previous years these interannual fluctuations have been attributed to the high mobility and flexibility, in terms of fishing in other areas within the TAC area, whereas the Northern Irish effort is mostly concentrated on FU15. Fishing activity from the Irish fleet in FU15 increasingly concentrates on good fishing periods during the year, resulting in a larger and increasing lpue. The lpue and effort lpue series for Northern Ireland are updated to provide kW days (kWd) and lpue as kg/kWd. A change to e-logbooks and recording of fishing hours after 2013 means that the recent data are not comparable with the historic series. Recent lpue and effort after 2013 has remained stable. The lpue for the Northern Irish and Irish fleets in 2020 were similar x.xx kg/kWd and x.x kg/kWd but both increases since 2018 from 2.56 kg/kWd and 2.7 kg/kWd.

Sampling levels

Sampling of catches was affected by COVID-19, with cessation of sampling in the second quarter. Sampling resumed and achieved high levels in the third and fourth quarter. Fisher self-sampling for Northern Irish vessels achieved 63 samples collected from the reference fleet, with 35, 0, 15 and 13 samples in quarters 1–4 respectively. The number of discard and catch samples collected from the Irish fleet was five, one, ten and two samples collected in quarters 1–4 respectively. These rates correspond to one sample per 71.4 t landed by the Northern Irish fleet and one sample for every 97.0 t landed by the Irish fleet. Sampling levels due to changes in the schemes to adapted to COVID-19 impacts on working and social distancing requirements.

Commercial length–frequency distributions

Length and sex compositions of *Nephrops* landed from the Irish Sea West are estimated from port sampling by Ireland and Northern Ireland. Sampling of Northern Ireland catches was not possible during 2003–2007, with the Irish length frequencies raised to the international catch for these years. Northern Ireland sampling resumed in 2008 and these data are combined with those from Ireland for that year.

This Northern Irish fisher self-sampling scheme uses a reference fleet of vessels selected vessels from the main Northern Irish ports. The reference vessels selection is designed to be representative of the entire fleet with systematic rota sampling. The mean sizes of *Nephrops* in the catches of both the Northern Ireland and Ireland fisheries have fluctuated for the last decade (Tables 19.4–19.5; Figure 16.1). There is little evidence to suggest a long term trend in the mean size of males and females in the landings and catches which continues to fluctuate around the series mean (Figure 16.2).

Sex ratio

The sex ratio by year is shown in Figure 16.3. This shows some fluctuations over time. In general, the sex ratio in landings and catches are biased toward males, with a geomean of 56.2% males in landings (1986–2020) and 52.4% in catches (1986–2020). There was little bias toward males in catches was observed in 2020 comprising 51.7% in landings and 49.3% in the catch compared to 60.4% in the landings and 57.2% in catch in 2019. Historically the stronger bias of males in landings relates to the average larger size of male *Nephrops*.

Mean weights

Explorations of the mean weight in the catch samples by sex shows a strong seasonal pattern in the females (Figure 16.4). This corresponds to the emergence of mature females from the burrows to mate in summer. There is no evidence of a recent trend toward decreasing mean weights (Figure 16.5), however compared to the early part of the time-series mean weights have decreased. The mean weights in landings (2016–2020) and mean weights in discards (2016–2020) are used in the basis for calculating catch options (Section 19.4).

Discards

Annual discard rates are estimated using unsorted catch and discards sampling. Unsorted catches and samples of retained catch are provided by vessels. The catch sample is partitioned into landings and discards using a discard selection ogive. This selection ogive can be derived per sample or as aggregation of samples within a quarter or year when sampling rates are low. Sampling effort is stratified weekly, but quarterly aggregations are used for quarterly length frequencies and discard estimates. The length–weight regression parameters given in the stock annex are used to calculate sampled weights and appropriate raising factors. Discarding practice is highly variable, mainly driven by market demand, and was 26.7% of the catch by number in 2020 (Table 16.6). A discard survival rate of 10% is assumed for *Nephrops* from this FU (WKNEPH 2009).

Surveys

Abundance indices from UWTV surveys

Since 2003, Ireland and Northern Ireland have jointly carried out underwater television surveys of the main *Nephrops* grounds in the western Irish Sea. These surveys were based on a randomised fixed-grid design. The methods used during the surveys were similar to those employed for UWTV surveys of other *Nephrops* stocks and were as agreed by WKNEPHTV (ICES, 2007), WKNEPBID (ICES, 2008), SGNEPS (ICES, 2009; 2010; 2012) , WKNEPH (ICES, 2009) and WGNEPS (ICES, 2013; 2014; 2015; 2016). From 2003 to 2011 year an average of 146 valid stations was covered by the two surveys combined, and the data were raised to a stock area of around 5290 x 10-6 km^2 as detailed in Table 16.7. The number of stations were significantly reduced in 2012 following a recommendation from SGNEPS 2012 that a CV (or relative standard error) of <20% is an acceptable precision level for UWTV survey estimates of abundance. This allowed sampling intensity to be reduced and survey effort allocated to other areas and FUs in area 7. Details of the survey methodology are available in WGNEPS (ICES, 2016). Figure 16.6 shows the distribution of stations sampled in 2021. In 2021 the survey was completed on both the RV Corystes (82 stations) and Celtic Explorer (13 stations). In 2021 there was change to using High Definition 'still' image cameras to collect footage onboard the RV Corystes. This change provides significantly improved image quality. A similar change has also taken place in other functional units in ICES area 7. A trial in FU 16 showed no significant different in the burrow estimates derived from standard video imagery and high definition still imagery. In 2020 95 stations were completed, footage form five stations were not collected because of poor visibility. Figures 16.7–16.10 are contour plot of the krigged-density estimates for FU15 over the period 2003–2019. The resulting krigged burrow abundance estimate was 4733 million burrows. This was a similar result of that obtained in 2019 of 4775 million burrows. A violin plot of the burrow densities observed in the survey (2003–2021) is shown in Figure 16.11. The character of the burrow densities encountered has remained consistent over time; characterised by a relatively high occurrence of low density stations and a normal distribution densities around 0.7 burrow/m^2. Confidence in the survey estimates and design are assured through the maintained low coefficient of variation on the burrow estimates. This low coefficient of variation, despite the loss of 5 survey stations supports that the survey provides high quality information

The use of the UWTV surveys for the provision of *Nephrops* management advice was extensively reviewed by WKNEPH (ICES, 2009) and potential biases were highlighted including those due to edge effects; species burrow misidentification and burrow occupancy. A cumulative bias correction factor estimated for FU15 was 1.14 which means the TV survey is likely to overestimate *Nephrops* abundance by 14%.

Nephrops trawl surveys

In addition to UWTV surveys Northern Ireland have completed spring (April) and summer (August) *Nephrops* trawl surveys since 1994 and provide data on catch rates, size composition and biological data from fixed stations in the western Irish Sea as detailed in the Stock Annex (Stock Annex Figure 1). Survey CPUE has remained stable over time. Mean carapace length-by-sex (from the trawl survey) shows interannual variation fluctuating around mean with no apparent trend over time (Figure 16.12).

Due to reduced resources, spring survey series was terminated in 2010 as part of a national rationalisation of the survey programme after considering benefits to management and stock assessment. Due to a major ship break-down, no data are available for the 2013 summer survey. Summer trawl survey catch rates correlate somewhat with UWTV survey abundance estimates (Figure 16.13), but showed a deviating trend, especially in 2010. The longer time-series of the trawl survey shows that catch rates in the last few years (2005–2009, 2011) are close to the mean of the series when UWTV burrow abundances were in the range of 5–6 billion burrows. The reduction in the 2010 trawl estimate, that showed a conflicting trend to the UWTV abundance, is most likely associated with the survey taking place in suboptimal tidal conditions. Usually the trawl survey coincides with slack tides, but this was not optimal in 2010 due to availability of the ship and synchronisation with the UWTV survey.

16.3 Assessment

Comparison with previous assessments

The assessment approach used by WGCSE 20120 is consistent with that set out in the stock annex and WK*NEPH* (WK*NEPH*, 2009). Since the most recent three years of sampling data were available, three-year averages of mean weights in the landings and proportions retained in the fishery have been used. This is in line with the procedure used for other stocks in areas 6 and 7 by WGCSE.

State of the stock

The stock size is estimated to show a decrease, but within the limits previously observed for the stock. The harvest ratio has decreased in 2020 and remains below F_{MSY} (Figure 16.14). This stock has previously sustained landings at around 9000 t for many years. The stock increased until 2003, with a general decrease until 2014 and has increased since then. The most recent UWTV abundance estimate of 4733 million in 2019 follows a period (2016–2017) of above average size. The geometric mean of current series is 4908 million. Figure 16.14 is the stock summary plot for FU15. Recent harvest rates have fluctuated around F_{MSY}, but is estimated as 10.6 in 2020, having decreased from 19.9 in 2015 (Table 16.6). The stock is estimated to be well above $MSYB_{trigger}$ (3000 million).

16.4 Catch option table

Catch option table inputs are presented in Table 16.6 and summarised below. A three-year average (2018–2020) of mean weight in the landings and proportion of removals retained was used.

A stock abundance prediction for 2022 was made for FU15 using the approach agreed at the Benchmark Workshop (WK*NEPH*, 2009) and outlined in the stock annex made on the basis of the 2021 UWTV survey.

The basis for the catch options.

Variable	Value	Notes
Stock abundance	4733	Numbers of individuals (millions); UWTV survey 2021
Mean weight in landings	15.26	Average 2018–2020 in grammes
Mean weight in discards	7.87	Average 2018–2020 in grammes
Discard rate	26.7	Percentage by number; average 2018–2020
Discard survival rate	10	Percentage by number
Dead discard rate	24.7	Percentage by number; average 2018–2020

16.5 Reference points

A decision-making framework for the choice of F_{MSY} proxy reference points is available in the introduction to the *Nephrops* ICES advice sheets. The current F_{MSY} proxy reference points for FU15 *Nephrops* was evaluated at WKMSYRef4. The MSY reference point for FU15 *Nephrops* is the F_{max} for combined sexes. No precautionary reference points have been defined for *Nephrops* stocks. Whereas the F_{MSY} proxy reference points were chosen with the intent that they should lead to a low probability of stock overfishing.

Previously the CPUE data from the trawl surveys were scaled to the UWTV index to provide a $B_{trigger}$ approximation based on the mean of the five lowest survey catch rates in the time-series (Figure 16.8), this is still accepted as an appropriate $B_{trigger}$ for FU15.

Stock code	MSY Flower	F_{MSY}	MSY Fupper with AR	MSY $B_{trigger}$	MSY Fupper with no AR
nep-15	12.4	18.2	18.2	3000*	18.2

***Abundance in millions.**

16.6 Management strategy

As yet there are no explicit management strategies for this stock.

16.7 Quality of assessment and forecast

Uncertainties in the survey, mean weight in the landings and discard rates are not taken into account in the deterministic catch option. There is some variability of these over time.

There are several key uncertainties and bias sources in the method used here (these are discussed further in WK*NEPH* 2009). Various agreed procedures have been put in place to ensure the quality and consistency of the survey estimates following the recommendations of several ICES groups (WKNEPTV 2007; WKNEPHBID 2008; SGNEPS 2009). These have led to a revision in the historical time-series of survey abundance estimates for FU15, which was presented to last year's Working Group. Ultimately there still remains a degree of subjectivity in the production of UWTV abundance estimates (Marrs *et al*., 1996).

Taking explicit note of the likely biases in the surveys may at least provide an estimate of absolute abundance that was more accurate but no more precise (WK*NEPH* 2009). The survey estimates themselves are very precisely estimated (CVs 2–5%) given the homogeneous distribution of burrow density and the modelling of spatial structuring. The cumulative bias estimates for FU15 are largely based on expert opinion (see Stock Annex). The precision of these bias corrections cannot yet be characterised but is likely to be higher than that observed in the survey.

In the provision of catch options based on the absolute survey estimates additional uncertainties related to mean weight in the landings and the discard rates also arise. These parameters are quite variable, in future years the uncertainty in these key parameters should be estimated.

The quality of landings data has improved since 2007 with the implementation of sales notes and buyers and sellers legislation. Prior to that there were concerns that landings were underreported. The harvest ratio may be underestimated prior to 2007.

16.8 Recommendations for next benchmark

WGCSE will keep the stock under review and recommend future benchmark as required.

16.9 Management considerations

The FU15 *Nephrops* fishery first developed in the late 1950s. Since then it has sustained landings of around 8500 t for more than 30 years. Fishing effort in the past has been very high but has declined somewhat in recent years. The environment in the Western Irish Sea is very suitable for *Nephrops* with a large mud patch and gyre, which retains the larvae over the mud patch thus ensuring good recruitment. The ground can be characterised as an area of very high densities of small *Nephrops*. All available information indicates that size structure of catches appears to have changed little since the fishery first began.

The *Nephrops* trawl fisheries take bycatches of other species, especially juvenile whiting, but also cod. Catches of these species should be reduced to as low as possible because of the poor status of these stocks. A conditional national licence has been introduced by Ireland since March 2012, making the use of grids or separator panels mandatory for all TR2 boats fishing in the Irish Sea. Around 55% of the Irish vessels use separator trawls and while 45% have opted to use Swedish grids to reduce bycatch. Additionally, there has been a trend for Irish vessels to switch to multi (quad) rig trawls. Provisional data suggest a ~30% increase in *Nephrops* catch rates and a reduction in fish bycatch of ~30% due to the lower headline height.

Since October 2012, all TR2 vessels in the UK (Northern Ireland) fleet are required to use a highly selective fishing gear. In the Irish Sea these currently include Seltra 300 mm box trawl, 270 mm diamond mesh panel Seltra box trawl and 300 mm square mesh panel. All these gears are being developed with the aim of achieving exemption from the cod recovery plan under Article 11 (less than 1.5% cod catch). Enforcement is through the issue cod recovery zone fishing authorisations, where no authorisation is given to a vessel that is not using a highly selective gear.

ICES has repeatedly advised that management should be at a smaller scale than the ICES Subarea 7. Management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort are at the same scale as the resource.

A number of cod recovery measures have been introduced since 2000 to promote recovery of Irish Sea cod stocks. These include a closure of the western Irish Sea cod spawning grounds from mid-February to end of April since 2000, with a later extension to the eastern Irish Sea closure. Despite a partial derogation for *Nephrops* vessels during the closed period the distribution of effort on *Nephrops* has been affected by this management plan. There have also been decommissioning schemes to reduce fishing effort. During 2016-2020 the EU landing obligation was applied to all catches of Norway lobster fisheries in ICES Subarea 7 with exemptions for high survival. From 2021, this stock is still under a landing obligation and there are still exemptions in place. Observations from the 2016–2020 fishery indicate that discarding above the minimum conservation reference size (MCRS) continues and has not changed markedly (Figure 3). ICES is providing advice for 2022 assuming average discard rates as observed over the last three years. This is considered to be the most realistic assumption.

16.10 References

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Table 16.1. Irish Sea West (FU15): Landings (tonnes) by country, 2000–2018.

Year	Ireland	Isle of Man	UK	Other countries	Total
2000	3433	0	4937	0	8370
2001	2689	3	4749	0	7441
2002	2291	1	4501	0	6793
2003	2709	4	4352	0	7065
2004	2786	13	4470	1	7270
2005	2133	0	4420	0	6554
2006	2051	1	5508	1	7561
2007	2767	0	5724	0	8491
2008	3132	50	7323	2	10508
2009	2343	1	6855	0	9198
2010	2578	0	6384	0	8963
2011	3575	2	6584	0	10162
2012	3794	3	6732	0.2	10529
2013	2465	31	6175	0.2	8672
2014	2938	0**	5676	0.0	8613
2015	2199	0**	6433	0.3	8632
2016	1609	0**	5715	3	7327
2017	1253	0**	4896	0	6150
2018	1387		4369	0	5756
2019*	1859		5731	0	7590
2020	1555		4560		6115

*** provisional. **included in UK landings.**

Table 16.2. Irish Sea West (FU15): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and lpue (kg/hour trawling) Republic of Ireland *Nephrops* Directed Trawlers 2000–2019.

Year	Landings (Kg)	Effort (Hours)	Effort (days)	Effort (kwdays)	lpue
1995	1706969	44459	3516	835977	2.041885
1996	1406140	31409	2326	607785	2.313549
1997	2801501	60502	4518	1124379	2.491599
1998	2696979	52277	4051	1053491	2.560039
1999	4031508	73786	5260	1367903	2.947217
2000	3227565	61936	4396	1199896	2.68987
2001	2428587	51111	3435	939387	2.585289
2002	2015965	46072	2900	873563	2.307749
2003	1620391	47704	3120	878568	1.844355
2004	2586760	52673	3500	1033073	2.503946
2005	2111185	50825	3414	1003901	2.102981
2006	2031881	53461	3535	1084251	1.873995
2007	2728841	52550	3575	1056291	2.583419
2008	3165781	49218	3401	1027919	3.079796
2009	2333433	34651	2368	706178	3.304312
2010	2505061	36504	2546	739345	3.388218
2011	3554343	47640	3229	921298	3.857972
2012	3725318	49313	3560	966006	3.856413
2013	2269336	33818	2571	682793	3.323608
2014	2449612	40371	3007	852740	2.872635
2015	2119880	35898	2733	756719	2.80141
2016	1529418	28249	2301	556452	2.748516
2017	1120690	22516	1749	410628	2.729208
2018	1363911	27084	1919	535002	2.549353
2019	1803134	33981	2304	700132	2.57542
2020	1517909	25717	2250	570314	2.661534

Table 16.3. Irish Sea West (FU15): Landings (tonnes), effort (‘000 hours trawling), lpue (kg/hour trawling), effort (‘000 kW days) and lpue (kg/kWd) of Northern Ireland *Nephrops* trawlers, 2000–2019.

Year	Landings	Effort ('000 hours)	lpue ('000 hrs)	kW days ('000)	lpue kWd
2000	4758	168.7	28.2		
2001	4587	163.7	28.0		
2002	4495	130.8	34.4		
2003	4146	136.1	29.0		
2004	4273	144.3	29.6		
2005	4235	138.4	30.6		
2006	5356	144.1	37.2		
2007	5512	126.9	43.4		
2008	7056	141.4	49.9		
2009	6487	134.7	48.2		
2010	5888	141.1	41.7		
2011	5952	132.7	44.9		
2012	5865	137.8	42.6		
2013	5605	135.7	41.3	2151.9	2.60
2014	5190	114.6	45.3	2111.2	2.46
2015	6396			1962.6	3.26
2016	5638			2107.3	2.68
2017	4789			1904.3	2.51
2018	4293			2079.3	2.06
2019*	5539			2166.5	2.56
2020*	4550			1852.0	2.46

* provisional.

Table 16.4. Irish Sea West (FU15): Mean sizes (mm CL) of male and female *Nephrops* in Northern Ireland catches, landings and discards, 2000–2018.

Year	Catches		Landings		Discards	
	Males	Females	Males	Females	Males	Females
2000	27.7	24.5	29.4	26.3	22.5	22.6
2001	25.7	23.6	26.1	24.4	21.7	21.2
2002	26.7	24.1	26.7	24.9	21.8	21.7
2003	na	na	na	na	na	na
2004	na	na	na	na	na	na
2005	na	na	na	na	na	na
2006	na	na	na	na	na	na
2007	na	na	na	na	na	na
2008	25.9	24.6	26.9	25.5	21.4	21.5
2009	27.7	25.1	29.3	26.5	23.6	23.2
2010	28.3	25.6	29.5	26.3	23.2	22.8
2011	27.6	26.0	29.3	27.7	22.6	22.8
2012	26.8	24.3	27.7	25.4	21.7	21.1
2013	26.2	24.2	27.2	25.4	21.5	21.3
2014	26.3	23.9	27.1	24.9	21.1	20.6
2015	25.3	23.4	26.8	24.7	21.6	21.3
2016	25.9	24.3	26.9	25.5	22.3	21.8
2017	27.0	24.8	28.0	26.1	22.9	22.5
2018	27.6	25.1	28.8	26.6	23.3	22.5
2019	27.1	24.1	27.9	24.8	22.6	21.7
2020	27.5	26.5	29.1	28.1	22.6	22.5

na = not available.

Table 16.5. Irish Sea West (FU15): Mean sizes (mm CL) of male and female *Nephrops* in Republic of Ireland catches, landings and discards, 2000–2018.

Year	Catches		Landings		Discards	
	Males	Females	Males	Females	Males	Females
2000	29.1	27.1	32.2	29.7	24.3	24.0
2001	26.7	24.8	28.6	27.0	23.0	22.2
2002	28.9	25.4	30.2	27.8	24.6	23.6
2003	27.7	24.9	29.7	26.9	24.0	23.1
2004	28.1	26.1	29.7	27.8	23.9	23.7
2005	28.5	26.8	30.1	29.1	23.9	23.2
2006	27.7	25.5	29.5	27.1	23.8	23.1
2007	27.7	25.4	29.8	27.9	24.0	23.3
2008	27.4	24.6	28.9	26.6	22.0	21.4
2009	28.5	26.3	30.5	29.2	24.3	23.4
2010	28.0	25.9	29.6	27.6	23.8	23.3
2011	27.0	25.7	28.8	27.3	23.7	23.5
2012	26.8	25.6	28.3	27.0	23.2	23.0
2013	26.3	25.1	27.4	26.5	23.1	22.6
2014	27.7	24.9	29.2	26.3	23.6	23.3
2015	27.7	25.7	29.5	27.4	24.4	24.0
2016	26.0	25.0	27.3	26.4	23.5	23.3
2017	27.2	25.0	28.1	26.2	23.4	22.6
2018	27.4	24.9	29.8	22.8	24.6	22.8
2019	27.9	25.0	29.5	27.0	22.8	22.3
2020	28.0	26.3	29.7	27.9	24.1	24.1

Table 16.6. Irish Sea West (FU15): Proportion discarded by weight and number from FU15. (Note a 10% survivorship of discards is assumed in HR and forecast calculations).

Year	UWTV abundance estimate	95% Confidence Interval	Landings in number	Total discards in number*	Removals in number	Harvest rate (by number)	Landings	Total discards*	Discard rate (by number)	Dead discard rate (by number)	Mean weight in landings	Mean weight in discards
	Millions		millions			%	tonnes		%		grammes	
2003	5485	255	404	291	666	12.1	7065	2659	41.9	39.3	17.5	9.14
2004	5547	237	416	218	612	11.0	7270	1993	34.4	32.0	17.5	9.14
2005	5673	327	346	157	488	8.6	6554	1412	31.2	29.1	18.9	8.99
2006	5402	314	467	261	701	13.0	7561	2285	35.9	33.4	16.2	8.75
2007	5150	228	511	375	848	16.5	8491	3246	42.3	39.7	16.6	8.66
2008	4288	144	755	191	927	21.6	10508	1421	20.2	18.6	13.9	7.44
2009	4623	190	567	335	868	18.8	9198	2934	37.1	34.7	16.2	8.76
2010	4990	198	572	180	733	14.7	8963	1539	23.9	22.0	15.7	8.55
2011	4871	176	644	332	943	19.4	10162	2683	34.0	31.7	15.8	8.08
2012	5062	249	771	258	1003	19.8	10529	1871	25.1	23.1	13.7	7.25
2013	4310	174	662	229	867	20.1	8672	1590	25.7	23.6	13.1	6.94
2014	4593	161	641	198	819	17.8	8613	1418	23.6	21.7	13.4	7.16
2015	4373	202	620	280	872	19.9	8643	2228	31.1	28.9	13.9	7.96

Year	UWTV abundance estimate	95% Confidence Interval	Landings in number	Total discards in number*	Removals in number	Harvest rate (by number)	Landings	Total discards*	Discard rate (by number)	Dead discard rate (by number)	Mean weight in landings	Mean weight in discards
	Millions		millions			%	tonnes		%		grammes	
2016	5076	232	562	245	783	15.4	7327	1939	30.4	28.2	13.0	7.91
2017	5312	267	426	152	563	10.6	6150	1222	26.3	24.3	14.4	8.04
2018	4932	188	360	145	491	10.0	5756	1231	28.7	26.6	16.1	7.43
2019	4404	183	536	154	675	15.3	7591	1159	22.3	20.5	14.2	7.54
2020	4775	291	371	153	509	10.6	6115	1294	26.7	24.7	15.5	8.64
2021	4733	281										

Table 16.7. Irish Sea West (FU15): Results from NI/ROI collaborative UWTV surveys of *Nephrops* grounds in 2003–2020.

Ground	Year	Number of stations	Mean Density (No./M^2)	Domain Area (km^2)	Estimate (billions)	CV on Burrow estimate
Western Irish Sea	2003	160	0.99	5295	5.5	3%
	2004	147	1.00	5310	5.5	3%
	2005	141	1.02	5281	5.7	4%
	2006	138	0.97	5194	5.4	4%
	2007	148	0.93	5285	5.1	3%
	2008	141	0.77	5287	4.3	3%
	2009	142	0.83	5267	4.6	3%
	2010	149	0.90	5307	5.0	3%
	2011	156	0.88	5289	4.9	2%
	2012	99	0.91	5291	5.1	3%
	2013	80	0.78	5278	4.3	3%
	2014	99	0.83	5272	4.6	3%
	2015	100	0.79	5279	4.4	3%
	2016	100	0.84	5260	5.1	3%

Ground	Year	Number of stations	Mean Density (No./M^2)	Domain Area (km^2)	Estimate (billions)	CV on Burrow estimate
	2017	101	0.90	5304	5.3	3%
	2018	100	0.85	5791	4.9	3%
	2019	100	0.76	5370	4.4	3%
	2020	99	0.82	5791	4.8	3%
	2021	95	0.78	5790	4.7	4%

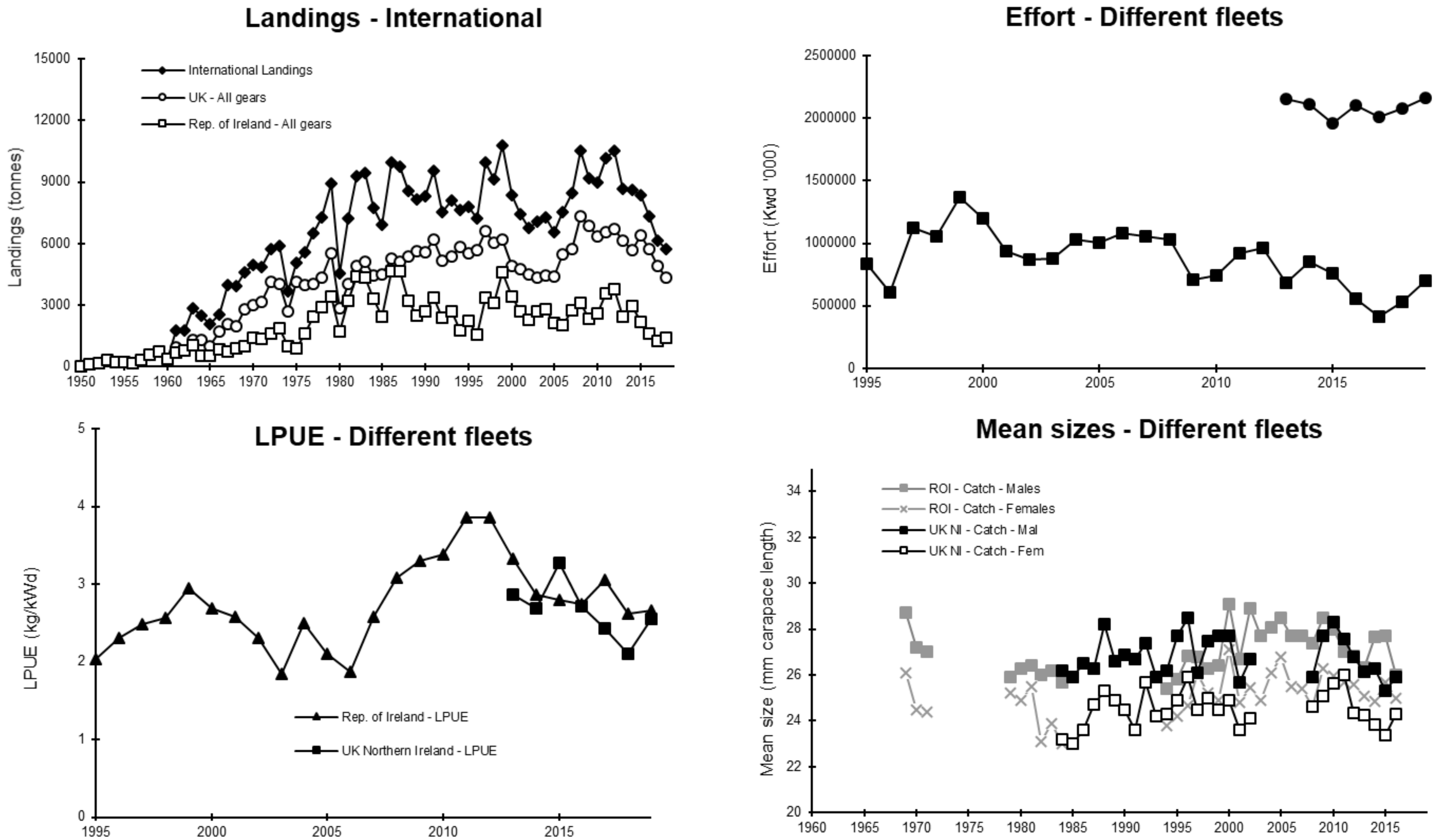


Figure 16.1. Irish Sea West (FU15): Long term trends in landings, effort, lpue, and mean sizes of *Nephrops*. [The quality of landings data has improved since 2007 with the implementation of sales notes and buyers and sellers legislation, which result in misleading lpue trend plots pre- and post-2007].

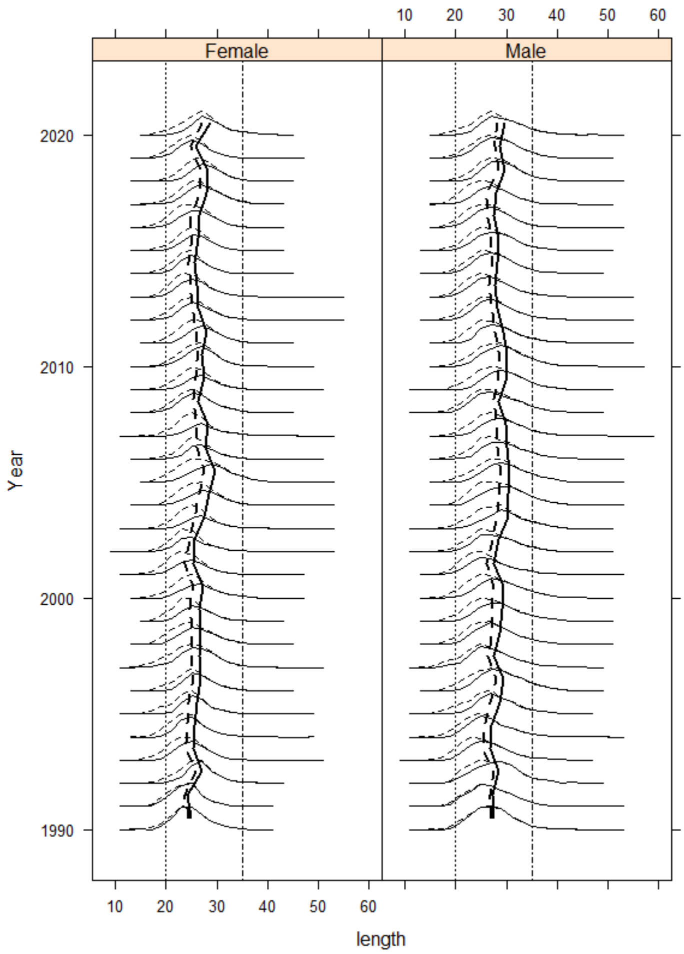


Figure 16.2. Irish Sea West (FU15): Length distributions in the landings (solid) and catches (dotted) 1986–2021.

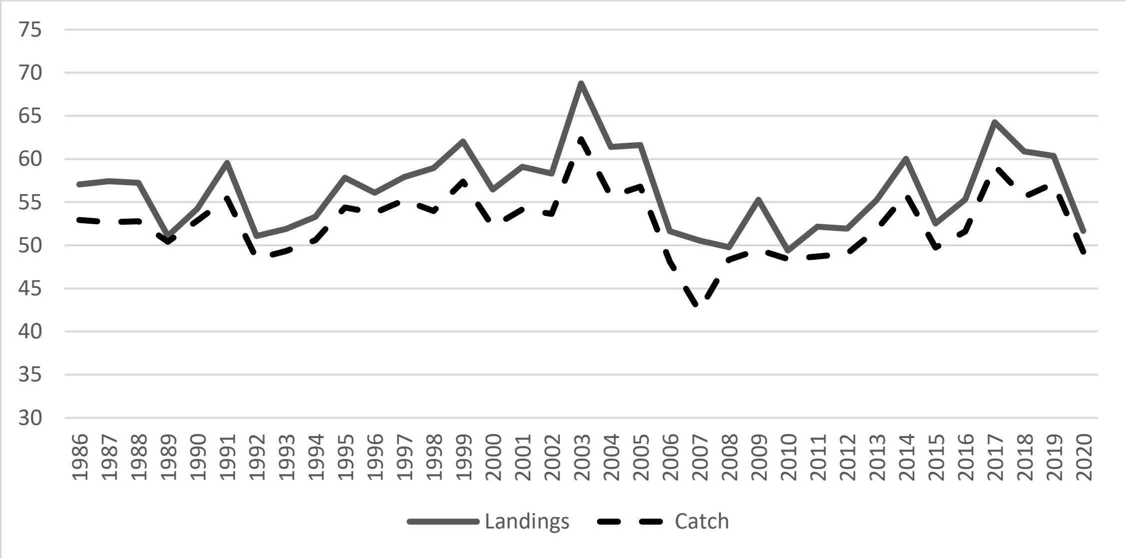


Figure 16.3 ***Nephrops*** **in FU15 (Irish Sea West). Sex ratio (percentage of males) of landings and discards (1986–2020).**

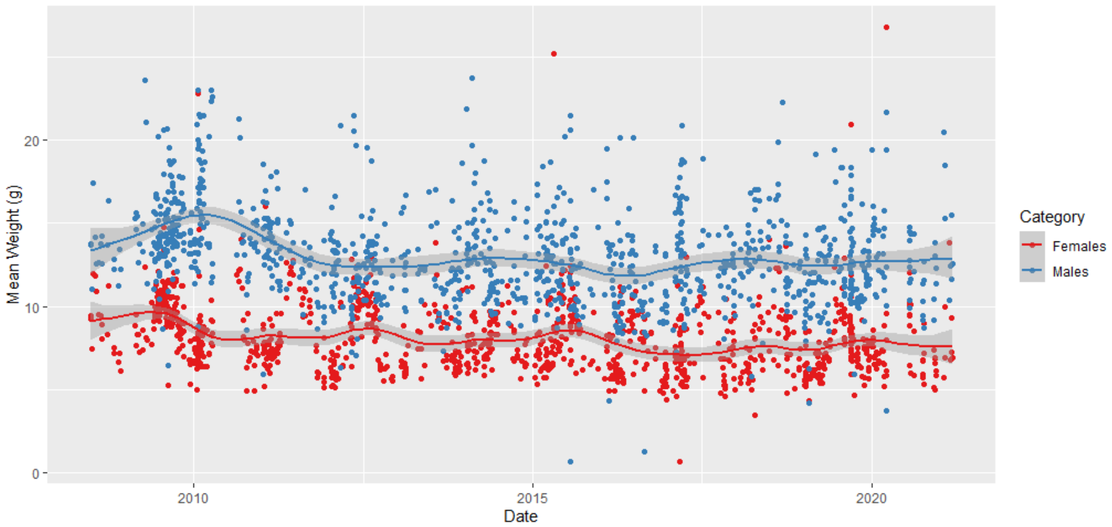


Figure 16.4 ***Nephrops*** **in FU15 (Irish Sea West).Mean weight in catch samples by sex with GAM loess smoother (k=20).**

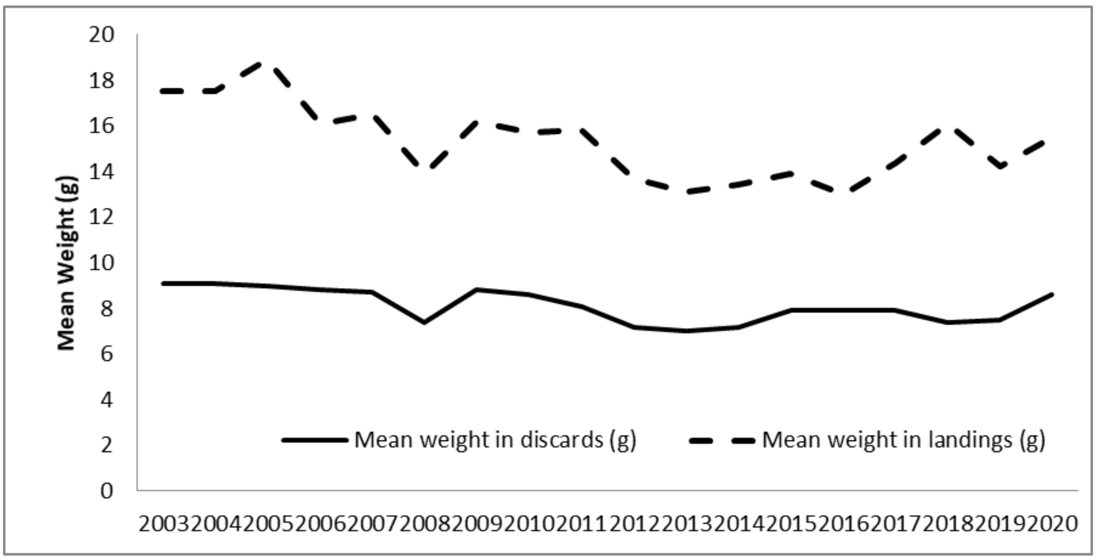


Figure 16.5 *Nephrops* in FU15 (Irish Sea West). Mean weight in landings and discards.

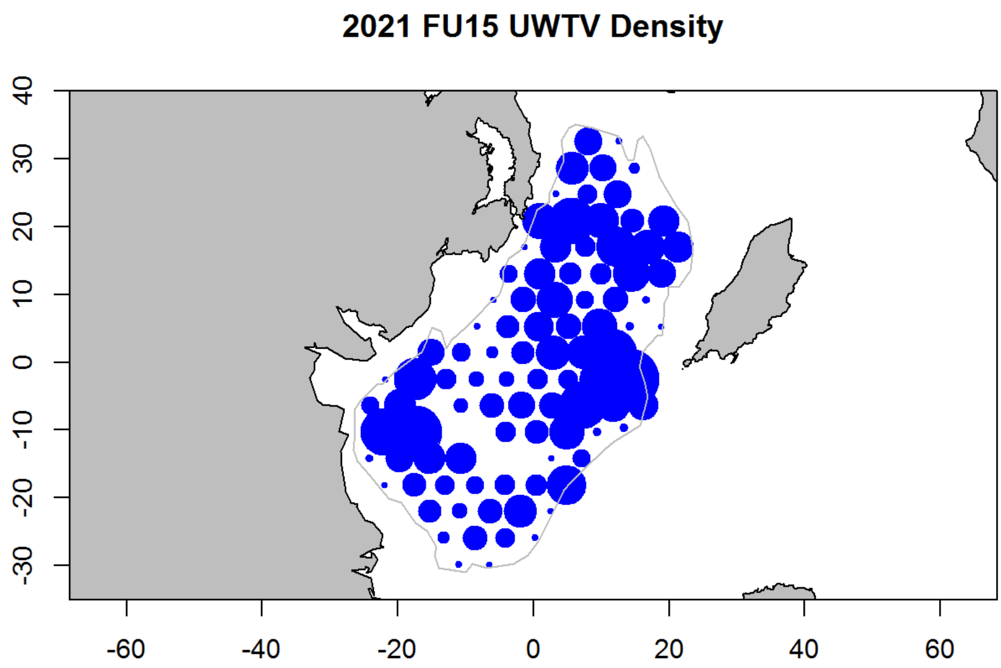


Figure 16.6. Irish Sea West (FU15): 2021 UWTV survey stations, symbol size reflects the burrow density.

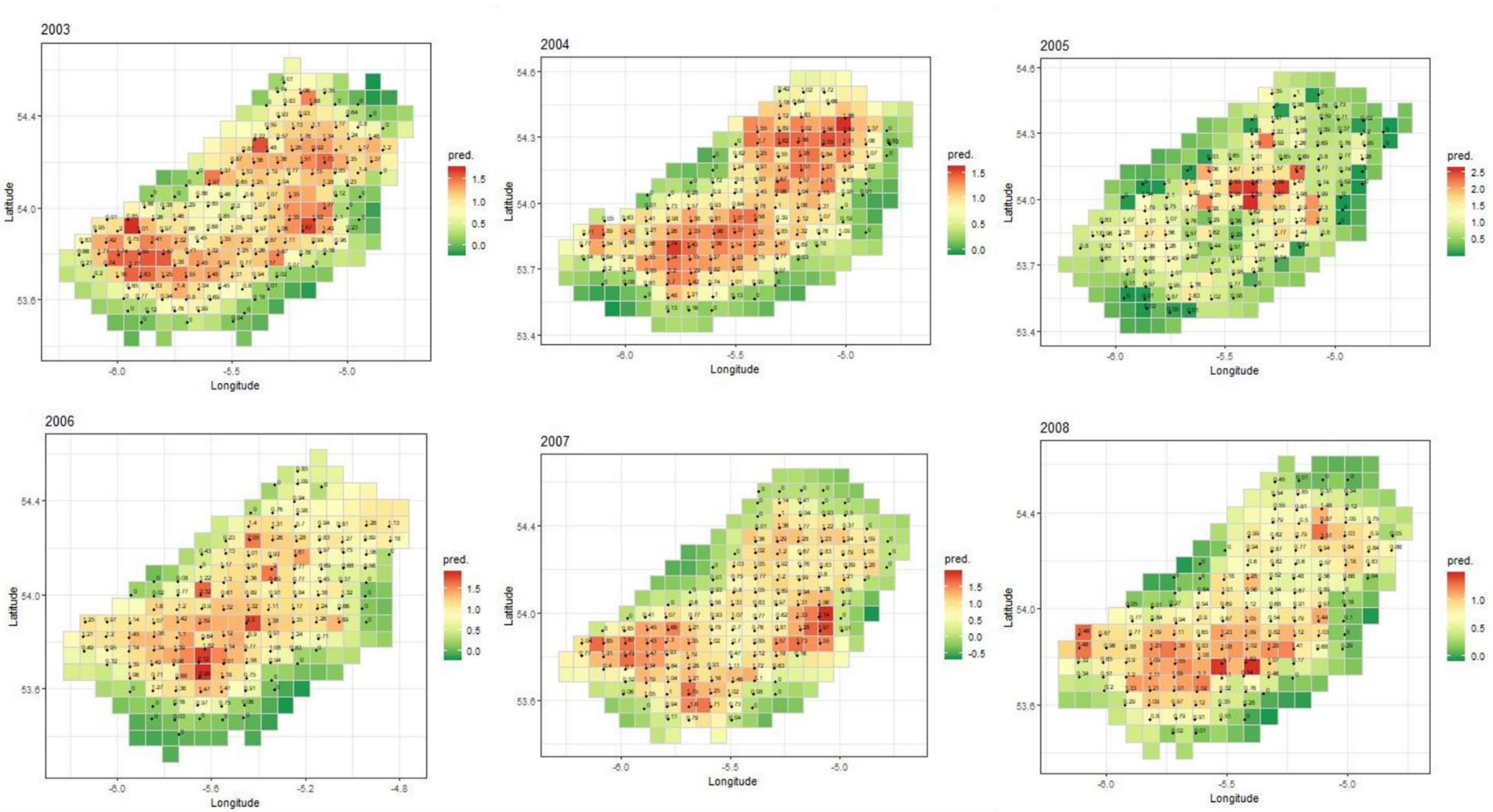


Figure 16.7. Irish Sea West (FU15): Contour plots of the krigged density estimates for the Irish Sea from 2003–2008.

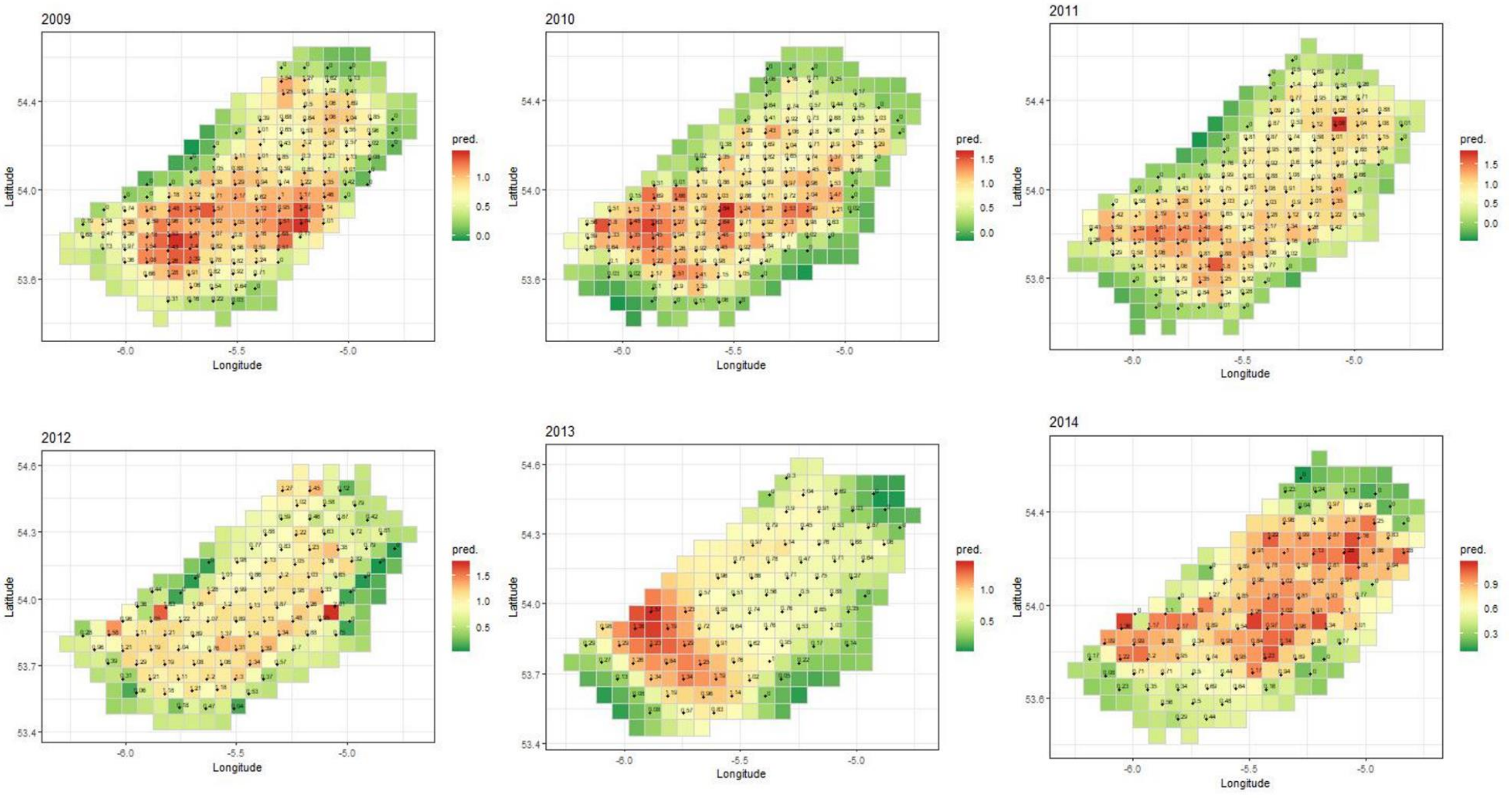


Figure 16.8. Irish Sea West (FU15): Contour plots of the krigged density estimates for the Irish Sea from 2009–2014.

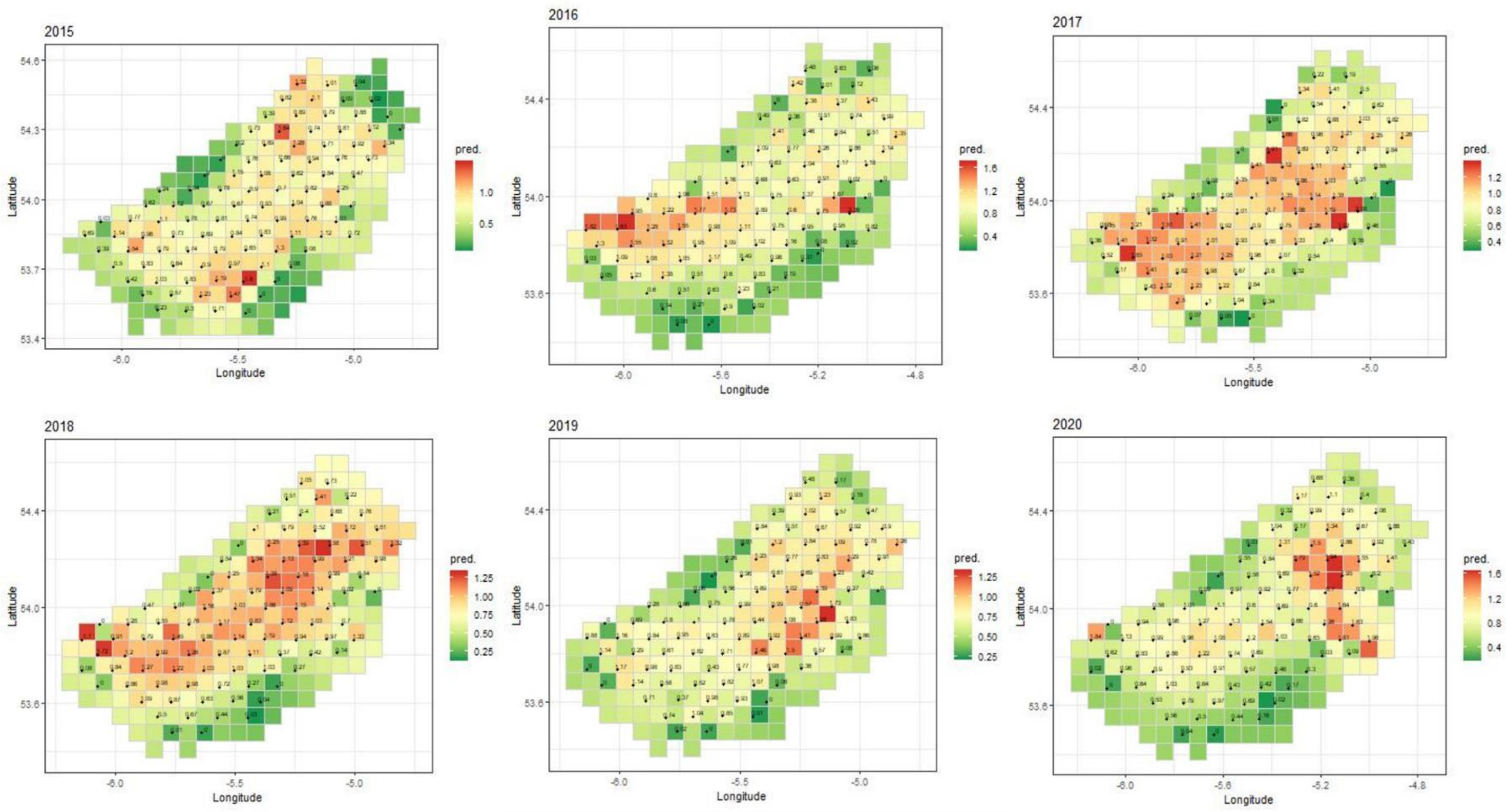


Figure 16.9. Irish Sea West (FU15): Contour plots of the krigged density estimates for the Irish Sea from 2009–2020.

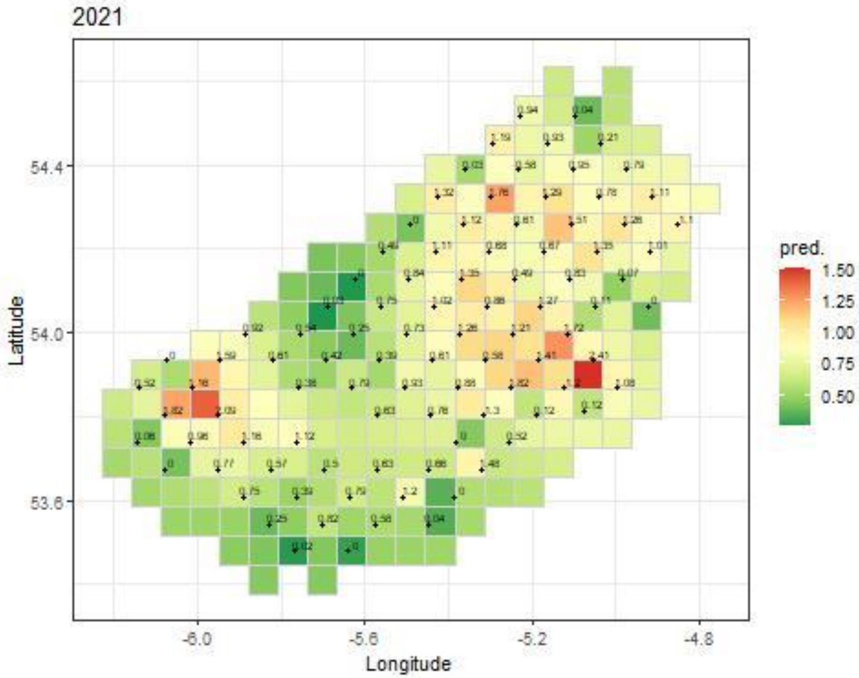


Figure 16.10. Irish Sea West (FU15): Contour plots of the krigged density estimates for the Irish Sea from 2021

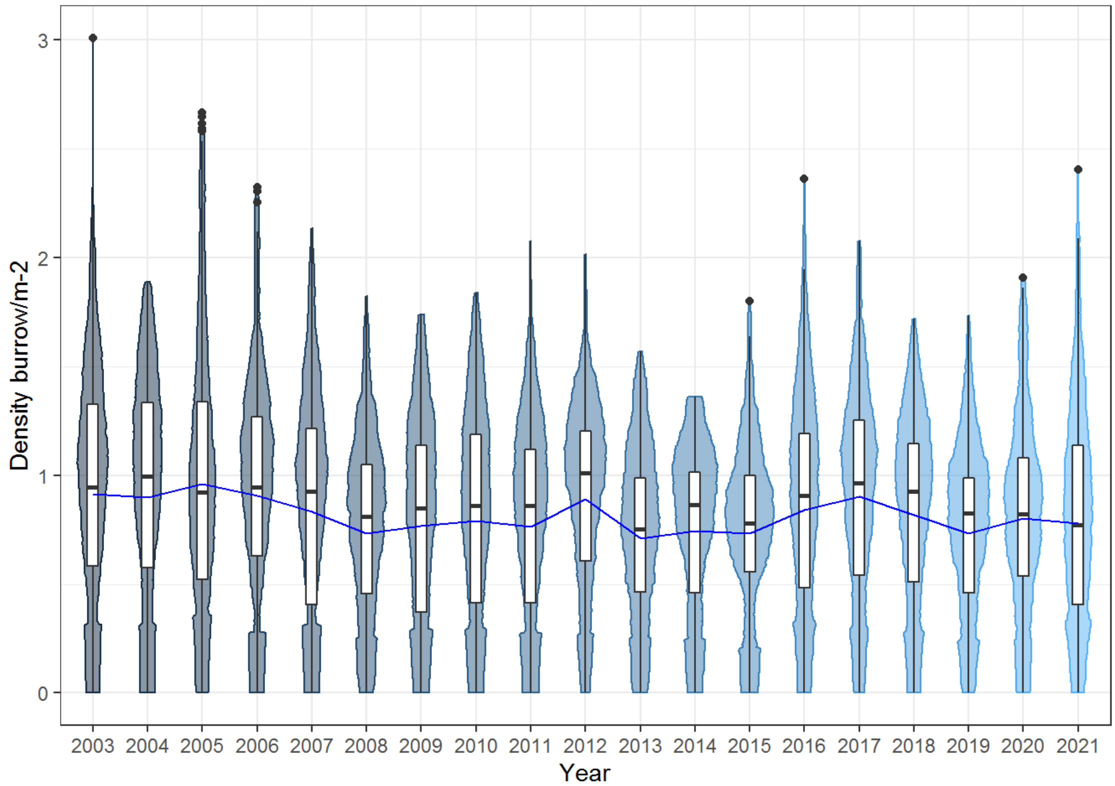


Figure 16.11. Irish Sea West (FU15): Box and kite plot of burrow density observed during UWTV survey 2003–2021.

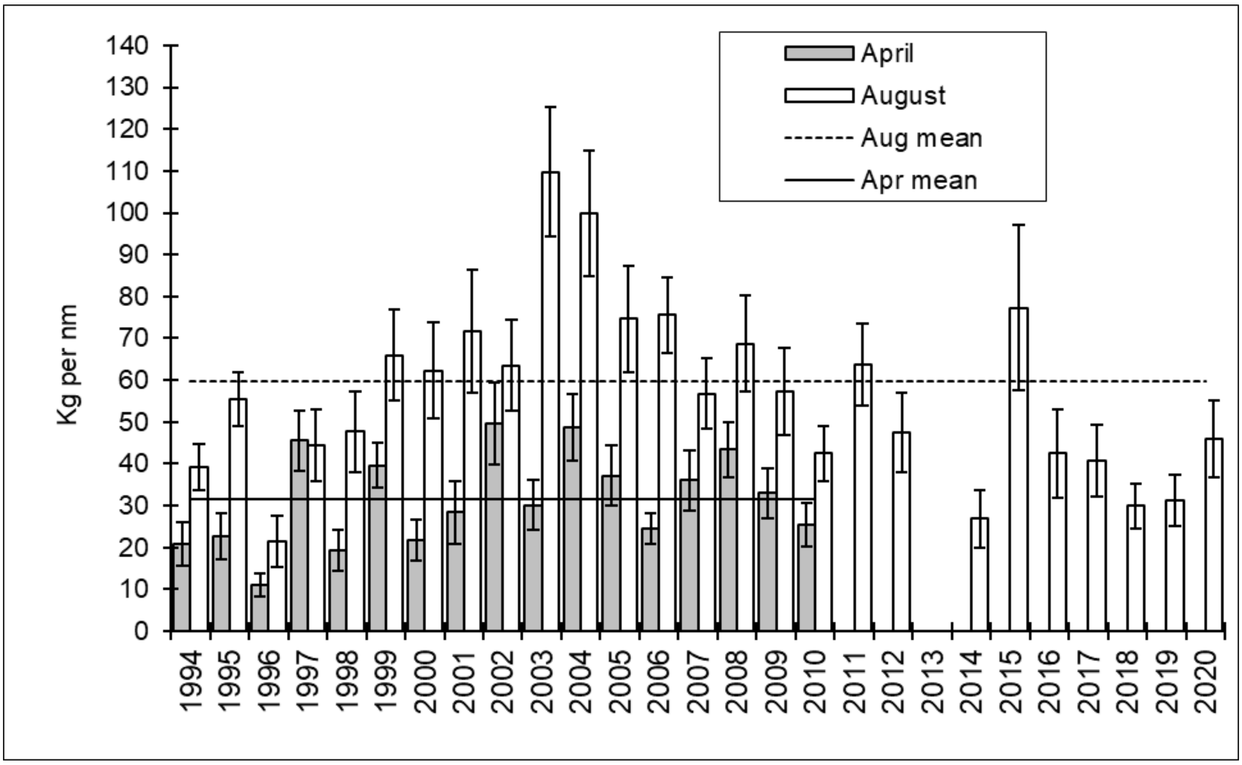


Figure 16.12 Irish Sea West (FU15): *Nephrops* catches (kg per nm) from NI trawl surveys. No data available in 2013 due to ship breakdown.

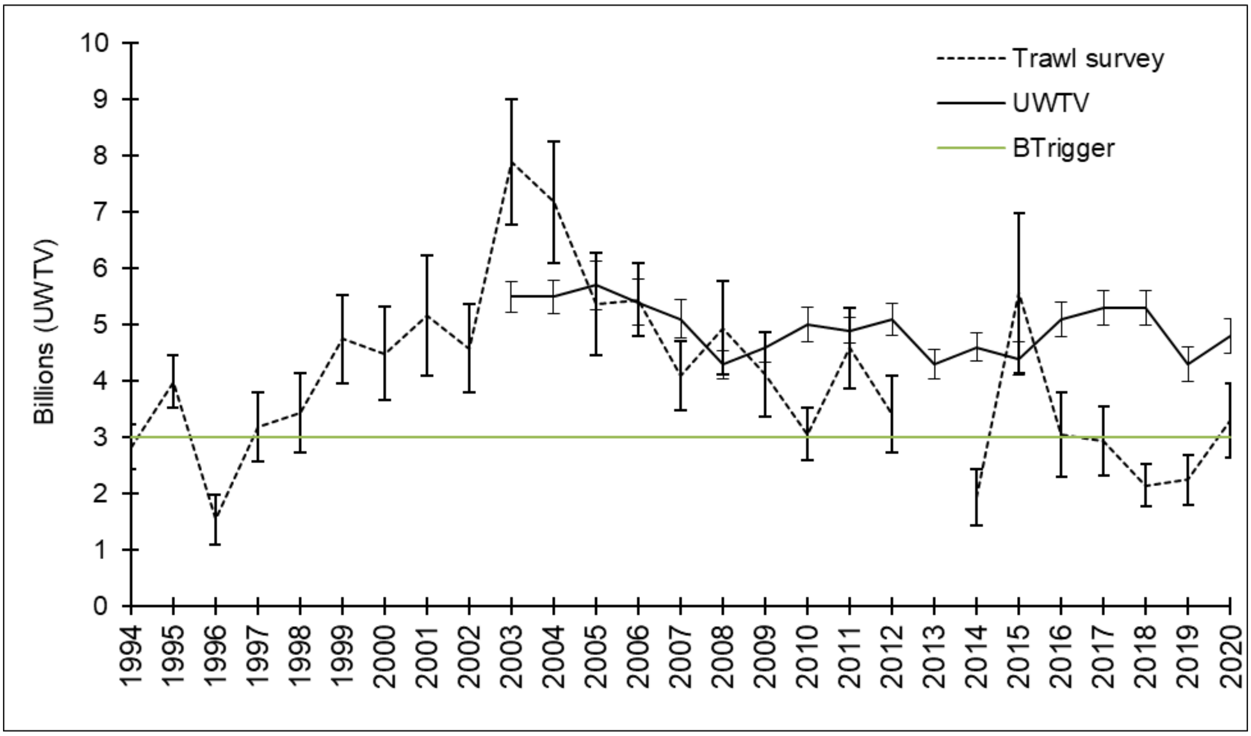


Figure 16.13. Irish Sea West (FU15): Revised UWTV index and scaled trawl survey. Cpue along with $B_{trigger}$ based upon mean of five lowest trawl survey values. Abundance figures have not been bias corrected.

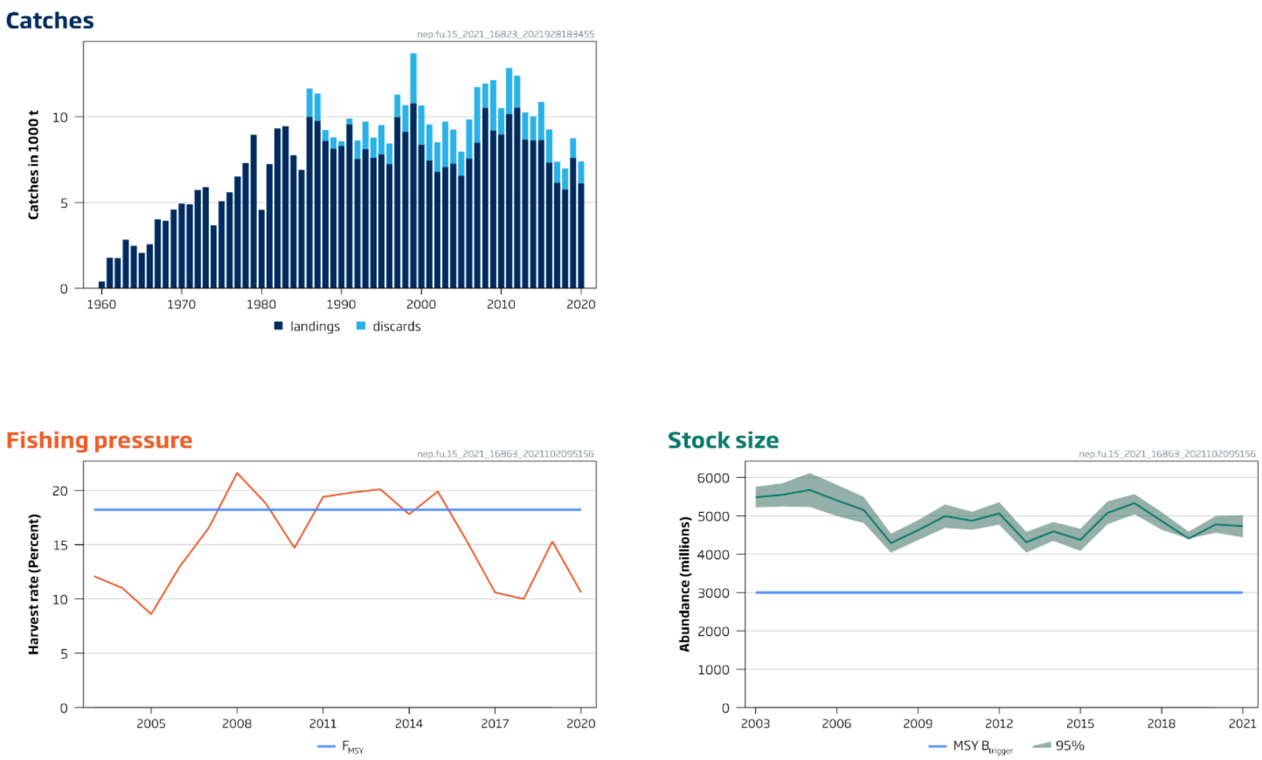


Figure 16.14 Norway lobster in Division 7.a, Functional Unit 15. Summary of the stock assessment. Catches (discard data are only available from 1986), harvest rate (sum of landings and dead discards in numbers, divided by total abundance), survey abundance (Underwater TV, billions; SSB proxy; 95% confidence intervals). Harvest rates between 2003 and 2006 may be underestimated because of underreporting of landings. Orange lines represent MSY Btrigger and the F_{MSY} harvest rate.

17 Norway lobster (*Nephrops norvgicus*) in divisions 7.b–c and 7.j–Km Functional Unit 16 (west and southwest of Ireland)

Type of assessment in 2021

Available data on the fishery for 2020 and other stock indicators have been updated here according to the stock annex (*Nephrops* FU16). The assessment and catch options follow the agreed procedures set out in the stock annex; however, mean weight calculations for 2020 deviated from the stock annex and are detailed in 17.4 Data section below.

ICES advice applicable to 2020

"ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, and assuming zero discards, catches in 2020 that correspond to the F ranges in the MAP are between 2127 tonnes and 2637 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit (FU) 16 is exploited sustainably, management should be implemented at the functional unit level."

ICES advice applicable to 2021

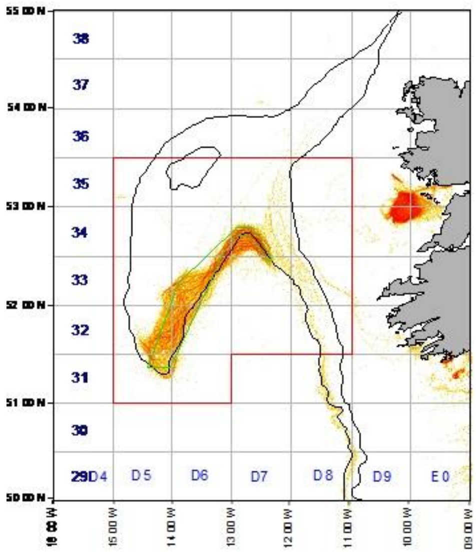
"ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, and assuming zero discards, catches in 2021 that correspond to the F ranges in the MAP are between 2653 tonnes and 3290 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit (FU) 16 is exploited sustainably, management should be implemented at the functional unit level."

17.1 General

Stock description and management units

The TAC area is Subarea 7, since 2011 an 'of which' clause was introduced specifically for the Porcupine Bank (FU16) see Table 20.1. The Functional Unit for assessment includes some parts of the following ICES divisions 7.b, c, j, and k. The exact stock area is shown on the map below and includes the following ICES Statistical rectangles: 31–35 D5–D6; 32–35 D7–D8.



The FU16 outlined by the red line. The closed area from 1 May–31 July since 2010 (reduced to only May since 2013) is shown with a green line. Irish *Nephrops* directed fishing effort between 2006–2009 derived from integrated VMS and logbook information is shown as a heat map.

Management applicable to 2020 and 2021

TAC in 2020

Council Regulation (EU) 2020/123 of 27 January 2020 fixing for 2020 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters.

Species:	Norway lobster *Nephrops norvegicus*	**Zone:**	7 (NEP/07.)
Spain	1 009 (1)	Analytical TAC	
France	4 089 (1)		
Ireland	6 201 (1)		
United Kingdom	5 516 (1)		
Union	16 815 (1)		
TAC	16 815 (1)		

(1) Special condition: within the limits of the abovementioned quotas, no more than the quantities given below may be taken in the following zone:

	Functional Unit 16 of ICES Subarea 7 (NEP/*07U16):
Spain	795
France	498
Ireland	957
United Kingdom	387
Union	2 637

TAC in 2021

Council Regulation (EU) 2021/92 of 28 January 2021 fixing for 2021 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union fishing vessels, in certain non-Union waters.

Species:	Norway lobster *Nephrops norvegicus*		Zone:	7 (NEP/07.)
Spain	993	(1)	Analytical TAC	
France	4 023	(1)		
Ireland	6 102	(1)		
Union	11 118	(1)		
United Kingdom	6 908	(1)		
TAC	18 026	(1)		

(1) Special condition: within the limits of the abovementioned quotas, no more than the quantities given below may be taken in the following zone:

Functional Unit 16 of ICES Subarea 7 (NEP/*07U16):

Spain	992
France	621
Ireland	1 194
Union	2 807
United Kingdom	483
TAC	3 290

17.2 Closed area restrictions

A seasonal closed area has been in place for three months May 1–31 July between 2010–2012 (shown in the map above and coordinates below). The period of the EU regulatory closure was reduced to only one month between 2013 and 2019 (Council Regulation 2019/124).

The following TCMs are in place for *Nephrops* in 7 (excluding 7.a) after EC 850/98 in operation since 2000. Minimum Landing Sizes (MLS); total length >85 mm, carapace length >25 mm, tail length >46 mm. Although it is legal to land smaller prawns from this fishery, marketing restrictions imposed by producer organizations in France mean smaller *Nephrops* (<35 mm CL or 115 mm whole length) are not retained in this fishery.

The mesh size restrictions apply to towed gears in 7.b–k targeting *Nephrops and* are given in Section 7.1. Vessels mainly used 80–99 mm mesh to target *Nephrops* on the Porcupine Bank.

The landing obligation applied since 2016 for certain vessels that matched the criteria set out in the discard plans: https://ec.europa.eu/fisheries/cfp/fishing_rules/discards_en

17.3 Fishery in 2020

WGCSE reviewed effort trends for Irish vessels that accounted for over 80% of the total landings in 2020. The fishery in 2020 took place up to April, after which the fishery was closed, but was reopened from October to December. In 2017 the industry reported very good catches of *Nephrops* but commented that the mean size declined significantly; however, mean sizes have increased since then.

Effect of regulations

Prior to 2011 TACs and quotas were applied to the whole Subarea 7, so the FU16 fishery was not restricted by quotas. Since 2011, the "of which clause" was implemented in the TAC regulation specifically for the Porcupine Bank. Quotas have been very restrictive for Irish vessels and this has led to various changes in fishing patterns. Vessels have tried to optimise the economic value of the catch by targeting areas and periods with relatively smaller[1] volumes of larger higher value *Nephrops*. The FU16 specific quota has also increased area misreporting in the past and the risk of discarding. An unallocated component related to area misreporting was included in the assessment from 2011 to 2017. Since 2018, following the implementation of new legislation limiting fishing trips to single functional units, misreporting was not included in the assessment.

Information from stakeholders

The provision of grade information by individual fishers and coops remains a highly important assessment input. However, in 2020 graded information was not used in the assessment.

Year	% of Irish landings where grade data were provided
2011	60%
2012	45%
2013	57%
2014	33%
2015	44%
2016	49%
2017	31%
2018	31%
2019	50%

The industry collaborated with the development of an Irish Fisheries Science Research Partnership survey in 2010 (Stokes and Lordan, 2011).

The Irish industry considers that the stock has increased significantly and no longer requires the Functional Unit "*of which*" clause.

17.4 Data

InterCatch

Data were available in InterCatch and used on a trial basis.

[1] There is a large price differential between the large and small grades. So less volume of the larger grade generates an economically viable return for fishing.

Landings

Total international landings decreased by ~16% in 2020 to 1877 t (Figure 20.1 and Table 20.2). From 2011 to 2017 total landings for FU16 had included "unallocated landings" from other FU due to misreporting. Since 2018 no reallocation has been applied as there was no information concerning misreporting.

Sampling levels

Sampling levels, data aggregating and raising procedures were reviewed by WKNEPH 2013, and are documented in the stock annex. Recent sampling rate is provided in Table 20.3.

Since 2010 landings length distributions have been reconstructed using the methods outlined in the stock annex. This involves using samples of the grade length structure from Irish sampling and estimates of the volume of each commercial size grade provided by the fishing industry. This was used to reconstruct Irish LFDs; landings by other fleets, which accounted for ~23% of the total landings from 2010 to 2019, were unsampled.

In 2020, due to the low sampling levels of graded landings caused by COVID-19 restrictions, efforts were made to adapt the sampling programme. Unsorted catch samples were collected from a total of five *Nephrops* fishing trips.

Commercial length–frequency distributions

The time-series of raised international length–frequency distributions of the sampled landings by sex are given in Figure 20.2. This also shows significant shift towards larger individuals in the landings between 2002–2009 when few individuals at smaller sizes were observed. The length distribution in 2019 was similar to 2018. The mean lengths by sex and year are presented in Table 20.4. These figures and tables are not updated for 2020.

Sex ratio

Previous *Nephrops* working groups have highlighted stability in sex ratio as an important indicator for *Nephrops* stocks. The landings and fishery-independent survey catches show a dramatic switch in the sex ratio for this stock with larger proportions of females in the catches of 2008 and 2009 (Figure 20.3). Both the commercial and survey data indicate that sex ratio switched back to a more usual situation since 2010 with males accounting for larger proportions of the catch/landings.

Nephrops moult once a year shortly after hatching of eggs in April or May. There is a 24 hour period after moulting when the male *Nephrops* can mate with the female (Farmer, 1974). If there are insufficient males in the population to mate with the recently moulted females, this can result in a change in female behaviour whereby unmated females concentrate on feeding and growth instead of reproduction. This so called "sperm limitation" hypothesis could explain the sex ratio changes observed in the Porcupine *Nephrops*. WKNEPH 2013 examined the available scientific data on proportions of females mated observed on the Spanish survey. These results showed large proportions of unmated females and a high L_{50} for mated females in catches in 2009. Simulations were also carried out to investigate the densities at which sperm limitation may become an issue given plausible ranges of stock density, sex ratios, search radii. The conclusion was that at the densities recently observed on the Porcupine Bank that sperm limitation was a real possibility.

Mean weight explorations

The mean weights in the landings are shown for the full time-series in Figure 20.4 and Table 20.5. In 2020, due to COVID-19 restrictions, mean weight calculations deviated from the stock annex and were estimated using the average mean weights of catch samples from five *Nephrops* fishing trips.

Discards

There are few historical estimates of discards for this stock. Irish sampling up to 2016 observed very minimal discarding (mainly limited to small and damaged individuals <5% by number). Four Irish trips were sampled in 2016. Discards were not recorded on one of these trips. However on the other three trips, discards were estimated to be around 8%, 9% and 15% by number (3%, 3% and 6% by weight). In 2017 there were two trips where discards were recorded, 17% and 43% by number. In 2018 discards were observed on one of the two trips (74% by number) no discards were observed on the other trip. In 2019, discards were observed in two of the four trips (13% and 29% by number). In 2020 discards were observed in two of the five trips. The discarding observed on these trips is likely not reflective of the overall discard pattern as the skippers advised the scientist on board that they had increased their discards to remain within quota during the observed trip. This means that the current discard pattern is unknown, but can be no longer considered negligible.

A detailed examination of discard estimates was provided in Spain in 2014. No estimate was provided in InterCatch by Spain since 2015.

Abundance indices from UWTV surveys

Operational details of the 2021 UWTV survey are available (Aristegui *et al*., 2021). These surveys use the standard UWTV methodology and conforms to WGNEPS best practice and guidelines, documented in Dobby H., *et al*., 2021. WKNEPH 2013 recommended that these surveys could be used for assessment and provision of catch options. The results are given in Table 20.6. Further detail of the survey is provided in the annex and annual survey reports are available at http://oar.marine.ie/handle/10793/59.

Trawl surveys

The longest time-series of fishery-independent source of data are from the Spanish Porcupine trawl survey 2001–2020 (SpPGFS-WIBTS-Q4). This survey is carried out in September when *Nephrops* catchability is quite low, particularly of adults. Further information on this survey is provided in the IBTS report (ICES, 2015) and in previous IBTS reports.

Distribution of *Nephrops* catches and biomass in Porcupine surveys between 2001 and 2020 is shown in Figure 20.5. There was a year effect in 2008 when unusual gear parameters were observed. Catch rates in 2011 may also have been reduced due to exceptionally poor weather and gear performance issues. The stratified abundance estimate and biomass increased significantly from 2015 to 2018, and decreased again in 2019 and 2020 (Figure 20.6).

The size structure of the catches in the survey shows two things: a lower mean size than in the commercial fleets and an increasing trend in mean size for both sexes up to 2008. In 2009, there is large reduction of mean size in both sexes due to a recruiting year class with a modal length at around 27 mm (possibly the 2006 year class). Tracking of cohorts was carried out at WKNEPH 2013 but the results are inconclusive (ICES, 2013). The survey shows increased recruitment since

2013 with significantly increased catch rates of individuals <24 mm (Figure 20.7). This has also led to increase catch rates of juveniles and adult *Nephrops* since 2016.

An Irish Fisheries Science Research Partnership (IFSRP) survey was developed in collaboration with the Irish fishing industry to obtain data from the closed area in 2010–2012. Details of the design and methodology are presented in Stokes and Lordan (2011). The survey uses both commercial gear (Comm) and a baca trawl similar to the SpPGFS-WIBTS-Q4. WKNEPH concluded that the IFSRP trawl survey is too short (with changes in coverage, gears and vessels) to draw an inference about CPUE changes reflecting changing stock abundance (ICES, 2013). The surveys carried out between 2010–2012 provided very useful data on population structure across the ground as well as data on grade structure and maturity-at-length.

Commercial CPUE

In the past the *Nephrops* fishery on the Porcupine Bank was both seasonal and opportunistic with increased targeting during periods of high *Nephrops* emergence and good weather. Freezing of catches at sea has become increasingly prevalent since 2006, and the fishery now operates throughout the year, mainly targeting larger more valuable *Nephrops* in lower volumes. Fishing effort has fluctuated considerably in the recent past in response to availability of *Nephrops*.

Effort and lpue/CPUE data are generally not standardized, and hence do not take into account vessel capacity, efficiency, seasonality or other factors that may bias perception of lpue/CPUE and abundance trends over the longer term. WKNEPH concluded that effort and lpue series should be maintain in the WGCSE report for information purposes (ICES, 2013). WGCSE 2016 recommended presenting the effort in KWDays and lpue in tonnes/ KWDays. Any inferences about changes in stock abundance from these data, should take account of the quality and bias concerns raised above.

These data are presented by country in Table 20.7.

17.5 Stock assessment

Comparison with previous assessments

This assessment is based on UWTV approach outlined in WKNEPH 2013 and using parameter in the stock annex (ICES, 2013). This year's assessment has been updated based on the results of the August 2021 UWTV survey.

State of the stock

The UWTV results are shown in Table 20.6. In 2017 the harvest rate was above FMSY for the first time. However, since 2018 the harvest rate has been below FMSY again, due to relatively high abundance estimates on the 2018, 2019 and 2020 UWTV surveys, and to the increase in mean weight in the landings, which resulted in a decrease in the landed numbers. Total abundance decreased in 2021, but it is still the 3rd highest value in the time-series.

Catch options table

The inputs to the catch options are given below. At this point, it is not possible to estimate the numbers and mean weights of discards in the fishery, although there are indications that discards have increased since 2016.

Variable	Value	Notes
Stock abundance (2022)	1018	UWTV survey 2021; numbers of individuals in millions
Mean weight in projected landings	44.4	Average 2018 - 2020; in grammes
Mean weight in projected discards	-	Unknown
Projected discards	-	Discarding assumed negligible
Discards survival	-	Not applicable
Projected dead discards	-	Assumed to be zero

17.6 Reference points

New reference points were evaluated by WKMSYREF4 (ICES, 2016a) and advised by ICES (2016b). The F_{MSY} for this stock was increased from 5.0% to 6.2%. The F_{MSY} for this stock is based on $F_{0.1}$ for both sexes combined given the low density of *Nephrops* on the Porcupine Bank.

Stock code	MSY Flower*	F_{MSY}*	MSY F_{upper}* with AR	MSY $B_{trigger}$	MSY F_{upper}* with no AR
nep-16	5.0%	6.2%	6.2%	Not defined	6.2%

*** Harvest rate (HR).**

17.7 Management strategies

There is no management plan for this stock.

The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to Norway lobster (*Nephrops norvegicus*) by functional unit in ICES Subarea 7 and also demersal stocks.

17.8 Quality of assessment and forecast

The main quality considerations for this stock are related to mean weight and discarding. The mean weight for this stock has been fluctuating, the most recent estimates maybe overestimate due to the non-inclusion of discards. The mean weight has declined in the last few years as strong year classes recruit to the fishery. Since 2017 a recent mean weight in the landing was considered the most appropriate basis in the calculation of catch scenarios. In previous years a long term mean weight was used.

There is good evidence from surveys and length structure of landings that recruitment improved between 2015 and 2017, and this resulted in a reduction in mean weight in the stock in those years. As expected, the mean weight increased in 2018 and 2019 as the stronger cohorts grows, and decreased again in 2020. Currently there is no methodology to take this into account in the calculation of catch options.

Up to 2015 discarding was considered negligible for this functional unit. Since 2016 the amount of discards observed on catch sampling trips have increased. This may be temporary linked to the incoming recruitment. It will result is an underestimate of recent harvest rates of similar magnitude to the numbers. The main concern is that the mean weight derived from the landings grades maybe bias due to unknown discarding levels.

The UWTV survey provides abundance since 2012 (except 2015) with high precision, but the time-series is short and an abundance MSY $B_{trigger}$ hast yet to be defined.

The landings are considered fairly well estimated up to 2020 (an unallocated component related to area misreporting was included from 2011 to 2017).

17.9 Recommendation for next benchmark

This stock was benchmark in 2013 at WK*NEPH*. WGCSE will keep the stock under close review and recommend future benchmark as required.

17.10 Management considerations

There is a separate catch limit for Functional Unit (FU) 16 within the wider TAC for Subarea 7. This has resulted in very restrictive quotas for some vessels which increased area misreporting and the risk of discarding from 2011 to 2017. Area misreporting diminished in 2018 with the introduction of a national legislation restricting Irish vessels' fishing areas, where since March 2018 Irish vessels targeting *Nephrops* in subareas 6 and 7 may only fish in either of (1) Subarea 6 and Subarea 7, excluding FU16, or (2) FU16 of Sub-area 7 (Fisheries Management Notice No. 20 of 2018). Given the vulnerability of this stock to over exploitation the separate catch limit for Functional Unit (FU) 16 should remain in place.

A seasonal closed area (May 1–July 31) has been in place since 2010. The period of the closure was reduced to one month, May, since 2013. There hasn't been an ICES evaluation of the impact of this closure and whether it provides a conservation benefit over and above catch limits. Some sectors of the fishing industry want to extend the period of closure because they believe that this is a more effective conservation measure than catch limits.

Productivity of deep-water *Nephrops* stocks is generally lower than that in shelf waters, though individual *Nephrops* grow to relatively large sizes and attain high market prices. Other deep-water *Nephrops* stocks off the Spanish and Portuguese coast have collapsed and have been subject to recovery measures for several years e.g. FU25, 26, 27 and 31. Recruitment in *Nephrops* populations in deep water may be more sporadic than for shelf stocks with strong larval retention mechanisms. This makes these stocks more vulnerable to over exploitation and potential recruitment failure as has been observed on the Porcupine Bank in the early 2000s.

From 2019 vessels using highly selective gears in Subarea 7 can be exempted from the landings obligation on the basis of the high survival exemption (see discard plans). It is unknown if *Nephrops* discarded on the Porcupine Bank could actually survive the discarding process.

Discarding by the *Nephrops* trawl fishery is around 50% of the total catch by weight. The main species that are discarded by weight are blue mouth-red fish, blue whiting and argentines (Marine Institute and Bord Iascaigh Mhara, 2011).

17.11 References

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Table 20.1. *Nephrops* Porcupine Bank (FU 16): Of which catch limit.

Year	France	Ireland	Spain	UK	Total
2011	241	454	377	188	1260
2012	238	457	380	185	1260
2013	340	653	543	264	1800
2014	349	671	557	271	1848
2015	349	671	558	272	1850
2016	349	671	558	272	1850
2017	586	1124	935	455	3100
2018	516	992	825	401	2734
2019	500	959	798	388	2645
2020	498	957	795	387	2637
2021	621	1194	992	483	3290

Table 20.2. ***Nephrops*** **Porcupine Bank (FU 16): Landings (tonnes) by country.**

Year	France	Ireland	Spain	UK (E& W)	UK (NI)	UK (Scotland)	Unallocated	Total
1965	514							514
1966	0							0
1967	441							441
1968	441							441
1969	609							609
1970	256							256
1971	500		1444					1944
1972	0		1738					1738
1973	811		2135					2946
1974	900		1894					2794
1975	0		2150					2150
1976	6		1321					1327
1977	0		1545					1545
1978	2		1742					1744
1979	14		2255					2269
1980	21		2904					2925
1981	66		3315					3381
1982	358		3931					4289
1983	615		2811					3426
1984	1067		2504					3571
1985	1181		2738					3919
1986	1060		1462	69				2591
1987	609		1677	213				2499
1988	600		1555	220				2375
1989	324	350	1417	24				2115
1990	336	169	1349	41				1895
1991	348	170	1021	101				1640
1992	665	311	822	217				2015
1993	799	206	752	100				1857

Year	France	Ireland	Spain	UK (E& W)	UK (NI)	UK (Scotland)	Unallocated	Total
1994	1088	512	809	103				2512
1995	1234	971	579	152				2936
1996	1069	508	471	182				2230
1997	1028	653	473	255				2409
1998	879	598	405	273				2155
1999	1047	609	448	185				2290
2000	351	227	213	120				910
2001	425	369	270	158				1222
2002	369	543	276	139				1327
2003	131	307	489	108		29		1064
2004	289	494	468	126		28		1406
2005	397	754	681	208		156		2197
2006	462	731	636	201		155		2185
2007	302	1060	384	146		183		2074
2008	26	562	234	41		138		1000
2009	4	356	348	13		159		879
2010	4	579	240	10		90		922
2011	8	643	182	23		122	301	1278
2012	0.46	605	198	0		134	320	1258
2013	5.8	651	132	1		118	234	1141
2014	3	813	129	0		96	148	1189
2015	3	744	84	0		109	454	1394
2016	35	1052	58	1		160	849	2154
2017	63	743	73	4	245	131	1373	2632
2018	81	2079	158	8	280	144	0	2751
2019	54	1529	112	7	325	201	0	2229
2020	41	1494	82	1	259	0	0	1877

Table 20.3. *Nephrops* Porcupine Bank (FU 16): Recent sampling used in the assessment.

Year	Spain		France		Ireland	
	Number of Trips	Type	Number of Trips	Type	Number of Trips	Type
2010	0		0		3	Graded Landings
2011	0		0		2	Graded Landings
2012	0		0		3	Graded Landings
2013					3	Graded Landings
2014					3	Graded Landings
2015					3	Graded Landings
2016					4	Graded Landings
2017					2	Graded Landings
2018					2	Graded Landings
2019					4	Graded Landings
2020					5	Unsorted Catch

Table 20.4. *Nephrops* Porcupine Bank (FU 16): Mean sizes (mm CL) of male and female *Nephrops* in Spanish, French and Irish landings and the Spanish Porcupine Groundfish survey 1981–2019.

Year	Spain Landings		Ireland Landings		France Landings		Porcupine Survey Catch	
	Males	Females	Males	Females	Males	Females	Males	Females
1981	39.9	34.5	-	-	-	-	-	-
1982	40.9	34.8	-	-	-	-	-	-
1983	40.8	34.0	-	-	-	-	-	-
1984	39.7	33.1	-	-	-	-	-	-
1985	38.7	33.5	-	-	-	-	-	-
1986	40.7	36.4	-	-	-	-	-	-
1987	39.3	35.0	-	-	-	-	-	-
1988	40.7	38.3	-	-	-	-	-	-
1989	40.5	36.8	-	-	-	-	-	-
1990	41.0	36.1	-	-	-	-	-	-
1991	39.4	34.5	-	-	-	-	-	-
1992	39.2	34.1	-	-	-	-	-	-
1993	41.6	36.1	-	-	-	-	-	-
1994	40.8	36.5	-	-	-	-	-	-
1995	41.3	36.6	40.7	36.5	43.2	38.3	-	-
1996	41.6	35.1	34.6	35.3	41.7	38.9	-	-
1997	39.7	34.8	35.9	34.5	41.9	38.4	-	-
1998	41.1	34.6	37.2	35.6	41.9	38.4	-	-
1999	41.5	35.7	36.6	33.7	43.1	39.1	-	-
2000	41.1	34.8	na	na	45.3	40.5	-	-
2001	41.1	36.3	37.8	35.4	45.4	39.4	36.0	28.9
2002	39.7	35.3	36.1	38.5	45.3	40.3	37.5	31.7
2003	41.4	37.8	44.5	36.2	46.2	38.9	39.7	30.9
2004	43.5	38.5	43.5	35.7	46.4	41.5	39.9	30.5
2005	43.4	38.1	46.9	40.6	45.9	41.0	45.1	33.8
2006	43.9	38.0	na	na	48.9	41.4	44.3	35.0

Year	Spain Landings		Ireland Landings		France Landings		Porcupine Survey Catch	
	Males	Females	Males	Females	Males	Females	Males	Females
2007	43.7	41.0	na	na	48.3	43.8	45.9	37.8
2008	51.0	40.6	43.3	37.5	na	na	48.8	38.7
2009	43.0	42.7	44.1	40.1	na	na	32.6	28.9
2010	na	na	43.2	40.4	na	na	36.3	31.8
2011	na	na	39.5	38.4	na	na	39.0	33.6
2012	na	na	41.1	38.1	na	na	41.1	30.8
2013	na	na	42.9	38.9	na	na	37.6	25.1
2014	na	na	45.1	40.9	na	na	36.4	31.0
2015	na	na	40.3	39.7	na	na	35.5	32.7
2016	na	na	37.8	37.3	na	na	32.2	27.8
2017	na	na	35.7	32.9	na	na	34.1	26.8
2018	na	na	38.8	35.3	na	na	35.0	28.2
2019	na	na	41.3	36.2	na	na	35.2	29.3
2020	na	na	na	na	na	na	37.5	29.0

Table 20.5. *Nephrops* Porcupine Bank (FU16): Time-series of numbers landed and mean weight in the landings.

Year	Numbers (millions)	Weight Landed (Tonnes)	Mean Weight in landings (gr)
1986	55.7	2591	46.53
1987	60.3	2499	41.42
1988	48.1	2375	49.34
1989	45.6	2115	46.4
1990	38.9	1895	48.67
1991	37.3	1640	43.98
1992	47	2015	42.84
1993	38.5	1857	48.29
1994	54.4	2512	46.15
1995	65.5	2936	44.79
1996	52.9	2230	42.15
1997	59.1	2409	40.73
1998	49.9	2155	43.16
1999	52.3	2290	43.76
2000	15.1	910	60.13
2001	24.6	1222	49.65
2002	32	1327	41.49
2003	18.4	1064	57.76
2004	21.5	1406	65.28
2005	31.5	2197	69.84
2006	28.7	2185	76.24
2007	29.2	2074	71.05
2008	17.9	1000	55.89
2009	16.5	879	53.19
2010	14.1	922	65.32
2011	27.9	1278	45.81
2012	25.0	1258	50.36
2013	19.8	1141	57.54
2014	17.3	1189	68.54

Year	Numbers (millions)	Weight Landed (Tonnes)	Mean Weight in landings (gr)
2015	27.4	1394	50.86
2016	53.5	2154	40.29
2017	84.9	2632	31.01
2018	66.2	2751	41.55
2019	41.8	2229	53.38
2020	49.1	1877	38.26
	Average 2018–2020		44.40

Table 20.6. *Nephrops* Porcupine Bank (FU16): Assessment summary.

Year	UWTV abundance estimate	95% Confidence Interval	Landings in number	Total discards in number*	Removals in number	Harvest rate (by number)***	Landings	Total discards*	Discard rate (by number)	Dead discard rate (by number)	Mean weight in landings	Mean weight in discards
	Millions					%	tonnes		%		grammes	
2012	787	79	25	0	25	3.2	1258	0	0	0	50.4	NA
2013	768	61	20	0	20	2.6	1141	0	0	0	57.5	NA
2014	722	35	17	0	17	2.4	1189	0	0	0	68.5	NA
2015	NA	NA	27	0	27	3.3**	1394	0	0	0	50.9	NA
2016	958	68	53	NA	53	5.6	2154	NA	NA	NA	40.3	NA
2017	850	90	85	NA	85	10.0	2632	NA	NA	NA	31.0	NA
2018	1117	92	66	NA	66	5.9	2751	NA	NA	NA	41.6	NA
2019	1010	101	42	NA	42	4.1	2229	NA	NA	NA	53.4	NA
2020	1264	94	49	NA	49	3.9	1877	NA	NA	NA	38.3	NA
2021	1018	92										

***Discarding up to 2015 was considered to be negligible. Discard estimates are not available since 2016 and are therefore not included in the assessment.**

**** The harvest rate is estimated based on a linear interpolation of abundance for 2015 as no survey was carried out in this year.**

***** Values since 2016 onwards may be underestimates due to insufficient discard data.**

NA = not available.

Table 20.7. *Nephrops* Porcupine Bank (FU16): Effort and lpue for the various different fleets exploiting the stock 1971–2019.

Year	Spain[1]		France[2]		Ireland[3]	
	Effort ('000's Hrs)	Lpue (kg/hr)	Effort[2] ('000's Hrs)	lpue (>10%; kg/hr)	Effort[3] ('000's KwDays)	Lpue (t/KWdays)
1980	318	9				
1981	272	12				
1982	237	17				
1983	196	14	18	35		
1984	194	13	30	35		
1985	200	14	33	36		
1986	162	9	28	38		
1987	174	10	24	26		
1988	180	9	22	27		
1989	173	8	14	23		
1990	159	9	15	23		
1991	138	7	19	18		
1992	96	9	32	21		
1993	80	9	36	22		
1994	80	10	38	28		
1995	67	9	42	30	584.9	1.4
1996	58	8	41	26	192.5	1.59
1997	57	8	41	25	327.3	1.26
1998	56	7	40	22	284.6	1.59
1999	53	8	43	21	278	1.29
2000	47	5	23	14	92.8	1.25

Year	Spain[1]		France[2]		Ireland[3]	
	Effort ('000's Hrs)	Lpue (kg/hr)	Effort[2] ('000's Hrs)	lpue (>10%; kg/hr)	Effort[3] ('000's KwDays)	Lpue (t/KWdays)
2001	44	6	24	15	230.2	1.12
2002	54	5	18	18	339.8	1.3
2003	66	5	7	19	294.7	0.8
2004	59	10	9	25	569.2	0.68
2005	60	13	15	26	756.2	0.83
2006	65	9	22	21	952.8	0.72
2007	58	8	17	18	1199.4	0.81
2008	42	6	4	7	830.7	0.67
2009	44	7			411.3	0.83
2010	42	6			704.1	0.81
2011	na	na			986.9	0.63
2012	15	na			817.1	0.63
2013	na	na			885.7	0.92
2014	na	na			1019.8	0.92
2015	na	na			1219.2	0.99
2016	na	na			1359.3	1.43
2017	na	na			1328.9	1.59
2018	na	na			1721.2	1.21
2019	na	na			1463.3	1.01
2020	na	na			1468.3	0.97

1 = Effort and lpue between 1980 and 2010 was estimated based on fishing days in 7. Effort in 2012 was based on logbooks for FU16.

2 = Effort and lpue for vessels where <10% of landed value was *Nephrops*.

3 = Effort and lpue for vessels where 30% of the landed weight was *Nephrops*.

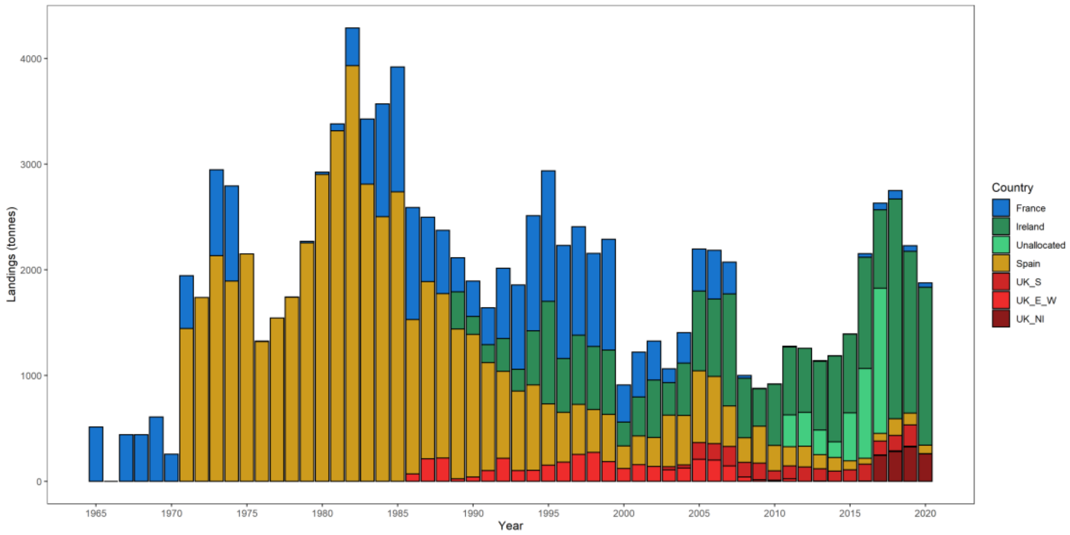


Figure 20.1. *Nephrops* in FU16 (Porcupine Bank). WG's best estimates of landings in tonnes by country.

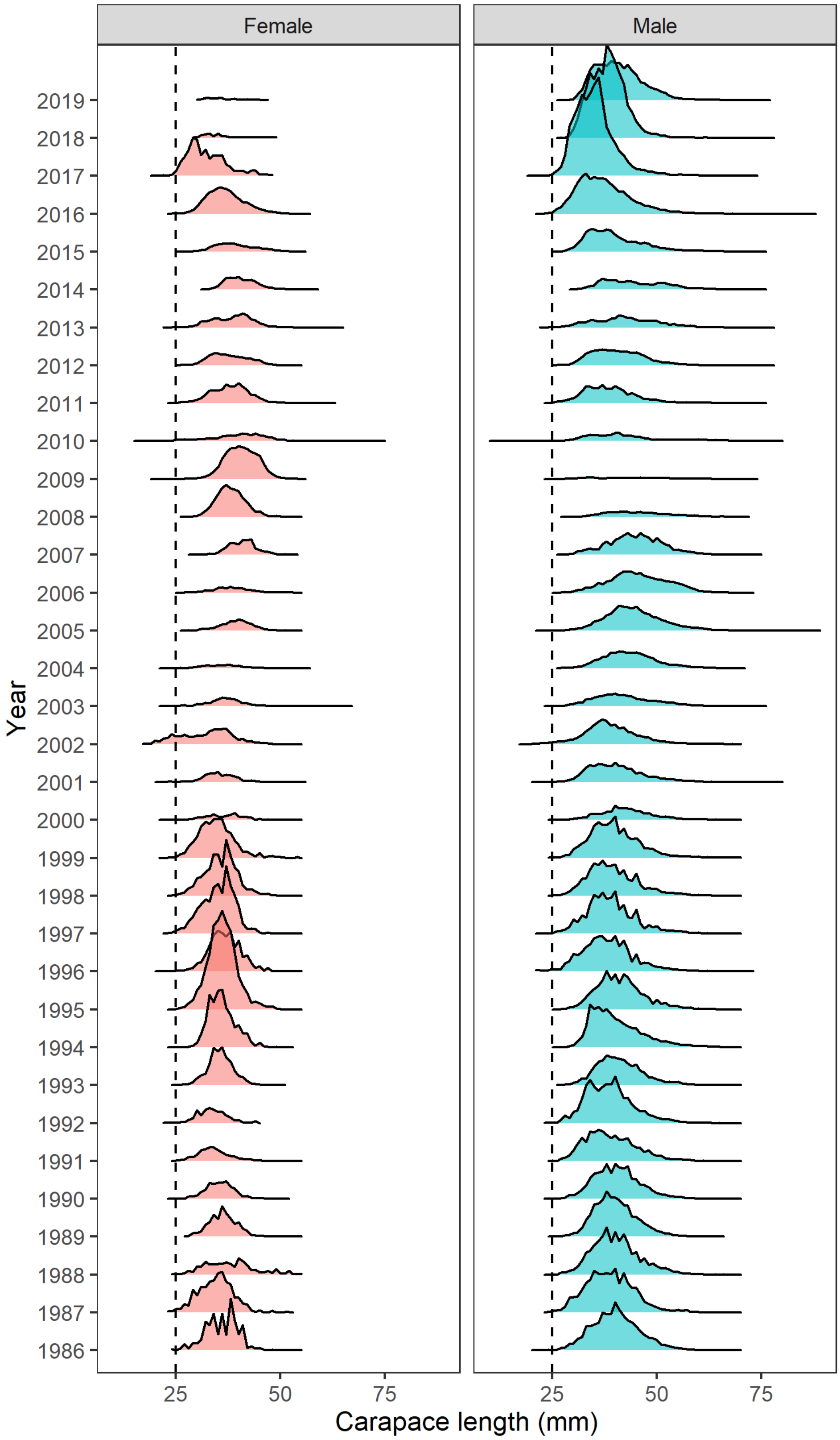


Figure 20.2. *Nephrops* in FU16 (Porcupine Bank). Female and male length distributions of raised international landings. Vertical dashed lines refer to Minimum Landing Size (25 mm).

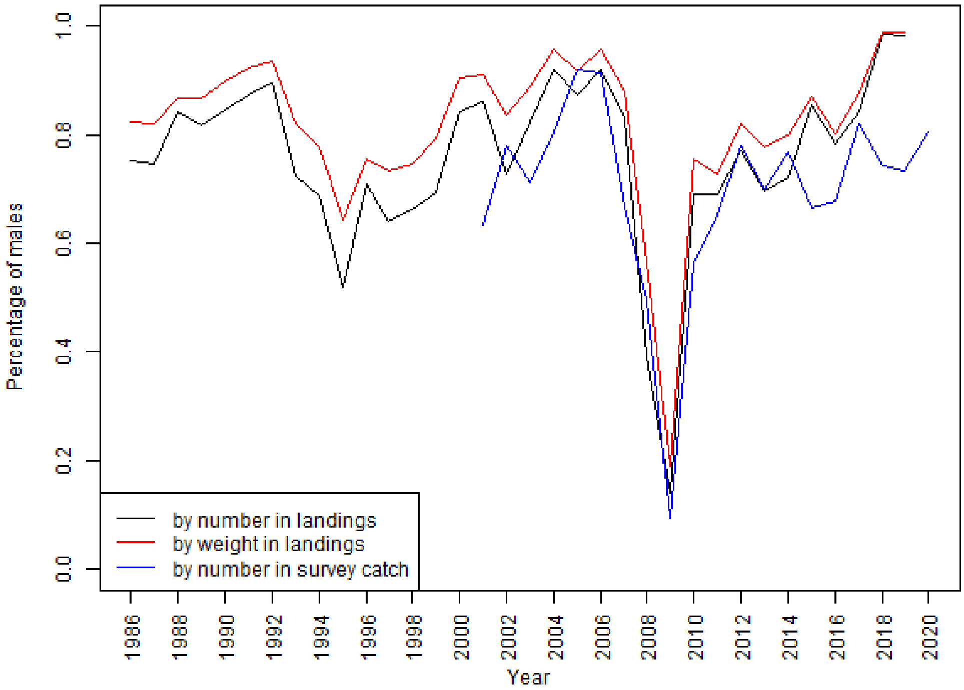


Figure 20.3. ***Nephrops*** **in FU16 (Porcupine Bank). The percentage males in the landings and survey over time.**

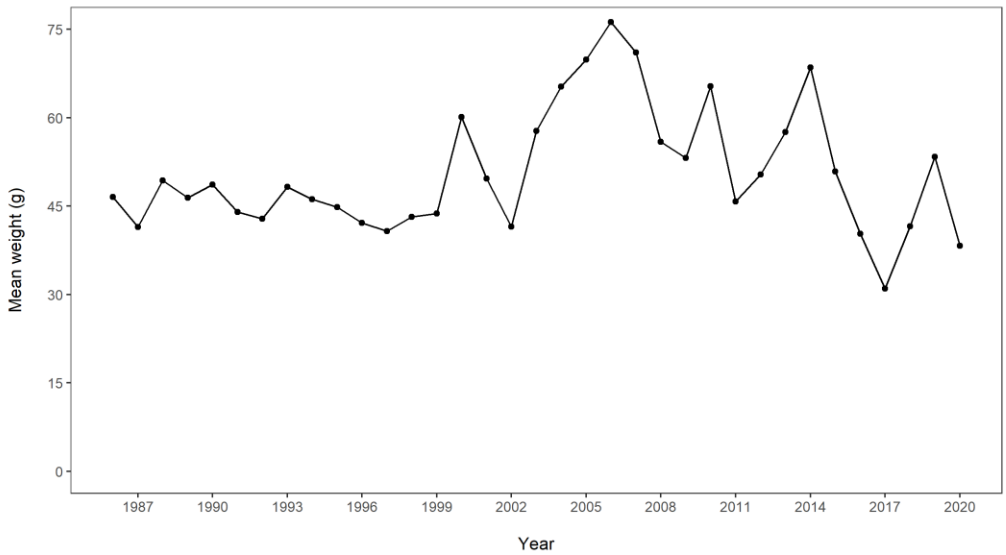


Figure 20.4. ***Nephrops*** **in FU16 (Porcupine Bank). Mean weight in the commercial landings.**

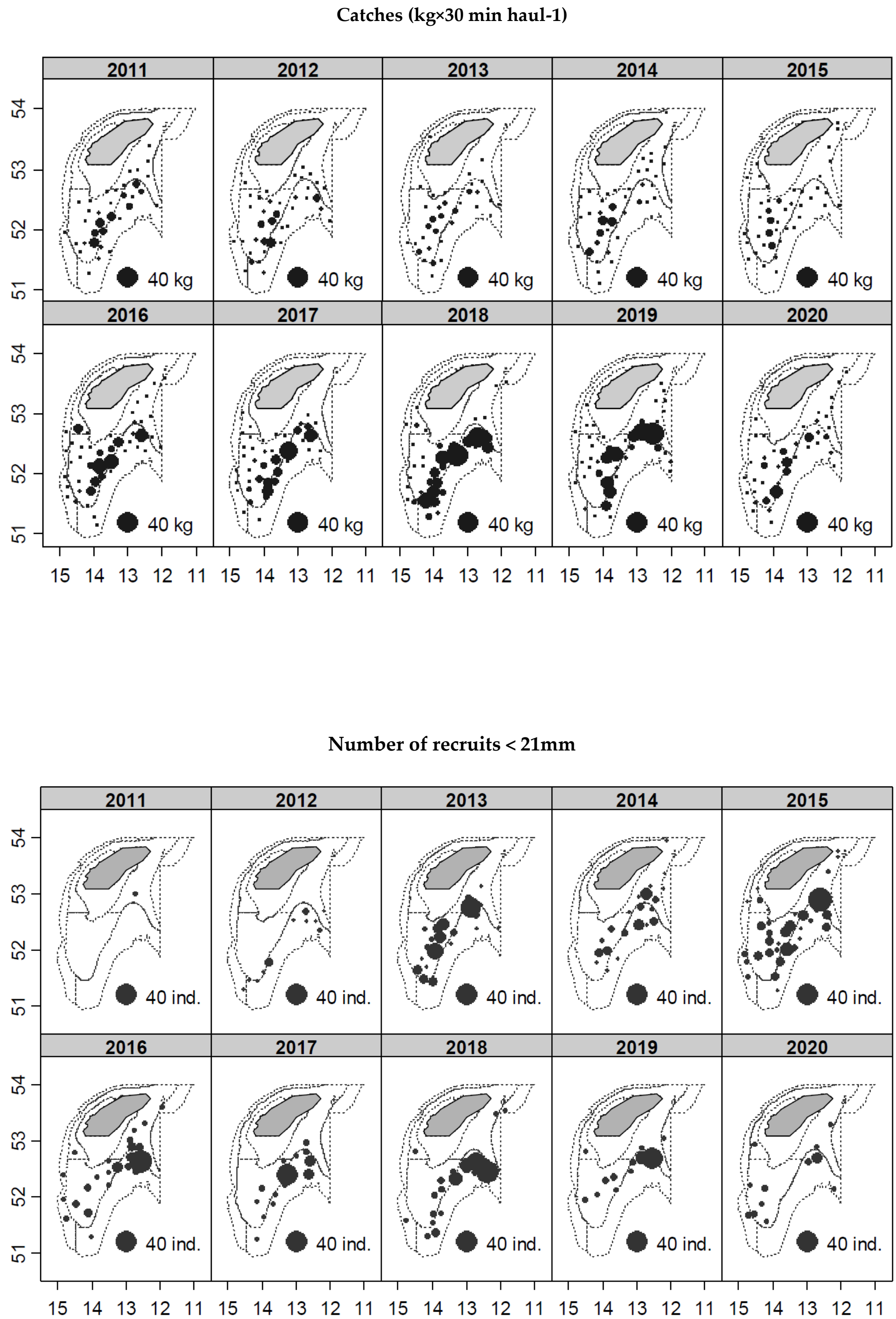


Figure 20.5. *Nephrops* in FU16 (Porcupine Bank). Geographic distribution of *Nephrops norvegicus* in Porcupine surveys between 2011 and 2020. Top panel: catches (kg×30 min haul-1). Bottom panel: Number of recruits (<21 mm carapace length).

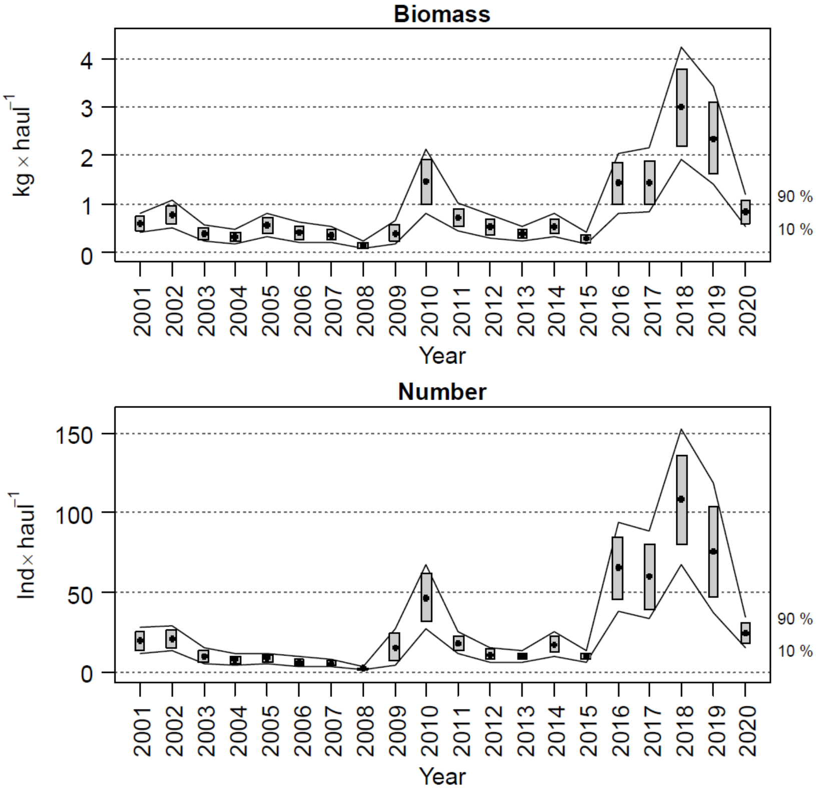


Figure 20.6. ***Nephrops*** **in FU16 (Porcupine Bank). Evolution of *Nephrops norvegicus* biomass and abundance indices in Porcupine surveys (2001-2020). Boxes mark parametric standard error of the stratified abundance index. Lines mark boot-strap confidence intervals (α = 0.80, mbootstrap iterations = 1000).**

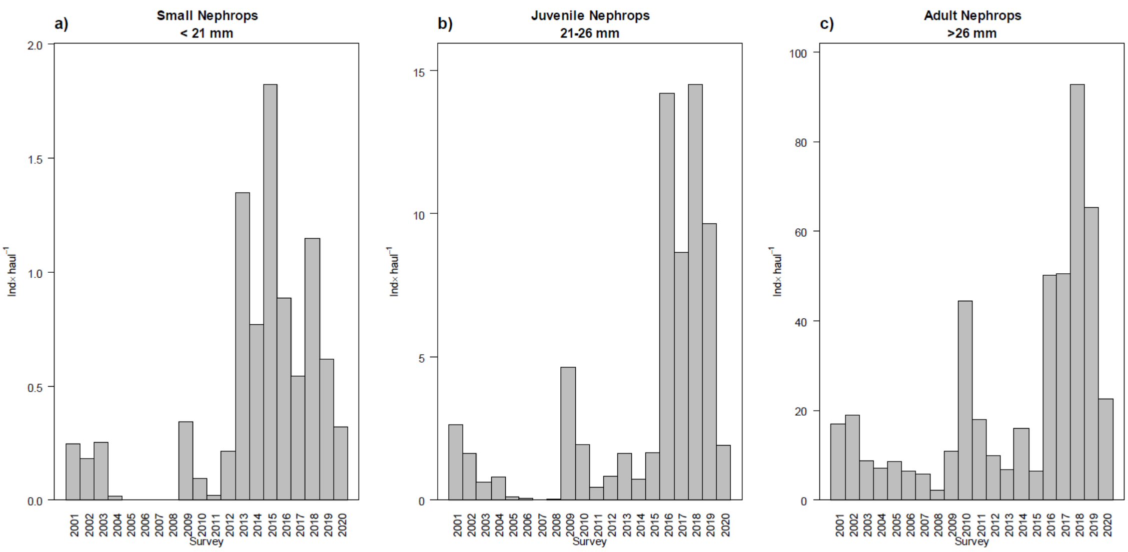


Figure 20.7. ***Nephrops*** **in FU16 (Porcupine Bank). Abundance of small *Nephrops* (<21 mm), juveniles between 21-26 mm and adults (>26 mm) in Porcupine survey 2001-2020.**

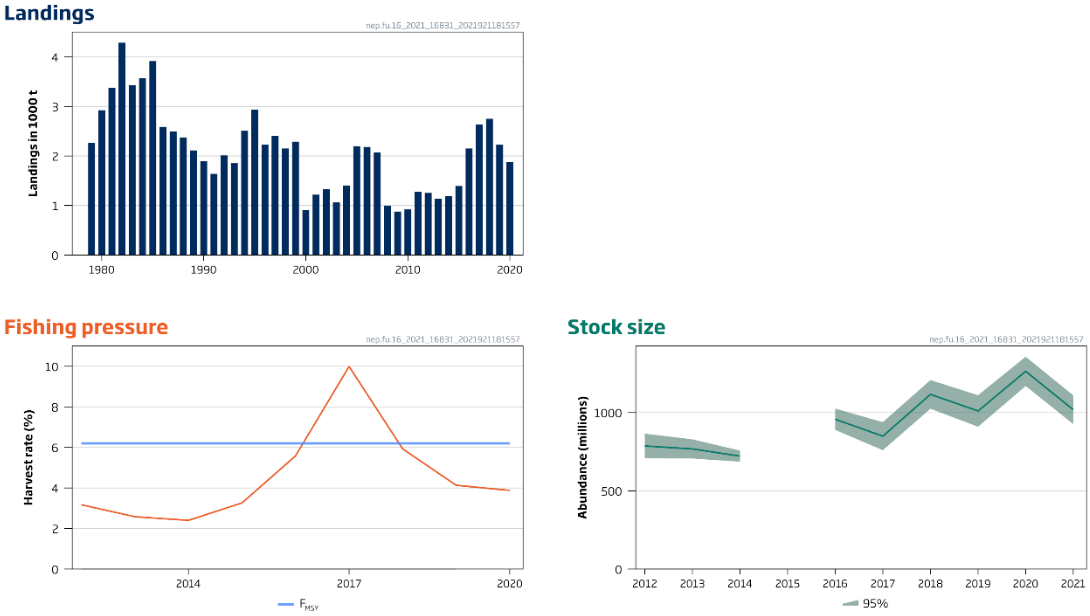


Figure 20.8. *Nephrops* in FU16 (Porcupine Bank). Summary of stock status for Porcupine *Nephrops*.

18 Norway lobster (*Nephrops norvegicus*) in Division 7.b, Functional Unit 17 (west of Ireland, Aran grounds)

Type of assessment in 2021

This stock was interbenchmarked in September 2015 by correspondence (ICES, 2016a). The assessment and catch options follow the agreed procedures set out in the stock annex.

ICES advice applicable to 2020

"ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 696 tonnes and 800 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit (FU) 17 is exploited sustainably, management should be implemented at the functional unit level."

ICES advice applicable to 2021

"ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 443 tonnes and 508 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule.

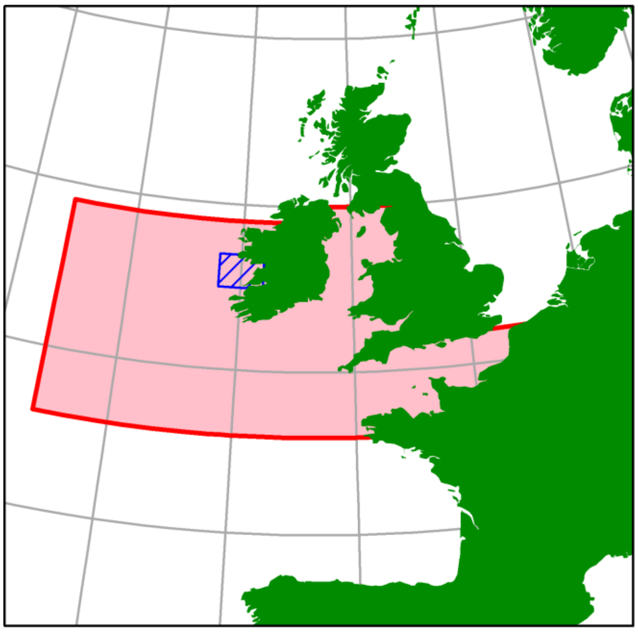
To ensure that the stock in Functional Unit (FU) 17 is exploited sustainably, management should be implemented at the functional unit level."

18.1 General

Stock description and management units

The Aran Grounds *Nephrops* stock (FU17) covers ICES rectangles 34–35 D9–E0 within 7.b. This stock is included as part of the TAC Area 7 *Nephrops* which includes the following stocks: Irish Sea East and West (FU14, FU15), Porcupine Bank (FU16), northwestern Irish Coast (FU18), southeastern and southwestern Irish Coast (FU19) and the Celtic Sea (FU20–22).

Map below shows FU17 assessment area (blue) and TAC area (red). See Section 18 for details on *Nephrops* Subarea 7 general section.



Ecosystem aspects

Details of the ecosystem on the Aran grounds are provided in the stock annex updated by IBPNeph (ICES, 2016a).

Fishery description

A description of the fleet is given in the stock annex. The time-series of numbers of vessels is updated in Figure 21.1.1. The numbers of vessels had been relatively stable from 1995 to 2018, but it decreased in 2019 and 2020 to half. The time-series of vessel power is shown as a box and kite plot in Figure 21.1.2.

The majority of the landings are made with 80 mm mesh.

The majority of the landings come from the grounds to the west and southwest of the Aran Islands known as the 'back of the Aran ground' (See stock annex). The fishery on the Aran Grounds operates throughout the year, weather permitting with a seasonal trend (See stock annex).

Fishery in 2020

In recent years several newer vessels specializing in *Nephrops* fishing have participated periodically in this fishery. These vessels target *Nephrops* on several other grounds within the TAC area and move around to optimize catch rates. There has been a trend for Irish vessels to switch to multi (quad) rig trawls since 2012. These vessels are more efficient at catching *Nephrops* (BIM, 2014).

Information from stakeholders

Voluntary effort restriction were put in place by the Irish fishing industry in April and May 2015. These measures reduced catches and effort significantly on the stock in advance of the 2015 UWTV survey.

18.2 Data

InterCatch

Data were available in InterCatch and used for catch data only.

Landings

The reported landings time-series is shown in Figure 21.2.1 and Table 21.2.1. The 2020 landings increased by about 33% from those made in 2019 and amounted to 222 t.

Effort

The IBPNeph 2015 reviewed Irish commercial landings and effort data in detail. They concluded that effort should be reported in the WGCSE report in KWdays and lpue should be reported in KG/kwdays in the knowledge that the trend is likely to be a biased underestimate because it is not adjusted for efficiency or behavioural changes. The time-series of effort and lpue is updated in Figure 21.2.2 and Table 21.2.2. There was a significant decline in lpue and effort in 2015 due to the local management efforts put in place in April and May. In 2016 effort level increased to values similar to those observed previously prior to 2011. However, since 2017 effort levels have declined, reaching in 2020 the lowest values in the dataseries.

Sampling levels

Sampling levels, data aggregating and raising procedures were reviewed by IBPNeph 2015 and are documented in the stock annex. The time-series of samples is shown in Figure 21.2.3 and Table 21.2.3. Sampling levels in 2020 were similar to 2019.

Commercial length–frequency distributions

The raised catch length distributions are shown in Figure 21.2.4. The mean length of females decreased in 2018, increasing the discard rate for females. Female lengths increased in 2019 and 2020 to similar values of 2017.

Sex ratio

In 2020 the difference on the proportion of males between the catches and the landings is lower than in recent years and similar to 2016 (Figure 21.2.5). Sex ratio has a distinct seasonal pattern with lowest male proportions in the samples in May and June. Males dominate the catches in autumn and winter.

Mean weight explorations

Explorations of the mean weight in the catch samples by sex shows a strong cyclical pattern in females, which corresponds to the emergence of mature females from the burrows to mate in summer (Figure 21.2.6). The annual mean weight estimate for landings and discards is shown in Figure 21.2.7. The mean weight estimates have been relatively stable from 2011, where main change occurred in 2008–2011. In 2020 the landings mean weight increased slightly, while the discards mean weight increased significantly.

Discarding

Table 21.2.4 gives weights, numbers and proportions of the landings and discard raised internationally according to the stock annex. A 25% discard survival rate is assumed in line with other *Nephrops* stocks in the Celtic sea (see stock annex) as the basis for the catch scenarios. Gear selectivity trials by Bord Iascaigh Mhara (BIM, 2017) reported a 64% survivor rate for *Nephrops* caught in a trawl with a SELTRA selectivity device in the outer Galway Bay area.

Abundance indices from UWTV surveys

The spatial extent of the *Nephrops* grounds in FU17 was re-defined by IBPNeph 2015 and the total abundance estimates were revised using a new procedure (ICES, 2016a). The redefinition of the polygons in FU17 resulted in ~30% increase in overall area from 1007 km² to 1320 km² (stock annex). Operational details of the 2021 UWTV survey are available (Aristegui et al., 2021).

The spatial distributions of burrow densities are shown in Figure 21.2.8. The densities have fluctuated considerably over the time-series and throughout the Aran grounds. In general the densities are higher towards the middle-western side of the ground and there is a notable trend towards lower densities towards the east. On the southwestern boundary, there are often high densities close to the boundary. In this area, there is a sharp transition from mud to rocky substratum.

The summary statistics from this geostatistical analysis are given in Table 21.2.5 and plotted in Figure 21.2.10. The geostatistical abundance estimate adjusted is derived using the mean of the krigged grid where the mean of the observations is reported in Table 21.2.5. In 2021 the Aran Grounds account for ~94% of the total estimated burrow abundance from FU17 (Table 21.2.5). Galway Bay accounts for ~3.5% and Slyne Head for ~2.5% (Table 21.2.6). The Galway Bay estimates fluctuate widely but appear to be highly correlated with the Aran ground except in 2004 (Figure 21.2.9). Estimates for the Slyne Head ground also fluctuate considerably but show no significant correlation with the other areas except for the peaks of 2010, 2015 and 2018 (Figure 21.2.9).

Aran ground abundance estimate's CV (4%; Table 21.2.5) is well below the recommendation of 20% by SGNEPS (ICES, 2012). The CV on the abundance estimates for Galway Bay and Slyne Head also stay low at 4% (Table 21.2.6) and within the recommendation, showing the surveys are precise. Figure 21.2.10 and Table 21.2.7 show the total abundance estimate for FU17 with the IBPNeph proposed MSY $B_{trigger}$. The 2021 combined abundance estimate (331 million) was 16% lower than in 2020 and is below the MSY $B_{trigger}$ (540 million).

18.3 Assessment

Comparison with previous assessments

The WGCSE 2021 carried out an UWTV based assessment for this stock. The methods used were very much in line with WKNEPH (ICES, 2009a) and the approach taken for other *Nephrops* stocks in 6 and 7 by WGCSE. This approach was interbenchmarked at IBPNeph (ICES, 2016a).

State of the stock

UWTV abundance estimates suggest that the stock size has fluctuated widely with an overall declining trend and is below MSY $B_{trigger}$ since 2012 (except 2015 and 2018). The 2021 estimate is lowest observed in the time-series and is below the MSY $B_{trigger}$. The 2021 abundance remains below the average of the series (geomean [2002–2019]: 617 million). Harvest rate [calculated as (landings + dead discards)/abundance estimate] has been below the $F_{MSYproxy}$ since 2017 (Table 21.3.1 and Figure 21.3.1).

18.4 Catch scenario table

Catch scenario table inputs and historical estimates of mean weight in landings and harvest ratios are presented in Table 21.3.1 and summarised below. The calculation of catch options for the Aran Grounds follows the procedure outlined in the stock annex.

The basis for the catch scenarios.

Variable	Value	Notes
Stock abundance (2022)	331	UWTV survey 2021; numbers of individuals in millions
Mean weight in projected landings	22.4	Average 2008–2020; in grammes
Mean weight in projected discards	11.3	Average 2008–2020; in grammes
Projected discards	26.9	Average 2017–2020; percentage by number
Discards survival	25	Percentage by number
Projected dead discards	21.8	Average 2017–2020; percentage by number

Given the fluctuations observed in mean weights for landings and discards (Figure 21.2.7) an average from 2008 to the most recent year is used in the calculation of catch options as set out in the stock annex. The discard rates and proportions for the last three years are used to account for recent on-board retention practices (this is also according to the stock annex).

18.5 Reference points

New reference points were defined for this stock at the IBPNeph (ICES, 2016a) and no new proposals were made by WKMSYRef4 (ICES, 2016b). For *Nephrops* stocks MSY $B_{trigger}$ has been defined as the lowest stock size from which the abundance has increased. This corresponds to the abundance observed in 2008 rounded to the nearest 10 = 540 million individuals (Figure 21.2.10 and Table 21.2.7).

The F_{MSY} proxy was revised during the benchmark in 2015. The observed burrow density has declined, from high (>0.8 individuals m^{-2}) at the start of the series to medium density (~0.3 individuals m^{-2}) towards the end of the time-series. The nature of the fishery has also changed, from a continuous fishery throughout the year to a fishery which is more concentrated on sporadic periods of high catch rates. For these reasons a harvest rate consistent with a combined sex $F_{0.1}$ = 8.5% is considered an appropriate proxy for F_{MSY}.

These should remain under review by WGCSE and may be revised while data become available.

18.6 Management strategies

As yet there are no explicit management strategies for this stock but there have been some discussions among the fishing industry and scientists about developing a long term plan for the management of the Aran fishery. Sustainable utilization of the *Nephrops* stock will form the cornerstone of any management strategy for this fishery.

The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to Norway lobster (*Nephrops norvegicus*) by functional unit in ICES Subarea 7 and also demersal stocks.

18.7 Quality of assessment and forecast

Biological sampling for this stock is adequate. Since 2002 a dedicated annual UWTV survey has provided abundance estimates for the Aran Grounds with high precision. The area of the Aran Grounds was revised in 2015, resulting in a recalculation of the abundance time-series which now also includes Galway Bay and Slyne Head. A number of other biological parameters such as mean weights and length distributions have also been revised. The revisions were made as part of an interbenchmark process and have improved the quality of the assessment.

In the provision of catch options based on the absolute survey estimates additional uncertainties related to mean weight in the landings and the discard rates also arise. From 2016, fisheries catching *Nephrops* in Subarea 7 are covered by the EU landings obligation (EU, 2015). Creel fisheries are exempted from the landings obligation, with a *de minimis* exemption consisting of a 5% discard rate by weight for the trawl fishery in 2019 (reduced from 6% in 2018 and 7% in both 2016 and 2017). The average discard rate by weight for FU17 over the last three years is 12.4%. Catch advice and scenarios are provided this year on the assumption that discarding is assumed to continue at recent average.

Irish discard survival experiments indicate that the trawl discard survival may be around 64% (BIM, 2017). As a result, an exemption from the landings obligation based on high survivability has been granted by the European Commission. ICES continues to use the survival rate of 25% (ICES, 2016c) as the survival rates estimated by BIM (2017) have not been evaluated by ICES.

There are several key uncertainties and bias sources in the method used here (these are discussed further in WK*Neph* 2009). Various agreed procedures have been put in place to ensure the quality and consistency of the survey estimates following the recommendations of several ICES groups (WKNEPTV 2007; WKNEPHBID 2008; SGNEPS 2009b; WGNEPS 2014; WKNEPS 2016d; Dobby *et al.*, 2021). Ultimately there still remains a degree of subjectivity in the production of UWTV abundance estimates (Marrs *et al.*, 1996). Taking explicit note of the likely biases in the surveys may at least provide an estimate of absolute abundance that is more accurate, although no more precise (ICES, 2009a).

Landings data were adjusted to take into account landings that had been misreported from FU16 from 2011 to 2017. This adjustment is thought to be reasonably accurate (See Section 18).

18.8 Recommendation for next benchmark

This stock was last benchmarked by IBPNeph (ICES, 2016a). WGCSE will keep the stock under close review and recommend future benchmark as required.

18.9 Management considerations

A meeting was held with stakeholders in March 2015 to discuss the state of the Aran *Nephrops* stock. In response to this meeting voluntary effort limits were put in place for April, May and June 2015. These voluntary measures have significantly reduced effort and catches on the Aran grounds in 2015 before the UWTV survey.

Small whole *Nephrops* are the main species comprising the discards. The main fish species discarded are haddock, hake, whiting, megrim and dogfish (Anon, 2011).

The ICES and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management at the Functional Unit level could provide controls to ensure effort and catch were in line with resources available.

18.10 References

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Table 21.2.1. *Nephrops* in FU17 (Aran Grounds). Landings in tonnes by country.

Year	France	Rep. of Ireland	UK	Total
1974	477			477
1975	822			822
1976	131			131
1977	272			272
1978	481			481
1979	452			452
1980	442			442
1981	414			414
1982	210			210
1983	131			131
1984	324			324
1985	207			207
1986	147		1	148
1987	62		0	62
1988	14	814		828
1989	27	317	3	347
1990	30	489		519
1991	11	399		410
1992	11	361	2	374
1993	11	361	0	372
1994	18	707	4	729
1995	91	774	2	867
1996	2	519	7	528
1997	2	839	0	841
1998	9	1401	0	1410
1999	0	1140	0	1140
2000	1	879	0	880
2001	1	912	0	913
2002	2	1152	0	1154

Year	France	Rep. of Ireland	UK	Total
2003	0	933	0	933
2004	0	525	0	525
2005	0	778	0	778
2006	0	637	0	637
2007	0	913	0	913
2008	0	1050	7	1057
2009	0	625	0	625
2010	0	930	9	939
2011	0	659	0	659
2012	0	1246	0	1246
2013	0	1295	0	1295
2014	0	766	0	766
2015	0	370	0	370
2016	0	641	0	641
2017	0	295	0.4	295
2018	0	494	42	536
2019	0	162	4	167
2020	0	188	34	222

Table 21.2.2. ***Nephrops*** **in FU17 (Aran Grounds). Effort data for the Irish otter trawl** ***Nephrops*** **directed fleet.**

Year	Effort (Kw Days)	Landings (Kgs)
1995	286,939	522,007
1996	174,030	312,421
1997	260,676	442,218
1998	445,308	940,902
1999	366,839	782,407
2000	293,684	561,244
2001	362,754	586,462
2002	350,346	798,744
2003	492,284	801,813
2004	355,673	420,652
2005	396,202	708,540
2006	337,503	618,515
2007	460,396	905,282
2008	512,245	1,052,077
2009	319,873	613,220
2010	441,080	910,346
2011	332,300	667,564
2012	488,721	1,139,413
2013	571,916	1,239,469
2014	460,818	774,097
2015	232,190	461,409
2016	396,502	578,420
2017	277,117	258,052
2018	233,793	483,723
2019	136,278	148,795
2020	91,263	177,895

Table 21.2.3. *Nephrops* in FU17 (Aran Grounds). Sampling levels.

Year	Quarter	Number of samples		Numbers Measured	
		Catch	Discards	Catch	Discards
2008	1	2	3	565	1376
2008	2	9	8	2224	3758
2008	3	5	4	1266	1834
2008	4	3	3	889	1733
2009	1	3	3	800	1184
2009	2	6	6	1685	1978
2009	3	6	6	2260	2726
2009	4	2	2	1491	1149
2010	1	4	4	3322	2322
2010	2	8	7	3577	2957
2010	3	2	2	951	742
2010	4	6	4	3209	1802
2011	1	7	7	3755	3537
2011	2	7	7	7399	6617
2011	3	4	2	3531	2386
2011	4	5	5	2440	2271
2012	1	3	3	1538	1250
2012	2	17	15	6481	5113
2012	3	0	0	-	-
2012	4	5	5	2333	1945
2013	1	10	9	3108	2983
2013	2	11	11	3733	3733
2013	2	3	3	1163	1263
2013	4	7	7	2956	1779
2014	1	3	3	1208	1223
2014	2	12	12	5365	3563
2014	3	2	2	786	499
2014	4	8	8	3542	2760

Year	Quarter	Number of samples		Numbers Measured	
		Catch	Discards	Catch	Discards
2015	1	2	2	827	611
2015	2	2	2	961	664
2015	3	0	0	-	-
2015	4	2	2	1047	1388
2016	1	5	4	2292	876
2016	2	11	11	4756	3383
2016	3	6	5	3020	2048
2016	4	6	6	1389	1311
2017	1	3	3	1214	845
2017	2	6	4	2911	1569
2017	3	2	1	1018	223
2017	4	3	3	1176	839
2018	1	3	3	1224	1241
2018	2	8	8	3179	2971
2018	3	1	1	467	388
2018	4	6	6	1894	2487
2019	1	3	3	1151	1368
2019	2	5	5	1552	1441
2019	3	2	2	628	480
2019	4	2	2	519	558
2020	1	4	4	1037	984
2020	2	5	5	1706	1666
2020	4	1	0	302	-

Table 21.2.4. *Nephrops* in FU17 (Aran Grounds). Raised landings and discard weight and numbers by year.

Year	Landings (t)	Discards (t)	Landings in number ('000s)	Discards in number ('000s)	Discards by weight (%)	Discards by number (%)
2008	1057	248	48,162	22,074	19.0	31.4
2009	626	129	24,935	9,487	17.1	27.6
2010	939	224	37,341	15,246	19.3	29.0
2011	659	92	31,950	8,542	12.2	21.1
2012	1246	86	61,076	8,292	6.5	12.0
2013	1295	129	60,016	12,034	9.1	16.7
2014	766	48	33,882	5,038	5.9	12.9
2015	370	15	17,693	1,622	3.8	8.4
2016	641	69	30,231	6,375	9.7	17.4
2017	295	38	13,269	3,605	11.3	21.4
2018	536	106	22,049	10,490	16.5	32.2
2019	167	21	7,568	2,098	11.1	21.7
2020	222	54	9,516	3,525	19.5	27.0

Table 21.2.5. *Nephrops* in FU17 (Aran Grounds). Results summary table for geostatistical analysis of UWTV survey.

Ground	Year	Number of stations	Mean Density adjusted** (burrow/m²)	Domain Area (km²)	Geostatistical Abundance Estimate adjusted (millions burrows)	CV on Burrow estimate %
Aran Grounds	2002	49	0.79	1196	947	3
	2003	41	0.94	1196	1118	6
	2004	64	1.08	1196	1297	3
	2005	70	0.81	1196	972	2
	2006	67	0.46	1196	556	3
	2007	71	0.69	1196	828	2
	2008	63	0.41	1196	494	3
	2009	82	0.52	1196	627	2
	2010	87	0.63	1196	752	2
	2011	76	0.51	1196	609	2
	2012	31*	0.33	1196	397	3
	2013	31*	0.33	1196	390	4
	2014	33*	0.28	1196	332	4
	2015	34*	0.40	1197	480	4
	2016	34*	0.29	1197	343	3
	2017	31*	0.31	1196	377	3
	2018	33*	0.40	1196	488	3
	2019	31*	0.39	1196	458	4
	2020	34	0.29	1196	359	4
	2021	34*	0.26	1196	311	4

*** reduced isometric grid.**

**** mean density of the observations.**

Table 21.2.6. *Nephrops* in FU17 (Galway Bay and Slyne Head). Results summary table for analysis of UWTV survey. Random stratified estimates given for these grounds only.

Ground	Year	Number of stations	Mean Density adjusted (burrow/m²)	Domain Area (km²)	Raised Abundance Estimate adjusted (millions burrows)*	CV on Burrow estimate %
Galway Bay	2002	7	1.18	79.0	93.1	7
	2003	3	1.30	79.0	102.6	16
	2004	8	1.17	79.0	92.2	14
	2005	4	1.30	79.0	103.0	11
	2006	3	0.74	79.0	58.8	9
	2007	5	0.91	79.0	71.8	8
	2008	5	0.40	79.0	31.6	4
	2009	8	0.71	79.0	56.3	4
	2010	10	1.24	79.0	97.6	11
	2011	6	0.55	79.0	43.2	12
	2012	4	0.64	79.0	50.9	10
	2013	5	0.37	79.0	29.6	10
	2014	3	0.50	79.0	39.8	6
	2015	5	0.71	79.0	55.8	15
	2016	7	0.32	79.0	25.1	7
	2017	5	0.20	79.0	15.8	4
	2018	5	0.41	79.0	32.5	17
	2019	5	0.29	79.0	22.8	11
	2020	5	0.34	79.0	27.2	13
	2021	5	0.15	79.0	11.5	2

Ground	Year	Number of stations	Mean Density adjusted (burrow/m²)	Domain Area (km²)	Raised Abundance Estimate adjusted (millions burrows)*	CV on Burrow estimate %
Slyne Head	2002	5	0.76	39.1	29.8	8
	2003*	0	0.65	39.1	25.3	0
	2004	3	0.53	39.1	20.8	10
	2005	3	0.44	39.1	17.4	1
	2006	3	0.30	39.1	11.8	9
	2007	4	0.51	39.1	19.8	12
	2008*	0	0.41	39.1	16.0	0
	2009	6	0.31	39.1	12.2	7
	2010	7	0.73	39.1	28.7	4
	2011	7	0.51	39.1	20.0	5
	2012	3	0.52	39.1	20.5	2
	2013	4	0.54	39.1	21.1	10
	2014	4	0.28	39.1	11.0	6
	2015	5	0.50	39.1	19.6	4
	2016	4	0.27	39.1	10.8	3
	2017	4	0.27	39.1	10.7	4
	2018	5	0.84	39.1	33.0	12
	2019	5	0.29	39.1	11.5	8
	2020	5	0.19	39.1	7.4	4
	2021	5	0.23	39.1	9.1	2

***estimated as no survey data available for these years.**

Table 21.2.7. *Nephrops* in FU17. Results summary table for analysis of UWTV survey for the combined grounds.

Year	Abundance (Millions)	Upper bound	Lower bound
2002	1070	1154	985
2003	1246	1434	1059
2004	1410	1517	1302
2005	1092	1154	1030
2006	627	703	551
2007	920	982	858
2008	541	588	494
2009	696	739	653
2010	879	926	831
2011	672	720	624
2012	468	520	417
2013	441	506	376
2014	383	440	327
2015	556	627	484
2016	379	420	339
2017	404	445	362
2018	554	637	471
2019	493	558	427
2020	394	453	335
2021	331	362	301

Table 21.3.1. *Nephrops* in FU17 (Aran Grounds). Forecast inputs (bold) and historical estimates of mean weight in landings and harvest rate. Removals estimated in years with no sampling (*) using ratio of removals to landings in adjacent years. na= not available due to non-cooperation with sampling programmes.

Year	UWTV abundance estimate	95% Confi-dence Interval	Landings in number	Total discards in number*	Removals in number	Harvest rate (by number)***	Landings	Total discards*	Discard rate (by number)	Dead discard rate (by number)	Mean weight in landings	Mean weight in discards
	millions					%	tonnes		%		grammes	
2002	1070	84	55	18	68	6.3	1154	192	24.5	19.6	21.2	10.8
2003	1246	187	44	18	58	4.6	933	183	29.3	23.7	21.2	10.0
2004	1410	108	29	11	38	2.7	525	112	28.2	22.9	18.1	9.9
2005	1092	62	42	20	57	5.2	778	182	31.7	25.9	18.4	9.2
2006	627	76	n/a	n/a	50	7.9	637	n/a	n/a	n/a	n/a	n/a
2007	920	62	n/a	n/a	57	6.2	913	n/a	n/a	n/a	n/a	n/a
2008	541	47	48	22	65	12.0	1057	248	31.4	25.6	21.94	11.23
2009	696	43	25	9	32	4.6	625	129	27.6	22.2	25.12	13.63
2010	879	47	37	15	49	5.6	939	224	29.0	23.4	25.16	14.70
2011	672	48	32	9	38	5.7	659	92	21.1	16.7	20.62	10.75
2012	468	52	61	8	67	14.4	1246	86	12.0	9.2	20.40	10.39
2013	441	65	60	12	69	15.7	1295	129	16.7	13.1	21.59	10.73
2014	383	57	34	5	38	9.8	766	48	12.9	10.0	22.62	9.56

Year	UWTV abundance estimate	95% Confidence Interval	Landings in number	Total discards in number*	Removals in number	Harvest rate (by number)***	Landings	Total discards*	Discard rate (by number)	Dead discard rate (by number)	Mean weight in landings	Mean weight in discards
	millions					%	tonnes		%		grammes	
2015	556	71	18	2	19	3.4	370	15	8.4	6.4	20.91	9.13
2016	379	41	30	6	35	9.2	641	69	17.4	13.7	21.21	10.85
2017	404	41	13	4	16	4.0	295	38	21.4	16.9	22.23	10.46
2018	554	83	22	10	30	5.4	536	106	32.2	26.3	24.33	10.11
2019	493	66	8	2	9	1.9	167	21	21.7	17.2	22.00	9.94
2020	394	59	10	4	12	3.1	222	54	27.0	21.7	23.31	15.29
2021	331	31										

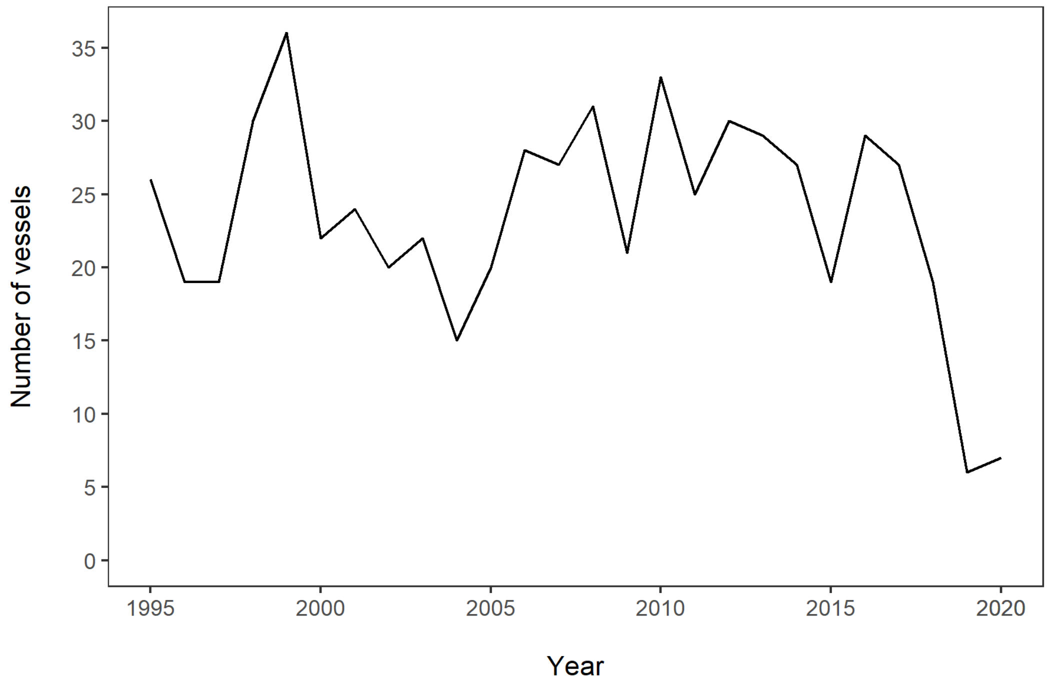


Figure 21.1.1. *Nephrops* in FU17 (Aran Grounds). Time-series of the number of Irish vessels reporting landings of *Nephrops* from FU17 with a >10 t threshold.

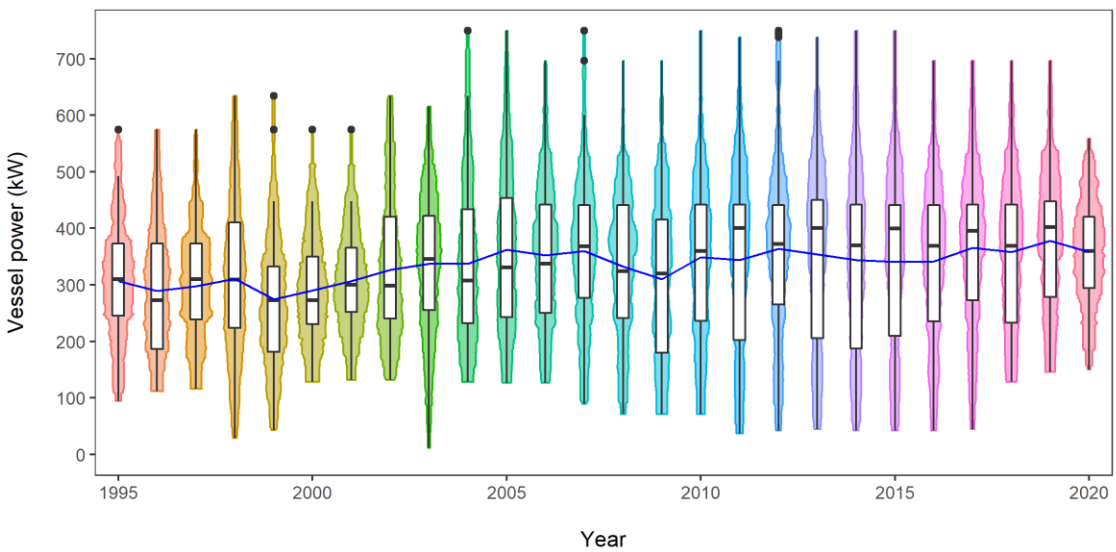


Figure 21.1.2. *Nephrops* in FU17 (Aran Grounds). Combined box and kite plot of Irish vessel's power on the Aran Grounds by year. The blue line indicates the mean.

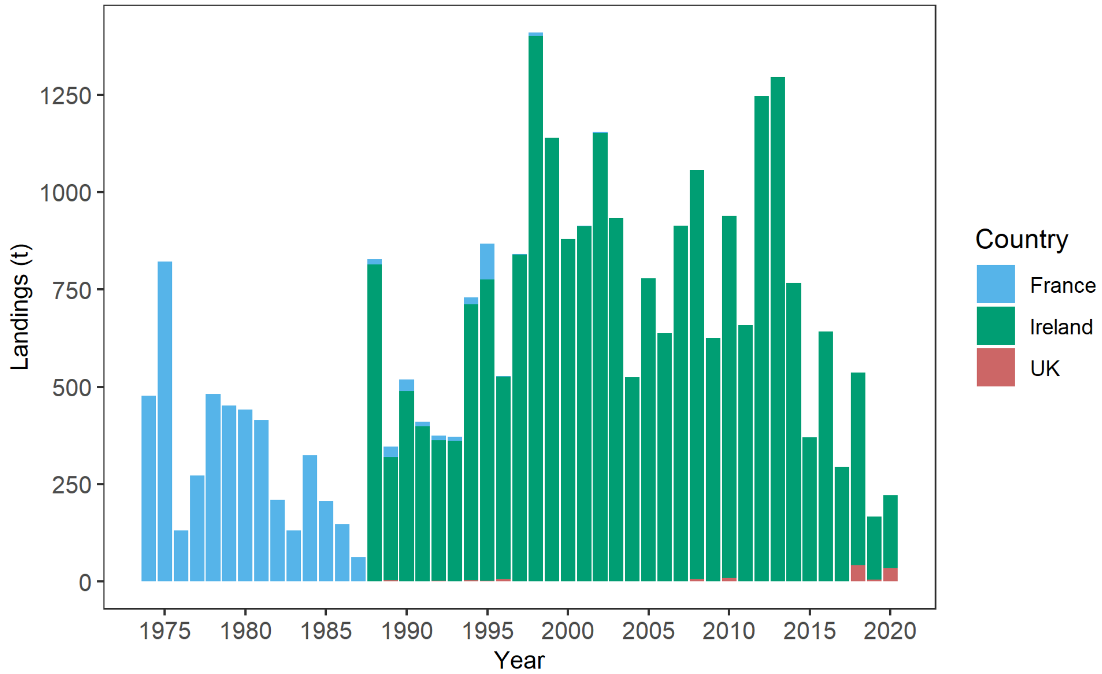


Figure 21.2.1. ***Nephrops*** **in FU17 (Aran Grounds). Landings in tonnes by country.**

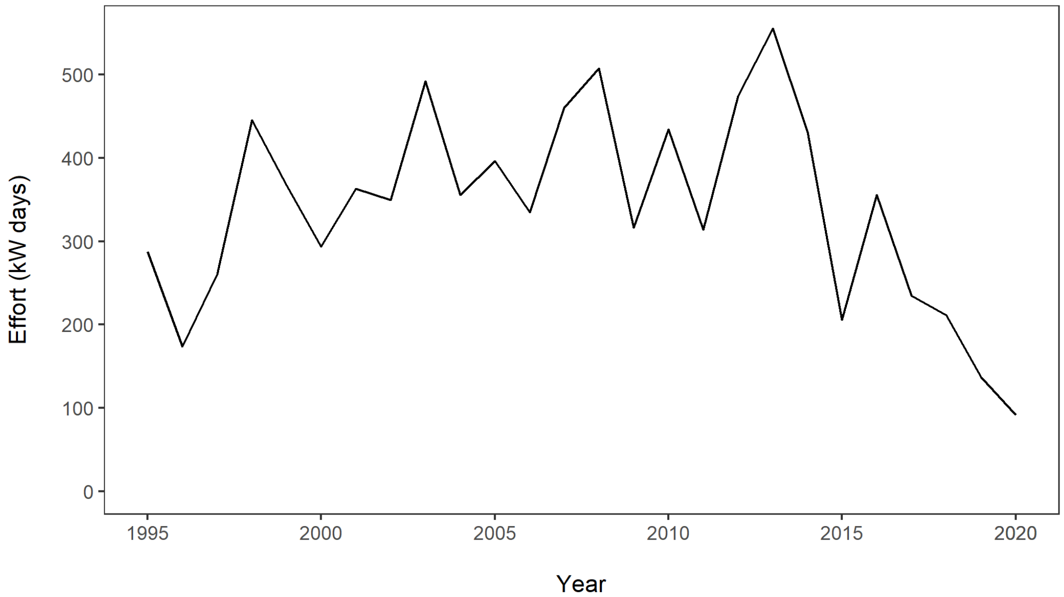


Figure 21.2.2. ***Nephrops*** **in FU17 (Aran Grounds). Effort data (kW days) for Irish directed** ***Nephrops*** **fleet.**

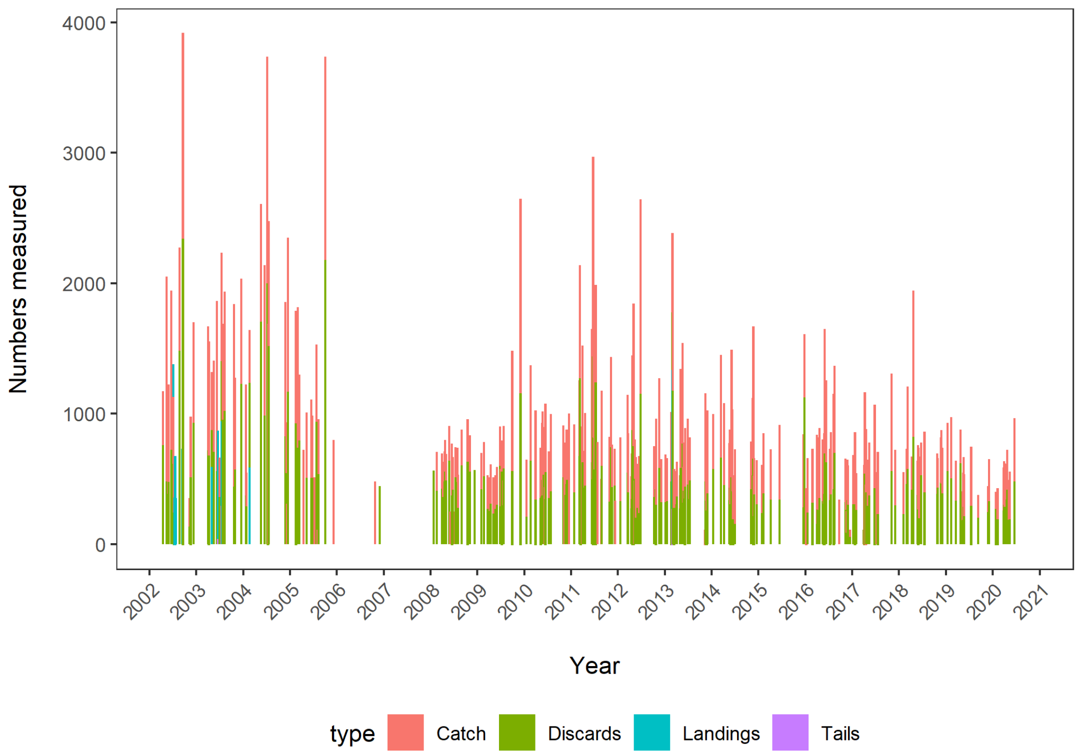


Figure 21.2.3. *Nephrops* FU17 (Aran Grounds). Sampling levels for the Aran grounds.

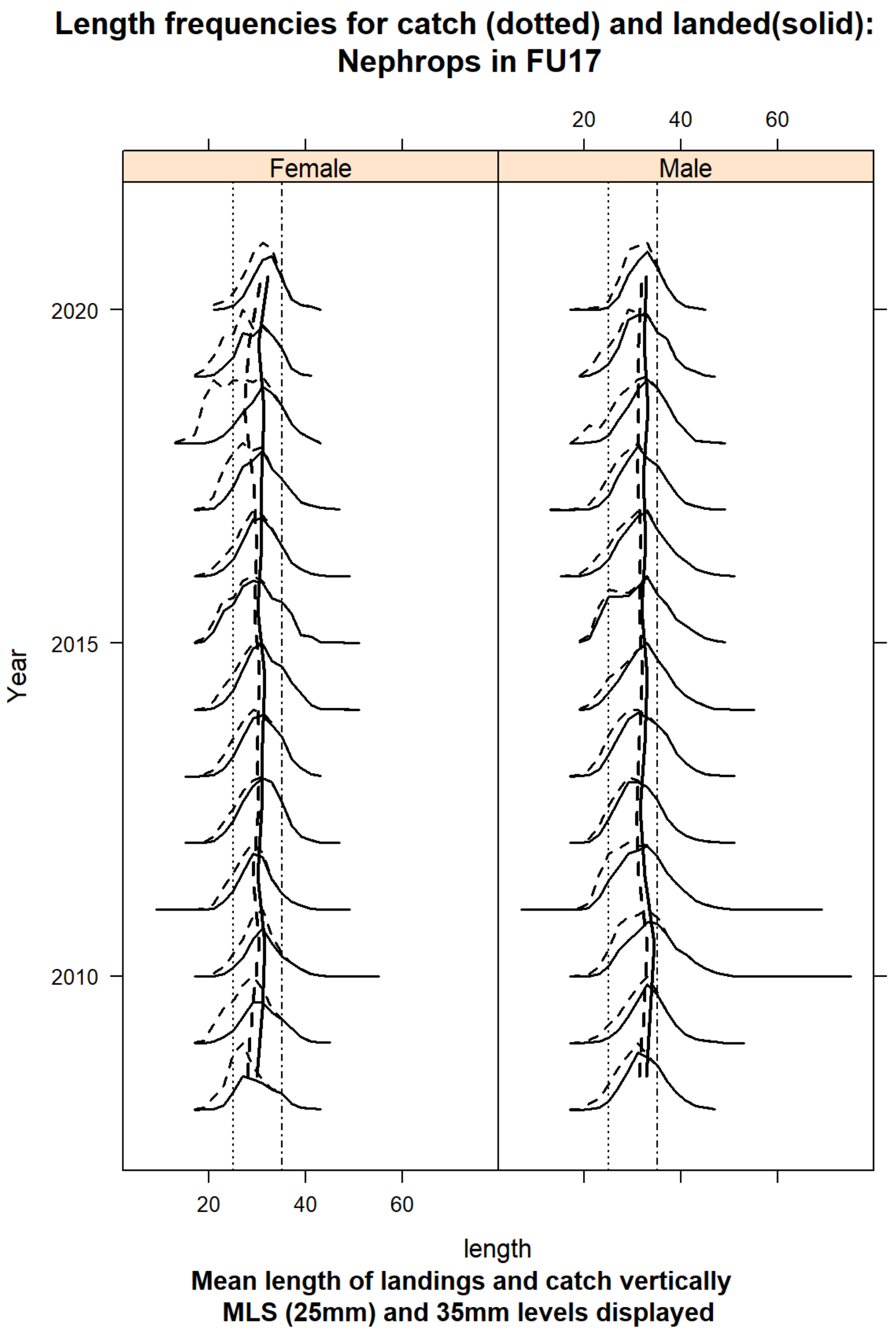


Figure 21.2.4. ***Nephrops*** **FU17 Aran Grounds. Annual length composition of catches (dotted line) and landings (solid line) for females (left) and males (right) from 2008 (bottom) to 2020 (top). Annual mean length of catches (dotted vertical line) and landings (solid vertical line) are also shown. Minimum Landing Size (25 mm) and 35 mm levels are also displayed with vertical lines.**

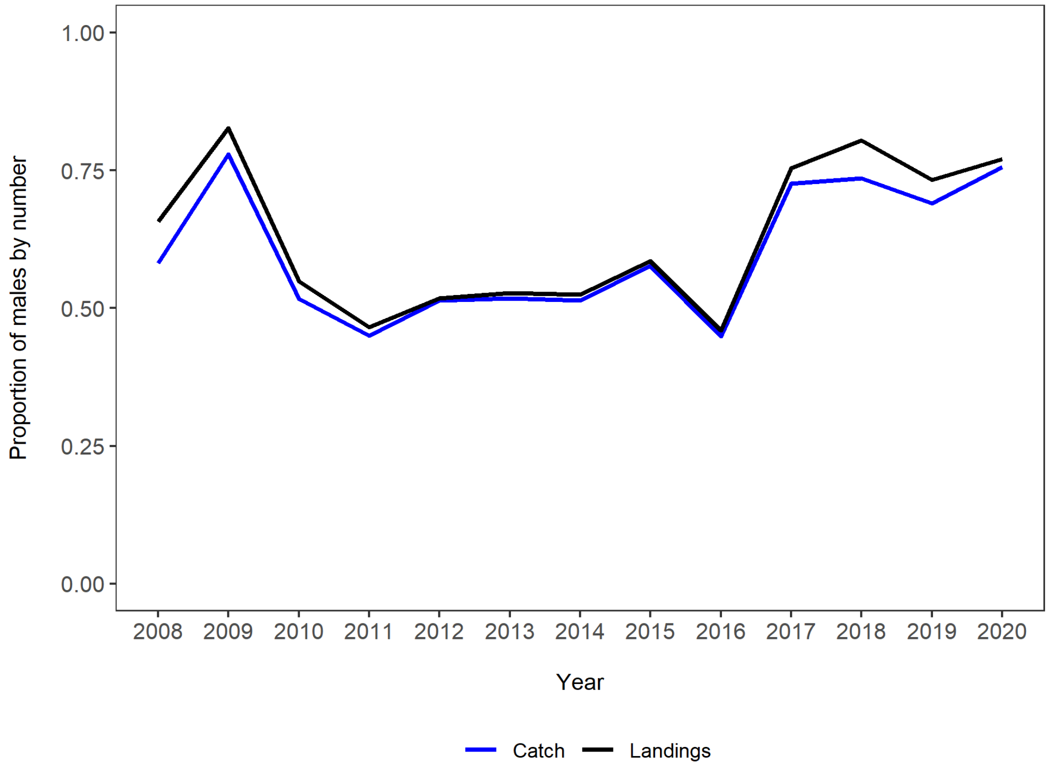


Figure 21.2.5. *Nephrops* FU17 (Aran Grounds). Proportion of males by number in the catch (blue) and landings (black).

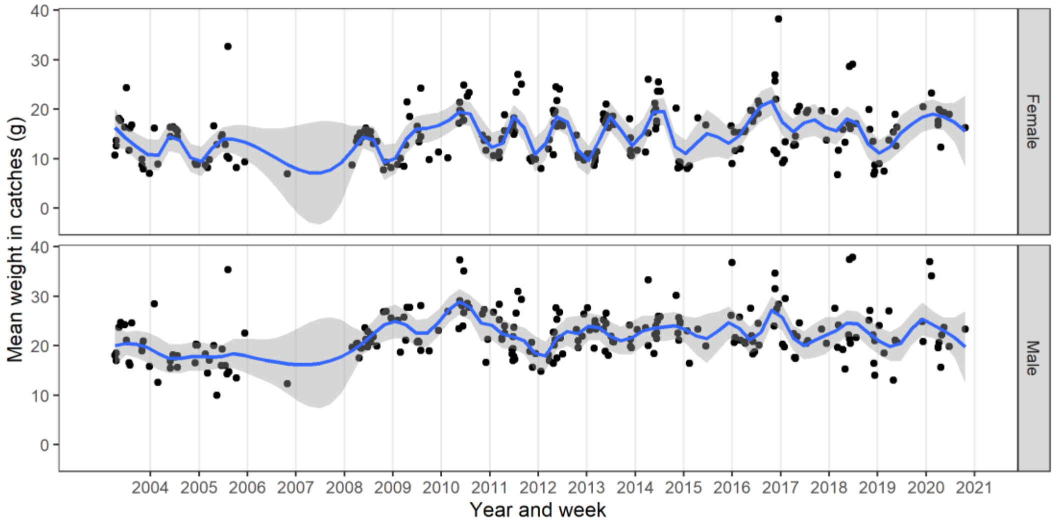


Figure 21.2.6. *Nephrops* FU17 (Aran Grounds). Mean weight in catch samples by sex showing cyclical trends.

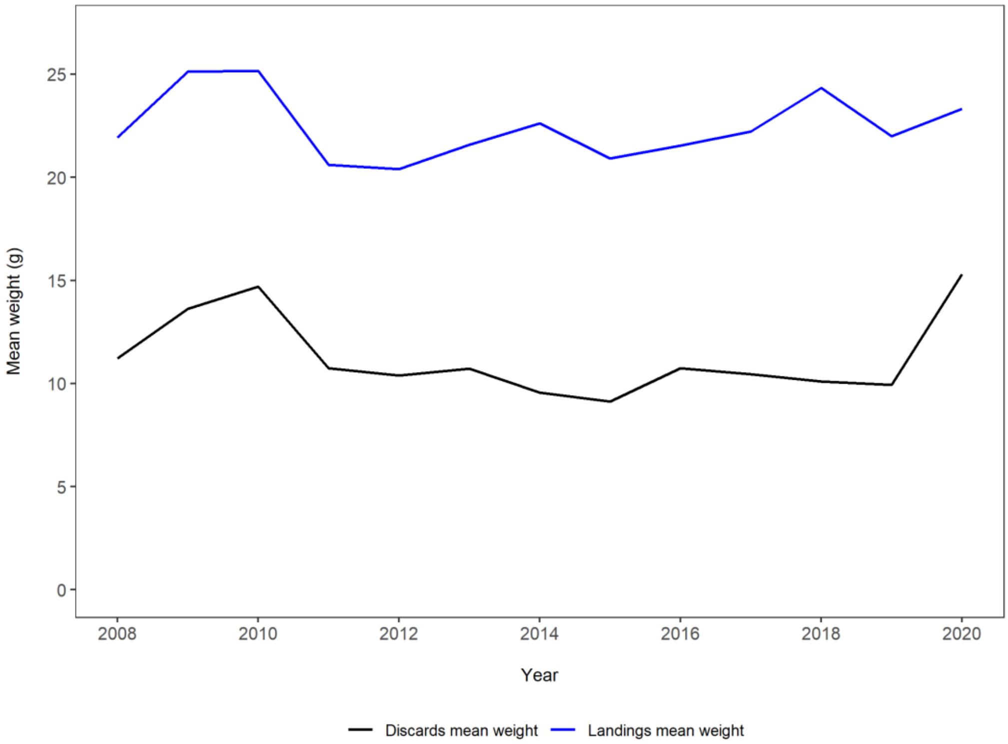


Figure 21.2.7. *Nephrops* FU17 (Aran Grounds). Annual mean weight (g) estimates of landings (blue) and discards (black).

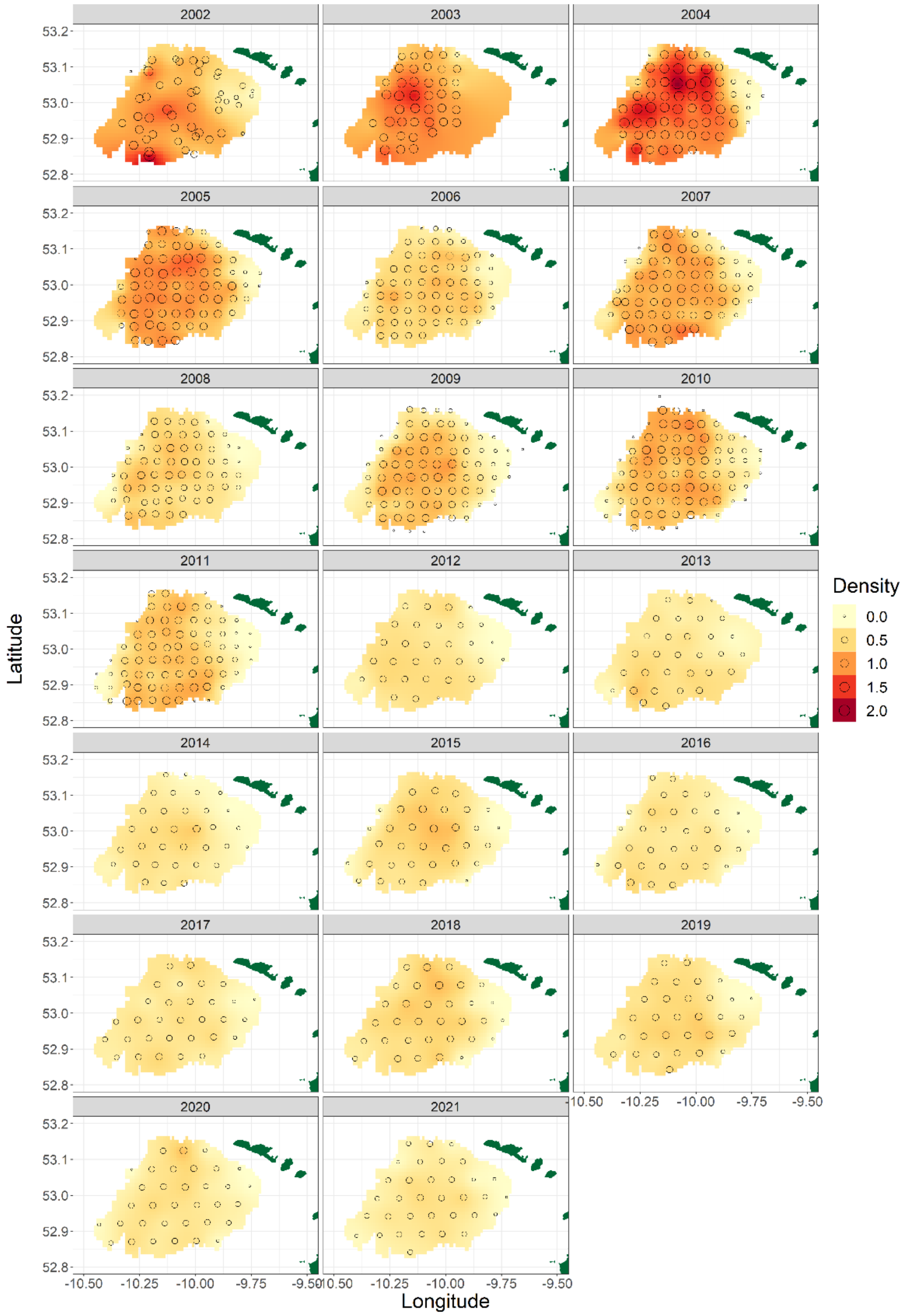


Figure 21.2.8. ***Nephrops* in FU17 (Aran Grounds). Contour plots of the krigged density estimates for the Aran Ground UWTV surveys from 2002 (top left) to 2021 (bottom).**

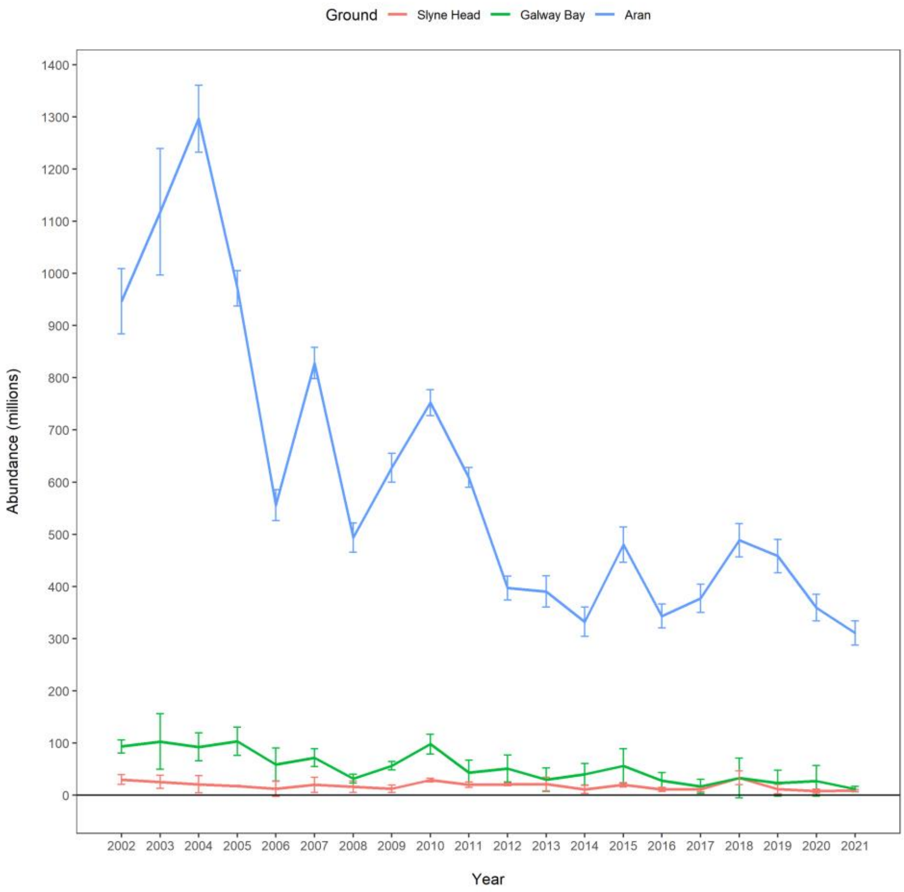


Figure 21.2.9. *Nephrops* FU17 Aran Grounds. *Nephrops* burrow estimates in FU17 Aran (blue), Galway Bay (green) and Slyne Head (red) grounds 2002–2021.

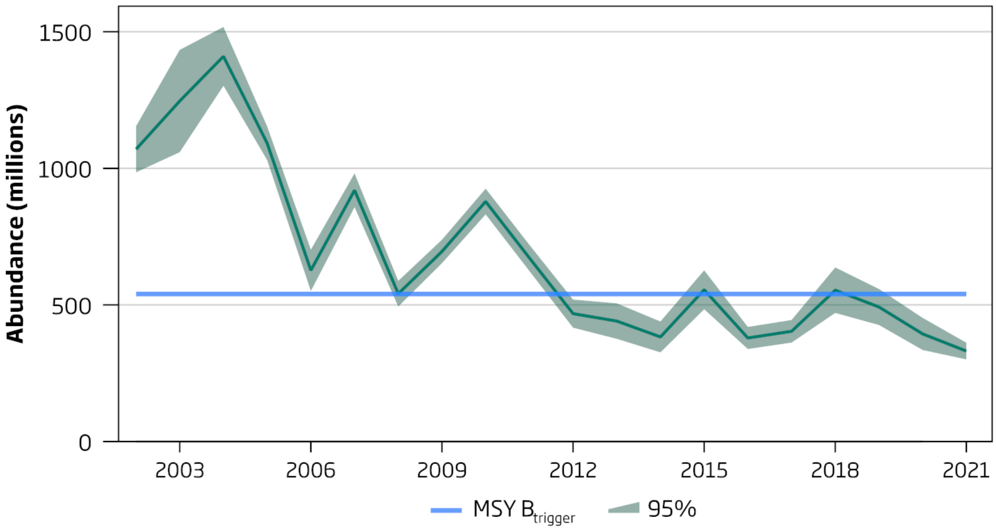


Figure 21.2.10. Time-series of total abundance estimates for FU17.

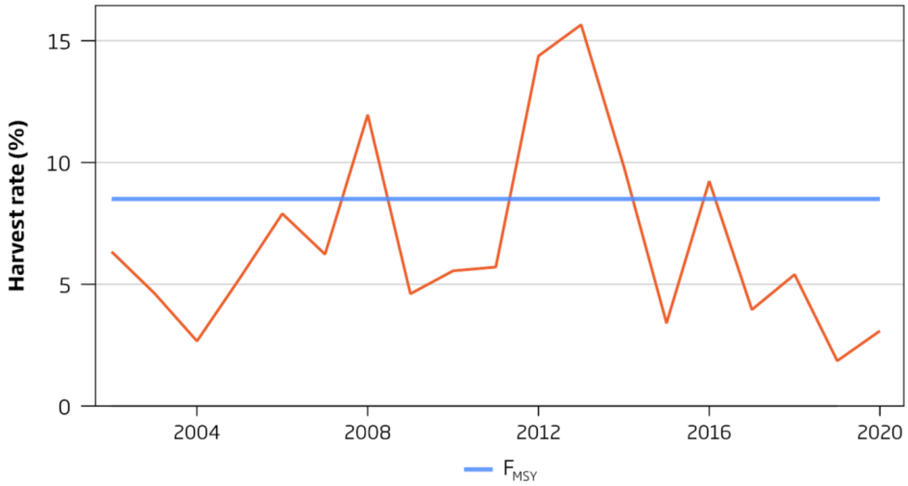


Figure 21.3.1. ***Nephrops*** **FU17 Aran Grounds. Harvest Rate represented by red line (% dead removed/UWTV abundance).**

19 Norway lobster (*Nephrops norvegicus*) in divisions 7.a, 7.g and 7.j, Functional Unit 19 (Irish Sea, Celtic Sea, eastern part of southwest of Ireland)

Type of assessment in 2021

This stock was benchmarked in February 2014 and the assessment and provision of catch advice through the use of the UWTV survey data and other commercial fishery data follows the process defined by the benchmark WG (ICES, 2014) and set out in the stock annex.

ICES advice applicable to 2020

"ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 749 tonnes and 839 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in Functional Unit (FU) 19 is exploited sustainably, management should be implemented at the functional unit level."

ICES advice applicable to 2020

"ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 531 tonnes and 595 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule.

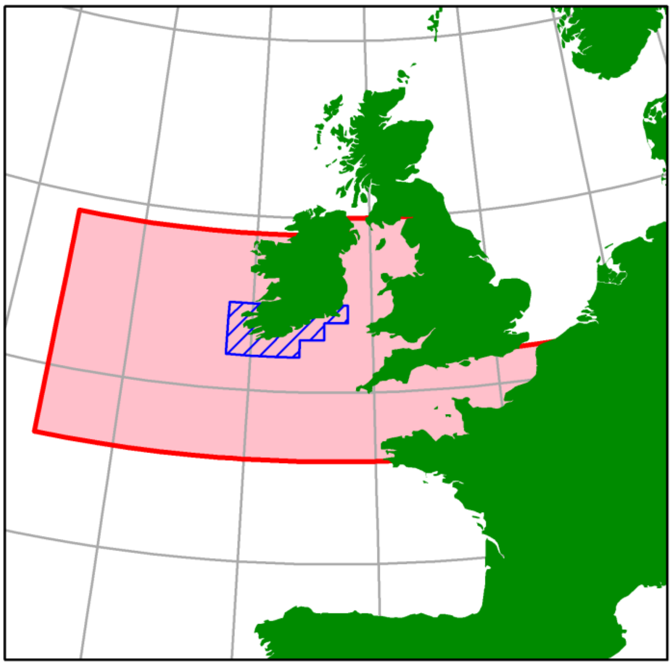
To ensure that the stock in Functional Unit (FU) 19 is exploited sustainably, management should be implemented at the functional unit level."

19.1 General

Stock description and management units

In FU19 *Nephrops* are caught on a large number of spatially discrete small inshore grounds and on some larger grounds further offshore and of these the 'Galley ground 4' and around Cork channels appear to be the most important (see Figure 19.1.1). The *Nephrops* stock (FU19) covers ICES rectangles ; 31–33 D9–E0; 31E1; 32E1–E2; 33E2–E3 within 7.a, 7.g, and 7.j. This stock is included as part of the TAC Area 7 *Nephrops* which includes the following stocks: Irish Sea East and West (FU14, FU15), Porcupine Bank (FU16), northwestern Irish Coast (FU18) and the Celtic Sea (FU20–22).

The map below shows FU19 assessment area (blue) and TAC area (red). There is no evidence that the individual functional units belong to the same stock. See Section 18 for details on *Nephrops* in Subarea 7 general section.



Ecosystem aspects

This section is detailed in stock annex. There are no updates.

Fishery description

A description of the fleet is given in the stock annex.

The time-series of numbers of vessels reporting landings greater than 10 t is updated in Figure 19.1.2. The numbers of vessels has been relatively stable since 1995 except in 2018, where there was a sharp decrease. The time-series of vessel power is shown as a box and kite plot in Figure 19.1.3.

Fishery in 2020

There has been a trend for Irish vessels (>18 m) to switch to multi (quad) rig trawls. Provisional data suggest a ~30% increase in *Nephrops* catch rates and a reduction in fish bycatch of ~30% due to the lower headline height. The number of French vessels reporting landings in FU19, has decreased from 35 vessels in 2005 to five vessels in 2020.

Information from stakeholders

None available.

19.2 Data

InterCatch

All data were available in InterCatch and used for catch data only. French catch data provided directly by the national expert and not extracted from InterCatch.

Landings

Landings data for FU19 are summarized in Table 19.2.1. The Republic of Ireland, France and the UK report landings for FU19. Landings data for Ireland were revised back to 2008 which resulted in minor revisions in the order of 1 to 5 % (stock annex). These revised data has been used in the assessment this year. The Republic of Ireland landings have fluctuated considerably throughout the time-series, with a marked dip in 1994 (Table 19.2.1; Figure 19.2.1). The highest landings in the time-series were observed in 2002–2004 (>1000 t). Landings in 2005 and 2006 have been below average for the series. In 2017 landings decreased by approximately 30% for the Irish fleet and were below the series average. This can be explained due to the poor weather conditions in quarter 1 which hampered fishing activities of smaller vessels and the larger vessels maximising effort in other FUs. There was a minor revision to 2018 landings for Ireland. Landing in 2020 were at a similar level to that in 2019. Landings by the French fleet have fluctuated with a declining trend throughout the time-series from the highest value in 1989 of 245 t to 1.1 t in 2020. There was a minor revision to the 2019 UK(EandW) landings due to a code error (from 1.4 t to 1.1 t). Landings from the UK are minor < 0.5 t in 2020. This had a minimal effect on combined international data workup for that fishery year (Table 19.3.1.).

Total landings for years 2019 (value 249.1477 t) and 2020 (value 248.9602 t) are the same (249 t) due to rounding.

Effort

In line with WGCSE 2015 recommendation effort is reported in KWdays and lpue reported in KG/kwdays in the knowledge that the trend is likely to be a biased underestimate because it is not adjusted for efficiency or behavioural changes. The effort series is based on the same criteria for FU15, 16, 17, 22 and 20–21 (30% landings threshold) and will be contingent on the accuracy of landings data reported in logbooks.

Disaggregated effort and landings data are available for the Irish *Nephrops* directed fleet in FU19 from 1995–2020 for all vessels and vessels >18 metres total length. (Table 19.2.2; Figure 19.2.2). For vessels >18 effort (since early 2000s) has fluctuated with an overall decreasing trend in recent three years. This can be explained by fleet mobility where vessels target *Nephrops* in this area in periods of good emergence. For vessels <18 effort has decreased in 2017 to 2019 due to weather conditions.

Sampling levels

Sampling levels, data aggregating and raising procedures were reviewed by WKCELT 2014, and are documented in the stock annex. The time-series of samples is shown in Figure 21.2.3 and Table 21.2.3. Sampling levels in 2020 were good and are comparable to recent levels.

Commercial length–frequency distributions

Length–frequency data of the landings were collected on a regular basis from 2002 to 2020. Spatial and temporal coverage is problematic with landings from FU19 coming from several discrete grounds (see stock annex.) The sampling intensity and coverage has varied over the time-series (see stock annex). Since 2008 sampling has been good although the majority of the samples come from Bantry Bay recently. Also sampling of the discards is quite sparse over the time-series and are difficult to obtain due to the spatial coverage of the grounds. The catch samples from 2008 to 2020 were split using the discard selection ogive agreed at the benchmark. The length–weight regression parameters given in the stock annex are used to calculate sampled weights and appropriate quarterly raising factors. The length distributions are shown in Figure 19.2.4. The mean size has remained relatively stable and the trend in mean size is stable in recent years.

Sex ratio

The sex ratio in the landings is male biased in most years but there is a trend towards increased percentage of females in the landings (Figure 19.2.5). The proportion of females was higher in 2013 and this was confirmed by the industry.

Mean weight explorations

Explorations of the mean weight in the catch samples by sex shows a strong cyclical pattern in the females for all grounds combined (Figure 19.2.6). This corresponds to the emergence of mature females from the burrows to mate in summer. These data also show an increase in mean weights for males in 2016. The annual mean weight estimate for landings and discards is shown in Figure 19.2.7. The landings mean weight estimates increased in 2019 and then show a decrease in 2020.

Discarding

Sampling of the discards has quite sparse over the time-series and are difficult to obtain due to the spatial coverage of the grounds (see stock annex). Since 2002 discard rates have been estimated using unsorted catch and discards sampling (as described in the stock annex). WKCELT 2014 examined the available discard data observations for FU19. An average discard selection ogive using data from Bantry Bay in years 2008 and 2013 was generated and deemed appropriate given the variable sampling intensity and coverage. The catch data from 2008 to 2013 were then revised and split into landings and discards. Catch data sampling for years previous to 2008 was not revised as was considered to be not of good enough quality. Since 2008 the catch data were split using this selection ogive.

Discard rates range between 25–86% of total catch by weight and 40–80% of total catch by number (Table 19.2.4). These high discard rates are very high compared with other FUs. This is because the fleet is mainly smaller inshore vessels with limited space for extra crew. On-board "tailing" of the smaller *Nephrops* is not usually practised and the bigger *Nephrops* are picked from catches. There is no information on discard survival rate in this fishery but a 25% discard survival rate is assumed in line with other *Nephrops* stocks in the Celtic Sea.

Gear selectivity trials by Bord Iascaigh Mhara (BIM, 2017) reported a 64% survivor rate for *Nephrops* caught in a trawl with a SELTRA selectivity device in the outer Galway Bay area.

Table 19.3.1 gives weights, numbers and mean weights of the landings and discard raised internationally according to the stock annex.

Abundance indices from UWTV surveys

The methods used during the survey were similar to those employed for UWTV surveys [U5917] of *Nephrops* stocks around Ireland and elsewhere are documented by WKNEPHTV (ICES, 2007), WKNEPHBID (ICES, 2008), SGNEPS (ICES, 2009; 2010; 2012), WGNEPS (ICES, 2013; 2014; 2015; 2016a; 2017; 2018a, 2020, 2021), WKNEPS (ICES, 2016b; 2018b), Leocádio, A., *et al.*, 2018 and Dobby H., *et al.*, 2021. SGNEPS 2012 (ICES, 2012) recommended that a CV (or relative standard error) of <20% is an acceptable precision level for UWTV survey estimates of abundance. Given the scale of the area and the number of distinct patches it is unrealistic to expect sufficient stations (~10) in each individual patch to estimate densities separately. The random stratified approach may cause problems in years where the planned survey coverage is not achieved. WKCELT 2014 concluded that WGCSE or WGNEPS should make recommendations on the most appropriate fill in procedure to be adopted in these cases.

The spatial extent of the *Nephrops* grounds in FU19 has been re-defined by WKCELT 2014 and the abundance estimates are calculated using these areas. The redefinition of the polygons in FU19 resulted in ~16% increase in overall area from 1653 km² to 1973 km² (see stock annex). The discrete grounds have been named as: Bantry Bay, Galley Ground 1–4, Cork Channels and Helvick 1–2 and are shown in Figure 19.1.1. In terms of area the Galley Grounds (1–4) account for 61% of the total grounds in FU19 and Galley Ground 4 is the largest of these representing 47% of the total area (Table 19.2.5). Helvick patches 2 and 3 were also amalgamated and renamed Helvick 2 based on the information from the VMS data.

From 2011 to 2021 an average of 42 stations have been completed annually. The survey design is based on randomly picked stations from the ground polygons and the sampling effort on each ground was determined by relative area.

All grounds except Galley Ground 4 in 2011 and Galley Ground 1 in 2012 were covered by the TV survey. Since 2015 a new patch Kenmare Bay was surveyed.

Detailed summary statistics for the various *Nephrops* patches in FU19 over the time-series are presented in Table 21.2.6. The mean density varies across the different patches, but there is some consistency to the estimates over time. The UWTV coverage has improved. In 2021 all discrete grounds were covered by the TV survey (Doyle *et al.*, 2021).

The 2021 mean density estimates vary between patches from the lowest value 0.05 (no./m²) observed at Kenmare Bay to the highest observed at 0.31 (no./m²) at Galley ground 2 (Table 19.2.6, Figure 19.2.8). The overall mean density for FU19 in 2021 is 0.14 (no./m²) which is the lowest observed in the time-series (Table 19.2.7).

Figure 19.2.9 and Table 19.2.7 shows the total abundance estimate for FU19 with the WKMSYRef4 proposed MSY $B_{trigger}$ (ICES, 2016XX, ICESYY). The 2021 abundance estimate was 16% lower than in 202 and at 270 million is below the MSY $B_{trigger}$ (430 million) with a RSE of 15% which is below the 20% limit recommended by SGNEPs (2012).

Information from Irish Groundfish survey

Length–frequency data of the *Nephrops* catches on the Irish groundfish survey-Q4: IGFS-WIBTS-Q4 [G7212] from 2003–2020 are available (Stokes *et al.*, 2014; ICES, 2015). These data were investigated for trends in indicators such as possible recruitment signals (Figure 19.2.10). The mean size of males and females in from the survey was fairly stable over time at 33 mm for males and 25 mm for females.

19.3 Assessment

Comparison with previous assessments

The WGCSE 2019 carried out an UWTV based assessment for this stock. The methods used were very much in line with WK*NEPH* (ICES, 2009) and the approach taken for other *Nephrops* stocks in 6 and 7 by WGCSE. This approach was benchmarked at WKCELT 2014 (ICES, 2014).

State of the stock

UWTV abundance estimates suggest that the stock size has fluctuated although the series is quite short. The 2021 estimate is the lowest observed and is below the MSY $B_{trigger}$. The 2021 abundance remains below the average of the series (geomean: [2011–2021]: 432 million).

Table 19.3.1 summarizes recent abundance estimates, harvest rates for the stock along with other stock parameters. Harvest rate is calculated as (landings + dead discards)/(abundance estimate).

Table 19.3.1.and Figure 19.3.1 summarize recent harvest ratios which have been below the F_{MSY} proxy for the last three years.

19.4 Catch scenario table

Catch scenario table inputs and historical estimates of mean weight in landings and harvest ratios are presented in Table 19.3.1 and summarised below.

The basis for the catch options:

Variable	Value	Notes
Stock abundance (2022)	270	Numbers of individuals (millions); UWTV survey 2021
Mean weight in projected landings	29.2	Average 2018–2020 in grammes
Mean weight in projected discards	15.2	Average 2018–2020 in grammes
Projected discards	44.7	Proportion by number; average 2018–2020
Discards survival	25	Proportion by number
Projected dead discards	37.9	Proportion by number; average 2018–2020

The average in the recent three years is used to calculate the mean weight for landings and discards. The discard rates and proportions for the last three years are used to account for recent on-board retention practices (this is also according to the stock annex).

A prediction of landings for the FU19 using the approach agreed procedure proposed at WK*NEPH* 2009 and outlined in the stock annex will be made on the basis of the 2021 UWTV survey. This will be presented in October 2021 for the provision of advice.

19.5 Reference points

WKMSYRef4 updated the F_{MSY} reference points for FU19 (ICES, 2016XX; 2016YY) on the basis of an average of estimated F_{MSY} proxy harvest rates over a period of years, this corresponds more closely to the methodology for finfish. The updated harvest rate calculated at 9.3% is expected to deliver high long term yield with a low probability of recruitment overfishing. This is close to the harvest rate of 8.1% calculated by WKCELT (ICES, 2014)

This stock previously did not have MSY $B_{trigger}$ specified, the time-series and range of indicator biomass is also limited such that direct use of B_{loss} is considered too close to equilibrium biomass. The workshop proposed to use the 5% interval on the probability distribution of indicator biomass assuming a normal distribution, which is analogous to the 5% on B_{MSY} proposed for finfish stocks assuming these *Nephrops* FU have been exploited at a rate close to near $HR_{MSY.}$ The MSY $B_{trigger}$ for FU 19 is 434 million individuals rounded to 430 million.

These reference points shown in text table below should remain under review by WGCSE should improved data become available.

Stock code	MSY F_{lower}*	F_{MSY}*	MSY F_{upper}* with AR	MSY $B_{trigger}$	MSY F_{upper}* with no AR
nep-19	8.3%	9.3%	9.3%	430***	9.3%

*** Harvest rate (H).**

***** Abundance in millions.**

19.6 Management strategies

No specific management plan exists for this stock.

The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to Norway lobster (*Nephrops norvegicus*) by functional unit in ICES Subarea 7 and also demersal stocks.

19.7 Quality of assessment and forecast

Biological sampling for this stock is improving given the spatial distribution of the *Nephrops* mud patches. A number of other biological parameters such as mean weights and length distributions have also been revised. The revisions were made as part of the benchmark process and have improved the quality of the assessment.

In the provision of catch options based on the absolute survey estimates additional uncertainties related to mean weight in the landings and the discard rates also arise. For FU19 deterministic estimates of the mean weight in the landings and discard rates for 2018–2020 are used although there is some variability of these over time.

From 2016, fisheries catching *Nephrops* in Subarea 7 are covered by the EU landings obligation (EU, 2015). Creel fisheries are exempted from the landings obligation, with a *de minimis* exemption consisting of a 5% discard rate by weight for the trawl fishery in 2019 (reduced from 6% in 2018 and 7% in both 2016 and 2017).

Irish discard survival experiments indicate that the trawl discard survival may be around 64% (BIM, 2017). As a result, an exemption from the landings obligation based on high survivability has been granted by the European Commission. The average discard rate by weight for FU19 over the last three years is 30%. Catch advice and scenarios are provided this year on the assumption that discarding is assumed to continue at the recent average.

There are several key uncertainties and bias sources in the method used here (these are discussed further in WK*NEPH* 2009). Various agreed procedures have been put in place to ensure the quality and consistency of the survey estimates following the recommendations of several ICES groups (WKNEPTV 2007; WKNEPHBID 2008; SGNEPS 2009; WGNEPS 2014). Ultimately there still remains a degree of subjectivity in the production of UWTV abundance estimates (Marrs *et al.*, 1996). Taking explicit note of the likely biases in the surveys may at least provide an estimate of absolute abundance that is more accurate, although no more precise WK*NEPH* (ICES, 2009). Different densities are apparent on the various different grounds within this FU. For the 2021 survey the number of observations on each individual patch is relatively low making the relative standard error (RSE) estimates not that relevant. Aggregating all areas together gives a mean burrow density of 0.14 with a RSE of around 15% which is below the 20% threshold recommended by SGNEPS (ICES, 2012). The cumulative bias estimates for FU19 are largely based on expert opinion. The precision of these bias corrections cannot yet be characterized, but is likely to be lower than that observed in the survey.

Landings data are adjusted to take into account landings that have been misreported from FU16 since 2011. This adjustment is thought to be reasonably accurate (See Section 19).

19.8 Recommendations for next benchmark

This stock was benchmarked by ICES in February 2014 (ICES, 2014). WGCSE will keep the stock under close review and recommend future benchmark as required.

19.9 Management considerations

The trends from the fishery (landings, effort, mean size, etc.) appear to show a decline. The UWTV abundance and mean density estimates vary between the discrete patches and population dynamics between these are not fully understood. The 2021 survey result is the lowest observed in the time-series.

In recent years several newer vessels specializing in *Nephrops* fishing have participated in this fishery. These vessels target *Nephrops* on several other grounds within the TAC area and move around to optimize catch rates. Since the introduction of effort management associated with the cod long term plan (EC 1342/2008) there have been concerns that effort will be displaced towards FU19 and other *Nephrops* grounds where effort control has not been put in place.

Nephrops fisheries in this area are fairly mixed also catching megrim, anglerfish and other demersal species. There are also some catches of hake, and in the offshore parts of the area. The *Nephrops* grounds in FU19 coincide with an important nursery area for juvenile hake and anglerfish among other species (ICES, 2009).

19.10 References

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Table 19.2.1. *Nephrops* in FU19 (SW and SE Ireland). Landings in tonnes by country. The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.

Year	FU 19			
	France	Rep. of Ireland	UK	Total
1989	245	652	2	899
1990	181	569	4	754
1991	212	860	5	1077
1992	233	640	15	888
1993	229	672	4	905
1994	216	153	21	390
1995	175	507	12	694
1996	145	736	7	888
1997	93	656	7	756
1998	92	733	2	827
1999	77	499	3	579
2000	144	541	11	696
2001	111	702	2	815
2002	188	1130	0	1318
2003	165	1075	0	1240
2004	76	997	1	1074
2005	62	648	2	712
2006	65	675	1	741
2007	63	894	0	957
2008	46	790	15	851
2009	55	798	15	868
2010	14	660	13	687
2011	23	619	1	643
2012	11	837	1	849
2013	4	783	6	794
2014	6	459	3	468

Year	FU 19			
	France	Rep. of Ireland	UK	Total
2015	5	502	0	507
2016	4	583	3	590
2017	4	412	4	420
2018	4	229	5	238
2019	2	247	1	249
2020	1	247	1	249

Table 19.2.2. *Nephrops* in FU19 (SW and SE Ireland). Irish *Nephrops* directed effort (Kw Days) and landings.

Year	Irish Fleet - *Nephrops* trawlers (>30% landings weight)			
	All Vessels		Vessels >18 m	
	kW days ('000)	Landings Tonnes	kW days ('000)	Landings Tonnes
1995	222.0	380	80.7	121
1996	178.6	355	55.6	86
1997	161.0	306	53.9	101
1998	329.6	498	144.6	189
1999	182.9	236	42.3	47
2000	142.0	217	56.2	86
2001	193.3	397	89.1	139
2002	506.7	883	323.7	446
2003	555.9	693	318.8	364
2004	488.1	558	303.0	311
2005	405.0	471	220.6	219
2006	424.2	478	208.8	186
2007	558.8	713	287.4	262
2008	534.1	643	288.1	319
2009	472.0	613	224.5	243
2010	382.2	494	103.7	114
2011	337.3	449	142.9	167
2012	355.5	541	91.9	126
2013	336.1	571	88.6	133
2014	213.6	332	52.1	74
2015	244.6	393	85.5	118
2016	287.3	558	111.2	233
2017	118.2	425	111.4	179
2018	71.6	107.1	24.1	29.9
2019	91.4	145.9	31.6	37.5
2020	72.3	133.4	12.7	19.1

Table 19.2.3. ***Nephrops*** **in FU19 (SW and SE Ireland). Irish Sampling levels.**

Year	Quarter	Number of samples			Numbers Measured		
		Catch	Discards	Landings	Catch	Discards	Landings
2008	1	3	0	0	1502	0	0
2008	2	6	0	0	3521	0	0
2008	3	6	0	0	6412	0	0
2008	4	3	0	0	876	0	0
2009	1	3	0	0	1347	0	0
2009	2	6	0	0	3369	0	0
2009	3	2	0	0	1003	0	0
2009	4	5	0	0	1882	0	0
2010	1	2	0	0	840	0	0
2010	2	7	0	0	2989	0	0
2010	3	4	0	0	1457	0	0
2010	4	6	0	0	2376	0	0
2011	1	3	0	0	1493	0	0
2011	2	5	0	0	2747	0	0
2011	3	2	0	0	938	0	0
2011	4	5	0	0	2686	0	0
2012	1	6	0	0	2053	0	0
2012	2	7	0	0	3956	0	0
2012	3	4	0	0	1980	0	0
2012	4	4	0	0	1969	0	0
2013	1	3	0	0	1857	0	0
2013	2	8	5	0	4117	2059	0
2013	2	3	3	0	1177	1250	0
2013	4	3	3	0	1472	1276	0
2014	1	3	2	0	1137	941	0
2014	2	7	7	0	3331	2319	0
2014	3	3	2	0	1344	682	0

Year	Quarter	Number of samples			Numbers Measured		
		Catch	Discards	Landings	Catch	Discards	Landings
2014	4	10	8	0	3455	2200	0
2015	1	1	1	0	417	310	0
2015	2	3	3	0	1417	1267	0
2015	3	2	2	1	856	648	321
2015	4	3	2	0	1250	774	0
2016	1	3	3	0	1500	1631	0
2016	2	6	5	0	2310	1760	0
2016	3	9	7	0	3328	2448	0
2016	4	5	5	0	1,923	1521	0

Table 19.2.3. Continued.

Year	Quarter	Number of samples			Numbers Measured		
		Catch	Discards	Landings	Catch	Discards	Landings
2017	1	4	4	0	1860	1283	0
2017	2	3	3	0	1572	1281	0
2017	3	2	2	0	998	943	0
2017	4	4	2	0	1200	785	0
2018	1	1	1	0	304	380	0
2018	2	7	7	0	3579	3230	0
2018	3	1	1	0	255	275	0
2018	4	1	1	0	370	404	0
2019	1	4	5	0	1630	2222	0
2019	2	3	3	0	1275	1398	0
2019	3	0	0	0	0	0	0
2019	4	4	4	0	1810	1798	0
2020	1	2	2	0	728	702	0
2020	2	7	7	0	3095	2855	0
2020	3	1	1	0	489	404	0
2020	4	3	4	0	1671	1900	0

Table 19.2.4. *Nephrops* in FU19 (SW and SE Ireland). Landings and estimated discards by weight and numbers.

	Female		Male		Both sexes
Year	Landings (t)	Discards (t)	Landings (t)	Discards (t)	% Discard
2008	99	29	691	69	11
2009	117	106	681	141	24
2010	138	98	522	148	27
2011	169	155	450	250	39
2012	190	202	647	265	36
2013	259	210	525	220	35
2014	106	71	353	87	26
2015	79	64	423	101	25
2016	154	91	429	100	25
2017	133	58	280	79	25
2018	71	27	157	40	23
2019	66	48	181	63	31
2020	40	46	207	89	35
	FEMALE NUMBERS '000S		MALE NUMBERS '000S		BOTH SEXES
Year	Landings	Discards	Landings	Discards	% Discard
2008	3,893	1,781	19,516	3,255	18
2009	5,819	8,250	20,324	8,793	39
2010	6,276	8,147	16,001	10,117	45
2011	7,295	12,895	16,900	18,192	56
2012	9,266	17,635	22,540	19,108	54
2013	11,680	18,945	17,399	17,034	55
2014	4,862	5,647	11,183	5,572	41
2015	3,706	5,255	13,111	6,462	41
2016	6,877	6,761	12,610	6,668	41
2017	5,295	4,400	9,022	5,044	40
2018	2,908	1,866	5,197	2,454	35
2019	2,970	3,909	6,023	4,474	48
2020	2,006	3,971	7,595	6,026	51

Table 19.2.5. *Nephrops* in FU19 (SW and SE Ireland). Area (Km²) of discrete patches and percentage contribution to overall area.

Ground	Area (Km²)	% Contribution
Bantry	121.5	6%
Cork Channels	562.0	28%
Galley Grounds 1	60.9	3%
Galley Grounds 2	76.7	4%
Galley Grounds 3	133.9	7%
Galley Grounds 4	925.1	47%
Helvick 1	33.1	2%
Helvick 2	59.5	3%
Total	1972.8	

Table 19.2.6. *Nephrops* in FU19 (SW and SE Ireland). Detailed summary statistics for the various *Nephrops* patches in FU19 over the time-series. (N = number of stations, Mean Density (burrow/m^2) is adjusted for the bias correction factor in Table 3, sd, se and ci are the standard deviation, standard error and 95% confidence intervals on the mean density).

Year	Ground	N	Mean Density	sd	se	ci
2006	Galley Grounds 4	6	0.21	0.18	0.08	0.19
2011	Bantry	5	0.33	0.23	0.1	0.28
2011	Cork Channels	12	0.35	0.32	0.09	0.2
2011	Galley Grounds 1	3	0.52	0.41	0.24	1.02
2011	Galley Grounds 2	3	0.59	0.43	0.25	1.07
2011	Galley Grounds 3	4	0.58	0.22	0.11	0.35
2011	Helvick 1	3	0.6	0.01	0.01	0.04
2011	Helvick 2	5	0.12	0.21	0.09	0.26
2012	Bantry	1	0.2	NA	NA	NA
2012	Cork Channels	9	0.27	0.17	0.06	0.13
2012	Galley Grounds 2	4	0.59	0.12	0.06	0.19
2012	Galley Grounds 3	1	0.51	NA	NA	NA
2012	Galley Grounds 4	16	0.39	0.16	0.04	0.09
2012	Helvick 1	3	0.33	0.13	0.08	0.33
2012	Helvick 2	6	0.33	0.41	0.17	0.43
2013	Bantry	4	0.38	0.2	0.1	0.31
2013	Cork Channels	11	0.12	0.1	0.03	0.07
2013	Galley Grounds 1	2	0.23	0.18	0.13	1.59
2013	Galley Grounds 2	3	0.48	0.44	0.25	1.09
2013	Galley Grounds 3	4	0.59	0.24	0.12	0.38
2013	Galley Grounds 4	13	0.19	0.27	0.07	0.16
2013	Helvick 1	1	0.09	NA	NA	NA
2013	Helvick 2	2	0.06	0.05	0.04	0.48
2014	Bantry	4	0.25	0.05	0.03	0.09
2014	Cork Channels	10	0.1	0.06	0.02	0.04
2014	Galley Grounds 1	2	0.61	0.41	0.29	3.69
2014	Galley Grounds 2	2	0.82	0.14	0.1	1.23
2014	Galley Grounds 3	4	0.66	0.23	0.12	0.37

Year	Ground	N	Mean Density	sd	se	ci
2014	Galley Grounds 4	14	0.29	0.29	0.08	0.17
2014	Helvick 1	2	0.67	0.28	0.2	2.53
2014	Helvick 2	2	0.03	0.04	0.03	0.39
2015	Bantry	2	0.32	0.11	0.08	1.02
2015	Cork Channels	10	0.08	0.11	0.03	0.08
2015	Galley Grounds 1	2	0.32	0.46	0.32	4.12
2015	Galley Grounds 2	2	0.53	0.08	0.06	0.74
2015	Galley Grounds 3	4	0.40	0.14	0.07	0.23
2015	Galley Grounds 4	14	0.27	0.19	0.05	0.11
2015	Helvick 1	2	0.30	0.23	0.16	2.08
2015	Helvick 2	2	0.09	0.09	0.06	0.79
2015	Kenmare Bay	1	0.30	NA	NA	NA

Table 19.2.6. Continued.

Year	Ground	N	Mean Density	sd	se	ci
2016	Bantry	4	0.20	0.07	0.04	0.12
2016	Cork Channels	10	0.21	0.11	0.03	0.08
2016	Galley Grounds 1	2	0.03	0.01	0.01	0.08
2016	Galley Grounds 2	2	0.53	0.12	0.09	1.11
2016	Galley Grounds 3	4	0.16	0.12	0.06	0.19
2016	Galley Grounds 4	14	0.17	0.20	0.05	0.12
2016	Helvick 1	2	0.38	0.08	0.06	0.70
2016	Helvick 2	2	0.07	0.09	0.06	0.81
2016	Kenmare Bay	2	0.24	0.15	0.11	1.33
2017	Bantry	3	0.29	0.15	0.09	0.37
2017	Cork Channels	10	0.25	0.20	0.06	0.14
2017	Galley Grounds 1	2	0.24	0.11	0.08	1.00
2017	Galley Grounds 2	2	0.63	0.06	0.04	0.55
2017	Galley Grounds 3	3	0.45	0.12	0.07	0.30
2017	Galley Grounds 4	15	0.16	0.16	0.04	0.09
2017	Helvick 1	2	0.46	0.07	0.05	0.66
2017	Helvick 2	2	0.16	0.23	0.16	2.03
2017	Kenmare Bay	2	0.16	0.22	0.16	1.97
2018	Bantry	4	0.06	0.02	0.01	0.04
2018	Cork Channels	10	0.11	0.11	0.04	0.08
2018	Galley Grounds 1	2	0.06	0.01	0.01	0.10
2018	Galley Grounds 2	2	0.19	0.19	0.14	1.75
2018	Galley Grounds 3	4	0.11	0.09	0.05	0.14
2018	Galley Grounds 4	14	0.07	0.08	0.02	0.05
2018	Helvick 1	2	0.11	0.10	0.07	0.92
2018	Helvick 2	2	0.06	0.03	0.02	0.28
2018	Kenmare Bay	2	0.07	0.03	0.02	0.25
2019	Bantry	4	0.13	0.04	0.02	0.06
2019	Cork Channels	10	0.16	0.17	0.06	0.13

Year	Ground	N	Mean Density	sd	se	ci
2019	Galley Grounds 1	2	0.12	0.17	0.12	1.57
2019	Galley Grounds 2	2	0.66	0.38	0.27	3.40
2019	Galley Grounds 3	4	0.21	0.14	0.07	0.23
2019	Galley Grounds 4	14	0.18	0.23	0.06	0.13
2019	Helvick 1	2	0.34	0.27	0.19	2.46
2019	Helvick 2	2	0.00	0.00	0.00	0.00
2019	Kenmare Bay	2	0.27	0.10	0.07	0.88
2019	Dunmanus Bay	2	0	0	0	0
2020	Bantry	0.31	0.11	0.05	0.17	0.31
2020	Cork Channels	0.13	0.20	0.06	0.14	0.13
2020	Galley Grounds 1	0.13	0.10	0.07	0.87	0.13
2020	Galley Grounds 2	0.43	0.24	0.17	2.14	0.43
2020	Galley Grounds 3	0.20	0.15	0.08	0.24	0.20
2020	Galley Grounds 4	0.10	0.10	0.03	0.06	0.10
2020	Helvick 1	0.24	0.05	0.04	0.48	0.24
2020	Helvick 2	0.06	0.08	0.06	0.73	0.06
2020	Kenmare Bay	0.18	0.12	0.09	1.11	0.18
2021	Bantry	4	0.09	0.03	0.01	0.04
2021	Cork Channels	10	0.20	0.19	0.06	0.14
2021	Galley Grounds 1	2	0.08	0.06	0.04	0.54
2021	Galley Grounds 2	2	0.31	0.10	0.07	0.87
2021	Galley Grounds 3	4	0.22	0.13	0.06	0.20
2021	Galley Grounds 4	14	0.09	0.07	0.02	0.04
2021	Helvick 1	2	0.09	0.08	0.05	0.69
2021	Helvick 2	2	0.08	0.05	0.04	0.48
2021	Kenmare Bay	2	0.05	0.03	0.02	0.30

Table 19.2.7. *Nephrops* in FU19 (SW and SE Ireland). Summary statistics for FU19 combined over the time-series.

Year	Number of stations	Mean Density adjusted (burrow /m²)	Standard Deviation	Raised abundance estimate adjusted (million burrows)	Upper 95%CI on Abundance	Lower 95%CI on Abundance	CVs (%)
2006	6	0.21	0.18	408	789	26	36
2007*							
2008*							
2009*							
2010*							
2011	35	0.34	0.26	665	842	488	13
2012	40	0.3	0.18	594	708	480	9
2013	40	0.25	0.26	487	653	320	17
2014	40	0.32	0.31	636	829	442	15
2015	39	0.24	0.2	482	612	352	13
2016	42	0.2	0.17	399	501	296	13
2017	41	0.25	0.20	499	622	376	12
2018	42	0.09	0.09	176	230	122	15
2019	42	0.20	0.21	386	517	255	17
2020	42	0.16	0.16	320	415	224	15
2021	42	0.14	0.13	270	349	190	15

***No TV survey from 2007 to 2010.**

Table 19.3.1. *Nephrops* in FU19 (SW and SE Ireland). Forecast inputs (bold) and historical estimates of mean weight in landings and harvest rate (landings + dead discards)/(abundance estimate), discard rate (discards divided by landings + discards) and dead discard rate as dead discards divided by removals (landings + dead discards).

Year	Landings in number	Total discards* in number	Removals in number	Discard Rate number	Dead discard rate number	UWTV abundance estimate	95% Conf. intervals	Harvest rate	Landings	Total discards*	Mean weight in landings	Mean weight in discards
	millions	**millions**	**millions**	**%**	**%**	**millions**	**millions**	**%**	**tonnes**	**tonnes**	**grammes**	**grammes**
2006	26.2	2.6	28.1	8.9	6.8	na	na	na	741	37	28.3	14.4
2007	30.8	1.5	31.9	4.8	3.6	na	na	na	957	26	31.1	17
2008	25.2	5.4	29.3	17.7	13.9	na	na	na	851	105	33.7	19.4
2009	28.4	18.5	42.3	39.5	32.8	na	na	na	868	269	30.5	14.5
2010	23.2	19.0	37.4	45.1	38.1	na	na	na	687	257	29.6	13.5
2011	25.8	32.4	50.1	55.7	48.5	665	171	7.5	643	409	24.9	12.6
2012	32.3	37.3	60.2	53.6	46.4	594	111	10.1	849	473	26.3	12.7
2013	29.5	36.5	56.8	55.3	48.1	487	161	11.7	794	436	26.9	11.9
2014	16.3	11.4	24.9	41.1	34.4	636	188	3.9	468	161	28.6	14.1
2015	17.0	11.8	25.9	41.1	34.3	482	126	5.5	507	167	29.8	13.8
2016	19.7	13.6	29.9	40.8	34.1	399	100	7.5	590	193	29.9	14.2
2017	14.6	9.6	21.8	39.7	33.1	499	120	4.4	420	139	28.8	14.5
2018	8.4	4.5	11.8	34.8	28.6	176	53	6.7	238	71	28.2	15.7
2019	7.4	6.9	12.6	48.2	41.1	386	127	3.3	249	112	33.6	16.3
2020	9.7	10.1	17.2	51	43.9	320	93	5.4	249	136	25.8	13.5
2021						**270**	**77**					
Average 2018–2020				**44.7**	**37.9**						**29.2**	**15.2**

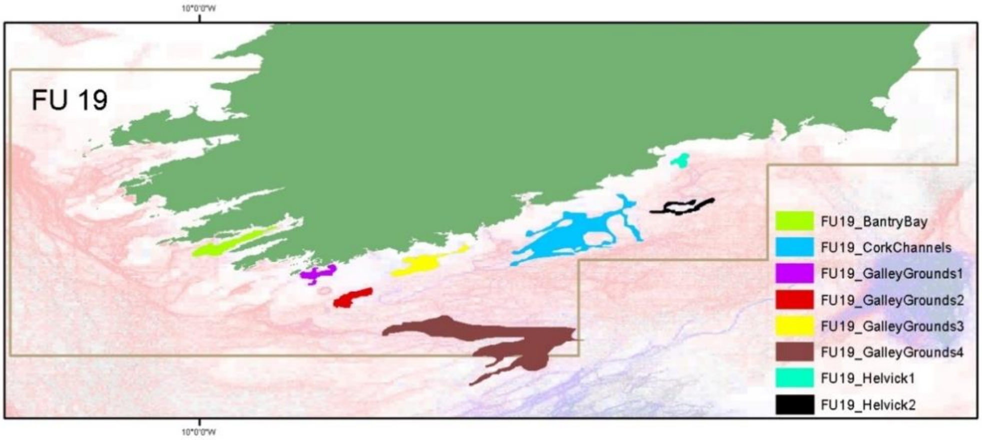


Figure 19.1.1. *Nephrops* in FU19 (Ireland SW and SE Coast). Revised discrete patches overlaid on overlaid on proportion of *Nephrops* in the Irish landings overlaid on international OTB effort (red=0% *Nephrops*; blue=50–60% *Nephrops*; grey=unknown (no Irish landings).

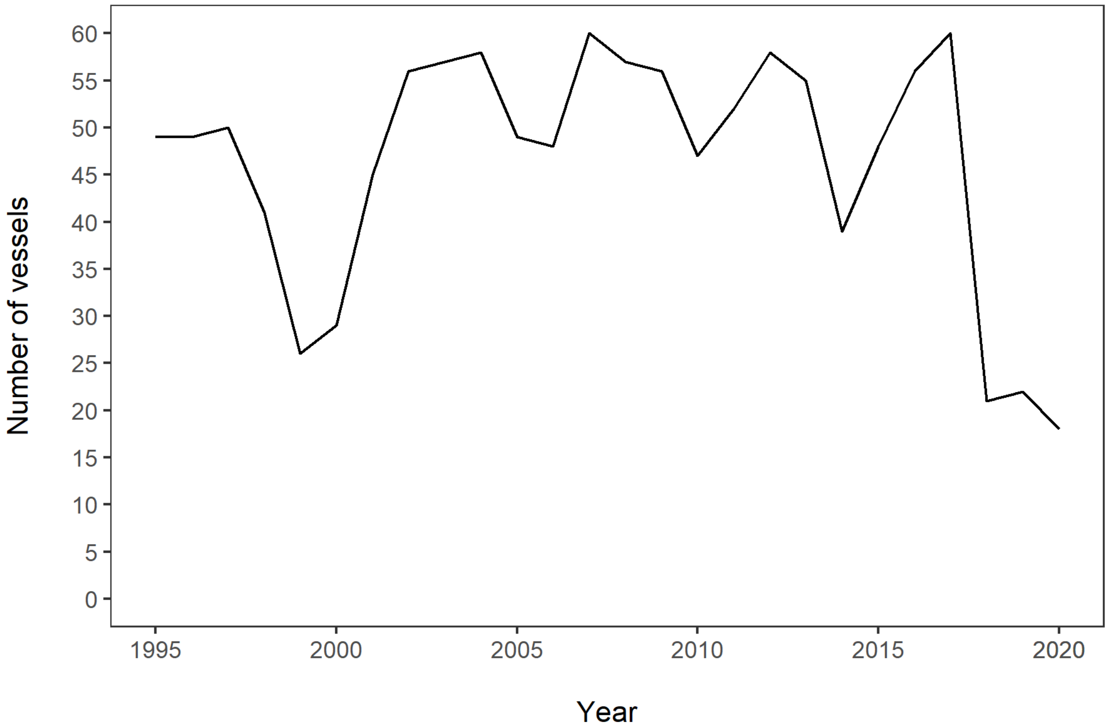


Figure 19.1.2. *Nephrops* in FU19 (Ireland SW and SE Coast). Time-series of the number of Irish vessels reporting landings of *Nephrops* from FU19 with a >10 t threshold.

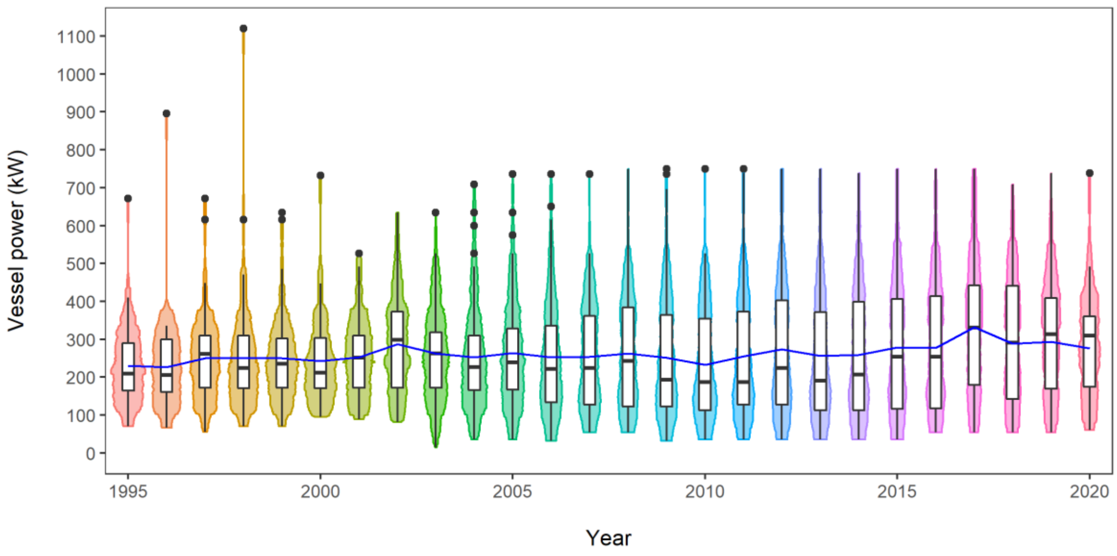


Figure 19.1.3. ***Nephrops*** **in FU19 (Ireland SW and SE Coast). Combined box and kite plot of vessel power by year. The blue line indicates the mean.**

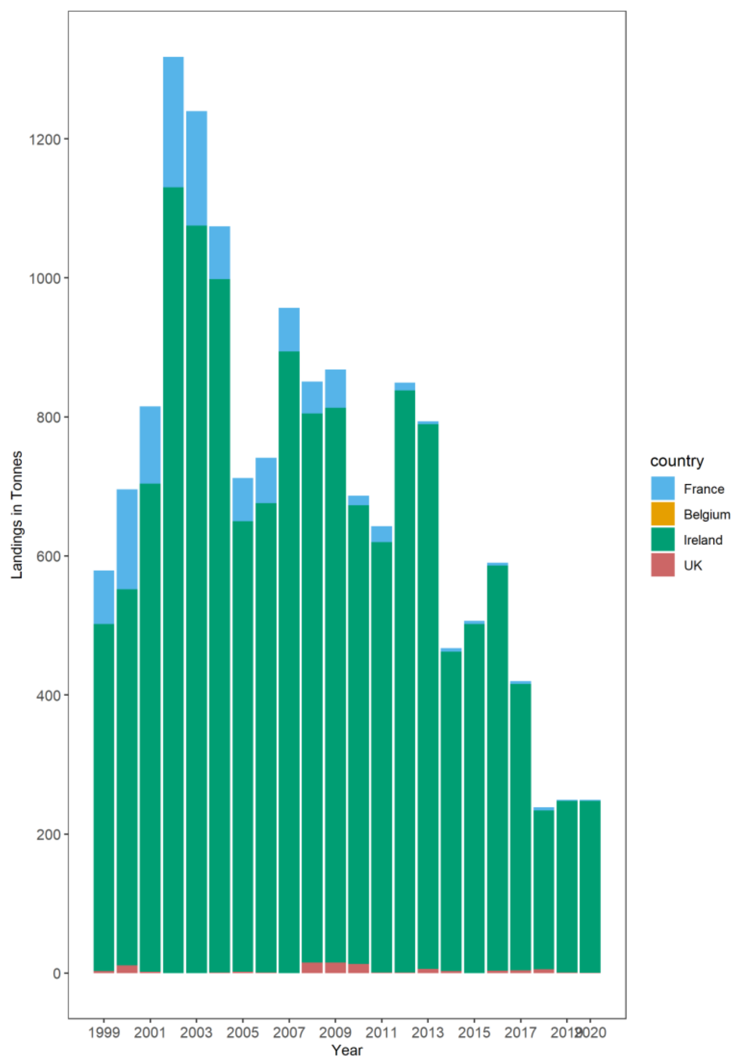


Figure 19.2.1. ***Nephrops*** **in FU19 (Ireland SW and SE Coast). Landings in tonnes by country.**

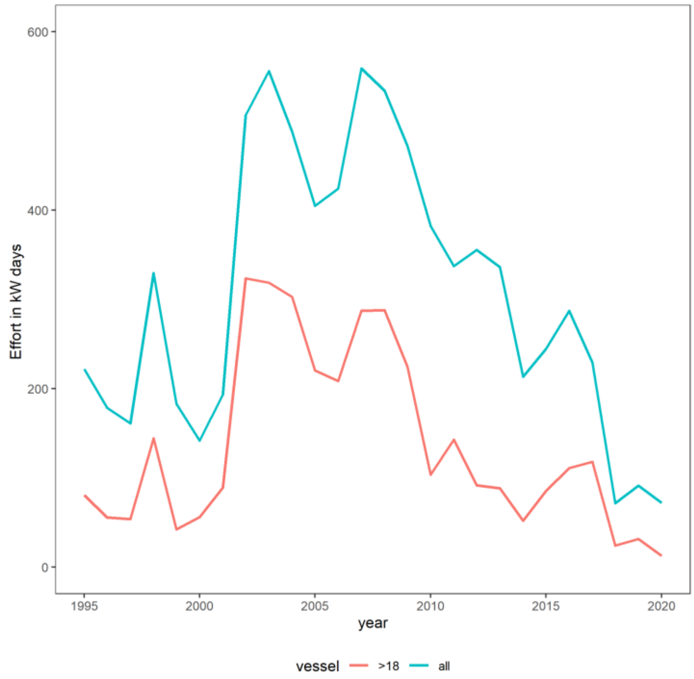


Figure 19.2.2. *Nephrops* in FU19 (Ireland SW and SE Coast). Trawl effort for Irish OTB vessels where >30% of landed weight was *Nephrops.*

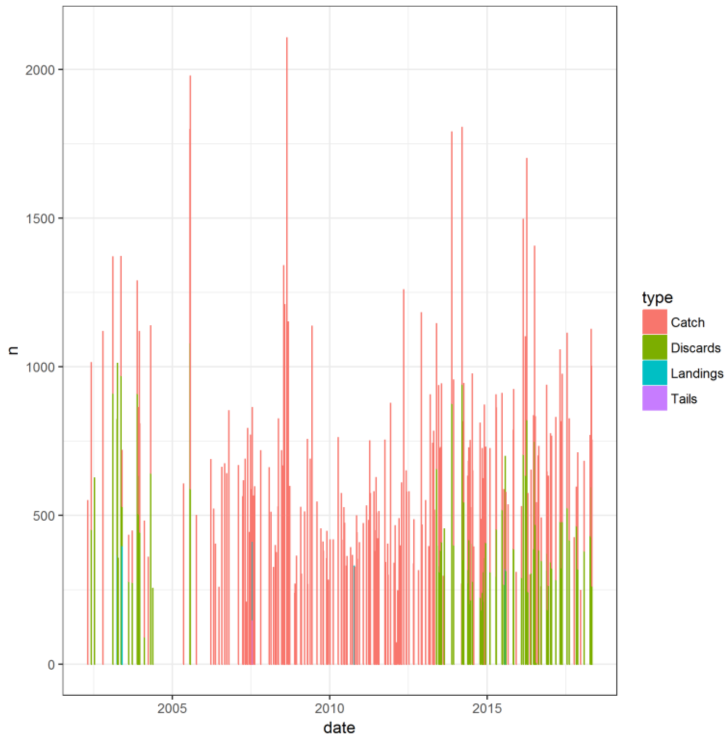


Figure 19.2.3. *Nephrops* in FU19 (Ireland SW and SE Coast). Sampling levels for FU19.

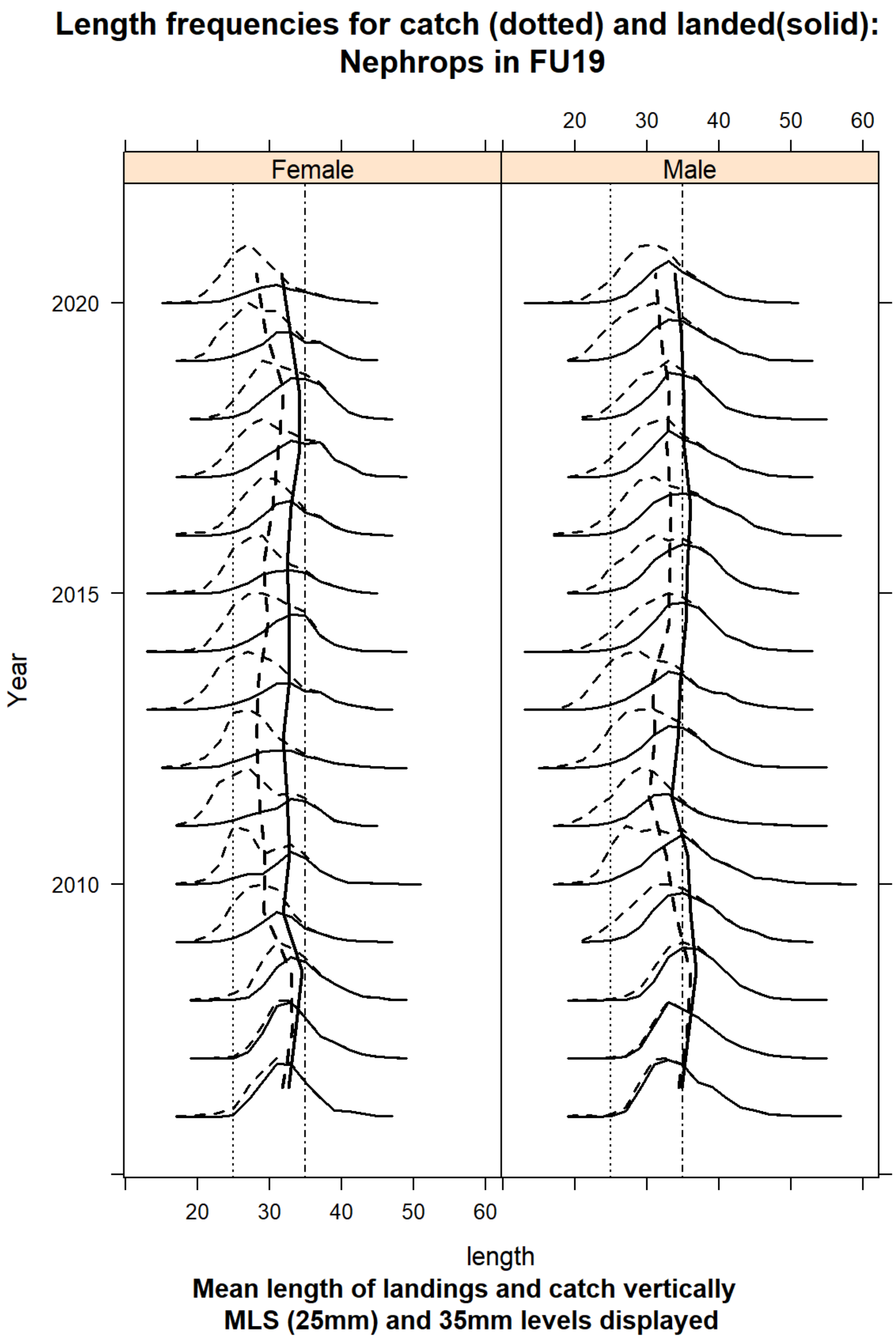


Figure 19.2.4. ***Nephrops*** **in FU19 (Ireland SW and SE Coast). Mean size trends for catches (dotted) and whole landings (solid) by sex 2002–2020. Vertical lines displayed are Minimum Conservation Reference Size 25 mm Carapace Length (CL) and 35 mm CL.**

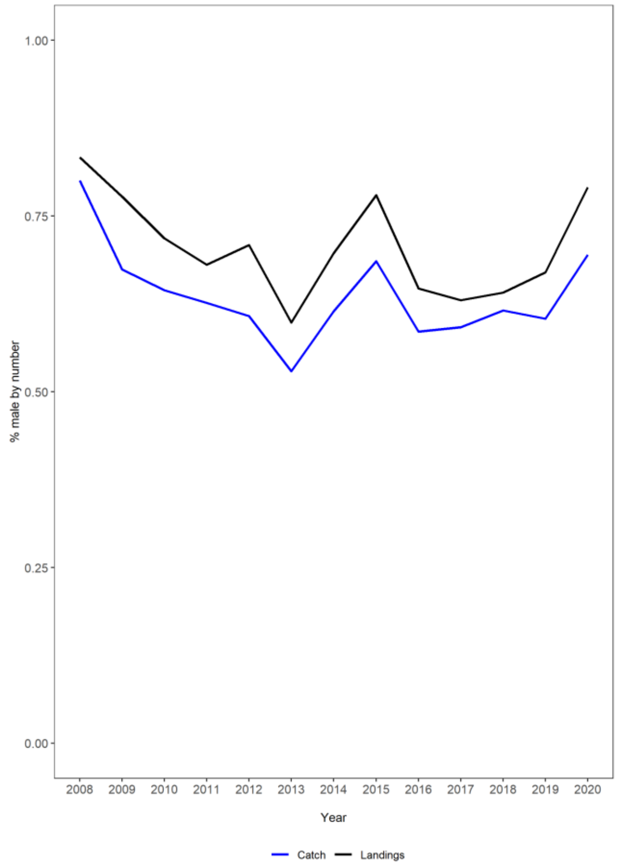


Figure 19.2.5. ***Nephrops*** **in FU19 (Ireland SW and SE Coast). Annual sex ratio of landings (2008–2020) and catch (2008–2020).**

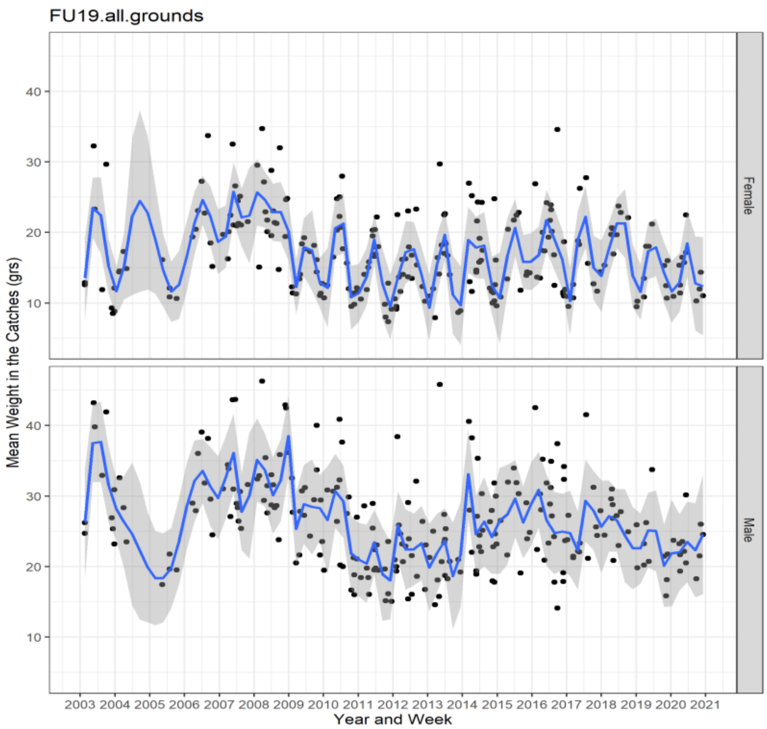


Figure 19.2.6. ***Nephrops*** **in FU19 (Ireland SW and SE Coast). Mean weight in catch data for all grounds in FU19 by sex with loess smoother and showing cyclical trends.**

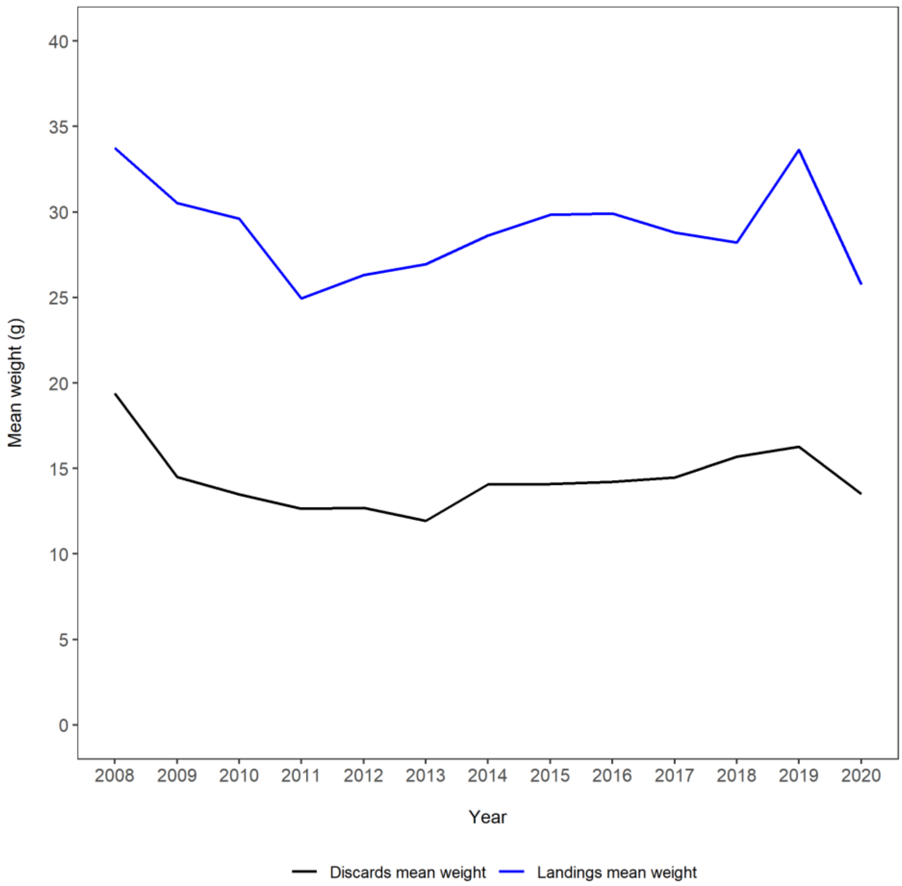


Figure 19.2.7. *Nephrops* in FU19 (Ireland SW and SE Coast). Annual estimated mean weights (gr) in the landings and discards.

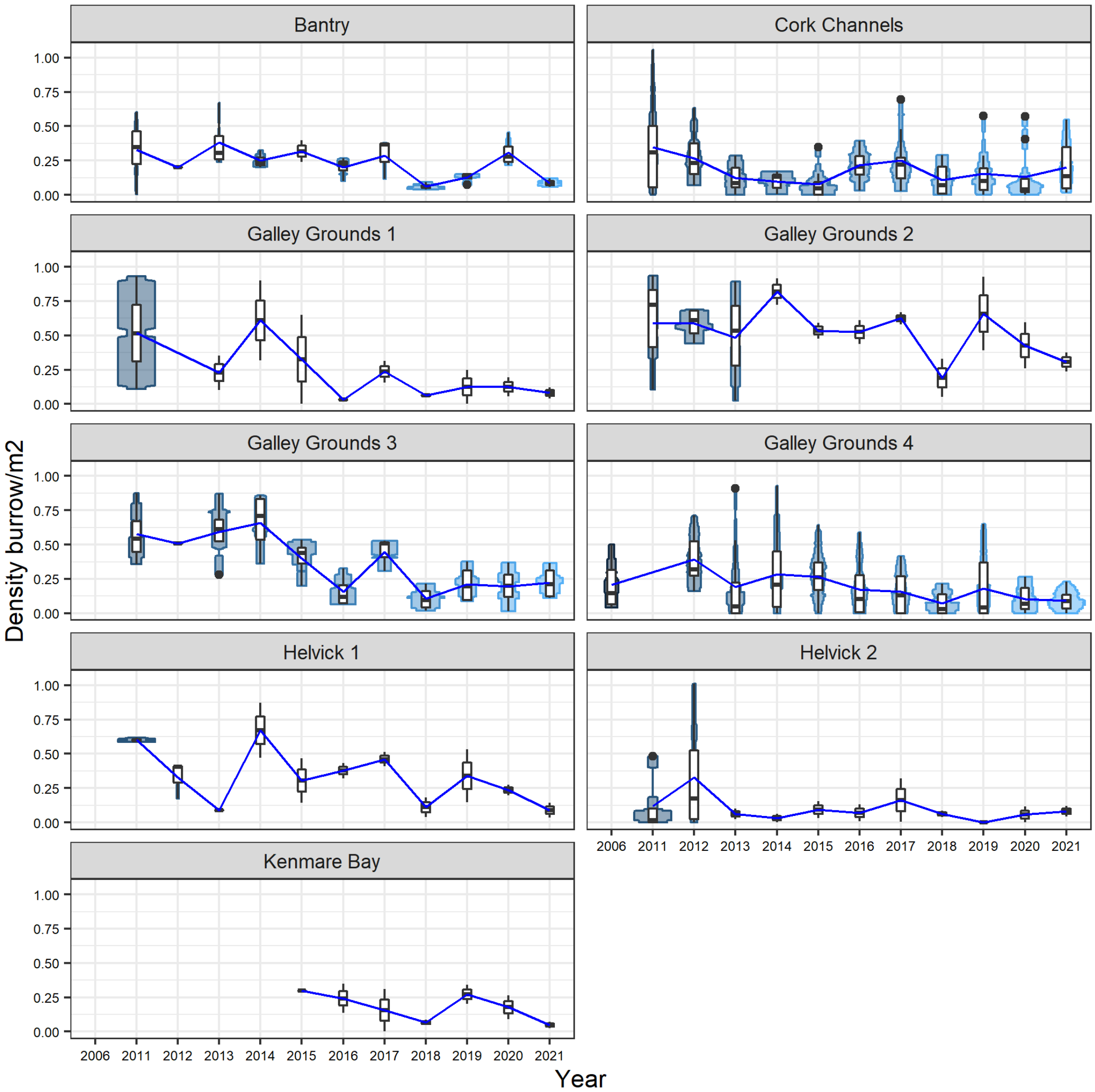


Figure 19.2.8. ***Nephrops*** **in FU19 (Ireland SW and SE Coast). Violin and box plot a of adjusted burrow density (burrow/m²) distributions by year from 2006–2021. The blue line indicates the mean density over time. The horizontal black line represents the median, white box is the interquartile range, the black vertical line is the range and the black dots are outliers. No estimate available for Galley Ground 4 in 2011, Galley Ground 1 in 2012. No TV survey from 2007 to 2010.**

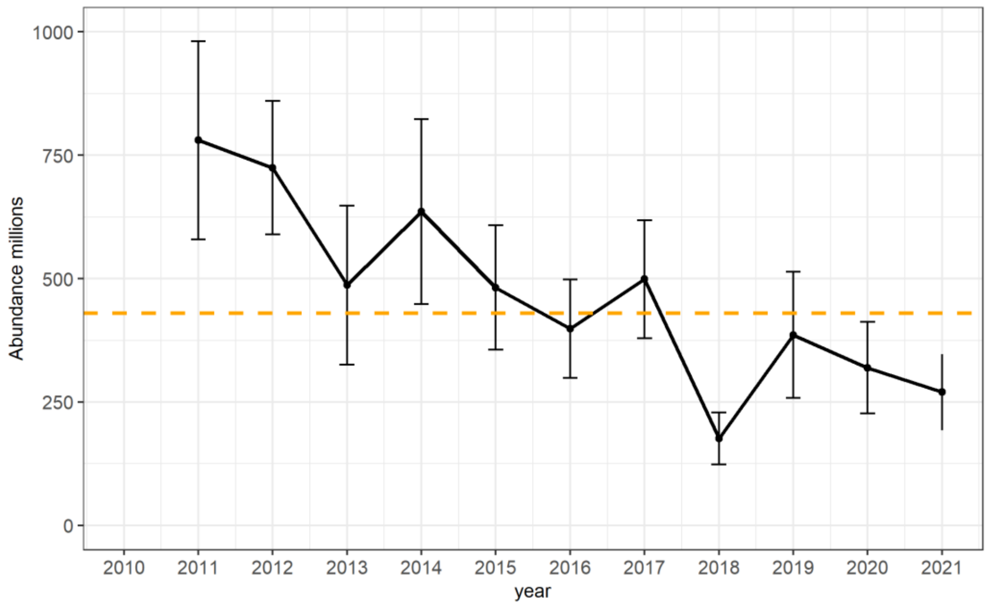


Figure 19.2.9. ***Nephrops*** **in FU19 (Ireland SW and SE Coast). Time-series of total abundance estimates for FU19 (error bars indicate 95% confidence intervals) and $B_{trigger}$ is dashed green line.**

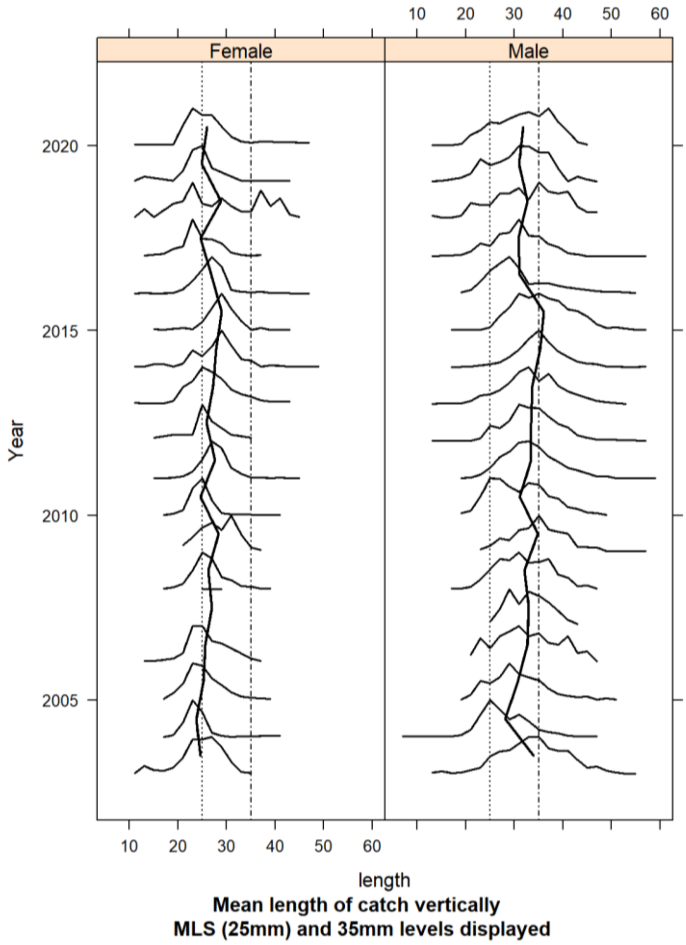


Figure 19.2.10. ***Nephrops*** **in FU19 (Ireland SW and SE Coast). Mean size trends for catches by sex from Irish Groundfish Survey 2003–2020. Vertical lines displayed are Minimum Conservation Reference Size 25 mm Carapace Length (CL) and 35 mm CL.**

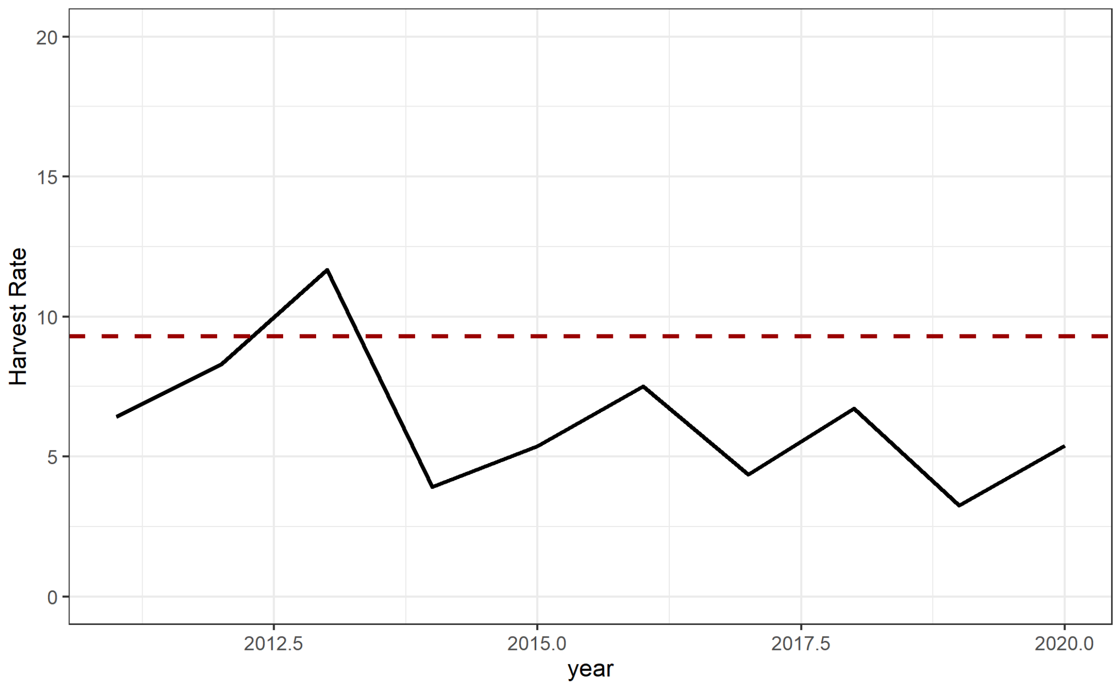


Figure 19.3.1. ***Nephrops*** **in FU19 (Ireland SW and SE Coast). Harvest Rate (% dead removed/UWTV abundance). The dashed and solid lines are the MSY proxy and the harvest rate respectively.**

20 Norway lobster (*Nephrops novegicus*) in divisions 7.g and 7.h, Functional Units 20 and 21 (Celtic Sea)

Type of assessment in 2021

A full UWTV based assessment was carried out and catch options based on the stock-specific F_{MSY} reference point estimated by WGCSE 2016 using the methods applied to other *Nephrops* stocks at WKFMSYREF4 (ICES, 2016) and a newly proposed MSY $B_{trigger}$ estimate (ICES, 2021a; Annex 3). This stock is now available in the ICES Transparent Assessment Framework (TAF) here.

ICES advice applicable to 2020

"ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 1131 tonnes and 1150 tonnes. The entire range is considered precautionary when applying the ICES advice rule.

To ensure that the stock in functional units 20 and 21 is exploited sustainably, management should be implemented at the level of the combined functional units 20 and 21."

ICES advice applicable to 2021

"ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 1682 tonnes and 1710 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule.

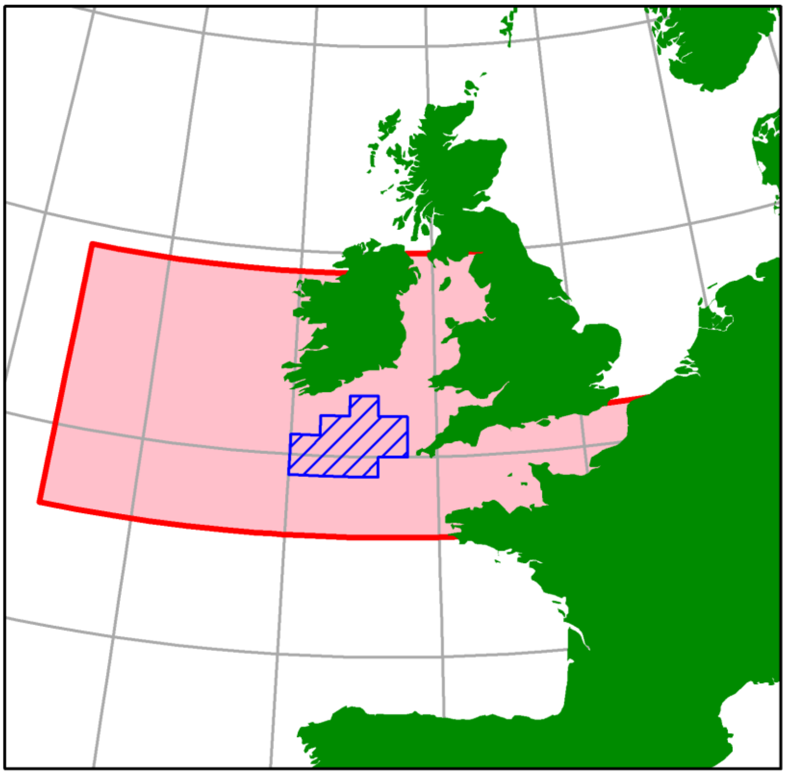
To ensure that the stock in functional units 20 and 21 is exploited sustainably, management should be implemented at the level of the combined functional units 20 and 21."

20.1 General

Stock description and management units

The FU20–21 *Nephrops* stock is included in the whole ICES Area 7 together with Irish Sea East and West [FU14, FU15], Porcupine Bank [FU16], Aran Islands [FU17], northwest Irish Coast [FU18], southeast and southwest Irish Coast [FU19], Smalls [FU22]. The TAC is set for Subarea 7 which does not correspond to the stock area.

Historically FU20–22 fishery and sampling data covered an amalgamation of several spatially distinct mud patches; FU20 NW Labadie, Baltimore and Galley, FU21 Jones and Cockburn and FU22 the Smalls. WGCSE 2013 recommended that FU20–22 should be split into FU20–21 combined and FU22 for the purposes of assessment and advice provision. There is evidence that the Celtic Sea *Nephrops* patches are linked in meta-population sense (O'Sullivan *et al*., 2015). However, fishing mortality and biological parameters (density, growth, M, etc.) may vary across the different patches. The map below shows FU20–21 assessment area (blue) and TAC area (red). There is no evidence that the individual functional units belong to the same stock. See Section 18 for details on *Nephrops* in Subarea 7 general section.



Ecosystem aspects

Details of the ecosystem on FU20–21 are provided in the stock annex updated by WKCELT.

Fishery description

Ireland, France and the UK are the main countries involved in the FU20–21 *Nephrops* fishery. In the early 2000s the Republic of Ireland fleet had on average less than 10% of the landings and this has increased to over 60% from this FU in recent times. A description of this fleet is given in the stock annex. The fishery on FU20–21 grounds operates throughout the year with a seasonal trend, weather permitting, and has expanded in the mid-2000s. The time-series of numbers of vessels with landings greater than 10 tonnes is updated in Figure 20.1.1. The time-series of vessel power is shown as a box and kite plot in Figure 20.1.2. In recent years the Irish fleet have increased landings from the southern part of the grounds (see stock annex). In recent years several newer vessels specializing in *Nephrops* fishing have participated periodically in this fishery. These vessels target *Nephrops* on several other grounds within the TAC area and move around to optimize catch rates. There has been a trend for Irish vessels to switch to multi (quad) rig trawls since 2012. These vessels are more efficient at catching *Nephrops* (BIM, 2015).

French trawlers targeting *Nephrops* in the Celtic Sea operate mainly in the FU20–21. France dominated in the landings in the early 2000s on average 90% of landings and this has decreased to about 12% in recent times (2018–2020). A description of this fleet is given in the stock annex.

There is an increase in participation by the UK in this fishery in the most recent years. The UK fleet had on average 11 % of the landings from this FU in recent times (2018–2020) with highest landings recorded in 2019 (561 t).

Fishery in 2020

Ireland

In 2020, 52 Irish vessels reported landings from FU2021. Of these, 21vessels reported landings in excess of 10 t which is a significant reduction compared to previous years

Landings by metier is quite mixed compared to other *Nephrops* fishery, however, in 2020 there was a significant decrease in landings by metier OTB_CRU-100_119 as shown in Figure 20.1.3 with the majority of landings now taken by the OTB_DEF_100-119 metier. The reason for this is not known and will be investigated.

France

In 2020, 32 French vessels reported landings from FU20–21 where many of these switch between FU20–21 and FU22 within a trip. Of these 2 vessels reported landings in excess of 10 t.

UK

5 UK(EandW) vessels reported landings for FU20–21.

Information from stakeholders

None presented.

20.2 Data

InterCatch

Data were available in InterCatch and used for catch data only. French data were provided directly by the national expert and not extracted from InterCatch.

Landings

The reported landings time-series is shown in Figure 20.2.1 and Table 20.2.1.

The reported Irish landings from FU20-21 have increased since the mid-2000s to the highest in the Irish time-series in 2019 (2219 t). In 2020 Irish landings were the lowest value (336 t) since 2005. French landings have gradually decreased since the early 2000s to the present reported landings of 75 t. Reported landings from the UK have fluctuated with an increasing trend since 2015. There was revision to the 2019 UK(EandW) landings from 551 t to 276 t due to a code error and these revised data are now used. Minor landings were reported by the UK (2 t) and Belgium (less than 0.1 t) in 2020.

The overall fishing profile remains typically seasonal with the majority of the Irish and UK landings coming from the second quarter (see stock annex).

Effort

Effort data are available for the Irish *Nephrops* directed fleet in FU2021 from 1995–2020. The effort series is based on the same criteria for FU15, 16, 17, 19and 22 (30% landings threshold) and will be contingent on the accuracy of landings data reported in logbooks. Effort data are not standardized, and hence do not take into account vessel capabilities, efficiency, seasonality or other factors that may bias perception of lpue as an abundance trend over the longer term. These data are not used in the assessment.

WGCSE 2015 recommended that effort data in Kw days should be presented as these data are more informative than effort data uncorrected for vessel power. Effort data are available from 1995 for the Irish otter trawl *Nephrops* directed fleet. In 2019, this fleet accounted for ~90% of the Irish landings compared with an average of 70% over the period. Effort shows a generally increasing trend since the mid-2000s with a sharp decrease between 2015 and 2017 and also in 2020. (Figure 20.2.2 and Table 20.2.2).

Effort data in KW days are not available for France. Previously effort data were reported from 1983 to 2008 for the French *Nephrops* fleet for the combined Celtic Sea FU20–22 (see stock annex). Since 2009, a new registration system of official French statistics has changed the way fishing effort is computed and a new threshold method of 500 kg landed by trip is used to report effort. French fishing effort reported in hours and lpue (kg/hr) since 2009 shows an overall declining trend (Table 20.2.3).

Sampling levels

Sampling levels, data aggregating and raising procedures were reviewed by WKCELT 2014 and are documented in the stock annex. The time-series of sampling levels is shown in Table 20.2.4, and remains sparse due to the offshore nature of the fishery although good progress is being made by Ireland in recent years.

There was a revision to the Ireland 2019 sampling dataset due to the inclusion of a valid sample that was discovered as a result of QA process of a SQL server migration. The inclusion of this sample data to the 2019 Ireland fishery data summary had a minor affect on the assessment summary. The details data of this revision was presented to the WGCSE meeting and was accepted.

Commercial length–frequency distributions

Prior to 2012 there was insufficient Irish sampling to generate length–frequency distributions although since then sampling levels have improved. For France limited data were available for 1997 and 2010–2013. In 2019 sampling data were not used due to quality issues (see stock annex for details). In 2020 one sample was available but not deemed useful for assessment purposes.

Length–frequency distributions of landings and discards for both countries from 2012 to 2020 are presented in Figure 20.2.3 along with the European minimum conservation reference size (25 CL mm) and French (35 CL mm) minimum landings size also shown. In 2019 France provided sample data numbers and raised data, however, it was not included in the assessment this year due to data quality issues. In 2020 sampling data were not available from France due to the COVID-19 pandemic and also the quite low level of participation in the fishery.

In 2020 there is a lack of small individuals in the catch in 2020 from Irish sampling the reason for this is unclear at present but will be investigated.

The short series on LFDs for both countries shows that the LFDs differ between the two countries. A larger proportion of the French catch consists of large individuals (>35 mm) - on average 70% compared to 41% for the Irish fishery for the available time-series.

Sex ratio

The sex ratio is male biased from the available French and Irish sampling data (Table 20.2.5).

Mean weight explorations

The French dataset provided to WGCSE 2017 (years 2012–2015) results in an increase in mean weights and decrease in removals from that previously reported at WGCSE 2016 (Table 20.2.6). The working group accepted the French dataset, and this is used to calculate the estimated annual mean weights in the landings and discards.

The length–weight relationship as described in stock annex is used to raise both countries sampling data, which are based on Scottish data (Pope and Thomas, 1955).

The mean weight in the landings for France is higher than that in the Irish landings (Table 20.2.7). The estimated annual mean weights in the landings and discards by country and also combined scaled to the international landings is shown in Table 20.2.8 and Figure 20.2.4). There is a big decline in 2016 to 2017 which coincides with the very high UWTV estimate of abundance – which could indicate a strong year class.

Discards

For the Irish data, discard rates have been estimated using unsorted catch and discards sampling. This involves unsorted catch and discard samples being provided by vessels or collected by observers at-sea on discard trips. The catch sample is partitioned into landings and discards using an on-board discard selection ogive derived for the discard samples. Due to sparse sampling effort, annual data are used to derive length distributions and selection ogives. Figure 20.2.5 shows the annual discard ogive from the Irish sampling used to partition the catch. The lack of smaller individuals was also evident in the 2020 discard ogive. The length–weight regression parameters given in the stock annex are used to calculate sampled weights and appropriate annual raising factors. The sampling intensity and coverage has varied over the short time-series, and is relatively poor compared to other *Nephrops* stocks, but is considered adequate for stock assessment purposes.

Estimated discard rates range between 12–41% of total catch by number and 7–27% of total catch by weight in the Irish fishery shown in Table 20.2.7. The 2020 discard rates could be related to a change in this fishery mainly comprised of OTB_DEF metiér, however, this will be investigated further. In the French fishery estimated discard rates range between 25–78% of total catch by number and 16–56% of total catch by weight shown in Table 20.2.6.

Estimated discard rates for both countries combined in shown in Table 20.2.8 and these range between 24–52% of total catch by number and 14–31% of total catch by weight. Discard rate of females tends to be higher due to the smaller average size and market reasons as is observed in other *Nephrops* fisheries.

There is no information on discard survival rate in this fishery. 25% is assumed in line with other *Nephrops* stocks in the Celtic Sea (Charuau *et al*., 1982).

Gear selectivity trials by Bord Iascaigh Mhara (BIM, 2017) reported a 64% survivor rate for *Nephrops* caught in a trawl with a SELTRA selectivity device in the outer Galway Bay area.

Table 20.3.1 gives weights, numbers and mean weights of the landings and discard raised internationally according to the stock annex.

Abundance indices from UWTV surveys

The methods used during the survey were similar to those usually employed for UWTV surveys [U5917] of *Nephrops* stocks around Ireland and elsewhere and are documented by WKNEPHTV (ICES, 2007), WKNEPHBID (ICES, 2008), SGNEPS (ICES, 2009; 2010; 2012), WGNEPS (ICES, 2013; 2014; 2015; 2016a; 2017; 2018a, 2020, 2021), WKNEPS (ICES, 2016b; 2018b), Leocádio, A., *et al.*, 2018 and Dobby H., *et al.*, 2021.

SGNEPS (ICES, 2012) recommended that a CV (or relative standard error) of <20% is an acceptable precision level for UWTV survey estimates of abundance. UWTV surveys conducted in 2012 are deemed exploratory as stations were chosen based on areas heavily fished by vessels (Doyle *et al.*, 2013). These are likely to give biased estimates of density and cannot be extrapolated to estimate density for the whole area. A randomised isometric grid design was employed with UWTV stations at 6.0 nautical mile intervals for 2013–2021 surveys.

A review of the kriging analyses by two different software packages for survey years 2013 and 2014 was investigated as part of the transition of the assessment to the ICES TAF process This was reviewed by an external expert. The results from SURFER and RGeostats software were very close and full details are available on the ICES TAF stock GitHub repo and also in Annex 3 (ICES, 2021a). The summary statistics from the RGeostats software are now used in the assessment for those years. The 2013 survey achieved partial coverage ~60% of the total area. The 2013 abundance has been scaled up to the entire area since densities in the un-surveyed part of the ground were not significantly different in 2014. From 2014 to 2021 full survey coverage was achieved. The geo-statistical analysis for years 2013 to 2021 follows the steps documented in Doyle *et al.*, 2021.

The 2021 mean burrow density was 0.12 burrows/m^2 compared with 0.10 burrows/m^2 in 2020. The 2021 geostatistical abundance estimate was 1202 million a 18% increase on the abundance for 2020 with a CV of 4% which is well below the upper limit of 20% recommended by SGNEPS 2012. There was a slight increase in densities observed in 2021. Figure 20.2.6 shows the krigged contour and density plots for the time-series. The summary statistics from this geostatistical analysis are given in Table 20.2.9 and plotted in Figure 20.2.7. The geostatistical abundance estimate adjusted is derived using the mean of the krigged grid, where the mean of the observations is reported in Table 20.2.9. The estimation variance of the survey is very low (CVs in the order 5%).

Groundfish survey data

There are two IBTS-GFS catching *Nephrops* in FU20–21: French groundfish survey EVHOE-WIBTS-Q4 [G9527] since 1997 and Irish groundfish survey-Q4: IGFS-WIBTS-Q4 [G7212] commenced in 2003 (Stokes *et al.*, 2014). These provide information on length–frequency compositions, mean size in the catches, CPUE of *Nephrops* in FU20–21 (ICES, 2015). The mean size of the catches is stable over the time-series except in 2006 and 2008 which signals recruitment into the fishery in 2006 and 2007 as shown by the Irish IBTS survey in Figure 23.2.8 and the French IBTS survey (Figure 23.2.9). There is also a signal of recruitment in 2018 mean size from IGFS survey. There is no 2017 length dataset for EVHOE due to research vessel breakdown.

20.3 Assessment

Comparison with previous assessments

The WGCSE 2021 carried out a full UWTV based assessment for this stock using the stock-specific reference points were estimated by the 2016 working group based on methods for other *Nephrops* stocks used by WKMSYREF4 (ICES, 2016). This is in accordance with recommendations by WKCELT 2014 where data improvements have been made for this stock such as:

- complete survey coverage of the stock area giving quality assured density estimates and abundance estimates conforming to WGNEPS recommendations; and also

- improved sampling data achieving better coverage and robust estimates of the various parameters need to calculate catch options (e.g. mean weight in the landings and discards, discard percentage in numbers).
- Proposal of MSY $B_{trigger}$ based on seven years of survey data.

State of the stock

UWTV abundance estimates suggest that the stock size has fluctuated over the time-series. The 2021 estimate is an increase from 2020 estimate by 18%.

The 2021 estimate is above the newly proposed MSY $B_{trigger}$ (450 million). The 2021 estimate (1202 million) is below the average of the series (geomean [2014–2021]: 1699 million).

Table 23.3.1 and Figure 23.3.1 summarize recent harvest rates which have been below the F_{MSY} proxy except in 2019 where the harvest rate is 19.2% which is a result of the low stock abundance estimate and high catches.

20.4 Catch scenario table

Catch scenario table inputs and estimates of mean weight in landings and harvest ratios are presented in Table 23.3.1 and summarised below.

In line with previous practice an average (2018–2020) of mean weights is used to account for this variability. Three year average (2018–2020) of proportion of removals retained was used as is standard for other *Nephrops* stocks.

The basis for the catch scenario:

Variable	Value	Notes
Stock abundance (2022)	1202	Numbers of individuals (millions); UWTV survey 2021
Mean weight in projected landings	28.6	Average 2018–2020 in grammes
Mean weight in projected discards	16.5	Average 2018–2020 in grammes
Projected discards	21.8	Proportion by number; Average 2018–2020
Discards survival	25	Proportion by number
Projected dead discards	17.4	Proportion by number; Average 2018–2020

A prediction of landings for the FU20–21 using the approach agreed procedure proposed at WK*NEPH* 2009 and outlined in the stock annex will be made on the basis of the 2021 UWTV survey. This will be presented in October 2021 for the provision of advice.

20.5 Reference points

New reference points were estimated by WGCSE 2016 using the same method and approach used at WKMSYREF4 (ICES, 2016). The detailed analysis is available in working document 11 (WGCSE, 2016). In the case of FU20–21 there is a limited number of years for which length–frequency data were available, so the three-year moving window could only be applied to give two estimates. The resulting potential F_{MSY} harvest rates and ranges are given in the following table.

YEAR	FMAX	FMAX.LOW	FMAX.UP	F35	F35.LOW	F35.UP	F0.1	F0.1.LOW	F0.1.UP
2012	9.12	6.51	12.60	11.03	6.11	13.21	5.91	5.08	15.11
2013	9.45	6.71	13.26	11.17	6.30	13.78	6.10	5.23	15.93

Given the low density in the area and combined sex $F_{0.1}$ was considered and appropriate F_{MSY} proxy.

STOCK CODE	MSY FLOWER*	FMSY*	MSY FUPPER*WITH AR	MSY BTRIGGER	MSY FUPPER*WITH NO AR
nep-2021	5.9%	6.0%	6.0%	Not defined	6.0%

*** Harvest rate (H).**

In 2021 MSY $B_{trigger}$ estimate was proposed using the same method and process used at WKMSYREF4 (ICES, 2016). The detailed analysis is available and was externally reviewed (ICES, 2021a; Annex 3). The estimate was based data on survey years 2014 to 2021 excluding year 2017 and value is given in table below:

STOCK CODE	MSY $B_{TRIGGER}$
nep-2021	450 million

20.6 Management plans

There is no specific management plan for the FU 20–21 *Nephrops.*

The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to Norway lobster (Nephrops norvegicus) by functional unit in ICES Subarea 7 and also demersal stocks. There is currently no agreement with the UK regarding this plan.

20.7 Quality of assessment and forecast

Since the benchmark in 2014 UWTV and sampling coverage has been improving in this area. There are now eight years of full UWTV survey coverage (2014–2021). Since 2019 the survey camera system and reviewing method changed where a new HD system is used (ICES, 2019). A comparison showed no significant difference in density estimates between the new and the old method for FU 16 (ICES, 2019). No comparison analysis has been carried out yet for this FU. Previous assumptions relating to correction factors are still applied for this FU 20-21.

There are several key uncertainties and bias sources in the method used here (these are discussed further in WK*NEPH* 2009). Various agreed procedures have been put in place to ensure the quality and consistency of the survey estimates following the recommendations of several ICES groups (WKNEPTV 2007; WKNEPHBID 2008; SGNEPS 2009; WGNEPS 2014 and Dobby et al., 2021). Ultimately there still remains a degree of subjectivity in the production of UWTV abundance estimates (Marrs *et al.*, 1996). Taking explicit note of the likely biases in the surveys may at least provide an estimate of absolute abundance that is more accurate, although no more precise (WK*NEPH*, 2009). The survey estimates themselves are very precisely estimated (CVs ~5%) given the homogeneous distribution of burrow density and the modelling of spatial structuring.

The cumulative bias estimates for FU20–21 are largely based on expert opinion. The precision of these bias corrections cannot yet be characterised, but is likely to be lower than that observed in the survey.

At WGCSE 2018, the group recommended that a review of historical survey data should be undertaken given the large fluctuations observed in the short time-series to date for this survey, that is, to randomly check 20% of UWTV stations in years 2016 and 2017. This process was conducted in July 2018 during the FU20-21 UWTV survey. The analysis was presented to WGNEPS (2018a) and subsequently to the 2019 WGCSE meeting where full details are available in R-markdown (ICES, 2018a; Annex 7). Results are briefly summarised here. The analyses showed a low increase in the review counts for 2016 stations comparing them with the survey counts (3.8% increase), and a high decrease in the review counts for 2017 stations comparing them with the survey counts (30.8% decrease). Next the review count data were swapped with the survey count data and abundance was calculated for both years using the "RGeostats" package (Renard D. *et al.*, 2015), following the same procedure that was carried out in those years previously. The geo-statistical results showed an increase of 4.6% in 2016 abundance estimate (from 1879 million to 1966 million), and a decrease of 4% in 2017 abundance estimate (from 4428 million to 4250 million). The geo-statistical CVs were in the order of 3.7% to 4.4%, which are well below the upper limit recommendation of 20% (ICES, 2012).

Following this analysis WGNEPS 2018 recommended to include guidelines on quality control where there are large unexplained fluctuations between abundance estimates from previous years in the manual for *Nephrops* underwater TV surveys (Dobby et al., 2021). In that it is recommended to review 20% of the survey stations, and when the partial review differs more than 20% from the survey counts, then a full review of the survey should be considered.

These were also followed in 2019 given the substantial decrease observed. A random selection of 20% of UWTV stations were reviewed. Full details are available in R-markdown (ICES, 2019). The results showed an overall increase in the review counts for these selected stations comparing them with the survey counts (15.5% increase). This process confirmed the observed low density estimates which are used to calculate the abundance estimate for determining catch scenarios for 2020.

Sampling of landing and discards for FU20–21 remains low but there is a limited number of years for which length–frequency data were available so the three year moving window could only be applied to give two estimates to calculate F_{MSY} reference points.

French and Irish trawlers cover different areas and have presented contrasting features over the last decade. The French fleet moved gradually from the "Smalls" Ground (mainly 31E3) to the "Labadie" (30E2, increase of 28E2 in the early 2010s, although no trend is revealed within FU20–21 throughout the overall time-series): in the late 1990s, more than 40% of French landings were reported from the "Smalls" area whereas by the end of 2000s the contribution of this rectangle became minor (less than 10%). Irish vessels have increased their production on FU20–21 since the mid-2000s and a gradual expansion towards the southern rectangles is obvious during the recent years (stock annex).

20.8 Recommendations for next benchmark

This stock was last benchmarked by WKCELT (ICES, 2014). WGCSE will keep the stock under close review and recommend future benchmark as required.

20.9 Management considerations

The indications are the *Nephrops* in FU20–21 are well exploited now relative to the past. Overall effort in the French fishery has declined to less than 25% of the peak effort observed in the early 1990s whereas there has been a big increase in Irish effort over the recent years with sharp decline in 2020.

Overall the Irish fishery in the area expanded with the exception of 2020, whereas the French fishery continued to decline. The fishing patterns of the French and Irish fleet are very different with the Irish fleet specialising on *Nephrops* whereas the French fishery remains more mixed. French *Nephrops* fisheries in this area are fairly mixed also catching whiting, cod, megrim, anglerfish and other demersal species (Davie and Lordan, 2011). *Nephrops* tend to dominate the landings of Irish fisheries in the area but catches are more mixed in the North (~50% *Nephrops*) and cleaner *Nephrops* towards the south (~75% *Nephrops*; Gerritsen *et al.*, 2012). The French trawlers showed an overall decline in effort and landings during the last decade, mainly explained by decommissioning schemes associated with constraints linked to fuel prices.

In recent years several newer vessels specializing in *Nephrops* fishing have participated in this fishery. These vessels target *Nephrops* on several other grounds within the TAC area and move around to optimize catch rates.

From 2016, fisheries catching *Nephrops* in Subarea 7 are covered by the EU landings obligation (EU, 2015). A high survivability exemption applies to creel fisheries from the landings obligation. Irish discard survival experiments indicate that the trawl discard survival may be around 64% (BIM, 2017). As a result, an exemption from the landings obligation based on high survivability has been granted by the European Commission. The average discard rate by weight for FU20–21 over the last three years is 16%. Catch advice and scenarios are provided this year on the assumption that discarding is assumed to continue at the recent average.

UWTV survey coverage has improved. A new survey point available by autumn 2021 provides a more up to date estimate of density and abundance. The most up to date survey information is used as an abundance estimate for this stock.

Landings data are adjusted to take into account landings that have been misreported from FU16 since 2011. This adjustment is thought to be reasonably accurate (See Section 19).

ICES and STECF have repeatedly advised that management should be at a smaller scale than the ICES division level. Management at the functional unit level could provide controls to ensure effort and catch were in line with resources available.

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Table 20.2.1. ***Nephrops*** **FU 20–21. Landings in tonnes by country.**

	FU 20–21 Landings (t)				
Year	France	Rep. of Ireland	UK	Belgium	Total
1995	3419	117	na		3536
1996	2721	101	na		2822
1997	1957	81	na		2038
1998	1583	130	na		1713
1999	1051	83	18		1152
2000	1661	107	10		1778
2001	1750	69	14		1833
2002	2559	104	11		2674
2003	2796	148	9		2953
2004	2140	299	4		2443
2005	2008	455	6		2469
2006	2066	450	7		2523
2007	1816	600	3		2419
2008	2036	937	7		2980
2009	1930	1202	13		3145
2010	975	756	62		1793
2011	566	637	34		1237
2012	453	708	28		1189
2013	486	844	57		1387
2014	465	1342	29		1837
2015	355	1620	141		2116
2016	477	1531	445		2453
2017	341	1113	395	0.2	1849
2018	195	1197	411	0.2	1803
2019	218	2219	286	0.1	2723
2020	75	336	2	0.03	413

Table 20.2.2. *Nephrops* FU 20–21. Effort data for the Irish otter trawl *Nephrops* directed fleet. Effort for vessels where 30% of the landed weight was *Nephrops*.

Year	Effort ('000's KwDays)	Landings (tonnes)
1995	57	104
1996	49	74
1997	40	59
1998	56	102
1999	37	48
2000	39	62
2001	29	45
2002	78	165
2003	82	86
2004	159	164
2005	255	360
2006	301	348
2007	402	512
2008	562	920
2009	801	1,249
2010	498	633
2011	424	535
2012	357	534
2013	445	672
2014	885	1,170
2015	1,180	1,542
2016	920	1,404
2017	704	1,004
2018	695	1,084
2019	1,185	2,153
2020	184	245

Table 20.2.3. *Nephrops* FU 20–21. Effort data for the French fleet.

Year	Effort France ('000 hrs)	Lpue France (kg/h)
1983	231	14
1984	205	16
1985	203	16
1986	163	15
1987	190	15
1988	171	16
1989	179	17
1990	230	16
1991	225	11
1992	277	12
1993	268	13
1994	259	14
1995	239	15
1996	220	14
1997	187	13
1998	155	13
1999	151	11
2000	194	14
2001	170	15
2002	166	19
2003	192	18
2004	153	16
2005	147	16
2006	137	16
2007	102	19
2008	100	23
2009	93	23
2010	67	17

Year	Effort France ('000 hrs)	Lpue France (kg/h)
2011	52	12
2012	42	13
2013	48	12
2014	36	15
2015	35	11
2016	35	15
2017	34	11
2018	21	10
2019	22	11
2020	12.5	6.1

Table 20.2.4.a. *Nephrops* FU 20–21. Sampling levels by Ireland.

IRELAND		Number of Samples			Numbers Measured		
Year	Quarter	Catch	Discards	Landings	Catch	Discards	Landings
2009	2	1	0		489	0	
2010	2	1	0		461	0	
2011	2	1	0		270	0	
2012	1	8	5	1	2,654	2,024	1,747
2013	1	1	1		319	423	
2013	2	9	7	1	2,514	2,038	2,187
2014	2	2	2		718	782	
2015	1	0	0	1	0	0	1,724
2015	2	6	6	2	2,714	3,997	3,204
2015	3	0	0	4	0	0	4,750
2015	4	2	2		650	419	
2016	2	8	5	1	2,859	1,485	384
2016	4	3	2	4	767	1,678	1,743
2017	1	2	1	1	722	297	1,616
2017	2	7	4	1	2,813	1,035	365
2017	3	3	1		1,154	296	
2017	4	12	7		3,631	1,983	
2018	1	3	3		987	1,036	
2018	2	17	17		6,691	5,742	
2018	3	2	0		389	0	
2018	4	2	1		544	369	
2019	1	8	6		2,691	3,103	
2019	2	12	10		4318	3,738	
2019	3	1	1		373	520	
2019	4	0	0		0	0	

Table 20.2.4.a. *Nephrops* FU 20–21. Sampling levels by Ireland.

IRELAND		**Number of Samples**			**Numbers Measured**		
Year	Quarter	Catch	Discards	Landings	Catch	Discards	Landings
2020	1	11	9		3,412	1,934	
2020	2	10	8		3,581	2,448	
2020	3	2	0		689	0	
2020	4	0	0		0	0	

Table 20.2.4.b. *Nephrops* FU 20–21. Sampling levels by France.

FRANCE		**Number of Samples**			**Numbers Measured**		
Year	Quarter	Catch	Discards	Landings	Catch	Discards	Landings
2012	1		31	9		391	1431
2012	2		13	8		198	1202
2012	3		47	8		667	1155
2012	4		6	6		16	860
2013	1		0	12		0	1362
2013	2		68	72		1,120	3151
2013	3		16	68		131	1917
2013	4		2	14		12	1303
2014	1		0	10		0	1221
2014	2		40	47		1,127	3536
2014	3		20	33		458	1934
2014	4		0	9		0	1360
2015	1		2	14		60	1508
2015	2		24	44		520	3249
2015	3		1	9		1	1366
2015	4		0	9		0	1357
2016	1		3	44		464	3164
2016	2		4	42		519	1263
2016	3		1	25		217	1971
2016	4		2	20		5	1935
2017	1		3	46		429	1659
2017	2		3	80		852	2390
2017	3		2	9		84	344
2017	4		1	23		307	952
2018	1		8	8		460	36
2018	2		9	9		1190	254
2018	3		30	30		1140	105
2018	4		10	10		149	19

FRANCE		Number of Samples			Numbers Measured		
Year	Quarter	Catch	Discards	Landings	Catch	Discards	Landings
2019	1		8	12		588	51
2019	2		9	21		1,501	46
2019	3		30	5		486	32
2019	4		10	3		631	27
2020*	all		na	na		na	na

***No sampling in 2020 due to low level fishery participation.**

Table 20.2.5. *Nephrops* FU 20–21. Sex ratio in the landings by country based on available sampling.

Ireland			
Year	Females (‘000s)	Males (‘000s)	% Males in Landings
2012	1,171	25,304	96
2013	8,369	15,596	65
2014	13,650	25,503	65
2015	8,930	39,078	81
2016	15,807	23,835	60
2017	11,836	29,183	71
2018	15,967	28,486	64
2019	23,578	51,264	68
2020	2,768	9,124	77

France			
Year	Females (‘000s)	Males (‘000s)	% Males in Landings
2012	1,545	9,323	86
2013	1,678	7,641	82
2014	3,292	7,316	69
2015	1,144	6,244	85
2016	819	8,815	91
2017	1,119	5,110	82
2018	1,863	3,605	66
2019*	-	-	-
2020**	-	-	-

***Sampling data provided but not used due to quality issues.**

****No sampling in 2020 due to low level fishery participation.**

Table 20.2.6. *Nephrops* FU 20–21. Landings and discards by number and weight (t), dead discard rate and discard rate by number, discard rate by weight and estimated mean weights (grs) in the landings and discards for France. 25% discards survival.

France										
Year	Landings in number	Total discards in number*	Removals in number	Dead Discard Rate number	Discard Rate number	Discard Rate weight	Landings	Total discards*	Mean weight in landings	Mean weight in discards
	millions	millions	millions	%	%	%	tonnes	tonnes	gramme	gramme
2012	10.9	17.8	24.2	55.1	62.1	41.5	453	322	41.7	18.1
2013	9.3	10.0	16.9	44.7	51.9	26.6	486	176	52.2	17.6
2014	10.6	37.0	38.4	72.4	77.7	55.8	465	588	43.8	15.9
2015	7.4	7.7	13.2	43.9	51.1	31.7	355	165	48.1	21.4
2016	9.6	3.2	12.0	19.7	24.7	16.2	477	92	49.5	29.1
2017	6.2	5.9	10.7	41.6	48.7	26.2	341	121	54.8	20.5
2018	5.5	4.7	9.0	39.0	46.1	32.3	195	93	35.6	19.9
2019*	-	-	-	-	-	-	-	-	-	-
2020**	-	-	-	-	-	-	-	-	-	-

***Sampling data provided but not used due to quality issues.**

****Sampling data not available due to low level fishery participation.**

Table 20.2.7. *Nephrops* FU 20–21. Landings and discards by number and weight (t), dead discard rate and discard rate by number, discard rate by weight and estimated mean weights (grs) in the landings and discards for Ireland. 25% discards survival.

Ireland										
Year	Landings in number	Total discards in number*	Removals in number	Dead Discard Rate number	Discard Rate number	Discard Rate weight	Landings	Total discards*	Mean weight in landings	Mean weight in discards
	millions	millions	millions	%	%	%	tonnes	tonnes	gramme	gramme
2012	26.5	17.5	39.6	33.1	39.7	22.6	708	207	26.7	11.9
2013	24.2	8.3	30.5	20.5	25.6	14.0	844	137	34.9	16.4
2014	39.1	17.6	52.3	25.3	31.1	14.8	1342	233	34.3	13.3
2015	47.9	18.6	61.9	22.5	27.9	13.3	1620	248	33.8	13.4
2016	39.6	27.5	60.3	34.2	41.0	26.9	1531	564	38.6	20.5
2017	41.0	9.2	47.9	14.4	18.4	9.7	1113	120	27.1	13.0
2018	44.5	11.9	53.4	16.8	21.2	14.4	1197	201	26.9	16.9
2019*	74.8	29.2	96.7	22.6	28.1	16.5	2219	439	29.7	15.0
2020	11.9	1.7	13.1	9.5	12.3	7.6	336	28	28.2	16.7

***2019 data revision due to valid sample inclusion.**

Table 20.2.8. *Nephrops* FU 20–21. Landings and discards by number and weight (t), dead discard rate and discard rate by number, discard rate by weight and estimated mean weights (grs) in the landings combined by both countries based on available sampling and scaled to international landings. 25% discards survival.

Combined and scaled to the international landings										
Year	Landings in number	Total discards in number*	Removals in number	Dead Discard Rate number	Discard Rate number	Discard Rate weight	Landings	Total discards*	Mean weight in landings	Mean weight in discards
	millions	millions	millions	%	%	%	tonnes	tonnes	gramme	gramme
2012	38.2	36.1	65.3	41.4	48.5	31.3	1,189	542	31.1	15.0
2013	34.8	19.2	49.2	29.3	35.6	19.1	1,387	327	39.9	17.0
2014	50.6	55.5	92.2	45.2	52.3	31.2	1,836	834	36.3	15.0
2015	59.4	28.1	80.5	26.2	32.2	17.3	2,116	442	35.7	15.7
2016	60.2	37.5	88.3	31.8	38.4	24.6	2,453	801	40.7	21.4
2017	60.1	19.2	74.5	19.4	24.3	14.2	1,849	306	30.8	15.9
2018	64.7	21.5	80.8	20.0	25.0	17.5	1,803	381	27.9	17.7
2019*	91.8	35.8	118.7	22.6	28.1	16.5	2,723	539	29.7	15.0
2020	14.6	2.0	16.2	9.5	12.3	7.6	413	34	28.2	16.7

***2019 data revision due to valid sample inclusion for Ireland and revision to UK landings.**

Table 20.2.9. *Nephrops* FU 20–21. Results summary table for geo-statistical analysis of UWTV survey.

Ground	Year	Number of stations	Mean Density** (burrows/m²)	Domain Area (Km²)	Geostatistical Abundance Estimate adjusted (millions burrows)	CV on Burrow estimate (%)	Analysis Method software
FU 2021	2012	54	0.57		nr	nr	na
	2013*	55	0.16	10, 014	1640	8.1	RGeostats
	2014	98	0.19	10, 014	2021	3.9	RGeostats
	2015	96	0.2	10,014	2003	3.2	RGeostats
	2016	93	0.18	10,014	1879	4.3	RGeostats
	2017	86	0.44	10,014	4428	3.8	RGeostats
	2018	96	0.27	10,014	2721	4.0	RGeostats
	2019	95	0.06	10,014	617	4.8	RGeostats
	2020	97	0.10	10,014	1020	4.8	RGeostats
	2021	97	0.12	10, 014	1202	3.9	RGeostats

*** the 2013 survey achieved partial coverage ~60% of the total area. The abundance has been scaled up to the entire area since densities in the unsurveyed part of the ground were not significantly different in 2014.**

nr= no reliable abundance estimate could be calculated because survey coverage was partial.

**** mean density adjusted of the observations.**

Table 20.3.1. *Nephrops* FU 20–21. Short term catch options prediction inputs and recent estimates of mean weight in landings and harvest rates. Cells in bold indicates inputs to catch option calculations.

Year	Landings in number	Total discards in number*	Removals in number	Dead Discard Proportion number	Discard Proportion number	UWTV abundance estimate	95% Confidence Interval	Harvest rate	Landings	Total discards*	Mean weight in landings	Mean weight in discards
	millions	**millions**	**millions**	**%**	**%**	**millions**		**%**	**tonnes**	**tonnes**	**gramme**	**gramme**
2012	38.2	36.1	65.3	41.4	48.5				1189	542	31.1	15.0
2013	34.8	19.2	49.2	29.3	35.6	1640	261	3.0	1387	327	39.9	17.0
2014	50.6	55.5	92.2	45.2	52.3	2021	154	4.6	1836	834	36.3	15.0
2015	59.4	28.1	80.5	26.2	32.2	2003	129	4.0	2116	442	35.7	15.7
2016	60.2	37.5	88.3	31.8	38.4	1879	157	4.7	2453	801	40.7	21.4
2017	60.1	19.2	74.5	19.4	24.3	4428	332	1.7	1849	306	30.8	15.9
2018	64.7	21.5	80.8	20.0	25.0	2721	212	3.0	1803	381	27.9	17.7
2019	91.8	35.8	118.7	22.6	28.1	617	58	19.2	2723	539	29.7	15.0
2020	14.6	2.0	16.2	9.5	12.3	1020	96	1.6	413	34	28.2	16.7
2021						**1202**	**92**					
Average 2018–2020				**17.4**	**21.8**						**28.6**	**16.5**

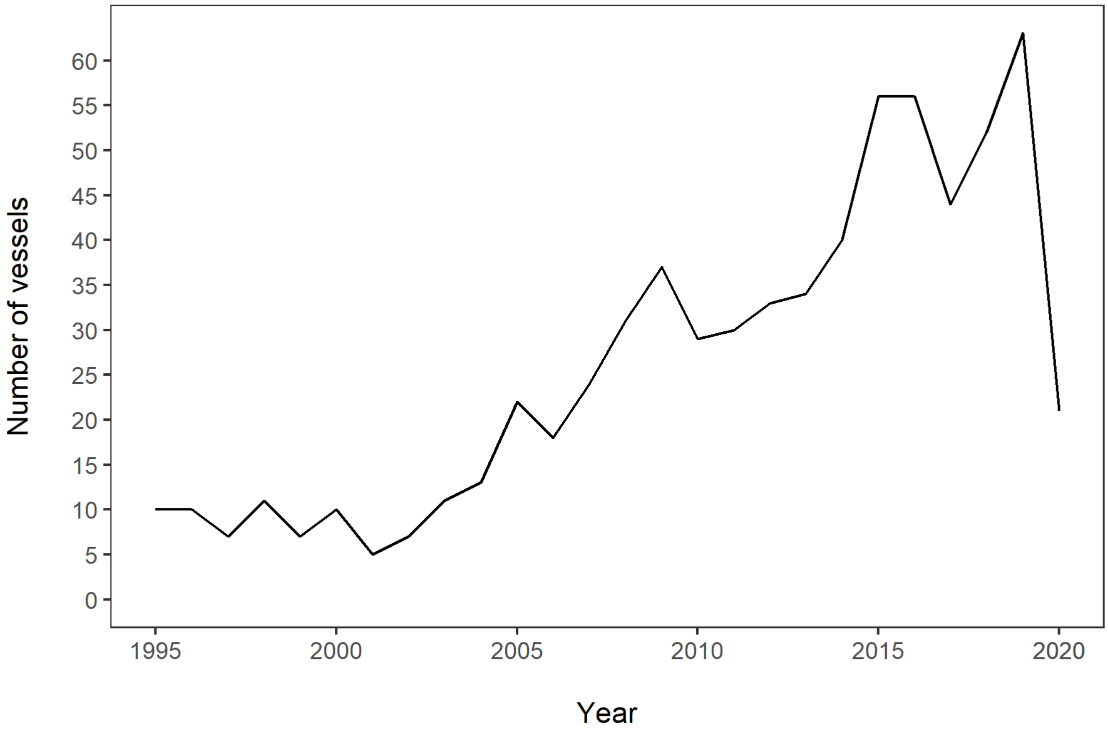


Figure 20.1.1. ***Nephrops*** **FU 20–21. Number of Irish vessels reporting landings >10 t by year.**

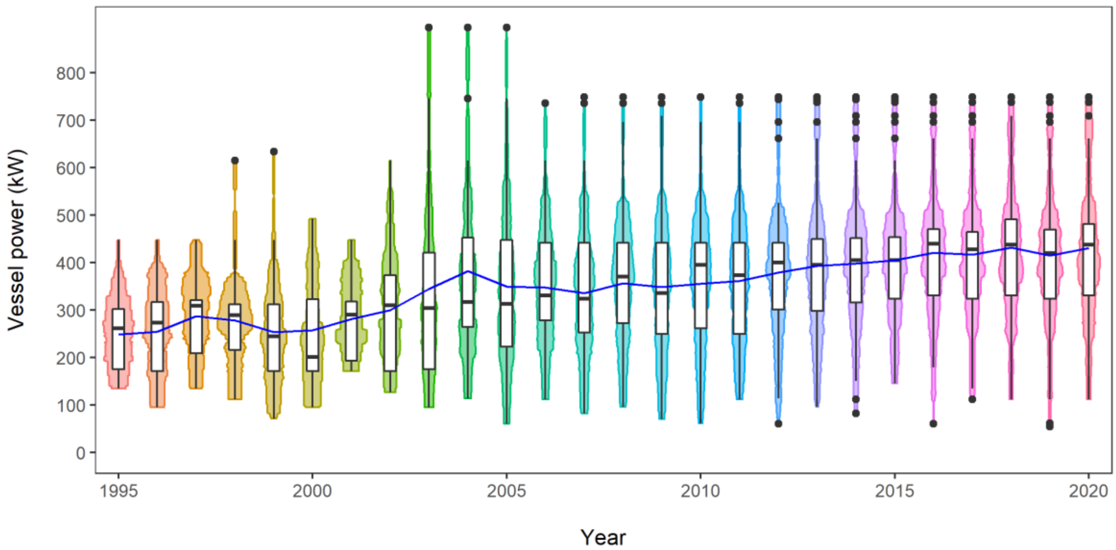


Figure 20.1.2. ***Nephrops*** **FU 20–21. Combined box and kite plot of vessel power on the FU20–21 grounds by year. The blue line indicates the mean.**

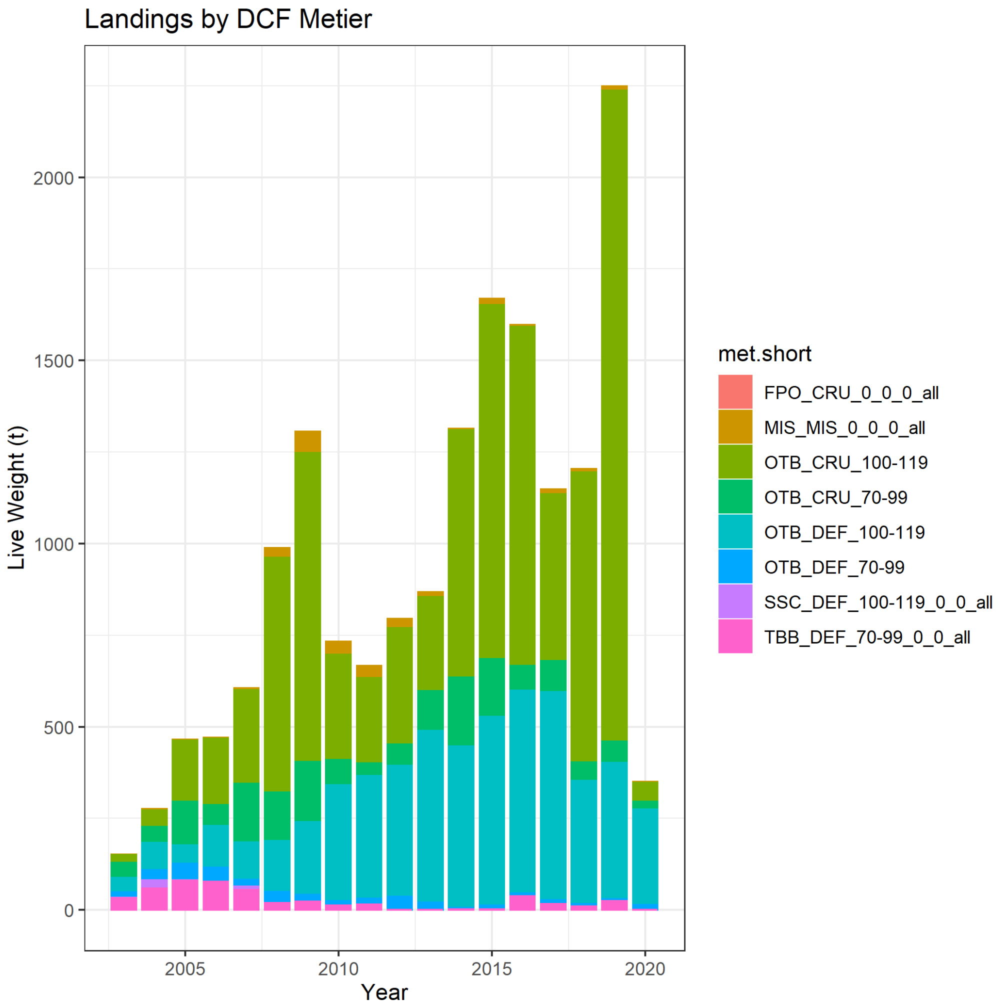


Figure 20.1.3. *Nephrops* FU 20–21. Irish Landings by DCF Metiér.

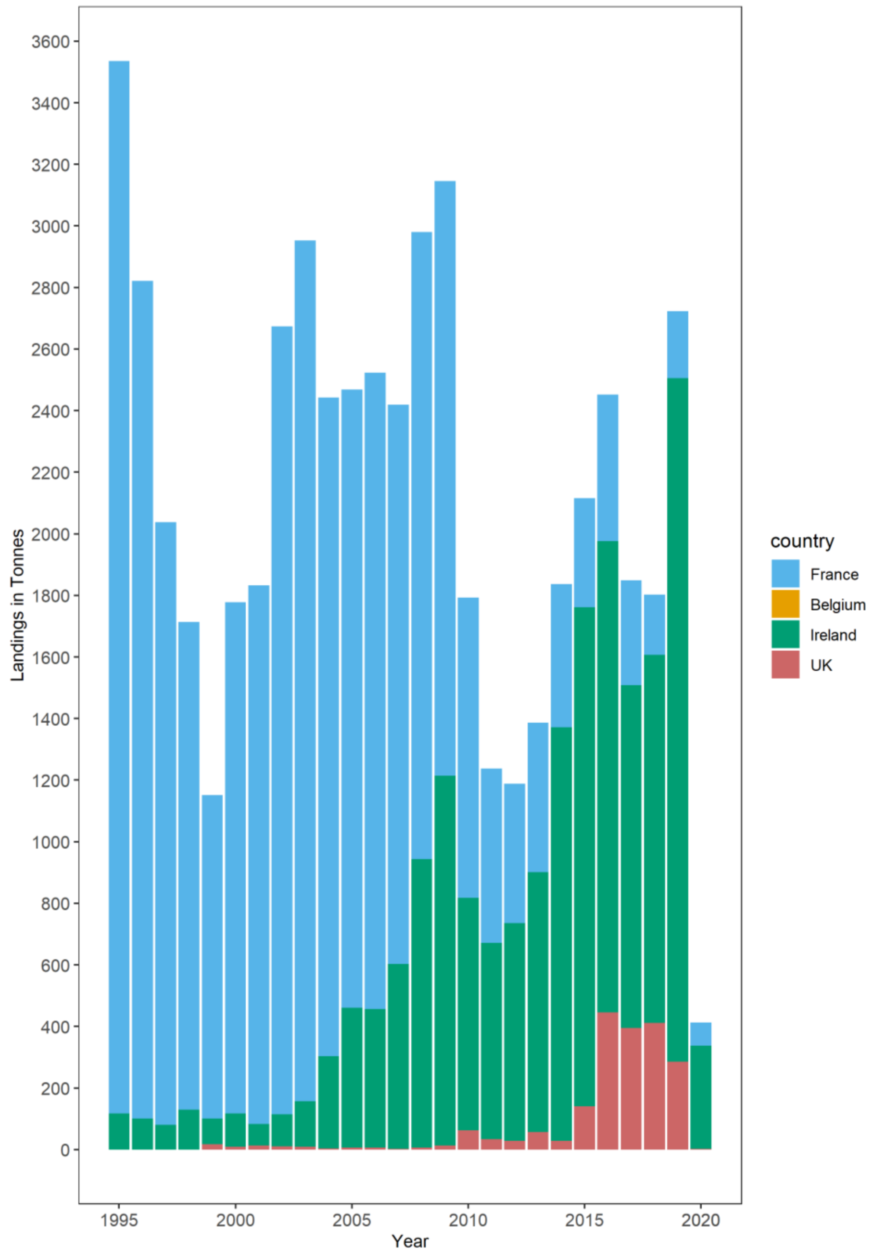


Figure 20.2.1. *Nephrops* FU 20–21. Landings in tonnes by country.

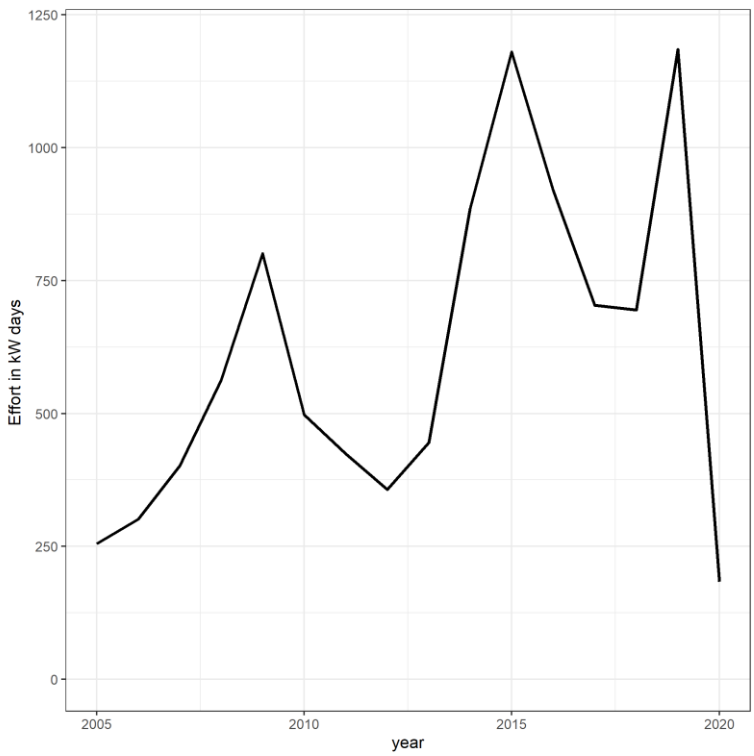


Figure 20.2.2. *Nephrops* FU 20–21. Effort data (Kw days) for the Irish otter trawl *Nephrops* directed fleet.

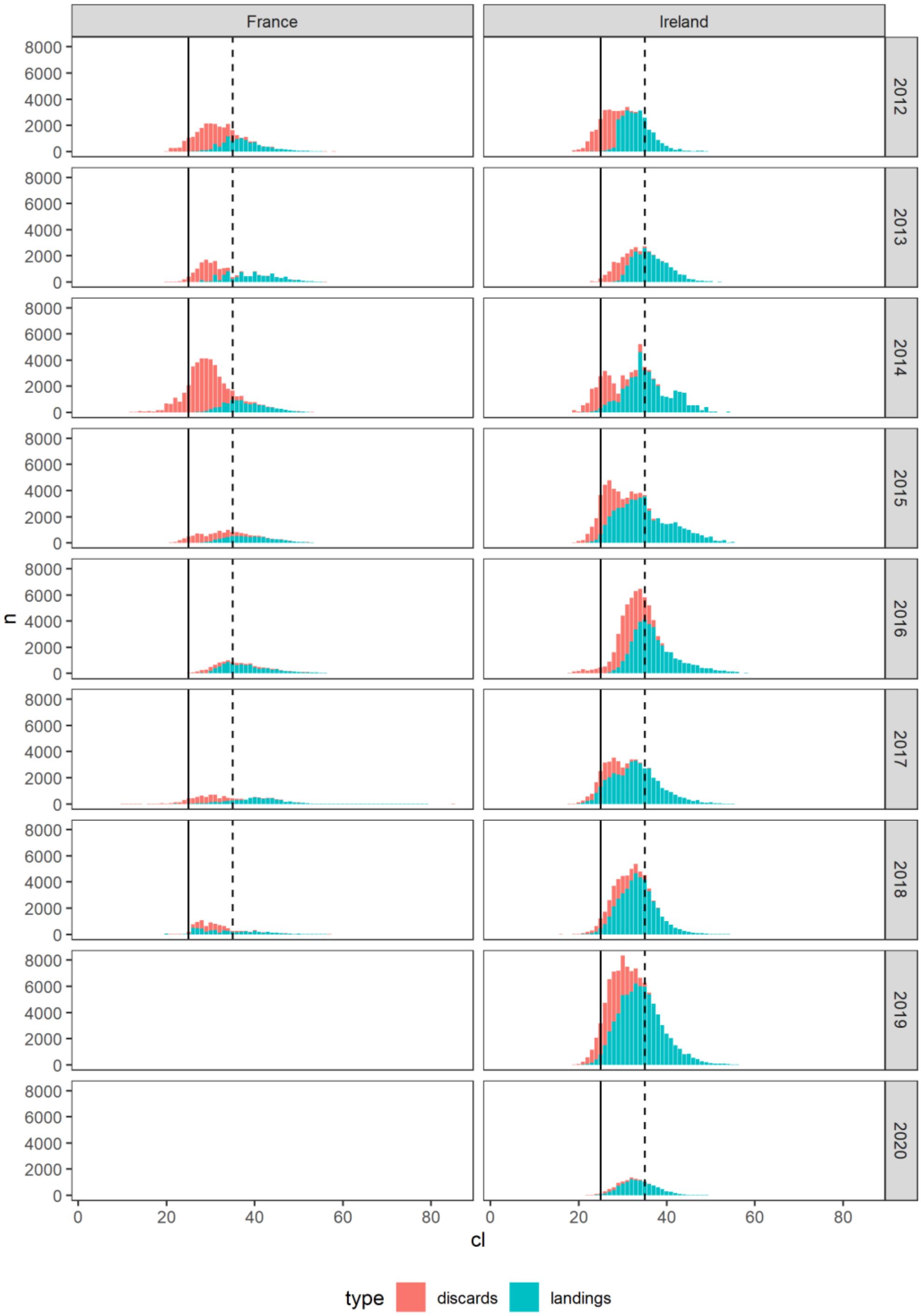


Figure 20.2.3. ***Nephrops*** **FU 20–21. Commercial length–frequency distribution by country. Minimum conservation reference size of 25 CL mm (European MCR) and 35 CL mm (French MLS) displayed. 2019 data provided by France but not included in the assessment. Data not available for France in 2020 due to low fishery participation.**

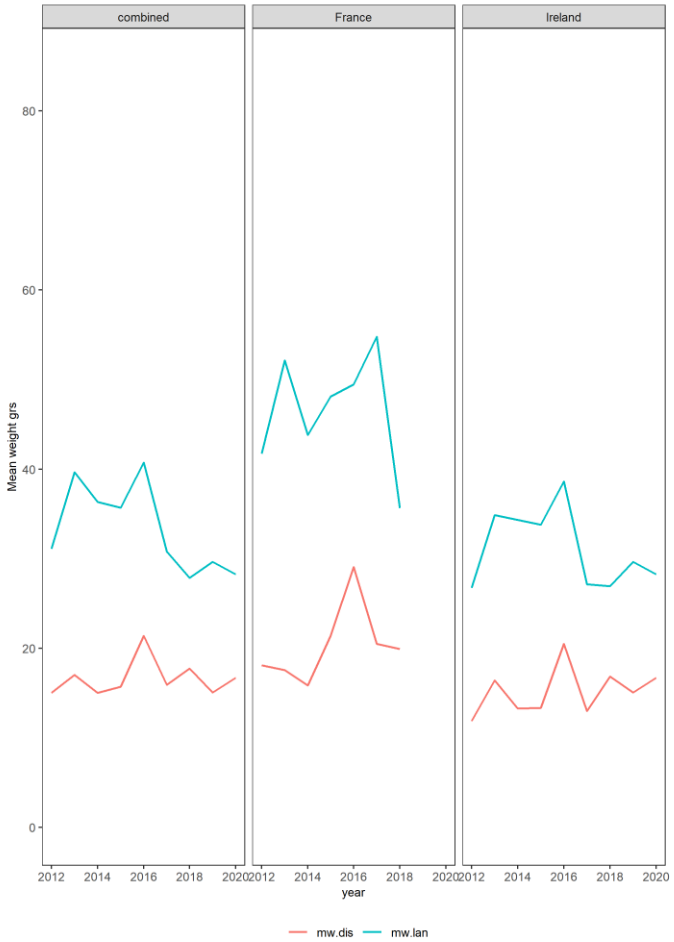


Figure 20.2.4. *Nephrops* FU 20–21. Annual mean weights (gr) in the landings (blue line) and discards (red line) by country and combined scaled to international landings.

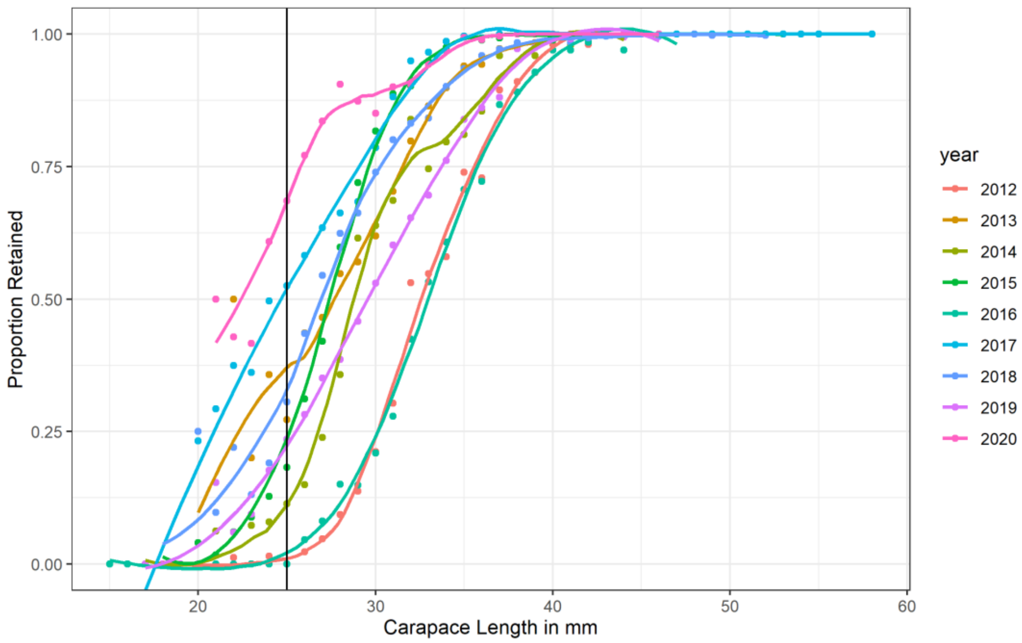


Figure 20.2.5. *Nephrops* FU 20–21. Annual discard ogive derived from Irish sampling. Minimum landing size of 25 CL mm (European MCR) as black line.

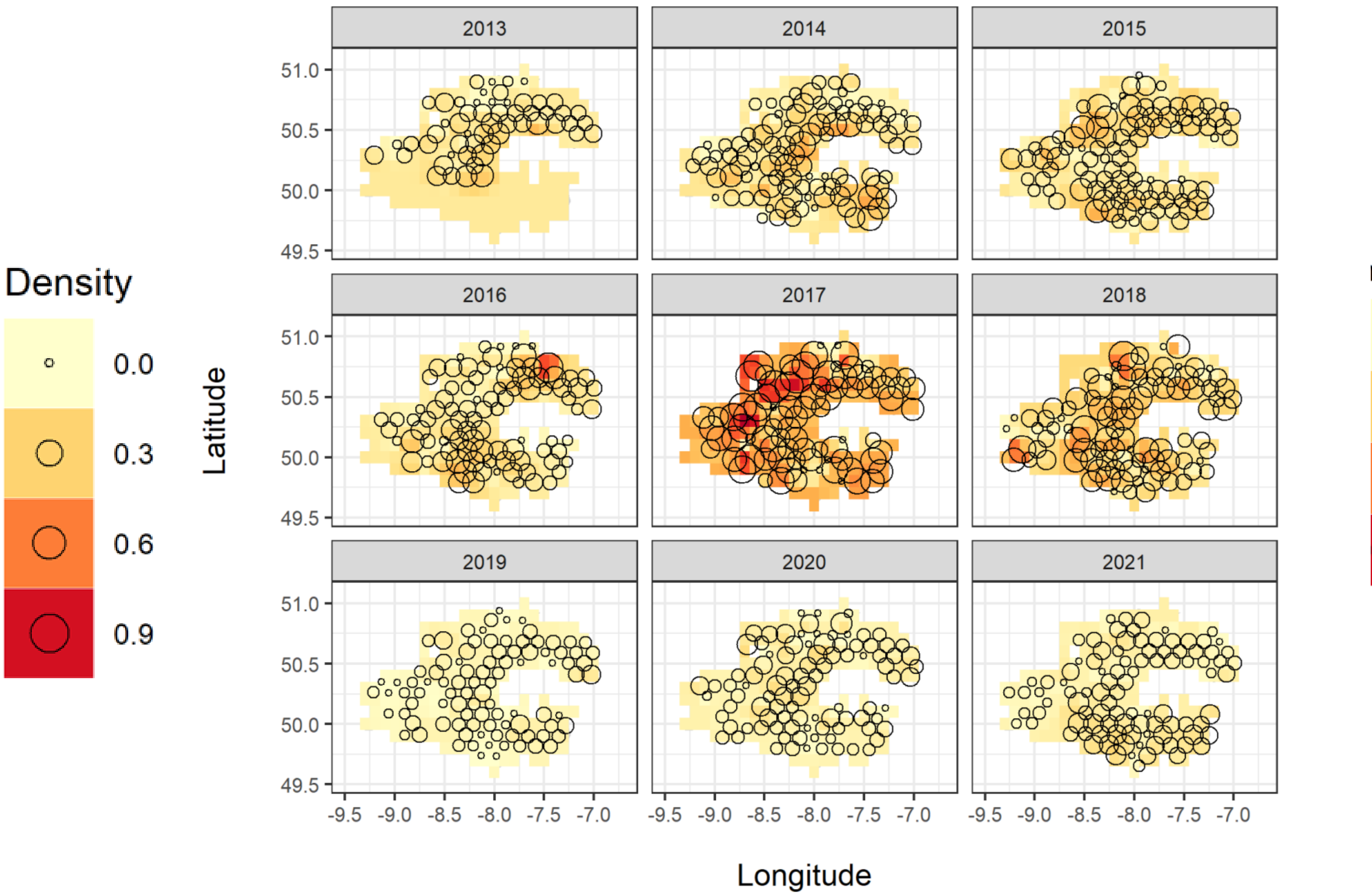


Figure 20.2.6. *Nephrops* FU 20–21. Contour plots of krigged density estimates for the UWTV surveys from 2013 to 2021.

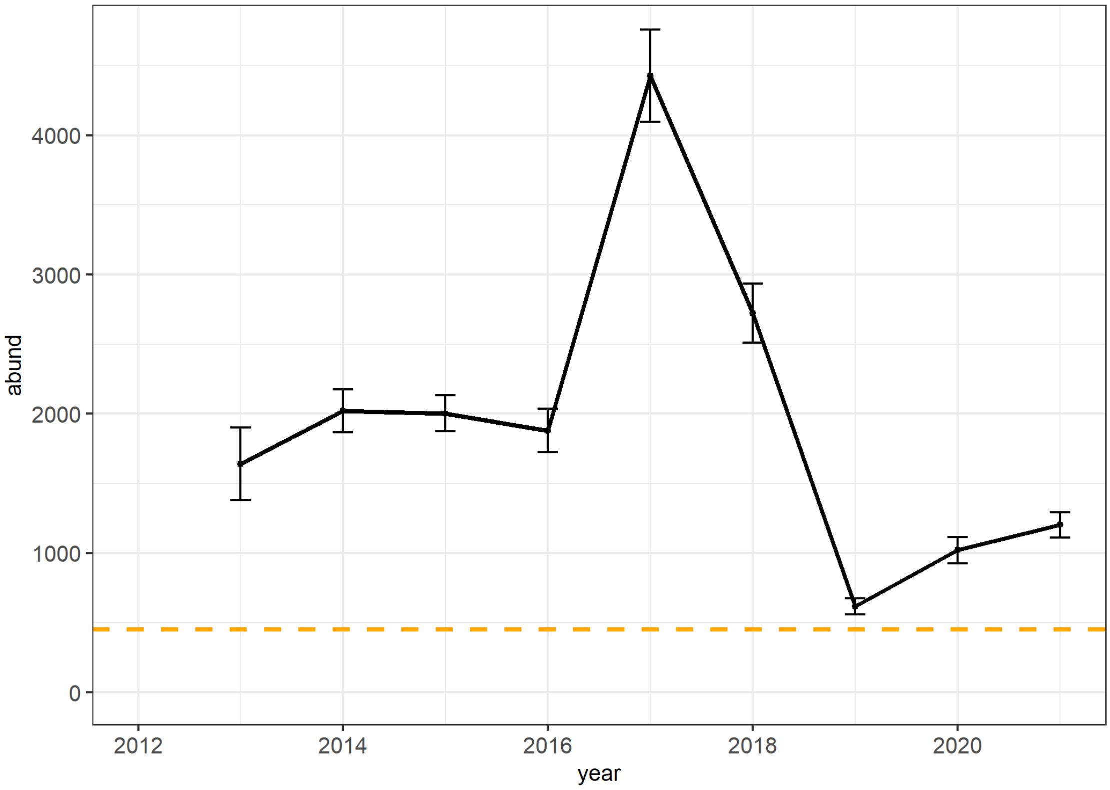


Figure 20.2.8. *Nephrops* FU 20–21. Time-series of abundance estimates (millions burrows) for FU20–21 (error bars indicate 95% confidence intervals) and MSY $B_{trigger}$ is dashed line.

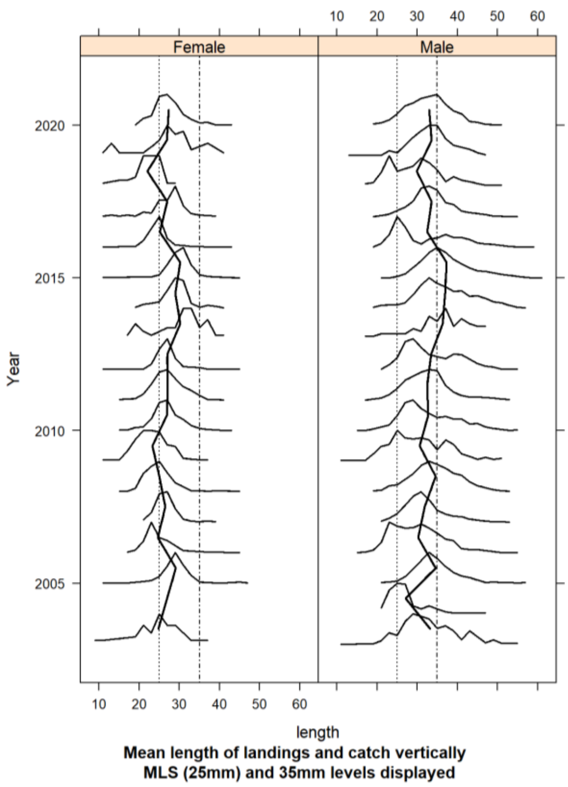


Figure 20.2.9. *Nephrops* FU 20–21. Mean size trends for catches by sex from the IBTS-IGFS Irish survey in the Celtic Sea.

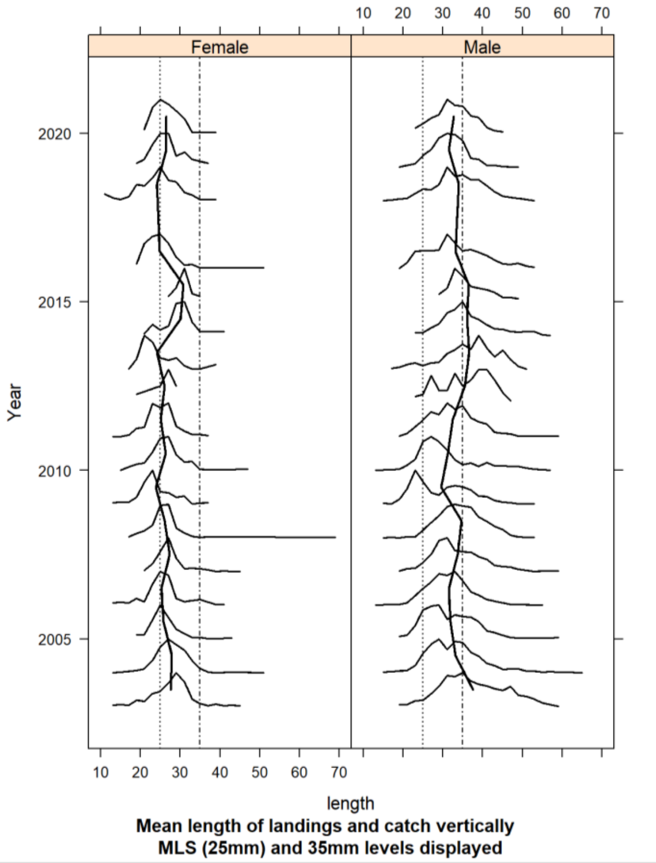


Figure 20.2.10. ***Nephrops*** **FU 20–21. Mean size trends for catches by sex from the IBTS-EVHOE French survey in the Celtic Sea. No survey data available for 2017.**

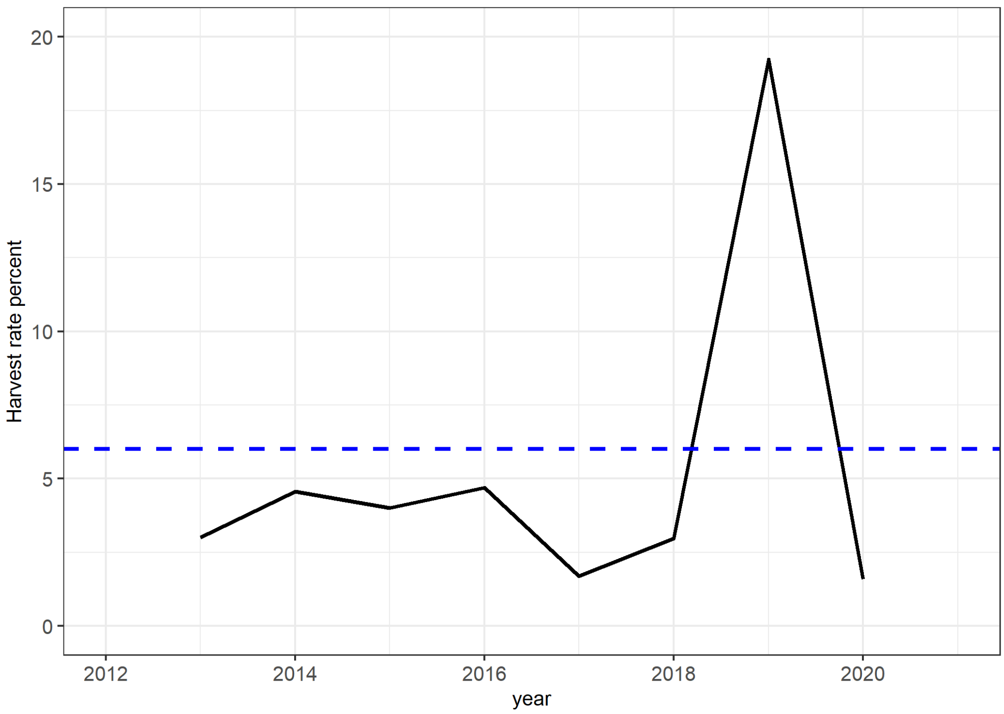


Figure 20.3.11. ***Nephrops*** **FU 20–21. Harvest rate (% dead removed / UWTV abundance). The dashed and solid lines are the MSY proxy and the harvest rate respectively.**

21 Norway lobster (*Nephrops norvegicus*) in divisions 7.g and 7.f, Functional Unit 22 (Celtic Sea, Bristol Channel)

Type of assessment in 2021

UWTV based assessment using WK*NEPH* 2009 protocol as described in the stock annex. The TV survey is due to be repeated in summer 2021 and the new survey will form the basis of advice for this stock in autumn. This stock is now available in the ICES Transparent Assessment Framework (TAF) here.

ICES advice applicable to 2020

"ICES advises that when the EU multiannual plan (MAP) for Western waters and adjacent waters is applied, catches in 2020 that correspond to the F ranges in the MAP are between 2247 tonnes and 2820 tonnes. The entire range is considered precautionary when applying the ICES advice rule.
To ensure that the stock in Functional Unit (FU) 22 is exploited sustainably, management should be implemented at the functional unit level."

ICES advice applicable to 2021

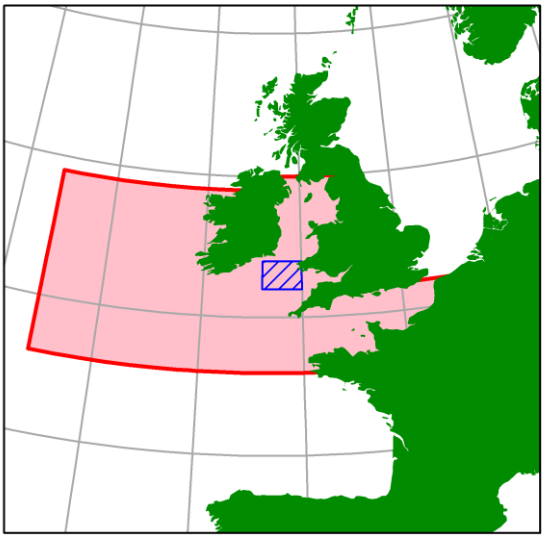
"ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 1238 tonnes and 1560 tonnes, assuming recent discard rates. The entire range is considered precautionary when applying the ICES advice rule.
To ensure that the stock in Functional Unit (FU) 22 is exploited sustainably, management should be implemented at the functional unit level."

21.1 General

Stock description and management units

The Smalls *Nephrops* stock (FU22) covers ICES rectangles 31–32E3, 31–32E4 within 7.f.g. It is included in the whole ICES Area 7 together with Irish Sea East and West [FU14, FU15], Porcupine Bank [FU16], Aran Grounds [FU17], northwest Irish Coast [FU18], southeast and southwest Irish Coast [FU19], NW Labadie, Baltimore and Galley [FU20–21], Jones and Cockburn [FU21].

Historically FU20–22 has covered an amalgamation of several spatially distinct mud patches; FU 20 NW Labadie, Baltimore and Galley, FU 21 Jones and Cockburn and FU22 the Smalls. There is no evidence that the whole exploited area belongs to the same stock or that there are several patches linked in meta-population sense. WGCSE 2013 recommended that FU20–22 should be split into FU20–21 and FU22 for the purposes of assessment and advice provision. The map below shows FU22 assessment area (blue) and TAC area (red). There is no evidence that the individual functional units belong to the same stock. See Section 18 for details on *Nephrops* in Subarea 7 general section.



Ecosystem aspects

This section is detailed in stock annex.

Fishery description

Ireland, France and the UK are the main countries involved in the FU22 *Nephrops* fishery. In the early 2000s the Republic of Ireland fleet had on average over 70% of the landings and this has increased to over 85% from this FU in recent times. A description of this fleet is given in the stock annex. The time-series of numbers of vessels is updated in Figure 21.1.1. The numbers of vessels has been decreasing in recent years where the largest number was recorded in 2016. The time-series of vessel power is shown as a box and kite plot in Figure 21.1.2.

Irish landings from this FU come mainly from ICES statistical rectangle 31E3. The fishery on the Smalls grounds operates throughout the year, weather permitting with a seasonal trend.

French trawlers targeting *Nephrops* in the Celtic Sea operate mainly in FU20–21. In the early 2000s French fleet had on average 30% of the landings from FU22 where this has decreased to <1% in recent times. 80–90% of the FU22 French landings come from ICES statistical rectangle 31E3.

UK fleet had on average ~10% of the landings in recent year and is mainly UK-Northern Irish vessels in this fishery.

Fishery in 2020

In 2020, 56 Irish vessels reported landings from FU22. Of these, 47 vessels reported landings in excess of 10 t. Vessels >18 m account for 90% of the landings in 2020. In recent years several newer vessels specializing in *Nephrops* fishing have participated periodically in this fishery. These vessels target *Nephrops* on several other grounds within the TAC area and move around to optimize catch rates.

In 2020, ten French trawlers reported landings for FU22. French vessels switch between FU20–21 and FU22. In 2020, one Northern Ireland and two UK(EandW) vessels reported landings for this FU.

The French minimum mesh size of codend was set at 100 mm since January 2000 the majority of Irish landings are from vessels with 80–99 mm codend mesh.

Information from stakeholders

None presented.

21.2 Data

InterCatch

Data were available in InterCatch and used for catch data only. French catch data provided directly by the national expert.

Landings

The reported landings time-series by country is shown in Figure 21.2.1 and Table 21.2.1. The reported Irish landings from FU22 have increased since 2000. In 2020 the landings increased from 2019 by 23% to approximately 1448 t. French landings have gradually decreased since the early 2000s to the present. Reported landings from the UK have fluctuated with a decrease in 2020. Northern Ireland had the highest landings at 16 t followed by England and Wales reporting 6 t. Belgium reported minimal landings <2.5 t in general from this FU.

Effort

In line with WGCSE 2015 recommendation effort is reported in Kwdays and lpue reported in t/Kwdays in the knowledge that the trend is likely to be a biased underestimate because it is not adjusted for efficiency or behavioural changes. The effort series is based on the same criteria for FU15, 16, 17, 22 and 20–21 (30% landings threshold) and will be contingent on the accuracy of landings data reported in logbooks. Effort data are available for the Irish *Nephrops* directed fleet in FU22 from 1995–2020. The time-series of effort and lpue is updated in Figure 21.2.2 and Table 21.2.2.

Effort shows an increasing trend since the early 2000s (Table 21.2.2. and Figure 21.2.2) with a decreasing trend since 2018.

Sampling levels

Dedicated sampling of landings and discards began in 2003 by Ireland. Sampling levels in 2020 were good except for quarter 1 where there was one sample only (Figure 21.2.3).

Sampling and Raising Procedure Review

The national sample raising procedures for FU22 were reviewed and fully documented through an R markdown document (Annex 3, ICES, 2018 and stock annex). Annual discard ogives are calculated and are applied to quarterly length distributions and then raised to total quarterly landings before aggregation. A further raising procedure is applied to raise the annual sampled Irish data, where this addresses quarters with missing length samples. Next the international raising factor is applied. This raising procedure is used to assess this stock and to calculate mean weights, sex ratio and discard rates as inputs for catch scenarios and advice. A minor data revision to 2018 sample data were presented to WGCSE 2020 and resulting calculations were accepted.

Commercial length–frequency distributions

The Irish sampling programme started in 2003 and since then coverage and intensity have been very good covering the seasonal trend of the fishery. The mean size of *Nephrops* in Irish landings has remained stable for both sexes. The mean size of *Nephrops* in the catch has remained relatively stable since 2005 (Figure 21.2.5). There is an increase in mean size in the catches in 2007 to 2009 for both sexes which is linked to the recruitment signal picked up by both the 2006 UWTV [U5917] and IGFS-WIBTS-Q4 [G7212].

Sex ratio

The sex ratio by year is shown in Figure 21.2.6. This shows some fluctuations over time. The sex ratio has a distinct seasonal pattern (Figure 21.2.7) with lowest male proportions in the samples in May and June. Males dominate the catches in autumn and winter.

Mean weight explorations

Explorations of the mean weight in the catch samples by sex shows a strong cyclical pattern in the females (Figure 21.2.7). This corresponds to the emergence of mature females from the burrows to mate in summer. There is an increase in mean weight in 2007 to 2009 for both sexes which is linked to the recruitment signal picked up by both the UWTV [U5917] and IGFS-WIBTS-Q4 [G7212] (Figure 21.2.11). The annual mean weight estimate for landings and discards is shown in Figure 21.2.8. The mean weight estimates in the landings show a slight decrease in 2020 compared to the increase in 2019.

Discarding

Since 2003 discard rates have been estimated using unsorted catch and discards sampling. This involves unsorted catch and discard samples being provided by vessels or collected by observers at sea on discard trips. The catch sample is partitioned into landings and discards using an on-board discard selection ogive derived for the discard samples. Sampling effort is stratified monthly, but annual aggregations are used to derive length distributions and selection ogives. The length–weight regression parameters given in the stock annex are used to calculate sampled weights and appropriate quarterly raising factors. The sampling intensity and coverage has varied over the time-series, but overall has been good.

Discard rates range between 9–39% of total catch by weight and 15–52% of total catch by number (Table 21.2.4). Discard rate of females tends to be higher due to the smaller average size and market reasons. There is no information on discard survival rate in this fishery. 25% is assumed in line with other *Nephrops* stocks in the Celtic Sea (Charuau *et al*., 1982). Highest discard rates were observed in 2007 as a result of the recruitment into the fishery in 2006.

Gear selectivity trials by Bord Iascaigh Mhara (BIM, 2017) reported a 64% survivor rate for *Nephrops* caught in a trawl with a SELTRA selectivity device in the outer Galway Bay area.

Table 21.3.1 gives weights, numbers and mean weights of the landings and discard raised internationally according to the stock annex.

Surveys

Abundance indices from UWTV surveys

The methods used during the survey were similar to those employed for UWTV surveys [U5917] of *Nephrops* stocks around Ireland and elsewhere are documented by WKNEPHTV (ICES, 2007), WKNEPHBID (ICES, 2008), SGNEPS (ICES, 2009; 2010; 2012), WGNEPS (ICES, 2013; 2014; 2015; 2016a; 2017; 2018a, 2020, 2021), WKNEPS (ICES, 2016b; 2018b), Leocádio, A., *et al.*, 2018 and Dobby H., *et al.*, 2021.

SGNEPS 2012 (ICES, 2012) recommended that a CV (or relative standard error) of <20% is an acceptable precision level for UWTV survey estimates of abundance. This allowed sampling intensity to be reduced from around 90 stations in the past to around 42 on the Smalls grounds in 2021 which allowed survey coverage of other FUs. A randomised isometric grid design was employed with UWTV stations at 4.5 nautical mile intervals, whereas previously a 3.0 nautical mile square grid was used. Operational details of the 2021 UWTV survey are available (Aristegui *et al.*, 2021).

Seven stations in FU22 were not surveyed successfully in 2015 due to very poor visibility conditions encountered as a result of strong tides. WKCELT 2014 concluded that WGCSE or WGNEPS should make recommendations on the most appropriate fill in procedure to be adopted in cases when stations could not be surveyed. WGCSE 2015 agreed the following procedure for this case: Two buffer zones of 1 nautical mile and 2 nautical mile distance were generated around the missing stations. The counts and mean of historic density estimates within the 1 and 2 nautical mile buffers were calculated. The standard kriging procedure was carried out and summary results were computed for the 1 and 2 nautical mile "fill-ins". Finally the mean of historic densities within 2 nautical mile buffer of the planned stations were used in the calculation of the 2015 abundance.

The blanked krigged contour plot and posted point density data are shown in Figure 21.2.9. The krigged contours correspond very well to the observed data. In general, the densities are higher in the central area of the ground with a localised hot spot centrally and also in the southwestern leg. Densities and abundance have remained stable in the time-series with the exception of the first year and 2017, which were the highest in the series. The 2021 mean density 0.23 burrows/m^2 is approximately 13% decrease compared with density 0.27 burrows/m^2 in 2020. The summary statistics from this geostatistical analysis are given in Table 21.2.5 and plotted in Figure 21.2.10. The geostatistical abundance estimate adjusted is derived using the mean of the krigged grid where the mean of the observations is reported in Table 21.2.5.

The 2021 estimate of 656 million burrows is below the MSY $B_{trigger}$ (990 million). The estimation variance of the survey as calculated by EVA is very low (CVs in the order <9%).

Groundfish survey data

The Irish groundfish survey IGFS-WIBTS-Q4 [G7212] has been carried out since 2003 (Stokes *et al.*, 2014; ICES, 2017b). This provides information on length–frequency compositions, mean size in the catches, CPUE of *Nephrops* in FU22. The mean size of the catches is stable over the time-series except in 2006 and 2008, which signals recruitment into the fishery in 2006 and 2007 (Figure 21.2.11). This signal of recruitment was also picked up during the 2006 UWTV [U5917] survey (Doyle *et al.*, 2012). The groundfish survey provides a useful indicator of recruitment in this FU.

21.3 Assessment

Comparison with previous assessments

The WGCSE 2021 carried out an UWTV-based assessment for this stock. The methods used were very much in line with WK*NEPH* (ICES, 2009) and the approach taken for other *Nephrops* stocks in areas 6 and 7 by WGCSE.

State of the stock

UWTV abundance estimates suggest that the stock size shows a recent declining trend with a decrease in 2021. The 2021estimate is below the MSY $B_{trigger}$ (990 million). The 2021 estimate (656 million) is below the average of the series (geomean [2006–2021]: 1141 million).

Harvest rate is calculated as (landings + dead discards)/(abundance estimate). Table 21.3.1 and Figure 21.3.1 summarize recent harvest rates. Recent harvest rates have fluctuated due to recruitment pulses into the fishery in 2006 and 2010 and is currently 9.7% which is below F_{MSY}.

21.4 Catch scenarios table

Catch scenario table inputs and historical estimates of mean weight in landings and harvest rates are presented in Table 21.3.1 and summarised below.

Since 2003, mean weight in the landings has varied between 18–27 grammes (Figure 21.2.8). Since WGCSE 2019 given the stability in mean weights in the recent years, the recent three year average of mean weights is used to calculate catch scenarios. The three year average (2018–2020) of proportion of removals retained was used as is standard for other *Nephrops* stocks. The estimate harvest rate has also varied a lot, from 6–27% with 2007 being the highest observed (Figure 21.3.1). This is a result of recruitment into the fishery in 2006 and 2007.

The basis for the catch scenarios:

Variable	Value	Notes
Stock abundance (2022)	656	Number of individuals (million); UWTV survey 2021
Mean weight in projected landings	23.9	Average 2018–2020 in grammes
Mean weight in projected discards	12.7	Average 2018–2020 in grammes
Projected discards	23.1	Proportion by number; average 2018–2020
Discards survival	25	Proportion by number
Projected dead discards	18.4	Proportion by number; average 2018–2020

A prediction of landings for FU22 using the approach agreed procedure proposed at WK*NEPH* 2009 and outlined in the stock annex will be made on the basis of the 2021 UWTV survey. This will be presented in October 2021 for the provision of advice.

21.5 Reference points

New reference points were derived by WKMSYRef4 (ICES, 2016XX, 2016YY) for FU22. These were updated on the basis of an average of estimated F_{MSY} proxy harvest rates over a period of years, this corresponds more closely to the methodology for finfish. In cases where there is a clear trend in the values a five year average was chosen. Similarly, the five year average of the F at 95% of the YPR obtained at the F_{MSY} proxy reference point was proposed as the F_{MSY} lower bound and the five year average of the F above F_{max} that leads to YPR of 95% of the maximum as the upper bound. Using an average value also has the advantage of reducing the effect of any unusually high or low estimates of the F_{MSY} proxy which occasionally appear.

This stock previously did not have MSY $B_{trigger}$ specified, the time-series and range of indicator biomass is also limited such that direct use of B_{loss} is considered too close to equilibrium biomass. The workshop proposed to use the 5% interval on the probability distribution of indicator biomass assuming a normal distribution, which is analogous to the 5% on B_{MSY} proposed for finfish stocks assuming these *Nephrops* FU's have been exploited at a rate close to near HR_{MSY}. The MSY $B_{trigger}$ for FU22 is 987 million individuals rounded to 990 million.

Stock code	MSY F_{lower}*	F_{MSY}*	MSY Fupper* with AR	MSY $B_{trigger}$	MSY Fupper* with no AR
nep-22	10.2%	12.8%	12.8%	990***	12.8%

*** Harvest rate (H).**

***** Abundance in millions.**

21.6 Management strategies

The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to Norway lobster (*Nephrops norvegicus*) by functional unit in ICES Subarea 7 and also demersal stocks. There is currently no agreement with the UK regarding this plan.

21.7 Quality of assessment and forecast

Since 2006, a dedicated annual UWTV survey has provided abundance estimates for FU22 with high precision. There are several key uncertainties and bias sources in the method used here (these are discussed further in WK*NEPH* 2009). Various agreed procedures have been put in place to ensure the quality and consistency of the survey estimates following the recommendations of several ICES groups (WKNEPTV 2007; WKNEPHBID 2008; SGNEPS 2009; WGNEPS 2016, WGNEPS 2018b). Ultimately there still remains a degree of subjectivity in the production of UWTV abundance estimates (Marrs *et al.*, 1996). Taking explicit note of the likely biases in the surveys may at least provide an estimate of absolute abundance that is more accurate, although no more precise (WK*NEPH* 2009). The survey estimates themselves are very precisely estimated (CVs 2–9%) given the homogeneous distribution of burrow density and the modelling of spatial structuring. The cumulative bias estimates for FU22 are largely based on expert opinion. The precision of these bias corrections cannot yet be characterised, but is likely to be lower than that observed in the survey.

In 2015, there is added uncertainty, not accounted for in the model or CV estimate, because 17% of the planned TV stations could not be successfully surveyed due to poor visibility on the seabed. However, the spatial distributions of densities have been fairly consistent over time and the overall density has also been relatively stable. The fill in procedure used to generate density estimates for the seven missing stations should be a good approximation.

A review of sampling and raising procedures was presented to WGCSE 2018 and is accepted as the current method to calculate the fishery dependant inputs FU22 (Annex 3, ICES, 2018 and stock annex).

In the provision of catch scenarios based on the absolute survey estimates additional uncertainties related to mean weight in the landings and the discard rates also arise. Given the recent stability in mean weights in landings and unwanted catch - for FU22 deterministic estimates of the mean weight in the landings and discard rates for 2018–2020 are used by the WG. Previously the full time-series was used to account for the variability over time where this had occurred when large recruitments are observed in the stock as was the case in 2006 and 2007.

From 2016, fisheries catching *Nephrops* in Subarea 7 are covered by the EU landings obligation with several exemptions (EU, 2015). The average discard rate by weight for FU22 over the last three years is 14%. Irish discard survival experiments indicate that the trawl discard survival may be around 64% (BIM, 2017). As a result, an exemption from the landings obligation based on high survivability has been granted by the European Commission. Catch advice and scenarios are provided this year on the assumption that discarding is assumed to continue at the recent average.

Landings data are adjusted to take into account landings that have been misreported from FU16 since 2011. This adjustment is thought to be reasonably accurate (See Section 20).

Sampling and discard estimates have improved over the time-series.

21.8 Recommendation for next benchmark

This stock has not been formally benchmarked by ICES although the approach used has. WGCSE recommends that the issue list below can be addressed through an inter-bench process:

- The biological parameters used as inputs to the SCA should be reconsidered; growth parameters, length-at-maturity and natural mortality.
- The historical time-series of landings and effort by rectangle should be disaggregated and options for standardisation of lpue investigated.
- Historical sampling and groundfish survey data in this FU should also be disaggregated as far as possible back in time, and investigated for useful trends and signals.

21.9 Management considerations

The trends from the fishery (landings, effort, mean size, etc.) appear to show stock is exploited. The UWTV abundance and mean density estimates show some fluctuations in burrow abundance in the recent three years to the lowest level observed in the series. There are fluctuations in the harvest rates which are related to the signals of recruitment into the fishery in 2006 and 2007 picked up by the UWTV survey and IGFS-WIBTS-Q4. Recent harvest rates for the FU22 Smalls fluctuate and suggest the stock is exploited below F_{MSY}.

A new survey point available in September 2021 will provide a more up to date prognosis of stock status. This up to date survey information will be used to generate catch options and the provision of advice in October 2021.

In recent years, several newer vessels specializing in *Nephrops* fishing have participated in this fishery. These vessels target *Nephrops* on several other grounds within the TAC area and move around to optimize catch rates. There have been concerns that effort could be displaced towards the Smalls and other *Nephrops* grounds due to effort controls in 7.a and 6.a. This has not happened to date, and the 2014 and 2020 effort was just below the recent average in the time-series.

There has been a trend for Irish vessels (>18 m) to switch to multi (quad) rig trawls. Provisional data suggest a ~30% increase in *Nephrops* catch rates and a reduction in fish bycatch of ~30% due to the lower headline height.

Nephrops fisheries in the Smalls have non-*Nephrops* bycatch composition. Cod, whiting and to a lesser extent haddock are the main bycatch species (Davie and Lordan, 2011). A targetted whiting fishery also overlaps with the *Nephrops* fishery in this area, but this has negligible bycatch of *Nephrops*.

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Table 21.2.1. *Nephrops* in FU22 (Smalls Grounds). Landings in tonnes by country.

FU 22 Landings (t)					
Year	France	Rep. of Ireland	UK	Belgium	Total
1999	1034	741	0		1775
2000	1192	1687	11		2890
2001	882	2054	2		2938
2002	598	1392	3		1993
2003	799	1257	10		2065
2004	454	1349	26		1828
2005	478	1987	68		2533
2006	293	1442	19	7	1761
2007	216	2716	13	5	2950
2008	301	2539	241	9	3090
2009	258	1609	306	12	2185
2010	129	2219	351	15	2714
2011	64	1521	44	7	1636
2012	65	2506	41	6	2618
2013	83	2054	107	12	2257
2014	29	2428	61	8	2526
2015	9	2215	121	5	2350
2016	5	2967	354	3	3329
2017	7	2815	737	1	3560
2018	3	1639	331	1	1974
2019	9	1884	187	2	2083
2020	3	1448	22	2	1476

Table 21.2.2. *Nephrops* in FU22 (Smalls Grounds). Effort data for the Irish otter trawl *Nephrops* directed fleet.

Year	Effort ('000s Kw Days)	Landings (tonnes)	lpue (t/KwDays)
1995	552	1226	2.2
1996	412	1010	2.5
1997	474	1096	2.3
1998	524	1353	2.6
1999	292	620	2.1
2000	586	1335	2.3
2001	789	1964	2.5
2002	615	1298	2.1
2003	639	1000	1.6
2004	620	981	1.6
2005	986	1882	1.9
2006	855	1374	1.6
2007	1131	2677	2.4
2008	1047	2501	2.4
2009	702	1605	2.3
2010	962	2198	2.3
2011	724	1497	2.1
2012	970	2260	2.3
2013	902	1849	2.0
2014	915	2182	2.4
2015	971	2076	2.1
2016	1270	2761	2.2
2017	1229	2712	2.2
2018	748	1509	2.0
2019	786	1736	2.2
2020	681	1408	2.1

Table 21.2.4. *Nephrops* in FU22 (Smalls Grounds). Landings and discards weight and numbers by year from Irish sampling programme.

Year	Landings (t)	Discards (t)	Landings ('000s numbers)	Discards ('000s numbers)	Discard by weight (%)	Discard by number (%)
2003	1257	438	57.9	41.1	25.8	41.5
2004	1349	149	52.1	9.7	9.9	15.6
2005	1987	1292	93.6	100.9	39.4	51.9
2006	1442	372	82.0	37.0	20.5	31.1
2007	2716	1755	152.1	166.5	39.3	52.3
2008	2539	237	118.0	21.4	8.5	15.3
2009	1609	274	67.7	24.3	14.5	26.4
2010	2219	520	99.6	36.4	19.0	26.8
2011	1521	183	55.7	12.2	10.7	18.0
2012	2506	332	115.2	30.0	11.7	20.7
2013	2054	452	85.1	36.5	18.1	30.0
2014	2428	442	96.3	32.1	15.4	25.0
2015	2215	424	107.6	41.8	16.1	28.0
2016	2967	463	142.7	47.7	13.5	25.1
2017	2815	336	130.0	31.0	10.7	19.2
2018	1639	279	81.2	25.3	14.5	23.7
2019	1884	237	73.1	17.3	11.2	19.2
2020	1448	273	56.5	20.3	15.9	26.5

Table 21.2.5. *Nephrops* in FU22 (Smalls Grounds). Results summary table for geostatistical analysis of UWTV survey.

Year	Number of stations	Mean Density adjusted** (burrows/m²)	Domain Area (km²)	Geostatistical Abundance Estimate adjusted (millions burrows)	CV on Burrow estimate %
2006	100	0.49	2962	1503	2.4
2007	107	0.37	2955	1136	5.7
2008	76	0.36	2698	1114	5.6
2009	67	0.36	2824	1093	5.0
2010	90	0.37	2861	1141	3.9
2011	107	0.41	2881	1256	2.9
2012*	47	0.49	2934	1498	8.1
2013*	41	0.41	2975	1254	7.2
2014*	52	0.53	2970	1622	8.4
2015*	40	0.49	3064	1363	7.0
2016*	41	0.31	3063	866	6.6
2017*	40	0.55	3063	1600	4.9
2018*	42	0.31	3063	876	9.0
2019*	41	0.40	3063	1121	6.4
2020*	40	0.27	3063	750	8.0
2021*	42	0.23	3063	656	6.7

*** reduced isometric grid 4.5 nautical mile**

**** mean density adjusted of the observations.**

Table 21.3.1. *Nephrops* in FU22 (Smalls Grounds). Short term catch option prediction inputs and recent estimates of mean weight in landings and harvest rate (cells in bold indicates inputs to catch scenario calculations).

Year	Landings in number millions	Total discards in number* millions	Removals in number millions	Dead Discard Rate number %	Discard Rate number %	UWTV abundance estimate millions	95% Confidence Interval	Harvest rate %	Landings tonnes	Total discards* tonnes	Mean weight in landings gramme	Mean weight in discards gramme
2003	95.2	67.6	145.8	34.7	41.5	NA	NA	NA	2,065	720	21.7	10.7
2004	70.7	13.1	80.5	12.2	15.6	NA	NA	NA	1,828	202	25.9	15.4
2005	119.3	128.6	215.7	44.7	51.9	NA	NA	NA	2,533	1648	21.2	12.8
2006	100.2	45.2	134.1	25.3	31.1	1503	70	8.9	1,761	454	17.6	10.1
2007	165.2	180.9	300.8	45.1	52.3	1136	126	26.5	2,950	1906	17.9	10.5
2008	143.6	26.0	163.1	12.0	15.3	1114	123	14.6	3,090	289	21.5	11.1
2009	92.0	33.0	116.8	21.2	26.4	1093	108	10.7	2,185	371	23.7	11.3
2010	121.8	44.5	155.2	21.5	26.8	1141	88	13.6	2,714	636	22.3	14.3
2011	60.0	13.2	69.8	14.1	18.0	1256	72	5.6	1,636	196	27.3	14.9
2012	120.3	31.4	143.9	16.3	20.7	1498	239	9.6	2,618	347	21.8	11.1
2013	93.5	40.1	123.6	24.3	30.0	1254	177	9.9	2,257	497	24.1	12.4
2014	100.2	33.4	125.2	20.0	25.0	1622	268	7.7	2,526	460	25.2	13.8

Year	Landings in number (millions)	Total discards in number* (millions)	Removals in number (millions)	Dead Discard Rate number (%)	Discard Rate number (%)	UWTV abundance estimate (millions)	95% Confidence Interval	Harvest rate (%)	Landings (tonnes)	Total discards* (tonnes)	Mean weight in landings (gramme)	Mean weight in discards (gramme)
2015	114.1	44.4	147.4	22.6	28.0	1363	180	10.8	2,350	450	20.6	10.1
2016	160.2	53.5	200.3	20.0	25.1	866	112	23.1	3,329	519	20.8	9.7
2017	164.4	39.2	193.7	15.2	19.2	1600	153	12.1	3,560	424	21.7	10.8
2018	97.8	30.4	120.6	18.9	23.7	876	154	13.8	1,974	336	20.2	11.0
2019	80.9	19.2	95.2	15.1	19.2	1121	141	8.5	2,083	262	25.8	13.7
2020	57.6	20.7	73.1	21.3	26.5	750	118	9.7	1476	278	25.6	13.4
2021						**656**	**87**					
Average 2018-2020				**18.4**	**23.1**						**23.9**	**12.7**

Year | Landings in number millions | Total discards in number* millions | Removals in number millions | Dead Discard Rate number % | Discard Rate number % | UWTV abundance estimate millions | 95% Confidence Interval | Harvest rate % | Landings tonnes | Total discards* tonnes | Mean weight in landings gramme | Mean weight in discards gramme

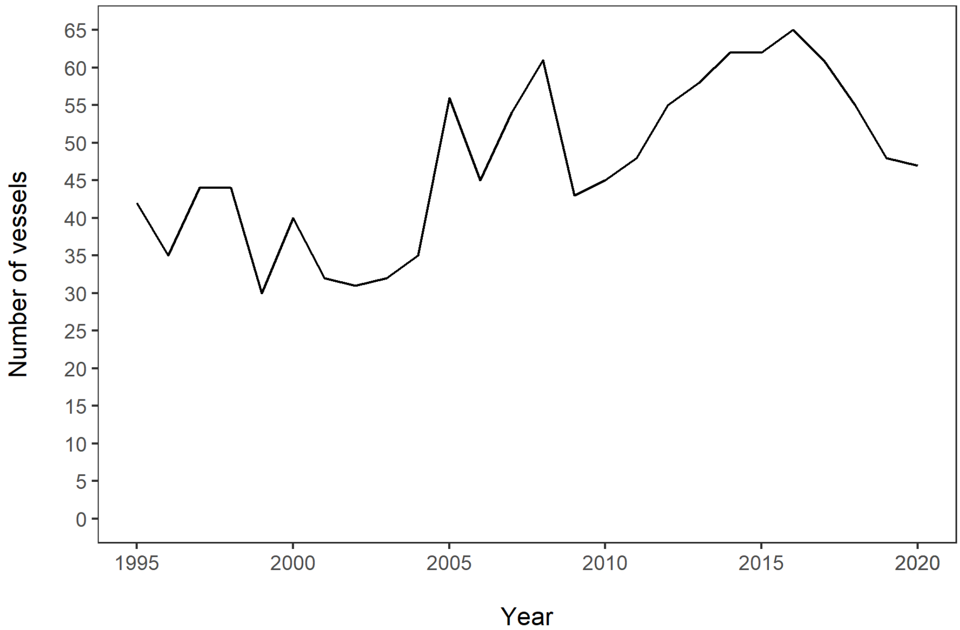

Figure 21.1.1. *Nephrops* in FU22 (Smalls Grounds). Time-series of the number of Irish vessels reporting landings of *Nephrops* from FU22 with a >10 t threshold.

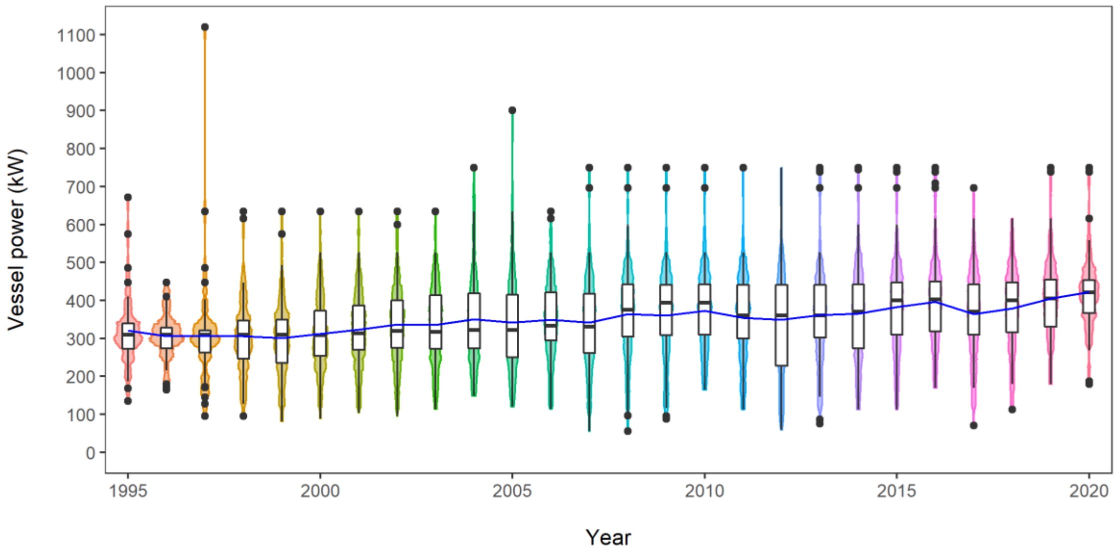

Figure 21.1.2. *Nephrops* in FU22 (Smalls Grounds). Combined box and kite plot of vessel power on the Smalls Grounds by year. The blue line indicates the mean.

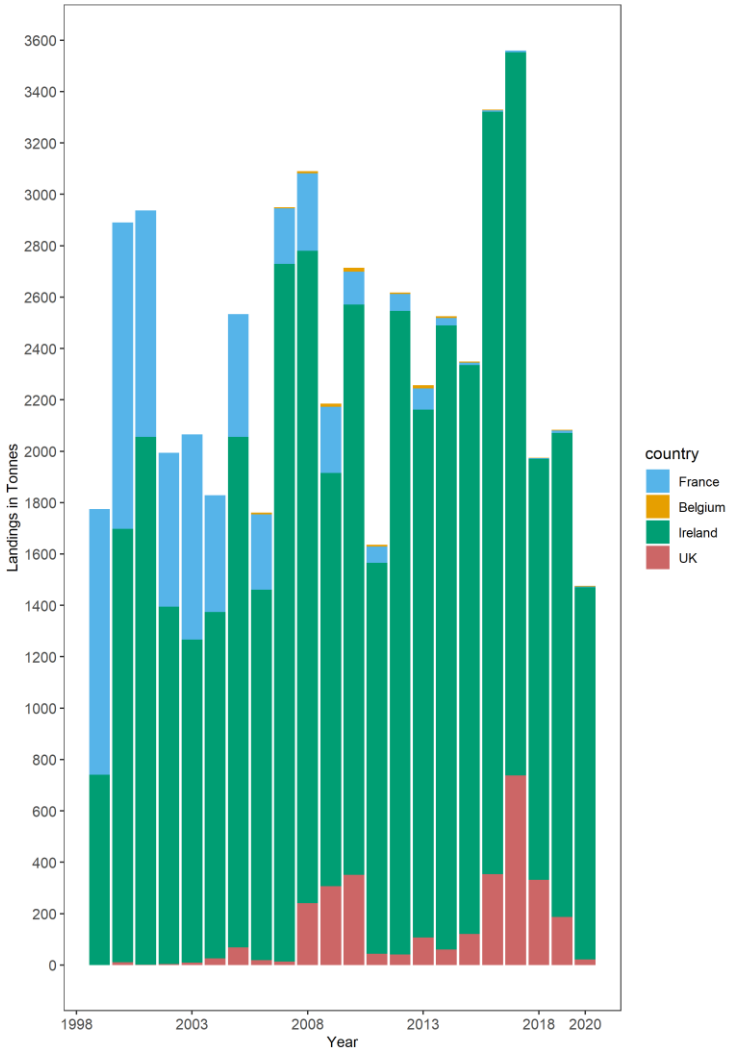

Figure 21.2.1. ***Nephrops*** **in FU22 (Smalls Grounds). Landings in tonnes by country.**

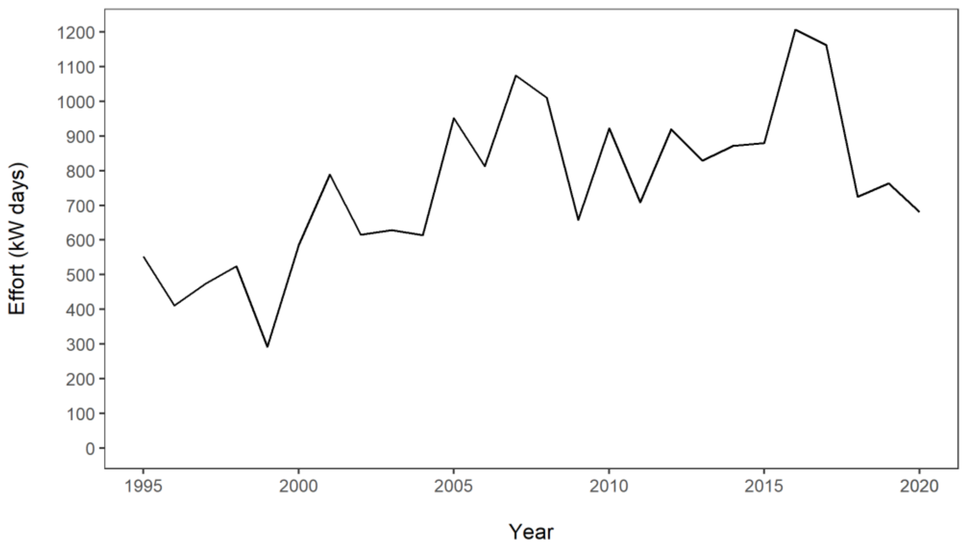

Figure 21.2.2. ***Nephrops*** **in FU22 (Smalls Grounds). Fishing effort Kw days for the Irish otter trawl** ***Nephrops*** **directed fleet (30% of** ***Nephrops*** **weight in total landings).**

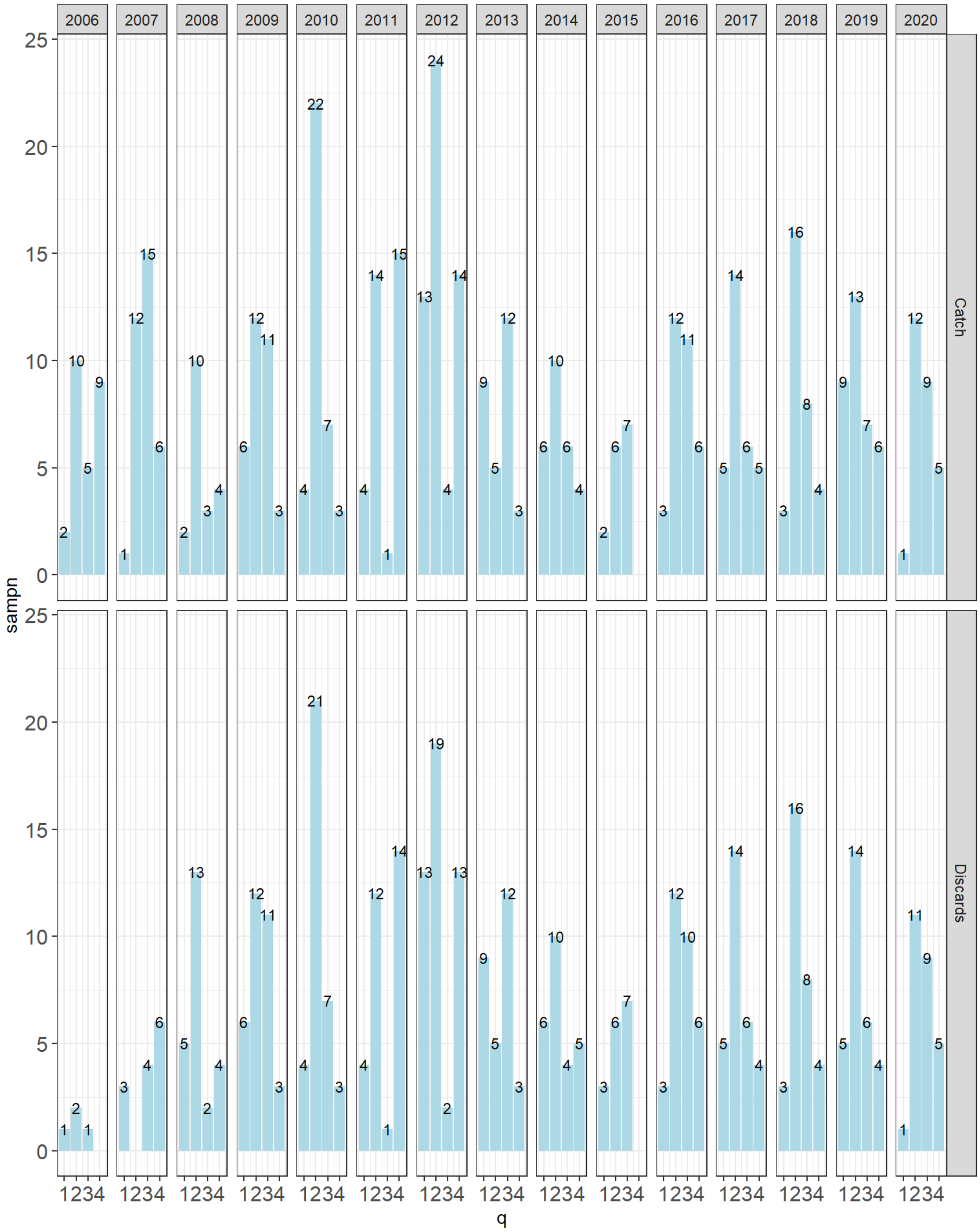

Figure 21.2.3. ***Nephrops* in FU22 (Smalls Grounds). Sampling levels by year and quarter and sample type.**

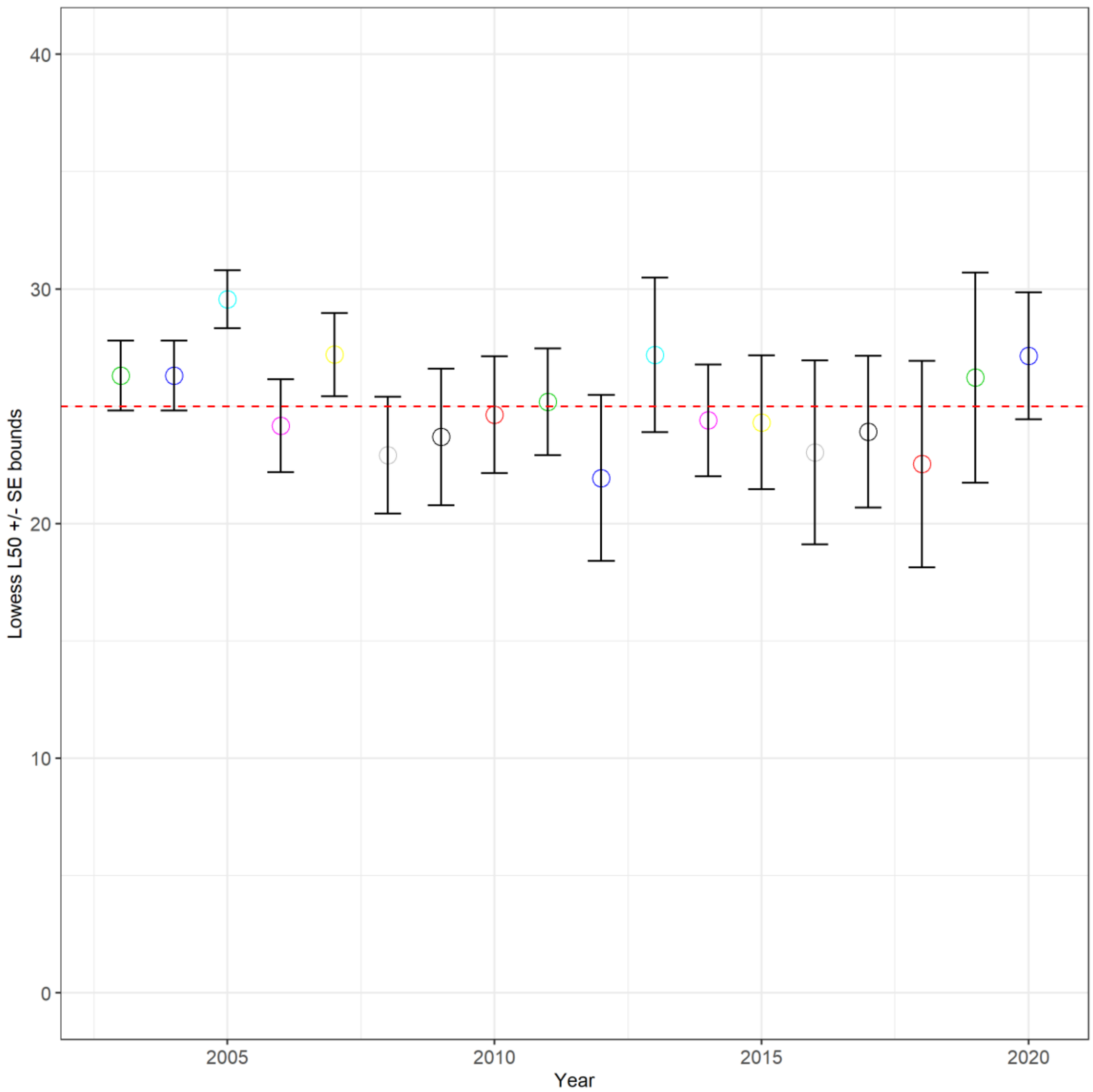

Figure 21.2.4. *Nephrops* in FU22 (Smalls Grounds). The annual estimated L_{50} with standard error bounds for the on-board retention ogives for samples from the Smalls grounds. Minimum conservation size (MCR) 25 Carapace Length (CL mm) shown as dashed line.

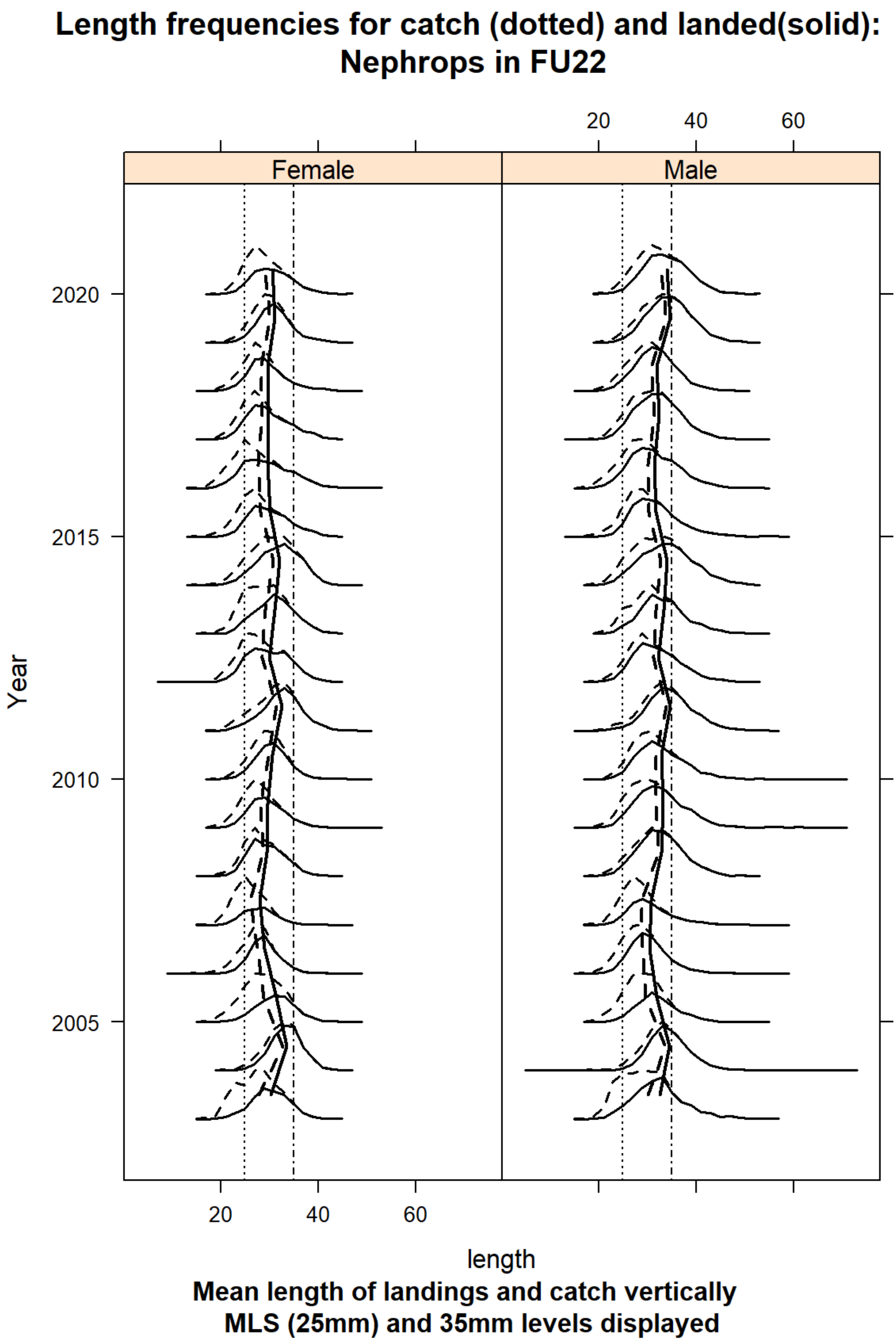

Figure 21.2.5. *Nephrops* in FU22 (Smalls Grounds). Mean size trends for catches and whole landings by sex over the time-series.

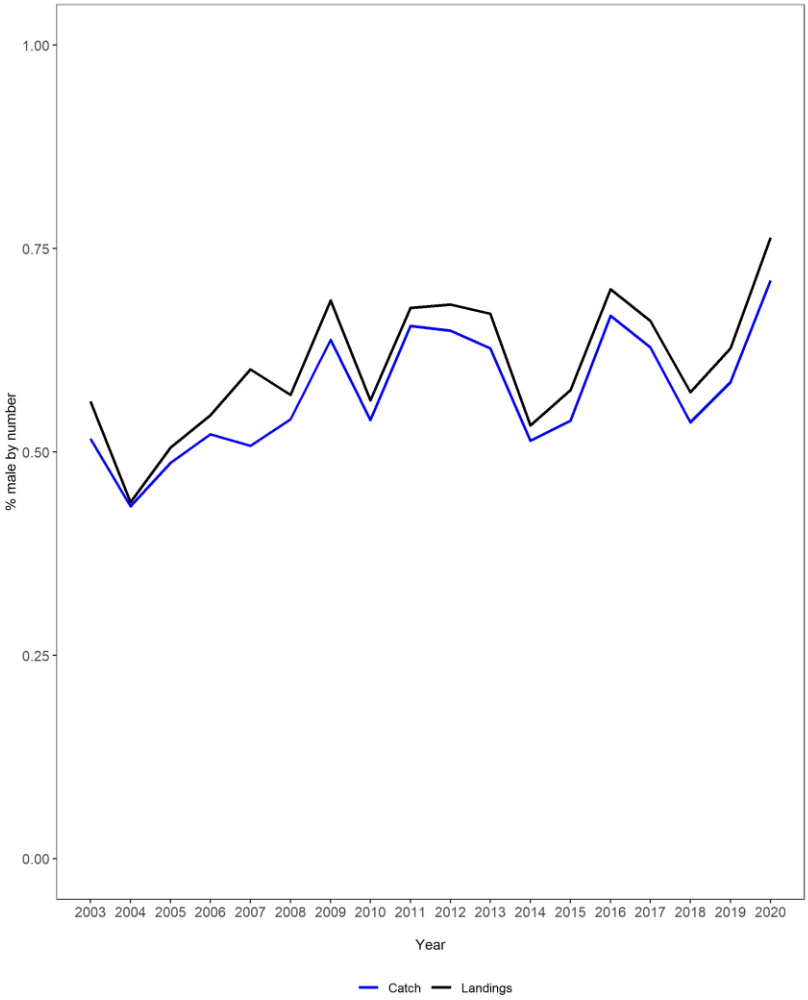

Figure 21.2.6. *Nephrops* in FU22 (Smalls Grounds). Sex ratio of the percentage males over the time-series.

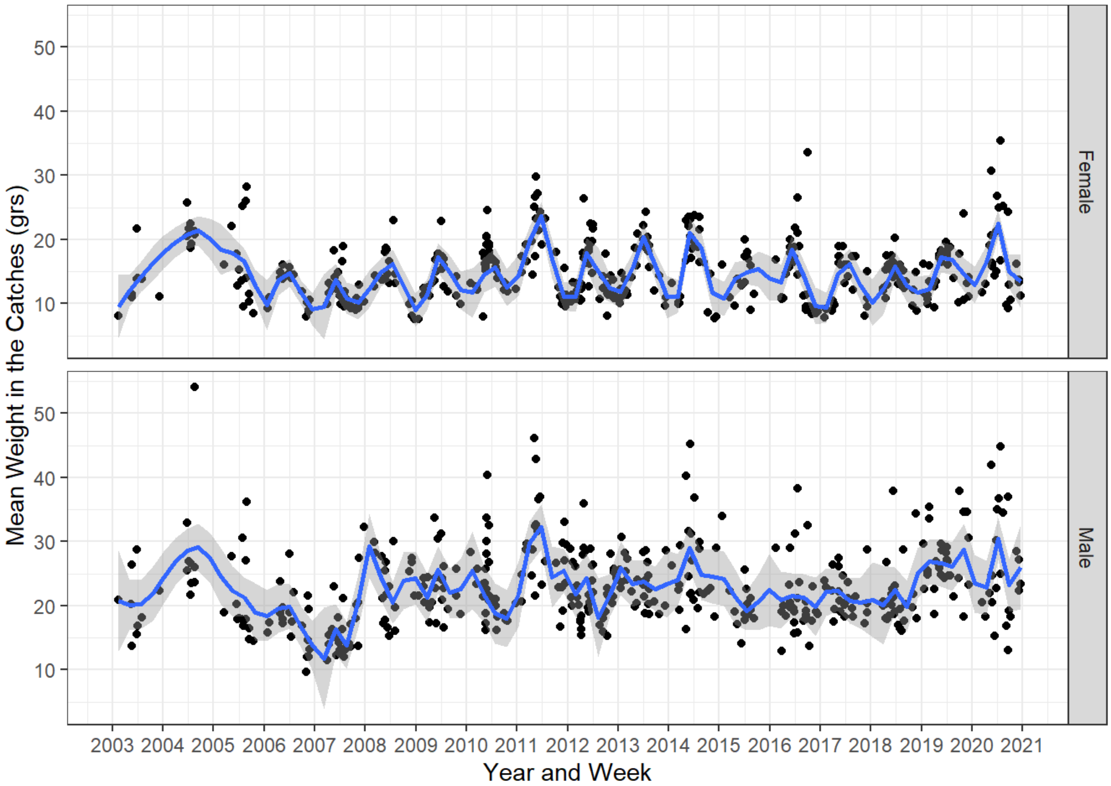

Figure 21.2.7. ***Nephrops*** **in FU22 (Smalls Grounds). Mean weight in catch samples by sex with loess smoother and showing cyclical trends.**

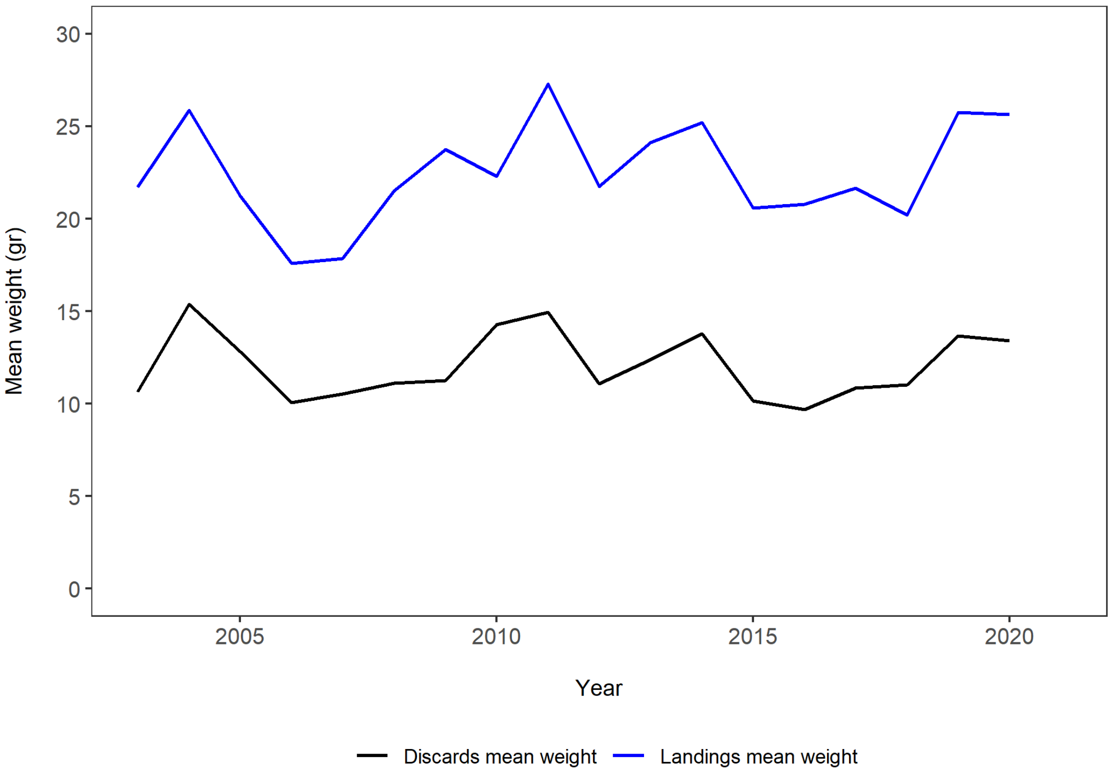

Figure 21.2.8. ***Nephrops*** **in FU22 (Smalls Grounds). Annual mean weights (gr) in the landings and discards.**

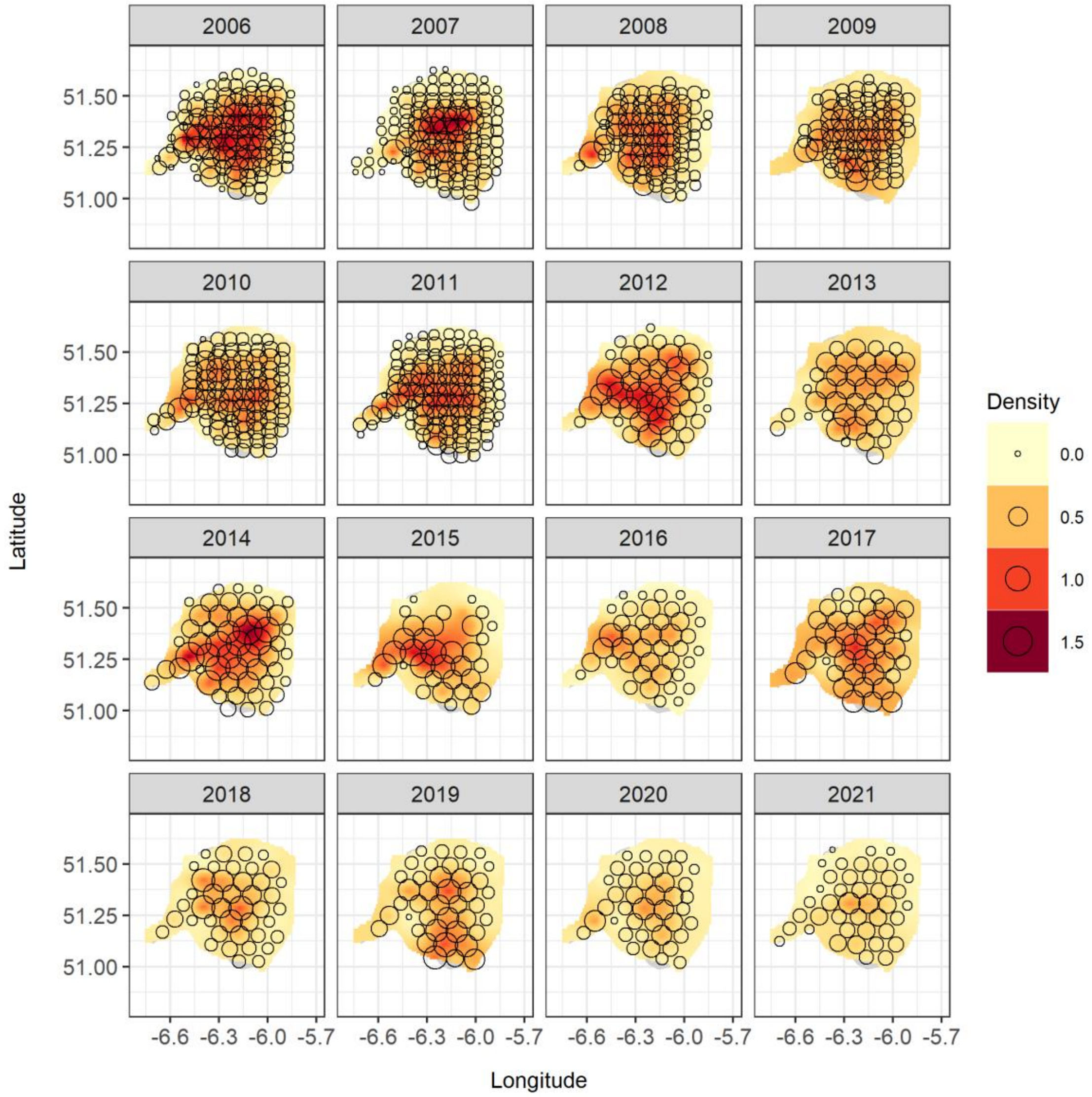

Figure 21.2.9. ***Nephrops*** **in FU22 (Smalls Grounds). Contour plots of the krigged density estimates for the UWTV surveys over the time-series.**

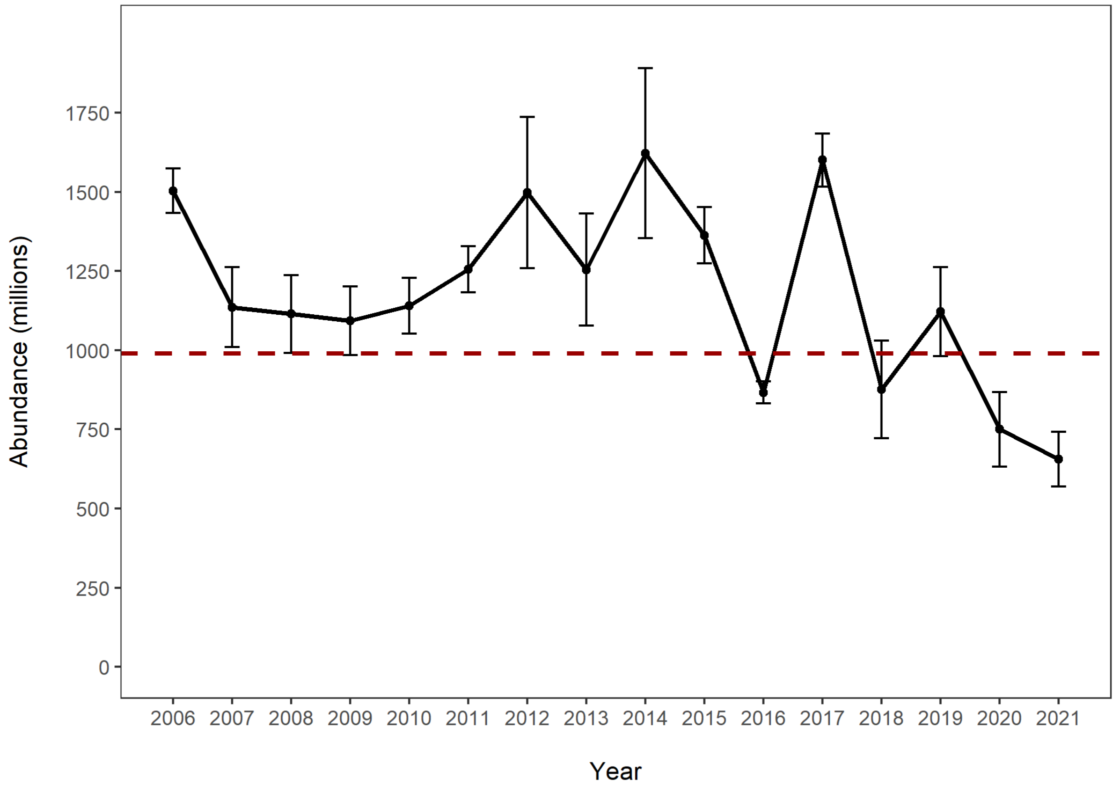

Figure 21.2.10. *Nephrops* in FU22 (Smalls Grounds). Time-series of abundance estimates for FU22 (error bars indicate 95% confidence intervals) and MSY $B_{trigger}$ is dashed line.

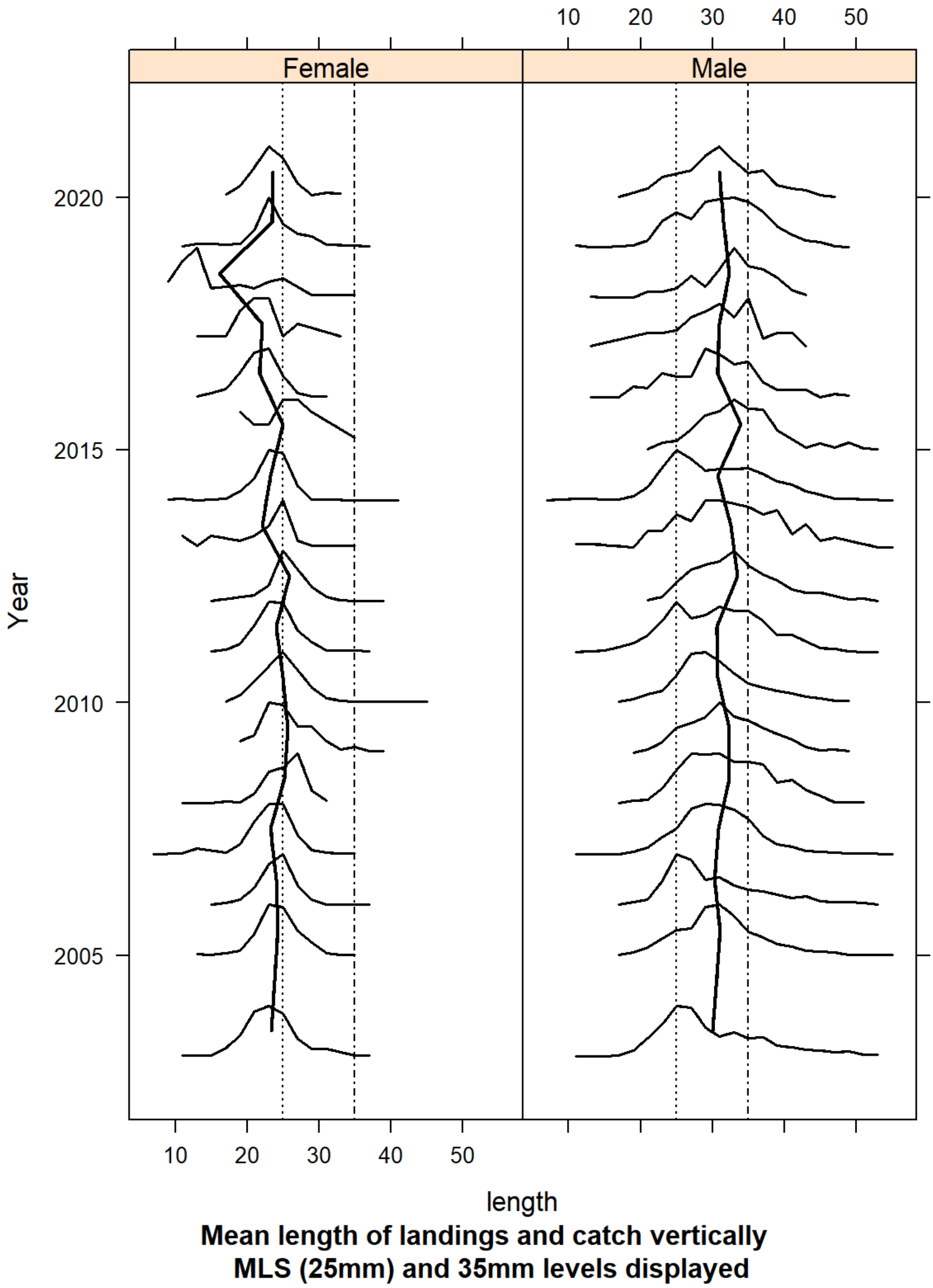

Figure 21.2.11. *Nephrops* in FU22 (Smalls Grounds). Mean size trends (Carapace length CL mm) for catches by sex from IGFS-WIBTS-Q4 [G7212].

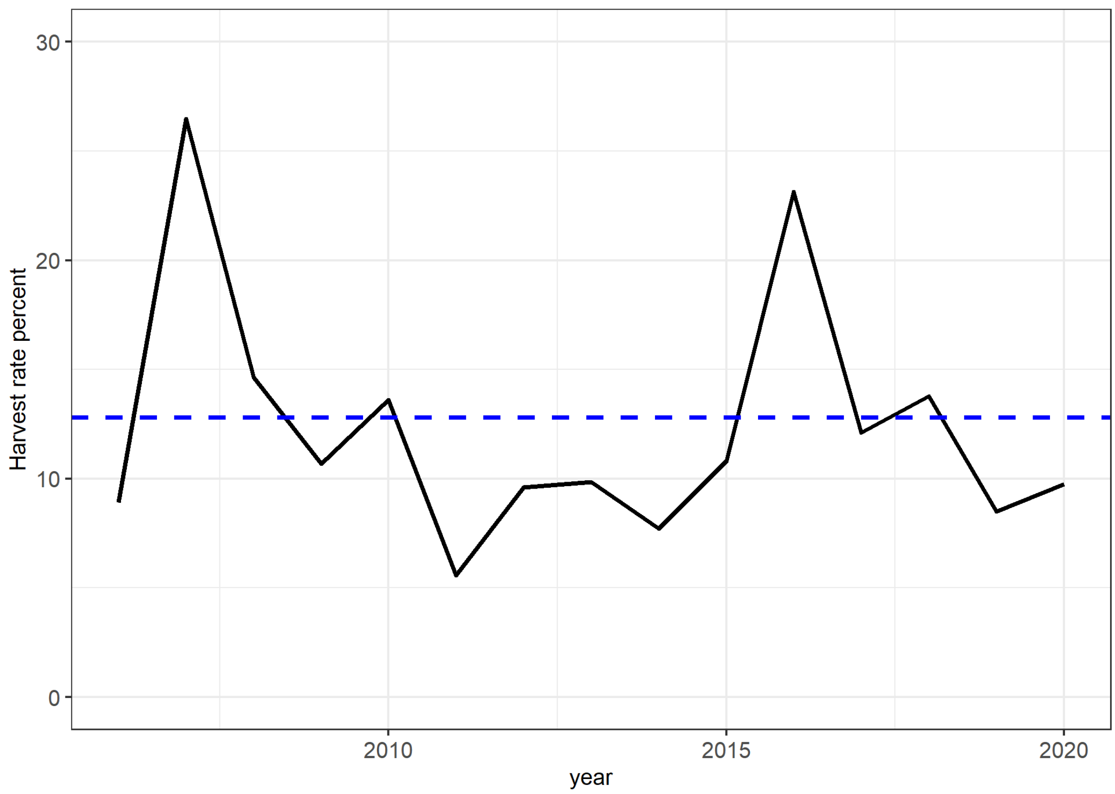

Figure 21.3.1. ***Nephrops*** **in FU22 (Smalls Grounds). Harvest Rate (% dead removed/UWTV abundance). The dashed and solid lines are the MSY proxy and the harvest rate respectively.**

24 Plaice in Division 27.7.a (Irish Sea)

Type of assessment in 2021

WKIrish3 (ICES, 2017) benchmarked this assessment and choose the SAM model, including estimates of discards-at-age into the catch matrix. A baseline run of the model was performed using discards since 1981 reconstructed according to the medium discard scenario (ICES, 2017).

The plaice in Division 27.7.a stock, its fishery, and data sampling were affected by the implications of the COVID-19 pandemic in 2020. The UK BTS survey could not take place in this area due to Covid-19 pandemic and as a result estimates of young fish abundance are more uncertain than in previous years. Discard estimates in 2020 are based on incomplete sampling of the fisheries. However, these are considered to have a negligible impact on the perception of the stock status.

ICES advice applicable to 2020

In the context of the EU multiannual plan for Western Waters and adjacent waters in which this stock is considered bycatch, the EC has requested that ICES provide advice based on the precautionary approach. ICES advises that catches of up to 5640 tonnes are considered to be precautionary.

Advice for 2020 is available at:

http://ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/ple.27.7a.pdf

ICES advice applicable to 2021

ICES advises that when the MSY approach is applied, catches in 2021 should be no more than 2846 tonnes.

Advice for 2021 is available at:

http://ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/ple.27.7a.pdf

24.1 General

Stock description and management units

The stock assessment area and the management unit are both Division 27.7.a (Irish Sea).

Management applicable in 2020 and 2021

Management of plaice in Division 27.7.a is by TAC and there is a Minimum Conservation Reference Size (MCRS) of 27 cm in force. The agreed TACs and associated implications for plaice in Division 27.7.a are detailed in the tables below. To be noted that for the year 2021 and at the time of writing the report no TAC was available.

2020

Species:	Plaice *Pleuronectes platessa*	**Zone:**	7a (PLE/07A.)
Belgium	115	Analytical TAC	
France	50	Article 7(2) of this Regulation applies	
Ireland	1 442		
The Netherlands	35		
United Kingdom	1 148		
Union	2 790		
TAC	2 790		

(Source: Council Regulation (EU) 2020/123, ANNEX IA)

2021

There was no agreed international TAC by the time of WGCSE in May 2021.

The fishery in 2020

National landings data reported to ICES and Working Group estimates of total landings are given in Table 24.1. A summary by gear is given below.

Catch (2020)		Landings			Discards		
82% dead	18% surviving	Beam trawl	Otter trawl	Other gear types	Beam trawl	Otter trawl	Other gear types
		61%	36%	3.1%	48%	49%	2.5%
601 t		330 t			271 t		
					60% dead		40% surviving

The TAC for 2020 was 2790 tonnes and the working group estimate of landings in 2020 was 330 tonnes. The poor uptake of the quota is not a consequence of an inability to catch sufficient quantities of plaice greater than the MCRS but rather is most likely due to the limited market demand and poor value of the catch.

Landings (based on working group estimates) by the Irish, NI, UK and Belgian fleets comprised approximately 53%, 4%, 17% and 26% respectively of total landings in 2020. The landings of plaice are mainly split between beam trawlers (63%; primarily Belgian vessels then Irish vessels) targeting sole, and otter trawlers (37%; Irish and UK vessels). Historically, otter trawling was dominated by UK vessels fishing for whitefish, but in recent years, many vessels have switched to target *Nephrops* (Figure 24.1). Otter trawlers from Ireland and N. Ireland typically target *Nephrops* in the western Irish Sea.

High levels of discarding are known to occur in all fisheries that catch plaice in the Irish Sea (see Figures 24.4 and 24.5).

A general description of the fishery can be found in the stock annex and also in 'Other Relevant Data' section below.

24.2 Data

Landings

National landings data reported to ICES and Working Group estimates of total landings are given in Table 24.1. The working group procedures used to determine the total international landings numbers- and weights-at-age are documented in the stock annex. As a result of increased rates of discarding, landed numbers-at-age for the younger ages (ages 2 to 4) have declined more rapidly over the last two decades than landings of older fish (Figure 24.2a).

Discards

Discard sampling has been conducted by the UK(E&W) since 2002 and by Ireland since 1993; Northern Ireland has collected data from 1996 (but not between 2003 and 2005), and Belgium since 2003. Length distributions (LD) of landed and discarded fish estimates for year 2020 are available from InterCatch are presented for UK(E&W) and Irish otter trawlers targeting demersal fish and to *Nephrops* (Figures 24.4 and 24.5).

WKFLAT (ICES, 2011) first estimated total international discards-at-age and introduced them to the assessment of the stock for the first time. Due to limitations in the data available by gear type, discards for Ireland, France and Northern Ireland, for the years 2004–2011 were raised using UK estimates on the basis of equivalent gear types. A raising factor based on tonnages landed for these countries was calculated and applied to the UK(E&W) estimates of discard numbers. Finally, these estimates were added to those calculated for Belgium to give estimates of total international discard numbers-at-age.

Since 2012, catch data (landings and discards) are available from InterCatch disaggregated by country and fleet. Total international discards are raised from available discards data.

The total discard estimates (Table 24.1, Figure 24.2b) confirm the significant proportion of discarding that occurs in the fishery, which has increased in time. Since 2004, the majority of the catch has been discarded (60% and 71% average discard in weight and in numbers respectively, since 2004).

There is a considerable historic time period (1981–2003) for which no international raised discard estimates are available. The method for reconstructing discards prior to 2004 is based on size-varying discard rates and is documented in Annex 4 of the WKIrish3 report (ICES, 2017).

Biological

Landings numbers-at-age are given in Table 24.5 and plotted in Figure 24.2a. Weights-at-age in the landings are given in Table 24.6. Discard weights-at-age are given in Table 24.7 and weights-at-age in the stock in Table 24.8. The history of the derivation of the landings weights and stock weights used in this assessment is described in the stock annex.

Mean weight-at-age in the landings and survey data indicate declines in both sexes throughout the Irish Sea since 1993 so that plaice at ages ≤4 are typically below MRCS.

Surveys

All available tuning data are shown in Tables 24.2, 24.3 (a and b) and 24.4. Due to inconsistencies in the available commercial tuning fleets, Irish Sea plaice assessments since 2004 have only included the UK (E&W) beam trawl survey (UK (E&W)-BTS-Q3) (B6596) and the two NIGFS-WIBTS spawning biomass indices based on ground fish surveys (NIGFS-WIBTS-Q1 (G7144) and NIGFS-WIBTS-Q4 (G7655)). For more information see WGNSDS (ICES, 2004). The UK (E&W)-BTS-Q3 index was revised by WKFLAT 2011 to include stations in the western Irish Sea and in St George's Channel. A second revision was conducted in 2017 to correct for some inconsistency in the index calculation This revision did not substantially change the trend of the biomass index (see WD Cambiè and Earl, 2017 in WGCSE 2017 report).

Reviews of the UK (E&W)-BTS-Q3 mean standardised cpue trends have indicated that the survey has good internal consistency in monitoring trends across the stock area. For the entire Irish Sea, the biomass index of ages 1–4 fish calculated from the UK (E&W)-BTS-Q3 (Figure 24.3, right) indicates two periods of upwards trend, 1993–2003 and from 2007–2015. It is however, detected to have dropped from 2016. An increase of biomass in older ages is observed (Figure 24.3, left). The NIGFS-WIBTS surveys show similar increases in biomass between 1993 and 2003 and then a further increase subsequently until most recent years.

The NIGFS-WIBTS survey strata can be disaggregated into western (Strata 1–3) and eastern (Strata 4–7) subareas, where the subareas are divided by the deep trench that runs roughly north–south to the west of the Isle of Man (Figure 24.6, Tables 24.3a and b).

The SSB of plaice in the Irish Sea is also independently estimated using the Annual Egg Production Method (AEPM), according to Armstrong *et al.*, 2001 methodology.

Year	SSB (tonnes)	Catch/SSB harvest rate
1995	9081	
2000	13 303	
2006	14 417	15.16
2008	14 352	12.77
2010	15 071	19.5

Catch (discards available from 2004) to egg survey biomass ratios indicate historically that the plaice in the Irish Sea has been lightly exploited. Splitting the SSB estimates from the AEPM into eastern and western Irish Sea areas (Figure 24.7) also indicates that the perceived increase in plaice biomass is due to increased production in the eastern Irish Sea only (for more details see stock annex).

In summary, the UK (E&W)-BTS-Q3 in September, the NIGFS-WIBTS-Q4 index in October (but not NIGFS-WIBTS-Q1 March), and the AEPM indicate a sustained increasing trend in biomass in the eastern Irish Sea, but this rise does not appear to extend across the deep channel to plaice in the western Irish Sea (Figure 24.7).

Commercial cpue

Age-based tuning data available for this assessment, comprise three commercial fleets: the UK(E&W) otter trawl fleet (UK(E&W) OTB, from 2008), the UK(E&W) beam trawl fleet (UK(E&W) BT, from 1989) and the Irish otter trawl fleet (IR-OTB, from 1995). Due to inconsistencies in the available tuning fleets, Irish Sea plaice assessments since 2004 have omitted these indices. For more information, see WGNSDS 2004. The effort and catch by these commercial fleets has been very low in recent years and the cpue data are no longer considered informative.

Other relevant data

Table 24.2 and Figure 24.1 show that effort levels have decreased since 2002 for the majority of fleets. Both the UK otter and beam trawl fleets are close to their lowest recorded effort levels in time-series extending back to 1972 and 1983 respectively. Effort by UK *Nephrops* trawlers has greatly increased in the years 2006–2014 but has decreased in the last years. However, this fleet is now the dominant UK fleet in terms of hours fished in 27.7.a. Belgian vessels operating in Division 7 typically move in and out of the Irish Sea, depending on the season, from specifically the Bristol Channel and Celtic Sea, the Bay of Biscay and the southern North Sea.

Since 2013, a problem with the gear effort information (000s hours fished) reported for the UK (E+W) commercial beam trawl fleet has been registered. Effort information from this fleet is largely missing as a result of a larger component of the fleet using the EU electronic logbook system to report its activities. Gear effort information reporting has not been mandatory with this system to date. As a result, few trips reported their gear effort information rendering the overall effort reported and resulting lpue unusable. However, an initial inspection of an alternate effort indicator for this gear (days fished) suggests that UK beam trawl effort in 2013, 2014, 2015, 2016, and 2017 is at the level observed in 2012. The otter trawl fleet effort reporting was unaffected by this as these vessels were not reporting their landings via this method in these years.

24.3 Historical stock development

Model: Age-based analytical assessment (State–space Assessment Model, SAM) that uses landings and discards (Nielsen and Berg, 2014).

Software: R version 4.0.2 with additional packages (version in parenthesis):

stockassessment (0.10.0); FLCore (2.6.15); reshape (0.8.8); ggplot2 (3.3.3); Cairo (1.5.12.2); doParallel (1.0.16); TMB (1.7.19); devtools (2.3.2).

Model options chosen

The AP model (Aarts and Poos, 2009) was replaced by SAM. WGCSE (ICES, 2016) agreed that the AP model was not the definitive assessment tool for Irish Sea plaice but a temporary solution to the fitting of datasets which included recent discards estimates but for which historic discard information was not available. Reconstructed values of historic discards (prior to 2004) were provided in the WKIrish3 (ICES, 2017). The SAM model incorporates the estimated historic discards and is used to run the assessment since 2017.

The model runs were performed using the R package 'stockassessment'. Settings for this update stock assessment are given in the table below. The update assessment follows the same procedure as in the WKIrish3 benchmark assessment. A baseline run of the model was performed using discards since 1981 reconstructed according to the medium discard scenario (ICES, 2017). Discard survival was set at 40%, and natural mortality followed a Lorenzen curve, scaled to 0.12.

Input data types and characteristics

Commercial catch-at-age data. Discards values available from 2004. Estimates of discards reconstructed for 1981–2003 (WKIrish3). Only the dead fraction of discards (0.6) is accounted for in the model. Three survey indices (UK (E&W)-BTS-Q3, NIGFS-WIBTS-Q1, and NIGFS-WIBTS-Q4); fixed maturity ogive; natural mortality constant over years and different across ages.

Sensitivity test

A sensitivity test to evaluate the impact of no discard data in the final year was performed. Specifically, runs of the assessment with and without discards for the year 2020 were used to assess the sensitivity of the model to missing discards. The results showed a noticeable increase in recruits in the assessment with missing discards in 2020. Consequently, in the 2021 assessment the final year of the recruitment was excluded.

Final update assessment

WKIrish3 benchmarked this assessment and included estimates of discards-at-age into the catch matrix.

The assessment settings are shown in the following table, with changes to the previous year's settings highlighted in bold. Historic settings are given in the stock annex.

Assessment year		2016	2017	2018	2019	2020	2021
Assessment model		AP	SAM	SAM	SAM	SAM	SAM
Tuning fleets	UK (E&W)-BTS-Q3	Survey omitted	Survey omitted	Survey omitted	Survey omitted	Survey omitted	Survey omitted
	Extended UK (E&W)-BTS-Q3	1993–2015, ages 1–6	1993–2016, ages 1–7	1993–2017, ages 1–7	1993–2018, ages 1–7	1993–2019, ages 1–7	1993–2019, ages 1–7
	UK(E&W) BTS Mar	Survey omitted	Survey omitted	Survey omitted	Survey omitted	Survey omitted	Survey omitted
	UK(E&W) OTB	Series omitted	Series omitted	Series omitted	Series omitted	Series omitted	Series omitted
	UK(E&W) BT	Series omitted	Series omitted	Series omitted	Series omitted	Series omitted	Series omitted
	IR-OTB	Series omitted	Series omitted	Series omitted	Series omitted	Series omitted	Series omitted
	NIGFS-WIBTS-Q1	1992–2015	1992–2016	1992–2017	1992–2018	1992–2019	1992–2020
	NIGFS-WIBTS-Q4	1992–2015	1992–2016	1992–2017	1992–2018	1992–2019	1992–2020
Selectivity model		Linear Time Varying Spline at age (TVS)	Correlated random walk	Correlated random walk	Correlated random walk	Correlated random walk	Correlated random walk
Discard fraction		Polynomial Time Varying Spline at age (PTVS)	Estimated by WKIRISH3	Estimated by WKIrish3	Estimated by WKIRISH3	Estimated by WKIRISH3	Estimated by WKIRISH3
Landings N at age		1–9+	1–8+	1981–2017, ages 1–8+	1981–2018, ages 1–8+	1981–2019, ages 1–8+	1981–2020, ages 1–8+
Discards N at age		2004–2014, ages 1–5	1981–2016, ages 1–8+	1981–2017, ages 1–8+	1981–2018, ages 1–8+	1981–2019, ages 1–8+	1981–2020, ages 1–8+

The estimated selectivity patterns split into the landed and discarded components are shown in Figure 24.8. Until early 1990s, the landings selectivity had the highest values for fish aged 4 (indicating that four years age fish were selected). This selectivity shifted to age 5 in late the 1990s and early 2000s, due to the increase of the MCRS in 1998 (from 250 mm to 270 mm). Since late 2000s landings gradually fell over time to very low values relative to the discard pattern, which became dominant and expanded to the older aged fish during the most recent years.

The catchability of the UK(E&W)-BTS-Q3 survey is elevated for ages 1 and 2 and reflects the nature of the survey, which was designed as a recruit index (Figure 24.9).

Diagnostic output from the SAM model is shown in Figure 24.10. In the catch residuals, negative values are apparent in ages 8+ from 1998. A year effect in 2004 is present in the UK(E&W)–BTS-Q3 residuals (which is the first year for which discard data are available). A pattern of negative residuals between 2004 and 2009 is present in the residuals of the NIGFS-WIBTS due to large fluctuations in the SSB indices, which are due potentially to variable catchability of the survey.

Recruitment is fluctuating without an overall trend, and it is estimated at its lowest values in 2017–2020. The standardised values of the recruitment estimated by the SAM model and the standardised value of age 1 from the UK-BTS survey are characterised by similar pattern, demonstrating consistency in the model estimates (Figure 24.11).

The estimated SSB from the SAM model shows an increasing trend from 1995 until 2004–2005, followed by a drop in 2006 and 2007. This change in SSB trend from 2004 is probably due to the inclusion of more reliable discards values since 2004, when international raised discard estimates became available. Since 2012, SSB has increased reaching the highest value of the whole time-series in 2016. A slight decrease has been observed in estimated SSB since then. The SSB estimates are largely in agreement with independent SSB estimates from the Annual Egg Production Method (AEPM), up to the most recent estimate in 2010, as well as showing a similar trend to the survey data used in the assessment (NIGFS-WIBTS-Q1 and -Q4; UK(E&W)-BTS-Q3, Figure 24.12).

Estimates of numbers-at-age in the landings, discards and population, and fishing mortality numbers-at-age are given in Tables 24.9–24.12. A summary plot for the SAM assessment is shown in Figure 24.13 and the time-series estimates for F_{bar}, SSB and recruitment are given in Table 24.13.

Comparison with previous assessments

In 2017, the Aarts and Poos model was replaced by the state–space assessment model (SAM). The assessment used the Lorenzen M scaled to 0.12, and the most recent maturity ogive for the survey.

The methodology provided is as robust as possible and does not currently appear to suffer from a serious retrospective pattern (Figures 24.14 and 24.15). The ten assessment model configurations compared in WKIrish3 perform similarly in terms of temporal trends in SSB, recruitment, catch and F_{bar}. Small retrospective bias in SSB in 2004 likely resulted from the introduction of discards estimates based on samples collected from that year (prior to 2004, discards estimates are reconstructed values based on size-varying discard rates). A Mohn's rho analysis for a five-year peel resulted in values of 2.9% for recruitment, 8.6% for SSB and -8.0% for F_{bar}.

State of the stock

Trends in F_{bar} SSB, recruitment and catch, for the full time-series, are shown in Table 24.13 and Figure 24.13. The assessment consistently estimates that fishing mortality declined from high levels in the 1980s and early 1990s to very low levels, having been <0.1 since 2013. Since 2012, SSB has increased reaching the highest value of the whole time-series in 2016, whereas it has slightly decreased in 2017. Estimated recruitments are highly variable. An increasing trend was present until 2015 although it seems to have dropped to the lowest values in 2017–2020. Catch has decreased to low levels and, since 2006, the majority of the catch has been discarded (60% in weight and 71% and number respectively, averaged since 2004).

24.4 Short-term projections

Forecasting takes the form of short-term stochastic projections. A total of 1000 samples are generated from the estimated distribution of survivors. These replicates are then simulated forward according to model and forecast assumptions (see table below), using the usual exponential decay equations, but also incorporating the stochastic survival process (using the estimated survival standard deviation) and subject to different catch-options scenarios. Recruitment in the intermediate year (2021) was taken as the median from a distribution about the assessment estimate. Estimates of recruitment for intermediate year and subsequent years were resampled from the 2015–2019 year classes, reflecting recent low levels of recruitment. The 2020 estimates recruits were not used in the forecast due to an increase in the uncertainty in the assessment caused by missing survey data. These re-sampled recruitments are only used for SAM forecasts in order to evaluate future stock dynamics.

Initial stock size	Starting populations are simulated from the estimated distribution at the start of the intermediate year (including covariances)
Maturity	Average of final three years of assessment data
Natural mortality	Average of final three years of assessment data
F and M before spawning	Both taken as zero
Weight at age in the catch	Average of final three years of assessment data
Weight at age in the stock	Assumed to be the same as weight-at-age in the catch
Exploitation pattern	Fishing mortalities taken as a three-year average
Stock recruitment model used	Recruitment for the intermediate year onwards is sampled, from 2015 to the final year of catch data. In 2021 assessment the final year of the recruitment was excluded
Procedures used for splitting projected catches	An average of final three years of landing fractions are used in the forecast period. Discard values are raised to include the live portion. Discard numbers multiplied by 5/3 to account for discard survival. Total catch is sum of three components: landings, discards assumed to die, and discards assumed to survive.

F estimates 2017–2019 has fluctuated around similar values, from 0.069 (2017) to 0.071 (2019), with further decline in 2020 (0.044). F *status quo*, Fsq, has been estimated by averaging the F over 2018–2020.

A full management options table is provided in Table 24.15, based on the intermediate year assumption in Table 24.14. Note that the values that appear in the catch scenarios are medians from the distributions that result from the stochastic forecast. Implementing the management plan for this stock with F_{MSY}=0.196 leads to a total catch of 2747 t (1407 t of landings and 1341 t of discards including dead and survivors) in 2022 and SSB of 14 628 t in 2023.

24.5 Medium-term projections

There are no medium-term projections for this stock.

24.6 MSY explorations

The reference points for this stock were estimated in 2018 (ICES, 2018) as ICES request for EU western waters stocks and are presented in the table below. Please note that ICES changed the basis for F_{pa} to $F_{p.05}$, and the updated F_{pa} value is shown in the below table.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	8757 tonnes	Lower 5th percentile of B F_{MSY}	ICES (2018)
	F_{MSY}	0.196	Stochastic simulations with segmented regression from the entire time-series (1981–2017)	ICES (2018)
Precautionary approach	B_{lim}	3958 tonnes	B_{loss} = minimum SSB observed	ICES (2018))
	B_{pa}	5294 tonnes	$B_{lim} \times \exp(1.645 \times \sigma)$; $\sigma = 0.177$	ICES (2018)
	F_{lim}	0. 50	F with 50% probability of SSB < B_{lim}	ICES (2018)
	F_{pa}	0.403	$F_{p.05}$; the F that leads to SSB ≥ B_{lim} with 95% probability	ICES (2018)
Management plan	SSB_{mgt}	Not applica-ble		
	F_{mgt}	Not applica-ble		

Yield per Recruit analysis
There are no yield per recruit analyses for this stock.

24.7 Management plans

There are no management plans for this stock.

24.8 Uncertainties and bias in assessment and forecast

The assessment was benchmarked in 2017 (WKIrish3), which resulted in the SAM model being fitted using catches based on reconstructed estimates of discards prior to 2004. This discard reconstruction introduces additional uncertainty in the model. The model estimates of stock development since 2004 are more reliable as based on direct discard estimates. The SAM model considered only the dead portion of the discards (60%), but in the forecast the estimates are raised to include the surviving discards. The Mohn's rho measure of retrospective bias for this assessment is low (Section 24.3).

The assessment indicates that recruitment and F have both been falling in recent years, and as a result the average age of catches has been increasing. An increasing amount of the stock is contained within the modelled plus group (41% in the last five years is age 8+). Consequently, the assessment and forecast have increased uncertainty and a pattern of retrospective adjustment of terminal year SSB downwards is seen in the recent history of the assessment.

24.9 Recommendations for next benchmark

There is evidence of substantial substock structure and incorporating information about the differences in growth and maturity between the east and west sides of the Irish Sea, as well as by sex should be explored.

Incorporating data on changes in maturity and natural mortality over time, linked to the decreasing in weights-at-age observed in survey data, should also be considered. There is evidence of a decline in weight-at-age from the commercial landings data and survey data. The UK(E&W)-BTS-Q3 survey data also indicate declines in length-at-age and maturity-at-age.

Creating age-based indices for the NI groundfish surveys would improve the assessment.

Ecosystem information ought to be explored.

Type	Problem/Aim	Work required	Data required	Expertise required
Sampling	The split between OTB and BTT has changed, and sample raising may not adequately reflect the changed split	Review consistency of sample raising to ensure the change of OTB/BTT is accurately and consistently reflected in the raised samples	Data already available in InterCatch	Catch sampling expertise
Assessment method	The assessment indicates that recruitment and F have both been falling in recent years, and as a result the average age of catches has been increasing. An increasing amount of the stock is contained within the modelled plusgroup (41% in the last five years is age 8+). Consequently, the assessment and forecast have increased uncertainty and a pattern of retrospective adjustment of terminal year SSB downwards is seen in the recent history of the assessment.	Recompile age distributions with a higher plusgroup, test effect of different Catchability assumptions in this age group. Consider whether F_{bar} age range needs changing. Possible recalculation of reference points	Landings data by age, as disaggregated as possible. Should be available post 2004 in InterCatch, but historic data availability unknown	Historic catch age composition raising
Other issues	Fits to NIGFS indices use SSB indices, assuming constant selectivity for all age/length	Explore whether age/length compositions can inform the selectivity of the survey and whether this can be included in the assessment	Survey age/length compositions	Survey index compilation experts
Biological parameters	Natural mortality and maturity may be connected with size which has varied substantially over time and between parts of the stock.	Investigate whether time varying biological parameters can be derived and used in this stock	Stock size data, relationships between M and stock size, relationships between maturity and stock size. Has the catch split changed between East and West of the area, and does this affect average M and maturity?	

24.10 Management considerations

The high level of discarding in this fishery indicates a mismatch between the minimum landing size and the mesh size of the gear being used. Any measures that effect a reduction in discards will result in increased future yield. However, the market demand for plaice is poor and small plaice are particularly undesirable. Strong year effects are seen in the discard data and these are likely due to spatial structure in the stock. Spatial management of fleets in the Irish Sea may reduce the discarding of plaice.

The overall state of the stock is consistently estimated to have low fishing mortality and high spawning biomass. Therefore, the stock is considered to be within safe biological limits.

Discarding has increased throughout the period in which data are available, while landings of plaice have decreased, even though the TAC is not restrictive. Effort has decreased in fisheries targeting plaice (including UK(E&W) and Belgian beam-trawl fisheries, and UK(E&W) and Irish otter trawl fisheries targeting demersal fish). In contrast, effort by the UK(E&W) *Nephrops* fleet has increased, however, this is still small in comparison to effort by the Irish *Nephrops* fleet. The main *Nephrops* grounds are located in the western Irish Sea, where relatively small plaice are found. Technical measures to mitigate discarding by all *Nephrops* fleets could include the use of sorting grids: gear selectivity trials and monitoring from four Irish *Nephrops* trawlers using grids since 2009 indicate a potential reduction in fish discarding by 75% (BIM, 2009).

24.11 References

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Table 24.1. Plaice in Division 7.a. History of official landings and ICES estimates of discards. Weights are in tonnes.

Year	Belgium	France	Ireland	Netherlands	UK (NI, Eng.&Wales)	UK (Isle of Man)	UK (Scotland)	Total official landings	Discards
1994	332	13	547	-	1082	14	63	2051	
1995	327	10	557	-	1050	20	60	2024	
1996	344	11	538	69	878	16	18	1874	
1997	459	8	543	110	798	11	25	1954	
1998	327	8	730	27	679	14	18	1803	
1999	275	5	541	30	687	5	23	1566	
2000	325	14	420	47	610	6	21	1443	
2001	482	9	378	-	607	1	11	1488	
2002	636	8	370	-	569	1	7	1591	
2003	628	7	490	-	409	1	9	1544	
2004	431	2	328	-	369	0	4	1134	1031
2005	566	9	272	-	422	0	1	1270	1210
2006	343	2	179	0	413	0	0	937	1254
2007	194	2	194	0	412	0	-	802	1744
2008	157	2	102	0	301	1	1	564	1268
2009	197	0	73	0	187	1	2	460	1132
2010	138	0	89	0	150	0	3	380	2561
2011	332	0	118	0	146	0	0	596	603
2012	236	0	108	0	164	0	0	508	1010
2013	144	0	103	0	92	0	0	339	725
2014	100	0	123	0	59	0	0	282	943
2015	115	0	244	0	80	0	0	439	572
2016	82	0	605	-	56	-	-	742	437
2017	77	0	446	-	62	-	-	585	852
2018	52	0	315	-	64	-	-	435	395
2019*	168	0	244	-	53	0	-	466	537
2020*	84	-	177	-	70	2	-	333	271

*** Preliminary.**

Table 24.2. Irish Sea plaice: English standardised lpue and effort, Belgian beam trawl lpue and effort and Irish otter trawl lpue and effort series.

Year	CPUE			LPUE							Effort							
	UK(E&W) Beam trawl survey[1]			UK (E&W)[2]				Belgian[5]	Irish[7]		UK (E&W)					Belgian	Irish[9]	
	March	September Prime only	September Extended	Otter[3] Trawl	Otter[4] Trawl	Beam[3] Trawl	Beam[4] Trawl	Beam Trawl	Otter Trawl	Beam Trawl	Otter[3] Trawl	Otter[4] Trawl	Bean Traw	Beam[4] Trawl	Nephrops[3] Trawl	Beam Trawl	Otter Trawl	Beam Trawl
1972				6.96				9.8			128.4					6.8		
1973				6.33				9.0			147.6					16.5		
1974				7.45				10.4			115.2					14.2		
1975				7.71				10.7			130.7					16.2		
1976				5.03				5.8			122.3					15.1		
1977				4.82				5.3			101.9					13.4		
1978				6.77		4.88		6.9			89.1		0.9			12.0		
1979				7.18		15.23		8.0			89.9		1.7			13.7		
1980				8.24		8.98		8.6			107.0		4.3			20.8		
1981				6.87		4.91		7.1			107.1		6.4			26.7		
1982				4.92		1.77		4.4			127.2		5.5			21.3		
1983				5.32	1021	3.08	0	7.8			88.1	1716.5	2.8	0		18.5		
1984				7.77	1472	6.98	810	6.8			103.1	7932.1	4.1	263		13.6		
1985				9.97	1946	25.70	5487	8.8			102.9	6930.8	7.4	428.1		21.9		
1986				9.27	1597	4.21	753	8.7			90.3	6693.2	17.0	1122.9		38.3		
1987				7.20	1479	3.57	963	8.2			130.6	9008.9	22.0	1178.5		43.2		
1988		392		5.02	1060	3.05	743	6.3			132.0	8292.4	18.6	1019.2		32.7		
1989		253		5.51	1109	13.59	2559	6.2			139.5	16161.4	25.3	1344.5		36.7		
1990		239		5.93	1074	12.02	3011	7.2			117.1	7724.5	31.0	1473.1		38.3		
1991		157		4.79	916	10.56	2807	7.5			107.3	7081.1	25.8	1211.3		15.4		
1992		188		4.20	719	9.99	2303	11.9			96.8	6671.8	23.4	908.1		23.0		
1993	91	235	149	3.97	667	9.50	2220	5.0			78.9	6013.1	21.5	826.9		24.4		
1994	128	225	132	4.90	770	7.79	1020	9.2			43.0	3060	20.1	1451.6	0	31.6		
1995	134	169	109	5.08	806	7.69	1001	9.5	3.2	17.3	43.1	3357	20.9	1429.4	0	27.1	80.1	8.5
1996	-[6]	210	111	5.37	732	12.96	2587	11.8	4.1	19.0	42.2	3085.1	13.3	894.3	0	22.2	64.7	6.2
1997	147	262	148	5.25	662	7.66	944	13.9	3.1	13.7	39.9	2903.3	10.8	784.4	0	29.3	92.0	9.9
1998	113	249	146	5.00	657	5.66	766	12.3	3.7	22.3	36.9	2620.6	10.4	696	0	23.8	93.5	11.5
1999	-[6]	264	151	5.38	632	7.76	895	7.1	2.3	23.2	22.9	1803.5	11.0	778.9	0	37.2	109.7	14.7
2000	-[6]	357	169	5.02	828	13.04	1773	7.8	2.0	13.8	27.0	2034.9	6.3	410.7	0	27.0	82.6	11.4
2001		281	147	3.35	539	8.33	1017	9.2	2.9	14.0	33.0	2352.9	12.5	767.4	0	41.9	77.4	13.1
2002		340	200	5.66	840	5.46	445	7.4	2.8	7.9	24.8	1774	8.0	535.1	0	52.5	77.4	17.7
2003		503	247	2.60	414	3.76	400	7.5	4.1	9.5	23.9	1728.3	14.0	863.7	0	48.7	73.8	18.6
2004		540	249	3.17	472	4.20	255	11.2	2.1	8.6	23.5	1727	7.4	419.9	0	36.1	72.5	14.2
2005		367	177	4.85	540	4.67	381	12.8	2.0	8.0	16.7	1313.6	11.6	627.8	1	42.1	69	14.7
2006		356	166	6.50	610	2.19	202	10.8	1.4	6.2	5.2	478.5	4.6	280.1	10.9	28.9	66.8	12.2
2007		432	190	17.94	756	4.22	550	6.9	1.3	6.1	4.4	397.2	3.2	193.5	12.6	23.8	75.9	14.2
2008		416	189	9.03	469	4.47	267	9.5	0.9	5.1	2.7	320.4	1.3	98	11.5	12.4	59.9	9.5
2009		467	199	6.46	338	1.21	169	10.1	1.1	3.8	1.5	157.7	0.46	24.9	10.0	14.7	42.8	7.6
2010		400	164	11.55	371	14.39	151	7.9	1.0	4.8	1.0	151	0.19	10.2	9.2	15.2	45.8	9.4
2011		417	140	4.35	183	11.95	701	17.3	1.2	6.8	0.69	72.7	1.56	91.2	8.6	16.4	54.5	8.1
2012		460	188	0.74	276	7.25	164	14.9	1.0	5.0	0.4	85	0.9	60.7	12.1	14.5	58.3	7.2
2013		550	207	7.41	236	-[8]	0	14.0	1.6	5.4	0.3	31.9	-[8]	1.3	10.6	8.9	42.6	5.0
2014		592	255	-	87	-[8]	0	13.9	1.5	8.3	-	16.1	-[8]	0.4	8.3	5.1	47.8	6.0
2015		564	230	-	0	-[8]	48	20.4	3.3	8.6	-	0	-[8]	0.9	4.5	4.6	39.8	8.3
2016		582	220	-	0	-[8]	0	26.4	4.6	32.8	-	0	-[8]	3.9	2.5	2.5	33.4	7.9
2017		525	170	-	244	-[8]	0	17.1	11.3	35.4	-	160.7	-[8]	0	0.3	4.2	12.1	7.5
2018		554	139	-	237	-[8]	0	14.6	8.4	19.5	-	238	-[8]	0	-	3.5	13.6	9.6
2019		496	-	-	361	-[8]	35	11.1	4.9	11.4	-	247	-[8]	7	-	14.1	17.2	13.3
2020		-	-	-	1239	-[8]	277	5.9	4.5	10.6	-	73	-[8]	199	-	13.6	13.3	10.4

1 Kg/100km. Sept Prime: ISS/ISN Traditional Prime Stations Only. Sept Extended: ISS/ISN/ISW/SGC All Stations.
2 Whole weight (kg) per corrected hour fished, weighted by area
3 '000 hours fished (corrected for fishing power GRT)
4 days fished
5 Corrected for fishing power (HP) [data for 1999-2010, replaced at 2011WG following recalculation at WKFLAT 2011]
6 Carhelmar survey, Kg/100km not available
7 All years updated in 2007 due to slight historical differences
8 Effort not reported in hours for this fleet, see Section 6.7.2 for more detail
9 '000s hours
Fishing power corrections are detailed in Appendix 2 of the 2000 working group report

Table 24.3a. Irish Sea plaice: NIGFS-WIBTS-Q1 indices of relative biomass trends by region in spring.

NIGFS-WIBTS-Q1	ESTIMATED MEAN ABUNDANCE (kg/3 miles)			ESTIMATED STANDARD ERROR		
Mar (Spring)	Combined	West	East	Combined	West	East
Year	Str 1–7	Str 1–3	Str 4–7	Str 1–7	Str 1–3	Str 4–7
1992	8.35	5.47	9.20	3.45	1.96	4.44
1993	12.36	18.43	10.54	2.14	4.78	2.39
1994	9.65	4.47	11.09	2.43	1.46	3.12
1995	7.27	4.79	7.64	1.24	0.83	1.59
1996	7.29	12.60	5.70	1.64	5.71	1.28
1997	13.87	14.72	13.54	3.19	5.68	3.77
1998	10.40	13.32	9.00	2.73	7.10	2.84
1999	10.71	13.53	9.59	1.81	4.92	1.84
2000	12.92	26.29	8.88	4.11	17.00	1.66
2001	12.06	18.03	9.92	1.41	4.25	1.31
2002	15.27	27.95	11.17	2.53	8.39	2.14
2003	20.97	40.71	15.09	6.11	23.98	3.44
2004	8.55	5.69	9.40	1.74	1.21	2.24
2005	11.10	19.43	8.62	1.93	5.99	1.76
2006	7.85	12.14	6.39	1.39	4.62	1.16
2007	6.25	14.47	3.80	1.27	4.80	0.83
2008	4.46	5.11	4.57	0.76	1.23	0.91
2009	7.90	7.85	7.86	1.27	2.04	1.53
2010	19.40	8.77	17.30	1.86	2.70	2.28
2011	16.34	26.20	13.03	3.51	10.11	3.41
2012	14.22	21.47	11.05	2.37	7.48	2.13
2013	21.89	28.98	16.57	3.74	8.04	4.21
2014	11.43	10.96	9.65	2.04	4.82	2.22
2015	22.81	22.57	18.66	2.84	7.18	3.01
2016	34.52	30.29	35.77	7.17	9.95	8.82
2017	16.10	14.85	16.47	3.16	3.90	3.70
2018	19.26	22.86	18.18	4.11	10.19	4.39
2019	5.47	6.61	5.14	1.14	2.06	1.34
2020	5.90	4.28	6.38	1.16	1.26	1.45

Table 24.3b. Irish Sea plaice: NIGFS-WIBTS-Q4 indices of relative biomass trends by region in autumn.

NIGFS-WIBTS-Q4	ESTIMATED MEAN ABUNDANCE (kg/3 miles)			ESTIMATED STANDARD ERROR		
Oct (Autumn)	Combined	West	East	Combined	West	East
Year	Str 1–7	Str 1–3	Str 4–7	Str 1–7	Str 1–3	Str 4–7
1992	4.81	2.31	5.55	0.92	1.10	1.15
1993	4.48	2.08	5.20	1.00	0.87	1.27
1994	8.73	5.49	9.69	2.30	2.83	2.86
1995	4.17	5.50	3.77	1.13	2.23	1.31
1996	8.68	8.85	8.63	2.25	5.94	2.33
1997	7.93	5.76	8.58	2.24	2.59	2.80
1998	5.33	3.68	5.82	1.46	2.48	1.74
1999	5.81	4.30	6.26	1.67	3.08	1.97
2000	9.75	2.20	12.00	5.76	1.13	7.47
2001	13.85	2.30	17.30	6.57	1.67	8.51
2002	9.80	5.90	10.97	3.91	3.61	4.97
2003	18.01	7.52	21.14	5.84	4.16	7.48
2004	7.79	1.64	9.63	1.80	0.81	2.33
2005	11.35	3.41	13.72	4.51	2.18	5.82
2006	6.61	2.56	7.82	1.53	1.42	1.94
2007	7.15	4.07	8.07	1.41	2.00	1.73
2008	8.68	3.28	10.27	2.20	2.09	2.78
2009	12.44	4.06	15.01	2.59	3.12	3.23
2010	15.58	5.83	18.53	5.26	5.21	6.65
2011	14.48	5.39	15.94	3.55	2.66	4.55
2012	16.05	17.89	15.65	4.43	11.16	4.68
2013	17.90	13.55	19.09	4.33	11.27	4.51
2014	22.18	27.67	20.35	7.61	24.88	6.52
2015	18.21	11.15	20.31	4.39	8.76	5.06
2016	17.57	0.95	22.53	4.52	0.43	5.86
2017	18.55	2.96	23.20	4.25	1.59	5.50
2018	7.21	6.89	7.30	1.86	6.08	1.59
2019	5.54	3.16	6.25	1.35	2.30	1.62
2020	6.06	1.12	7.48	1.37	0.66	1.76

Table 24.4. Irish Sea plaice: UK (E&W)-BTS-Q3 biomass index (extended area). Ages in bold are those used in the assessment (ages 1–7).

Year	Distance towed (kms)	0	1	2	3	4	5	6	7	8	9+
1993	292.77	0.13	4.64	4.03	0.82	0.43	0.03	0.04	0.08	0.01	0.02
1994	218.65	0.33	4.13	2.48	1.42	0.28	0.10	0.03	0.02	0.03	0.04
1995	218.65	0.78	5.56	1.96	0.84	0.41	0.07	0.05	0.02	0.00	0.03
1996	222.36	0.26	5.79	2.17	0.53	0.19	0.20	0.05	0.02	0.00	0.02
1997	218.65	0.96	5.47	2.91	1.26	0.30	0.16	0.17	0.05	0.02	0.03
1998	218.65	0.56	4.50	4.26	1.09	0.38	0.21	0.08	0.06	0.01	0.04
1999	214.95	1.86	3.96	3.91	1.99	0.68	0.29	0.09	0.07	0.03	0.05
2000	218.65	1.22	8.74	2.80	1.47	1.11	0.47	0.12	0.09	0.03	0.04
2001	214.95	0.83	5.99	3.62	1.11	0.60	0.54	0.11	0.06	0.02	0.01
2002	214.95	0.23	6.46	4.94	2.27	0.88	0.53	0.48	0.10	0.04	0.04
2003	211.24	2.07	6.12	5.85	2.61	1.58	0.58	0.38	0.25	0.07	0.07
2004	214.95	1.09	8.07	5.36	3.94	1.88	1.15	0.21	0.19	0.13	0.10
2005	211.24	1.75	3.76	4.75	1.98	1.42	0.80	0.48	0.11	0.09	0.06
2006	214.95	3.56	5.01	3.45	2.46	1.10	0.79	0.36	0.20	0.02	0.07
2007	214.95	1.15	7.97	4.47	1.66	1.20	0.65	0.33	0.25	0.14	0.06
2008	200.12	1.22	4.68	5.71	2.03	1.15	0.82	0.31	0.12	0.08	0.05
2009	214.95	1.23	4.74	3.40	3.30	0.99	0.66	0.63	0.16	0.11	0.20
2010	211.24	2.01	6.22	4.31	2.05	1.44	0.66	0.54	0.36	0.20	0.19
2011	211.24	1.02	6.73	4.28	1.75	1.00	1.08	0.47	0.27	0.24	0.37
2012	214.95	1.40	6.52	6.37	1.71	1.03	0.47	0.53	0.30	0.14	0.42
2013	214.95	2.04	4.33	5.05	3.08	1.60	1.07	0.47	0.44	0.20	0.42
2014	214.95	1.56	7.82	6.85	3.13	2.16	0.99	0.77	0.44	0.20	0.28
2015	214.95	1.02	6.16	6.88	2.60	1.80	1.04	0.66	0.37	0.19	0.50
2016	211.24	0.18	2.91	5.97	3.95	2.45	1.61	0.96	0.74	0.45	0.58
2017	214.95	0.03	1.35	4.77	2.81	2.23	1.84	0.75	0.59	0.38	0.26
2018	214.95	0.36	1.97	2.75	2.28	1.51	1.37	1.24	0.75	0.56	0.27
2019	214.95	0.33	3.02	4.50	2.31	1.48	1.22	1.00	0.90	0.41	0.20
2020	0	-	-	-	-	-	-	-	-	-	-

Table 24.5. Irish Sea plaice: Landings number-at-age 1 to 8+ (thousands), where rows are years 1981–2020 and columns are ages 1 to 8+.

IRISH SEA PLAICE

1 2

1981 2020

1 8

1

22	1742	5939	2984	837	222	105	236
27	715	3288	3082	1358	330	137	213
51	2924	2494	3211	1521	648	211	252
41	3159	5179	1182	1054	459	299	252
4	2357	6152	3301	614	429	262	340
31	1652	5280	2942	1287	344	371	308
62	3717	5317	5252	1341	1072	123	338
46	2923	5040	2552	1400	750	316	405
24	1735	5945	2671	854	436	214	364
15	1019	2715	2935	1132	465	259	223
180	2008	1506	1929	1205	465	182	226
151	1958	3209	1435	1358	903	388	294
28	910	1649	1357	474	556	377	302
97	1146	2173	1309	644	318	245	263
21	961	1703	1936	764	318	138	157
37	856	1345	1196	943	370	128	135
28	830	1590	1513	1003	482	285	257
6	691	1739	1025	612	476	403	385
68	803	1505	1294	696	280	196	242
0	450	1174	1284	686	212	219	203
14	374	1138	1083	767	409	179	166
1	206	940	1482	842	539	318	170
0	286	1031	1314	707	415	253	222
8	198	967	1104	705	247	114	186
6	228	708	1177	890	461	204	213
5	180	620	550	684	346	220	218
0	64	351	860	507	401	151	164
1	99	386	389	409	215	141	119
0	13	204	374	351	272	117	120
0	7	75	271	306	193	160	115
2	53	199	357	483	305	194	191
0	8	150	292	301	367	218	226
1	16	87	203	166	149	144	165
3	6	65	165	160	143	70	158
0	1	43	93	185	210	149	349
14	14	58	162	224	346	180	482
0	4	24	145	206	241	209	520
0	6	84	110	201	178	151	358
0	11	53	145	273	219	187	356
2	17	24	118	192	168	150	287

Table 24.6. Irish Sea plaice: Landings weight-at-age 1 to 8+ (kg), where rows are years 1981–2020 and columns are ages 1 to 8+

IRISH SEA PLAICE

1 3

1981 2020

1 8

1

0.069	0.176	0.267	0.376	0.512	0.592	0.678	1.085
0.201	0.274	0.284	0.348	0.421	0.545	0.650	0.889
0.232	0.261	0.290	0.319	0.368	0.426	0.484	0.699
0.260	0.290	0.330	0.380	0.470	0.560	0.660	0.964
0.290	0.310	0.340	0.390	0.470	0.540	0.630	0.851
0.270	0.280	0.340	0.420	0.500	0.540	0.630	0.980
0.260	0.290	0.315	0.370	0.440	0.520	0.610	0.916
0.230	0.260	0.300	0.370	0.460	0.550	0.680	1.243
0.227	0.272	0.321	0.374	0.430	0.491	0.555	0.761
0.200	0.257	0.316	0.376	0.439	0.504	0.570	0.747
0.247	0.267	0.295	0.332	0.377	0.431	0.494	0.652
0.169	0.218	0.274	0.337	0.407	0.484	0.568	0.799
0.260	0.270	0.292	0.328	0.375	0.436	0.508	0.690
0.156	0.207	0.268	0.338	0.416	0.504	0.600	0.816
0.189	0.224	0.262	0.329	0.353	0.406	0.461	0.699
0.204	0.223	0.270	0.333	0.398	0.493	0.584	0.837
0.205	0.233	0.241	0.286	0.354	0.410	0.510	0.620
0.185	0.226	0.249	0.316	0.353	0.410	0.468	0.655
0.205	0.236	0.250	0.300	0.375	0.457	0.483	0.615
0.000	0.259	0.270	0.307	0.337	0.429	0.437	0.623
0.232	0.233	0.271	0.334	0.396	0.439	0.571	0.764
0.228	0.271	0.267	0.308	0.386	0.476	0.518	0.673
0.000	0.235	0.289	0.335	0.383	0.458	0.567	0.678
0.214	0.239	0.258	0.297	0.347	0.416	0.543	0.571
0.235	0.245	0.265	0.292	0.322	0.394	0.441	0.632
0.200	0.256	0.265	0.282	0.321	0.378	0.425	0.568
0.000	0.280	0.266	0.281	0.320	0.371	0.416	0.481
0.246	0.228	0.257	0.281	0.311	0.364	0.431	0.553
0.000	0.257	0.256	0.265	0.305	0.330	0.395	0.482
0.000	0.260	0.265	0.282	0.301	0.356	0.392	0.492
0.236	0.251	0.257	0.283	0.298	0.354	0.404	0.513
0.117	0.259	0.254	0.281	0.299	0.318	0.345	0.430
0.249	0.245	0.249	0.267	0.297	0.330	0.386	0.417
0.181	0.250	0.282	0.300	0.336	0.373	0.457	0.492
NA	0.183	0.264	0.287	0.299	0.340	0.403	0.617
0.113	0.149	0.229	0.318	0.422	0.362	0.433	0.660
0.166	0.222	0.273	0.345	0.370	0.405	0.442	0. 505
0.000	0.292	0.327	0.353	0.345	0.398	0.399	0.465
0.108	0.251	0.270	0.283	0.288	0.350	0.379	0.509
0.107	0.130	0.190	0.280	0.331	0.360	0.363	0.390

Table 24.7. Irish Sea plaice: Discards weight-at-age 1 to 8+ (kg), where rows are years 1981–2020 and columns are ages 1 to 8+.

IRISH SEA PLAICE

1 23

1981 2020

1 8

1

0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.087	0.105	0.130	0.153	0.170	0.231	0.318	0.211
0.057	0.115	0.145	0.164	0.211	0.290	0.238	0.210
0.099	0.117	0.134	0.179	0.178	0.277	0.644	0.356
0.141	0.113	0.141	0.145	0.162	0.210	0.274	0.077
0.044	0.081	0.113	0.140	0.150	0.205	0.219	0.243
0.096	0.097	0.116	0.135	0.151	0.173	0.217	0.170
0.033	0.080	0.119	0.147	0.165	0.196	0.232	0.276
0.083	0.101	0.138	0.183	0.201	0.140	0.194	0.225
0.077	0.098	0.116	0.141	0.157	0.168	0.164	0.176
0.026	0.038	0.081	0.119	0.162	0.200	0.157	0.182
0.064	0.069	0.094	0.116	0.144	0.157	0.181	0.181
0.056	0.067	0.084	0.120	0.128	0.150	0.152	0.153
0.088	0.059	0.079	0.101	0.095	0.126	0.152	0.136
0.136	0.103	0.109	0.120	0.146	0.161	0.155	0.170
0.093	0. 080	0. 118	0. 124	0. 128	0. 153	0. 137	0. 157
0.022	0.053	0.075	0.109	0.142	0.143	0.146	0.202
0.054	0.062	0.082	0.104	0.127	0.136	0.167	0.149
0.513	0.081	0.103	0.121	0.133	0.150	0.157	0.151

Table 24.8. Irish Sea plaice: New stock weights-at-age modified to include discard element (kg), where rows are years 1981–2020 and columns are ages 1 to 8+.

IRISH SEA PLAICE

1 4

1981 2020

1 8

1

0.087	0.124	0.190	0.351	0.509	0.592	0.678	1.085
0.091	0.141	0.210	0.327	0.418	0.545	0.650	0.889
0.097	0.173	0.231	0.303	0.366	0.426	0.484	0.699
0.100	0.196	0.275	0.362	0.467	0.560	0.660	0.964
0.089	0.203	0.293	0.374	0.468	0.540	0.630	0.851
0.098	0.171	0.292	0.401	0.497	0.540	0.630	0.980
0.102	0.208	0.266	0.353	0.437	0.519	0.610	0.916
0.104	0.171	0.250	0.351	0.456	0.549	0.680	1.243
0.100	0.183	0.261	0.352	0.425	0.490	0.555	0.761
0.090	0.172	0.253	0.349	0.431	0.502	0.570	0.747
0.140	0.165	0.230	0.305	0.369	0.429	0.494	0.652
0.106	0.159	0.209	0.302	0.395	0.481	0.568	0.799
0.097	0.141	0.209	0.291	0.363	0.434	0.508	0.690
0.101	0.134	0.193	0.299	0.400	0.501	0.600	0.816
0.091	0.138	0.184	0.289	0.340	0.404	0.461	0.699
0.091	0.130	0.181	0.286	0.377	0.488	0.583	0.837
0.091	0.118	0.168	0.247	0.335	0.406	0.509	0.620
0.088	0.116	0.148	0.223	0.305	0.399	0.466	0.655
0.100	0.125	0.150	0.216	0.321	0.444	0.480	0.615
NA	0.121	0.157	0.222	0.300	0.420	0.436	0.623
0.091	0.119	0.161	0.239	0.352	0.431	0.569	0.764
0.088	0.114	0.161	0.228	0.347	0.467	0.517	0.673
NA	0.115	0.165	0.234	0.335	0.448	0.566	0.678
0.070	0.131	0.169	0.217	0.304	0.407	0.540	0.570
0.103	0.127	0.161	0.238	0.234	0.377	0.454	0.602
0.141	0.122	0.162	0.175	0.256	0.323	0.417	0.564
0.044	0.084	0.123	0.167	0.209	0.290	0.335	0.377
0.096	0.100	0.131	0.168	0.204	0.279	0.397	0.285
0.033	0.081	0.125	0.173	0.213	0.266	0.333	0.413
0.083	0.101	0.140	0.191	0.211	0.190	0.226	0.290
0.078	0.104	0.137	0.182	0.221	0.271	0.334	0.364
0.026	0.038	0.088	0.142	0.199	0.246	0.232	0.294
0.065	0.071	0.098	0.133	0.185	0.240	0.292	0.363
0.056	0.068	0.089	0.135	0.153	0.194	0.214	0.296
0.088	0.060	0.083	0.115	0.130	0.163	0.269	0.515
0.133	0.105	0.117	0.152	0.240	0.259	0.307	0.522
0. 093	0. 081	0. 121	0. 145	0. 163	0.198	0.223	0. 303
0.022	0.054	0.098	0.138	0.199	0.253	0.269	0.39
0.054	0.062	0.088	0.127	0.180	0.218	0.304	0.427
0.063	0.084	0.106	0.151	0.198	0.240	0.269	0.298

Table 24.9. Irish Sea plaice: Estimated landed numbers-at-age (thousands).

year\age	1	2	3	4	5	6	7	8	total
1981	22	1742	5939	2984	837	222	105	236	12087
1982	27	715	3288	3082	1358	330	137	213	9150
1983	51	2924	2494	3211	1521	648	211	252	11312
1984	41	3159	5179	1182	1054	459	299	252	11625
1985	4	2357	6152	3301	614	429	262	340	13459
1986	31	1652	5280	2942	1287	344	371	308	12215
1987	62	3717	5317	5252	1341	1072	123	338	17222
1988	46	2923	5040	2552	1400	750	316	405	13432
1989	24	1735	5945	2671	854	436	214	364	12243
1990	15	1019	2715	2935	1132	465	259	223	8763
1991	180	2008	1506	1929	1205	465	182	226	7701
1992	151	1958	3209	1435	1358	903	388	294	9696
1993	28	910	1649	1357	474	556	377	302	5653
1994	97	1146	2173	1309	644	318	245	263	6195
1995	21	961	1703	1936	764	318	138	157	5998
1996	37	856	1345	1196	943	370	128	135	5011
1997	28	830	1590	1513	1003	482	285	257	5988
1998	6	691	1739	1025	612	476	403	385	5336
1999	68	803	1505	1294	696	280	196	242	5083
2000	0	450	1174	1284	686	212	219	203	4228
2001	14	374	1138	1083	767	409	178	166	4130
2002	1	206	940	1482	842	539	318	170	4497
2003	0	286	1031	1314	707	415	253	222	4227
2004	8	198	967	1104	705	247	114	186	3529
2005	6	228	708	1177	890	461	204	213	3888
2006	5	180	620	550	684	346	220	218	2823
2007	0	64	351	860	507	401	151	164	2497
2008	1	99	386	389	409	215	141	119	1757
2009	0	13	204	374	351	272	117	120	1451
2010	0	7	75	271	306	193	160	115	1127
2011	2	53	199	357	483	305	194	191	1785
2012	0	8	150	292	301	367	218	226	1561
2013	1	16	87	203	166	149	144	165	931
2014	3	6	65	165	160	143	70	158	772
2015	0	1	43	93	185	210	149	349	1030
2016	14	14	58	162	224	346	180	482	1479
2017	0	4	24	145	206	241	209	519	1348
2018	0	6	84	109	201	178	151	358	1087
2019	0	11	53	145	273	219	187	356	1245
2020	2	17	24	118	192	168	150	287	959

Table 24.10. Irish Sea plaice: Estimated discarded numbers-at-age (thousands). All discards are included (dead and alive portions).

year\age	1	2	3	4	5	6	7	8	total
1981	451	4589	7613	377	7	0	0	0	13037
1982	765	2570	3062	375	14	0	0	0	6786
1983	724	3771	1457	346	18	1	0	0	6316
1984	532	3218	1970	102	11	1	0	0	5834
1985	508	2572	1781	232	5	1	0	0	5098
1986	495	2707	1572	228	12	1	0	0	5015
1987	668	2962	1917	446	14	2	0	0	6010
1988	360	3903	2081	249	21	2	0	0	6615
1989	240	1987	2710	290	17	2	0	0	5246
1990	604	1278	1398	403	34	3	0	0	3719
1991	364	3363	980	348	50	4	0	0	5109
1992	528	2124	2661	342	75	9	1	0	5740
1993	460	3187	1726	358	29	6	1	0	5767
1994	406	2849	2606	353	45	4	0	0	6265
1995	507	2502	2423	561	59	4	0	0	6057
1996	1205	3086	2329	417	94	7	0	0	7138
1997	935	7406	3079	619	116	11	1	0	12166
1998	686	6642	9665	1364	215	31	6	0	18609
1999	582	4459	7451	1734	247	18	4	0	14495
2000	0	3763	4922	1558	193	10	3	0	10449
2001	513	2934	4078	1201	186	16	1	0	8931
2002	490	3399	3168	1558	188	21	1	0	8825
2003	0	3281	3685	1623	204	19	1	0	8813
2004	85	1381	3570	1679	324	19	1	0	7059
2005	198	2844	2793	1096	1392	78	14	26	8441
2006	854	2775	2964	1968	479	170	12	2	9224
2007	837	4704	4892	3568	947	381	104	127	15560
2008	831	4393	3188	1354	837	171	27	278	11079
2009	56	2862	4318	1318	677	251	71	60	9613
2010	980	4066	4113	3254	2853	638	836	359	17099
2011	540	1344	1134	888	589	245	79	151	4970
2012	219	4415	3492	1755	800	567	329	274	11851
2013	238	1610	3066	1633	450	163	122	49	7331
2014	1027	1886	2710	1843	1149	591	274	218	9697
2015	18	1348	1659	1104	896	997	170	93	6285
2016	101	300	858	831	430	364	149	189	3222
2017	45	529	1057	1376	1198	1118	530	723	6576
2018	321	1464	823	814	524	235	159	143	4482
2019	167	2147	1729	990	549	352	103	105	6142
2020	9	289	511	501	395	227	128	177	2237

Table 24.11. Irish Sea plaice: Estimated population numbers-at-age (thousands).

year\age	1	2	3	4	5	6	7	8	total
1981	16179	19740	17775	7226	2014	691	326	758	64710
1982	22776	12340	13178	7666	3262	1005	393	649	61269
1983	24276	20712	7781	6355	3306	1657	568	633	65286
1984	23081	21436	14370	3308	2721	1484	878	686	67964
1985	21125	20423	14755	7264	1526	1409	804	917	68223
1986	21991	17772	14814	7048	3479	774	822	971	67670
1987	21660	19811	12339	7581	3131	1809	394	1006	67732
1988	15439	20494	13222	5327	2944	1380	848	767	60422
1989	12027	13314	14701	5962	2144	1254	623	821	50847
1990	16060	9058	9104	7434	2718	1045	645	733	46797
1991	16202	14440	5536	4559	3607	1346	534	726	46948
1992	17807	12783	9687	2491	2121	1970	734	689	48282
1993	15617	16187	7561	4069	846	841	1002	687	46809
1994	14687	12203	11266	3431	1588	474	407	807	44863
1995	17464	10739	7506	5365	1485	742	259	601	44161
1996	22178	13358	6667	3401	2719	876	378	497	50075
1997	22932	17879	9483	3769	1992	1681	622	590	58947
1998	19464	20824	12102	4661	2125	1176	992	793	62138
1999	18438	16811	15212	6265	2447	1222	776	1031	62201
2000	24145	14518	11568	8903	3458	1333	900	1129	65954
2001	24161	18730	10379	6687	5366	1888	862	1301	69374
2002	25014	20682	14844	6964	4526	3848	1386	1471	78735
2003	22061	22303	16393	10755	4275	3144	2650	2023	83603
2004	20727	17658	17565	11464	7134	2457	2077	3008	82089
2005	17385	18481	12982	10774	7262	4461	1676	3320	76340
2006	22724	14984	14659	8480	6219	4158	2721	3217	77162
2007	27099	18623	11868	10444	5330	3567	2820	3792	83544
2008	21225	23349	13032	8134	7099	3217	2070	4357	82481
2009	16685	16487	18185	8831	5953	5557	2266	4298	78263
2010	23236	15457	12565	12690	6987	4763	4568	4841	85106
2011	27460	17435	11065	7903	8559	4950	3432	6492	87296
2012	23488	24789	13930	8987	5687	6331	3940	7242	94395
2013	23449	20174	19275	11509	7500	4697	4949	7794	99347
2014	29380	21750	17288	14767	9463	6490	4330	9670	113138
2015	16650	24319	17579	13427	10919	8210	5105	11605	107815
2016	14461	15116	18939	15281	11166	9251	7241	13855	105309
2017	10346	13504	13280	14860	13029	9046	7510	15990	97566
2018	13362	11477	11733	10720	11032	9950	7191	14912	90377
2019	10859	14033	11264	10050	9010	8913	8115	14456	86700
2020	6098	8896	10849	9176	8375	7368	7479	17143	75383

Table 24.12. Irish Sea plaice: Estimated fishing mortality-at-age.

year\age	1	2	3	4	5	6	7	8	F_{bar} (3-6)
1981	0.020	0.272	0.654	0.688	0.575	0.475	0.427	0.427	0.598
1982	0.020	0.264	0.633	0.675	0.569	0.474	0.428	0.428	0.588
1983	0.021	0.283	0.681	0.734	0.626	0.528	0.477	0.477	0.642
1984	0.018	0.247	0.592	0.645	0.555	0.476	0.434	0.434	0.567
1985	0.018	0.239	0.576	0.634	0.551	0.479	0.436	0.436	0.560
1986	0.019	0.247	0.594	0.664	0.583	0.516	0.467	0.467	0.589
1987	0.022	0.295	0.704	0.792	0.698	0.619	0.552	0.552	0.703
1988	0.022	0.292	0.690	0.781	0.701	0.630	0.568	0.568	0.700
1989	0.020	0.260	0.601	0.675	0.610	0.549	0.501	0.501	0.609
1990	0.021	0.264	0.595	0.662	0.597	0.536	0.489	0.489	0.598
1991	0.022	0.273	0.605	0.668	0.600	0.533	0.485	0.485	0.601
1992	0.027	0.339	0.751	0.843	0.770	0.680	0.617	0.617	0.761
1993	0.024	0.297	0.655	0.739	0.694	0.622	0.566	0.566	0.678
1994	0.025	0.301	0.646	0.717	0.669	0.598	0.548	0.548	0.658
1995	0.025	0.294	0.617	0.662	0.603	0.530	0.484	0.484	0.603
1996	0.024	0.283	0.579	0.601	0.530	0.458	0.417	0.417	0.542
1997	0.025	0.288	0.583	0.596	0.520	0.445	0.406	0.406	0.536
1998	0.025	0.289	0.587	0.595	0.514	0.438	0.396	0.396	0.534
1999	0.020	0.233	0.467	0.470	0.400	0.334	0.294	0.294	0.418
2000	0.017	0.193	0.387	0.389	0.330	0.271	0.233	0.233	0.344
2001	0.015	0.164	0.332	0.340	0.288	0.235	0.195	0.195	0.299
2002	0.012	0.139	0.280	0.293	0.250	0.199	0.159	0.159	0.255
2003	0.010	0.114	0.228	0.240	0.206	0.160	0.122	0.122	0.208
2004	0.008	0.085	0.168	0.177	0.152	0.116	0.085	0.085	0.153
2005	0.011	0.117	0.225	0.234	0.200	0.149	0.105	0.105	0.202
2006	0.013	0.138	0.251	0.253	0.212	0.155	0.104	0.104	0.218
2007	0.016	0.159	0.282	0.279	0.233	0.168	0.109	0.109	0.240
2008	0.013	0.126	0.217	0.213	0.179	0.131	0.085	0.085	0.185

year\age	1	2	3	4	5	6	7	8	F_{bar} (3-6)
2009	0.009	0.090	0.156	0.155	0.134	0.100	0.065	0.065	0.136
2010	0.014	0.138	0.235	0.235	0.206	0.155	0.101	0.101	0.208
2011	0.009	0.086	0.144	0.146	0.131	0.102	0.067	0.067	0.131
2012	0.009	0.088	0.148	0.152	0.138	0.110	0.072	0.072	0.137
2013	0.006	0.058	0.096	0.098	0.089	0.073	0.048	0.048	0.089
2014	0.006	0.059	0.098	0.102	0.096	0.081	0.054	0.054	0.094
2015	0.004	0.035	0.059	0.065	0.065	0.059	0.040	0.040	0.062
2016	0.003	0.031	0.051	0.056	0.057	0.053	0.037	0.037	0.054
2017	0.005	0.040	0.065	0.071	0.072	0.066	0.046	0.046	0.069
2018	0.005	0.047	0.070	0.073	0.070	0.061	0.041	0.041	0.068
2019	0.006	0.050	0.074	0.077	0.072	0.062	0.041	0.041	0.071
2020	0.003	0.029	0.044	0.047	0.046	0.040	0.027	0.027	0.044
year\age	1	2	3	4	5	6	7	8	Fbar (3–6)

Table 24.13. Irish Sea plaice: SAM stock assessment summary (± 2 standard deviation uncertainty). Recruitment (000s), spawning–stock biomass (SSB, tonnes), mean fishing mortality (F_{bar}) for ages 3–6, total stock biomass (TSB, tonnes) and dead catch tonnage (the sum of landings and 60% of discards).

Year	Recruitment (thousands)			SSB (t)			F_{bar} (3–6)			TSB (t)			Dead catch (t)		
	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High
1981	10751	16179	24347	5715	7062	8728	0.459	0.598	0.779	10506	12772	15527	3268	4432	6010
1982	15902	22776	32622	5524	6738	8219	0.46	0.588	0.751	10379	12415	14851	3111	4032	5226
1983	17069	24276	34526	5045	6062	7284	0.504	0.642	0.818	10832	13014	15634	3080	3914	4975
1984	16309	23081	32667	6373	7687	9271	0.444	0.567	0.724	13228	15952	19236	3564	4568	5855
1985	14951	21125	29850	7018	8476	10236	0.44	0.56	0.713	13832	16656	20057	3947	5078	6534
1986	15556	21991	31088	7502	9052	10924	0.465	0.589	0.746	14065	16793	20051	4222	5410	6931
1987	15200	21660	30865	7074	8472	10147	0.558	0.703	0.886	13937	16631	19845	4527	5764	7339
1988	10943	15439	21784	6589	7897	9466	0.555	0.7	0.884	12354	14710	17516	4120	5222	6618
1989	8310	12027	17409	5819	7024	8478	0.48	0.609	0.771	10652	12770	15309	3398	4374	5630
1990	11414	16060	22597	5253	6342	7657	0.473	0.598	0.756	9234	10978	13051	2918	3731	4770
1991	11619	16202	22591	4220	5052	6048	0.477	0.601	0.758	9020	10731	12767	2366	2979	3750
1992	12931	17807	24521	4235	5064	6056	0.61	0.761	0.95	8425	9977	11816	2757	3472	4373
1993	11748	15617	20760	3471	4155	4975	0.536	0.678	0.856	7427	8801	10428	2202	2770	3485
1994	11020	14687	19573	3555	4309	5223	0.522	0.658	0.828	7202	8572	10202	2246	2821	3542
1995	13133	17464	23223	3094	3769	4591	0.475	0.603	0.766	6503	7752	9240	1882	2365	2971
1996	16627	22178	29583	3266	4009	4922	0.424	0.542	0.692	7034	8425	10090	1803	2241	2787
1997	17235	22932	30511	3463	4241	5195	0.423	0.536	0.679	7599	9110	10922	1943	2422	3018
1998	14641	19464	25876	3757	4629	5703	0.415	0.534	0.686	7866	9456	11367	2117	2650	3316
1999	13781	18438	24668	4290	5346	6663	0.318	0.418	0.549	8691	10522	12740	2005	2511	3143
2000	17709	24145	32919	4624	5833	7358	0.254	0.344	0.468	8882	10860	13280	1764	2228	2814

Year	Recruitment (thousands)			SSB (t)			F_{bar} (3–6)			TSB (t)			Dead catch (t)		
	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High
2001	17986	24161	32456	5483	7036	9029	0.218	0.299	0.41	10102	12480	15417	1767	2208	2759
2002	18519	25014	33786	6456	8390	10902	0.186	0.255	0.351	11314	14154	17707	1789	2228	2775
2003	16119	22061	30193	7645	10073	13274	0.148	0.208	0.294	12715	16151	20516	1741	2193	2761
2004	15272	20727	28131	7807	10330	13669	0.107	0.153	0.219	12518	16007	20469	1334	1696	2154
2005	12852	17385	23517	7621	10072	13312	0.143	0.202	0.286	12269	15568	19753	1615	2034	2563
2006	16885	22724	30582	6793	9047	12048	0.155	0.218	0.305	12132	15334	19382	1528	1914	2398
2007	19939	27099	36830	5580	7449	9945	0.172	0.24	0.335	8675	11086	14168	1338	1679	2106
2008	15756	21225	28592	5580	7429	9891	0.133	0.185	0.258	9916	12554	15894	1143	1426	1780
2009	12162	16685	22892	6223	8372	11264	0.096	0.136	0.192	8844	11471	14878	879	1114	1412
2010	17198	23236	31393	6281	8284	10925	0.148	0.208	0.293	10206	12919	16354	1332	1700	2170
2011	20196	27460	37336	7165	9743	13248	0.093	0.131	0.184	11246	14564	18862	938	1175	1472
2012	17358	23488	31782	5951	8143	11143	0.098	0.137	0.192	7933	10482	13850	772	965	1206
2013	17322	23449	31745	7186	9845	13487	0.063	0.089	0.125	10576	13858	18158	641	801	1002
2014	20976	29380	41150	7350	10010	13633	0.067	0.094	0.132	10815	14135	18475	700	876	1095
2015	12016	16650	23071	9438	13347	18874	0.044	0.062	0.087	12628	17116	23200	556	702	887
2016	10635	14461	19663	13955	19394	26955	0.038	0.054	0.077	18156	24384	32748	745	937	1178
2017	7420	10346	14426	10584	14596	20130	0.049	0.069	0.097	13344	17873	23940	707	889	1116
2018	9573	13362	18651	11100	15563	21822	0.048	0.068	0.097	12722	17492	24051	677	854	1077
2019	7458	10859	15809	10420	14915	21348	0.05	0.071	0.102	12289	17106	23810	638	808	1024
2020	2956	6098	12580	9385	13434	19229	0.03	0.044	0.065	11064	15463	21609	374	482	623

Table 24.14 Short-term forecast. Annual catch options. Intermediate year assumptions.

Variable	Value	Notes
Fages 3–6 (2021)	0.061	$F_{sq}=F_{average\ (2018\text{-}2020)}$
SSB (2022)	16160	Tonnes; Fishing at *status quo* (F_{sq}).
Rage 1 (2021 and 2022)	13362	Median resampled recruitment (2015–2019) as estimated by a stochastic projection; in thousands.
Total catch (2021)	898	Tonnes; Fishing at F_{sq} plus surviving discards.
Projected landings (2021)	460	Tonnes; Assuming average discard pattern (2018–2020).
Projected discards (2021)	438	Tonnes; Assuming average discard pattern (2018–2020).
Discard survival rate	40%	Catchpole *et al*. (2015).
Projected surviving discards (2021)	175	Tonnes; Assuming average discard pattern (2018–2020) where 40% of the discards survive.
Projected dead discards (2021)	263	Tonnes; Assuming average discard pattern (2018–2020) where 40% of the discards survive.

Table 24.15. Short-term forecast. Annual catch options. All weights are in tonnes.

Basis	Total catch (2022)	Projected landings (2022)		Projected Surviving discards (2022)	Projected dead discards (2022)	Total projected discards * (2022)	Ftotal (2022)	Fprojected landings (2022)	Fprojected discards ** (2022)	SSB (2023)	% SSB change ***	% advice change ^
ICES advice basis												
FMSY	2747	1407		536	805	1341	0.196	0.061	0.135	14628	-9.5	-3.5
Other scenarios												
FMSY lower	1911	978		373	560	933	0.133	0.041	0.092	15335	-5.1	-33
FMSY upper	3967	2031		774	1162	1936	0.29	0.091	0.20	13536	-16.2	39
Fpa	5236	2681		1022	1533	2555	0.40	0.125	0.28	12534	-22	84
F = 0	0	0		0	0	0	0	0	0	17180	6.3	-100
F = Flim	6218	3183		1214	1821	3035	0.50	0.154	0.34	11863	-27	118
SSB2023 = Blim	15756	8066		3076	4614	7690	2.1	0.66	1.47	3958	-76	450
SSB2023 = Bpa	14233	7287		2779	4168	6947	1.68	0.52	1.16	5294	-67	400
SSB2023 = MSY Btrigger	10093	5167		1970	2956	4926	0.94	0.29	0.65	8758	-46	250
Rollover TAC	2846	1457		556	833	1389	0.20	0.060	0.140	14562	-9.9	0
F = F2021	905	464		177	265	442	0.061	0.0190	0.042	16210	0.30	-68
SSB2023 = SSB2022	982	503		192	287	479	0.067	0.020	0.046	16160	0	-66

*** Dead + surviving projected discards.**

**** $F_{projected\ discards}$ concerns dead projected discards only.**

***** SSB 2023 relative to SSB 2022.**

^ Advice value for 2022 relative to the advice value for 2021 (2846 tonnes).

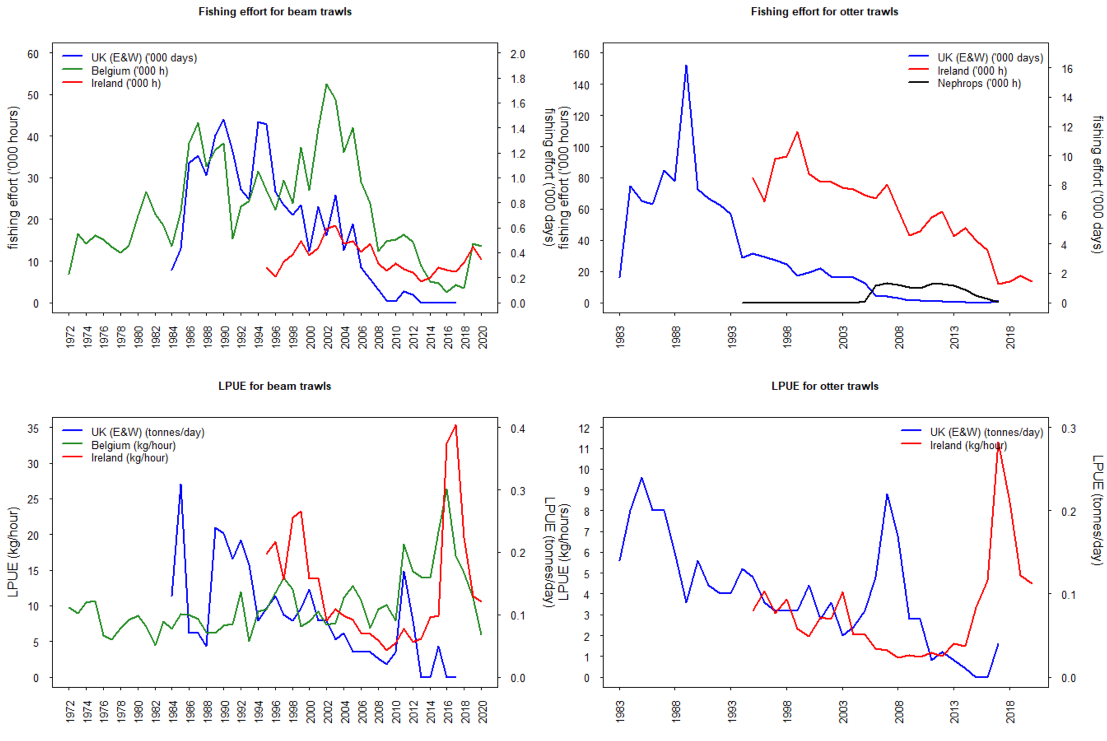


Figure 24.1. Irish Sea plaice: Effort and lpue for commercial fleets from UK (E&W), Ireland and Belgium.

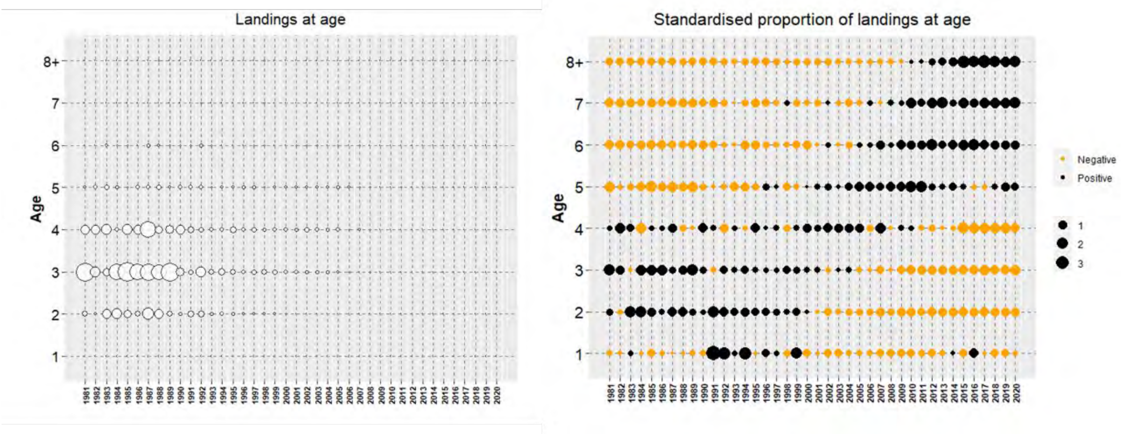


Figure 24.2a. Landings-at-age data (left) and mean standardised proportion-at-age (right, black bubbles are positive values and orange bubbles are negative). Mean standardised proportion-at-age = [(proportion-at-age in year) – mean (proportion-at-age over all years)] / STDEV(proportion-at-age over all years).

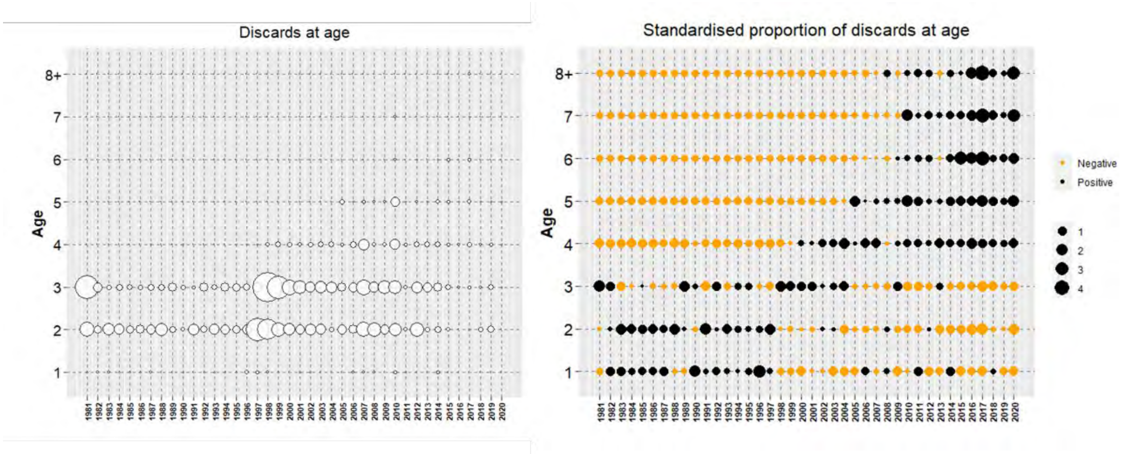


Figure 24.2b. Discards-at-age data (left) and mean standardised proportion-at-age (right, black bubbles are positive values and orange bubbles are negative). Mean standardised proportion-at-age = [(proportion-at-age in year) – mean (proportion-at-age over all years)] / STDEV(proportion-at-age over all years).

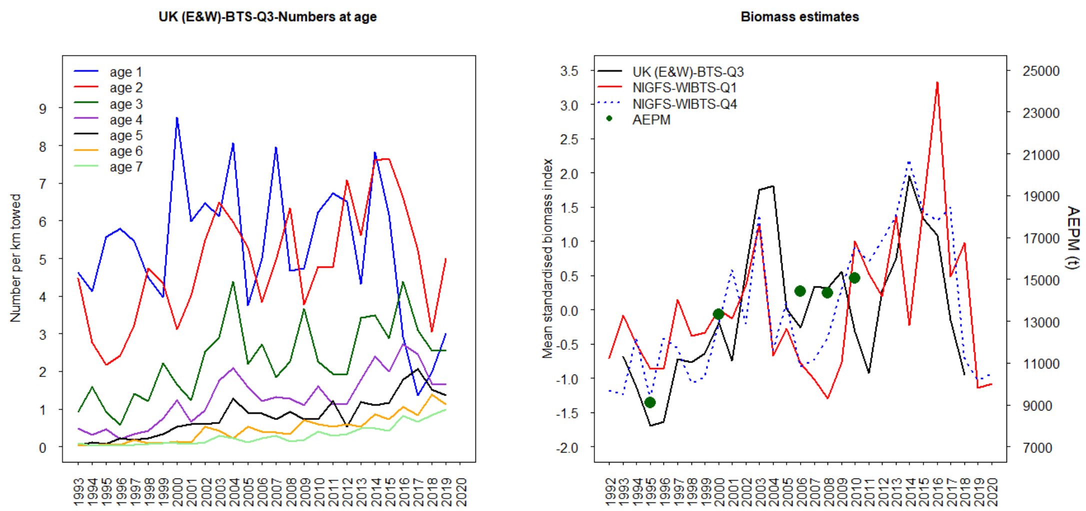


Figure 24.3. Left: UK(E&W)-BTS-Q3 (extended area) cpue by age. Right: standardised indices of SSB derived from NIGFS-WIBTS, biomass of ages 1–4 from UK(E&W)-BTS-Q3 (extended area) and the SSB estimates from the Annual Egg Production Methods (circles, right).

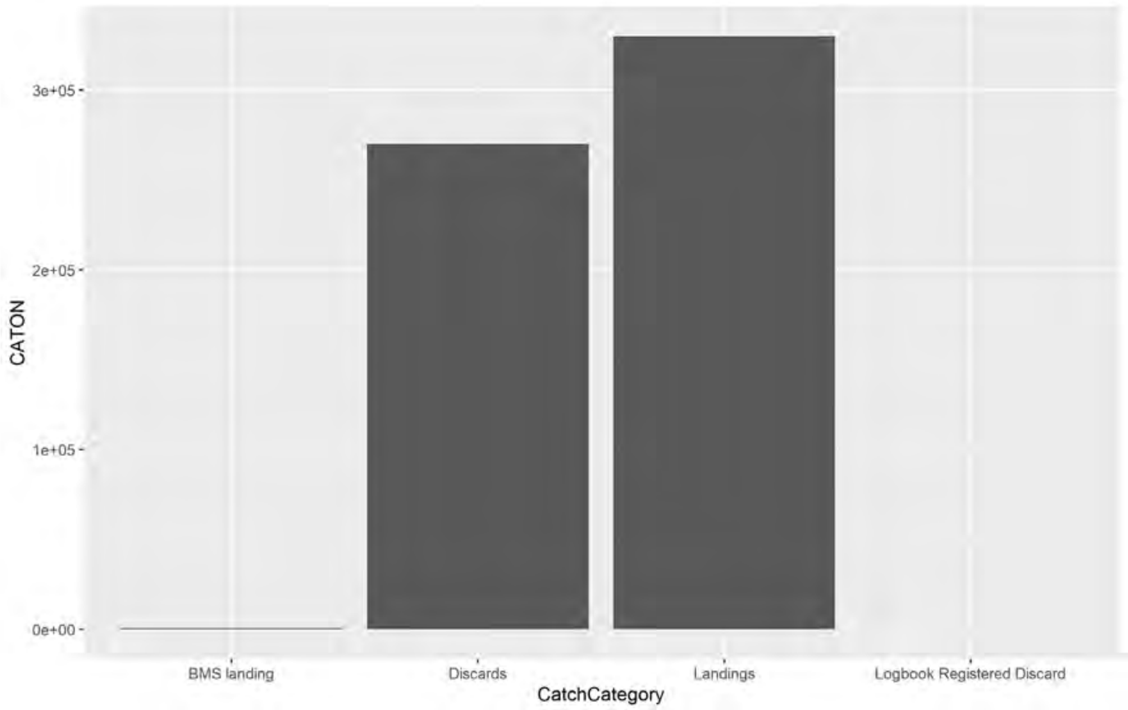


Figure 24.4. Make up of catch estimates from InterCatch.

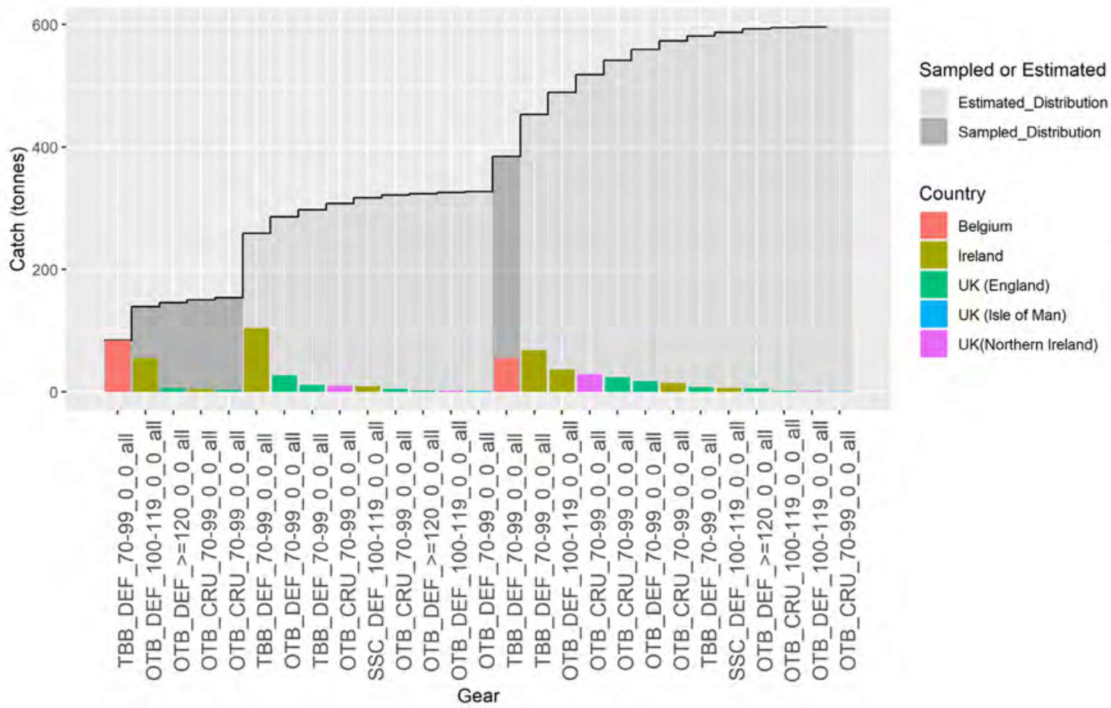


Figure 24.5. Catch sampling for landings (left) and discards (right) by country and gear type. Gears contributing less than 1 tonne are excluded for clarity

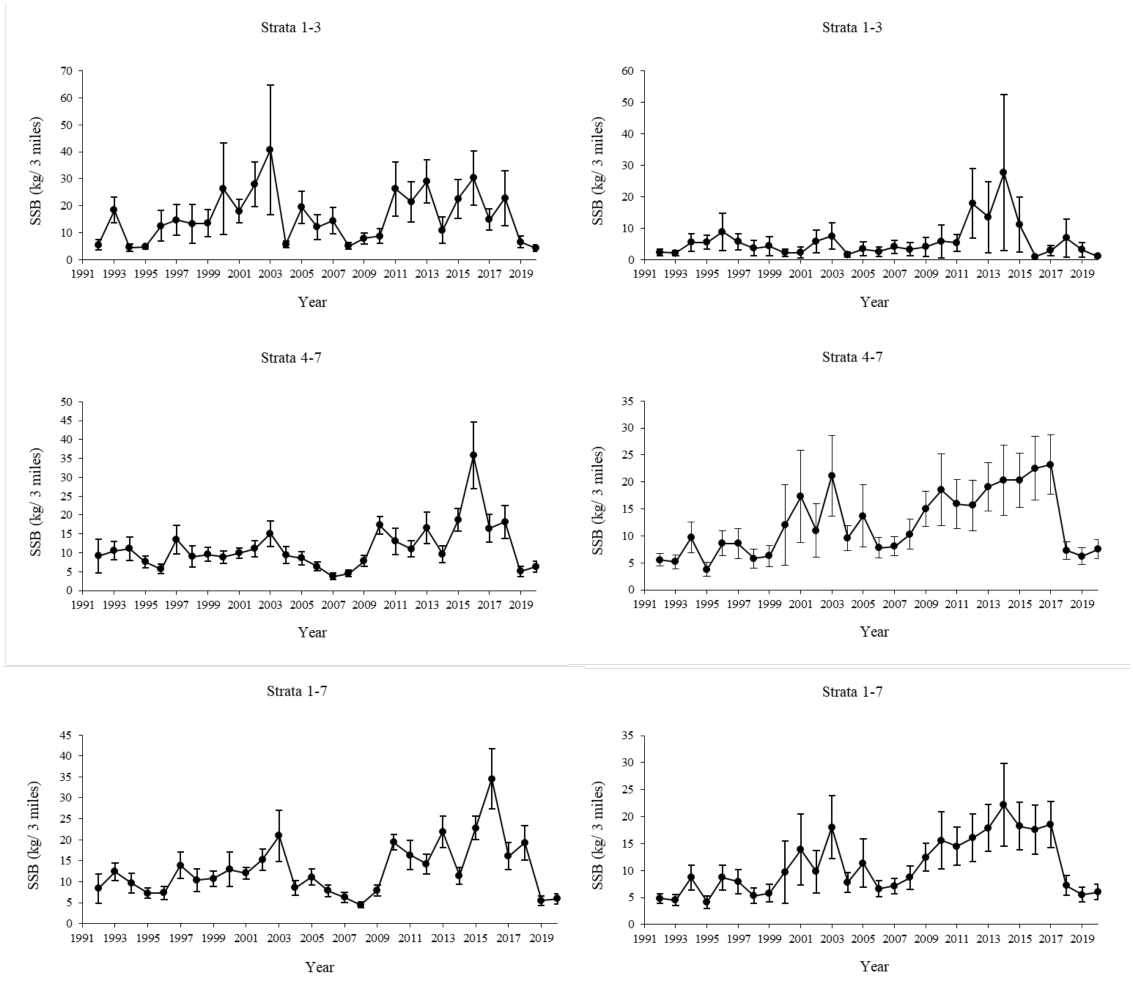


Figure 24.6. Northern Irish Groundfish Survey SSB indices split into spring (left hand panels) and autumn (right hand panels) sampling by western strata (1–3), eastern strata (4–7) and total survey area (strata 1–7) with confidence intervals (± 1 standard error, vertical lines).

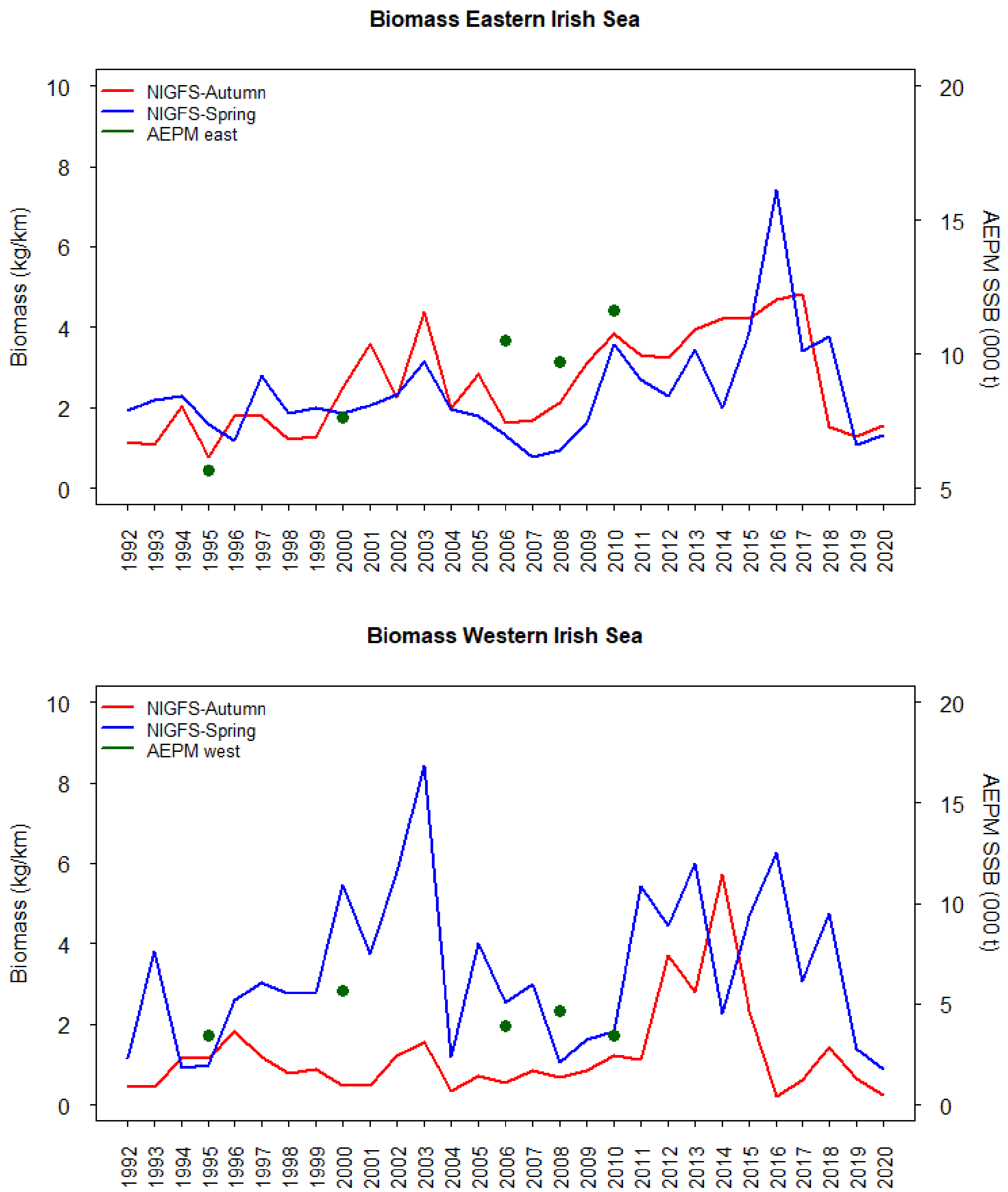


Figure 24.7. Trends in biomass indices (kg per km towed) the NIGFS-WIBTS-Q1 and -Q4 (blue and red lines respectively) in the eastern Irish Sea (top) and the western and southern Irish Sea (bottom). Also shown (green dots, right axis) are the estimates of SSB from the Annual Egg Production Method (AEPM) from Armstrong *et al.* (2001).

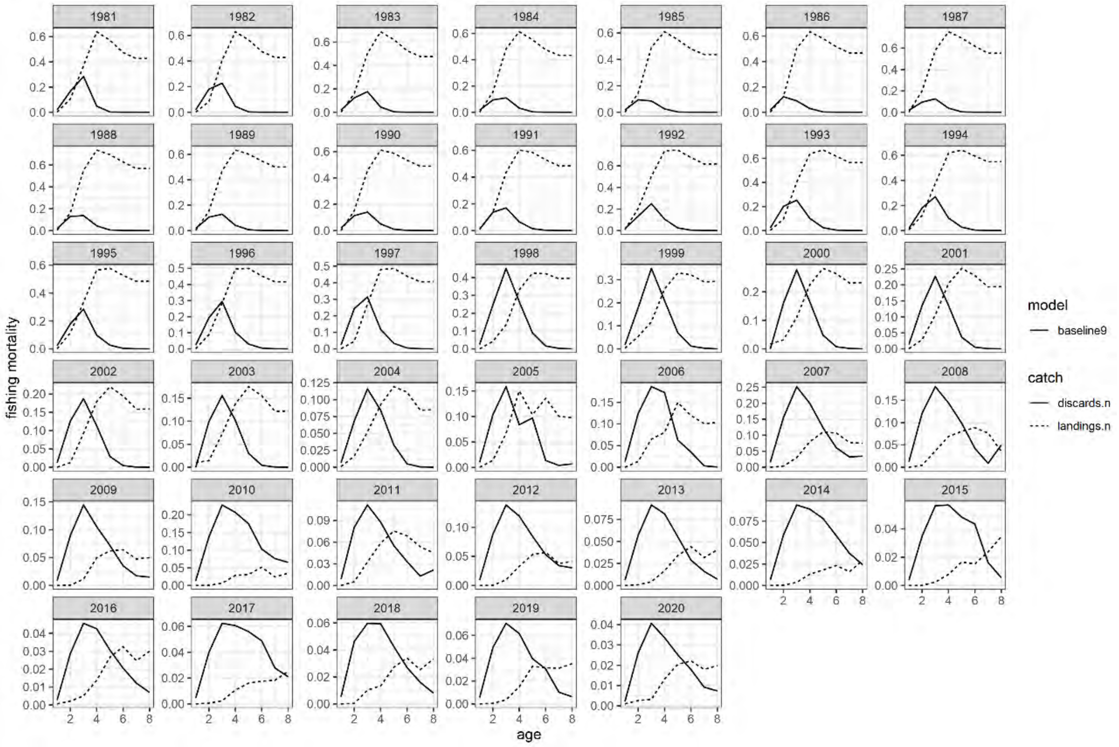


Figure 24.8. Selectivity of the fishery split into the landed (solid) and discarded (dashed) components as estimated by the SAM model, where the x-axis shows age and the y-axis gives the fishing mortality-at-age scaled so that the maximum value is 1 and split by the proportion of fish (by number) discarded and landed at-age.

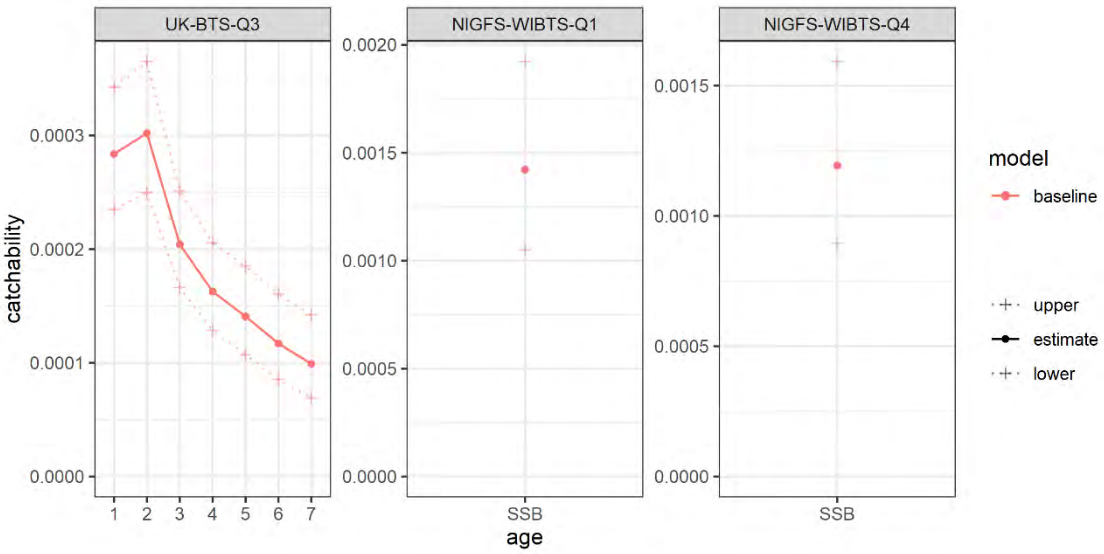


Figure 24.9. Catchability for the UK (E&W)-BTS-Q3 extended index by age, NIGFS-WIBTS-Q1 and NIGFS-WIBTS-Q4 as estimated by the SAM model.

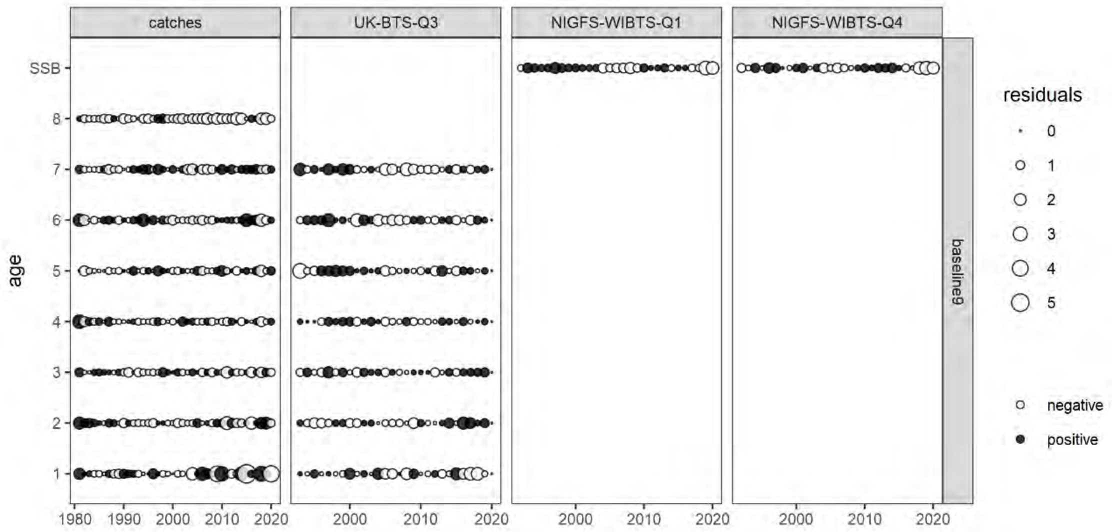


Figure 24.10. Residuals in fits to catch and survey data from the baseline model. Expected values were estimated by the SAM model.

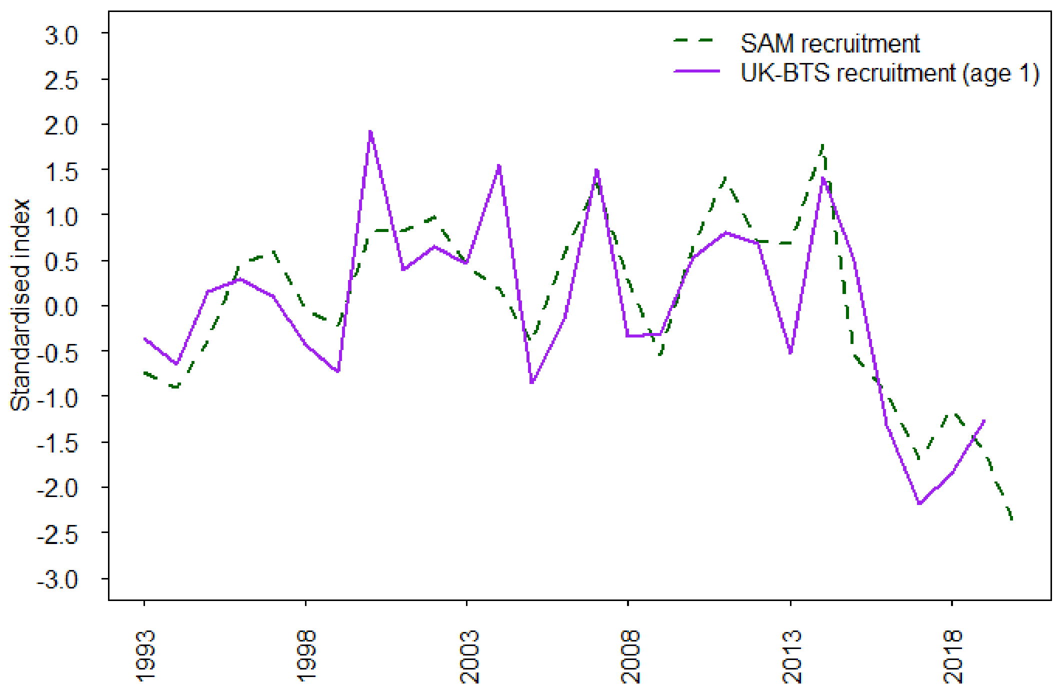


Figure 24.11. Comparison of the standardised age 1 index from the UK (E&W)-BTS-Q3 extended area (purple) and the standardised recruitment (green dashed line) estimated by the SAM model.

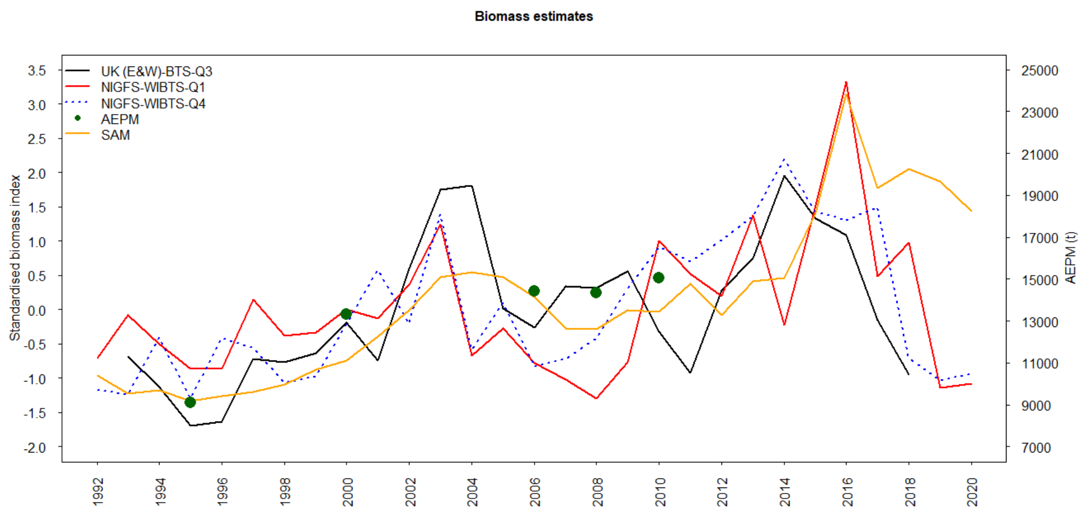


Figure 24.12. SAM model estimates of mean standardised SSB (orange line) overlain with standardised NIGFS in spring (red) and autumn (blue dashed) relative SSB indices, standardised biomass (ages 1–4) from the UK(E&W)-BTS (black solid line) and AEPM SSB index (circles, right axis). Standardized: minus mean and divided by standard deviation.

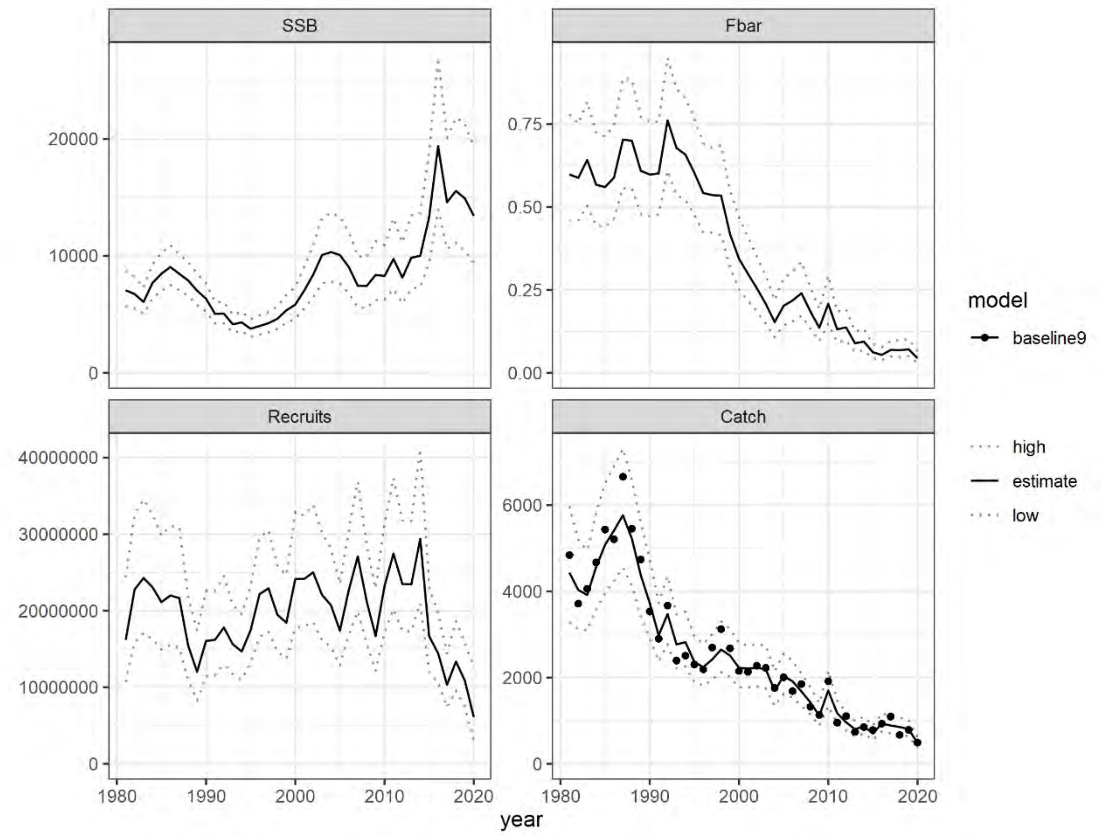


Figure 24.13. Modelled SSB (tonnes, top left), recruitment (thousands, bottom left), F_{bar} (ages 3–6, bottom right) catch tonnage (bottom right) using the SAM model. Error dashed lines indicate 2 × standard deviation.

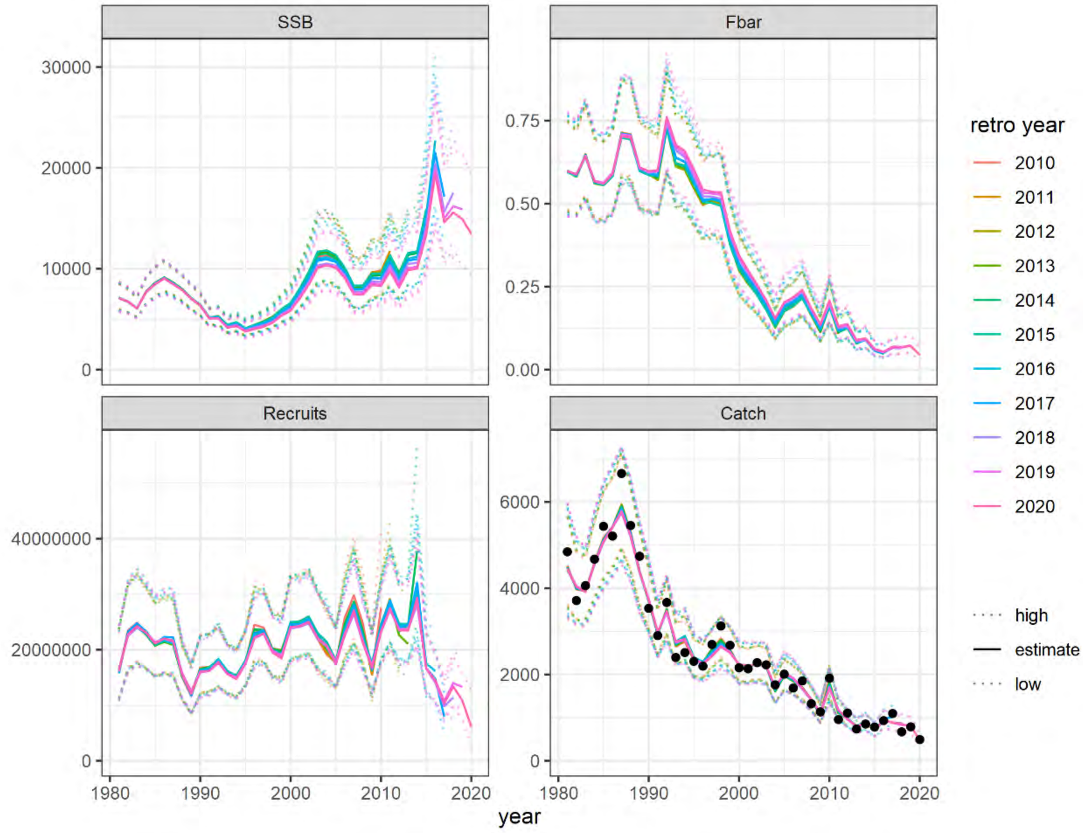


Figure 24.14. Retrospective assessments for years 2010–2020 from the baseline model. SSB (tonnes, top left), recruitment (thousands, bottom left), F_{bar} (ages 3–6, bottom right) catch tonnage (bottom right). Error dashed lines indicate 2 × standard deviation.

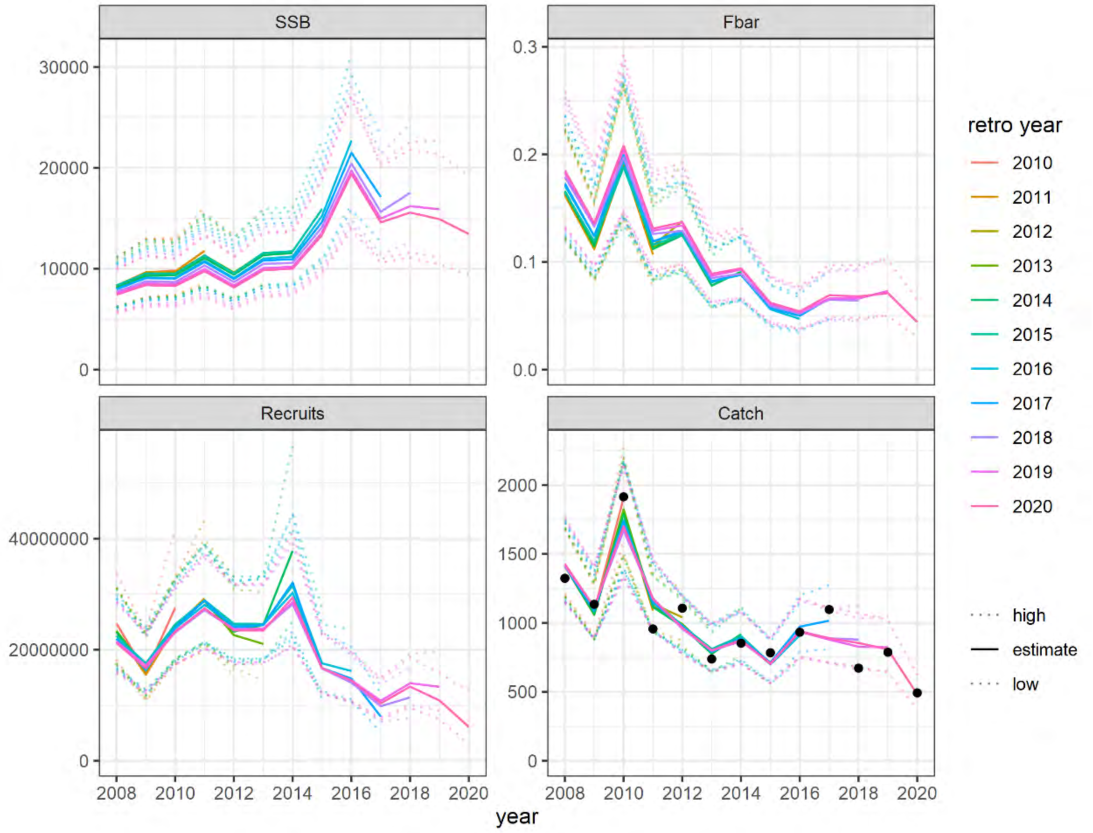


Figure 24.15. Retrospective assessments for years 2010–2020 from the baseline model, showing final 11 years. SSB (tonnes, top left), recruitment (thousands, bottom left), F_{bar} (ages 3–6, bottom right) catch tonnage (bottom right). Error dashed lines indicate 2 × standard deviation.

25 Plaice (*Pleuronectes platessa*) in Division 7.e (western English Channel

Type of assessment in 2020

Last year's assessment report is available at: https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WGCSE/28_Section_26_Plaice_7e_2020.pdf.

ICES advice applicable to 2021

Last year's advice is available at https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/ple.27.7e.pdf and stated:

ICES advises that when the precautionary approach is applied, catches of the Division 7.e plaice stock in 2021 should be no more than 2177 tonnes.

25.1 Impact of the COVID-19 pandemic

The plaice in Division 7.e stock, its fishery, and data sampling were largely unaffected by the implications of the COVID-19 pandemic in 2020.

Despite national restrictions on scientific sampling activities, sampling levels were high for landings for this stock and are sufficient to support an age-structured stock assessment indicative of trends. Details of sampling levels are detailed in this report. Discard sampling was reduced in 2020 but are not used in the assessment and only included to top up the landings advice to derive the catch advice.

Data for all commercial and scientific tuning indices were received for 2020. One scientific survey (Q1SWBeam) was delayed from March 2020 to June 2020. The impact of this change in survey timing is discussed in this report and considered negligible.

25.2 ICES Transparent Assessment Framework

The Division 7.e plaice stock is included in the ICES Transparent Assessment Framework (TAF, https://taf.ices.dk, https://github.com/ices-taf). All WGCSE assessments since 2019 are available from the ICES TAF GitHub page (https://github.com/ices-taf/2019_ple.27.7e, https://github.com/ices-taf/2020_ple.27.7e_assessment; please note, access to these repositories is so far restricted to ICES and members of WGCSE). The current WGCSE 2021 assessment is available from https://github.com/ices-taf/2021_ple.27.7e_assessment.

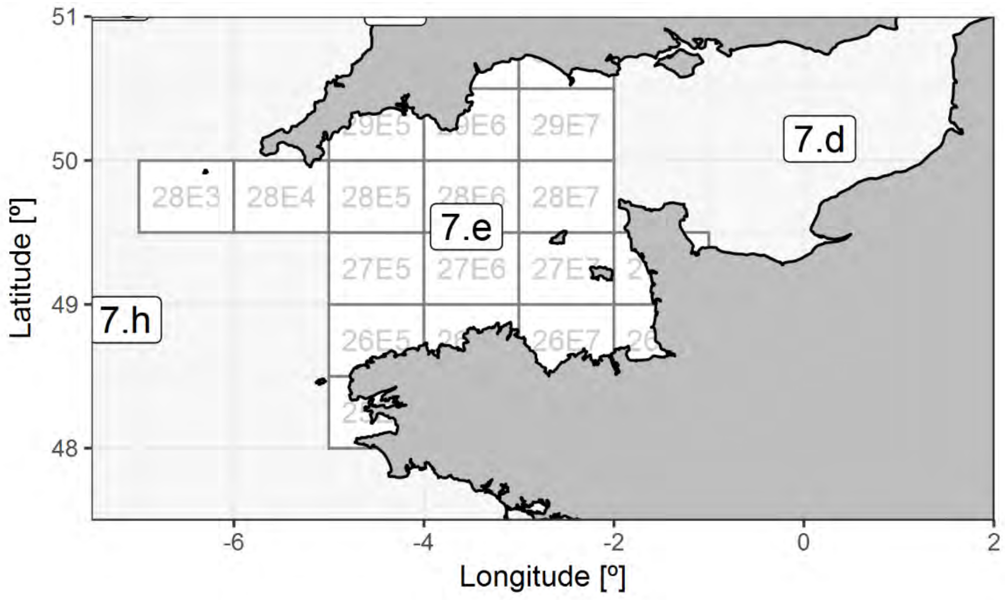
All changes since last year's assessment can be accessed with the following link: https://github.com/ices-taf/2021_ple.27.7e_assessment/compare/5e2340fbb50609ba4990c3b7071a0c47aba196f5...main.

The TAF repository includes all input data, R scripts for processing data, preparing and running the stock assessment and advice rule, and scripts for creating all figures and tables presented in this report. This repository also contains documentation on how to reproduce the WGCSE assessment for plaice.

25.3 General

Stock description and management units

The management area for this stock is strictly that for ICES Division 7.e, called the Western English Channel. The TAC area does not correspond to the stock area, given that it includes the larger component of 7.d (Eastern English Channel). However, WKFLAT 2010 (ICES, 2010) found that a significant proportion of the catches of the 7.e stock are taken in the adjacent division during the spawning period. Plaice is not the main target species in 7.e, and it is generally taken as bycatch in fisheries targeting sole.



TAC area = 7.d–e; Assessment area = 7.e.

Management applicable to 2020 and 2021

There are technical measures in operation, including a minimum 80 mm mesh size and a minimum landings size (27 cm) for this species.

The TAC and the national quotas by country for 2020

Species	**Plaice** *Pleuronectes platessa*	**Zone:**	**7d and 7e** **(PLE/7DE.)**
Belgium	1498	Analytical TAC	
France	4993	Article 7(2) of this Regulation applies	
United Kingdom	2663		
Union	9154		
TAC	9154		

(Source: Council Regulation (EU) 2020/123, EU, 2020).

The TAC and the national quotas by country for 2021

There was no agreed international TAC by the time of WGCSE in May 2021.

Landing obligation

The EU landing obligation is being phased in between 2019 and 2021 for plaice in 7.e with a discard plan defined in the Commission Delegated Regulation (EU) 2018/2034 (EU, 2018) and Commission Delegated Regulation (EU) 2019/2239 (EU, 2019) and referring to Regulation (EU) No 1380/2013 (EU, 2013). According to this discard plan, the landing obligation applies to plaice in 7.e. since 1 January 2019. There are, however, survivability exemptions for plaice when caught with specific gears. This includes all (a) trammelnets (gear codes GTR, GTN, GEN, GN) and (b) otter trawls (gear codes OTT, OTB, TBS, TBN, TB, PTB, OT, PT, TX). Furthermore, Commission Delegated Regulation (EU) 2018/2034 (EU, 2018a) set a provisional exemption for 2019, including BT2 beam trawls (i.e. 80 mm to 120 mm mesh size) for (c) vessels with a maximum engine power greater than 221 kW and fitted with a flip-up rope or benthic release panel, and (d) for vessels with a maximum engine power of 221 kW or a maximum length of 24 m, when fishing within 12 nautical miles of the coast and with average tow durations of no more than 1:30 hours (Commission Delegated Regulation (EU) 2018/2034, Article 6, EU, 2018a).

This provisional exemption was extended to 2020 in Commission Delegated Regulation (EU) 2019/2239 (EU, 2019) and points (c) and (d) extended to beam trawls irrespective of mesh size (Commission Delegated Regulation (EU) 2019/2239, Article 6, EU, 2019).

Prior to introducing the landing obligation, a substantial part of the plaice 7.e catches has been discarded and not accounted for in the stock assessment. In the first year of the phasing in of the landing obligation, the exemptions are likely to cover most of the plaice catches, and the impact on fishing or stock assessment is likely to be negligible. In the following two years of the discard plan, the situation should be closely monitored because of potential changes in the landings data and composition, which might affect the stock assessment.

25.4 Data

25.4.1 InterCatch

International catch data are collated on the ICES InterCatch platform. In the Western English Channel, plaice is taken mainly as bycatch in bottom trawls targeting sole and anglerfish. In 2020, 72% of the landings were taken by beam trawls, 21% by otter trawls, 3.4% by gillnets and 2.7% by other gears. Of the total international landings 88.1% were taken by the UK, 6.1% by France, 5.8% by Belgium, and 0.1% by the Netherlands (Table 25.1, Figures 25.1 and 25.2).

This stock is the smaller of the two plaice stocks that make up the larger TAC Area 7.d–e. The official landings from this stock amounted to 16% of the TAC in 2018, 15% in 2019 and 14% in 2020. The combined catches of plaice in 7.d-e accounted for 50% of the TAC in 2019 and 74% in 2020.

25.4.2 Landings

National landings data reported to ICES and estimates of total landings used by the Working Group are given in Table 25.1. Total international plaice landings in Division 7.e were 1520 t in 2019 and 1275 t in 2020, a decline of 16%.

In addition to the estimated 2020 landings for Division 7.e, an extra of 98 tonnes (204 t in 2020) was added from the 7.d plaice stock representing an adjustment for migration of 15% of the mature component of quarter 1 landings between the two divisions. This process was agreed at WKFLAT 2010 (ICES, 2010), and the migration correction was revised at WKPLE 2015 (ICES, 2015a). The process has been described in the Stock Annex. A reciprocal correction was made to the 7.d plaice stock at WGNSSK 2021. Figure 25.3 shows the total annual landings split by divisions 7.e and 7.d.

25.4.3 Discards

Although discards have not been used in the assessment of 7.e plaice in the past, some discard data are available. Discard tonnages are available within InterCatch and were provided by the UK(E&W) for the years 2012–2020, by France for 2014–2020, by Belgium for 2012–2013 and 2015–2020, the Netherlands for 2015–2019 and by Ireland for 2017–2020 (zero discards reported).

Discard coverage and sampling used to be at a high level, and, e.g. 88% of the landings had associated discard estimates in 2019. Discard sampling was reduced due to the restrictions imposed by the COVID-19 pandemic in 2020. This meant that only 22% of landings were covered in 2020. Discard estimates were only available from quarter 1 (French OTB_DEF_70-99, English OTB_DEF_70-99 and >=120, and TBB_DEF_70-99), quarter 4 (French and English OTB_DEF_70-99) and annual estimates (Belgian TBB_DEF_70-99). Total discard estimates were raised with available data.

Age samples have only been provided by the UK(E&W) but cover the years 2012–2020 and Belgium for 2020. In 2020, the sampled discards covered 89% of the submitted discards.

In analogy to the landings, the discards are also uplifted by a migration correction from 7.d. For 2020, 67 t (15% of the mature Q1 plaice discards in 7.d) were added, resulting in total discards of 514 t for the 7.e plaice stock.

For historical consistency reasons, Figure 25.4 shows various discard rates for plaice in 7.e. Since WGCSE 2017, the discard rate is calculated as the contribution of total discards (raised, including migration correction) to the total plaice landings (including migration component), and this discard rate was 27.2% in 2020 (Figure 25.5).

25.4.4 Sampling

Sampling levels for this stock have been high in recent years.

This year, all nations (apart from Scotland and the Belgian beam trawl fleet) provided data disaggregated by fleet and by quarter, and these were all uploaded into the ICES InterCatch database. Quarterly age compositions for landings in 2020 were available only from the UK (England) only and were provided for four fleets (GNS_DEF_all_0_0_all Q1, Q2, Q3, Q4, OTB_DEF_>=120_0_0_all Q1, Q2, Q3 Q4, OTB_DEF_70-99_0_0_all Q1, Q2, Q3, Q4, and TBB_DEF_70-99_0_0_all Q1, Q2, Q3, Q4). Despite the restrictions of the COVID-19 pandemic in 2020, sampling levels for discards were good for plaice and age samples covered 86% of the total reported international landings. Figure 25.6 visualises age samples and gives details about the number of samples and age readings in 2020.

Additional landings data were available by quarter/fleet from Belgium, France, Ireland (0 landings), the Netherlands (<1t), UK (E+W, Guernsey, Jersey) and UK Scotland (annual, <1 t). These datasets were aggregated to an international age-structured catch using the ICES InterCatch platform.

Length compositions were provided by the UK(E&W), Belgium and France and covered 95% of all submitted landings. Figure 25.7 visualises age samples and gives details about the number of samples and length readings in 2020.

An additional age composition representing the migration adjustment (15% of the mature component of quarter 1 landings for 7.d) was supplied on request by the WGNSSK stock coordinator for the 7.d plaice stock.

The method for deriving the international catch numbers and the calculation of the catch and stock weights-at-age has been fully described in the Stock Annex, Section B1. Landings numbers-at-age (including the migration element) are given in Table 25.2 and in Figure 25.9. Landings and stock weights-at-age are given in Tables 25.3 and 25.4, and plotted in Figures 25.9 and 25.10.

Catch weights are assumed to be mid-year values, and stock weights are interpolated back (in year) to 1 January, as standard for this stock (Figure 25.9).

25.4.5 Revisions

No revisions to data prior to 2020 were provided in 2021.

25.4.6 Biological

The natural mortality and the maturity ogives used were identical to previous assessments and as described in the Stock Annex.

25.4.7 Surveys

Two surveys currently provide abundance estimates to the Working Group (Figure 25.11, Figure 25.12, Table 25.5 and Figure 25.13 for internal consistency).

25.4.7.1 UK Fisheries Science Partnership

The UK Fisheries Science Partnership (UK-FSP, quarter 3, ICES survey code B4381, Burt *et al.*, 2021) conducted another survey of sole and plaice abundance in the Western English Channel, 2020. The survey uses two 4m beam trawls with 80mm nominal codend mesh and focuses on the area around the English coast. 88 out of 90 tows were completed in 2020. Catch rates are reported standardised as numbers per hour per meter of beam length.

The plaice biomass from the FSP survey has been decreasing continuously since 2018. Plaice were encountered at 84% of the survey stations, with a similar distribution to previous years, with greater numbers in Bigbury Bay and Great West Bay but less abundant towards the west of the survey area (Figure 25.14, Burt *et al.*, 2021). Plaice catches comprised mainly fish aged 2–4.

Restrictions caused by the COVID-19 pandemic meant reduced sampling for other species but did not affect plaice.

Internal consistency is acceptable for this survey for ages three and above (Figure 25.13).

25.4.7.2 Q1SWBeam

The second survey used for sole is the Quarter 1 South West Beam trawl (Q1SWBeam, also called Q1SWECOS, ICES survey code B2732), which started in 2006. This survey deploys two 4 m beam trawls and uses a fully random stratified approach. In contrast to the FPS survey, the Q1SWBeam covers the entire western English Channel, and if conditions permit adjacent areas. In 2020, all 81 tows were completed.

Cpue estimates for the Q1SWBeam survey gradually increased from 2006 to 2012 and increased rapidly thereafter to reach the highest levels on record in 2014. Since then, the index is very variable, mainly caused by changes in the abundance of plaice aged three and four. The internal consistency is moderate for ages three to seven (Figure 25.13). There is no statistically significant correlation ($p>0.05$) between the catches-at-age two and three, between six and seven, seven and eight, and eight and nine.

Usually, this survey takes place in late March. However, due to a lockdown in England caused by the COVID-19 pandemic, the survey could not start in March. Nevertheless, the survey did go ahead in June 2020, approximately three months later than usual. Due to the delay, only the core survey area of the western English Channel was covered. In order to evaluate the impact of the delay on the stock assessment, two stock assessment model runs were performed; one without where the values from 2020 were included and one where this year was omitted. The working group agreed to include the values for 2020 due to the negligible impact on the assessment.

25.4.8 Commercial fleet effort and lpue

UK(E&W) beam trawl and otter trawl time-series are shown in Figure 25.15.

UK(E&W) beam trawl effort is relatively stable at high levels since the early 2000s but the landings increased substantially between 2015 and 2016 but have been decreasing since.

UK(E&W) otter trawl effort (days fished-GRT corrected) has declined since 1989 to very low levels in recent years. In 2016, this fleet reported 0 effort and no landings, i.e. there is no lpue value for 2016. The reason for is that the lpue otter trawl index is calculated only with vessels of at least 12 m length and in 2016 only smaller vessels deploying otter trawls reported any activity. Due to a change in the database system, there are values available for the otter trawl fleet after 2016 consistent with the earlier period.

25.5 Data-limited methods

In 2017, ICES requested to trial data-limited methods for category 3 stocks in order to try to estimate the stock status relative to proxy MSY reference points, and this is being provided since then.

During WGCSE 2021, the length-based indicator (LBI) MSY approximation, as developed during WKLIFE workshops (ICES, 2014; 2015b), and the Surplus Production in Continuous Time (SPiCT, Pedersen and Berg, 2017) were again applied.

25.5.1 Length-based analysis

The first step for a length-based analysis is determining life-history parameters such as von Bertalanffy growth function parameters. Despite plaice being classified as a category 3 data-limit stock, extensive age–length data are available for this stock.

The UK takes most of the plaice catches in Division 7.e; therefore, it is appropriate to focus on data from the UK. There have been attempts to estimate von Bertalanffy growth parameters from UK commercial data in previous years, but without much success because commercial age–length samples usually do not cover enough younger (shorter) individuals, impairing the model fit and producing unrealistic values. However, data from the Q1SWBeam survey is now available on DATRAS and could be included for the first time. Commercial and survey data were combined to create a comprehensive age–length dataset (Figure 25.16). A von Bertalanffy growth model of the form:

$$L_t = L_\infty\left(1 - e^{-k(t-t_0)}\right)$$

was fitted to these data, where commercial and survey data were given equal weighting. This resulted in the following von Bertalanffy growth function parameters:

von Bertalanffy parameter	L_∞	k	t_0
value	66 cm	0.10 year^{-1}	-2.0 years

Internationally raised length frequencies from InterCatch were only available for 2014–2020. Figure 25.17 shows these length distributions (landings and discards).

The length at first capture (L_c) can be defined as the first length class, where the abundance is at or above 50% of the maximum abundance (mode) in any length class (WKLIFE II, ICES, 2012b). This calculation is relatively stable over recent years and gives:

$$L_c = 26 \text{ cm}$$

A reference length, meant as an approximation of the length at MSY and assuming and M/k ratio of 1.5 can be calculated as:

$$L_{F=M} = 0.25L_\infty + 0.75L_c$$

Using the estimates of L_∞=66cm and L_c = 26 cm, this returns:

$$L_{F=M} = 36 \text{ cm.}$$

The mean catch length (considering individuals at or above L_c) has been below $L_{F=M}$ in recent years (Figure 25.17), indicating the stock is subject to overfishing. This perception is the same as returned by analytical stock assessments described later in this report.

SPiCT

During WKProxy (ICES, 2016b) a SPiCT assessment with a set of predefined parameter settings was used to assess plaice in 7.e. The workshop came up with reference values for biomass (exploitable biomass) and fishing mortality and found that the stock is in a desirable state, both in terms of biomass and fishing mortality. The results from this assessment are also available on www.stockassessment.org. This assessment was reviewed at WGCSE 2017 and rejected, as it could not be reproduced.

Similarly to previous years, trial assessments with SPiCT were conducted for plaice in 7.e. The input data comprised the same two tuning surveys as used in the traditional XSA assessment (FSP-UK and Q1SWBeam). For both surveys, an annual biomass value was created by summing up the biomass catch-at-age for the same ages as used in XSA. The catch input for SPiCT consisted of the total landings time-series. Two assessments were run, one with the landings as catch input and an alternative with the total catch, including discards. The results are shown in Figures 25.18–25.20 and Table 25.11.

Even though the models converged, the results are not appropriate. The uncertainty in the estimates was enormous. This was true for the absolute and relative estimates, as well as the estimated reference points. Furthermore, the datapoints on the production curve are all far on the left, indicating a lack of contrast required for a good model fit. According to the assessment estimates, the stock is currently below 50% of B_{MSY} and the fishing mortality well above F_{MSY}, indicating an undesirable stock status.

The model was highly sensitive to the input data range. Figure 25.20 shows retrospective and "inverted retrospective" (removing years from the beginning of the time-series) analyses. Removing years from the end or the beginning of the time-series led to massive rescaling. This indicates a lack of consistency, and the results of the model should be treated very cautiously.

One issue when trying to fit SPiCT to the Division 7.e plaice stock is the migration component. Plaice are known to migrate between divisions 7.e and 7.d, and this is accounted for in the XSA assessment. SPiCT can only assess the total (or exploitable) biomass and, consequently, cannot account for possible migration elements or changes in recruitment.

Stock assessments for some other ICES stock units have been moved into SPiCT. However, some of these models required either fixing parameters (e.g. the shape parameter defining the production curve) or setting informative priors (e.g. on depletion or intrinsic growth rate). For data-limited stocks, such information is usually not available and fixing/limiting parameters about which there is no/limited knowledge appears questionable.

Consequently, due to the high uncertainty, missing consistency and the inability to track stock dynamics properly, the SPiCT model fit was rejected and should not be used to inform on the stock status.

As during previous years, instead of using proxy reference points, the stock status evaluation for plaice in 7.e is based on analytical reference points from an XSA assessment and is described later in this report.

25.6 Stock assessment

25.6.1 Catch-at-age analysis

During this year's WGCSE, an XSA assessment was performed with the settings defined in the Stock Annex.

25.6.2 Data compilation and screening

The age range for the analysis was 2–10+ in accordance with the procedures outlined at IBPWCFlat2 2015 (ICES, 2015c) and detailed in the Stock Annex. The landings data were processed according to the Stock Annex and formed the reference dataset for this year's assessment.

As this was an update assessment, full data screening, tuning data and extensive exploratory XSA trials were not carried out.

25.6.3 Exploration of the COVID-19 impact on the stock assessment

The impact of excluding the 2020 values of the Q1SWBeam index on the stock assessment was explored. Removing these values had a negligible impact on the results (Figure 25.21), and the decision was to include these values in the final assessment.

25.6.4 Assessment configuration

The settings used for the final run are shown in the table below. The assessment history is given in the Stock Annex.

		setting
Catch-at-age data	Landings	1980–last data year, 2–10+, 15% mature Q1 catch from 7.d added
	Discards	–
Fleets	UK-WEC-BTS – Survey	–
	UK WECOT – Commercial	–
	UK WECOT–Commercial historic	–
	UK WECBT – Commercial	–
	FSP-7e – Survey	2003–last data year (excluding 2008), 2–8
	Q1SWBeam – Survey	2006–last data year, 2–9
Taper		No
Taper range		–
Ages catch dep. Stock size		None
q plateau		6
F shrinkage se		1.0
Year range		3
Age range		3
Fleet SE threshold		0.3
Prior weighting		–
Plus group		10
F Bar Range		F(3–6)

25.6.5 Final assessment

The log-catchability residuals for the XSA run (landings only) are shown in Figure 25.22. For 2016, most residuals for the UK-FSP survey are negative, whereas they are positive for the Q1SWBeam survey. This is because of contradictory signals from the two surveys. This behaviour did not repeat afterwards.

Fishing mortalities and stock numbers estimated from the final run are given in Tables 25.6 and 25.7, and the assessment summary is shown in Table 25.8 and Figure 25.26.

Retrospective patterns in stock status and fishing mortality estimates exhibited an unacceptably high degree of temporal variability since the late 1990s, thereby indicating an excessive level of uncertainty and a lack of robustness in the assessment outputs. Consequently, since 2015 the Working Group assessed the status of the plaice 7.e stock using a qualitative evaluation of trends in accordance with the ICES Data-Limited Stock (DLS) category 3 approach (ICES, 2012a). This means that fishing mortality and SSB values are considered on a relative scale. Table 25.9 presents the results of this evaluation, where F and SSB are relative to their time-series average.

The stock is still treated as a category 3 stock, mainly because of the lack of an agreed discard time-series.

A five-year retrospective analysis (Figure 25.23) was conducted. The retrospective pattern had been reduced in the assessments after 2015. However, this year, a retrospective pattern is appearing again. Fishing mortality tends to be underestimated, and SSB overestimated.

A Mohn's rho analysis was conducted based on the XSA stock assessment results, i.e. the last data year (2020) was used as the final year to compare SSB, F and recruitment and based on retrospective analysis with a five-year peel. The results from the Mohn's rho analysis are shown in the following table:

	SSB	F (ages 3–6)	recruitment
Mohn's rho value	-0.184	0.175	-0.111

Based on the recommendations of the ICES WKFORBIAS workshop (ICES, 2020b), Mohn's rho values for long-lived stocks should be within a range of -0.15 and +0.20. The SSB Mohn's rho value for plaice is outside this range. However, the recommendations are only applicable to category 1 data-rich stocks. This does not cause imminent concern for plaice, particularly because only trends are considered, and the trends are not affected by retrospective patterns.

25.6.5.1 Comparison with previous assessments

The assessment shows some rescaling in recent years (26.25).

25.6.5.2 Intermediate year

As recommended by the advice drafting group (ADG) in 2017, the SSB is now presented until the intermediate year. All age groups used in the assessment contribute to the SSB (plaice at age 2, the recruitment age, are thought to be 26% mature). Therefore, to obtain an SSB estimate for the intermediate year 2021, an assumption about the recruitment in this year is required. Due to a lack of data to predict recruitment, the long-term (entire time-series) geometric mean was used (5244 thousand individuals, or 90% of long-term average).

25.6.5.3 State of the stock

As in the last years, the XSA assessment based on landings data only was used as final assessment run. A summary of this assessment is given in Table 25.9 and Figure 25.24.

As this is a category 3 stock, the results of the stock assessment are indicative of trends only for giving advice. In Figure 25.24, relative (to mean of time-series) results of the stock assessment are presented. Table 25.8 shows the absolute assessment results and Table 25.9 relative assessment summary results.

Spawning–stock biomass was relatively stable from 1982 to 1985 and then increased until 1989 above the long-term average following strong recruitment events during the mid-1980s. Subsequently, spawning–stock biomass decreased until 1996. A strong year class in 1996 generated an increase in spawning–stock biomass between 1996 and 2000. However, successive poor year classes resulted in spawning–stock biomass declining to the lowest levels in 2007. A combination of above-average recruitment and a reduction in fishing mortality has increased spawning–stock biomass since 2008 to reach the highest level on record in 2016. However, since then, the SSB has been continuously decreasing and only increased slightly in 2021.

Fishing mortality gradually increased from the 1980s up until the 2000s, peaking briefly in 2007. Following a large reduction in fishing mortality in 2009, this assessment shows a general decline that has reached the lowest levels on record in 2015. Since then, F has increased again.

However, the optimistic stock size in recent years is uncertain due to assessment uncertainty and omitting discard information. The decision to omit discard data is mainly due to uncertainty in the actual discard rate and an unknown proportion of surviving plaice in the discards.

25.6.5.4 State of the stock in comparison to analytical reference points

Analytical reference points for the landings only XSA assessment were estimated during WKMSYREF4 (ICES, 2016a) but not used due to the downgrading of the stock to category 3 in 2015. The main reason for this was an unacceptable retrospective pattern. This problem declined afterwards, and consequently, the analytical reference points were restored in 2017.

In comparison with reference points, F surpassed F_{MSY} in 2016 and is above since then. The SSB is well above $MSYB_{trigger}$, B_{pa} and B_{lim}.

25.7 Short-term projections

As in the last years, plaice in 7.e continues to be treated as a category 3 stock, and the assessment is indicative of trends only. Therefore, catch advice was provided by applying the ICES DLS framework for category 3 stocks where temporal trends in spawning–stock biomass are used as an index of stock development. The advice is based on a comparison of the average of the two latest index values (index A) with the average of the three preceding values (index B), multiplied by the recent advised catch. The SSB estimates from the landings only assessment are used as index values for this stock.

As basis for calculating the landings corresponding to the catch advice, the total catches as raised in InterCatch, including the migration correction from 7.d are used.

The basis for the catch options is presented in Table 25.10. For stocks in ICES data categories 3–6, one catch option is provided.

The index ratio (2021–2020 / 2019–2017) is 0.74; therefore, the uncertainty cap (0.8) was applied to limit the change to 20%. The last year for calculating the index ratio is the intermediate year 2021, for which assumptions about the recruitment had to be made (long-term geometric mean, see the previous section).

The fishing mortality derived from XSA is above F_{MSY}. The precautionary buffer was applied in 2019 for the 2020 catch advice and has, therefore, not been applied again this year.

The advised catch in 2020 for 2021 was 2177 tonnes, and this value is used as the basis for calculating the new advice.

This leads to the following advice for the 7.e plaice stock:

ICES advises that when the precautionary approach is applied, catches of the Division 7.e plaice stock should be no more than 1742 tonnes in 2022.

The average proportion of the landings of the 7.e plaice stock taken in Division 7.e between 2003–2020 is 10%. The year range (2003 until most recent year) was agreed between the two stocks (7.e and 7.d) and is also used in the advice for the 7.d stock. The calculation of this proportion only includes landings and disregards discards, as discard estimates for the plaice 7.e stock only exist from 2012 onwards. The advised catch for the stock is reduced by the average proportion to give advice for the 7.e area.

This leads to the following advice for plaice in Division 7e:

Assuming the same proportion of the Division 7.e plaice stock is taken in Division 7.d as during 2003-2020, this will correspond to catches of plaice in Division 7.e in 2022 of no more than 1572 tonnes.

25.8 Biological reference points

The currently used reference points are were calculated at WKMSYREF4 (ICES, 2016a) and shown in the following table. Please note that ICES changed the basis for F_{pa} to $F_{p.05}$, and the updated F_{pa} value is shown here:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$*	2443 t	B_{pa}	ICES (2016a)
	F_{MSY}	0.238	Eqsim run with segmented regression with breakpoint at B_{loss}. F_{MSY} was taken as the peak of the median landings yield curve.	ICES (2016a)
Precautionary approach	B_{lim}	1745 t	B_{loss}	ICES (2016a)
	B_{pa}	2443 t	1.4*B_{lim}	ICES (2016a)
	F_{lim}	0.88	Based on segmented regression simulation of recruitment without error	ICES (2016a)
	F_{pa}	0.69	$F_{p.05}$; the F that leads to SSB ≥ B_{lim} with 95% probability.	ICES (2016a)

*** The value for MSY $B_{trigger}$ is not the value published in WKMSYREF4. The advice drafting group in 2017 and 2018 decided to base MSY $B_{trigger}$ on B_{pa}.**

Reference points for 7.e plaice were calculated at WKMSYREF4 (ICES, 2016a) using the results from an XSA with parameters implemented at WGCSE 2015. In contrast to the WGCSE assessment 2015, absolute values from the XSA assessment were used instead of the relative values for the calculation of the values. ICES did not adopt these reference points initially due to the classification of the plaice 7.e as category 3.

Instead, MSY proxies were calculated at WKMSYPROXY 2015 (ICES, 2016b), presented in the following table.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$ proxy	1910 t	F_{MSY} (estimated by SPiCT from model parameters using data from 1980–2014)	WKPROXY 2015 (ICES, 2016b)
	F_{MSY} proxy	0.56	0.5 x B_{MSY} (estimated by SPiCT from model parameters using data from 1980–2014)	WKPROXY 2015 (ICES, 2016b)

These values have been used to assess the relative stock status at WGCSE 2016. At WGCSE 2017, these values have been rejected. Instead, the values from the WKMSYREF4 were restored and used since 2017.

25.9 Exploratory XSA assessment including discards

The accepted landings only XSA assessment does not include discards, but discards are substantial in recent years. Therefore, exploratory XSA assessments, which include discards estimates, are routinely conducted during WGCSE.

Reliable discard data are available from 2012 onwards from InterCatch but are not routinely used in the stock assessment. For the years for which discard data are available, the raising was done inside InterCatch, and for the strata for which no discard estimates were available, discards were estimated based on available discard information. Age allocations for discards were performed in InterCatch the same way as for landings.

Before the start of regular discard sampling for InterCatch in 2012, in 2010, the WKFLAT workshop (ICES, 2010) considered discard estimations and a working document was submitted to the workshop with estimated discards rates for the period 2001-2009 based on English discard sampling. According to this estimation, discards are assumed to be 0 in 2001 and then increased gradually to around 13% in 2008. There is a gap with now discard data in 2010 and 2011. For these years, a simplistic assumption was made, and the discard rate assumed to be the average of 2009 (last WKFLAT estimate) and 2012 (first InterCatch estimate). Figure 25.24 shows the resulting discard estimates.

This approach provided total discard rates for 2001–2011 but without any data on the age structure. For the simple discard estimation used here, discard weights-at-age were assumed to be the average of the first five years with available age-disaggregated discards (2012–2016). To generate age-structured discards, the average age structure of discards for the same years (2012–2016) was assumed, and the numbers were scaled to match the total discard rate.

Based on the total catch estimates, an exploratory XSA assessment was conducted using identical XSA assessment settings as for the accepted landings only assessment. The results of this total catch assessment in comparison to the landings only assessment are shown in Figure 25.25. SSB estimates are similar to the landings only assessment; however, fishing mortality diverges in recent years and is estimated to be substantially higher.

The reference points from the landings only assessment are not necessarily appropriate for the total catch assessment because of different stock dynamics. Therefore, new reference points were calculated with EqSim following ICES guidelines and assuming that plaice is a “type 5” stock with no clear stock–recruitment relationship. B_{lim} was set to B_{loss} as the SSB in 2017, B_{pa} set to 1.4 B_{lim} and MSY $B_{trigger}$ to B_{pa}. F_{lim} was calculated by a deterministic projection and assuming a segmented regression recruitment model with B_{lim} used as a breakpoint. F_{pa} was set to $F_{lim}/1.4$. F_{MSY} was derived by a projection with a mixture of segmented regression and Beverton–Holt stock–recruitment models and assuming default uncertainties.

According to the total catch assessment and the revised reference points, the stock is estimated to be well above all biomass reference points. However, the fishing mortality is higher and well above F_{MSY} at around F_{pa} but below F_{lim}.

A five-year retrospective analysis was conducted, and this revealed reduced retrospective patterns compared to the landings only XSA. The Mohn’s rho values of the XSA assessments are compared in the following table:

	SSB	F (ages 3–6)	recruitment
landings only XSA	-0.184	0.175	-0.111
total catch XSA	0.078	-0.079	-0.285

Please note that this assessment is only exploratory and has not been reviewed, and should not yet be used to provide advice. Further work, particularly on the historical discard estimates and model validations, are required.

The conclusion from this exploratory assessment run is that the stock is likely to be in less favourable condition than estimated by the accepted routine landings only assessment.

25.10 Exploratory SAM assessment

Prior to WGCSE, an attempt was made to fit the state–space assessment model (SAM; Nielsen and Berg, 2014). This model is described briefly.

The input data were the same as used for the total catch XSA assessment described in the previous section, i.e. included discards. The model configuration followed the XSA model configuration. This meant that the survey catchability was linked for ages six and higher. Apart from that, the default SAM configuration was retained.

The model fit of this SAM assessment is very similar to the total catch XSA assessment (described in the previous section), in terms of SSB, F and recruitment (Figure 25.28). Figure 25.29 shows the results of the SAM assessment, including uncertainty estimates.

Model diagnostics are presented in Figure 29.30. These include a retrospective analysis, leave-out runs (removing survey indices), model residuals (one-step ahead residuals, for catch and survey observations) and process residuals (numbers and fishing mortality). Retrospective peels are slightly outside the confidence intervals. This might indicate that further refinements to the model configuration are required. Furthermore, usual model stability tests were performed. These included (i) simulating data from the model fit and re-fitting the model and (ii) jitter runs where arbitrary random initial parameters values are tested. Both stability tests did not indicate any issues with the model fit.

25.11 Considerations for providing ICES advice in the future

25.11.1 Current advice framework

The current basis for providing advice is the ICES data-limited framework from 2012 (ICES, 2012a), i.e. the catch advice is based on the "2 over 3" rule (applied to the relative SSB from XSA), in combination with an uncertainty cap and a precautionary buffer. The ICES WKLIFE workshop series has been working on revising the data-limited advisory framework and drafted guidelines in 2020, meant to replace the current system (WKLIFE X; ICES, 2020).

25.11.2 The rfb rule

If the plaice in Division 7.e stock remains in category 3, this will likely result in applying the "rfb" rule (ICES, 2020a). This rule has been extensively simulation tested (Fischer *et al.*, 2020, 2021). The rfb rule expands on the 2 over 3 rule by adding a target for the mean catch length and a biomass safeguard, reducing catch advice when the stock index drops below a threshold (replacing the precautionary buffer).

The plaice 7.e is stock is ready for applying the rfb rule, and all required data are available.

25.11.3 Considerations towards a management strategy evaluation

This plaice stock could be considered an ideal case study for simulation testing of data-limited control rules because the stock is classified as category 3, but extensive data about this stock exist.

Some very preliminary analyses for a management strategy evaluation (MSE) were conducted for WGCSE 2021.

The operating model was conditioned on the SAM model fit (with total catches) described in the previous section and following the procedures developed at the Workshop on North Sea Stocks Management Strategy Evaluation (WKNSMSE; ICES, 2019). This meant that the stock status was based on the perception of the stock from SAM, and uncertainty was quantified through SAM's variance-covariance matrix (for observations and processes). Stock–recruit pairs did not exhibit any explicit stock–recruitment function (Figure 25.31). Consequently, recruitment in the operating model could be modelled with a hockey-stick model and quantifying variability through resampling from the kernel-density distribution of observed residuals. Both surveys (UK-FSP and Q1SWBeam) were simulated. The mean catch length was simulated with stochastic age–length keys.

The MSE framework was based on Fischer *et al*. (2021). Three management strategies were explored:

1. **The current management**: Conduct annual landings-only XSA, apply the 2 over 3 rule to the SSB trend, and complement with the PA buffer and the uncertainty cap.
2. **The original 2 over 3 rule**: Apply the 2 over 3 rule to a biomass index (Q1SWBeam), with PA buffer and uncertainty cap, give advice biennially.
3. **The rfb rule**: Apply rfb-rule according to the WKLIFE X (ICES, 2020a) guidelines, use biomass Q1SWBeam for the stock trend (for r) and biomass safeguard (for b), mean catch length (for f), set multiplier to 0.95 (because von Bertalanffy $k<0.2 \text{year}^{-1}$), give biennial advice and apply +20%/-30% uncertainty cap.

These control rules were simulated for 100 years and with 500 simulation replicates. These projections are summarised in Figure 25.32, and risk (risk of the SSB dropping below B_{lim}, defined as B_{loss} from the historical period) is plotted in Figure 25.33. These simulations indicate that the current management does not provide long-term precautionary management. The rfb rule showed superior performance and even kept risk at or below 5%.

Please note that these MSE explorations are very preliminary, and further work is recommended.

25.12 Management plans

There is no management plan in place for this stock apart from the EU multiannual plan for the region.

25.13 Uncertainties and bias in assessment and forecast

A degree of uncertainty exists over the landings statistics for this stock, given that mature plaice migrate between 7.d and 7.e during the spawning period. The current assessment applies a spawning migration correction that reallocates 15% of quarter 1 landings for the mature proportion of the catch from 7.d to 7.e. Consequently, the assessment results depend on the mixing rate assumption estimated from existing tagging data. Further work is required to examine the stock structure and the mixing rate during the spawning period. Additional data are also needed to determine if the current mixing rate remains valid given the increased abundance of plaice stocks in the English Channel in recent years.

There is a heavy reliance on the age composition data derived from UK(E&W) sampling. Around 25% of the landings for this stock are taken by countries that do not provide age-based data, and this situation is improved only slightly once the migration correction data from 7.d are added.

Discard data are only available for 2012–2020, and these data are mainly from the UK(E&W). Historical discarding rates are highly uncertain, but available discard data imply a substantial increase between 2012 and 2015. Discards are not included in the assessment.

France had to revise their 2018 discard data due to inaccuracies in the raising procedure. However, the same procedure has already been used in previous years, which have not been revised.

The assessment contains a certain degree of uncertainty due to excluding discards and is likely to be overly optimistic. Fishing mortality is likely to be higher and SSB lower than estimated by the current assessment. The decision to exclude discards in the assessment is based on the uncertainty in the available discards data and unknown discard survival rate of plaice.

25.14 Recommendations for next Benchmark

There is a growing list of issues for this stock. An updated issue list is kept on the ICES system for rolling issues (https://sid.ices.dk/Manage/rollingissues.aspx).

Most of the following points have been described in previous reports and are repeated this year.

A benchmark assessment was developed for this stock at WKFLAT 2010 (ICES, 2010), and an inter-benchmark meeting (IBPWCFlat2, ICES, 2015c) subsequently convened in 2015 to revise the input data and update the XSA assessment settings. Nevertheless, any future benchmark meeting will need to consider the following issues.

Since 2017, ICES asked for the additional application of data-limited methods for category 3 stocks. This has massively increased the workload for the stock coordinator and assessor but with little benefit for this stock. Upgrading this stock to category 1 is desirable and feasible within a reasonable timeframe.

The decisive reason for downgrading the stock to category 3 in 2015 were unacceptable retrospective patterns in the XSA assessment. These patterns reduced subsequently. For the application of an analytical assessment, the following issues need to be considered:

- A discard time-series should be developed and included in the assessment as discarding was substantial in recent years. The current assessment is based on landings only and, therefore, possibly fails to accurately model actual stock dynamics, particularly as the discard rate in recent years is variable.
- Discards, including age compositions, are now routinely estimated within InterCatch and exist for 2012–2020. Some UK discards data prior to 2012 exist but are not used so far. The discard time-series should be extended back in time, as it has been done for other plaice and similar stocks. An exploratory assessment with a historical discard guestimation is being conducted since WGCSE 2020 and indicates considerably higher fishing mortality in recent years compared to the accepted landings only assessment.
- Including discards in the assessment might require a re-parameterisation of XSA settings and exploring alternative age-structured assessment models, such as SAM.
- Biological data such as natural mortality and maturity ogives are time-invariant in the current assessment and borrowed from other plaice stocks (divisions 7.fg and 7.a). There have been benchmarks for other plaice stocks, and a similar approach could be made for plaice in 7.e. The natural mortality used for plaice in 7.e was originally borrowed from

plaice in Division 7.a. The values for plaice in 7.a have been changed recently but the original values are still used for plaice in 7.e.

Furthermore, the following points should be considered:

- Smoothing of stock and catch weights. The raw catch weights are corrected for migration from 7.d and then smoothed using a polynomial function of 2nd degree. Even though the fit seems to be quite reasonable different, more appropriate methods should be evaluated.
- Abundance estimates derived from the UK FSP-7e and Q1SWBeam surveys included in the assessment are spatially restricted to the same areas as the commercial tuning fleets, and therefore little population abundance information exists along the French coast. Cpue estimates from additional research surveys in French coastal waters would improve the robustness of future assessment outputs.
- Cohort tracking in the two survey indices is only mediocre.
- Investigate the addition of age composition information from the French and Belgian fleets. These fleets collectively accounted for about 16% of the total landings of this stock. In particular, the inclusion of French data would add information on the stock dynamics on the French coast.
- In 2019/2020 there was a revision of the Q1SWBeam survey index, with changes to station validities and the calculation of the index. This should be further reviewed.
- France revised 2018 discard data due to an issue with the raising procedure. However, the same procedure has been used for previous which have not been revised.

New issues arising in 2021:

- The landings only XSA assessment is again exhibiting larger retrospective patterns. These patterns are reduced when discards are included in the assessment.

25.15 Management considerations

There is a mixed-fishery for sole and plaice in Division 7.e, and the two stocks are dominant commercially caught species with beam trawls. The catch advice for plaice was a reduction by 25% for 2020 compared to 2019 and another 20% for 2021 compared to 2020 (preliminary). For sole, on the other hand, the catch advice increased by 16% (2020 vs 2019) and 30% (preliminary, 2021 vs 2020). This means that there are contrasting changes recommend for sole and plaice by ICES which could cause higher catches, including discards of plaice, which should be closely monitored and might cause a continued negative trend for the plaice stock.

The stock unit (Division 7.e) does not correspond with the management unit (divisions 7.d and 7.e), and this divisional mismatch hampers the effective management of plaice in the Western English Channel. However, some provision must be made to consider the effective management of adjacent plaice stocks, given that components of the 7.e stock are also taken during the spawning period in 7.d. WKPLE 2015 revised the established migration correction so that 15% of quarter 1 landings for the mature proportion of the catch are reallocated from 7.d to 7.e, and the associated age composition is applied to plaice 7.e.

Due to migration patterns, catches of this stock also occur in Division 7.d during the spawning period; therefore, to be consistent with the advised catch for the Division 7.e plaice stock, the actual catches of plaice in Division 7.e should be lower than the advised catch for the stock. ICES has calculated the corresponding actual catches in Division 7.e, assuming that the proportion of Division 7.e stock catches taken in Division 7.d remains as in previous years (i.e. 10%, the average of 2003–2020, taking the age structure of the population into account). As the mixing rate of the two plaice stocks is uncertain, this calculation provides only an approximation.

The total allowable catch (TAC) for the management area has not always been following scientific recommendation for the combined divisions 7.e and 7.d. for 2016 has been doubled compared to 2015 but was reduced slightly in the following years.

25.16 Stock assessment audit

The 2021 stock assessment for this stock has been audited internally within WGCSE, and no issues were found.

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25.18 Tables

Table 25.1. Plaice in 7.e. History of official landings by country and ICES estimates of landings and discards. All weights are in tonnes.

Year	Belgium	Netherlands	France	UK (E &W) incl. CI's	Others	Total reported	Total*	7.e stock caught in 7.d**	ICES estimated landings	Discards***
1976	5	-	323	312	-	640	640	-	640	
1977	3	-	336	363	-	702	702	-	702	
1978	3	-	314	467	-	784	784	-	784	
1979	2	-	458	515	-	975	977	-	977	
1980	23	-	325	609	9	966	1079	99	1178	
1981	27	-	537	953	-	1517	1501	175	1676	
1982	81	-	363	1109	-	1553	1688	190	1878	
1983	20	-	371	1195	-	1586	1495	219	1714	
1984	24	-	278	1144	-	1446	1547	211	1758	
1985	39	-	197	1122	-	1358	1441	236	1677	
1986	26	-	276	1389	-	1691	1810	268	2078	
1987	68	-	435	1419	-	1922	1958	314	2272	
1988	90	-	584	1654	-	2328	2458	377	2835	
1989	89	-	448	1712	-	2249	2358	384	2742	
1990	82	-	N/A	1891	2	1977	2593	392	2985	
1991	57	-	251	1326	-	1634	1848	335	2183	
1992	25	-	419	1110	14	1568	1624	258	1882	
1993	56	-	284	1080	24	1444	1417	197	1614	
1994	10	-	277	998	-	1285	1156	248	1404	
1995	13	-	288	857	-	1158	1031	216	1247	
1996	4	-	279	855	-	1138	1044	222	1266	
1997	6	-	329	1038	1	1374	1323	260	1583	
1998	22	-	327	892	1	1242	1131	215	1346	
1999	12	-	194	947	-	1153	1299	244	1543	
2000	4	-	360	926	< 1	1290	1281	345	1625	

Year	Belgium	Netherlands	France	UK (E &W) incl. CI's	Others	Total reported	Total*	7.e stock caught in 7.d**	ICES estimated landings	Discards***
2001	12	-	303	797	-	1112	1106	204	1310	
2002	27	-	242	978	< 1	1247	1257	215	1472	
2003	39	-	216	985	-	1240	1277	110	1387	
2004	46	-	184	912	-	1142	1212	126	1337	
2005	48	-	198	887	-	1133	1203	117	1319	
2006	52	-	223	965	< 1	1239	1313	97	1411	
2007	84	-	202	680	-	966	1003	143	1146	
2008	66	-	148	679	-	893	976	135	1112	
2009	53	2	191	731	-	977	923	101	1024	
2010	51	2	227	843	-	1123	1092	116	1208	
2011	141	3	274	936	-	1354	1334	83	1417	
2012	134	2	224	1004	< 1	1364	1366	126	1492	448
2013	97	1	221	1041	-	1360	1351	121	1472	351
2014	41	-	323	976	-	1340	1341	149	1490	1133
2015	111	1	224	912	1	1249	1246	178	1424	1276
2016	145	< 1	204	1430	-	1780	1777	235	2013	618
2017	151	< 1	153	1605	1	1911	1915	213	2128	821
2018	142	3	118	1377	3	1644	1644	236	1880	633
2019^	73	1	95	1350	< 1	1520	1520	204	1725	633
2020^	73	< 1	79	1122	-	1276	1275	98	1373	514

***Estimated by the working group.**

****Migration correction (15% of the mature population caught in Quarter 1 in Division 7.d) added to stock.**

*****Discard estimated by the working group, including discards from the migration correction.**

^Preliminary official landings.

Table 25.2. Plaice in 7.e. Landings numbers-at-age.

	Numbers-at-age [thousands]								
year/age	2	3	4	5	6	7	8	9	10+	TOTAL NUM
1980	754	758	244	226	62	63	22	13	137	2279
1981	667	2068	555	118	101	20	46	18	94	3688
1982	279	1928	1371	257	87	82	16	28	121	4168
1983	720	799	1613	586	101	40	47	2	99	4009
1984	928	1650	659	518	191	90	28	33	50	4146
1985	596	1424	1326	154	248	140	27	15	51	3980
1986	914	2326	908	478	110	127	66	28	61	5018
1987	1063	2083	1355	648	228	86	49	44	51	5608
1988	1817	4627	1087	456	149	112	38	24	52	8362
1989	269	2748	2873	825	268	118	94	31	100	7326
1990	331	3151	2668	1198	263	133	76	56	71	7946
1991	557	1192	1876	956	510	103	43	33	51	5320
1992	699	1299	734	646	441	258	69	32	49	4227
1993	670	1377	631	262	267	216	165	39	85	3712
1994	326	1503	831	250	106	116	78	84	63	3357
1995	322	732	943	263	118	56	79	68	88	2667
1996	1050	668	379	382	122	59	38	47	105	2848
1997	861	2228	435	177	147	75	31	17	99	4070
1998	536	1482	1107	155	64	60	22	21	61	3507
1999	650	2135	1124	407	92	37	39	17	45	4546
2000	351	1157	2037	496	181	38	14	22	52	4348
2001	469	785	788	950	145	79	19	11	37	3283
2002	1017	1190	460	394	456	106	42	12	40	3718
2003	886	964	532	182	166	236	58	45	38	3107
2004	471	1364	566	338	107	74	109	51	38	3119
2005	796	880	775	277	146	50	49	58	48	3080
2006	995	1358	517	379	115	61	27	18	53	3523
2007	393	1077	699	287	199	72	31	10	50	2819

	Numbers-at-age [thousands]									
year/age	2	3	4	5	6	7	8	9	10+	TOTAL NUM
2008	919	703	570	259	112	87	32	15	29	2727
2009	647	1255	297	151	79	32	21	7	17	2505
2010	759	974	758	215	114	47	16	18	23	2924
2011	1132	1441	725	255	75	50	27	12	18	3735
2012	204	1561	1066	373	253	101	51	21	35	3664
2013	137	1075	1377	510	200	149	45	49	36	3579
2014	135	636	1407	845	356	135	70	54	35	3673
2015	90	392	642	924	553	234	61	50	35	2982
2016	61	888	1116	828	897	426	155	64	55	4490
2017	88	460	1619	1148	646	468	220	133	134	4917
2018	71	393	924	1329	723	338	223	120	111	4232
2019	85	436	690	790	841	412	224	187	201	3867
2020	365	631	630	486	388	364	217	103	167	3350

Table 25.3. Plaice in 7.e. Landings weights-at-age.

	Weights-at-age [kg]								
year/age	2	3	4	5	6	7	8	9	10+
1980	0.329	0.435	0.538	0.64	0.741	0.84	0.939	1.035	1.392
1981	0.273	0.4	0.526	0.647	0.767	0.883	0.997	1.108	1.448
1982	0.302	0.391	0.474	0.548	0.617	0.678	0.732	0.78	0.89
1983	0.224	0.338	0.446	0.547	0.642	0.73	0.812	0.888	1.085
1984	0.254	0.356	0.461	0.57	0.682	0.797	0.914	1.034	1.51
1985	0.222	0.337	0.45	0.561	0.669	0.775	0.878	0.979	1.341
1986	0.26	0.353	0.45	0.551	0.655	0.764	0.877	0.994	1.49
1987	0.287	0.347	0.418	0.503	0.599	0.71	0.833	0.968	1.387
1988	0.225	0.31	0.407	0.515	0.634	0.765	0.906	1.059	1.398
1989	0.224	0.293	0.37	0.454	0.547	0.647	0.756	0.872	1.167
1990	0.27	0.315	0.371	0.437	0.514	0.602	0.7	0.809	1.081
1991	0.252	0.316	0.389	0.473	0.566	0.67	0.784	0.908	1.246
1992	0.286	0.345	0.417	0.503	0.601	0.713	0.838	0.976	1.33
1993	0.263	0.338	0.418	0.503	0.596	0.694	0.798	0.907	1.194
1994	0.266	0.336	0.412	0.494	0.582	0.676	0.775	0.879	1.136
1995	0.282	0.362	0.445	0.531	0.619	0.709	0.803	0.899	1.083
1996	0.268	0.371	0.474	0.577	0.681	0.786	0.891	0.997	1.216
1997	0.272	0.345	0.427	0.514	0.608	0.709	0.816	0.931	1.196
1998	0.19	0.313	0.435	0.556	0.674	0.793	0.911	1.028	1.339
1999	0.206	0.295	0.382	0.466	0.548	0.628	0.706	0.781	1.006
2000	0.206	0.293	0.38	0.468	0.555	0.642	0.729	0.817	1.066
2001	0.218	0.301	0.388	0.48	0.576	0.677	0.782	0.891	1.268
2002	0.256	0.331	0.41	0.496	0.588	0.686	0.788	0.895	1.208
2003	0.266	0.371	0.475	0.577	0.675	0.772	0.866	0.959	1.273
2004	0.3	0.361	0.429	0.505	0.588	0.679	0.778	0.883	1.203
2005	0.293	0.366	0.445	0.528	0.616	0.709	0.806	0.908	1.134
2006	0.296	0.361	0.433	0.512	0.6	0.694	0.795	0.904	1.121
2007	0.255	0.333	0.415	0.499	0.586	0.677	0.77	0.868	1.105

	Weights-at-age [kg]								
year/age	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
2008	0.281	0.357	0.441	0.531	0.627	0.729	0.838	0.954	1.308
2009	0.242	0.379	0.513	0.644	0.771	0.894	1.013	1.128	1.383
2010	0.274	0.364	0.46	0.562	0.668	0.779	0.895	1.016	1.285
2011	0.241	0.351	0.463	0.577	0.693	0.811	0.931	1.052	1.376
2012	0.249	0.323	0.404	0.492	0.588	0.692	0.803	0.922	1.26
2013	0.254	0.314	0.384	0.464	0.554	0.654	0.765	0.885	1.332
2014	0.207	0.28	0.358	0.441	0.528	0.619	0.714	0.814	1.164
2015	0.244	0.306	0.38	0.466	0.563	0.672	0.792	0.923	1.251
2016	0.279	0.325	0.379	0.441	0.512	0.591	0.677	0.773	1.001
2017	0.27	0.31	0.357	0.411	0.472	0.54	0.616	0.697	0.926
2018	0.219	0.262	0.32	0.395	0.485	0.591	0.714	0.852	1.17
2019	0.324	0.322	0.339	0.375	0.431	0.507	0.602	0.716	0.923
2020	0.241	0.282	0.33	0.386	0.451	0.523	0.603	0.691	0.866

Table 25.4. Plaice in 7.e. Stock weights-at-age.

	Stock weights-at-age [kg]								
year/age	2	3	4	5	6	7	8	9	10+
1980	0.275	0.381	0.485	0.587	0.688	0.788	0.886	0.983	1.342
1981	0.207	0.336	0.462	0.585	0.705	0.823	0.937	1.049	1.393
1982	0.253	0.345	0.43	0.508	0.579	0.643	0.701	0.751	0.874
1983	0.164	0.282	0.393	0.497	0.595	0.687	0.772	0.851	1.059
1984	0.202	0.302	0.405	0.512	0.621	0.733	0.849	0.967	1.433
1985	0.163	0.28	0.394	0.506	0.615	0.722	0.827	0.929	1.295
1986	0.215	0.306	0.401	0.5	0.603	0.709	0.82	0.935	1.422
1987	0.261	0.313	0.378	0.455	0.545	0.648	0.764	0.892	1.292
1988	0.186	0.266	0.357	0.46	0.573	0.698	0.833	0.98	1.309
1989	0.193	0.258	0.33	0.411	0.5	0.596	0.701	0.813	1.098
1990	0.25	0.29	0.34	0.401	0.472	0.554	0.647	0.75	1.009
1991	0.224	0.282	0.35	0.428	0.516	0.615	0.723	0.842	1.167
1992	0.259	0.31	0.375	0.453	0.544	0.648	0.765	0.895	1.231
1993	0.227	0.298	0.375	0.458	0.547	0.641	0.742	0.848	1.126
1994	0.23	0.297	0.369	0.447	0.531	0.62	0.715	0.816	1.063
1995	0.243	0.322	0.403	0.487	0.573	0.663	0.755	0.85	1.031
1996	0.217	0.319	0.421	0.524	0.628	0.732	0.837	0.943	1.16
1997	0.237	0.308	0.385	0.469	0.559	0.657	0.761	0.872	1.129
1998	0.128	0.251	0.374	0.495	0.616	0.735	0.853	0.971	1.283
1999	0.16	0.25	0.339	0.424	0.508	0.589	0.667	0.743	0.972
2000	0.162	0.248	0.335	0.422	0.509	0.596	0.683	0.771	1.019
2001	0.178	0.259	0.344	0.434	0.528	0.626	0.729	0.836	1.205
2002	0.215	0.285	0.361	0.443	0.529	0.621	0.719	0.822	1.119
2003	0.211	0.318	0.422	0.524	0.624	0.722	0.817	0.911	1.227
2004	0.272	0.329	0.393	0.464	0.544	0.63	0.725	0.827	1.136
2005	0.257	0.328	0.404	0.484	0.569	0.659	0.754	0.853	1.074
2006	0.265	0.326	0.395	0.471	0.554	0.644	0.741	0.846	1.057
2007	0.217	0.294	0.374	0.457	0.542	0.631	0.723	0.818	1.052

	Stock weights-at-age [kg]								
year/age	2	3	4	5	6	7	8	9	10+
2008	0.245	0.318	0.398	0.484	0.577	0.676	0.782	0.894	1.238
2009	0.171	0.311	0.447	0.579	0.707	0.832	0.953	1.07	1.329
2010	0.229	0.318	0.411	0.509	0.612	0.72	0.834	0.952	1.215
2011	0.186	0.295	0.407	0.52	0.635	0.752	0.87	0.991	1.313
2012	0.216	0.285	0.362	0.447	0.539	0.639	0.746	0.861	1.206
2013	0.228	0.283	0.348	0.423	0.508	0.603	0.708	0.824	1.271
2014	0.172	0.243	0.319	0.399	0.484	0.573	0.666	0.763	1.119
2015	0.217	0.274	0.342	0.422	0.513	0.616	0.73	0.856	1.181
2016	0.259	0.301	0.35	0.409	0.475	0.55	0.633	0.725	0.948
2017	0.252	0.289	0.333	0.383	0.441	0.505	0.577	0.655	0.881
2018	0.204	0.238	0.289	0.355	0.438	0.536	0.65	0.781	1.09
2019	0.333	0.32	0.328	0.355	0.401	0.467	0.552	0.656	0.851
2020	0.224	0.261	0.305	0.357	0.417	0.486	0.562	0.646	0.815

Table 25.5. Plaice in 7.e. Tuning fleet data available. Not all years and ages as shown here are used in the assessment.

```
ple.27.7e WGCSE 2021
103
FSP-7e
2003 2020
1 1 0.75 0.80
1 27
1               0.0209770126   0.3436760427   0.3438565748   0.21573342     0.0410775576
                0.0419977077   0.0509216245   0.0336840543   0.0218724711   0.0021259953
                0.000963324    0.0004982792   7.93538e-05    3.69074e-05    0
                3.69074e-05    0              3.69074e-05    0.000191009    0              0
                0              0              0              0              0              0
1               0.0067754535   0.2142713766   0.8391764093   0.169067456    0.2830906871
                0.0295920817   0.0180891769   0.0459783707   0.0114596296   0.0026341395
                0.00082671     0.0002011072   0.000162673    0              0.000192977    0
                0              0              0.0001228108   0              0              0
                0              0              0              0              0
1               0.0084930716   0.3271099173   0.4255951803   0.2404409927   0.0900371664
                0.0395287705   0.0127361504   0.0174592138   0.0371790541   0.0070178609
                0.0043464537   0              0              0              0.0006865187
                0.0006011272   0.0005708894   0              0.0005994339   0.0014134667   0
                0              0              0              0              0              0
1               0.0264706605   0.6226160902   0.4216897498   0.1859126341   0.099837907
                0.0442377935   0.0213837161   0.0045703626   0.0063647949   0.0140975761
                0.0015007319   0.0043230363   0              0              0.0005854935   0
                0              0.0006888159   0              0              0              0
                0              0              0              0              0
1               0              0.117014537    0.2742350811   0.1567513605   0.0653599832
                0.026616889    0.008325896    0.0058923584   0.0054585815   0.005636939
                0.0019316523   0.002303838    0.0022915293   0              0              0
                0              0              0              0              0              0
                0              0              0              0              0
1               0.0017564806   0.4978930589   0.2151254659   0.1256971005   0.031804751
                0.019273551    0.0152824098   0.0046998005   0.0019257017   0.0005475203
                0.0002061533   0.0001398448   8.0202e-05     2.51903e-05    2.98214e-05
                2.51903e-05    0              2.98214e-05    2.98214e-05    2.98214e-05    0
                0              0              0              0              0              0
1               0.0211943046   0.4353288543   0.4422219627   0.1528394796   0.0598128665
                0.0331030404   0.0226941756   0.0079648565   0.0033431925   0.0013018772   0
                0.0026037544   0              0              0              0              0
                0              0              0              0              0              0
                0              0              0              0
1               0.0647388571   0.7402133171   0.5829812879   0.3845761643   0.0479189382
                0.0415029509   0.0119952249   0.0061701869   0.0023009922   0.0047470993
                0.0011504961   0.006622702    0              0              0              0
                0              0              0              0              0              0
                0              0              0              0              0
1               0.0047548175   1.0375641226   0.8018594122   0.3141243215   0.1105079566
                0.0103299847   0.0181567711   0.0132676864   0.0020353747   0.0020192508
                0.0016602188   0.0001019445   6.52445e-05    0.0029854977   0
                0.0011871962   0              3.67e-05       0              0              0
                0              0              0              0              0              0
1               0.0498236793   0.3213803938   1.2432341572   0.5820013318   0.1364686475
                0.1347918963   0.0121371085   0.0144254043   0.0115270917   0.0025913556
                0.0051989993   0.0049471333   0              0              0              0
                0              0              0              0              0              0
                0              0              0              0              0
1               0              0.2266890224   1.4641865697   1.2671043524   0.4403084123
                0.2032552981   0.0755061094   0.0275649015   0.0077368789   0.0037886636   0
                0.0012684957   0.0012684957   0              0              0              0
                0.0012684957   0              0              0              0              0
                0              0              0              0
1               0.03548275     1.319797284    1.6647790616   2.1308293497   0.8328568122
                0.6237114226   0.1572964824   0.0350538578   0.0371484109   0
                0.0035336667   0.00265025     0              0              0.0011778889   0
                0              0              0              0              0              0
                0              0              0              0              0
1               0.0016784148   0.8297622663   1.257130266    0.9233582109   1.0196856517
                0.5143824561   0.1222270476   0.0128853381   0.0566453575   0.0023985076
                0.0093404666   4.58918e-05    2.29459e-05    2.29459e-05    0
                2.29459e-05    0              2.29459e-05    0              0              0
                0              0              0              0              0              0
1               0.0033568296   0.3887210579   1.50073462     0.8157445965   0.3896522219
                0.3426977969   0.2351356472   0.0186050167   0.056730528    0
                0.0098937394   0              0.0028762403   0              0              0
                0              0              0              0              0              0
                0              0              0              0              0
1               0.0083920741   0.2734688532   0.5985856837   1.5809798468   0.3446727423
                0.4536494278   0.2886734237   0.0563499887   0.1485529321   0.013814645
                0.0264081583   0.0106433051   0.0054248655   0              0.0033568296   0
                0              0              0              0              0              0
                0              0              0              0              0
1               0              0.2730774994   0.765289223    0.9806866884   0.6563497784
                0.1850327432   0.1112903326   0.0873483927   0.0302633863   0.0263229229
                0.0030350849   0.0017983016   0              0              0              0
```

	0	0	0	0	0	0
	0	0	0	0	0	
1	0.0004756859	0.1740496312	0.4982191132	0.5246601483	0.4820598027	
	0.3039476624	0.1153367817	0.0630658514	0.0315684791	0.01902716	
	0.0124644406	0	0.0012684957	0.0015856197	0	0
	0	0	0	0	0	0
	0	0	0	0	0	
1	0	0.7236873888	0.6876859008	0.286551445	0.1324310278	
	0.0833516837	0.0646730791	0.0146861296	0.0183201245	0.0088404566	
	0.0073055273	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	
Q1SWBeam						
2006 2020						
1 1 0 0.25						
1 27						
1	1.84355	39.0324	28.978	22.789	6.4116	
	2.0366	0.2017	0.1706	0.3412	0.64363	0
	0.42633	0.22583	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0		
1	0.86782	16.0343	35.474	17.601	4.9816	
	4.1461	1.6719	3.5545	0.2503	4.42522	
	0.2503	2.73176	1.43235	0.2503	0	0
	0	0	0	0	0	0
	0	0	0	0	0	
1	0.78546	34.0493	14.432	5.388	7.7622	
	1.1251	1.4744	2.178	1.979	0	
	0.87797	0.12102	0.18772	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	
1	1.54002	60.3357	50.609	16.203	15.6705	
	4.8047	4.7493	0.4567	0.2861	0.45666	
	0.45666	0	1.86925	0	2.47554	0
	0	0	0	0	0	0
	0	0	0	0	0	
1	1.15633	46.939	38.568	27.266	3.2952	
	4.1844	6.4977	0.8659	0.3754	0	0
	0.18772	0	4.58514	0	0	0
	0	0.14928	0	0	0	0
	0	0	0	0		
1	1.80958	59.7233	106.793	41.826	7.3508	
	6.3969	4.5944	0.4679	1.5832	0.11377	
	0.35757	0	0.11919	0.11919	0.11919	0
	0	0	0	0	0	0
	0	0	0	0	0	
1	0	10.4168	55.348	34.255	11.0874	
	7.7031	11.5037	0.3472	3.2114	0	0
	0.21454	0	0	0.1644	0	0
	0	0	0	0	0	0
	0	0	0	0		
1	0.30036	18.0693	94.898	71.939	16.1513	
	4.4771	2.337	1.0774	1.9311	0	0
	0	0.13968	0	0	0	
	0.12637	0	0	0	0	0
	0	0	0	0	0	
1	1.01423	68.7637	155.902	195.574	70.5165	
	10.792	1.4612	2.9894	0.9387	0.48829	
	0.28101	0.15884	0.1706	0	0	0
	0.15884	0	0	0	0	0
	0	0	0	0	0	
1	0	45.2386	48.128	25.168	37.4127	
	21.7209	5.1873	2.273	1.0775	2.08315	0
	1.23777	0	0.18772	0	0.1976	0
	0	0	0	0	0	0
	0	0	0	0		
1	0.22085	21.6309	243.345	66.815	39.6987	
	40.1547	29.5983	7.9856	17.8855	0	
	8.59375	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	
1	0	17.263	84.717	194.995	39.4563	
	37.3536	18.272	3.4646	6.9322	0.50248	
	0.65697	0	0.38299	0	0.2503	0
	0	0	0	0	0	0
	0	0	0	0	0	
1	0	9.0674	40.928	32.98	49.1506	
	19.0937	13.197	12.3342	8.2191	1.41506	
	1.03906	0.13269	0	0.13269	0	0
	0	0	0	0	0	0
	0	0	0	0	0	
1	0	18.5742	40.702	52.361	43.0245	
	51.7778	21.8301	5.9516	4.1325	0.94572	
	0.55842	0	0	0.23838	0	0
	0	0	0	0	0	0
	0	0	0	0	0	

```
1               0               47.2232         66.046          34.599          19.2905
                8.3288          6.0213          4.6533          3.5152          1.35155
                3.19601         0.14679         0               0               0               0
                0               0               0               0               0               0
                0               0               0               0               0
FSP-7e-biomass
2003 2020
1 1 0.75 0.80
1 27
1               0               0.017016367     0.0688757606    0.0966061428    0.0267062571
                0.0304515944    0.0394253638    0.0232279389    0.0212273134    0.0030361805
                0.0017211792    0.0010041223    0.0001201678    5.90965e-05     0
                5.90965e-05     0               5.90965e-05     0.000412429     0               0
                0               0               0               0               0               0
1               0               0.0090667679    0.1472882537    0.0780042612    0.143088054
                0.0190885999    0.0139592328    0.0453616929    0.0094022151    0.0046179543
                0.0011256657    0.000209328     0.0001770265    0               0.0002987599    0
                0               0               0.0002408385    0               0               0
                0               0               0               0               0
1               0               0.0156218436    0.0730656867    0.1018963791    0.0538242596
                0.0270754542    0.0102591669    0.0178596772    0.0345549048    0.0076868425
                0.0060651528    0               0               0               0.0012186908
                0.0009625308    0.0013530215    0               0.0012943051    0.0027718823    0
                0               0               0               0               0               0
1               0               0.0263692884    0.0689478802    0.0855964846    0.0597592009
                0.028978287     0.0158729934    0.0040622491    0.0063580172    0.0152819209
                0.0025594871    0.0036230017    0               0               0.0003474219    0
                0               0.0011029388    0               0               0               0
                0               0               0               0               0
1               0               0.0048548379    0.046738111     0.0623769633    0.0383347839
                0.0201717899    0.0079485584    0.0036769609    0.0052152438    0.0057022622
                0.0022468606    0.0041954154    0.0012809892    0               0               0
                0               0               0               0               0               0
                0               0               0               0               0
1               0               0.0232060806    0.0432528571    0.0620243386    0.0227453703
                0.0166104191    0.014761934     0.0060019504    0.0015914499    0.0007852894
                0.0002855136    0.0002403104    0.0001233477    3.24332e-05     5.84813e-05
                3.24332e-05     0               5.84813e-05     5.84813e-05     5.84813e-05     0
                0               0               0               0               0               0
1               0               0.0215725431    0.0887328739    0.0708853383    0.0399585878
                0.0305261874    0.0183867908    0.0071709534    0.0053531527    0.0025530495    0
                0.0038770762    0               0               0               0               0
                0               0               0               0               0               0
                0               0               0               0
1               0               0.0311281451    0.1082469735    0.1766765633    0.0320283526
                0.0283853654    0.0115565349    0.0061370637    0.0029625913    0.00716298
                0.002042332     0.0030410605    0               0               0               0
                0               0               0               0               0               0
                0               0               0               0               0
1               0               0.0396368085    0.1241834636    0.1260251504    0.0657333626
                0.0063537489    0.0199243311    0.0109420203    0.0028378997    0.0027852462
                0.002274287     0.0001585983    9.98338e-05     0.0042163133    0
                0.0015400601    0               5.87645e-05     0               0               0
                0               0               0               0               0               0
1               0               0.0113939787    0.180250252     0.207402214     0.0749219808
                0.0802592315    0.0132626993    0.0093944286    0.011571324     0.0024658113
                0.0058594291    0.0047321321    0               0               0               0
                0               0               0               0               0               0
                0               0               0               0               0
1               0               0.0069079758    0.1807580845    0.4105531087    0.2027741237
                0.1086554592    0.0542549173    0.0202150747    0.010110847     0.0035528435    0
                0.0014550441    0.0014550441    0               0               0               0
                0.0032902929    0               0               0               0               0
                0               0               0               0
1               0               0.0414447594    0.2055514357    0.631560929     0.3339077616
                0.2615754031    0.0794357472    0.025108143     0.0290915886    0
                0.0049700235    0.0018371369    0               0               0.000926584     0
                0               0               0               0               0               0
                0               0               0               0               0
1               0               0.0259976638    0.1785456298    0.3123608027    0.4239455316
                0.2540299873    0.0773365727    0.0127076399    0.0374520696    0.001585112
                0.0132388536    7.34824e-05     3.67412e-05     3.67412e-05     0
                3.67412e-05     0               3.67412e-05     0               0               0
                0               0               0               0               0               0
1               0               0.0124223576    0.1944765311    0.2906585088    0.1832748786
                0.1805528336    0.1252767374    0.0139593132    0.0459469671    0
                0.0088635596    0               0.0019439633    0               0               0
                0               0               0               0               0               0
                0               0               0               0               0
1               0               0.0089076024    0.0759872804    0.4847631306    0.1492603275
                0.2072453377    0.1556498663    0.0338106702    0.0918858901    0.0124465021
                0.0197142882    0.0106094533    0.0053076674    0               0.003212512     0
                0               0               0               0               0               0
                0               0               0               0               0
1               0               0.0092612801    0.0957148459    0.287166203     0.2779266438
                0.105983836     0.0688427721    0.0691574641    0.0223061018    0.0231423024
                0.003509849     0.0035265638    0               0               0               0
```

	0	0	0	0	0	0
	0	0	0	0	0	
1	0	0.0055044584	0.0665074063	0.1555115381	0.2010923874	
	0.1566429404	0.069133305	0.0459155059	0.0218357553	0.0174043329	
	0.0104956824	0	0.0016332234	0.0006883778	0	0
	0	0	0	0	0	0
	0	0	0	0	0	
1	0	0.0199275891	0.0808068508	0.0878204797	0.0620927826	
	0.0495348585	0.0472016563	0.0178293735	0.0199326151	0.0084231594	
	0.0096456266	0	0	0	0	0
	0	0	0	0	0	0
	0	0	0	0	0	

Table 25.6. Plaice in 7.e. Fishing mortality-at-age. The values in the table are rounded to three digits.

	Fishing mortality-at-age									
year/age	2	3	4	5	6	7	8	9	10+	F(3–6)
1980	0.12	0.419	0.457	0.423	0.766	0.407	0.341	0.507	0.507	0.516
1981	0.107	0.503	0.562	0.378	0.309	0.553	0.54	0.469	0.469	0.438
1982	0.104	0.461	0.67	0.502	0.481	0.401	1.073	0.655	0.655	0.528
1983	0.128	0.436	0.803	0.616	0.342	0.392	0.389	0.375	0.375	0.549
1984	0.187	0.433	0.71	0.591	0.375	0.525	0.469	0.458	0.458	0.527
1985	0.095	0.438	0.676	0.318	0.571	0.474	0.261	0.437	0.437	0.501
1986	0.144	0.58	0.504	0.498	0.358	0.585	0.39	0.446	0.446	0.485
1987	0.08	0.508	0.727	0.748	0.427	0.477	0.425	0.445	0.445	0.602
1988	0.174	0.523	0.493	0.52	0.341	0.348	0.361	0.351	0.351	0.469
1989	0.033	0.392	0.656	0.789	0.602	0.452	0.501	0.521	0.521	0.61
1990	0.101	0.593	0.746	0.572	0.566	0.616	0.531	0.574	0.574	0.619
1991	0.164	0.568	0.784	0.594	0.463	0.409	0.376	0.418	0.418	0.602
1992	0.184	0.631	0.757	0.62	0.548	0.408	0.476	0.48	0.48	0.639
1993	0.154	0.594	0.657	0.608	0.511	0.515	0.453	0.495	0.495	0.593
1994	0.162	0.548	0.804	0.537	0.481	0.397	0.32	0.401	0.401	0.593
1995	0.159	0.59	0.726	0.581	0.472	0.453	0.47	0.467	0.467	0.592
1996	0.181	0.517	0.636	0.668	0.528	0.414	0.577	0.508	0.508	0.587
1997	0.17	0.645	0.687	0.63	0.531	0.666	0.361	0.522	0.522	0.623
1998	0.065	0.446	0.709	0.508	0.442	0.392	0.367	0.402	0.402	0.526
1999	0.172	0.356	0.655	0.559	0.58	0.458	0.425	0.49	0.49	0.538
2000	0.155	0.472	0.615	0.617	0.471	0.457	0.286	0.406	0.406	0.544
2001	0.144	0.55	0.622	0.593	0.331	0.35	0.389	0.358	0.358	0.524
2002	0.325	0.584	0.662	0.668	0.576	0.39	0.292	0.421	0.421	0.623
2003	0.216	0.529	0.51	0.542	0.601	0.605	0.348	0.521	0.521	0.546
2004	0.175	0.54	0.619	0.649	0.653	0.531	0.566	0.54	0.54	0.615
2005	0.221	0.518	0.614	0.64	0.589	0.656	0.755	0.618	0.618	0.59
2006	0.31	0.646	0.597	0.631	0.546	0.472	0.815	0.62	0.62	0.605
2007	0.174	0.585	0.749	0.717	0.734	0.716	0.426	0.756	0.756	0.696

	Fishing mortality-at-age									
year/age	2	3	4	5	6	7	8	9	10+	F(3–6)
2008	0.212	0.482	0.644	0.625	0.62	0.767	0.743	0.347	0.347	0.593
2009	0.161	0.453	0.348	0.314	0.355	0.325	0.365	0.326	0.326	0.368
2010	0.124	0.352	0.495	0.417	0.378	0.334	0.243	0.588	0.588	0.411
2011	0.132	0.332	0.437	0.279	0.228	0.258	0.297	0.254	0.254	0.319
2012	0.024	0.249	0.397	0.382	0.445	0.493	0.413	0.367	0.367	0.368
2013	0.024	0.156	0.33	0.305	0.332	0.467	0.384	0.795	0.795	0.281
2014	0.021	0.137	0.286	0.315	0.33	0.356	0.378	1.005	1.005	0.267
2015	0.01	0.073	0.183	0.28	0.319	0.342	0.246	0.461	0.461	0.214
2016	0.013	0.124	0.279	0.345	0.438	0.395	0.363	0.399	0.399	0.296
2017	0.025	0.121	0.316	0.467	0.45	0.39	0.331	0.55	0.55	0.339
2018	0.026	0.139	0.344	0.422	0.549	0.409	0.296	0.276	0.276	0.363
2019	0.023	0.201	0.348	0.504	0.47	0.635	0.475	0.395	0.395	0.381
2020	0.041	0.218	0.45	0.402	0.451	0.346	0.746	0.377	0.377	0.38

Table 25.7. Plaice in 7.e. Stock numbers-at-age. Numbers are rounded to the nearest thousand.

	Stock numbers-at-age [thousands]									
year/age	2	3	4	5	6	7	8	9	10+	sum
1980	7067	2350	707	696	122	199	82	36	364	11623
1981	6961	5558	1371	397	404	50	118	52	265	15175
1982	3004	5545	2981	693	241	263	26	61	266	13080
1983	6382	2402	3102	1353	372	132	156	8	335	14243
1984	5788	4982	1378	1232	648	235	79	94	143	14579
1985	6959	4260	2865	601	605	395	123	44	154	16006
1986	7233	5611	2437	1293	388	303	218	84	180	17748
1987	14731	5555	2786	1306	697	240	150	131	151	25747
1988	12070	12064	2965	1194	548	403	132	87	186	29650
1989	8717	8994	6342	1606	630	346	253	82	259	27228
1990	3645	7478	5389	2920	647	306	195	136	172	20887
1991	3916	2922	3665	2267	1461	326	147	102	156	14961
1992	4420	2949	1469	1484	1110	816	192	89	137	12666
1993	4976	3262	1392	611	708	569	481	106	229	12334
1994	2311	3783	1597	639	295	377	302	271	200	9775
1995	2322	1743	1939	634	332	162	225	194	249	7799
1996	6723	1757	857	832	314	183	91	125	279	11161
1997	5845	4974	929	402	379	165	108	45	257	13104
1998	9109	4373	2313	415	190	197	75	66	194	16933
1999	4371	7574	2483	1010	221	108	118	46	122	16055
2000	2593	3265	4708	1144	512	110	61	69	165	12625
2001	3717	1970	1806	2256	547	284	62	40	131	10813
2002	3890	2855	1008	860	1106	349	177	37	124	10406
2003	4854	2492	1412	461	391	551	209	117	100	10588
2004	3105	3470	1303	752	238	190	267	131	96	9552
2005	4262	2311	1793	622	348	110	99	134	110	9790
2006	3967	3031	1221	860	291	171	51	41	121	9754
2007	2622	2581	1409	596	406	149	95	20	99	7977

	Stock numbers-at-age [thousands]									
year/age	2	3	4	5	6	7	8	9	10+	sum
2008	5099	1955	1275	591	258	173	65	55	106	9576
2009	4615	3657	1071	594	281	123	71	27	64	10503
2010	6918	3484	2061	671	384	174	79	44	54	13870
2011	9693	5421	2173	1115	392	234	111	55	86	19279
2012	9151	7530	3451	1245	748	277	160	73	120	22755
2013	6093	7924	5209	2057	753	425	150	94	68	22774
2014	6802	5275	6016	3323	1344	479	236	91	59	23624
2015	9216	5906	4079	4010	2152	857	298	144	100	26762
2016	4901	8089	4869	3013	2687	1387	540	206	175	25868
2017	3733	4289	6338	3267	1892	1538	829	333	335	22555
2018	2944	3228	3371	4096	1816	1069	924	528	489	18465
2019	3954	2544	2492	2120	2382	930	630	610	650	16312
2020	9744	3426	1845	1560	1136	1320	437	348	561	20378

Table 25.8. Plaice in 7.e. Assessment summary (raw values, not standardised, following ICES rounding rules).

Year	Recruitment (age 2) [thousands]	SSB [tonnes]	Landings [tonnes]	Discards [tonnes]	Fbar(3–6)
1980	7067	2512	1178		0.52
1981	6961	2983	1676		0.44
1982	3004	3252	1878		0.53
1983	6382	3139	1714		0.55
1984	5788	3135	1758		0.53
1985	6959	3189	1677		0.5
1986	7233	3747	2078		0.49
1987	14731	4366	2272		0.6
1988	12070	4746	2835		0.47
1989	8717	5153	2742		0.61
1990	3645	4987	2985		0.62
1991	3916	4059	2183		0.6
1992	4420	3447	1882		0.64
1993	4976	2985	1614		0.59
1994	2311	2555	1404		0.59
1995	2322	2308	1247		0.59
1996	6723	2266	1266		0.59
1997	5845	2384	1583		0.62
1998	9109	2463	1346		0.53
1999	4371	2727	1543		0.54
2000	2593	2958	1626		0.54
2001	3717	2654	1310		0.52
2002	3890	2433	1472		0.62
2003	4854	2475	1387		0.55
2004	3105	2263	1337		0.62
2005	4262	2181	1319		0.59
2006	3967	2079	1411		0.61
2007	2622	1772	1146		0.7

Year	Recruitment (age 2) [thousands]	SSB [tonnes]	Landings [tonnes]	Discards [tonnes]	Fbar(3–6)
2008	5099	1867	1112		0.59
2009	4615	2036	1024		0.37
2010	6918	2592	1207		0.41
2011	9693	3329	1417		0.32
2012	9151	4168	1492	448	0.37
2013	6093	4866	1472	351	0.28
2014	6802	5164	1490	1133	0.27
2015	9216	6344	1424	1276	0.21
2016	4901	6991	2013	618	0.3
2017	3733	6558	2128	821	0.34
2018	2944	5762	1880	633	0.36
2019	3954	4912	1725	366	0.38
2020	9744	4116	1373	514	0.38
2021	5244*	4369			

*** geometric mean of time-series.**

Table 25.9. Plaice in 7.e. Assessment summary (relative values).

Year	Recruitment (age 2) [relative]	SSB [relative]	Landings [tonnes]	Discards [tonnes]	Fbar(3–6) [relative]
1980	1.22	0.71	1178		1.03
1981	1.2	0.84	1676		0.88
1982	0.52	0.92	1878		1.06
1983	1.1	0.89	1714		1.1
1984	1	0.89	1758		1.06
1985	1.2	0.9	1677		1
1986	1.24	1.06	2078		0.97
1987	2.5	1.24	2272		1.21
1988	2.1	1.34	2835		0.94
1989	1.5	1.46	2742		1.22
1990	0.63	1.41	2985		1.24
1991	0.67	1.15	2183		1.21
1992	0.76	0.98	1882		1.28
1993	0.86	0.85	1614		1.19
1994	0.4	0.72	1404		1.19
1995	0.4	0.65	1247		1.19
1996	1.16	0.64	1266		1.18
1997	1.01	0.68	1583		1.25
1998	1.57	0.7	1346		1.05
1999	0.75	0.77	1543		1.08
2000	0.45	0.84	1626		1.09
2001	0.64	0.75	1310		1.05
2002	0.67	0.69	1472		1.25
2003	0.83	0.7	1387		1.09
2004	0.53	0.64	1337		1.23
2005	0.73	0.62	1319		1.18
2006	0.68	0.59	1411		1.21

Year	Recruitment (age 2) [relative]	SSB [relative]	Landings [tonnes]	Discards [tonnes]	Fbar(3–6) [relative]
2007	0.45	0.5	1146		1.4
2008	0.88	0.53	1112		1.19
2009	0.79	0.58	1024		0.74
2010	1.19	0.73	1207		0.82
2011	1.67	0.94	1417		0.64
2012	1.57	1.18	1492	448	0.74
2013	1.05	1.38	1472	351	0.56
2014	1.17	1.46	1490	1133	0.53
2015	1.58	1.8	1424	1276	0.43
2016	0.84	1.98	2013	618	0.59
2017	0.64	1.86	2128	821	0.68
2018	0.51	1.63	1880	633	0.73
2019	0.68	1.39	1725	366	0.76
2020	1.68	1.17	1373	514	0.76
2021	0.9*	1.24			

*** geometric mean of time-series (before standardisation).**

Table 25.10. Plaice in 7e. The basis for the catch options for 2020. Note that one catch option is provided for stocks in ICES data categories 3–6. The values presented here are the values presented during the working group.

Division 7.e plaice stock		
Index A (2020–2021)	1.20	
Index B (2017–2019)	1.63	
Index ratio (A/B)	0.74	
Uncertainty cap	Applied	0.8
Advised catch for 2021	2177 tonnes	
Discard rate (2012–2020)	0.28	
Precautionary buffer	Not applied (last applied in 2019)	-
Catch advice **	1742 tonnes	
Projected landings corresponding to advice ***	1250 tonnes	
% advice change (plaice Division 7.e stock) ^	−20	
Plaice in Division 7.e		
Proportion of Division 7.e stock landings caught in Division 7.e (2003–2020)	0.90	
Catch of plaice in Division 7.e corresponding to the advice for the stock	1572 tonnes	
Projected landings of plaice in Division 7.e corresponding to the advice for the stock ***	1128 tonnes	

*** The figures in the table are rounded. Calculations were done with unrounded inputs and computed values may not match exactly when calculated using the rounded figures in the table.**

**** [advised catch for 2021] × [uncertainty cap].**

***** [advised catch for 2022] × [1 – discard rate].**

^ Advice value for 2022 relative to the advice value for 2021.

Table 25.11a. Plaice in 7e. Results of the SPiCT model fit. Landings only assessment.

```
Convergence: 0  MSG: both X-convergence and relative convergence (5)
Objective function at optimum: 1.2164517
Euler time step (years):  1/16 or 0.0625
Nobs C: 41,  Nobs I1: 15,  Nobs I2: 18

Residual diagnostics (p-values)
    shapiro   bias    acf   LBox shapiro bias acf LBox
 C   0.0259 0.1870 0.2501 0.2778       *    -   -    -
 I1  0.6236 0.9374 0.3075 0.6187       -    -   -    -
 I2  0.6879 0.9537 0.2578 0.5082       -    -   -    -

Priors
     logn  ~  dnorm[log(2), 2^2]
 logalpha  ~  dnorm[log(1), 2^2]
  logbeta  ~  dnorm[log(1), 2^2]

Model parameter estimates w 95% CI
            estimate       cilow        ciupp    log.est
 alpha1 3.310829e+00   0.7383356 1.484635e+01  1.1971986
 alpha2 2.152436e+00   0.4013284 1.154411e+01  0.7666001
 beta   1.630910e-01   0.0383977 6.927157e-01 -1.8134472
 r      1.336075e-01   0.0029642 6.022251e+00 -2.0128490
 rc     7.700694e-01   0.0300557 1.973029e+01 -0.2612747
 rold   2.046060e-01   0.0033448 1.251593e+01 -1.5866691
 m      2.418855e+03 923.5332549 6.335299e+03  7.7910495
 K      3.177207e+04 330.5612832 3.053788e+06 10.3663428
 q1     3.341633e-01   0.1885510 5.922275e-01 -1.0961256
 q2     1.031700e-03   0.0005902 1.803300e-03 -6.8765683
 n      3.470012e-01   0.1886382 6.383109e-01 -1.0584271
 sdb    1.035510e-01   0.0240011 4.467632e-01 -2.2676909
 sdf    2.144496e-01   0.1543492 2.979519e-01 -1.5396805
 sdi1   3.428397e-01   0.2314337 5.078735e-01 -1.0704923
 sdi2   2.228869e-01   0.1382212 3.594135e-01 -1.5010908
 sdc    3.497480e-02   0.0088646 1.379912e-01 -3.3531278

Deterministic reference points (Drp)
           estimate       cilow        ciupp    log.est
 Bmsyd 6282.1737915  95.0074362 4.153960e+05  8.7454713
 Fmsyd    0.3850347   0.0150278 9.865144e+00 -0.9544218
 MSYd  2418.8548624 923.5332549 6.335299e+03  7.7910495
Stochastic reference points (Srp)
           estimate       cilow        ciupp    log.est rel.diff.Drp
 Bmsys 6236.4407957  96.6150518 4.025583e+05  8.7381649 -0.007333188
 Fmsys    0.3866857   0.0153594 9.735128e+00 -0.9501431  0.004269633
 MSYs  2411.6178992 926.7844852 6.275354e+03  7.7880531 -0.003000875

States w 95% CI (inp$msytype: s)
                   estimate       cilow       ciupp   log.est
 B_2020.94      482.0825770 213.1632864 1090.260969  6.178115
 F_2020.94        2.7868810   1.2496634    6.215038  1.024923
 B_2020.94/Bmsy   0.0773009   0.0012221    4.889323 -2.560049
 F_2020.94/Fmsy   7.2070963   0.2921933  177.766667  1.975066

Predictions w 95% CI (inp$msytype: s)
                 prediction        cilow       ciupp   log.est
 B_2022.00       516.713988  187.6840411 1422.568183  6.247490
 F_2022.00         2.786882    1.1200065    6.934521  1.024923
 B_2022.00/Bmsy    0.082854    0.0012313    5.575177 -2.490675
 F_2022.00/Fmsy    7.207098    0.2837995  183.024496  1.975066
 Catch_2021.00  1409.129973 1187.9968369 1671.424720  7.250728
 E(B_inf)        525.113893           NA          NA  6.263615
```

Table 25.11b. Plaice in 7e. Results of the SPiCT model fit. Total catch (including discards) assessment.

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: -1.9898578
Euler time step (years):  1/16 or 0.0625
Nobs C: 41,  Nobs I1: 15,  Nobs I2: 18

Residual diagnostics (p-values)
    shapiro   bias    acf   LBox shapiro bias acf LBox
 C   0.4111 0.8541 0.4522 0.7991       -    -   -    -
 I1  0.8384 0.8813 0.2793 0.6069       -    -   -    -
 I2  0.9294 0.9412 0.2444 0.5420       -    -   -    -

Priors
     logn  ~  dnorm[log(2), 2^2]
 logalpha  ~  dnorm[log(1), 2^2]
  logbeta  ~  dnorm[log(1), 2^2]

Model parameter estimates w 95% CI
            estimate       cilow        ciupp    log.est
 alpha1 3.496769e+00   0.6731552 1.816431e+01  1.2518395
 alpha2 1.215796e+00   0.1991223 7.423377e+00  0.1953990
 beta   3.305130e-01   0.1564286 6.983304e-01 -1.1071094
 r      1.551547e-01   0.0032943 7.307471e+00 -1.8633326
 rc     6.298561e-01   0.0165823 2.392428e+01 -0.4622639
 rold   3.058243e-01   0.0052507 1.781241e+01 -1.1847446
 m      9.204927e+03 723.8572647 1.170544e+05  9.1274942
 K      1.179816e+05 222.6631633 6.251443e+07 11.6782840
 q1     5.752891e-01   0.4102163 8.067878e-01 -0.5528827
 q2     1.823200e-03   0.0013744 2.418500e-03 -6.3071790
 n      4.926671e-01   0.3845780 6.311357e-01 -0.7079215
 sdb    1.084274e-01   0.0214813 5.472906e-01 -2.2216747
 sdf    1.641706e-01   0.1152656 2.338251e-01 -1.8068488
 sdi1   3.791455e-01   0.2594905 5.539753e-01 -0.9698352
 sdi2   1.318256e-01   0.0687726 2.526875e-01 -2.0262757
 sdc    5.426050e-02   0.0295883 9.950560e-02 -2.9139583

Deterministic reference points (Drp)
           estimate       cilow        ciupp   log.est
 Bmsyd 29228.667577  62.5021504 1.366857e+07 10.282905
 Fmsyd     0.314928   0.0082911 1.196214e+01 -1.155411
 MSYd   9204.927038 723.8572647 1.170544e+05  9.127494
Stochastic reference points (Srp)
           estimate       cilow        ciupp   log.est rel.diff.Drp
 Bmsys 2.893560e+04  63.8603036 1.311095e+07 10.272828 -0.010128169
 Fmsys 3.163671e-01   0.0084778 1.180593e+01 -1.150852  0.004548698
 MSYs  9.154694e+03 729.6991164 1.148534e+05  9.122022 -0.005487167

States w 95% CI (inp$msytype: s)
                   estimate       cilow      ciupp   log.est
 B_2020.94      237.1546355 156.3729527 359.667834  5.468712
 F_2020.94        6.9497649   4.9117416   9.833423  1.938708
 B_2020.94/Bmsy   0.0081959   0.0000198   3.398144 -4.804116
 F_2020.94/Fmsy  21.9674089   0.6524676 739.603038  3.089560

Predictions w 95% CI (inp$msytype: s)
                  prediction        cilow       ciupp   log.est
 B_2022.00       229.4273462  110.3181337  477.137397  5.435586
 F_2022.00         6.9497659    4.3000684   11.232204  1.938708
 B_2022.00/Bmsy    0.0079289    0.0000184    3.408173 -4.837242
 F_2022.00/Fmsy   21.9674123    0.6423637  751.236762  3.089560
 Catch_2021.00  1604.9793136 1307.5024123 1970.136784  7.380866
 E(B_inf)        231.5060427           NA          NA  5.444606
```

25.19 Figures

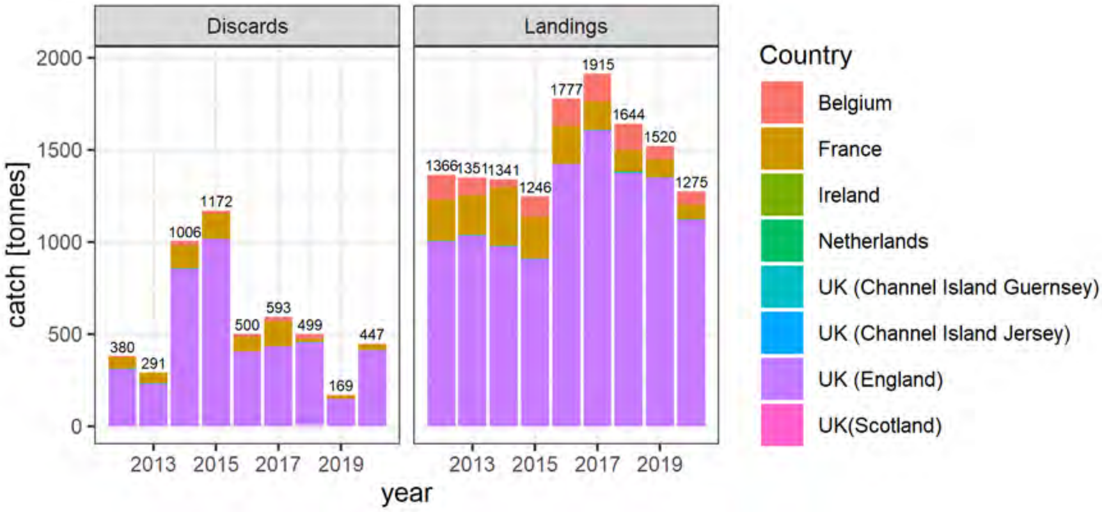

Figure 25.1. Plaice in 7.e. International landings and discards by country as extracted from InterCatch.

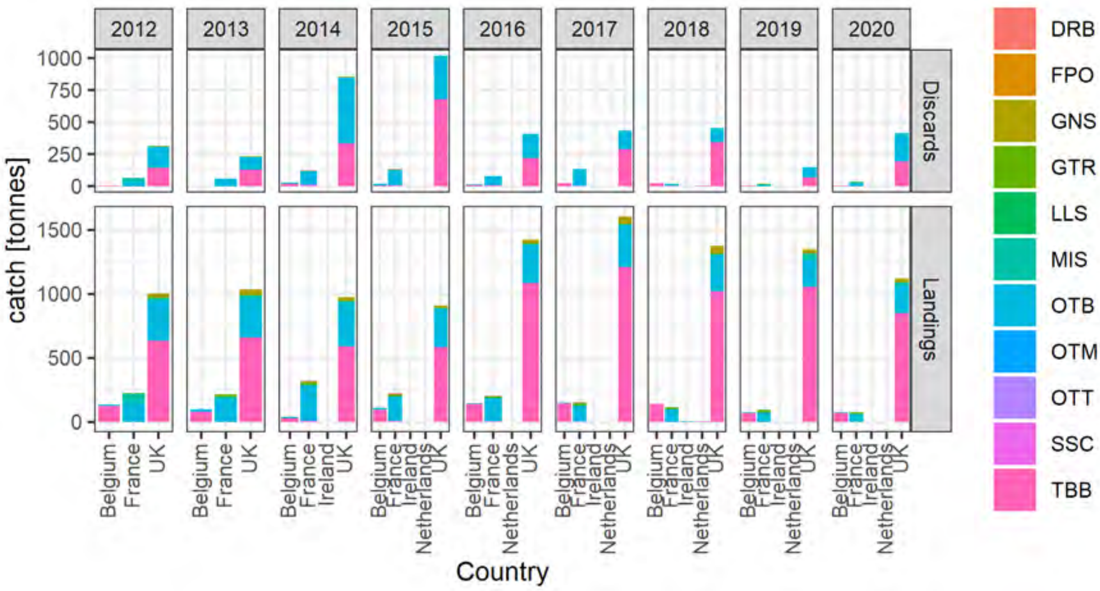

Figure 25.2. Plaice in 7.e. International landings and discards reported to InterCatch per country and fleet.

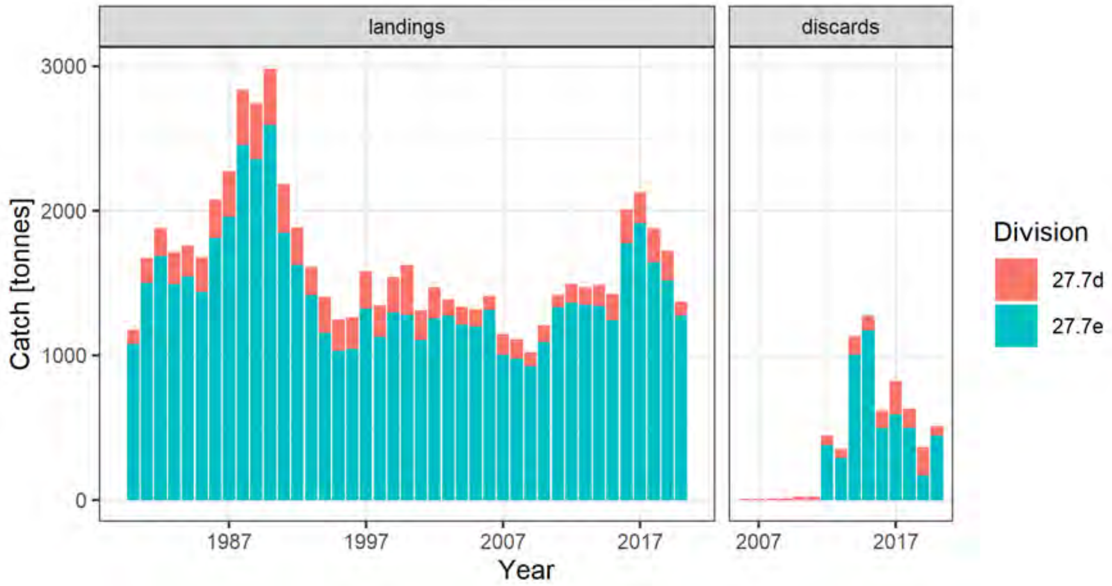

Figure 25.3. Plaice in 7.e. Landings and discards of the plaice 7.e stock disaggregated by the 7.e and the migration component from 7.d. Discard data are only available starting from 2012 for the Division 7.e.

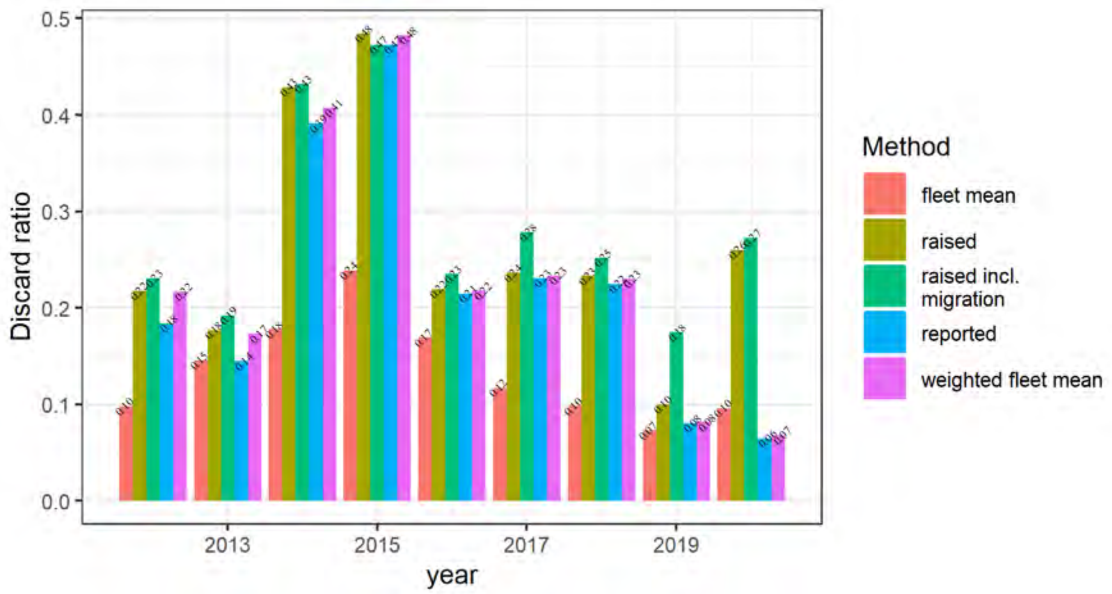

Figure 25.4. Plaice in 7.e. Discard ratios for 2012–2019. "Fleet mean" is the mean of the ratios for all fleets which reported discards, "reported" is the proportion of reported discards in the reported catches, "weighted fleet mean" is the mean of the ratios for all fleets which reported discards weighted by the catch of the individual fleets, "raised" is the proportion of the discards as raised within InterCatch in the total catch for 7.e and "raised incl. migration" includes the catch (discards and landings) from Division 7.d used in the migration correction.

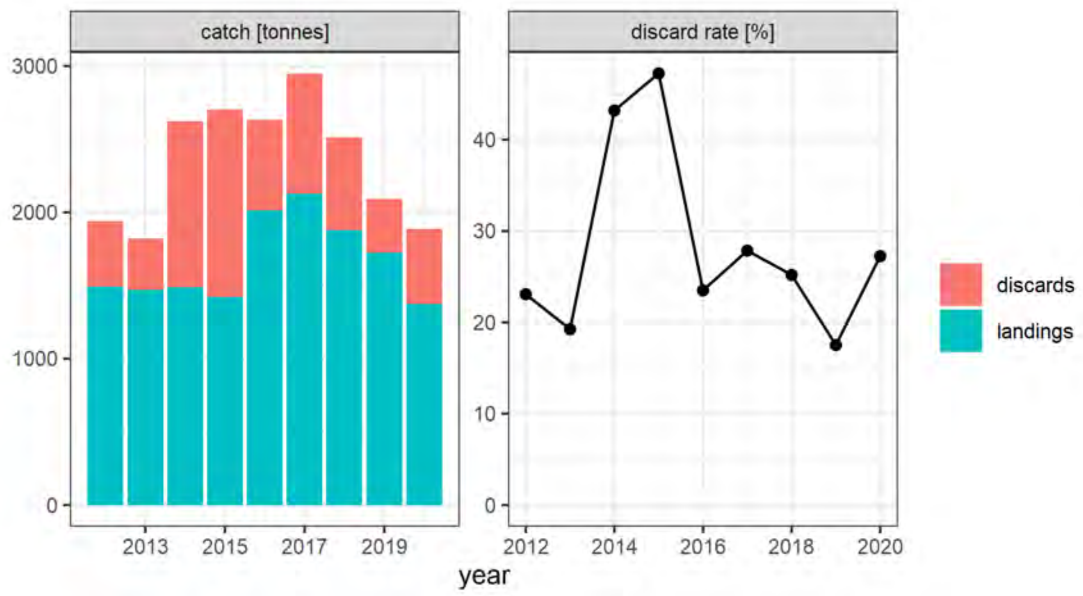

Figure 25.5. Plaice in 7.e. Landings, Discards and discard rate.

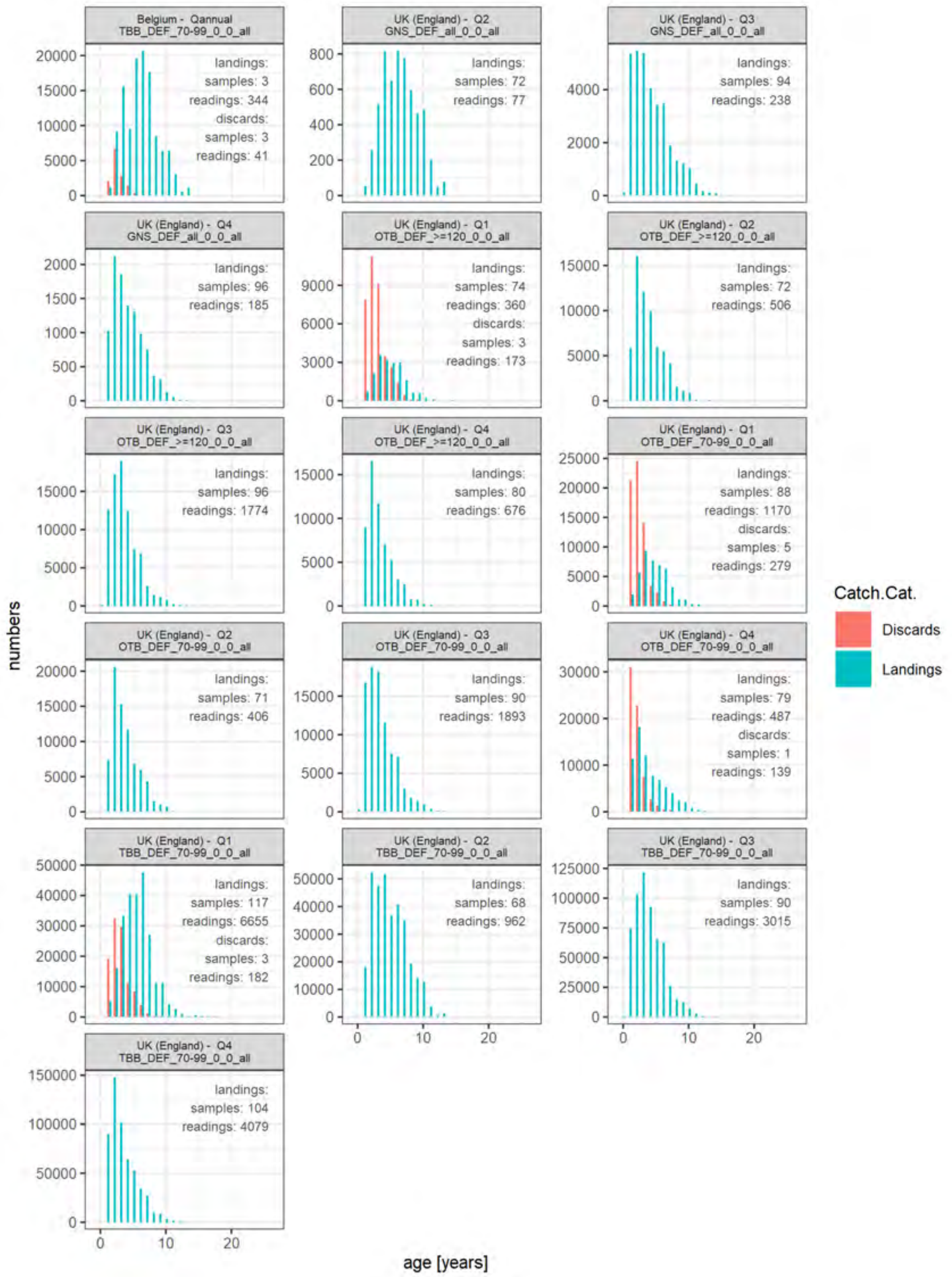

Figure 25.6. Plaice in 7.e. Age samples from InterCatch. The numbers are raised to fleet level.

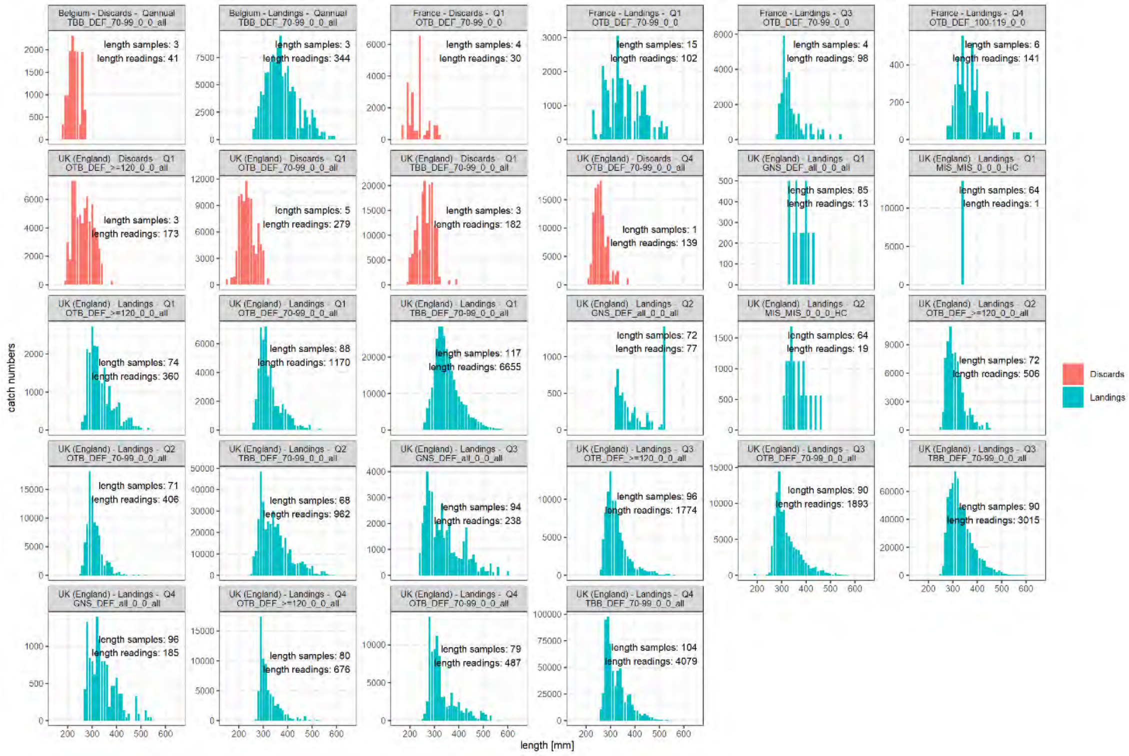

Figure 25.7. Plaice in 7.e. Length samples from InterCatch. The numbers are raised to fleet level.

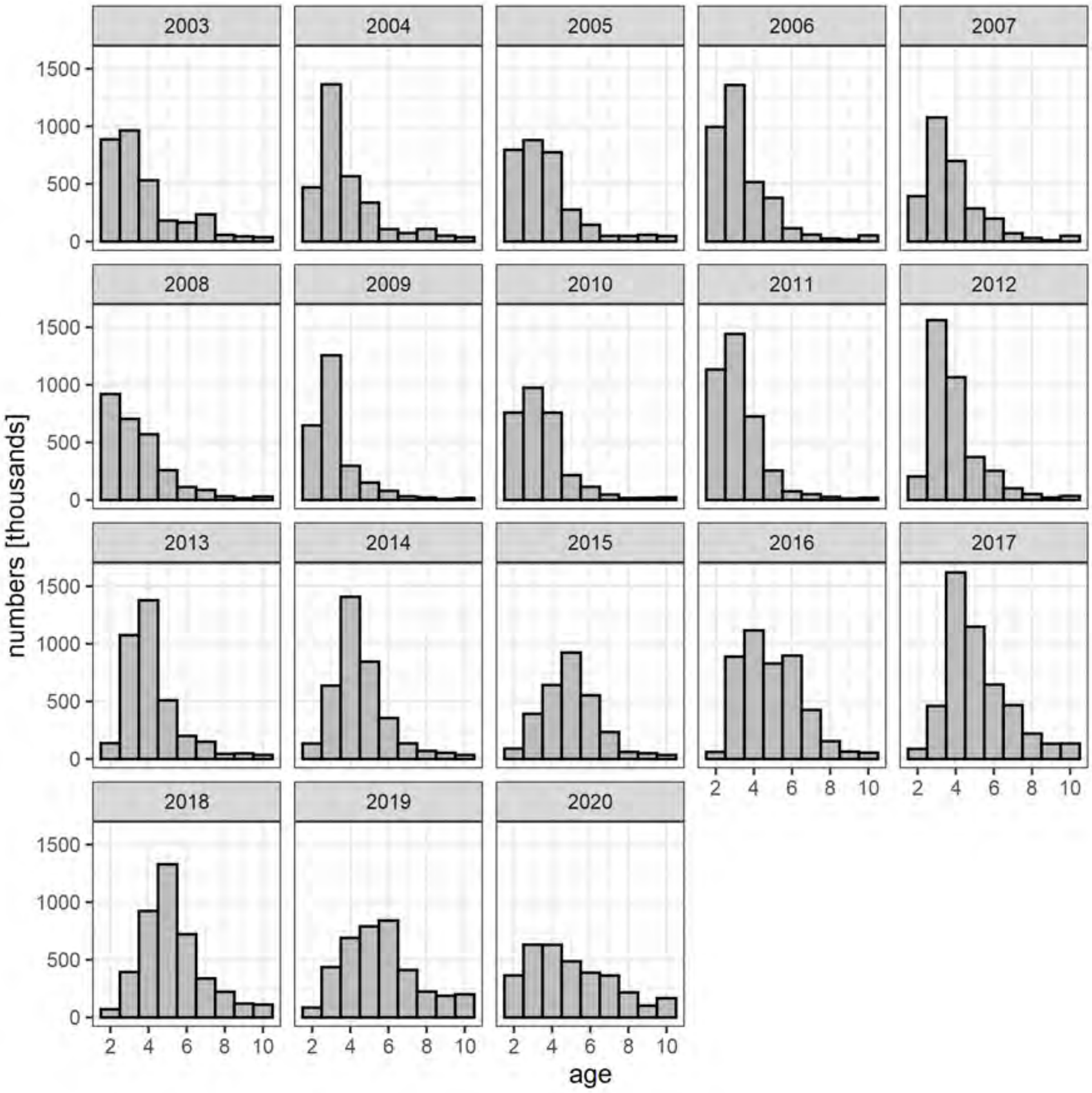

Figure 25.8. Plaice in 7.e. Landings age distribution.

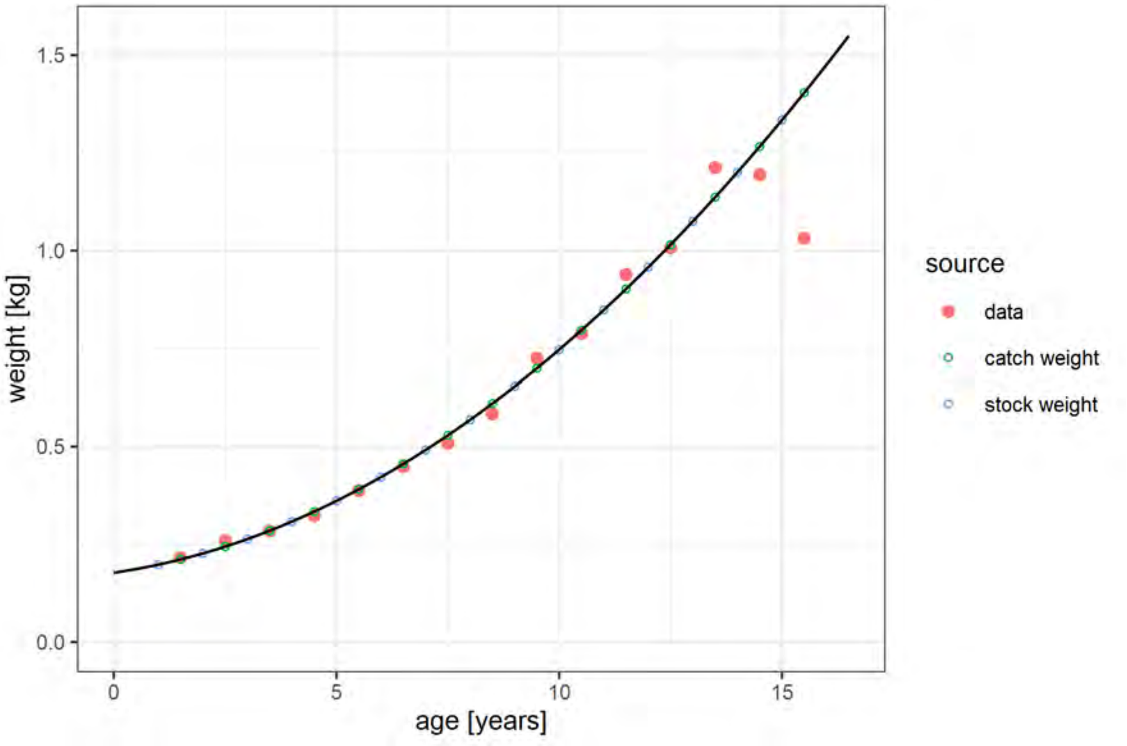

Figure 25.9. Plaice in 7.e. Derivation of the 2019 stock and catch (landings) weights by applying a polynomial model to the raw InterCatch weights-at-age.

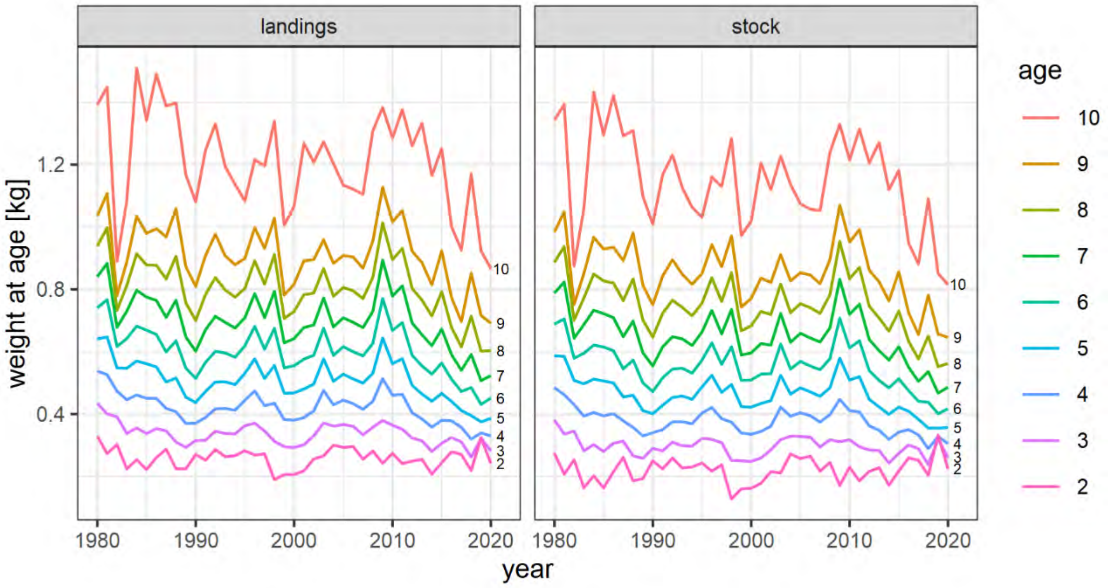

Figure 25.10. Plaice in 7.e. Landings and stock weights-at-age used in the assessment.

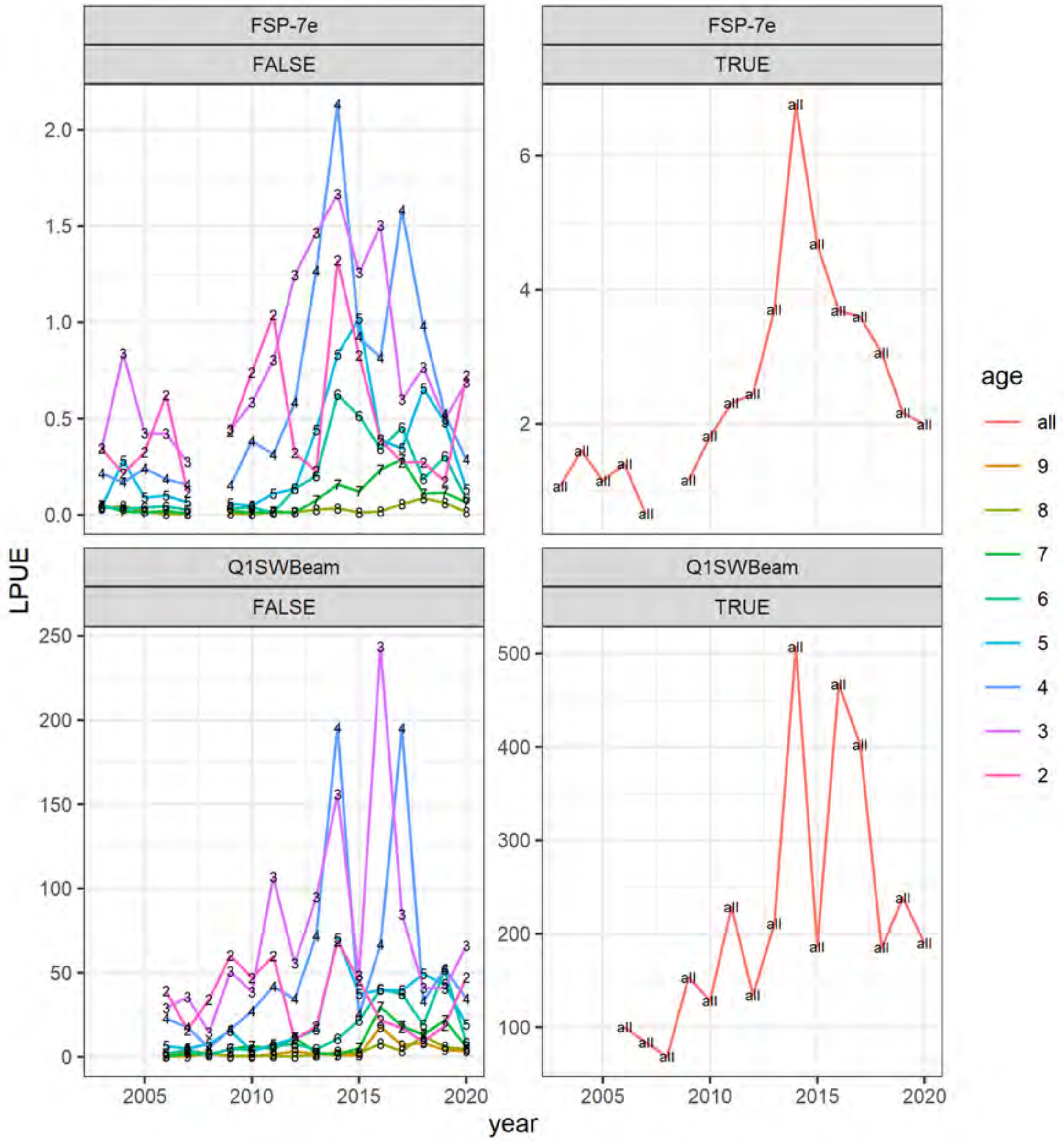

Figure 25.11. Plaice in 7.e. Scientific tuning information used in the assessment including sum over all ages (right side).

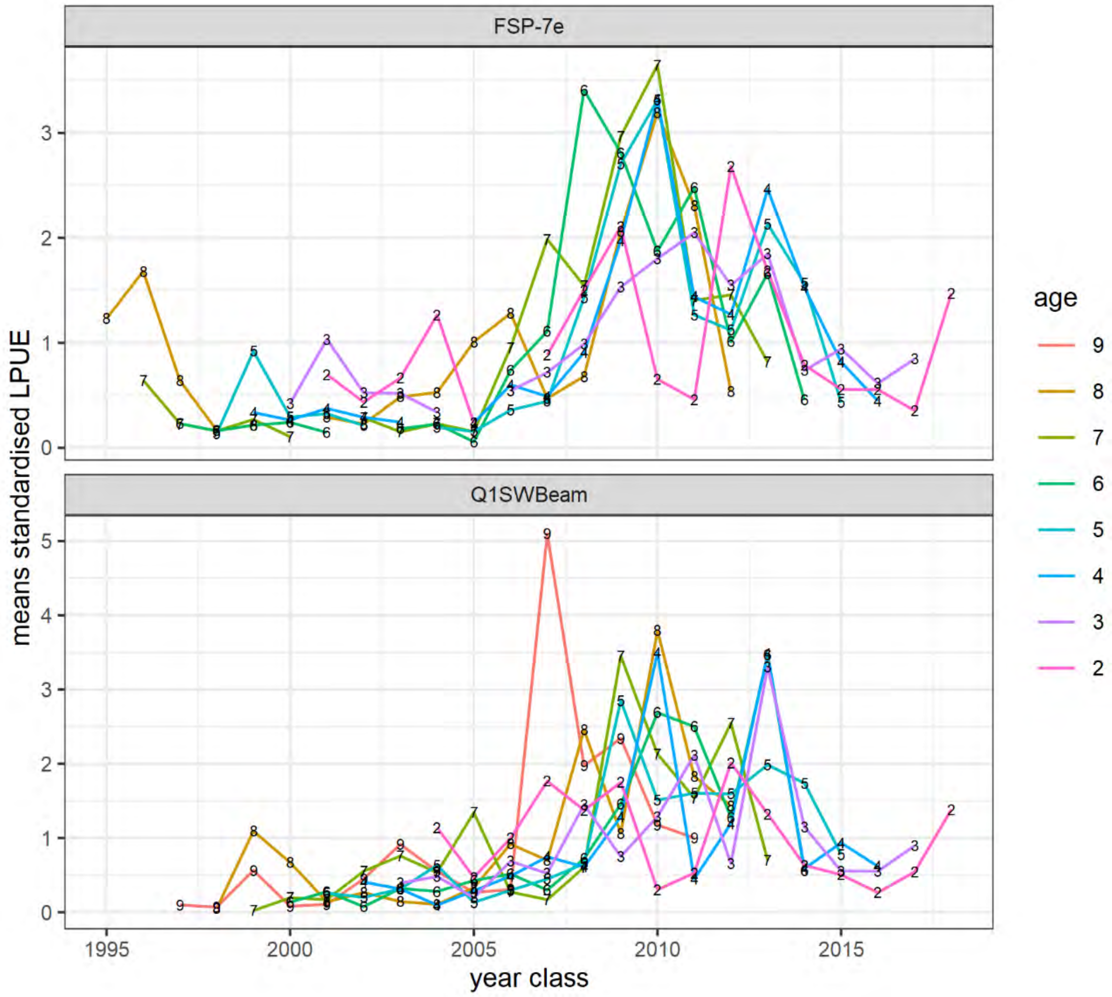

Figure 25.12. Plaice in 7.e. Scientific tuning information used in the assessment standardised and cohort wise.

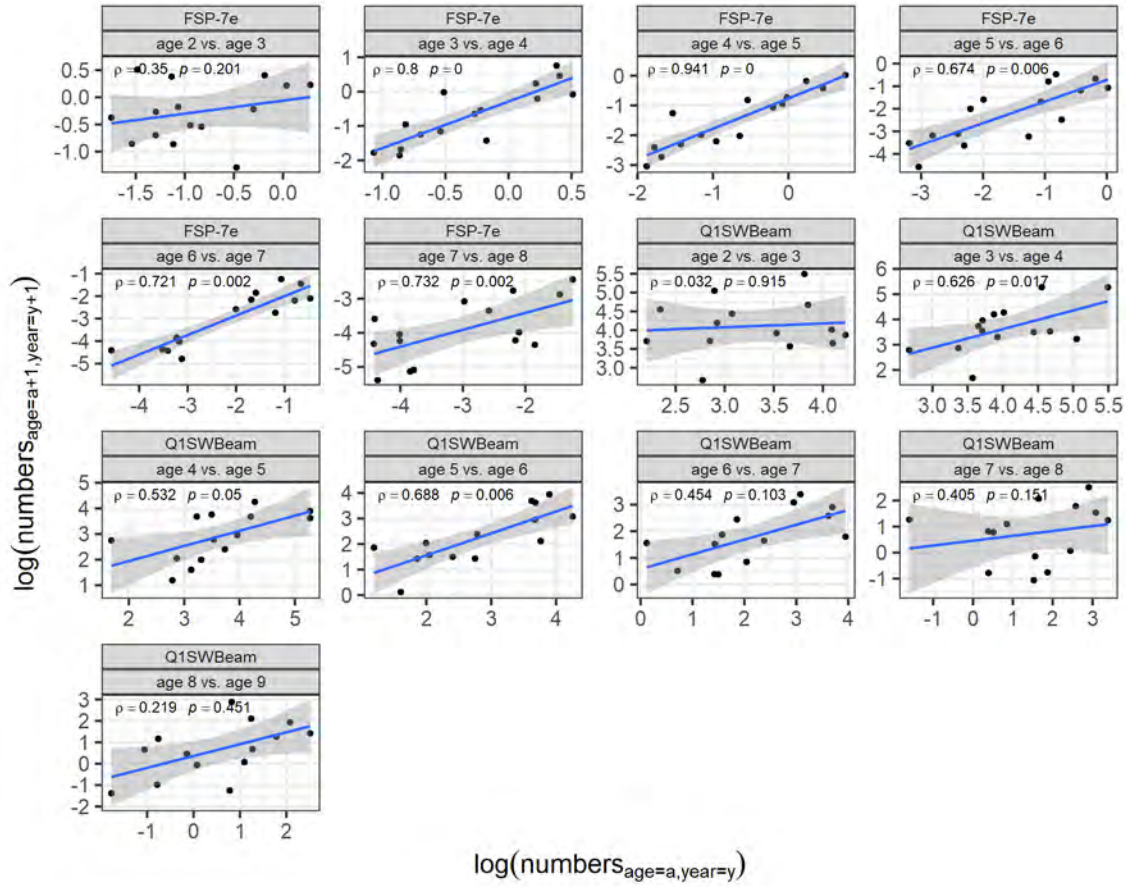

Figure 25.13. Plaice in 7.e. Internal consistency of the two survey time-series including correlation analysis.

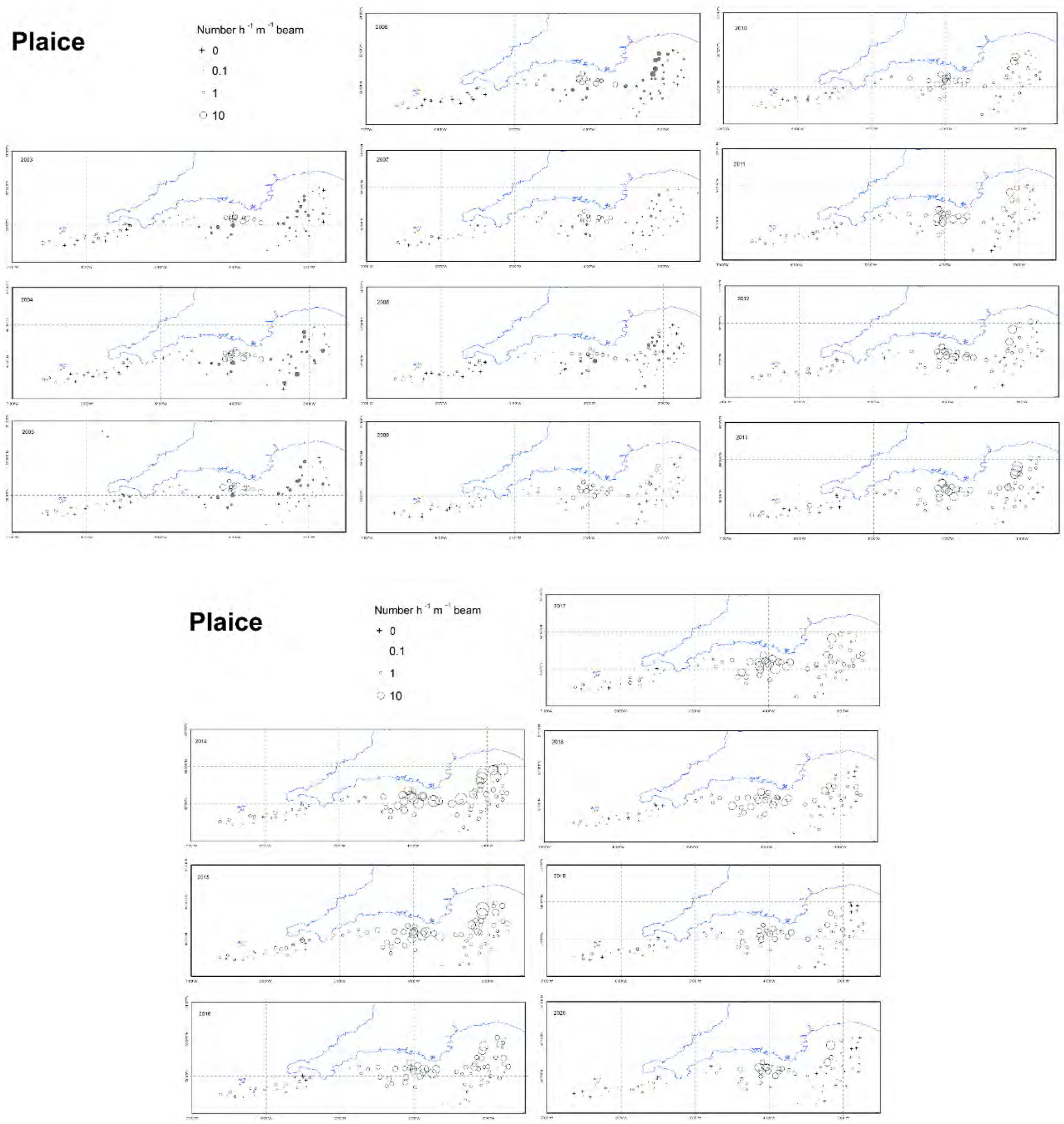

Figure 25.14. Plaice in Division 7.e. Plaice catch rates during FSP "Western Channel Sole and Plaice" surveys, 2003–2020 (number h^{-1} m $beam^{-1}$). Open circles: FV Nellie and FV Carhelmar tows; filled circles: FV Lady T Emiel tows. Source: Burt *et al*. (2021).

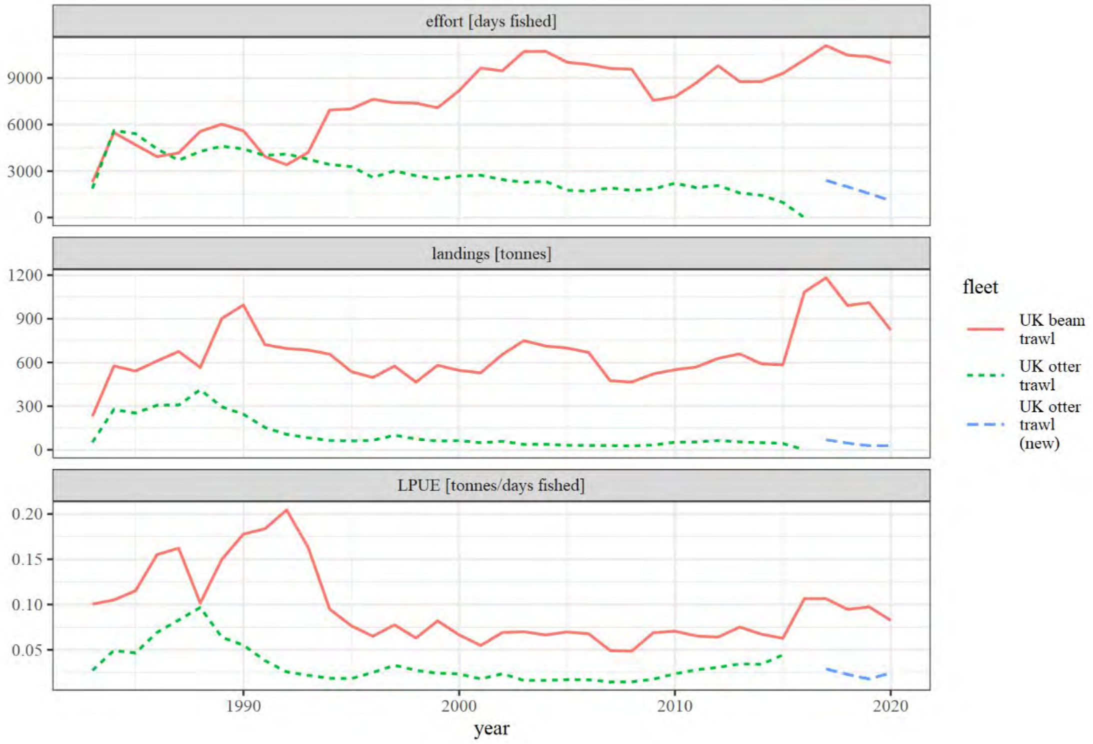

Figure 25.15. UK commercial lpue time-series. Lpue values are only shown for historical reasons but were not used in the assessment.

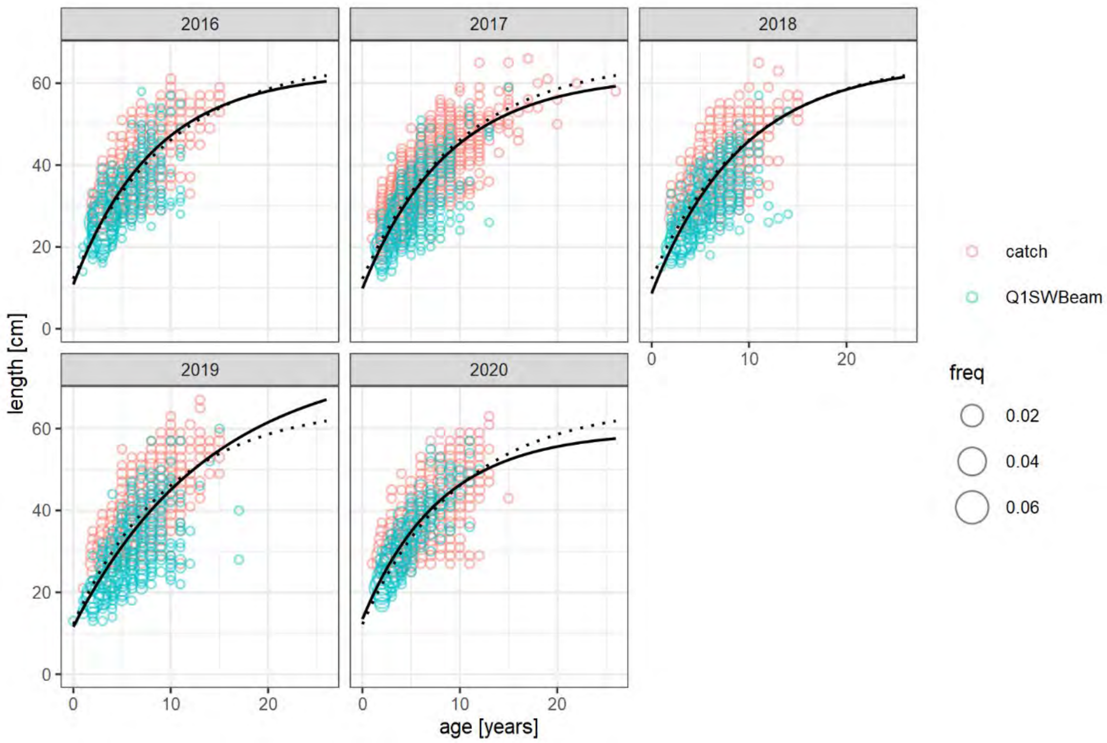

Figure 25.16. Plaice in 7.e. Age–length keys for the past five years. The red circles represent data from sampling of the UK commercial catches and blue/green circles represent the fish aged from the Q1SWBeam survey. Solid black lines indicate annual fits of a von Bertalanffy growth function, dotted lines a fit to the combined data from all years.

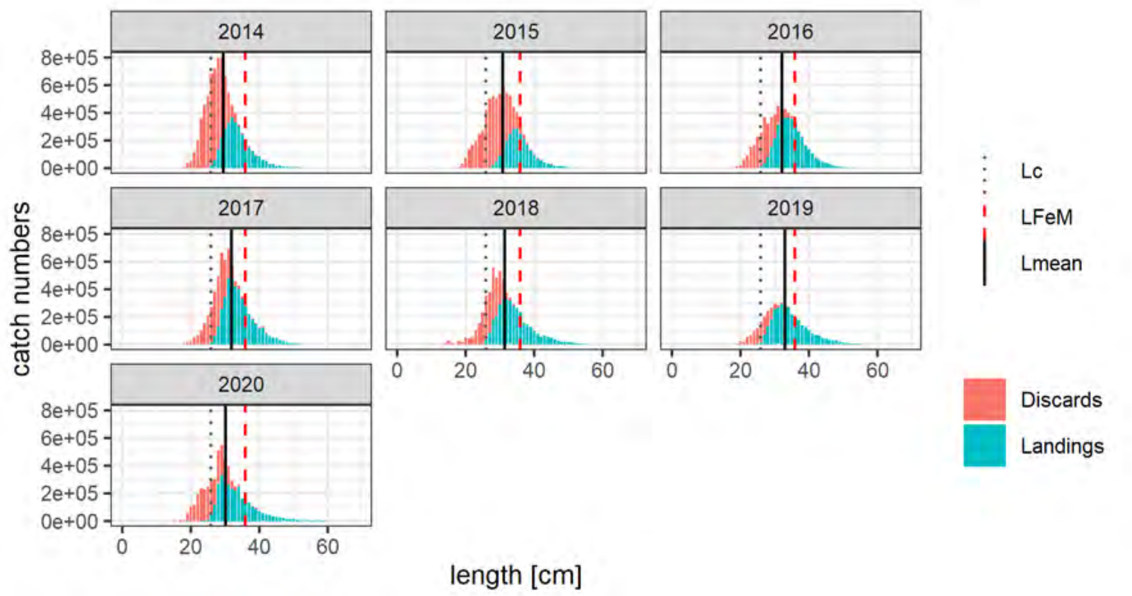

Figure 25.17. Plaice in 7.e. Total international length frequencies for 2014–2019 as raised within InterCatch for landings and discards including Length of first capture (Lc, calculated as first length class where the abundance is bigger or equal to half of maximum abundance) and mean length in the catch (Lmean, mean length above Lc).

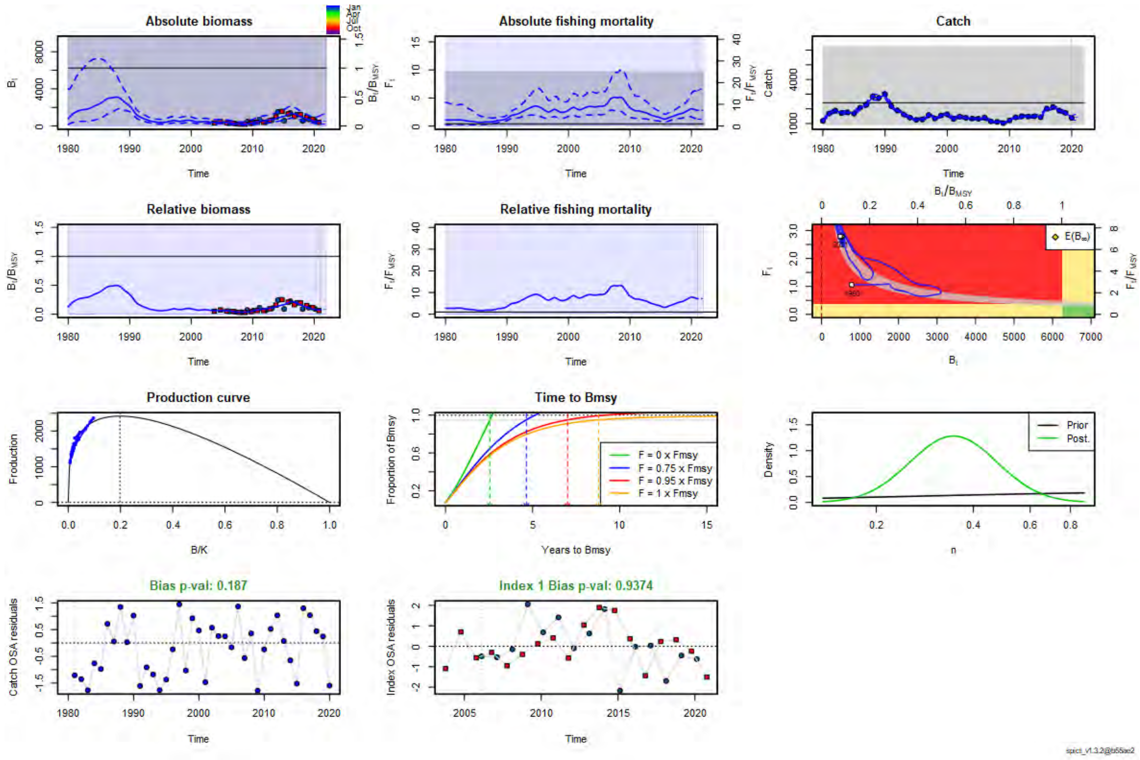

Figure 25.18a. Plaice in 7.e. Results of fitting a SPiCT model to the plaice 7.e stock. Landings only assessment.

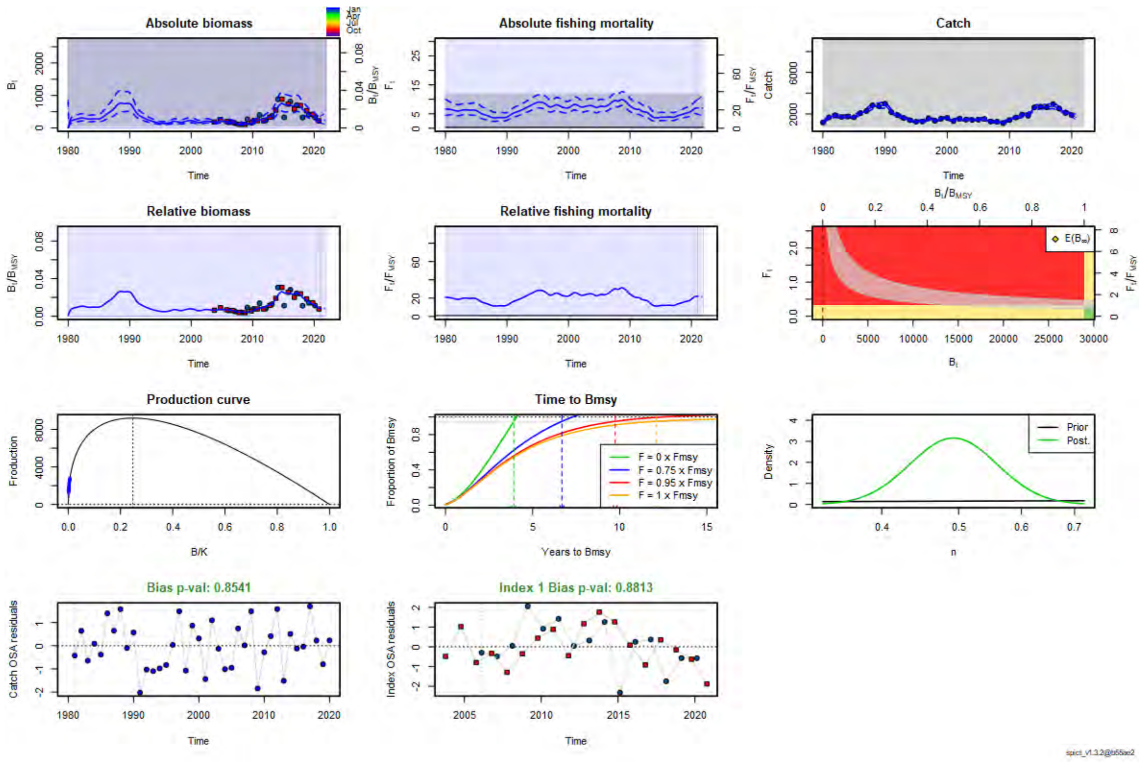

Figure 25.18b. Plaice in 7.e. Results of fitting a SPiCT model to the plaice 7.e stock. Total catch (including discards) assessment.

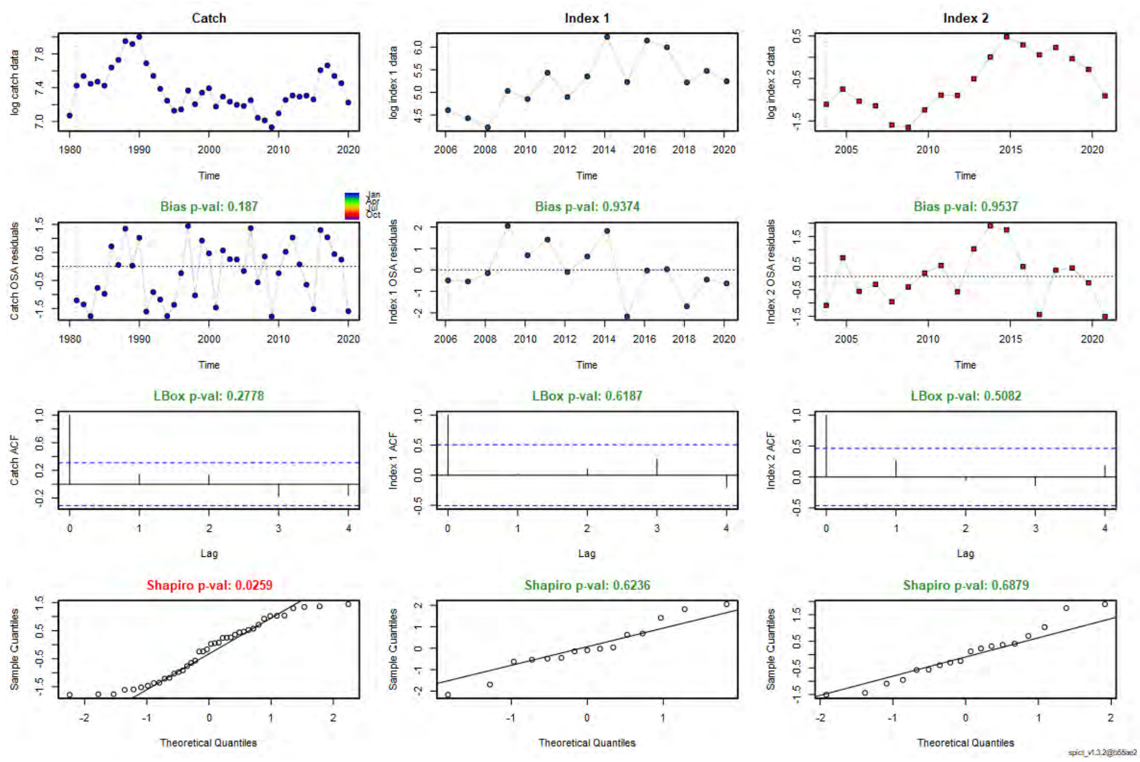

Figure 25.19a. Plaice in 7.e. Diagnostic plots of the SPiCT fit. Landings only assessment.

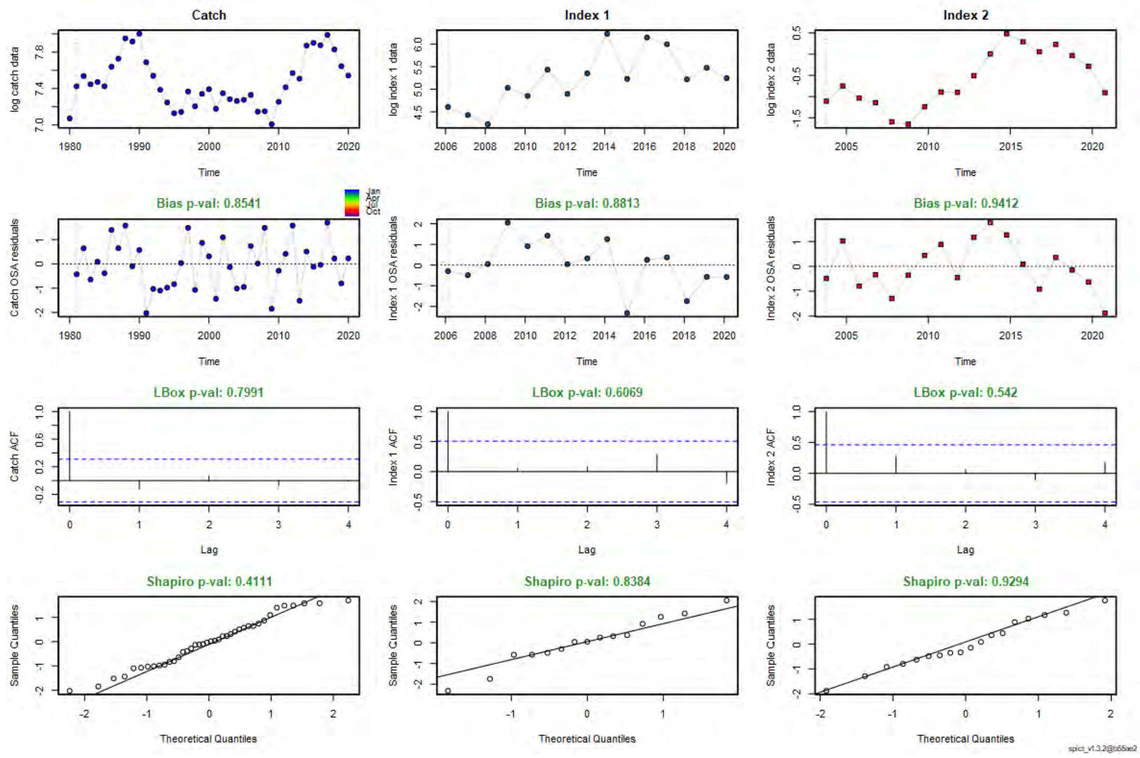

Figure 25.19b. Plaice in 7.e. Diagnostic plots of the SPiCT fit. Total catch (including discards) assessment.

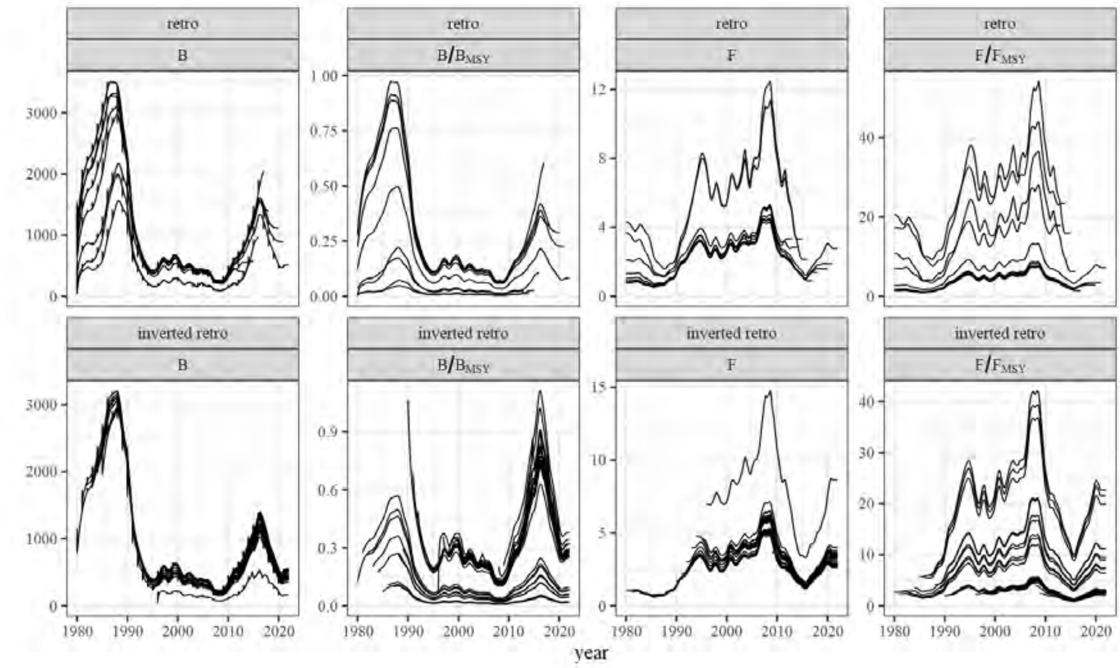

Figure 25.20a. Plaice in 7.e. Retrospective and inverted retrospective SPiCT analysis. Landings only assessment.

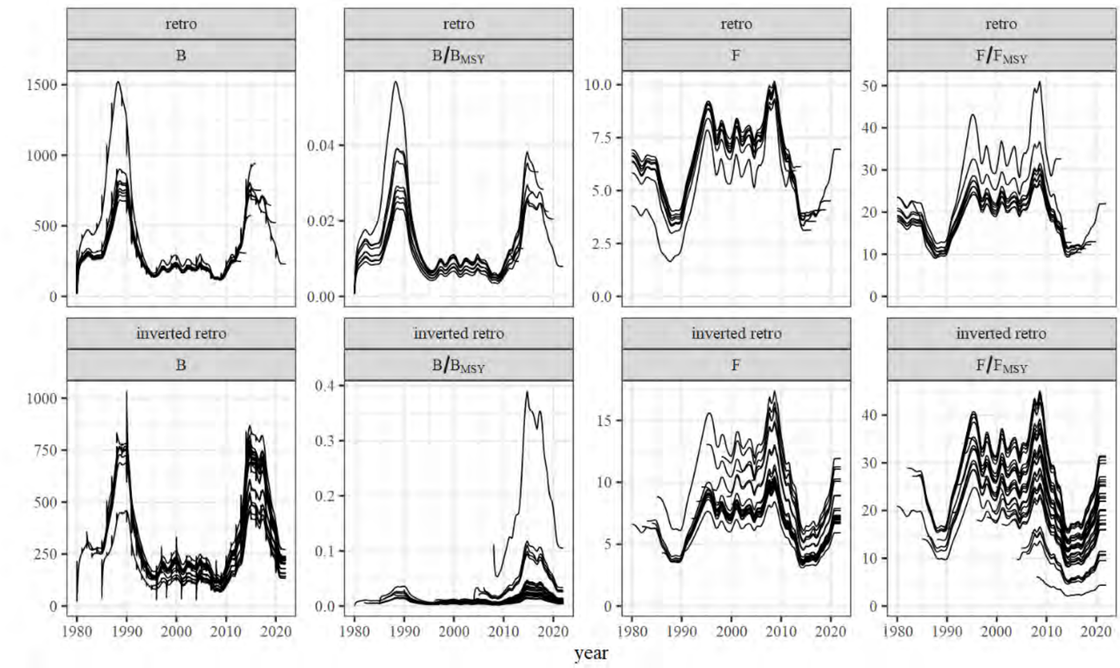

Figure 25.20b. Plaice in 7.e. Retrospective and inverted retrospective SPiCT analysis. Total catch (including discards) assessment.

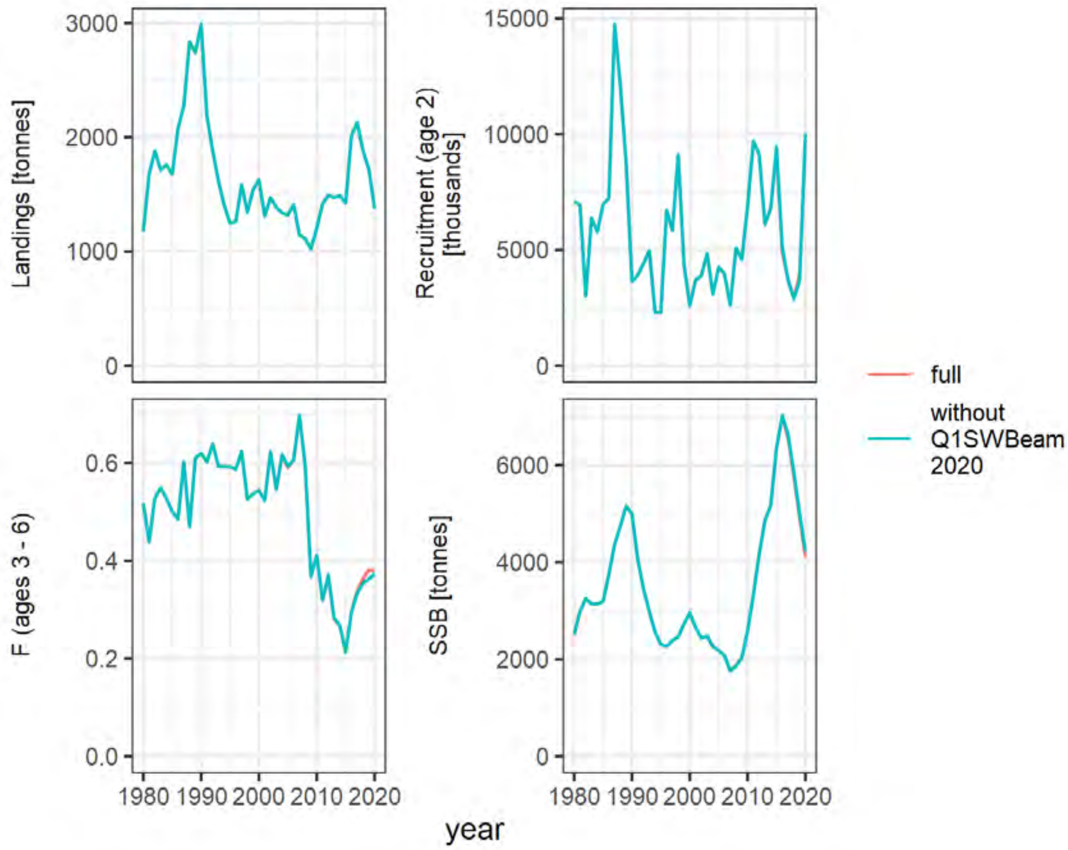

Figure 25.21. Plaice in 7.e. Impact of excluding the 2020 Q1SWBeam index values on the stock assessment.

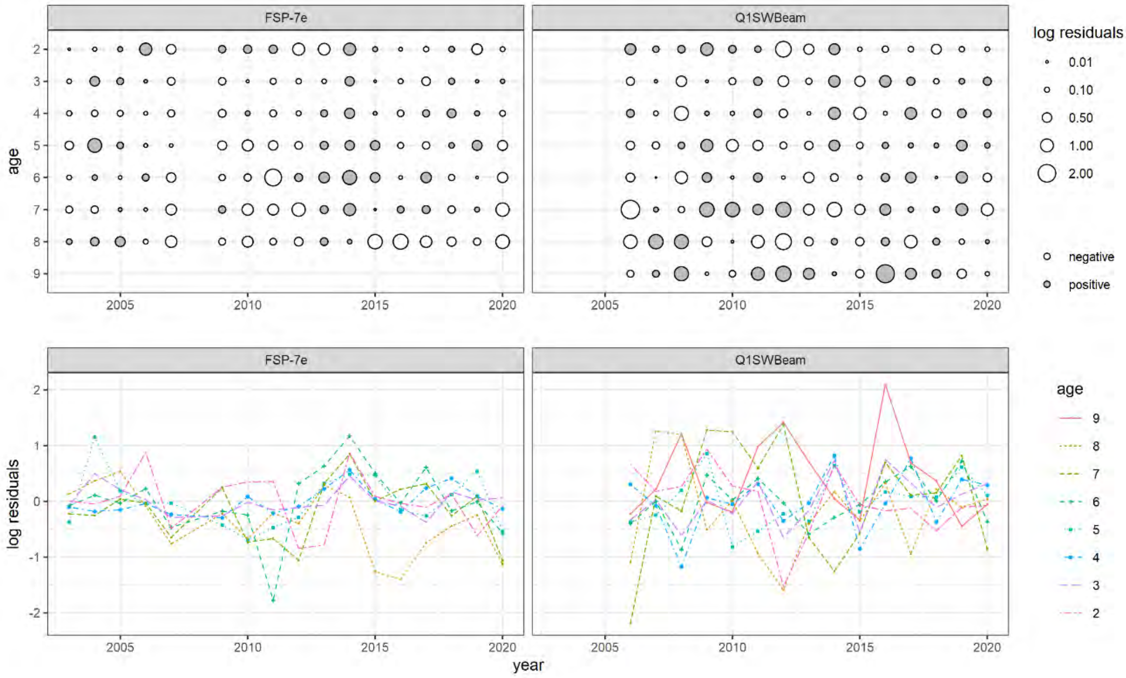

Figure 25.22. Plaice in 7.e. XSA survey log catchability residuals.

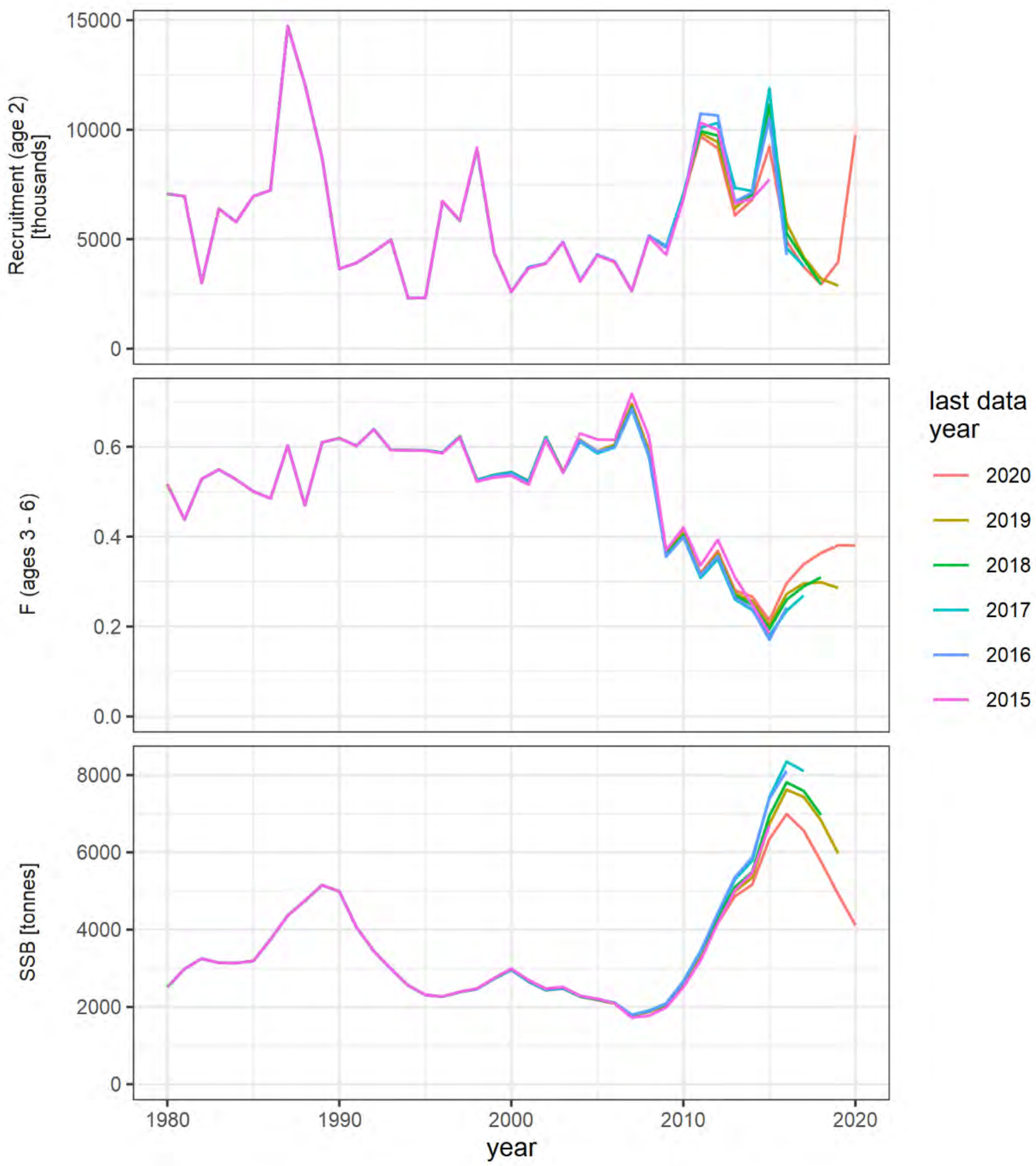

Figure 25.23. Plaice in 7.e. Five-year retrospective of recruitment, spawning–stock biomass and fishing mortality estimates.

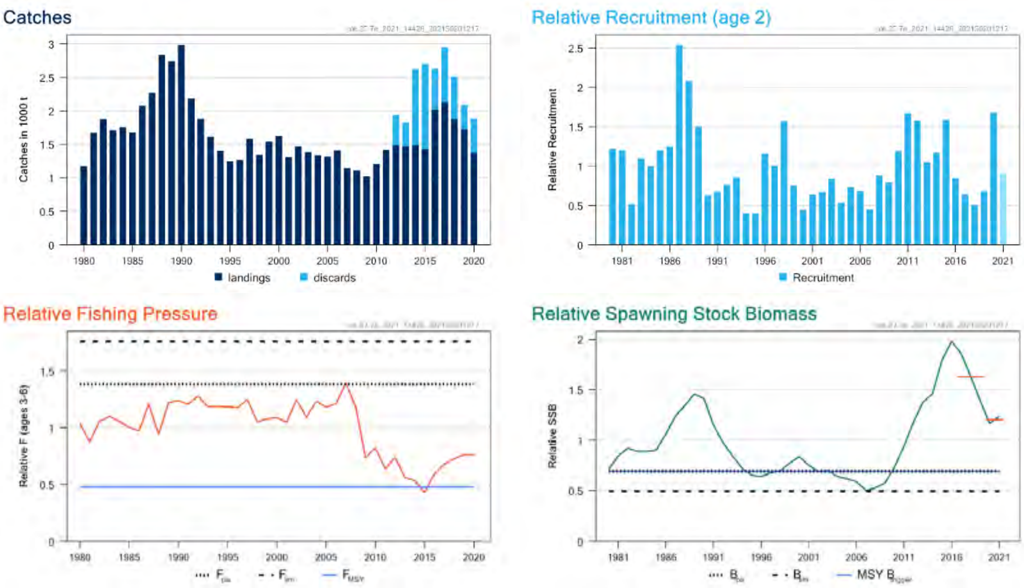

Figure 25.24. Plaice in 7.e. Summary of XSA final assessment. Fishing pressure (F) and spawning–stock biomass (SSB) are shown relative to their time-series average.

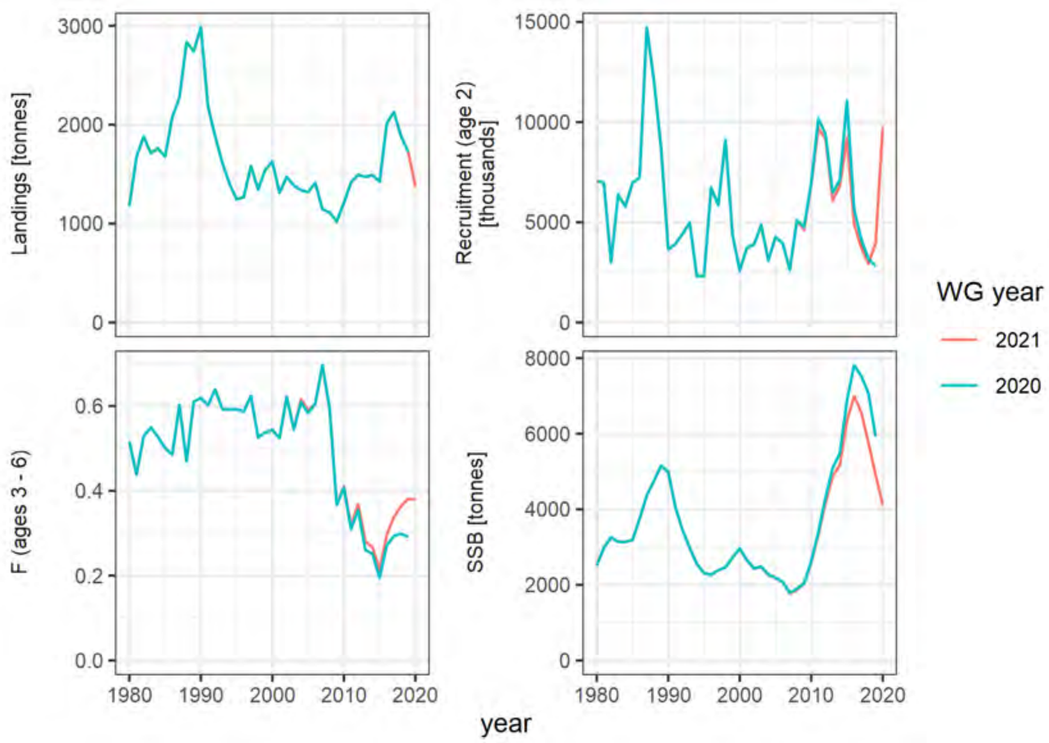

Figure 25.25. Plaice in 7.e. Comparison of the final XSA assessment with last year's assessment.

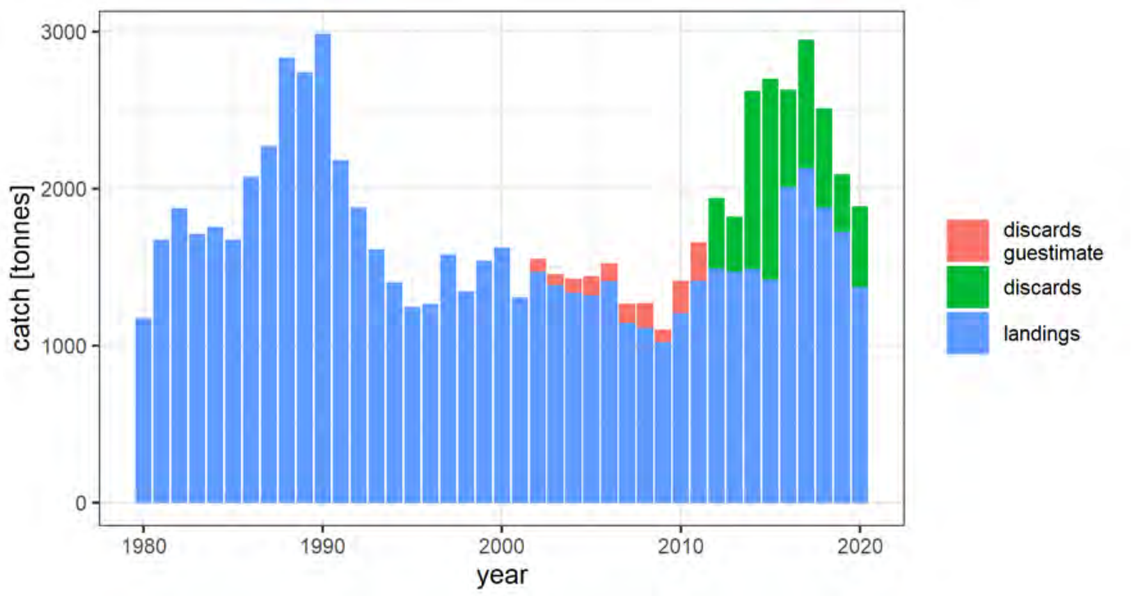

Figure 25.26. Plaice in 7.e. Total historical catches, split into landings and discards, including discard estimations prior to 2012.

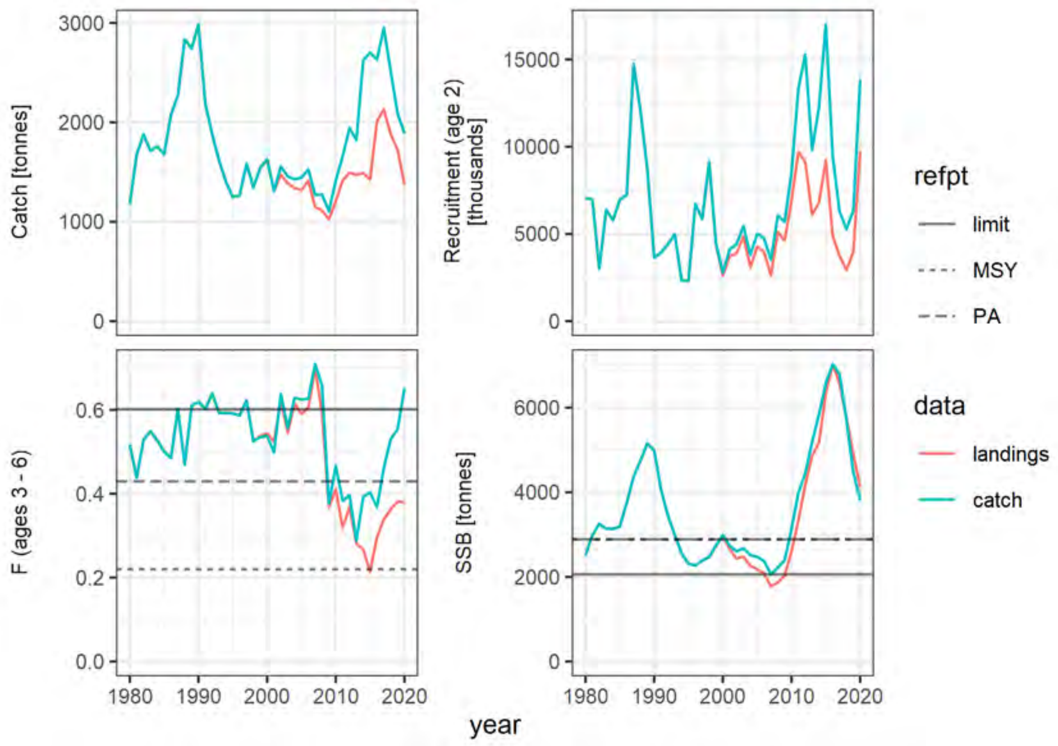

Figure 25.27. Plaice in 7.e. Results of an *exploratory* total catch XSA assessment, in comparison to the landings only assessment and including reference points based on the total catch assessment.

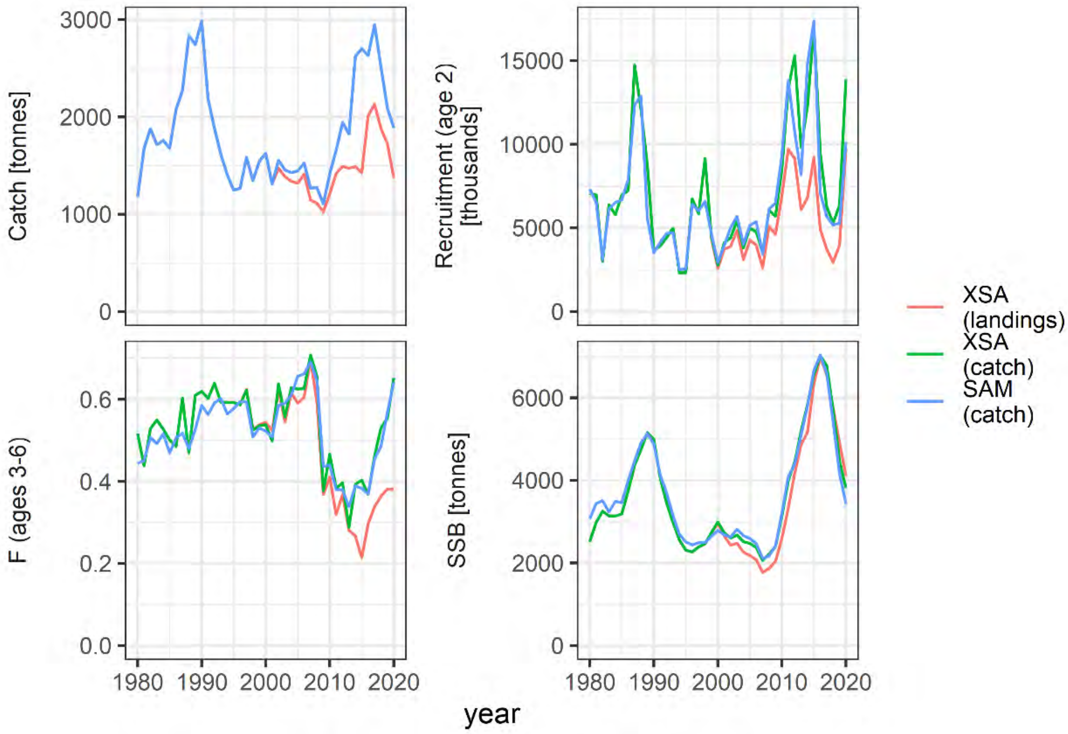

Figure 25.28. Plaice in 7.e. Results of an exploratory total catch SAM assessment, in comparison to the XSA assessments.

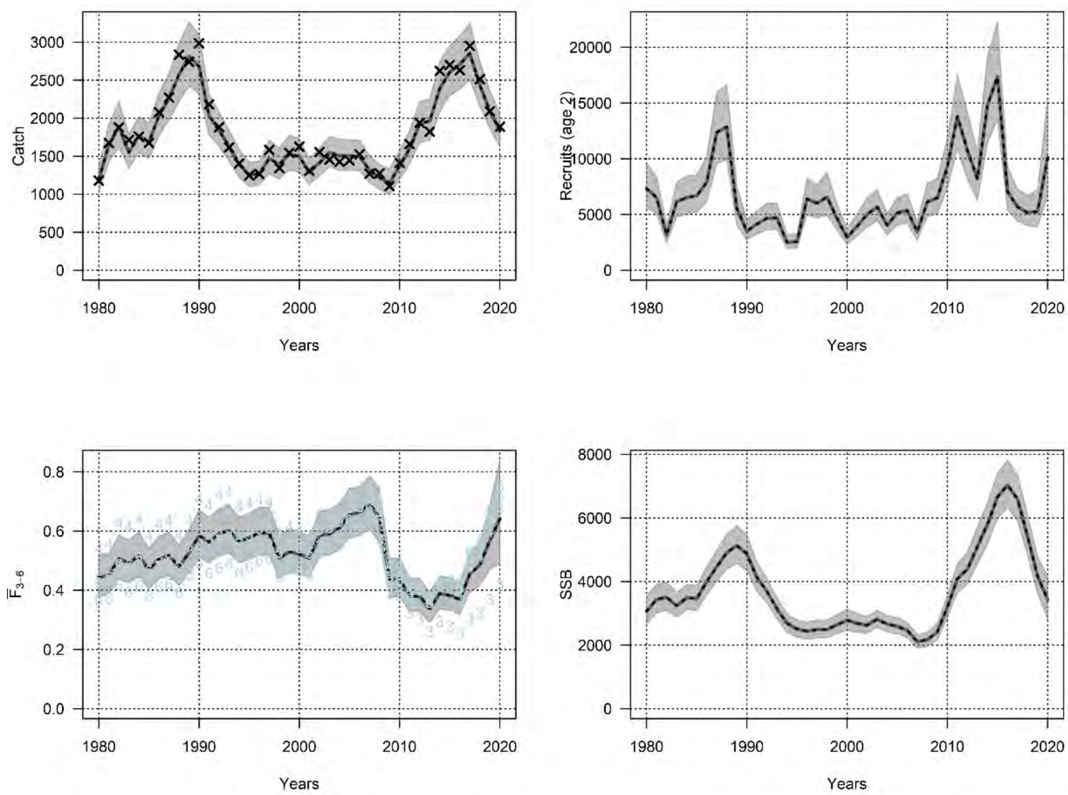

Figure 25.29. Plaice in 7.e. Exploratory SAM assessment.

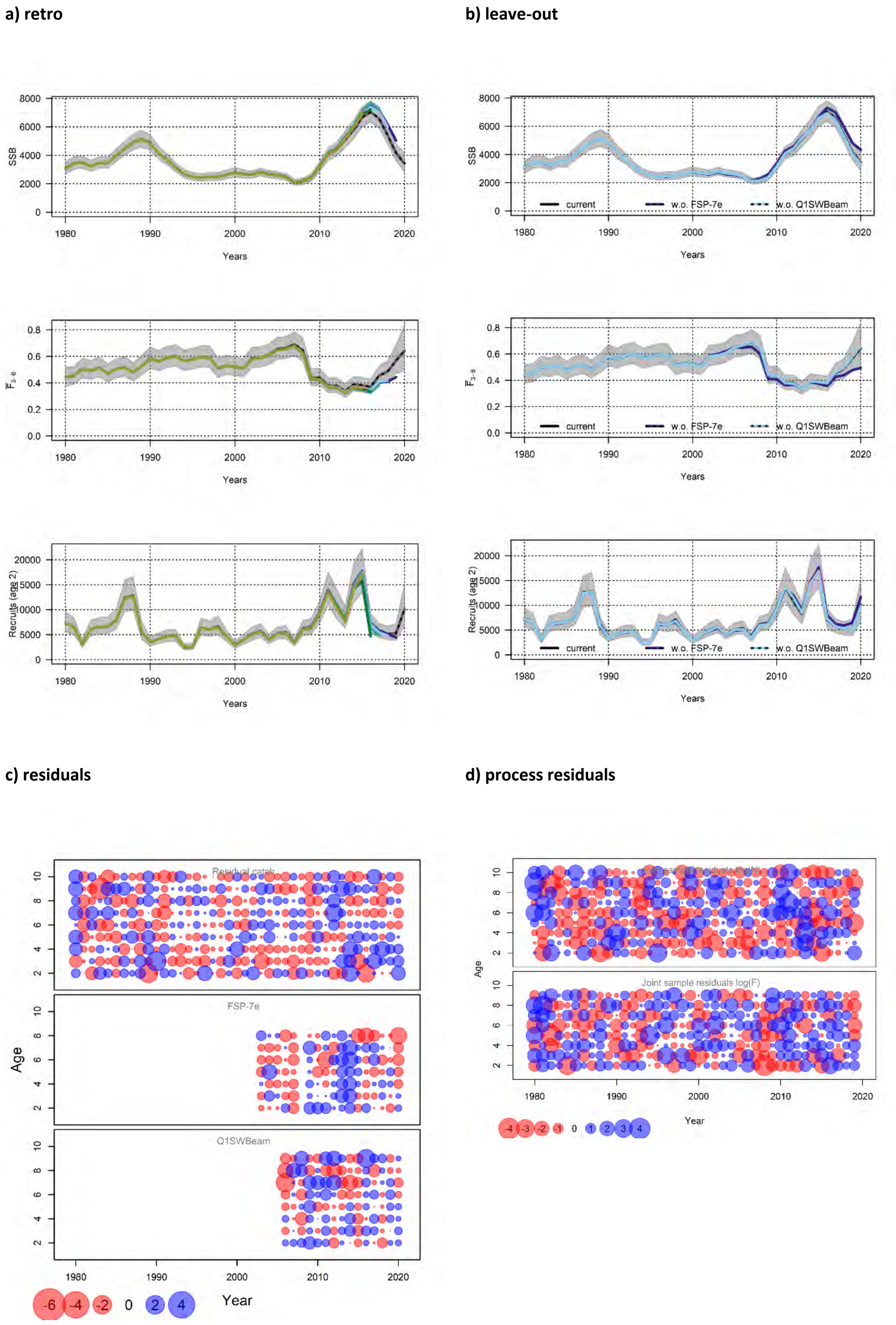

Figure 25.30. Plaice in 7.e. Model diagnostics of the exploratory SAM assessment.

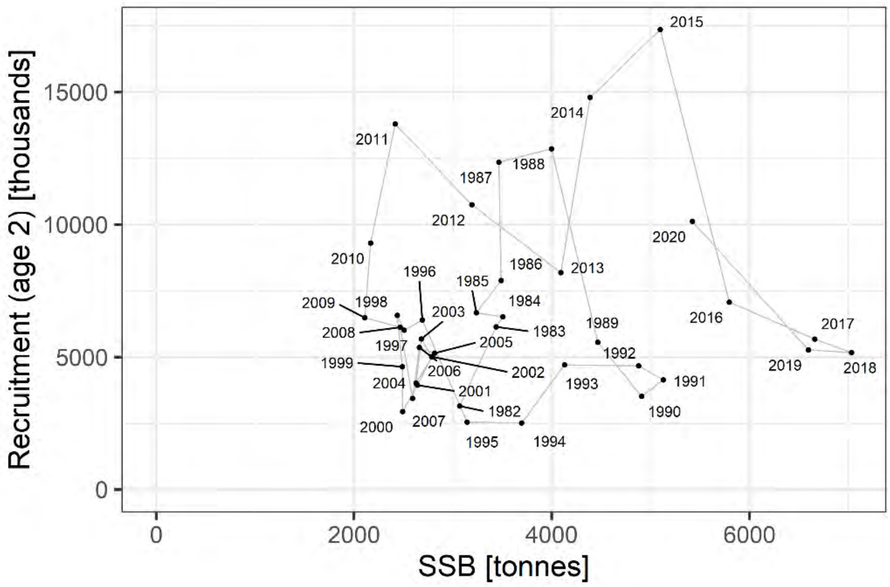

Figure 25.31. Plaice in 7.e. Stock–recruitment pairs from the exploratory SAM assessment.

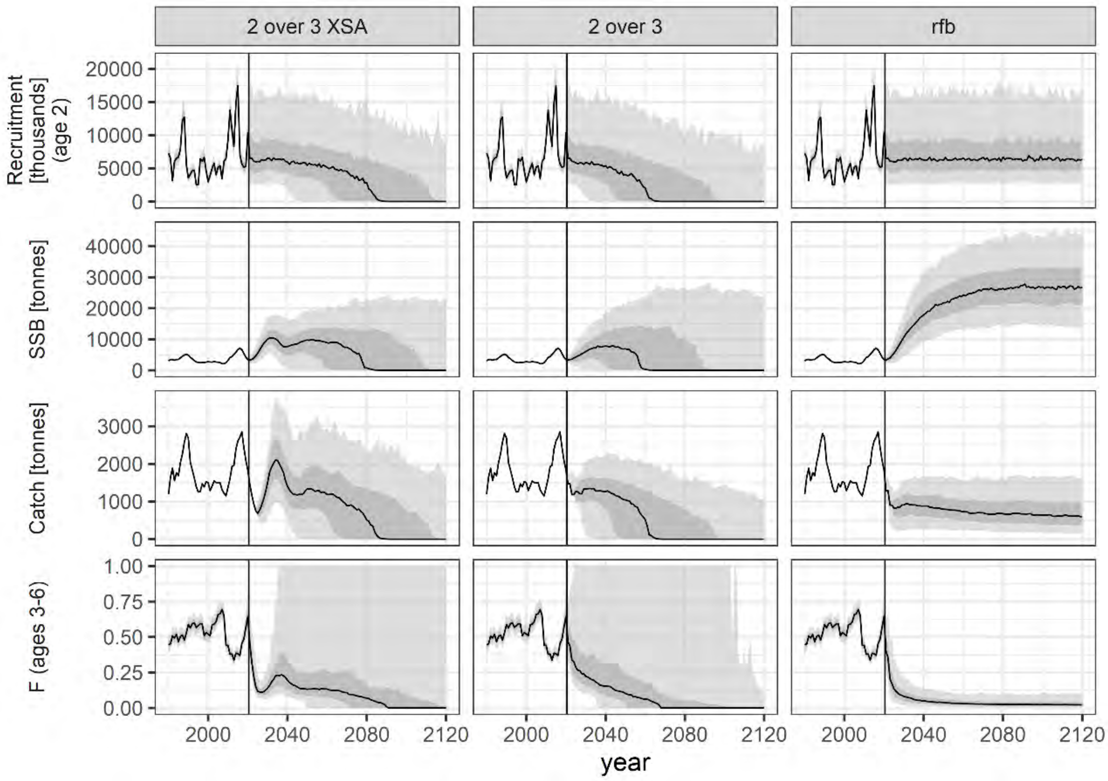

Figure 25.32. Plaice in 7.e. Preliminary MSE projections. Solid curves show the median, surrounded by 50% (darker shaded area) and 90% (lighter shaded area) confidence intervals. The solid vertical line indicates the start of the projection.

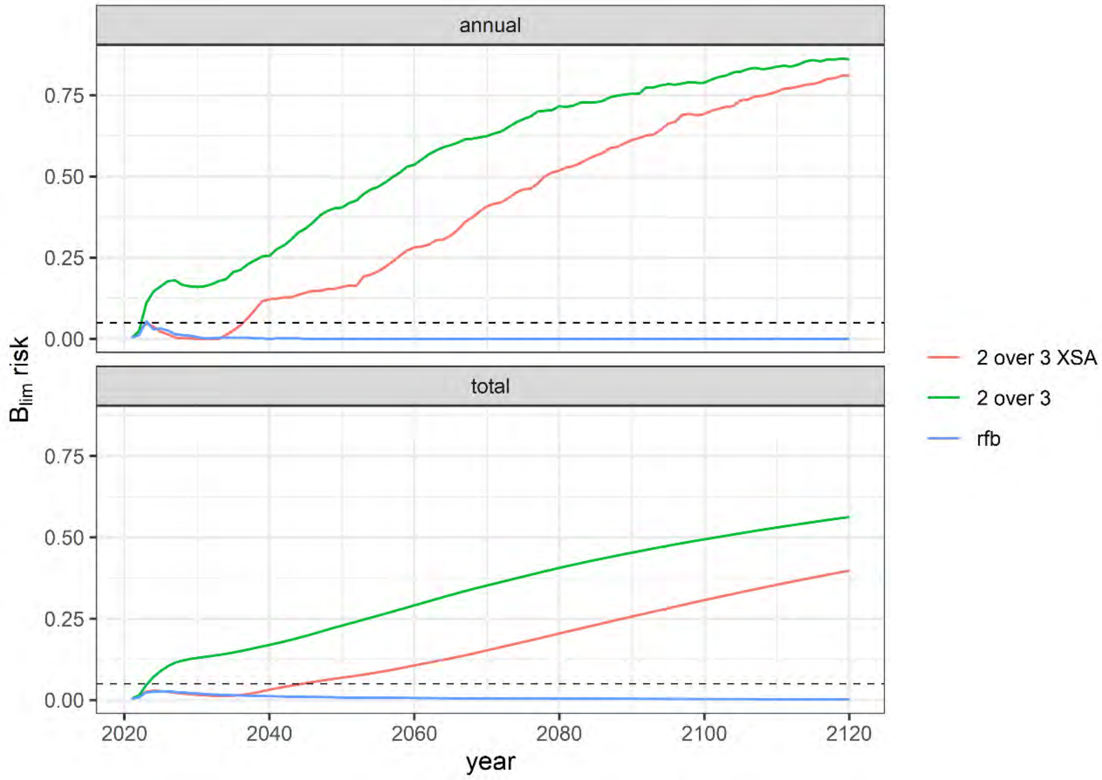

Figure 25.33. Plaice in 7.e. Risk for preliminary MSE projections.

26 Plaice in Divisions 7.f–g (Celtic Sea)

26.1 Type of assessment in 2021

Following the decision of the benchmark meeting WGFLAT 2011, the assessment of plaice stocks in ICES divisions 7.f–g should be carried out with analytic assessment model by Aarts and Poos (2009). This model derives relative trends, which include estimates of discards-at-age and was used for advice since 2012. In 2013 and 2015–2018 the AAP model had difficulties in interpreting the data due to conflicting trends between survey time-series and commercial time-series, particularly after 2010. The data have known issues in the recent years due to changes in effort reporting, as well as changes in discard practice. Therefore, the AAP was not used to provide advice at WGCSE 2015–2018 and advice was based instead on survey trends. As previous ICES advice used a catch/landings and biomass index series for assessment of this stock, stock dynamics was investigated in 2018-2021 by applying a biomass dynamic model (SPiCT-Stochastic Production model in Continuous Time), which provides model diagnostics. The diagnostics were found to be acceptable and therefore SPiCT was used as the basis for advice.

ICES advice applicable to 2021

Based on the ICES approach for data-limited stocks, ICES advises that catches in 2020 should be no more than 1911 tonnes.

General stock description and management units

A TAC is allocated to ICES areas 7.f–g which corresponds to the stock area.

Management applicable to 2019 and 2020

TACs and quotas set for 2020 (source COUNCIL REGULATION (EU) No 123/2020)

Species: Plaice *Pleuronectes platessa*, Zone: 7.f and 7.g (PLE/7FG.)

Belgium	466
France	842
Ireland	255
United Kingdom	440
Total EU	2003
Total TAC	2003

TACs and quotas set for 2021 (source COUNCIL REGULATION (EU) No 92/2021)
Species: Plaice *Pleuronectes platessa*, Zone: 7.f and 7.g (PLE/7FG.)

Belgium	117
France	211
Ireland	64
Total EU	392
United Kingdom	110
Total TAC	502

Fishery in 2020

As usual, the main fishery was concentrated on the Trevose Head ground off the north Cornish coast and around Land's End. Plaice was harvested throughout the year, with the highest amount of fish landed in Q3. The fleets harvesting plaice in the Celtic Sea primarily involved vessels from Belgium, France, Ireland and the UK with negligible amounts taken by Netherlands and Spain. In 2020 Belgium reported 61.9%% of the landings, France 8.7%, Ireland 20.5% and the UK 8.8%. The contribution of individual countries to total landings was similar to 2013–2019. The Working Group estimated that total international landings for 2019 were 535.8 t with the reconstructed total catch (including discards) being estimated as 892.8 t. It is 61.1% lower than the TAC of 2295 t, which also included discards (Table 26.1). Discards were less significant component of catch (~40% in 2020), with the available time-series extending from 2004 to 2020. In recent years (2010–2019) they always exceeded landings and ranged between 56 and 75% of the total catch.

Most of the catch (69.2%) were taken by beam trawlers, and 27.1% by bottom otter trawlers. Other gears accounted for 3.7%. Effort and lpue of fishing fleets are presented in Tables 26.2–26.4.

26.2 Data

Landings

National landings data and estimates of total landings and discards used by the WG are given in Table 26.1.

Discards

Prior to 2010 indications were that discard rates, although variable, were substantial in some fleets/periods. At the ICES WKFLAT (2010) meeting discard data from the countries participating in the fishery was raised and collated to the total international level for first time, a process that will be continued annually. The total estimates (Table 26.1) confirm the perception of the ongoing significant level of discarding. During the assessment of 2021, the discard information was available as annual summaries for Belgium and Ireland, and on quarterly basis for France. Wherever this information was absent, discards were raised based on similarity of gear and quarter /annual type of data. WG estimates of the level of discards available from 2004 show a steady increase in time to levels higher than landings since 2006; in 2007 a substantial increase occurred in the discarding by all fleets. This is followed by a return to the previously lower levels until 2011 after which discards always exceeded landings until 2019 and 2020, where they were lower than landings. Data from national discard sampling programmes are summarised in Figures 26.1–26.3.

Biological information

Quarterly or annual age compositions for 2020 were available for Belgium, Ireland, and UK(E+W) all together representing approximately 83.9% of the total landings.

International landings and discard numbers-at-age in years for which both are available (2004–2020) are compared in Figure 26.3; in recent years discards considerably exceeds landing in numbers but in 2019–2020, when most of captured fish was landed. A strong recruitment cohort that appeared first in 2012 as two year olds, in 2015 attained the age of 5 y.o. and began to predominate in landings, being still important in 2017 as 7 y.o fish. The next moderately strong generation (2 y.o. in 2015) appeared in 2015 and in 2017 represented important part of both landings and discards being the most abundant age group in 2018. In 2019 the most abundant group was fish of 4 y.o., which one year ago was only marginally less abundant than the generation born in 2015. Recruitment born in 2017 was abundant in 2019 and became the dominating group in 2020 being 3.y.o. Numbers- and weights-at-age for landings, discards and the stock used in the assessment are presented in Tables 26.5–26.9.

Landings weight-at-age

Historically, landings weights-at-age were constructed by fitting a quadratic smoother through the aggregated catch weights for each year. WKFLAT (2011) decided not to continue with this approach following concerns raised by WGCSE that poor fits of the quadratic smoothing curve were resulting in the youngest ages being estimated to have heavier weights than adjacent older ages. WKFLAT (2011) rejected the use of the polynomial smoother for weights-at-age and suggested that raw landings weights are used in future. Raw data back to 1995 was obtained by WKFLAT (2011) and used to update the catch weights and stock weights files (Tables 26.6 and 26.9).

Discard weight-at-age

Discard length and weight-at-age raw data were available for Belgium and Ireland. The national weight-at-age matrices were averaged to a total international estimate by weighting the individual weights-at-age for each year, by the catch numbers-at-age for each year and age (Tables 26.7 and 26.8).

Stock weight–at–age

Where discard estimates were available from 2004 onwards, a revised set of stock weights-at-age were calculated. The stock weights were derived from the total international landings weights-at-age and the discard weights-at-age averaged by numbers-at-age from the respective datasets. Prior to 2004, a revised set of stock weights-at-age based on international landings data was produced. These new values were based on collected weight data with a SOP correction (Table 26.9).

Natural mortality and maturity

Estimates of natural mortality (0.12 for all years and all ages from tagging studies) were based on the value estimated for Irish Sea plaice. The maturity ogive is based on UK(E&W) 7.f–g survey data for March 1993 and March 1994 (Pawson and Harley, 1997). This maturity ogive was produced in 1997 and applied to all years in the assessment. Data were not used in the current assessment as AP model provided unsatisfactory residuals, so SPiCT was used instead.

Age	1	2	3	4	5+
Maturity	0	0.26	0.52	0.86	1.00

Surveys

Indices of abundance from the UK(E&W)-BTS-Q3 beam trawl survey in 7.f and the Irish IBTS survey (IGFS-WIBTS-Q4) in 7.g are presented in Table 26.10. Both surveys show consistent trends of the stock increases and decreases (Figure 26.4). The UK(E&W)-BTS-Q3 started in 1995 and was always used for tuning the AP model. The Irish Celtic Explorer IBTS survey (IGFS-WIBTS-Q4) time-series started in 2003 and was not used in earlier years. The both survey time-series were used for the stock trend-based advice in the years 2015, 2016 and 2017 and for SPiCT in 2018–2020.

Commercial landings per unit of effort

Commercial indices of abundance from the different fisheries provide contradictory trends (Figures 26.5 and 26.6). It occurred because of varying discarding practices from 2011 onwards, when fishermen began to discard substantial numbers of fish of commercial size. Therefore, these lpues, regardless their precision and objectiveness, could not be considered as proxies for adult fish abundance. However, in 2018 and particularly in 2019–2020 the situation began to return to normal when most of fish of commercial size was retained.

During this assessment, data on landings age structure were used up to the year 2010 (inclusive) because of a significant increase in the number of fish above MLS being discarded by fishermen thereafter. Up to the year 2012 the bulk of annual discards (all fleets combined) consisted of 2 or 2–3 y.o. fish, and in 2013–2018 mostly 3–5 y.o. fish (Figure 26.3). The level of discarding of adult fish differs between fleets (Figure 26.1).

Historically, the commercial lpue data illustrate a general pattern of steep decline since the high levels in the early 1990s, followed by a more gradual decline in the late 1990s. Since 2000, lpue has been relatively stable at a low level with small increases in some métiers, notably, in Belgian beam trawlers, the most important harvesters of the stock (Figures 26.5–26.6). Overall, the lpue rates remain at a relatively low level compared to historic catch rates.

Other relevant data

There were no early closures of the fishery for plaice in 2020. The misreporting of landings of this stock is not considered to be a problem. Recent research on discard survival in the English Channel revealed that discard mortality of adult plaice captured by beam trawl varied with season, fish size and other factors like vessel type (Revill *et al.*, 2013; Depestele *et al.*, 2014; Uhlmann *et al.*, 2016 a,b) Therefore significant amounts (4 to 93%, mostly <50% in Belgian beam trawlers and mean 48% in French beam trawlers) might survive discarding which has been confirmed by several (3–15) days of observations in captivity (Depestele *et al.*, 2014; Uhlmann *et al.*, 2016 a). The survival estimate for the UK otter trawl fishery in the Western Channel was 47–63% and for the trammelnet fishery 71–72%. The discard survival was also estimated as 19–20% for the North Sea UK otter trawl fishery and 4–15% in the Western Channel UK beam trawl fishery (Catchpole *et al.*, 2015). Smaller undersized plaice that represent the bulk of discards are likely to have relatively higher mortality as with other flatfish species (review: Hendrikson, Nies, 2007). As discard survival is unknown it might be not adequately be taken into consideration. There is no formal mixed-fishery analysis for this area, but plaice in 7.fg is considered to be primarily a by-catch of the targeted sole fishery, so changes in effort in the directed sole fishery as well as multiannual management measures (EU 2019) will impact fishing mortality on plaice.

26.3 Stock assessment

Assessment model

WKFLAT (2011) agreed that the model that will be used as a temporary basis for the assessment and provision of advice for the Celtic Sea plaice is AP model (Aarts and Poos, 2009). This was selected on the basis that it was the only model available to WKFLAT which reconstructs the historic discarding rates (derived from the survey dataseries).

WKFLAT (2011) concluded that:

1. Due to the change in estimated fishing mortality when discards are included within the model fit, discards should be retained within the assessment model structure.
2. Given that the time-series of discard data, to which the models are fitted, is short and that, consequently, there are likely to be changes in the management estimates as discard data are added in subsequent years, no definitive model structure can be recommended at this stage in the development process.
3. The most flexible of the models TVS_PTVS should be used as the basis for advice; in terms of relative changes in estimated total fishing mortality and biomass.
4. The other two models which provide similar structures should continue to be fitted at the WG to provide sensitivity comparisons.
5. As the dataseries are extended, a final model selection can be then determined.

In 2013, no assessment was presented for this stock given that the "preferred" Aarts and Poos (2009) model failed to converge and other model variants could not provide realistic representations of observed landings and discards. Consequently, WGCSE 2013 decided to avoid the use of the "preferred" TV_PTVS AP model variant and instead focus on assessing the stock using trends derived from the fishery-independent UK(E&W) beam trawl survey. Trends derived from the UK(E&W) beam trawl survey were selected for the basis of advice given that this survey most appropriately covered the spatial extent of the stock and well represented the mean age (2–5) landed in the fishery. The UK(E&W) beam trawl survey was used to infer trends in recruitment, stock size (spawning–stock biomass) and fishing mortality.

In 2014, corrected TV_PTVS Aarts and Poos (2009) model converged and produced realistic results and confirmed conclusions derived in 2013 from the fishery-independent UK(E&W) beam trawl survey. In 2015–2017 all three model variants converged, but only of the "preferred" TV_PTVS AP variant provided estimations consistent with the previous run, observed catches and landings. However, trends of both UK(E&W)-BTS-Q3 beam trawl and IGFS-WIBTS-Q4 surveys on one hand (Table 26.10) and data on lpues of commercial fleets (Table 26.11) produced conflicting signal that resulted in asymmetrical distribution of residuals. Because of this, the ICES stock advice was based on both surveys' cpue trends.

Independently of WGCSE, the stock status was explored in 2015 by WKLIFE using a biomass dynamic model (SPiCT) (ICES, 2016 a). As discard data were not available prior 2004, the group approximated the total catch values from 1977 to 2003. An adjustment was made to the data by applying the 2004 discard ratio back in time (landings prior to 2004 were multiplied by K=1.54).

These total catch data were combined with cpue trends of both surveys expressed in two mean-standardized biomass index series of +3-year-old plaice, which were considered to reflect "exploitable biomass" for this stock.

Results of modelling were found to be sensitive to truncating the catch to ensure 100% overlap between the survey and catch time-series. In this case, truncation lead to a ~60% increase in B_{MSY} and ~30% decrease in F_{MSY}, whereas CVs were hugely increased (by ~200% and ~75% respectively). Therefore, the time-series was not truncated. Estimation of the observation error corresponding to the catch (β) and survey (α) was tried, but the model did not converge when trying to estimate both of these, so α was fixed at 1, while β was estimated. Under all these assumptions the results indicated current stock status (2015) to be well above the biomass reference point 0.5 B_{MSY}, and F (2015) to be well be F_{MSY} (ICES, 2016a).

In 2017, the ICES framework for category 3.2 stocks was applied (ICES, 2012; 2016 b–d). As the previous ICES advice used both catch/landings and biomass index series, the stock was investigated by applying SPiCT. The SPiCT results were chosen to support the basis for advice using comparison of the two latest biomass index (B/ B_{MSY}) values (index A) with the three preceding values (index B), multiplied by the recent advised catch. The same approach was used later in both 2018 and 2019.

Parameters of assessment

The settings and data for the model fits are set out in the table below the same way as in the previous year:

ASSESSMENT YEAR		2021
Assessment model		SPiCT
Catch data		Including discards 1977–2020 (reported and raised discards for 2004–2020, and estimated discards for 1977–2003)
Discard rate		Average (proportion by number) 2004–2010. Calculated as discards/(landings + discards).
Tuning fleets	UK(E&W)-BTS-Q3	1995–2020 ages 3+
	IGFS-WIBTS-Q4	2003–2020 ages 3+
	UK commercial beam trawl	1995–2010 ages 4–8
	UK commercial otter trawl	1995–2010 ages 4–8

Figure 26.7 presents the output plots for the model, and 26.8 it's diagnostics. Tables 26.12 and 26.13 contain information about the model diagnostics, deterministic and stochastic reference points and primary data of the model output.

State of the stock

On the relative scale the spawning biomass is estimated to have been increasing between 2005 and 2017 and stabilised between 2018 and 2020, whereas F followed the reverse pattern (Figure 26.11, Table 26.14). The estimated biomass was above B_{MSY} from 2013. Estimated F was below

F_{MSY} from 2010, and upper limit of this estimation, from 2013. The stock has been increasing from ~2008 after a period of low abundance in ~1995–2007. However, after three years of relatively low abundance of recruitment born in 2014–2016 (Figure 26.4) the stock size levelled. As with other plaice stocks around the UK, like in the divisions 7e, 7h–k (ICES, 2017) and North Sea (Dutz *et al*., 2016) this might be caused by some ongoing environmental changes. Recruitment of 2 y.o. was relatively strong in 2019 and 2020, so the stock decline in 2021–2022 is unlikely.

26.4 Short-term projections

The short-term projection from the model for 2020 (Table 26.15) forecasts $B > B_{MSY}$ and $F < F_{MSY}$ within 95% confidence intervals.

26.5 Precautionary approach reference points

On the basis of the revision of the assessment data structures and the AP model no MSY reference points were recommended for this stock. Meanwhile, using the SPiCT model at ICES WK Proxy (ICES, 2015) resulted in estimation of $B_{trigger}$ as 3800 t (50% of B_{MSY}) and $F_{MSY} = 0.27$. In 2021, application of the same model resulted in estimation of B_{MSY} as 5233 t and $F_{MSY} = 0.40$. A comparison of the two latest B/ B_{MSY} index values with the three preceding values, multiplied by the recent advised catch demonstrated that estimated biomass decreased by 9.1%, so the uncertainty cap was not applied.

26.6 Management plans

The EU has proposed a multiannual management plan for the Western Waters (EU, 2018). However, this stock was excluded from the final version (EU 2019, approved on 05/03/2019 Meeting n°3676 - https://www.consilium.europa.eu/en/meetings/env/2019/03/05/). Therefore, there is no management plan for Celtic Sea plaice.

26.7 Uncertainties in assessment and forecast

Landings

In spite of the COVID-19 pandemic, the sampling levels of landed catch (Figure 26.3) in recent years are sufficient to support current assessment approaches.

Discards

Estimates of discarding are included in the assessment. From 2003 onwards, discard sampling for Ireland, Belgium, France and the UK(E&W) has been improved under the Data Collection Regulation. Unknown levels of partial discard survival varying with fishing gear and season bring uncertainty into the assessment, which assumes that all discarded fish die. Discarding remained too high (exceeding landings) in this fishery until 2019, thereby compromising the effectiveness of quota management on landings. In 2019 and then in 2020, landings first time exceeded discards. It is difficult to predict fishing fleet behaviour, as it is a commercial species of a low value taken mostly as a bycatch to fishery for sole, and to lesser extent, to *Nephrops*.

Consistency

In 2015–2017, the advice for this stock was provided on the basis of research survey trends due to unreliability of the AP model results as well as conflicting trends between commercial vessels lpues (due to increasing discarding) and cpues of research surveys. In 2016–2021, the WGCSE decided to use results of the SPiCT model as a support source, output of which was consistent with trends in abundance of commercially sized fish aged 3+ as represented by data of research surveys.

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Table 26.1. Plaice in divisions 7.f–g. Nominal landings (t) as reported to ICES, and total landings as used by ICES WG CSE

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Belgium	214	196	171	372	365	341	314	283	357	665
UK (Engl. & Wales)	150	152	176	227	251	196	279	366	466	529
France	365	527	467	706	697	568	532	558	493	878
Ireland	28	0	49	61	64	198	48	72	91	302
N. Ireland										
Netherlands										9
Scotland	0	0	0	7	0	0	0	0	0	1
Total reported	757	875	863	1373	1377	1303	1173	1279	1407	2384
Discards	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Unallocated	0	0	0	0	0	0	-27	-69	345	-693
Landings used by WG	757	875	863	1373	1377	1303	1146	1210	1752	1691
Catch as used by WG	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	1987	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Belgium	581	617	843	794	836	371	542	350	346	410
UK (Engl. & Wales)	496	629	471	497	392	302	290	251	284	239
France	708	721	1089	767	444	504	373	298	254	246
Ireland	127	226	180	160	155	180	89	82	70	83
N. Ireland		1								
Scotland				1		5	9	1	2	
Total reported	1912	2194	2583	2219	1827	1362	1303	982	956	978
Discards	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Unallocated	-11	-78	-432	-137	-326	-174	-189	88	72	-26
Landings used by WG	1901	2116	2151	2082	1501	1188	1114	1070	1028	952
Catch as used by WG	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Belgium	594	540	371	224	241	248	221	212	168	172
UK (Engl. & Wales)	258	176	170	134	136	105	127	87	55	88
France	329	298		287	262	186	165	145	132	106
Ireland	78	135	115	76	45	79	51	45	44	48
Total reported	1259	1149	656	721	684	618	564	489	399	414
Discards	N/A	N/A	N/A	N/A	N/A	N/A	N/A	274	321	453
Unallocated	-42	-82	312	-3	30	24	30	21	-13	-10
Landings used by WG	1217	1067	968	718	714	642	594	510	386	404
Catch as used by WG	N/A	N/A	N/A	N/A	N/A	N/A	N/A	784	707	857

Table 26.1. Plaice in divisions 7.f–g. Nominal landings (t) as reported to ICES, and total landings as used by ICES WGCSE (continued).

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Belgium	194	188	216	188	210	203	185	182	185	243
UK	61	63	55	54	45	45	41	25	25	27
France	104	70	NA	136	98	125	106	155	111	108
Ireland	58	64	63	63	67	76	80	49	59	52
Total reported	417	385	NA	442	420	450	412	411	381	430
Discards	1288	583	608	670	1107	1123	1274	772	778	571
Unallocated	-7	52	-1	-9	7	-8	-2	-1	0	0
Landings used by WG	410	437	481	442	427	442	414	410	381	431
Catch as used by WG	1698	1020	1089	1112	1534	1565	1688	1183	1159	1002

	2017	**2018**	**2019**	**2020**
Belgium	179	204	263	332
UK	38	40	45	47
France	108	127	84	47
Spain			1	0
Netherlands			<1	0
Ireland	63	51	68	110
Total reported	388	422	463	536
Discards	895	508	179	357
Unallocated	1	0	-2	0
Landings used by WG	389	422	642	536
Catch as used by WG	1284	930	930	893

Table 26.2. Plaice in divisions 7.f–g: lpue and cpue for UK(E&W) fleets.

		LANDINGS PER UNIT of EFFORT (LPUE) kg\day										**TRAWL**	**BEAM TRAWL**		**VIIfg EFFORT**	
		RECT. GROUP	RECT. GROUP		VIIg EAST (grp 2)		RECT. GROUP		VIIg WEST (grp 3)		RECT. GROUP		RECT. GROUP			
		VIIf (grp 1)	VIIg EAST (grp 2)		Effort		VIIg WEST (grp 3)		Effort	VIIf (grp 1)		VIIf (grp 1)		TRAWL	BEAM	
YEAR	TRAWL	BEAM TRAWL	TRAWL	BEAM TRAWL	TRAWL (Days fished)	BEAM (Days fished)	TRAWL	BEAM TRAWL	TRAWL (Days fished)	BEAM (Days fished)	LAND-INGS (t)	EFFORT (Days fished)	LAND-INGS (t)	EFFORT (Days fished)	(000 (Days fished)	(000 (Days fished)
1983	86.39	30.33	71.84	54.85	82	149	0.00	75.69	0	8	53.96	620	5.62	195	702	353
1984	79.67	99.69	94.50	106.65	316	298	0.00	66.96	0	129	156.33	1723	99.01	901	2039	1328
1985	115.93	122.91	119.63	174.39	206	285	67.62	233.25	23	92	188.60	1493	146.71	1101	1722	1478
1986	119.81	113.62	103.37	183.72	334	180	49.93	380.20	35	29	138.48	1125	91.16	973	1494	1182
1987	131.27	114.34	223.13	291.30	364	187	33.68	446.46	26	26	196.01	1211	148.39	1681	1601	1894
1988	232.51	247.91	217.11	356.02	351	77	48.43	670.38	20	36	200.68	838	205.01	1102	1210	1215
1989	130.84	138.62	137.76	293.89	327	125	86.54	575.30	15	7	129.65	966	96.15	861	1309	994
1990	75.55	88.83	59.00	166.69	435	165	78.13	147.13	24	194	97.39	1229	155.84	1256	1689	1615
1991	48.20	93.83	44.90	73.40	306	483	42.22	109.40	45	104	55.72	1066	190.79	1667	1417	2254
1992	49.33	57.20	41.29	69.80	303	633	45.00	70.04	435	90	44.92	898	91.34	1420	1636	2143
1993	43.85	69.98	23.83	65.14	251	694	56.64	32.85	30	135	38.41	836	109.37	1669	1117	2497

		LANDINGS PER UNIT of EFFORT (LPUE) kg\day										**TRAWL**		**BEAM TRAWL**		**VIIfg EFFORT**
		RECT. GROUP		RECT. GROUP		VIIg EAST (grp 2)		RECT. GROUP		VIIg WEST (grp 3)	RECT. GROUP		RECT. GROUP			
		VIIf (grp 1)	VIIg EAST (grp 2)		Effort		VIIg WEST (grp 3)		Effort		VIIf (grp 1)	VIIf (grp 1)		TRAWL		BEAM
	TRAWL	BEAM	TRAWL	BEAM	TRAWL	BEAM	TRAWL	BEAM	TRAWL	BEAM	LAND-INGS	EFFORT	LAND-INGS	EFFORT	(000	(000
YEAR		TRAWL		TRAWL	(Days fished)	(Days fished)		TRAWL	(Days fished)	(Days fished)	(t)	(Days fished)	(t)	(Days fished)	(Days fished)	(Days fished)
1994	39.67	40.41	31.76	49.39	225	610	10.70	70.61	19	116	23.21	623	86.14	2219	866	2945
1995	41.81	43.01	30.91	54.05	196	694	61.67	37.12	30	128	26.39	580	96.10	2303	807	3125
1996	38.80	33.67	26.25	27.49	341	560	6.15	11.82	105	220	23.68	593	81.19	2391	1038	3170
1997	34.61	31.01	21.37	33.42	370	770	17.47	7.50	122	146	20.76	577	85.13	2661	1069	3578
1998	21.86	26.07	15.53	15.33	385	591	5.12	12.65	94	159	10.97	517	85.15	2846	995	3597
1999	35.60	26.62	20.65	12.00	176	1461	5.14	11.96	235	312	12.06	395	85.55	3058	806	4831
2000	32.09	16.10	40.58	11.64	187	1007	3.35	10.10	160	200	10.99	284	53.59	3133	630	4341
2001	34.02	16.69	32.30	15.26	187	1155	4.66	11.04	179	91	9.82	309	53.47	3172	675	4418
2002	19.78	15.64	48.80	20.81	123	463	7.43	4.81	170	60	6.91	416	38.85	2652	709	3174
2003	23.45	18.24	8.19	20.78	51	772	4.48	1.49	124	158	15.85	696	50.94	2669	871	3599
2004	18.77	15.54	8.66	7.81	198	923	3.09	3.39	125	178	12.45	641	40.72	2503	965	3604

		LANDINGS PER UNIT of EFFORT (LPUE) kg\day										**TRAWL**		**BEAM TRAWL**	**VIIfg EFFORT**	
		RECT. GROUP		RECT. GROUP		VIIg EAST (grp 2)		RECT. GROUP		VIIg WEST (grp 3)		RECT. GROUP		RECT. GROUP		
		VIIf (grp 1)	VIIg EAST (grp 2)		Effort		VIIg WEST (grp 3)		Effort	VIIf (grp 1)		VIIf (grp 1)		TRAWL	BEAM	
YEAR	TRAWL	BEAM TRAWL	TRAWL	BEAM TRAWL	TRAWL (Days fished)	BEAM (Days fished)	TRAWL	BEAM TRAWL	TRAWL (Days fished)	BEAM (Days fished)	LAND-INGS (t)	EFFORT (Days fished)	LAND-INGS (t)	EFFORT (Days fished)	(000 (Days fished)	(000 (Days fished)
2005	11.20	11.00	2.14	8.25	21	618	0.25	1.33	154	116	9.55	876	23.25	1968	1051	2702
2006	21.21	12.77	5.91	15.19	23	630	0.64	0.58	233	70	19.94	924	14.31	1330	1181	2030
2007	14.79	17.93	20.42	10.58	31	518	1.71	5.90	219	12	12.09	798	18.18	1407	1048	1937
2008	18.01	21.20	21.10	10.22	109	290	0.08	1.72	229	5	13.23	711	18.85	1202	1049	1497
2009	14.40	15.66	11.58	14.77	244	266	1.63	0.76	296	48	8.33	656	24.33	1105	1197	1419
2010	14.09	27.93	12.88	11.82	84	327	0.31	1.06	469	78	7.79	565	19.63	1162	1117	1567
2011	11.11	32.98	5.43	17.11	8	180	2.09	0.76	353	111	6.32	525	18.79	868	887	1158
2012	10.96	17.70	3.11	9.38	138	275	0.67	0.51	487	102	6.11	543	22.18	1408	1168	1785
2013	6.40	12.29	0.89	8.18	72	265	0.44	0.61	37	77	1.47	280	20.68	1611	389	1947
2014	5.76	15.52	7.43	10.61	10	131	0.08	2.50	176	24	0.90	156	10.25	959	165	1114
2015	18.82	11.87	37.87	14.58	3	245	0.00	3.65	165	56	1.39	79	7.80	726	82	1027

		LANDINGS PER UNIT of EFFORT (LPUE) kg\day										**TRAWL**		**BEAM TRAWL**	**VIIfg EFFORT**	
		RECT. GROUP		RECT. GROUP	VIIg EAST (grp 2)		RECT. GROUP		VIIg WEST (grp 3)		RECT. GROUP		RECT. GROUP			
		VIIf (grp 1)	VIIg EAST (grp 2)		Effort		VIIg WEST (grp 3)	Effort		VIIf (grp 1)		VIIf (grp 1)		TRAWL	BEAM	
	TRAWL	BEAM	TRAWL	BEAM	TRAWL	BEAM	TRAWL	BEAM	TRAWL	BEAM	LAND-INGS	EFFORT	LAND-INGS	EFFORT	(000	(000
YEAR		TRAWL		TRAWL	(Days fished)	(Days fished)		TRAWL	(Days fished)	(Days fished)	(t)	(Days fished)	(t)	(Days fished)	(Days fished)	(Days fished)
2016	0.00	14.91	0.00	9.57	0	396	0.07	0.05	329	34	0.00	136	11.28	915	525	1346
2017	24.98	18.57	2.97	10.28	95	514	0.05	2.47	193	74	1.73	93	15.69	986	381	1573
2018	11.10	19.53	27.10	7.77	71	440	0.93	10.70	210	15	1.59	127	22.37	1071	407	1527
2019*	19.61	32.92	11.95	28.83	34	253	1.11	8.58	277	4	3.08	164	24.91	960	475	1218
2020*	8.40	35.32	2.31	26.41	10	346	0.00	0.17	40	99	0.61	100	26.28	1012	150	1457

Table 26.3. Plaice in divisions 7.f–g: lpue and effort for Belgian fleets in 7.f–g.

BELGIAN Beam Trawl 7fg			
Year	Landings (t)	Effort (000 hr)	lpue (kg/h)
1996	356.89	53.27	6.70
1997	474.71	57.36	8.28
1998	443.38	57.79	7.67
1999	410.22	55.11	7.44
2000	230.63	51.34	4.49
2001	274.84	54.90	5.01
2002	259.80	49.60	5.24
2003	215.95	62.73	3.44
2004	207.27	78.73	2.63
2005	153.73	64.50	2.38
2006	134.44	50.28	2.67
2007	139.39	45.72	3.05
2008	106.29	28.71	3.70
2009	140.76	30.84	4.56
2010	127.15	32.74	3.88
2011	159.03	41.41	3.84
2012	165.73	46.25	3.58
2013	155.973	45.159	3.454
2014	155.317	31.271	4.967
2015	165.17	31.792	5.195
2016	212.01	32.34	6.556
2017	169.03	33.35	5.07
2018	186.861	31.48	5.94
2019	228.443	32.033	7.131
2020	293.355	41.699	7.035

Table 26.4. Plaice in Divisions 7.f–g: lpue and effort for Irish otter trawl, beam and seine fleets in 7.g.

	IR-OTB-7G			IR-SCC-7G		
Year	Landings (t)	Effort (000 hr)	lpue (kg/h)	Landings (t)	Effort (000 hr)	lpue (kg/h)
1995	94.23	63.56	1.48	9.55	6.43	1.49
1996	133.66	60.04	2.23	14.20	9.73	1.46
1997	119.84	65.10	1.84	38.79	16.13	2.40
1998	96.72	72.30	1.34	21.38	14.94	1.43
1999	60.05	51.66	1.16	10.40	8.01	1.30
2000	28.78	60.60	0.47	11.40	9.90	1.15
2001	23.82	69.43	0.34	10.93	16.33	0.67
2002	42.30	77.69	0.54	16.42	20.86	0.79
2003	26.35	86.79	0.30	13.80	20.91	0.66
2004	26.62	96.99	0.27	5.04	19.38	0.26
2005	22.78	124.40	0.18	6.47	14.81	0.44
2006	25.17	119.23	0.21	5.10	14.79	0.34
2007	30.99	136.52	0.23	4.76	15.82	0.30
2008	39.17	125.81	0.31	8.38	11.65	0.72
2009	43.81	137.11	0.32	7.98	8.19	0.98
2010	44.29	140.65	0.31	10.71	9.69	1.11
2011	44.68	120.33	0.37	11.12	11.01	1.01
2012	43.21	121.08	0.35	18.41	14.15	1.30
2013	31.91	118.13	0.28	11.10	12.06	0.84
2014	28.00	127.40	0.22	7.60	12.00	0.61
2015	33.34	132.69	0.25	8.36	9.28	0.90
2016	34.80	148.17	0.23	9.37	10.44	0.90
2017	40.86	135.98	0.30	10.49	9.75	1.08
2018	33.64	105.81	0.32	8.13	9.69	0.84
2019	33.89	103.89	0.33	16.40	14.26	1.15
2020	54.63	89.91	0.61	17.45	13.59	1.28

	IR-TBB-7G						
Year	Landings (t)	Effort (000 hr)	lpue (kg/h)	Year	Landings (t)	Effort (000 hr)	lpue (kg/h)
1995	37.92	20.78	1.83	2008	14.18	37.22	0.38
1996	53.02	26.76	1.98	2009	6.96	37.96	0.18
1997	94.59	28.25	3.35	2010	6.56	40.22	0.16
1998	122.13	35.25	3.46	2011	6.71	35.33	0.19
1999	25.80	40.87	0.63	2012	33.63	40.33	0.83
2000	12.62	37.03	0.34	2013	32.32	38.48	0.84
2001	4.80	39.71	0.12	2014	12.50	37.80	0.33
2002	7.08	31.62	0.22	2015	12.10	37.79	0.32
2003	9.37	49.26	0.19	2016	9.83	39.55	0.25
2004	6.17	54.86	0.11	2017	12.39	35.21	0.35
2005	9.49	49.65	0.19	2018	9.62	37.42	0.26
2006	14.46	60.48	0.24	2019	20.32	34.08	0.60
2007	21.18	55.86	0.38	2020	43.20	29.14	1.48

Table 26.5. Plaice in divisions 7.f–g. Landings numbers-at-age.

Landings numbers-at-age			**Numbers*10**-3**							
AGE\YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0	0	0	0	0	0	0	0	0	0
2	989	851	877	1921	822	300	750	704	1461	703
3	426	903	673	1207	2111	1180	560	918	2503	2595
4	411	291	638	658	681	955	827	343	393	1332
5	105	136	72	146	109	443	372	373	102	156
6	72	76	70	21	54	86	92	209	177	59
7	37	47	34	16	53	51	44	70	62	48
8	59	23	8	16	11	14	27	41	25	32
+gp	75	98	46	32	44	60	23	42	38	24
TOTALNUM	2175	2426	2419	4018	3886	3090	2696	2701	4762	4950
AGE\YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0	0	0	0	0	0	25	100	43	0
2	434	967	797	164	279	800	1019	428	488	812
3	1883	2099	3550	2078	1072	526	1179	936	572	734
4	1812	1568	1807	2427	1193	357	284	730	743	515
5	772	612	741	655	578	471	139	164	334	219
6	156	413	160	242	179	275	185	117	117	137
7	22	65	98	86	94	80	115	86	57	59
8	125	16	24	70	78	21	62	92	48	37
+gp	76	73	23	46	79	96	59	65	132	96
TOTALNUM	5281	5814	7201	5769	3553	2627	3066	2716	2534	2609

Landings numbers-at-age			Numbers*10**-3							
AGE\YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	8	17	22	19	75	3	15	6	24	12
2	420	426	243	320	651	170	239	126	201	331
3	1318	921	982	606	371	661	571	578	327	458
4	929	849	802	482	323	543	465	428	265	140
5	272	287	372	203	199	183	150	261	134	134
6	121	96	116	145	108	113	85	46	73	76
7	60	82	45	53	62	65	34	27	24	50
8	20	39	27	22	23	24	26	15	14	12
+gp	82	56	69	32	28	28	24	17	16	15
TOTALNUM	3231	2773	2678	1881	1838	1789	1608	1504	1078	1229
AGE\YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	8	15	2	3	1	2	3	0	0	2
2	130	270	127	135	135	106	64	24	55	20
3	513	341	626	223	326	485	328	123	122	332
4	340	443	345	430	208	288	383	452	231	201
5	104	145	273	191	248	164	192	247	410	182
6	76	47	68	152	130	163	67	109	127	228
7	46	29	20	44	69	65	70	33	43	94
8	26	11	10	8	28	33	29	36	17	42
+gp	13	15	12	8	17	23	31	30	26	37
TOTALNUM	1257	1315	1485	1187	1161	1329	1167	1054	1052	1138

Landings numbers-at-age		**Numbers*10**-3**		
AGE\YEAR	2017	2018	2019	2020
1	0	3	4	1
2	33	32	28	98
3	57	143	85	155
4	380	122	248	190
5	167	393	187	256
6	112	160	336	229
7	145	92	215	337
8	56	89	63	163
+gp	35	62	83	145
TOTALNUM	985	1096	1249	1574

Table 26.6. Plaice in divisions 7.f–g. Landings weights-at-age.

Landings weights-at-age (kg)										
AGE\YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.078	0.194	0.076	0.118	0.185	0.151	0.178	0.276	0.135	0.000
2	0.205	0.258	0.203	0.238	0.255	0.245	0.274	0.324	0.251	0.160
3	0.323	0.323	0.325	0.354	0.330	0.339	0.369	0.384	0.363	0.301
4	0.430	0.389	0.440	0.467	0.412	0.433	0.464	0.455	0.470	0.434
5	0.528	0.457	0.550	0.576	0.500	0.526	0.559	0.538	0.572	0.559
6	0.615	0.525	0.652	0.682	0.595	0.620	0.654	0.633	0.670	0.677
7	0.693	0.595	0.749	0.784	0.695	0.714	0.749	0.739	0.763	0.787
8	0.760	0.666	0.839	0.882	0.802	0.808	0.844	0.857	0.851	0.889
+gp	0.8762	0.8435	1.0653	1.1812	1.1824	1.0948	1.1579	1.2661	1.0036	1.1033
SOPCOFAC	1.0052	1.0262	1.0225	1.0135	1.0042	1.0125	0.9995	1.0000	1.0047	0.9997
AGE\YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.129	0.260	0.102	0.240	0.200	0.148	0.171	0.236	0.219	0.000
2	0.208	0.288	0.176	0.270	0.260	0.257	0.263	0.296	0.254	0.247
3	0.288	0.325	0.255	0.309	0.327	0.362	0.314	0.308	0.304	0.295
4	0.368	0.370	0.337	0.358	0.400	0.464	0.405	0.397	0.364	0.349
5	0.449	0.423	0.423	0.416	0.481	0.563	0.500	0.455	0.485	0.512
6	0.530	0.484	0.514	0.483	0.567	0.658	0.598	0.598	0.603	0.553
7	0.612	0.554	0.608	0.560	0.661	0.750	0.643	0.801	0.714	0.523
8	0.694	0.633	0.706	0.646	0.761	0.839	0.728	0.728	0.752	0.947
+gp	0.8632	0.8887	0.9932	0.9097	1.0465	1.0399	0.9886	0.9585	1.0655	1.0667
SOPCOFAC	1.0034	1.0024	1.0006	1.0009	1.0113	1.0022	0.9997	1.0001	1.0004	0.9998

Landings weights-at-age (kg)										
AGE\YEAR	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.249	0.213	0.213	0.245	0.268	0.246	0.205	0.221	0.237	0.238
2	0.291	0.256	0.268	0.260	0.305	0.284	0.295	0.258	0.260	0.246
3	0.304	0.317	0.278	0.302	0.340	0.281	0.321	0.287	0.295	0.291
4	0.357	0.380	0.332	0.370	0.398	0.343	0.353	0.330	0.356	0.339
5	0.466	0.463	0.440	0.479	0.466	0.433	0.439	0.382	0.425	0.385
6	0.663	0.604	0.538	0.539	0.556	0.484	0.502	0.514	0.525	0.513
7	0.745	0.661	0.618	0.672	0.675	0.541	0.651	0.649	0.631	0.549
8	0.877	0.690	0.839	0.875	0.695	0.859	0.681	0.750	0.714	0.638
+gp	1.1007	1.1886	1.1906	1.2018	1.0905	1.1262	1.0389	0.9919	1.0163	0.8369
SOPCOFAC	1.0002	1.0009	1.0000	1.0007	1.0007	1.0004	0.9994	1.0007	1.0011	1.0008
AGE\YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
1	0.278	0.260	0.279	0.233	0.228	0.235	0.273	0.156	0.15	0.211
2	0.271	0.273	0.267	0.292	0.242	0.246	0.285	0.28	0.24	0.253
3	0.277	0.298	0.275	0.331	0.283	0.280	0.286	0.312	0.275	0.278
4	0.303	0.329	0.329	0.328	0.335	0.307	0.320	0.346	0.3	0.318
5	0.389	0.386	0.376	0.376	0.378	0.345	0.370	0.386	0.365	0.365
6	0.457	0.433	0.469	0.458	0.465	0.418	0.465	0.504	0.467	0.416
7	0.537	0.511	0.499	0.598	0.600	0.498	0.517	0.473	0.514	0.510
8	0.547	0.719	0.605	0.469	0.690	0.570	0.602	0.599	0.609	0.567
+gp	0.9862	0.9042	0.7197	1.0433	1.1810	0.6750	0.6550	0.735	0.946	1.003
SOPCOFAC	1.0005	1.0001	0.9993	1.0002	1.0000	1.0001	0.9994	1.001	1.002	1.005

Landings weights-at-age (kg)				
AGE\YEAR	2017	2018	2019	2020
1	0.231	0.198	0.206	0.185
2	0.279	0.229	0.231	0.225
3	0.289	0.262	0.277	0.245
4	0.325	0.297	0.306	0.275
5	0.370	0.326	0.337	0.31
6	0.426	0.407	0.377	0.318
7	0.460	0.468	0.376	0.358
8	0.590	0.515	0.513	0.415
+gp	0.7620	0.739	0.809	0.594
SOPCOFAC	1.0400	0.978	1.03	1.005

Table 26.7. Plaice in divisions 7.f–g. Discards numbers-at-age.

Discard numbers-at-age Numbers*10-3**														
AGE\YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	0	0	0	455	572	542	1829	73	671	385	960	142	614	83
2	0	0	0	360	1211	2584	3331	3595	985	2719	2656	2496	1283	987
3	0	0	0	641	441	750	3408	632	2041	1017	1429	1950	3581	1672
4	0	0	0	171	118	74	814	393	761	550	1019	502	1004	3195
5	0	0	0	68	41	47	81	69	399	345	501	179	231	454
6	0	0	0	3	12	12	32	4	44	54	45	163	32	173
7	0	0	0	4	4	1	11	1	4	8	99	58	44	77
8	0	0	0	1	22	1	9	1	5	0	56	25	11	27
+gp	0	0	0	0	0	0	0	0	0	0	0	8	8	36
TOTALNUM	0	0	0	1703	2421	4011	9515	4768	4910	5078	6765	5523	6808	6704
TONSLAND	0	0	0	274	321	453	1288	583	608	670	1107	852	1260	1158
SOPCOFAC	0	0	0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Discard numbers-at-age Numbers*10**-3						
AGE\YEAR	2015	2016	2017	2018	2019	2020
0	-	-	0	0	0	0
1	38	29	169	3	29	13
2	1527	224	739	92	260	448
3	1253	1610	1078	587	157	673
4	753	615	1257	444	328	388
5	1106	229	478	668	149	394
6	303	209	312	346	111	169
7	54	34	147	307	38	148
8	33	15	32	11	0	32
+gp	80	9	13	103	8	26
TOTALNUM	5145	2974	4225	2561	1080	2291
TONSLAND	870	591	895	508	179	536
SOPCOF %	1.03	1.03	0.99	1.00	1.00	1.00

Table 26.8. Plaice in divisions 7.f–g. Discards weights-at-age.

Discard weights-at-age (kg)														
AGE\YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	0	0	0	0.123	0.095	0.064	0.088	0.092	0.088	0.085	0.118	0.104	0.097	0.040
2	0	0	0	0.152	0.127	0.107	0.126	0.11	0.127	0.125	0.148	0.124	0.129	0.112
3	0	0	0	0.177	0.154	0.154	0.159	0.154	0.127	0.143	0.173	0.167	0.180	0.160
4	0	0	0	0.194	0.188	0.176	0.163	0.172	0.127	0.149	0.168	0.192	0.233	0.181
5	0	0	0	0.212	0.202	0.201	0.204	0.211	0.143	0.163	0.225	0.239	0.277	0.214
6	0	0	0	0.337	0.344	0.242	0.249	0.282	0.194	0.189	0.304	0.247	0.459	0.227
7	0	0	0	0.23	0.403	0.395	0.368	0.365	0.2	0.445	0.339	0.238	0.380	0.300
8	0	0	0	0.455	0.419	0.349	0.425	0.283	0.257	0.523	0.389	0.337	0.312	0.470
+gp	0	0	0	0	0	0	0	0	0	0	0	0	0	0.713

Discard weights-at-age (kg)						
Discard weights-at-age (kg)						
AGE\YEAR	2015	2016	2017	2018	2019	2020
0			0.058			
1	0.12	0.148	0.14	0.105	0.084	0.095
2	0.124	0.153	0.147	0.126	0.118	0.127
3	0.143	0.177	0.186	0.150	0.169	0.143
4	0.171	0.205	0.225	0.188	0.196	0.161
5	0.219	0.261	0.258	0.182	0.180	0.172
6	0.315	0.288	0.324	0.207	0.183	0.18
7	0.208	0.341	0.271	0.324	0.159	0.187
8	0.204	0.416	0.29	0.350	0.258	0.298
+gp	0.529	0.462	0.442	0.873	0.182	0.196

Table 26.9. Plaice in divisions 7.f–g. Stock weights-at-age.

Stock weights-at-age (kg)										
AGE\YEAR	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.112	0.086	0.107	0.109	0.082	0.096	0.103	0.256	0.075	0.000
2	0.216	0.170	0.212	0.217	0.167	0.192	0.206	0.298	0.193	0.087
3	0.315	0.252	0.313	0.322	0.257	0.288	0.307	0.352	0.307	0.232
4	0.406	0.334	0.412	0.426	0.350	0.383	0.408	0.418	0.417	0.369
5	0.492	0.414	0.507	0.528	0.447	0.479	0.507	0.495	0.521	0.498
6	0.570	0.493	0.599	0.628	0.548	0.574	0.606	0.584	0.621	0.619
7	0.642	0.570	0.689	0.727	0.653	0.668	0.704	0.685	0.717	0.733
8	0.707	0.646	0.775	0.823	0.762	0.763	0.801	0.797	0.808	0.839
+gp	0.839	0.822	1.015	1.132	1.129	1.049	1.114	1.190	0.965	1.064
AGE\YEAR	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
1	0.089	0.249	0.066	0.228	0.173	0.092	0.171	0.236	0.219	0.000
2	0.168	0.273	0.139	0.254	0.229	0.203	0.263	0.296	0.254	0.247
3	0.248	0.305	0.215	0.288	0.293	0.310	0.314	0.308	0.304	0.295
4	0.328	0.346	0.295	0.332	0.363	0.414	0.405	0.397	0.364	0.349
5	0.408	0.395	0.380	0.386	0.440	0.514	0.500	0.455	0.485	0.512
6	0.489	0.453	0.468	0.448	0.523	0.611	0.598	0.598	0.603	0.553
7	0.571	0.518	0.560	0.520	0.613	0.705	0.643	0.801	0.714	0.523
8	0.653	0.593	0.657	0.602	0.710	0.795	0.728	0.728	0.752	0.947
+gp	0.822	0.837	0.938	0.854	0.987	1.000	0.989	0.959	1.066	1.067
AGE\YEAR	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1	0.249	0.213	0.213	0.245	0.268	0.246	0.205	0.221	0.237	0.238
2	0.291	0.256	0.268	0.260	0.305	0.284	0.295	0.258	0.260	0.246
3	0.304	0.317	0.278	0.302	0.340	0.281	0.321	0.287	0.295	0.291
4	0.357	0.380	0.332	0.370	0.398	0.343	0.353	0.330	0.356	0.339
5	0.466	0.463	0.440	0.479	0.466	0.433	0.439	0.382	0.425	0.385
6	0.663	0.604	0.538	0.539	0.556	0.484	0.502	0.514	0.525	0.513
7	0.745	0.661	0.618	0.672	0.675	0.541	0.651	0.649	0.631	0.549
8	0.877	0.690	0.839	0.875	0.695	0.859	0.681	0.750	0.714	0.638
+gp	1.101	1.189	1.191	1.202	1.091	1.126	1.039	0.992	1.016	0.837

Stock weights-at-age (kg)										
AGE\YEAR	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
1	0.278	0.260	0.279	0.233	0.228	0.106	0.098	0.095	0.129	0.153
2	0.271	0.273	0.267	0.292	0.242	0.129	0.136	0.116	0.128	0.161
3	0.277	0.298	0.275	0.331	0.283	0.190	0.188	0.171	0.155	0.194
4	0.303	0.329	0.329	0.328	0.335	0.234	0.257	0.202	0.202	0.233
5	0.389	0.386	0.376	0.376	0.378	0.290	0.319	0.275	0.259	0.307
6	0.457	0.433	0.469	0.458	0.465	0.332	0.463	0.334	0.36	0.355
7	0.537	0.511	0.499	0.598	0.600	0.375	0.465	0.353	0.343	0.465
8	0.547	0.719	0.605	0.469	0.690	0.470	0.525	0.543	0.339	0.527
+gp	0.986	0.904	0.720	1.043	1.181	0.549	0.654	0.594	0.563	0.998
AGE\YEAR	**2017**	**2018**	**2019**							
0	0.058									
1	0.14	0.150	0.099	0.102						
2	0.153	0.152	0.129	0.144						
3	0.191	0.172	0.207	0.162						
4	0.248	0.212	0.243	0.198						
5	0.286	0.235	0.267	0.227						
6	0.350	0.270	0.328	0.26						
7	0.365	0.357	0.344	0.306						
8	0.482	0.498	0.512	0.396						
+gp	0.675	0.838	0.588	0.555						

Table 26.10. Plaice in divisions 7.f–g: Survey abundance indices.

IRGFS							
2003	2018						
1	1	0.79	0.92				
1	7						
1	0.0	3.2	6.0	2.7	0.6	0.2	0.1
1	0.1	0.4	1.9	3.1	1.2	0.8	0.1
1	2.8	4.4	5.9	1.3	0.7	0.2	0.2
1	0.2	6.0	4.6	1.2	1.0	0.6	0.7
1	0.1	2.6	8.5	3.5	1.1	0.5	0.4
1	0.4	6.0	5.6	3.8	1.0	0.4	0.2
1	12.5	11.7	32.3	14.6	5.9	1.2	0.9
1	10.1	37.9	13.2	20.8	8.6	3.7	1.0
1	10.8	49.5	30.2	8.4	9.1	3.6	4.6
1	14.6	40.5	36.8	11.3	2.1	2.0	2.9
1	1.5	16.1	37.3	19.7	7.2	1.9	6.2
1	0.4	7.9	14.3	13.6	6.1	3.4	2.2
1	0.8	37.8	28.2	13.0	15.2	3.0	5.0
1	1.1	13.8	33.6	13.9	9.2	9.0	4.2
1	0.8	11.5	12.8	13.0	10.8	3.7	4.6
1	0.1	5.5	9.8	6.6	7.9	3.2	3.2
1	1.6	7.2	5.8	13.1	5.8	5.1	4.0
1	0.8	8.1	7.0	5.1	5.9	3.8	6.6

E+W BT Survey					
1995 2019					
1 1 0.75 0.85					
1 5					
1	239.590	90.480	17.230	2.960	6.840
1	223.690	288.110	30.780	0.990	2.620
1	225.370	102.140	34.540	4.250	1.770
1	237.200	126.220	46.990	8.920	2.000
1	152.590	79.620	29.030	19.670	7.000
1	339.630	63.170	31.250	6.560	5.500
1	211.440	156.140	15.810	8.740	4.230
1	136.740	175.120	80.450	5.930	6.130
1	98.370	80.480	60.950	21.830	2.720
1	258.510	33.410	27.080	13.420	2.190
1	192.500	75.220	20.870	8.060	10.930
1	85.780	101.970	34.160	9.570	1.790
1	150.400	92.250	47.260	15.110	1.670
1	140.690	217.040	46.790	15.700	4.820
1	161.810	55.960	78.580	21.450	10.890
1	331.760	88.540	26.410	39.940	6.680
1	362.260	300.140	55.040	21.860	21.370
1	142.130	430.790	100.570	22.360	9.020
1	329.790	139.060	185.390	46.850	5.770
1	371.760	202.300	64.650	105.700	23.800
1	28.360	454.080	162.340	52.370	76.660
1	12.520	163.100	268.260	102.300	27.500
1	11.490	104.1	137.39	121.110	91.87
1	4.15	45.26	90.2	58.1	75.08
1	114.94	138.97	38.18	15.37	11.19
1	7.17	113.19	139.61	42.71	11.95

Table 26.11. Plaice in divisions 7.f–g: Commercial fleet abundance indices.

UK (E+W) BEAM TRAWL 7F.					
1990 2010					
1 1 0 1					
4 8					
1	12.6	3.656	2.103	0.868	0.725
1	8.372	5.158	1.715	0.894	0.834
1	2.254	3.289	1.93	0.528	0.162
1	1.528	0.947	1.498	0.923	0.443
1	2.245	0.424	0.415	0.347	0.446
1	1.715	1.289	0.43	0.252	0.278
1	0.569	0.569	0.535	0.159	0.184
1	0.909	0.319	0.256	0.169	0.026
1	2.221	0.618	0.127	0.151	0.095
1	1.72	0.844	0.252	0.078	0.062
1	0.858	0.568	0.405	0.156	0.057
1	0.867	0.558	0.318	0.186	0.076
1	0.637	0.294	0.279	0.143	0.079
1	1.349	0.393	0.199	0.135	0.094
1	1.051	0.711	0.136	0.104	0.08
1	0.671	0.396	0.269	0.102	0.061
1	0.353	0.338	0.233	0.12	0.03
1	0.853	0.227	0.142	0.099	0.043
1	1.506	0.433	0.158	0.117	0.075
1	1.375	0.968	0.271	0.09	0.054
1	1.601	0.62	0.508	0.146	0.009

UK E+W OTTER TRAWL 7F					
1989	2010				
1 1 0 1					
4 8					
1	6.366	2.37	0.766	0.518	0.041
1	10.452	2.774	1.074	0.333	0.35
1	7.29	3.415	1.529	0.413	0.46
1	1.391	2.059	0.946	0.156	0.045
1	1.065	0.479	0.754	0.491	0.335
1	2.407	0.433	0.498	0.225	0.273
1	2.5	0.948	0.276	0.138	0.121
1	0.725	0.574	0.422	0.169	0.186
1	0.953	0.208	0.121	0.069	0.017
1	1.664	0.387	0.097	0.135	0.039
1	1.997	0.961	0.228	0.051	0.025
1	2.327	0.882	0.458	0.141	0.035
1	1.326	0.809	0.42	0.194	0.065
1	0.696	0.36	0.264	0.12	0.048
1	1.335	0.302	0.187	0.129	0.086
1	1.622	0.905	0.14	0.078	0.047
1	0.628	0.331	0.171	0.057	0.034
1	0.736	0.703	0.487	0.26	0.065
1	0.939	0.276	0.175	0.125	0.063
1	1.645	0.52	0.197	0.098	0.056
1	0.731	0.472	0.122	0.046	0.03
1	1.311	0.496	0.407	0.089	0.018

Table 26.12. Plaice in divisions 7.f–g: Reconstructed annual catches and abundance indices used for SPiCT modelling.

Year	Catch	IRGFS	E+W BT Survey	UK (E+W) BEAM TRAWL 7F.	UK E+W OTTER TRAWL 7F
1977	1166				
1978	1348				
1979	1329				
1980	2114				
1981	2121				
1982	2007				
1983	1765				
1984	1863				
1985	2698				
1986	2604				
1987	2928				
1988	3259				
1989	3313				
1990	3206				
1991	2312				
1992	1830				
1993	1716				
1994	1648				
1995	1583		30.3	0.065	3.983
1996	1466		35.2	0.074	2.076
1997	1874		43.1	0.075	1.368
1998	1643		59.8	0.078	2.322
1999	1491		57.4	0.058	3.262
2000	1106		44.2	0.033	3.843
2001	1100		33.8	0.043	2.814
2002	989		98.9	0.038	1.488
2003	915	9.6	90.8	0.051	2.039
2004	784	7.1	49.0	0.040	2.792
2005	707	8.3	44.0	0.027	1.221

Year	Catch	IRGFS	E+W BT Survey	UK (E+W) BEAM TRAWL 7F.	UK E+W OTTER TRAWL 7F
2006	857	8.1	57.8	0.033	2.251
2007	1698	14.0	69.9	0.038	1.578
2008	1020	11.0	71.5	0.046	2.516
2009	1089	54.9	117.4	0.065	1.401
2010	1112	47.3	80.8	0.044	2.321
2011	1534	56.0	118.3		
2012	1565	55.0	150.3		
2013	1688	72.3	253.9		
2014	1183	39.5	203.9		
2015	1159	64.2	371.1		
2016	1002	69.9	455.6		
2017	1285	45.0	408.0		
2018	930	30.6	319		
2019	642	33.8	145.1		
2020	893	28.3	237.2		

Table 26.13. Diagnostic of the SPiCT model, stochastic and deterministic reference points.

```
Convergence: 0  MSG: relative convergence (4)
Objective function at optimum: 59.6416612
Euler time step (years):  1/16 or 0.0625
Nobs C: 44,  Nobs I1: 26,  Nobs I2: 18,  Nobs I3: 16,  Nobs I4: 16

Residual diagnostics (p-values)
   shapiro   bias    acf   LBox shapiro bias acf LBox
 C   0.4350 0.2548 0.2839 0.6389      -    -   -    -
 I1  0.3362 0.6984 0.0123 0.0149      -    -   *    *
 I2  0.1725 0.6882 0.0106 0.0160      -    -   *    *
 I3  0.3327 0.7271 0.4272 0.6818      -    -   -    -
 I4  0.8987 0.8786 0.0737 0.2554      -    -   .    -

Priors
    logn  ~  dnorm[log(2), 2^2]
 logalpha  ~  dnorm[log(1), 2^2]
  logbeta  ~  dnorm[log(1), 2^2]

Model parameter estimates w 95% CI
           estimate       cilow       ciupp     log.est
 alpha1    2.1124038    1.0589357 4.213901e+00   0.7478265
 alpha2    2.2590020    1.0661205 4.786598e+00   0.8149231
 alpha3    1.2549452    0.5565064 2.829954e+00   0.2270919
 alpha4    2.1537992    1.1061970 4.193512e+00   0.7672333
 beta      0.5148770    0.2068238 1.281759e+00  -0.6638273
 r         1.0714121    0.3381671 3.394547e+00   0.0689775
 rc        0.8263785    0.4291966 1.591116e+00  -0.1907024
 rold      0.6725624    0.2922877 1.547586e+00  -0.3966604
 m      2252.0246177 1802.9360302 2.812975e+03   7.7195849
 K      9912.5508309 4886.2847793 2.010907e+04   9.2015570
 q1        0.0283254    0.0135340 5.928230e-02  -3.5639979
 q2        0.0063768    0.0030327 1.340860e-02  -5.0550843
 q3        0.0000219    0.0000102 4.720000e-05 -10.7289789
 q4        0.0009999    0.0004558 2.193600e-03  -6.9078594
 n         2.5930300    1.0525312 6.388224e+00   0.9528271
 sdb       0.1918891    0.1085925 3.390789e-01  -1.6508378
 sdf       0.1817874    0.1174908 2.812703e-01  -1.7049174
 sdi1      0.4053472    0.2892595 5.680240e-01  -0.9030113
 sdi2      0.4334778    0.2922462 6.429613e-01  -0.8359147
 sdi3      0.2408103    0.1444218 4.015292e-01  -1.4237459
 sdi4      0.4132905    0.2835544 6.023854e-01  -0.8836045
 sdc       0.0935982    0.0481846 1.818137e-01  -2.3687447

Deterministic reference points (Drp)
          estimate        cilow        ciupp    log.est
 Bmsyd 5450.3467242 2761.9468926 1.075556e+04  8.6034345
 Fmsyd    0.4131892    0.2145983 7.955579e-01 -0.8838496
 MSYd  2252.0246177 1802.9360302 2.812975e+03  7.7195849
Stochastic reference points (Srp)
          estimate        cilow        ciupp    log.est
 Bmsys 5233.8166605 2658.3170588 1.030458e+04  8.5628961
 Fmsys    0.3995191    0.2033189 7.850503e-01 -0.9174937
```

```
 MSYs  2088.0498442 1680.6682296 2.594178e+03  7.6439858
      rel.diff.Drp
 Bmsys  -0.04137135
 Fmsys  -0.03421649
 MSYs   -0.07853011

States w 95% CI (inp$msytype: s)
                  estimate       cilow       ciupp    log.est
 B_2020.88      7873.9247658 3946.2522931 1.571078e+04  8.9713119
 F_2020.88         0.1143901    0.0552507 2.368314e-01 -2.1681404
 B_2020.88/Bmsy    1.5044327    1.1002913 2.057017e+00  0.4084159
 F_2020.88/Fmsy    0.2863196    0.1818052 4.509160e-01 -1.2506467

Predictions w 95% CI (inp$msytype: s)
                prediction       cilow       ciupp    log.est
 B_2021.00      7950.6316925 3987.0804019 1.585434e+04  8.9810067
 F_2021.00         0.1144657    0.0547241 2.394262e-01 -2.1674804
 B_2021.00/Bmsy    1.5190887    1.1063761 2.085756e+00  0.4181106
 F_2021.00/Fmsy    0.2865086    0.1789670 4.586721e-01 -1.2499868
 Catch_2021.00   933.2999183  618.3236063 1.408726e+03  6.8387266
 E(B_inf)       8287.2489084          NA          NA  9.0224733
```

Table 26.14. Output of the SPiCT model: B (biomass), F (Fishing mortality), B/ B_{MSY} and F/ F_{MSY}. Estimates (est), upper (upp) and lower (low) 95% CI. Weights are in tonnes.

Year	F/Fmsy low	F/Fmsy (estimate)	F/Fmsy upp	B/Bmsy low	B/Bmsy (est)	B/Bmsy upp	B low	B (est)	B upp	F low	F (est)	F upp
1977	0.464	0.958	1.978	0.250	0.536	1.151	957	2807	8232	0.130	0.383	1.127
1978	0.477	0.957	1.920	0.285	0.634	1.411	1155	3319	9541	0.134	0.382	1.090
1979	0.452	0.911	1.839	0.317	0.700	1.545	1308	3662	10251	0.131	0.364	1.012
1980	0.486	0.953	1.869	0.396	0.850	1.823	1688	4449	11725	0.145	0.381	0.998
1981	0.544	1.051	2.030	0.462	0.976	2.061	2001	5108	13039	0.165	0.420	1.067
1982	0.538	1.031	1.976	0.463	0.958	1.985	1996	5015	12602	0.165	0.412	1.031
1983	0.515	0.971	1.829	0.458	0.922	1.859	1968	4828	11841	0.159	0.388	0.947
1984	0.509	0.923	1.674	0.487	0.933	1.787	2090	4884	11410	0.159	0.369	0.856
1985	0.598	1.008	1.697	0.606	1.073	1.899	2609	5616	12091	0.188	0.403	0.862
1986	0.703	1.119	1.779	0.681	1.132	1.882	2881	5927	12191	0.219	0.447	0.911
1987	0.774	1.181	1.802	0.700	1.110	1.760	2909	5811	11609	0.239	0.472	0.931
1988	0.897	1.323	1.951	0.722	1.112	1.712	2980	5821	11369	0.275	0.529	1.015
1989	1.026	1.486	2.152	0.691	1.050	1.596	2825	5497	10698	0.311	0.594	1.134
1990	1.148	1.662	2.404	0.612	0.939	1.438	2483	4912	9717	0.341	0.664	1.292
1991	1.180	1.712	2.485	0.489	0.750	1.150	1912	3924	8052	0.337	0.684	1.388
1992	1.114	1.606	2.315	0.397	0.601	0.911	1493	3147	6634	0.308	0.642	1.334

Year	F/Fmsy low	F/Fmsy (estimate)	F/Fmsy upp	B/Bmsy low	B/Bmsy (est)	B/Bmsy upp	B low	B (est)	B upp	F low	F (est)	F upp
1993	1.072	1.543	2.222	0.363	0.544	0.817	1343	2850	6046	0.294	0.616	1.293
1994	1.067	1.531	2.198	0.352	0.523	0.778	1287	2738	5822	0.290	0.612	1.290
1995	1.072	1.528	2.177	0.346	0.507	0.743	1245	2654	5659	0.288	0.610	1.294
1996	1.052	1.496	2.126	0.330	0.480	0.696	1167	2510	5398	0.282	0.598	1.268
1997	1.107	1.572	2.233	0.348	0.504	0.731	1246	2637	5581	0.299	0.628	1.318
1998	1.157	1.644	2.337	0.346	0.506	0.741	1234	2649	5688	0.309	0.657	1.395
1999	1.138	1.613	2.288	0.321	0.470	0.688	1123	2460	5386	0.295	0.645	1.409
2000	1.081	1.547	2.215	0.271	0.395	0.575	914	2067	4674	0.273	0.618	1.400
2001	1.023	1.463	2.093	0.247	0.359	0.521	824	1879	4285	0.257	0.585	1.330
2002	0.984	1.410	2.020	0.241	0.351	0.512	802	1839	4213	0.246	0.563	1.292
2003	0.916	1.312	1.879	0.241	0.352	0.514	801	1841	4230	0.227	0.524	1.211
2004	0.872	1.256	1.808	0.229	0.331	0.478	755	1733	3976	0.214	0.502	1.174
2005	0.848	1.222	1.761	0.204	0.290	0.412	660	1518	3491	0.210	0.488	1.138
2006	0.849	1.214	1.736	0.212	0.299	0.422	692	1566	3546	0.216	0.485	1.091
2007	1.001	1.443	2.078	0.285	0.401	0.565	969	2099	4547	0.263	0.576	1.262
2008	0.963	1.416	2.082	0.297	0.430	0.622	995	2251	5092	0.249	0.566	1.285
2009	0.751	1.076	1.543	0.317	0.454	0.649	1044	2374	5398	0.190	0.430	0.973

Year	F/Fmsy low	F/Fmsy (estimate)	F/Fmsy upp	B/Bmsy low	B/Bmsy (est)	B/Bmsy upp	B low	B (est)	B upp	F low	F (est)	F upp
2010	0.628	0.915	1.334	0.398	0.584	0.856	1359	3054	6866	0.162	0.366	0.827
2011	0.543	0.799	1.173	0.526	0.780	1.158	1850	4084	9017	0.145	0.319	0.702
2012	0.472	0.698	1.033	0.718	1.075	1.611	2601	5628	12176	0.129	0.279	0.604
2013	0.403	0.593	0.872	0.898	1.324	1.954	3248	6932	14796	0.111	0.237	0.506
2014	0.326	0.472	0.684	1.001	1.430	2.044	3542	7486	15821	0.089	0.189	0.401
2015	0.265	0.378	0.541	1.062	1.465	2.022	3667	7668	16033	0.072	0.151	0.319
2016	0.228	0.325	0.461	1.159	1.594	2.191	3998	8341	17403	0.061	0.130	0.274
2017	0.228	0.319	0.446	1.249	1.742	2.428	4366	9115	19030	0.061	0.127	0.265
2018	0.222	0.312	0.439	1.222	1.672	2.287	4254	8749	17994	0.061	0.125	0.256
2019	0.180	0.265	0.390	0.991	1.370	1.896	3482	7173	14774	0.051	0.106	0.218
2020	0.176	0.265	0.400	0.982	1.377	1.931	3544	7207	14658	0.052	0.106	0.216
2021	0.179	0.287	0.459	1.106	1.519	2.086	3987	7951	15854	0.055	0.114	0.239

Table 26.15. Short-term projection of the SPiCT model, plaice 7.fg for 2022.

Reference Point	Estimate	CI 95% $_{LOW}$	CI 95% $_{UPP}$	CV, %
B/B_{MSYS}	1.59	1.15	2.21	16.9
F/F_{MSYS}	0.29	0.16	0.52	30.8

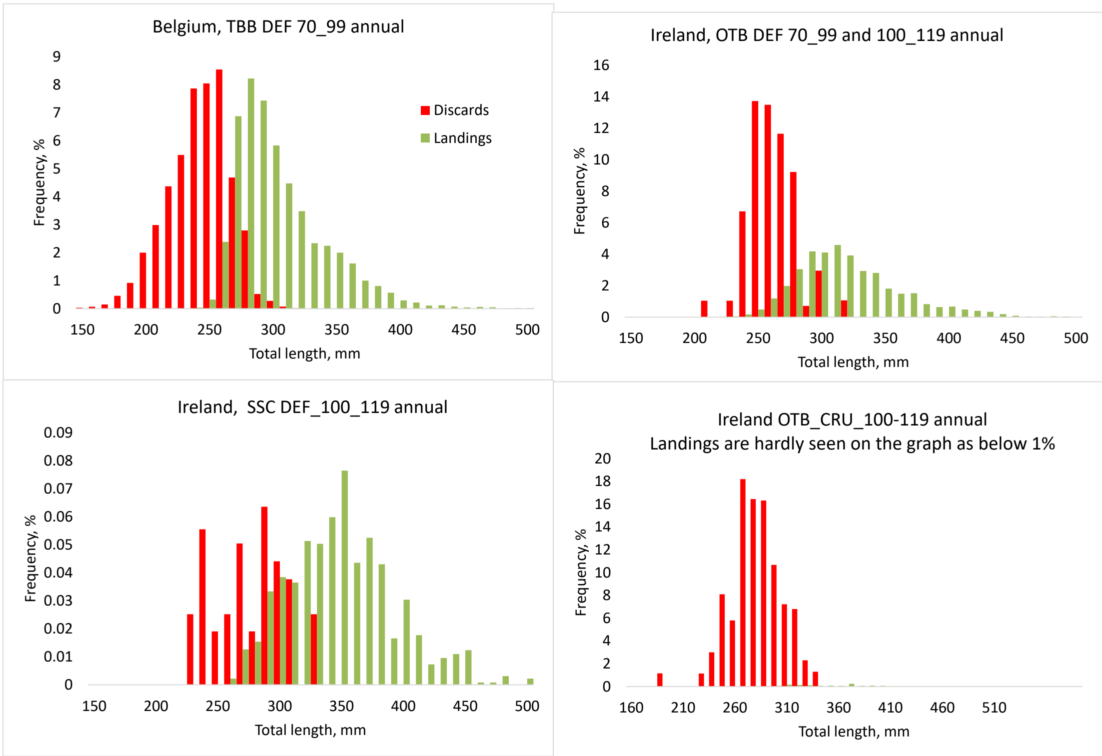


Figure 26.1. Plaice in divisions 7.f–g: Landing and discards by different metiers when both landings and discards were sampled simultaneously.

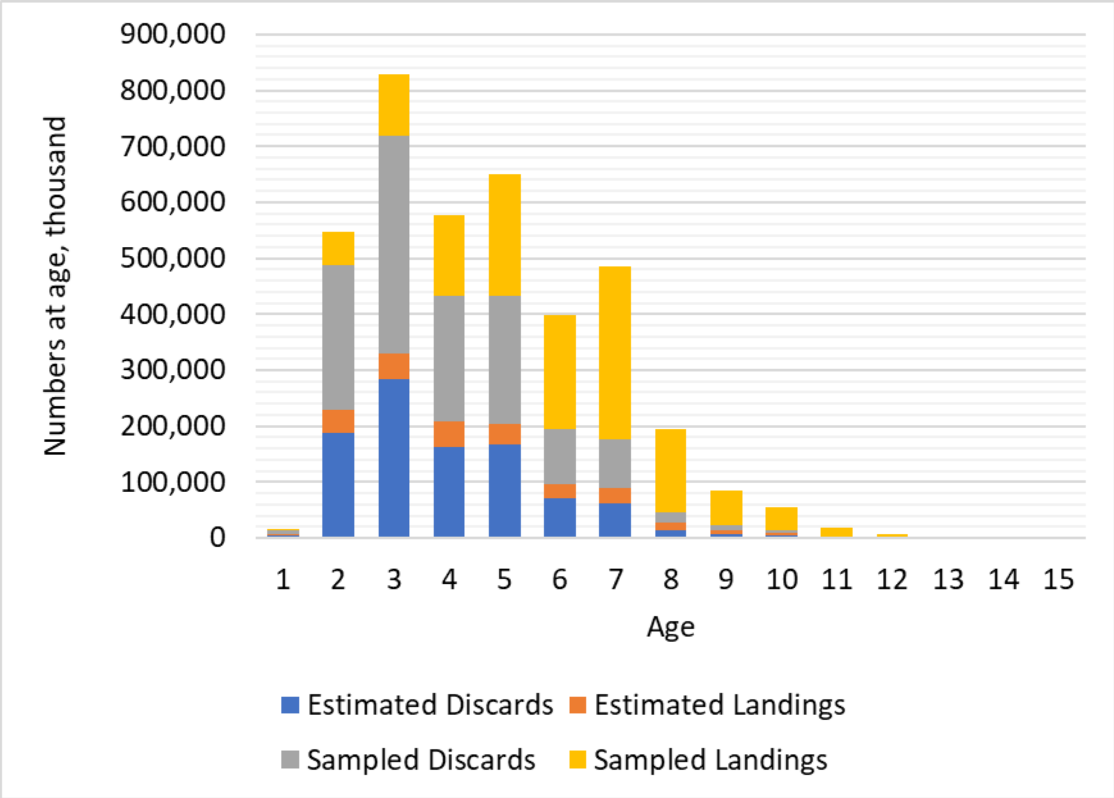


Figure 26.2. Plaice in divisions 7.f–g: Contribution of sampled and unsampled landings and discards to final assessment catch numbers-at-age in 2019.

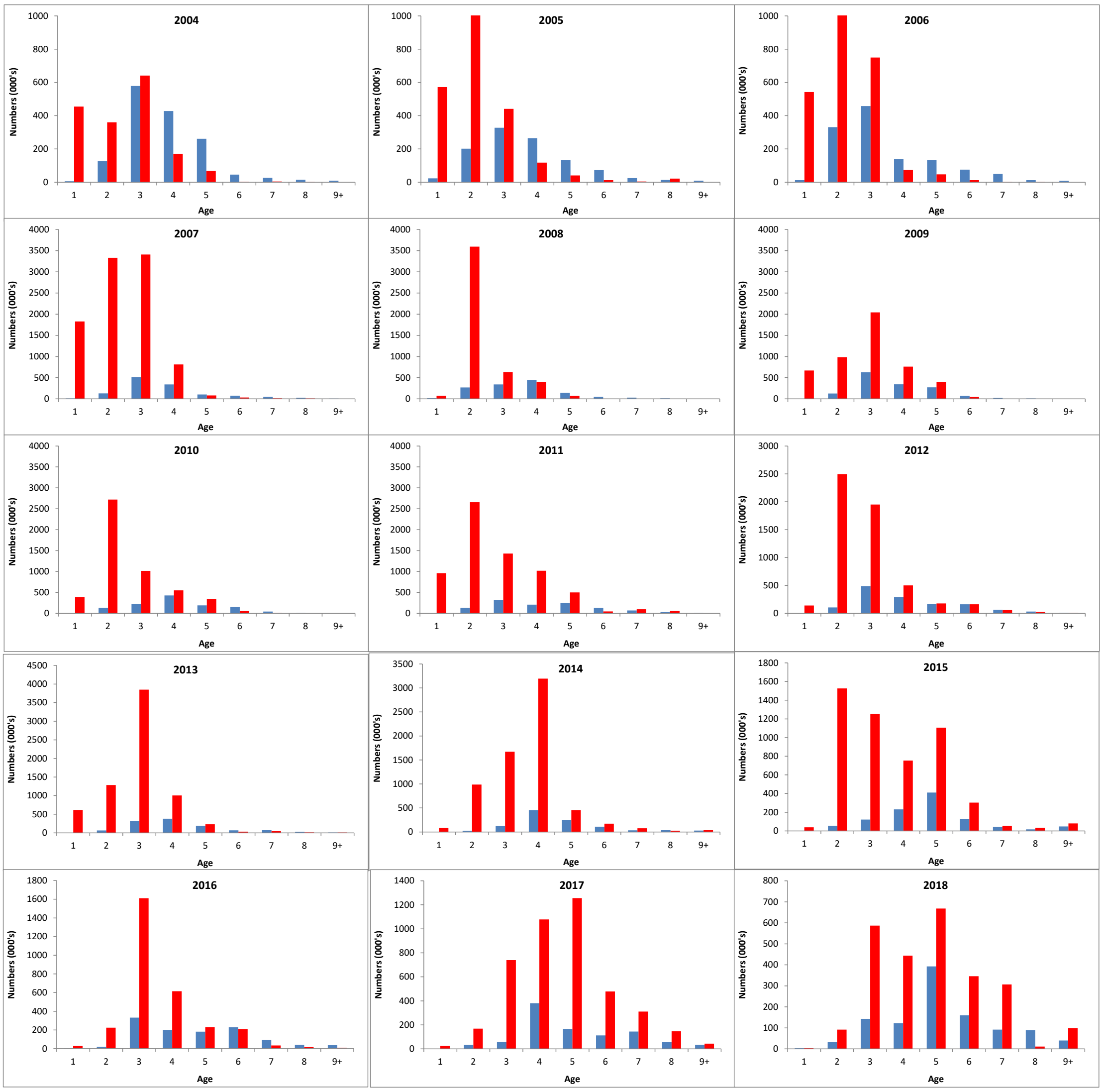


Figure 26.3. Plaice in divisions 7.f–g: Age composition of international landings (blue) and discards (red) from 2004 to 2019.

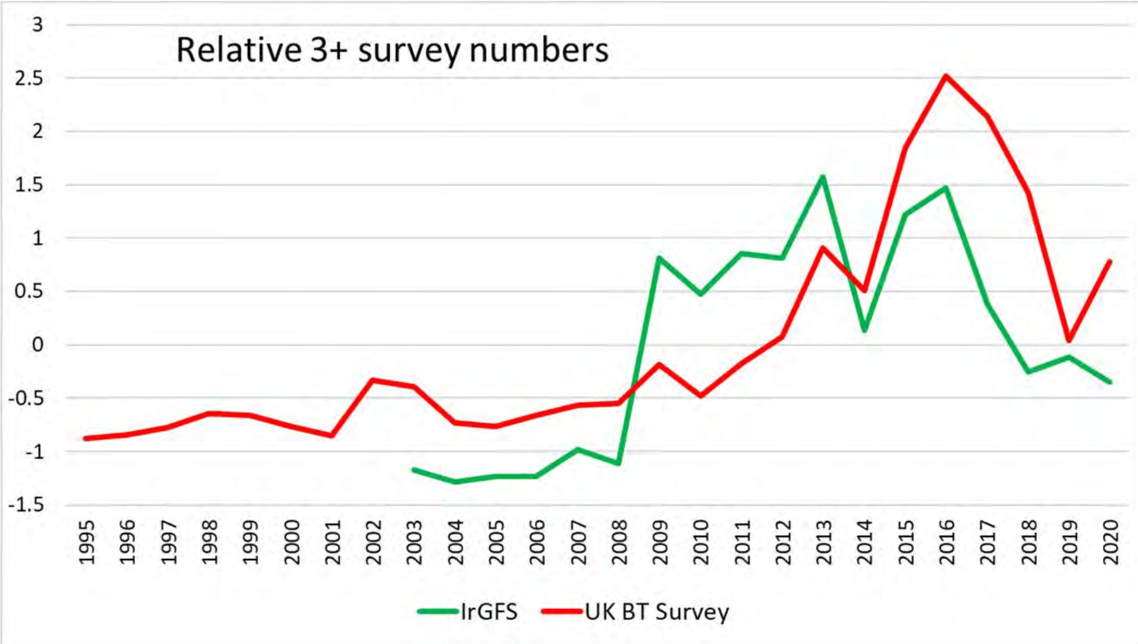
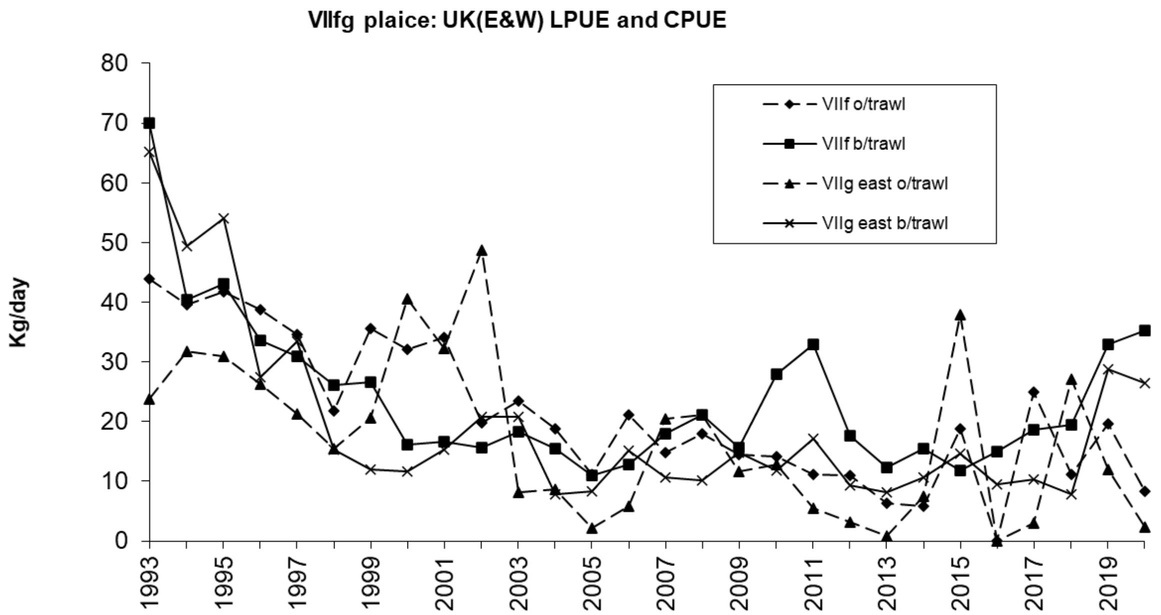


Figure 26.4. Trends cpues of surveys.



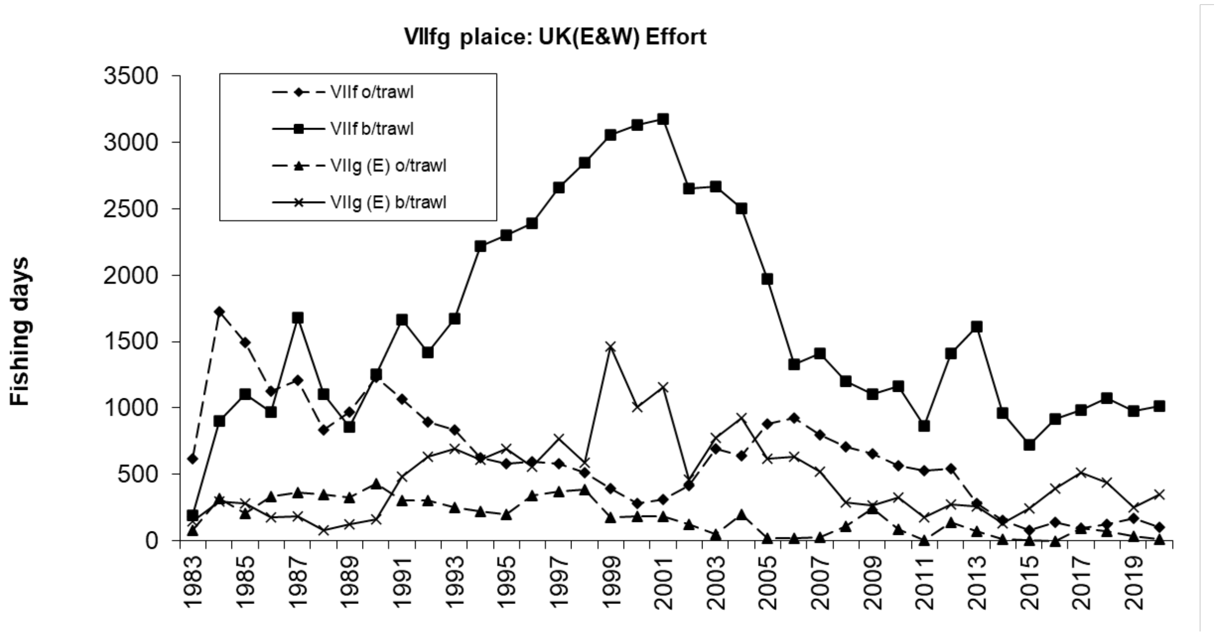
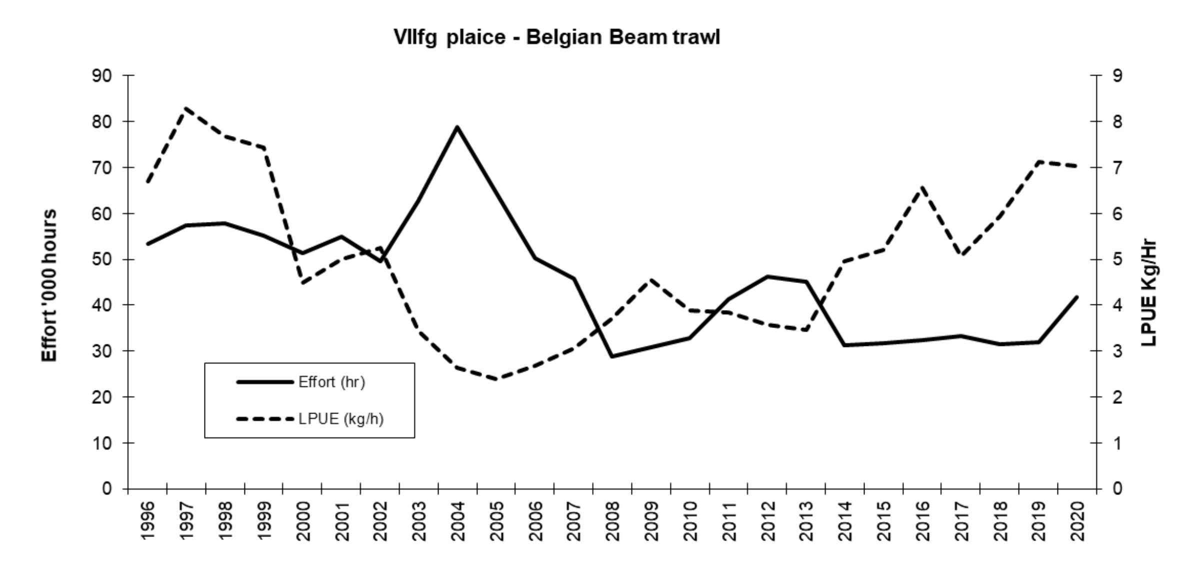
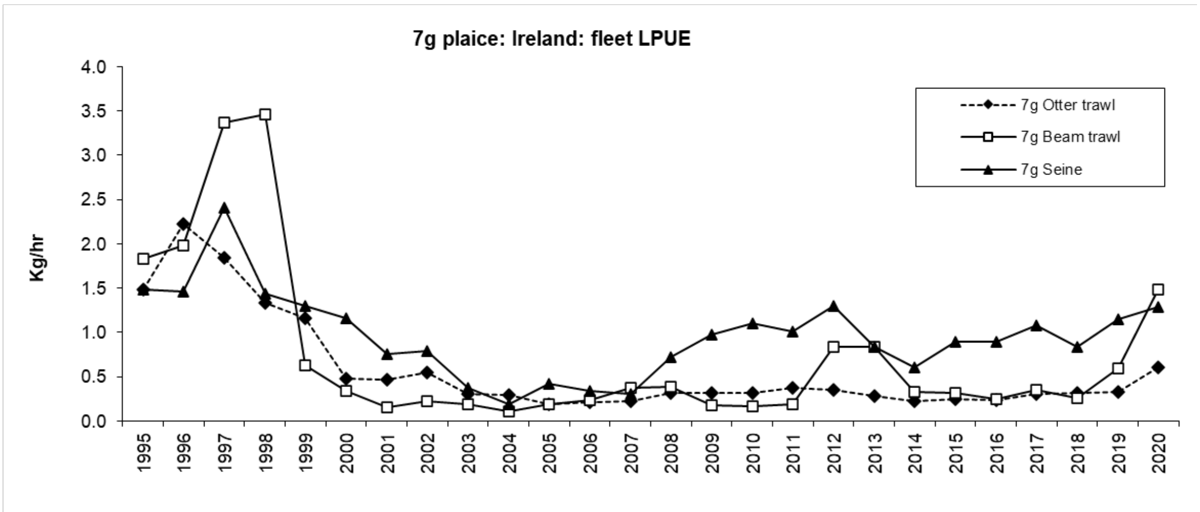


Figure 26.5. Plaice in divisions 7.f–g: UK (E&W) lpue and effort by fleet.





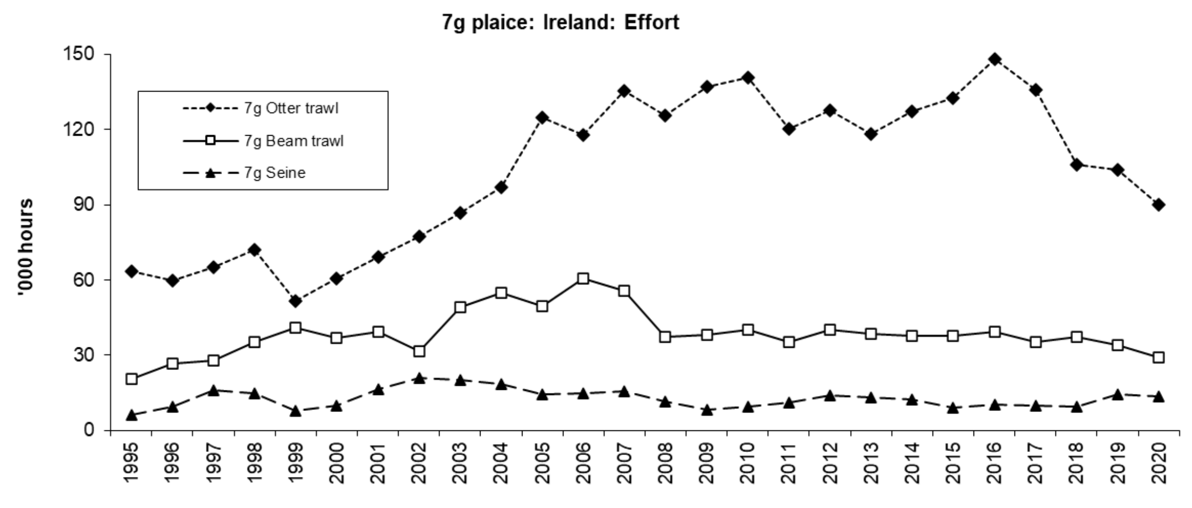


Figure 26.6. Plaice in divisions 7.f–g: Ireland and Belgium: lpue and effort by fleet.

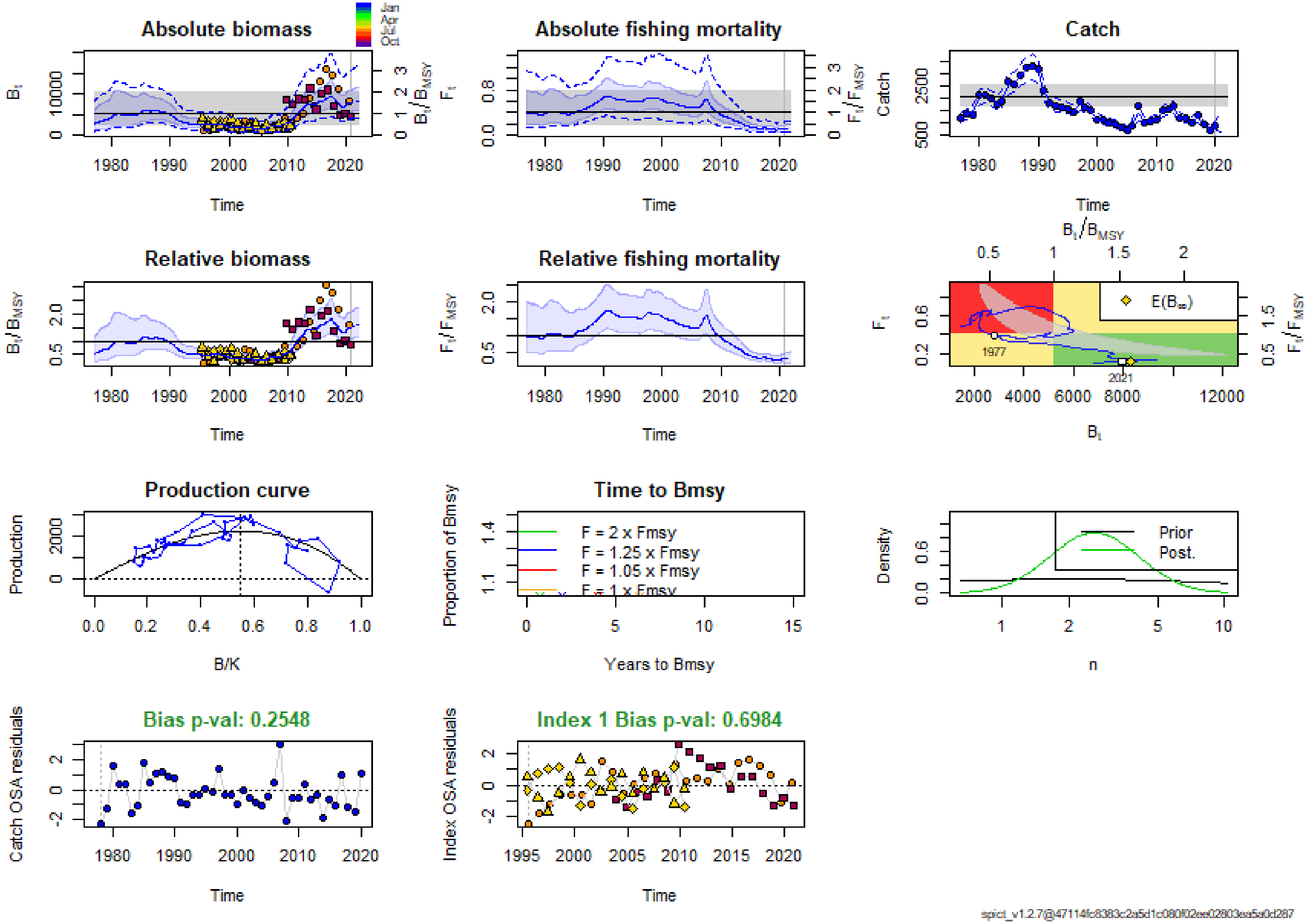


Figure 26.7. Output of the SPiCT model: dynamics of biomass, catch and fishing mortality.

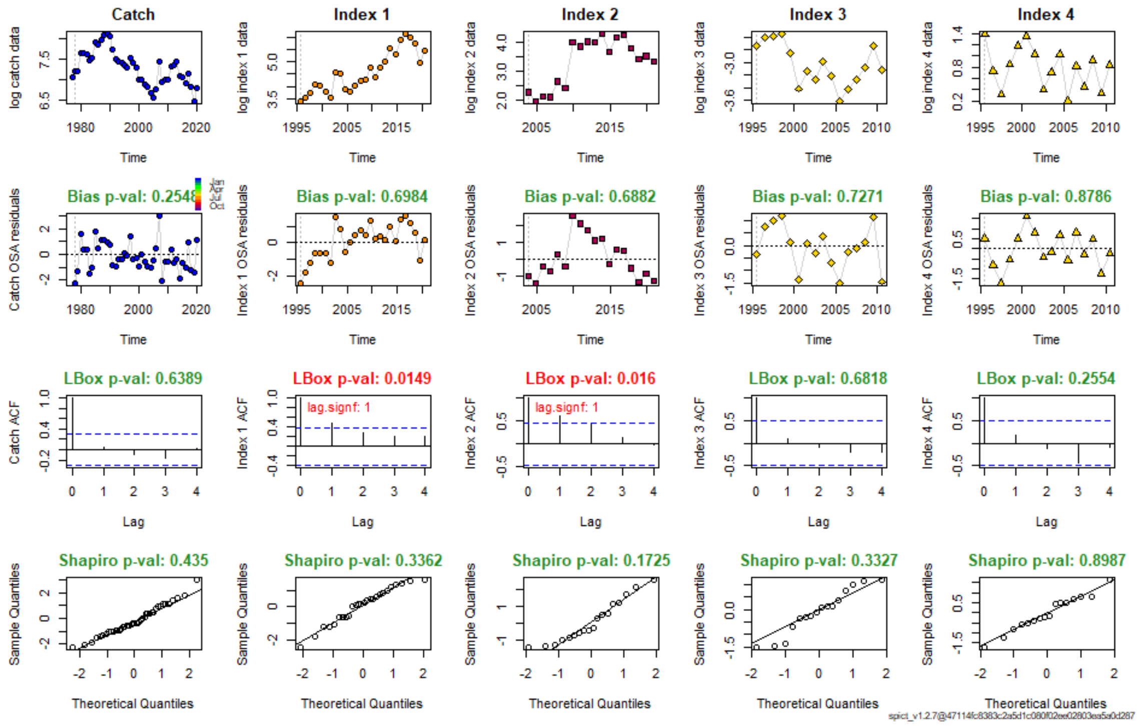
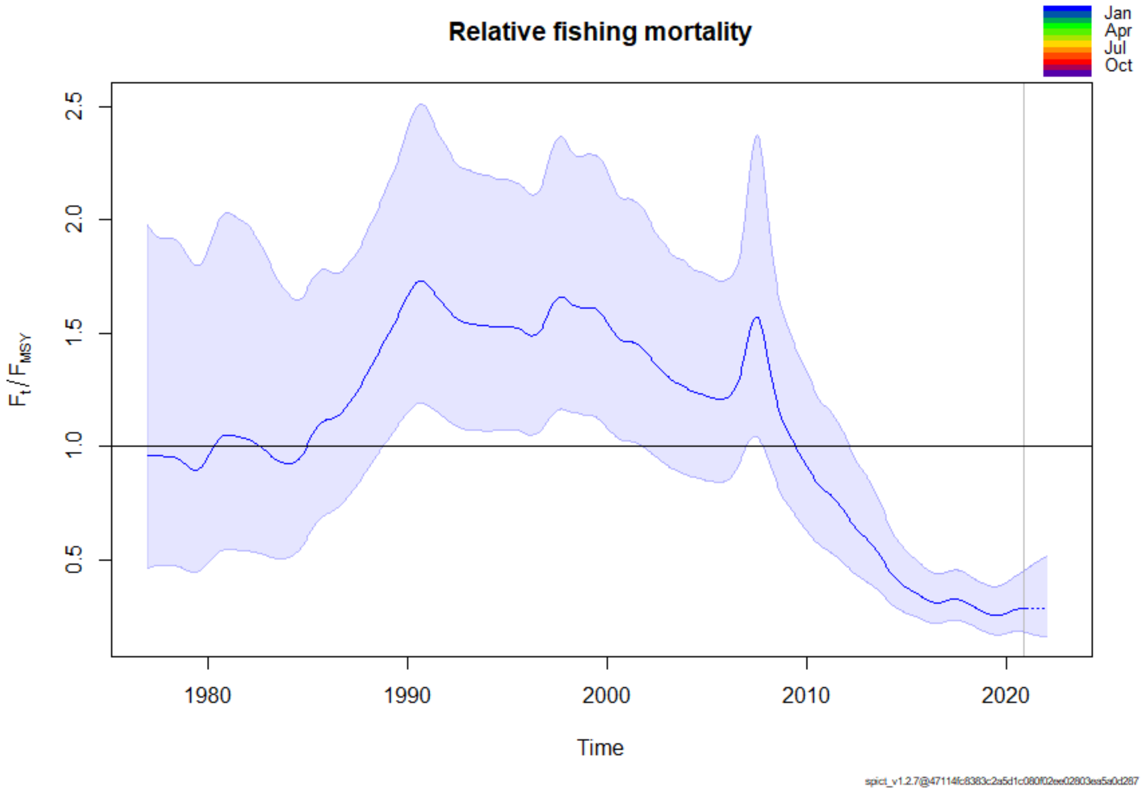


Figure 26.10. Diagnostics of the SPiCT model.



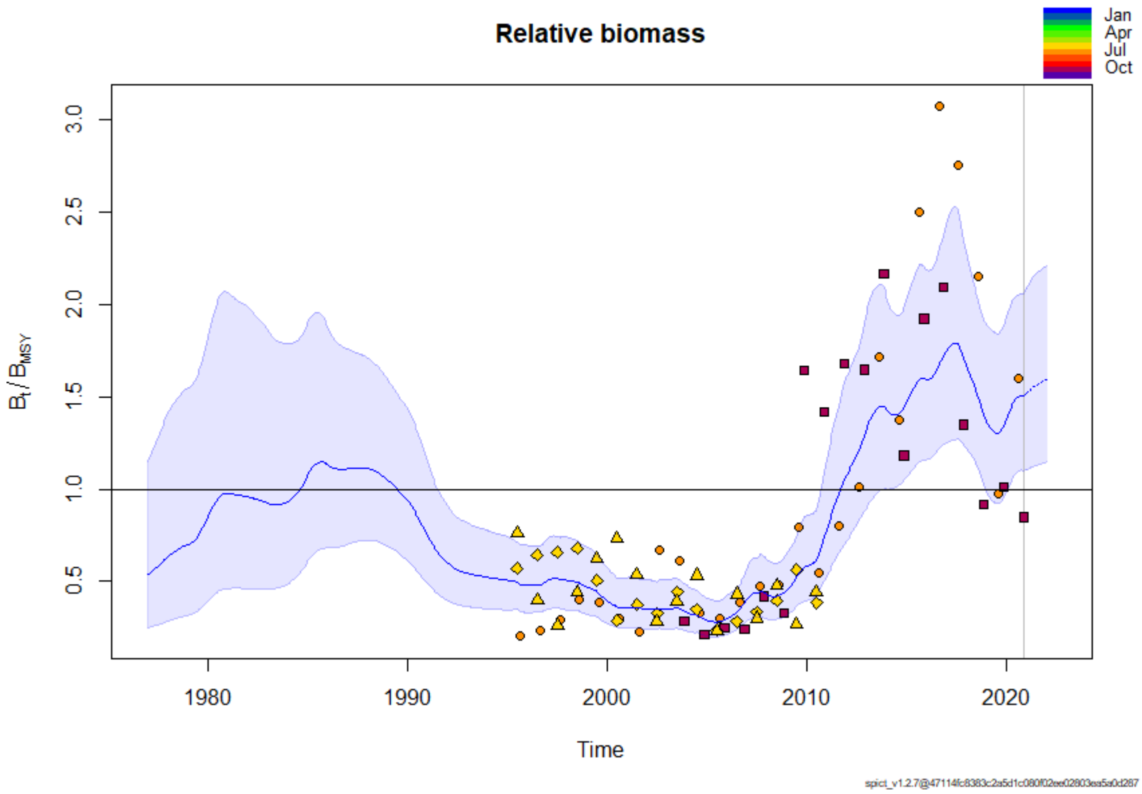


Figure 26.11. Ple 7 f&g. Dynamics of B/B_{MSY} and F/F_{MSY} from SPiCT run.

27 Plaice (*Pleuronectes platessa*) in divisions 7h–k (Celtic Sea South, southwest of Ireland)

Type of assessment in 2021

In 2021, a trends-based assessment was conducted using a combined survey index produced using VAST biomass index of the VAST model to which an 'rfb' advice rule was applied. Stock status and proxy MSY reference points were estimated from SPiCT.

ICES advice applicable to 2022

ICES advises that when the MSY approach is applied, catches in 2022 should be no more than 35 tonnes.

27.1 Impact of the COVID-19 pandemic

Both the fishery and sampling of plaice in 27.7h–k was affected by the implications of the COVID-19 pandemic in 2020. Sampling levels were lower than previous years due to national restrictions on scientific sampling activities. However, there was sufficient information to provide an estimate of discards.

Data for all scientific tuning indices were received for 2020. One scientific survey (Q1SWBeam) was delayed from March 2020 to June 2020. The impact of this change in survey timing is discussed in this report and considered negligible.

27.2 General

27.2.1 Stock description and management units

The TAC specified for plaice in ICES Division 7.h–k is consistent with the assessment area. Official national landings data as reported to ICES and the landings estimates as used by the Working Group are given in Table 27.1. Official landings in 2020 were 40 t, a 40% undershoot of the 2020 TAC (67 t).

Plaice in 7.h–k is on the south-western margins of the species distribution. Landings of plaice are similar in ICES divisions 7h and 7j, but are considered negligible in 7k. Plaice in 7j is typically targeted by the Irish otter trawl fleet, which operate on sandy grounds off the southwest of Ireland, close to shore and this species is a small, but valuable component of the landings in a mixed fishery. Whereas, plaice in 7h is mostly targeted by the beam trawl fleet, and some otter trawl, which operate close to the boundaries of other plaice stocks (ple.27.7.fg and ple.27.7.e) (Figure 27.1).

To date, no stock identification studies have been conducted on plaice in 7h–k, which is on the southwestern margins of the species distribution, which is reflected in the reported landings that show high landings in adjoining stock areas, 27.7.e and 27.7.fg (Figure 27.1). There are no relevant tagging studies completed in this area. There is evidence in other areas to suggest that plaice is a highly mobile species, and therefore it is possible that ple.27.7.h–k is an extension of larger adjoining populations, but tagging and genetic would need to be completed to determine this (ICES, 2021).

27.2.2 Landings obligation

The EU multiannual plan (MAP) for stocks in the Western Waters and adjacent waters (EU, 2019) applies to bycatches of this stock. As of 2020, the EU landing obligation fully applied to plaice in divisions 7h–k. The landing obligation was phased in between 2016–2019 (Commission Delegated Regulations (EU) 2015/2438, 2016/2375, 2018/46, EU, 2015, 2016, 2018). A survivability exemption for plaice caught in ICES divisions 7h–k for vessels using beam trawls, with a maximum engine power of 221 kW, a maximum length of 24 metres, fishing within 12 nautical miles of the coast and with tow durations of no more than ninety minutes, and by vessels using beam trawls with an engine power of more than 221 kW, using a flip-up rope or benthic release panel (Commission Delegated Regulations (EU) 2020/2015). Additional survivability exemption available for plaice caught in pots, traps and creels in North-Western Waters (ICES subareas 5, 6 and 7) (Commission Delegated Regulations (EU) 2020/2015).

27.2.3 Management applicable to 2021 and 2020

TAC table 2021

At the time of the working group, the total allowable catch (TAC) for this area had not been published.

TAC table 2020

Species:	Plaice *Pleuronectes platessa*	**Zone:**	7h, 7j and 7k (PLE/7HJK.)
Belgium	4 ([1])	Precautionary TAC	
France	8 ([1])	Article 8 of this Regulation applies	
Ireland	30 ([1])	Article 3 of Regulation (EC) No 847/96 shall not apply	
The Netherlands	17 ([1])	Article 4 of Regulation (EC) No 847/96 shall not apply	
United Kingdom	8 ([1])		
Union	67 ([1])		
TAC	67 ([1])		

([1]) Exclusively for by-catches of plaice in fisheries for other species. No directed fisheries for plaice are permitted under this quota.

27.3 Data

27.3.1 Commercial catch data

Belgium, France, Ireland, Spain, and the United Kingdom (England) uploaded commercial catch data for 2020 to InterCatch (Figures 27.2 and 27.3). All submitted age samples are presented in Figure 27.4 and length samples in Figure 27.5. Although these samples are not used directly in the stock assessment they are used to determine a number of biological parameters which are used within the estimation of MSY proxy reference points.

Landings reported to InterCatch for this stock totalled 40 tonnes in 2020, which shows a 50% decrease from 2019. This decrease was driven by a change in the behaviour of the Irish fleet in response to COVID. The OTB_DEF fleet, which typically targets this stock, significantly reduced its effort inshore along the southwest coast, where is typically catches plaice, and increased along the shelf edge, resulting in increased catches of anglerfish (Figure 27.6).

Discards submitted to InterCatch of plaice in divisions 7.h–k totalled 36 tonnes in 2020. Although there was a decrease in sampling due to COVID it was concluded that there was sufficient data to calculate discard rates. These rates are highly variable over time (Figure 27.7), this variability may be driven by low and variable sample sampling numbers. Therefore, an average discard rate was calculated from the of the average discard rates of all years, resulting in 44% (Figure 27.8). To ensure that any increase in future discarding is captured, future years will be calculated using an average of the preceding three years.

27.3.2 Revisions

No revisions to previous years were submitted.

27.3.3 Survey indices

Seven fisheries-independent surveys were combined to model the first biomass index for plaice in this stock area. This modelled index was produced using VAST, which is a Vector Autoregressive Spatiotemporal model in R (Thorson *et al*., 2016). This model implements a spatial delta-generalized linear mixed model (delta-GLMM) to standardizing survey. VAST is spatially explicit model that predicts population density for all locations within a spatial domain, and then predicts derived quantities (i.e. biomass abundance) by aggregating population density across spatial domain while weighting density estimates by the area associated with each estimate.

The model was parametrised using haul level data from seven fisheries-independent surveys undertaken in the Celtic Sea (1997–2020) (Table 27.2). The coverage of these surveys varies in space and time, a full description of which can be found in Table 27.2 and Figure 27.9. The raw survey data were checked for quality (specifically, the estimated weights of the catch numbers-at-length were checked against the reported catch weights). For each valid haul, the catch weight, tow duration, tow position (midpoint), survey series and year were used as input values for the VAST model. The model was specified to have spatial autocorrelation but no temporal autocorrelation (i.e. years are independent). VAST can optionally estimate, and correct for, differences in catchability between the two survey series as there is a significant spatial overlap between the two surveys. The model first estimates the likelihood of occurrence and then the biomass using a gamma error distribution or the abundance using a lognormal error distribution. Historically, none of these surveys were used to estimate abundances of plaice as individually they do not cover the full stock area, spatially/ temporally, and now of the surveys have been designed with this stock and species in mind. Vast offers a number of advantages over more traditional ways of estimating abundances. It has an ability to deal with gaps in survey coverage, and an ability to account for differences in catchability between surveys or vessels, providing an objective way to combine multiple indices even when the gear is not standardised.

The spatial domain was defined as 1000 knots, and implemented using k-means clustering to give knot positions proportional to sampling intensity (Thorson, 2019) (Figure 27.10). Residual diagnostics on the encounter probability appeared acceptable (Figure 27.11). Visualisation of the Pearson's residuals of positive catches (Figure 27.12a) and encounter probability (Figure 27.12b) show no strong patterns. These plots are the default output from the package, however in the future the presence/absence residuals should be revisited. The estimated survey biomass indices are presented in Table 27.3 and Figure 27.14, along with associated uncertainty. Visualisation of spatiotemporal variability in estimated log density of plaice in ICES division 7h–k (Figure 27.13), show distributional trends in areas of high abundance that mirror that of the known fishery, with high incidence of reported landings occurring in areas similar to the biomass from this VAST index, along the southwest coast of Ireland and the southwest coast of the UK. It is clear that these patches of high abundance spill over into adjoining stock area, plaice 7fg, where landings are substantially higher than the plaice in 27.7h–k.

27.3.4 Biological

A number of length based parameters were required for the calculation of the new 'rfb' catch advice rule (ICES, 2020): mean length in observed catch ($\bar{L}_{y-1}$), the length at first capture relative to the target length ($L_{F=M}$), asymptotic length at which growth is zero (L_∞), length at first catch (length at 50% of mode) L_c.

The calculation of the 'rfb' catch advice rule requires the calculation of *f* which is the ratio of mean length ($\bar{L}_{y-1}$) in the observed catch that is above the length of the first capture relative to the target length ($L_{F=M}$). The mean length in the observed catch was calculated by plotting the landings and discards data submitted to InterCatch over all years (2004–2020). The length of the first capture relative to the target length ($L_{F=M}$) is calculated ($L_{F=M} = 0.75*L_c + 0.25*L_\infty$). Length at first catch (length at 50% of mode)(L_c) was calculated from the landings and discards data submitted to InterCatch. L_c were calculated for each year, but was found to be highly variable due to the variable and low sample number submitted for discards (Figure 27.15, Figure 27.16). Therefore, a mean of the time-series, 234.4 mm, was estimated as the L_c of this stock (Figure 27.17) and used in the calculation of rfb. Similarly, the mean length in observed catch ($\bar{L}_{y-1}$) was found to be was found to be highly variable due to the variable and low sample number submitted for discards (Figures 27.15 and 27.16). Therefore, a mean of the time-series, 299.3 mm, was estimated as the $\bar{L}_{y-1}$ of this stock (Figure 27.18) and used in the calculation of rfb.

L_∞ is calculated from the von Bertalanfy growth model. Samples available through DATRAS were used to calculate these length parameters. These samples were collected by three surveys, Irish ground fish survey (IGFS, 2004–2020), Irish anglerfish and megrim survey (IAMS, 2016–2020) and the French southern Atlantic bottom trawl survey (EVOHE, 2014–2020). Although none of these surveys are designed to capture the dynamics of this stock, they do provide the samples required to produce estimates of life history parameters. Only samples from 7j (n= 1533) were used to calculate these parameters due to low sample size in 7h (n=13).

The FSA package in R (Ogle et al. 2020) was used to determine the starting values Ford-Walford (vbStarts{FSA}) and to fit a von Bertalanfy growth curve was fit to the survey data for all areas combined, by bootstrapping a nonlinear regression (nls{stats}(R Core, 2020)). Due to the uneven sample size it was not possible to determine if these growth parameters vary between ICES divisions 7j and 7h. However, we could estimate the growth parameters for the whole stock as linf = 463.64 mm (SD ± 21.26), K = 0.19 (SD± 0.03), t0 = -1.99 (SD± 0.30) (Figure 27.19). Residuals of model fitted considered acceptable (Figure 27.20).

27.4 Advice

27.4.1 Analyses of stock trends and potential status indicators

Advice is given based on trends in the VAST survey biomass index, and the outcome of the Surplus Production in Continuous Time (SPiCT) model, as described in the stock annex.

The advice for 2022 was set using the HCR 'rfb' as outlined in the table below (ICES, 2020).

Basis for catch scenario			
Advised catch 2022	*C2022* = C_{2021}*r*f*b*m		93 tonnes
Input variables			
C_{2021}	Due to non-zero advice in 2021, an average of catch in 2017–2019 was used to provide this value	C_{2021} = mean(C_{2017} - C_{2019})	163 tonnes
r	The rate of change in biomass index. Based on the average of the two years of data (index A, 2020–2021) relative to the average of three years prior (index B, 2017–2019)	*r* = index A/ index B *r* = 516 tonnes / 883 tonnes	0.580
f	The ratio of mean length ($\bar{L}_{y-1}$) in the observed catch that is above the length of the first capture relative to the target length ($L_{F=M}$)	$f = \bar{L}_{y-1}/ L_{F=M}$ f = 29.93/29.17 = 1.03 $\bar{L}_{y-1}$ = 29.93 $L_{F=M} = 0.75*L_c + 0.25*L_\infty$ $L_{F=M}$ = 0.75*23.44 + 0.25*46.36 $L_{F=M}$ = 29.17 L_c = 23.44 L_∞ = 46.36	1.03
b	Biomass safeguard is an adjustment to reduce catch when the most recent index data $Iy{-}1$ is less than $I_{trigger}$=1.4I_{loss} such that *b* is set equal to $Iy{-}1$/ $I_{trigger}$. When the most recent index data $Iy{-}1$ is greater than $I_{trigger}$, *b* is set equal to 1. I_{loss} is generally defined as the lowest observed index value for that stock.	$I_{y-1} > I_{trigger} \therefore b = 1$ I_{y-1} = 719 tonnes $I_{trigger} = 1.4 I_{loss}$ I_{loss} =153 tonnes	1
m	Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to less than 5% (ICES, 2020)	$k = 0.18 < 0.2$ m = 0.95 (ICES, 2021)	0.95

In order to decide whether the precautionary buffer should be applied, the Surplus Production in Continuous Time (SPiCT, Pedersen and Berg, 2017) was run, which was parametrised as per the stock annex. Input data include the catch time-series set out in the benchmark which combines official landing (1995–2003), InterCatch landings (2004–2020), and discard estimates of 44% per year (2004–2020) (Table 27.4). This model was tuned with the VAST biomass index (1997–2020). A summary of the SPiCT assessment is given in Figures 27.21 and 27.23, and in Table xx. The model diagnostics are shown in Figures 27.22 and 27.23. These results suggest that the relative fishing mortality is below the reference F_{MSY} proxy and the relative biomass is well-above the reference B_{MSY}* 0.5 proxy. Therefore, the Precautionary Approach Buffer (PA Buffer) was not applied for the advice for this stock.

27.4.2 State of the stock

On the relative scale, the spawning biomass is estimated to have been since 2004 and has in remained high and stable in recent years (Figure 27.21). Estimated F was below F_{MSY} from 2004, and is now at the lowest point in the time-series.

27.4.3 Biological reference points

The table below summarises all known reference points for plaice in 27.7h–k and their technical basis. No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} are used to estimate stock status relative to the proxy MSY reference points.

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger\ proxy}$	$\frac{B}{B_{MSY}} = 0.5$*	Estimated by SPiCT
	$F_{MSY\ proxy}$	$\frac{F}{F_{MSY}} = 1$*	Estimated by SPiCT
Precautionary approach	B_{lim}	Not defined	
	B_{pa}	Not defined	
	F_{lim}	Not relevant	
	F_{pa}	Not relevant	
Management plan	SSB_{MGT}	Not relevant applicable	
	F_{MGT}	Not relevant applicable	

*** No reference points are defined for this stock in terms of absolute values. The SPiCT-estimated values of the ratios F/F_{MSY} and B/B_{MSY} are used to estimate stock status relative to the proxy MSY reference points.**

27.5 Recommendations for the next benchmark

This stock should be considered for the next SPiCT workshop to assess if it can be moved to a category 2 stock.

27.6 References

ICES. 2020. Tenth Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE X). ICES Scientific Reports. 2:98. 72 pp. http://doi.org/10.17895/ices.pub.5985

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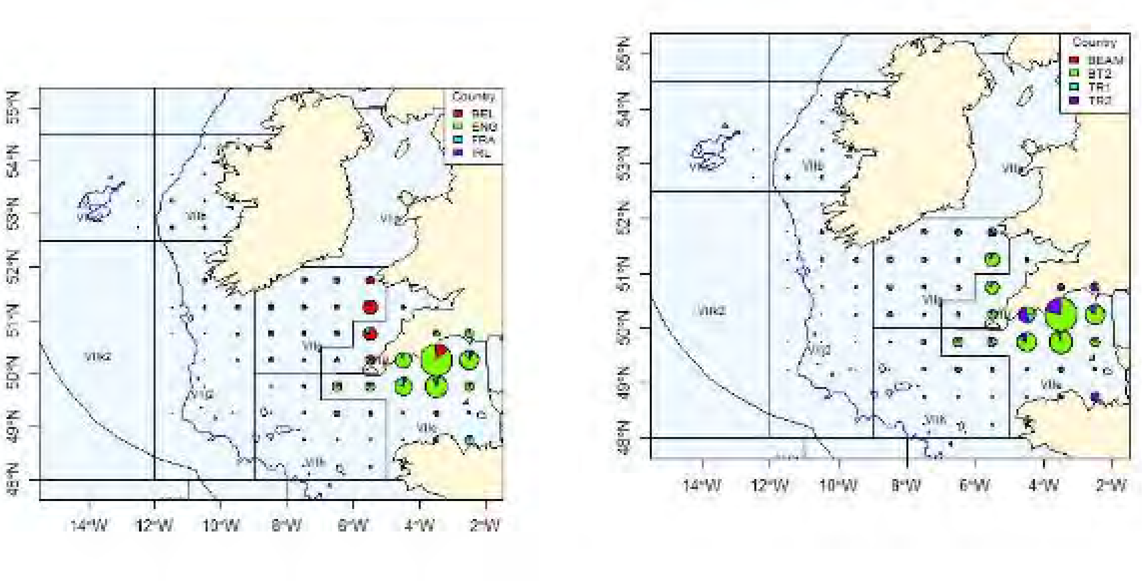

Figure 27.1. The spatial distribution of plaice landings reported to the STECF fisheries dependant information data call in 2016 (the last data year available), disaggregated by Member State (left) and gear (right). Note beam trawlers are described as beam and BT2, and otter trawlers are described as TR1 and TR2.

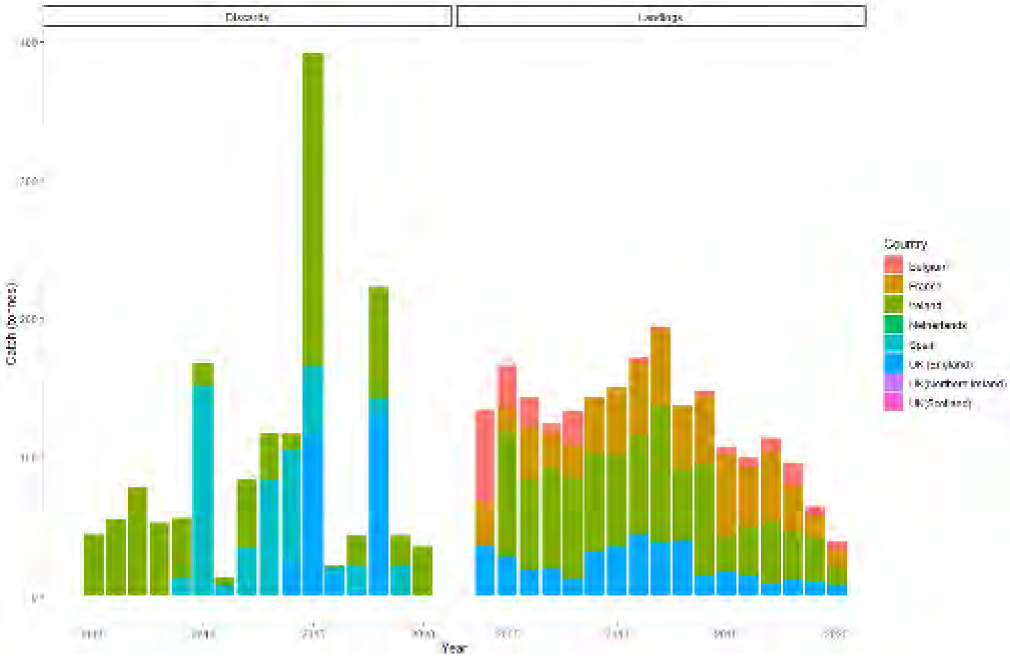

Figure 27.2. Plaice in Divisions 7.h–k. Landings and discards reported in InterCatch by country.

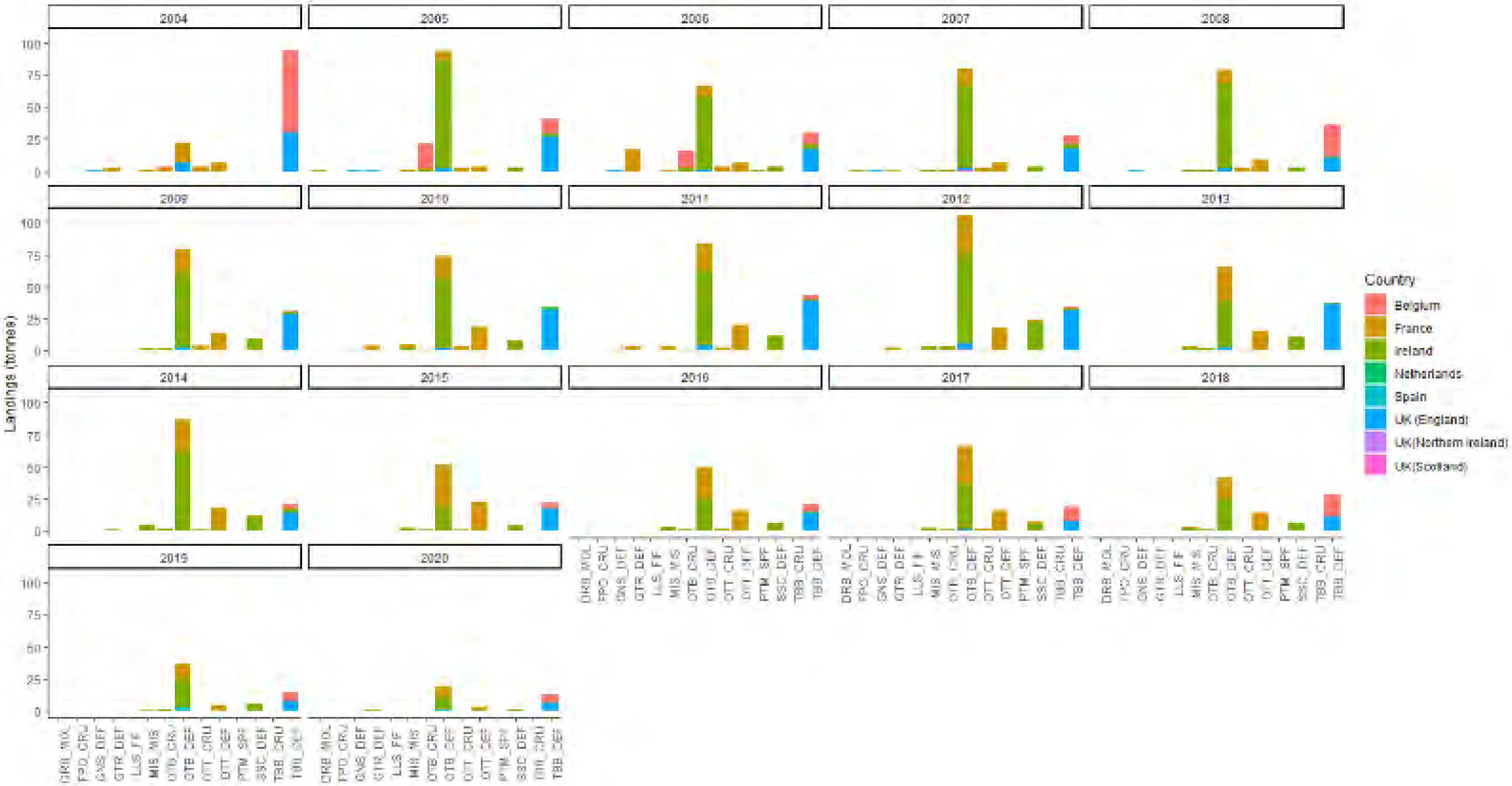

Figure 27.3. Plaice in Division 7.h–k. International landings reported in InterCatch by fleet and year.

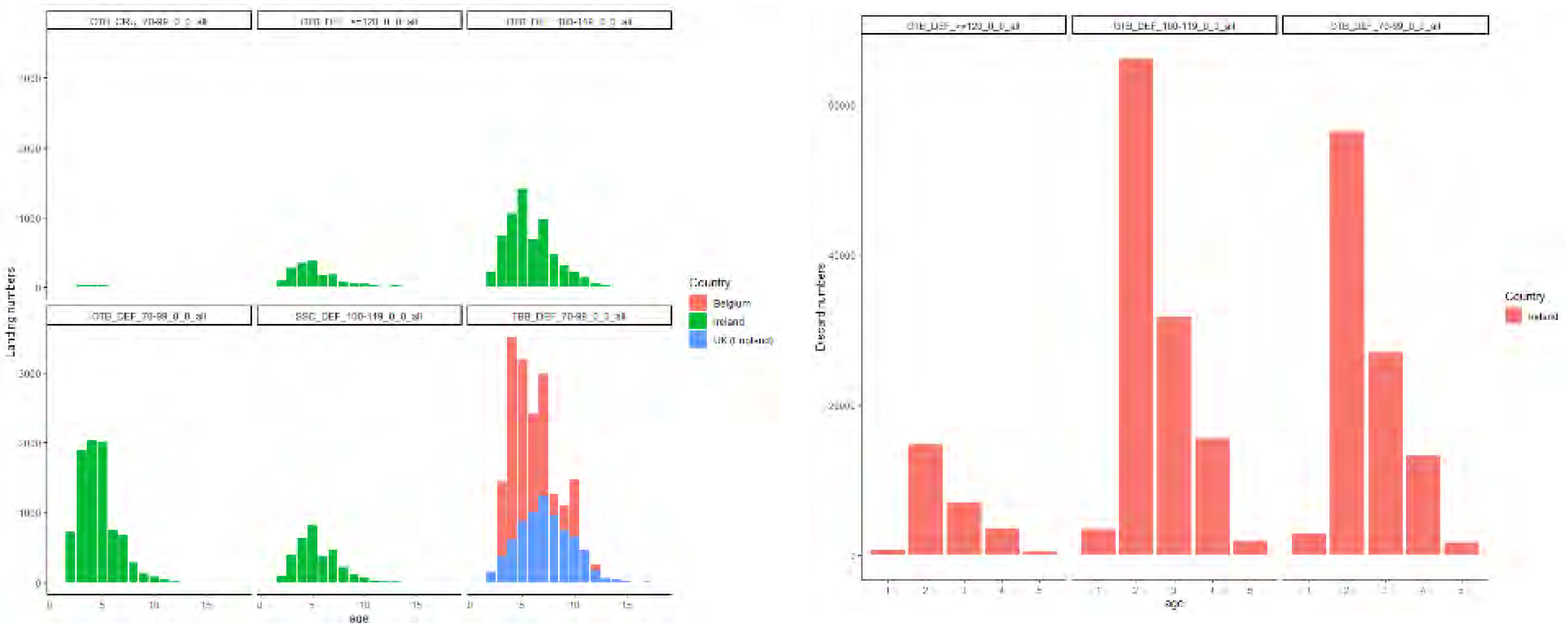

Figure 27.4. Plaice in Division 7.h–k. Unraised landings (left) and discard (right) age distributions submitted to InterCatch.

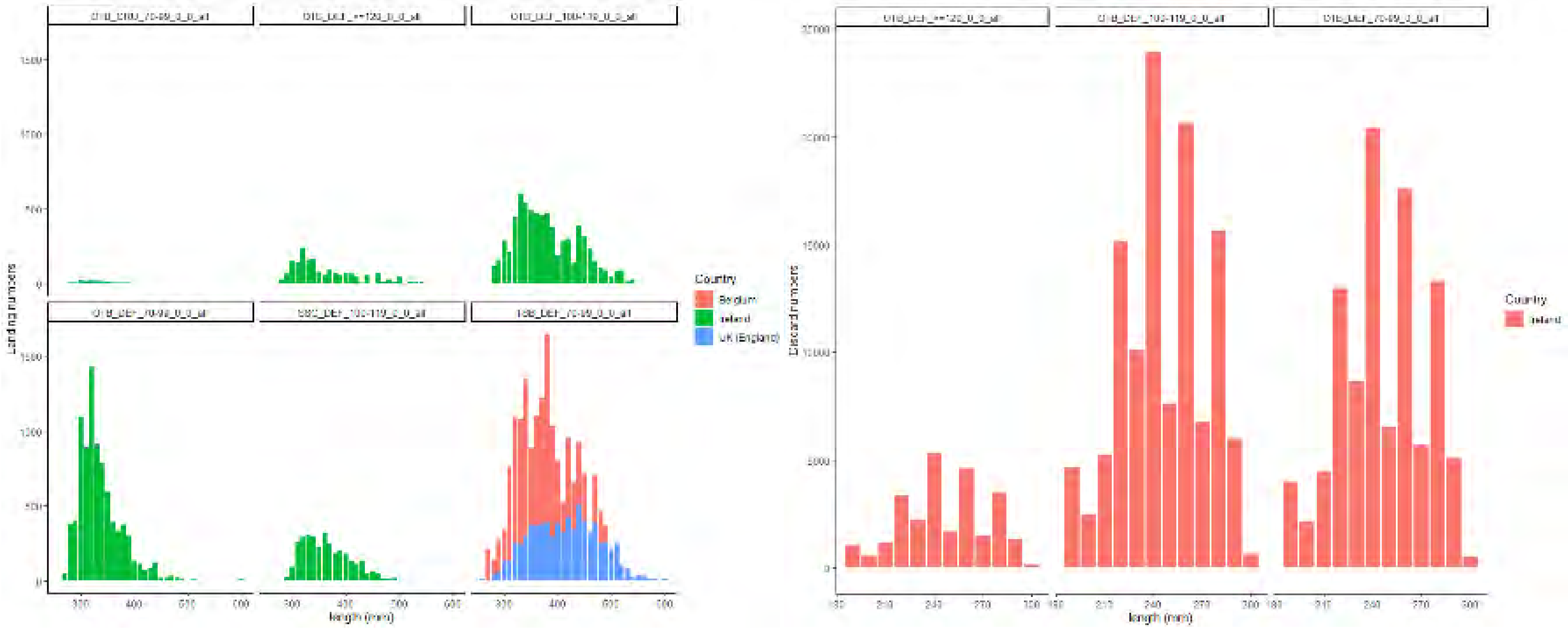

Figure 27.5. Plaice in Division 7.h–k. Unraised landings (left) and discard (right) length distributions submitted to InterCatch.

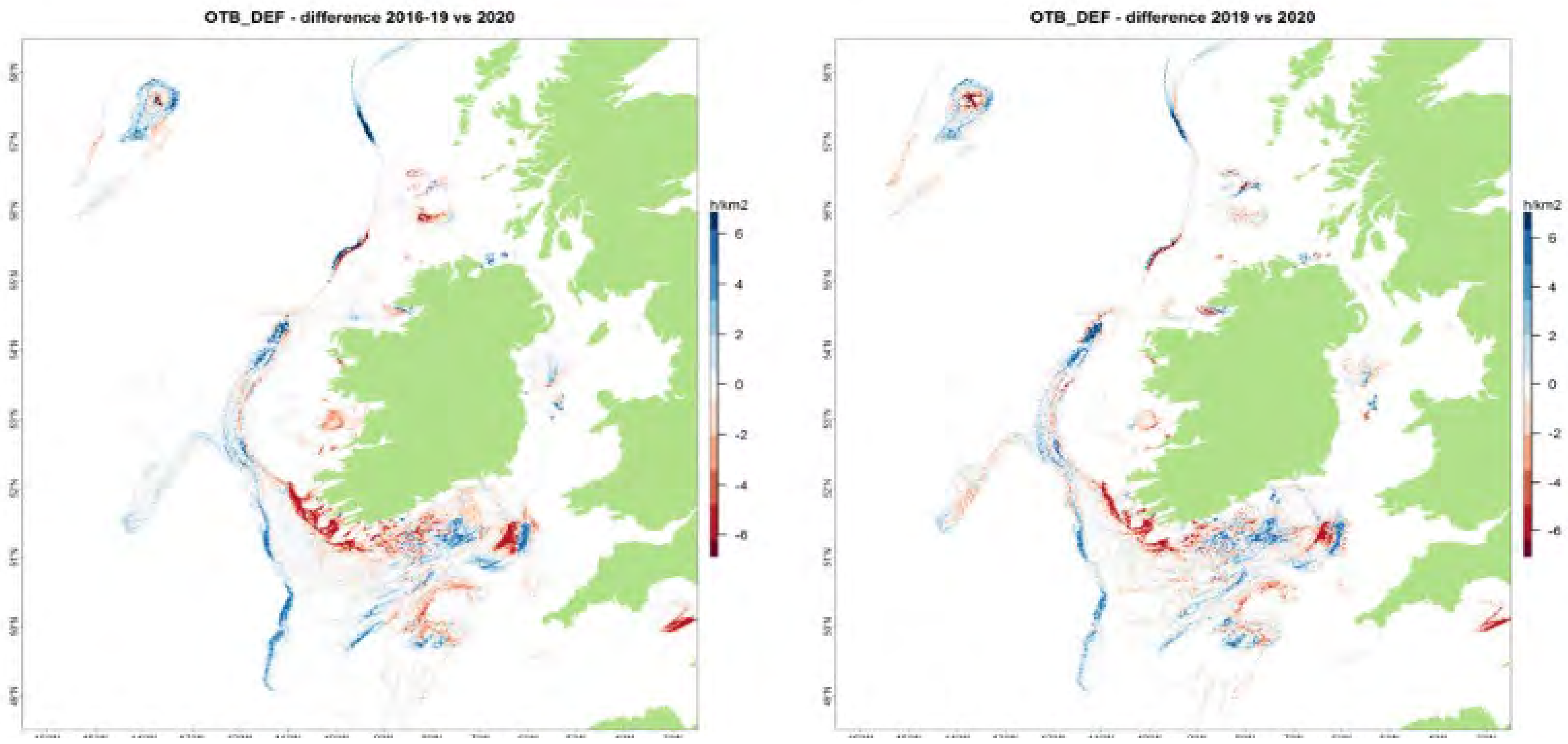

Figure 27.6. Plaice in Division 7.h–k. (red = decrease and blue = increase) The OTB_DEF fleet significantly reduced its effort inshore along the south-west coast (plaice and sole) and increased along the shelf edge (anglerfish). There is also a distinct move from the eastern to the western side of the smalls and an increase in the central Celtic Sea except around the Labadie/Jones ground.

Figure 27.7. Plaice in Division 7.h–k. Raw variable discard rates.

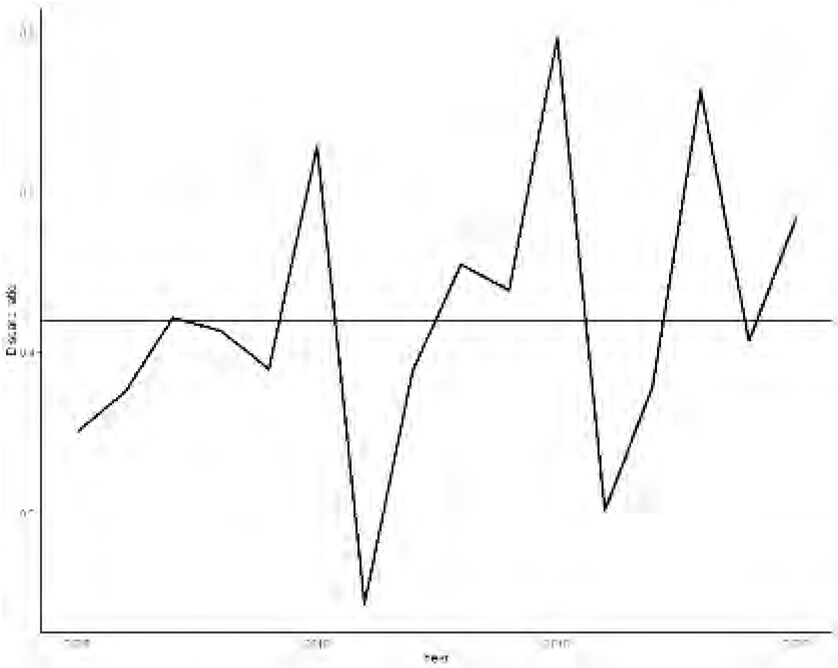

Figure 27.8. Plaice in Division 7.h–k. Annual average discard rate 44%.

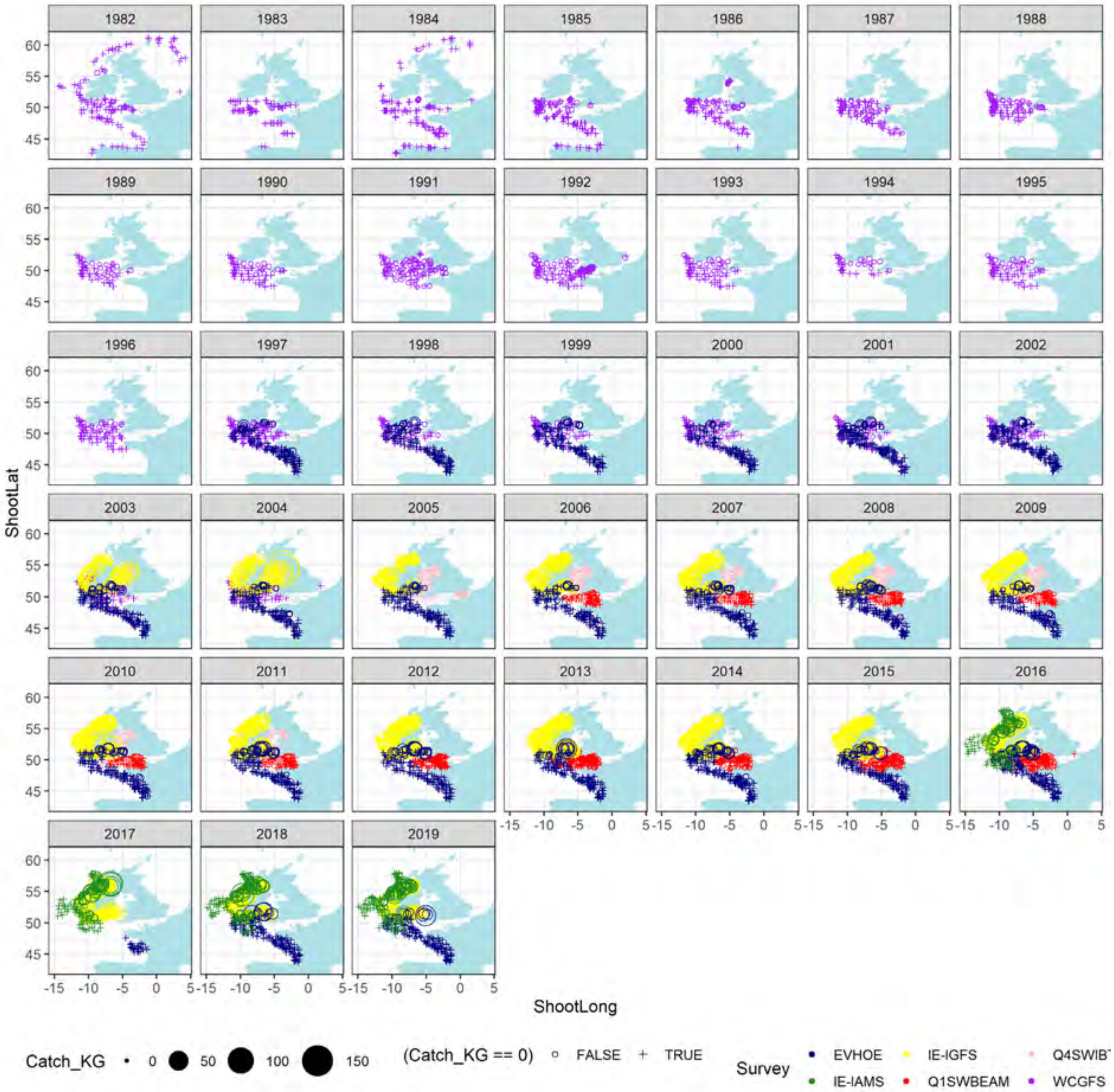

Figure 27.9. Plaice in Division 7.h–k. Survey numbers per haul by year. Each point represents haul with a positive count shown as a circle and a zero as a '+' symbol. Circle diameter is proportional to the count. Colours denote the surveys.

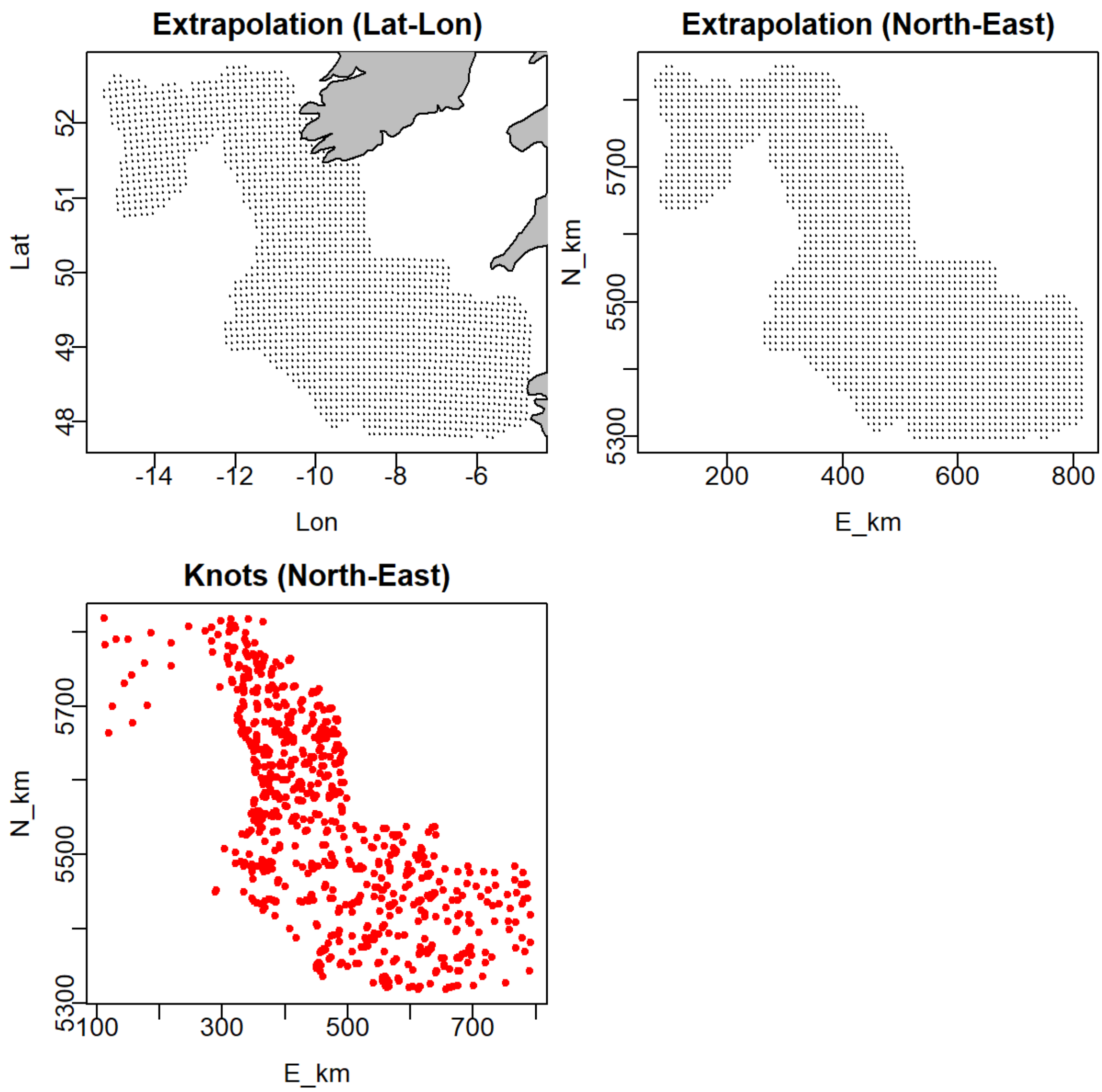

Figure 27.10. Plaice in Division 7.h–k. The spatial area defined within the model in terms of latitude and longitude (top left), kilometres (top right) and knots (bottom).

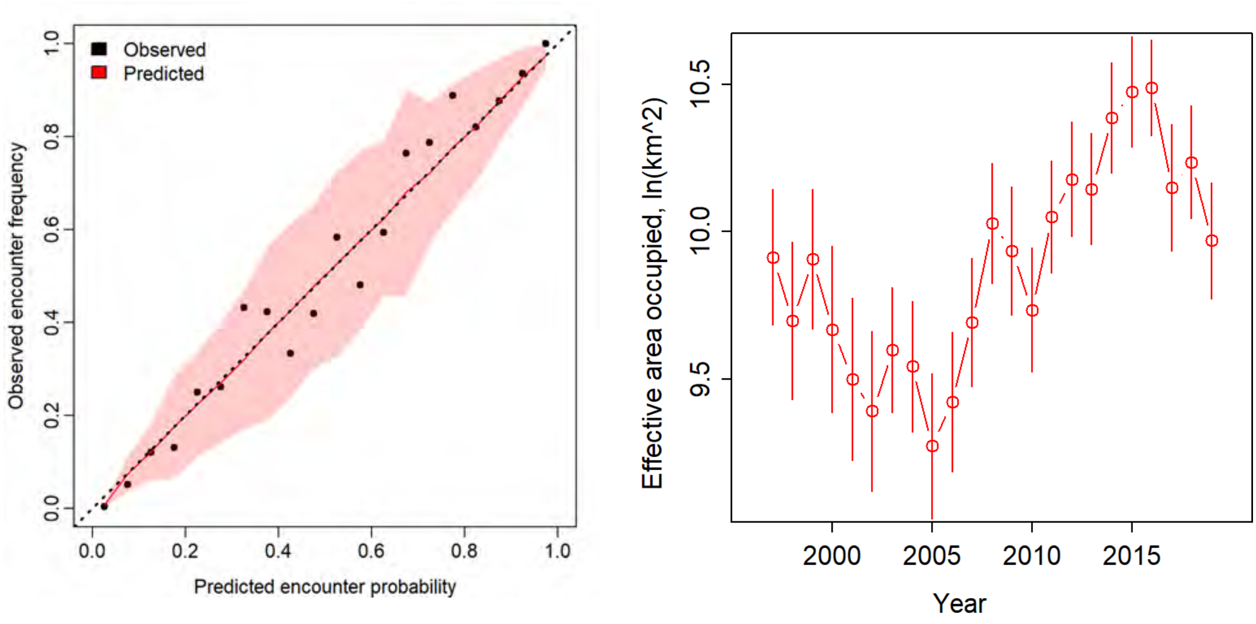

Figure 27.11. Plaice in Division 7.h–k. Residual diagnostics showing predicted encounter probability against observed encounter probability (left) and QQ plot for positive catches (right).

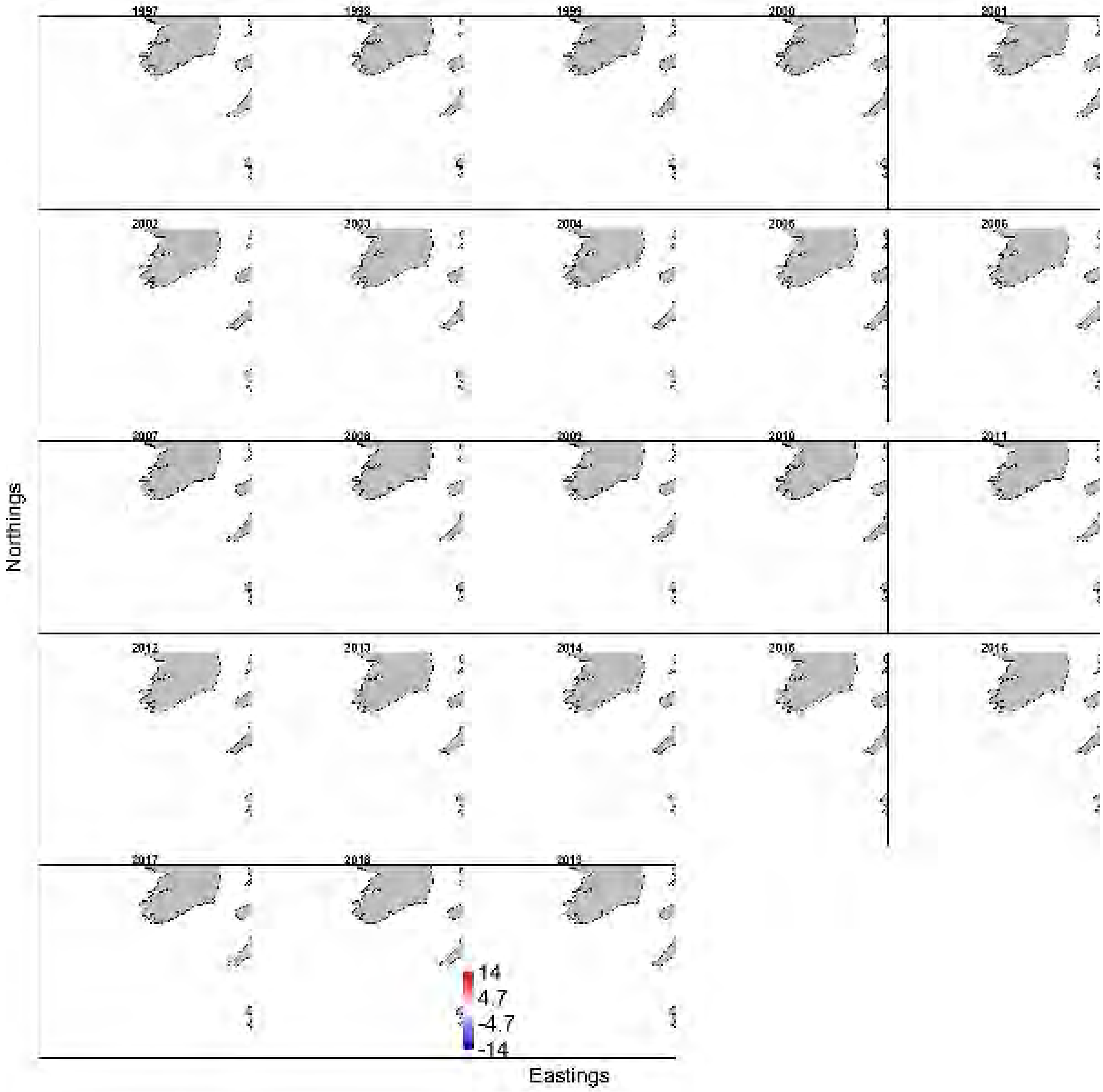

Figure 27.12(a). Plaice in Division 7.h–k. Spatio-temporal persons residuals (1) of encounter probability.

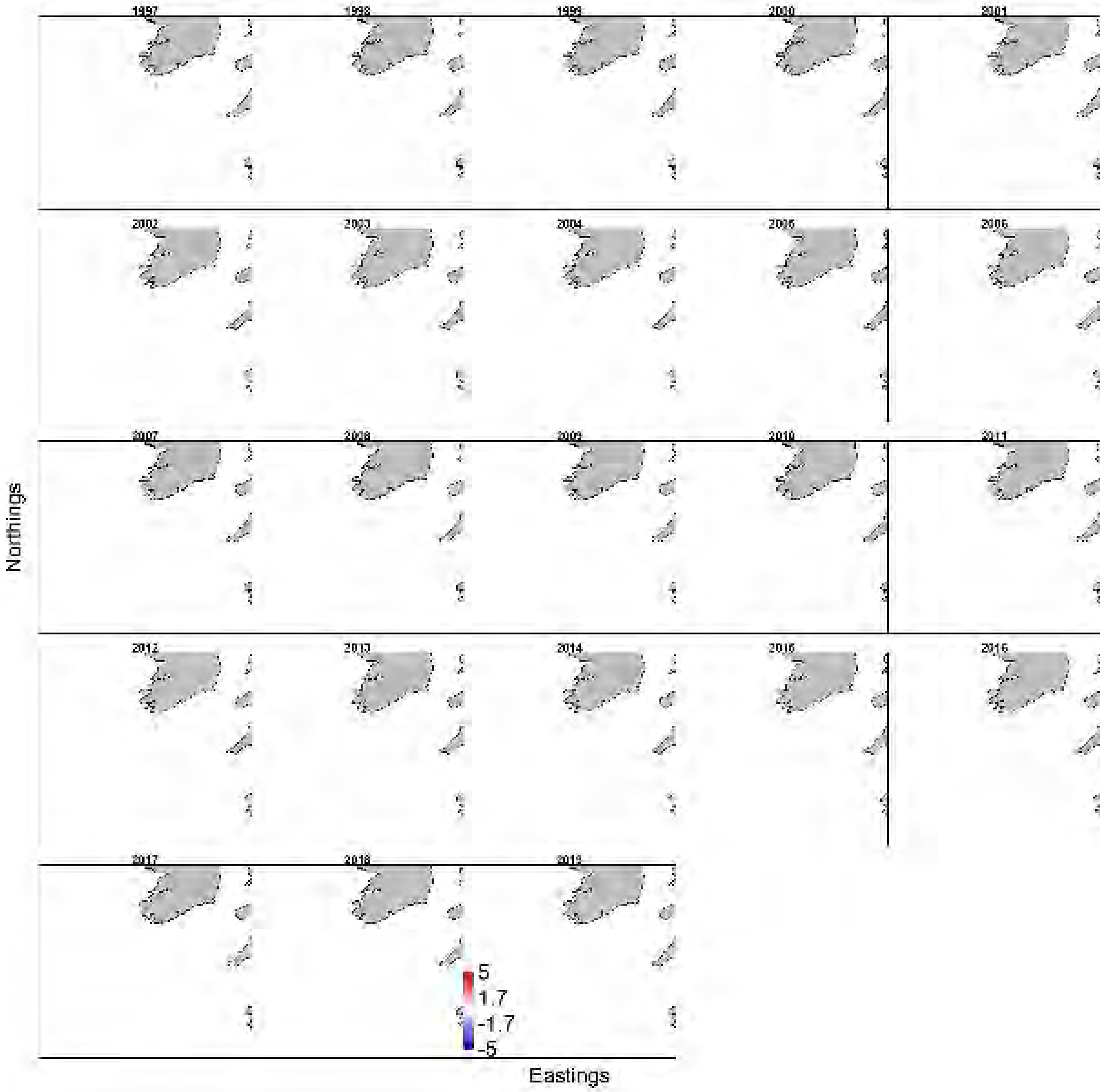

Figure 27.12(b). Plaice in Division 7.h–k. Spatio-temporal persons residuals (2) of encounter probability.

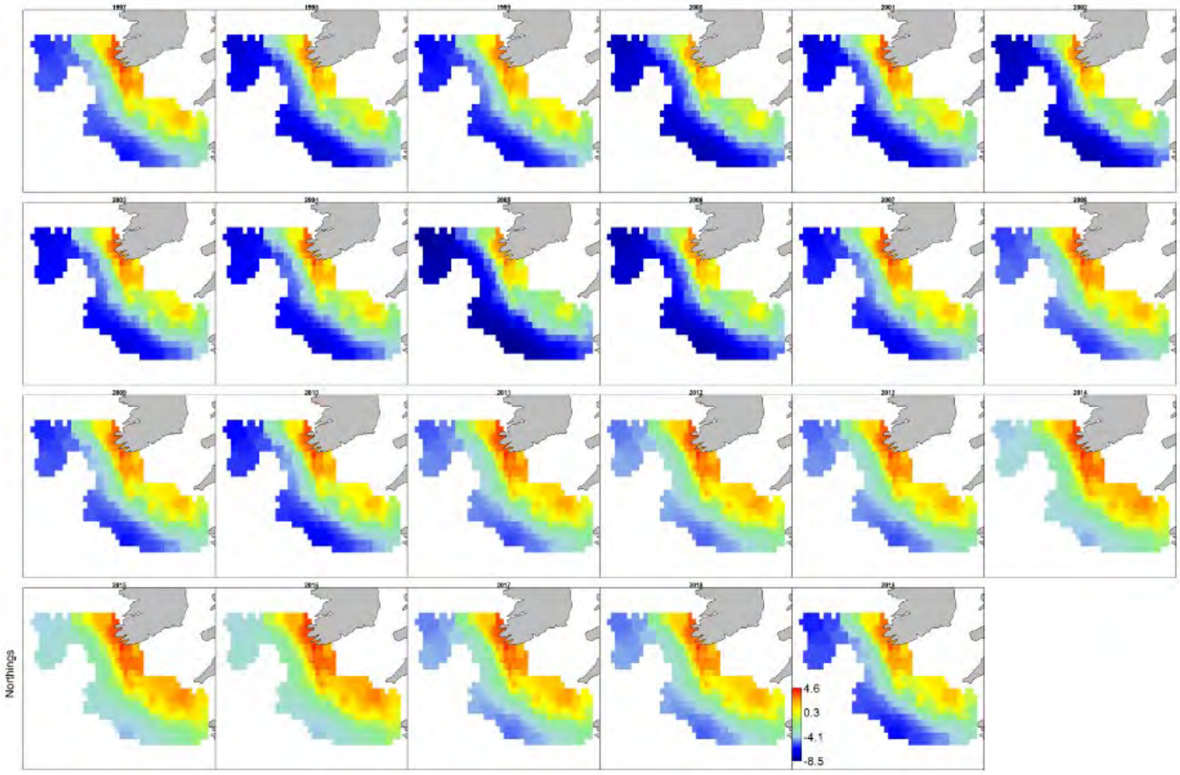

Figure 27.13. Plaice in Division 7.h–k. Spatiotemporal variability in estimated log density of plaice.

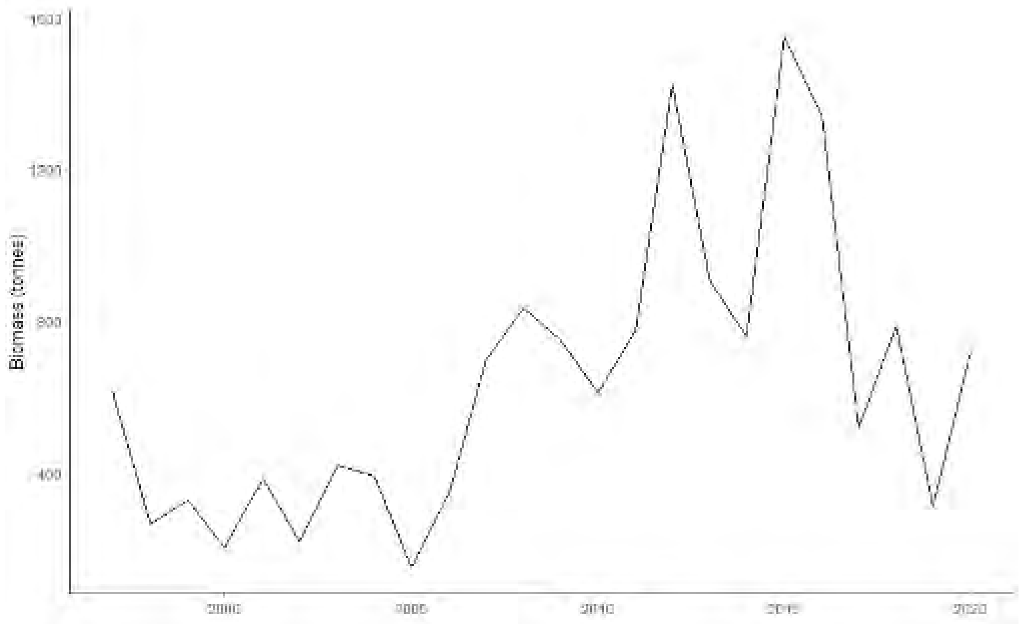

Figure 27.14. Plaice in Division 7.h–k. VAST estimated biomass in tonnes.

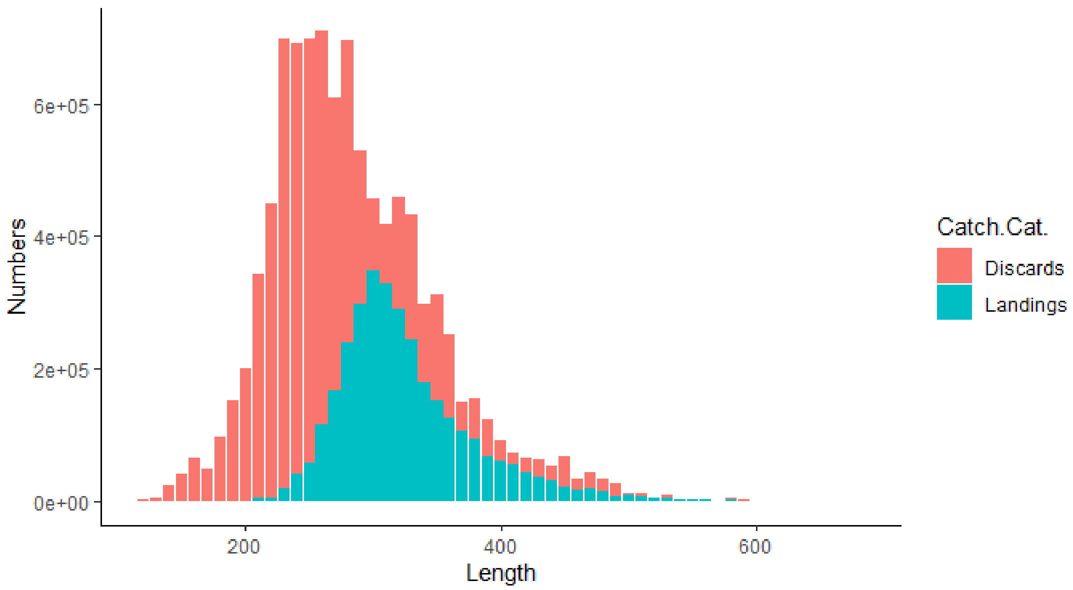

Figure 27.15. Plaice in Division 7.h–k.

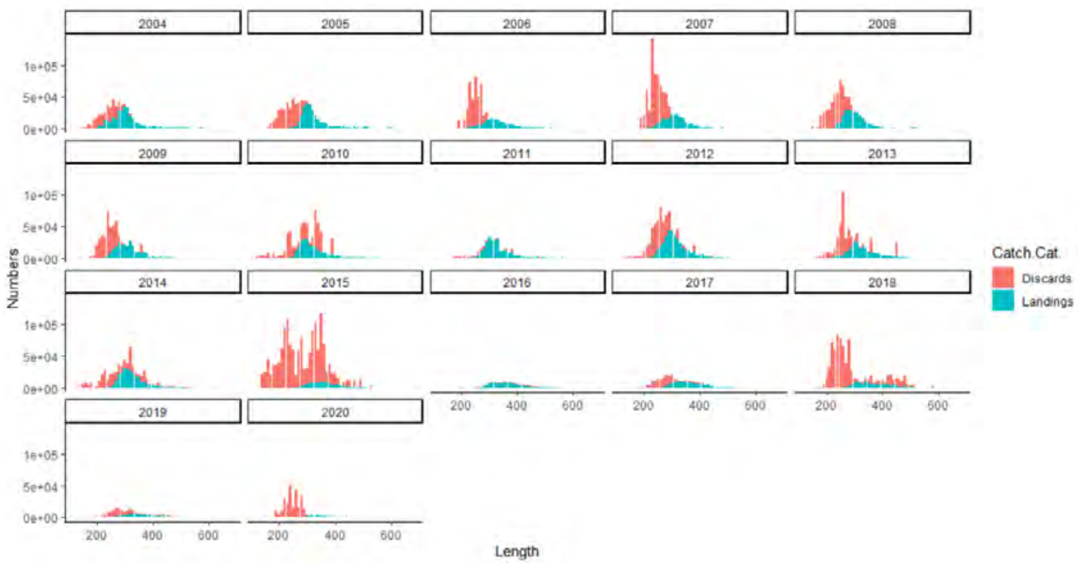

Figure 27.16. Plaice in Division 7.h–k.

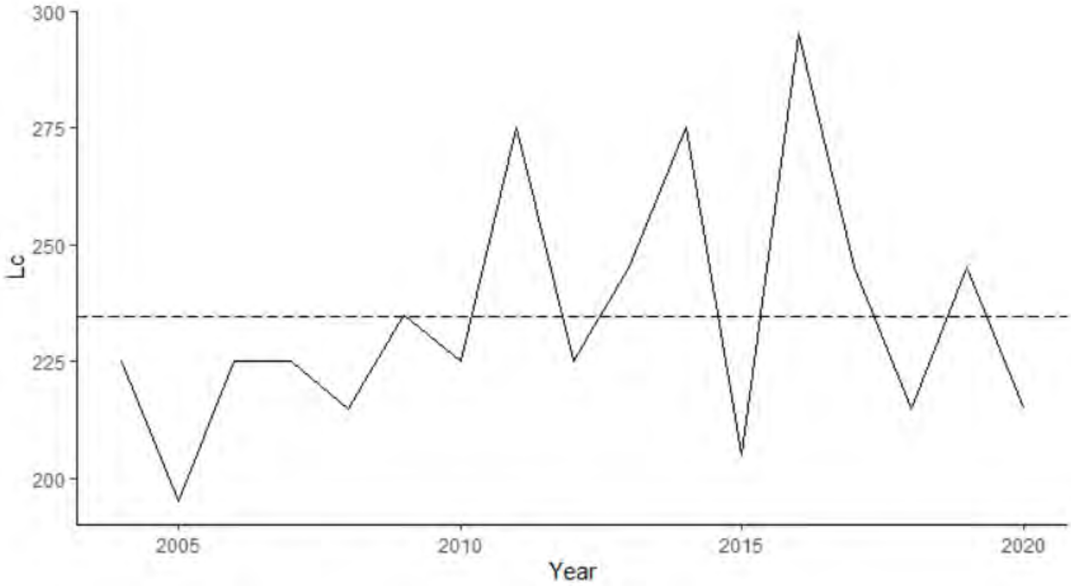

Figure 27.17. Plaice in Division 7.h–k. Length at first catch (length at 50% of mode) L_c.

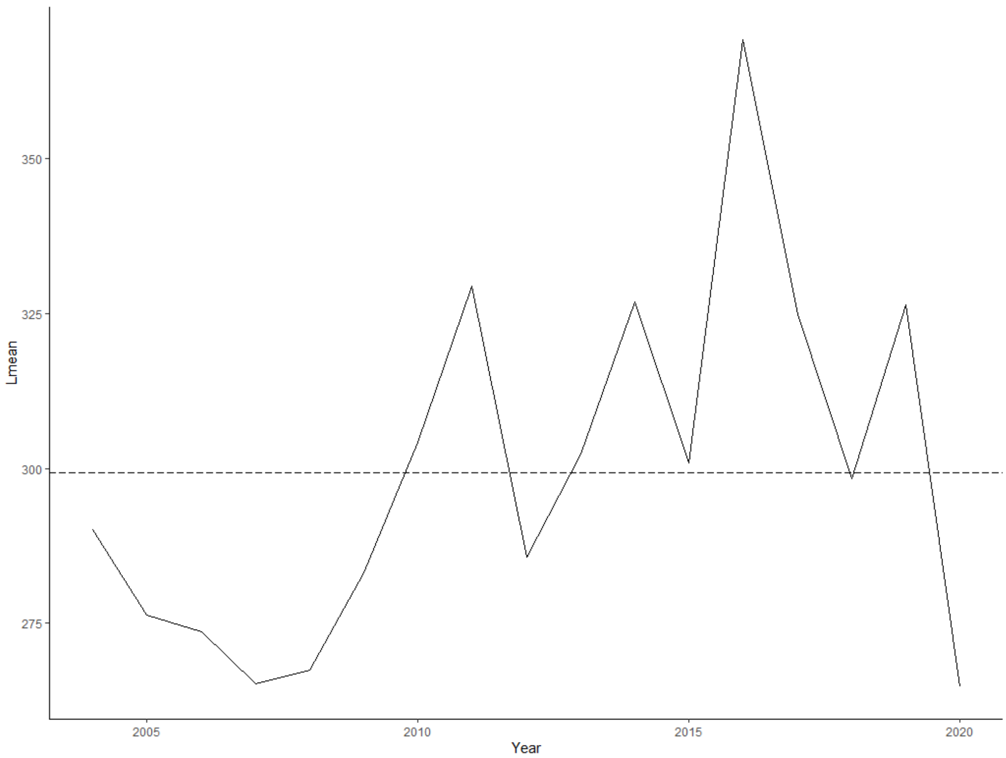

Figure 27.18. Plaice in Division 7.h–k. Mean length in observed catch ($\bar{L}_{y-1}$).

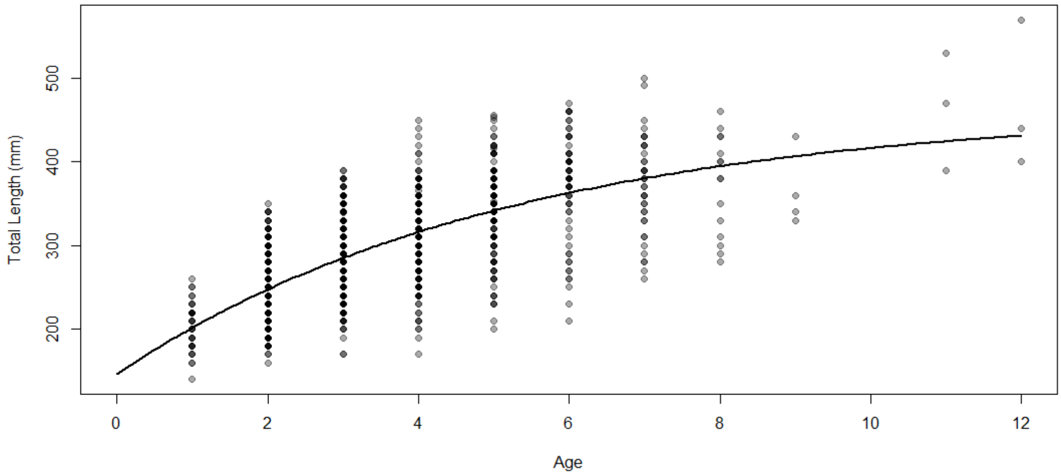

Figure 27.19. Plaice in Division 7.h–k. Length (mm) versus age (dots) with superimposed best-fit von Bertalanffy growth function (black line) of all plaice in ICES divisions 27.7h and 27.7j available in DATRAS.

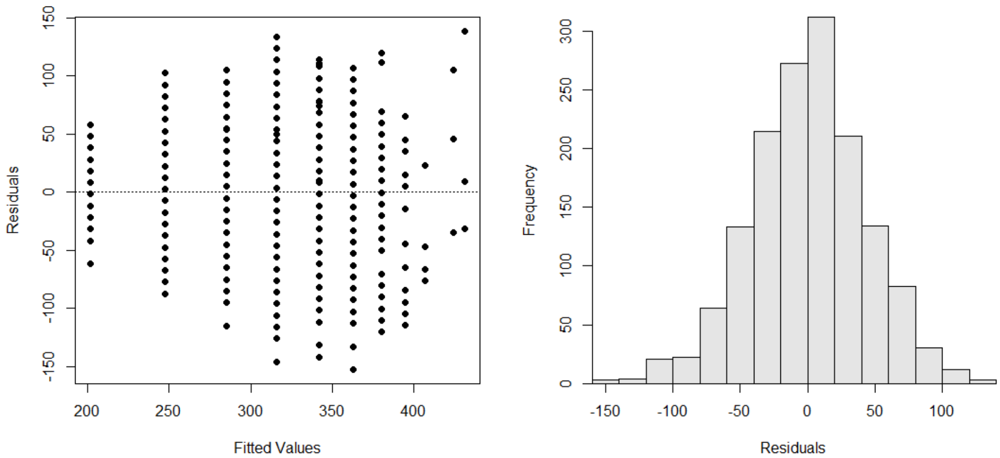

Figure 27.20. Plaice in Division 7.h–k. Residual plot (left) and histogram of residuals (right) of von Bertalanffy growth function (black line) on plaice in ICES divisions 27.7h and 27.7j available in DATRAS.

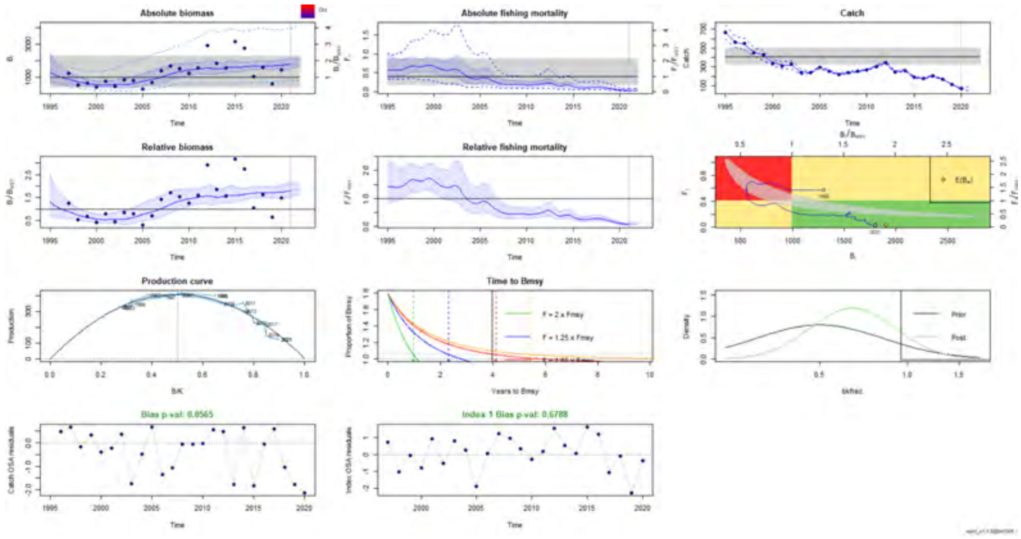

Figure 27.21. Plaice in Division 7.h–k. SPiCT model results from WGCSE 2021. Top row: absolute biomass, absolute F estimates, and fitted catch. Middle row: relative biomass and F, and a Kobe plot comparing biomass and F. The grey area in the Kobe plot represents the uncertainty in the relative biomass and F estimates. Bottom row: production curve, estimated time to B_{MSY}, and prior and posterior parameter distributions. The dashed lines are 95% CI bounds for absolute estimated values, shaded blue regions are 95% CIs for relative estimates, shaded grey regions are 95% CIs for estimated absolute reference points (horizontal lines).

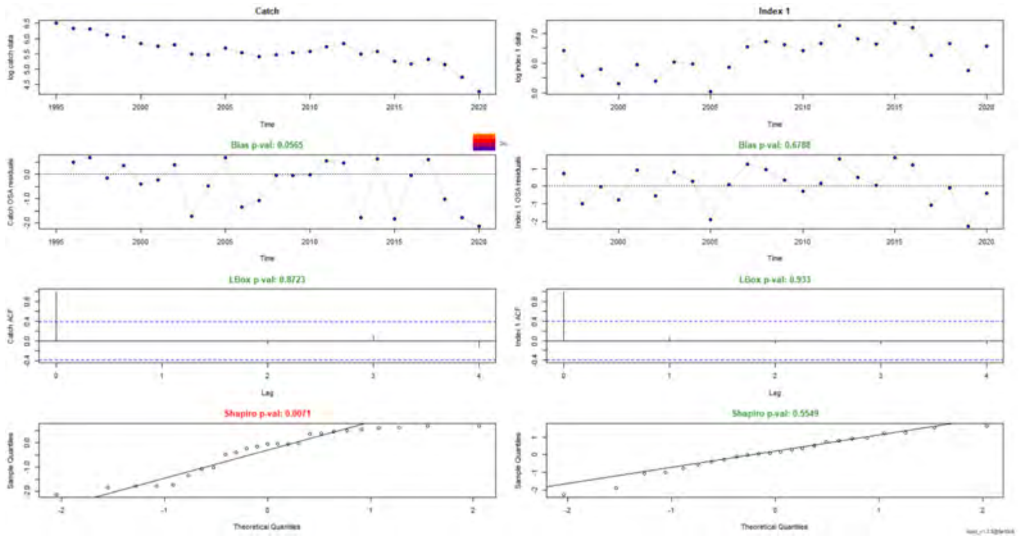

Figure 27.22. Plaice in Division 7.h–k. SPiCT model diagnostics.

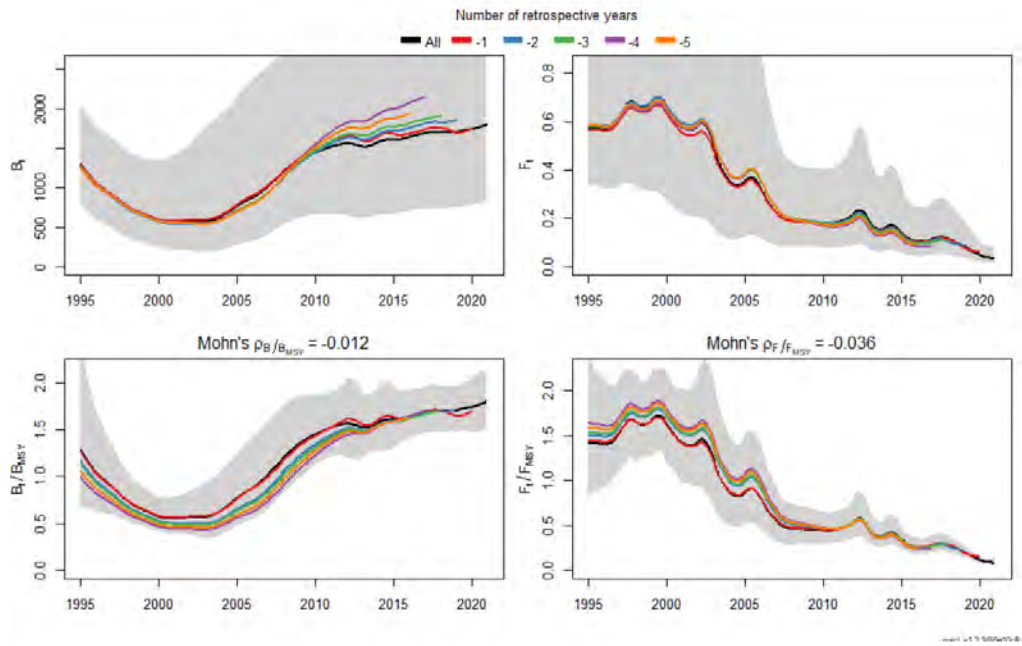

Figure 27.23. Plaice in Division 7.h–k. Retrospective analysis of the SPiCT model from WGCSE 2021. Top row: absolute biomass and absolute F; bottom row: relative biomass and relative F.

Table 27.1. Plaice in divisions 7.h–k. History of official landings by country and ICES estimated landings (tonnes).

Year	BEL	FRA	IRL	UK	OTH	Official landings	ICES landings
1995	0	60	321	286	0	667	542
1996	0	48	305	155	52	560	453
1997	0	69	344	138	0	551	645
1998	0	49	286	106	13	454	444
1999	45	0	299	82	1	437	406
2000	4	54	200	76	7	341	299
2001	27	50	160	73	3	313	261
2002	69	45	155	59	2	330	313
2003	20	32	127	56	6	241	217
2004	67	32	91	36	6	232	134
2005	32	20	90	28	0	170	167
2006	22	36	66	18	1	143	143
2007	7	30	72	20	13	141	124
2008	25	13	73	12	1	124	133
2009	1	44	72	32	0	149	143
2010	<1	54	66	35	0	155	150
2011	4	58	72	44	0	178	172
2012	2	62	99	38	0	201	193
2013	0	49	52	40	0	141	137
2014	4	52	82	15	0	153	147
2015	0	60	25	18	0	103	107
2016	7	46	32	15	0	100	99
2017	11	53	42	10	0	116	114
2018	17	35	32	0	11	96	96
2019*	6	17	30	9	1	63	64
2020*	7	12	12	7	1	39	40

Table 27.2. Plaice in divisions 7.h–k. History of official landings by country and ICES estimated landings (tonnes).

Survey	Years	Quarters	Gear	Sources	Wing spread
IGFS	2003–2020	4	Otter	DATRAS	Available at haul level
IAMS	2003–2020	1	Otter & Beam	DATRAS	Available at haul level
EVOHE	2003–2020	4	Otter	DATRAS	Available at haul level
WGCFS	1997–2004	1,2,4	Otter	CEFAS	Set to 21 m (average of other otter trawl surveys in series)
SWBEAM	2006–2020	1	Beam	DATRAS	Available at haul level
SWIBTS	2003–2011	4	Otter	CEFAS	Set to 21 m (average of other otter trawl surveys in series)

Table 27.3. Plaice in divisions 7.h–k. Table abundance index – what is the SD log and SD mt.

Year	Biomass estimate (tonnes)	SD_log	SD_mt
1997	613.0517	0.513818	314.997
1998	265.298	0.697368	185.0104
1999	327.5187	0.520476	170.4656
2000	202.5768	0.761158	154.193
2001	383.5487	0.685484	262.9164
2002	218.7698	0.774431	169.4221
2003	422.1918	0.425115	179.4802
2004	393.8839	0.455639	179.4688
2005	152.7392	0.568388	86.81507
2006	349.8971	0.400284	140.0582
2007	696.661	0.327698	228.2945
2008	835.2461	0.325016	271.4685
2009	751.3008	0.333764	250.7574
2010	612.2614	0.31014	189.8866
2011	776.2532	0.308728	239.6511
2012	1424.42	0.313323	446.3032
2013	906.7181	0.319166	289.394
2014	760.9168	0.307039	233.6309
2015	1548.039	0.295024	456.7085
2016	1341.959	0.261019	350.2773
2017	519.4532	0.33833	175.7464
2018	787.2254	0.314604	247.6646
2019	311.841	0.33327	103.9273
2020	718.733	0.360299	258.9584

Table 27.4. Summary table for ple-7.jk assessment in input values.

Year	Biomass index	Landings	Discards
1995		667	
1996		560	
1997	613	551	
1998	265	454	
1999	328	437	
2000	203	341	
2001	384	313	
2002	219	330	
2003	422	241	
2004	394	134	105
2005	153	167	131
2006	350	143	112
2007	697	124	98
2008	835	133	105
2009	751	143	113
2010	612	150	118
2011	776	172	135
2012	1424	193	152
2013	907	138	108
2014	761	147	116
2015	1548	107	84
2016	1342	99	78
2017	519	114	90
2018	787	96	75
2019	312	64	51
2020	719	39	31

28 Pollack in the Celtic Seas (ICES subareas 6 and 7)

Type of assessment in 2021

The Celtic Sea and West of Scotland (subareas 6 and 7) Pollack stock is considered a Data-Limited Stock, classified by ICES WKLIFE II (ICES, 2012) as category 4.1.2. DCAC (Depletion-Corrected Average Catch) method is recommended to assess this stock, which is performed through the NOAA toolbox.

ICES advice applicable to 2021

ICES advises that when the precautionary approach is applied, commercial catches should not exceed 2688 tonnes in 2022.

28.1 General

Stock Identity

This section is not dedicated to a 'stock', it relates to a species in a wider region where data are available. The stock structure of Pollack populations in this ecoregion is not clear. ICES does not necessarily advocate that subareas 6 and 7 constitutes a management unit for Pollack, and further work is required.

Management applicable to 2021

The 2020 TAC for Pollack was set for ICES subareas 6 (and 5.a, b; international waters of 12 and 14) and 7 separately, Table 28.1. The full year TAC for 2021 is not yet available.

The 2020 TAC uptake for Subarea 6 was low at 20.2% and varied considerably between countries. France, which holds 47.9% of the TAC, did not utilise any of their quota. The UK utilised 36.8% of the 36.6% TAC allocation, Ireland had the largest quota uptake at 47.1% constituting 14.3% of the TAC allocation and finally Spain utilised none of their 1.3% TAC allocation.

In Subarea 7, the uptake was also low at 18.2% and again varied considerably between countries. France, which holds the majority of the TAC allocation (71.6%), only utilised 6.8% of this. The UK utilised 46.6% of its 17.4% TAC allocation, Ireland utilised 65.9% of its 7.6% TAC allocation, Belgium and Spain, which hold very low TAC allocations at 3.1% and 0.2%, utilised 4.5% and 13.0% respectively.

Fishery in 2020

Landings

2258 tonnes of pollack were landed in 2020, 98% of which came from Subarea 7.

The nominal landings for ICES subareas 6 and 7 are shown in Tables 28.2 and 28.3 respectively.

For Subarea 6, there was an 11.1% decrease in landings (48 tonnes) in 2020 compared to the landings in 2018 (54 tonnes). The UK declared the highest landings (66.7%) followed by Ireland (33.3%). There was a 2% increase in landings (2210 tonnes) for Subarea 7 in 2020 compared to

2019 (2165 tonnes). The UK had the highest landings (44.7%) followed by Ireland (27.7%), France (26.7%), Belgium (0.77%) and Spain (0.14%).

Landings by division

In 2020, 97.8% of catches came from Subarea 7, with only 2.2% of landings derived from Subarea 6 and of those, over 99% came from division 6.a. In Subarea 7, the division with the highest proportion of landings derived from 7.e (37.9%) followed by 7.g (28.3%), 7.h (19.2%) and 7.f (8.6%). Landings in divisions 7.a, b, c, d, j and k were negligible (6.0%).

Landings by gear

The majority of Pollack landings in the Celtic Sea ecoregions were caught by gillnets and trammelnets (53.5%) followed by bottom trawlers (15.3%), set lines (14.9%), miscellaneous gears (14.5%) and beam trawlers (1.9%). When separated by subarea, the predominant gears landing pollack in Subarea 6 were bottom trawlers (69.1%) followed by nets (20.6%) and miscellaneous gears (10.4%). In Subarea 7, nets had the highest landings (54.2%) followed by lines (15.2%), miscellaneous gears (14.6%), bottom trawlers (14.1%) and beam trawlers (1.9%).

Landings by quarter

Pollack are not historically targeted throughout the entire year, and are mainly targeted during the first quarter, which coincides with spawning. The breakdown of landings per quarter shows that the highest landings were in quarter 1 (40.0%) followed by quarter 2 (20.8%), quarter 3 (20.1%) and quarter 4 (17.7%) respectively.

Discards

Discarding was negligible at 3.5 tonnes. 87.7% of which coming from gillnetters, followed by miscellaneous gears at 11.5%.

Landings uncertainty

Pollack is a known recreational fishing species, however; it is unknown as to the quantities exploited by recreational fisheries. A phone study conducted in France in 2011–2013 by Levrel *et al.* (2013) estimated that 3300 tonnes are landed annually through recreational fishing, 2274 tonnes of which are retained. Radford *et al.*, 2018 further suggest that pollack landings may be similar to or above commercial landings. Work is currently being undertaken to provide recreational landing data.

28.2 Stock assessment

A DCAC (Depletion-Corrected Average Catch) method is used to estimate a yield likely to be sustainable (MacCall, 2009). Subarea 6 and 7 are run independently. For Subarea 6; six separate model runs using various parameters are conducted giving an average DCAC value plus an upper and lower 95% confidence interval and for Subarea 7; nine separate model runs using various parameters are conducted given an average DCAC value, plus an upper and lower 95% confidence interval.

The information provided for the assessment is insufficient to evaluate the exploitation and the trends of pollack in the Celtic Seas ecoregion. Commercial catches have declined since the late 1980s, and in 2020 are at historical lows for Subarea 6 and in Subarea 7 catches only 2.1% higher than the lowest recorded catches (from 2019).

The input data and parameters used for the assessment are detailed in Tables 28.4 and 28.5.

2021 Results

The average DCAC values (Figure 28.1) show that in both subareas 6 and 7, commercial landings are below the average DCAC by 95 tonnes in Subarea 6 and 1696 tonnes in Subarea 7. This suggests that yield in Subarea 6 could be increased up to 143 tonnes and 3906 tonnes in Subarea 7.

Comparison with previous assessment

Table 28.6 compares the results with the previous year's assessment. The results are consistent with the range of DCAC values estimated when the method was previously applied.

Uncertainties in assessment and forecast

The DCAC model relies solely on commercial catch data and does not include any biological or survey data that are available for this stock. The model also cannot estimate reference points.

By construction, the DCAC method only uses long time-series of official landings. As the output is a smoothed value of the landings over the assessed time-series, the computations of DCAC are always similar to the previous year's results, even when recruitment or SSB fluctuate.

Management considerations

TAC for Subarea 7 includes ICES Division 7.d, which is not in the remit of the Celtic Sea ecoregion. TAC set for both subareas 6 and 7 are not in line with the current estimates of catches and estimated sustainable yields, and therefore are not constraining.

Management plan

The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to demersal stocks including pollack in ICES subareas 6 and 7.

Recommendations

This stock began the benchmark process in 2020 (ICES, WKWEST 2021), but did not proceed past the data compilation phase. This was due to difficulties in quantifying the substantial recreational catch and concerns that at present scientific surveys were unable to provide a representative abundance index. This was due to low Pollack catches in the surveys and the inshore, reef-based population that were not adequately sampled by existing surveys. Progress was made with regards to improved age and length sampling data from the main countries involved in the fishery so there is potential to push forward with data-limited methods utilising these data.

There is potential to collaborate with ICES Working Group on Recreational Fisheries Surveys (WGRFS) to improve on the existing UK data and to bolster ongoing work in France and Ireland to provide data on the extent of their recreational fishing of Pollack. Although the recent benchmark did not lead to an improved assessment for Pollack, progress was made in identifying the data shortcomings that exist and potential routes forward. The need for an improvement on the existing DCAC assessment remains, and there is a commitment to progressing the data and assessment options.

28.3 References

EU. 2019. Regulation (EU) 2019/472 of the European Parliament and of the Council of 19 March 2019 establishing a multiannual plan for stocks fished in the Western Waters and adjacent waters, and for fisheries exploiting those stocks, amending Regulations (EU) 2016/1139 and (EU) 2018/973, and repealing Council Regulations (EC) No 811/2004, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007 and (EC) No 1300/2008. Official Journal of the European Union, L 83: 1–17. http://data.europa.eu/eli/reg/2019/472/oj.

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Table 29.1. 2020 TAC for Pollack in ICES subareas 6 (and 5.a, b; international waters of 12 and 14) and 7.

Species:	Pollack *Pollachius pollachius*	Zone:	6; Union and international waters of 5b; international waters of 12 and 14 (POL/56-14)
Spain	3	Precautionary TAC	
France	114		
Ireland	34		
United Kingdom	87		
Union	238		
TAC	238		

Species:	Pollack *Pollachius pollachius*	Zone:	7 (POL/07.)
Belgium	378 (1)	Precautionary TAC	
Spain	23 (1)		
France	8 712 (1)		
Ireland	929 (1)		
United Kingdom	2 121 (1)		
Union	12 163 (1)		
TAC	12 163		

(1) Special condition: of which up to 2 % may be fished in: 8a, 8b, 8d and 8e (POL/*8ABDE).

Table 29.2. Landings of Pollack in Subarea 6 as officially reported to ICES.

Year	Belgium	Denmark	France	Germany	Ireland	Netherlands	Norway	Portugal	Spain	Sweden	UK	Total Sub-area 6
1950	1	-	-	-	-	-	-	-	-	-	295	296
1951	-	-	-	-	-	-	-	-	-	-	484	484
1952	-	-	-	-	-	1	-	-	-	-	503	504
1953	-	-	-	-	-	-	-	-	-	-	422	422
1954	-	-	-	-	-	-	-	-	-	-	452	452
1955	-	-	-	-	-	-	-	-	-	-	566	566
1956	-	-	-	-	-	-	-	-	-	-	528	528
1957	-	-	-	-	-	-	-	-	-	-	547	547
1958	.	-	-	23	-	-	-	-	-	-	710	733
1959	1	-	-	6	-	-	-	-	-	-	607	614
1960	15	-	-	-	-	-	-	-	-	-	441	456
1961	1	-	-	1	125	-	-	-	-	-	259	386
1962	2	-	-	8	197	-	-	-	-	-	235	442
1963	6	-	-	2	204	-	-	-	-	-	320	532
1964	1	-	-	1	130	-	-	-	-	-	368	500

Year	Bel-gium	Den-mark	France	Ger-many	Ire-land	Nether-lands	Nor-way	Portu-gal	Spain	Swe-den	UK	Total Sub-area 6
1965	1	-	-	1	402	-	-	-	-	-	496	900
1966	2	-	-	-	200	-	-	-	-	-	428	630
1967	1	-	-	1	263	-	-	-	-	1106	413	1784
1968	5	-	-	2	214	-	148	-	-	1012	500	1881
1969	1	-	-	4	282	-	-	-	-	1224	667	2178
1970	2	-	-	1	398	-	-	-	-	756	447	1604
1971	1	-	-	5	75	-	-	-	-	750	256	1087
1972	1	-	-	1	127	-	-	-	-	779	317	1225
1973	2	-	-	-	-	-	-	-	-	-	503	505
1974	6	-	-	-	-	3	-	-	-	-	359	368
1975	< 0.5	-	-	1	-	1	4	-	-	-	393	399
1976	7	-	-	-	-	1	-	-	-	-	519	527
1977	-	-	196	-	-	1	2	-	-	-	493	692
1978	-	-	196	-	-	-	4	-	-	-	553	753
1979	-	-	310	-	-	-	-	-	-	-	350	660
1980	-	-	36	-	-	-	-	-	-	-	233	269
1981	-	-	342	-	-	-	-	-	55	-	185	582
1982	-	< 0.5	272	-	-	-	-	-	95	-	103	470
1983	-	-	331	-	-	-	-	-	86	-	148	565
1984	-	-	212	-	-	-	-	-	222	-	194	628
1985	< 0.5	-	224	1	-	-	-	-	283	-	328	836
1986	-	-	145	-	223	-	-	-	2217	-	187	2772
1987	-	< 0.5	108	-	103	-	-	-	860	-	259	1330
1988	-	< 0.5	128	-	163	-	-	-	1925	-	221	2437
1989	-	< 0.5	111	1	103	-	-	-	-	-	179	394
1990	-	-	76	-	150	-	1	-	-	-	192	419
1991	-	-	31	-	145	-	-	-	4	-	189	369
1992	-	< 0.5	21	-	23	-	-	-	< 0.5	-	203	247

Year	Bel-gium	Den-mark	France	Ger-many	Ire-land	Nether-lands	Nor-way	Portu-gal	Spain	Swe-den	UK	Total Sub-area 6
1993	-	-	39	-	12	-	-	-	-	-	273	324
1994	-	-	34	< 0.5	26	-	< 0.5	-	-	-	276	336
1995	-	-	64	3	83	-	-	-	-	-	354	504
1996	-	< 0.5	29	< 0.5	97	-	1	-	-	-	210	337
1997	-	-	14	1	69	-	2	-	-	-	162	248
1998	-	-	21	-	60	-	-	< 0.5	< 0.5	-	147	228
1999	-	-	-	-	73	-	3	-	< 0.5	-	136	212
2000	-	-	11	2	62	-	-	-	-	-	116	191
2001	-	-	8	-	108	-	-	-	-	-	101	217
2002	-	-	9	-	26	-	-	-	-	-	96	131
2003	< 0.5	-	3	-	88	-	1	-	-	-	111	203
2004	< 0.5	-	2	-	68	-	1	-	-	-	65	136
2005	-	-	23	-	28	-	-	-	-	-	16	67
2006	-	-	3	-	25	-	< 0.5	-	4	-	5	37
2007	-	-	10	-	21	-	6	-	-	-	21	58
2008	-	-	8	-	21	-	1	-	-	-	23	53
2009	-	-	7	-	5	-	< 0.5	-	-	-	25	37
2010	-	-	6	-	34	-	< 0.5	-	-	-	38	78
2011	-	-	3	-	8	-	-	-	-	-	34	45
2012	-	-	2	-	10	-	-	-	-	-	33	45
2013	-	-	1	-	34	-	-	-	-	-	22	57
2014	-	-	1	-	25	-	-	-	-	-	18	44
2015	-	-	< 0.5	-	23	-	< 0.5	-	-	-	25	48
2016	-	-	< 0.5	-	44	-	< 0.5	-	-	-	29	74
2017	-	-	< 0.5	-	30	-	< 0.5	-	-	-	14	44
2018	-	-	< 0.5	-	34	-	< 0.5	-	< 0.5	-	28	63
2019	-	-	3	-	24	-	-	-	< 0.5	-	27	54
2020*	-	-	< 0.5	-	13	-	-	-	-	-	32	45

***Preliminary commercial landings.**

Table 29.3. Landings of Pollack in Subarea 7 as officially reported to ICES.

Year	Belgium	Denmark	France	Germany	Ireland	Netherlands	Norway	Spain	UK	Total Subarea 7
1950	53	-	-	-	-	-	-	-	349	402
1951	48	-	-	-	-	-	-	-	346	394
1952	39	-	-	-	-	-	-	-	301	340
1953	22	-	-	-	-	-	-	-	191	213
1954	5	-	-	-	-	-	-	-	293	298
1955	30	-	-	-	-	-	-	-	177	207
1956	65	-	-	-	-	-	-	-	98	163
1957	214	-	-	-	-	-	-	-	320	534
1958	338	-	-	16	-	-	-	-	175	529
1959	153	-	-	32	-	-	-	-	156	341
1960	310	-	-	-	-	-	-	-	177	487
1961	264	-	-	-	360	-	-	-	146	770
1962	361	-	-	1	369	-	-	-	116	847
1963	73	-	-	-	411	-	-	-	123	607
1964	291	-	-	-	342	-	-	-	122	755
1965	302	-	-	-	335	-	-	-	114	751
1966	451	-	-	-	438	-	-	-	133	1022
1967	410	-	-	-	474	-	-	-	147	1031
1968	166	-	-	-	508	-	-	-	117	791
1969	111	-	-	-	794	-	-	-	123	1028
1970	141	-	-	1	724	-	-	-	72	938
1971	89	-	-	-	673	-	-	-	76	838
1972	115	-	-	-	1073	-	-	-	79	1267
1973	62	-	-	-	-	1	-	-	81	144
1974	245	-	-	-	-	11	-	-	114	370
1975	280	-	-	-	-	14	-	-	288	582
1976	308	-	-	-	-	2	-	-	416	726

Year	Belgium	Denmark	France	Germany	Ireland	Netherlands	Norway	Spain	UK	Total Subarea 7
1977	139	-	2976	-	-	1	-	-	461	3577
1978	164	-	4440	14	-	8	-	-	504	5130
1979	120	-	4529	76	-	1	-	-	685	5411
1980	220	-	4668	-	-	1	-	1	761	5651
1981	225	-	5376	-	-	3	-	23	775	6402
1982	138	-	4106	-	-	-	-	32	1008	5284
1983	148	-	5683	-	-	-	-	26	1029	6886
1984	181	-	3464	-	-	-	-	486	1084	5215
1985	249	-	3360	-	-	-	-	20	1016	4645
1986	225	-	3866	-	1335	-	-	17	1773	7216
1987	124	-	3957	-	848	-	-	19	1986	6934
1988	159	-	3969	-	1066	-	-	22	1728	6944
1989	129	-	3893	-	994	-	-	18	1468	6502
1990	105	-	4831	-	1066	-	-	26	1886	7914
1991	61	-	3211	-	1045	-	-	22	1919	6258
1992	40	-	2536	-	1014	-	-	19	1700	5309
1993	41	-	2030	-	1137	-	-	7	2001	5216
1994	77	-	2268	-	921	-	-	8	2317	5591
1995	75	2	1983	-	1107	-	-	4	2114	5285
1996	77	-	2301	-	1190	6	-	5	2486	6065
1997	81	-	2101	-	984	4	< 0.5	7	2509	5686
1998	77	-	1936	-	886	1	-	11	2296	5207
1999	61	-	2000	-	976	-	3	19	1672	4731
2000	48	-	2081	-	1069	-	-	5	1789	4992
2001	71	-	2168	-	1274	-	-	9	1961	5483
2002	82	-	2027	-	1308	-	-	17	1979	5413
2003	78	-	1987	-	1151	-	-	12	1769	4997
2004	63	-	1639	-	1049	-	-	13	1687	4451

Year	Belgium	Denmark	France	Germany	Ireland	Netherlands	Norway	Spain	UK	Total Subarea 7
2005	72	-	1901	-	728	-	-	16	1670	4387
2006	43	-	1946	-	809	-	-	28	1516	4342
2007	67	-	1717	-	782	1	-	1	1741	4309
2008	76	-	1578	-	738	1	-	14	1453	3860
2009	42	-	1641	-	828	4	-	3	1545	4063
2010	35	-	1846	-	942	2	-	3	1381	4209
2011	37	-	1784	-	967	2	-	4	1825	4619
2012	43	-	1421	-	1165	1	-	3	1836	4469
2013	11	-	1728	-	1223	1	-	-	1813	4776
2014	84	-	2019	-	1018	-	-	15	2109	5245
2015	32	-	1143	-	1060	-	-	21	1485	3741
2016	41	-	1247	-	934	< 0.5	-	16	1894	4132
2017	19	-	959	-	891	< 0.5	-	14	1377	3260
2018*	21	-	827	-	741	-	-	12	1231	2832
2019*	12	-	551	-	617	< 0.5	-	3	982	2165
2020*	17		584	-	395	2		3	938	1939

***Preliminary commercial landings.**

Table 29.4. Input parameters for the six DCAC runs carried out for Pollack in Subarea 6.

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Sum of catch	6884	6884	6884	6884	6884	6884
CV sumC	0	0	0	0	0	0
no of years	35	35	35	35	35	35
iterations	10000	10000	10000	10000	10000	10000
M	0.2	0.2	0.2	0.2	0.2	0.2
stdev M	0.4	0.4	0.4	0.4	0.4	0.4
F_{MSY}/M	0.6	0.8	1	0.6	0.8	1
stdev F_{MSY} to M	0.2	0.2	0.2	0.2	0.2	0.2
distr F_{MSY} to M	lognormal	lognormal	lognormal	lognormal	lognormal	lognormal
$B_{MSY}/B0$	0.5	0.5	0.5	0.5	0.5	0.5
stdev $B_{MSY}/B0$	0.1	0.1	0.1	0.1	0.1	0.1
up lim $B_{MSY}/B0$	1	1	1	1	1	1
low lim $B_{MSY}/B0$	0	0	0	0	0	0
depletion delta Δ	0.8	0.8	0.8	0.9	0.9	0.9
stdev Δ	0.1	0.1	0.1	0.1	0.1	0.1
distr Δ	normal	normal	normal	normal	normal	normal

Table 29.5. Input parameters for the 9 DCAC runs carried out for Pollack in Subarea 7.

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9
Sum of catch	172813	172813	172813	172813	172813	172813	172813	172813	172813
CV sumC	0	0	0	0	0	0	0	0	0
no of years	35	35	35	35	35	35	35	35	35
iterations	10000	10000	10000	10000	10000	10000	10000	10000	10000
M	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
stdev M	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
F_{MSY}/M	0.6	0.8	1	0.6	0.8	1	0.6	0.8	1
stdev F_{MSY} to M	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
distr F_{MSY} to M	lognormal	lognormal	lognormal	lognormal	lognormal	lognormal	lognormal	lognormal	lognormal
B_{MSY}/B0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
stdev B_{MSY}/B0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
up lim B_{MSY}/B0	1	1	1	1	1	1	1	1	1
low lim B_{MSY}/B0	0	0	0	0	0	0	0	0	0
depletion delta Δ	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7
stdev Δ	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
distr Δ	normal	normal	normal	normal	normal	normal	normal	normal	normal

Table 29.6. Comparison of the 2020 DCAC assessment and previous DCAC results.

	Subarea 6		**Subarea 7**	
	Landing (t)	Average DCAC	Landing (t)	Average DCAC
2020	48	143	2210	3906
2019	54	146	2165	3966
2018	63	148	2895	4010
2017	44	150	3260	4042
2016	74	152	4131	4063
2015	48	155	3740	4062
2014	44	156	5359	4020
2013	57	158	4468	3953

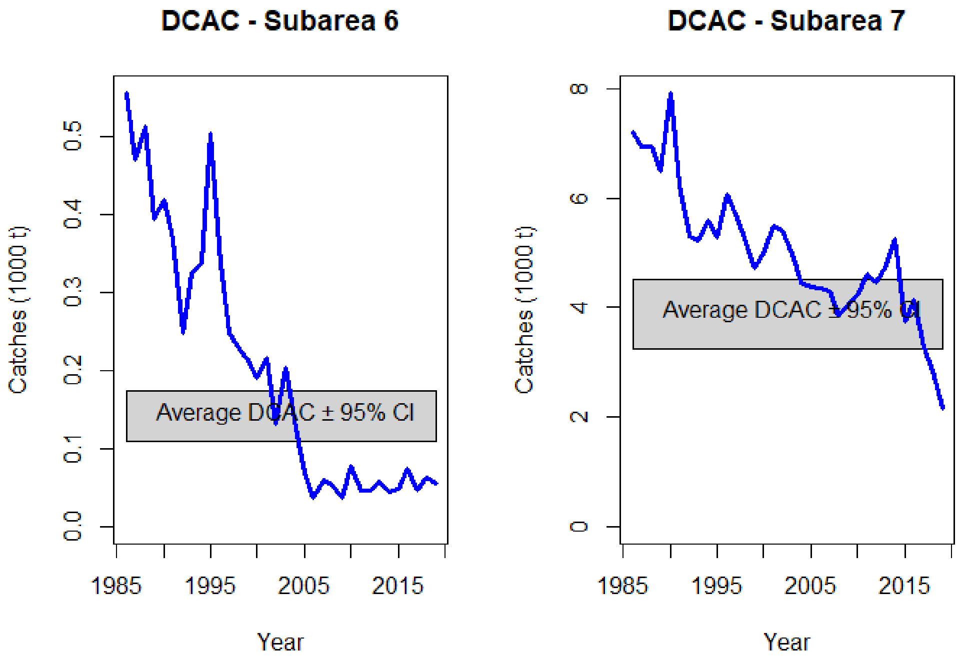


Figure 29.1. Pollack in subareas 6 and 7. The results of the depletion-corrected average catch (DCAC) assessment method as applied to commercial catch data since 1986. The grey box indicates the proxy for the maximum sustainable catch ±95% confidence intervals.

29 Seabass (*Dicentrarchus labrax*) in divisions 4.b–c, 7.a, and 7.d–h (central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and Celtic Sea)

Type of assessment

This is an update of the assessment accepted as the agreed methods to use at the benchmark workshop for the seabass: WKBASS (ICES, 2017–2018). The assessment is performed using the Stock Synthesis model implementation (SS3; Methot, 2000; 2011). The stock is treated as Category 1 with a full analytical assessment and forecast.

ICES advice applicable to 2020

The ICES advice for management of seabass fisheries in 2020 is available in the ICES Advice released in 2019, and states that "*when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, total removals in 2020 that correspond to the F ranges in the MAP are between 1634 tonnes and 1946 tonnes*".

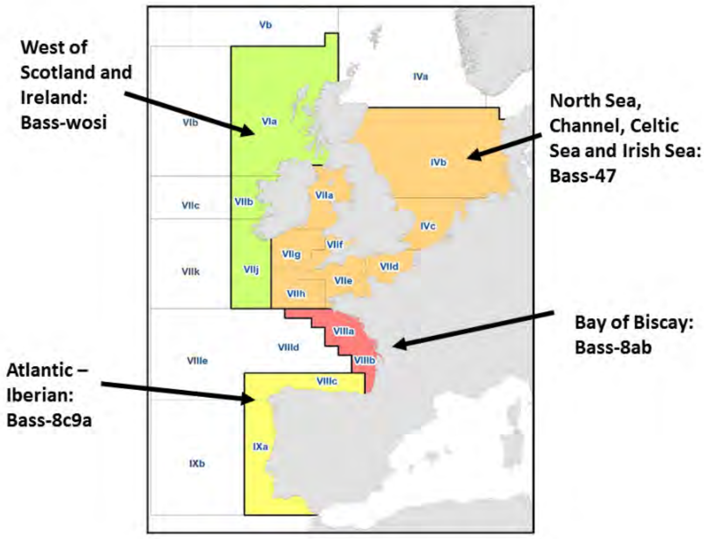
ICES advice applicable to 2021

The ICES advice for management of seabass fisheries in 2021 is available in the ICES Advice released in 2019, and states that "*when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, total removals† in 2021 that correspond to the F ranges in the plan are between 1680 tonnes and 2000 tonnes*".

29.1 General

29.1.1 Stock definition and ecosystem aspects

Studies including tagging programmes and microchemistry are underway to provide information on the movement of sea bass and levels of mixing between stocks. Currently Atlantic stock identities are assumed to be as follows (ICES, 2012a,b):



In 2021, WGCSE included a session shared with WGBIE where a summary of some studies into stock identity summarized work from data storage tags, conventional tags, genetics, otolith microchemistry and larval dispersion models. The Working Groups recognized the complexity of these issues and considered that a stock identity workshop might be convened to allow relevant experts to consider these and any other relevant studies, and advise whether the existing stock boundaries remain appropriate.

29.1.2 Management

Historical management is described in the Stock Annex.

29.1.2.1 Management applicable to 2019 and 2020

In 2020 the seabass fishery of stock bss.27.4bc7ad–h was prohibited, with derogations as shown in the simplified table below (season length, catch limits given per vessel for commercial and per fisher for recreational). In 2021, management measures for this stock have been set by the EU for the first THREE months of the year. See official regulations for full details[1,2].

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32020R0123

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0092

Year	Demersal trawl[3]	Seines[4]	Hook and Lines[5]	Fixed Gillnets[6]	Recreational
2020	10 months; < 520 kg/2 months; < 5% total catch/day	10 months; < 520 kg/2 months; < 5% total catch/day	10 months; 5.7 t/year	10 months; 1.4 t/year	9 months; 2 fish/day
2021			To be agreed		

29.1.3 Fishery description

29.1.3.1 Total landings (official)

The history of the fishery is described in the Stock Annex. Table 1 and Figure 1 present official and total ICES landings. A large decrease in total landings was observed in 2014 due to poor weather conditions during winter and then from 2015 onwards due to management measures. Historically the bulk of the landings were made by the French fishery, but since implementation of management measures, landings are shared between French, UK and NL, and to a lesser extent Belgium. In 2019, 925 tonnes were landed (official source): 406 t by UK, 299 t by France, 202 t by Netherland and 18 t by Belgium. Landings from France and the UK by gear are given in Figure 2, with lines being the main gear used by both countries in 2018 and 2019. Despite the effects of the COVID-19 pandemic, commercial catches in 2020 remain similar to 2018 and 2019.

29.2 Data

29.2.1 Commercial landings

Landings are used for six fleets where selectivity is modelled (Table 2): fleet 1- UK bottom trawls and nets; fleet 2- UK lines; fleet 3- UK midwater pair trawls; fleet 4- French combined fleets; fleet 5- other countries plus UK gears not included in fleet 1, with selectivity based on fleet 4; and fleet 6- recreational fisheries, where 2012 is the reference year. The source of information for the commercial fleets is the ICES database InterCatch. The time-series of recreational fisheries removals is calculated iteratively, so that fishing mortality remains constant and equal to the fishing mortality in 2012 over the period 1985–2014. After the implementation of the management in 2015, a multiplier is applied to recreational fishing mortality based on the severity of the measures (see chapter below). The landings are census data (EU logbooks and/or sales slips) from several sources:

1. Official statistics recorded in the ICES official landings database since the mid-1970s, with data from 1985 are used in this assessment.
2. French landings for 2000–2019 from a separate analysis of logbook, auction data and VMS data (SACROIS database) by Ifremer – extracted from the ICES database InterCatch.
3. Landings for Belgian vessels – extracted from the ICES database InterCatch.
4. Landings for Netherlands – extracted from the ICES database InterCatch Exception where a mistake was found in InterCatch, i.e. 2018 landings were updated for the 2020 assessment using official data.

[3] All types of demersal trawls, including OTB, OTT, PTB, TBB, TBN, TBS, TB.

[4] All types of seines, including SSC, SDN, SPR, SV, SB, SX.

[5] All longlines or pole and line or rod and line fisheries, including LHP, LHM, LLD, LL, LTL, LX and LLS.

[6] All fixed gillnets and traps, including GTR, GNS, FYK, FPN and FIX.

5. UK landings by gear type recorded in official UK landings databases (historically and "InterCatch" database).

Details of the methodology used to calculate French and UK historical landings can be found in the Stock Annex.

29.2.2 Commercial length and age compositions

IBPBass2 (ICES, 2016) developed the Stock Synthesis model to include both the length and age compositions for the landings of fleets for which selectivity is estimated (Fleet 1: UK combined bottom trawl and nets -1985 onwards; Fleet 2: UK lines -1985 onwards; Fleet 3: UK midwater trawlers -1985 onwards; Fleet 4: French combined gears -2000 onwards). Fitting to length composition data helps the estimation of length-based selectivity, whilst the age compositions (from application of age–length keys to length frequencies according to stratified sampling schemes) provide direct fitting of model estimates of catch-at-age. Since the length data are effectively being used twice, the length and age datasets are down weighted to avoid over-fitting of the data. The composition data for the fleets are given in the SS3 data file. Input sample sizes for the multinomial composition data are derived from numbers of fishing trips sampled, as proxy for effective sample size. The relative sample sizes between years are maintained in any reweighting.

29.2.2.1 Sampling rates

UK (England and Wales) sampling effort for length and age compositions by gear group are given in Table 3. The UK midwater trawl fleet landings were not sampled in 1997, 2013–2017 and 2019-2020 due to the small number of trips targeting seabass. This has negligible impact on the assessment as this UK métier represented only 1% of total seabass landings in 2013 and landed 2 t or less each year for 2014–2019. In addition, Stock Synthesis will impute age distributions for missing years from the selectivity curve and landings.

Sampling of seabass in France also varied between gears (Table 4). Numbers of fish sampled decreased from 2015 due to the implementation of management measures and the fact that relatively few fish are now landed. The level of sampling was very low in 2019, with some of the main métiers, including lines and nets, not sampled. Level of sampling has nevertheless increased in 2020.

The number of trips sampled in the UK is used as input in the stock assessment, with exception of a set number being attributed to UK midwater trawl and French fleet age composition. These numbers are then iteratively adjusted using the Francis method of weighting, reducing the disproportionate effect of the different datasets used.

29.2.2.2 Length composition estimates

Figure 3 and Table 5 give fleet-raised length compositions for all French gears combined. French numbers-at-length are available from 2000 onwards. The French fleet is the combination of several types of subfleets using a variety of fishing gears: pelagic trawlers, bottom trawlers, netters, liners, Danish seiners and purse-seiners (see details in Table 4). Figure 4, Figure 5 and **Error! Reference source not found.** give fleet-raised length compositions per UK métier used in the assessment (UK bottom trawls and nets; Lines; Midwater trawls).

29.2.2.3 Age composition estimates

The French age composition time-series from 2000 is from the application of an annual age–length key to the annual length composition of landings.

Fleet-raised age compositions were obtained for UK fleets from 1985 onwards by application of age–length keys developed for the areas 4.bc, 7.d, 7.e&h, and 7.a,f,g. The annual age compositions for the combined bottom trawl and nets fleet and the line fleet are given in Table 7 and Table 8, and the age compositions for the UK midwater pair trawl fleet since 1996 are given in Table 9.

29.2.3 Commercial discards

29.2.3.1 Discards and post release mortality

Discarding of seabass below the MCRS occurs in most commercial fisheries to a variable extent. Previously, ICES advice sheets indicated overall international discard rates of only 5% by weight for the bss.27.4bc7ad–h stock. The WGCSE and WKBASS (ICES, 2017) showed that discard rates have typically been the highest in bottom otter trawls (OTB) and have increased following the introduction of additional management measures in 2015. Discards are now included in the assessment of this stock and in the absence of any data on discard survival, this has been assumed to be zero for all commercial fisheries. This has the potential to overestimate commercial fishing mortality, but the effect was initially expected to be small due to the low discard rates prior to 2015. This has changed in recent years, since the management measures have been implemented and discard rates are expected to increase in the short term as fishers adjust to take account of the changes, such as the increase in minimum conservation reference size from 36 cm to 42 cm.

Survival of fish discarded by commercial line vessels may be similar to survival of recreational angling releases (see next section), but work is needed to establish the typical gear, handling, and condition of fish to be released. Survival of seabass caught by trawls, seines, fixed or driftnets and longlines will depend on many factors including tow duration, soaking times, gear design, deep-hooking, and time on deck. There is need for studies on discard survival of seabass in different commercial fisheries.

29.2.3.2 Commercial discards data

Data sources for discards estimates and sampling design are described in the Stock Annex, with a summary of data from the UK and French on-board sampling programmes from 1985 to present given in Table 10, Table 11 and Table 12. Note that in the assessment, from 2015 onwards, discards from French observer data were replaced by logbook estimates, more realistics.

The observer estimates of annual discards by UK and French vessels from 2009 to 2014 was less than 5% of total landings. Between 2016 and 2019, the level of discarding observed in the French fleet as a whole increased compared to the previous period and varied between 10% and 22% (Table 12). This was mainly attributed to bottom trawlers where seabass is often a bycatch. French logbook data led to higher discards rate estimates of 23%, 38%, 59% and 53% from 2016 to 2019. For the UK fleet a level of 9% was observed in 2016, 6% in 2018 and up to 18% in 2019, all mainly due to bottom trawlers (Table 11). In 2019, UK bottom trawlers discarded an estimated 85% of their catches. The level of sampling of the UK fleets in 2017–2020 was low and so no raised estimate of discard length distribution was included in the assessment for these years.

French log book data from 2016 to 2020 showed that discard rates estimated from on-board sampling were much lower than those reported in logbooks. The logbook data provided estimates of discards of 155.6, 270.9, 456.4, 374.6 and 313 tonnes respectively, as opposed to the on-board sampling programme estimates of 152.7, 161.7, 34.2, 79.2 and 3 tonnes for 2016, 2017, 2018, 2019, 2020 respectively. The increase in discards in 2018 may be explained by more restrictive management measures, but also by the fact that French fishers have been encouraged to report their discards in logbooks because of the landings obligation.

29.2.4 Recreational catches

The approach used for recreational catches is described in detail in the Stock Annex, but is briefly summarised here including the latest relevant data.

29.2.4.1 Recreational catches point estimates

Only a single year of recreational catches was available: 1440 t in 2012. This value of 1440 t was obtained by summing international recreational activities survey estimates for France, the Netherlands and the UK. It represented total removals through adding the retained fish and releases assuming a 5% post-release mortality. A composite length–frequency distribution was generated for recreational removals from the same survey data, with a post-release mortality of 5% applied to the release component.

29.2.4.2 Recreational removals time-series reconstruction

F for the recreational fishery was assumed to be constant prior to the introduction of management measures in 2015. Limited survey data were available after the implementation of management measures at the time of the benchmark in 2017–2018, so no reliable catch estimates existed. As a result, a method was developed for estimating the impact of combinations of the MCRS, season length and bag limits on removals by recreational fishing. A multiplier was derived from 2012 catches in terms of numbers of fish for the recreational F that related to the reduction in catch due to management. This corresponded to multipliers of 0.821 in 2015, 0.282 in 2016 and 2017, 0.191 in 2018, 0.312 in 2019 and 0.464 for 2020 and 2021 (Table 13).

Since completion of the benchmark in 2018, further surveys have been conducted in the UK, France, Belgium, and the Netherlands that provide estimates of recreational catches of seabass. However, these surveys have been done in different years, using different methods, and have different associated biases. It is not obvious how best to combine the data for use in the assessment and would represent a significant departure from the current approach. Hence, this should be done as part of the next benchmark and peer-reviewed to ensure it robustness. As a result, the current approach will continue to be used until the next benchmark and recreational catches included on the issue list.

29.2.5 Biological data

All parameters for growth, weight, maturity, natural mortality and ageing error were as described in the Stock Annex.

29.2.6 Survey data used in assessment

29.2.6.1 Pre-recruit surveys in UK

An inshore trawl survey in autumn in a major bass nursery area in the Solent (7.d English coast) provides abundance indices-at-ages 2 to 4 for the stock assessment (Figure 7). Data are available from 1982, although there are intermittent years when the survey did not take place. The index calculation was updated in 2020 after a rigorous quality assessment was conducted (see WD in Annex 3 – Solent seabass numbers-at-age) (**Error! Reference source not found.**; Table 14 and Table 15). The Stock Annex provides details of this survey and of some other pre-recruit survey series not considered appropriate by previous WGs and IBPBass for inclusion in the assessment.

29.2.6.2 Pre-recruit surveys in France

Similar surveys have been done by Ifremer along the coast of France since 2014 to provide insight into French seabass nurseries areas and pre-recruit dynamics. The new time-series is not available to WGCSE, but is expected to provide additional information on seabass age groups 0–3 to be considered for inclusion in the assessment. In the Channel, the survey takes place in the Seine estuary and preliminary indices are available from 2017. The survey is expected to continue until 2021 under a European Maritime and Fisheries Fund (EMFF) program (NOURDEM) and the working group will encourage its continuation after the index generated is reviewed and if it provides valuable information and supports the assessments.

29.2.6.3 Channel Groundfish survey CGFS

The French Channel Groundfish survey has been carried out in October each year since 1988. It provides swept-area indices of seabass abundance in the Eastern Channel (7.d) together with length compositions. The swept-area indices are given in Table 16. Details of the survey can be found in Coppin *et al*. (2002) and sampling stations shown in Figure 8. The majority of seabass are caught in the coastal waters of England and France. The original time-series finished in 2014 as a new vessel was used for the survey from 2015. The new time-series now includes six years of data, so may be considered for inclusion in the assessment at the next benchmark.

29.2.7 Commercial landings per unit of effort

Following the recommendation from WKBASS (2018) the French lpue index is now calculated by modelling the zeros and non-zeros values using a delta-GLM approach (see Stock Annex for details). Confidence interval calculated through a bootstrap estimation are presented in Table 17 and Figure 9, with the updated lpue series used in the assessment.

29.2.8 Other relevant data

None.

29.3 Stock assessment

29.3.1 Model structure and input data / parameters for update assessment

The assessment was conducted using Stock Synthesis (Methot, 2000; 2011), using version 3.24u (Methot, 2011). The structure and input data / parameters of the SS3 model are summarized below and details are available in previous sections.

29.3.1.1 Model structure

- Temporal unit: annual based data (landings, discards, survey and commercial tuning indices, age and length frequencies).
- Spatial structure: One area.
- Sex: Both sexes combined.

29.3.1.2 Fleet definition

Six fleets defined: 1. UK bottom trawls, nets; 2. UK lines; 3. UK midwater trawls; 4. French fleets (combined); 5. Other (other countries and other UK fleets combined); 6. Recreational fisheries.

29.3.1.3 Landings and discards

Annual landings in tonnes from 1985 to final assessment year for the five fleets from ICES subdivisions 4.b and c, 7.a, d–h. Recreational catch for 2012 with the time-series from 1985 to present iteratively reconstructed conditioned on the 2012 estimated value of 1440 t.

Discards in tonnes for fleet 1 (UK bottom trawls, nets) from 2002 and fleet 4 (French) from 2009.

29.3.1.4 Abundance indices and compositional data

Channel Groundfish Survey in 7.d in autumn (France), 1988 to 2014: total swept-area abundance index and associated length composition data (Table 16). Input CV for survey is 0.60 for 1988–1990 and 0.30 for 1991 to 2014. First three years of composition data are excluded due to sampling levels and high uncertainty in the data. For remaining years, number of stations with seabass is used as input effective sample size of compositional length data.

Cefas Solent Autumn bass survey (7.d), years 1986 to 2009, 2011, 2013 to present, for ages 2–4. Selection was fitted as a function of length using a double normal model, with minimum and maximum ages specified as 2 and 4 in the age selection function (Table 15).

French lpue as updated every year.

29.3.1.5 Fishery landings age composition data

The age bin is set from 0 to 15 with a plus group for ages 16 and over. Age compositions for fleets are expressed as fleet-raised numbers-at-age, although they are treated as relative compositions in SS3. Year range for UK bottom trawls/nets and UK lines is 1985 to present; UK midwater pair trawl is 1996 to 2018 (no samples for 1997, 2013–2014, 2016–2017, 2019-2020); French is all fleets from 2000 to present.

29.3.1.6 Fishery landings length composition data

The length bin is set from 4 to 100 cm by 2 cm intervals. Length compositions for fleets are expressed as fleet-raised number-at-length. Year range for UK bottom trawls/nets is 1985 to present; UK lines 1985 to present; UK midwater pair trawl 1985 to 2012 (no samples for 1997, 2013–2019-2020); French all fleets from 2000 to present.

29.3.1.7 Model assumptions and parameters

Table 18 summarises key model assumptions and parameters. Other parameter values and input data characteristics are defined in the SS3 control file BassIVVII.ctl, the start.SS file, the forecast file Forecast.SS and the data file BassIVVII.dat.

29.3.1.8 Incorporation of recreational fishery catch estimates

2012 catch input and F multipliers on all other years to iteratively estimate the full time-series of recreational catches; calculations for the final assessment run are given in Table 21.

29.3.1.9 Final update assessment: diagnostics

The likelihood components (log L * Lambda) for the update SS3 assessment are given below:

Likelihood components	Likelihood
TOTAL	694.1
Catch	7.347e-013
Equilibrium catch	0.02727
Survey	-41.26
Discards	26.35
Length compositions	390.0
Age compositions	294.8
Recruitment	24.19
Forecast Recruitment	0.003954
Parameter soft bounds	0.01868

A range of model outputs and diagnostics are given in Figures 13–33.

Good correspondence was found between the observed and fitted length and age compositions for each fleet (Figures 16–28). However, the fit to the French length compositions was poorer since 2014 (especially in the last two or three years) and the fit to French age composition was variable throughout the time-series. Some diagonal residual patterns are noted in the commercial age compositions indicating some problems in fitting extreme variations in recruitment.

Any smearing of age estimates from a strong year class into neighbouring weak ones could be responsible for year-class residuals in the UK age compositions that are apparent in the first half of the series. The age error vector included in the model helps to accommodate this in the fit to age compositions. The combined fit of the age and length composition data aggregated over the series good (Figure 19 and Figure 25).

The survey abundance indices both fisheries-independent and fishery-dependent are fitted reasonably well (Figure 26, Figure 27 and Figure 28).The UK Solent autumn survey is characterised by a large variability with outliers present in the model fit (Figure 26). The model fits closely to the low indices for recent years because there are few fishery composition data for estimating these recent year classes.

The model is able to predict recruitment deviations back to around the 1974 year class due to the strong year classes captured in the data in the early years (Figure 29) allowing a longer term perception of recruitment dynamics. Recruitment is highly variable with no evidence of a reduction in average recruitment at the lower SSB values (Figure 29) although this perception is affected by the imposition of a steepness value of 0.999 for the fitted Beverton–Holt stock–recruit curve. Sensitivities to differing values for this parameter carried out during the benchmark workshops found that likelihoods progressively worsened as the steepness value was reduced.

29.3.2 Analytical retrospective analyses

Retrospective analysis with a five-year peel was carried out for the calculation of the Mohn's rho. This analysis shows that there is some evidence of a retrospective pattern, see table below and Figure 30, for recruitment, SSB and fishing mortality. However, the retrospective bias is within the tolerance threshold accepted by ICES (-15 to +20) for SSB and fishing mortality, there has been no tolerance threshold set for recruitment.

	Mohn's rho
Spawn–stock biomass	0.172
Fishing mortality (ages 4–15)	-0.142
Recruitment (age 0)	0.72

The model is sensitive to the recent change in selectivity due to management measures where a block change in the selectivity and retention parameter estimates where introduced for data proceeding 2015.

29.3.3 Final update assessment: long-term trends

The time-series of estimates of numbers-at-age, combined recreational and commercial $F_{(4–15)}$, are given in Table 19 and Table 20, and a summary of SSB, recruitment, F and commercial and recreational catch are given in Table 21 and Figure 31. These series are based on the final SS3 update run with 2020 set as the final year. In order to obtain biomass estimates for 2021 and Fs for 2020 for the forecast the final year is set to 2021.

A sharp increase in F between 2011 and 2013 is generated because the assessment model interprets that landings were maintained despite a rapid decline in biomass. This may be a plausible scenario where aggregations or predictable migration routes of seabass can be targeted, and it is possible for fisheries to maintain landings as total stock size declines, and hence inflict an increasing fishing mortality rate. The F has since decreased in-line with sharp reduction in catches due to the discontinuation of the French midwater trawl and the implementation of additional management measures. In 2020 the stock shows a moderate increase in F which may have resulted from the less restrictive management measures in the final year. SSB also increased slightly which may have resulted from the management measures in place since 2015, and some above average recruitment events since 2013 as described below.

WGCSE has concluded that strong year classes in 1989 and some subsequent years caused a rapid increase in biomass throughout the stock area, and landings and fishing mortality in the commercial fishery also increased. The combined commercial and recreational fishery F was well above F_{MSY} prior to 2015. Recruitment has been declining since the mid-2000s, and has been very poor since 2008, however the recruitment estimated for 2013, 2014, 2016 and 2018 is above the long-term geometric mean of 15 610. Uncertainties in the assessment are explored in a subsequent section.

29.3.4 Comparison with previous assessments

With the addition of the 2020 data and the updated French lpue, the time-series of recreational catch was updated to remain consistent with the assumption of a constant F for the period 1985 to 2014 and an F multiplier reduction for 2015 to present (Figure 32).

With these changes included in the update assessment, the perception of the stock has remained largely unchanged, albeit spawning stock biomass showing a slightly lower biomass level and higher F than that estimated in 2020 for the period 2000-2015.

The spawning–stock biomass, fishing mortality and recruitment estimated in 2020 when compared with the recent assessment (Figure 33) is within the 95% confidence intervals.

29.3.5 The state of the stock

The marked increase in biomass in the 1990s was driven by the very strong 1989 year class and a number of subsequent strong year classes. The biomass prior to this was declining during a period of poor recruitment, and the recent decline in biomass also coincided with a period of poor recruitment, but under conditions of higher F than estimated for the 1980s. The stock has been characterised by periods of poor recruitment in the 1980s and since 2008. These periods of poor recruitment have a major impact on biomass, which is exacerbated by any increase in F. Total biomass changes more quickly than SSB, due to the time taken for fish to reach maturity. An increasing trend in biomass was estimated since 2018, which may have resulted from the management measures in place to restrict catches since 2015 and the occurrence of a number of just above average recruitment events since 2013.

The period of increasing SSB in the 1990s and early 2000s also coincided with expansion of the stock in the North Sea. The enhanced productivity and geographic range of the stock at this time also coincided with a period of elevated sea temperatures (see WGCSE and Stock Annex for UK inshore sea temperature trends in relation to seabass recruitment).

The assumption of a constant recreational fishing mortality over time implies that recreational harvests were a much larger fraction of total fishery removals in the 1980s compared with the 2000s onwards (Figure 10). It is likely that in the 1970s or earlier, seabass was primarily the target of recreational fishing.

29.4 Biological reference points

The fishing pressure and biomass PA and MSY reference points defined by WKBASS (2018) were updated during WGCSE 2019 due to the inclusion of additional 2018 data and a new lpue series which changed the perception of the stock. The details of the calculations of the new reference points are given in the Stock Annex with reference points given below.

In 2021, ICES revised the basis F_{pa} for all stocks to use $F_{P.05}$, as a result the value is now 0.203. All other reference points were unchanged.

Reference points	Value
Precautionary Approach	
B_{lim}	10 313
B_{pa}	14 439
F_{lim}	0.254
F_{pa}	0.203
MSY Approach	
F_{MSY}	0.1713
$F_{MSY\ lower}$	0.142
$F_{MSY\ upper}$	0.1713
MSY $B_{trigger}$	14 439

29.5 Short-term predictions

Inputs for a short-term forecast are given in Table 22, and their derivation is explained below.

29.5.1 Recruiting year-class strength

Recruitment estimates for seabass were below average from 2008 to 2012 (Table 21). Since recruitment is at a low level since 2008 the working group agreed to only include 2009 to 2018 for the geometric mean recruitment for the forecast (9 696 thousand), this was also identified and advised by the ADG in 2019. This is summarised in the text table below:

Year class	SS3 (age 0)	GM 2008–2017
2018	17 019 thousand	
2019		9696 thousand
2020		9696 thousand
2021		9696 thousand

29.5.2 Numbers of fish in 2021

These were derived from the update Stock Synthesis run with final year set at 2019. The numbers for ages 0–2 in 2021 were adjusted using the ratio of LTGM to SS3 values for 2019–2021 age 0 as explained above and in Stock Annex.

29.5.3 F-at-age vectors

Status quo F-at-age for the commercial fishery was taken as the average F-at-age as estimated from the last three years derived from the update Stock Synthesis run with final year set at 2020. This approach was taken to allow for the change in selectivity associated with the implementation of new management measures (Table 13).

The recreational F vector was estimated in a similar way using the average of the last three years, however the final F_{bar} was scaled using F multipliers on the 2012 F in Table 13 taking into account the management measures in place. For the intermediate year (2021), this was a nine-month open season with a two bag limit and a MCRS of 42 cm. Additional years' Fs were scaled to keep the F of the recreational fleet proportional to the F of the commercial fleet as in the intermediate year 2021.

29.5.4 Weights-at-age

Mean weights-at-age in the stock were taken from the Stock Synthesis output. The commercial fishery weights for 2020 were derived as a weighted mean of the values for French and UK fleets given in the Stock Synthesis output, using the model estimates of catch numbers for the two fleets as weighting factors. The annual weights-at-age for any fleet are time-invariant, as they are derived from length-at-age derived from von Bertalanffy growth curve parameters, with selectivity applied where appropriate. Length at A_{MAX} (30 years) was estimated as 80.26 cm.

29.5.5 Maturity ogive

The proportion mature at-age is the length-based ogive applied to the length-at-age distributions around the input VB growth curve, calculated within Stock Synthesis.

29.5.6 Detailed short-term forecast output at *status quo* F

A detailed short-term forecast is given in Table 22, assuming that F in 2021 and 2022 is the average of 2018–2020 from the assessment for the commercial fleet, and for the recreation fleet the partial F used is that described in Section 29.5.3.

Fishing in 2021 at the same fishing mortality as in 2018–2020 for the commercial fleet, and with the current two bag limit for nine months for the recreational fleet, an SSB of 12 153 t is predicted in 2022, increasing from 11 619 t in 2021. With the same fishing effort in 2022 the SSB would go up to 12 371 t. There is uncertainty in the forecast, as the actual rate of decline in population abundance in recent years is likely to be more uncertain than indicated by the SS3 model confidence limits. Also, the effect of the final package of technical and other management measures for seabass in 2015 to present are not fully known at this stage, and information will be needed on their implementation and effectiveness before their impact on fishing mortality can be ascertained. The assumption of constant recreational F is also untested.

29.5.7 Management options

WGCSE provides management options in which F multipliers are applied proportionally to commercial and recreational F-at-age (Table 23). In reality, fisheries managers may wish to allocate the combined forecasted landings in any way considered appropriate, and this would imply differing F-multipliers applied to each fishery.

The management options table includes options for F multipliers for a number of different scenarios and include the multiplier giving F of 0.144 calculated by reducing F_{MSY} by the stock size relative to MSY $B_{trigger}$ for combined commercial and recreational fishing. This would provide combined commercial and recreational catches of 2249 tonnes. This would be an increase of 12.5% compared to the advice for 2021. The allocation between commercial and recreational fisheries depends on the balance of controls applied on recreational and commercial fishing in 2020 and 2021.

With zero F in 2022, SSB is expected to increase from 12 153 t in 2022 to 13 762 t in 2023. Therefore, it is not possible to achieve B_{pa} or MSY $B_{trigger}$ (both 14 439 tonnes) in this time period.

29.6 Uncertainties and bias in assessment and forecast

29.6.1 Landings and discards data

Historical landings of small-scale national fisheries not supplying EU logbooks or sales slips are known to be inaccurate. IBPBass ran the Stock Synthesis model with and without additional UK landings for nets and lines estimated from a separate Cefas logbook scheme, and found this had relatively little impact on stock trends or fishing mortality, but rescaled the biomass and recruitment due to the additional catch. However, if the extent of non-reporting is changing over time, for example to develop track record in the possible event of a future TAC, then bias will be introduced in the assessment trends.

Discard rates are low in most fisheries other than trawls. Estimates of discards are available only from the early 2000s, but do not cover all fisheries, are imprecise, and are only included for some fleets in the assessment. The overall discard rate by weight is thought to be less than 5% before the implementation of management measures, increasing in recent years. Nonetheless, a time-series of discards at-length or -age is needed for all fleets if the impact of technical measures to improve selectivity is to be evaluated as part of any future bass management.

29.6.2 Fishery composition data

The ability to fit selectivity patterns for defined groups of fishery métiers, and to detect changes in selectivity, depends on collection of adequate numbers of independent, representative samples of length and age to sufficiently characterise the length or age compositions of the selected métier groups. What constitutes "sufficient" is impossible to define without simulation studies to examine relationship between precision of input data and the precision of estimates required for management.

The absence of length composition data for French fisheries prior to 2000 is a serious deficiency in the model preventing any evaluation of changes in selectivity that may have occurred, for example due to changes in the mix of gear types. The numbers of trips of each métier group sampled on shore in France and the UK has varied widely over time, and in the UK has declined substantially since the 2000s. In France, sampling effort has also been very low in recent years and now appears to only cover trawls when a large portion of the fleet is composed of other nets and lines. Currently, there are no composition data supplied by Netherlands and Belgium.

ICES has developed extensive advice on establishing statistically-sound sampling designs for estimating fishery length and age compositions and discard quantities (see reports of ICES Workshops on Practical Implementation of Statistically Sound Catch Sampling Programmes (WKPICS1–3, available on ICES website). Stratified random sampling of fishing vessels or harbours may lead to low sample sizes for species such as seabass for which large fractions of the total catches may be taken in relatively small numbers of fishing trips. The cost-benefit of expanding the sampling in vessel or harbour strata where most seabass landings are recorded, without compromising statistical sampling design, should be investigated. The next benchmark should evaluate if sampling is currently sufficient to support continued application of Stock Synthesis fitting selection parameters to fishery composition data.

29.6.3 Recreational fishery harvests

Current assessments accommodate an estimate of recreational fishery landings in the assessment and forecasts based on landings from 2012 (ICES, 2016; 2018). This a crude approach based on surveys for only a year or two in France, UK, and the Netherlands, and leads to an assumption of constant recreational fishing mortality over time. Recreational catches have been observed to vary significantly over time in other fisheries, so this assumption of constant mortality is unlikely to be true.

Since completion of the benchmark in 2018, further surveys have been done of recreational catches, but it is not obvious how best to combine the data for use in the assessment and would represent a significant departure from the current approach. Hence, this should be done as part of the next benchmark and peer-reviewed to ensure its robustness. At this stage, it will also be necessary to review the assumptions made related to changes in recreational fishing mortality and selectivity over time, and consider splitting recreational catches by country and/or fate of fish.

Release rates are expected to increase due to bag limits and increases in MLS that are in place or planned. Current studies of post-release mortality are limited, and more studies are needed to develop a better understanding of the fate of released fish given the high incidence of catch-and-release practices in sea angling for seabass.

29.6.4 Surveys

The Channel Groundfish Survey included in the assessment provides data on a wider range of sizes and ages than the Cefas Solent survey, though with a steeply domed size selection pattern. From 2015 onwards, Ifremer no longer used the scientific vessel “Gwen Drez” which was replaced by the larger vessel “Thalassa”. A calibration exercise was carried out in 2014 to assess the effect of this change to a larger vessel. WGCSE noted a concern that coverage of the coastal waters of 7.d could be altered by the use of this new vessel (the size of the vessel may prevent fishing as close to the coast as was possible with the previous vessel). The results of the calibration exercise were evaluated and it was found that the series could not be extended beyond 2014 and that a new series would need to be created from 2015 onward. This new dataseries is still to be considered for inclusion in the assessment.

The Cefas pre-recruit surveys are now reduced to just the Solent autumn survey, with the Solent spring and the Thames survey having been removed by previous benchmark assessments as being unsuitable. Recruitment estimates for the most recent years are heavily dependent on the Solent survey, and it is important to maintain this series. However, there is a need for information on recruitment trends in other areas, as it cannot be assumed that the Solent index will in the long term represent overall recruitment patterns throughout areas 4 and 7. There are several studies that have demonstrated spatial and temporal variation in abundance of seabass in estuaries in the UK, France, and Ireland. It would be useful to review and, if possible, include additional time-series at the next benchmark and consider a developing a broader survey of nursery habitats for all species. For information, such a survey is conducted in France from 2017 onwards in the Seine estuary through the project Nourdem (and also in the Bay of Biscay in the Loire estuary from 2016 and in the Gironde estuary from 2019). In 2021, a time-series of five years will be available, also a juvenile seabass index should be tested in the model. The trawl used was developed for catching seabass. An average of 5500 bass are caught during the survey, allowing a calculation of robust index.

29.6.5 Commercial lpue indices

The reliance of the assessment on the Solent and Channel trawl surveys is a potential source of bias because they cover only a part of the stock range, and the selectivity is heavily skewed towards young bass. This is of principle concern in establishing the current rate of decline in spawning–stock biomass and associated trends in fishing mortality. In the absence of relative abundance indices for older bass from surveys or commercial fishing vessels covering the range of the stock, it is difficult for the model to fit the recent stock trends and fishing mortality. Statistical modelling of French lpue data by vessel and rectangle by Laurec and Drogou (WGCSE 2015, Annex 3, WD 07) is used in the assessment.

Analyses of UK commercial fishery lpue, based on averaging across ICES rectangles where the bulk of seabass catches have been recorded, was presented to IBPNEW in 2012 (ICES, 2012a). There were divergent trends between fleets where seabass are typically a bycatch, and mainly under 10 m vessels where increased targeting has probably been occurring using lines and nets. Future development of UK lpue indices together with equivalent French data would require careful evaluation of potential for lpue of each fleet to track abundance. Further analyses on the validity of the French lpue as an index of abundance should also be considered, especially in light of the current restrictions of fishing activities.

29.6.6 Stock structure and migrations

The assessment treats all seabass in 4.b,c and 7.a,d–h as a single biological stock, but there can be extensive migrations. For example, migrations are expected to occur between the south of the area and the Bay of Biscay (which is treated separately in the WGBIE group), or between the North Sea and the Channel, there is also strong site fidelity (Pawson *et al*., 2008) resulting in a high proportion of tagged fish being recaptured at the same coastal location, even in subsequent years after migrations to offshore spawning sites. Immature seabass may remain close inshore, and exploitation of young fish in coastal waters (<6 nautical miles offshore) may be predominantly by inshore fleets of that country. Mature fish originating from coastal waters of the UK, France or Netherlands or other countries may become increasingly vulnerable to offshore pelagic pair trawlers fishing mainly on mature fish during December to April. These spatial, ontogenetic patterns may lead to complex responses of length and age compositions to previous fishery catches of each country and fleet. This could potentially be addressed using spatial structuring in Stock Synthesis, but the data demands would increase substantially. Both the UK (England) and France have studies underway to improve knowledge of seabass movement and mixing.

29.6.7 Biological parameters

The maturity ogive used in the assessment was derived from sampling from the 1980s onwards. There has been no coordinated sampling across the full range of the stock in recent years to determine if the current ogive is still valid. Sporadic recent sampling has suggested that seabass may be spawning at sizes smaller than recorded historically (see Stock Annex). This would alter the F_{MSY} and could also be associated with changes in growth parameters. Mean length-at-age in UK samples remained more or less constant over several decades of sampling, but this analysis needs updating. Changes in growth, or inappropriate growth parameters, will lead to bias in fitting length-selectivity parameters to the French fishery and survey data.

29.6.8 Intermediate year fishing mortality and catch levels for forecasts

Measures introduced by the UK government and EU commission to reduce fishing mortality toward F_{MSY} have the potential to affect the short-term forecast assumptions for this stock. Table 22 and Table 23 provide a detailed short-term *status quo* forecast and a range of management options from the forecast run.

29.7 Recommendations

29.7.1 Management considerations

Seabass in this stock are characterised by slow growth, late maturity and low natural mortality of adults, which imply the need for comparatively low rates of fishing mortality to avoid depletion of spawning potential in each year class. Productivity of the stock is affected by extended periods of enhanced or reduced recruitment, which appear to be related to changes in sea temperature. Warm conditions facilitate northward penetration of seabass in the North Sea and Northeast Atlantic and enhance the growth and survival of young fish in estuarine and other coastal nursery habitats. A period of above-average sea temperatures and enhanced recruitment between 1989 and the mid-2000s generated a large increase in biomass and a geographic expansion. Increased abundance and a lack of a TAC or other means to control fishing outside of nursery areas stimulated a growth of fisheries and markets for seabass. Many small-scale artisanal fisheries, especially line fishing and some forms of netting, have developed a high seasonal dependency on seabass, and there is also a significant recreational fishing mortality in inshore waters. The behaviour of seabass, forming predictable aggregations for spawning and moving close inshore to feed at other times of year, increase their vulnerability to exploitation by offshore and inshore fisheries. Increased targeting of seabass has resulted in a progressive increase in fishing mortality above values considered appropriate to achieve F_{MSY}. The combination of increasing fishing mortality and environmental conditions causing poor recruitment since 2008 appears responsible for a continuous decline in biomass since 2010. Catches appear to be declining in fisheries where seabass is mainly a bycatch, but some other fisheries such as netting in the UK appear to be expanding and may be exploiting known seasonal migration routes and local aggregations of fish despite a more widespread contraction of the population.

Careful management of fishing pressure on seabass is needed to prevent SSB declining to such an extent that the stock's ability to produce strong recruitment in more favourable environmental conditions is impaired. Since 2013, the European Commission developed a package of management measures to promote recovery of the stock. This resulted in emergency measures to stop the offshore pelagic trawl fishery on spawning aggregations between January and April 2015, bag limits for recreational fishing, and an increase the MLS to 42 cm. Further measures to restrict catches without resorting to a TAC have been implemented. Any management measures applied to commercial and recreational fisheries should take into account the need for collection of data to demonstrate the effectiveness of the measures, and the ability to enforce the measures adequately.

ICES advice in 2004 recommended that "implementation of 'input' controls, preferably through technical measures aimed at protecting juvenile fish, in conjunction with entry limitations into the offshore fishery in particular should be promoted", and that "any consideration of catch limitation (output control) would need to take into account that seabass are a bycatch in mixed fisheries to a various extent, depending on gear and country; this incites discarding and should be avoided". This form of advice has re-occurred in subsequent ICES advice for seabass.

WGCSE notes that protection of juvenile fish through technical measures is good to improve the fishery selectivity and increase the number of seabass that are able to spawn at least once, but this is probably not enough to ensure a sufficient decrease in F. Protection of juveniles already exists to an extent already through designation of 37 UK seabass nursery areas where certain types of fishing on seabass is prevented annually or seasonally. However, catching and discarding of seabass by trawlers fishing close to nursery areas remains an issue. Data available to WGCSE indicate that discarding is mainly by otter trawlers using 80–90 mm mesh in or near areas where juvenile bass are most abundant, for example in UK coastal waters of the eastern Channel. Improvements to fishery selectivity to successfully achieve a large reduction in fishing mortality on pre-spawning fish without increasing discarding would require changes to gear designs, which could have a strong spatial management component.

Entry limitation can prevent an increase in effort but will not decrease F to the extent needed, unless existing licences are withdrawn. The occurrence of seabass as a small bycatch in many fisheries raises the problem of this becoming a "choke species" if vessel catch limits are introduced under EU legislation and seabass fall under the landings obligation.

ICES also previously advised that "Management of seabass fisheries needs to take into account the distinctive characteristics and economic value of the different fisheries. Seabass is of high social and economic value to the large inshore artisanal fleets and to sea angling and other recreational fishing that contribute substantially to local economies". Data from France indicated that the first sale value of the high-volume and lower quality catches of seabass caught by pelagic trawlers targeting offshore spawning fish during December to March had been up to three times lower per kg than for smaller volume sales of higher-quality fish from métiers fishing inshore (Drogou *et al*., 2011). However, there is at present insufficient information to accurately evaluate the total economic value and impact of seabass fisheries beyond just the first sale value and covering direct incomes from sales and direct as well as indirect and induced costs, employment and added value generated downstream. The interrelationship between markets for wild caught and farmed seabass also needs to be evaluated. A number of studies on the economic value of recreational sea fisheries have been conducted in recent and these demonstrate high levels of spend into national economies years (e.g. Armstrong *et al*., 2013; Roberts *et al*., 2017; Hyder *et al.* 2018a). Marine recreational fisheries in Europe has been shown to have a total economic impact of 10.5 billion and support almost 100,000 jobs in Europe (Hyder *et al.*, 2017; 2018a), but this cannot be easily split between individual species.

No bio-economic scenarios are available at present to appreciate the effect of management measures for seabass, based on economic considerations, and work is urgently needed in this area. The importance of seabass to recreational fisheries, artisanal and other inshore commercial fisheries and large-scale offshore fisheries in different regions means that resource sharing is an important management consideration that has implications for the type of scientific evidence needed. A number of studies have shown that recreational catches of bss.27.4bc7ad–h represent around one quarter of the total catch (Armstrong *et al.*, 2013; Hyder *et al.*, 2018b; Radford *et al.*, 2018).

The effects of targeting of offshore spawning aggregations of seabass in the English Channel and Celtic Sea are poorly understood, particularly how the fishing effort is distributed in relation to mixing of fish from different nursery grounds or summer feeding grounds in the UK, France and other countries, given the strong site fidelity of seabass.

The current stock structure assumptions are pragmatic and need further evaluation. The seabass population in coastal waters of the Republic of Ireland is currently considered as a separate stock, although it extends into at least one of the ICES divisions defining the 4.bc and 7.a,d–h stock. Further studies are needed to determine if the seabass in Irish coastal waters are indeed functionally separate, or if they also mix with the other stock during spawning time and contribute to commercial catches on the offshore spawning grounds. Moreover, the Bay of Biscay is also currently considered as a separate stock although tagging program indicates some exchange with the area 4 and 7 stock studied assessed by WGCSE.

As bass is, at present, a non-TAC species, there is potential for continued displacement of fishing effort from other species with limiting quotas. The fisheries on seabass have grown in the 1990s and 2000s due to good recruitment, and new markets have been established, competing with farmed bass. Fishing mortality gradually increased over time and was above F_{MSY} for many years. With the stock in decline measures were introduced to prevent the risk of stock collapse. Currently the likelihood of collapse remains high unless strong year classes are produced again and the management measures in place are continued and remain flexible to improving the fishery selection pattern, and limit total fishing mortality across all ages of seabass.

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Table 1. Bss.27.4bc7ad–h: Annual landings from 4b&c and 7a,.d–h (official landings per country and total ICES estimates).

Year	Belgium	Denmark	Germany	France*	UK	Netherlands	Channel Is.	Total official	Total ICES
1985	0	0	0	620	105	0	18	743	994
1986	0	0	0	841	124	0	15	980	1319
1987	0	0	0	1226	123	0	14	1363	1980
1988	0	18	0	714	173	8	12	925	1239
1989	0	2	0	675	192	2	48	919	1161
1990	0	0	0	609	189	0	25	824	1063
1991	0	0	0	726	239	0	16	982	1227
1992	0	0	0	721	148	0	36	906	1186
1993	0	1	0	718	230	0	45	994	1255
1994	0	1	0	593	535	0	49	1178	1371
1995	0	1	0	801	708	0	69	1579	1835
1996	0	1	0	1703	563	8	56	2331	3022
1997	0	1	0	1429	561	1	74	2066	2620
1998	0	2	0	1363	488	48	79	1980	2390
1999	0	1	0	NA	685	32	108	826	2670
2000	0	5	0	1522	407	60	130	2124	2407
2001	0	2	0	1619	458	77	80	2236	2500
2002	0	1	0	1580	627	96	73	2377	2622
2003	154	1	0	1903	586	163	84	2891	3459
2004	159	1	0	1883	617	191	159	3010	3731
2005	206	1	0	1937	512	327	220	3203	4430
2006	211	2	0	2116	736	308	23	3396	4377
2007	178	1	0	2075	873	376	18	3521	4064
2008	187	0	0	1506	934	380	20	3027	4107
2009	174	0	0	2904	801	395	15	4288	3889
2010	216	4	0	3441	879	399	14	4952	4562
2011	152	2	0	2688	928	395	17	4183	3858
2012	154	3	0	2492	946	376	12	3982	3987
2013	146	4	2	2868	841	370	12	4243	4137
2014	148	1	1	1322	1080	253	11	2816	2682
2015	40	0	0	1113	701	218	9	2081	2066
2016	23	0	1	545	551	156	24	1300	1295
2017	22	0		423	438	132	12	1027	984
2018	18	0	0	297	432	172	11	931	948
2019	18	0	0	299	406	202	0	927	972
2020	24	0	0	387	521	218	0	1150	1042

Source: Official Landings Statistics. 2019 and 2020 provisional data; Total ICES, from InterCatch database.

Table 2. Bss.27.4bc7ad–h: Landings for the country / fleet components included separately in the assessment model.

Year	Fleet 1 : UK Trawls, nets	Fleet 2 : UK Lines	Fleet 3 : UK pelagic trawlers	Fleet 4 : France combined gears	Fleet 5: Other countries and gears	Fleet 6 : RecFish
1985	70	30	1	870	23	1771
1986	84	33	2	1180	19	1597
1987	96	18	0	1840	25	1457
1988	129	30	8	1028	44	1353
1989	141	29	7	917	67	1253
1990	128	18	22	849	47	1129
1991	152	60	14	971	29	1037
1992	105	23	8	1001	49	1061
1993	146	62	1	979	68	1235
1994	354	154	0	786	76	1481
1995	424	169	4	1057	181	1661
1996	308	128	87	2395	104	1673
1997	335	119	71	1984	111	1588
1998	241	121	85	1773	170	1534
1999	274	148	220	1843	185	1536
2000	236	53	52	1805	261	1590
2001	263	58	97	1883	199	1675
2002	361	75	110	1825	251	1771
2003	353	65	127	2471	443	1852
2004	380	72	131	2604	544	1896
2005	353	59	68	3161	789	1892
2006	359	119	11	3259	629	1860
2007	413	166	37	2771	677	1855
2008	514	163	17	2750	663	1862
2009	486	147	9	2649	598	1836
2010	452	183	42	3236	649	1739
2011	462	143	98	2526	629	1598
2012	564	185	49	2610	579	1440
2013	530	191	39	2871	506	1229
2014	751	236	1	1303	391	1021
2015	440	199	0	1110	317	703
2016	305	210	2	547	231	215
2017	125	147	0	442	270	212
2018	160	267	0	313	208	153
2019	134	259	1	329	249	277
2020	190	306	0	409	137	447

Table 3. Bss.27.4bc7ad–h: Sampling of commercial fishery landings of otter (A.), pelagic midwater trawls (A.), lines (B.) and nets (B.) for length and age in the UK (England and Wales). Nsamp is the number of landings (trips) sampled; Nfish is the number of fish measured.

A.	UK Otter trawl					UK Pelagic/midwater				
Year	Age Nsamp	Nfish	Length Nsamp	Nfish	Landings (t)	Age Nsamp	Nfish	Length Nsamp	Nfish	Landings (t)
1985	45	235	15	225	27	3	44	2	43	1
1986	18	216	28	2591	24					2
1987	41	421	54	1181	41	4	42	1	589	0.02
1988	23	257	23	1298	65	2	64	2	1684	8
1989	63	531	44	1595	80	4	126	4	1451	7
1990	63	883	48	773	67	8	19			22
1991	92	983	32	731	39	12	125	1	1490	14
1992	69	699	17	398	41	2	50	2	220	8
1993	118	1219	38	836	80	9	39			1
1994	182	1927	113	3925	125			1	127	0.3
1995	28	529	66	1995	162			1	19	4
1996	49	660	39	1041	122	1	41	3	392	87
1997	59	1660	52	2445	140	1	49			71
1998	28	676	39	1442	133	20	95	4	167	85
1999	24	379	46	1216	138	12	382	9	770	220
2000	92	759	42	1814	133	23	847	14	2463	52
2001	45	851	49	2152	141	3	58	5	691	97
2002	54	523	47	1454	161			4	545	110
2003	48	512	45	1418	207	15	459	4	744	127
2004	33	361	31	1295	173	8	161	5	522	131
2005	35	498	31	2432	181	3	149	2	299	68
2006	15	252	17	810	160	1	43	1	100	11
2007	44	385	21	903	173	1	20	3	355	37
2008	37	580	32	2151	196	6	409	8	1283	17
2009	24	1184	13	807	175	8	317	6	625	9
2010	25	360	28	1312	150	7	153	3	376	42
2011	25	577	49	1903	137	3	103	4	463	98
2012	18	182	41	751	157			1	199	49
2013	15	289	23	859	125					39
2014	14	164	22	523	104					1
2015	28	377	39	1277	100	1	4	1	4	1
2016	19	256	90	527	52					2
2017	38	510	128	915	51	0	0	0	0	0
2018	43	263	43	492	28	1	15	1	33	0
2019	30	105	89	686	15	0	0	0	0	1
2020	47	90	47	251	27	0	0	0	0	0

B.	UK Lines					UK Nets				
	Age		Length		Landings (t)	Age		Length		Landings (t)
Year	Nsamp	Nfish	Nsamp	Nfish		Nsamp	Nfish	Nsamp	Nfish	
1985	53	395	19	285	30	34	332	15	181	43
1986	60	496	31	894	33	18	251	18	1132	61
1987	92	313	69	557	18	37	528	44	1321	55
1988	66	538	53	1325	30	37	584	40	1397	64
1989	249	652	26	310	29	49	469	45	1248	60
1990	281	918	22	260	18	24	207	11	456	61
1991	346	1468	53	963	60	57	481	30	583	113
1992	418	2905	111	2077	23	40	281	28	1248	64
1993	287	1787	123	1426	62	127	1141	94	1686	66
1994	212	1616	155	3783	154	146	2846	157	5130	229
1995	160	1043	107	1493	169	95	1786	150	6248	262
1996	155	1326	106	1790	128	85	1371	113	3348	186
1997	141	1262	137	2072	119	73	1055	106	2747	195
1998	182	1215	111	2820	121	88	1119	82	2465	108
1999	237	1304	149	3793	148	127	1189	74	2966	137
2000	405	1395	65	1964	53	119	1719	104	5482	103
2001	451	2485	114	2935	58	140	2027	92	3309	122
2002	210	1286	146	3031	75	220	3800	206	6680	201
2003	151	1009	90	3108	65	171	1720	224	5899	146
2004	127	906	66	1980	72	83	974	150	3567	207
2005	87	380	25	921	59	73	768	33	1126	172
2006	54	359	67	989	119	56	598	47	1197	199
2007	94	713	31	1088	166	90	753	40	1811	239
2008	37	552	28	1325	163	100	1444	63	3361	318
2009	49	304	18	915	147	116	1571	100	3247	311
2010	34	418	40	970	183	63	1214	66	2350	302
2011	46	1091	55	2250	143	34	793	41	1433	324
2012	89	1295	100	2215	185	35	909	56	2809	407
2013	41	896	42	1236	191	42	1123	49	2342	405
2014	67	1247	73	1889	236	60	1161	71	2781	647
2015	72	1183	79	3055	199	48	776	67	3985	338
2016	69	1151	110	1236	210	59	1165	83	1974	252
2017	28	303	171	2225	158	0	0	41	727	74
2018	103	1478	123	2166	267	55	694	55	1763	132
2019	99	1815	103	3083	259	57	783	92	1929	120
2020	95	943	95	2425	306	61	572	61	1872	163

Table 4. Bss.27.4bc7a d-h: Sampling of commercial fishery seabass landings for length and age in France for lines, nets (A), Danish seines and other gears (B), and pelagic trawls and bottom trawls (C) (2017 real sampling excluding simulated). Nsamp is the number of landings (trips) sampled; Nfish is the number of fish measured.

A.	FR_lines					FR_nets				
	Age		Length		Landings	Age		Length		Landings
Year	Nsamp	Nfish	Nsamp	Nfish		Nsamp	Nfish	Nsamp	Nfish	
2000	NA	NA	53	1613	305	NA	NA	2	72	108
2001	NA	NA	101	2659	375	NA	NA	1	5	110
2002	NA	NA	79	2076	349	NA	NA	0	0	128
2003	NA	NA	78	1732	438	NA	NA	1	4	152
2004	NA	NA	78	1748	381	NA	NA	6	84	150
2005	NA	NA	34	949	439	NA	NA	4	110	148
2006	NA	NA	73	1719	554	NA	NA	11	291	140
2007	NA	NA	69	2235	560	NA	NA	28	641	158
2008	NA	NA	41	1280	425	NA	NA	25	496	128
2009	12	211	33	1339	251			25	159	94
2010	4	169	10	334	278			49	615	160
2011	39	443	17	540	359			156	278	129
2012	37	385	10	681	295			60	408	142
2013	6	174	16	309	291	3	130	26	512	126
2014			10	299	285			29	218	163
2015	23	70	16	326	210			35	242	109
2016			2	84	156	5	67	32	293	64
2017			9	219	166			18	151	35
2018			4	208	151	9	45	9	45	74
2019			0	0	139			0	0	70
2020			27	703	164			13	193	78

B.	FR_danish seine					FR_other gears				
	Age		Length		Landings	Age		Length		Landings
Year	Nsamp	Nfish	Nsamp	Nfish		Nsamp	Nfish	Nsamp	Nfish	
2000	NA	NA	0	0	0	NA	NA	0	0	20
2001	NA	NA	0	0	0	NA	NA	0	0	27
2002	NA	NA	0	0	0	NA	NA	0	0	22
2003	NA	NA	0	0	0	NA	NA	0	0	23
2004	NA	NA	0	0	0	NA	NA	0	0	17
2005	NA	NA	0	0	0	NA	NA	0	0	17
2006	NA	NA	0	0	0	NA	NA	0	0	35
2007	NA	NA	0	0	0	NA	NA	0	0	24
2008	NA	NA	0	0	0	NA	NA	0	0	40
2009			0	0	27			0	0	127
2010			0	0	61			2	2	90
2011			2	6	43			36	292	62
2012	16	153	6	370	112			7	154	91
2013			2	28	18			1	1	82
2014			12	23	9			1	1	25
2015	10	36	0	12	26			0	0	16
2016			28	78	20			0	0	20
2017			14	42	22			0	0	40
2018			0	0	9			0	0	16
2019			0	0	21			0	0	22
2020			2	77	11			0	0	20

C.	FR_pelagic trawl					FR_bottom trawl				
	Age		Length		Landings	Age		Length		Landings
Year	Nsamp	Nfish	Nsamp	Nfish		Nsamp	Nfish	Nsamp	Nfish	
2000	NA	NA	2	629	681	NA	NA	2	196	692
2001	NA	NA	0	0	659	NA	NA	0	0	713
2002	NA	NA	3	680	415	NA	NA	4	710	911
2003	NA	NA	4	753	773	NA	NA	8	998	1087
2004	NA	NA	6	938	820	NA	NA	12	887	1236
2005	NA	NA	11	1239	1319	NA	NA	14	689	1239
2006	NA	NA	16	2597	1420	NA	NA	11	1240	1110
2007	NA	NA	8	1800	841	NA	NA	11	588	1187
2008	NA	NA	8	1065	1012	NA	NA	18	1927	1145
2009	13	299	55	899	1098	20	164	93	1468	1052
2010	14	741	28	1299	1828	37	201	64	626	819
2011	38	1591	30	2309	1142	61	525	151	1955	791
2012	33	1587	9	1649	1143	51	478	87	1204	824
2013	17	737	10	1253	1516	34	344	73	2060	737
2014	11	202	23	455	242	50	326	137	2139	571
2015			12	158	107	57	203	76	1628	642
2016			6	48	17	103	407	183	1396	271
2017			0	0	6	37	120	126	495	33
2018			0	0	1	23	265	31	163	63
2019			0	0	1	13	73	22	104	76
2020			0	0	2			30	572	133

Table 5. Bss.27.4bc7a d-h: Numbers-at-length in French commercial all-gears fishery landings (input to assessment at lengths 14–94 cm with <20 and >88 size classes empty).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
20	0	0	0	0	0	0	0	0	0	0	717	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63	0	0	0
28	0	0	0	3455	0	0	0	0	0	292	0	0	1219	0	0	291	0	0	0	0	0
30	0	0	1015	13054	14	0	15689	0	0	473	0	0	0	146	0	346	71	0	0	0	0
32	0	0	0	58717	13057	9903	32459	181	8250	2239	9811	1976	1583	0	3076	2678	1481	0	0	0	0
34	9931	17962	12469	105655	78811	29872	179130	4715	28986	10714	28290	13885	6518	1504	3620	5102	1440	137	0	0	0
36	34932	19809	38249	125326	127801	97890	285704	39335	229758	124925	169311	57121	85760	29667	33532	44175	2814	2646	0	0	194
38	85866	68920	46427	180475	124051	128022	217657	102714	263071	211881	177571	87842	172510	88507	68262	75546	4340	2523	91	0	1030
40	126730	76594	62503	119495	227214	231750	178250	146272	266408	225545	182105	128838	140273	149070	74871	93273	7417	3572	814	0	6255
42	102836	98008	82461	145456	282390	266905	196868	145122	237160	193030	283064	187586	147895	146130	82684	115713	24816	9257	2444	2034	16127
44	80478	109595	91064	104545	243107	344681	289998	164011	270810	222613	251956	201447	162333	123170	51365	122460	20422	14861	2954	2198	17867
46	93344	106857	86723	130023	188494	270532	285451	130859	228996	238849	230227	199487	180752	140677	61292	95208	22427	9603	4379	1948	12708
48	80934	77694	62163	115806	126685	239265	263272	100043	142650	155222	188149	194697	158490	127136	39844	59668	20653	7367	2606	635	9921
50	55399	57055	55905	91915	72581	169478	200874	99210	112385	159658	186310	145447	130759	116842	38109	51436	15619	6801	3549	1246	5488
52	52948	51658	46180	93878	82331	115269	119836	75929	74336	114530	109212	124239	107214	99156	29929	37860	10415	4599	2861	345	3890
54	42094	36737	35998	48742	50633	62106	99509	74405	66260	84649	120550	92526	90638	103818	39911	21406	16034	3586	2702	456	2456

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
56	26460	35839	26001	60839	60284	67741	99674	55147	48853	96257	71590	72471	78934	89197	32298	20681	9753	1012	2538	415	1515
58	27357	22762	19019	31614	31334	61132	54522	46087	39689	51578	62211	46869	54869	59004	30016	13591	12328	2519	3581	0	1226
60	23581	25834	14210	33688	19126	43591	45908	28056	29840	36547	31544	31690	35387	65851	21467	11946	7678	913	2008	0	1064
62	14295	18773	11129	30691	23996	35774	23763	23057	28335	57472	19076	19998	33085	64579	16797	11776	7506	1120	1669	373	636
64	18044	13532	16771	18823	14799	25788	20607	18091	14420	24016	62005	17624	17714	53482	16261	9356	4348	1369	1641	0	641
66	10773	11068	11011	13230	10650	12456	14969	8715	12694	21415	26388	14720	15170	37744	8387	6653	2634	510	778	124	333
68	9903	9120	5447	7960	8569	13360	13976	8793	9039	27466	9340	7906	9374	23884	5579	2485	4465	315	463	124	378
70	5709	11771	4795	5374	4880	8908	9653	4835	6821	20198	8541	6114	8114	32512	8995	1163	1353	345	255	0	133
72	5721	5733	4559	5617	2974	8053	4521	2707	4714	12083	29128	2082	4147	14996	3027	660	956	408	47	0	62
74	2345	5345	1825	3275	2675	9811	3424	1962	1623	7551	1884	1163	2313	9001	642	628	219	652	0	0	0
76	2595	2782	1260	1356	2567	5020	2883	1010	1257	979	2114	1096	1540	2640	773	431	0	92	0	0	0
78	2102	1691	357	297	548	2378	731	399	534	1765	182	476	1134	2073	0	9	127	718	0	0	00
80	888	583	155	783	425	1365	201	158	261	264	5525	148	282	176	198	16	0	0	0	0	0
82	1021	296	109	112	149	107	261	37	8	1004	6097	104	451	1566	0	278	0	92	0	0	0
84	548	204	0	148	295	0	30	59	0	0	863	0	29	0	0	0	0	0	0	0	0
86	123	0	0	0	0	0	0	0	0	0	0	0	27	1115	0	0	301	0	0	0	0
88	0	61	0	0	149	0	0	0	0	0	1207	0	0	0	0	0	0	0	0	0	0

Table 6. Bss.27.4bc7ad–h: Numbers-at-age in French commercial fishery landings, 2000–2019, all gears combined (with <2 year old age classes empty). Data from 2009 were corrected in 2020.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
age2	0	0	0	2611	3	0	3138	0	1208	878	0	0	0	0	0	0	0	0	0	0	0
age3	0	2651	8114	10800	4	24195	74600	5307	79917	17292	6830	0	0	0	0	0	0	98	0	0	0
age4	9440	55640	73892	364427	80483	77794	131099	73224	175402	92501	64070	3481	265	0	2300	10607	1850	1065	0	2251	7217
age5	222655	47734	125531	241694	627951	253455	564668	135809	545960	77583	74708	109582	17233	6417	4138	28960	20182	1605	0	2392	17734
age6	273687	298773	90294	318445	438799	735235	361515	460583	401231	49868	135505	152702	216615	16487	36582	39482	18999	6568	735	2391	37642
age7	139562	211740	236147	96562	297961	352182	841651	124606	456312	17981	112579	142896	266517	133787	54484	30417	18589	4507	5490	112	3170
age8	79413	90962	86108	254050	65297	443765	146484	139879	143871	17887	117368	121070	240104	88986	43902	60049	20496	6102	1582	1682	4038
age9	47258	44742	31151	114829	131612	39104	253945	79978	147881	0	57320	264916	222113	109206	41316	27137	14682	3870	1571	454	6130
age10	43924	21074	23025	57883	77533	161572	13655	69214	40719	28366	22351	105282	172833	143048	4541	17343	14879	2085	776	231	4343
age11	49293	39908	17823	26223	25416	69617	132370	33191	57341	1248	10523	58721	82759	103915	1742	5353	10075	1160	2704	386	211
age12	20207	36007	14760	19879	14848	26314	84910	65868	17882	0	10414	24328	35102	47660	202	3804	0	727	70	0	1403
age13	10767	17787	15912	14232	14254	17996	22068	68599	35092	0	7096	18672	21967	18471	178	2650	1423	649	0	0	0
age14	4925	4394	9752	18088	13528	19238	6648	11131	12669	0	7652	4666	8640	16817	121	4485	131	351	306	0	0
age15	4927	6838	3743	6600	7628	17974	6999	9034	5518	0	213	3149	2570	1275	0	0	81	455	0	0	0
age16+	10901	8034	1553	4028	5270	22718	16069	5486	6091	0	2322	410	1374	4149	0	0	0	0	0	0	0

Table 7. Bss.27.4bc7ad–h: Numbers-at-age in the UK (England and Wales) bottom trawl, nets (with <2 year old age classes empty).

	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16+
1985	65	11844	30828	6121	9692	1240	3914	9713	2454	2581	1320	343	841	286	892
1986	0	15673	20303	18759	3453	7662	704	3197	10503	1833	1403	2889	1222	1688	3595
1987	0	439	30263	58458	13753	2095	2437	656	726	5731	2565	1889	761	817	2796
1988	0	1930	20862	54472	41710	12803	1721	2315	780	451	5503	2024	1312	801	2589
1989	33394	5411	1223	7659	43911	26891	9002	3076	2901	1878	2896	8914	1499	1286	3436
1990	0	3035	2503	3770	16047	31459	21020	5042	2186	1463	846	1100	4837	353	2703
1991	1533	6933	36938	2381	1283	6576	18064	16248	7033	589	2617	2321	480	6659	3674
1992	0	15982	55550	33557	1183	796	1956	4750	4762	1230	451	433	139	497	3202
1993	0	657	81429	65981	21858	1351	627	1796	4803	3920	1500	710	735	475	2347
1994	2	1328	30970	369416	41472	16079	1130	294	2282	5842	4387	1596	650	646	3717
1995	0	5599	37064	81529	334815	17932	6931	702	415	1046	3440	3215	1846	2699	2680
1996	191	11473	43831	31632	64618	173733	8235	3622	216	315	454	1881	1688	534	1784
1997	0	2490	8501	64000	45238	39229	145407	8105	4456	632	640	294	2689	1712	2235
1998	0	1103	44997	49461	69489	25366	15136	41057	2671	860	96	96	385	623	811
1999	241	82	80414	146338	43841	28582	9612	6192	18072	1112	729	40	270	97	830
2000	0	9528	2584	151515	72747	11772	11046	4992	4636	8323	818	184	14	55	643
2001	614	11085	92408	29064	105169	25329	7388	8742	5811	8136	7522	804	768	69	759
2002	338	11495	43605	240476	16779	67647	16021	7450	8022	2682	3842	10166	645	193	568

	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16+
2003	0	5698	75254	70415	154267	8719	38901	14072	4789	3196	2260	1599	3937	937	756
2004	0	4406	38270	214112	76652	95133	2733	12227	4039	1583	994	802	263	1029	221
2005	0	18910	135210	89202	124422	33796	30175	3112	7357	1390	1123	363	173	650	842
2006	0	20497	141335	144890	54069	56281	17344	24148	2207	3475	2277	859	210	188	1433
2007	0	955	33606	169272	96625	44423	34061	12877	14366	11530	4527	1621	11	254	428
2008	0	9338	110875	296983	139083	47617	19838	17332	8660	6128	852	793	988	317	824
2009	0	2659	73056	169969	172602	64997	19002	14443	9064	8631	3610	2235	1302	0	249
2010	0	319	77100	155258	118179	78410	28938	11821	6979	6043	2645	2083	2273	534	1663
2011	0	845	28630	124625	92582	71094	54338	31775	10438	11227	6347	2933	2203	675	1692
2012	0	1620	14135	166965	219883	61319	39609	31669	15268	9427	4092	3864	2546	538	930
2013	0	0	45016	60547	182858	117821	33448	30222	22727	17473	11825	2908	2687	2429	2133
2014	0	6622	31923	107001	58412	114826	78809	38859	27037	30548	19853	5152	1776	1857	1487
2015	0	50	3716	20172	45807	36830	63272	35025	17302	12685	10431	2917	7265	7308	966
2016	0	0	1591	7863	13991	31088	24925	40386	24807	10618	8218	4788	1960	2098	1528
2017	0	0	39	454	2176	1179	881	928	852	713	107	257	41	144	236
2018	0	130	4361	18582	26874	18792	9488	6826	4615	6186	5377	1562	1164	960	766
2019	0	105	2168	26492	29521	14508	9155	4501	4944	4192	4556	2635	1331	803	2066
2020	0	1058	4481	16161	85080	29885	12476	5890	3316	3182	2712	2768	2351	1456	1772

Table 8. Bss.27.4bc7ad–h: Numbers-at-age in the UK (England and Wales) lines (with <2 year old age classes empty).

	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16+
1986	0	577	8939	3343	933	2354	358	758	5428	960	871	953	573	645	1307
1987	0	108	1052	3719	2132	581	477	432	523	1578	845	211	167	179	1187
1988	0	33	1751	13389	5067	2398	551	1014	209	456	1863	895	715	523	977
1989	22	0	538	8171	36046	1842	371	104	208	58	215	1040	115	87	334
1990	0	305	82	185	1284	3456	2407	897	357	369	193	242	1261	81	828
1991	0	131	8420	471	177	792	4927	4024	1842	89	1229	1685	367	4831	2887
1992	0	1195	5473	5267	294	269	518	1193	1633	563	130	195	169	143	1411
1993	16	526	11652	11776	7569	590	289	931	3941	3344	1367	663	703	643	3789
1994	0	71	4059	119784	18540	9393	943	173	1754	5414	5570	1205	639	274	2790
1995	0	486	6943	21979	97509	7380	5313	480	699	831	5684	3696	1936	840	4733
1996	0	210	8804	12487	15338	57127	4566	4979	127	510	364	2521	1573	1300	2346
1997	59	454	3102	15613	11415	8287	50819	2853	1635	557	354	243	2195	1065	1570
1998	0	3676	8366	10920	22630	10485	6452	28231	2949	1091	138	196	793	1381	1254
1999	479	255	25158	37306	13589	13697	5288	5001	20522	1669	2038	247	777	315	3314
2000	0	421	294	19380	12402	2696	3285	1476	1248	4697	330	258	16	88	559
2001	54	471	7385	1392	17864	7702	2027	3239	1685	1761	3774	440	301	27	420
2002	30	729	2609	14173	2686	17358	7757	2621	5179	1463	1766	3687	322	101	180
2003	0	80	7166	7917	25014	2167	10164	3262	1473	982	796	681	1704	186	166
2004	0	279	1697	13884	8601	17310	2398	6365	3626	1181	1189	1172	406	2243	143
2005	0	621	2669	5059	14699	5529	6985	589	5697	1845	236	1307	33	189	606
2006	0	44	16121	35990	13714	22306	5794	12717	1644	3135	1258	305	358	1016	734
2007	0	22	6611	31578	28396	14511	17834	8499	10951	5163	3121	5119	85	344	485
2008	0	199	5010	27319	42071	21561	12265	12566	5458	4960	1372	1032	3431	198	992
2009	0	315	8415	19843	33661	25695	12017	9320	5021	5371	4748	811	1075	0	0
2010	0	814	7029	45515	54766	39716	15835	5147	2395	2910	706	522	359	81	277
2011	0	8	5209	11538	24667	19293	16668	13032	4947	6066	2695	1941	2187	522	657
2012	0	91	1695	18362	28593	23507	22946	17909	10199	7725	2994	2672	2158	596	820
2013	0	0	1187	6979	35135	32251	18057	14762	10333	10543	6106	3730	2886	1957	1938
2014	0	980	4985	26081	20743	39548	28357	15323	12440	12413	8018	4889	1976	1673	1322
2015	0	6	1834	5941	23369	22221	31442	19014	10344	8210	7036	2504	3136	744	798
2016	0	0	742	7020	11858	20142	15479	25838	13362	7406	5904	4674	2548	3894	2567
2017	0	0	1734	4007	5766	2324	2362	1036	4159	993	356	469	202	475	330
2018	0	454	6992	23652	41538	31173	17352	16753	11214	14117	9044	4650	3791	2220	3945
2019	0	85	3010	36477	41315	26099	16791	9320	10364	11061	9434	5936	3248	2068	4291
2020	0	431	3437	11667	90256	53606	27720	13526	7890	7117	5823	5194	3678	2127	3184.78

Table 9. Bss.27.4bc7ad–h: Numbers-at-age in the UK (England and Wales) midwater pair trawl fleet (no samples for 1997, 2013-2017, 2019-2020) (with <3 year old age classes empty).

	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15	Age16+
1996	0	289	796	3892	71666	5583	1648	21	334	154	622	485	199	559
1998	0	245	5979	11845	8553	8135	25138	2517	345	93	53	119	893	569
1999	0	2983	18409	15106	27147	13818	18060	43097	4389	1686	324	387	308	2689
2000	15	60	2476	7587	3270	4497	1459	2830	7077	634	174	39	96	420
2001	0	179	899	19777	20290	7042	5268	3124	2845	9666	857	636	123	261
2002	3	37	2380	1578	24087	9693	6297	5978	450	5664	9215	0	0	530
2003	0	2689	10619	39257	7971	40551	10293	3162	3254	618	169	4043	77	281
2004	7	1254	12502	14372	48109	3199	20694	8010	353	1797	1141	91	968	18
2005	0	114	2103	15321	14397	17408	1907	5182	0	1831	99	0	40	599
2006	0	227	567	608	4076	1423	3085	254	176	111	0	0	0	53
2007	0	385	2517	7038	5387	6833	2795	1900	631	807	12	37	19	121
2008	45	445	1540	3279	1787	1412	1557	755	960	30	183	490	0	40
2009	0	90	635	2175	2596	843	784	168	298	173	11	169	0	0
2010	9	36	1741	5546	8261	6678	4755	403	3786	152	294	313	551	50
2011	0	255	4397	10231	13640	15909	13642	4424	4233	2773	1688	1003	264	423
2012	0	391	4461	10776	10016	8757	5789	2741	1134	290	433	143	127	226
2015	0	7	23	85	103	137	30	6	3	0	0	0	0	0
2018	0	0	2	9	5	1	1	0	0	0	0	0	0	0

Table 10. Bss.27.4bc7ad–h: Numbers of trips sampled for discards by Cefas (UK): 2002–2020, by gear group and area.

Division & fleet	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
(a) bottom otter trawls																			
4	16	34	56	37	41	85	58	49	46	42	54	30	53	45	12	0	1	3	
7.afg	8	15	23	8	11	43	50	28	22	22	22	12	14	16	2	0	0	5	
7.d	1	2	4	3	1	2	1	6	7	9	4	5	7	3	13	1	1	7	
7.eh	9	24	37	31	49	90	87	38	29	32	29	45	73	68	29	0	10	18	4
Total	34	75	120	79	102	220	196	121	104	105	109	92	147	132	56	1	12	33	
(b) Fixed/driftnets																			
4	0	0	2	1	11	31	15	20	15	11	13	18	10	7	0	0	0	0	
7.afg	3	7	5	3	7	8	9	10	7	16	22	16	25	12	3	0	0	0	
7.d	0	0	1	0	0	17	6	4	1	7	10	42	25	17	10	0	0	16	
7.eh	1	5	9	2	3	16	10	14	19	17	25	24	24	15	0	0	0	0	
Total	4	12	17	6	21	72	40	48	42	51	70	100	84	51	13	0	0	16	
(c) Lines																			
4	0	1	0	0	0	1	2	0	0	0	0	0	1	1	0	0	0	0	
7.afg	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	
7.d	0	0	0	0	0	0	0	0	0	0	0	0	1	0	33	2	0	0	
7.eh	0	0	1	0	0	0	0	0	0	0	1	0	8	5	4	0	0	0	
Total	0	1	1	0	0	1	2	0	0	0	2	1	10	6	37	2	0	0	

Division & fleet	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
(d) Midwater trawls																			
4	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7.afg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7.d	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7.eh	0	1	1	1	2	1	0	0	0	0	0	2	1	0	0	0	0	0	
Total	1	1	1	3	2	1	0	0	0	0	0	2		0	0	0	0	0	
(e) Other gears																			
4	8	5	10	1	2	1	1	7	6	8	4	10		0	6	0	0	0	
7.afg	4	11	8	4	9	1	2	3	3	1	4	8		0	5	0	0	0	
7.d	0	1	5	2	3	1	1	2	4	1	2	3	1	2	0	0	0	0	
7.eh	10	17	27	16	24	32	18	13	17	27	22	21	14	15	1	0	0	0	
Total	22	34	50	23	38	35	22	25	30	37	32	42	15	17	12	0	0	0	

Table 11. Bss.27.4bc7ad–h: Estimated annual numbers and weight of seabass retained and discarded by UK using fixed or driftnets, otter trawl, beam trawl and lines fleets in areas 4, 7.d, 7.eh and 7.afg, based on at-sea sampling, and raised from landings in sampled strata to landings in all strata. Numbers of sampled trips (Ntrip) are shown.

	Otter trawl				Nets				Beam trawl				Lines				Total OTB, nets, lines and BTS		
	discards	retained	rate (%)	Nti-rip	discards	retained	rate %	Nti-rip	discards	retained	rate %	Nti-rip	discards	retained	rate (%)	Nti-rip	discards	retained	rate%
2002	17	161	9	34	0	201	0	4	0.2	24	0.7	-	-	-	-	-	17	386	4
2003	16	207	7	75	0	146	0	12	1.9	21	8.1	-	-	-	-	-	18	374	5
2004	59	173	25	120	0	207	0	17	0.3	24	1.3	-	-	-	-	-	59	404	13
2005	6	181	3	79	90	172	34	6	2.4	15	13.7	-	-	-	-	-	99	368	21
2006	34	160	17	102	19	199	9	21	0.4	14	2.5	-	-	-	-	-	53	373	12
2007	49	173	22	220	1	239	0.4	72	0.0	19	0.0	-	-	-	-	-	50	432	10
2008	5	196	3	196	3	318	0.9	40	1.2	21	5.6	-	-	-	-	-	9	535	2
2009	85	175	33	121	0	311	0.1	48	0.2	10	1.5	-	-	-	-	-	86	495	15
2010	49	150	25	104	1	302	0.3	42	1.2	6	17.1	-	-	-	-	-	51	458	10
2011	8	137	6	105	14	324	4.2	51	0.0	5	0.0	-	-	-	-	-	22	467	5
2012	27	157	15	109	2	407	0.5	70	0.0	5	0.0	-	-	-	-	-	29	569	5
2013	4	125	3	92	2	405	0.4	100	1.1	4	20.1	-	-	-	-	-	6	534	1
2014	1	104	1	147	6	647	0.9	84	0.0	8	0.0	-	-	-	-	-	7	758	1
2015	6	77	7	132	1	340	0.4	51	0.0	8	0.0	-	-	-	-	-	7	425	2
2016	35	52	40	56	8	252	3	13	0.1	23	0.0		8.4	210.0	4.0	37.0	52	537	9
2017*	0	35	1	1	-	74	-	0	-	16	-	0	11	147	7	2		272	-
2018*	11	13	46	5	-	132	-	0	15	13	54	7	-	267	-	0	26	425	6
2019*	83	15	85	3	6	120	5		0.1	12	1		0	258	0		89	410	18
2020*	12	27	44	1	0	163	0	3	13	15	87	0	0	306	0	0	25	522	5

***Not used in assessment (lack of information. High probability of underestimation considering management measures).**

Table 12. Bss.27.4bc7ad–h: Number of fishing trips sampled for retained and discarded weight of seabass on French vessels using different gear types: 2009–2020. (Data are clearly underestimated from 2015 and are not used in assessment).

pelagic trawl FR	discards (t)	Landings (t)	discard rates	cv indicator	Nb trip sampled	Nb fish sampled
2003	0	773	0.00%	NA		
2004	0	820	0.00%	NA		
2005	0	1319	0.00%	NA		
2006	0	1420	0.00%	NA		
2007	0	841	0.00%	NA	12	2
2008	2	1012	0.20%	3.93	21	4
2009	21.2	1098	1.89%	0.05		
2010	7.4	1828	0.40%	0.71	35	106
2011	7.2	1142	0.63%	0.12	9	46
2012	0.9	1143	0.08%	2.38	7	29
2013	0.3	1516	0.02%	2		
2014	0	242	0.00%	NA		
2015	11.7	107	9.86%	0.03	32	5
2016*	0.5	17.43081	2.79%	NA	19	2
2017*		6		NA	0	0
2018*	0.2	1	17%		28	1
2019*		1				
2020*	-	2	-	-	0	0
bottom trawlFR	**discards (t)**	**Landings (t)**	**discard rates**	**cv indicator**	**Nb trip sampled**	**Nb fish sampled**
2003	73.8	1087	6.36%	0.35	18	26
2004		1236	NA	NA	24	3
2005	43.9	1239	3.42%	0.9		
2006	42.9	1110	3.72%	1.07	24	36
2007	9.6	1187	0.80%	0.73		
2008	40.7	1145	3.43%	0.94	57	63
2009		1052	NA	NA	143	102
2010	76.6	819	8.55%	0.32	137	5
2011	27.2	791	3.32%	0.46	122	57
2012	24.5	824	2.89%	0.23	151	118
2013	26.3	737	3.45%	0.37	139	145
2014		571	NA	NA	133	29
2015	35.4	642	5.23%	0.49	189	356
2016*	126.9	271	31.86%	NA	512	90
2017*	156	178	47%	NA	61	141
2018*	32	72	31%		217	71
2019*	76	76	100%		9	31
2020*	3	133	2%	-	4	4

netsFR	discards (t)	Landings (t)	discard rates	cv indicator	Nb trip sampled	Nb fish sampled
2003	31.7	152	17.26%	1.2		
2004	77.6	150	34.09%	0.1		
2005	0	148	0.00%	NA		
2006	125.5	140	47.27%	0.34		
2007	2.2	158	1.37%	0.61	32	2
2008	0.5	128	0.39%	0.79		
2009	6.4	94	6.37%	0.41	196	3
2010	6.1	160	3.67%	0.29	108	5
2011	9	129	6.52%	0.35		
2012	11.8	142	7.67%	0.55	269	9
2013	21.6	126	14.63%	0.18	173	2
2014	21.7	163	11.75%	0.11	118	3
2015	14.7	109	11.88%	0.2	217	8
2016*	19.4	64	23.25%	NA	258	209
2017*	0.7	34	2%	NA	0	0
2018*	2	74	3%		101	17
2019*	3	70	4%			
2020*	-	78	-	-	12	0

linesFR	discards (t)	Landings (t)	discard rates	cv indicator	Nb trip sampled	Nb fish sampled
2003	0	438	0.00%	NA		
2004	0	381	0.00%	NA		
2005	0	439	0.00%	NA		
2006	0	554	0.00%	NA		
2007	0	560	0.00%	NA		
2008	100.3	425	19.09%	0.35		
2009	5.6	251	2.18%	0.71	17	21
2010	3.9	278	1.38%	1.24		
2011	13.1	359	3.52%	0.35		
2012	15.8	295	5.08%	0.26		
2013	14.2	291	4.65%	0.45		
2014	15.8	285	5.25%	0.4		
2015	7.4	210	3.40%	0.32	28	21
2016*		156		NA		
2017*		166		NA	0	0
2018*		151			0	0
2019*		139				
2020*	-	164	-	-	0	0

OtherFR	discards (t)	Landings (t)	discard rates	cv indicator	Nb trip sampled	Nb fish sampled
2003	0	23	0.00%	NA		
2004	6.6	17	27.97%	NA		
2005	0	17	0.00%	NA		
2006	0	35	0.00%	NA		
2007	0	24	0.00%	NA		
2008	0	40	NA	NA		
2009	0	127	NA	NA		
2010	0	90	0.00%	NA		
2011	44.8	62	41.95%	5.97		
2012	1.1	91	1.19%	0.25	6	9
2013	0	82	0.00%	NA		
2014	0	25	0.00%	NA	130	96
2015	11	11	50.00%	0.58		
2016*	5.9	19.82406	22.94%	NA	64	9
2017*	5	58	8%	NA	0	0
2018*		15			0	0
2019*		43				
2020*	-	20	-	-	-	-

FR_ALL	discards (t)	Landings (t)	discard rates	cv indicator	Nb trip sampled	Nb fish sampled
2003	105.5	2473	4%		18	26
2004	84.2	2604	3%		24	3
2005	43.9	3162	1%		0	0
2006	168.4	3259	5%		24	36
2007	11.8	2770	0%		44	4
2008	143.5	2750	5%		78	67
2009^	33.2	2622	1%		356	126
2010^	94	3175	3%		280	116
2011^	101.3	2483	4%	7.25	131	103
2012^	54.1	2495	2%	3.67	433	165
2013^	62.4	2752	2%		312	147
2014^	37.5	1286	3%		381	128
2015^	80.2	1079	7%	1.62	466	390
2016*	152.7	529	22%		853	310
2017*	161.7	442	27%		61	141
2018*	34.2	313	10%			
2019*	79.2	329	19%		9	31
2016**	155.6	*529*	23%			
2017**	270.9	*442*	38%			
2018**	456.4	*313*	59%			
2019**	374.6	*329*	53%			
2020*	313	*409*	43%			

^ included in the assessment (source onboard sampling programme)

*** not included in the assessment (source onboard sampling programme)**

**** included in the assessment (source logbook data).**

Table 13. Bss.27.4bc7ad–h: Values of expected recreational F reductions associated with management measures applied to bss.27.4bc7ad–h since 2015. Frec multiplier represents the recreational F relative to 2012. Note that the emergency measures were implemented part way through 2015, so the reduction was applied for half the year.

Year	Management scenario			Frec Multiplier
	MCRS	Bag limit	Open season	
Pre-2015	36 cm	none	All year	1.000
2015 Jan-Jun	36 cm	none	All year	0.821
2015 Jul -Dec	42 cm	three fish		
2016 & 2017	42 cm	one fish	6 months	0.282
2018	42 cm	one fish	3 months	0.191
2019	42 cm	one fish	7 months	0.312
2020	42 cm	two fish	9 months	0.464
2021	To be confirmed			

Table 14. Bss.27.4bc7ad–h: Time-series of Cefas Solent autumn survey of juvenile seabass. Indices were revised in 2020 and updated in the assessment. A change in trawl design took place in 1993, and calibration factors are applied.

Year	Solent Index prior to 2020 revision	2020 Solent Index
1986	5.84	5.84
1987	2.6	2.6
1989	7.05	7.05
1990	3.98	3.98
1991	3.32	3.32
1992	19.7	19.7
1993	14.63	14.63
1994	5.46	6.69
1995	10.24	10.53
1996	6.06	6.35
1997	38.2	40.4
1998	7.34	7.22
1999	20.91	19.02
2000	17.46	17.8
2001	39.91	42.69
2002	11.7	13.95
2003	13.55	14.18
2005	21.93	23.46
2006	19.73	19.76
2007	5.5	5.5
2008	25.52	25.52
2009	19.83	19.83
2011	4.05	4.05
2013	1.52	1.56
2014	1.4	1.45
2015	7.44	7.45
2016	6.03	6.2
2017	3.54	3.54
2018	2.66	2.66
2019		1.95
2020		4.92

Table 15. Bss.27.4bc7ad–h: Numbers-at-age in Solent survey 1986–2020: updated time-series of Cefas Solent autumn survey of juvenile seabass (2020 revised).

Year	Age 2	Age 3	Age 4
1986	0.27	4.26	1.31
1987	0.05	0.28	2.27
1989	6.68	0.37	0.00
1990	2.81	1.15	0.02
1991	3.08	0.21	0.03
1992	0.95	18.59	0.16
1993	6.65	3.59	4.39
1994	3.67	2.69	0.34
1995	4.19	5.88	0.46
1996	5.86	0.38	0.12
1997	33.78	6.54	0.08
1998	1.23	5.41	0.58
1999	17.62	0.59	0.82
2000	5.91	11.86	0.03
2001	36.70	4.21	1.77
2002	7.07	6.56	0.31
2003	8.51	5.07	0.60
2005	14.21	8.37	0.88
2006	9.53	9.21	1.02
2007	3.42	1.78	0.30
2008	18.52	6.66	0.34
2009	13.19	6.31	0.32
2011	2.25	1.39	0.41
2013	1.38	0.08	0.10
2014	0.76	0.67	0.02
2015	6.95	0.44	0.05
2016	3.86	2.24	0.11
2017	0.86	2.56	0.12
2018	2.17	0.32	0.18
2019	0.57	1.36	0.02
2020	0.39	0.87	0.20

Table 16. Bss.27.4bc7ad–h: Seabass indices of abundance 2000–2014 (swept area) from the Channel Groundfish Survey. The relative standard error CV is the log-transformed value used in SS3 (sqrt(loge (1+CV^2)).

year	Total hauls	No. hauls with seabass	Percentage of hauls with seabass	Mean no. seabass per positive haul	Swept-area abundance index	CV
1988	68	6	9	2	245776	0.15
1989	61	3	5	1	77716	0.58
1990	75	8	11	8	1129914	0.12
1991	79	19	24	9	4250636	0.03
1992	60	23	38	13	2617986	0.11
1993	65	21	32	8	2299919	0.10
1994	86	19	22	5	1097828	0.11
1995	166	17	10	5	1021741	0.09
1996	134	26	19	3	1224238	0.13
1997	169	31	18	6	1817599	0.12
1998	82	38	46	8	2531043	0.08
1999	102	37	36	8	1642271	0.12
2000	100	36	36	9	2570994	0.08
2001	109	39	36	9	3150674	0.14
2002	100	44	44	12	3872427	0.11
2003	94	41	44	20	8739056	0.11
2004	94	44	47	8	3598436	0.10
2005	105	40	38	7	3005315	0.08
2006	110	36	33	14	5518000	0.12
2007	103	33	32	8	3661314	0.14
2008	105	40	38	10	6468839	0.15
2009	102	26	26	7	2564694	0.09
2010	101	30	30	4	1804538	0.10
2011	108	27	25	4	1513742	0.12
2012	96	25	26	5	2034552	0.11
2013	96	19	20	4	995987	0.13
2014	98	20	20	3	669931	0.13

Table 17. Bss.27.4bc7ad–h: Commercial lpue index for French fleet updated for the 2021 assessment.

Year	Index	+- SE
2001	0.920	0.128
2002	0.966	0.103
2003	0.948	0.135
2004	0.929	0.091
2005	1.019	0.080
2006	1.023	0.086
2007	1.104	0.084
2008	1.083	0.097
2009	1.000	0.055
2010	0.927	0.049
2011	0.812	0.048
2012	0.748	0.061
2013	0.742	0.066
2014	0.620	0.055
2015	0.625	0.064
2016	0.518	0.051
2017	0.491	0.053
2018	0.516	0.083
2019	0.688	0.113
2020	0.749	0.118

Table 18. Bss.27.4bc7ad–h: Key model assumptions and parameters from the WGCSE 2021 update assessment.

Characteristic	Settings
Starting year	1985
Ending year	Assessment year-1 (2020)
Equilibrium commercial catch for starting year	0.82* landings in 1985 by fleet.
Equilibrium recreational catch for starting year	Constant F estimated using 2012 survey results 1985–2014; 2015–present Frec multiplier on F 2012 survey results
Number of areas	1
Number of seasons	1
Number of fishing fleets	6
Number of surveys	2: CGFS; Solent autumn survey.
Number of commercial tunning fleets	1
Individual growth	von Bertalanffy, parameters fixed, combined sex
Number of active parameters	113
Population characteristics	
Maximum age	30
Genders	1
Population length bins	4–100, 2 cm bins
Ages for summary total biomass	0–30
Data characteristics	
Data length bins (for length structured fleets)	6–94, 2 cm bins
Data age bins (for age structured fleets)	0–16+
Minimum age for growth model	2
Maximum age for growth model	30
Maturity	Logistic 2-parameter – females; L50 = 40.65 cm
Fishery characteristics	
Fishery timing	-1 (whole year)
Fishing mortality method	Hybrid
Maximum F	2.9
Fleet 1: UK Trawl/nets selectivity	Double normal, length-based
Fleet 2: UK Line selectivity	Asymptotic, length-based
Fleet 3: UK Midwater trawl selectivity	Asymptotic, length-based
Fleet 4: Combined French fleet selectivity	Asymptotic 1985–2014, Double normal 2015–present, length-based
Fleet 5: Other fleets/gears selectivity	Mirrors French fleet
Fleet 6: Rrecreational fishery	Double normal, length-based
Blocks: Selectivity and Retention	Fleets 1, 2, 4, 5 and 6 2015 to present
Survey characteristics	
Solent autumn survey timing (yr)	0.83

Characteristic	Settings
CGFS survey timing (yr)	0.75
French LPUE timing (yr)	-1
Catchabilities (all surveys)	Analytical solution
Survey selectivities: Solent autumn:	Double normal, length-based constrained by Min-Max age selectivity, age-based
Survey selectivities: CGFS	Double normal, length-based
Tunning fleet: French LPUE	Mirrors French fleet
Fixed biological characteristics	
Natural mortality	0.24
Beverton–Holt steepness	0.999
Recruitment variability (σR)	0.9
Weight–length coefficient	0.00001296
Weight–length exponent	2.969
Maturity inflection (L50%)	40.649 cm
Maturity slope	-0.33349
Length-at-age Amin	19.6 cm at Amin=2
Length-at-Amax	80.26 cm
von Bertalanffy k	0.09699
von Bertalanffy Linf	84.55 cm
von Bertalanffy t0	-0.730 yr
Std. Deviation length-at-age (cm)	SD = 0.1166 * age + 3.5609
Age error matrix	CV 12% at-age
Other model settings	
First year for main recruitment deviations	1955
Last year for recruit deviations	2017
Last year no bias adjustment	1973.3
First year full bias adjustment	1982.1
Last year full bias adjustment	2017.9
First year recent year no bias adjustment	2018.6
Maximum bias adjustment	0.915

Table 19. Bss.27.4bc7ad–h: Final seabass update assessment: model estimated stock numbers-at-age (thousands of fish).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
1985	858	1205	21968	8040	4910	1609	1459	1222	1678	4087	1438	906	681	518	378	263	578
1986	2507	675	946	17176	6217	3724	1191	1056	869	1180	2858	1003	631	474	361	264	586
1987	21261	1972	530	739	13239	4687	2730	850	738	599	808	1949	683	429	323	246	578
1988	17341	16725	1547	413	566	9863	3372	1899	575	490	393	527	1267	443	279	209	535
1989	91288	13641	13132	1208	318	425	7198	2393	1319	394	333	266	356	856	300	188	504
1990	7457	71809	10711	10249	929	239	310	5100	1660	902	268	225	180	241	579	202	468
1991	15422	5866	56382	8359	7885	698	174	219	3530	1133	611	181	152	121	162	390	453
1992	22821	12131	4604	43948	6409	5877	502	121	149	2361	751	403	119	100	80	107	556
1993	8729	17952	9520	3587	33697	4782	4237	350	82	100	1561	494	265	78	66	52	435
1994	33723	6867	14091	7423	2754	25193	3458	2969	239	55	66	1036	327	175	52	43	323
1995	50200	26528	5392	11000	5710	2064	18276	2437	2050	163	38	45	700	221	118	35	249
1996	3153	39488	20827	4206	8443	4259	1486	12756	1663	1380	109	25	30	466	147	79	190
1997	57980	2480	30966	16184	3202	6209	2997	1002	8317	1060	867	68	16	19	289	91	167
1998	17301	45609	1946	24085	12345	2362	4391	2037	661	5370	676	550	43	10	12	183	164
1999	56876	13609	35780	1514	18398	9134	1678	2999	1349	429	3444	431	349	27	6	7	221
2000	24520	44741	10675	27830	1155	13579	6452	1135	1960	862	271	2159	269	218	17	4	143
2001	27540	19288	35095	8305	21253	855	9663	4419	754	1275	554	173	1374	171	139	11	93
2002	43463	21664	15131	27306	6344	15734	608	6615	2934	490	819	354	110	874	109	88	66
2003	44286	34189	16996	11775	20860	4695	11191	417	4395	1911	316	525	226	70	558	70	99
2004	33890	34837	26806	13199	8953	15306	3294	7511	270	2777	1190	195	323	139	43	343	104

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
2005	22741	26659	27310	20808	10026	6556	10704	2201	4839	169	1718	730	119	197	85	26	273
2006	24432	17889	20884	21152	15725	7274	4520	7016	1384	2953	102	1019	431	70	116	50	176
2007	28175	19219	14014	16172	15977	11394	5003	2956	4401	843	1765	60	599	253	41	68	133
2008	14730	22164	15061	10865	12247	11625	7886	3300	1875	2718	512	1062	36	359	151	25	120
2009	12940	11587	17370	11678	8225	8901	8035	5197	2094	1159	1654	309	638	22	215	91	87
2010	2514	10179	9082	13474	8850	5992	6177	5325	3321	1305	711	1006	187	386	13	130	108
2011	10481	1978	7973	7028	10155	6378	4084	3989	3293	1992	768	414	583	108	223	8	138
2012	4586	8245	1550	6178	5313	7358	4384	2668	2503	2010	1196	457	245	345	64	132	87
2013	16354	3608	6458	1199	4649	3812	4979	2809	1638	1493	1177	694	264	142	199	37	127
2014	27691	12864	2824	4984	896	3291	2524	3097	1663	937	835	651	382	145	78	110	91
2015	5337	21782	10085	2188	3750	640	2209	1610	1909	1003	559	496	387	227	87	47	121
2016	20925	4198	17125	7894	1677	2724	431	1399	989	1161	610	341	304	238	141	54	105
2017	5458	16460	3302	13439	6124	1261	1952	296	939	660	775	408	229	205	161	95	108
2018	17019	4294	12945	2591	10434	4621	914	1370	204	646	454	534	282	158	142	112	142
2019	21601	13387	3377	10167	2020	7968	3411	652	960	142	450	317	373	197	111	100	179
2020	21588	16992	10529	2651	7918	1541	5883	2441	459	672	100	315	222	262	139	78	197
2021	21590	16982	13362	8262	2063	6029	1134	4184	1703	318	465	69	219	154	183	97	192

Table 20. Bss.27.4bc7ad–h: Final seabass update assessment: model estimated fishing mortality-at-age.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
1985	0.000	0.001	0.006	0.017	0.036	0.061	0.084	0.101	0.112	0.118	0.120	0.122	0.122	0.122	0.122	0.122	0.122
1986	0.000	0.002	0.007	0.020	0.043	0.070	0.097	0.118	0.131	0.139	0.143	0.144	0.145	0.145	0.145	0.145	0.145
1987	0.000	0.003	0.010	0.027	0.054	0.089	0.123	0.151	0.170	0.181	0.188	0.191	0.192	0.192	0.192	0.192	0.192
1988	0.000	0.002	0.008	0.022	0.045	0.075	0.103	0.125	0.138	0.146	0.150	0.151	0.152	0.152	0.152	0.151	0.151
1989	0.000	0.002	0.008	0.022	0.046	0.076	0.104	0.126	0.139	0.147	0.151	0.152	0.152	0.152	0.152	0.151	0.151
1990	0.000	0.002	0.008	0.022	0.047	0.077	0.106	0.128	0.142	0.149	0.153	0.154	0.155	0.154	0.154	0.154	0.153
1991	0.000	0.002	0.009	0.026	0.054	0.089	0.122	0.147	0.163	0.171	0.176	0.178	0.178	0.178	0.177	0.176	0.176
1992	0.000	0.002	0.009	0.026	0.053	0.087	0.120	0.146	0.163	0.173	0.179	0.181	0.182	0.182	0.182	0.182	0.181
1993	0.000	0.002	0.009	0.024	0.051	0.084	0.116	0.140	0.156	0.166	0.170	0.173	0.173	0.173	0.173	0.173	0.173
1994	0.000	0.002	0.008	0.022	0.049	0.081	0.110	0.130	0.142	0.149	0.151	0.152	0.152	0.151	0.150	0.150	0.149
1995	0.000	0.002	0.009	0.025	0.053	0.088	0.120	0.142	0.156	0.163	0.167	0.168	0.167	0.167	0.166	0.165	0.164
1996	0.000	0.003	0.012	0.033	0.067	0.111	0.154	0.188	0.211	0.224	0.232	0.235	0.236	0.236	0.236	0.236	0.235
1997	0.000	0.003	0.011	0.031	0.064	0.106	0.146	0.177	0.197	0.209	0.216	0.218	0.219	0.219	0.218	0.217	0.217
1998	0.000	0.003	0.011	0.029	0.061	0.102	0.141	0.172	0.192	0.204	0.210	0.213	0.214	0.214	0.214	0.213	0.213
1999	0.000	0.003	0.011	0.030	0.064	0.108	0.151	0.186	0.208	0.220	0.227	0.230	0.231	0.231	0.231	0.230	0.230
2000	0.000	0.003	0.011	0.030	0.061	0.100	0.139	0.169	0.190	0.202	0.209	0.212	0.213	0.213	0.213	0.212	0.212
2001	0.000	0.003	0.011	0.029	0.061	0.100	0.139	0.170	0.190	0.202	0.209	0.212	0.213	0.213	0.213	0.212	0.212
2002	0.000	0.003	0.011	0.029	0.061	0.101	0.139	0.169	0.189	0.200	0.206	0.208	0.209	0.209	0.208	0.208	0.207

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
2003	0.000	0.003	0.013	0.034	0.070	0.114	0.159	0.194	0.219	0.234	0.242	0.245	0.247	0.247	0.247	0.246	0.246
2004	0.000	0.003	0.013	0.035	0.072	0.118	0.163	0.200	0.225	0.240	0.248	0.252	0.254	0.254	0.253	0.253	0.252
2005	0.000	0.004	0.016	0.040	0.081	0.132	0.182	0.224	0.254	0.272	0.283	0.288	0.290	0.291	0.290	0.290	0.289
2006	0.000	0.004	0.016	0.041	0.082	0.134	0.185	0.226	0.256	0.275	0.285	0.290	0.292	0.293	0.293	0.292	0.292
2007	0.000	0.004	0.014	0.038	0.078	0.128	0.176	0.215	0.242	0.259	0.268	0.272	0.274	0.274	0.273	0.273	0.272
2008	0.000	0.004	0.014	0.038	0.079	0.129	0.177	0.215	0.241	0.257	0.266	0.270	0.271	0.271	0.270	0.269	0.269
2009	0.000	0.004	0.014	0.037	0.077	0.125	0.171	0.208	0.233	0.249	0.257	0.260	0.262	0.261	0.261	0.260	0.259
2010	0.000	0.004	0.016	0.043	0.088	0.143	0.197	0.241	0.271	0.290	0.301	0.306	0.307	0.308	0.307	0.307	0.306
2011	0.000	0.004	0.015	0.040	0.082	0.135	0.186	0.226	0.253	0.270	0.279	0.283	0.284	0.284	0.284	0.283	0.282
2012	0.000	0.004	0.016	0.044	0.092	0.151	0.205	0.248	0.277	0.295	0.304	0.308	0.309	0.309	0.307	0.306	0.305
2013	0.000	0.005	0.019	0.051	0.105	0.172	0.235	0.284	0.319	0.340	0.352	0.357	0.358	0.358	0.357	0.355	0.354
2014	0.000	0.003	0.015	0.044	0.097	0.159	0.209	0.244	0.265	0.276	0.280	0.280	0.278	0.275	0.272	0.269	0.267
2015	0.000	0.001	0.005	0.026	0.080	0.155	0.217	0.247	0.257	0.257	0.254	0.250	0.246	0.242	0.238	0.234	0.230
2016	0.000	0.000	0.002	0.014	0.045	0.093	0.137	0.159	0.165	0.165	0.162	0.159	0.156	0.152	0.149	0.146	0.144
2017	0.000	0.000	0.002	0.013	0.042	0.081	0.114	0.129	0.134	0.134	0.133	0.131	0.129	0.127	0.125	0.124	0.122
2018	0.000	0.000	0.002	0.009	0.030	0.063	0.098	0.116	0.121	0.122	0.120	0.119	0.117	0.115	0.113	0.111	0.109
2019	0.000	0.000	0.002	0.010	0.031	0.063	0.095	0.112	0.117	0.117	0.116	0.115	0.114	0.112	0.111	0.109	0.108
2020	0.000	0.000	0.002	0.011	0.033	0.067	0.101	0.120	0.126	0.127	0.126	0.124	0.123	0.121	0.120	0.118	0.117

Table 21. Bss.27.4bc7ad–h: Final seabass update assessment: stock summary table.

Year	Low	Recruitment (Age 0, thousands)	High	Low	SSB (Tonnes)	High	Low	F(4-15)	High	$F_{commercial}$	$F_{recreational}$	Commercial landings	Commercial discards*	Recreational removals
1985	74	858	1643	17307	23458	29609	0.075	0.103	0.132	0.040	0.063	994		1771
1986	438	2507	4576	15118	20630	26142	0.088	0.122	0.156	0.059	0.063	1318		1597
1987	14961	21261	27562	13519	18446	23373	0.115	0.160	0.204	0.098	0.062	1979		1457
1988	9894	17341	24788	12335	16791	21247	0.093	0.128	0.163	0.066	0.062	1239		1353
1989	76474	91288	106101	11993	16164	20334	0.094	0.129	0.165	0.067	0.062	1161		1253
1990	2283	7457	12630	10870	14828	18785	0.093	0.131	0.169	0.069	0.062	1064		1129
1991	9269	15422	21575	9305	13002	16699	0.106	0.151	0.195	0.089	0.062	1226		1037
1992	15647	22821	29996	8027	11422	14816	0.108	0.153	0.197	0.091	0.062	1186		1061
1993	4101	8729	13357	8682	11825	14969	0.109	0.146	0.183	0.084	0.062	1256		1235
1994	23998	33723	43448	11473	14494	17514	0.102	0.131	0.159	0.068	0.062	1370		1481
1995	39118	50200	61281	15078	18234	21390	0.115	0.143	0.172	0.081	0.062	1835		1661
1996	455	3153	5851	16835	20206	23578	0.157	0.197	0.24	0.136	0.061	3022		1673
1997	45556	57980	70404	15945	19368	22791	0.146	0.184	0.22	0.122	0.062	2620		1588
1998	8016	17301	26585	14747	18117	21486	0.141	0.179	0.22	0.118	0.062	2390		1534
1999	43408	56876	70344	14215	17487	20759	0.152	0.193	0.23	0.131	0.062	2670		1536
2000	15250	24520	33791	14359	17574	20788	0.140	0.178	0.22	0.116	0.062	2407		1590
2001	15469	27540	39611	15270	18559	21848	0.140	0.178	0.22	0.116	0.062	2500		1675
2002	28607	43463	58319	16044	19420	22796	0.139	0.175	0.21	0.114	0.062	2622	17	1771
2003	31478	44286	57095	17162	20640	24117	0.162	0.21	0.25	0.144	0.061	3459	16	1852
2004	23080	33890	44699	17837	21395	24954	0.166	0.21	0.26	0.150	0.061	3731	59	1896
2005	14860	22741	30623	18282	21910	25537	0.188	0.24	0.29	0.179	0.061	4430	96	1892
2006	16864	24432	31999	17744	21418	25092	0.189	0.24	0.30	0.181	0.061	4377	53	1860
2007	19335	28175	37016	17288	20929	24571	0.178	0.23	0.28	0.166	0.061	4064	50	1855

Year	Low	Recruitment (Age 0, thousands)	High	Low	SSB (Tonnes)	High	Low	F(4-15)	High	$F_{commercial}$	$F_{recreational}$	Commercial landings	Commercial discards*	Recreational removals
2008	7991	14730	21468	17625	21185	24746	0.178	0.23	0.27	0.165	0.061	4107	8	1862
2009	8123	12940	17757	17968	21444	24920	0.173	0.22	0.26	0.158	0.061	3889	151.2	1836
2010	331	2514	4697	17803	21172	24541	0.20	0.26	0.31	0.194	0.061	4562	147.9	1739
2011	6868	10481	14095	16381	19566	22752	0.189	0.24	0.29	0.176	0.061	3858	22	1598
2012	2221	4586	6952	15131	18100	21069	0.21	0.26	0.31	0.198	0.061	3987	156.6	1440
2013	9951	16354	22756	13390	16176	18963	0.23	0.30	0.37	0.24	0.061	4137	53.4	1229
2014	17495	27691	37887	10810	13483	16156	0.184	0.24	0.30	0.181	0.061	2682	24.7	1021
2015	1642	5337	9032	8786	11408	14031	0.165	0.22	0.28	0.170	0.053	2066	39.5	703
2016	8355	20925	33494	6908	9496	12084	0.099	0.141	0.182	0.123	0.0178	1295	198.6	215
2017	1270	5458	9647	6120	8709	11298	0.080	0.117	0.153	0.099	0.0183	984	271.102	212
2018	2682	17019	31355	6020	8720	11420	0.070	0.104	0.137	0.092	0.0120	948	482.4	153
2019		9696**		6546	9543	12540	0.068	0.101	0.134	0.081	0.020	972	463.9	277
2020		9696**		7313	10773	14232	0.071	0.109	0.146	0.079	0.030	1042	325	447
2021		9696**		7717	11619	15522								

***Partial discards, discard data are not available for all fleets in some years.**

****Geometric mean recruitment 2009–2018.**

Table 22. Bss.27.4bc7ad–h: Inputs for short-term forecast. Fishing mortality is the estimates for 2020. Numbers-at-ages 0–2 in 2020 are adjusted by replacing Stock Synthesis values for 0-group in 2018–2019 (years with no recruit deviations estimated) with the long-term GM, adjusted for natural mortality.

age	Stock numbers 2021	weight in stock	Proportion mature (female)	H.Cons retained mean F (2019)	H.Cons Discarded mean F (2019)	H.Cons retained mean weights	H.Cons discarded mean weights	H.Cons proportion retained	Recreational F	Recreational removals mean weight	M
0	**9696**	0.003	0.000	0.000	0.000	0.000	0.000	-	0.000	0.020	0.24
1	**7627**	0.024	0.000	0.000	0.000	0.119	0.119	0.207	0.000	0.079	0.24
2	**5998**	0.097	0.000	0.000	0.000	0.238	0.238	0.209	0.001	0.191	0.24
3	**8262**	0.210	0.000	0.001	0.004	0.386	0.387	0.230	0.005	0.342	0.24
4	**2063**	0.370	0.093	0.007	0.013	0.582	0.562	0.349	0.010	0.532	0.24
5	**6029**	0.571	0.298	0.029	0.018	0.804	0.753	0.621	0.018	0.753	0.24
6	**1134**	0.808	0.579	0.061	0.011	1.010	0.968	0.845	0.025	0.995	0.24
7	**4184**	1.073	0.797	0.081	0.005	1.242	1.221	0.947	0.030	1.254	0.24
8	**1703**	1.359	0.914	0.087	0.002	1.511	1.506	0.983	0.032	1.530	0.24
9	**318**	1.658	0.965	0.088	0.000	1.805	1.806	0.995	0.033	1.822	0.24
10	**465**	1.966	0.985	0.087	0.000	2.107	2.113	0.998	0.034	2.125	0.24
11	**69**	2.276	0.993	0.086	0.000	2.411	2.420	0.999	0.034	2.433	0.24
12	**219**	2.585	0.997	0.084	0.000	2.711	2.723	1.000	0.034	2.738	0.24
13	**154**	2.888	0.998	0.082	0.000	3.004	3.018	1.000	0.034	3.038	0.24
14	**183**	3.184	0.999	0.081	0.000	3.287	3.304	1.000	0.034	3.328	0.24
15	**97**	3.469	0.999	0.079	0.000	3.560	3.580	1.000	0.034	3.608	0.24
16	**192**	4.179	1.000	0.078	0.000	4.161	4.880	1.000	0.034	3.875	0.24

Age 0,1,2 over-written as follows:

2021 yc 2021 age 0 replaced by 2009–2018 LTGM (9 696);

2020 yc 2021 age 1 from SS3 survivor estimate at-age 1, 2021 * LTGM / SS3 estimate of age 0 in 2020;

2019 yc 2021 age 2 from SS3 survivor estimate at-age 2, 2021 * LTGM / SS3 estimate of age 0 in 2019.

Table 23. Bss.27.4bc7ad–h: Management options table. F-Multipliers for 2022 are applied to both the commercial and recreational fishery. Note that the combined total commercial and recreational forecasted catch could be allocated in different ways.

Basis	Total removals* (2022)	Projected landings (2022)	Projected discards (2022)	Recreational removals (2022)	F_{total} (2022)	$F_{projected\ landings}$ (2022)	$F_{projected\ discards}$ (2022)	F recreational removals (2022)	SSB (2023)	% SSB change **	% advice change ***
ICES advice basis											
MSY approach: F_{MSY} × SSB_{2022} / $MS_{Y\ Btrigger}$	2216	1469	164	583	0.143	0.099	0.0057	0.038	11827	-1.87%	10.8%
Other scenarios											
EU MAP ^: F_{MSY} × SSB_{2022} / MSY $B_{trigger}$	2216	1469	164	583	0.143	0.099	0.0057	0.038	11827	-1.87%	10.8%
EU MAP ^: $F_{MSY\ upper}$ × SSB_{2022} / MSY $B_{trigger}$	2216	1469	164	583	0.143	0.099	0.0057	0.038	11827	-1.87%	10.8%
EU MAP ^: $F_{MSY\ lower}$ × SSB_{2022} / MSY $B_{trigger}$	1859	1233	137	489	0.119	0.082	0.0047	0.032	12121	0.57%	-7.1%
F = F_{MSY}	2620	1736	195	690	0.171	0.119	0.0068	0.046	11496	-4.6%	31%
F = 0	0	0	0	0	0	0	0	0	13660	13.3%	-100
F_{pa}	3059	2025	229	805	0.20	0.141	0.0081	0.054	11137	-7.6%	53%
F_{lim}	3738	2472	282	984	0.25	0.176	0.0101	0.068	10584	-12.2%	87%
SSB_{2023} = B_{lim}	4072	2691	308	1073	0.28	0.194	0.0112	0.075	10313	-14.4%	104%
SSB_{2023} = B_{pa} ^^											
SSB_{2023} = MSY $B_{trigger}$ ^^											
F = F_{2021}	1790	1188	132	471	0.114	0.079	0.0045	0.030	12177	1.03%	-10.5%
SSB_{2023} = SSB_{2022}	1941	1288	143	511	0.124	0.086	0.0049	0.033	12052	0.00%	-2.9%

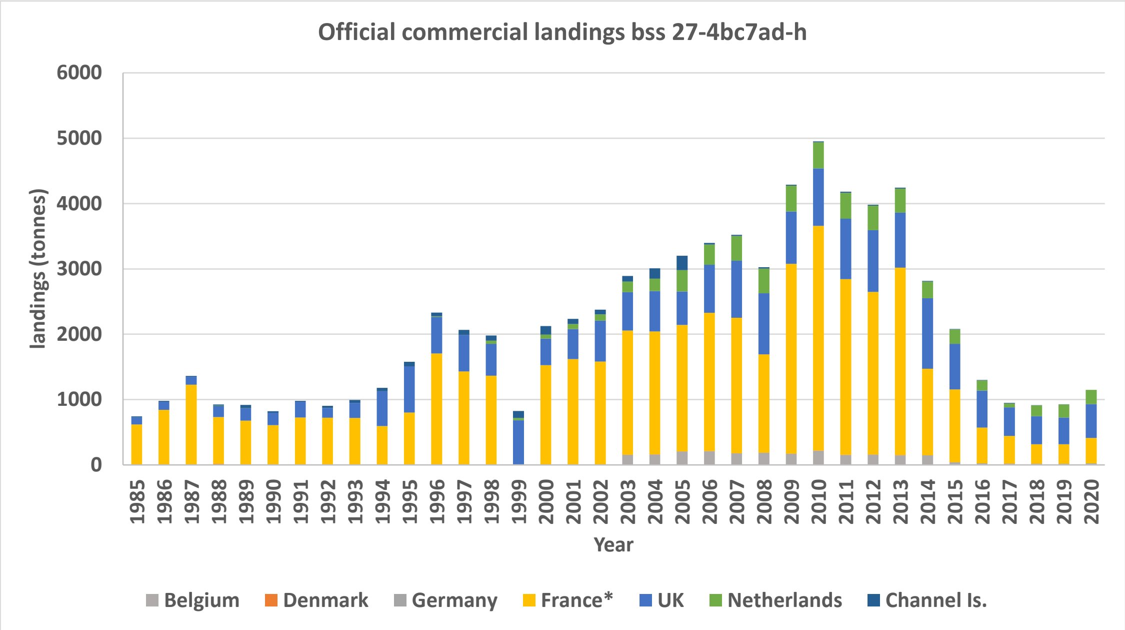
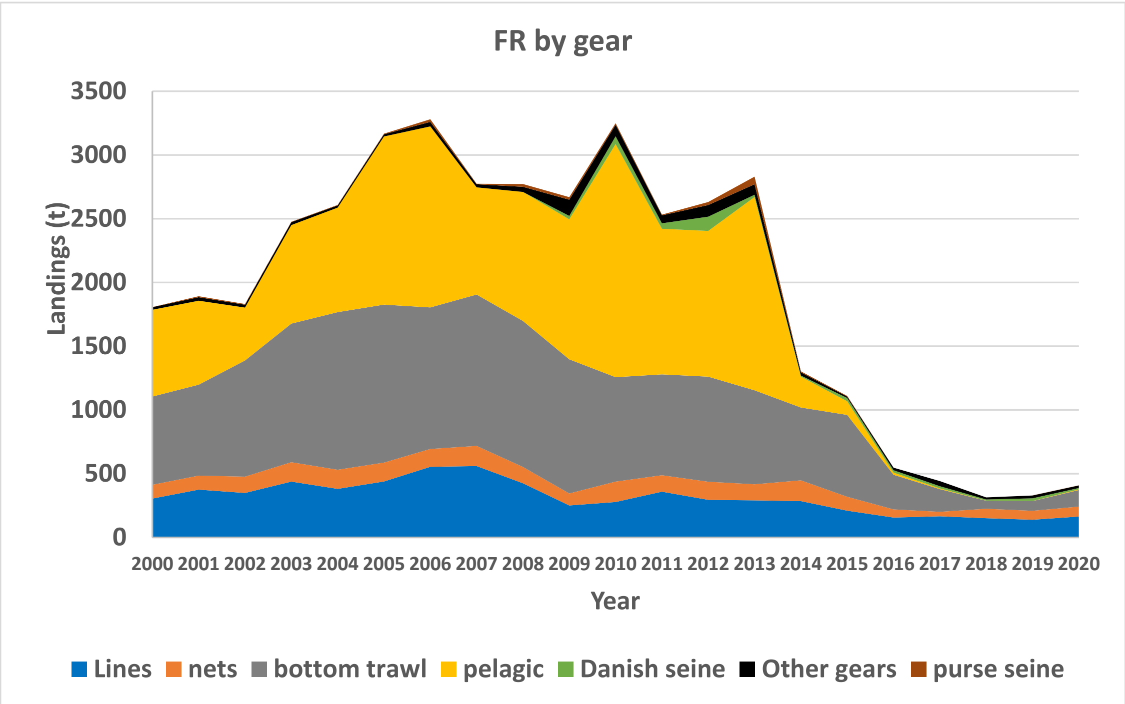


Figure 1. Bss.27.4bc7ad–h: Trends in official sea bass landings by country.



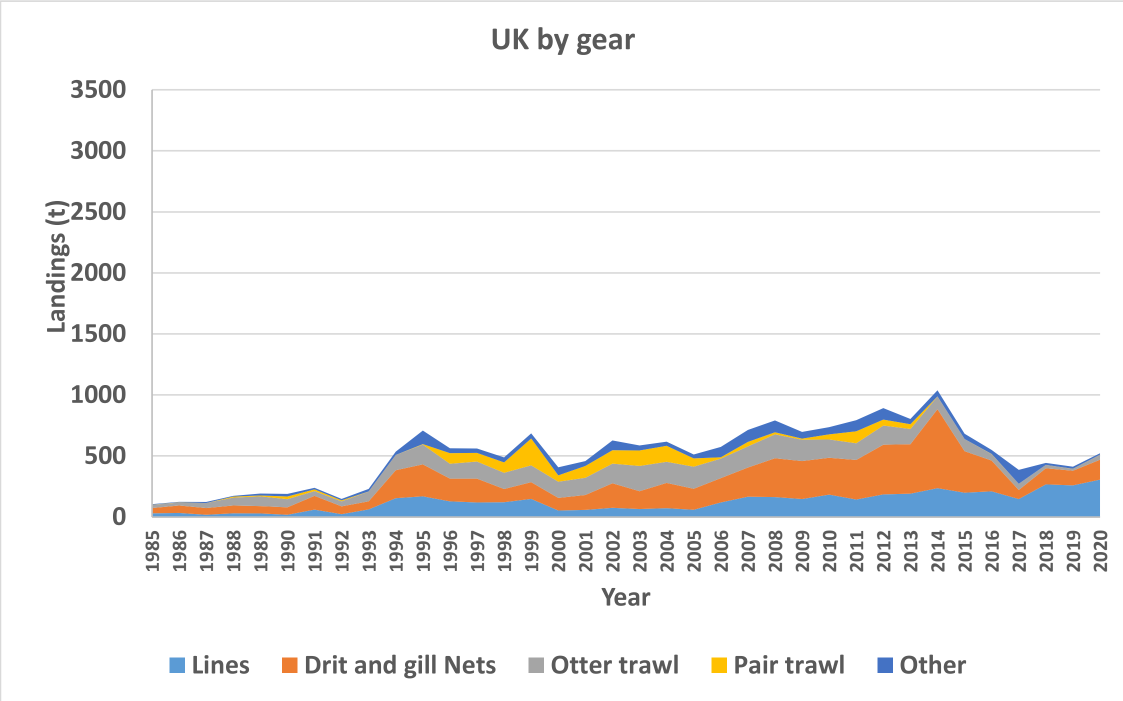


Figure 2. Bss.27.4bc7ad–h: Trends in ICES estimates of seabass landings by gear (France –top- and UK –bottom).

a

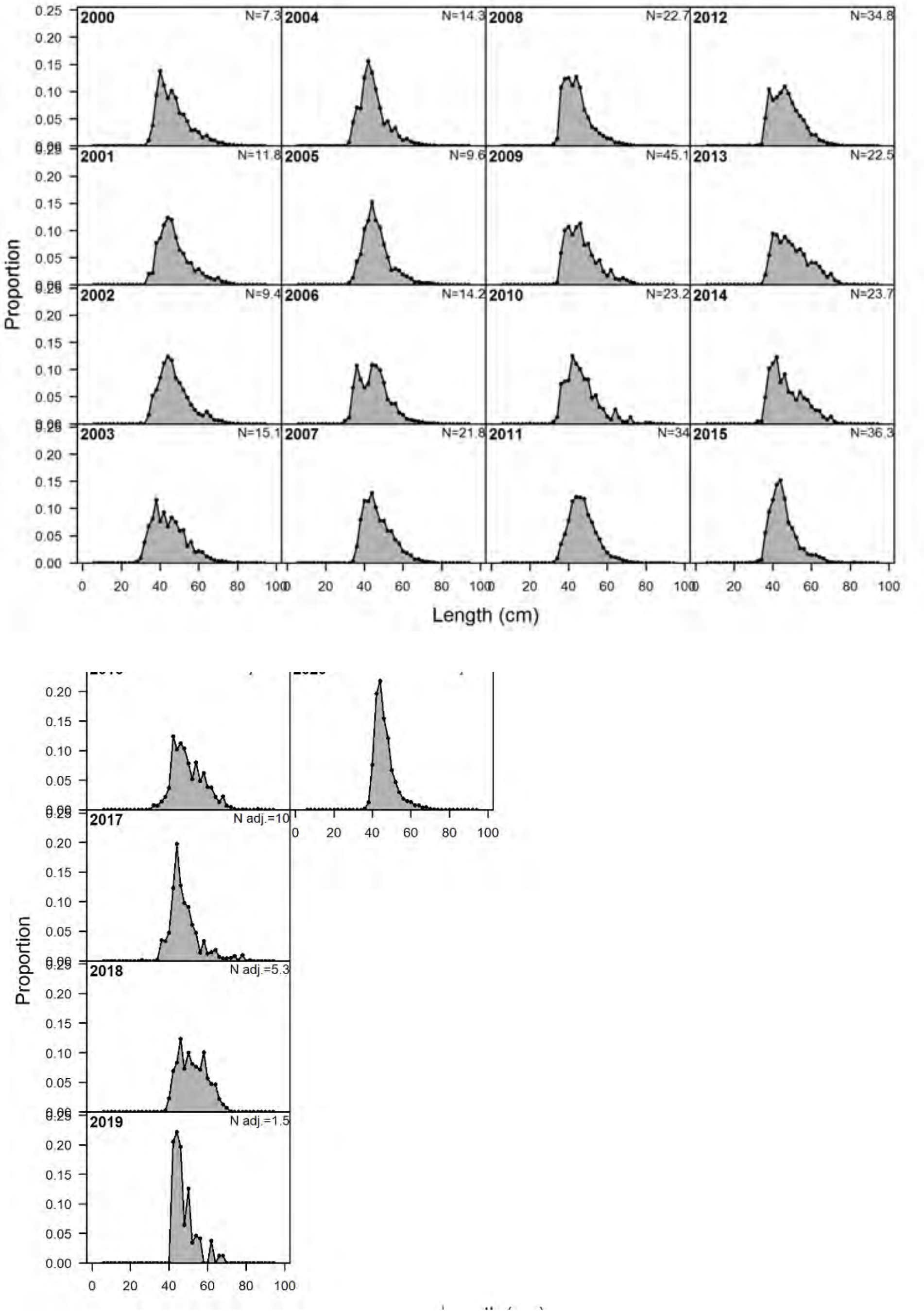


Figure 3. Bss.27.4bc7ad–h: Length composition for the combined French fleet from 2000 onwards.

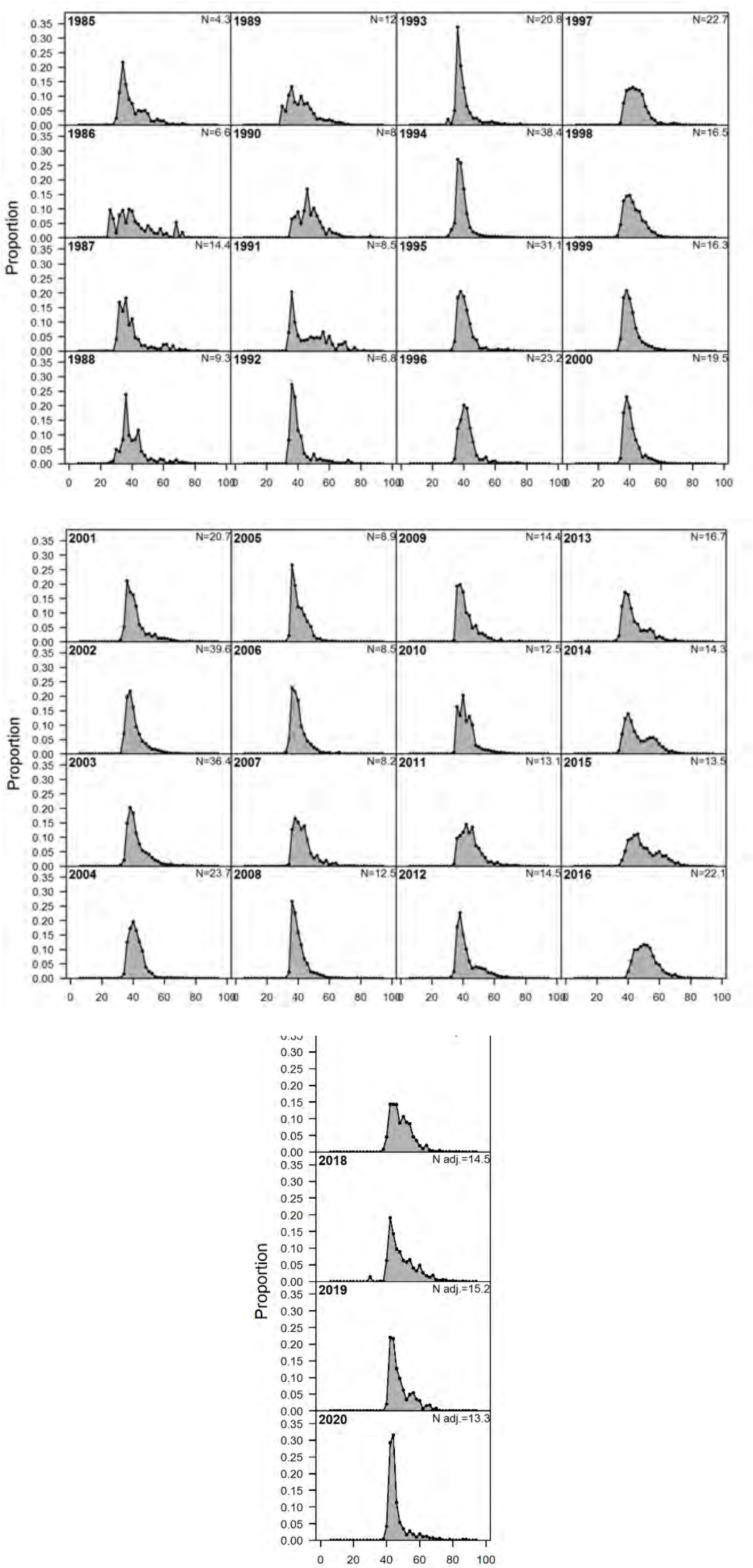


Figure 4. Bss.27.4bc7ad–h: Length composition of UK bottom trawls and nets fleet landings from 1985 onwards.

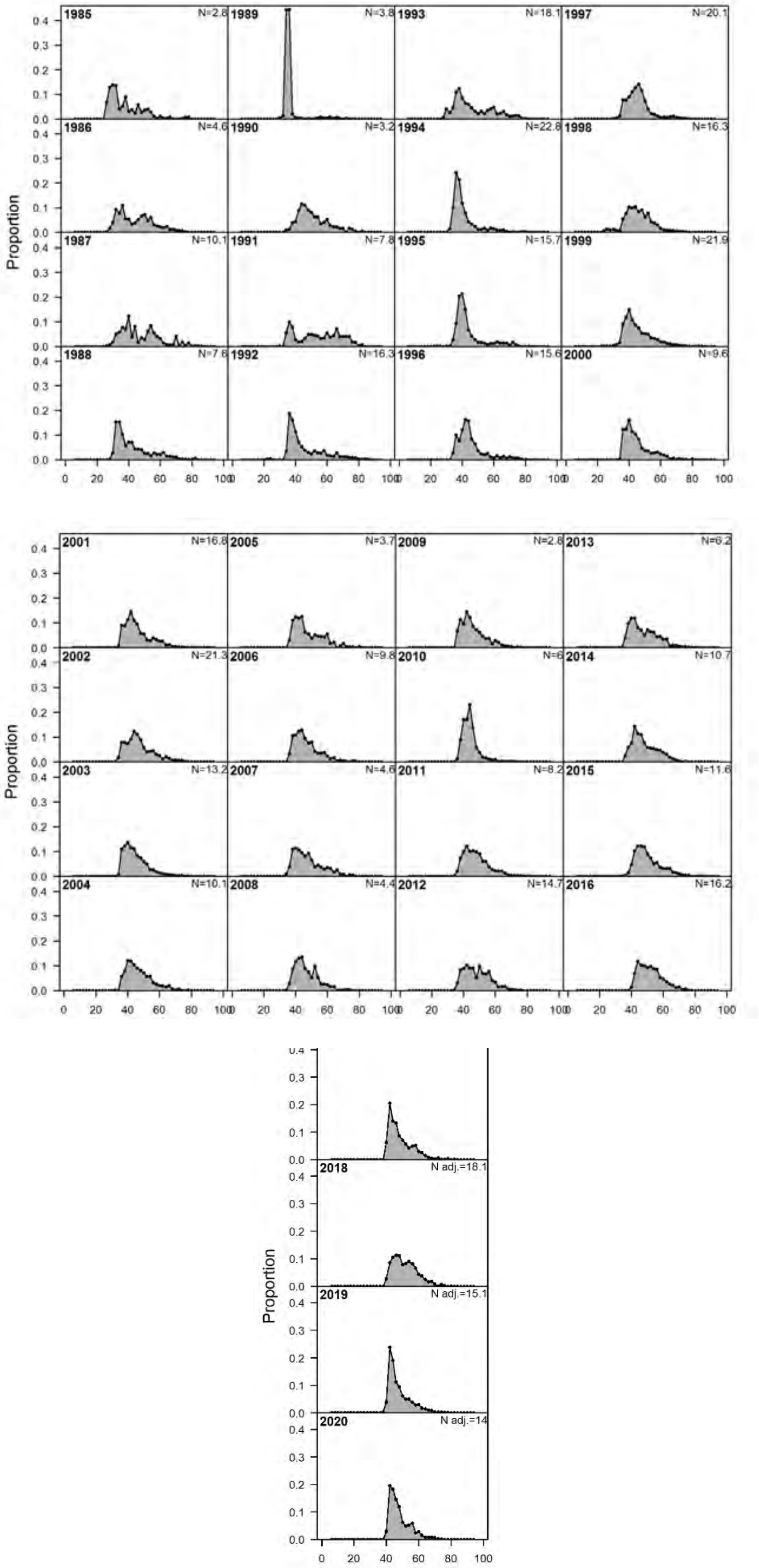


Figure 5. Bss.27.4bc7ad–h: Length composition of UK Lines fleet landings from 1985 onwards.

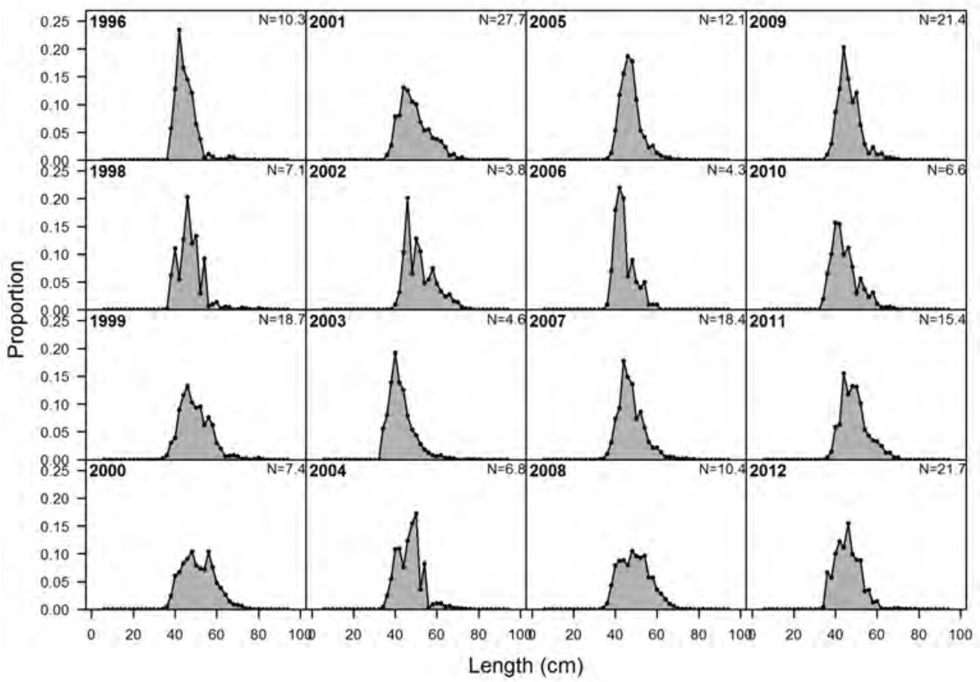


Figure 6. Bss.27.4bc7ad–h: Available length composition of UK Midwater pair trawl fleet landings.

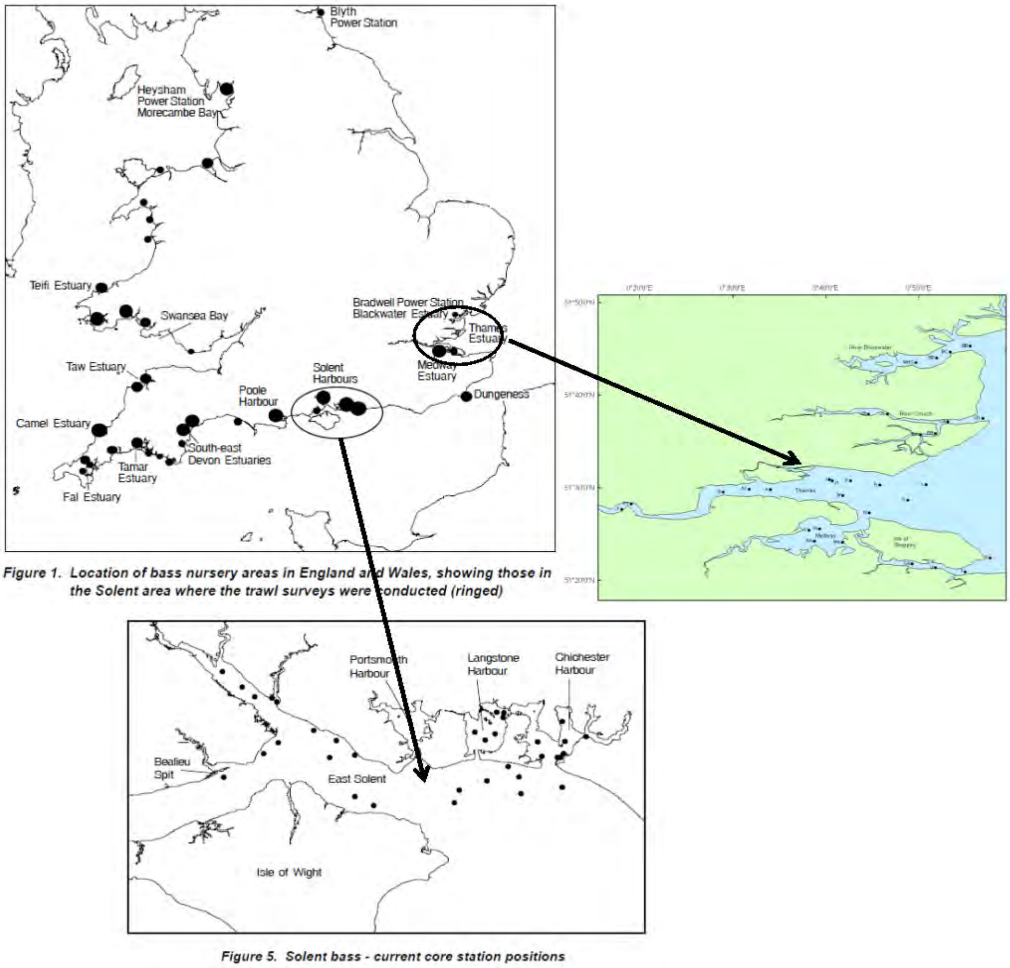


Figure 7. Bss.27.4bc7ad–h: Location of Cefas Solent and Thames juvenile seabass surveys.

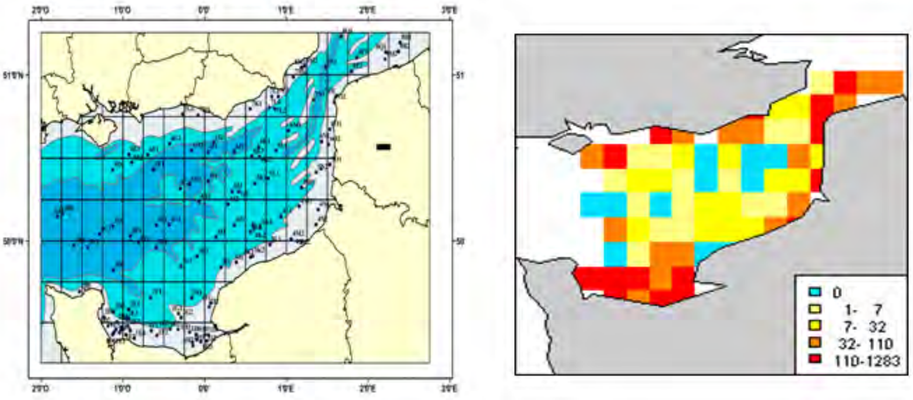


Figure 8. Bss.27.4bc7ad–h: Left: stations fished during the Channel Groundfish Survey carried out annually by France. Right: distribution of total catches of seabass over the survey series.

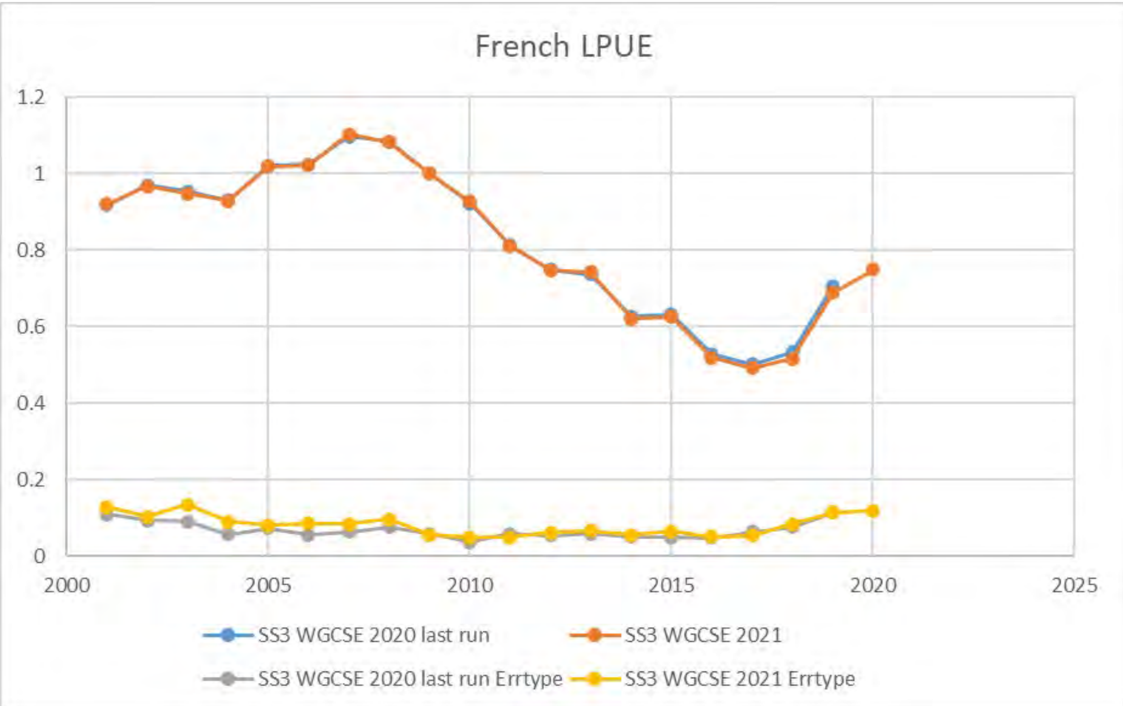
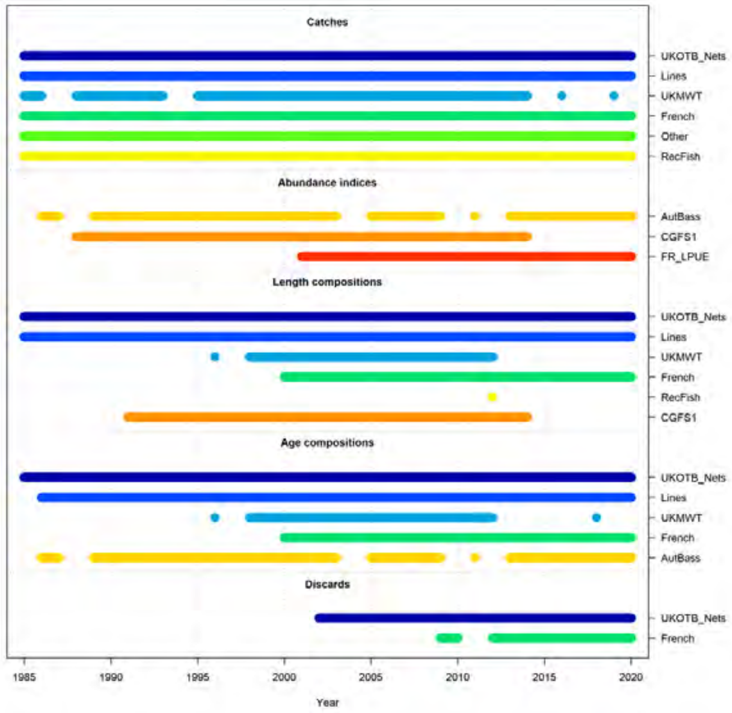


Figure 9. Bss.27.4bc7ad–h: Comparison of French commercial lpue index for European seabass in ICES divisions 4bc and 7a,d–h between last year's assessment and the updated 2021 lpue.



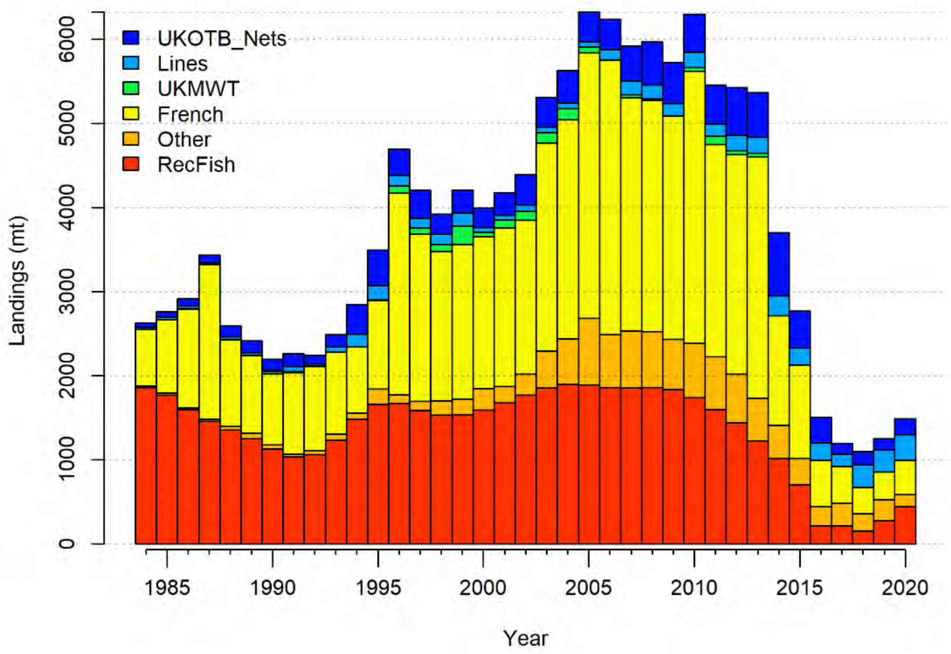
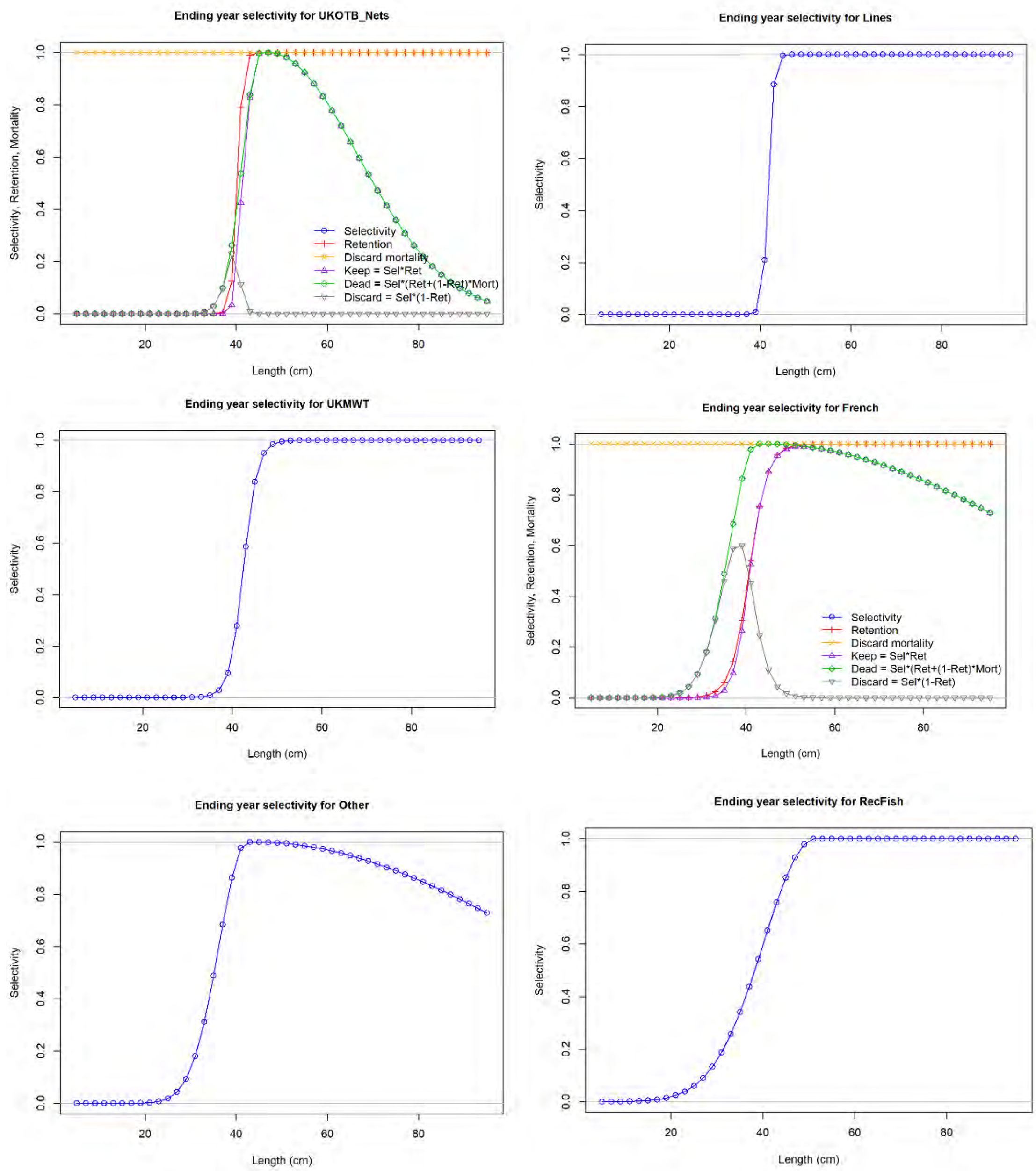


Figure 10. Bss.27.4bc7ad–h: Top: Datasets used in the updated assessment. Bottom: Catch series for the six fleets.


Ending year selectivity for UKOTB_Nets
Selectivity, Retention, Mortality
Length (cm)
Selectivity
Retention
Discard mortality
Keep = Sel*Ret
Dead = Sel*(Ret+(1-Ret)*Mort)
Discard = Sel*(1-Ret)
Ending year selectivity for Lines
Selectivity
Length (cm)
Ending year selectivity for UKMWT
Selectivity
Length (cm)
Ending year selectivity for French
Selectivity, Retention, Mortality
Length (cm)
Selectivity
Retention
Discard mortality
Keep = Sel*Ret
Dead = Sel*(Ret+(1-Ret)*Mort)
Discard = Sel*(1-Ret)
Ending year selectivity for Other
Selectivity
Length (cm)
Ending year selectivity for RecFish
Selectivity
Length (cm)

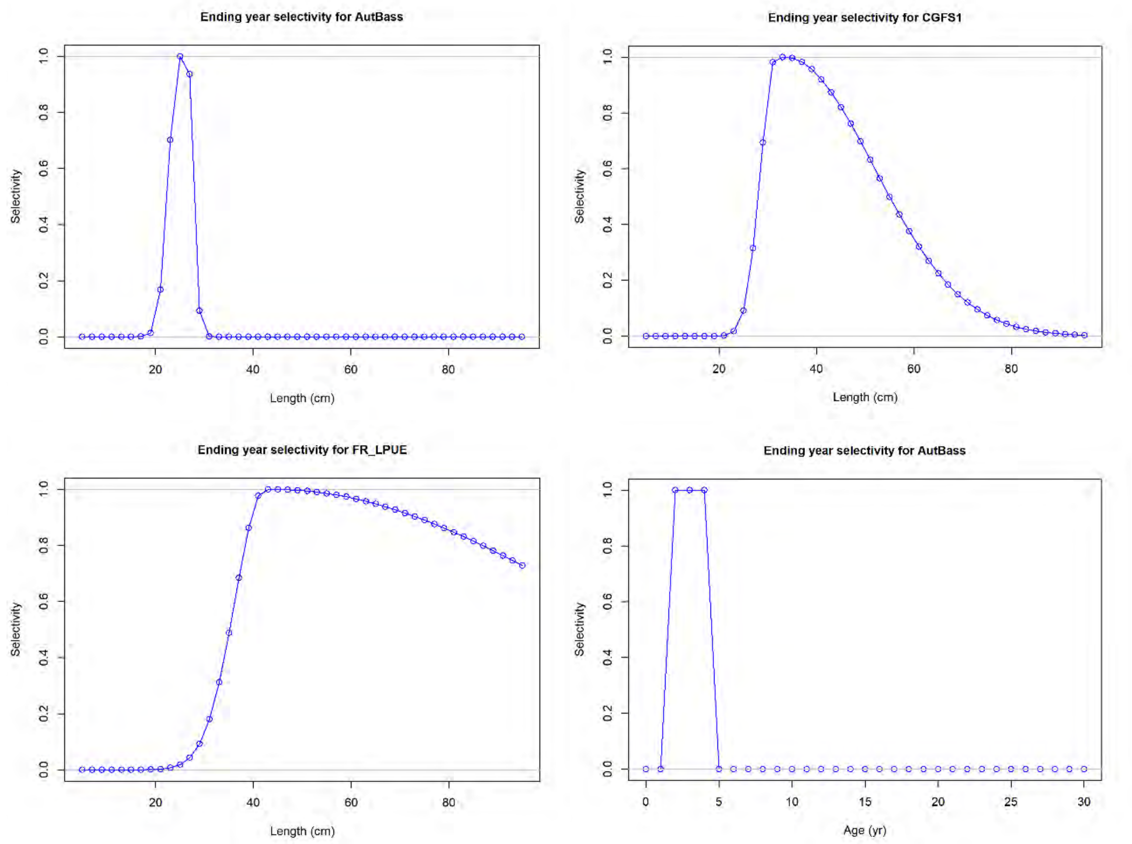


Figure 11. Bss.27.4bc7ad–h: Final seabass update assessment: Fitted length-based and age-based selectivity curves.

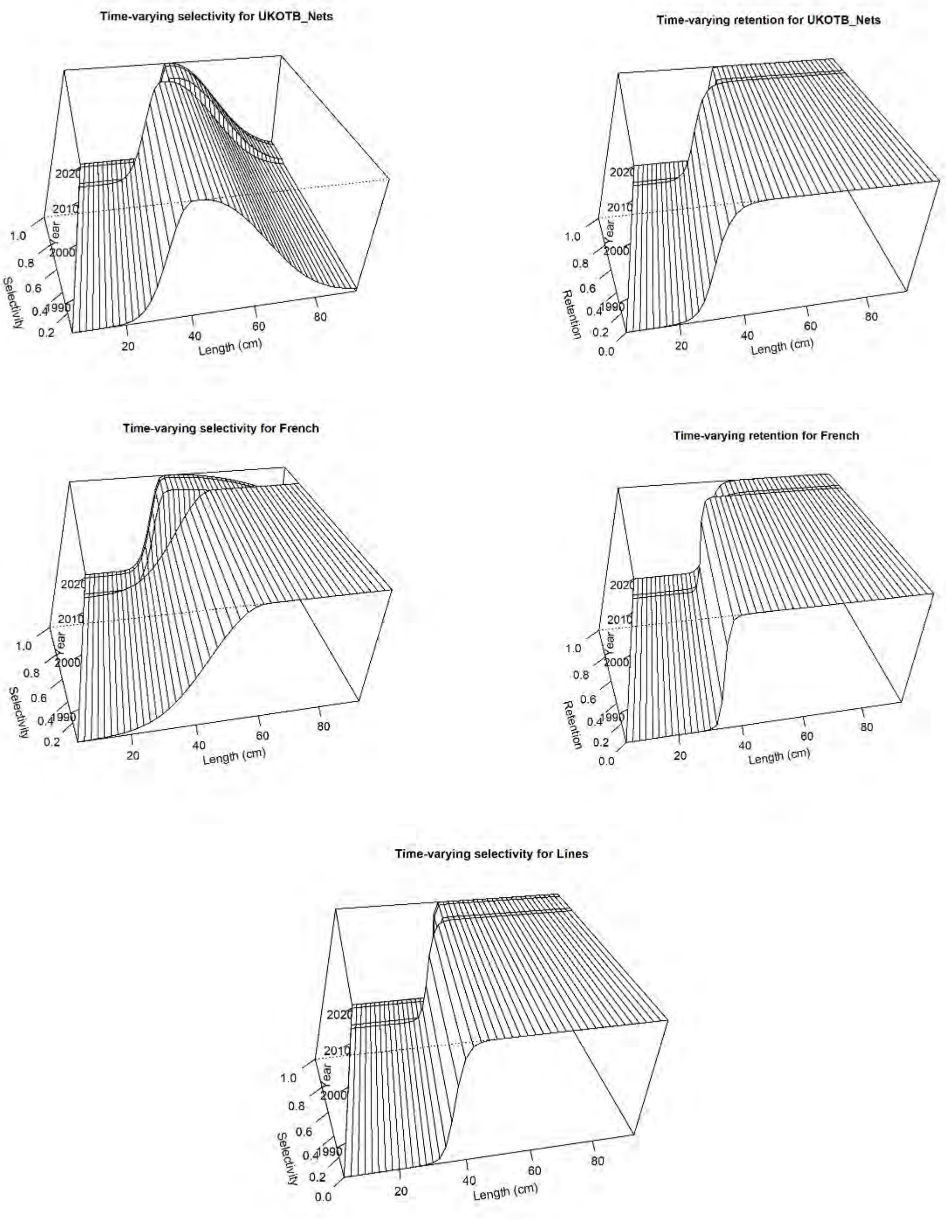


Figure 12. Bss.27.4bc7ad–h: Final seabass update assessment: Fitted time-series of length-based and age-based selectivity and retention curves for fleets with blocks.

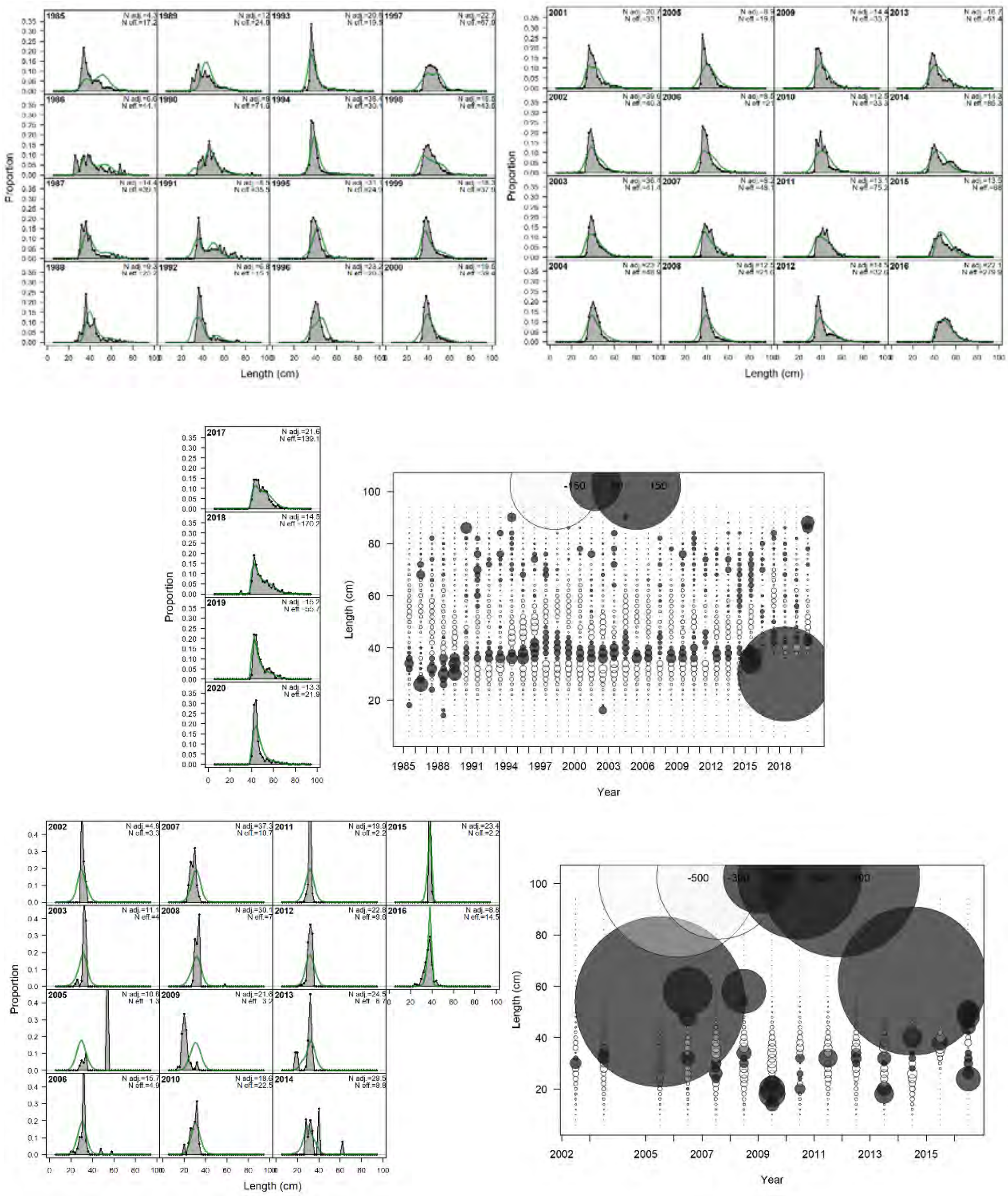


Figure 13. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of UK trawl and net fishery-length composition data for the retained (top 4) and discarded (bottom 2) catch components.

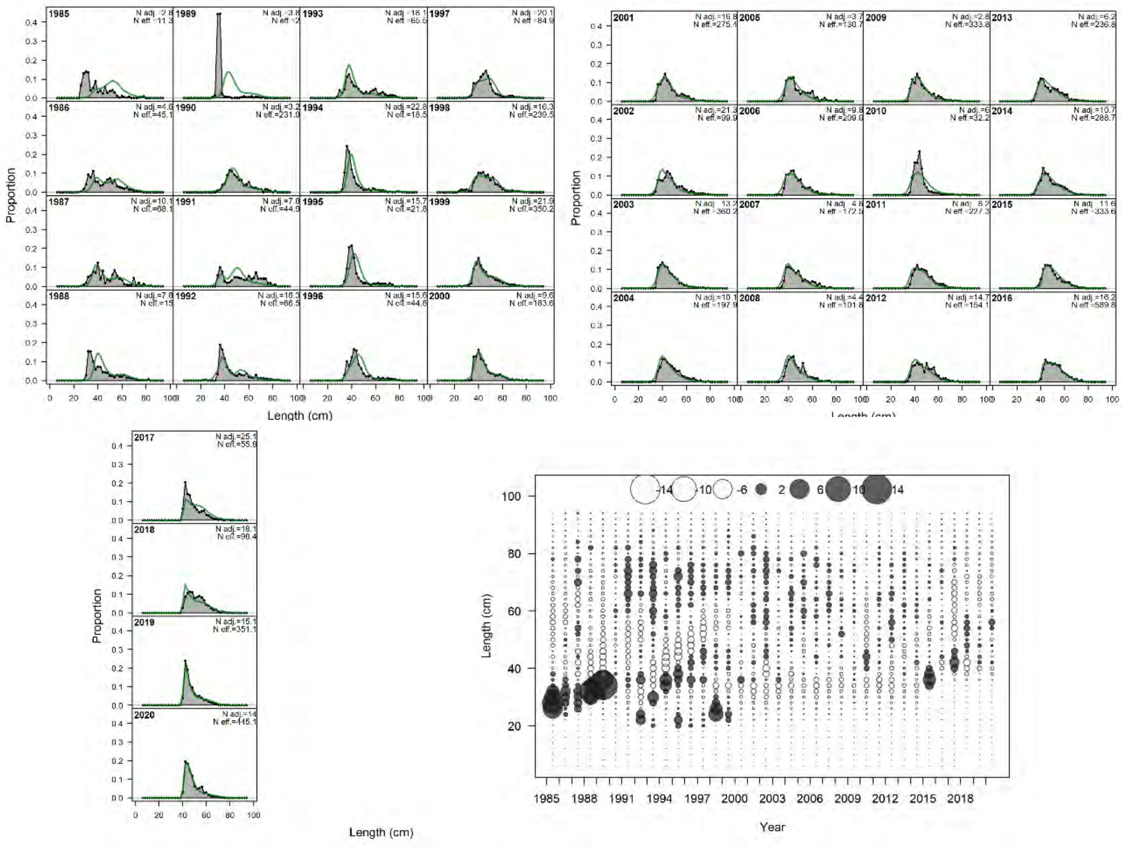


Figure 14. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of UK lines length-composition data for the retained catch components.

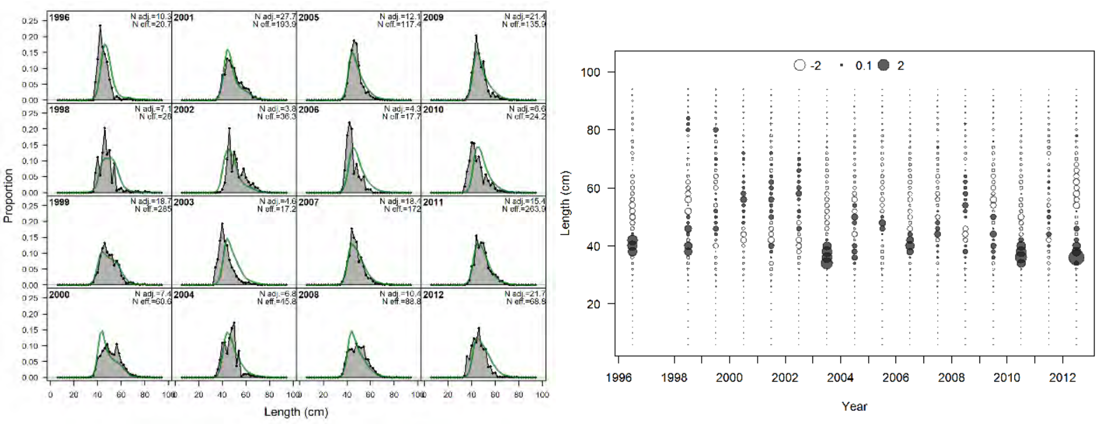


Figure 15. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of UK midwater trawl fishery length-composition data for the retained catch components.

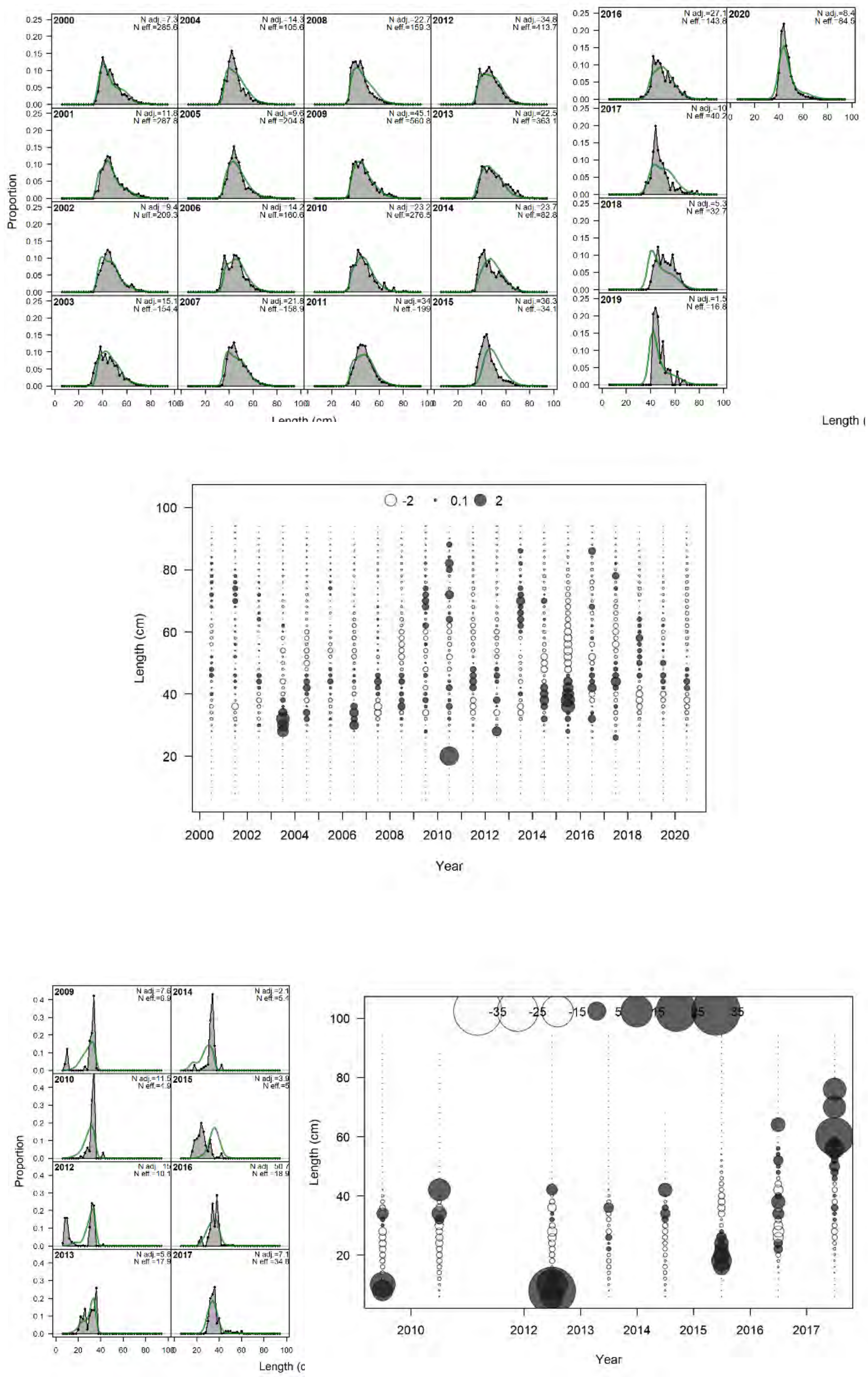


Figure 16. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of French fishery length-composition data for the retained (top 2 rows) and discarded (bottom row) catch components.

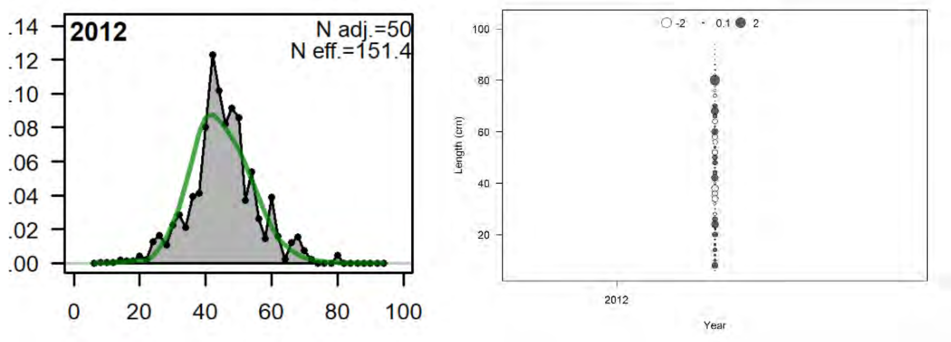
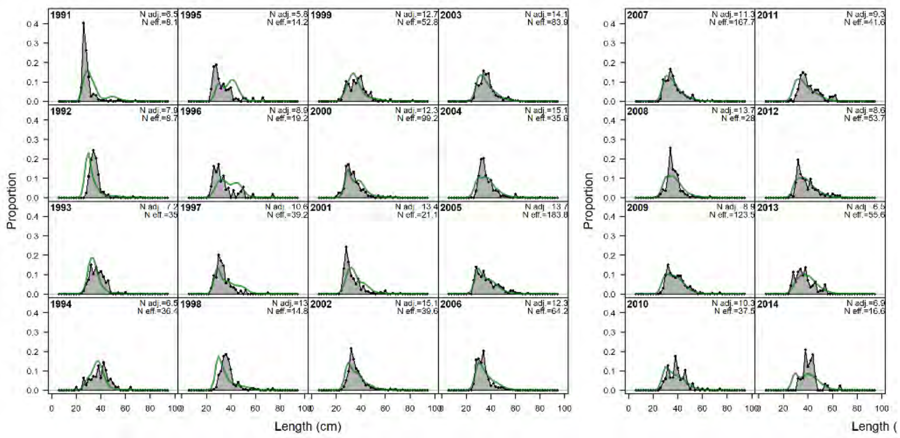


Figure 17. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of recreational length-compositions data.



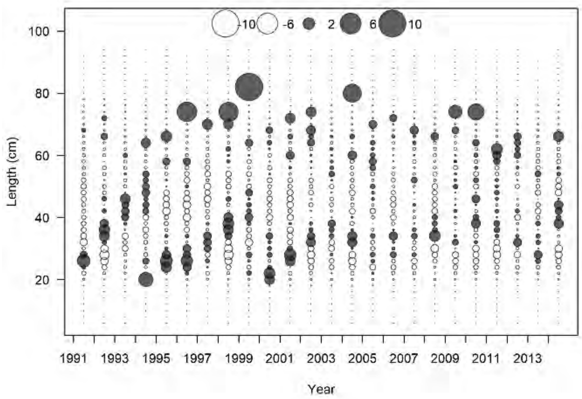


Figure 18. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of Channel groundfish survey length-compositions.

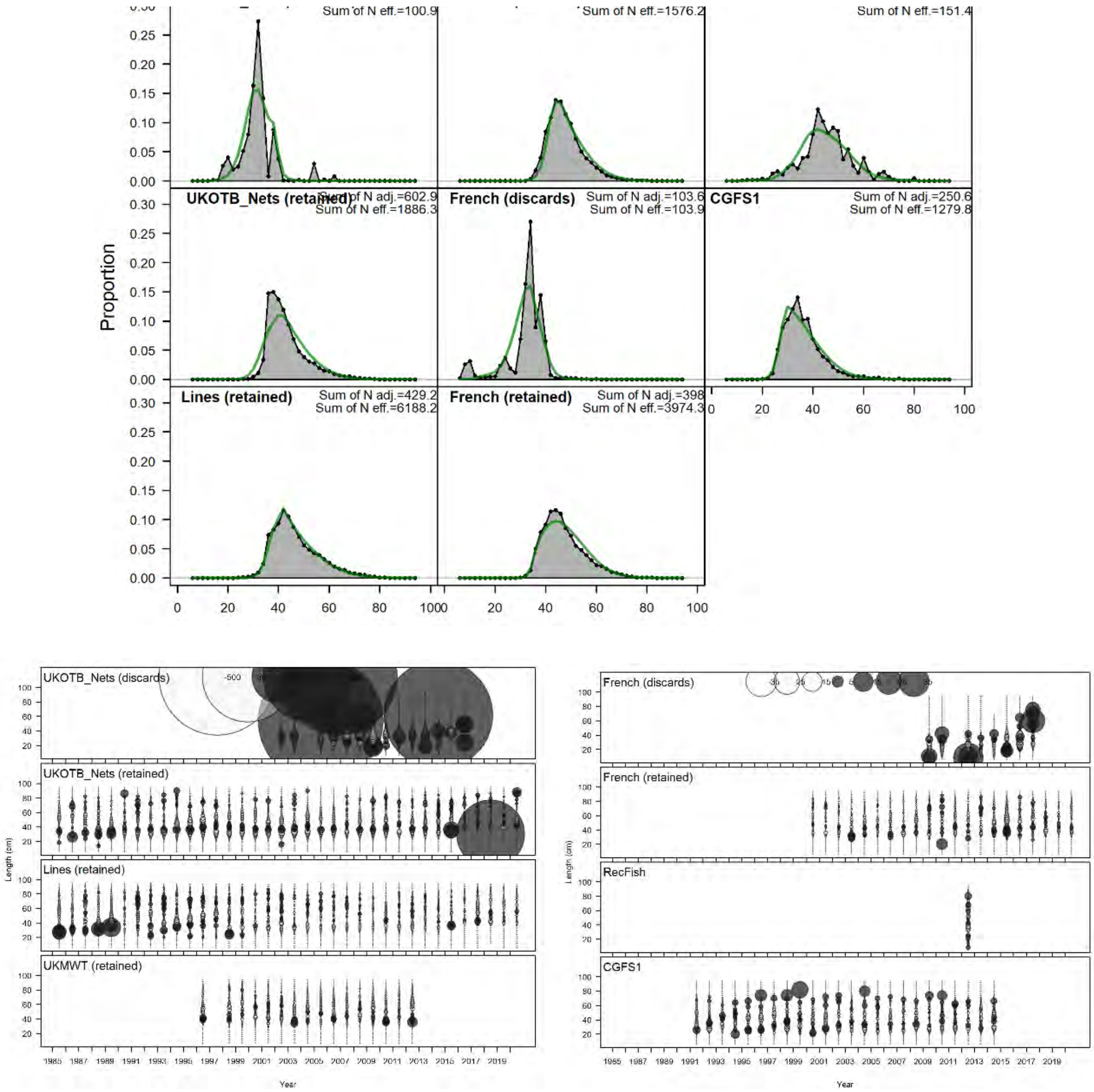


Figure 19. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of the commercial fisheries and Channel groundfish survey length compositions, aggregated across time for the retained and discarded catch components.

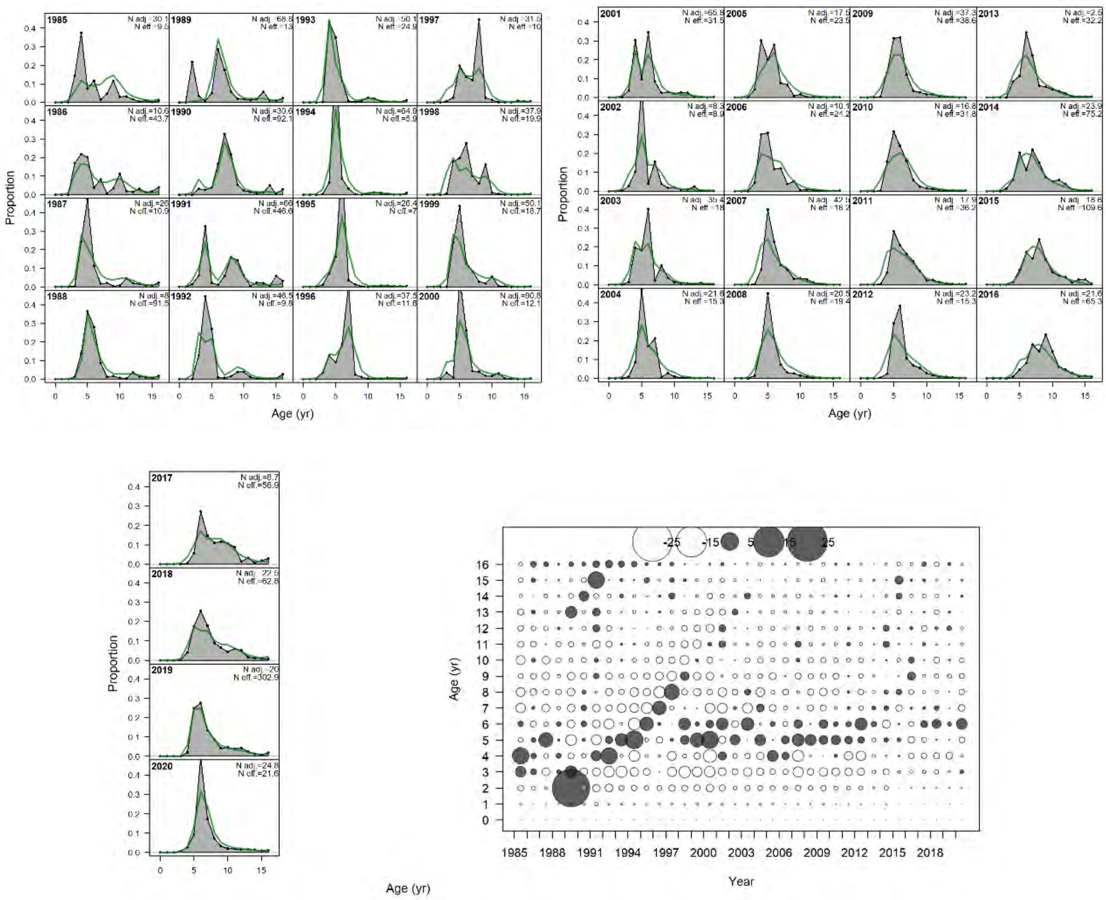


Figure 20. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of age-composition data for the combined UK otter trawl and nets fleets.

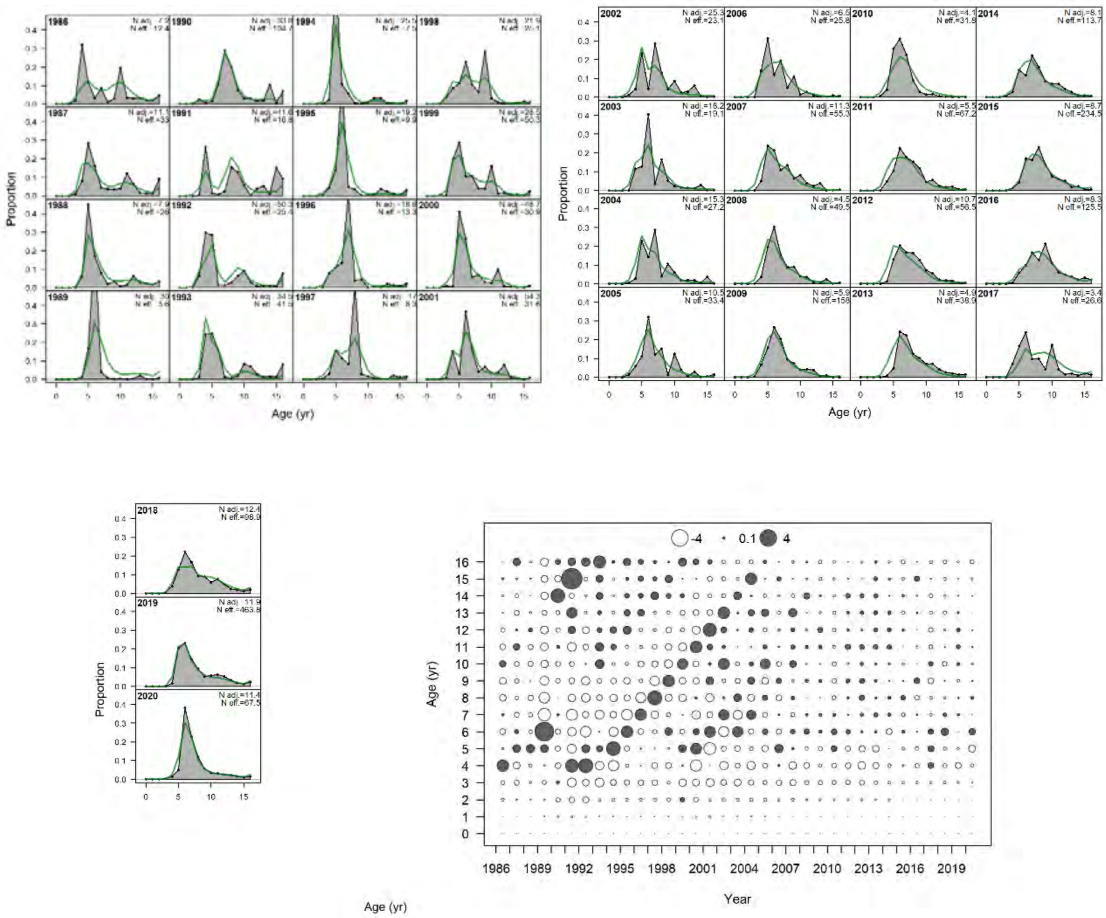


Figure 21. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of age-composition data for the combined UK lines fleet.

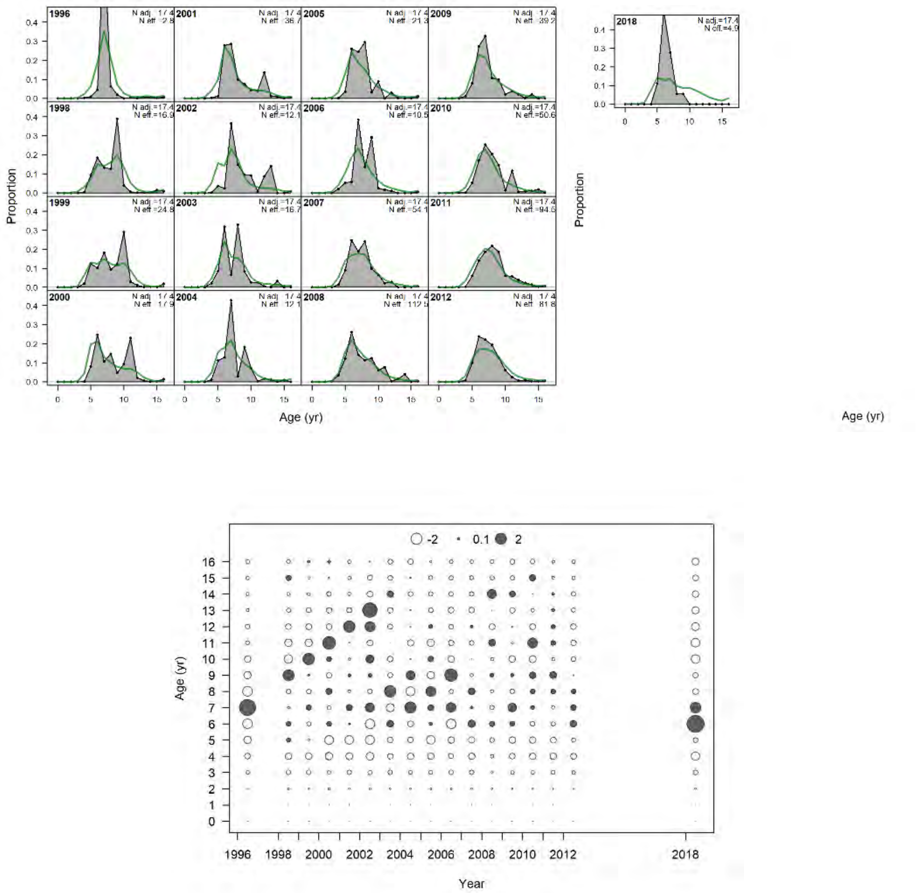
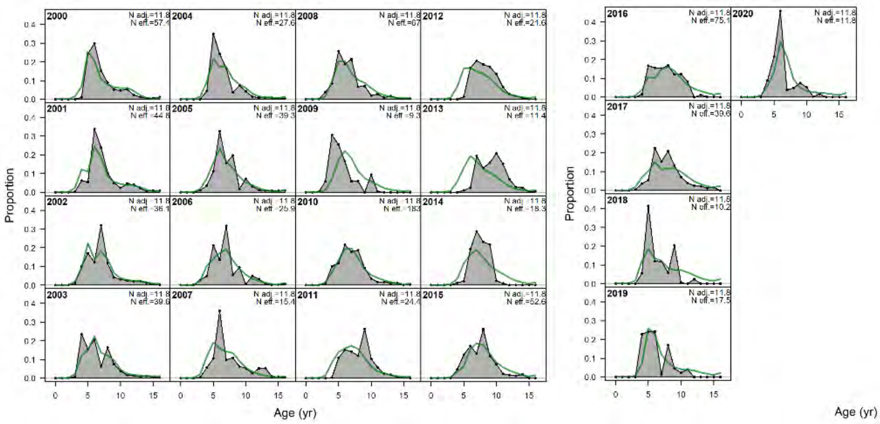


Figure 22. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of age-composition data for the UK mid-water trawl fleet.



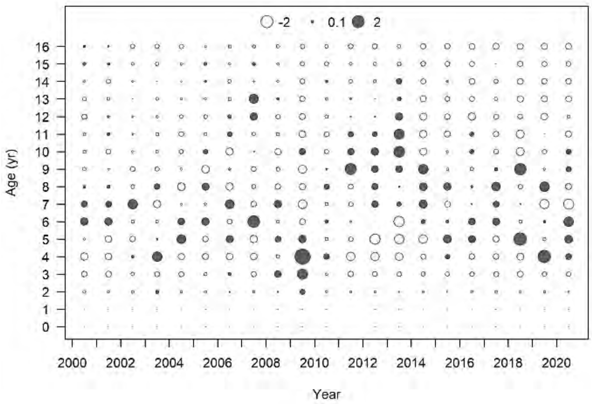


Figure 23. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of age-composition data for the combined French fleets.

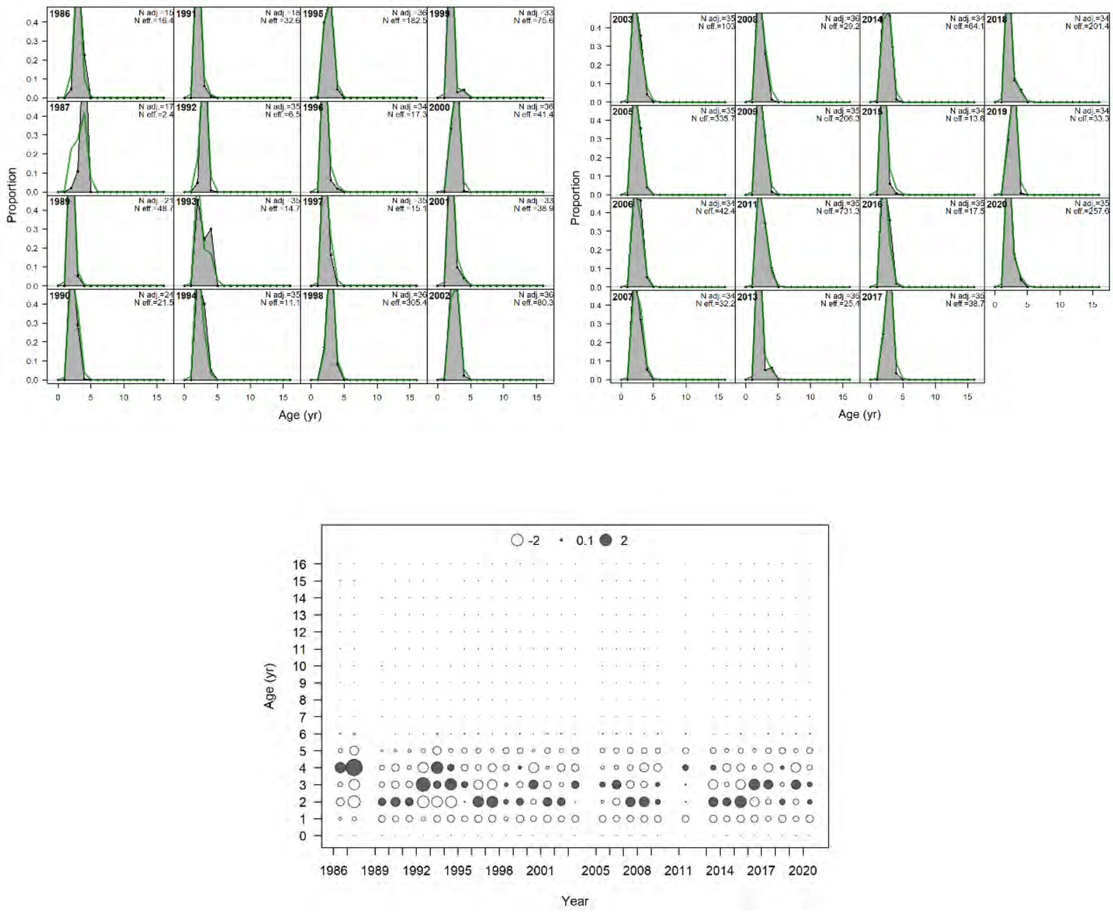


Figure 24. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of age-composition data for the Solent Autumn bass survey.

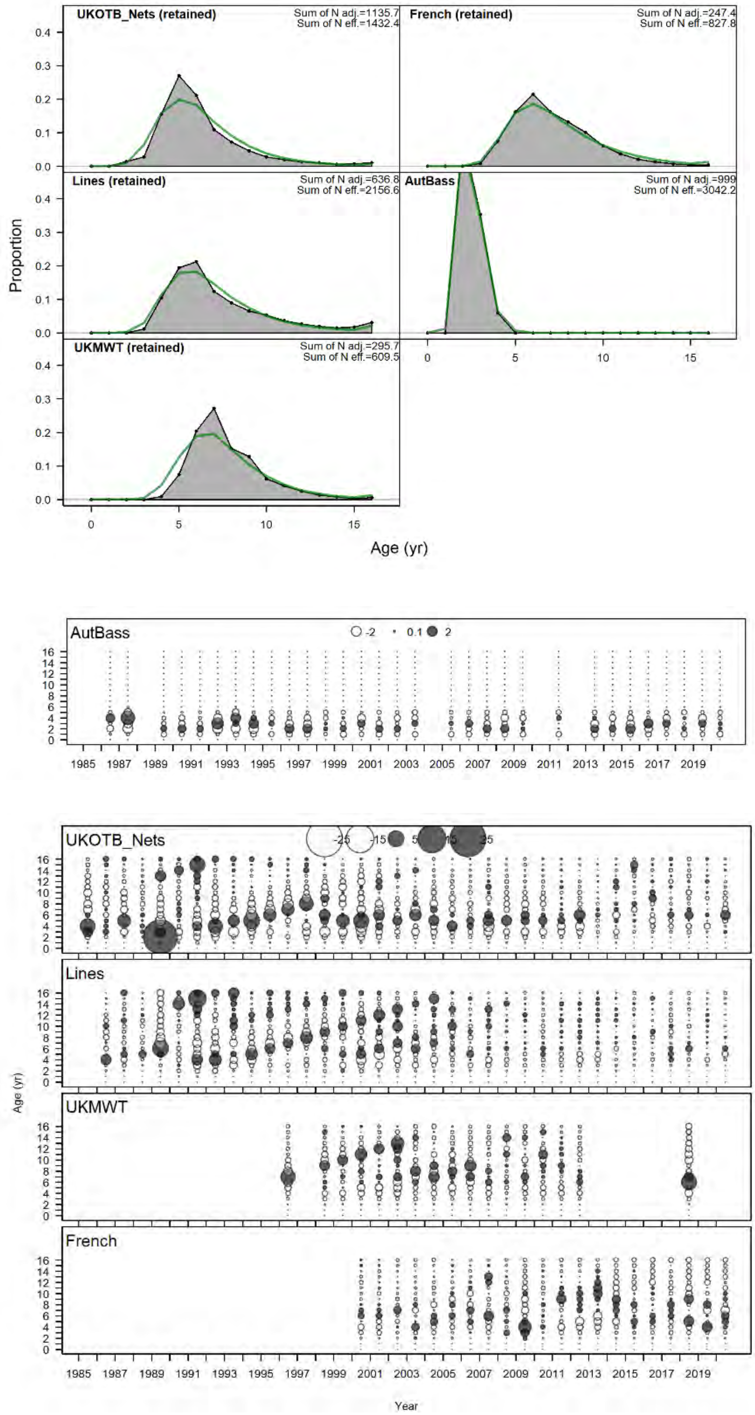


Figure 25. Bss.27.4bc7ad–h: Final seabass update assessment: Fit and residuals of UK fleets age compositions, aggregated across time.

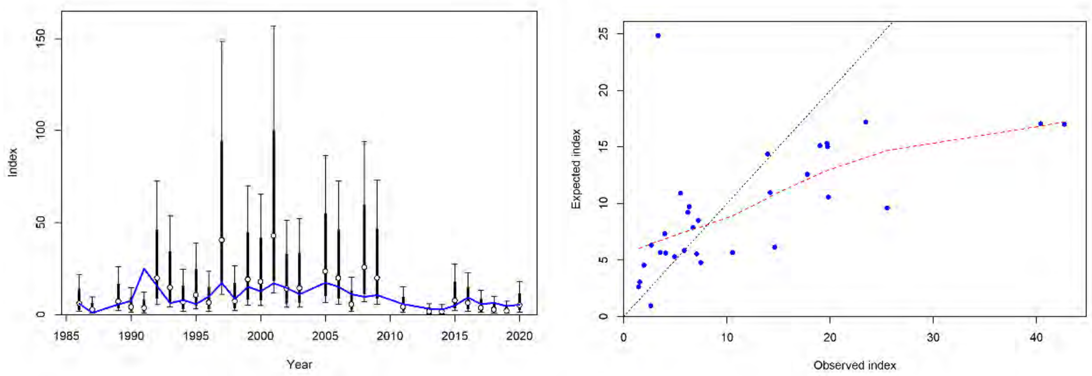


Figure 26. Bss.27.4bc7ad–h: Final seabass update assessment: Fit to Solent Autumn bass survey total abundance index, accounting for age and length-based selectivity.

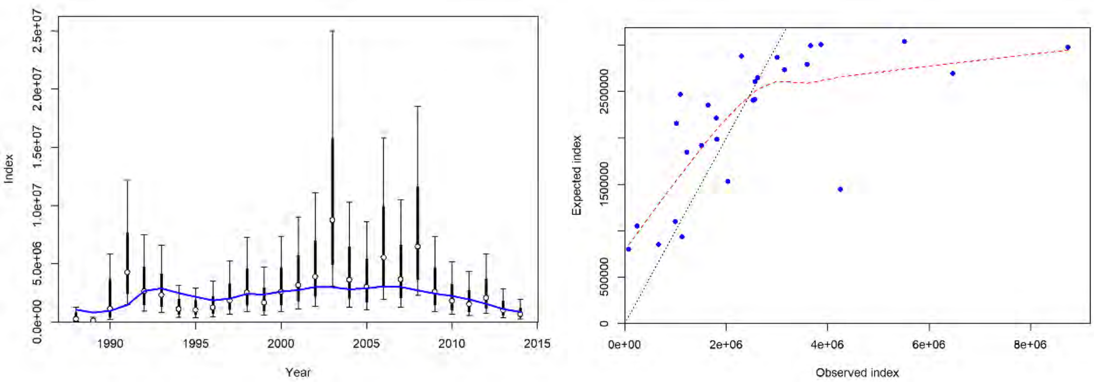


Figure 27. Bss.27.4bc7ad–h: Final seabass update assessment: Fit to Channel groundfish survey total abundance index, accounting for length-based selectivity.

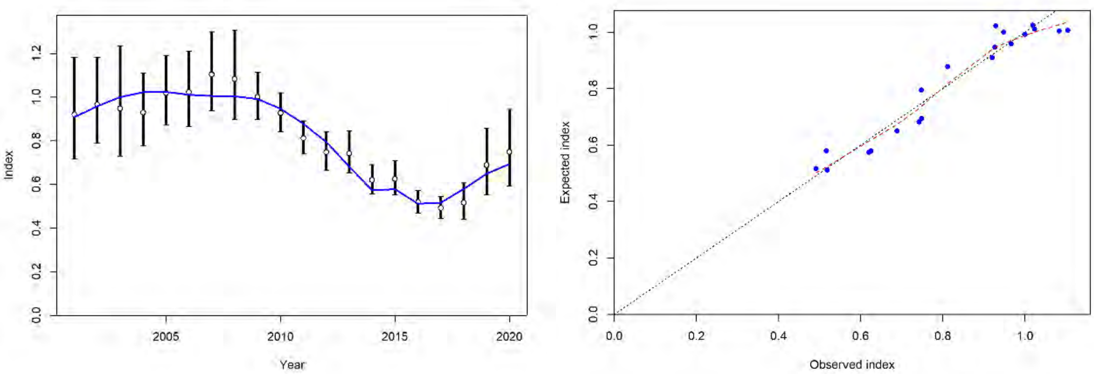


Figure 28. Bss.27.4bc7ad–h: Final seabass update assessment: Fit to the French landings per unit of effort commercial index, accounting for length-based selectivity.

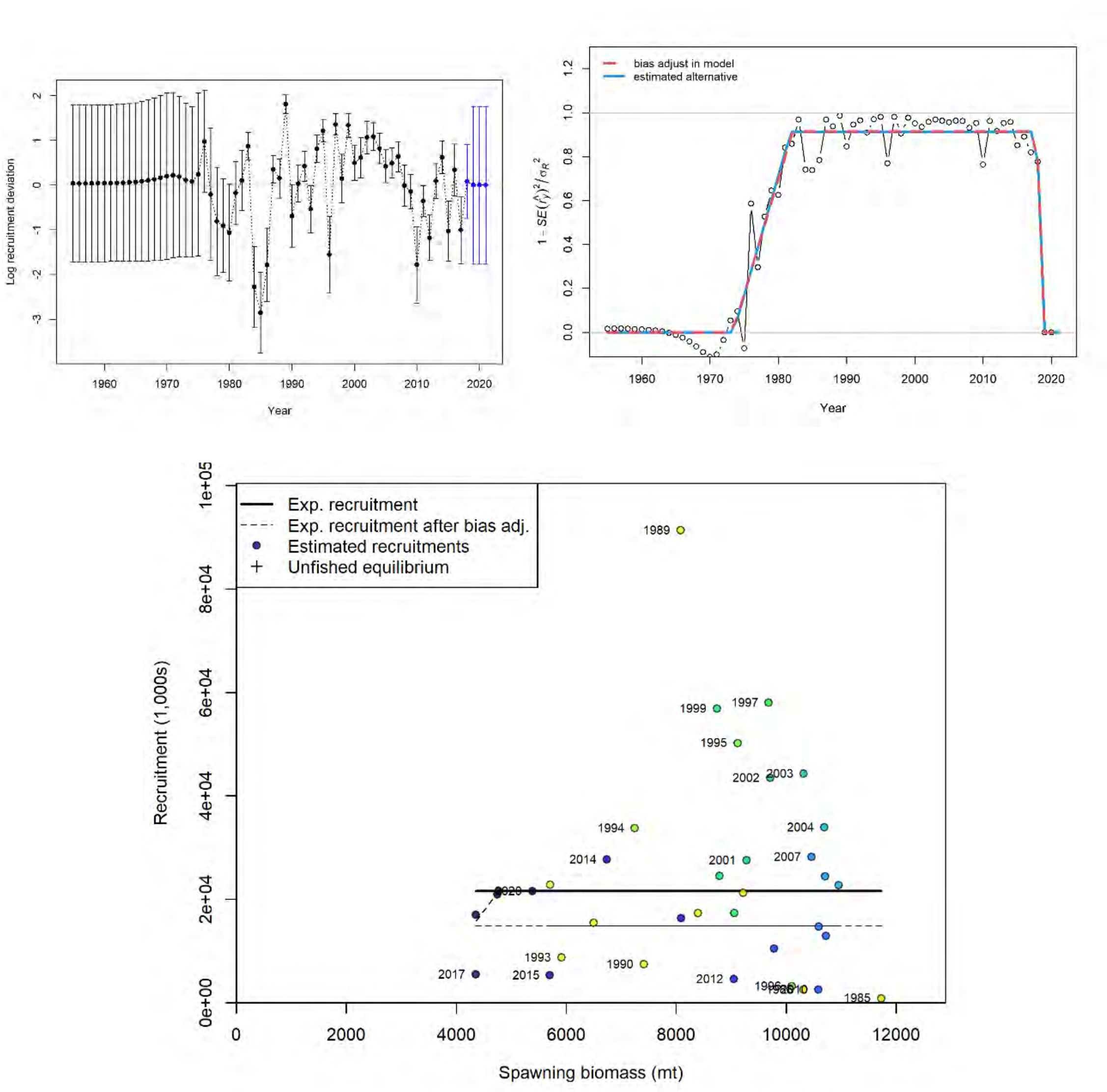


Figure 29. Bss.27.4bc7ad–h: Final seabass update assessment: Top: time-series of log-recruit deviations (deviations for 1965–1984 precede the period of input catch data). Below: stock–recruit scatter (model is fitted assuming Beverton–Holt stock–recruit model and steepness = 0.999).

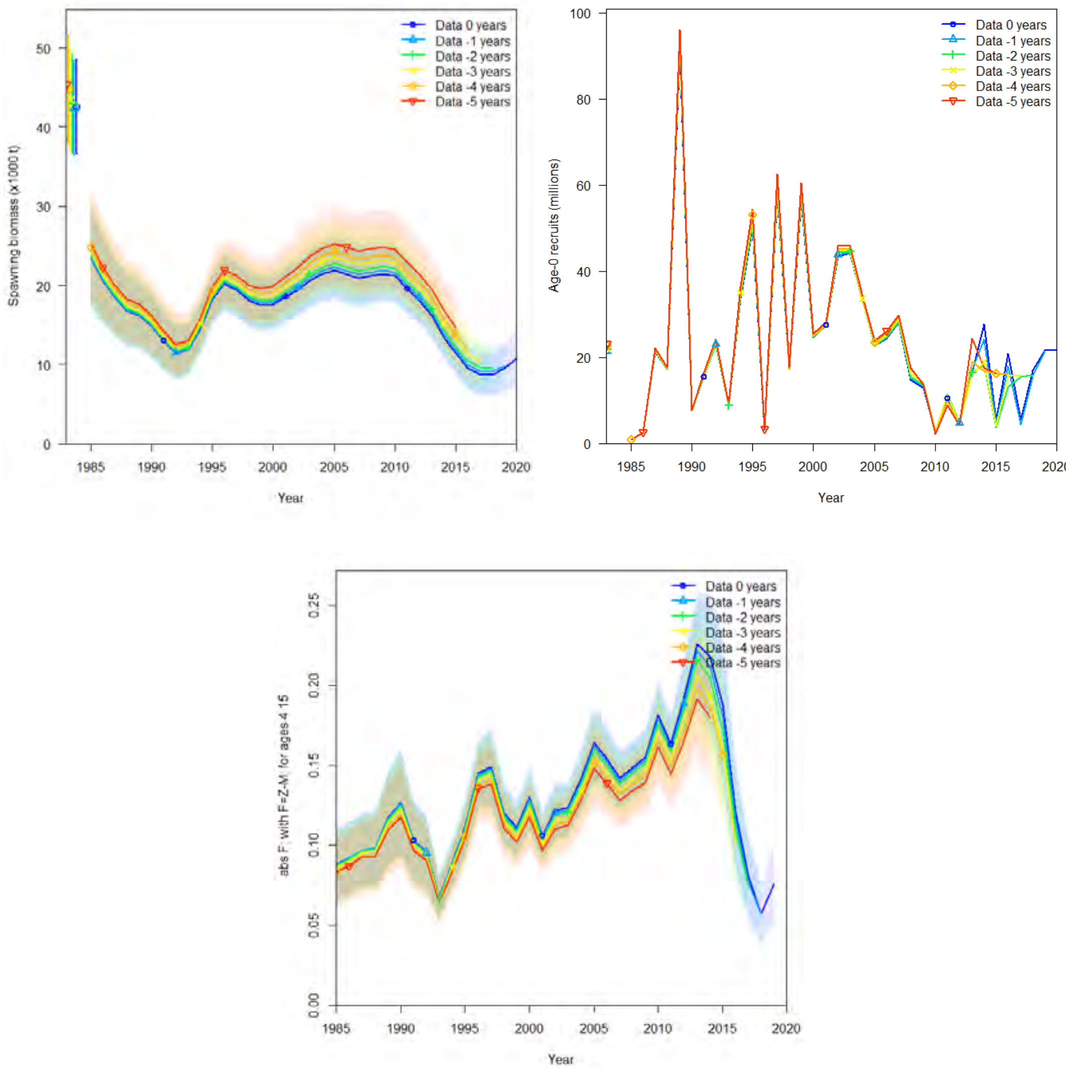


Figure 30. Bss.27.4bc7ad–h: Retrospective analysis of stock trends from final update assessment, based on Stock Synthesis run final year set to 2020 and peeling back five years (for the final run, terminal F is for 2019 and SSB and total biomass terminate in 2020).

Figure 31. Bss.27.4bc7ad–h: Stock trends from final update assessment, based on Stock Synthesis run final year set at 2020 to give 2021 numbers and biomass and 2020 F. Recruitment in 2019–2021 is the geometric mean 2008–2018. Recruitment, F and SSB are shown with 95% confidence intervals.

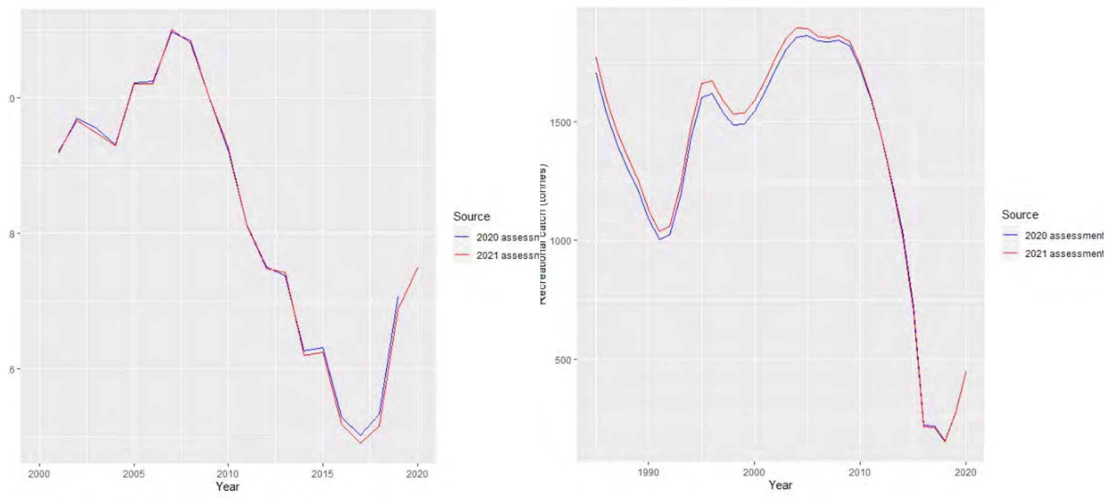


Figure 32. Bss.27.4bc7ad–h: Comparison between lpue and recreational catch time-series from this year's final update assessment and the 2020 WGCSE assessment.

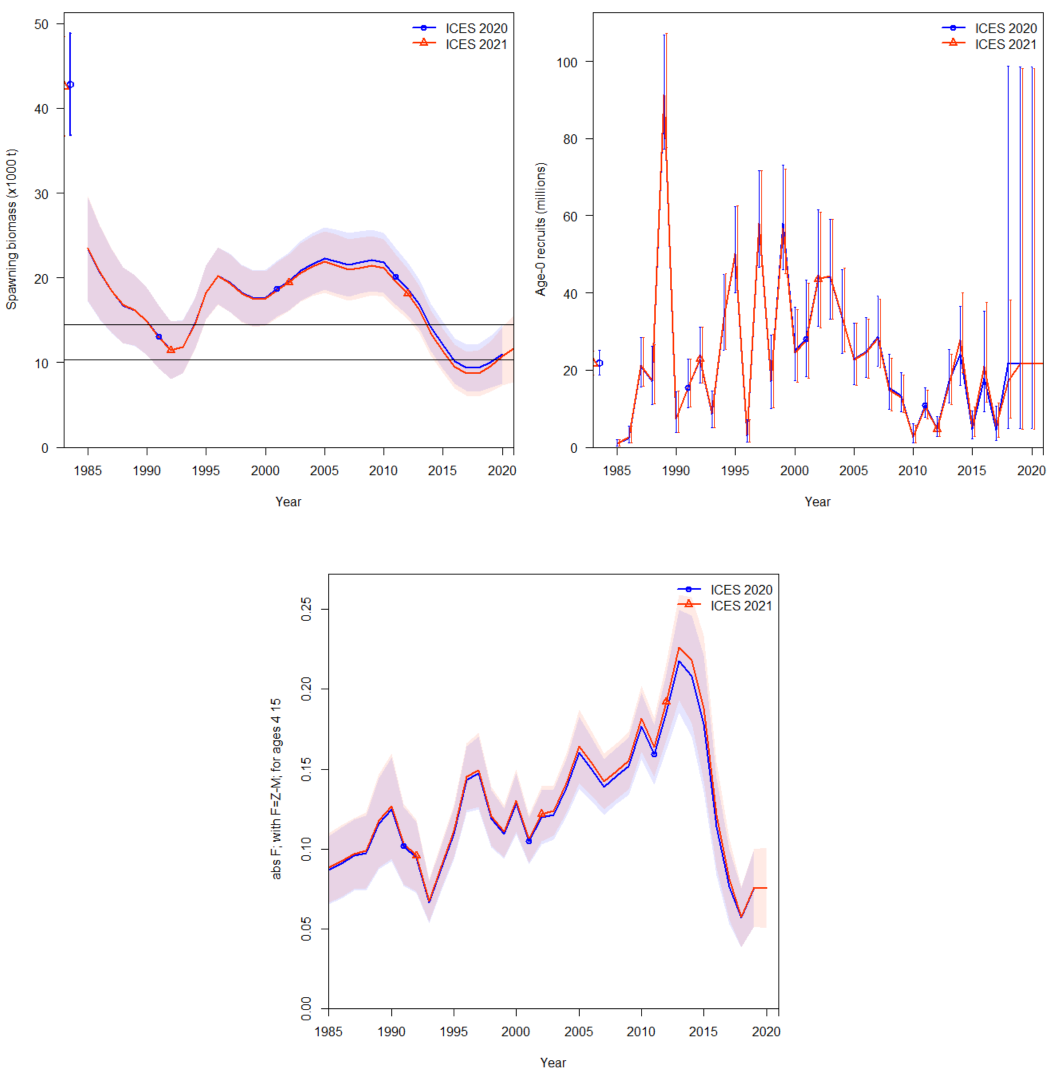


Figure 33. Bss.27.4bc7ad–h: Comparison between stock trends from this year's final update assessment and the 2020 WGCSE assessment.

31 Sole in Division 7.a (Irish Sea)

Type of assessment in 2021

This assessment is an update assessment.

ICES advice applicable to 2021

In the advice for 2021, the stock status was presented as follows:

		Fishing pressure				Stock size			
		2017	2018	2019		2018	2019	2020	
Maximum sustainable yield	F_{MSY}	✓	✓	✓	Below	MSY $B_{trigger}$	✗	✗	✓ Above trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	○	○	✓ Full reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	– Not applicable

ICES advises that when the MSY approach is applied, catches in 2020 should be no more than 768 tonnes.

Comments made by the audit of last year's assessment

No major deficiencies for the sole assessment in the Irish sea were reported.

31.1 General

Stock description and management units

The sole fisheries in the Irish Sea are managed by TAC (see text tables below) and technical measures, with the assessment area corresponding to the stock area. Technical measures in force are minimum mesh sizes and minimum landing size (24 cm). In addition, beam trawlers, fishing with mesh sizes equal to or greater than 80 mm, are obliged to have 180 mm mesh sizes in the entire upper half of the anterior part of their net. More details can be found in Council Regulation (EC) N°254/2002 and the Stock Annex.

Since 2000, a spawning closure for cod has been in force. The first year of the regulation the closure covered the Western and Eastern Irish Sea. Since then, closure has been mainly in the Western part whereas the sole fishery takes place mainly in the Eastern part of the Irish Sea (Liverpool Bay and Cardigan Bay). No direct impact on the sole stock is expected from this closure.

For 2009, Council Regulation (EC) N°43/2009 allocates different amounts of kW*days by Member States and area to different effort groups of vessels depending on gear and mesh size. The area's are Kattegat, part of IIIa not covered by Skagerrak and Kattegat, ICES zone IV, EC waters of ICES zone IIa, ICES zone VIId, ICES zone VIIa, ICES zone VIa and EC waters of ICES zone Vb. The grouping of fishing gear concerned are: bottom trawls, Danish seines and similar gear, excluding beam trawls of mesh size: TR1 (≥ 100 mm) – TR2 (≥ 70 and < 100 mm) – TR3 (≥ 16 and < 32 mm); beam trawl of mesh size: BT1 (≥ 120 mm) – BT2 (≥ 80 and < 120 mm); gillnets excluding trammelnets: GN1; trammelnets: GT1 and Longlines: LL1.

For 2010-–2016, Council Regulation (EC) N°53/2010, Council Regulation (EC) N°57/2011, Council Regulation (EC) N°43/2012, Council Regulation (EC) N°40/2013, Council Regulation (EC) N°43/2014, Council Regulation (EC) N°2015/104 and Council Regulation (EC) N°2016/72 were updates of the Council Regulation (EC) N°43/2009 with new allocations, based on the same effort groups of vessels and areas as stipulated in Council Regulation (EC) N°43/2009.

Since the 1st of April 2015 all Belgian beam trawl vessels with mesh size of 80–119 mm fishing in ICES Division 7.a are obliged by national decree to use the 'Flemish Panel' to increase selectivity. This means the last tapered netting section of a beam trawl anterior is directly attached to the codend, the upper and lower netting sections are constructed of at least 120 mm mesh (as measured between the knots) and the stretched length is at least 3 m.

Management applicable to 2020 and 2021

TAC 2020

Species:	Common sole *Solea solea*	**Zone:**	7a (SOL/07A.)
Belgium	213	Analytical TAC	
France	3	Article 3 of Regulation (EC) No 847/96 shall not apply	
Ireland	77	Article 4 of Regulation (EC) No 847/96 shall not apply	
The Netherlands	68		
United Kingdom	96		
Union	457		
TAC	457		

The agreed TAC for 2021 was not available.

Fishery in 2020

A full description of the fishery is provided in the Stock Annex, Section A2.

An overview of the landings data provided and used by the Working Group (WG) is shown in Table 31.1. The landings reached a level of 2808 t in the mid-1980s due to good recruitments in 1982–1984, but then subsequently dropped to a lowest of 818 t in 2000. After a small increase to 1090 t in the beginning of the 2000s, the landings have fallen to under 350 t in 2008–2012. From 2013 to 2018, the landings continued to decrease as they dropped to under 150 t. In 2017, the record low value of 34 t was recorded. From 2016 to 2018, there has been no targeted fisheries for sole in ICES Division 7.a. Afterwards the landings increased again to about 400 t.

In 2020, the WG estimated landings are 404 t, of which Belgium landed 73% (295 t), Ireland 12% (48 t), 13% (54 t) by the UK (England & Wales) and the remainder by Northern Ireland, Scotland and France. This corresponds to an international uptake of 88% of the agreed TAC in 2020 (457 t) and last year’s forecast.

The WG estimate of the 2019 landings was not revised.

In 2020, 91% of the landings were taken by beam trawls, 7.6% by otter trawls, <2% by other gears.

31.2 Data

Landings

Age compositions for 2020 were available from the countries that take the major part of the international landings (98%) (Belgium, UK (E&W) and Ireland). The raw age data were combined for the three countries without weighting. The combined ALK was applied to the raised length distribution of the national catches to obtain a combined age distribution. This distribution was applied to the landings from Northern Ireland, Scotland and France to obtain the catch numbers-at-age for 2020 (Table 31.2, Figure 31.1). The standardised catch proportion-at-age is presented in Figure 31.2. Annual length distributions of the three major countries involved are given in Table 31.3. Because of the substantial reduction of the TAC in 2014–2018, sampling levels in this period were also substantially reduced.

Catch weights-at-age for 2020 were taken from the combined age–weight key (Table 31.4).

Stock weights-at-age for 2000–2020 were derived from the mean catch weights by cohort interpolation to the first of January (Rivard weight calculator) (Table 31.5).

Further details on raising methods are given in the stock annex.

As last year, the combined age data (calculated outside InterCatch) as well as the landings from Northern Ireland, Scotland, Isle of Man and France were uploaded to InterCatch. It should be noted that the international age distribution is uploaded as "BE" as no international country code is available in InterCatch at present.

Discards

The available discard information (Table 31.6 and Figure 31.3) suggests that discarding is not a major problem in the Irish Sea sole fishery. However, discards have increased recently from 3.5% (average 2016–2018) to 10% (average 2018–2020). Belgian beam trawl length distributions of retained and discarded catches of sole for 2020 (Figure 31.3) indicate that predominantly 2 and 3-year old fish are discarded. In 2020, no observer information from the UK and Irish fleet was available. The working group decided not to include discards in the assessment at this stage due to the scarcity of the data, but will monitor the situation in the future.

As an attempt, estimating an overall discard rate for the stock, individual discard estimates for 2018–2020 from the main métiers and countries (Belgium, Ireland and UK) were averaged to obtain an overall discard rate (Table 31.6b). In 2020, only discard information from the Belgian beam trawl fleet was provided. The percent of the métiers with discard information covering the total international landings is 66%, 90% and 74% for 2018, 2019 and 2020 respectively. Assuming that discard rates do not change from the average of the last three years (2018–2020) and a fixed proportion of discards survive, a discard rate of around 10% (of the catch) could be assumed for this stock at the moment.

Biological

Natural mortality, maturity and proportions of natural mortality and fishing mortality before spawning were set as in previous years, details of which can be found in the Stock Annex Section B2.

Surveys

The UK (E&W) September beam-trawl survey (UK(E&W)-BTS-Q3) was unable to cover the 7.a division in 2020 due to the Covid-19 disruption. Therefore, the final year is missing from the lpue and effort series (1988–2019). The UK (E&W) March beam-trawl survey (UK(E&W)-BTS-Q1) provides information from 1993 to 1998 (Tables 31.7b and Figure 31.4). From 2006 until 2010, the two UK beam trawl surveys have been used as tuning indices in the Irish Sea sole assessments. Following the outcome of WKFLAT 2011, the March survey (UK(E&W)-BTS-Q1) was omitted from the following assessments.

The lpue from the UK(E&W)-BTS-Q3 has fluctuated since the beginning of the time-series (1988) between 90 and 200 kg/100 Km fished. Since 2000, it has dropped gradually to the lowest value in 2012 (26.47 kg/100 Km fished). Thereafter, it slowly increased to 118.66 kg/100 Km fished in 2019.

The UK[E&W]-BTS-Q3 survey was unable to cover the 7.a division in 2020 due to Covid-19. The assessment was performed without tuning data for 2020.

Detailed information on the survey protocols and area coverage can be found in the Stock Annex.

Commercial lpue

Trends in lpue and effort are given in Table 31.7 and Figures 31.5a and 31.5b.

Commercial lpue and effort data were available for Belgian beam trawlers, UK (E&W) beam and otter trawlers and Irish otter and beam trawlers. It should be noted that the most recent lpue values of the UK (E&W) beam trawlers (2013–2019) and the UK (E&W) otter trawlers (2014–2020) are not available as the effort values (hours fished) for those years are missing. In 2013, the UK administration switched to the EU electronic logbook system. Therefore, a lot of the reported effort is missing and the 2013 value cannot be used as an absolute number. Details of the 2013 UK beam trawl were unavailable due to reduced numbers of trips reporting this gear specific effort information via the newly introduced e-logbook system. The otter trawl fleet effort reporting was unaffected by this as these vessels were not reporting their landings via this method in 2013. However, from 2014 onwards both the UK beam trawl and otter trawl effort values are unavailable because of the reporting issues.

Effort from both Belgian and UK commercial beam trawl fleets increased from the early seventies until the beginning of the nineties. Since then UK beam trawl effort has shown a continuing declining trend. Inspection of an alternate effort indicator (days fished) suggests that the declining trend continues in the period 2013–2018, followed by a slight increase in 2019. In 2020, effort continues to increase to a similar level as observed in 2007. In contrast, the Belgian beam trawl effort has shown a more fluctuating pattern. After the decline in the early nineties, it reached its highest level in 2002 and decreased again afterwards. For the period 2008–2012, it remained stable at a very low level but in 2013 it continued to decrease, and in 2016 it dropped to the lowest level in the time-series. In 2017–2018, there's a slight increase. In 2019 and 2020, effort further increased to the level recorded in 2012. The substantial decrease of the Belgian and UK commercial beam trawl effort in the period 2013–2018, is in line with the substantial reductions of the TAC. From 2019 onwards, a sole directed fisheries is again allowed, and a higher TAC is set. This is clearly reflected in the higher activity of the Belgian beam trawlers in 2019 and 2020.

The effort of the Irish beam trawlers shows a slow decline since 2004 and reached the lowest level in the time-series in 2013. Since 2014, the Irish beam trawl effort has increased, followed by a slight decrease in 2020. In 2008, all beam trawl fleets showed a substantial reduction in effort compared to 2007.

The effort from the UK otter trawlers remained stable until the beginning of the nineties. Since then the UK otter trawl effort has continuously declined and is at the lowest level in 2013. As, in 2015 and 2016 all otter trawl vessels active in the Irish Sea were under 12 m, no effort (days fished) was recorded. Since 2017, the otter trawl effort (days fished) has increased, followed by a decrease in 2020. The Irish otter trawlers have shown a striking reduction in effort since 2000, followed by a slight increase in the period 2010-2012. In 2017, the Irish otter trawl effort fell back to the lowest observed level in the time-series. It remains at this lower level, except for the slightly higher value observed in 2019.

Lpue for both UK and Belgian beam trawlers was at a high level in the late seventies and early eighties but since early 2000s, lpue for these fleets has fluctuated at a lower level. In the period 2007–2009 there has been a small increase in the UK beam trawl lpue. However, in 2012 the lpue has dropped to a remarkable low level in the time-series (4.3 kg/hour fished). An update for 2013–2017 was not available. However, the alternate lpue indicator (kg/days fished) suggests that the UK beam trawl lpue increased in 2015. For 2016–2018 no catches of sole and/or no effort were recorded therefore the lpue is zero. After a slight increase in 2019, the lpue further increased in 2020 to a similar level as observed in 2009. The Belgian beam trawlers hold on to a higher lpue value (18–20 kg/hour fished) for the period 2008–2012. However, in 2013 the lpue decreased (13.2 kg/hour fished) and in 2017 it dropped to the lowest level in the time-series (3.8 kg/hour fished). In 2018, there's a slight increase to 5.4 kg/hour fished, followed by a substantial increase to 32.3 kg/hour fished in 2019 and 30.8 kg/hour fished in 2020. The Irish beam trawl lpue shows a gradually diminishing trend over the whole time-series. After the slight increase in 2013, it fell back to a record low level in 2016–2018. In 2019 and 2020, there's a slight increase.

The UK otter trawl lpue remained stable until the beginning of the 2000s but is at the record low level in 2012. The alternative lpue indicator (kg/days fished) suggests that the declining trend continues after 2012. In 2018, there's a slight increase to the level observed in the period 2011–2012 (12.6 kg/days fished). The increasing trend continues to 48.5 kg/days fished in 2019 and 97.2 kg/days fished in 2020. In 2012–2016, the lpue of Irish otter trawlers is fluctuating at a lower level. In 2017–2020 a higher value was recorded.

In 2020 during which the COVID-19 disruptions took place, a shift between the UK beam and otter trawl fleet was noted, as the activity of the beam trawlers substantially increased whereas that of the otter trawlers was substantially reduced. Further, no substantial changes in effort or lpue compared to 2019 were recorded.

Historical Stock Development

In 2010, the Irish Sea sole assessment was based on XSA with two survey tuning indices (UK(E&W)-BTS-Q3 and UK(E&W)-BTS-Q1 (Table 31.8). The UK(E&W)-BTS-Q1 indices only provide information for the years 1993 up to 1999 and therefore no longer contribute to the final survivor estimates. At WKFLAT 2011, the exclusion of the UK(E&W)-BTS-Q1 from the assessment was investigated, and it was found that there was little effect on the catchability residuals and that the retrospective pattern was slightly improved. WKFLAT 2011 therefore decided to omit this survey from the assessment. In 2020, the assessment was performed without tuning data for 2020, as the UK(E&W)-BTS-Q3 could not take place in Division 7.a due to the Covid-19 disruptions.

31.3 Stock assessment

Data screening

The age range for the analysis was 2–8+.

The screening of the tuning indices (UK(E&W)-BTS-Q3) showed good cohort tracking (Figure 31.6a) and consistency between ages for year-class strength (Figure 31.7).

Final Update Assessment

The model settings for the final assessment are summarized below.

Assmnt Year	:2010	:2011–2020
Assmnt Model	: XSA	:XSA
Fleets	:	:
Bel Beam Trwl	: omitted	:omitted
UK Trawl	: omitted	:omitted
UK Sept BTS	:1988–2009 2–7	:1988–2019 2–7
UK Mar BTS	:1993–1999 2–7	:omitted
Time Ser. Wts	: linear 20 yrs	:no taper weighting
Power Model	: none	:none
Q plateau	: 7	:4
Shk se	:1.5	:1.5
Shk age-yr	:5 yrs 3 ages	:5 yrs 3 ages
Pop Shk se	: 0.3	: 0.3
Prior Wting	: none	: none
Plusgroup	:8	: 8
F_{bar}	: 4–7	: 4–7

The UK[E&W]-BTS-Q3 survey was unable to cover the 7.a Division in 2020 due to Covid-19. The assessment was performed without tuning data for 2020. Therefore, the recruitment estimate for 2020 is considered uncertain, and is replaced by the geometric mean of recruitment (GM, 2015–2019).

The final XSA output is given in Table 31.9 (diagnostics), Table 31.10 (fishing mortalities) and Table 31.11 (stock numbers). Log catchability residuals for the final assessment are given in Figure 31.8. A summary of the XSA results is given in Table 31.12 and trends in yield, fishing mortality, recruitment and spawning–stock biomass are shown in Figure 31.9. Retrospective patterns for the final run are shown in Figure 31.10.

Adding the 2020 data to the time-series did not cause any additional anomalies compared to last year. The log catchability residual pattern showed no trends apart from the year effect in 2016. The positive residuals (higher estimates from the UK(E&W)-BTS-Q3 fleet compared to the VPA estimates) in 2016 are likely due to the fact that de age composition in the catch is flattened.

The survivor estimates and fishing mortality estimates are almost entirely determined by the UK(E&W)-BTS-Q3 survey as it gets a high weighting (>96%) at all ages.

A Mohn’s rho analysis was conducted based on the XSA stock assessment results, i.e. the last data year (2020) was used as the final year for comparison of SSB, F and recruitment and based on a five-year retrospective analysis. The results from the Mohn's rho analysis are shown in the following table:

	SSB	F (ages 4–7)	recruitment
Mohn's rho value	0.023	-0.033	-0.027

The Mohn's rho values for this assessment are very low and are well within the range of -15% and +20% imposed by ICES for 2021 assessments, i.e. the current assessment indicates a high consistency.

Comparison with previous assessments

A comparison of the estimates of this year's assessment with last year's is given in Figure 31.11. Trends in fishing mortality, SSB and recruitment are very similar.

State of the stock

Estimated trends of Irish Sea sole landings, SSB, fishing mortality and recruitment are presented in Table 31.12 and Figure 31.9. Since the late eighties, the landings of Irish Sea sole have been declining to the lowest level of the time-series (34 t) in 2017. SSB has been at a higher level until the late eighties. Since then SSB has been fluctuating between B_{pa} and B_{lim} and since 2004, it dropped below B_{lim}. After the record low value in 2014 (874 t), SSB gradually increased again to 3493 t in 2020. High fishing mortalities were observed during the late eighties until the mid-nineties. Thereafter fishing mortality declined to a level fluctuating just above F_{lim}. From 2013 onwards, fishing mortality has dropped under the level of F_{pa}/F_{MSY}. In 2018, the lowest level of the time-series was recorded (0.0141). The decline in F is supported by a substantial reduction of the TAC in this period. In 2019, F increased again to 0.148 and was 0.131 in 2020. Since 2001, recruitment has been well below the mean (5459 thousand fish) and the 2011 recruitment (year class 2009) is estimated to be the lowest in the time-series (636 thousand fish). The 2016 recruitment (4580 thousand fish, year class 2014) is estimated to be 7 times higher than the record low recruitment in 2011. The lower 2017 recruitment (1840 thousand fish) is followed by a higher recruitment in 2018 (4280 thousand fish) and in 2019 (3463 thousand fish). The 2020 recruitment value was considered uncertain because of the lack of the UK[E&W]-BTS-Q3 survey data for 2020. Therefore, the recruitment estimate for 2020 is replaced by the geometric mean of recruitment (2931 thousand fish, GM, 2015–2019).

31.4 Short-term projections

Estimating year-class abundance

The 2011–2014 recruitments have been the lowest in the time-series. Higher recruitment was observed from 2015 onwards. The 2017 year class ((2019 recruitment) is now estimated at 3463 thousand fish at age 2 (Table 31.12), which is 158% higher than the short-term GM (2009–2017 (1339 thousand fish) used in the 2019 forecast. The age 2 estimates are almost solely coming from the UK(E&W)-BTS-Q3. From 2010 to 2014, the UK(E&W)-BTS-Q3 abundance for age 2 fluctuated around the level of the lowest abundance in 2011 (0.29). In 2016, the UK(E&W)-BTS-Q3 abundance for age 2 increased to the higher level of early 2000 (2.97). In 2017, there's a decrease (0.8), followed by slightly higher values in 2018 (2.18) and 2019 (1.78). Survey data for 2020 are not available.

Figure 31.6b shows the age 1 and age 2 UK(E&W)-BTS-Q3 abundances by year class. There is a good agreement between age 1 and age 2 of the same year class. Age 1 in 2019 shows the third highest peak of the time-series, suggesting that the age 2 abundance in 2020 would also be relatively high. Given the consecutive higher recruitments from 2015 onwards and the high age 1 value in the 2019 UK(E&W)-BTS-Q3 survey, the WG decided to assume a shorter term GM (2015–2019, 2931 thousand fish) for the 2019 year class instead of the 2010–2019 GM (1579 thousand fish). This shorter term GM (2015–2019) recruitment was also assumed for the 2020 and subsequent year classes.

The working group estimates of year-class strength used for prediction can be summarised as follows:

Year Class	XSA	GM 10-19	GM 15-19
2018 (age 3 in 2021)	2637	1348	-
2019 (age 2 in 2021)	-	1579	2931
2020 & 2021 (recruits)	-	1579	2931

Fishing mortality was calculated as the mean of 2018–2020, scaled to 2020 (0.1307). Catch and stock weights-at-age were also averages for the years 2018–2020. Population numbers at the start of 2021 for ages 3 and older, were taken from the XSA output.

The working group agreed to use a landings constraint (691 t) for the intermediate year (2021). The TAC for 2021 was not available, therefore the ICES catch advice (768 t) minus the estimated discards (77 t) was used. Because of the restricted fishing opportunities by the main countries fishing for Irish Sea sole, it seemed reasonable that the landings in 2021 would be in line with the ICES advice. However, it should be noted that the COVID-19 crisis and the uncertainty around the TAC for 2021 could have an impact on the uptake of the final TAC.

The input for the short-term catch predictions and sensitivity analysis is given in Table 31.13, the short-term management option table is given in Table 31.14 and a detailed output is presented in Table 31.15.

Assuming a landings constraint for 2021 of 691 t, implies a fishing mortality in 2021 of 0.182. The assumed landings using a *status quo* fishing mortality scaled to 2020 (0.1307) in 2022 is 479 t. This results in an SSB of 4067 t in 2021 and 3974 t in 2022. The proportional contributions of recent year classes to the predicted landings and SSB are given in Figure 31.12. The assumed short-term GM recruitments accounts for about 15% of the landings in 2022 and about 26% of the 2023 SSB.

31.5 MSY explorations

Investigations for possible F_{MSY} candidates for this stock were carried out at WGCSE 2010. ACOM adopted an F_{MSY} value of 0.16, based on stochastic simulations using a Ricker model (PLOTMSY program). $B_{trigger}$ was set to the B_{pa} value of 3100 t.

Exploratory analysis investigating possible revisions of MSY estimates were conducted at WGCSE 2014 with a recent version of PLOTMSY (Cefas, 2014). The simulations indicated the use of equally weighting for the stock recruitment relationships and the resulting F_{MSY} value was in line with the F_{MSY} of 0.16 used at that moment for this stock.

In response to the EC long-term management plans for western EU waters (ICES subareas 5 to 10), ICES WKMSYREF4 (October 2015, Brest (France)) used long-term stochastic simulations

(Eqsim) to estimate F_{MSY} and appropriate ranges. The methodology used for stocks with age-based assessments follows the approaches developed in ICES WKMSYREF2 (ICES, 2014a) and WKMSYREF3 (ICES, 2014b) and is documented in the report of WKMSYREF4 (ICES, 2016a). Estimates of reference points B_{lim}, B_{pa}, F_{lim} and F_{pa} were provided, and the F_{MSY} ranges [F_{lower}, F_{upper}] deliver no more than 5% reduction in long-term yield compared with MSY.

The sole 7.a stock was at a low level during 2010–2015, and mean recruitment has been seen to be reduced at these low biomass values, simulations were conducted with S–R function (Beverton–Holt and Ricker models) that followed the mean of the recruitment data, giving some reduction in recruitment at B_{lim}. The revised MSY reference points are less restrictive (F_{MSY}=0.20 instead of 0.16 and MSY $B_{trigger}$=3500 t instead of 3100 t).

In order to be consistent with the ICES precautionary approach, F_{upper} is capped, so that the probability of SSB < B_{lim} is no more than 5%. Two approaches have been used to derive the values of the cap on F_{upper}. One conforms to the ICES MSY advice rule (AR), and requires reducing F linearly towards zero when SSB is below MSY $B_{trigger}$. The second uses a constant F without an advice rule; i.e. no reduction in F with SSB less than MSY $B_{trigger}$. Although the first often provides a wider F_{MSY} range, it requires the ICES MSY advice rule to be used (ICES, 2016b).

Stock code	MSY F_{lower}	F_{MSY}	MSY F_{upper} with AR	MSY F_{upper} with no AR
Sol.27.7a	0.16	0.20	0.24	0.22

31.6 Biological reference points

Precautionary approach reference points

The Working Group's current approach to reference points is outlined in Section 31.5. Current biological reference points are given in the text table below:

Reference points	ACFM 2007 onwards	2016 onwards	2021 onwards
F_{MSY}	0.16 (PLOTMSY, WG2010)	0.20 (Eqsim, WKMSYREF 4)	0.20 (Eqsim, WKMSYREF 4)
F_{lim}	0.4 (based on F_{loss})	0.29 (based on simulated recruitment to give median biomass = B_{lim})	0.29 (based on simulated recruitment to give median biomass = B_{lim})
F_{PA}	0.3 (high probability of avoiding F_{lim})	0.21 (F_{lim}*1.4)	0.22 ($F_{p.05}$; F that leads to SSB ≥ B_{lim} with 95% probability)
B_{lim}	2200 t (B_{loss} estimated in 2007)	2500 t (lowest value with above average recruitment)	2500 t (lowest value with above average recruitment)
B_{PA}	3100 t (B_{pa}~B_{lim}*1.4)	3500 t (B_{lim} *1.4)	3500 t (B_{lim} *1.4)
$B_{trigger}$	B_{PA}	3500 t	3500 t

31.7 Management Plans

No management plan is currently in place for Irish Sea sole.

31.8 Uncertainties and bias in assessment and forecast

Sampling

The deteriorating quality of the historic catch numbers-at-age data were considered to be a consequence of the low biological sampling intensity, and in particular, the limited sampling in the first quarter. Therefore, the combined age distribution was introduced in 2000 as an alternative method for raising the international catch numbers-at-age. The mean catch weights from this combined key were taken and the stock weights-at-age were obtained using a cohort interpolation method from the catch weights-at-age. Under the DCF there is an initiative to co-ordinate sampling across the three countries involved in the fishery. However, as the TAC is substantially reduced in recent years, sampling levels were also significantly reduced. In 2019, the TAC increased again and additionally a scientific sole quota is reserved for Belgian vessels fishing in ICES Division 7.a to assure a qualitative sampling. Due to Covid-19, only discard information from the Belgian beam trawl fleet was provided for 2020.

Landings

There is no reliable information on the accuracy of the landing statistics. For the period 2005–2012, the total TAC uptake was only in the range of 50–98%. In this context, misreporting was not considered to be a major problem. In the most recent years, the TAC was substantially reduced and was restrictive in 2013 and 2014. In 2015–2019, 84%–97% of the TAC has been taken. 404 t sole were landed and 42 t were discarded in 2020, a total catch of 446 t, while the agreed TAC was 457 t.

Discards

The absence of discard data in the assessment is considered to have a minor effect on the quality of the assessment, as the average discarding by weight has been low in the past (3–8%). However, in 2019 and 2020, a discard rate of 14% and 12% respectively was recorded. If this increase in discarding continues, it might be recommended to included discards in the assessment.

Effort

There are no indications of Irish Sea sole fisheries misreporting effort. Effort in beam trawl fisheries that target sole has declined substantially in the last few years in accordance with the significant reductions in TAC. In 2019 and 2020, higher effort values were recorded as the TAC increased from 40 t (2018) to 414 t (2019) and 457 t (2020) and sole directed fisheries were again allowed.

Surveys

The UK(E&W)-BTS-Q3 survey appears to track year-class strength well. As previously investigated, this tuning fleet is also consistent in estimating year-class strength of the same year class at different ages. Therefore, the Working Group had confidence in using the UK(E&W)-BTS-Q3

survey as the only tuning fleet. The bias problem in the assessment maybe the result of the precise survey and less precise catch-at-age data.

The 2020 recruitment value was considered uncertain because of the lack of The UK[E&W]-BTS-Q3 survey data for 2020. The age 2 estimates are almost solely coming from the UK(E&W)-BTS-Q3. Therefore, the recruitment estimate for 2020 is replaced by the geometric mean of recruitment (2931 thousand fish, GM, 2015–2019).

Model formulation

At present XSA is used to assess Irish Sea sole. In the WG of 2007 the model settings were changed which had a considerable impact on the estimates of SSB and fishing mortality. Due to these major revisions, ACFM changed the biomass reference points at its meeting of 2007. In the next two update assessments (2008–2009) no major changes were apparent. In the assessment of 2011, the settings were changed according to the outcome of WKFLAT 2011. The following assessments were update assessments. In 2016, the reference points were updated (see Section 31.5–31.6).

31.9 Recommendations for next Benchmark

The assessment diagnostics indicate a good correlation between the catch data and the survey tuning series. However, in the recent years there has been great uncertainty from the fishing industry on the actual status of the sole stock in the Irish Sea. Fishermen are concerned that due to ecosystem changes and the changing fishing behaviour in the Irish Sea, science is no longer capturing the current situation. Because of this mismatch, an EU action plan for the Irish Sea fisheries was set up. First, a comparative fishing study was suggested to compare the catch efficiency between the UK-BTS-Q3 and a Belgian commercial vessel. Secondly, a pilot industry–science beam trawl survey should reveal the spatial distribution of sole. The outcome of those work packages will indicate whether the data gathered by the UK-BTS-Q3 are still representative for the current situation or whether the implementation of an additional (annual) industry–science industry survey is needed. Thirdly, stock identification techniques (i.e. genetic fingerprinting and otolith shape analysis) will be performed to give insight on the origin and potential migration routes of sole that is caught in the Irish Sea.

The industry survey was not able to identify other areas of importance for sole in the Irish Sea than is already covered by the UK-BTS-Q3. Also, catchability and composition of catches in both surveys were comparable. These results suggest that the UK-BTS-Q3 gives a good representation of sole abundance and that an annual industry survey additional to this survey would not be of added value to the assessment. With regards to the stock identification study, the combination of otolith shape analysis and genetic markers (SNPs) show subtle differences between the Irish Sea, Celtic Sea and Bristol Channel populations. However more samples from the different areas and from different years need to be analyzed to reveal what is driving these differences. Also, in the attempt to effectively reassign adult sole to their place of origin, it would be preferable to include a third stock identification technique: micro-chemical fingerprinting. Despite many questions yet unsolved, the pilot industry survey delivered valuable information that can be added to an ecosystem model for the Irish Sea (one of the aims of WKIrish: an ecosystem benchmark for the Irish Sea). Moreover, the survey was an example of a fruitful cooperation between fishermen and fisheries scientists, and gave useful insights on how to cooperate with the fishing industry and to gain their trust in the collection of fisheries-independent data.

31.10 Management considerations

There is a stock–recruitment relationship for this stock and evidence of reduced recruitment at low levels of SSB. However, the recruitment for higher levels of SSB is less well defined (Figure 31.13).

Recruitment-at-age 2 has been well below average since 2001. In 2016 and 2018, recruitment is estimated to be six times higher than the record low levels in 2011–2014. SSB has increased since 2014 and is between B_{lim} and MSY $B_{trigger}$ in 2018 and 2019. SSB in 2020 was 3493 and slightly below MSY $B_{trigger}$ (3500 t). Over the last couple of years fishing mortality has decreased to close to zero. In 2019 and 2020, fishing mortality increased but is still well below F_{MSY}.

Sole is caught in a mixed-fishery with other flatfish as well as gadoids. Information from observer trips indicates that discarding of sole is relatively low.

31.11 Ecosystem considerations

Sole and plaice are primarily targeted by beam trawl fisheries. Beam trawling, is known to have an impact on the benthic communities, although less so on soft substrates and in areas which have been historically exploited by this fishing method. Some beam trawlers are using benthic drop-out panels that release about 75% of benthic invertebrates from the catches. Full square mesh codends are being tested in order to reduce the capture of benthos further and improve the selection profile of gadoids (Connolly, P.L. *et al.*, 2009).

A complete ecosystem overview can be found in the stock annex Section A.3.

31.12 References

Connolly, P.L., Kelly, E., Dransfeld, L., Slattery, N., Paramor, O.A.L., and Frid, C.L.J. 2009. MEFEPO North Western Waters Atlas. Marine Institute.

ICES. 2014a. Report of the Workshop to consider reference points for all stocks (WKMSYREF2), 8–10 January 2014, ICES Headquarters, Copenhagen, Denmark. ICES CM 2014/ACOM:47. 91 pp.

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Table 31.1. Sol.27.7a - Nominal landings (tonnes) as officially reported by ICES, and working group estimates of the landings. Last year's landings are preliminary.

Year	Belgium	France	Ireland	Netherlands	UK (E+W)	UK (Isle of Man)	UK (N. Ireland)[1]	UK (Scotland)	Officially reported	Unallocated	Total used by WG	TAC
1973	793	12	27	281	258	-	46	11	1428	0	1428	
1974	664	54	28	320	218	-	23	-	1307	0	1307	
1975	805	59	24	234	281	-	24	15	1442	-1	1441	
1976	674	72	74	381	195	-	49	18	1463	0	1463	
1977	566	39	84	227	160	-	49	21	1146	1	1147	
1978	453	65	127	177	189	-	57	30	1098	8	1106	
1979	779	48	134	247	290	-	47	42	1587	27	1614	
1980	1002	41	229	169	367	-	44	68	1920	21	1941	
1981	884	13	167	186	311	-	41	45	1647	20	1667	
1982	669	9	161	138	277	-	31	44	1329	9	1338	
1983	544	3	203	224	219	-	33	29	1255	-86	1169	
1984	425	10	187	113	230	-	38	17	1020	38	1058	
1985	589	9	180	546	269	-	36	28	1657	-511	1146	
1986	930	17	235	-	637	1	50	46	1916	79	1995	
1987	987	5	312	-	599	3	72	63	2041	767	2808	2100
1988	915	11	366	-	507	1	47	38	1885	114	1999	1750
1989	1010	5	155	-	613	2	.	38	1823	10	1833	1480
1990	786	2	170	-	569	10	.	39	1576	7	1583	1500
1991	371	3	198	-	581	44	.	26	1223	-11	1212	1500
1992	531	11	164	-	477	14	.	37	1234	25	1259	1350
1993	495	8	98	-	338	4	.	28	971	52	1023	1000
1994	706	7	226	-	409	5	.	14	1367	7	1374	1500
1995	675	5	176	-	424	12	.	8	1300	-34	1266	1300
1996	533	5	133	149	194	4	.	5	1023	-21	1002	1000
1997	570	3	130	123	189	5	.	7	1027	-24	1003	1000
1998	525	3	134	60	161	3	.	9	895	16	911	900

Year	Belgium	France	Ireland	Netherlands	UK (E+W)	UK (Isle of Man)	UK (N. Ireland)[1]	UK (Scotland)	Officially reported	Unallocated	Total used by WG	TAC
1999	469	<1	120	46	165	1	.	8	810	53	863	900
2000	493	3	135	60	133	1	.	8	833	-15	818	1080
2001	674	4	135	-	195	+	.	4	1012	41	1053	1100
2002	817	4	96	-	165	+	.	3	1085	5	1090	1100
2003	687	4	103	-	217	+	.	3	1014	0	1014	1010
2004	527	1	77	-	106	+	.	1	712	-3	709	800
2005	662	3	85	-	103	+	.	1	854	1	855	960
2006	419	1	85	-	69	+	.	2	576	-7	569	960
2007	305	1	115	-	66	<1	.	4	491	1	492	820
2008	216	1	66	-	37	n/a	.	n/a	320	12	332	669
2009	257	n/a	47	-	19	1	.	1	325	0	325	502
2010	217	<1	47	-	12	<1	.	n/a	277	0	277	402
2011	250	<1	48	-	31	<1	.	n/a	330	0	330	390
2012	222	<1	51	-	23	<1	-	n/a	296	0	298	300
2013	96	<1	40	-	12	<1	-	n/a	148	0	148	140
2014	43	n/a	43	-	10	<1	-	n/a	96	0	99	95
2015	37	n/a	32	-	7	n/a	-	n/a	76	0	76	90
2016	14	n/a	15	-	6	n/a	-	n/a	35	0	35	40
2017	14	n/a	14	-	4	n/a	-	n/a	32	2	34	40
2018	14	n/a	16	-	6	n/a	-	n/a	36	0	36	40
2019	329	<1	55	-	15	n/a	-	n/a	400	0	400	414
2020	284	<1	48	-	65	<1	-	n/a	398	6	404	457

[1] 1989 onwards: N. Ireland included with England & Wales.

Table 31.2. Sol.27.7a - Catch numbers-at-age (in thousands).

Age/Year	1970	1971	1972	1973	1974	1975	1976	1977	1978
2	29	113	31	368	25	262	29	221	65
3	895	434	673	363	891	733	375	416	958
4	1009	2096	730	2195	576	2386	1331	1292	649
5	467	1130	1538	557	1713	539	2329	774	1009
6	1457	232	537	815	383	842	247	1066	442
7	289	878	172	267	422	157	544	150	638
+gp	2537	1886	1501	1143	971	1006	739	648	587
Age/Year	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**
2	108	187	70	8	37	651	154	141	189
3	1027	940	580	346	165	786	1600	3334	3347
4	3432	1969	1668	1241	998	380	1085	3465	4104
5	829	3057	1480	1298	758	610	343	960	3184
6	637	521	1640	711	757	343	334	235	844
7	326	512	114	641	416	424	164	277	307
+gp	620	1146	865	397	709	557	739	848	808
Age/Year	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
2	32	179	564	1316	363	83	122	132	60
3	444	771	1185	1269	2431	543	1343	920	469
4	4747	775	986	841	917	1965	1070	1444	1188
5	2100	3979	598	300	556	559	1579	737	741
6	1309	1178	2320	226	190	251	394	1010	430
7	203	552	592	1172	156	199	133	179	509
+gp	515	255	466	459	928	686	524	350	347

Age/Year	1997	1998	1999	2000	2001	2002	2003	2004	2005
2	790	167	301	178	240	148	437	299	536
3	714	1728	1069	906	1438	930	825	862	1052
4	475	466	1259	907	822	1623	966	342	626
5	711	256	297	600	717	740	795	368	271
6	409	315	115	150	511	575	302	304	314
7	258	191	136	55	80	254	217	139	279
+gp	532	423	232	258	272	217	345	181	368
Age/Year	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
2	112	171	99	92	22	17	17	23	12
3	670	356	353	414	336	225	148	99	49
4	649	348	190	333	233	401	311	75	59
5	203	243	195	146	177	176	274	106	37
6	113	86	156	132	65	97	116	78	38
7	151	41	56	127	72	54	52	34	51
+gp	379	298	209	162	158	122	115	82	56
Age/Year	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**			
2	15	1	2	4	48	96			
3	36	18	41	22	553	282			
4	37	22	19	46	279	425			
5	30	14	15	14	300	176			
6	17	10	5	9	89	192			
7	21	7	6	3	64	79			
+gp	74	32	13	10	82	130			

Table 31.3. Sol.27.7a - Annual length distributions by country (2020).

	UK (England & Wales)	Belgium	Ireland
Length (cm)	All gears	All gears	All gears
20			
21		195	
22	282	1101	
23	304	5815	94
24	1473	36414	94
25	4481	94917	4720
26	16137	110960	3562
27	13395	109472	5073
28	16429	113055	11553
29	24689	110831	18045
30	19074	94971	14521
31	16863	81093	15510
32	14905	70959	10801
33	7029	52870	8411
34	6304	49154	6961
35	6062	34892	9533
36	5802	23562	9147
37	4704	16605	5293
38	3729	13082	2819
39	2566	9819	3105
40	1912	6497	3105
41	1534	4157	317
42	908	2495	
43	446	1931	1225
44	430	1688	755
45	357	924	106
46	179	494	
47		333	
48	89	228	
49	89	70	
50			
51		65	

Table 31.4. Sol.27.7a - Catch weights-at-age (kg).

Age/Year	1970	1971	1972	1973	1974	1975	1976	1977	1978
2	0.13	0.152	0.126	0.151	0.138	0.13	0.12	0.085	0.093
3	0.153	0.178	0.164	0.178	0.174	0.172	0.161	0.146	0.147
4	0.178	0.204	0.201	0.204	0.209	0.21	0.2	0.202	0.197
5	0.204	0.23	0.237	0.23	0.241	0.244	0.239	0.251	0.243
6	0.232	0.257	0.272	0.256	0.272	0.275	0.276	0.293	0.286
7	0.26	0.284	0.306	0.283	0.301	0.303	0.313	0.33	0.326
+gp	0.377	0.419	0.417	0.392	0.396	0.367	0.457	0.387	0.429
Age/Year	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**
2	0.134	0.146	0.162	0.112	0.189	0.191	0.144	0.122	0.135
3	0.165	0.169	0.183	0.171	0.212	0.225	0.189	0.164	0.164
4	0.199	0.193	0.207	0.225	0.238	0.257	0.231	0.203	0.196
5	0.234	0.219	0.234	0.275	0.266	0.288	0.272	0.241	0.231
6	0.271	0.247	0.264	0.321	0.298	0.318	0.31	0.277	0.268
7	0.311	0.275	0.296	0.362	0.332	0.347	0.346	0.311	0.308
+gp	0.451	0.380	0.452	0.456	0.458	0.408	0.430	0.407	0.462
Age/Year	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
2	0.111	0.125	0.135	0.133	0.149	0.102	0.175	0.129	0.156
3	0.147	0.163	0.162	0.172	0.177	0.156	0.198	0.182	0.193
4	0.183	0.201	0.192	0.208	0.207	0.205	0.227	0.232	0.228
5	0.218	0.237	0.227	0.241	0.239	0.248	0.261	0.277	0.263
6	0.252	0.271	0.265	0.272	0.274	0.285	0.301	0.318	0.296
7	0.286	0.304	0.307	0.3	0.31	0.318	0.346	0.356	0.327
+gp	0.419	0.389	0.414	0.345	0.379	0.370	0.509	0.451	0.410

Age/Year	1997	1998	1999	2000	2001	2002	2003	2004	2005
2	0.154	0.187	0.179	0.14	0.175	0.162	0.16	0.17	0.16
3	0.197	0.209	0.217	0.189	0.18	0.172	0.187	0.219	0.203
4	0.237	0.234	0.252	0.25	0.271	0.211	0.247	0.289	0.256
5	0.275	0.263	0.285	0.311	0.293	0.283	0.294	0.338	0.286
6	0.311	0.295	0.314	0.368	0.326	0.328	0.342	0.371	0.312
7	0.345	0.331	0.341	0.428	0.42	0.333	0.326	0.383	0.326
+gp	0.407	0.440	0.399	0.504	0.438	0.375	0.415	0.444	0.352
Age/Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
2	0.179	0.172	0.148	0.141	0.166	0.215	0.187	0.17	0.17
3	0.194	0.224	0.189	0.195	0.193	0.213	0.22	0.213	0.196
4	0.224	0.296	0.248	0.229	0.266	0.276	0.26	0.278	0.269
5	0.297	0.36	0.279	0.279	0.285	0.362	0.311	0.32	0.328
6	0.293	0.38	0.291	0.277	0.321	0.413	0.331	0.347	0.369
7	0.318	0.429	0.386	0.261	0.308	0.368	0.368	0.353	0.397
+gp	0.349	0.479	0.392	0.277	0.335	0.364	0.335	0.354	0.441
Age/Year	2015	2016	2017	2018	2019	2020			
2	0.18	0.187	0.177	0.186	0.186	0.169			
3	0.221	0.223	0.239	0.24	0.22	0.219			
4	0.309	0.269	0.323	0.31	0.278	0.273			
5	0.342	0.356	0.386	0.389	0.324	0.335			
6	0.381	0.332	0.495	0.476	0.392	0.378			
7	0.4	0.414	0.493	0.485	0.366	0.371			
+gp	0.384	0.436	0.457	0.472	0.440	0.38			

Table 31.5. Sol.27.7a - Stock weights-at-age (kg).

Age/Year	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**
2	0.130	0.152	0.126	0.151	0.138	0.130	0.120	0.085	0.093
3	0.153	0.178	0.164	0.178	0.174	0.172	0.161	0.146	0.147
4	0.178	0.204	0.201	0.204	0.209	0.210	0.200	0.202	0.197
5	0.204	0.230	0.237	0.230	0.241	0.244	0.239	0.251	0.243
6	0.232	0.257	0.272	0.256	0.272	0.275	0.276	0.293	0.286
7	0.260	0.284	0.306	0.283	0.301	0.303	0.313	0.330	0.326
+gp	0.377	0.419	0.417	0.392	0.396	0.367	0.457	0.387	0.429
Age/Year	1979	1980	1981	1982	1983	1984	1985	1986	1987
2	0.134	0.146	0.162	0.112	0.189	0.191	0.144	0.122	0.135
3	0.165	0.169	0.183	0.171	0.212	0.225	0.189	0.164	0.164
4	0.199	0.193	0.207	0.225	0.238	0.257	0.231	0.203	0.196
5	0.234	0.219	0.234	0.275	0.266	0.288	0.272	0.241	0.231
6	0.271	0.247	0.264	0.321	0.298	0.318	0.310	0.277	0.268
7	0.311	0.275	0.296	0.362	0.332	0.347	0.346	0.311	0.308
+gp	0.451	0.380	0.452	0.456	0.458	0.408	0.430	0.407	0.462
Age/Year	1988	1989	1990	1991	1992	1993	1994	1995	1996
2	0.111	0.125	0.135	0.133	0.149	0.102	0.175	0.129	0.156
3	0.147	0.163	0.162	0.172	0.177	0.156	0.198	0.182	0.193
4	0.183	0.201	0.192	0.208	0.207	0.205	0.227	0.232	0.228
5	0.218	0.237	0.227	0.241	0.239	0.248	0.261	0.277	0.263
6	0.252	0.271	0.265	0.272	0.274	0.285	0.301	0.318	0.296
7	0.286	0.304	0.307	0.300	0.310	0.318	0.346	0.356	0.327
+gp	0.419	0.389	0.414	0.345	0.379	0.370	0.509	0.451	0.410

Age/Year	1997	1998	1999	2000	2001	2002	2003	2004	2005
2	0.154	0.187	0.179	0.124	0.151	0.145	0.144	0.150	0.144
3	0.197	0.209	0.217	0.158	0.159	0.174	0.174	0.187	0.186
4	0.237	0.234	0.252	0.230	0.226	0.195	0.207	0.232	0.237
5	0.275	0.263	0.285	0.303	0.271	0.277	0.249	0.289	0.288
6	0.311	0.295	0.314	0.345	0.318	0.310	0.311	0.331	0.325
7	0.345	0.331	0.341	0.410	0.393	0.330	0.327	0.362	0.348
+gp	0.407	0.440	0.399	0.530	0.450	0.397	0.383	0.419	0.383
Age/Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
2	0.152	0.156	0.134	0.129	0.158	0.167	0.156	0.149	0.111
3	0.177	0.200	0.181	0.170	0.165	0.188	0.218	0.200	0.183
4	0.213	0.240	0.236	0.208	0.228	0.231	0.235	0.248	0.240
5	0.276	0.284	0.288	0.263	0.256	0.310	0.293	0.288	0.302
6	0.289	0.336	0.324	0.278	0.300	0.343	0.346	0.329	0.343
7	0.315	0.354	0.383	0.276	0.292	0.344	0.390	0.342	0.371
+gp	0.348	0.419	0.424	0.319	0.305	0.340	0.345	0.358	0.399
Age/Year	2015	2016	2017	2018	2019	2020			
2	0.153	0.127	0.152	0.149	0.155	0.119			
3	0.194	0.20	0.212	0.206	0.202	0.202			
4	0.246	0.244	0.268	0.273	0.259	0.245			
5	0.303	0.332	0.322	0.354	0.317	0.305			
6	0.353	0.337	0.420	0.428	0.390	0.350			
7	0.384	0.397	0.405	0.49	0.417	0.381			
+gp	0.397	0.411	0.443	0.468	0.458	0.391			

Table 31.6a. Sol.27.7a - Discard rates for the main fleets operational in the Irish Sea (Belgian, UK and Irish beam trawl, UK and Irish otter trawl, UK and Irish *Nephrops* trawl).

	BEL	UK						IRL		
Gear	TBB	TBB	OTB	TWIN OTB	NEPH OTB	TWIN NEPH	Other	TBB	NEPH OTB	OTB DEF
Landings (t)	716	284	61	4	25	6	Na	427	/	/
Discard ratio	0.05	0.08	0.05	0.01	0.08	0.02	Na	0.02	/	/
years	2007–2009	2002, 2005–2007	2002–2009	2003,2004,2007	2003, 2006–2009	2002,2003,2008	Na	2003–2009	/	/
Landings (t) 2010	210.917	1.721	1.071	0.014	3.329	0.501	0.741	38.283	5.327	3.632
Discard ratio 2010	0.04	Na	0.00	Na	0.05	Na	Na	0.05	0.16*	0.39*
Landings (t) 2011	239.483	13.662	2.866	0.05	5.201	0.414	0.821	32.514	10.116	5.581
Discard ratio 2011	0.04	Na	0.02	Na	0.00	Na	Na	0.003	0.16*	0.00

*** It should be noted that the 16% discard rate for 2010-2011 of the Irish *Nephrops* fleet and the 39% discard rate for 2010 of the Irish otter trawl fleet only accounts for respectively 1.9%, 3.1% and 1.3% of the total international landings.**

Table 31.6b. Sol.27.7a - Discard rates.

Country	**Year**	**Landings (L) (t)**	**Discards (D) (t)**		
BE		TBB	OTB	other	
	2012	213.392	8.301	0	16.222
	2013	93.009	3.028	0	8.538
	2014	36.144	7.288	0	2.286
	2015	32.2	3.995	0	2.343
	2016	12.533	1.538	0	0.336
	2017	11.047	2.154	0	0.436
	2018	13.2	1.085	0	0.5
	2019	324.835	4.06	0	51.157
	2020	293.321	1.628	0	41
UK (England)	2012	7.278	5.459	1.229	0
	2013	0.168	5.108	1.258	0
	2014	0.149	3.579	1.582	1.404
	2015	0.164	3.505	0.491	0
	2016	0.110	2.700	0.641	0.029
	2017	0.06	1.449	1.004	0
	2018	0.099	2.259	0.877	0
	2019	0.940	5.663	0.784	—
	2020	46.350	3.482	3.992	—

Country	Year	Landings (L) (t)	Discards (D) (t)			
IR	2012	38.79	8.162	3.824	1	
	2013	30.934	9.23	0.009	0	
	2014	37.007	6.016	0.1613	0.4	
	2015	24.306	7.19	0.031	1.394	
	2016	9.205	5.842	0.037	0.273	
	2017	7.214	6.493	0.961	0.205	
	2018	9.079	7.041	0.376	0.474	
	2019	28.562	26.588	0.879	4.149	
	2020	28.820	18.773	0.087	—	
Total		total L	L corresponding with discard info	% coverage of L	total D	rate
	2012	286.44	227.01	0.79	17.22	0.071
	2013	142.74	107.35	0.75	8.54	0.074
	2014	91.93	45.74	0.50	4.09	0.082
	2015	71.88	42.89	0.60	3.74	0.080
	2016	32.61	21.08	0.65	0.64	0.029
	2017	30.38	18.99	0.63	0.64	0.033

Table 31.7a. Sol.27.7a - Effort series.

	Belgium	UK(E&W)				Ireland	
	beam[1]	beam [2]	beam[3]	otter[2]	otter[3]	otter[4]	beam[4]
Year	Whole year	Whole year	Whole year	Whole year	Whole year	Whole year	Whole year
1972	-	-	-	128.4	-	-	-
1973	-	-	-	147.6	-	-	-
1974	-	-	-	115.2	-	-	-
1975	28.4	-	-	130.7	-	-	-
1976	24.9	-	-	122.3	-	-	-
1977	22.1	-	-	101.9	-	-	-
1978	17.5	0.9	-	89.1	-	-	-
1979	20.4	1.7	-	89.9	-	-	-
1980	32.0	4.3	-	107.0	-	-	-
1981	36.5	6.4	-	107.1	-	-	-
1982	26.5	5.5	-	127.2	-	-	-
1983	28.7	2.8	0.0	88.1	1716.5	-	-
1984	17.5	4.1	263.0	103.1	7932.1	-	-
1985	27.0	7.4	428.1	102.9	6930.8	-	-
1986	44.5	17.0	1122.9	90.3	6693.2	-	-
1987	51.6	22.0	1178.5	130.6	9008.9	-	-
1988	38.2	18.6	1019.2	132.0	8292.4	-	-
1989	42.2	25.3	1344.5	139.5	16161.4	-	-
1990	42.4	31.0	1473.1	117.1	7724.5	-	-
1991	17.1	25.8	1211.3	107.3	7081.1	-	-
1992	25.1	23.4	908.1	96.8	6671.8	-	-
1993	23.9	21.5	826.9	78.9	6013.1	-	-
1994	32.5	20.1	1451.6	43.0	3060.0	-	-
1995	28.6	20.9	1429.4	43.1	3357.0	80.3	8.6
1996	23.2	13.3	894.3	42.2	3085.1	64.8	6.3
1997	30.7	10.8	784.4	39.9	2903.3	92.2	9.9

	Belgium	UK(E&W)				Ireland	
	beam[1]	beam [2]	beam[3]	otter[2]	otter[3]	otter[4]	beam[4]
Year	Whole year	Whole year	Whole year	Whole year	Whole year	Whole year	Whole year
1998	24.7	10.4	696.0	36.9	2620.6	93.5	11.6
1999	22.7	11.0	778.9	22.9	1803.5	110.3	14.7
2000	26.0	6.3	410.7	27.0	2034.9	82.7	11.4
2001	36.8	12.5	767.4	32.8	2352.9	77.5	13.1
2002	47.0	8.0	535.1	24.8	1774.0	77.9	17.7
2003	44.3	14.0	863.7	23.9	1728.3	73.9	18.7
2004	32.3	7.4	419.9	23.5	1727.0	72.5	14.2
2005	37.5	11.4	627.8	16.7	1313.6	68.3	14.7
2006	24.8	4.6	280.1	5.2	478.5	66.2	12.2
2007	19.5	3.2	193.5	4.4	397.2	74.1	14.2
2008	10.3	1.3	98.0	2.7	320.4	58.8	9.5
2009	11.7	0.5	24.9	1.5	157.7	42.8	7.6
2010	11.3	0.2	10.2	1.4	151.0	45.8	9.4
2011	12.4	1.6	91.2	0.7	72.7	54.5	8.1
2012	10.9	0.9	60.7	0.4	85.0	58.3	7.2
2013	7.0	0.0	1.3	0.3	31.9	42.6	5.0
2014	3.9	-	0.4	-	16.1	47.7	6.0
2015	3.5	-	0.9	-	0.0	39.8	8.3
2016	1.8	-	3.9	-	0.0	33.4	7.9
2017	3.0	-	0.0	-	160.7	12.1	7.5
2018	2.5	-	0.0	-	238.1	13.6	9.6
2019	10.1	-	7.0	-	247.2	17.2	13.3

All the trawlers fishing in the Irish sea (UK fleet) are below 12 meters in length.

1 000' hours fishing.

2 000'hours fished (GRT corrected > 40 vessels).

3 days fished.

4 000'hours.

7 days fished.

*** Provisional.**

Table 31.7b. Sol.27.7a – lpue.

		Belgium		UK(E&W)		UK		Ireland	
	beam[1]	beam[3]	beam[2]	otter[3]	otter[2]	beam survey[4]		otter	beam
Year	Whole year	Whole year	Whole year	Whole year	Whole year	Sept	March	Whole year	Whole year
1972	-	-	-	1.06	-	-	-	-	-
1973	-	-	-	1.06	-	-	-	-	-
1974	-	-	-	1.09	-	-	-	-	-
1975	21.39	-	-	1.39	-	-	-	-	-
1976	23.13	-	-	0.94	-	-	-	-	-
1977	19.79	-	-	0.80	-	-	-	-	-
1978	18.10	34.32	-	1.04	-	-	-	-	-
1979	33.41	32.01	-	1.43	-	-	-	-	-
1980	28.18	31.70	-	1.01	-	-	-	-	-
1981	22.16	21.32	-	0.75	-	-	-	-	-
1982	22.01	29.94	-	0.53	-	-	-	-	-
1983	13.88	37.31	0.0	0.57	150.2	-	-	-	-
1984	22.47	16.24	2851.4	0.71	119.3	-	-	-	-
1985	20.58	17.34	2956.3	0.56	135.7	-	-	-	-
1986	19.12	19.23	3925.7	0.84	174.9	-	-	-	-
1987	17.73	14.82	3726.9	0.77	144.9	-	-	-	-
1988	21.29	11.81	2673.3	0.46	80.3	161.92	-	-	-
1989	21.93	9.17	1750.6	0.70	138.9	150.07	-	-	-
1990	17.52	9.52	2300.9	0.61	119.7	196.90	-	-	-
1991	18.70	10.43	2420.9	1.12	177.4	175.76	-	-	-
1992	19.21	9.50	2763.0	1.02	126.0	162.64	-	-	-
1993	19.97	7.60	1879.8	0.54	69.1	100.16	104.7	-	-
1994	19.06	11.76	1479.9	0.74	88.1	110.71	91.9		-
1995	18.12	14.96	1721.1	0.95	142.3	92.04	79.3	0.38	12.69
1996	17.72	9.44	1471.7	0.53	47.7	89.48	-	0.25	14.94

	Belgium		UK(E&W)		UK			Ireland	
	beam[1]	beam[3]	beam[2]	otter[3]	otter[2]	beam survey[4]		otter	beam
Year	Whole year	Whole year	Whole year	Whole year	Whole year	Sept	March	Whole year	Whole year
1997	16.62	10.49	961.8	0.73	103.2	155.79	63.3	0.23	8.53
1998	18.96	8.42	907.8	0.48	50.5	144.97	89.3	0.38	7.77
1999	19.47	9.94	1124.9	0.60	64.8	116.02	-	0.29	9.22
2000	15.52	12.90	1604.7	0.44	34.6	130.70	-	0.29	8.49
2001	15.02	11.72	1537.4	0.15	23.4	96.87	-	0.38	7.86
2002	14.95	16.73	1484.3	1.48	98.8	76.73	-	0.32	4.67
2003	15.41	13.20	1351.6	0.15	340.4	88.55	-	0.34	4.20
2004	16.25	13.86	941.7	0.17	27.6	98.92	-	0.14	4.31
2005	17.52	9.14	1199.9	0.19	21.3	48.91	-	0.16	4.70
2006	16.32	7.83	826.1	0.52	34.8	52.63	-	0.16	6.00
2007	14.32	16.38	1629.9	0.42	21.4	53.05	-	0.37	6.37
2008	19.85	15.25	887.4	0.30	16.4	50.67	-	0.20	6.08
2009	19.96	18.88	1201.2	0.22	13.6	45.75	-	0.28	4.53
2010	18.68	13.90	262.3	0.46	17.8	27.80	-	0.19	4.09
2011	19.34	4.45	322.5	0.18	13.7	36.97	-	0.30	4.13
2012	19.61	4.27	99.9	0.08	10.5	26.47	-	0.14	5.41
2013	13.23	-	27.7	0.10	3.4	31.65	-	0.22	6.27
2014	9.16	-	0.0	-	0.0	41.14	-	0.14	5.40
2015	9.24	-	146.1	-	0.0	58.88	-	0.18	3.14
2016	6.81	-	0.0	-	0.0	69.35	-	0.18	1.17
2017	3.81	-	0.0	-	5.6	64.24	-	0.36	1.23
2018	5.36	-	0.0	-	12.6	78.51	-	0.28	1.49
2019	32.26	-	124.8	-	48.5	118.66	-	0.63	2.23

All lpue values in Kg/hr.

1 Kg/000'hr.

2 Kg/day.

3 Kg/000'hr fished (GRT corrected > 40' vessels).

4 Kg/100 km fished.

Table 31.8. Sol.27.7a - Tuning series (values in bold are used in the assessment).

BE-CBT	**Belgium Commercial Beam Trawl (Effort=Corrected formula)**										
1975 2005											
1 1							**0**		**1**		
4 14											
12.3	1045	275	393	69	105	94	61	72	11	15	64
11.8	568	1066	80	263	64	58	35	5	56	5	5
10.7	434	307	509	76	93	45	23	20	2	35	32
9.9	169	304	155	258	41	90	12	29	12	7	17
11.2	1455	510	323	193	162	37	36	9	41	0	0
16.7	958	1644	296	268	247	210	30	64	31	14	7
22.6	909	721	998	62	92	44	161	13	92	10	8
19.5	451	608	378	394	52	64	11	29	24	5	0
20.5	259	310	394	238	216	44	38	28	49	3	26
12	107	204	143	188	91	121	2	1	4	14	0
19.6	606	171	186	99	150	125	83	27	13	4	23
38	1531	468	138	135	90	104	69	69	20	8	21
43.2	1527	881	297	167	69	39	54	59	40	13	9
30.5	2027	1012	480	21	33	37	34	42	35	0	7
34	376	2423	751	250	59	15	9	2	14	0	1
36.1	307	223	1263	276	142	13	9	11	11	8	5
13.8	253	78	60	588	115	40	16	1	1	11	3
23.9	298	330	68	40	203	93	36	12	0	0	0
24.5	862	253	149	89	79	160	66	77	0	0	0
31	680	786	164	103	39	117	58	19	15	0	7
26.2	729	366	410	52	27	6	28	15	6	11	3
21.6	537	334	241	219	53	13	11	14	9	7	2
28.5	270	376	180	162	134	28	27	15	9	8	1
23.3	248	146	142	89	73	62	20	20	9	10	3
21.7	693	199	65	50	37	21	17	9	6	4	6
18.6	685	220	107	31	15	33	13	7	9	0.6	8
30.5	600	284	248	39	35	44	33	1	3	0.2	4
38.6	1138	814	349	109	30	9	2	1	1	1	0
24.45	724	436	196	84	20	7	2	1	0	2	1
25.58	313	197	159	47	12	11	6	3	0	0	0
32.15	505	342	156	71	87	9	7	1	13	2	1

UK (E&W)-BTS-Q3 September beam trawl survey									
1988 2020									
1 1						0.75		0.85	
1 9									
100.062	118	196	180	410	76	40	4	0	4
129.71	218	304	180	74	284	56	32	8	6
128.969	1712	534	122	42	88	194	40	20	6
123.78	148	1286	122	26	16	14	55	19	7
129.525	220	309	657	142	34	22	7	75	17
131.192	83	330	143	211	40	17	7	16	36
124.892	60	408	203	73	132	49	11	13	6
126.004	246	154	253	110	30	67	12	5	5
126.004	886	126	32	76	46	23	31	8	2
126.004	1158	577	72	24	55	27	16	30	7
126.004	539	716	292	18	6	24	23	5	18
126.004	385	293	255	203	29	8	26	5	6
126.004	354	464	147	219	91	13	2	13	6
126.004	91	284	192	65	96	63	6	3	12
126.004	205	61	121	126	42	79	49	2	1
126.004	242	210	51	97	81	40	43	26	1
126.004	406	240	119	27	77	45	41	17	19
122.298	53	165	69	25	13	35	25	4	6
126.004	107	110	90	45	36	9	16	15	10
126.004	125	93	49	57	41	11	4	6	12
122.298	126	126	60	21	43	23	6	2	9
126.004	60	150	68	40	19	30	12	7	1
126.004	26	60	74	37	17	5	9	9	3
122.298	88	35	62	68	35	12	4	13	6
122.298	22	49	16	46	25	12	11	2	6
126.004	75	57	36	21	33	18	21	9	1
126.004	172	43	22	35	14	26	21	14	6
126.004	421	150	41	20	23	5	15	29	8
122.298	129	363	91	29	20	24	8	8	9
126.004	237	101	177	56	24	15	9	7	7
126.004	268	275	75	144	38	21	9	6	9
126.004	1018	224	167	68	132	37	11	4	3

Table 31.8. Sole in 7.a. Continued (values in bold are used in the assessment).

UK (E&W)-BTS-Q1	**March beam trawl survey**								
1993	**1999**								
1	**1**			**0.15**			**0.25**		
2	**9**								
126.931	18	337	147	332	73	15	17	10	41
115.442	8	354	208	69	151	51	14	11	9
126.189	24	96	186	140	30	104	27	10	8
134.343	651	114	49	110	78	32	54	10	12
121.742	130	417	33	17	69	23	11	46	17
130.081	47	421	330	39	19	48	27	12	37
130.822	45	227	284	177	14	4	34	12	7

UK (E&W)-CBT	March beam trawl survey												
1991	2013												
1	1						0						1
2	14												
25.838	267	426	212	84	58	218	53	34	4	1	2	1	0
23.399	36	460	176	68	37	32	121	34	38	3	1	0	0
21.503	11	74	355	98	36	48	25	34	13	22	5	2	4
20.145	24	228	150	234	87	17	25	19	42	10	17	1	0
20.392	47	239	231	130	199	55	11	22	5	34	10	11	3
13.32	0	13	109	98	49	100	37	9	8	6	14	8	3
10.76	0	111	50	81	58	24	46	34	12	12	0	8	1
10.386	43	219	40	28	49	31	12	22	11	9	2	1	0
11.016	53	115	134	12	15	25	10	9	14	9	0	1	2
6.275	16	90	84	82	9	6	10	5	5	7	2	1	1
12.495	33	184	100	145	107	12	4	17	12	10	6	4	2
8.017	4	63	152	50	79	47	5	4	6	3	1	1	1
13.996	28	63	178	149	78	52	72	7	5	8	3	7	14
7.396	54	61	29	43	25	12	10	5	1	1	4	0	1
11.406	10	81	44	16	45	37	17	10	17	3	0	3	3
4.649	7	28	33	11	5	10	12	7	9	5	2	0	1
3.197	22	20	34	17	6	1	7	7	6	3	2	1	1
1.302	1	11	5	7	12	1	2	4	3	4	0	3	1
0.462	0	0	0	0	0	0	0	0	0	0	0	0	0
0.186	0	0	0	0	0	0	0	0	0	0	0	0	0
1.564	0	3	6	3	3	1	1	1	0	0	0	0	0
0.849	0	0	0	0	0	0	0	0	0	0	0	0	0
0.003	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 31.8. Sole in 7.a. Continued (values in bold are used in the assessment).

UK(E&W)-COT	UK Commercial Otter trawl												
1991	2013												
1	1						0						1
2	14												
107.3	265	155	63	29	19	71	20	11	2	0	1	1	1
96.8	16	224	69	22	16	10	36	10	10	1	0	0	0
78.9	9	27	77	19	3	7	4	5	1	2	0	0	0
43	4	66	34	50	20	3	4	4	7	1	2	0	0
43.1	17	50	34	15	24	7	1	2	0	2	1	1	0
42.2	2	5	18	12	7	12	4	1	1	1	1	1	1
39.9	14	15	7	14	9	3	7	3	1	1	0	1	0
36.9	5	24	5	3	5	3	2	2	1	1	0	0	0
22.8	5	15	12	2	0	2	1	1	1	1	0	0	0
27	2	12	9	8	1	0	1	1	0	0	0	0	0
32.9	3	10	6	8	5	0	0	0	0	0	0	0	0
24.8	0	8	16	3	5	3	1	0	1	0	0	0	0
23.9	1	2	6	4	2	1	2	0	0	0	0	0	0
23.5	3	5	3	4	3	2	1	1	0	0	0	0	0
16.7	2	4	2	1	2	2	1	1	1	0	0	0	0
5.2	1	2	4	1	1	1	1	1	1	1	0	0	0
4.4	1	1	2	2	0	0	1	1	1	0	0	0	0
2.7	0	1	1	1	1	0	0	0	0	0	0	0	0
1.54	0	0	0.2	0.3	0.1	0.2	0.2	0	0	0.1	0	0	0
1.42	0	0.1	0.2	0.3	0.1	0.1	0.2	0.1	0	0.1	0.1	0.1	0
0.686	0	0.1	0.1	0	0	0	0	0	0	0	0	0	0
0.241	0	0	0	0	0	0	0	0	0	0	0	0	0
0.272	0	0	0	0	0	0	0	0	0	0	0	0	0

IR-COT	Irish Commercial Otter Trawl										
1995	2005										
1	1							0			1
2	10										
70682	6.8	17.7	25.5	9.2	25.8	3.6	0.8	1.5	1.9	1995	
58166	0	5.7	12.9	12.7	4.7	4.7	2.2	0.2	0	1996	
75029	27.8	10.2	4.1	9.2	6.4	3.5	3.9	1	0.2	1997	
81073	5.5	40.7	14.7	6.6	12.3	5.4	2.7	4.1	1	1998	
93221	26.6	36.8	30.9	5.1	3.8	5.3	2.4	0.5	1.2	1999	
64320	1.6	13.2	13.4	11	3.4	1.1	1	0.4	0	2000	
77541	0.2	6.1	18.6	18.6	10.8	2.1	4.1	1.3	0.3	2001	
39996	20.3	20	30.2	16.4	8.2	2.9	2.4	1.4	0.5	2002	
73854	0.9	35.9	21.7	9.8	3.3	0.5	0.8	0.2	0.2	2003	
72507	9	15.1	4.1	3.2	1.9	1.6	0.3	0.2	0.1	2004	
31142	4	1.7	1.6	1.6	0.6	0.1	0	0	0	2005	

Please note the 2005 data are based only on Q3 and Q4 data and have not been raised to annual effort.
It should not be included as part of this time-series.

Table 31.9. Sol.27.7a – Diagnostics.

```
FLR XSA Diagnostics


CPUE data from indices

Catch data for 51 years. 1970 to 2020. Ages 2 to 8.

            fleet first age last age first year last year alpha beta
1 UK (E&W)-BTS-Q3         2        7       1988      2020  0.75 0.85


 Time-series weights :

   Tapered time weighting not applied

Catchability analysis :

    Catchability independent of size for all ages

    Catchability independent of age for ages >   4

Terminal population estimation :

    Survivor estimates shrunk towards the mean F
    of the final   5 years or the  3 oldest ages.

    S.E. of the mean to which the estimates are shrunk =   1.5

    Minimum standard error for population
    estimates derived from each fleet =  0.3

   prior weighting not applied

Regression weights
     year
age   2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
  all    1    1    1    1    1    1    1    1    1    1


 Fishing mortalities
   year
age  2011  2012  2013  2014  2015  2016  2017  2018  2019  2020
  2 0.028 0.021 0.038 0.016 0.009 0.000 0.001 0.001 0.015 0.005
  3 0.180 0.326 0.144 0.097 0.056 0.012 0.010 0.014 0.163 0.101
  4 0.341 0.359 0.244 0.108 0.089 0.039 0.015 0.013 0.220 0.163
  5 0.265 0.366 0.178 0.163 0.066 0.039 0.032 0.012 0.100 0.188
  6 0.293 0.250 0.150 0.080 0.095 0.025 0.016 0.021 0.088 0.077
  7 0.505 0.226 0.097 0.125 0.053 0.045 0.018 0.011 0.183 0.095
  8 0.505 0.226 0.097 0.125 0.053 0.045 0.018 0.011 0.183 0.095


 XSA population number (Thousand)
```

year \ age	2	3	4	5	6	7	8
2011	636	1435	1459	794	401	143	322
2012	878	559	1084	939	551	271	597
2013	644	778	365	685	589	388	936
2014	782	561	610	259	519	459	503
2015	1732	696	461	496	199	433	1526
2016	4580	1553	595	382	420	164	771
2017	1840	4144	1389	518	332	371	802
2018	4280	1663	3710	1238	454	296	986
2019	3463	3869	1484	3314	1107	403	515
2020	2931	3088	2974	1077	2713	917	1507

Estimated population abundance at 1st Jan 2021

year \ age	2	3	4	5	6	7	8
2021	NaN	17304	2525	2287	808	2272	755

Fleet: UK (E&W)-BTS-Q3

Log catchability residuals.

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
2	0.053	0.036	0.420	0.518	-0.042	-0.264	0.171	0.186	-0.271	0.106	0.454	-0.139	0.009	-0.034	-0.892	0.147	0.049	0.010	0.285	-0.223
3	0.588	0.371	-0.121	-0.289	0.476	-0.269	-0.040	0.298	-0.673	-0.070	0.115	0.013	-0.202	-0.219	-0.223	-0.171	0.423	-0.362	0.153	0.253
4	-0.004	0.058	-0.250	-0.934	0.441	-0.108	-0.296	0.041	-0.255	-0.173	-0.776	0.314	0.317	-0.492	0.060	0.227	-0.109	-0.226	-0.101	0.258
5	-0.392	-0.027	0.958	-0.619	-0.026	-0.319	0.022	-0.588	-0.227	0.026	-0.763	0.330	-0.122	-0.143	-0.392	0.198	0.439	-0.073	0.711	0.261
6	-0.238	-0.239	0.297	-0.206	0.168	-0.073	0.537	-0.022	-0.178	-0.159	-0.283	0.354	0.149	-0.097	0.074	0.003	0.038	0.171	0.246	-0.034
7	-0.121	0.087	0.195	-0.187	-0.198	-0.071	0.193	-0.334	-0.148	0.284	0.207	0.189	-0.112	-0.014	-0.013	-0.231	0.356	-0.025	-0.206	-0.024

age \ year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2	0.026	0.013	-0.583	-0.152	-0.145	0.300	-0.193	0.255	0.190	-0.207	-0.049	-0.032	NA
3	0.033	0.052	-0.105	0.049	-0.246	0.058	-0.145	0.229	0.219	-0.128	-0.071	0.004	NA
4	0.039	0.202	-0.076	0.375	0.297	0.479	0.367	0.073	0.178	-0.059	-0.099	0.233	NA
5	0.388	0.466	-0.191	0.259	-0.164	0.249	0.353	0.122	0.251	0.092	-0.335	-0.003	NA
6	0.123	0.365	-0.386	-0.105	-0.458	-0.229	0.210	-0.468	0.327	0.054	0.082	-0.188	NA
7	-0.205	-0.083	-0.524	-0.003	0.147	0.299	0.155	-0.182	0.187	-0.564	-0.345	-0.314	NA

Fleet = UK (E&W)-BTS-Q3

Catchability residuals:

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	0.05	0.04	0.42	0.52	-0.04	-0.26	0.17	0.19	-0.27	0.11	0.45	-0.14	0.01	-0.03	-0.89	0.15	0.05	0.01	0.28	-0.22	0.03	0.01	-0.58
3	0.59	0.37	-0.12	-0.29	0.48	-0.27	-0.04	0.30	-0.67	-0.07	0.12	0.01	-0.20	-0.22	-0.22	-0.17	0.42	-0.36	0.15	0.25	0.03	0.05	-0.10
4	0.00	0.06	-0.25	-0.93	0.44	-0.11	-0.30	0.04	-0.26	-0.17	-0.78	0.31	0.32	-0.49	0.06	0.23	-0.11	-0.23	-0.10	0.26	0.04	0.20	-0.08
5	-0.39	-0.03	0.96	-0.62	-0.03	-0.32	0.02	-0.59	-0.23	0.03	-0.76	0.33	-0.12	-0.14	-0.39	0.20	0.44	-0.07	0.71	0.26	0.39	0.47	-0.19

```
6 -0.24 -0.24  0.30 -0.21  0.17 -0.07  0.54 -0.02 -0.18 -0.16 -0.28  0.35  0.15 -0.10  0.07  0.00  0.04  0.17  0.25 -0.03  0.12  0.36 -0.39
7 -0.12  0.09  0.20 -0.19 -0.20 -0.07  0.19 -0.33 -0.15  0.28  0.21  0.19 -0.11 -0.01 -0.01 -0.23  0.36 -0.03 -0.21 -0.02 -0.20 -0.08 -0.52
   2011  2012  2013  2014  2015 2016  2017  2018  2019 2020
2 -0.15 -0.14  0.30 -0.19  0.26 0.19 -0.21 -0.05 -0.03  NaN
3  0.05 -0.25  0.06 -0.15  0.23 0.22 -0.13 -0.07  0.00  NaN
4  0.38  0.30  0.48  0.37  0.07 0.18 -0.06 -0.10  0.23  NaN
5  0.26 -0.16  0.25  0.35  0.12 0.25  0.09 -0.33  0.00  NaN
6 -0.11 -0.46 -0.23  0.21 -0.47 0.33  0.05  0.08 -0.19  NaN
7  0.00  0.15  0.30  0.15 -0.18 0.19 -0.56 -0.34 -0.31  NaN


 Mean log catchability and standard error of ages with
 independant of year class strength and constant w.r.t time:

                2       3       4       5       6       7
Mean log q -7.4511 -7.7727 -7.8958 -7.8958 -7.8958 -7.8958
S.E. log q  0.2836  0.2683  0.3275  0.3822  0.2512  0.2380


 Regression Statistics:

  Model used? slope  Intercept RSquare Num Pts Reg s.e Mean Q
2 "No"        "0.9"  "7.5"     "0.9"   "32"    "0.25"  "-7.45"
3 "No"        "0.98" "7.77"    "0.89"  "32"    "0.27"  "-7.77"
4 "No"        "1.08" "7.93"    "0.85"  "32"    "0.35"  "-7.9"
5 "No"        "1.15" "7.99"    "0.8"   "32"    "0.43"  "-7.87"
6 "No"        "1"    "7.9"     "0.91"  "32"    "0.25"  "-7.9"
7 "No"        "0.99" "7.92"    "0.92"  "32"    "0.23"  "-7.95"


Terminal year survivor and F summaries:

Age =  2 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2018

Fleet =  fshk
                    2
Survivors   17304.000
Raw weights     0.444

     Fleet  Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "fshk" "17304"      "1.496"   "Inf"     "Inf"     "1" "1"         "0.005"


 Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "17304"  ""       ""       ""        "0.005"

Age =  3 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2017

Fleet =  fshk
                   3
```

```
Survivors   5120.000
Raw weights    0.444

Fleet =  UK (E&W)-BTS-Q3
                   2
Survivors   2446.000
Raw weights    9.896

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "fshk"            "5120"       "1.426"   "Inf"     "Inf"     "1" "0.043"     "0.051"
[2,] "UK (E&W)-BTS-Q3" "2446"       "0.3"     "Inf"     "Inf"     "1" "0.957"     "0.104"

 Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "2525"   ""       ""       ""        "0.101"

Age =  4 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2016

Fleet =  fshk
                   4
Survivors   5178.000
Raw weights    0.444

Fleet =  UK (E&W)-BTS-Q3
                   3        2
Survivors   2296.000 2177.000
Raw weights    8.021    8.014

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "fshk"            "5178"       "1.383"   "Inf"     "Inf"     "1" "0.027"     "0.075"
[2,] "UK (E&W)-BTS-Q3" "2235"       "0.212"   "0.027"   "0.127"   "2" "0.973"     "0.166"

 Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "2287"   ""       ""       ""        "0.163"


Age =  5 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2015

Fleet =  fshk
                   5
Survivors   3280.000
Raw weights    0.444


Fleet =  UK (E&W)-BTS-Q3
                   4       3       2
Survivors   1019.000 752.000 657.000
Raw weights    6.029   7.283   7.275

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
```

```
[1,] "fshk"            "3280"       "1.365"   "Inf"     "Inf"     "1" "0.021"     "0.05"
[2,] "UK (E&W)-BTS-Q3" "784"        "0.179"   "0.126"   "0.704"   "3" "0.979"     "0.193"


 Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "808"    ""       ""       ""        "0.188"

Age =  6 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2014

Fleet =  fshk
                   6
Survivors   3624.000
Raw weights    0.444


Fleet =  UK (E&W)-BTS-Q3
                   5        4       3        2
Survivors   2265.000 2058.000 1999.00 2747.000
Raw weights    5.557    7.499    9.09    9.088


     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "fshk"            "3624"       "1.443"   "Inf"     "Inf"     "1" "0.014"     "0.049"
[2,] "UK (E&W)-BTS-Q3" "2257"       "0.162"   "0.077"   "0.475"   "4" "0.986"     "0.078"


 Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "2272"   ""       ""       ""        "0.077"


Age =  7 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2013

Fleet =  fshk
                  7
Survivors   488.000
Raw weights   0.444

Fleet =  UK (E&W)-BTS-Q3
                  6       5       4     3       2
Survivors   625.000 540.000 711.000 939.0 974.000
Raw weights   9.252   5.459   7.353   8.9   8.819

     Fleet             Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "fshk"            "488"        "1.431"   "Inf"     "Inf"     "1" "0.011"     "0.143"
[2,] "UK (E&W)-BTS-Q3" "758"        "0.143"   "0.111"   "0.776"   "5" "0.989"     "0.094"

 Weighted prediction:
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "755"    ""       ""       ""        "0.095"
```

Table 31.10. Sol.27.7a - Fishing mortality.

Age /Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	0.0083	0.0117	0.0103	0.0299	0.0045	0.0421	0.0079	0.0148	0.0076	0.0129	0.0396	0.0165
3	0.1196	0.1480	0.0810	0.1436	0.0847	0.1575	0.0704	0.1350	0.0743	0.1427	0.1335	0.1488
4	0.2956	0.3987	0.3520	0.3621	0.3158	0.3033	0.4192	0.3255	0.2866	0.3645	0.3932	0.3289
5	0.4445	0.5543	0.5060	0.4394	0.4723	0.4845	0.4816	0.4072	0.4036	0.6321	0.5673	0.5110
6	0.4292	0.3670	0.4932	0.4874	0.5436	0.3973	0.3792	0.3752	0.3815	0.4260	0.9493	0.6028
7	0.3909	0.4415	0.4519	0.4310	0.4454	0.3962	0.4281	0.3704	0.3583	0.4759	0.6393	0.4826
+gp	0.3909	0.4415	0.4519	0.4310	0.4454	0.3962	0.4281	0.3704	0.3583	0.4759	0.6393	0.4826
F_{BAR} 4–7	0.3901	0.4404	0.4508	0.4300	0.4442	0.3953	0.4270	0.3696	0.3575	0.4746	0.6373	0.4813

Age /Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
2	0.0034	0.0070	0.0453	0.0100	0.0063	0.0592	0.0097	0.0440	0.1130	0.1157	0.0802	0.0142
3	0.0953	0.0814	0.1809	0.1344	0.2759	0.1804	0.1721	0.2998	0.3996	0.3529	0.2882	0.1486
4	0.4773	0.3836	0.2431	0.3605	0.4221	0.5659	0.3709	0.4505	0.6815	0.4861	0.4125	0.3543
5	0.4079	0.5322	0.3796	0.3208	0.5524	0.7623	0.5628	0.5376	0.6644	0.3977	0.6111	0.4211
6	0.4371	0.3923	0.4330	0.3275	0.3374	1.2589	0.7325	0.6320	0.6140	0.5003	0.4183	0.5454
7	0.4422	0.4375	0.3529	0.3372	0.4388	0.8667	1.1079	0.7004	0.6727	0.6415	0.6835	0.9195
+gp	0.4422	0.4375	0.3529	0.3372	0.4388	0.8667	1.1079	0.7004	0.6727	0.6415	0.6835	0.9195
F_{BAR} 4–7	0.4411	0.4364	0.3521	0.3365	0.4377	0.8635	0.6935	0.5801	0.6582	0.5064	0.5313	0.5600

Age /Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
2	0.0248	0.0717	0.0256	0.1047	0.0259	0.0623	0.0272	0.0570	0.0693	0.1628	0.0904	0.2117
3	0.2958	0.2346	0.3456	0.4171	0.3103	0.2053	0.2407	0.2835	0.2893	0.5818	0.4873	0.4583
4	0.4293	0.5258	0.4740	0.6193	0.4673	0.3465	0.2404	0.3184	0.5256	0.4869	0.4482	0.7007
5	0.4742	0.5245	0.4985	0.5126	0.7156	0.5444	0.2461	0.2709	0.4671	0.4692	0.3066	0.6839
6	0.5248	0.5599	0.5887	0.5004	0.3973	0.7324	0.5157	0.3048	0.3224	0.3132	0.2919	0.4126
7	0.5538	0.4250	0.5416	0.7597	0.4087	0.2650	0.8429	0.5083	0.2176	0.1732	0.2066	0.4206
+gp	0.5538	0.4250	0.5416	0.7597	0.4087	0.2650	0.8429	0.5083	0.2176	0.1732	0.2066	0.4206
F_{BAR} 4–7	0.4955	0.5088	0.5257	0.5980	0.4972	0.4721	0.4613	0.3506	0.3832	0.3606	0.3133	0.5545

Age /Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
2	0.0931	0.1012	0.0545	0.0435	0.0145	0.0285	0.0206	0.0383	0.0163	0.0092	0.0002	0.0012
3	0.3941	0.4211	0.2784	0.3005	0.1981	0.1800	0.3264	0.1436	0.0967	0.0562	0.0120	0.0104
4	0.5047	0.3245	0.3706	0.4074	0.2462	0.3406	0.3591	0.2436	0.1076	0.0886	0.0388	0.0148
5	0.4529	0.3168	0.2718	0.4782	0.3506	0.2650	0.3665	0.1777	0.1635	0.0661	0.0385	0.0316
6	0.5998	0.3116	0.3085	0.2654	0.3595	0.2932	0.2501	0.1500	0.0804	0.0947	0.0248	0.0163
7	0.3165	0.4008	0.3044	0.3916	0.2026	0.5055	0.2258	0.0966	0.1247	0.0526	0.0450	0.0176
+gp	0.3165	0.4008	0.3044	0.3916	0.2026	0.5055	0.2258	0.0966	0.1247	0.0526	0.0450	0.0176
F_{BAR} 4–7	0.4685	0.3384	0.3138	0.3857	0.2897	0.3510	0.3004	0.1669	0.1191	0.0755	0.0368	0.0201

Age/Year	2018	2019	2020	average 18–20
2	0.0010	0.0147	0.0053	0.0070
3	0.0139	0.1630	0.1011	0.0927
4	0.0131	0.2204	0.1629	0.1321
5	0.0119	0.1001	0.1881	0.1000
6	0.0209	0.0884	0.0772	0.0622
7	0.0107	0.1830	0.0948	0.0961
+gp	0.0107	0.1830	0.0948	0.0961
F_{BAR} 4–7	0.0141	0.1479	0.1307	

Table 31.11. Sol.27.7a - Stock numbers-at-age (start of year, in thousands).

Age/Year	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**
2	3695	10177	3186	13133	5870	6680	3857	15772	9040	8848	5070	4497	2460
3	8349	3316	9101	2853	11533	5288	5795	3462	14061	8118	7903	4410	4002
4	4145	6703	2588	7595	2236	9588	4087	4887	2737	11812	6369	6257	3438
5	1368	2791	4071	1647	4784	1475	6406	2432	3193	1859	7423	3890	4075
6	4389	794	1451	2221	960	2699	822	3581	1464	1930	894	3809	2111
7	939	2585	498	802	1234	504	1642	509	2227	905	1140	313	1886
+gp	8212	5534	4321	3418	2829	3220	2221	2192	2042	1713	2536	2365	1163
TOTAL	31097	31900	25214	31667	29447	29455	24830	32835	34764	35185	31336	25540	19136

Age/Year	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
2	5557	15464	16229	23709	3458	3493	4369	5553	12666	4947	6181	5239	2004
3	2219	4993	13373	14538	21318	2949	3130	3783	4488	10208	4131	5514	4624
4	3292	1851	3770	10578	9983	16106	2247	2099	2295	2853	6924	3222	3711
5	1930	2030	1313	2379	6276	5129	10057	1296	961	1277	1709	4396	1898
6	2452	1026	1257	862	1239	2649	2644	5316	603	584	627	1015	2476
7	1234	1499	602	819	557	318	1152	1271	2603	331	348	329	543
+gp	2095	1962	2704	2498	1454	802	529	995	1013	1959	1189	1290	1058
TOTAL	18778	28824	39248	55384	44285	31446	24128	20312	24628	22160	21110	21004	16315

Age/Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
2	2496	8356	6871	5240	6955	4552	2330	3056	3638	2952	1320	1866	1956
3	1688	2201	6809	6058	4455	6124	3890	1967	2349	3007	2162	1088	1526
4	3309	1081	1312	4518	4464	3169	4173	2636	995	1306	1721	1319	646
5	1985	1864	527	744	2891	3176	2085	2232	1466	575	586	940	863
6	1016	1091	1010	233	391	2045	2192	1183	1264	976	263	337	620
7	1280	510	599	614	101	211	1364	1437	782	854	584	130	223
+gp	868	1043	1320	1045	472	714	1162	2273	1014	1122	1465	944	836
TOTAL	12642	16147	18448	18452	19728	19991	17197	14783	11508	10792	8100	6624	6669
Age/Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**GMST 70-19**
2	2270	1609	636	878	644	782	1732	4580	1840	4280	3463	2931	4001
3	1676	1966	1435	559	778	561	696	1553	4144	1663	3869	3088	
4	1045	1123	1459	1084	365	610	461	595	1389	3710	1484	2974	**GMST 2015-2019**
5	404	629	794	939	685	259	496	382	518	1238	3314	1077	2931
6	595	226	401	551	589	519	199	420	332	454	1107	2713	
7	412	413	143	271	388	459	433	164	371	296	403	917	
+gp	523	904	322	597	936	503	1526	771	802	986	515	1507	
TOTAL	6924	6870	5190	4880	4386	3693	5543	8465	9396	12627	14153	15206	

Age/Year	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**

2	3695	10177	3186	13133	5870	6680	3857	15772	9040	8848	5070	4497	2460
3	8349	3316	9101	2853	11533	5288	5795	3462	14061	8118	7903	4410	4002
4	4145	6703	2588	7595	2236	9588	4087	4887	2737	11812	6369	6257	3438
5	1368	2791	4071	1647	4784	1475	6406	2432	3193	1859	7423	3890	4075
6	4389	794	1451	2221	960	2699	822	3581	1464	1930	894	3809	2111
7	939	2585	498	802	1234	504	1642	509	2227	905	1140	313	1886
+gp	8212	5534	4321	3418	2829	3220	2221	2192	2042	1713	2536	2365	1163
TOTAL	31097	31900	25214	31667	29447	29455	24830	32835	34764	35185	31336	25540	19136

Age/Year	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**
2	5557	15464	16229	23709	3458	3493	4369	5553	12666	4947	6181	5239	2004
3	2219	4993	13373	14538	21318	2949	3130	3783	4488	10208	4131	5514	4624
4	3292	1851	3770	10578	9983	16106	2247	2099	2295	2853	6924	3222	3711
5	1930	2030	1313	2379	6276	5129	10057	1296	961	1277	1709	4396	1898
6	2452	1026	1257	862	1239	2649	2644	5316	603	584	627	1015	2476
7	1234	1499	602	819	557	318	1152	1271	2603	331	348	329	543
+gp	2095	1962	2704	2498	1454	802	529	995	1013	1959	1189	1290	1058
TOTAL	18778	28824	39248	55384	44285	31446	24128	20312	24628	22160	21110	21004	16315
Age/Year	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**

2	2496	8356	6871	5240	6955	4552	2330	3056	3638	2952	1320	1866	1956
3	1688	2201	6809	6058	4455	6124	3890	1967	2349	3007	2162	1088	1526
4	3309	1081	1312	4518	4464	3169	4173	2636	995	1306	1721	1319	646
5	1985	1864	527	744	2891	3176	2085	2232	1466	575	586	940	863
6	1016	1091	1010	233	391	2045	2192	1183	1264	976	263	337	620
7	1280	510	599	614	101	211	1364	1437	782	854	584	130	223
+gp	868	1043	1320	1045	472	714	1162	2273	1014	1122	1465	944	836
TOTAL	12642	16147	18448	18452	19728	19991	17197	14783	11508	10792	8100	6624	6669

Age/Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**GMST 70-19**
2	2270	1609	636	878	644	782	1732	4580	1840	4280	3463	2931	4001
3	1676	1966	1435	559	778	561	696	1553	4144	1663	3869	3088	
4	1045	1123	1459	1084	365	610	461	595	1389	3710	1484	2974	**GMST 15-19**
5	404	629	794	939	685	259	496	382	518	1238	3314	1077	2931
6	595	226	401	551	589	519	199	420	332	454	1107	2713	
7	412	413	143	271	388	459	433	164	371	296	403	917	
+gp	523	904	322	597	936	503	1526	771	802	986	515	1507	
TOTAL	6924	6870	5190	4880	4386	3693	5543	8465	9396	12627	14153	15206	

Table 31.12. Sol.27.7a – Summary.

	RECRUITS Age 2	SSB	BIOMASS	LANDINGS	F_{BAR} 4–7	YIELD/SSB
1970	3695	6436	7132	1785	0.390	0.28
1971	10177	6222	7406	1882	0.440	0.30
1972	3186	5011	5727	1450	0.451	0.29
1973	13133	5123	6553	1428	0.430	0.28
1974	5870	5068	6189	1307	0.444	0.26
1975	6680	5359	6229	1441	0.395	0.27
1976	3857	4889	5501	1463	0.427	0.30
1977	15772	4490	5509	1147	0.370	0.26
1978	9040	5092	6244	1106	0.358	0.22
1979	8848	5685	6887	1614	0.475	0.28
1980	5070	5513	6429	1941	0.637	0.35
1981	4497	5165	5908	1667	0.481	0.32
1982	2460	4331	4745	1338	0.441	0.31
1983	5557	4095	4917	1169	0.436	0.29
1984	15464	4602	6785	1058	0.352	0.23
1985	16229	5637	7852	1146	0.337	0.20
1986	23709	6947	9508	1995	0.438	0.29
1987	3458	7153	8544	2808	0.864	0.39
1988	3493	5504	5981	1999	0.694	0.36
1989	4369	4616	5164	1833	0.580	0.40
1990	5553	3610	4270	1583	0.658	0.44
1991	12666	3173	4460	1212	0.506	0.38
1992	4947	3440	4445	1259	0.531	0.37
1993	6181	3219	3848	1023	0.560	0.32
1994	5239	4034	4964	1374	0.496	0.34
1995	2004	3504	3945	1266	0.509	0.36
1996	2496	2698	3067	1002	0.526	0.37

	RECRUITS Age 2	SSB	BIOMASS	LANDINGS	F_{BAR} 4–7	YIELD/SSB
1997	8356	2488	3429	1003	0.598	0.40
1998	6871	3009	4231	911	0.497	0.30
1999	5240	3302	4303	863	0.472	0.26
2000	6955	3108	3895	818	0.461	0.26
2001	4552	3545	4293	1053	0.351	0.30
2002	2330	3556	3997	1090	0.383	0.31
2003	3056	3193	3592	1014	0.361	0.32
2004	3638	2285	2766	709	0.313	0.31
2005	2952	2065	2504	855	0.555	0.41
2006	1320	1632	1882	569	0.469	0.35
2007	1866	1389	1647	492	0.338	0.35
2008	1956	1328	1580	332	0.314	0.25
2009	2270	1074	1347	325	0.386	0.30
2010	1609	1197	1460	277	0.290	0.23
2011	636	1096	1255	330	0.351	0.30
2012	878	1158	1291	298	0.300	0.26
2013	644	1090	1201	148	0.167	0.14
2014	782	874	963	99	0.119	0.11
2015	1732	1297	1507	76	0.076	0.06
2016	4580	1230	1688	35	0.037	0.03
2017	1840	1900	2342	34	0.020	0.02
2018	4280	2698	3232	36	0.014	0.01
2019	3463	2997	3589	400	0.148	0.13
2020	2931*	3493	3918	404	0.131	0.12
Arith. Mean	5459	3561	4316	1029	0.399	0.27

Table 31.13. Sole in 7.a - Input for catch forecast and Fmsy analysis.

Input: F 2021: Based on landings of 691t for 2021, The TAC 2021 was not available. Therefore, the catch advice for 2021 was used.

F 2022–2023: mean 18-20 scaled to 2020

Catch and stock weights are mean 18–20

Recruits age 2 in 2020–2023 GM(15–19)

2021								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	2931	0.1	0.38	0	0	0.141	0.013	0.18
3	2638	0.1	0.71	0	0	0.203	0.17281	0.226
4	2525	0.1	0.97	0	0	0.259	0.24632	0.287
5	2287	0.1	0.98	0	0	0.325	0.1865	0.349
6	808	0.1	1	0	0	0.389	0.11591	0.415
7	2272	0.1	1	0	0	0.429	0.17927	0.407
+gp	1995	0.1	1	0	0	0.439	0.17927	0.43
fbar 4-7							0.182	
2022								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	2931	0.1	0.38	0	0	0.141	0.0093	0.18
3	2618	0.1	0.71	0	0	0.203	0.1241	0.226
4	2008	0.1	0.97	0	0	0.259	0.1769	0.287
5	1786	0.1	0.98	0	0	0.325	0.1339	0.349
6	1717	0.1	1	0	0	0.389	0.0833	0.415
7	651	0.1	1	0	0	0.429	0.1288	0.407
+gp	3227	0.1	1	0	0	0.439	0.1288	0.43
fbar 4-7							0.130713	

2023								
Age	N	M	Mat	PF	PM	SWt	Sel	CWt
2	2931	0.1	0.38	0	0	0.141	0.0093	0.18
3	2627	0.1	0.71	0	0	0.203	0.1241	0.226
4	2092	0.1	0.97	0	0	0.259	0.1769	0.287
5	1523	0.1	0.98	0	0	0.325	0.1339	0.349
6	1413	0.1	1	0	0	0.389	0.0833	0.415
7	1429	0.1	1	0	0	0.429	0.1288	0.407
+gp	3085	0.1	1	0	0	0.439	0.1288	0.43
fbar 4-7							0.130713	

Table 29.14. Sol.27.7a - Management option table.

F 2020: TAC constraint for 2020 (projected landings 2020: 425 t)

F 2021–2022: mean 17–19 scaled to 2019

Catch and stock weights are mean 17–19

Recruits age 2 in 2020–2022 GM(10–18)

Fbar age range: 4–7

2021				
Biomass	SSB	FMult	FBar	Landings
4514	4067	1.392	0.1820	691
2022				2023
SSB	FMult	FBar	Landings	SSB
3974	0.0	0.0000	0	4551
3974	0.1	0.0131	51	4500
3974	0.2	0.0261	101	4449
3974	0.3	0.0392	150	4399
3974	0.4	0.0523	199	4350
3974	0.5	0.0654	247	4301
3974	0.6	0.0784	295	4253
3974	0.7	0.0915	342	4205
3974	0.8	0.1046	388	4158
3974	0.9	0.1176	434	4112
3974	1.0	0.1307	479	4066
3974	1.1	0.1438	523	4021
3974	1.2	0.1569	567	3977
3974	1.3	0.1699	611	3933
3974	1.4	0.1830	654	3889
3974	1.5	0.1961	696	3847
3974	1.6	0.2091	738	3804
3974	1.7	0.2222	779	3763
3974	1.8	0.2353	820	3722
3974	1.9	0.2484	860	3681
3974	2.0	0.2614	900	3641

Input units are thousands and kg - output in tonnes

2022			**2023**	**2023–2022**	**2022-2021**	
FMult	Landings	FBar	SSB	SSB change	TAC change	Basis
1.5301	708	0.200	3834	-4	*	Fmsy
1.8361	834	0.240	3707	-7	*	MSY upper
1.2241	578	0.160	3966	0	*	MSY lower
1.49	691	0.195	3851	-3	*	TACstable**
1.7391	795	0.227	3747	-6	*	TACplus15**
1.2466	588	0.163	3956	0	*	TACminus15**
1.6831	772	0.220	3770	-5	*	Fpa
2.2186	985	0.290	3555	-11	*	Flim
1.3924	650	0.182	3893	-2	*	F2021
2.3627	1039	0.309	3500	-12	*	Btrigger
5.5899	2037	0.731	2500	-37	*	Blim

2022			**2023**	**2023–2022**	**2022–2021**	
FMult	Landings	FBar	SSB	SSB change	TAC change	Basis
1.5301	708	0.200	3834	-4	*	Fmsy
1.8361	834	0.240	3707	-7	*	MSY upper
1.2241	578	0.160	3966	0	*	MSY lower
1.49	691	0.195	3851	-3	*	TACstable**
1.7391	795	0.227	3747	-6	*	TACplus15**
1.2466	588	0.163	3956	0	*	TACminus15**
1.6831	772	0.220	3770	-5	*	Fpa
2.2186	985	0.290	3555	-11	*	Flim
1.3924	650	0.182	3893	-2	*	F2021
2.3627	1039	0.309	3500	-12	*	Btrigger
5.5899	2037	0.731	2500	-37	*	Blim

2022			2023	2023–2022	2022–2021	
FMult	Landings	FBar	SSB	SSB change	TAC change	Basis
1.5301	708	0.200	3834	-4	*	Fmsy
1.8361	834	0.240	3707	-7	*	MSY upper
1.2241	578	0.160	3966	0	*	MSY lower
1.49	691	0.195	3851	-3	*	TACstable**
1.7391	795	0.227	3747	-6	*	TACplus15**
1.2466	588	0.163	3956	0	*	TACminus15**
1.6831	772	0.220	3770	-5	*	Fpa
2.2186	985	0.290	3555	-11	*	Flim
1.3924	650	0.182	3893	-2	*	F2021
2.3627	1039	0.309	3500	-12	*	Btrigger
5.5899	2037	0.731	2500	-37	*	Blim
1.2059	570	0.158	3974	0		SSB_{2023}= SSB_{2022}

*** The TAC 2021 was not available.**

****The TAC 2021 was not available, therefore the landings advice for 2021 was used.**

Table 31.15. Sol.27.7a - Detailed results.

F 2021: Based on landings of 691 t. The TAC 2021 was not available, therefore, the catch advice for 2021 was used.

F 2022–2023: mean 18–20 scaled to 2020.

Catch and stock weights are mean 18–20.

Recruits age 2 in 2020-2023 GM(15–19).

Fbar age range: 4–7.

Year:	**2021**	**F multiplier:**	**1.392**	**Fbar:**	**0.1820**		
Age	**F**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SSNos**	**SSB**
2	0.01300	36	7	2931	413	1114	157
3	0.17281	399	90	2638	536	1873	381
4	0.24632	526	151	2525	654	2449	634
5	0.18650	371	130	2287	744	2241	729
6	0.11591	84	35	808	314	808	314
7	0.17927	355	145	2272	976	2272	976
8	0.17927	312	134	1995	876	1995	876
Total	0.18200	2083	691	15456	4514	12752	4067
Year:	**2022**	F multiplier:	1.00000	Fbar:	0.13071		
Age	**F**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SSNos**	**SSB**
2	0.00934	26	5	2931	413	1114	157
3	0.12411	291	66	2618	532	1859	378
4	0.17691	310	89	2008	520	1948	505
5	0.13394	213	75	1786	581	1750	569
6	0.08325	131	54	1717	668	1717	668
7	0.12875	75	31	651	279	651	279
8	0.12875	371	160	3227	1417	3227	1417
Total	0.13071	1417	479	14938	4412	12266	3974

Year:	**2023**	F multiplier:	1.00000	Fbar:	0.13071		
Age	**F**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SSNos**	**SSB**
2	0.00934	26	5	2931	413	1114	157
3	0.12411	292	66	2627	534	1865	379
4	0.17691	323	93	2092	542	2029	526
5	0.13394	182	64	1523	495	1492	485
6	0.08325	108	45	1413	550	1413	550
7	0.12875	165	67	1429	614	1429	614
8	0.12875	355	153	3085	1355	3085	1355
Total	0.13071	1451	492	15100	4504	12427	4066

Input units are thousands and kg - output in tonnes.

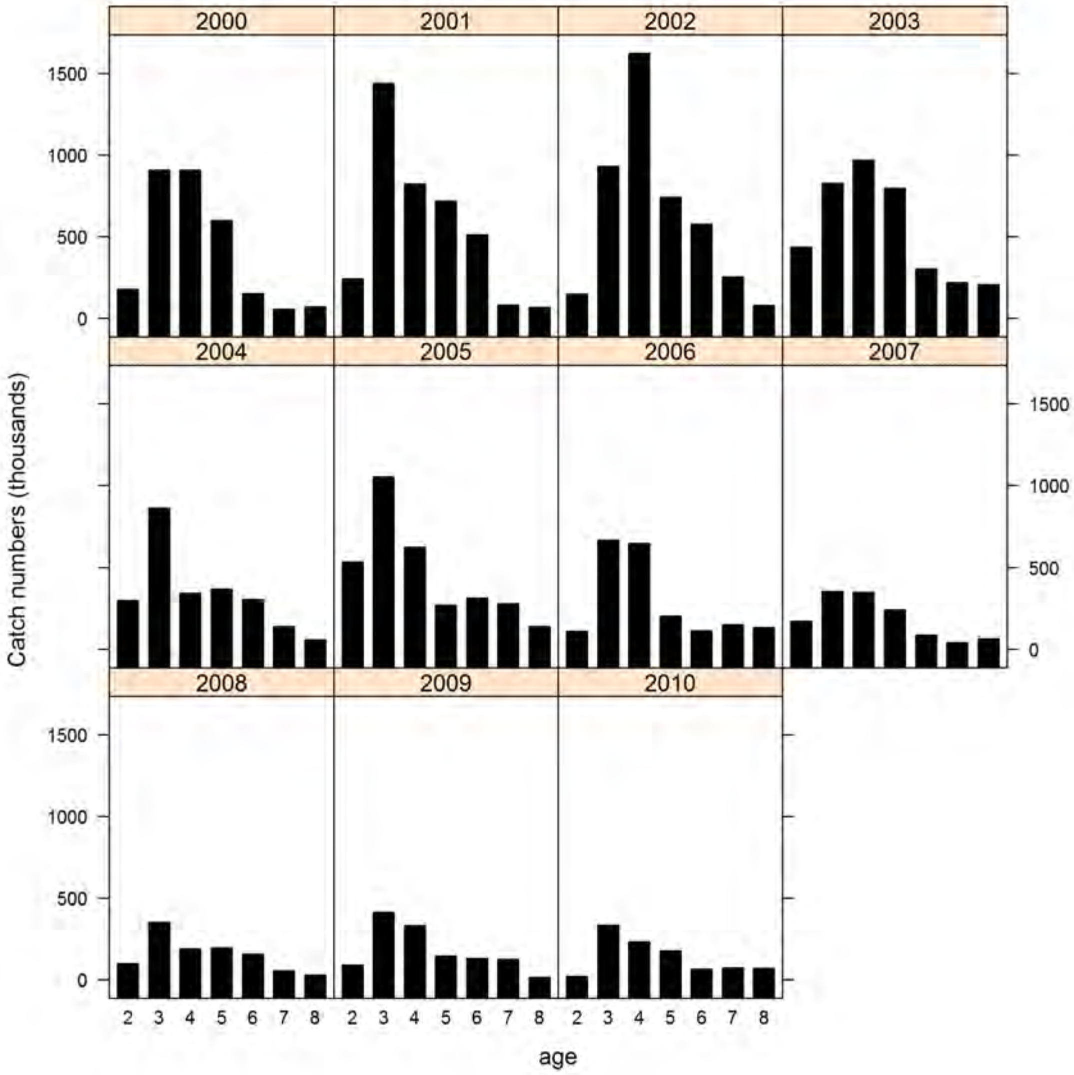

Figure 31.1a. Sol.27.7a - Age composition of landings.

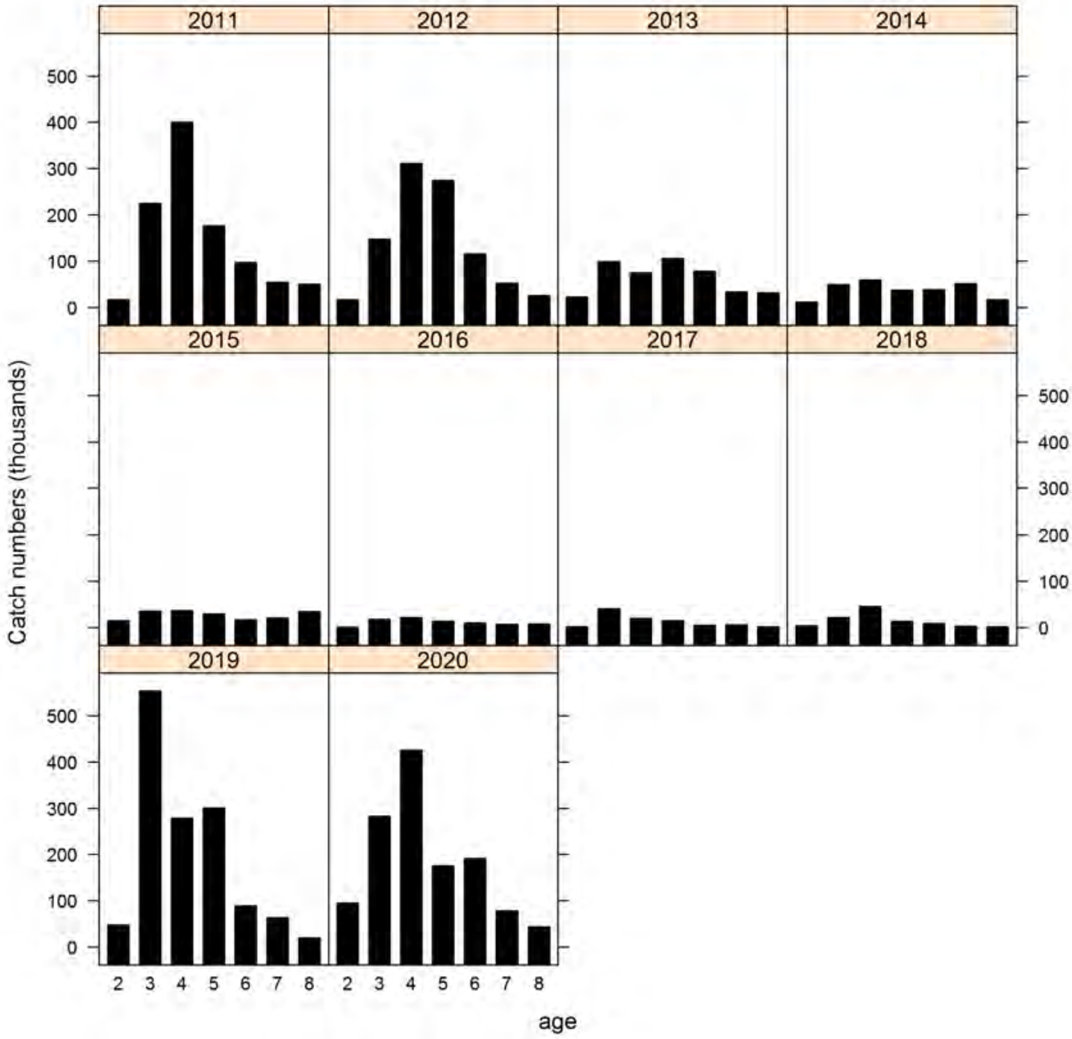

Figure 31.1b. Sol.27.7a - Age composition of landings.

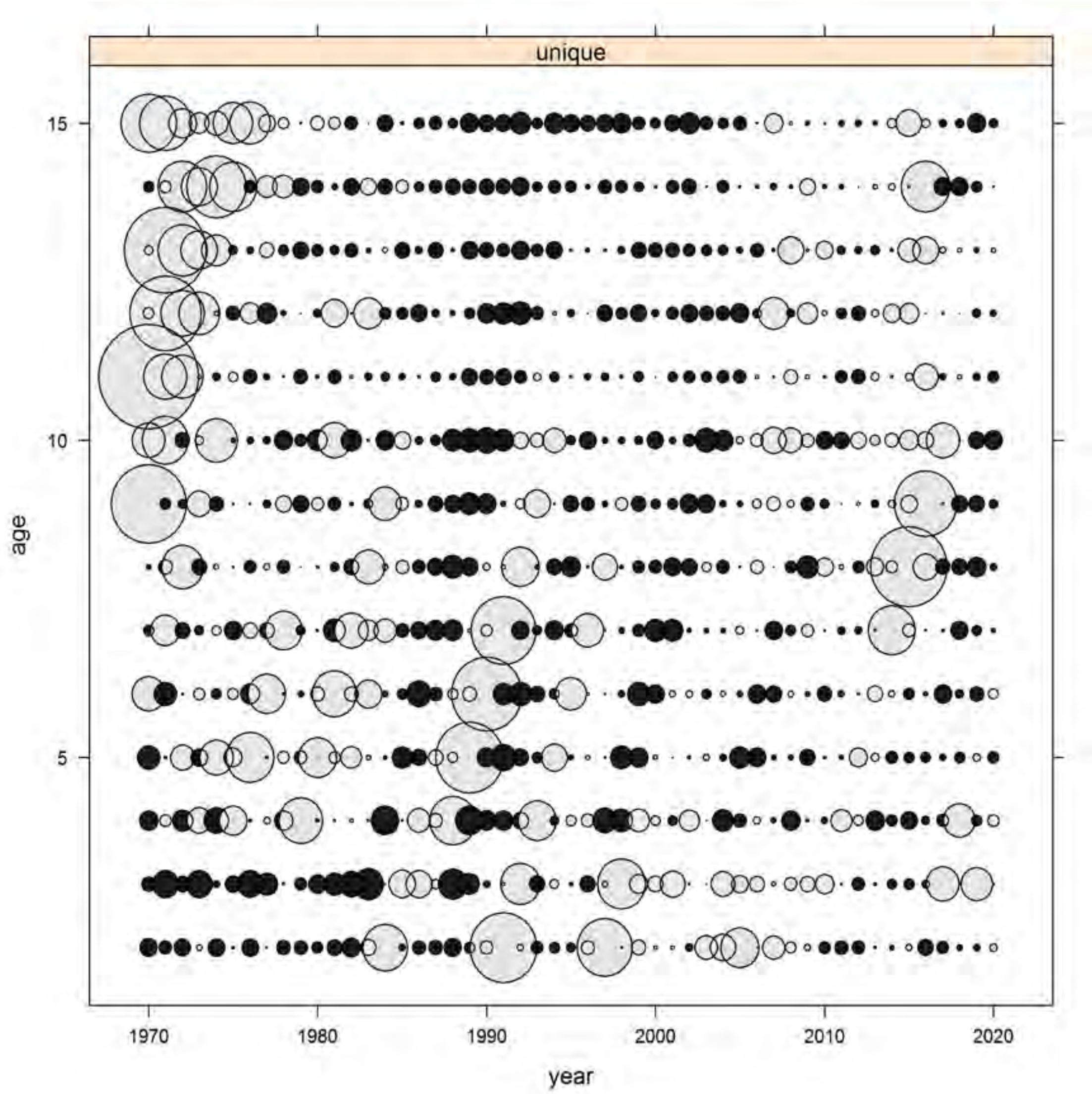

Figure 31.2. - Sol.27.7a - Standardized catch proportion.

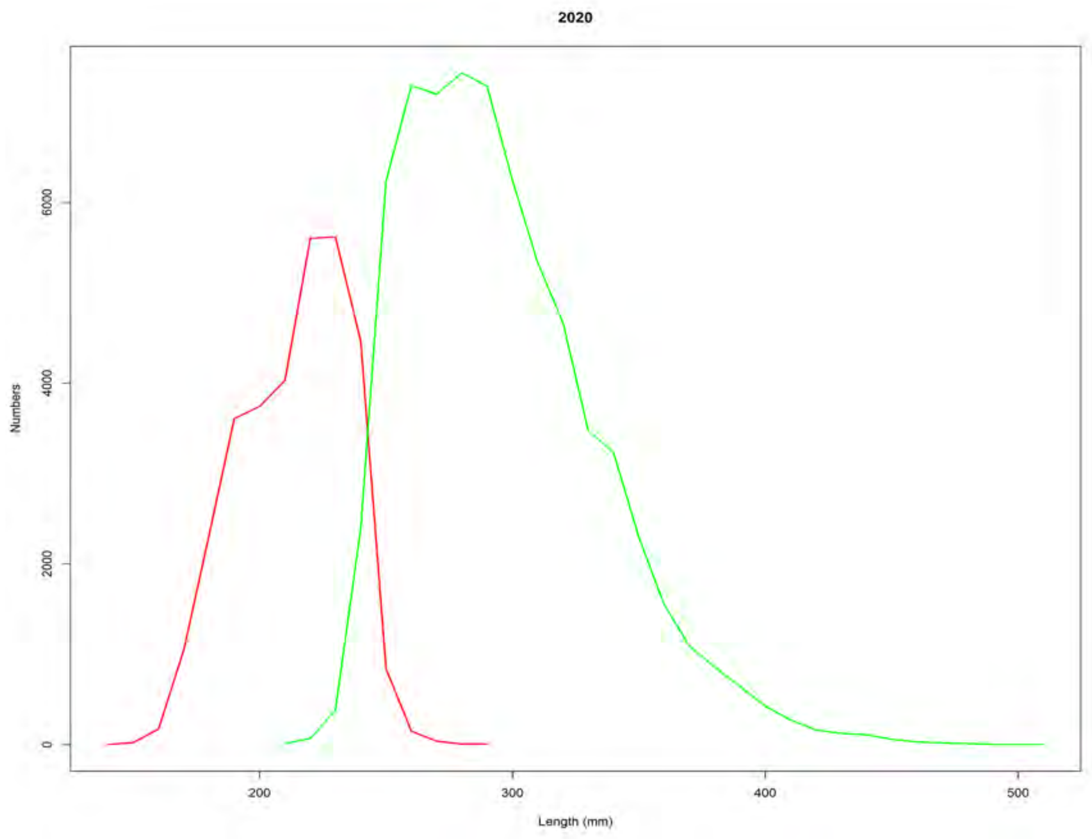

Figure 31.3. Sol.27.7a - BE Length distributions of discarded and retained fish from discard sampling studies (Beam trawl).

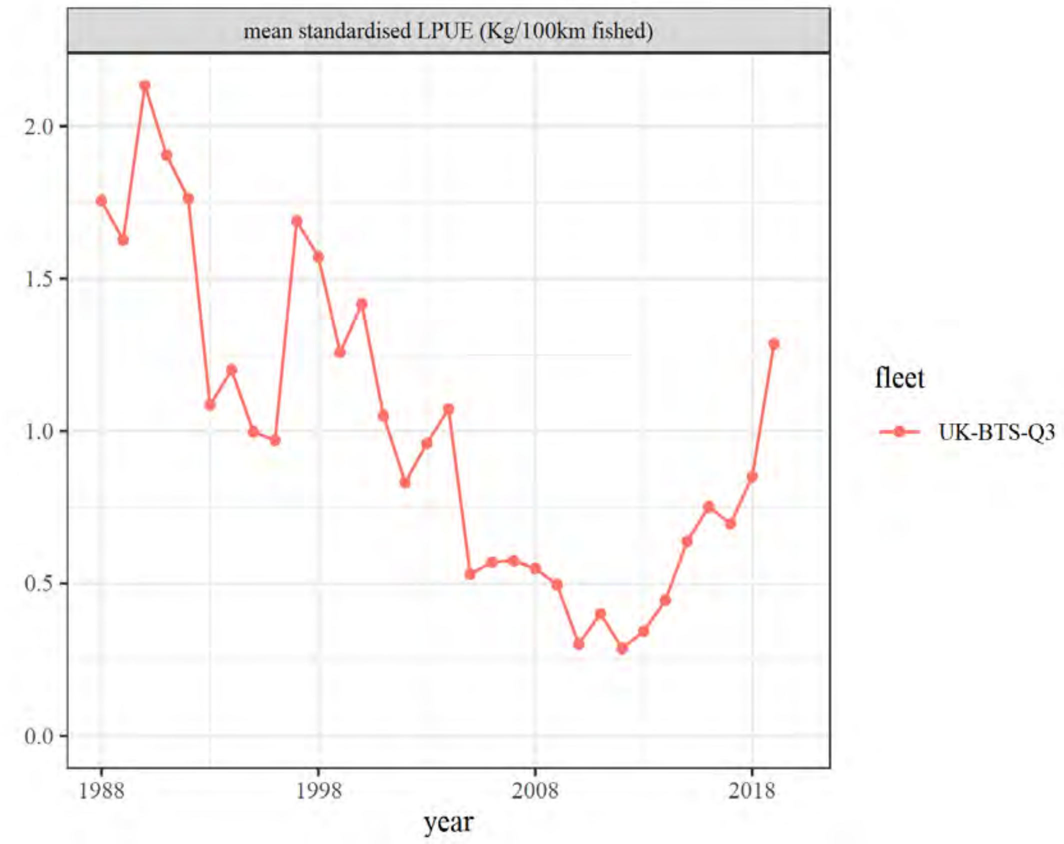

Figure 31.4. Figure 31.4 Sole in 7.a - Mean standardised lpue for the UK (E&W) September beam-trawl survey (UK(E&W)-BTS-Q3).

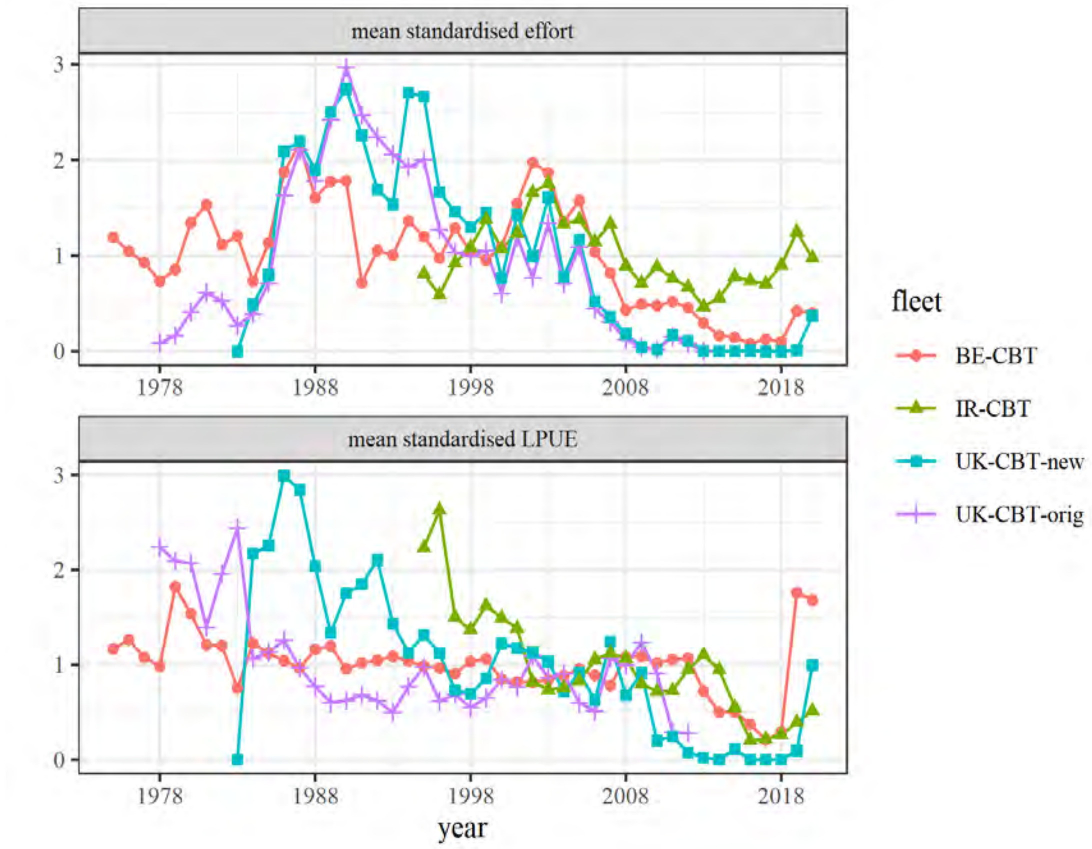

Figure 31.5a. Sole in 7.a - Mean standardised effort and lpue for the commercial beam trawl fleets.

Lpue: BE-CBT: Kg/000'hr; IR-CBT: Kg/hr; UK-CBT-new: Kg/day; UK-CBT-orig: Kg/000'hr fished (GRT corrected >40' vessels).

EFFORT: BE-CBT: 000' hours fishing; IR-CBT: 000'hours; UK-CBT-new: days fished; UK-CBT-orig: 000'hours fished (GRT corrected > 40' vessels)

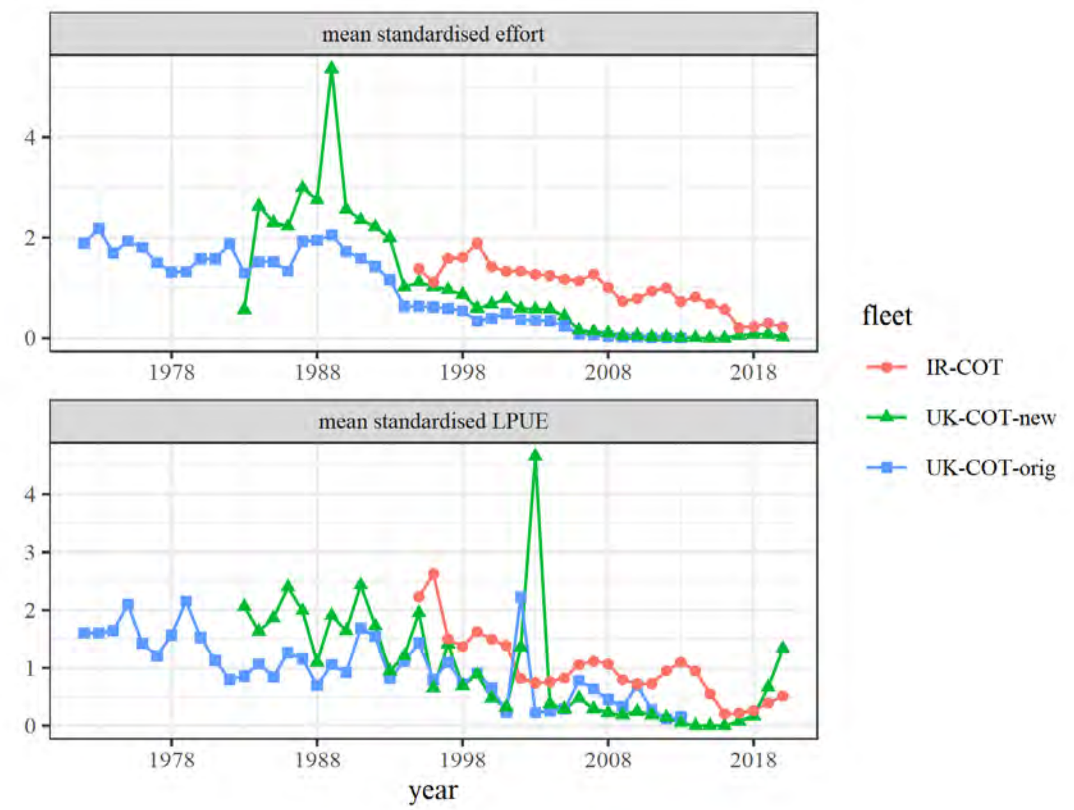

Figure 31.5b. Sole in 7.a - Mean standardised effort and lpue for the commercial otter trawl fleets.

Lpue: IR-COT: Kg/hr; UK-COT-new: Kg/day; UK-COT-orig: Kg/000'hr fished (GRT corrected > 40' vessels).

EFFORT: IR-CBT: 000'hours; UK-CBT-new: days fished; UK-CBT-orig: 000'hours fished (GRT corrected > 40' vessels).

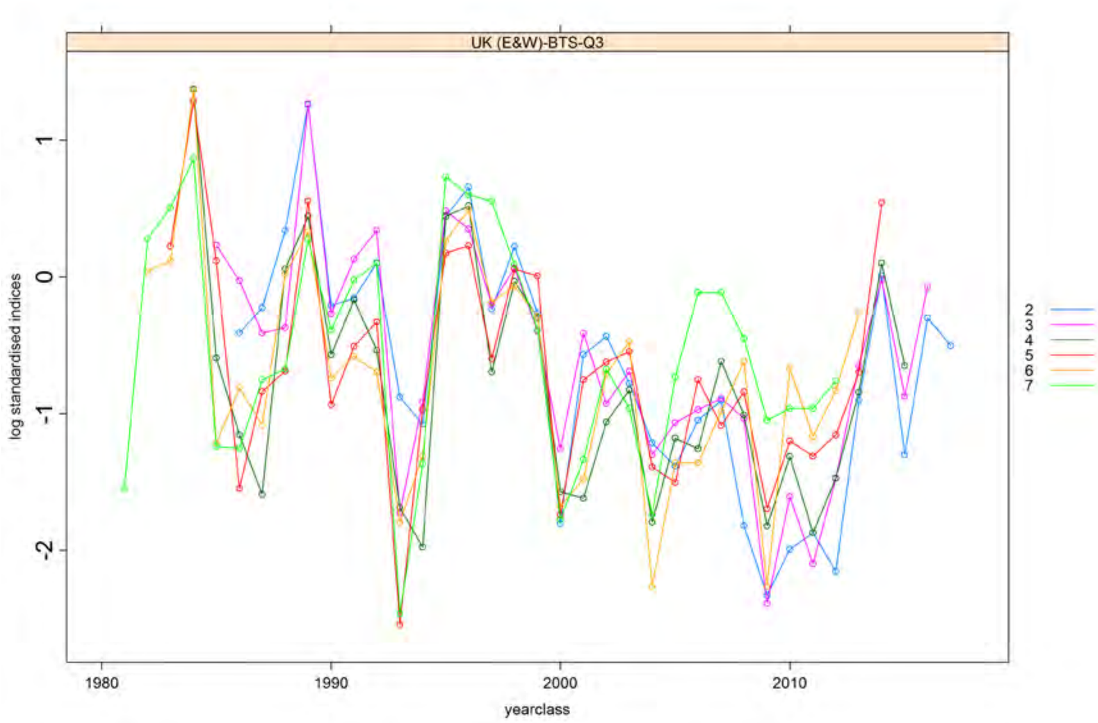

Figure 31.6a. Sol.27.7.a - Mean-standardised indices.

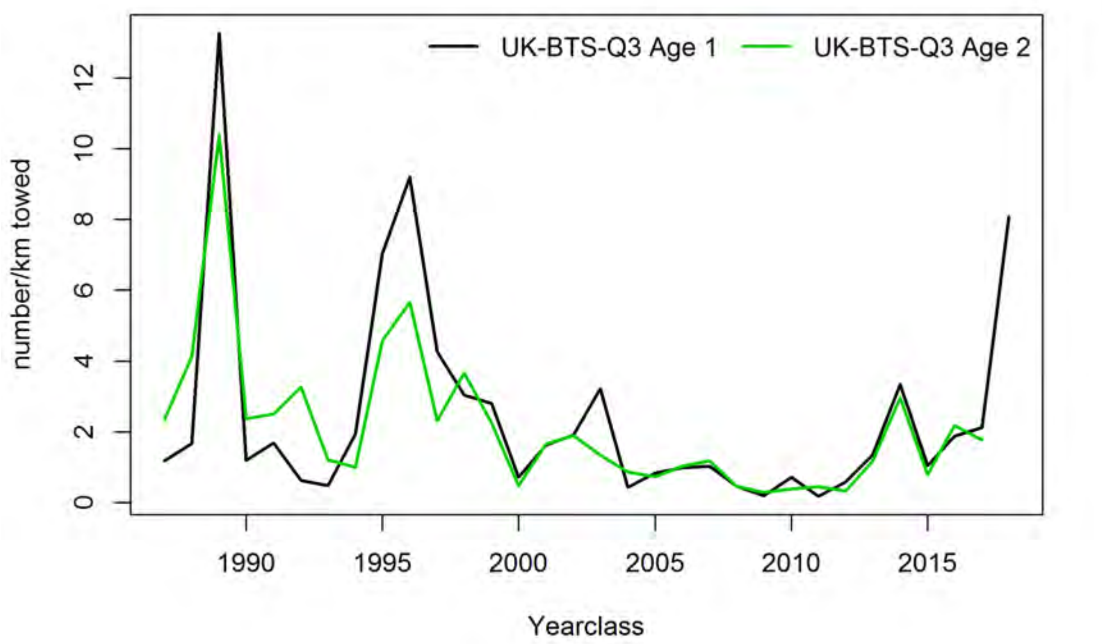

Figure 31.6b. Sol.27.7.a. UK(E&W)-BTS-Q3 age 1 and age 2 by year class.

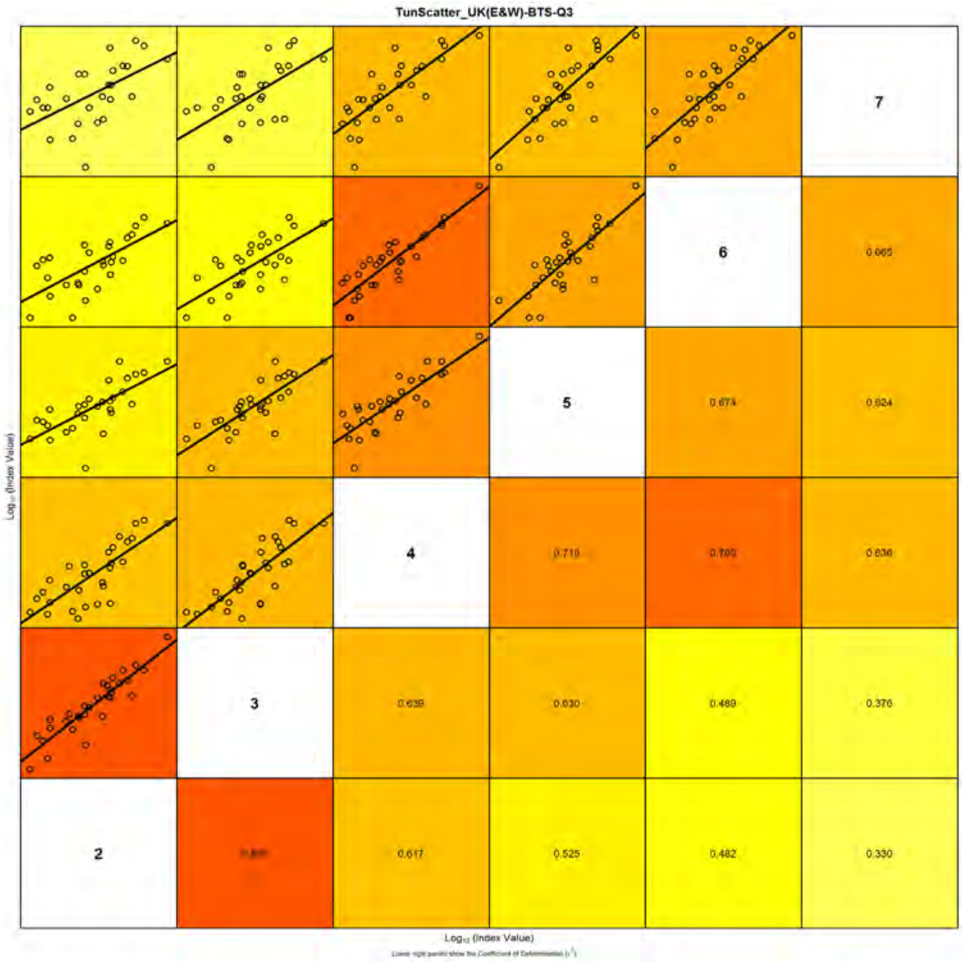

Figure 31.7. Sol.27.7a - Consistency plot UK(E&W)-BTS-Q3 survey.

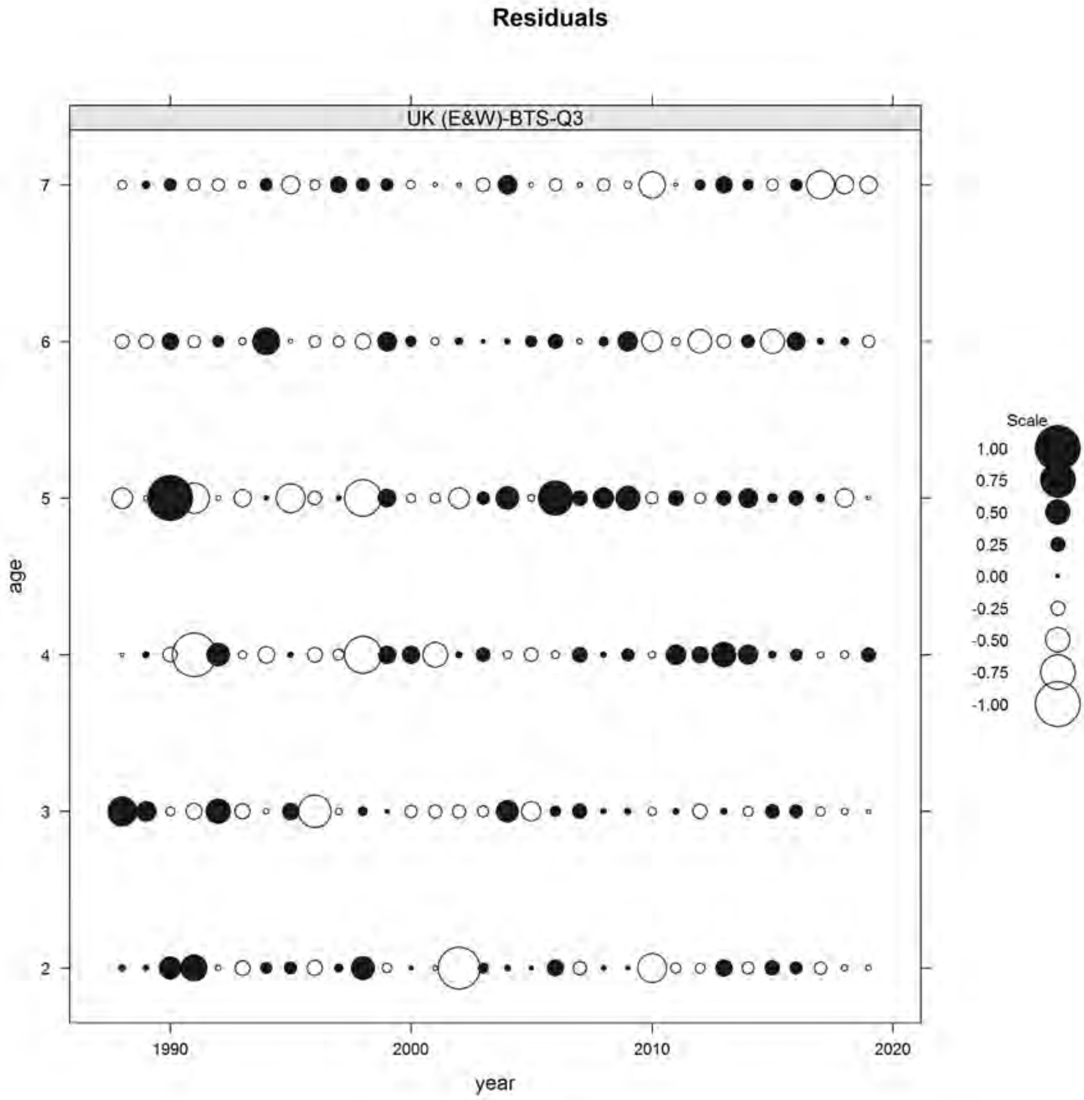

Figure 31.8. Sol.27.7a - LOG CATCHABILITY RESIDUAL PLOTS - Final XSA.

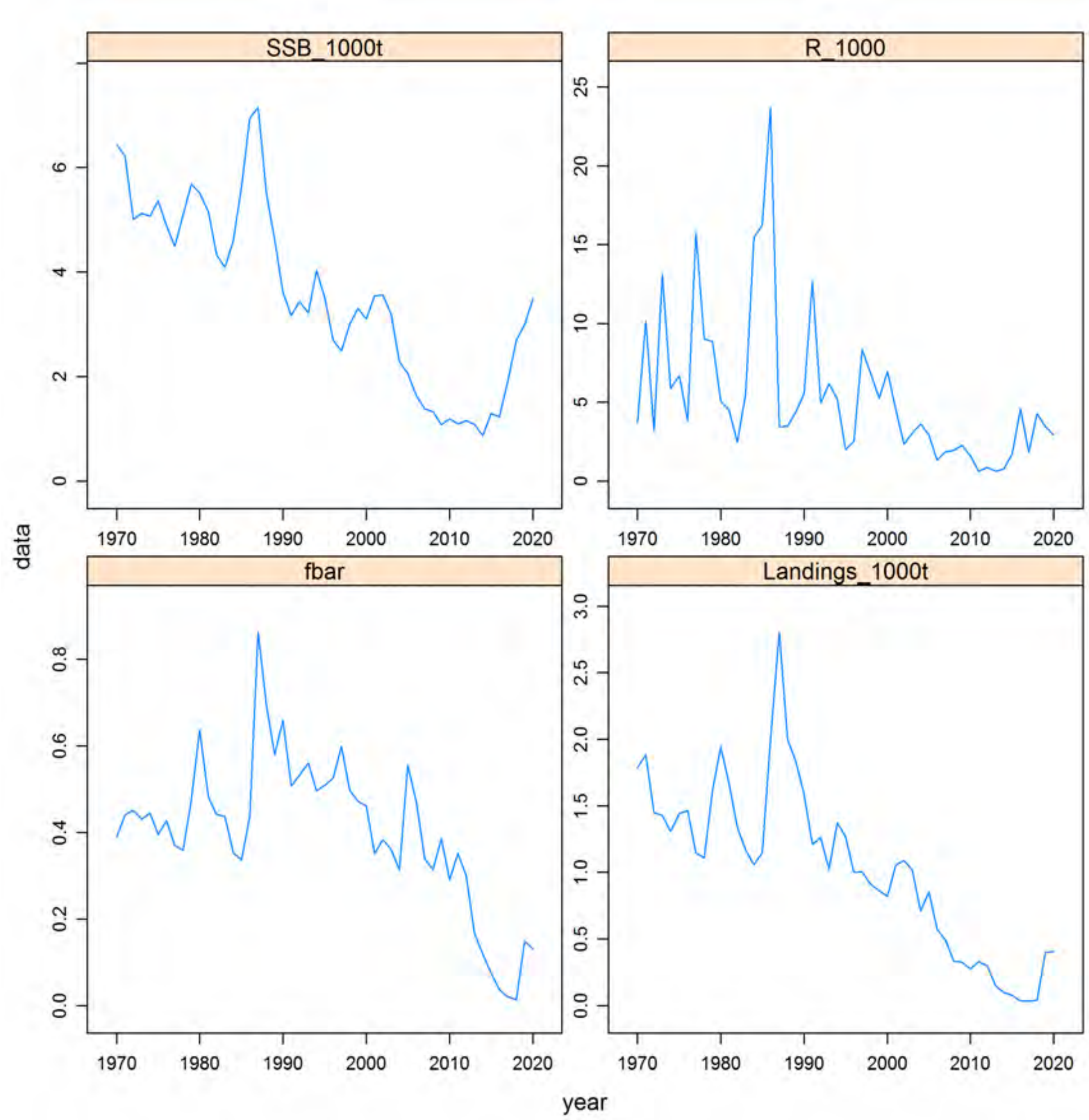

Figure 31.9. Sol.27.7a - Summary plots.

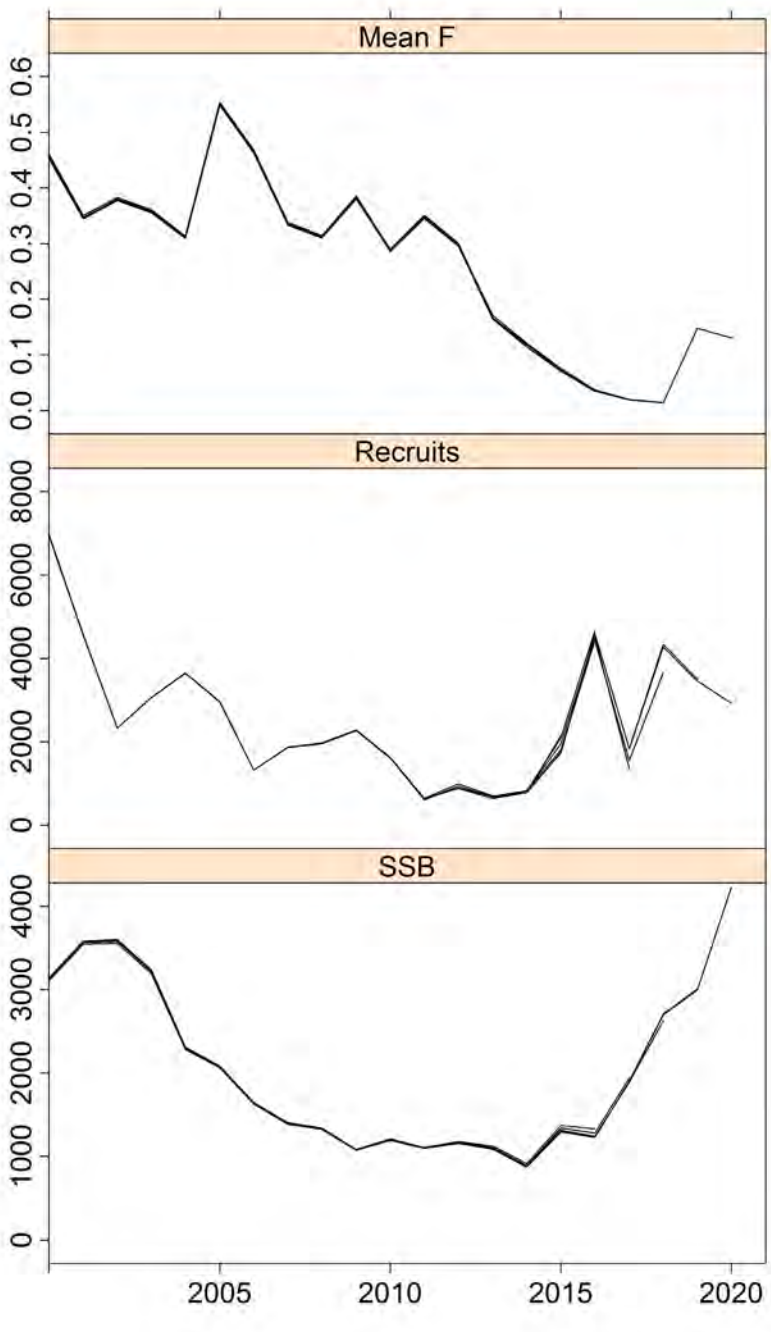

Figure 31.10. Sol.27.7a - Retrospective XSA analysys (shinkage SE=1.5).

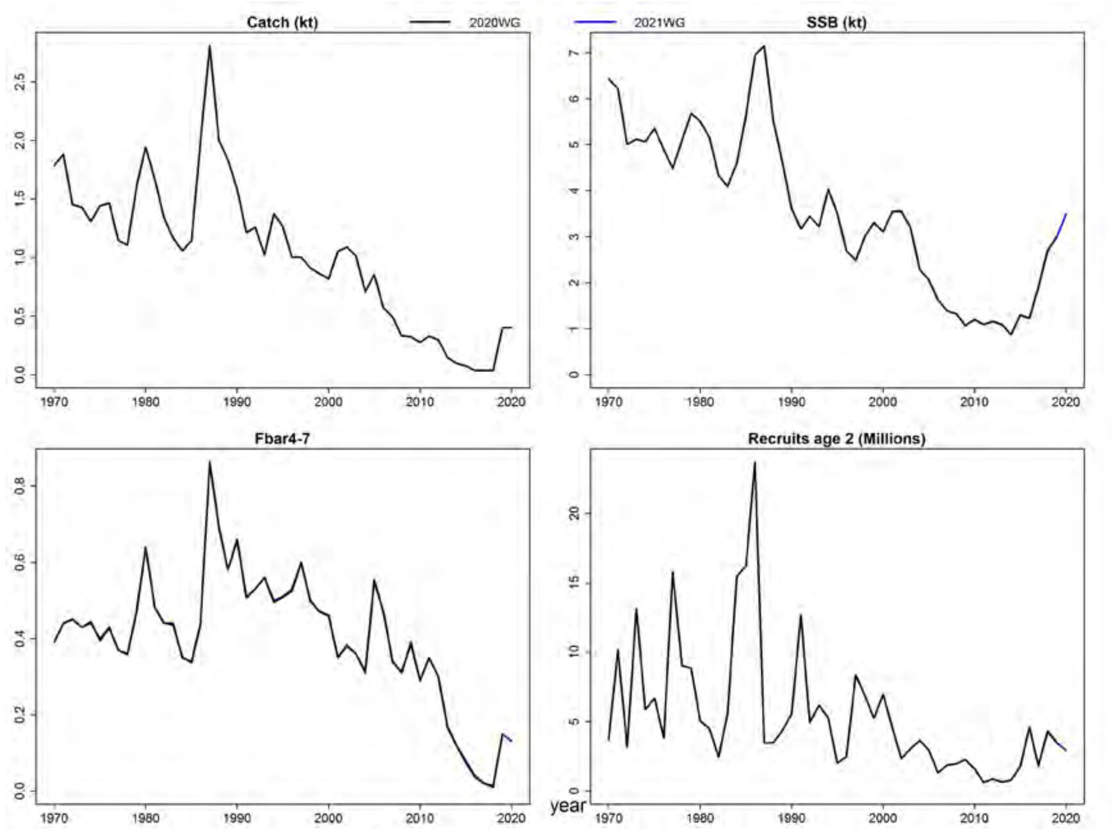

Figure 31.11. Sol.27.7a - comparison with last year's assessment.

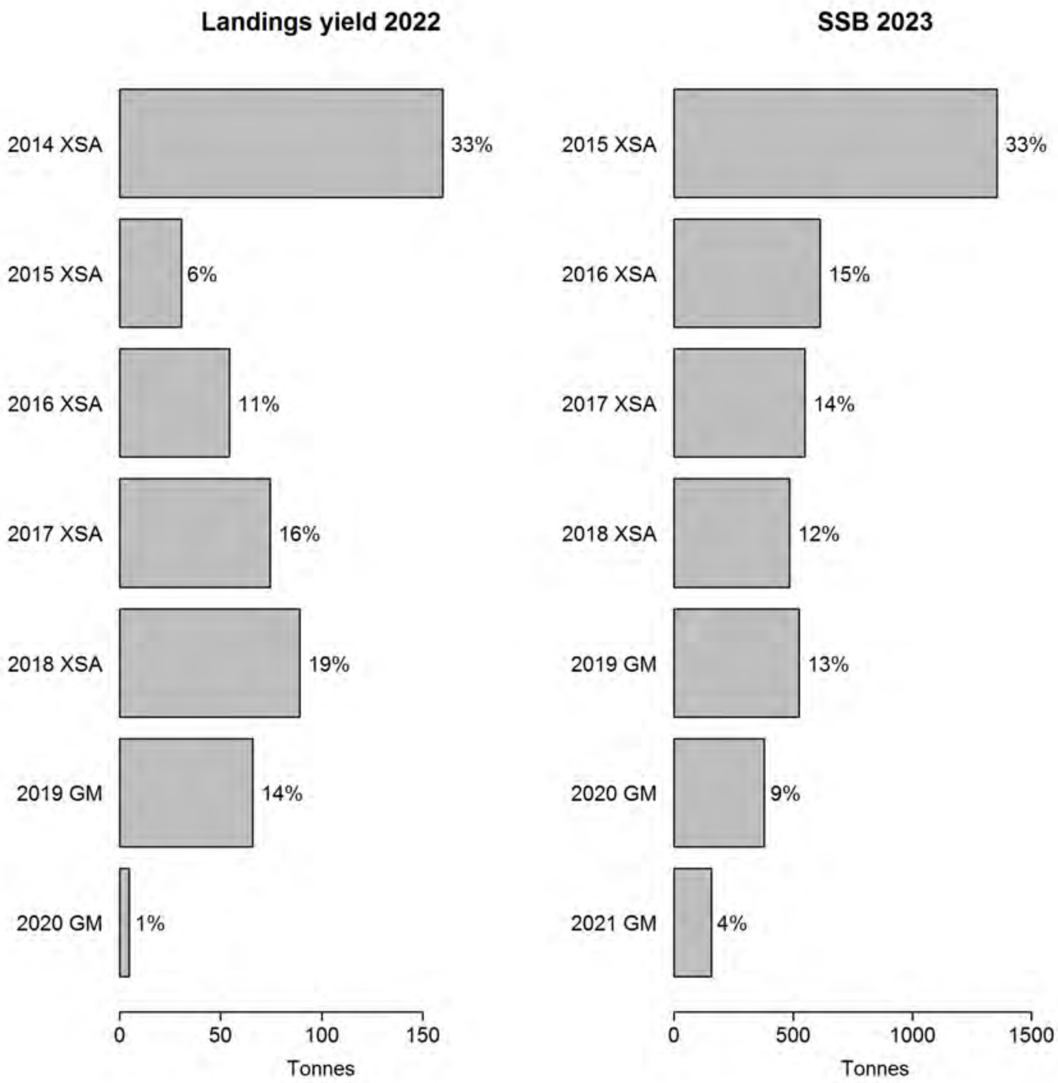

Figure 31.12. Sol.27.7a - Year-class sources and contributions for the short-term forecast.

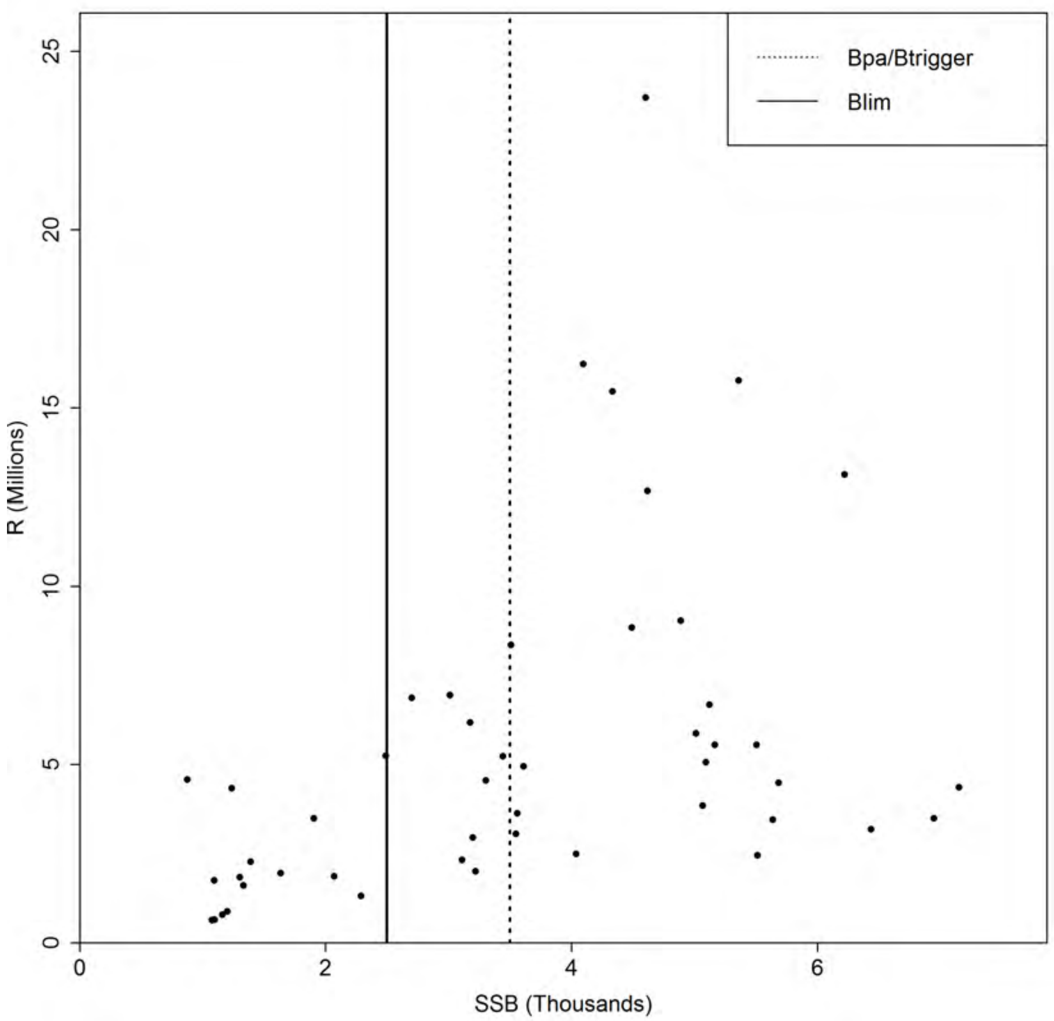

Figure 29.13. Sol.27.7a – Stock–recruitment plot.

32 Sole (*Solea solea*) in Division 7.e (western English Channel)

Type of assessment in 2020

Last year's assessment report is available at:

https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WGCSE/35_Section33_Sole_7e_2020.pdf

ICES advice applicable to 2021

Last year's advice is available at:

https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/sol.27.7e.pdf

32.1 Impact of the COVID-19 pandemic

The sole in Division 7.e stock, its fishery, and data sampling were largely unaffected by the implications of the COVID-19 pandemic in 2020.

Despite national restrictions on scientific sampling activities, sampling levels were high for this stock and sufficient to support an age-structured quantitative stock assessment and the short-term forecast. Details of sampling levels are detailed in this report. Discard sampling was reduced in 2020, but because discards are considered negligible for sole, this did not affect the stock assessment.

Data for all commercial and scientific tuning indices were received for 2020. One scientific survey (Q1SWBeam) was delayed from March 2020 to June 2020. The impact of this change in survey timing is discussed in this report and considered negligible.

32.2 ICES Transparent Assessment Framework

The Division 7.e sole stock is included in the ICES Transparent Assessment Framework (TAF, https://taf.ices.dk, https://github.com/ices-taf). All WGCSE assessments since 2018 are available from the ICES TAF GitHub page (https://github.com/ices-taf/2018_sol.27.7e, https://github.com/ices-taf/2019_sol.27.7e, https://github.com/ices-taf/2020_sol.27.7e_assessment; please note, access to these repositories is so far restricted to ICES and members of WGCSE). The current WGCSE 2021 assessment is available from https://github.com/ices-taf/2021_sol.27.7e_assessment.

All changes since last year's assessment can be accessed with the following link: https://github.com/ices-taf/2021_sol.27.7e_assessment/compare/c2fba0780bf2e7ac681fb1244f7e020a4fd4b6b9...main.

The TAF repository includes all input data, R scripts for processing data, preparing and running the stock assessment and forecast, and scripts for creating all figures and tables presented in this report. This repository also contains documentation on how to reproduce the WGCSE assessment for sole.

32.3 General

Stock description and management units

The TAC specified for ICES Division 7.e is consistent with the assessment area.

Official national landings data as reported to ICES and the landings estimates as used by the Working Group are given in Table 32.1.

Official landings in 2020 were 1218 t, a 32% undershoot of the 2020 TAC (1780 t).

The TAC and the national quotas by country for 2020

Species	**Sole** ***Solea solea***	**Zone:**	**7e** **(Sol/07E.)**
Belgium	52		
France	556		
United Kingdom	870		
Union	1478		
TAC	1478		Analytical TAC Article 7(2) of this Regulation applies

Article 7(2): "2. The stocks of non-target species within safe biological limits referred to in Article 15(8) of Regulation (EU) No 1380/2013 are identified in Annex I to this Regulation for the purposes of the derogation from the obligation to count catches against the relevant quotas provided for in that Article."

(Source: Council Regulation (EU) 2020/123, EU, 2020)

The TAC and the national quotas by country for 2021

There was no agreed international TAC by the time of WGCSE in May 2021.

Maximum number of days a vessel may be present within the area by category of regulated gear per year for 2020

Regulated gear	Maximum number of days	
Beam trawls of mesh size ≥ 80 mm	BE	176
	FR	188
	UK	222
Static nets with mesh size ≤ 220 mm	BE	176
	FR	191
	UK	176

(Source: Council Regulation (EU) 2020/123, ANNEX II, EU, 2020)

Landing obligation

As of 2020, the EU landing obligation fully applied to sole in Division 7.e.

The landing obligation was phased in between 2016–2019 (Commission Delegated Regulations (EU) 2015/2438, 2016/2375, 2018/46, EU, 2015, 2016, 2018). During the phasing in, the landing obligation applied to all catches of sole in 7.e with trammel and gillnets (gear codes GNS, GN, GND, GNC, GTN, GTR, GEN) and all beam trawls. However, a *de minimis* exemption applied, allowing up to 3% discards of annual catches for all trammel and gillnets and for beam trawls with a mesh size of 80–199 mm with increased selectivity. In 2016, the first year of the application, the landing obligation applied only to vessels for which the total landings consisted of more than 10% sole during two reference years (2013 and 2014, Commission Delegated Regulation (EU) 2015/2438, EU, 2015). This threshold was tightened for 2017, and the landing obligation applied to vessels landing more than 5% in the reference years 2014 and 2015 (Commission Delegated Regulation (EU) 2016/2375, EU, 2016). Subsequently, this restriction was lifted altogether, and for 2018 (Commission Delegated Regulation (EU) 2018/46, EU, 2018), the landing obligation applied to all vessels using trammel and gillnets and beam trawls, as described above.

Given the low discards observed in the fishery, the landing obligation is unlikely to impact this stock or the advice significantly.

32.4 Data

InterCatch

International catch data are collated using the ICES InterCatch platform. For 2020, data for Belgium, France, Ireland, the Netherlands and the United Kingdom (England, Scotland and the Channel Islands Guernsey and Jersey) were uploaded into InterCatch (Figures 32.1 and 32.2). All submitted age samples are presented in Figure 32.8 and length samples in Figure 32.9. The raising procedure is described in the Stock Annex.

Landings

Landings of sole in Division 7.e were below 500 t at the beginning of the time-series in the 1970s. Subsequently, landings increased and stayed around 1500 t in the 1980s and have been around 1000 t in the 1990s and 2000s (Table 32.1). The landings dropped in the late 2000s below 750 t and increased since 2015 to 1219 t in 2020.

Only the UK provided age-structured landings samples in InterCatch (Figure 32.8).

Total international landings numbers-at-age (Table 32.2 and Figure 32.5) and landings and stock weights-at-age (Tables 32.3 and 32.4 and Figure 32.6), as used in the assessment, were derived following the procedures outlined in the Stock Annex.

The fleets for which age-distributions were submitted accounted for 84.8% of the 2020 total international landings, based on the InterCatch level (year, country, fleet, and quarter), up from 77.8% for 2019.

Discards

Discards for this stock are very low and not included in the assessment.

For 2020, discards estimates were provided by Belgium, France, and the UK for some fleets in InterCatch based on discard sampling. No age samples were provided. As discards are considered very low, discards were not raised to an international level or allocated with an age structure from sample data.

Discards data are only available from InterCatch for the years 2012–2020. In general, the discard rates are low (Figure 32.3). A higher discard rate was observed in 2015, attributed to high discards from the Multi-rig otter trawl (mesh size 90–99 mm) fleet. The three-year average (2018–2020) discard rate is 0.2%. This reduction in the discard rate might be linked to introducing the landing obligation in 2016.

The discard rate by fleet and country is shown in Figure 32.4 (shown are only discards submitted to InterCatch).

No discard information is included in the assessment, given that it is currently not possible to provide discard estimates for the entire time-series. Nevertheless, excluding discard estimates from the assessment is unlikely to have any major impact on the perception of stock status given the minor scale of the problem.

Revisions

No revisions to previous years were submitted.

Biological data

Natural mortality was assumed to be constant over all ages and years at 0.1. The maturity ogive from divisions 7.f and 7.g was used following the procedures outlined in the Stock Annex and adopted in previous assessments.

In agreement with the Stock Annex, stock and catch weights-at-age were derived by fitting a 2nd-degree polynomial model to the raw landings weights-at-age extracted from InterCatch (Figure 32.7). For 2020 data, the youngest age for which data (catch numbers and weights) were provided was age 1.

Survey indices

Abundance estimates derived from the surveys as used in the assessment are given in Table 32.6 and shown in Figures 32.10, 32.11, 32.12 and 32.13, and internal consistencies in Figures 32.14, 32.15 and 32.16. In general, cohort tracking and internal consistency are better in the commercial tuning fleets and less pronounced in the scientific surveys.

The UK-FSP survey

The UK Fisheries Science Partnership (UK-FSP, quarter 3, ICES survey code B4381, Burt *et al.*, 2021) conducted another survey of sole and plaice abundance in the Western English Channel, 2020. The survey uses two 4 m beam trawls with 80 mm nominal codend mesh and focuses on the area around the English coast. 88 out of 90 tows were completed in 2020. Catch rates are reported standardised as numbers per hour per meter of beam length. The results indicate that sole continues to be widespread in the area (Figure 32.17) and that many cohorts contribute to the stock. The total cpue increased since 2016 and only dropped slightly in 2020. The index is mainly driven by ages 2, 3 and 4. The internal consistency in the survey is good for ages 3+. Some year and cohort effects are visible.

Restrictions caused by the COVID-19 pandemic meant reduced sampling for other species but did not affect sole.

The Q1SWBeam survey

The second survey used for sole is the Quarter 1 South West Beam trawl (Q1SWBeam, also called Q1SWECOS, ICES survey code B2732), which started in 2006. This survey deploys two 4 m beam trawls and uses a fully random stratified approach. In contrast to the FPS survey, the Q1SWBeam covers the entire western English Channel, and if conditions permit adjacent areas. In 2020, all 81 tows were completed. The landings per unit of effort (lpue) numbers-at-age as well as aggregated over all ages are variable without particular trends or patterns, and internal consistency is mediocre.

Usually, this survey takes place in late March. However, due to a lockdown in England caused by the COVID-19 pandemic, the survey could not start in March. Nevertheless, the survey did go ahead in June 2020, approximately three months later than usual. Due to the delay, only the core survey area of the western English Channel was covered. In order to evaluate the impact of the delay on the stock assessment, two stock assessment model runs were performed; one without where the values from 2020 were included and one where this year was omitted. The working group agreed to include the values for 2020 due to the negligible impact on the assessment.

Commercial fleets effort and lpue

Two commercial tuning series from the UK are used (commercial beam trawl UK-CBT and commercial otter trawl UK-COT).

Effort for under 24 m UK beam trawlers in days fished steadily increased from 1992, and reached the highest levels on record in 2012 and stayed around this level until the end of the time-series (Figure 32.10). Currently, the effort is well above the long-term average. In contrast, the effort for over 24 m UK beam trawlers increased from 1992 to 2004 and then decreased to below the average of the time-series, reaching a minimum in 2013. Since then, the effort increased again slightly and is currently around the long-term average. When the effort of all UK beam trawl vessels is combined, the effort stayed almost constant since the early 2000s.

UK otter trawl (UK-COT) effort has been in continual decline since the early-1970s and was at the lowest levels on record in 2015. For 2016, this fleet reported zero effort and landings. This could be explained by a shift in the size of fishing vessels to smaller vessels. Since 2017, a new database is being used for recording, but the data are not consistent with historical data and are therefore not used in the stock assessment.

Age-disaggregated commercial abundance indices for the UK-CBT-late (UK-CBT values from 2003 onwards) and UK-COT fleets as used in the assessment are given in Tables 32.5 and 32.6 and plotted in Figures 32.10–32.13.

Information from the fishing industry

No comments were received regarding the assessment or management of this stock beyond the information from the UK fisheries–science partnership already formally included in the assessment process.

32.5 Stock assessment

Model used: Extended Survivors Analysis (XSA) as outlined in the Stock Annex by IBPWCFlat2 2015.

Software used: FLR – FLXSA.

Model options chosen: Data included in the assessment were identical to previous years, apart from one additional data year.

Assessment input data characteristics: catch numbers-at-age excluding discards and four tuning fleets (two fishery-independent surveys: UK-FSP and Q1SWBeam; and two commercial lpue time-series: UK-CBT-late and UK-COT).

Data screening

Data screening procedures identified no major anomalies in the catch numbers-at-age, weights or tuning information used in the 2021 assessment.

The landings numbers-at-age 3 were exceptionally high in 2017 but returned to usual levels in 2018 (Figure 32.5). This anomaly was evident in age samples from the UK and France and various fleets (see WGCSE 2018 report), i.e. does not seem to be a sampling issue.

Tuning information consisted of four fleets: two UK commercial time-series (UK-CBT-late and UK-COT) and two UK standardised research surveys (UK-FSP and Q1SWBeam).

The UK commercial otter trawl fleet (UK-COT) reported zero effort in 2016. Therefore, there is no lpue value for this fleet for 2016. Consequently, this tuning index only influences the assessment up to and including 2015.

Details of the derivation of the tuning fleets are presented in the Stock Annex. The tuning information available for this assessment is shown in Table 32.6.

Exploration of the COVID-19 impact on the stock assessment

The impact of excluding the 2020 values of the Q1SWBeam index on the stock assessment were explored. Removing these values had a negligible impact on the results (Figure 32.18), and the decision was to include these values in the final assessment.

Final update assessment

The working group fitted the XSA model developed by WKFLAT 2012 (ICES, 2012) using the updated assessment settings agreed at IBPWCFlat2 (ICES, 2015).

The XSA assessment settings used at the last three working groups are shown in the table below, and more historical settings have been included in the Stock Annex.

	WGCSE 2019	WGCSE 2020	WGCSE 2021
Assessment age range	2–12+	2–12+	2–12+
Fbar age range	F(3–9)	F(3–9)	F(3–9)
Assessment method	XSA	XSA	XSA
Tuning Fleets:			
Q1SWBeam	2006–2018 Ages 2–11 (non-offset)	2006–2019 Ages 2–11 (non-offset)	2006–2020 Ages 2–11 (non-offset)
UK-FSP	2004–2018 Ages 2–11	20014–2019 Ages 2–11	20014–2020 Ages 2–11
UK combined beam (late)	2003–2018 Ages 3–11	2003–2019 Ages 3–11	2003–2020 Ages 3–11
UK otter trawl	1988–2016 Ages 3–11	1988–2016 Ages 3–11	1988–2016 Ages 3–11
Time taper	Yes	Yes	Yes
Power model	Tricubic	Tricubic	Tricubic
Taper range	15 years	15 years	15 years
P shrinkage	No	No	No
Q plateau age	7	7	7
F shrinkage S.E	0.5	0.5	0.5
Number of years	3	3	3
Number of ages	5	5	5
Fleet S.E.	0.4	0.4	0.4

Figure 32.19 shows the results from the final XSA model fit, Figure 32.20 the model residuals, Figure 32.21 a comparison of the current assessment with last years' assessments, Figure 32.22 XSA survivor weightings for the last two years and Figure 32.23 a five-year retrospective.

A Mohn's rho analysis was conducted based on the XSA stock assessment results, i.e. the last data year (2020) was used as the final year for comparison of SSB, F and recruitment and based on a five-year retrospective analysis. The results from the Mohn's rho analysis are shown in the following table:

	SSB	F (ages 3–9)	recruitment
Mohn's rho value	-0.0776592728392359	0.13338449435683	-0.0193140462643207

The Mohn's rho values for this assessment are well within the ICES WKFORBIAS thresholds (+0.2, -0.15), i.e. the current assessment indicates sufficient consistency for advice purposes.

XSA diagnostic of the final assessment are presented in Table 32.7, stock numbers-at-age in Table 32.8, fishing mortalities-at-age in Table 32.9 and an assessment summary in Table 32.10.

Consistency of the stock assessment

The comparison of historical stock assessment results (historical retro, Figure 32.21) and the analytical retrospective analysis (Figure 32.23) show slightly different retrospective patterns. It is worth noting that the historical comparison (Figure 32.21) shows the assessment results (including short-term forecast assumptions for the intermediate year) from conducting the stock assessment in the corresponding years. These values are stored in an ICES database and not updated afterwards. On the other hand, the analytical retrospective analysis (Figure 32.23) is conducted with the most recent version of the input data, and its retrospective runs are also based on these most recent (possibly updated or revised) data and only removing data years from the end.

The differences between the historical and analytical retro can be explained through revisions of historical input data over the years, namely:

- Q1SWBeam: The scientific Q1SWBeam survey was revised prior to WGCSE 2020 because of a quality control process of the survey data and data processing. This is described in last year's WGCSE report. This has led to some changes of historical data, which means all historical assessment results prior to 2020 are based on slightly different historical Q1SWBeam data compared to the assessment afterwards.
- FSP: The FSP survey index values used in the assessment are a product of a model fitting to the raw data. This means that the entire time-series is updated every year, including historical values.

Furthermore, the terminal year of the historical retro includes assumptions for the intermediate year. In the following year's assessment, the observed perception of the fishery can be different from that assumed in the previous year.

State of the stock

Stock trends are shown in Table 32.10 and plotted in Figure 32.19. The stock is in a desirable state, both in terms of spawning–stock biomass and fishing mortality.

SSB is estimated to have increased between 1972 and 1980 following successive strong recruitment events. Subsequently, SSB declined from 1980 to 1993 and remained relatively stable until 2008. After this period, SSB has been increasing and is currently well above MSY $B_{trigger}$.

The base level of recruitment has remained relatively stable throughout the time-series, fluctuating without major temporal trend at around 4 million recruits. Recruitment variability has decreased since 1991. Recruitment has been at or above the long-term geometric mean for the last three years. The 2020 recruitment estimate at almost 12 million is the highest in the time-series.

Fishing mortality was relatively stable at a low level between 1969 and 1978, after which it increased sharply until 1983 and fluctuated at a higher level before peaking briefly in 1989–1990. After a period of temporal variability, F decreased abruptly to below the F_{MSY} target of 0.29 in 2009. Since then, F has remained below this level. Fishing mortality was estimated to be well below all reference points in 2020.

The age structure of sole in 7.e continues to be more extended than other sole stocks in European waters, implying low mortality rates, with the plus group at age 12 containing a high proportion of the catches and including some individuals aged 33–38 in recent years.

32.6 Short-term projections

Forecast assumptions

Figure 32.22 shows three different targets for the intermediate year: status quo ($F = F_{2020}$), average ($F = F_{average\ 2018\text{-}2020}$) and TAC (landings = catch advice for 2021 in the absence of an agreed international TAC for 2021). F estimates in 2018–2020 fluctuated around 0.25 and are slightly lower in 2020 compared to 2020.

Landings have been below the international TAC and the advised catch in the previous years (Figure 32.25). The catch advice for 2021 (1925) is substantially higher than in previous years, and reaching this level would mean an increase in landings of 58% compared to 2020. This appears unlikely given the recent trend in landings, fleet capacity and legal limitations on fishing effort.

F_{2020} (0.258) is very similar to $F_{average\ 2018\text{-}2020}$ (0.255). However, because there is no specific trend in the last three Fs (see Figure 32.19), the decision was to use $F_{2021} = F_{average\ 2018\text{-}2020} = 0.255$, and the selectivity set to the average of the same years (2018–2020).

Weights-at-age were calculated as the average of the last three historical years.

In previous years, the intermediate year recruitment was set to the geometric mean of the full recruitment time-series (1969–2019 at WGCSE 2020). However, recent recruitment is estimated to be above the long-term average (Figure 32.19). Consequently, the recruitment assumption was based on a shorter period and calculated as the geometric mean of the last ten years (4.967 million, geometric mean of 2011–2020, 21% higher than when using the geometric mean of 1969–2020 of 4.111 million).

The forecast was conducted with FLR's FLash R package using the output from the landings only XSA assessment. The resulting yield was obtained by adding discards to the landing with an average discard rate of the last three historical years (2018–2020, 0.21%).

The input data for the short-term forecast are shown in Table 32.11.

MSY forecast

Table 32.12 shows a detailed output of the forecast targeting F_{MSY} for 2022–2023, and Table 32.13 the year classes contributing to the forecast yield and SSB.

Figure 32.26 shows the forecast results for F_{MSY}, and Figure 32.27 the forecast, including F_{MSY} ranges.

Additional options

A management options table is provided in Table 32.14, and Table 32.15 shows additional options.

Implementing the MSY approach with F_{MSY}=0.29 leads to a total yield of 1810 t in 2022, and an SSB of 6034 t in 2023.

32.7 Biological reference points

The most recent reference points for this stock were developed by WKMSYREF4 in 2015 (ICES, 2016). These reference points are presented in the following table. Please note that ICES changed the basis for F_{pa} to $F_{p.05}$, and the updated F_{pa} value is shown here.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	2900 t	The 5th percentile of the distribution of SSB when fishing at F_{MSY} (0.29) with no error.	ICES (2016, 2017)
	F_{MSY}	0.29	The peak of the median landings yield curve.	ICES (2016, 2017)
	F_{MSY} lower	0.16	Minimum F which produces at least 95% of maximum yield.	ICES (2016, 2017)
	F_{MSY} upper	0.34	Maximum F which produces at least 95% of maximum yield.	ICES (2016, 2017)
Precautionary approach	B_{lim}	2000 t	Rounded B_{pa}/1.4.	ICES (2016, 2017)
	B_{pa}	2900 t	Rounded B_{loss} (1999 year class). Lowest SSB with high recruitment.	ICES (2016, 2017)
	F_{lim}	0.44	Segmented regression simulation of recruitment with B_{lim} as the breakpoint and no error.	ICES (2016, 2017)
	F_{pa}	0.39	Fp.05; the F that leads to SSB ≥ Blim with 95% probability.	ICES (2016, 2017)
Previous management plan	SSB_{MGT}	Not defined		
	F_{MGT}	0.27		EU (2007)

32.8 Management plan

The European Commission implemented a management plan for the recovery of the stock early in 2007 (Council Regulation (EC) No 509/2007). The management plan has not been formally evaluated, but the working group concluded that: The long-term management target (F_{MGT} =

0.27) is precautionary in the sense that it ensures that there is a less than 5% chance of SSB declining below previously observed levels, as well as maintaining yield within 10% of MSY (*WGCSE note: long-term yield at F_{MAX}*) (working group, 2005; working group, 2006).

This management plan has not been used in recent years, and the ICES advice has been based on the MSY approach, targeting F_{MSY}.

The management plan (Council Regulation (EC) No 509/2007) is no longer in force since 2019 and has been repealed by an EU multiannual plan for stocks fished in the Western Waters and adjacent waters (Regulation (EU) 2019/472, EU, 2019) which aims at targeting MSY.

32.9 Uncertainties in assessment and forecast

The methodology provided is as robust as possible and does not currently appear to suffer from a serious retrospective pattern.

Discarding

Discarding is considered negligible in the sole fishery, averaging only 0.2% of total international catch weight in 2020. Nevertheless, a time-series of available discards information raised to the fleet level should be developed to effectively deal with potential future discard issues and improve estimates of total mortality. The EU landing obligation was implemented during 2016–2019 with a discard plan and seemed to have reduced the already low discards even more. The landings advice has been topped up with the available discard information to give catch advice. Developing a time-series of discard information appears to be less urgent than in the past.

Surveys

The assessment methodology includes two survey indices. The UK-Q1SWBeam survey added to the assessment in 2012 covers the entire management area, providing fishery-independent tuning information for the entire age range used in the assessment. Therefore, the assessment relies much less on the commercial tuning information and is less susceptible to localised exploitation by the fishery. Consequently, commercial tuning information is still used in the assessment to maintain the balance between accuracy and precision required by management. Survey information for the recruiting year class remains temporally variable and is not used in the forecast for this reason.

Sampling

Age and length sampling for this stock is mostly adequate. Age data from the largest sector operating in this fishery (UK) are included in the assessment. France submitted no age samples for the 2019 season. Due to reprocessing of age data submitted by France in 2018, age samples from several strata were retracted. French age data between 2009 and 2014 were insufficient at older ages to raise the length compositions, and therefore UK age data were used to cover the larger fish.

There are very limited discard age samples, but this does not impose a problem on the assessment or forecast due to very low discarding.

Consistency

The assessment for this stock was last benchmarked in 2012, and an inter-benchmark was held in 2015. The 2021 assessment is consistent with the previous assessments conducted in recent years. Temporal trends in SSB and F estimates were virtually identical.

32.10 Recommendation for the next benchmark

There is no requirement to benchmark this stock in the short term.

The XSA assessment uses a taper range of 15 years for the tuning indices, effectively down-weighting older tuning data and removing data older than 15 years altogether. As tuning time-series become longer, potentially important information might get lost in the process. Therefore, a re-evaluation of assessment parametrisation should be considered.

Lpue estimates for the UK-CBT and UK-COT fleets should be closely monitored to avoid the recurrence of inaccuracies in commercial tuning information observed at the 2014 and 2015 working groups. A rescaling observed in the 2018 and 2019 assessments can be explained by underlying data. Consequently, the next benchmark should evaluate the temporal stability of the retrospective patterns and determine whether the assessment settings need to be revised.

The UK-COT effort has been in continuous decline and reported no activity in 2016 and subsequently, due to a new database system, cannot be replicated anymore. Consequently, a benchmark could investigate the removal of commercial tuning information altogether from the assessment.

As the time-series on discards increases, a future benchmark might look into including discard estimates in the assessment and estimating historical discards. Discards are very low and, due to the implementation of the landing obligation in 2016, unlikely to become a problem in the future.

32.11 Management considerations

France provided discard estimates for the first time at the 2016 working group. Discard estimates from France are higher than from the other countries.

Plaice is taken as bycatch in this fishery, and therefore management advice for sole must also consider the advice for plaice. Anglerfish, cuttlefish, and lemon sole are also important bycatches in this fishery.

32.12 Ecosystem considerations and changes in the environment

See Stock Annex.

32.13 Regulations and their effects

Management of this stock is mainly by TAC. In 2005, effort restrictions were implemented for beam trawlers and entangling gears targeting sole in this fishery to enforce the TAC and improve data quality. The effort restrictions were included in the 2007 management plan (EU, 2007) and are continued in the EU multiannual plan (EU, 2019). The effort restrictions limit the numbers of days at sea for vessels in 7.e using beam trawls (≥80 mm mesh size) and static nets (≤120 mm mesh size). The limits for effort are set annually in the EU council with the TAC and apply only for vessels, which catch more than 300 kg of sole annually.

Mesh restrictions for towed gears are set to 80 mm codends, which correspond well with the minimum landing size of sole at 24 cm (25 cm for Belgian vessels since December 2017).

32.14 References

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32.15 Tables

Table 32.1. Sole in Division 7.e. History of official landings and ICES estimates. All weights are in tonnes.

Year	Belgium	France	Netherlands	Ireland	UK and Channel Islands	Official total	ICES landings	ICES discards
1974		323				323	427	
1975	3	271			217	491	491	
1976	4	352			260	616	616	
1977	3	331			272	606	606	
1978	4	384			453	841	861	
1979	1	515			665	1181	1181	
1980	45	447		13	764	1269	1269	
1981	16	415	1		788	1220	1215	
1982	98	321			1028	1447	1446	
1983	47	405	3		1043	1498	1498	
1984	48	421			901	1370	1370	
1985	58	130			911	1099	1409	
1986	62	467			840	1369	1419	
1987	48	432			632	1112	1280	
1988	67	98			784	949	1444	
1989	69	112	6		613	800	1390	
1990	41	81			636	758	1315	
1991	35	325			477	837	852	
1992	41	267			468	776	895	
1993	59	236			498	793	904	
1994	33	257			546	836	800	
1995	21	294			565	880	856	
1996	8	297			428	733	833	
1997	13	348		1	496	858	949	
1998	40	343			389	772	880	
1999	13				396	409	957	

Year	Belgium	France	Netherlands	Ireland	UK and Channel Islands	Official total	ICES landings	ICES discards
2000	4	241			413	658	914	
2001	19	224			407	650	1069	
2002	33	198			309	540	1106	
2003	1	363		1	255	620	1078	
2004	7	302			185	494	1075	
2005	26	406			527	959	1039	
2006	32	357			575	964	1022	
2007	34	384			536	953	1015	
2008	28	312		< 1	474	815	908	
2009	17	386			382	785	701	
2010	17	375			369	761	698	
2011	22	424			431	877	801	
2012	39	325		< 1	506	871	872	2
2013	30	319			540	889	883	1
2014	25	351		< 1	510	886	885	10
2015	42	245		< 1	490	777	774	54
2016	46	245			624	915	913	10
2017	56	198		< 1	746	1000	1007	4
2018	68	217	< 1	< 1	801	1086	1075	3
2019^	47	203	< 1	< 1	926	1176	1185	4
2020^	58	194	< 1		966	1218	1219	< 1

^Preliminary.

Table 32.2. Sole in Division 7.e. Landings numbers-at-age (thousands).

YEAR\AGE	2	3	4	5	6	7	8	9	10	11	12+	TOTAL
1969	89	322	80	148	210	21	50	26	20	9	63	1037
1970	53	232	322	90	83	112	13	35	52	22	113	1127
1971	51	200	246	198	65	80	156	10	35	54	113	1207
1972	146	412	167	115	112	14	25	134	38	54	106	1323
1973	71	396	433	89	99	120	17	52	30	4	136	1446
1974	45	349	220	178	71	80	43	32	24	55	106	1202
1975	82	567	170	199	115	28	53	26	22	24	171	1456
1976	167	419	472	161	135	92	46	58	51	14	213	1830
1977	426	318	384	206	102	70	74	10	24	32	159	1804
1978	250	1123	347	214	189	103	72	77	38	27	203	2644
1979	227	803	811	250	229	174	103	90	104	28	290	3108
1980	175	559	497	630	126	183	140	65	56	130	342	2902
1981	245	806	651	467	389	179	126	76	58	55	211	3262
1982	128	1451	916	553	352	240	136	113	81	61	294	4324
1983	91	753	1573	583	351	267	294	119	73	37	262	4401
1984	333	663	826	758	325	204	129	152	54	28	255	3727
1985	287	1700	756	469	585	179	97	103	85	29	125	4414
1986	246	1618	971	421	321	336	84	75	90	74	127	4363
1987	487	808	1090	427	204	224	229	47	50	41	162	3770
1988	443	1438	596	728	374	153	162	109	39	50	171	4262
1989	390	871	1233	497	509	225	110	107	113	48	214	4316
1990	341	902	581	553	244	264	143	103	75	85	235	3525
1991	450	415	482	289	220	93	111	68	37	31	145	2341
1992	316	1434	417	297	115	112	61	74	26	23	90	2964
1993	209	704	1107	350	219	151	78	60	56	31	79	3045
1994	97	657	558	558	112	106	49	57	44	50	99	2388
1995	95	308	629	427	411	131	101	61	33	18	142	2356
1996	365	445	364	298	235	257	68	61	49	37	143	2321
1997	216	831	724	325	180	194	173	44	20	40	88	2835

YEAR\AGE	2	3	4	5	6	7	8	9	10	11	12+	TOTAL
1998	265	606	536	336	209	151	80	127	35	34	162	2543
1999	280	915	500	398	255	114	103	54	107	25	123	2874
2000	307	599	751	367	229	107	53	68	51	88	91	2710
2001	145	1401	531	497	268	178	100	55	43	42	159	3419
2002	332	1251	843	387	322	129	105	94	33	18	85	3599
2003	598	835	953	645	130	74	50	58	63	14	61	3482
2004	398	1080	448	445	526	164	116	61	54	35	85	3412
2005	258	468	834	449	366	293	113	80	45	24	96	3027
2006	500	786	472	606	250	224	185	85	56	31	87	3282
2007	201	852	755	293	362	179	130	110	55	27	99	3062
2008	281	752	678	376	163	184	105	71	67	39	89	2805
2009	166	540	385	333	202	66	74	37	50	35	65	1955
2010	68	348	394	329	204	127	49	71	20	34	78	1723
2011	91	499	476	405	233	156	80	39	34	28	93	2136
2012	31	227	525	400	355	231	137	67	44	39	124	2180
2013	120	324	483	595	280	214	147	98	48	23	110	2441
2014	198	320	466	426	410	168	112	79	61	27	97	2364
2015	177	329	395	336	261	206	115	78	45	30	82	2054
2016	92	420	469	276	249	242	189	67	50	33	107	2194
2017	123	1188	334	307	277	130	94	41	36	129	78	2737
2018	80	446	410	272	339	156	242	99	82	221	154	2501
2019	115	874	659	633	381	198	168	123	70	86	157	3463
2020	169	558	1194	613	444	254	137	83	72	33	159	3716

Table 32.3. Sole in Division 7.e. Landings weights-at-age (kg).

year\age	2	3	4	5	6	7	8	9	10	11	12+
1969	0.188	0.245	0.332	0.329	0.367	0.522	0.455	0.463	0.606	0.648	0.661
1970	0.188	0.224	0.295	0.315	0.355	0.436	0.5	0.444	0.514	0.53	0.596
1971	0.151	0.222	0.296	0.367	0.35	0.359	0.431	0.455	0.476	0.388	0.654
1972	0.194	0.227	0.272	0.369	0.408	0.458	0.496	0.402	0.454	0.509	0.601
1973	0.203	0.224	0.262	0.311	0.382	0.415	0.46	0.467	0.538	0.655	0.562
1974	0.183	0.224	0.281	0.379	0.434	0.372	0.465	0.476	0.488	0.475	0.732
1975	0.178	0.21	0.293	0.351	0.395	0.427	0.487	0.58	0.638	0.525	0.663
1976	0.17	0.218	0.287	0.324	0.391	0.455	0.414	0.476	0.479	0.585	0.629
1977	0.197	0.249	0.303	0.357	0.4	0.503	0.464	0.518	0.485	0.553	0.683
1978	0.178	0.239	0.3	0.387	0.435	0.374	0.482	0.485	0.484	0.535	0.665
1979	0.189	0.239	0.33	0.427	0.464	0.472	0.481	0.57	0.527	0.574	0.732
1980	0.189	0.254	0.343	0.389	0.525	0.56	0.609	0.646	0.655	0.6	0.783
1981	0.174	0.225	0.321	0.381	0.477	0.514	0.533	0.598	0.619	0.708	0.66
1982	0.214	0.209	0.278	0.347	0.426	0.498	0.51	0.523	0.526	0.564	0.663
1983	0.187	0.25	0.271	0.306	0.388	0.417	0.473	0.53	0.608	0.551	0.665
1984	0.21	0.243	0.306	0.381	0.391	0.481	0.542	0.562	0.604	0.726	0.643
1985	0.163	0.226	0.298	0.36	0.391	0.472	0.523	0.534	0.522	0.588	0.822
1986	0.174	0.237	0.297	0.354	0.407	0.456	0.502	0.544	0.583	0.618	0.703
1987	0.174	0.245	0.31	0.37	0.425	0.474	0.518	0.557	0.59	0.618	0.665
1988	0.17	0.244	0.312	0.375	0.432	0.484	0.531	0.572	0.608	0.639	0.694
1989	0.167	0.222	0.275	0.326	0.375	0.422	0.467	0.51	0.551	0.59	0.692
1990	0.217	0.272	0.324	0.372	0.419	0.461	0.501	0.538	0.571	0.601	0.669
1991	0.182	0.255	0.323	0.386	0.445	0.499	0.549	0.594	0.634	0.669	0.741
1992	0.166	0.238	0.305	0.366	0.423	0.474	0.52	0.561	0.597	0.627	0.683
1993	0.146	0.209	0.268	0.324	0.376	0.425	0.47	0.513	0.551	0.587	0.672
1994	0.183	0.241	0.295	0.347	0.396	0.442	0.484	0.524	0.561	0.595	0.671
1995	0.192	0.248	0.301	0.351	0.397	0.441	0.481	0.518	0.552	0.583	0.652
1996	0.214	0.262	0.308	0.354	0.399	0.442	0.484	0.524	0.564	0.602	0.694
1997	0.186	0.244	0.3	0.354	0.406	0.455	0.503	0.548	0.592	0.633	0.734

year\age	2	3	4	5	6	7	8	9	10	11	12+
1998	0.191	0.247	0.3	0.35	0.397	0.441	0.482	0.52	0.555	0.586	0.661
1999	0.208	0.257	0.303	0.347	0.389	0.429	0.468	0.503	0.536	0.567	0.637
2000	0.202	0.258	0.31	0.358	0.401	0.441	0.476	0.508	0.535	0.558	0.647
2001	0.203	0.245	0.287	0.326	0.365	0.402	0.438	0.472	0.505	0.537	0.616
2002	0.181	0.236	0.29	0.342	0.391	0.439	0.485	0.529	0.57	0.61	0.706
2003	0.173	0.241	0.306	0.367	0.425	0.479	0.53	0.577	0.62	0.66	0.746
2004	0.176	0.23	0.282	0.334	0.385	0.435	0.485	0.534	0.582	0.629	0.757
2005	0.18	0.236	0.29	0.343	0.394	0.444	0.493	0.54	0.586	0.63	0.747
2006	0.169	0.228	0.282	0.333	0.381	0.424	0.464	0.501	0.533	0.562	0.672
2007	0.183	0.244	0.299	0.35	0.395	0.436	0.471	0.501	0.526	0.546	0.616
2008	0.197	0.245	0.292	0.337	0.382	0.425	0.468	0.509	0.549	0.588	0.652
2009	0.176	0.252	0.322	0.385	0.443	0.494	0.54	0.579	0.612	0.639	0.703
2010	0.169	0.258	0.339	0.412	0.476	0.532	0.58	0.619	0.65	0.673	0.699
2011	0.2	0.261	0.319	0.375	0.428	0.48	0.528	0.575	0.618	0.66	0.749
2012	0.162	0.24	0.311	0.373	0.428	0.476	0.516	0.548	0.572	0.589	0.664
2013	0.172	0.228	0.283	0.337	0.389	0.439	0.489	0.536	0.583	0.628	0.74
2014	0.191	0.254	0.313	0.366	0.415	0.459	0.499	0.533	0.563	0.588	0.709
2015	0.182	0.25	0.313	0.37	0.423	0.471	0.513	0.551	0.583	0.611	0.697
2016	0.215	0.282	0.345	0.401	0.453	0.499	0.541	0.576	0.606	0.631	0.72
2017	0.225	0.279	0.331	0.382	0.432	0.479	0.525	0.568	0.61	0.651	0.763
2018	0.205	0.264	0.321	0.374	0.425	0.473	0.518	0.56	0.6	0.636	0.768
2019	0.18	0.233	0.284	0.333	0.379	0.423	0.464	0.503	0.54	0.574	0.682
2020	0.188	0.235	0.28	0.323	0.365	0.406	0.445	0.483	0.519	0.553	0.642

Table 32.4. Sole in Division 7.e. Stock weights-at-age (kg).

year\age	2	3	4	5	6	7	8	9	10	11	12+
1969	0.125	0.2	0.27	0.33	0.38	0.425	0.46	0.49	0.52	0.55	0.609
1970	0.12	0.195	0.255	0.305	0.355	0.395	0.43	0.465	0.49	0.51	0.541
1971	0.09	0.17	0.24	0.295	0.345	0.39	0.42	0.445	0.47	0.49	0.544
1972	0.13	0.2	0.265	0.325	0.38	0.42	0.46	0.49	0.52	0.54	0.558
1973	0.105	0.17	0.235	0.29	0.34	0.39	0.435	0.475	0.51	0.54	0.585
1974	0.125	0.2	0.265	0.32	0.37	0.41	0.455	0.49	0.515	0.53	0.571
1975	0.144	0.221	0.267	0.327	0.385	0.435	0.479	0.516	0.545	0.569	0.628
1976	0.146	0.198	0.247	0.294	0.338	0.38	0.417	0.456	0.491	0.523	0.595
1977	0.156	0.221	0.278	0.332	0.382	0.425	0.462	0.497	0.527	0.553	0.629
1978	0.156	0.217	0.276	0.33	0.38	0.425	0.463	0.498	0.526	0.555	0.63
1979	0.141	0.216	0.287	0.352	0.414	0.463	0.502	0.539	0.574	0.608	0.719
1980	0.125	0.206	0.288	0.36	0.436	0.513	0.575	0.62	0.65	0.674	0.714
1981	0.119	0.197	0.276	0.358	0.427	0.49	0.543	0.582	0.616	0.645	0.699
1982	0.117	0.195	0.265	0.335	0.398	0.455	0.506	0.536	0.562	0.585	0.632
1983	0.12	0.195	0.25	0.307	0.365	0.42	0.475	0.52	0.57	0.615	0.709
1984	0.108	0.192	0.268	0.339	0.4	0.453	0.501	0.545	0.577	0.607	0.696
1985	0.15	0.204	0.258	0.311	0.364	0.416	0.468	0.52	0.571	0.621	0.79
1986	0.14	0.206	0.268	0.326	0.381	0.432	0.48	0.524	0.564	0.601	0.691
1987	0.137	0.21	0.278	0.341	0.398	0.45	0.497	0.538	0.574	0.605	0.659
1988	0.131	0.208	0.278	0.344	0.404	0.459	0.508	0.552	0.591	0.624	0.687
1989	0.139	0.195	0.249	0.3	0.35	0.398	0.444	0.488	0.531	0.571	0.675
1990	0.187	0.243	0.296	0.346	0.393	0.437	0.478	0.516	0.551	0.583	0.654
1991	0.144	0.219	0.29	0.355	0.416	0.473	0.524	0.572	0.614	0.652	0.731
1992	0.128	0.202	0.272	0.336	0.395	0.449	0.498	0.542	0.58	0.613	0.677
1993	0.114	0.178	0.239	0.296	0.35	0.401	0.448	0.492	0.532	0.57	0.659
1994	0.153	0.212	0.268	0.322	0.372	0.419	0.463	0.505	0.543	0.578	0.659
1995	0.163	0.221	0.275	0.326	0.374	0.419	0.461	0.5	0.536	0.568	0.641
1996	0.189	0.238	0.285	0.331	0.376	0.42	0.463	0.504	0.544	0.583	0.677
1997	0.156	0.215	0.272	0.327	0.38	0.431	0.48	0.526	0.57	0.612	0.717

year\age	2	3	4	5	6	7	8	9	10	11	12+
1998	0.162	0.22	0.274	0.325	0.374	0.419	0.462	0.501	0.537	0.571	0.65
1999	0.183	0.233	0.28	0.326	0.369	0.41	0.448	0.485	0.519	0.551	0.624
2000	0.172	0.23	0.284	0.333	0.379	0.421	0.458	0.492	0.521	0.546	0.643
2001	0.181	0.224	0.266	0.307	0.346	0.384	0.42	0.455	0.489	0.521	0.602
2002	0.152	0.209	0.263	0.316	0.367	0.415	0.462	0.507	0.55	0.591	0.688
2003	0.137	0.207	0.274	0.337	0.396	0.452	0.505	0.554	0.599	0.641	0.732
2004	0.149	0.203	0.256	0.308	0.36	0.41	0.46	0.509	0.557	0.605	0.734
2005	0.152	0.208	0.263	0.316	0.368	0.419	0.468	0.516	0.562	0.607	0.726
2006	0.138	0.197	0.254	0.306	0.355	0.4	0.442	0.479	0.514	0.544	0.661
2007	0.151	0.214	0.272	0.325	0.373	0.416	0.454	0.486	0.514	0.536	0.614
2008	0.172	0.221	0.268	0.315	0.36	0.404	0.447	0.489	0.529	0.569	0.64
2009	0.136	0.215	0.287	0.354	0.415	0.469	0.518	0.56	0.596	0.626	0.698
2010	0.121	0.215	0.3	0.376	0.445	0.505	0.557	0.6	0.636	0.663	0.696
2011	0.169	0.231	0.29	0.347	0.402	0.454	0.504	0.552	0.597	0.639	0.738
2012	0.12	0.202	0.276	0.343	0.402	0.453	0.497	0.532	0.561	0.581	0.664
2013	0.144	0.2	0.256	0.31	0.363	0.414	0.464	0.513	0.56	0.606	0.729
2014	0.157	0.223	0.284	0.34	0.391	0.438	0.48	0.517	0.549	0.576	0.706
2015	0.147	0.217	0.282	0.342	0.397	0.448	0.493	0.533	0.568	0.598	0.692
2016	0.178	0.248	0.313	0.373	0.427	0.476	0.519	0.557	0.59	0.617	0.714
2017	0.197	0.252	0.305	0.357	0.407	0.455	0.501	0.546	0.588	0.630	0.749
2018	0.174	0.235	0.293	0.348	0.400	0.450	0.496	0.540	0.580	0.618	0.760
2019	0.152	0.207	0.259	0.309	0.356	0.401	0.444	0.484	0.522	0.557	0.672
2020	0.165	0.212	0.257	0.302	0.344	0.386	0.426	0.464	0.501	0.536	0.632

Table 32.5. Sole in Division 7.e. Landings, effort and mean standardised lpue for the UK commercial fleets.

Fleet	Year	Effort [days]	Landings [tonnes]	Lpue [tonnes/1000 days]	means standardised lpue
UK-CBT<24 m	1988	2527	293	115.97	1.94
	1989	1956	162	83.06	1.39
	1990	1958	179	91.51	1.53
	1991	1458	134	92.22	1.54
	1992	1342	142	106.22	1.78
	1993	1432	154	107.71	1.8
	1994	2241	161	71.97	1.2
	1995	2017	134	66.28	1.11
	1996	1999	106	52.99	0.89
	1997	1991	132	66.3	1.11
	1998	2357	99	42.12	0.7
	1999	2518	115	45.7	0.76
	2000	2913	134	45.85	0.77
	2001	3746	148	39.57	0.66
	2002	3482	110	31.55	0.53
	2003	3785	93	24.44	0.41
	2004	3512	64	18.12	0.3
	2005	3305	191	57.72	0.97
	2006	3277	224	68.27	1.14
	2007	4027	225	55.77	0.93
	2008	4629	213	45.94	0.77
	2009	4040	185	45.85	0.77
	2010	4727	201	42.42	0.71
	2011	5913	258	43.65	0.73
	2012	7188	314	43.65	0.73
	2013	6322	329	52.02	0.87
	2014	5870	308	52.54	0.88
	2015	6260	310	49.54	0.83

Fleet	Year	Effort [days]	Landings [tonnes]	Lpue [tonnes/1000 days]	means standardised lpue
	2016	6114	355	58.1	0.97
	2017	6578	402	61.08	1.02
	2018	6366	386	60.66	1.01
	2019	6067	397	65.49	1.09
	2020	5643	393	69.61	1.16
UK-CBT>24 m	1988	2971	391	131.77	2.79
	1989	3938	340	86.37	1.83
	1990	3518	314	89.12	1.89
	1991	2412	206	85.47	1.81
	1992	1993	197	98.63	2.09
	1993	2678	194	72.54	1.54
	1994	4574	236	51.5	1.09
	1995	4917	257	52.3	1.11
	1996	5592	178	31.84	0.67
	1997	5377	199	37.1	0.79
	1998	4945	164	33.19	0.7
	1999	4512	141	31.32	0.66
	2000	5237	151	28.84	0.61
	2001	5874	142	24.11	0.51
	2002	5957	104	17.51	0.37
	2003	6810	94	13.78	0.29
	2004	7100	69	9.66	0.2
	2005	6684	236	35.27	0.75
	2006	6595	236	35.79	0.76
	2007	5594	196	35.1	0.74
	2008	4924	154	31.36	0.66
	2009	3523	115	32.66	0.69
	2010	3064	94	30.64	0.65

Fleet	Year	Effort [days]	Landings [tonnes]	Lpue [tonnes/1000 days]	means standardised lpue
	2011	2790	92	32.95	0.7
	2012	2609	86	33.01	0.7
	2013	2444	93	38.13	0.81
	2014	2900	104	35.95	0.76
	2015	3039	101	33.12	0.7
	2016	4064	166	40.79	0.86
	2017	4556	207	45.41	0.96
	2018	4116	231	56.17	1.19
	2019	4329	313	72.36	1.53
	2020	4335	321	74.07	1.57
UK-CBT	1988	5497	684	124.51	2.37
	1989	5894	503	85.27	1.62
	1990	5476	493	89.97	1.71
	1991	3870	341	88.02	1.67
	1992	3334	339	101.69	1.93
	1993	4111	349	84.79	1.61
	1994	6814	397	58.23	1.11
	1995	6935	391	56.37	1.07
	1996	7591	284	37.41	0.71
	1997	7368	331	44.99	0.86
	1998	7302	263	36.07	0.69
	1999	7031	256	36.47	0.69
	2000	8150	285	34.92	0.66
	2001	9620	290	30.13	0.57
	2002	9439	214	22.69	0.43
	2003	10596	186	17.59	0.33
	2004	10612	132	12.46	0.24
	2005	9990	427	42.7	0.81
	2006	9873	460	46.57	0.89

Fleet	Year	Effort [days]	Landings [tonnes]	Lpue [tonnes/1000 days]	means standardised lpue
	2007	9621	421	43.75	0.83
	2008	9552	367	38.42	0.73
	2009	7563	300	39.7	0.75
	2010	7791	294	37.79	0.72
	2011	8703	350	40.22	0.76
	2012	9797	400	40.82	0.78
	2013	8767	422	48.15	0.92
	2014	8769	413	47.05	0.89
	2015	9298	411	44.17	0.84
	2016	10178	521	51.19	0.97
	2017	11114	606	54.57	1.04
	2018	10482	617	58.9	1.12
	2019	10396	711	68.35	1.3
	2020	9978	714	71.55	1.36
UK-COT	1988	4265	29	6.77	1.43
	1989	4607	28	6.18	1.31
	1990	4423	26	5.97	1.27
	1991	4004	14	3.39	0.72
	1992	4108	12	3.02	0.64
	1993	3761	15	3.95	0.84
	1994	3423	18	5.27	1.12
	1995	3294	13	3.99	0.84
	1996	2589	12	4.83	1.02
	1997	3011	15	4.96	1.05
	1998	2699	11	4.22	0.89
	1999	2486	13	5.16	1.09
	2000	2681	11	4.11	0.87
	2001	2732	13	4.9	1.04

Fleet	Year	Effort [days]	Landings [tonnes]	Lpue [tonnes/1000 days]	means standardised lpue
	2002	2448	9	3.66	0.78
	2003	2273	8	3.31	0.7
	2004	2334	6	2.46	0.52
	2005	1762	12	6.86	1.45
	2006	1699	8	4.57	0.97
	2007	1917	9	4.9	1.04
	2008	1750	7	4.26	0.9
	2009	1847	10	5.36	1.14
	2010	2213	10	4.53	0.96
	2011	1930	8	4.08	0.86
	2012	2068	12	5.96	1.26
	2013	1587	8	4.96	1.05
	2014	1440	8	5.56	1.18
	2015	978	5	4.98	1.06
	2016	0	0	NA	NA
UK-COT new	2016	2020	14	7.08	0.79
	2017	2398	15	6.1	0.68
	2018	1986	17	8.42	0.94
	2019	1548	14	9.33	1.04

Table 32.6. Sole in Division 7.e. Tuning data file. Not all tuning time-series, years and ages shown here were used in the assessment.

```
sol.27.7e WGCSE 2021
104
UK-CBT-late
2003 2020
1 1 0 1
3 14
  10.59557    130.7    168.87    129.96     21.43     18.32     10.28     13.49
6.67     2.19     2.06     3.35     2.82
  10.61183    146.5     61.53     53.46     75.23     11.35     14.96      7.49
5.98     4.27     2.12     1.18     1.89
   9.98951   210.39     326.3    132.94    155.21    132.09     27.41      32.6
22.54    14.24      8.3      5.95      4.84
   9.87254   376.87    186.46    243.45     85.59    108.34    106.98     37.22
20.67    13.69    13.61     6.68      2.99
    9.6207   456.04    261.42    105.82    103.55     54.21     62.07     51.47
15.34    11.12    10.41     8.44      8.17
   9.55231   294.03    286.06     126.1     67.89     65.42     42.34     39.54
36.27    14.54     11.8      4.3         6
   7.56283   190.03    182.63    152.83     89.59     26.02      27.9     13.23
16.1    12.91     4.85     3.74     1.92
   7.79112    80.09     179.7    157.57    101.24     51.98     25.24     22.59
8.23    16.75    25.39     7.42     3.88
   8.70287   243.76    148.58    186.66    121.43     81.66     35.56     15.79
20.25    10.83    14.11     8.26      2.1
   9.79734   129.79    307.88    139.02    143.59     91.49     66.22     30.49
17.81    14.83     8.55    12.25    11.03
   8.76655    81.92    242.49    288.92    134.34     93.18     72.27     44.15
24.5    10.73     9.84     8.14     9.84
    8.7692   111.72    201.15    169.62    201.19     99.91     67.46     43.84
30.63    15.94     7.71      9.34      4.9
   9.29849   137.05    178.21    198.83    135.74    117.19     65.74     45.95
31.78    20.59    11.01     5.52      5.96
  10.17804   263.46    217.34    158.93    161.88    118.88    102.14     49.07
45.22     21.3    23.14    13.03      5.69
  11.11408   454.27    353.27    177.37    142.06    120.28     81.72     72.95
42.23    28.03    16.59    11.97      9.63
  10.48248   217.63    454.82    260.75    116.59     118.4     76.79     51.54
49.36    33.91    24.42    21.84    10.92
  10.39628   618.98    411.51    357.08    217.83     105.4     69.38        57
36.74    40.95    22.94    13.23    10.34
   9.97809   366.94    668.87    351.11    232.91    155.36     85.53     44.65
28.78    13.68    12.36     13.5     10.39
UK-COT
1988 2016
1 1 0 1
3 11
4264.71    30.97     15.73     19.29     8.63     2.55     2.55
           1.83      0.35      0.76
4607.04    15.09     18.34     9.22      11.75    4.72     2.42
           2.36      2.01      1.4
```

4422.52	18.3	12.56	9.21	6.09	5.53	2.08
	1.83	1.12	0.9			
4004.37	10.04	7.03	4.12	2.46	0.96	1.44
	0.42	0.41	0.23			
4107.71	26.24	6	3.6	1.19	1.14	0.48
	0.65	0.17	0.09			
3761	12.45	17.56	5.38	3.44	2.49	1.26
	1	0.92	0.56			
3423.03	12.42	11.46	12.35	2.5	2.6	1.23
	1.35	1.03	1.18			
3294.06	5.25	9.75	6.34	6.17	1.89	1.49
	0.91	0.52	0.25			
2589.38	9.47	6.54	4.37	3.15	3.54	0.95
	0.76	0.68	0.45			
3010.66	15.16	8.81	4.78	2.83	2.9	2.53
	0.63	0.28	0.43			
2698.6	8.74	7.58	4.25	2.49	1.53	0.93
	1.47	0.31	0.44			
2486.17	11.56	5.84	4.91	2.89	1.45	1.46
	0.74	1.49	0.39			
2680.63	6.67	8.41	4.03	2.64	1.24	0.59
	0.81	0.62	0.99			
2731.54	18.02	5.27	4.96	2.69	2.01	1.12
	0.7	0.51	0.5			
2448.37	9.88	6.12	2.39	2.67	1.27	0.82
	0.33	0.2	0.25			
2272.9	4.61	5.87	4.8	1.04	0.85	0.49
	0.54	0.27	0.13			
2334.16	6.05	2.58	2.23	3.25	0.46	0.57
	0.3	0.24	0.18			
1762.36	6.44	9.56	3.53	4.13	3.44	0.74
	0.9	0.58	0.45			
1699.49	6.93	3.27	4.13	1.36	1.63	1.75
	0.6	0.31	0.2			
1916.84	9.32	5.44	2.3	2.32	1.19	1.41
	1.13	0.36	0.21			
1750.36	5.61	4.85	2.08	1.15	1.18	0.75
	0.75	0.7	0.32			
1847.2	7.97	5.47	3.92	2.17	0.64	0.83
	0.39	0.52	0.45			
2212.85	2.71	5.85	4.74	3.15	1.63	0.81
	0.74	0.3	0.6			
1930.5	6.51	3.32	3.89	2.46	1.64	0.58
	0.31	0.37	0.19			
2068.16	4.24	9.16	3.97	4.06	2.3	1.76
	0.82	0.49	0.46			
1586.58	2.01	4.55	5.64	2.66	1.74	1.49
	0.89	0.56	0.26			
1440.22	2.13	3.57	2.99	3.56	1.8	1.29
	0.9	0.68	0.34			
977.63	1.62	1.98	1.86	1.59	1.35	0.7
	0.5	0.42	0.25			

```
0       0        0        0        0        0        0
        0        0        0
Q1SWBeam-nonoffset
2006 2020
1 1 0.1 0.25
1 27
1       0        20.9617  24.3417  10.5008  29.9494  15.518
        15.7871  13.7063  12.2623  9.09681  8.07492
        1.29966  3.32659  0.71346  1.24661  4.26735
        1.11282  0.66165  0        0        0        0
        0        0        0        0        0
1       0.2503   17.4443  46.7889  15.0922  2.073    7.4772
        2.9714   3.2638   8.2173   6.17255  2.70645  0
        1.92946  1.46792  0.60148  0        1.04005
        0.31768  0        0        0        0.50834  0
        0        0.12415  0        0
1       0        11.9694  38.5327  44.2588  16.8101
        17.9839  5.8217   8.2188   15.3684  6.56008
        4.07772  3.63512  3.3578   2.4216   0.75185  0.2483
        0.2483   0        5.56781  0        0        0
        0        0        0        0        0
1       0        5.235    33.4672  22.5017  25.8667
        12.4215  1.7615   3.6862   0.3434   7.53917
        7.88458  1.66924  1.35582  0.26643  0.10484  0
        0.10668  2.23934  3.64113  0        0        0
        0        0        0.10455  1.76165  1.76165
1       0        23.8814  25.2679  44.1021  28.7077
        18.1813  16.9984  1.0967   2.19     1.87814
        3.87783  1.63973  1.19362  1.11282  0.70528  0
        0.65966  0        0        0        1.11282  0
        0        0        0        0        0
1       0        15.6093  31.6425  19.472   13.4385  6.9196
        3.0124   4.3092   2.6587   0.38676  2.81983
        1.21893  0.7916   0        0.30255  0.11824  0
        0        0.17878  0        0        0.11824  0
        0        0        0        0
1       0        2.4032   35.864   28.1768  11.668   8.48
        10.0964  7.2705   5.3933   0        0.20648
        4.31641  0.67921  0        0.09932  0.65966  0
        0.09932  0        0        0        0        0
        0        0        0        0
1       0        4.3218   17.2513  32.7718  26.2459
        15.6648  12.9839  10.3966  9.301    7.65213
        1.25131  7.2166   0        4.88124  1.36061  0
        0        0        0        0        0
        7.49313  1.20296  0        0        0        0
1       1.2565   6.1443   38.1218  37.1957  10.5263  20.342
        13.5544  26.5539  6.0348   2.87995  3.19119
        1.29615  1.32124  2.31644  1.6562   2.0409
        0.66062  0        0        2.0409   0.24598  0
        0        0        0        0        0
1       0.9895   7.8397   16.9527  10.4441  12.6618
        15.7945  22.0161  12.8365  11.1984  4.78045
```

```
              4.96361      2.26539      7.19622      1.99517      0
              4.59811      0.50271      1.08277      0.13153      0.38463
              3.34157      0            0            0            0            0
              0
1             0.12515      17.0147      37.47        16.1717      17.0353
              12.0928      11.7792      15.8913      3.3377       3.79163
              5.62407      3.36633      1.86454      0.12415      0
              0.50124      0            0            0            1.67202      0
              0.45985      0            0            0            0            0
1             1.38477      8.3704       21.7183      25.912       13.405
              10.9208      8.4759       3.8099       2.7153       2.4744       0.5697
              8.26016      0.86427      3.74239      0.16748      0.40391      0
              0            0.33721      0.52773      0.19391      0            0
              0            0            0            0
1             0            13.509       25.4432      38.4368      31.8088
              12.9337      17.061       10.5022      8.6894       9.04688
              2.42789      6.10779      5.71409      7.21492      1.67776      0
              0            0            0            0.73992      0            0
              0            0            0            0            0
1             0            23.4314      61.6211      29.4074      31.5671
              17.6249      5.5207       3.9496       3.5844       2.57041
              6.82601      0.1729       4.50089      1.29713      3.98425      0
              0            0.39571      0            0.45154      0            0
              0.83462      0            0            0            0
1             0.34121      21.5071      36.9707      39.7765      19.9786
              14.7538      11.4951      5.0737       5.4513       4.28901
              8.38046      0.94747      0.80528      0            0.18163      0
              0            0            0            0            0            0.2699
              0            0            0            0            0
FSP-UK
2003 2020
1 1 0.7 0.75
1 27
1             0.0005996525 0.1640287001 0.3331577428 0.3421042854 0.3077896855
              0.0276877607 0.0434349878 0.001199431  0.0606079973 0.0452031639
              0.0762864358 0.0041900979 0.0044704097 0.0017318557 0.000259465
              0.0014588961 0            0            0.0001297325 0.0001297325 0
              0.000259465  0.0001297325 0            0.0001297325 0            0
1             0.0001435343 0.1564180959 0.5518121981 0.3108590208 0.2562291625
              0.1244375129 0.0559530093 0.0858395255 0.0350134068 0.0163936207
              0.016768046  0.0104210025 0.0060034305 0.0060639809 0.0044333371
              0.0010308537 0.0010435917 0.0005835287 0.0035079692 0.0014116548
              0.0004350037 0.0013341341 0.0022825215 0.0007329086 0.0008245222 0
              0
1             0            0.1033295175 0.19641048   0.2419913717 0.1091266279
              0.1568026119 0.145326301  0.036140277  0.0293963588 0.0143508007
              0.0153718894 0.0071929565 0.0067527739 0.0018681385 0.009940521
              0.00740716   0.0023788354 0.002716705  0.0021409311 0.0017422746
              0.0005904058 0.0033955813 0.0006752624 0            0
              0.0002352598 0
1             0.0039665065 0.1530465703 0.3381190891 0.1553930286 0.2150083739
              0.0964620868 0.1165659253 0.1314668162 0.0263237496 0.0256813866
              0.0180424786 0.0143510769 0.0090679498 0.0018093328 0.0041907309
```

```
              0.0038075919 0.0035475624 0.002627083  0.0019733574 0.0012711384
              0.0005654985 0.0007600117 0.0005739187 0.0012711384 3.43551e-05
              3.43551e-05  0
1             0.0010962171 0.1222741336 0.4498553047 0.2031795541 0.0752568916
              0.0913421932 0.0585642238 0.0482046412 0.0990784093 0.0183456175
              0.0234301884 0.0051412317 0.0112336251 0.0042618881 0.0040821708
              0.0039301402 0            0.0003138761 0.0004997104 0.0009808918
              0.0008212451 0.0011351212 0.001694755  0.0009721986 0            0
              0
1             2.2964e-05   0.2195351408 0.3064609908 0.2655869407 0.2476274228
              0.0431133845 0.0375139272 0.0145996729 0.0569702212 0.0329406912
              0.0020529802 0.0103840127 0.0052219576 0.0003452428 0.0019353965
              0.0012419322 0.0002517583 0.0023048193 0.001756005  0.0001149613
              0.001942533  0.0014628682 4.2774e-05   0.0001044024 0.0016033953
              1.07384e-05  0
1             0            0.0871756844 0.2996241409 0.3111598691 0.1612888821
              0.0607181418 0.0399573377 0.0280004615 0.0151930886 0.0179131136
              0.047375509  0.0070657871 0.0029069767 0.0028085641 0.0034248136 0
              0.0023009922 0            0            0            0.0014487729 0
              0            0            0            0            0
1             0            0.1198634134 0.196874246  0.2457977047 0.1811689438
              0.1272699744 0.0356769991 0.020992322  0.0271910269 0.0175688686
              0.0235333828 0.0111317663 0.0040175529 0.0028670567 0.0098378335
              0.0061571312 0            0            0.0017165606 0
              0.0014381202 0.001962611  0.0014381202 0            0            0
              0
1             0            0.06241178   0.4007807363 0.0936432403 0.1661392336
              0.0841724049 0.0489667592 0.0045392188 0.01332639   0.007273471
              0.0107261897 0.0124012632 0.0133069687 0.0012463708 0.003751685
              7.98956e-05  0.0047457965 4.79373e-05  0.0012303917 1.59791e-05
              3.19582e-05  6.39165e-05  3.19582e-05  1.59791e-05  1.59791e-05
              0.0034491003 0
1             0            0.0462429317 0.3661074051 0.3751123378 0.171327639
              0.1173729434 0.0335259216 0.0444066234 0.0275603154 0.0030803347
              0.006453779  0.0001320431 0.0090582307 0.0102501203 0.0064423865
              0.006337584  0.0019806469 0            6.60216e-05  6.60216e-05
              0.0012992471 0.0001320431 6.60216e-05  0            6.60216e-05  0
              0
1             0            0.0497881333 0.3584337435 0.4301705234 0.3611324055
              0.1699642895 0.0915132656 0.0522974874 0.0372679269 0.0063585644 0
              0.0155682804 0.0169229843 0.0150488511 0            0.0065329235
              0.0065015519 0            0            0            0.0005752481 0
              0            0            0            0            0
1             0            0.0992979309 0.3132769061 0.404824384  0.3187756661
              0.2144234295 0.1202334108 0.0707920098 0.0346720214 0.0427286271
              0.0019981129 0.0122453312 0.0035399024 0.0091491166 0.0040710437
              0.0080827697 0.0039462729 0.0059770088 9.99056e-05  0.0015076265
              9.99056e-05  0            0            9.99056e-05  0            0
              0
1             0.0048896085 0.1093931233 0.2409909098 0.342222128  0.1843469436
              0.1273706237 0.1082327865 0.0763853928 0.0576452317 0.0237495021
              0.0250038238 0.00933254   0.0036693854 0.0111649666 0.0028229153
```

```
             0.0031227752 0.0034365469 0.0047588703 0.0011504961 0            0
             0            0            0            0.0014642678 0            0
1            0            0.106692296  0.462891223  0.1532642147 0.1442259017
             0.1230641606 0.0781141924 0.102312786  0.0301074486 0.0478016471
             0.014684173  0.0168037935 0.0050194129 0.0033997592 0.0021956008
             0.0063508475 0.0048557028 0.003975375  0.0011243485 0.0027226531 0
             0.0017564806 0            0            0            0            0
1            0            0.12886873   0.4887237516 0.3304347223 0.0960669305
             0.0858467213 0.0726999591 0.0391128558 0.0589537549 0.0200598221
             0.0122974024 0.0180049259 0.0119845876 0.0039815527 0.0027961056 0
             0.0024247625 0.005117608  0.0059944095 0.0011243485 0            0
             0            0            0            0            0
1            0            0.1586709782 0.2933003672 0.4153420564 0.2476762135
             0.0907601391 0.0694807344 0.0922203076 0.0271016214 0.0610983845
             0.0369478639 0.0380261073 0.0120135944 0.0073046846 0.0019174935 0
             0            0.0011504961 0.0014381202 0.0026932068 0.0024055828 0
             0            0            0.0011504961 0            0
1            0            0.2112724882 0.9077480144 0.1994578656 0.1528107317
             0.0897784456 0.0471313352 0.0455976848 0.0374275951 0.0276157117
             0.0403826099 0.0079840292 0.0096721581 0.0032406206 0.0017564806 0
             0.0017564806 0.0028808291 0.0064020338 0            0.0045777045 0
             0.00148414   0            0            0            0
1            0.001278329  0.3004545955 0.3368668308 0.4213025839 0.1902005191
             0.1366910259 0.0642090392 0.0396043703 0.0304288901 0.054332713
             0.0184063028 0.0425658867 0.0141144489 0.0039946788 0.0064514184
             0.0041504261 0.002478778  0.0012254254 0.0001248821 2.49764e-05
             0.0022771953 0.0053250755 4.99528e-05  2.49764e-05  2.49764e-05
             2.49764e-05  0
UK-CBT-early
1988 2002
1 1 0 1
3 11
5.50         660.36       337.83       439.11       199.29       63.46        62.34
             58.95        13.18        21.70        13.33        27.52        6.95
5.89         334.92       420.18       206.01       239.87       86.59        36.69
             36.30        34.02        21.23        13.23        14.64        8.91
5.48         330.59       249.78       187.83       120.79       118.15       45.22
             34.04        22.00        18.96        10.14        16.62        8.71
3.87         169.69       178.00       138.03       89.94        39.06        50.15
             27.73        13.14        9.08         16.74        3.98         7.26
3.33         569.33       159.31       112.20       42.39        44.18        21.30
             30.70        7.94         5.60         5.48         5.88         5.21
4.11         276.52       436.07       135.24       82.61        58.75        29.82
             23.11        22.81        11.35        3.31         8.58         5.80
6.81         347.00       282.99       271.57       54.29        49.16        24.17
             27.27        20.69        23.17        11.03        8.54         4.49
6.93         139.39       287.26       193.06       187.53       57.49        45.54
             26.86        14.72        8.08         17.93        7.45         5.17
7.59         146.04       118.70       100.89       81.14        87.63        23.24
             21.23        16.83        12.69        13.77        12.60        5.11
7.37         300.18       244.82       114.67       60.06        66.02        58.33
             14.54        6.74         13.71        5.51         6.41         4.75
```

7.30	188.05	166.31	103.86	61.72	44.52	23.65
	35.65	9.80	9.76	8.10	8.57	3.78
7.03	264.75	137.13	101.88	64.10	27.00	25.49
	13.29	26.52	5.87	9.91	2.81	2.98
8.15	194.23	235.47	112.00	69.45	33.41	16.90
	19.70	14.88	26.19	2.84	4.35	1.86
9.62	400.24	142.06	135.26	69.22	46.01	25.81
	13.47	11.17	10.68	12.43	4.64	3.50
9.44	280.20	169.83	62.21	62.54	27.88	19.67
	8.64	3.97	4.69	2.63	4.92	2.28
UK-WEC-BTS						
1988 2013						
1 1 0.75 0.8						
1 9						
128.20	2.00	39.00	129.00	52.00	75.00	22.00
	0.00	12.00	3.00			
165.70	5.00	56.00	120.00	107.00	34.00	40.00
	17.00	5.00	7.00			
175.70	23.00	52.00	76.00	31.00	24.00	7.00
	15.00	3.00	6.00			
171.70	11.00	231.00	79.00	51.00	23.00	21.00
	5.00	17.00	4.00			
196.60	5.00	140.00	316.00	44.00	36.00	12.00
	7.00	5.00	11.00			
189.20	5.00	54.00	115.00	105.00	14.00	10.00
	9.00	3.00	3.00			
205.90	6.00	47.00	106.00	62.00	44.00	5.00
	5.00	2.00	3.00			
187.20	14.00	37.00	44.00	42.00	26.00	31.00
	4.00	5.00	5.00			
184.40	28.00	112.00	67.00	25.00	32.00	20.00
	17.00	3.00	2.00			
184.70	11.00	130.00	126.00	43.00	14.00	16.00
	13.00	14.00	5.00			
185.50	11.00	141.00	114.00	76.00	22.00	10.00
	14.00	6.00	8.00			
187.90	11.00	97.00	128.00	47.00	23.00	8.00
	4.00	4.00	4.00			
180.40	12.00	136.00	70.00	52.00	23.00	16.00
	5.00	3.00	5.00			
178.00	9.00	197.00	162.00	52.00	31.00	12.00
	12.00	4.00	1.00			
180.00	6.00	37.00	113.00	48.00	27.00	6.00
	3.00	2.00	0.00			
170.70	23.00	124.00	78.00	56.00	28.00	6.00
	1.00	1.00	2.00			
164.90	16.00	110.00	120.00	24.00	15.00	10.00
	16.00	9.00	4.00			
186.60	8.00	110.00	39.00	53.00	12.00	12.00
	6.00	2.00	4.00			
184.70	5.00	120.00	95.00	26.00	37.00	10.00
	7.00	9.00	0.00			

181.00	7.00	188.00	135.00	50.00	11.00	23.00
	3.00	3.00	1.00			
174.70	10.00	85.00	158.00	77.00	40.00	2.00
	14.00	3.00	6.00			
172.00	11.00	104.00	126.00	96.00	49.00	13.00
	13.00	12.00	1.00			
179.90	20.00	175.00	154.00	84.00	59.00	31.00
	20.00	7.00	12.00			
176.20	9.00	156.00	231.00	62.00	39.00	25.00
	24.00	8.00	2.00			
179.70	3.00	47.00	162.00	125.00	40.00	27.00
	13.00	3.00	6.00			
181.60	4.00	36.00	100.00	106.00	80.00	21.00
	9.00	6.00	3.00			

Table 32.7. Sole in Division 7.e. Detailed XSA survivor diagnostics.

FLR XSA Diagnostics 2021-04-23 15:49:13

CPUE data from indices

Catch data for 52 years 1969 to 2020. Ages 2 to 12.

	fleet	first age	last age	first year	last year	alpha	beta
1	UK-CBT-late	3	11	2003	2020	<NA>	<NA>
2	UK-COT	3	11	1988	2015	<NA>	<NA>
3	Q1SWBeam-nonoffset	2	11	2006	2020	<NA>	<NA>
4	FSP-UK	2	11	2004	2020	<NA>	<NA>

Time-series weights :

Tapered time weighting applied
Power = 3 over 15 years

Catchability analysis :

Catchability independent of size for all ages

Catchability independent of age for ages > 6

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 3 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1

Minimum standard error for population
estimates derived from each fleet = 0.4

prior weighting not applied

Regression weights

age \ year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
all	0.482	0.61	0.725	0.82	0.893	0.944	0.976	0.993	0.999	1

Fishing mortalities

age \ year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
2	0.028	0.009	0.040	0.063	0.046	0.017	0.028	0.010	0.019	0.015
3	0.129	0.082	0.115	0.129	0.128	0.130	0.282	0.123	0.131	0.107
4	0.213	0.175	0.223	0.215	0.208	0.243	0.131	0.133	0.240	0.238
5	0.232	0.249	0.273	0.280	0.212	0.196	0.222	0.135	0.277	0.328
6	0.216	0.292	0.247	0.274	0.246	0.215	0.275	0.361	0.252	0.284
7	0.210	0.306	0.255	0.205	0.192	0.337	0.148	0.220	0.330	0.238
8	0.221	0.256	0.289	0.184	0.189	0.242	0.190	0.399	0.345	0.354
9	0.220	0.263	0.262	0.222	0.170	0.143	0.068	0.276	0.322	0.256
10	0.233	0.365	0.273	0.232	0.169	0.141	0.096	0.168	0.285	0.282
11	0.352	0.394	0.290	0.216	0.154	0.163	0.563	1.154	0.239	0.189
12	0.352	0.394	0.290	0.216	0.154	0.163	0.563	1.154	0.239	0.189

XSA population number (Thousand)

year \ age	2	3	4	5	6	7	8	9	10	11	12
2011	3458	4330	2612	2056	1263	868	422	208	173	100	328
2012	3507	3042	3443	1910	1476	921	637	306	151	124	400
2013	3202	3145	2536	2615	1348	997	614	446	213	95	458
2014	3382	2784	2537	1835	1800	953	699	416	311	147	525
2015	4172	2872	2214	1852	1256	1239	702	526	301	223	607
2016	5715	3606	2286	1628	1356	888	925	526	401	230	747
2017	4605	5084	2864	1622	1210	990	574	657	413	316	189
2018	8338	4050	3470	2274	1176	832	772	429	555	339	234
2019	6486	7468	3240	2750	1798	741	604	469	295	425	775
2020	11728	5759	5926	2305	1886	1265	482	387	307	201	965

Estimated population abundance at 1st Jan 2021

year \ age	2	3	4	5	6	7	8	9	10	11	12
2021	0	10452	4680	4226	1503	1285	903	306	271	210	150

Fleet: UK-CBT-late

Log catchability residuals.

```
    year
age    2003   2004   2005   2006   2007   2008   2009   2010   2011   2012
  3  -0.278 -0.494  0.566  0.755  0.877  0.534  0.238 -0.599  0.122 -0.296
  4  -0.606 -1.245  0.192  0.260  0.252  0.210  0.013 -0.186 -0.437 -0.121
  5  -0.829 -1.427 -0.090  0.304  0.098 -0.089  0.099  0.036 -0.066 -0.398
  6  -1.673 -0.968  0.079 -0.060 -0.011  0.098  0.185 -0.051 -0.046 -0.117
  7  -1.317 -1.989  0.116  0.167  0.007  0.058 -0.252 -0.023 -0.071 -0.090
  8  -1.386 -1.176 -0.661  0.349  0.042  0.299 -0.145 -0.010 -0.176 -0.067
  9  -0.711 -1.373  0.121  0.063  0.054 -0.047 -0.188 -0.007 -0.279 -0.107
  10 -1.238 -1.053  0.199  0.176 -0.373  0.091 -0.393 -0.383  0.156  0.111
  11 -1.334 -1.211  0.375  0.151  0.068  0.020 -0.380 -0.078  0.141  0.134
    year
age    2013   2014   2015   2016   2017   2018   2019   2020
  3  -0.663 -0.224 -0.110  0.227  0.412 -0.113  0.332  0.099
  4   0.080 -0.112 -0.159 -0.066  0.053  0.173  0.201  0.123
  5   0.142 -0.034  0.026 -0.167 -0.129 -0.065  0.135  0.360
  6  -0.003  0.124  0.019  0.013 -0.063 -0.133  0.024  0.100
  7  -0.063  0.028 -0.140  0.185 -0.089  0.162  0.221  0.072
  8   0.184 -0.065 -0.152 -0.052  0.090 -0.113  0.015  0.495
  9  -0.002  0.041 -0.230 -0.268 -0.218  0.018  0.061  0.019
  10  0.153 -0.020 -0.042 -0.080 -0.285 -0.333  0.068 -0.178
  11  0.146  0.069 -0.181 -0.267 -0.210  0.216 -0.210 -0.539
```

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

```
                 3       4       5       6       7       8       9      10
Mean_Logq -5.0507 -4.4408 -4.3354 -4.3058 -4.3058 -4.3058 -4.3058 -4.3058
S.E_Logq   0.4559  0.3759  0.4194  0.4546  0.5664  0.4841  0.3597  0.4063
                11
Mean_Logq -4.3058
S.E_Logq   0.4619
```

Fleet: UK-COT

Log catchability residuals.

```
    year
age    1988   1989   1990   1991   1992   1993   1994   1995   1996   1997
  3   1.069  0.709  0.981  0.707  0.673  0.631  0.864  0.309  0.749  1.081
  4   0.628  0.444  0.442 -0.012 -0.055  0.182  0.436  0.518  0.506  0.316
  5   0.529  0.409  0.294 -0.267 -0.426  0.263  0.192  0.183  0.301  0.343
  6   0.359  0.317  0.477 -0.553 -1.334 -0.099 -0.111 -0.233  0.028 -0.007
  7  -0.344  0.174  0.085 -0.823 -0.976 -0.191  0.097  0.021 -0.202  0.230
  8  -0.153 -0.095 -0.104 -0.779 -1.195 -0.463 -0.494 -0.051 -0.012 -0.366
  9  -0.535  0.148  0.113 -1.140 -1.298  0.013  0.022 -0.495 -0.079 -0.209
  10 -1.261 -0.141 -0.071 -0.854 -1.727 -0.570  0.607 -0.595 -0.235 -0.915
  11 -0.370  0.423 -0.436 -1.110 -2.081 -0.129  0.088 -0.333 -0.184 -0.507
    year
age    1998   1999   2000   2001   2002   2003   2004   2005   2006   2007
  3   0.747  0.843  0.420  0.785  0.468  0.206  0.123  1.104  0.808  0.890
  4   0.325  0.222  0.298 -0.050 -0.384 -0.112 -0.588  0.710  0.290  0.307
  5   0.017  0.275  0.079  0.117 -0.435 -0.295 -0.796  0.309  0.280  0.176
  6   0.169 -0.004 -0.110  0.011  0.010 -0.959 -0.396  0.386 -0.243  0.003
  7  -0.090  0.192 -0.558  0.041 -0.162 -0.648 -1.481  0.402 -0.071  0.001
  8  -0.384  0.428 -0.378 -0.352 -0.278 -0.690 -0.730 -0.338  0.195  0.070
  9  -0.485 -0.200  0.286  0.187 -1.057 -0.190 -0.877  0.465 -0.106  0.048
  10 -0.435 -0.055 -0.093  0.379 -0.474 -0.707 -0.555  0.473 -0.065 -0.313
  11 -0.040  0.280 -0.162  0.115  0.320 -0.420 -0.664  0.855 -0.117 -0.089
    year
age    2008   2009   2010   2011   2012   2013   2014   2015
  3   0.562  0.765 -0.437  0.295  0.127 -0.371 -0.088 -0.006
  4   0.144  0.228 -0.039 -0.419  0.233  0.127 -0.023 -0.092
  5  -0.204  0.139  0.084 -0.138 -0.105  0.209  0.028 -0.100
  6  -0.084  0.074 -0.063 -0.240  0.072 -0.016  0.096  0.024
  7  -0.061 -0.348 -0.027 -0.273 -0.018 -0.135  0.018 -0.151
  8   0.162 -0.051  0.009 -0.586  0.060  0.211 -0.016 -0.242
  9  -0.116 -0.103  0.032 -0.504  0.032  0.002  0.161 -0.299
  10  0.039 -0.217 -0.236 -0.141  0.273  0.283  0.178  0.083
  11  0.100 -0.127  0.051 -0.197  0.416  0.334  0.227 -0.141
```

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

```
                  3        4        5        6        7        8        9
Mean_Logq -14.2479 -13.6624 -13.5365 -13.4129 -13.4129 -13.4129 -13.4129
S.E_Logq    0.4225   0.3134   0.2995   0.3764   0.4004   0.3563   0.4378
                 10       11
Mean_Logq -13.4129 -13.4129
S.E_Logq    0.5220   0.5432
```

Fleet: Q1SWBeam-nonoffset

```
 Log catchability residuals.

    year
age    2006   2007  2008   2009   2010   2011   2012   2013   2014   2015
  2   0.815  0.779 0.338 -0.384  0.875  0.791 -1.097 -0.414 -0.113 -0.082
  3  -0.010  0.550 0.448  0.241  0.034 -0.025  0.445 -0.315  0.603 -0.239
  4  -0.249 -0.269 0.694  0.077  0.603 -0.178 -0.091  0.374  0.498 -0.637
  5   0.641 -1.413 0.323  0.546  0.592 -0.331 -0.396  0.105 -0.454 -0.290
  6   0.640 -0.280 1.152  0.377  0.452 -0.585 -0.523  0.173  0.150  0.252
  7   0.661 -0.533 0.009 -0.754  1.065 -1.042  0.125  0.288  0.368  0.588
  8   0.714 -0.497 1.017  0.011 -0.926  0.039  0.157  0.557  1.347  0.616
  9   1.373  0.624 1.426 -1.660 -0.158  0.265  0.592  0.761  0.391  0.765
  10  1.746  1.112 0.787  1.035  0.367 -1.480  0.000  1.306 -0.055  0.470
  11  2.036  1.047 1.127  1.321  0.681  1.082 -1.747  0.309  0.795  0.808
    year
age    2016   2017   2018   2019   2020
  2   0.373 -0.118 -0.236  0.567 -0.112
  3   0.327 -0.536 -0.177  0.096 -0.159
  4  -0.225  0.001  0.204  0.024 -0.279
  5   0.133 -0.098  0.413  0.240 -0.032
  6  -0.097 -0.075  0.138  0.004 -0.216
  7   0.321 -0.150  0.736 -0.257 -0.074
  8   0.563 -0.397  0.357 -0.385  0.093
  9  -0.450 -0.892  0.733 -0.232  0.367
  10 -0.053 -0.515  0.497 -0.108  0.362
  11  0.901 -1.634 -0.154  0.496  1.443


 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

                2       3       4       5       6       7       8       9
Mean_Logq -6.1695 -4.8534 -4.6661 -4.6412 -4.5675 -4.5675 -4.5675 -4.5675
S.E_Logq   0.5732  0.3412  0.3751  0.5334  0.4482  0.5798  0.6109  0.8252
               10      11
Mean_Logq -4.5675 -4.5675
S.E_Logq   0.7970  1.0463


 Fleet:  FSP-UK

 Log catchability residuals.

    year
age    2004   2005  2006   2007   2008   2009   2010   2011   2012   2013
  2   0.961  0.151 0.437  0.324  0.855  0.022  0.064 -0.239 -0.567 -0.380
  3   0.431  0.022 0.167  0.357  0.059 -0.080 -0.456 -0.024  0.204  0.173
  4   0.482 -0.034 0.143  0.051  0.155  0.296 -0.099 -1.003  0.081  0.559
  5   0.393 -0.061 0.403 -0.059  0.751  0.058  0.105 -0.139 -0.023  0.427
  6  -0.059  0.425 0.390  0.191 -0.066 -0.163  0.229 -0.248 -0.015  0.413
  7  -0.013  0.545 0.560  0.406 -0.196  0.198 -0.335 -0.418 -0.787  0.101
  8   0.967 -0.062 0.875  0.072 -0.451 -0.112 -0.143 -2.067 -0.173  0.052
  9   0.552  0.361 0.036  0.995  0.578 -0.019  0.261 -0.282  0.088  0.012
  10  0.382  0.079 0.741  0.099  0.265 -0.262  0.421 -0.698 -1.321 -1.009
  11  0.556  0.786 0.753  1.109 -1.643  0.939  0.311  0.332 -0.368  0.000
    year
age    2014   2015   2016   2017   2018   2019   2020
  2   0.273  0.147 -0.214  0.199 -0.200  0.344  0.101
  3   0.171 -0.123  0.303  0.124 -0.274  0.249 -0.499
  4   0.491  0.454 -0.355  0.106  0.144 -0.442 -0.300
  5   0.661  0.055 -0.073 -0.457  0.089 -0.481 -0.049
  6   0.376  0.195  0.061 -0.142  0.005 -0.510 -0.114
  7   0.384  0.006  0.118 -0.199 -0.019 -0.211 -0.504
  8   0.148  0.223  0.278 -0.243  0.469 -0.029  0.063
  9  -0.019  0.217 -0.452 -0.057 -0.258  0.010 -0.053
  10  0.489 -0.114  0.279 -0.649  0.219  0.143  0.776
  11 -1.835  0.229 -0.330 -0.532  0.925  0.125  0.053


 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

                2      3       4       5       6      7       8       9      10
Mean_Logq -10.590 -9.097 -9.0061 -9.0437 -9.1400 -9.140 -9.1400 -9.1400 -9.1400
S.E_Logq    0.399  0.266  0.4003  0.3399  0.2633  0.376  0.6464  0.3547  0.5968
               11
Mean_Logq -9.1400
S.E_Logq   0.8372


 Terminal year survivor and F summaries:

 ,Age 2 Year class =2018

source
                   scaledWts survivors yrcls
```

```
Q1SWBeam-nonoffset     0.331      9347  2018
FSP-UK                 0.576     11566  2018
fshk                   0.094      8317  2018

 ,Age 3 Year class =2017

source
                   scaledWts survivors yrcls
UK-CBT-late            0.315      5167  2017
Q1SWBeam-nonoffset     0.315      3993  2017
FSP-UK                 0.315      2841  2017
fshk                   0.056      2707  2017

 ,Age 4 Year class =2016

source
                   scaledWts survivors yrcls
UK-CBT-late            0.338      4780  2016
Q1SWBeam-nonoffset     0.338      3198  2016
FSP-UK                 0.256      3130  2016
fshk                   0.069      6201  2016

 ,Age 5 Year class =2015

source
                   scaledWts survivors yrcls
UK-CBT-late            0.310      2153  2015
Q1SWBeam-nonoffset     0.310      1455  2015
FSP-UK                 0.310      1431  2015
fshk                   0.069      2474  2015

 ,Age 6 Year class =2014

source
                   scaledWts survivors yrcls
UK-CBT-late            0.311      1419  2014
Q1SWBeam-nonoffset     0.311      1035  2014
FSP-UK                 0.311      1146  2014
fshk                   0.066      1222  2014

 ,Age 7 Year class =2013

source
                   scaledWts survivors yrcls
UK-CBT-late            0.368       970  2013
Q1SWBeam-nonoffset     0.190       838  2013
FSP-UK                 0.368       545  2013
fshk                   0.075       920  2013

 ,Age 8 Year class =2012

source
                   scaledWts survivors yrcls
UK-CBT-late            0.486       502  2012
Q1SWBeam-nonoffset     0.177       336  2012
FSP-UK                 0.226       326  2012
fshk                   0.111       355  2012

 ,Age 9 Year class =2011

source
                   scaledWts survivors yrcls
UK-CBT-late            0.398       276  2011
Q1SWBeam-nonoffset     0.121       391  2011
FSP-UK                 0.398       257  2011
fshk                   0.082       317  2011

 ,Age 10 Year class =2010

source
                   scaledWts survivors yrcls
UK-CBT-late            0.539       176  2010
Q1SWBeam-nonoffset     0.164       301  2010
FSP-UK                 0.182       456  2010
fshk                   0.114       339  2010

 ,Age 11 Year class =2009

source
                   scaledWts survivors yrcls
UK-CBT-late            0.652        88  2009
Q1SWBeam-nonoffset     0.076       636  2009
FSP-UK                 0.145       158  2009

fshk                   0.126        95  2009
```

Table 32.8. Sole in Division 7.e. Estimated stock numbers-at-age (thousands).

year\age	2	3	4	5	6	7	8	9	10	11	12+	total
1969	1874	2380	625	966	1513	159	507	572	262	90	636	9585
1970	1343	1611	1848	490	732	1170	124	412	494	218	1123	9564
1971	3826	1164	1237	1365	358	584	952	100	340	397	821	11144
1972	2568	3414	863	885	1047	262	452	713	81	274	542	11102
1973	2264	2185	2698	621	691	840	224	386	518	37	1222	11687
1974	3107	1981	1600	2029	478	532	646	187	300	440	850	12149
1975	2967	2769	1461	1238	1667	365	406	544	138	248	1756	13559
1976	2791	2606	1966	1160	931	1399	304	317	468	105	1598	13645
1977	6556	2367	1960	1330	896	714	1178	230	231	375	1866	17703
1978	4657	5527	1839	1408	1007	714	580	995	199	186	1385	18497
1979	4389	3976	3933	1334	1070	732	547	456	827	144	1493	18901
1980	4702	3755	2834	2787	970	751	497	397	327	650	1702	19373
1981	8130	4088	2866	2091	1923	758	506	316	298	243	934	22154
1982	4680	7124	2933	1974	1448	1370	516	337	214	214	1035	21844
1983	3866	4113	5066	1782	1260	976	1011	337	198	117	828	19554
1984	5968	3412	3006	3087	1058	806	629	635	192	110	982	19885
1985	6982	5083	2456	1934	2073	648	535	446	430	123	532	21242
1986	3765	6045	2982	1504	1303	1319	417	392	306	309	529	18870
1987	5848	3173	3930	1775	961	874	874	297	283	191	754	18960
1988	3878	4828	2102	2519	1199	675	578	573	224	208	713	17498
1989	3736	3088	3001	1335	1587	729	465	369	415	166	743	15634
1990	2818	3009	1965	1543	736	952	445	316	232	268	739	13024
1991	7163	2225	1865	1225	870	434	610	267	189	139	656	15642
1992	3903	6053	1619	1228	834	578	304	446	177	136	528	15805
1993	3351	3231	4113	1068	829	645	416	217	334	136	344	14684
1994	2378	2833	2254	2668	633	541	440	302	140	249	488	12926
1995	3454	2060	1939	1509	1884	466	389	351	218	84	647	13001
1996	3942	3035	1570	1155	959	1313	298	256	260	167	650	13605
1997	3335	3219	2323	1075	762	644	944	205	174	188	412	13282

year\age	2	3	4	5	6	7	8	9	10	11	12+	total
1998	4409	2812	2122	1414	663	519	398	690	144	138	649	13958
1999	3576	3738	1969	1410	959	401	326	284	503	97	479	13741
2000	6548	2970	2512	1306	898	625	254	197	206	353	366	16235
2001	5429	5633	2117	1559	832	594	464	180	114	138	517	17576
2002	3808	4774	3765	1411	938	499	368	324	110	62	288	16346
2003	5380	3129	3130	2605	908	542	329	233	204	69	304	16833
2004	2865	4299	2037	1925	1744	698	420	250	156	124	300	14818
2005	3995	2214	2862	1417	1319	1077	475	269	169	90	354	14241
2006	4610	3369	1558	1796	855	845	696	322	168	110	307	14636
2007	3931	3696	2301	961	1049	535	552	454	211	99	365	14153
2008	4205	3366	2534	1363	591	605	314	376	307	138	311	14110
2009	3769	3538	2330	1648	876	380	372	185	273	213	393	13977
2010	4857	3253	2687	1742	1174	600	281	266	132	199	462	15653
2011	3458	4330	2612	2056	1263	868	422	208	173	100	328	15818
2012	3507	3042	3443	1910	1476	921	637	306	151	124	400	15917
2013	3202	3145	2536	2615	1348	997	614	446	213	95	458	15669
2014	3382	2784	2537	1835	1800	953	699	416	311	147	525	15388
2015	4172	2872	2214	1852	1256	1239	702	526	301	223	607	15965
2016	5715	3606	2286	1628	1356	888	925	526	401	230	747	18309
2017	4605	5084	2864	1622	1210	990	574	657	413	316	189	18523
2018	8338	4050	3470	2274	1176	832	772	429	555	339	234	22470
2019	6486	7468	3240	2750	1798	741	604	469	295	425	775	25051
2020	11728	5759	5926	2305	1886	1265	482	387	307	201	965	31212

Table 32.9. Sole in Division 7.e. Estimated fishing mortality-at-age.

year\age	2	3	4	5	6	7	8	9	10	11	12+	Fbar(3–9)
1969	0.051	0.153	0.144	0.176	0.157	0.151	0.108	0.048	0.084	0.11	0.11	0.134
1970	0.043	0.164	0.202	0.213	0.126	0.106	0.115	0.093	0.118	0.112	0.112	0.146
1971	0.014	0.2	0.234	0.165	0.212	0.155	0.188	0.109	0.113	0.156	0.156	0.181
1972	0.062	0.136	0.228	0.147	0.12	0.059	0.059	0.219	0.69	0.23	0.23	0.138
1973	0.034	0.212	0.185	0.163	0.163	0.162	0.081	0.151	0.063	0.124	0.124	0.16
1974	0.015	0.205	0.156	0.097	0.17	0.171	0.072	0.199	0.089	0.14	0.14	0.153
1975	0.029	0.243	0.13	0.185	0.075	0.083	0.147	0.051	0.181	0.108	0.108	0.131
1976	0.065	0.185	0.291	0.158	0.166	0.072	0.176	0.216	0.122	0.151	0.151	0.18
1977	0.071	0.152	0.23	0.178	0.128	0.108	0.069	0.048	0.114	0.093	0.093	0.13
1978	0.058	0.24	0.221	0.174	0.22	0.165	0.14	0.085	0.226	0.167	0.167	0.178
1979	0.056	0.239	0.244	0.219	0.254	0.287	0.221	0.232	0.142	0.228	0.228	0.242
1980	0.04	0.17	0.204	0.271	0.147	0.295	0.352	0.188	0.198	0.236	0.236	0.232
1981	0.032	0.232	0.273	0.268	0.239	0.285	0.305	0.289	0.229	0.27	0.27	0.27
1982	0.029	0.241	0.398	0.349	0.295	0.203	0.325	0.434	0.503	0.353	0.353	0.321
1983	0.025	0.214	0.395	0.421	0.347	0.34	0.365	0.461	0.489	0.402	0.402	0.363
1984	0.061	0.229	0.341	0.298	0.39	0.309	0.244	0.29	0.35	0.317	0.317	0.3
1985	0.044	0.433	0.391	0.294	0.352	0.342	0.212	0.277	0.232	0.284	0.284	0.329
1986	0.071	0.33	0.419	0.348	0.3	0.312	0.238	0.226	0.37	0.29	0.29	0.31
1987	0.092	0.312	0.345	0.292	0.252	0.314	0.322	0.182	0.205	0.256	0.256	0.288
1988	0.128	0.376	0.354	0.362	0.397	0.272	0.348	0.223	0.201	0.289	0.289	0.333
1989	0.116	0.352	0.565	0.496	0.411	0.393	0.285	0.363	0.337	0.359	0.359	0.409
1990	0.136	0.378	0.372	0.473	0.428	0.345	0.41	0.417	0.413	0.404	0.404	0.403
1991	0.068	0.218	0.317	0.285	0.309	0.255	0.211	0.311	0.23	0.264	0.264	0.272
1992	0.089	0.286	0.316	0.293	0.156	0.229	0.237	0.191	0.167	0.196	0.196	0.244
1993	0.068	0.26	0.332	0.423	0.326	0.282	0.22	0.341	0.193	0.273	0.273	0.312
1994	0.044	0.279	0.301	0.248	0.206	0.23	0.125	0.223	0.404	0.238	0.238	0.23
1995	0.029	0.171	0.417	0.353	0.26	0.348	0.317	0.202	0.171	0.26	0.26	0.295
1996	0.102	0.167	0.279	0.315	0.297	0.23	0.274	0.288	0.22	0.262	0.262	0.264

year\age	2	3	4	5	6	7	8	9	10	11	12+	Fbar(3–9)
1969	0.051	0.153	0.144	0.176	0.157	0.151	0.108	0.048	0.084	0.11	0.11	0.134
1970	0.043	0.164	0.203	0.213	0.126	0.106	0.115	0.093	0.118	0.112	0.112	0.146
1971	0.014	0.2	0.234	0.165	0.212	0.155	0.188	0.109	0.113	0.156	0.156	0.181
1972	0.062	0.136	0.228	0.147	0.12	0.059	0.059	0.219	0.69	0.23	0.23	0.138
1973	0.034	0.212	0.185	0.163	0.163	0.162	0.081	0.152	0.063	0.124	0.124	0.16
1974	0.015	0.205	0.156	0.097	0.17	0.171	0.072	0.199	0.089	0.14	0.14	0.153
1975	0.029	0.243	0.13	0.185	0.075	0.083	0.147	0.051	0.181	0.108	0.108	0.131
1976	0.065	0.185	0.291	0.158	0.166	0.072	0.176	0.216	0.122	0.151	0.151	0.18
1977	0.071	0.152	0.23	0.178	0.128	0.108	0.069	0.048	0.114	0.093	0.093	0.13
1978	0.058	0.24	0.221	0.174	0.22	0.165	0.14	0.085	0.226	0.167	0.167	0.178
1979	0.056	0.239	0.244	0.219	0.254	0.287	0.221	0.232	0.142	0.228	0.228	0.242
1980	0.04	0.17	0.204	0.271	0.147	0.295	0.352	0.188	0.198	0.236	0.236	0.232
1981	0.032	0.232	0.273	0.268	0.239	0.285	0.305	0.289	0.229	0.27	0.27	0.27
1982	0.029	0.241	0.398	0.349	0.295	0.203	0.325	0.434	0.503	0.353	0.353	0.321
1983	0.025	0.214	0.395	0.421	0.347	0.34	0.365	0.462	0.489	0.402	0.402	0.363
1984	0.061	0.229	0.341	0.298	0.39	0.309	0.244	0.29	0.35	0.317	0.317	0.3
1985	0.044	0.433	0.391	0.294	0.352	0.342	0.212	0.277	0.232	0.284	0.284	0.329
1986	0.071	0.33	0.419	0.348	0.3	0.312	0.238	0.226	0.37	0.29	0.29	0.31
1987	0.092	0.312	0.345	0.292	0.253	0.314	0.322	0.182	0.205	0.256	0.256	0.288
1988	0.128	0.376	0.354	0.362	0.398	0.272	0.349	0.224	0.201	0.289	0.289	0.333
1989	0.116	0.352	0.565	0.496	0.411	0.393	0.285	0.363	0.337	0.359	0.359	0.409
1990	0.136	0.379	0.373	0.473	0.428	0.345	0.41	0.417	0.413	0.404	0.404	0.404
1991	0.068	0.218	0.317	0.285	0.309	0.256	0.212	0.311	0.23	0.264	0.264	0.273
1992	0.089	0.286	0.316	0.293	0.156	0.229	0.237	0.191	0.167	0.196	0.196	0.244

Table 32.10. Sole in Division 7.e. Assessment summary.

Year	Recruitment Age 2 [thousands]	TSB [tonnes]	SSB [tonnes]	Landings [tonnes]	Yield/SSB	F_{bar} (Ages 3–9)
1969	1874	2927	2437	353	0.14	0.134
1970	1343	3023	2652	391	0.15	0.146
1971	3826	2838	2390	432	0.18	0.181
1972	2568	3091	2395	437	0.18	0.138
1973	2264	3266	2778	459	0.17	0.160
1974	3107	3512	2896	427	0.15	0.153
1975	2967	4428	3670	491	0.13	0.131
1976	2791	4102	3403	616	0.18	0.180
1977	6556	5339	4098	606	0.15	0.130
1978	4657	5429	4074	861	0.21	0.178
1979	4389	6014	4865	1181	0.24	0.242
1980	4702	6387	5338	1269	0.24	0.232
1981	8130	5957	4572	1215	0.27	0.270
1982	4680	5916	4575	1446	0.32	0.321
1983	3866	5377	4374	1498	0.34	0.363
1984	5968	5462	4430	1370	0.31	0.300
1985	6982	5568	4009	1409	0.35	0.329
1986	3765	5257	4013	1419	0.35	0.310
1987	5848	5310	4112	1280	0.31	0.288
1988	3878	5120	4043	1444	0.36	0.333
1989	3736	4318	3443	1390	0.4	0.409
1990	2818	4223	3287	1315	0.4	0.404
1991	7163	4220	2991	852	0.28	0.273
1992	3903	4101	2938	895	0.3	0.244
1993	3351	3580	2811	904	0.32	0.312
1994	2378	3787	3054	800	0.26	0.231
1995	3454	3877	3069	856	0.28	0.296
1996	3942	4155	3056	833	0.27	0.265

Year	Recruitment Age 2 [thousands]	TSB [tonnes]	SSB [tonnes]	Landings [tonnes]	Yield/SSB	F_{bar} (Ages 3–9)
1997	3335	3834	2923	949	0.32	0.319
1998	4409	3946	2913	880	0.3	0.296
1999	3576	3951	2834	957	0.34	0.324
2000	6548	4310	2871	914	0.32	0.310
2001	5429	4517	2901	1069	0.37	0.351
2002	3808	4193	3019	1106	0.37	0.345
2003	5380	4409	3298	1078	0.33	0.259
2004	2865	4031	3109	1075	0.35	0.307
2005	3995	3973	3098	1039	0.34	0.338
2006	4610	3698	2727	1023	0.38	0.350
2007	3931	3793	2766	1015	0.37	0.364
2008	4205	3797	2676	908	0.34	0.332
2009	3769	3934	2983	701	0.23	0.223
2010	4857	4427	3427	698	0.2	0.213
2011	3458	4694	3536	801	0.23	0.206
2012	3507	4553	3726	872	0.23	0.232
2013	3202	4477	3640	883	0.24	0.238
2014	3382	4794	3897	885	0.23	0.215
2015	4172	4899	3941	774	0.2	0.192
2016	5715	5922	4457	913	0.2	0.215
2017	4605	5813	4212	1007	0.24	0.188
2018	8338	6380	4471	1075	0.24	0.235
2019	6486	6565	4749	1185	0.25	0.271
2020	11728	7768	5236	1219	0.23	0.258

Table 32.11. Sole in Division 7.e. Input data for the short-term forecast.

Age	N2021	N2022	N2023	M	Mat	PF	PM	SWt	Sel	CWt
2	4967	4967	4967	0.1	0.14	0	0	0.164	0.015	0.191
3	10452	4429	4420	0.1	0.45	0	0	0.218	0.122	0.244
4	4680	8382	3493	0.1	0.88	0	0	0.27	0.206	0.295
5	4226	3454	6015	0.1	0.98	0	0	0.32	0.25	0.344
6	1503	2988	2361	0.1	1	0	0	0.367	0.303	0.39
7	1284	1008	1924	0.1	1	0	0	0.412	0.266	0.434
8	903	894	676	0.1	1	0	0	0.455	0.371	0.476
9	306	566	533	0.1	1	0	0	0.496	0.288	0.516
10	271	208	371	0.1	1	0	0	0.534	0.248	0.553
11	210	192	143	0.1	1	0	0	0.57	0.534	0.588
12	873	578	382	0.1	1	0	0	0.688	0.534	0.697

Table 32.12. Sole in Division 7.e. Single option output of the short-term forecast (targeting F_{MSY}).

Age	F	Catch.No	Yield	Stock.No	Biomass	SSNo	SSB
Year = 2021, Fbar = 0.255							
2	0.015	69	13	4967	813	695	114
3	0.121	1132	276	10452	2278	4703	1025
4	0.204	822	243	4680	1262	4119	1111
5	0.247	880	302	4226	1351	4141	1324
6	0.299	370	144	1503	551	1503	551
7	0.263	283	123	1284	530	1284	530
8	0.366	264	126	903	411	903	411
9	0.285	72	37	306	152	306	152
10	0.245	56	31	271	145	271	145
11	0.527	82	48	210	120	210	120
12	0.527	342	239	873	601	873	601
Total	NA	4374	1583	29675	8213	19008	6082
Year = 2022, Fbar = 0.290							
2	0.017	78	15	4967	813	695	114
3	0.137	541	132	4429	966	1993	434
4	0.232	1654	488	8382	2260	7376	1989
5	0.281	806	277	3454	1104	3385	1082
6	0.34	823	321	2988	1096	2988	1096
7	0.299	249	108	1008	416	1008	416
8	0.417	291	138	894	407	894	407
9	0.324	149	77	566	281	566	281
10	0.279	48	27	208	111	208	111
11	0.6	83	49	192	109	192	109
12	0.6	250	174	578	398	578	398
Total	NA	4972	1806	27668	7961	19885	6437
Year = 2023, Fbar = 0.290							
2	0.017	78	15	4967	813	695	114
3	0.137	540	132	4420	964	1989	434

Age	F	Catch.No	Yield	Stock.No	Biomass	SSNo	SSB
4	0.232	689	203	3493	942	3074	829
5	0.281	1403	482	6015	1923	5894	1884
6	0.34	a650	253	2361	866	2361	866
7	0.299	474	206	1924	793	1924	793
8	0.417	220	105	676	308	676	308
9	0.324	141	73	533	264	533	264
10	0.279	86	48	371	198	371	198
11	0.6	62	36	143	81	143	81
12	0.6	165	115	382	263	382	263
Total	NA	4509	1668	25285	7415	18043	6034

Units are thousands (for numbers) and tonnes (for weights).

Table 32.13. Sole in Division 7.e. Year-class sources and contributions for the short-term forecast (in percent).

cohort	Yield 2021	Yield 2022	SSB 2021	SSB 2022	SSB 2023
2009	15.1		9.9		
2010	3.1	9.6	2	6.2	
2011	2	2.7	2.4	1.7	4.4
2012	2.4	1.5	2.5	1.7	1.3
2013	7.9	4.3	6.8	4.4	3.3
2014	7.8	7.7	8.7	6.3	4.4
2015	9.1	6	9.1	6.5	5.1
2016	19.1	17.8	21.8	17	13.1
2017	15.3	15.3	18.3	16.8	14.3
2018	17.5	27	16.9	30.9	31.2
2019	0.8	7.3	1.9	6.7	13.7
2020		0.8		1.8	7.2
2021					1.9

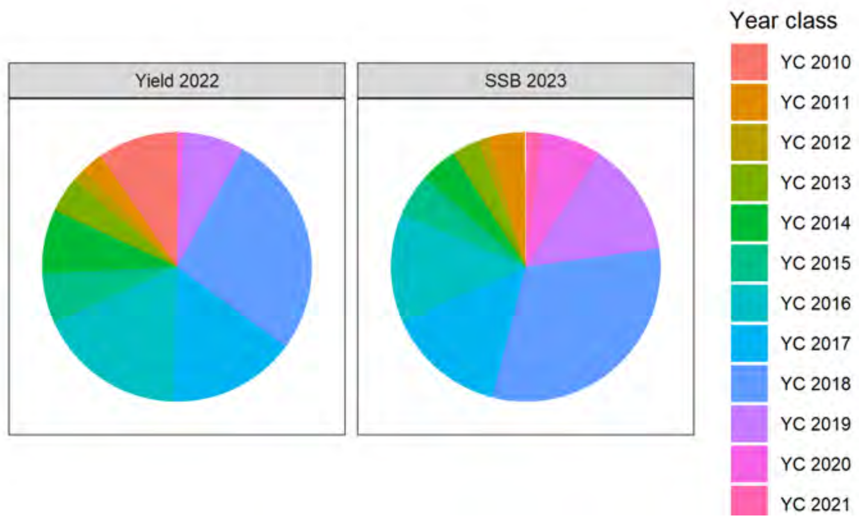


Table 32.14. Sole in Division 7.e. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch* (2022)	Projected landings (2022)	Projected discards (2022)	$F_{projected\ landings}$ (2022)	SSB (2023)	% SSB change **	% TAC change***	% advice change^^
ICES advice basis								
EU MAP^^^: F_{MSY}	1810	1806	4	0.29	6034	-6.3		-6
F = MAP $F_{MSY\ lower}$	1068	1066	2	0.16	6765	5.1		-6.4#
F = MAP $F_{MSY\ upper}$	2069	2065	4	0.34	5780	-10.2		-5.8#
Other options								
F = 0	0	0	0	0	7820	21		-100
F_{pa}	2316	2311	5	0.39	5538	-14		20
F_{lim}	2550	2544	5	0.44	5309	-17.5		32
SSB_{2023} = B_{lim}	5991	5978	13	1.78	2000	-69		210
Rollover TAC##	1925	1921	4	0.31	5921	-8		0
SSB_{2023} = B_{pa}= MSY $B_{trigger}$	5036	5025	11	1.22	2900	-55		162
SSB_{2023} = SSB_{2022}	1400	1397	3	0.22	6437	0		-27
F = F_{2021}	1619	1616	3	0.25	6222	-3.3		-15.9

*** Total catch derived from the projected landings and the assumed discard rate.**

**** SSB 2023 relative to SSB 2022.**

***** The agreed TAC was not available.**

^ Advice value for 2022 relative to the advice value for 2021 (1925 tonnes).

^^ EU multiannual plan (MAP) for the Western Waters (EU, 2019).

 # Advice value this year relative to the advice value last year for the MAP FMSY lower (1141 tonnes) and MAP FMSY upper (2197 tonnes).

The TAC 2021 was not available. Therefore, the catch advice for 2021 (EU MAP^^) was used.

Table 32.15. Sole in Division 7.e. Annual catch scenarios (more options and more digits provided, sorted by fishing mortality in intermediate year). All weights are in tonnes.

Basis	Total catch* (2022)	Projected landings (2022)	Projected discards (2022)	$F_{\text{projected landings}}$ (2022)	SSB (2023)	% SSB change **	% TAC change***	% advice change^
F0	3.25E-30	3.24E-30	6.97E-33	4.47E-34	7819.963042	21.47659793	NA	-100
Fsq0.6	1035.667414	1033.447147	2.220266521	0.154756255	6796.739164	5.581669141	NA	-46.19909539
FMSY_lower	1067.808448	1065.519278	2.289170556	0.16	6765.044092	5.089312665	NA	-6.414684627#
F=0.17	1128.603835	1126.184331	2.419503865	0.17	6705.103065	4.15817885	NA	-41.37122936
F=0.18	1188.751833	1186.203384	2.548449302	0.18	6645.814438	3.237179515	NA	-38.24665802
F=0.19	1248.260486	1245.584462	2.676024107	0.19	6587.170055	2.326187987	NA	-35.15529945
F=0.2	1307.13772	1304.335475	2.802245277	0.2	6529.16188	1.425079402	NA	-32.09674182
Fsq0.8	1344.152115	1341.270519	2.881596835	0.206341673	6492.701045	0.858690768	NA	-30.17391609
F=0.21	1365.391351	1362.464221	2.927129564	0.21	6471.781987	0.533730674	NA	-29.07057917
SSB_stable	1400.279848	1397.277924	3.001923614	0.216040371	6437.423484	-1.11E-14	NA	-27.25818973
F=0.22	1423.029083	1419.978389	3.050693484	0.22	6415.022568	-0.34797953	NA	-26.0764113
F=0.23	1480.058509	1476.885556	3.172953318	0.23	6358.875921	-1.220170822	NA	-23.11384369
F=0.24	1536.487117	1533.193192	3.293925117	0.24	6303.334456	-2.082961116	NA	-20.18248741
F=0.25	1592.322289	1588.908664	3.413624704	0.25	6248.390689	-2.936466659	NA	-17.28195902
Fsq	1619.015458	1615.544608	3.47084959	0.254818265	6222.128515	-3.344427617	NA	-15.8953009
TAC085	1636.25	1632.742203	3.507797047	0.257942253	6205.173925	-3.607803024	NA	-15
F=0.26	1647.5713	1644.039233	3.53206768	0.26	6194.037244	-3.780802056	NA	-14.4118805
MP	1702.241327	1698.592057	3.649269426	0.27	6140.266847	-4.616080294	NA	-11.57187913
F=0.27	1702.241327	1698.592057	3.649269426	0.27	6140.266847	-4.616080294	NA	-11.57187913

Basis	Total catch* (2022)	Projected landings (2022)	Projected discards (2022)	$F_{projected\ landings}$ (2022)	SSB (2023)	% SSB change **	% TAC change***	% advice change^
MP2	1702.241327	1698.592057	3.649269426	0.27	6140.266847	-4.616080294	NA	-11.57187913
F=0.28	1756.339441	1752.574196	3.765245107	0.28	6087.072326	-5.442412772	NA	-8.761587456
FMSY	1809.872619	1805.99261	3.880009674	0.29	6034.446611	-6.259909323	NA	-5.980643159
F=0.3	1862.847737	1858.854159	3.99357787	0.3	5982.382731	-7.068678239	NA	-3.228689003
F=0.31	1915.271575	1911.16561	4.105964231	0.31	5930.873812	-7.868826297	NA	-0.505372746
TAC##	1925	1920.87318	4.126820055	0.311867273	5921.316627	-8.017289179	NA	-1.11E-14
F=0.32	1967.150819	1962.933636	4.217183092	0.32	5879.913076	-8.660458781	NA	2.189652942
F=0.33	2018.492063	2014.164815	4.327248585	0.33	5829.493841	-9.443679506	NA	4.85673055
FMSY_upper	2069.301808	2064.865633	4.43617465	0.34	5779.609517	-10.21859084	NA	-5.812389267#
TAC115	2213.75	2209.004157	4.745843063	0.369009528	5637.864426	-12.42048251	NA	15
Fpa	2315.599351	2310.635163	4.964187969	0.39	5537.987235	-13.9719913	NA	20.29087537
Flim	2549.534351	2544.068652	5.465698436	0.44	5308.800239	-17.53221996	NA	32.44334289
Bpa	5036.25697	5025.460229	10.79674092	1.220870035	2900	-54.95092086	NA	161.6237387
Btrigger	5036.25697	5025.460229	10.79674092	1.220870035	2900	-54.95092086	NA	161.6237387
Blim	5990.538537	5977.696005	12.84253225	1.782105571	2000	-68.93166956	NA	211.1968071

*** Total catch derived from the projected landings and the assumed discard rate.**

**** SSB 2023 relative to SSB 2022.**

***** The agreed TAC was not available.**

^ Advice value for 2022 relative to the advice value for 2021 (1925 tonnes).

^^ EU multiannual plan (MAP) for the Western Waters (EU, 2019).

 # Advice value this year relative to the advice value last year for the MAP FMSY lower (1141 tonnes) and MAP FMSY upper (2197 tonnes).

The TAC 2021 was not available. Therefore, the catch advice for 2021 (EU MAP^^) was used.

32.16 Figures

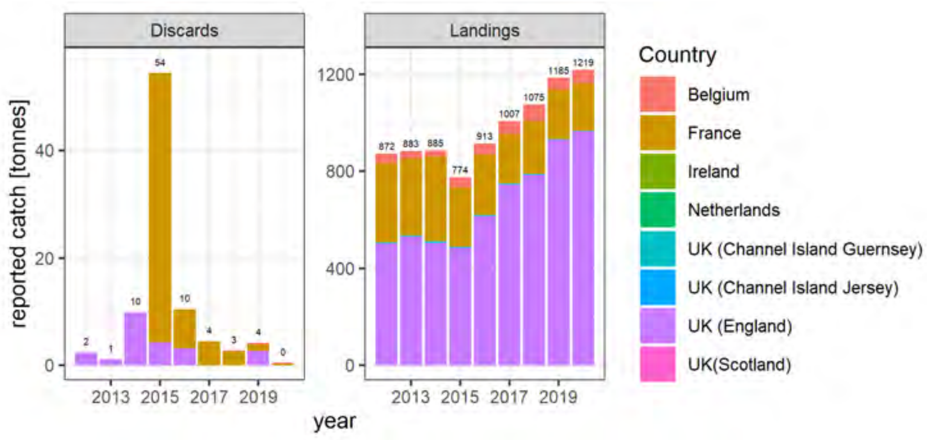


Figure 32.1. Sole in Division 7.e. Landings and discards reported in InterCatch by country.

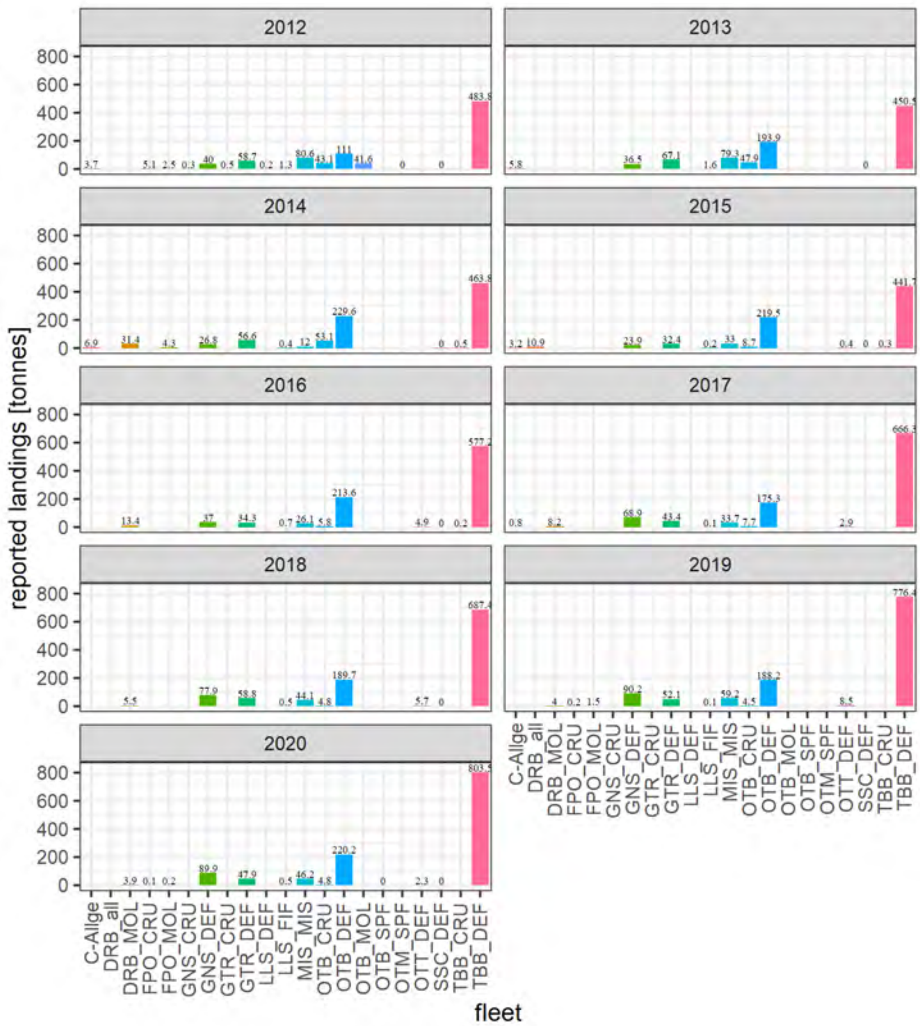


Figure 32.2. Sole in Division 7.e. International landings reported in InterCatch by fleet and year.

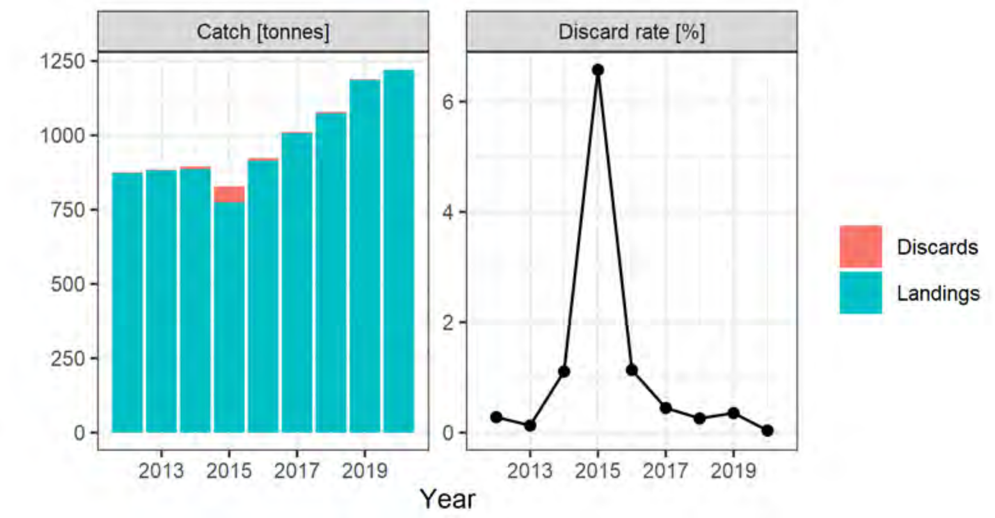


Figure 32.3. Sole in Division 7.e. Discard rates for discards reported in InterCatch.

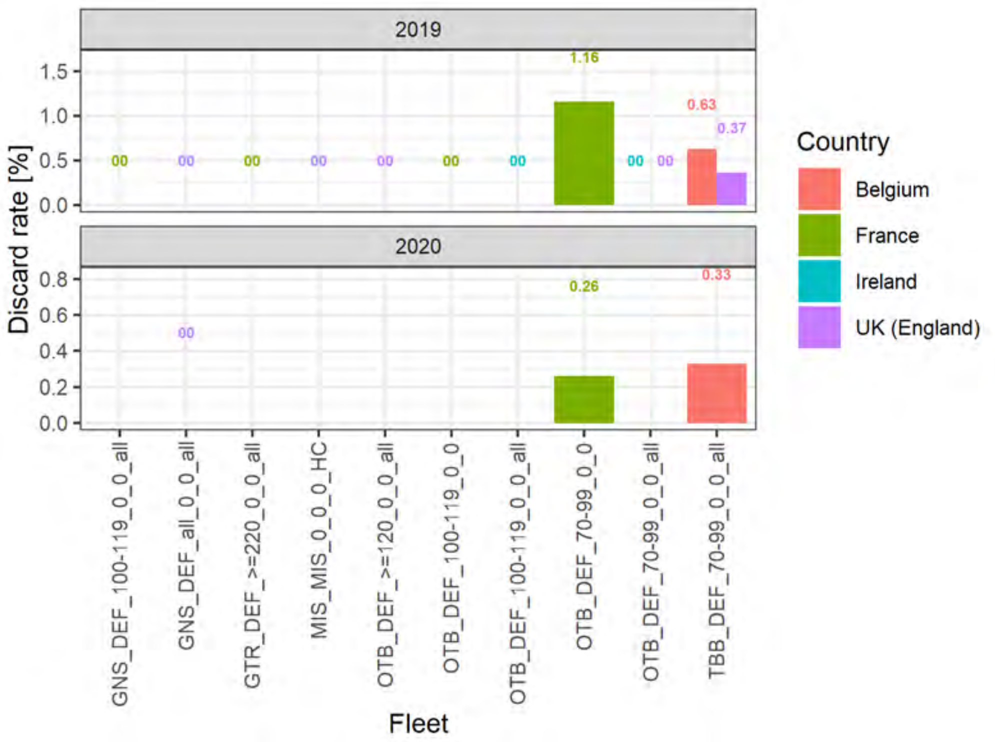


Figure 32.4. Sole in Division 7.e. Annual reported discard rates in InterCatch by fleet and country.

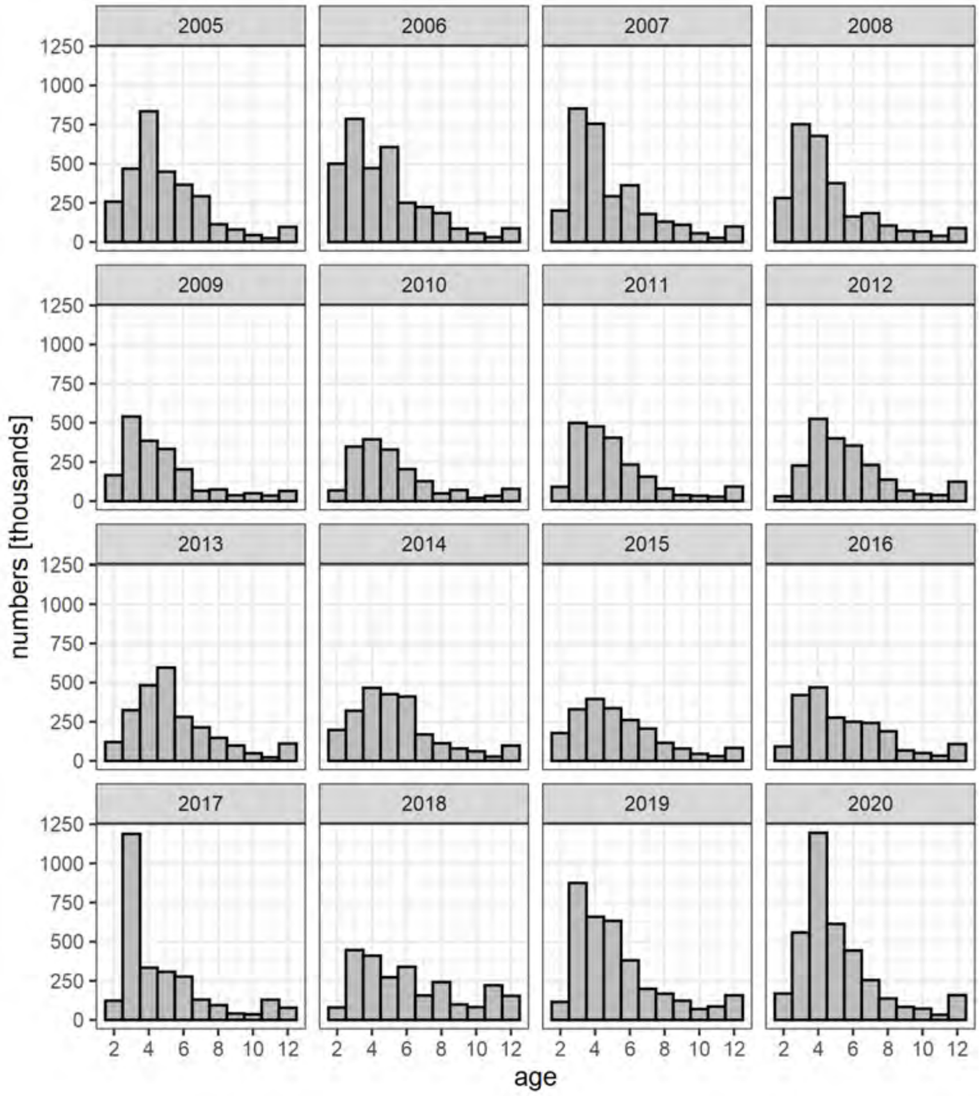


Figure 32.5. Sole in Division 7.e. International landings numbers-at-age (last 16 years).

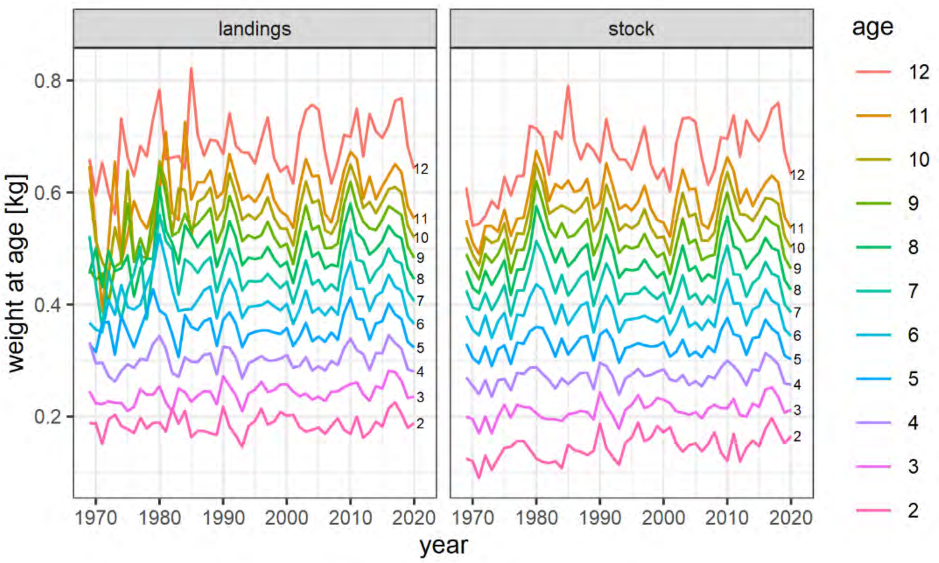


Figure 32.6. Sole in Division 7.e. Catch (landings) and stock weights-at-age.

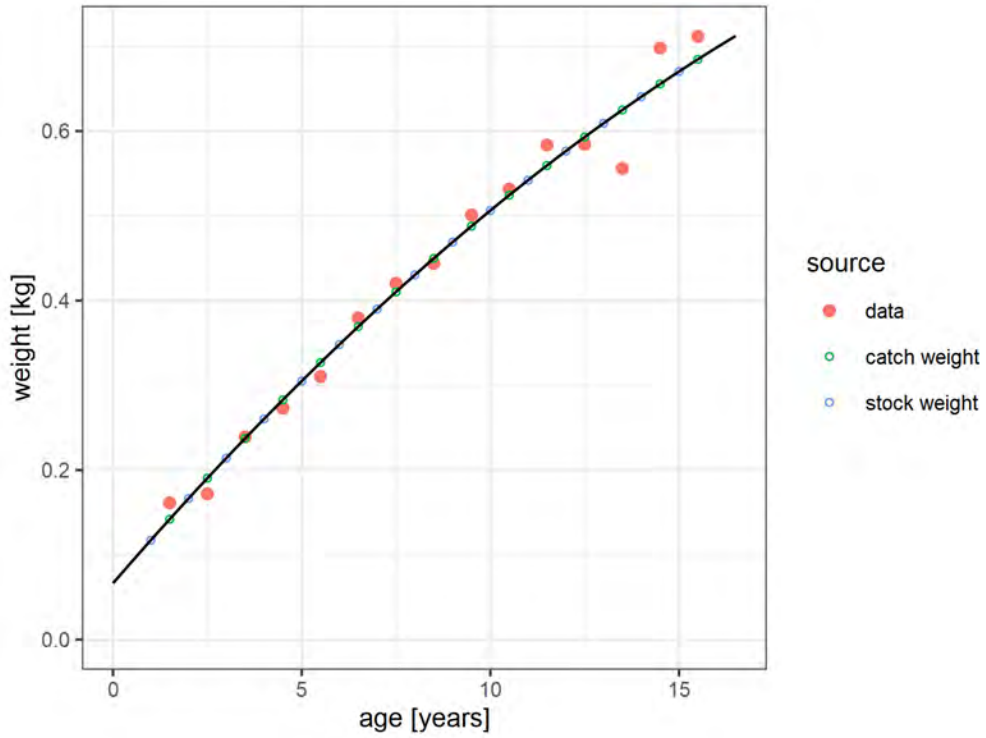


Figure 32.7. Sole in Division 7.e. Generation of stock and catch weights from landings weights-at-age.

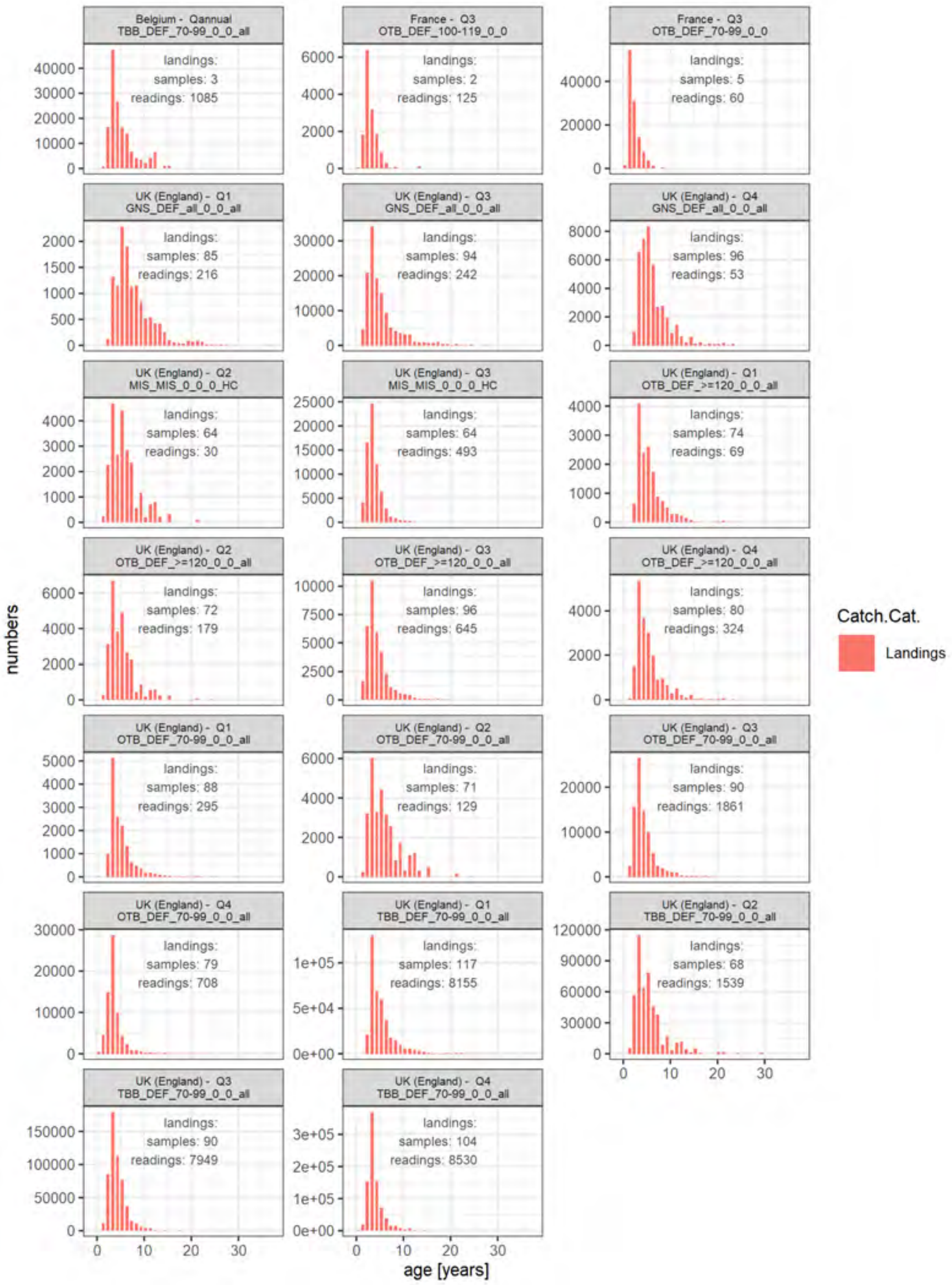


Figure 32.8. Sole in Division 7.e. Landings age distributions submitted to InterCatch. Numbers are raised to fleet level.

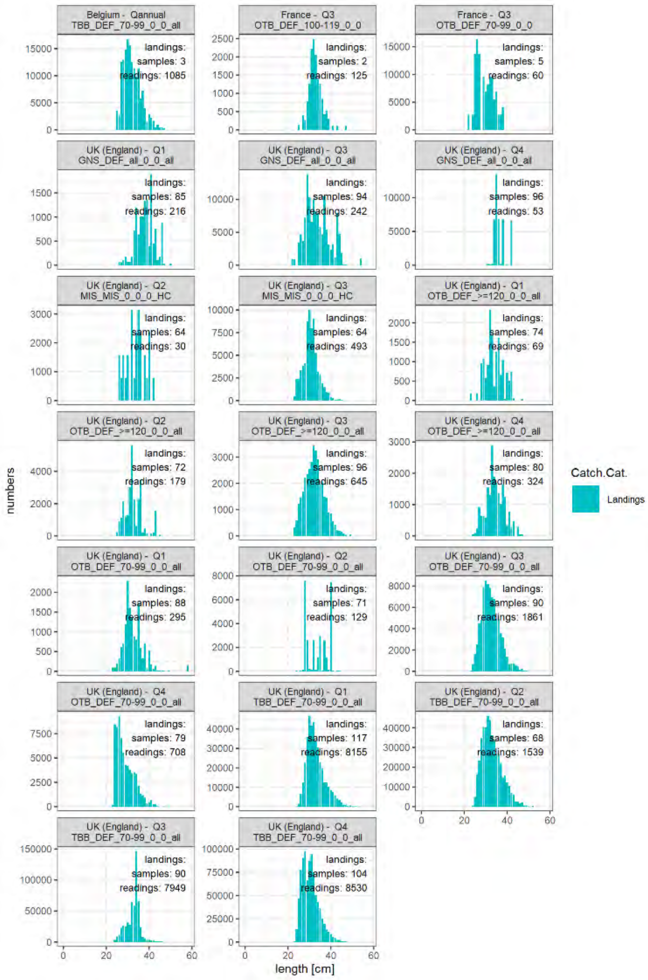


Figure 32.9. Sole in Division 7.e. Length distributions submitted to InterCatch. Numbers are raised to fleet level.

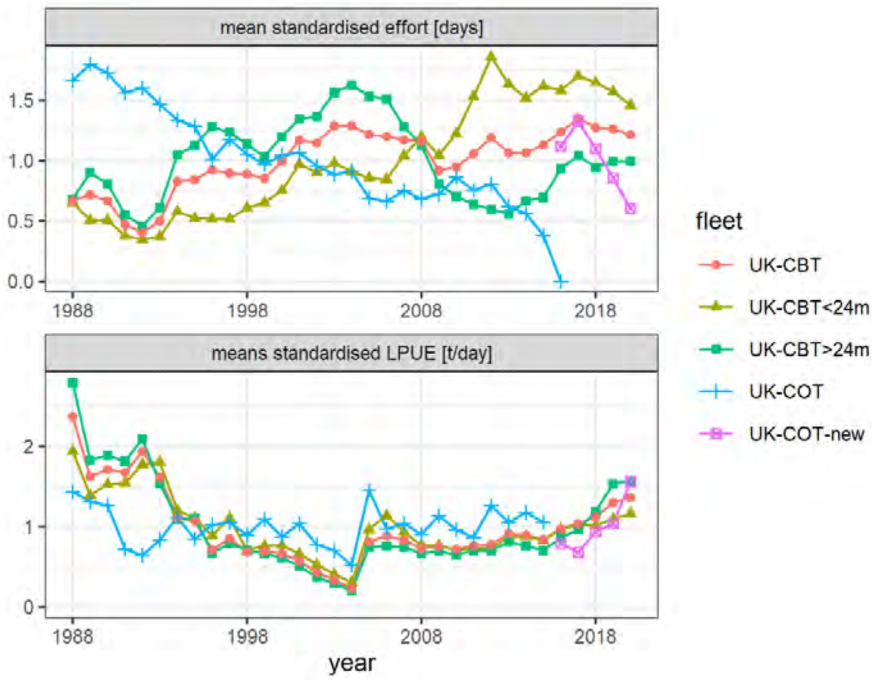


Figure 32.10. Sole in Division 7.e. Means standardised lpue and effort for the UK commercial fleets.

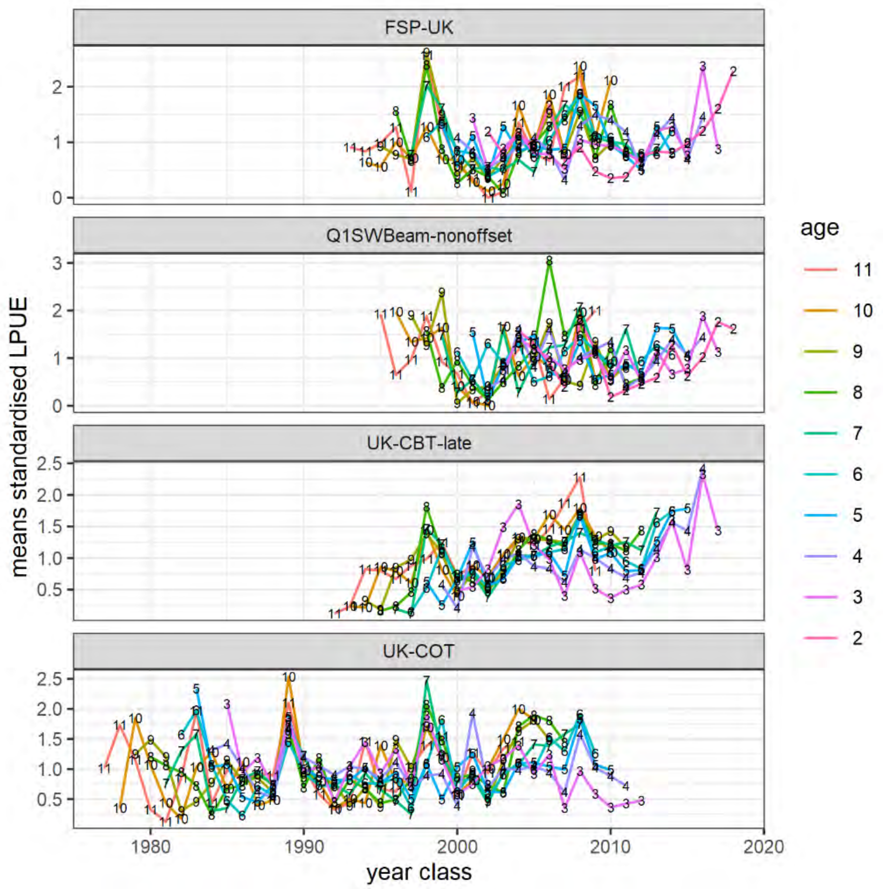


Figure 32.11. Sole in Division 7.e. Means standardised lpue/cpue by year class. Note, the cohorts differ on the x-axes due to the differences in the length and age ranges of the tuning series.

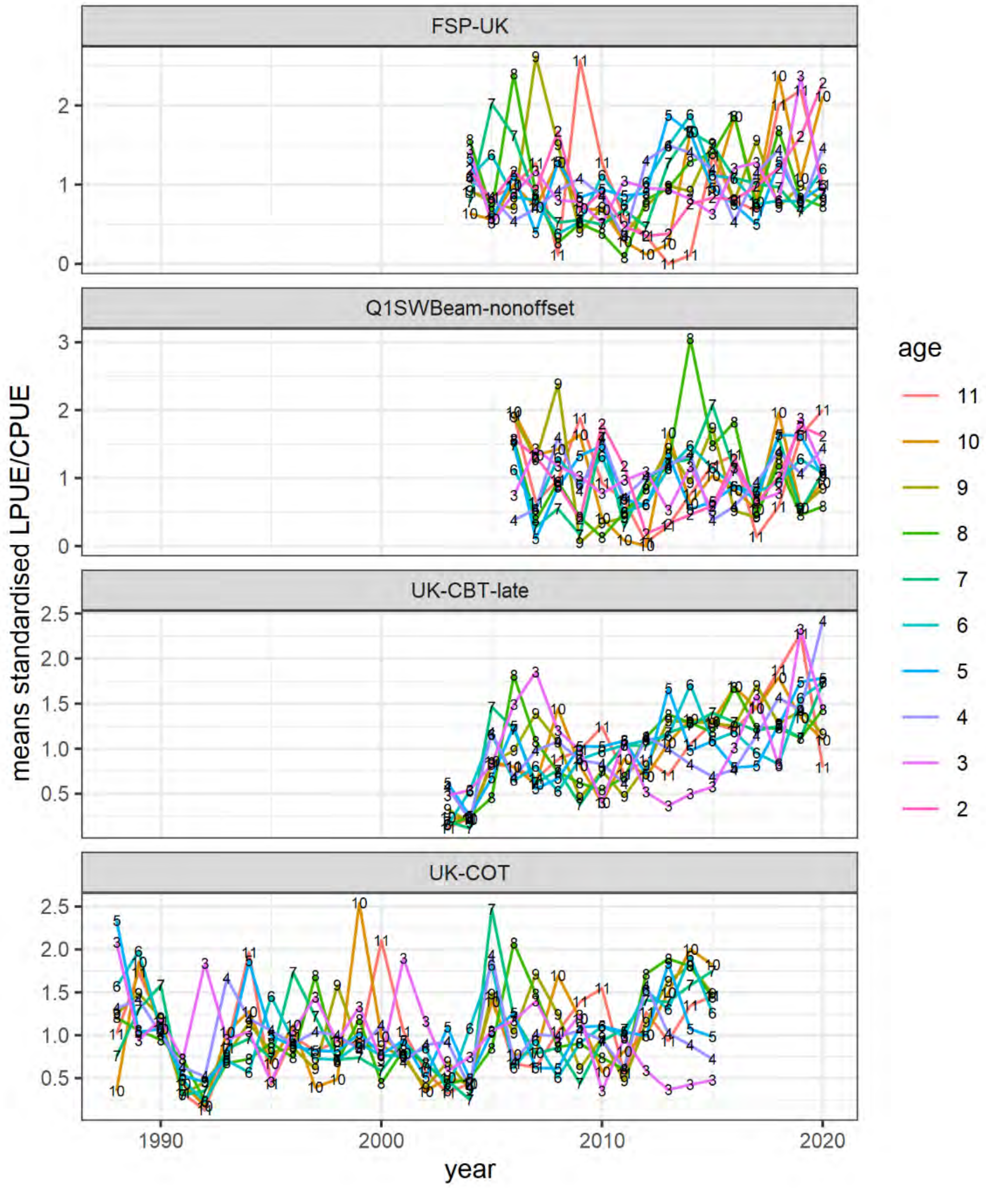


Figure 32.12. Sole in Division 7.e. Means standardised lpue/cpue by year. Note, the lines differ on the x-axes due to the differences in the length and age ranges of the tuning series.

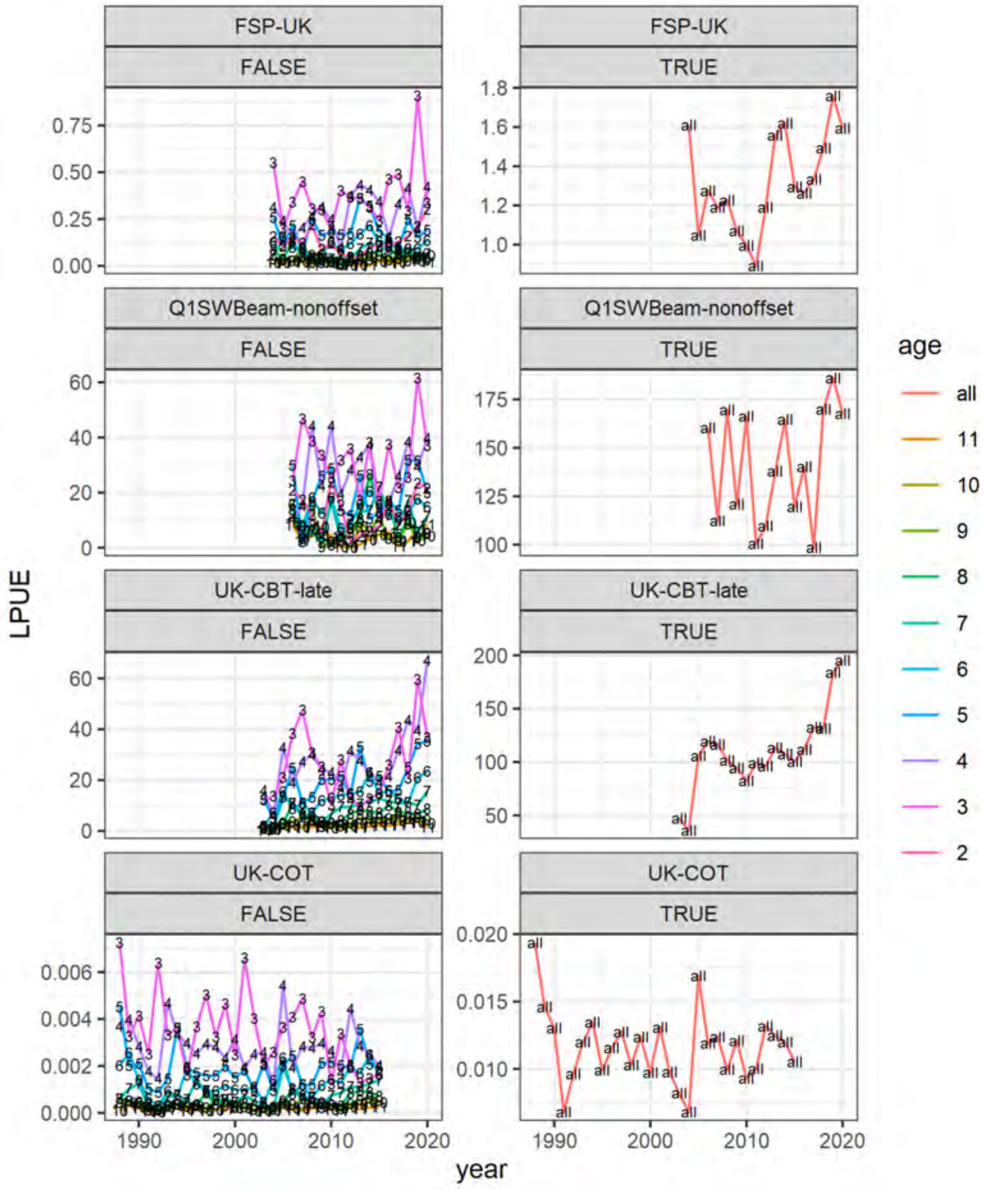


Figure 32.13. Sole in Division 7.e. Survey indices (raw values) for all commercial and scientific surveys. The plots on the left show the index values at-age, on the right are the values aggregated over all ages.

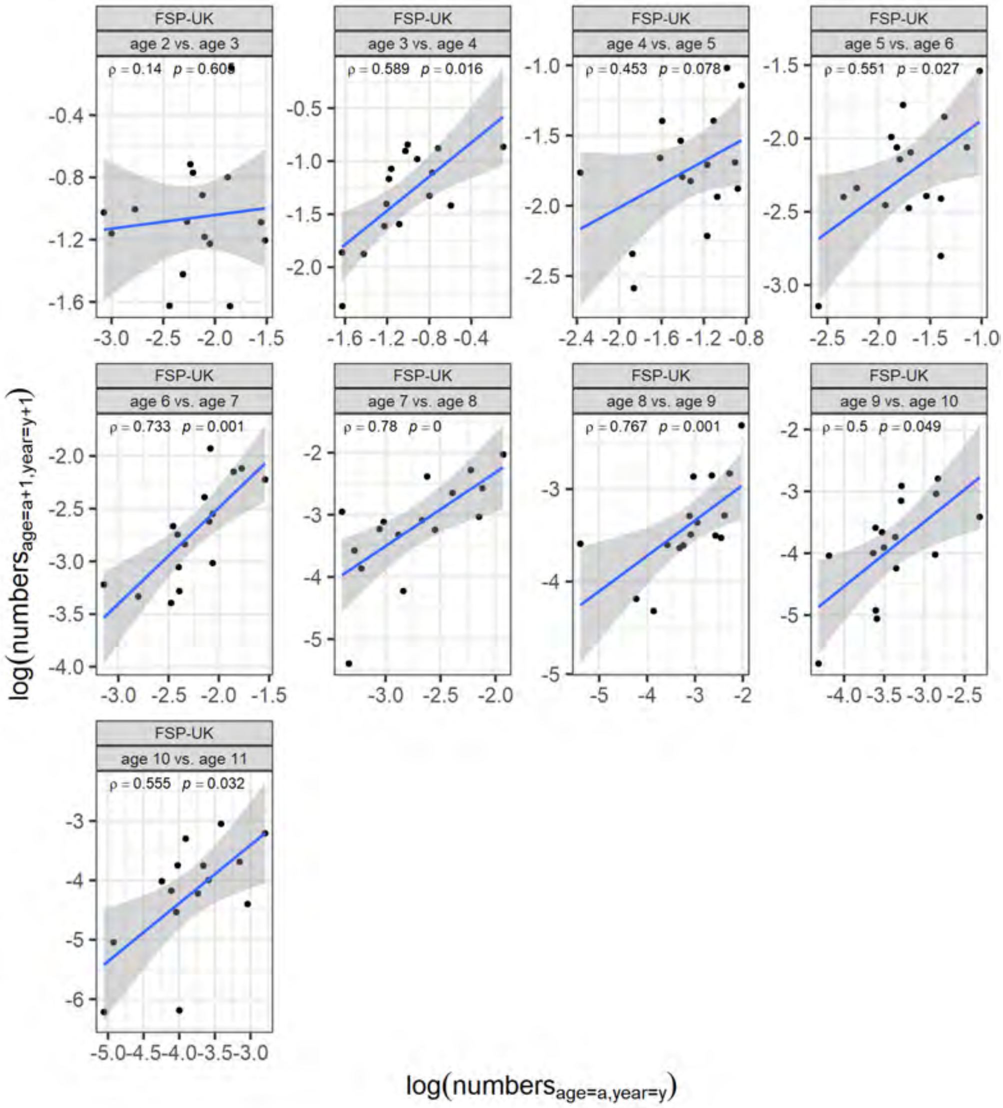


Figure 32.14. Sole in Division 7.e. Internal consistencies in the scientific surveys. Shown is the correlation between numbers-at-age and the numbers of the same cohort one year later, including Pearson correlation coefficient *ρ* and the *p*-value.

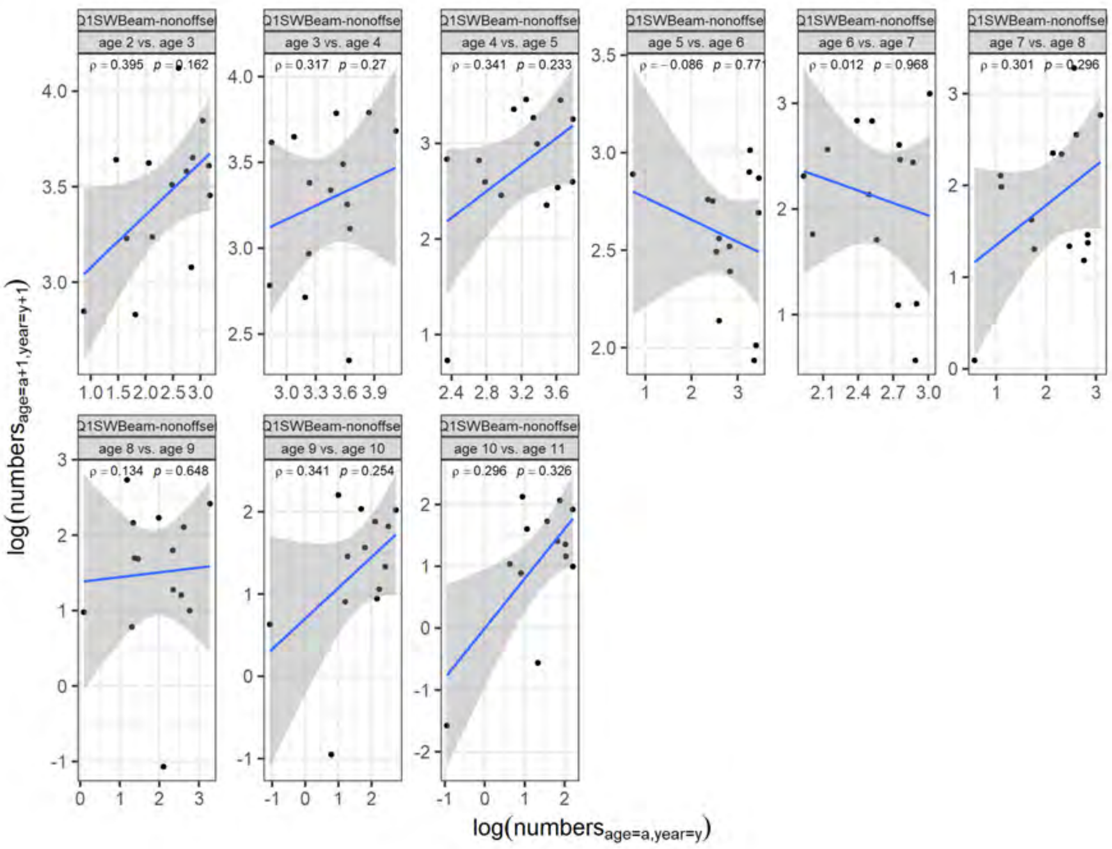


Figure 32.15. Sole in Division 7.e. Internal consistencies in the scientific surveys. Shown is the correlation between numbers-at-age and the numbers of the same cohort one year later, including Pearson correlation coefficient ρ and the p-value.

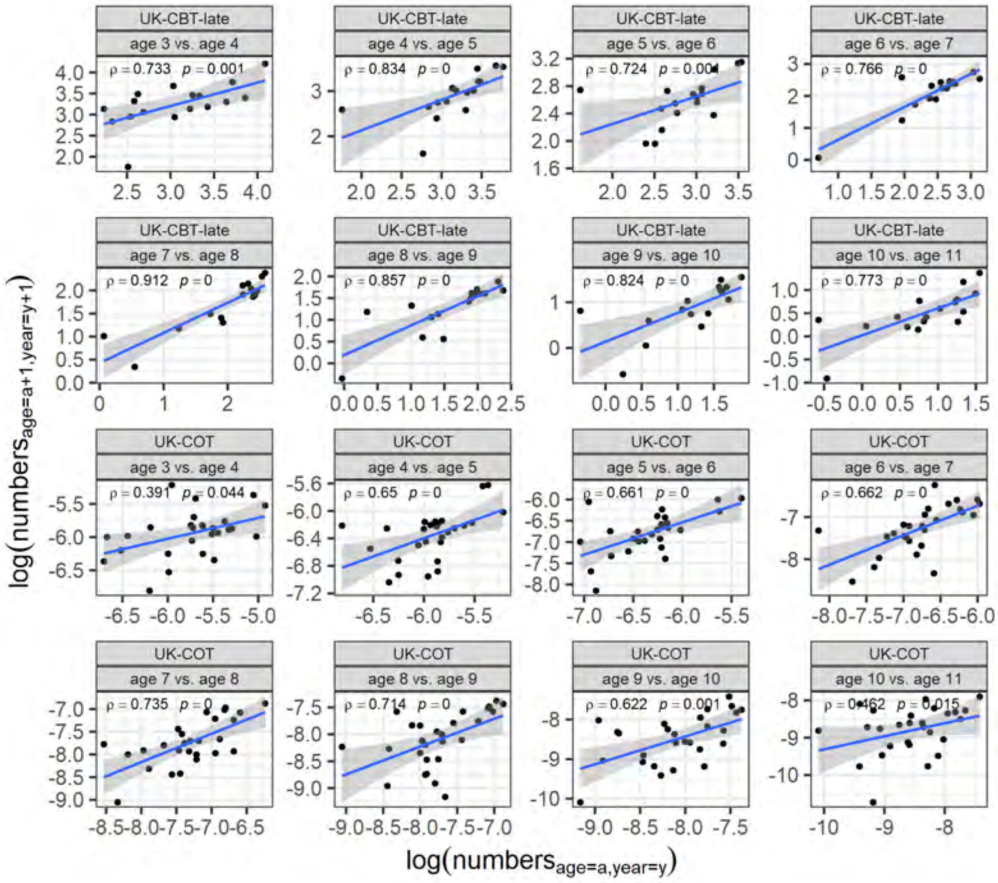


Figure 32.16. Sole in Division 7.e. Internal consistencies in the commercial surveys. Shown is the correlation between numbers-at-age and the numbers of the same cohort one year later, including Pearson correlation coefficient *ρ* and the *p*-value.

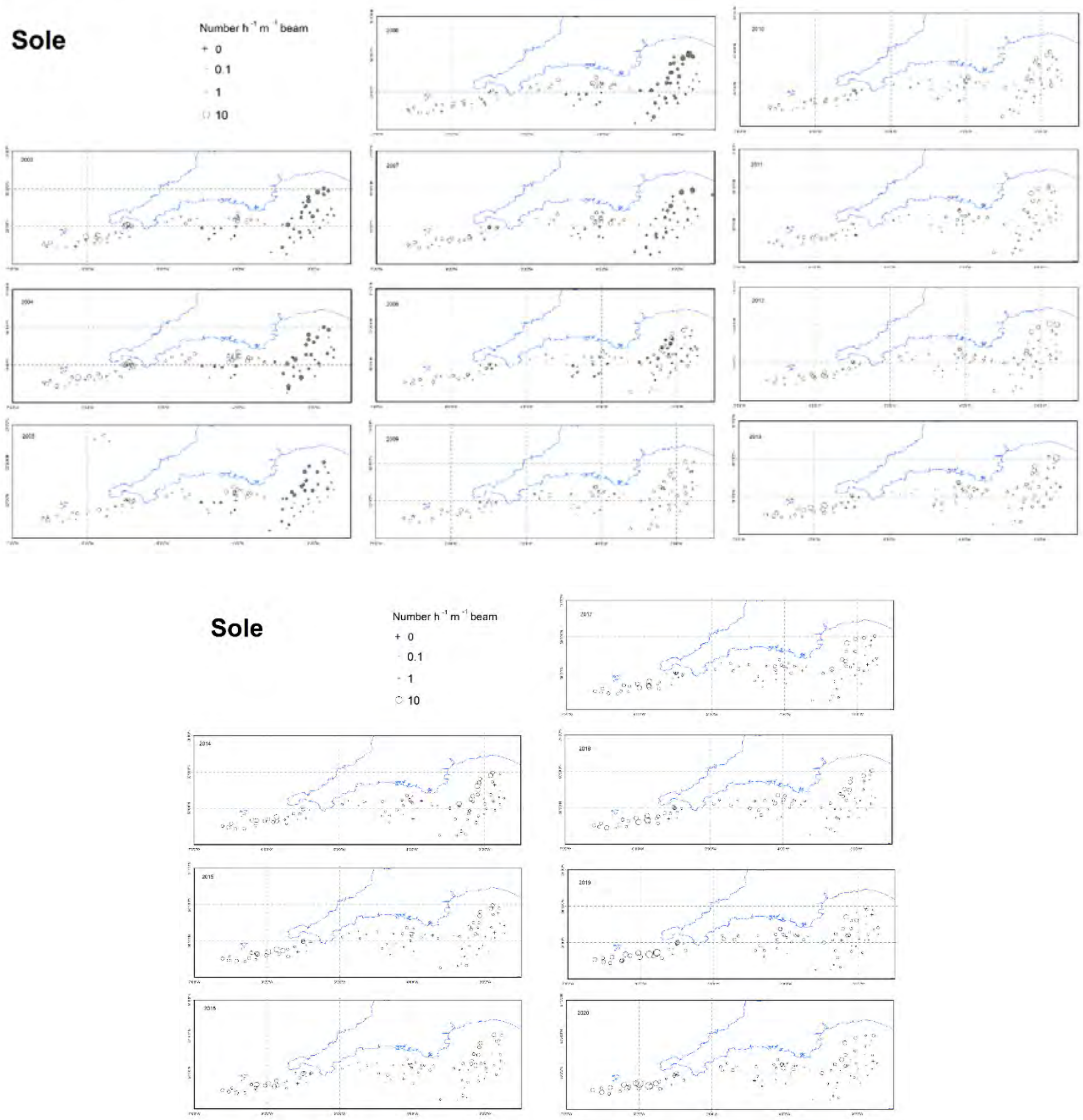


Figure 32.17. Sole in Division 7.e. Sole catch rates during FSP "Western Channel Sole and Plaice" surveys, 2003–2020 (number h^{-1} m beam^{-1}). Open circles: FV Nellie and FV Carhelmar tows; filled circles: FV Lady T Emiel tows. Source: Burt *et al*. (2021).

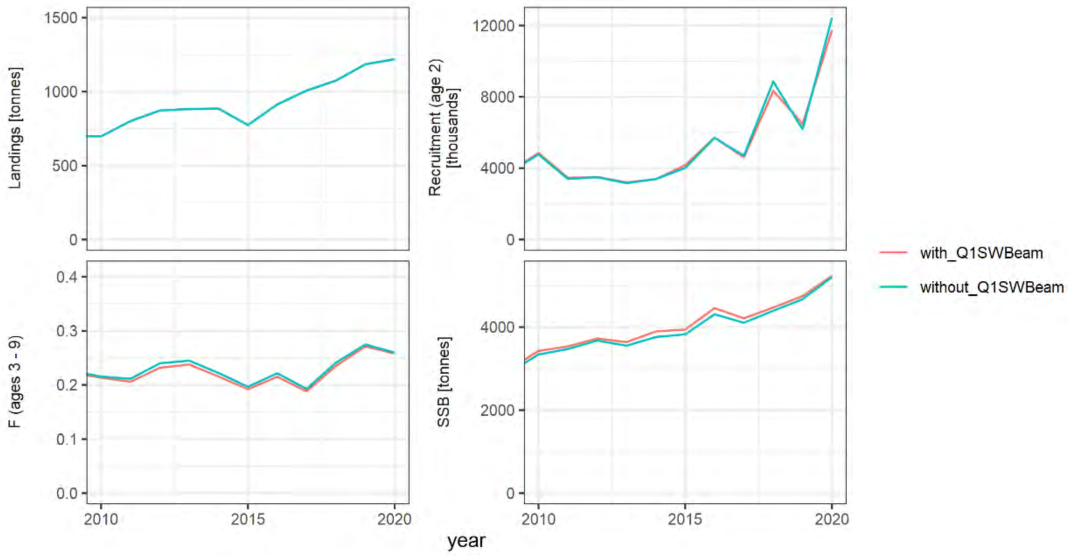


Figure 32.18. Sole in Division 7.e. Impact of excluding the 2020 Q1SWBeam index values on the stock assessment.

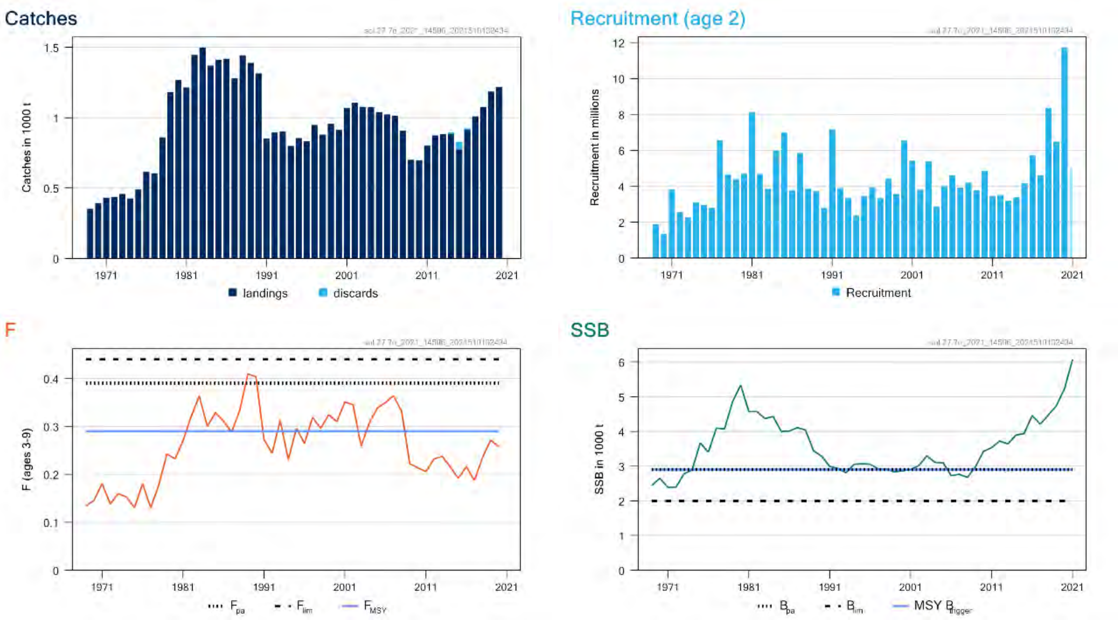


Figure 32.19. Sole in Division 7.e. Results of the final XSA run. Summary of the stock assessment. ICES estimated catches, recruitment (age 2), fishing mortality (F), and spawning-stock biomass (SSB). The assumed recruitment value for 2021 is shaded in a lighter colour. Discard estimates are only available from 2012 onwards.

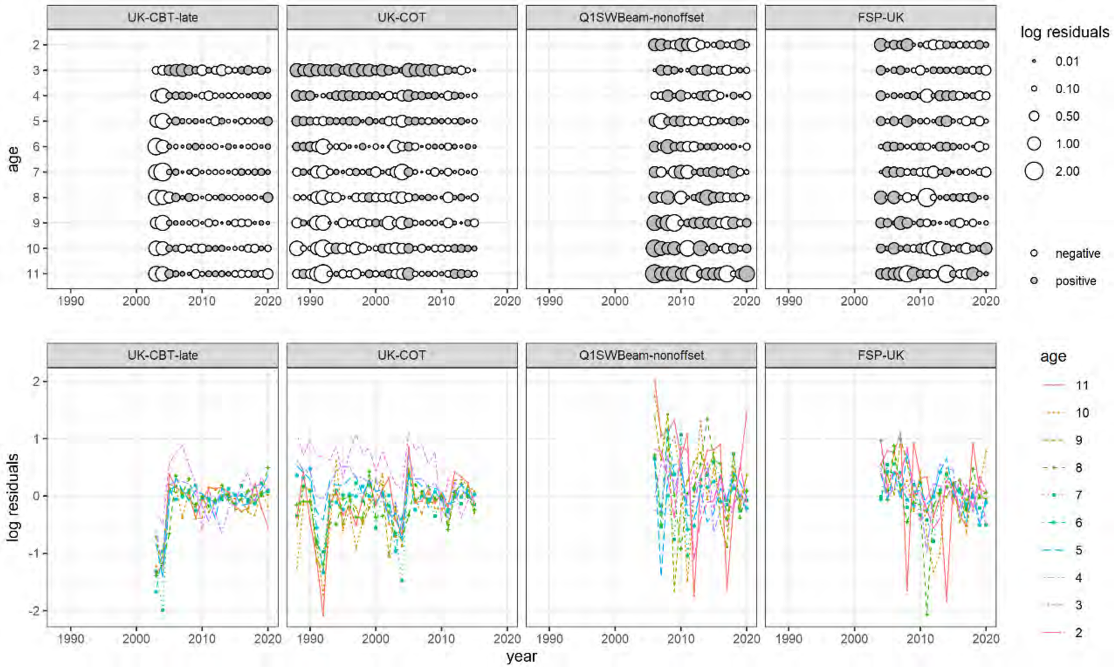


Figure 32.20. Sole in Division 7.e. XSA fleet log catchability residuals for. Note that the application of time-series weighting set as a tricubic taper with a range of 15 years excludes log catchability residuals prior to 2004.

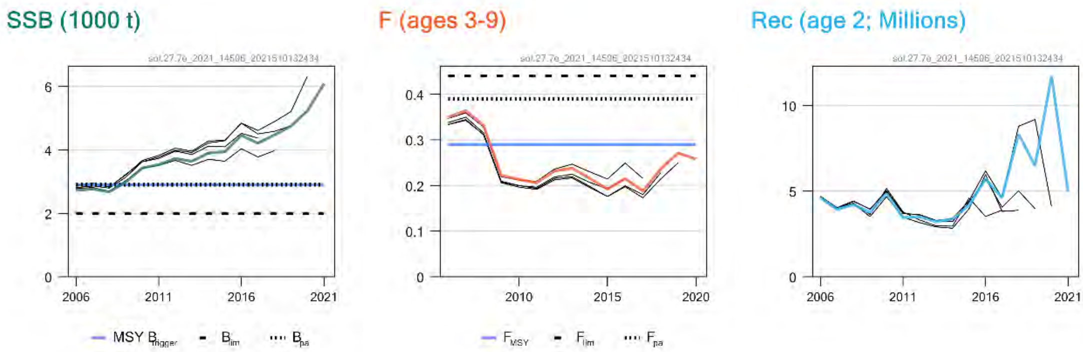


Figure 32.21. Sole in Division 7.e. Comparison of the current XSA assessment with the final assessment runs from the last years.

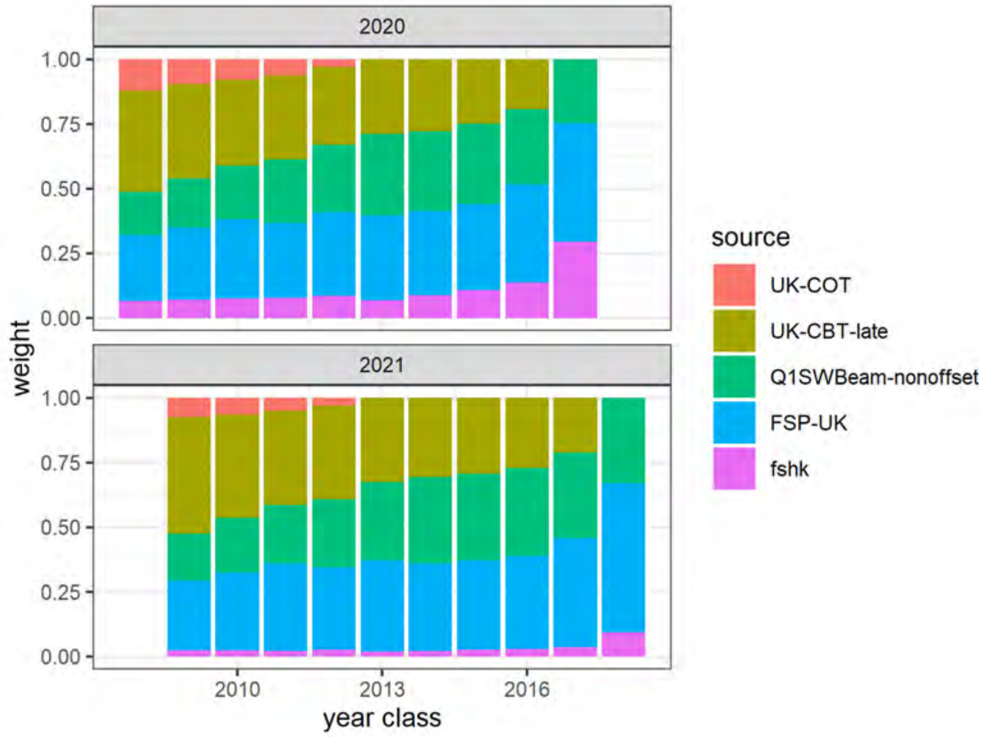


Figure 32.22. Sole in Division 7.e. Scaled weights for the current XSA assessment and the previous XSA assessment conducted at last year's WGCSE.

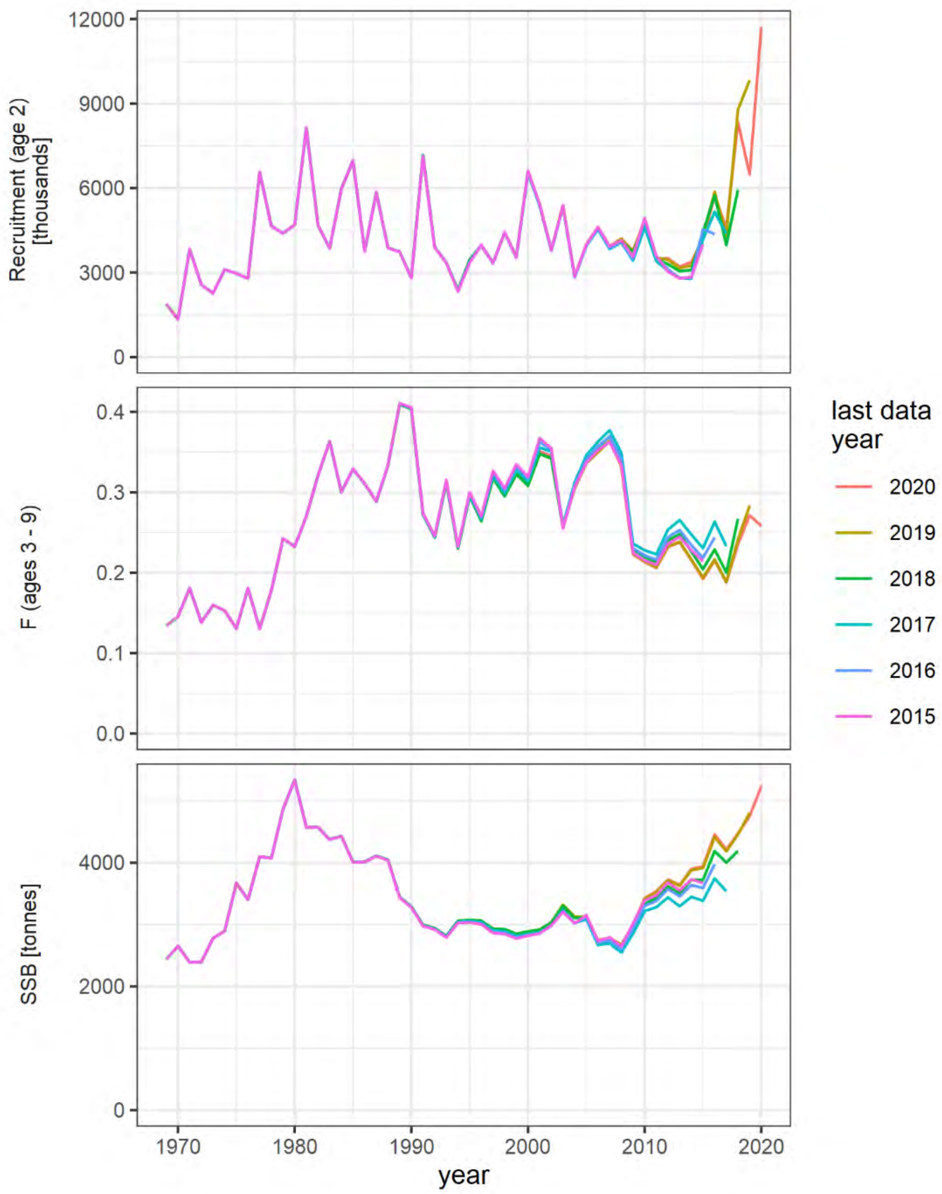


Figure 32.23. Sole in Division 7.e. Five-year retrospective of stock status and fishing mortality estimates.

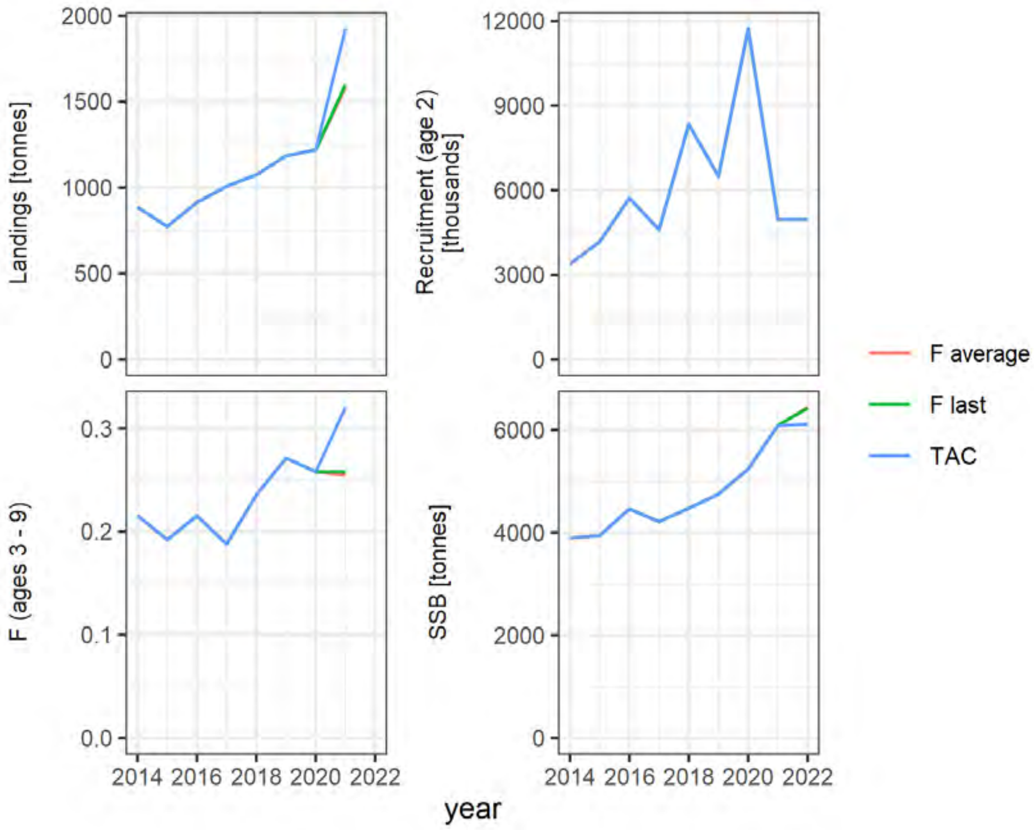


Figure 32.24. Sole in Division 7.e. Options for the intermediate year in the short-term forecast.

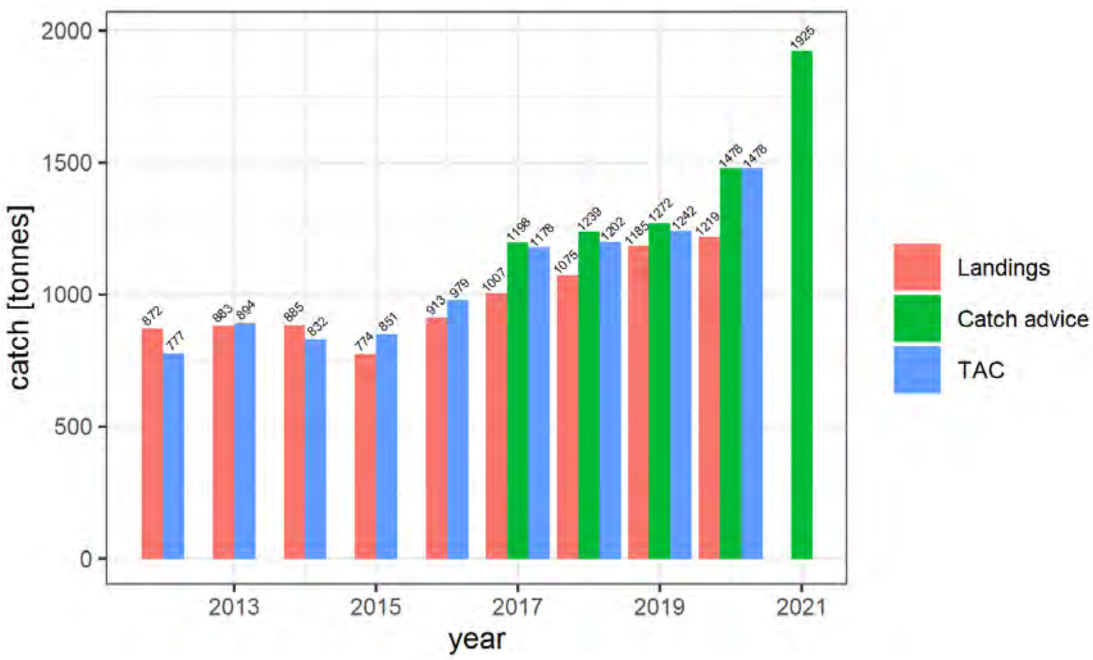


Figure 32.25. Sole in Division 7.e. Comparison of international TAC, catch advice and realised landings.

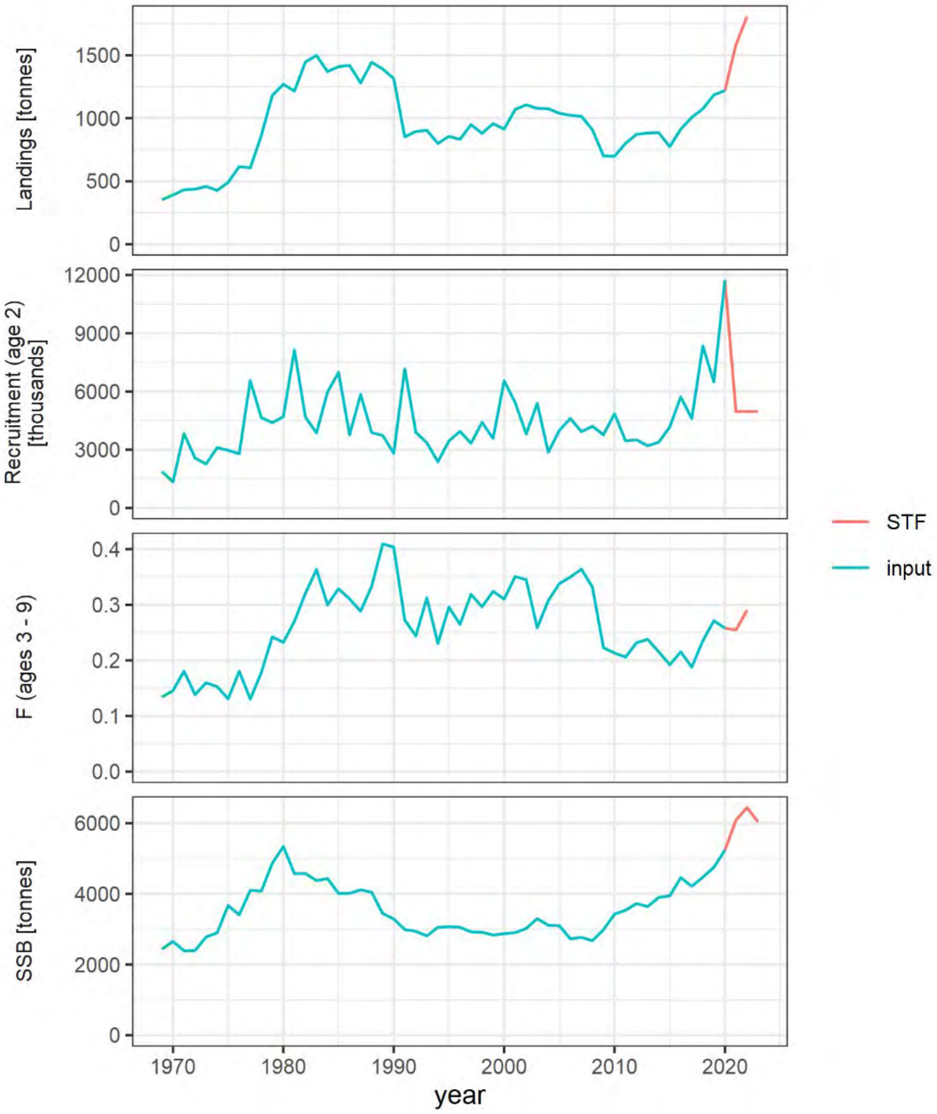


Figure 32.26. Sole in Division 7.e. Output for the short-term forecast under the MSY approach.

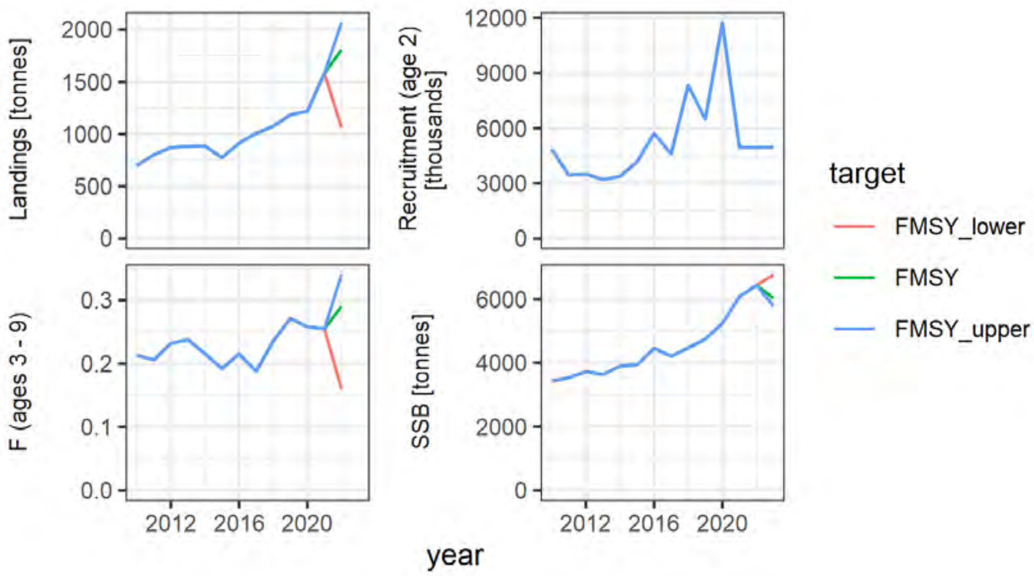


Figure 32.27. Sole in Division 7.e. Output of the short-term forecast of the MSY approach, including F_{MSY} ranges.

33 Sole in divisions 7.f and 7.g (Bristol Channel, Celtic Sea)

Type of assessment in 2021

This assessment is an update assessment.

ICES advice applicable to 2021

In the advice for 2021, the stock status was presented as follows:

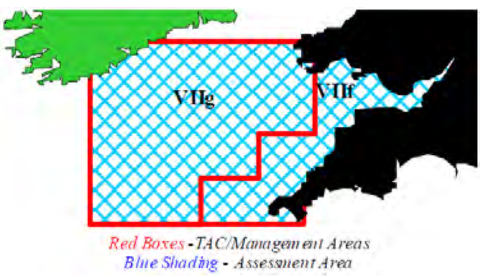
	Fishing pressure				Stock size			
		2017	2018	2019		2018	2019	2020
Maximum sustainable yield	F_{MSY}	✔	✔	✔ Below	MSY $B_{trigger}$	✔	✔	✔ Above trigger
Precautionary approach	F_{pa},F_{lim}	✔	✔	✔ Harvested sustainably	B_{pa},B_{lim}	✔	✔	✔ Full reproductive capacity
Management plan	F_{MGT}	✔	✔	✔ Within the range	B_{MGT}	✔	✔	✔ Above trigger

ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the plan are between 811 tonnes and 2364 tonnes. According to the MAP, catches higher than those corresponding to F_{MSY} (1413 tonnes) can only be taken under conditions specified in the MAP, whilst the entire range is considered precautionary when applying the ICES advice rule.

The advice change (−16.2%) is due to a slightly lower predicted biomass in 2021 and the downward revision of the F_{MSY} reference point.

33.1 General

Stock description and management units



A TAC is in place for ICES divisions 7.f and 7.g. These divisions do correspond to the stock area. The basis for the stock assessment area 7.f and 7.g is described in detail in the Stock Annex.

33.1.1 Management applicable to 2020 and 2021

The sole fisheries in the Celtic Sea are managed by TAC and technical measures. The agreed TAC in 2020 is presented in the text tables below. Technical measures in force for this stock are minimum mesh sizes and minimum conservation reference sizes (MCRS, 25 cm for Belgian vessels from March 11th 2017 onwards, except vessels with engine power <221 kW and/or volume <70 GT). National regulations also restricted areas for certain types of vessels.

Three rectangles in the Celtic Sea (30E4, 31E4 and 32E3, referred to as the "Trevose Box") were closed during the first quarter of 2005, and in February–March each year from 2006 onwards. A derogation has permitted beam trawlers to fish there in March 2005. The effects of this closure have been discussed in previous WGSSDS meetings and ACFM 2007, and evaluated at WKCELT 2014.

2020 TAC

Species:	Common sole *Solea solea*	**Zone:**	7f and 7g (SOL/7FG.)
Belgium	1 032	Analytical TAC	
France	103	Article 7(2) of this Regulation applies	
Ireland	52		
United Kingdom	465		
Union	1 652		
TAC	1 652		

The agreed TAC for 2021 was not available.

33.1.2 Fishery in 2020

The total official nominal landings were 1507 t in 2020 (Table 36.1), of which Belgium landed 74% (1121 t), UK 19% (291 t), France 3% (44 t), and 3% by Ireland (51 t). The Expert Group estimated the total international landings to be at 1524 t. Discards were estimated to be at 106 t. This catch figure corresponds to an international uptake of 99% of the agreed TAC in 2020 (1652 t).

In 2020, 89% of the landings were taken by beam trawls, 11% by otter trawls, <1% by other gears.

33.2 Data

33.2.1 Catch data

InterCatch was used for estimation of both landings and discards numbers and age compositions, as input for the assessment. Catch data for the years 2004–2018 were processed in InterCatch during the WKFlatNSCS 2020 (ICES, 2020). New catch data for 2019 and 2020 in InterCatch were added during the WGCSE 2020 and WGCSE 2021 respectively.

Belgium, Ireland, France, Spain and UK have provided data this year under the ICES InterCatch format on a métier basis. Quarterly/yearly data for 2020 were available for landing numbers and weight-at-age, for most of the Belgian, Irish and UK fleets. These comprise 92% of the international landings.

If discards were not included for a particular year-quarter-country-métier combination, they were raised. Discards on a year-quarter-country-métier basis were automatically matched by InterCatch to the corresponding landings. The matched discards-landings provided a landing-discard ratio estimate used for further raising. The weighting factor for raising the discards was 'Landings CATON' (landings catch). Discard raising was performed on a gear level regardless of season or country. Discard weights were available for 72% of the landings (almost exclusively TBB_DEF_70-99 from Belgium). Fig. 36.2b shows the available landings and discards data by country, gear and year.

Raised discard data from InterCatch were available from 2004 onwards. To estimate discard mean weight-at-age and numbers-at-age prior to 2004, a constant ratio of discards to landings by age was applied using data from 2004–2018 (WKFlatNSCS 2020).

To allocate age compositions, landings and discards were handled separately; samples from landings were used only for landings and vice versa. When age distributions were lacking, allocations were performed on a gear level. The gear groups used for discard raising were also applied here. The weighting factor used was '*Mean Weight weighted by numbers-at-age*'.

Early in the time-series officially reported landings included divisions 7.g–k for some countries and their total was higher than the WG estimate. Since 1999, official landings correspond to divisions 7.f and 7.g, and the total is lower than the working group estimate. During the period 2002–2005, the difference between the two estimates was substantial. This was mainly due to area misreporting, which was taken into account in the working group estimates (WKCELT ICES, 2014). In the recent years, the estimates are more similar.

During the inter-benchmark protocol on sole in in ICES divisions 7.f and 7.g in 2019, a revision of the Belgian commercial beam trawl tuning fleet occurred (ICES, 2019a). Investigating the Belgian sole landings data revealed that pure trips, i.e. trips in which fishing activity was limited to one of the sole stock areas (ICES divisions 7.f and 7.g), often a considerably different mean landing rate (kg.h-1) than mixed trips (i.e. trips in which fishing occurred in multiple ICES divisions). Further analyses during the WKFlatNSCS (ICES, 2020) showed substantial differences between estimated and reported sole landings in 7.f and 7.g in 2004–2007, and fishermen confirmed that there were compliance issues at that time. Therefore, these landing numbers were adjusted as the Belgian landings for sole in ICES divisions 7.f and 7.g are probably higher.

Annual length compositions for 2020 are given by fleet in Table 36.2. Length distributions of the total Belgian and UK(E&W) landings for the last 20 years are plotted in Figure 36.1. Belgian vessels generally land a greater proportion of small fish compared to the UK(England & Wales).

33.2.2 Discards

The available discard data indicate that discarding of sole has increased in 2018 and 2019 (to 141 t and 145 t respectively) and decreased again in 2020 to 106 t (Table 36.1). The length distributions for 2020 of retained and discarded catches of sole are presented in Figure 36.4a from the Belgium beam trawl fleet, and in Figure 36.4b for the UK beam trawlers.

The Belgian beam trawl fleet mainly discarded fish of 23 and 24 cm (Figure 36.4a). According to the Belgian age–length samples, these fish were mainly age 4 and to a lesser extent age 3. These discarded fish thus belong to the strong 2016 and 2017 year classes. Given the strong recruitment of these year classes, it makes sense that there has been an increase in discarding.

33.2.3 Weights, maturities, growth

Catch numbers-at-age are given in Table 36.3, and weights-at-age in the catch and the stock are given in Tables 36.4–36.5. Age compositions over the last 20 years are plotted in Figure 36.2. The standardised catch proportion-at-age is presented in Figure 36.3.

The stock weights were obtained using the Rivard weight calculator (http://nft.nefsc.noaa.gov./), that conducts a cohort interpolation of the catch weights. The resulting stock weight for age 1 was very variable, and it was decided during the benchmark to set the stock weight of age 1 to the lowest estimated stock weight for age 2 for 1971–2019.

A new maturity ogive was estimated during the WKFlatNSCS (ICES, 2020) using only survey data of the UK(E&W)-Q1SWECOS. Maturity data are available for 2013–2019. The new maturity ogive is calculated with a length-based model with sex specific ALK. This new ogive indicates that >60% of the 2 and 3-year old individuals are mature, while this was not the case in the maturity ogive used until the WGCSE 2019. The maturity at-age 1 was manually set to 0 as no mature sole at age 1 were encountered at the UK(E&W)-Q1SWECOS survey.

Updated maturity at-age based on data from the UK(E&W)-Q1SWECOS survey.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Maturity	0.0	0.67	0.91	0.98	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Natural mortality was assumed to be 0.1 for all ages and years

33.2.4 Surveys

The WGCSE 2021 Celtic Sea sole stock assessment used one scientific survey index: UK(E&W)-BTS-Q3 (1988–2020), from age 1 to 5. It is the only index providing information on the recruiting age (age 1). Standardised abundance indices for the UK beam trawl survey (UK(E&W)-BTS-Q3)) are shown in Table 36.6 and Figures 36.5a and b. Abundance-at-age 0 is highly variable and not used further on. The UK-survey appears to track the stronger year classes reasonably well. The internal consistency plot indicates also a reasonable fit for most of the ages (Figure 36.6).

33.2.5 Commercial lpue

Available estimates of effort and lpue are presented in Tables 36.7–36.8 and Figure 36.7.

Commercial lpue and effort data were available for Belgian beam trawlers, UK (E&W) beam and otter trawlers and Irish seiners, otter and beam trawlers. It should be noted that in 2013, the UK administration switched to the EU electronic logbook system. Therefore, effort and lpue reporting is now based on days fished.

Belgian beam trawl effort was at highest levels in 2003–2005. During these years, effort shifted from the Eastern English Channel (Division 7.d) to the Celtic Sea (divisions 7.fg) because of days-at-sea limitations in the former area. In 2006, these restrictions had been lifted and effort decreased substantially to about half of the values observed in the early 2000s. The sharp effort reduction in 2008 may be a combined result of the unrestricted effort regime in Division 7.d and the high fuel prices. The increase in 2012–2013 is due to the good opportunities of sole catches in the Celtic Sea taken by the mobile Belgian fleet. Afterwards, effort decreased again to lower levels and is stable during the last six years.

The effort from the UK(E&W) beam trawl fleet has declined sharply since the early 2000s to a record low in 2009, and stayed at that level since. The effort from the UK(E&W) otter trawlers has shown a gradually declining trend over time (Table 36.7).

Lpue of the Belgian beam trawlers (Figure 36.7) peaked in 2002. After a sharp decline to its record low in 2004, lpue has been increasing gradually, levelling off in 2010–2013 at around 15 kg/hour. In 2014–2015, lpue increased to around 19–20 kg/hour. In 2016 and 2017, a decrease to 15.63–15.08 kg/hour was recorded. In 2018, lpue increased to 18 kg/hour and in 2019 and 2020, it further increased and was at the highest level of the time-series in 200 (25.74 kg/hour).

Lpue of the UK beam trawlers was stable in the 1990s and 2000s, but at lower levels compared to the period before. In 2007, lpue increased considerably and gave a similar value for 2008. In 2009, there was a decrease to a level just above the mean of the time-series, followed by similar values for 2010, 2011 and 2012. The lpue peaked in 2014, since then it was relatively stable at a lower level, but increased again in 2020.

The lpue of the UK otter trawlers (Table 36.8) is relatively stable at a lower level, but increased the last two years in the Division 7f.

Irish effort and lpue data are also presented (Table 36.8, Figure 36.7). The main target species in the Irish fisheries are megrim, anglerfish, etc. The vessels usually operate on fishing grounds in the Western Celtic Sea with lower sole densities and therefore the lpue values are low.

33.2.6 Tuning series

The age-structured UK(E&W)-BTS-Q3 scientific survey tuning series is the only scientific survey used for tuning.

During the WGCSE 2019, two age-structured commercial tuning series (UK(E&W)-CBT and BE-CBT) were used in the assessment. The UK(E&W)-CBT tuning-series used in the WGCSE 2019 assessment was limited to 2012 and earlier, because of effort reporting issues. As the hours fished became an optional field in the logbooks and not consistently filled, this field is inappropriate to use as a metric for effort.

During the WKFlatNSCS (ICES, 2020) an updated UK(E&W)-CBT tuning-series was introduced in the assessment. The new UK(E&W)-CBT series from 1987–2020 was generated using a random effects model. Activity days was used as an effort measure, since it is mandatory to record.

The Belgian commercial beam trawl tuning fleet consists of two parts (1971–1996 and 2006–2020, BE_CBT and BE_CBT3). During the IBPBrisol (ICES, 2019b), the BE_CBT3 was constructed focusing on the landings and effort data of pure trips from the large fleet segment of the Belgian beam trawl fleet fishing in divisions 7.f and 7.g. Several models were tested and a GLMM including a categorical year effect, a log-linear relationship between the engine power of a beam trawler and the landing rate, a categorical temporal effect 'month' and a categorical spatial effect 'ICES statistical rectangle' were retained. The exponent of the estimated coefficients of the year effect were used as landing rate for the tuning series. More information is provided in the stock annex and the WKFlatNSCS report (ICES, 2020).

During the Benchmark, these commercial tuning series were used as commercial biomass tuning series. These time-series of the commercial tuning series were split in order to better account for changes in catchability due to e.g. technological creep (see figure below). Figure 36.8 shows the evolution through time of the commercial biomass tuning series. The Belgian BE_CBT3 and the UK(E&W)-CBT 2006–20120 tuning series show a relatively similar increasing trend during the last years.

33.2.7 Other relevant data

Reports from UK industry suggest that the main issues affecting the fishery in 7.f and 7.g were displacement of effort due to the rectangle closures and the restrictions on the use of 80 mm mesh west of 7°W (Trebilcock and Rozarieux, 2009).

No additional information was received from the Belgian, French and Irish industries.

33.3 Stock assessment

The method used to assess Celtic Sea sole was XSA until the WGCSE 2019. During the WKFlatNSCS (ICES, 2020), the assessment was transferred to a state–space stock assessment model (SAM). This was done by using the *stock assessment* package, which enables to interface a performant SAM implementation (https://github.com/fishfollower/SAM/) in *Template Model Builder* (TMB)[1] from the R statistical software.

The main feature of SAM is that it includes both process models on survival, recruitment and fishing mortality, describing the internal states of the system, and observation models for catch and tuning data. Additionally, tuning data can be introduced in different ways, e.g. as SSB (spawning–stock biomass), TSB (total stock biomass) or landings indices, while the random effects formulation of the process models resulting from the hierarchical nature of the state–space modelling framework, can easily be used to handle missing observations as is the case with catch information on age 1. Finally, SAM allows to specify different model configurations, and parametrization of both process and observation models.

During the benchmark, it was decided to transfer the age-structured commercial tuning series (BEL-CBT, BEL-CBT3 and UK(E&W)-CBT) into biomass indices. These time-series of the commercial tuning series were split, in order to better account for changes in catchability due to e.g. technological creep (Figure 36.8). The age-structured UK(E&W)-BTS-Q3 survey tuning series was also included. The model was further optimized in terms of parameter configuration for the process and observation models (see table below).

The F_{bar} calculates the mean fishing mortality for the set age range and should represent a significant part of the catch. The F_{bar} in the WGCSE 2019 assessment was set at age 4–8. However, as age 3 represents a large proportion of the catch (Figure 36.2), during the WKFlatNSCS it was decided to expand the F_{bar} to ages 3–8. The F_{bar} with ages 3–8 represents an average 77% of the catch, with a minimum of 48% and a maximum of 97%.

The model configuration and the data that were used in the final SAM assessment model are shown in the table below. The data that were used are also shown in Figure 36.2c.

[1] TMB offers a modelling framework for fast estimation of hierarchical models written in C code through the Laplace approximation. In addition, increased performance of nonlinear optimization procedures is achieved through the use of AUTODIFF (automatic differentiation), and performant C libraries for linear algebra (Eigen and CholMod).

DATA & SETTINGS	
tuning indices	
UK(E&W)-BTS survey	Age (1-5)
BE-CBT_1971-1983	Biomass
BE-CBT_1984-1996	Biomass
BE-CBT3_2006-2020	Biomass
UK(E&W)-CBT_1984-2005	Biomass
UK(E&W)-CBT_2006-2020	Biomass
catch numbers-at-age	Catch numbers for age 1 and 2 set to NA prior 2004
maturity ogive	Age1 = 0; Age2 = 0.67; Age3 = .91; Age4 = .98; Age5 = .99; Age6 = .99; Age6+ = 1
natural mortality	0.1 for all ages and years
prop. M < spawning	0 for all years
prop. F < spawning	0 for all years
Plus group	10
Fbar	3-8
MODEL CONFIGURATION	
stock-recruitment	plain random walk on logN(1)
correlation F-at-age	AR(1)
F parameters-at-age	6 = 0, 1, 2, 3, 3, 3, 4, 4, 5, 5
q parameters (-at-age)	
UK(E&W)-BTS survey	4 = 0, 1, 2, 3, 3, -1, -1, -1, -1, -1
BE-CBT_1971-1983	1
BE-CBT_1984-1996	1
BE-CBT3_2006-2020	1
UK(E&W)-CBT_1984-2005	1
UK(E&W)-CBT_2006-2020	1
σ^2 F parameters-at-age	1 = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
σ^2 N parameters-at-age	2 = 0, 1, 1, 1, 1, 1, 1, 1, 1, 1
σ^2 obs pars (-at-age)	
catch numbers-at-age	2 = 0, 0, 1, 1, 1, 1, 1, 1, 1, 1
UK(E&W)-BTS survey	3 = 2, 3, 3, 4, 4, -1, -1, -1, -1
BE-CBT_1971-1983	1
BE-CBT_1984-1996	1
BE-CBT3_2006-2020	1
UK(E&W)-CBT_1984-2005	1
UK(E&W)-CBT_2006-2020	1
ρ observations at-age	
catch numbers-at-age	"AR(1)" (single ρ for all ages)
UK(E&W)-BTS survey	"ID"
BE-CBT_1971-1983	-
BE-CBT_1984-1996	-
BE-CBT3_2006-2019	-
UK(E&W)-CBT_1984-2005	-
UK(E&W)-CBT_2006-2020	-

33.3.1 This year's assessment

The catch, recruitment, F_{bar} and SSB are shown in Figure 36.11 and Table 36.13. In general, the estimated catches from the SAM model are close to the observed catches. Mainly at the start of the time-series, some observed catches do not fall within the confidence bounds of the estimated catches. The SAM catch estimate for 2020 is also considerably lower than the ICES catch estimate.

Spawning–stock biomass (SSB) has been above MSY $B_{trigger}$ since 2009 and shows an increasing trend over the last years, with the 2020 estimate at the same level as in 2019. Fishing mortality (F) was below F_{MSY} in 2017–2019 but increased again and is above F_{MSY} in 2020. Recruitment has been variable without an overall trend. The 2017 recruitment is estimated to be among the highest in the time-series. Recruitment estimates have been above average since 2015 (Table 36.13).

The one-step ahead residuals for the final SAM assessment are shown in Figure 36.9. There may be some indications of a trend in the UK beam trawl fleet (UK(E&W)-CBT) with predominantly negative residuals in the last years, in contrast to the positive residuals of the BE_CBT3 during the last years.

Retrospective patterns for the final run are shown in Figure 36.10. Retrospective analysis does not indicate major problems; the retrospective patterns are within the confidence bounds. A Mohn's rho analysis was conducted based on the SAM stock assessment results, i.e. the last data year (2019) was used as the final year for comparison of SSB, F and recruitment and based on a five-year retrospective analysis. The Mohn's rho values for this assessment are low and well within the bounds of -15% to 20% suggested by ICES, i.e. the current assessment indicates a high consistency.

The results from the Mohn's rho analysis are shown in the following table:

	SSB	F (ages 3–8)	Recruitment
Mohn's rho value	0.5%	-0.4%	2.8%

Further information on the assessment is given in Table 36.10. Fishing mortalities and stock numbers are shown in Tables 36.11 and 36.12.

33.3.2 Comparison with previous assessment

A comparison of the estimates of this year's assessment with last year's is given in Figure 36.12. The main difference between the two is the downscaling of the 2019 recruitment in the latest assessment.

33.3.3 State of the stock

Trends in landings, SSB, F(3–8) and recruitment are presented in Table 36.13 and Figure 36.11.

In the beginning of the time-series, fishing mortality fluctuated around F_{MSY}. During the eighties and nineties fishing mortality increased for this stock to levels well above F_{MSY}. In the following decades, fishing mortality decreased. Fishing mortality (F) has been below F_{MSY} in 2017–2019 but increased again and is above F_{MSY} in 2020.

Recruitment has fluctuated around 5 million recruits with occasional strong year classes. The 1998 year class is estimated to be the among the strongest in the time-series. Recruitment has been above average since 2015, and the recruitment of 2017 is estimated to be among the highest of the time-series.

SSB has declined almost continuously from the highest value of 6552 t in 1971, to the lowest observed in the time-series in 1997 (2205 t). The exceptional year class of 1998 has increased SSB to above the long-term average. Spawning–stock biomass (SSB) has been above MSY $B_{trigger}$ since 2011. The SSB increased during the last years, as a result of the decreasing fishing mortality and good recruitment. The SSB is currently at its highest level since 1973.

33.4 Short-term projections

The long-term median resampled recruitment (1971–2018) as estimated by a stochastic projection (SAM, 5246 thousand fish) was assumed for recruitment in 2020 and subsequent years.

Population numbers at the start of 2021, estimated for ages 2 and older, were taken from the SAM output.

Fishing mortality for 2021 was a catch constraint F based on a catch of 1413 t for 2021. The TAC 2021 was not available at the time of the WGCSE, therefore the catch advice for 2021 was used. Weights-at-age in the catch and in the stock are averages for the years 2018–2020. Input to the short-term predictions and the sensitivity analysis are shown in Table 36.14. Results are presented in Table 36.15 (management options) and Table 36.16 (detailed output).

The working group decided to use a catch constraint for the intermediate year (2021) as recent landings have been close to the TAC or only limited overshot. The TAC 2021 was not available. Therefore, the catch advice for 2021 was used.

Assuming a catch constraint for 2021 of 1413 t, implies a fishing mortality in 2021 of 0.262. This results in an SSB of 5864 t in 2022 and 5647 t in 2023 (for $F_{2022}= F_{MSY}$).

Assuming a catch constraint for 2021 and a F at F_{MSY} in 2022, the proportional contributions of the different ages to the predicted SSB are given in Figure 36.13.

There are no known specific environmental drivers known for this stock.

33.5 MSY explorations

Investigations for possible F_{MSY} candidates for this stock were done at WGCSE 2010. ACOM adopted an F_{MSY} value of 0.31, based on stochastic simulations using a "Ricker" model (PLOT-MSY program). $B_{trigger}$ was set to the B_{pa} value of 2200 t.

Exploratory analysis investigating possible revisions of MSY estimates were conducted at WGCSE 2014 with a recent version of PLotMSY (Cefas, 2014). The simulations indicated that there is no reason for using a particular weighting for any of the stock–recruitment relationships. The resulting F_{MSY} values were in line with the F_{MSY} of 0.31 used at that moment for this stock.

In response to the EC long-term management plans for western EU waters (ICES subareas 5 to 10), ICES WKMSYREF4 (October 2015, Brest (France)) used long-term stochastic simulations (Eqsim) to estimate F_{MSY} and appropriate ranges. The methodology used for stocks with age-based assessments follows the approaches developed in ICES WKMSYREF2 (ICES, 2014b) and WKMSYREF3 (ICES, 2014c) and is documented in the report of WKMSYREF4 (ICES, 2016). Estimates of reference points B_{lim}, B_{pa}, F_{lim} and F_{pa} were provided, and the F_{MSY} ranges [F_{lower}, F_{upper}] deliver no more than 5% reduction in long-term yield compared with MSY.

The full available time-series of sole 7.f and 7.g recruitment was used to fit stock–recruitment models. The simulations indicated that there is no reason for using a particular weighting for any of the stock–recruitment relationships. The workshop decided to use a more conservative approach and to base the analysis on a segmented regression only with a breakpoint set at B_{lim} of 1700 t. B_{lim} was chosen as the lowest value of the SSB time-series (B_{loss}). The revised MSY reference points are more restrictive (F_{MSY}=0.27 instead of 0.31 and MSY $B_{trigger}$=2400 t instead of 2200 t) and demand a larger reduction in F to achieve the MSY objectives as foreseen in the basic regulation.

The inter-benchmark (IBPBrisol, ICES, 2019) for sole in divisions 27.7f and 27.7g updated MSY and PA reference points according to ICES guidelines. The results of the IBP were presented during the 2019 WGCSE assessment working group. However, the proposed reference points were rejected by the WG and re-estimated during the WG. The F_{MSY} value was perceived too high compared to the value prior to the inter-benchmark. The main reason was that a decreasing trend in recruitment when SSB is high (Ricker model), was not considered realistic for this stock. During the IBP, the F_{MSY} value was estimated based on both the Ricker and Segmented Regression models. The WGCSE 2019 suggested to only consider the segmented regression model. A working document describes the calculation of the reference points taking into account the remarks from the WGCSE 2019 (ICES, 2019. WGCSE. ICES Scientific Reports. 1:29).

The 2020 benchmark (WKFlatNSCS, ICES, 2020) for sole in divisions 27.7f and 27.7g updated MSY and PA reference points according to ICES guidelines. However, those reference points were re-estimated during the WGCSE 2020 in accordance with the deviations from the assessment agreed at the benchmark. The current reference points are shown below.

33.6 Biological reference points

33.6.1 Precautionary approach reference points

The Working Group's current approach to reference points is outlined in Section 33.5. Current biological reference points calculated during the WGCSE 2020 are given in the text table below:

Framework	Reference point	Value	Technical basis
MSY approach	MSY $B_{trigger}$	3057	Tonnes; B_{pa}
	F_{MSY}	0.251	EQsim analysis based on the recruitment period 1971–2018
Precautionary approach	B_{lim}	2184	Tonnes; B_{loss} estimated in 2020, corresponding to SSB in 1997
	B_{pa}	3057	Tonnes; $B_{lim} \times 1.4$
	F_{lim}	0.543	EQsim analysis, based on the recruitment period 1971–2018
	F_{pa}	0.402	$Fp_{.05}$; F that leads to SSB ≥ Blim with 95% probability.
Management plan	MAP MSY $B_{trigger}$	3057	Tonnes; MSY $B_{trigger}$
	MAP B_{pa}	3057	Tonnes; B_{pa}
	MAP B_{lim}	2184	Tonnes; B_{lim}
	MAP F_{MSY}	0. 251	F_{MSY}
	MAP range F_{lower}	0.136–0.251	Consistent with ranges provided by ICES (2020), resulting in no more than 5% reduction in long-term yield compared with MSY
	MAP range F_{upper}	0.251–0.462	Consistent with ranges provided by ICES (2020), resulting in no more than 5% reduction in long-term yield compared with MSY

*** EU multiannual plan (MAP) for the Western Waters (EU, 2019).**

33.7 Management plans

The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to demersal stocks including sole in ICES divisions 7.f and 7.g.

33.8 Uncertainties and bias in assessment and forecast

33.8.1 Sampling

The major fleets fishing for 7.f and 7.g sole are sampled (approximately 90% of the total landings). Sampling is considered to be at a reasonable level.

33.8.2 Discards

Discard estimates used to be low, but are increasing. Discards are included in the assessment since the WGCSE 2020.

33.8.3 Surveys

The UK(E&W)-BTS-Q3 survey, which is solely responsible for the recruiting estimates, has been able to track year-class strength at-ages greater than 0 rather well in the past. However, the estimates of strong year classes have sometimes been revised downward in previous assessments and may cause bias in the forecast.

33.8.4 Consistency

The new assessment shows a low retrospective bias and is thus fairly consistent compared to the assessment of the last year's working group.

33.8.5 Misreporting

Area misreporting is known to have been considerable over the period 2002–2005. This was due to a combination of the good 1998 year class still being an important part of the catch composition and more restrictive TACs. The area misreporting has been corrected for the years 2002–2006 (WGSSDS 2007). At the WKCELT 2014, analysis revealed that there was additional misreporting taking place in 2002–2003 and 2004, which was not accounted for in the first correction done at WGSSDS in 2007. Since 2007, the area misreporting that could be estimated was negligible. During the WKFlatNSCS (ICES, 2020) a further correction for 2004–2007 landings data was done.

33.9 Recommendation for next Benchmark

Sole in 7.f and 7.g has been benchmarked in February 2020. The issues are listed below.

Problem / Aim	Work needed / Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?
Natural mortality Alternate rates of natural mortality. Natural mortality is assumed constant over ages and years at 0.1. When new information is available, this should be investigated.	*estimates of natural mortality	* estimates of natural mortality
Effect of changing exploitation patterns Effect of changing exploitation patterns related to the Trevose Box closure. ICES rectangles 30E4, 31E4 and 32E3 form the Trevose Box which is closed for fishing from February 1st until March 31st. This management measure is in place since 2006 and aims to protect spawning fish, cod and other demersal stocks such as sole in particular (ICES special request, 2007). This measure has a significant effect on the behaviour of the fleets. During the first week after re-opening of the Trevose box, catch rates of the Belgian beam trawl fleet are estimated to be twice as high with respect to the situation before the closure of the Trevose Box (prior to 2006) (Sys *et al.,* 2017). Those temporal and spatial effects were accounted for in the new modelled Belgian commercial tuning index (ICES, 2019b). However, this change in exploitation pattern may also have an effect on the mortality of mature females or exhibit hyperstability, in which catch per unit effort (CPUE) remains elevated as stock abundance declines.	* Check for hyperstability * Check mortality of mature females	
Scientific survey information The UK-BTS-Q3 survey is the only survey used in the current assessment and is solely providing information on the recruiting age (age 1). The new UK-Q1SWECOS tuning series was considered during the WKFlatNSCS 2020, but not retained. Criteria such as length of the time-series, amount of spatial coverage and consistent statistical sampling design were considered for including/excluding the new UK-Q1SWECOS tuning series. However, we recommend that those survey data will be uploaded into DATRAS and that the survey design will be reviewed by the WGBEAM (The Working Group on Beam Trawl Surveys), to assure quality control of the data. The time-series was too short for any strong conclusions now, but the inclusion of those survey indices should be reconsidered during the next benchmark.	*Investigate if additional survey information (e.g. UK-Q1SWBeam, started in 2006) is available and can be incorporated in the assessment. *Additional survey data can confirm the info provided by the UK-BTS-Q3 survey.	*UK-Q1SWBeam tuning series *other available survey data
Fisheries & ecosystem issues and data **Trends in mean weights** • Trends and reasons for the decreasing catch and stock weights for the older ages	*What drives this change? *Is it driven by an ecosystem change? *Is there a similar trend in the weights from other stocks?	*information on the evolution in the Celtic Sea ecosystem

33.10 Management considerations

Following the recent strong year classes, SSB is now at its highest level since 1973.

The Celtic Sea is an area without days-at-sea limitations for demersal fisheries. In this context and given that many demersal vessels are very mobile, changes in effort measures in areas other than the Celtic Sea, can influence the effort regime in the Celtic Sea (cfr. increased effort in Celtic Sea for Belgian beamers during 2004–2005 when days-at-sea limitations were in place for the Eastern English Channel).

33.11 Ecosystem considerations

Sole and plaice are predominantly caught by beam trawl fisheries. Beam trawling is known to have an impact on the benthic communities, although less so on soft substrates and in areas which have been historically exploited by this fishing method. Benthic drop-out panels have been shown to release around 75% of benthic invertebrates from the catches. Information from the UK industry (Trebilcock and Rozarieux, 2009) suggests that uptake in 2008 was minimal.

33.12 References

EU. 2019. REGULATION (EU) 2019/472 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a multiannual plan for stocks fished in the Western Waters and adjacent waters, and for fisheries exploiting those stocks, amending Regulations (EU) 2016/1139 and (EU) 2018/973, and repealing Council Regulations (EC) No 811/2004, (EC) No 2166/2005, (EC) No 388/2006, (EC) No 509/2007 and (EC) No 1300/2008. 17pp. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0472.

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Trebilcock P. and N. de Rozarieux. 2009. National Federation Fishermen's Organisation Annual Fisheries Reports. Cornish Fish Producers Organisation / Seafood Cornwall Training Ltd, March 2009.

Table 36.1 - Sol.27.7fg - Official Nominal landings and landings and discard data used by the Working Group (t)

Year	Belgium	Denmark	France	Ireland	UK(E.&W,NI.)	UK(Scotland)	Other	Total-Official	Unallocated	Used by WG	TAC	Discards**
1986	1039 *	2	146	188	611	-	3	1989	-389	1600		80
1987	701 *	-	117	9	437	-	-	1264	-42	1222	1600	56
1988	705 *	-	110	72	317	-	-	1204	-58	1146	1100	61
1989	684 *	-	87	18	203	-	-	992	0	992	1000	70
1990	716 *	-	130	40	353	0	-	1239	-50	1189	1200	57
1991	982 *	-	80	32	402	0	-	1496	-389	1107	1200	126
1992	543 *	-	141	45	325	6	-	1060	-79	981	1200	77
1993	575 *	-	108	51	285	11	-	1030	-102	928	1100	56
1994	619 *	-	90	37	264	8	-	1018	-9	1009	1100	52
1995	763 *	-	88	20	294	-	-	1165	-8	1157	1100	50
1996	695 *	-	102	19	265	0	-	1081	-86	995	1000	47
1997	660 *	-	99	28	251	0	-	1038	-111	927	900	46
1998	675 *	-	98	42	198	-	-	1013	-138	875	850	43
1999	604	-	61	51	231	0	-	947	65	1012	960	89
2000	694	-	74	29	243	-	-	1040	51	1091	1160	158
2001	720	-	77	35	288	-	-	1120	48	1168	1020	101
2002	703	-	65	32	318	+	-	1118	227	1345	1070	58
2003	715	-	124	26	342	+	-	1207	185	1392	1240	54
2004	735	-	79	33	283	-	-	1130	119	1249	1050	140
2005	645	-	101	34	217	-	-	997	47	1044	1000	23
2006	576	-	75	38	232	-	-	921	25	946	950	41
2007	582	-	85	32	244	-	-	943	2	945	890	36
2008	466	-	68	28	218	-	-	780	20	800	964	8
2009	513	-	74	26	194	-	-	807	-2	805	993	30
2010	620	-	45	27	179	-	-	871	5	876	993	56
2011	766	-	50	30	168	-	-	1013	16	1029	1241	28
2012	843	-	48	33	175	-	-	1099	5	1104	1060	32
2013	789	-	49	42	206	-	-	1086	6	1092	1100	26
2014	705	-	59	28	252	-	-	1044	-2	1042	1001	27
2015	671	-	24	27	105	-	-	827	3	830	851	17
2016	563	-	72	21	175	-	-	831	0	831	779	31
2017	553	-	49	28	149	-	-	780	-4	776	845	65
2018	607	-	44	28	171	-	-	849	1	850	920	141
2019 ^	800	-	42	33	193	-	<1	1068	0	1068	1009	145
2020 ^	1121	-	44	51	291	-	<1	1507	-17	1524	1652	106

^Landings are preliminary

* including 7.g-k

** Discards estimated by ICES

Table 36.2 - Sol.27.7fg - Annual landings length distributions by fleet

	UK (England & Wales)	Belgium
Length (cm)	Beam trawl	Beam trawl
17		
18		
19		
20		660
21		264
22	276	3707
23	917	23917
24	3412	137915
25	16210	437261
26	30310	548132
27	46020	525461
28	65180	475193
29	89024	402006
30	115825	337814
31	79629	261300
32	92875	222243
33	52665	152252
34	57980	145986
35	35513	92630
36	27437	72612
37	26107	64616
38	16096	42181
39	11579	40478
40	8795	29936
41	8390	20030
42	5300	10903
43	3146	7753
44	1565	5871
45	1233	3214
46	490	3849
47	489	508
48	90	832
49	89	898
50	86	1080
51		
52		
53	80	
54		
55		
56	18	
57		
58		
59		
60		
Total	796828	4071502

Table 36.3 - Sol.27.7fg - Catch numbers at age (in thousands)

Age/Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0	0	0	0	0	0	0	0	0	0	0
2	610	855	575	245	188	493	496	502	519	1038	951
3	303	1014	2116	492	323	937	492	833	630	1092	759
4	1377	322	768	886	345	575	358	348	767	899	813
5	638	684	311	420	652	624	277	157	212	596	407
6	439	334	357	212	308	567	248	161	156	183	382
7	541	214	120	241	111	263	407	100	198	62	151
8	770	234	111	98	103	132	121	200	125	97	121
9	379	317	117	110	68	199	28	72	154	101	95
+gp	1231	739	649	547	375	469	368	175	170	355	383

Age/Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0	0	0	0	0	0	0	0	0	0	0
2	540	1023	1062	310	781	503	831	757	438	2304	684
3	934	1212	951	1656	1457	1076	522	1308	1117	776	1911
4	317	748	622	786	1204	818	902	617	1207	676	661
5	477	290	553	577	537	589	450	634	407	507	418
6	284	354	187	300	363	277	393	240	459	153	257
7	208	227	279	101	194	206	128	189	139	157	61
8	93	194	107	141	88	101	79	83	116	56	60
9	112	52	47	74	104	61	68	24	50	46	28
+gp	328	322	276	241	330	180	270	102	130	163	89

Age/Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0	0	0	0	0	0	0	0	0	0	0
2	559	466	204	280	387	311	961	2720	1111	46	209
3	970	888	1299	1163	1000	1048	1931	1664	2155	1647	871
4	1133	759	1127	928	615	743	856	701	883	2261	1294
5	339	882	429	433	408	303	288	246	445	674	2111
6	189	287	490	232	256	173	145	61	245	253	453
7	162	150	134	193	128	109	81	56	65	96	250
8	64	66	113	58	127	51	31	43	39	55	90
9	84	42	66	43	45	52	23	19	26	36	29
+gp	99	146	109	106	106	87	44	51	81	51	84

Age/Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	5	12	8	19	10	30	26	18	29	13	14
2	393	418	485	697	180	549	506	170	361	545	173
3	1846	1096	1151	979	515	511	1510	1103	318	998	684
4	941	1028	844	721	499	588	657	1389	1039	523	735
5	1086	592	706	435	387	435	380	394	1339	826	308
6	742	499	250	382	212	259	257	308	370	652	388
7	132	336	229	149	209	164	140	187	222	222	381
8	100	72	169	142	85	121	103	118	130	104	122
9	54	55	60	155	109	51	80	56	84	61	99
+gp	100	89	106	93	150	203	119	168	219	160	243

Age/Year	2015	2016	2017	2018	2019	2020
1	0	66	47	4	53	0
2	193	727	432	989	373	242
3	837	458	1157	840	2240	777
4	924	635	493	1105	729	2775
5	433	663	421	275	874	1161
6	145	303	353	293	306	789
7	201	111	147	186	162	304
8	114	132	55	95	115	160
9	69	94	59	56	105	106
+gp	113	70	101	122	118	189

Table 36.4 - Sol.27.7fg - Catch weights at age (kg)

Age/Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.039	0.106	0.081	0.063	0.046	0.114	0.098	0.068	0.023	0.048
2	0.110	0.136	0.134	0.130	0.127	0.149	0.150	0.141	0.127	0.134
3	0.168	0.185	0.200	0.202	0.208	0.214	0.229	0.228	0.226	0.228
4	0.224	0.227	0.259	0.270	0.286	0.268	0.297	0.308	0.320	0.315
5	0.273	0.265	0.311	0.329	0.355	0.316	0.355	0.377	0.400	0.391
6	0.316	0.303	0.361	0.385	0.416	0.363	0.408	0.440	0.470	0.459
7	0.353	0.340	0.408	0.436	0.473	0.409	0.460	0.498	0.531	0.523
8	0.384	0.377	0.452	0.483	0.523	0.453	0.506	0.550	0.580	0.578
9	0.408	0.413	0.493	0.524	0.565	0.496	0.548	0.596	0.621	0.625
+gp	0.441	0.534	0.607	0.631	0.665	0.632	0.658	0.708	0.671	0.732

Age/Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.078	0.061	0.085	0.019	0.089	0.046	0.048	0.074	0.013	0.049
2	0.141	0.142	0.153	0.126	0.151	0.134	0.136	0.143	0.112	0.128
3	0.220	0.236	0.247	0.229	0.239	0.230	0.230	0.229	0.196	0.210
4	0.292	0.323	0.329	0.329	0.316	0.320	0.319	0.308	0.280	0.291
5	0.355	0.396	0.397	0.414	0.382	0.399	0.395	0.377	0.355	0.362
6	0.413	0.461	0.458	0.492	0.443	0.470	0.465	0.441	0.423	0.429
7	0.469	0.521	0.513	0.561	0.499	0.536	0.528	0.502	0.487	0.494
8	0.519	0.571	0.560	0.621	0.551	0.593	0.583	0.556	0.542	0.552
9	0.564	0.616	0.602	0.673	0.596	0.643	0.632	0.606	0.592	0.609
+gp	0.687	0.703	0.681	0.768	0.712	0.759	0.736	0.742	0.702	0.761

Age/Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	0.054	0.073	0.057	0.081	0.068	0.027	0.074	0.079	0.015	0.078
2	0.138	0.136	0.128	0.139	0.136	0.122	0.142	0.147	0.121	0.148
3	0.232	0.212	0.204	0.212	0.216	0.210	0.228	0.237	0.217	0.240
4	0.319	0.281	0.275	0.276	0.288	0.296	0.306	0.319	0.314	0.321
5	0.392	0.342	0.338	0.331	0.351	0.371	0.375	0.392	0.399	0.389
6	0.458	0.397	0.396	0.380	0.408	0.438	0.439	0.461	0.476	0.450
7	0.516	0.451	0.450	0.425	0.462	0.500	0.500	0.527	0.548	0.506
8	0.564	0.499	0.500	0.465	0.510	0.551	0.554	0.589	0.613	0.553
9	0.608	0.543	0.544	0.500	0.552	0.598	0.605	0.647	0.670	0.594
+gp	0.681	0.658	0.659	0.575	0.658	0.688	0.738	0.813	0.801	0.673

Age/Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.066	0.054	0.123	0.099	0.109	0.142	0.161	0.149	0.105	0.110
2	0.137	0.126	0.151	0.152	0.155	0.144	0.157	0.163	0.157	0.144
3	0.220	0.200	0.214	0.194	0.203	0.186	0.221	0.210	0.188	0.179
4	0.296	0.271	0.266	0.274	0.267	0.272	0.284	0.281	0.242	0.234
5	0.362	0.336	0.313	0.347	0.346	0.330	0.335	0.361	0.294	0.312
6	0.424	0.398	0.361	0.371	0.439	0.401	0.372	0.359	0.348	0.358
7	0.482	0.457	0.408	0.459	0.473	0.412	0.414	0.449	0.378	0.387
8	0.533	0.512	0.454	0.522	0.595	0.411	0.488	0.620	0.476	0.414
9	0.579	0.564	0.501	0.524	0.624	0.465	0.511	0.625	0.485	0.524
+gp	0.694	0.714	0.662	0.613	0.714	0.612	0.604	0.632	0.579	0.673

Age/Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.123	0.102	0.092	0.138	0.135	0.109	0.093	0.082	0.099	0.155
2	0.155	0.142	0.158	0.150	0.132	0.165	0.151	0.175	0.120	0.114
3	0.185	0.206	0.195	0.199	0.193	0.203	0.200	0.187	0.170	0.176
4	0.233	0.243	0.249	0.268	0.248	0.251	0.255	0.251	0.240	0.205
5	0.277	0.271	0.290	0.347	0.311	0.285	0.315	0.294	0.307	0.257
6	0.361	0.312	0.329	0.394	0.367	0.342	0.330	0.327	0.327	0.331
7	0.431	0.350	0.361	0.427	0.438	0.416	0.382	0.385	0.419	0.363
8	0.465	0.380	0.463	0.496	0.502	0.429	0.444	0.436	0.451	0.415
9	0.483	0.417	0.492	0.523	0.463	0.470	0.513	0.425	0.445	0.504
+gp	0.725	0.570	0.589	0.699	0.624	0.629	0.580	0.592	0.618	0.612

Table 36.5 - Sol.27.7fg - Stock weights at age (kg)

Age/Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
2	0.085	0.073	0.119	0.103	0.089	0.083	0.131	0.118	0.093	0.056	0.082	0.105	0.097
3	0.145	0.143	0.165	0.165	0.165	0.165	0.185	0.185	0.179	0.170	0.172	0.182	0.187
4	0.205	0.196	0.219	0.232	0.241	0.237	0.252	0.266	0.270	0.267	0.258	0.267	0.279
5	0.260	0.244	0.266	0.292	0.310	0.301	0.308	0.335	0.351	0.354	0.334	0.340	0.358
6	0.304	0.288	0.310	0.346	0.370	0.359	0.359	0.395	0.421	0.429	0.402	0.404	0.426
7	0.341	0.328	0.352	0.397	0.426	0.413	0.409	0.451	0.483	0.496	0.464	0.464	0.486
8	0.370	0.365	0.392	0.444	0.477	0.463	0.455	0.503	0.538	0.554	0.521	0.517	0.540
9	0.390	0.398	0.431	0.487	0.523	0.509	0.498	0.549	0.585	0.602	0.571	0.565	0.586
+gp	0.415	0.498	0.559	0.607	0.638	0.639	0.628	0.674	0.669	0.707	0.697	0.679	0.682

Age/Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
2	0.104	0.054	0.109	0.079	0.083	0.091	0.041	0.082	0.086	0.097	0.089	0.105	0.091
3	0.187	0.174	0.186	0.176	0.176	0.167	0.154	0.173	0.171	0.167	0.165	0.173	0.169
4	0.285	0.269	0.276	0.271	0.266	0.253	0.239	0.259	0.256	0.242	0.237	0.247	0.253
5	0.369	0.354	0.355	0.355	0.347	0.331	0.319	0.338	0.330	0.308	0.302	0.311	0.327
6	0.442	0.428	0.424	0.430	0.417	0.400	0.390	0.407	0.395	0.368	0.358	0.368	0.392
7	0.507	0.496	0.487	0.498	0.483	0.463	0.457	0.470	0.454	0.423	0.410	0.419	0.452
8	0.564	0.556	0.544	0.559	0.542	0.521	0.519	0.528	0.507	0.475	0.458	0.466	0.504
9	0.614	0.608	0.596	0.612	0.594	0.574	0.575	0.580	0.554	0.521	0.500	0.507	0.552
+gp	0.722	0.728	0.725	0.733	0.731	0.701	0.727	0.692	0.664	0.645	0.594	0.615	0.661

Age/Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
2	0.062	0.104	0.098	0.047	0.103	0.091	0.090	0.137	0.124	0.125	0.149	0.162	0.153
3	0.167	0.184	0.179	0.170	0.181	0.165	0.164	0.172	0.175	0.170	0.178	0.181	0.175
4	0.254	0.270	0.273	0.264	0.267	0.244	0.231	0.242	0.228	0.235	0.230	0.249	0.226
5	0.333	0.346	0.357	0.350	0.341	0.315	0.292	0.304	0.308	0.297	0.302	0.320	0.287
6	0.404	0.416	0.432	0.423	0.406	0.380	0.348	0.341	0.391	0.373	0.350	0.347	0.355
7	0.468	0.481	0.502	0.491	0.466	0.440	0.403	0.407	0.419	0.425	0.408	0.409	0.368
8	0.526	0.542	0.569	0.550	0.519	0.497	0.456	0.462	0.523	0.441	0.448	0.507	0.462
9	0.577	0.599	0.628	0.603	0.566	0.548	0.507	0.488	0.571	0.526	0.458	0.552	0.548
+gp	0.711	0.768	0.783	0.708	0.679	0.695	0.669	0.614	0.669	0.637	0.583	0.615	0.596

Age/Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
2	0.123	0.130	0.132	0.127	0.118	0.135	0.149	0.128	0.128	0.099	0.106
3	0.168	0.163	0.179	0.167	0.177	0.171	0.164	0.182	0.168	0.172	0.145
4	0.210	0.204	0.212	0.227	0.229	0.222	0.221	0.227	0.224	0.212	0.187
5	0.275	0.254	0.251	0.266	0.294	0.288	0.266	0.281	0.274	0.277	0.249
6	0.325	0.336	0.294	0.299	0.338	0.357	0.326	0.306	0.321	0.310	0.319
7	0.367	0.393	0.356	0.336	0.375	0.415	0.391	0.361	0.356	0.370	0.344
8	0.396	0.424	0.405	0.403	0.423	0.463	0.434	0.430	0.408	0.417	0.417
9	0.499	0.447	0.440	0.432	0.492	0.479	0.486	0.469	0.434	0.440	0.477
+gp	0.600	0.702	0.610	0.558	0.662	0.624	0.614	0.576	0.588	0.578	0.611667

Table 36.6 - Sol.27.7fg - Indices of abundance (No/100km) for UK(E&W)-BTS-Q3

	0	1	2	3	4	5	6	7	8	9
1988	30	81	326	49	19	5	0	0	0	0
1989	144	222	331	176	20	15	7	4	2	2
1990	30	385	313	50	16	4	7	3	0	0
1991	32	241	517	67	17	15	4	0	2	2
1992	4	394	260	139	30	18	10	1	2	1
1993	3	169	320	43	19	1	2	2	1	1
1994	1	333	387	99	14	7	7	0	0	2
1995	27	124	222	52	11	6	12	1	1	1
1996	3	150	212	54	23	6	3	3	1	3
1997	32	433	180	18	11	12	4	3	5	0
1998	91	770	411	50	10	8	4	2	1	4
1999	24	2464	250	32	13	6	3	4	1	0
2000	13	916	1356	31	22	5	0	2	1	1
2001	22	379	600	259	19	8	5	2	0	2
2002	8	663	239	127	102	12	6	2	3	0
2003	12	392	530	46	25	47	8	3	3	0
2004	56	749	378	86	13	19	37	3	3	0
2005	37	343	225	32	13	6	4	14	1	2
2006	11	273	201	40	13	7	0	2	10	0
2007	91	358	108	43	13	7	6	3	3	11
2008	5	1039	105	13	15	6	8	3	3	4
2009	1	509	318	24	7	8	3	3	3	2
2010	18	85	471	121	17	2	4	8	3	2
2011	18	502	52	138	69	7	2	6	3	0
2012	13	542	231	8	53	24	1	1	1	3
2013	9	279	518	43	13	24	15	1	5	1
2014	34	244	257	76	13	5	23	8	1	1
2015	28	746	48	44	31	7	3	13	6	0
2016	26	573	359	12	27	13	7	3	5	8
2017	6	1046	174	67	13	16	17	4	3	11
2018	27	434	906	279	45	17	9	15	11	4
2019	2	708	326	164	22	29	3	6	6	5
2020	2	331	237	74	67	24	17	2	6	6
Mean	26.04	511.43	344.49	77.48	24.68	12.01	7.27	3.85	2.92	2.37

Table 36.7 - Sol.27.7fg- Indices of effort.

	England & Wales				Belgium		Ireland		
Year	Otter trawl[1]	Beam trawl[1]	Otter trawl[2]	Beam trawl[2]	Beam trawl[3]	Beam trawl[5]	Otter trawl[4]	Scottish seine[5]	Beam trawl[5]
1971					11.06	-	-	-	-
1972					8.44	-	-	-	-
1973					17.39	-	-	-	-
1974					18.83	-	-	-	-
1975					16.38	-	-	-	-
1976					28.07	-	-	-	-
1977					24.11	-	-	-	-
1978					18.09	-	-	-	-
1979					18.90	-	-	-	-
1980					29.02	-	-	-	-
1981					35.39	-	-	-	-
1982					28.77	-	-	-	-
1983	620	195	82	149	34.95	-	-	-	-
1984	1723	901	316	298	33.48	-	-	-	-
1985	1493	1101	206	285	40.49	-	-	-	-
1986	1125	973	334	180	52.46	-	-	-	-
1987	1211	1681	364	187	37.26	-	-	-	-
1988	838	1102	351	77	42.92	-	-	-	-
1989	966	861	327	125	53.58	-	-	-	-
1990	1229	1256	435	165	40.27	-	-	-	-
1991	1066	1667	306	483	18.05	-	-	-	-
1992	898	1420	303	633	25.47	-	-	-	-
1993	836	1669	251	694	31.27	-	-	-	-
1994	623	2219	225	610	38.35	-	-	-	-
1995	580	2303	196	694	47.81	-	63.33	6.43	20.69
1996	593	2391	341	560	47.63	53.27	59.97	9.73	26.70
1997	577	2661	370	770	51.98	57.36	65.00	16.07	28.06
1998	517	2846	385	591	52.11	57.79	72.25	14.88	35.21
1999	395	3058	176	1461	55.03	55.11	51.48	8.01	40.83
2000	284	3133	187	1007	56.05	51.34	60.56	9.86	36.83
2001	309	3172	187	1155	52.06	54.90	69.37	16.33	39.50
2002	416	2652	123	463	43.24	49.60	77.20	20.88	31.49
2003	696	2669	51	772	42.81	62.73	86.78	20.07	49.22
2004	641	2503	198	923	-	78.73	97.12	18.42	54.89
2005	876	1968	21	618	-	64.50	124.67	14.64	49.56
2006	924	1330	23	630	-	49.61	118.04	14.78	60.47
2007	798	1407	31	518	-	45.91	135.36	15.81	55.81
2008	711	1202	109	290	-	28.72	125.41	11.65	37.20
2009	656	1105	244	266	-	30.65	137.11	8.18	37.94
2010	565	1162	84	327	-	32.46	140.79	9.68	40.22
2011	525	868	8	180	-	38.77	120.33	11.01	35.33
2012	543	1408	138	275	-	46.25	127.68	14.14	40.33
2013	280	1611	72	265	-	45.23	118.20	13.15	38.48
2014	156	959	10	131	-	31.30	127.34	12.46	37.84
2015	79	726	3	245	-	31.79	132.69	9.28	37.79
2016	0	915	0	396	-	32.34	148.17	10.44	39.55
2017	93	986	95	514	-	33.35	136.05	9.75	35.21
2018	127	1071	71	440	-	31.48	105.81	9.69	37.42
2019	169	981	34	255	-	32.03	103.89	14.26	34.08
2020	100	1012	10	346	-	41.70	89.91	13.59	29.14

[1]Division VIIf only -days fished (Corrected)

[2] VIIfg EAST - days fished (corrected)

[3]Fishing hours (x 10^3) corrected for fishing power using P = 0.000204 BHP^1.23

[4]Division VIIg only - Fishing hours (x10^3)

[5]Fishing hours (x10^3)

Table 36.8 - Sol.27.7fg - LPUE

	UK					Belgium		Ireland		
	BT Survey[1]	Otter trawl[2]	Beam trawl[2]	Otter trawl2	Beam trawl2	Beam trawl3	Beam trawl[4]	Otter trawl[4]	Scottish sein[4]	Beam trawl[4]
Year	Division VIIfg	Division VIIf	Division VIIf	Division VIIgEast	Division VIIgEast	Division VIIfg	Division VIIfg	Division VIIg	Division VIIg	Division VIIg
1971	-	-	-	-	-	47.92	-	-	-	-
1972	-	-	-	-	-	37.06	-	-	-	-
1973	-	-	-	-	-	39.47	-	-	-	-
1974	-	-	-	-	-	37.81	-	-	-	-
1975	-	-	-	-	-	31.41	-	-	-	-
1976	-	-	-	-	-	30.50	-	-	-	-
1977	-	-	-	-	-	27.90	-	-	-	-
1978	-	-	-	-	-	23.35	-	-	-	-
1979	-	-	-	-	-	33.19	-	-	-	-
1980	-	-	-	-	-	29.73	-	-	-	-
1981	-	-	-	-	-	24.03	-	-	-	-
1982	-	-	-	-	-	25.93	-	-	-	-
1983	-	30.54	201.80	35.75	250.70	22.18	-	-	-	-
1984	-	19.53	204.65	28.04	130.61	20.78	-	-	-	-
1985	-	26.58	240.45	37.31	235.62	17.94	-	-	-	-
1986	-	25.55	247.74	21.27	190.11	17.83	-	-	-	-
1987	-	19.85	179.34	36.02	225.56	17.32	-	-	-	-
1988	79.52	11.13	110.35	8.88	304.43	15.29	-	-	-	-
1989	150.02	17.36	130.42	18.75	247.17	11.33	-	-	-	-
1990	93.61	13.41	148.47	18.08	269.40	15.64	-	-	-	-
1991	122.06	12.26	119.52	16.20	117.12	24.24	-	-	-	-
1992	121.41	17.90	105.84	20.99	119.32	18.57	-	-	-	-
1993	76.37	8.85	118.08	4.27	119.85	15.21	-	-	-	-
1994	109.74	13.00	70.00	3.50	74.32	13.94	-	-	-	-
1995	69.91	13.76	73.20	12.75	63.20	13.62	-	0.40	0.62	0.81
1996	71.71	9.69	65.05	6.95	43.84	11.27	11.45	0.73	0.05	0.88
1997	81.67	12.55	53.81	6.42	43.77	9.96	9.68	0.42	0.23	1.16
1998	137.11	8.24	44.86	4.85	27.16	10.12	9.64	0.48	0.11	1.11
1999	168.46	13.25	52.36	8.18	26.19	11.26	12.14	0.17	0.09	0.50
2000	228.46	7.01	53.85	23.26	36.94	11.90	13.77	0.19	0.05	0.26
2001	158.08	17.1	62.39	27.5	33.01	13.25	13.60	0.31	0.55	0.18
2002	121.89	11.61	79.47	47.01	54.15	18.71	17.80	0.43	0.29	0.14
2003	123.91	8.03	80.85	0.00	45.42	19.48	11.40	0.12	0.03	0.19
2004	152.03	8.84	76.09	2.70	37.88	-	9.17	0.19	0.02	0.20
2005	76.28	10.67	70.02	3.07	41.36	-	9.78	0.14	0.00	0.29
2006	68.96	16.40	81.57	6.23	45.13	-	10.63	0.11	0.05	0.26
2007	80.95	10.75	92.17	15.04	43.57	-	11.53	0.13	0.02	0.20
2008	115.96	11.94	94.85	10.67	41.48	-	14.35	0.12	0.02	0.29
2009	90.64	13.13	69.37	6.88	50.65	-	14.01	0.10	0.00	0.28
2010	109.55	13.59	79.90	8.63	53.69	-	16.68	0.13	0.01	0.20
2011	99.47	20.78	109.20	4.47	98.38	-	17.90	0.19	0.01	0.20
2012	101.45	24.10	80.16	5.17	53.43	-	17.01	0.15	0.01	0.48
2013	119.38	27.81	82.82	4.62	44.52	-	16.54	0.14	0.01	0.65
2014	86.75	6.19	107.25	11.56	42.11	-	21.30	0.12	-	0.34
2015	85.45	51.13	103.07	5.62	57.39	-	20.14	0.11	-	0.31
2016	113.55	0.00	113.16	0	33.65	-	16.25	0.10	0.01	0.20
2017	111.38	31.29	100.03	18.09	35.05	-	15.72	0.18	0.05	0.22
2018	206.44	36.37	119.89	4.86	47.74	-	18.09	0.18	-	0.27
2019	150.04	46.55	129.79	11.12	61.33	-	23.08	0.25	0.00	0.26
2020	111.72	51.82	170.32	5.58	117.30	-	25.74	0.31	0.02	0.93

[1]Kg/100km

[1]Kg/day

[3]Kg/hr corrected for fishing power using P = 0.000204 BHP^1.23

[5]Kg/hour

* provisional

Table 36.9 - Sol.27.7fg - Tuning series

BE-CBT_1971_1983	Belgium Beam trawl (Biomass tuning index)		
1971	1983		
1	1	0	0
1	-1		
1	45.319		
1	33.193		
1	35.906		
1	35.915		
1	29.286		
1	27.369		
1	25.677		
1	23.971		
1	32.663		
1	28.343		
1	23.326		
1	26.083		
1	20.742		

BE-CBT_1984_1996	Belgium Beam trawl (Biomass tuning index)		
1984	1996		
1	1	0	0
1	-1		
1	19.788		
1	20.556		
1	19.824		
1	18.996		
1	15.129		
1	12.805		
1	16.620		
1	23.442		
1	20.455		
1	16.472		
1	15.722		
1	15.199		
1	12.243		

BE-CBT3-2006-2020	Belgium Beam trawl (Biomass tuning index)		
2006	2020		
1	1	0	0
1	-1		
1	1.277		
1	1.168		
1	1.137		
1	1.053		
1	1.295		
1	1.492		
1	1.480		
1	1.292		
1	1.621		
1	1.520		
1	1.467		
1	1.601		
1	1.955		
1	2.340		
1	2.444		

Table 36.9 - Sol.27.7fg -Tuning series continued

UK(E&W)-CBT_1984_2005	UK(E+W) Beam trawl (Biomass tuning index)		
1984	2005		
1	1	0	0
1	-1		
1	144.81		
1	127.06		
1	139.65		
1	103.20		
1	88.73		
1	69.98		
1	89.25		
1	67.02		
1	52.94		
1	42.69		
1	44.13		
1	46.17		
1	40.14		
1	53.85		
1	74.17		
1	80.67		
1	56.27		
1	51.17		
1	61.30		
1	71.98		
1	79.08		
1	83.60		

UK(E&W)-CBT_2006_2020	UK(E+W) Beam trawl (Biomass tuning index)	
2006	2020	
1	1	0
1	-1	
1	128.87	
1	215.26	
1	236.99	
1	204.09	
1	227.42	
1	274.68	
1	242.9	
1	207.9	
1	291.23	
1	230.19	
1	198.22	
1	201.66	
1	250.59	
1	229.61	
1	282.32	

Table 36.9 - Sol.27.7fg -Tuning series continued

UK(E&W)-BTS-Q3 **UK(E+W) 7.f Corystes (automated indices since 1995). Ages used in the assessment are in bold**

	1988	**2020**									
	1	**1**		**0.75**	**0.85**						
	0	**9**									
74.120			22	**60**	**242**	**36**	**14**	**4**	0	0	0	0
91.909			132	**204**	**304**	**162**	**18**	**14**	6	4	2	2
69.858			21	**269**	**219**	**35**	**11**	**3**	5	2	0	0
123.410			40	**297**	**638**	**83**	**21**	**18**	5	0	3	2
125.078			5	**493**	**325**	**174**	**37**	**23**	12	1	2	1
127.672			6	**207**	**436**	**52**	**28**	**3**	2	2	1	1
120.816			1	**424**	**430**	**133**	**23**	**11**	9	0	0	3
114.886			31	**142**	**255**	**60**	**13**	**7**	14	1	1	1
118.592			3	**178**	**251**	**64**	**27**	**7**	3	4	1	3
114.886			37	**498**	**207**	**21**	**13**	**14**	5	3	6	0
114.886			104	**885**	**472**	**58**	**11**	**9**	5	2	1	5
118.592			29	**2922**	**297**	**38**	**16**	**7**	4	5	1	0
118.592			16	**1086**	**1608**	**37**	**26**	**6**	0	2	1	1
118.592			26	**449**	**711**	**307**	**23**	**9**	6	2	0	2
118.592			9	**786**	**283**	**151**	**121**	**14**	7	2	3	0
118.592			14	**465**	**628**	**55**	**30**	**56**	9	3	3	0
114.886			64	**860**	**434**	**99**	**15**	**22**	42	4	3	0
118.592			44	**407**	**267**	**38**	**16**	**7**	5	17	1	2
118.592			13	**324**	**238**	**47**	**16**	**8**	0	2	12	0
118.592			108	**424**	**128**	**51**	**16**	**8**	7	3	4	13
118.592			6	**1232**	**124**	**15**	**18**	**7**	9	4	3	5
118.592			1	**604**	**377**	**29**	**8**	**10**	4	3	3	2
118.592			21	**101**	**558**	**144**	**20**	**2**	5	9	4	2
118.592			21	**595**	**62**	**164**	**82**	**8**	2	7	3	0
118.592			16	**643**	**274**	**9**	**63**	**28**	1	1	1	3
118.592			11	**331**	**614**	**51**	**16**	**29**	18	1	6	1
118.592			40	**289**	**305**	**90**	**16**	**6**	27	9	1	1
118.592			33	**885**	**57**	**52**	**37**	**8**	4	16	7	0
118.592			31	**680**	**426**	**14**	**32**	**15**	8	4	6	9
118.592			7	**1240**	**206**	**80**	**15**	**19**	20	5	4	13
118.592			32	**515**	**1074**	**331**	**53**	**20**	11	18	13	5
118.592			2	**840**	**386**	**195**	**27**	**34**	4	7	8	5
118.592			3	**393**	**282**	**88**	**80**	**28**	20	2	7	8

Table 36.10. Sol.27.7fg – Diagnostics.

The model works by assuming that stock-sizes at age (N) and fishing mortalities at age (F) are unobserved processes. The first age group is age 1 and the last age group is age 10+. The data period covers 50 years (from 1971 to 2020). The data contains 7 fleets. The model is a state-space stock assessment (SAM from the package "stockassessment" version **0.11.0**).

```
# modelVersionInfo(SAM_fit_sol_7fg)
# The fit was run with a specific version of stockassessment package.
# If in the mean time version on your system has been updated
# you can revert back to the version used by inserting this:

devtools::install_github("fishfollower/SAM/stockassessment@69d926d0437d")

# right before the stockassessment package is loaded

sessionInfo()$R.version$version.string

R version 3.6.0

stockassessment_0.11.0

#modeltable(SAM_fit_sol_7fg)

      log(L) #par      AIC
M1 -274.3397   24 596.6795

#Survey_table(tuning_list = sam_data$tun)
                   name      type     years ages
1        UK(E&W)-BTS-Q3 age-based 1988-2019  1-5
2      BE-CBT_1971_1983   biomass 1971-1983   -1
3      BE-CBT_1984_1996   biomass 1984-1996   -1
4              BE-CBT3   biomass 2006-2019   -1
5 UK(E&W)-CBT_1984_2005   biomass 1984-2005   -1
6 UK(E&W)-CBT_2006_2019   biomass 2006-2019   -1

#Catch at age data 1971-2020
```

#Configuration #

```
# //1// how should the tuning series go into the model?
conf$keyBiomassTreat
# biomass or catch survey
conf$keyBiomassTreat <- c(-1,-1,0,0,0,0,0)

# //2// define the fbar range
conf$fbarRange       <- c(3,8)

#  //3//correlation between F-at-age
conf$corFlag         <- 2          # Correlation of fishing mortality across
ages (0 independent, 1 compound symmetry, or 2 AR(1)
```

```
# //4// number of parameters describing F-at-age
conf$keyLogFsta[1,] <- c(0, 1, 2, 3, 3, 3, 4, 4, 5, 5)

# //5// number of parameters in the suryey processes
conf$keyLogFpar[2,] <- c(0, 1, 2, 3, 3, -1, -1, -1, -1, -1)

# //6// variance of parameters on F
# use a single parameter!!!
conf$keyVarF[1,]      # Coupling of process variance parameters for log(F)-
process (nomally only first row is used)

# //7// variance parameters on the observations
conf$keyVarObs[1,1:2]   <- 0
conf$keyVarObs[1,3:10]  <- 1
conf$keyVarObs[2,1:5]  <- max(conf$keyVarObs[1,]) + c(1,2,2,3,3)           #
max(conf$keyVarObs[1,]) + 1 #c (5,6,6,8,8) #
conf$keyVarObs[3:7,1]    <-  (max(conf$keyVarObs[2,]) +1) : (max(conf$keyVa-
rObs[2,]) + 5)

# //8// correlation at age between observations
conf$obsCorStruct    <- factor(c("AR","ID","ID","ID","ID","ID","ID"), levels
= c("ID","AR","US"))

# Coupling of correlation parameters can only be specified if the AR(1) struc-
ture is chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they
cannot).
conf$keyCorObs[1,]   <- 0 #NA #c(0,0,0,1,1,1,1,1,1)
```

```
#Survey Catchabilities

qtable(SAM_fit_sol_7fg)
                                1         2       3         4         5  6  7  8  9 10
UK(E&W)-BTS-Q3        -7.216649 -7.381387 -8.5931 -9.226127 -9.226127 NA NA NA NA NA
BE-CBT_1971_1983      -5.119445        NA      NA        NA        NA NA NA NA NA NA
BE-CBT_1984_1996      -5.247828        NA      NA        NA        NA NA NA NA NA NA
BE-CBT3               -7.831005        NA      NA        NA        NA NA NA NA NA NA
UK(E&W)-CBT_1984_2005 -3.826183        NA      NA        NA        NA NA NA NA NA NA
UK(E&W)-CBT_2006_2020 -2.821268        NA      NA        NA        NA NA NA NA NA NA
attr(,"sd")
                               1          2          3          4          5  6  7  8  9 10
UK(E&W)-BTS-Q3        0.09879730 0.09959733 0.09900827 0.06447593 0.06447593 NA NA NA NA NA
BE-CBT_1971_1983      0.06122832         NA         NA         NA         NA NA NA NA NA NA
BE-CBT_1984_1996      0.05445691         NA         NA         NA         NA NA NA NA NA NA
BE-CBT3               0.04951472         NA         NA         NA         NA NA NA NA NA NA
UK(E&W)-CBT_1984_2005 0.07534595         NA         NA         NA         NA NA NA NA NA NA
UK(E&W)-CBT_2006_2020 0.07462266         NA         NA         NA         NA NA NA NA NA NA
attr(,"class")
[1] "samqtable"
```

Table 36.11 - Sol.27.7fg - Fishing mortality

Age/Year	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**
1	0.0043	0.0041	0.0039	0.0037	0.0036	0.0042	0.0038	0.0035	0.0037	0.0041
2	0.1228	0.1148	0.1086	0.1026	0.0997	0.1179	0.1063	0.0965	0.1028	0.1167
3	0.2769	0.2583	0.2437	0.2296	0.2232	0.2681	0.2406	0.2173	0.2335	0.2689
4	0.3362	0.3045	0.2805	0.2621	0.2513	0.2984	0.2653	0.2376	0.2566	0.2957
5	0.3362	0.3045	0.2805	0.2621	0.2513	0.2984	0.2653	0.2376	0.2566	0.2957
6	0.3362	0.3045	0.2805	0.2621	0.2513	0.2984	0.2653	0.2376	0.2566	0.2957
7	0.3037	0.2715	0.2480	0.2335	0.2251	0.2670	0.2347	0.2071	0.2216	0.2517
8	0.3037	0.2715	0.2480	0.2335	0.2251	0.2670	0.2347	0.2071	0.2216	0.2517
9	0.2864	0.2564	0.2350	0.2222	0.2133	0.2477	0.2155	0.1891	0.1999	0.2261
+gp	0.2864	0.2564	0.2350	0.2222	0.2133	0.2477	0.2155	0.1891	0.1999	0.2261
FBAR 3-8	0.3155	0.2858	0.2635	0.2471	0.2379	0.2829	0.2510	0.2241	0.2411	0.2765

Age/Year	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
1	0.0046	0.0047	0.0048	0.0048	0.0050	0.0053	0.0051	0.0048	0.0045	0.0047
2	0.1298	0.1332	0.1378	0.1355	0.1426	0.1528	0.1452	0.1379	0.1291	0.1348
3	0.3049	0.3178	0.3340	0.3333	0.3585	0.3909	0.3740	0.3591	0.3403	0.3630
4	0.3353	0.3513	0.3732	0.3785	0.4163	0.4675	0.4606	0.4505	0.4271	0.4575
5	0.3353	0.3513	0.3732	0.3785	0.4163	0.4675	0.4606	0.4505	0.4271	0.4575
6	0.3353	0.3513	0.3732	0.3785	0.4163	0.4675	0.4606	0.4505	0.4271	0.4575
7	0.2890	0.3066	0.3262	0.3274	0.3547	0.3974	0.3926	0.3814	0.3561	0.3768
8	0.2890	0.3066	0.3262	0.3274	0.3547	0.3974	0.3926	0.3814	0.3561	0.3768
9	0.2561	0.2690	0.2807	0.2798	0.3031	0.3399	0.3359	0.3274	0.3025	0.3223
+gp	0.2561	0.2690	0.2807	0.2798	0.3031	0.3399	0.3359	0.3274	0.3025	0.3223
FBAR 3-8	0.3148	0.3308	0.3510	0.3539	0.3862	0.4314	0.4235	0.4122	0.3889	0.4149

Age/Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
1	0.0045	0.0043	0.0045	0.0047	0.0051	0.0050	0.0051	0.0048	0.0043	0.0037
2	0.1272	0.1221	0.1273	0.1340	0.1449	0.1440	0.1454	0.1354	0.1203	0.1031
3	0.3470	0.3401	0.3648	0.3958	0.4420	0.4480	0.4602	0.4317	0.3838	0.3279
4	0.4349	0.4225	0.4561	0.5001	0.5578	0.5588	0.5707	0.5318	0.4641	0.3953
5	0.4349	0.4225	0.4561	0.5001	0.5578	0.5588	0.5707	0.5318	0.4641	0.3953
6	0.4349	0.4225	0.4561	0.5001	0.5578	0.5588	0.5707	0.5318	0.4641	0.3953
7	0.3555	0.3404	0.3702	0.4039	0.4498	0.4506	0.4619	0.4297	0.3703	0.3179
8	0.3555	0.3404	0.3702	0.4039	0.4498	0.4506	0.4619	0.4297	0.3703	0.3179
9	0.3106	0.3012	0.3299	0.3617	0.3993	0.3999	0.4098	0.3821	0.3294	0.2865
+gp	0.3106	0.3012	0.3299	0.3617	0.3993	0.3999	0.4098	0.3821	0.3294	0.2865
FBAR 3-8	0.3938	0.3814	0.4123	0.4507	0.5025	0.5043	0.5160	0.4811	0.4194	0.3583

Age/Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1	0.0036	0.0036	0.0039	0.0040	0.0039	0.0037	0.0035	0.0033	0.0031	0.0030
2	0.0990	0.1002	0.1089	0.1117	0.1076	0.1022	0.0960	0.0863	0.0808	0.0773
3	0.3179	0.3270	0.3592	0.3682	0.3512	0.3294	0.3046	0.2698	0.2492	0.2357
4	0.3923	0.4092	0.4571	0.4710	0.4519	0.4285	0.4031	0.3658	0.3466	0.3328
5	0.3923	0.4092	0.4571	0.4710	0.4519	0.4285	0.4031	0.3658	0.3466	0.3328
6	0.3923	0.4092	0.4571	0.4710	0.4519	0.4285	0.4031	0.3658	0.3466	0.3328
7	0.3160	0.3310	0.3723	0.3867	0.3755	0.3633	0.3510	0.3280	0.3168	0.3081
8	0.3160	0.3310	0.3723	0.3867	0.3755	0.3633	0.3510	0.3280	0.3168	0.3081
9	0.2892	0.3041	0.3448	0.3656	0.3617	0.3563	0.3475	0.3277	0.3184	0.3097
+gp	0.2892	0.3041	0.3448	0.3656	0.3617	0.3563	0.3475	0.3277	0.3184	0.3097
FBAR 3-8	0.3545	0.3694	0.4125	0.4258	0.4096	0.3902	0.3693	0.3372	0.3204	0.3083

Age/Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
1	0.0031	0.0033	0.0033	0.0033	0.0031	0.0028	0.0026	0.0024	0.002561	0.002803
2	0.0783	0.0832	0.0835	0.0830	0.0762	0.0695	0.0628	0.059146	0.062099	0.06841
3	0.2371	0.2518	0.2522	0.2499	0.2272	0.2051	0.1843	0.173273	0.18245	0.202954
4	0.3414	0.3713	0.3740	0.3734	0.3345	0.2993	0.2664	0.249839	0.262494	0.296012
5	0.3414	0.3713	0.3740	0.3734	0.3345	0.2993	0.2664	0.249839	0.262494	0.296012
6	0.3414	0.3713	0.3740	0.3734	0.3345	0.2993	0.2664	0.249839	0.262494	0.296012
7	0.3216	0.3547	0.3597	0.3629	0.3210	0.2831	0.2494	0.234414	0.245654	0.277595
8	0.3216	0.3547	0.3597	0.3629	0.3210	0.2831	0.2494	0.234414	0.245654	0.277595
9	0.3255	0.3636	0.3743	0.3864	0.3450	0.3034	0.2693	0.256206	0.268101	0.300126
+gp	0.3255	0.3636	0.3743	0.3864	0.3450	0.3034	0.2693	0.256206	0.268101	0.300126
FBAR 3-8	0.3174	0.3459	0.3490	0.3493	0.3121	0.2782	0.2470	0.2319	0.2435	0.2744

Table 36.12 - Sol.27.7fg - Stock numbers at age (start of year, in thousands)

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	9426	4652	3559	3552	3489	5430	4915	5368	3813	5170
2	5690	8797	4101	3166	3205	3075	5027	4389	4945	3328
3	1886	4480	7384	3258	2536	2626	2426	4205	3580	4062
4	4547	1417	3025	5111	2363	1900	1677	1693	3174	2612
5	1996	2770	1064	2051	3523	1756	1351	1077	1163	2134
6	1523	1248	1747	771	1429	2476	1154	1008	760	811
7	1768	994	789	1154	537	1000	1770	795	776	534
8	2612	1135	701	549	793	370	686	1288	615	561
9	1433	1693	757	514	403	605	230	489	969	466
+gp	4733	3955	3768	3061	2429	2006	1811	1375	1360	1744
TOTAL	35615	31141	26895	23187	20707	21243	21047	21688	21156	21422

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	5182	5239	7079	5616	5785	3945	6063	4831	4697	7969
2	4730	4665	4651	6546	4992	5317	3409	5640	4508	4163
3	2538	3803	3679	3620	5274	3941	4227	2538	4525	3677
4	2876	1579	2477	2358	2331	3251	2335	2793	1639	2957
5	1690	1921	999	1579	1510	1394	1818	1260	1700	959
6	1362	1099	1248	628	955	892	789	1039	698	1047
7	531	841	707	828	407	560	493	457	588	403
8	424	344	535	462	538	276	331	272	294	358
9	395	321	223	317	306	341	182	206	156	189
+gp	1604	1425	1273	1104	1004	913	803	674	573	510
TOTAL	21332	21238	22870	23058	23100	20829	20449	19710	19378	22233

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	5004	5158	5020	4294	3730	4435	6089	7412	14147	9921
2	7625	4446	4642	4662	3840	3384	4054	5505	6435	12990
3	3209	6119	3472	3655	3751	3042	2703	3261	4376	5015
4	2339	2034	3771	2140	2255	2181	1715	1544	1951	2575
5	1678	1364	1155	2130	1135	1130	1104	873	766	1103
6	542	937	775	667	1153	594	581	547	465	399
7	604	318	530	459	361	583	312	291	296	273
8	242	377	209	306	279	205	327	177	158	182
9	212	152	257	135	188	158	121	181	108	98
+gp	488	450	395	433	356	336	303	256	258	247
TOTAL	21942	21356	20226	18882	17048	16048	17309	20048	28960	32802

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	5302	6825	5246	4710	4220	3477	3847	7655	7036	3092
2	8974	4567	6240	4676	4251	3822	3116	3336	7136	6513
3	10457	7269	3762	5171	3689	3452	3139	2533	2703	6548
4	3128	7194	4550	2404	3142	2277	2209	2055	1779	2032
5	1517	1846	4436	2676	1393	1850	1330	1333	1305	1184
6	684	929	1028	2384	1493	791	1128	805	831	857
7	252	410	583	549	1296	861	471	701	523	544
8	183	171	271	359	326	778	542	294	456	350
9	117	127	110	172	219	206	508	358	188	310
+gp	250	248	271	262	284	323	334	546	609	535
TOTAL	30862	29588	26497	23363	20313	17836	16625	19615	22567	21965

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	5494	6610	5315	4027	8252	8145	14673	6396	7597	6386
2	2611	4985	5990	4886	3432	7647	6961	14107	5686	6735
3	5652	2101	4117	4998	4102	2817	6641	5785	12735	4815
4	5077	4032	1568	2906	3593	2862	2158	5167	4300	9887
5	1378	3348	2454	1030	1782	2296	1894	1580	3723	3222
6	846	946	1965	1478	658	1148	1475	1306	1228	2587
7	567	570	617	1175	901	444	768	958	890	912
8	377	371	364	392	672	561	313	549	646	629
9	229	249	231	235	251	432	360	230	417	447
+gp	607	587	543	506	433	404	540	598	572	703
TOTAL	22839	23798	23164	21632	24074	26756	35783	36675	37793	36322

Table 36.13 - Sol.27.7fg - Summary

	R(age 1)	Low	High	SSB	Low	High	Fbar(3-8)	Low	High	Catch	Low	High
1971	9426	6652	13357	6552	5599	7667	0.315	0.253	0.393	1742	1414	2145
1972	4652	3371	6421	5695	4898	6621	0.286	0.236	0.347	1446	1221	1712
1973	3559	2576	4918	5885	5094	6798	0.264	0.218	0.319	1431	1213	1688
1974	3552	2572	4906	5536	4791	6397	0.247	0.204	0.3	1256	1061	1487
1975	3489	2521	4829	5101	4414	5894	0.238	0.195	0.29	1138	960	1348
1976	5430	3958	7450	4584	3972	5291	0.283	0.231	0.346	1117	932	1339
1977	4915	3586	6738	4373	3811	5018	0.251	0.208	0.303	984	838	1156
1978	5368	3890	7408	4449	3881	5100	0.224	0.182	0.275	915	766	1093
1979	3813	2747	5291	4635	4058	5295	0.241	0.199	0.292	1024	867	1209
1980	5170	3771	7089	4618	4046	5271	0.277	0.232	0.33	1183	1004	1393
1981	5182	3781	7103	4295	3779	4882	0.315	0.264	0.375	1161	982	1373
1982	5239	3818	7189	4175	3698	4712	0.331	0.278	0.393	1246	1058	1467
1983	7079	5144	9742	4116	3656	4634	0.351	0.296	0.416	1275	1081	1504
1984	5616	4077	7737	4255	3797	4768	0.354	0.3	0.418	1295	1100	1524
1985	5785	4172	8020	3981	3546	4469	0.386	0.329	0.454	1391	1176	1645
1986	3945	2870	5422	4087	3644	4585	0.431	0.365	0.51	1492	1254	1775
1987	6063	4456	8249	3582	3192	4020	0.423	0.36	0.498	1328	1122	1571
1988	4831	3568	6541	3294	2942	3688	0.412	0.35	0.485	1171	990	1386
1989	4697	3472	6353	3119	2795	3480	0.389	0.33	0.459	1004	848	1189
1990	7969	5874	10811	2880	2577	3218	0.415	0.35	0.491	1123	949	1329
1991	5004	3717	6736	3169	2825	3557	0.394	0.333	0.465	1132	951	1346
1992	5158	3849	6913	3250	2887	3657	0.381	0.321	0.454	1074	891	1294
1993	5020	3736	6745	3070	2743	3437	0.412	0.35	0.485	1091	915	1300
1994	4294	3201	5761	2850	2554	3180	0.451	0.386	0.526	1102	930	1306
1995	3730	2767	5028	2772	2488	3088	0.503	0.43	0.587	1178	994	1396
1996	4435	3290	5978	2488	2233	2772	0.504	0.433	0.588	1059	898	1247
1997	6089	4522	8200	2205	1972	2465	0.516	0.439	0.606	1005	848	1190
1998	7412	5429	10120	2403	2142	2696	0.481	0.408	0.567	972	816	1157
1999	14147	10428	19192	2635	2341	2966	0.419	0.354	0.496	929	774	1116
2000	9921	7379	13338	2868	2546	3231	0.358	0.298	0.431	1067	871	1307
2001	5302	3923	7165	4395	3858	5006	0.354	0.298	0.422	1370	1127	1667
2002	6825	5074	9182	4523	3976	5147	0.369	0.313	0.437	1519	1256	1838
2003	5246	3901	7055	4200	3719	4743	0.412	0.351	0.485	1541	1282	1853
2004	4710	3529	6287	4053	3620	4538	0.426	0.362	0.5	1463	1227	1744
2005	4220	3178	5605	3674	3297	4094	0.41	0.348	0.482	1303	1102	1541
2006	3477	2610	4631	3238	2918	3592	0.39	0.332	0.459	1019	870	1193
2007	3847	2888	5125	2968	2668	3302	0.369	0.313	0.436	951	813	1111
2008	7655	5659	10356	2949	2628	3309	0.337	0.283	0.402	844	724	985
2009	7036	5291	9355	3089	2707	3525	0.32	0.27	0.381	724	615	851
2010	3092	2286	4182	3368	3003	3777	0.308	0.26	0.366	836	711	982
2011	5494	4133	7303	3620	3234	4052	0.317	0.268	0.375	1014	863	1191
2012	6610	4988	8758	3549	3164	3980	0.346	0.291	0.411	1018	863	1203
2013	5315	3978	7100	3469	3104	3877	0.349	0.291	0.419	1008	861	1180
2014	4027	2997	5409	3694	3271	4172	0.349	0.287	0.425	1127	959	1324
2015	8252	6185	11008	3546	3121	4028	0.312	0.254	0.383	945	802	1114
2016	8145	6145	10797	3654	3232	4132	0.278	0.225	0.344	834	707	984
2017	14673	10914	19725	4042	3573	4572	0.247	0.198	0.308	844	714	998
2018	6396	4532	9026	5089	4506	5746	0.232	0.184	0.292	980	820	1171
2019	7597	4725	12214	5774	5073	6573	0.244	0.192	0.309	1211	1019	1438
2020	6386	3110	13113	5756	4935	6713	0.274	0.208	0.362	1406	1150	1720
Arith. Mean	5896	4329	8038	3874	3420.265	4388.20	0.35	0.29	0.42	1140	960	1354
Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)								

Table 36.14 - Sol.27.7fg
Input for catch forecast and Fmsy analysis

Input: F in 2021: Based on a catch of 1413t, ICES catch advice for 2021
F in 2022-2023: mean 18-20 scaled to 2020
Catch and stock weights: mean 18-20
N age 1 in 2021-2023: Median resampled recruitment (1971–2018) as estimated by a stochastic projection

2021

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	5239	0.1	0	0	0	0.041	0.003	0.112
2	5754	0.1	0.67	0	0	0.111	0.065	0.136
3	5676	0.1	0.91	0	0	0.162	0.194	0.178
4	3548	0.1	0.98	0	0	0.208	0.283	0.232
5	6630	0.1	0.99	0	0	0.267	0.283	0.286
6	2170	0.1	0.99	0	0	0.317	0.283	0.328
7	1742	0.1	1	0	0	0.357	0.264	0.389
8	625	0.1	1	0	0	0.414	0.264	0.434
9	432	0.1	1	0	0	0.450	0.286	0.458
+gp	774	0.1	1	0	0	0.593	0.286	0.607
fbar 3-8							0.262	

2022

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	5246	0.1	0	0	0	0.041	0.003	0.112
2	4723	0.1	0.67	0	0	0.111	0.068	0.136
3	4859	0.1	0.91	0	0	0.162	0.203	0.178
4	4237	0.1	0.98	0	0	0.208	0.295	0.232
5	2408	0.1	0.99	0	0	0.267	0.295	0.286
6	4523	0.1	0.99	0	0	0.317	0.295	0.328
7	1479	0.1	1	0	0	0.357	0.276	0.389
8	1210	0.1	1	0	0	0.414	0.276	0.434
9	432	0.1	1	0	0	0.450	0.301	0.458
+gp	819	0.1	1	0	0	0.593	0.301	0.607
fbar 3-8							0.273	

2023

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	5246	0.1	0	0	0	0.041	0.003	0.112
2	4759	0.1	0.67	0	0	0.111	0.068	0.136
3	4004	0.1	0.91	0	0	0.162	0.203	0.178
4	3590	0.1	0.98	0	0	0.208	0.295	0.232
5	2832	0.1	0.99	0	0	0.267	0.295	0.286
6	1621	0.1	0.99	0	0	0.317	0.295	0.328
7	3022	0.1	1	0	0	0.357	0.276	0.389
8	1008	0.1	1	0	0	0.414	0.276	0.434
9	828	0.1	1	0	0	0.450	0.301	0.458
+gp	842	0.1	1	0	0	0.593	0.301	0.607
fbar 3-8							0.273	

Table 36.15 - Sol.27.7fg - Management option table

F in 2021: Based on a catch of 1413 t, ICES advice for 2021. The TAC 2021 was not available.
Catch and stock weights: mean 18-20
N age 1 in 2021-2023: Median resampled recruitment (1971–2018) as estimated by a stochastic projection

2021 SSB	FBar	Landings
6054	0.262	1413

2022				2023
SSB	FMult	FBar	Catch	SSB
5864	0.0000	0.0000	0	6997
5864	0.1000	0.0260	154	6839
5864	0.2000	0.0520	303	6686
5864	0.3000	0.0790	449	6534
5864	0.4000	0.1050	590	6380
5864	0.5000	0.1310	728	6233
5864	0.6000	0.1570	863	6091
5864	0.7000	0.1830	995	5964
5864	0.8000	0.2100	1123	5840
5864	0.9000	0.2360	1246	5710
5864	1.0000	0.2620	1369	5593
5864	1.1000	0.2880	1487	5473
5864	1.2000	0.3140	1601	5353
5864	1.3000	0.3410	1713	5242
5864	1.4000	0.3670	1823	5118
5864	1.5000	0.3930	1930	5004
5864	1.6000	0.4190	2031	4896
5864	1.7000	0.4450	2133	4796
5864	1.8000	0.4720	2232	4696
5864	1.9000	0.4980	2328	4598
5864	2.0000	0.5240	2420	4502

Input units are thousands and kg - output in tonnes

Basis	Total catch (2022)	Projected landings * (2022)	Projected discards ** (2022)	F_{total} (2022)	$F_{projected\ landings}$ (2022)	$F_{projected\ discards}$ (2022)	SSB (2023)	% SSB change ***	% TAC change ^	% Advice change ^^
ICES advice basis										
F=EU MAP ^^^: F_{MSY}	1320	1244	76	0.25	0.24	0.014	5647	-3.7		-6.6
F=EU MAP ^^^ $F_{MSY\ lower}$	753	711	42	0.14	0.128	0.008	6230	6.2		-14.5 #
F=EU MAP ^^^ $F_{MSY\ upper}$	2190	2060	130	0.46	0.44	0.027	4724	-19.4		7.4 #
Other scenarios										
F = 0	0	0	0	0	0	0	7027	19.8		-100
F_{pa}	1960	1843	117	0.4	0.38	0.024	4962	-15.4		39
F_{lim}	2481	2330	151	0.54	0.51	0.032	4418	-24.7		76
SSB_{2023} = B_{lim}	4664	4336	328	1.51	1.42	0.089	2184	-63		230
SSB_{2023} = B_{pa} = MSY $B_{trigger}$	3804	3556	248	1.02	0.96	0.06	3057	-48		169
F = F_{2021}	1365	1285	80	0.26	0.25	0.015	5585	-4.8		-3.4
SSB_{2023}= SSB_{2022}	1100	1036	64	0.21	0.193	0.012	5864	0		-22

* Marketable landings, assuming recent discard rate.
** Including BMS landings (EU stocks), assuming recent discard rate.
*** SSB 2023 relative to SSB 2022.
^ The agreed TAC for 2021 was not available.
^^ Advice value for 2022 relative to the advice value for 2021 (1413 tonnes).
^^^ EU multiannual plan (MAP) for the Western Waters and adjacent waters (EU, 2019).
#Advice value this year relative to the advice value last year for the MAP FMSY lower (811 tonnes) and MAP FMSY upper (2364 tonnes).

Table 36.16 - Sol.27.7fg - Details Input Data

F in 2021: Based on a catch of 1413t, ICES catch advice for 2021
F in 2022-2023: mean 18-20 scaled to 2020
Catch and stock weights: mean 18-20
N age 1 in 2021-2023: Median resampled recruitment (1971–2018) as estimated by a stochastic projection

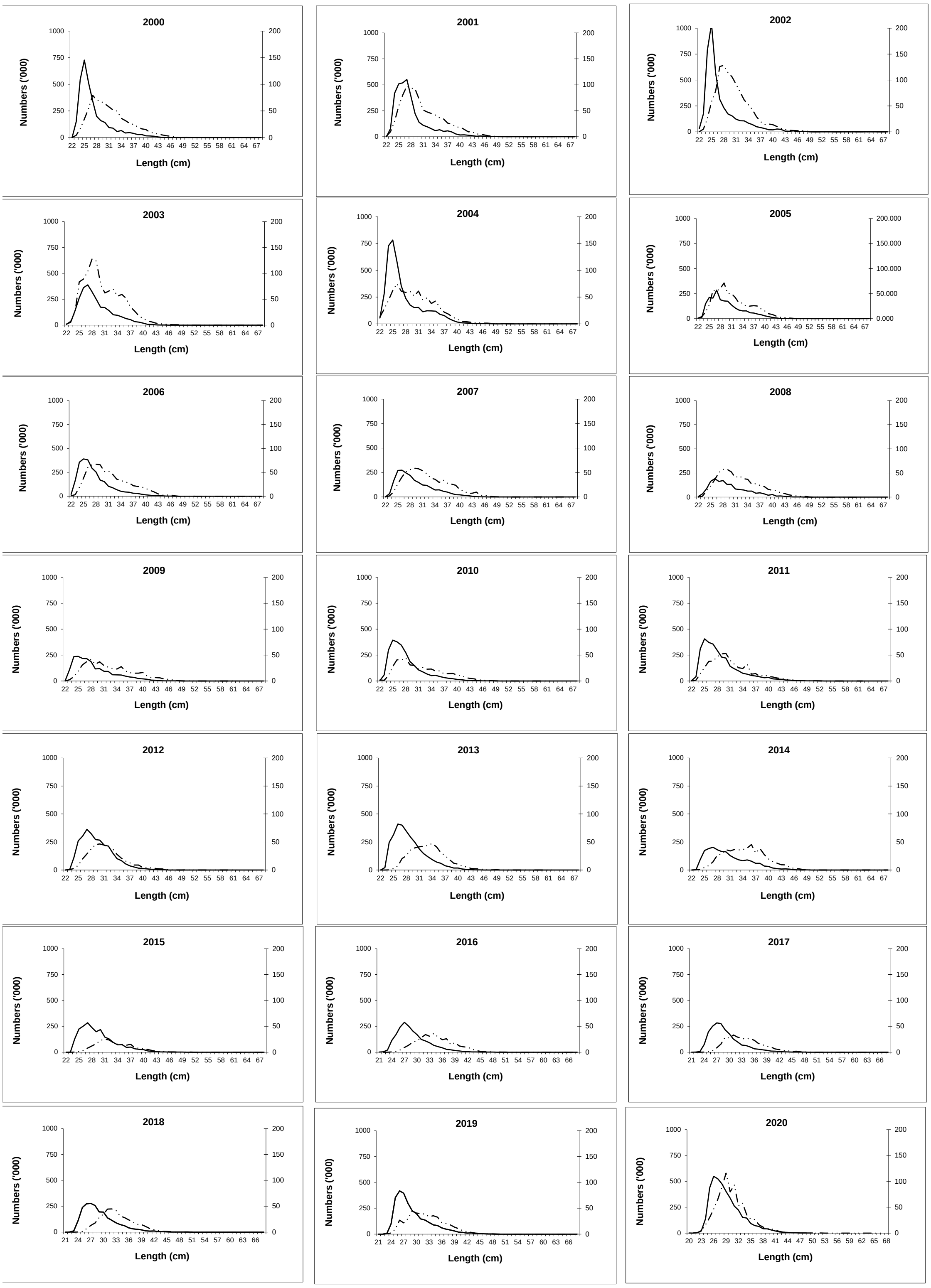
Year:	**2021**	F multiplier:	1.22293	Fbar:	0.261		
Age	**F**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SSNos**	**SSB**
1	0.003	13	1	5239	215	0	0
2	0.065	346	47	5754	639	3855	428
3	0.194	953	169	5676	918	5166	835
4	0.282	831	193	3548	737	3477	722
5	0.282	1553	444	6630	1768	6563	1750
6	0.282	508	167	2170	687	2148	680
7	0.265	386	150	1742	621	1742	621
8	0.265	139	60	625	259	625	259
9	0.287	103	47	432	195	432	195
10	0.287	184	112	774	459	774	459
Total	0.261	5017	1391	32591	6497	24783	5949

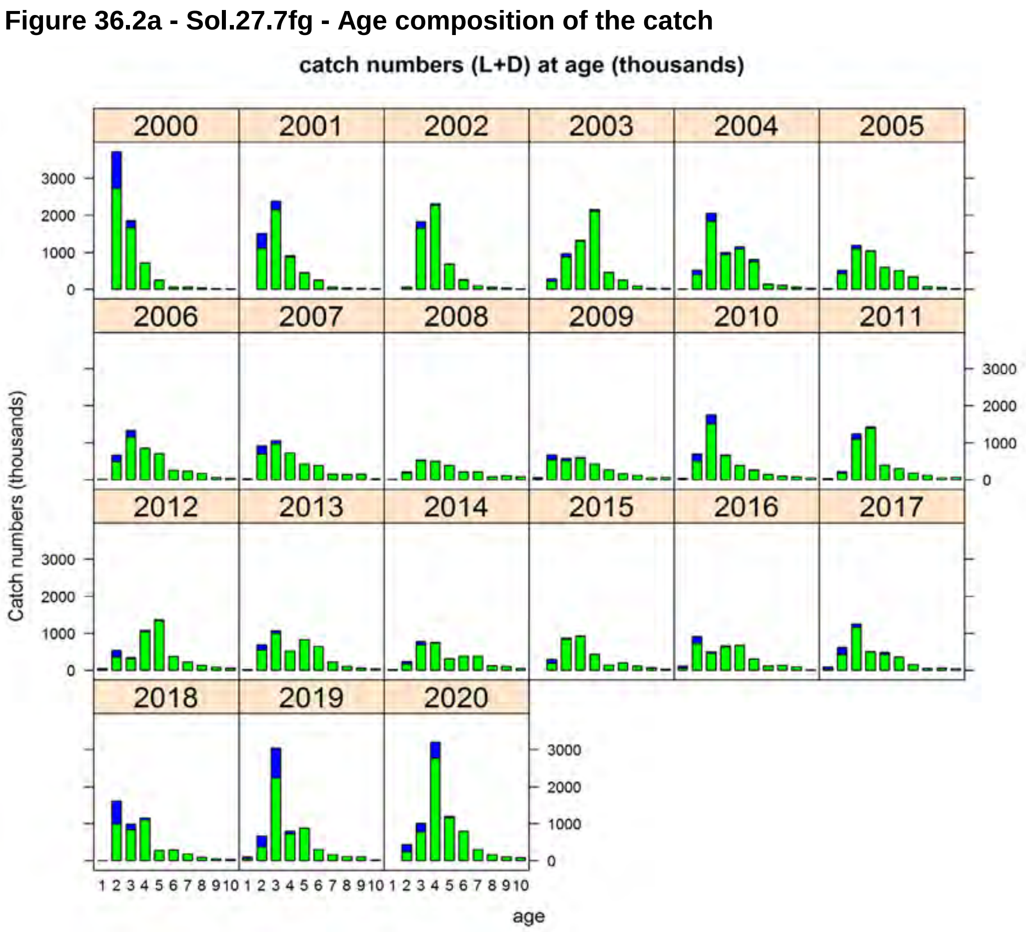
Year:	**2022**	F multiplier:	1	Fbar:	0.27346		
Age	**F**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SSNos**	**SSB**
1	0.003	14	2	5246	215	0	0
2	0.068	297	41	4723	524	3165	351
3	0.203	850	151	4859	786	4422	715
4	0.295	1033	240	4237	880	4152	862
5	0.295	587	168	2408	642	2384	636
6	0.295	1103	362	4523	1432	4478	1418
7	0.276	341	132	1479	528	1479	528
8	0.276	279	121	1210	501	1210	501
9	0.301	107	49	432	195	432	195
10	0.301	203	123	819	485	819	485
Total	0.273	4813	1388	29937	6576	22541	5691

Year:	**2023**	F multiplier:	1	Fbar:	0.27346		
Age	**F**	**CatchNos**	**Yield**	**StockNos**	**Biomass**	**SSNos**	**SSB**
1	0.003	14	2	5246	215	0	0
2	0.068	300	41	4759	528	3188	354
3	0.203	701	124	4004	647	3644	589
4	0.295	875	203	3590	746	3518	731
5	0.295	690	197	2832	755	2804	748
6	0.295	395	130	1621	513	1604	508
7	0.276	696	271	3022	1078	3022	1078
8	0.276	232	101	1008	417	1008	417
9	0.301	205	94	828	373	828	373
10	0.301	209	127	842	499	842	499
Total	0.273	4317	1289	27751	5771	20458	5296

Input units are thousands and kg - output in tonnes

Figure 36.1 - Sol.27.7fg - Dotted lines give the length distributions of UK (England and Wales) landings; solid lines of Belgian landings





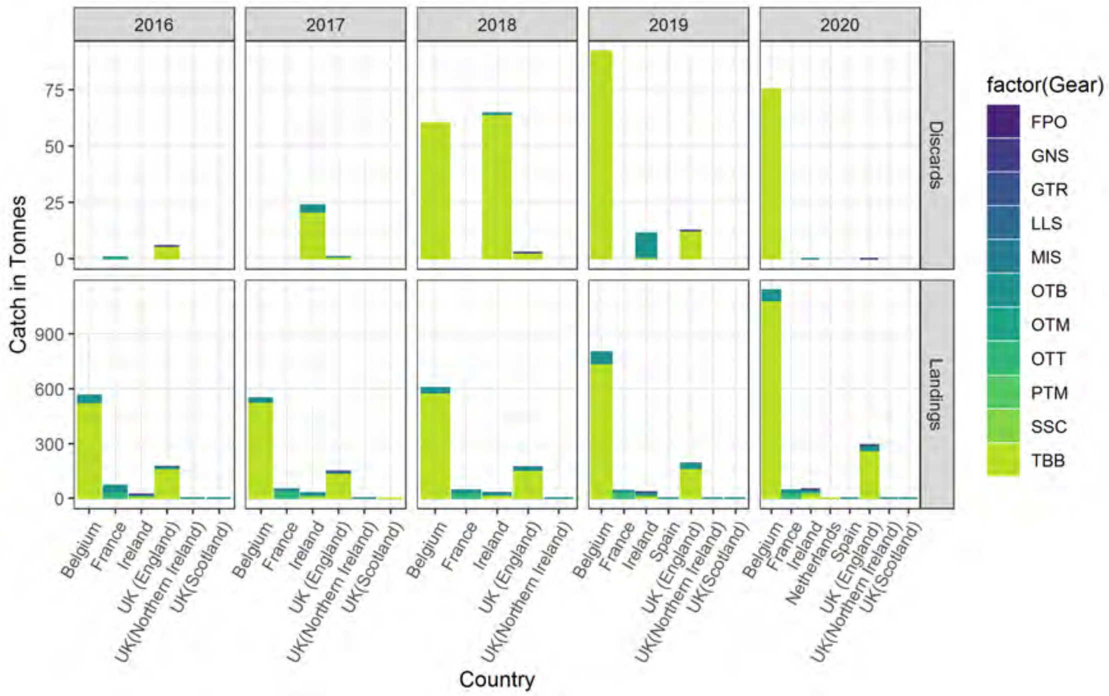


Figure 36.2b. Sol.27.7fg. InterCatch landings and discard data by year, country and gear.

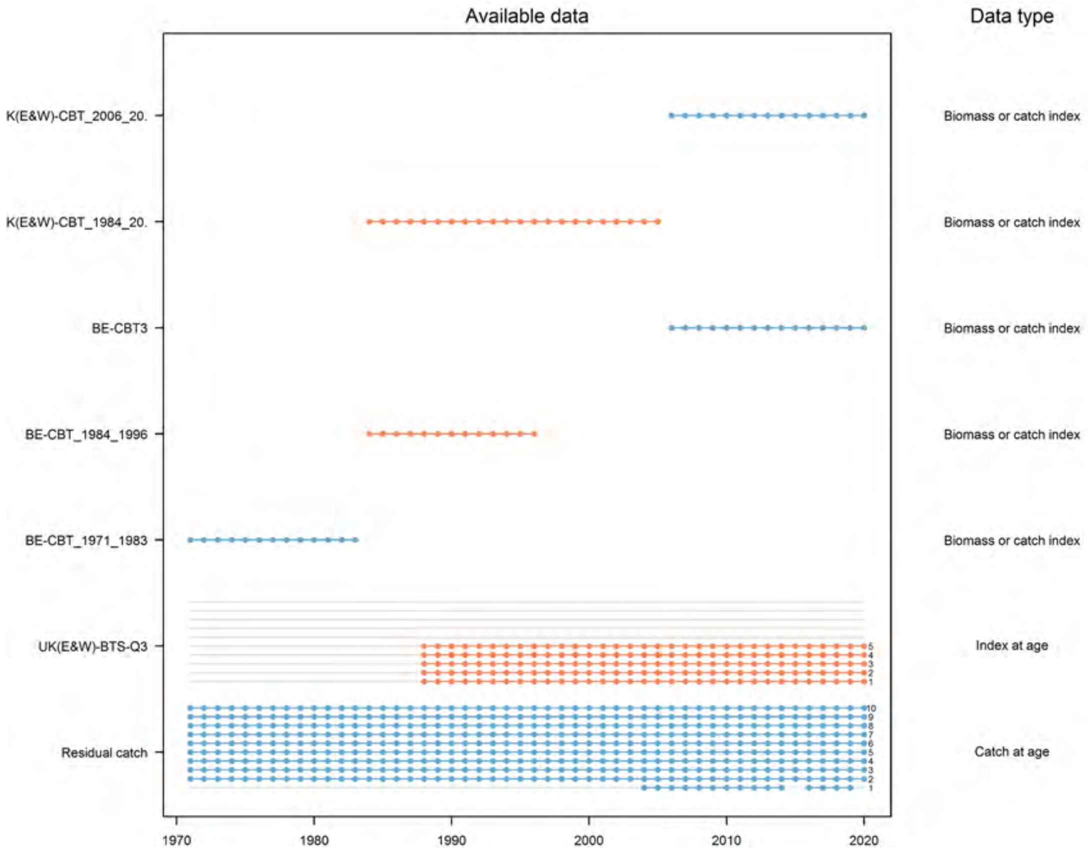


Figure 36.2c. Sol.27.7fg. Overview of the tuning and catch data used in the assessment. Colours have no meaning.

Figure 36.3 - Sol.27.7fg - Standardized catch proportion

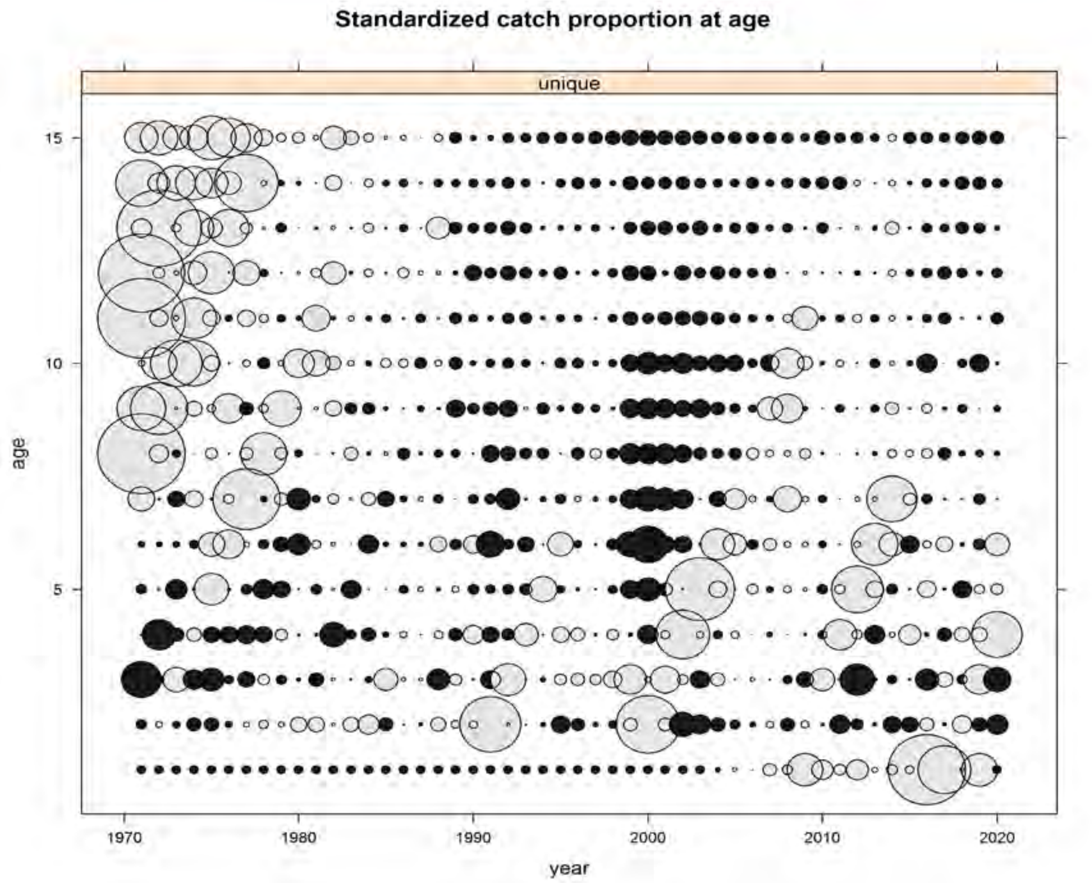


Figure 36.4a - Sol.27.7fg - Belgian length distributions of discarded and retained fish from discard sampling studies

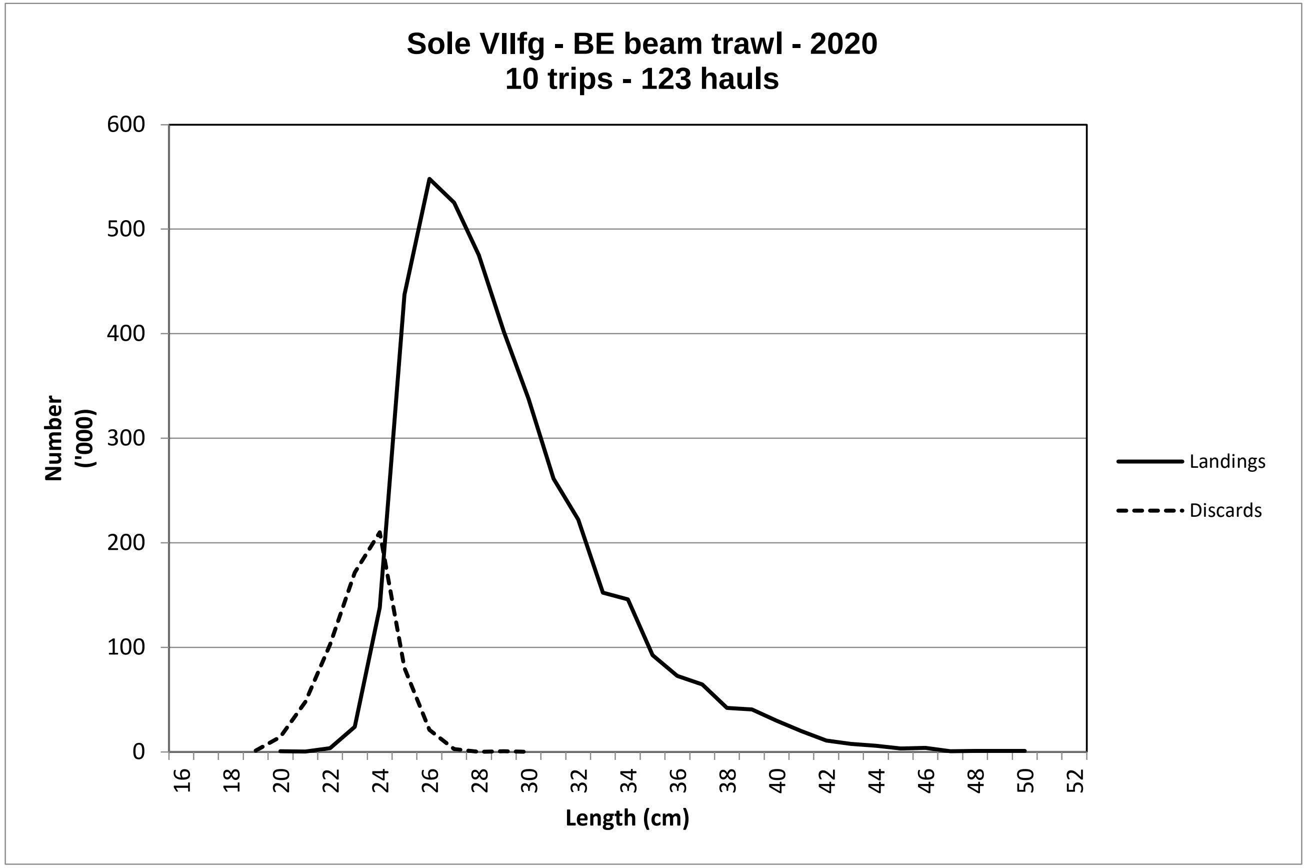


Figure 36.4b - Sol.27.7fg - UK (E+W) Length distributions of retained fish

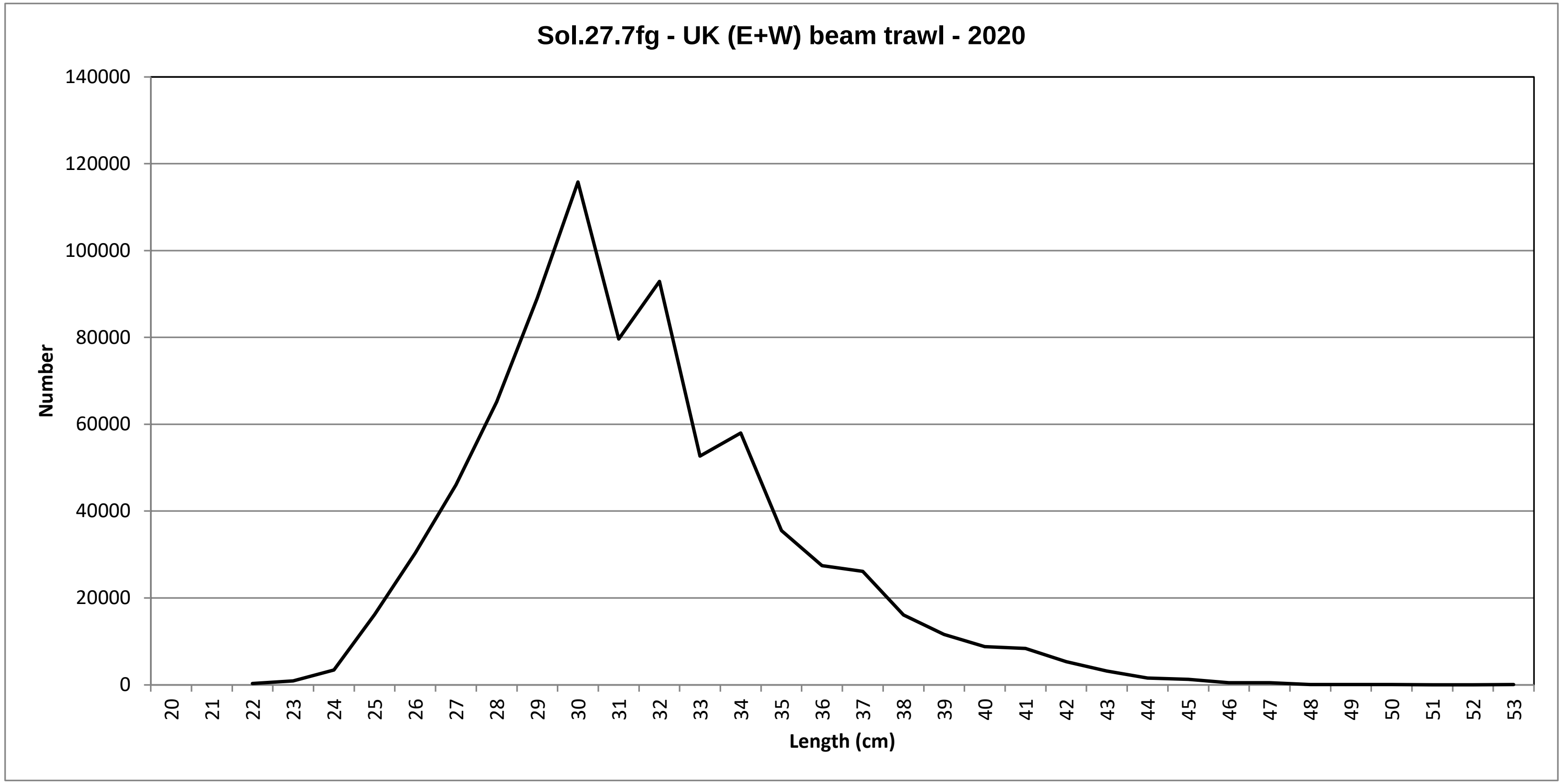


Figure 36.5a - Sol.27.7.fg - Mean-standardised indices

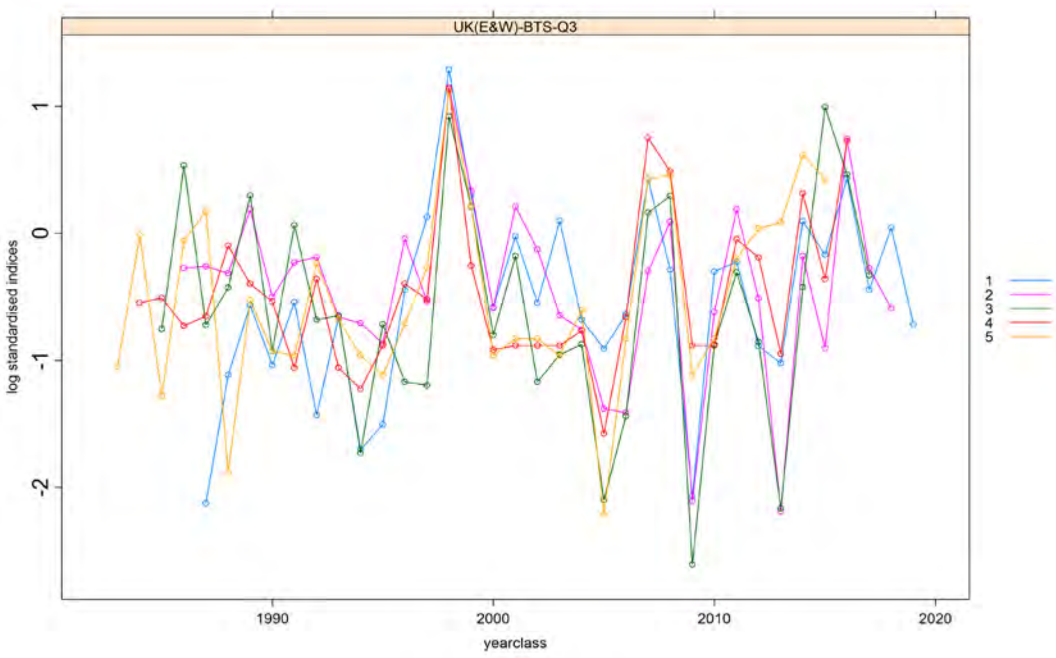


Figure 36.5b - Sol.27.7.fg - Mean-standardised indices

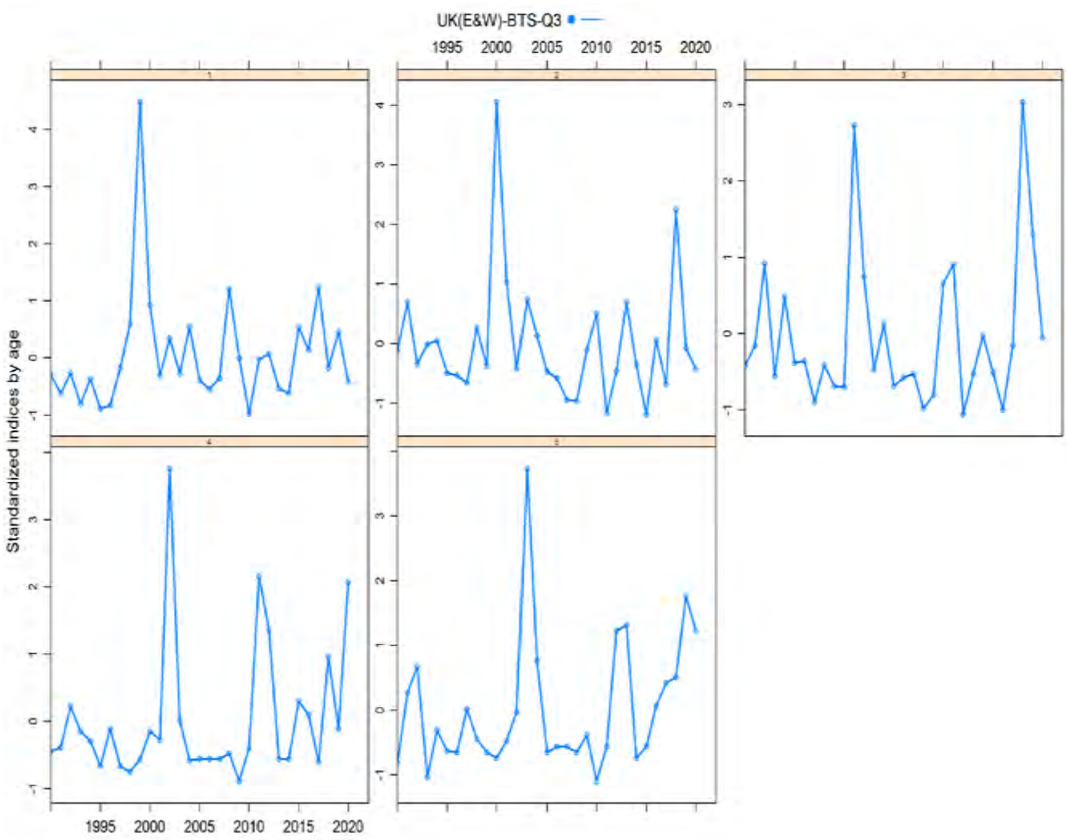


Figure 36.6 - Sol.27.7fg - Consistency plot UK(E&W)-BTS-Q3 survey

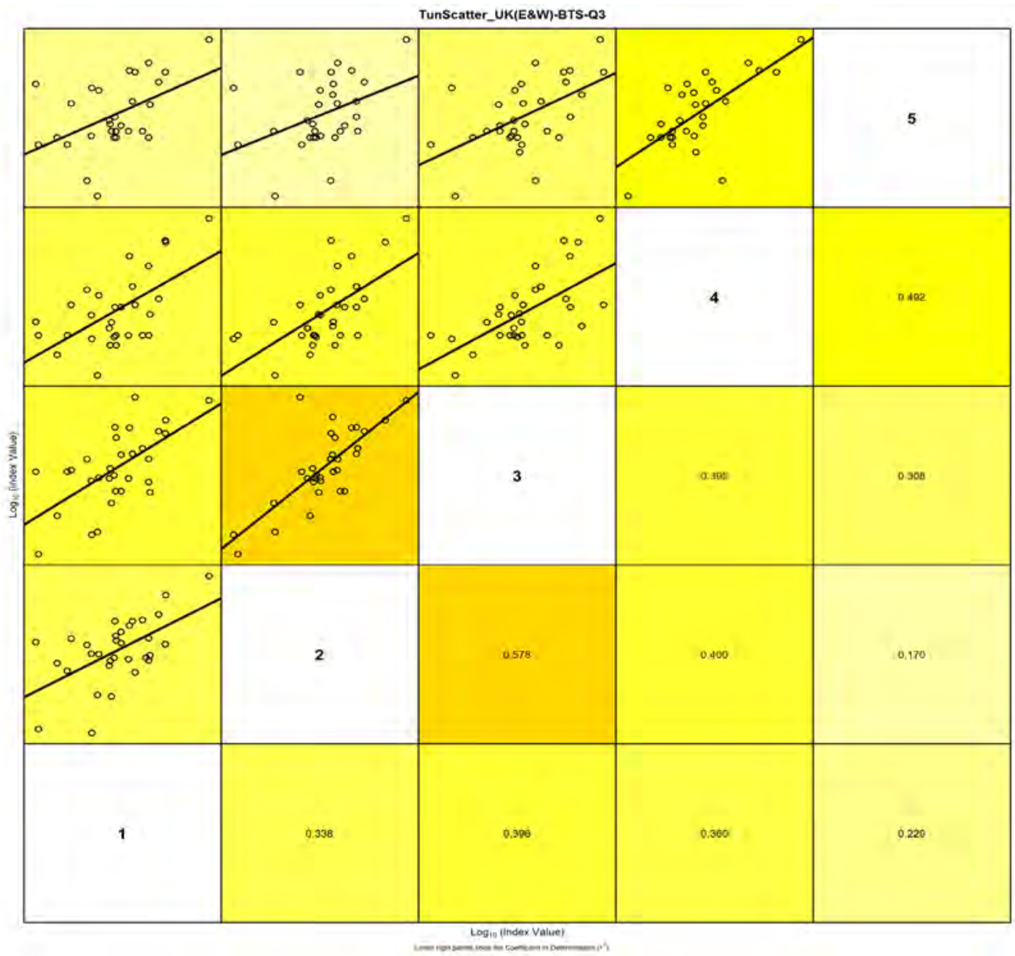


Figure 36.7 - Sol.27.7.fg - Effort (BE-CBT,IR-CBT,UK-CBT) and LPUE (kg/hour (BE-CBT and IR-CBT), kg/day (UK-CBT), kg/100km (UK-BTS-3Q))

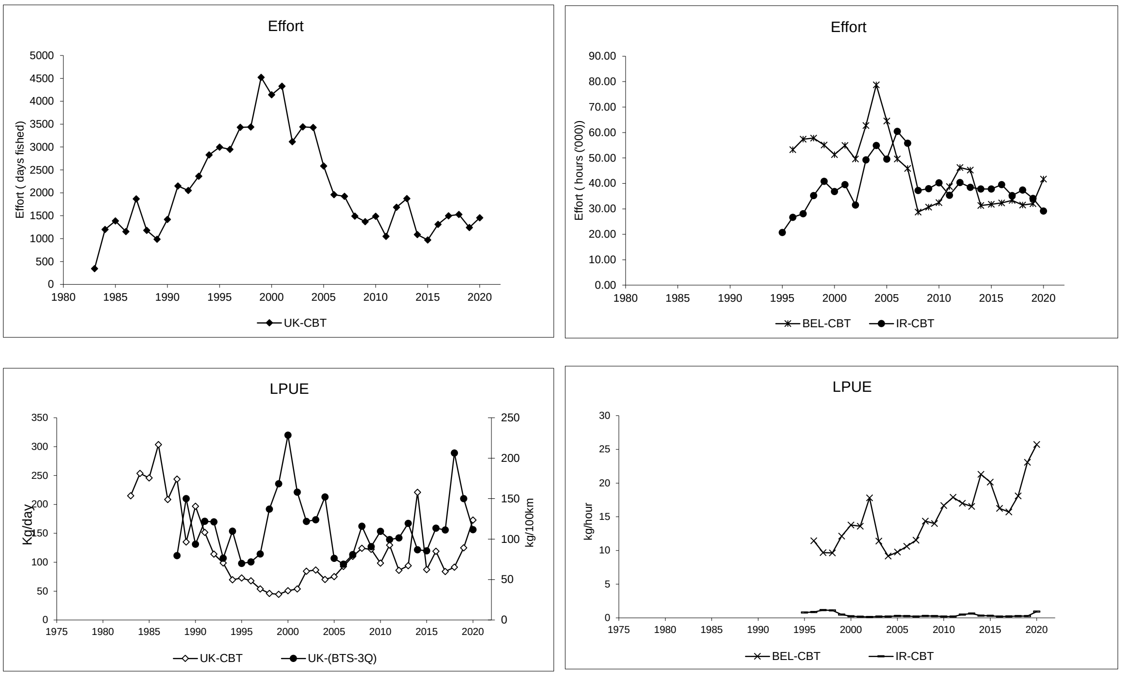


Figure 36.8 - Sol.27.7fg - Commercial biomass tuning indices

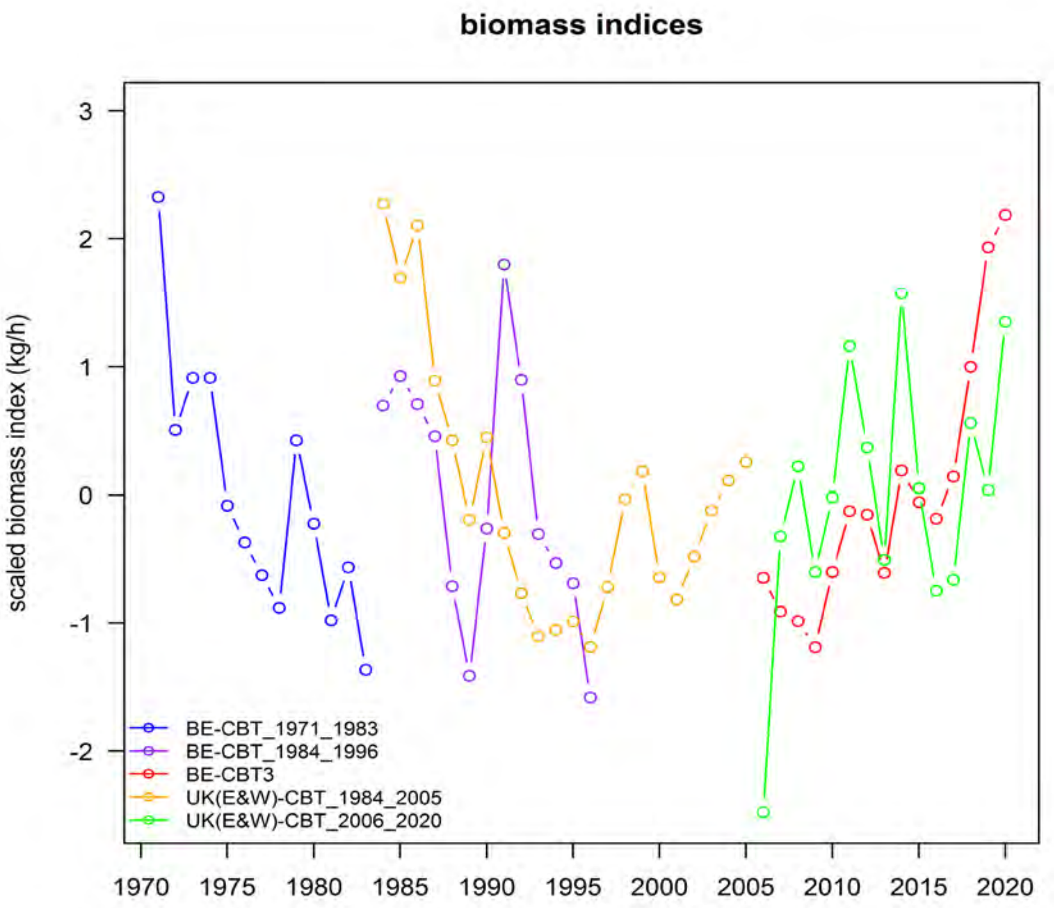


Figure 36.9 - Sol.27.7fg One Step Ahead residuals for the final SAM run

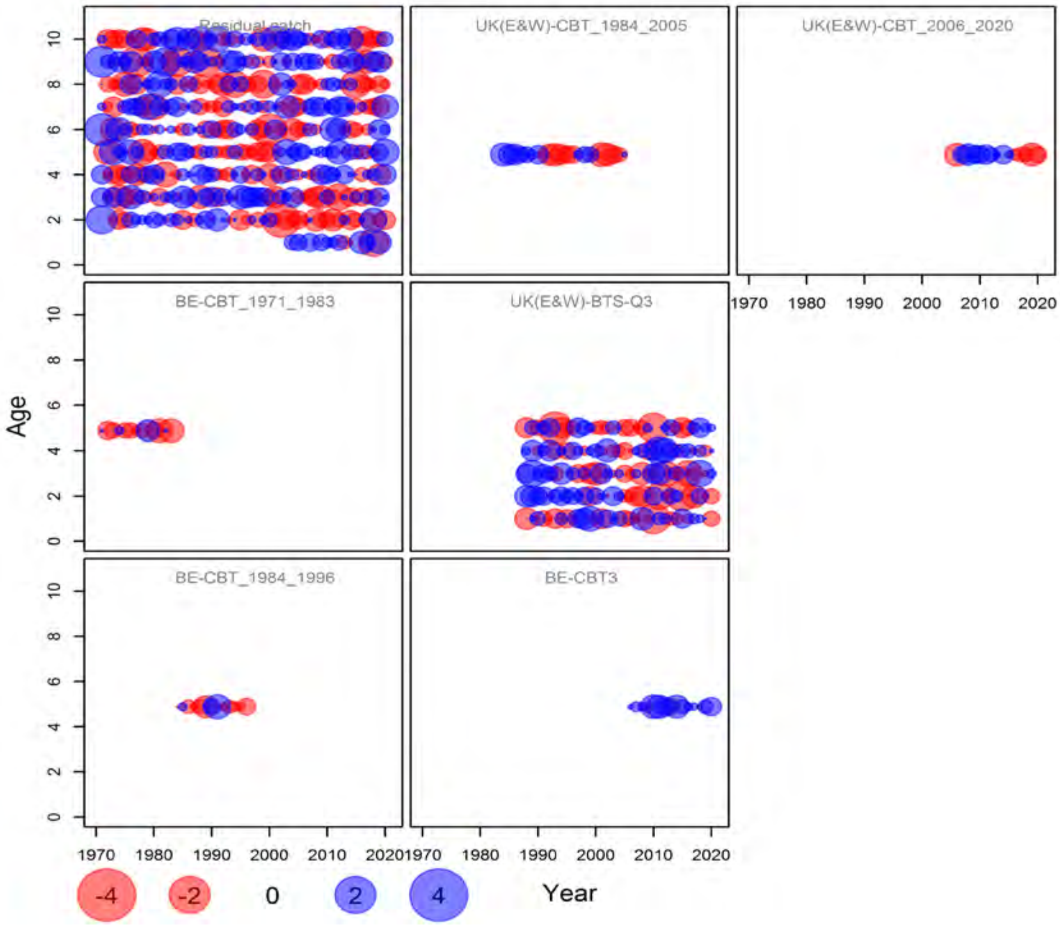


Figure 36.10- Sol.27.7fg - Retrospective

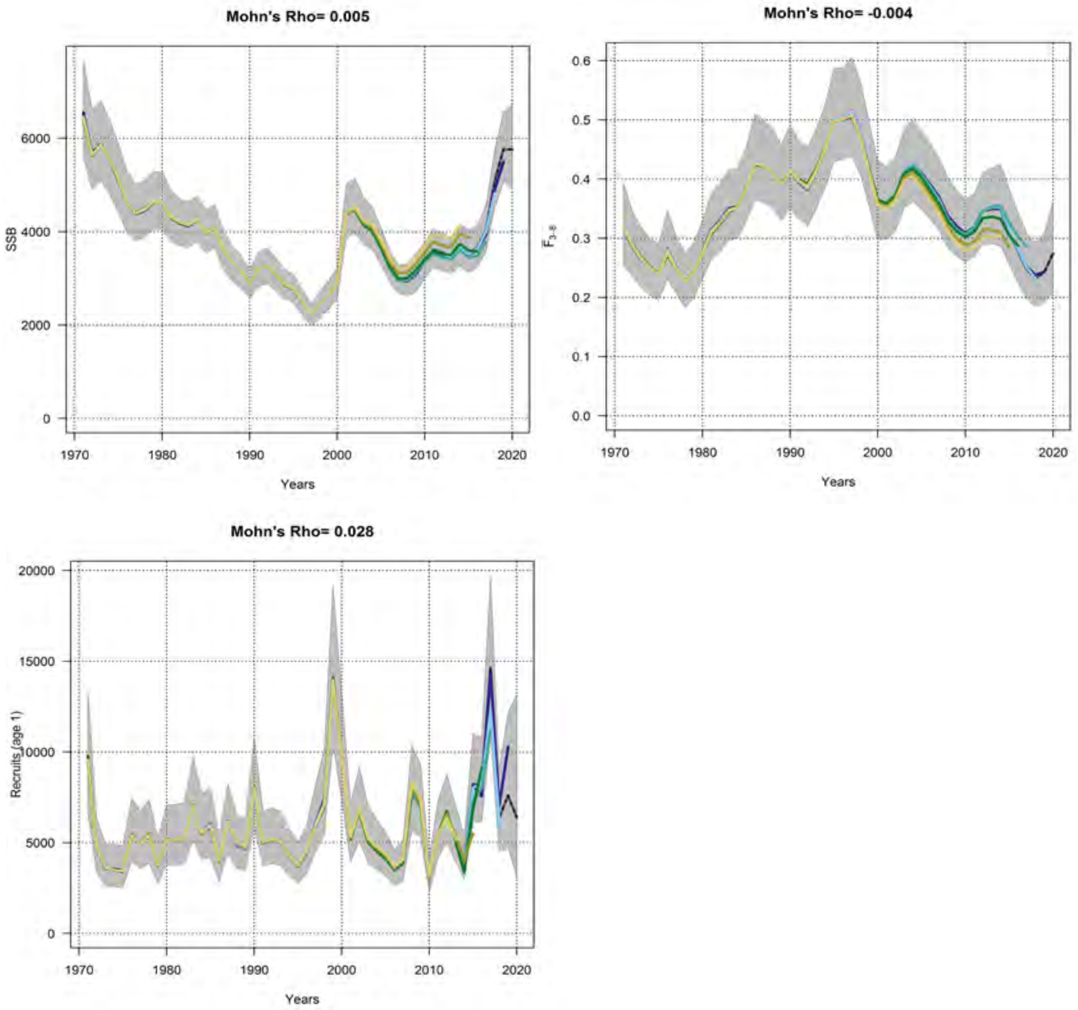


Figure 36.11 - Sol.27.7fg - Summary plots

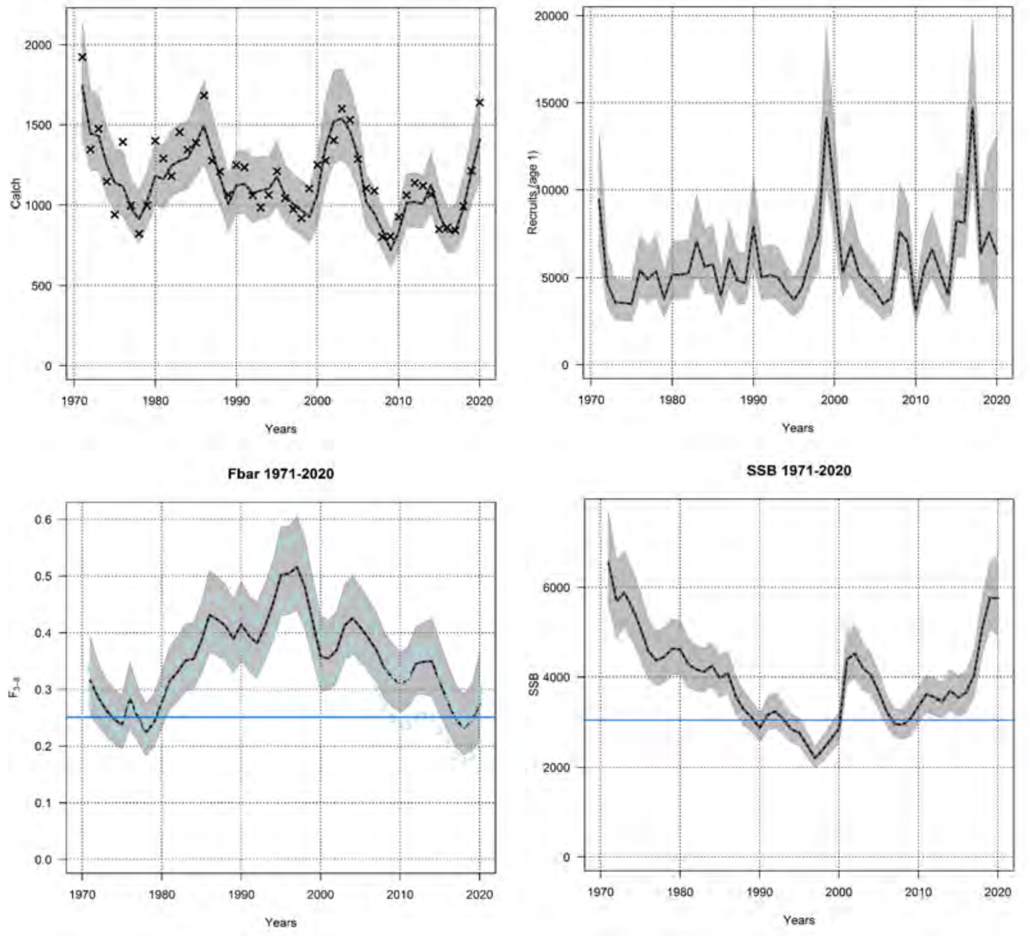


Figure 36.12 - Sol.27.7fg - Comparison with last year's assessment

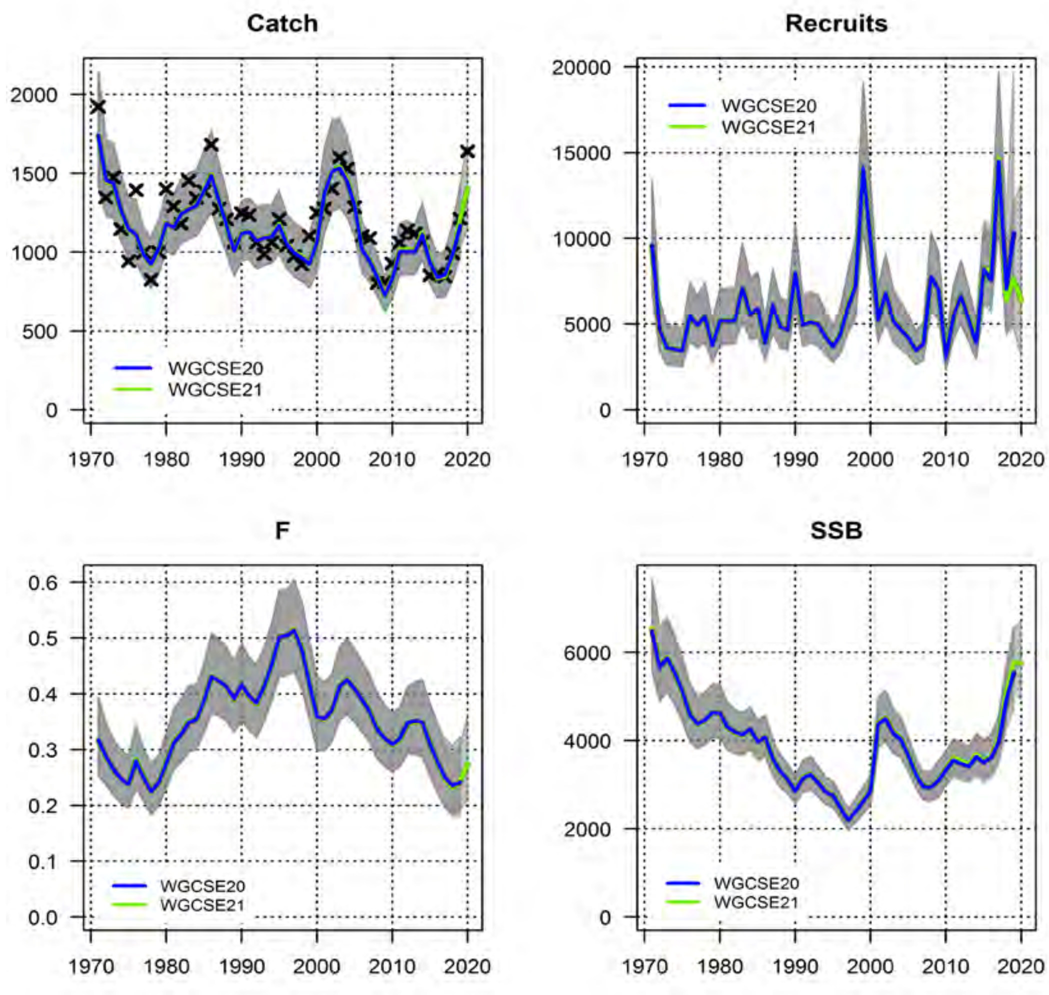
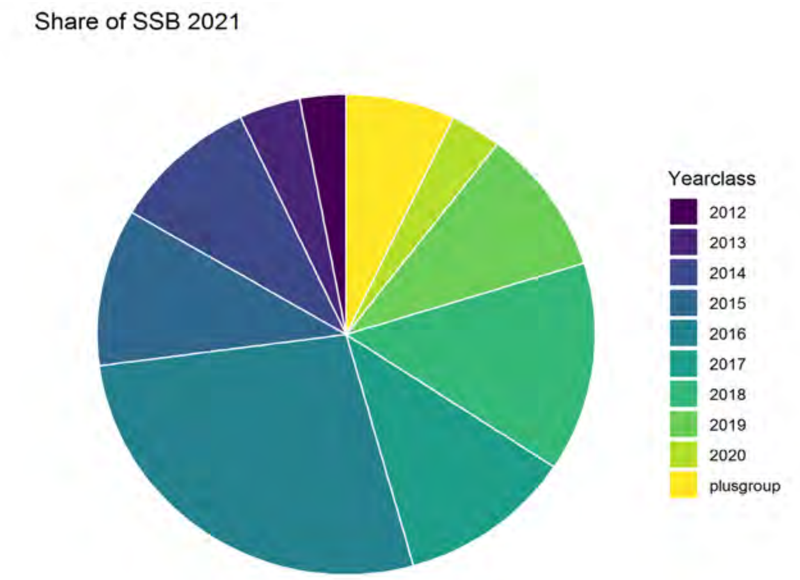


Figure 36.13 - Sol.27.7fg -
Year-class sources and contributions for the short-term forecast



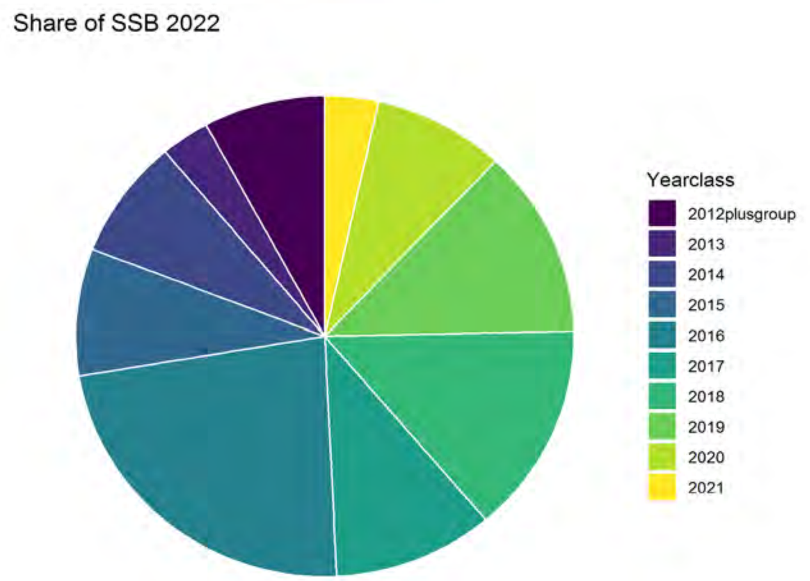
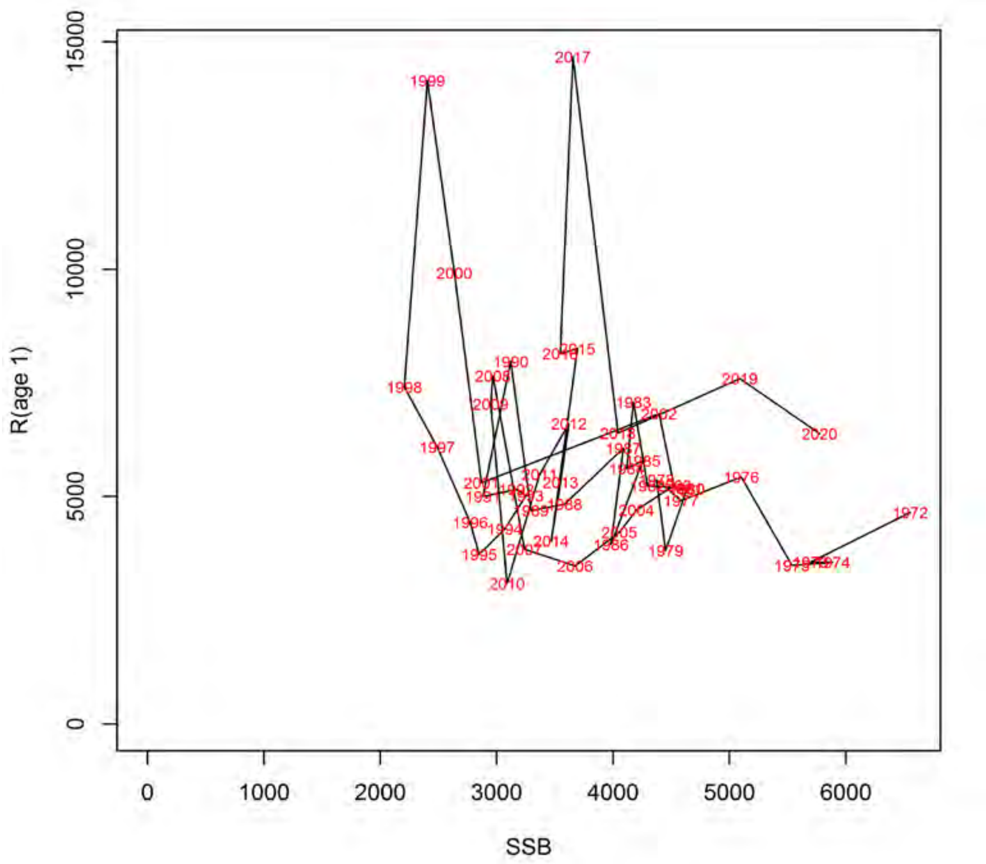
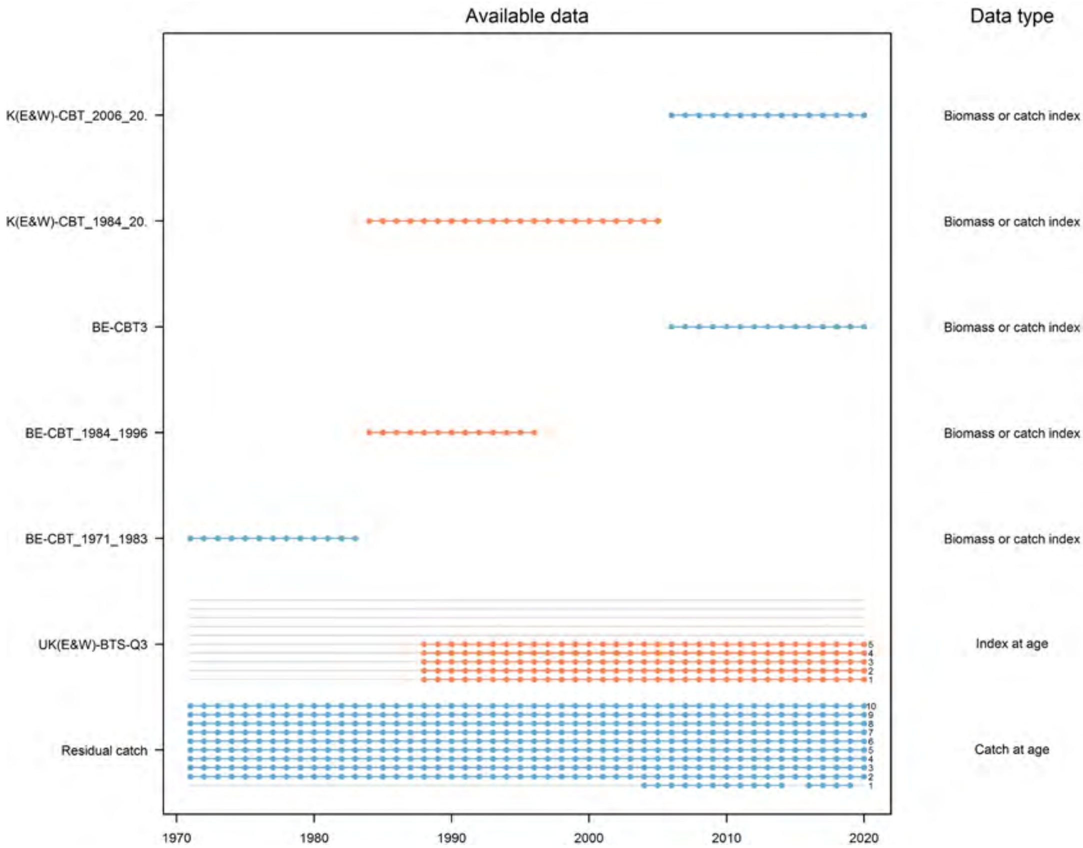


Figure 36.14 - Sol.27.7fg - Three year average exploitation pattern, standardised to Fbar (3-8)

Figure 36.15 - Sol.27.7fg - Stock/recruitment plot




Available data
Data type
K(E&W)-CBT_2006_20.
K(E&W)-CBT_1984_20.
BE-CBT3
BE-CBT_1984_1996
BE-CBT_1971_1983
UK(E&W)-BTS-Q3
Residual catch
Biomass or catch index
Biomass or catch index
Biomass or catch index
Biomass or catch index
Biomass or catch index
Index at age
Catch at age
1970
1980
1990
2000
2010
2020

34 Sole (*Solea solea*) in divisions 7.h–k (Celtic Sea South, southwest of Ireland)

Type of assessment in 2021

No assessment was performed as this is a category 5 stock. No precautionary buffer was applied as it was applied last year. Catches in 2022 should be no more than 213 tonnes.

ICES advice applicable to 2020

No assessment was performed. During the WKFlatNSCS benchmark this stock was moved from a category 3 to a category 5 stock. ICES advises that when the precautionary approach is applied, catches in 2021 should be no more than 213 tonnes.

https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/sol.27.7h-k.pdf

34.1 General

Stock identity

Sole is a valued, bycatch species in area 27.7hjk and represents a data-limited stock. This stock was benchmarked for the first time in 2020 as part of WKFlatNSCS (ICES, 2020). During the literature review for this benchmark, no information was found on the identity of this stock. A number of different auxiliary data sources were used to determine the geographical spread and behaviour of this fishery, and where possible its life-history parameters.

Landings data submitted to STECF Fisheries Dependant Information (FDI) (https://stecf.jrc.ec.europa.eu/dd/effort) were used to explore trends in the geographical spread and behaviour of fleets targeting sole in 7h–k. Unlike ICES InterCatch data, this data source provides a summary of landings by Member State, gear type, and statistical rectangle. The geographical separation between where the landings in 7h and 7j are taken, suggests that there are two discrete fisheries occurring in the stock area (Figure 34.1). This perception is further supported by the clear variation in the gears used to catch sole within the two ICES divisions. Within 7j, sole is predominantly landed by otter trawls, whereas the 7h fishery is mainly targeted by beam trawls (Figure 34.1 right). This would suggest the two separate assessments are required to effectively manage this fishery.

Due to the data-poor nature of this fishery, there is currently no reliable evidence by which to separate the population of sole in 7h and 7j. However, geographical distribution of the landings data would suggest that the fleets are targeting of two discrete populations. Therefore, it is the recommendation of this group to propose sole in 7h–k to the stock identity working group (SIMWG) for further discussion on the possible separation.

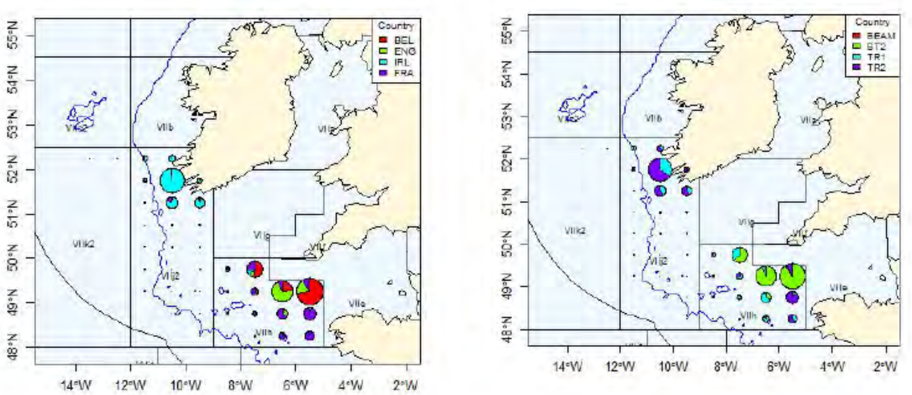


Figure 34.1. The spatial distribution of sole landing as reported to the STECF FDI data call in 2016. The landings are plotted by statistical rectangle and show the relative landings reported by Member State (left) and gear type (right), and weighted by the overall landings of sole in ICES divisions 7hjk in 2016.

Management applicable to 2021 and 2020

TAC table 2021

The finalised total allowable catch (TAC) was not available for 2021 at the time of the working group.

TAC table 2020

Species:	Common sole *Solea solea*	**Zone:**	7h, 7j and 7k (SOL/7HJK.)
Belgium	27	Precautionary TAC	
France	55	Article 7(2) of this Regulation applies	
Ireland	148		
The Netherlands	44		
United Kingdom	55		
Union	329		
TAC	329		

Landings obligation

In 2016, the landings obligation applied to this stock for the first time. According to the regulation (EC, 2015) vessels where more than 5% of their landings using beam trawls were sole during the reference years (2013 and 2014) in ICES divisions 7.b, 7.c and 7.f–7k will be covered by the Landings Obligation. The landings obligation also applies to all catches of sole with trammelnets or gillnets. These vessels will have to land all sole from 2016 onwards. However, a *de minimis* exemption also applies, allowing for up to a maximum of 3% of the annual catch to be discarded. Given the low discards observed in the fishery the landings obligation considered to have had no significant impact on this stock or the advice given.

34.2 Data

34.2.1 Landings and discards

The official and ICES estimates of landings are presented in Table 35.1. The differences between the official and ICES estimated of landing is shown in the unallocated column.

Misreporting is considered to be an issue for this stock but remains difficult to fully quantify. In the past, deviations between official catch statistics and ICES estimates of landings may be due to this misreporting, driven by restrictive TACs in this area (7h–k) and adjoining areas (7e), but also the completeness of data submitted to ICES. Since 2004, these deviations are less due to an improvement in the quality of the data submitted to ICES following on from the introduction of the Data Collection Regulation (EU 2001). Discarding of sole in 7.jk is considered negligible.

34.3 Historical stock development

This stock was benchmarked during WKFlatNSCS in 2020 to address the inclusion of available new landings-at-age data for the Division 7.h component, fishery-independent indices, and to consider stock identity (ICES, 2020a). The benchmark concluded that there was no appropriate method for evaluating the stock status and trends, as the sampling only covers a small part of the total fishery, which is not considered representative of the whole area. Therefore, the benchmark agreed to use category 5 to provide advice for this stock.

Prior to the benchmark sole in h–k was defined as a category 3 stock as was assessed using an XSA model with commercial landings and lpue from area 27.7j as data inputs. However, during the benchmark it was concluded that this stock should be assessed as a category 5. The age data from the landings-at-age data were presented and indicated that cohort tracking was relatively poor. Landings data were available, but age information was not available from area 27.7h and precluded using XSA to assess the stock in this area. During previous assessments, it was assumed that the trends in areas 27.7jk were representative of 27.7h. The assessment results from the previous assessment were presented during the workshop. The model resulted in relatively poor fits to the data and severe retrospective variability, although the Mohn's rho was within the range of acceptability.

The TAC area includes Division 7h. However, the landings from divisions 7jk are taken in the northeastern part of Division 7j which is remote from the northern part of Division 7h, where most of the Division 7h landings are taken. It is likely that the sole from Division 7h are part of the divisions 7e or 7fg stocks. No further information on stock structure is likely to become available in the short term.

The catches are taken in a mixed-fisheries and should be managed as such. Constraining the landings by TAC will not constrain the catches. Because sole are caught in spatially distinct areas, restricting effort in these areas will be more effective than limiting landings. The TAC is currently not restrictive, but for some countries, the quota appears to have become restrictive.

A commercial index of landings per unit of effort (lpue) is available for the Irish fleet in 27.7j and it indicates a decreasing trend in lpue since a peak in 2016 (Figure 34.2). No other lpue index is available in this stock area.

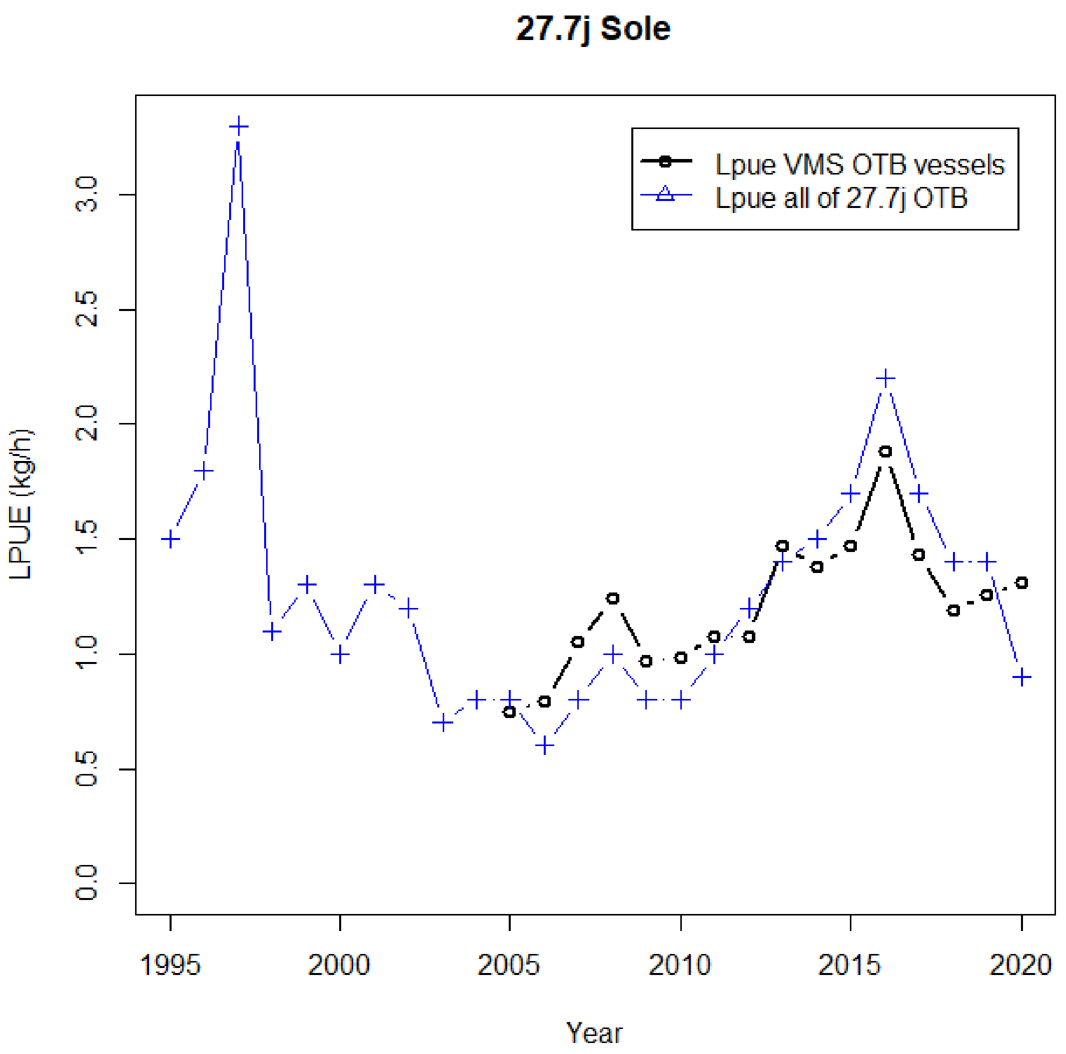


Figure 34.2. The trend in VMS lpue index of the Irish OTB fleet (black line) compared and the lpue of sole taken by all vessels and gears in the Irish fleet in 27.7.j.

34.4 References

ICES. 2020. Benchmark Workshop for Flatfish stocks in the North Sea and Celtic Sea (WKFlatNSCS). ICES Scientific Reports. 2:23. 966 pp. http://doi.org/10.17895/ices.pub.5976.

EU. 2001. Commission Regulation (EC) No 1639/2001 of 25 July 2001 establishing the minimum and extended Community programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No 1543/2000.

Table 34.1. Sole in divisions 7.h–k. History of official landings by country and ICES estimated landings (tonnes).

Year	Official landings						ICES landings	ICES discards
	Belgium	France	UK	Ireland	Other countries	Total		
1951	21	150	91	56	0	318		
1952	37	220	88	44	0	389		
1953	23	227	100	54	0	404		
1954	13	317	167	75	0	572		
1955	125	634	174	65	0	998		
1956	251	511	98	64	0	924		
1957	454	359	86	67	0	966		
1958	397	605	72	88	0	1162		
1959	241	576	61	101	0	979		
1960	0	506	48	96	0	650		
1961	197	525	61	110	0	893		
1962	144	397	31	123	0	695		
1963	149	502	25	127	0	803		
1964	310	578	34	118	0	1040		
1965	335	1128	15	123	0	1601		
1966	123	0	36	118	0	277		
1967	168	474	20	123	0	785		
1968	113	474	29	116	0	732		
1969	175	633	23	120	0	951		
1970	436	537	19	122	0	1114		
1971	394	1382	4	93	0	1873		
1972	203	1011	11	131	7	1363		
1973	406	390	6	108	4	914		
1974	369	143	5	116	15	648		
1975	210	207	24	97	2	540		
1976	638	19	11	152	33	853		
1977	519	103	12	126	140	900		

Year	Official landings						ICES landings	ICES discards
	Belgium	France	UK	Ireland	Other countries	Total		
1978	290	23	11	73	60	457		
1979	384	29	18	109	0	540		
1980	522	27	42	162	0	753		
1981	576	107	83	195	0	961		
1982	471	104	108	172	0	855		
1983	411	176	129	176	51	943		
1984	474	120	151	156	194	1095		
1985	318	25	200	201	280	1024		
1986	442	38	261	188	3	932		
1987	271	44	193	168	0	676		
1988	254	53	166	182	0	655		
1989	252	84	177	206	0	719		
1990	353	66	144	266	0	829		
1991	358	55	234	306	0	953		
1992	312	43	217	255	0	827		
1993	317	44	214	237	0	812		
1994	338	42	174	184	0	738		
1995	433	47	192	243	0	915		
1996	375	50	148	182	70	825	443	
1997	368	58	113	203	0	742	564	
1998	346	74	111	221	7	759	423	
1999	101	0	97	207	1	406	381	
2000	8	78	95	111	10	302	329	
2001	13	99	111	124	0	347	325	
2002	154	108	124	129	0	515	430	
2003	170	133	78	105	0	486	245	
2004	157	102	79	111	0	449	454	7
2005	90	93	112	97	0	392	375	1

Year	Official landings						ICES landings	ICES discards
	Belgium	France	UK	Ireland	Other countries	Total		
2006	36	99	88	63	1	288	230	1
2007	31	79	91	77	0	278	232	2
2008	10	58	80	72	0	220	221	1
2009	11	79	58	61	0	208	188	0
2010	20	87	51	71	0	228	206	0
2011	10	95	54	65	0	224	208	0
2012	18	85	46	85	0	234	212	1
2013	4	76	47	85	0	213	204	0
2014	42	61	54	85	0	242	207	0
2015	40	74	53	77	0	244	226	0
2016	91	77	63	99	0	330	269	1
2017	75	81	39	86	0	281	250	4
2018	96	91	33	63	0	283	235	1
2019*	75	88	48	70	8	288	308	1
2020*	88	102	50	37	7	284	299	<1

*** Preliminary data.**

35 Whiting (*Merlangius merlangus*) in Division 6.a (West of Scotland)

Type of assessment in 2021

Following the decision made during the benchmark meeting WKNSEA 2021 (ICES, 2021), this year's assessment was carried out using the state-based assessment model (SAM; Nielsen and Berg, 2014) along with catch and survey data. The assessment followed the procedure outlined in the Stock Annex. A forecast was conducted with short-term stochastic projections according to model and forecast assumptions agreed upon at the WG meeting. These differ to the assumptions agreed at the benchmark and detailed in the Stock Annex as it was believed to be important to account for the change in discarding which appears to have occurred in the fishery since the full implementation of the landing obligation in 2019. (Further details in Section 35.4).

ICES advice applicable to 2021

ICES advises that when the precautionary approach is applied, there should be zero catches in each of the years 2021 and 2022.

http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2020/2020/whg.27.6a.pdf

Although biennial advice was issued in 2020, following the benchmark in 2021, the perception of stock status has changed substantially and therefore new advice is issued this year for 2022.

ICES advice applicable to 2019 and 2020

ICES advises that when the precautionary approach is applied, there should be zero catch in each of the years 2019 and 2020.

http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/whg.27.6a.pdf

35.1 General

Stock description

General information is presented in the Stock Annex.

Management applicable to 2020 and 2021

The TAC for whiting (in tonnes) is set for ICES subareas 6, 12 and 14 and EU and international waters of ICES Division 5b, for 2021 and 2020 is shown below.

TAC for 2021

The agreed TAC was not available.

TAC for 2020

Species:	Whiting *Merlangius merlangus*		Zone:	6; Union and international waters of 5b; international waters of 12 and 14 (WHG/56-14)
Germany	3	(1)	Analytical TAC	
France	57	(1)	Article 8 of this Regulation applies	
Ireland	273	(1)	Article 3 of Regulation (EC) No 847/96 shall not apply	
United Kingdom	604	(1)	Article 4 of Regulation (EC) No 847/96 shall not apply	
Union	937	(1)		
TAC	937	(1)		

(1) Exclusively for by-catches of whiting in fisheries for other species. No directed fisheries for whiting are permitted under this quota.

(Council Regulation (EU) 2020/123).

Fishery in 2020

A description of the fisheries in the West of Scotland is given in the Stock Annex.

The year 2019 ended the transition period in the imposition of the landing obligation and in 2020, the obligation applied in full force. The increased TAC (in 2019–2020) following the introduction of the landing obligation has resulted in an increase in landings, although quota uptake has declined.

Total landings (nominal landings, ICES statistics) in 2020 were 537 t, up by 11% from 2019 (Table 35.1). They were the highest in the last 16 years. The majority were landed by Scottish and Irish vessels, and smaller amounts by Danish, Dutch and French vessels. The UK landings in Division 6.a in 2020 constituted two thirds of the quota for the UK, while Ireland used half of its quota. Total landings in 2020 constituted 57% of the TAC for that year.

The total estimated international catch of all age groups in 2020 was 1375 t, of which 834 t were discards (Table 35.2). Of the discards, 92% were discarded by the trawl fleet targeting crustaceans (*Nephrops*).

Mandatory introduction of larger square mesh panels for the *Nephrops* fleet in 2008 seems not to have had much of an effect on the discards of whiting in Division 6.a. In terms of quantity, the discards in 2020 (all ages) were lower (by 13%) than those in 2019, and also below the average in the last decade. In terms of discard rate (discards as a proportion of catch), they were the lowest in the last 12 years (Table 35.2).

The general perception from fishermen is that large number of whiting are being discarded by the *Nephrops* fleet, and that the numbers of smaller whiting has increased substantially in recent years, but mainly in inshore areas.

35.2 Data

Landings

Total landings, as officially reported to ICES, are shown in Figure 35.1 (in 1965–2020) and Table 35.2 (in 1989–2020).

In the past, there had been concerns that the quality of landings data was deteriorating, giving a possible reason for the different stock dynamics implied by the commercial fleet and the annual survey (ScoGFS-WIBTS-Q1) being in operation at that time (see Section 5.1.6.1.3 in the 2005 WG Report; ICES, 2005). However, a review of previously supplied estimates of misreporting and underreporting (ICES, 2012) carried out at WKNSEA (ICES, 2021) suggested this to have been a relatively minor issue (in the order of ~5% of total landings) in the past (since 2001). Therefore, the benchmark agreed that no catch scaling factor for the period 1995–2006 was required in which it differs from previous analytical assessments of this stock (ICES, 2020a).

During WKDEM 2020, the catch data (landings and discards) for 2003 onwards were revised using InterCatch (ICES, 2020b). The age structure in unsampled landings was estimated from that in sampled landings. This was done separately for the two fleets, TR1 (gadoid fishery) and TR2 (*Nephrops* fishery), on account of the different discard rates observed in them.

The sampling levels in 2020 were lower compared to previous years due to COVID-19. The number of primary sampling units (PSU = number of trips sampled) in the area from 2016 to 2020 is shown in the table below:

Year	UK (Scotland)				Ireland			
	Landings		Discards*		Landings		Discards*	
	TR1	TR2	TR1	TR2	TR1	TR2	TR1	TR2
2020	11	1	12	4	28	0	20	0
2019	16	0	18	23	23	0	28	0
2018	14	1	11	30	28	0	60	0
2017	11	0	13	39	23	0	48	0
2016	13	1	13	36	19	0	40	0

*** The number of sampled trips that took place.**

Landings uploaded to InterCatch by métier and country for 2020 are shown in Figure 35.2. As in previous assessments, age distributions were estimated from market samples. Total catch (including landings) by métier for 2020 is shown in Figure 35.3. Catch numbers-at-age (including landings) from 2003 onwards are shown in Figure 35.4. Annual numbers-at-age in the landings are given in Table 35.3. Annual mean weights-at-age in the landings are given in Table 35.6 and shown in Figure 35.5. Last year, they increased slightly in most age groups. Overall, the mean weights-at-age in the landings have been variable in recent years due to the variability associated with low sample sizes. Efforts to increase sampling in these fisheries are being pursued.

Discards

This WG's estimates of discards have been based on data collected in the Irish and Scottish discard programme and raised by landings. Discard age compositions from Scottish and Irish samples have been applied to unsampled fleets. As agreed at WKDEM 2020, the raising and age allocations for discards were done separately for the TR1 and TR2 fleets (ICES, 2020b).

Discards uploaded to InterCatch by métier and country for 2020 are shown in Figure 35.2.

Annual numbers-at-age in the discards are given in Table 35.4. Annual mean weights-at-age in the discards are given in Table 35.7 and shown in Figure 35.5. No whiting in the 0-group were recorded in 2020 as the samples were taken only in the first quarter and this was caused by COVID-19. Also, for the same reason, mean weights-at-age 1 in discards were considerably lower compared to previous years.

Biological

Annual numbers-at-age in the total catch are given in Table 35.5. Annual mean weights-at-age in the total catch are given in Table 35.8 and shown in Figure 35.5.

In previous assessments, mean catch weights-at-age were used as mean stock weights-at-age. This year, the latter were estimated using the method elaborated at WKNSEA 2021 (ICES, 2021) that combines catch and survey weights-at-age (see the Stock Annex). Two sets of stock mean weights-at-age are delivered: one to be used as stock weights-at-age input into the SAM stock assessment model to calculate SSB, and one to be used to estimate size-dependent natural mortality-at-age. The estimates from the former (smoothed with a General Additive Model, GAM) are shown in Table 35.9.

In previous assessments of whiting in Division 6.a, natural mortality was assumed to vary and be dependent on fish weight (Lorenzen, 1996). *M* values were time-invariant and were calculated as:

$$M_a = 3.0\overline{W}_a^{-0.29}$$

where M_a is natural mortality-at-age *a*, $\overline{W}_a$ is the mean stock weight-at-age *a* (in g) and the numbers are the Lorenzen's parameters for fish in natural ecosystems.

During WKNSEA in 2021, it was agreed to first smooth the time-series of stock mean weights-at-age using a GAM and then use these smoothed weights-at-age in the Lorenzen (1996) equation to obtain a time-series of mortality-at-age estimates to be used as input in the stock assessment model (ICES, 2021).

The time-series of smoothed stock mean weights-at-age obtained from a combination of catch data and survey data from Q1 and Q4 are used in the Lorenzen equation. The smoothed stock mean weights-at-age are shown in Figure 35.6. These estimated natural mortality at age is shown in Table 35.10 and Figure 35.7.

In earlier assessments, maturity-at-age was assumed to be knife-edge with the value 0 at age 1 and full maturity-at-age 2+. An analysis of Scottish survey data conducted at WKDEM 2020 and updated at WKNSEA 2021, showed no clear temporal trends in maturity (ICES, 2020b; ICES, 2021). The analysis provided coefficients of the logistic model (being time-invariant, with data up to 2020): -6.307 (intercept) and 5.228 (slope). The midpoint of the modelled maturity ogive, A50, was estimated to be 1.206 (±0.031) years. The estimated proportions of mature whiting are shown in the table below:

Age	0	1	2	3	4	5	6	7+
Maturity ogive	0	0.254	0.984	1	1	1	1	1

The analysis revealed that considerable proportion of fish at age 1 (a quarter) and nearly all fish at age 2 were mature. There was little variability in the data resulting in relatively narrow confidence intervals (ICES, 2021).

Surveys

Five research vessel survey series for whiting in 6.a were available to the WG in previous years. They included the two 'old' Scottish surveys:

- Scottish first-quarter west coast groundfish survey (ScoGFS-WIBTS-Q1): all ages 1 and older, years 1985–2010;
- Scottish fourth-quarter west coast groundfish survey (ScoGFS-WIBTS-Q4): all ages including age 0, years 1996–2009.

The Q1 Scottish Groundfish Survey was performed using a repeat station format with the GOV survey trawl together with the west coast groundgear rig 'C'. The Q4 Scottish Groundfish Survey also used the GOV survey trawl with groundgear 'C' and the fixed station format. The Q4 survey was not carried out in 2010 due to an engine break down of the research vessel.

In 2011, the Q1 and Q4 Scottish Groundfish Surveys were re-designed. The previous repeat station survey format consisting of the same series of survey trawl positions being sampled at approximately the same temporal period every year is considered a rather imprecise method for surveying both these subareas. Therefore, a move towards some sort of random stratified survey design was judged necessary (see further details of the modified survey design in the Stock Annex). The introduction of the new design initiated two 'new' time-series:

- Scottish first-quarter west coast groundfish survey (UK-SCOWCGFS-Q1): all ages 1 and older, years 2011–2020;
- Scottish fourth-quarter west coast groundfish survey (UK-SCOWCGFS-Q4): all ages including age 0, years 2011–2019.

The distribution and densities of whiting at-age (standardised as cpue) in the Q1 and Q4 surveys in 2017–2021 are shown in Figure 35.8. The Q4 survey in 2013 was not fully implemented due to adverse weather conditions. It covered only the northern half of Division 6.a and therefore, the index for that year was not used in assessments prior to 2020. The Q1 survey in 2021 has recently been completed and processed. As a result, 11 years of data are currently available in the time-series for the Q1 survey and nine years of data for the Q4 survey (as valid indices).

The Irish Groundfish Survey has partly been conducted in Division 6.a:

- Irish fourth-quarter west coast groundfish survey (IGFS-WIBTS-Q4): all ages including age 0, years 2003–2020.

The distribution and densities of whiting at-age in the two Q4 surveys, UKSGFS-WIBTS-Q4 and IGFS-WIBTS-Q4 in 2016–2020 are shown in Figure 35.9 (only the southern part of Division 6.a). The Irish survey uses the RV Celtic Explorer and is part of the IBTS coordinated western waters surveys. The vessel uses a GOV trawl, and the design is a depth-stratified survey with randomised stations. Effort is recorded in terms of minutes towed. The previous Irish survey (IreGFS), being in operation in 1993–2002 (see the Stock Annex), is not used anymore in the assessment.

Further descriptions of the above five surveys can be found in 'Manual of the IBTS North Eastern Atlantic Surveys' (ICES, 2017) and in the last IBTSWG report (ICES, 2020c).

During WKNSEA 2021, it was agreed to combine all the three Q4 surveys into one survey index for use in the stock assessment (ICES, 2021). The analysis of the combined index was conducted using a GAM-based delta-lognormal model Berg *et al.* (2014) including a number of explanatory variables. The combined index (denoted as Comb-WCGFS-Q4) derived from the model fit is shown on Figure 35.10. The index provides a more complete representation of the population compared to the respective indices used on their own. It simplifies the modelling procedure in the annual assessments of the stock (with three rather than five indices) and provides a longer continuous time-series.

Commercial cpue

Four commercial catch-effort time-series were previously available to the WG, but they have not been used for a number of years. They are only presented in the Stock Annex.

35.3 Stock assessment

In the years 2011–2019, the assessment was done using a Time-Series Analysis (TSA) model (Gudmundson, 1994; Fryer, 2002; Needle and Fryer, 2002). At that time, the stock was classified as category 1. During the benchmark process of WKDEM 2020, it was found that running TSA with the new data and changed survey configuration posed a challenge (ICES, 2020b). Poorly converged optimisation runs (with some parameters being found on the boundary of the assumed parameter space) in conjunction with excessive running times were a major obstacle to complete the assessment successfully. In these circumstances, it was decided *ad hoc* to run the benchmark assessment using an alternative method; namely, a SPiCT model (Pedersen and Berg, 2017). At the same time, the stock was downgraded to category 3 and further to category 5 according to the ICES guidelines for data-limited stocks (ICES, 2019).

In the benchmark process of WKNSEA 2021, it was decided to use SAM as the assessment method (ICES, 2021). It was agreed that the model should be run over the entire time period for which catch numbers-at-age data were available in order to capture the earliest part of the time-series (during which catches were relatively high). To facilitate this in SAM, it was assumed that catch and discards mean weights-at-age zero between 1981 and 2002, and landings mean weights-at-age zero for the entire modelled time period, were equal to the average of mean weights-at-age zero between 2003 and 2020. In addition, stock mean weights-at-age and natural mortality-at-age between 1981 and 1984 were assumed to equal estimates for the equivalent quantity from the earliest available year (i.e. 1985). Catch numbers-at age zero are only available from 2003 onwards (from the WKDEM data call) and therefore values between 1981 and 2002 were treated as missing and estimated in the assessment model.

Data screening

The diagnostics for commercial catch data and the three indices considered as tuning series (ScoGFS-WIBTS-Q4, UK-SCOWCGFS-Q1 and Comb-WCGFS-Q4) for the assessment are shown in Figures 35.11–35.13).

The log catch curves for the commercial catch and for the surveys in the current assessment are shown in Figure 35.11. In most cases, the curves are relatively linear and not very noisy. They also show a fairly steep and consistent drop in abundance. The curves for the commercial catch have a strong 'hook', especially at age 0 (from 2003 onwards).

The plots of mean standardised catch proportions at age by year (Figure 35.12) demonstrate that there is some general consistency in the estimates of year-class strength across age groups. They indicate strong year classes in recent years (2009 and 2014 year classes), but also markedly weak year classes (2012 and 2017 year classes). A clear year effect can be seen for ages 1+ in 2007 and 2008.

The within-survey correlation plots generally show significant correlations between consecutive age groups (Figure 35.13). There is a general consistency in the estimates of year-class strength across age groups, but the points are more scattered for old age groups.

The three indices used as tuning series in the current assessment are shown in Table 35.11.

Final assessment

Model used: SAM

Software used: stockassessment package in R; stockassessment.org

Input data types and characteristics:

- Catch numbers-at-age: ages 1–7+, 1981–2020; age 0, 2003–2019
- Landings fraction-at-age, ages 0–7+, years 1981–2020,
- Catch weights-at-age: ages 1–7+, 1981–2020; age 0, 2003–2019
- Landings weights-at-age, ages 0–7+, years 1981–2020,
- Discards weights-at-age: ages 1–7+, years 1981–2020; age 0, 2003–2019
- ScoGFS-WIBTS-Q1, ages 1–6, years 1985−2010,
- UK-SCOWCGFS-Q1, ages 1–6, years 2011–2021,
- Modelled Q4 index, Comb-WCGFS-Q4, fitted to data from ScoGFS-WIBTS-Q4 (G4299), UK-SCOWCGFS-Q4 (G4815), and IGFS-WIBTS-Q4 (G7212); ages 0–7+ with variance estimates; 1996–2020.

Zero age-0 discards were recorded in 2020. This is assumed to be due to a lack of discard sampling in the *Nephrops* fishery from Q2 onwards and therefore age 0 discards are treated as missing in 2020 (as in the years before 2003). Missing catch weights-at-age zero are assumed equal to the average of 2003–2019.

The assessment of whiting in 6.a was conducted using a SAM model fitted to the updated catch and survey dataseries. Full details of the model implementation are presented in the Stock Annex. The SAM configuration file for the final assessment model run is given in Table 35.12. To summarise the main configuration settings:

- Fishing mortality states processes are uncoupled across all age classes.
- Catchabilities for each survey index are freely estimated with the exception of the two oldest age classes for each index; ages 5 and 6 in ScoGFS-WIBTS-Q1 and UK-SCOWCGFS-Q1, and ages six and seven+ in Comb-WCGFS-Q4.
- Catch observation variance parameters are allowed to differ for age 0 and age 7+ while all other age groups are coupled.
- Survey observation variance parameters are coupled across all ages for ScoGFS-WIBTS-Q1 and UK-SCOWCGFS-Q1, whereas for Comb-WCGFS-Q4 observation variance parameters were uncoupled for age zero, and coupled for ages 1 to 4 and ages 5 to 7+.
- The catch, ScoGFS-WIBTS-Q1, and UK-SCOWCGFS-Q1 fleets are modelled with independent covariance structures, whereas the Comb-WCGFS-Q4 fleet is modelled with a first order autoregressive variance structure (AR1) with ages 0 and 1, ages 1 to 6, and ages 6 and 7+ coupled.
- Recruitment is modelled as a random walk.
- $\bar{F}$ was calculated for ages 1 to 3 in order to reflect changes in fishery selectivity, moving from a target fishery in the 1980s and 1990s to a bycatch and discard component of the *Nephrops* trawl fishery from the early 2000s onwards. This is a change from previously accepted analytical assessments of this stock which used an $\bar{F}$ range of ages 2 to 4.

Table 35.13 shows the SAM parameter estimates for the assessment model. Table 35.14 shows the population numbers-at-age estimated in SAM, and estimated F-at-age is shown in Table 35.15. A summary of the full model output is detailed in Table 35.16. The summary plots for the final assessment are shown in Figure 35.14.

The fits of the model to observations (catch and survey indices on a log scale) are shown in Figure 35.15. The fits to the ScoGFS-WIBTS-Q1 appear better at younger ages while for ages five and six some of the trend in the early part of the time-series is not captured. Fits to Comb-WCGFS-Q4 are also generally good, although there is a tendency towards overestimation of age zero individuals, and some deficiency in tracking the variability of age seven+. The shorter time-series of UK-SCOWCGFS-Q1 makes it more difficult to assess the model fit in terms of trends, but the model seems to fit the observations reasonably well. The model also appears to follow the catch data well for most ages, but perhaps tracks less of the inter annual variability for ages 6 and 7+.

The diagnostics of the quality of the model fit were: examination of the residuals; a leave-one-out analysis of the relative influence of indices on model estimates; a retrospective peel analysis. One observation ahead residuals-at-age for catch and survey indices are shown in Figure 35.16. The residuals were not substantially affected by the updates made to the model, showing similar patterns to those of the model agreed at the latest benchmark. There is an observable trend in the catch residuals from the late 1990s to mid-2000s, particularly between ages two and four, where the fishery shifted from being directly targeted to bycatch. There is some tendency towards negative residuals in the oldest age class of the Q4 survey index, but they are still occasionally interspersed with positive residuals. Otherwise, there are no particularly problematic trends in magnitude or direction.

The model leave-one-out analysis is shown in Figure 35.17. Exclusion of each index in turn results in estimates of SSB, $\bar{F}$ and recruitment which follow very similar trends over time, suggesting generally good agreement between indices. Estimates of SSB in more recent years have a tendency towards being generally lower with the exclusion of each index, when compared to the final model. However, they remain within the confidence interval of model estimates. Estimates of $\bar{F}$ in each case diverge the most between 2000 and 2010. Excluding the early Q1 survey (ScoGFS-WIBTS-Q1) results in higher estimates of $\bar{F}$ for much of the time-series from 2000 onwards, while excluding the Q4 index (Comb-WCGFS-Q4) results in generally lower estimates of F for the same period.

Retrospective peels for the updated assessment model are shown in Figure 35.18. Retrospective bias in SSB is not substantial, with some downward revision with the addition of new data in recent years. The Mohn's rho values are as follows:

SSB	$\bar{F}$	Recruitment
0.17	-0.17	0.41

The recruitment Mohn's rho includes the intermediate year in each assessment peel (as there is an intermediate year survey included in the assessment). The relatively high Mohn's rho value is a result of the consistently low recruitment values estimated in recent years. Only one recruitment peel falls outside the confidence interval envelope.

The SAM stock–recruit plot is presented in Figure 35.19 and suggests a relationship which has experienced a number of reasonably distinct phases over time. SSB and recruitments were relatively high, but decreasing, in the early 1980s. At the latest benchmark, it was suggested that this phase was related to the gadoid outburst of the 1960s and 1970s, and the decreasing stock size at the beginning of the modelled period is the time at which the population was returning to its usual size (Holden, 1991; Hislop, 1996). Stock size was then relatively stable for much of the 1990s, but declined in the early 2000s. SSB has shown an increasing trend since ~2010, and average recruitment since then is higher than in the previous ten years.

Comparison with last year's assessment

Last year, the assessment was conducted with SPiCT and was delivered in relative terms. However, this was rejected by the ADG in 2020 and therefore no comparison between this year and last year's assessments is presented.

This year, the WG estimates with SAM are as follows:

$F_{(1\text{-}3)}$ in 2020 = 0.065,

SSB in 2021 = 32 659 t.

The estimated fishing pressure continued to be very low. The stock biomass is estimated to increase slightly in 2021.

Compared to previous analytical assessments, the stock has increased somewhat more rapidly in recent years. This may in part be due to previous TSA assessments allowing the increases in the survey indices to be attributed to an increase in survey catchability while the SAM assessment interprets the differing signals between catch and survey data as changing fishery selectivity. Additionally, the change in maturity ogive in the SAM assessment (compare to previous TSA assessments) means that a proportion of age 1 individuals are now considered mature.

SURBAR analysis

An alternative exploratory assessment conducted using SURBA (Needle, 2015) was presented at the WKNSEA benchmark (ICES, 2021; WD 5.5 Whiting 6a SURBAR) and its updated run was presented to the WG.

This method requires stock weights-at-age, maturity ogive and survey indices. The smoothed estimates of stock weights-at-age were deployed in the model (those used to calculate SSB and shown in Table 35.9). The same three tuning series were considered for the model for SAM:

- ScoGFS-WIBTS-Q1 for the period 1985–2010;
- UK-SCOWCGFS-Q1 for the period 2011–2021;
- Comb-WCGFS-Q4 for the period 1996–2020.

The model used the following settings:

- Three survey series (as above);
- Reference age for separable model = 3;
- Lambda smoother = 1.0;
- All SSQ weightings and catchabilities q set to 1.0.

The model produced the output given in Figures 35.20. The stock summary plots show rather variable estimates of mean Z being generally lower from the mid-2000s onwards. SSB rose to a peak in the mid-1990s, before returning back down to the levels seen in the late 1980s with a substantial increase in the recent period. Also, it seems to fluctuate more in recent years compared to the historical period. The increase between 2019 and 2020 can be explained by relatively high recruitments in these two years and very low mean Z (associated with almost flat catch curves between 2019 and 2021 across a number of cohorts in UK-SCOWCGFS-Q1, Figure 35.11). Recruitment (at age 1) between 2005 and 2013 remained on a very low level. In recent years, it has been fluctuating, mostly above the average except for 2018 and 2021.

The assessment with SURBAR shows similar trends to those seen in the SAM runs (Figure 35.21).

State of the stock

The spawning–stock biomass (SSB) in 2021 is estimated to be above MSY $B_{trigger}$. It has increased since 2010 and is now at a level consistent with that estimated for the late 1990s. (Figure 35.22). Fishing pressure (F) was declined almost continuously since around 2000 and has been below F_{MSY} since 2005. After a period of somewhat higher recruitment (2014–2019), recruitment in 2020 is estimated to be lower.

35.4 Short-term projections

The WG conducted a forecast using SAM in the form of short-term stochastic projections. A total of 1 x 10^5 samples were generated from the estimated distribution of survivors. These replicates were then simulated forward according to model and forecast assumptions (see below), using the usual exponential decay equations, but also incorporating the stochastic survival process (using the estimated survival standard deviation) and subject to different catch-options scenarios.

Recruitment in the intermediate year (2021) was taken as the SAM estimate, equal to the estimate of recruitment for 2020. The estimate of recruitment for the forecast year(s) were resampled from 2012–2021, to reflect recent levels of recruitment.

Fishing mortality in the intermediate year (2021) was taken as a five-year average over 2016 to 2020 (Figure 35.23) of the exploitation pattern rescaled to the 2020 mean F.

The stock has been subject to the landings obligation since 2019, at which point a bycatch TAC of 1112 t was set to allow fisheries with a whiting bycatch component to continue (this represented an increase from the 213 t TAC set for the preceding three years). This increased TAC appears to have resulted in a change in discarding practices in 2019 and 2020. In Figure 35.24, the observed proportion discarded at-age shows a significant decline in the proportion of discards for ages three to five in 2019 and 2020. For the forecast, total catch is partitioned into landings and discards on the basis of the mean discard proportions-at-age of 2019 and 2020 (rather than the more five-year average agreed at the benchmark and documented in the Stock Annex) with the assumption that this observed change in behaviour will continue in 2021 and 2022.

The observed mean weight-at-age 1 in the 2020 discard data was very low (the lowest recorded, and approximately 49% lower than the same value from the previous year), due to limited sampling of fleets discarding whiting (COVID-19 pandemic related sampling issue, see Section 35.2 for further details). For the purpose of forecasting, it was agreed that this value should be replaced with the equivalent value from 2019.

Variable	Value	Notes
$F_{ages\ 1–3}$ (2021)	0.065	$F = F_{average\ (2016-2020)}$ rescaled to F_{2020}
SSB (2022)	31 548	Short-term forecast; tonnes
$R_{age\ 0}$ (2021)	202 757	Assessment estimate in 2021; thousands
$R_{age\ 0}$ (2022)	268 962	Median recruitment, resampled from the years 2012–2021; thousands
Catch (2021)	1245	Short-term forecast using an F_{2020}; tonnes
Projected landings (2021)	552	Short-term forecast; assuming average landings ratio by age 2019–2020; tonnes
Projected discards (2021)	693	Short-term forecast; assuming average discard ratio by age 2019–2020; tonnes

Under the forecast assumption of status quo F, landings in 2021 are predicted to be 552 t and discards to be 693 t. The SSB in 2022 is forecast to be 31 548 t, which is above B_{lim} and MSY $B_{trigger}$. A summary of the forecast run under different catch scenarios for 2022 is shown in Table 35.17 (the values that appear in the catch scenarios are medians from the distributions that result from the stochastic forecast).

The forecast stock trajectory under the proposed advice for 2022 (4114 t) shows a decrease in SSB in 2023 (Figure 35.25). Figure 35.26 shows the contribution by recruitment year to SSB in 2023 and catch in 2022 (when fished at F_{MSY}). The assumption regarding recruitment in 2021 and 2022 contribute approximately 15% and 2% to the forecast 2023 SSB, and 10% and 12% to the forecast 2022 catch, respectively.

35.5 MSY and biological reference points

The reference points for this stock were updated at WKNSEA 2021 (ICES, 2021), following the general approach agreed at WKMSYREF4 (ICES, 2016a).

The reference points estimated in 2021 are summarised in the table below:

Reference point	WKMSY-REF4 2016	WGCSE 2016	WKNSEA 2021	Rationale (WKNSEA 2021); details
B_{lim}	28 500 t	31 900 t	17 286	Lowest SSB (1999) within period of high recruitment (pre 2000)
B_{pa}	39 900 t	44 600 t	25 597	B_{lim} x exp(1.645 x σ); σ = 0.239 (CV on estimate of SSB2020)
F_{lim}	0.25	0.27	0.31	F giving 50% probability of SSB<B_{lim} in stochastic simulation (EqSim) Uses segmented regression recruitment with breakpoint=B_{lim} (S–R pairs from 1985 onwards).
F_{pa}	0.18	0.19	0.21	$F_{p.05}$; the F that leads to SSB ≥ B_{lim} with 95% probability.
F_{MSY}	0.22	0.23	0.21	$F_{p.05}$ (F_{MSY} uncapped = 0.23)
F_{MSY} upper	0.34	0.32	0.21	$F_{p.05}$ (F_{MSY} upper uncapped = 0.27)
F_{MSY} lower	0.16	0.15	0.173	F resulting in no more than 5% reduction in long-term yield compared with MSY without ICES AR (95 % yield at $F_{p.05}$).

35.6 Management plans

There are no specific management objectives or a management plan for this stock, but the EU multiannual plan takes bycatch of this species into account (EU, 2019).

35.7 Uncertainties and bias in the assessment and forecast

Some uncertainties signalled in previous assessments were related to area misreporting of landings. Marine Scotland Compliance have provided estimates based on their surveillance and monitoring programme which suggest area misreporting of whiting to be in the order of 10–15% of reported landings in recent years (ICES, 2012). This issue is thus considered to be of relatively minor importance.

As a result of the 2021 benchmark, the stock was changed from a category 5 stock to a category 1 stock. The assessment, which is now based on SAM, includes revised catch and survey data, updated biological parameters, and accounts for changes in fishery selectivity (rather than changes in survey catchability). These changes have resulted in an improved assessment of the stock status.

The retrospective bias observed for F is potentially an issue – the Mohn's rho has been found outside the bounds suggested by WKFORBIAS (ICES, 2020d). However, the assessment is deemed to be valid and provide advice based on the WKFORBIAS decision tree.

The sampling levels in 2020 were lower compared to previous years due to COVID-19. Zero age-0 discards were recorded as discard sampling in the *Nephrops* fishery was undertaken only in the first quarter. Therefore, age 0 discards were treated as missing in 2020. For the same reason, mean weights-at-age 1 in discards were considerably lower compared to previous years. However, this is considered to have had minimal impact on the perception of the stock status.

35.8 Recommendation for next benchmark

Although the combined Q4 index is considered as representative of the population, there is scope for its further improvement. During WKNSEA 2021, the potential need for inclusion of an interaction term between year and geographical coordinates was discussed. Exploratory analysis suggested some temporal changes in the distribution of age groups, but it was found that the inclusion of the interaction term had little effect on the index values or the internal consistency. Additional analyses and careful sense checking of estimated covariates would be necessary to find optimal settings for such an augmented model.

The Q1 indices used in the assessment represent cpue calculated for age groups. While they integrate information for specific areas or strata, other sources' information are thereby ignored. It seems plausible that these indices can be improved by including other explanatory variables, in a similar way as for the Q4 index.

While a Random Walk on recruitment was selected for the assessment for practical reasons, alternative approaches should be explored in modelling the S–R relationship model with internal calculation of reference points.

35.9 Management considerations

SSB in 2021 is estimated to be above MSY $B_{trigger}$. It has increased since 2010, and is now at a level consistent with that estimated for the late 1990s. Fishing pressure (F) declined almost continuously since around 2000 and is below F_{MSY} since 2005. After a period of somewhat higher recruitment (2014–2019), recruitment in 2020 is estimated to be lower. The first non-zero advice has been given for five years. The SSB is forecast to decline in the following two years in all catch scenarios.

Whiting are caught and heavily discarded in small-meshed fisheries for *Nephrops*. Under the landing obligation (since 2019), discards have considerably reduced. However, they still make up a significant proportion of the catch (61% in 2020). Reported BMS landings are negligible – they are much lower than ICES estimates of catches below minimum size (i.e. estimated discards at age 0–2).

TAC increased under the landing obligation to allow continuation of mixed-fisheries. In response to this, the discard rate declined. The forecast assumes that this behaviour will continue in 2021 and 2022.

It should be noted that TAC have been set for a larger area than Division 6.a. and include areas 6.b, 5.b and international waters of 12 and 14 (Council Regulation (EU) 2020/123).

Whiting are caught in mixed-fisheries with cod and haddock in Division 6.a. There have been several technical conservation measures introduced in the 6.a gadoid fishery in recent years. The increase in mesh size from 100 mm to 120 mm, established under the emergency measures since 2010, and the introduction of large square mesh panels in the *Nephrops* fishery, are likely to have contributed to the observed reductions in fishing mortality.

35.10 References

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Table 35.1. Whiting in Division 6.a. Nominal landings (in tonnes) as officially reported to ICES.

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Belgium	1	-	+	-	+	+	+	-	1	1	+	-	-	-	-	+	-	-	-	-
Denmark	1	+	3	1	1	+	+	+	+	-	-	-	-	-	+	+	-	-	-	-
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
France	199	180	352	105	149	191	362	202	108	82	300	48	52	21	11	6	9	7	6	1
Germany	+	+	+	1	1	+	-	+	-	-	+	-	-	-	-	-	-	+	1	-
Ireland	1315	977	1200	1377	1192	1213	1448	1182	977	952	1121	793	764	577	568	356	172	196	56	69
Netherlands	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain	-	-	-	-	-	-	1	-	1	2	+	-	2	-	-	-	-	-	-	-
UK (E, W and NI)	44	50	218	196	184	233	204	237	453	251	210	104	71	73	35	13	5	2	1	
UK (Scot.)	6109	4819	5135	4330	5224	4149	4263	5021	4638	3369	3046	2258	1654	1064	751	444	103	178	424	
UK (total)																				370
Total landings	7669	6026	6908	6010	6751	5786	6278	6642	6178	4657	4677	3203	2543	1735	1365	819	289	383	488	441

Table 35.1. Continued.

Country	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*
Belgium	-	-	-	-	-	-	-	-	-	-	-	-
Denmark	-	-	-	-	-	-	-	-	-	2	56	10
Faroe Islands	-	+	1	1	-	-	-	-	-	-	-	-
France	1	3	+	+	1	1	+	5	3	2	6	10
Germany	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	125	99	149	96	97	97	88	77	53	72	160	126
Netherlands	-	-	-	-	-	-	11	52	19	2	23	4
Norway	2	-	-	-	-	-	-	-	-	+	-	-
Spain	-	-	-	-	-	-	-	-	-	-	+	-
UK (E, W and NI)												
UK (Scot.)												
UK (total)	354	247	80	204	116	83	122	98	94	108	240	388
Total landings	482	349	230	301	214	181	221	232	169	187	485	537

*** Preliminary.**

+ <0.5 t.

Table 35.2. Whiting in Division 6.a. Landings, discards and catch estimates for 1981–2020, as used by the WG. Values are totals for ages 1 to 7+ (in 1981–2002) and for ages 0 to 7+ (in 2003–2020). Discard and catch values for the years 1981–2002 are revised compared to previous assessments because of a revised method for raising discards (Millar and Fryer, 2005). Landings, discard and catch values for the years 2003–2018 are revised InterCatch estimates (ICES, 2020) compared to previous assessments.

Year	Landings	Discards	Total	Discard rate (%)
1981	12203	2132	14335	15
1982	13871	5485	19356	28
1983	15970	6294	22264	28
1984	16458	4017	20475	20
1985	12893	4840	17733	27
1986	8454	2669	11123	24
1987	11544	11918	23462	51
1988	11352	8132	19484	42
1989	7531	5876	13407	44
1990	5643	4530	10173	45
1991	6660	4883	11543	42
1992	6004	9249	15253	61
1993	6872	4759	11631	41
1994	5901	3455	9356	37
1995	6076	5771	11847	49
1996	7156	7940	15096	53
1997	6285	5251	11536	46
1998	4631	9216	13847	67
1999	4613	3975	8588	46
2000	3010	13285	16295	82
2001	2438	4263	6701	64
2002	1709	2851	4560	63
2003	1331	1984	3316	60
2004	798	2887	3686	78
2005	335	972	1307	74
2006	378	746	1124	66

Year	Landings	Discards	Total	Discard rate (%)
2007	481	366	847	43
2008	441	156	598	26
2009	480	826	1305	63
2010	345	1091	1436	76
2011	231	630	861	73
2012	300	742	1042	71
2013	215	1172	1387	85
2014	181	745	926	80
2015	221	1458	1679	87
2016	227	1040	1266	82
2017	168	1331	1498	89
2018	189	666	855	78
2019	484	960	1444	66
2020	541	834	1375	61
Min	168	156	598	15
Mean	4615	3735	8350	56
Max	16458	13285	23462	89

Table 35.3. Whiting in Division 6.a. Landings-at-age (thousands).

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
1981	0	3593	24395	11297	4611	1518	452	201
1982	0	2991	5783	29094	6821	2043	803	348
1983	0	3418	7094	8040	22757	6070	1439	540
1984	0	7209	12765	8221	4387	14825	1953	858
1985	0	4139	19520	8574	3351	1997	4764	822
1986	0	2674	14824	9770	2653	532	291	529
1987	0	6430	13935	13988	5442	837	330	259
1988	0	1842	20587	9638	6168	1949	290	207
1989	0	2529	5887	11889	4767	1266	468	71
1990	0	3203	8028	2393	4009	1326	204	37
1991	0	3294	8826	10046	1208	1391	286	51
1992	0	2695	9440	4473	4782	396	373	106
1993	0	1051	10179	6293	2673	2738	163	147
1994	0	909	4889	9158	3607	712	715	69
1995	0	215	4322	6516	5654	1397	376	282
1996	0	990	5410	7675	5052	2461	583	157
1997	0	877	3658	8514	4316	1441	338	106
1998	0	840	3504	4277	3698	1442	338	288
1999	0	1013	6131	4546	2040	1774	355	112
2000	0	484	2952	4211	1570	485	328	89
2001	0	461	3271	2630	1567	401	131	16
2002	0	62	1624	3018	799	227	23	13
2003	0	98	652	1309	1481	414	93	2
2004	0	49	699	544	517	620	74	33
2005	0	26	273	460	145	107	49	5
2006	0	83	135	386	276	67	86	25
2007	0	193	190	294	361	152	31	53
2008	0	3	277	387	335	150	54	25
2009	0	108	255	258	417	107	49	14
2010	0	50	81	150	148	141	43	52

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
2011	0	0	256	144	94	27	26	8
2012	0	13	39	374	203	53	16	9
2013	0	4	41	76	269	74	19	6
2014	0	13	26	130	101	101	23	11
2015	0	7	74	56	157	71	73	30
2016	0	19	93	147	77	86	19	28
2017	0	17	37	167	69	52	39	10
2018	0	0	73	89	199	60	8	8
2019	0	23	54	427	255	258	48	5
2020	0	7	309	258	310	156	39	3

Table 35.4. Whiting in Division 6.a. Discards-at-age (thousands). Previous discard estimates for the years 1978–2003 were replaced by those estimated by Millar and Fryer (2005).

	Age							
Year		**1**	**2**	**3**	**4**	**5**	**6**	**7+**
1981	NA	1128	10415	1397	201	27	12	0
1982	NA	19511	3421	12683	1197	187	4	0
1983	NA	21690	6748	2909	5372	158	8	0
1984	NA	34330	2400	909	371	811	73	1
1985	NA	17615	9858	3273	672	205	363	40
1986	NA	6159	9823	1962	185	1	0	10
1987	NA	97611	17427	1763	154	0	0	0
1988	NA	28057	38019	2239	467	11	0	0
1989	NA	31079	5598	8570	223	13	5	0
1990	NA	20952	11176	71	23	3	0	0
1991	NA	23211	7540	7355	266	236	56	0
1992	NA	50665	16729	2810	954	0	0	0
1993	NA	14057	11139	2903	588	431	0	1
1994	NA	12700	6859	3872	1152	189	150	4
1995	NA	21974	21786	3416	484	7	1	1
1996	NA	33621	18625	5086	1535	13	1	20
1997	NA	22422	9632	3806	540	71	2	1
1998	NA	53742	16058	3553	847	177	31	8
1999	NA	7928	17097	1402	503	275	44	0
2000	NA	158913	5254	2238	154	16	41	0
2001	NA	5666	23084	715	172	0	0	0
2002	NA	11055	8531	2428	415	175	9	3
2003	5678	9448	2489	1775	375	25	7	1
2004	10577	14941	5095	1011	660	125	4	2
2005	7873	3246	2298	769	60	22	8	4
2006	5866	4691	528	637	169	29	6	2
2007	1259	1016	966	283	88	38	3	0
2008	840	630	144	114	31	37	4	0
2009	9685	6880	114	66	44	15	4	0
2010	5903	17678	1581	264	37	54	6	16

	Age							
Year		**1**	**2**	**3**	**4**	**5**	**6**	**7+**
2011	13306	2047	998	122	7	2	0	0
2012	1434	7810	429	547	94	19	1	0
2013	3188	16415	1578	172	255	8	2	2
2014	6261	9831	51	55	27	30	8	3
2015	17740	7930	909	287	112	18	17	0
2016	3745	5506	1910	268	16	12	4	2
2017	8518	7563	788	889	65	160	2	0
2018	1777	2371	962	469	276	21	5	0
2019	2188	10379	526	413	232	34	0	0
2020	NA	23481	807	59	29	10	3	0

Table 35.5. Whiting in Division 6.a. Total catch-at-age (thousands).

	Age							
Year	0	1	2	3	4	5	6	7+
1981	NA	4721	34810	12694	4812	1545	464	201
1982	NA	22502	9204	41777	8018	2230	807	348
1983	NA	25108	13842	10949	28129	6228	1447	540
1984	NA	41539	15165	9130	4758	15636	2026	859
1985	NA	21754	29378	11847	4023	2202	5127	862
1986	NA	8833	24647	11732	2838	533	291	539
1987	NA	104041	31362	15751	5596	837	330	259
1988	NA	29899	58606	11877	6635	1960	290	207
1989	NA	33608	11485	20459	4990	1279	473	71
1990	NA	24155	19204	2464	4032	1329	204	37
1991	NA	26505	16366	17401	1474	1627	342	51
1992	NA	53360	26169	7283	5736	396	373	106
1993	NA	15108	21318	9196	3261	3169	163	148
1994	NA	13609	11748	13030	4759	901	865	73
1995	NA	22189	26108	9932	6138	1404	377	283
1996	NA	34611	24035	12761	6587	2474	584	177
1997	NA	23299	13290	12320	4856	1512	340	107
1998	NA	54582	19562	7830	4545	1619	369	296
1999	NA	8941	23228	5948	2543	2049	399	112
2000	NA	159397	8206	6449	1724	501	369	89
2001	NA	6127	26355	3345	1739	401	131	16
2002	NA	11117	10155	5446	1214	402	32	16
2003	5678	9546	3141	3083	1856	439	100	3
2004	10577	14990	5794	1556	1176	745	78	35
2005	7873	3272	2571	1229	205	129	57	10
2006	5866	4773	663	1023	445	96	93	27
2007	1259	1209	1156	578	449	190	33	53
2008	840	632	421	500	366	187	58	25
2009	9685	6988	370	324	462	123	53	14
2010	5903	17729	1662	414	185	196	49	68

	Age							
Year	0	1	2	3	4	5	6	7+
2011	13306	2048	1254	267	101	29	26	8
2012	1434	7823	469	920	298	72	17	9
2013	3188	16419	1619	247	523	82	21	7
2014	6261	9844	77	185	127	130	31	14
2015	17740	7937	983	343	269	90	90	30
2016	3745	5525	2003	415	92	98	23	30
2017	8518	7580	825	1056	134	212	41	10
2018	1777	2371	1035	557	475	81	13	8
2019	2188	10402	580	840	486	293	48	5
2020	0	23488	1116	317	339	166	42	3

Table 35.6. Whiting in Division 6.a. Mean weight-at-age (kg) in landings.

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
1981	NA	0.192	0.228	0.289	0.382	0.409	0.409	0.547
1982	NA	0.184	0.22	0.276	0.352	0.505	0.513	0.526
1983	NA	0.216	0.249	0.28	0.34	0.409	0.494	0.51
1984	NA	0.216	0.259	0.313	0.371	0.412	0.458	0.458
1985	NA	0.185	0.238	0.306	0.402	0.43	0.461	0.538
1986	NA	0.174	0.236	0.294	0.365	0.468	0.482	0.499
1987	NA	0.188	0.237	0.304	0.373	0.511	0.52	0.576
1988	NA	0.176	0.215	0.301	0.4	0.483	0.567	0.6
1989	NA	0.171	0.22	0.279	0.348	0.459	0.425	0.555
1990	NA	0.225	0.251	0.324	0.359	0.417	0.582	0.543
1991	NA	0.199	0.22	0.291	0.354	0.391	0.442	0.761
1992	NA	0.193	0.23	0.288	0.349	0.388	0.397	0.51
1993	NA	0.186	0.242	0.314	0.361	0.412	0.452	0.474
1994	NA	0.161	0.217	0.29	0.371	0.451	0.482	0.483
1995	NA	0.19	0.225	0.296	0.381	0.469	0.473	0.528
1996	NA	0.195	0.245	0.288	0.365	0.483	0.526	0.569
1997	NA	0.198	0.245	0.297	0.384	0.522	0.629	0.661
1998	NA	0.215	0.236	0.301	0.364	0.438	0.5	0.646
1999	NA	0.181	0.225	0.28	0.365	0.44	0.524	0.594
2000	NA	0.205	0.241	0.298	0.336	0.419	0.488	0.617
2001	NA	0.173	0.234	0.303	0.37	0.395	0.376	0.595
2002	NA	0.213	0.257	0.304	0.363	0.464	0.650	0.707
2003	NA	0.236	0.272	0.301	0.373	0.349	0.409	0.659
2004	NA	0.189	0.257	0.296	0.342	0.376	0.378	0.305
2005	NA	0.215	0.253	0.297	0.366	0.426	0.455	0.383
2006	NA	0.221	0.290	0.321	0.395	0.452	0.496	0.574
2007	NA	0.215	0.289	0.356	0.416	0.497	0.598	0.667
2008	NA	0.285	0.245	0.319	0.379	0.516	0.534	0.652
2009	NA	0.288	0.317	0.406	0.446	0.439	0.444	0.603
2010	NA	0.286	0.353	0.436	0.540	0.647	0.654	0.575

Year	Age 0	1	2	3	4	5	6	7+
2011	NA	0.201	0.356	0.396	0.502	0.571	0.578	0.370
2012	NA	0.320	0.300	0.374	0.504	0.594	0.665	0.482
2013	NA	0.225	0.325	0.355	0.441	0.546	0.597	0.770
2014	NA	0.248	0.295	0.375	0.457	0.528	0.641	0.678
2015	NA	0.261	0.347	0.447	0.468	0.508	0.596	0.600
2016	NA	0.137	0.325	0.483	0.509	0.606	0.676	0.664
2017	NA	0.340	0.352	0.413	0.546	0.497	0.510	0.684
2018	NA	0.173	0.407	0.396	0.435	0.520	0.472	0.564
2019	NA	0.244	0.288	0.415	0.506	0.529	0.698	0.879
2020	NA	0.235	0.406	0.482	0.551	0.597	0.657	1.058

Table 35.7. Whiting in Division 6.a. Mean weight-at-age (kg) in discards.

	Age							
Year	0	1	2	3	4	5	6	7+
1981	NA	0.108	0.16	0.195	0.298	0.286	0.295	NA
1982	NA	0.096	0.18	0.209	0.243	0.283	0.44	NA
1983	NA	0.141	0.186	0.228	0.237	0.267	0.267	NA
1984	NA	0.087	0.199	0.246	0.26	0.259	0.303	0.227
1985	NA	0.102	0.191	0.237	0.286	0.326	0.312	0.316
1986	NA	0.092	0.17	0.196	0.245	0.258	0.33	0.263
1987	NA	0.085	0.182	0.233	0.249	0.225	NA	NA
1988	NA	0.076	0.143	0.203	0.227	0.262	NA	NA
1989	NA	0.099	0.177	0.205	0.209	0.294	0.305	NA
1990	NA	0.124	0.171	0.214	0.219	0.237	0.264	NA
1991	NA	0.085	0.169	0.205	0.223	0.226	0.281	NA
1992	NA	0.109	0.173	0.219	0.227	NA	NA	NA
1993	NA	0.118	0.197	0.225	0.242	0.256	NA	0.436
1994	NA	0.087	0.157	0.22	0.283	0.297	0.253	0.299
1995	NA	0.075	0.154	0.189	0.246	0.278	0.597	0.493
1996	NA	0.095	0.18	0.203	0.229	0.302	0.421	0.26
1997	NA	0.112	0.182	0.221	0.235	0.243	0.422	0.819
1998	NA	0.098	0.179	0.225	0.254	0.282	0.264	0.245
1999	NA	0.077	0.168	0.217	0.205	0.266	0.268	NA
2000	NA	0.075	0.164	0.203	0.233	0.282	0.250	NA
2001	NA	0.094	0.154	0.196	0.203	0.381	0.000	NA
2002	NA	0.073	0.162	0.212	0.245	0.240	0.295	0.276
2003	0.051	0.091	0.161	0.193	0.243	0.209	0.291	0.278
2004	0.020	0.091	0.178	0.223	0.233	0.302	0.343	0.282
2005	0.028	0.074	0.145	0.207	0.188	0.302	0.289	0.368
2006	0.037	0.047	0.195	0.233	0.285	0.311	0.494	0.361
2007	0.042	0.064	0.157	0.232	0.223	0.231	0.787	0.266
2008	0.019	0.076	0.211	0.305	0.350	0.423	0.233	0.289
2009	0.043	0.051	0.283	0.227	0.262	0.250	0.248	NA
2010	0.018	0.040	0.119	0.239	0.360	0.360	0.382	0.224

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
2011	0.029	0.034	0.136	0.307	0.256	0.228	NA	NA
2012	0.042	0.057	0.152	0.292	0.362	0.356	0.386	NA
2013	0.027	0.041	0.209	0.229	0.358	0.385	0.299	0.371
2014	0.040	0.045	0.182	0.289	0.362	0.427	0.422	0.757
2015	0.035	0.072	0.171	0.212	0.336	0.316	0.427	NA
2016	0.050	0.068	0.206	0.276	0.292	0.304	0.261	0.367
2017	0.033	0.066	0.197	0.351	0.409	0.331	0.881	NA
2018	0.054	0.067	0.184	0.250	0.307	0.414	1.107	NA
2019	0.029	0.055	0.199	0.267	0.278	0.436	0.489	NA
2020	NA	0.028	0.163	0.254	0.313	0.286	0.255	NA

Table 35.8. Whiting in Division 6.a. Mean weight-at-age (kg) in total catch.

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
1981	NA	0.172	0.208	0.279	0.378	0.407	0.406	0.547
1982	NA	0.108	0.205	0.256	0.336	0.486	0.513	0.526
1983	NA	0.151	0.218	0.266	0.320	0.405	0.493	0.510
1984	NA	0.109	0.250	0.306	0.362	0.404	0.452	0.458
1985	NA	0.118	0.222	0.287	0.383	0.420	0.450	0.528
1986	NA	0.117	0.210	0.278	0.357	0.468	0.482	0.495
1987	NA	0.091	0.206	0.296	0.370	0.511	0.520	0.576
1988	NA	0.082	0.168	0.283	0.388	0.482	0.567	0.600
1989	NA	0.104	0.199	0.248	0.342	0.457	0.424	0.555
1990	NA	0.137	0.204	0.321	0.358	0.417	0.582	0.543
1991	NA	0.099	0.197	0.255	0.330	0.367	0.416	0.761
1992	NA	0.113	0.194	0.261	0.329	0.388	0.397	0.510
1993	NA	0.123	0.218	0.286	0.340	0.391	0.452	0.474
1994	NA	0.092	0.182	0.269	0.350	0.419	0.442	0.473
1995	NA	0.076	0.166	0.259	0.370	0.468	0.473	0.528
1996	NA	0.098	0.195	0.254	0.333	0.482	0.526	0.534
1997	NA	0.115	0.199	0.274	0.367	0.509	0.628	0.662
1998	NA	0.100	0.189	0.267	0.344	0.421	0.480	0.635
1999	NA	0.089	0.183	0.265	0.333	0.417	0.496	0.594
2000	NA	0.075	0.192	0.265	0.327	0.415	0.462	0.617
2001	NA	0.100	0.164	0.280	0.353	0.395	0.376	0.595
2002	NA	0.074	0.177	0.263	0.323	0.366	0.550	0.626
2003	0.051	0.092	0.184	0.239	0.347	0.341	0.401	0.516
2004	0.020	0.091	0.188	0.249	0.281	0.364	0.377	0.304
2005	0.028	0.075	0.156	0.241	0.313	0.405	0.432	0.376
2006	0.037	0.050	0.214	0.266	0.353	0.410	0.495	0.557
2007	0.042	0.088	0.179	0.295	0.378	0.444	0.613	0.666
2008	0.019	0.077	0.233	0.316	0.376	0.498	0.514	0.648
2009	0.043	0.054	0.307	0.369	0.429	0.415	0.430	0.603
2010	0.018	0.040	0.130	0.311	0.504	0.567	0.622	0.492

	Age							
Year	0	1	2	3	4	5	6	7+
2011	0.029	0.034	0.181	0.355	0.485	0.546	0.578	0.370
2012	0.042	0.057	0.164	0.325	0.459	0.531	0.643	0.482
2013	0.027	0.041	0.212	0.268	0.401	0.530	0.571	0.679
2014	0.040	0.045	0.220	0.349	0.437	0.505	0.581	0.694
2015	0.035	0.072	0.185	0.250	0.413	0.469	0.565	0.600
2016	0.050	0.068	0.211	0.349	0.472	0.568	0.601	0.649
2017	0.033	0.066	0.204	0.361	0.480	0.372	0.524	0.684
2018	0.054	0.067	0.199	0.273	0.361	0.492	0.731	0.564
2019	0.029	0.055	0.207	0.342	0.397	0.518	0.697	0.879
2020	NA	0.028	0.230	0.439	0.531	0.579	0.625	1.058

Table 35.9. Whiting in Division 6.a. Mean weight-at-age (kg) in stock. These are smoothed estimates for use in SSB calculation.

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
1981	0.037	0.048	0.154	0.265	0.371	0.489	0.599	0.725
1982	0.037	0.048	0.154	0.265	0.371	0.489	0.599	0.725
1983	0.037	0.048	0.154	0.265	0.371	0.489	0.599	0.725
1984	0.037	0.048	0.154	0.265	0.371	0.489	0.599	0.725
1985	0.037	0.048	0.154	0.265	0.371	0.489	0.599	0.725
1986	0.036	0.048	0.154	0.258	0.367	0.484	0.598	0.714
1987	0.036	0.048	0.153	0.251	0.364	0.478	0.597	0.703
1988	0.036	0.048	0.152	0.246	0.362	0.473	0.596	0.691
1989	0.036	0.049	0.151	0.242	0.36	0.468	0.595	0.68
1990	0.036	0.049	0.15	0.239	0.359	0.462	0.594	0.668
1991	0.036	0.049	0.149	0.238	0.358	0.458	0.593	0.656
1992	0.036	0.049	0.147	0.237	0.357	0.454	0.592	0.645
1993	0.035	0.049	0.146	0.237	0.356	0.451	0.591	0.634
1994	0.035	0.049	0.144	0.236	0.355	0.449	0.59	0.623
1995	0.035	0.049	0.143	0.235	0.353	0.448	0.59	0.613
1996	0.035	0.049	0.141	0.234	0.35	0.446	0.589	0.604
1997	0.035	0.049	0.14	0.233	0.347	0.445	0.589	0.596
1998	0.035	0.049	0.139	0.232	0.343	0.444	0.589	0.588
1999	0.034	0.05	0.138	0.23	0.339	0.443	0.589	0.583
2000	0.034	0.05	0.138	0.228	0.335	0.443	0.589	0.578
2001	0.034	0.05	0.138	0.225	0.332	0.444	0.589	0.575
2002	0.034	0.05	0.138	0.223	0.331	0.447	0.59	0.573
2003	0.034	0.05	0.139	0.222	0.332	0.452	0.591	0.574
2004	0.034	0.05	0.14	0.224	0.337	0.459	0.592	0.576
2005	0.034	0.05	0.141	0.229	0.345	0.468	0.593	0.58
2006	0.033	0.05	0.143	0.238	0.357	0.479	0.595	0.585
2007	0.033	0.051	0.145	0.25	0.373	0.492	0.597	0.592
2008	0.033	0.051	0.148	0.265	0.39	0.505	0.599	0.6
2009	0.033	0.051	0.15	0.279	0.408	0.519	0.602	0.609
2010	0.034	0.051	0.152	0.293	0.426	0.532	0.604	0.619

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
2011	0.034	0.052	0.155	0.305	0.441	0.544	0.607	0.63
2012	0.034	0.052	0.157	0.313	0.454	0.555	0.61	0.641
2013	0.034	0.052	0.159	0.318	0.462	0.563	0.613	0.653
2014	0.034	0.052	0.161	0.319	0.466	0.57	0.615	0.666
2015	0.034	0.053	0.163	0.317	0.465	0.574	0.618	0.678
2016	0.034	0.053	0.165	0.311	0.462	0.577	0.621	0.69
2017	0.034	0.053	0.167	0.303	0.456	0.579	0.623	0.703
2018	0.035	0.053	0.168	0.293	0.448	0.579	0.626	0.715
2019	0.035	0.054	0.17	0.282	0.44	0.58	0.629	0.727
2020	0.035	0.054	0.171	0.271	0.431	0.58	0.631	0.739

Table 35.10. Whiting in Division 6.a. Natural mortality.

	Age							
Year	0	1	2	3	4	5	6	7+
1981	1.056	1.033	0.709	0.594	0.547	0.496	0.462	0.444
1982	1.056	1.033	0.709	0.594	0.547	0.496	0.462	0.444
1983	1.056	1.033	0.709	0.594	0.547	0.496	0.462	0.444
1984	1.056	1.033	0.709	0.594	0.547	0.496	0.462	0.444
1985	1.056	1.033	0.709	0.594	0.547	0.496	0.462	0.444
1986	1.057	1.013	0.707	0.599	0.547	0.498	0.464	0.446
1987	1.059	0.994	0.705	0.604	0.547	0.500	0.465	0.448
1988	1.060	0.977	0.704	0.609	0.546	0.502	0.467	0.450
1989	1.061	0.961	0.702	0.612	0.546	0.505	0.469	0.453
1990	1.063	0.947	0.700	0.615	0.546	0.507	0.470	0.455
1991	1.064	0.933	0.698	0.617	0.545	0.508	0.472	0.457
1992	1.065	0.920	0.697	0.617	0.545	0.509	0.474	0.459
1993	1.067	0.908	0.695	0.616	0.544	0.510	0.476	0.462
1994	1.068	0.896	0.692	0.614	0.543	0.509	0.478	0.464
1995	1.069	0.885	0.690	0.611	0.543	0.509	0.479	0.466
1996	1.071	0.875	0.687	0.606	0.542	0.509	0.481	0.468
1997	1.072	0.866	0.683	0.601	0.541	0.509	0.483	0.470
1998	1.073	0.858	0.680	0.597	0.540	0.510	0.484	0.472
1999	1.075	0.851	0.677	0.593	0.539	0.512	0.485	0.474
2000	1.076	0.846	0.674	0.591	0.537	0.514	0.486	0.475
2001	1.078	0.841	0.671	0.590	0.536	0.516	0.487	0.476
2002	1.079	0.838	0.668	0.590	0.535	0.518	0.487	0.477
2003	1.081	0.835	0.665	0.590	0.533	0.519	0.486	0.477
2004	1.082	0.833	0.662	0.590	0.531	0.519	0.486	0.477
2005	1.083	0.832	0.659	0.588	0.529	0.517	0.484	0.477
2006	1.084	0.831	0.657	0.585	0.527	0.513	0.483	0.476
2007	1.084	0.831	0.654	0.579	0.525	0.509	0.481	0.475
2008	1.084	0.831	0.652	0.572	0.523	0.503	0.479	0.474
2009	1.084	0.831	0.649	0.565	0.521	0.496	0.477	0.472
2010	1.083	0.831	0.647	0.558	0.518	0.490	0.474	0.471

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
2011	1.083	0.831	0.646	0.552	0.516	0.484	0.472	0.469
2012	1.082	0.830	0.645	0.548	0.514	0.479	0.470	0.467
2013	1.080	0.830	0.644	0.546	0.513	0.476	0.468	0.465
2014	1.079	0.829	0.643	0.545	0.511	0.474	0.466	0.463
2015	1.078	0.829	0.644	0.546	0.509	0.473	0.465	0.460
2016	1.076	0.829	0.644	0.550	0.508	0.473	0.463	0.458
2017	1.075	0.830	0.645	0.555	0.506	0.474	0.462	0.456
2018	1.074	0.831	0.646	0.562	0.505	0.474	0.461	0.454
2019	1.072	0.832	0.648	0.570	0.504	0.475	0.460	0.452
2020	1.071	0.833	0.649	0.579	0.503	0.476	0.458	0.450

Table 35.11. Whiting in Division 6.a. Survey data made available to the WG. For the Scottish and Irish surveys, numbers are standardised to catch-rate per ten hours. The Scottish surveys from 2011 have been conducted according to the new design and ground gear.

ScoGFS-WIBTS-Q1 – Scottish Groundfish Survey – numbers-at-age/10 h								
Year	**Effort**	**Age**						
	(hours)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1985	10	3140	1792	380	85	23	156	18
1986	10	1456	1525	403	68	10	9	10
1987	10	6938	1054	584	142	36	2	1
1988	10	567	3469	654	189	42	5	1
1989	10	910	505	586	237	48	3	0
1990	10	1818	571	122	216	61	4	1
1991	10	3203	276	299	22	39	9	1
1992	10	4777	1597	410	517	56	18	0
1993	10	5532	6829	644	91	30	11	2
1994	10	6614	2443	1487	174	56	15	6
1995	10	5598	2831	1160	370	70	17	32
1996	10	9385	2237	635	341	135	30	4
1997	10	5663	2444	1531	355	102	17	4
1998	10	9851	1352	294	195	50	14	1
1999	10	6125	4952	489	103	16	1	0
2000	10	12862	471	152	34	10	11	0
2001	10	4653	1955	242	41	8	1	1
2002	10	5542	1028	964	89	15	1	1
2003	10	6934	746	436	300	32	2	4
2004	10	5887	1566	189	131	44	9	1
2005	10	1308	723	183	35	8	11	2
2006	10	1441	466	282	77	0	3	1
2007	10	614	522	127	75	16	3	2
2008	10	593	127	77	26	8	3	0
2009	10	906	387	103	105	20	9	7
2010	10	3523	340	108	52	40	4	3

Table 35.11. Continued.

UK-SCOWCGFS-Q1 – Scottish Groundfish Survey – numbers-at-age/10 h															
		Index							Variance						
Year	Effort	Age							Age						
	(hours)	1	2	3	4	5	6	7	1	2	3	4	5	6	7
2011	10	222	1884	397	64	37	45	12	6431	150861	5654	209	80	133	11
2012	10	3441	293	738	72	14	5	7	600264	8104	18380	184	9	2	3
2013	10	552	1031	302	463	61	7	3	62915	46672	5056	15023	443	7	1
2014	10	5805	125	246	110	74	7	1	2230995	556	2133	657	333	2	0
2015	10	2545	760	285	259	65	58	8	144266	46202	8599	4562	305	352	10
2016	10	3226	3485	576	148	84	42	25	397138	1880448	28776	691	260	95	48
2017	10	4970	1981	1707	203	49	32	5	2335667	309373	227966	2958	172	99	3
2018	10	1960	1827	1069	1142	132	14	2	763992	330295	91346	108990	2138	70	0
2019	10	3231	666	577	191	99	25	0	345197	29689	21447	1786	536	30	0
2020	10	3795	2263	711	572	178	110	27	1369852	699830	68242	27213	3694	1736	415
2021	10	774	1679	703	272	140	24	11	29371	129127	23776	3259	1173	30	10

Table 35.11. Continued.

Comb-WCGFS-Q4 – Combined Scottish and Irish Groundfish Survey – numbers-at-age per hour									
Index									
Year	Effort	Age							
	(hours)	0	1	2	3	4	5	6	7+
1996	1	7627.8	493.8	111.3	32.3	8.2	3.2	0.5	0.0
1997	1	1812.1	697.6	161.4	33.9	10.6	2.3	0.4	0.1
1998	1	527.0	590.9	195.5	20.3	8.9	2.0	0.4	0.7
1999	1	1963.6	216.6	97.7	14.8	4.7	2.1	0.2	0.3
2000	1	2428.5	1054.6	163.2	24.6	1.4	1.2	0.2	0.4
2001	1	265.3	407.6	407.4	30.8	4.7	2.5	0.3	0.1
2002	1	1994.4	282.2	113.6	58.6	4.1	1.0	0.6	0.2
2003	1	545.4	507.7	76.7	34.1	10.8	2.1	0.4	0.1
2004	1	207.5	201.5	75.5	7.7	4.6	3.1	0.2	0.2
2005	1	167.8	67.0	43.7	10.7	1.1	0.4	0.1	0.1
2006	1	130.2	50.4	27.8	12.3	3.4	0.8	0.1	0.0
2007	1	110.0	55.8	38.4	11.4	4.5	2.6	0.3	0.1
2008	1	19.0	42.2	19.6	16.6	4.4	3.2	0.6	0.1
2009	1	1476.5	24.7	17.6	5.5	2.8	0.8	0.4	0.5
2010	1	82.4	322.5	37.5	9.3	2.7	1.2	0.3	0.3
2011	1	443.9	33.4	154.2	20.4	7.2	2.4	1.4	0.4
2012	1	103.2	242.8	51.1	71.1	16.8	2.4	0.7	0.3
2013	1	2244.5	40.8	93.6	29.2	31.2	5.1	0.7	0.1
2014	1	7794.4	250.7	47.2	39.5	10.5	8.3	2.1	0.3
2015	1	822.5	795.9	124.9	29.4	19.7	4.5	2.9	0.2
2016	1	528.6	317.7	304.1	41.9	9.2	10.7	1.7	2.3
2017	1	621.2	163.7	119.9	126.4	19.8	2.7	1.4	0.7
2018	1	2845.4	136.5	96.9	39.6	21.2	3.0	0.1	0.4
2019	1	2874.1	449.3	49.3	23.6	10.0	3.7	0.6	0.1
2020	1	981.6	426.9	172.1	25.0	12.4	4.1	2.2	0.2

Table 35.11. Continued.

Comb-WCGFS-Q4 – Combined Scottish and Irish Groundfish Survey – numbers-at-age per hour									
Index upper bound									
Year	Effort	Age							
	(hours)	0	1	2	3	4	5	6	7+
1996	1	17003.4	1000.3	215.7	63.4	16.0	6.3	1.1	0.1
1997	1	3671.4	1267.2	280.2	59.6	18.0	3.7	0.7	0.2
1998	1	1079.8	1114.6	348.0	34.2	15.0	3.5	0.8	1.1
1999	1	4267.0	399.0	177.4	26.0	8.5	4.1	0.4	0.6
2000	1	4894.9	1867.0	266.3	40.4	2.6	2.0	0.5	0.7
2001	1	525.5	703.9	690.1	48.7	7.8	4.0	0.7	0.2
2002	1	3656.9	450.6	182.4	95.0	6.1	1.9	1.1	0.3
2003	1	989.5	773.9	116.6	51.1	15.4	3.0	0.6	0.2
2004	1	383.7	319.9	111.7	11.9	6.6	4.4	0.3	0.4
2005	1	288.8	103.2	66.5	15.9	1.7	0.9	0.2	0.2
2006	1	272.3	81.1	42.7	18.4	5.1	1.2	0.3	0.1
2007	1	198.7	90.7	57.8	17.2	6.6	3.8	0.6	0.2
2008	1	43.1	66.0	29.5	24.7	6.4	4.6	0.8	0.2
2009	1	2395.1	38.4	27.4	8.4	4.1	1.3	0.7	0.8
2010	1	202.8	587.9	68.0	16.1	5.5	2.4	0.5	0.7
2011	1	870.1	52.9	233.3	30.2	10.4	3.5	2.0	0.6
2012	1	202.7	381.7	78.0	103.5	24.6	3.5	1.0	0.5
2013	1	4292.5	71.6	148.1	44.7	46.9	7.5	1.1	0.3
2014	1	13483.9	383.0	74.6	58.2	15.2	11.7	3.0	0.5
2015	1	1427.0	1214.7	187.7	43.3	28.7	6.4	4.0	0.3
2016	1	919.7	483.8	470.9	61.9	13.8	15.1	2.3	3.0
2017	1	1178.6	262.0	188.9	192.5	29.2	4.0	2.0	1.0
2018	1	5029.4	215.5	148.2	59.2	31.2	4.4	0.2	0.6
2019	1	5217.2	687.6	75.0	34.7	14.5	5.4	1.0	0.2
2020	1	1798.3	666.6	268.2	37.0	18.3	6.0	3.1	0.3

Table 35.11. Continued.

Comb-WCGFS-Q4 – Combined Scottish and Irish Groundfish Survey – numbers-at-age per hour									
Index lower bound									
Year	Effort	Age							
	(hours)	0	1	2	3	4	5	6	7+
1996	1	3597.2	231.9	56.3	16.6	4.4	1.7	0.3	0.0
1997	1	1002.5	392.4	89.6	19.3	6.2	1.5	0.2	0.0
1998	1	255.4	325.2	107.7	11.8	5.2	1.1	0.2	0.4
1999	1	993.6	117.8	56.3	8.4	2.7	1.1	0.1	0.2
2000	1	1385.6	630.5	97.4	15.1	0.8	0.7	0.1	0.2
2001	1	136.2	255.5	247.2	19.3	3.0	1.6	0.2	0.0
2002	1	1151.4	177.0	70.9	38.9	2.8	0.6	0.3	0.1
2003	1	328.4	337.3	54.1	24.0	7.8	1.5	0.2	0.1
2004	1	118.3	132.0	50.6	5.3	3.3	2.2	0.1	0.1
2005	1	103.3	42.5	28.3	7.5	0.7	0.2	0.0	0.0
2006	1	67.9	33.2	18.4	8.5	2.4	0.5	0.1	0.0
2007	1	64.4	36.5	26.3	7.6	3.2	1.9	0.2	0.1
2008	1	8.2	27.2	12.8	11.2	2.9	2.3	0.4	0.1
2009	1	903.3	15.5	11.3	3.6	1.8	0.6	0.2	0.3
2010	1	35.1	182.3	20.6	5.2	1.4	0.6	0.1	0.1
2011	1	248.8	21.2	106.0	14.2	5.0	1.7	1.0	0.3
2012	1	53.9	159.4	34.7	48.6	12.2	1.8	0.5	0.2
2013	1	1258.2	24.5	60.2	19.2	20.9	3.5	0.4	0.1
2014	1	5044.7	167.9	31.7	27.1	7.4	6.1	1.5	0.2
2015	1	501.5	504.8	84.3	19.7	13.4	3.3	2.1	0.1
2016	1	319.8	209.4	204.4	29.7	6.3	7.9	1.2	1.7
2017	1	338.3	107.6	79.5	86.9	13.9	1.9	1.0	0.5
2018	1	1735.8	89.4	62.3	26.1	14.8	2.2	0.0	0.2
2019	1	1795.7	300.7	33.0	16.3	6.8	2.6	0.4	0.0
2020	1	561.5	274.1	114.7	17.1	8.9	3.0	1.6	0.1

Table 35.12. Whiting in Division 6.a. SAM configuration settings for assessment of 6.a whiting agreed at WKNSEA 2021.

Model Setting	Setting name	Configuration & details
Minimum age in model	$minAge	0
Maximum age in model	$maxAge	7
Maximum age plus group	$maxAgePlusGroup	Maximum age plus group applies to both the commercial catch data and modelled Q4 survey index
Coupling of the fishing mortality states processes	$keyLogFsta	Uncoupled across all age classes
Correlation of fishing mortality across ages	$corFlag	AR(1) first order autoregressive
Coupling of the survey catchability parameters	$keyLogFpar	WCIBTS.Q1: ages 1 to 4 uncoupled; ages 5 and 6 coupled SCO.Q1: ages 1 to 4 uncoupled; ages 5 and 6 coupled SWC.Q4: ages 0 to 5 uncoupled; ages 6 and 7+ coupled
Density dependent catchability power parameters	$keyQpow	n/a
Coupling of process variance parameters for *log*(F) process	$keyVarF	Coupled across all age classes
Coupling of the recruitment and survival process variance parameters	$keyVarLogN	Age 0 uncoupled; ages 1 to 7+ coupled
Coupling of the variance parameters for the observations	$keyVarObs	Catch: age 0 uncoupled; ages 1 to 6 coupled; age 7+ uncoupled WCIBTS.Q1: ages 1 to 6 coupled SCO.Q1: ages 1 to 6 coupled SWC.Q4: age 0 uncoupled; ages 1 to 4 coupled; ages 5 to 7+ coupled
Covariance structure for each fleet	$obsCorStruct	Catch: Independent (”ID”) WCIBTS.Q1: ”ID” SCO.Q1: ”ID” SWC.Q4: first order autoregressive (”AR1”)
Coupling of correlation parameters for fleet covariance	$keyCorObs	SWC.Q4: ages 0 and 1 coupled; ages 1 to 6 coupled; ages 6 and 7+ coupled
Stock recruitment code	$stockRecruitmentModelCode	0; Plain random walk
Number of years where catch scaling is applied	$noScaledYears	0
Years where catch is scaled	$keyScaledYears	n/a
Matrix specifying the couplings of scale parameters	$keyParScaledYA	n/a
Lowest and highest ages included in $\bar{F}$	$fbarRange	1, 3

Model Setting	Setting name	Configuration & details
Biomass survey configuration	$keyBiomassTreat	n/a
Observational likelihood	$obsLikelihoodFlag	Catch: ”LN” WCIBTS.Q1: ”LN” SCO.Q1: ”LN” SWC.Q4: ”LN”
Observation weighting configuration	$fixVarToWeight	0
Fraction of t(3) distribution used in logF increment distribution	$fracMixF	0
Fraction of t(3) distribution used in logN increment distribution	$fracMixN	0
Fraction of t(3) distribution used in distribution of fleets	$fracMixObs	Catch: 0 WCIBTS.Q1: 0 SCO.Q1: 0 SWC.Q4: 0
Break years between which recruitment is constant	$constRecBreaks	n/a
Coupling of parameters used in a prediction-variance link for observations	$predVarObsLink	n/a

Table 35.13. Whiting in Division 6.a. Parameter estimates from the updated SAM assessment model.

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-5.901	0.156	0.003	0.002	0.004
logFpar_1	-5.934	0.157	0.003	0.002	0.004
logFpar_2	-6.086	0.159	0.002	0.002	0.003
logFpar_3	-6.190	0.167	0.002	0.001	0.003
logFpar_4	-6.813	0.181	0.001	0.001	0.002
logFpar_5	-5.906	0.240	0.003	0.002	0.004
logFpar_6	-5.714	0.253	0.003	0.002	0.005
logFpar_7	-5.488	0.249	0.004	0.003	0.007
logFpar_8	-5.684	0.259	0.003	0.002	0.006
logFpar_9	-6.300	0.255	0.002	0.001	0.003
logFpar_10	-4.809	0.221	0.008	0.005	0.013
logFpar_11	-5.143	0.179	0.006	0.004	0.008
logFpar_12	-5.112	0.179	0.006	0.004	0.009
logFpar_13	-5.492	0.185	0.004	0.003	0.006
logFpar_14	-5.895	0.202	0.003	0.002	0.004
logFpar_15	-6.171	0.247	0.002	0.001	0.003
logFpar_16	-6.960	0.291	0.001	0.001	0.002
logSdLogFsta_0	-1.016	0.141	0.362	0.273	0.480
logSdLogN_0	-0.501	0.169	0.606	0.432	0.849
logSdLogN_1	-1.729	0.251	0.178	0.108	0.293
logSdLogObs_0	-0.137	0.206	0.872	0.578	1.315
logSdLogObs_1	-1.039	0.079	0.354	0.302	0.415
logSdLogObs_2	-0.621	0.176	0.538	0.378	0.765
logSdLogObs_3	-0.340	0.067	0.711	0.623	0.813
logSdLogObs_4	0.743	0.102	2.103	1.716	2.577
logSdLogObs_5	0.987	0.153	2.683	1.977	3.642
logSdLogObs_6	0.758	0.135	2.135	1.628	2.799
logSdLogObs_7	1.137	0.104	3.117	2.532	3.837
transfIRARdist_0	3.386	1 080	29.558	0.000	Inf
transfIRARdist_1	-0.895	0.304	0.408	0.222	0.750
transfIRARdist_2	1.485	1.641	4.415	0.166	117.567
itrans_rho_0	1.598	0.198	4.944	3.328	7.345

*** The relatively large standard deviation (and associated uncertainty) around the estimate of transfIRARdist_0, the coupled AR1 parameter for ages 0 and 1, indicates a weak to non-existent level of autocorrelation between age groups 0 and 1.**

Table 35.14. Whiting in Division 6.a. SAM estimated population numbers-at-age (thousands).

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
1981	812 632	190 004	460 159	80 615	22 104	6 845	2 077	1 667
1982	832 298	271 627	69 958	206 787	35 441	9 440	2 990	1 834
1983	1 082 047	270 142	79 397	31 090	87 289	14 348	3 768	2 139
1984	880 298	368 292	78 907	26 830	11 220	30 707	4 515	2 219
1985	743 245	284 524	110 602	26 451	7 534	3 248	8 336	2 041
1986	1 354 517	224 571	95 103	35 855	6 941	1 606	672	2 232
1987	510 155	507 257	86 177	36 828	12 342	2 097	469	1 085
1988	749 690	144 775	157 786	31 486	11 130	3 317	495	521
1989	657 216	246 418	38 411	45 398	9 918	2 575	677	276
1990	860 236	201 161	87 343	10 970	12 633	2 872	560	247
1991	1 145 112	277 608	64 776	38 913	3 948	4 188	918	292
1992	771 780	392 449	97 835	23 977	16 040	1 419	1 319	458
1993	785 939	241 193	135 496	35 629	8 692	6 132	495	697
1994	755 366	258 089	88 144	51 322	13 251	3 074	2 163	511
1995	696 054	248 654	102 010	36 863	18 592	4 694	1 083	1 072
1996	657 609	225 094	90 322	37 733	13 410	5 822	1 516	860
1997	657 222	201 917	66 690	32 340	11 627	3 681	1 415	823
1998	402 613	218 664	63 712	20 215	10 893	3 176	999	897
1999	866 442	114 544	64 224	15 616	5 324	2 789	636	635
2000	328 494	314 276	38 388	16 405	3 342	1 204	597	425
2001	213 390	92 863	87 754	11 567	3 474	794	246	299
2002	287 758	64 886	33 086	26 161	3 671	1 016	215	222
2003	217 260	91 550	17 038	12 104	7 643	1 321	383	188
2004	117 059	72 796	27 735	5 201	4 047	2 740	471	296
2005	106 349	34 603	21 161	8 424	1 510	1 264	914	365
2006	65 960	35 520	12 152	8 161	3 302	673	613	701
2007	59 396	19 990	13 621	5 463	3 393	1 552	336	746
2008	98 577	18 962	7 333	6 619	2 537	1 708	729	608
2009	302 352	33 753	8 691	3 754	3 391	1 260	897	745
2010	96 013	114 756	14 143	4 432	1 874	1 874	642	974

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
2011	204 747	26 006	42 776	7 178	2 316	927	1 059	850
2012	113 307	72 890	11 331	19 263	4 504	1 137	537	1 012
2013	257 644	35 005	26 288	6 729	10 034	2 331	662	888
2014	477 394	84 225	10 085	11 212	3 994	4 792	1 367	977
2015	324 234	157 244	27 556	6 539	6 724	2 279	3 038	1 447
2016	268 962	101 409	67 677	13 372	3 608	3 791	1 347	2 654
2017	206 089	92 181	38 650	34 438	7 191	2 124	2 068	2 047
2018	427 777	60 091	37 250	19 984	16 775	3 856	1 100	2 090
2019	480 698	150 509	22 666	18 335	10 486	8 158	2 187	1 691
2020	202 293	175 829	54 711	11 984	10 375	5 431	4 688	2 063
2021	202 293	60 808	65 511	26 052	6 828	6 155	2 901	4 216

Table 35.15. Whiting in Division 6.a. SAM estimates for F-at-age

	Age							
Year	0	1	2	3	4	5	6	7+
1981	0.022	0.060	0.130	0.222	0.279	0.317	0.343	0.180
1982	0.033	0.094	0.196	0.316	0.381	0.425	0.455	0.236
1983	0.046	0.136	0.292	0.472	0.567	0.637	0.678	0.341
1984	0.054	0.162	0.366	0.603	0.742	0.839	0.908	0.447
1985	0.059	0.177	0.426	0.717	0.935	1.074	1.181	0.562
1986	0.045	0.134	0.315	0.496	0.643	0.745	0.846	0.402
1987	0.070	0.214	0.459	0.652	0.815	0.945	1.062	0.483
1988	0.084	0.262	0.541	0.727	0.916	1.085	1.196	0.531
1989	0.076	0.235	0.488	0.659	0.810	0.974	1.051	0.458
1990	0.056	0.169	0.336	0.450	0.549	0.647	0.673	0.296
1991	0.055	0.167	0.339	0.457	0.545	0.619	0.620	0.273
1992	0.053	0.161	0.325	0.441	0.520	0.572	0.563	0.250
1993	0.044	0.130	0.273	0.401	0.507	0.574	0.560	0.245
1994	0.040	0.117	0.245	0.371	0.477	0.537	0.520	0.223
1995	0.051	0.155	0.315	0.461	0.577	0.638	0.596	0.249
1996	0.070	0.218	0.424	0.615	0.752	0.825	0.721	0.283
1997	0.070	0.218	0.409	0.590	0.689	0.751	0.632	0.238
1998	0.097	0.309	0.564	0.811	0.916	1.014	0.861	0.305
1999	0.094	0.301	0.555	0.840	0.971	1.052	0.913	0.301
2000	0.110	0.356	0.579	0.869	1.033	1.043	0.887	0.276
2001	0.080	0.252	0.405	0.594	0.728	0.705	0.556	0.166
2002	0.081	0.257	0.367	0.501	0.569	0.509	0.359	0.108
2003	0.077	0.244	0.317	0.437	0.485	0.415	0.281	0.083
2004	0.100	0.320	0.362	0.501	0.536	0.436	0.290	0.092
2005	0.058	0.176	0.167	0.226	0.244	0.198	0.136	0.047
2006	0.053	0.163	0.134	0.191	0.226	0.197	0.144	0.052
2007	0.042	0.134	0.103	0.150	0.192	0.174	0.130	0.049
2008	0.035	0.113	0.076	0.111	0.148	0.137	0.100	0.039
2009	0.050	0.174	0.092	0.120	0.151	0.133	0.092	0.036
2010	0.064	0.231	0.105	0.125	0.149	0.133	0.091	0.036

	Age							
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7+**
2011	0.038	0.137	0.051	0.056	0.064	0.057	0.038	0.015
2012	0.046	0.181	0.059	0.063	0.071	0.064	0.041	0.016
2013	0.056	0.232	0.065	0.064	0.069	0.063	0.040	0.015
2014	0.029	0.115	0.031	0.034	0.039	0.040	0.026	0.010
2015	0.032	0.131	0.040	0.047	0.051	0.054	0.034	0.013
2016	0.025	0.105	0.033	0.038	0.040	0.044	0.025	0.009
2017	0.026	0.112	0.035	0.042	0.044	0.049	0.025	0.008
2018	0.020	0.089	0.029	0.035	0.036	0.036	0.017	0.005
2019	0.025	0.117	0.037	0.046	0.047	0.045	0.020	0.006
2020	0.025	0.119	0.034	0.040	0.039	0.036	0.015	0.004

Table 35.16. Whiting in Division 6.a. Assessment summary with weights in tonnes and recruitment in thousands. 'High' and 'Low' refer to 95% confidence intervals

Year	Recruitment age 0			SSB			Landings*	Discards*	Fishing mortality ages 1-3		
	Low	Value	High	Low	Value	High			Low	Value	High
1981	465 262	812 632	1 419 351	74 077	103 635	144 988	12 194	2 132	0.092	0.137	0.21
1982	501 677	832 298	1 380 808	66 723	89 433	119 873	13 880	5 485	0.143	0.20	0.28
1983	657 335	1 082 047	1 781 169	51 338	65 543	83 679	15 962	6 294	0.22	0.30	0.41
1984	535 282	880 298	1 447 695	36 533	45 164	55 834	16 459	4 017	0.28	0.38	0.51
1985	445 080	743 245	1 241 153	29 124	36 258	45 139	12 879	4 840	0.33	0.44	0.59
1986	805 575	1 354 517	2 277 523	24 445	30 897	39 051	8 458	2 669	0.23	0.32	0.43
1987	306 843	510 155	848 182	27 854	34 540	42 830	11 542	11 918	0.33	0.44	0.59
1988	440 604	749 690	1 275 601	30 585	39 326	50 565	11 349	8 132	0.38	0.51	0.68
1989	400 876	657 216	1 077 470	20 587	25 845	32 445	7 523	5 876	0.34	0.46	0.63
1990	527 857	860 236	1 401 908	19 065	24 713	32 034	5 642	4 530	0.23	0.32	0.44
1991	699 569	1 145 112	1 874 414	21 738	27 507	34 806	6 657	4 883	0.24	0.32	0.44
1992	473 316	771 780	1 258 450	27 081	33 953	42 570	6 004	9 249	0.23	0.31	0.42
1993	483 253	785 939	1 278 212	31 336	39 854	50 688	6 871	4 759	0.194	0.27	0.37
1994	469 025	755 366	1 216 520	30 672	38 262	47 730	5 900	3 455	0.177	0.25	0.34
1995	433 842	696 054	1 116 743	31 775	39 359	48 754	6 078	5 771	0.23	0.31	0.42
1996	410 330	657 609	1 053 908	29 801	36 665	45 110	7 158	7 940	0.31	0.42	0.56
1997	417 443	657 222	1 034 728	24 193	29 797	36 700	6 291	5 251	0.30	0.41	0.55
1998	252 031	402 613	643 164	21 186	26 139	32 251	4 628	9 216	0.42	0.56	0.75
1999	540 952	866 442	1 387 781	16 587	20 824	26 144	4 613	3 975	0.42	0.56	0.76
2000	205 250	328 494	525 742	15 476	19 360	24 218	3 011	13 285	0.45	0.60	0.81
2001	126 774	213 390	359 184	16 617	21 924	28 925	2 439	4 263	0.30	0.42	0.58
2002	178 714	287 758	463 337	12 338	16 093	20 990	1 768	2 851	0.26	0.38	0.55

Year	Recruitment age 0			SSB			Landings*	Discards*	Fishing mortality ages 1-3		
	Low	Value	High	Low	Value	High			Low	Value	High
2003	138 394	217 260	341 069	8 886	11 725	15 472	1 331	1 987	0.22	0.33	0.51
2004	73 390	117 059	186 712	8 068	10 887	14 691	799	2 889	0.25	0.39	0.63
2005	66 983	106 349	168 850	6 193	8 716	12 266	335	971	0.121	0.190	0.30
2006	40 679	65 960	106 951	5 427	7 594	10 625	378	748	0.106	0.162	0.25
2007	36 687	59 396	96 160	5 116	7 207	10 152	481	367	0.084	0.129	0.198
2008	60 072	98 577	161 761	4 496	6 381	9 054	441	156	0.065	0.100	0.154
2009	182 003	302 352	502 283	4 620	6 540	9 259	480	826	0.084	0.128	0.196
2010	56 583	96 013	162 923	6 574	9 349	13 295	338	1 094	0.098	0.153	0.24
2011	123 313	204 747	339 959	9 270	13 982	21 088	229	631	0.050	0.081	0.132
2012	65 608	113 307	195 684	9 143	13 726	20 606	304	772	0.062	0.101	0.165
2013	151 416	257 644	438 396	9 845	15 121	23 223	216	1 225	0.070	0.120	0.21
2014	281 295	477 394	810 199	8 832	13 503	20 643	181	748	0.036	0.060	0.101
2015	190 603	324 234	551 552	11 906	18 159	27 698	223	1 457	0.044	0.072	0.120
2016	159 543	268 962	453 425	16 856	26 328	41 122	226	1 038	0.035	0.059	0.099
2017	116 683	206 089	364 003	18 052	27 995	43 413	178	1 326	0.038	0.063	0.106
2018	247 842	427 777	738 345	17 347	26 677	41 027	190	648	0.030	0.051	0.086
2019	266 965	480 698	865 547	16 342	24 840	37 756	502	925	0.040	0.067	0.113
2020	86 502	202 293	473 082	19 032	29 416	45 466	544	826	0.036	0.065	0.115
2021	46 062	202 293	888 426	20 282	32 659	52 590					

*** Calculated using Sum of Products from the catch numbers-at-age and mean weights-at-age. Pre-2003 Discards are estimated for ages 1+ only.**

Table 35.17. Whiting in Division 6.a. Annual catch scenarios. All weights are in tonnes.

Basis	Total catch (2022)	Projected landings * (2022)	Projected discards ** (2022)	F_{total} (2022)	$F_{projected\ landings}$ (2022)	$F_{projected\ discards}$ (2022)	SSB (2023)	% SSB change ***	% Advice change^
MSY approach = F_{MSY}	4 114	2 142	1 972	0.21	0.038	0.172	26 294	-16.70	
F = 0	0	0	0	0	0	0	31 193	-1.13	
$F_{MSY\ lower}$	3 433	1 784	1 649	0.173	0.031	0.142	27 062	-14.20	
$F_{MSY\ upper}$	4 114	2 142	1 972	0.21	0.038	0.172	26 294	-16.70	
F_{pa}	4 114	2 142	1 972	0.21	0.038	0.172	26 294	-16.70	
F_{lim}	5 870	3 074	2 796	0.31	0.056	0.25	24 383	-23	
SSB (2023) = B_{lim}	13 196	7 039	6 157	0.82	0.148	0.67	17 286	-45	
SSB (2023) = B_{pa}	4 750	2 479	2 271	0.25	0.044	0.2	25 597	-18.90	
SSB (2023) = MSY $B_{trigger}$	4 750	2 479	2 271	0.25	0.044	0.2	25 597	-18.90	
SSB (2023) = SSB (2022) ^^									
F = F_{2021}	1 332	688	644	0.065	0.0117	0.053	29 530	-6.40	

*** * Marketable landings, assuming recent discard rate.**

**** Including BMS landings (EU stocks), assuming recent discard rate.**

***** SSB 2023 relative to SSB 2022.**

^ This is not provided because the advice for 2021 was zero.

^^ The SSB (2023) = SSB (2022) option was left blank because this cannot be achieved in 2023, even with zero catch in 2022.

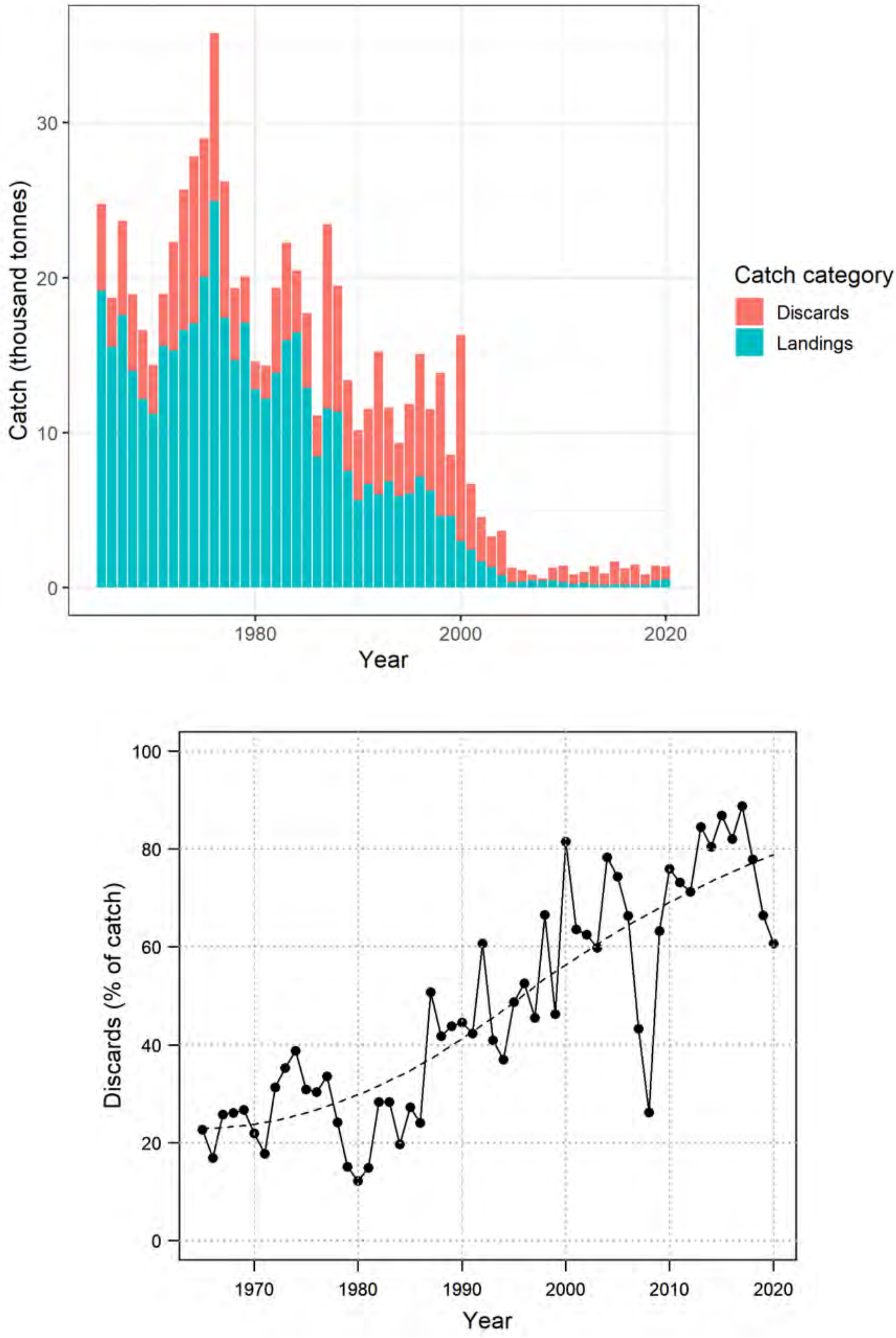

Figure 35.1. Whiting in Division 6.a. Landings and discards (in thousand tonnes) as officially reported to ICES (upper panel) and discards (as % of catch, lower panel). Pre-2003 discards are estimated for ages 1+ only; from 2003 onwards, they are estimated for all ages.

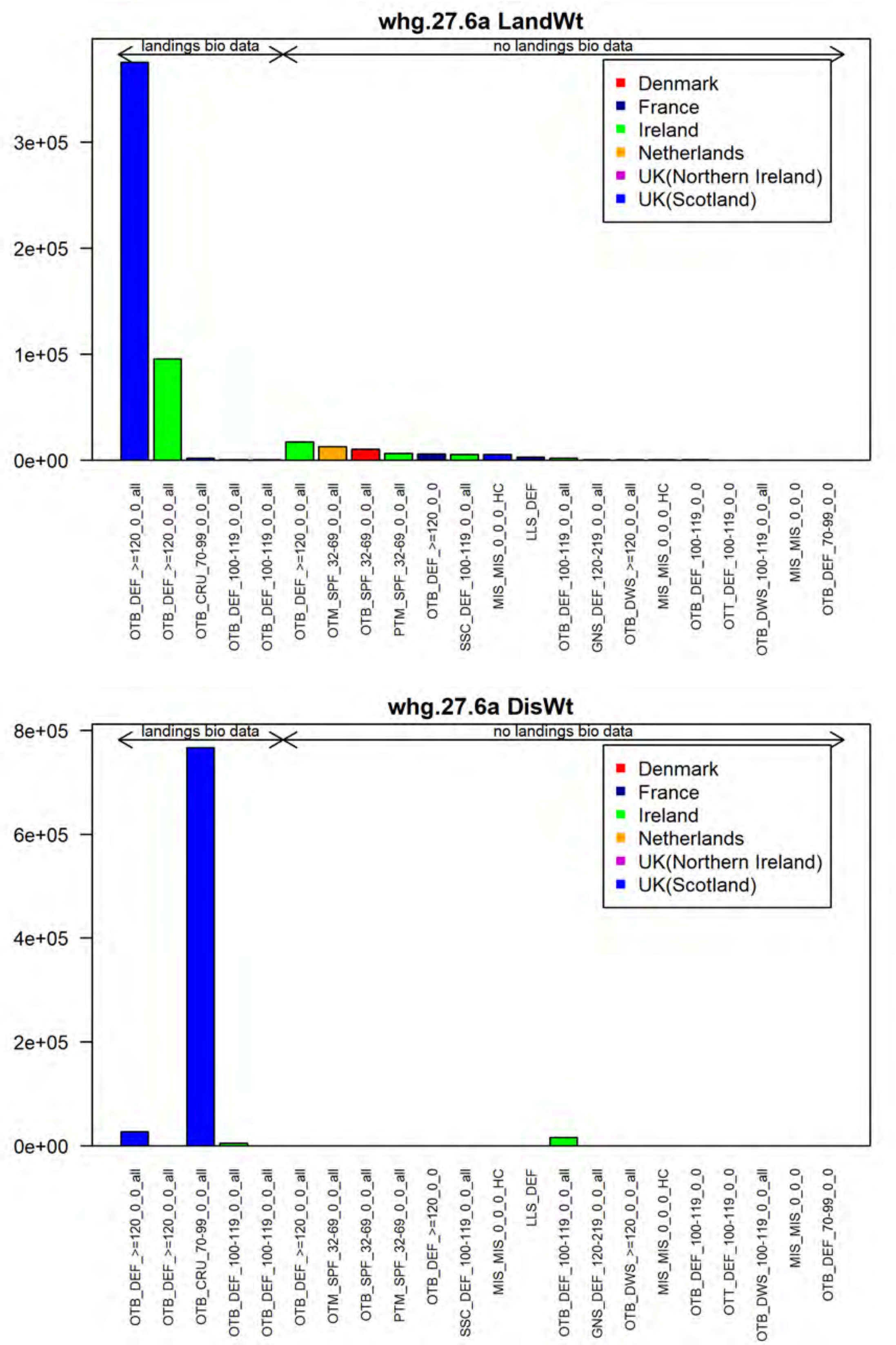

Figure 35.2. Whiting in Division 6.a. Landings (upper panel) and discards (all ages, lower panel) by métier (kg) in 2019 as entered into InterCatch.

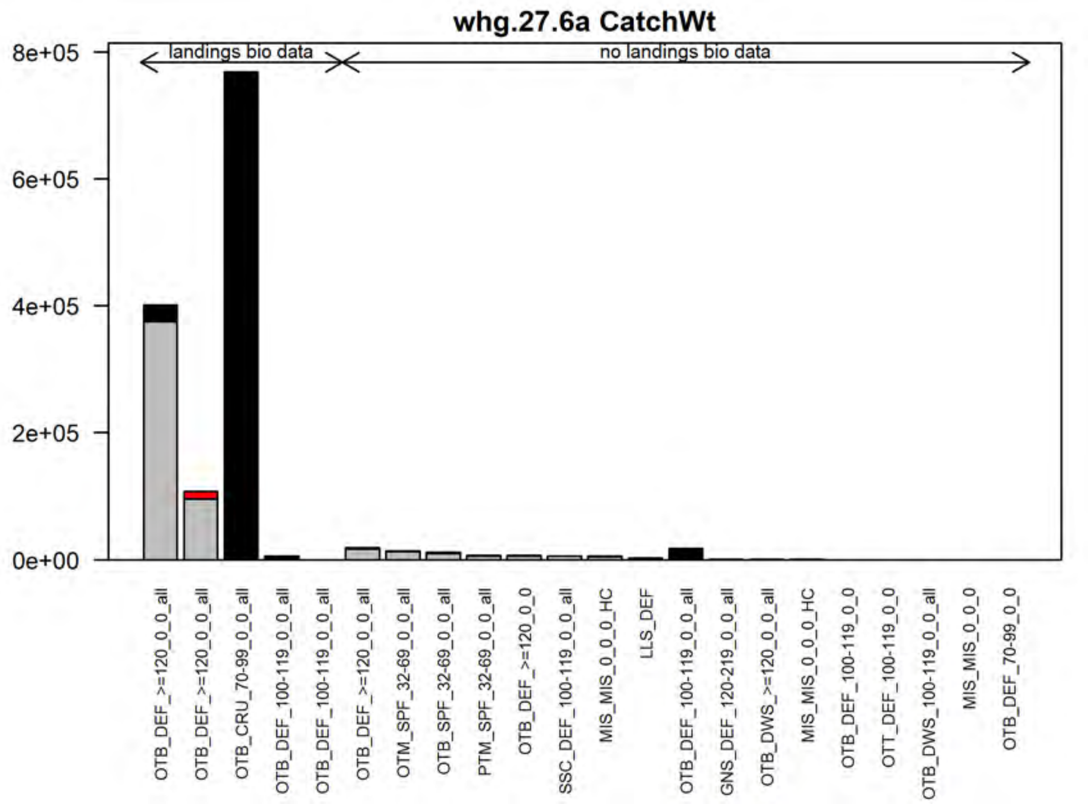

Figure 35.3. Whiting in Division 6.a. Landings (sampled and unsampled, in grey), sampled discards (in black) and raised unsampled discards (in red) after allocations within InterCatch.

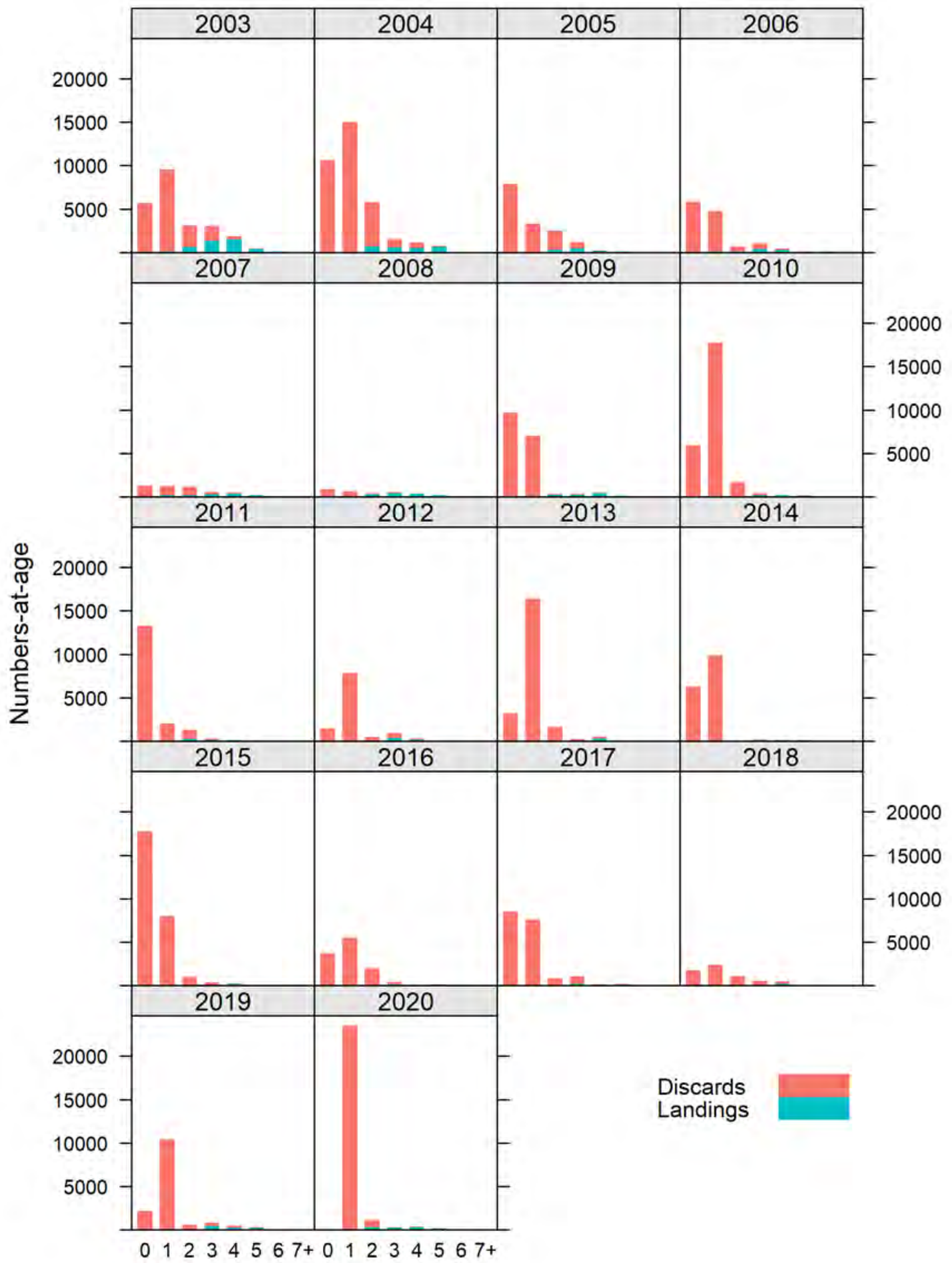

Figure 35.4. Whiting in Division 6.a. Catch numbers-at-age by year.

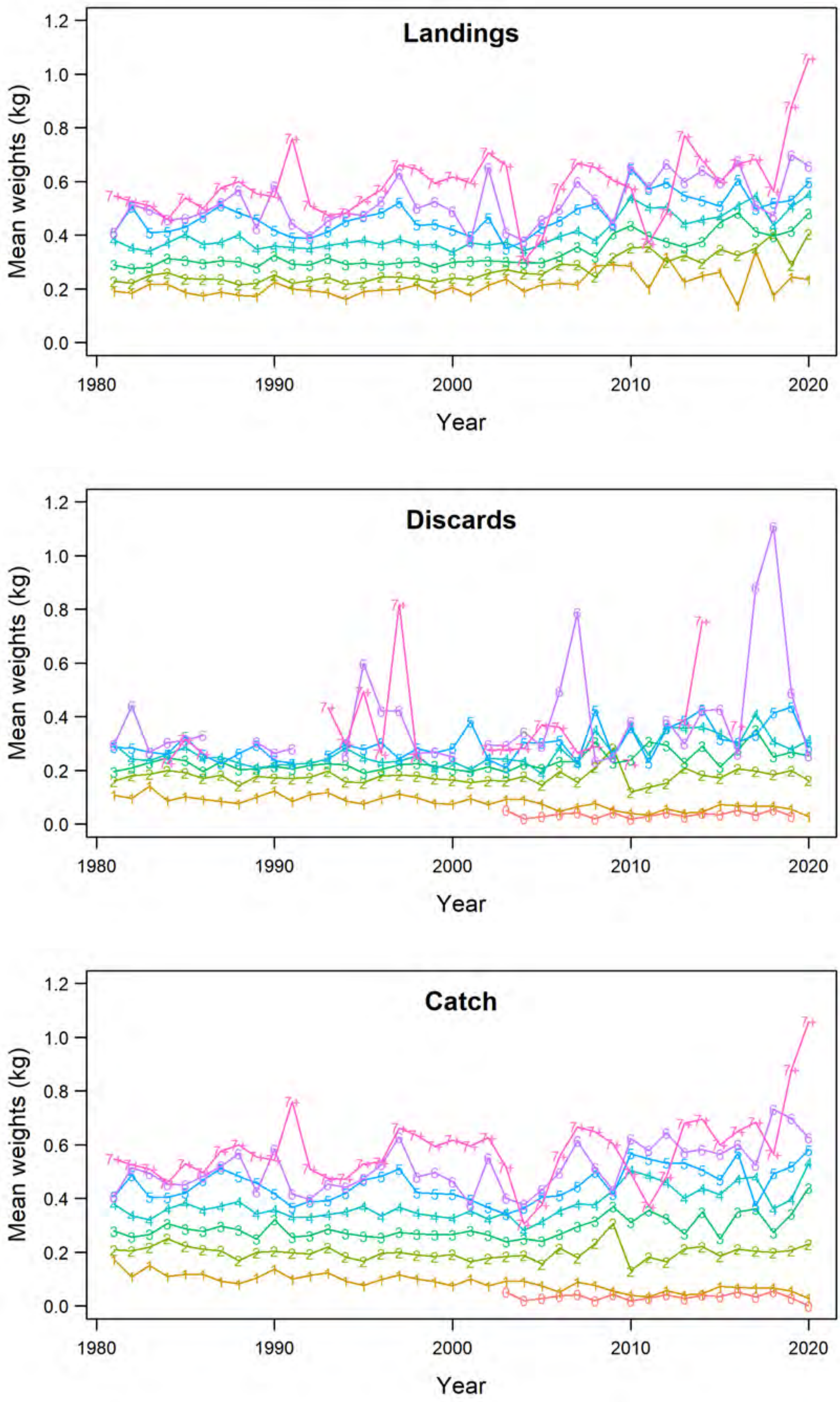

Figure 35.5. Whiting in Division 6.a. Mean weight-at-age in the landings (upper panel), discards (middle panel) and catch (lower panel).

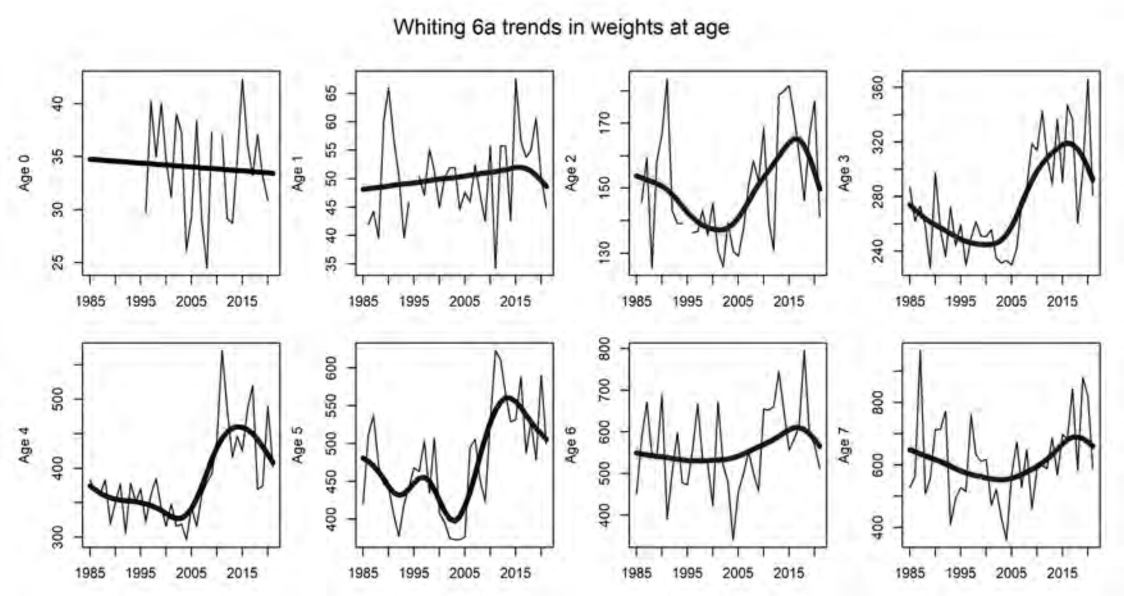

Figure 35.6. Whiting in Division 6.a. Combined Q1 and Q4 survey weights-at-age time-series for 6a whiting, together with catch weights-at-age time-series. Only Q4 surveys contain data for the zero age class. The smoothed estimates were used for M calculation.

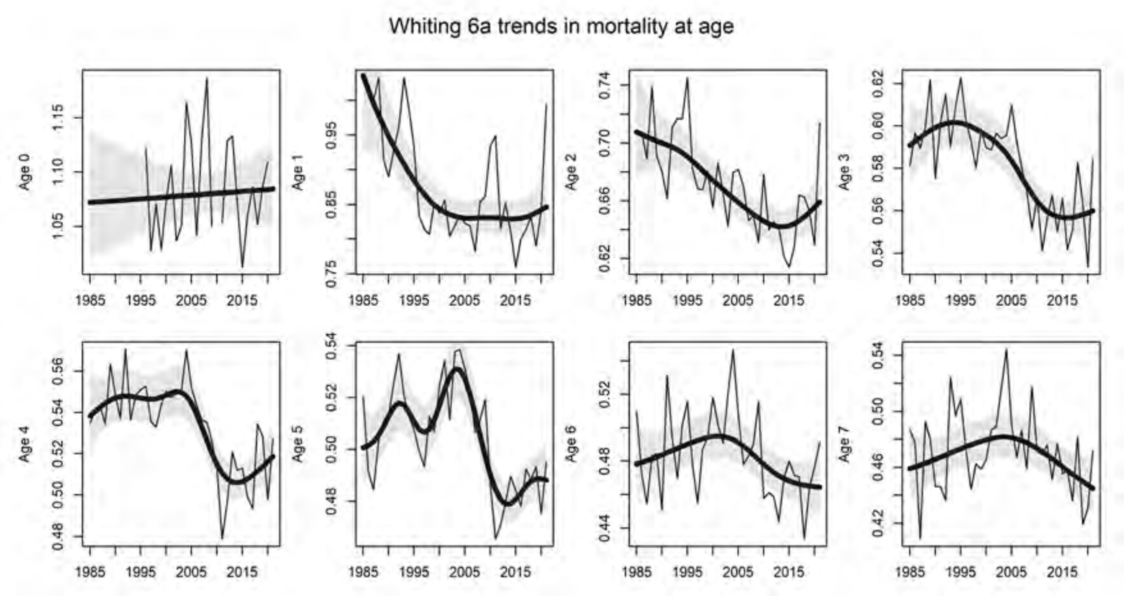

Figure 35.7. Whiting in Division 6.a. Time-series of natural mortality-at-age estimated with Lorenzen's (1996) model. The thick black line shows the natural mortality obtained with the smoothed weights-at-age with the corresponding 95% confidence interval shown in grey. The thin black line shows the natural mortality obtained with unsmoothed weights-at-age, for comparison.

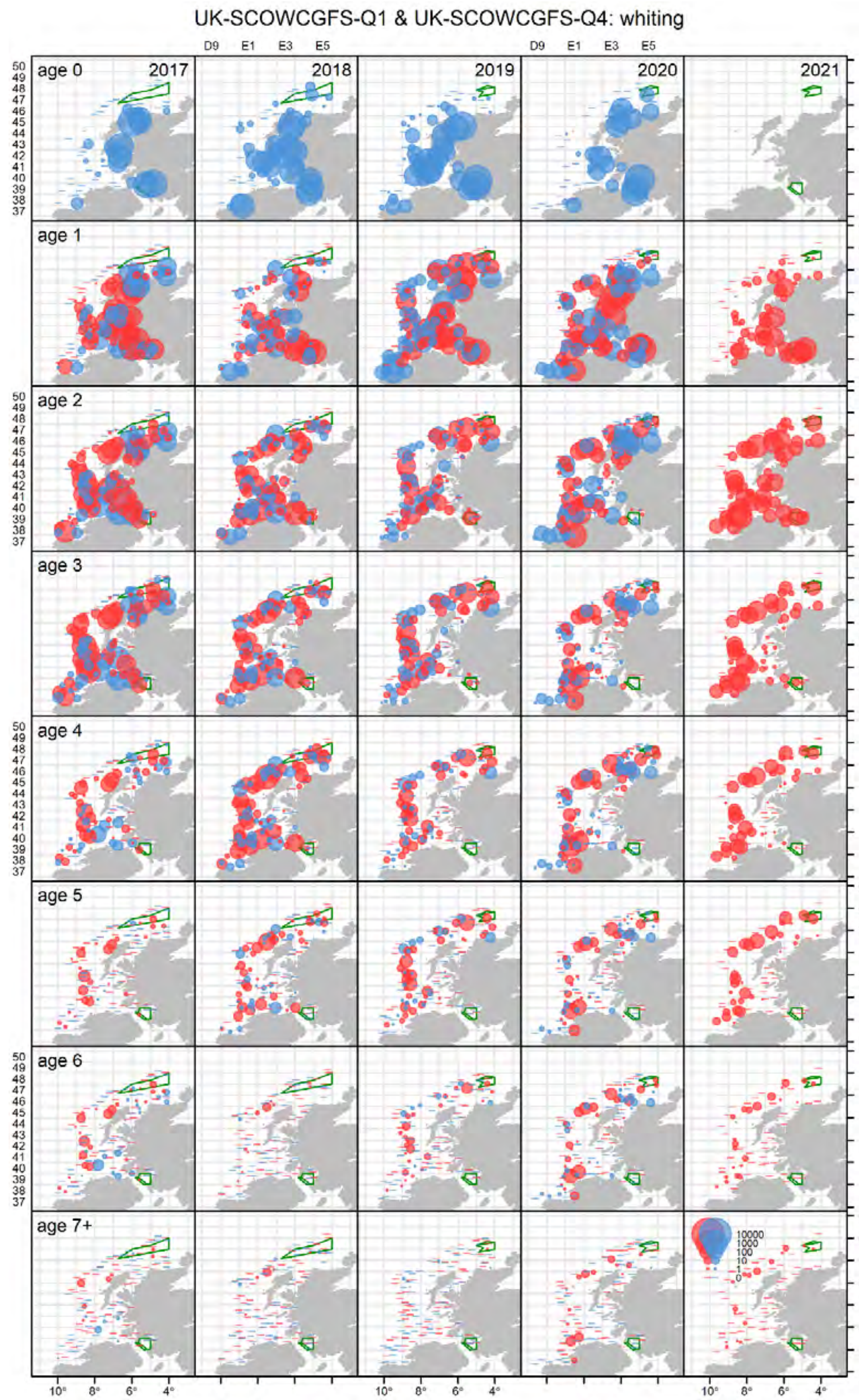

Figure 35.8. Whiting in Division 6.a. Cpue from the Scottish first quarter west coast groundfish survey (UK-SCOWCGFS-Q1, in red) and the Scottish fourth quarter groundfish survey (UK-SCOWCGFS-Q4, in blue) in 2017–2021. Numbers are standardised to 30 minutes towing. The closed areas, the Windsock and West Shetland Shelf in the north, and the Clyde in the south, are shown as green polygons.

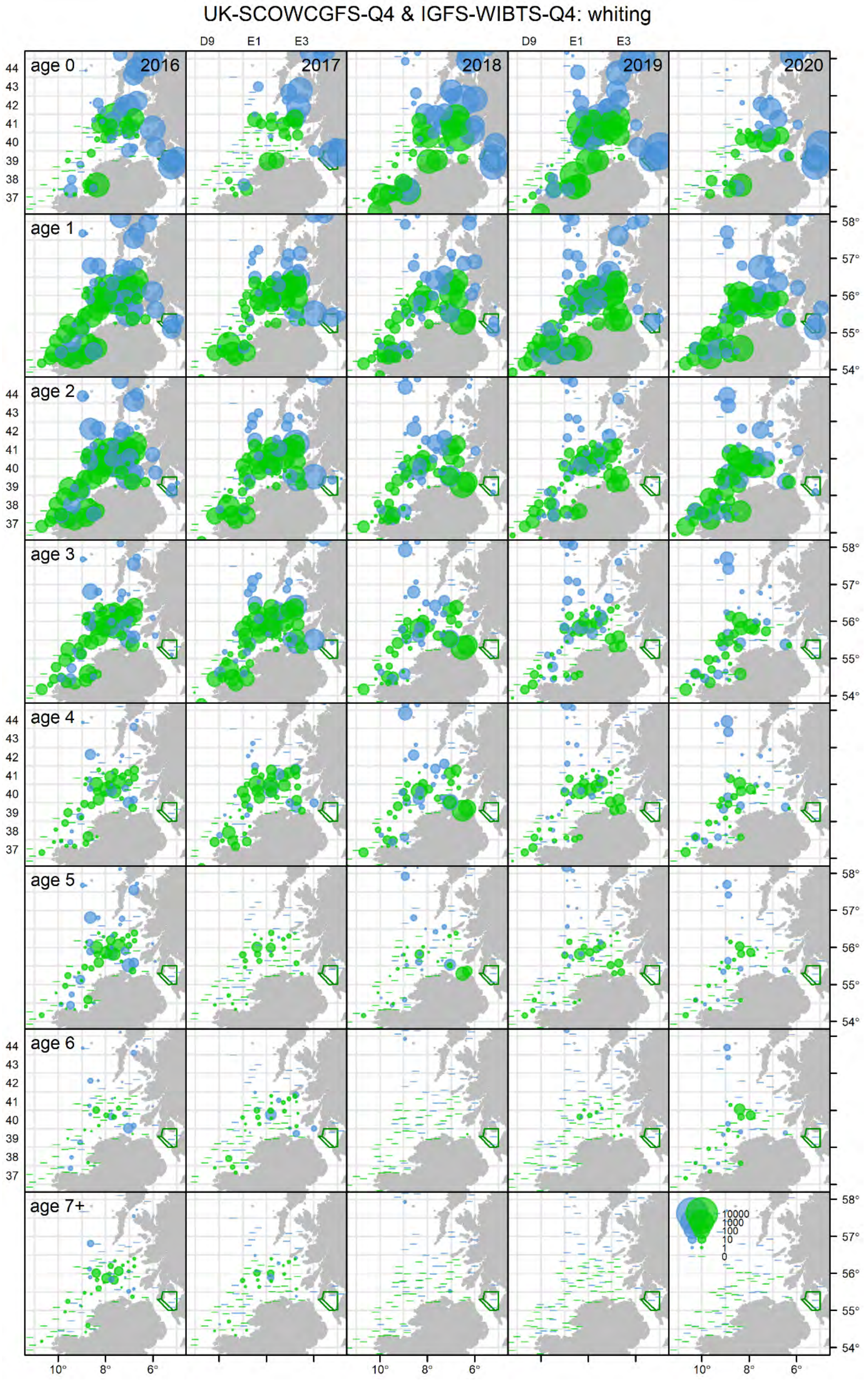

Figure 35.9. Whiting in Division 6.a. Cpue from the Scottish fourth quarter west coast groundfish survey (UK-SCOWCGFS-Q4, only the southern part of the survey area, in blue) and the Irish fourth quarter groundfish survey (IGFS-WIBTS-Q4, in green) in 2016–2020. Numbers are standardised to 30 minutes towing. The Clyde closed area is shown as a green polygon.

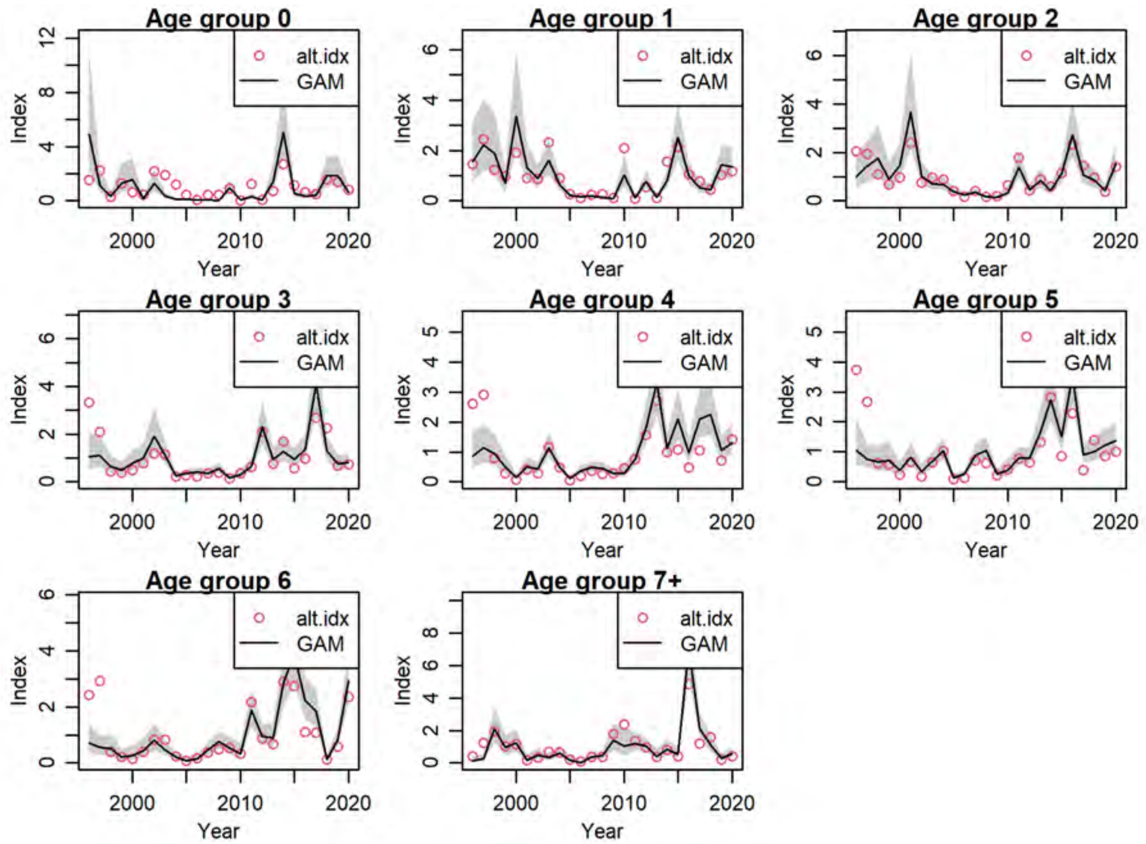

Figure 35.10. Whiting in Division 6.a. The combined index derived from a delta-GAM model fit to data from the three Q4 surveys (black line) with 95% confidence limits (in grey). Indices are derived by summing model predictions on a spatial grid. The survey index calculated using the stratified mean method for ICES statistical rectangles as strata are shown as red points. The indices are mean-standardised.

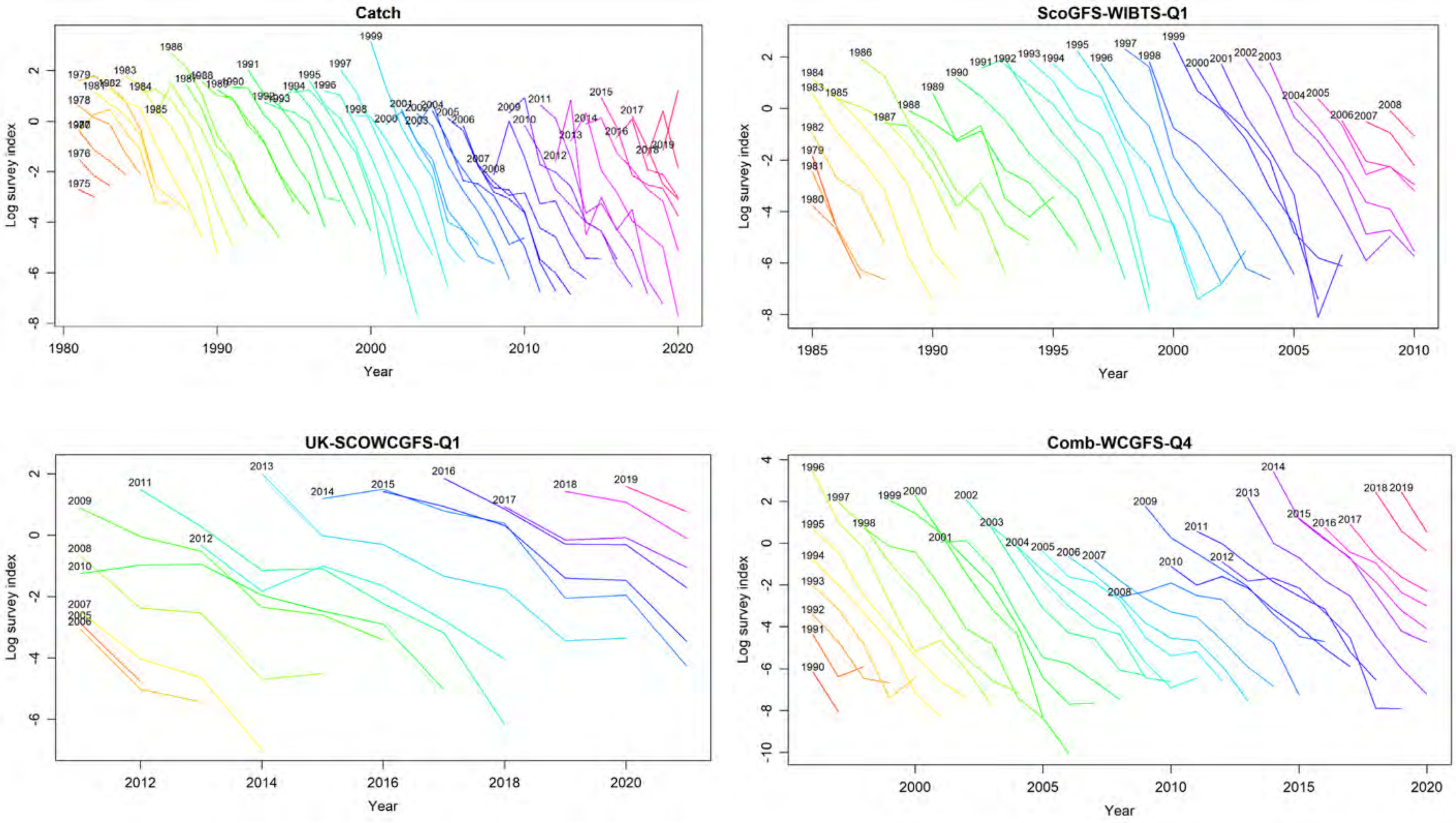

Figure 35.11. Whiting in Division 6.a. Log abundance indices by year with a line for each cohort, for catch and the three survey series. The spawning year of each cohort is indicated at the start of each line. Note the age range 1–7+ in 1981–2002 and 0–7+ in 2003–2020 for the catch data.

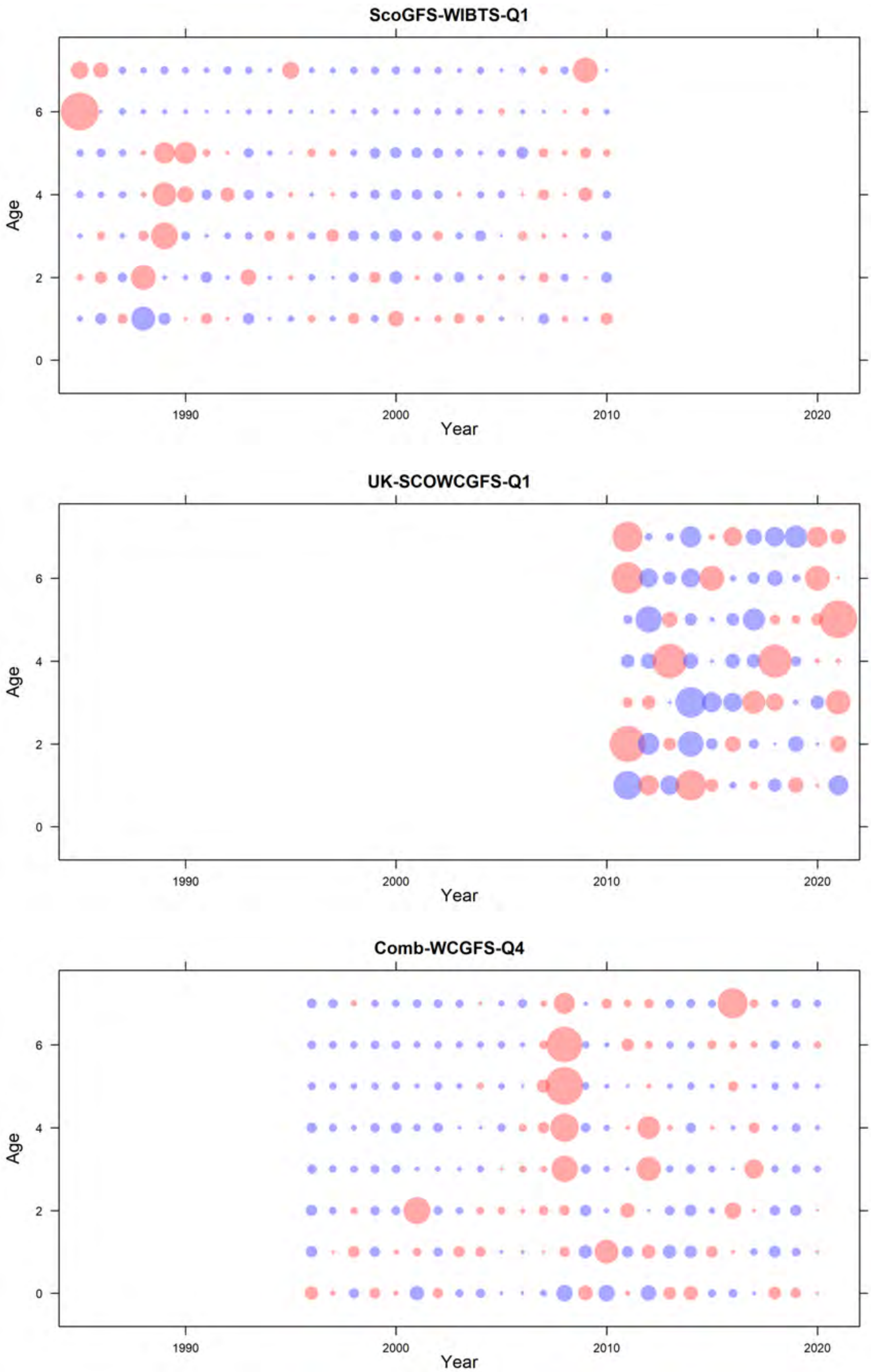

Figure 35.12. Whiting in Division 6.a. Standardised proportions at age per year ("spay") for the three survey series. The positive values are shown in red, the negative values are shown in blue.

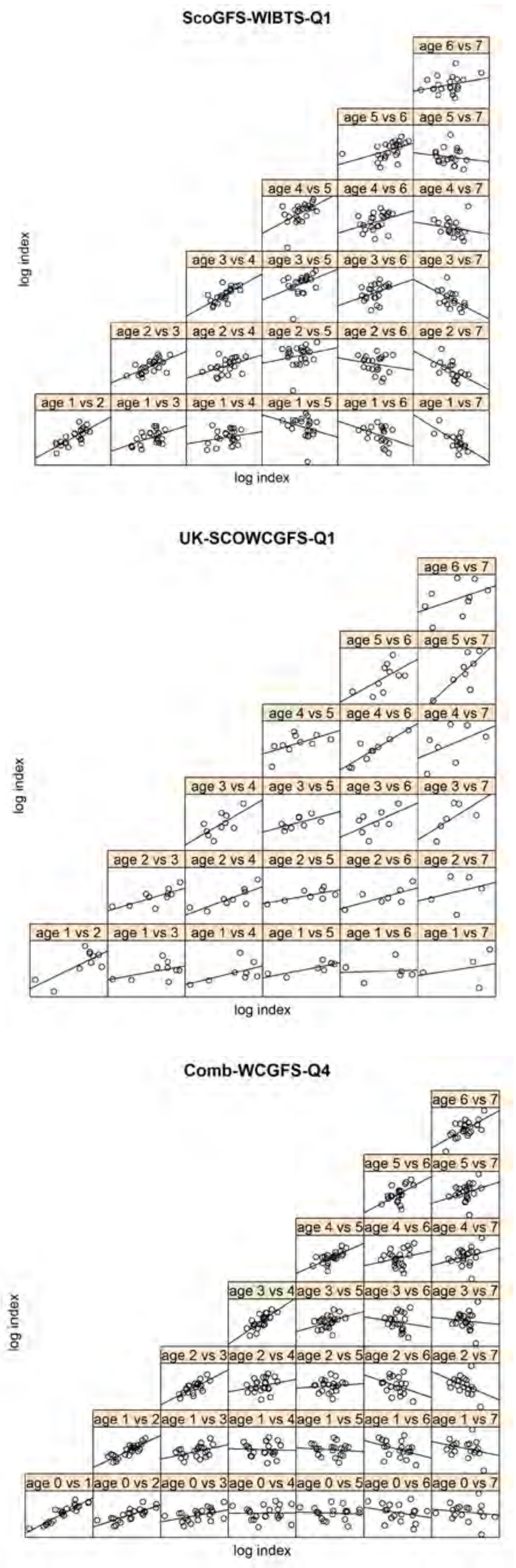

Figure 35.13. Whiting in Division 6.a. Within-survey correlations comparing index values at different ages for the same year classes for the three survey series. The straight line is a linear regression.

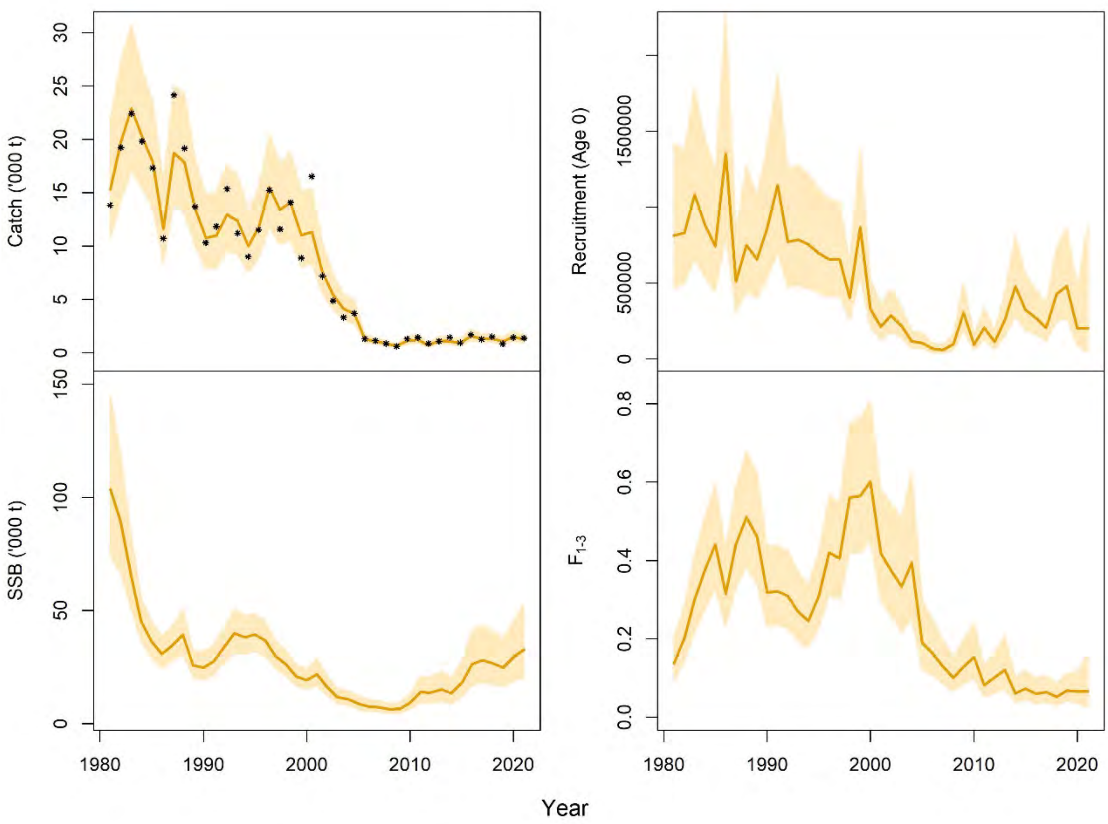

Figure 35.14. Whiting in Division 6.a. Summary of the SAM assessment model estimates (orange line) with 95% confidence intervals (yellow polygon).

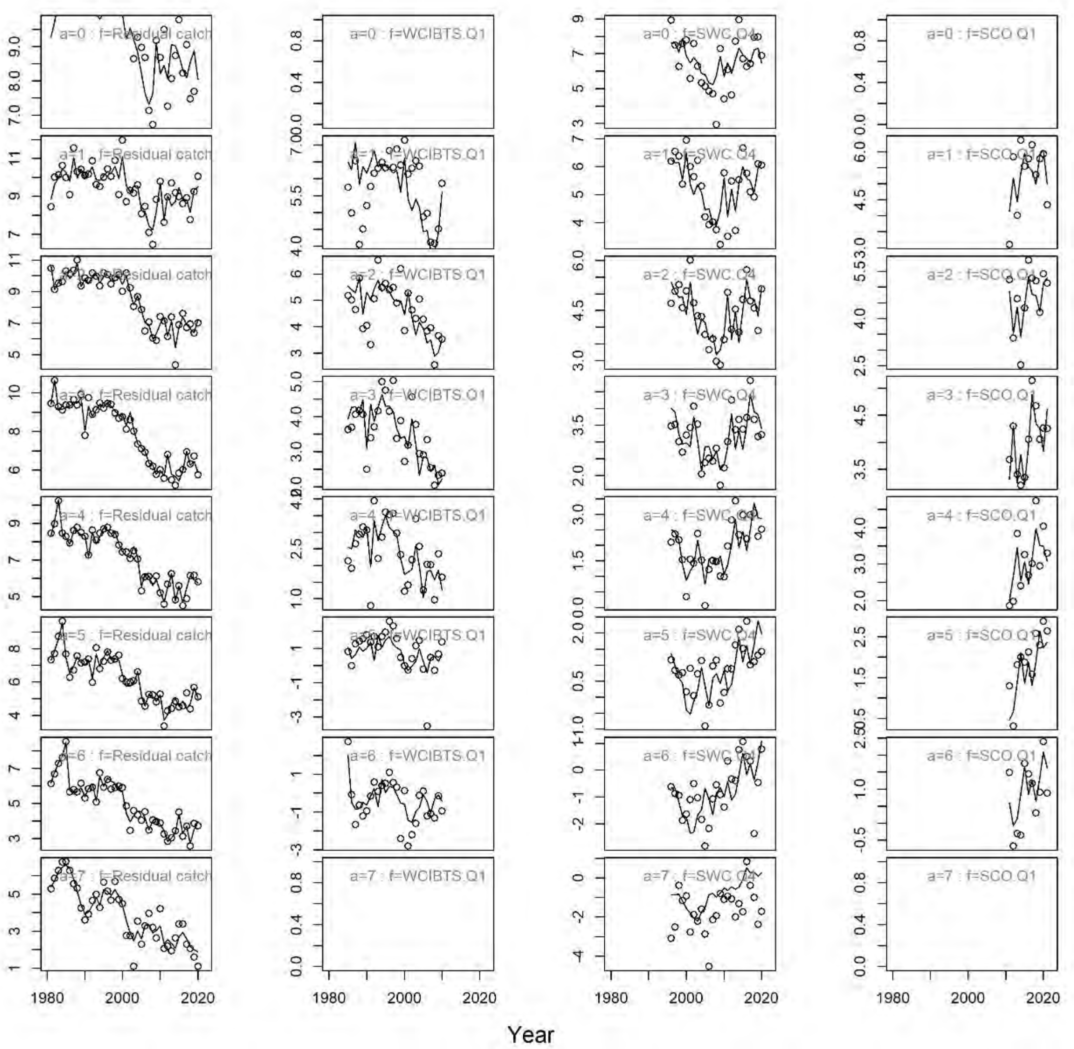

Figure 35.15. Whiting in Division 6.a. Comparison of the SAM assessment model estimates with observed log catch numbers-at-age (first column of panels) and observed log survey indices-at-age for ScoGFS-WIBTS-Q1 (second column), Comb-WCGFS-Q4 (third column), and UK-SCOWCGFS-Q1 (fourth column).

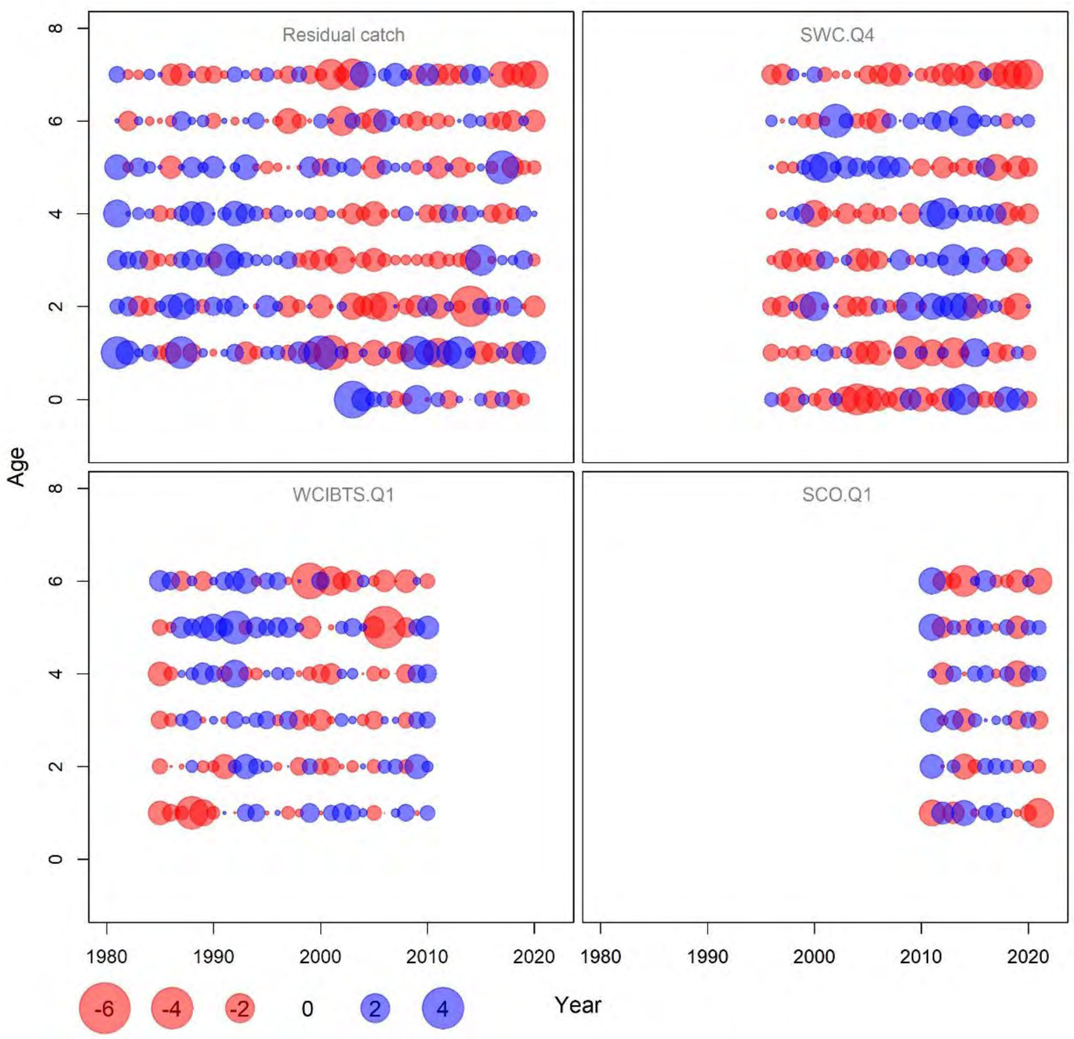

Figure 35.16. Whiting in Division 6.a. Standardized one-observation-ahead residuals-at-age by fleet from the SAM assessment model: catch (top left), ScoGFS-WIBTS-Q1 (bottom left), UK-SCOWCGFS-Q1 (bottom right), and Comb-WCGFS-Q4 (top right).

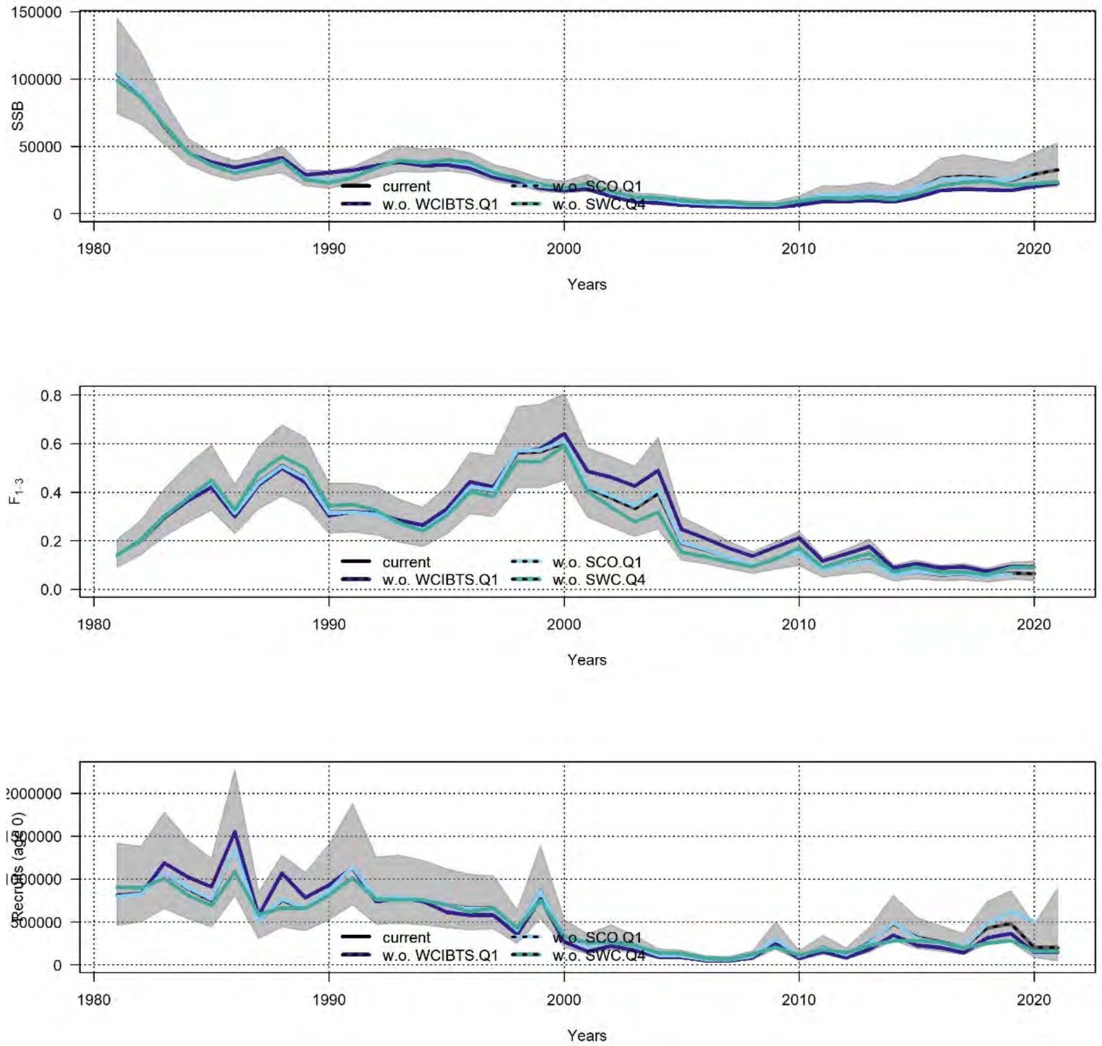

Figure 35.17. Whiting in Division 6.a. Leave-one-out sensitivity analysis of the SAM assessment model,

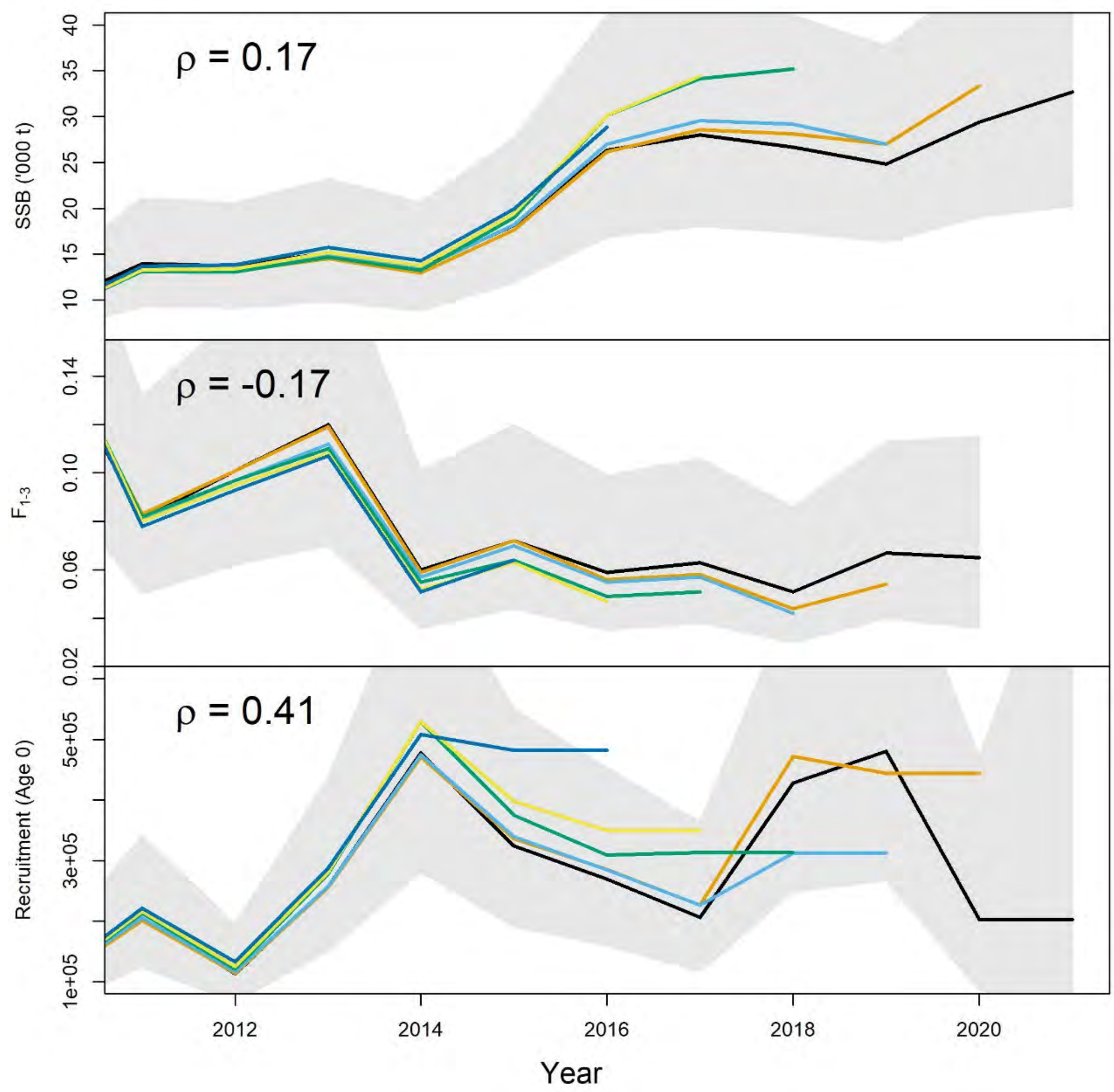

Figure 35.18. Whiting in Division 6.a. Retrospective patterns for the SAM assessment model.

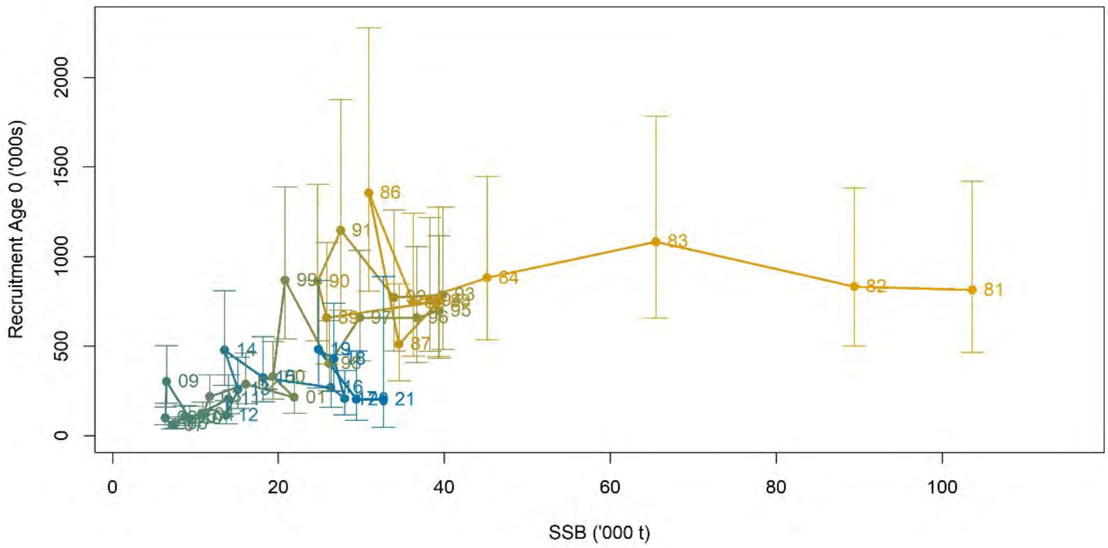

Figure 35.19. Whiting in Division 6.a. The SAM assessment model Stock-Recruit relationship.

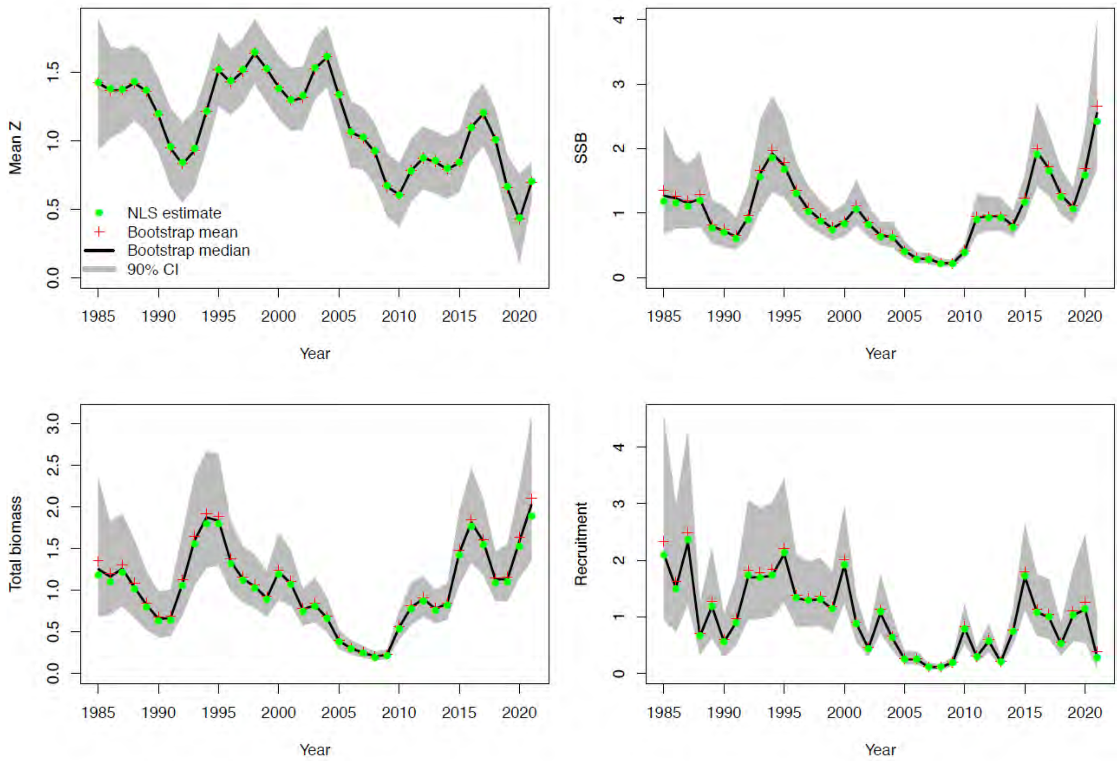

Figure 35.20. Whiting in Division 6.a. Results of SURBAR analysis (see legend on mean Z plot for details). SSB, TSB and recruitment are relative estimates.

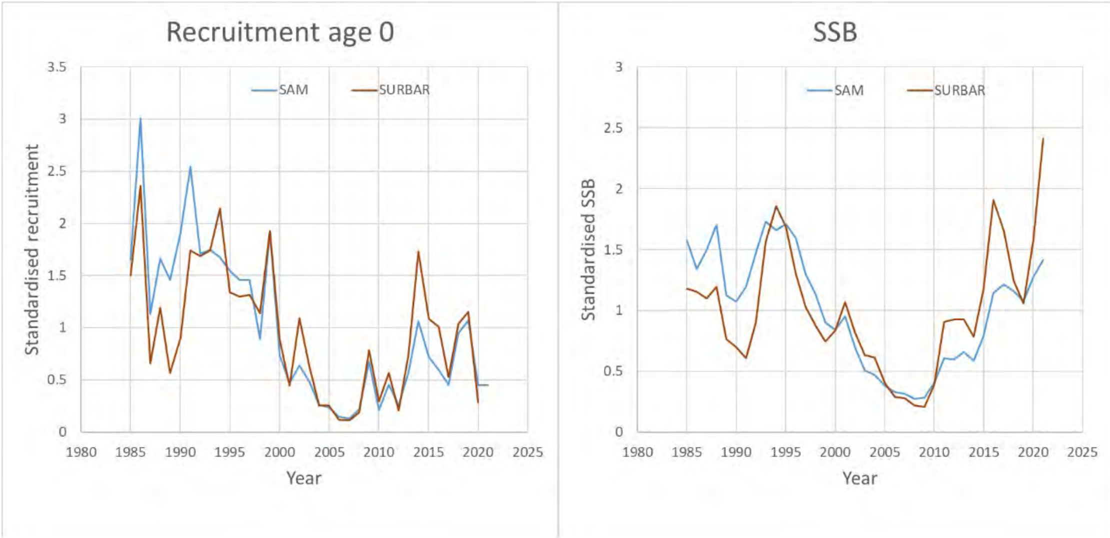

Figure 35.21. Whiting in Division 6.a. Comparison of the Recruitment and SSB estimates by SAM and SURBAR (the run with three tuning series).

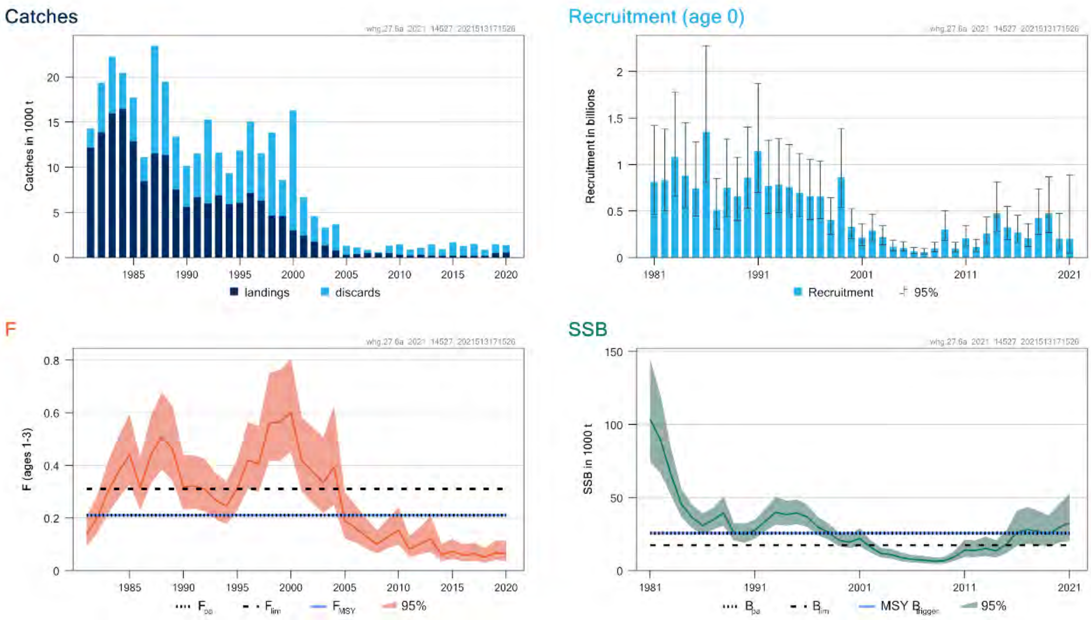

Figure 35.22. Whiting in Division 6.a. ICES Standard Graphs for the SAM assessment.

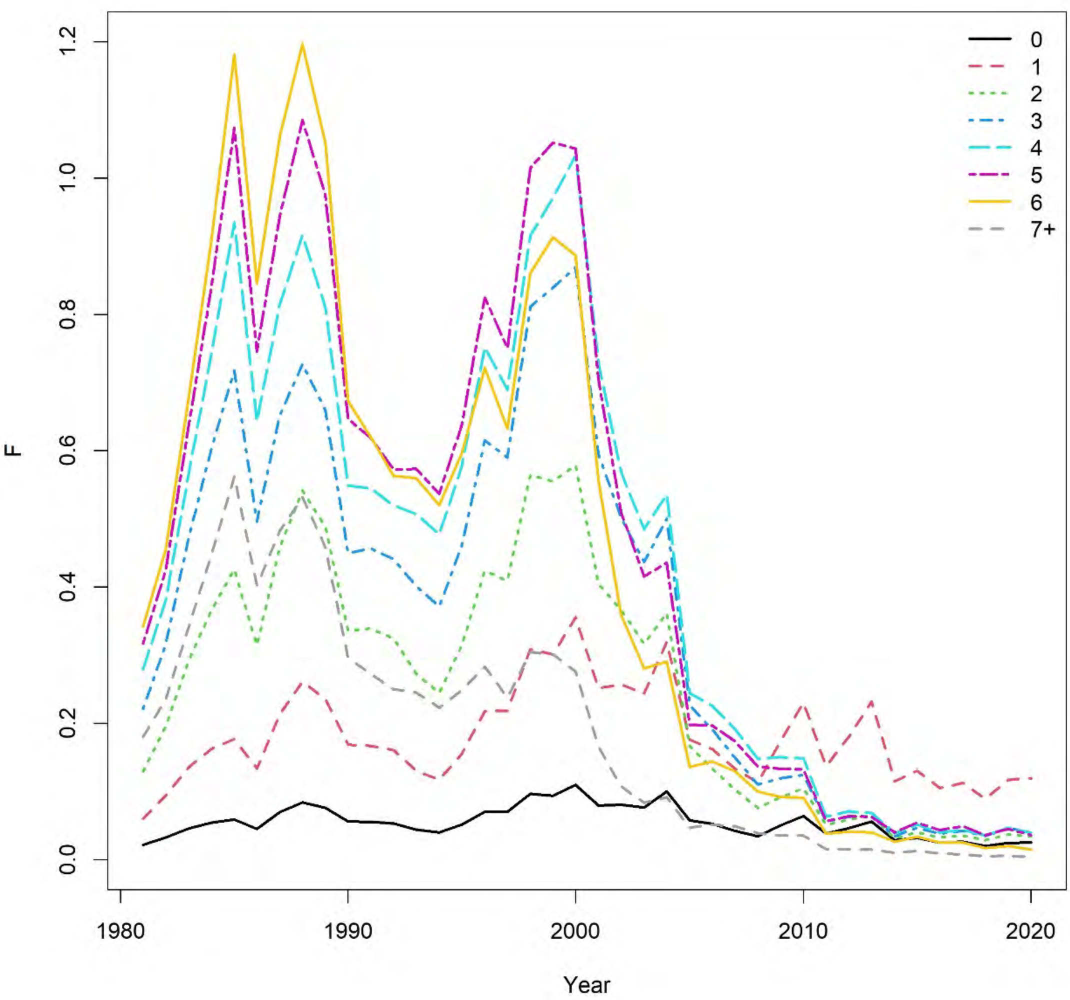

Figure 35.23. Whiting in Division 6.a. The SAM assessment model estimated F-at-age.

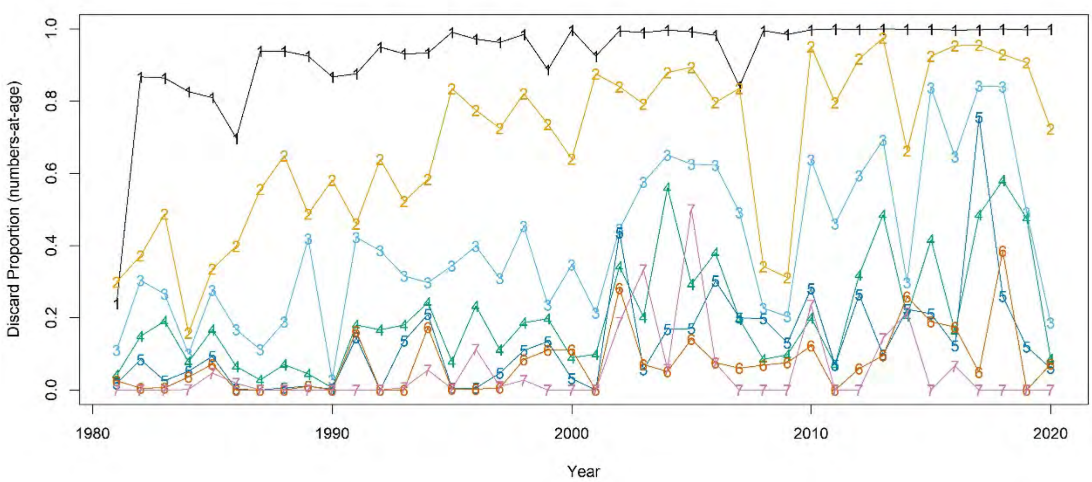

Figure 35.24. Whiting in Division 6.a. Proportion of catch discarded-at-age, from SAM landing fraction input file.

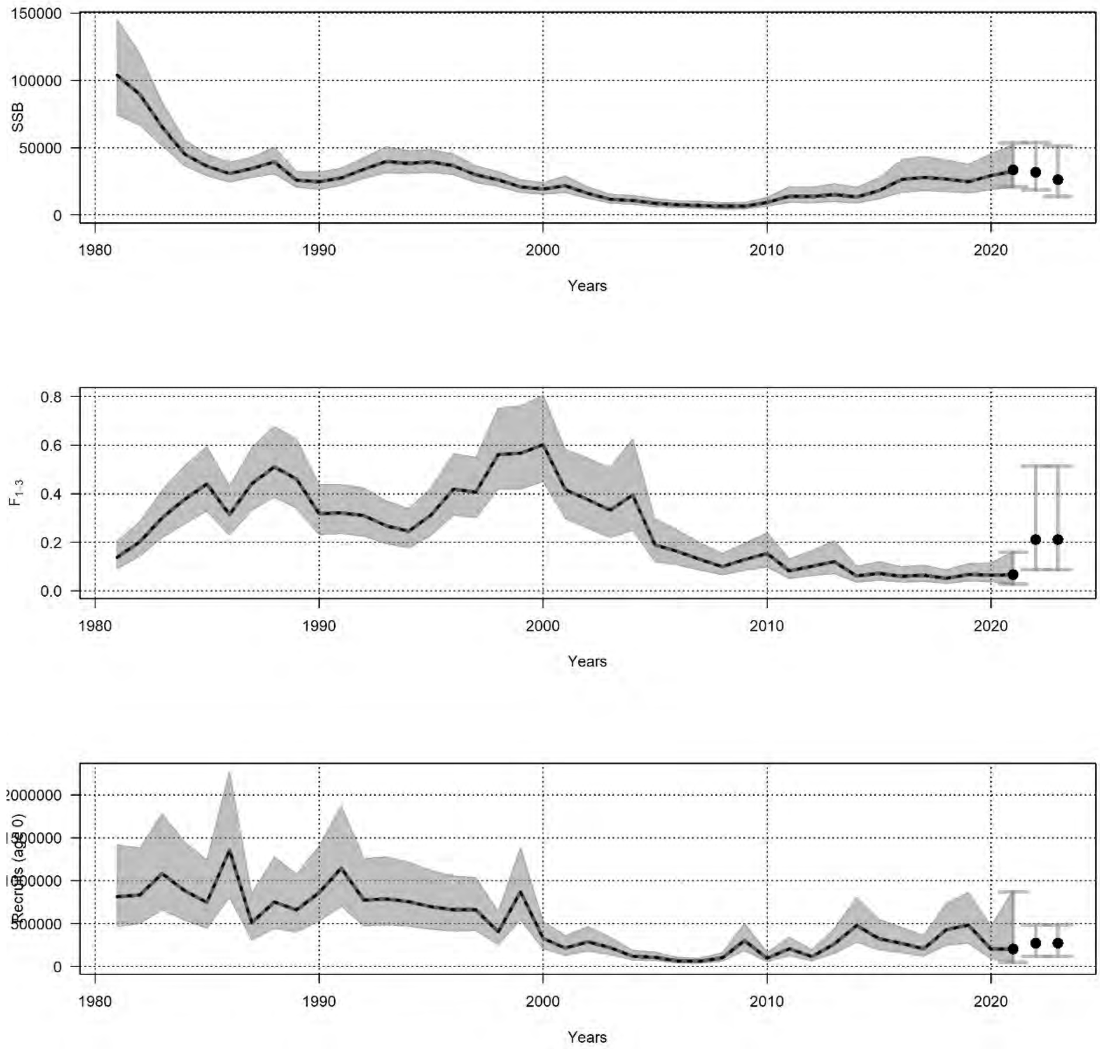

Figure 35.25. Whiting in Division 6.a. SAM forecast in the intermediate year followed by F_{MSY} (the proposed advice) in subsequent years.

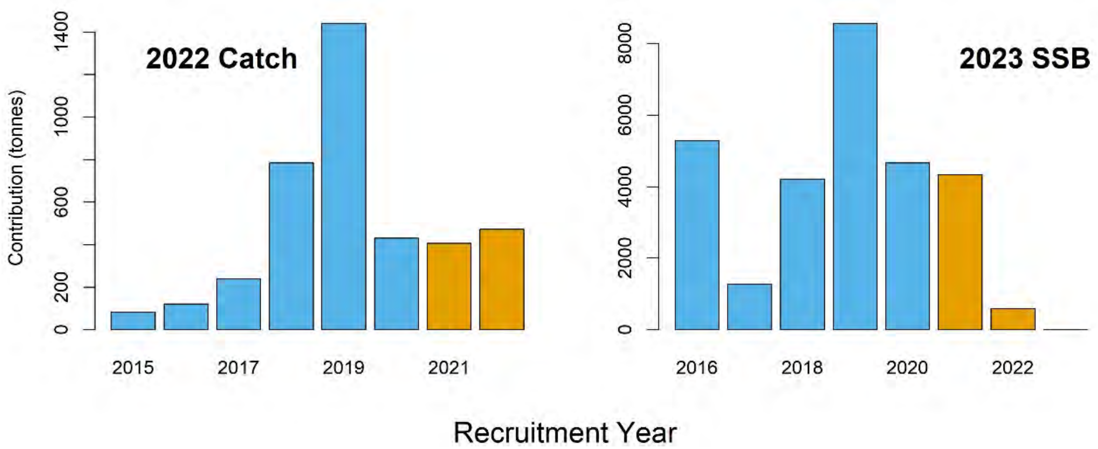

Figure 35.26. Whiting in Division 6.a. Contribution of recruitment years to projected 2022 catch and 2023 SSB under an F_{MSY} catch scenario.

36 Whiting (*Merlangius merlangus*) in Division 6.b (Rockall)

Type of assessment in 2021

No assessment was performed in 2021.

ICES advice applicable to 2019–2021

In 2018, ICES provided multiyear advice:

ICES advises that when the precautionary approach is applied, wanted catches should be no more than 9 tonnes in each of the years 2019, 2020, and 2021. ICES cannot quantify the corresponding total catches.

http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/whg.27.6b.pdf

36.1 General

Stock description

There is an absence of information on whiting stock structure in this region and whiting caught at Rockall may potentially be part of the adjacent 6.a stock.

Management applicable to 2020 and 2021

The TAC for whiting (in tonnes) is set for ICES subareas 6, 12 and 14 and EU and international waters of ICES Division 5b, for 2020 and 2019 is shown below.

TAC for 2021

The agreed TAC was not available.

TAC for 2020

Species:	Whiting *Merlangius merlangus*		**Zone:**	6; Union and international waters of 5b; international waters of 12 and 14 (WHG/56-14)
Germany	3	(1)	Analytical TAC	
France	57	(1)	Article 8 of this Regulation applies	
Ireland	273	(1)	Article 3 of Regulation (EC) No 847/96 shall not apply	
United Kingdom	604	(1)	Article 4 of Regulation (EC) No 847/96 shall not apply	
Union	937	(1)		
TAC	937	(1)		

(1) Exclusively for by-catches of whiting in fisheries for other species. No directed fisheries for whiting are permitted under this quota.

(Council Regulation (EU) 2020/123).

Fishery in 2020

No specific information is available for 2020. Whiting at Rockall are taken as a bycatch in fisheries for other species such as haddock and anglerfish.

36.2 Data

Landings data for whiting in 27.6.b are shown by nation in Table 36.1 and Figure 36.1. Total officially reported landings were 38 t in 2020, of which 25 t were reported by the UK and 13 t by Ireland. In the past, official landings have shown very high interannual variation and it is not known whether these are a true reflection of removals.

Only landings have been uploaded to InterCatch for 2020 (Figure 36.2). No discards were recorded in 2020 and there were no trips sampled for discards. No information on the age composition in landings was available. About 65% of the total landings (38 t) were from the Scottish TR1. The data available in InterCatch are shown below.

Country	Landings(tonnes)	Discards (tonnes)	Total (tonnes)
Ireland	13.2	0	13.2
UK (Scotland)	24.6	0	24.6
Grand total	37.8	0	37.8

Survey catch rates of whiting at Rockall are extremely low (Table 36.2) and are therefore unlikely to provide a reliable index of abundance.

Catches of whiting (both survey and commercial) are too low to support the collection of the necessary information for an assessment of stock status.

36.3 Target category

In 2012, advice was provided using the DL approach for category 6; stocks with negligible landings stocks and stocks caught in minor amounts as bycatch with no indication of F in relation to reference points and no marked positive trends in stock indicators. WKLIFE has previously suggested a target category of 4 for this stock. Given the comments in Section 36.2 regarding the potential unreliability of landings data and lack of sampled data, WGCSE considers that whiting in 27.6.b is likely to remain a category 6 stock.

36.4 Management considerations

Rockall whiting is managed under a TAC for the combined divisions 6.a and 6.b and therefore cannot be effective in limiting catches in Rockall.

Table 36.1. Whiting in Division 27.6.b. Nominal landings (in tonnes) as officially reported to ICES.

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
France	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	32	10	4	23	3	1	-	-	10	-	2	3	3	104
Norway	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
UK (E, W & NI)	16	6	1	5	10	2	5	26	49	20	-	-	-	-	-	-	-	-
UK (Scotland)	18	482	459	283	86	68	53	36	65	23	44	58	4	7	11	1	1	1
UK (all)																		
Total	34	488	460	288	128	80	62	85	117	44	44	58	14	7	13	4	4	105

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019*	2020*
Faroe Islands	-	-	-	-	-	-	-	-	-	-	-	-	-	-
France	+	-	-	-	-	-	-	-	-	-	-	-	+	-
Ireland	16	23	4	2	3	-	+	6	6	9	7	9	24	13
Norway	-	-	-	-	-	-	-	-	-	1	-	+	-	-
Spain	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (E, W & NI)	-	-	-	-	-	-	-	-						
UK (Scotland)	1	8	12	16	6	1	3	23						
UK (all)									46	22	32	34	65	25
Total	17	31	16	18	9	1	3	29	52	33	40	43	89	38

* Preliminary.

\+ < 0.5 t.

Table 36.2. Whiting in Division 27.6.b. Survey data made available to the WG: Scottish Q3 groundfish survey (UK-SCORoc-Q3). Catch rates are given as number per ten hours.

UK-SCORoc-Q3 – Scottish Groundfish Survey – numbers at age/10 h									
Year	Effort	Age							
	(hours)	0	1	2	3	4	5	6	7
2011	10	0	0	0	0	0	0	0	0
2012	10	33.279	0	0.358	0	0	0	0	0
2013	10	6.687	1.924	0	0	0	0	0	0
2014	10	17.425	3.426	0.838	0.307	0	0	0	0
2015	10	8.853	0.559	0.559	0.55	0	0	0	0
2016	10	250.012	0.782	0	0.223	0.447	0	0	0
2017	10	23.147	10.84	0	0	0	0	0	0
2018	10	0.531	0.754	0.894	0	0	0.307	0	0
2019	10	0.144	0.169	0.175	0	0	0.094	0	0
2020	10	9.388	0	0	0	0	0	0	0

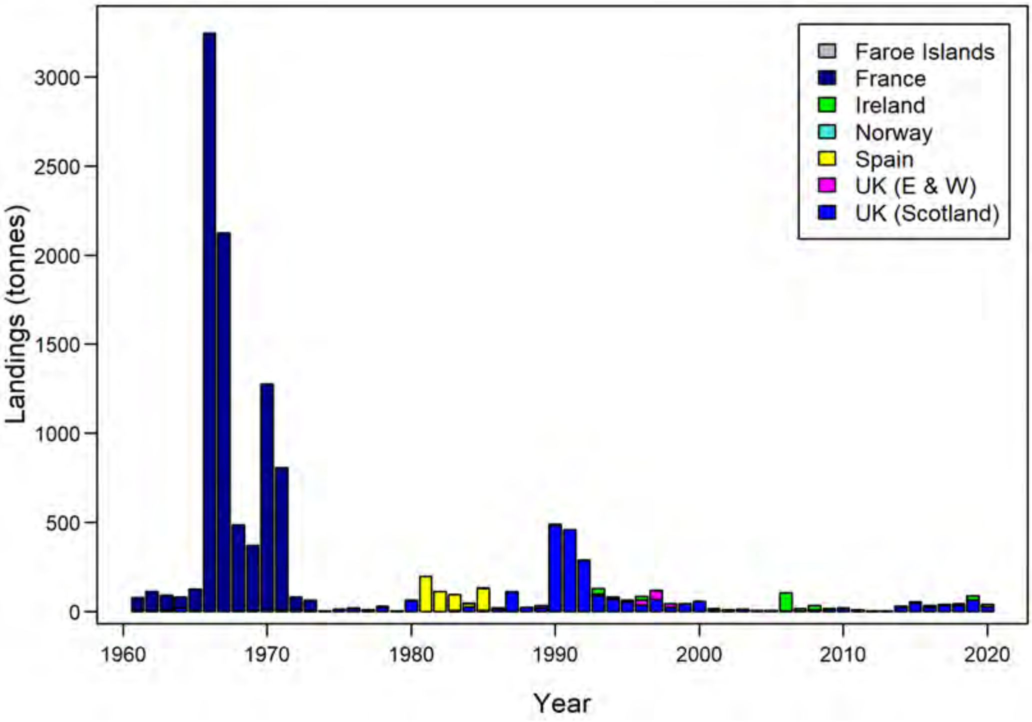

Figure 36.1. Whiting in Division 27.6.b. Official landings of whiting in 27.6.b by nation.

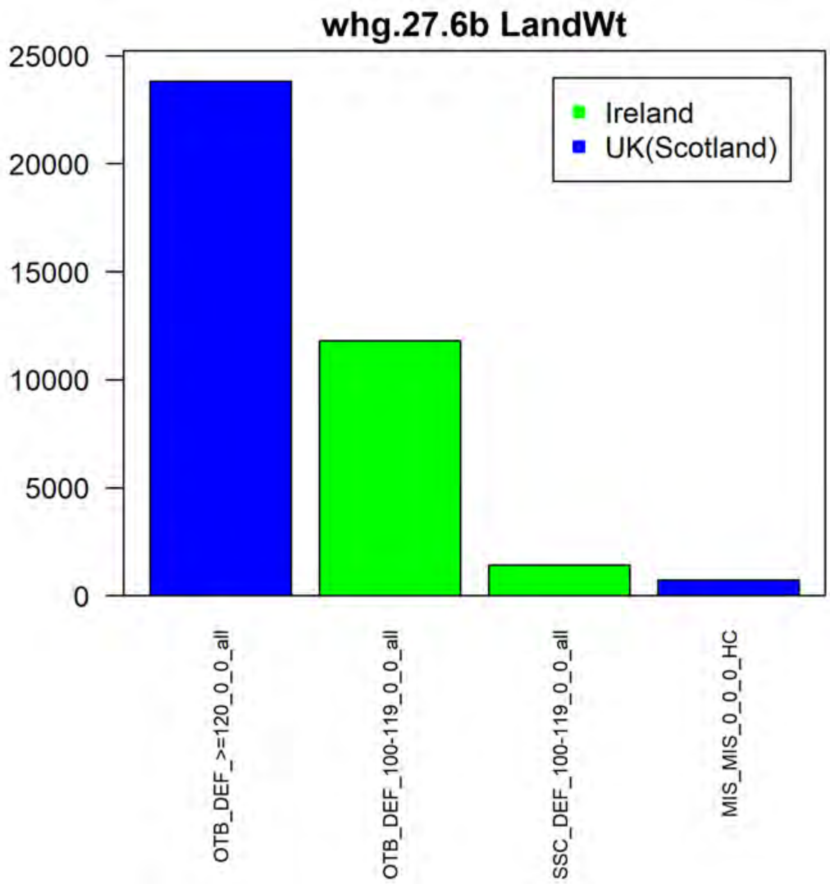

Figure 36.2. Whiting in Division 27.6.b. Landings (all ages) by metier (kg) in 2020 as entered into InterCatch. No discards were recorded in 2020.

37 Whiting in 7.a

2020 Assessment and advice

WGCSE 2021 updated the assessment with 2020 data. The advice for this stock is biennial and was updated in 2021.

This stock was benchmarked in 2017, and the outcome was to upgrade the assessment from category 3 (trends based) to category 1 (analytical assessment and forecast). Data exploration was carried out at WKIrish 2 (ICES, 2017). A full analytical assessment procedure was developed during WKIrish 3 (ICES, 2017) using ASAP. Reference points were also estimated during WKIrish 3.

The advice for this stock was updated in October 2018 following a special request to ICES to update the advice based on the most recent discard estimates. Furthermore, in response to an EC request for advice on the removal of TACs for certain stocks, ICES advised that removing the EU TAC for whiting in ICES Division 7.a may generate a high risk of the stock being unsustainably exploited. However, ICES notes that the TAC is not currently controlling exploitation. http://www.ices.dk/sites/pub/Publication%20Reports/Forms/DispForm.aspx?ID=34726

Type of assessment

SPALY update of ASAP assessment.

ICES advice applicable to 2020 and 2021

ICES advises that when the MSY approach is applied, there should zero catches in 2020 and 2021.

http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/2019/whg.27.7a.pdf

37.1 General

Stock description and management units

The stock and the management unit are both ICES Division 7.a (Irish Sea). Whiting landings taken or reported in ICES rectangles 33E2 and 33E3 have been reassigned to the 7.b,c,e–k whiting stock since 2003.

Management applicable to 2020 and 2021

The minimum conservation reference size of whiting is 27 cm. This stock is subject to the landings obligation as part of the Commission Delegated Regulation (EU) 2018/2034.

In 2021, there was no agreed TAC.

In 2020, the TAC was set to 721 t. This followed an ICES technical service that examined the likely catches in 2020 for specific bycatch stocks that have zero catch advice.

https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/Special_Requests/eu.2019.23.pdf

In 2019 the TAC was set to 727 t. This TAC was later increased to 1246 t following from ICES advice in March 2019.

https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2019/Special_Requests/eu.2019.02.pdf

Official landings as reported to ICES in 2020 were 102 t.

TAC 2020

Species:	Whiting *Merlangius merlangus*	**Zone:**	7a (WHG/07A.)
Belgium	2 (1)	Analytical TAC	
France	25 (1)	Article 8 of this Regulation applies	
Ireland	415 (1)	Article 3 of Regulation (EC) No 847/96 shall not apply	
The Netherlands	0	Article 4 of Regulation (EC) No 847/96 shall not apply	
United Kingdom	279 (1)		
Union	721 (1)		
TAC	721 (1)		

(1) Exclusively for by-catches of whiting in fisheries for other species. No directed fisheries for whiting are permitted under this quota.

Fishery in 2020

The characteristics of the fishery are described in the stock annex.

The fishery in 2020 was prosecuted by the same fleets and gears as in recent years.

The majority of catches are discards are from *Nephrops* directed fleets. The main fleets landing whiting are finfish directed fleets from Ireland and Northern Ireland. In recent years, landings were submitted for the PTM_SPF metier. These are likely from trips targeting herring where whiting was a bycatch. Figure 37.2 shows the contribution of catch by fleet.

Table 37.1 gives the official nominal landings of 7.a whiting as reported by each country to ICES. Working Group estimates of the landings and discards for the main fleets are given in Table 37.2. In recent years, the values provided to the WG are very similar to officially reported landings. Ireland did not submit discard estimates in 2020 so an average value was calculated from the preceding three years resulting in 102 t of estimated discards for the IR-OTB fleet. Total discard estimates were to be 1030 t in 2020.

No BMS landings or logbook registered discards were submitted to ICES for 2020.

The closure of the western Irish Sea to whitefish fishing from mid-February till the end of April, designed to protect cod, was continued in 2020, but is unlikely to have affected whiting catches which are mainly bycatch in the derogated *Nephrops* fishery. *Nephrops* vessels can obtain a derogation to fish in certain sections of the closed area, providing they fit separator panels to their nets to allow escape of cod and other fish. The TR2 fleet in 7.a are obliged to use one of four types of cod selective measures, namely a 'Swedish' grid; the inclined separator panel, SELTRA trawl or 300 square mesh panel.

A summary of the 2020 catches by main gear types is presented below.

Catch (2020)	Landings			Discards	
1118 tonnes	Finfish-directed otter trawls	*Nephrops*-directed otter trawls	Other gears	*Nephrops*-directed otter trawls	Other gears
	94.5%	0.3%	5.2%	98%	2%
	88 tonnes			1030 tonnes	

37.2 Information from the Industry

There was no information on the whiting stock from the industry.

37.3 Data

Data were provided by all countries according to the data call.

For WGCSE (2021) all data have been updated where possible. To allow an age-based assessment, catch numbers-at-age, catch weights-at-age, stock weights-at-age have all be constructed since 2003 (WGCSE, 2017). These updates are documented in the Stock Annex.

Fishery landings

Working Group estimates of catch available since 1980 are illustrated in Figure 37.1 and indicate the declining trend since the start of the time-series. In 2020, there was a decrease in landings from 172 t to 88 t.

The introduction of UK and Irish legislation requiring registration of fish buyers and sellers may mean that the reported landings from 2006 onwards are more representative of actual landings.

Working group estimates of landings are corrected for misreporting in the past. There is information that officially reported landings of whiting, especially around the mid-1990s, have been inaccurate due to misreporting. Landings data have previously been partially corrected for by using sample-based estimates of landings at a number of Irish Sea ports. Due to the low level of landings recently, this has not been carried out since 2003. As for 7.a cod and haddock, the whiting landings taken or reported in ICES rectangles 33E2 and 33E3 have been reassigned to the 7.e–k whiting stock since 2003 (Table 37.3).

Fishery discards

Discard estimates are available from Northern Ireland and Belgian fleets. Raising methods used are described in the stock annex for 7.a whiting.

Data exploration of short-term forecast carried out in WGCSE, 2020

Due to the disruption in sampling as a result of COVID-19, an investigation was carried out to explore the potential of extending the short-term forecast for the assessment carried out in 2020 the if a catch-at-age assessment in 2021 was not possible. Two scenarios were investigated and are shown in Figure 37.3. The first scenario investigated was assuming zero catch in each of the years 2020–2022. The second scenario used a catch constraint of the realised catch in 2020 of 1118 t. Geometric recruitment was used in 2021 and F_{sq} for 2021 and beyond. Both scenarios resulted in SSB values far below that of B_{lim} (10 000 t) and are unlikely options to use in lieu of a full catch-at-age assessment.

Landings-at-age data

Landings numbers-at-age are given in Table 37.4. For the 2003 data onwards, the catch and mean weight-at-age are estimated using combined UK (NI) and Irish quarterly length–weight relationships and age–length keys. These data are raised to the international catch data provided to ICES. Typically, quarterly landings are provided by the UK (Scotland), Belgium and France and annual landings are provided by UK (IOM). The quality of the landings-at-age data has been declining in recent years due to reduced sample numbers commensurate with the decline in landings. In 2020, landings-at-age were provided by Ireland and Northern Ireland.

Sampling and raising methods previously used are described in the stock annex for 7.a whiting. Methods for estimating quantities and composition of landings are described in the stock annex.

Discards numbers-at-age data

In 2020, discard sampling numbers-at-age were available from Northern Ireland only. These data were only available for Q1. The possibility of applying this Q1 sampling across the remaining three quarters was investigated, but due to differences in age structure between quarters, this was not suitable (Figure 37.4).

Therefore, for the NI OTB_CRU fleet, observations at sea in Q1 were applied to Q2 to produce a combined Q1 and Q2 discard numbers-at-age using age data from the NIGFS-WIBTS-Q1 (G7144).

Length data from the Q3 and Q4 Northern Irish self-sampling programme were used and applied to age–length data from the NIGFS-WIBTS-Q4 (G7655) survey to produce an amalgamated Q3 and Q4 discard number-at-age structure.

A discard ogive from 2017–2019, at sea sampling, was used to partition the catch length frequency from the self-sampling to discards and landings (although landings are negligible) in order to provide landings numbers-at-age for the NI-OTB-CRU fleet.

To account for variability in the catch numbers-at-age as a result of the different raising procedure used for the discards in 2020, the CV of the catch data was set to 0.3 where previously it would have been set to 0.2 as used in the benchmarked assessment, WKIrish, 2017.

Discard number-at-age are given in Table 37.5. Discarding of whiting is high within the Irish Sea. Discard numbers-at-age were combined for ages 0 to 6+ and then raised to the international discards. There has been a high number of age 1 and 2 discarded at the start of the time-series with almost all age 1 and 2 discarded later in time-series (Figure 37.6).

The length frequency of discards of national sampled fleets in 2019 is given in Figure 37.5 This information has not been updated for 2020. More detailed information is available in the stock annex.

Biological data

The derivation of these parameters and variables is described in the stock annex. The Lorenzen method was used to estimate M. This was derived during WKIrish 2 and investigated during WKIrish 3. Maturity-at-age is knife-edge at age 2. Stock weights were also revised at the benchmark meeting. Stock weights-at-age were derived from the catch weights, and then smoothed using a three-year moving average. Figure 37.7 shows the stock weights used. There are strong trends in mean weights-at-age over the time-series with a minimum around 2000s for most ages. There was a small increase in the mid-2000s but overall mean weights are significantly lower than at the start of the series.

Survey data used in assessment

Table 37.6 describes the survey data made available to the Working Group.

Survey series for whiting provided to the Working Group are further described in the stock annex for 7.a whiting (Section B.3). Five survey series were available. The inclusion of the different available surveys was tested in a series of preliminary model runs at WKIrish 3.

The three surveys used in the assessment are NIGFS-WIBTS-Q1 (G7144), NIGFS-WIBTS-Q4 (G7655), and NI MIK (I9826).

The NI MIK (I9826) survey was not carried out in 2020 due to COVID-19. The omission of this survey in the 2021 assessment was investigated by comparing the omission of the 2019 index for the survey in the 2020 assessment. Figure 37. 8 shows that the starting point of the assessment is sensitive to input data. Excluding the 2019 NI-MIK results in lower starting F and higher SSB, but that is probably unlikely given that there was a target fishery for whiting in the early 1980s. The missing NI-MIK in 2019 very slightly revises down SSB (Figure 37. 9) and the conclusion is that the missing NI-MIK in 2020 would have negligible impact given the other uncertainties in the assessment.

Figure 37.10 shows the log standardized indices by cohort of the tuning fleets used in the assessment. There are very little cohort signals in any of the indices. The survey data show a major change in the age structure of the stock around the mid-2000s. The two NI surveys show that older fish disappear around 2003 in the Q1 survey and around 2004 in the Q4 survey. This is mainly due to a decline whiting catches in the Eastern Irish Sea stratum which was explored in detail at WKIrish.

37.4 Historical stock development

Model used: ASAP

Software used: ASAP V3.0.17 NOAA Fisheries toolbox (http://nft.nefsc.noaa.gov)

FLR with R version 3.6.1 (64-bit) with packages FLEDA 2.5.2, FLCore 2.6.15, FLAssess 2.6.3, and Flash (http://flr-project.org)

Data screening

The general approach to data screening and analysis was followed in addition to the data exploration tools available in the FLR package FLEDA. The results of the data screening are fully documented using R markdown and are available in the folder 'Data\Whg 7.a \Assessment. on SharePoint. Table 37.7 shows the ASAP input data.

Final update assessment

The final assessment was run using the same settings as described in WKIrish 3. These final settings are described in the Stock Annex. The exception to this is the CV of 0.3 used for catch numbers-at-age for 2020.

Figure 37.11 shows the selectivity-at-age in the catch. Full selectivity is assumed for age 3, and the model is allowed to estimate ages 1 and 2. Table 37.8 shows the model estimates.

The observed and predicted index cpue values are shown in Figure 37.12. There is poor fit to the Northern Irish groundfish survey indices in the first half of the series, but it improves in recent years.

The observed and predicted catches are shown in Figure 37.13. Fit to the overall catch is reasonably good. There is some deviation in the early to mid-1990s. This is most likely due to the introduction of the survey data into the assessment model.

Figure 37.14 shows the retrospective analysis. The predicted catch shows no obvious retrospective pattern. The recruitment shows a slight underestimate in the last year. There is some deviation in the early part of the time-series when the surveys were first introduced. However, recent estimates of SSB and F are consistent with no apparent bias.

A Mohn's rho analysis was conducted based on the ASAP stock assessment results, i.e. the last data year (2020) was used as the final year for comparison of SSB, F and recruitment and based on a five-year retrospective analysis. The results from the Mohn's rho analysis are shown in the following table:

	SSB	F (ages 1–3)	recruitment
Mohn's rho value	0.128	-0.114	0.23

The Mohn's rho values for this assessment are below the threshold imposed by ICES of 20% for recruitment and 15% for fishing mortality.

The state of the stock

Table 37.9 shows the estimated fishing mortality-at-age and Table 37.10 shows the stock numbers-at-age. The stock summary is given in Table 37.11 and Figure 37.15.

The present stock size is extremely low. SSB has declined since the start of the time-series and has been well below B_{lim} since the mid-1990s. Recruitment has been low since the early 1990s with a slight increase in recent years. Large variations in fishing mortality estimates have been observed in recent years. F has been well above F_{lim} since the early 1990s.

37.5 Short-term predictions

Short-term projections were performed using FLR libraries. Recruitment for 2021–2023 was estimated at 119 971 (GM 2000–2019:thousands). As the retrospective pattern shows an underestimate of recruitment, the terminal year was excluded from the GM for the WGCSE, 2021 assessment. Three-year averages (2018–2020) were used for F (unscaled) and weights-at-age.

Input data for the short-term forecast are given in Table 37.12. The single-option output is given in Table 37.13 , Table 37.14 and Table 37.15 gives the management options.

Estimates of the relative contribution of recent year classes to the 2022 landings and 2023 SSB are shown in Figure 37.16. The 2018–2019 year class estimates from ASAP accounts for 76% of the projected landings in 2022. The 2021 GM assumption contributes considerably to the estimated SSB in 2023 as does the 2020 ASAP assessment.

37.6 Medium-term projection

There is no analytical assessment for this stock.

37.7 MSY evaluations and Biological Reference Points

ICES carried out and evaluation of MSY and PA reference points for this stock at WKIrish 3. The results are summarized below:

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	16 300 t	B_{pa}
Approach	F_{MSY}	0.22	Median point estimates of EqSim with combined S–R
	$F_{MSY\ lower}$	0.158	Median point estimates of EqSim with combined S–R
	$F_{MSY\ upper}$	0.294	Median point estimates of EqSim with combined S–R
	B_{lim}	10 000 t	Below 10 000 t recruitment is impaired
Precautionary	B_{pa}	16 300 t	B_{lim} combined with the assessment error
Approach	F_{lim}	0.37	F with 50% probability of SSB less than B_{lim}
	F_{pa}	0.22	$F_{p.05}$; the F that leads to SSB ≥ B_{lim} with 95% probability

In 2021, ICES updated the basis for F_{pa} as "the F that leads to SSB ≥ B_{lim} with 95% probability", ICES (2021). Prior to this, it was based on "F_{lim} combined with the assessment error", ICES (2017). The F_{pa} value of 0.22 remains unchanged.

37.8 Management plans

No management plan has been agreed or proposed.

37.9 Uncertainties and bias in assessment and forecast

This stock was benchmarked in January 2017. The result of the benchmark was that the stock was elevated from a category 3 stock (trend-based assessment) to a category 1 stock (analytical assessment). The assessment includes information from the commercial fishery, including both landings and discards, and takes into account selectivity changes that have occurred in 1995. Three survey series are used within the assessment. Natural mortality parameters were updated to reflect current stock dynamics. The highly fluctuating estimates of fishing mortality in recent years (2002–present) are likely to be the result of variability in the sampling data and discard estimates. Despite this inherent uncertainty it is clear from the assessment and additional information from surveys that the stock remains extremely low.

Stock status classification relative to MSY proxies is given below. This has been updated for WGCSE 2021.

	Fishing pressure					Stock size				
		2018	2019	2020			2019	2020	2021	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✗	✗	✗	Below trigger
Precautionary approach	F_{pa},F_{lim}	✗	✗	✗	Harvested unsustainably	B_{pa},B_{lim}	✗	✗	✗	Reduced reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	–	Not applicable

37.10 Recommendations for next benchmark assessment

This stock was benchmarked in 2017 as part of the WKIrish process. A number of recommendations for future work were made and these are listed below. Given the current stock status, there is no urgency to schedule another benchmark for this stock in the short term.

Assessment method

Currently a single fleet ASAP with fixed selection assumption is used. Exploring alternative modelling frameworks which allow for changes in selection should be investigated. There are very little data to inform the question whether survey catchability is flat-topped or dome-shaped. At the moment, the highly truncated age structure means that this makes little difference in the model outputs. However, if the stock recovers and more older fish appear, then this will need to be revisited.

Biological parameters

New natural mortality estimates from the Irish Sea EWE model should be included in the assessment. The stock shows very strong changes in weights-at-age over time (they can change by a factor of up to 2). This is likely to affect the natural mortality. Further information to support this would be very useful for future benchmarks.

Discards

Discards data remain highly uncertain for this stock. This probably contributes to the variable F patterns observed. Partitioning catch data into landings and discards or by fleet with different CVs, may help smooth out some of this variability.

Life-history parameters

Mean weights show trends which are currently smoothed. This should be explored further with a view to improving the approach and possibly using it in forecasts.

Other issues

Stock identity is assumed to be appropriate but there are east–west differences in population structure, and in the past there has been speculation about emigration to 7g.

Sampling

Discard sampling should be improved for this stock since discards account for the vast majority of the catch in number. Despite various management initiatives discarding remains sporadic and high in the *Nephrops* fishery.

Tuning series

Currently calculated survey CVs are not used in ASAP. It might be worth exploring the impacts of using actual values instead of an assumed fixed CV in future assessment models.

The FSP survey potentially has useful information on the older fish (even though the survey is discontinued). Including the survey in the final assessment run resulted in many of the retrospective runs to fail to converge. It appears therefore that it causes the model to be unstable and was omitted from the final run. For future benchmarks it may be useful to investigate why this survey makes the model unstable.

37.11 Management considerations

Discarding in the *Nephrops* fishery is the main management issue. Despite the implementation of several technical measures, which experimentally reduce whiting catches, as part of the cod long-term management plan and the full implementation of the landings obligation in 2019, the discards estimates still remain high, ca. 1089 t. This stock is a major 'choke species' for the 7.a *Nephrops* fishery in the context of the landing obligation.

Effort limitations are in force within the Irish Sea as a result of the cod long-term management plan. These effort limitations have not significant reduced mortality on whiting.

Whiting has a low market value, which is likely to contribute to discarding rates.

Technical measures applied to this stock include a minimum conservation reference size (≥27 cm), whiting now mature well below this MCRS.

37.12 References

ICES, 2017 :Report of the Benchmark Workshop on the Irish Sea Ecosystem (WKIrish3), 30 January–3 February 2017, Galway, Ireland, ICES CM 2017/BSG:01.

ICES. 2017. Report of the Second Workshop on the Impact of Ecosystem and Environmental Drivers on Irish Sea Fisheries Management (WKIrish2), 26–29 September 2016, Belfast, Northern Ireland, ICES CM 2016/BSG:02.

ICES. 2021a. Advice on fishing opportunities. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, section 1.1.1. https://doi.org/10.17895/ices.advice.7720.

37.13 Tables

Table 37.1. Official landings (t) of Whiting in Division 7.a as reported to ICES.

Year	Belgium	France	Ireland	Netherlands	UK(NI, Engl. & Wales)	Spain	UK (Isle of Man)	UK (Scotland)	UK	Total human consumption
1988	90	1,063	4,394		5,823		15	107		11,492
1989	92	533	3,871		6,652		26	154		11,328
1990	142	528	2,000		5,202		75	236		8,183
1991	53	611	2,200		4,250		74	223		7,411
1992	78	509	2,100		4,089		44	274		7,094
1993	50	255	1,440		3,859		55	318		5,977
1994	80	163	1,418		3,724		44	208		5,637
1995	92	169	1,840		3,125		41	198		5,465
1996	80	78	1,773	17	3,557		28	48		5,581
1997	47	86	1,119	14	3,152		24	30		4,472
1998	52	81	1,260	7	1,900		33	22		3,355
1999	46	150	509	6	1,229		5	44		1,989
2000	30	59	353	1	670		2	15		1,130
2001	27	25	482		506		1	25		1,066
2002	22	33	347		284		1	27		714
2003	13	29	265		130	85	1	31		554
2004	11	8	96		82		1	6		204
2005	10	13	94		47			<0.5		164
2006	4	4	55		22			<0.5		85
2007	3	3	187		3		1	<0.5		197
2008	2	2	68		11		1			84
2009	2		78		20					100
2010	5	3	97		16		<0.5			121
2011	4	3	95		16		<0.5			118
2012	5	1	58		10			1	11	86
2013	2	<0.5	44				<0.1	2	20	68
2014	2	<0.5	60		11		<0.1			73
2,015	1	<0.5	49		8					59
2,016	1	<0.5	44		5		<0.1			50
2,017	2	<0.5	32		17		<0.1			50
2018	1		44		19		<0.5			63
2019*	4		129		63		<0.1			196
2020*	5	<0.1	56		42		<0.1			102

* Preliminary.

Table 37.2. ICES estimates of discards, landings and catch of whiting in Division 7.a.

Year	Discards by Country/Fleet					Discards	Landings	Catch
	Nephrops fishery [b]	IR-OTB fleet [ce]	NI *Nephrops* fishery [d]	Belgium	UK (E&W) fleet			
1988	1,611					1,611	10,245	11,856
1989	2,103					2,103	11,305	13,408
1990	2,444					2,444	8,212	10,656
1991	2,598					2,598	7,348	9,946
1992	4,203					4,203	8,588	12,791
1993	2,707					2,707	6,523	9,230
1994	1,173					1,173	6,763	7,936
1995	2,151					2,151	4,893	7,044
1996	3,631					3,631	4,335	7,966
1997	1,928					1,928	2,277	4,205
1998	1,304					1,304	2,229	3,533
1999	1,092					1,092	1,670	2,762
2000	2,118					2,118	762	2,880
2001	1,012					1,012	733	1,745
2002	740					740	747	1,487
2003		480				480	517	996
2004		905				905	133	1,038
2005		272				272	125	397
2006		1,580	193			1,773	64	1,837
2007		725	787			1,512	35	1,547
2008		693	476			1,169	37	1,206
2009		688	633			1,321	39	1,360
2010		240	914			1,154	30	1,184
2011		330	616			946	31	977
2012		257	1,065	17	1	1,339	60	1,399
2013		95	833	17	3	948	33	981
2014		263	1,645	15	28	1,951	23	1,974
2015		438	1,074	9	1	1,521	28	1,549
2016		173	589		3	765	15	780
2017		122	544		1	667	36	703
2018		98	754		<0.5	853	46	899
2019*		86	897	20	87	1,089	172	1,261
2020*		102[f]	906	22	Na	1,030	88	1,118

[b] Based on UK(N. Ireland) and Ireland data.

[c] Based on data from Ireland.

[d] Based on data from Northern Ireland.

* Preliminary (and rounded).

[e] Raised using Days.

[f] Average IR-OTB discards (2017–2019).

Table 37.3. Whiting landings taken or reported in ICES rectangles 33E2, 33E3 and 33E4 have been reassigned to the 7.e–k whiting stock since 2003.

Year	Official landings	ICES landings	ICES Discards	ICES catch	Landings taken or reported in rectangles 33E2 and 33E3
1988	11,492	10,245	1,611	11,856	
1989	11,328	11,305	2,103	13,408	
1990	8,183	8,212	2,444	10,656	
1991	7,411	7,348	2,598	9,946	
1992	7,094	8,588	4,203	12,791	
1993	5,977	6,523	2,707	9,230	
1994	5,637	6,763	1,173	7,936	
1995	5,465	4,893	2,151	7,044	
1996	5,581	4,335	3,631	7,966	
1997	4,472	2,277	1,928	4,205	
1998	3,355	2,229	1,304	3,533	
1999	1,989	1,670	1,092	2,762	
2000	1,130	762	2,118	2,880	
2001	1,066	733	1,012	1,745	
2002	714	747	740	1,487	
2003	554	517	480	996	159
2004	204	133	905	1,038	51
2005	164	125	272	397	33
2006	85	64	1,773	1,837	22
2007	197	35	1,512	1,547	161
2008	84	37	1,169	1,206	44
2009	100	39	1,321	1,360	63
2010	121	30	1,154	1,184	91
2011	118	31	946	977	75
2012	86	60	1,339	1,399	43
2013	68	33	948	981	33

Year	Official landings	ICES landings	ICES Discards	ICES catch	Landings taken or reported in rectangles 33E2 and 33E3
2014	73	23	1,951	1,974	50
2015	59	28	1,521	1,549	34
2016	50	15	765	780	40
2017	50	36	667	703	20
2018	63	46	853	899	18
2019	196	172	1,089	1,261	24
2020	102	88	1,030*	1,118	14

***this includes the ICES estimate of 102t for IR-OTB discards.**

Table 37.4. Whiting7.a. Landings numbers-at-age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1980	0	14520	21811	6468	2548	350	0
1981	0	11203	29011	16004	2596	821	0
1982	41	5427	18098	19340	6108	813	0
1983	0	4886	9943	9100	4530	1165	321
1984	0	18254	12683	5257	2571	1045	402
1985	0	15540	35324	8687	996	0	675
1986	0	6306	16839	10809	1877	285	0
1987	0	10149	21563	6968	1943	242	0
1988	0	6983	25768	6989	1513	396	0
1989	0	11645	14029	13011	3645	490	0
1990	0	9502	17604	4734	1477	318	0
1991	102	7426	18406	5829	993	0	311
1992	0	8380	21907	7959	1374	462	0
1993	38	2742	21468	7327	932	0	135
1994	0	3245	6983	18509	1801	208	0
1995	0	1124	10095	3020	4444	233	0
1996	129	1652	6162	7432	1263	1082	135
1997	0	610	4239	2567	1795	87	79
1998	0	329	3287	4727	888	261	95
1999	1	341	2806	2607	741	160	119
2000	0	319	1364	1002	299	115	15
2001	0	111	1189	1006	171	53	20
2002	0	67	748	1480	376	48	41
2003	0	89	1051	606	199	0	0
2004	0	0	17	117	150	17	0
2005	0	0	101	216	95	21	3
2006	0	34	41	88	39	9	1
2007	0	24	41	32	10	3	0

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
2008	**0**	**38**	**66**	**25**	**5**	**1**	**0**
2009	**0**	**65**	**44**	**22**	**4**	**1**	**0**
2010	**0**	**18**	**83**	**11**	**3**	**0**	**0**
2011	**0**	**1**	**17**	**59**	**15**	**3**	**0**
2012	**0**	**4**	**29**	**80**	**60**	**9**	**1**
2013	**8**	**81**	**36**	**20**	**5**	**1**	**1**
2014	**0**	**2**	**25**	**24**	**11**	**1**	**1**
2015	**0**	**2**	**25**	**24**	**11**	**1**	**1**
2016	**0**	**0**	**6**	**21**	**10**	**3**	**0**
2017	**0**	**0**	**9**	**50**	**43**	**5**	**1**
2018	0	1	14	70	38	19	2
2019	0	0	146	181	72	45	23
2020	0	0	58	138	93	18	10

Table 37.5. Whiting7.a. Discards numbers-at-age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1980	12786	32318	6888	65	26	0	0
1981	9865	24935	9162	162	26	0	0
1982	4047	8489	560	19	0	0	0
1983	23847	7328	2036	9	0	0	0
1984	26394	33900	1568	11	0	0	0
1985	12380	26461	1859	9	0	0	0
1986	28364	21111	1464	33	0	0	0
1987	16594	40598	1875	0	0	0	0
1988	6922	17958	1940	0	0	0	0
1989	17247	20701	2476	26	0	0	0
1990	4216	31810	3353	72	0	0	0
1991	20349	29334	3823	146	1	0	0
1992	1497	61451	10404	97	0	0	0
1993	12639	13979	17707	426	5	0	0
1994	3731	12063	1812	1702	29	0	0
1995	7118	17613	7015	492	234	0	0
1996	12732	39647	8168	1976	81	0	0
1997	8163	25497	5352	689	141	0	0
1998	6096	27131	2293	550	44	0	0
1999	20851	7677	2117	228	34	2	2
2000	7321	38922	4395	564	55	1	10
2001	16940	12631	3150	102	10	0	0
2002	8538	13412	1588	231	33	0	1
2003	12389	4595	201	0	0	0	0
2004	19699	14938	345	59	0	0	0
2005	643	5797	346	16	3	0	0
2006	15764	20590	613	21	0	0	0
2007	17436	24319	747	50	0	0	0
2008	10645	19994	676	16	0	0	0

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
2009	6622	27448	1176	0	0	0	0
2010	3946	15102	2810	64	1	0	0
2011	25982	8197	658	314	0	0	0
2012	6637	31020	790	37	1	3	0
2013	8493	11945	613	4	0	0	0
2014	13467	27553	2425	259	10	0	0
2015	3883	23595	2603	223	1	0	0
2016	4509	5780	4804	294	15	0	0
2017	3559	5870	4385	240	14	0	0
2018	6523	7386	2557	614	92	10	0
2019	6429	14041	3986	571	57	7	0
2020	11987	26870	978	50	3	0	0

Table 37.5. Whiting in 7.a. Survey data available.

NIGFS-WIBTS-Q1: Northern Ireland March Groundfish Survey

1993	2020					
1	1	0.21	0.25			
1	6					
1	665.6	710.3	81.2	11.7	4.3	0.8
1	1804.6	262.1	299.2	44.7	11.9	8.1
1	1688.9	635.7	174.2	88.4	22.0	6.3
1	1468.4	334.0	213.0	35.1	37.2	5.4
1	1406.1	1536.4	156.0	52.8	4.5	13.7
1	1485.0	754.4	415.4	29.7	7.4	1.8
1	1369.4	373.2	111.2	41.5	3.7	1.0
1	2302.4	410.9	181.8	26.6	3.7	0.0
1	1065.7	696.5	124.6	13.7	5.9	2.7
1	2307.7	686.7	175.3	52.9	11.2	1.4
1	1495.1	905.2	130.2	10.9	1.6	0.1
1	1609.8	231.7	61.4	2.7	1.3	0.2
1	689.3	124.0	28.5	12.3	2.8	0.1
1	959.8	235.6	30.3	6.0	0.1	0.1
1	905.0	158.6	14.9	2.7	0.2	0.0
1	756.7	347.0	45.0	2.8	0.3	0.4
1	1062.3	281.1	36.3	1.8	0.2	0.1
1	739.4	545.8	51.6	4.7	6.4	0.0
1	586.4	156.5	36.0	3.9	0.6	0.0
1	972.2	354.4	42.3	5.9	1.2	0.0
1	629.6	649.3	66.7	3.5	0.5	0.0
1	922.1	367.6	67.0	4.3	0.2	0.1
1	2797.3	469.3	18.8	2.3	0.0	0.0
1	1409.1	924.8	38.7	1.5	0.1	0.1
1	888.1	831.8	142.2	11.2	0.7	0.1
1	431.4	296.8	119.4	17.9	2.3	0.0
1	568.0	831.9	347.2	43.2	6.2	0.5
1	1573.5	583.4	127.3	9.2	0.3	0.6

NIGFS-WIBTS-Q4: Northern Ireland October Groundfish Survey

1993	2020						
1	1	0.83	0.88				
0	6						
1	714.0	1040.5	475.9	67.5	8.2	3.1	0.3
1	1113.1	1320.0	208.6	150.7	33.9	2.3	0.5
1	3124.4	477.3	166.5	30.6	35.6	5.4	1.2
1	2306.2	591.2	134.4	52.4	10.5	7.0	1.3
1	2626.5	676.6	497.6	61.0	18.2	4.6	4.5
1	2863.5	466.8	153.8	72.8	6.2	2.2	0.1
1	2478.4	1079.7	192.0	51.7	43.3	3.7	1.8
1	2374.3	1084.7	126.0	20.0	16.9	6.0	2.7
1	6356.4	658.3	270.8	28.9	4.9	2.3	0.0
1	2692.4	1322.5	268.3	41.6	4.5	1.2	0.0
1	4431.0	1572.3	921.1	74.8	16.8	1.5	0.0
1	4457.1	699.6	268.3	113.8	4.4	1.9	0.0
1	2377.2	487.8	183.3	15.8	1.5	0.4	0.0
1	2849.2	144.8	46.8	7.9	1.8	0.0	0.0
1	2163.1	957.6	149.1	16.7	4.8	4.3	0.2
1	4884.6	1312.6	114.3	3.8	0.2	0.0	0.0
1	2246.5	510.8	71.7	7.5	1.6	0.0	0.2
1	2274.4	312.1	259.6	8.2	0.7	0.2	0.0
1	3534.1	348.4	139.7	26.3	3.5	0.9	0.0
1	1330.9	402.5	134.7	19.5	6.2	0.1	0.0
1	7135.8	354.7	155.9	31.1	1.5	0.5	0.9
1	4504.0	507.7	135.5	8.8	0.7	0.0	0.0
1	2802.4	891.0	115.2	6.3	0.7	0.0	0.0
1	2718.7	859.3	203.5	31.7	3.5	0.4	0
1	3011.1	714.1	368.4	78.4	4.2	0.0	0.1
1	4424.7	897.5	367.6	23.4	8.3	0.2	0.04
1	5613.5	643.2	148.5	27.4	3.2	0.3	0.00
1	2416.2	1157.8	98.4	16.0	0.2	0.5	0.00

NIMIK: Northern Ireland MIK Net Survey

1994	2019		
1	1	0.46	0.5
0	0		
1	778	1994	
1	225	1995	
1	397	1996	
1	205	1997	
1	59	1998	
1	91	1999	
1	40	2000	
1	167	2001	
1	19	2002	
1	148	2003	
1	101	2004	
1	135	2005	
1	118	2006	
1	82	2007	
1	99	2008	
1	173	2009	
1	78	2010	
1	122.2	2011	
1	123.9	2012	
1	197.6	2013	
1	54.9	2014	
1	59.5	2015	
1	6.7	2016	
1	175.45	2017	
1	90.74	2018	
1	164.42	2019	

UK (E&W)-BTS-Q3: Corystes Irish Sea Beam-Trawl Survey - Prime stations only – Effort and numbers-at-age (per km towed)

1988	2019		
1	1	0.75	0.79
0	1		
1	96	26	1988
1	93	21	1989
1	99	33	1990
1	216	25	1991
1	405	206	1992
1	253	95	1993
1	205	125	1994
1	1949	87	1995
1	169	194	1996
1	409	254	1997
1	893	199	1998
1	550	137	1999
1	320	122	2000
1	585	195	2001
1	280	96	2002
1	456	229	2003
1	917	330	2004
1	849	294	2005
1	1010	228	2006
1	339	89	2007
1	780	72	2008
1	389	371	2009
1	324	33	2010
1	1002	341	2011
1	442	426	2012
1	1535	228	2013
1	261	113	2014
1	211	112	2015
1	666	213	2016
1	489	230	2017
1	662	380	2018
1	340	207	2019

Eastern Irish Sea FSP: Isadale 2005–2013: Numbers of fish per hour towed.

2005	2013						
1	1	0.2	0.2				
1	6.0						
1	0.2	11.1	21.1	5.3	1.0	0.0	0.7
1	8.7	46.7	15.2	1.9	0.5	0.0	0.0
1	4.2	10.8	5.6	1.0	0.3	0.0	0.0
1	3.7	10.3	8.6	2.0	0.4	0.3	0.0
1	27.3	84.9	48.7	3.6	0.3	0.0	0.0
1	4.5	57.9	43.5	5.0	0.2	0.1	0.0
1	2.2	8.4	31.9	5.1	1.0	0.0	0.0
1	5.2	80.9	29.8	22.1	1.2	0.1	0.0
1	4.2	47.4	26.4	3.1	1.7	0.0	0.0

Table 37.6. Whiting 7.a. ASAP input data.

ASAP VERSION 3.0
Irish Sea Whiting
#
ASAP GUI 15 AUG 2012
#
Number of Years
41
First Year
1980
Number of Ages
7
Number of Fleets
1
Number of Sensitivity Blocks
2
Number of Available Survey Indices
5
Natural Mortality

1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518

1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518
1.078	0.803	0.718	0.608	0.554	0.518	0.518

Fecundity Option

0

Fraction of year that elapses prior to SSB calculation (0=Jan-1)

0

Maturity

0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1
0	0	1	1	1	1	1

Number of Weights-at-age Matrices
2
Weight Matrix - 1

0	0.11	0.235	0.363	0.529	0.63	0.772
0.04	0.118	0.24	0.364	0.529	0.63	0.888
0.031	0.135	0.265	0.365	0.533	0.63	0.736
0.033	0.146	0.256	0.397	0.491	0.605	0.655
0.032	0.125	0.244	0.403	0.55	0.7	0.745
0.021	0.107	0.245	0.333	0.478	0.567	0.642
0.025	0.1	0.217	0.342	0.512	0.709	0.94
0.024	0.101	0.217	0.363	0.535	0.72	0.933
0.021	0.088	0.201	0.33	0.547	0.763	1.005
0.026	0.111	0.193	0.269	0.433	0.68	1.079
0.036	0.094	0.204	0.31	0.436	0.676	0.8
0.031	0.077	0.194	0.263	0.352	0.453	0.692
0.014	0.063	0.17	0.272	0.361	0.513	1.007
0.029	0.067	0.142	0.228	0.331	0.454	0.892
0.03	0.074	0.183	0.221	0.301	0.378	0.496
0.031	0.063	0.179	0.257	0.326	0.551	1.32
0.027	0.057	0.159	0.23	0.284	0.364	0.715
0.026	0.044	0.153	0.222	0.287	0.396	0.679
0.017	0.035	0.156	0.228	0.268	0.35	0.421
0.028	0.044	0.161	0.246	0.324	0.351	0.325
0.024	0.038	0.127	0.218	0.291	0.347	0.31
0.017	0.036	0.132	0.301	0.338	0.538	0.337
0.016	0.033	0.124	0.253	0.339	0.449	0.425
0.02	0.048	0.232	0.295	0.259	0	0
0.017	0.034	0.131	0.324	0.509	0.466	0
0.017	0.037	0.148	0.263	0.363	0.36	0.32
0.017	0.069	0.152	0.268	0.361	0.36	0.32
0.023	0.042	0.122	0.295	0.434	0.624	1.26
0.022	0.044	0.118	0.262	0.374	0.834	1.354
0.023	0.039	0.094	0.34	0.323	0.543	0
0.02	0.048	0.125	0.256	0.401	0.375	0
0.018	0.044	0.104	0.196	0.405	0.462	0.799
0.023	0.035	0.109	0.275	0.398	0.41	0.305
0.03	0.052	0.112	0.24	0.346	0.28	0.38
0.03	0.042	0.133	0.226	0.425	0.659	1.012
0.022	0.044	0.127	0.291	0.448	0.298	0.482
0.022	0.035	0.085	0.195	0.341	0.466	0.882
0.028	0.032	0.075	0.198	0.362	0.432	0.5
0.021	0.045	0.104	0.161	0.24	0.319	0.408
0.02	0.033	0.104	0.175	0.268	0.436	0.433
0.019	0.027	0.067	0.166	0.27	0.358	0.367

Weight Matrix - 2

0	0.0733	0.1733	0.2992	0.446	0.5795	0.7203
0	0.0785	0.1797	0.3003	0.4468	0.5795	0.7143
0	0.084	0.1873	0.311	0.4408	0.576	0.6948
0	0.085	0.194	0.321	0.45	0.5813	0.6668
0	0.079	0.1918	0.3163	0.4473	0.5743	0.6628
0	0.0697	0.1807	0.3038	0.4455	0.5825	0.6998
0	0.0643	0.1685	0.2907	0.4338	0.5893	0.7485
0	0.0598	0.1572	0.2857	0.4387	0.6195	0.8123

0	0.0617	0.15	0.2662	0.425	0.6262	0.8682
0	0.0607	0.1497	0.2533	0.3963	0.6057	0.8412
0	0.0608	0.1473	0.24	0.355	0.5375	0.7817
0	0.0545	0.1417	0.2393	0.3318	0.4772	0.718
0	0.048	0.1233	0.2218	0.3148	0.4282	0.7055
0	0.0463	0.117	0.2045	0.2927	0.3982	0.6358
0	0.0462	0.118	0.2002	0.2798	0.396	0.6755
0	0.0473	0.1208	0.202	0.2695	0.3752	0.6523
0	0.042	0.1142	0.205	0.2675	0.3703	0.6678
0	0.0367	0.1053	0.1952	0.258	0.3345	0.521
0	0.0322	0.101	0.194	0.2598	0.3227	0.4225
0	0.0313	0.0945	0.1937	0.2632	0.3212	0.3588
0	0.0312	0.0895	0.2015	0.2742	0.3532	0.3367
0	0.0293	0.0835	0.1987	0.2888	0.3812	0.3847
0	0.029	0.0992	0.2054	0.2847	0.4021	0.4114
0	0.0281	0.1007	0.2267	0.3261	0.3847	0.4357
0	0.0288	0.1045	0.2282	0.3338	0.3984	0.4062
0	0.0323	0.0918	0.2277	0.3525	0.3862	0.3827
0	0.0331	0.0939	0.2097	0.3355	0.4296	0.5145
0	0.0352	0.0901	0.2082	0.3326	0.4961	0.7133
0	0.0311	0.0815	0.2152	0.3261	0.5283	0.9183
0	0.0331	0.077	0.1989	0.3325	0.4804	0.9181
0	0.0326	0.0756	0.1883	0.3311	0.4127	0.784
0	0.0313	0.078	0.175	0.3326	0.3957	0.5933
0	0.032	0.0753	0.1748	0.3127	0.3924	0.455
0	0.0334	0.0808	0.1777	0.3134	0.4162	0.4746
0	0.0369	0.0836	0.1851	0.3267	0.4009	0.5369
0	0.0339	0.0805	0.1806	0.3283	0.4403	0.6021
0	0.0308	0.068	0.1713	0.3104	0.4016	0.555
0	0.0306	0.0625	0.1401	0.2712	0.3946	0.505
0	0.0301	0.0658	0.133	0.2375	0.3551	0.4336
0	0.029	0.0641	0.1307	0.2187	0.3307	0.3992
0	0.0252	0.062176	0.1371	0.2185	0.3257	0.3888

Weights-at-age Pointers
1
1
1
1
2
2
Selectivity Block Assignment
Fleet 1 Selectivity Block Assignment
1
1
1
1
1
1
1
1
1
1
1

1
1
1
1
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
2
Selectivity Options for each block 1=by age, 2=logisitic, 3=double logistic
2 2
Selectivity Block #1 Data

0	1	0	0.25
0.5	1	0	0.25
0.9	1	0	0.25
1	-1	0	0.25
1	-1	0	0.25
1	-1	0	0.25
1	-1	0	0.25
3	1	0	1
0.5	1	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Selectivity Block #2 Data

0.2	1	0	0.5
1	-1	0	0
1	-1	0	0
1	-1	0	0
1	-1	0	0
1	-1	0	0

1	-1	0	0
2	1	0	1
0.5	1	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Fleet Start Age
1
Fleet End Age
7
Age Range for Average F
2 4
Average F report option (1=unweighted, 2=Nweighted, 3=Bweighted)
1
Use Likelihood constants? (1=yes)
1
Release Mortality by Fleet
1
Catch Data
Fleet-1 Catch Data

0	46838	28699	6533	2574	350	621	16737
9865	36138	38173	16166	2622	821	339	21331
4088	13916	18658	19359	6108	813	400	17969
23847	12214	11979	9109	4530	1165	321	12405
26394	52154	14250	5268	2571	1045	402	14999
12380	42001	37183	8696	996	675	372	18169
28364	27417	18303	10842	1877	285	270	12129
16594	50747	23438	6968	1943	242	111	14270
6922	24941	27708	6989	1513	396	197	11856
17247	32346	16505	13037	3645	490	177	13408
4216	41312	20957	4806	1477	318	128	10656
20451	36760	22229	5975	994	311	84	9946
1497	69831	32311	8056	1374	462	93	12791
12677	16721	39175	7753	937	135	27	9230
3731	15308	8795	20211	1830	208	50	7936
7118	18737	17110	3512	4678	233	21	7044
12861	41299	14330	9408	1344	1082	135	7966
8163	26107	9591	3256	1936	87	79	4205
6096	27460	5580	5277	932	261	95	3533
20852	8018	4923	2835	776	161	121	2762
7321	39242	5758	1566	354	115	25	2880
16940	12742	4338	1108	181	53	20	1745
8538	13480	2336	1710	408	48	42	1487
12389	4685	1252	606	199	0	0	996
19699	14938	362	176	150	17	0	1038
643	5797	448	232	98	21	3	397
15764	20624	654	109	39	9	1	1837
17436	24343	787	82	10	3	0	1547
10645	20032	742	41	5	1	0	1206
6622	27513	1220	22	4	1	0	1360
3946	15120	2894	75	4	0	0	1184
25982	8198	675	373	15	3	0	977

6637	31023	819	116	61	12	1	1399
8501	12026	649	24	5	1	1	981
13467	27555	2450	284	21	1	1	1974
3883	23595	2613	267	15	1	1	1549
4509	5780	4809	315	25	3	0	780
3559	5871	4394	290	57	5	1	704
6523	7386	2571	684	129	29	2	899
6429	14041	4132	752	129	52	23	1261
11987	26870	1036	188	96	18	10	1118

Discards

Fleet-1 Discards Data

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Release Proportion

Fleet-1 Release Data

0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

Survey Index Data

Aggregate Index Units

2 2 2 2 2

Age Proportion Index Units

2 2 2 2 2

Weight at Age Matrix

1 1 1 1 1

Index Month

3 10 5 9 5

Index Selectivity Link to Fleet

-1 -1 -1 -1 -1

Index Selectivity Options 1=by age, 2=logisitic, 3=double logistic
1 1 1 1 2
Index Start Age
2 1 1 1 2
Index End Age
7 7 1 2 7
Estimate Proportion (Yes=1)
1 1 0 0 0
Use Index (Yes=1)
1 1 1 0 0
Index-1 Selectivity Data

0	-1	0	0
0.5	1	0	0.5
1	-1	0	0
1	-1	0	0
1	-1	0	0
1	-1	0	0
1	-1	0	0
2	1	0	1
0.5	1	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Index-2 Selectivity Data

0.2	1	0	0.5
0.5	1	0	0.5
1	-1	0	0
1	-1	0	0
1	-1	0	0
1	-1	0	0
1	-1	0	0
2	1	0	1
0.5	1	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Index-3 Selectivity Data

1	-1	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0
0	-1	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Index-4 Selectivity Data

1	-1	0	1
1	-1	0	0
1	-1	0	0
1	-1	0	0
1	-1	0	0
1	-1	0	0
1	-1	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Index-5 Selectivity Data

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
4	1	0	1
0.5	1	0	1
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Index-1 Data

1980	0	0	0	0	0	0	0	0	0	0	
1981	0	0	0	0	0	0	0	0	0	0	
1982	0	0	0	0	0	0	0	0	0	0	
1983	0	0	0	0	0	0	0	0	0	0	
1984	0	0	0	0	0	0	0	0	0	0	
1985	0	0	0	0	0	0	0	0	0	0	
1986	0	0	0	0	0	0	0	0	0	0	
1987	0	0	0	0	0	0	0	0	0	0	
1988	0	0	0	0	0	0	0	0	0	0	
1989	0	0	0	0	0	0	0	0	0	0	
1990	0	0	0	0	0	0	0	0	0	0	
1991	0	0	0	0	0	0	0	0	0	0	
1992	0	0	0	0	0	0	0	0	0	0	
1993	1474	0.3	0	0.452	0.482	0.055	0.008	0.003	0.001	50	
1994	2431	0.3	0	0.742	0.108	0.123	0.018	0.005	0.003	50	
1995	2615	0.3	0	0.646	0.243	0.067	0.034	0.008	0.002	50	
1996	2093	0.3	0	0.702	0.16	0.102	0.017	0.018	0.003	50	
1997	3169	0.3	0	0.444	0.485	0.049	0.017	0.001	0.004	50	
1998	2694	0.3	0	0.551	0.28	0.154	0.011	0.003	0.001	50	
1999	1900	0.3	0	0.721	0.196	0.059	0.022	0.002	0.001	50	
2000	2925	0.3	0	0.787	0.14	0.062	0.009	0.001	0	50	
2001	1909	0.3	0	0.558	0.365	0.065	0.007	0.003	0.001	50	
2002	3235	0.3	0	0.713	0.212	0.054	0.016	0.003	0	50	
2003	2543	0.3	0	0.588	0.356	0.051	0.004	0.001	0	50	
2004	1907	0.3	0	0.844	0.121	0.032	0.001	0.001	0	50	

2005	857	0.3	0	0.804	0.145	0.033	0.014	0.003	0	50
2006	1232	0.3	0	0.779	0.191	0.025	0.005	0	0	50
2007	1081	0.3	0	0.837	0.147	0.014	0.002	0	0	50
2008	1152	0.3	0	0.657	0.301	0.039	0.002	0	0	50
2009	1382	0.3	0	0.769	0.203	0.026	0.001	0	0	50
2010	1348	0.3	0	0.549	0.405	0.038	0.003	0.005	0	50
2011	783	0.3	0	0.749	0.2	0.046	0.005	0.001	0	50
2012	1376	0.3	0	0.707	0.258	0.031	0.004	0.001	0	50
2013	1350	0.3	0	0.466	0.481	0.049	0.003	0	0	50
2014	1361	0.3	0	0.677	0.27	0.049	0.003	0	0	50
2015	3288	0.3	0	0.851	0.143	0.006	0.001	0	0	50
2016	2374	0.3	0	0.594	0.39	1E-06	0.016	0.001	0	50
2017	1874	0.3	0	0.474	0.444	0.076	0.006	0.001	0	50
2018	868	0.3	0	0.497	0.342	0.138	0.021	0.003	0	50
2019	1797	0.3	0	0.316	0.463	0.193	0.024	0.003	0	50
2020	2294	0.3	0	0.686	0.254	0.055	0.004	0	0	50

Index-2 Data

1980	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0
1993	2309	0.3	0.309	0.451	0.206	0.029	0.004	0.001	0	50
1994	2829	0.3	0.393	0.467	0.074	0.053	0.012	0.001	0	50
1995	3841	0.3	0.813	0.124	0.043	0.008	0.009	0.001	0	50
1996	3103	0.3	0.743	0.191	0.043	0.017	0.003	0.002	0	50
1997	3889	0.3	0.675	0.174	0.128	0.016	0.005	0.001	0.001	50
1998	3566	0.3	0.803	0.131	0.043	0.02	0.002	0.001	0	50
1999	3851	0.3	0.644	0.28	0.05	0.013	0.011	0.001	0	50
2000	3631	0.3	0.654	0.299	0.035	0.006	0.005	0.002	0.001	50
2001	7322	0.3	0.868	0.09	0.037	0.004	0.001	0	0	50
2002	4331	0.3	0.622	0.305	0.062	0.01	0.001	0	0	50
2003	7017	0.3	0.631	0.224	0.131	0.011	0.002	0	0	50
2004	5545	0.3	0.804	0.126	0.048	0.021	0.001	0	0	50
2005	3066	0.3	0.775	0.159	0.06	0.005	0	0	0	50
2006	3050	0.3	0.934	0.047	0.015	0.003	0.001	0	0	50
2007	3296	0.3	0.656	0.291	0.045	0.005	0.001	0.001	0	50
2008	6315	0.3	0.773	0.208	0.018	0.001	0	0	0	50
2009	2838	0.3	0.791	0.18	0.025	0.003	0.001	0	0	50
2010	2855	0.3	0.797	0.109	0.091	0.003	0	0	0	50
2011	4053	0.3	0.872	0.086	0.034	0.006	0.001	0	0	50
2012	1894	0.3	0.703	0.213	0.071	0.01	0.003	0	0	50
2013	7680	0.3	0.929	0.046	0.02	0.004	0	0	0	50
2014	5157	0.3	0.873	0.098	0.026	0.002	0	0	0	50
2015	3816	0.3	0.734	0.234	0.03	0.002	0	0	0	50

2016 3817 0.3 0.712 0.225 0.053 0.008 0 0 0 50
2017 4176 0.3 0.721 0.171 0.088 0.019 0 0 0 50
2018 5722 0.3 0.774 0.157 0 0.064 0 0 0 50
2019 6436 0.3 0.872 0.1 0.023 0.004 0 0 0 50
2020 3689 0.3 0.655 0.314 0.027 0.004 0 0 0 50
Index-3 Data
1980 0 0 0 0 0 0 0 0 0 0
1981 0 0 0 0 0 0 0 0 0 0
1982 0 0 0 0 0 0 0 0 0 0
1983 0 0 0 0 0 0 0 0 0 0
1984 0 0 0 0 0 0 0 0 0 0
1985 0 0 0 0 0 0 0 0 0 0
1986 0 0 0 0 0 0 0 0 0 0
1987 0 0 0 0 0 0 0 0 0 0
1988 0 0 0 0 0 0 0 0 0 0
1989 0 0 0 0 0 0 0 0 0 0
1990 0 0 0 0 0 0 0 0 0 0
1991 0 0 0 0 0 0 0 0 0 0
1992 0 0 0 0 0 0 0 0 0 0
1993 0 0 0 0 0 0 0 0 0 0
1994 778 0.5 0 0 0 0 0 0 0 0
1995 225 0.5 0 0 0 0 0 0 0 0
1996 397 0.5 0 0 0 0 0 0 0 0
1997 205 0.5 0 0 0 0 0 0 0 0
1998 59 0.5 0 0 0 0 0 0 0 0
1999 91 0.5 0 0 0 0 0 0 0 0
2000 40 0.5 0 0 0 0 0 0 0 0
2001 167 0.5 0 0 0 0 0 0 0 0
2002 19 0.5 0 0 0 0 0 0 0 0
2003 148 0.5 0 0 0 0 0 0 0 0
2004 101 0.5 0 0 0 0 0 0 0 0
2005 135 0.5 0 0 0 0 0 0 0 0
2006 118 0.5 0 0 0 0 0 0 0 0
2007 82 0.5 0 0 0 0 0 0 0 0
2008 99 0.5 0 0 0 0 0 0 0 0
2009 173 0.5 0 0 0 0 0 0 0 0
2010 78 0.5 0 0 0 0 0 0 0 0
2011 122.2 0.5 0 0 0 0 0 0 0 0
2012 123.9 0.5 0 0 0 0 0 0 0 0
2013 197.6 0.5 0 0 0 0 0 0 0 0
2014 54.9 0.5 0 0 0 0 0 0 0 0
2015 59.5 0.5 0 0 0 0 0 0 0 0
2016 6.7 0.5 0 0 0 0 0 0 0 0
2017 175.4 0.5 0 0 0 0 0 0 0 0
2018 90.74 0.5 0 0 0 0 0 0 0 0
2019 164.4284624 0.5 0 0 0 0 0 0 0 0
2020 0 0 0 0 0 0 0 0 0 0
Index-4 Data
1980 0 0 0 0 0 0 0 0 0 0
1981 0 0 0 0 0 0 0 0 0 0
1982 0 0 0 0 0 0 0 0 0 0
1983 0 0 0 0 0 0 0 0 0 0
1984 0 0 0 0 0 0 0 0 0 0

1985	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0
1988	96	0.5	0	0	0	0	0	0	0	0
1989	93	0.5	0	0	0	0	0	0	0	0
1990	99	0.5	0	0	0	0	0	0	0	0
1991	216	0.5	0	0	0	0	0	0	0	0
1992	405	0.5	0	0	0	0	0	0	0	0
1993	253	0.5	0	0	0	0	0	0	0	0
1994	205	0.5	0	0	0	0	0	0	0	0
1995	1949	0.5	0	0	0	0	0	0	0	0
1996	169	0.5	0	0	0	0	0	0	0	0
1997	409	0.5	0	0	0	0	0	0	0	0
1998	893	0.5	0	0	0	0	0	0	0	0
1999	550	0.5	0	0	0	0	0	0	0	0
2000	320	0.5	0	0	0	0	0	0	0	0
2001	585	0.5	0	0	0	0	0	0	0	0
2002	280	0.5	0	0	0	0	0	0	0	0
2003	456	0.5	0	0	0	0	0	0	0	0
2004	917	0.5	0	0	0	0	0	0	0	0
2005	849	0.5	0	0	0	0	0	0	0	0
2006	1010	0.5	0	0	0	0	0	0	0	0
2007	339	0.5	0	0	0	0	0	0	0	0
2008	780	0.5	0	0	0	0	0	0	0	0
2009	389	0.5	0	0	0	0	0	0	0	0
2010	324	0.5	0	0	0	0	0	0	0	0
2011	1002	0.5	0	0	0	0	0	0	0	0
2012	442	0.5	0	0	0	0	0	0	0	0
2013	1535	0.5	0	0	0	0	0	0	0	0
2014	261	0.5	0	0	0	0	0	0	0	0
2015	211	0.5	0	0	0	0	0	0	0	0
2016	666	0.5	0	0	0	0	0	0	0	0
2017	489	0.5	0	0	0	0	0	0	0	0
2018	661.75	0.5	0	0	0	0	0	0	0	0
2019	340	0.5	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0

Index-5 Data

1980	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0

1996	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0
2005	38.66	0.5	0	0	0	0	0	0	0	0
2006	72.953	0.5	0	0	0	0	0	0	0	0
2007	21.87	0.5	0	0	0	0	0	0	0	0
2008	25.23	0.5	0	0	0	0	0	0	0	0
2009	164.82	0.5	0	0	0	0	0	0	0	0
2010	111.12	0.5	0	0	0	0	0	0	0	0
2011	48.6	0.5	0	0	0	0	0	0	0	0
2012	139.25	0.5	0	0	0	0	0	0	0	0
2013	82.85	0.5	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0

Phase Control
Phase for F mult in 1st Year
1
Phase for F mult Deviations
1
Phase for Recruitment Deviations
3
Phase for N in 1st Year
1
Phase for Catchability in 1st Year
2
Phase for Catchability Deviations
-5
Phase for Stock Recruitment Relationship
3
Phase for Steepness
-5
Recruitment CV by Year
1
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Lambdas by Index
1 1 1 1 1
Lambda for Total Catch in Weight by Fleet
1
Lambda for Total Discards at Age by Fleet
0
Catch Total CV by Year and Fleet
0.2
0.2
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0.3
Discard Total CV by Year and Fleet
0
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Catch Effective Sample Size by Year and Fleet
10
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Discard Effective Sample Size by Year and Fleet
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Lambda for F Mult in First year by Fleet
0
CV for F Mult in First year by Fleet
0.9
Lambda for F Mult Deviations by Fleet
0
CV for F Mult Deviations by Fleet

0.9
Lambda for N in 1st Year Deviations
0
CV for N in 1st Year Deviations
.9
Lambda for Recruitment Deviations
.1
Lambda for Catchability in First year by Index
0 0 0 0 0
CV for Catchability in First year by Index
0.9 0.9 0.9 0.9 .9
Lambda for Catchability Deviations by Index
0 0 0 0 0
CV for Catchability Deviations by Index
.9 .9 .9 .9 .9
Lambda for Deviation from Initial Steepness
0
CV for Deviation from Initial Steepness
.9
Lambda for Deviation from Unexploited Stock Size
0
CV for Deviation from Unexploited Stock Size
.9
NAA Deviations Flag
1
Initial Numbers-at-age in 1st Year
1000000 500000 250000 125000 60000 30000 10000
Initial F Mult in 1st Year by Fleet
1
Initial Catchabilty by Index
.001 .001 .001 .001 0.001
Stock Recruitment Flag
0
Initial Unexploited Stock
1000
Initial Steepness
1
Maximum F
2.5
Ignore Guesses (Yes=1)
0
Projection Control
Do Projections (Yes=1)
0
Fleet Directed Flag
1
Final Year in Projection
2021
Projection Data by Year
2021 -1 3 -99 1
Do MCMC (Yes=1)
0
MCMC Year Option

```
1
# MCMC Iterations
0
# MCMC Thinning Factor
0
# MCMC Random Seed
0
# Agepro R Option
-1
# Agepro R Option Start Year
0
# Agepro R Option End Year
0
# Export R Flag
1
# Test Value
-23456
######
###### FINIS ######
# Fleet Names
#$All
# Survey Names
#$NI-Q1
#$NI_Q2
#$NI-MIK
#$UK-BTS
#$UK-FSP
#
```

Table 37.7. Whiting 7.a. Selectivity of the catches and indices.

Age	Catch	NI-Q1	NI-Q4	NI-MIK
0	0.118	0.000	0.659	1.000
1	0.848	0.494	0.749	0.000
2	0.996	1.000	1.000	0.000
3	1.000	1.000	1.000	0.000
4	1.000	1.000	1.000	0.000
5	1.000	1.000	1.000	0.000
6	1.000	1.000	1.000	0.000

Table 37.8. Whiting 7.a Fishing mortality- (F) -at age.

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1980	0.024	0.17	0.411	0.475	0.482	0.482	0.483
1981	0.029	0.206	0.499	0.576	0.585	0.586	0.586
1982	0.033	0.238	0.577	0.667	0.677	0.678	0.678
1983	0.034	0.247	0.598	0.691	0.701	0.702	0.702
1984	0.041	0.297	0.718	0.83	0.843	0.844	0.844
1985	0.05	0.358	0.868	1.003	1.018	1.02	1.02
1986	0.039	0.28	0.679	0.785	0.796	0.798	0.798
1987	0.041	0.295	0.715	0.826	0.838	0.84	0.84
1988	0.035	0.251	0.608	0.703	0.714	0.715	0.715
1989	0.049	0.354	0.856	0.99	1.005	1.006	1.006
1990	0.042	0.302	0.73	0.844	0.857	0.858	0.858
1991	0.043	0.305	0.739	0.854	0.867	0.868	0.869
1992	0.07	0.5	1.211	1.4	1.421	1.423	1.423
1993	0.055	0.399	0.965	1.115	1.132	1.134	1.134
1994	0.058	0.414	1.002	1.159	1.176	1.178	1.178
1995	0.105	0.756	0.888	0.891	0.891	0.891	0.891
1996	0.114	0.821	0.964	0.968	0.968	0.968	0.968
1997	0.1	0.716	0.841	0.844	0.844	0.844	0.844
1998	0.14	1.006	1.181	1.186	1.186	1.186	1.186
1999	0.11	0.793	0.931	0.935	0.935	0.935	0.935
2000	0.143	1.031	1.211	1.216	1.216	1.216	1.216
2001	0.116	0.837	0.983	0.987	0.987	0.987	0.987
2002	0.159	1.144	1.343	1.348	1.349	1.349	1.349
2003	0.08	0.572	0.672	0.674	0.675	0.675	0.675
2004	0.222	1.597	1.875	1.883	1.883	1.883	1.883
2005	0.06	0.43	0.505	0.507	0.507	0.507	0.507
2006	0.196	1.408	1.653	1.66	1.66	1.66	1.66
2007	0.154	1.109	1.303	1.308	1.308	1.308	1.308
2008	0.125	0.899	1.056	1.06	1.06	1.06	1.06

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
2009	0.142	1.019	1.196	1.201	1.201	1.201	1.201
2010	0.148	1.066	1.251	1.257	1.257	1.257	1.257
2011	0.111	0.798	0.937	0.941	0.941	0.941	0.941
2012	0.147	1.054	1.238	1.243	1.243	1.243	1.243
2013	0.085	0.608	0.714	0.716	0.717	0.717	0.717
2014	0.193	1.389	1.631	1.637	1.638	1.638	1.638
2015	0.126	0.903	1.06	1.064	1.064	1.064	1.064
2016	0.071	0.511	0.6	0.603	0.603	0.603	0.603
2017	0.057	0.406	0.477	0.479	0.479	0.479	0.479
2018	0.056	0.404	0.474	0.476	0.476	0.476	0.476
2019	0.091	0.654	0.768	0.771	0.771	0.771	0.771
2020	0.095	0.679	0.798	0.801	0.801	0.801	0.801

Table 37.9. Whiting 7.a Stock Numbers-at-age (start of year) ('1000).

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
1980	542928	406361	132235	22468	7945	1078	1905
1981	317099	180434	153646	42776	7610	2820	1097
1982	281120	104850	65785	45512	13086	2436	1299
1983	881413	92537	37013	18021	12720	3822	1130
1984	632132	289790	32388	9931	4917	3625	1461
1985	513038	206393	96488	7701	2357	1216	1303
1986	871624	166077	64613	19762	1538	489	541
1987	472840	285238	56211	15986	4910	399	277
1988	484433	154417	95123	13417	3810	1220	174
1989	594310	159174	53808	25252	3616	1072	406
1990	517611	192511	50065	11147	5109	761	322
1991	668786	168887	63789	11766	2609	1247	274
1992	230093	218101	55756	14858	2726	630	380
1993	212460	73027	59244	8099	1994	378	145
1994	183093	68392	21961	11010	1445	369	100
1995	339894	58812	20253	3932	1882	256	86
1996	203161	104114	12372	4066	878	443	84
1997	171419	61672	20527	2302	841	192	119
1998	167329	52801	13504	4320	539	208	80
1999	208488	49505	8653	2022	719	95	52
2000	109709	63534	10036	1663	432	162	34
2001	192756	32343	10149	1458	268	74	35
2002	79853	58383	6275	1853	296	58	24
2003	121161	23176	8334	799	262	44	13
2004	94481	38075	5860	2077	222	77	17
2005	105994	25746	3455	438	172	19	9
2006	154757	33972	7502	1017	144	60	10
2007	103910	43293	3723	700	105	16	8
2008	149069	30302	6395	494	103	16	4

	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
2009	92879	44760	5523	1085	93	21	4
2010	92454	27429	7240	814	178	16	4
2011	151434	27125	4233	1010	126	29	3
2012	79035	46115	5471	809	215	28	8
2013	160728	23225	7199	774	127	36	6
2014	197009	50259	5666	1720	206	36	12
2015	123897	55261	5615	541	182	23	6
2016	82217	37185	10039	949	102	36	6
2017	104346	26056	9991	2686	283	32	14
2018	108122	33555	7775	3024	906	101	17
2019	207690	34782	10038	2360	1023	323	43
2020	129971	64529	8104	2272	594	272	101
2021	119971	40237	14652	1780	555	153	100

Table 37.10. Whiting 7.a Stock Summary: weights in tonnes: CatchPred is predicted catch from ASAP. Recruitment-at-age zero ('1000), F_{bar} ages (1–3).

Year	Lan	Dis	Cat	CatPred	Tsb	Ssb	SsbCv	Recr	RecrCv	Fbar	FbarCv
1980	13422	3314	16737	16777.05	64965.9	35179.64	0.318508	542927.9	0.35187	0.351613	0.319983
1981	18267	3064	21331	21260.15	60437.84	46273.82	0.240136	317098.6	0.425167	0.42703	0.292556
1982	17167	801	17969	17869.53	43356.97	34549.54	0.27253	281119.8	0.445895	0.49397	0.33168
1983	10577	1829	12405	12316.39	29529.71	21664.09	0.351642	881412.6	0.25323	0.511731	0.391573
1984	11619	3380	14999	14697.96	37497.01	14603.58	0.420952	632132.3	0.313906	0.615216	0.353827
1985	15525	2644	18169	17939.76	36830.59	22445.02	0.296796	513037.8	0.344419	0.742998	0.32486
1986	10063	2066	12129	12068.38	28671.52	17992.79	0.325186	871624.1	0.26212	0.581211	0.350355
1987	10411	3859	14270	14058.58	33086.1	16028.88	0.341359	472839.5	0.346968	0.611937	0.323628
1988	10245	1611	11856	11797.03	29901.46	20373.92	0.280957	484433.2	0.322975	0.52087	0.326991
1989	11305	2103	13408	13394.75	26537.69	16875.84	0.309087	594309.9	0.266965	0.733286	0.322316
1990	8212	2444	10656	10634.25	24228.78	12524.12	0.33061	517610.6	0.250285	0.625239	0.306267
1991	7348	2598	9946	9912.497	22715.81	13511.46	0.263332	668785.9	0.168215	0.632874	0.253352
1992	8588	4203	12791	12554.3	22035.03	11566.16	0.210493	230093.1	0.151821	1.037236	0.183189
1993	6523	2707	9230	6776.442	12795.49	9414.361	0.1518	212460.1	0.130429	0.826275	0.167015
1994	6763	1173	7936	4996.876	8573.764	5414.036	0.16016	183092.7	0.136608	0.858224	0.173696
1995	4893	2151	7044	4547.557	6682.161	3900.33	0.162999	339893.7	0.11794	0.844907	0.168811
1996	4335	3631	7966	4382.642	7074.235	2701.459	0.185781	203160.8	0.128199	0.917378	0.146821

Year	Lan	Dis	Cat	CatPred	Tsb	Ssb	SsbCv	Recr	RecrCv	Fbar	FbarCv
1997	2277	1928	4205	3006.596	5217.51	2954.149	0.150751	171419.3	0.138928	0.800133	0.164548
1998	2229	1304	3533	2887.52	4142.88	2442.679	0.159575	167329.1	0.129876	1.124052	0.164245
1999	1670	1092	2762	2249.851	2997.196	1447.69	0.1971	208487.6	0.127365	0.886272	0.175635
2000	762	2118	2880	2355.519	3403.025	1420.75	0.189534	109709.2	0.13863	1.152666	0.151284
2001	733	1012	1745	1622.509	2203.778	1256.141	0.172361	192755.6	0.130113	0.935332	0.181273
2002	747	740	1487	1889.33	2813.49	1120.391	0.193754	79852.83	0.135712	1.27829	0.155614
2003	517	480	996	1277.655	1779.579	1128.344	0.170569	121161.2	0.14834	0.639393	0.234957
2004	133	905	1038	2067.757	2294.277	1197.727	0.196372	94481.23	0.124099	1.784665	0.163683
2005	125	272	397	506.7107	1320.018	488.4056	0.257839	105993.5	0.138056	0.480785	0.275737
2006	64	1773	1837	2571.48	2121.123	996.6411	0.216186	154756.8	0.125616	1.573834	0.178844
2007	35	1512	1547	1524.268	2053.583	529.6707	0.27064	103910	0.130584	1.240068	0.166475
2008	37	1169	1206	1284.512	1615.54	673.1624	0.207379	149069.3	0.124486	1.005152	0.189902
2009	39	1321	1360	1497.981	2167.281	685.7182	0.21293	92878.94	0.133292	1.138655	0.172493
2010	30	1154	1184	1451.419	1663.84	769.6641	0.191642	92453.51	0.127729	1.19125	0.185326
2011	31	946	977	981.2216	1411.503	562.4919	0.230154	151434.3	0.125427	0.891998	0.194642
2012	60	1339	1399	1434.218	2110.689	635.0035	0.212393	79034.59	0.134713	1.178349	0.168728
2013	33	948	981	1036.783	1552.456	776.7334	0.197738	160727.9	0.139845	0.679227	0.219661
2014	23	1951	1974	2643.096	2734.712	880.168	0.210801	197008.7	0.117619	1.552218	0.173384

Year	Lan	Dis	Cat	CatPred	Tsb	Ssb	SsbCv	Recr	RecrCv	Fbar	FbarCv
2015	28	1521	1549	1734.782	2496.38	623.0211	0.251661	123897.3	0.115967	1.008875	0.177187
2016	15	765	780	816.2923	2039.818	894.529	0.181515	82216.64	0.127213	0.571405	0.203026
2017	36	668	704	696.2063	1894.344	1097.032	0.16562	104346.4	0.12423	0.454238	0.215618
2018	46	853	899	872.182	2181.908	1171.903	0.171388	108122.4	0.142394	0.451336	0.214534
2019	172	1089	1261	1394.196	2308.536	1299.863	0.171241	207690.4	0.154668	0.730717	0.243596
2020	88	1030	1118	1269.942	2699.271	1073.146	0.238001	129970.7	0.279217	0.759466	0.396686
2021*	NA	NA	NA	NA	NA	1393.129	NA	119971	NA	0.647173	NA

Table 37.11. Whiting 7.a. Input values for short-term forecast. Note that Sel and CWt refer to the landings and DSel and DCWt refer to the discards. Numbers in thousands; Weights in kg.

2021										
Age	N	M	Mat	PF	PM	SWt	Sel	CWt	DSel	DCWt
0	119971	1.078	0	0	0	0	0	0	0.08	0.02
1	40237	0.803	0	0	0	0.028	0.062	0.099	0.517	0.035
2	14653	0.718	1	0	0	0.064	0.291	0.245	0.389	0.09
3	1780	0.608	1	0	0	0.134	0.503	0.321	0.179	0.135
4	555	0.554	1	0	0	0.225	0.624	0.362	0.058	0.183
5	153	0.518	1	0	0	0.337	0.67	0.426	0.013	0.164
6	100	0.518	1	0	0	0.407	0.675	0.403	0.008	0
2022										
Age	N	M	Mat	PF	PM	SWt	Sel	CWt	DSel	DCWt
0	119971	1.078	0	0	0	0	0	0	0.08	0.02
1	37664	0.803	0	0	0	0.028	0.062	0.099	0.517	0.035
2	10103	0.718	1	0	0	0.064	0.291	0.245	0.389	0.09
3	3621	0.608	1	0	0	0.134	0.503	0.321	0.179	0.135
4	490	0.554	1	0	0	0.225	0.624	0.362	0.058	0.183
5	161	0.518	1	0	0	0.337	0.67	0.426	0.013	0.164
6	76	0.518	1	0	0	0.407	0.675	0.403	0.008	0

2023										
Age	N	M	Mat	PF	PM	SWt	Sel	CWt	DSel	DCWt
0	119971	1.078	0	0	0	0	0	0	0.08	0.02
1	37664	0.803	0	0	0	0.028	0.062	0.099	0.517	0.035
2	9457	0.718	1	0	0	0.064	0.291	0.245	0.389	0.09
3	2497	0.608	1	0	0	0.134	0.503	0.321	0.179	0.135
4	996	0.554	1	0	0	0.225	0.624	0.362	0.058	0.183
5	142	0.518	1	0	0	0.337	0.67	0.426	0.013	0.164
6	71	0.518	1	0	0	0.407	0.675	0.403	0.008	0

Table 37.12. Whiting 7.a. Single-option output of the short-term forecast (F = mean F 2018–2020). Numbers in thousands, weights in tonnes.

2021										
Age	F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos	SSB
0	0	0	0	0.08	5722	114	119971	0	0	0
1	0.062	1	0	0.517	12625	442	40237	1131	0	0
2	0.291	173	42	0.389	5192	469	14653	938	14653	938
3	0.503	245	79	0.179	437	59	1780	238	1780	238
4	0.624	132	48	0.058	86	16	555	125	555	125
5	0.67	51	22	0.013	10	2	153	52	153	52
6	0.675	40	16	0.008	0	0	100	41	100	41
Total	0.285	642	207	0.362	24072	1102	177449	2525	17241	1394
2022										
Age	F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos	SSB
0	0	0	0	0.08	5722	114	119971	0	0	0
1	0.062	0	0	0.517	11817	414	37664	1058	0	0
2	0.291	120	29	0.389	3580	323	10103	647	10103	647
3	0.503	499	160	0.179	890	120	3621	484	3621	484
4	0.624	116	42	0.058	76	14	490	110	490	110
5	0.67	54	23	0.013	10	2	161	54	161	54
6	0.675	30	12	0.008	0	0	76	31	76	31
Total	0.285	819	266	0.362	22095	987	172086	2384	14451	1326

2023										
Age	F	CatchNos	Yield	DF	DCatchNos	DYield	StockNos	Biomass	SSNos	SSB
0	0	0	0	0.08	5722	114	119971	0	0	0
1	0.062	0	0	0.517	11817	414	37664	1058	0	0
2	0.291	112	27	0.389	3351	303	9457	605	9457	605
3	0.503	344	111	0.179	613	83	2497	334	2497	334
4	0.624	236	85	0.058	154	28	996	224	996	224
5	0.67	47	20	0.013	9	1	142	48	142	48
6	0.675	28	11	0.008	0	0	71	29	71	29
Total	0.285	767	254	0.362	21666	943	170798	2298	13163	1240

Table 37.13. Whiting 7.a. Management options table. Weights in tonnes.

Fmult	Catch22	Land22	Dis22	Basis	FCatch22	FLand22	FDis22	SSB23	dSSB
0	0	0	0		0	NA	NA	2334	76.02%
0.1	157	35	122		0.06472	0.00891	0.05581	2191	65.23%
0.2	305	67	238		0.12943	0.01782	0.11162	2057	55.13%
0.3	446	98	349		0.19415	0.02672	0.16743	1930	45.55%
0.4	580	126	454		0.25887	0.03563	0.22324	1812	36.65%
0.5	707	153	554		0.32359	0.04454	0.27905	1701	28.28%
0.6	828	179	649		0.3883	0.05345	0.33486	1597	20.44%
0.7	942	203	740		0.45302	0.06236	0.39067	1499	13.05%
0.8	1051	225	826		0.51774	0.07126	0.44648	1407	6.11%
0.9	1155	247	909		0.58246	0.08017	0.50228	1321	-0.38%
1	1254	267	987		0.64717	0.08908	0.55809	1240	-6.49%
1.1	1348	286	1062		0.71189	0.09799	0.6139	1164	-12.22%
1.2	1438	303	1134		0.77661	0.10689	0.66971	1093	-17.57%
1.3	1523	320	1203		0.84133	0.1158	0.72552	1026	-22.62%
1.4	1604	336	1268		0.90604	0.12471	0.78133	964	-27.30%
1.5	1682	351	1331		0.97076	0.13362	0.83714	905	-31.75%
1.6	1756	365	1391		1.03548	0.14253	0.89295	849	-35.97%
1.7	1827	378	1449		1.10019	0.15143	0.94876	798	-39.82%
1.8	1895	391	1504		1.16491	0.16034	1.00457	749	-43.51%
1.9	1959	403	1556		1.22963	0.16925	1.06038	703	-46.98%
2	2021	414	1607		1.29435	0.17816	1.11619	660	-50.23%
2.1	2081	425	1656		1.35906	0.18707	1.172	620	-53.24%
2.2	2137	435	1702		1.42378	0.19597	1.22781	582	-56.11%
2.3	2192	444	1747		1.4885	0.20488	1.28362	547	-58.75%
2.4	2244	453	1791		1.55322	0.21379	1.33943	514	-61.24%
2.5	2294	462	1832		1.61793	0.2227	1.39524	482	-63.65%

Table 37.14. Whiting 7.a. Management options Advice table. Weights in tonnes.

Catch22	Land22	Dis22	Basis	FCatch22	FLand22	FDis22	SSB23	dSSB
498	109	390	FMSY	0.219	0.03014	0.18886	1884	42.08%
44	10	34	FMSY x SSB(2022)/M	0.01782	0.00245	0.01536	2294	73.00%
0	0	0	F = 0	0	NA	NA	2334	76.02%
1254	267	987	F = Fsq	0.64717	0.08908	0.55809	1240	-6.49%
794	172	622	F = Flim	0.37	0.05093	0.31907	1625	22.55%
498	109	390	F = Fpa	0.219	0.03014	0.18886	1884	42.08%
368	81	288	Min FMSY	0.158	0.02175	0.13625	2000	50.83%
32	7	25	Min FMSY x SSB(202	0.01285	0.00177	0.01108	2305	73.83%
498	109	390	Max FMSY	0.219	0.03014	0.18886	1884	42.08%
44	10	34	Max FMSY x SSB(202	0.01782	0.00245	0.01536	2294	73.00%
1149	245	904	Stable SSB	0.5785	0.07963	0.49887	1326	0%
834	180	654	SSB * 1.2	0.39179	0.05393	0.33786	1591	19.99%

37.14 Figures

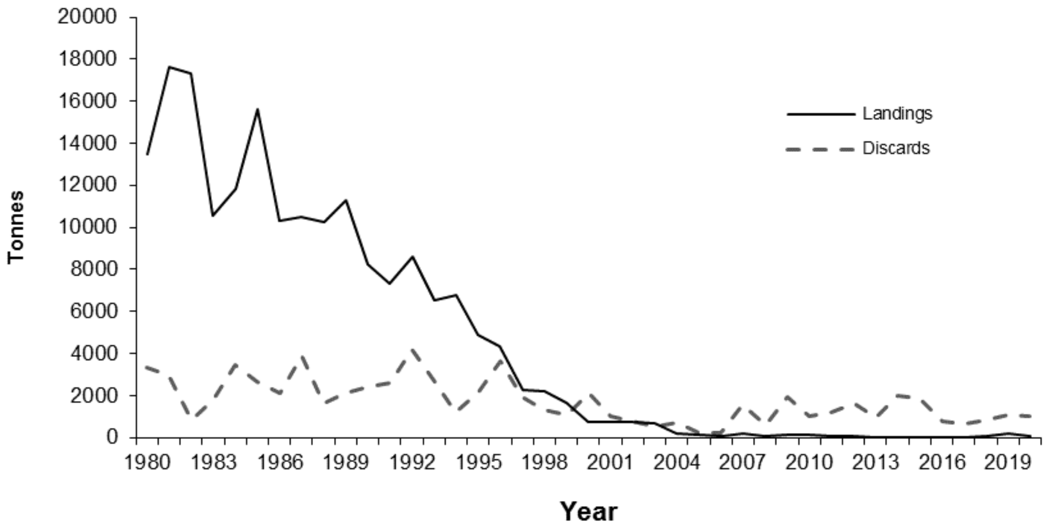


Figure 37.1. Whiting 7.a. Working group estimates of International landings and discards.

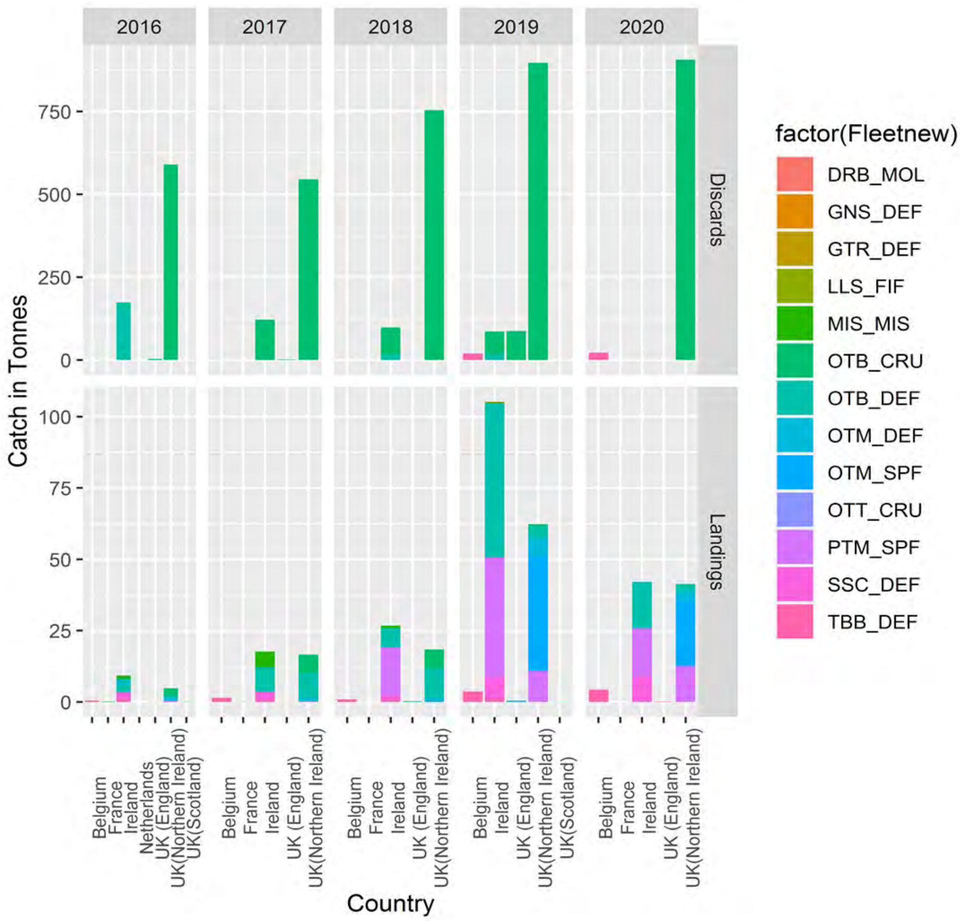


Figure 37.2. Whiting 7.a. Landings and discards by fleet.

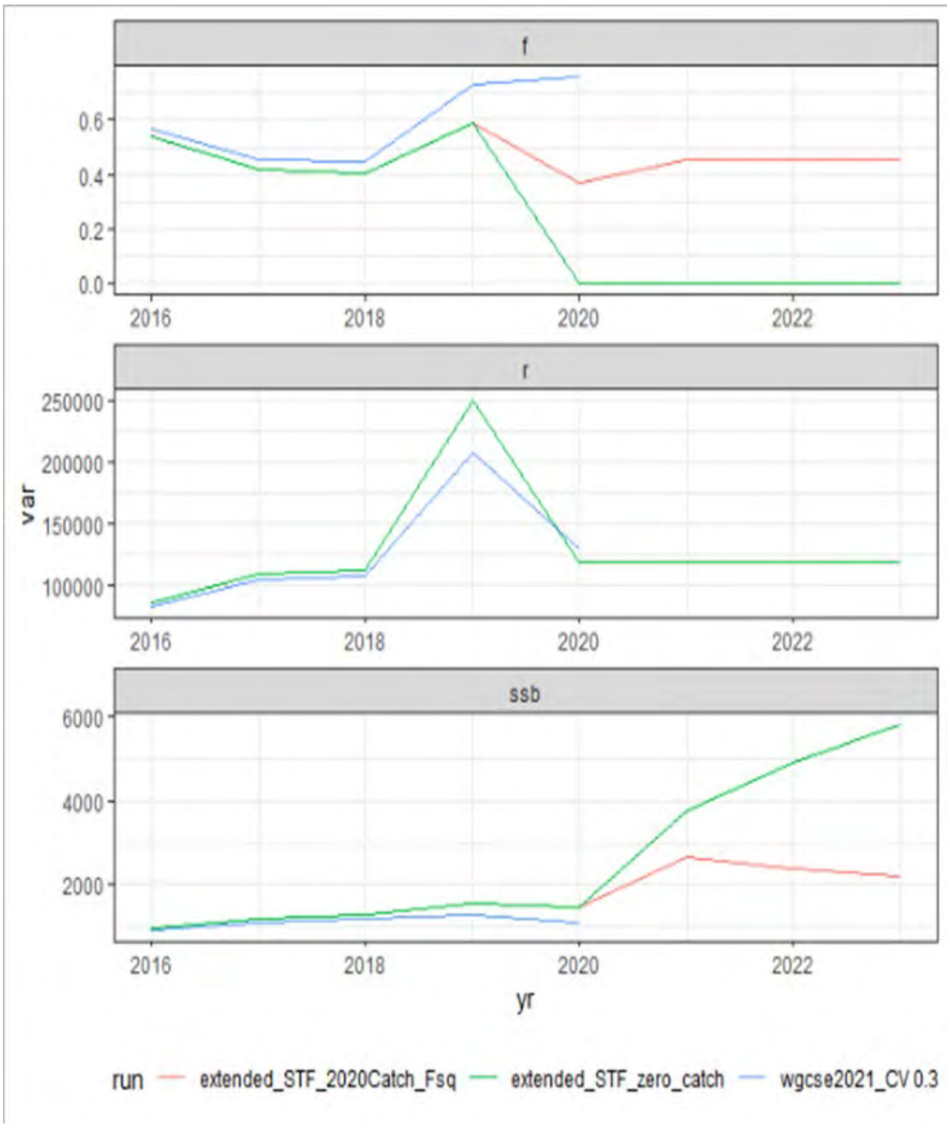


Figure 37.3. Extension of the Short-term forecast carried out in WGCSE, 2020.

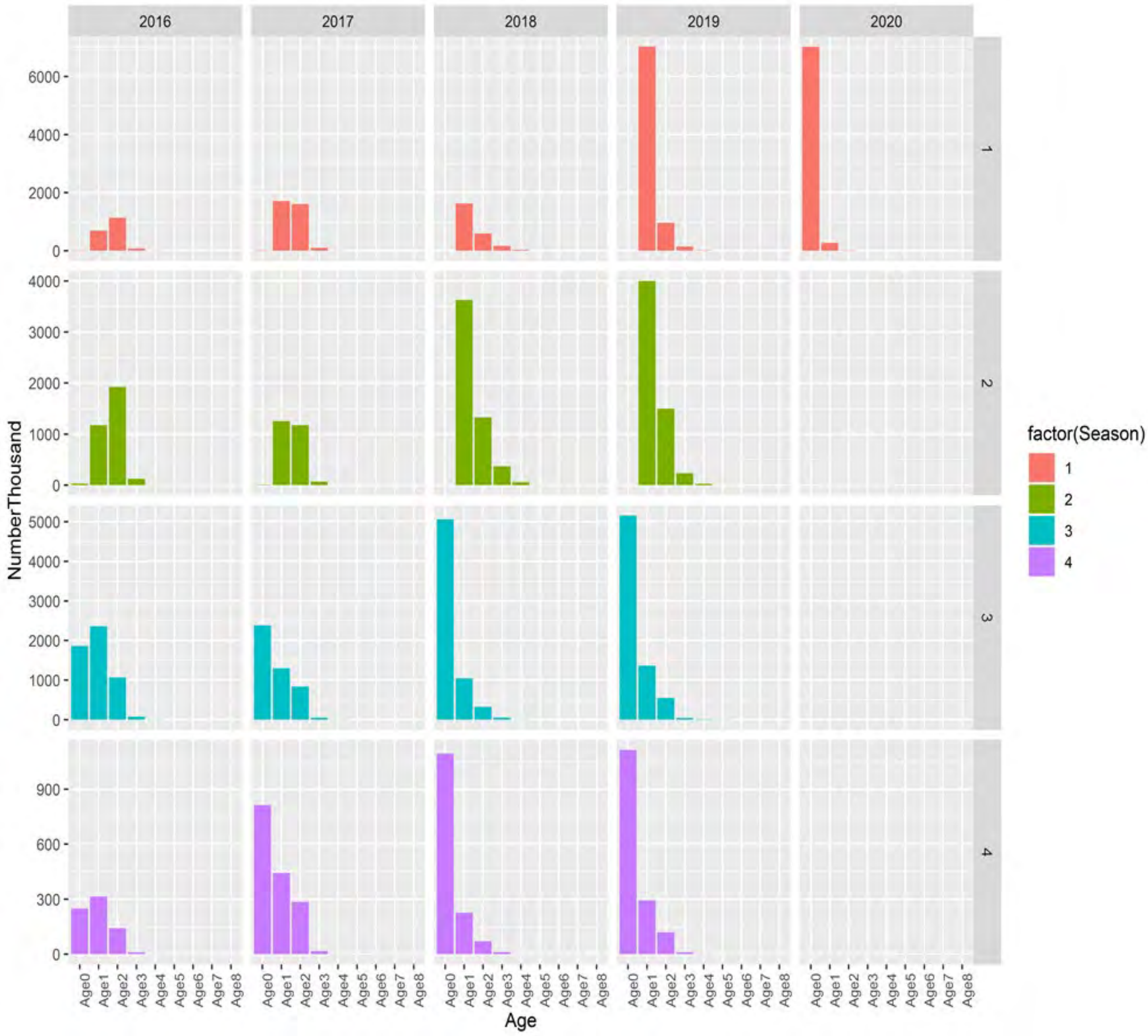
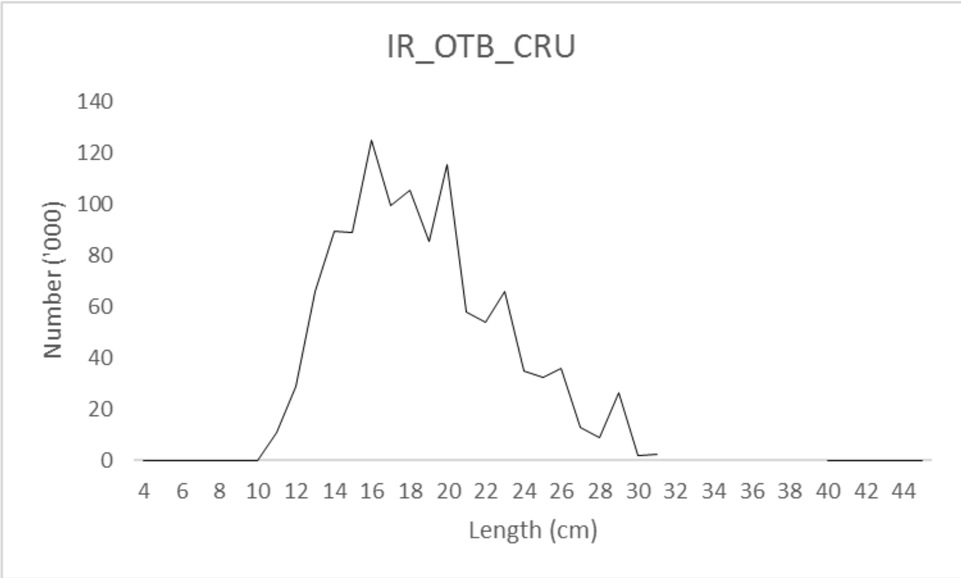


Figure 37.4. Discard Numbers-at-age for the NI-OTB-CRU fleet.



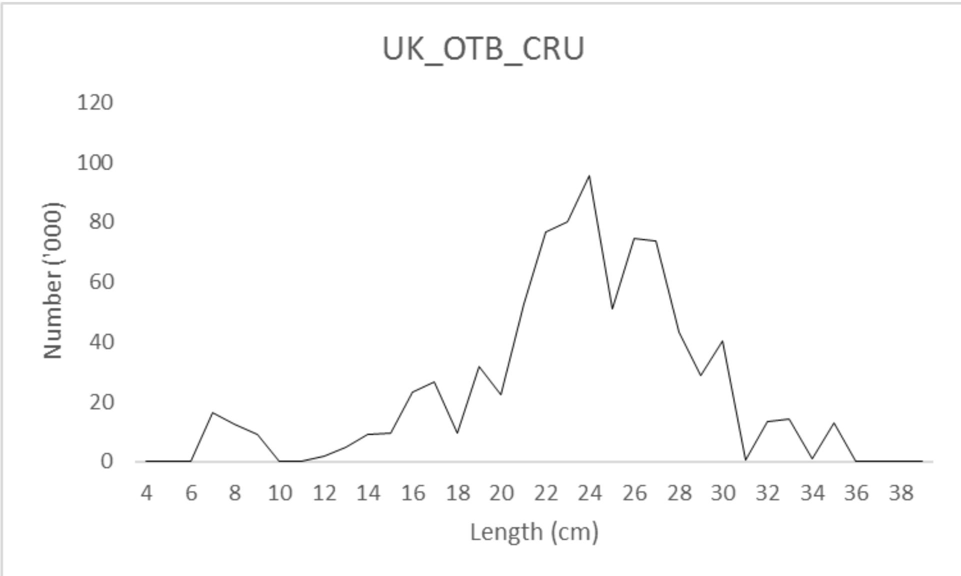


Figure 37.5. Whiting 7.a discard length–frequency by national fleets for the OTB_CRU metier. Note due to low levels of retained catch, and hence low sampling, these data are not presented. Not updated at WGCSE, 2021.

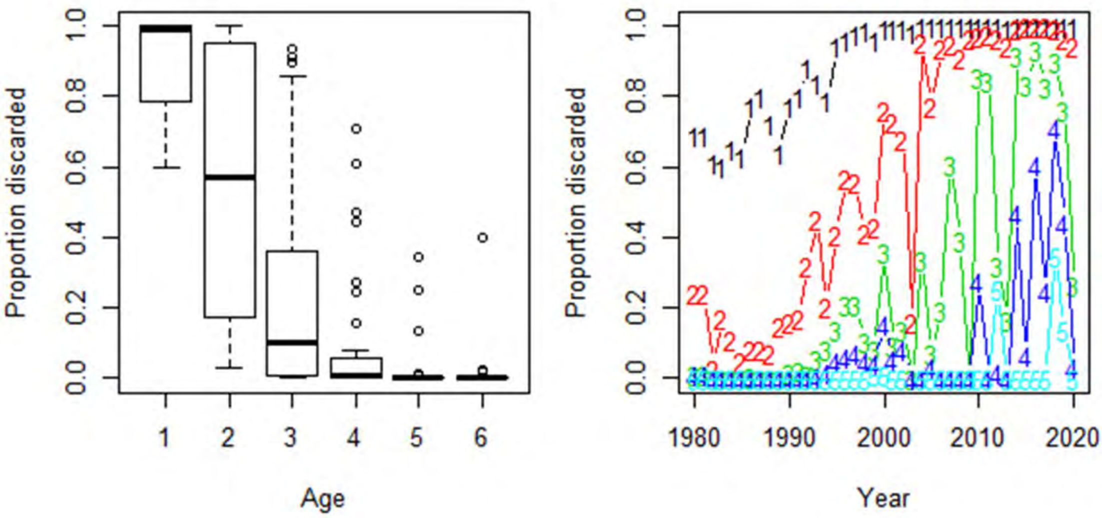


Figure 37.6. Whiting 7.a. Proportion of discards by age (left) and year (right).

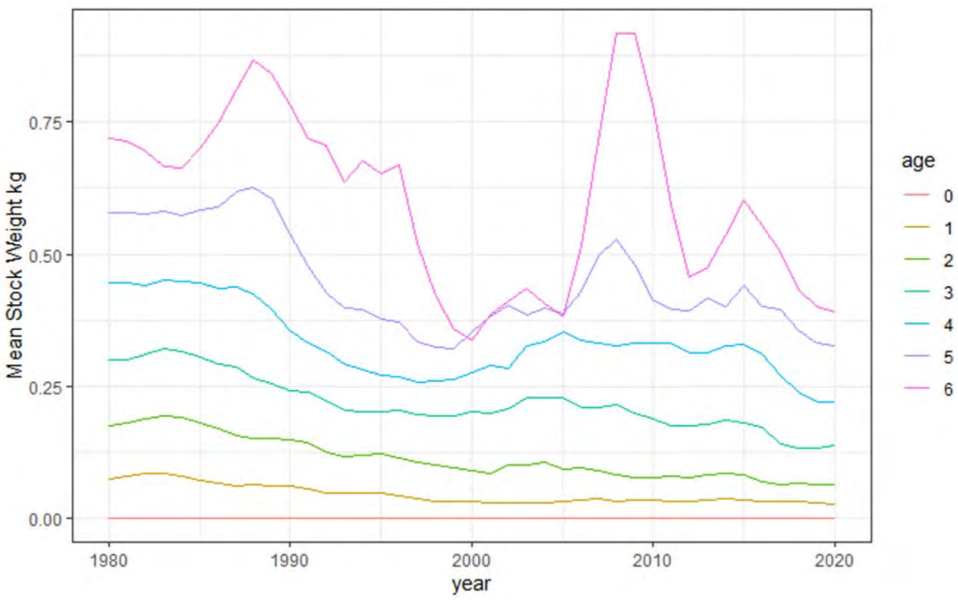


Figure 37.7. Whiting 7.a. Smoothed Stock Weights (Three year running average).

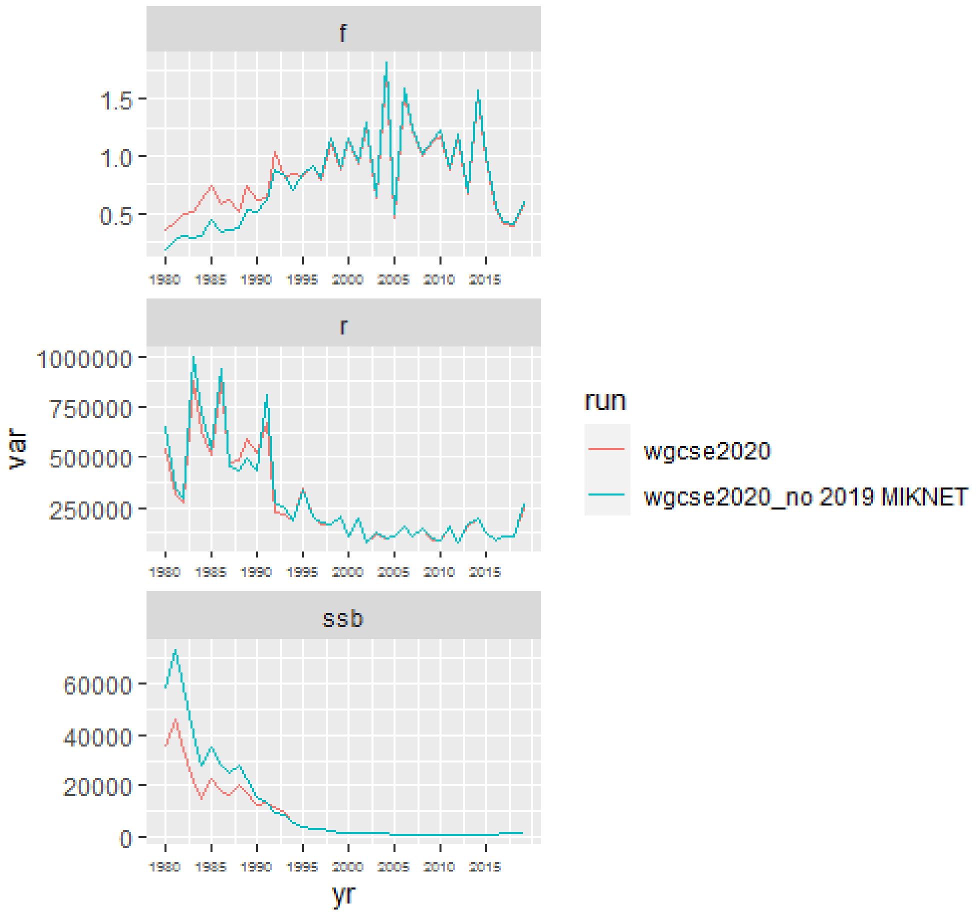


Figure 37.8. Whiting 7.a. The 2020 ASAP assessment with and without the NI MIK survey for the terminal year (2019).

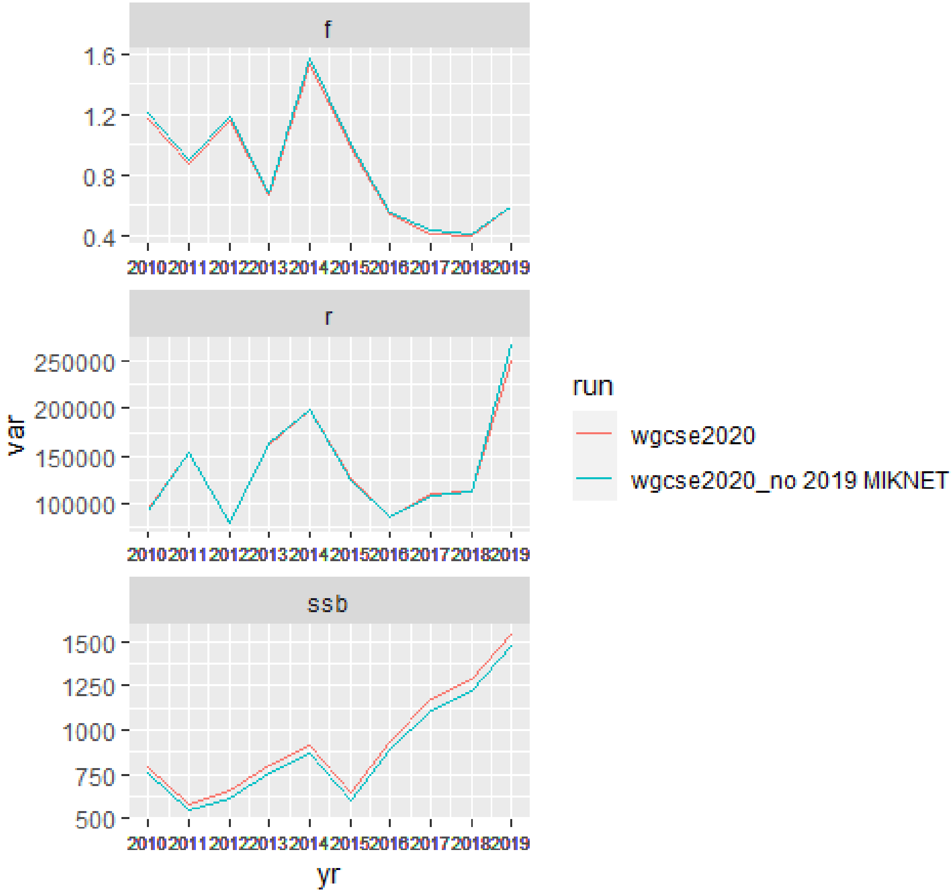


Figure 37.9. Whiting 7.a. The 2020 ASAP assessment with and without the NI MIK survey in the terminal year. The figure shows the impact in the most recent years of the assessment.

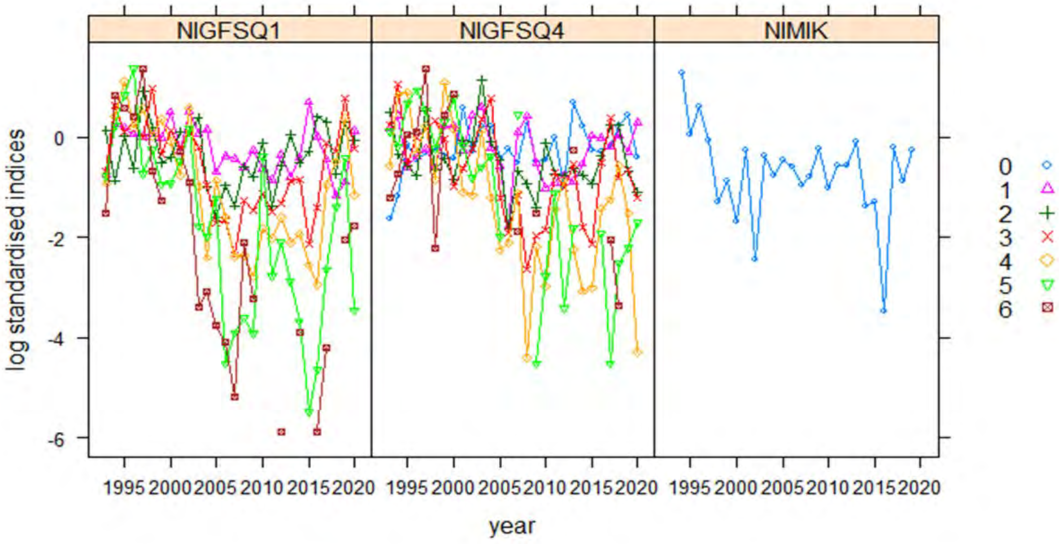


Figure 37.10. Whiting 7.a. Log Standardized indices of tuning fleets by cohort.

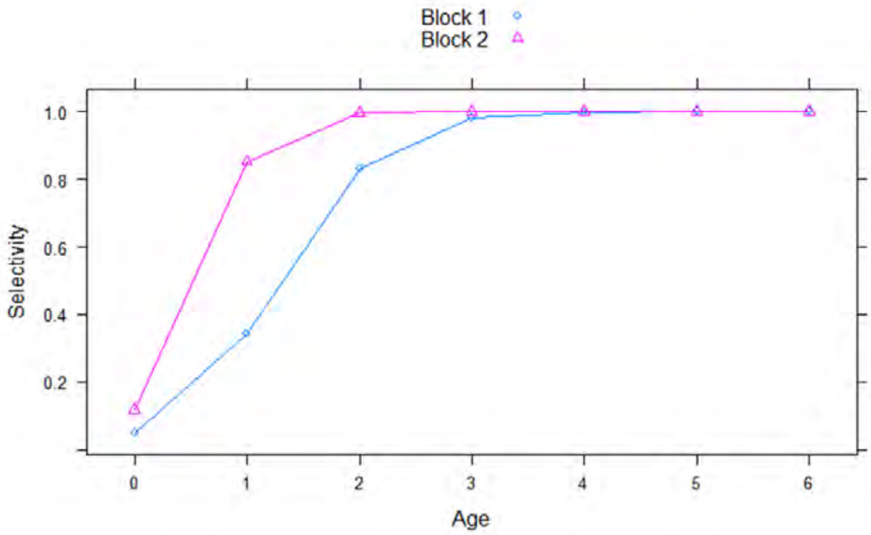


Figure 37.11. Whiting 7.a. Selectivity-at-age in the Catch.

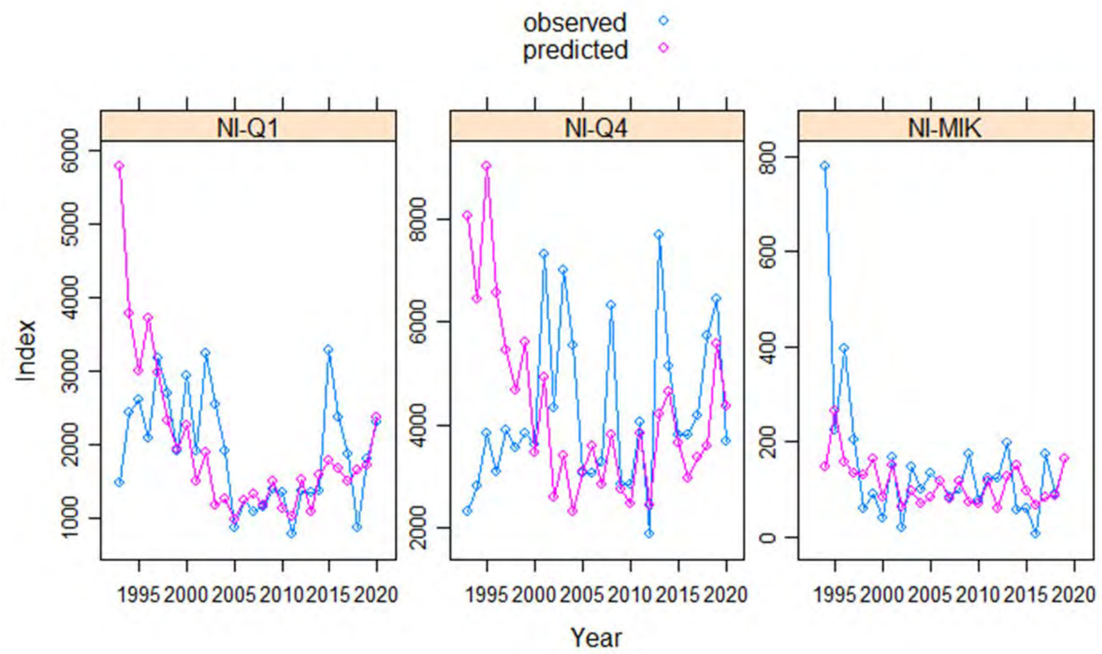


Figure 37.12. Whiting 7.a. Observed and Predicted index cpue.

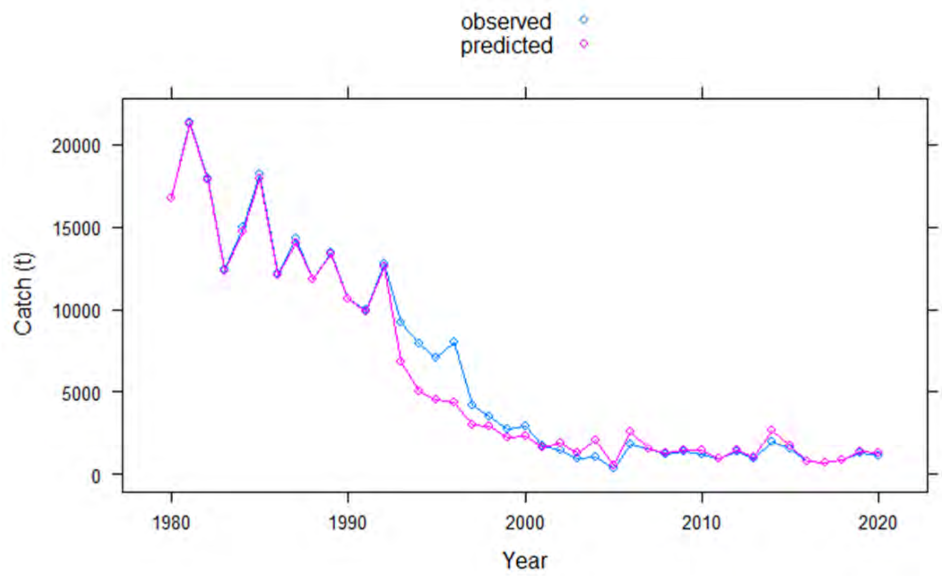


Figure 37.13. Whiting 7.a. Observed and Predicted catch.

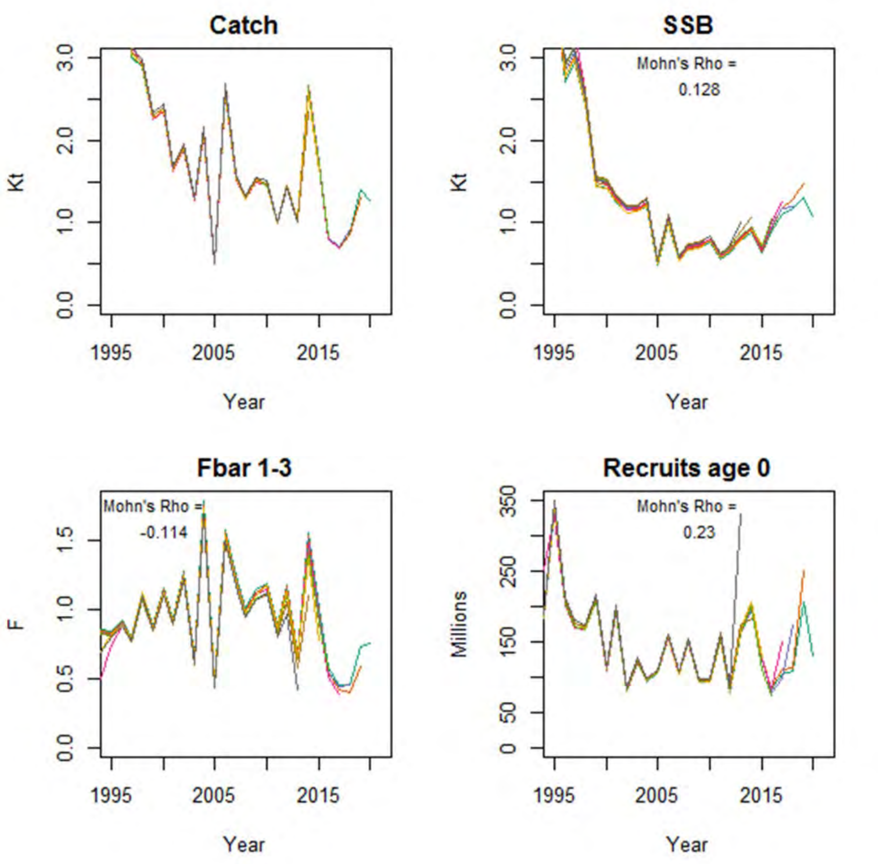


Figure 37.14. Whiting 7.a. Retrospective analysis of the final ASAP run with Mohn's Rho calculation. Image shows >five peels but calculation is based on five peels only.

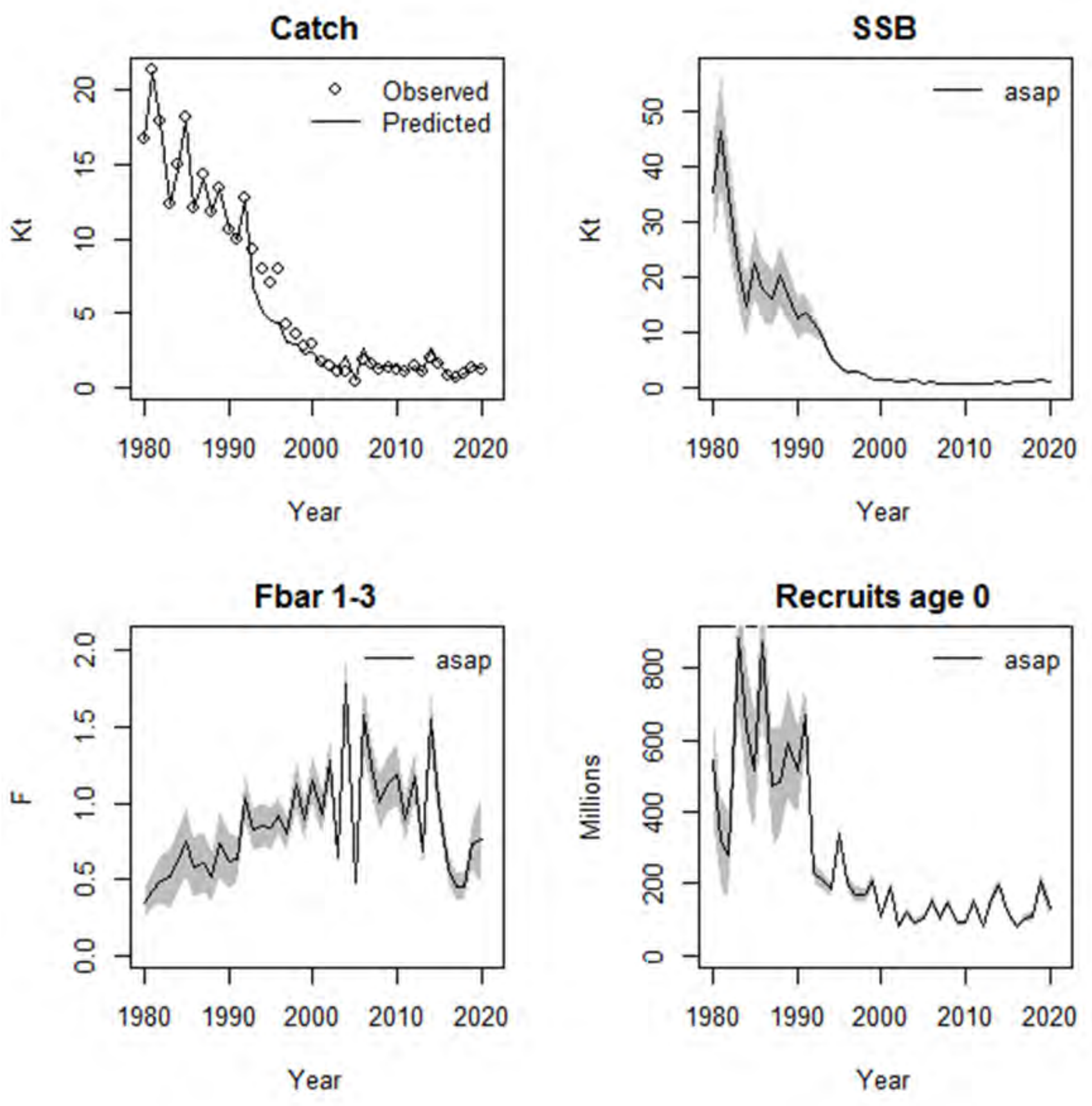


Figure 37.15. Whiting 7.a. Stock Summary Plot. The thick black line represents the ASAP assessment. Standard deviations from ASAP are shaded grey. The thick black line in the catch plot represents the predicted catch from ASAP.

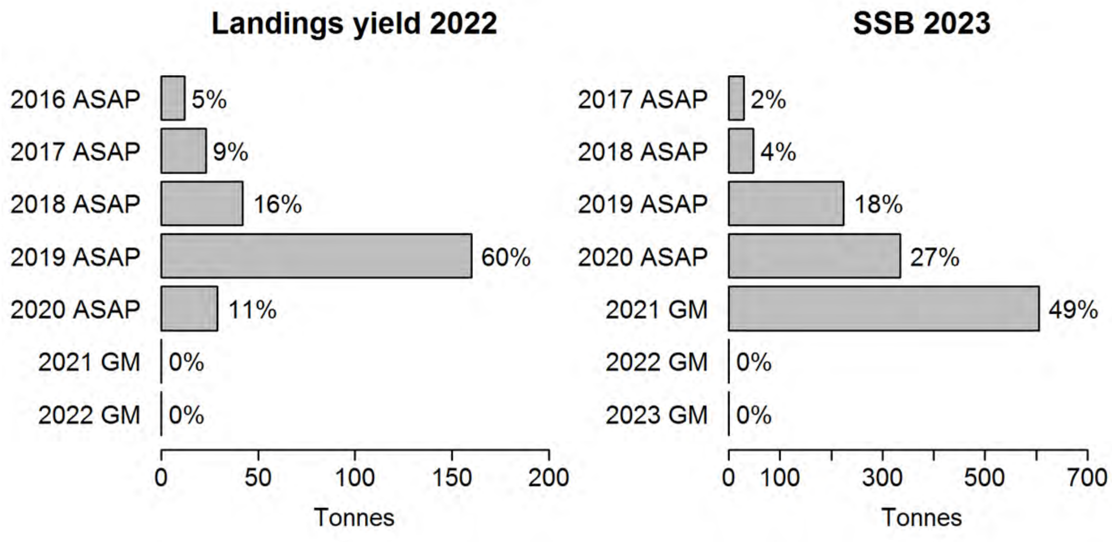


Figure 37.16. Whiting 7.a. Stock numbers of recruits and their source for recent year classes used in predictions, and the relative (%) contributions to landings and SSB (by weight) of these year classes.

39 Whiting (*Merlangius merlangus*) in divisions 7.b–c and 7.e–k (southern Celtic Seas and eastern English Channel)

Type of assessment in 2021

This stock assessment was benchmarked in 2020 (ICES, 2020). The model has been changed to a stochastic State-Space Assessment Model (SAM) and detailed in the Stock Annex. An interbenchmark was also carried out for this stock in 2021 (ICES, 2021). The model input data were updated with additional discard data, re-estimated weights-at-age, and a revision to the allocation of sampling across catch. Reference points were revised accordingly.

ICES advice applicable to 2021

ICES advises that when the EU multiannual plan (MAP) for Western Waters and adjacent waters is applied, catches in 2021 that correspond to the F ranges in the MAP are between 4458 tonnes and 5261 tonnes.

ICES advice applicable to 2020

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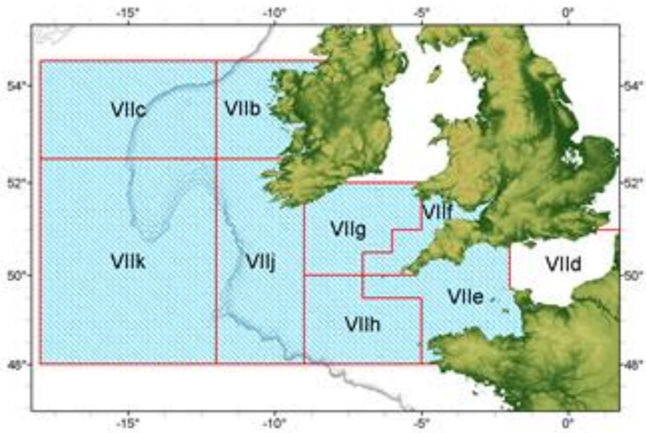
39.1 General

Stock description and management units

The TAC for whiting is set for divisions 7.b, 7.c, 7.d, 7.e, 7.f, 7.g, 7.h, 7.j and 7.k. The assessment area does not correspond to the TAC area. Since the 2014 Benchmark (WKCELT), Whiting in 7.b,c are now assessed as part of 7.bc, e–k, while whiting in 7.d remain part of the WGNSSK assessment of the North Sea stock. Any management measures implemented for this stock should be consistent with the assessment area.



Red Boxes-TAC/Management Areas Blue Shading-Assessment Area.

The TAC for whiting 7.bc, e–k decreased from 19 184t (2019) to 10 259t (2021). ICES official landings for whiting 7.bc, e–k in 2020 are 5 931 t and estimated catch of 7 197 t.

Thus, the current TAC for whiting catches in the 7.b-ce-k stock area is not restrictive in the 7.bc, e–k assessment area.

TAC in 2021/1239

Species:	Whiting *Merlangius merlangus*	Zone:	7b, 7c, 7d, 7e, 7f, 7g, 7h, 7j and 7k (WHG/7X7A-C)
Belgium	74	Analytical TAC	
France	4 663		
Ireland	3 916		
The Netherlands	39		
Union	8 692		
United Kingdom	1 134		
TAC	10 259		

Landings obligation

Since 2017 the landings obligation (LO) has applied to this stock in accordance with Delegated Regulation (EC, 2016) superseded by (EU) 2019/2239[1]. This implies that all catches of whiting in the Celtic Sea and Western Channel by those vessels must be landed. However, a 6% *de minimus* applies to bottom trawls using a mesh size of ≥80mm, as well as pelagic trawls and beam trawls using 80-119mm mesh. There are also 3 specific technical measures in operation for vessels using bottom trawls or seines in the Celtic Sea Protection Zone.

A significant proportion of unwanted catch is above the Minimum Conservation Reference Size (MCRS = 27cm) in whiting, although discards are assessed by ICES to have reduced in 2019 to 14% from 48-17% for 2016 – 2018 respectively. Whiting is also the least limiting stock for most fleets in a mixed fishery context for the Celtic Sea, where cod is most commonly considered the choke species. In this context it is difficult to accurately predict the impact of the LO on Celtic Sea whiting.

39.2 The fishery in 2020

ICES officially reported landings for Divisions 7.b, c, e–k and landings as used by the Working Group are given in Tables

Table 1 1.

Catch for whiting 7.b-ce–k assessment is presented in Table 1, in addition to landings for 7.d as a guide figure for comparison to the 7.b–k TAC (i.e. management area).

The 7.bc, e–k whiting stock is primarily targeted by otter trawlers and to a lesser extent Scottish seines and beam trawls. An overview of landings by fleet is given in Table 2 and more generally effort trends in fleets catching whiting in the Celtic Sea is provided by STECF (STECF, 2018).

The spatial distribution of international otter trawl effort by country 2014–2018 is given in Figure 1. Irish OTB effort is primarily from within 7.g (the Smalls fishing grounds

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019R2239

gadoid fishery) and to a lesser extent 7.j and the Porcupine Bank (Nephrops fishery). In previous years, French landings have exhibited similar spatial and temporal focus around the Smalls.

39.3 Data

Catch

A general data handling approach was agreed during the WKCELTIC 2020 preparatory data workshop and reviewed again during IBPCSWhiting (ICES, 2021) following an error in the data and codesed to allocate sampling to un-sampled catch data. Data is submitted to Intercatch (IC) by France, Ireland, Belgium, UK, Spain and the Netherlands. A standardized approach to international catch data exploration and QC is taken across the cod, haddock and whiting stocks in the form of a shared R markdown document[2]. In so far as is possible, the allocation of sampling to un-sampled métiers is likewise standardized across stocks using the same R markdown template and editing only where necessary.

Fishery dependent data is therefore collated in INTERCATCH, but raised and documented outside of INTERCATCH using these shared open source R Markdown documents.

Raising of un-sampled catches to International CNAA was implemented using a simple hierarchy for available samples where priority was given to the same:

i. Country & Season & Year

ii. Season & Year

iii. Year

With gears set to: GNS_DEF, OTB_CRU, OTB_DEF, TBB_DEF and MIS_MIS.

Discard raising was likewise implemented where samples were missing by estimating ratios at three levels:

i. Year, country and gear

ii. Year and gear

iii. Year

The international catch numbers-at-age are given in Table 3 and Figure 2. It is possible to track the strong 1999 and 2013 year classes, but the strong 2009 recruitment is only apparent at some older ages. Generally, the proportion of un-sampled catch that requires raising is minimal Figure 3. The age distribution has remained similar over time with the exception of periods where strong year classes pass through older ages. Discarding of age 2 and above highlights significant fishing mortality above the minimum conservation reference size (MCRS – 27cm).

While poorly represented in the survey data, the 0-group age class is incorporated into the assessment data to allow inclusion of -group indices, although landings at this age are not recorded in most years. Mean weights-at-age in the catch (Table 5) and stock

[2]https://community.ices.dk/ExpertGroups/benchmarks/2019/wkceltic/2014%20Meeting%20docs/02.%20Background%20documents/WHG/aggregate_IC_data_whg.27.7b-ce-k_Oct_2020.html

(Table 6) were derived as per methodology described in the stock annex. The stock weights are shown in Figure 4. There is some variability of stock weights particularly at older ages, but 0-5 yr old corrected weights are relatively stable.

Discards

The time-series of discard data was revised by WKCELTIC and are included in the assessment. Procedures for raising discards to international catch at age are summarised above and detailed in the stock annex. More accurate national data, and for more member states, are now available through InterCatch. Historically, Irish and French OTB discards were simply raised to international landings to produce an estimate of discards at age.

A summary of discarding rates-at-age for the revised time series 2003-2020, available in InterCatch, is presented in Figure 5. The two main fleets exploiting whiting, FRA_OTB and IRL_OTB, have shown some downward trend in discarding in recent years. The remaining lesser metiers have remained largely constant over time. Numbers and weights by age and country for the most recent data year (2019) are given in Table 7 for both landings and discards.

Figure 6 presents the proportion of landings and discards. The data suggest that the proportion of young being landed, versus discarded, has increased significantly in the last four years suggesting a distinct shift towards landing more fish around the MCRS.

Biological

Mean stock and catch weights-at-age data were calculated following the methodology described in the stock annex. Natural mortality is based on Lorenzen's model and thus a power function of catch weights-at-age.

Mortality Ogive

Age	0	1	2	3	4	5	6	7+
Proportion Mature	1.136	0.805	0.644	0.545	0.499	0.473	0.473	0.460

Maturity was historically knife-edge at age 2, but has been replaced at the Benchmark to a revised maturity ogive based on survey data.

Maturity Ogive

Age	0	1	2	3	4	5	6	7+
Proportion Mature	0	0.61	0.94	0.97	0.97	1	1	1

Surveys

Two IBTS Q4 surveys, FR-EVHOE and IE-IGFS, have been combined to provide the survey index for the assessment of Celtic Sea whiting since the previous benchmark in 2014.

Issues with survey data gaps in particular, highlighted by WGCSE for review by the benchmark, led to significant work being undertaken to implement a modelling approach to survey index calculation. The approach selected was the VAST (Vector Autoregressive Spatio-Temporal) model (www.github.com/james-thorson/VAST).

Internal consistency is >50% for all age classes above 0-group and almost 80% for ages 2:3 (Fig. 7). However, following evaluation with different survey age ranges during assessment model fitting, the survey index was truncated to 0-2 (Table 8).

Log mean standardised indices are given in Figure 8. Plot by cohort the index has got quite noisy in recent years. Plotting by years shows a marked downward trend since 2015 across age classes.

Commercial lpue

An updated French commercial tuning fleet for whiting was made available (Table 9). The Working Document Laviale et al 2019[3] details the issues raised by the old commercial tuning fleet and the work done to provide the updated French commercial tuning index. In summary, the list of species and the threshold used to select trips has been modified to better account for the fact that cod is no longer a target of these fisheries, but more a bytcatch of whiting and haddock directed fisheries. Moreover, the commercial tuning now accounts for both landings and discards.

39.4 Historical stock development

A State-space (SAM) assessment was carried out for this stock applying the settings as agreed at WKCELTIC. Runs are available at Stockassessment.org (https://www.stockassessment.org/setStock.php?stock=whg.7b-ce-k_IBP_final). The full time series was used (1999–2020) with one survey index (VAST) and one commercial index (FRA-OTB-lpue). The settings are detailed within the stock annex.

Data screening

The methodology agreed at WKCELTIC was implemented and documented as an R Markdown document and available on the WKCELTIC[4] sharepoint site. For consistency, routine exploratory analysis was carried out in parallel as in previous years using FLR under R version 4.0.2. The packages FLCore 2.6.15, and FLXSA 2.6.4 and FLEDA 2.5.2 were used.

Final update assessment

The final assessment was run as per https://www.stockassessment.org/setStock.php?stock=whg.7b-ce-k_IBP_final

[3] https://community.ices.dk/ExpertGroups/benchmarks/2019/wkceltic/2014%20Meeting%20docs/04.%20Working%20documents/WD_03_WKCELTIC%20-%20French%20commercial%20tuning%20fleets_Final_2020.pdf

[4] https://community.ices.dk/ExpertGroups/benchmarks/2019/wkceltic/2014%20Meeting%20docs/06.%20Data/WHG/aggregate_IC_data_whg.27.7b-ce-k_Oct_2020.html

Final model inputs and settings were:

• *FULL TIME-SERIES OF CATCH DATA(1999 TO 2019, AGES 0 TO 7+)*
• *Model-filled discards for ages 5 – 7+ in 1999-2002*
• *VAST Model index for ages 0-2 from IGFS:EVHOE 2003 - 2020*
• *French Commercial biomass index in Kg/Hr for 2000 - 2020*
• *Fishing mortality states were bound for ages 6+*
• *Catchability for ages 1+ were bound for the survey index*
• *Default settings for remaining configuration*
• *Observation error on the first age in the survey was estimated separately from the older ages (i.e. ages 1 -2 were bound).*

Fishing mortality at age and stock numbers at age are presented in Table 10 and Table 11 respectively. Summary plots for SSB, Fbar and Recruitment are given in Figure 9. The last small pulse in recruitment in 2013 resulted in a small rise in SSB as harvestable 2yr olds in 2015. With poor recruitment since there has been little to bolster the stock or fishery since 2016.

Model fits to the data are presented in Figure 10. The overall catch fits is reasonably well with IBTS survey tending to observe higher than expected 0 and 1-group fish and less than expected 2 yr olds on recent years. Fit for the commercial biomass index is less precise, but shows similar trend to the IBTS survey 1-2yr old fish and did improve the retrospective patterns so was recommended to be retained in the assessment by WKCELTIC. The same patterns are reflected in the residuals presented in Figure 11 with indices slightly higher than predicted for recent years and catch observations conversely appearing slightly lower.

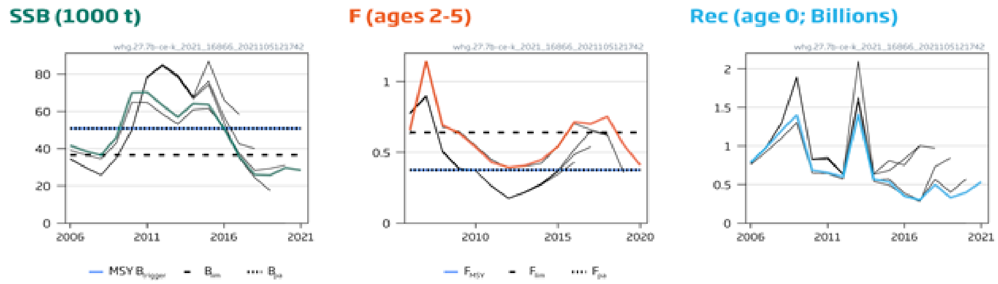
Comparison with previous assessments

Retrospective patterns for the current assessment shows an upward revision in F for the last year as well as a slight upward revision in recruitment. The previous recruitment peels back to 2014 show a general downward revision however. Again, this is likely due to survey observations being generally higher than predicted for recent years.

State of the stock

Trends in landings, F(2–5), SSB, and recruitment are presented in Table 12. For the recent time-series, SSB displays a peak biomass in 2010 following strong recruitment from the 2009 year class. Again in 2014-2015 following the 2013 recruitment. The 2013 cohort, estimated to be the third highest in the time-series, now seems to have passed through the fishery without being evident in 2018 in substantial numbers resulting in both recruitment and SSB being revised down in the assessment and F_{bar} revised upwards.

Fishing mortality (F_{bar}) has increased since 2012, but is now assessed to be just above F_{msy} and F_{lim}. SSB however was estimated at a time series low and below current reference points, but increased slightly since last year.



Whiting in divisions 7.b–c and 7.e–k. Historical assessment results (final-year recruitment assumption = median 2010-2019). Black lines show the results of the previous assessments of the stock. Revised assessment method and inputs following WKCELTIC and IBPCSWhiting result in revisions to SSB, F and reference points.

39.5 Short-term projections

The short-term projections were carried out in SAM (stockassessment.org) and described in the stock annex.

Whiting in the Celtic Sea, as with many gadoid fisheries, is heavily reliant on younger age classes and therefore recruitment. Recruitment is very sporadic and thus the span over which a mean or median recruitment assumption is taken for the intermediate year is important. Historically this was taken as GM for the time series minus the last year. Following discussion at WKCELTIC, and further the ADG, this was revised to median since 2010 which covers the more modern history of the stock. The median resampled recruitment then from 2010-2020 in 000's was estimated as 533,781 and used as 0-group numbers in the forecast for 2021-2022.

Table 13 gives the management option table. Given the status of SSB, the ICES Advice Rule was applied such that Fmsy (0.375) becomes Fmsy*SSB_{2022}/MSY $B_{trigger}$. Fishing at EU Map F_{Total} = 0.209 then in 2022 implies catches of 3 796 t, landings of 2 917 t and discards of 879 t.

The basis for the catch forecast are given in Table 14. Whiting is aligned with the other benchmarked species (cod and haddock) in this mixed fishery. A catch constraint is generated by taking the whiting catch predicted by Mixed Fish (8 678 t) for F at Haddock F_{msy}. The resulting Fmix (0.492) was then used as the F assumption in the intermediate year (2021).

39.6 MSY evaluations and Biological reference points

ICES carried out an evaluation of MSY and PA reference points for this stock at IBPCSWhiting (ICES, 2021). The results are summarised below:

Reference points

Reference Point	IBPCSWhiting 2021 Value	WKCELTIC 2020 Value	Rationale
MSY $B_{trigger}$	50 818 t	47 963 t	B_{pa}
F_{msy}	0.375	0.4	From EqSim with segmented regression and fixed breakpoint (Blim) capped to Fp0.5.
$F_{msyLower}$	0.315	0.332	Median lower point estimates of (F05)
$F_{msyUpper}$	0.375	0.4	Fp.05
B_{lim}	36 571 t	34 516 t	B_{loss}; lowest observed

			SSB (2008) from which stock re-covery was observed.
B_{pa}	50 818 t	47 963 t	B_{lim} combined with the assessment error; $B_{lim} \times \exp(1.645 \times \sigma)$; σ = 0.20 (default setting)
F_{lim}	0.64	0.89	F with 50% probability of SSB less than B_{lim}

39.7 Management plans

39.8 The European Parliament and the Council have published a multiannual management plan (MAP) for the Western Waters (EU, 2019). This plan applies to demersal stocks including whiting in ICES divisions 7.b-ce-k.

39.9 Uncertainties and bias in assessment and forecast

Sampling

Sampling levels of the landed catch for recent years are considered to be sufficient to support current assessment approaches. Revised data for 2002-2020 is now included in the assessment with sampling from more countries which should give greater accuracy. While the overall SOP checks have invariably been ≤3%, any difference in the sampled catch at age going into the assessment vs those coming out will cause concern. Rather than correct the national data provided, a SOP correction is applied as part of the revised raising procedures outlined above and the stock annex.

Ageing

Cohort tracking in the landings-at-age matrix appears fairly consistent up to age 6. Tracking deteriorates at older ages.

Discards

Discarding is a major feature of most fisheries catching whiting in the Celtic Sea. Sampling coverage of discarding has improved over time particularly since 2004. Discard estimates for the UK and Belgium are now included along with those of Ireland and France.

Selectivity

Square-mesh panels were introduced in the second half of 2012 to reduce catches and discards of smaller whiting and haddock. The current assessment does not show an obvious reduction in F-at-age since the introduction of this TCM.

Surveys

The survey indices for whiting are prone to some year effects. However, cohort tracking for the 1+ fish is quite consistent and has improved further using the VAST model. There is a noticeable downward trend since 2016 in the indices plotted by year and higher noise when plotted by cohort (Figure 8).

Misreporting

The level of misreporting of this stock is not known and underreporting has previously been considered unlikely to have been a significant source of unaccounted mortality of whiting in the assessment because the TAC has been in excess of recent landings.

39.10 Recommendation for next benchmark

The survey indices were truncated from 0-5yr olds down to 0-2yr olds as part of model fit optimization. This should be revisited again to ensure the model is not over fitting to the catch data. Commercial tuning was only available from France at the recent benchmark, whose fleet have a somewhat different spatial extent to that of Ireland, the other main country involved in the fishery. Potential to extend the coverage of the commercial tuning index should be examined.

39.11 Management considerations

Catches and SSB in 7.b, c, e–k whiting fluctuate considerably depending on year-class strength. The 2008 and 2009 year classes were above average with 2013 being third highest in the time-series. These contributed to catches and SSB in the short term but the upturn in catches and SSB was short lived as recruitment is episodic and SSB is now below all reference points.

Discarding in this stock for different fleets is substantial and highly variable depending on gear and year-class strength. High levels of discarding for a species like whiting reduce the longer term yields one might expect so efforts to improve selection and reduce discards in the mixed fishery should be encouraged. ICES notes the introduction of square mesh panels in all trawl fisheries operating in ICES divisions 7.fg. It is important that these measures are fully implemented and their effectiveness in reducing discards and the impact on commercial catches is monitored and evaluated. Further gear modifications to increase the likelihood of small whiting passing through the gear, such as introduction of larger minimum mesh sizes, separator panels, or grids may be needed.

Ireland has the only directed fishery for whiting which is part of mixed fishery throughout the Celtic Sea, as well as bycatch within *Nephrops* fisheries. Discard rates are high as a consequence of the low market value of the species, particularly at smaller sizes. High-grading above the MCRS to some extent is also prevalent in most fisheries.

From the 1 February to the 31 March fishing activity has been prohibited within ICES rectangles: 30E4, 31E4, 32E3 (excluding within six nautical miles from the baseline) annually since 2005 to protect the cod stock.

There have been major changes in fleet dynamics over the period of the assessment. Effort in the French gadoid fleet has been declining since 1999, but the effort has fluctuated in recent years due to the way the effort series is derived. Irish otter-trawl effort in 7.b–k has also declined slightly over the time-series.

The full impact of the Landings Obligation is complex and unknown as yet and will depend on whether there is a measurable impact on discarding behaviour or whether variable practices continue and simply data becomes more reliable (for a summary of issues see http://www.discardless.eu/media/results/Celtic_Sea_Year2.pdf).

39.12 References

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Download the stock assessment data and figures.

Recommended citation: ICES. 2021. Whiting (*Merlangius merlangus*) in divisions 7.b-c and 7.e-k (southern Celtic Seas and eastern English Channel). *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, whg.27.7b-ce-k, https://doi.org/10.17895/ices.advice.7888.

39.13 Tables

Table 1. Whiting in Divisions 7.bc,e–k. Nominal Landings (t) as reported to ICES, and total landings as used by the Working Group.

	Official ICES Landings							Used by WG			7.bc,e–k Catch +	
Year	BEL	FRA	IRL	UK_EW	Others	Total	Unallocated	WG Total	Dicards	Catch	7.d Landings	TAC
1998	479	11748	5549	1755	179	19710	-	-	-	-		
1999[a]	448	16418	6013	1354	27	24260	4082	20178	5420	25598	31401	
2000	194	9186	5358	1255	39	16032	387	15645	4400	20045	26117	
2001	171	7317	5365	948	31	13832	640	13192	9877	23070	29684	
2002	149	7548	5718	847	35	14297	657	13640	7336	20977	26338	
2003	129	5989	4516	763	21	11418	321	11097	3559	14656	21661	
2004	180	4874	4350	587	132	10123	-66	10189	6481	16670	21953	
2005	218	5913	5774	482	136	12523	312	12211	6700	18911	23812	
2006	128	4710	4570	413	129	9951	291	9660	12031	21691	25440	
2007	127	3574	4864	576	86	9226	139	9087	8456	17543	20934	19900
2008	121	3072	2406	620	35	6255	395	5860	2880	8740	11933	19900
2009	87	2814	2798	827	25	6551	38	6513	4101	10614	17183	16950
2010	102	3463	4330	798	85	8779	191	8588	3008	11596	17729	14407
2011	100	4312	4752	740	174	10077	593	9484	1954	11438	16902	16658
2012	170	3710	5841	764	141	10627	439	10188	2449	12637	16234	19053
2013	226	4006	6888	907	92	12119	188	11931	2512	14443	18700	24500
2014	222	4928	6874	1062	35	13121	274	12847	3977	16824	19954	19162
2015	152	5634	6437	828	97	13149	-25	13174	6101	19275	19954	17742

	Official ICES Landings							Used by WG			7.bc,e-k Catch +	
Year	BEL	FRA	IRL	UK_EW	Others	Total	Unallocated	WG Total	Dicards	Catch	7.d Landings	TAC
2016	186	6294	7700	892	39	15110	-69	15179	7278	22457	26187	22778
2017	102	5256	6296	607	32	12293	600	11693	4505	17098	17780	27500
2018	103	3666	4628	592	31	9019	246	8773	1495	10268	12625	22213
2019*	73	3203	2599	487	126	6488	946	5542	752	6294	9393	19184
2020	82	2669	2650	336	90	5827	104	5931	1266	7197	1970	10863

*Provisional data.

[a]French Official landings not available, not updated.

Table 2. Whiting in Divisions 7.b-ce-k. Landings (t) by fleet.

LANDINGS	Others	OTB	SSC	TBB	Total	%
BEL	0	9	0	71	80	1%
FRA	67	2630	0	0	2697	45%
IRL	16	1816	813	25	2669	45%
UK	69	216	9	43	337	6%
Others	61	4	82	0	147	2%
Total	214	4675	903	138	5931	100%
	4%	79%	15%	2%	100%	

Table 3. Whiting in Divisions 7.bc,e–k. The strong 1999 year class is distinct in both the catch and landings data, with evidence of the strong 2009 and 2013 year classes appearing at older ages. Catch numbers-at-age ('000).

1999	**2020**						
0	7						
1							
5370.0	20744.1	25957.7	14662.4	8744.8	8987.8	6670.2	1498.7
8176.3	26561.7	26303.7	12529.9	6122.5	2605.9	2100.9	2424.3
8795.0	26105.8	51390.6	13715.2	5317.1	2049.0	763.1	627.3
4568.6	13387.4	34319.6	24356.6	5968.2	1057.6	291.6	111.0
13563.8	20962.0	34625.2	14881.0	15187.9	2698.4	369.8	4.2
35663.6	20301.8	60277.3	30276.2	15671.1	6833.3	541.1	77.0
5540.3	33978.7	44751.0	18055.2	8245.2	6434.5	2651.8	126.4
13472.7	16455.6	8974.9	9465.6	4559.3	2821.7	4419.0	634.9
926.1	10977.9	29863.4	22446.5	6347.2	2601.3	821.3	1016.0
1430.2	10540.5	14640.9	10936.2	3775.9	865.0	220.4	89.7
809.6	6124.2	17584.6	10350.5	3958.6	1266.2	248.0	78.2
495.8	12773.2	15669.6	14991.2	4803.2	1207.5	283.2	104.8
559.8	4153.3	15044.6	12540.0	6502.9	1626.1	375.8	102.2
3798.5	6573.8	9025.6	15864.1	7519.9	2653.6	605.5	134.1
770.0	3346.0	8808.5	7320.9	12392.4	4809.3	1054.1	294.5
133.9	14770.7	6808.8	7768.4	6684.4	7574.4	1746.7	301.5
4647.2	5651.8	32558.2	7710.9	6203.1	2815.4	3111.9	650.8
2074.9	10980.8	13651.0	33791.0	5935.6	3085.0	1079.9	1193.1
933.6	2840.6	12286.9	7615.0	11764.8	2010.4	771.2	282.8
1803.3	2888.6	8804.0	7711.5	3749.0	3979.7	575.2	219.5
93.0	3025.8	4713.2	4371.8	3044.0	1017.7	745.5	75.3
1417.2	3684.5	8679.1	3972.3	1534.9	758.1	219.9	126.2

Table 4. Whiting in Divisions 7.bc,e–k. Catch weights-at-age (Tons).

1999	**2020**						
0	7						
1							
603.1	2588.8	6681.7	4496.2	6085.5	1416.0	250.9	2.5
748.8	3135.3	10982.9	7433.9	4674.5	2629.2	204.7	32.8
229.2	3989.7	8773.7	5791.2	3439.3	2739.9	1143.7	66.1
467.9	2433.0	2529.3	3491.9	2416.2	1601.7	1673.4	392.8
42.6	1403.4	5695.9	6364.0	2407.3	1230.4	374.8	345.0
54.0	1298.9	3080.3	3088.6	1658.0	424.3	159.9	76.6
54.7	844.6	3662.2	3466.6	1780.3	838.7	147.6	60.2
20.4	1932.4	3935.0	5696.2	2404.7	684.4	183.8	59.5
17.7	716.1	3557.8	4520.9	3559.4	1104.6	263.8	94.0
217.0	677.7	2014.9	6407.2	4094.8	1945.2	462.3	130.5
35.2	493.6	1860.8	2657.4	6926.6	3052.4	905.4	225.0
6.5	2046.5	1742.6	3076.4	3667.0	5455.4	1365.1	295.4
258.3	682.6	7744.0	2961.8	3345.0	2059.2	2125.4	461.4
89.3	1355.3	2896.0	12098.1	3279.0	2093.7	777.7	871.1
39.6	409.9	2885.4	3015.1	6421.4	1450.4	689.8	256.3
98.4	364.0	1742.9	2878.6	2260.6	3064.2	516.5	221.3
5.8	496.3	1608.6	2056.9	1890.0	794.9	625.9	80.2
27.4	609.7	2686.0	2080.6	964.8	536.8	174.2	117.3

Table 5. Whiting in Divisions 7.bc,e–k. Mean catch weights-at-age (kg).

	Age							
		1	2	3	4	5	6	7+
1999	0.0271	0.1331	0.2216	0.3412	0.4274	0.4402	0.4963	0.623
2000	0.0314	0.069	0.2204	0.3955	0.5053	0.563	0.5804	0.5868
2001	0.0315	0.1116	0.1853	0.3778	0.5293	0.6335	0.76	0.7775
2002	0.0272	0.0965	0.1966	0.3506	0.5315	0.7069	0.8249	1.0133
2003	0.0445	0.1235	0.1930	0.3021	0.4007	0.5248	0.6786	0.6038
2004	0.0210	0.1544	0.1822	0.2455	0.2983	0.3848	0.3783	0.4263
2005	0.0414	0.1174	0.1961	0.3207	0.4171	0.4258	0.4313	0.5232
2006	0.0347	0.1479	0.2818	0.3689	0.5300	0.5676	0.3787	0.6186
2007	0.0460	0.1278	0.1907	0.2835	0.3793	0.4730	0.4563	0.3395
2008	0.0377	0.1232	0.2104	0.2824	0.4391	0.4905	0.7256	0.8543
2009	0.0675	0.1379	0.2083	0.3349	0.4497	0.6624	0.5952	0.7689
2010	0.0411	0.1513	0.2511	0.3800	0.5007	0.5668	0.6489	0.5674
2011	0.0316	0.1724	0.2365	0.3605	0.5474	0.6793	0.7019	0.9197
2012	0.0571	0.1031	0.2232	0.4039	0.5445	0.7331	0.7635	0.9731
2013	0.0457	0.1475	0.2113	0.3630	0.5589	0.6347	0.8589	0.7641
2014	0.0484	0.1386	0.2559	0.3960	0.5486	0.7202	0.7815	0.9798
2015	0.0556	0.1208	0.2379	0.3841	0.5392	0.7314	0.6830	0.7089
2016	0.0431	0.1234	0.2121	0.3580	0.5524	0.6787	0.7201	0.7301
2017	0.0424	0.1443	0.2348	0.3959	0.5458	0.7214	0.8945	0.9065
2018	0.0546	0.1260	0.1980	0.3733	0.6030	0.7700	0.8980	1.0080
2019	0.0625	0.1640	0.3413	0.4705	0.6209	0.7811	0.8396	1.0646
2020	0.0193	0.1655	0.3095	0.5238	0.6286	0.7081	0.7922	0.9297

Table 6. Whiting in Divisions 7.bc,e–k. Q1 Stock weights-at-age (kg) from Rivard corrected annual mean catch weights.

	Age							
	0	1	2	3	4	5	6	7+
1999	0.017	0.043	0.171	0.296	0.415	0.491	0.505	0.540
2000	0.017	0.043	0.171	0.296	0.415	0.491	0.505	0.540
2001	0.018	0.059	0.113	0.289	0.458	0.566	0.654	0.672
2002	0.013	0.055	0.148	0.255	0.448	0.612	0.723	0.878
2003	0.024	0.058	0.136	0.244	0.375	0.528	0.693	0.706
2004	0.009	0.083	0.150	0.218	0.300	0.393	0.446	0.538
2005	0.022	0.050	0.174	0.242	0.320	0.356	0.407	0.445
2006	0.018	0.078	0.182	0.269	0.412	0.487	0.402	0.517
2007	0.028	0.067	0.168	0.283	0.374	0.501	0.509	0.359
2008	0.020	0.075	0.164	0.232	0.353	0.431	0.586	0.624
2009	0.045	0.072	0.160	0.265	0.356	0.539	0.540	0.747
2010	0.020	0.101	0.186	0.281	0.409	0.505	0.656	0.581
2011	0.018	0.084	0.189	0.301	0.456	0.583	0.631	0.773
2012	0.036	0.057	0.196	0.309	0.443	0.633	0.720	0.826
2013	0.026	0.092	0.148	0.285	0.475	0.588	0.793	0.764
2014	0.031	0.080	0.194	0.289	0.446	0.634	0.704	0.917
2015	0.037	0.076	0.182	0.314	0.462	0.633	0.701	0.744
2016	0.024	0.083	0.160	0.292	0.461	0.605	0.726	0.706
2017	0.025	0.079	0.170	0.290	0.442	0.631	0.779	0.808
2018	0.031	0.073	0.169	0.296	0.489	0.648	0.805	0.950
2019	0.047	0.095	0.207	0.305	0.481	0.686	0.804	0.978
2020	0.035	0.082	0.182	0.297	0.471	0.655	0.796	0.912

Table 7. Whiting in Divisions 7.e–k. Summary of landings and discard data for 2020 provided to the Working Group.

weight in tonnes

DISCARDS	COUNTRY	0	1	2	3	4	5	6	7+	GRAND TOTAL
	Belgium	2.2	18.6	54.3	13.2	5.2	3.9	0.0	1.1	98.6
	France	18.1	150.6	421.6	89.3	37.1	24.1	0.2	9.6	750.7
	Ireland	4.2	26.7	73.9	21.0	8.3	7.1	0.0	2.5	143.6
	UK (England)	2.7	44.7	146.5	39.6	18.0	10.2	0.8	1.8	264.3
	Other	0.2	1.6	4.7	1.4	0.6	0.4	0.0	0.1	9.0
	Total	27.4	242.2	701.1	164.4	69.3	45.7	1.1	15.2	1266.3
Landings	Belgium	0.0	3.5	22.8	26.9	14.6	7.8	2.9	1.7	80.2
	France	0.0	327.2	943.0	702.5	400.7	214.0	55.4	54.0	2696.8
	Ireland	0.0	17.4	841.8	1061.3	388.2	228.1	92.5	40.0	2669.3
	UK (England)	0.0	12.1	122.3	81.3	68.4	29.9	18.7	4.3	337.0
	Other	0.0	7.4	55.1	44.1	23.8	11.4	3.6	2.1	147.5
	Total	0.0	367.5	1984.9	1916.2	895.6	491.2	173.1	102.1	5930.7

Number in 000's

	Country		1	2	3	4	5	6	7	Grand Total
Discards										
	Belgium	117.2	164.2	267.2	43.2	13.1	7.9	0.1	1.0	613.9
	France	910.0	1208.5	2012.6	294.5	92.6	48.8	0.4	8.2	4575.6
	Ireland	232.1	234.5	374.4	69.0	19.7	14.3	0.0	2.1	946.0
	UK (England)	147.5	414.0	722.2	126.4	46.6	21.6	1.6	2.0	1481.9
	Other	10.4	12.5	23.7	4.5	1.4	0.9	0.0	0.1	53.5
	Total	1417.2	2033.7	3400.1	537.6	173.4	93.5	2.0	13.3	7670.9
Landings	Belgium	0.0	14.8	59.0	47.2	22.1	10.7	3.6	1.9	159.4
	France	0.0	1505.0	2758.3	1320.1	606.9	317.0	72.1	62.9	6642.4
	Ireland	0.0	54.5	1956.9	1819.9	565.9	276.3	118.1	40.0	4831.6
	UK (England)	0.0	49.7	373.7	173.1	133.5	45.3	19.5	5.9	800.7
	Other	0.0	26.8	131.2	74.4	33.1	15.3	4.4	2.2	287.4
	Total	0.0	1650.9	5279.0	3434.7	1361.5	664.7	217.8	112.9	12721.5

Table 8. Whiting in Divisions 7.bc,e–k. Combined (IE-IGFS and FR_EVHOE) VAST recruitment survey index for age groups 0–2 (No/Km2).

	IGFSEVHOE No/Hr		
	Age		
		1	2
2003	42307.947	43020.539	13672.634
2004	129487.849	27328.251	7956.554
2005	34730.202	27185.788	4968.426
2006	65812.789	21399.208	8684.774
2007	198014.624	28506.939	4919.955
2008	150834.78	36355.503	9535.894
2009	212244.604	61389.178	10509.453
2010	19603.566	39465.78	20879.734
2011	58396.948	20359.451	31230.235
2012	34854.236	17652.443	10770.617
2013	193550.625	15796.262	9111.008
2014	29960.342	42339.107	7597.574
2015	68143.732	15928.967	22275.026
2016	63432.966	22427.637	13057.676
2017	66121.887	9936.248	4570.093
2018	88860.398	5906.709	2927.374
2019	45436.073	20989.575	3255.209
2020	38249.572	8243.484	5009.421

Table 9. Whiting in Divisions 7.bc,e–k. FRA-OTB commercial biomass index (Kg/Hr).

	KG/HR
2000	38.10363867
2001	20.72032437
2002	19.72791635
2003	15.04609422
2004	15.08119522
2005	24.65779777
2006	24.11897529
2007	14.66450994
2008	11.05968544
2009	11.14466828
2010	14.68285952
2011	13.01333083
2012	10.45746782
2013	13.16969924
2014	19.60473794

2015	20.3091624
2016	25.69082281
2017	25.06670645
2018	22.20498986
2019	22.43714973
2020	18.57563875

Table 10. Whiting in Divisions 7.b, c, e–k. Fishing mortality (F)-at-age. F_{bar} range is 2–5.

	0	1	2	3	4	5	6	7+
1999	0.008	0.092	0.429	0.665	0.942	1.18	1.527	1.527
2000	0.008	0.087	0.388	0.638	0.978	1.239	1.738	1.738
2001	0.008	0.083	0.347	0.577	1.061	1.588	2.414	2.414
2002	0.008	0.071	0.269	0.385	0.701	1.111	2.008	2.008
2003	0.01	0.089	0.321	0.361	0.583	0.981	1.571	1.571
2004	0.015	0.16	0.631	0.692	0.665	0.835	1.267	1.267
2005	0.013	0.155	0.621	0.8	0.789	0.826	1.28	1.28
2006	0.006	0.074	0.275	0.548	0.748	1.056	1.599	1.599
2007	0.007	0.097	0.48	1.016	1.343	1.731	2.076	2.076
2008	0.004	0.056	0.279	0.632	0.836	1.019	1.206	1.206
2009	0.003	0.044	0.223	0.537	0.788	0.993	1.143	1.143
2010	0.002	0.037	0.176	0.445	0.68	0.845	0.987	0.987
2011	0.002	0.031	0.135	0.321	0.542	0.715	0.863	0.863
2012	0.002	0.035	0.147	0.29	0.473	0.667	0.808	0.808
2013	0.002	0.034	0.15	0.291	0.487	0.699	0.84	0.84
2014	0.002	0.036	0.159	0.319	0.557	0.752	0.91	0.91
2015	0.004	0.054	0.235	0.418	0.648	0.865	1.087	1.087
2016	0.005	0.073	0.332	0.612	0.841	1.07	1.3	1.3
2017	0.004	0.069	0.329	0.596	0.838	1.042	1.254	1.254
2018	0.004	0.067	0.339	0.635	0.903	1.135	1.315	1.315
2019	0.003	0.046	0.233	0.481	0.674	0.821	0.911	0.911
2020	0.003	0.046	0.217	0.405	0.476	0.536	0.593	0.593

Table 11. Whiting in Divisions 7.b, c, e–k. Stock number-at-age ('000).

	0	1	2	3	4	5	6	7+
1999	2164746	289817	93072	36981	17610	14742	10091	2525
2000	1854498	637752	111716	31443	11529	4480	3029	1889
2001	1406546	544410	248678	39512	9962	2812	876	597
2002	1270409	409918	212718	92816	13464	2224	382	91
2003	969463	373748	161253	86004	38677	4325	496	43
2004	843915	283519	144608	61122	38121	14114	1065	77
2005	746124	242362	102393	40087	18235	13361	4120	220
2006	788980	218161	85922	28654	10890	5299	4099	827
2007	977045	229318	85807	35005	10030	3354	1219	685
2008	1201563	286857	86489	27670	7742	1699	396	165
2009	1400384	354142	113897	33683	8869	2194	413	115
2010	685700	419546	141293	47407	11886	2616	543	116
2011	653475	202424	175058	60766	18212	3906	754	169

2012	600632	193189	83461	81092	26475	6798	1282	267
2013	1414790	173367	79541	37428	37628	10733	2321	474
2014	567204	431191	69973	35772	16946	15353	3561	827
2015	533781	166927	182259	31126	15793	6246	4905	1212
2016	348159	156573	67065	76435	12541	5390	1758	1418
2017	299364	100838	60350	24525	25058	3551	1239	596
2018	497185	86241	39344	22455	8109	7018	844	360
2019	328106	147579	33962	14518	7200	2127	1506	222
2020	395701	96135	59285	14139	5396	2369	623	476

Table 12. Whiting in Divisions 7.b, c, e–k. Summary table.

Year	Recruitment age 0			SSB			Land-ings	Dis-cards	F ages 2–5		
	Value	Low	High	Value	Low	High			Value	Low	High
1999	2164746	1630362	2874285	61155	54562	68545	20180	5420	0.804	0.69	0.937
2000	1854498	1302778	2639869	53303	47616	59669	15644	4400	0.811	0.698	0.941
2001	1406546	1100727	1797332	64208	54794	75239	13196	9877	0.893	0.77	1.036
2002	1270409	996812	1619099	73921	63504	86047	13640	7336	0.616	0.515	0.737
2003	969463	754657	1245413	70959	62752	80239	11788	10337	0.562	0.466	0.677
2004	843915	665849	1069600	64785	57046	73574	10321	19522	0.706	0.602	0.828
2005	746124	594158	936959	45709	40839	51161	12575	13598	0.759	0.655	0.879
2006	788980	608365	1023217	41667	37324	46515	9908	5098	0.657	0.549	0.787
2007	977045	773793	1233686	38626	34034	43838	9424	8439	1.143	0.982	1.329
2008	1201563	950051	1519659	36493	32390	41117	6080	3760	0.692	0.58	0.824
2009	1400384	975170	2011010	45959	40621	51999	6574	4281	0.635	0.524	0.769
2010	685700	547050	859492	69991	61094	80182	9570	5346	0.536	0.432	0.666
2011	653475	519382	822188	70233	61565	80121	10084	3750	0.428	0.338	0.542
2012	600632	468107	770676	63302	55938	71636	10834	5116	0.394	0.312	0.498
2013	1414790	927480	2158141	56931	50490	64194	12131	4026	0.407	0.328	0.505
2014	567204	443861	724824	64149	55692	73892	12983	4672	0.447	0.367	0.544
2015	533781	401170	710229	63702	55396	73253	13110	6528	0.541	0.446	0.656
2016	348159	245858	493028	50810	43212	59744	15201	8259	0.714	0.584	0.873
2017	299364	206517	433954	35894	29262	44029	12377	2791	0.701	0.514	0.957
2018	497185	346494	713413	25981	19060	35415	9007	2139	0.753	0.441	1.284
2019	328106	206650	520948	25705	17431	37904	6588	970	0.552	0.238	1.279
2020	395701	191470	817776	29668	19636	44824	5931	1266	0.409	0.158	1.06
2021	533781*	299364	1414790	28381	17873	48042					

* Median resampled (2010–2020).

Table 13. Whiting in Divisions 7.b, c, e–k. Management options table.

Basis	Total catch (2022)	Projected landings (2022)	Projected discards (2022)	F_{total} (2022)	$F_{projected\ landings}$ (2022)	$F_{projected\ discards}$ (2022)	SSB (2023)	% SSB change*	% advice change **	% Probability of falling below B_{lim} in 2023
ICES advice basis										
MSY approach: $F_{MSY} \times SSB_{2022}$/MSY $B_{trigger}$	4452	3539	913	0.228	0.189	0.039	37372	21	−15.4	47
Other scenarios										
EU MAP^^: $F_{MSY} \times SSB_{2022}$/MSY $B_{trigger}$	4452	3539	913	0.228	0.189	0.039	37372	21	−15.4	47
EU MAP^^: $F_{MSY\ lower} \times SSB_{2022}$/MSY $B_{trigger}$	3801	3028	773	0.191	0.158	0.033	37930	23	−28	44
F = 0	0	0	0	0.000	0.000	0.000	41192	33	−100	29
$F = F_{MSY} = F_{pa}$	6883	5440	1443	0.375	0.310	0.065	35338	15	31	55
$SSB_{2023} = B_{lim}$	5414	4296	1118	0.284	0.235	0.049	36571	19	3	50
$SSB_{2023} = B_{pa} = B_{trigger}$ ^										
$F = F_{2021}$	7803	6060	1743	0.492	0.407	0.085	33115	7	48	63
$SSB_{2023} = SSB_{2022}$	11274	8706	2568	0.756	0.625	0.131	30856	0	114	70

Input units are thousands and kg, outputs in tonnes.

Table 14. Whiting in divisions 7.b, c, e–k. Basis for the catch forecast scenarios.

Variable	Value	Notes
$F_{ages\ 2–5}$ (2021)	0.492	F based on catch of 8678 tonnes for 2021
SSB (2022)	30856	Short-term forecast fishing at F = 0.492; in tonnes
Recruitment age 0 (2021–2022)	533781	Median resampled (2010–2020); in thousands
Catch (2021)	8678	Catch based on mixed fisheries considerations (ICES, 2020a) when haddock is fished in 2021 at F = 0.353; in tonnes
Projected landings (2021)	7036	Short-term forecast assuming average 2018–2020 landings pattern; in tonnes
Projected discards (2021)	1642	Short-term forecast assuming average 2018–2020 discard pattern; in tonne.

Input units are thousands and kg output in tonnes.

39.14 Figures

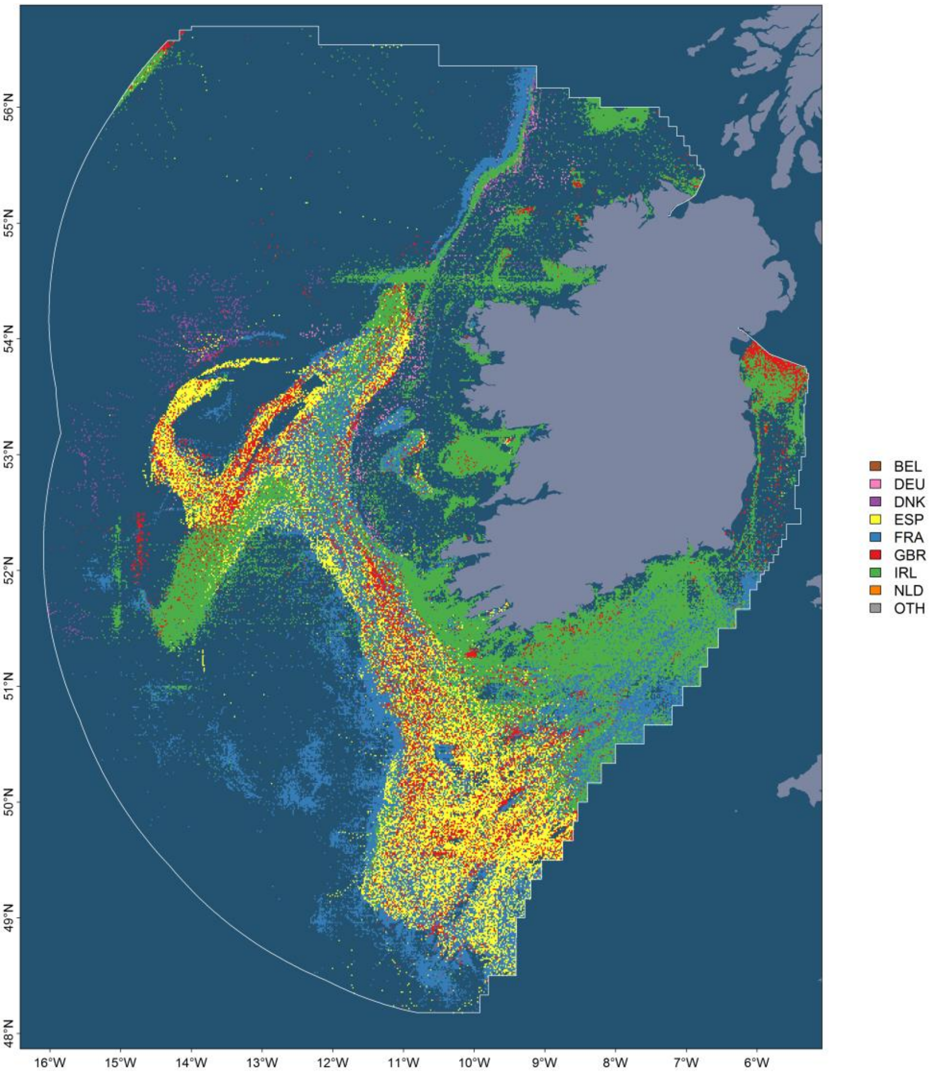


Figure 1. Distribution of international OTB effort within the Irish EEZ 2014 - 2018.

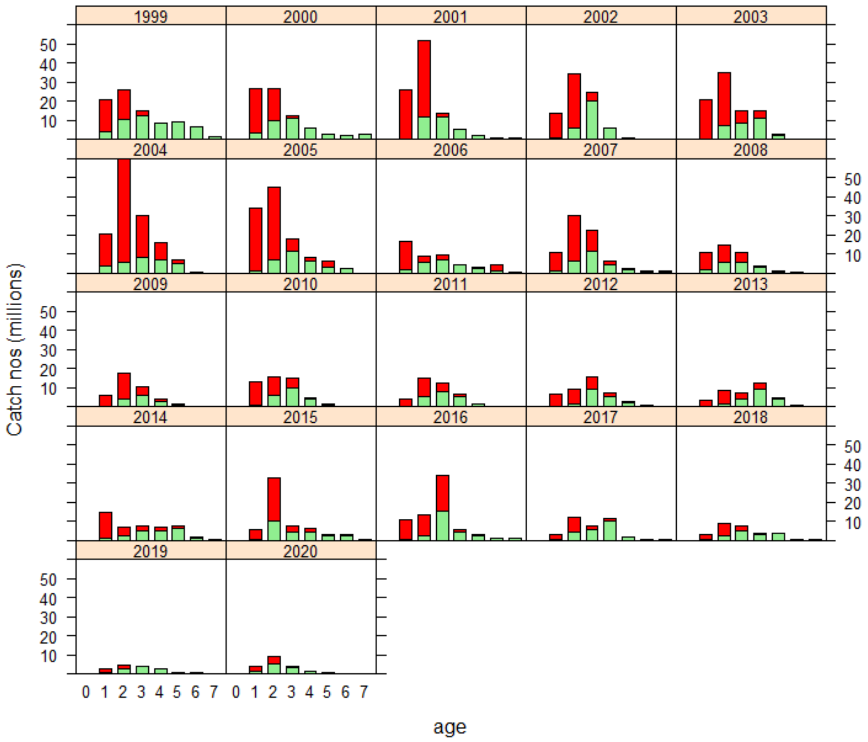


Figure 2. Whiting in 7.b-ce–k (Celtic Sea), annual Landings (Green) and Discards (red) at age.

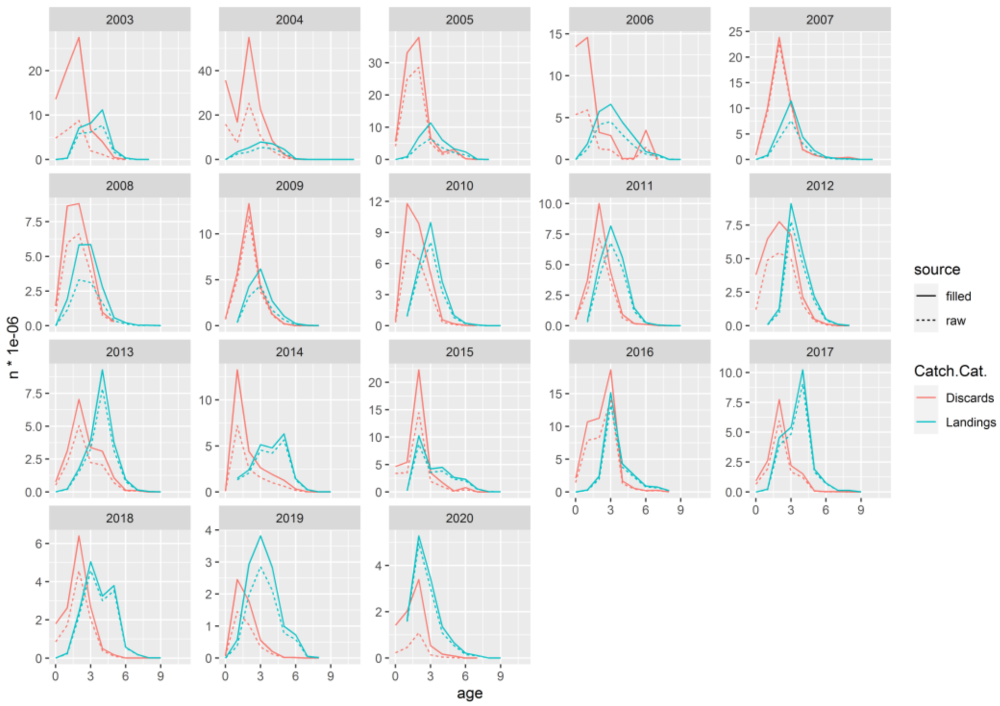


Figure 3. Whiting in 7.b-ce–k (Celtic Sea), annual Landings (Blue) and Discards (red) at age. Dashed lines give revised data uploaded to Intercatch. Solid lines show the final raised International Catch Numbers as Age used in the assessment.

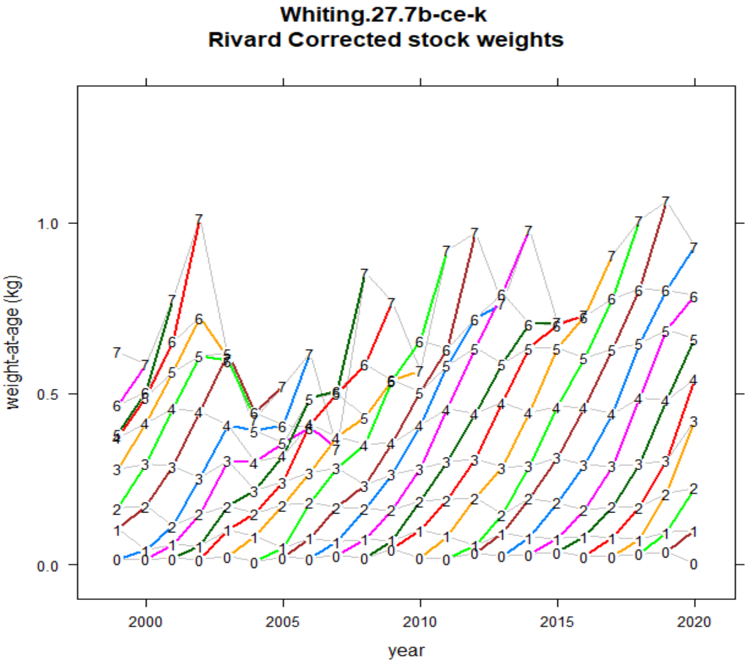


Figure 4. Whiting in 7.b, c, e–k (Celtic Sea). Rivard corrected stock weights-at-age.

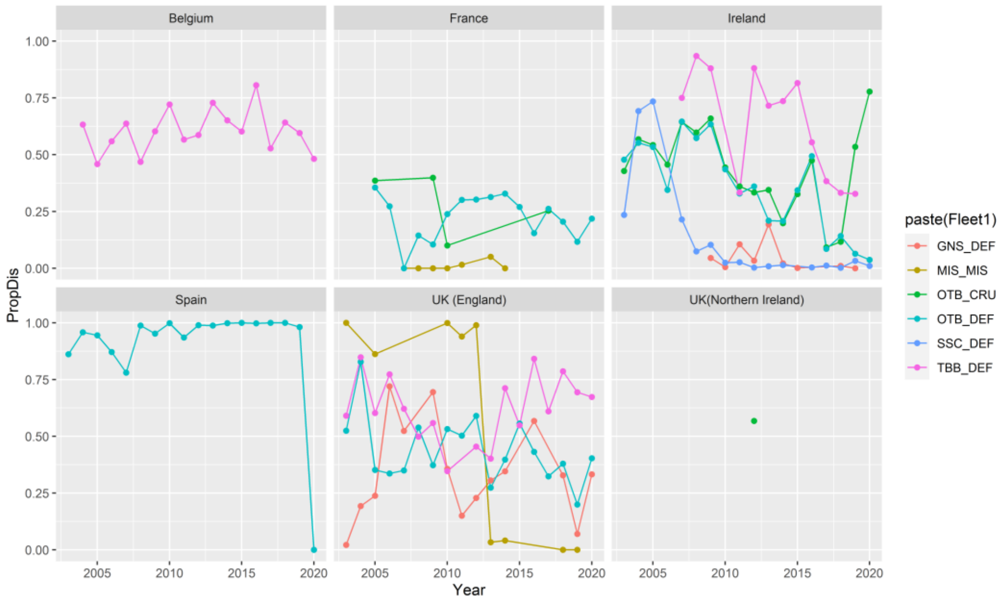


Figure 5. Annual proportions of Discarding (by weight) for the Celtic Sea whiting revised time series (2003-2020).

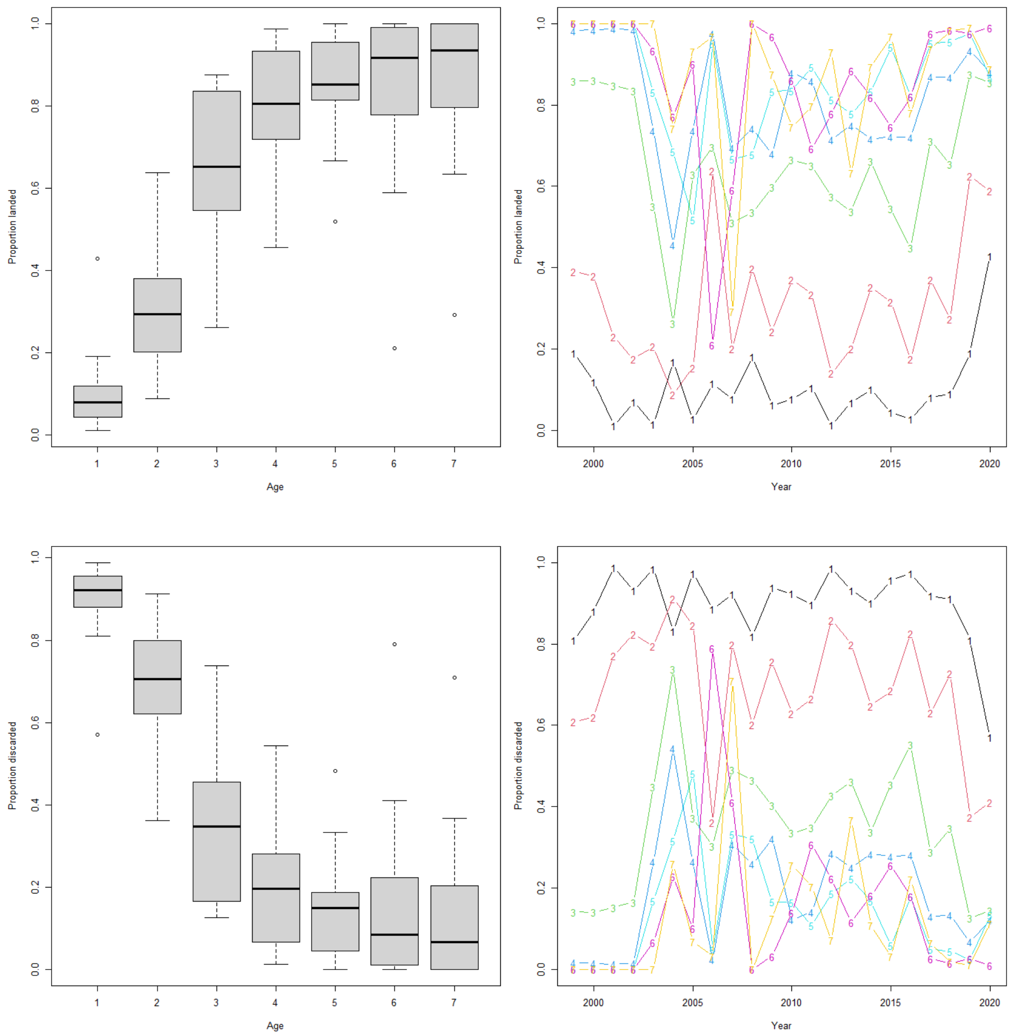


Figure 6. Proportion of landings (upper panels) and discards (lower panels) for Celtic Sea whiting (2003-2020).

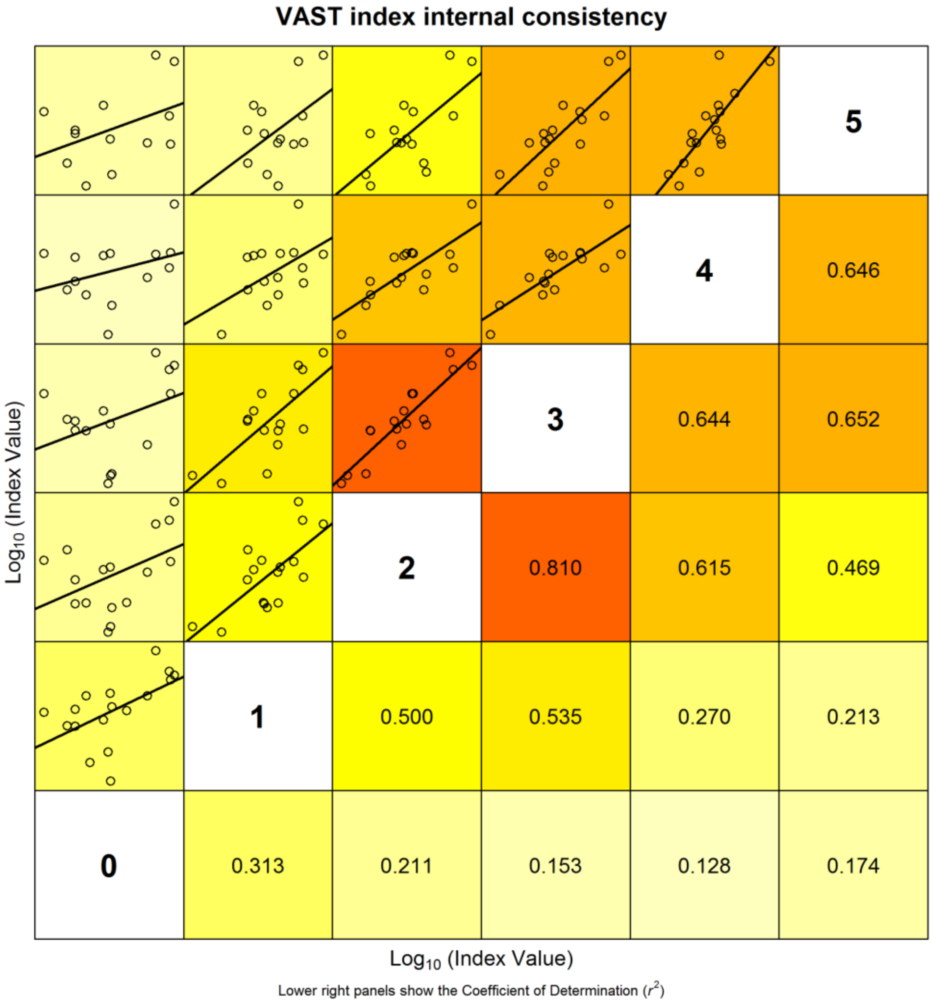
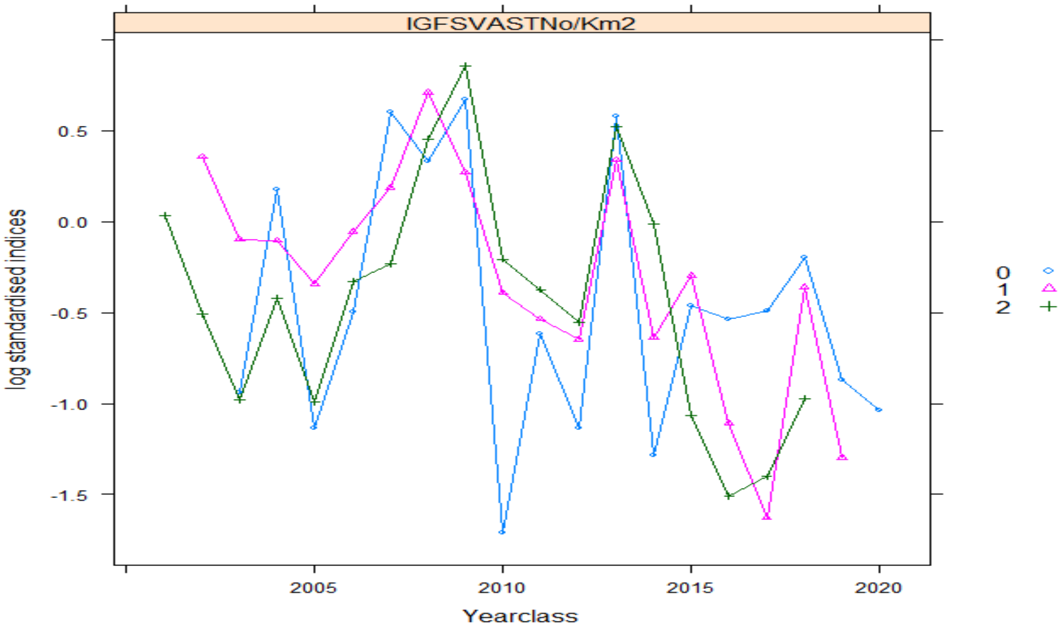


Figure 7. Whiting in 7.b, c, e–k (Celtic Sea). Pairwise scatterplots for the log numbers-at-age for the VAST combined survey index.



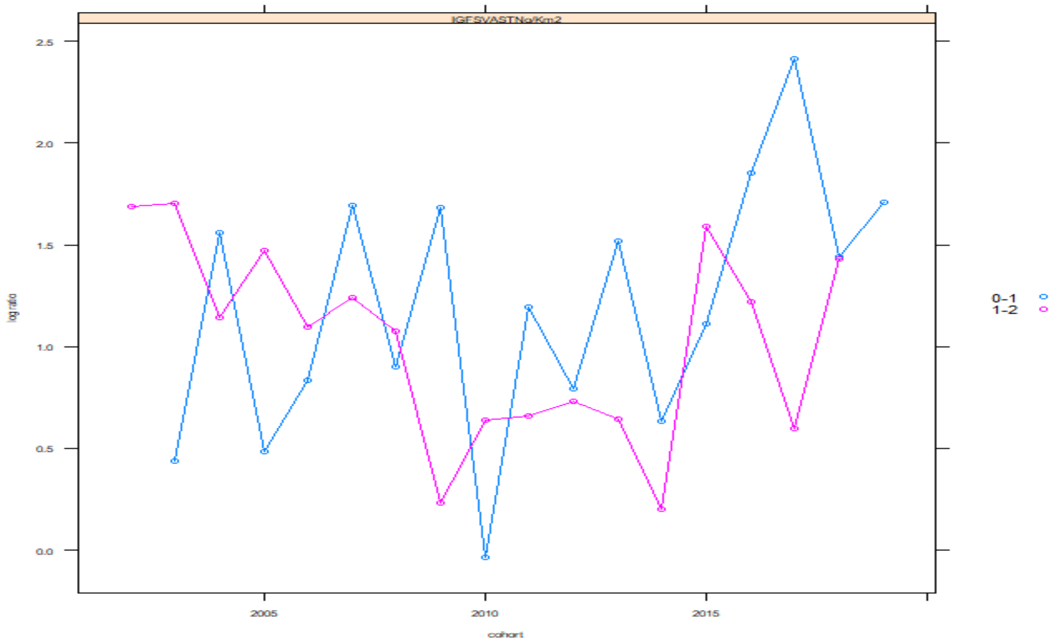


Figure 8. Whiting in 7.e–k (Celtic Sea). Mean log standardized plots of combined IE-IGFS & FR-EVHOE indices by year class (top panel) and by year (lower panel). Only age 0-2 is included in the assessment.

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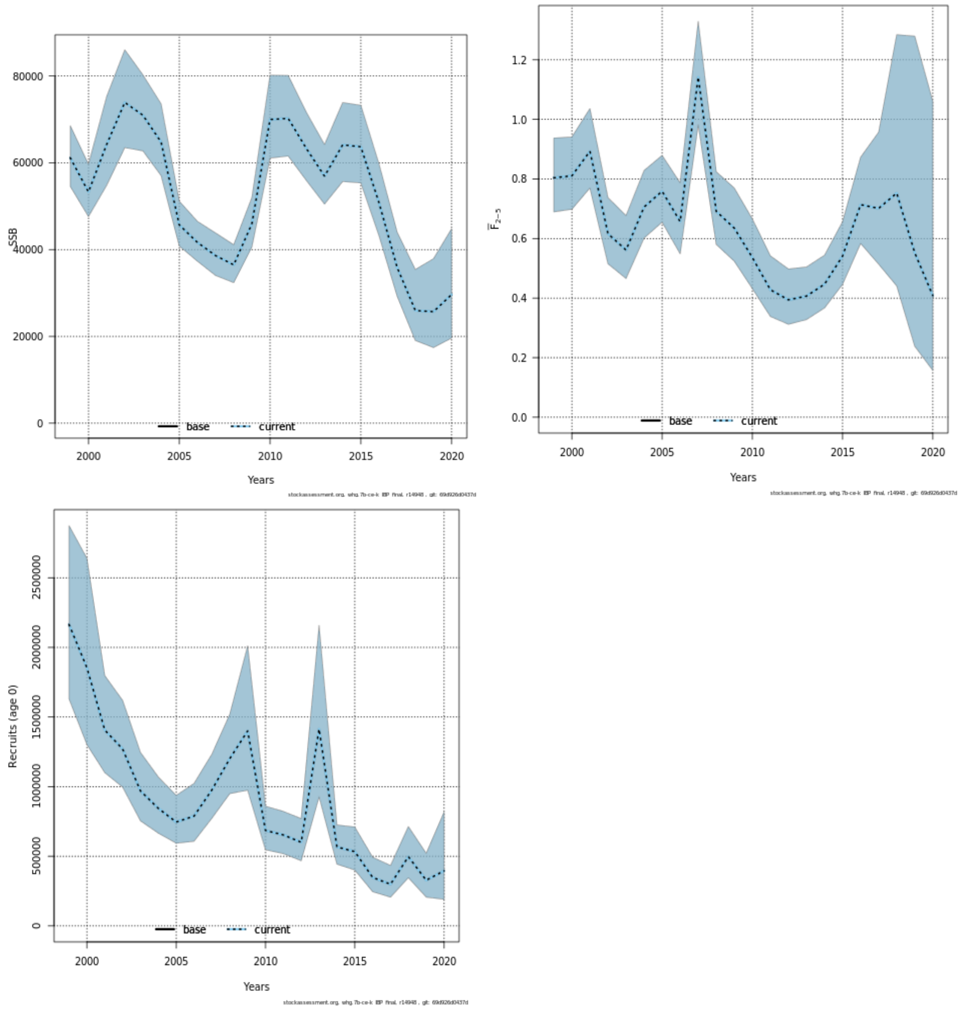


Figure 9. Whiting in 7.b, c, e–k (Celtic Sea). SAM assessment summary plots of SSB (top left), Fbar2-5 (top right) and recruitment (bottom left) at Age 0. An overall downward trend in biomass and recruitment since the last small pulse in 2013 is evident and followed by a significant drop in fishing effort as that biomass was removed.

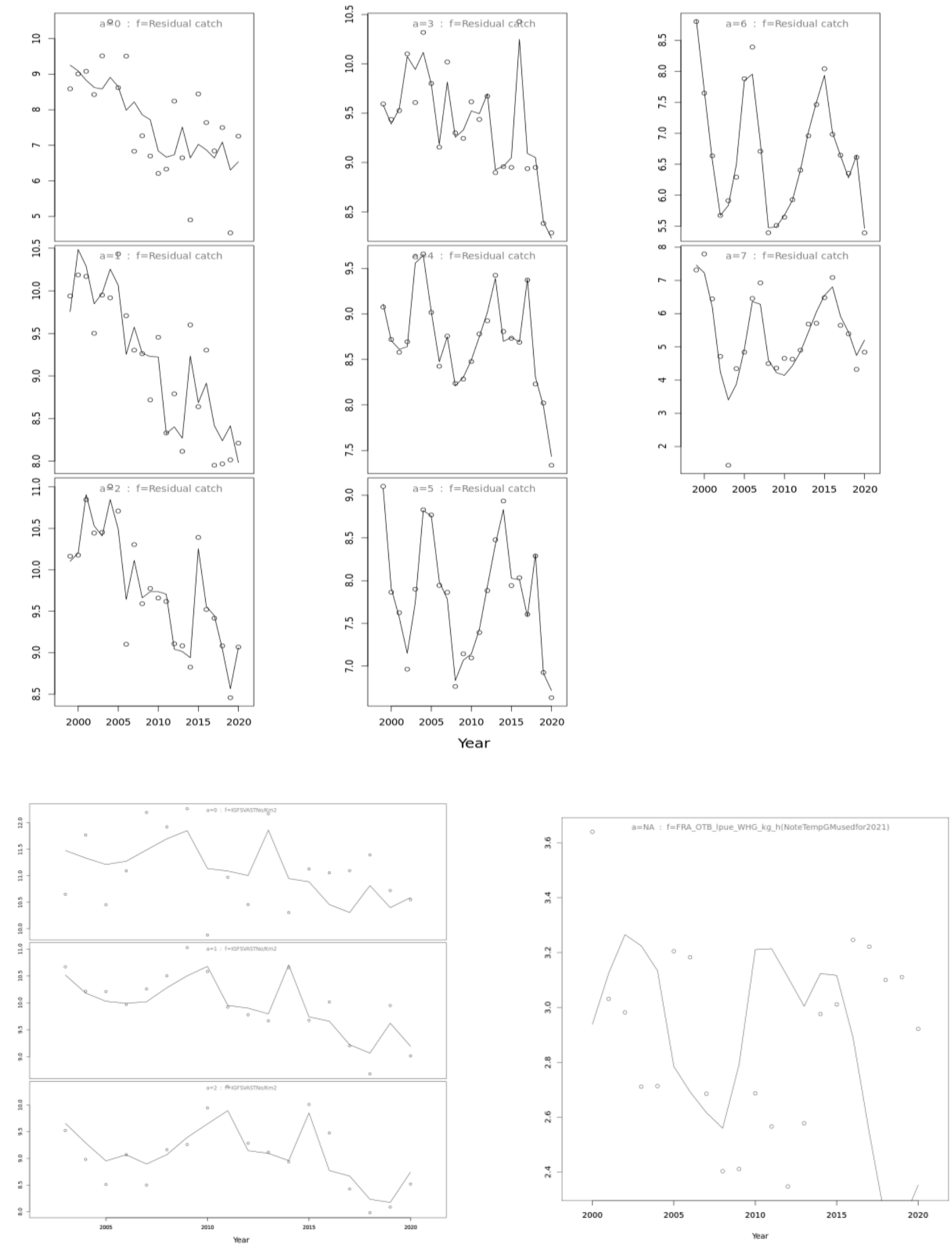
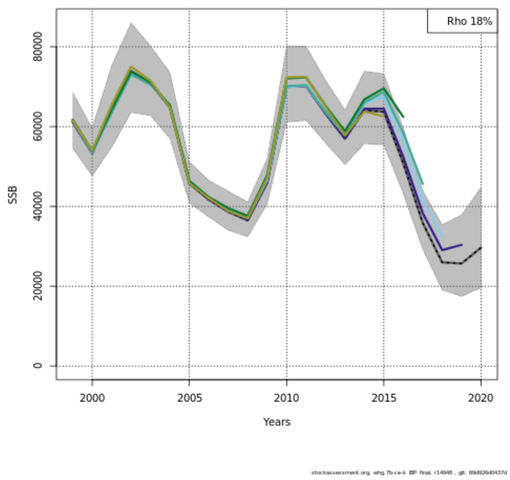
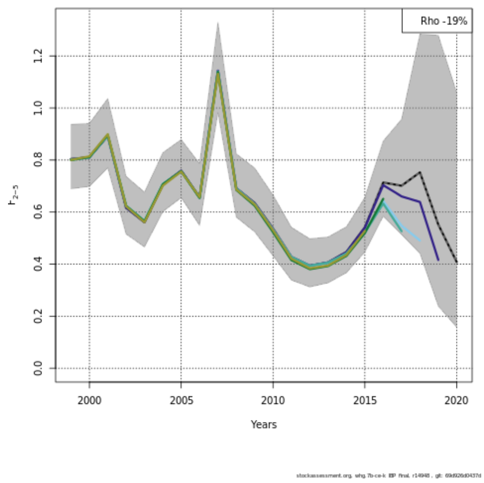


Figure 10. Fit to the catch at age data (top) and **VAST** index (bottom left) **for** final **SAM assessment run. Model fits for commercial biomass index are given in lower** right panel. Point observations are presented along with model prediction lines.

Figure 11. Residual patterns for the catch at age data (top), commercial biomass index (middle) and VAST IBTS index (bottom) for final SAM assessment run.





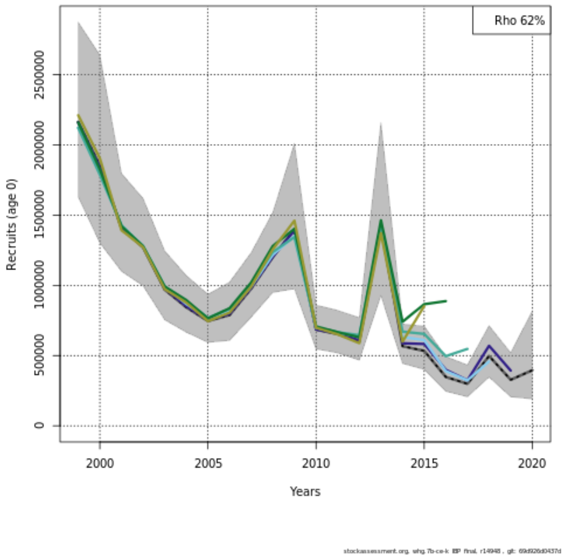


Figure 12. Retrospective patters and Mohn's Rho calculations for SSB (top left), Fbar (top right) and recruitment (bottom left).

References:

Annex 1: List of participants

Name	Institute	Country	E-mail
Gianfranco Anastasi	Cefas	UK	gianfranco.anastasi@cefas.co.uk
Paul Bouch	Marine Institute	Ireland	paul.bouch@marine.ie
Rui Catarino	ICES	Denmark	rui.catarino@ices.dk
Paul Coleman	Marine Institute	Ireland	Paul.coleman@marine.ie
Helen Dobby	Marine Scotland-Science	Scotland, UK	h.dobby@marlab.ac.uk
Jennifer Doyle	Marine Institute	Ireland	Jennifer.doyle@marine.ie
Mickael Drogou	Ifremer Centre de Brest	France	Mickael.Drogou@ifremer.fr
Timothy Earl	Cefas	UK	timothy.earl@cefas.co.uk
Ailsa Ellis	Marine Scotland Science	UK	Ailsa.Ellis@gov.scot
Niall Fallon	Marine Laboratory	Scotland, UK	niall.fallon@gov.scot
Chris Firmin	Cefas	UK	chris.firmin@cefas.co.uk
Simon Fischer	Cefas	UK	simon.fischer@cefas.co.uk
Samuel Hardman	Marine Scotland Science	Scotland, UK	Samuel.Hardman@gov.scot
Kieran Hyder	Cefas	UK	Kieran.hyder@cefas.co.uk
Andrzej Jaworski	Marine Scotland-Science	Scotland, UK	a.jaworski@marlab.ac.uk
Ruth Kelly	Agri-food and Biosciences Institute	NI, UK	ruth.kelly@afbini.gov.uk
Vladimir Khlivnoi	Knipovich Polar Research Institute of Marine Fisheries and Oceanography(PINRO)	Russian Federation	khlivn@pinro.ru
Vladimir Laptikovsky	Cefas	UK	Vladimir.laptikhovsky@cefas.co.uk
Mathieu Lundy Chair	Agri-food and Biosciences Institute	NI, UK	mathieu.lundy@afbini.gov.uk
Claire Moore	Marine Institute	Ireland	claire.moore@Marine.ie
Sara-Jane Moore	Marine Institute	Ireland	Sara-jane.moore@marine.ie
Sofie Nimmegeers	Research Institute for Agriculture, Fisheries and Food (ILVO)	Belgium	sofie.nimmegeers@ilvo.vlaanderen.be

Name	Institute	Country	E-mail
Chair			
David Stokes	Marine Institute	Ireland	david.stokes@marine.ie
Pia Suchert	Agri-food and Biosciences Institute	NI, UK	Pia.Schuchert@afbini.gov.uk
Bart Vanelslander	Research Institute for Agriculture, Fisheries and Food (ILVO)	Belgium	bart.vanelslander@ilvo.vlaanderen.be
Marianne Robert	Ifremer Lorient Station	France	marianne.robert@ifremer.fr
Jonathan White	Demersal fisheries Fisheries Ecosystems Advisory Services Marine Institute	Ireland	Jonathan.white@marine.ie
Please note: The below names were added to the list in October 2021			
Elisa Barreto	Marine Laboratory	UK	barretoe@marlab.ac.uk
Mikel Aristegui	Marine Institute	Ireland	Mikel.Aristegui@Marine.ie

Annex 2: Stock Annexes

The table below provides an overview of the WGCSE Stock Annexes. Stock Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species,* and *acronym* of the relevant ICES expert group.

Stock ID	**Stock name**	**Last updated**	**Link**
anf.27.3a46	Anglerfish (*Lophius budegassa*, *Lophius piscatorius*) in subareas 4 and 6, and in Division 3.a (North Sea, Rockall and West of Scotland, Skagerrak and Kattegat)	October 2019	Anglerfish 3.a46
bss.27.4bc7d–h	Seabass (*Dicentrarchus labrax*) in divisions 4.b–c, 7.a, and 7.d–h (central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and Celtic Sea)	May 2020	Sea bass 47
cod.27.7e–k	Cod (*Gadus morhua*) in divisions 7.e–k (eastern English Channel and southern Celtic Seas)	October 2020	Cod 7.e–k
cod.27.7a	Cod (*Gadus morhua*) in Division 7.a (Irish Sea)	March 2017	Cod 7.a
cod.27.6b	Cod (*Gadus morhua*) in Division 6.b (Rockall)	May 2013	Cod 6.b
cod.27.6a	Cod (*Gadus morhua*) in Division 6.a (West of Scotland)	June 2021	Cod 6.a
gug-celt	Grey gurnard in Subarea 6 and Divisions 7.a–c and e–k	March 2014	Grey gurnard
had.27.7b–k	Haddock (*Melanogrammus aeglefinus*) in divisions 7.b–k (southern Celtic Seas and English Channel)	May 2017	Haddock 7.b–k
had.27.7a	Haddock (*Melanogrammus aeglefinus*) in Division 7.a (Irish Sea)	June 2021	Haddock 7.a
had.27.6b	Haddock (*Melanogrammus aeglefinus*) in Division 6.b (Rockall)	May 2020	Haddock 6.b
had.27.46a20	Haddock (*Melanogrammus aeglefinus*) in Subarea 4, Division 6.a and Subdivision 20 (North Sea, West of Scotland, Skagerrak)	May 2009	Haddock 6.a
lez.27.4a6a	Megrim (*Lepidorhombus* ssp.) in divisions 4.a and 6.a (northern North Sea, West of Scotland)	June 2021	Megrim 4a6a
nep.fu.11	Norway lobster (*Nephrops norvegicus*) in Division 6.a, Functional Unit 11 (West of Scotland, North Minch)	May 2016	*Nephrops* FU11

Stock ID	Stock name	Last updated	Link
nep.fu.12	Norway lobster (*Nephrops norvegicus*) in Division 6.a, Functional Unit 12 (West of Scotland, South Minch)	May 2016	*Nephrops* FU12
nep.fu.13	Norway lobster (*Nephrops norvegicus*) in Division 6.a, Functional Unit 13 (West of Scotland, the Firth of Clyde and Sound of Jura)	May 2017	*Nephrops* FU13
nep.fu.14	Norway lobster (*Nephrops norvegicus*) in Division 7.a, Functional Unit 14 (Irish Sea, East)	September 2018	*Nephrops* FU14
nep.fu.15	Norway lobster (*Nephrops norvegicus*) in Division 7.a, Functional Unit 15 (Irish Sea, West)	May 2018	*Nephrops* FU15
nep.fu.16	Norway lobster (*Nephrops norvegicus*) in divisions 7.b–c and 7.j–k, Functional Unit 16 (west and southwest of Ireland, Porcupine Bank)	March 2013	*Nephrops* FU16
nep.fu.17	Norway lobster (*Nephrops norvegicus*) in Division 7.b, Functional Unit 17 (west of Ireland, Aran grounds)	May 2016	*Nephrops* FU17
nep.fu.19	Norway lobster (*Nephrops norvegicus*) in divisions 7.a, 7.g, and 7.j, Functional Unit 19 (Irish Sea, Celtic Sea, eastern part of south-west of Ireland)	October 2019	*Nephrops* FU19
nep.fu.2021	Norway lobster (*Nephrops norvegicus*) in divisions 7.g and 7.h, functional units 20 and 21 (Celtic Sea)	October 2019	*Nephrops* FU2021
nep.fu.22	Norway lobster (*Nephrops norvegicus*) in divisions 7.g and 7.f, Functional Unit 22 (Celtic Sea, Bristol Channel)	May 2018	*Nephrops* FU22
nep.fu.2324	Norway lobster (*Nephrops norvegicus*) in divisions 8.a and 8.b, functional units 23–24 (northern and central Bay of Biscay)		Not available
ple.27.7bc	Plaice (*Pleuronectes platessa*) in divisions 7.b–c (West of Ireland)	April 2013	Plaice 7.bc
ple.27.7h–k	Plaice (*Pleuronectes platessa*) in divisions 7h–k (Celtic Sea South, southwest of Ireland)	May 2021	Plaice 7.h–k
ple.27.7fg	Plaice (*Pleuronectes platessa*) in divisions 7.f and 7.g (Bristol Channel, Celtic Sea)	May 2018	Plaice 7.fg
ple.27.7e	Plaice (*Pleuronectes platessa*) in Division 7.e (western English Channel)	April 2016	Plaice 7.e
ple.27.7a	Plaice (*Pleuronectes platessa*) in Division 7.a (Irish Sea)	June 2021	Plaice 7.a
sol.27.7bc	Sole (*Solea solea*) in divisions 7.b and 7.c (West of Ireland)	April 2013	Sole 7.bc
sol.27.7h–k	Sole (*Solea solea*) in divisions 7.h–k (Celtic Sea South, Southwest of Ireland)	May 2020	Sole 7.h–k

Stock ID	Stock name	Last updated	Link
sol.27.7fg	Sole (*Solea solea*) in divisions 7.f and 7.g (Bristol Channel, Celtic Sea)	May 2020	Sole 7.fg
sol.27.7e	Sole (*Solea solea*) in Division 7.e (western English Channel)	June 2021	Sole 7.e
sol.27.7a	Sole (*Solea solea*) in Division 7.a (Irish Sea)	June 2021	Sole 7.a
whg.27.7b–ce–k	Whiting (*Merlangius merlangus*) in divisions 7.b–c and 7.e–k (southern Celtic Seas and eastern English Channel)	June 2019	Whiting 7.bc,e–k
whg.27.7a	Whiting (*Merlangius merlangus*) in Division 7.a (Irish Sea)	May 2017	Whiting 7.a
whg.27.6b	Whiting (*Merlangius merlangus*) in Division 6.b (Rockall)	May 2013	Whiting 6.b
whg.27.6a	Whiting (*Merlangius merlangus*) in Division 6.a (West of Scotland)	June 2021	Whiting 6.a

Annex 3: Working Documents

ICES Working Group for the Celtic Seas
Ecoregion
5–14 May 2021

Review of the total burrow abundance estimates for FU 20 and 21 (Celtic Sea) stock calculated by two software packages for survey years 2013 to 2014 and preliminary estimations of MSY $B_{trigger}$ based on two time frame selections.

Jennifer Doyle
Marine Institute
Galway
Ireland

Background

This document provides details on the review of the geo-statistical analysis to calculate total abundance estimates for Norway lobster (*Nephrops norvegicus*) in divisions 7.g and 7.h, functional units 20 and 21 (Celtic Sea) stock for survey years 2013 to 2014 where the results calculated by SURFER software and RGeostats "R package" are compared. This review was conducted as part of the process to move the stock assessment within the ICES Transparent Assessment Framework for the Working Group for the Celtic Seas Ecoregion (WGCSE) in 2021.

This stock currently has no MSY $B_{trigger}$ reference point to provide advice on reduced fishing mortality; where the ICES maximum sustainable yield (MSY) approach states when a stock is below MSY $B_{trigger}$, the FMSY harvest rate be reduced by multiplying it by the ratio of current abundance to MSY $B_{trigger}$. Following the recommendation of the 2020 ICES Advice drafting group, MSY $B_{trigger}$ investigations are documented here where there is currently eight years of 100% coverage of the survey area.

The process set out by WKFMSYREF4 (ICES, 2017), where preliminary MSY $B_{trigger}$ values were set based on the 5th percentile of a distribution fitted to the observed abundances assuming a normal distribution for several stocks (FU 17, FU 19 and FU 22), was followed here.

The UWTV survey data series for FU 20-21 starts in 2013 and is conducted annually according to standards set out by WGNEPS (ICES, 2021 and Dobby et al, 2021). In 2013, only 60% of the total survey area was achieved due to logistical issues. Since 2014, 100% coverage of the survey area has been achieved. Details of survey operations are available in annual survey reports available here. Prior to 2015 final mean density estimates were extracted and calculated using MS Access queries in the local survey database. These data were then transferred to a csv file for use in SURFER software to conduct kriging analysis. Since 2015 annual survey data is uploaded to a SQL server database and a SQL view calculates and extracts the mean density estimates where geo-statistical analysis is carried out using RGeostats package software in the "R" environment.

Methods

UWTV survey input data quality assurance check:

The input data (number of stations, total burrows counts and distance over ground by year) used to calculate the mean density estimates extracted by the local MS Access queries and SQL server script were checked. This is available as a separate R markdown document.

Survey area boundary file:

The boundary file for this survey was investigated and proposed at the WKCELT benchmark (ICES, 2014) where it is based on Irish and French VMS data linked to *Nephrops* logbook landings. The survey area is estimated at 10, 014 Km^2. The same boundary file has been used in SURFER and RGeostats kriging analysis.

SURFER software kriging analyses:

For years 2013 to 2014, kriging analyses to estimate total abundance estimates were carried out using SURFER Version 10.7.972 using the csv file for input data. Details of the steps are found in the survey report (Doyle et al., 2014). Local network files hold details of variogram settings used (spherical), grid information (100x100) and the same boundary file was used throughout. SURFER does not provide the krigged estimation variance or CV. This was carried out using the EVA: Estimation VAriance software (Petitgas and Lafont, 1997). Figure 2 shows the contour plots of the krigged density estimates for 2013 to 2014 from SURFER software.

2013 to 2014 RGeostats software kriging analyses review 2013 to 2014:

The input data extracted using SQL server scripts were used for years 2013-2014. The spatial co-variance and other spatial structuring and geo-statistical analysis of the mean and variance were carried out using RGeostats (Renard D. *et al*., 2018; Petitgas *et.al*. 2017).

The input data and details of this analysis are available on the ICES TAF GitHub here. Variogram settings (spherical), set-up of grid (100X100) and boundary file used were similar to that used in SURFER programme.

MSY $B_{trigger}$ estimations:

Calculation of preliminary estimates of MSY $B_{trigger}$ followed the same process that was used for other *Nephrops* stocks (FU 17, FU 19 and FU 22) at the FMSYREF4 meeting (ICES, 2017).

Two time frames were explored for the input data range; option 1: survey years 2014 to 2021 where 100% coverage was achieved; option 2: survey years 2014 to 2021 excluding year 2017 and option 3: lowest observed in time series to date.

The 2017 abundance estimate is the highest in the series to date with a 135% increase from the 2016 abundance estimate (Table 2, Figure 3a). WGCSE 2018 recommended that the survey data from 2016 and 2017 should be reviewed (re-counted) to determine if this change was a result of the year effect or counting behaviour. The results of the partial

review (15% random selection of stations from both years) showed a low increase (3.8%) in the review counts for 2016 stations comparing them with the survey counts and a high decrease (30.8%) in the review counts for 2017 stations comparing them with the survey counts. All of the analysis is available in R markdown document (Annex 7, ICES, 2018).
The input data and details of MSY $B_{trigger}$ analysis for the two options are available on the ICES TAF GitHub here.

2019 Sampling data revision:
As part of a SQL server database migration in early 2021 - one valid sample (catch and discards) was found from the 2019 Irish quarter 2 fishery data set. This sampled commercial data was included and used to calculate an annual discard ogive to partition the catch length frequency into landings and discards by number and weight.

Results
Table 1 shows the revision to the Irish fishery data set for sampling year 2019. There is a minor downward revision in the estimated mean weight of the landings and minor increase in numbers of removals. This revised data set is used for the assessment summary and catch scenarios this year and was presented to WGCSE in May.

Figure 1a-c shows the comparisons of total numbers of stations, total number of burrows and total distance over ground (metres) by data extraction method (excel =csv file input, full= SQL view script, rec=local MS Access queries). Total number of stations for all data processing methods are the same. There was a minor difference (< 0.1%) in total burrow counts for year 2014 only between the excel (4142.5) and the full and rec processing method (4138.5). There were minor differences in total distance over ground for both years between excel, the full and rec processing method. The final mean density data calculated by SQL view was used as input data for this review process for years 2013 and 2014. This is in line with the current data processing method in place since 2015.

Table 2 shows the total summary of results from the geo-statistical analysis for each software. For both years the total abundance estimate is quite similar (Figure 3a) and in 2014 the mean density estimates are very similar (Figure 3b).
Estimated coefficient of variation (CV) for the review period are quite similar from the RGeostats analysis compared to the EVA output (Figure 3c). The range for both is well within the 20% limit recommended by SGNEPS (ICES, 2012) as an acceptable precision level for UWTV survey estimates of abundance.

The minor update in total abundance estimates from RGeostats also requires the harvest rates to be recalculated. Harvest rates are derived by: removals in numbers / tv abundance. The recalculated harvest rates do not vary much from those previously reported and are shown in the assessment summary (Table 3). The revision to the 2019 Irish fishery sample dataset results in a slight downward revision to the harvest rate from 21.2 % to 19.2 %.

The abundance estimates from RGeostats analyses are used to estimate MSY $B_{trigger.}$
A larger sample from the “rnorm” R function was used where the value calculated is more stable to estimate the 5th percentile of the distributions fitted to the observed abundances
Three options are presented, option 1: full survey series 2014 to 2021 which gives estimate

of 27 million individuals, option 2: excluding the 2017 survey abundance gives estimate of 450 million individuals and option 3: compare 1 and 2 to the lowest observed to date from the 2019 survey estimate of 617 million (Figure 4).

Discussion

Improvement in data quality assurance and reproducibility in relation to SQL script extraction and code visibility in TAF for stock assessment is achieved. The results from the geo-statistical analysis from RGeostats package are used for years 2013 to 2014 in line with data analyses for the entire time series and these data will be used in the assessment summary where this is a very minor difference to that reported previously.

For the FMSY $B_{trigger}$ estimation, analysing the full survey data (2014 to 2021) series results in a very low estimate (27 million) and is not realistic.

Exclusion of 2017 abundance estimate mainly due to the results of the partial review which showed a large decrease indicating that this is a possible outlier data point seems a reasonable option and was proposed by WGCSE. This option results in a MSY $B_{trigger}$ estimate (450 million) that is also similar to the lowest observed to date (617 million). It is then proposed to use this estimate of 450 million as the MSY $B_{trigger}$ reference point for this stock. The stock size status is above MSY $B_{trigger}$ for the time series to date when this value is applied.

References

ICES. 2012. Report of the Study Group on *Nephrops* Surveys (SGNEPS), 6–8 March 2012, Acona, Italy. ICES CM 2012/SSGESST:19. 36 pp.

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Table 1. FU 20-21 revision to 2019 Irish fishery dataset.

Year	Landings in number	Total discards in number*	Removals in number	Dead Discard Rate number	Discard Rate number	Discard Rate weight	Landings	Total discards*	Mean weight in landings	Mean weight in discards
	millions			%			tonnes		grammes	
2012	26.5	17.5	39.6	33.1	39.7	22.6	708	207	26.7	11.9
2013	24.2	8.3	30.5	20.5	25.6	14	844	137	34.9	16.4
2014	39.1	17.6	52.3	25.3	31.1	14.8	1,342	233	34.3	13.3
2015	47.9	18.6	61.9	22.5	27.9	13.3	1,620	248	33.8	13.4
2016	39.6	27.5	60.3	34.2	41	26.9	1,531	564	38.6	20.5
2017	41	9.2	47.9	14.4	18.4	9.7	1,113	120	27.1	13
2018	44.5	11.9	53.4	16.8	21.2	14.4	1,197	201	26.9	16.9
2019	73.4	31.3	96.9	24.3	29.9	17.5	2,219	471	30.2	15
2019 revised	74.8	29.2	96.7	22.6	28.1	16.5	2,219	439	29.7	15
2020	11.9	1.7	13.1	9.5	12.3	7.6	336	28	28.2	16.7
2021										

Table 2. FU 20-21 Summary of results of the kriging analyses from SURFER software and RGeostats package. Review years 2013 to 2014 outlined by box.

		SURFER & EVA CV estimate				RGeostats			
Year	Number of stations	Mean Density adjusted (burrow/m²)	Domain Area (Km²)	Geostatistical Abundance adjusted (millions of burrows)	CV on Burrow estimate (%)	Mean Density adjusted (burrow/m²)	Domain Area (Km²)	Geostatistical Abundance adjusted (millions of burrows)	CV on Burrow estimate (%)
2013*	55	NA ^	9835	1624	3.3	0.16	9931	1640	8.1
2014	98	0.19	9835	2051	3.3	0.19	9980	2021	3.9
2015	96					0.2	9835	2003	3.2
2016	93					0.18	9974	1879	4.3
2017	86					0.44	9978	4428	3.8
2018	96					0.27	9987	2721	4
2019	95					0.06	9982	617	4.8
2020	97					0.10	9978	1020	4.7
2021	97					0.12	9987	1202	3.9
*scaled to total area ^ mean density not provided due to scaling									

Table 3. FU 20-21 Assessment summary table. Geostatistical results from SURFER software and RGeostats package, derived harvest rates and fishery data (landings, discards and removals). Review years 2013 to 2014 outlined by box.

Year	SURFER			RGeostats			Fishery Data				
	abundance	ci	harvest rate	abundance	ci	harvest rate	Landings number	Discards number	Removals numbers	Landings weight	Discards weight
	millions		(%)	millions		(%)	millions			(tonnes)	
2012	NA	NA	NA	NA	NA	NA	38.2	36.1	65.3	1189	542
2013	1624	103	3.0	1640	261	3.1	35.0	19.2	49.2	1387	327
2014	2051	131	4.5	2021	154	4.6	50.5	55.5	92.2	1836	834
2015				2003	129	4.0	59.3	28.1	80.5	2116	442
2016				1879	157	4.7	60.2	37.5	88.3	2453	801
2017				4428	332	1.7	60.1	19.2	74.5	1849	306
2018				2721	212	3.0	64.7	21.5	80.8	1803	381
2019				617	58	19.2	91.8	35.8	118.7	2723	539
2020				1020	96	1.6	14.6	2.0	16.2	413	34
2021				1202	92	NA	NA	NA	NA	NA	NA

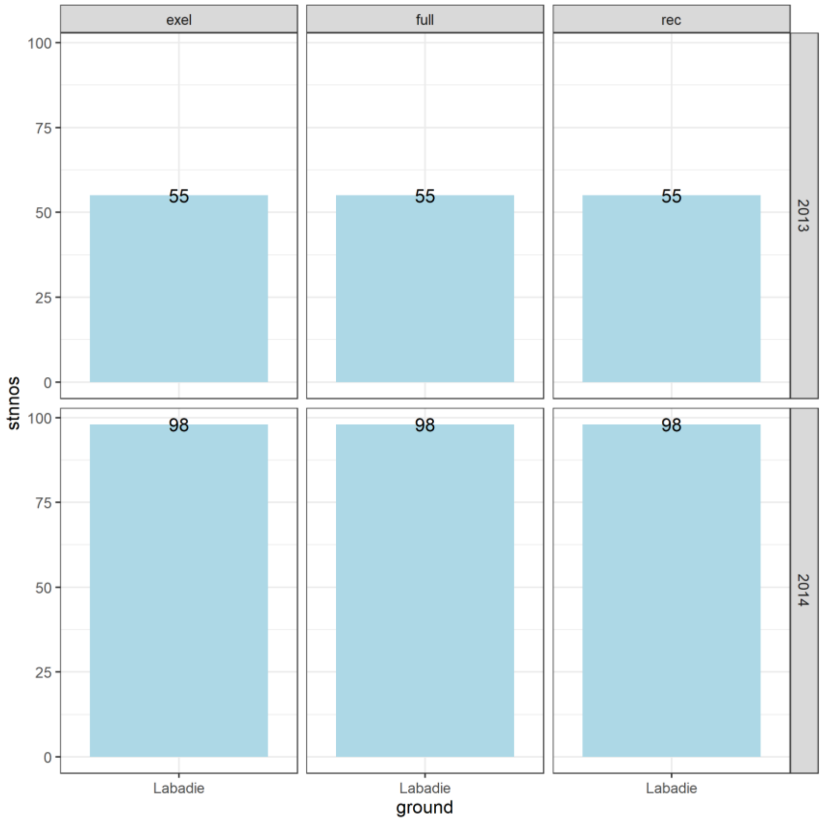

Figure 1a. FU 20-21 total number of stations by data extraction method.

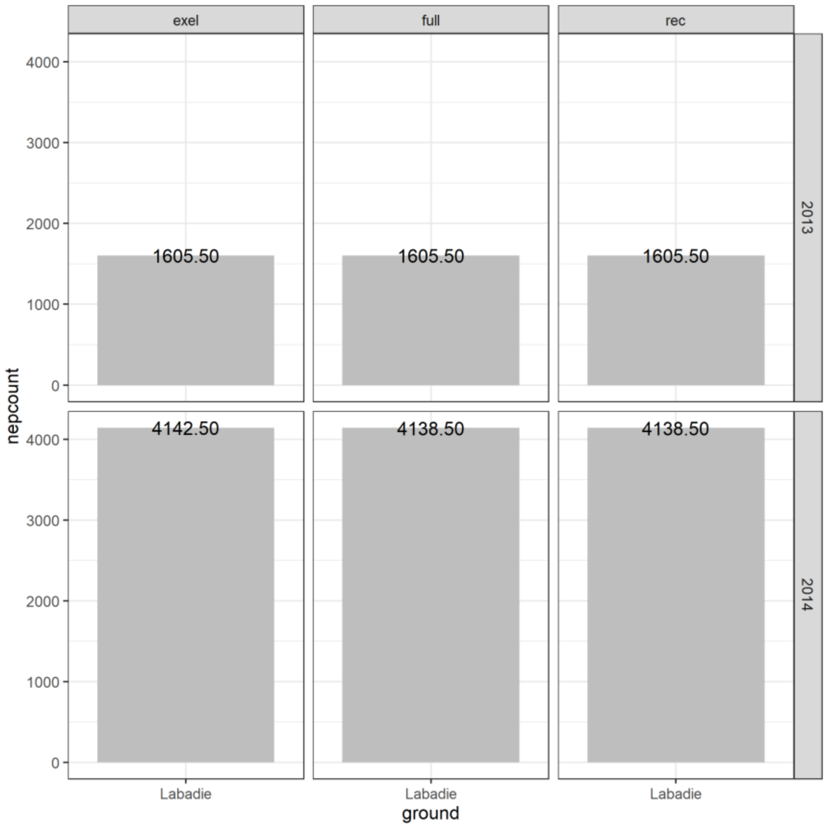

Figure 1b. FU 20-21 total number of burrows by data extraction method.

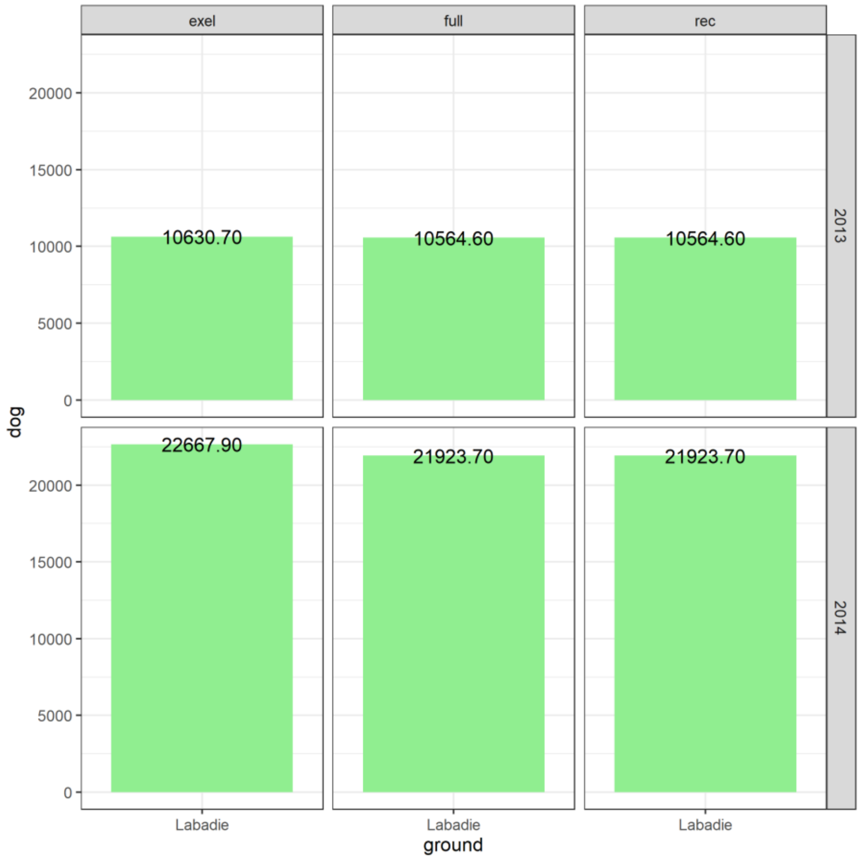

Figure 1c. FU 20-21 total distance over ground (metres) by data extraction method.

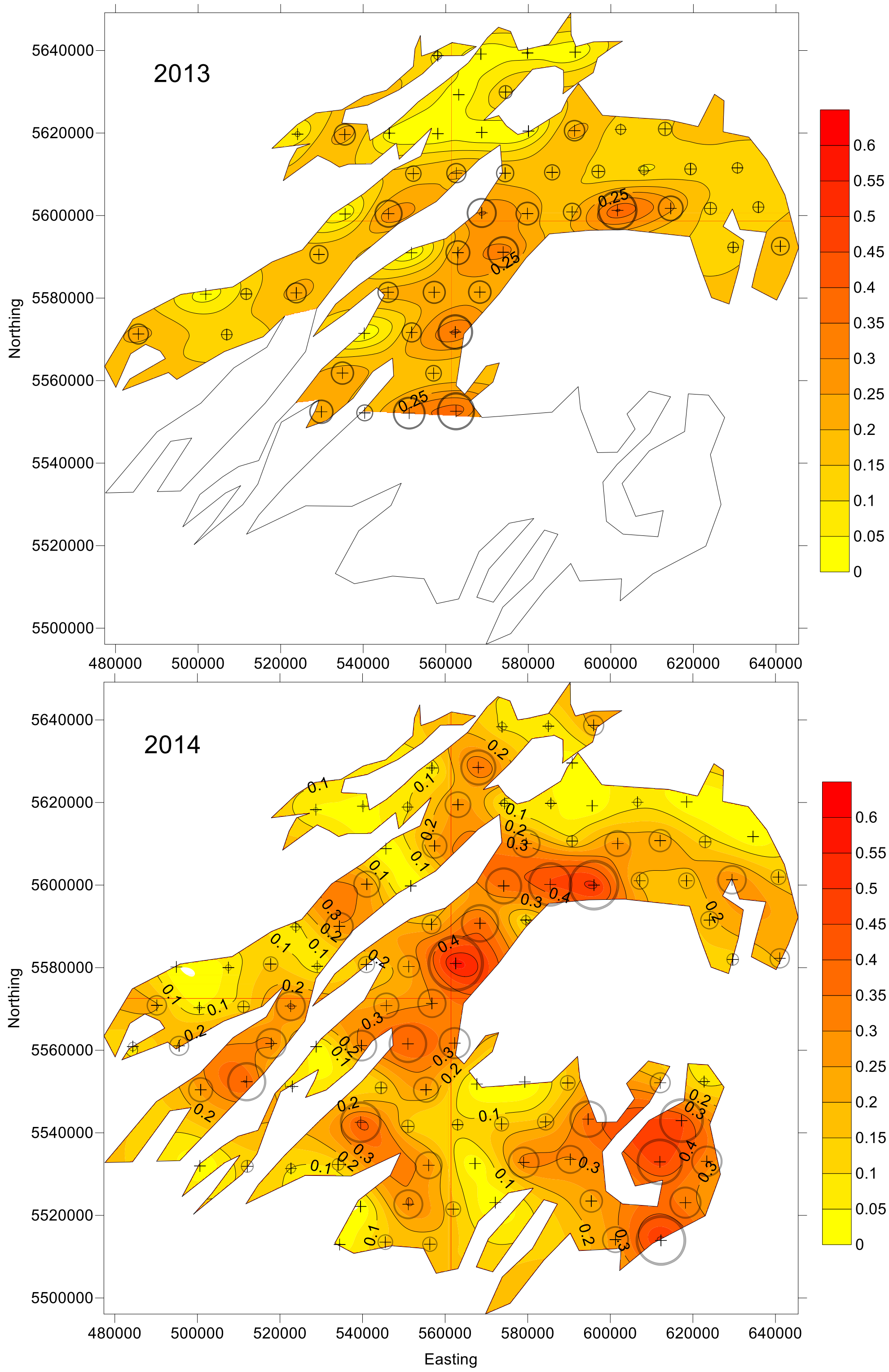

Figure 2. FU 20-21 Contour plots of the krigged density estimates by year from 2013 (top panel) to 2014 (bottom panel) from SURFER software.

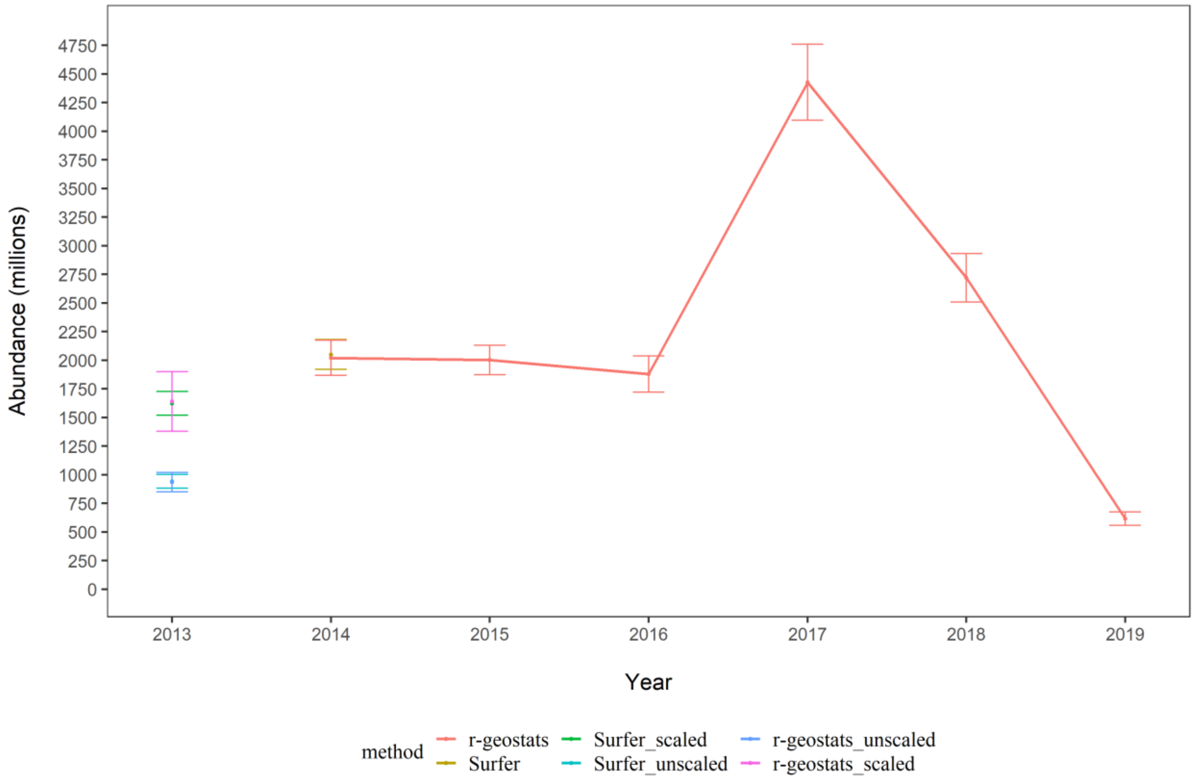

Figure 3a. FU 20-21 Total burrow abundance estimates (millions) by software analysis method.

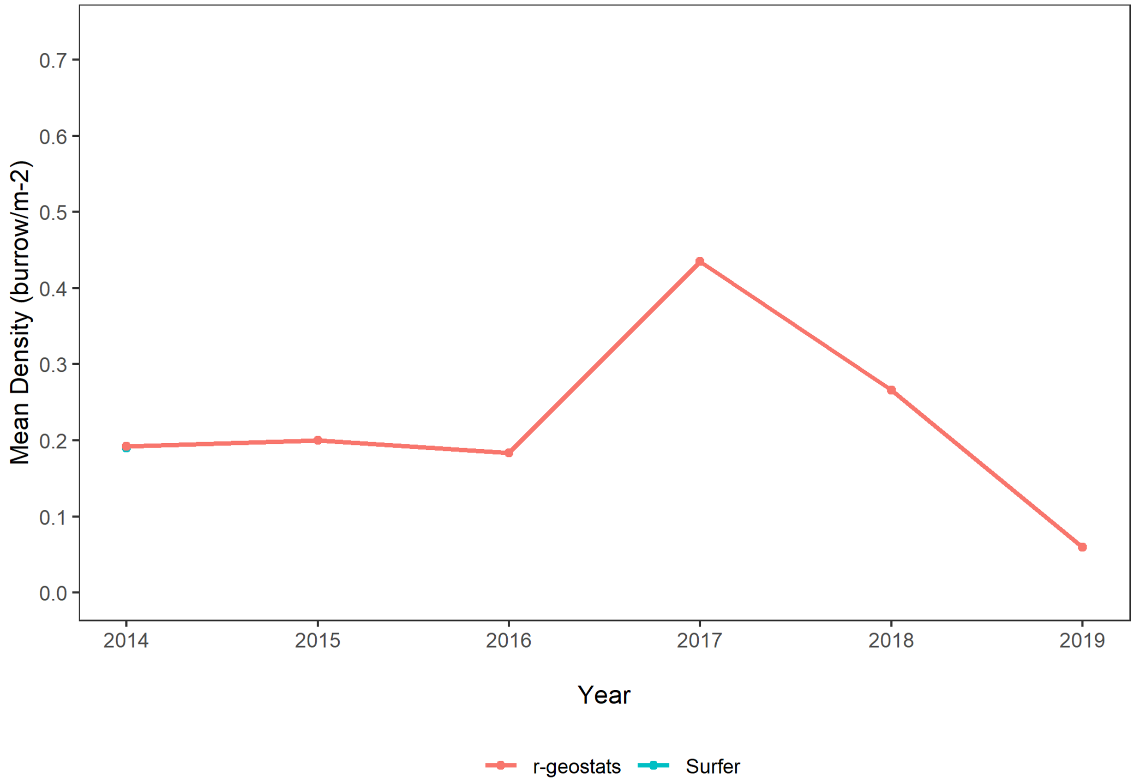

Figure 3b. FU 20-21 Mean density (burrow m/²) estimates by by software analysis method.

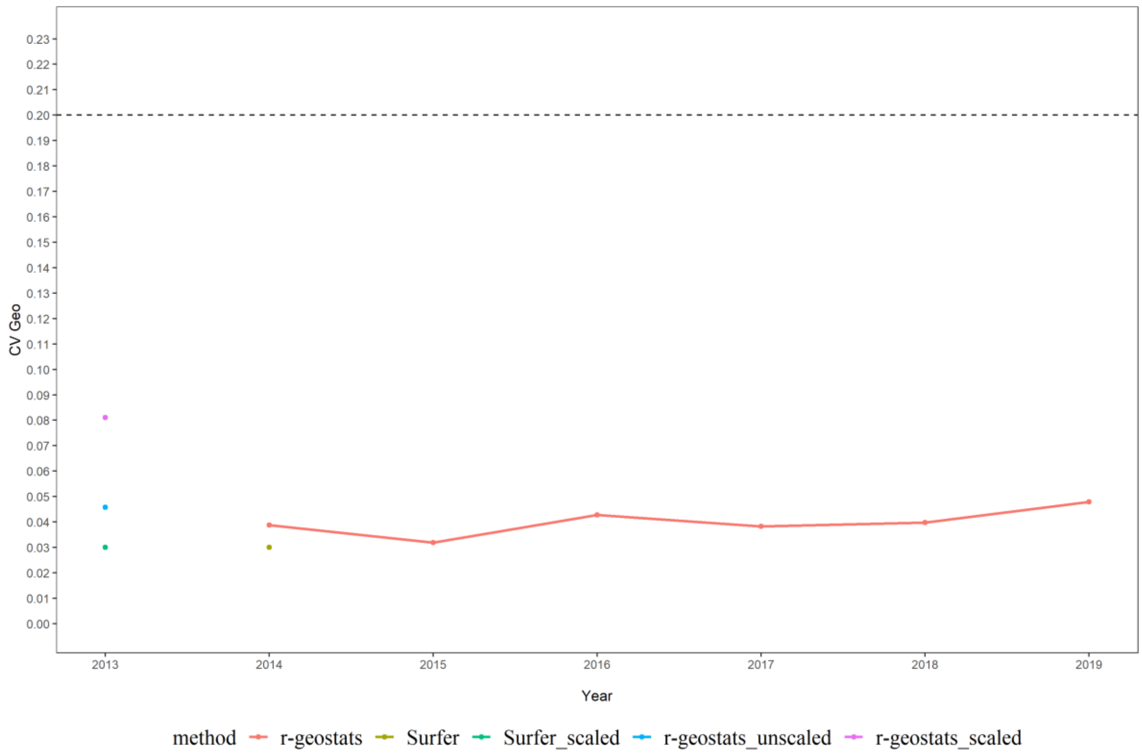

Figure 3c. FU 20-21. Estimated coefficient of variation (CV) % by software analysis method. Surfer CV is estimated from EVA.

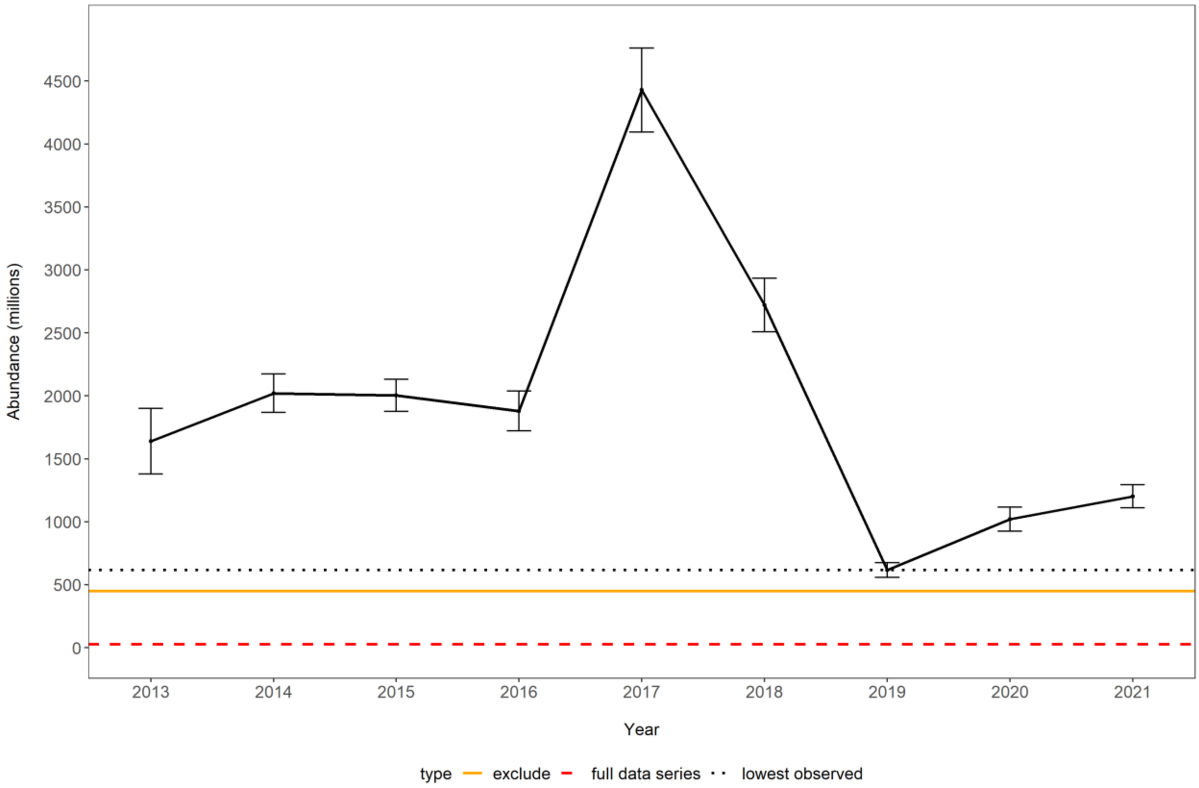

Figure 4. FU 20-21 Abundance estimate and confidence intervals plot with the three options for MSY $B_{trigger}$ estimates: exclude year 2017 from data series (orange line), full data series (red dashed line) and lowest observed survey (black dotted line).

Working document

ICES Working Group for the Celtic Seas Ecoregion
5–14 May 2021
By Correspondence

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At-Sea Sampling in Ireland for 2020

Sara-Jane Moore and Hans Gerritsen
Marine Institute
Galway
Ireland

Introduction

In 2020, normal at-sea sampling ceased after quarter 1 and the MI moved towards an at-sea **self** sampling scheme to collect catch data at-sea. This document is a guide to the sampling levels that occurred in 2020.

Material and Methods

The Marine Institute's at-sea data collection programme is based on statistically sound sampling using guidelines from WKPICS, 2013. There are 3 main demersal draw lists for ICES areas 6ab, 7a, 7b-k. A list of randomly selected vessels is contacted in sequence over the period of a quarter and the selection probability of each vessel is proportional to its catches in the preceding year. The theory is that the random selection should result in a representative sample of the catches by the Irish demersal fleet.

Usually, the owner of the vessel is contacted by the industry liaison team leader for a trip to be arranged and an observer is then sent out on that vessel. In Quarter 1 of 2020, the normal programme of at-sea collection was in place.

In Quarter 2, following the COVID-19 outbreak, those normal operations ceased and a new self-sampling programme was introduced whereby the fisher collected a sample of unwanted catch rather than the observer.

The fishers were asked to sample only one haul per day. This included the recording of positional data, bulk catch information, a landings tally and the collection of a random box of unwanted catch. These protocols were the same as the normal observer scheme with the exception of the number of hauls sampled (normally at least 75% of the hauls in a trip would be sampled by observers). As a result, the number of hauls sampled are greatly reduced for Quarters 2-4. The decision to only sample one haul per day was a balance of data collection and resource management. As the protocols were the same as the normal sampling strategy and the data was validated and quality checked, the hauls were treated the same as per the usual raising procedure for stock assessments.

Results

Seven at-sea sampling trips were carried out in Quarter 1 and 35 at-sea self-sampling trips were carried out in Quarters 2-4. A total of 351 hauls were sampled and although sampling was reduced (780 hauls were sampled in 2019) coverage was similar to previous years (Figure 1).

Figure 2 shows the targets and achieved sampling per sampling frame between in 2016 and 2020. This figure is displayed as number of trips so does not reflect the low sampling levels per haul. The biggest impact of reduced sampling is in 7a although sampling numbers have been reduced in this sampling frame in recent years. A total of 3 trips across two metiers was sampled and as a result no discard estimates were submitted for any of the 7a stocks. Sampling levels in 6ab and 7bk are similar but for some stocks there were not enough samples to submit raised discard estimates. Figure 3 displays the number of sampled trips by métier for each sampling frame. Typically the best sampled métiers are the OTB_CRU and OTB_DEF métiers.

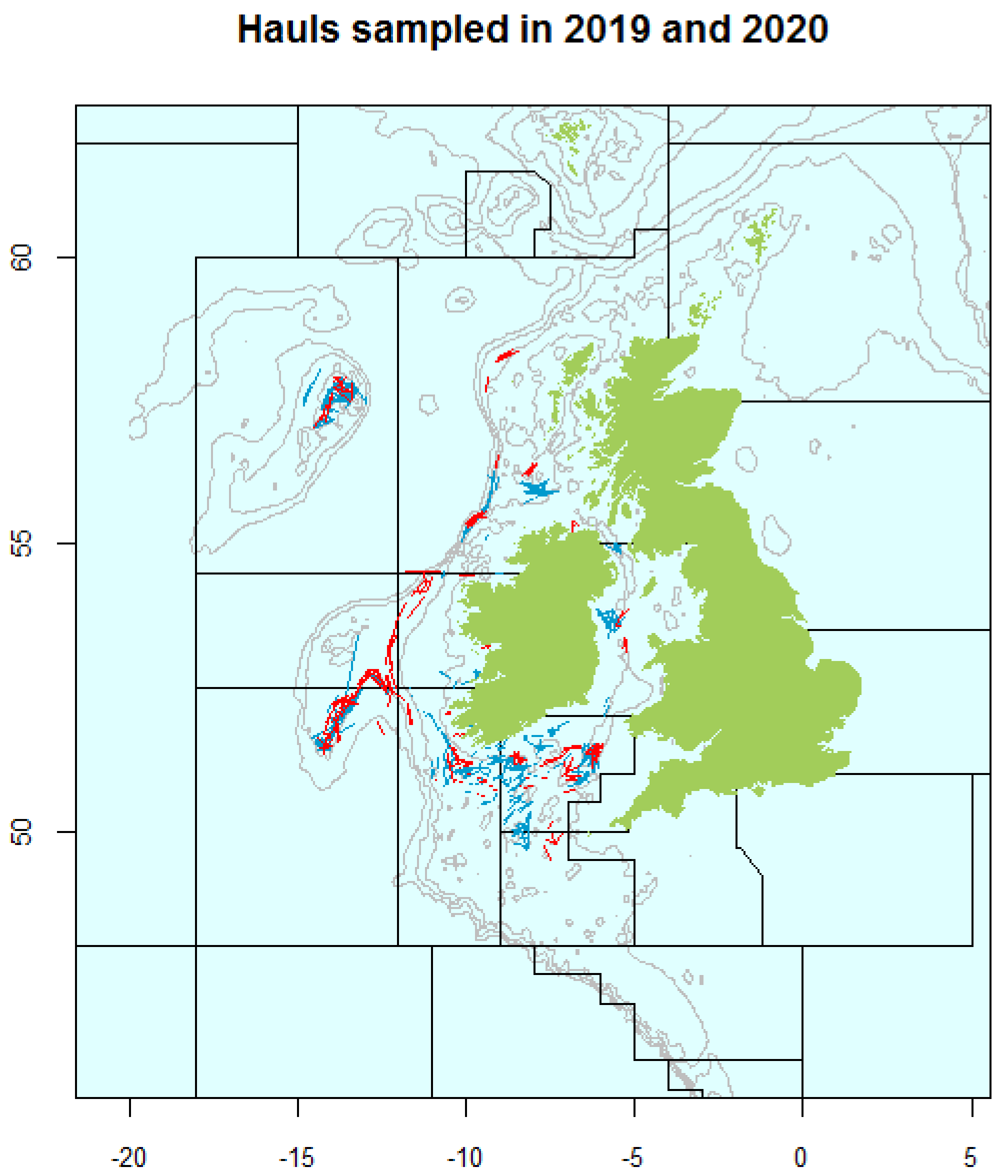

Figure 1. Haul positions sampled in 2020 (red) and for comparison 2019 (blue).

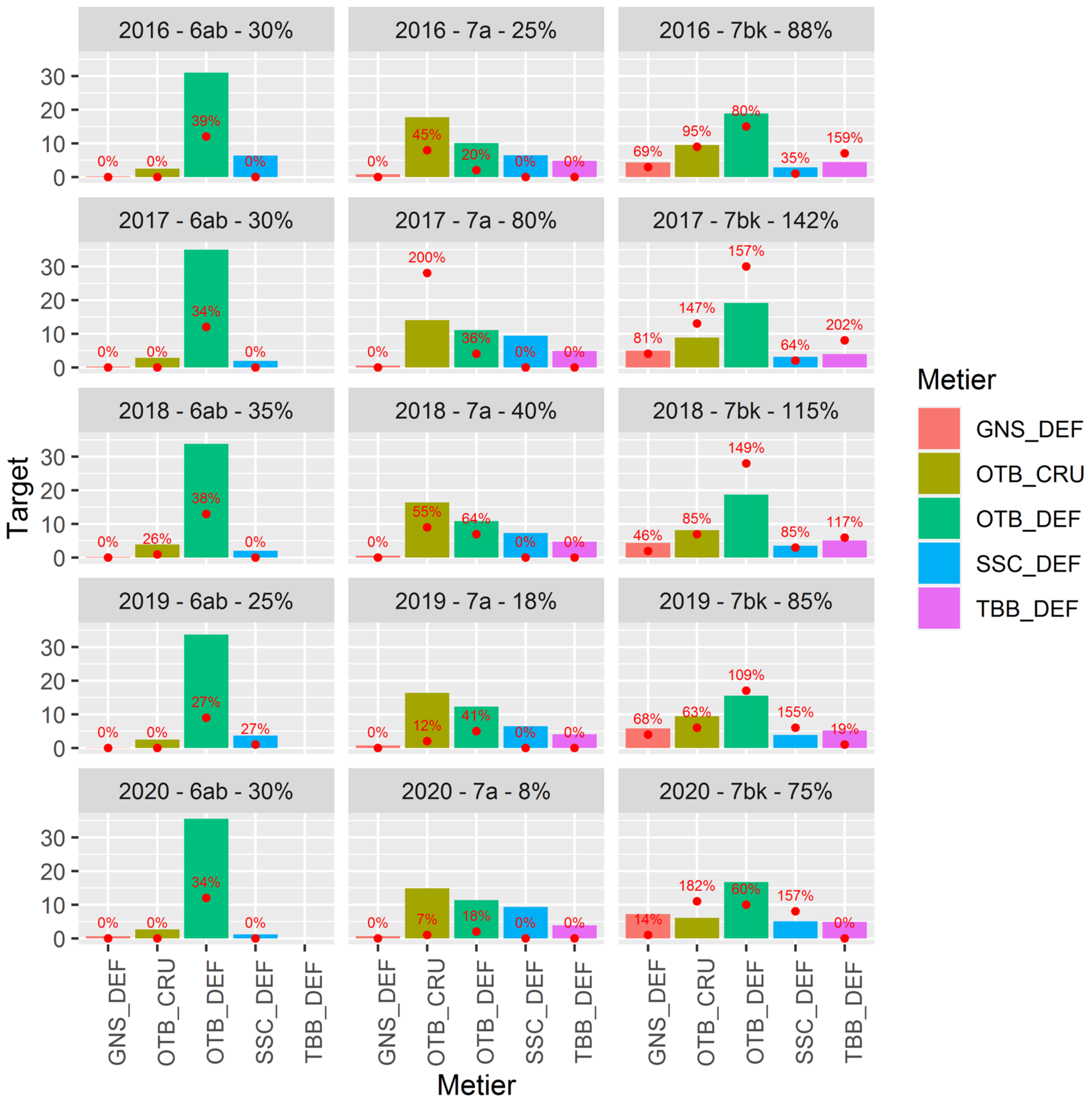

Figure 2. Achieved and target trips per sampling frame for 2016-2020.

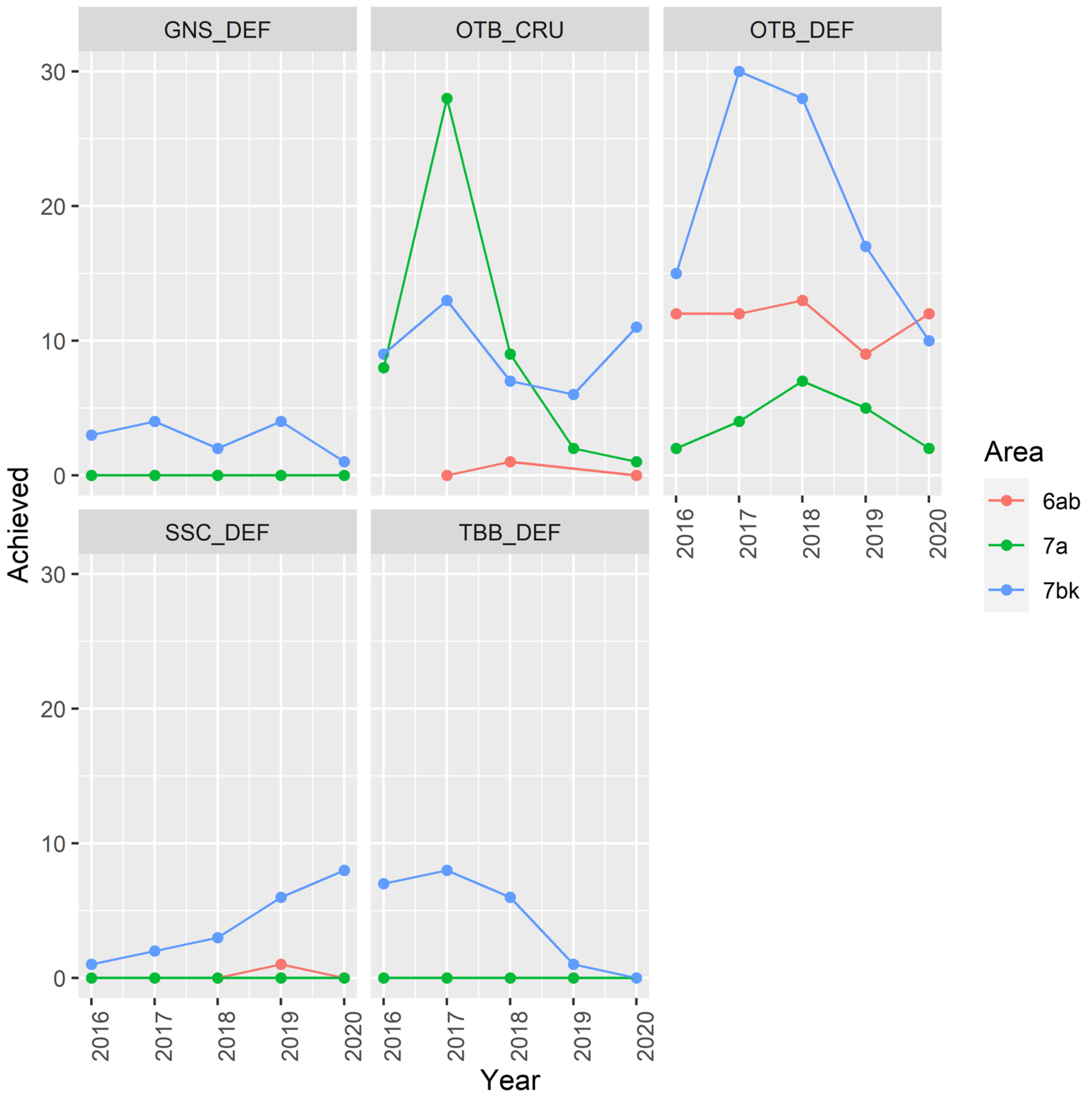

Figure 3. Number of sampled trips by métier for each sampling frame

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Working document X

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ICES Working Group for the Assessment of the Bay of Biscay and the Iberic waters Ecoregion
5–12 May 2021
By Correspondence

Maturity-at-age estimates for Irish Demersal Stocks in 6.a and 7.b-k between 2004-2020

Sara-Jane Moore and Hans Gerritsen
Marine Institute
Galway
Ireland

Introduction

This document provides maturity-at-age estimates for stocks assessed by the WGCSE and WGBIE. All data are obtained on surveys and commercial sampling carried out by the Marine Institute.

Methods

Data was used from the Marine Institute Q1 Biological sampling programme (2010-2020), At-Sea Observer programme (2010-2020), Irish Anglerfish and megrim survey (2016-2020), the Irish beam trawl Ecosystem survey (2016-2018) and the MI Biological sampling survey (2004-2009). Sampling levels were reduced in 2020 as a result of COVID 19 and diminished access to at-sea samples and also port samples. Proportions mature-at-age were estimated by constructing a matrix containing the sample numbers by age, sex and maturity state (mature/immature) at each length class. Unsexed individuals (usually small fish with undeveloped gonads) were assigned in equal numbers to both sexes. This Age-Sex-Maturity-Length Key (ASMLK) was applied to the length-frequency data to estimate the proportions mature-at-age for either sex and both sexes combined. Any gaps in the ASMLK were filled in using a multinomial model (Gerritsen et al., 2006). Estimates for 7a stocks are not included in this document as there was no sampling in 2020.

Results

Because overall there was no clear evidence of trends in maturity over time for any stock, data from all years (2004-2020) were combined. Overall, the perception of age at maturity has not changed from previous years working documents. Figure 1 shows that for most stocks there are no clear trends in the L_{50} over time. Estimates for cod in area 7e-k varied from around 40cm to 60cm, however the sample sizes for this stock were generally very low at the start of the time-series; in recent years the estimates are quite variable (around 40cm) with a slight increase in 2019. Sole in area 7 also exhibited variable estimates in recent years. Plaice in area 7 shows two outlying estimates in 2013 and 2019 but these was estimated with low precision. Whiting in 7b-k shows a decline in L_{50} in 2019 but the data is based on low sample levels. In 2020, the L_{50} increased again.

Table 1(a) shows the estimated proportions mature-at-age. "All" sexes is a weighted maturity ogive and included unsexed individuals most likely to be immature. Following from the submission of an updated version of this document for WKCELTIC, 2020 changes to the maturity ogives were made to Cod 7e-k, Haddock 7b-k and Whiting 7e-k stocks.
For Megrim 7&8, maturity at age is slightly lower than that used by WGBIE. Estimated proportions mature for plaice and sole were also slightly lower than those used by the working group. Whiting and Haddock estimates for 6a are variable over time.

Discussion
Some (relatively minor) differences were found between the ogives used by the working groups and the current findings. Because Irish sampling generally does not cover the full extent of the stocks, it is difficult to determine whether the Irish estimates are unbiased. It is possible that the lack of full spatial coverage can explain some of the differences.

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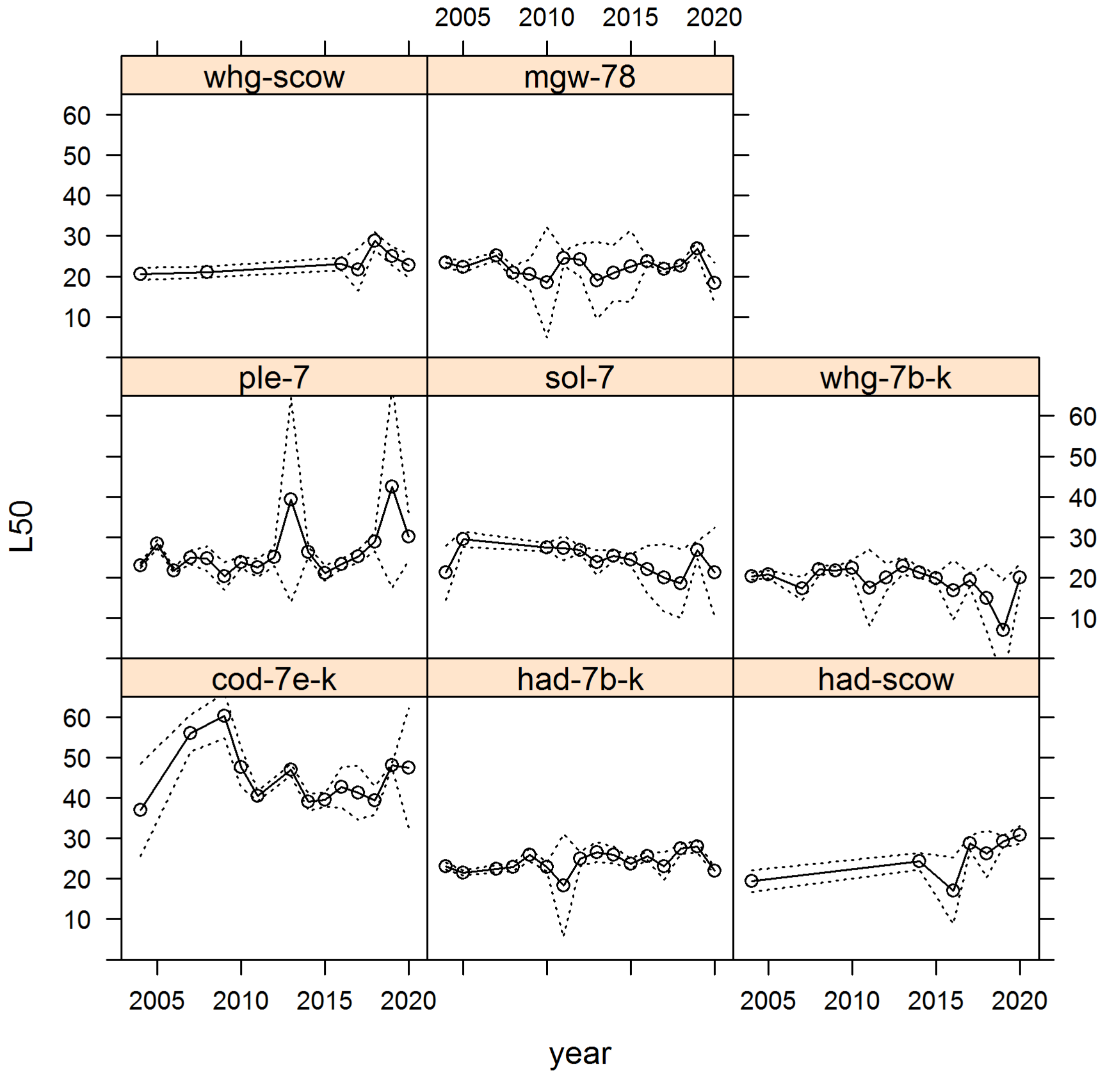


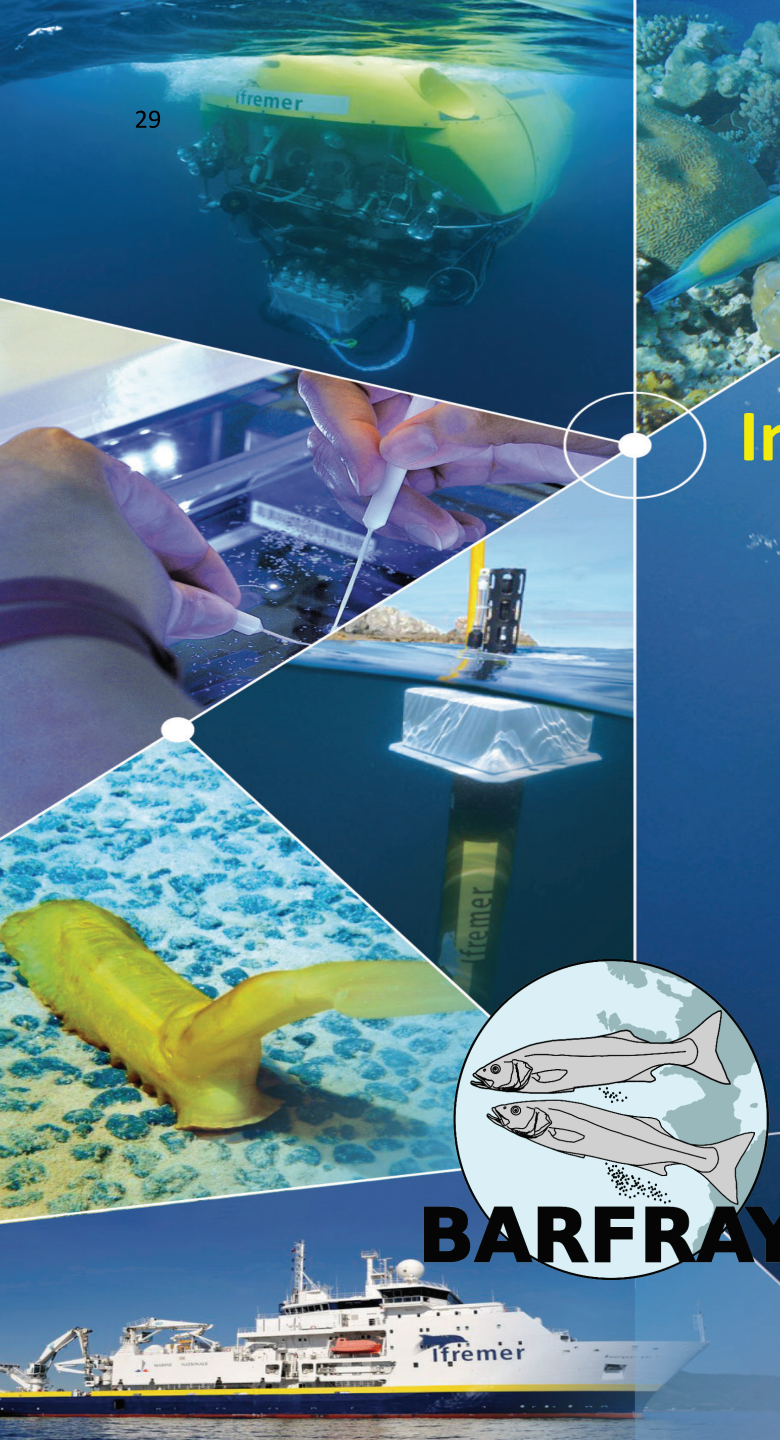
Figure 1. Length at 50% maturity (L50; cm) for females by stock and year.

Table 1 (a). Estimated proportions mature (sample numbers in table below) by stock, sex and age. Maturity ogives used by the WG are also given.

Stock	Sex/WG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
cod-7e-k	**All**	0.01	0.39	0.69	1	1	1	1											
	F	0.02	0.49	0.90	1	1	1	1											
	M	0.01	0.56	0.96	1														
	WKCELTIC	0	0.54	0.93	1	1	1	1	1	1	1								
had-7b-k	**All**	0.21	0.85	0.94	0.94	0.96	0.98	1	1	1	1	0	0						
	F	0.01	0.90	0.98	0.98	0.97	0.99	1	1	1	1	1							
	M	0.28	0.80	0.89	0.90	1	0.95	0.95	1	1			1						
	WKCELTIC	0.04	0.91	0.97	0.98	1	1	1	1										
had 6.a	**All**	0.08	0.65	0.66	0.76	0.72	0.76	0.92	0.83	0.79	1.00								
	F	0.03	0.81	0.76	0.80	0.85	0.89	0.98	1	0.91	1								
	M	0.08	0.67	0.65	0.71	0.44	0.37	0.64	0.34	0.43									
	WGNSSK	0	0	1	1	1	1	1	1	1	1								
mgw-78	**All**	0.30	0.34	0.63	0.82	0.81	0.82	0.82	0.84	0.86	0.83	0.87	0.88	0.93	0.91	0.93	0.97	1.00	1
	F	0.11	0.29	0.68	0.86	0.86	0.86	0.82	0.81	0.87	0.86	0.88	0.87	0.91	0.89	0.93	0.96	1.00	1
	M	0.64	0.35	0.55	0.70	0.72	0.77	0.84	0.89	0.88	0.78	0.75	0.88	1.00			1		
	WGBIE	0.04	0.21	0.6	0.9	0.98	1	1	1	1	1								
ple-7	**All**	0	0.31	0.57	0.73	0.81	0.91	0.91	0.86	0.81	0.93	0.7159	0.7433						
	F	0	0.14	0.44	0.65	0.77	0.89	0.89	0.82	0.78	0.86	0.7621	0.8447						
	M	0	0.32	0.58	0.72	0.81	0.87	0.88	0.91	0.84	1	1	1						
ple 7.a	**WGCSE**	0	0.24	0.57	0.74	0.93	1.00	1.00	1.00	1.00	1								
ple 7.fg	**WGCSE**	0	0.26	0.52	0.86	1	1	1	1	1	1								
sol-7	**All**	0	0.15	0.41	0.59	0.83	0.84	0.86	0.86	0.87	0.89	0.9064	0.9079	0.9437	0.9172	0.8508	0.9765	0.9787	0.9558
	F	0	0.16	0.46	0.64	0.87	0.92	0.96	0.98	0.95	0.96	0.9484	0.9516	0.9384	1	0.899	1	1	1
	M		0.22	0.38	0.50	0.58	0.71	0.69	0.76	0.70	0.71	0.8504	0.7222	0.8375	0.7843	1	0.7796	0.8111	0.7027
sol 7.fg	**WGCSE**	0.00	0.14	0.45	0.88	0.98	1.00	1.00	1.00	1.00	1.00								
whg 7b-k	**All**	0.50	0.53	0.92	0.96	0.92	0.889	1	1	1									
	F	0.30	0.30	0.96	0.98	0.9864	1	1	1	1									
	M	0.49	0.50	0.83	0.94	0.85	0.801	1	1	1									
	WKCELTIC	0.61	0.94	0.97	0.97	1	1	1											
whg 6.a	**All**	0.43	0.73	0.70	0.81	0.88	0.82	0.90	1										
	F	0.44	0.89	0.93	0.91	0.96	1	1	1										
	M	0.48	0.59	0.47	0.62	0.65	0.46	0.73	1										
	WGCSE	0	1	1	1	1	1	1	1										

Table 1 (b). Sample numbers by stock, sex and age for associated maturity in Table 1(a) above.

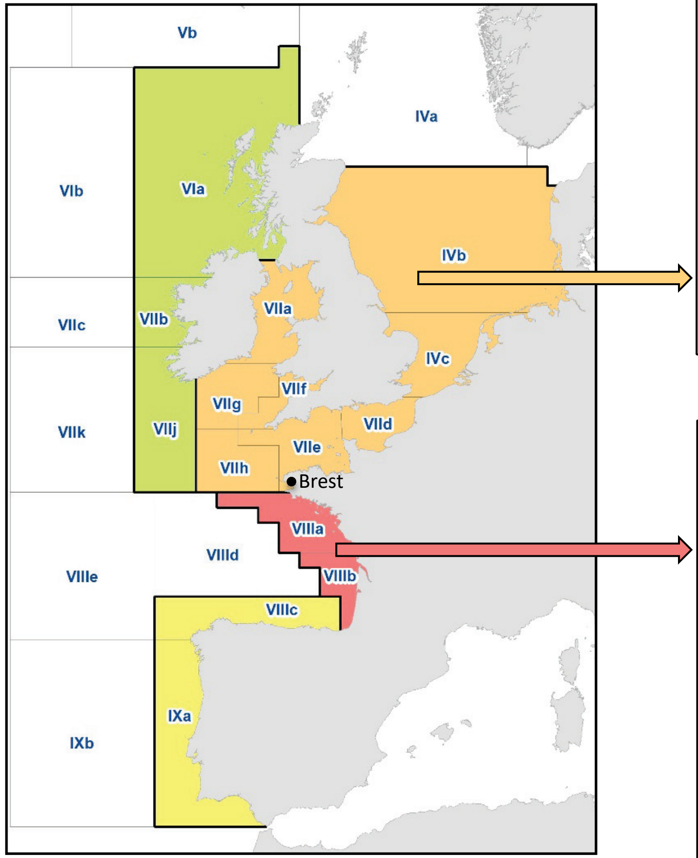
Stock	Sex/WG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
cod-7e-k	**All**	1642	1657	130	23	2	2	3											
	F	730	747	58	12	2	2	3											
	M	837	903	72	11														
had-7b-k	**All**	42	1170	2026	1323	508	256	142	89	36	17	4	1	1					
	F	20	462	1148	784	300	159	98	58	21	13	4	1						
	M	17	555	870	537	208	96	44	31	15	4			1					
had-scow	**All**	129	476	397	302	282	156	64	47	32	8								
	F	55	255	240	201	196	119	52	36	25	7								
	M	63	219	157	101	86	37	12	11	7									
mgw-78	**All**	54	1217	1960	1399	886	619	387	260	191	156	140	114	60	53	44	30	24	9
	F	32	593	1200	974	631	428	239	178	153	133	135	107	58	53	44	29	24	9
	M	21	618	748	424	255	191	148	82	38	23	5	7	2			1		
ple-7	**All**	28	511	1304	972	654	296	164	93	38	25	10	6						
	F	13	225	745	564	430	182	108	52	24	17	9	5						
	M	14	261	533	395	218	114	55	40	14	8	1	1						
sol-7	**All**	2	71	620	911	597	421	297	216	157	87	66	55	46	23	13	12	9	8
	F	2	43	511	767	494	284	176	102	83	41	22	26	24	10	8	8	4	5
	M		23	108	143	102	136	120	114	73	44	43	29	22	13	4	4	5	3
sol 7.fg																			
whg-7b-k	**All**	1257	1270	790	349	116	26	4	2										
	F	577	723	430	186	60	10	2	1										
	M	629	544	360	163	55	16	2	1										
whg-scow	**All**	198	385	384	252	132	43	11	3										
	F	94	208	224	163	97	26	5	2										
	M	103	177	160	89	35	17	6	1										

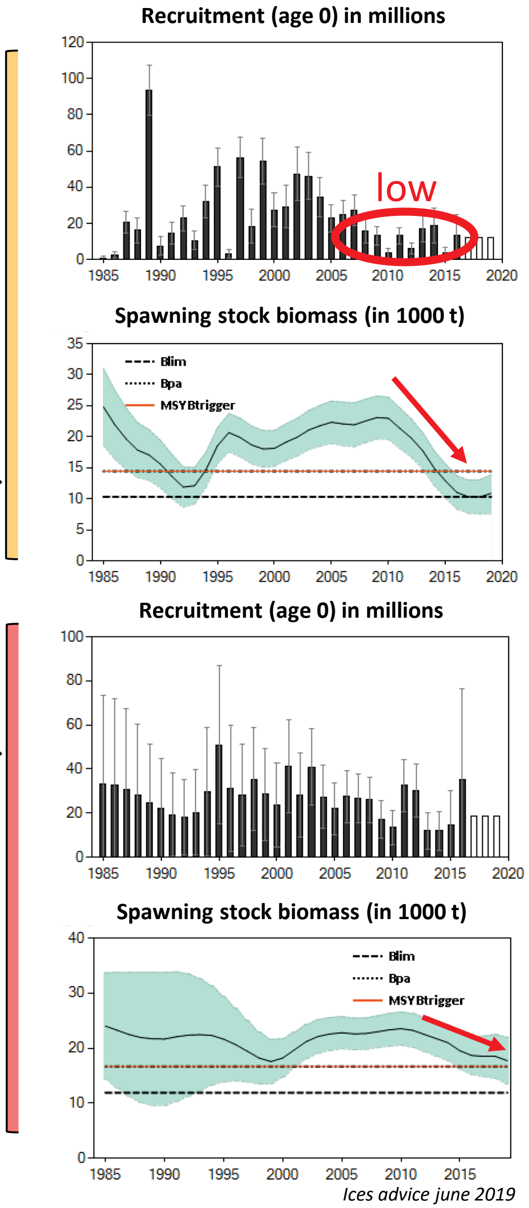


Inferring fish population structure and connectivity by the combination of individual markers: application to the European seabass

Mathieu Woillez, Chloé Dambrine, Martin Huret, Pierre-Alexandre Gagnaire, Françoise Daverat, Emilie Le Luherne, Hélène de Pontual

The European seabass





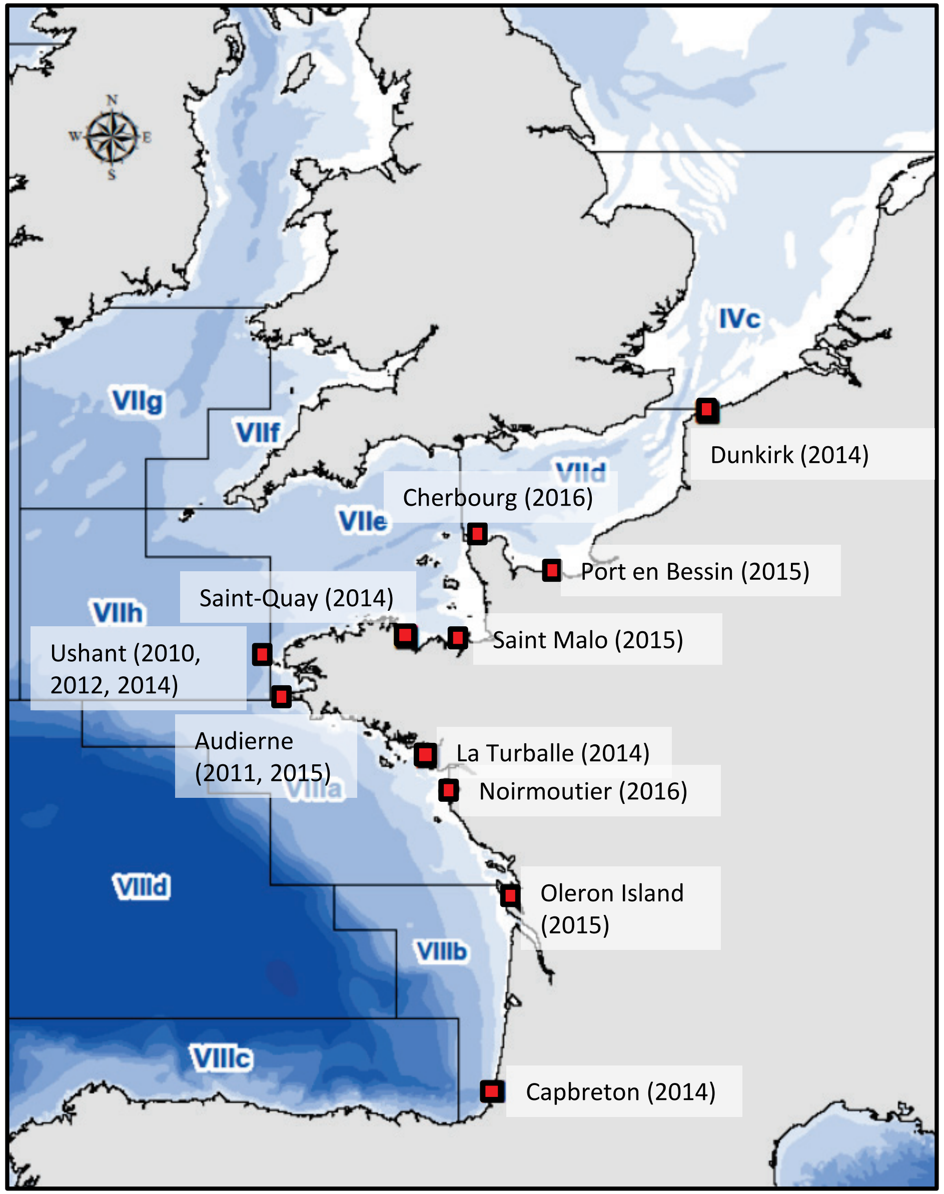
- A strong socio-economic weight in France : professional and recreative fishing

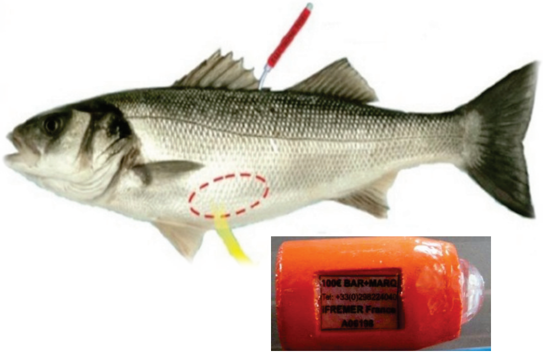
- Decreasing trends for two seabass stocks
- Northern stock is in a worrying state
  - High fishing pressure
  - Series of low recruitments
- Management measures since 2015

- **Knowledge gaps in the population structure and connectivity** → consequences on its actual states and its management

Ifremer

Individual markers

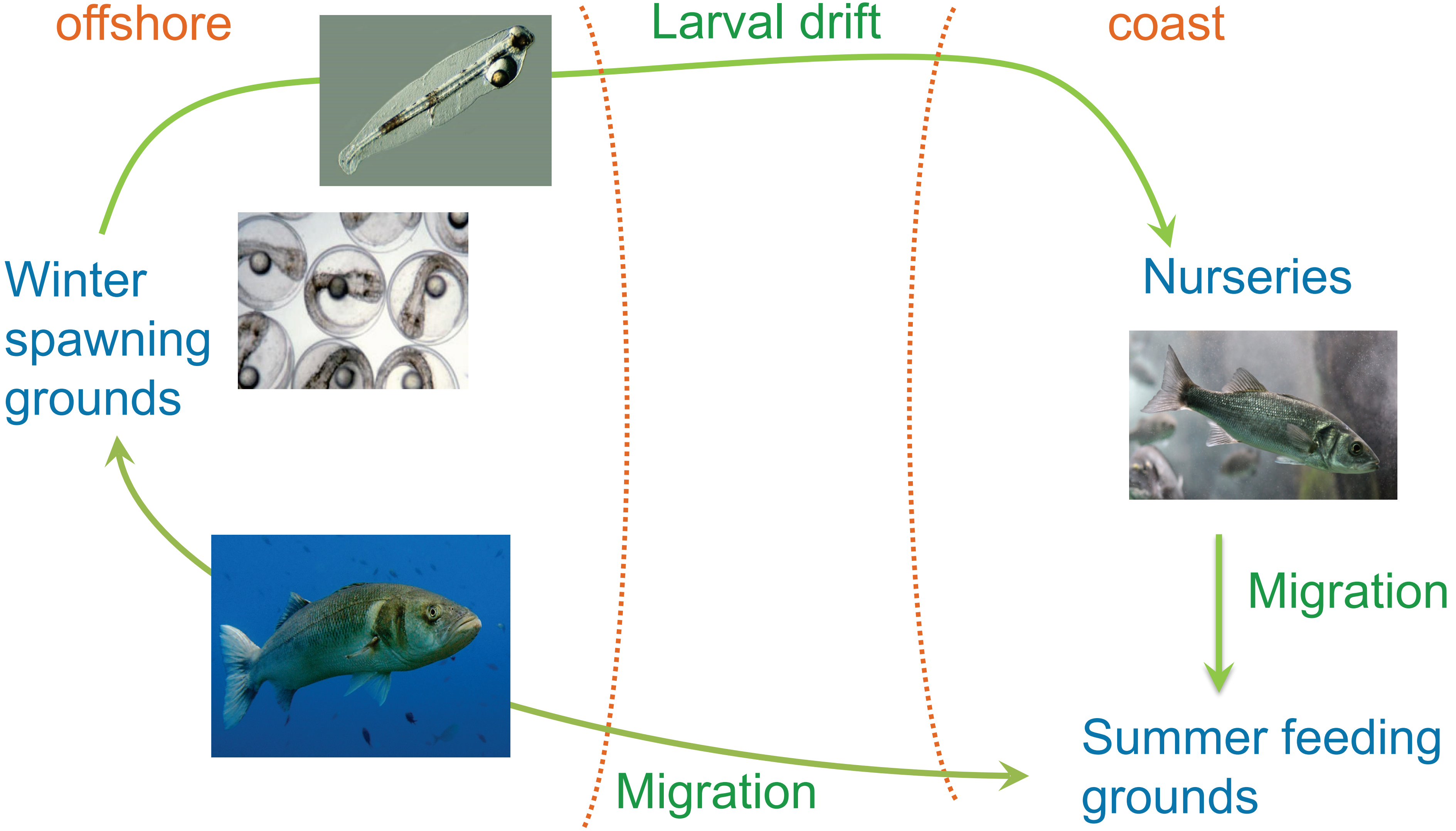




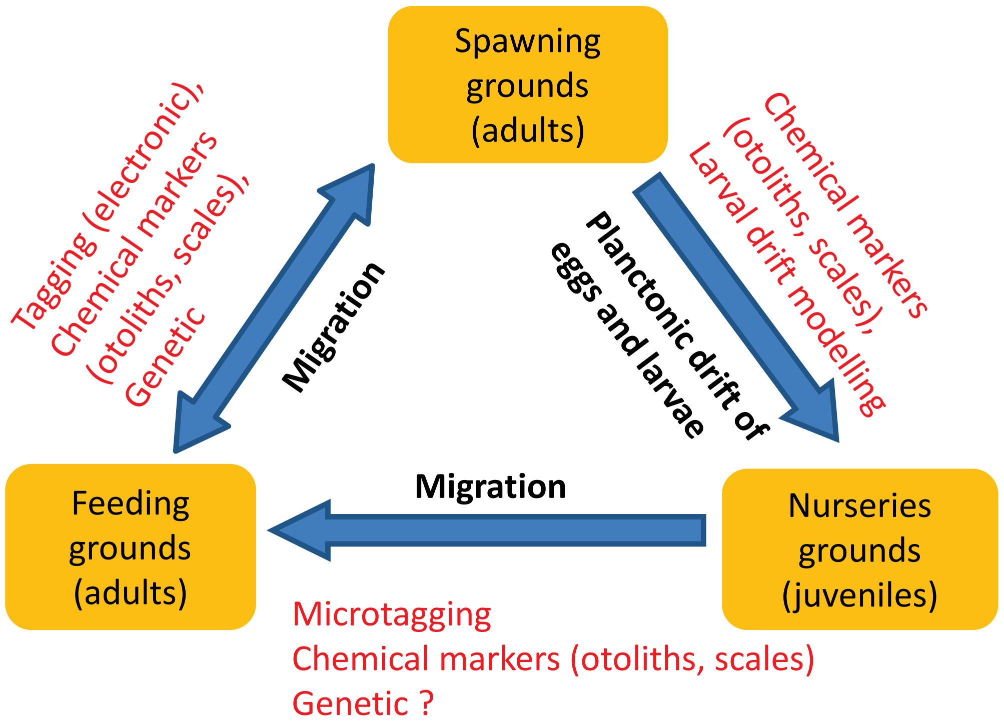
Project	Year	Nb tagged	Nb returned	%
Parc naturel marin Iroise	2010-2012	246	40	16
BARGIP	2014-2016	1220	460	37
All	2010-2016	1466	500	34

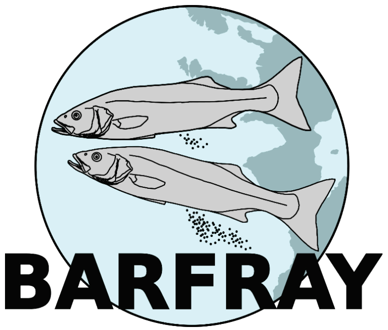
- Otoliths and scales at recapture when available

Seabass life cycle



Research objectives



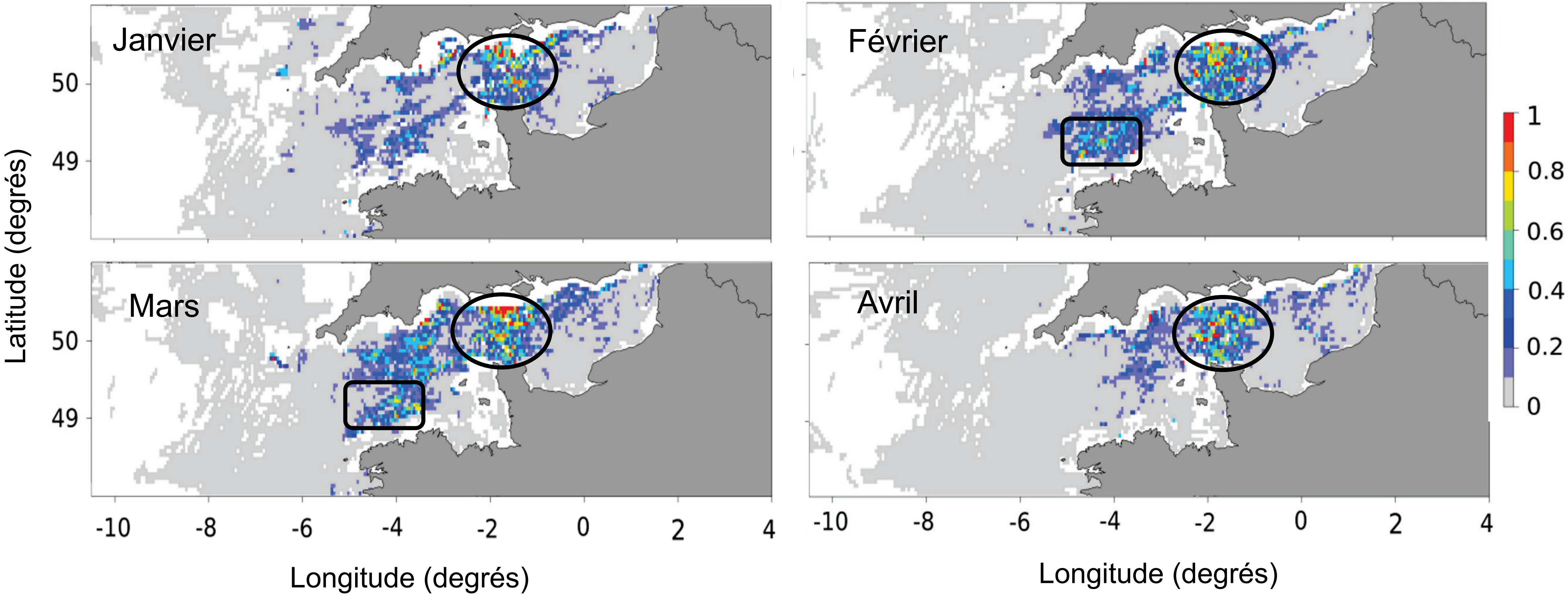


Identify the main spawning grounds and understand the dynamical relationship with the nursery and the adult feeding grounds (understand the spatio-temporal dynamics of the population)

1. **Identification and characterisation of the main spawning grounds and the relationship with nurseries**
2. **Functioning of the spawning grounds and relationship with feeding grounds**
3. **Feeding grounds diversity contributing to man spawning grounds**

Monthly mapping of spawning grounds

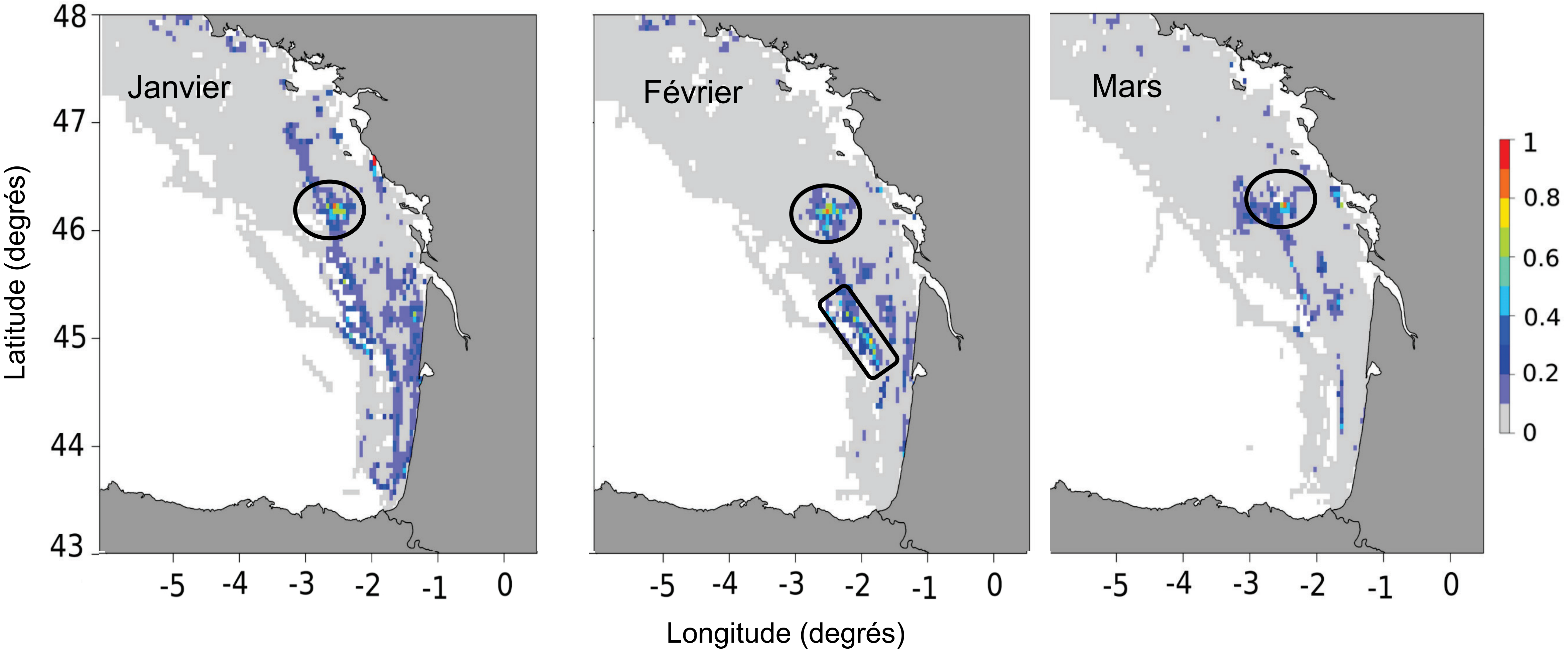
In the English Channel



Dambrine, C., Woillez, M., Huret, M., & De Pontual, H. Characterising Essential Fish Habitat using spatio-temporal analysis of fishery data: A case study of the European seabass spawning areas. *Fisheries Oceanography*. https://doi.org/10.1111/fog.12527

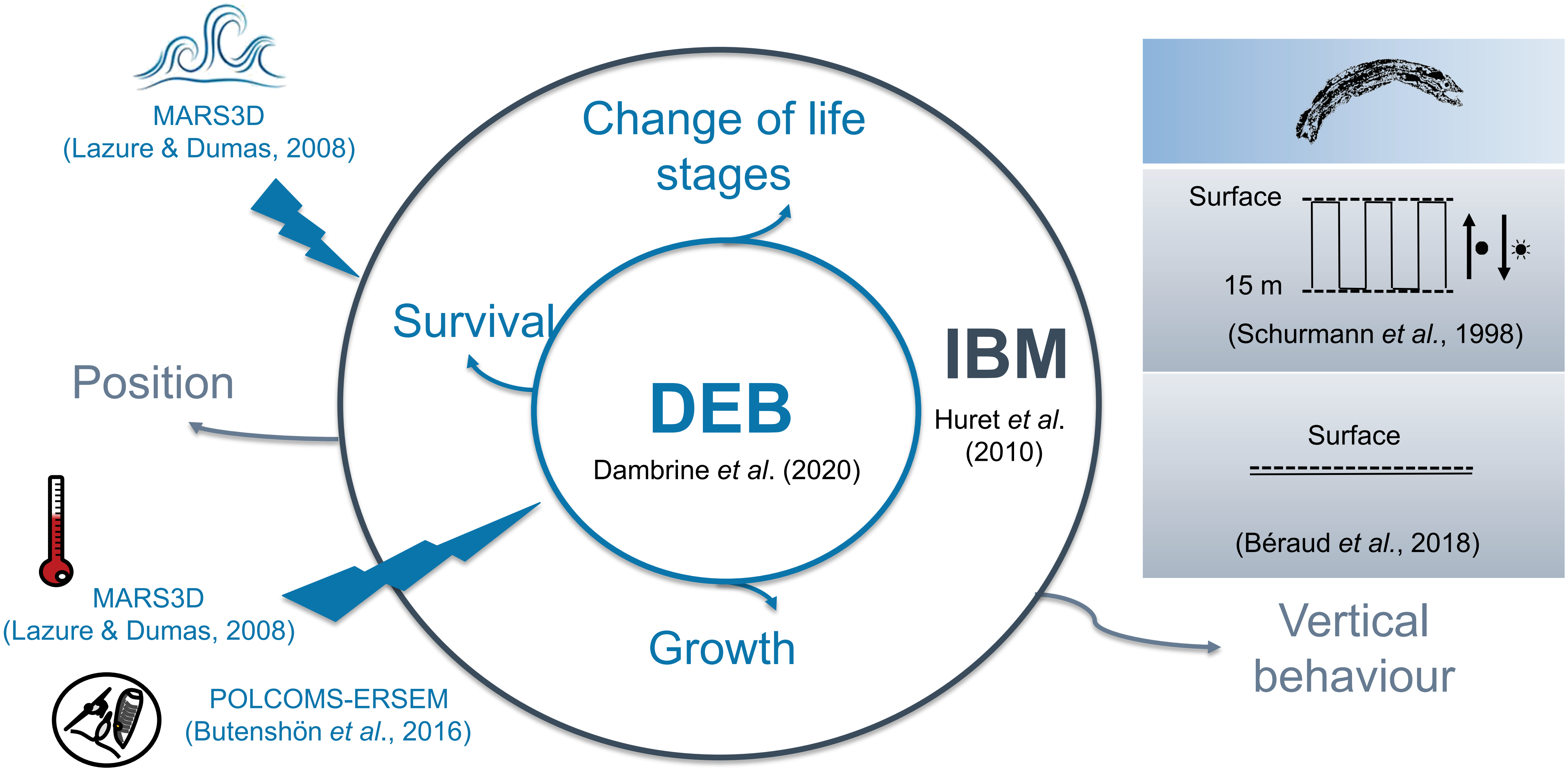
Monthly mapping of spawning grounds

In the Bay of Biscay



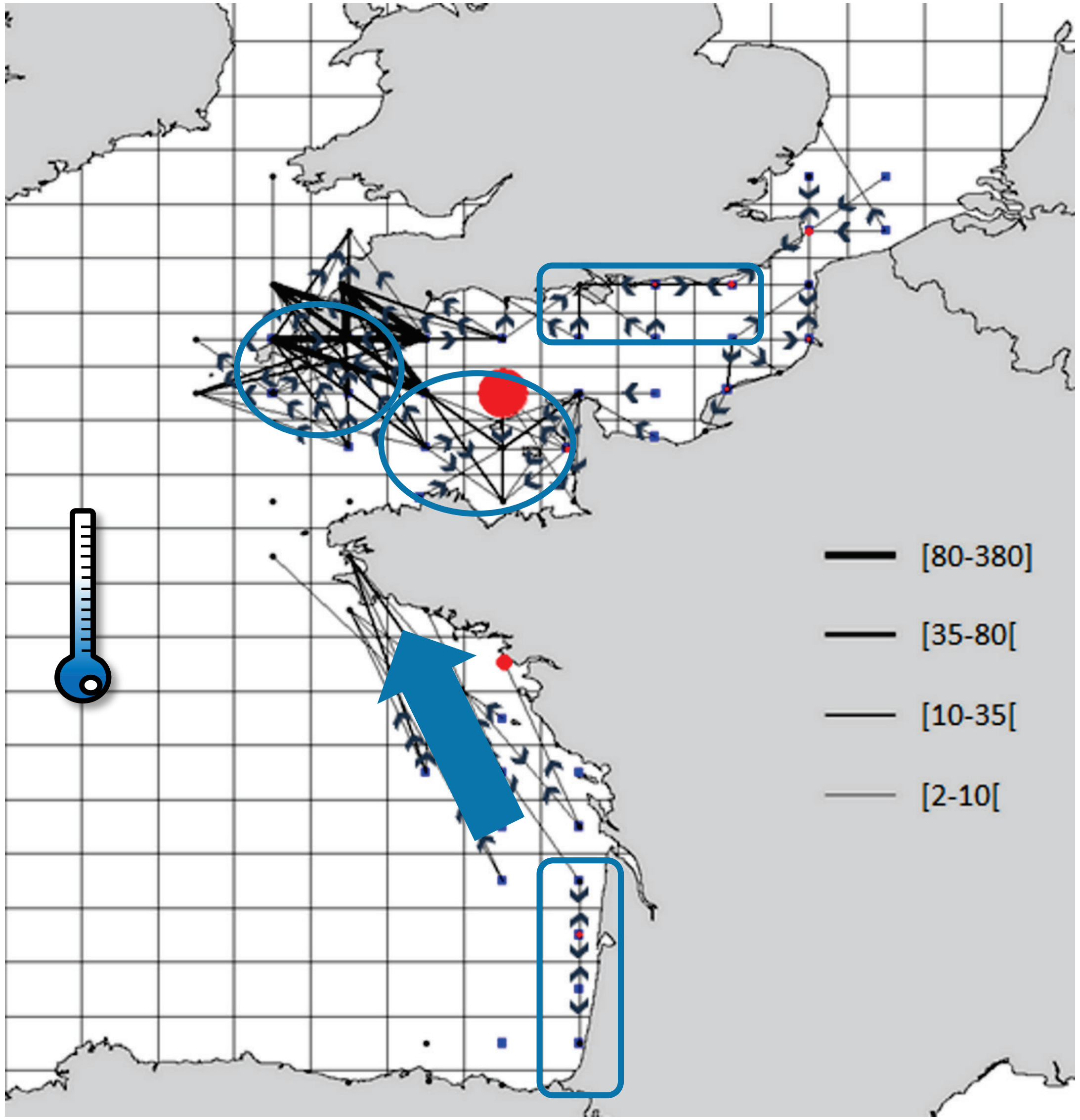
Dambrine, C., Woillez, M., Huret, M., & De Pontual, H. Characterising Essential Fish Habitat using spatio-temporal analysis of fishery data: A case study of the European seabass spawning areas. *Fisheries Oceanography*. https://doi.org/10.1111/fog.12527

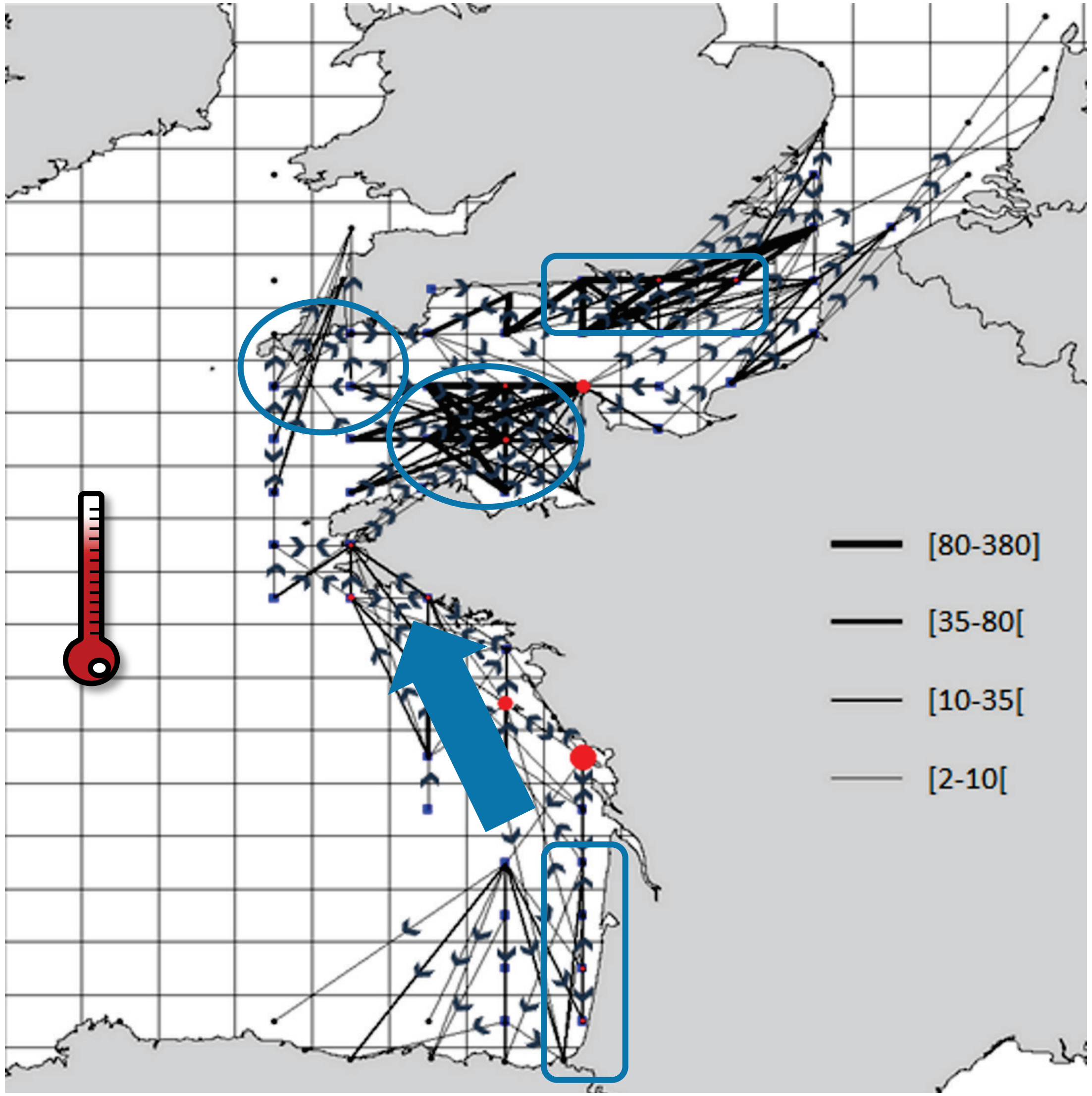
Modelling egg and larvae drift



Dambrine, C., Huret, M., Woillez, M., Pecquerie, L., Allal, F., Servili, A., & De Pontual, H. (2020). Contribution of a bioenergetics model to investigate the growth and survival of European seabass in the Bay of Biscay–English Channel area. *Ecological Modelling*, *423*, 109007. https://doi.org/10.1016/j.ecolmodel.2020.109007

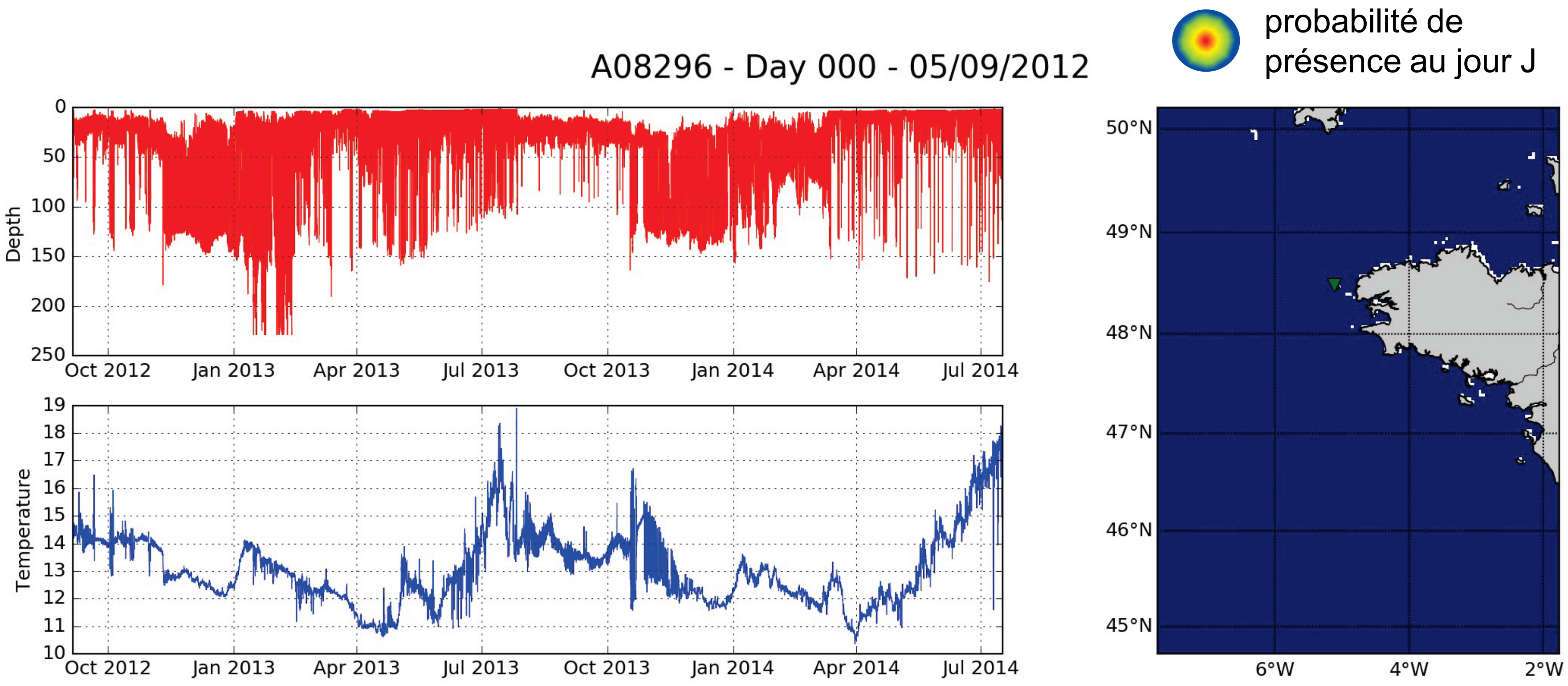
Identify important spawning-nursery pairs





Dambrine, C., Huret, M., Woillez, M., & De Pontual, H. (submitted). Connectivity patterns between spawning and nursery areas of European seabass in the Northeast Atlantic using a Lagrangian biophysical IBM. ICES journal of marine science

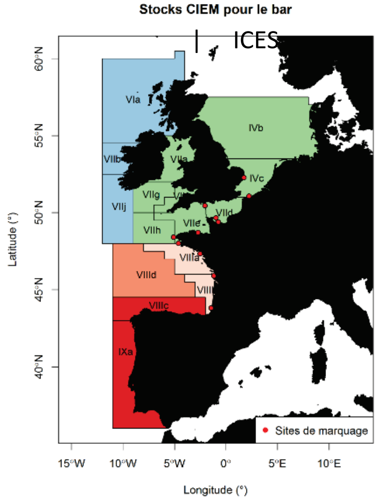
Geolocation model: trajectory reconstruction exemple



- A fish tagged in summer in Ushant
- Migrates the following winter to the Bay of Biscay
- Returns the following summer to the Iroise Sea
- Migrates again the 2nd winter in the Bay of Biscay

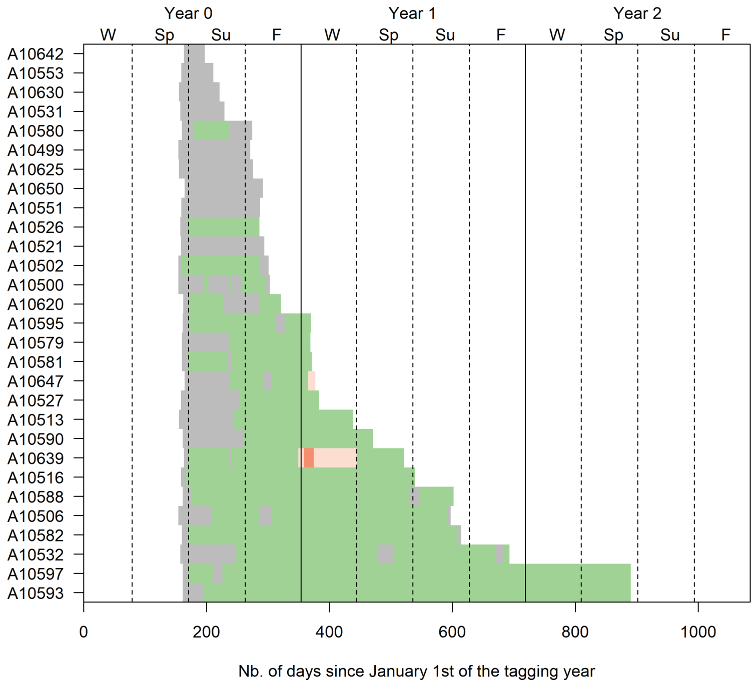
Mouvements are not random

Eastern English channel

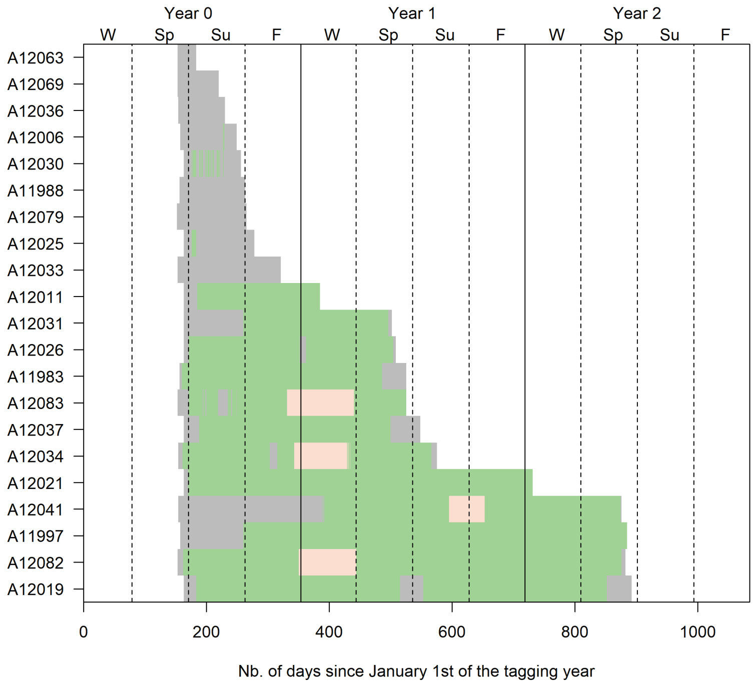


- Migration occurred mainly in the northern area
- Fidelity occurrences to summer feeding and winter spawning grounds

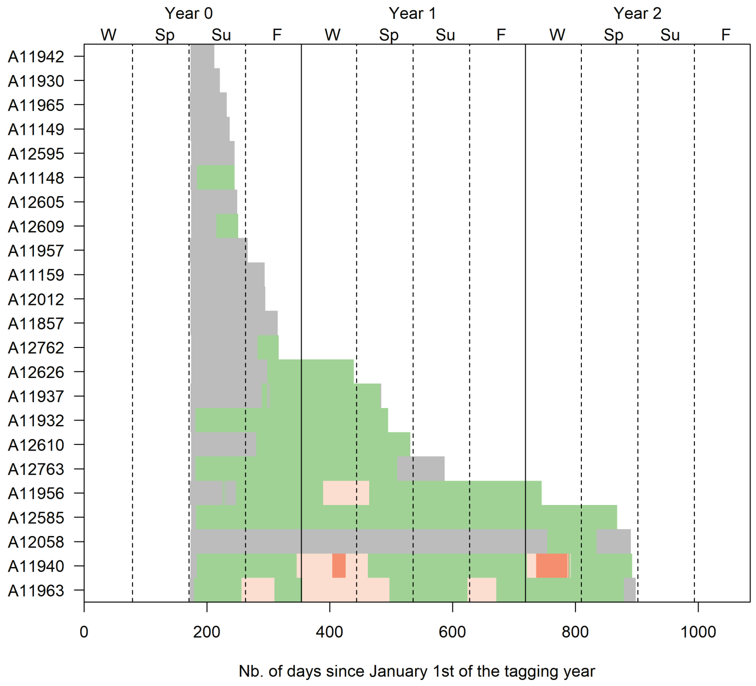
Dunkerque



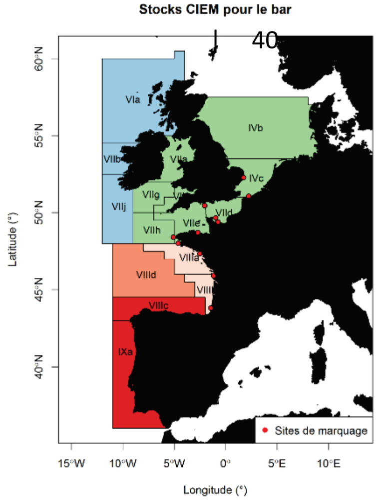
Port-en-Bessin



Saint-Vaast-la-Hougue

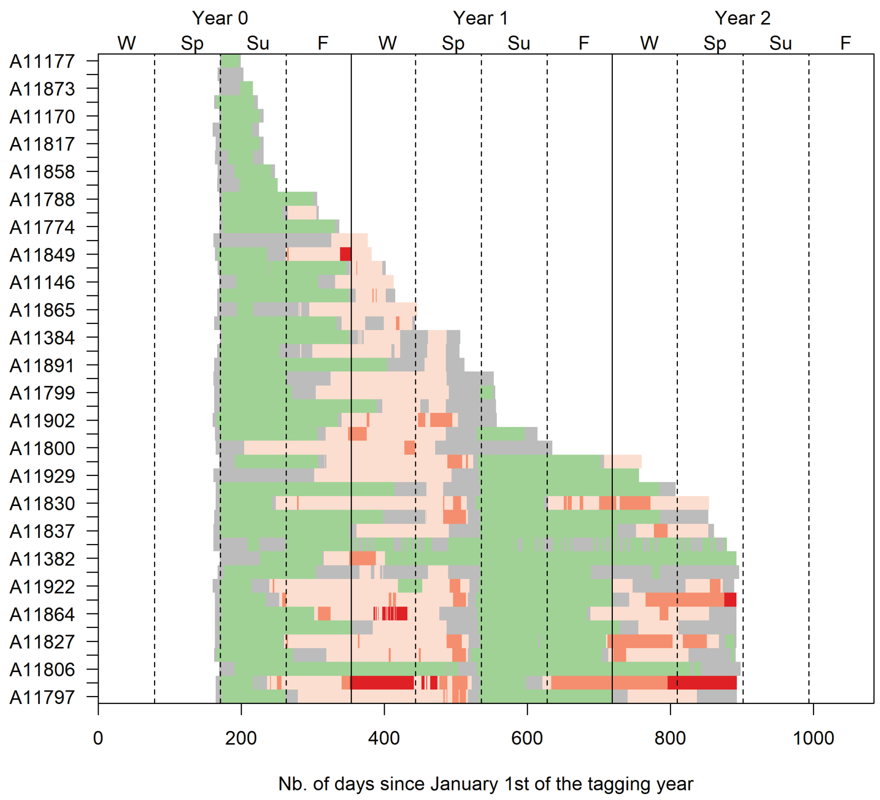


Western English channel and West of Brittany

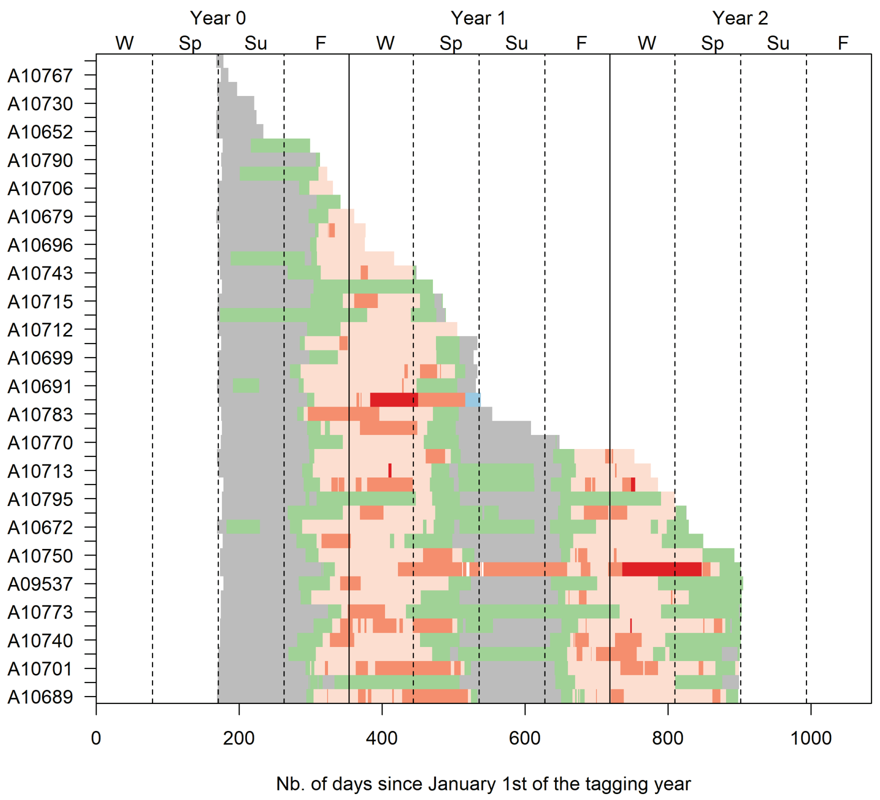


- Different migration strategies (stay in the north or migrate towards south)
- Numerous occurrences of fidelity to summer feeding and winter spawning grounds
- Stock mixing area

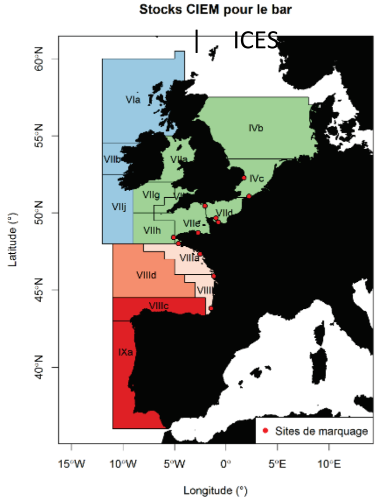
Audierne



Saint Quay Portrieux

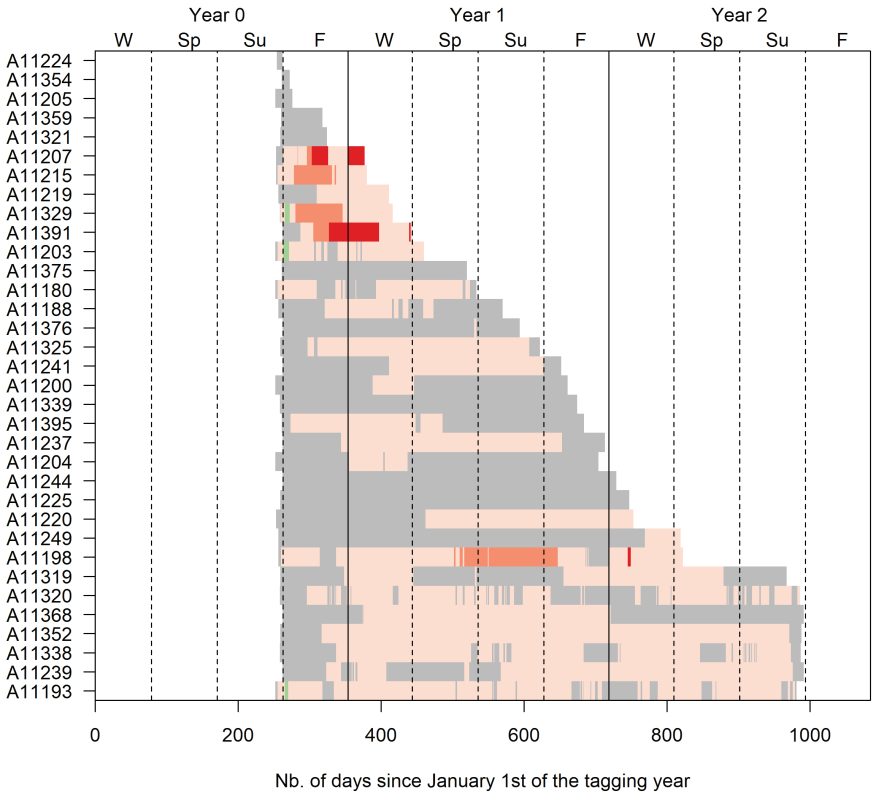


North of the Bay of Biscay

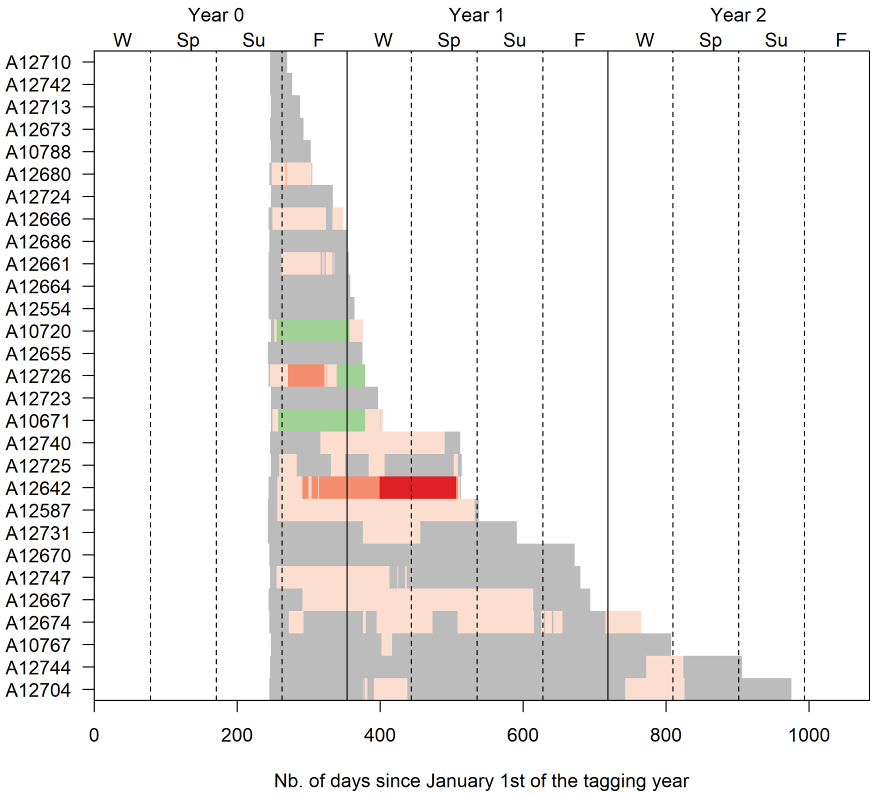


- Majority of seabass stay in the Bay of Biscay area
- Numerous occurrences of fidelity to summer feeding and winter spawning grounds

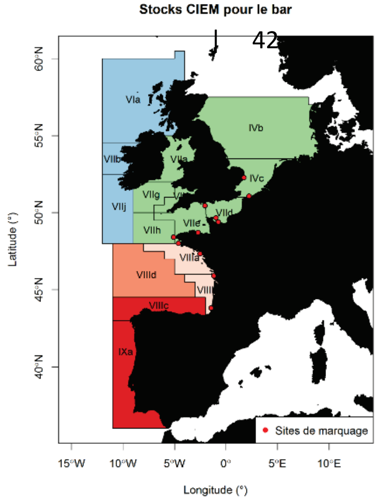
La Turballe



Noirmoutier

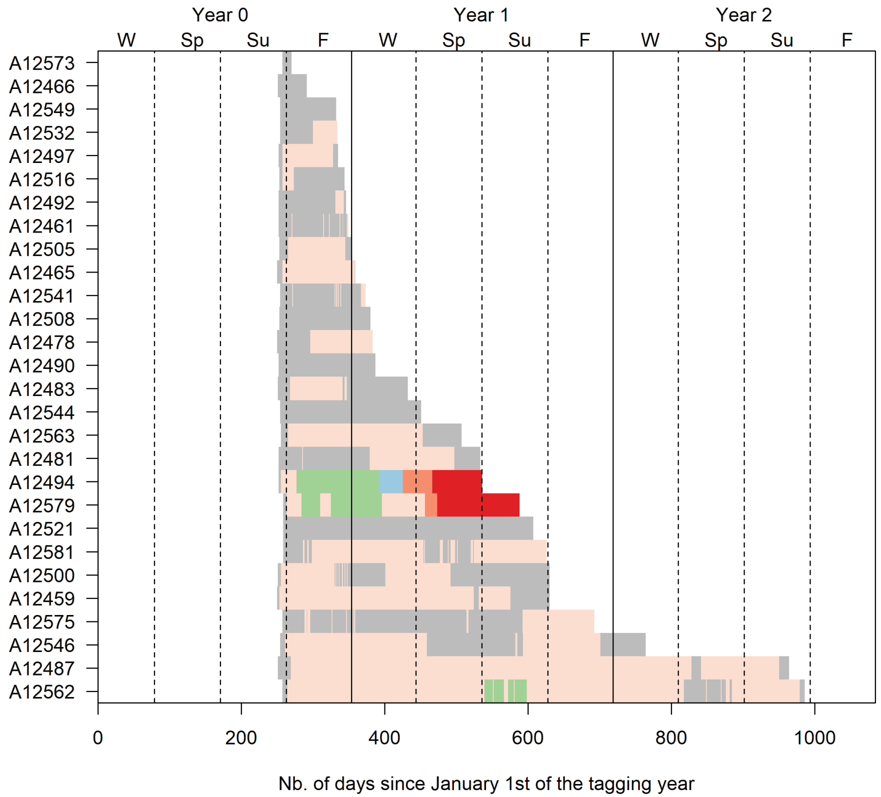


South of the Bay of Biscay

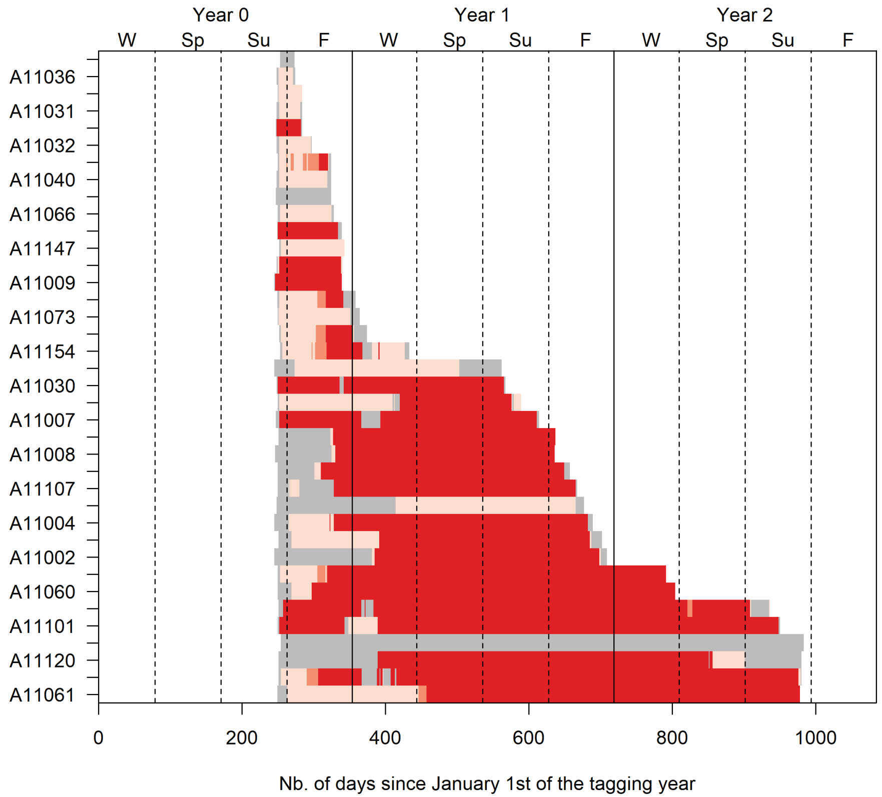


- Numerous occurrences of residency phenomenon
- Migration in the Bay of Biscay and towards Iberic peninsula
- Stock mixing area in Capbreton

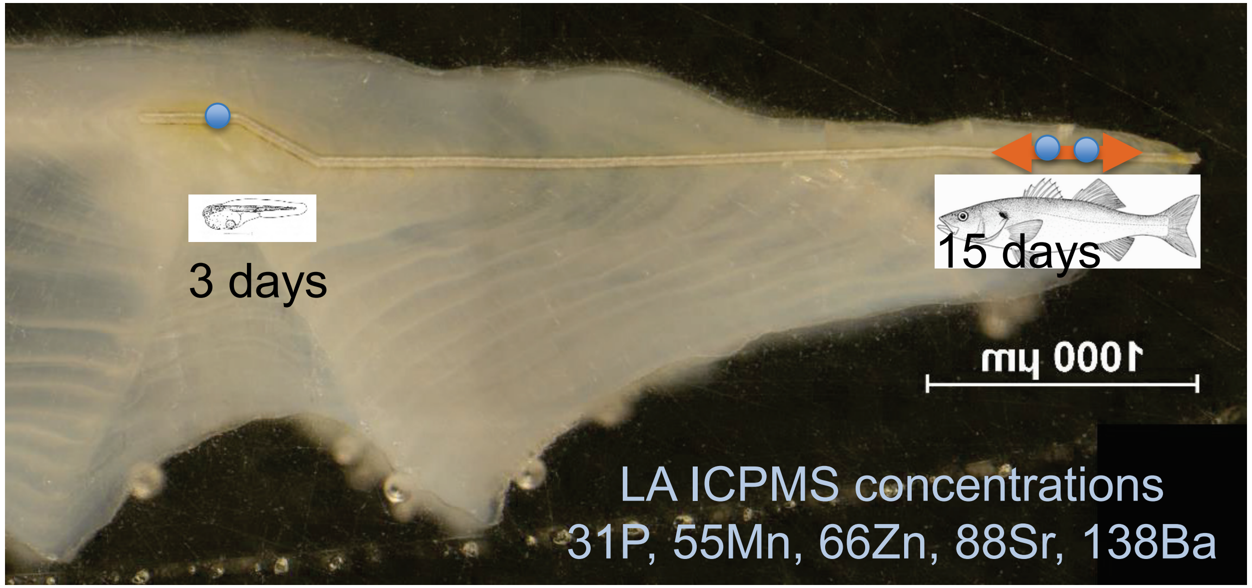
L'Ile d'Oléron



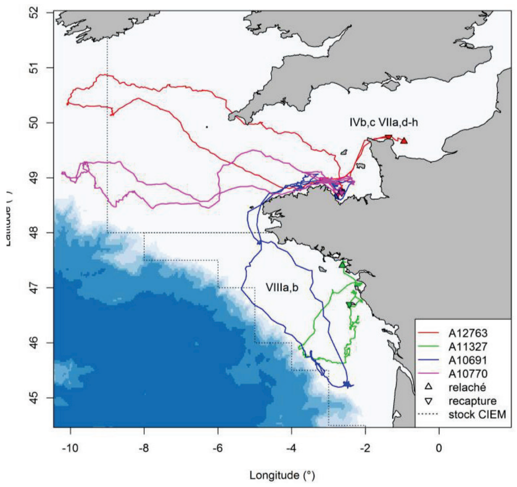
Capbreton

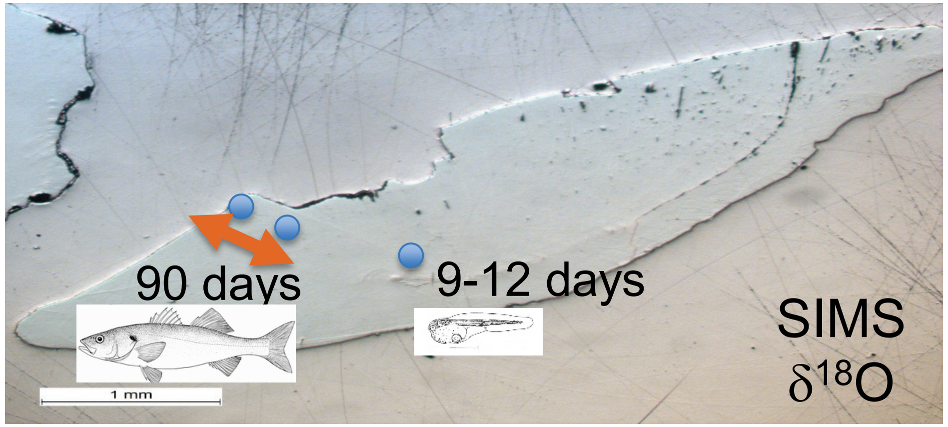


Strategy of data coupling



48 seabass (2 winter tracked per DST)

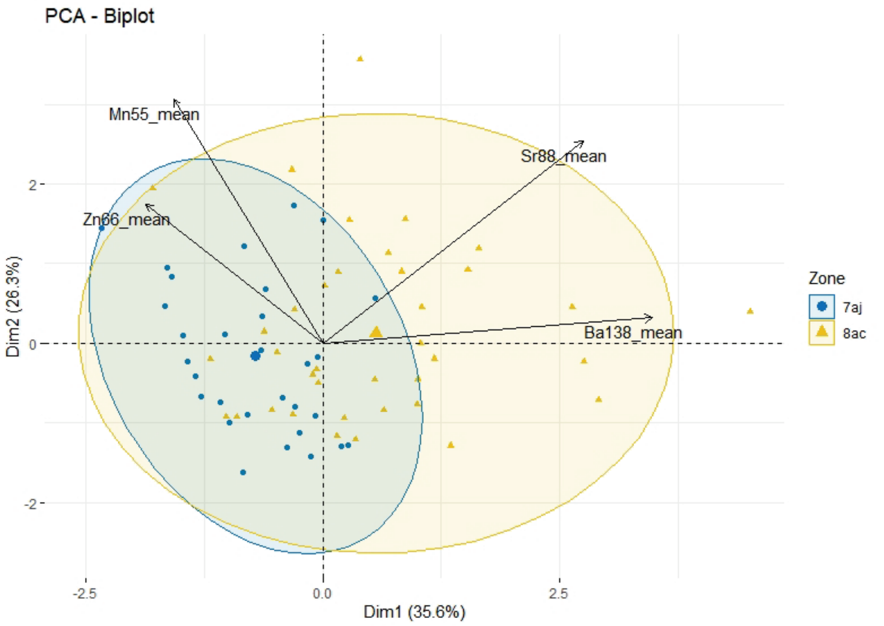


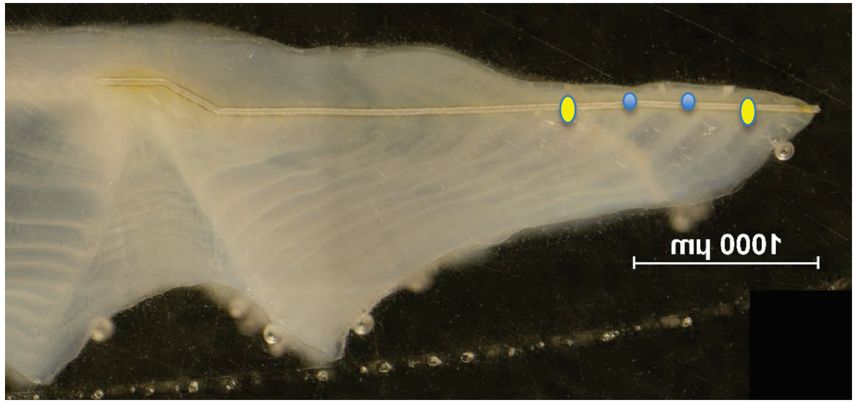


→ elementary spawning ground signature BOB or EC ?

→ Oxygen isotopes ($\delta^{18}O$) → T°C ?

Results of adult fidelity to spawning grounds





Random Forest classification model ^{55}Mn, ^{66}Zn, ^{138}Ba

Out of Bag estimate of error rate: 19.12%

Confusion matrix

	EC	BOB	class.error
EC	24	6	0,20
BOB	7	31	0,18

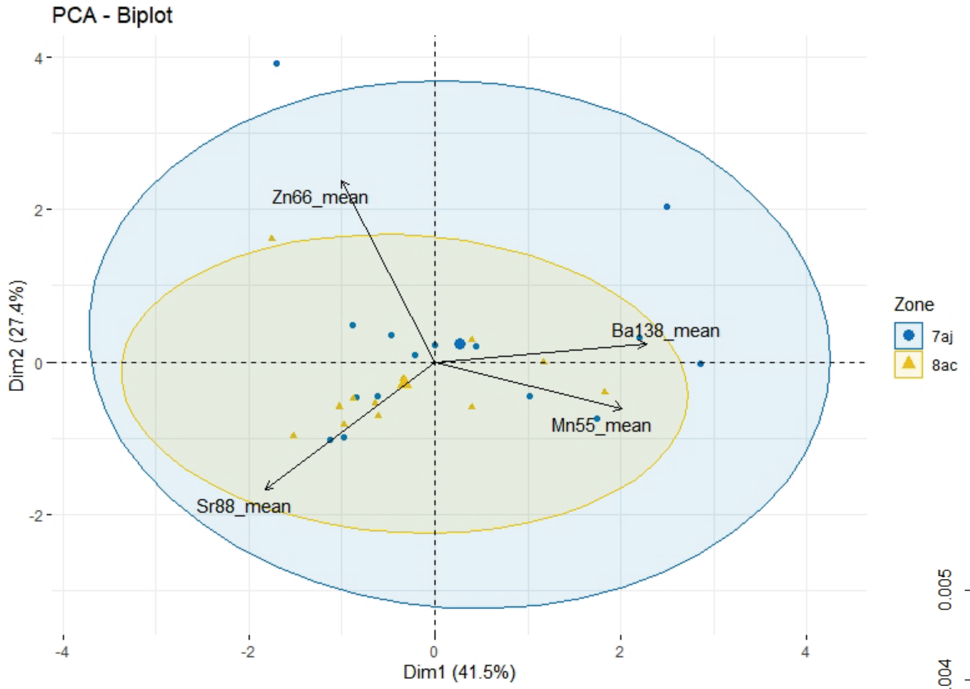
Reallocation of winter spawning grounds not tracked by DSTs with this classification model :

Fidelity 27 seabass/35 = 77,14 % of fidelity to spawning ground
Of which 12 seabass attributed to BOB, and 15 seabass attributed to EC.

Faithful to EC tagged at AD(1) CH(2) DK(3) PB(4) SB(4) SM(1)

Faithful to BOB tagged at AD(1) CB(4) LT(2) NO(2) OL(2) SB(1)

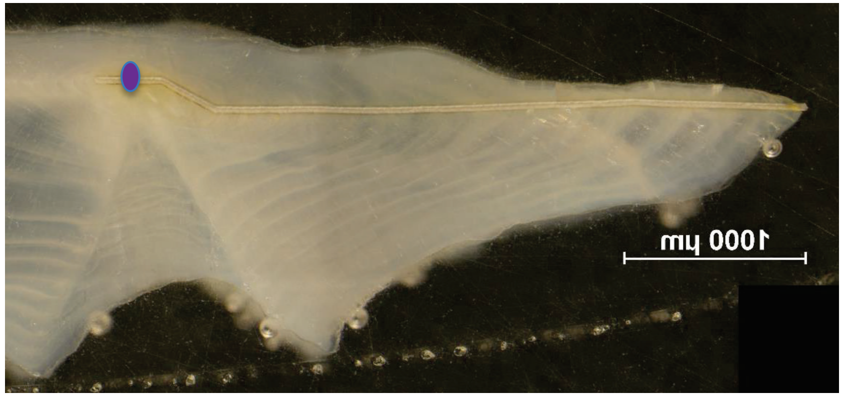
Larval phase analysis (homing?): elementary signature

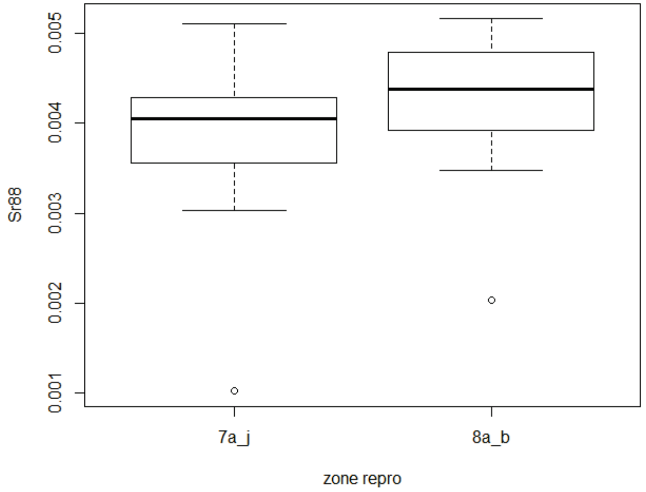


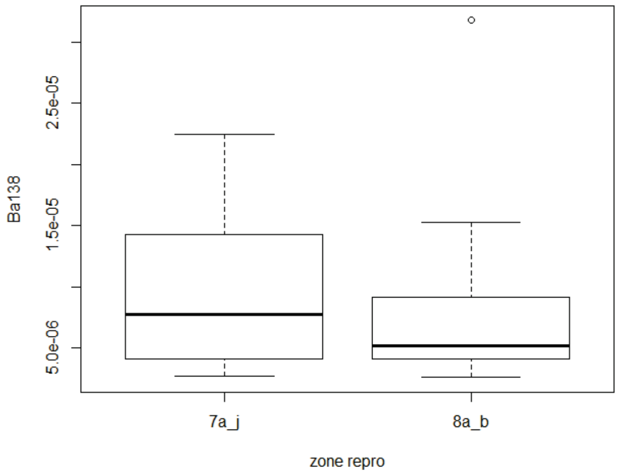
Do fish loyal to a spawning ground have a larval signature characteristic of their ground ?

Results not conclusive (Random forest model fails to reallocate larval elemental signatures because chemical composition varies between stages (ontogenic effect).

There are differences but not significant

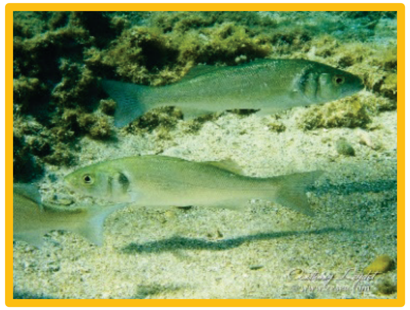




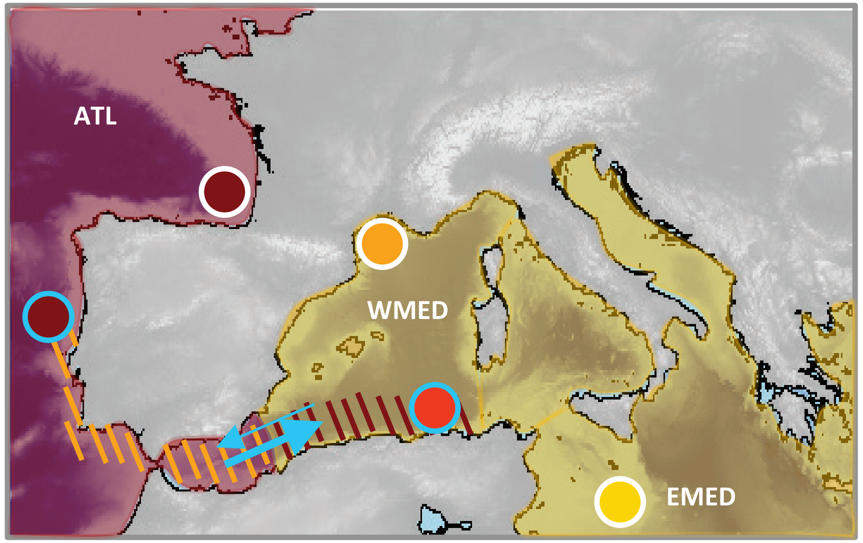


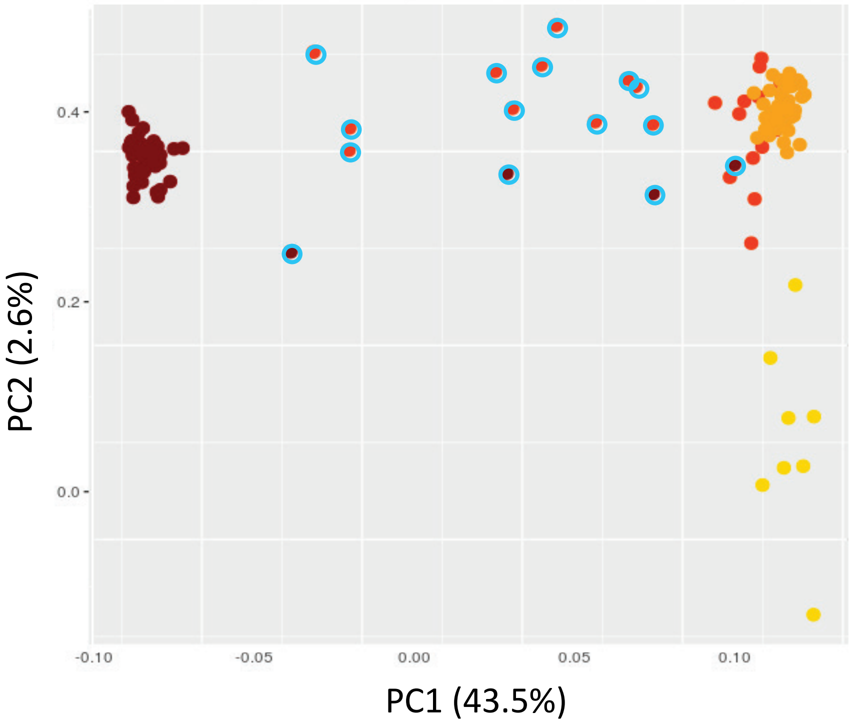
Consequences of the fidelity to essential fish habitats on the genetic structure

Atlantic



Mediterranean

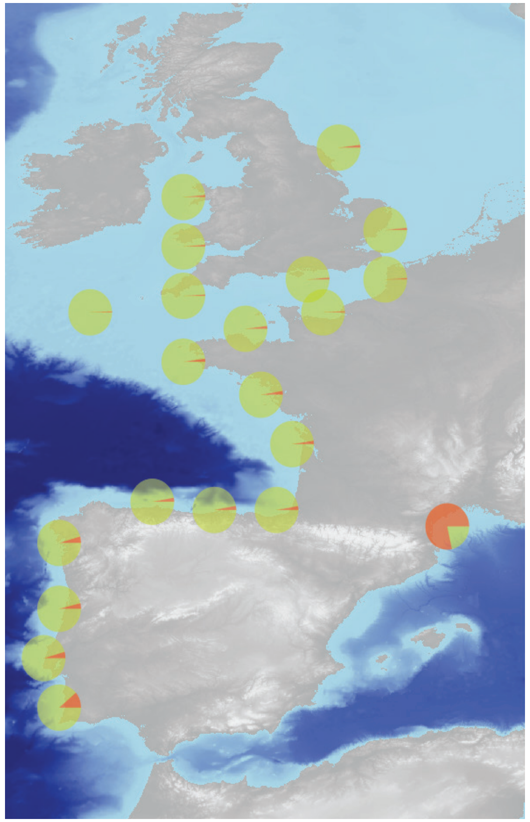


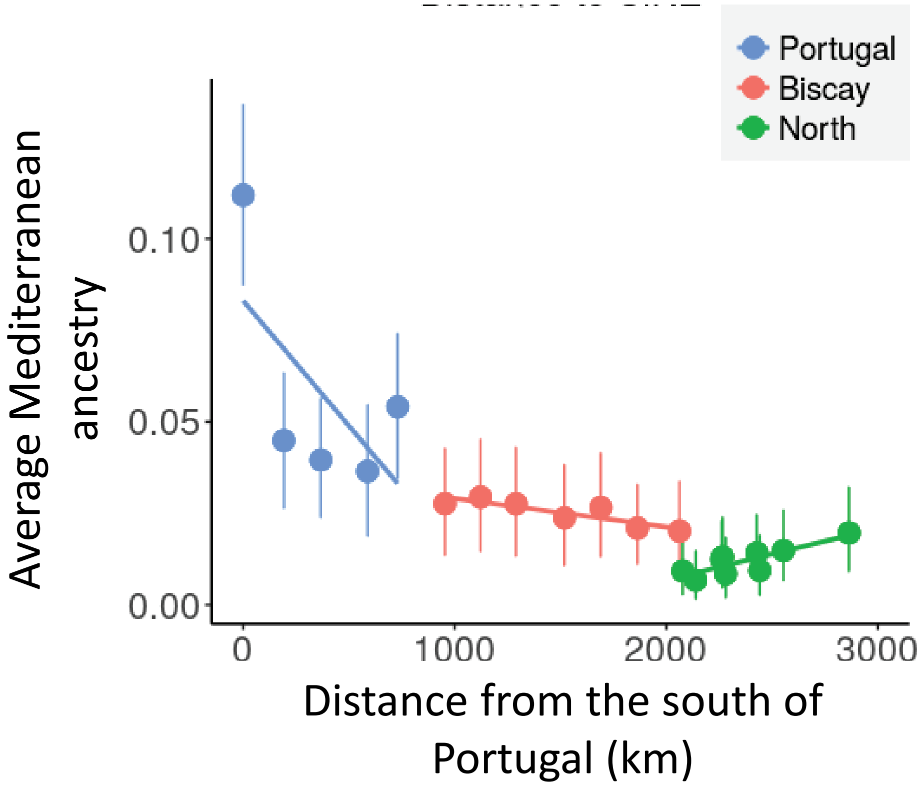


- **Two divergent evolutionary lineages**
- Contemporary gene exchange by **hybridisation and introgression**

Tine *et al.*, Nature Comms., 2014

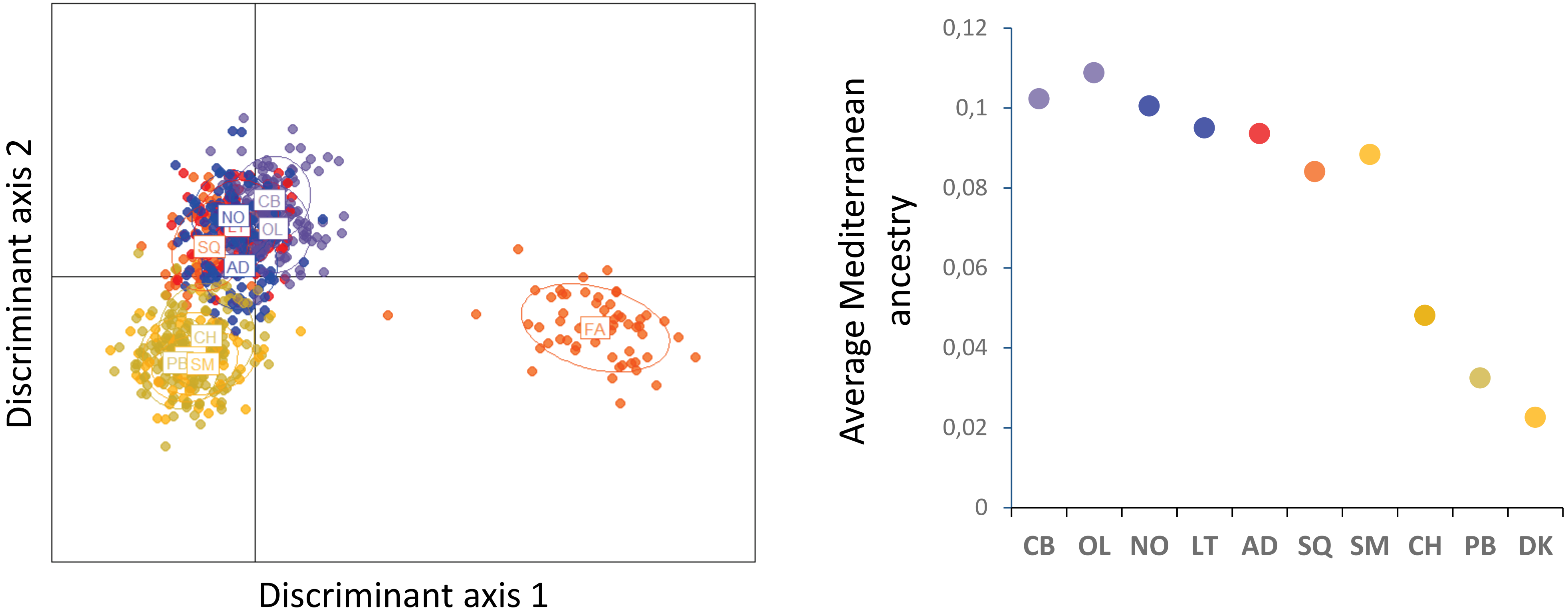
- **Two discontinuities in the Mediterranean gradient** indicate **local barriers to connectivity**



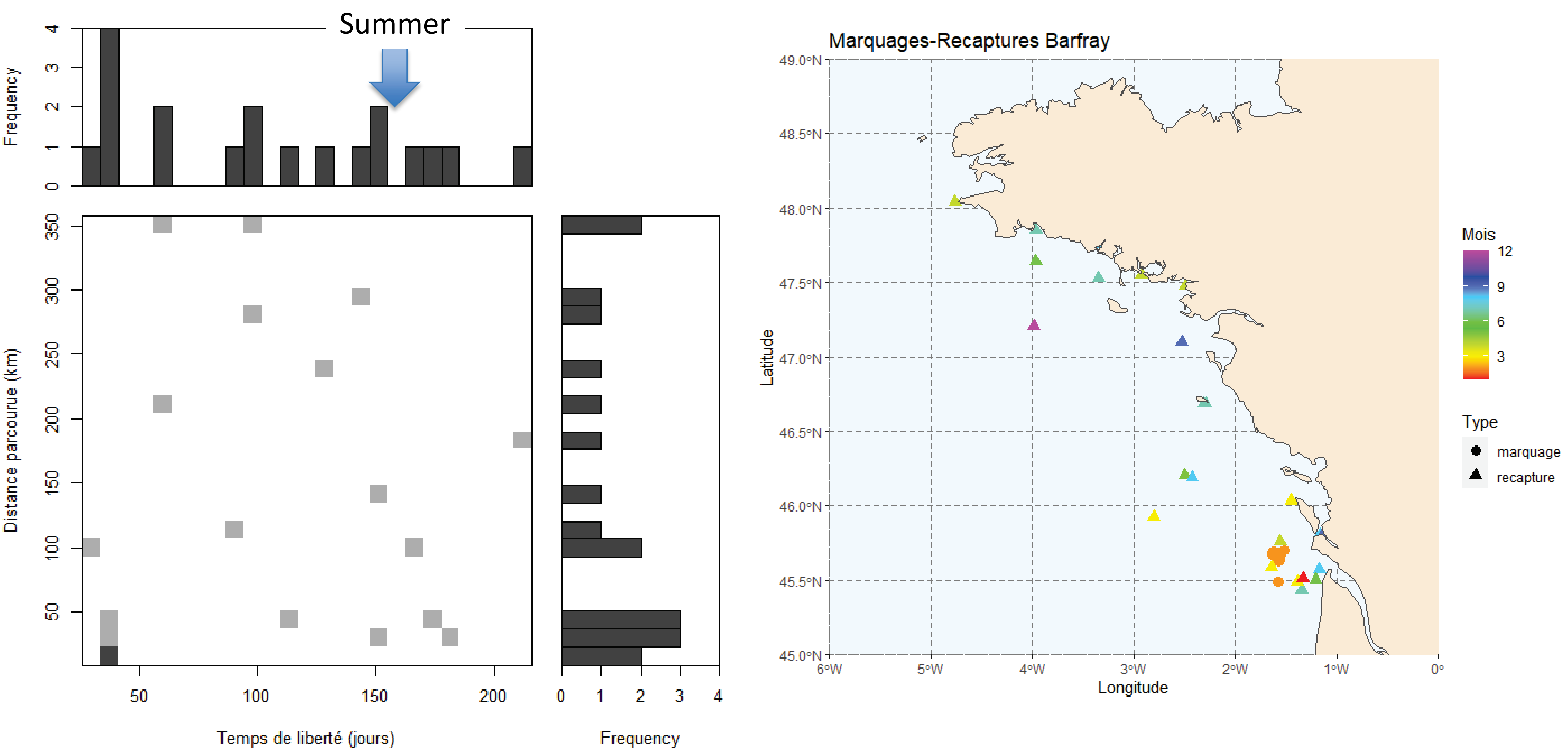


Robinet *et al.*, Mol. Ecol., 2020

- **Spatial genetic structure** revisited using **50,000 SNPs** in 770 individuals from 11 populations
- Confirmation of a **zone of genetic discontinuity** between the **Bay of Biscay and East Channel** populations
- Assumes **demographic independence of the two stocks**

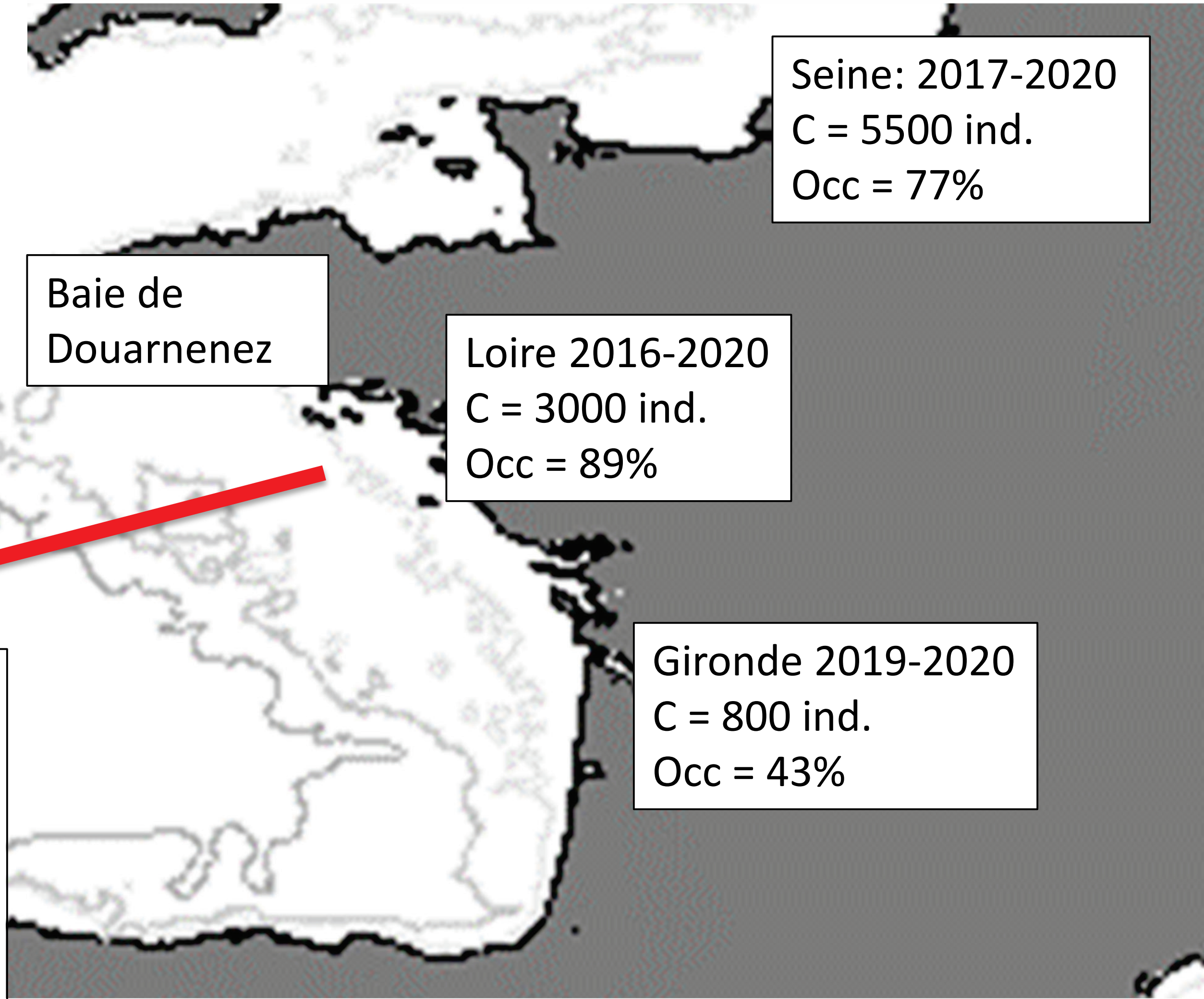


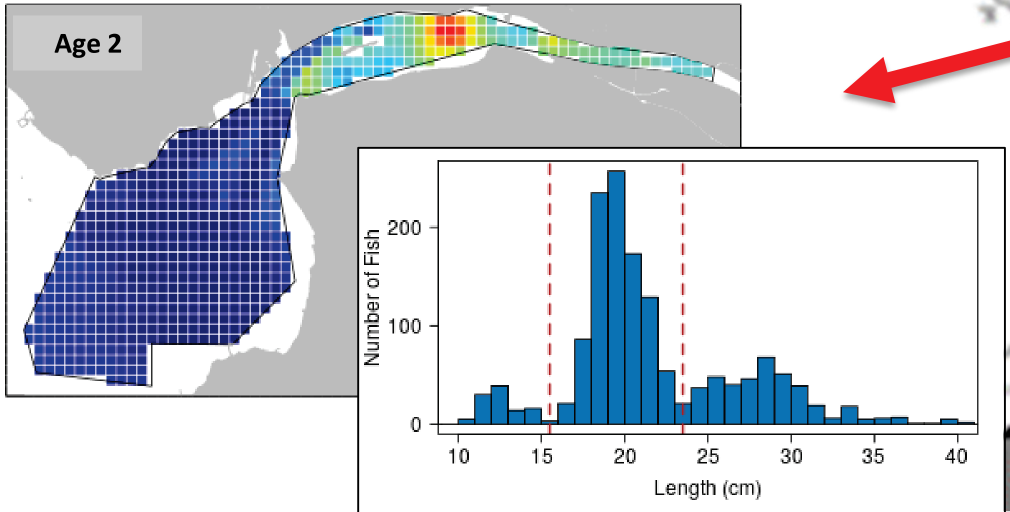
Conventional tagging pilot study on spawning seabass



New survey time-series of abundance indices for pre-recruited seabass

- Small GOV Trawl (7m x 2,2m)
- Random stratified sampling (75-92 stations)
- 3 estuaries and 1 coastal bay surveyed to estimate demersal fish abundance
- Manuscript in preparation on **estimating abundance indices of juvenile fish in estuaries using Geostatistics: an example of European Seabass** (*Dicentrarchus labrax*)





Improved knowledge of the ecology of the population

Larval connectivity

- Connectivity patterns showing a relative separation between Eastern and Western Channel. Results consistent with published British work.
- West Brittany supplied with larvae from the Gironde to the Western Channel.
- Strong interannual variation (warm vs. cold year) which could explain variations in recruitment. Identification of important spawning-nursery pairs

Adult migrations

- Behavioral differences (sedentary individuals vs. migratory behavior)
- Migratory strategies: confirmation of fidelity to spawning and summer feeding grounds for a majority of individuals.
- Convergence of trajectometry results/basic otolith signatures (environmental proxies)

Drivers of reproduction migration

- Natal homing? Or learning process?

Population structure

- Geo-genetic correlations indicating discontinuities in the Cotentin Peninsula & Iberian Peninsula (but few individuals)
- 2 areas of mixing of stocks (North Brittany on the one hand and South Bay of Biscay on the other).

Impacts on ICES assessment and management

Tools and knowledge to **test conservation measures** (spawning/nursery grounds)

Results questioning the current functioning of **ICES stock assessment models**:
- Independent management of the northern and southern stocks (exchange at unknown rate)
- Relevance of the 48th parallel delimitation

→ **Work development and need for a benchmark to:**
- Evaluate the consequences of a change in stock delimitation or exchanges between stocks
- Include the new survey time-series of pre-recruitment abundance indices

Limits: Need of English and Spanish data (larval connectivity, genetic, etc.)

BARFRAY

NourDem

Thanks for your attention

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MINISTÈRE DE L'AGRICULTURE ET DE L'ALIMENTATION

Ifremer

FU2021 WGCSE WD Kriging 2013+2014

Jennifer Doyle

2021-05-10

Contents

Introduction

This markdown document contains the full kriging procedue for the FU2021 ground from 2013 to 2014. Reported abundance estimates for years 2013 - 2014 were calculated using Surfer programme and EVA gave the uncertainty estimate. For WGCSE 2021 it was decided to present this working document which uses RGeostats to krig the surface densities to provide abundance estimates for years 2013 to 2014. kriging is carried out using RGeostats package from MINES ParisTech - Fontainebleau - France. Download here: http://rgeostats.free.fr/download.php

Marine Institute UWTV survey reports for this stock are available @ http://hdl.handle.net/10793/1657.

The Working Group on Nephrops Surveys (WGNEPS) is the international coordination group for Nephrops underwater television and trawl surveys within ICES @ https://www.ices.dk/community/groups/Pages/WGNEPS.aspx

In survey year 2013 only 60% coverage. From 2014 to 2020 100% coverage has been achieved for ground.

The 2013 abundance has been scaled up to the entire area since densities in the unsurveyed part of the ground were not significantly different in 2014. This approach was done for both Surfer and RGeostats kriging.

I am using R version 3.6.3 (2020-02-29). First we load the required packages.

```
rm(list=ls())

library(RODBC)
library(tidyverse)
library(lattice)
library(lubridate)
library(maptools)
library(mapplots)
library(sp)
library(reshape2)
```

```
library(captioner)
library(readxl)
library(knitr)
library(DataCombine)
library(lattice)
library(vioplot)
library("magrittr")
library(icesTAF)
library(RGeostats)
library(maps)
library(mapproj)
.Last.projection=list(active=F,projection="mean",parameters=NULL,orientation=NULL)
library(fields)
```

Now to check the versions of the different packages:

Package	Version
RGeostats	11.2.9
Rcpp	1.0.6
maps	3.3.0
mapproj	1.2.7
fields	11.6/,k,l/.

Extract the UWTV survey mean density estimates data

Back to top . The data is available only in MI SQL database and it is extracted as a data object. Data has been extracted from 2015 by sql server scripts. Prior to that it was local Access database queries transformed to csv file for use in Surfer. Data quality checks have show some minor differences in distance over ground (both in 2013 & 2014), burrow counts (2014 only) and station numbers (in 2014 two stations are not in sql server and these are zero density stations 221 & 269).

```
# check connection

setwd("N:\\Surveys\\UWTV SURVEYS FU2022 CELTIC SEA\\2020 Labadie\\KrigingAllYears")

channel <- odbcDriverConnect("Driver=SQL Server; Server=VMFSSSQL02; Database=UWTV_Surveys; ")

nep.all <- sqlQuery(channel, "select * from dbo.Summary_FullWorkUp_Vw")
close(channel)

nep2021 <- nep.all %>% filter(Ground =="Labadie", Year <= '2014') %>%
  select (Year, Ship_Mid_Longitude, SHIP_Mid_Latitude,AdjustedBurrowDensity)

nep.all %>% group_by(Year) %>% filter(Ground =="Labadie") %>%
 summarise(tot.stns= length(unique(StationNumber)),
             tot.dog= sum(DistanceOverGround),
             tot.burrow=sum(NephropsBurrowCount))
```

```
## # A tibble: 8 x 4
##    Year tot.stns tot.dog tot.burrow
##   <int>    <int>   <dbl>      <dbl>
```

```
## 1  2013       55  10565.      1606.
## 2  2014       96  21886.      4138.
## 3  2015       96  20055.      3824.
## 4  2016       93  20644.      3607
## 5  2017       86  15241.      6256.
## 6  2018       96  19686.      5054.
## 7  2019       95  18733.      1498.
## 8  2020       97  16231.      2116.
```

Year 2013 truncated survey area analysis

Back to top

Plot density estimates

Back to top

The data is available only in MI SQL database and it is extracted as a data object. Then we create a RGeosStat database and plot the data to check it.

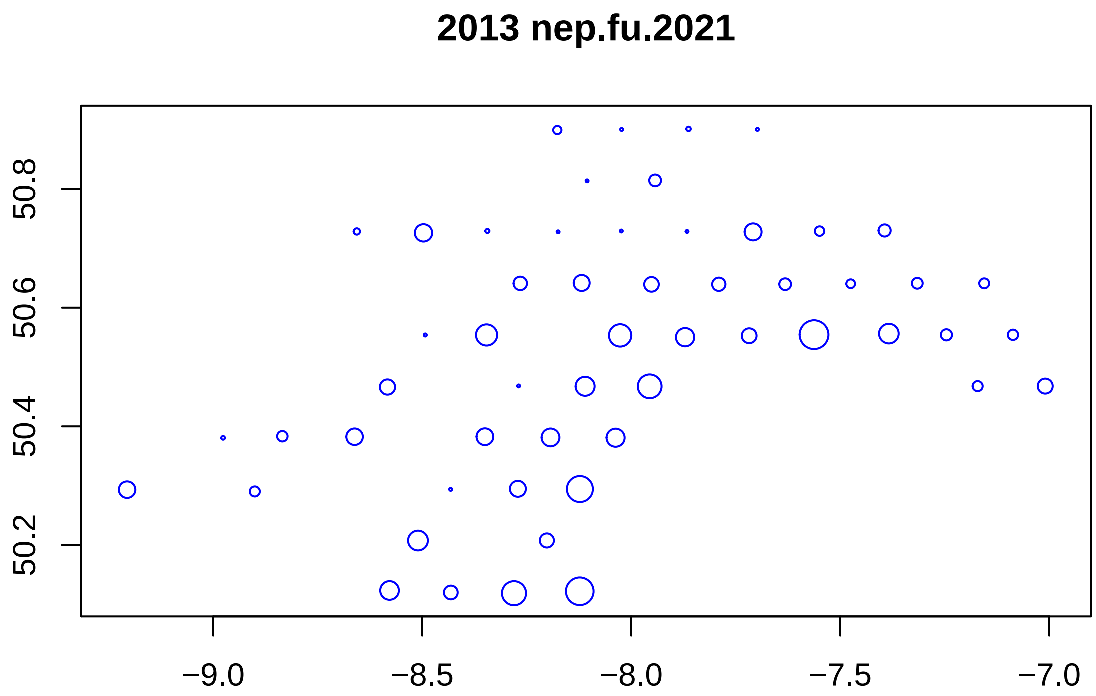
```
nep <- nep2021 %>% filter(Year == 2013)

surv.yr<- mean(nep$Year)
mt <- paste(surv.yr, "nep.fu.2021")
data.db <- db.create(nep,flag.grid=FALSE,ndim=2,autoname=F)
# Data management (define lat/lon)
data.db<- db.locate(data.db,3:4,loctype="x")
# Data management (define density)
data.db <- db.locate(data.db,5,loctype="z")
projec.define(projection="mean",db=data.db)
```

```
##
## Parameters for Projection
## -------------------------
## Projection is switched ON
## Use 'projec.define' to modify previous values
```

```
projec.toggle(mode=0)

  #png("../FU2021_krig.datapoints.png", height=2000, width=1500, res=200)
plot(data.db,title=mt)
```




```
#dev.off()
```

Figure 1: UWTV survey datapoints plot.

Define the truncated survey domain

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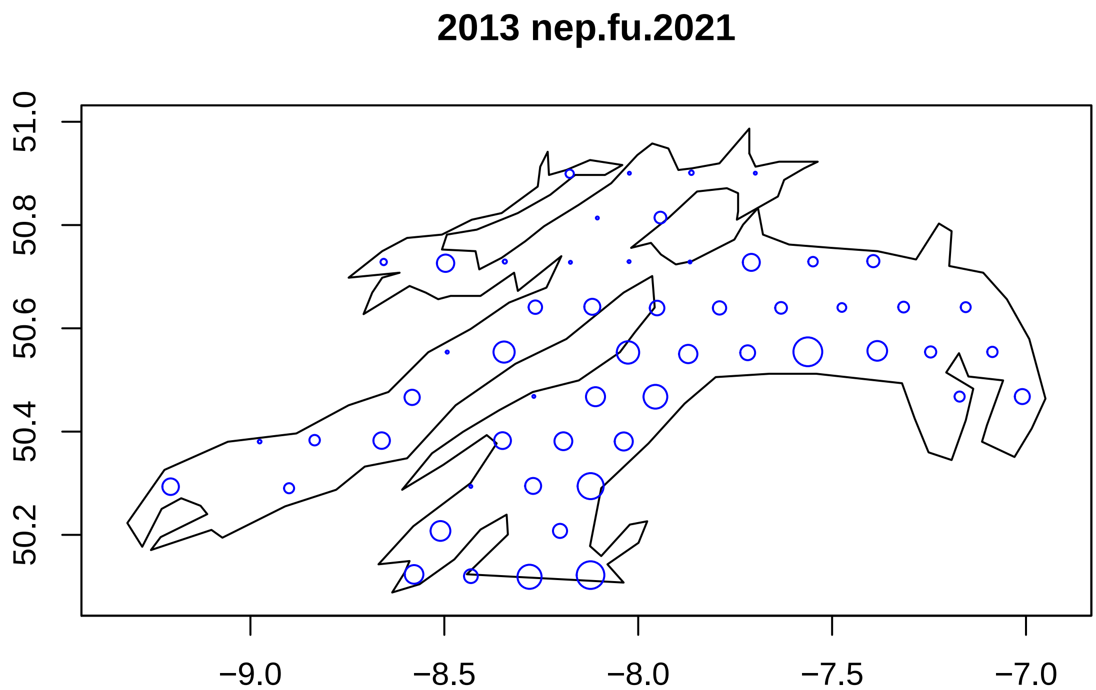
Load truncated polygon and create polygon structure.

```
pol.FU2021 <- read.table("2013_Labadie_pol.csv",header=T, sep=",")
poly <- polygon.create(x=pol.FU2021$x,y=pol.FU2021$y)
plot(poly)
plot(data.db,main=mt, add=T)
```




```
db.poly<-polygon.create(x=pol.FU2021[,1],y=pol.FU2021[,2],polygon=NA)
europa <- read.table("europa.txt",header=T)
plot(data.db,pch=21, title = mt,
     inches=5,asp=1/cos(mean(db.extract(data.db,"x1"))*pi/180),
     xlim=c(-9.5,-6.65),ylim=c(49.5,51.2))

plot(poly,col=8,add=T)
polygon(europa,col=8);box()
```

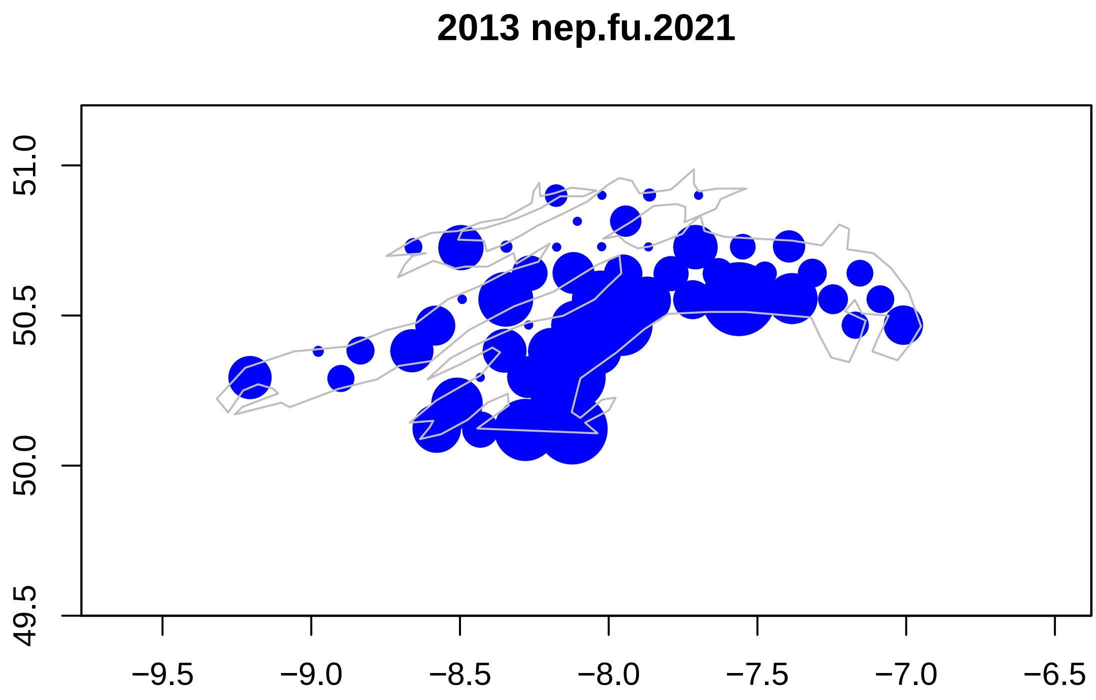


Figure 2: UWTV survey domain plot

Visualizing the data set in projected space based on the mean of the points

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Then checking the data points that fall inside and outside the polygon.

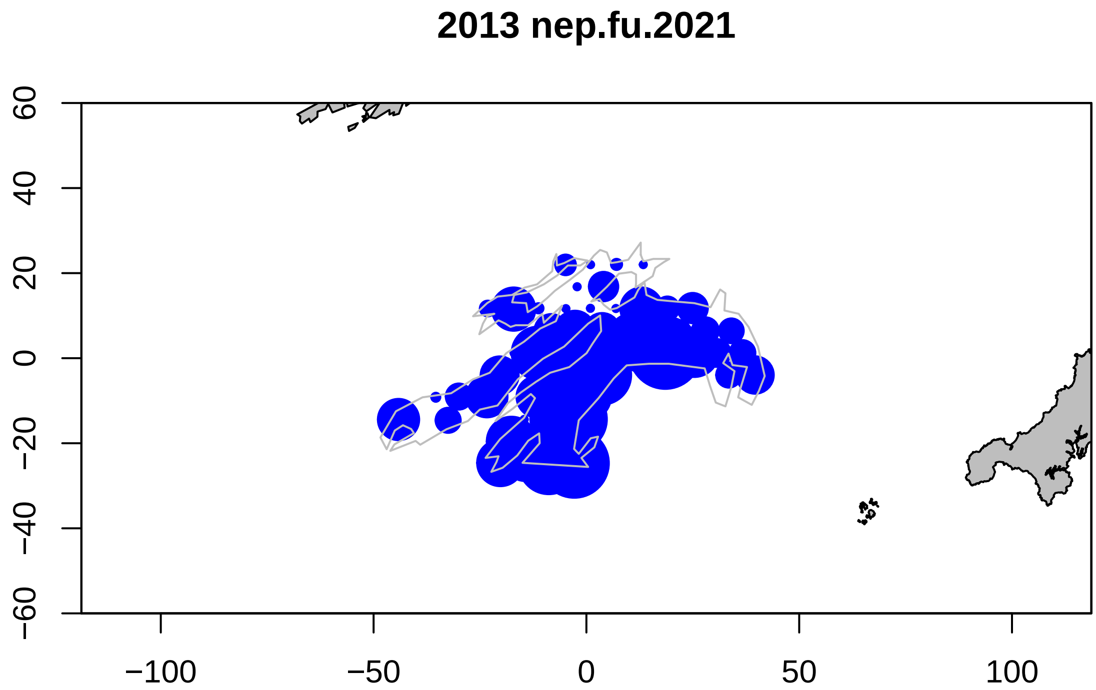
```
projec.define(projection="mean",db=data.db)
```

```
##
## Parameters for Projection
## -------------------------
## Projection is switched ON
## Use 'projec.define' to modify previous values
```

```
projec.toggle(mode=1)
```

```
##
## Parameters for Projection
## -------------------------
## Projection is switched ON
## Use 'projec.define' to modify previous values
```

```
plot(data.db,pch=21,title= mt,inches=5,asp=1,xlim=c(-60,60),ylim=c(-60,60))
plot(poly,col=8,add=T)
europa.p<-projec.operate(x=europa$x,y=europa$y)
polygon(europa.p,col=8);box()
```




```
db.c1 <- data.db
# select points inside polygon
db.c1 = db.polygon(db.c1,db.poly)
cat("nb points: ",db.c1$nech," ; outside polygon: ",sum(!db.c1@items$Polygon),"\n")
```

```
## nb points:  55  ; outside polygon:  1
```

Figure 3: Projected space and check datapoints inside survey domain plot

Calculate summary statistics inside the polygon.

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Inside the polygon. Histogram of densitites.

```
# mean, variance, histogramme of data inside polygon
zm<-mean(db.c1[,5][db.c1[,6]],na.rm=T)
zv<-var(db.c1[,5][db.c1[,6]],na.rm=T)*(sum(db.c1[,6],na.rm=T)-1)/sum(db.c1[,6],na.rm=T)
cat("mean: ",zm,"    var: ",zv,"    cv: ",sqrt(zv)/zm,"\n")
```

```
## mean:  0.1594177     var:  0.01236113    cv:  0.6974168
```

```
hist(db.c1[,5][db.c1[,6]],nclass=15,xlab="burrow density n/m?",main=mt)
```

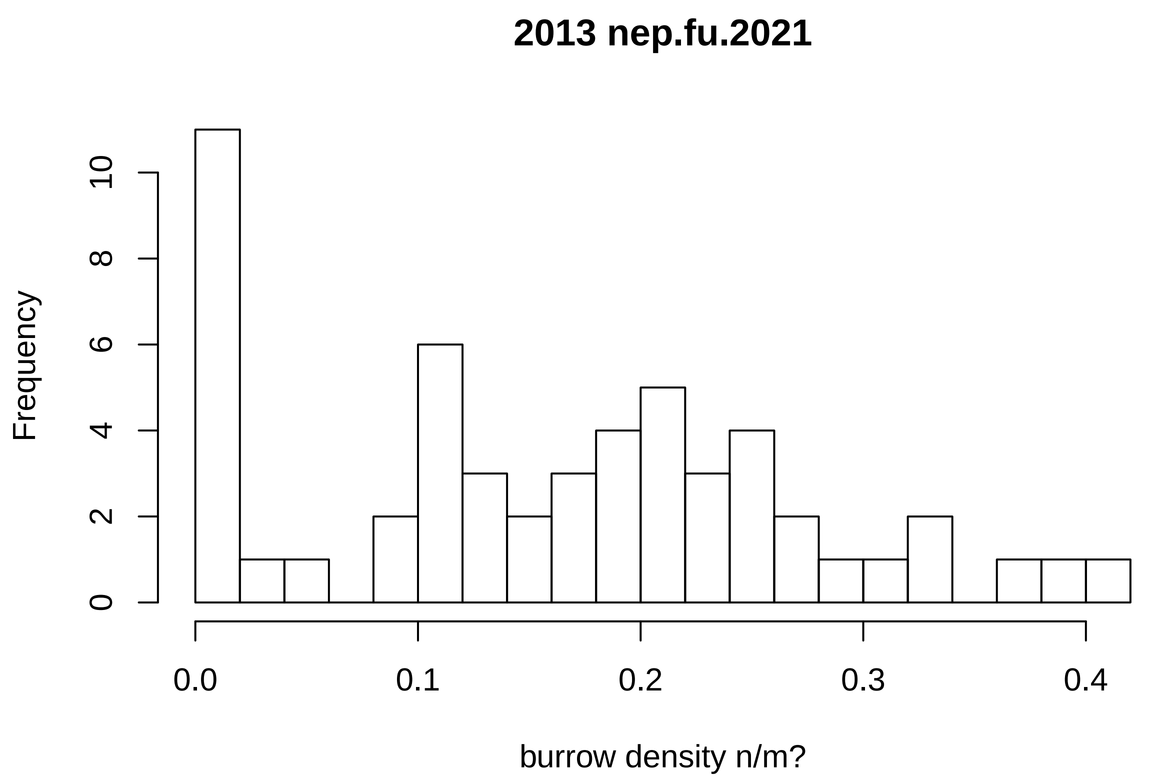

Figure 4: Histogram of adjusted densities.

Setting up the experimental variogram and plotting the points.

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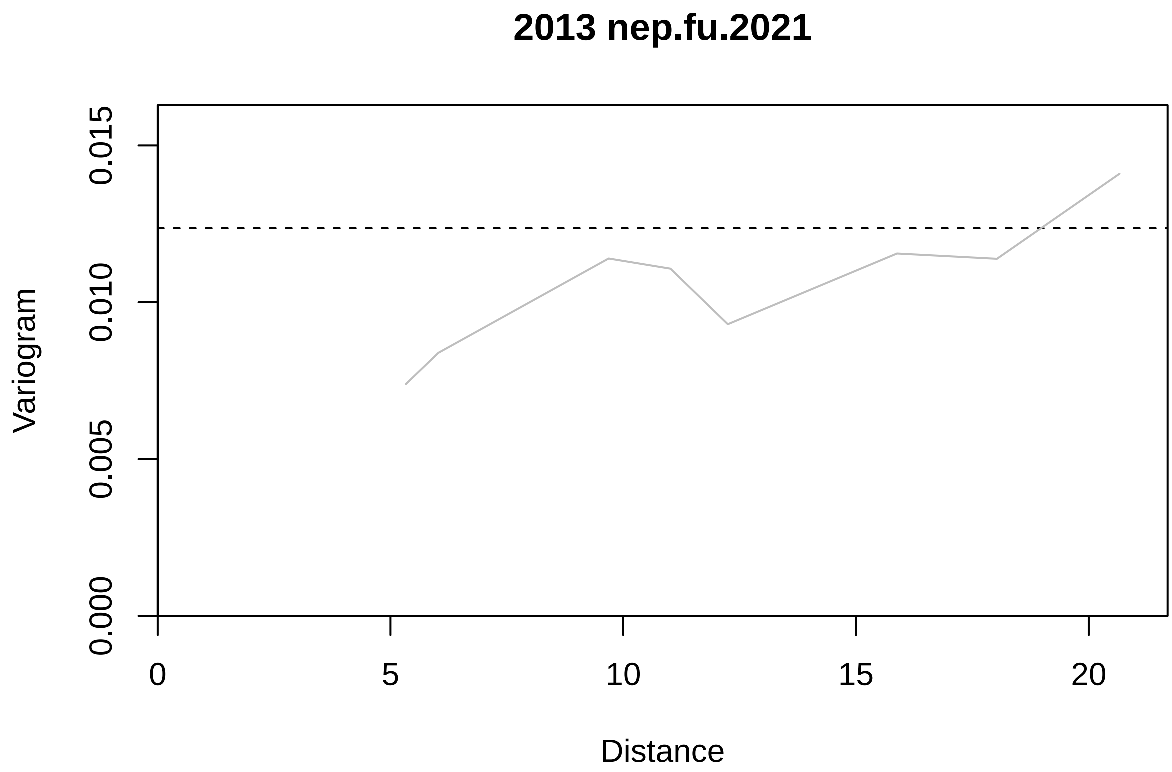
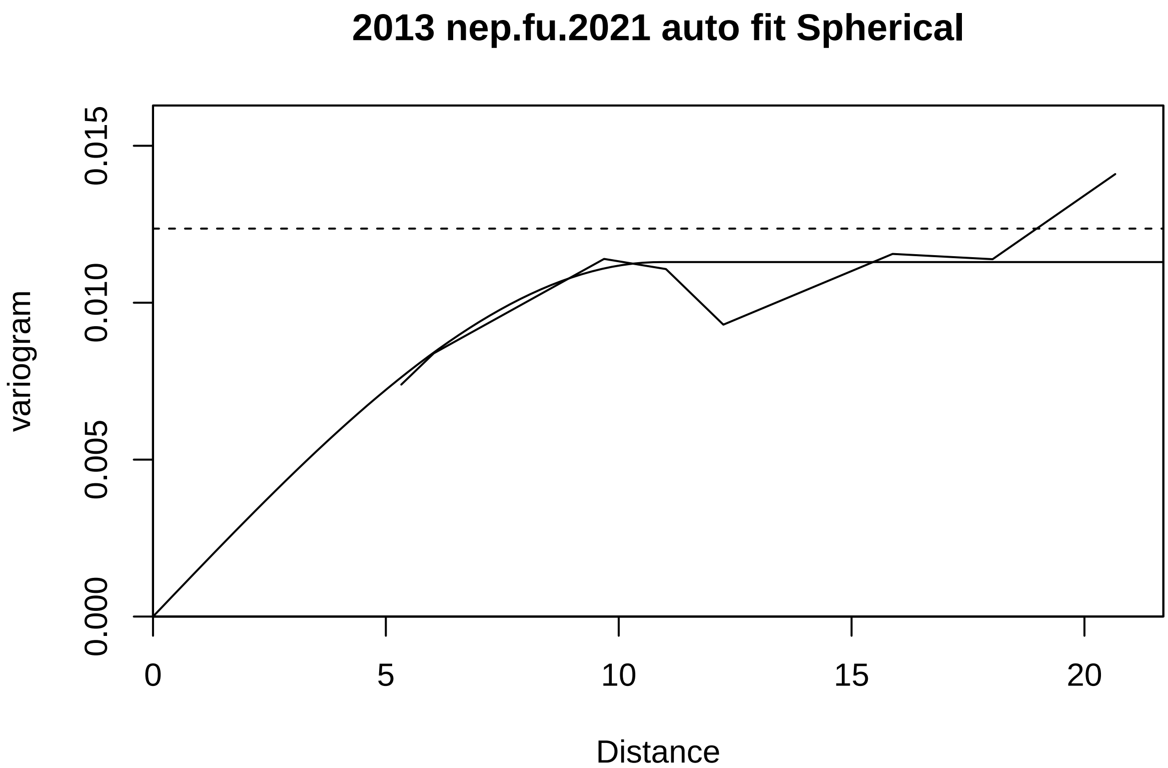
Fitting an experimental variogram to the pairs.

```
Lag=2.2; Nlag=10
vg1=vario.calc(db.c1,lag=Lag, nlag=Nlag)
  vario.plot(vg1,npairpt=1,xlab="Distance",ylab="Variogram",pch=9,cex=0.001,col="grey", title=mt)
```




```
vg.fit=model.auto(vg1,struc=c("Spherical"),
                  title = paste(mt, "auto fit Spherical"),
                  xlab="Distance", ylab="variogram")
```




```
vg.fit
```

```
##
## Model characteristics
## =====================
## Space dimension              = 2
## Number of variable(s)        = 1
## Number of basic structure(s) = 1
## Number of drift function(s)  = 1
## Number of drift equation(s)  = 1
##
## Covariance Part
## ---------------
## - Spherical
##   Range       =     10.902
##   Sill        =      0.011
## Total Sill    =      0.011
##
## Drift Part
## ----------
## Universality Condition
```

Figure 5: Fitted variogram.

Gridding data set

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This step involves making a grid of points within the domain area.
This grid is used for the modelled surface.
A grid of 100X100 points was choosed because it was similiar to the previous methodology used in SURFER.
The grid is plotted along with the domain boundary and bubbles of density.

```
poldat<-read.table("pol.Labadie.IBP.csv",header=T,sep=',')

gnx=100;gny=100
gx0=min(poldat$x); gx1=max(poldat$x)
gy0=min(poldat$y); gy1=max(poldat$y)
gdx=(gx1-gx0)/gnx; gdy=(gy1-gy0)/gny
gd.disc=db.create(flag.grid=T,x0=c(gx0,gy0),dx=c(gdx,gdy),nx=c(gnx,gny))
gd.disc=db.polygon(gd.disc,db.poly)
plot(gd.disc,pch=3,col=1,
     xlim=c(-60,60),ylim=c(-60,60),title=mt);
     plot(db.c1,add=T,pch=21);
     plot(db.poly,add=T)
```

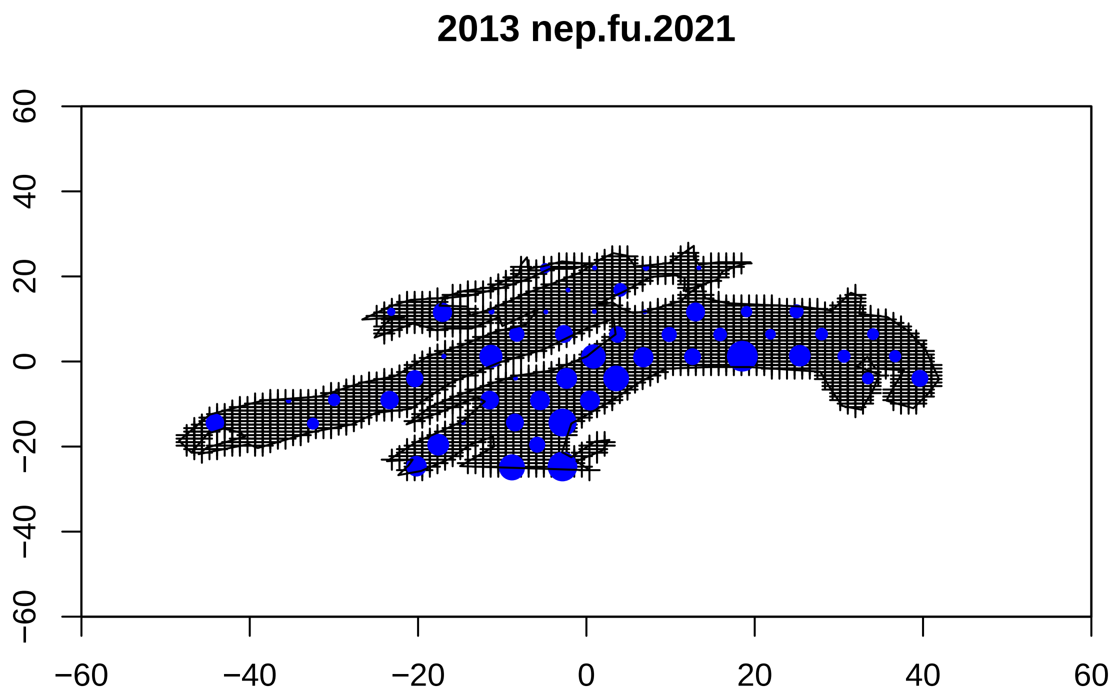

Figure 6: Gridded data plot.

Calculate mean burrow density and geostistical CV for the grid.

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This mean and CV is different to the krigging estimates calculated later but they should be fairly close for this type of dataset.

```
# calculation of CVV
cvv=model.cvv(polygon=db.poly,model=vg.fit,ndisc=c(gnx,gny))
# Global estimate = arithmetic mean. s2est=cvv+cxx-2*cxv
cxx=model.cxx(db1=db.c1,model=vg.fit)
cxv=model.cxv(db=db.c1,polygon=db.poly,model=vg.fit,ndisc=c(gnx,gny))
sse=sqrt(cvv+cxx-2*cxv)
cat("arith.mean: ",round(zm,5)," CV.geo: ",round(sse/zm,5),"\n")
```

```
## arith.mean:  0.15942  CV.geo:  0.05024
```

Kriging Model

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Here we carry out the kriging using the fitted variogram. Neighbourhood weighting is not needed given the properties of this data set (i.e. <50 observations which are fairly homogoneous and strongly auto-corellated).

```
global.ma=global(dbin=db.c1, dbout=gd.disc, model = vg.fit, uc=c("1"),
                 polygon = db.poly, calcul = "krige",
                 flag.polin=T, flag.wgt=F, ivar = 1, verbose = 1)
```

```
## Global estimation kriging
## =========================
## Total number of data             = 55
## Number of active data            = 54
## Number of variables              = 1
## Cvv                              = 0.000339
## Estimation by kriging            = 0.162122
## Lagrange Parameter #1            = -0.000062
## Estimation St. Dev. of the mean  = 0.007409
## CVgeo                            = 0.045701
##
## Surface                          = 1684.980072
## Q (Estimation * Surface)         = 273.172567
```

```
toto <- db.create(x1=pol.FU2021[,1],x2=pol.FU2021[,2])
grid <- db.grid.init(toto,nodes=100) # number of nodes if related with the fining of the grid
#when using all data as neighbours
uniquenei <- neigh.init(2,0)
```

```
## The function 'neigh.init'will soon become obsolete
## Please use function 'neigh.create' instead (same arguments)
```

```
kri <- kriging(dbin=db.c1,db.polygon(grid,poly),vg.fit,uniquenei)

ggin <- as.data.frame(kri@items)

write.csv(ggin, file= paste0("ggin",surv.yr,".csv"))
```

Kriging Model Plot1 Back to top

The krigged surface and the error structure is plotted and the grid is saved for plotting purposes later.

```
plot(kri,col=tim.colors(200),asp=1,xlim=c(-60,60),ylim=c(-60,60),
     name.image="Kriging.AdjustedBurrowDensity.estim")
plot(poly,col=22,add=T)
plot(db.c1,col='black',add=T)
```

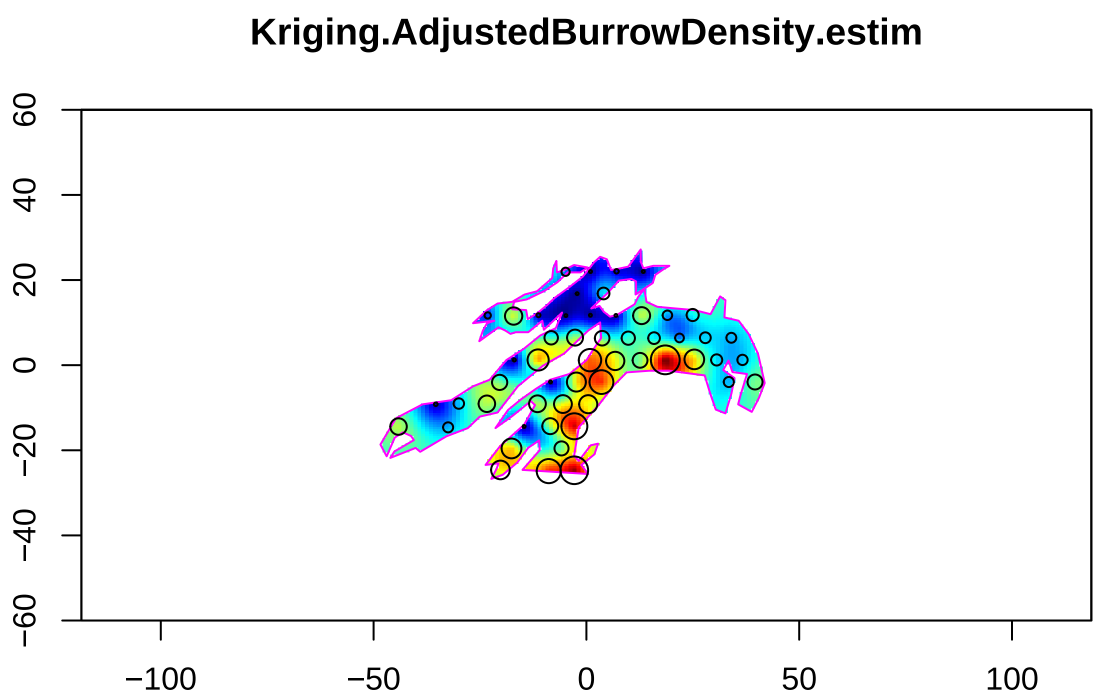

Figure 7: Kriged Density Adjusted.estimated.

Kriging Model Plot2 Back to top

map of the estimation variance The krigged surface and the error structure is plotted and the grid is saved for plotting purposes later.

```
plot(kri,col=tim.colors(10),name.image="Kriging.AdjustedBurrowDensity.stdev")
plot(poly,col=22,add=T)
plot(db.c1,col=1,add=T)
```

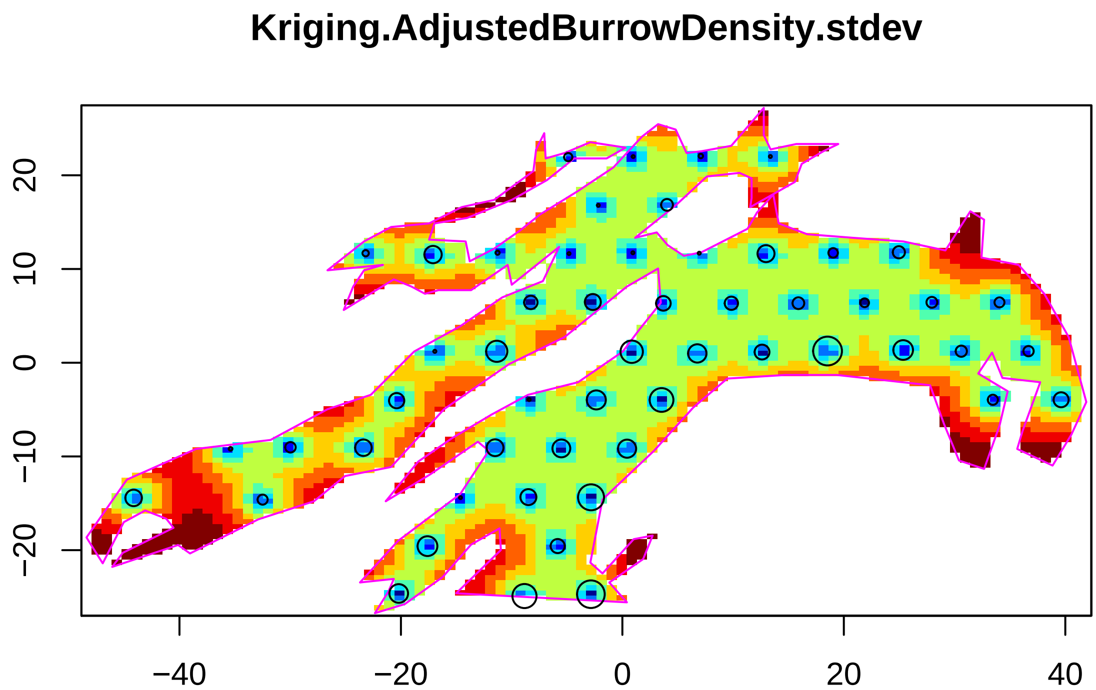

Figure 8: Kriged Density Adjusted.standrd deviation.

UWTV Survey Summary Statistics

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The mean z estimate from kriging is multiplied by the polygon surface 5779.3198888km^2 to calculate the total abundance. The summary object contains all the salient infomation for the final results. ggin file is outputted which is used to create kriged contour plots.

```
#Survey abundance estimate in numbers (millions)
abun <- global.ma$zest*poly$surface*1.852^2


k.sum <-data.frame(Year=mean(nep$Year), Ground ="Labadie", mean= zm,  N= db.c1$nech,
                   sd = zv/zv^.05, se= sse, ciMult=NA, ci= abun*global.ma$cv*1.96,
                   area= poly$surface*1.852^2, abund = abun,
                   upper= abun+abun*global.ma$cv*1.96,
                  lower= abun-abun*global.ma$cv*1.96,
                   CViid= zv/zm, meanGeo=  global.ma$zest, CVgeo= global.ma$cv,
                  method="Rgeostats_truncated")
```

UWTV SummaryData

UWTV summary statistcs

```
knitr::kable(k.sum[,1:9] )
```

Year	Ground	mean	N	sd	se	ciMult	ci	area
2013	Labadie	0.1594177	55	0.0153977	0.0080094	NA	83.92692	5779.32

```
knitr::kable(k.sum[,c(1:2, 10:16)])
```

Year	Ground	abund	upper	lower	CViid	meanGeo	CVgeo	method
2013	Labadie	936.9557	1020.883	853.0288	0.0775392	0.1621221	0.045701	Rgeostats_truncated

The final check is a cross validation plot.

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```
data.db <- xvalid(db.c1,model=vg.fit,uniquenei)
hist(db.extract(data.db,"Xvalid.AdjustedBurrowDensity.esterr"),nclass=30,
     main="CrossValidation",xlab="Cross validation error",col="blue")
```

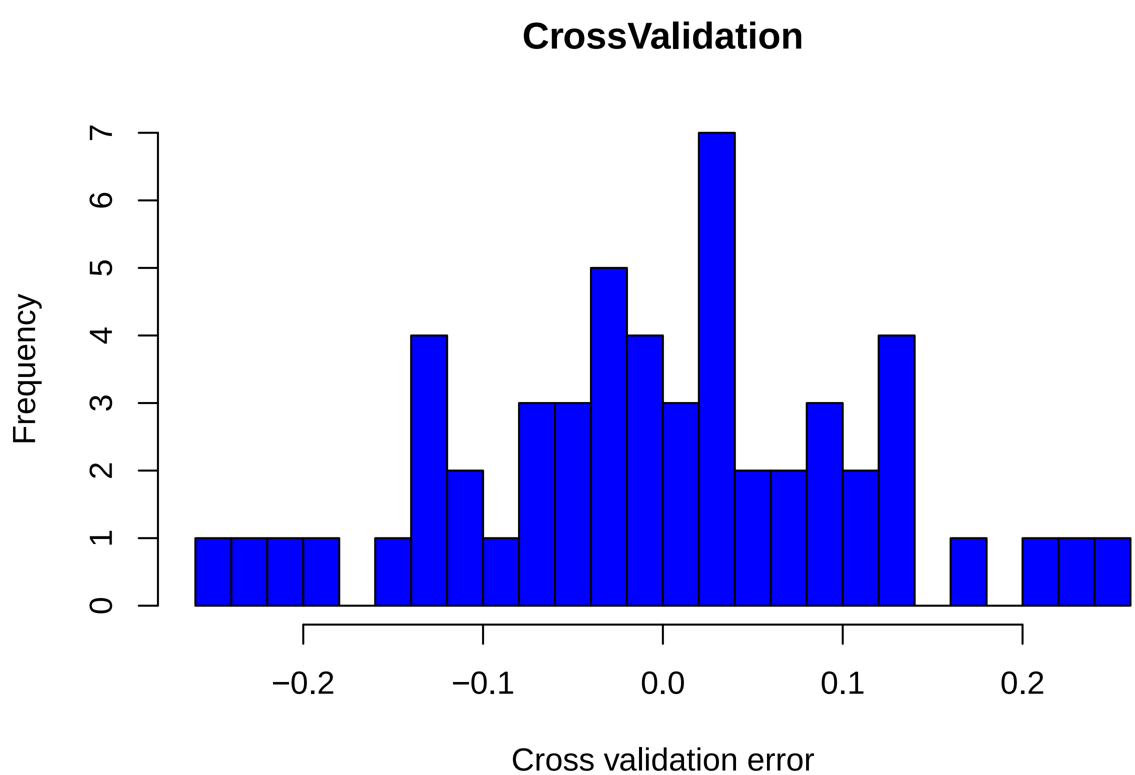

Figure 9: Cross validation plot.

Year 2013 full survey area analysis

Krige to the full survey polygon estimated at benchmark. Back to top

Plot density estimates

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The data is available only in MI SQL database and it is extracted as a data object. Then we create a RGeosStat database and plot the data to check it.

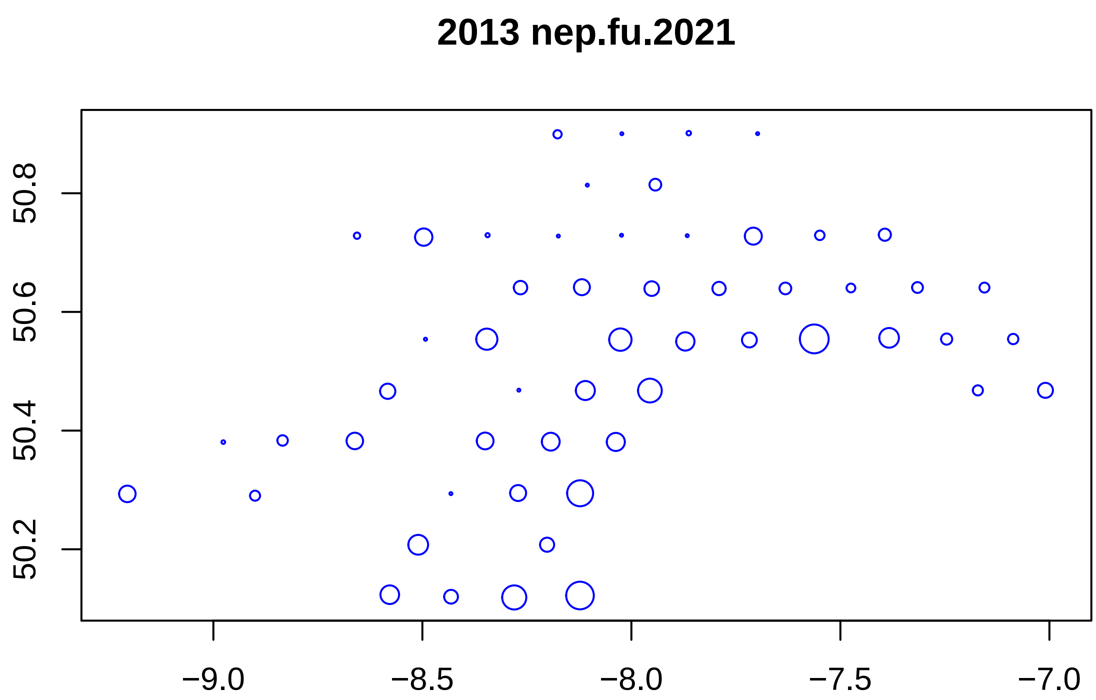
```
nep <- nep2021 %>% filter(Year == 2013)

surv.yr<- mean(nep$Year)
mt <- paste(surv.yr, "nep.fu.2021")
data.db <- db.create(nep,flag.grid=FALSE,ndim=2,autoname=F)
# Data management (define lat/lon)
data.db<- db.locate(data.db,3:4,loctype="x")
# Data management (define density)
data.db <- db.locate(data.db,5,loctype="z")
projec.define(projection="mean",db=data.db)
```

```
##
## Parameters for Projection
## -------------------------
## Projection is switched ON
## Use 'projec.define' to modify previous values
```

```
projec.toggle(mode=0)

  #png("../FU22_krig.datapoints.png", height=2000, width=1500, res=200)
plot(data.db,title=mt)
```




```
#dev.off()
```

Figure 1: UWTV survey datapoints plot.

Define the survey domain

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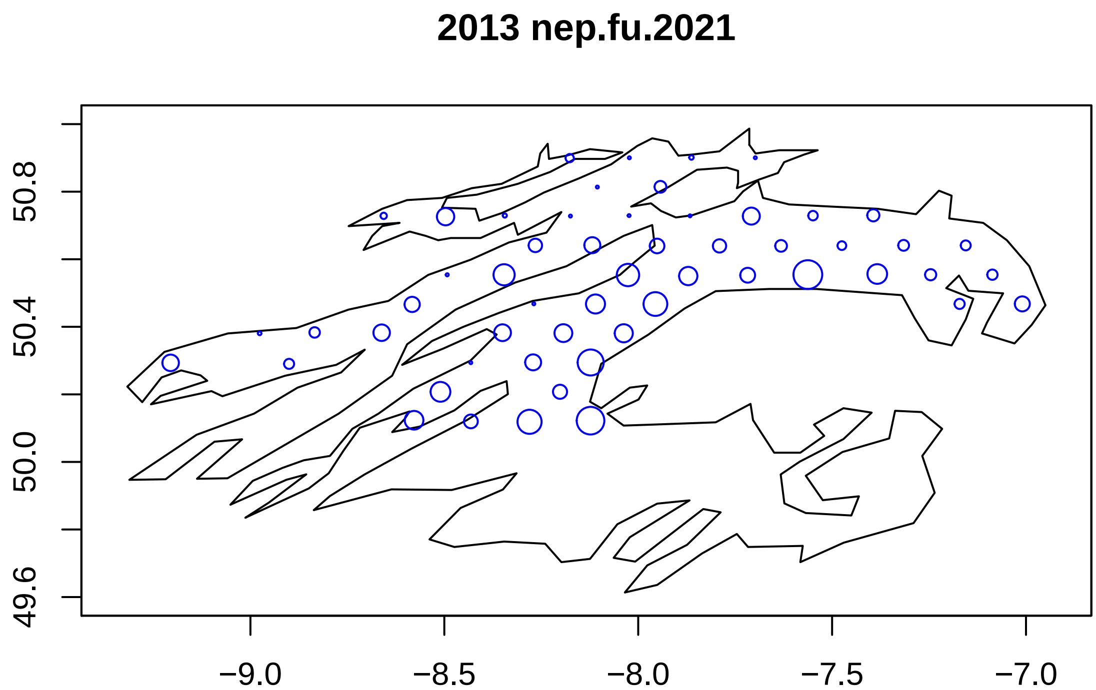
Load a polygon and create polygon structure. The same polygon is used for all years.

```
pol.FU2021 <- read.table("pol.Labadie.IBP.csv",header=T, sep=",")
poly <- polygon.create(x=pol.FU2021$x,y=pol.FU2021$y)
plot(poly)
plot(data.db,main=mt, add=T)
```




```
db.poly<-polygon.create(x=pol.FU2021[,1],y=pol.FU2021[,2],polygon=NA)
europa <- read.table("europa.txt",header=T)
plot(data.db,pch=21, title = mt,inches=5,asp=1/cos(mean(db.extract(data.db,"x1"))*pi/180),
     xlim=c(-9.5,-6.65),ylim=c(49.5,51.2))
plot(poly,col=8,add=T)
polygon(europa,col=8);box()
```

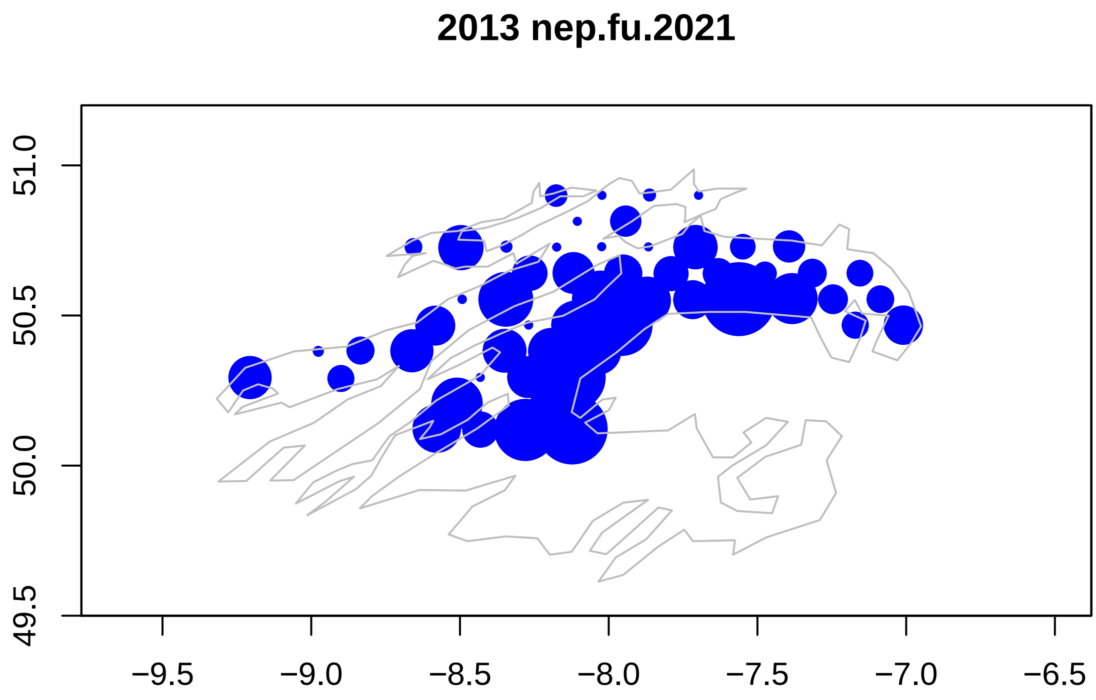


Figure 2: UWTV survey domain plot

Visualizing the data set in projected space based on the mean of the points

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Then checking the data points that fall inside and outside the polygon.

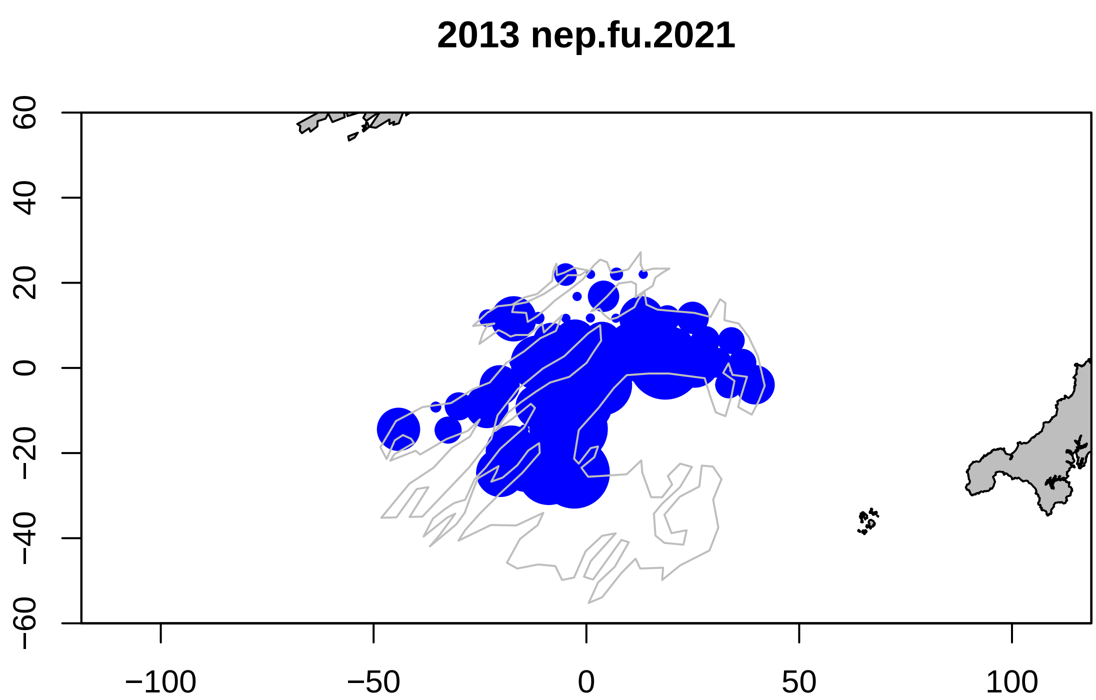
```
projec.define(projection="mean",db=data.db)
```

```
##
## Parameters for Projection
## -------------------------
## Projection is switched ON
## Use 'projec.define' to modify previous values
```

```
projec.toggle(mode=1)
```

```
##
## Parameters for Projection
## -------------------------
## Projection is switched ON
## Use 'projec.define' to modify previous values
```

```
plot(data.db,pch=21,title= mt,inches=5,asp=1,xlim=c(-60,60),ylim=c(-60,60))
plot(poly,col=8,add=T)
europa.p<-projec.operate(x=europa$x,y=europa$y)
polygon(europa.p,col=8);box()
```




```
db.c1 <- data.db
# select points inside polygon
db.c1 = db.polygon(db.c1,db.poly)
cat("nb points: ",db.c1$nech," ; outside polygon: ",sum(!db.c1@items$Polygon),"\n")
```

```
## nb points:  55  ; outside polygon:  0
```

Figure 3: Projected space and check datapoints inside survey domain plot

Calculate summary statistics inside the polygon.

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Inside the polygon. Histogram of densitites.

```
# mean, variance, histogramme of data inside polygon
zm<-mean(db.c1[,5][db.c1[,6]],na.rm=T)
zv<-var(db.c1[,5][db.c1[,6]],na.rm=T)*(sum(db.c1[,6],na.rm=T)-1)/sum(db.c1[,6],na.rm=T)
cat("mean: ",zm,"    var: ",zv,"   cv: ",sqrt(zv)/zm,"\n")
```

```
## mean:  0.1596379     var:  0.01213899    cv:  0.6901691
```

```
hist(db.c1[,5][db.c1[,6]],nclass=15,xlab="burrow density n/m?",main=mt)
```

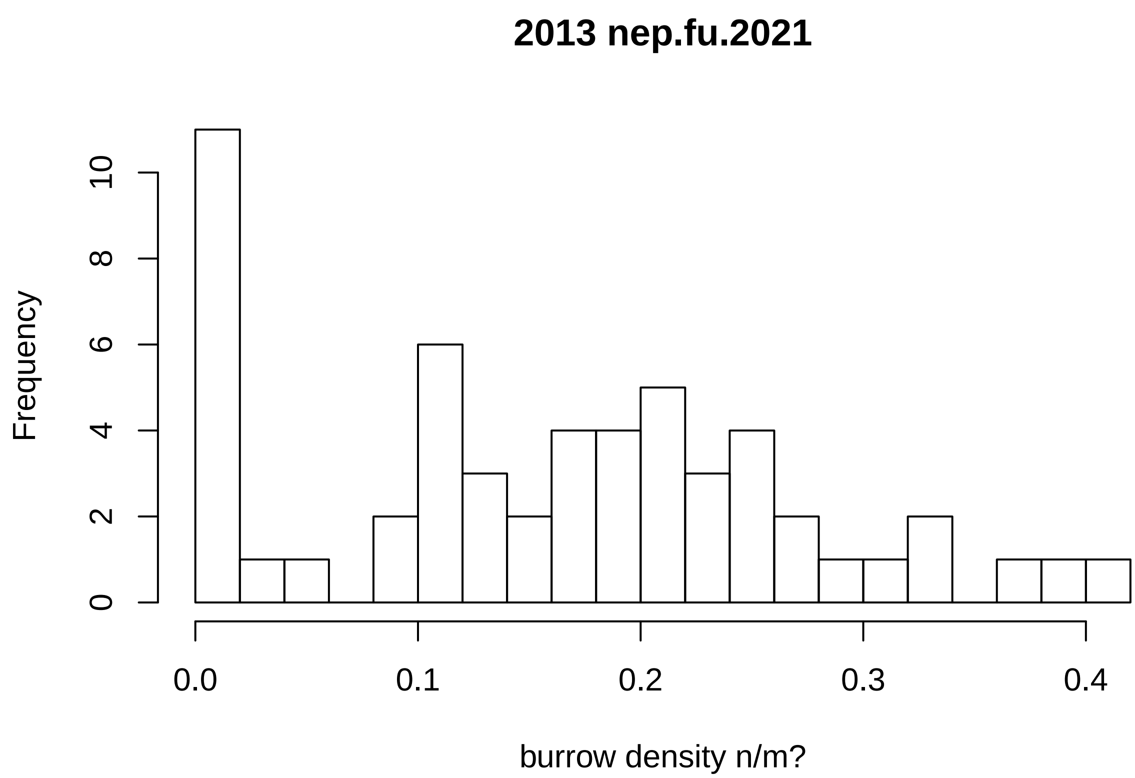

Figure 4: Histogram of adjusted densities.

Setting up the experimental variogram and plotting the points.

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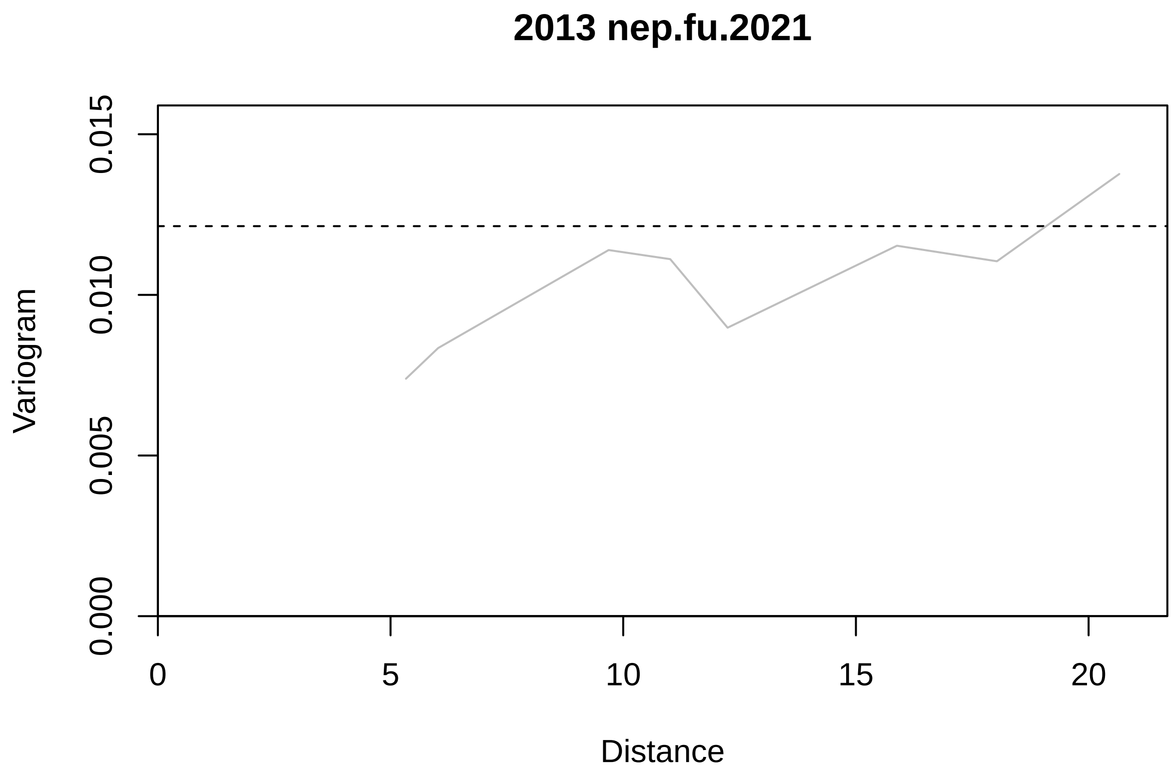
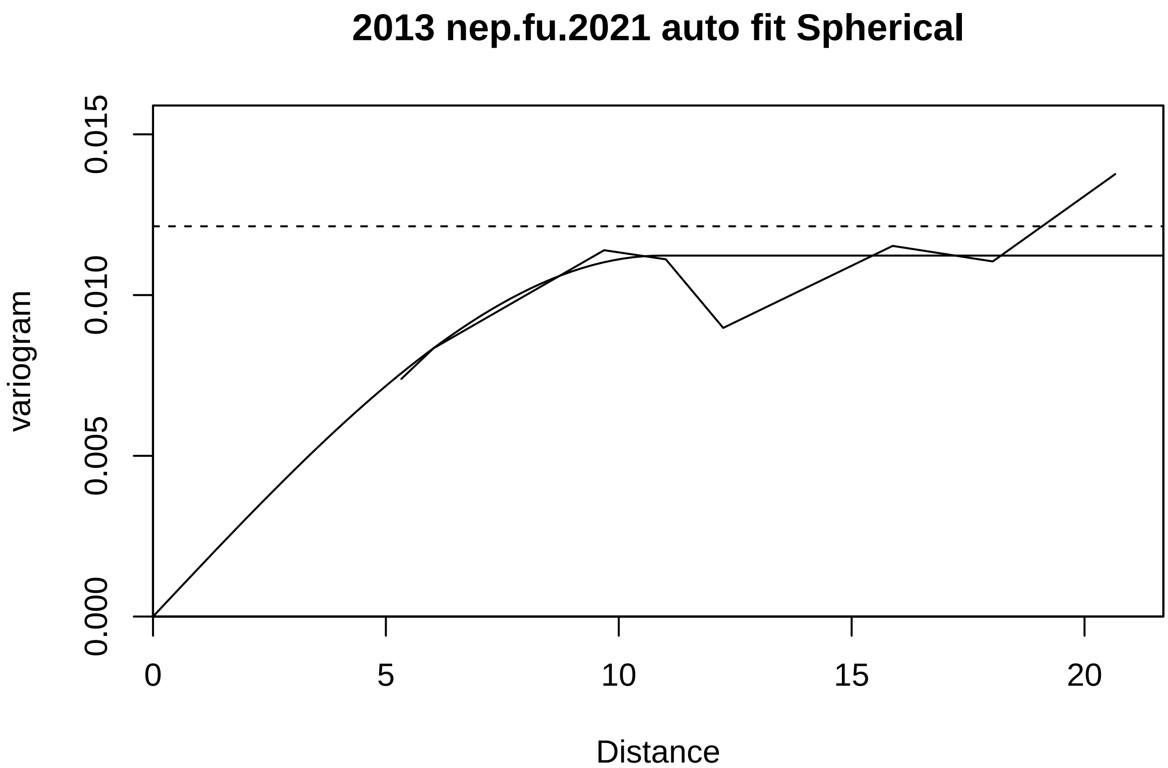
Fitting an experimental variogram to the pairs.

```
Lag=2.2; Nlag=10
vg1=vario.calc(db.c1,lag=Lag, nlag=Nlag)
  vario.plot(vg1,npairpt=1,xlab="Distance",ylab="Variogram",pch=9,cex=0.001,col="grey", title=mt)
```




```
vg.fit=model.auto(vg1,struc=c("Spherical"),title = paste(mt, "auto fit Spherical"), xlab="Distance", yl
```




```
vg.fit
```

```
##
## Model characteristics
## =====================
## Space dimension              = 2
## Number of variable(s)        = 1
## Number of basic structure(s) = 1
## Number of drift function(s)  = 1
## Number of drift equation(s)  = 1
##
## Covariance Part
## ---------------
## - Spherical
##   Range       =     10.919
##   Sill        =      0.011
## Total Sill    =      0.011
##
## Drift Part
## ----------
## Universality Condition
```

Figure 5: Fitted variogram.

Gridding data set

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This step involves making a grid of points within the domain area.
This grid is used for the modelled surface.
A grid of 100X100 points was choosed because it was similiar to the previous methodology used in SURFER.
The grid is plotted along with the domain boundary and bubbles of density.

```
poldat<-read.table("pol.Labadie.IBP.csv",header=T,sep=',')

gnx=100;gny=100
gx0=min(poldat$x); gx1=max(poldat$x)
gy0=min(poldat$y); gy1=max(poldat$y)
gdx=(gx1-gx0)/gnx; gdy=(gy1-gy0)/gny
gd.disc=db.create(flag.grid=T,x0=c(gx0,gy0),dx=c(gdx,gdy),nx=c(gnx,gny))
gd.disc=db.polygon(gd.disc,db.poly)
plot(gd.disc,pch=3,col=1, xlim=c(-60,60),ylim=c(-60,60),title=mt);
plot(db.c1,add=T,pch=21); plot(db.poly,add=T)
```

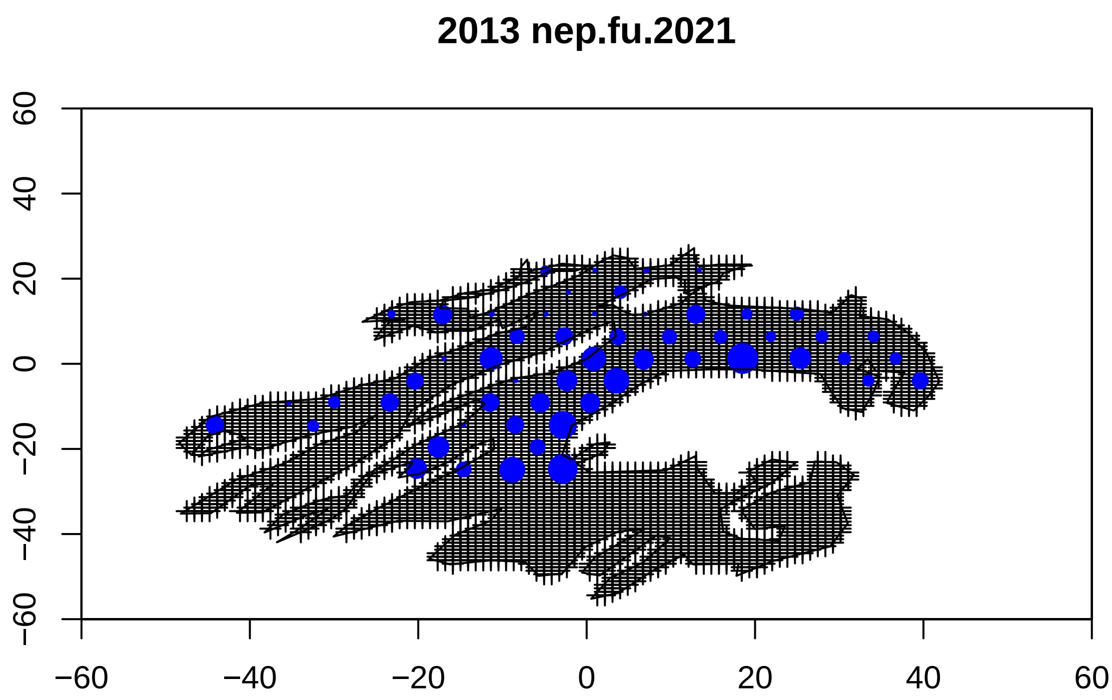

Figure 6: Gridded data plot.

Calculate mean burrow density and geostistical CV for the grid.

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This mean and CV is different to the krigging estimates calculated later but they should be fairly close for this type of dataset.

```
# calculation of CVV
cvv=model.cvv(polygon=db.poly,model=vg.fit,ndisc=c(gnx,gny))
# Global estimate = arithmetic mean. s2est=cvv+cxx-2*cxv
cxx=model.cxx(db1=db.c1,model=vg.fit)
cxv=model.cxv(db=db.c1,polygon=db.poly,model=vg.fit,ndisc=c(gnx,gny))
sse=sqrt(cvv+cxx-2*cxv)
cat("arith.mean: ",round(zm,5)," CV.geo: ",round(sse/zm,5),"\n")
```

```
## arith.mean:  0.15964  CV.geo:  0.08627
```

Kriging Model

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Here we carry out the kriging using the fitted variogram. Neighbourhood weighting is not needed given the properties of this data set (i.e. <50 observations which are fairly homogoneous and strongly auto-corellated).

```
global.ma=global(dbin=db.c1, dbout=gd.disc, model = vg.fit, uc=c("1"),
                 polygon = db.poly, calcul = "krige",
                 flag.polin=T, flag.wgt=F, ivar = 1, verbose = 1)
```

```
## Global estimation kriging
## =========================
## Total number of data              = 55
## Number of active data             = 55
## Number of variables               = 1
## Cvv                               = 0.000203
## Estimation by kriging             = 0.165117
## Lagrange Parameter #1             = -0.000181
## Estimation St. Dev. of the mean   = 0.013392
## CVgeo                             = 0.081104
##
## Surface                           = 2895.523332
## Q (Estimation * Surface)          = 478.099920
```

```
toto <- db.create(x1=pol.FU2021[,1],x2=pol.FU2021[,2])
grid <- db.grid.init(toto,nodes=100) # number of nodes if related with the fining of the grid
#when using all data as neighbours
uniquenei <- neigh.init(2,0)
```

```
## The function 'neigh.init'will soon become obsolete
## Please use function 'neigh.create' instead (same arguments)
```

```
kri <- kriging(dbin=db.c1,db.polygon(grid,poly),vg.fit,uniquenei)

ggin <- as.data.frame(kri@items)

write.csv(ggin, file= paste0("ggin",surv.yr,".csv"))
```

Kriging Model Plot1 Back to top

The krigged surface and the error structure is plotted and the grid is saved for plotting purposes later.

```
plot(kri,col=tim.colors(200),asp=1,xlim=c(-60,60),ylim=c(-60,60),
     name.image="Kriging.AdjustedBurrowDensity.estim")
plot(poly,col=22,add=T)
plot(db.c1,col='black',add=T)
```

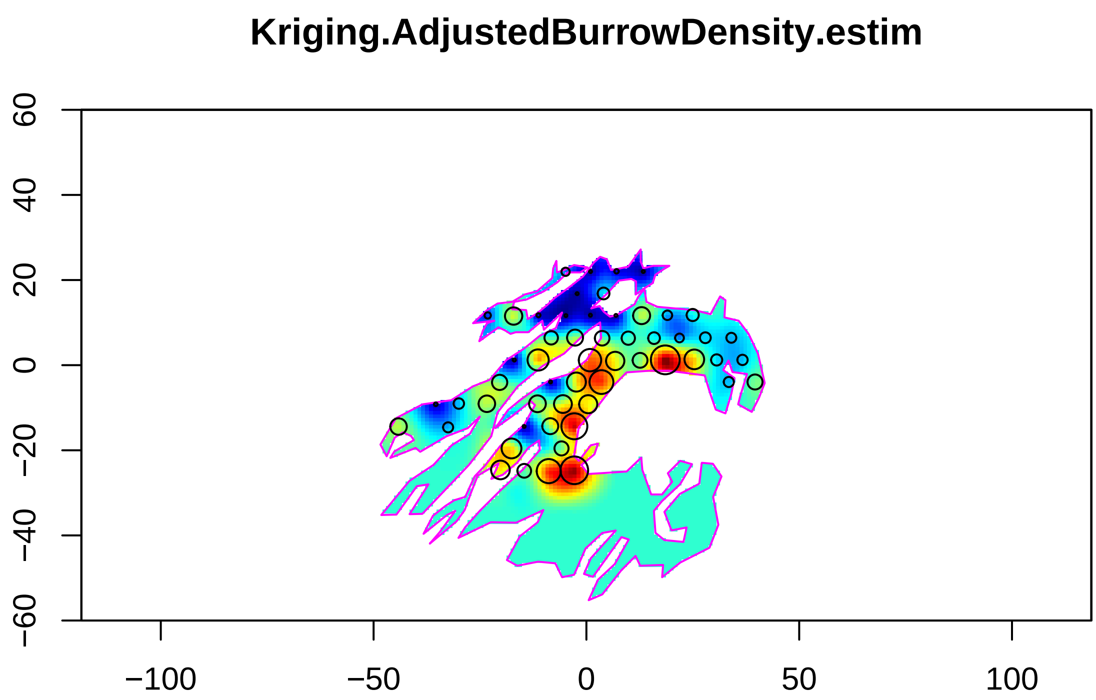

Figure 7: Kriged Density Adjusted.estimated.

Kriging Model Plot2 Back to top

map of the estimation variance The krigged surface and the error structure is plotted and the grid is saved for plotting purposes later.

```
plot(kri,col=tim.colors(10),name.image="Kriging.AdjustedBurrowDensity.stdev")
plot(poly,col=22,add=T)
plot(db.c1,col=1,add=T)
```

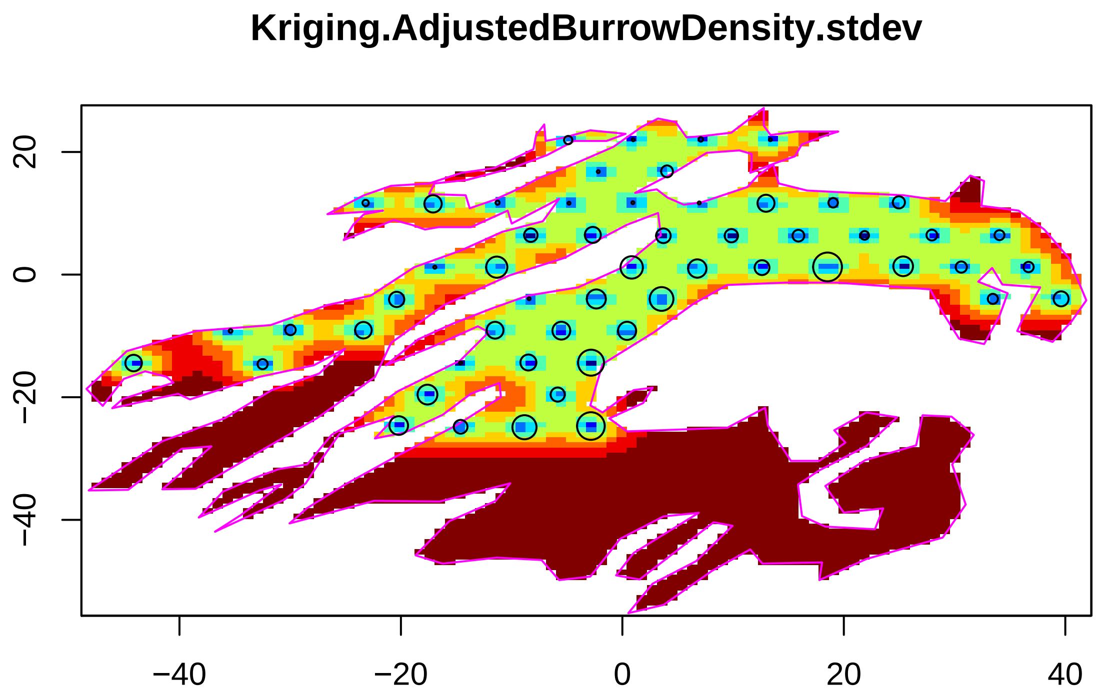

Figure 8: Kriged Density Adjusted.standrd deviation.

UWTV Survey Summary Statistics

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The mean z estimate from kriging is multiplied by the polygon surface 9931.3670601km^2 to calculate the total abundance. The summary object contains all the salient infomation for the final results. ggin file is outputted which is used to create kriged contour plots.

```
#Survey abundance estimate in numbers (millions)
abun <- global.ma$zest*poly$surface*1.852^2


k.sum <- rbind(k.sum, data.frame(Year=mean(nep$Year),Ground ="Labadie", mean= zm,  N= db.c1$nech,
                   sd = zv/zv^.05, se= sse, ciMult=NA, ci= abun*global.ma$cv*1.96,
                   area= poly$surface*1.852^2, abund = abun,
                   upper= abun+abun*global.ma$cv*1.96,
                  lower= abun-abun*global.ma$cv*1.96,
                   CViid= zv/zm, meanGeo=  global.ma$zest, CVgeo= global.ma$cv,
                  method="Rgeostats"))
```

UWTV SummaryData

UWTV summary statistcs

```
knitr::kable(k.sum[,1:9] )
```

Year	Ground	mean	N	sd	se	ciMult	ci	area
2013	Labadie	0.1594177	55	0.0153977	0.0080094	NA	83.92692	5779.320
2013	Labadie	0.1596379	55	0.0151347	0.0137716	NA	260.67600	9931.367

```
knitr::kable(k.sum[,c(1:2, 10:16)])
```

Year	Ground	abund	upper	lower	CViid	meanGeo	CVgeo	method
2013	Labadie	936.9557	1020.883	853.0288	0.0775392	0.1621221	0.0457010	Rgeostats_truncated
2013	Labadie	1639.8368	1900.513	1379.1608	0.0760408	0.1651169	0.0811044	Rgeostats

The final check is a cross validation plot.

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```
data.db <- xvalid(db.c1,model=vg.fit,uniquenei)
hist(db.extract(data.db,"Xvalid.AdjustedBurrowDensity.esterr"),nclass=30,
     main="CrossValidation",xlab="Cross validation error",col="blue")
```

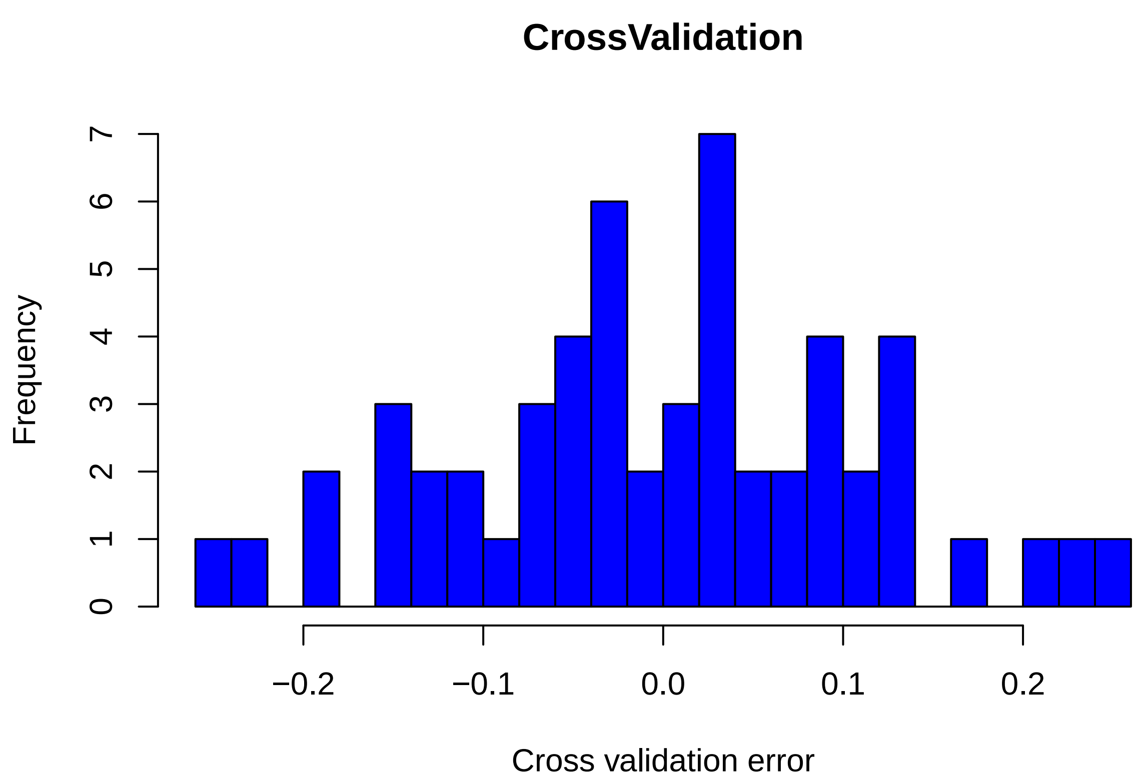


Figure 9: Cross validation plot.

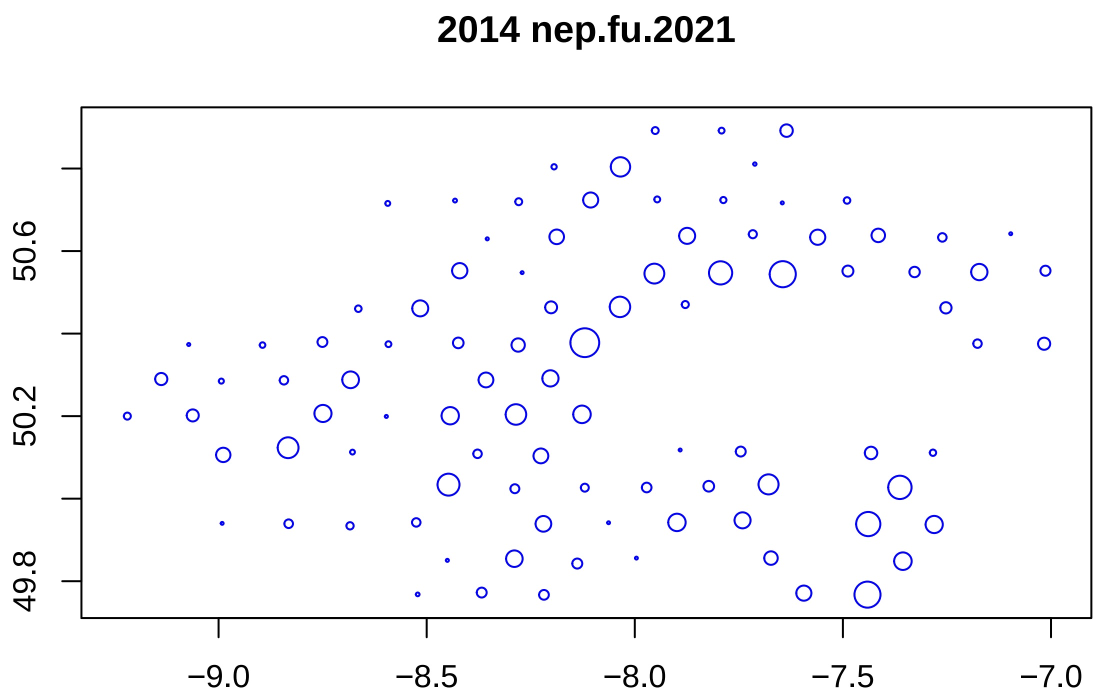
Now for the next year 2014

```
nep <- subset(nep2021, Year==(surv.yr+1))
surv.yr<- mean(nep$Year)
mt <- paste(surv.yr, "nep.fu.2021")
data.db <- db.create(nep,flag.grid=FALSE,ndim=2,autoname=F)
# Data management (define lat/lon)
data.db<- db.locate(data.db,3:4,loctype="x")
# Data management (define density)
data.db <- db.locate(data.db,5,loctype="z")
projec.define(projection="mean",db=data.db)
```

```
##
## Parameters for Projection
## -------------------------
## Projection is switched ON
## Use 'projec.define' to modify previous values
```

```
projec.toggle(mode=0)

  #png("../FU22_krig.datapoints.png", height=2000, width=1500, res=200)
plot(data.db,title=mt)
```



```
#dev.off()
```

Figure 1: UWTV survey datapoints plot.

Define the survey domain

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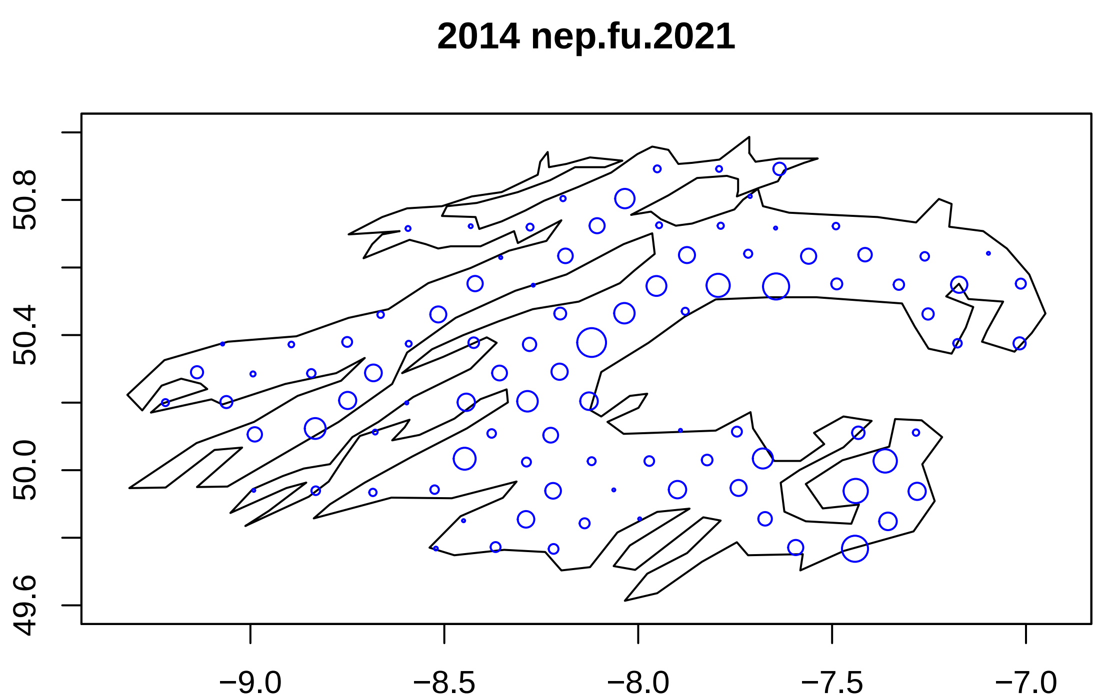
Load a polygon and create polygon structure. Polygon from Interbenchmark.

```
pol.FU2021 <- read.table("pol.Labadie.IBP.csv",header=T, sep=",")
poly <- polygon.create(x=pol.FU2021$x,y=pol.FU2021$y)
plot(poly)
plot(data.db,main=mt, add=T)
```




```
db.poly<-polygon.create(x=pol.FU2021[,1],y=pol.FU2021[,2],polygon=NA)
europa <- read.table("europa.txt",header=T)
plot(data.db,pch=21, title = mt,inches=5,asp=1/cos(mean(db.extract(data.db,"x1"))*pi/180),
     xlim=c(-9.5,-6.65),ylim=c(49.5,51.2))
plot(poly,col=8,add=T)
polygon(europa,col=8);box()
```

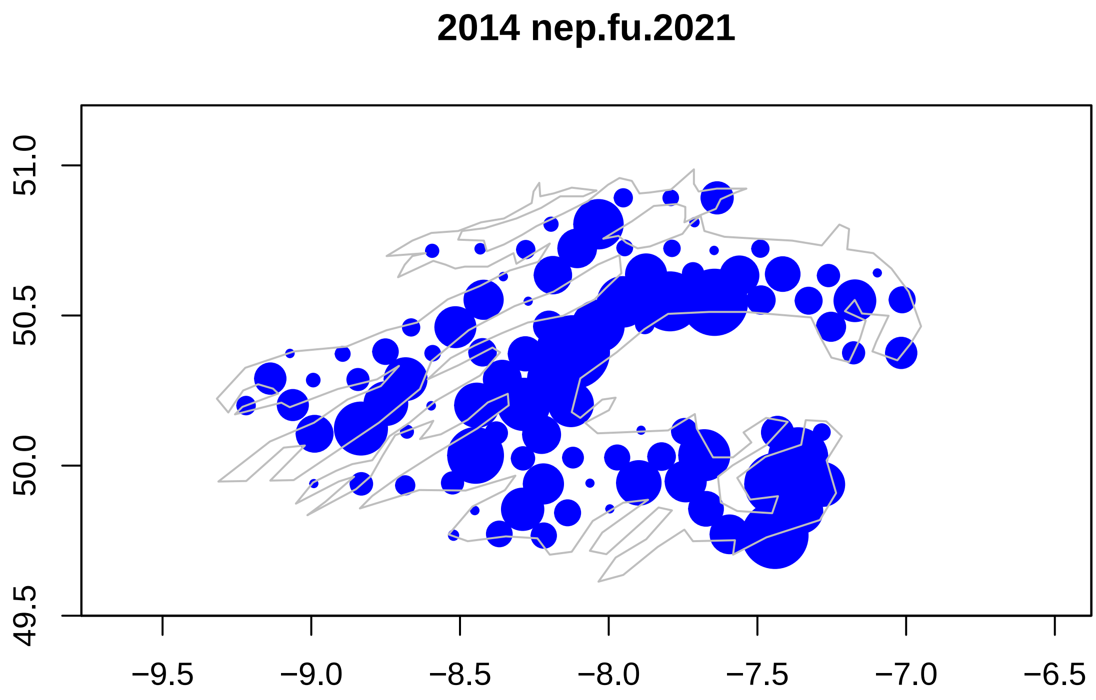


Figure 2: UWTV survey domain plot

Visualizing the data set in projected space based on the mean of the points

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Then checking the data points that fall inside and outside the polygon.

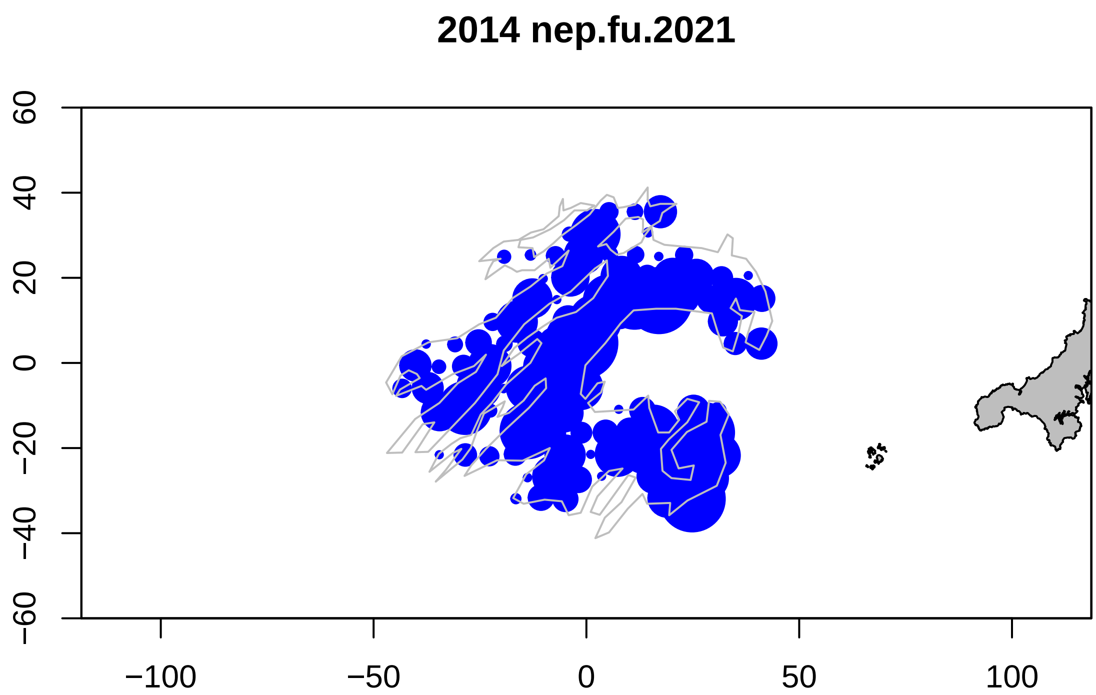
```
projec.define(projection="mean",db=data.db)
```

```
##
## Parameters for Projection
## -------------------------
## Projection is switched ON
## Use 'projec.define' to modify previous values
```

```
projec.toggle(mode=1)
```

```
##
## Parameters for Projection
## -------------------------
## Projection is switched ON
## Use 'projec.define' to modify previous values
```

```
plot(data.db,pch=21,title= mt,inches=5,asp=1,xlim=c(-60,60),ylim=c(-60,60))
plot(poly,col=8,add=T)
europa.p<-projec.operate(x=europa$x,y=europa$y)
polygon(europa.p,col=8);box()
```




```
db.c1 <- data.db
# select points inside polygon
db.c1 = db.polygon(db.c1,db.poly)
cat("nb points: ",db.c1$nech," ; outside polygon: ",sum(!db.c1@items$Polygon),"\n")
```

```
## nb points:  96  ; outside polygon:  6
```

Figure 3: Projected space and check datapoints inside survey domain plot

Calculate summary statistics inside the polygon.

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Inside the polygon. Histogram of densitites.

```
# mean, variance, histogramme of data inside polygon
zm<-mean(db.c1[,5][db.c1[,6]],na.rm=T)
zv<-var(db.c1[,5][db.c1[,6]],na.rm=T)*(sum(db.c1[,6],na.rm=T)-1)/sum(db.c1[,6],na.rm=T)
cat("mean: ",zm,"    var: ",zv,"    cv: ",sqrt(zv)/zm,"\n")
```

```
## mean:  0.1960857     var:  0.01889695    cv:  0.7010516
```

```
hist(db.c1[,5][db.c1[,6]],nclass=15,xlab="burrow density n/m?",main=mt)
```

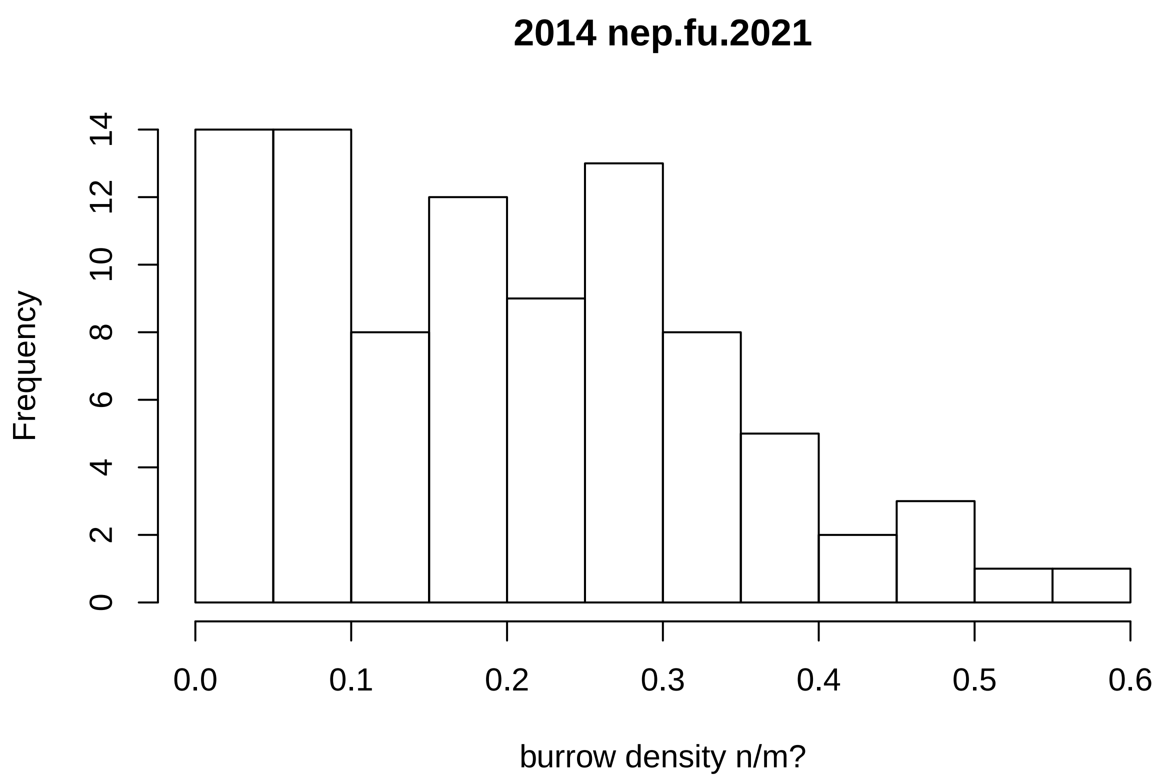

Figure 4: Histogram of adjusted densities.

Setting up the experimental variogram and plotting the points.

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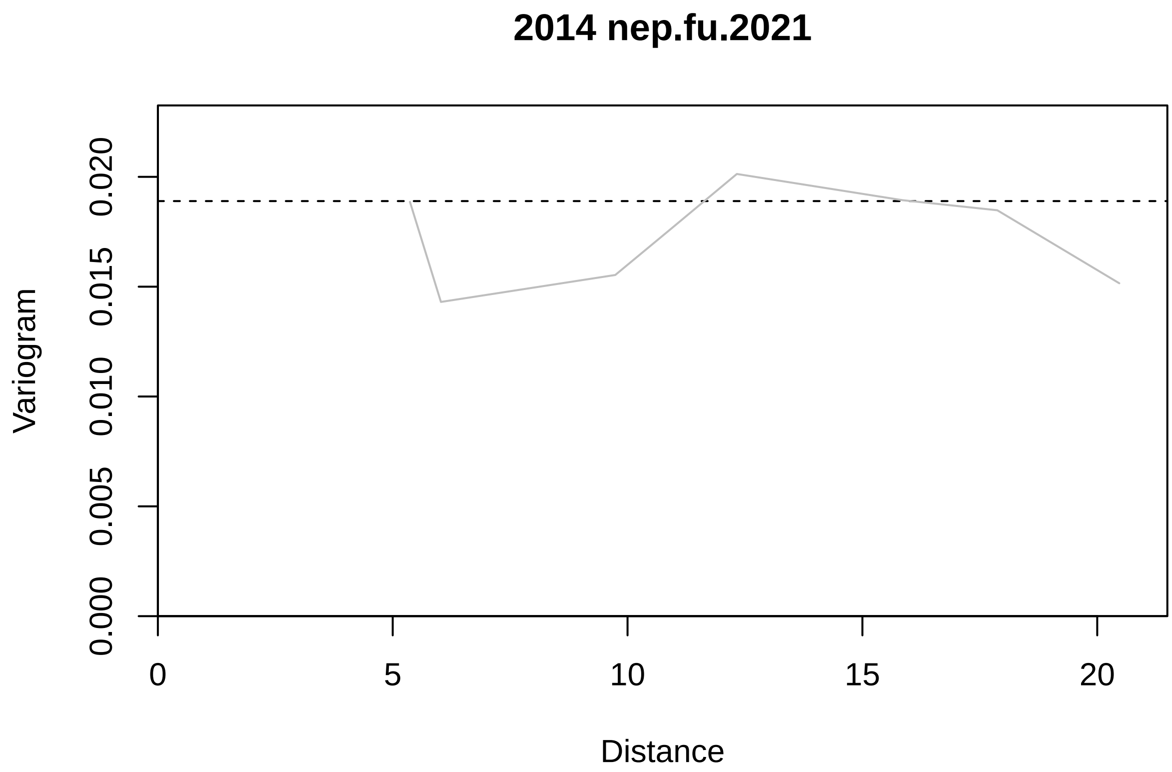
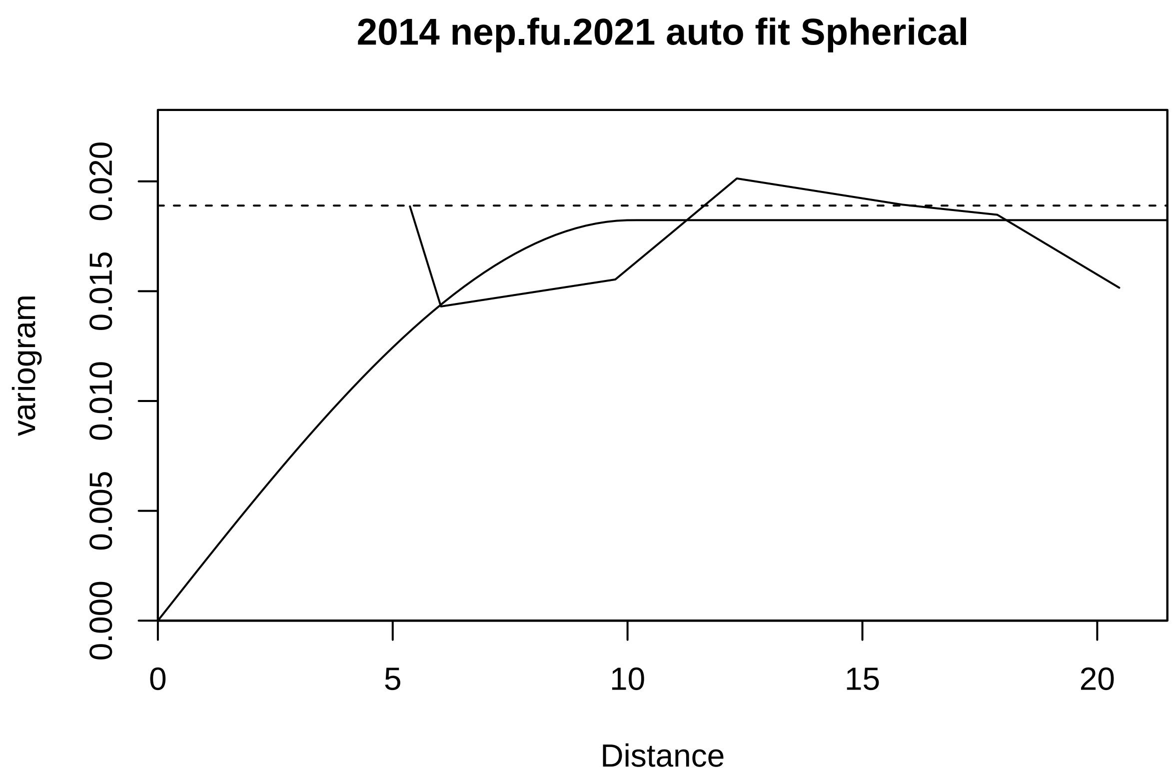
Fitting an experimental variogram to the pairs.

```
Lag=2.2; Nlag=10
vg1=vario.calc(db.c1,lag=Lag, nlag=Nlag)
  vario.plot(vg1,npairpt=1,xlab="Distance",ylab="Variogram",pch=9,cex=0.001,col="grey", title=mt)
```




```
vg.fit=model.auto(vg1,struc=c("Spherical"),title = paste(mt, "auto fit Spherical"),
                  xlab="Distance", ylab="variogram")
```




```
vg.fit
```

```
##
## Model characteristics
## =====================
## Space dimension              = 2
## Number of variable(s)        = 1
## Number of basic structure(s) = 1
## Number of drift function(s)  = 1
## Number of drift equation(s)  = 1
##
## Covariance Part
## ---------------
## - Spherical
##   Range       =     10.095
##   Sill        =      0.018
## Total Sill    =      0.018
##
## Drift Part
## ----------
## Universality Condition
```

Figure 5: Fitted variogram.

Gridding data set

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This step involves making a grid of points within the domain area.
This grid is used for the modelled surface.
A grid of 100X100 points was choosed because it was similiar to the previous methodology used in SURFER.
The grid is plotted along with the domain boundary and bubbles of density.

```
poldat<-read.table("pol.Labadie.IBP.csv",header=T,sep=',')

gnx=100;gny=100
gx0=min(poldat$x); gx1=max(poldat$x)
gy0=min(poldat$y); gy1=max(poldat$y)
gdx=(gx1-gx0)/gnx; gdy=(gy1-gy0)/gny
gd.disc=db.create(flag.grid=T,x0=c(gx0,gy0),dx=c(gdx,gdy),nx=c(gnx,gny))
gd.disc=db.polygon(gd.disc,db.poly)
plot(gd.disc,pch=3,col=1, xlim=c(-60,60),ylim=c(-60,60),title=mt);
plot(db.c1,add=T,pch=21); plot(db.poly,add=T)
```

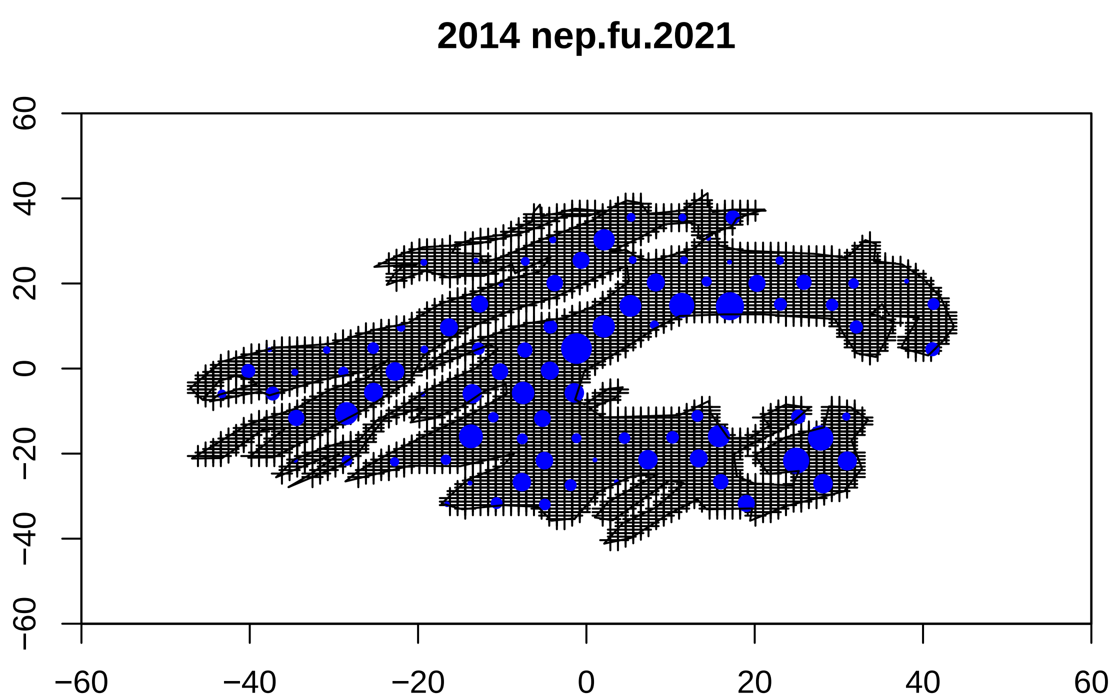

Figure 6: Gridded data plot.

Calculate mean burrow density and geostistical CV for the grid.

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This mean and CV is different to the krigging estimates calculated later but they should be fairly close for this type of dataset.

```
# calculation of CVV
cvv=model.cvv(polygon=db.poly,model=vg.fit,ndisc=c(gnx,gny))
# Global estimate = arithmetic mean. s2est=cvv+cxx-2*cxv
cxx=model.cxx(db1=db.c1,model=vg.fit)
cxv=model.cxv(db=db.c1,polygon=db.poly,model=vg.fit,ndisc=c(gnx,gny))
sse=sqrt(cvv+cxx-2*cxv)
cat("arith.mean: ",round(zm,5)," CV.geo: ",round(sse/zm,5),"\n")
```

```
## arith.mean:  0.19609  CV.geo:  0.04447
```

Kriging Model

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Here we carry out the kriging using the fitted variogram. Neighbourhood weighting is not needed given the properties of this data set (i.e. <50 observations which are fairly homogoneous and strongly auto-corellated).

```
global.ma=global(dbin=db.c1, dbout=gd.disc, model = vg.fit, uc=c("1"),
                 polygon = db.poly, calcul = "krige",
                 flag.polin=T, flag.wgt=F, ivar = 1, verbose = 1)
```

```
## Global estimation kriging
## =========================
## Total number of data              = 96
## Number of active data             = 90
## Number of variables               = 1
## Cvv                               = 0.000285
## Estimation by kriging             = 0.206699
## Lagrange Parameter #1             = -0.000073
## Estimation St. Dev. of the mean   = 0.008157
## CVgeo                             = 0.039461
##
## Surface                           = 2909.866588
## Q (Estimation * Surface)          = 601.466890
```

```
toto <- db.create(x1=pol.FU2021[,1],x2=pol.FU2021[,2])
grid <- db.grid.init(toto,nodes=100) # number of nodes if related with the fining of the grid
#when using all data as neighbours
uniquenei <- neigh.init(2,0)
```

```
## The function 'neigh.init'will soon become obsolete
## Please use function 'neigh.create' instead (same arguments)
```

```
kri <- kriging(dbin=db.c1,db.polygon(grid,poly),vg.fit,uniquenei)

ggin <- as.data.frame(kri@items)

write.csv(ggin, file= paste0("ggin",surv.yr,".csv"))
```

Kriging Model Plot1 Back to top

The krigged surface and the error structure is plotted and the grid is saved for plotting purposes later.

```
plot(kri,col=tim.colors(200),asp=1,xlim=c(-60,60),ylim=c(-60,60),
     name.image="Kriging.AdjustedBurrowDensity.estim")
plot(poly,col=22,add=T)
plot(db.c1,col='black',add=T)
```

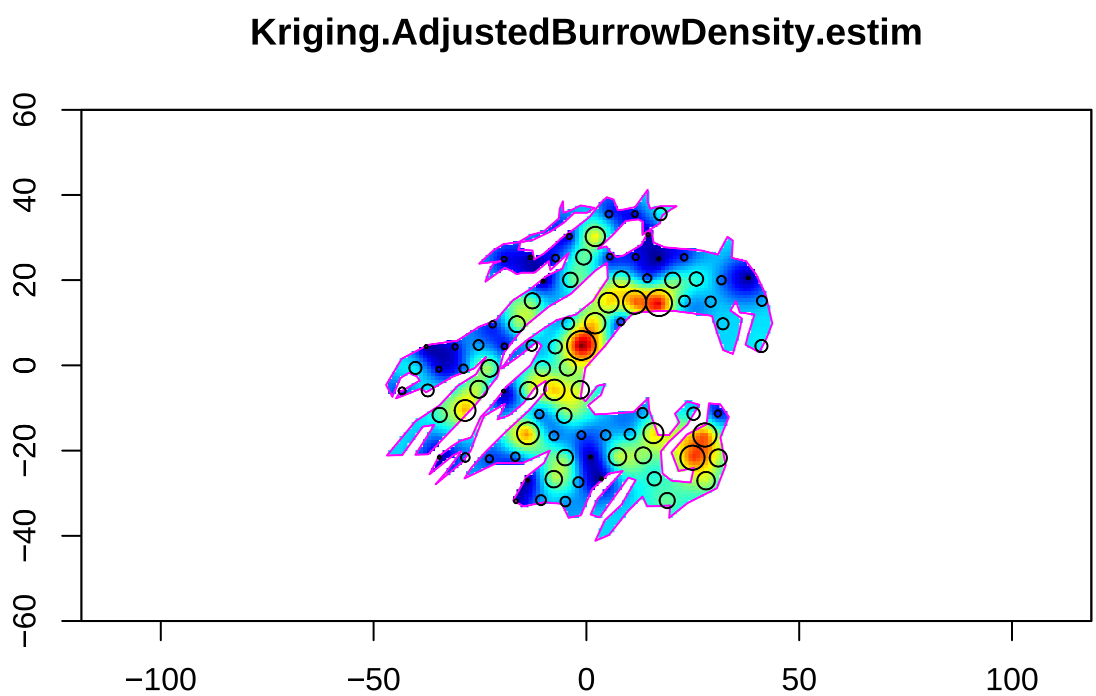

Figure 7: Kriged Density Adjusted.estimated.

Kriging Model Plot2 Back to top map of the estimation variance

The krigged surface and the error structure is plotted and the grid is saved for plotting purposes later.

```
plot(kri,col=tim.colors(10),name.image="Kriging.AdjustedBurrowDensity.stdev") #
plot(poly,col=22,add=T)
plot(db.c1,col=1,add=T)
```

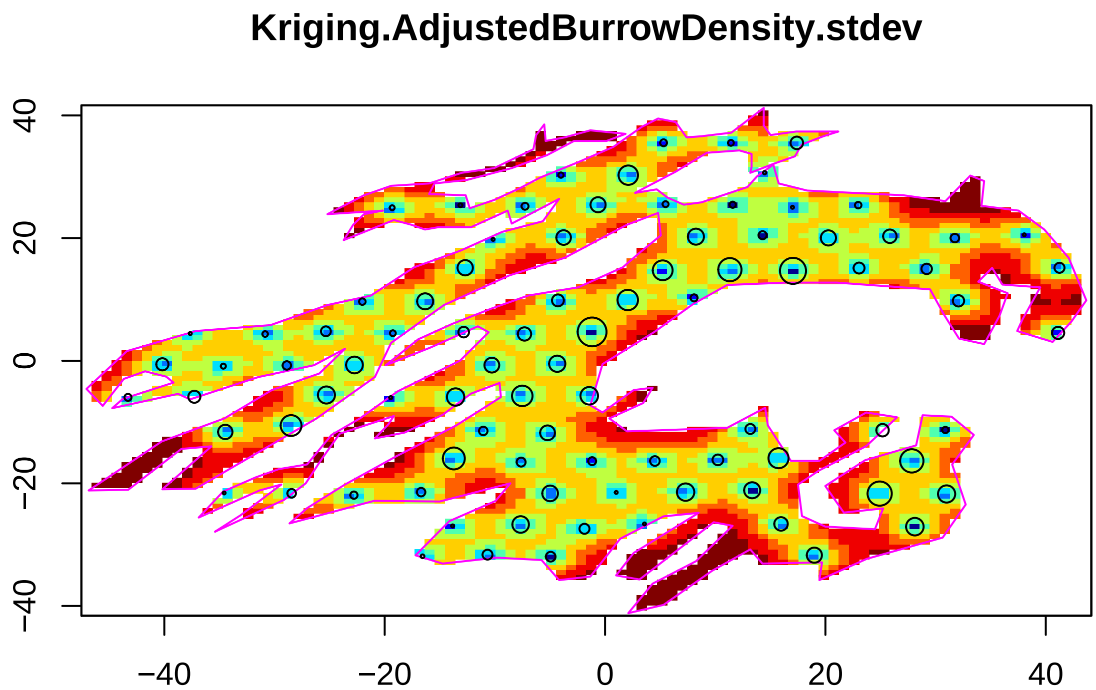

Figure 8: Kriged Density Adjusted.standrd deviation.

UWTV Survey Summary Statistics

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The mean z estimate from kriging is multiplied by the polygon surface 9980.5630497km^2 to calculate the total abundance. The summary object contains all the salient infomation for the final results. ggin file is outputted which is used to create kriged contour plots.

```
#Survey abundance estimate in numbers (millions)
abun <- global.ma$zest*poly$surface*1.852^2

k.sum <- rbind(k.sum, data.frame(Year=mean(nep$Year),Ground ="Labadie", mean= zm,  N= db.c1$nech,
                   sd = zv/zv^.05, se= sse, ciMult=NA, ci= abun*global.ma$cv*1.96,
                   area= poly$surface*1.852^2, abund = abun,
                   upper= abun+abun*global.ma$cv*1.96,
                  lower= abun-abun*global.ma$cv*1.96,
                   CViid= zv/zm, meanGeo=  global.ma$zest, CVgeo= global.ma$cv,
                  method="Rgeostats"))
```

UWTV SummaryData

UWTV summary statistcs

```
knitr::kable(k.sum[,1:9] )
```

Year	Ground	mean	N	sd	se	ciMult	ci	area
2013	Labadie	0.1594177	55	0.0153977	0.0080094	NA	83.92692	5779.320
2013	Labadie	0.1596379	55	0.0151347	0.0137716	NA	260.67600	9931.367
2014	Labadie	0.1960857	96	0.0230448	0.0087205	NA	159.55727	9980.563

```
knitr::kable(k.sum[,c(1:2, 10:16)])
```

Year	Ground	abund	upper	lower	CViid	meanGeo	CVgeo	method
2013	Labadie	936.9557	1020.883	853.0288	0.0775392	0.1621221	0.0457010	Rgeostats_truncated
2013	Labadie	1639.8368	1900.513	1379.1608	0.0760408	0.1651169	0.0811044	Rgeostats
2014	Labadie	2062.9737	2222.531	1903.4164	0.0963709	0.2066991	0.0394609	Rgeostats

The final check is a cross validation plot.

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```
data.db <- xvalid(db.c1,model=vg.fit,uniquenei)
hist(db.extract(data.db,"Xvalid.AdjustedBurrowDensity.esterr"),nclass=30,
     main="CrossValidation",xlab="Cross validation error",col="blue")
```

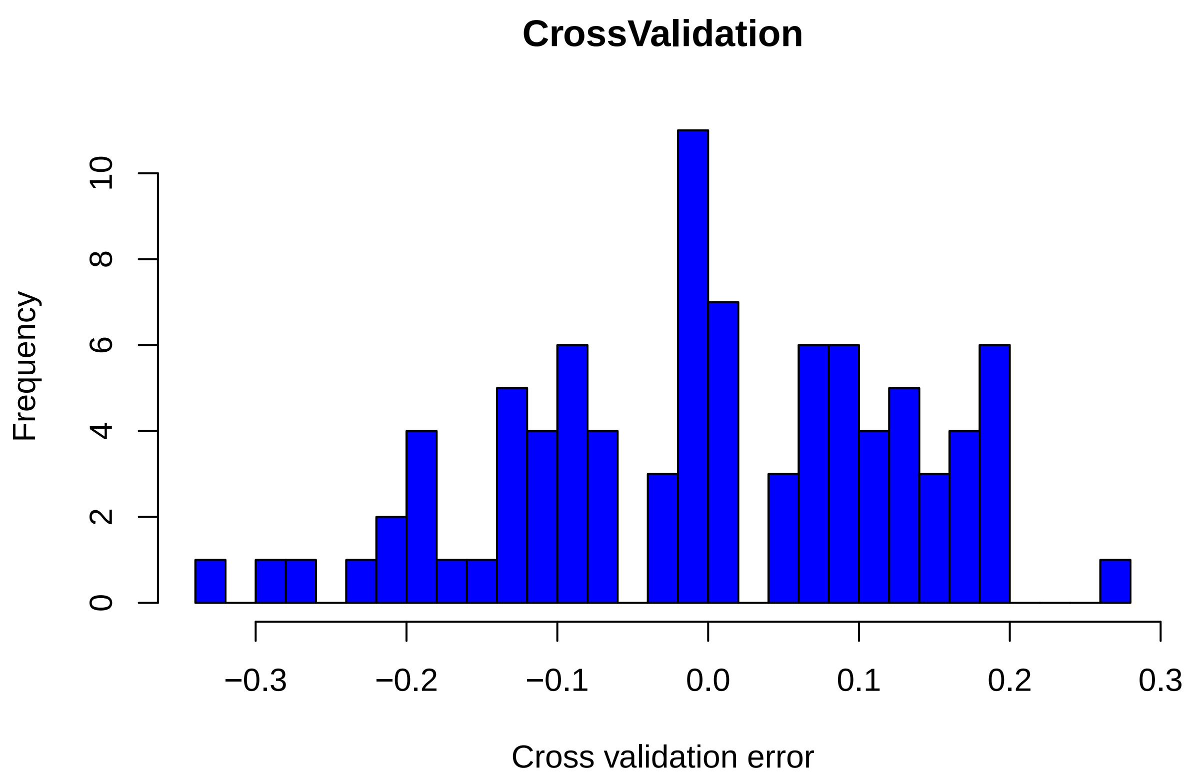

Figure 9: Cross validation plot.

Load in Surfer Data file

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```
#cmp <- read.csv("N:\\Surveys\\UWTV SURVEYS FU2022 CELTIC SEA\\2020 Labadie\\Kriging_AllYears\\Labadie_

cmp <- read.csv("Labadie_Summary_ADG_2020.csv")

cmp <- cmp %>% filter (Year >=2013) %>%
                select("Year", "mean", "abund", "upper", "lower", "ci", "CVgeo", "method")

datr <- k.sum %>% select("Year","mean", "abund", "upper", "lower", "ci", "CVgeo","method")

dat.all <- rbind(cmp, datr)

knitr::kable(dat.all)
```

Year	mean	abund	upper	lower	ci	CVgeo	method
2013	NA	1624.0000	1728.000	1521.0000	103.47752	0.0325000	Surfer
2014	0.1900000	2051.0000	2181.000	1920.0000	130.63800	0.0325000	Surfer
2015	0.2000000	2003.0000	2132.000	1875.0000	128.70800	0.0318820	Rgeostats
2016	0.1835318	1879.0000	2037.000	1722.0000	157.41383	0.0427346	Rgeostats
2017	0.4352394	4428.0000	4760.000	4095.0000	332.40700	0.0383048	Rgeostats
2018	0.2661938	2721.0000	2933.000	2509.0000	212.18791	0.0397878	Rgeostats
2019	0.0596517	617.0000	675.000	559.0000	57.89691	0.0478823	Rgeostats
2020	0.1022111	1020.4381	1116.197	924.6792	95.75894	0.0478781	Rgeostats
2013	0.1594177	936.9557	1020.883	853.0288	83.92692	0.0457010	Rgeostats_truncated
2013	0.1596379	1639.8368	1900.513	1379.1608	260.67600	0.0811044	Rgeostats
2014	0.1960857	2062.9737	2222.531	1903.4164	159.55727	0.0394609	Rgeostats

Plot Abundance Estimates Comparison

```
ggplot(dat.all, aes(x=Year, y= abund, colour=method)) +
          theme_bw() +
          geom_errorbar(aes(ymax=upper, ymin=lower, width=0.2)) +
          geom_line(size = 1) +
          geom_point(size=1) +
          scale_x_continuous(name="\nYear",
                             breaks = seq(min(dat.all$Year), max(dat.all$Year), 1)) +
          scale_y_continuous(name = "Abundance (millions)\n",
                             breaks = seq(0, max(dat.all$upper)+100, 250),
                             limits = c(0, max(dat.all$upper)+100)) +
  theme(panel.grid=element_blank(), legend.position = "bottom")
```

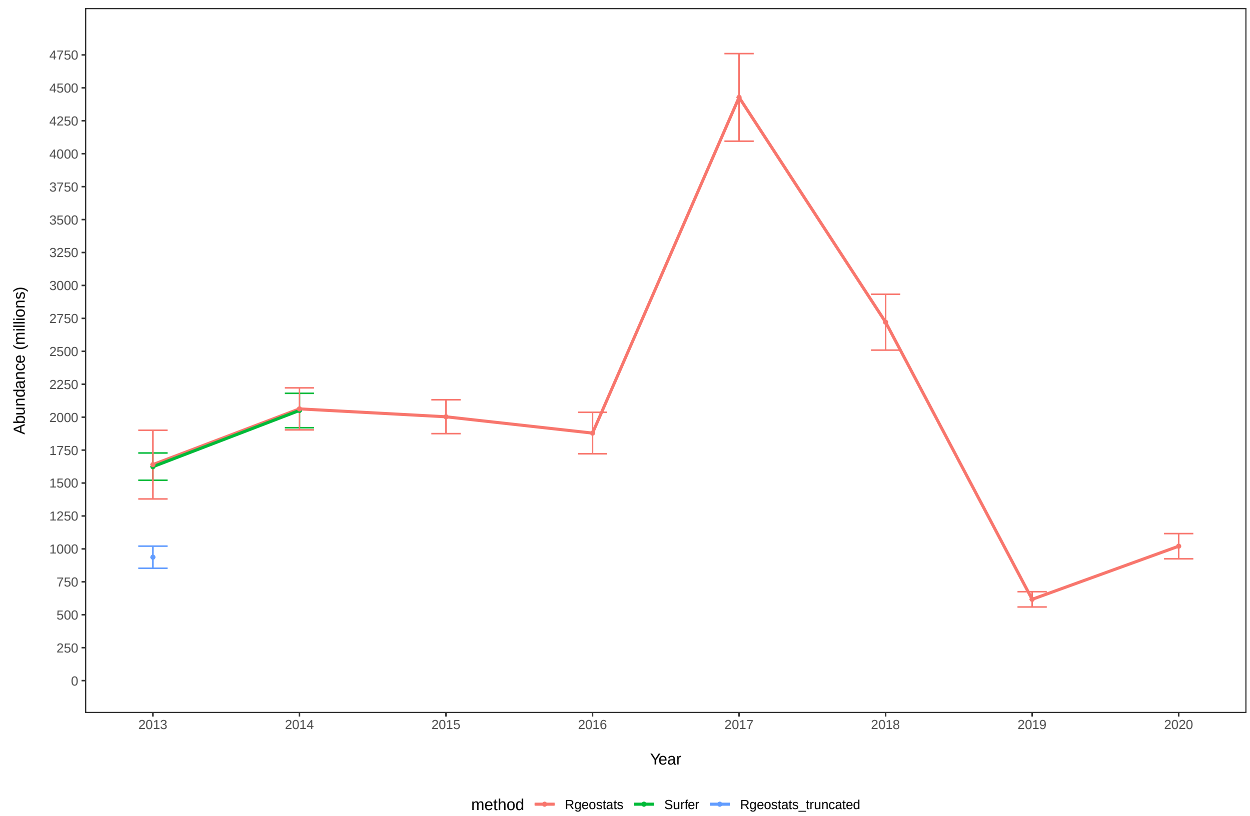

Figure 10: Abundance estimate (millions of individuals).

Plot CVgeo Comparison

```
ggplot(dat.all, aes(x=Year, y= CVgeo, colour=method)) +
          theme_bw() +
          geom_line(size = 1) +
          geom_point() +
          theme_bw() +
          geom_hline(aes(yintercept=0.20),colour="black",linetype="dashed",size = 0.5) +
          scale_x_continuous(name="\nYear",
                             breaks = seq(min(dat.all$Year), max(dat.all$Year), 1)) +
          scale_y_continuous(name = "CV Geo",
                             breaks = seq(0, max(dat.all$CVgeo)+0.15, 0.01),
                             limits = c(0, max(dat.all$CVgeo)+0.15)) +
  theme(panel.grid=element_blank(), legend.position = "bottom")
```

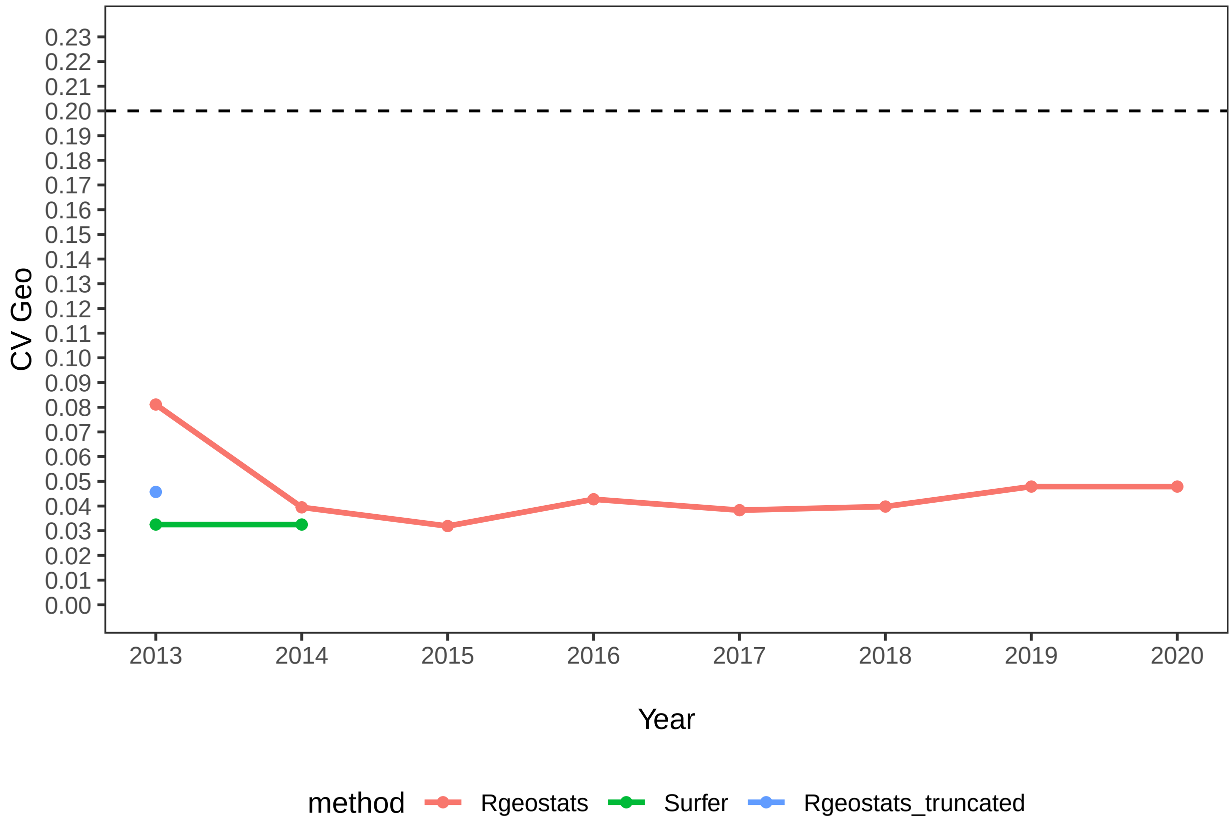

Figure 11: Uncertainty estimate. Dashed line is 20% limit.

Conclusions

Comparison of total abundance estimates from both methods are very similiar. The CVs are below the recommended 20% limit. In 2013 the CV estimated by RGeostats package compared to EVA method is higher (8.1% versus 3%) and this can be explained by the use of the truncated survey area.

For transparency and reproducibility propose to update the 2013 to 2014 survey estimates from RGeostats method.

Annex 4: Resolution

WGCSE – Working Group for the Celtic Seas Ecoregion

2020/2/FRSG09 The Working Group for the Celtic Seas Ecoregion (WGCSE), chaired by Mathieu Lundy, UK and Sofie Nimmegeers, Belgium will meet Online, 5–14 May 2021 and by correspondence September / October 2021 to:

a) Address generic ToRs for Regional and Species Working Groups;

b) Report on reopened advice as appropriate;

The assessments will be carried out on the basis of the stock annex. The assessments must be available for audit on the first day of the meeting.

Material and data relevant for the meeting must be available to the group on the dates specified in the 2020 ICES data call.

WGCSE will report by 25 May 2021 for the attention of ACOM, and by 1 October 2021 for *Nephrops* stocks, anglerfish and megrim in Rockall. Concerning ToR b) the group will report on the ACOM guidelines on reopening procedure of the advice before XX October and will report on reopened advice before XX October.

Only experts appointed by national Delegates or appointed in consultation with the national Delegates of the expert's country can attend this Expert Group

Annex 4: Audits

Audit of Cod in divisions 7.e–k (eastern English Channel and southern Celtic Seas)

Date: 03/06/2020

Auditor: Jonathan White

Short description of the assessment as follows:

1. Assessment type: update
2. Assessment: accepted
3. Forecast: accepted
4. **Assessment model:** SAM – proposed by expert group and benchmarked in 2020, Commercial landings, ages, and length frequencies from sampling by métier; one combined VAST-modelled survey index (combined IGFS-WIBTS-Q4 [G7212] and EVHOE-WIBTS-Q4 [G9527])); one commercial index (FR-OTDEF Q2+3+4 trawlers in divisions 7.e–k); fixed maturity ogive derived from UK-WCGFS survey-Q1 data; age-dependent natural mortalities (Lorenzen, 1996).
5. **Consistenc**y: last year's assessment accepted, this year's accepted; the assessment this year as Category 1, shows strong analytic retrospective patterns in SSB , F and Recruitment. However, the assessment and forecast were accepted as they are consistent with the previous understanding of stock status and advice will be zero.
6. Stock status: F is above F_{lim} for the second year, though declining on the last year; SSB is well below $MSYB_{trigger}$, B_{pa} and B_{lim}. Recruitment is low, with 2014 the last notable recruitment event (at age 1). Catches are lowest recorded (since 1980). 2019 was the last lowest, continuing a steady decline since 2012. This is being moderated by TAC, however catch has been below TAC since 2013, though not in 2020 (TAC 805 tonnes; Landings 922 t; Discards 231 t).
7. Management plan: Celtic sea cod fall under the EU MAP.

General comments

The applied stock assessment follows the stock annex. Sampling in 2020 owing to Covid-19 pandemic restrictions to movement have impacted sampling levels.

The report noted that: The impact of the Covid-19 pandemic on the fishery cannot be quantitatively determined, but may be assumed to have reduced fishing effort in quarter 2 of 2020. Sampling levels were reduced in quarters 2, 3 and 4 for almost all nations, leading to less data (discards ration and sampled age structure) uploaded in InterCatch in 2021 compared to previous years.

UK did not collect data for the stock from Q2 and Q3, and the trips sampled in Q1 and Q4 had zero discards for cod. More generalisations across gear and countries have been applied in 2021 than in previous years.

However, the percentage of sampled versus raised data as well as the distribution of sampled data over the quarters were considered satisfactory (Figure 6.5).

Technical comments

The retrospective analytical bias is an issue and should be looked into further.

The analytic, Category 1 assessment is important as it feed into the WGMixFish work and advice owing to its intrinsically linked place in the environment with whiting and haddock.

It may not be possible to reduce the retro bias as there are small values of catch in the recent past, which is recognised as being difficult to model.

Conclusions

The stock assessment and forecast and a robust reflection of the current knowledge and state of the stock. They are in line with observed catch. The report is a reliable report of assessment and forecast. The advice is a true representation of the expected state of the stock based upon interim year assumptions, which are reasonable with the given knowledge of the stock and fishery, and stock status in 2021.

Audit of had.27.6.b

Date: 15/06/2021

Auditor: Sara-Jane Moore

General

For single-stock summary sheet advice

1. **Assessment type:** Update Assessment
2. **Assessment**: analytical
3. **Forecast**: presented
4. **Assessment model**: FXSA/ Tuning indices: one survey index (Scottish Rock-IBTS-Q3)
5. **Data issues:** At-sea observer sampling for discards remains sparse for Rockall haddock, which leads to uncertainty in fishery selectivity patterns and catch estimates data used in the assessment. The assessment model used (FLXSA) assumes catch is measured with no uncertainty, and so does not account for this sampling issue. In 2020 discard data were only available form Scottish samples.
6. **Consistency**: Benchmarked in 2019, no changes in data types compared to the previous assessment.
7. **Stock status**: SSB is >B_{lim}, >MSY $B_{trigger}$, and >B_{lim} and Fishing pressure is>F_{MSY} but below F_{pa} and F_{lim}.
8. **Management Plan**: No but two management strategies (NEAFC and EU MAP) have been assessed to be precautionary. NEAFC has requested ICES to evaluate the harvest control rules using F_{MSY} as target. ICES concluded that the NEAFC harvest control rules in the long-term management strategy for Rockall haddock were consistent with the precautionary approach (ICES, 2019a).

General comments

Data files are on SharePoint but not FLXSA code so difficult to re-run XSA assessment.

Small editorial changes were made and emailed to stock assessor.

Technical comments

If track changes are accepted, plus tables and graphs edited, report should be easier to follow.

Mohn's reho values should be included in the assessment report, either in a Table or Figure 4.3.28.

Conclusions

The assessment seems to have been performed correctly. It would be helpful to have FLXSA code on SharePoint also.

The short-term forecast is run using MFDP.

It would be useful to include a table/code with the calculation of the all the catch scenarios e.g. F_{pa} and F_{lim} in the stock folder.

Audit of haddock in the Irish Sea (had.27.7a)

Date: 06/06/2021

Auditor: Andrzej Jaworski

General

ICES provides annual catch advice for this stock based on the MSY approach. A full analytical assessment and forecast were performed in 2021 in accordance with the procedures outlined in the stock annex. The assessment is based on an age-structured model.

For single stock summary sheet advice

1. **Assessment type:** Update (following the WKIrish3 benchmark assessment). Age-structured assessment. The stock was benchmarked by WKIrish in 2017.
2. **Assessment**: Age-structure assessment. Stock Category 1.
3. **Forecast**: Short-term forecast is presented. Conducted using FLR libraries. The introduction of ASAP has considerably changed the catch advice compared to previous years.
4. **Assessment model**: Age-structured assessment model using Age Structured Assessment Program (ASAP) with commercial catches and four survey indices.
5. **Consistency**: There is close agreement of the stock trends in the current assessment and the benchmark assessment.
6. **Stock status**: Spawning–stock biomass (SSB) is at relatively high levels in the time-series and above MSY $B_{trigger}$. But it has declined in recent years. Fishing mortality (F) has been below F_{MSY} since 2012. The stock is characterized by highly variable recruitment. Recent recruitment has been extremely low (and below the time-series mean).
7. **Man. Plan**: There is no specific management plan for the stock.

General comments

The assessment was conducted correctly and it followed the methods detailed in the stock annex.

Technical comments

ASAP analysis was correctly performed.

Conclusions

The assessment has been performed correctly and provides an appropriate basis for providing catch advice.

Checklist for review process

General aspects

- Has the EG answered those ToRs relevant to providing advice? **Yes**
- Is the assessment according to the stock annex description? **Yes**
- Is general ecosystem information provided and is it used in the individual stock sections. **Yes**
- If a management plan has been agreed, has the plan been evaluated? **No**

For update assessments

- Have the data been used as specified in the stock annex? **Yes**
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? **Yes**

- Is there any **major** reason to deviate from the standard procedure for this stock? **No**
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? **Yes**

Audit of Haddock in divisions 7.b–k (southern Celtic Seas and English Channel)

Date: 03/06/2020

Auditor: Ruth Kelly

General

This stock was bench marked by WKCELTIC in 2020, and assessment methods have been updated according to guidance from this benchmark assessment as detailed in the stock annex. There have been some changes to the methods used for the estimation of catch, due to disruption of the 2020 fisheries sampling programs due to COVID-19 (detailed below). These are not considered to have a major impact on the perception of stock status, and the assessment is considered to be fit for the provision of advice.

For single stock summary sheet advice

1. Assessment type: Update
2. Assessment: Analytical
3. Forecast: Presented
4. Assessment model: State–Space Assessment Model (SAM)
5. Data issues: Due to COVID-19 catch sampling of this stock was disrupted in 2020. As a result, changes were made to the processing of input data for this stock for the 2020 year. Specifically, for some gear types in some countries, discard estimates were based either on previous data or data from similar gear types from other countries. Furthermore, catch weights from 2020 sampling for some age classes were considered to be unrealistically low, and average weights-at-age from 2017–2019 were used as inputs in the assessment. Catch numbers-at-age were also SOP corrected accordingly. These procedures are fully documented in the report, described in the advice sheet and were agreed as the most appropriate by the working group after detailed consideration of a range of options. They are unlikely to influence the perception of stock status, which remains above relevant reference points.
6. Consistency: New assessment method (SAM) has been applied based on 2020 WKCELTIC benchmark of this stock. Some changes were made to data processing steps due to sampling disruptions in 2020, see point 5) above.
7. Stock status: Fishing pressure on the stock is below F_{MSY} and spawning–stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.
8. Management Plan: EU multiannual management plan (MAP) for the Western Waters (EU, 2019).

General comments

Assessment is well documented in advice sheet, report and stock annex.

Technical comments

Data have been provided via ICES SharePoint, and SAM assessment based on VAST modelled time-series are available on stockassessment.org.

Conclusions

Report, advice sheets and analysis are available, and analysis appears to have been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those ToRs relevant to providing advice? - Yes
- Is the assessment according to the stock annex description? – Yes
- If a management plan is used as the basis of the advice, has this been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? - Yes
- Have the data been used as specified in the stock annex?- Yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? - Yes
- Is there any **major** reason to deviate from the standard procedure for this stock? – Not major, but some changes were made to the data processing steps due to disruptions to catch sampling in 2020.
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? - Yes

Audit of Megrim (*Lepidorhombus* spp.) in divisions 4.a and 6.a (northern North Sea, West of Scotland)

Date: 24/05/2021

Auditor: Simon Fischer

General

This assessment for megrim in 4.a and 6.a is complex. For this year's audit, it was not possible to reproduce the forecast.

For single stock summary sheet advice

1. Assessment type: update
2. Assessment: analytical
3. Forecast: presented
4. Assessment model: Custom Bayesian surplus production (Schaefer) model with six survey indices, some of them from delta-gamma GLMs. Discards before 2013 are estimated but used as input for the assessment model.
5. Data issues: One survey missing in 2020, but impact considered negligible
6. Consistency: High consistency of estimates relative to MSY reference points. Absolute values (used for forecast) more variable.
7. Stock status: B > MSY $B_{trigger}$ and F < F_{MSY}.
8. Management Plan: EU multiannual plan (MAP) for Western Waters and adjacent waters, using F_{MSY} ranges and MSY $B_{trigger}$.

General comments

The report is concise and could benefit from more detailed descriptions of the assessment and forecast procedure and outcomes.

Stock Annex

The Stock Annex (SA) would benefit from a rewrite and update. There are outdated sections and tables, descriptions of redundant stock assessment results from several years ago. There is a lack of model specifications for the assessment model and the description for the short-term forecast is extremely short and does not give details about how to perform it. The SA lists the B_{pa} reference point as "not defined", it is however, shown in the advice sheet.

Technical comments

The assessment is run with a model in WinBUGS, which is very slow, particularly for a surplus production model. Also, the forecast takes >0.5 hour to run. The assessment is conducted with numerous R/Markdown scripts and appears overly complex with several versions run concurrently which makes auditing this stock challenging. The assessment would benefit from cleaning the assessment procedure, e.g. by creating an R package for the model, which would also remove the possibility of accidentally introducing mistakes.

The forecast is conducted by running a wide range of discrete catch options and then selecting them based on catch, F, biomass or risk considerations. There is no documentation (SA or report) on how to derive the scenarios shown in the advice sheet from the numerous catch scenarios.

The assessment runs could be reproduced.

Reproduction of the forecast was not possible this year and the values provided in the advice sheet can only be regarded as correct under the condition that the provided model output files are correct.

The derivation of the final forecast is somewhat intransparent but follows the same procedure as in previous years.

Conclusions

The assessment is complex but consistent with the approach used in previous years. Full compliance with the stock annex cannot be evaluated because the stock annex is vague and does not give comprehensive details about the data, assessment and forecast procedures.

Audit of Plaice (*Pleuronectes platessa*) in Division 7.a (Irish Sea)

Date: 06/06/2021

Auditor: Claire Moore

General

For single stock summary sheet advice

1. Assessment type: update
2. Assessment: analytical
3. Forecast: presented
4. Assessment model: SAM – age-based – three survey indices
5. Data issues: The UK BTS survey could not take place in this area due to Covid-19 pandemic and as a result estimates of young fish abundance are more uncertain than in previous years. Discard estimates in 2020 are based on incomplete sampling of the fisheries. However, these are considered to have a negligible impact on the perception of the stock status.
6. Consistency: same methodology as in recent years
7. Stock status: SSB has increased slightly and F decreased slightly in 2021 but remain close to the mean of recent years. Fishing pressure on the stock is below F_{MSY} and spawning–stock size is above MSY $B_{trigger}$, B_{pa}, and B_{lim}.
8. Management Plan: None

General comments

Report is very detailed, and scientifically sound, but perhaps too long. There is a lot of repetition and it could do with 'clear out' of redundant sentences and phrases. For example, "WKIrish" is referred to repeatedly in the chapter (14 times), and referenced correctly only (three times). It would help to improve the readability and functionality of the text if correct referencing was used; i.e. instead of "The update assessment follows the same procedure as in the WKIrish3 benchmark assessment", perhaps you could say, "The updated assessment follows the stock annex (ICES, 2017)"?

Technical comments

A sensitivity test to evaluate the impact of no discard data in the final year was performed. Specifically, runs of the assessment with and without discards for the year 2020 were used to assess the sensitivity of the model to missing discards. The results showed a noticeable increase in recruits in the assessment with missing discards in 2020. Consequently, in the 2021 assessment the final year of the recruitment was excluded.

Conclusions

Data and assessment code made available on the SharePoint. They have been run and match the outputs provided. Issues identified were resolved by stock assessor.

Audit of Plaice (*Pleuronectes platessa*) in Division 7.e (western English Channel)

Date: 27/05/2021

Auditor: Gianfranco Anastasi

General

For single stock summary sheet advice

1. Assessment type: update
2. Assessment: analytical
3. Forecast: presented
4. Assessment model: Age-based analytical assessment (XSA) with two survey indices. Discards available from 2012 onwards and used to provide advice, but not included in the assessment.
5. Data issues: As a result of Covid-19, scientific survey (Q1SWBeam) was delayed from March 2020 to June 2020, but impact considered negligible.
6. Consistency: The assessment is considered only indicative of trends because it is based on landings data only. Discards data are only available from 2012. Exploratory assessments using discard information indicate that the recent fishing mortality is likely to be higher, and recent spawning–stock biomass lower than in the current landings only assessment.
7. Stock status: B >MSY $B_{trigger\ proxy}$, $B>B_{pa}$, $B>B_{lim}$ and $F>F_{MSY\ proxy}$, $F<F_{pa}$, $F<F_{lim}$
8. Management Plan: There is no management plan in place for this stock apart from the EU multiannual plan for the region.

General comments

The report is well documented with detailed descriptions of the assessment and forecast procedure and results. Two exploratory assessments were presented (XSA assessment including discards and SAM assessment).

Technical comments

Plaice assessment is on the ICES Transparent Assessment Framework (TAF) on GitHub. This should provide an easy and simple way to run and reproduce the stock assessment.

Conclusions

The assessment has been performed correctly.

Audit of Ple.27.7fg

Date: 3/06/2021

Auditor: Bart Vanelslander

General

For single stock summary sheet advice

1. Assessment type: update
2. Assessment: Cat 3, trend based
3. Forecast: yes
4. Assessment model: SPiCT using two surveys and two commercial indices
5. Data issues: no data issues mentioned
6. Consistency:
   a) Same methodology as in 2018–2020
   b) Sampling levels of landings and discards decreased in 2020 due to COVID-19. Sampling was still considered sufficient to estimate the total catch. There was no important impact on both surveys.
7. Stock status: fishing pressure on the stock is below $F_{MSY\ proxy}$ and biomass is above MSY $B_{trigger\ proxy}$.
8. Management Plan: None

General comments

The report is well-structured and concise.

Technical comments

Some minor corrections made in the report.

Figure 28.3 seems to lack data for 2019 and 2020.

Conclusions

The assessment has been performed correctly

Checklist for audit process

General aspects

- Has the EG answered those ToRs relevant to providing advice? yes
- Is the assessment according to the stock annex description? yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? N/A
- Have the data been used as specified in the stock annex? yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? yes
- Is there any **major** reason to deviate from the standard procedure for this stock? no
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? yes

Pollack (*Pollachius pollachius*) in subareas 6–7 (Celtic Seas and the English Channel)

Date: 02/06/2021

Auditor: Ruth Kelly

General

Fishing pressure on this stock is assessed as being below DCAC reference points, but the stock size is unknown. Uncertainty about stock size relates mainly to a lack of fishery-independent survey data, and a lack of data on recreational catches. The precautionary buffer was last applied in 2018, and has, therefore, been reapplied this year due to uncertainty about the stock status relative. Assessment procedures have been carried out appropriately.

For single stock summary sheet advice

1. **Assessment type:** Cat. 4 assessment. Depletion-Corrected Average Catch (DCAC) assessment.
2. **Assessment**: Catch trends
3. **Forecast**: No forecast possible from this assessment type. The advice base on proceeding year's advice, and on the application of the precautionary buffer.
4. **Assessment model**: DCAC
5. **Data issues:** Data included are consistent with previous year's assessments.
6. **Consistency:** Assessment is consistent with previous years
7. **Stock status**: Stock status cannot be estimated based on current methods for this data-limited stock (see general comments below).
8. **Management Plan**: Multiannual management plan (MAP) for the Western Waters (EU, 2019).

General comments

This assessment has been performed correctly according to the DCAC method. However, as noted in the advice sheet, report and working group there is a lack of important data for the assessment of this stock. Specifically, in the absence of appropriate survey data and sufficient data on recreational fishery catches, it is not possible to assess stock status or biomass reference points. This stock was considered for benchmark in 2020, but further work is needed to compile adequate data for this stock. As described in the working group report for this stock 'The need for an improvement on the existing DCAC assessment remains and there is a commitment to progressing the data and assessment options'.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

- Has the EG answered those ToRs relevant to providing advice? Yes
- Is the assessment according to the stock annex description? NA
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Yes
- Have the data been used as specified in the stock annex? NA
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? No forecast model

- Is there any major reason to deviate from the standard procedure for this stock? No
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? Yes

Audit of Sole (*Solea solea*) in Division 7.a (Irish Sea)

Date: 28/05/2021

Auditor: Simon Fischer

General

For single stock summary sheet advice

1. Assessment type: update
2. Assessment: analytical
3. Forecast: presented
4. Assessment model: XSA (in FLR: FLXSA) – tuning by 1 survey
5. Data issues: The only survey did not go ahead in 2020 due to COVID-19 restrictions.
6. Consistency: same methodology as in recent years
7. Stock status: SSB increasing and has now surpassed MSY $B_{trigger}$, F has been increasing recently but is still below F_{MSY}.
8. Management Plan: None

General comments

Concise report.

Technical comments

The only survey for this stock did not happen in 2020 because of COVID-19 restrictions but catch data, including sampling, were sufficient for an update assessment. To account for the missing tuning information in 2020, the 2020 recruitment value is uncertain and was overwritten with a recent average. This approach seems appropriate and makes use of 2020 catch data, instead of relying on a two-year forecast and disregarding catch sampling.

The Stock Annex was updated in 2021 to record the missing survey data for 2021 and the updated basis of F_{pa} (now based on $F_{p.05}$).

Conclusions

The assessment and forecast have been performed correctly and are reproducible.

Audit of Sol.27.7e

Date: 3/06/2021

Auditor: Bart Vanelslander

General

For single stock summary sheet advice

1. Assessment type: update
2. Assessment: analytical
3. Forecast: presented
4. Assessment model: XSA (in FLR: FLXSA) – tuning by two survey tuning fleets and two commercial tuning fleets executed on the TAF server.
5. Data issues: no data issues mentioned
6. Consistency:
   a) The Quarter 1 South West Beam trawl (Q1SWBeam) survey usually takes place in late March. Due to Covid-19, this survey took place approximately three months later than usual. To evaluate the impact of this delay, two model runs were performed, one without the Q1SWBeam 2020 survey data and one including the 2020 Q1SWBeam data. The delay proved to have a very minor impact on the assessment, and therefore the working group agreed to include the values for 2020.
   b) In previous years, the intermediate year recruitment was estimated as the geometric mean of the full recruitment time-series. Recently, recruitment was well above this geometric mean, therefore a shorted period was used for the calculation of the geometric mean. (2011–2020 instead of 1969–last data year).
   c) Despite the Covid-19 pandemic, sampling levels of landings were high, but lower for the discards. Given the very low discard rate, this is considered not to affect the stock assessment for this stock.
7. Stock status: SSB is above MSY $B_{trigger}$, B_{PA} and B_{lim} and increasing, F is well-below all reference points
8. Management Plan: Advice is given according to the EU MAP

General comments

The report is well-structured and contains a series of very informative graphs.

Technical comments

The SSB is increasing, the recruitment for 2020 is among the strongest of the time-series and the geometric mean that's being used in the forecast is higher than previous year. Yet, the advice for 2022 has slightly decreased compared to 2021. Some insights in this in the report would be useful.

Conclusions

The assessment has been performed correctly.

Checklist for audit process

General aspects

- Has the EG answered those TORs relevant to providing advice? yes
- Is the assessment according to the stock annex description? yes
- If a management plan is used as the basis of the advice, has been agreed to by the relevant parties and has the plan been evaluated by ICES to be precautionary? Yes, EU MAP for Western Waters

- Have the data been used as specified in the stock annex? yes
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex? yes
- Is there any **major** reason to deviate from the standard procedure for this stock? no
- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice? yes

Audit of Sole (*Solea solea*) in divisions 7fg (Bristol Channel, Celtic Sea South)

Date: 02/06/21

Auditor: Helen Dobby

General

For single stock summary sheet advice

1. Assessment type: Category 1
2. Assessment: SAM assessment
3. Forecast: Stochastic forecast in SAM
4. Assessment model: SAM
5. Data issues: No major issues in data. Catch estimation appears to have been conducted as per stock annex.
6. Consistency: Update assessment following the stock annex for the assessment and forecast.
7. Stock status: SSB>>MSY $B_{trigger}$; F>F_{MSY} & < F_{pa}
8. Management Plan: EU multiannual plan (MAP) for Western Waters and adjacent waters. However, this is joint stock with UK.

General comments

The report is concise and generally well written. Some minor editorial suggestions in track changes on the document.

There are also a number of sections which contain historical information which could potentially (in future) be shortened and/or moved to the stock annex (e.g. MSY ref pt exploration).

Technical comments

I have not re-run the assessment and forecast due to lack of time. However, the assessment summary appears consistent with the SAM output Rdata file available on the SharePoint and in the WG report. Additionally, the catch options table in advice sheet is mostly internally consistent (although one of the % needs checking) and agrees with the output file available on the WG SharePoint and in the WG report.

However, some of the tables in the WG report & advice sheet need cross-checking as follows:

1. SSB2021 – there appear to be three different values available: 5807 t (WG report – Table 36.15), 5949 t (WG report – Table 36.16) and 6054 t (Table 9 in the Advice sheet). Not clear why these are different – maybe to do with stochastic forecast, but needs checking/explaining or ensuring they are consistent. Not clear that the value in Advice sheet is the correct one.
2. SSB2022 – also three different values available: 5691 t (WG report – Table 36.16), 5866 t (csv forecast assumptions file) & 5864 t (Table 1 in the Advice Sheet).
3. Table 2 36.14 & 26.16 have Rec2021=5239 and Rec2022=5246, however in advice sheet both are =5246 in Table 1.

Conclusions

Category 1 stock. Assuming that the inconsistencies in SSB values can be reconciled, the assessment and forecast appear to have been done correctly.

Audit of Sole (*Solea solea*) in divisions 7h–k (Celtic Sea South, southwest of Ireland)

Date: 24/05/2021

Auditor: Helen Dobby

General

For single stock summary sheet advice

1. Assessment type: NA
2. Assessment: no assessment – category 5 stock
3. Forecast: no forecast – category 5 stock
4. Assessment model: NA.
5. Data issues:
6. Consistency: Same approach to provision of advice as last year – precautionary approach (same advice – no application of PA buffer).
7. Stock status: unknown.
8. Management Plan: EU multiannual plan (MAP) for Western Waters and adjacent waters, using precautionary approach since F_{MSY} ranges are not available.

General comments

The report is concise and generally well-written. Some minor editorial suggestions in track changes on the document.

Technical comments

Suggest include the estimated discards in the WG report as they are in the advice sheet.

Conclusions

Category 5 stock. The advice has been drafted as per stock annex.

Audit of Whiting 6.a

Date: 01/06/2021

Auditor: Pia Schuchert

General

For single stock summary sheet advice

1. **Assessment type:** new assessment following benchmark
2. **Assessment:** analytical age-based
3. **Forecast**: Presented, in form of short-term stochastic projections
4. **Assessment model**: SAM with catch and survey data, SURBA assessment for comparison
5. **Data issues:** As a result of Covid-19, the miknet survey was not undertaken in 2020, and only limited discard samples were available. Discard numbers were inferred from an average pattern from 2017–2019 and catch in 2020 was down-weighted to reflect the extra uncertainty.
6. **Consistency**: This is a new assessment, which has been benchmarked in 2020/2021. The last assessment (SPiCT, benchmarked in 2019) has been rejected in 2020, and the new assessment seems to perform considerably better. The retrospective patterns show a consistent downwards revision of SSB and upward revision of F, with the Mohn's Rho for F surpassing the limit (-0.17). However, both SSB and F remain in their respective envelopes and SSB is considered high above MSY $B_{trigger}$ and F consistently below F_{MSY}.
7. **Stock status**: SSB is considered to be close to the 1990s state and above MSY $B_{trigger}$, increasing in recent years. Fishing mortality has been consistently below F_{MSY} since 2005.
8. **Management Plan**: There are no specific management objectives or a management plan for this stock. The EU map takes discards of this stock into account.

General comments

The report contained the expected information in a clear manner and is very thorough. A complementary assessment in SURBAR is provided, which supports the findings from the SAM assessment.

The advice is on MSY basis for the first time after years of precautionary advice.

Conclusions

The assessment has been performed correctly.

Audit of Whiting 7.a

Date: 28/05/2021

Auditor: Tim Earl

General

For single stock summary sheet advice

1. Assessment type: SPALY
2. Assessment: Analytical
3. Forecast: Presented
4. Assessment model: ASAP using NI Q1 and Q4 GFS, and miknet. Forecast using FLR
5. Data issues: As a result of Covid-19, the miknet survey was not undertaken in 2020, and only limited discard samples were available. Discard numbers were inferred from an average pattern from 2017–2019 and catch in 2020 was down-weighted to reflect the extra uncertainty.
6. Consistency: Apart from the reduced data for 2020, the assessment was consistent with assessments since the benchmark in 2017. Sensitivity tests and the poor state of the stock suggest that the data availability has had no impact on the advice (although there is likely to be some effect on the 'other options'). Values of Mohn's Rho remain acceptable.
7. Stock status: SSB very low (below B_{lim} since 1990s). Fishing mortality high (above F_{lim} since 1980) and variable between years.
8. Management Plan: MSY approach used for providing advice, stock is bycatch under EU MAP. Zero catch advice for two years as the stock remains way below B_{lim} even with no catch in 2022.

General comments

The report contained the expected information in a clear manner.

Technical comments

The technical basis for F_{pa} has been changed in the report and advice sheet, reflecting the ICES guidance. It would be good to highlight this change in the report.

Conclusions

The assessment has been performed correctly.