BENCHMARK ON SELECTED SEA BASS STOCKS (WKBSEABASS)

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i Executive summary

The benchmark workshop on sea bass (*Dicentrarchus labrax*) (WKBSEABASS) was conducted over an extended period, spanning from 2023 to 2024, to agree on the stock identities, stock structure, and assessment methodologies in future assessments of sea bass in the North Sea, Northeast Atlantic, and down to the Bay of Biscay. The benchmark had a strong focus on the investigation of spatial boundaries of the population within the area and the migratory behaviour and mixing between units.

As part of the current benchmarking process, the evidence on stock identity for sea bass in Northern and Biscay stocks was reviewed, and plausible stock structure scenarios for the ICES sea bass benchmark were proposed (ICES, 2023). This generated several potential stock identities that included: a single stock covering the whole area; the current Northern (ICES divisions 4.b–c, 7.a, and 7.d–h) and Biscay (ICES divisions 8.a–b) stocks with mixing; and three equally plausible scenarios with three subpopulations and mixing (ICES, 2023). At the data workshop, it was identified that there was insufficient data to model the Irish Sea (7.a) separately, and catch was low in this area, so it was merged with the Celtic Sea for modelling. In addition, there was insufficient resource to test all scenarios, so two were chosen: the current Northern and Biscay stocks with exchange of catches; and a single meta-population model containing North Sea (4.b–c, 7.d), Celtic and Irish Seas (7.a, 7.e–h), and Biscay (8.a–b) subpopulations with mixing (Figure 1). At the modelling workshop, it was decided to start with the simpler of the two scenarios (i.e. Northern and Biscay stocks with exchange of catches; Figure 1A) due to the complexity of the full mixing model (Figure 1B). As a result, only scenario A, Northern and Biscay stocks with exchange of catches (Figure 1A), was taken forward to the benchmark.

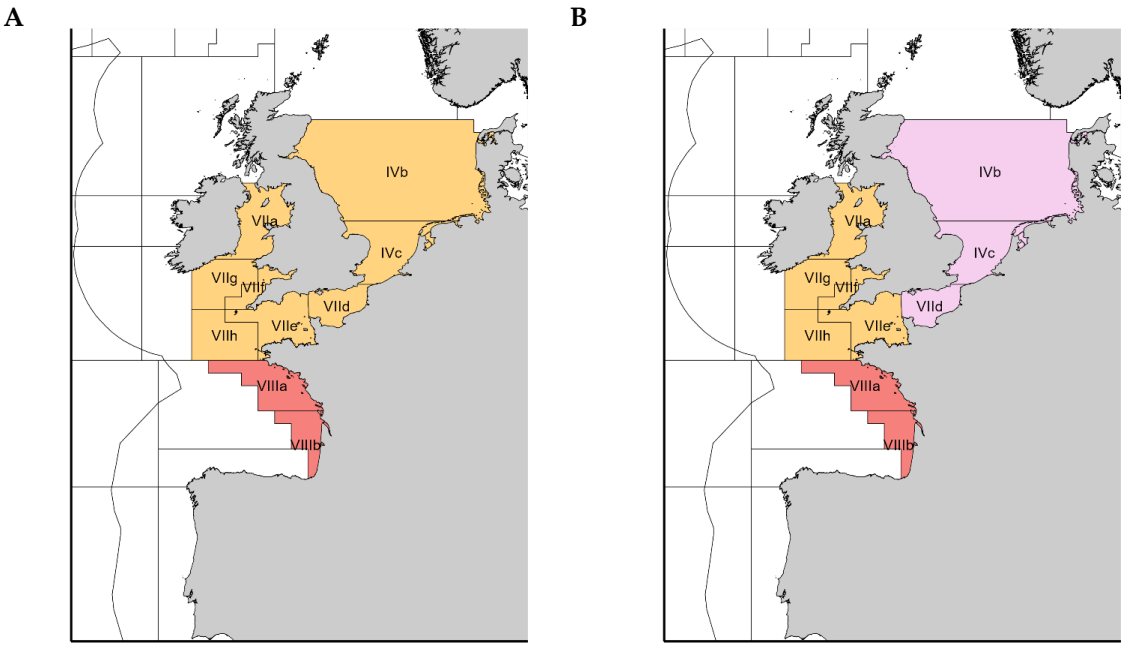


Figure 1. Stock identity scenarios agreed at the data workshop to be taken forward for assessment models: A. Northern and Biscay stocks with exchange of catches; B. Single meta-population model containing North Sea (4.b–c, 7.d), Celtic and Irish Seas (7.a, 7.e–h), and Biscay (8.a–b) subpopulations with mixing.

The data workshop was conducted from 29 January to 2 February 2024 in Copenhagen, followed by intersessional work in groups to address and produce the missing data identified at the workshop. Catch numbers at length, natural mortality-at-age, recreational catches and survey indices were recalculated based on the latest insights and tools provided and additional data becoming available. Key to this process was also the advanced understanding and estimation processes of the recreational fishery data, while tagging data provided a quantity for the mixing of the stocks.

For both regions, new SS3 models were created, with a proportion of the catches, according to data from tagging studies, being reallocated from the Northern to the Southern stock. Baseline models for both areas were created, which had to pass a set of diagnostics, including diagnostics on catch and survey residuals, parameter uncertainty estimates, trends in spawning-stock biomass (SSB), Fishing mortality (F), Recruitment (R) and retrospective analyses, set out at the beginning of the benchmark workshop. Setting out a set of diagnostics before the benchmark will considerably improve the transparency and comparability of such a process and improve the flow of the workshop. Discussion focused on some poor fits to specific fleets, which is outlined under the individual headings of the stocks. Once the base models had been finalized, each of them was assigned several sensitivity tests and alternative scenarios to find the best model to describe the state of the stock:

Northern stock

- Different time-series of recreational fisheries catches.
- Turn off the extra standard deviation for juvenile surveys.
- Discard as retention function for OTB and SEINE as catch fleet.
- Mirror OTB discard fleet to OTB landings fleet and remove discard length information.
- Recreational fleet as landed and discarded fraction.
- Use of Lorenzen M.
- M profiling.
- Steepness profiling.
- Associate ALK to a different fleet than OTB.
- Estimate all growth parameters.
- Assume no movement of fish from the Southern to the Northern stock.
- Leave one out (surveys).

Southern stock

- Use of Lorenzen M.
- M profiling.
- Steepness profiling.
- Estimate all growth parameters setting A for L2 at 16 years old.
- Assume no movement of fish from the Southern to the Northern stock.
- Leave one out (surveys).
- Random walk for GTR and LL instead than blocks.
- Switch off extra standard deviation for LPUE.
- Switch off the random walk for GNS and substitute with blocks.
- Decrease CV of the last 2 years of the OTB discards.
- Associate ALK to a different fleet than OTB.

All scenarios were then tested with a script comparing the previously created diagnostics to find the models with the best fit. Some of the scenarios were purely done for the sensitivity of the model (such as the scenario not to transfer the catches from the northern model to the southern model to account for mixing). In contrast, others focused on the selectivities of the various time-series, the setting of natural mortality, etc. It was agreed to treat some of the dataseries the same way in both models, such as the re-calculation of the recreational data back in time; both models were successfully completed, and the reference points were estimated

ii Expert group information

Expert group name	Benchmark workshop on selected sea bass stocks (WKBSEABASS)
Expert group cycle	Annual
Year cycle started	2023
Reporting year in cycle	1/1
Chairs	Pia Schuchert, UK
	Massimiliano Cardinale, Sweden
Reviewers	Vladlena Gertseva, USA
	Laurie Kell, UK
Meeting venues and dates	Data: 29 January–2 February 2024, Copenhagen, Denmark
	Assessment: 25–29 November 2024, Copenhagen, Denmark
	Additional meetings: 12 November 2024 and 29–30 January 2025 (online)

1 Introduction

Benchmark on selected sea bass stocks 2025 report

The WKBSEABASS benchmark workshop and data meeting were both held in person in Copenhagen, from 29 January to 2 February 2024 (data meeting) and from 25 to 29 November 2024 (benchmark meeting). A final online meeting of the benchmark to set reference points took place from 29 to 30 January 2025. The meetings were chaired by Massimiliano Cardinale (Sweden) and Pia Schuchert (UK) and reviewed by external reviewers Vladlena Gertseva (US) and Laurence Kell (UK).

Scientists and stakeholders from the UK, France, Belgium, the Netherlands, and Ireland attended the meeting. The list of participants for the two in-person workshops are presented in Annex 1.

This report is split into three parts: the data preparation and description part, the assessment of the sea bass stock 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) and the assessment of the sea bass stock in divisions 8.a–b (northern and central Bay of Biscay).

1.1 Terms of reference

1.1.1 Data workshop

1. Conduct a 4-day data workshop (DWK). Stakeholders are invited to contribute data (including data from non-traditional sources) and to contribute to data preparation and evaluation of data quality. Data, particularly catch information, should be collated as far back in time as possible. As part of the data compilation workshop, consider the quality of data, including discarding and estimating.
2. Make a proposal to the benchmark on the use and treatment of data for each assessment, including discards, surveys, life history, recreational fisheries, etc.
3. Following the DWK, produce working documents to be reviewed during the Benchmark workshop at least one month prior to the workshop.

1.1.2 Benchmark workshop

1. Evaluate the appropriateness of data and methods to determine stock status and investigate methods for short-term forecast, taking agreed or proposed management plans into account for the stocks listed in the text table below. The evaluation shall include consideration of:
    a) Life-history data.
    b) Fishery-dependent and fishery-independent data.
    c) Recreational fishery data.
    d) Further consideration of environmental drivers, multispecies information, and ecosystem impacts for stock dynamics in the assessments and outlook.
2. Agree and document the most appropriate method for evaluating stock status and (where applicable) short-term forecast and update the Stock Annex as appropriate. Knowledge of environmental drivers, including multispecies interactions, and ecosystem impacts should be integrated into the methodology.

3. A full suite of diagnostics (regarding data, retrospective behaviour, model fit, etc.) should be examined as a whole to evaluate the appropriateness of any model developed and proposed for use in generating advice. If no analytical assessment method can be agreed, then an alternative method for providing advice (ideally one of the WKLIFE X (https://doi.org/10.17895/ices.pub.5985) methods should be put forward.
4. Re-examine and update (if necessary) MSY and PA reference points according to ICES guidelines (see Technical document on reference points).
5. Draft Stock Annexes for each of the stocks part of the benchmark outcomes.
6. Develop recommendations for future improvements of the assessment methodology and data collection.
7. Provide detailed guidance on the mechanics of the sea bass allocation tool.

Stock	Assessment Lead
Bss.27.4bc7ad-h – Sea bass (*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)	Gwladys Lambert
Bss.27.8ab – Sea bass (*Dicentrarchus labrax*) in Divisions 8.a-b (northern and central Bay of Biscay)	Mathieu Woillez

1.2 Participants

Name	Institute	Country (of institute)	E-mail	Data Workshop	Benchmark Workshop
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Name	Institute	Country (of institute)	E-mail	Data Workshop	Benchmark Workshop
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1.3 Background

1.3.1 Stock identity workshop

The 2024 joint benchmark for Northern (ICES division 4.b–c, 7.a and 7.d–h) and Biscay (ICES divisions 8.a–b) stocks of sea bass requires information on the probable biologically relevant stock structures within the Northeast Atlantic. This workshop and its members were specifically tasked to generate potential stock scenarios for consideration at the benchmark.

Connectivity between the Northern and Biscay has long been recognized through adult movement and larval drift, but the evidence was not available at the last benchmark in 2018 to assess stock structure. However, recent studies on genomics, tagging and particle tracking have increased the evidence available for assessing the validity of current ICES sea bass advice units as well as delineating new boundaries. The report contains the evidence provided to the WKBSEABASS-ID stock identification workshop (ICES, 2023) as well as the group members' conclusions.

WKBSEABASS-ID agreed that evidence suggested a single meta-population structure, meaning a group of spatially separated populations interacting at some level (i.e. migrating, reproducing, feeding). Based on the evidence provided, three plausible population scenarios were identified:

- Hypothesis 1: Three subpopulations, Irish Sea (7.a), North Sea (4b–c), southern Bay of Biscay (8.b); with mixing among the Celtic Sea (7.f–g), Bristol Channel (7.h), English Channel (7.d–e) and Northern Bay of Biscay. Mixing is seasonally dependent, with more mixing occurring during summer compared to winter.
- Hypothesis 2: Three subpopulations, Irish Sea (7.a), North Sea (4.b–c) and Bay of Biscay (8.a–b); with mixing among the Celtic Sea (7.f–g), Bristol Channel (7.h) and English Channel (7.d–e). Mixing is seasonally dependent, with more mixing occurring during summer compared to winter.
- Hypothesis 3: Three subpopulations, Irish Sea (7.a), North Sea/eastern English Channel (4.b–c, 7.d) and Bay Biscay (8a–b); with mixing among the Celtic Sea (7.f–g), Bristol

Channel (7.h) and western English Channel (7.e). Mixing is seasonally dependent, with more mixing occurring during summer compared to winter.

It was not possible to choose between these scenarios or rank them in order of likelihood. National data should be requested by ICES Division within the data call, as this will allow assessment approaches to be developed at relevant scales. ICES stock assessors will need to agree on the necessary data to consider these three scenarios before the WKSEABASS data call and benchmark. However, if the available data are insufficient to accurately assess stocks based on these hypotheses, then the group agreed on two other scenarios that could be considered:

- Scenario A: Continue to assess the 'southern' (ICES divisions 8a–b) and 'northern' (ICES divisions 4.b–c, 7.a and 7.d–h) stocks separately but incorporate mixing between stocks.
- Scenario B: Single meta-population between northern and southern stocks.

2 Data workshop

2.1 Summary and recommendations from data workshop

Several recommendations were made at the data workshop that impacted on the data selection and modelling approach.

It was identified that there was insufficient data to model the Irish Sea (7.a) separately and catch was low in this area, so it was merged with the Celtic Sea for modelling. In addition, there was insufficient resource to test all scenarios, so two were chosen: the current Northern and Biscay stocks with exchange of catches; and a single meta-population model containing North Sea (4.b–c, 7.d), Celtic and Irish Seas (7.a, 7.e–h), and Biscay (8.a-b) subpopulations with mixing (Figure 1).

Discards will be integrated in the model for both stocks. There was a lack of data on the survival of discards, so survival was assumed to be zero for all commercial gears. Discard for lines is unknow and will be assumed to be 0 in the models.

Country was not seen as being a useful dimension in the definition of fleets as selectivity is more likely to be driven by gear. Instead, gear combinations were chosen based on the selectivity which resulted in inclusion of the following fleets:

- Northern stock: GNS, LHM, LLS, OTB (including TBB), OTM (including PTM), OTH, SEINE, RECR
- Biscay stock: GNS, GTR, LLS, OTB, OTM (including PTM), OTH (including OTT, SEINE), RECR

For the LPUE standardization, it was recommended that a separate review process is put in place by ICES before the benchmark meeting, and that ideally the reviewer would support development of the standardization model. While this has not happened, a stand-alone modelling approach to estimate the LPUE was produced and is in Working Document 7 in Annex 3.

For the sample size of the compositions, it was recommended to use the method developed by Stewart and Hamel (2014). The scripts were made available by Ian Taylor and are stored in the data folder of the SharePoint. It is important to note that NOAA scripts are tailored to their stocks and sampling design, so that if we want to use the method the analysis described in the paper would need to be redone for our data. It was suggested that as an alternative we use number of hauls for survey compositions, number of trips for commercial composition and number of aged fish for ALK. Finally Ninput = f(N_fish and N_trips) was used as recommended by Vladalena Gertseva.

For the estimation of growth parameters, it was recommended to use the LEP method developed by Paige Eveson and applied for Western Baltic cod by Katie McQueen and coauthors. The scripts were made kindly available by Paige Eveson and are stored in the data folder of the sharepoint. It was recommended to test the use ALK and length distributions in the models instead than marginal catch-at-age. It was decided to use a single sex model as the differences in growth between the two sexes are small.

It is recommended to set up separate processes to finalize the estimation of the recreational data to be used in the assessment models. Three dedicated online workshops took place in 2024 bringing together recreational data collection experts, stock assessors and the angling community to develop an approach. This resulted in development of an agreed dataset for recreational catches (Working Document 1, Annex 3).

Movements estimates between areas in the 2 stocks needed to be updated using tagging data. A working document was produced that provided mixing rates from tagging data to use to reallocate catches between the Northern and Biscay stocks (Working Document 6, Annex 3)

The status of the decline of the northern and Biscay stocks of sea bass is thought to be driven by a combination of overfishing and poor year-class strength, and there is large variation in the year-class strength in all sea bass stocks. Understanding year-class strength is a vital part of modelling the dynamics of sea bass stock, but time-series across the whole stock area are lacking. Year-class strength is usually measured through surveys of nursery areas in shallow water and estuaries, with studies in the UK and Ireland showing that there is variation in signals between nursery areas (Watson *et al*., 2024). As a result, it is important for the assessment to have surveys of year-class strength from several different nursery areas across the stock area. In addition to the Solent survey, data were provided for the Fal and Helford (Working Document 4, Annex 3) by the UK alongside seine nets from Irish Rivers. The Nourdem series generates series of year-class strength in 4 nursery areas (Seine, Loire, Gironde estuaries and Douarnenez bay) and are the only data from the coast of France (Working Document 3, Annex 3). These will become a vital fisheries independent index in the sea bass assessment going forwards. As a result, it is important that funding for the Nourdem survey continues, and the index is provided routinely as part of the data provided to update the assessment going forwards.

2.2 Working documents on available data and intersessional work

Several working documents have been provided and are included in Annex 3 of the benchmark report; these include the estimation and analysis of recreational catches (Working Document 1, Annex 3).

Descriptions of the various surveys considered for use in the assessment that comprised of survey design, data, and rationale for inclusion:

1. Channel groundfish survey (CGFS) on the RV Thalassa (Working Document 2, Annex 3)
2. French Nourdem juvenile fish survey (Working Document 3, Annex 3)
3. Fal and Helford sea bass prerecruit survey (Working Document 4, Annex 3)

A description and analysis of the commercial data are presented (Working Document 5, Annex 3). This document discusses the various commercial fleets across the full sea bass area in the North Sea, the Northeast Atlantic and Biscay, their targeting and discard practices, and sampling schemes involved to monitor the fleets. The document also discusses the reallocation of part of the commercial catches from the Northern to the Southern stock to account for the mixing of stocks, following the derivation of mixing rates through analysis of the tagging data (Working Document 6, Annex 3). Insights on the UK discard data and its uses were generated (Working Document 8, Annex 3).

For both sea bass stocks, LPUE indices have been developed and used for stock assessment since the last benchmark (ICES, 2018). Both indices relied on logbook data of a combined French fleet. As the group decided to change the fleet structure (i.e. split and merged the combined French fleet according to gears, but not countries), new LPUE indices were developed using a spatio-temporal Generalized Linear Mixed Model (Working Document 7, Annex 3). LPUE indices were based on OTB LPUEs, because it was considered as a good candidate to reflect changes of abundance of sea bass.

Parts of this work were done before and during the data workshop, while major work provided in Working Documents 1–8 (Annex 3) were conducted in individual work and stand-alone 1–2 day group work between the data workshops and the benchmark workshop.

3 Benchmark workshop

3.1 Summary

The stock delineation hypotheses identified created several challenges for stock assessments and management advice (e.g. splitting stocks, incorporating mixing rates). These relate to the resolution and robustness of the data available and the modelling approach. Specific challenges are outlined in this section alongside alternative scenarios that could be considered if none of the hypotheses can be implemented.

After careful review of the data and management needs, the 2018 (ICES, 2018) benchmark approach to assess the Northern and Biscay stocks independently was retained (Figure 1). However, mixing between the two areas in summer is being considered in the new model using exchange of catches.

Stock Synthesis (SS) was retained as the current framework within which the sea bass stocks are assessed. Model selection criteria and diagnostics were based on diagnostics (see Pandalus (ICES, 2022) and Central Baltic herring benchmark reports (ICES, 2023a)) and agreed at the beginning of the meeting. A dedicated script to run the diagnostics for the various scenarios and create a comparative table has been provided by Max Cardinale and is available from the data folder on SharePoint.

A time-series of recreational removals was generated for the period 2010–2023, but there was need to reconstruct removals for the period before data which was done assuming a constant fishing mortality for both the Northern and Biscay stocks. A full time-series for fishing effort F was re-calculated backwards in time, and the same strategy to estimate the full time-series was applied to both stocks.

A range of analyses were conducted to understand the various discard patterns and the fit of the models to the length frequencies.

New reference points for both stocks were estimated using the EqSim Framework.

Both assessments were accepted by the benchmark working group and the reviewers and provide the best possible assessments and understanding of currently available data.

3.2 Northern stock (bss.27.4bc7d-h)

A full description of the benchmark model of the Northern stock can be found in Annex 4.

3.3 Southern stock (bss.27.8ab)

A full description of the benchmark model of the Southern stock can be found in Annex 5.

4 Future recommendations

There is a need in ICES to provide a standardization of stock assessment benchmarks to streamline the process. This is currently being built within the TAF framework, and should include the:

- Data description.
- The preselected choice of diagnostics.
- A script for the model selection process.
- The application of reference point selection, once/if ICES moves away from EqSim.

All data and baseline models should be ready at the beginning of the benchmark. This can be difficult due to time constraints of the stock assessors/ stock coordinators and the time allocated to them by their institutes, however their needs to be a recognition that a benchmark is not purely conducted within the week allocated by ICES.

4.1 Recommendation on sea bass stocks

Catch reallocation was employed as a pragmatic approach to account for sea bass stocks mixing. Alternative methodologies should be investigated to better account for sea bass movement and population spatial structure.

In addition to the Solent survey, data were provided for the Fal and Helford (Working Document 4, Annex 3) by the UK alongside seine nets from Irish Rivers. The Nourdem series generates series of year-class strength in 4 nursery areas (Seine, Loire, Gironde estuaries and Douarnenez bay) and are the only data from the coast of France (Working Document 3, Annex 3). These will become a vital fisheries independent index in the sea bass assessment going forwards. As a result, it is important that funding for the Nourdem survey continues, and the index is provided routinely as part of the data provided to update the assessment going forwards. It is recommended that WGBIE and WGCSE should support the need for funding to continue the Nourdem survey in future.

The analysis done for recreational fisheries represents a step change towards synthesising data from diverse sources and understanding the issues, uncertainties, and biases (Working Document 1, Annex 3). However, continued refinement of the approach should be done as more survey data are generated.

5 References

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6 Reviewer reports

6.1 Report 1 (Laurence Kell, SEA++)

Executive Summary

This benchmark workshop (WKBSEABASS) on sea bass stocks (*Dicentrarchus labrax*) in the Northeast Atlantic (Divisions 4.b–c, 7.a, 7.d–h and 8.a–b used the integrated assessment model, Stock Synthesis (SS3), to evaluate stock status relative to MSY and Precautionary Approach (PA) reference points. Recreational fisheries are important for sea bass and measures such as bag limits are in place.

- **Diagnostics:** The group employed a range of diagnostics, notably including hindcasting, to evaluate the prediction skill of models against withheld data. This rigorous approach to model validation is a significant improvement over relying solely on goodness-of-fit measures and retrospective patterns, which can be misleading.
- **Integrated Stock–recruitment Analysis:** The use of Stock Synthesis allowed stock–recruitment relationships to be fitted within the assessment model. This allowed hypotheses related to productivity and their implications for biological reference points to be evaluated. Estimating stock–recruitment relationships within the stock assessment, rather than externally using EqSim, facilitates the propagation of uncertainty throughout the assessment, this is particularly important given the complexities of modelling the stock–recruitment relationships and the impact on reference points (Mangel *et al*., 2013).
- **$MSYB_{trigger}$:** Both assessments show instability when a retrospective analysis is conducted, there is variability of the terminal estimates as years are removed. Even in the absence of a retrospective pattern variability of SSB estimates, may means that assessment updates could trigger unnecessary management actions if relying solely on $MSYB_{trigger}$. Therefore a Biomass Target (B_{MSY}) should be defined to mitigate against uncertainty in terminal year SSB estimates and environmental effects.
- **Meta-population Considerations:** Recognizing evidence of connectivity between the northern and southern stocks, the group has prepared the groundwork for a potential future multistock assessment. For example. adopting consistent hypotheses for processes such as natural mortality represents a crucial step toward a more holistic assessment approach.
- **Exploration of Uncertainty:** An analysis started to explore uncertainties around key parameters like natural mortality (M) and stock–recruitment steepness (h) using likelihood profiles. This provides valuable insight into data conflicts and the impact of fixed parameters and could be developed further.
- **Ensembles:** Given the uncertainties in fixed parameters, recreational catch reporting and other data inputs, future assessments should further explore ensemble modelling and weighting of alternative hypotheses based on empirical performance. Ensemble modelling, allows management advice to be based on the most plausible models, reflecting the major dimensions of uncertainty.

Role

My involvement was an Invited Expert. The main aims of the assessment workshop were to explore alternative models and select a base case. My role as an invited expert at an ICES benchmark workshop is to provide scientific guidance, ensure the credibility and quality of the

process, and contribute to the development of the best available assessment methods (ICES, 2023a). Specifically, this includes:

- **Guiding the Workshop Scientifically:** Invited experts are responsible for leading the scientific discussions during the preparation and execution of the benchmark. They help review current assessment methods, evaluate new data or methodologies, and analyse proposed changes to ensure they are scientifically robust.
- **Auditing and Reviewing:** They audit the resulting Stock Annexes (documentation of agreed methodologies) and ensure that the assessment methods are based on sound scientific principles. This includes reviewing assumptions, data inputs, and analytical approaches to confirm their validity.
- **Consensus Building:** Experts facilitate consensus among participants on the most appropriate assessment methodologies to be used in future stock assessments. This includes determining reference points, integrating new knowledge, and addressing uncertainties.
- **Enhancing Credibility:** By being external to ICES or its specific working groups, invited experts bring an independent perspective that enhances the credibility and transparency of the benchmark outcomes.
- **Supporting Ecosystem Integration**: They may also help identify ways to incorporate ecosystem considerations or new scientific knowledge into stock assessments, aligning with broader ecosystem-based management goals.

Advice framework

Both stocks are assessed using stock synthesis Stock Synthesis 3 (ICES, 2024) an integrated assessment model that combines age, length, landings discards, tagging, biological and abundance data, and are managed under the ICES MSY and PA Advice Framework. Recreational fisheries play a significant role in the total removals and catches have to be reconstructed from samples. There is also evidence (ICES, 2023c) that the northern and southern sea bass are not distinct populations, but a meta-population made up of specific subpopulations with connectivity. For both stocks recreational removals and discards are included in the total catch advice, with recreational bag limits as part of the management framework. However, uncertainties exist in the data for recreational removals and discards, and management measures like bag limits for recreational fisheries continue to be critical for controlling fishing pressure.

The provision of fisheries management advice requires the assessment of stock status relative to reference points, the prediction of the response of a stock to management, and checking that predictions are consistent with reality (Kell *et al*., 2016). The adoption of the Precautionary Approach also requires providing advice that is robust to uncertainty. Quantities used to formulate advice, such as biomass and exploitation rate, however, are unobservable and need to be estimated by models conditioned on data and assumptions about stock structure, natural mortality, recruitment, and vulnerability to fishing, which are uncertain. Therefore, when conducting stock assessment alternative, model structures and datasets are commonly considered. The primary diagnostics used to compare models are to examine residuals patterns to check goodness-of-fit and to conduct retrospective analysis to check the stability of estimates. However, residual patterns can be removed by adding more parameters than justified by the data, and retrospective patterns are not a reliable measure of bias Cadrin (2025) and can be removed by ignoring the data. Therefore, neither alone can be used for validation, which requires assessing whether it is plausible that a system identical with the model generated the data for example using cross validation where predictions are compared to observations not used in fitting (Kell 2021). A problem, however, is that many of the inputs for the assessment are themselves model outputs. It appreciated that the group used a range of diagnostics including hindcasting.

In the previous assessment (ICES 2023b) for 8.a–b spawning-stock biomass (SSB) was estimated to be above B_{pa}, and around MSY $B_{trigger}$, while fishing mortality was below F_{MSY}. However, recent recruitment is uncertain and is based on historical averages and so may not reflect future productivity. For Sea Bass in Divisions 4.b–c, 7.a, and 7.d–h (ICES 2024c) SSB was above B_{lim} but below MSY $B_{trigger}$, although fishing mortality was below F_{MSY}.

B_{MSY}, is an explicit target but undefined and it is assumed that it will be produced by fishing at F_{MSY}. B_{MSY} must be greater than MSY $B_{trigger}$, since at if the stock falls below the latter reference value F is decreased. However, fish at F_{MSY} results in a biomass less or equal to than MSY $B_{trigger}$. In the absence of feedback due to bias in the assessment (e.g. Edgar, 2024), environmental variability (e.g. Rouyer *et al*., 2014) and complex interactions between them (Bjørnstad *et al*., 2004), biomass could cycle around the threshold or fail to achieve the B_{MSY} target.

Retrospective analysis is one of the main diagnostics used by ICES, however, assuming that the most recent stock assessment is the most reliable, is flawed since the logical fallacy of this interpretation is exposed when another new year of data are added, and the estimates that were assumed to be true are now considered to be biased (Cadrin, 2025). Since the stock is assessed as close to MSY $B_{trigger}$ a new assessment could cause an apparent recovery or decline requiring a change in management action, even if fishing was at the advised level. This is why a target corresponding to B_{MSY} that is greater than MSY $B_{trigger}$ should be defined as used in management, particularly since recruitment and productivity is uncertain, and the assessment relies on the reconstruction of recreational data. Therefore, continued improvement in data collection on recruitment, discards, and recreational catches are required to ensure the robustness of stock assessments and the management advice based upon them.

Estimation of reference points

ICES to calculate MSY and PA reference points uses the EqSim software (Simmonds *et al*., 2010). Within EqSim, F_{MSY} is estimated under stochastic future conditions as the F that achieves maximum median long-term yield but is conditioned on the Precautionary Approach such that fishing at F_{MSY} cannot result in a 95% probability of the spawning-stock biomass (SSB) falling below the limit reference point B_{lim}. However, the assessment showed that this results in SSB being below or close to MSY $B_{trigger}$ a consequence due to uncertainty, bias and environmental variability could be constant change in advice.

In age-based assessment, the production function and hence reference points are largely determined parameters that are fixed, e.g. growth, fecundity, and natural mortality-at-age, and the steepness of the Stock–recruitment relationship (Mangel *et al*., 2013). Ideally the stock–recruitment relationship and reference points should be estimated within the model, as this allows for a fully integrated analysis where all sources of data and uncertainty can be considered simultaneously. If the stock assessment is conducted using integrated or statistical catch-at-age models, formal diagnostics (Carvalho *et al*., 2021) can be applied, the sensitivity of estimates of the stock status relative to reference points evaluated, and uncertainty propagated by sampling the values of fixed parameters from prespecified distributions. Although this is not common practice in ICES this was done by the group and is to be commended.

Diagnostics

Recent papers by Edgar *et al*. (2024) and Froese and Pauly (2024) highlighted some critical limitations and biases in current fisheries stock assessment models that could lead to overestimation of stock productivity and response to management. Kell *et al*. (2024) provide a constructive path forward, within the current system, by demonstrating how stock assessment models can be validated using a diagnostic toolbox focused on prediction skill, the ability of models to forecast

data not used in model fitting. By objectively evaluating model performances against empirical observations, a rigorous framework can be established to accept, reject, and weight alternative model hypotheses and can be used to inform and adapt management. Kell *et al.* (2025) also revealed the limitations of relying on a single "best assessment" model, as performed in most stock assessments. Instead, diverse model ensembles, which capture the key uncertainties, and weighting models based on their empirical prediction skill should be conducted. This allows management advice to be based on the most plausible models, based on both likelihood and knowledge, that reflect the major dimensions of uncertainty.

Uncertainty analysis

Quantities used to formulate advice, such as biomass and exploitation rate, are unobservable and must be estimated by models conditioned on assumptions about resource dynamics and data. However, processes such as natural mortality, recruitment, and vulnerability to fishing are uncertain. Given these uncertainties, reliance often falls on generic solutions and expert opinion to fix parameters, e.g. for natural mortality (M), the steepness of the stock recruitment relationship (h) or selection pattern. Furthermore, different datasets may provide inconsistent information about a fish stock's dynamics or state, stemming from incorrect assumptions about data collection (observation error) or population dynamics (Maunder and Piner, 2017). These inconsistencies can arise because datasets used in stock assessment are often not direct observations but model outputs, such as standardized catch per unit effort. Ideally, such conflicts should be resolved before running a stock assessment model (Peterson *et al*., 2021), but a response to these inconsistencies often involves removing or down-weighting conflicting datasets. Unresolved conflicts and multiple hypotheses can lead to multiple valid interpretations of the data, each supporting different management strategies. Kell *et al*. (2024) advocate using diverse model ensembles, which capture key uncertainties, and weighting models based on diagnostics, including empirical prediction skill. This allows management advice to be based on the most plausible models, based on both likelihood and knowledge, that reflect the major dimensions of uncertainty.

Once the Base Cases is agreed a sensitivity analysis for a grid of M and steepness can be conducted. These parameters are normally fixed in stock assessments and have a big impact on the estimates of stock status, reference points, and management advice. It is important to see if there is any information in the data to support the choices made as well as the consequences. Likelihood profiles can be used to identify where there are data conflicts and whether fixed parameters are supported by the data and what drives the assessment and the grid the importance for management.

As a first step, we propose the creation of an uncertainty grid to compare the likelihood components, historical stock dynamics, and current status. Likelihood profiles by data component can then help to identify where there are conflicts between datasets, the impact of assumptions and fixed parameters on estimates of stock status and consequences for management advice.

As an example, here we describe, and interpret, and results of likelihood profiles for a grid based on natural mortality and steepness and the corresponding production functions, then discuss implications for management.

Likelihood profiles

Due to limited direct information in stock assessment datasets, parameters such as natural mortality (M) and the steepness of the stock–recruitment steepness (h) parameters are often fixed or provided as priors. Therefore, likelihood profiles were generated by systematically varying M and h across a grid (Figure 1). The x-axis corresponds to the multiplier on the M base case, and

curves to h which represent the total negative likelihood across parameter combinations. Lower values indicate parameter combinations better supported by the data. While the curves for the Northern stock are smooth that for the Southern stock are variable indicating instability in finding a unique solution. However, values in general are equal or greater than the base case, so do not suggest that the base case does not represent the maximum likelihood. Stability of estimates can be tested by perturbing initial parameter values and assessing resulting changes in likelihood. If alternative plausible parameter combinations improve likelihood significantly, the base case may not represent a global optimum. This suggests potential data conflicts or inadequacies in the base case assumptions. In the case of the North the "Best" value of M is less and for the South greater than the base case. Importantly, given the evidence that there are not two distinct stocks, and so in future a joint assessment may be conducted the choice of M should be based on what is the correct hypothesis across both stocks.

Figure 2 shows the likelihood profile by component, i.e. for age composition, length composition, survey indices, recruitment deviations, catch data, priors. Components with larger likelihood values have greater influence on model fitting. Significant variation in a component's likelihood across parameter values indicates strong sensitivity to that parameter. Conflicting minima across components suggest data conflicts. The dominant components, age and length composition, strongly influence the overall model fit. Smaller contributions are seen from survey indices, catch data, and recruitment deviations imply limited sensitivity and lower influence on parameter estimation.

Production functions

Production functions illustrate the relationship between Yield and spawning-stock biomass (SSB) across different scenarios of natural mortality and steepness. Production functions represent the equilibrium state and allow reference points to be derived to identify sustainable fishing levels. Figure 3 plots yield and surplus production against SSB. The curve, represents the production function with a peak at MSY; the dashed line is the border between the orange and yellow regions identifies fishing mortality at MSY (F_{MSY}); the red line is current fishing mortality level (F_{Cur}) and the intersection with production curve indicates equilibrium biomass at current F. The green quadrant is where SSB > B_{MSY} and F<F_{MSY} indicating sustainable conditions and the red quadrant is where SSB < B_{MSY} and F>F_{MSY}, indicating unsustainable conditions; the green lines show the ICES target region based on 40% of unfished biomass (B_0), and the orange triangle is the region where yield can exceed MSY as biomass is currently above B_{MSY}.

If current catches (red point) lie above the production curve, biomass removal exceeds replacement; thus, stock biomass will decline over time. If current catches lie below the curve, biomass replacement exceeds removals; thus, stock biomass will increase. There is the dynamics are driven by the model assumptions then the stock will cycle anticlockwise around the production function. Process error due to dynamics not included in the model (e.g. stock structure or environmental drivers) may result in deviations from the expected behaviour. Lower values of M result in higher unfished biomass estimates (B_0), higher M reduces B_0 and increases F_{MSY}. For the Northern stock MSY remains relatively stable. The ICES target region is achievable primarily under scenarios with higher natural mortality due to an inverse relationship between M and fishing mortality (F), maintaining relatively constant total mortality (Z=M+F). Steepness has a smaller effect compared to natural mortality; however, higher steepness generally allows for higher sustainable fishing levels.

Summary of results

- Age and length composition data dominate model fitting; they are critical for accurate parameter estimation.
- Survey indices, catch data, recruitment deviations have smaller impacts but may still influence specific parameters or scenarios.
- Natural mortality significantly affects reference points such as B_0, B_{MSY}/B_0, and F_{MSY}. Thus, uncertainty in natural mortality directly impacts management advice.
- Steepness has less influence but still affects sustainable fishing levels; higher steepness allows higher sustainable harvest rates.
- Reliance on a single base-case scenario may not be robust due to uncertainties around fixed parameters like natural mortality and steepness.
- An ensemble modelling approach or Management Strategy Evaluation (MSE) using multiple plausible scenarios is recommended to ensure robust management advice.
- Resolving data conflicts identified through likelihood profiles before finalizing assessments can improve reliability of stock status estimates.

Likelihood profiles and production functions provide valuable diagnostic tools for understanding uncertainties in stock assessments. Identifying influential datasets and parameters will help improve model robustness, where improved data collection will be of benefit, and ensures that fisheries management decisions are based on comprehensive understanding of uncertainties affecting stock status estimates.

Comparative analysis of north and south stocks

Similarities:

- Both stocks show strong sensitivity to natural mortality (MMM). Lower values of MMM result in higher unfished biomass estimates, while higher values of MMM increase the fishing mortality rate at MSY.
- In both stocks, age and length composition data dominate the likelihood contributions, highlighting their importance for accurate parameter estimation.
- Survey indices, catch data, recruitment deviations consistently play smaller roles in both analyses, suggesting limited sensitivity to these components.

Differences:

- The North stock shows evidence that the base case may not represent a global optimum (likelihood improves at lower values of MMM than the base case), indicating potential unresolved conflicts or uncertainties in parameter selection. Such an indication was not explicitly mentioned for the South stock.
- The specific relationship between current fishing mortality (FFF), ICES targets, and sustainability differs slightly between stocks:
    - In the North, achieving ICES targets appears possible primarily under scenarios with higher natural mortality due to an inverse relationship between MMM and FFF.
    - For the South stock (assuming similar analysis methods), differences in achieving ICES targets would depend similarly on natural mortality but might differ quantitatively depending on local biological dynamics.

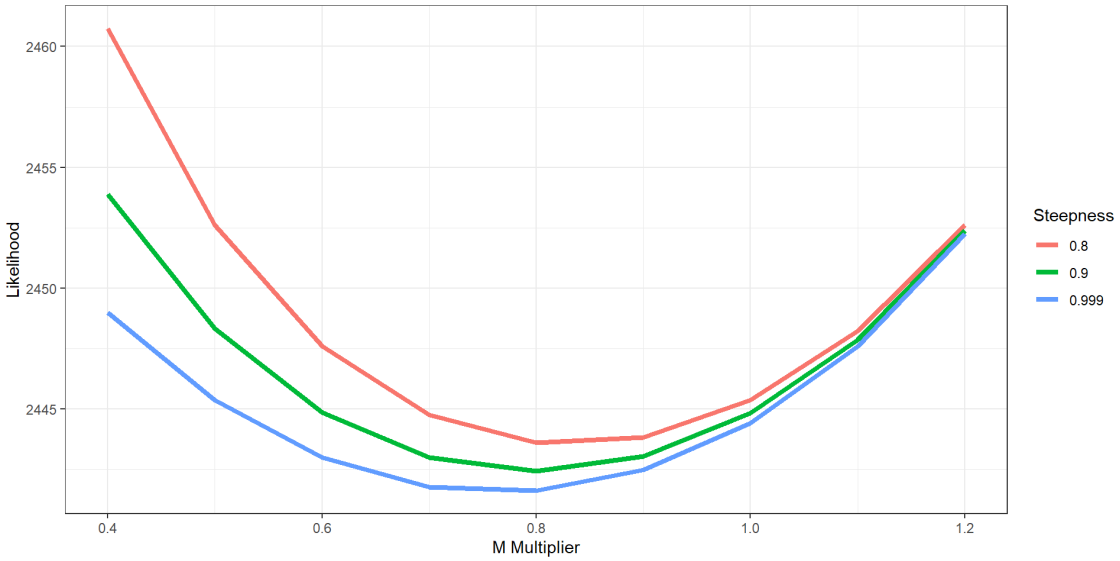


Figure 1a. North, Likelihood profile of M and steepness.

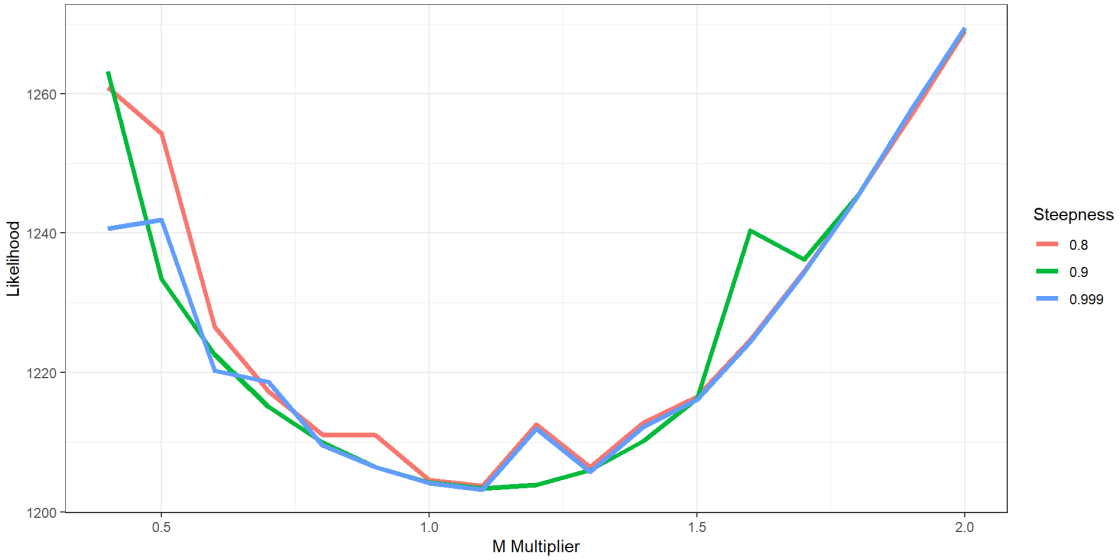


Figure 1b. South, Likelihood profile of M and steepness.

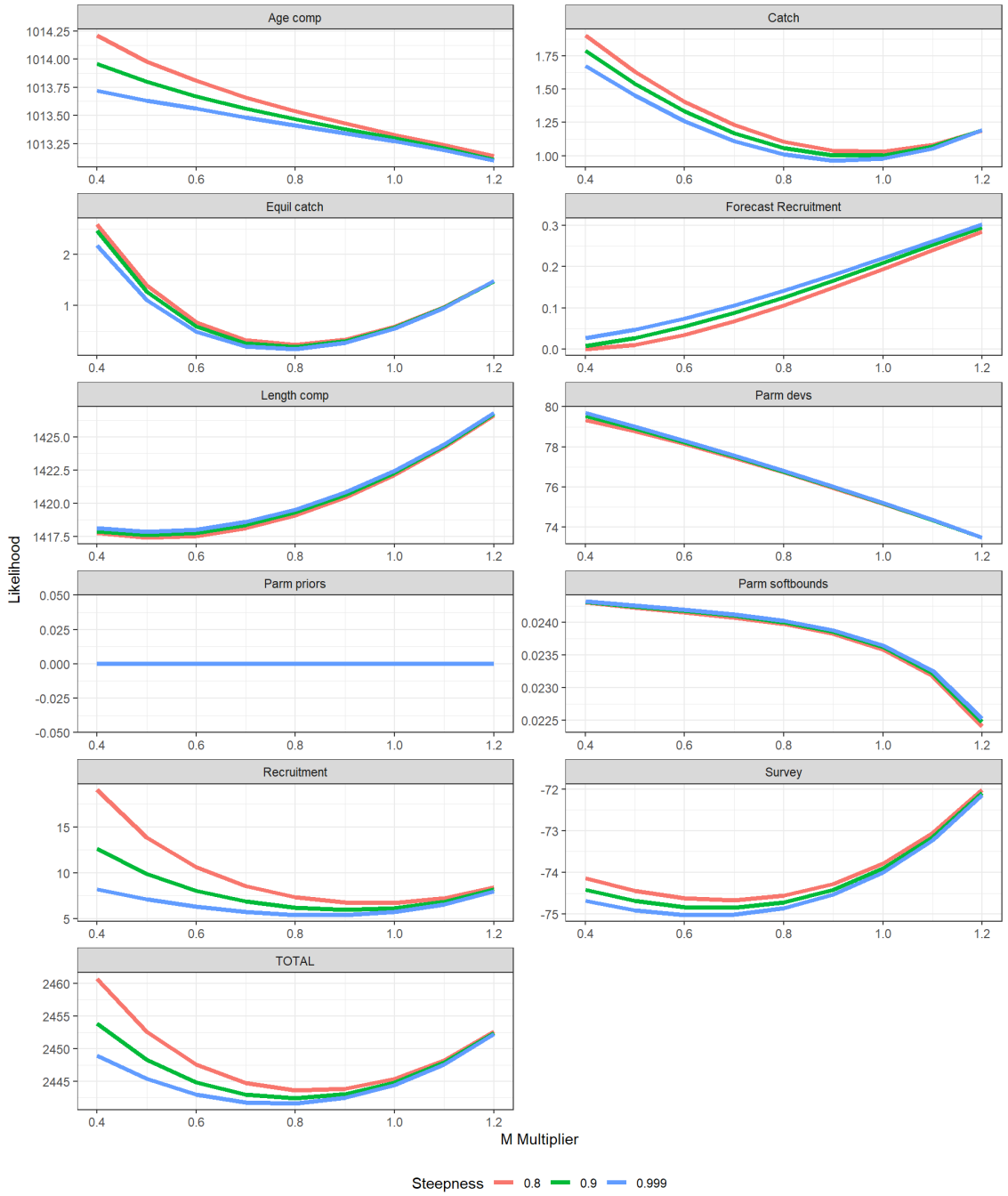


Figure 2. North likelihood profile by component of M and steepness

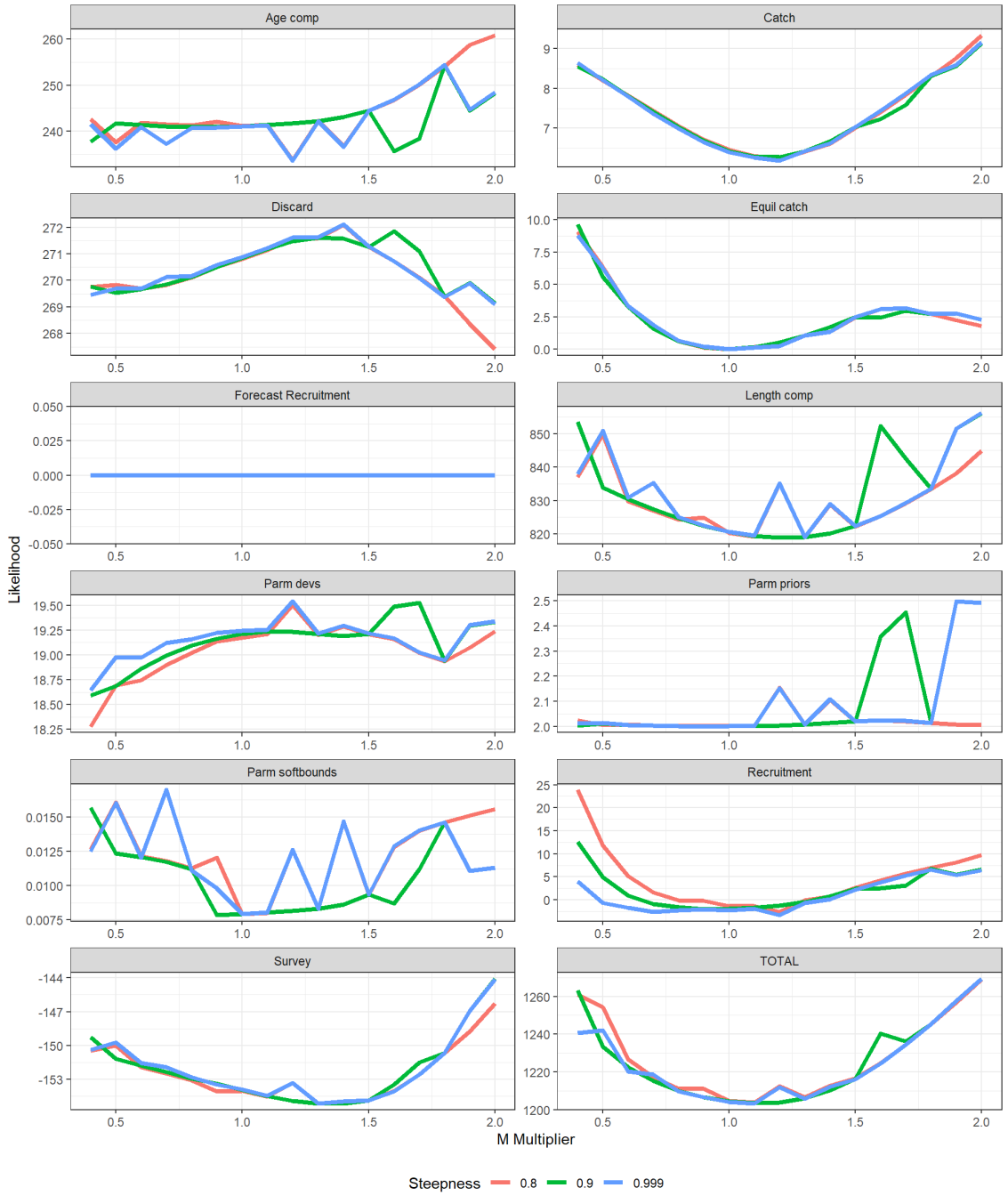


Figure 2b. South likelihood profile by component of M and steepness

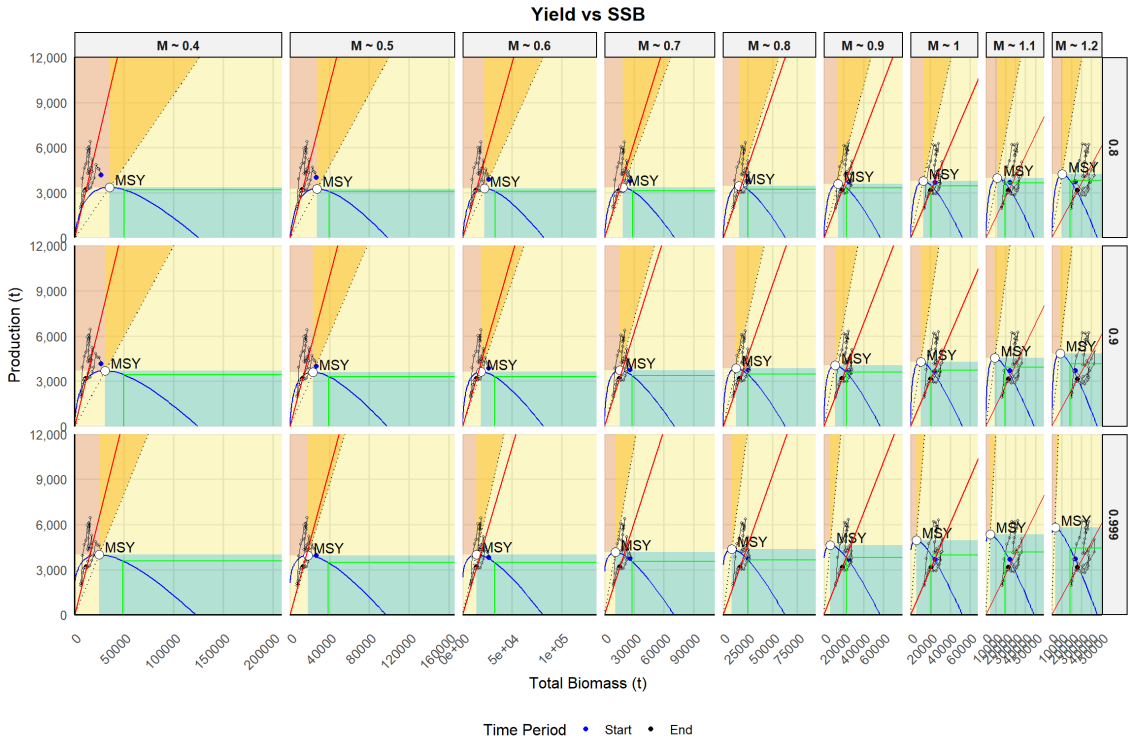


Figure 3a. North.

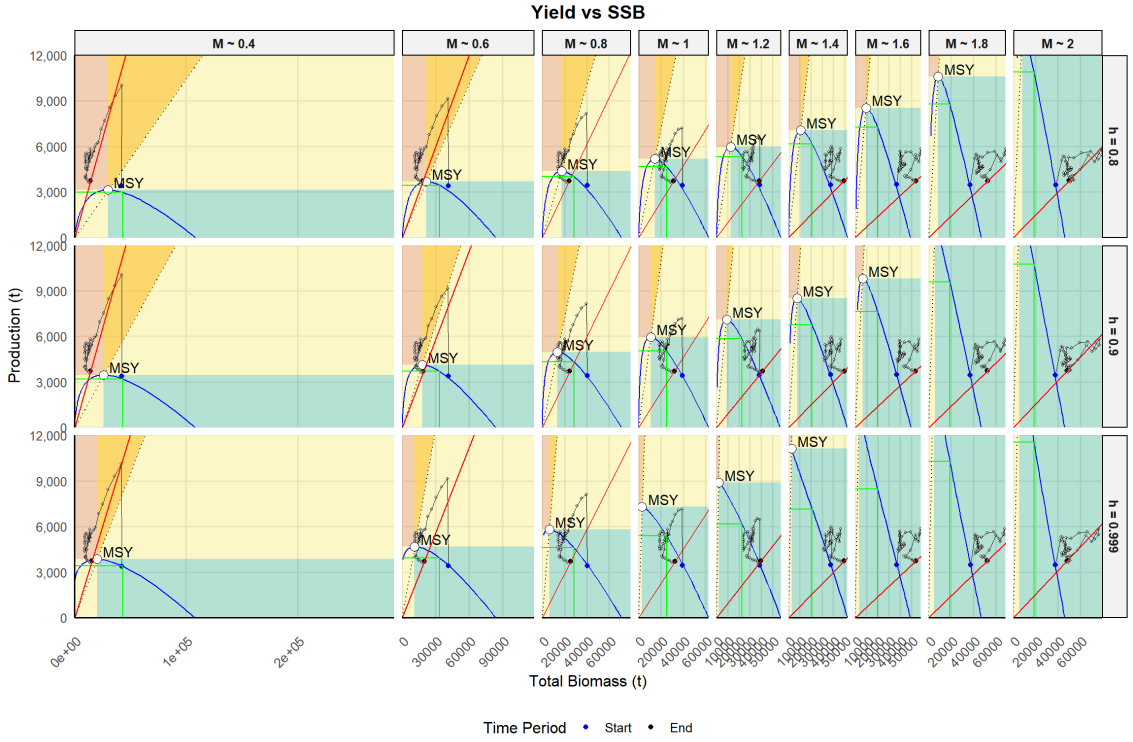


Figure 3b. South.

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6.2 Report 2 (Vladlena Gertseva, NOAA)

General

A workshop for benchmark assessments ("benchmark") on selected sea bass stocks (WKBSEABASS) was conducted between 25–29 November of 2024 in the ICES Secretariat in Copenhagen, Denmark (with participants attending in person and online).

The benchmark evaluated data and modelling approaches used for assessments of sea bass stocks (Dicentrarchus labrax) in the Northeast Atlantic (Divisions 4.b-c, 7.a, 7.d-h and 8.a-b sea bass stock in central and southern North Sea, Irish Sea, English Channel and Celtic Sea (Divisions 4.b-c, 7.a, and 7.d–h) and the sea bass stock in Bay of Biscay (Divisions 8-a, b).

Both assessments used the Stock Synthesis (SS3) modelling platform (Methot and Wetzel 2013). This is a flexible platform that allows one to incorporate a variety of available information, and explore various assumptions and modelling choices regarding the stock.

The most recent benchmark for these stocks was conducted in 2018. Since the last benchmark, progress has been made in understanding connectivity between the Northern and Biscay stocks, from recent studies on genomics, tagging and particle tracking. These studies provided information that can be incorporated into the stock assessment process through reallocation of catch between models.

The panel discussed model inputs, explored model structural choices, and agreed on configuration of the base models for both assessments. The Panel also reviewed the SS3 input files in detail, to ensure that current best practices were used in data inputs, parameter settings, and data weighting techniques.

The Panel then evaluated performance and diagnostics of the consensus base model, and concluded that the data and modelling approaches used to assess the sea bass stocks, represent the best available science. The Panel recommended using both assessments for management decision-making. Biological reference points were estimated using those base models.

Comments specific to sea bass stock in Bay of Biscay (Divisions 8-a, b).

The current stock assessment model relies on a more complex fleet structure (compared to previous benchmark assessment). The more complex fleet structure provides a framework for exploring connectivity between two sea bass stocks more efficiently, as Northern sea bass model has a similar fleet structure. It also allows to better track impact of management measures directed to different gear types and fisheries.

Multiple improvements have been made in treating the data in the model, to allow more reliable estimation of model parameters (e.g. using conditional ages at length as input for age composition data).

Approximate asymptotic confidence intervals were estimated within the model for key parameters and management quantities. This uncertainty does not encompass the uncertainty associated with fixed parameters and model assumptions. Therefore, sensitivity analysis and multiple

profile analyses were conducted to evaluate model response to various assumptions and alternative parameter values.

The major sources of uncertainty in the stock assessment model are related to historical removals (specifically in the recreational fleet) and life-history parameters, such as natural mortality and spawner-recruit steepness. The model did not have enough information to reliably estimate these quantities, and therefore they were fixed in the model at the values informed by meta-analytical studies from multiple stocks. Further improvement in understanding of these parameters is recommended.

In the current model, connectivity with the Northeast stock is accounted for through catch reallocation between the two models. Further exploration on methods to account for stock connectivity is also recommended.

Comments specific to sea bass stock in central and southern North Sea, Irish Sea, English Channel and Celtic Sea (Divisions 4.b-c, 7.a, and 7.d–h)

The Northern sea bass assessment model also modified the fleet structure compared to previous benchmark, in order to account for current fisheries, and provide model structure that could more accurately describe selectivity of different fleets. It also re-evaluated assumptions regarding discard, which has become more of an issue in recent years due to management restrictions. These changes were considered improvements.

The model fits the data well. As in case of Southern stock, the Northern model exhibits sensitivity to assumptions about natural mortality and spawner-recruit steepness, and further investigation into maximum age (as a predictor of natural mortality) and other methods to inform natural mortality and steepness are recommended. Further improvements to estimating historical landings and discards is also recommended.

General comments on benchmark process

The benchmark process would be more efficient if the draft models (model files and draft descriptions) would be made available prior to the benchmark meeting. This would allow reviewers to front-load their efforts by familiarizing themselves with the model before the benchmark, and, to join the meeting with already formulated questions, rather than spending a substantial amount of meeting time trying to understand what was done and extending beyond the assigned benchmark meeting time in order to finish.

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Annex 1: List of participants

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Annex 2: Resolutions

Approved in Resolutions meeting on 31 October 2023

2023/WK/FRSG22

The **Benchmark workshop on selected sea bass stocks** (WKBSEABASS) chaired by Pia Schuchert, UK, and Massimiliano Cardinale, Sweden, and attended by invited external experts Vladlena Gertseva, USA, and Laurie Kell, UK, will be established and meet 29 January–2 February 2024, in Copenhagen, Denmark for a data workshop, and 25–29 November 2024, in Copenhagen, Denmark for an assessment methods workshop. Approval for this benchmark was conditional upon the completion of a Stock ID workshop, which took place 29 November–31 2022.

As part of the Stock ID workshop

a) Review information on stock identification for bss.27.4bc7ad-h and bss.27.8ab and conduct a comparative review of Atlantic sea bass population structure, including critical evaluation of inferences from each source of information, to build up a picture of sea bass stock structure in Celtic Sea, Bay of Biscay and adjacent areas, based on the following:
    1. Distribution and movements of different life-stages of sea bass, including changes over time, inferred from:
        i. Tagging;
        ii. Scientific Surveys;
        iii. Commercial landings;
        iv. Dispersal models (e.g. of larva/juveniles).
    2. Genetic analyses;
    3. Otolith microchemistry;
    4. Morphometrics and meristics;
    5. Life-history and parasites;
    6. Other approaches not listed above.

b) Based on the evidence from ToR A, formulate scenarios for sea bass stocks in the Celtic Sea, Bay of Biscay and adjacent areas, and assess the evidence-based plausibility of each of these scenarios (including current definitions).

c) Consider the practical implications, for data, particularly time-series of catch data and year-class strength, and mixing rates of each of the scenarios in ToR B, and how any difficulties might be dealt with. For example, considering spatial components with mixing in a single model has different implications for data compared to split stock units. Considerations should include how to deal with changes over time.

d) Make recommendations for which sea bass stock scenario(s) to take forward in the forthcoming sea bass benchmark, including in what format data should be requested and prepared.

The Stock ID workshop took place 29 November–31 2022. Stock ID workshop chair: David Murray, UK; Stock ID invited experts: Naiara Rodríguez-Ezpeleta, Spain, and Florian Berg, Norway. The report can be found at: ICES. 2023. Benchmark on selected sea bass stocks–stock ID workshop (WKBSEABASS-ID). ICES Scientific Reports. 5:52. 31 pp. https://doi.org/10.17895/ices.pub.22794737

As part of the data workshop 29 January–2 February 2024, in Copenhagen, Denmark:

a) As part of the data workshop (building on work from Stock ID workshop):
    1. Consider the quality of data proposed for use in the assessment;
    2. (Further) consider stock identity and migration issues;
    3. Make a proposal to the benchmark on the use and treatment of data for each assessment, including discards, surveys, life history, recreational fisheries, etc.;
    4. Invite stakeholders to contribute data in advance of the data workshop (including data from non-traditional sources) and to contribute to data preparation and evaluation of data quality.

b) In preparation for the assessment methods workshop:
    1. Produce working documents to be reviewed during the assessment methods workshop at least one month prior to the meeting.

As part of the assessment workshop 25–29 November 2024, in Copenhagen, Denmark:

c) Evaluate the appropriateness of data and methods to determine stock status and investigate methods for short-term forecast taking agreed or proposed management plans into account for the stocks listed in the text table below. The evaluation shall include consideration of:
    1. Life-history data;
    2. Fishery-dependent and fishery-independent data;
    3. Further consideration of environmental drivers, multispecies information, and ecosystem impacts for stock dynamics in the assessments and outlook

d) Agree and document the most appropriate method for evaluating stock status and (where applicable) short-term forecast and update the Stock Annex as appropriate. Knowledge about environmental drivers, including multispecies interactions, and ecosystem impacts should be integrated in the methodology.

e) A full suite of diagnostics (regarding e.g. data, retrospective behaviour, model fit, predictive power etc.) should be examined to evaluate the appropriateness of any model developed and proposed for use in generating advice;

f) If no analytical assessment method can be agreed upon, then an alternative method (the former method or following the ICES data-limited stock approach as outlined in WKLIFE XI) should be put forward by the benchmark;

g) Re-examine and update (if necessary) MSY and PA reference points according to ICES guideline (see latest Technical guidelines on reference points);
    1. Note: If additional time is needed to conduct the work and agree to reference points, an additional reference point workshop could be scheduled

h) Update the Stock Annex; and

i) Develop recommendations for future improvements in the assessment methodology and data collection;

j) Provide detailed guidance on the mechanics of the sea bass allocation tool.

WKBSEABASS will report by end 2024 for the attention of ACOM.

Stock list	
bss.27.4bc7ad-h	Sea bass (*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)
bss.27.8ab	Sea bass (*Dicentrarchus labrax*) in divisions 8.a-b (northern and central Bay of Biscay)

Annex 3: Working documents

WD #	WD Title	Authors
01	Synthesising sea bass recreational catches, length-frequencies, and post-release mortality for stock assessment	Kieran Hyder, Wendy Edwards, Max Cardinale, Rui Catarino, Chun Chen, David Curtis, Mickael Drogou, Timothy Earl, Gwladys Lambert, Thomas Lanssens, Hans Jakob Olesen, Lennert van de Pol, Amélie Régimbart, William Roche, Diarmuid Ryan, Hannah Rudd, Lara Salvany, Pia Schuchert, Jules Selles, Christian Skov, Harry V. Strehlow, Thomas Verleye, Nicola Walker, Anna-Marie Winter, Ciara Wögerbauer, Mathieu Woillez, David Vertegaal, Marc Simon Weltersbach, Jonathan White, and Zachary Radford
02	SURVEY CGFS Channel Ground Survey	Ifremer
03	French Nourdem Survey	Mickael Drogou, Ronan Le Goff, Christophe Lebigre, Mathieu Woillez, Damien Delaunay, Anne-Sophie Cornou, Olivier Berthelé, Stéphane Martin, Loïc Le Rû, Hervé Barone, Didier Le Roy, François Garren, Tiphaine Chouvelon, Yann Aminot, Catherine Munschy, Nicolas Briant, Gaël Durand, Gwendolina Limon, Emmanuelle Guillerm, Léa Edin-Leroux, Nicolas Michelet, Pascal Nguyen, Fayza Nfis, Emilie Le Roy, Cindy Marhic.
04	Analysis of the Fal and Helford sea bass prerecruit survey	Zachary Radford, Robin Bradley, Ben Ciotti, Derek Godwin, Ariadne Thompson, and Kieran Hyder
05	Catches description and gears grouping	Mickael Drogou
06	Estimating seasonal migration rates for European sea bass (*Dicentrarchus labrax*) using electronic tagging data	Michel Bertignac, Edel Lheureux, Mickael Drogou, Jolien Goossens, Serena Wright, and Mathieu Woillez
07	Standardized OTB-based LPUE abundance indices for adult European sea bass	Mathieu Woillez
08	A summary of English data and data sources for estimation of sea bass discards	Rebecca Skirrow, Wendy Edwards, Kieran Hyder, Ana Ribeiro Santos, and Thomas Catchpole
08	A summary of English data and data sources for estimation of sea bass discards	Rebecca Skirrow, Wendy Edwards, Kieran Hyder, Ana Ribeiro Santos, and Thomas Catchpole

Synthesising sea bass recreational catches, length-frequencies, and post-release mortality for stock assessment

Kieran Hyder*, Wendy Edwards, Max Cardinale, Rui Catarino, Chun Chen, David Curtis, Mickael Drogou, Timothy Earl, Gwladys Lambert, Thomas Lanssens, Hans Jakob Olesen, Lennert van de Pol, Amélie Régimbart, William Roche, Diarmuid Ryan, Hannah Rudd, Lara Salvany, Pia Schuchert, Jules Selles, Christian Skov, Harry V. Strehlow, Thomas Verleye, Nicola Walker, Anna-Marie Winter, Ciara Wögerbauer, Mathieu Woillez, David Vertegaal, Marc Simon Weltersbach, Jonathan White, & Zachary Radford

Working document for WKBSEABASS, 17 December 2024

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Executive summary

Marine recreational fisheries catch of sea bass represented 27% of total removals in 2012, so need to be included in the stock assessment. This working document outlines the synthesis of recreational catches, length-frequencies, and post-release mortality, for use in the sea bass benchmark (WKBSEABASS) and inclusion in future stock assessments. There were many challenges in integrating national survey data across countries exploiting the stock (i.e., Belgium, Denmark, France, Germany, Ireland, the Netherlands, and the UK). The surveys covered both retained and released catches, as well as length-frequency data. National surveys had different coverage, methodology, and temporal resolution which made creating a comprehensive time series challenging. Management measures have been implemented and changed regularly, making constructing time series of the retained and released components more difficult. This meant that it was important to generate catches and the associated uncertainty and biases.

Kept and released estimates and associated errors were combined for each modelling scenario and area accounting for missing errors, countries, years, and partitioning between areas. An assessment of bias was generated from individual surveys, which was negative before 2015 and positive for 2016 onwards. An approach for assessing the impact of management measures provided forward projections of the levels of catches. Forward projections overestimated the impact of management measures with the difference largest for the released component. Backward projections from surveys done after the implementation of management were calculated using ratios to forward projections. Seasonality in raw catches showed highest catches in summer and lowest in winter. A similar approach was used to reconstruct annual length-frequencies. Catches were reassigned to Biscay from the Northern stock based on exchange rates and seasonality. Limited studies of post-release mortality exist, with the most robust estimate of 5.0% [1.7, 14.4%]. It is important that the uncertainties in the estimates are used to inform a broad sensitivity analysis to understand the impact on outcomes from the assessment. The analysis done represents a step change towards synthesising marine recreational fisheries data from diverse sources and understanding the issues, uncertainties, and biases. However, continued refinement of the approach should be done as more survey data is generated.

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1 Introduction

Marine recreational fisheries for sea bass are important, representing around 27% of total removals in 2012 (Hyder et al. 2018; Radford et al. 2018) generating a recreational fishing mortality of 0.032 out of a total fishing mortality of 0.119 (ICES 2024). There was a rapid decline in the spawning stock biomass of the Northern stock (4.b-c, 7.a, 7.d-h) from 2009-17 (ICES 2024), which was thought to be due to a combination of overfishing and poor year class strength. To conserve the Northern stock, management measures were introduced in 2015 for both commercial and recreational fisheries. For recreational fisheries these included bag limits, closed season, and an increase to the minimum conservation reference size (MCRS) that have varied over time (Table 1A). An increasing trend in biomass was estimated since 2018 which may have resulted from the management measures since 2015, but the rate of increase is slowing (ICES 2024). Similar recreational fisheries management measures were also introduced for the Biscay stock (8.a-b) to conserve the stock (Table 1B).

Table 1: Summary of recreational fisheries management measures associated with sea bass in the Northern (A) and Biscay (B) stock areas.

A. Northern	MCRS	Bag limit	Season
1983	32	none	Jan-Dec
1990	36	none	Jan-Dec
2015 Jan-Mar	36	none	Jan-Mar
2015 Apr-Aug	36	3	Apr-Sep
2015 Sep-Dec	42	3	Sep-Dec
2016	42	1	Jul-Dec
2017	42	1	Jul-Dec
2018	42	1	Oct-Dec
2019	42	1	Apr-Oct
2020	42	2	Mar-Nov
2021	42	2	Mar-Nov
2022	42	2	Mar-Nov
2023	42	2	Mar-Nov
2024	42	2	Jan, Apr-Dec

B. Biscay	MCRS	Bag limit	Season
2013	42	none	Jan-Dec
2017	42	5	Jan-Dec
2018	42	3	Jan-Dec
2020	42	2	Jan-Dec
2023	42	1	Jan-Dec

Recreational fisheries removals were included in the stock assessment at the 2018 benchmark (ICES 2018). For the Northern stock, only data from France, the Netherlands, and the UK were available for 2012, with no survey estimates after the implementation of management measures in 2015 (ICES 2018). As a substantial proportion of recreational sea bass captures are released (Ferter et al 2013), recreational removals comprised of the harvest plus fish that died after release (ICES 2018). Post-release mortality was assumed to be 5% (Lewin et al. 2018). To include

recreational fishery removals in the stock assessment model, fishing mortality was assumed to be constant prior to the introduction of management measures, while the impact of combinations of the MCRS, season length, and bag limits on removals was estimated subsequently using a modelling approach (ICES 2018).

Since the previous benchmark, additional recreational surveys have been done that include catches of sea bass by Belgium, Denmark, France, Ireland, Germany, the Netherlands, and the UK. However, these surveys have been done using different methods both within and among countries, with associated errors, coverage issues, and biases. As a result, it is difficult to bring together recreational estimates into a single time series for catches and length-frequencies with associated errors and biases that can be used to inform the stock assessment modelling.

As part of the current benchmarking process, the evidence on stock identity for sea bass in Northern and Biscay stocks was reviewed and plausible stock structure scenarios for the ICES sea bass benchmark proposed (ICES 2023). This generated several potential stock identities that included: a single stock covering the whole area; the current Northern (ICES divisions 4.b-c, 7.a and 7.d-h) and Biscay (ICES divisions 8.a-b) stocks with mixing; and three equally plausible scenarios with three subpopulations and mixing (ICES 2023). At the data evaluation workshop, it was identified that there was insufficient data to model the Irish Sea (7.a) separately and catch was low in this area, so it was merged with the Celtic Sea for modelling. In addition, there was insufficient resource to test all scenarios, so two were chosen: the current Northern and Biscay stocks with exchange of catches; and a single meta-population model containing North Sea (4.b-c, 7.d), Celtic and Irish Seas (7.a,e-h), and Biscay (8.a-b) subpopulations with mixing (Figure 1).

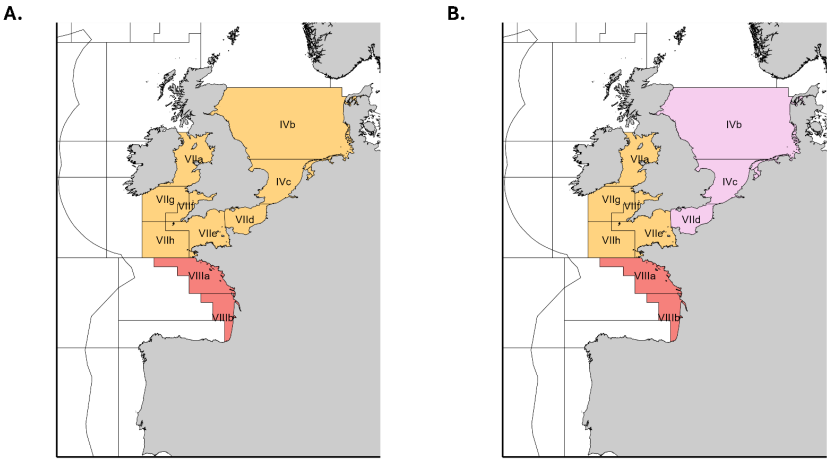


Figure 1: Stock identity scenarios agreed at the data evaluation workshop to be taken forwards for assessment models. A. Northern and Biscay stocks with exchange of catches; and B. Single meta-population model containing North Sea (4.b-c, 7.d), Celtic and Irish Seas (7.a, 7.e-h), and Biscay (8.a-b) subpopulations with mixing.

This working document represents the outcomes from three workshops attended by experts in recreational fisheries surveys and stock assessment, alongside members of the angling community. The overall aim of the workshops was to agree an approach to bring together recreational catches of sea bass from the different countries for use in the assessment. Separate times series were required for the retained and released component of the catch alongside length-frequencies with associated error, bias, and seasonality for each area proposed in the two stock identity scenarios (Figure 1). This working document contains the agreed approach and time series for inclusion in the stock assessment model.

2 Methods

2.1 Survey data

As part of the ICES data call for the sea bass benchmark, recreational data were requested from all countries covering the stocks (i.e. Belgium, Denmark, France, Germany, Ireland, the Netherlands, and the UK). This covered estimates of kept and released number and tonnages alongside length-frequencies of the fish caught for all the years with survey data. In addition, an assessment of survey bias and seasonality in raw catches were supplied. Finally, a summary of each of the survey methods was provided.

National surveys varied with a combination of onsite and offsite methods both over time within a country and between countries (Table 2). There was also variation in spatial resolution (e.g. country, sea, ICES division) alongside coverage of platforms (i.e. shore, boat, charter boat) and gears (i.e. angling, spearfishing, nets, pots, traps). A full description of the national surveys can be found in Annex 1. Data were imported and all analysis was done using R (R Core Team 2024).

Table 2: Summary of national estimates for sea bass. C: catch; L: length-frequencies; A: angling; S: spearfishing; and N: nets. Green area offsite surveys and grey dappling onsite surveys. Blue box denotes data used for the previous benchmark (ICES 2018).

Year	Belgium 4.c	Germany 4.b	Denmark 4.b	France 7.d-e, 8a-b	Ireland 7.a, 7.g	Netherlands 4.c	UK 4b-c, 7.a,d-h
2009				C,L,A,S			
2010						C,A	
2011				C,L,A,S			
2012						C,L,A	C,L,A
2013							
2014		C,A				C,L,A	
2015							
2016						C,L,A	C,L,A
2017	C,L,A		C,L,A				
2018				C,L,A,S		C,L,A	
2019					C,L,A		
2020						C,L,A	
2021		C,L,A		C,L,A,S			
2022					C,L,A	C,L,A	
2023							

2.2 Catches

It was necessary to generate time series of estimates of kept and release tonnages with associated errors and biases alongside length-frequencies and seasonality. This was required for each of the stock areas in the two scenarios for modelling (Figure 1), resulting in four separate areas to generate estimates. These were: Greater North Sea (4.b-c, 7.d); Celtic and Irish Seas (7.a, 7.e-h); Northern stock area (4.b-c, 7.a, 7.d-h); and Biscay (8.a-b).

There were several issues with the coverage of the national survey estimates that needed to be address through the analysis, including: lack of tonnage and numbers for all catch components; lack of errors for all components of the catch; and lack of partitioning of catches at the appropriate geographical scale for modelling scenarios. In addition, there were challenges associated with combining estimates across countries including: incomplete coverage for all countries in all years; combining errors to generate uncertainties for the modelling scenarios; and generating estimates for specific management measures where survey data were lacking. Approaches were created to address all these issues that are described in this section and required several assumptions to be made.

2.2.1 Reconstructing catches

Recreational catch estimates were provided by all countries covering the stocks (Belgium, Denmark, France, Germany, Ireland, the Netherlands, and the UK) for any available years from 2010 to 2023 (Table 3). It was clear that country data was not available for all components of the catch with associated errors at the correct spatial resolution (Table 3). As a result, it was necessary to generate the correct information for each area for all countries, then bring these together to generate area-wide estimates with associated errors.

Table 3: Summary of data reconstruction methods for each year for each country involved. Data indicates where a country had data available for each year while a % indicates where the catch estimates were calculated from the catch proportions in 2022. A year indicates the year in which the catch estimates and RSE were taken from, which only occurred where the management measures were the same for both years.

Year	Belgium	Denmark	France (Northern)	France (Biscay)	Ireland	Netherlands	UK
2010	%	%	Data	Data	%	Data	2012
2011							
2012	%	%	2010		%	Data	Data
2013							
2014	%	%	2010		%	Data	2012
2015							
2016	2017	2017	%		%	Data	Data
2017	Data	Data	%		%	2016	Data
2018	Data	Data	%*		%	Data	Data
2019	Data	Data	%*		%	%	Data
2020	Data	Data	2021-3		2022	Data	Data
2021	Data	Data	Data	Data	2022	2020	Data
2022	Data	Data	Data	Data	Data	Data	Data
2023	Data	Data	Data	Data	2022	2022	Data

*Catch estimates were supplied but excluded from this analysis because they were considered unreliable.

Catch estimates were provided for the total tonnage and number retained and released where available (Table 3, Annex 1). Where estimates were not available for all catch components with associated errors, these needed to be reconstructed. The approach varied by country, but a consistent approach was used to partition errors. This assumed that RSEs were equal for all components based on the additive properties of variances. For the simple case with kept (k) and released (r) components of a total catch (t), R_t is the RSE of the whole catch, and n_t is the magnitude of catch, the RSE for all components of the catch ($\hat{R}$) was:

$$\hat{R} = \sqrt{\frac{(n_t R_t)^2}{n_k^2 + n_r^2}}. \quad (1)$$

Germany was excluded from the analysis as robust estimation of catch was not available, and catches were likely to be minimal as sea angling was only possible at remote locations along the outer coasts of the Frisian Islands thus restricting access (see Annex A1.4). Numbers released and tonnage retained were available for Denmark (see Annex A1.2), so it was necessary to estimate numbers retained and tonnage released. This was calculated using the average weight from other countries in the same year in the same division. As the UK was the only country with data in the same ICES division, the average weight from the UK was used. In 2012, data were only provided for England (see Annex A1.7), so the average proportion England takes up of the Sea Angling Diary (2016-2021) was used to calculate catches for the whole of the UK. These were partitioned between ICES divisions using proportions from the Sea Angling Diary (2016-2021) and errors generated using Equation (1).

French national estimates were generated using several different approaches (Annex A1.3). It was not possible to use data from 2011-12 (Levrel et al. 2012; 2013) due to lack of access to data and limited documentation. In addition, estimates from 2018-19 (FranceAgriMer 2019; 2020) were also excluded due to the small numbers of diarists. As a result, it was possible to use the French estimates from 2009-11 (Rocklin et al. 2014) and 2021-2023 (Selles et al. 2024). Estimates generated over a three-year period (2009 to 2011) were assigned to 2010. These were produced for the whole of France (7.d-e, 8.a-b), so needed to be partitioned between areas required for modelling. Estimates were split between ICES divisions based on the proportional distribution from the most recent surveys (2021-2023), which allocated 7d: 26%, 7e: 16%, and 8.a-b: 58%. It was assumed that these proportions remained constant across years for the entire period considered and that changes in regulatory context did not significantly affect the distribution of fishing effort between divisions. Finally, estimates from 2021-23 were combined to provide a single annual estimate. This was because the management measures are the same, and it was unlikely that effort or stock size have changed greatly. As a result, the 3 years were likely to be estimating the same catch with the difference between years representing error. Errors were partition using Equation (1) and standard variance formulae for multiplication by a constant.

To resolve years with missing data at a country level, catch estimates were reconstructed based on management measures (Table 1). If data were available from a year with the same management measures, the estimates and RSE were taken from that year. If no data were available from a year with the same management measures, estimates were generated based on the proportion of the total estimate for 2022, the only year with estimates for each modelling scenario from all countries. Errors were combined using standard properties that variances are additive.

2.2.2 Assessing bias

The scope and methods used by recreational fisheries surveys differ, so an assessment of the potential bias in the estimates was conducted using a semi-quantitative approach (Hyder et al. 2018; Radford et al. 2018). For each component of the catch and survey, a bias value was assigned by the country expert on a seven-point scale (ranging from -3, denoting highly underestimated, to +3, denoting highly overestimated) to determine the magnitude and direction of bias for each study (b_i). All potential sources of bias listed were considered. Each survey bias was weighted (v_i) by the contribution to the total catch, to reduce the impact of large bias in small estimates. Hence, to calculate the relative bias in each area s (B_s) the following equation was used:

$$B_S = \sum_{i=1}^{m} b_i v_i / \sum_{i=1}^{m} v_i \quad (2)$$

2.2.3 Management measures

The approach generated for estimating the impacts of management measures was used to model recreational removals in the current assessment (ICES 2018). However, it was unclear if this approach accurately predicted the impact of management measures. Hence, the removals generated using the assessment model were compared to the survey estimates. In addition, given the difference in survey methods before the implementation of management measures, catches were reconstructed from surveys using the method outlined below. This was because the survey approaches were different with potential for different biases.

Management measures for recreational fisheries changed regularly (Table 1) and many countries did not have data for all years with different management measures. As a result, it was necessary to identify an approach to estimate the impact of management measures. The approach chosen was developed during the previous benchmark (ICES 2018) with the equations provided here accounting for any length of season and bag limit. A small extension to the approach was made to provide retained and released components separately.

To calculate the total numbers (N_t) for a particular year, it was necessary to sum the numbers for each country ($N_{t,i}$) for n countries calculated from the numbers of retained fish ($N_{oh,i}$) and number of released fish ($N_{or,i}$):

$$N_t = \sum_i^n N_{t,i} = \sum_i^n \left(N_{oh,i} + N_{or,i}\right). \quad (1)$$

If management measures were implemented that reflect a combination of a proportion of the year with open season (s) and a bag limit that results in a reduction in retained fish (r_i) in each country (i) (Table 4). Seasons and bag limits will result in fewer fish being harvested than if these management measures were not in place. Hence, it is possible to calculate the number of fish harvested for each country under management measures ($N_{mh,i}$) assuming the same stock structure and complete compliance from the number of additional fish released ($N_{ar,i}$) as:

$$N_{mh,i} = N_{oh,i} - N_{ar,i} = sN_{oh,i} - sr_iN_{oh,i} = s(1 - r_i)N_{oh,i}. \quad (2)$$

The number of fish released for each country under management measures ($N_{mr,i}$) can also be calculated as:

$$N_{mr,i} = N_{or,i} + N_{oh,i} - sN_{oh,i} + sr_iN_{oh,i} = N_{or,i} + (1 - s + sr_i)N_{oh,i}. \quad (3)$$

For each management scenario, summing across countries gives total catches that would have been expected in the years of the surveys. Biomass of fish harvested ($B_{mh,i}$) and released ($B_{mr,i}$) under different management measures are:

$$B_{mh,i} = s(1 - r_i)\bar{w}_{oh,i}N_{oh,i} \quad (4)$$

and $$B_{mr,i} = \bar{w}_{or,i}N_{or,i} + (1 - s + sr_i)\bar{w}_{oh,i}N_{oh,i}, \quad (5)$$

where $\bar{w}_{oh,i}$ and $\bar{w}_{or,i}$ are the average weights of the fish harvested and released from the surveys.

As emergency measures only existed for part of the year in 2015 (Table 1), different equations are used assuming no closed season and bag limits in place for half the year:

$$N_{mh,i} = \left(1 - {}^{r_i}/_{2}\right)N_{oh,i}, \quad (6)$$

and $$N_{mr,i} = N_{or,i} + {}^{r_i N_{oh,i}}/_{2}. \quad (7)$$

Biomass can be calculated using the average weights of fish harvested and released. Finally, the kept and released components for 2011 and 2013 were calculated using linear interpolation between the estimates for 2010 and 2012 and 2012 and 2014, respectively. This resulted in a full time series from 2010 to 2023.

Backward projections from the survey data collected after the introduction of management measures were done using the ratio between survey data and forward projections in 2016 and 2020 for the Northern and Biscay stocks, respectively.

Table 4: Country specific proportion reduction in retained catch numbers obtained by applying bag limits and increased MCRS from 36 to 42 cm to catch numbers in fishing trips observed in national recreational fishing surveys taking place before the new management measures were introduced (Armstrong et al. 2014). BL represents bag limit and MCRS is the increase from 36 to 42 cm.

	Management measure					
Country	BL1	BL2	BL3	BL4	BL5	MCRS only
France (all)	0.61	0.46	0.39	0.36	0.35	0.35
Netherlands	0.64	0.64	0.64	0.64	0.64	0.64
UK	0.52	0.32	0.23	0.23	0.23	0.23

2.2.4 Seasonality

It was not possible to generate seasonal raised estimates of catch due to issues with partitioning effort and catch per unit effort. Instead, monthly variation in raw catches was used to assess seasonality. The proportion of raw numbers of fish caught in each month during the year was provided by France, Ireland, the Netherlands, and the UK, but were not available for Denmark or Belgium. This was used to assess the seasonal cycle of sea bass catches by stock area for both potential stock definition scenarios. Individual countries seasonal patterns were averaged across years then a weighted average of the proportions accounting for differences in numbers caught within a country generated for each area and scenario.

2.2.5 Partitioning catches between areas

As adult sea bass move, it was necessary to reassign recreational catches between stock areas. Fish were assigned to a stock based on their location during the spawning season with the proportion of recreational catch reassigned using seasonal movement rates from tagging studies (Bertignac et al. 2024). This was only done for the Northern and Biscay scenario, which mean that assignment of catches was only done from Northern to Biscay due to the direction of spawning migrations. The proportion of catches from the Northern stock reassigned to Biscay was estimated from tagging studies by quarter (Q3: July to September, Q4: October to December) and half-year (S2: April to September) (Table 5; Bertignac et al. 2024). Kept and released catches were partitioned between quarters or half-years using the raw catches (see Section 2.2.4) and then multiplied by the exchange rates to give the overall proportion of catch to be reassigned. This was multiplied by the annual catches to give the tonnage kept and released to be reassigned from the Northern to Biscay stock.

Table 5: Exchange rates between the Northern and Biscay stocks by quarter (A) and half year (B) (Bertignac et al. 2024).

A. Quarter	Proportion
Q3: Jul-Sep	0.28803
Q4: Oct-Dec	0.40665

B. Half Year	Proportion
S2: Apr-Sept	0.40716

2.3 Length-frequencies

Not all countries provided data on the size of fish caught by marine recreational fisheries. Length distributions alongside sample sizes were provided by Belgium, France, Ireland, the Netherlands, and the UK, but not by Denmark (Table 6). Ireland and France provided raw unraised information, whereas Belgium, the Netherlands, and the UK provided estimates raised to the total catch (Table 6). German catches were assumed to be negligible, and French estimates from 2011-12 and 2018-19 were excluded due to quality issues.

Annual length-frequency distributions were generated for each stock area and scenario. Not all countries provided data for all years, so these were reconstructed using a similar approach to catches. Where length-frequency did not exist for a particular country, the length distribution was used from the average of all countries for the same area and year. The proportion of numbers at length was then combined with the average total number of sea bass retained or released and summed to generate estimates for each area required within modelling scenarios.

2.4 Post-release mortality

European marine recreational anglers often release more than 50% of their sea bass (Ferter et al. 2013). With the introduction of recreational bag limits and increase in MCRS, the proportion of released sea bass is likely to increase. Hence, post-release mortality of recreationally caught fish is a large uncertainty and should be included in the assessment of sea bass stocks. Post-release mortality of hook-and-line caught fish is not easy to measure and can vary significantly between species and fisheries. Many factors are also important including water temperature, hooking damage, and handling (Bartholomew & Bohnsack 2005; Brownscombe et al. 2017). Extrapolation of existing post-release mortality to other species or regions is likely to depend on the similarity of the fishing practices and environmental conditions. All studies were compiled for post-release

mortality of sea bass and similar species, and used alongside characteristics of the fisheries to generate a best estimate for post-release mortality across the whole area.

Table 6: National data on the length-frequencies of sea bass retained and released. Some countries provided raised estimates and others raw unraised numbers.

	Belgium		France		Ireland		Netherlands		UK	
Year	Retained	Released	Retained	Released	Retained	Released	Retained	Released	Retained	Released
2009										
2010			Raised*	Raised*			Raised	Raised		
2011										
2012							Raised		Raised*	Raised*
2013										
2014					Raw	Raw	Raised			
2015					Raw	Raw				
2016					Raw	Raw	Raised	Raised	Raised	Raised
2017	Raised	Raised			Raw	Raw			Raised	Raised
2018	Raised	Raised			Raw	Raw	Raised	Raised	Raised	Raised
2019	Raised	Raised			Raw	Raw			Raised	Raised
2020	Raised	Raised			Raw	Raw	Raised	Raised	Raised	Raised
2021	Raised	Raised	Raw	Raw					Raised	Raised
2022	Raised	Raised	Raw	Raw			Raised	Raised	Raised	Raised
2023	Raised	Raised	Raw	Raw					Raised	Raised

*Raised estimates were provided but recalculated to account for difference in proportional split between regions.

3 Results

3.1 Survey data

There was large variation in both the numbers (Figure 2) and tonnages (Figure 3) of sea bass retained and released over time both within and among countries. Errors varied between countries, with RSEs on annual estimates ranging from 6 to 56%. Most of the catches were from France, the Netherlands, and the UK (Figure 2; Figure 3).

3.2 Catches

Due to issues with data quality, national estimates for 2011-12 and 2018-19 for France were excluded from the analysis. The only year with data from all countries was 2022, with France and the UK contributing the largest share of both retained and released catch in the Celtic Sea regions (Figure 4). The Netherlands and France represented the largest catches in the North Sea, with the UK less important, while Belgium and Denmark had a small share (Figure 4).

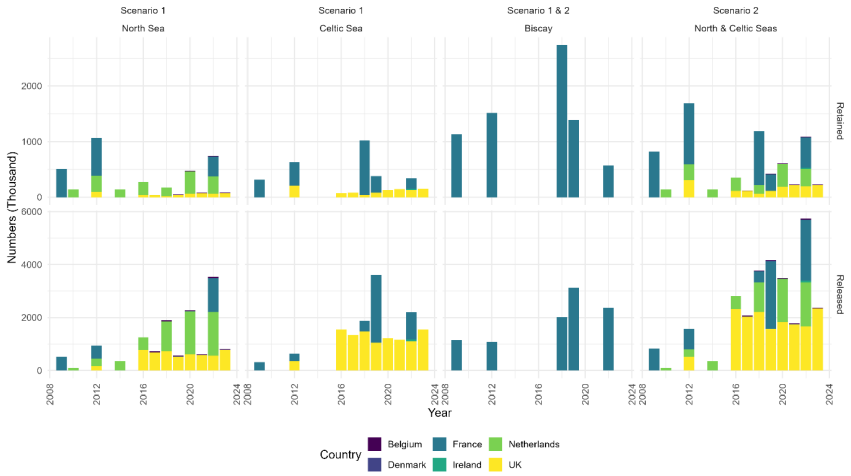


Figure 2: Number of sea bass retained and released by country for each scenario and area prior to any removal or reconstruction.

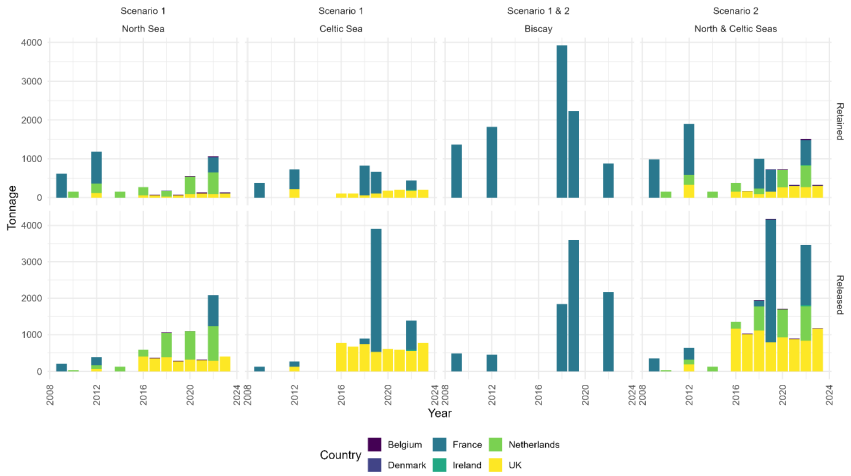


Figure 3: Tonnage of sea bass retained and released by country for each scenario and area prior to any removal or reconstruction.

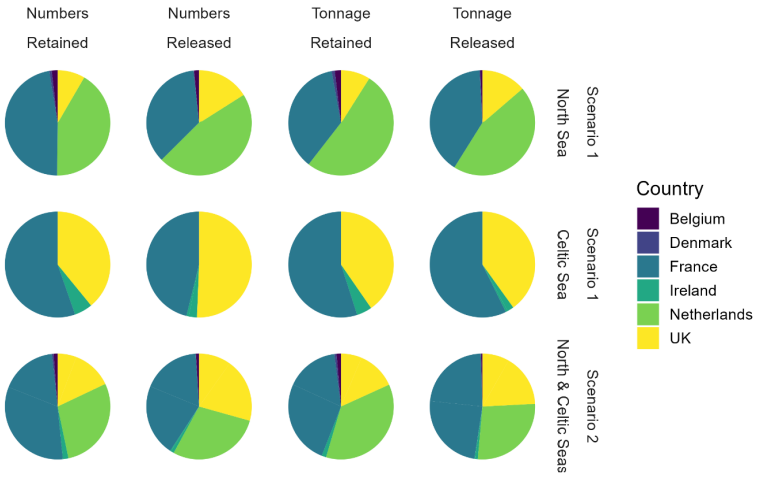


Figure 4: Catch estimate distribution between countries for each scenario and area for 2022, the only year with all countries. Biscay was excluded as only France contributes data to this area.

3.2.1 Reconstructing catches

Catch estimates were reconstructed for years with missing data if at least one record was available. No reconstructions were done for 2011, 2013, or 2015 for the Northern stock, and for Biscay from 2013-19. Reconstructions from 2021 were generally based on survey estimates, with 2022 being the only year with full geographical coverage, but prior to 2021 estimates often included more copied and calculated catches (Figure 5). In the Celtic Sea (2021-2023), 39-100% of estimates came from country-supplied data, while 41-61% (0% in 2022) were copied from years with the same management measures; none were proportion-based (Figure 5). In the North Sea, 10-64% (100% in 2022) of estimates were from surveys, and 36-90% (0% in 2022) copied from other years. When combined, 40-81% were copied, and 19-60% were from surveys while 100% was from surveys in 2022 (Figure 5). For 2016-2019, 36-89% of estimates used 2022 proportions, while earlier years relied more on copying from years with the same management measures, with 13-94% of estimates copied, peaking in 2014 at 79-94% (Figure 5).

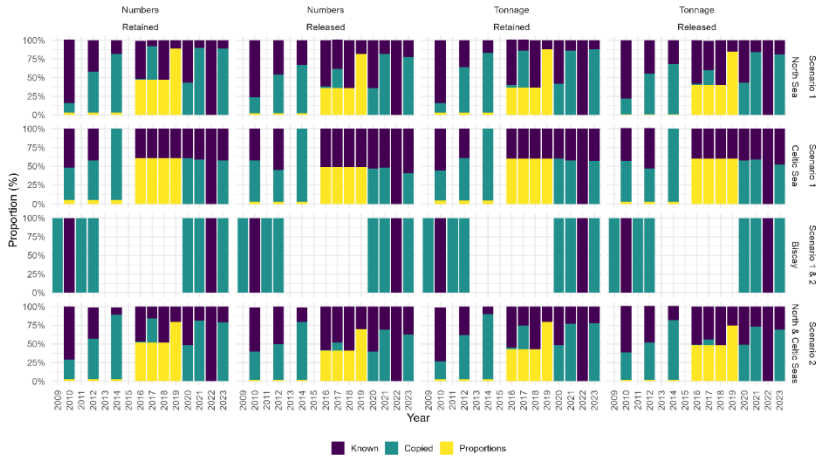


Figure 5: Constituents of the reconstructed catch estimates with the amount known, copied from other years, and reconstructed using 2022 catch proportions.

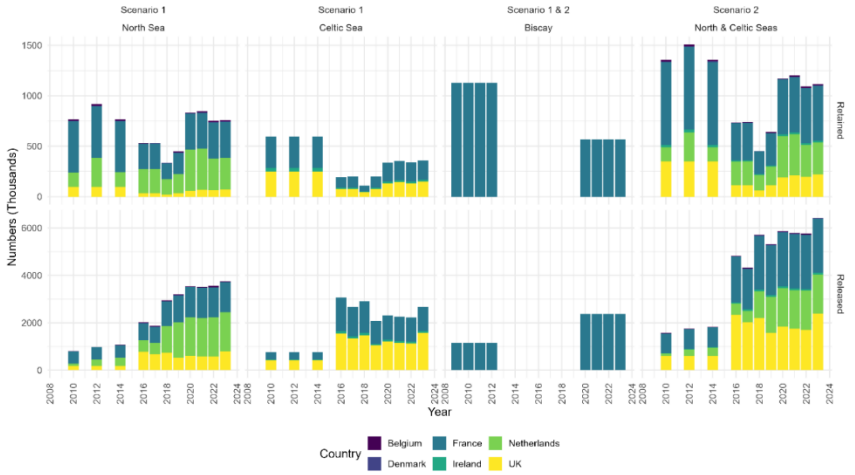


Figure 6: Number of sea bass retained and released by country after reconstruction.

Retained catches were generally higher before the introduction of management measures in 2015 and reflected the severity of management measures from 2016 onwards (Figure 6; Figure 7). The exception was that retained catches in the North Sea were high from 2020 to 2023 driven by large catches from France and the Netherlands (Figure 6; Figure 7). Released catches showed the opposite pattern, with releases much higher after the introduction of management measures (Figure 6; Figure 7). Generally, both retained and released catches were highest in the North Sea and Biscay, with lower levels in the Celtic Sea (Figure 6; Figure 7). RSEs ranged from 0.06-0.56 for numbers and 0.06-0.51 for tonnage, with errors largest before the introduction of management measures. The reconstructed annual catches by area alongside associated errors are given in full in Table 7 and Table 8. Release rates were much higher after the introduction of management measures in 2015 (Figure 8; Figure 9). Release rates by numbers increased from 56-58% in 2014 to 79-94% from 2016 onwards, with a peak in 2018 (Figure 8; Figure 9).

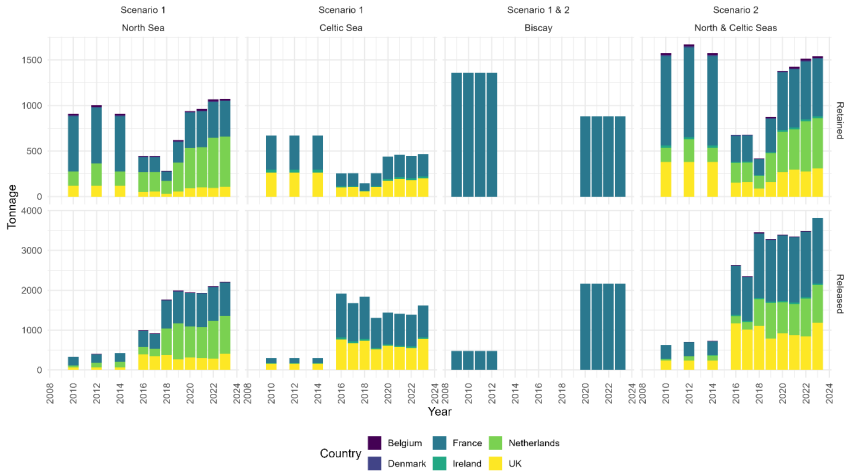


Figure 7: Tonnage of sea bass retained and released by country after reconstruction.

Table 7: Numbers of fish retained (A) and released (B) for different scenarios and areas. North Sea (4.b-c, 7.d), Celtic Seas (7.a, 7.e-h), Northern (4.b-c, 7.a, 7.e-h) and Biscay (8.a-b).

	Scenario 1				Scenario 1 & 2		Scenario 2	
Year	North Sea	RSE	Celtic Sea	RSE	Biscay	RSE	Northern	RSE
A. Retained								
2009					1,130,420	0.56		
2010	765,564	0.38	596,839	0.35	1,130,420	0.56	1,357,013	0.27
2011					1,130,420	0.56		
2012	917,124	0.33	596,839	0.35	1,130,420	0.56	1,510,057	0.24
2013								
2014	766,479	0.38	596,839	0.35			1,357,936	0.26
2015								
2016	530,584	0.24	195,211	0.12			734,594	0.17
2017	531,667	0.24	198,019	0.12			738,037	0.17
2018	334,375	0.18	110,285	0.12			452,672	0.13
2019	449,065	0.13	197,954	0.11			641,409	0.10
2020	833,983	0.20	338,380	0.12	567,000	0.11	1,172,363	0.15
2021	848,204	0.20	353,536	0.11	567,000	0.11	1,201,740	0.14
2022	752,630	0.13	341,362	0.12	567,000	0.11	1,093,992	0.10
2023	756,747	0.13	357,273	0.11	567,000	0.11	1,114,020	0.10
B. Released								
2009					1,151,880	0.56		
2010	807,881	0.39	763,090	0.42	1,151,880	0.56	1,568,488	0.29
2011					1,151,880	0.56		
2012	986,592	0.32	763,090	0.42	1,151,880	0.56	1,748,271	0.26
2013								
2014	1,065,937	0.30	763,090	0.42			1,828,091	0.25
2015								
2016	2,027,164	0.09	3,059,920	0.07			4,831,262	0.06
2017	1,872,820	0.09	2,662,915	0.07			4,322,778	0.06
2018	2,949,693	0.21	2,909,111	0.07			5,706,613	0.11
2019	3,199,895	0.11	2,069,116	0.06			5,316,416	0.07
2020	3,543,603	0.12	2,314,801	0.07	2,375,000	0.10	5,858,404	0.08
2021	3,516,282	0.12	2,260,145	0.07	2,375,000	0.10	5,776,427	0.08
2022	3,554,405	0.11	2,219,297	0.07	2,375,000	0.10	5,773,702	0.07
2023	3,749,801	0.10	2,676,916	0.07	2,375,000	0.10	6,426,717	0.07

Table 8: Tonnage of fish retained (A) and released (B) for different scenarios and areas. North Sea (4.b-c, 7.d), Celtic Seas (7.a, 7.e-h), Northern (4.b-c, 7.a, 7.e-h) and Biscay (8.a-b).

	Scenario 1				Scenario 1 & 2		Scenario 2	
Year	North Sea	RSE	Celtic Sea	RSE	Biscay	RSE	Northern	RSE
A. Retained								
2009					1,360	0.51		
2010	909	0.35	671	0.34	1,360	0.51	1,576	0.25
2011					1,360	0.51		
2012	1,004	0.32	671	0.34	1,360	0.51	1,672	0.24
2013								
2014	909	0.35	671	0.34			1,576	0.25
2015								
2016	443	0.29	255	0.13			678	0.20
2017	444	0.29	258	0.13			681	0.20
2018	280	0.20	144	0.13			416	0.14
2019	620	0.17	258	0.12			877	0.13
2020	939	0.23	441	0.12	881	0.10	1,381	0.16
2021	964	0.22	462	0.12	881	0.10	1,426	0.16
2022	1,068	0.17	446	0.13	881	0.10	1,514	0.13
2023	1,073	0.17	466	0.12	881	0.10	1,539	0.13
B. Released								
2009					480	0.51		
2010	329	0.36	302	0.39	480	0.51	630	0.26
2011					480	0.51		
2012	399	0.30	302	0.39	480	0.51	701	0.24
2013								
2014	424	0.28	302	0.39			726	0.23
2015								
2016	1,000	0.10	1,923	0.09			2,634	0.07
2017	917	0.10	1,675	0.08			2,347	0.06
2018	1,769	0.25	1,834	0.08			3,451	0.14
2019	1,994	0.13	1,302	0.08			3,286	0.08
2020	1,949	0.14	1,440	0.08	2,165	0.08	3,390	0.09
2021	1,936	0.14	1,412	0.08	2,165	0.08	3,348	0.09
2022	2,100	0.13	1,389	0.08	2,165	0.08	3,489	0.08
2023	2,207	0.12	1,613	0.08	2,165	0.08	3,820	0.08

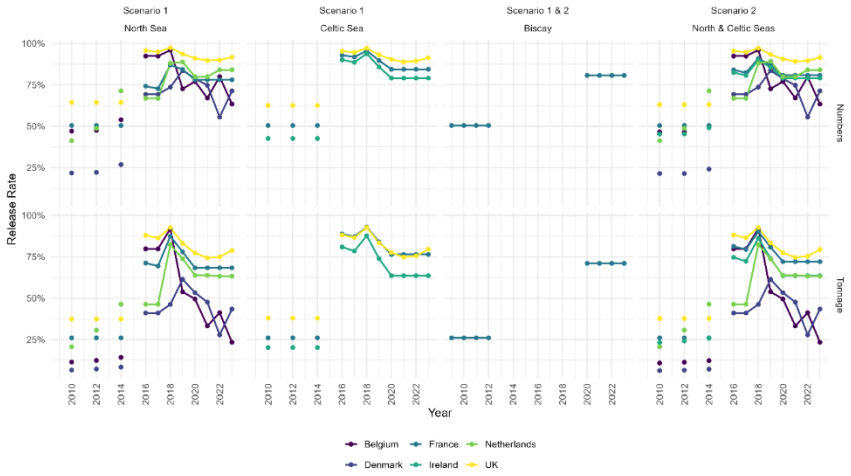


Figure 8: Release rates of sea bass by country after reconstruction.

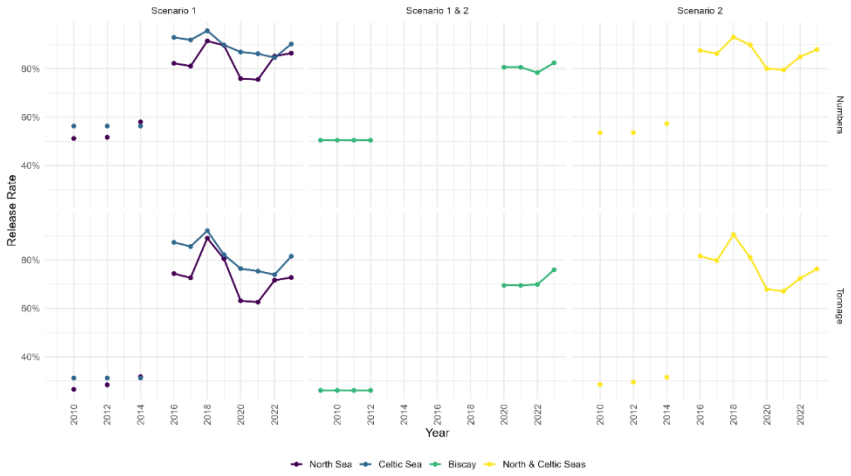


Figure 9: Release rates of sea bass by area after reconstruction.

3.2.2 Assessing bias

Expert judgement for the semi-quantitative estimate of bias was provided for each national survey with earlier surveys (2010-2014) generally thought to represent small to moderate underestimate (-1 to -2) and later surveys moderate to large overestimate (2 to 3) (Figure 10). National estimates of bias were combined weighting for difference in catches to calculate bias for the catches for each area. This resulted in underestimates prior to 2014 with a range from - 1.19 to -1.53 in the North and Celtic Seas, while Biscay remained at -2.00. From 2016 onwards, an overestimate of between 0.86 and 1.60 was found in retained catches while released was higher at 1.60 to 2.57 (Figure 11).

3.2.3 Management measures

Comparison of the impact of management measures on tonnage of removals between survey data and outputs from the assessment showed that generally the modelling approach tended to over-estimate the reduction (Figure 12). However, it should be noted that different approaches were used to generate the survey estimates alongside different biases (Figure 11). Modelled impact of management measures was more like survey data in Biscay than the Celtic and North Seas, with this difference generated by the larger released component in later surveys (Figure 12). Forward projections of the modelling approach showed similar results for both numbers (Figure 13; Table 9) and tonnage (Figure 14; Table 10), with the difference largest for the released components apart from the North Sea where both retained and released were higher. Backward projections were done using the ratio of survey estimates to forward projection in 2016 for the Northern stock and 2020 for Biscay which generated a second time series for numbers (Figure 13; Table 9) and tonnage (Figure 14; Table 10).



Figure 10: Semi-quantitative assessment of bias in national surveys before and after management measures ranging from -3, denoting highly underestimated, to +3, denoting highly overestimated.

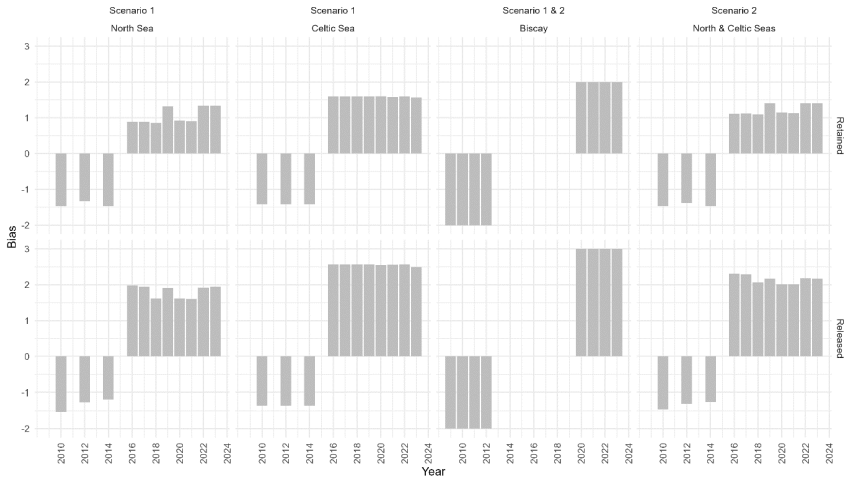


Figure 11: Combined semi-quantitative assessment of bias for annual estimates of retained and released catch for each area.

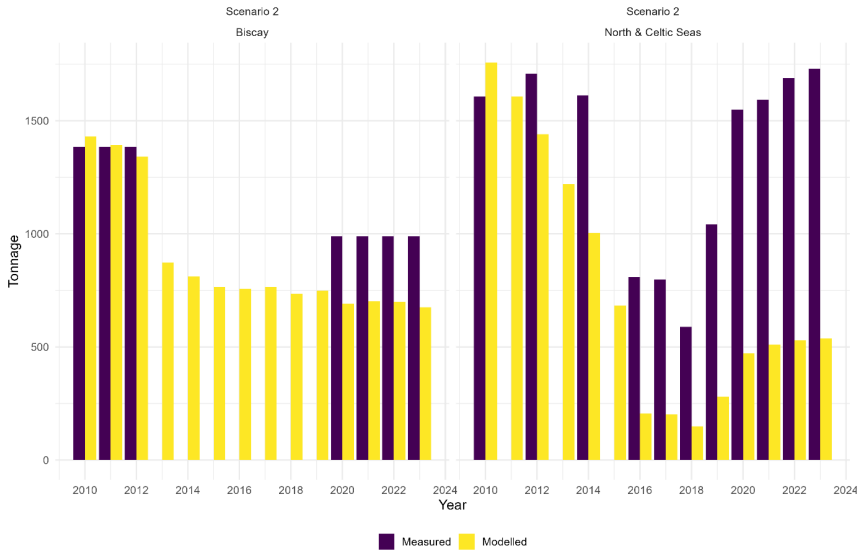


Figure 12: Removals of sea bass generated using the modelling approach compared to estimates from surveys.

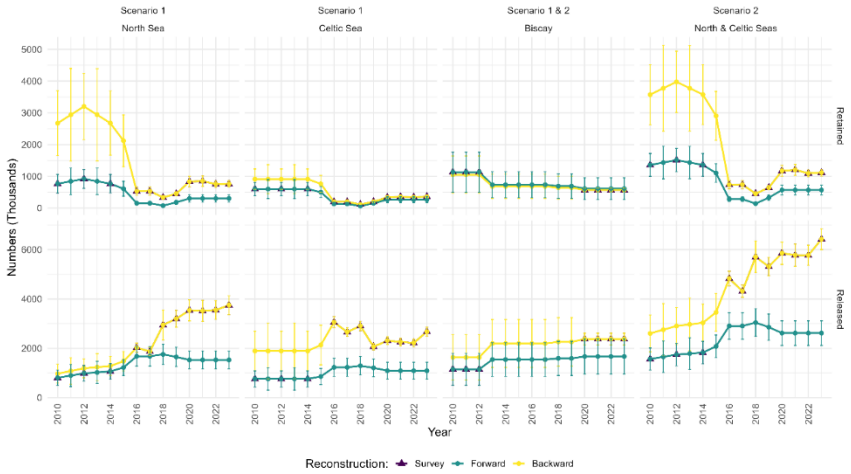


Figure 13: Comparisons of forwards and backwards projections of the impact of management measures with survey estimates in numbers for each scenario and area.

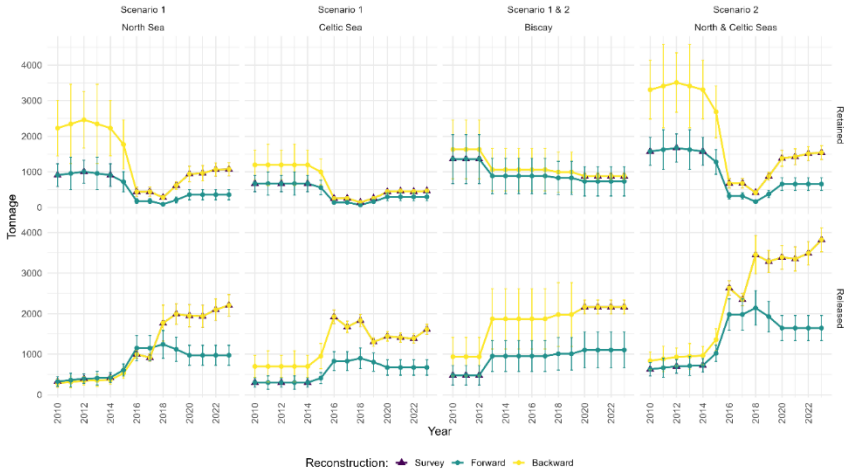


Figure 14: Comparisons of forwards and backwards projections of the impact of management measures with survey estimates in tonnage for each scenario and area.

Table 9: Numbers of fish retained (A) and released (B) for different scenarios and area using projections of impacts of management measures. North Sea (4.b-c, 7.d), Celtic Seas (7.a, 7.e-h), Northern (4.b-c, 7.a, 7.e-h) and Biscay (8.a-b).

Year	Forwards Projection								Backwards Projection							
	Scenario 1				Scenario 1 & 2		Scenario 2		Scenario 1				Scenario 1 & 2		Scenario 2	
	North Sea	RSE	Celtic Sea	RSE	Biscay	RSE	Northern	RSE	North Sea	RSE	Celtic Sea	RSE	Biscay	RSE	Northern	RSE
A. Retained																
2010	765,564	0.38	596,839	0.35	1,130,420	0.56	1,357,013	0.27	2,672,595	0.38	909,910	0.35	1,050,000	0.56	3,573,883	0.27
2011	841,344	0.50	596,839	0.50	1,130,420	0.56	1,433,535	0.36	2,937,143	0.50	909,910	0.50	1,050,000	0.56	3,775,415	0.36
2012	917,124	0.33	596,839	0.35	1,130,420	0.56	1,510,057	0.24	3,201,691	0.33	909,910	0.35	1,050,000	0.56	3,976,946	0.24
2013	841,801	0.49	596,839	0.50	734,773	0.56	1,433,996	0.36	2,938,739	0.49	909,910	0.50	682,500	0.56	3,776,631	0.36
2014	766,479	0.38	596,839	0.35	734,773	0.56	1,357,936	0.26	2,675,787	0.38	909,910	0.35	682,500	0.56	3,576,315	0.26
2015	606,956	0.38	500,097	0.35	734,773	0.56	1,102,802	0.26	2,118,893	0.38	762,422	0.35	682,500	0.56	2,904,383	0.26
2016	151,986	0.37	128,045	0.35	734,773	0.56	278,927	0.26	530,584	0.24	195,211	0.12	682,500	0.56	734,594	0.17
2017	151,986	0.37	128,045	0.35	734,773	0.56	278,927	0.26	531,667	0.24	198,019	0.12	682,500	0.56	738,037	0.17
2018	75,993	0.37	64,022	0.35	689,556	0.56	139,464	0.26	334,375	0.18	110,285	0.12	640,500	0.56	452,672	0.13
2019	177,317	0.37	149,386	0.35	689,556	0.56	325,415	0.26	449,065	0.13	197,954	0.11	640,500	0.56	641,409	0.10
2020	301,520	0.39	267,821	0.35	610,427	0.56	567,215	0.26	833,983	0.20	338,380	0.12	567,000	0.11	1,172,363	0.15
2021	301,520	0.39	267,821	0.35	610,427	0.56	567,215	0.26	848,204	0.20	353,536	0.11	567,000	0.11	1,201,740	0.14
2022	301,520	0.39	267,821	0.35	610,427	0.56	567,215	0.26	752,630	0.13	341,362	0.12	567,000	0.11	1,093,992	0.10
2023	301,520	0.39	267,821	0.35	610,427	0.56	567,215	0.26	756,747	0.13	357,273	0.11	567,000	0.11	1,114,020	0.10
B. Released																
2010	807,881	0.39	763,090	0.42	1,151,880	0.56	1,568,488	0.29	974,576	0.39	1,895,466	0.42	1,636,317	0.56	2,606,645	0.29
2011	897,236	0.50	763,090	0.60	1,151,880	0.56	1,658,380	0.38	1,082,369	0.50	1,895,466	0.60	1,636,317	0.56	2,756,034	0.38
2012	986,592	0.32	763,090	0.42	1,151,880	0.56	1,748,271	0.26	1,190,162	0.32	1,895,466	0.42	1,636,317	0.56	2,905,422	0.26
2013	1,026,264	0.44	763,090	0.60	1,547,527	0.44	1,788,181	0.36	1,238,021	0.44	1,895,466	0.60	2,198,358	0.44	2,971,749	0.36
2014	1,065,937	0.30	763,090	0.42	1,547,527	0.44	1,828,091	0.25	1,285,879	0.30	1,895,466	0.42	2,198,358	0.44	3,038,075	0.25
2015	1,225,460	0.27	859,832	0.38	1,547,527	0.44	2,083,226	0.22	1,478,317	0.27	2,135,768	0.38	2,198,358	0.44	3,462,078	0.22
2016	1,680,430	0.24	1,231,884	0.29	1,547,527	0.44	2,907,100	0.18	2,027,164	0.09	3,059,920	0.07	2,198,358	0.44	4,831,262	0.06
2017	1,680,430	0.24	1,231,884	0.29	1,547,527	0.44	2,907,100	0.18	1,872,820	0.09	2,662,915	0.07	2,198,358	0.44	4,322,778	0.06
2018	1,756,423	0.24	1,295,907	0.29	1,592,744	0.43	3,046,564	0.18	2,949,693	0.21	2,909,111	0.07	2,262,592	0.43	5,706,613	0.11
2019	1,655,099	0.24	1,210,543	0.30	1,592,744	0.43	2,860,612	0.19	3,199,895	0.11	2,069,116	0.06	2,262,592	0.43	5,316,416	0.07
2020	1,530,896	0.24	1,092,108	0.31	1,671,873	0.42	2,618,812	0.19	3,543,603	0.12	2,314,801	0.07	2,375,000	0.10	5,858,404	0.08
2021	1,530,896	0.24	1,092,108	0.31	1,671,873	0.42	2,618,812	0.19	3,516,282	0.12	2,260,145	0.07	2,375,000	0.10	5,776,427	0.08
2022	1,530,896	0.24	1,092,108	0.31	1,671,873	0.42	2,618,812	0.19	3,554,405	0.11	2,219,297	0.07	2,375,000	0.10	5,773,702	0.07
2023	1,530,896	0.24	1,092,108	0.31	1,671,873	0.42	2,618,812	0.19	3,749,801	0.10	2,676,916	0.07	2,375,000	0.10	6,426,717	0.07

Table 10: Tonnage of fish retained (A) and released (B) for different scenarios and area using projections of impacts of management measures. North Sea (4.b-c, 7.d), Celtic Seas (7.a, 7.e-h), Northern (4.b-c, 7.a, 7.e-h) and Biscay (8.a-b).

Year	Forwards Projection								Backwards Projection							
	Scenario 1				Scenario 1 & 2		Scenario 2		Scenario 1				Scenario 1 & 2		Scenario 2	
	North Sea	RSE	Celtic Sea	RSE	Biscay	RSE	Northern	RSE	North Sea	RSE	Celtic Sea	RSE	Biscay	RSE	Northern	RSE
A. Retained																
2010	909	0.35	671	0.34	1,360	0.51	1,576	0.25	2,230	0.35	1,195	0.34	1,631	0.51	3,308	0.25
2011	956	0.47	671	0.48	1,360	0.51	1,624	0.34	2,347	0.47	1,195	0.48	1,631	0.51	3,409	0.34
2012	1,004	0.32	671	0.34	1,360	0.51	1,672	0.24	2,464	0.32	1,195	0.34	1,631	0.51	3,510	0.24
2013	957	0.47	671	0.48	884	0.56	1,624	0.34	2,348	0.47	1,195	0.48	1,060	0.56	3,410	0.34
2014	909	0.35	671	0.34	884	0.56	1,576	0.25	2,231	0.35	1,195	0.34	1,060	0.56	3,310	0.25
2015	721	0.39	561	0.36	884	0.56	1,279	0.27	1,770	0.39	999	0.36	1,060	0.56	2,686	0.27
2016	180	0.38	143	0.35	884	0.56	323	0.26	443	0.29	255	0.13	1,060	0.56	678	0.20
2017	180	0.38	143	0.35	884	0.56	323	0.26	444	0.29	258	0.13	1,060	0.56	681	0.20
2018	90	0.38	72	0.35	830	0.56	161	0.26	280	0.20	144	0.13	995	0.56	416	0.14
2019	211	0.38	167	0.35	830	0.56	377	0.26	620	0.17	258	0.12	995	0.56	877	0.13
2020	359	0.39	299	0.36	734	0.56	657	0.27	939	0.23	441	0.12	881	0.10	1,381	0.16
2021	359	0.39	299	0.36	734	0.56	657	0.27	964	0.22	462	0.12	881	0.10	1,426	0.16
2022	359	0.39	299	0.36	734	0.56	657	0.27	1,068	0.17	446	0.13	881	0.10	1,514	0.13
2023	359	0.39	299	0.36	734	0.56	657	0.27	1,073	0.17	466	0.12	881	0.10	1,539	0.13
B. Released																
2010	329	0.36	302	0.39	480	0.51	630	0.26	285	0.36	700	0.39	940	0.51	839	0.26
2011	364	0.46	302	0.55	480	0.51	666	0.35	316	0.46	700	0.55	940	0.51	886	0.35
2012	399	0.30	302	0.39	480	0.51	701	0.24	346	0.30	700	0.39	940	0.51	933	0.24
2013	412	0.41	302	0.55	956	0.40	714	0.33	357	0.41	700	0.55	1,872	0.40	949	0.33
2014	424	0.28	302	0.39	956	0.40	726	0.23	368	0.28	700	0.39	1,872	0.40	966	0.23
2015	612	0.24	413	0.33	956	0.40	1,023	0.20	531	0.24	955	0.33	1,872	0.40	1,362	0.20
2016	1,153	0.27	830	0.28	956	0.40	1,980	0.20	1,000	0.10	1,923	0.09	1,872	0.40	2,634	0.07
2017	1,153	0.27	830	0.28	956	0.40	1,980	0.20	917	0.10	1,675	0.08	1,872	0.40	2,347	0.06
2018	1,243	0.27	902	0.28	1,011	0.40	2,141	0.20	1,769	0.25	1,834	0.08	1,979	0.40	3,451	0.14
2019	1,123	0.27	807	0.28	1,011	0.40	1,926	0.19	1,994	0.13	1,302	0.08	1,979	0.40	3,286	0.08
2020	974	0.25	674	0.28	1,106	0.40	1,646	0.19	1,949	0.14	1,440	0.08	2,165	0.08	3,390	0.09
2021	974	0.25	674	0.28	1,106	0.40	1,646	0.19	1,936	0.14	1,412	0.08	2,165	0.08	3,348	0.09
2022	974	0.25	674	0.28	1,106	0.40	1,646	0.19	2,100	0.13	1,389	0.08	2,165	0.08	3,489	0.08
2023	974	0.25	674	0.28	1,106	0.40	1,646	0.19	2,207	0.12	1,613	0.08	2,165	0.08	3,820	0.08

3.2.4 Seasonality

Seasonality in catch estimates was not possible to generate due to issues with lack of effort data and large errors. Instead, monthly variation in raw catches was analysed to assess seasonality across the four countries that provided data: France, Ireland, the Netherlands, and the UK. The pattern was of higher catches in summer than winter (Figure 15). However, the yearly average proportion of sea bass caught per month varied among these countries (Figure 15). Combining seasonality for all countries within each area showed similar patterns with catches highest in summer (Figure 16).

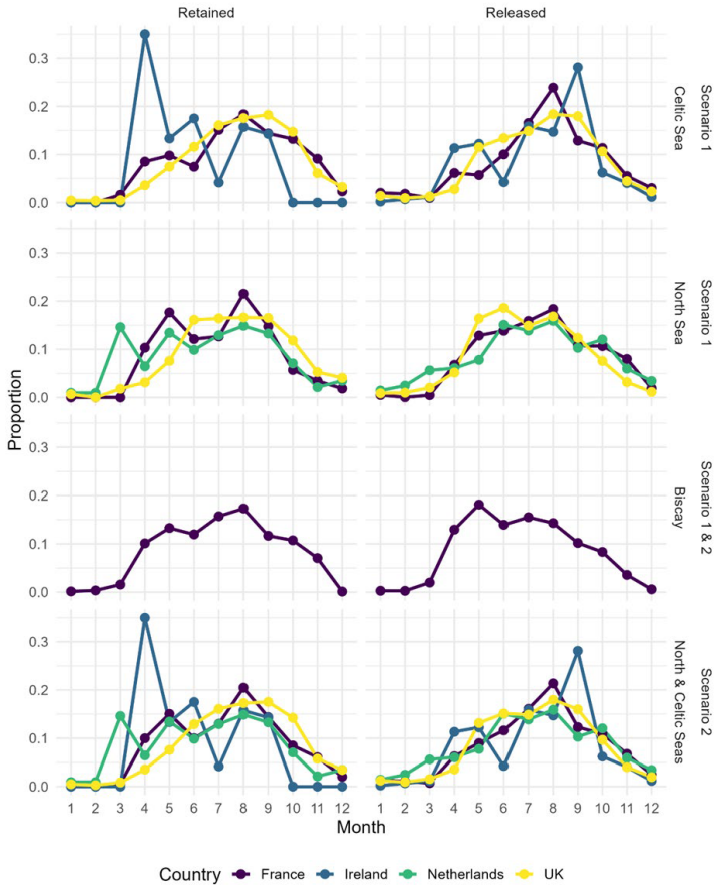


Figure 15: Proportion of sea bass caught in each month averaged across all available years for each country in the different scenarios and areas.

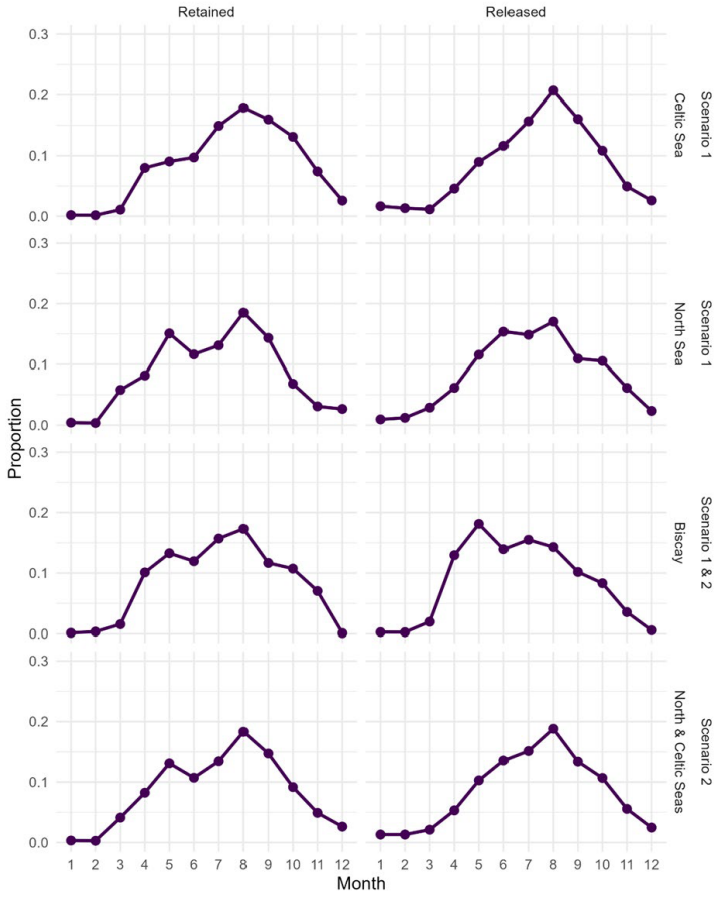


Figure 16: Proportion of sea bass caught in each month averaged across all available years and weighted by catches in each country for the different scenarios and areas.

3.2.5 Partitioning catches between areas

A proportion of the tonnage caught in the Northern stock area comprised of fish that spawn in Biscay. Combining exchange rates (Bertignac et al. 2024) with seasonality resulted in very similar proportions for retained and released with the half-year generating higher proportions than by quarter (Table 11). This resulted in estimates of catches and associated errors for forward and backward reconstructions (Figure 17).

Table 11: Proportion of retained (A) and released (B) catch to be reassigned from the Northern to Biscay stock area.

Proportion	Quarter Q3: Jul-Sep	Q4: Oct-Dec	Half-year S2:Apr-Sep
Exchange	0.28803	0.40665	0.40716
A. Retained			
Season	0.46501	0.16708	0.78532
Total	0.13394	0.06794	
Overall	0.20188		0.31975
B. Released			
Season	0.47361	0.18710	0.76517
Total	0.13641	0.07609	
Overall	0.21250		0.31155

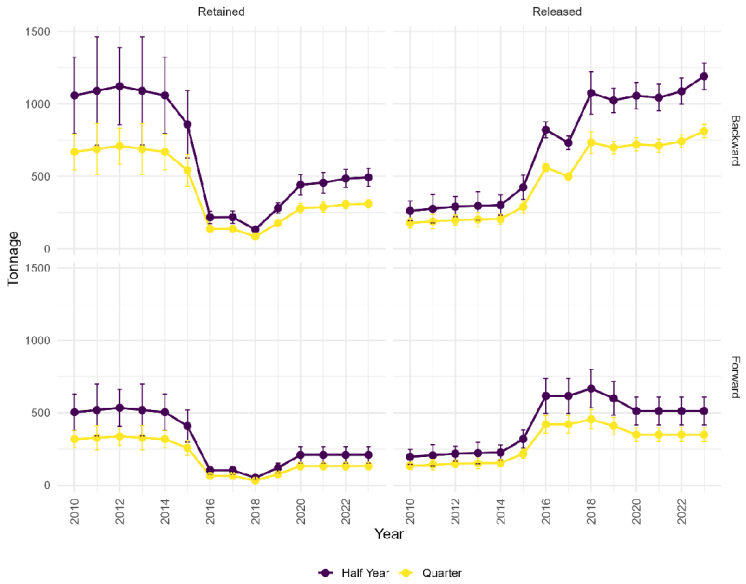


Figure 17: Tonnage of kept and released sea bass to be reassigned from the Northern to Biscay stock based on the quarterly and half-year exchange rates for the forward and backward projections.

3.3 Length-frequencies

Length frequencies of fish retained and released were provided by Belgium, France, Ireland, the Netherlands, and the UK for all years surveyed. Distributions were similar across years with variation between countries (Figure 18). Bringing together the distributions for each area and scenario showed similarities between years with an increase in both the numbers and size of released fish after the implementation of management measures (Figure 19). More fish were released than retained, and retained fish were larger than released fish (Figure 19).

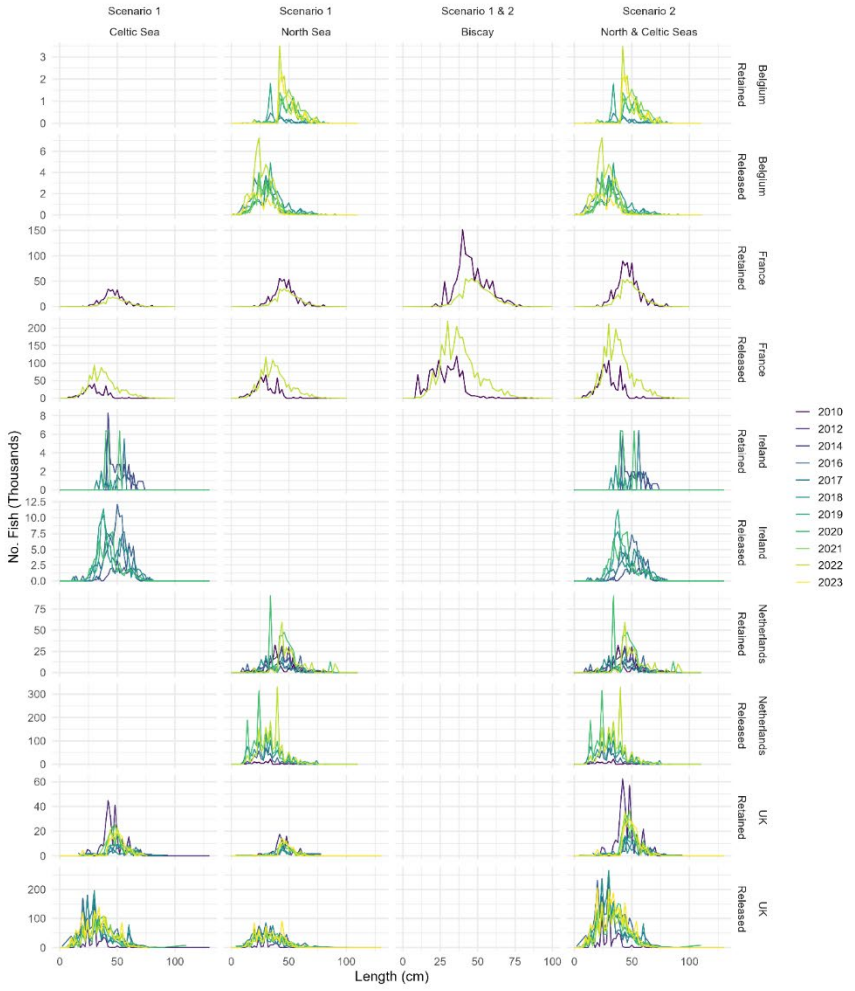


Figure 18: Length-frequency of sea bass for each country and year across the different scenarios and areas.

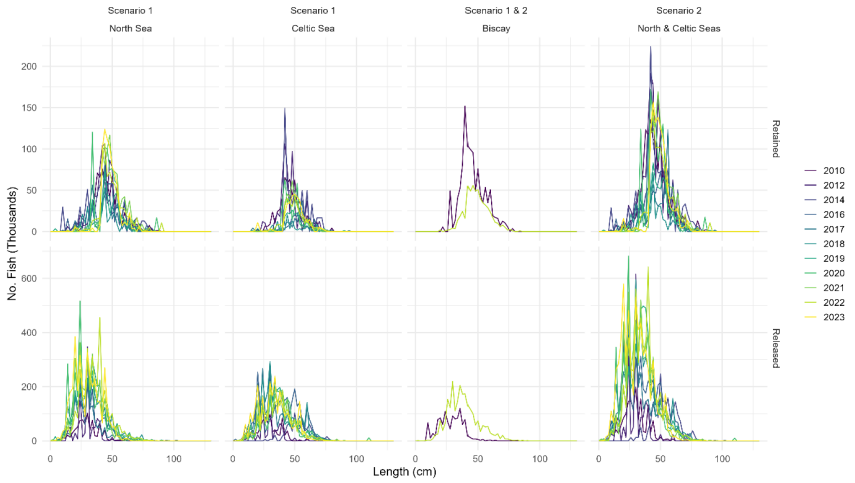


Figure 19: Length-frequency of sea bass by year across the different scenarios and areas.

3.4 Post-release mortality

Two studies have examined post-release mortality in sea bass, though only one has been published. The first study, conducted in the port of Bilbao, Northern Spain, aimed to compare mortality rates from recreational fishing based on several factors such as fishing methods (bait, lures, hook type), fight duration, and hooking injuries (Ruiz et al. 2016). Sea bass were captured, tested for impairment using RAMP scores (Davis 2007), and then held in cages for seven days to monitor mortality (Ruiz et al. 2016). A total of 103 sea bass, with an average length of 33 cm (ranging from 23 to 44 cm), were caught. While a full analysis of the data has not been conducted, an initial review suggested a post-release mortality rate of 15.5%, or 16 fish, most of which died within the first 2.5 hours after capture (Ruiz et al. 2016). The second study took place at an aquaculture facility (Lewin et al. 2018). In July 2015, 144 sea bass were caught using common recreational fishing gear and held for 10 days to assess mortality. The study investigated the effects of different bait types, air exposure, and deep hooking, with mortality found to be higher with natural bait (13.9%, 95% CI=4.7–29.5%) and deep hooking (76.5%, 95% CI=50.0–93.2%). By integrating these findings with country-specific data on sea angling practices, it was estimated that the average post-release mortality for sea bass caught by recreational anglers in 2012 was 5.0% (95% CI=1.7–14.4%) for the Northern sea bass stock (Lewin et al. 2018). This study did not assess the impact of barotrauma, so may represent an underestimate of mortality for fish released from boats.

Table 12: Number of fish measured by country for each scenario and area.

Year	Belgium North	France North	Celtic	Biscay	Ireland Celtic	Netherlands North	UK North	Celtic	Total North	Celtic	Biscay	Northern
A. Retained												
2010		178	110	397		169			347	110	397	457
2012						360	30	78	390	78		468
2014					41	179			179	41		220
2016					37	95	22	66	117	103		220
2017	171				14		34	139	205	153		358
2018	37				7	59	12	85	108	92		200
2019	144				6		71	193	215	199		414
2020	106				9	94	116	199	316	208		524
2021	136						97	204	233	204		437
2022	101	215	114	343		211	97	174	624	288	343	912
2023	98						103	210	201	210		411
B. Released												
2010		181	112	405		126			307	112	405	419
2012							57	134	57	134		191
2014					237					237		237
2016					227	609	556	1599	1165	1826		2991
2017	1166				342		1197	2573	2363	2915		5278
2018	823				277	280	1048	1972	2151	2249		4400
2019	413				306		1027	2374	1440	2680		4120
2020	419				344	669	1039	1315	2127	1659		3786
2021	291						807	1164	1098	1164		2262
2022	431	640	517	1198		1113	671	1179	2855	1696	1198	4551
2023	305						791	1720	1096	1720		2816

Several studies have also been conducted on striped bass (*Morone saxatilis*), offering an alternative estimate for post-release mortality (Diodati & Richards 1996). Given the similarities in morphology and habitat between striped bass and European sea bass, striped bass data might be used as a proxy. The U.S. National Marine Fisheries Service adopted an average hooking mortality rate of 9% for striped bass (Diodati & Richards 1996) in their 2016 assessment (ASMFC 2016). In their study, fish measuring between 27 and 52 cm were observed over 58 days, having been caught using different methods (bait and lures) from a 2-hectare pond. The average hooking mortality was 9%, but rates ranged from 3% to 26%, depending on the conditions (N = 173). Additionally, fish that had been previously hooked were in worse condition than those unhooked by the end of the study (Diodati & Richards 1996). A review by the Massachusetts Division of Marine Fisheries compiled data from 40 experiments by 16 different authors, estimating striped bass hooking mortality over periods of two or more days, with a mean mortality rate of 0.19 (SD 0.19).

Only one study of post-release mortality, conducted in an aquaculture facility, has been published (Lewin et al. 2018), supplemented by unpublished data from another sea bass study (Ruiz et al. 2016), alongside several studies on striped bass. Due to potential differences in angling practices between the US and Europe, applying striped bass data directly may not be appropriate. The Lewin et al. (2018) study, having undergone peer review and accounting for angling practices, provides the most reliable data. Therefore, the 5.0% [1.7, 14.4%] post-release mortality estimate from Lewin et al. (2018) should be considered the most robust and utilised.

4 Discussion

The integration of sea bass recreational fisheries data across multiple countries highlighted several challenges, particularly in terms of consistency and the effects of management measures. National surveys, conducted by countries such as Belgium, France, Ireland, the Netherlands, and the UK, varied significantly in their approaches to collecting data, creating difficulties in synthesising a consistent time series. These inconsistencies in coverage and methodology complicated the estimation of total catches and length-frequencies, both critical for stock assessments. Moreover, the evolving management measures, including changes to the MCRS, bag limits, and closed seasons, added further complexity. For instance, after 2015, stricter management measures for the Northern stock correlated with an increase in the release rates of sea bass. However, the changes in survey methods over the years also contributed to variations in the catch data, making it difficult to isolate the effects of the regulations from those of the data collection processes themselves.

One of the key challenges was assessing potential biases in the data. Expert evaluations suggested that earlier surveys may have underestimated catches, whereas more recent surveys could be overestimating them. This created a significant hurdle in producing accurate estimates, as the magnitude and direction of these biases varied over time. The variability in bias must be accounted for when synthesising data to create meaningful time series for stock assessment. In particular, the assumptions made about compliance with management measures, such as adherence to bag limits and the increase in MCRS, may not always be accurate, which introduced further uncertainty. For example, data from the UK and France, two of the largest contributors to recreational sea bass catches, showed higher release rates post-2015, reflecting both the influence of management measures and potential changes in angler behaviour.

To ensure that this uncertainty is properly incorporated into stock assessments, it was crucial to conduct thorough sensitivity and uncertainty analyses. These analyses would allow for a range of potential outcomes to be explored, helping to understand the impact of varying assumptions about bias and compliance. The reconstructed time series, particularly those based on more complete data sets from 2022, provided a foundation for these analyses. However, it is essential that the uncertainties associated with data reconstruction, particularly for years with incomplete or inconsistent survey data, are clearly communicated.

While this document represents a significant step forward in understanding the recreational sea bass fishery, particularly in terms of the effects of management measures and post-release mortality, there remains a need for ongoing refinement. The integration of national surveys into a coherent data set for stock assessments is a challenging but necessary task. The analysis done represents a step change towards synthesising marine recreational fisheries data from diverse sources and understanding the issues, uncertainties, and biases. However, a consistent time series and robust uncertainty analyses are needed, so continued refinement of the approach should be done as more survey data is generated.

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Annex 1: Summary of national surveys

A1.1: Belgium

In 2017, Belgium started a national marine recreational fisheries monitoring programme in collaboration with fishers. Within the programme, separate surveys were done to generate: effort data collected by VLIZ/ILVO during field surveys; and catch per unit effort data reported by recreational sea anglers on the platform www.recreatievezeevisserij.be.

Effort data was collected separately for shore- and boat-based fishing. Port surveys were done from 2014-2017 to estimate the average number of angling and trawling vessel movements per day alongside the average trip duration for each Belgian marina. The limited number of observation dates (n=63) meant that it was not possible to assess seasonality. For shore-based fishing, aerial surveys were done in 2016-17 and 2021-23 generating counts of numbers of fishers by gear type (anglers, waders for shrimps, passive nets, horseback fisheries). Seasonality was included through strata related to low and high season, alongside weekdays and weekends. Analysis was done to assess temporal variation through movement of fishers over 48 random coastal sections (5 km) over a time span of 12 hours to investigate relative activity per gear in relation to tide. Aerial surveys were combined with temporal variation to generate effort in terms of fishing hours for each gear.

Catch per unit effort was generated using an offsite diary containing 407 fishers from 2017, but not all were active. After each fishing trip, participants uploaded their trip details through an online portal (https://www.recreatievezeevisserij.be/mijn-vangsten/) which included date, duration, technique, bait type, location, and number/weight of retained/released fish. For each gear, catch reporting was standardized to 'average catch/species/hour'. Avidity was excluded due to reporting limitations.

Catches for the entire population were generated by combining effort and catch per unit effort estimates. Effort data was estimated considering the weather conditions, with no boat fishing assumed to occur on days with wind speeds of above 8 $m.s^{-1}$ and shore with wind speeds of above 10 $m.s^{-1}$. Counts of fishing hours were multiplied by the number of days with weather that allowed fishing. Finally, the effort (fishing hours per year) was multiplied by catch per hour to generate total catch and associated errors.

Several biases are inherent in the Belgian survey. The self-selecting nature of the diary survey meant there is the potential for a positive bias in the catch rates, despite the work that has gone into reducing this bias (e.g. broad communication about the programme via a multitude of platforms). Night fishing was excluded in the fishing effort, leading to an underestimation for the total effort and catch. Fishing competitions were excluded from the survey. Integration of different field observations and logbook data was complex, so calculating statistical error rates was difficult. Meteorological assumptions used to calculate total fishing effort were simple and may not hold leading to an underestimation of effort. Finally, the effort survey was only done every five years, so is assumed to be constant during that period.

A full description of the methods can be found in Verleye et al. (2019; 2022).

A1.2: Denmark

A comprehensive survey strategy involving telephone and internet methodologies was developed in collaboration with Statistic Denmark. The survey is combined as two distinct recall surveys: the "licence list survey" targeting individuals with valid fishing licences, and the "omnibus survey" addressing a broader sample of the Danish population. A full description can be found in Sparrevohn & Storr-Paulsen (2012) with a summary provided below.

The licence list survey focused on licensed fishers, utilising registration through the Danish social security number. However, it excluded tourists, unlicenced fishers, and those exempt for valid reasons. The survey, conducted via internet, collects detailed information on harvested species and fishing efforts over the past half year. For the omnibus survey, a subsample of the entire population was targeted to estimate the number of unlicenced fishers and their fishing effort. Unlike the licence list survey, this survey did not include questions about the catch.

The analysis aimed at estimating harvest and release by ICES area and quarter. For some species, including sea bass, the respondents were asked about their catches per half-year. The respondents were provided with a map to facilitate reporting on this level. Exceptions, such as short-term licences, were considered in the total harvest estimation. In addition, specific groups exempt from licensing requirements were identified, ensuring a comprehensive understanding of fishing activities in the Danish population.

The omnibus survey conducted monthly by Statistic Denmark is used by many other entities including companies, newspapers, and research institutes. In the October, November, and December omnibus of 2009, questions about recreational fishing were included. Randomly selected phone numbers were dialled, and individuals aged 16 to 74 interviewed. Respondents were asked about fishing activities in the past 12 months and whether they held a fishing licence. Those without a licence were queried about their reasons. Respondents reported the number of days spent fishing, aiding in estimating the effort of unlicensed versus licenced individuals.

The study aimed to estimate the harvest of cod and eels by Danish recreational fishers initially and was extended to include the species mandated by EU regulations. The harvest was estimated based on reported data from a licence list recall survey. These values were then extrapolated to the entire population of fishers, including both licence holders and those without a licence, using a specific map that delineated different sampling areas.

The estimation included strata for avidity and distinguished between those with and without licences. The data used in the calculation included respondents, licence status, effort in days per year, year, week, day, and a factor for those fishing without a licence. The total harvest was calculated considering the information collected during an omnibus survey.

To estimate the total harvest in tonnes or released numbers per quarter or half year (i) and area (j) the following equation was used:

$$\widehat{Y_{ij}} = \frac{\sum_{k=1}^{n_{ij}} y_{ijk}}{n} N$$

where n is the number of respondents and y the reported harvest per respondent (k). The total population N was calculated as:

$$N = \left(\rho_a + \rho_a \frac{\varepsilon_w}{\varepsilon_a} + \rho_d \frac{\varepsilon_d}{\varepsilon_a} + \rho_m \frac{\varepsilon_m}{\varepsilon_a}\right)$$

where ρ is the number licences issued for a year (a), week (w) or day (d). The number of unlicenced fishers (m) was calculated by estimating the percentage that fished without a mandatory licence multiplied by the number of Danish citizens between age 18 and 65. The values were weighted by the fishing effort ε which for those holding an annual licence was derived from the omnibus survey and assumed to be 1 day for those holding a daily licence and 3 days for those holding a weekly licence.

A1.3: France

France has data sets from 2009-11 (Rocklin et al. 2013), 2012-13 (Levrel et al. 2012; 2013), 2018-19 (FranceAgriMer, 2019; 2020), and 2021-23 (Selles et al. 2024).

2009-11

A survey of recreational fishers, focusing on sea bass, was conducted between 2009 and 2011. Estimates of sea bass recreational catches were obtained from a panel of 121 recreational fishers recruited from a random digit dialling screening survey of 15,000 households in the targeted districts. The results demonstrated that half of the total catches (small fish) were released at sea and the mean length of a kept sea bass was 46.6 cm. Different patterns of fishing methods and type of gear used were highlighted. Catches from boats were greater than from the shore, both in abundance and biomass, considering mean values per fishing trip as well as CPUE. Spearfishers caught the highest biomass of sea bass per fishing trip, but the fishing rod with lure was the most effective type of gear in terms of CPUE. Longlines had the highest CPUE value in abundance but not in biomass: they caught numerous but small sea bass. Handlines were less effective, catching few sea bass in both abundance and biomass.

The estimated recreational catch of sea bass in the Bay of Biscay and in the Channel was 3170t of which 2350t was kept and 830t released. The estimates for Subareas 4 and 7 were 940t kept and 332t released. The precision of the combined Biscay and Channel estimate was low (CV=26%). This gave an average and 95% confidence intervals of 3170t [1554t; 4786t] for the whole Subareas 4, 7 and 8.

A full description is available in Rocklin et al. (2013).

2011-12

A recreational fisheries survey was conducted from July 2011 to December 2012 using a similar methodology to Rocklin et al. (2014) that was extended to include other species in addition to sea bass. A random digit dialling screening survey of households led to the recruitment of a panel of 183 fishers to keep logbooks. In parallel, 151 fishers were recruited on site by the Promopeche association, and 30 from the sea bass fishers panel established in 2009. This resulted in 364 panel members keeping logbooks describing their catches (species, weight, size, etc.) Recreational catches of sea bass in Atlantic (Bay of Biscay and Channel), in 2012 was 3922t of which 3146t was kept and 776t released. Limited documentation is available for this survey, but a brief description can be found in Levrel et al. (2012; 2013).

2018-19

In 2017, FranceAgriMer, a public institution, was tasked with collecting data on recreational fisheries in France. As was the case with previous surveys, the pilot study was carried out in two phases by a polling institute. The initial step comprised a telephone survey conducted in 2017, using quota sampling. The objective was to gain insight into the demographic profile and geographic distribution of the recreational fishing population across metropolitan France. A representative sample of 14,320 households was constructed from French socio-demographic data, and regional stratification was also applied to consider specific coastal characteristics. Results indicated that 5-6% of individuals aged 15 and above engaged in recreational fishing.

In the second step, a sample of recreational fishers were invited to record their monthly catches in logbooks over a two-year period, from 2018 to 2019. On a quarterly basis, participants were required to submit logbook data, detailing fishing frequency, catch quantity, and locations. These were submitted either by post or online. To ensure the representativeness of the sample, adjustments were made using weighting factors linked to predefined strata. By the end of each year, data had been extrapolated to provide estimates by species and area.

Despite the implementation of recruitment and retention strategies throughout the 2018-2019 period, the number of volunteers engaged in the logbook survey fell below the target of 250 panellists, with only 74 panellists registered at the end of the survey. Hence, the results are unreliable with very wide confidence intervals, so should not be used. The results of these surveys are available in reports (FranceAgriMer 2019; 2020) but are not available to the public because of the low reliability of the results.

2021-present

A nationwide, multi-species, non-probabilistic study was done for the whole of France divided into two stages. In 2021, a screening survey was based on an online panel of 10,042 individuals, adjusted using the quota method. An additional survey was carried out on a sample of 2,646 fishers, excluding onshore shellfish gatherers and charters, to provide a broader characterization of fishing activities. Between 2021 and 2023, an off-site logbook survey was conducted on a panel of 441 fishers. Panellists were asked to keep a fishing logbook and systematically record their fishing sessions and catches using a phone application.

The total number of participants per avidity group and sub-zones was obtained by combining surveys. Fishing methods were categorised according to fishing practice (from a boat, from the shore, or underwater fishing) and associated fishing gear: lines, nets, harpoons, etc. This information was used to weight the profiles of the panellists (Figure A1).

Once the qualification level of the panellists had been established, any declarations from those deemed unqualified were excluded. Partial non-response was corrected using a multivariate imputation approach based on a 'random forest' algorithm. Sea bass biomass was estimated from the number of fish caught and the size-weight relationships, which are derived from panel data and scientific surveys (Selles et al. 2024).

Data were aggregated at the primary sampling unit (PSU) level and expanded to the population using the total number of fishers in each sub-zone and avidity group. A weighting factor was assigned to each fisher per quarter, thereby enabling the panel data to be extrapolated to the entire French recreational fisher population. Confidence intervals for catch estimates were

determined by bootstrapping the dataset 5,000 times and using the percentile distribution of the parameter estimates. This involved random sampling (with replacement) from the dataset, recalculating expansion factors for the new sample, and generating expanded estimates for each parameter. Once summed, these estimates gave the total catches by main species taken by recreational fishers (Figure A2).

The 2021 screening survey showed that 3.8 million fishers (excluding shellfish gathering) practice at sea in France, with the majority concentrated along the north-eastern Atlantic coastline. During the 2021-2023 period, panellists who participated in the logbook survey indicated that they primarily engaged in fishing from a boat, targeting fish in the northern region of the Bay of Biscay and Celtic Seas. Additionally, 41% of them identified as occasional fishers, with an average of 1 to 3 fishing trips per year. Over the 2021-2023 period, 3,027 fish were measured, with an average size of 49.3 cm for retained fish and 40.4 cm for released fish. Length-frequency distributions were provided for both the kept and released portions of the catch. To reduce the uncertainty of the estimates, the data were aggregated over a three-year period. The proportion of catches appears higher for Biscay than for the Northern stock with an average of 881 t or 898 t for retained catches, depending on the scenario tested (7.d-7.e-8.a-b vs 7.d-e-8.a-b). The volume of catches was greater in division 8.a than in 8.b. It was observed that nearly 80% of catches were released, with most catches occurring in spring and summer.

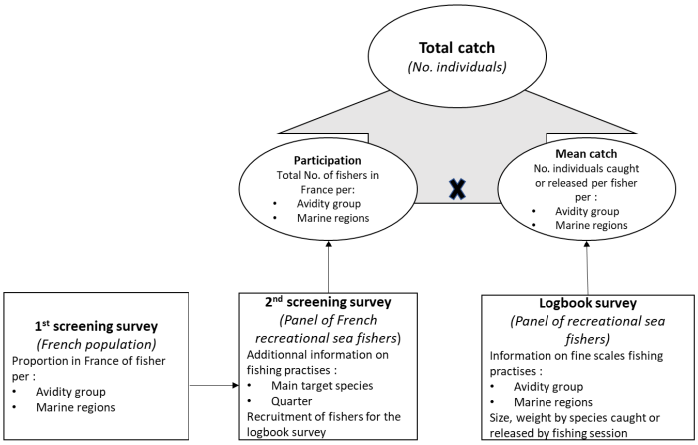


Figure A1: Diagram of the various components of the total catch estimation procedure (source: Selles et al. 2024)

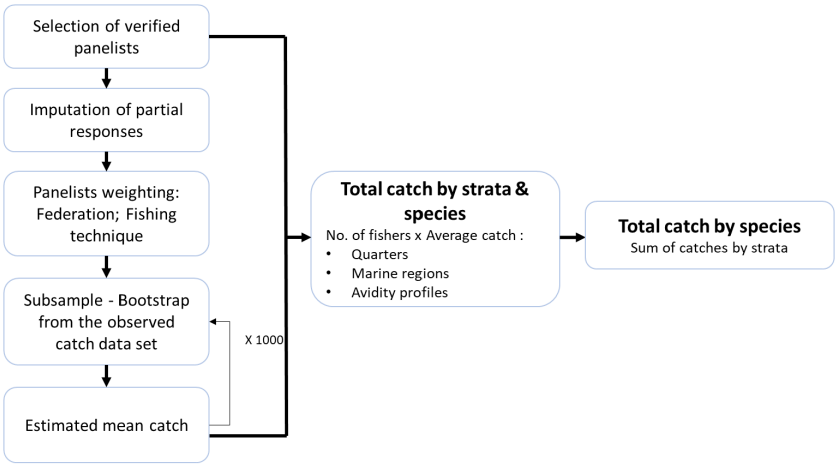


Figure A2: Flow chart showing the structure of the Bootstrap estimation procedure (Selles et al. 2024)

French data selected for stock assessment

The data collected in 2018 and 2019 were considered unreliable for the following reasons:

(i) A change in survey design between the 2017-2018 and 2021-2023 periods, resulting in very different penetration rates for the two surveys (5% versus 13%).

(ii) An over-representation of regular recreational anglers in the 2018 and 2019 panel, as well as a high dropout rate, which led to unreliable catch estimates for these two years.

Additionally, the previous surveys from 2011-12 (Levrel et al. 2012; 2013) and 2018-19 (FranceAgriMer 2019; 2020) were poorly documented and did not include a description of the analysis procedures. In the absence of this information, it was not possible for the 2018-2020 period. It has therefore been decided to use estimates produced for 2009-11 (Rocklin et al. 2014) and 2021-23 (Selles et al. 2024).

A1.4: Germany

The Thünen Institute of Baltic Sea Fisheries has been collecting marine recreational fisheries data in Germany since 2002 and consistently on an annual basis since 2005 (Weltersbach et al., 2024). The German data privacy protection legislation prevents the routine use of personal data from fishing license registries for research purposes. Thus, no representative sampling frames (e.g., all German fishing license holders) are available for recreational fisheries surveys. Therefore, a data collection programme using various survey methods has been developed over the years to provide the required data, in particular, recreational catches and releases for stock assessment purposes (Weltersbach et al., 2024). Recreational fishing activities in German waters of the North Sea are regularly monitored (every 5-7 years due to cost constraints) with off-site population screening surveys of the general population, which are complemented with diary

studies to estimate participation rates, fishing effort, and catches and releases for several species, including sea bass (Weltersbach et al., 2024).

The latest nationwide representative CATI screening survey targeting 150,000 German households and followed by a one-year diary survey was carried out from October 2020 to June 2022 (Lewin et al., 2023). A total of 1,541,182 numbers (mobile 44% and landline 56%) were used to realize 150,232 interviews. An angler was defined as a person who had fished at least once in Germany during the last 12 months preceding the survey or who planned to do so in the next 12 months. A total of 5,781 German households with at least one angler were identified (Lewin et al., 2023). The following screening interview contained questions regarding fishing effort in different waters, target species, angler heterogeneity, impact of COVID-19 on fishing effort, and socio-demographics of the anglers. In total, 2,793 angler interviews could be completed. At the end of the interview, all anglers were asked to participate in a one-year diary survey. This resulted in a total of 1,892 diarists (Lewin et al., 2023).

All diary participants were asked to report every angling day in Germany over an observation period of 12 months starting from the day they received the diary. For every angling day, the date, fishing time, fishing location, travel distance, expenditures, number of other anglers sighted, angling platform (boat, charter boat, shore), target species, and the number of fish caught, harvested, and released per species had to be reported. To maintain the motivation to participate, retrieve diary data, and reduce panel attrition bias, the participants were contacted by telephone at quarterly intervals during the entire observation period (Lewin et al., 2023).

To obtain representative estimates of the size of the German angler population, the corresponding fishing effort and catches, harvests, and releases for all species both the data of the CATI and the diary survey were weighted and extrapolated in several ways (Lewin et al., 2023).

The CATI survey revealed that 68,577 (95% CI: 59,521 – 79,009) persons had fished at least once in the German waters of the North Sea in 2020/2021 with a fishing effort of 128,299 (95% CI: 111,356 – 147,816) days (Lewin et al., 2023).

A total of 12,542 angling days were reported in the diaries. However, only 0.5% (n = 61) of the reported angling days originated from the North Sea (Lewin et al., 2023). These 61 angling days were reported by 16 anglers of whom three caught a total of n = 33 sea bass during 17 angling days. Fifteen of these angling days were conducted by a single angler who caught 30 out of the 33 reported sea bass. Hence, no robust estimation of the German recreational sea bass catches was possible. However, based on expert opinion, German sea bass catches are minimal as sea bass angling in Germany only takes place at some locations along the outer coasts of the Frisian Islands, which hampers fast and easy access for the general angling population. This is also reflected in the small number of sea bass anglers in the survey.

A1.5: Ireland

The Irish Marine Recreational Angling Survey uses several sampling programmes to assess catches around the Irish coast. A full description can be found in Ryan et al. (2022; 2023) with a summary provided below.

An onsite roving creel survey of shore anglers has been done. The IMREC survey of shore anglers utilises a spatio-temporal sampling method to collect catch per unit effort (CPUE) data of sea anglers around the Irish coast. The survey incorporates spatial and temporal stratification into its

design, where increased sampling effort is allocated to the places and times with greater angling effort. The spatio-temporal sampling frame consists of two spatial strata: East (ICES regions 7.a and 7.g) and West (ICES regions 7.j2, 7.b and 6.a) and two temporal strata: Winter (November to March) and Summer, (April to October). To increase the likelihood of encountering anglers during sampling, weighted angling activity strata were also written into the sampling programme. At the start of the sampling season, sampling schedules were produced which instructed samplers to visit a randomly selected PSU on a particular sampling day.

All anglers are interviewed about their catch on site and all information is uploaded and a follow up interview is requested to collect a complete picture of their angling trip. The mean catch-per-unit-effort (CPUE) of all marine recreational fisheries species caught during each shore angling trip is estimated where an angling trip is defined as one daily angler trip for shore angling. A ratio of the means estimator was used to calculate average species specific CPUE across all strata. Retained or released fish of a particular species were considered as a separate catch.

An onsite bus route access point survey of small boat anglers was also done. The IMREC survey of private small boat anglers also uses a spatio-temporal sampling method to collect catch per unit effort data around the Irish coast. The most appropriate method of collection of catch data for this survey is through a random-access point survey. Unlike the roving-creel type approach, access point surveys capture complete angling trip data as the interview occurs when the angler has completed their fishing trip. This survey also incorporated spatio-temporal stratification into its final design to maximise sampling efficiency and PSU selection procedures followed the steps described in the roving creel survey of shore anglers.

The onboard charter catch survey randomly selects and samples chartered angling trips to record species numbers, and measure lengths and weights of all captured and released fish. A sampling frame was developed from charter skippers operating around the Irish coast. As per the surveys, the sampling frame was stratified spatially (east and west coasts) and temporally (summer and winter). Surveys were selected through a well-defined random sampling frame. Samplers were assigned to randomly selected vessel trips to count and measure captured fish.

An offsite citizen science angling diary was designed to provide a simple recording platform for anglers (hereafter referred to as “diarists”) to submit catch information from their shore angling trips. This citizen science approach to data collection allows participating shore anglers to submit data on numbers of fish species caught and released or retained over the course of their daily angling trip. It followed a non-probabilistic, self-selection approach to data collection.

The IMREC Diary was launched in August 2021. The diary was open to all anglers that expressed an interest in participating in the project. Several techniques were deployed to encourage anglers to participate in the programme. To encourage participating diarists to keep submitting trips, monthly draws for angling vouchers were offered to anglers who submitted angling trips to the diary within the previous month. To further incentivise anglers to participate in the online diary, a dashboard that displays their submitted angling trips and catches on an interactive map was developed. Diarist recruitment and retention is ongoing. There is uncertainty regarding reporting bias associated with the diary. Currently this data is used to assess catch seasonality for some species of interest.

A1.6: Netherlands

The screening survey is an online panel survey which is conducted biennially by the commercial marketing company Verian (earlier called Kantar and TNS NIPO). The demographics of the panel such as age, gender, education level, and place of residence are controlled by Verian to ensure that it resembles the demographics of the Dutch population as much as possible. The questions about recreational fishing are offered in December in an omnibus questionnaire containing questions on a range of different topics. Participants do not know the topics of the before filling in the questionnaire and are not allowed to skip topics. This is assumed to lower possible non-response that is directed to fisheries questions. In the screening survey, respondents were asked if they had fished recreationally the year before, what gear(s) they had used, if they were intending to participate in freshwater and/or marine recreational fisheries in the next year and if they would be interested in participating in a 12-month logbook survey. In addition, they were asked to indicate how many fishing trips they had made the year before to determine their level of fishing 'avidity' (number of trips per year).

Participants for the logbook survey are recruited from the screening survey in the year before. In the earlier survey years, participants were selected with a probability of inclusion based on an analysis of demographics including age, gender, and region of residence such that it matched ratios found in the screening survey as much as possible. In the more recent years, due to the lower participation rate and the decreased size of the Verian database, this was not always possible, especially for marine recreational fishers. Since 2019 all fishers who wanted to, were included in the logbook survey. Anglers were grouped by their - in the screening survey stated- fishing avidity. To recruit additional participants, from the 2012-13 survey onwards, anglers from external sources (the Dutch angler organisation, social media, recreational fisheries websites, previous participants) were also asked to join the survey. This resulted in a group of externally recruited anglers joining the logbook survey. This group is usually much smaller compared to the group of anglers recruited through the Verian database. To make equal groups, marine water participants were grouped in three avidity groups (1-5, 5-10 and > 10 yearly fishing trips). Participants were asked to maintain the logbook in which they record per fishing trip information on catch and effort. The information in the logbooks included among other questions: fishing location, water body type, start and end date and time of the fishing trip, gear used, catch (number of fish, species, size), whether a fish was retained or released and whether the recorded length of fish was measured or estimated. Participants were contacted online once a month by Verian and requested to transfer the data recorded in their logbooks to online questionnaires. The participants were also expected to indicate if they had not fished during that month. The logbook surveys usually start in March.

The screening survey is used to estimate the proportion of fresh and marine recreational anglers in the Dutch population. Each participant in the screening survey is also provided with a weight by Verian, which is used to correct for deviations in the obtained proportions from the representativeness of the entire Dutch population. The total number of inhabitants in the Netherlands was obtained from Statistics Netherlands (CBS), which are then used to raise the corrected proportions found in the screening survey to the total number of fresh and marine anglers. Subsequently, the logbooks are used to estimate the yearly catches for each fish species. To ensure representativeness of the logbook participants to the recreational fishing community, it is corrected for deviations in the proportion of participants per avidity class. The average catches per year per respondent in number and weight are estimated per avidity class. Subsequently, these are multiplied with the total number of anglers within the avidity class (as

estimated from the screening), leading to the total number or weight per species and avidity group. Summing these estimates for each avidity group results in the total catch estimate per species. Confidence intervals were estimated by bootstrapping: in each of 10,000 iterations a participant was removed randomly from the dataset to estimate the variance.

A full description of the approach can be found in van der Hammen & Chen (2023).

A1.7: United Kingdom

Sea Angling 2012

The Sea Angling 2012 survey programme started in 2012 to estimate fishing effort, catches (kept and released) and fish sizes for shore based and boat angling in England (Armstrong et al. 2013). The survey does not cover other forms of recreational fishing.

The surveys adopted, where possible, statistically-sound, probability-based survey designs. Two survey approaches were adopted: firstly, a stratified random survey of charter boats from a list frame covering ports in England; and secondly an on-site stratified random survey of shore anglers and private boat anglers to estimate mean catch per day, combined with annual effort estimates derived from questions added to a monthly Office of National Statistics household survey covering Great Britain.

A list of almost 400 charter boats was compiled for the charter boat survey, and 166 skippers agreed to participate. Each month over a twelve-month period in 2012 and 2013, 34 randomly selected skippers completed a diary documenting their activities, catches, and sizes of fish. A diary was completed whether any fishing took place. Data from 5,300 anglers were collected. Total annual catches were estimated by raising the monthly catches per vessel from the diaries to all vessel-month combinations in the frame and raising this to all vessels including refusals. The estimated total annual catch of sea bass for the entire coast of England was 44t (RSE 31%) of which 31t was kept. The release rate by number was 37%. The charter boat survey has potential bias due to the large non-response rate, if non-respondents have different catch rates to respondents.

The Office of National Statistics (ONS) household survey covered 12,000 households during 2012, and from this it was estimated that 2.2% of adults over 16 years old went sea angling at least once in the previous year. The surveys estimated there are 884,000 sea anglers in England. Estimation of fishing effort by shore and private boat anglers proved difficult due to the overall low number of households with sea anglers in the survey. A range of methods was explored to estimate annual and seasonal effort using the ONS data alone and combining it with observations from on-site and on-line surveys. It was not possible yet to agree on a best estimate of effort, and for that reason the estimates of total catch (cpue × effort) for shore and private boat angling were given as a range of plausible values.

The survey of anglers fishing from the shore and private boats to estimate cpue was carried out throughout 2012 using on-site interviews. A stratified random design was adopted to select shore sites and boat landing sites on a weekly basis from site lists stratified into low-activity and high-activity sites. The shore survey used roving-creel methods (collecting data from partial angling trips), and the private boat survey a roving access-point survey (data from completed trips). Visits were made to 1475 shore sites and 425 private boat sites, and 2440 anglers were interviewed. The mean daily catch rate of kept and released fish of each species was estimated based on the survey design, and sizes of caught fish were recorded. Cpue for shore angling was estimated

using catches for the observed trip duration and estimates of expected total trip duration for that day. A length-of-stay bias correction was applied based on expected total trip duration. The catch-per-day estimates were combined with estimates of total annual fishing effort (days fished) obtained from the ONS survey to estimate total annual catches. Release rates, by number, were 82% for shore angling and 57% for private boats. Non-response rates were low (<10%) in this survey. The range of point estimates for shore-caught sea bass was 98–143t (total) and 38–56t (kept), and for private and rented boats was 194–546t (total) and 142–367t (kept). The relative standard errors for the individual shore and private boat estimates were high at 40–50%.

Combining the catch estimates for charter boats, private boats and shore angling, the point estimates of annual kept weights of sea bass ranged from 230t–440t, compared with total UK commercial landings of almost 900t in 2012. The combined estimates of sea bass catches had precision (relative standard error) estimates of 26%–38%for the different effort estimation methods.

Sea Angling Diary (2016-present)

The Sea Angling Diary programme has been running since 2016 with the aim of estimating the number of sea anglers, how often they fish, what they catch, and the social and economic benefits that they generate (Hyder et al. 2020; 2021; 2024). This is done through combining the outputs from two surveys: a survey of 12,000 individuals that generates estimates of the numbers of anglers and their characteristics; and sea anglers that volunteer as 'citizen scientists' to report their catches through the Sea Angling Diary. These estimates are combined accounting for differences in characteristics of sea anglers to generate the numbers and tonnages of fish kept and released by sea anglers in the UK. From 2016-21, over 5,000 sea anglers provided data on over 48,000 fishing sessions and 362,000 catch records from 216,000 hours of angling activity.

To estimate the participation and effort by UK sea anglers, questions were added to a survey of 12,000 residents (Watersports Participation Survey - WPS). Due to COVID restrictions, it was not possible to do face-to-face surveys as in 2016-19, so an online panel was used instead. The 2020 online panel generated much higher estimates than previous surveys, probably due to the different approaches. This meant that it was not possible to use the 2020 results in the analysis as it would impact on the consistency of the time series. Instead, data from the WPS from 2016-19 were modelled and used to derive estimates. This approach utilised all existing data to generate more consistent and robust results than previous annual estimates.

Catch per unit effort was generated from an offsite diary panel. For example, a total of 15,064 sessions and 107,697 individual catches across over 100 species were reported in 2020-21 by up to 900 sea anglers each year. Data from 2016-23 were used to model the number of fish kept and released by individual sea anglers each year and the weights of individual fish. Numbers of sea anglers were combined with diary panel catch per angler, to estimate total UK catches, after correcting for differences between the diary sample and the UK population.

Each year, around 7 million fish were retained and 28 million were released, representing a release rate of around 80%. Catch composition was similar between years with mackerel, whiting, lesser spotted dogfish, and sea bass the most caught fish. All results can be accessed through the UKSAIL website (https://rconnect.cefas.co.uk/sea_angling_library/).

Total catch estimates were higher than those in the English 2012 onsite survey. It is likely that a combination of survey bias, sampling error, or changes in fish abundance generated the differences. The consistent difference between the approaches indicated that it is likely due to the methods, both of which are uncertain and subject to bias. As a result, a side-by-side comparison between diary and onsite approaches is underway to validate the diary approach (www.catchwise.org).

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SURVEY CGFS Channel Ground Survey

R/V Thalassa



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1 Introduction

The CGFS campaign is part of a historical series of fishing surveys that began in 1988 (CGFS Eastern part, conducted on the R/V Gwen Drez which has been replaced by the R/V Thalassa in 2015) and was extended to cover the entire English Channel on a recurring basis from 2018 (on R/V Thalassa). Its main objective is to collect basic data for estimating the state of resources through direct assessment of stock abundance and distribution, along with biological sampling of the catches. Taking place every year between mid-September and mid-October, it contributes to the European project for the contractualisation of basic fishery data collection (DCF).



The campaign also allows for sampling and a better understanding of the entire ecosystem, aligning with the implementation of an ecosystem-based approach to fisheries at the community level. The CGFS also provides data for numerous national and international research projects. The collected and validated data are transmitted at the end of each campaign to national databases (SIH, Harmonie, Coriolis) and the European database (DATRAS), enabling their use by different working groups and ensuring public access to this data.

2 Scientific context

The English Channel is a sector with a strong fishing influence, mainly for the coastal countries but also more broadly for the countries of Northern Europe. The ecological and economic impact of exploiting fishery resources must be measured to ensure that fishing remains a sustainable activity, taking into account the limits of the resource and its effect on the ecosystem. To address this need, the member states of the European Union must conduct scientific campaigns at sea to assess the abundance and distribution of stocks, independently of data from commercial fisheries. In this regard, the CGFS (Channel Ground Fish Survey) campaign is integrated into the European program for monitoring fishery resources, providing a set of data on exploited stocks (maturity, size/age structure, abundance indices).

Time series data are used each year by European stock assessment groups to provide management advice for shared stocks and to assess the state of the ecosystem. Initially focused on the Eastern Channel, the CGFS now aims to cover the entire Channel to also provide independent data for the Western area. In the Eastern Channel (zone 7d), the data derived from this campaign are used each year by international working groups of the ICES, mainly WGNSSK (Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak) and WGCEPH (Working Group on Cephalopod Fisheries and Life History). In the Western Channel (zone 7e), the CGFS has been collecting data since 2018 with the aim of providing the necessary data for the evaluation of cephalopods, fish (bass, haddock, cod, whiting), and elasmobranchs by the ICES working groups (WGCEPH, Working Group on Cephalopod Fisheries and Life History; WGCSE, Working Group for the Celtic Seas Ecoregion; WGEF, Working Group on Elasmobranch Fishes).

In general, the CGFS campaign aims to monitor the structure and functioning of the marine ecosystem, in line with the ecosystem-based approach to fisheries that is gradually being implemented in Europe. Thus, the secondary objective of the CGFS campaign is to collect data on the biotic and abiotic environment of exploited species in the Channel to better understand their dynamics within the ecosystem. The series of CGFS campaigns will allow the monitoring of the ecological status of French waters in the Channel. The survey also allows to collect data to calculate indicators for biodiversity descriptors, invasive species, commercial species, trophic networks, eutrophication, contaminants, waste, and noise. Furthermore, the physicochemical characteristics of the water, phytoplankton, and zooplankton communities, fish egg abundance, and the specific composition of nectonic communities are measured and analyzed throughout the campaign to contribute to this effort.

The CGFS campaign is coordinated internationally by the working group "International Bottom Trawl Survey".

3 Inclusion of seabass index from the CGFS 1988–2014 times series (IBPBASS 2014)

Data on sea bass from the French scientific trawl survey "Channel Ground Fish Survey - CGFS" conducted on the vessel Gwen Drez were available for IBPBASS 2014 (IBPBASS, ICES, 2014). Details of the survey are given in Coppin et al. (2002). Since 1988, the ICES area 7d has been sampled annually during 30 days in October following a fixed sampling design with a mean of 80 trawling stations (Figure 1).

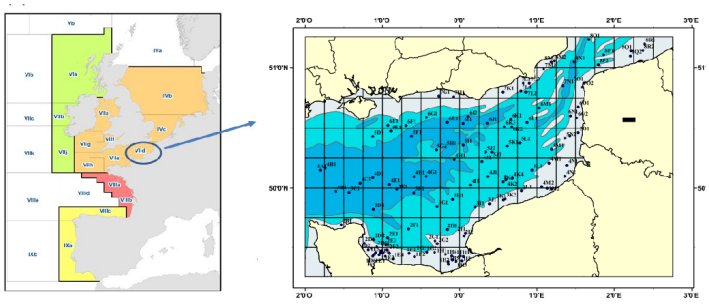


Figure 1 : localisation of the CGFS survey

The abundance indices for seabass were calculated applying a stratified random swept-area based estimator. Strata correspond to ICES statistical rectangles. As this is a stratified swept-are based indicator, uncertainty is based on between haul variance within a strata and summation of variances across strata.

A mean of 247 seabass per survey was observed on the period 1985 to 2012. This allowed to calculate an abundance index for the Eastern Channel (IBPBASS Ices 2014). Indices calculated and length compositions associated are used in the current model Bss 47 (WGCSE) for the time series 1988-2014 (Figure 2).

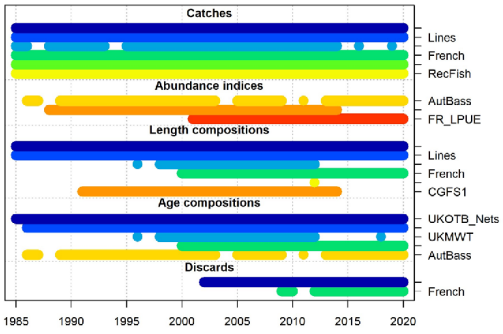


Figure 2 : data used in the Bss 47 model. Ices WGCSE 2023. CGFS indices from 1988 to 2014 and length compositions associated.

4 The new time series 2015 onwards

From 2015 onwards, time series stopped: the vessel Gwen Drez used for the scientific campaign having replaced by a larger one R/V Thalassa and the intercalibration hasn't given satisfactory results for seabass. It was decided not to use the seabass indices anymore, preferring a new time series rather than an intercalibration as mentioned in the WGCSE 2016 and 2019 report:

WGCSE 2016: "*A number of comparative tows were conducted to develop a calibration factor, but ICES had concerns over the methodology and excluded the 2015 data from the sea bass assessment. ICES undertook to have the calibration methods reviewed by an external expert, who concluded that "Overall, the small sample sizes, large number of zero tows per species, lack of length-specific conversion factors and possible bias of changes in sampling locations due to depth do not make this calibration ideal for use in future assessments"*

WGCSE 2019: "As there were significant changes in how the index was calculated along with the introduction of a new vessel and gear the EWG agreed that a full review was needed before the index could be used in the assessment. The review revealed that the index could be used up to and including 2014 and the series from 2015 onward should be considered a new timeseries. Therefore, the CGFS index discontinues in 2014. The new timeseries from 2020 when 5 years of data become available."

4.1 Note on the spatial distribution of CGFS new time series from 2018 onwards

From 2018 onwards, the survey can be broken down into two parts, with the use of a different trawl nets for the Eastern and Western parts of the Channel (Figure 3).

-In the Western Channel explored, 48 trawling stations are carried out with a GOV 36/49 trawl equipped with a 400 mm diameter "diabolos" bead in the middle and a fork rig. The sampling plan is based on a stratified random selection of 48 stations out of the 79 trawl hauls available.

-In the Eastern Channel, 74 stations are retained out of the 115 historical stations of the CGFS, allowing the historical series to be consistent. These stations are carried out every year with a GOV 36/47 trawl (standard for IBTS surveys), with a modified bead (diabolos with a diameter of 250 mm in the middle).

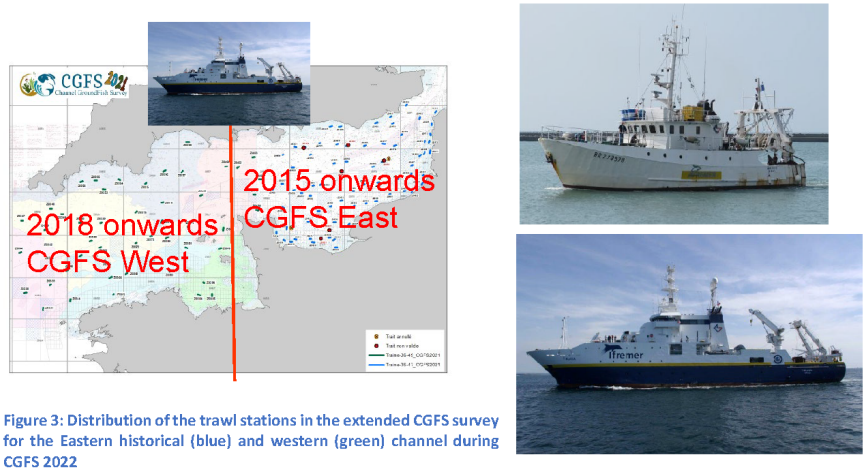


Figure 3: Distribution of the trawl stations in the extended CGFS survey for the Eastern historical (blue) and western (green) channel during CGFS 2022

Because trawls used are different between the west Channel and the East, because the sampling plan may yet evolve in the west, because time series in the western part 2015-2017 doesn't exist and because numbers of seabass caught are generally small and non-representative for seabass (comm pers from head of the survey), the proposal is not to use it. **WKSEABASS recommend to focus on the Eastern Channel**.

Erreur ! Source du renvoi introuvable. presents occurrence of seabass during the western CGFS survey and Figure 4 comparison of seabass caught and occurrence between CGFS west and east

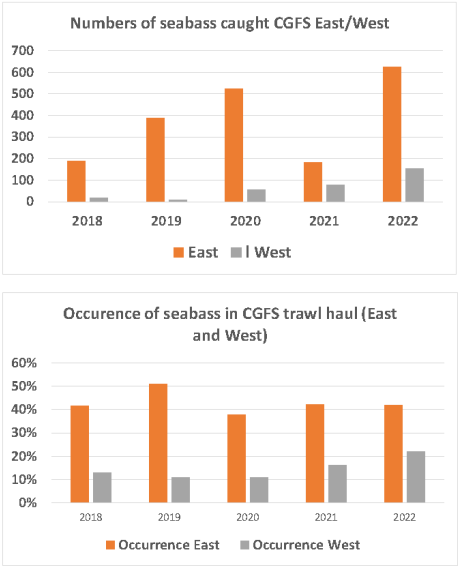


Figure 4 : comparison of numbers of seabass caught and occurrence between CGFS east and west.

4.2 Note on the spatial distribution of the survey over the period 2020–2022. Issues.

In 2020, there were no authorisations in UK waters to conduct the survey, which means that the sampling plan initially planned had to be adapted, reducing the number of trawl hauls from 74 to 58 in the Eastern Channel. As there was no access to English waters, all the sampling was carried out in the French Exclusive Economic Zone (Figure 5 left). In 2021, CGFS in the Eastern Channel proceeded normally. In 2022 authorization to work in British waters was granted at the beginning of the survey, with the restriction not to work within 6 nautical miles of British waters. This access restriction affects 5 trawling stations, located in coastal nursery areas (Figure 5 right).

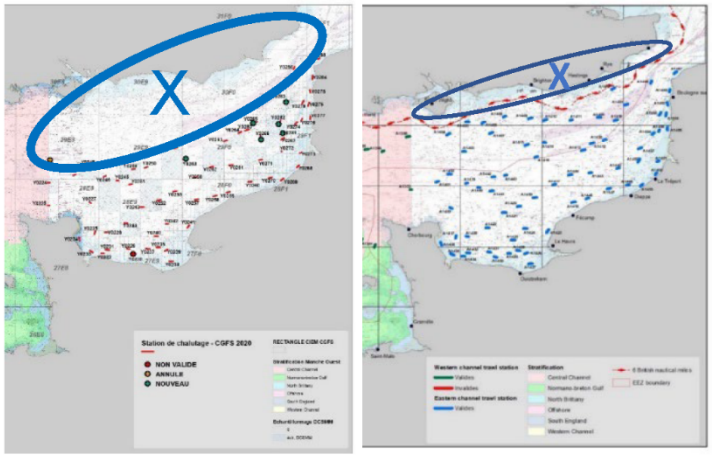


Figure 5 : sampling plan of CGFS East in 2020 (left) and 2022 (right)

5 Results–CGFS Eastern channel

5.1 Raw data

Tableau 1 and Figure 6 present raw seabass data from the CGFS survey (eastern channel).

Tableau 1: raw data of the CGFS East survey from 1988 to 2014 (historical time series) and from 2015 onwards (new time series proposed)

year	Source	numbers of total trawl haul	numbers of trawl haul with seabass (=nsamp in SS3)	proportion of haul with seabass	numbers of seabass caught per haul
1988	current time series	68	6	9%	9
1989	current time series	61	3	5%	4
1990	current time series	75	8	11%	63
1991	current time series	79	19	24%	163
1992	current time series	60	23	38%	305
1993	current time series	65	21	32%	177
1994	current time series	86	19	22%	103
1995	current time series	166	17	10%	78
1996	current time series	134	26	19%	82
1997	current time series	169	31	18%	181
1998	current time series	82	38	46%	317
1999	current time series	102	37	36%	286
2000	current time series	100	36	36%	325
2001	current time series	109	39	36%	363
2002	current time series	100	44	44%	506
2003	current time series	94	41	44%	813
2004	current time series	94	44	47%	344
2005	current time series	105	40	38%	297
2006	current time series	110	36	33%	521
2007	current time series	103	33	32%	261
2008	current time series	105	40	38%	401
2009	current time series	102	26	25%	192
2010	current time series	101	30	30%	123
2011	current time series	108	27	25%	108
2012	current time series	96	25	26%	135
2013	current time series	84	19	23%	69
2014	current time series	89	20	22%	58
2015	NEW TIME SERIES	71	24	34%	67
2016	NEW TIME SERIES	72	25	35%	222
2017	NEW TIME SERIES	65	35	54%	6308
2018	NEW TIME SERIES	72	30	42%	188
2019	NEW TIME SERIES	63	32	51%	388
2020	NEW TIME SERIES	58	22	38%	525
2021	NEW TIME SERIES	64	27	42%	181
2022	NEW TIME SERIES	67	28	42%	624

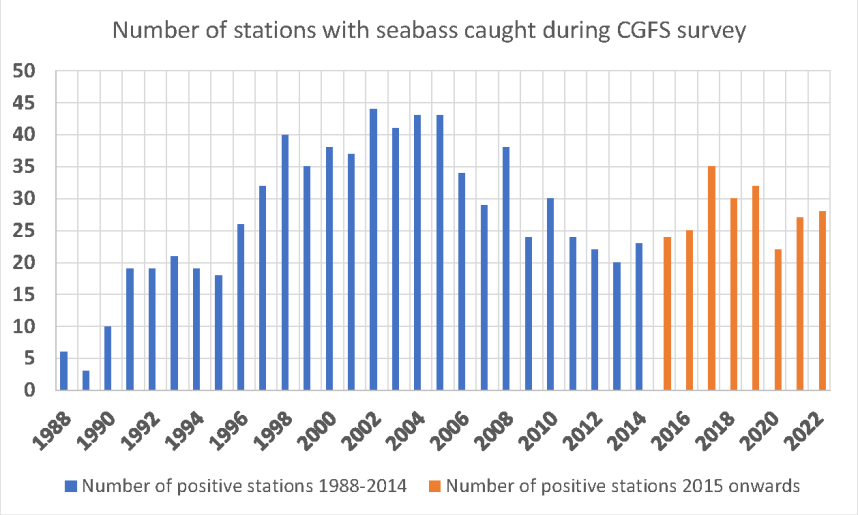


Figure 6: Occurrence of seabass in trawl haul of the CGFS survey (in blue the historical times series, in orange the new time series). Eastern Channel.

Proportion of haul with seabass is presented in Figure 7 in comparison with SSB calculated during WGCSE 2023. The trends in the proportion of stations with sea bass showed similarities to the trend in total biomass estimates from the ICES SSB (Figure 7)

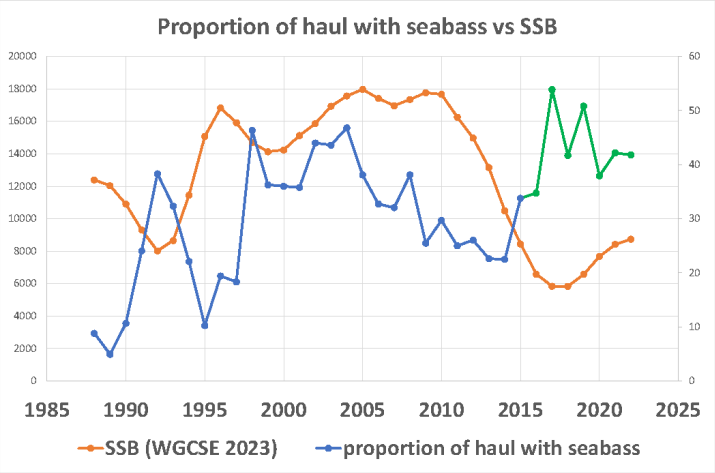


Figure 7: proportion of haul with seabass in CGFS survey compared to SSB (Ices advice Bss 47)

5.2 CGFS index eastern Channel

RSUFI is based on a fixed stratification of the sampled areas. The CGFS abundance indices are calculated applying a stratified-random swept-area based estimator. Strata correspond to ICES statistical rectangle. Uncertainty is based on between haul variance within a strata and summation of variances across strata.

An "R" package for calculating abundance or biodiversity indices, called "RSUFI", was developed by IFREMER in the early 2000's to process data from its fisheries campaigns. The indices produced via RSUFI were selected for their ability to provide information on the impact of fishing, with a view to their integration into dashboards of indicators of changes in species abundance within ecosystems exploited by fishing (Rochet & Trenkel 2003; Trenkel & Rochet 2003; Rochet et al. 2005). RSUFI can be used to produce specific indices, i.e. for each of the main species sampled, or community indices (i.e. at the scale of the entire sampled area, with all species aggregated).

Among the specific indices (for each species taken separately) that RSUFI can produce, we have selected for Seabass Index calculation the abundance Index (N) associated with its framing ranges at the 5% error threshold (Fourch. = 1.96 times the standard deviation) or the coefficient of variation (CV = standard deviation/IA or IB), expressed in %.

Details of the calculation formulas used by the RSUFI script to produce both types of indicator can be downloaded from the SIH website at http://www.ifremer.fr/SIH-indices-campagnes/.

$$N_i = \sum_j N_{i,j} = \sum_j A_j \sum_{k=1}^{nj} y_{i,k,j} \Big/ \sum_{k=1}^{nj} a_{k,j} \qquad Var(N_i) = \sum_j \frac{A_j^{\,2}}{n_j - 1} \sum_{k=1}^{n_j} \left(\frac{y_{k,j}}{a_{k,j}} - \frac{\sum_{k=1}^{n_j} y_{k,j}}{\sum_{k=1}^{n_j} a_{k,j}} \right)^2$$

Ni(t) Total abundance index for species i

Nl,i (t) Total abundance index for length class l for

species i

Aj Area of stratum j

ak,j Area swept by line k in stratum j

yl,i Number caught in length class l for species i

yi,k j Number of species i caught in haul k in stratum j

wi,k j Number of species i caught in haul k of stratum j

The indices used in WKSEABASS assessment are given in Tableau 2. 1988 to 2014 corresponds to the first survey CGFS1, and 2015 onwards to the new time series CGFS2 added to the assessment.

Indices for 1988 and 1989 are not used in the assessment: the sampling scheme of CGFS was still under construction at this time and was not completely established. Index for 2020 is not used too, as mentioned in Figure 5, because it corresponds to a lower sampling rate this year.

Tableau 2 : CGFS Indices proposed for WKDSEABASS

year	Series	Numbers	Errtype
-1988	CGFS1	245776	0.15
-1989	CGFS1	77716	0.58
1990	CGFS1	1129914	0.12
1991	CGFS1	4250636	0.03
1992	CGFS1	2617986	0.11
1993	CGFS1	2299919	0.1
1994	CGFS1	1097828	0.11
1995	CGFS1	1021741	0.09
1996	CGFS1	1224238	0.13
1997	CGFS1	1817599	0.12
1998	CGFS1	2531043	0.08
1999	CGFS1	1642271	0.12
2000	CGFS1	2570994	0.08
2001	CGFS1	3150674	0.14
2002	CGFS1	3872427	0.11
2003	CGFS1	8739056	0.11
2004	CGFS1	3598436	0.1
2005	CGFS1	3005315	0.08
2006	CGFS1	5518000	0.12
2007	CGFS1	3661314	0.14
2008	CGFS1	6468839	0.15
2009	CGFS1	2564694	0.09
2010	CGFS1	1804538	0.1
2011	CGFS1	1513742	0.12
2012	CGFS1	2034552	0.11
2013	CGFS1	995987	0.22
2014	CGFS1	669931	0.33
2015	CGFS2	587231	0.28
2016	CGFS2	1269196	0.19
2017	CGFS2	21392907	0.75
2018	CGFS2	2082614	0.33
2019	CGFS2	4695004	0.55
-2020	CGFS2	4523903	0.51
2021	CGFS2	2666997	0.55
2022	CGFS2	5970945	0.52
2023	CGFS2	5016906	0.37

The trends in both the index and in the proportion of stations with sea bass showed similarities to the trend in total biomass estimates from the ICES SSB (Figure 8). Orange line correspond to the survey CGFS1 currently used in assessment and green line corresponds to the new time series CGFS2 proposed for WKSEABASS

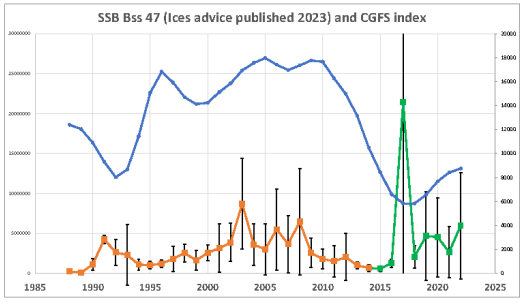


Figure 8: CGFS index compared to the SSB (Ices advice 2023 seabass Bss47)

Note that 2017 is a special year, with a high amount of seabass caught in only one trawl haul: the high value of the index is also associated with a high standard error.

5.3 Numbers at length CGFS1 and CGFS2

Figure 9 shows the range of size caught during the 2 surveys CGFS1 and CGFS2. CGFS1 was used to catch younger individuals than CGFS 2 because of the sampling scheme: the use of a smallest vessel allowed to have some more trawling haul close to the shore.

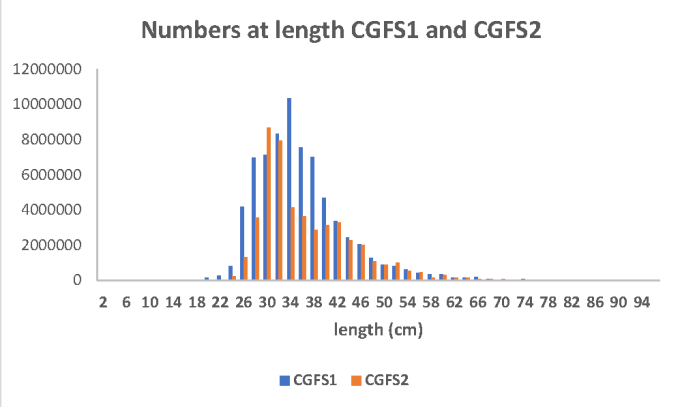


Figure 9 : Numbers at length associated to the indices for CGFS 1 and CGFS2

5.4 Age Length Key CGFS1 and CGFS2

ALK are available from 2009 onwards and are presented below.

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2009	CGFS1	26	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	28	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	30	0	0	3	6	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	32	0	0	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	34	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	36	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	38	0	0	0	4	3	0	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	40	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	42	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	44	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	46	0	0	0	1	1	2	0	1	1	0	0	0	0	0	0	0	0
2009	CGFS1	52	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2009	CGFS1	68	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
2009	CGFS1	74	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2010	CGFS1	26	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	CGFS1	28	0	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	CGFS1	30	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	CGFS1	32	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	CGFS1	34	0	0	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0
2010	CGFS1	36	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
2010	CGFS1	38	0	0	0	2	5	0	0	0	0	0	0	0	0	0	0	0	0
2010	CGFS1	40	0	0	0	0	4	0	1	0	0	0	0	0	0	0	0	0	0
2010	CGFS1	46	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
2010	CGFS1	48	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
2010	CGFS1	50	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2010	CGFS1	52	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0
2010	CGFS1	56	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
2010	CGFS1	60	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2010	CGFS1	74	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2011	CGFS1	30	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2011	CGFS1	32	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0
2011	CGFS1	34	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0	0	0
2011	CGFS1	36	0	0	0	0	1	4	6	0	0	0	0	0	0	0	0	0	0
2011	CGFS1	38	0	0	0	0	0	8	3	1	0	0	0	0	0	0	0	0	0
2011	CGFS1	40	0	0	0	0	0	2	3	1	0	0	0	0	0	0	0	0	0
2011	CGFS1	42	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0
2011	CGFS1	44	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0
2011	CGFS1	46	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0
2011	CGFS1	48	0	0	0	0	0	0	0	1	4	1	0	0	0	0	0	0	0
2011	CGFS1	50	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0
2011	CGFS1	52	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
2011	CGFS1	54	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
2011	CGFS1	56	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2011	CGFS1	58	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2011	CGFS1	60	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2012	CGFS1	26	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	CGFS1	28	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
2012	CGFS1	30	0	0	0	0	8	1	0	0	0	0	0	0	0	0	0	0	0
2012	CGFS1	32	0	0	0	1	11	2	1	0	0	0	0	0	0	0	0	0	0
2012	CGFS1	34	0	0	0	0	6	1	0	0	0	0	0	0	0	0	0	0	0
2012	CGFS1	36	0	0	0	0	6	3	1	0	0	0	0	0	0	0	0	0	0
2012	CGFS1	38	0	0	0	0	0	4	5	0	0	0	1	0	0	0	0	0	0
2012	CGFS1	40	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0	0
2012	CGFS1	42	0	0	0	0	0	2	6	1	0	0	0	0	0	0	0	0	0
2012	CGFS1	44	0	0	0	0	0	1	3	6	0	0	0	0	0	0	0	0	0
2012	CGFS1	46	0	0	0	0	0	0	1	2	0	1	0	0	0	0	0	0	0
2012	CGFS1	48	0	0	0	0	0	0	2	2	2	1	0	0	0	0	0	0	0
2012	CGFS1	50	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0
2012	CGFS1	52	0	0	0	0	0	0	1	0	2	1	0	0	0	0	0	0	0
2012	CGFS1	54	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
2012	CGFS1	56	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
2012	CGFS1	58	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
2012	CGFS1	62	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2013	CGFS1	28	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	CGFS1	30	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
2013	CGFS1	32	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
2013	CGFS1	34	0	0	0	0	5	2	0	0	0	0	0	0	0	0	0	0	0
2013	CGFS1	36	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
2013	CGFS1	38	0	0	0	0	0	5	1	0	0	0	0	0	0	0	0	0	0
2013	CGFS1	40	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0
2013	CGFS1	42	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
2013	CGFS1	44	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0
2013	CGFS1	46	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0
2013	CGFS1	48	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2013	CGFS1	50	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2013	CGFS1	52	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2013	CGFS1	54	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2014	CGFS1	32	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0
2014	CGFS1	34	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
2014	CGFS1	36	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
2014	CGFS1	38	0	0	0	0	0	0	6	2	0	0	0	0	0	0	0	0	0
2014	CGFS1	40	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
2014	CGFS1	42	0	0	0	0	0	0	4	2	0	0	0	0	0	0	0	0	0
2014	CGFS1	44	0	0	0	0	0	0	2	4	1	0	0	0	0	0	0	0	0
2014	CGFS1	46	0	0	0	0	0	0	2	1	1	0	0	0	0	0	0	0	0
2014	CGFS1	48	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
2014	CGFS1	50	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0
2014	CGFS1	52	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2014	CGFS1	54	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
2014	CGFS1	56	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2014	CGFS1	58	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
2014	CGFS1	66	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
2014	CGFS1	68	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2015	CGFS2	30	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
2015	CGFS2	32	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	CGFS2	34	0	0	0	3	5	0	0	0	0	0	0	0	0	0	0	0	0
2015	CGFS2	36	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0
2015	CGFS2	38	0	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	0
2015	CGFS2	40	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
2015	CGFS2	42	0	0	0	0	6	1	3	0	0	0	0	0	0	0	0	0	0
2015	CGFS2	44	0	0	0	0	1	2	0	1	1	0	0	0	0	0	0	0	0
2015	CGFS2	46	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
2015	CGFS2	48	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0
2015	CGFS2	50	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0
2015	CGFS2	52	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
2015	CGFS2	54	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
2015	CGFS2	56	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2015	CGFS2	58	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2015	CGFS2	60	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
2015	CGFS2	64	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
2015	CGFS2	66	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
2015	CGFS2	68	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
2015	CGFS2	74	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
2015	CGFS2	76	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2016	CGFS2	30	0	0	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0
2016	CGFS2	32	0	0	0	3	3	1	0	0	0	0	0	0	0	0	0	0	0
2016	CGFS2	34	0	0	0	0	5	3	0	0	0	0	0	0	0	0	0	0	0
2016	CGFS2	36	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0
2016	CGFS2	38	0	0	0	0	1	7	2	0	0	0	0	0	0	0	0	0	0
2016	CGFS2	40	0	0	0	0	0	3	4	0	0	0	0	0	0	0	0	0	0
2016	CGFS2	42	0	0	0	0	0	5	2	0	0	0	0	0	0	0	0	0	0
2016	CGFS2	44	0	0	0	0	0	0	5	1	0	0	0	0	0	0	0	0	0
2016	CGFS2	46	0	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0
2016	CGFS2	48	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
2016	CGFS2	50	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0	0
2016	CGFS2	52	0	0	0	0	0	0	0	0	4	3	0	0	0	0	0	0	0
2016	CGFS2	54	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0
2016	CGFS2	56	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0
2016	CGFS2	58	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0
2016	CGFS2	60	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0
2016	CGFS2	64	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0
2016	CGFS2	66	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
2016	CGFS2	68	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
2016	CGFS2	74	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
2016	CGFS2	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2017	CGFS2	28	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	CGFS2	30	0	0	0	5	8	3	0	0	0	0	0	0	0	0	0	0	0
2017	CGFS2	32	0	0	0	4	10	2	0	0	0	0	0	0	0	0	0	0	0
2017	CGFS2	34	0	0	0	3	10	3	0	0	0	0	0	0	0	0	0	0	0
2017	CGFS2	36	0	0	0	2	9	5	0	0	0	0	0	0	0	0	0	0	0
2017	CGFS2	38	0	0	0	0	3	8	5	0	0	0	0	0	0	0	0	0	0
2017	CGFS2	40	0	0	0	0	0	5	12	0	0	0	0	0	0	0	0	0	0
2017	CGFS2	42	0	0	0	0	0	6	10	1	0	0	0	0	0	0	0	0	0
2017	CGFS2	44	0	0	0	0	0	0	9	6	1	0	0	0	0	0	0	0	0
2017	CGFS2	46	0	0	0	0	0	1	7	6	0	0	1	0	0	0	0	0	0
2017	CGFS2	48	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	0
2017	CGFS2	50	0	0	0	0	0	1	0	4	3	5	0	0	0	0	0	0	0
2017	CGFS2	52	0	0	0	0	0	0	0	3	5	2	0	0	1	0	0	0	0
2017	CGFS2	54	0	0	0	0	0	0	0	2	2	3	0	1	0	0	0	0	0
2017	CGFS2	56	0	0	0	0	0	0	0	1	6	3	0	2	0	0	0	0	0
2017	CGFS2	58	0	0	0	0	0	0	0	1	5	1	0	0	0	0	0	0	0
2017	CGFS2	60	0	0	0	0	0	0	0	0	0	3	3	0	3	0	0	0	0
2017	CGFS2	62	0	0	0	0	0	0	0	0	0	0	0	3	2	1	0	0	0
2017	CGFS2	64	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
2017	CGFS2	66	0	0	0	0	0	0	0	0	0	0	2	2	0	1	0	0	0
2017	CGFS2	68	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
2017	CGFS2	70	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0
2017	CGFS2	72	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
2017	CGFS2	74	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
2017	CGFS2	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
2017	CGFS2	80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2018	CGFS2	30	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0
2018	CGFS2	32	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2018	CGFS2	34	0	0	0	6	7	2	0	0	0	0	0	0	0	0	0	0	0
2018	CGFS2	36	0	0	0	1	11	5	0	0	0	0	0	0	0	0	0	0	0
2018	CGFS2	38	0	0	0	1	11	4	0	0	0	0	0	0	0	0	0	0	0
2018	CGFS2	40	0	0	0	0	2	13	1	1	0	0	0	0	0	0	0	0	0
2018	CGFS2	42	0	0	0	0	3	8	5	0	0	0	0	0	0	0	0	0	0
2018	CGFS2	44	0	0	0	0	1	9	0	3	0	0	0	0	0	0	0	0	0
2018	CGFS2	46	0	0	0	0	0	5	1	0	0	0	0	0	0	0	0	0	0
2018	CGFS2	48	0	0	0	0	0	3	1	1	0	0	0	0	0	0	0	0	0
2018	CGFS2	50	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2018	CGFS2	52	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2018	CGFS2	54	0	0	0	0	0	0	1	2	1	0	1	0	0	0	0	0	0
2018	CGFS2	56	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0
2018	CGFS2	60	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
2018	CGFS2	62	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2018	CGFS2	66	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2020	CGFS2	26	0	1	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	CGFS2	28	0	0	14	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	CGFS2	30	0	0	10	4	1	0	0	0	0	0	0	0	0	0	0	0	0
2020	CGFS2	32	0	0	2	14	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	CGFS2	34	0	0	0	13	3	0	0	0	0	0	0	0	0	0	0	0	0
2020	CGFS2	36	0	0	0	13	3	0	0	0	0	0	0	0	0	0	0	0	0
2020	CGFS2	38	0	0	0	10	6	1	0	0	0	0	0	0	0	0	0	0	0
2020	CGFS2	40	0	0	0	1	9	5	2	0	0	0	0	0	0	0	0	0	0
2020	CGFS2	42	0	0	0	0	7	5	4	0	0	0	0	0	0	0	0	0	0
2020	CGFS2	44	0	0	0	0	4	2	4	3	0	0	0	0	0	0	0	0	0
2020	CGFS2	46	0	0	0	0	1	4	6	2	0	0	0	0	0	0	0	0	0
2020	CGFS2	48	0	0	0	0	0	4	8	2	0	0	0	0	0	0	0	0	0
2020	CGFS2	50	0	0	0	0	0	1	9	1	0	0	0	0	0	0	0	0	0
2020	CGFS2	52	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
2020	CGFS2	54	0	0	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0
2020	CGFS2	56	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0
2020	CGFS2	58	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
2020	CGFS2	68	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2021	CGFS2	26	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	CGFS2	28	0	0	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	CGFS2	30	0	0	4	6	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	CGFS2	32	0	0	1	7	1	0	0	0	0	0	0	0	0	0	0	0	0
2021	CGFS2	34	0	0	1	7	2	0	0	0	0	0	0	0	0	0	0	0	0
2021	CGFS2	36	0	0	0	2	5	2	0	0	1	0	0	0	0	0	0	0	0
2021	CGFS2	38	0	0	0	0	5	4	0	0	0	0	0	0	0	0	0	0	0
2021	CGFS2	40	0	0	0	0	6	4	1	0	0	0	0	0	0	0	0	0	0
2021	CGFS2	42	0	0	0	0	5	3	4	1	1	0	0	0	0	0	0	0	0
2021	CGFS2	44	0	0	0	0	0	4	2	6	0	1	0	0	0	0	0	0	0
2021	CGFS2	46	0	0	0	2	2	1	1	3	0	0	0	0	0	0	0	0	0
2021	CGFS2	48	0	0	0	0	1	1	1	2	1	0	0	0	0	0	0	0	0
2021	CGFS2	50	0	0	0	0	0	2	1	1	2	0	0	0	0	0	0	0	0
2021	CGFS2	52	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
2021	CGFS2	54	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
2021	CGFS2	56	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
2021	CGFS2	60	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
2021	CGFS2	62	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
2021	CGFS2	76	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2022	CGFS2	22	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	CGFS2	28	0	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	CGFS2	30	0	0	8	4	2	0	0	0	0	0	0	0	0	0	0	0	0
2022	CGFS2	32	0	0	2	11	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	CGFS2	34	0	0	0	12	2	2	0	0	0	0	0	0	0	0	0	0	0
2022	CGFS2	36	0	0	1	3	9	3	1	0	0	0	0	0	0	0	0	0	0
2022	CGFS2	38	0	0	0	2	7	6	3	0	0	0	0	0	0	0	0	0	0
2022	CGFS2	40	0	0	0	1	8	7	5	0	0	0	0	0	0	0	0	0	0
2022	CGFS2	42	0	0	0	0	2	12	6	0	1	0	0	0	0	0	0	0	0
2022	CGFS2	44	0	0	0	0	2	0	12	2	0	0	0	0	0	0	0	0	0
2022	CGFS2	46	0	0	0	0	0	6	7	2	2	0	0	0	0	0	0	0	0
2022	CGFS2	48	0	0	0	0	0	1	2	1	5	2	1	0	0	0	0	0	0
2022	CGFS2	50	0	0	0	0	0	2	0	3	2	0	0	0	0	0	0	0	0
2022	CGFS2	52	0	0	0	0	0	2	1	1	3	2	0	0	0	0	0	0	0
2022	CGFS2	54	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
2022	CGFS2	56	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
2022	CGFS2	60	0	0	0	0	0	0	0	1	1	2	2	0	0	0	0	0	0
2022	CGFS2	64	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2022	CGFS2	66	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

#_Yr	FltSvy	Lbin_hi	a0	a1	a2	a3	a4	a5	a6	a7	a8	a9	a10	a11	a12	a13	a14	a15	a16
2023	CGFS2	30	0	0	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	CGFS2	32	0	0	0	9	3	0	0	0	0	0	0	0	0	0	0	0	0
2023	CGFS2	34	0	0	0	7	6	0	1	0	0	0	0	0	0	0	0	0	0
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2023	CGFS2	44	0	0	0	0	4	11	1	1	0	0	0	0	0	0	0	0	0
2023	CGFS2	46	0	0	0	0	1	5	8	3	1	0	0	0	0	0	0	0	0
2023	CGFS2	48	0	0	0	0	1	5	3	1	0	0	0	0	0	0	0	0	0
2023	CGFS2	50	0	0	0	0	0	4	3	3	2	0	0	0	0	0	0	0	0
2023	CGFS2	52	0	0	0	0	0	2	6	4	2	1	0	0	0	0	0	0	0
2023	CGFS2	54	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0
2023	CGFS2	56	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0
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Working document

ICES Benchmark on selected sea bass stocks WKSEABASS-Data workshop

29–02 February 2024

ICES Copenhaguen

French Nourdem Survey

Mickael Drogou, Ronan Le Goff, Christophe Lebigre, Mathieu Woillez, Damien Delaunay, Anne-Sophie Cornou, Olivier Berthelé, Stéphane Martin, Loïc Le Rû, Hervé Barone, Didier Le Roy, François Garren, Tiphaine Chouvelon, Yann Aminot, Catherine Munschy, Nicolas Briant, Gaël Durand, Gwendolina Limon, Emmanuelle Guillerm, Léa Edin-Leroux, Nicolas Michelet, Pascal Nguyen, Fayza Nfis, Emilie Le Roy, Cindy Marhic.

1 Introduction

NourDem project has its origins in the "Bargip Nurseries" project (2014-2016) focused on seabass juveniles and conducted, at the request of the french Ministry DGAMPA (Department of Maritime Fisheries and Aquaculture of the Ministry in charge of Fisheries), in collaboration with Ifremer and the CNPMEM (National Committee for Marine Fisheries and Fish Farming).

In the Ices advice 2014 bss IVbc, VIIa, and VIId–h, it was mentionned that Data requirements Time-series of relative abundance indices need to be developed throughout the range of the stock, for both the adult and pre-recruit components of the stock. This has been regularly mentioned in the advices and reports of the seabass 8.a-b and 4.b-c, 7.a, 7.d-h from 2015 onwards. This has led ifremer to develop projects to answer to this need

The Bargip project enabled the validation of a protocol including the development of the Ifremer-NourDem 11.90X16.45 trawl and the production of a first set of reliable data on seabass in the Loire estuary in 2016. It has been systematically applied from 2017 onwards.

Then from 2017, the aim of the project is to carry out annual trawl surveys in the main french estuaries: Seine, Loire and Gironde and in the coastal Douanenez Bay (Figure 1) in order to:

-Produce annual abundance indices for seabass and for major species of fishing; but also to

-Produce population indices determined globally, on the scale of the fauna communities;

-Map the main nursery areas and get data which, in time, should make it possible to identify the environmental factors likely to explain these spatial distributions (salinity, depth, etc.);

-Assess the "quality" of the three estuaries as nursery areas, based on comparisons of growth rates, stress levels and contamination (trace metals and organochlorine compounds) in juvenile European sea bass Dicentrarchus labrax, the sentinel species.

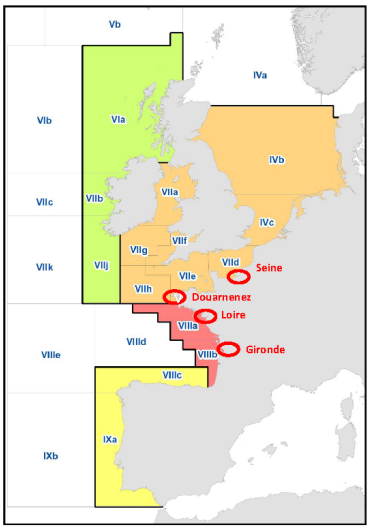


Figure 1 : Localisation of the 4 Nourdem surveys along the French coast

One of the specific features of the project is that sampling survey (trawling) are systematically carried out on board small local professional trawlers (Figure 2). This "Scientists/Fishermen" cooperation makes it possible

to benefit from the fishing skippers' knowledge of the areas, as well as shallow-draught vessels, which allow trawling in very shallow waters, where the main nurseries are located.



Figure 2 : Vessel used during the Nourdem Douarnenez Survey

For the 3 estuaries Seine, Loire, Gironde, NourDem project was carried out in collaboration between Ifremer and the Comité National des Pêches Maritimes et Elevages Marins (CNPMEM), with operational support from the regional fisheries committees involved: CRPMEM Normandie, COREPEM Pays de la Loire and CRPMEM Nouvelle Aquitaine. The project was financed by the European Fisheries Fund (FEAMP) (measure 40), the Directorate of Maritime Fisheries and Aquaculture (DPMA/DGAMPA) of the French Ministry of Fisheries, and France Filière Pêche (FFP). It was managed on behalf of the Union and the State by the Direction Interministérielle de la Mer de Manche-Est et de la Mer du Nord (DIRM MEMN).

For the Bay of Douarnenez, Nourdem project was carried out in collaboration between Ifremer and the Natural Marine Park of Iroise (PNMI) depending of the French Biodiversity Agency (OFB)

2 Protocol

2.1 Ifremer NourDem trawl

One of the original features of this protocol is the use of the "GOV Ifremer NourDem" trawl developed and perfected during the above-mentioned "preparatory" projects. This is a "Large Vertical Opening" (GOV) otter trawl with a bead measuring 11.90 m and a backstroke measuring 16.45 m (Figure 3). The trawl doors (Tiboron) weigh 135kg each and have a surface area of 1.4m². The trawl is designed to be towed at 3.5 knots (surface speed) empty, with around 120 m of wraps. Abundance calculations are based on the area trawled. A set of specific sensors is used to monitor panel spacing during the haul. Horizontal opening is 7 m, and vertical opening is between 1.80 and 2.20 meters.

The end meshes measure 18 mm stretched, enabling us to catch fish as small as 3 to 4 cm in length. The trawl's high pulling speed (3.5 knots relative to the water mass for a small trawl) also enables it to catch species with strong acceleration and avoidance capacities. All in all, these features make the trawl ideal for catching benthic species (sole, flounder, etc.), as well as demersal species (sea bass, whiting, etc.) and certain pelagic species (sprat, anchovy, mackerel, etc.).

A multiparameter sensor is also positioned on the trawl to record depth, salinity and temperature during the haul, useful data for characterizing the preferential habitats and functional zones of the species making up the ecosystem (Figure 3).

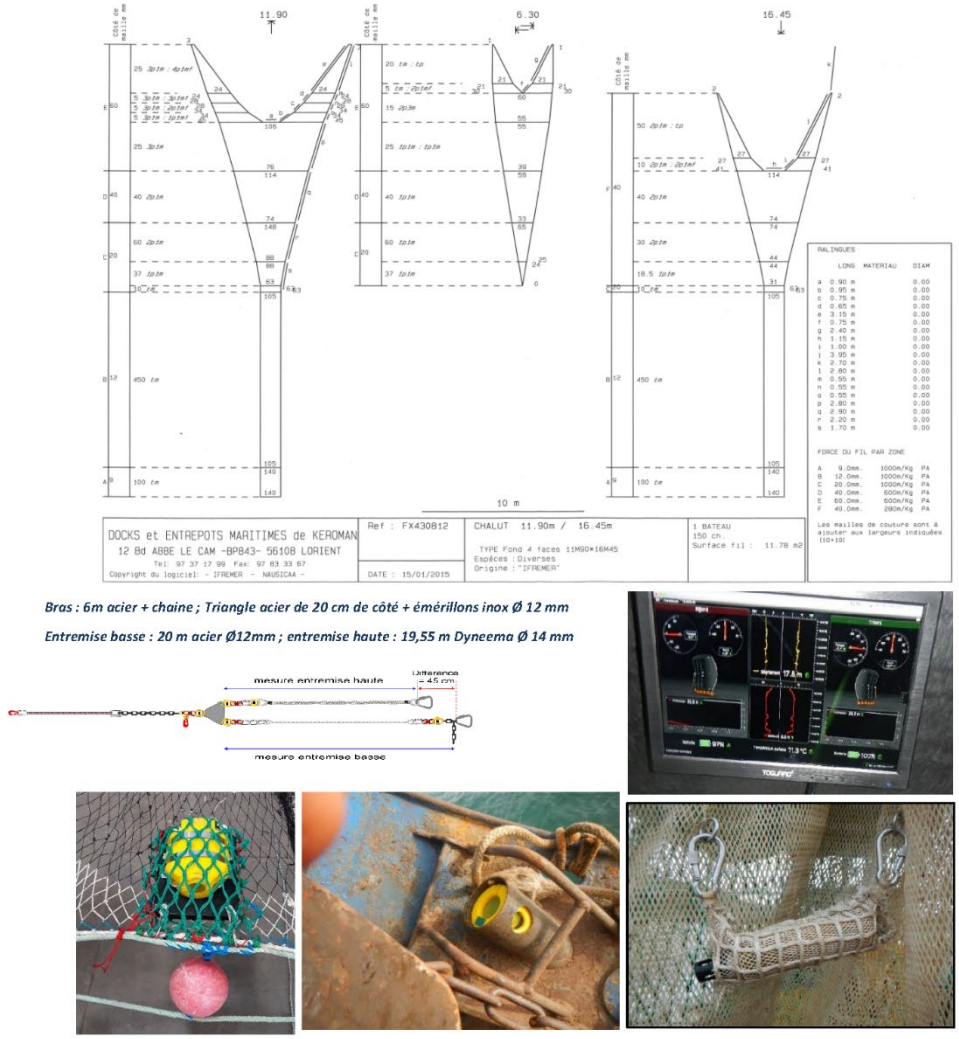


Figure 3: Ifremer NourDem trawl 11.90-16.45 m. Detail of the arms and braces (bottom left). NetSonde" sensor positioned at the center of the back rope to measure the trawl's vertical opening (top right). Panel gap sensor positioned on a panel (center right), and PC screen allowing live monitoring of panel gap and inclination/angulation throughout the tow (to validate the tow, or possibly cancel it if the gap falls outside the tolerances set at 15 and 20 m).

Sampling is carried out aboard small local professional trawlers, around ten meters in length, with a draught of no more than 2 meters, in order to be able to sample the shallower sectors and, in particular, to be able to get onto the foreshore zones as soon as the tide is halfway out. Crews are usually made up of two professional sailors and 4 scientists, three from Ifremer and one from the relevant regional fisheries committee.

The optimization of haul duration was the subject of numerous tests during the first project conducted between 2014 and 2016 (Bargip Nurseries; Cf. Le Goff et al, 2017): this duration is now set at 15 minutes. The times and positions of all the tows are recorded on the MaxSea navigation software embedded in the project, enabling precise trawl times and lengths to be obtained.

Experience has shown that it is imperative to carry out the surveys:

- During neap tides, to minimize tidal currents and zero salinity oscillations during the tide,

- At identical times in each estuary, given the high intra-annual variability in abundance of most species.

As the period of least flow variability in the rivers is between late spring and summer, the dates of the campaigns were set for the low-water periods of late June/early July in the Loire, late July/early August in the Seine and late August/early September in the Gironde.

The areas sampled in the three estuaries extend, as far as possible, from zero salinity upstream to at least the 12 m isobath downstream (which corresponds to a salinity close to 34-35 per thousand in the three estuaries when the campaign is carried out during low-water or low-flow periods), in order to cover all the main estuarine nurseries. The campaigns last 8 full days of trawling, allowing 60 to 75 tows to be made, depending on the estuary. In the first year of sampling an area (the estuary and its immediate downstream reaches), a set of trawlable stations is identified and mapped on the project's navigation software, so that the trawls selected can be carried out as identically as possible in subsequent years.

2.2 Catch processing on board

At the end of each haul, the entire catch is systematically weighed, then the different species are identified and sorted. They are then weighed separately, and all or part of each fish species is measured, to the nearest cm for the vast majority of species, and to the nearest ½ cm for small pelagics. If the trawl is heavily loaded, a sample of the total is weighed and measured: the total weight of the bag is weighed, and a fraction of this total is analyzed after being weighed. Prior to this sampling, the largest individuals, or those belonging to remarkable/rare species, are extracted and processed as "Hors Vrac" (individual measurements and specific weighing). All data acquired (weighing, measurements, debris/waste, haul characteristics, etc.) are then recorded on sea sheets and entered, once ashore, into Ifremer's "Allegro-Campagne" database (which is used to enter all data from the Institute's fishing campaigns). Some individuals are euthanized and frozen before being brought back to the laboratory for measurement, scale sampling, weighing and analysis.

2.3 Catch data processing

2.3.1 Capture, validation and storage of data

Over the last few years, Ifremer has developed a range of IT tools for entering, storing and making available data from the French fishing campaigns for which it is responsible.

Survey data (catches, dates, locations, environmental parameters, metadata, etc.) are entered using the "Allegro campagnes" tool. Once the data have been entered, they are checked using the "tutti control" tool: checking the validity of positions, durations and lengths of hauls, identifying and correcting outliers in length or individual or global weights per species, typing errors when entering data, etc. Once validated, the data is transferred to the "Harmonie" database, where it is both protected (saved permanently) and made available ("public data") via a query website (https://sih.ifremer.fr/Donnees). Harmonie brings together all official French fisheries data produced by Ifremer. Data from all NourDem campaigns (since 2016 in the Loire, 2017

in the Seine and 2019 in the Gironde) have therefore been saved in Harmonie, and have a DOI. (https://campagnes.flotteoceanographique.fr/search).

2.3.2 Production of specific and community indices: RSUFI

An "R" package for calculating abundance or biodiversity indices, called "RSUFI", was developed by IFREMER in the early 2000's to process data from its fisheries campaigns. The indices produced via RSUFI were selected for their ability to provide information on the impact of fishing, with a view to their integration into dashboards of indicators of changes in species abundance within ecosystems exploited by fishing (Rochet & Trenkel 2003; Trenkel & Rochet 2003; Rochet et al. 2005). RSUFI can be used to produce specific indices, i.e. for each of the main species sampled, or community indices (i.e. at the scale of the entire sampled area, with all species aggregated).

Among the specific indices (for each species taken separately) that RSUFI can produce, we have selected for Seabass Index calculation the abundance Index (N) associated with its framing ranges at the 5% error threshold (Fourch. = 1.96 times the standard deviation) or the coefficient of variation (CV = standard deviation/IA or IB), expressed in %.

Details of the calculation formulas used by the RSUFI script to produce both types of indicator can be downloaded from the SIH website at http://www.ifremer.fr/SIH-indices-campagnes/.

$$N_i = \sum_j N_{i,j} = \sum_j A_j \sum_{k=1}^{nj} y_{i,k,j} \Big/ \sum_{k=1}^{nj} a_{k,j} \qquad Var(N_i) = \sum_j \frac{A_j^{\,2}}{n_j - 1} \sum_{k=1}^{n_j} \left(\frac{y_{k,j}}{a_{k,j}} - \frac{\sum_{k=1}^{n_j} y_{k,j}}{\sum_{k=1}^{n_j} a_{k,j}} \right)^2$$

Ni(t) Total abundance index for species i

Nl,i (t) Total abundance index for length class l for species i

Aj Area of stratum j

ak,j Area swept by line k in stratum j

yl,i Number caught in length class l for species i

yi,k j Number of species i caught in haul k in stratum j

wi,k j Number of species i caught in haul k of stratum j

RSUFI is based on a fixed stratification of the sampled areas carried out once and for all, i.e. identical regardless of species or years. For each estuary, the stratification was carried out following the first campaigns, based on bathymetry, water desalination levels, and the respective abundances of juvenile sea bass. This stratification was maintained during the subsequent NourDem campaigns, to enable inter-annual comparisons to be made.

3 NourDem surveys carried out between 2016 and 2022.

The 8-days surveys produced between 58 and 76 tows, depending on the site and the year. Figure 5, Figure 6, Figure 7 and Figure 8 show the positioning of the tows within the three estuaries, and the stratification chosen for the RSUFI data processing script (corresponding to the coloured areas). The aim is to sample all the stations each year, so that inter-annual comparisons can be made. The areas sampled each year extend, if possible, from zero salinity upstream to the 8 m (Seine), 11 m (Loire) and 25 m (Gironde) isobaths. They include channels, lateral flats (infratidal and slikke sectors), and extend to mid-tidal zones (at high tide), as juveniles of many species (sea bass, sole, etc.) are fond of these very shallow sectors, rising and falling on the edges as the tide changes.

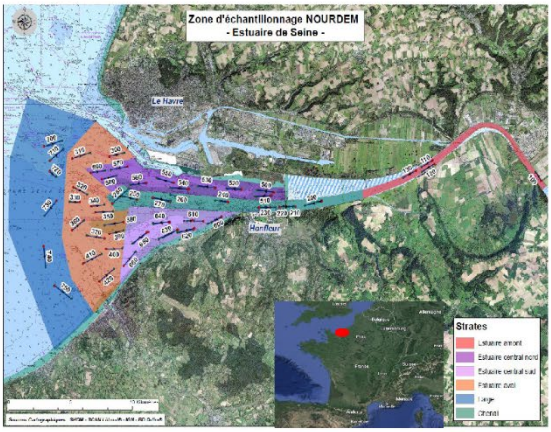


Figure 4 : Nourdem in Seine estuary. Trawling stations and stratification

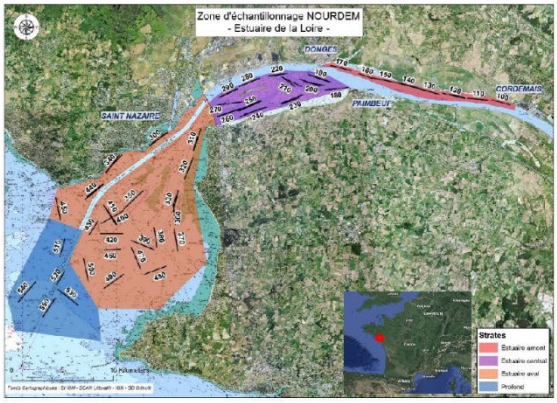


Figure 5 : Nourdem in Loire estuary. Trawling stations and stratification

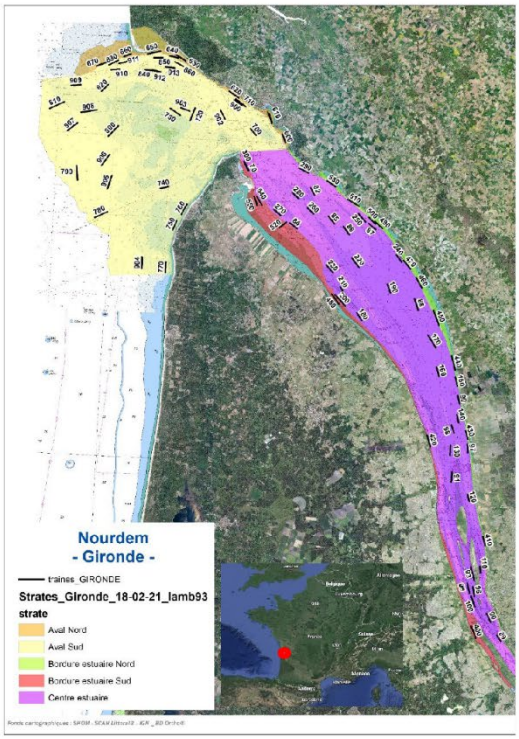


Figure 6 : Nourdem in Gironde estuary. Trawling stations and stratification

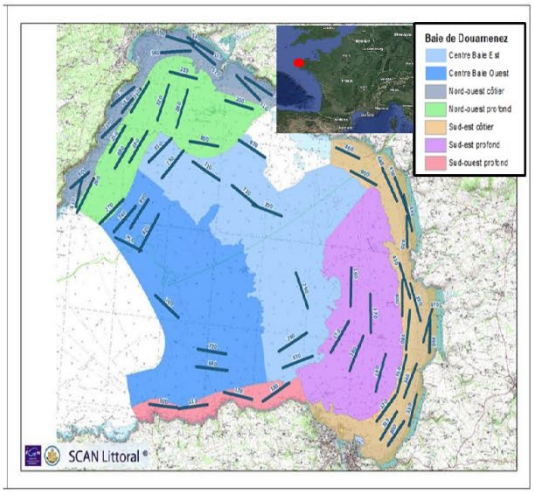


Figure 7 : Nourdem in Douarnenez bay. Trawling stations and stratification

4 RESULTS

Note: results are given until 2022. Studies on the year 2023 are still ongoing. Fulle time series will be available for WKSEABASS in November 2024.

This section provides an overview of data collected during each survey and presents in details results obtained for seabass in the 4 areas by age group, using a plus group (depending of the area). For WKSEABASS, annual indices calculated on all ages, associated with number at length of all the catches and Age length key will be integrated and tested in the future assessment model. Those raw data are presented in section 5.

4.1 European sea bass Dicentrarchus labrax in the Seine estuary

Dicentrarchus labrax has, on average between 2017 and 2022, all age classes combined, a catch occurrence of 76.48% (Tableau 1)

Tableau 1 : Overview of seabass catches in the Seine estuary

Raw data Seine Estuary					
year	Total trawl haul	Number of trawl haul with seabass	Occurrence	Number of seabass	weight (Kg)
2017	67	48	72%	3513	408
2018	74	59	80%	3870	887
2019	73	65	89%	8355	722
2020	73	48	66%	6542	453
2021	70	58	83%	3822	410
2022	73	51	70%	3183	391

Figure 9 presents seabass index calculated across time with standard deviation associated. This index will be tested in the future assessment model. Following chapter details by age group results observed.

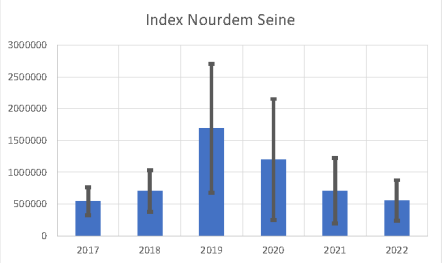
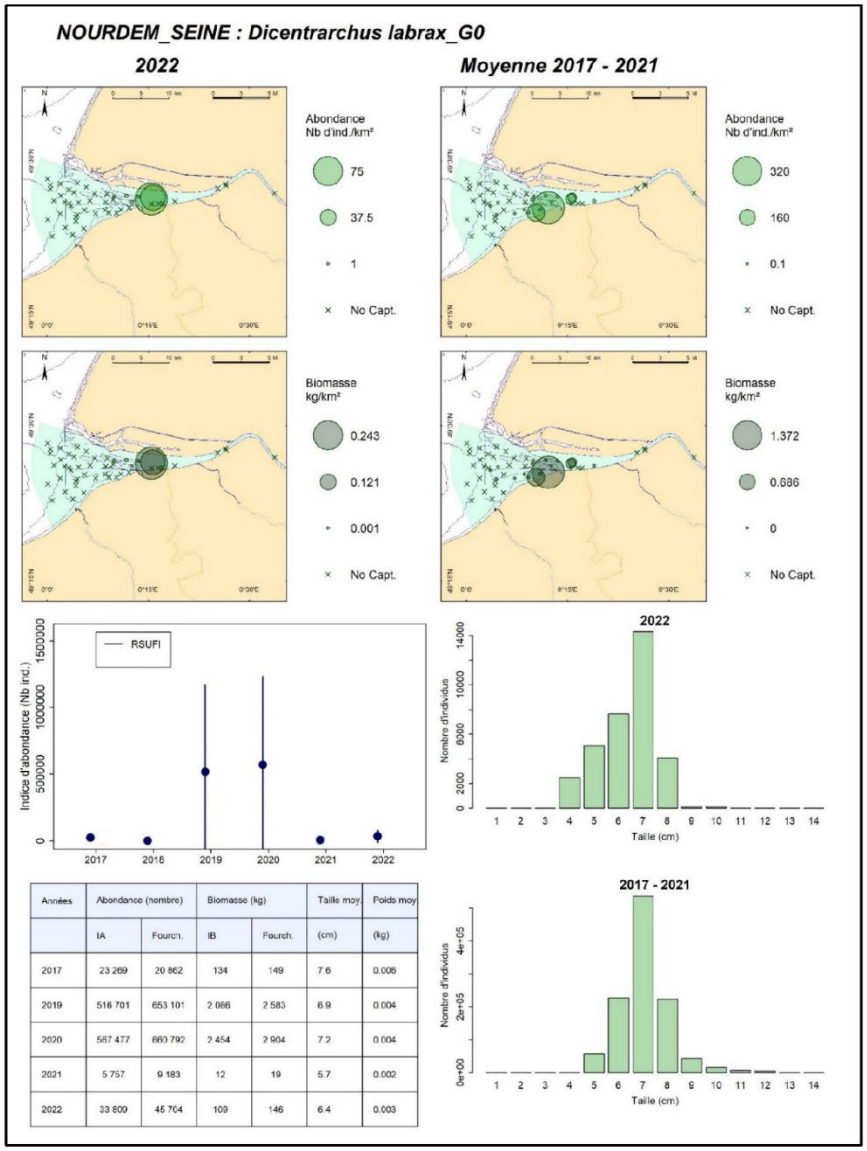


Figure 8 : Seabass index and standard deviation associated across time calculated for Nourdem Seine (all ages combined)

4.2 Group 0 European sea bass in the Seine estuary

Their average catches rate has been 14.89% since monitoring began, and their average abundance index 191,169 individuals.

The abundance index for this age group showed significant inter-annual variation, rising from 5,757 +/- 9,183 individuals in 2021 to over 500,000 +/- ≈ 650,000 individuals and 2019 and 2020. In 2022, the abundance index is estimated at 33,809 +/- 45,705 individuals for a biomass of around 100 kg (Figure 10). This age group, because of its position in very shallow sectors, is difficult to access with a trawl. Numbers are concentrated on just a few tows, mainly located in the "central estuary south" and "central estuary north" strata, which include the lateral banks and flats extending from the outside of the channel to the foreshores. No catches of this age group are recorded on tows deeper than 4 meters (no catches during a tow are symbolized by a cross on the map), and areas less than 2 meters deep. Catch sizes for 2022 are comparable to those obtained on average over the 2017-2021 period: modal value of 7 cm, average size of 6.4 cm, and average weight of around 3 grams.



Années	Abondance (nombre)		Biomasse (kg)		Taille moy.	Poids moy.
	IA	Fourch.	IB	Fourch.	(cm)	(kg)
2017	23 269	20 862	134	149	7.6	0.006
2019	516 701	653 101	2 066	2 583	6.9	0.004
2020	567 477	660 792	2 454	2 904	7.2	0.004
2021	5 757	9 183	12	19	5.7	0.002
2022	33 809	45 704	109	146	6.4	0.003

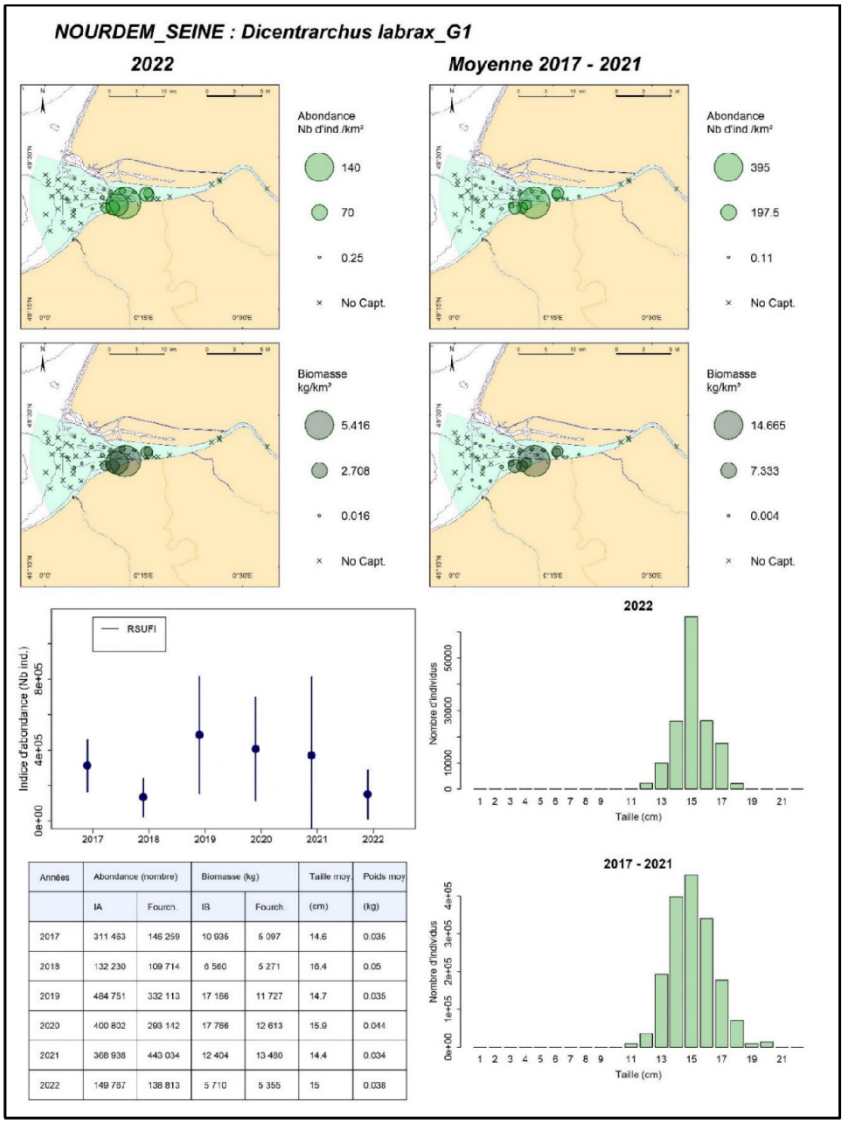
Figure 9: Group 0 European sea bass Dicentrarchus labrax in the Seine estuary: maps of surface densities and biomasses at each of the stations sampled, in 2022 (left) and between 2017 and 2021 (right); graph (center) of annual abundance indices determined using the RSUFI scripts and their framing ranges at the 5% error threshold; summary table of annual values of abundance and biomass indices, their framing ranges at the 5% error threshold, mean sizes and mean weights (RSUFI script; bottom left). High catch size distributions (domain-wide) in 2022 vs. 2017-2021 (bottom right).

4.3 Group 1 European sea bass in the Seine estuary

Overall, the average abundance index for juvenile group 1 sea bass since the start of NourDem monitoring in the Seine has been ≈ 308,000 individuals for an average biomass of ≈ 11.7 tonnes. Annual abundance indices are given in Figure 11. 2022 would be, along with 2018, one of the worst years in the series: abundance index of 149,767 +/- 138,813 individuals for a biomass index of 5.7 tonnes.

It should nevertheless be pointed out that although some individuals in group 1 are becoming less dependent on the shallower edge sectors of the estuary, their preferred habitats are still very similar to those of group 0.

Size distributions in 2022 are comparable to those obtained previously: modal value corresponding to the average size, i.e. 15 cm, and average weight of 38 grams.



Années	Abondance (nombre)		Biomasse (kg)		Taille moy	Poids moy
	IA	Fourch.	IB	Fourch.	(cm)	(kg)
2017	311 463	146 259	10 935	5 097	14.6	0.035
2018	132 230	109 714	6 560	5 271	16.4	0.05
2019	484 751	332 113	17 186	11 727	14.7	0.035
2020	400 802	293 142	17 786	12 613	15.9	0.044
2021	368 936	443 034	12 404	13 490	14.4	0.034
2022	149 787	138 813	5 710	5 355	15	0.038

Figure 10: Group 1 European sea bass in the Seine estuary: maps of surface densities and biomasses at each of the stations sampled, in 2022 (left) and between 2017 and 2021 (right); graph (center) of annual indices of abundance determined using the RSUFI scripts, and of their framing ranges at the 5% error threshold; summary table of annual values of abundance and biomass indices, their framing ranges at the 5% error threshold, mean sizes and mean weights (RSUFI script; bottom left). High catch size distributions (domain-wide) in 2022 vs. 2017-2021 (bottom righ

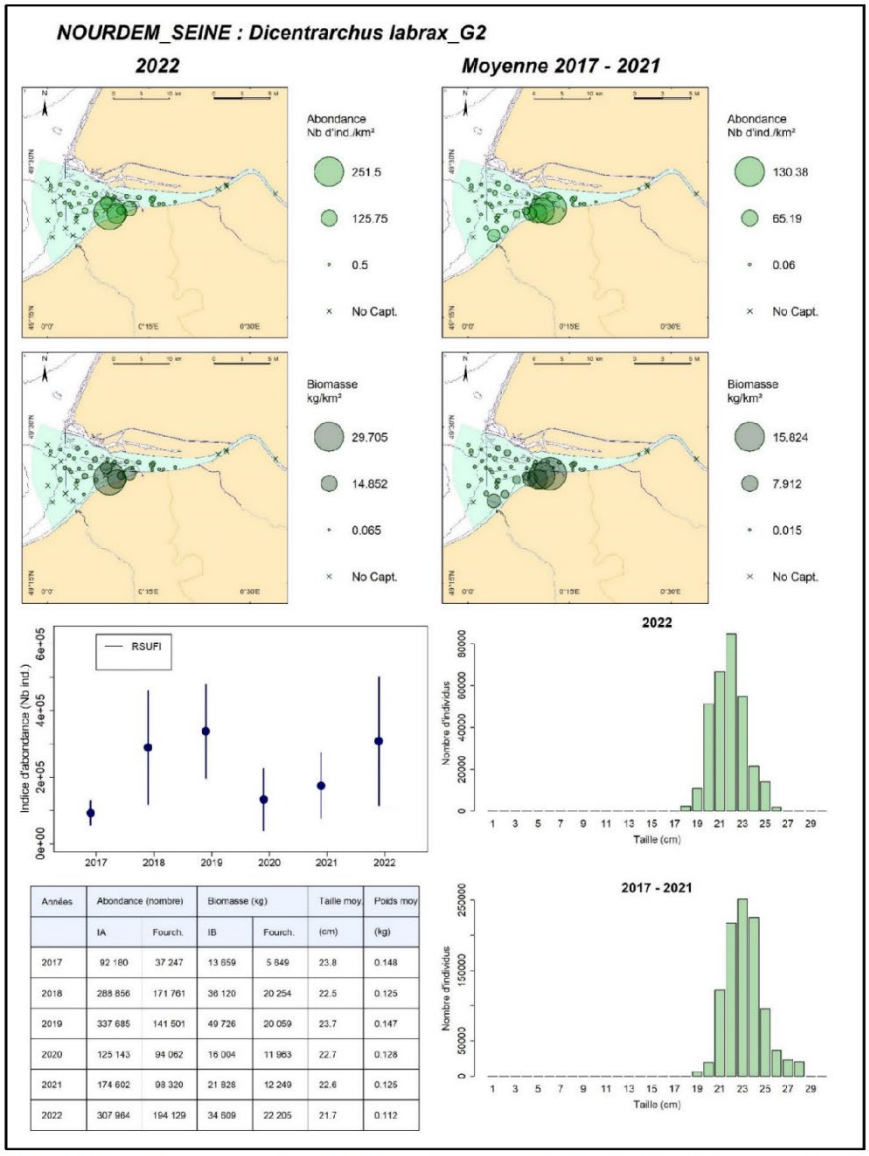
4.4 Group 2 European sea bass in the Seine estuary

Group 2 sea bass still use the estuary as a nursery, but colonize sectors further downstream and deeper than those of groups 0 and 1 (Figure 12). Average catch occurrences are the highest of the 4 age groups considered (68.34%), and the average abundance index reaches ≈ 221,000 individuals for an average biomass index of ≈ 28.7 tonnes.

Abundance indices, allow us to conclude that the G2 sea bass abundance index for 2019 was significantly higher than that for 2017 at the 5% error threshold. The RSUFI script does not distinguish any other significant differences. Abundance in 2022 appears higher than in the previous two years, but with no significant difference due to the width of the index framing ranges (307,964 +/- 194,129 individuals).

The entire estuary is colonized, from the most upstream reaches (except for the two most upstream reaches of the channel bottom) to the most downstream reaches. The areas of greatest abundance are the upstream flats of the "south central estuary" stratum, followed by the southernmost coastal sector of the "downstream estuary" stratum.

Between 2017 and 2021, the sizes of Group 2 individuals at the time of the NourDem campaign ranged from 19 to 28 cm, with an average size of between 22.5 and 23.8 cm depending on the year, and a modal value of 23 cm. Measurements for 2022 are slightly lower, with a modal value of 22 cm and an average height of 21.7 cm. These decreases in mean and modal size in 2022 are therefore of the order of 1 to 2 cm, to be confirmed by future monitoring.



Années	Abondance (nombre)		Biomasse (kg)		Taille moy	Poids moy
	IA	Fourch.	IB	Fourch.	(cm)	(kg)
2017	92 180	37 247	13 659	5 849	23.8	0.148
2018	288 856	171 761	36 120	20 254	22.5	0.125
2019	337 685	141 501	49 726	20 059	23.7	0.147
2020	125 143	94 062	16 004	11 953	22.7	0.128
2021	174 602	98 320	21 828	12 249	22.6	0.125
2022	307 984	194 129	34 609	22 205	21.7	0.112

Figure 11: Group 2 European sea bass in the Seine estuary: maps of surface densities and biomasses at each of the stations sampled, in 2022 (left) and between 2017 and 2021 (right); graph (center) of annual indices of abundance determined using the RSUFI scripts, and of their framing ranges at the 5% error threshold; summary table of annual values of abundance and biomass indices, their framing ranges at the 5% error threshold, mean sizes and mean weights (RSUFI script; bottom left). High catch size distributions (domain-wide) in 2022 vs. 2017-2021 (bottom right).

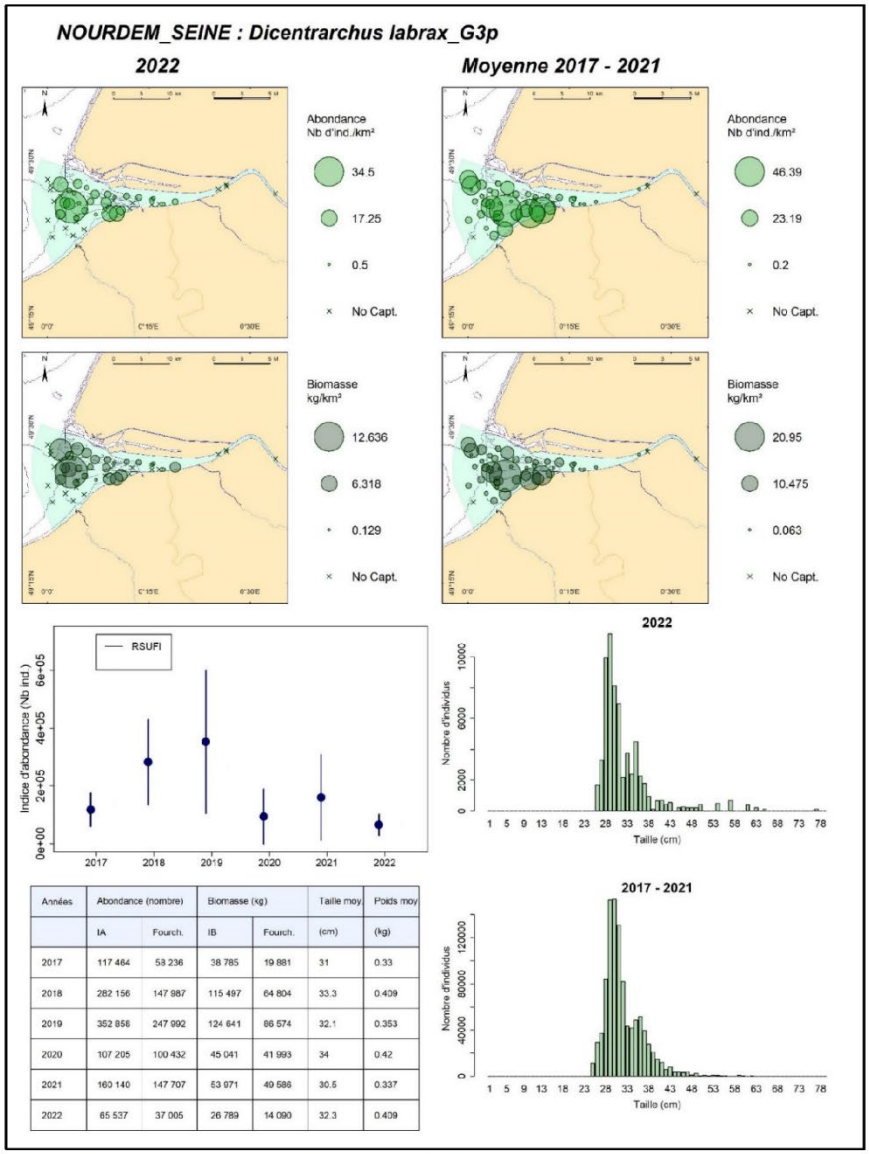
4.5 European sea bass groups 3+ in the Seine estuary

Like those in group 2, European sea bass in groups 3 and above have a high average capture rate of 65.13% over the 2017-2022 period. Their average abundance index is also very comparable to that of group 2 (180,893 individuals). However, their average biomass index is much higher, at around 67.5 tonnes (Figure 13).

Eastern European sea bass begin their first winter migration offshore in November-December at the end of group 3 or group 4, and return to coastal waters in late spring, as do adults in general. At the time of the NourDem campaign, 3+ groups colonized the entire estuary, from the most upstream to the most downstream stretches (always excluding the two upstream stretches at the bottom of the channel). They are present in greater numbers than group 2 on the northern features of the domain (strata "central estuary north", and above all "downstream estuary" and even "wide").

The 2022 abundance index is the lowest in the whole series (65,537 +/- 37,005 individuals), but the difference is only significant at the 5% error threshold with those of 2018 and 2019 (RSUFI indices).

Catch sizes for groups 3+ range from 25 to 76 cm, with average sizes between 31 and 34 cm (32.3 cm in 2022).



Années	Abondance (nombre)		Biomasse (kg)		Taille moy	Poids moy
	IA	Fourch.	IB	Fourch.	(cm)	(kg)
2017	117 464	53 236	38 785	19 881	31	0.33
2018	282 156	147 987	115 497	64 804	33.3	0.409
2019	352 858	247 992	124 641	86 574	32.1	0.353
2020	107 205	100 432	45 041	41 993	34	0.42
2021	160 140	147 707	53 971	40 586	30.5	0.337
2022	65 537	37 005	26 789	14 090	32.3	0.409

Figure 12: European sea bass groups 3 and above in the Seine estuary: maps of surface densities and biomasses at each of the stations sampled, in 2022 (left) and between 2017 and 2021 (right); graph (center) of annual abundance indices determined using the RSUFI scripts, and their framing ranges at the 5% error threshold; summary table of annual values of abundance and biomass indices, their framing ranges at the 5% error threshold, mean sizes and mean weights (RSUFI script; bottom left). High catch size distributions (domain-wide) in 2022 vs. 2017-2021 (bottom right).

Figure 14 summarizes the average positions of these four age groups. It confirms the gradual descent of juveniles of the species from the shallower areas of the southern edge of the Central Estuary during their first years of life, towards increasingly downstream and deeper sectors, resulting in increasingly complete colonization of the estuary.

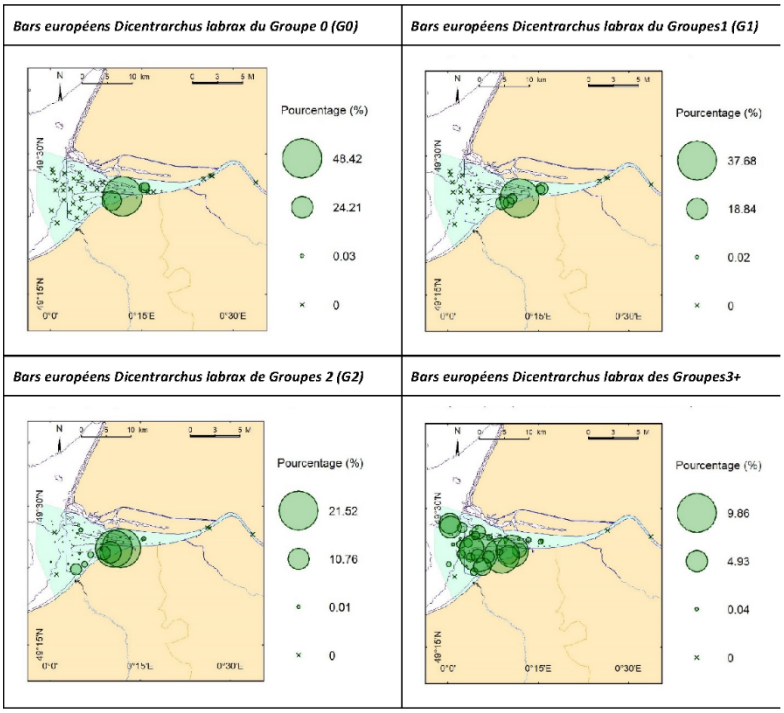


Figure 13: European sea bass in the Seine estuary: averages, over the period 2017-2022, of catches per haul (expressed as a percentage of the total average number of individuals caught) of European sea bass Dicentrarchus labrax of different age groups; NourDem data.

4.6 European sea bass Dicentrarchus labrax in the Loire estuary

The European sea bass is the most common species in the Loire estuary sampling: 88.79% of average occurrence (Tableau 2).

Tableau 2 : Overview of seabass catches in the Loire estuary

Raw data Loire Estuary					
year	Total trawl haul	Number of trawl haul with seabass	Occurrence	Number of seabass	weight (Kg)
2016	73	62	85%	1503	228
2017	74	69	93%	824	179
2018	77	72	94%	3538	288
2019	75	67	89%	8155	662
2020	76	63	83%	1040	164
2021	76	69	91%	1028	274
2022	76	66	87%	1914	383

Figure 15 presents seabass index calculated across time with standard deviation associated. This index will be tested in the future assessment model. Following chapter details by age group results.

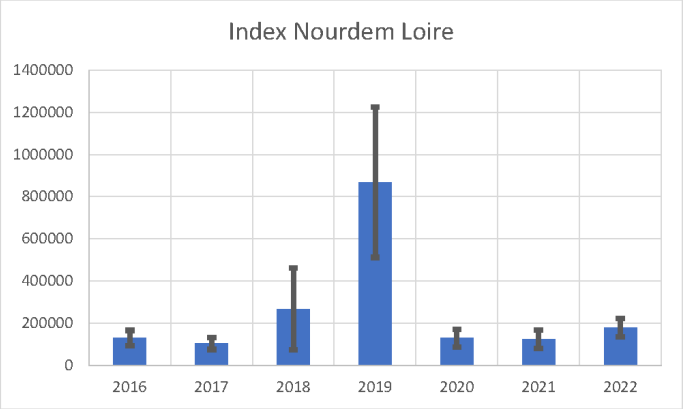
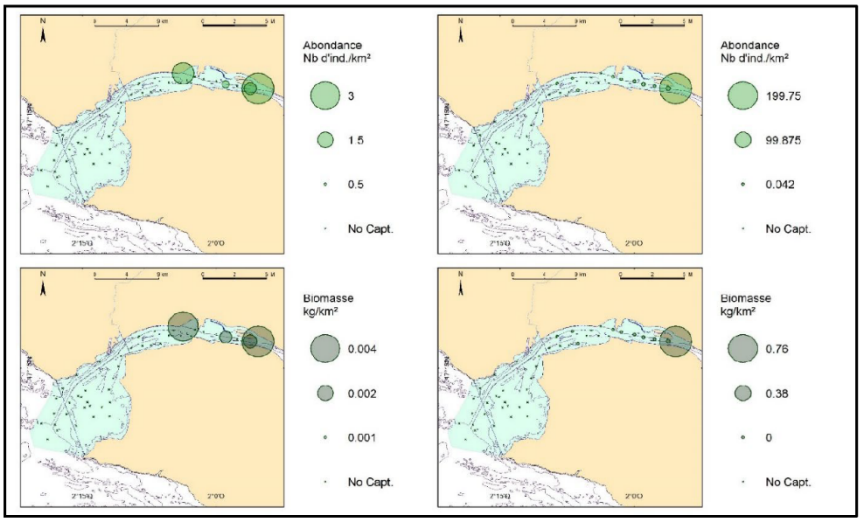


Figure 14 : Seabass index and standard deviation associated across time calculated for Nourdem Loire (all ages combined)

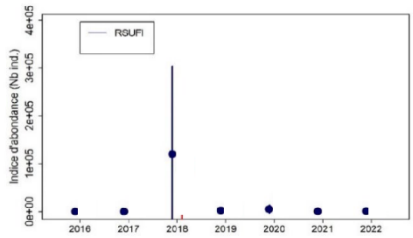
4.7 Group 0 European sea bass

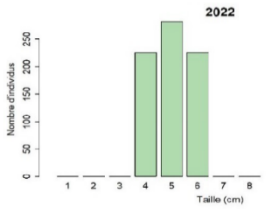
As is the case in the other two estuaries, catches of group 0 sea bass in the Loire are generally low (average catch occurrence over the 2016/2022 period of 5.08%, average abundance index of 18,371 individuals for an average biomass index of 68 kg and variable. Catches are also highly localized, with this age group confined to the most upstream sectors of the estuary ("upstream estuary" stratum), close to zero salinity, and most often at depths of less than 2 meters (Figure 16)

Abundance indices for group 0 individuals are more often than not lower than those for group 1, which in turn are lower than those for group 2, due to the greater vulnerability/capturability of the largest age classes. The capture sizes of these Group 0 individuals range from 2 to 10 cm.



Années	IA	Fourch.IA	IB	Fourch.IB
2016	72	127	0	1
2017	0	0	0	0
2018	120 133	184 222	457	664
2019	2 087	2 628	8	13
2020	5 274	8 610	11	18
2021	302	639	0	1
2022	732	764	1	1





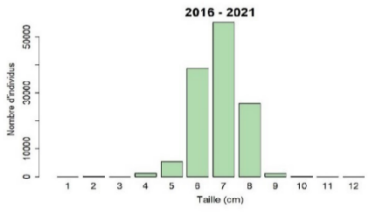
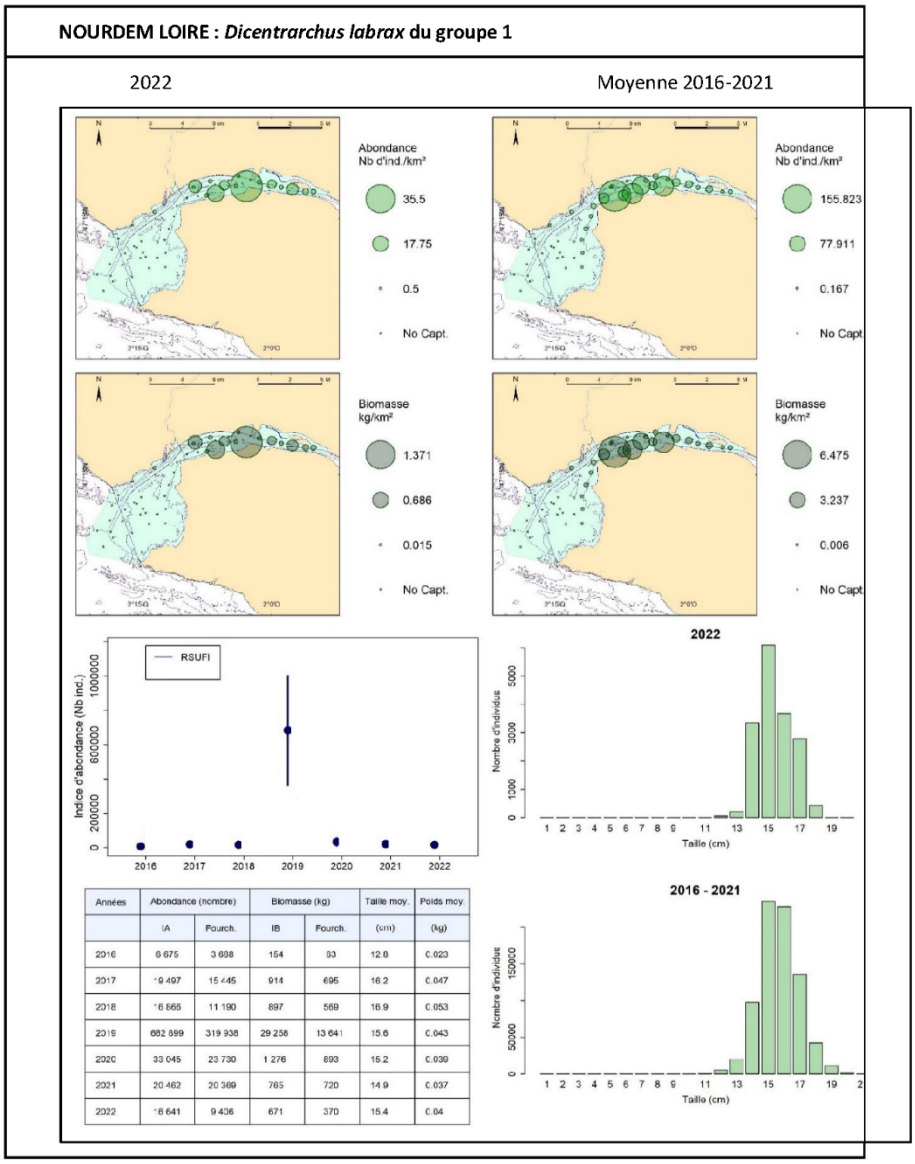


Figure 15: Group 0 European sea bass Dicentrarchus labrax in the Loire estuary: maps of surface densities and biomasses at each of the stations sampled, in 2022 (left) and between 2016 and 2021 (right); graph (center) of annual abundance indices determined using the RSUFI scripts and their framing ranges at the 5% error threshold; summary table of annual values of abundance index (IA) and biomass index (IB) and their framing ranges at the 5% error threshold (RSUFI script; bottom left). High catch size distributions (domain-wide) in 2022 vs. 2016-2021 (bottom right).

4.8 Group 1 European seabass

Group 1 sea bass are located slightly further downstream and above all slightly deeper (mainly in the two strata "central estuary" and "upstream estuary", with a few catches in the upstream stratum "downstream estuary") than Group 0 (Figure 16). Their average catch rate over the period 2016-2022 was 37.17%, with an average abundance index of 113,726 individuals and an average biomass index of ≈ 4.85 tons.

The 2019 abundance index is significantly higher than all other years monitored, which is consistent with the high index obtained in 2018 for Group 0. There are no significant differences among the other annual abundance indices (Figure 17)



Années	Abondance (nombre)		Biomasse (kg)		Taille moy.	Poids moy.
	IA	Fourch.	IB	Fourch.	(cm)	(kg)
2016	6 675	3 698	154	93	12.8	0.023
2017	19 497	15 445	914	695	16.2	0.047
2018	16 665	11 190	897	569	16.9	0.053
2019	682 899	319 938	29 256	13 641	15.6	0.043
2020	33 045	23 730	1 276	893	15.2	0.039
2021	20 462	20 389	765	720	14.9	0.037
2022	16 641	9 406	671	370	15.4	0.04

Figure 16: Group 1 European sea bass Dicentrarchus labrax in the Loire estuary: maps of surface densities and biomasses at each of the stations sampled, in 2022 (left) and between 2016 and 2021 (right); graph (center) of annual abundance indices determined using the RSUFI scripts, and their framing ranges at the 5% error threshold; summary table of annual values of abundance and biomass indices, their framing ranges at the 5% error threshold, mean sizes and mean weights (RSUFI script; bottom left). High catch size distributions (domain-wide) in 2022 vs. 2016-2021 (bottom right).

4.9 Group 2 European sea bass

Group 2 sea bass are found in slightly deeper areas than Group 1 and especially Group 0, allowing for better sampling of their population. They colonize the entire estuary, from zero salinity to salinities of 35 per thousand, with catches recorded well downstream of the St Nazaire bridge on the "downstream estuary" stratum (Figure 18). Some catches were even recorded on the deepest tows within the "wide" stratum, but the center of their distribution range remains mainly positioned on the two most upstream strata ("central estuary" and "upstream estuary") and the upstream part of the "downstream estuary" stratum. As a result of their improved catchability, and the increased extent of their habitat zone within the sampled area, their catch occurrence is higher than that of the previous two groups. It averages 67.92% over the period 2016-2022 with an average abundance index of 63,553 individuals and an average biomass index of 8.22 tonnes.

In line with what was observed for groups 0 and 1 in previous years, the 2019 abundance index for individuals in group 2 is the highest in the series: it is significantly higher than those for 2016, 2017, 2018 and 2021 (no difference with those for 2020 and 2022). The 2022 index, one of the highest in the series, is significantly higher than those for 2017, 2018 and 2021.

Catch sizes of European sea bass in Group 2 ranged from 18 to 29 cm, with mean annual sizes ranging from 20 cm (year 2016) to 24.5 cm (2019). Average annual individual weights ranged from 86 to 161 grams (in 2016 and 2018 respectively).

4.10 European sea bass groups 3+

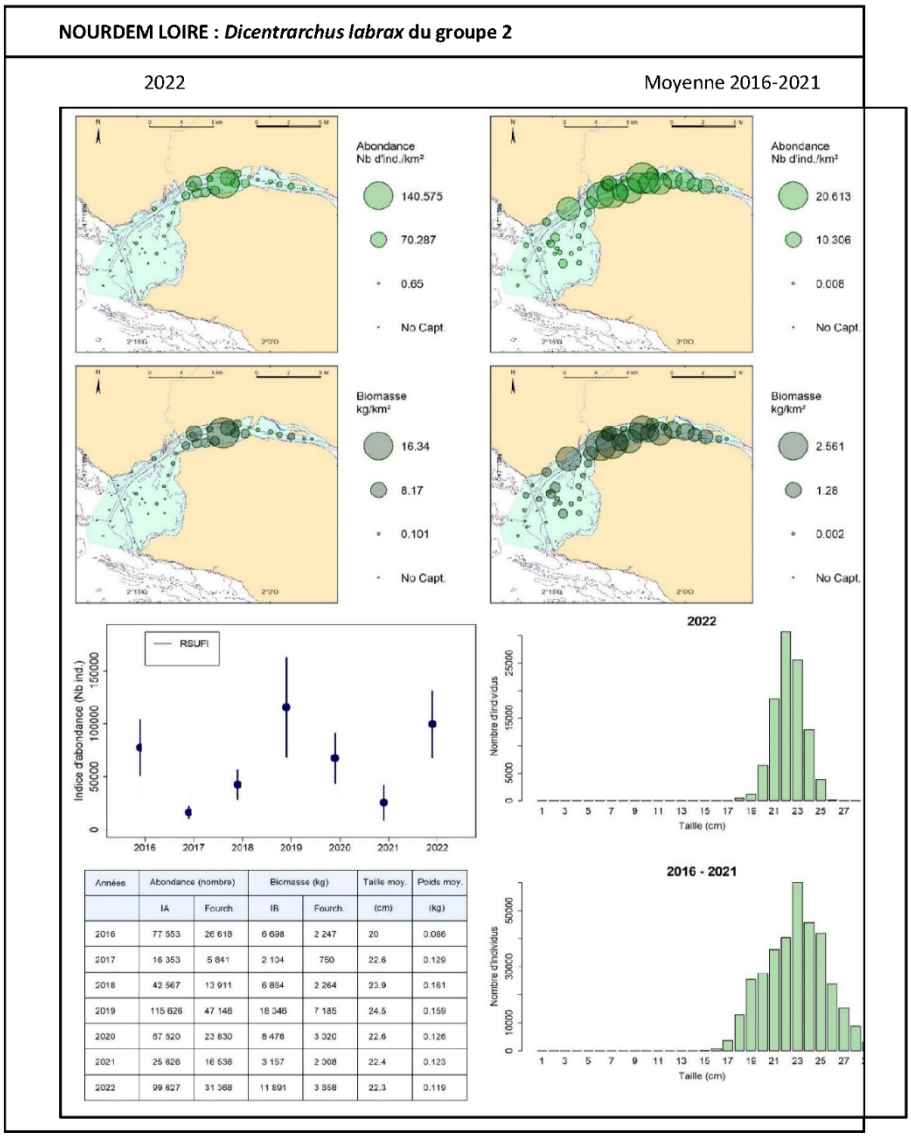
Group 3 and above sea bass colonize the entire estuary (Figure 19), and are caught from the furthest upstream to the furthest downstream reaches, with no clearly distinguishable preferential area of presence. Annual capture occurrences are systematically above 70%, averaging 79.93% over the 2016/2022 period. The average abundance index stood at 61,124 individuals over the entire monitoring period, and the average biomass index at 27.84 tonnes.

The annual abundance indices of these large age groups are less variable than those of the younger groups, and only 2020 stands out with an abundance index significantly lower than that of all other years. The abundance index for 2022 is slightly lower, at 61,400 individuals, for a biomass index of around 28.8 tonnes.

Sizes ranged from 23 to 87 cm (24 to 81 cm in 2022), and the size distribution histograms do not allow us to separate the different age groups beyond group 3. Average annual heights ranged from 29.9 cm (year 2016) to 37.3 cm (2020), and average individual weights from 335 grams (2017) to 634 grams (2020).

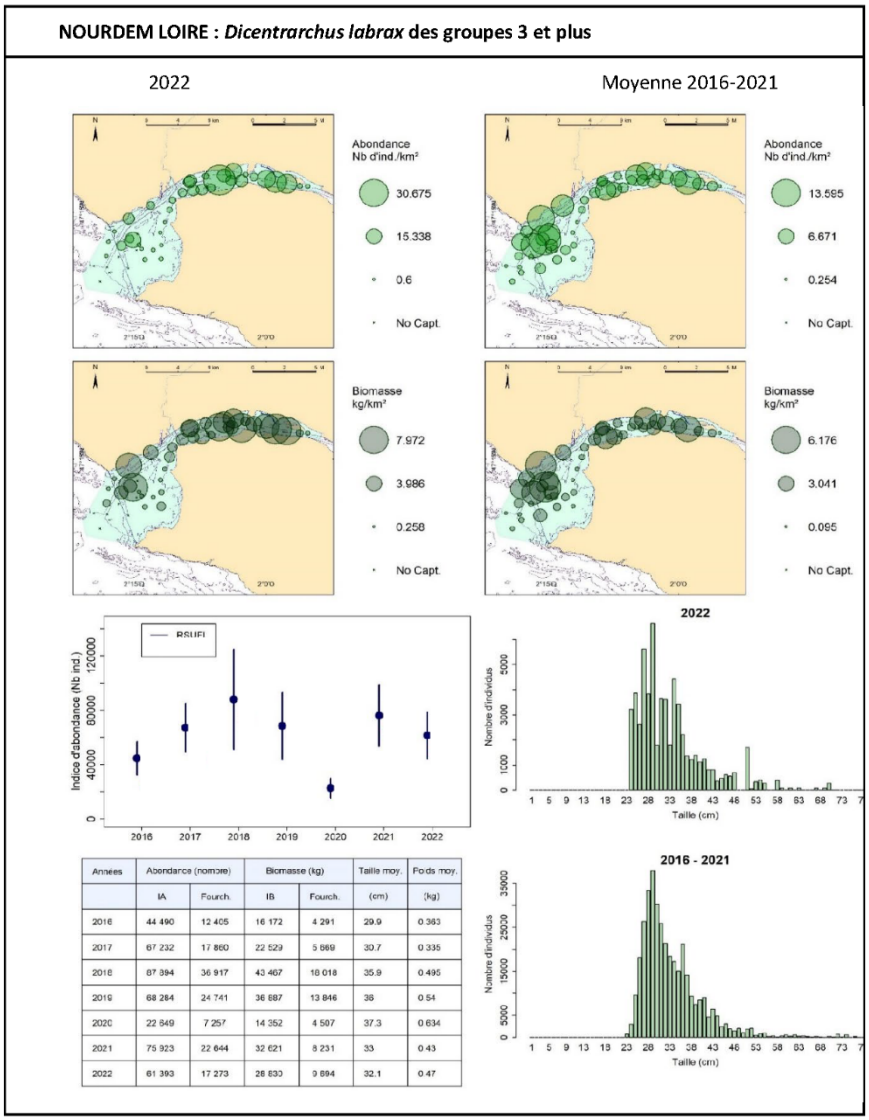
4.11 Summary of age group positioning

Figure 20 shows catches per haul averaged over the period 2016-2022, providing a summary map of the preferred areas of presence of the different age groups. Even more so than in the Seine estuary, this figure shows that juvenile sea bass in group 0 are found in the most upstream sectors of the area, and that as they age, they tend to colonize more and more of the area, moving into deeper, more downstream sectors, to end up being caught throughout the entire area sampled from group 3 onwards.



Années	Abondance (nombre)		Biomasse (kg)		Taille moy.	Poids moy.
	IA	Fourch.	IB	Fourch.	(cm)	(kg)
2016	77 553	26 618	6 698	2 247	20	0.086
2017	16 353	5 841	2 104	750	22.6	0.129
2018	42 567	13 911	6 884	2 264	23.9	0.161
2019	115 626	47 148	18 346	7 185	24.5	0.159
2020	67 520	23 630	8 476	3 020	22.6	0.126
2021	25 626	16 538	3 157	2 008	22.4	0.123
2022	99 627	31 368	11 891	3 858	22.3	0.119

Figure 17: Group 2 European sea bass Dicentrarchus labrax in the Loire estuary: maps of surface densities and biomasses at each of the stations sampled, in 2022 (left) and between 2016 and 2021 (right); graph (center) of annual abundance indices determined using the RSUFI scripts and their framing ranges at the 5% error threshold; summary table of annual values of abundance and biomass indices, their framing ranges at the 5% error threshold, mean sizes and mean weights (RSUFI script; bottom left). High catch size distributions (domain-wide) in 2022 vs. 2016-2021 (bottom right).



Années	Abondance (nombre)		Biomasse (kg)		Taille moy.	Poids moy.
	IA	Fourch.	IB	Fourch.	(cm)	(kg)
2016	44 490	12 405	16 172	4 291	29.9	0.363
2017	67 232	17 860	22 529	5 869	30.7	0.335
2018	87 394	36 917	43 467	18 018	35.9	0.495
2019	68 284	24 741	36 887	13 846	38	0.54
2020	22 849	7 257	14 352	4 597	37.3	0.634
2021	75 923	22 644	32 621	9 231	33	0.43
2022	61 393	17 273	28 830	9 894	32.1	0.47

Figure 18: European sea bass Dicentrarchus labrax groups 3 and above in the Loire estuary: maps of surface densities and biomasses at each of the stations sampled, in 2022 (left) and between 2016 and 2021 (right); graph (center) of annual abundance indices determined using the RSUFI scripts and their framing ranges at the 5% error threshold; summary table of annual values of abundance and biomass indices, their framing ranges at the 5% error threshold, mean sizes and mean weights (RSUFI script; bottom left). High catch size distributions (domain-wide) in 2022 vs. 2016-2021 (bottom right).

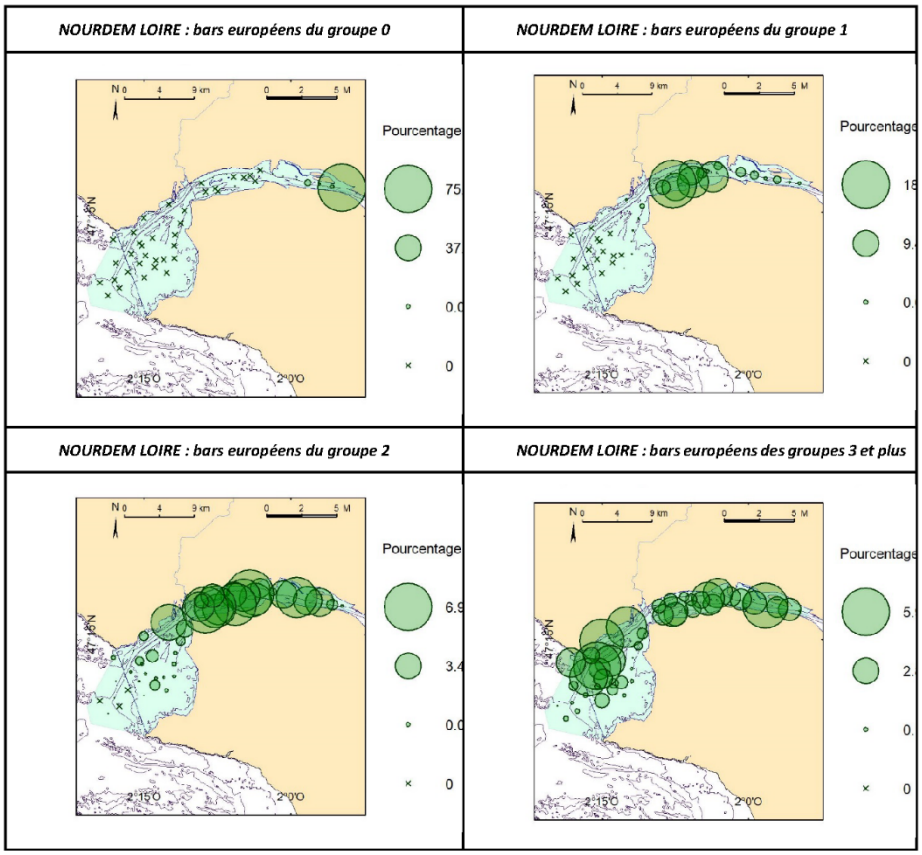


Figure 19: European sea bass Dicentrarchus labrax in the Loire estuary: averages, over the period 2016-2022, of catches per haul (expressed as a percentage of the total average number of individuals caught) of European sea bass Dicentrarchus labrax in age groups 0, 1, 2, and 3+; NourDem (2017-2022) and Bargip Nourriceries (2016) data.

5 European sea bass Dicentrarchus labrax in the Gironde estuary

As in the Seine and Loire, the European sea bass Dicentrarchus labrax is one of the core species of the Gironde estuary, which it uses as a nursery. Its average capture occurrence, all age classes combined, amounted to 40.7% over the 2019-2022 period (Tableau 3)

Tableau 3 : Overview of seabass catches in the Gironde estuary

Raw data Gironde Estuary					
year	Total trawl haul	Number of trawl haul with seabass	Occurrence	Number of seabass	weight (Kg)
2019	91	33	36%	1232	76
2020	61	30	49%	373	48
2021	60	18	30%	207	27
2022	57	27	47%	226	29

Figure 21 presents seabass index calculated across time with standard deviation associated. This index will be tested in the future assessment model. Following chapter details by age group results.

In this estuary, we had to settle for distinguishing two age groups only, juveniles in group 0 on the one hand, and individuals in groups 1 and above on the other, as separating older groups became too random without increasing the number of age determinations from scale "readings".

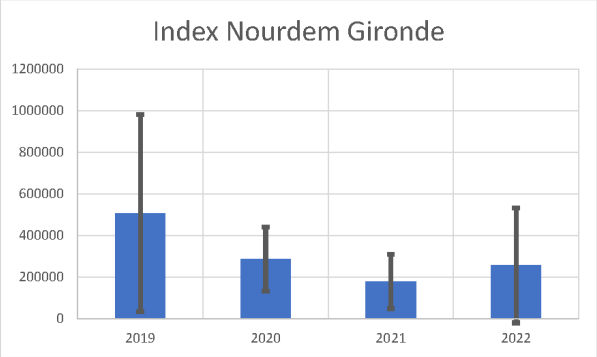


Figure 20 : Seabass index and standard deviation associated across time calculated for Nourdem Gironde (all ages combined)

5.1 Group 0 European sea bass

On average over the four years, these small individuals were caught in 18.45% of tows, and their average index of abundance was around 86,600 individuals (Figure 21).

The index of abundance passed through a minimum value in 2021, with 2022 showing the maximum index, but with no significant inter-annual difference. The catch sizes of these Group 0 individuals ranged from 5 to 14 cm, with mean annual sizes of between 9 and 10.6 cm, and mean weights of between 9 and 15 grams.

European sea bass in group 0 were mainly caught on the shallower, marginal stretches from upstream to downstream of the inner estuary (no catches outside the estuary). A positioning of this age group only

upstream, as is clearly the case in the Loire or the Aulne (Le Goff et al, 2017 and 2022), and to a lesser extent in the Seine, is not apparent here. The only constant is that catches are only recorded on shallow-water tows.

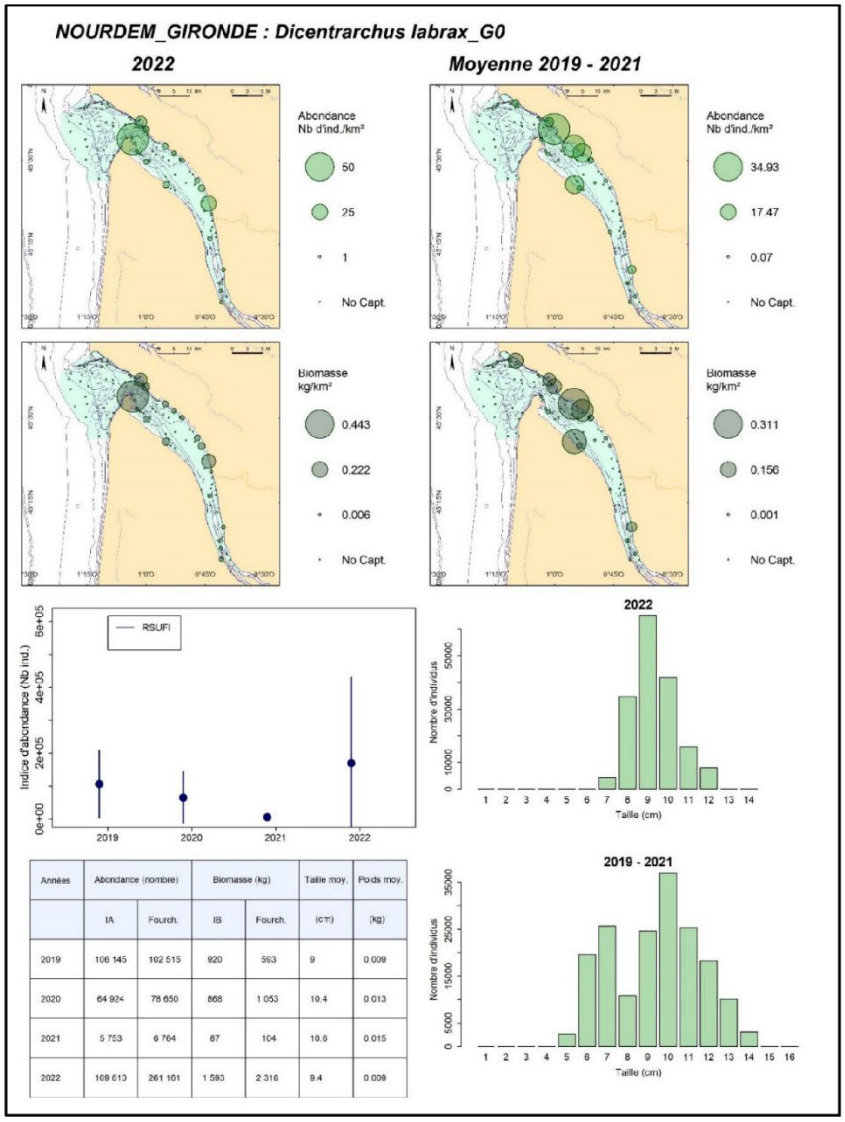
5.2 European seabass in groups 1+

Average catch occurrence was 37.03% over the 2019-2022 period, with an average abundance index of 221,434 individuals for an average biomass index of 29.5 tonnes (Figure 21).

Annual indices of abundance appear to be declining over the 2019-2022 period, but the differences are not significant.

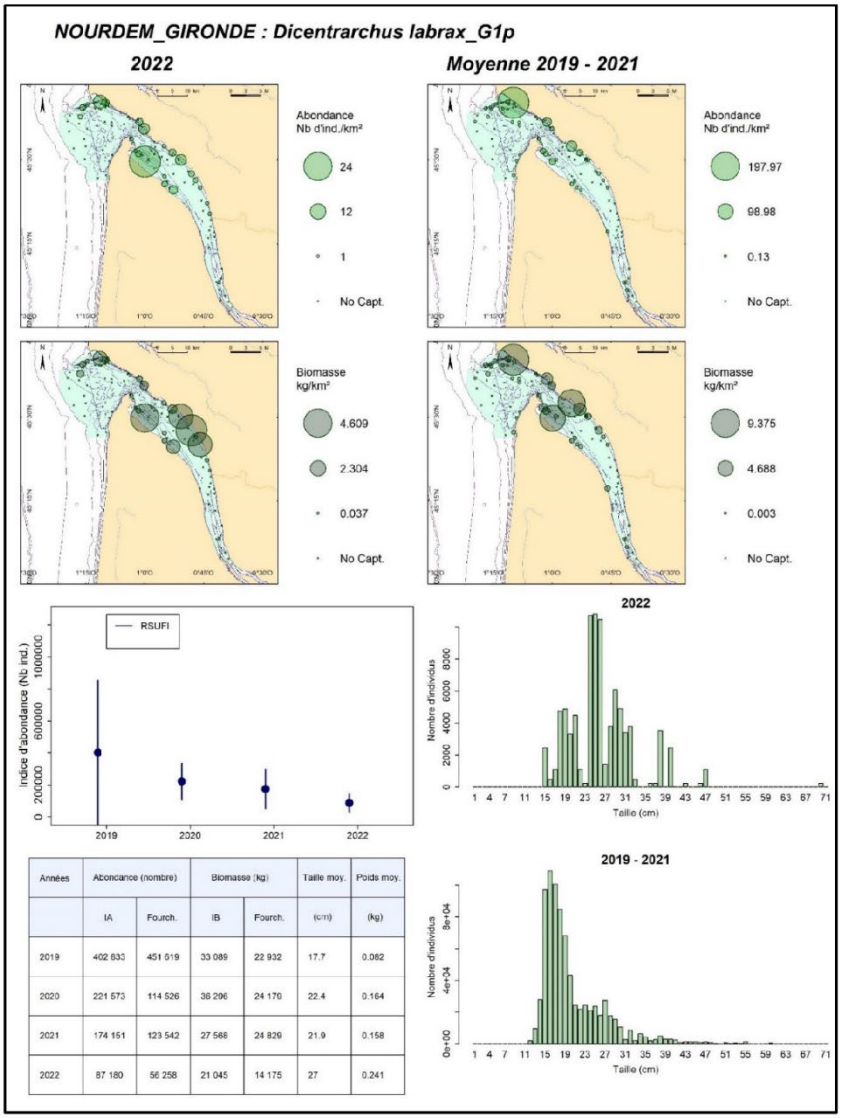
Catches are mainly made along the edge of the estuary, almost from the bec d'Ambez upstream to the downstream boundary lines outside the estuary.

Catch sizes range from 13 to 70 cm, with annual averages between 17.7 cm (2019; average weight 82 grams) and 27 cm (2022; average weight 241 grams). This relative increase in the number of large individuals in 2022 is in fact due to the disappearance of the smallest ones, as Group 1 individuals were caught in low proportions in 2022. This is in line with the low recruitment of group 0s observed in 2021, and future campaigns will have to verify whether the slightly higher recruitment of G0s observed in 2022 will translate into an increase in G1+ numbers from 2023 onwards.



Années	Abondance (nombre)		Biomasse (kg)		Taille moy.	Poids moy.
	IA	Fourch.	IB	Fourch.	(cm)	(kg)
2019	106 145	102 515	920	593	9	0.009
2020	64 924	78 650	868	1 053	10.4	0.013
2021	5 753	6 764	87	104	10.6	0.015
2022	169 613	261 161	1 593	2 316	9.4	0.009

Figure 21: Group 0 European sea bass Dicentrarchus labrax in the Gironde estuary: maps of surface densities and biomasses at each of the stations sampled, in 2022 (left) and between 2019 and 2021 (right); graph (center) of annual abundance indices determined using the RSUFI scripts and their framing ranges at the 5% error threshold; summary table of annual values of abundance and biomass indices, their framing ranges at the 5% error threshold, mean sizes and mean weights (RSUFI script; bottom left). Domain-wide high catch size distributions in 2022 vs. 2019-2021 (bottom right).



Années	Abondance (nombre)		Biomasse (kg)		Taille moy.	Poids moy.
	IA	Fourch.	IB	Fourch.	(cm)	(kg)
2019	402 833	451 819	33 089	22 932	17.7	0.082
2020	221 573	114 526	36 296	24 176	22.4	0.164
2021	174 151	123 542	27 568	24 829	21.9	0.158
2022	87 180	56 258	21 045	14 175	27	0.241

Figure 22: European sea bass Dicentrarchus labrax groups 1 and above in the Gironde estuary: maps of surface densities and biomasses at each of the stations sampled, in 2022 (left) and between 2019 and 2021 (right); graph (center) of annual abundance indices determined using the RSUFI (blue) and RSTRATI (red) scripts and their framing ranges at the 5% error threshold; summary table of annual values of abundance and biomass indices, their framing ranges at the 5% error threshold, mean sizes and mean weights (RSUFI script; bottom left). Domain-wide high catch size distributions in 2022 vs. 2019-2021 (bottom right).

6 European sea bass Dicentrarchus labrax in the Douarnenez Bay

As in the Seine et Loire, the European sea bass Dicentrarchus labrax is one of the core species of the Douarnenez bay. Its average capture occurrence, all age classes combined, amounted to 48.7% over the 2018-2023 period (Tableau 4)

Tableau 4 : Overview of seabass catches in the Douarnenez bay

Raw data Douarnenez Bay				
year	Total trawl haul	Number of trawl haul with seabass	Number of seabass	weight (Kg)
2018	43	30	747	292
2021	63	8	404	45
2022	64	44	201	77
2023	60	30	323	122

Figure 24 presents seabass index calculated across time with standard deviation associated. This index will be tested in the future assessment model. Following chapter details by age group results.

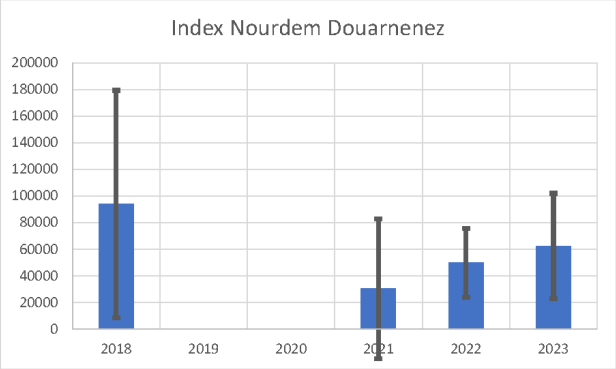


Figure 23 : Seabass index and standard deviation associated across time calculated for Nourdem Douarnenez (all ages combined)

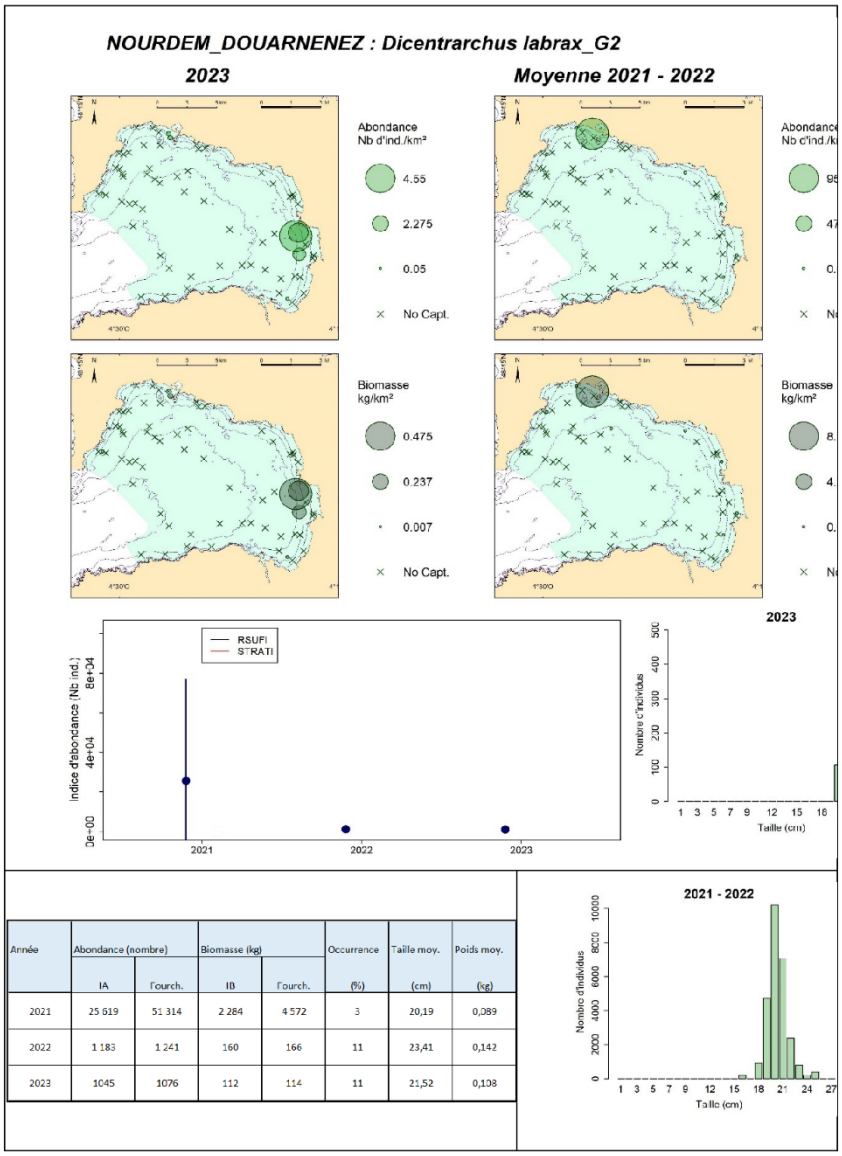
6.1 Group 0 and 1 European sea bass

Although the bay is bordered by fishing "spots" known for their richness in adults, we have not caught any G0 or G1 during the campaigns carried out to date. These very young individuals are known to live in very coastal water, and are therefore difficult to sample using a trawl towed behind a fishing vessel. The Marine Park's PNMI beach trawl surveys show the presence of some juveniles of these first two age groups in the freshwater inlets of the Aber, Kervel and Ris beaches, but in small quantities. The total absence of catches during our NourDem campaigns, coupled with the very low catches recorded by the PNMI as part of its coastal monitoring, indicate that the bay does not constitute a real nursery area for this species.

6.2 Group 2 European sea bass

Catches of G2 bass were infrequent and insignificant (except in 2021) compared with those of G3+ over the 3 campaigns. The average occurrence of catches of individuals in this age group was only 8.5% (Figure 25):

3% in 2021 (i.e. catches during 2 hauls only), and ≈ 11% in 2022 and 2023 (catches during 7 hauls). The abundance and biomass indices are therefore low, and also not very accurate due to the large framing ranges obtained (no significant inter-annual differences). The catches (384 individuals in 2021, 7 in 2022 and 9 in 2023) were recorded almost exclusively on coastal features, and in particular on the beaches of Aber and Kervel, i.e. the places where G0 and G1 catches are recorded by the PNMI. Average annual sizes ranged from 20.2 to 23.4 cm.



Année	Abondance (nombre)		Biomasse (kg)		Occurrence	Taille moy.	Poids moy.
	IA	Fourch.	IB	Fourch.	(%)	(cm)	(kg)
2021	25 619	51 314	2 284	4 572	3	20,19	0,089
2022	1 183	1 241	160	166	11	23,41	0,142
2023	1045	1076	112	114	11	21,52	0,108

Figure 24 European sea bass Dicentrarchus labrax from Group 2 (i.e. born in 2019 for the 2021 season, in 2020 for the 2022 season and in 2021 for the 2023 season) in Douarnenez Bay: maps of surface abundance and biomass in 2023 (top left) and averaged over the years 2021 and 2022 (top right). Plot of annual changes in abundance indices and their framing ranges at the 5% error threshold. Summary table of the annual values of the indices of abundance and biomass, their framing ranges (RSUFI script; 5% error threshold), capture occurrences, and mean sizes and weights. Histograms of size distributions, raised to the entire domain, in 2023, and cumulated over the years 2021 and 2022. NourDem PNMI-DZ data.

On the other sites monitored as part of the NourDem campaigns (Seine, Loire and Gironde estuaries in particular), the experience acquired to date shows us that group 2 sea bass leave the shallowest waters immediately adjacent to the coast, and that they are therefore fully accessible to sampling using the GOV trawl. The low catches of G2 in Douarnenez Bay support the idea that this bay is not, strictly speaking, a nursery area for this species. This is still only a hypothesis, to be verified in future monitoring.

At the time of the surveys, the individuals in group 2 measured between 16 and 25 cm (for an average size of ≈ 21 cm).

6.3 Group 3+ European sea bass

These age groups showed significantly higher capture occurrences and indices of abundance and biomass than the G2:

- In 2021: 9.5% occurrence (captured during 6 of the 63 tows), with the capture of 19 individuals for a total biomass of 14.17 kg,

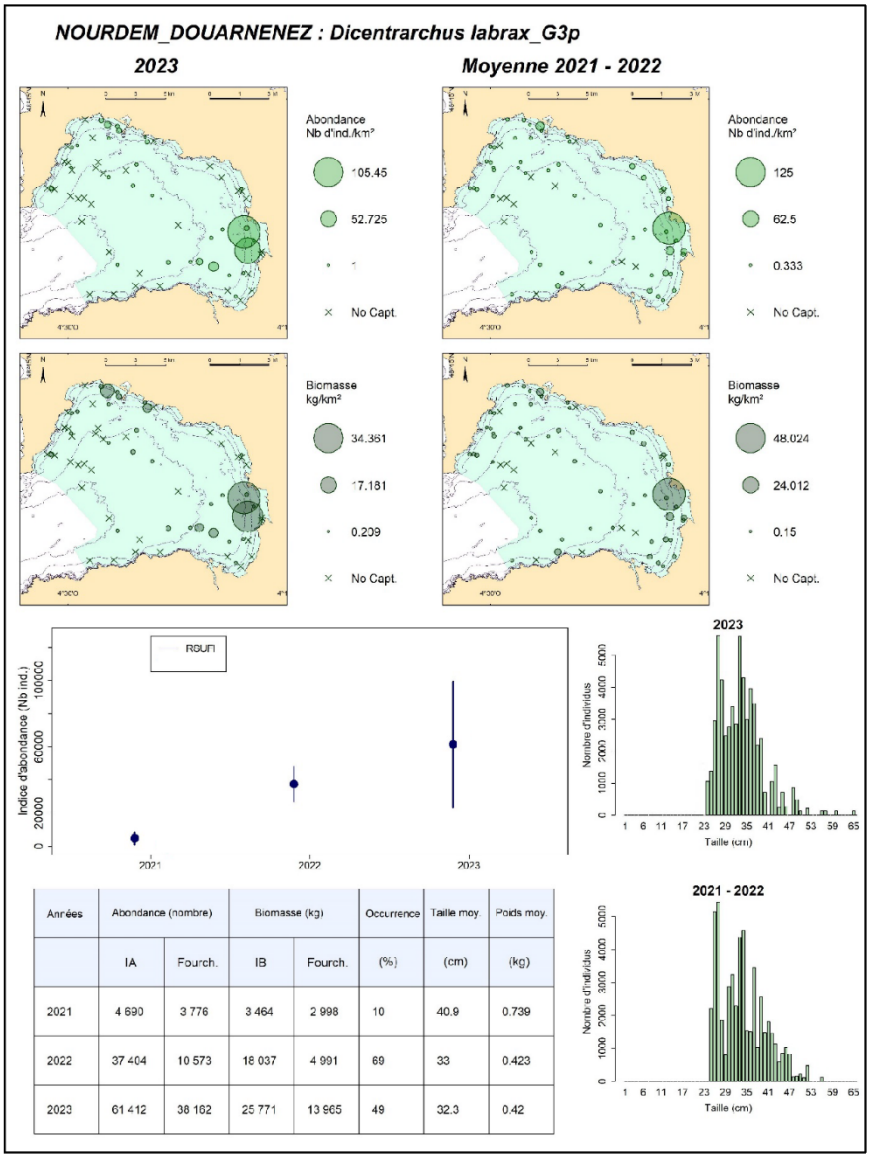
- In 2022: 68.75% capture rate (44 hauls out of 64) for a total capture of 195 individuals and a biomass of 85.1 kg.

- In 2023: 50% catch rate (30 hauls out of 60) for a total catch of 313 individuals and a biomass of 127.86 kg.

Taken over the entire area sampled, these catches give abundance indices IA of 4,690 +/- 3,776 individuals for a biomass IB of 3,464 +/- 2,998 tonnes in 2021, compared with 37,404 +/- 10,573 individuals and a biomass IB of 18,037 +/- 4,991 tonnes in 2022, 991 tonnes in 2022 and 61,412 +/- 38,162 individuals for 25,771 +/- 13,965 tonnes in 2023. The indices of abundance and biomass for 2022 and 2023 are significantly higher (at the 5% threshold) than those for 2021 but do not differ according to the RSUFI script.

After 3 years of monitoring, the entire area sampled appears to be colonised by G3+ sea bass, with the possible exception of a few deep sectors in the north of the central area of the bay. On the other hand, the coastal sectors around the north-east and the beaches of St Anne la Palud/Kervijen in the east have the highest densities (distribution to be confirmed by future monitoring).

Average catch sizes and weights were highest in 2021: 40.9 cm and 739 grams. In 2022 and 2023, the values are very similar: 32.3 and 33 cm average length for ≈ 420 and 423 grams average individual weight.



Années	Abondance (nombre)		Biomasse (kg)		Occurrence	Taille moy.	Poids moy.
	IA	Fourch.	IB	Fourch.	(%)	(cm)	(kg)
2021	4 690	3 776	3 464	2 998	10	40.9	0.739
2022	37 404	10 573	16 037	4 991	69	33	0.423
2023	61 412	38 162	25 771	13 965	49	32.3	0.42

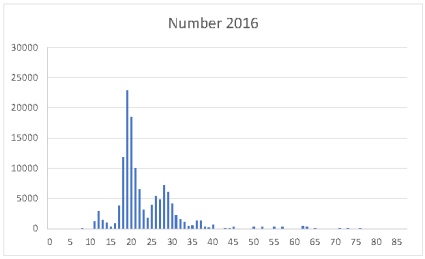
Figure 25: European sea bass Dicentrarchus labrax of Groups 3 and + (born in 2018 or earlier for the 2021 season, in 2019 or earlier for the 2022 season, and in 2020 or earlier for the 2023 season) in Douarnenez Bay: maps of surface abundance and biomass in 2023 (top left) and averaged over the years 2021 and 2022 (top right). Plot of annual changes in abundance indices and their framing ranges at the 5% error threshold. Summary table of the annual values of the indices of abundance and biomass, their framing ranges (RSUFI script; 5% error threshold), capture occurrences, and mean sizes and weights. Histograms of size distributions, raised to the entire domain, in 2023, and cumulated over the years 2021 and 2022. NourDem PNMI-DZ data.

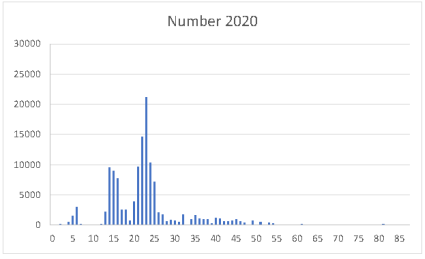
7 ANNEX: Numbers at length and ALK

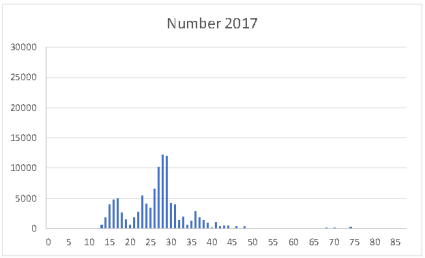
This section provides all raw information available, numbers at length and Age length key for each survey. These data will be used as input data in the future model developed at WKSEABASS in November 2024. This will complete indices presented in Figure 9, Figure 15, Figure 21, Figure 24.

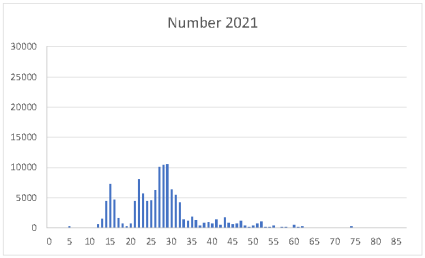
Loire estuary

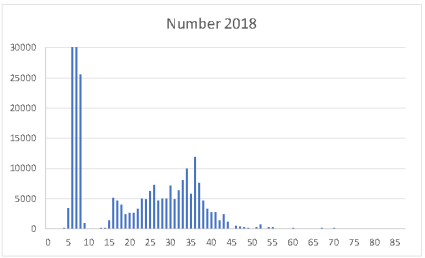
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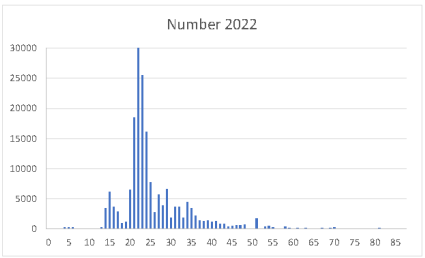

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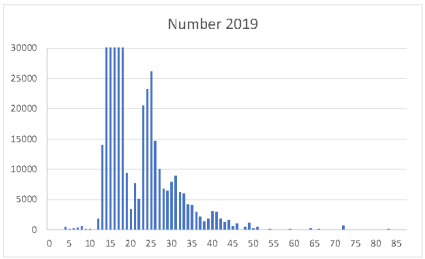

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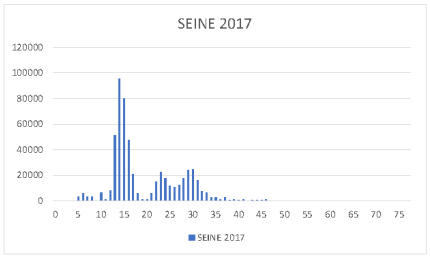

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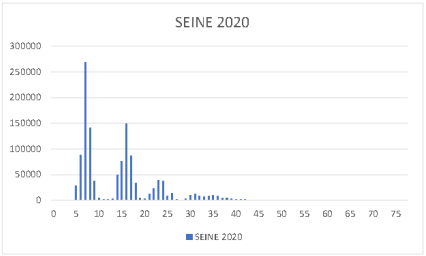

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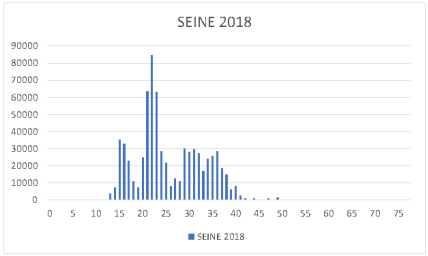

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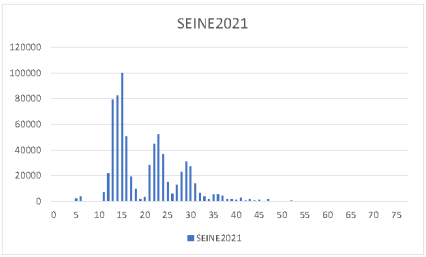
Seine estuary

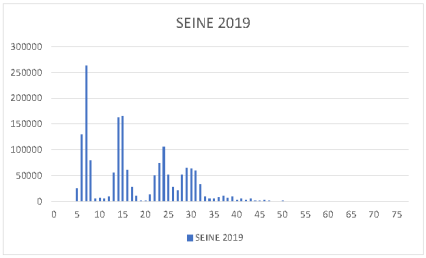
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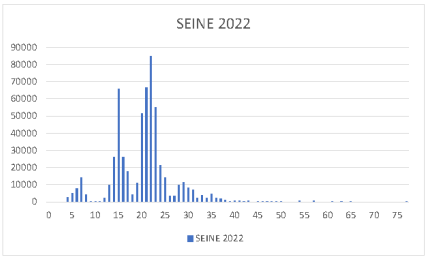

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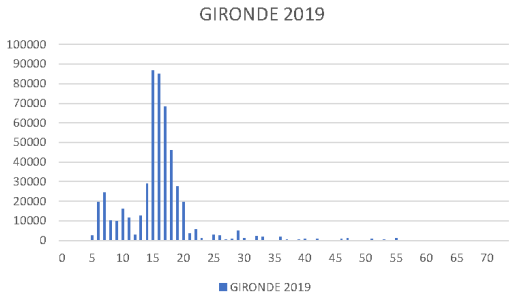

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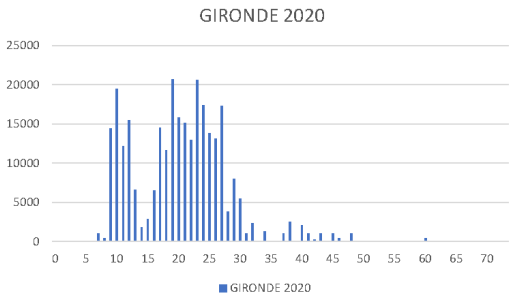

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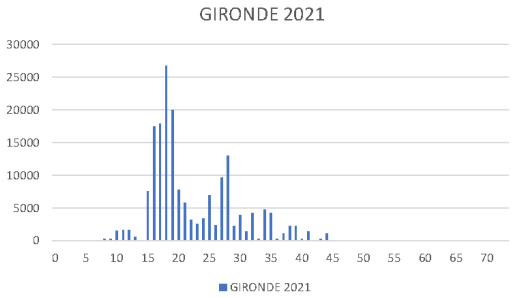

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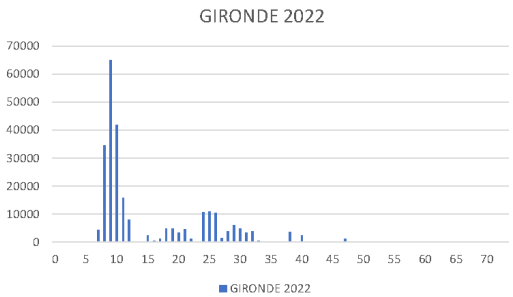

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SEINE 2022

Gironde estuary											
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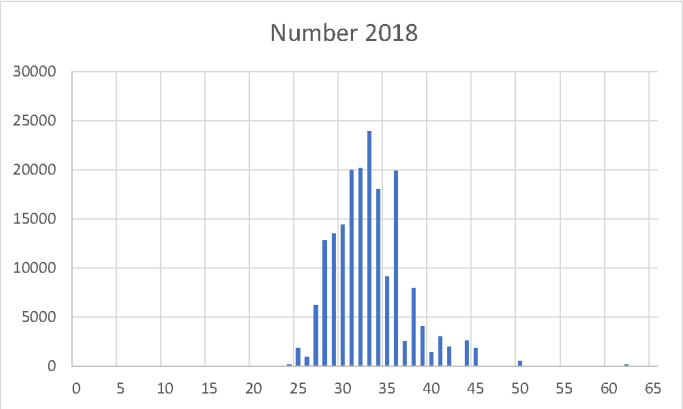

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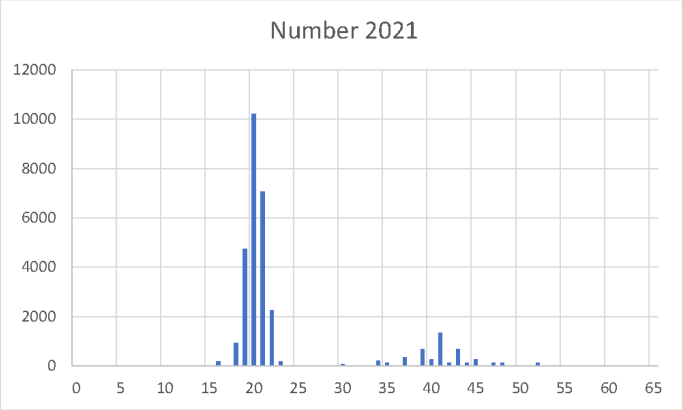

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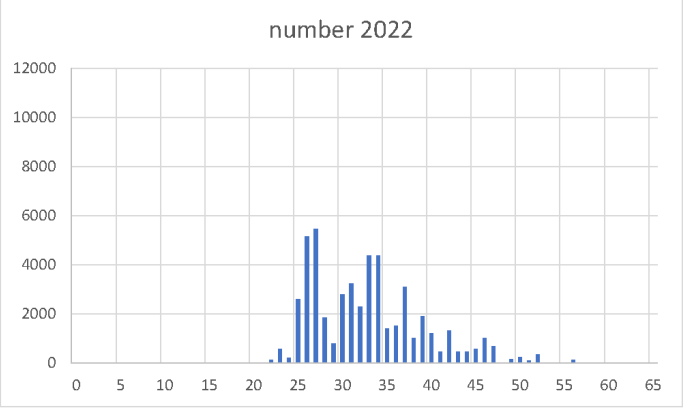

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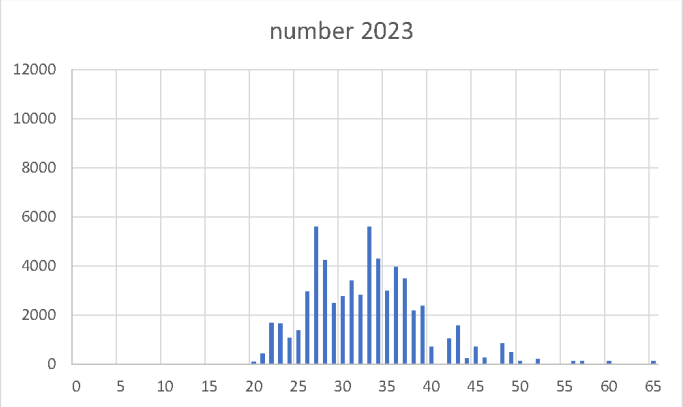

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Douarnenez Bay								
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Number 2021
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number 2022
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number 2023
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ALK Seine estuary								
2017								
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50								
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70								
80								
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100								
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360								
370								
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400								
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ALK Seine estuary								
2018								
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420								
430								
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450								
ALK Seine estuary								
2019								
size (mm)	age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
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80								
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400					1	1		
410								
420								
430								
440								

450								
ALK Seine estuary								
2020								
size (mm)	age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
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50								
60								
70								
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ALK Seine estuary								
2021								
size (mm)	age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
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ALK Seine estuary								
2022								
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ALK Loire estuary								
2016								
size (mm)	age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
50								
60								
70	2							
80	3							
90	4							
100	3	1						
110	5	6						
120	3	22						
130	1	10						
140		4						
150		3						
160		3	7					
170		5	15					
180		7	30					
190		4	24					
200		1	17					
210		2	9	1				
220		1	8					
230			8					
240			7	7				
250			11	12				
260			7	18				
270			6	11				
280			2	15				
290			3	13				
300				12				
310				15				
320				14				

330				9	1			
340				1				
350				5				
360				2	2			
370				5	2	1		
380				1	2			
390								
400						1		
410				1	1			
420					1			
430				1		1		
440					1		1	
450					1	3		

ALK Loire estuary								
2017								
size (mm)	age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
50								
60								
70								
80								
90								
100								
110								
120								
130		2						
140		5						
150		9						
160		5						
170		3						
180		1						
190		1						
200		1	1					

210								
220			3					
230			4					
240			1					
250				3				
260				7				
270				5				
280				7				
290				3				
300				4	1			
310								
320								
330				1				
340					3			
350					3			
360								
370					1			
380					1			
390								
400								
410						2		
420								
430								
440								
450								

ALK Loire estuary								
2018								
size (mm)	age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
50								
60	2							
70	7							
80	2							

90								
100								
110								
120								
130								
140		5						
150		8						
160		7						
170		5						
180		5						
190		2	1					
200		1	2					
210			1					
220			2					
230			5					
240			10					
250			4					
260			1					
270								
280			1					
290				1				
300				3				
310				3				
320								
330						1		
340					5			
350					2	2		
360					3			
370					2		1	
380					1	2		
390					2			
400								
410								
420					1	1		
430								

440								
450								

ALK Loire estuary								
2019								
size (mm)	age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
50								
60								
70								
80								
90								
100								
110								
120								
130		1						
140		4						
150		7						
160		7						
170		2						
180		1						
190		3	1					
200		5	1					
210		5	1					
220		2	3					
230		1	6					
240			5					
250			2	1				
260			3	1				
270			2	1				
280			2	3				
290			2	1				
300			1	5				
310				2				

320			2	3				
330				4				
340				4				
350				5		1		
360				1	4			
370				1				
380								
390				1	1			
400						1		
410								
420						1		
430								
440								
450								

ALK Loire estuary								
2020								
size (mm)	age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
50		3						
60								
70								
80								
90								
100								
110								
120		1						
130		8						
140		10						
150		8	1					
160		7	1					
170		4	1					
180		4	4					
190		3	1					

200			5					
210			9					
220			10	1				
230			8	1				
240			8	2				
250			4	1				
260		1	5	4	1			
270			5	2	1			
280			4	2				
290			1	5				
300				3				
310				3	1			
320				5	1			
330				6				
340				6	1			
350				6	2			
360			1	4		2		
370					2			
380					1			
390								
400					2			
410					2			
420					3			
430					2		1	
440					1	1	1	
450							2	

ALK Loire estuary								
2021								
size (mm)	age 0	age 1	age 2	age 3	age 4	age 5	age 6	age 7
50								
60								
70								

80								
90								
100								
110								
120		1						
130		7	1					
140		8	1					
150		3	2					
160		2	2					
170			1					
180			1					
190			1					
200			1	1				
210		1	12	1	1			
220			4	1				
230			4	2				
240			3	2				
250			2	5				
260			1	7	1			
270			1	6	1			
280			1	6	1			
290			1	4	3			
300				7	1			
310				5				
320				10	1			
330			1	6	1			
340				6	1			
350				5	1			
360				3				
370				1				
380					1			
390				1	3			
400					2	1		
410					2	3		
420					1	2		

430						3	2	
440					2		2	1
450					2		2	

ALK Douarnenez Bay							
2018							
size (mm)	a ge0	a ge1	a ge2	a ge3	a ge4	a ge5	a ge6
50							
60							
70							
80							
90							
100							
110							
120							
130							
140							
150							
160							
170							
180							
190							
200							
210							
220							
230							
240							
250							
260				1			
270				1	2	1	
280				2	8		
290					4		
300					1		
310					1		

320					1		
330					1	1	
340					2		
350							
360						3	
370					1	1	
380						3	
390					1	2	
400							1
410							
420							1
430							
440							
450							

ALK Douarnenez Bay				
2021				
size (mm)	age0	age1	age2	age3
50				
60				
70				
80				
90				
100				
110				
120				
130				
140				
150				
160				
170				
180				
190		8		
200		4		
210		6		

220		2		
230				
240				
250				
260				
270				
280				
290				
300				
310				
320				
330				
340				
350				1
360				
370				
380				
390				
400				
410				
420				
430				
440				
450				

ALK Gironde estuary						
2019						
size (mm)	age0	age1	age2	age3	age4	age5
70	1					
80	1					
90	2					
100	2					
110	2					
120	1	1				

130						
140						
150		2				
160		4				
170		2				
180		5				
190		3				
200		3				
210		2				
220		1				
230		1				
240						
250						
260						
270						
280						
290						
300						
310				1		
320				1		
330						
340						
350				1		
360						
370						
380						
390						
400						
410						
420						
430						
440						
450						

ALK Gironde estuary						
2020						
size (mm)	age0	age1	age2	age3	age4	age5
70						
80						
90	2	5				
100		10				
110		4				
120	5	2				
130	3	1				
140	3					
150		3				
160		3	1			
170		3	5			
180		1	2	1		
190			7	1		
200		1	2			
210		4	5	2		
220		1	3			
230		1	2	2		
240			1	3		
250			6	5		
260			1	4	1	
270			1	3	1	
280			1	3	1	
290			1	1	1	
300				2		
310				1	1	
320				1		
330				1		
340					1	
350					1	
360						
370					1	

380						
390						
400					1	
410					1	1
420						
430					1	
440						
450						

ALK Gironde estuary						
2021						
size (mm)	age0	age1	age2	age3	age4	age5
70						
80						
90						
100						
110						
120		1				
130		1				
140						
150		5				
160		7				
170		6				
180		9				
190		10				
200			1			
210		3	2			
220		3	3			
230		3	1			
240		1	2			
250			3			
260			10			
270		1	1			

280			6			
290			3			
300				2		
310			2			
320			1	3		
330				1		
340			1	2		
350				1		
360						
370				2		
380						
390				1	1	
400				1		
410				1	1	
420						
430				1		
440					1	
450						

ALK Gironde estuary						
2022						
size (mm)	age0	age1	age2	age3	age4	age5
70						
80						
90						
100						
110						
120						
130						
140						
150						
160						
170						

180						
190						
200		2				
210		5				
220		5				
230			5			
240			6			
250			5			
260			5			
270			4	1		
280			3	2		
290			1	2		
300			2	4		
310			2	2		
320				3		
330				4	1	
340				1	1	
350				2		
360						
370					2	
380					2	
390					4	
400					1	
410						
420						
430						
440						
450						

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Analysis of the Fal and Helford seabass pre-recruit survey

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Executive summary

This report presents an analysis of the Fal and Helford estuary sea bass (*Dicentrarchus labrax*) survey, which has been conducted annually by volunteers in the Cornwall Bass Investigations Group since 1997 to assess sea bass year class strength. The survey uses seine netting techniques to capture age 0 and age 1 sea bass in shallow estuarine habitats, providing valuable insights into the year-class strength of these early life stages. This dataset is important as an additional time series of year class strength of sea bass in the UK alongside the Solent survey. The survey employs two netting methods: "haul" and held. Data collection is typically conducted from May to September, with sampling efforts adjusted to protect newly settling fry and account for volunteer availability. Due to inconsistencies in data recording, only data from 2006 onwards were included in this analysis.

To generate a standardised index, a hierarchical clustering method was used to identify consistently sampled sites across years. This approach addressed interannual variability in site selection, which arises from logistical constraints. The index was generated by calculating catch per unit effort (CPUE) separately for each netting method, followed by z-score scaling to account for differences in effort units between the haul and held methods. The scaled CPUE values were then averaged across methods to produce a combined index that provides a stable and consistent measure of year class strength over time.

Fluctuations in year class strength were observed, with peaks in age 0 sea bass in 2016-2017 and 2023-2024. The combined CPUE for age 0 fish followed the trend observed in the haul method, though with reduced variation due to the inclusion of data from the held method. For age 1 sea bass, the index appeared more variable, reflecting the natural dispersion and movement patterns of older juveniles, as well as potential sampling limitations. This index is a valuable additional data set for the sea bass stock assessment and fisheries management, complementing the Solent survey in offering insights into juvenile abundance trends that are critical for understanding population dynamics and sustainable management practices.

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1 Introduction

European sea bass (*Dicentrarchus labrax*) is a species of significant ecological and economic value, supporting both commercial and recreational fisheries across the UK and Europe (Hyder *et al.*, 2018; Radford *et al.*, 2018; Watson *et al.*, 2024). Effective management of sea bass stocks relies heavily on an understanding of year class strength (Pickett *et al.*, 2004; ICES, 2020) particularly for the early life stages that determine future population abundance. Currently, the primary survey utilised for sea bass recruitment is the Solent survey, which has a standardised index for seabass between age 2-4. However, the Solent survey is limited in its ability to capture age 0 and 1 fish, as these juveniles tend to inhabit areas close to the shore and further upstream in estuaries that are not sampled. Consequently, the index derived from the Solent survey may underrepresent the actual abundance of these critical juvenile age groups. In addition, patterns in year class strength vary between estuaries (Watson *et al.*, 2024), meaning that the relavance of the Solent survey to the whole of the Northern stock is unclear.

Given these limitations, it is essential to explore alternative sources of data that can provide a more comprehensive view of sea bass year class strength in the UK. The Fal and Helford estuary survey, conducted annually since 1997 by volunteers in the Cornwall Bass Investigations Group (Bradley, 2023), presents addition useful data. This survey employs seine netting techniques that are suited to capturing juvenile sea bass within shallow estuarine habitats. By targeting specific estuarine zones where juvenile sea bass are known to occur, the Fal and Helford survey can support understanding of year class strength in stock assessments.

This survey design incorporates two netting techniques, haul and held. The haul method is well-suited for shallow, sheltered areas, while the held method is employed in more open or tidal locations, offering complementary data across different habitat types. With a focus on both age 0 and age 1 sea bass, the survey provides valuable insights into juvenile sea bass abundance and variability in year-class strength (Bradley, 2023).

Through the analysis of this multi-decade dataset, this report seeks to contribute a robust index of year class strength for the Fal and Helford. By integrating such data, fisheries scientists and managers can develop a more accurate picture of year class strength, informing sustainable management practices and supporting the long-term viability of seabass populations.

2 Methods

2.1 Data collection

The Fal and Helford estuaries are in the southwest of England (Figure 1) where juvenile sea bass are known to occur (Catherall, 2020). An annual seine net survey has been conducted in the Helford estuary since 1996, and the Fal in 2000, to assess sea bass year class strength. The main netting period is between May and September, and so covers the late spring, summer, and early autumn, with July excluded to protect newly settling fry from net damage. Two methods are used for sampling (see Figure 2): hauling the net up a gulley or inlet and bringing the ends together before bringing the net ashore (termed haul); and holding the net across the tide before bringing it ashore in a 'J' shape (termed held). Netting took place on average 14 times per year and was carried out at similar tidal states, restricted by boat availability, volunteer availability,

and weather. Efforts were made to cover a range of sites in both estuaries in the spring and the summer, with the main sites sampled twice within the spring and summer periods.



Figure 1: The location of the Fal and Helford Estuaries



Figure 2: A 'held' survey on the left and 'haul' survey on the right. Photo: Robin Bradley.

2.2 Data analysis

2.2.1 Timeseries selection

Due to inconsistencies with the records of the catch-at-age, effort, and location data pre-2006, these data were not included in the analysis. Furthermore, the survey has both spring (May – June) and summer (August – September) sampling wave with the spring survey to capture age 1 fish, and the summer to capture age 0. However, there is less consistency in the sites selected in the spring survey so only data for the summer survey are presented here.

2.2.2 Site selection

The sampling locations in this survey have varied across years due to the availability of volunteers with boats to access sites that cannot be accessed by foot. Additionally, opportunistic sampling of sites is conducted when extra resources are available, leading to annual fluctuations in the number of sites sampled. This variability may result in interannual variation in catch per unit effort (CPUE), particularly where productive but infrequently sampled sites are included. Further, minor shifts over time in sample site locations have occurred in response to changes in site morphology and inconsistencies in site names recorded have further complicated the identification of sampling sites.

To address these challenges, hierarchical clustering with a spatial tolerance of 1 km was applied. Distances between sampling coordinates were calculated using the sf package in R (Pebesma, 2018), followed by hierarchical clustering using the hclust function in R version 4.2.2 (R Core Team, 2022). This approach aimed to standardise site identification across years, enabling a more consistent comparison of sampling efforts and CPUE trends.

2.2.3 Generation of the index

A standardised catch per unit effort (CPUE) index was generated using only consistently sampled sites. Held and haul sampling have different metrics of effort, with held measured in time (minutes) and haul by area (m^2). Hence, held and haul were analysed separately.

CPUE standardisation was done using the following procedure. Catch (C) and effort (E) for each site i within year y, sampling method m and age a is defined as:

$$C_{i,y,m,a} = \sum_{j=i}^{n} C_{i,y,m,a,j} \quad (1)$$

and

$$E_{i,y,m,a} = \sum_{j=i}^{n} E_{i,y,m,a,j} \quad (2)$$

where j denotes each sample taken within a site. CPUE (P) for each site i was calculated by dividing the total catch by the total effort, and multiplying by the standard unit sampled (haul = 1000m^2, held = 10 minutes):

$$P_{y,m,a} = \begin{cases} 1000 \times C_{i,y,m,a}/E_{i,y,m,a} & for\ m = haul \\ 10 \times C_{i,y,m,a}/E_{i,y,m,a} & for\ m = held \end{cases} \quad (3)$$

The average CPUE for each year and method is then averaged across all sites sampled:

$$\bar{P}_{y,m,a} = \frac{\sum_{i=1}^{N_{y,m}} P_{i,y,m,a}}{N_{y,m}} \quad (4)$$

where $N_{y,m}$ is the total number of sites sampled in year y and method m. A normalised CPUE ($\hat{P}_{y,m,a}$) for each method was generated using the among year standard deviation between years ($\sigma_{\bar{P}_{m,a}}$):

$$\hat{P}_{y,m,a} = \frac{\bar{P}_{y,m,a}}{\sigma_{\bar{P}_{m,a}}}. \quad (5)$$

Finally, the index ($I_{y,a}$) in year y and age a were generated by creating an average scaled CPUE across the two methods:

$$I_{y,a} = \sum_{m=1}^{N_y} \hat{P}_{y,m,a} / N_y \quad (6)$$

where N_y is the number of sampling methods used in year y. In 2020, only the haul CPUE value was used as Covid restrictions meant that held sampling was not possible.

3 Results

3.1 Site selection

Hierarchical clustering revealed 10 distinct sampling clusters in the summer survey (Figure 3). However, only two of these for the haul and held sampling methods were sampled consistently over time (Table 1). Thus, only sites within these clusters were used for generation of the index for each sampling method (Figure 4; Table 2).

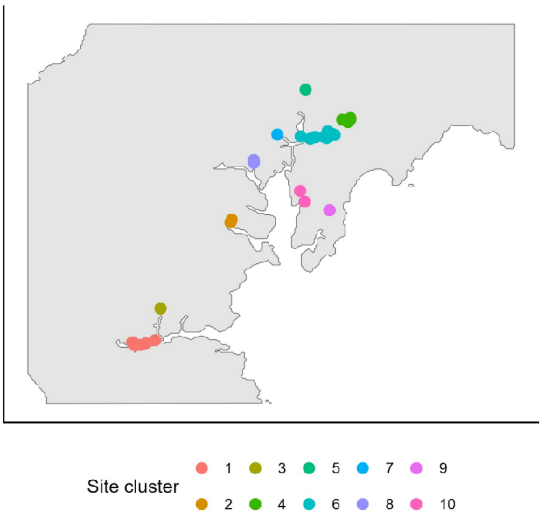


Figure 3: The clusters of sites as identified by hierarchical clustering with a distance tolerance of 1km.

Table 1: The number of years each of the sample clusters was sampled for the haul and held sampling methods.

Site cluster	Haul	Held
1	1	15
2	0	4
3	19	1
4	14	3
5	0	2
6	4	15
7	2	0
8	5	0
9	4	0
10	1	1

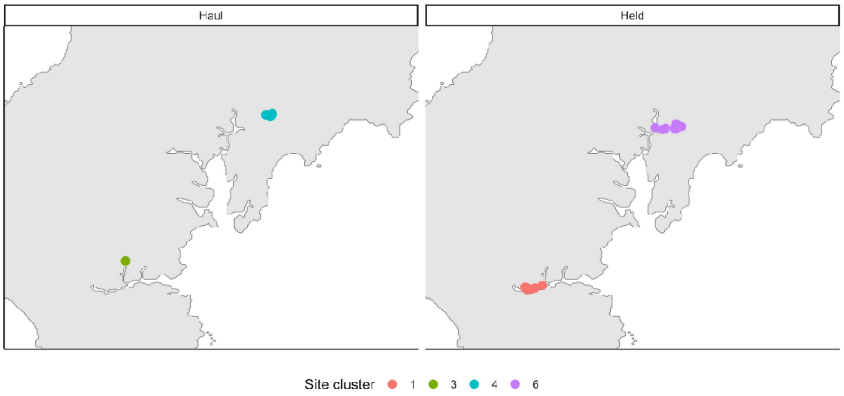


Figure 4: The site clusters used to generate the index for the haul and held survey methods.

Table 2: The sies within each site cluster used for generation of the index.

Site cluster	Site name	Used for
1	Merthen	Held
	Bonallack Main Channel	Held
3	Head of Polwheveral Creek	Haul
4	Lamorran	Haul
6	Ruan creek	Held

3.2 Generation of the index

For both age 0 and age 1 fish, the raw CPUE values for the haul and held methods show notable differences (Figure 5). For instance, in many years, the raw haul CPUE for age 0 fish appears much higher than that of the held CPUE, reflecting that the haul method captures more juvenile sea bass than the held method. After z-score scaling the CPUE, both sampling methods show a

similar trend in age 0 fish caught, with a peak around 2016-17, and an increase in CPUE in 2014, 2019 and 2023-24 (Figure 6). For age 1 fish, the standardised CPUE index appears to be highly variable. The combined CPUE for age 0 (Figure 7) generally followed the trend observed in the haul method, though with reduced variation due to the inclusion of data from the held method. For age 1 sea bass, the index appeared more variable (Figure 7).

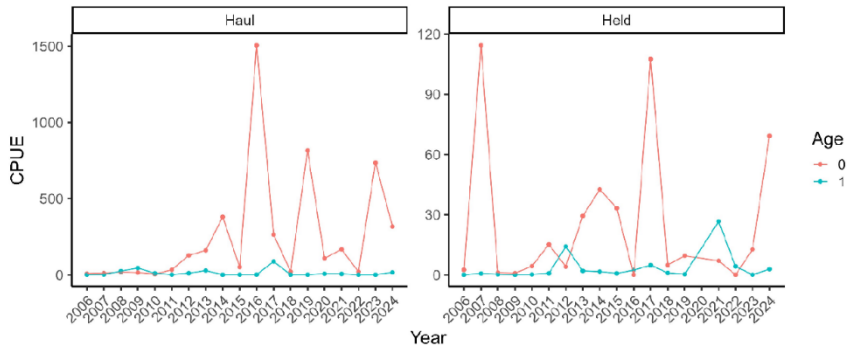


Figure 5: The average CPUE per year for the haul and held sampling methods where the CPUE for haul is standardised to 1km sampled, and held is standardised to 10 minutes sampled.

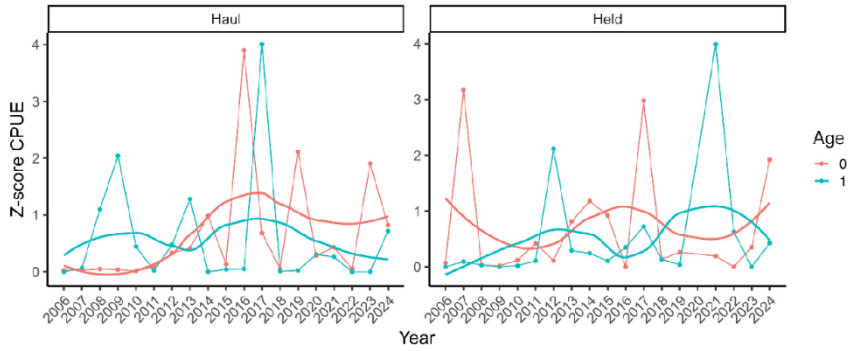


Figure 6: The average z-score scaled CPUE per year for the haul and held sampling methods where the CPUE for haul is standardised to 1 km sampled, and held is standardised to 10 minutes sampled. The lines represent a loess smooth function.

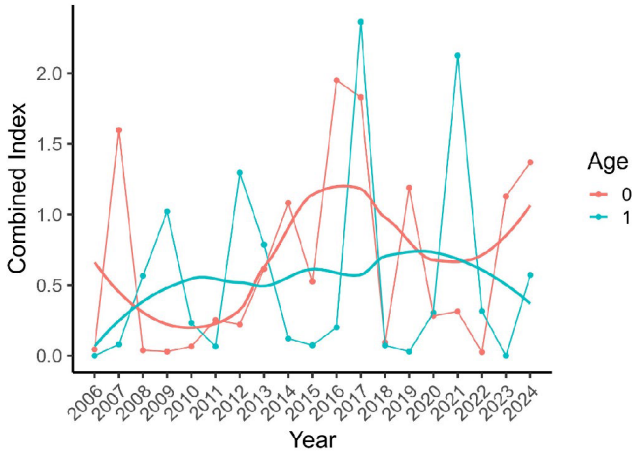


Figure 7: The combined and averaged z-score scaled CPUE from the haul and held sampling methods in the Fal and Helford survey for age 0 and 1 sea bass. The smooth lines represent a loess smooth function.

4 Discussion

The Fal and Helford estuary survey can be used to generate an index of year class strength for age 0 sea bass, capturing young fish within the shallow, estuarine nursery habitats where they are most likely to aggregate. However, there were challenges in developing a robust index for age 1 sea bass due to high variability and low catch rates.

For age 0 sea bass, the index of year class strength showed peaks in 2016-2017 and 2023-2024. These trends are important for stock assessments, as they indicate variations in early life-stage survival and year class strength that influence future population sizes. The Solent survey has provided a valuable index of sea bass year class strength for sea bass aged 2 to 4, but it is unclear how representative this is of the whole northern stock area. The Fal and Helford survey complements the Solent index, helping to form a more complete picture of sea bass year class strength. Together, these indices offer a more holistic view of sea bass year class strength, as they capture different life stages and estuarine systems.

In conclusion, the age 0 index derived from the Fal and Helford survey is a valuable additional data set for the sea bass stock assessment and fisheries management, complementing the Solent survey in offering insights into juvenile abundance trends that are critical for understanding population dynamics and sustainable management practices. Further analysis incorporating environmental conditions, such as temperature, could provide even deeper insights into drivers of year class strength (e.g., Watson *et al.*, 2024).

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Appendix 1: CPUE per year for age 0 and 1

Year	Raw Haul age 0	Raw Haul age 1	Raw Held age 0	Raw Held age 1	Scaled Haul age 0	Scaled Haul age 1	Scaled Held age 0	Scaled Held age 1	Combined age 0	Combined age 1
2006	8.2519	0.0000	2.4747	0.0000	0.0214	0.0000	0.0685	0.0000	0.0450	0.0000
2007	10.6803	1.4286	114.4015	0.6364	0.0277	0.0652	3.1686	0.0953	1.5981	0.0802
2008	18.6096	24.0909	1.0638	0.2128	0.0482	1.0997	0.0295	0.0318	0.0388	0.5658
2009	14.7059	44.7647	0.7692	0.0000	0.0381	2.0434	0.0213	0.0000	0.0297	1.0217
2010	4.4896	9.7244	4.3129	0.1389	0.0116	0.4439	0.1195	0.0208	0.0655	0.2323
2011	32.8771	0.4864	15.1642	0.7280	0.0851	0.0222	0.4200	0.1090	0.2526	0.0656
2012	127.3236	10.4195	4.0517	14.1379	0.3297	0.4756	0.1122	2.1162	0.2209	1.2959
2013	160.3968	28.0556	29.3333	1.9410	0.4153	1.2807	0.8124	0.2905	0.6139	0.7856
2014	380.3102	0.0000	42.5631	1.6216	0.9847	0.0000	1.1789	0.2427	1.0818	0.1214
2015	50.9722	0.9028	33.2121	0.7152	0.1320	0.0412	0.9199	0.1070	0.5259	0.0741
2016	1506.6667	1.1111	0.0000	2.3333	3.9011	0.0507	0.0000	0.3493	1.9506	0.2000
2017	263.3333	87.7778	107.5341	4.8220	0.6818	4.0069	2.9784	0.7218	1.8301	2.3643
2018	20.7593	0.1852	4.8605	0.9211	0.0538	0.0085	0.1346	0.1379	0.0942	0.0732
2019	816.3611	0.5000	9.5000	0.2500	2.1138	0.0228	0.2631	0.0374	1.1884	0.0301
2020	108.8889	6.6667	NA	NA	0.2819	0.3043	NA	NA	0.2819	0.3043
2021	166.7269	5.7407	7.0000	26.6500	0.4317	0.2621	0.1939	3.9891	0.3128	2.1256
2022	20.0000	0.0000	0.0000	4.2000	0.0518	0.0000	0.0000	0.6287	0.0259	0.3143
2023	736.1111	0.0000	12.6667	0.0000	1.9060	0.0000	0.3508	0.0000	1.1284	0.0000
2024	316.6111	15.7407	69.2991	2.8333	0.8198	0.7185	1.9194	0.4241	1.3696	0.5713

Ices Working document WKSEABASS
Catches description and Gears grouping

February 2025

Mickael Drogou

DRAFT

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1 Historical Commercial landings

1.1 Note on French estimates

Landings used in the assessment are extracted from Intercatch database. No data was available in Intercatch following the WKSEABASS data call for French fleet on the period 1985-1999. French landings from 1985 have been reconstructed during previous benchmarks (IBPNew 2012, IBPBASS 2014 and WKBASS 2017). In summary:

From 1999 onwards, French landings data from FishStat were replaced by more accurate figures from a separate analysis of logbook and auction data carried out by Ifremer (SACROIS methodology), in which landings have been correctly allocated to fishing ground. The time series for each component fishing ground therefore had a step change around 2000.

- for the Northern stock it has been necessary to assume that the ratio of landings for 2000 onwards can be applied for earlier years. Factors for adjustments have been calculated for each area and applied to the French landings data: for IVbc+VIId area 1.04 has been used; for VIIeh area 1.6 has been used, and for VIIafg 0.62 has been used (source: IBPNew 2012, WGCSE 2013, WGBASS 2005, IBPBASS 2014). Proportion of landings by metier has been calculated during WKSEABASS based on the proportion of landings of each metier before rescaling.

Figure 1 presents final landings by country for the Northern Stock used in WKSEABASS assessment.

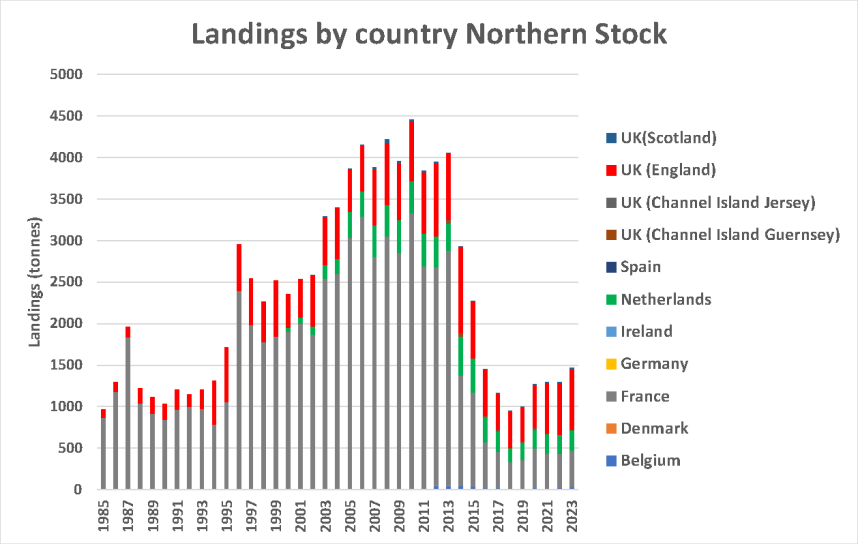


Figure 1: Commercial landings in the Northern Stock (source Intercatch)

-for the Bay of Biscay, WGBASS 2017 assessment meeting proposed to rescale the historical time-series of landings (before 1999), with the assumption that the step increase from 1998 to 1999 is an artefact of the change in the way the data were collected. Thus, the historical period from 1985 to 1998 have been rescaled by 943 tonnes (1998 Landings – average [landings 1999-2001]. Proportion of landings by metier has been calculated during WKSEABASS based on the proportion of landings of each metier before rescaling (historical data per gear available at IBPBASS 2014).

Figure 2 present final landings by country for the Southern Stock used in WKSEABASS assessment.

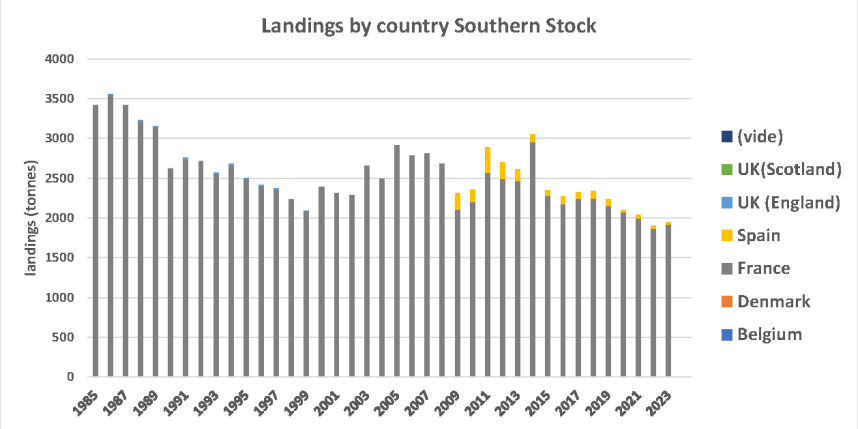


Figure 2 : Commercial landings in the Southern Stock (source Intercatch)

1.2 Note on historical UK and Dutch landings estimates

UK landings by gear type are recorded in official UK landings databases historically over the period 1985-2000.

The accuracy of total landings statistics for Subareas IV and VII are expected to have improved further since 2006 since the introduction of the registration of Buyers and Sellers in the UK, particularly for small vessels that do not have to supply EU logbooks.

The accuracy of Dutch landings data from area IV and VII has improved since the recreational line fishers were registered as commercial fishers when they want to sell their landings ((source IBPBass 2012)

No data was available for Netherlands prior 2000. From official landings (WGCSE 2024), very few NL seabass landings have been recorded in the database (no landings prior 1996, 8t in 1996, 1t in 1997, 48t in 1998 and 32t in 1999 representing respectively 0.3%, 0.04%, 2% and 1.2% of Ices estimates in the area (Source WGCSE 2024).

2 Focus on commercial landings by country over the period 2000-2024 (source Intercatch)-all stocks

French landings for 2000–present come from a separate analysis of logbook, auction data and VMS data (Sacrois database by Ifremer, which became in recent years official French official landings). UK landings by gear type are recorded in official UK landings databases (historically and "InterCatch" database). Other countries landings are extracted from Intercatch database. Level of confidence of data from 2000 onwards can be considered reliable.

Figure 3 presents total ICES seabass landings by country in areas 47 and 8ab. The bulk of seabass landings is made by France and to a lesser extent by the UK.

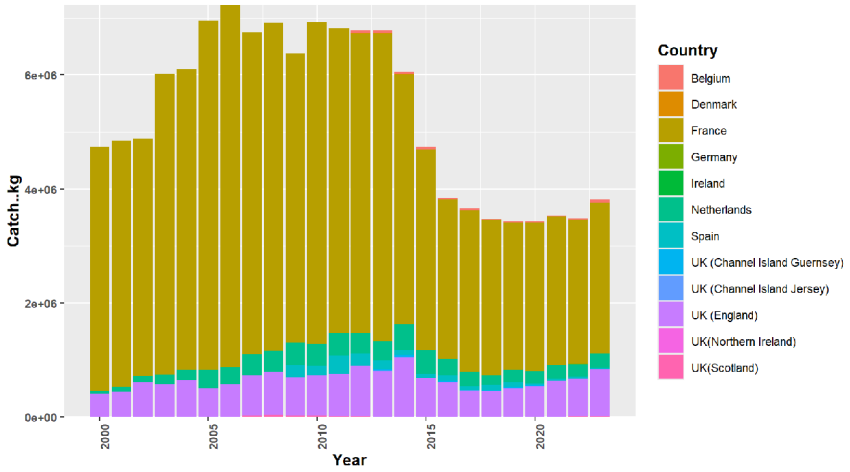


Figure 3 : landings by country in Northern and Southern Stock over the period 2000-2023 (source Intercatch)

2.1 Focus on commercial landings in the Southern stock over the period 2000-2024 (Source Intercatch) divisions 27.8ab

Sea bass in the Bay of Biscay is targeted mainly by France with more than 98.7% of international landings in 2023. Spain is responsible for about 1.3% of the catches in 2023. Proportion of landings by area 8a and 8b is given in Figure 4.

For France, the main metiers in the period 2000-2024 were nets (GNS and GTR), long liners (LLS), bottom trawlers (OTB) and pelagic trawlers (PTM). From 2000 onwards, PTM's landings have steadily decreased to a low level due to the movement of those vessels in the Channel (Ices division 7) during the 2000's. Following the strong management measures in this area in 2015, Pelagic trawlers practiced new métiers or disappeared of the area.

Line fisheries (handlines and longlines) take place all year-round (especially during quarters 3 and 4), while nets, pelagic and bottom-trawl fisheries take place from November to April, the period when prespawning and spawning sea bass aggregate to reproduce. In 2023, nets represent 37.6% of the landings of the area, lines 38.5%, bottom trawl 17.1%, pelagic trawl 2.5%, and other gears 4.3%.

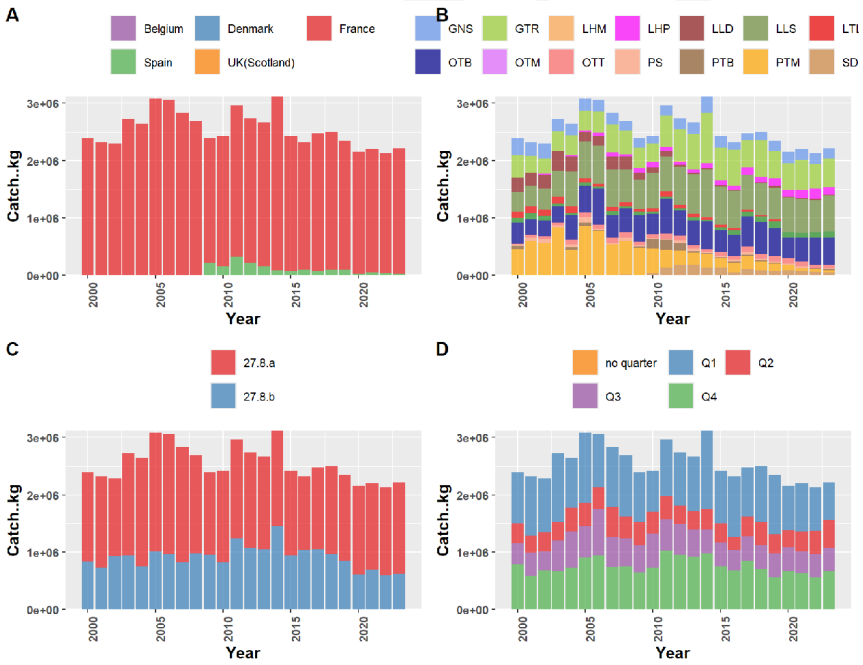


Figure 4 : Commercial landings in the Southern Stock (source Intercatch)

2.2 Focus on commercial landings in the Northern stock over the period 2000-2024 (source Intercatch) divisions 27.4bc7ad-h

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 2023, 1379 tonnes were landed (official source): 675 t by UK, 437 t by France, 231 t by Netherland, 32 t by Belgium 2t by Denmark, 2t by Germany and <1t by Channel Island (Figure 5).

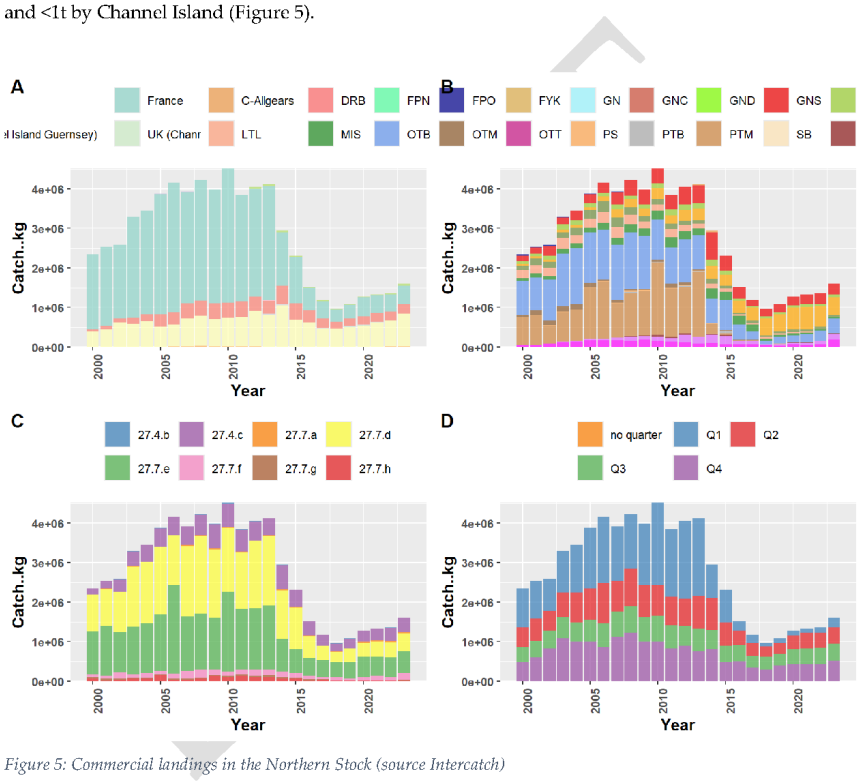


Figure 5: Commercial landings in the Northern Stock (source Intercatch)

3 Gear grouping in Southern stock for WKSEABASS assessment

Regarding the data call for WKSEABASS based on gears level 4, in the whole time series 1985-2024, gears groupings for SS3 assessment were made on the basis of landings in the area, length distribution of each gear, their selectivity and knowledge of the fishery.

Figure 6 presents by gears level 4 extracted from Intercatch numbers at length for landings (red) and discards (blue) over the period 2000-2023. Caton means catches and percentage indicate the proportion of catches of one gear compared to the whole catches.

Among 16 gears present in the Intercatch database, 12 main gears are also represented in Figure 6 with numbers at length associated.

Recommendation during WKSEABASS was to retain 6 main group of gears for the assessment in the Southern stock: LLS, GTR, GNS, OTB, PTM, and an OTHERS group (Table 1).

Table 1 : Gear grouping in Southern Stock

Gear Data call	LLS	LLD	GTR	OTB	PTM	OTM	GNS	OTT	MIS	SDN	LTL	PTB	PS	TBB	LHM	LHP
Grouping gears	LLS		GTR	OTB	PTM		GNS	OTHERS								

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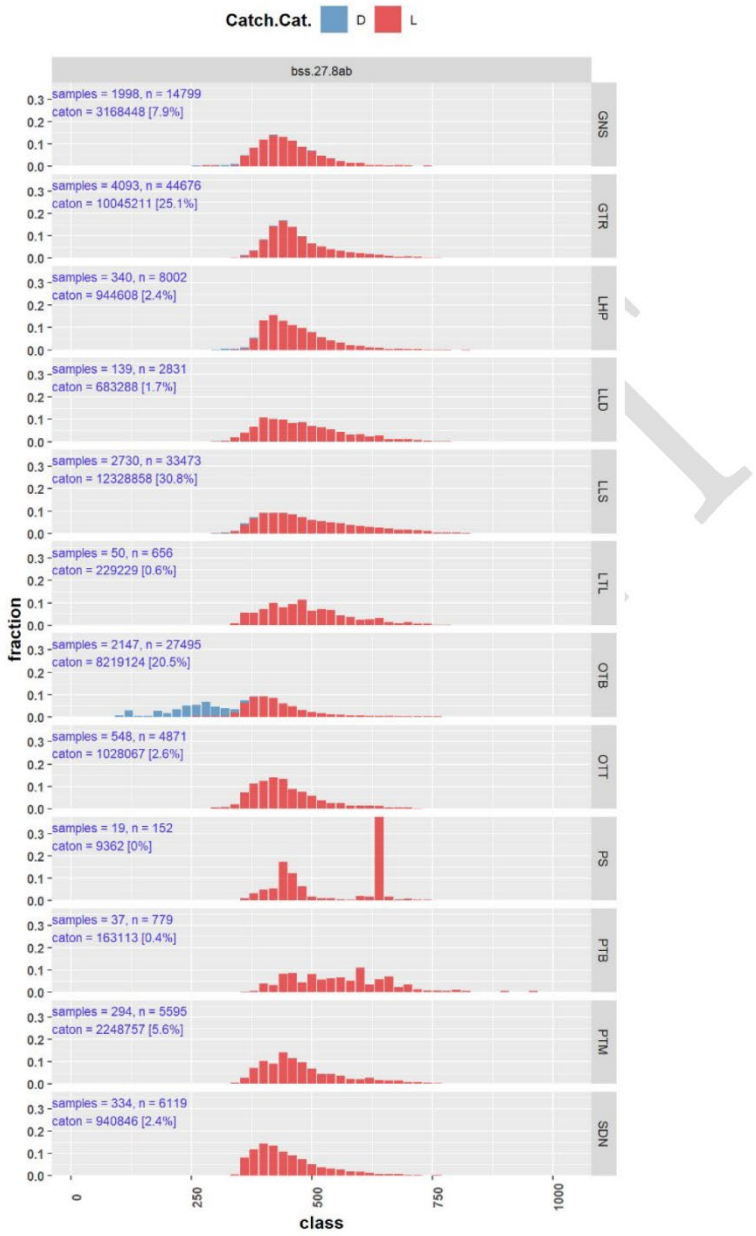


Figure 6: Numbers at length extracted from Intercatch data base by gears level 4 (all countries selected). Southern Stock Ices division 8a and 8b.

4 Gear grouping in Northern stock for WKSEABASS assessment

Regarding the data call for WKSEABASS based on gears level 4, in the whole time series 1985-2024, gears groupings for SS3 assessment were made on the basis of landings in the area, length distribution of each gear, their selectivity and knowledge of the fishery.

Figure 7 presents by gears level 4 extracted from Intercatch numbers at length for landings (red) and discards (blue) over the period 2000-2023. Caton means landings and percentage indicate the proportion of catches of one gear compared to the whole catches.

Among 26 gears present in the Intercatch database, 13 main gears are also represented in Figure 7 with numbers at length associated.

Recommendation during WKSEABASS in the Northern stock was to retain 7 main group of gears in the assessment (Table 2): GNS, LHM, LLS, OTB, PTM, SEINE and OTHERS.

Table 2: Gear grouping in Northern Stock

Gear Data call	Grouping gears
GNS	GNS
LHP	LHM
LTL	
LLS	LLS
OTB	OTB
TBB	
PTM	PTM
OTM	
SSC	SEINE
SDN	

Gear Data call	Grouping gears
MIS	OTHERS
GTR	OTHERS
PS	OTHERS
FPO	OTHERS
PTB	OTHERS
DRB	OTHERS
HMD	OTHERS
SB	OTHERS
OTT	OTHERS
FYK	OTHERS
LLD	OTHERS
SPR	OTHERS
FPN	OTHERS
GN	OTHERS
GNC	OTHERS
GND	OTHERS

NB: Gears groupings are different from one stock to another because of their amount of landings in the 2 areas, and their technical characteristics which are variable from one area/country to the other. For example, GTR used by French fishery is a main gear in the Bay of Biscay while it's not common in the Northern area.

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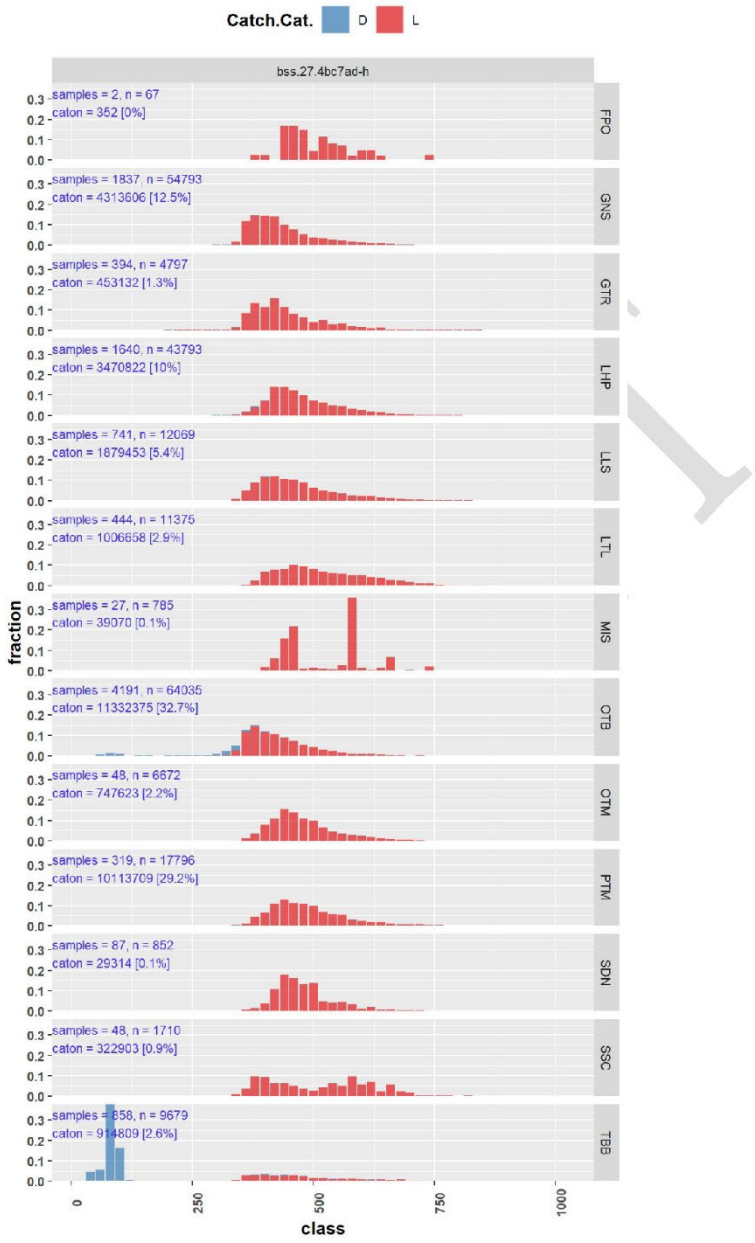


Figure 7: Numbers at length extracted from Intercatch data base by gears level 4 (all countries selected). Northern Stock Ices divisions 27.4bc7ad-h.

5 Commercial discards in the Northern stock

5.1 Sources of data

Discarding of sea bass 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.

In the absence of any data on discard survival, this has been assumed to be zero for all commercial fisheries.

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. Survival of sea bass 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 sea bass in different commercial fisheries.

Two sources of data are available for WKSEABASS to estimate commercial discards in the Northern Stock:

1/ Data from the UK and French on-board sampling programmes (source Intercatch). Those data are reported in Intercatch but seem to be underestimated because of the low level of trips sampled: the reason wouldn't be the nationals sampling schemes, but would be due to few fishing trips (mainly from trawlers), having a very high level of discards level. This makes hard to report seabass discarding through a sampling program.

Note that no discarding estimate are available for Netherlands which has limited findings in samples, does not meet data requirements for raising and do not have all important gears part in their sampling scheme

2/ Data from French log books: Following WGCSE recommendation, in the latest assessment (WGCSE), only for the French Fleet French observer data were replaced by logbook estimates, more realistic (French fishers have been encouraged to report their discards in logbooks because of the landings obligation).

Figure 8 plots landings, discards from Intercatch (observers programmes) and discards from French log books, showing the large difference between the 2 sources of information. Very few discards have been recorded except for OTB and to a lesser extent for SEINE.

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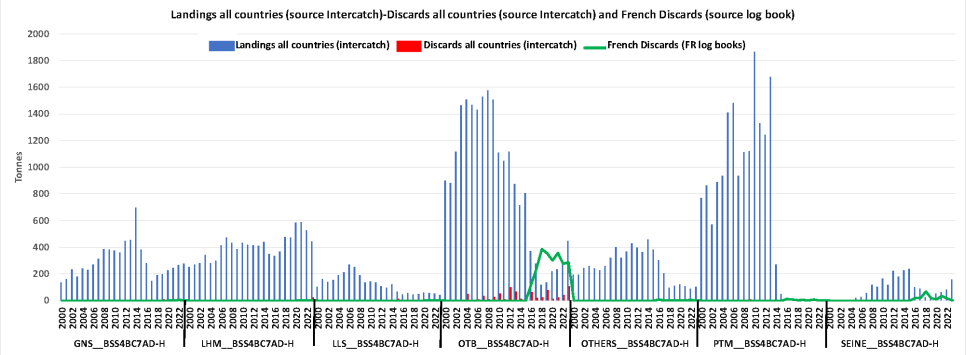


Figure 8: Landings and the 2 sources of discards estimates: from Intercatch (on-board sampling programmes) and from French Log books only.

Since management measures have been implemented in 2015, discard rates should have increased, which is not the case as shown in Table 3 with trawlers for example.

Table 3 : 2 sources of information for OTB discarding in the Northern Stock

	OTB__BSS4BC7AD-H		
Year	Landings (tonnes) all countries (source Intercatch)	Discards (tonnes) all countries (source Intercatch)	French discards tonnes (source French log book)
2010	1111	51	0
2011	1047	7	0
2012	1116	99	0
2013	875	68	0
2014	713	13	0
2015	805	35	0
2016	371	65	122
2017	277	21	243
2018	116	23	386
2019	135	79	353
2020	220	14	301
2021	234	25	357
2022	284	43	276
2023	446	108	286

5.2 WKSEABASS recommendation

WKSEABASS recommended for the current assessment to use the more realistic estimation of discards:

-To apply the French discards rates observed on OTB (OTB French discards from log books vs OTB French landings) to OTB landings of all countries from 2016 (year on which we can consider that French fishermen started to reliably declare their discards in their log books following management measures), and to use discards from Intercatch for OTB for the period 2000-2015 (sea See Table 4).

-To use all the discards from Intercatch for SEINE.

Also, in WKSEABASS assessment, discards used are from two sources: observers' programs from 2003 to 2015 and from a recalculation based on French log books from 2016 onwards. Only OTB and SEINE were taken into account. Discard for lines is unknow and will be assumed to be 0 in the models.

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Table 4 : OTB Discards time series retained by WKSEABASS for assessment (in green).

year	fleet name	French Landings Intercatch	French Discards log book	French discards rates log book	All countries Landings Intercatch	All countries Discards Intercatch	Discards All countries recalculated (French discards rates log book*All countries Landings Intercatch)
2000	OTB_BSS4BC7AD-H	707,6			900,6		
2001	OTB_BSS4BC7AD-H	686			882,9		
2002	OTB_BSS4BC7AD-H	867,1			1117,5	0,0	
2003	OTB_BSS4BC7AD-H	1113,7			1464,8	2,5	
2004	OTB_BSS4BC7AD-H	1173,7			1508,4	49,6	
2005	OTB_BSS4BC7AD-H	1082,7			1466,2	1,2	
2006	OTB_BSS4BC7AD-H	1043,5			1430,8	8,5	
2007	OTB_BSS4BC7AD-H	1134,6			1527,3	34,3	
2008	OTB_BSS4BC7AD-H	1167,6			1576,2	10,2	
2009	OTB_BSS4BC7AD-H	1108,9			1505,5	25,9	
2010	OTB_BSS4BC7AD-H	794,1			1110,8	51,1	
2011	OTB_BSS4BC7AD-H	759,2			1046,9	7	
2012	OTB_BSS4BC7AD-H	824,6			1116,2	98,6	
2013	OTB_BSS4BC7AD-H	644,2			874,8	68,3	
2014	OTB_BSS4BC7AD-H	492,1			712,7	12,8	
2015	OTB_BSS4BC7AD-H	617,7			805,4	34,5	
2016	OTB_BSS4BC7AD-H	255,6	121,6	0,3	370,8	64,6	119,5
2017	OTB_BSS4BC7AD-H	170,7	242,9	0,6	276,6	21,4	162,4
2018	OTB_BSS4BC7AD-H	63,5	385,5	0,9	116,3	23,1	99,9
2019	OTB_BSS4BC7AD-H	78,9	353,2	0,8	134,7	79,4	110,1
2020	OTB_BSS4BC7AD-H	140	300,8	0,7	220,3	13,6	150,3
2021	OTB_BSS4BC7AD-H	143,8	357,3	0,7	234,4	24,8	167,1
2022	OTB_BSS4BC7AD-H	161,5	275,7	0,6	284	42,9	179,1
2023	OTB_BSS4BC7AD-H	216,9	286,1	0,6	445,8	107,8	253,6

5.2.1 Note on UK discards (R.Skirrow et al, January 2024 for WKSEABASS).

3 discards data sources are available in UK: at sea observers programme (current source of discard data), scientific REM programme in the Celtic Sea and Fisher's catch recording. Pros and cons have been presented for each source.

5.2.1.1 Observer's programme:

Pros: discard data from observers are independently and consistently recorded, with high level of quality data on catches and discards from sampled fishing trips. The consistent data series of 20 years is currently used to estimate seabass discards for UK vessels.

Cons: Observer coverage of the English fleet is low, typically <1% of the total fishing activity. Therefore, less commonly caught or rare species may not be representatively sampled. The level of aggregation across vessel types and areas and the low sampling coverage can lead to high levels of uncertainties in estimated catch and discards when extrapolating data to the whole fleet.

5.2.1.2 REM programme:

This programme has been conducted on 3 Celtic Sea trawls since October 2020: all seabass are presently separately to a camera allowing the collection of length measurements

Pros: REM offers the potential for 100% coverage of all vessels and census data on all bass catches. However, the current programme is limited in scope (only sampling the otter trawl fleet in the Celtic Sea) so can only provide data on one metier, while the small number of participating vessels mean the data may not be representative of the wider fleet. The review level, currently at 10% (restricted by analyst resource) further limits the amount of data that can be generated.

Cons: Estimates derived from REM are independently and consistently generated, although further work is needed to compare the data generated from REM to that from observers. Also, if skippers' haul-level reported discards can be validated using REM, it would demonstrate the quality of the skippers' data, which could become the primary source of data, with REM used only for validation.

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5.2.1.3 Fishers' Catch Recording:

-Vessels >10m in length required to keep a record of their fishing activity via a logbook (>12m e-logs, 10-12m paper) since 2012. Skippers reporting of catches and fishing activities via logbooks is well established and the reporting requirements have been consistent for more than 10 years. The logbooks also have the function to record discards. However, it is more difficult to monitor compliance by fishers with discard reporting, as this happens at sea, moreover, there is a requirement to record discards only when they exceed 50kg per 24 hours. Therefore, with unknown levels of compliance with reporting and levels of consistency between skippers, the quality of the seabass discard data from logbooks cannot be determined. It is also noted that the reporting requirements are at intervals of 24h hours, and so cannot be compared directly with the haul-level information generated by observers and REM.

The number of fishers' records reporting bass discards is only 2% of the number of bass landings records:

- This is more likely due to lack of reporting rather than no discards
- Discard reporting is concentrated within some metiers and with a small number of vessels within those metiers, e.g. OTT in 7.e
- Do data from these specific metiers offer another source of bass discard data?...

Exploring a subset of the fishers' logbook data for metiers with higher levels of discard reporting:
- Fishers' reported discard rates for OTT in 7.e are 13-21%, and TBB in 7.e 10-63% for the period 2021-2023
- We do not know what the motivations are for skippers to report and not report discards

-Vessels under 10m in length and not part of a Producer Organisation (PO), to record details of all trips where fish are caught enforced since 2022. System will generate more consistent and accurate data on seabass landings and provide a mechanism for fishers to report seabass discards for the first time.

However, as with logbooks, it is more difficult to monitor compliance with discard reporting, because this happens at sea. Therefore, the new reporting requirements will improve seabass landings data, although it may take some time for the new system to become established, and the benefits of additional seabass discard data will be dependent on the consistent and accurate recording by fishers

Cefas for WKSEABASS recommends:

-More time and coverage needed for REM and fishers catch recording to provide robust data, including promoting importance of fishers recorded discards

-Observer programme has limited coverage of under 10s and may miss large sporadic discards of sea bass, but should at least be maintained at current level

-Observer programme is best data set at present, but many issues with use in assessment due to uncertainty

-Discard survival limited –need to consider

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6 Commercial discards in the Southern stock

6.1 Sources of data

In the Southern Stock where catches are largely dominated by the French fishery, national measures have been put in place, in order to follow Ices advices. Management measures, because of the state of the stock, are less restrictive compared to those of the Northern Stock. In the absence of very restrictive catch limitation such as in the North, fewer discards are observed in the area. It is assumed that the observer program allows for correct discards 'estimation. Figure 9 compares estimates from observers' program and estimates from French log books.

NB: No data from Spain is available but discarding is considered as negligible in the area compare to the very low level of Spanish landings.

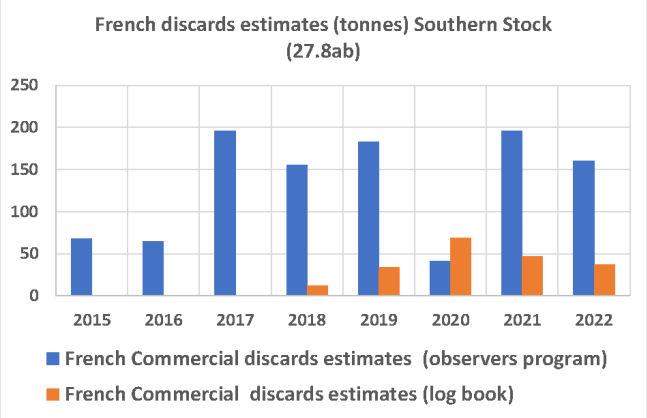


Figure 9: Sources of discard estimation for French fleet in Southern Stock (divisions 27.8ab)

6.2 WKSEABASS recommendation

WKSEABASS agreed to use discards estimates from observers' program (Intercatch data) in the assessment. Data are available from 2003 onwards for OTB, GNS, GTR and LLS (figure xxxx).

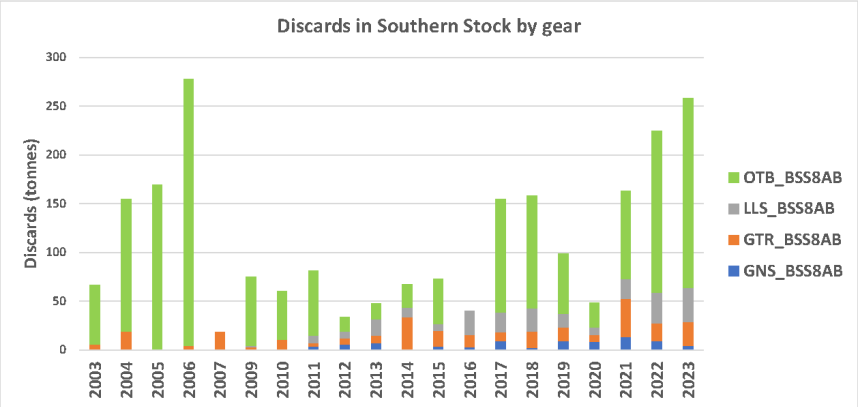


Figure 10: Discards used in WKSEABASS assessment by gears (Source onboard observers programme IntercatchFinal catches used for WKSEABASS assessment

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7 Reallocation of commercial and recreational landings from Northern Stock to Southern Stock

The analysis of the DST tagging data (Annex 6) shows that the stocks of seabass from the Bay of Biscay (Southern stock) and the Channel – North Sea (Northern stock) mix during the feeding season (summer and autumn). At that time, many seabasses from the Bay of Biscay are found in the western channel (and to a lesser extent in the eastern channel) where they can be caught by the fishery operating in that area.

From the tagging experiment, it was possible to estimate the proportion of fish in quarter 3 and quarter 4 present in the Channel and the North Sea that would migrate to the Bay of Biscay at the end of each of those two quarters. Hence, 28.8% of adult seabass are estimated to migrate from the Northern Stock to Southern Stock area at the end of quarter 3 (on the 1st of October) and 40.7% at the end of quarter 4 (on the 1st of January). 28.8 % of seabass caught in the Northern Stock area from July 1st to September 30 are therefore allocated to the Southern stock and, similarly, 40.7 % caught in the Northern Stock area from October 1st to December 31th.

Calculation have been made only on landings, considering that discards are mainly young individuals who do not migrate. To get the final reallocation, several steps have been necessary:

1/ Reconstruction of quarterly landings over the historical period 1985-2000: as shown previously historical times series are incomplete in Intercatch and have been recalculated, but without the quarterly information (only annually). Proportion of quarterly landings over the period 2000-2005 has been applied to historical period reconstructed in order to have quarterly landings reconstructed.

2/ Based on the proportion of fish that would migrate (28.8% and 40.7%) from one stock to the other, depending of the period (respectively quarter 3 and quarter 4) it has been possible to recalculate landings reallocated from North to South. An example of calculation on commercial landings is proposed on Figure 11. Also, for the year 2000, 306.7 tonnes are removed from the Northern Stock and added to the Southern Stock.

Northern commercial landings (tonnes) before calculation -example on year 2000-	Quarter 1 January 1st to March 31th	Quarter 2 April 1st to June 30th	Quarter 3 July 1st to September 30th	Quarter 4 October 1st to December 31th
	1004	483,6	389,4	478,3
Reallocation rates				
0,407 from North to South January 1st				
0,288 from North to South October 1st				
Reallocation landings (qua	"=478.3*0.407"=194.5			
	"=389.4*0.288"=112.2			
Total reallocation landings	"194.5+112.2=306.7"			

Figure 11 : example of reallocation calculation for the year 2000 based on migrating proportions of seabass from Northern Stock to Southern Stock

3/ Reallocation of landings calculated in 2/ has been split and applied to each gear group, using their proportion of landings to the total landings (for a given year).

NB: recreational landings have been integrated too in the calculation of reallocation. See Annex 1

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8 Final catches used in Southern Stock

Regarding proposal for gear grouping, reconstruction of historical times series and reallocation of landings from North to South, final catches used in WKSEABASS assessment are presented in Figure 12.

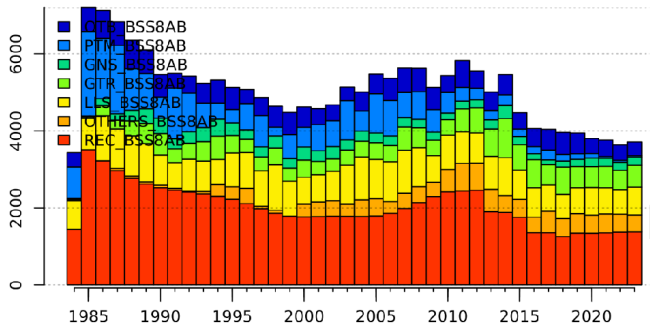


Figure 12 : final catches used in WKSEABASS assessment. Southern Stock, divisions 27.8ab

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9 Final catches used for WKSEABASS Northern Stock

Regarding proposal for gear grouping and reconstruction of historical times series, final landings used in WKSEABASS assessment are presented in Figure 13.

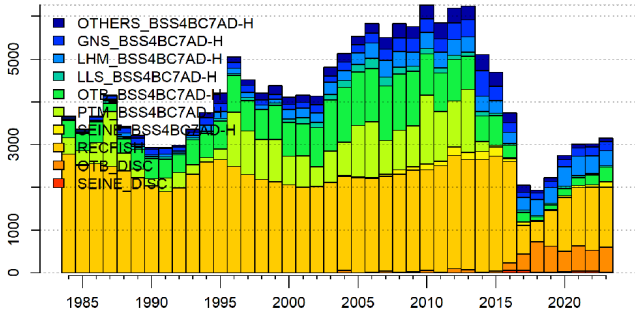


Figure 13: final catches used in WKSEABASS assessment. Northern Stock, divisions 27.4bc7ad-h

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10 Commercial length and age compositions

The landings length and age compositions have been thoroughly reviewed by previous inter-benchmarks, and are currently used in seabass assessment (WGBIE and WGCSE). Length composition and Age composition used for WKSEABASS are recorded under the database Intercatch. In the SS3 assessment ALK are finally used too. Those data haven't been asked during the data call. This has been later asked to stocks coordinators and has been sent in time for the assessment. Data are available only from France, UK and Netherlands.

10.1.1 Commercial length compositions in the Southern Stock

Figure 14 present length structure (landings and discards) per gears used in the WKSEABASS assessment (source Intercatch)

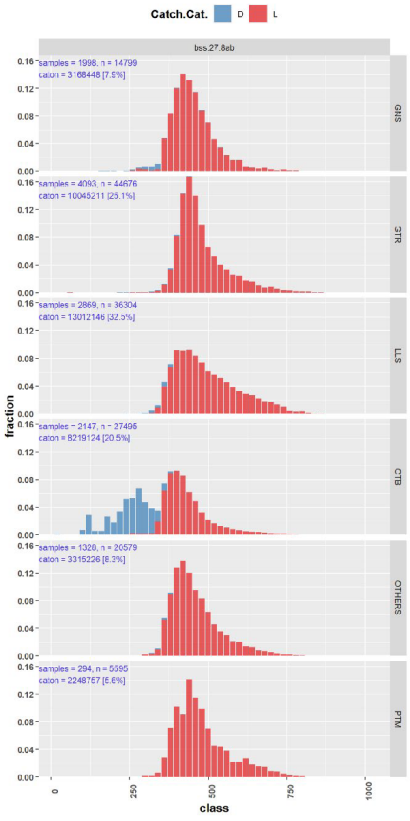


Figure 14 : Length frequencies by gear used in WKSEABASS assessment for Southern Stock

10.1.2 Commercial age compositions in the Southern Stock

Table 5: numbers of seabass aged by country (Southern Stocks)

Southern Stock	France
2004	28
2006	40
2009	1
2010	56
2011	174
2012	440
2013	874
2014	1282
2015	898
2016	1357
2017	808
2018	943
2019	1026
2020	1059
2021	1083
2022	944
2023	1225
2024	186

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10.1.3 Commercial length compositions in the Northern Stock

Figure 15 presents length structure (landings and discards) per gears used in the WKSEABASS assessment (source Intercatch)

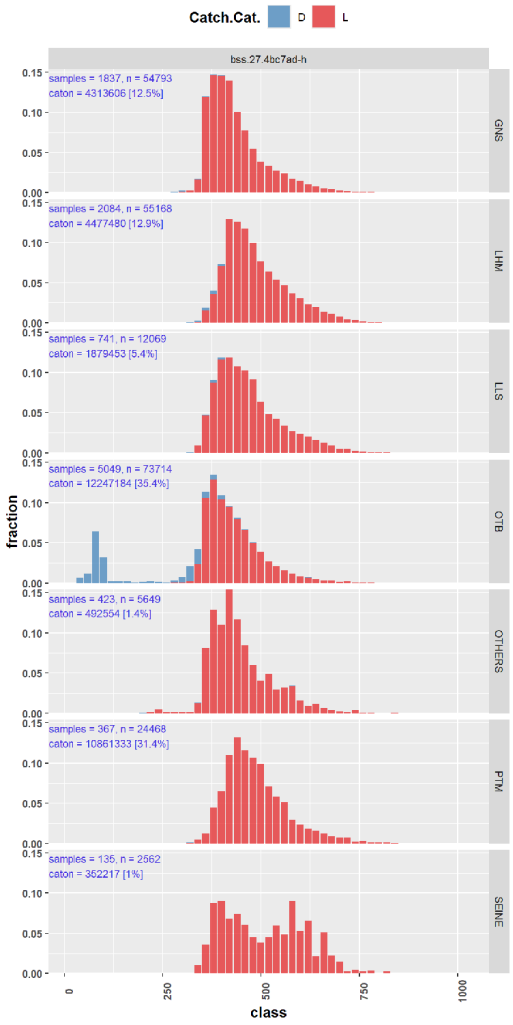


Figure 15: Length frequencies by gear used in WKSEABASS assessment for Northern Stock

As shown on Figure 15, OTB discard very small individuals. The smaller peak (roughly under 12cm) corresponds to samples taken from shrimpers (OTB_CRU which has been mixed with OTB for the WKSEABASS data call based on metiers level 4), both UK and France. Those gear do not catch commercial size bass, just small one, and their discards usually go back alive (from what observers report – minus some bird predation).

WKSEABASS recommends therefore be to remove those samples. This would bring us back to length distributions similar to what we have in the currently used assessment (i.e., get rid of the bi-modality).

10.1.4 Commercial age compositions in the Northern Stock

Table 6: numbers of seabass aged by country (Northern Stocks)

Northern Stock	France	UK	Netherlands
2001		5072	
2002		4762	
2003		3486	
2004		2383	
2005		1824	44
2006	1	1340	55
2007		1944	110
2008	69	3056	202
2009	174	3385	
2010	912	2165	170
2011	1322	2563	
2012	1004	2475	
2013	548	2330	111
2014	485	2675	
2015	408	2358	
2016	258	2815	139
2017	276	2166	
2018	56	2412	
2019	107	2651	120
2020	313	1578	
2021	232	2482	
2022	823	2199	386
2023	1083	2380	353

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Estimating migration and mortality rates for European seabass (*Dicentrarchus labrax*) using electronic tagging data – **an update**

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Introduction

This is an update of the Working Document presented at the WKBSEABASS Benchmark Workshop Meeting, ICES secretariat - from 29/01/2024 to 2/02/2024 (reproduced as an appendix of the current document). This update includes 26 additional individual trajectories from DST tagged seabass and is limited to the 2 areas spatial parameterisation of the model which is used to parameterise both seabass assessment models: the 'northern' (ICES divisions 4.b-c, 7.a and 7.d-h, thereafter noted Area 1) and 'southern' (ICES divisions 8a-b, thereafter noted Area 2) stocks.

Material and method

Tagging data

Electronic tagging data covering the period 2010-2022 were used in the analysis (Table 1). In France, a pilot study with four tagging surveys was first conducted in collaboration with the Iroise Natural Marine Park (de Pontual *et al.* 2019) in the Iroise Sea off Ouessant and Raz de Sein during summers 2010, 2011 and 2012 and off Pornichet in 2012. This pilot study was then followed by a second series of tagging experiments under the BARGIP project (de Pontual *et al.* 2023) during which the tagging was carried out at 10 locations off the French coats of the English Channel and the North east Atlantic from Dunkerque to Capbreton (Figure 1).

Table 1. Summary of the tagging experiments

Country	Project	Tagging experiment	Tagging periods	Tagging location	Number of releases

France	Pilot study	DST1	07 to 10/09/2010	Ouessant	98
		DST2	01 to 09/07/2011	Raz de Sein	74
		DST3	04 to 21/09/2012	Ouessant	74
		PO	23 to 25/07/2012	Pornichet	13
France	BARGIP	DK	03 to 13/06/2014	Dunkerque	150
		SQ	17 to 27/06/2014	Saint Quay	152
		CB	01 to 11/09/2014	Capbreton	123
		LT	09 to 19/09/2014	La Turballe	143
		PB	01 to 12/06/2015	Port en Bessin	89
		AD	09 to 19/06/2015	Audierne	179
		SM	09 to 11/09/2015	Saint Malo	16
		IO	07 to 16/09/2015	Oléron	132
		SV	21 to 24/06/2016	Saint Vaast	129
		NO	31/08 to 04/09/2016	Noirmoutier	107
Belgium		DL	2018		38
		DL	2019		29
		DL	2020		27
		DL	2021		15
		DL	2022		6
UK		104B	2017		5
		104C	2015, 2017		63
		107A	2017, 2018		52
		107E	2014, 2018, 2019, 2020		142
		107F	2019		69
Total					**1925**

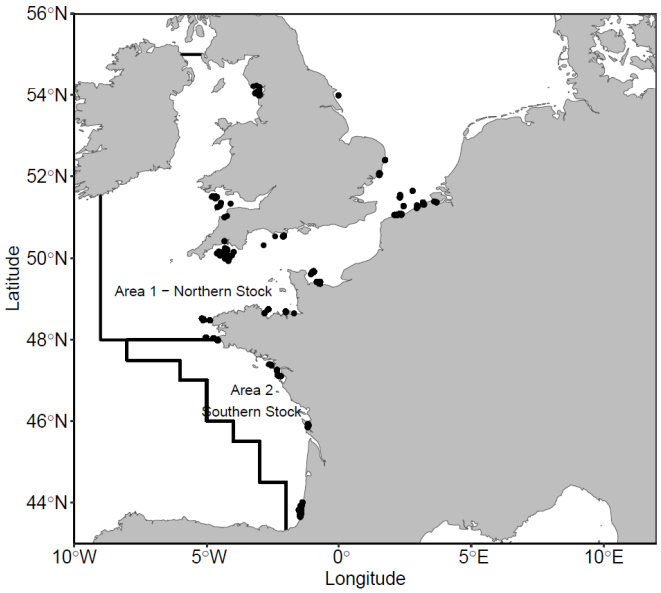


Figure 1. Area limits for the two areas spatial structure model. The locations of releases are indicated by black dots.

Surgically implanted DST tags (Cefas technology limited G5 tags with temperature and pressure sensors and a typical battery life of 2 years) were deployed on fish caught by professional fishers. Most of the tagging operations were conducted from a support vessel, moored in sheltered waters, where fish were transferred, tagged, and released on the same day they were caught. In some tagging operations of the initial pilot study shore-based infrastructures were also tested where fish were transferred, tagged, and maintained over one night prior to release. In case of over inflation of the swim bladder due to rapid depressurisation, swim bladders were bled to release excess air. Only carefully selected fish [>45 cm total length (TL), tag to body mass ratio <2%, apparently good condition] were tagged and released (de Pontual *et al.* 2019).

For UK deployments, mature bass were tagged and released from three areas around the English coastline between 2014 2019. Most tagged bass were captured by rod and line, but occasionally by net or longline. After capture, all bass were brought slowly to the surface to avoid rupture of the swim bladder and those in good condition (alert with no significant injuries or bleeding) were placed into 1000 litre holding tanks. Bass were then anaesthetised in a shallow (20 cm) bath containing 2-phenoxy-ethanol (0.5 ml–1). A small incision was made anterior to the anus on the midline of the ventral surface, and a Cefas buoyant G5 Data Storage Tag (DST) (Cefas Technology Ltd, Lowestoft UK) was then inserted into the intra-coelomic cavity (Quayle *et al.* 2009). All tagging procedures were carried out by trained and competent scientists under Home Office project licence PPL 70/7734, with tagging methods similar to methods used in Quayle *et al.* (2009) and Wright *et al.* (2021).

For Belgium deployments, sea bass were tagged and released between 2018-2022 in the Belgian part of the North Sea (Goossens *et al.* 2023). All fish were caught with rod and line. The DST tags were surgically inserted in the abdominal cavity through an incision across the midventral line, which was closed by three stitches using non-absorbable mono-filament. Before release, the tagged fish was placed in a tank for 5–15 min to recover from the surgery.

Estimates of the individual trajectories of the recovered DST tagged fish were obtained from a state-space geolocation model (Woillez *et al.* 2016) using the temperatures and depth time series recorded on the archival tag. The model produces probability of tagged fish daily positions from which the most probable trajectory can be estimated. To use those individual trajectories to estimate movement rate and fishing mortality at population scale, the individual data were discretised both in space and time. On the spatial scale, a "two areas" hypothesis based on the currently assessed 'northern' (ICES divisions 4.b-c, 7.a and 7.d-h, thereafter noted Area 1) and 'southern' (ICES divisions 8a-b, thereafter noted Area 2) stocks was used.

For the discretisation in time, two different seasonal time steps were considered to examine if the level of time discretisation would impact the parameter estimates and more particularly the movement rates between areas. Semesterly time steps with two "seasons": winter from 1/10 to 31/03 and summer from 1/04 to 30/09 and quarterly time steps with four seasons: winter from 1/01 to 31/03, spring from 1/04 to 30/06, summer from 1/07 to 30/09 and autumn from 1/10 to 31/12. Locations of the tagged fish in each time steps along their trajectories between release and recapture were then obtained by finding the area where the fish had spent most of the time (in number of days).

Model

The model is based on a multistate capture-recapture models (Arnason, 1973, Hestbeck et al., 1991 ; Lebreton et al., 1992 ; Brownie et al., 1993 ; Schwarz et al., 1993 , Eveson et al., 2012, Lecomte et al., 2020) with the transition probabilities among states consisting of two processes: movement and survival. Those two processes are assumed separated in time and independent. The movement process is based on instantaneous box-transfer rates between the two areas and occurs at the start of each time steps. This is consistent with previous conclusions drawn from the estimation of individual fish travelling speed (horizontal movements) and direction (fish heading) that seabass migrations are rather rapid events (de Pontual *et al.* 2019). We assume that the movement of a given fish is independent of the movement of the other fish. During each time intervals, we assume that the fish stay within the region they have moved or stayed in, where they can be caught by the fishery or die of natural death. The model describes the fate of each recaptured fish carrying a tag between release and recapture and calculates the

probabilities associated with individual trajectories. For simplicity of the notation below we consider only one tagging experiment but the approach is easily generalised to multiple tagging over several time intervals and areas of tagging as it is in the sea bass tagging experiment. Furthermore, the analysis assumes that all recaptured tags were reported. As the tagging experiments were largely advertised through various medias and high rewards were offered for the return of tags (de Pontual *et al.* 2019), this can be considered as a reasonable assumption. In addition to the above hypothesis, it is also assumed that the tagged fish in an area are representative of all the fish present in that area (complete mixing), the fate of each fish is independent of the fate of all other fish and there is no tag shedding or tag-induced mortality.

Let $T_t^{i\to j}$ be the transfer rates from area i to j at time step t (note that for each departing area i $\sum_j T^{i\to j} = 1$), S_t^i be the survival rate or the probability that a fish alive at the beginning of the time interval in area i will survive that time interval, F_t^i the fishing mortality rate in area i at time interval t and M the natural mortality rate assumed constant. For a fish with a trajectory k which survived s_k time intervals, was recaptured at time interval $s_k + 1$ and was present in areas $i = a_t^k$ in each time interval t, the probability associated with this particular trajectory can be expresses as:

$$p_k = \left(\prod_{t=1}^{s_k} T_t^{a_{t-1}^k \to a_t^k} S_t^{a_t^k}\right) \frac{F_{s_k+1}^{a_{s_k+1}^k}}{F_{s_k+1}^{a_{s_k+1}^k} + M} \left(1 - S_{s_k+1}^{a_{s_k+1}^k}\right) \quad (1)$$

with a_0^k the area of release and $S_t^{a_t^k} = e^{\left(-F_{s_k}^{a_{s_k}^k} - M\right)}$

For several fish, the tracks recorded on the archival tags stop before recovery because the battery expired. In that case, from the time the track stops to the time of recovery we are in a situation similar to a conventional tagging where only the positions of the fish when the battery fails and when it has been recovered are known. The probability associated with this part of the trajectory has then to account for all possible trajectories between battery expiration and recovery.

Model parameters are estimated by maximum likelihood using a multinomial likelihood function.

Noting p_k the probability associated with each distinct trajectory k, n_k the number of tagged and recovered fish having this trajectory and K the total number of observed trajectories the likelihood is given by:

$$L\left(F_t^i, T^{i\to j}\right) = \frac{N!}{\left(N-\sum_{k=1}^{K} n_k\right)! \prod_{k=1}^{K} n_k!}\left(1-\sum_{k=1}^{K} p_k\right)^{\left(N-\sum_{k=1}^{K} n_k\right)} \prod_{k=1}^{K} {p_k}^{n_h} \qquad (2)$$

The maximum was determined by minimizing the negative log of that function which, ignoring the combinatoric factors independent of the parameters, is given by:

$$-\log L = -\sum_{k=1}^{K} n_k \log p_k - \left(N-\sum_{k=1}^{K} n_k\right)\log\left[1-\sum_{k=1}^{K} p_k\right] \quad (3)$$

with N the total number of tagged and released fish and $\sum_{k=1}^{K} n_k$ the total number of recovered fishes with trajectory information.

The model implementation and the minimization of the negative loglikelihood were carried out with the AD Model Builder non-linear optimization package (Fournier *et al.* 2012). Uncertainties in the parameter estimates are derived from the Hessian matrix.

Parameterisation

Several model parameterisations were tested and compared to assess which model configuration would be best supported by the data. First, and as mentioned in the tagging data section above, two different seasonal time steps (semester and quarter) were implemented into the model. We also tested several versions of the models with different levels of spatial and seasonal variations in the transfer and fishing mortality rates. The fishing mortality was either assumed constant over area and season, variable by area but constant by season and variable by area and season. The transfer rates are by definition defined by area so they were either assumed constant or variable by season. In those parameterisations, both fishing mortality and transfer rates were assumed constant over the years of the experiment and the natural mortality rate M was not estimated and set to the values used by ICES for the stocks corresponding to the two areas defined in the model (i.e., M = 0.24). Model selection is based on the Akaike's information criterion (AIC).

The structure of the analytical model is such that tagged fish are assumed to be released at the start of a given time step. To make the observed data correspond to that scenario as closely as possible, the release data were aggregated into release sets by rounding the date of release to the nearest first day of the time step. In a semester model, the releases for a given semester thus includes release dates between the middle of the previous semester and the middle of that given semester. Applying the approach to the different combinations of time steps hypothesis results in variable number of datasets. In the case of the time discretisation based on semesters and a spatial discretisation based on two areas this leads to 21 release sets with unique date and area of release (Table 2).

Table 2. Sea bass tag release and return data summarised by release groups for the semesterly time discretisation and the two areas spatial structure.

Release Set	Date of release	Area of Release	Number of release	Recoveries used in the analysis
1	October-10	1	98	9
2	October-11	1	74	3
3	October-12	1	74	5
4	October-12	2	13	4
5	April-14	1	302	58
6	October-14	1	48	5
7	October-14	2	266	83
8	April-15	1	312	69
9	October-15	1	16	1
10	October-15	2	132	30
11	April-16	1	129	20
12	October-16	2	107	32
13	April-17	1	52	4
14	April-18	1	2	0
15	October-18	1	68	2
16	April-19	1	6	0
17	October-19	1	128	1
18	April-20	1	52	0
19	October-20	1	25	1
20	October-21	1	15	1
21	April-22	1	6	0
Total			1925	328

The returns assigned to a given time step are those with recapture dates any time within that step. Again, this corresponds to the structure of the analytical model, which predicts the recovery within each whole-time step following the release date. On some rare occasions with the above scheme, tags released in the last half of a time period would be recaptured in that same period, which would result in these recoveries being assigned a recapture one step before the assigned release time step. Recoveries such as these were

reassigned to the following time step. Finally, recoveries from stranding, with unknown recovery origin or with a lack of information on the trajectory and/or the position of the recovery were excluded from the analysis leading to 328 usable recoveries by the end of 2022.

Results

All models converged readily to a solution (Table 3). According to the AIC, for both time steps, the best fits were obtained for the full models with fishing mortality variable by area and season and seasonal movement (models 6, 12). For the semesterly models with seasonal movements however, the difference in AIC between the models with constant, area or area × season specific fishing mortality (models 2, 4 and 6) are small suggesting that no model performs significantly better than others. For the quarterly model, the AIC comparison largely favours the full models with AIC differences varying between 54 and 108 above the best model. Furthermore, it is worth noting that adding seasonality on movement in both the semesterly and quarterly models is the main factor of improvement of the fits; overall, the AIC are much lower for all the models with seasonal movement rates than those with constant movement rates. This is a strong indication that the tagging data supports the seasonality in movements between the two areas.

Table 3. Model parameterization and comparison. The comparison of AIC is only carried out among models fitted to the same data series (semesterly model or quarterly model). The best models are highlighted in bold.

Model	Spatial structure	Time step sizes	Fishing mortality	Movement	Number of parameters	$-\log L$	AIC	ΔAIC
1	2 areas	Semester	Constant	Constant	3	1561.2	3128	68
2			Constant	Seasonal	5	1527.5	3065	5
3			Area	Constant	4	1557.9	3124	63
4			Area	Seasonal	6	1525.2	3062	2
5			Area × Season	Constant	6	1550.9	3114	54
6			**Area × Season**	**Seasonal**	**8**	**1522.2**	**3060**	**0**
7	2 areas	Quarter	Constant	Constant	3	1792.2	3590	106
8			Constant	Seasonal	9	1760.3	3539	54
9			Area	Constant	4	1792.2	3592	108
10			Area	Seasonal	10	1760.2	3540	56
11			Area × Season	Constant	10	1762.7	3545	61
12			**Area × Season**	**Seasonal**	**16**	**1726.1**	**3484**	**0**

The model appears to predict the observations reasonably well as indicated by Figure 2 which shows the observed and predicted number of unique trajectories. From the probabilities associated with each individual trajectory and the number of tagged and released seabass by release sets it is also possible to calculate the predicted number of aggregated recoveries by calendar date (Figure 3). The agreement between predicted and observed recoveries for the main release sets is good but the model tends to predict less recoveries than observed over the more recent years of the experiment.

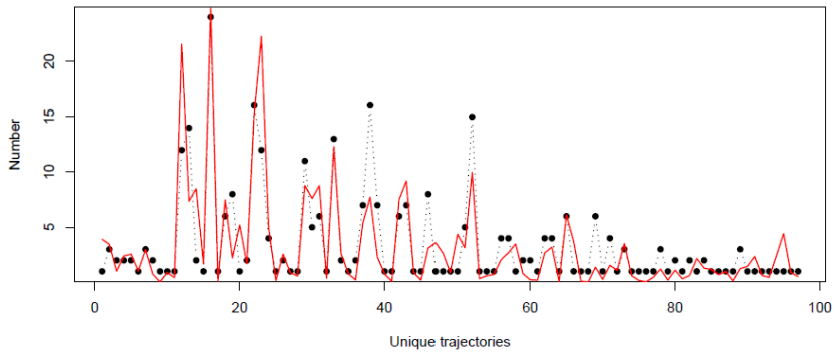


Figure 2. Number of unique trajectories under the semesterly time steps for model with F variable by area and season and T variable by season (model 6). Solid line indicates predicted and black dots indicate observed number of each individual trajectories.

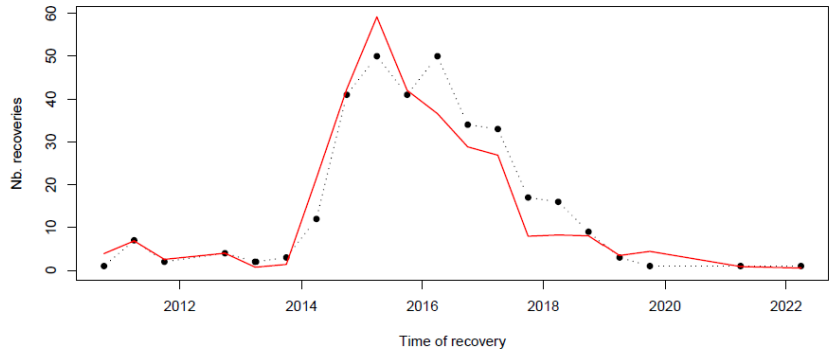


Figure 3. Overall tag recapture history under the semesterly time steps for model with F variable by area and season and T variable by season (model 6). Solid line indicates predicted and black dots indicate observed recaptures.

Parameter estimates are presented in Tables 4 and 5 for the "best" semesterly and quarterly models.

Table 4. Summary results for the preferred two areas semesterly model (model 6).

Parameter	Season	Area	Mean	SD
Fishing mortality				
F_1^1	Winter	North	0.064	0.011
F_2^1	Summer	North	0.091	0.011
F_1^2	Winter	South	0.110	0.012
F_2^2	Summer	South	0.141	0.021
Annual F (yr^{-1})		North	0.155	0.017
		South	0.251	0.026
Movement rate		From / to		
$T_1^{1\to2}$	Winter	North / South	0.407	0.039
$T_2^{1\to2}$	Summer	North / South	0.129	0.037
$T_1^{2\to1}$	Winter	South / North	0.049	0.023
$T_2^{2\to1}$	Summer	South / North	0.392	0.038

Table 5. Summary results for the preferred two areas quarterly model (model 12).

Parameter	Season	Area	Mean	SD
Fishing mortality				
F_1^1	Winter	North	0.031	0.011
F_2^1	Spring	North	0.131	0.023
F_3^1	Summer	North	0.065	0.008
F_4^1	Autumn	North	0.053	0.010
F_1^2	Winter	South	0.035	0.006
F_2^2	Spring	South	0.047	0.010
F_3^2	Summer	South	0.135	0.024
F_4^2	Autumn	South	0.102	0.012
Annual F (yr^{-1})		North	0.280	0.032
		South	0.319	0.033
Movement rate		From / to		
$T_1^{1\to2}$	Winter	North / South	0.407	0.047
$T_2^{1\to2}$	Spring	North / South	0.158	0.058
$T_3^{1\to2}$	Summer	North / South	0.062	0.026
$T_4^{1\to2}$	Autumn	North / South	0.288	0.036
$T_1^{2\to1}$	Winter	South / North	0.037	0.020
$T_2^{2\to1}$	Spring	South / North	0.261	0.035
$T_3^{2\to1}$	Summer	South / North	0.232	0.040
$T_4^{2\to1}$	Autumn	South / North	0.052	0.024

For the semesterly model (Table 4) and at the start of the so-called "winter" season (beginning of October), the rate of transfer is estimated to be higher (0.407; standard deviation, SD = 0.039) from the north (area 1) to the south (area 2) than from the south to the north (0.049; SD = 0.023). At the start of

the "summer" season (beginning of April), this is the opposite with a transfer rate from the south to the north estimated at 0.392 (SD = 0.038) and from the north to the south estimated at 0.129 (SD = 0.037). Similar estimates and seasonal variations are obtained for the quarterly model (Table 5) with high values at the start of autumn (beginning of October) and winter (beginning of January) from the north to the south (0.288 (SD = 0.036) and 0.407 (SD = 0.047) respectively) and at the start of spring (beginning of April) and summer (beginning of July) from the south to the north (0.261 (SD = 0.035) and 0.232 (SD = 0.040) respectively).

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APPENDIX

Working Document presented at the WKBSEABASS Benchmark Workshop Meeting

ICES secretariat - from 29/01/2024 to 2/02/2024

Estimating seasonal migration rates for European seabass (*Dicentrarchus labrax*) using electronic tagging data

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Introduction

European seabass (*Dicentrarchus labrax*) is widely distributed over the north-east Atlantic from Morocco to Norway and in the Mediterranean and Black Seas (Pickett and Pawson, 1994). For the Atlantic, the assessment is currently conducted separately for four stocks by ICES: The northern seabass stock from the Irish Sea, Celtic Sea, English Channel, and southern North Sea (ICES divisions IVb–c and VIIa, d–h), the west of Scotland and Ireland stock (ICES divisions VIa and VIIb, j), the Bay of Biscay stock (ICES divisions VIIIa–b), and the Iberian Peninsula stock (ICES divisions VIIIc, IXa). For stock assessment and subsequent fisheries management, the definition of the stock limits and the spatial structure is of major importance. If incorrectly specified, this can lead to bias in the estimation of the size of the population and the level of fishing mortality and to the implementation of inadequate management measures (Kerr *et al.*, 2017). For seabass, the current stock delineations mainly resulted from practical considerations and allowed the first quantitative assessments of the northern stock to be made (ICES, 2012). However, experts have highlighted a lack of biological evidence supporting this delineation and have pointed out the need for further research on population structure (de Pontual *et al.*, 2019).

A stock identification workshop, part of the 2023 ICES sea bass benchmark workshop (WKSEABASS) met in November 2022 to review new biological evidences from tagging data, genetic analyses, scientific surveys, fishery data, as well as stable isotope analysis. The workshop concluded that existing evidence does not support current ICES stock advice units and proposed several alternative and plausible stock structure scenarios. In the current working document, we use individual trajectories estimated from data storage tagged (DST) fish obtained from several tagging programs carried out by UK, Belgium

and France to examine seasonal movements and fishing mortality. The objective is to provide, as part of the WKSEABASS process, some elements, at population scale, that could potentially be used to revisit the current stock limits, improve the assessment and management by accounting for mixing and movements between the current stocks or even develop a spatial population and assessment model for seabass. A series of multistate spatial mark-recapture models, discrete in space and time, are developed and compared. They allow us to quantify in an integrated tagged-based model both seasonal transfer rates between areas and fishing mortality rates by areas.

Material and method

Tagging data

We use electronic tagging data covering the period 2010-2022. In France, a pilot study with four tagging surveys was first conducted in collaboration with the Iroise Natural Marine Park (de Pontual *et al.*, 2019) in the Iroise Sea off Ouessant and Raz de Sein during summers 2010, 2011 and 2012 and off Pornichet in 2012 (Table 1). This pilot study was then followed by a second series of tagging experiments under the BARGIP project (de Pontual *et al.*, 2023). Tagging was carried out at 10 locations off the French coats of the English Channel and the North east Atlantic from Dunkerque to Capbreton (Table 1).

Table 1 Summary of the tagging experiments

Country	Project	Tagging experiment	Tagging periods	Tagging location	Number of releases
France	Pilot study	DST1	07 to 10/09/2010	Ouessant	98
		DST2	01 to 09/07/2011	Raz de Sein	74
		DST3	04 to 21/09/2012	Ouessant	74
		PO	23 to 25/07/2012	Pornichet	13
France	BARGIP	DK	03 to 13/06/2014	Dunkerque	150
		SQ	17 to 27/06/2014	Saint Quay	152
		CB	01 to 11/09/2014	Capbreton	123
		LT	09 to 19/09/2014	La Turballe	143
		PB	01 to 12/06/2015	Port en Bessin	89
		AD	09 to 19/06/2015	Audierne	179
		SM	09 to 11/09/2015	Saint Malo	16
		IO	07 to 16/09/2015	Oléron	132
		SV	21 to 24/06/2016	Saint Vaast	129
		NO	31/08 to 04/09/2016	Noirmoutier	107
Belgium		DL	2018		38
		DL	2019		29
		DL	2020		27
		DL	2021		15
		DL	2022		6
UK		104B	2017		5
		104C	2015, 2017		63
		107A	2017, 2018		52
		107E	2014, 2018, 2019, 2020		142
		107F	2019		69
Total					**1925**

Surgically implanted DST tags (Cefas technology limited G5 tags with temperature and pressure sensors and a typical battery life of 2 years) were deployed on fish caught by professional fishers. Most of the tagging operations were conducted from a support vessel, moored in sheltered waters, where fish were transferred, tagged, and released on the same day they were caught. In some tagging operations of the initial pilot study shore-based infrastructures were also tested where fish were transferred, tagged, and maintained over one night prior to release. In case of over inflation of the swim bladder due to rapid depressurisation, swim bladders were bled to release excess air. Only carefully selected fish [>45 cm total length (TL), tag to body mass ratio <2%, apparently good condition] were tagged and released (de Pontual *et al.*, 2019).

For UK deployments, mature bass were tagged and released from three areas around the English coastline between 2014 – 2019. Most tagged bass were captured by rod and line, but occasionally by net or longline. After capture, all bass were brought slowly to the surface to avoid rupture of the swim bladder and those in good condition (alert with no significant injuries or bleeding) were placed into 1000 litre holding tanks. Bass were then anaesthetised in a shallow (20 cm) bath containing 2-phenoxy-ethanol (0.5 ml–1). A small incision was made anterior to the anus on the midline of the ventral surface, and a Cefas buoyant G5 Data Storage Tag (DST) (Cefas Technology Ltd, Lowestoft UK) was then inserted into the intra-coelomic cavity (Quayle *et al.*, 2009). All tagging procedures were carried out by trained and competent scientists under Home Office project licence PPL 70/7734, with tagging methods similar to methods used in Quayle *et al.* (2009) and Wright *et al.* (2021).

For Belgium deployments, sea bass were tagged and released between 2018-2022 in the Belgian part of the North Sea (Goossens *et al.*, 2023). All fish were caught with rod and line. The DST tags were surgically inserted in the abdominal cavity through an incision across the midventral line, which was closed by three stitches using non-absorbable mono-filament. Before release, the tagged fish was placed in a tank for 5–15 min to recover from the surgery.

Estimates of the trajectories of the recovered DST tagged fish were obtained from a state-space geolocation model (Woillez *et al.*, 2016) using the temperatures and depth time series recorded on the archival tag. The model produces probability of tagged fish daily positions from which the most probable trajectory can be estimated.

To analyse the individual trajectories and estimate movement rate and fishing mortality at population scale, the individual data were discretised both in space and time. On the spatial scale, three population structures identified by ICES (WKSEABASS, 2023) were considered (Annex 1):

Hypothesis 1: Three meta-populations, North Sea (4b-c) Area 1, Irish Sea (7.a) Area 2, southern Bay of Biscay (8.b) – Area 3; with mixing among the Celtic Sea (7.f-g), Bristol Channel (7.h), English Channel (7.d-e) and Northern Bay of Biscay Area 4. Mixing is seasonally dependant with more mixing occurring during summer compared to winter.

Hypothesis 2: Three meta-populations, North Sea (4.b-c) – Area 1, Irish Sea (7.a) – Area 2 and Bay Biscay (8.a-b) -Area 3; with mixing among the Celtic Sea (7.f-g), Bristol Channel (7.h) and English Channel (7.d-e) – Area 4. Mixing is seasonally dependant with more mixing occurring during summer compared to winter.

Hypothesis 3: Three meta-populations, North Sea/eastern English Channel (4.b-c, 7.d) – Area 1, Irish Sea (7.a) – Area 2, and Bay Biscay (8a-b) – Area 3; with mixing among the Celtic Sea (7.f-g), Bristol Channel (7.h) and western English Channel (7.e) – Area 4. Mixing is seasonally dependant with more mixing occurring during summer compared to winter.

A further "two areas with mixing" scenario based on the currently assessed 'southern' (ICES divisions 8a-b) and 'northern' (ICES divisions 4.b-c, 7.a and 7.d-h) stocks is also investigated (Hypothesis 4).

For the discretisation in time, two different seasonal time steps were considered to examine if the level of time discretisation would impact the parameter estimates and more particularly the movement rates between areas. Semesterly time steps with two "seasons": winter from 1/10 to 31/03 and summer from 1/04 to 30/09 and quarterly time steps with four seasons: winter from 1/01 to 31/03, spring from 1/04 to 30/06, summer from 1/07 to 30/09 and autumn from 1/10 to 31/12. Locations of the tagged fish in each time steps along their trajectories between release and recapture were then obtained by finding the area where the fish had spent most of the time (in number of days).

Model

The model used to analyse the seabass data is based on a multistate capture-recapture model (Arnason, 1973, Hestbeck et al., 1991 ; Lebreton et al., 1992 ; Brownie et al., 1993 ; Schwarz et al., 1993 , Eveson et al., 2012, Lecomte et al., 2020) with the transition probabilities among states consisting of two processes: movement and survival. Those two processes are assumed separated in time and independent. The movement process is based on instantaneous box-transfer rates between the areas and occurs at the start of each time steps. This is consistent with previous conclusions drawn from the estimation of individual fish travelling speed (horizontal movements) and direction (fish heading) that seabass migrations are rather rapid events (de Pontual *et al.*, 2019). We assume that the movement of a given fish is independent of the movement of the other fish. During each time intervals, we assume that the fish stay within the region they have moved or stayed in, where they can be caught by the fishery or die of natural death. The model describes the fate of each recaptured fish carrying a tag between release and recapture and calculates the probabilities associated with individual trajectories. For simplicity of the notation below we consider only one tagging experiment but the approach is easily generalised to multiple tagging over several time intervals and areas of tagging as it is in the sea bass tagging experiment. Furthermore, the analysis assumes that all recaptured tags were reported. As the tagging experiments were largely advertised through various medias and high rewards were offered for the return of tags (de Pontual *et al.*, 2019), this can be considered as a reasonable assumption. In addition to the

above hypothesis, it is also assumed that the tagged fish in an area are representative of all the fish present in that area (complete mixing), the fate of each fish is independent of the fate of all other fish and there is no tag shedding or tag-induced mortality.

Let $T_t^{i\to j}$ be the transfer rates (or movement probability) from area i ($i = 1,2,3,4$) to j ($j = 1,2,3,4$) at time step t respectively, S_t^i be the survival rate or the probability that a fish alive at the beginning of the time interval in area i will survive that time interval, F_t^i the fishing mortality rate in area i at time interval t and M the natural mortality rate assumed constant. Note the obvious constraint that the transfer rates for a given area and time step sum to one $\sum_{j=1}^{4} T_t^{i\to j} = 1$. For a fish with a trajectory k which survived s_k time intervals, was recaptured at time interval $s_k + 1$ and was present in areas $i = a_t^k$ in each time interval t, the probability associated with this particular trajectory can be expresses as:

$$p_{k=}\left(\prod_{t=1}^{s_k} T_t^{a_{t-1}^k \to a_t^k} S_t^{a_t^k}\right)\frac{F_{s_k+1}^{a_{s_k+1}^k}}{F_{s_k+1}^{a_{s_k+1}^k} + M}\left(1 - S_{s_k+1}^{a_{s_k+1}^k}\right)$$

with a_0^k the area of release and $S_t^{a_t^k} = e^{\left(F_{s_k}^{a_{s_k}^k} + M\right)}$

For several fish, the tracks recorded on the archival tags stop before recovery because the battery expired. In that case, from the time the track stops to the time of recovery we are in a situation similar to a conventional tagging where only the positions of the fish when the battery fails and when it has been recovered are known. The probability associated with this part of the trajectory has then to account for all possible trajectories between battery expiration and recovery.

Model parameters are estimated by maximum likelihood using a multinomial likelihood function.

Noting p_k the probability associated with each distinct trajectory k, n_k the number of tagged and recovered fish having this trajectory and K the total number of observed trajectories the likelihood is given by:

$$L\left(F_t^i, T^{i\to j}\right) = \frac{N!}{\left(N - \sum_{k=1}^{K} n_k\right)! \prod_{k=1}^{K} n_k!}\left(1 - \sum_{k=1}^{K} p_k\right)^{\left(N - \sum_{k=1}^{K} n_k\right)} \prod_{k=1}^{K} {p_k}^{n_h}$$

The maximum was determined by minimizing the negative log of that function which, ignoring the combinatorial factors independent of the parameters, is given by:

$$-\log L = -\sum_{k=1}^{K} n_k \log p_k - \left(N - \sum_{k=1}^{K} n_k\right) \log\left[1 - \sum_{k=1}^{K} p_k\right]$$

with N the total number of tagged and released fish and $\sum_{k=1}^{K} n_k$ the total number of recovered fishes with trajectory information.

The model implementation and the minimization of the negative loglikelihood were carried out with the AD Model Builder non-linear optimization package (Fournier *et al.*, 2012). Uncertainties in the parameter estimates are derived from the Hessian matrix.

Parameterisation

Several model parameterisations were tested and compared to assess which model configuration would be best supported by the data. First, and as mentioned in the tagging data section above, two different seasonal time steps (semester and quarter) were implemented into the model. We also tested several versions of the models with different levels of spatial and seasonal variations in the transfer and fishing mortality rates to see if any of those variations would be supported by the data. The fishing mortality was either assumed constant over area and season, variable by area but constant by season and variable by area and season. The transfer rates are by definition defined by area so they were either assumed constant or variable by season. In those parameterisations, both fishing mortality and transfer rates were assumed constant over the years of the experiment and the natural mortality rate M was not estimated and set to the values used by ICES for the stocks corresponding to the two areas defined in the model (i.e. $M = 0.24$). Model selection is based on the Akaike's information criterion (AIC).

Further data stratification

The structure of the analytical model is such that tagged fish are assumed to be released at the start of a given time step. To make the observed data correspond to that scenario as closely as possible, the release data were aggregated into release sets by rounding the date of release to the nearest first day of the time step. In a semester model, the releases for a given semester thus includes release dates between the middle of the previous semester and the middle of that given semester. Applying the approach to the different combinations of time steps and spatial structure hypothesis results in variable number of datasets. In the case of the time discretisation based on semesters and a spatial discretisation based on hypothesis 2 this leads to 28 release sets with unique date and area of release (Table 1).

Table 1. Sea bass tag release and return data summarised by release groups for the semesterly time discretisation and hypothesis 2 spatial structure.

Release Set	Date of release	Area of Release	Number of release	Recoveries used in the analysis
1	October-10	4	98	9

2	October-11	4	74	2
3	October-12	3	13	4
4	October-12	4	74	5
5	April-14	1	150	27
6	April-14	4	152	25
7	October-14	3	266	74
8	October-14	4	48	5
9	April-15	1	44	8
10	April-15	4	268	57
11	October-15	3	132	28
12	October-15	4	16	1
13	April-16	4	129	18
14	October-16	3	107	30
15	April-17	1	24	1
16	April-17	2	28	3
17	April-18	1	2	0
18	October-18	1	36	1
19	October-18	2	24	1
20	October-18	4	8	0
21	April-19	4	6	0
22	October-19	1	29	1
23	October-19	4	99	0
24	April-20	1	2	0
25	April-20	4	50	0
26	October-20	1	25	1
27	October-21	1	15	1
28	April-22	1	6	0
Total			1925	302

The returns assigned to a given time step are those with recapture dates any time within that step. Again, this corresponds to the structure of the analytical model, which predicts the recovery within each whole time-step following the release date. On some rare occasions with the above scheme, tags released in the last half of a time period would be recaptured in that same period, which would result in these recoveries being assigned a recapture one step before the assigned release time step. Recoveries such as these were reassigned to the following time step. Finally, recoveries from stranding, with unknown recovery origin or with a lack of information on the trajectory and/or the position of the recovery were excluded from the analysis leading to 302 usable recoveries by the end of 2022.

Results

All models except model 7 (Spatial structure based on hypothesis 1, quarterly time steps, constant fishing mortality and no seasonal variation in transfer rates) converged readily to a solution (Table 2). According to the AIC, the best fits were obtained for the full models with fishing mortality variable by area and season and seasonal movement (models 6, 12, 18, 24, 36, 42 and 48) except for the models structured by semester and based on a hypothesis 2 and hypothesis 3 spatial structures for which the best model was obtained with constant fishing mortality and seasonal movement rate (model 14 and 26). For the semesterly models with seasonal movements however, the difference in AIC between the models with constant, area or area × season specific fishing mortality (models 2, 4 and 6; 14, 16 and 18; 26, 28 and 30; 38, 40 and 42) are small suggesting that no model performs significantly better than others. For the quarterly model, the AIC comparison largely favours the full models with AIC differences varying

between 20 and 223 above the best model. Furthermore, it is worth noting that adding seasonality on movement in both the semesterly and quarterly models is the main factor of improvement of the fits: Overall, the AIC are much lower for all the models with seasonal movement rates than those with constant movement rates. This is a strong indication that the tagging data supports the seasonality in movements between the two areas.

Table 2. Model parameterization and comparison. The comparison of AIC is only carried out among models fitted to the same data series (semesterly model or quarterly model). The best models are highlighted in bold.

Model	Spatial structure	Time step sizes	Fishing mortality	Movement	Number of parameters	$-\log L$	AIC	ΔAIC
1	Hyp. 1	Semester	Constant	Constant	9	1470.0	2958	33
2			Constant	Seasonal	17	1454.7	2943	18
3			Area	Constant	12	1460.9	2946	20
4			Area	Seasonal	20	1446.8	2934	8
5			Area × Season	Constant	16	1456.7	2945	20
6			**Area × Season**	**Seasonal**	**23**	**1439.7**	**2925**	**0**
7	Hyp. 1	Quarter	Constant	Constant	9	No convergence		
8			Constant	Seasonal	33	1683.4	3433	31
9			Area	Constant	12	1755.8	3536	134
10			Area	Seasonal	36	1675.5	3423	21
11			Area × Season	Constant	21	1738.7	3519	118
12			**Area × Season**	**Seasonal**	**45**	**1655.8**	**3402**	**0**
13	Hyp. 2	Semester	Constant	Constant	9	1511.2	3040	80
14			**Constant**	**Seasonal**	**17**	**1463.0**	**2960**	**0**
15			Area	Constant	12	1509.7	3043	83
16			Area	Seasonal	20	1462.7	2965	5
17			Area × Season	Constant	16	1503.9	3040	80
18			Area × Season	Seasonal	23	1458.2	2962	2
19	Hyp. 2	Quarter	Constant	Constant	9	1786.9	3592	198
20			Constant	Seasonal	33	1685.6	3437	44
21			Area	Constant	12	1785.5	3595	202
22			Area	Seasonal	36	1683.3	3439	45
23			Area × Season	Constant	21	1757.0	3556	162
24			**Area × Season**	**Seasonal**	**45**	**1651.8**	**3394**	**0**
25	Hyp. 3	Semester	Constant	Constant	9	1523.5	3065	78
26			**Constant**	**Seasonal**	**17**	**1476.7**	**2987**	**0**
27			Area	Constant	12	1521.2	3066	79
28			Area	Seasonal	20	1475.7	2991	4
29			Area × Season	Constant	16	1519.0	3070	83
30			Area × Season	Seasonal	23	1472.7	2991	4
31	Hyp. 3	Quarter	Constant	Constant	9	1830.0	3678	222
32			Constant	Seasonal	33	1719.8	3506	50
33			Area	Constant	12	1827.4	3679	223
34			Area	Seasonal	36	1715.8	3504	48
35			Area × Season	Constant	21	1796.8	3636	180
36			**Area × Season**	**Seasonal**	**45**	**1682.8**	**3456**	**0**
37	Hyp. 4	Semester	Constant	Constant	3	1455.6	2917	61
38			Constant	Seasonal	5	1425.1	2860	4
39			Area	Constant	4	1452.4	2913	56
40			Area	Seasonal	6	1422.9	2858	1
41			Area × Season	Constant	6	1445.5	2903	47
42			**Area × Season**	**Seasonal**	**8**	**1420.2**	**2856**	**0**
43	Hyp. 4	Quarter	Constant	Constant	3	1706.3	3419	174
44			Constant	Seasonal	9	1636.2	3290	46
45			Area	Constant	4	1706.2	3420	176
46			Area	Seasonal	10	1636.2	3292	48
47			Area × Season	Constant	10	1678.2	3376	132
48			**Area × Season**	**Seasonal**	**16**	**1606.2**	**3244**	**0**

Parameter estimates are presented in Tables 3 and 4 for the "best" four areas semesterly and quarterly models and each hypothesis on spatial structure and in Tables 5 and 6 for both the "best" two areas semesterly and quarterly models. Estimates obtained for all model parameterisation are presented in Annex 2 and in Annex 3, a mapping of the estimation of transfer rates is presented for the "best" models.

No movement were actually observed between the Irish sea and the North Sea or the Bay of Biscay. Therefore, the transfer coefficients between those areas were not estimated and were assumed to equal zero.

For the semesterly model and at the start of the so-called "winter" season (beginning of October) the rates of transfer between areas are estimated to be higher towards the south: 0.60 for Hypothesis 1 (SD = 0.091), 0.47 for Hypothesis 2 (SD = 0.08) and 0.36 for Hypothesis 3 (standard deviation, SD = 0.065) from the North Sea to the Mixing area and 0.49 for Hypothesis 2 (SD = 0.043) and 0.54 for Hypothesis 3 (SD = 0.047) from the Mixing area to the Bay of Biscay. Between the Irish Sea and the Mixing Area, the highest transfer rates are also estimated in the southern direction (0.86 and 0.83 for spatial structure hypothesis 1 and 2 respectively), however those estimates are based on a limited number of observations (only 5 distinct trajectories observed with movement between the Irish Sea and the Mixing Area) and are thus very uncertain (SD around 0.15). At the start of the "summer" season (beginning of April), if the transfer rates between the Bay of Biscay and the Mixing Area are higher in the northern direction (0.47, 0.42 and 0.39 for spatial structure hypothesis 1, 2 and 3 respectively), there is no clear direction of movement estimated between the other areas. Here again, the confidence intervals associated with the transfer rates between the Irish Sea and the Mixing Area are very large (SD from 0.464 to 0.482) as they are associated with a low number of observed trajectories.

Table 3. Summary results for the preferred four areas semesterly models (model 6, 14 and 26). Greyed parameters are not estimated and set equal zero.

			Hyp. 1		Hyp. 2		Hyp. 3	
Parameters	Season	Area	Mean	SD	Mean	SD	Mean	SD
F_1^1	Winter	North Sea	0.14	0.06	0.12	0.009	0.13	0.009
F_2^1	Summer	North Sea	0.12	0.03	0.12	0.009	0.13	0.009
F_1^2	Winter	Irish Sea	0.21	0.18	0.12	0.009	0.13	0.009
F_2^2	Summer	Irish Sea	0.21	0.18	0.12	0.009	0.13	0.009
F_1^3	Winter	Biscay	0.19	0.03	0.12	0.009	0.13	0.009
F_2^3	Summer	Biscay	0.23	0.06	0.12	0.009	0.13	0.009
F_1^4	Winter	Mixing area	0.07	0.01	0.12	0.009	0.13	0.009
F_2^4	Summer	Mixing area	0.12	0.01	0.12	0.009	0.13	0.009
$T_1^{1\to2}$	Winter	North Sea to Irish Sea	0		0		0	
$T_2^{1\to2}$	Summer	North Sea to Irish Sea	0		0		0	
$T_1^{1\to3}$	Winter	North Sea to Biscay	0.00	0.000	0.10	0.056	0.15	0.054
$T_2^{1\to3}$	Summer	North Sea to Biscay	0.00	0.000	0.00	0.000	0.00	0.000
$T_1^{1\to4}$	Winter	North Sea to Mixing area	0.60	0.091	0.47	0.080	0.36	0.065
$T_2^{1\to4}$	Summer	North Sea to Mixing area	0.19	0.069	0.19	0.067	0.27	0.057
$T_1^{2\to1}$	Winter	Irish Sea to North Sea	0		0		0	
$T_2^{2\to1}$	Summer	Irish Sea to North Sea	0		0		0	

$T_1^{2\to3}$	Winter	Irish Sea to Biscay	0		0		0	
$T_2^{2\to3}$	Summer	Irish Sea to Biscay	0		0		0	
$T_1^{2\to4}$	Winter	Irish Sea to Mixing area	0.86	0.144	0.83	0.159	0.83	0.156
$T_2^{2\to4}$	Summer	Irish Sea to Mixing area	0.46	0.482	0.15	0.472	0.16	0.464
$T_1^{3\to1}$	Winter	Biscay to North Sea	0.00	0.000	0.00	0.000	0.01	0.014
$T_2^{3\to1}$	Summer	Biscay to North Sea	0.00	0.000	0.01	0.012	0.05	0.023
$T_1^{3\to2}$	Winter	Biscay to Irish Sea	0		0		0	
$T_2^{3\to2}$	Summer	Biscay to Irish Sea	0		0		0	
$T_1^{3\to4}$	Winter	Biscay to Mixing area	0.31	0.058	0.08	0.030	0.08	0.032
$T_2^{3\to4}$	Summer	Biscay to Mixing area	0.47	0.073	0.42	0.037	0.39	0.039
$T_1^{4\to1}$	Winter	Mixing to North Sea	0.01	0.014	0.02	0.018	0.00	0.000
$T_2^{4\to1}$	Summer	Mixing area to North Sea	0.14	0.030	0.20	0.042	0.30	0.049
$T_1^{4\to2}$	Winter	Mixing area to Irish Sea	0.00	0.000	0.00	0.000	0.00	0.000
$T_2^{4\to2}$	Summer	Mixing area to Irish Sea	0.03	0.019	0.05	0.027	0.05	0.028
$T_1^{4\to3}$	Winter	Mixing area to Biscay	0.13	0.025	0.49	0.043	0.54	0.047
$T_2^{4\to3}$	Summer	Mixing area to Biscay	0.16	0.034	0.10	0.031	0.12	0.036

For the quarterly model (Table 4) and at the start of the so-called "autumn" (beginning of October) and "winter" season (beginning of January) the rates of transfer between areas are estimated to be mainly higher towards the south: From the North Sea to the Mixing area the transfer rates estimates are equal to 0.56 for Hypothesis 1 (SD = 0.088), 0.55 for Hypothesis 2 (SD = 0.089) and 0.40 for Hypothesis 3 (standard deviation, SD = 0.073) in autumn and 0.41 for Hypothesis 1 (SD = 0.148), 0.41 for Hypothesis 2 (SD = 0.148) and 0.32 for Hypothesis 3 (standard deviation, SD = 0.094) in winter. From the Mixing area to the Bay of Biscay, the transfer rates estimates are equal to 0.31 for Hypothesis 2 (SD = 0.042) and 0.33 for Hypothesis 3 (standard deviation, SD = 0.046) in autumn and 0.42 for Hypothesis 2 (SD = 0.052) and 0.44 for Hypothesis 3 (standard deviation, SD = 0.056) in winter.

At the start of the spring (beginning of April) and "summer" season (beginning of July), similarly to the semesterly parameterisation, if the transfer rates between the Bay of Biscay and the Mixing Area are higher in the northern direction, there is no clear direction of movement estimated between the other areas: From the Bay of Biscay to the Mixing Area, the transfer rates estimates are equal to 0.42 for Hypothesis 1 (SD = 0.059), 0.27 for Hypothesis 2 (SD = 0.036) and 0.26 for Hypothesis 3 (standard deviation, SD = 0.036) in spring and 0.31 for Hypothesis 1 (SD = 0.071), 0.24 for Hypothesis 2 (SD = 0.044) and 0.25 for Hypothesis 3 (standard deviation, SD = 0.044) in summer.

Table 4. Summary results for the preferred four areas quarterly models (model 12, 24 and 36). Greyed parameters are not estimated and set equal zero.

			Hyp. 1		Hyp. 2		Hyp. 3	
Parameter	Season	Area	Mean	SD	Mean	SD	Mean	SD
F_1^1	Winter	North Sea	0.09	0.091	0.09	0.094	0.08	0.041
F_2^1	Spring	North Sea	0.51	0.195	0.56	0.211	0.38	0.098
F_3^1	Summer	North Sea	0.08	0.024	0.08	0.025	0.10	0.019
F_4^1	Autumn	North Sea	0.11	0.048	0.11	0.049	0.08	0.026
F_1^2	Winter	Irish Sea	0.09	0.046	0.09	0.046	0.09	0.047
F_2^2	Spring	Irish Sea	0.09	0.046	0.09	0.046	0.09	0.047
F_3^2	Summer	Irish Sea	0.09	0.046	0.09	0.046	0.09	0.047
F_4^2	Autumn	Irish Sea	0.09	0.046	0.09	0.046	0.09	0.047
F_1^3	Winter	Biscay	0.07	0.019	0.04	0.007	0.04	0.008

F_2^3	Spring	Biscay	0.10	0.038	0.05	0.011	0.05	0.012
F_3^3	Summer	Biscay	0.25	0.072	0.13	0.025	0.14	0.025
F_4^3	Autumn	Biscay	0.19	0.036	0.10	0.013	0.11	0.013
F_1^4	Winter	Mixing area	0.04	0.010	0.08	0.030	0.06	0.033
F_2^4	Spring	Mixing area	0.09	0.015	0.15	0.031	0.15	0.037
F_3^4	Summer	Mixing area	0.08	0.010	0.08	0.012	0.07	0.013
F_4^4	Autumn	Mixing area	0.07	0.009	0.05	0.012	0.04	0.013
$T_1^{1\to2}$	Winter	North Sea to Irish Sea	0		0		0	
$T_2^{1\to2}$	Spring	North Sea to Irish Sea	0		0		0	
$T_3^{1\to2}$	Summer	North Sea to Irish Sea	0		0		0	
$T_4^{1\to2}$	Autumn	North Sea to Irish Sea	0		0		0	
$T_1^{1\to3}$	Winter	North Sea to Biscay	0.00	0.000	0.00	0.000	0.12	0.077
$T_2^{1\to3}$	Spring	North Sea to Biscay	0.00	0.000	0.00	0.000	0.00	0.000
$T_3^{1\to3}$	Summer	North Sea to Biscay	0.00	0.000	0.00	0.000	0.00	0.000
$T_4^{1\to3}$	Autumn	North Sea to Biscay	0.00	0.000	0.00	0.000	0.03	0.033
$T_1^{1\to4}$	Winter	North Sea to Mixing area	0.41	0.148	0.41	0.148	0.32	0.094
$T_2^{1\to4}$	Spring	North Sea to Mixing area	0.00	0.000	0.00	0.000	0.19	0.111
$T_3^{1\to4}$	Summer	North Sea to Mixing area	0.17	0.066	0.20	0.073	0.21	0.062
$T_4^{1\to4}$	Autumn	North Sea to Mixing area	0.56	0.088	0.55	0.089	0.40	0.073
$T_1^{2\to1}$	Winter	Irish Sea to North Sea	0		0		0	
$T_2^{2\to1}$	Spring	Irish Sea to North Sea	0		0		0	
$T_3^{2\to1}$	Summer	Irish Sea to North Sea	0		0		0	
$T_4^{2\to1}$	Autumn	Irish Sea to North Sea	0		0		0	
$T_1^{2\to3}$	Winter	Irish Sea to Biscay	0		0		0	
$T_2^{2\to3}$	Spring	Irish Sea to Biscay	0		0		0	
$T_3^{2\to3}$	Summer	Irish Sea to Biscay	0		0		0	
$T_4^{2\to3}$	Autumn	Irish Sea to Biscay	0		0		0	
$T_1^{2\to4}$	Winter	Irish Sea to Mixing area	1.00	0.001	1.00	0.001	1.00	0.001
$T_2^{2\to4}$	Spring	Irish Sea to Mixing area	1.00	0.001	1.00	0.001	1.00	0.002
$T_3^{2\to4}$	Summer	Irish Sea to Mixing area	0.00	0.001	0.00	0.001	0.00	0.001
$T_4^{2\to4}$	Autumn	Irish Sea to Mixing area	0.36	0.253	0.36	0.257	0.36	0.258
$T_1^{3\to1}$	Winter	Biscay to North Sea	0.00	0.000	0.00	0.000	0.01	0.013
$T_2^{3\to1}$	Spring	Biscay to North Sea	0.00	0.000	0.02	0.012	0.04	0.019
$T_3^{3\to1}$	Summer	Biscay to North Sea	0.00	0.000	0.00	0.000	0.00	0.000
$T_4^{3\to1}$	Autumn	Biscay to North Sea	0.00	0.000	0.00	0.000	0.00	0.000
$T_1^{3\to2}$	Winter	Biscay to Irish Sea	0		0		0	
$T_2^{3\to2}$	Spring	Biscay to Irish Sea	0		0		0	
$T_3^{3\to2}$	Summer	Biscay to Irish Sea	0		0		0	
$T_4^{3\to2}$	Autumn	Biscay to Irish Sea	0		0		0	
$T_1^{3\to4}$	Winter	Biscay to Mixing area	0.21	0.066	0.04	0.022	0.03	0.020
$T_2^{3\to4}$	Spring	Biscay to Mixing area	0.42	0.059	0.27	0.036	0.26	0.036
$T_3^{3\to4}$	Summer	Biscay to Mixing area	0.31	0.071	0.24	0.044	0.25	0.044
$T_4^{3\to4}$	Autumn	Biscay to Mixing area	0.37	0.060	0.08	0.032	0.08	0.032
$T_1^{4\to1}$	Winter	Mixing area to North Sea	0.01	0.009	0.02	0.015	0.05	0.026
$T_2^{4\to1}$	Spring	Mixing area to North Sea	0.06	0.021	0.11	0.044	0.29	0.066
$T_3^{4\to1}$	Summer	Mixing area to North Sea	0.08	0.025	0.11	0.036	0.11	0.039
$T_4^{4\to1}$	Autumn	Mixing area to North Sea	0.01	0.009	0.01	0.013	0.00	0.000
$T_1^{4\to2}$	Winter	Mixing area to Irish Sea	0.00	0.000	0.00	0.000	0.00	0.000
$T_2^{4\to2}$	Spring	Mixing area to Irish Sea	0.04	0.020	0.08	0.042	0.08	0.043
$T_3^{4\to2}$	Summer	Mixing area to Irish Sea	0.00	0.000	0.00	0.000	0.00	0.000
$T_4^{4\to2}$	Autumn	Mixing area to Irish Sea	0.00	0.000	0.00	0.000	0.00	0.000
$T_1^{4\to3}$	Winter	Mixing area to Biscay	0.25	0.034	0.42	0.052	0.44	0.056
$T_2^{4\to3}$	Spring	Mixing area to Biscay	0.13	0.032	0.08	0.041	0.08	0.044
$T_3^{4\to3}$	Summer	Mixing area to Biscay	0.04	0.020	0.08	0.028	0.09	0.034
$T_4^{4\to3}$	Autumn	Mixing area to Biscay	0.13	0.028	0.31	0.042	0.33	0.046

For the semesterly model of the two areas parameterisation (hypothesis 4, Table 5), the rates of transfer between the two areas are estimated to be high, 0.425 (standard deviation, SD = 0.041) at the start of the so-called "winter" season (beginning of October) from the north to the south and 0.444 (SD = 0.040) at the start of the "summer" season (beginning of April). Similar estimates and seasonal variations are

obtained for the quarterly model (Table 6) with higher values at the start of autumn and winter from the north to the south (0.295 (SD = 0.038) and 0.433 (SD = 0.049) respectively) and at the start of spring and summer from the south to the north (0.288 (SD = 0.038) and 0.25 (SD = 0.045) respectively).

Table 5. Summary results for the preferred two areas semesterly model (Hypothesis 4, model 42).

Parameter	Season	Area	Mean	SD
Fishing mortality				
F_1^1	Winter	North	0.062	0.012
F_1^2	Summer	North	0.088	0.011
F_2^1	Winter	South	0.109	0.012
F_2^2	Summer	South	0.139	0.022
Movement rate				
$T_1^{1\to2}$	Winter	North to South	0.425	0.041
$T_2^{1\to2}$	Summer	North to South	0.158	0.041
$T_1^{2\to1}$	Winter	South to North	0.070	0.029
$T_2^{2\to1}$	Summer	South to North	0.444	0.040

Table 6. Summary results for the preferred two areas quarterly model (Hypothesis 4, model 48).

Parameter	Season	Area	Mean	SD
Fishing mortality				
F_1^1	Winter	North	0.034	0.012
F_2^1	Spring	North	0.130	0.023
F_3^1	Summer	North	0.063	0.008
F_4^1	Autumn	North	0.047	0.010
F_1^2	Winter	South	0.035	0.007
F_2^2	Spring	South	0.046	0.011
F_3^2	Summer	South	0.126	0.024
F_4^2	Autumn	South	0.100	0.013
Movement rate				
$T_1^{1\to2}$	Winter	North to South	0.433	0.049
$T_2^{1\to2}$	Spring	North to South	0.120	0.059
$T_3^{1\to2}$	Summer	North to South	0.097	0.034
$T_4^{1\to2}$	Autumn	North to South	0.295	0.038
$T_1^{2\to1}$	Winter	South to North	0.043	0.024
$T_2^{2\to1}$	Spring	South to North	0.288	0.038
$T_3^{2\to1}$	Summer	South to North	0.250	0.045
$T_4^{2\to1}$	Autumn	South to North	0.073	0.030

Average F estimates are higher in the trimester model than in the semester model. F estimates on a yearly basis are equal to 0.32 (SD = 0.191), 0.24 (SD = 0.018), 0.26 (SD = 0.018) and 0.20 (SD = 0.029) for the semester model and spatial structure hypothesis 1, 2, 3 and 4 respectively while for the quarterly model estimates are equal to 0.51 (SD = 0.21), 0.47 (SD = 0.21), 0.42 (SD = 0.14) and 0.30 (SD = 0.05). It is worth noting that the confidence intervals are relatively large for the quarterly model F estimates (with coefficient of variations from 34 to 46%). The choice of parameterisation in F has little influence on the estimates of movement as shown in Figure 1 for models 26, 28 and 30. Different F parameterisations for a given parameterisation of movement result in similar values for the seasonal

movement rates by season. Similar results are obtained for the fishing mortality rate estimation under different movement parameterisation (Figure 2, models 29 and 30).

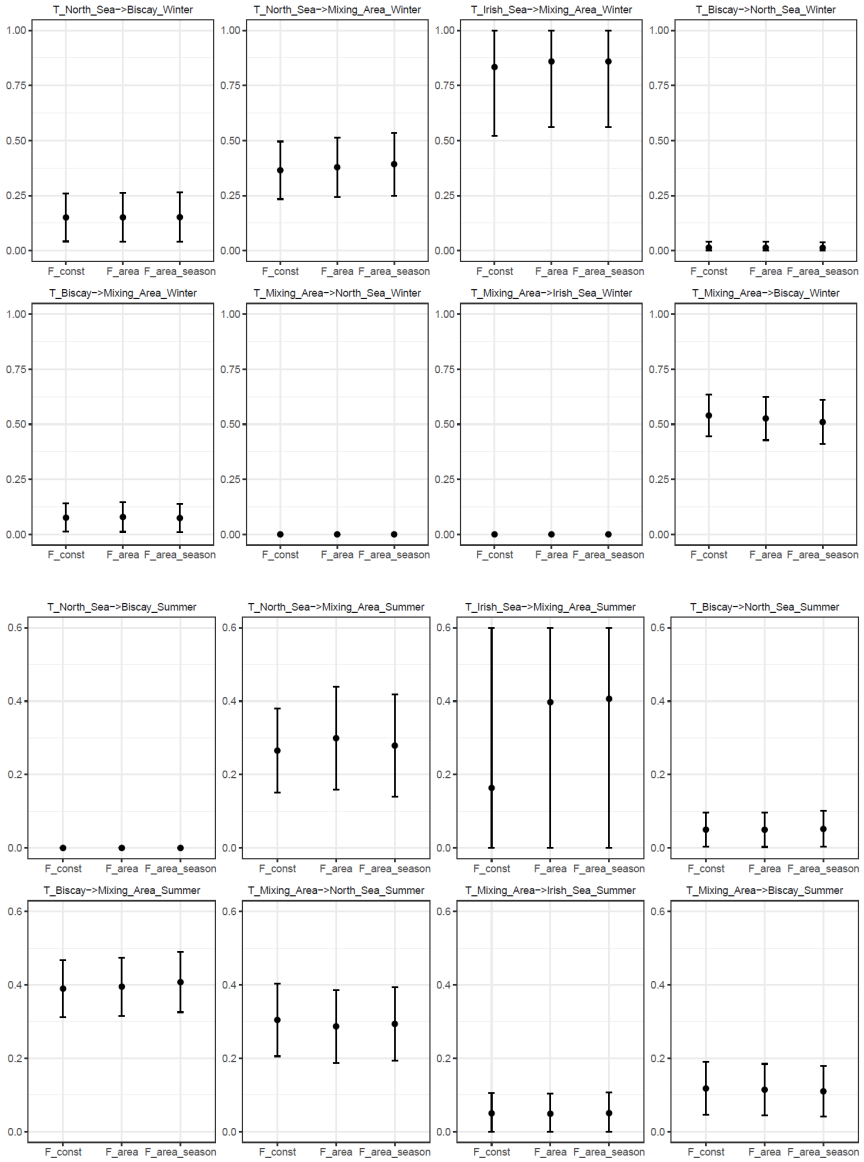


Figure 1. Seasonal movement rates (rows 1 and 2 = winter, rows 3 and 4 = summer) between the 4 areas under spatial structure hypothesis 3 and semesterly time steps with 95% confidence intervals for models with different parameterisation in F (Fconst = constant F over area and season, Farea = constant F over seasons but variable over areas, Farea_season = F variable by area and season; models 26, 28 and 30.

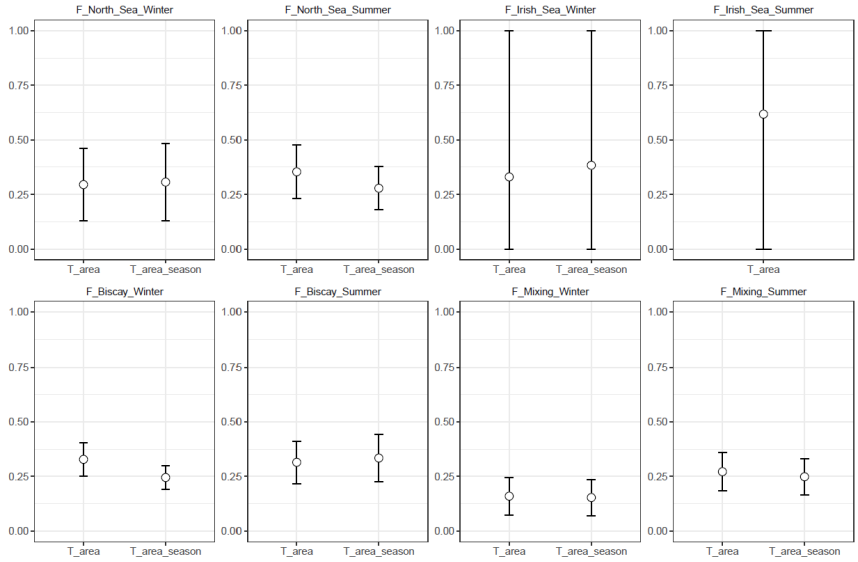


Figure 2. Seasonal fishing mortality rates by area with 95% confidence intervals for two models with different parameterisation in movement (T_area = constant T over seasons, T_area_season = T variable by area and season) and spatial structure hypothesis 3; models 29 and 30. Note that the confidence intervals for both F in the Irish sea have been trimmed to 0 and 1.

From the probabilities associated with each individual trajectory and the number of tagged and released seabass by release sets it is possible to calculate the predicted number of recoveries by time intervals and release sets (Figure 3). The agreement between predicted and observed recoveries for the main release sets is good but the model tends to predict less recoveries than observed over the more recent years of the experiment. This is also shown on Figure 4 for the overall (all release sets combined) and residual fits. Improvement in the fit can be obtained by allowing variations in F over time. This leads however to rather unrealistic increase in F (not presented).

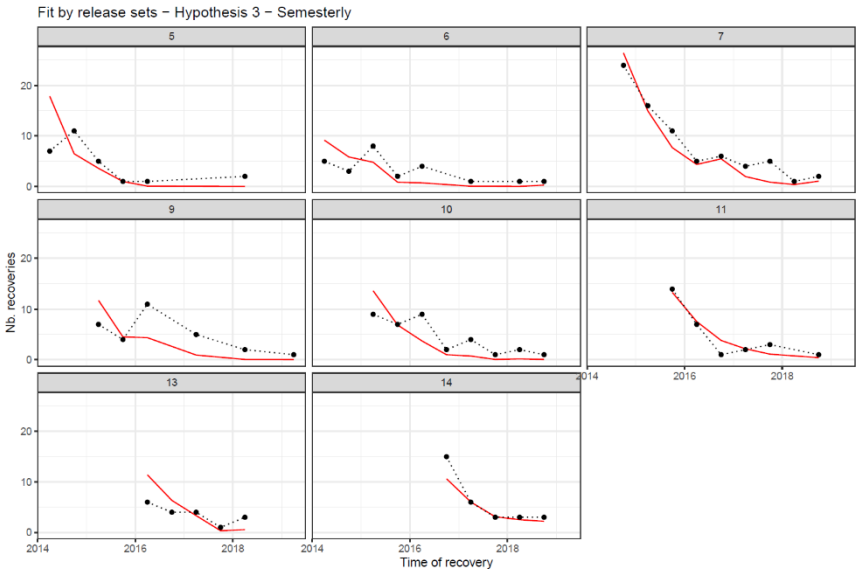


Figure 3. Tag recapture history by main release sets. Solid line indicates model prediction and black dots indicate observed recaptures; spatial structure hypothesis 3, semesterly time steps and F and T variable by area and season (model 30).

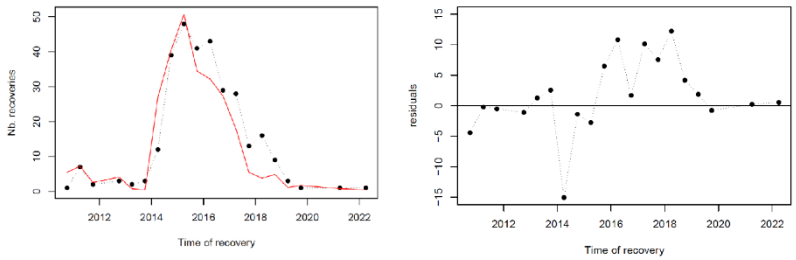


Figure 4. Overall tag recapture history (left) and residuals (right) for the spatial structure hypothesis 3, semesterly time steps and F and T variable by area and season (model 30).

Conclusion

Using a multi-state mark-recapture model fitted to individual trajectories of sea bass tagged with DST tags, we estimated movement and survival rates for four population structure hypotheses proposed by the ICES benchmark workshop WKSEABASS-2023. The present analysis confirms and refine some of the patterns of movement already described by de Pontual *et al.* (2019) and de Pontual *et al.* (2023). For a fraction of the sea bass population, it shows that non-negligible seasonal movements occur between areas, and notably between two of the current ICES stock assessment areas. This indicates, as already highlighted by de Pontual *et al.* (2023), that the current hypothesis of two independent stocks used in the ICES assessments (ICES, 2012) and management are inappropriate. From the two areas model, the analysis also shows that these seasonal movements occur preferentially from the current northern stock to the Bay of Biscay in relation with spawning in winter and in the other direction in relation with feeding in summer. This is also observed for two of the four areas hypotheses (Hypothesis 2 and 3) although these seasonal patterns in movement are, in that case, mainly observed between the "Area of mixing" (Celtic Sea, Western Channel or Celtic Sea, Western and Eastern Channel) and the Bay of Biscay and are less clear between the "Area of mixing" and the North Sea area.

It is worth noting that the current model is based on several assumptions that may not be fully satisfied and which may biased some of the parameter estimations. Tag shedding and tag induced mortality are assumed negligible and all recaptured fish are assumed reported. The model also assumes that tag and untagged animals are fully mixed throughout the range of the population. Finally, the trajectories to which the model is fitted are assumed known while they have been reconstructed from a geolocation model with some degree of uncertainty not accounted for.

The information used in the analysis comes only from the tags recovered by the fishery and several recoveries (beached tags) were not included. Those recoveries could potentially be used in future analysis to estimate natural mortality which, in the present analysis, is set to a constant value used by ICES for the assessment of the sea bass stocks (ICES, 2023).

Finally, conventional tagging (external tags) data from several tagging experiments carried out around British islands and France (Pawson *et al.*, 2007) could be used to supplement these results. This could be done by combining, in the same modelling framework, both conventional and archival tags (Miller and Andersen, 2008; Eveson *et al.*, 2012).

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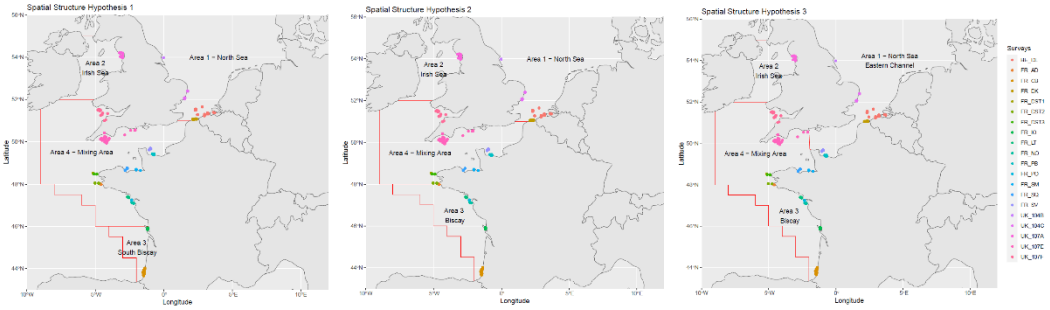
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Annex 1 Maps of the population structures and corresponding areas for the four areas hypotheses with the location of the tagging surveys used in the analysis.



Annex 2: Estimated Parameters for spatial structure hypothesis 1

Semester time steps

F	Fconstant	Fconstant	Farea	Farea	Farea,season	**Farea,season**
T	Tarea	Tarea,season	Tarea	Tarea,season	Tarea	**Tarea,season**
nb. parameters	9	17	12	20	16	**23**
likelihood	1469.98	1454.70	1460.87	1446.76	1456.69	**1439.67**
AIC	2958	2943	2946	2934	2945	**2925**
deltaAIC	33	18	20	8	20	**0**
F11	0.12	0.12	0.14	0.13	0.13	0.14
F12					0.15	0.12
F21			0.27	0.20	0.16	0.21
F22					0.31	0.21
F31			0.20	0.19	0.20	0.19
F32					0.22	0.23
F41			0.09	0.09	0.08	0.07
F42					0.11	0.12
T1_2_1	0	0	0	0	0	**0**
T1_2_2	0	0	0	0	0	**0**
T1_3_1	0.00	0.00	0.00	0.00	0.00	**0.00**
T1_3_2		0.00		0.00		**0.00**
T1_4_1	0.37	0.55	0.41	0.59	0.40	**0.60**
T1_4_2		0.18		0.20		**0.19**
T2_1_1	0	0	0	0	0	**0**
T2_1_2	0	0	0	0	0	**0**
T2_3_1	0	0	0	0	0	**0**
T2_3_2	0	0	0	0	0	**0**
T2_4_1	0.62	0.83	0.74	0.86	0.72	**0.86**
T2_4_2		0.15		0.45		**0.46**
T3_1_1	0.00	0.00	0.00	0.00	0.00	**0.00**
T3_1_2		0.00		0.00		**0.00**
T3_2_1	0	0	0	0	0	**0**
T3_2_2	0	0	0	0	0	**0**
T3_4_1	0.31	0.24	0.36	0.30	0.37	**0.31**
T3_4_2		0.41		0.45		**0.47**
T4_1_1	0.10	0.02	0.09	0.02	0.09	**0.01**
T4_1_2		0.13		0.13		**0.14**
T4_2_1	0.02	0.00	0.02	0.00	0.02	**0.00**
T4_2_2		0.03		0.03		**0.03**
T4_3_1	0.17	0.19	0.13	0.14	0.13	**0.13**
T4_3_2		0.16		0.15		**0.16**

Quarterly time steps

F	Fconstant	Fconstant	Farea	Farea	Farea,season	**Farea,season**
T	Tarea	Tarea,season	Tarea	Tarea,season	Tarea	**Tarea,season**
nb parameters	9	33	12	36	21	**45**
likelihood	not converged	1683.38	1755.81	1675.52	1738.66	**1655.84**
AIC		3433	3536	3423	3519	**3402**
deltaAIC		31	134	21	118	**0**
F11		0.09	0.13	0.12	0.07	**0.09**
F12					0.58	**0.51**
F13					0.10	**0.08**
F14					0.10	**0.11**
F21			0.15	0.09	0.15	**0.09**
F22					0.15	**0.09**
F23					0.15	**0.09**
F24					0.15	**0.09**
F31			0.15	0.13	0.10	**0.07**
F32					0.10	**0.10**
F33					0.27	**0.25**
F34					0.18	**0.19**
F41			0.08	0.07	0.05	**0.04**
F42					0.10	**0.09**
F43					0.09	**0.08**
F44					0.07	**0.07**
T1_2_1		0	0	0	0	**0**
T1_2_2		0	0	0	0	**0**
T1_2_3		0	0	0	0	**0**
T1_2_4		0	0	0	0	**0**
T1_3_1		0.00	0.00	0.00	0.00	**0.00**
T1_3_2		0.00		0.00		**0.00**
T1_3_3		0.00		0.00		**0.00**
T1_3_4		0.00		0.00		**0.00**
T1_4_1		0.36	0.34	0.37	0.33	**0.41**
T1_4_2		0.00		0.00		**0.00**
T1_4_3		0.16		0.20		**0.17**
T1_4_4		0.51		0.54		**0.56**
T2_1_1		0	0	0	0	**0**
T2_1_2		0	0	0	0	**0**
T2_1_3		0	0	0	0	**0**
T2_1_4		0	0	0	0	**0**
T2_3_1		0	0	0	0	**0**
T2_3_2		0	0	0	0	**0**
T2_3_3		0	0	0	0	**0**
T2_3_4		0	0	0	0	**0**
T2_4_1		1.00	0.42	1.00	0.42	**1.00**
T2_4_2		1.00		1.00		**1.00**
T2_4_3		0.00		0.00		**0.00**
T2_4_4		0.36		0.36		**0.36**
T3_1_1		0.00	0.00	0.00	0.00	**0.00**
T3_1_2		0.00		0.00		**0.00**
T3_1_3		0.00		0.00		**0.00**
T3_1_4		0.00		0.00		**0.00**
T3_2_1		0	0	0	0	**0**
T3_2_2		0	0	0	0	**0**
T3_2_3		0	0	0	0	**0**
T3_2_4		0	0	0	0	**0**
T3_4_1		0.22	0.33	0.25	0.34	**0.21**
T3_4_2		0.39		0.41		**0.42**
T3_4_3		0.28		0.28		**0.31**
T3_4_4		0.30		0.34		**0.37**

T4_1_1		0.01	0.03	0.01	0.03	**0.01**
T4_1_2		0.06		0.06		**0.06**
T4_1_3		0.09		0.08		**0.08**
T4_1_4		0.01		0.01		**0.01**
T4_2_1		0.00	0.01	0.00	0.01	**0.00**
T4_2_2		0.03		0.03		**0.04**
T4_2_3		0.00		0.00		**0.00**
T4_2_4		0.00		0.00		**0.00**
T4_3_1		0.26	0.13	0.24	0.13	**0.25**
T4_3_2		0.13		0.12		**0.13**
T4_3_3		0.05		0.04		**0.04**
T4_3_4		0.15		0.13		**0.13**

Annex 3: Estimated Parameters for spatial structure hypothesis 2

Semester time steps

F	Fconstant	**Fconstant**	Farea	Farea	Farea,season	Farea,season
T	Tarea	**Tarea,season**	Tarea	Tarea,season	Tarea	Tarea,season
nb. parameters	9	**17**	12	20	16	23
likelihood	1511.20	**1463.01**	1509.70	1462.72	1503.90	1458.23
AIC	3040	**2960**	3043	2965	3040	2962
deltaAIC	80	**0**	83	5	80	2
F11	0.14	**0.12**	0.15	0.13	0.13	0.15
F12					0.15	0.12
F21			0.27	0.20	0.16	0.20
F22					0.31	0.20
F31			0.15	0.13	0.16	0.12
F32					0.15	0.16
F41			0.12	0.12	0.07	0.08
F42					0.15	0.13
T1_2_1	0	**0**	0	0	0	0
T1_2_2	0	**0**	0	0	0	0
T1_3_1	0.08	**0.10**	0.07	0.10	0.07	0.10
T1_3_2		**0.00**		0.00		0.00
T1_4_1	0.33	**0.47**	0.35	0.48	0.34	0.50
T1_4_2		**0.19**		0.20		0.19
T2_1_1	0	**0**	0	0	0	0
T2_1_2	0	**0**	0	0	0	0
T2_3_1	0	**0**	0	0	0	0
T2_3_2	0	**0**	0	0	0	0
T2_4_1	0.64	**0.83**	0.74	0.86	0.72	0.86
T2_4_2		**0.15**		0.42		0.44
T3_1_1	0.01	**0.00**	0.01	0.00	0.01	0.00
T3_1_2		**0.01**		0.01		0.01
T3_2_1	0	**0**	0	0	0	0
T3_2_2	0	**0**	0	0	0	0
T3_4_1	0.27	**0.08**	0.28	0.08	0.28	0.08
T3_4_2		**0.42**		0.42		0.43
T4_1_1	0.11	**0.02**	0.11	0.02	0.10	0.02
T4_1_2		**0.20**		0.20		0.21
T4_2_1	0.02	**0.00**	0.02	0.00	0.02	0.00
T4_2_2		**0.05**		0.05		0.05
T4_3_1	0.31	**0.49**	0.29	0.48	0.29	0.46
T4_3_2		**0.10**		0.10		0.10

Quarterly time steps

F	Fconstant	Fconstant	Farea	Farea	Farea,season	**Farea,season**
T	Tarea	Tarea,season	Tarea	Tarea,season	Tarea	**Tarea,season**
nb parameters	9	33	12	36	21	**45**
likelihood	1786.94	1685.65	1785.55	1683.35	1757.02	**1651.79**
AIC	3592	3437	3595	3439	3556	**3394**
	198	44	202	45	162	**0**
F11	0.10	0.08	0.13	0.12	0.07	0.09
F12					0.61	0.56
F13					0.10	0.08
F14					0.10	0.11
F21			0.15	0.09	0.15	0.09
F22					0.15	0.09
F23					0.15	0.09
F24					0.15	0.09
F31			0.09	0.07	0.06	0.04
F32					0.06	0.05
F33					0.13	0.13
F34					0.12	0.10
F41			0.10	0.08	0.08	0.08
F42					0.20	0.15
F43					0.10	0.08
F44					0.05	0.05
T1_2_1	0	0	0	0	0	**0**
T1_2_2	0	0	0	0	0	**0**
T1_2_3	0	0	0	0	0	**0**
T1_2_4	0	0	0	0	0	**0**
T1_3_1	0.00	0.00	0.00	0.00	0.00	**0.00**
T1_3_2		0.00		0.00		**0.00**
T1_3_3		0.00		0.00		**0.00**
T1_3_4		0.00		0.00		**0.00**
T1_4_1	0.31	0.36	0.34	0.37	0.33	**0.41**
T1_4_2		0.00		0.00		**0.00**
T1_4_3		0.17		0.20		**0.20**
T1_4_4		0.50		0.54		**0.55**
T2_1_1	0	0	0	0	0	**0**
T2_1_2	0	0	0	0	0	**0**
T2_1_3	0	0	0	0	0	**0**
T2_1_4	0	0	0	0	0	**0**
T2_3_1	0	0	0	0	0	**0**
T2_3_2	0	0	0	0	0	**0**
T2_3_3	0	0	0	0	0	**0**
T2_3_4	0	0	0	0	0	**0**
T2_4_1	0.37	1.00	0.42	1.00	0.42	**1.00**
T2_4_2		1.00		1.00		**1.00**
T2_4_3		0.00		0.00		**0.00**
T2_4_4		0.35		0.36		**0.36**
T3_1_1	0.01	0.00	0.00	0.00	0.00	**0.00**
T3_1_2		0.02		0.02		**0.02**
T3_1_3		0.00		0.00		**0.00**
T3_1_4		0.00		0.00		**0.00**
T3_2_1	0	0	0	0	0	**0**
T3_2_2	0	0	0	0	0	**0**
T3_2_3	0	0	0	0	0	**0**
T3_2_4	0	0	0	0	0	**0**
T3_4_1	0.16	0.05	0.15	0.05	0.15	**0.04**
T3_4_2		0.29		0.28		**0.27**
T3_4_3		0.22		0.21		**0.24**
T3_4_4		0.09		0.08		**0.08**

T4_1_1	0.05	0.01	0.05	0.01	0.05	**0.02**
T4_1_2		0.10		0.10		**0.11**
T4_1_3		0.11		0.11		**0.11**
T4_1_4		0.01		0.01		**0.01**
T4_2_1	0.01	0.00	0.01	0.00	0.01	**0.00**
T4_2_2		0.07		0.07		**0.08**
T4_2_3		0.00		0.00		**0.00**
T4_2_4		0.00		0.00		**0.00**
T4_3_1	0.23	0.38	0.23	0.39	0.24	**0.42**
T4_3_2		0.07		0.06		**0.08**
T4_3_3		0.09		0.09		**0.08**
T4_3_4		0.31		0.32		**0.31**

Annex 4: Estimated Parameters for spatial structure hypothesis 3

Semesterly time steps

F	Fconstant	**Fconstant**	Farea	Farea	Farea,season	Farea,season
T	Tarea	**Tarea,season**	Tarea	Tarea,season	Tarea	Tarea,season
Number of parameters	9	**17**	12	20	16	23
likelihood	1523.50	**1476.66**	1521.18	1475.69	1519.01	1472.74
AIC	3065	**2987**	3066	2991	3070	2991
deltaAIC	78	**0**	79	4	83	4
F11	0.15	**0.13**	0.17	0.15	0.15	0.15
F12					0.18	0.14
F21			0.27	0.19	0.17	0.19
F22					0.31	0.19
F31			0.16	0.13	0.16	0.12
F32					0.16	0.17
F41			0.12	0.11	0.08	0.08
F42					0.14	0.12
T1_2_1	0	**0**	0	0	0	0
T1_2_2	0	**0**	0	0	0	0
T1_3_1	0.10	**0.15**	0.10	0.15	0.10	0.15
T1_3_2		**0.00**		0.00		0.00
T1_4_1	0.30	**0.36**	0.33	0.38	0.32	0.39
T1_4_2		**0.27**		0.30		0.28
T2_1_1	0	**0**	0	0	0	0
T2_1_2	0	**0**	0	0	0	0
T2_3_1	0	**0**	0	0	0	0
T2_3_2	0	**0**	0	0	0	0
T2_4_1	0.65	**0.83**	0.74	0.86	0.72	0.86
T2_4_2		**0.16**		0.40		0.41
T3_1_1	0.03	**0.01**	0.03	0.01	0.03	0.01
T3_1_2		**0.05**		0.05		0.05
T3_2_1	0	**0**	0	0	0	0
T3_2_2	0	**0**	0	0	0	0
T3_4_1	0.26	**0.08**	0.27	0.08	0.27	0.07
T3_4_2		**0.39**		0.40		0.41
T4_1_1	0.16	**0.00**	0.15	0.00	0.15	0.00
T4_1_2		**0.30**		0.29		0.29
T4_2_1	0.02	**0.00**	0.02	0.00	0.02	0.00
T4_2_2		**0.05**		0.05		0.05
T4_3_1	0.34	**0.54**	0.32	0.53	0.32	0.51
T4_3_2		**0.12**		0.11		0.11

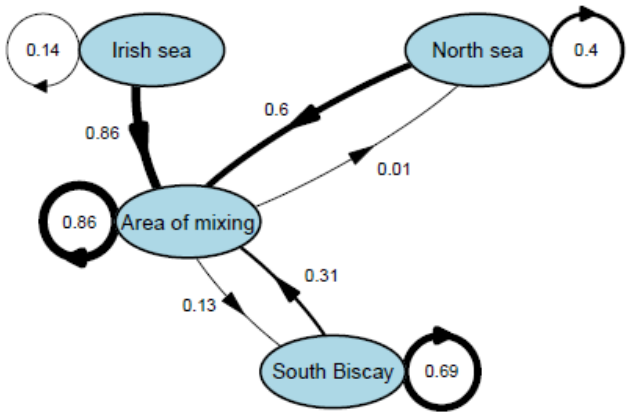
Quarterly time steps

F	Fconstant	Fconstant	Farea	Farea	Farea,season	**Farea,season**
T	Tarea	Tarea,season	Tarea	Tarea,season	Tarea	**Tarea,season**
nb of parameters	9	33	12	36	21	**45**
likelihood	1829.97	1719.81	1827.40	1715.84	1796.81	**1682.81**
AIC	3678	3506	3679	3504	3636	**3456**
	222	50	223	48	180	**0**
F11	0.10	0.08	0.13	0.12	0.08	**0.08**
F12					0.46	**0.38**
F13					0.12	**0.10**
F14					0.08	**0.08**
F21			0.15	0.09	0.15	**0.09**
F22					0.15	**0.09**
F23					0.15	**0.09**
F24					0.15	**0.09**
F31			0.09	0.08	0.06	**0.04**
F32					0.06	**0.05**
F33					0.13	**0.14**
F34					0.13	**0.11**
F41			0.09	0.07	0.05	**0.06**
F42					0.18	**0.15**
F43					0.09	**0.07**
F44					0.05	**0.04**
T1_2_1	0	0	0	0	0	**0**
T1_2_2	0	0	0	0	0	**0**
T1_2_3	0	0	0	0	0	**0**
T1_2_4	0	0	0	0	0	**0**
T1_3_1	0.03	0.08	0.03	0.09	0.03	**0.12**
T1_3_2		0.00		0.00		**0.00**
T1_3_3		0.00		0.00		**0.00**
T1_3_4		0.03		0.03		**0.03**
T1_4_1	0.26	0.33	0.29	0.34	0.28	**0.32**
T1_4_2		0.14		0.14		**0.19**
T1_4_3		0.18		0.26		**0.21**
T1_4_4		0.36		0.41		**0.40**
T2_1_1	0	0	0	0	0	**0**
T2_1_2	0	0	0	0	0	**0**
T2_1_3	0	0	0	0	0	**0**
T2_1_4	0	0	0	0	0	**0**
T2_3_1	0	0	0	0	0	**0**
T2_3_2	0	0	0	0	0	**0**
T2_3_3	0	0	0	0	0	**0**
T2_3_4	0	0	0	0	0	**0**
T2_4_1	0.37	1.00	0.42	1.00	0.42	**1.00**
T2_4_2		1.00		1.00		**1.00**
T2_4_3		0.00		0.00		**0.00**
T2_4_4		0.35		0.36		**0.36**
T3_1_1	0.01	0.02	0.01	0.01	0.01	**0.01**
T3_1_2		0.04		0.04		**0.04**
T3_1_3		0.00		0.00		**0.00**
T3_1_4		0.00		0.00		**0.00**
T3_2_1	0	0	0	0	0	**0**
T3_2_2	0	0	0	0	0	**0**
T3_2_3	0	0	0	0	0	**0**
T3_2_4	0	0	0	0	0	**0**
T3_4_1	0.15	0.04	0.15	0.04	0.15	**0.03**
T3_4_2		0.27		0.27		**0.26**
T3_4_3		0.22		0.21		**0.25**

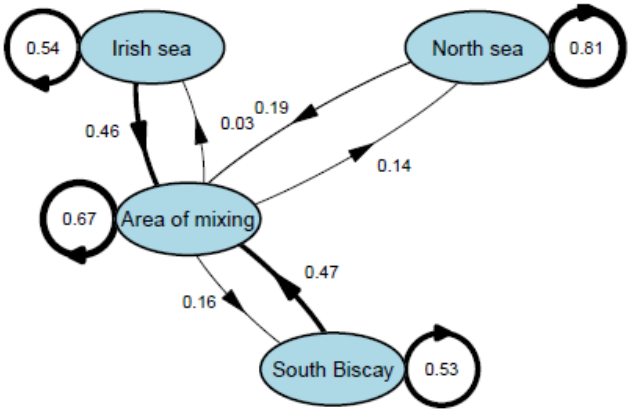
T3_4_4		0.08		0.08		**0.08**
T4_1_1	0.10	0.05	0.09	0.05	0.09	**0.05**
T4_1_2		0.32		0.31		**0.29**
T4_1_3		0.12		0.11		**0.11**
T4_1_4		0.00		0.00		**0.00**
T4_2_1	0.01	0.00	0.01	0.00	0.01	**0.00**
T4_2_2		0.07		0.07		**0.08**
T4_2_3		0.00		0.00		**0.00**
T4_2_4		0.00		0.00		**0.00**
T4_3_1	0.26	0.41	0.26	0.41	0.26	**0.44**
T4_3_2		0.07		0.07		**0.08**
T4_3_3		0.12		0.11		**0.09**
T4_3_4		0.34		0.34		**0.33**

Annex 5: Movement rates estimates between areas for the "best" 4 areas models, each spatial structure hypothesis and time discretisation (semester and quarter).

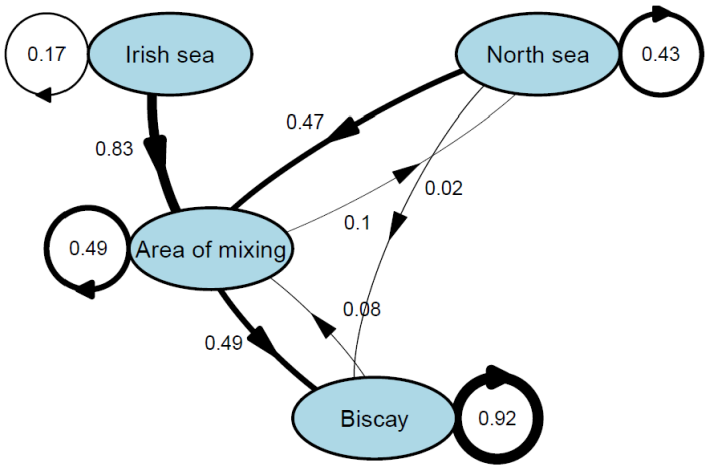
Movement rates by semester – begining of winter – H1



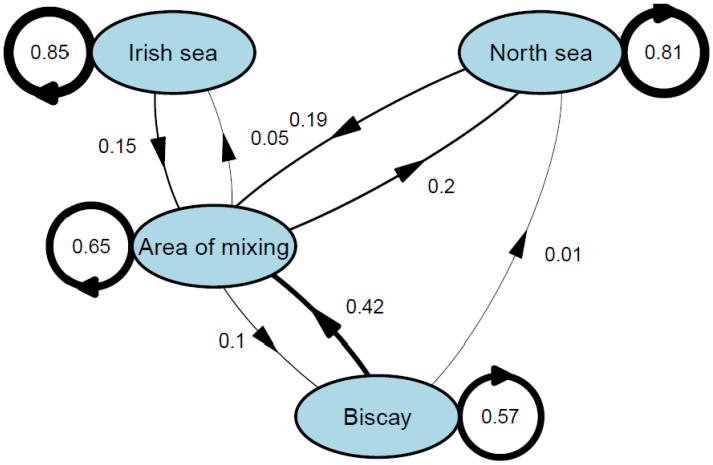
Movement rates by semester – begining of summer – H1



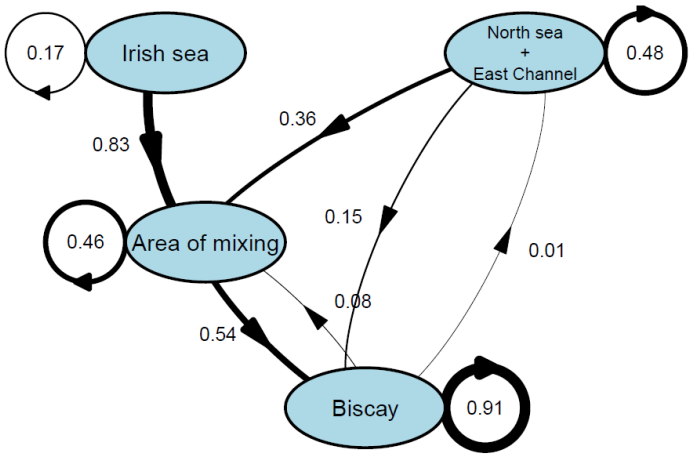
Movement rates by semester − begining of winter − H2



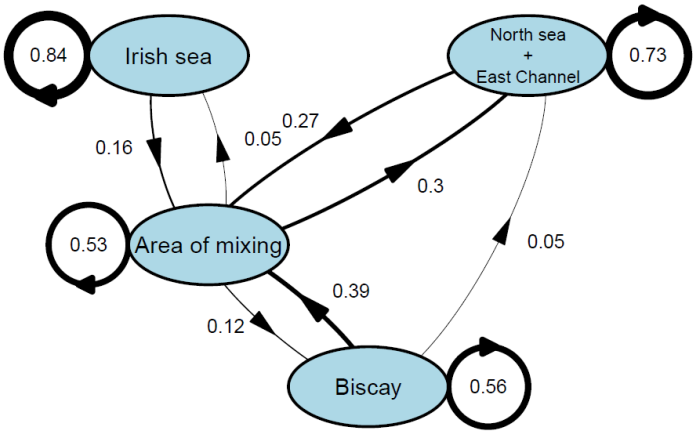
Movement rates by semester − begining of summer − H2



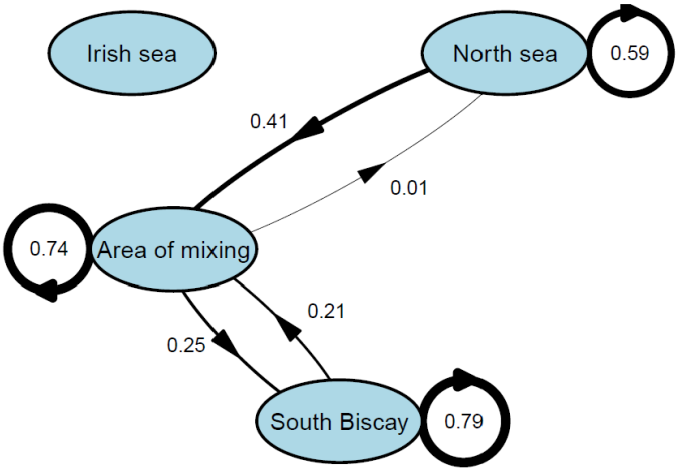
Movement rates by semester − begining of winter − H3



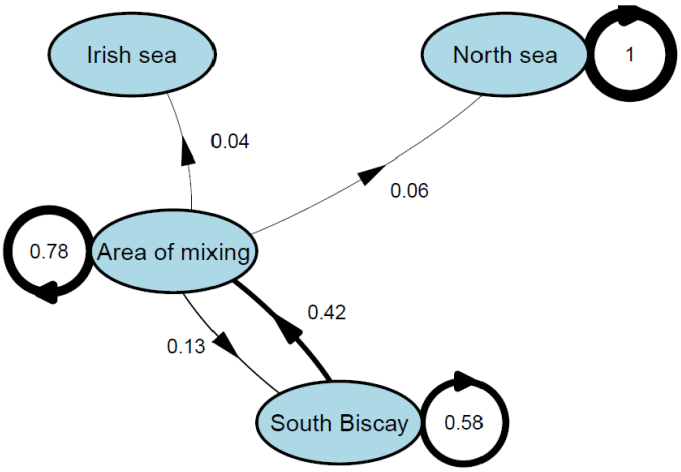
Movement rates by semester − begining of summer − H3



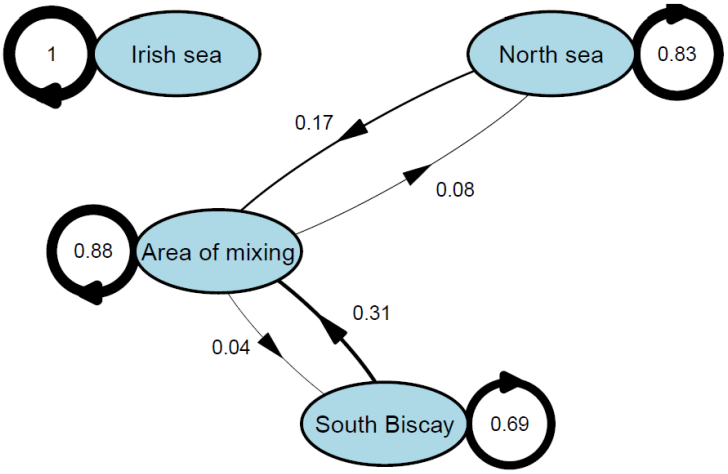
Movement rates by trimester − begining of winter − H1



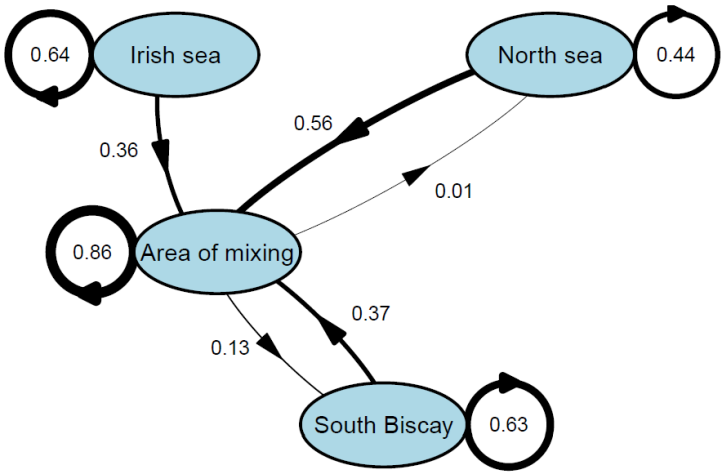
Movement rates by trimester − begining of spring − H1



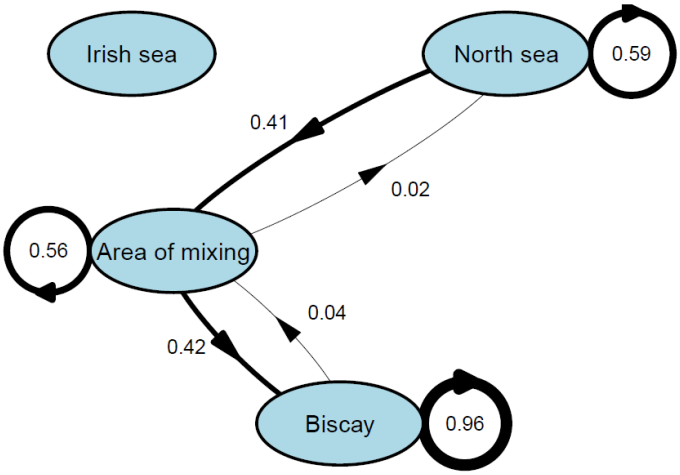
Movement rates by trimester – begining of summer – H1



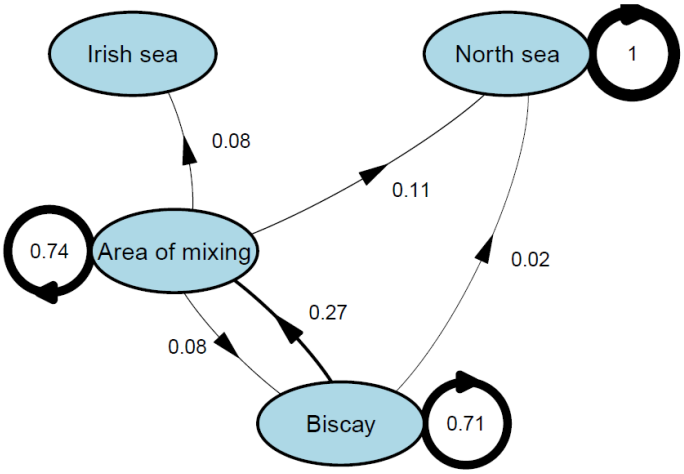
Movement rates by trimester – begining of autumn – H1



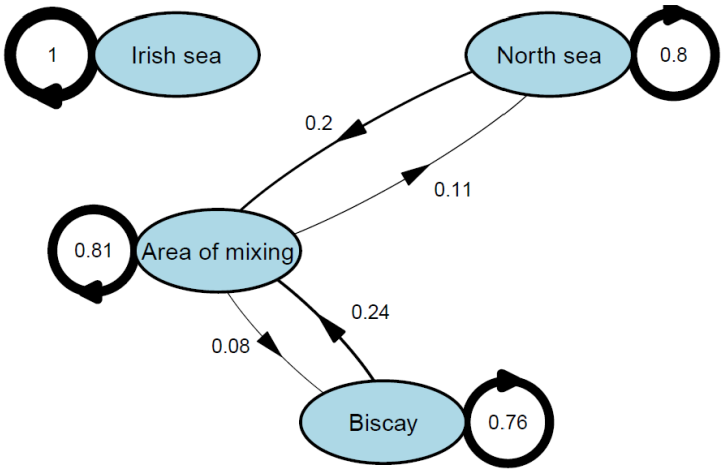
Movement rates by trimester − begining of winter − H2



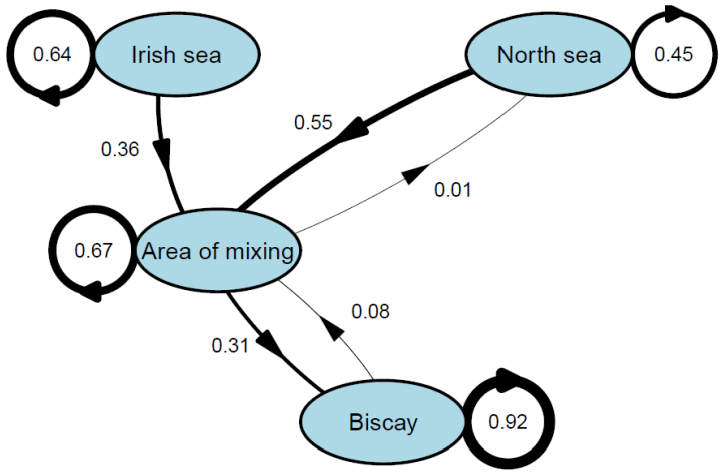
Movement rates by trimester − begining of spring − H2



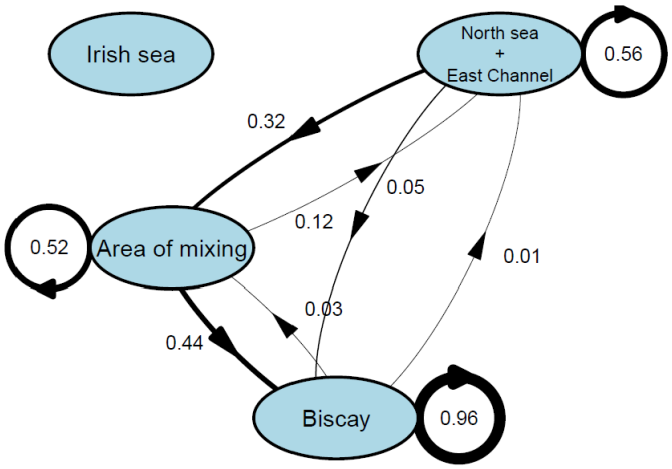
Movement rates by trimester − begining of summer − H2



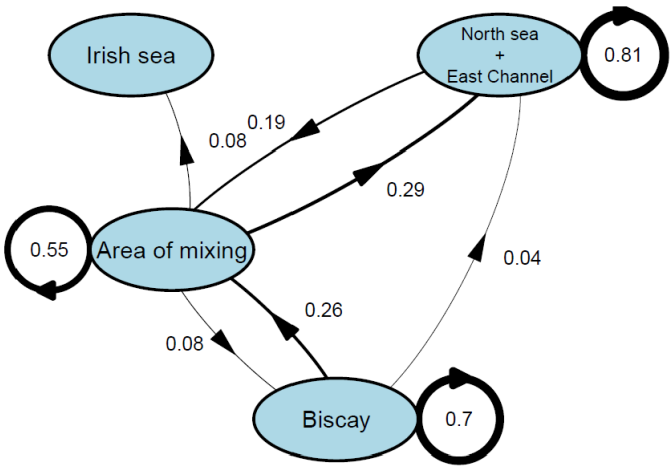
Movement rates by trimester − begining of autumn − H2



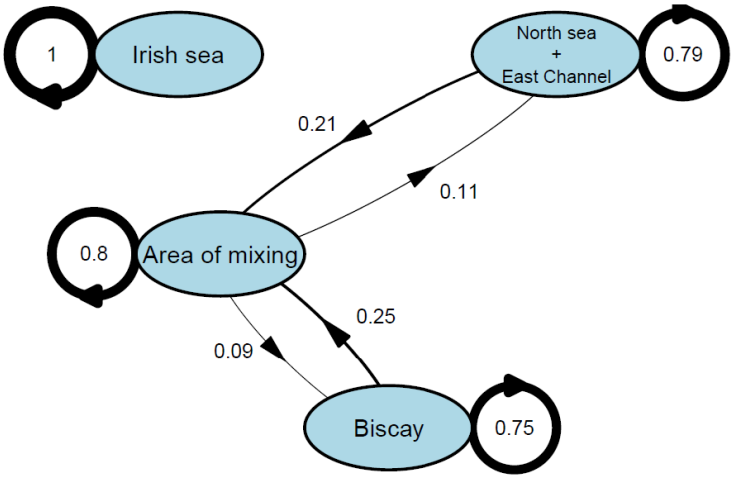
Movement rates by trimester − begining of winter − H3



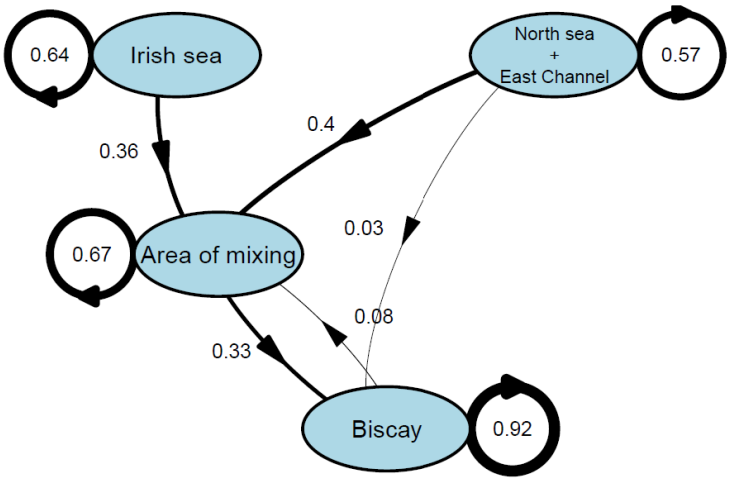
Movement rates by trimester − begining of spring − H3



Movement rates by trimester − begining of summer − H3



Movement rates by trimester − begining of autumn − H3



WORKING DOCUMENT

Standardized OTB-based LPUE abundance indices for adult European sea bass

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1. Introduction

For both sea bass stocks, LPUE indices have been developed and used for stock assessment since the last benchmark (ICES, 2018). Both indices relied on logbook data of a combined French fleet. The modelling approach was a delta model, i.e. a model splitting LPUE into two components: (1) a first component modeling zero vs. non-zero LPUE data, and (2) a second component modeling the positive LPUE data. The model and its fitting procedure were coded in Fortran, and did not used any standard R packages.

In addition, since the last sea bass stock ID benchmark (ICES, 2023), it now recognised that sea bass population shows seasonal migrations and spatial structure over time.

Thus, the objectives of this work were to :

1) develop a new LPUE index per fleet as recommended by the data workshop (here we focused on the OTB fleet as it was considered as a good candidate to reflect changes of abundance in the sea bass stocks);
2) account for the sea bass spatiotemporal dynamics within the model and
3) use the best available modelling approach to estimate spatiotemporal LPUE indices.

2. Material

Basic logbook data (all vessels < 10 m and > 10 m) from the French fleet have been used between 2000 and 2023, on the basis of daily sea bass declared catches. Dataset used contains all the french vessels that have fished at least once for sea bass in their year. From this list of vessels, it is associated their entire landings (sea bass and other species) by specifying: gear, statistics rectangles, day, month, year, sea bass landings, zero sea bass landings. Because discards are very low (less than 5% of the total catches; ICES, 2017), catches can be assimilated to landings. Although these logbooks may contain within a day detailed information (e.g. fishing time), it has been preferred to simply consider landings per day, and the associated ICES squares so that landings per unit of effort (LPUE) are expressed as kilograms of sea bass landed per day in an ICES square. LPUE below or equal to 0.99 kg/day were set to zero.

Over the period 2000-2023, the dataset compiled LPUEs from about 10 732 vessels-gears, which corresponds to more than 1,376,868 rows.

It is worth noting that 2000 and 2009 are years for which the data collection system has changed. Year 2000 should be excluded, as well as year 2008 for which the completeness of the logbook data was not reached.

3. Method

a. Data filtering

The following criteria were used to filter the dataset :

- sum of LPUEs per vessel > 10kg
- Number of days per vessel > 2
- Number of squares per vessel > 2
- Number of years per vessel > 2
- sum of the LPUEs per square != 0
- Number of days per square > 2

The filter was really conservative: the dataset reduced from 1,376,868 rows to 1,330,174 rows.

The spatiotemporal distribution of the LPUE were plotted per years and months (Figure 1 et 2). Distributions are variable over years, showing a decrease of the LPUE in the Northern stock following the management measures put in place since 2015. Distribution showed also seasonality, with LPUE being higher and more offshore in winter time and lower and more inshore in summer.

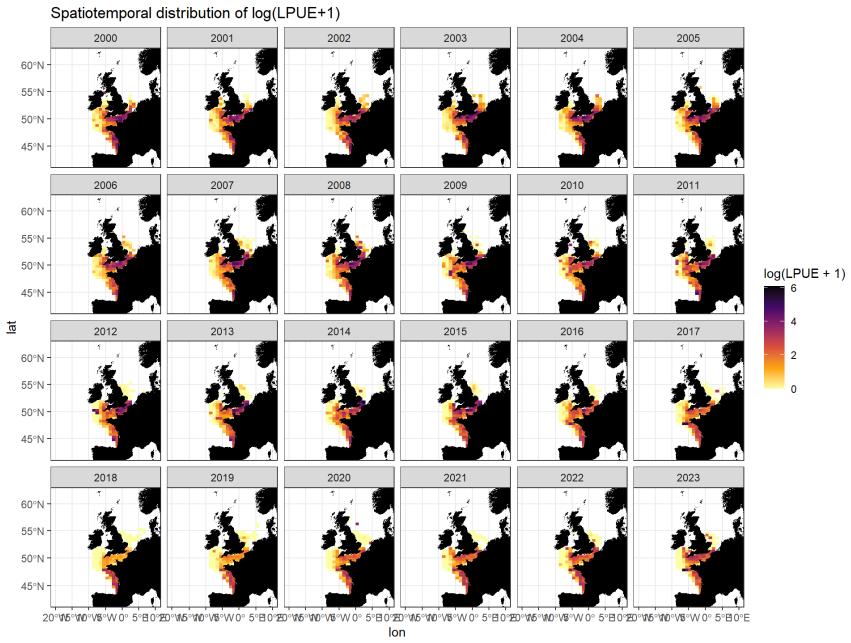


Figure 1: Yearly spatial distribution of log(LPUE + 1).

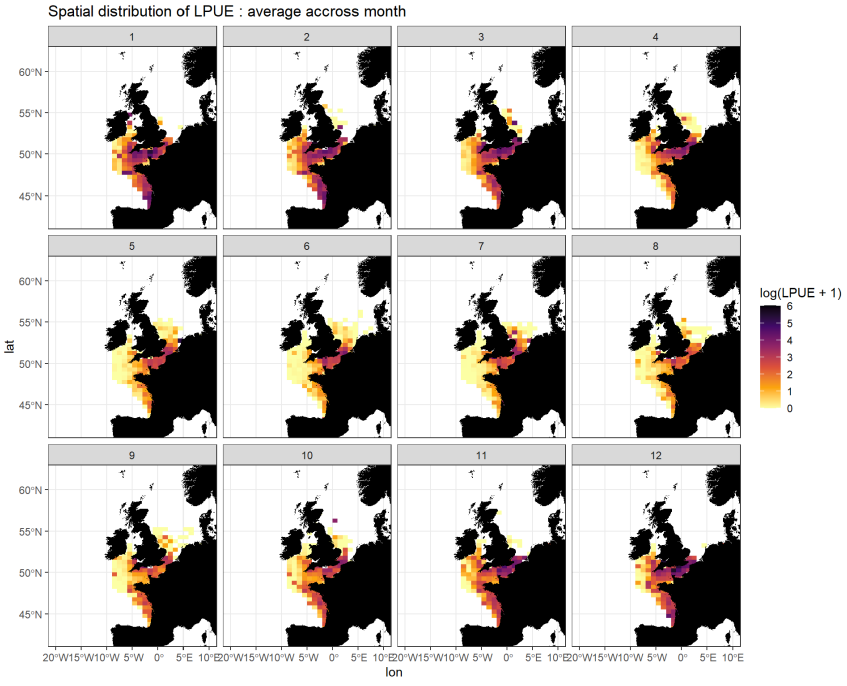


Figure 2: Monthly spatial distribution of log(LPUE + 1).

b. *Spatiotemporal generalized linear mixed effects model*

A spatiotemporal Generalized Linear Mixed Effects Models (GLMMs) was fitted to logbooks data (i.e. daily landings at the monthly and ICES square level). It used an R package named "sdmTMB" that fits spatial and spatiotemporal GLMMs using Template Model Builder (TMB), R-INLA, and Gaussian Markov random fields (Anderson et al., 2022). As in the model of the old LPUE index, the model followed a Delta modeling approach, i.e. an approach splitting LPUE into two components: (1) a first component modeling zero vs. non-zero LPUE data, and (2) a second component modeling the positive LPUE data. Here we fitted a Delta-lognormal model. This fits a binomial presence-absence model on the presence/absence data and then a model for the positive catches only with a lognormal observation distribution and a log link. The LPUE model write as:

$$\mathbb{E}\left[LPUE_{s,t}\right] = \mu_{s,t}$$

$$\mu_{s,t} = f^{-1}\left(X_{s,t}^{main}\beta + O_{s,t} + \alpha_g + \epsilon_{s,t}\right),$$

where

- $\mu_{s,t}$ represents the LPUE data at point s and time t (zero vs. non-zero LPUE data treated separately of the positive LPUE data respectively);
- μ represent the mean;

- f represents a link function (here a delta lognormal family was used with a logit and a log link respectively) and f^{-1} represents its inverse;
- $X_{s,t}^{main}$ represents the main effects (here a temporal effect combining years and months)
- β represents a vector of fixed-effects coefficients;
- $O_{s,t}$ represents an offset (here set to zero);
- α_g represents random intercepts by group g (here a vessel effect from the OTB fleet), $\alpha_g \sim \mathrm{N}(0, \sigma_\gamma^2)$;
- $\epsilon_{s,t}$ represents a spatiotemporal component (iid spatial Gaussian random fields that accounts for physical barriers; see Figure 3 and 4), $\epsilon_{s,t} \sim MVN(0, \Sigma_\epsilon)$.

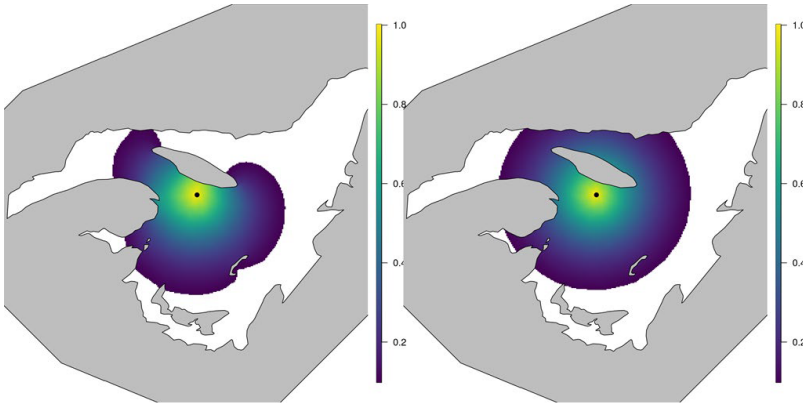


Figure 3: The left plot shows the correlation structure of the Barrier model, with respect to the black point, while the right plot shows the correlation structure of the stationary model (extracted from Krainski et al., 2018).

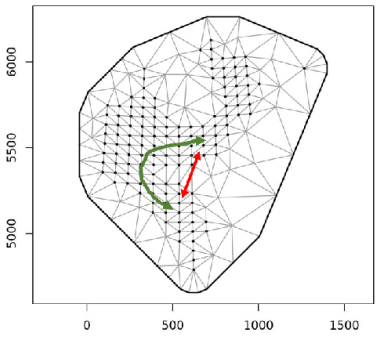


Figure 4: The mesh constructed both over water and land. Red arrow goes over land, while green arrow goes in the water.

4. Results

The model converged well (Table 1). The computing was intense and required the High Performance Computing infrastructure from Ifremer. It lasted 32h on 56 processors and 147 Gb of RAM. Parameters estimated by the model are compiled in the Table 2. Spatiotemporal predictions were performed over ICES squares and months of the years 2001-2023 (Figure 5). The vessel random effect was filtered out for the spatiotemporal predictions. Predictions were aggregated over the Northern and Southern stock areas (Figure 6) and over months April to November (as the previous combined French fleet LPUE indices) (Figure 7). It provided an annual OTB-based LPUE indices time-series comparable in trend with the previous combined fleet-based LPUE index for both stocks (Figure 8). The new indices showed similar trends. They both included most of the time within the confidence intervals the previous LPUE indices time-series. Note that 2000 & 2009 are years for which the data collection system has changed. The completeness of the logbook data was not reached in 2008. This year was excluded in the assessment model. Both indices looked stable when performing a retrospective analysis; the model was re-run entirely, while peeling off the last 4 years of the time-series (Figure 9).

Convergence checks
✓ Non-linear minimizer suggests successful convergence
✓ Hessian matrix is positive definite
✓ No extreme or very small eigenvalues detected
✓ No gradients with respect to fixed effects are >= 0.001
✓ No fixed-effect standard errors are NA
✓ No standard errors look unreasonably large
✓ No sigma parameters are < 0.01
✓ No sigma parameters are > 100
✓ Range parameters don't look unreasonably large

Table 1: convergence checks for the model.

Delta/hurdle model 1: --------------------

Family: binomial(link = 'logit')

	coef.est	coef.se
fyear_month2000_01	-0.89	0.72
fyear_month2000_02	-0.39	0.72
fyear_month2000_03	-0.99	0.72
fyear_month2000_04	-1.55	0.72
fyear_month2000_05	-2.21	0.72
fyear_month2000_06	-3.05	0.72
fyear_month2000_07	-2.81	0.72
fyear_month2000_08	-3.18	0.73
fyear_month2000_09	-2.19	0.72
fyear_month2000_10	-0.60	0.72
fyear_month2000_11	-0.48	0.72
fyear_month2000_12	-0.96	0.73
…		
fyear_month2022_01	-1.87	0.73
fyear_month2022_02	-3.57	0.74
fyear_month2022_03	-4.05	0.76
fyear_month2022_04	-2.53	0.73
fyear_month2022_05	-3.50	0.73
fyear_month2022_06	-3.48	0.73
fyear_month2022_07	-3.76	0.74
fyear_month2022_08	-3.45	0.74
fyear_month2022_09	-2.13	0.73

Delta/hurdle model 2: ----------------------

Family: lognormal(link = 'log')

	coef.est	coef.se
fyear_month2000_01	-4.15	0.28
fyear_month2000_02	-3.75	0.28
fyear_month2000_03	-4.17	0.28
fyear_month2000_04	-4.19	0.28
fyear_month2000_05	-4.53	0.29
fyear_month2000_06	-4.52	0.29
fyear_month2000_07	-4.58	0.29
fyear_month2000_08	-4.53	0.30
fyear_month2000_09	-4.53	0.29
fyear_month2000_10	-4.00	0.28
fyear_month2000_11	-3.89	0.28
fyear_month2000_12	-4.07	0.29
…		
fyear_month2022_01	-3.99	0.29
fyear_month2022_02	-3.50	0.31
fyear_month2022_03	-3.70	0.33
fyear_month2022_04	-4.20	0.29
fyear_month2022_05	-4.50	0.30
fyear_month2022_06	-4.72	0.30
fyear_month2022_07	-4.74	0.30
fyear_month2022_08	-4.68	0.30
fyear_month2022_09	-4.33	0.29

fyear_month2022_10 -2.07 0.73 fyear_month2022_11 -1.58 0.72 fyear_month2022_12 -2.66 0.74 Random intercepts: Std. Dev. fvessel_gear 1.13 Matérn range (spatial): 542.57 Matérn range (spatiotemporal): 232.98 Spatial SD: 69.38 Spatiotemporal IID SD: 23.61	fyear_month2022_10 -4.21 0.29 fyear_month2022_11 -4.02 0.29 fyear_month2022_12 -4.26 0.30 Random intercepts: Std. Dev. fvessel_gear 0.68 Dispersion parameter: 1.10 Matérn range (spatial): 519.75 Matérn range (spatiotemporal): 172.78 Spatial SD: 25.90 Spatiotemporal IID SD: 8.03
ML criterion at convergence: -606440.384	

Table 2: Parameters estimated by the model.

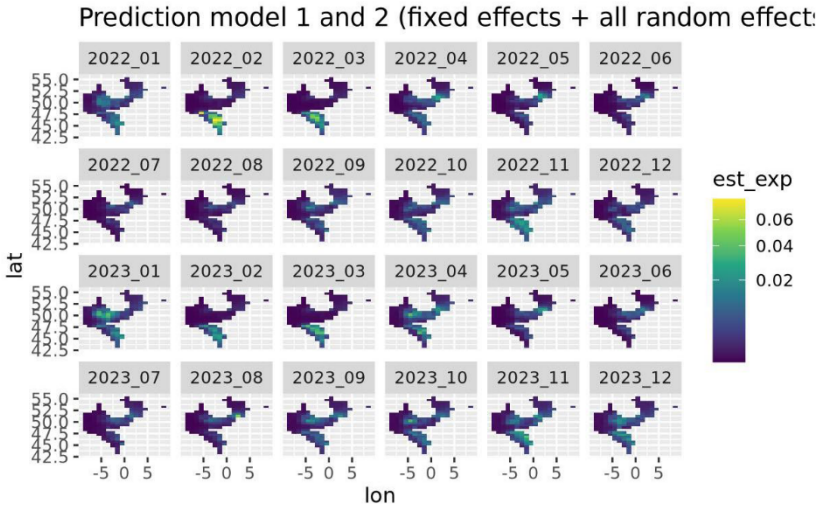


Figure 5: Model prediction estimates.

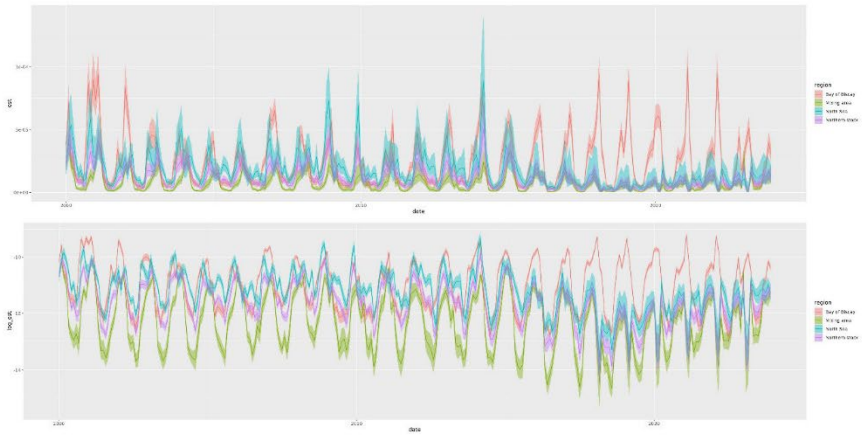


Figure 6: Monthly LPUE indices time-series for each areas identified at the stock ID benchmark in natural (top) and log space (bottom).

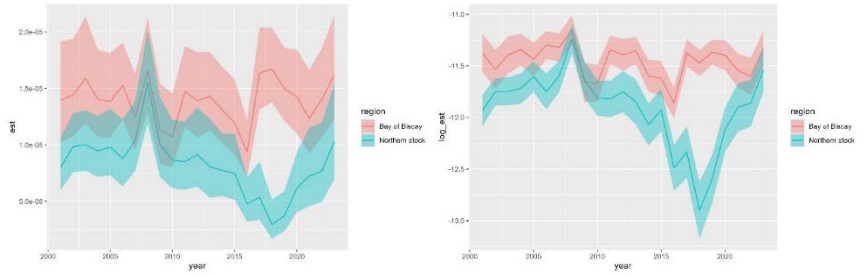


Figure 7: Northern and Bay of Biscay stocks annual LPUE indices time-series as the monthly estimates averaged over April-November in natural (left) and log space (right).

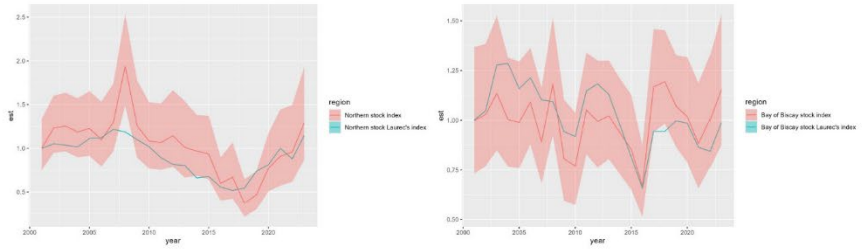


Figure 8: Left) Northern stock LPUE index time-series compared with the previous LPUE index. Right) Southern stock LPUE index time-series compared with the previous LPUE index.

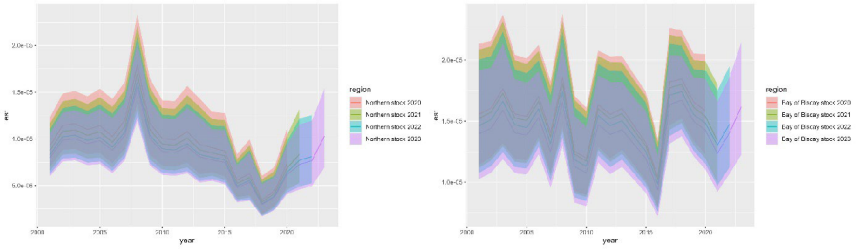


Figure 9: Left) Retrospective analysis of the Northern stock LPUE indices peeling off the 4 last years of the time-series. Right) Retrospective analysis of the Southern stock LPUE indices peeling off the 4 last years of the time-series.

5. Conclusions

The OTB-based LPUE indices time-series is comparable with current LPUE indices and available for the model assessment workshop. Other gears (GNS, GTR, LLS) also processed and available, but only for years 2000-2022. LHM and all gears grouped failed on convergence checks.

A proper model selection may be needed with cross-validation analysis and predictive performance comparison, but it would require much more dedicated time.

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Centre for Environment Fisheries & Aquaculture Science

Cefas

A summary of English data and data sources for estimation of sea bass discards

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1. Executive Summary

European sea bass (*Dicentrarchus labrax)* is an important species for both recreational and commercial fishers but, a combination of overfishing and poor year class strength led to a rapid decline, which inhabits ICES divisions 4.b-c, 7.a, 7.d-h, from 2009-2018. Since 2015, measures have been introduced to reverse this decline including prohibition on direct fishing for sea bass, closed seasons and increased Minimum Conservation Reference Size. The use of catch limits to allow stock recovery, is likely to mean that as the stock recovers, catches could exceed those limits, resulting in increasing levels of discarding. Moreover, the quality of sea bass stock assessment and advice is limited in part by low confidence in commercial discard estimates. The discard values currently used are estimated from scientific observer programmes, where sampling is limited and variable across fleets and years. Therefore, there is an interest in exploring and developing alternative data sources to enhance the stock assessment. Three sources of data we identified and assessed:

- The Cefas scientific observer programme
- Remote Electronic Monitoring (REM), specifically the Cefas scientific REM programme in the Celtic Sea
- Existing Fishers' catch recording

The Cefas at-sea scientific observer programme has been continuously collecting data since 2002, and samples all major demersal metiers. These data were the only source of UK sea bass discard estimates provided in response to the WKSEA BASS data call earlier this year. The data collected in this programme is independent and considered of high quality. However, the programme only samples a small proportion of the English fishing activity; this implies relatively high levels of uncertainty when these estimates are extrapolated to the whole fleet targeting sea bass, to estimate total discard levels.

Remote Electronic Monitoring (REM) has been successfully used to collect data on sea bass, including discards, which can be further enhanced when catches are presented to cameras for measuring. Two otter trawl vessels fitted with REM systems fishing in the ICES areas 7.e and 7.h generated discard rates of 27% and 37% (across the period 2021-2022) for each area respectively, which compared to a discard rate of 37% from the observer programme. However, REM is currently limited to discrete projects, with low participation, and until it is rolled out as part of routine monitoring, it does not offer a source of discard data sufficiently robust to be used in assessments.

The method fishers are required to record their catches depends on the vessel size. For all >10m vessels, fishers report information in logbooks: for vessels >12m these are electronic logbooks (E-logs), while vessels 10m to12m use paper logbooks. This is an established method of fisher reporting, having been consistent for over 10 years, but the consistency in reporting discards is unknown. This study has, for the first time, assessed if UK fishers' data can provide an additional sea bass discards data source. The records showed that only 9% of sea bass landing reports had a corresponding report of discards.

By contrast over the same period the Cefas observer programme recorded, when sea bass were caught, that more than 70% of sampled trips had both landed and discarded sea bass. This indicates that the level of reporting of sea bass discards by fishers is generally low, with many not reporting at all.

Nonetheless, some fisheries have higher levels of reporting, and a small number of fishers are frequently reporting sea bass discards. Here we explored the data generated by only those fishers that reported sea bass discards. For example, for otter trawlers operating in ICES area 7.e, when including only those vessels that have reported discards, the discard rate for the period 2021 and 2022, was 53%. This estimate is based on more data and is higher than estimates from the observer programme and REM, which could mean that sea bass discard rates are substantially higher than those currently used in the assessment. However, even within this subset of vessels, there is high variability in the level of reporting and the estimates recorded, even when fishing in the same area with the same gear type.

The motivation for these fishers to report sea bass discards and the methods used to generate estimates are unknown and so the quality is difficult to assess. However, these data could potentially be used to define a range of discard rates to be applied in the stock assessment for sensitivity analysis. Moreover, if fishers could be encouraged to report consistently, these data would provide a robust source of discard information.

For smaller vessels (<10m length), sales notes were previously used to monitor landings but this was assessed as not sufficiently accurate, so from 2022 a new licence condition came into force requiring fishers to record their catches via an online portal or mobile application (CatchApp). The new CatchApp offers the first opportunity for these fishers to record sea bass discards. As with larger vessels, if fishers reported consistently, fisher generated data from <10m vessels would provide a valuable source of discard information.

Therefore, while both fishers reported data and REM offer potentially important sources of sea bass discard data in the future, currently, the observer programme, despite its limitations in the level of coverage, is the only robust source of sea bass discard data at this time. Based on these findings we make the following recommendations:

1) Data from the Cefas observer programme continue to be the main source of UK sea bass discard estimations for the stock assessment.
2) Other estimates from fishers and REM are used to inform a range of discard estimates to undertake sensitivity analyses in the stock assessment.
3) The Cefas observer programme is at least maintained at its currently level, or expanded, if possible, to reduce the uncertainty in the sea bass discard estimates.
4) With the planned expansion of REM, the capability and resources needed to generate robust sea bass discard estimates from REM data are ensured.
5) Fishers are actively encouraged to record sea bass discards consistently and accurately through logbooks and the CatchApp.
6) The findings of this work are disseminated to the scientific community and to the fishing industry to promote these recommendations.

2. Available data from each source

3. Introduction

European sea bass (*Dicentrarchus labrax*) is an important target species for recreational and commercial fishers. There was a rapid decline in the Northern stock (ICES 4.b&c, 7.a, d-h) from 2009 to 2018, which was thought to be due to a combination of overfishing and poor year class strength (ICES, 2020). Since 2015, a series of management measures have been introduced, including a prohibition on direct fishing for sea bass, closed seasons and increased Minimum Conservation Reference Size for both commercial and recreational fishers. The stock appears to be recovering slowly, with ICES advising that removals of sea bass in areas 4.b-c and 7.d-h should not exceed 2432 tonnes in 2024 when the MSY approach is applied (ICES, 2023). Fishing pressure on the stock is below F_{MSY}, and spawning-stock size is below MSY $B_{trigger}$ and between B_{pa} and B_{lim}.

Unlike most other assessed commercial fish stocks, sea bass is not managed using a quota to directly limit the overall catches. Instead, a combination of spatial and season restrictions, and catch limits for commercial vessels and recreational fishers have been introduced to align catches with the science advice. As an independent coastal state since 2020, sea bass management measures have continued to be agreed jointly by the UK and EU. The current commercial catch limits for sea bass in 2024 are shown in Table 1. Further measures, including area restrictions, recreational catch limits and size limits (Minimum Conservation References Size) are also currently in place[1].

With the recovery of the stock, due to the use of catch limits, it is likely that discarding of sea bass which are caught incidentally, and exceed catch limits, will increase. The quality of the sea bass stock assessment is limited by the low confidence in the discard estimates and recreational catches. The discard values are estimated from scientific observer programmes, where sampling is limited and variable across fleets and years, and more recently from a combination of observer programmes and logbooks. Estimates of discards do not cover all fisheries, are imprecise and are only included for some fleets in the assessment. This leads to uncertainty in the catch estimates and increases uncertainty in the assessment and advice.

This document has been prepared to support the 2024 benchmark activities for sea bass. It is motivated by the recognition that a key limitation of the assessment and source of uncertainty in the advice, which has a direct effect on fishing opportunities, is the low confidence in the discard estimates. Here we summarise and compare the different

[1] Bass Fishing Guidance 2024 - GOV.UK (www.gov.uk) Fisheries management plan for sea bass in English and Welsh waters - GOV.UK (www.gov.uk)

sources of UK sea bass discard data. Established and developing data sources are included, to assess the potential to improve current estimates.

The document is structured into the following sections:

1. **UK data sources for commercial sea bass catch and discards** – identifying and describing data types for UK sea bass catch and discards, including an assessment of strengths and weaknesses.
2. **Summary of the available data from each source –** a summary of the UK commercial sea bass catch and discards data that is derived from each of the identified data sources.
3. **Comparisons of discard estimates from different data sources –** using subsets of the identified data to enable a comparison of the discard estimates from different data sources.
4. **Evaluation and recommendations –** conclusions on the most robust UK estimates of sea bass discards, currently and the potential for the future.

Table 1: Restrictions and catch limits for commercial removals of sea bass, by gear type, in 2024.

Management measures	Demersal Trawls and Seines	Hooks and Lines	Fixed Gillnets Nets	All other gears (including drift nets)
Fishery Restrictions	Closed February and March	Closed February and March	Closed February and March	All bass catches prohibited
Maximum catch limit	Maximum 5% by weight of all marine organisms per trip. Unavoidable by-catch 3.8 tonnes per vessel per year	6.2 tonnes per vessel per year	By-catch of 1.6 tonnes per vessel per year	All bass catches prohibited

4. UK data sources for commercial sea bass catch and discard

The identified sources of sea bass UK catch and discard data are described here including an assessment of the limitations for each. There are three main approaches to generating these data, with different methods used by fishers to record their catches depending on the length of their vessel:

1) At-sea Cefas scientific observer programme (current source of discard data as used in stock assessment)
2) Scientific REM (Remote Electronic Monitoring) programme in the Celtic Sea
3) Fishers catch recording:

a. Vessels >10m (logbooks, both paper and electronic)
b. Vessels <10m (sales notes, CatchApp)

4.1. At-sea Cefas scientific observer programme

The Cefas observer programme provides landed and discarded weights for all species caught on sampled fishing trips (Marine Management Organisation, 2024). The programme has been continuously collecting data on the English fishing fleet since 2002 and samples all major demersal metiers including bottom trawlers, beam trawlers and inshore and offshore netters, amongst others.

The sampling frame is a virtual frame of all fishing trips of vessels on a list, which comprises of all commercial fishing vessels (registered in England and Wales). The list of active vessels is updated quarterly to capture the polyvalent and seasonal nature of regional fisheries (UK Data Coordination Group, 2023).

From the list of fishing vessels, a stratified random selection is made for sampling by Cefas observers. The list of vessels is stratified by region - two strata in the North Sea and Eastern Arctic and three in the North Atlantic - and by predominant fishing method (nets, trawls, lines, beam trawl and scallop dredge). In addition, some combinations of region-fishing method are further stratified by vessel overall length (<10m; 10m+) (Table 2). Where gear specific fisheries are more distinct, then nets and trawls are separated. Beam trawl and scallop dredge vessels are also separated but cover all regions to reflect the nomadic nature of these vessels.

Table 2: Stratification of the current Observer programme (offshore)

<table>
<tr><td rowspan="2"></td><td colspan="4"><10m</td><td colspan="4">>10m</td></tr>
<tr><td>Beam</td><td>Scallop</td><td>Net</td><td>Trawl</td><td>Beam</td><td>Scallop</td><td>Net</td><td>Trawl</td></tr>
<tr><td>Northeast</td><td colspan="4">All gears</td><td rowspan="4">Beam (Shrimp as subset)</td><td rowspan="4">Scallop</td><td colspan="2">Net, Trawl & Lines</td></tr>
<tr><td>East</td><td colspan="4">All gears</td><td colspan="2">Net, Trawl & Lines</td></tr>
<tr><td>West</td><td colspan="4">All gears</td><td>Net</td><td>Trawl</td></tr>
<tr><td>Northwest</td><td colspan="4">All gears</td><td colspan="2">Net, Trawl & Lines</td></tr>
</table>

The following vessels are excluded from the sampling frame, so no data are collected from:

1. Vessels less than 7m, excluded for health & safety reasons.
2. Vessels considered unsafe to take observers for reasons other than size.

3. Vessels specialising in fishing methods or targeting species where the discard mortality is insignificant.
    a. Clam, oyster and cockle dredgers
    b. Some pelagic vessels
    c. Potting vessels
4. Vessels fishing from foreign ports or outside England and Wales. Flag Vessels effectively sampled by another country, or where the international métier is effectively sampled by another country.

Teams of regionally based observers work to quarterly fishing trip targets and use shared draw lists of randomly ordered vessels. Each vessel is approached in list order and non-responses and refusals by skippers are recorded. Skippers take Cefas observers aboard on a voluntary basis.

Once at sea, for each sampled haul, the observers collect the following information: gear type and mesh size, tow duration, shot and haul position, species catch composition and quantity of the landings and discards in the catch. The sampling scheme is a multistage process in which discards are either recorded for a haul or estimated from a fraction of a haul, and typically >60% of the hauls are sampled during a trip. In each sampled haul all the species are sampled; length measurements are recorded for all fish, commercial crustaceans and cephalopods species. When it is not possible to sample the full catch, the observer estimates the volume measured relative to the total catch, and a raising factor is used to estimate the total catch of the haul.

The discard estimates from sampled fishing trips are raised to the fleet level to estimate total discard amount. Observer programmes are currently the only source of data used to estimate sea bass discards for UK fisheries as described in the next section.

4.1.1. Details of the sea bass catch estimation procedures

Most recently, discards estimates, including quarterly estimates, for sea bass stock (bss.27.4bc7ad-h), between 2002 and 2022 were provided, by ICES division and fleet (métier level 4), in response to the data call issued by WKSEA BASS.

For each observed trip, numbers-at-length were raised to the haul level based on an estimated proportion of the total catch volume sampled, then to the trip level based on the proportion of sampled hauls and fished hauls. The length-based data are converted to biomass, using established length-weight relationships collected during scientific trawl surveys. The English sampling programmes do not collect individual fish weight data. Trip-raised estimates summed for sampled vessels in domain (Year x Quarter x ICES division x fleet – métier4) were then raised to the total catch using two methods:

i) Ratio between the reported total fleet landings and reported landings of each stock by the sampled vessels.
ii) When no landings were reported but discards are observed, we used the ratio of observed fishing effort (number of days fishing) to the total of fishing effort.

For the WKSEA BASS data call, quarterly discards estimates were provided by ICES division and fleet. To improve representativeness, discards estimates and discards length distributions were provided only when all the following conditions were met:

i) Two or more trips were sampled within a domain (Quarter x ICES division x fleet – regardless of sea bass catches).
ii) 25 or more fish measured (retained and discarded).
iii) 0.1% or more of the fishing effort were sampled within a domain.

4.1.2. Strengths & weaknesses

Discard data from observers are independently and consistently recorded, with high level of quality data on catches and discards from sampled fishing trips. The consistent data series of 20 years is currently used to estimate sea bass discards for UK vessels.

Observer coverage of the English fleet is low, typically <1% of the total fishing activity. Therefore, less commonly caught or rare species and rare events may not be representatively sampled or included in estimates if conditions for inclusion are not met (see 4.1.1). The level of aggregation across vessel types and areas and the low sampling coverage can lead to high levels of uncertainties in estimated catch and discards when extrapolating data to the whole fleet.

4.2. Scientific REM programme in the Celtic Sea

Cefas initiated a limited scientific data collection programme in the Celtic Sea, using Remote Electronic Monitoring (REM) as the data collection tool, in October 2020 (Walmsley et al., 2021). The programme aims to collect enhanced catch composition data on the otter trawl fleet, with a focus on Celtic Sea cod, as well as interactions in the mixed fishery. Participation in the programme was on a voluntary basis. The programme started with 3 vessels, but participation has varied over the years, with a maximum of 5 vessels.

Remote electronic monitoring systems were installed on the participating vessels. A vessel specific sampling plan was generated to facilitate the analysis of the video footage used to generate catch estimates. All hauls are recorded. On receiving the REM data from the vessels, sensory data are processed to identify fishing trips and hauls within a defined period. For each REM vessel, randomly selected hauls from a list of completed hauls are reviewed by trained analysts. If the haul is assessed as unacceptable for analysis, it is rejected, and a new haul selected (rejections recorded). A review level per time period is set, here this is 10% of hauls per vessel per month per strata (Celtic Sea otter trawls).

Sampling protocols generate estimated weights of the discards and retained catch for each analysed haul to the species level where possible, or the highest taxonomic resolution. Weights are generated using several methods, including converting lengths using length-weight relationships and converting counts of individuals or basket volumes (e.g. proportion of fish basket filled) using standard procedures. As the focus species for

the programme, vessels were instructed to present cod, both retained and discarded, to the cameras for measuring using the REM analysis software. Data on all other species was also collected, but at a lower resolution, meaning number of individuals and basket volumes.

A short trial was conducted in 2022 to assess the potential to collect high resolution data on sea bass. One vessel was asked to add sea bass as a focal species, meaning all catches were presented to the camera, allowing the collection of length measurements. To further demonstrate the utility of REM in this trial, in addition to collecting measurements of sea bass on the 10% of hauls randomly selected, additional trips were reviewed to confirm presence or absence of sea bass catches and collect additional measurements where sea bass was present. Routine collection of data on sea bass has now been extended to other participating vessels, but only on hauls selected as part of the wider programme. During 2020-2022 sea bass catch and discard weight data was derived from counts and volumetric estimates, while from 2022 most catch and discard weights are length-based estimates. Where it was no possible to generate length-based estimate, weights were again derived from count and volume estimates.

4.2.1. Strengths & weaknesses

REM offers the potential for 100% coverage of all vessels and census data on all sea bass catches where it is made visible to the cameras. The estimates derived from REM are independently and consistently generated. If skippers' haul-level reported discards can be validated using REM, it would demonstrate the quality of the skippers' data, which could become the primary source of data, with REM used only for validation. However, the current programme is limited in scope (only sampling the otter trawl fleet in the Celtic Sea) so can only provide data on one metier, while the small number of participating vessels mean the data may not be representative of the wider fleet. Moreover, the current review level of 10% (restricted by analyst resource) further limits the amount of data that can be generated. In the future, it is anticipated that machine learning and AI could make the video analysis more efficient.

4.3. Fishers' catch recording

4.3.1. Vessels >10m (logbooks)

Masters/owners of vessels >10m in length are required to keep a record of their fishing activity via a logbook. Electronic logbooks (E-logs) were first introduced in 2010 for vessels with an overall length of 24 metres or more and since 2012 all vessels of 12 metres or more have been required to use E-logs (Marine Management Organisation, 2017a, 2017b). Vessels of 10-12 metres are required to use paper logbooks. The records should include data on fishing activities for a vessel by trip, and for each day of activity within a trip, and contain details of the catch by species and quantity, including sea bass, in

addition to information on how and where the fish were caught. Information on both retained and discarded catch can be recorded.

4.3.1.1. Strengths & weaknesses

Skippers reporting of catches and fishing activities via logbooks is well established and the reporting requirements have been consistent for more than 10 years. The logbooks also have the function to record discards. However, it is more difficult to monitor compliance by fishers with discard reporting, as this happens at-sea, and moreover, as there is only a requirement to record discards when these exceed 50 kg per 24 hours. Therefore, with unknown levels of compliance with reporting and unknown consistency between skippers, the quality of the sea bass discard data from logbooks is difficult to determine. It is also noted that the reporting requirements are at intervals of 24 hours, and so cannot be compared directly with the haul-level information generated by observers and REM.

4.3.2. Vessels <10m (sales notes, CatchApp)

A new UK catch recording licence condition was introduced in 2020, which requires owners of vessels under 10m in length to record details of all trips where fish are caught. The previous system of using sales notes to monitor catches was shown to not accurately reflect the catch and activity of under 10m vessels. Enforcement of the new condition started in February 2022, with fishers now required to record their catch through an online web service, telephone or a recently developed mobile phone application (CatchApp; Marine Management Organisation, 2023a, 2023b). Each report is expected to detail:

- When and where the vessel sailed from and landed to.
- What gear was used and how many times it was deployed on the trip.
- Which ICES statistical sub-area(s) were fished.
- A list of the species caught in each sub-area. Each species must have a weight that were retained above MCRS (whole, in kg). Information on fish retained below MCRS and those legally discarded can also be added.

For the purposes of this report we have had to use a combination of data from sales notes and the CatchApp, due to the transition from one system to the other.

4.3.2.1. Strengths & weaknesses

The previous system of using sales notes to monitor catches for <10m vessels was proven to be inadequate, in terms of not only the quantities of landings, but also the information on the method of fishing and location of those catches. The new system will generate more consistent and accurate data on sea bass landings and provide a mechanism for fishers to report sea bass discards for the first time. However, as with logbooks, it is more difficult to monitor compliance with discard reporting, because this happens at sea. Therefore, the new reporting requirements will improve sea bass landings data, although it may take some time for the new system to become established, and the benefits of additional sea bass discard data will be dependent on the consistent and accurate recording by fishers.

5. Summary of available UK sea bass discards data from each source

The identified sources of data on sea bass discards have been generated over different time periods. For comparison, the total amount of sea bass catches from the different data sources for the years 2021 to 2022 is given in Table 3. Otter trawl vessels account for a large proportion of fishers reported landings, with vessels recording their gear as OTB/T accounting for 41.4% of the total. Landings by these vessels are shown separately in Table 3.

Table 3: Total Catch of sea bass (in tonnes) by all gear and by otter trawl vessels (OTB/T) split from four different data sources. Data between 2021 and 2022 is presented. Observer and REM data are raised to trip level.

Gear	Activity Type	Fisher reporting		Scientific Monitoring	
		<10m Vessels	>10m Vessels	Observer	REM
All	Discarded	23.3	45.8	1.3	0.9
	Retained	1101.6	137.1	1.5	1.6
	Total	1124.8	182.8	2.8	2.6
OTB/T	Discarded	3.0	12.3	0.6	0.9
	Retained	19.7	56.8	0.8	1.6
	Total	22.8	69.0	1.4	2.6

5.1. At-sea Cefas scientific observer programme

Data from the Observer programme are available from 2001. Table 4 summarises the numbers of trips and vessels sampled and trips where sea bass was caught and sampled. On average, sea bass was present in 26% of the trips sampled during this period (ranging between 16% in 2001 and 37% in 2008). In 2020 and 2021, of the observed trips recording catches of sea bass, 77% and 71%, reported that some of the catch had been discarded. Most of the trips with sea bass discards were by vessels using otter trawl (OTB) gear.

It should be noted that the observer sampling programme was still significantly affected by Covid in 2021, with restricted access to some vessels and fleets, and over half of samples undertaken via sampling onshore (co-sampling) rather than at sea.

Table 4: A summary of the data collected by the Cefas Observer programme between 2002 and 2022, including the number of trips and vessels sampled as well as specific information on trip where sea bass was caught.

Year	No. trips sampled	No. vessels sampled	No. vessels sampled with sea bass	No. trips sampled with sea bass	No. of length measurements collected	No. trips with discards

2001	61	52	9	10	35	3
2002	63	54	12	13	80	2
2003	124	97	32	36	1344	9
2004	191	118	39	55	1543	14
2005	108	77	27	33	154	8
2006	143	80	33	52	1232	16
2007	315	145	56	96	1686	20
2008	247	125	60	92	1823	22
2009	191	116	36	63	1649	23
2010	163	109	39	50	1178	16
2011	182	109	30	38	1148	10
2012	215	144	36	42	899	9
2013	236	139	39	48	695	9
2014	233	139	43	52	619	10
2015	193	122	32	40	755	9
2016	219	131	38	52	708	32
2017	225	140	48	53	667	25
2018	209	129	42	51	417	36
2019	210	110	42	52	803	32
2020	63	45	16	21	326	19
2021	146	79	23	36	502	28
2022	183	97	32	53	1415	38

It was not considered relevant to present all of the catch and discard estimates generated from the observer programme here. However, a subset of these data are presented in section 6 when comparing estimates from different sources.

5.2. Scientific REM programme in the Celtic Sea

Data from the scientific REM programme were available from 2000, here we focus on two vessels using OTB gear in the Celtic Sea (ICES areas 7.e and 7.h) that have provided data consistently. One vessel undertook all trips in 7.e, while the other operated mainly in 7.h, with some trips in 7.e. When selecting only trips where sea bass were caught, the dataset includes information from 57 trips (31 in 2021 and 26 in 2022), with 35 of those including sea bass discards.

Sea bass weights and lengths were recorded from selected hauls, with a total of 119 hauls with sea bass catch data over the two years. These data were raised to the trip level to estimate the overall weights retained and discarded (Figure 1). On average, the two vessels caught 0.045 tonnes (45kg) of sea bass per trip with an average 0.016 tonnes (16kg) discarded. Average catch per trip was comparable between years.

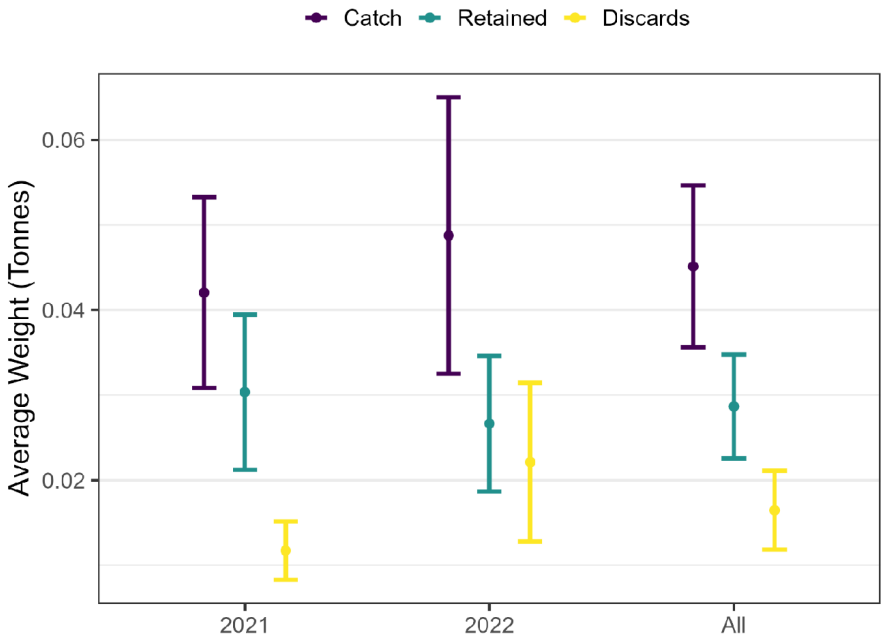


Figure 1: Average (+/- standard deviation) weight (in tonnes) of sea bass retained, discarded and total catch (overall) per trip by vessels in the Scientific REM programme for the years 2021 and 2022.

Across the two years we have data, when raised to the total number of fishing trips undertaken by the two REM vessels, an estimated total of 4.5 tonnes of sea bass were caught, with 1.5 tonnes of discards (Table 5). Most was caught in ICES area 7.h (2.9 tonnes) with an overall 37% discard rate in that period; 1.6 tonnes were caught in 7.e, with 27% discarded.

Table 5: Total Weight (in tonnes), retained and discarded, raised to vessel level for the years 2021 and 2022.

	2021	2022	Total
Retained	2t	0.98t	2.98t
7.e	1.03t	0.12t	1.15t

7.h	0.96t	0.86t	1.82t
Discards	**0.78t**	**0.74t**	**1.52t**
7.e	0.41t	0.02t	0.43t
7.h	0.37t	0.71t	1.08t
Total	**2.78t**	**1.71t**	**4.49t**

5.3. Fishers' catch recording

5.3.1. Vessels >10m (E-log, logbooks)

Fishers have recorded their catches for several decades, here we focus on the most recent years. Between 2021 and 2022, 167 individual vessels generated sea bass catch information (landings and/or discards). The number of vessels recording sea bass data was higher in 2022 (142) than in 2021 (135), with 110 individual vessels reporting in both years. The majority of reported landings and discards in 2021 and 2022 occurred within ICES areas 4.c, 7.d, 7.e and 7.f (Table 6), with the most records (>4700) from ICES area 7.e, equating to almost 80 tonnes of sea bass landed and 37 tonnes discarded during these two years. Although 166 vessels reported landings, only 29 vessels reported discards. Of these, 23 vessels reported discards from 7.e, with two vessels accounting for almost 48% of the records of discards.

Table 6: Total weight (tonnage) and total records of sea bass by ICES area reported as landings, discards and overall, for vessels over 10m from 2021 to 2022. The number of unique vessels reporting is given in brackets. This includes all gear types reported.

ICES area	Weight, in tonnes			Records (unique vessels)		
	Landings	Discards	Total	Landings	Discards	Total
4.a	0.05	0	0.05	15 (2)	0 (0)	15 (2)
4.b	0.26	0	0.26	47 (20)	0 (0)	47 (20)
4.c	27.49	0.003	27.49	517 (24)	1 (1)	518 (24)
6.a	0.001	0	0.001	1 (1)	0 (0)	1 (1)
7.a	0.002	0	0.002	2 (1)	0 (0)	2 (1)
7.d	20.34	3.79	24.12	818 (28)	24 (5)	842 (29)
7.e	78.37	36.56	114.92	4779 (112)	534 (23)	5313 (112)
7.f	8.55	5.05	13.61	262 (27)	42 (7)	304 (30)
7.g	0.35	0	0.35	36 (15)	0 (0)	36 (15)
7.h	2.87	0.36	3.23	56 (19)	4 (1)	60 (19)
Total	**138.29**	**45.76**	**184.05**	**6533 (166)**	**605 (29)**	**7138 (167)**

To explore these data further we focus only on sea bass caught in ICES areas 7.d, 7.e & 7.f and 4.c (English Channel and southern North Sea), where the majority of the landings and almost all of the discards are reported (Table 6).

In the areas of most landings, when vessels reported bass landings in only 9% of cases did they also report bass discards (Table 7). Within these areas, discard reporting is concentrated in some metiers and with a small number of vessels within those metiers, e.g. otter trawl (OTB) and beam trawl (TBB) in 7.e (Table 7). Within area 4c, only one record of discards was reported despite relatively high levels of landings (28 tonnes) generating a discard rate of less than 0.01%, while the discard rate in ICES area 7d, despite relatively similar level of total catch reported, was considerably higher (15%). This may be due to lack of consistency in reporting between areas, metiers and vessels, rather than an absence of discards.

Table 7: Total number of records of sea bass landings and discards, 2021-2022, for vessels over 10m, split by ICES area and gear type. Full gear names are listed in Annex 1.

Gear	Total Landing Records	Total Discard Records	% of discard records relative to landings records (unique vessels reporting discards)
ICES area 4.c (Southern North Sea)			
GN	54		
GND	8		
GTN	2		
GTR	7		
LHP	4		
LLS	8		
LX	5		
OTB	112	1	1 (1)
SDN	3		
SSC	302		
TBB	12		
ICES area 7.d (Eastern Channel)			
FIX	6		
GN	5		
GTN	5		
GTR	40		
LHP	28		
LX	16		
OTB	464	19	4 (3)
OTM		4	(1)
OTT	41		
SDN	2		
SSC	166	1	1 (1)
TBB	45		
ICES area 7.e (Western Channel)			
DRB	25		
FPO	4		
GN	9	3	33 (1)
GNS	24	1	4 (1)

GTN		4	(1)
GTR	1		
LHM	2		
LHP	2		
OTB	2153	154	7 (8)
OTM	2		
OTT	710		
PTB	11	1	9 (1)
SSC	2		
TB	2		
TBB	1832	371	20 (12)
ICES area 7.f (Bristol Channel)			
FPO	1		
GN	3		
GNS	3		
GTR	1		
LA		3	(1)
OTB	211	2	1 (1)
OTT	2		
TBB	41	37	90 (5)
Total	**6376**	**601**	**9 (29)**

5.3.1.1. Discard reports in selected metiers

Fishers' logbook data for metiers with higher levels of discard reporting was further explored (Table 8). Discard rates were highly variable between different metiers and areas, with no discards reported for beam trawl vessels in 7d but discard rates of 78-97% for the same gear type in 7f.

In 7.e, where discards were more consistently reported, discard rates for otter trawl vessels were calculated to be between 13-21%, while beam trawl vessels reported discarding 13-63% of their sea bass catch. Discard rates are indicated to be lower in 2022 than in 2021, 12-13% for otter trawl vessels in 7.d & 7.e compared to 21-43% in 2021. However, there were also fewer vessels reporting discards in 2021, 5, compared to 6 in 2022. Further analysis of the observer data to explore errors on the estimates or potential biases due to changes in reporting would be useful.

Table 8: Weight (tonnes) and discard rate of vessels reporting using otter trawl (OTB/T) and beam trawl (TBB) gear in the ICES areas 4.c, 7.d, 7.e & 7.f only. Values are given for 2021 and 2022.

Catch category	Year	4.c		7.d		7.e		7.f	
		OTB/T	TBB	OTB/T	TBB	OTB/T	TBB	OTB/T	TBB
Catch (tonnes)	2021	0.87	0	7.08	0.18	21.1	34.78	4.81	3.35
	2022	2.13	0.2	2.96	0.04	25.83	26.26	4.73	0.59
	Total	3	0.2	10.03	0.23	46.93	61.03	9.54	3.94
Landings (Tonnes)	2021	0.87	0	4.02	0.18	16.76	12.73	3.51	0.08
	2022	2.13	0.2	2.61	0.04	22.6	22.78	4.73	0.13
	Total	2.99	0.2	6.62	0.23	39.36	35.51	8.24	0.21
Discards (Tonnes)	2021	0	0	3.06	0	4.34	22.04	1.3	3.27
	2022	0	0	0.35	0	3.23	3.48	0	0.46
	Total	0	0	3.41	0	7.57	25.52	1.3	3.73
Discard Rate (%)	2021	0	0	43	0	21	63	27	97
	2022	0	0	12	0	13	13	0	78
	Total	0	0	34	0	16	42	14	95

5.3.1.2. Only vessels reporting landings and discards

Although landings records came from a large number of vessels, discards were not consistently reported, with much fewer fishers recording discards in logbooks. Looking at only otter trawl vessels in 7.e as an example, 47 vessels reported sea bass landings, but only 8 reported discards in the period 2021-22. If these vessels are assumed to consistently report their discards, they could effectively provide a reference fleet representative of the wider fleets. On that basis, when using data only from the vessels that had reported both landings and discards (at least once), the discard rate in for OTB/T in 7.e increases considerably from 16% (Table 8) to 53% across both years (Table 9).

Of the 8 otter trawl vessels reporting landings and discards (Table 9), there is high variability in the number of discard records relative to landings records and the proportion of the catch recorded as discarded (Figure 2). Vessel 5 accounted for nearly two thirds of discard records for this gear type, with 100 out of 154 records, but only accounted for 17% of the total weight of discards reported (Figure 2). It was also the only vessel that provided more reports of discards than landings.

Similarly, for beam trawl vessels in 7.e, nearly half the records come from Vessel 1, while two thirds of the total weight of discards recorded comes from Vessel 13 (Figure 2). Therefore, there is a minority of vessels that record discards, and within this group a high variability in the frequency of reporting and the estimates reported between individual vessels, even when fishing in the same area with the same gear type.

Table 9: Weight (tonnes) and discard rate of only vessels with at least one record of discards reported using OTB/T gear within the restricted ICES areas (4.c, 7.d, 7.e &7.f).

	Year	OTB				TBB	
		4.c	7.d	7.e	7.f	7.e	7.f
Discards (Tonnage)	2021	0.003	3.06	4.34	1.3	22.04	3.27
	2022	0	0.35	3.23	0	3.48	0.46
	All	0.003	3.41	7.57	1.3	25.52	3.73
Landings (Tonnage)	2021	0.01	1.37	2.47	2.44	3.88	0.00
	2022	0	0.32	4.35	0	8.07	0.04
	All	0.01	1.69	6.82	4.5	11.95	0.04
Catch (Tonnage)	2021	0.02	4.43	6.81	3.74	25.92	0.00
	2022	0	0.67	7.58	0	11.56	0.50
	All	0.02	5.1	14.39	5.8	37.47	3.77
Discard Rate (%)	2021	20	69	64	35	85	100
	2022	0	52	43	0	30	91
	All	20	67	53	22	68	99
Number of vessels reporting discards (total vessels reporting sea bass catch)	2021	1 (6)	3 (7)	5 (38)	1 (5)	10	1
	2022	0 (6)	1 (8)	6 (42)	0 (7)	8	5
	All	1 (9)	3 (10)	8 (47)	1 (8)	12	5

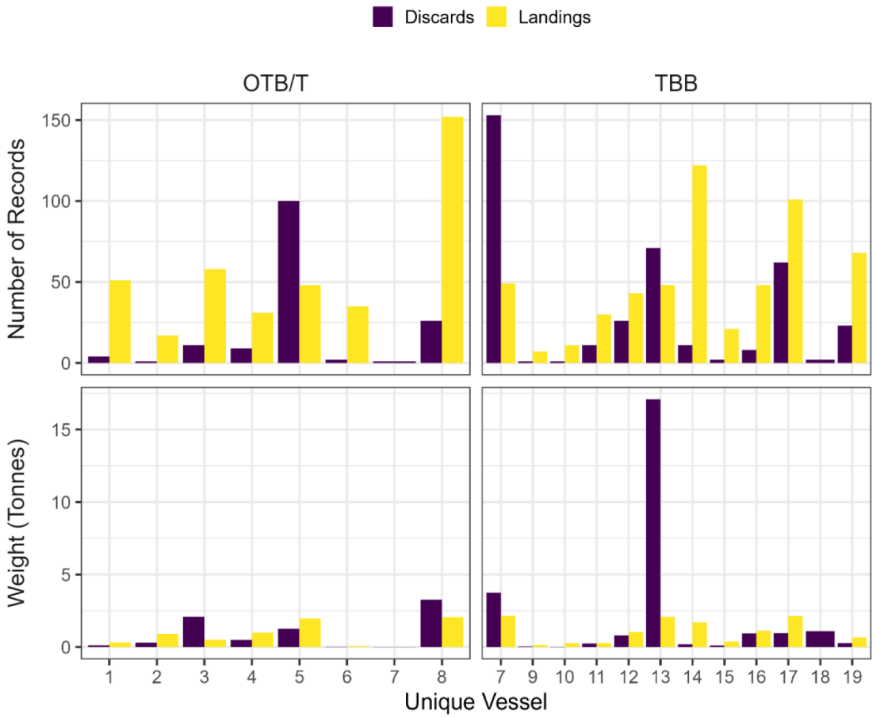


Figure 2: Number of records (top) and weight (in tonnes; bottom) of seabass landed and discarded, as reported in ICES area 7.e using OTB/T (left) and TBB (right) gear for 2021 and 2022 combined.

5.4. Vessels <10m (sales notes, CatchApp)

Anonymised sea bass catch data from <10m vessels for 2021 and 2022 was provided by the MMO. The landings data could only be provided from sales notes, while discards were reported by fishers using the CatchApp. As the landings and discards data are derived from two separate systems, caution must be applied in their interpretation. The datasets included dates, vessel IDs, ICES areas, gear details and weights, but did not provide trip identifiers. Therefore, it was possible to match landings and discards data only approximately based on vessel ID and date.

In 2021 and 2022, a total of 1174 individual vessels generated sea bass catch information, with 10.6% of vessels reporting discards (Table 10). Over the two-year period there were approximately 30,710 days of fishing reported where sea bass was caught, with 4% reporting discards. A majority of vessels reporting catches in 2021 also reported in 2022 (68%), with 36% of fishers that reported discards reporting in both years.

Table 10: A summary of the number of vessels reporting information on sea bass retained and discarded, in 2021 and 2022.

	2021	2022	All
All gears			
All	1009	971	1174
Retained	971	936	1131
Discards	90	79	124
Otter Trawls (OTB)			
All	85	82	110
Retained	82	82	108
Discards	5	4	8

In 2021 and 2022 fishers reported a total of 1,102 tonnes of sea bass landed and 23 tonnes of discards (2.1%) for all areas and gears. Total reported sea bass catches were 576 tonnes in 2021 (1.9% discards) and 549 tonnes in 2022 (2.2% discards). Figure 3 shows retained and discarded catches by gear type for vessels reporting sea bass catches, showing the majority of catches were taken using handlines and pole-lines (LHP, 345 tonnes), hooks and lines (not specified) (LX, 334 tonnes), and Gillnets (not specified) (GN, 286 tonnes), while the recorded discards were highest when using LX (7 tonnes), trammel nets (GTR, 4 tonnes), LHP (4 tonnes) and otter trawls - bottom (OTB, 3 tonnes).

The levels of reporting of discards relative to landed sea bass, both in terms of number of records (4%) and the estimated discard amount (2% of the catch) are considered very low, and likely reflect that the CatchApp, which enables fishers of <10m vessels to record discards for the first time, has only recently been introduced.

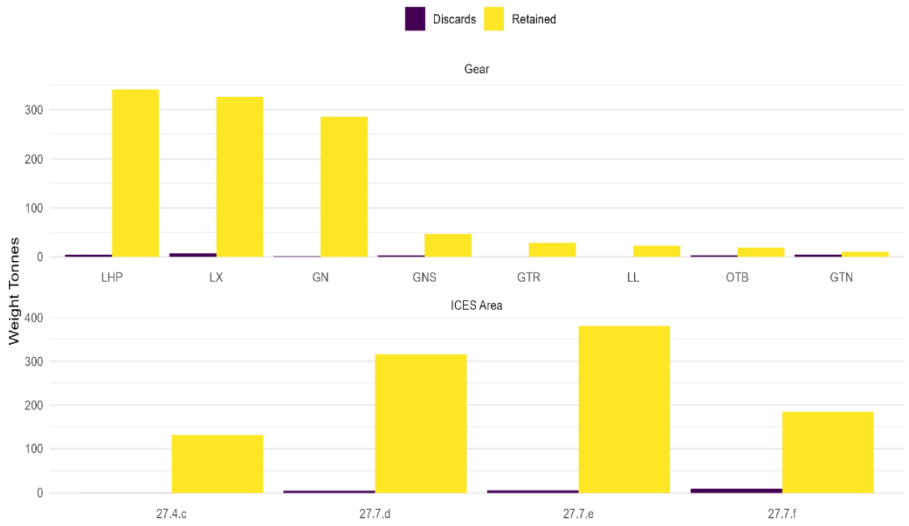


Figure 3: Weight (in tonnes) of retained and discarded catch by the top 8 gear types by weight (top), and for the top 4 areas by weight (bottom). Gear names can be found in Annex 1.

6. Comparisons of discard estimates from different data sources

6.1. >10m OTB in ICES area 7.e (observer, REM, >10m vessel fisher records)

With the data available, it was possible to make a direct comparison between three of the data sources; observer programme, REM, and fishers catch recording for >10m vessels. The comparison used data between 2021 and 2022 for >10m vessels fishing in ICES area 7.e using otter trawl gear (OTB/T). An additional data set was created from the fisher records, which uses data only from vessels that had reported at least one landing and discard event in either year. The data from fishers recording for <10m vessels, based on a combination of CatchApp and sales notes, was not considered sufficiently robust to include in the comparison.

Table 11 and Figure 4 summarise the data. Within each data source the results were comparable between the two years, except for the full fishers data set, which was notably lower in 2022. The discard rates ranged from 16% to 53% (Figure 4). The discard rates based on two years of data (2021-2022), showed the closest estimates were from the observer programme and REM, 37% and 27% respectively. The widest range was from the fishers reported data which was influenced by whether all vessels were included or only those that have recorded discards (16% and 53% respectively). When restricting it to only fishers that do record discards in their logbooks, their data generates the highest discard rates.

Table 11: A summary of the data available from 4 datasets. This includes the total number of vessels and trips that have been sampled or reported and the number including discards, as well as the total weight (in tonnes) retained and discarded, and a calculated discard rate.

Dataset	Year	Number of Vessels		Number of trips		Total Weight (tonnes)		Discard rate (%)
		Total	Discards	Total	Discards	Retained	Discards	
REM	2021	1	1	19	9	1.03	0.41	28%
	2022	1	1	8	3	0.12	0.02	14%
	Total	**1**	**1**	**27**	**12**	**1.15**	**0.43**	**27%**
Observer	2021	23	18	12	9	0.20	0.09	31%
	2022	32	28	23	17	0.49	0.31	39%
	Total	**45**	**35**	**35**	**26**	**0.69**	**0.40**	**37%**
>10m Vessels (all)	2021	37	5	1541	73	16.40	4.34	21%
	2022	42	6	1368	79	22.25	3.23	13%
	Total	**47**	**8**	**2909**	**152**	**38.65**	**7.57**	**16%**
>10m Discard reporting vessels (subset)	2021	5	5	237	73	2.47	4.34	64%
	2022	6	6	288	79	4.35	3.23	43%
	Total	**8**	**8**	**525**	**152**	**6.82**	**7.57**	**53%**

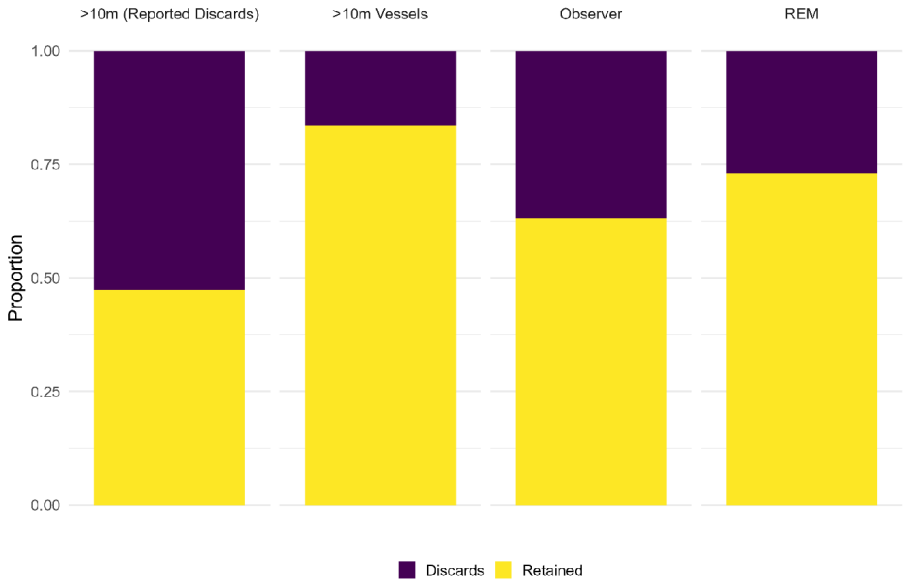


Figure 4: Discard rate calculated from fishers' recording for >10m vessel, a sub-set of only fishers that have reported discards, Observer and REM programmes for vessels using OTB in ICES area 7.e (including data from 2021 and 2022).

7. Evaluation and recommendations

There was a rapid decline in the sea bass Northern stock which prompted the introduction of a series of management measures to recover the stock. With the use of catch limits as a key management measure, as the stock recovers it is likely that discarding of incidentally caught sea bass will increase. Moreover, the quality of the sea bass stock assessment is limited by low confidence in the discard estimates. The discard values are currently estimated from scientific observer programmes, where sampling can be limited and variable across fleets and years, and in the selected years was also affected by COVID restrictions. Therefore, there is interest in exploring other data sources and new methods to improve discard estimates. Here we have compared three alternative sources of discard data, the Cefas observer programme, Remote Electronic Monitoring (REM) and fishers' records, and found that all have limitations and uncertainties.

REM has been used successfully to generate discard data on sea bass, and this is enhanced when catches of sea bass are made clearly visible to cameras to enable length measurements. The estimated discard rate using REM with two otter trawlers operating in ICES area 7.e was 27%, comparable to the equivalent rate of 37% from the Cefas

observer programme. However, the use of REM is currently limited to small discrete projects, and until it is rolled out more widely and part of routine ongoing monitoring it does not offer a main source of sea bass discard data. The Government response to the Defra consultation on the proposed expansion of REM in English waters states that there will be a phased approached to the mandatory use of REM in priority fisheries. These include fisheries where substantial catches of sea bass are taken. Therefore, REM is expected to offer a robust source of discard data in the future. It is also noted that even with a high proportion of vessels equipped with REM, the sampling coverage will be determined by the proportion of fishing activity that is captured by REM data that can be reviewed by analysts. In the future, it is anticipated that machine learning and AI could make the REM analysis more efficient.

Fishers' records have good potential to provide a source of robust sea bass discard data. For the first time, UK fishers' data were explored to determine whether they can provide an alternative data source. Skippers' reporting of catches via logbooks is well established and the reporting requirements have been consistent for more than 10 years. However, the levels of consistency in reporting are unknown and so the quality of the sea bass discard data from logbooks is difficult to determine. Here we show that only 9% of records of sea bass landings (from logbooks) are associated with records of discards, whereas in the observer programme, when sea bass are caught, more than 70% of sampled trips have both landed and discarded sea bass. This illustrates that the level of reporting of sea bass discards by fishers is very low and most do not report at all. Therefore, discard rates calculated from these data are low and could underestimate the actual discard levels.

Nonetheless, there are some fisheries, where reporting of sea bass discards is higher, and a small number of fishers are frequently reporting sea bass discards. For example, in ICES area 7.f, where catches of sea bass are reported, 90% of records from over 10m UK beam trawlers provide estimates of both landings and discards. We explored the over 10m vessel data further by selecting only those that reported discards to calculate discard rates. For otter trawlers operating in ICES area 7.e, when focusing on only those vessels that have reported discards, the discard rates were 64% and 43% in 2021 and 2022 respectively. These estimates are based on more data and are higher than those from the observer programme and REM, which could mean that discard rates are substantially higher than those currently used from the observer programme. However, even within this subset of vessels, there is high variability in the level of reporting and the estimates recorded, even when fishing in the same area with the same gear type.

The motivation for these fishers to report sea bass discards and the methods used to generate estimates are unknown and so the quality is difficult to assess. However, these data could potentially be used to define a range of discard rates to be applied in the stock assessment for sensitivity analysis. Moreover, if fishers could be encouraged to report consistently, and those data validated using REM or the observer programme, fishers' reports would provide a robust source of discard information. For those vessels <10m that are not required to complete logbooks, the new CatchApp offers the first opportunity for fishers to record sea bass discards. As for the larger vessels, if fishers of these vessels

reported consistently, and those data are quality assessed through other sources, fisher generated data would provide a robust and valuable source of discard information.

While both fishers reported data and REM offer potentially important sources of sea bass discard data in the future, currently, the observer programme, despite its limitations in the level of coverage, is the only robust source of sea bass discard data at this time. Based on these findings we suggest the following recommendations:

1) The Cefas observer programme data continue to be the main source of sea bass discard estimations for the stock assessment.
2) Other estimates from fishers and REM are used to inform a range of discard estimates to undertake sensitivity analyses in the stock assessment.
3) The Cefas observer programme is at least maintained at its current level, or expanded, to reduce the uncertainty in the sea bass discard estimates.
4) With the planned expansion of REM, the capability and resources needed to generate robust sea bass discard estimates from REM data are ensured.
5) Fishers are actively encouraged to record sea bass discards consistently and accurately through logbooks and the CatchApp.
6) The findings of this work are disseminated to the scientific community and to the fishing industry to promote these recommendations.

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9. Annex 1 – Gear Codes reference in the report, from the iFish database

Gear Code	Name	Category
DRB	Boat dredges	Dredges
FIX	Traps (not specified)	Traps
FPO	Pots	Traps
GN	Gillnets (not specified)	Gill nets and entangling nets
GNF	Fixed gillnets (on stakes)	Gill nets and entangling nets
GNS	Set gillnets (anchored)	Gill nets and entangling nets
GTN	Combined gillnets-trammel nets	Gill nets and entangling nets
GTR	Trammel nets	Gill nets and entangling nets
HMP	Pumps	Harvesting machines
LA	Without purse lines (lampara)	Surrounding nets
LHM	Handlines and pole-lines (mechanized)	Hooks and lines
LHP	Handlines and pole-lines (hand-operated)	Hooks and lines
LL	Longlines (not specified)	Hooks and lines
LLS	Set longlines	Hooks and lines
LX	Hooks and lines (not specified)	Hooks and lines
OTB	Otter trawls - bottom	Trawls
OTM	Otter trawls - midwater	Trawls
OTT	Otter twin trawls	Trawls
PTB	Pair trawls - bottom	Trawls
SSC	Scottish seines	Seine nets
TB	Bottom trawls (not specified)	Trawls
TBB	Beam trawls	Trawls

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Annex 4: Northern stock (bss.27.4bc7d-h) stock assessment model after benchmark

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1. Issue list

The WKBSEABASS 2024 model builds on previous work developed over the past 15 years, starting with IBP-BASS 2012 (ICES, 2012) recommending to WGCSE 2013 an assessment of the northern stock through SS3 and recommending that southern stock should be treated as functionally separate population (having insufficient data to develop analytical assessments).

For bss.27.4bc7d-h, further improvements linked to input data and model configuration were made during IBP-BASS 2014 (ICES, 2014). WKBASS 2017 and WKBASS 2018 addressed a number of issues, and explicitly modelled the management controls in place from 2015 onwards. The aim of WKBSEABASS, with regards to the northern stock specifically, was to address the latest issue list as detailed in the table below. The main objectives included:

- Review stock boundaries between the Biscay and Northern stocks as there is evidence of mixing.
- Review the fleet structure to address issues with including data from countries other than UK and France, as well as issues with sampling not reflecting selectivity of the French fleet.
- Improve the model fit to discard data where possible.
- Consider inclusions of other surveys (CGFS survey post 2015, as well as recruitment surveys).
- Use latest recreational survey data to characterize recreational removals.
- Review and update the method to calculate the LPUE index.

Table 1. Issues list for bss. 27.4bc7ad-h available to WKBSEABASS, and progress made at WKBSEABASS.

Problem/Aim	Work Required	Data Required	Achievement WKSEABASS 2024

The stock annex specifies that the number of trips sampled should be used as variance input for composition data. However, the numbers of trips sampled do not match between historical data recorded in the report and the data file of the assessment. For UK OTB_nets it is likely to be linked to what gears are included in the fleet in either source. It is unclear where the problem might lay for UK midwater trawls as the sample sizes used in the assessment are unrealistically large. For the French fleet it is not clear either where the problem originates from.	Investigate sample sizes and correct either or both assessment file and historic data in report	Sample sizes - i.e. number of trips sampled for ages and lengths, onshore and offshore, for landings and discards, all separately	New input sample sizes needed to be calculated as input fleets were re-structured. The input sample sizes for length and age data of the commercial fleets now follow the formula that uses information on number of trips and fish sampled.
It is not specified in readily available sources of information how the standard error of the indices have been calculated. This affects how they are used in the assessment. The errors should be calculated on the log-normal indices. A single value is also provided for the full Solent index time-series, where it should be an annual value. And no standard error estimate exists for the CGFS survey.	Calculate indices standard errors on log-transformed values for French LPUE and Solent survey index. Consider this for the CGFS survey as well as the assessment is using an arbitrary value of CV=0.3 at the moment.	Raw data going into the calculation of the French LPUE, Solent survey index and CGFS	The LPUE errors are now calculated and provided on the correct form, i.e. standard error of the log estimate. For Nourdem and CGFS surveys, value of standard error in natural log space is calculated as $\sqrt{log_e(1+(CV)^2)}$.
The number of samples from the French fleet has been very low in recent years and one of the main metiers "lines" has not been sampled in recent years. This is a problem as the assessment considers the French fleet as a single unit, with one selectivity curve, with composition data corresponding to bottom trawlers while most catches are from lines (very different selectivity curves).	Increase sampling in France and better target relevant gears. Consider splitting the French fleet into sperate fleets in the assessment. Evaluate if sampling is currently sufficient to support continued application of Stock Synthesis fitting selection parameters to all fisheries composition data.	French age and length composition data (landings and discards) by gear type; French landings and discards by gear type.	Fleets have been restructured. French fleets are now separated by gear type. This means that selectivity for lines, trawls and others are fitted using explicitly separate data.

The French LPUE is a strong driver of the assessment, however there is limited evidence that this time series is a good indicator of abundance, especially in light of all the recent management measures in place	Investigate the statistical properties of French LPUE index and get expert review on its use as an unbiased index of abundance	Raw data underlying the calculation of the French LPUE	The French LPUE index has been re-estimated using a statiscally robust approach and now corresponding to the trawl fleet only. No further work was done on assessing its unbiased-ness with respect to reflecting stock abundance trends.
Discards estimates are not reliable and the model is believed to under-estimate the truth	Assess the sensitivity of the model to discards and how discards are set up in the model. Get better data in short and long-term	Discards from logbooks and from sampling programmes	Discards of the two main discarding fleets are now modelled as separate fleets, so the model fits the input estimates. The estimates were adjusted using the French discarding rates, as those are based on logbook data as well as an observer programme (only observer programme in the UK)
There is a strong retrospective pattern, albeit still within "acceptable limits" according to the Mohn's rho estimate. The Mohn's rho is better if recreational catches are estimated at every peel but that is not what is done at the moment. The pattern remains either way though.	Investigate the cause of retrospective pattern (could it be due to a gradual change in commercial and/or recreational fishery selectivity due to management measures that the assessment does not capture?)	Assessment data (and maybe more disaggregated data as investigation progresses)	Numerous changes were made (data and configuration), included that the recreational catches are no longer estimated in the model. The WKSEABASS 2024 model does not present a strong retrospective pattern any longer.

Recreational removals are reconstructed for the full time series based on one single year of data. Surveys of recreational fishers have been conducted in the past 3-4 years in the UK, France and maybe other countries that should be evaluated.	Collate and evaluate recreational survey data; compare with assessment assumptions/re-constructed time series; re-consider assessment methodology according to output of the work	Recreational survey data	The latest recreational surveys from France, the UK and the Netherlands were collated and a new time series of recreational removal was constructed (outside the model).
The assessment uses the CGFS survey data up to 2014 as there was a change of vessel in 2015 and it was decided that data from that point onwards should be considered as a new time series due to differences in selectivity. There are now 5 years of data and the use of the time series should be re-evaluated.	Evaluate the new CGFS index since 2015 and test inclusion in assessment	CGFS index and standard errors of the log.	The latest CGFS data were included as a new time series starting in 2015.
The current assessment framework is SS3.24U. This is an old version of Stock Synthesis and so the assessment needs to be moved to the latest published SS3.3.xx version of SS. This is because latest versions correct for any bugs and offer a wider range of options. The R library, r4ss, will also evolve alongside the latest version of the framework. SS3.3.xx offers the possibility to estimate the time series of recreational catches as part of the model fit. Currently it is done iteratively outside of the model and it is not bullet proof.	Test that SS3.24U and SS3.3.xx give the same outputs (it was tested for WGCSE 2020 and found to produce almost identical outputs); Test the estimation of recreational removals inside the model in SS3.3.xx (tested during WGCSE 2020 but showed differences in model outputs in the early part of the time series that remain to be investigated)	-	WKSEABASS 2024 used SS3.30.23.00. Recreational data are now estimated outside the model so the option of calculating them inside is no longer required.

There exist evidence of migration between the northern and Biscay stock but the two areas are evaluated as separate stocks	Join up Northern and Biscay stock in a single spatially explicit model - Cefas has started work on that but did not have data to validate the predictions in terms of migration patterns and recruitment apportionment between areas - This work may also benefit from improved information on the French fleet in the model	Tagging data; Simulated data of larval dispersal (recruitment apportionment)	A stock ID workshop was run WKBSEABASS-ID (ICES, 2023) One of the possible configurations was taken forward due to data limitations and time constraints. The model presented by WKBSEABASS 2024 includes a seasonal catch exchange between the northern and Biscay stock.
The Netherlands seem to be responsible for an increasing portion of the catches, sampling data on age and length should be considered	Get sampling data of age and length distribution for the NLD fleet; get details on NLD fishing gear types	NLD landings, discards, age and length compositions	Data from all countries are now included in the length data as the new fleet structure suggested by WKBSEBASS 2024 does not distinguish between countries (which it was in the WKBASS 2018 model (ICES, 2018)). Age data (i.e. conditional age-at-length) are only provided by France, UK and NLD.

2. Model platform

WKBSEABASS 2024 used the latest version (V3.30.23.00) of the Stock Synthesis software which was used at the pervious benchmark (WKBASS 2018).

The Stock Synthesis framework was chosen again as the assessment requires a modelling framework capable of handling a mixture of age and length data for fisheries and surveys (fleet-based landings; landings age or length compositions, age-based survey indices for young sea bass; age-length-keys) and biological information on growth rates and maturity. It is a highly flexible statistical model framework allowing the building of simple to complex models using a mix of data compositions available. The model is written in ADMB (www.admb-project.org), is forward simulating and available online Stock Synthesis (SS3) Website – Stock Synthesis (SS3).

3. Assessment model data and general configuration

The assessment model of Northern seabass is a length and age-based, single sex, single area, multiple fleet, multiple surveys and single LPUE model with a population comprised of 16+ age classes

(with age 16 representing a plus group). The model has a yearly time step with sexes combined (males and females are modelled together). Fishing mortality was modelled using a fleet-specific method (Methot et al., 2022). Option 5 was selected for the F report basis as this option corresponds to the fishing mortality requested by the ICES framework (i.e., simple unweighted average of the F of the age classes chosen to represent the Fbar (age 4-15)).

3.1 Stock structure and reallocation

A stock ID workshop was run as part of WKBSEBASS 2024 (ICES 2023). The evidence reviewed pointed towards the need to consider the level of mixing between currently defined northern and Biscay stocks for assessment and management. The WKBSEABASS 2024 model therefore includes an element of mixing via a reallocation of commercial catches and recreational removals during the summer and autumn quarters between the two assessment areas.

The analysis of the DST tagging data from France, UK and Belgium (Annex 6) shows that the stocks of seabass from the Bay of Biscay (Southern stock) and the central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and Celtic Sea (Northern stock) mix during the feeding season (summer and autumn). At that time, many sea bass from the Bay of Biscay are found in the western channel where they can be caught by the fishery operating in that area.

From the tagging experiment, it was possible to estimate the proportion of fish in quarter 3 and quarter 4 present in the Northern stock that would migrate to the Bay of Biscay at the end of each of those two quarters. Hence, 28.8% of adult seabass are estimated to migrate from the Northern stock to Southern stock area at the end of quarter 3 (on the 1st of October) and 40.7% at the end quarter 4 (on the 1st of January). 28.8 % of seabass caught in the Northern stock area from July 1st to September 30 are therefore allocated to the Southern stock and, similarly, 40.7 % caught in the Northern stock area from October 1st to December 31th. More details can be found at the commercial landings and discards, and recreational removals sections.

3.2 Commercial Landings and discards

3.2.1 Fleet structure

The WKBASS 2018 assessment included a mix of UK gear-based fleets (bottom trawls and nets, lines, midwater trawls), and a French fleet including all gears. There was an 'Other' fleet to cover other UK gears and other countries, which was assumed to have the same selectivity as the French fleet.

With the development of the fishery in other countries such as the Netherlands, and the management measures which had the potential to affect the contribution of different gear types in the 'French fleet' (i.e. change the selectivity), together with the bias in the biological sampling scheme towards certain gears that may not have reflected the French catch as a whole, it was necessary to revise the categorisation.

Commercial landings were split according to the main fleets fishing seabass in the Northern area: gillnets (GNS), handlines (LHM), longlines (LLS), bottom trawls (OTB), pelagic trawls (PTM), demersal seine (SEINE) and other gears (OTHERS) (Annex 5).

The commercial landings data by country and gear grouping for the benchmark assessment are given in the input data file (Appendix 1).

3.2.2 Accuracy of landings series

Landings data by the 2 main countries catching bass (UK and France) both have limitations, as explained in details in WKBASS 2018 (ICES, 2018), with French landings having been reconstructed prior to 2000 and issues in reporting of the small-scale fleet (under 10m) in the UK. No changes have occurred since the last benchmark that has affected the quality of the data.

3.2.3 Commercial landings and length/age compositions

Landings data started in 1985, until present, for all commercial fleet.

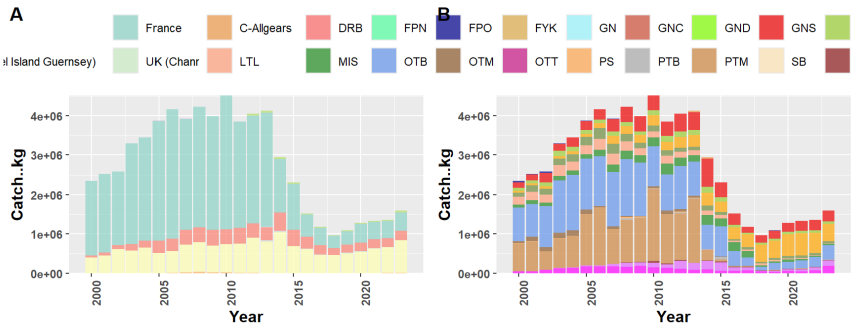


Figure 1. Northern seabass in ICES divisions 27.4bc7ad-h. Commercial catches split by country (A) and by gear (B).

As in WKBASS 2018, the length bin was set from 4 to 100 cm by 2 cm intervals. Length compositions for fleets are expressed as fleet-raised number-at-length. In WKBASS, UK fleet length data started in 1985. With the new groupement of fleets, length data now start in 2000 as this is when French length data are available from.

Age data was previously input as 'marginal composition', meaning that a vector of age distribution of the landings, discards or both, was given per year and fleet. WKSEABASS now uses age-length keys (ALKs) whereby the data is entered as samples with an age distribution per length class. This data is also available per year, but not by fleet as all samples are aggregated to produce the ALK. In the base model the ALK is associated with the trawls fleet, but an alternative configuration was also included with the ALK being associated to another commercial fleet. Marginal age compositions were not included in the model likelihood, but they were used for visual inspection.

3.2.4 Commercial discards and length/age compositions

3.2.4.1 Basis for WKBASS 2018 handling of discards

Before 2017, assessments did not include discards as the proportion discarded was relatively small (~5% by weight). Discarding has become more of an issue in recent years driven by more restrictive management measures such as an increase in minimum conservation reference (MCRS) to 42 cm and bycatch limits for trawls and nets. During the latest benchmarks WKBASS (ICES, 2017b; 2018), recent estimates of commercial discards and length compositions were added as input to the Stock Synthesis model.

There is a large potential for bias in the UK discards estimates, particularly for under 10 m vessels which take the bulk of the UK seabass catch, so data were used with caution and uncertainty included and set to 0.75 for the UK fleet and calculated uncertainty for the French fleet were available, defaulted to 0.75 if missing.

3.2.4.2 Changes made in WKSEABASS 2024

In WKSEABASS 2024, the fleet restructuring meant the assumption around the discard data had to be revised. The two main sources of discards were found to be the otter trawlers, as it used to, but also more recently the seine fleet seemed to have increased its discards. However, no length data were available to inform the retention ogive for the seine fleet.

Therefore, in the base model, the trawl discards were modelled as a separate fleet with its own selectivity (i.e. separate from trawl landings), and mirrored by the seine discards (also set up as its own fleet, separate from seine landings). A different configuration was tested as an alternative scenario, whereby the seine landings and discards are grouped as catches for the seine fleet, with a selectivity based on length data from landings only, while trawls discards are modelled with a retention curve.

To account for the under-estimation of discards in the UK fleet, the French discard ratio was applied to the UK fleet landings data. Discards estimates are therefore French discards + other discards estimated using the French discard ratio). Discard data have been collected since 2002. The trawls discards therefore start in 2002, with very small values pre-2015. Seine discards start appearing in 2016.

3.2.4.3 Fishery discards length composition data

Discards lengths data for the trawl fleet showed a peak around 10 cm and another closer to the minimum landing size (under 42cm). Upon investigation the peak in the smallest sizes originated from from trawls targeting shrimps. These do not tend to catch and land seabass of commercial size and so the whole catch is discarded. Observers report that the fish goes back 'looking mostly alive' and therefore these data were removed from the length dataset as they were not characterising the dead discards of the main trawl fleet they had been aggregated under.

3.2.5 Commercial catches reallocation

As described before, to account for seasonal stock mixing, it was necessary to reallocated catches based home location, mixing rates, and seasonality in the catches. Home location was defined as the area within which individual sea bass spawn. The detailed computation can be found in the Annex 5 and 6. Calculation have been made only on landings, considering that discards are mainly young individuals who do not migrate. To get the final reallocation, several steps have been necessary:

1. Reconstruction of quarterly landings over the historical period 1985-2000: as shown previously historical times series are incomplete in Intercatch and have been recalculated, but without the quarterly information (only annually). Proportion of quarterly landings over the period 2000-2005 has been applied to historical period reconstructed in order to have quarterly landings reconstructed.
2. Based on the proportion of fish that would migrate (28.8% and 40.7%) from one stock to the other, depending of the period (respectively end of quarter 3 and quarter 4) it has been possible to recalculate landings reallocated from North to South.

3.3 Recreational removals

For a full description of the approach for generating times series of recreational data see Annex 1.

3.3.1 Catch

National survey data for recreational catches was provided by countries exploiting the stock (i.e., Belgium, Denmark, France, Germany, Ireland, the Netherlands, and the UK). The surveys covered both retained and released catches, as well as length-frequency data. National surveys had different coverage, methodology, and temporal resolution which made creating a comprehensive time series challenging (Table 2). Management measures have been implemented and changed regularly, making constructing time series of the retained and released components more difficult.

Table 2. Summary of national estimates for sea bass. C: catch; L: length-frequencies; A: angling; S: spearfishing; and N: nets. Orange area offsite surveys and grey dappling onsite surveys. Purple box denotes data used for the previous benchmark (ICES 2018).

Year	Belgium 4.c	Germany 4.b	Denmark 4.b	France 7.d-e, 8a-b	Ireland 7.a, 7.g	Netherlands 4.c	UK 4b-c, 7.a,d-h
2009				C,L,A,S			
2010						C,A	
2011				C,L,A,S			
2012						C,L,A	C,L,A
2013							
2014		C,A				C,L,A	
2015							
2016						C,L,A	C,L,A
2017	C,L,A		C,L,A				
2018				C,L,A,S		C,L,A	
2019					C,L,A		
2020						C,L,A	
2021		C,L,A		C,L,A,S			
2022					C,L,A	C,L,A	
2023							

Kept and released estimates and associated errors were combined for each stock area accounting for missing errors, countries, years, and partitioning between areas. Germany was excluded from the analysis as robust estimation of catch was not available, and French estimates from 2011-12 and 2018-19 were excluded due to quality issues.

An approach for assessing the impact of management measures provided forward projections of the levels of catches. Forward projections overestimated the impact of management measures with the difference largest for the released component. Backward projections from surveys done after the implementation of management were calculated and used as inputs for the assessment. This resulted in generation of a time series of retained and released components from 2016 – 2023 (Figure 2).

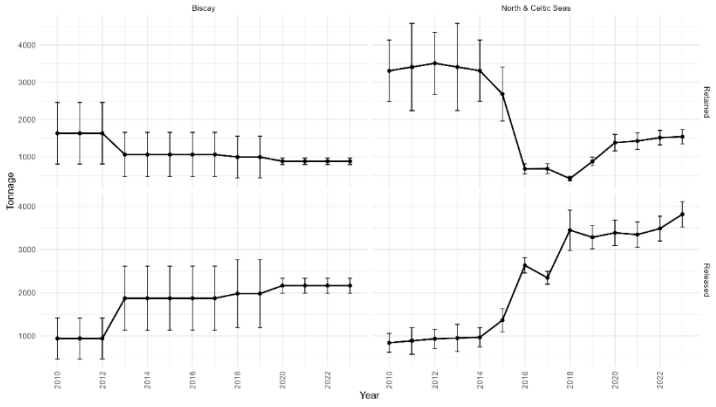


Figure 2: Backwards projections of the impact of management measures with survey estimates in tonnage for each area (top – retained, bottom – released).

Limited studies of post-release mortality (PRM) exist, with the most robust estimate of 5.0% (Lewin et al. 2018). Applying this PRM to the release component of the catch resulted in a time series of removals (kept + fish that die on or fter release) from 2016 to 2023 for use in the assessment.

3.3.2 Length frequency

Length distributions alongside sample sizes were provided by Belgium, France, Ireland, the Netherlands, and the UK, but not by Denmark. German catches were assumed to be negligible, and French estimates from 2011-12 and 2018-19 were excluded due to quality issues. Annual length-frequency distributions were generated for each stock area for all years with data. Not all countries provided data for all years, so these were reconstructed using a similar approach to catches. Where length-frequency did not exist for a particular country, the length distribution was used from the average of all countries for the same area and year. The proportion of numbers at length was then combined with the average total number of sea bass retained or released and summed to generate estimates for each area required within modelling scenarios (Figure 3). Applying this PRM to the release component of the catch resulted in a time series of removals (kept + fish that die on or fter release) from 2016 to 2023 for use in the assessment.

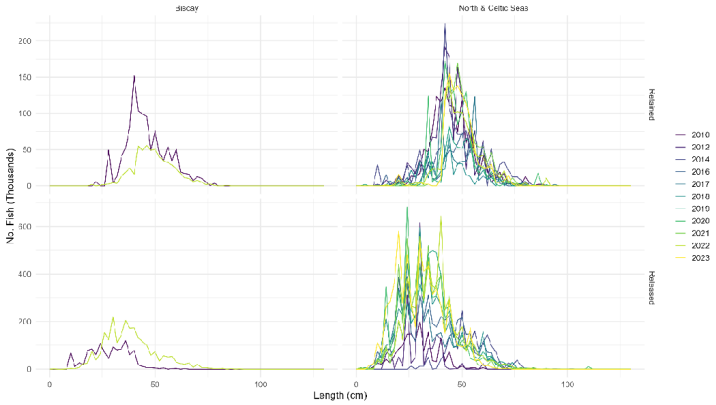


Figure 3: Length-frequency of sea bass by year for the different areas.

3.3.3 Catch reallocation between stock areas

The stock ID workshop highlighted the need to consider the exchange of catches between Northern and Biscay stocks as part of the assessment (ICES 2023). To achieve this, it was necessary to understand home location, mixing rates, and seaonality in the catches. Home location was defined as the area within which individual sea bass spawn and reallocation of catches were based on this.

Analysis of tagged sea bass data showed that the individual sea bass moved between the Northern and Biscay stock areas (Annex 6). Sea bass from Biscay moved into the western channel to feed during summer and autumn before returning to Biscay during winter and spring where they spawn. Conversely, some sea bass from the eastern channel, North Sea and Irish Sea moved into the western channel in winter to spawn. If a sea bass home stock is defined as the area within which individual sea bass spawn, then it is necessary to reallocate a proportion of catches made in the Nothern stock area to the Biscay stock.

Fish were assigned to a stock based on their location during the spawning season with the proportion of recreational catch reassigned using seasonal movement rates from tagging studies (Table 3). The assignment of catches was only done from Northern to Biscay due to the direction of spawning migrations.

Table 3: Exchange rates between the Northern and Biscay stocks . Proportion of fish from the Northern stock moving to the southern stock at the end of the quarters 3 and 4.

Quarter	Proportion
Q3: Jul-Sep	0.28803
Q4: Oct-Dec	0.40665

3.3.4 Seasonality

Monthly variation in raw catches was used to assess seasonality. The proportion of raw numbers of fish caught in each month during the year was provided by France, Ireland, the Netherlands, and the UK, but were not available for Denmark or Belgium. Individual countries seasonal patterns were averaged across years then a weighted average of the proportions accounting for differences in numbers

caught within a country generated for each area and scenario. Seasonality in raw catches showed highest catches in summer and lowest in winter (Figure 4).

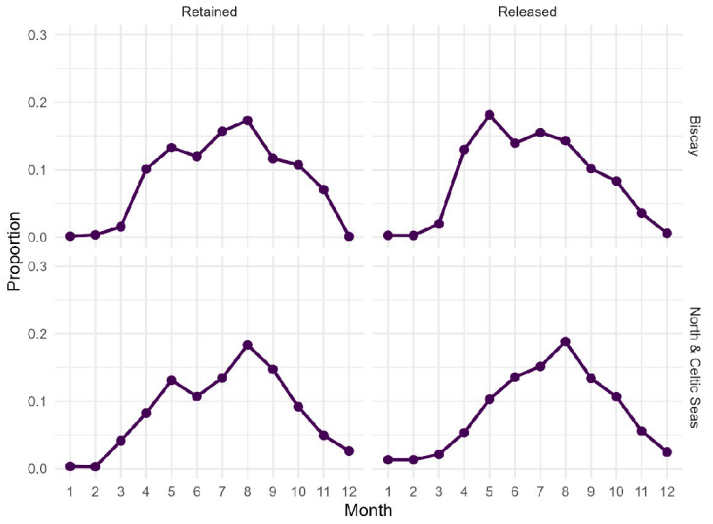


Figure 4. Proportion of sea bass caught in each month averaged across all available years and weighted by catches in each country for the different areas.

Catches were reassigned to Biscay from the Northern stock based on quarterly exchange rates (Table 2) and seasonality for retained (Table 4) and released components of the catch separately (Figure 5). A post-release mortality of 5% was applied to generate removals. For a full description of the approach see Annex 1.

Table 4. Proportion of retained (A) and released (B) catch to be reassigned from the Northern to Biscay stock area at the end of quarters 3 and 4.

	Quarter	
Proportion	**Q3: Jul-Sep**	**Q4: Oct-Dec**
Exchange	0.28803	0.40665
A. Retained		
Season	0.46501	0.16708
Total	0.13394	0.06794
Overall	0.20188	
B. Released		
Season	0.47361	0.18710
Total	0.13641	0.07609
Overall	0.21250	

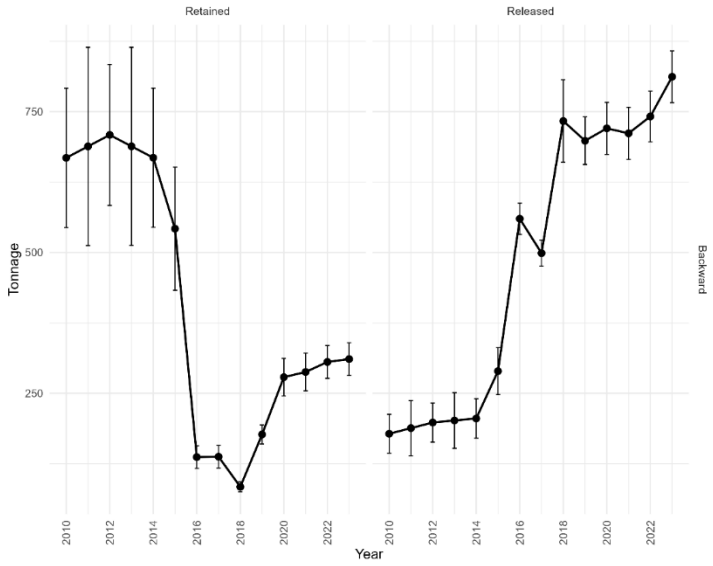


Figure 5: Tonnage of kept and released sea bass to be reassigned from the Northern to Biscay stock based on the quarterly exchange rates for the backward projection.

3.4 Abundance indices

3.3.1 LPUE

The WKBASS 2018 assessment included only an LPUE index for a French combined fleet. As the combined French fleet was split by gears, the LPUE methodology was revised for WKBSEABASS 2024 and an index calculated for the bottom trawl fleet as a whole (Annex 7).

The objectives were to: 1) develop a new LPUE index per fleet as recommended by the data workshop with a focus on the OTB fleet as it was considered as a good candidate to reflect changes of abundance in the seabass stocks; 2) account for the seabass spatio-temporal dynamics within the model; and 3) use the best available modelling approach to estimate LPUE indices.

A spatiotemporal Generalized Linear Mixed Effects Models (GLMMs) was fitted to logbook data (i.e. daily landings at the monthly and ICES square level). It used an R package named "sdmTMB" that fits spatial and spatiotemporal GLMMs using Template Model Builder (TMB), R-INLA, and Gaussian Markov random fields (Anderson et al., 2022). As for the previous LPUE index, the model followed a Delta modeling approach, i.e. an approach splitting LPUE into two components: (1) a first component modeling zero vs. non-zero LPUE data; and (2) a second component modeling the positive LPUE data. Here we fitted a Delta-lognormal model. This fits a binomial presence-absence model on the presence/absence data and then a model for the positive catches only with a lognormal observation distribution and a log link. The LPUE model write as:

$$\mathbb{E}\left[LPUE_{s,t}\right] = \mu_{s,t}$$

$$\mu_{s,t} = f^{-1}\left(X_{s,t}^{main}\beta + O_{s,t} + \alpha_g + \epsilon_{s,t}\right),$$

where

- $\mu_{s,t}$ represents the LPUE data at point s and time t (zero vs. non-zero LPUE data treated separately of the positive LPUE data respectively);
- μ represent the mean;
- f represents a link function (here a delta lognormal family was used with a logit and a log link respectively) and f^{-1} represents its inverse;
- $X_{s,t}^{main}$ represents the main effects (here a temporal effect combining years and months);
- β represents a vector of fixed-effects coefficients;
- $O_{s,t}$ represents an offset (here set to zero);
- α_g represents random intercepts by group g (here a vessel effect from the OTB fleet), $\alpha_g \sim \mathrm{N}\left(0, \sigma_\gamma^2\right)$;
- $\epsilon_{s,t}$ represents a spatiotemporal component (iid spatial Gaussian random fields that accounts for physical barriers), $\epsilon_{s,t} \sim MVN(0, \Sigma_\epsilon)$.

The model converged well. Spatiotemporal predictions were performed over ICES squares of the Northern stock area and months of the years 2001-2023. Predictions were aggregated over the Northern stock area and over months April to November (as the previous LPUE index). It provided an annual OTB-based LPUE index time-series comparable in trend with the previous combined fleet-based LPUE index (Figure 6). Note that 2000 & 2009 are years for which the data collection system changed. The completeness of the logbook data was not reached in 2008, so this year was excluded from the assessment model.



Figure 6. Northern seabass in ICES divisions 27.4bc7ad-h.. New annual OTB-based LPUE index and associated uncertainty (red) used in the current benchmark compared to the previous combined fleet-based LPUE index (blue). 2008 was excluded from the assessment model, because the completeness of the logbook data was not reached this year.

3.3.2 French CGFS (Annex 2)

The French CGFS survey was redesigned from 2015 and therefore data were only included up to 2014 in the WKBASS 2018 assessment. A new time series is now included in the model with data from 2015 on (length distributions and ALKs).

3.3.3 Recruitment surveys survey

The Solent survey was the sole recruitment index available to WKBASS 2018. Further recruitment surveys were identified as part of WKSEABASS 2024 and included in the model. Those were:

- The Fal and Hel survey (2006-2023) [UK]
- The NOURDEM Douarnenez survey (2018, 2021-2023) [France]
- The NOURDEM Seine survey (2017-2023) [France]

The Fal and Hel survey reports ages 0 and 1 (Annex 4) . Data are entered as indices at age 0 and age 1, with an age-based selectivity fitted. The Nourdem surveys catch mainly fish of age 1-4. The data are entered as length distributions with corresponging ALKs, and selectivity is length-based (Annex 3).

3.5 Biological parameters – growth, maturity

WKSEABASS assessment now incorporaties ALKs, as opposed to the marginal age distribution previously used. Therefore, growth parameters are now estimated in the model, except for length at age max, which is fixed at 80.26 for age 28, as per previous assessment. Estimating all growth parameters including L_max is tested in an alternative configuration.

Maturity parameters, and their use within the assessment model, remain unchanged from the previous assessment.

3.6 Natural mortality and stock-recruitment

WKBASS 2018 used a natural mortality of 0.24. Since then, a recent paper discussed the assumptions around natural mortality estimates (Lorenzen, 2022), reviewing biological considerations, empirical generalizations, and theoretical models which led to a new M paradigm described as 'generalized length-inverse mortality'. It was therefore decided to set a natural mortality vector with exponential decrease between age 0 and 5 after which individuals will have mostly reached maturity, and so M would be set equal to 0.24 as per previous benchmark. For consistency between the northern and Biscay stock, the M values for ages 0 to 4 were taken from the Lorenzen estimates of the Biscay model. An alternative model with a constant M at 0.24 was also tested. The vector of natural mortality at age 0 to 5+, that is now being used in the assessment, is: [0.840918, 0.463849, 0.365109, 0.306347, 0.267492, 0.24].

3.7 Stock-recruitment

The assumed shape of the stock–recruit curve acts with the assumed M to constrain any possible biological reference points (Mangel et al., 2013). A key parameter defining a stock–recruit curve is steepness, defined as the ratio of recruitment from an unfished population to recruitment when the spawning–stock biomass is at 20% of the unfished level.

In the model, recruitment was assumed to be a single event occurring at the beginning of the year. Recruitment was derived from a Beverton and Holt (BH) stock-recruitment relationship (SRR) and variation in recruitment was estimated as deviations from the SRR. Recruitment deviates were estimated for 1986 to 2022 as main recruitment deviations and for 1976 to 1985 as early recruitment

deviations. A standard deviation (σR) of 0.9 was assumed. The steepness (h) for the SRR is set at 0.876 based on meta-analysis data (FishLife, Thorson et al. 2023).

Spawning stock biomass was estimated at the beginning of the year and it was considered proportional to fecundity.

3.8 Data input summary

The table below summarises the data and parameter inputs available for the benchmark assessment. See Annexes 1-7 for detailed description of the individual datasets and basis for any recommendations for using the data in the assessment from the WKSEABASS 2024 data workshop. Changes from data or parameters used in the most recent WKBASS assessment in 2018 are described in the sections below in Table 5.

Table 5. Northern seabass in ICES divisions 27.4bc7ad-h. Data/parameter update in WKSEBASS 2024 compared to WKBASS 2018

Data parameter	Description	Update/Source
Growth	Fixed values of von Bertalanffy growth parameters K; Length-at-Amin and Amax; SD of length-atage; age error vecto	Unchanged from WKBASS 2018
Maturity	Female proportion mature at age	Unchanged from WKBASS 2018
Natural mortality	Mortality expressed as a function of age, with decreasing M down to 0.24 for age 5+. New method based on Lorenzen (2022).	Updated – WKBASS 2018 assessment used Then et al. (2015) M=0.24 for all ages.
Commercial landings 1985–2016	Split by gear: Gillnets, Handlines, Longlines, Bottom trawls, Pelagic Trawls Seine, Other commercial gears	Updated – WKBASS 2018 assessment used a mix of UK gear based fleet and French combined fleet.
Commercial landings length/age composition	Length composition by fleet and one ALK combined for all gears	Updated – WKBASS 2018 used the marginal age compositions by fleet rather than ALKs
Commercial discards catch numbers and weight	Fleet-raised estimates for trawls and seines. Small discards and insufficient data for other fleets. UK discards are raised based on	Updated – WKBASS 2018 used the UK estimates for the UK fleet.

	French discard rates due to limitations of the UK observer sampling scheme.	
Commercial discards length compositions	Fleet-raised length compostions, removing the shrimp fishery discard information as no landings, very small fish caught, and high survivabilty expected	Updated – as per specified above with new fleet structure
Recreational removals – kept and released	Estimates from surveys in France, UK and Netherlands are combined for the years they have occurred between 2012 and 2023. A procedure is used to calculate missing years outside of the model for 2010-2023). Historical series before 2010 is reconstructed with a constant F in the model.	Updated – WKBASS 2018 used an estimate for 2012 which was then used as a reference year, with a constant F up to 2015, reduced according to management measures after that.
Recreational fishery length compositions	Compiled from UK, France and the Netherlands for the years where data existed.	Updated – WKBASS 2018 used only 2012 length data
Recreational fishery postrelease mortality	5%	Unchanged from WKBASS 2018
Channel Groundfish Survey in VIId (France)	Numbers and length composition indices from 1988–2014. Vessel and design changed in 2015 resulting in start of new times series. Included in as 2 different surveys.	Updated – WKBASS 2018 used only the first timeseries (up to 2014)
Solent trawl survey (UK)	Otter trawl survey of a major nursery area (1986–2023). Indices by age class for ages 2–4.	Unchanged from WKBASS 2018
French commercial lpue series	LPUE estimated for the trawl fleet.	Updated – WKBASS 2018 used an LPUE for the French fleet as a whole, now it is still based on Frecnh data but specific to the trawl fleet only.
Nourdem La Seine	Recruitment time series for fish age 1-5 (2017-2023) Length composition and ALKs	New data
Nourdem Douarnenez	Recruitment time series for fish age 1-5 (2018,2021-2023) Length composition and ALKs	New data

Fal and Hel	Recruitment time series (2006-2023) Indices by age class for ages 0-1	New data

3.9 Data weighting

In Stock Synthesis, errors and sample sizes must be attributed to input data.

3.9.1 CVs, sample sizes

For the commercial fleets, the landings standard errors were set to 0.1. The standard error of the initial catches of the commercial fleets was also set to 0.1. The initial input sample sizes (N_{input}) for (retained and discards) length frequency distributions by year were calculated as a function of the number of trips and number of fish via the Stewart Method (Stewart, pers.com):

$$N_{input} = N_{trips} + 0.138N_{fish} \quad \text{when} \quad \frac{N_{fish}}{N_{trips}} < 44$$

$$N_{input} = 7.06N_{trips} \quad \text{when} \quad \frac{N_{fish}}{N_{trips}} \geq 44$$

The method is based on analysis of the input and model derived effective sample sizes from west coast groundfish stock assessments. A piece-wise linear regression was used to estimate the increase in effective sample size per sample based on fish-per-sample and the maximum effective sample size for large numbers of individual fish.

For the recreational fishery, the total removals standard errors were set to 0.25 for more recent years, for which a reconstructed time series was provided (years 2010-2023), and to 0.8 for the years before 2010. In addition, a constant survey index in fishing mortality unit was included for the period 1985-2010, with a low standard error (0.1) across. The idea for doing so was to let the SS model estimate the historical removals (1985-2009) of the recreational fishery with a constant fishing mortality based on the F of 2010. For the removals and released length composition data, , and use the input data for the years 2011-2023 otherwise. For the removals and released length composition data, the sample size is the number of fish measured divided by 10. The French data was provided aggregated for the whole of Biscay and the Northern stock, so the sample size was split up using the following percentages: 7d: 26%; 7e: 16% and 8ab: 58% (Annex 1).

For the surveys and the LPUE indices, the standard errors (in the log scale) were provided and calculated as $\sqrt{log_e(1 + (CV)^2)}$. For surveys, an input sample size depending of the number of hauls was attributed to the length composition data. The following equation was used (Stewart & Hamel, 2014):

Nsamp = 2.73×Nhauls

For all ALKs, the sample size was the actual number of fish samples being aged for a given length bin.

3.9.2 Ageing error

Exchange of sea bass scales and otoliths was done in 2020 to understand ageing error among different readers (ICES, 2020; 2021). Eight readers from three national laboratories (Cefas UK, Infremer FR,

ILVO BE) read both otoliths and scales of 100 sea bass from ICES area 27 (ICES, 2020). The scale calibration exercise showed an overall agreement of 68% with a CV in precision of 11% for fish of modal age of 2 to 16 years (ICES, 2020).

Data for all age readers were extracted from Table 51 of ICES (2020) and the standard deviation calculated for each modal age. This was used to inform ageing error in the model extrapolation from the next youngest age wwhere fish of that age did not exist in the sample (Table 6).

Table 6. Ageing error in terms of standard deviation (SD) for different model ages taking from a sea bass scale calibration exercise (ICES, 2020; 2021).

Modal age	2	3	4	5	6	7	8	9	10	11	12	15	16
SD	0.46	0.49	0.55	0.53	0.56	0.58	1.18	0.50	0.61	1.05	2.08	1.96	2.19

3.9.3 Iterative re-weighting

Francis method was used for data weighting with in the assessment model (Francis and Hilborn 2011). This method is based on variability in the observed mean length or age by year, where the sample sizes are adjusted such that the fit of the expected mean length or age should fit within the uncertainty intervals at a rate which is consistent with variability expected based on the adjusted sample sizes. Francis data weighing was performed, once the base model was achieved.

3.10 Fisheries dynamics

In WKBASS 2018, selectivity and retention blocks were included in the assessment from 2015 onwards for UK and French fleets and some correlated selectivity parameters were fixed. This was to reflect the introduction of management measures that were adapted each year. Yearly changes in management measures are still occruing, although with less significant changes in recent years. In WKSEABASS a random walk starting in 2015 was set up on some parameters of the selection curves for each fishing fleet to reflect this.

4. Selection of best model configuration

4.1 Exploratory runs

The following alternative configurations were explored (Table 7).

Table 7. Names, descriptions and justifications of the exploratory runs

NAME	BRIEF DESCRIPTION	REASON
base_run	As described in text	-
recre_low	Different time series of recreational data (lower removal estimates)	2 times series with different reconstruction methods were proposed at the benchmark
no_sd_survey	Turn off the extra standard deviation for juvenile surveys	Testing higher confidence in recruitment information
disc_ret	Discard as retention function for OTB, and SEINE as catch fleet	Treating discards as discards rather than setting them up as landings may be preferable (i.e. having a retention curve rather than a seperate selectivity for landings and discards), though no length data exist for Seine discard, therefore here it is added up to the Seine landings.
split_recre_ret_rel	Recreational fleet as landed and discarded fraction	Treat releases as discards, with a retention curve to make use of the seperate length distributions for retained and released
constant_M	Constant natural mortality M	Approach used in previous assessment
alk_to_other_flt	Associate ALK to a different fleet than OTB	The ALK pulls together age-length data from all fleets. In the model it is associated to OTB as it is one of the main fleets, but the effect of associating to another fleet (handlines) is unknown
growth	Estimate all growth parameters	The base model estimates all parameters but L_max
no_mvt	Assume no movement of fish from the Southern to the Northern stock	Test the effect of not accounting for stock mixing

4.2 Model selection and diagnostics

An objective methodology for selecting, pruning, and weighting hypotheses was agreed in advance of the modelling. Traditionally in ICES, diagnostics have been based on retrospective and visual analysis of the residuals. However, recent papers by Carvalho et al. showed that when several diagnostic tests are considered together, the power to detect model misspecification improves without a substantial increase in the probability of incorrectly rejecting a correctly specified model (Carvalho et al., 2017, 2021).

The different plausible model configurations were compared using model diagnostics based on recent papers from Carvalho et al. (2017, 2021), Kell et al. (2021) and Merino et al. (2022). The key model diagnostics used were convergence (which includes checking of parameters at the bounds, final gradient and inversion of the Hessian matrix for uncertainty estimation), runs test and RMSE, retrospective analysis, and hindcasting cross-validation (ICES 2022). Once the best plausible model configuration has been identified, additional model diagnostics (jittering and analysis of surplus production trend) were used to further assess the sensitivity and the validity of the best model. Estimates and trends in SSB, F, and R were used at the last step and only as a plausibility check.

4.3 Conclusions

Table 8 summarizes all diagnostics used to evaluate candidates' best model configurations. The table is an attempt to sum up a multidimensional space and thus it needs to be seen as a guidance more than as a definitive result.

All models invert the hessian matrix and have a good convergence. The ordinary runs test was failed 5 or 6 times for each model, except for the *disc_ret* alternative where only 3 tests failed. On the other hand, the RMSE was above 30% for all models.

The Mohn´s rho indices were inside the bounds of recommended values for long-lived species for all model alternatives. Hindcasting results showed poor prediction skills on four of the CPUE indices given that it was higher than the 1.0 threshold when predicting the index one year ahead, with exception of the *disc_ret* alternative which only failed 3 tests. On the other hand, *disc_ret* MASE value was above 1 for one length and one age time series while most other models had values below 1 for all length and age composition data.

From Table 8, all model alternatives performed similarly. The ones that marginally scored the highest overall are *disc_ret* and *no_sd_surv.* However, *disc_ret* predicted the spawning biomass to be very low

in the early years of the model, which is not realistic, while *no_sd_surv* had a high loglikelihood compared to the base model. Two other models had the same score as the base model, *alk_to_other_flt* and *no_mvt*. This would be expected and did not suggest that either of these models should be preferred. Therefore, the base model was the model taken forward as the best model.

Table 8. Northern seabass in ICES divisions 27.4bc7ad-h. Summary table of the diagnostics of the models tested as candidates of the best model. Values in red refer to tests that failed and in blue those that were passed. Percentage of tests passed are given on the last line of the table.

Run	*base_run*	*recre low*	*no_sd_surv*	*Disc_ret*	*split_recre_ret_rel*	*Constant_M*	*alk_to_other_flt*	*growth*	*no_mvt*
Convergence	9.69e-05	9.85e-05	9.70e-05	4.00e-05	8.55e-05	9.13e-05	1.45e-04	5.24e-05	9.45e-05
Total_LL	2444.94	2444.35	2710.43	2645.27	2489.2	2436.94	2444.94	2441.53	2445.43
N_Params	235	235	229	227	247	235	235	236	235
Runs_test_cpue1	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Failed
Runs_test_cpue2	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Failed
Runs_test_cpue3	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue4	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue5	Passed	Failed	Failed	Passed	Failed	Failed	Passed	Failed	Passed
Runs_test_cpue6	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue7	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue8	Failed	Failed	Passed	Passed	Failed	Failed	Failed	Failed	Failed
Runs_test_len1	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len2	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len3	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Failed
Runs_test_len4	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len5	Failed	Failed	Passed	Passed	Failed	Failed	Failed	Failed	Failed
Runs_test_len6	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len7	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len8	Passed	Passed	Passed	Passed	Failed	Passed	Passed	Passed	Passed
Runs_test_len9	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len10	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len11	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len12	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len13	Passed	Passed	Passed	NA	Passed	Passed	Passed	Passed	Passed
Runs_test_age1	Passed	Passed	Failed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_age2	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
RMSE_Perc	61.2	60.9	57.1	60.2	63.2	61.5	61.2	60.9	60.9
RMSE_Perc_1	69.4	69.4	76.5	69.5	69.1	69.4	69.4	69.3	69.4
Retro_Rho_SSB	-0.05	-0.03	0.06	0.02	0.03	-0.05	-0.05	-0.07	-0.03
Forecast_Rho_SSB	-0.12	-0.10	0.02	-0.02	-0.06	-0.12	-0.11	-0.13	-0.09
Retro_Rho_F	0.08	0.08	-0.05	-0.01	0.09	0.08	0.07	0.09	0.04
Forecast_Rho_F	0.15	0.17	-0.02	0.02	0.20	0.15	0.15	0.16	0.11
MASE_cpue2	1.27	1.31	1.73	1.25	1.18	1.48	1.27	1.23	1.29
MASE_cpue4	1.44	1.43	1.55	1.38	1.46	1.31	1.44	1.45	1.41
MASE_cpue5	1.37	1.23	1.24	1.50	1.30	1.29	1.36	1.36	1.32
MASE_cpue6	0.75	0.73	0.76	0.79	0.72	0.82	0.75	0.73	0.76
MASE_cpue7	1.07	1.07	0.99	1.05	1.08	1.08	1.07	1.07	1.07
MASE_cpue8	0.46	0.46	0.42	0.44	0.45	0.46	0.46	0.47	0.46
MASE_cpue9	0.89	0.89	0.95	0.89	0.87	0.92	0.89	0.89	0.89
MASE_len1	0.91	0.90	0.90	0.95	0.88	0.92	0.91	0.90	0.91
MASE_len2	0.23	0.24	0.23	0.18	0.25	0.22	0.23	0.24	0.23
MASE_len3	0.42	0.43	0.37	0.31	0.45	0.39	0.42	0.45	0.41
MASE_len4	0.56	0.56	0.53	0.53	0.56	0.55	0.56	0.57	0.56
MASE_len5	0.13	0.12	0.11	0.43	0.10	0.13	0.13	0.12	0.12
MASE_len7	0.90	0.78	1.07	0.94	0.79	0.86	0.90	0.75	0.90
MASE_len8	0.57	0.54	0.72	0.67	1.15	0.60	0.57	0.52	0.57

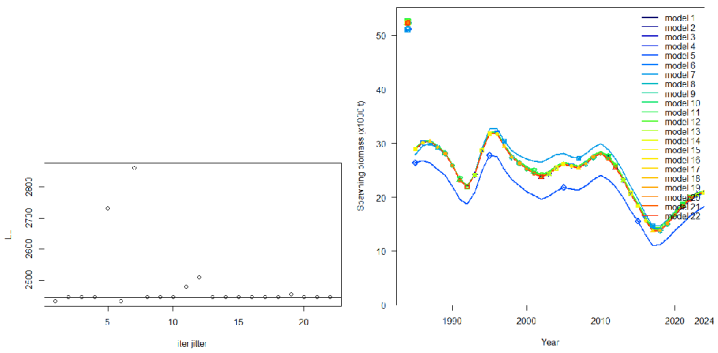
MASE_len10	0.29	0.30	0.18	0.29	0.37	0.27	0.29	0.29	0.29
MASE_len11	0.95	0.95	0.98	0.94	0.93	0.96	0.95	0.94	0.95
MASE_len12	0.92	0.92	0.90	1.00	0.82	0.81	0.91	0.93	0.92
MASE_len13	0.58	0.57	0.57	0.79	0.57	0.58	0.58	0.58	0.58
MASE_len14	0.73	0.72	0.74	NA	0.77	0.71	0.73	0.72	0.73
MASE_age8	0.74	0.74	1.07	0.73	0.75	0.75	0.74	0.73	0.74
MASE_age9	0.81	0.81	0.90	0.81	0.81	0.81	0.81	0.81	0.81
MASE_age11	0.81	0.81	0.91	NA	0.81	0.81	0.81	0.81	0.81
Weighted model score	**0.72**	**0.70**	**0.73**	**0.74**	**0.68**	**0.70**	**0.72**	**0.70**	**0.72**

4.4 Additional diagnostics of selected reference model

4.4.1 Jittering

The jittering procedure allows users to verify the stability of a model and its parameter estimates by examining the effect that small changes in its starting values have on model results. An accurate model should converge on a global solution (i.e., not be stuck in local minima of the likelihood surface) across a reasonable range of starting values for all input parameters. In this case, 25 runs were performed considering a 10% jitter of all initial parameters. In practice, this means that a small random jitter is added to the initial parameter values and the model is rerun. Starting values are jittered based on a normal distribution based on the pr(PMIN) = 0.1% and the pr(PMAX) = 99.9%.

Most jittered runs resulted in the same results as the selected model run (Figure 7) with a couple of runs with a likelihood slightly lower than the selected model. The resulting spawning biomass, F and recruitment of those runs were the same nonetheless.



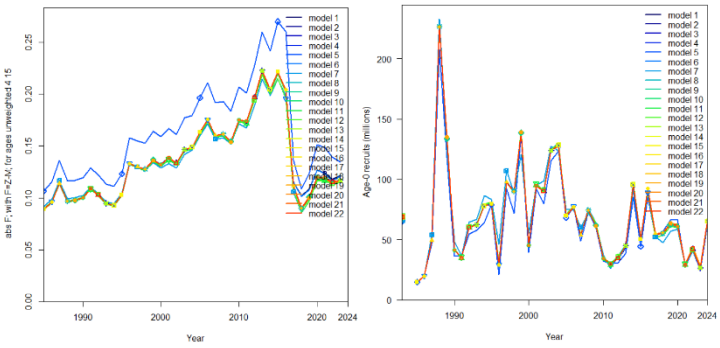


Figure 7. Northern seabass in ICES divisions 27.4bc7ad-h. Results from jitter using 25 iterations and an average jitter of 10%.

4.4.2 Analysis of surplus production trend

Estimates of Surplus Production (Walters, et al., 2008) can provide a check of whether predictions of changes in biomass can be made reliably based on catch and current biomass (clockwise or linear behaviour) or whether there has been non-stationarity in production processes, i.e., are dynamics driven by climate and oceanic conditions (counter clockwise). In the case of Northern sea bass, Figure 8 shows a general clockwise pattern indicating that changes in stock biomass can be made reliably based on catch and current biomass. Moreover, the production function (Figure 8) is typically left skewed and flat-topped, which implies that fishing at the naïve F_{MSY} brings the stock close to B_{lim} with very reduced theoretical gain in yields compared to a more conservative proxy as $B_{40\%}$.

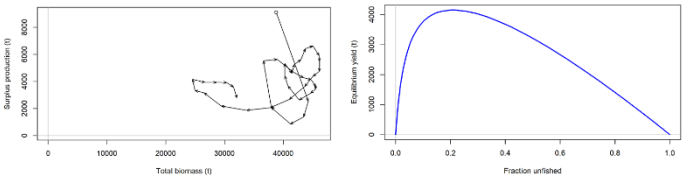


Figure 8. Northern sea bass in ICES divisions 27.4bc7ad-h. Left) Surplus production against biomass plot of the selected model. The round circle represents the first year of the time series (1985). Right) The production function of the selected model.

5. Best model

5.1 Description of selected model

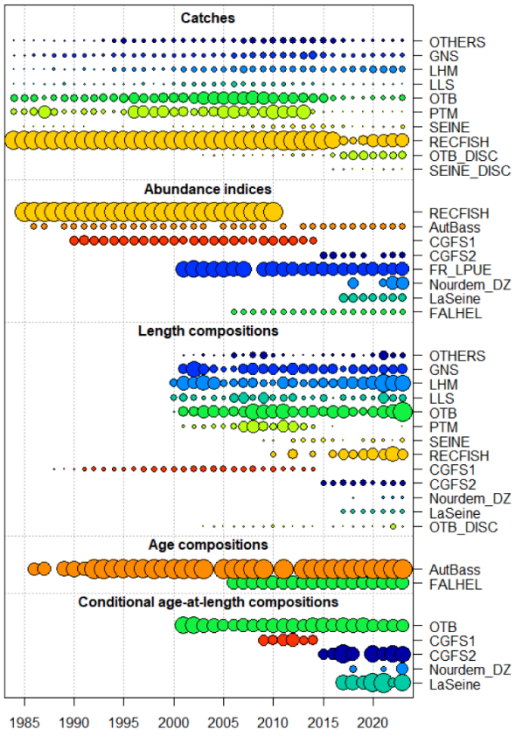


Figure 9. Northern seabass in ICES divisions 27.4bc7ad-h. Summary of the input time series included in the selected model. Note that the Recfish abundance index presented here is just a constant F index that is used for the model to estimate recreational catches.

Table 9. Northern seabass in ICES divisions 27.4bc7ad-h. Settings of the selected model compared to previous benchmark (WKBASS 2018)

CHARACTERISTIC	SETTINGS	
	WKBSS2 2018	**WKSEABASS 2024**
Starting year	1985	1985
Ending year	2016 (end year of data)	2023 (end year of data)
Equilibrium catch for starting year	0.82* landings in 1985 by fleet.	landings in 1985 by fleet
Number of areas	1	1

CHARACTERISTIC	SETTINGS	
	WKBSS2 2018	**WKSEABASS 2024**
Number of seasons	1	1
Number of fishing fleets	6	10 (=6 + 2 split into landing and discard fleets)
Number of surveys	Two surveys: CGFS, Solent autumn survey.	6 surveys (CGFS to 2014 and CGFS to 2023 + young fish surveys: Solent, Nourdem Seine, Nourdem Douarnenez; Fal & Hel)
Number of tuning fleets	One tuning fleet, French landings per unit of effort	One tuning fleet, bottom trawls landings per unit of effort
Individual growth	von Bertalanffy, parameters fixed, combined sex	von Bertalanffy, parameters estimated but one (L_at_Amax), combined sex
Number of active parameters	109	235
Population characteristics		
Maximum age	30	30
Genders	1	1
Population length bins	4–100, 2 cm bins	0-96, 2 cm bins
Ages for summary total biomass	0–30	0-30
Data characteristics		
Data length bins (for length structured fleets)	14–94, 2 cm bins	2–96, 2 cm bins
Data age bins (for age structured fleets)	0–16+	0–16+
Minimum age for growth model	2	2
Maximum age for growth model	30	28
Maturity	Logistic 2-parameter – females L50 = 40.65 cm	Logistic 2-parameter – females L50 = 40.65 cm
Fishery characteristics		
Fishery timing	-1 (whole year)	-1
Fishing mortality method	Hybrid	Fleet-specific parameter/hybrid
Maximum F	2.9	2.9
Fishing fleets	UK Trawl/nets selectivity: Double normal, length-based UK lines selectivity: Asymptotic, length-based UK Midwater trawl selectivity: Asymptotic, length-based Combined French fleet selectivity: Asymptotic 1985-2014, Double normal 2015 to present, length-based Other fleets/gears selectivity: Mirrors French fleet Recreational fishery selectivity: Double normal, length-based	Bottom trawls selectivity: Double normal, length-based Gillnets selectivity: Double normal, length-based Longlines selectivity: Asymptotic, length-based Handlines selectivity: Asymptotic, length-based Midwater trawls selectivity: Asymptotic, length-based Seine selectivity: Asymptotic, length-based Other selectivity: Double normal, length-based Recreational fishery selectivity: Asymptotic, length-based Bottom trawls discards selectivity: Double normal, length-based Seine discards selectivity: mirrors bottom trawls discards
Survey characteristics *(as fleets in latest SS versions)*		
Solent autumn survey timing	0.83 (yr)	10.96 (month)
CGFS to 2014 survey timing	0.75 (yr)	10 (month)
CGFS 2014-2023 survey timing		11 (month)
Nourdem Douarnenez survey timing		7 (month)
Nourdem Seine survey timing		8 (month)

CHARACTERISTIC	SETTINGS	
	WKBSS2 2018	**WKSEABASS 2024**
Fal & Hel survey timing		8 (month)
Catchabilities (all surveys)	Analytical solution	Analytical solution
Survey selectivities: Solent autumn	Age and length based selectivity	Age and length based selectivity
Survey selectivities: CGFS to 2014	Double normal, length based	Double normal, length based
Survey selectivities: CGFS 2015-23		Double normal, length based
Survey selectivities: Nourdem Douard.		Double normal, length based
Survey selectivities: Nourdem Seine		Double normal, length based
Survey selectivities: Fal & Hel		Age and length based selectivity
Fixed biological characteristics		
Natural mortality	0.24	age 0 to 5+: 0.84 0.46 0.37 0.31 0.27 0.24
Beverton–Holt steepness	0.999	0.876
Recruitment variability (sR)	0.9	0.9
Weight–length coefficient	0.00001296	0.00001296
Weight–length exponent	2.969	2.969
Maturity inflection (L50%)	40.649 cm	40.649 cm
Maturity slope	-0.33349	-0.33349
Length-at-age Amin	19.6 cm at Amin=2	
Length-at-Amax	80.26 cm	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	from 0.5 to 2.2 between age 0.5 and 15.5+
Other model settings		
First year for main recruitment deviations for burn-in period	1969	1986
Last year for recruit deviations	2014 (last year class with survey indices(end year -2))	2022
Last year no bias adjustment	1974.5	1980
First year full bias adjustment	1981.7	1988.1
Last year full bias adjustment	2013.9	2023
First year recent year no bias adjustment	2014.8	2023.1
Maximum bias adjustment	0.907	0.943

Table 10. Northern seabass in ICES divisions 27.4bc7ad-h. Estimated parameters of the selected model (excluding deviation parameters). The table columns (left to right) show: the parameter name, the estimated value, the phase at which the parameter is estimated, the min and max bound (interval over which the estimated values is searched), the initial values (from which the numerical optimization is started), the status (OK = do not hit one of the bound and gradient is low), the standard deviation of the parameter, the gradient, and an indication of where checks may be needed.

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Afterbound
L_at_Amin_Fem_GP_1	20.71	3	-1	30	19.85	OK	0.225	7.17E-06	OK
VonBert_K_Fem_GP_1	0.10	3	0.01	0.2	0.11	OK	0.002	-1.35E-06	OK
SD_young_Fem_GP_1	2.27	6	2	6	2.99	OK	0.116	4.63E-07	OK
SD_old_Fem_GP_1	10.00	6	4	10	9.47	HI	0.000	-1.31E-06	CHECK
SR_LN(R0)	11.14	1	1	16	9.87	OK	0.051	1.82E-06	OK
InitF_seas_1_flt_5OTB	0.02	1	0	3	0.02	LO	0.002	4.28E-08	OK
InitF_seas_1_flt_6PTM	0.02	1	0	3	0.01	LO	0.002	-2.87E-07	OK
InitF_seas_1_flt_8RECFISH	0.10	1	0	3	0.11	OK	0.014	-3.78E-07	OK

F_fleet_8_YR_1985_s_1	0.08	1	0	2.9	0.01	act	0.011	-8.21E-07	OK
[...]									
F_fleet_8_YR_2023_s_1	0.07	1	0	2.9	0.01	act	0.023	2.59E-07	OK
Q_extraSD_AutBass(9)	0.44	3	0	1	0.47	OK	0.110	-1.68E-07	OK
Q_extraSD_CGFS1(10)	0.35	3	0	1	0.50	OK	0.067	-1.80E-07	OK
Q_extraSD_CGFS2(11)	0.40	3	0	1	0.32	OK	0.212	2.31E-08	OK
Q_extraSD_Nourdem_DZ(13)	0.04	3	0	1	0.03	OK	0.105	1.11E-07	OK
Q_extraSD_LaSeine(14)	0.31	3	0	1	0.25	OK	0.133	-5.36E-08	OK
Q_extraSD_FALHEL(15)	0.92	3	0	1	0.92	OK	0.189	-2.45E-08	OK
Size_DblN_peak_OTHERS(1)	39.14	2	20	93	39.07	OK	0.496	-3.03E-08	OK
Size_DblN_ascend_se_OTHERS(1)	1.97	3	-15	20	1.96	OK	0.281	-2.66E-07	OK
Size_DblN_descend_se_OTHERS(1)	7.20	3	-15	20	7.26	OK	0.426	-3.56E-07	OK
Size_DblN_peak_GNS(2)	37.83	2	20	93	37.73	OK	0.200	-7.15E-07	OK
Size_DblN_ascend_se_GNS(2)	1.55	3	-20	9	1.52	OK	0.139	6.42E-07	OK
Size_DblN_descend_se_GNS(2)	6.29	3	-5	9	6.27	OK	0.110	-5.33E-09	OK
Size_inflection_LHM(3)	39.34	2	20	91	39.17	OK	0.213	-9.77E-08	OK
Size_95%width_LHM(3)	3.04	3	0.01	30	3.00	OK	0.200	3.71E-07	OK
Size_inflection_LLS(4)	38.39	2	20	91	38.22	OK	0.284	2.34E-07	OK
Size_95%width_LLS(4)	2.88	3	0.01	30	2.78	OK	0.322	-1.63E-07	OK
Size_DblN_peak_OTB(5)	38.77	2	20	93	38.70	OK	0.230	-1.62E-07	OK
Size_DblN_ascend_se_OTB(5)	2.35	3	-20	9	2.36	OK	0.112	-1.92E-07	OK
Size_DblN_descend_se_OTB(5)	6.40	3	-1	9	6.37	OK	0.110	1.84E-07	OK
Size_inflection_PTM(6)	41.21	2	20	91	41.05	OK	0.360	-6.18E-08	OK
Size_95%width_PTM(6)	4.87	3	0.01	50	4.83	OK	0.443	3.35E-09	OK
Size_DblN_peak_SEINE(7)	43.21	2	20	93	42.92	OK	2.457	8.16E-06	OK
Size_DblN_ascend_se_SEINE(7)	2.89	3	-20	20	2.82	OK	0.736	4.13E-06	OK
Size_DblN_descend_se_SEINE(7)	16.83	3	-10	20	16.90	OK	51.335	-1.08E-07	OK
Size_DblN_peak_RECFISH(8)	48.72	2	20	93	50.68	OK	1.329	-1.28E-07	OK
Size_DblN_ascend_se_RECFISH(8)	4.82	3	-20	25	5.21	OK	0.159	-7.70E-07	OK
Size_DblN_descend_se_RECFISH(8)	3.68	3	-20	25	3.57	OK	345.281	6.88E-07	OK
Size_DblN_peak_AutBass(9)	25.72	2	5	50	24.05	OK	1.381	3.86E-06	OK
Size_DblN_ascend_se_AutBass(9)	-0.85	3	-1	9	-0.26	OK	4.277	-7.48E-07	OK
Size_DblN_descend_se_AutBass(9)	-0.91	3	-1	9	-0.24	LO	2.495	-7.78E-07	OK
Size_DblN_peak_CGFS1(10)	32.01	2	20	93	31.48	OK	0.716	-6.91E-07	OK
Size_DblN_ascend_se_CGFS1(10)	3.09	3	-1	15	3.01	OK	0.230	3.16E-07	OK
Size_DblN_descend_se_CGFS1(10)	6.21	3	-5	15	6.15	OK	0.172	1.64E-07	OK
Size_DblN_peak_CGFS2(11)	36.01	2	20	93	34.92	OK	1.705	9.43E-07	OK
Size_DblN_ascend_se_CGFS2(11)	3.59	3	-1	15	3.37	OK	0.394	1.06E-06	OK
Size_DblN_descend_se_CGFS2(11)	7.45	3	-5	15	7.67	OK	0.684	-1.44E-06	OK
Size_DblN_peak_Nourdem_DZ(13)	21.24	2	19	93	21.05	OK	2.255	7.42E-08	OK
Size_DblN_ascend_se_Nourdem_DZ(13)	1.92	3	-1	9	1.56	OK	1.855	7.50E-08	OK
Size_DblN_descend_se_Nourdem_DZ(13)	6.49	3	-1	9	6.35	OK	0.639	2.61E-07	OK
Size_DblN_peak_LaSeine(14)	7.77	2	3	93	7.15	OK	0.690	-2.24E-07	OK
Size_DblN_ascend_se_LaSeine(14)	0.01	3	-1	9	-0.63	OK	1.654	1.12E-07	OK
Size_DblN_descend_se_LaSeine(14)	6.32	3	-1	9	6.37	OK	0.206	1.50E-07	OK
Size_DblN_peak_FALHEL(15)	9.93	2	3	93	7.15	OK	31.425	-3.52E-05	OK
Size_DblN_ascend_se_FALHEL(15)	1.55	3	-1	9	-0.63	OK	53.296	3.33E-06	OK
Size_DblN_descend_se_FALHEL(15)	0.48	3	-1	9	6.37	OK	25.164	-1.52E-06	OK
Size_DblN_peak_OTB_DISC(16)	33.47	2	0	93	41.28	OK	1.050	3.14E-06	OK
Size_DblN_top_logit_OTB_DISC(16)	-12.55	3	-15	4	-15.00	OK	43.964	2.69E-08	OK
Size_DblN_ascend_se_OTB_DISC(16)	4.04	3	-20	25	4.59	OK	0.289	1.47E-06	OK
Size_DblN_descend_se_OTB_DISC(16)	4.21	3	-20	20	6.60	OK	0.294	2.13E-06	OK

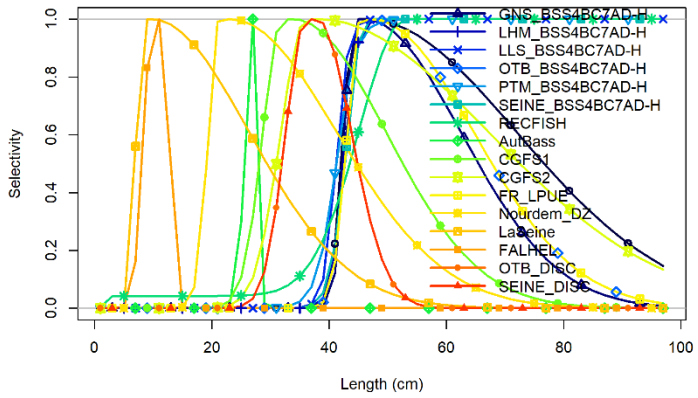


Figure 10. Northern sea bass in ICES divisions 27.4bc7ad-h. Length- selectivity of commercial fleets, recreational removals, LPUE index and surveys of the selected model configuration.

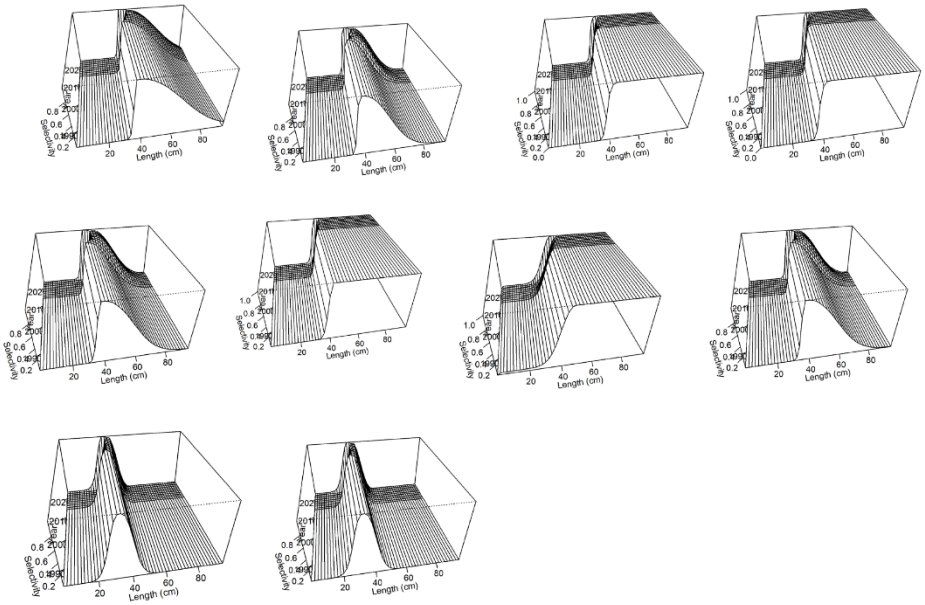


Figure 11. Northern sea bass in ICES divisions 27.4bc7ad-h. Surface plot of time-varying selectivity for fleets (top-left to bottom-right): Other, Gillnets (GNS), Handlines (LHM), Long-lines (LLS), Bottom-trawls (landings) (OTB), Mid-water trawls (PTM), Seine (landings) (SEINE), Recreational, Bottom trawl (OTB) discards, Seine (SEINE) discards.

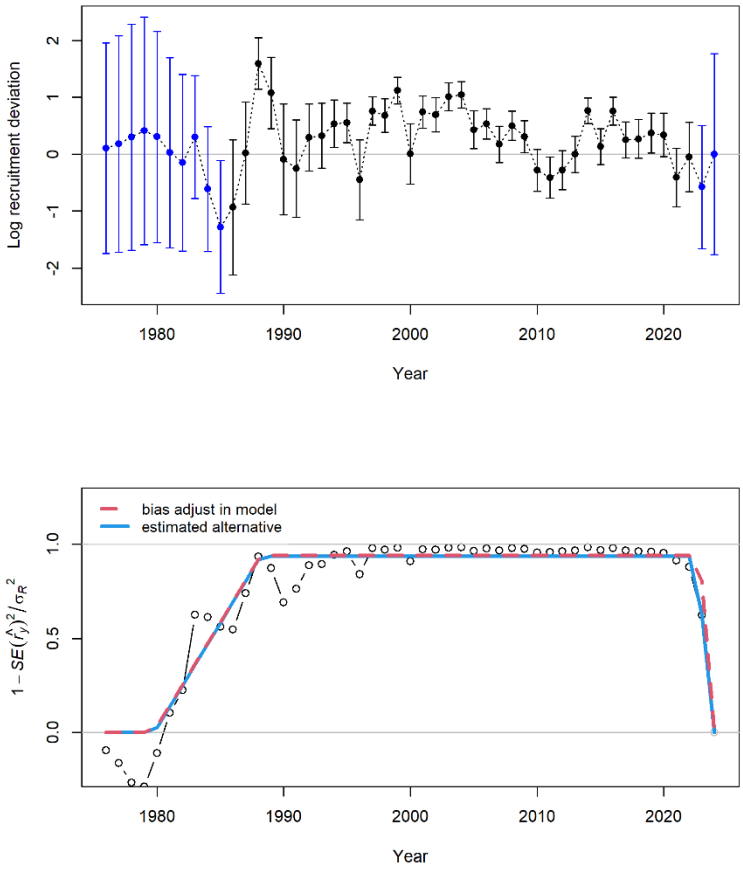
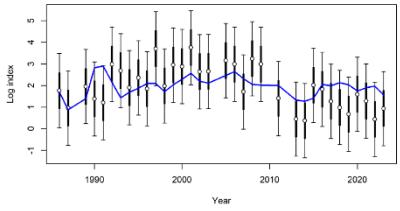
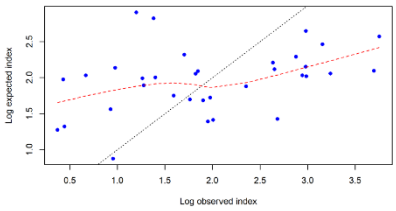
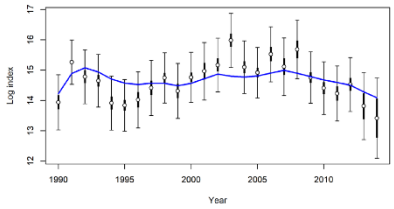


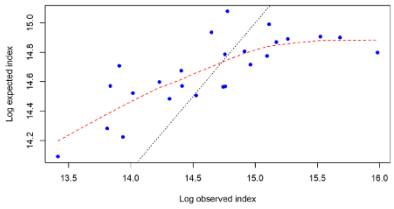
Figure 12. Northern sea bass in ICES divisions 27.4bc7ad-h. Recruitment deviations with 95% intervals and recruitment bias adjustment. Bottom) Points are transformed variances. Red line shows current settings for bias adjustment specified in control file. Blue line shows least squares estimate of alternative bias adjustment relationship for recruitment deviations (which may or may not be an improvement).



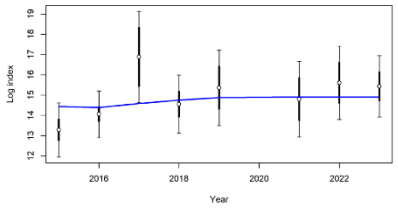


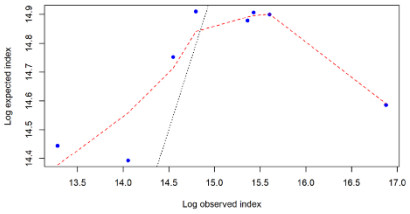
Solent



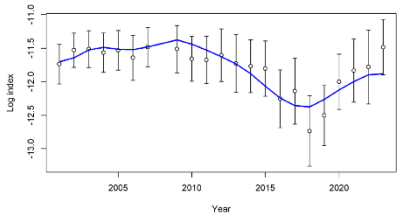


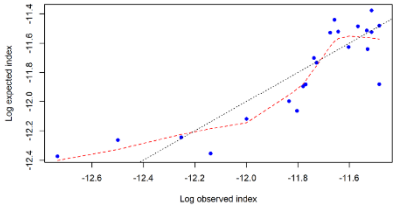
CGFS1



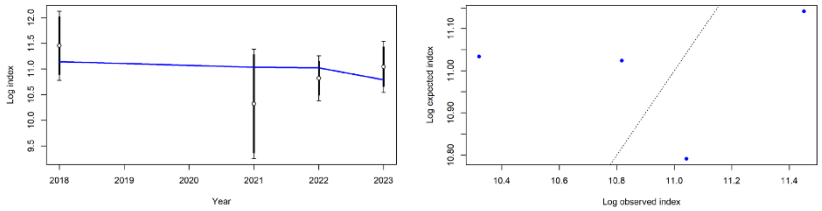


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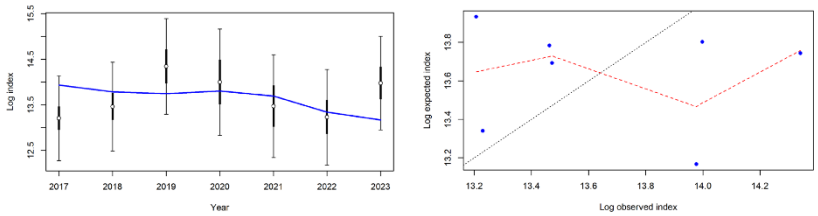




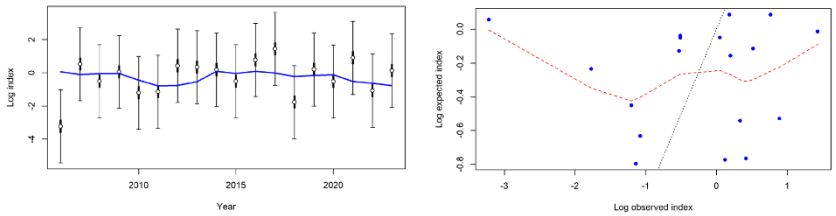
LPUE



Nourdem Douarnenez



Nourddem Seine



Fal & Hel

Figure 13. Northern sea bass in ICES divisions 27.4bc7ad-h. Fit to abundance index data. Left: fit to log index data on log scale. Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines (if present) indicate input uncertainty before addition of estimated additional uncertainty parameter. Right: log(observed) vs. log(expected) index values with smoother

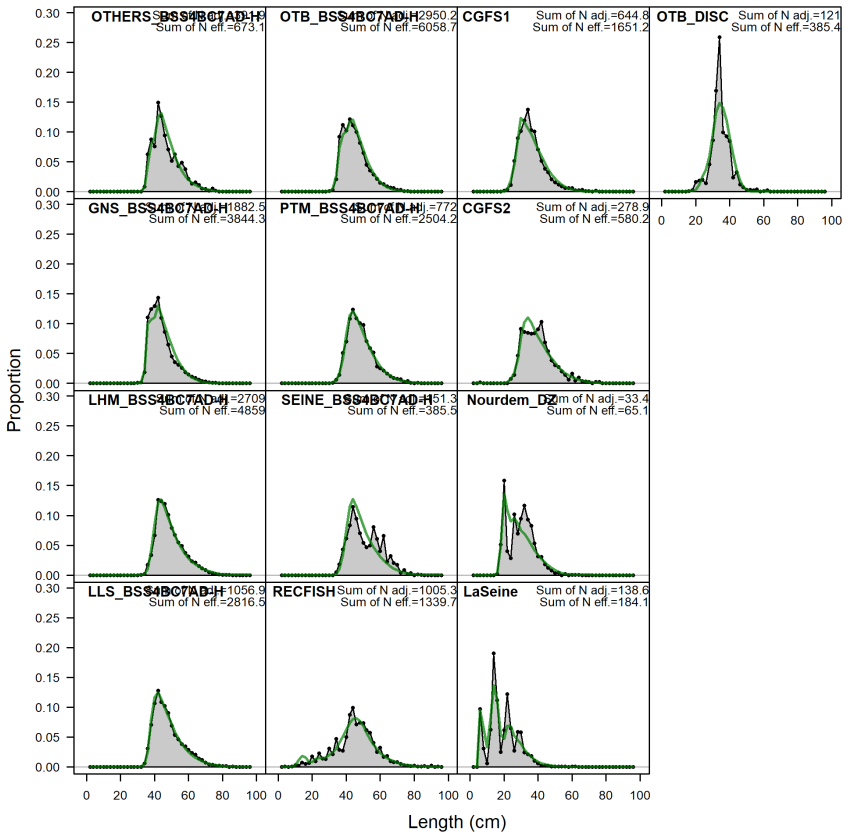


Figure 14. Northern sea bass in ICES divisions 27.4bc7ad-h. Fitted length composition for selected model configuration over all years for each fleet and survey. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.

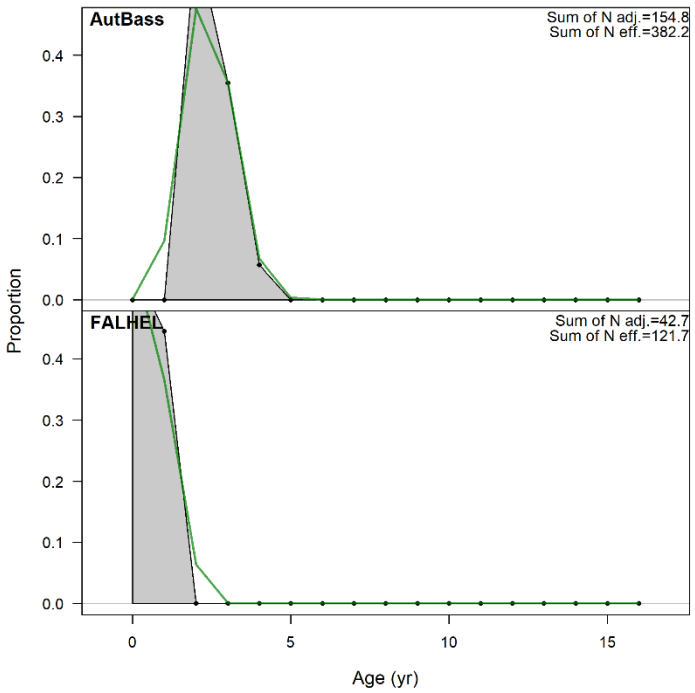
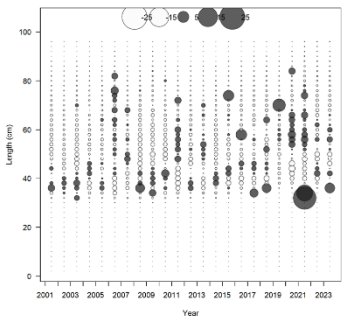
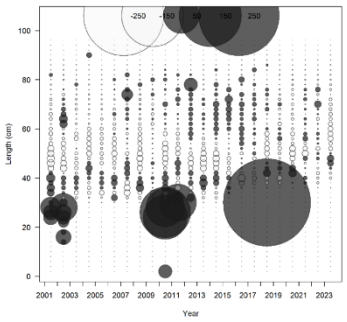


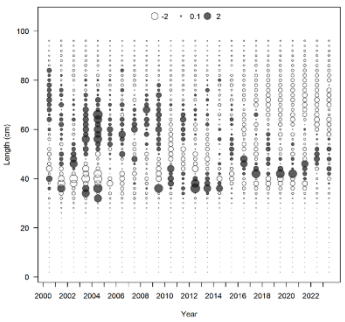
Figure 15. Northern sea bass in ICES divisions 27.4bc7ad-h. Fitted age composition for selected model configuration over all years for each survey. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method.



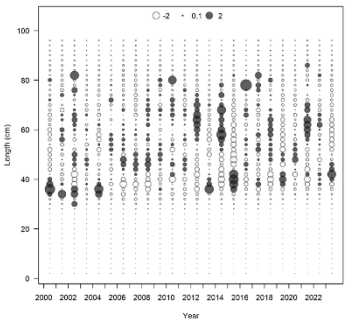
OTHERS



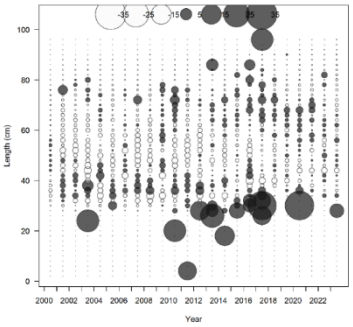
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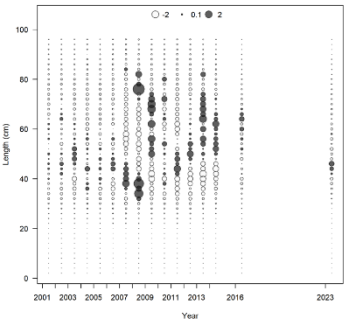
LHM



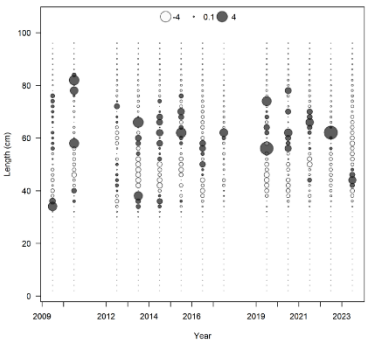
LLS



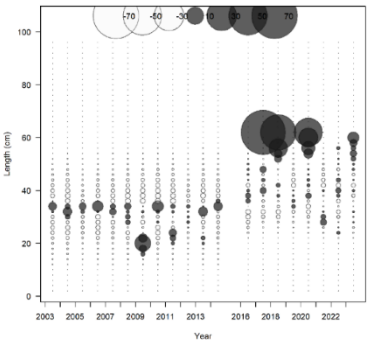
OTB



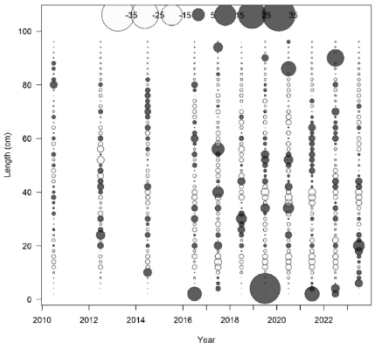
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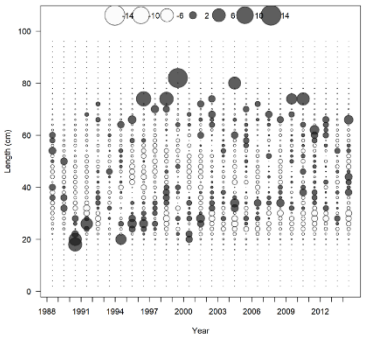
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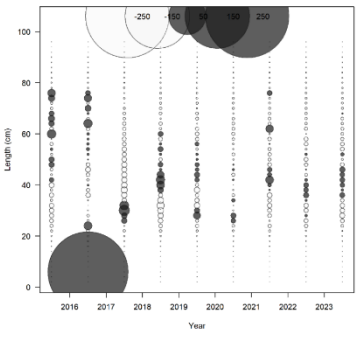
OTB_Disc



Recreational



CGFS1



CGFS2

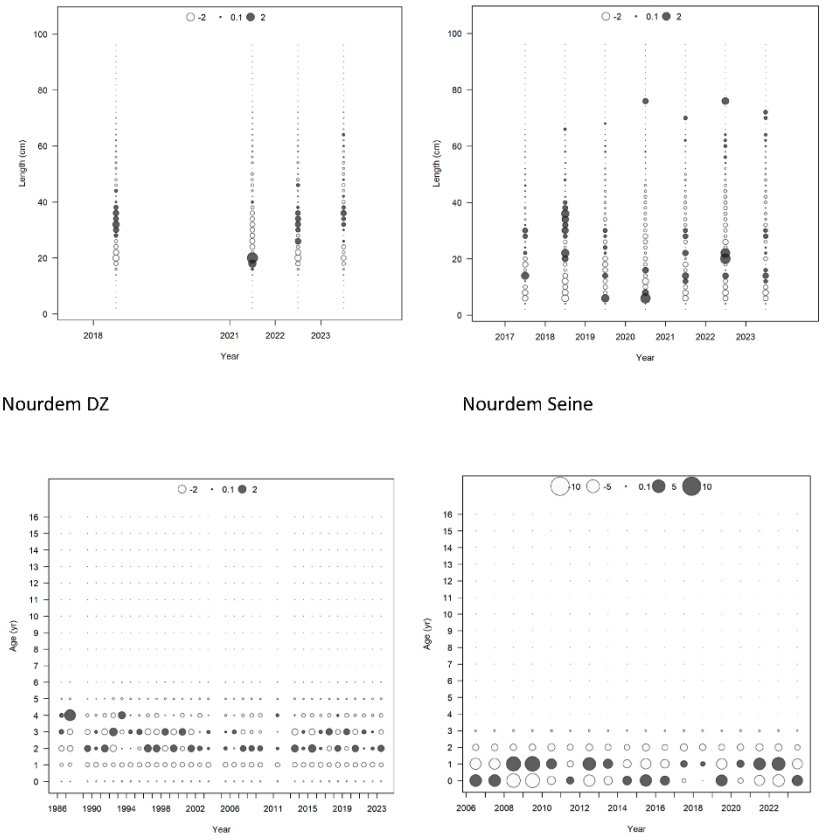
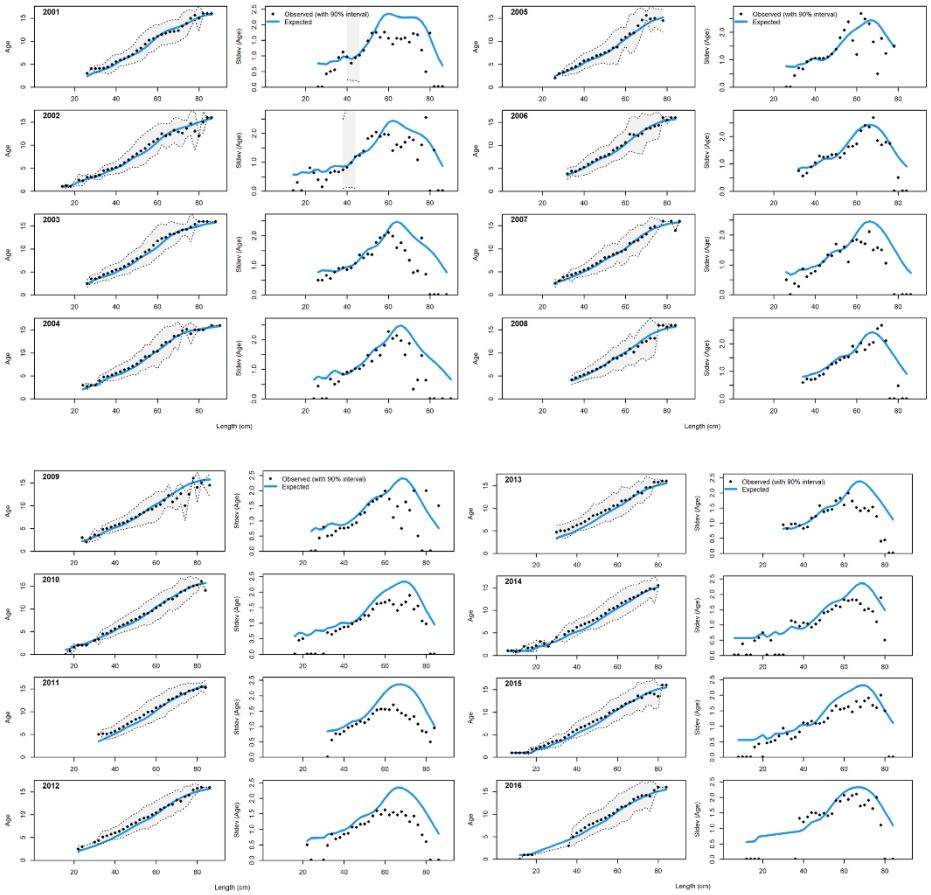
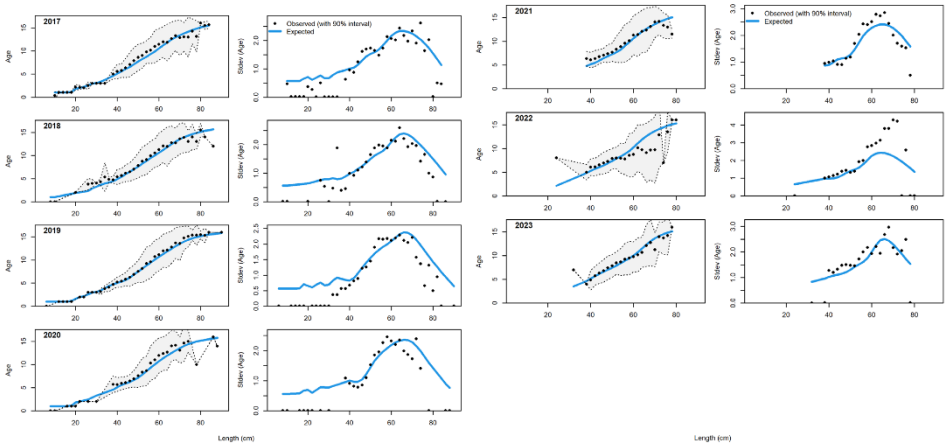


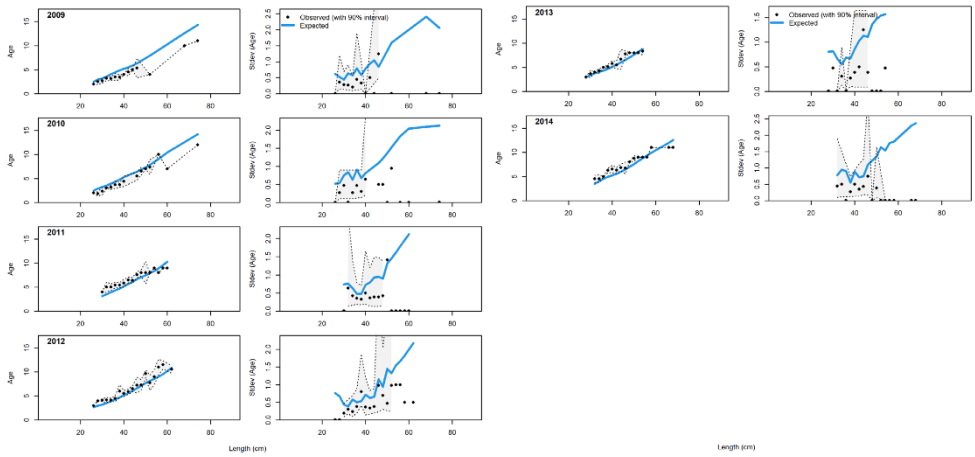
Figure 16. Northern sea bass in ICES divisions 27.4bc7ad-h. Pearson residuals of length and age composition for the selected model configuration for each fleet and survey. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).


2001
2002
2003
2004
2005
2006
2007
2008
Observed (with 90% interval)
Expected
Age
Stdev (Age)
Length (cm)

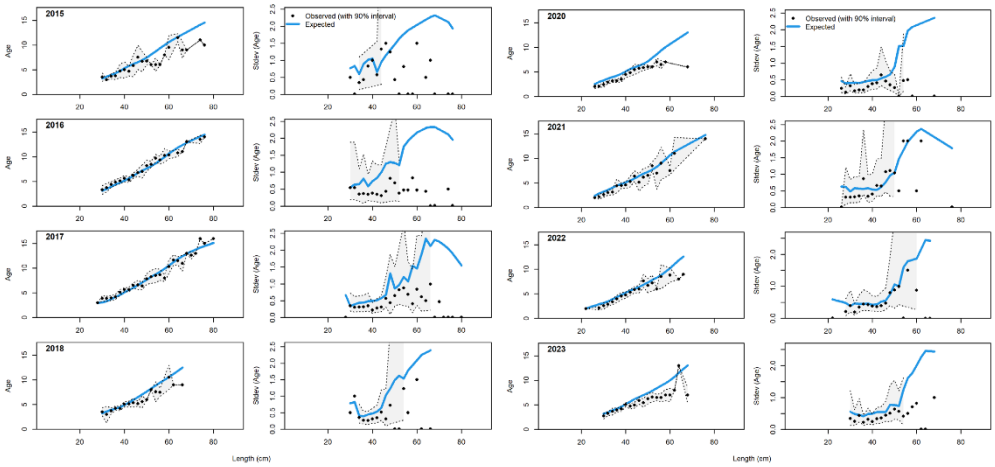
2009
2010
2011
2012
2013
2014
2015
2016
Observed (with 90% interval)
Expected
Age
Stdev (Age)
Length (cm)


2017
2018
2019
2020
2021
2022
2023
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)

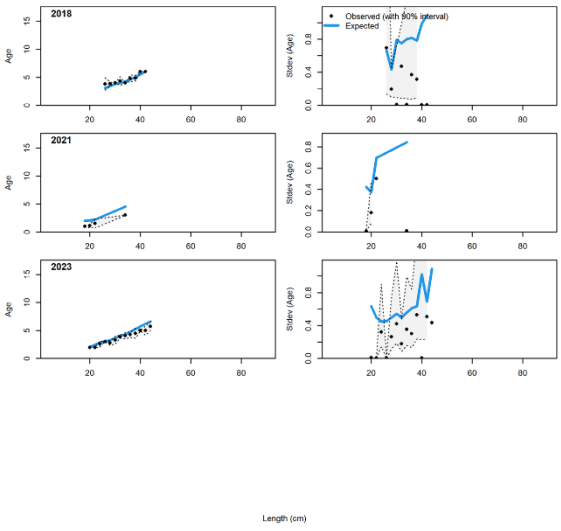
OTB


2009
2010
2011
2012
2013
2014
Age
Stdev (Age)
Observed (with 90% interval)
Expected
Length (cm)

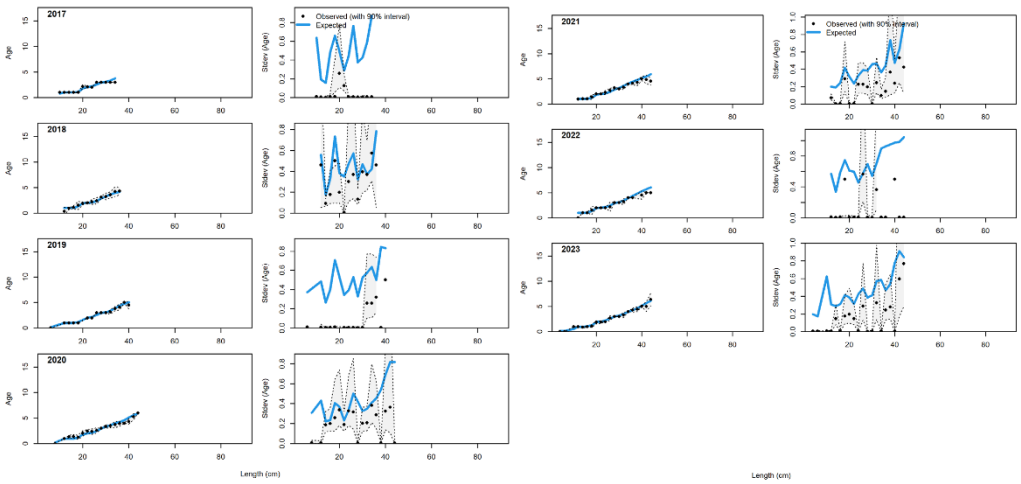
CGFS1



CGFS2



Nourdem Douarnenez



Nourdem Seine

Figure 17. Northern sea bass in ICES divisions 27.4bc7ad-h. Conditional age-at-length plot, whole catch, LPUE index. These plots show mean age and std. dev. in conditional age-at-length. Left plots are mean age-at-length by size-class (obs. and exp.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean age-at-length (obs. and exp.) with 90% CIs based on the chi-square distribution

The results of the runs test are presented in Figures 18 and 19. The RMSE runs test indicated that the fit to some of the recruitment survey data was problematic with some residuals larger than 1 and the RMSE above 30%, indicating the presence of a non-random pattern in survey indices. This is because of the conflict between the different local recruitment time series. The RMSE for length data is good, with a value of 7.2%. The ordinary runs tests passed for 19 out of 23 tests.

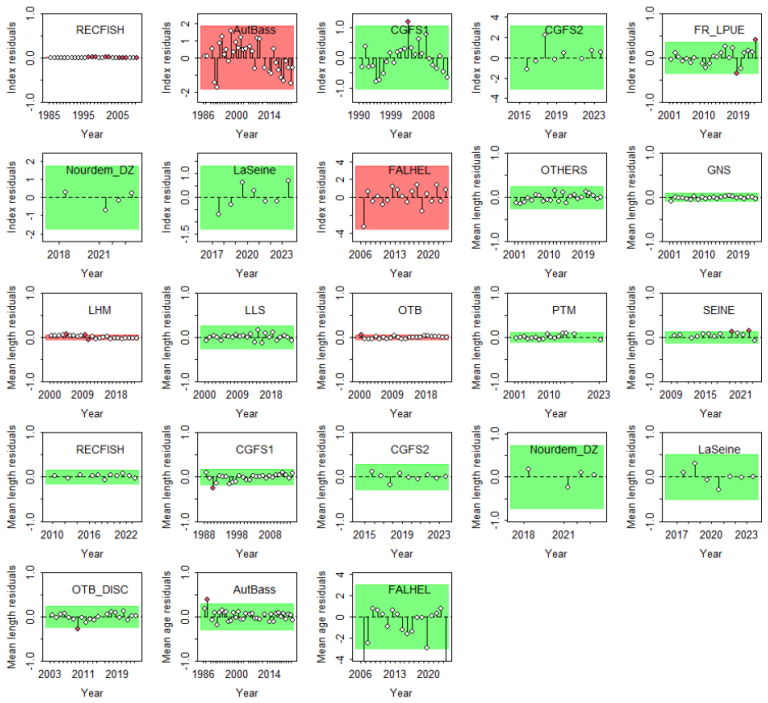


Figure 18. Northern seabass in ICES divisions 27.4bc7ad-h. Residual runs test

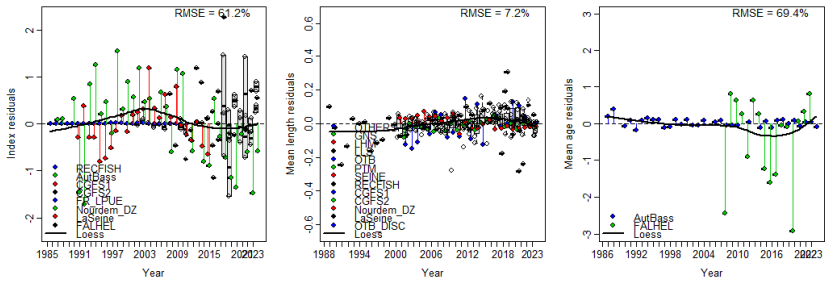


Figure 19. Northern sea bass in ICES divisions 27.4bc7ad-h. Residuals from the RMSE runs test

The retrospectives of the selected model (*base run*) were rather stable (Figure 20). The estimated Hurtado-Ferro et al. (2014) variant of the Mohn´s rho indices were just inside the ICES bounds of recommended values for long-lived species for both SSB (-0.05) and F (0.08).

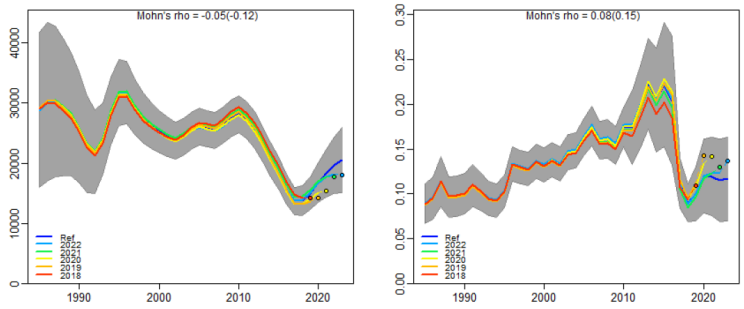


Figure 20. Northern seabass in ICES divisions 27.4bc7ad-h. Retrospective analysis for the selected model

The results of the hindcasting showed that the surveys performed poorly given that a number of the MASE values are higher than the 1.0 threshold when predicting the index one year ahead. MASE values for the length compositions of the catches and surveys generally performed better.

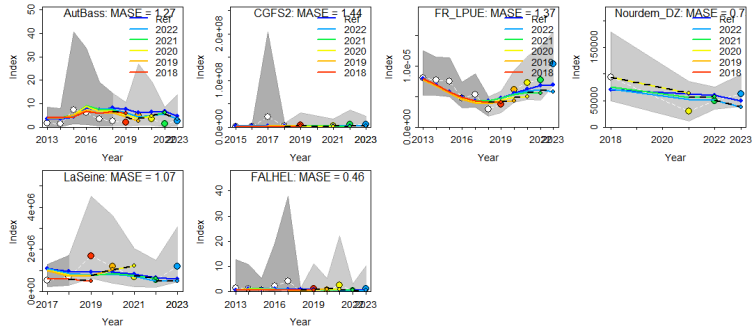


Figure 21. Northern seabass in ICES divisions 27.4bc7ad-h. Hindcasting results for LPUE and surveys showing observed (large white points connected with dashed line), fitted (solid lines) and one year-ahead forecast values (small terminal points). Hindcasting was performed using one reference model (Ref equal to last year data 2023) and 5 hindcast runs (solid-coloured lines) relative to the expected index. The observations used for cross-validation are highlighted as color-coded solid circles with associated 95 % confidence intervals (light-grey shading). The mean absolute scaled error (MASE) score associated with the acoustic survey index is denoted in each upper part of the panel.

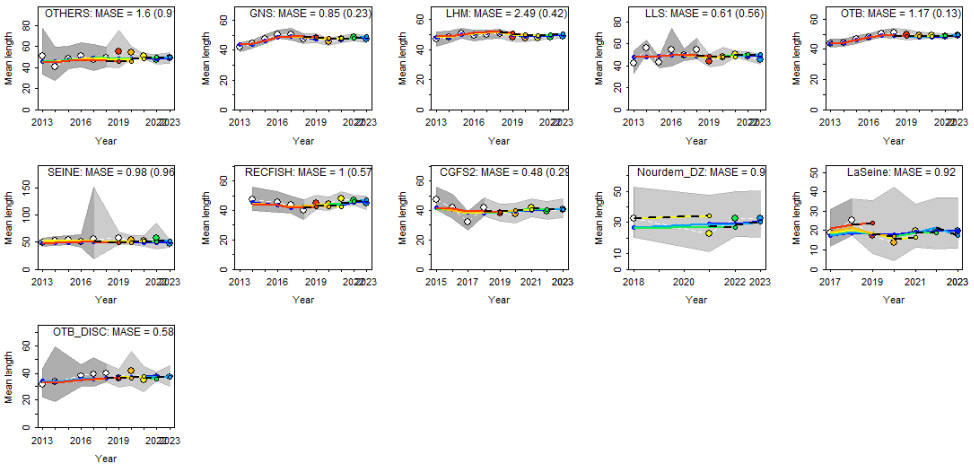


Figure 22. Northern seabass in ICES divisions 27.4bc7ad-h. Hindcasting results for length compositions showing observed (large white points connected with dashed line), fitted (solid lines) and one year-ahead forecast values (small terminal points). Hindcasting was performed using one reference model (Ref equal to last year data 2023) and 5 hindcast runs (solid-coloured lines) relative to the expected index. The observations used for cross-validation are highlighted as color-coded solid circles with associated 95 % confidence intervals (light-grey shading). The mean absolute scaled error (MASE) score associated with the acoustic survey index is denoted in each upper part of the panel.

5.2 Trends in SSB, F and R

The probabilistic Kobe plot with stock status in the last year of the assessment (2023) showed that the stock is not currently overfished and overfishing is not occurring with 43.2% probability (Figure 23). It is however important to note that the reference point is set to B30% only for representation and that reference points will be estimated hereafter.

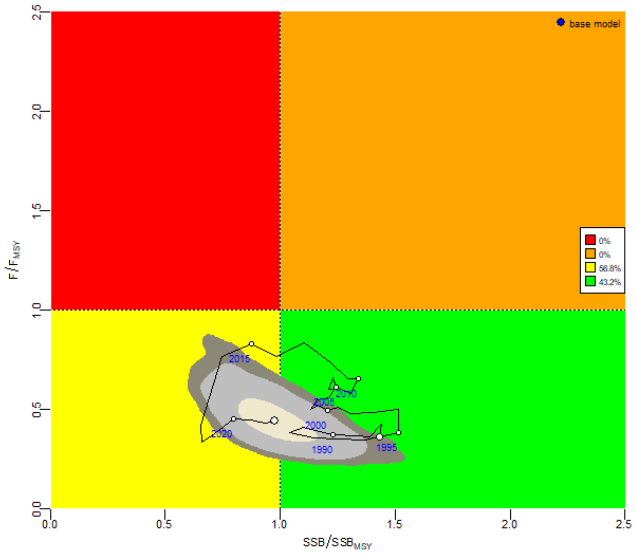


Figure 23. Northern seabass in ICES divisions 27.4bc7ad-h. Probabilistic Kobe plot with stock status in the last year of the assessment (2023). The legend indicates the estimated probability of the stock status being in each of the Kobe quadrant. The reference point is set to B30% only for representation.

The spawning stock biomass (SSB) showed a a variable but stable trend in the early part of the times series (1985-2010), declining from 2010. It then started to increase from around 2018. Fishing mortality (F) increased steadily until 2015, when management measures were put in place to reduce F. After a drastic reduction in F, it increased slightly between 2018 and 2020 and appears stable since. Recruitment (R) was higher in the early part of the time series, with larger peaks pre-2010. It is estimated to be particularly low again since 2021 (Figure 24).

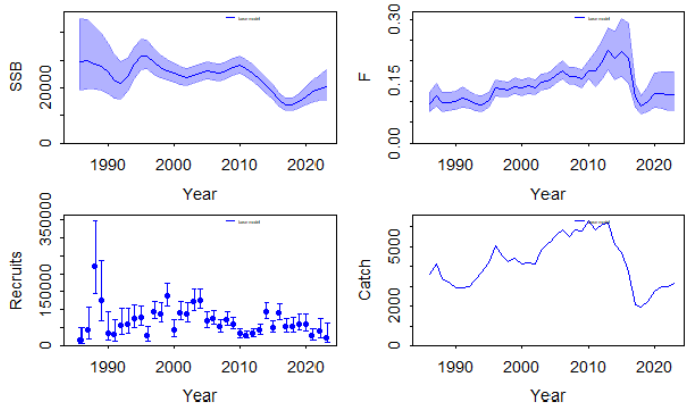


Figure 24. Northern seabass in ICES divisions 27.4bc7ad-h. Summary of the stock assessment. SSB, F and R with 95% confidence intervals. Catches by fleet and SSB are in tonnes R is in thousands of individuals.

6. Biological reference points

Reference points were established by following the ICES fisheries management reference points for category 1 and 2 stocks[1] (Published 1 March 2021). The ICES R package *msy* was used (EqSim approach; Simmonds et al. 2024). The reference points followed the technical guidelines, with the exception of F_{lim} which was not calculated, as the Workshop noted that the basis for calculating this reference point is inconsistent with the MSY reference points, and under review by ICES. Full details of the calculation of the reference points is given in Appendix 5. All MSY reference points were calculated using the total removals as the target yield, compared to maximising the yield of landed fish or fish caught above the MCRS. The rationale for this definition was that target yield may not be consistent between the within different sectors of the recreational and commercial fishery.

An FLR stock object was created from SS outputs using the R library ss3om. SSB was calculated from the stock numbers and weights-at-age and the *female* maturity ogive. Note that SS reports SSB in a

[1] ICES. 2021. ICES fisheries management reference points for category 1 and 2 stocks; Technical Guidelines. *In* Report of the ICES Advisory Committee, 2021. ICES Advice 2021, Section 16.4.3.1. https://doi.org/10.17895/ices.advice.7891.

2-sex model as the female-only SSB but the reference points were calculated relative to the combined-sex SSB. SSB, F and recruitment in the FLStock object were checked against the SS output (and matched closely).

The stock-recruitment relationship used within the eqsim software was taken directly from that estimated by SS3 (Beverton-Holt with a fixed steepness of 0.876, and an estimated B_0 of 52,318 t). The Workshop characterised the stock-recruitment relationship as ICES type 5 (no evidence of impaired recruitment), and so B_{lim} was set to B_{loss}, the biomass in 2017. This is around 25% of the estimated B_0 from the stock assessment. The value of B_{pa} was calculated from B_{lim} using the final year uncertainty estimated by the model.

The F_{MSY} range was capped to avoid F_{MSY} exceeding F_{p05}. This effects FMSY and FMSY_upper, but not FMSY_lower. The reference points derived for this stock are shown in Table 11 and Figure 25.

Table 11. Northern seabass in ICES divisions 27.4bc7ad-h. Reference points.

Reference Point	Value	Rationale
B_{lim}	13,722 t	B(2017); Bloss
B_{pa}	17,562 t	B_{lim} with assessment error
MSY $B_{trigger}$	17,562 t	B_{pa}
F_{pa}	0.192	F with 95% probability of SSB≥B_{lim} (BH with Btrigger)
F_{MSY}	0.192	F_{pa}
F_{MSY_Lower}	0.158	Stochastic simulations
F_{MSY_Upper}	0.192	F_{pa}
B_{MSY5pc}	8,093 t	Stochastic simulations

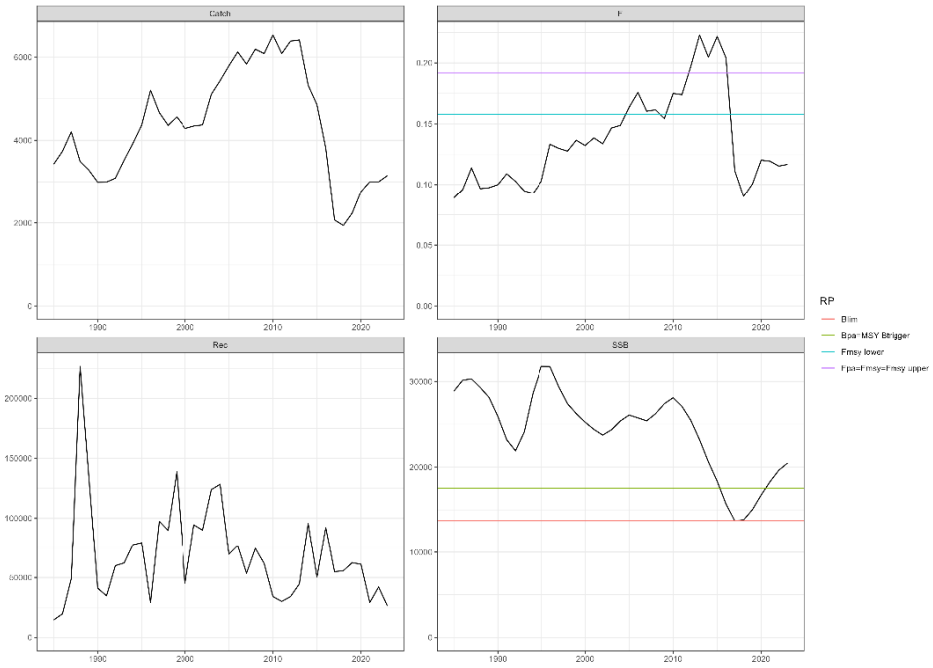


Figure 25. Northern seabass in ICES divisions 27.4bc7ad-h. Summary of the stock assessment with reference points. Catches (total removals) in tonnes, and model estimates of SSB in tonnes, R in thousands of individuals and F.

7. Forecast

The Workshop decided to implement short term forecasts within SS3 in order to ensure consistency between the assumptions (including uncertainty) made in the assessment and those carried on to the forecast. The Workshop agreed on the following default assumptions to be used in the short term forecast (stf):

- Stock numbers from the final year of the assessment and model parameter estimates for selectivity to be used in the stf.
- Recruitment uses stochastic projections from the stock-recruitment relationship.
- For the intermediate year F, all fleets would be assumed to have the average F of the last three years, unless there was a substantial trend in overall F, in which case the last year's values would be used
- For the advice year, all fleets would be scaled in the same proportions as in the intermediate year.

The Workshop noted that if future assessments show a substantial change in recruitment away from the estimated stock-recruitment relationship, it would be necessary to reflect this change by changing the recruitment assumption to use resampling from a suitable recent average recruitment.

The Workshop noted that the assumption that the split of the total removals between fleets remains constant may not reflect management known to be in place in the intermediate year, or anticipated for the advice year. This was considered to be acceptable given the uncertainties around management changing during the year, and uncertainty about the effects of management measures on catches, as seabass is managed through indirect measures (MCRS, closed season, trip limits etc) rather than a catch limit. The Workshop noted that the proposed ICES forecast tool would allow stakeholders to investigate the effect of changing the *status quo* distribution of fleet proportions.

8. References

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Appendices

Appendix 1 Data file

```
#V3.30.23.00;_safe;_compile_date:_Nov  4 2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_13.2
#_Stock_Synthesis_is_a_work_of_the_U.S._Government_and_is_not_subject_to_copyright_protec-
tion_in_the_United_States.
#_Foreign_copyrights_may_apply._See_copyright.txt_for_more_information.
#_User_support_available_at:NMFS.Stock.Synthesis@noaa.gov
#_User_info_available_at:https://vlab.noaa.gov/group/stock-synthesis
#_Source_code_at:_https://github.com/nmfs-ost/ss3-source-code

#_Start_time: Mon Mar  3 09:55:46 2025
#_echo_input_data
#C data file created using the SS_writedat function in the R package r4ss
#C should work with SS version: 3.24
#C file write time: 2024-05-13 10:06:22.391327
#V3.30.23.00;_safe;_compile_date:_Nov  4 2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_13.2
1985 #_StartYr
2023 #_EndYr
1 #_Nseas
 12 #_months/season
2 #_Nsubseasons (even number, minimum is 2)
1 #_spawn_month
1 #_Nsexes: 1, 2, -1  (use -1 for 1 sex setup with SSB multiplied by female_frac parameter)
30 #_Nages=accumulator age, first age is always age 0
1 #_Nareas
17 #_Nfleets (including surveys)
#_fleet_type: 1=catch fleet; 2=bycatch only fleet; 3=survey; 4=predator(M2)
#_sample_timing: -1 for fishing fleet to use season-long catch-at-age for observations, or 1 to use ob-
servation month;  (always 1 for surveys)
#_fleet_area:  area the fleet/survey operates in
#_units of catch:  1=bio; 2=num (ignored for surveys; their units read later)
#_catch_mult: 0=no; 1=yes
#_rows are fleets
#_fleet_type fishery_timing area catch_units need_catch_mult fleetname
 1 -1 1 1 0 OTHERS  # 1
 1 -1 1 1 0 GNS  # 2
 1 -1 1 1 0 LHM  # 3
 1 -1 1 1 0 LLS  # 4
 1 -1 1 1 0 OTB  # 5
 1 -1 1 1 0 PTM  # 6
 1 -1 1 1 0 SEINE  # 7
 1 -1 1 1 0 RECFISH  # 8
 3 1 1 1 0 AutBass  # 9
 3 1 1 1 0 CGFS1  # 10
 3 1 1 1 0 CGFS2  # 11
 3 1 1 1 0 FR_LPUE  # 12
 3 1 1 1 0 Nourdem_DZ  # 13
 3 1 1 1 0 LaSeine  # 14
 3 1 1 1 0 FALHEL  # 15
 1 -1 1 1 0 OTB_DISC  # 16
 1 -1 1 1 0 SEINE_DISC  # 17
#Bycatch_fleet_input_goes_next
#a:  fleet index
#b:  1=include dead bycatch in total dead catch for F0.1 and MSY optimizations and forecast ABC; 2=omit
from total catch for these purposes (but still include the mortality)
#c:  1=Fmult scales with other fleets; 2=bycatch F constant at input value; 3=bycatch F from range of
years
#d:  F or first year of range
#e:  last year of range
#f:  not used
# a   b   c   d   e   f
#_Catch data: year, seas, fleet, catch, catch_se
#_catch_se:  standard error of log(catch)
#_NOTE:  catch data is ignored for survey fleets
-999 1 1 25.2 0.1
1985 1 1 25.2 0.1
1986 1 1 25.3 0.1
1987 1 1 28.5 0.1
```

```
1988 1 1 34.6 0.1
1989 1 1 58.3 0.1
1990 1 1 44.7 0.1
1991 1 1 28.8 0.1
1992 1 1 44.8 0.1
1993 1 1 73.7 0.1
1994 1 1 132.2 0.1
1995 1 1 247.5 0.1
1996 1 1 123.2 0.1
1997 1 1 127.2 0.1
1998 1 1 155.7 0.1
1999 1 1 201.3 0.1
2000 1 1 168.1 0.1
2001 1 1 166.4 0.1
2002 1 1 200.6 0.1
2003 1 1 210.2 0.1
2004 1 1 203.4 0.1
2005 1 1 193.4 0.1
2006 1 1 226.8 0.1
2007 1 1 269.5 0.1
2008 1 1 335.1 0.1
2009 1 1 273.1 0.1
2010 1 1 320 0.1
2011 1 1 373 0.1
2012 1 1 346.2 0.1
2013 1 1 320.8 0.1
2014 1 1 385.1 0.1
2015 1 1 328.7 0.1
2016 1 1 236.5 0.1
2017 1 1 164.6 0.1
2018 1 1 74.9 0.1
2019 1 1 86.3 0.1
2020 1 1 94.4 0.1
2021 1 1 84.8 0.1
2022 1 1 70.3 0.1
2023 1 1 80.4 0.1
-999 1 2 34.9 0.1
1985 1 2 34.9 0.1
1986 1 2 77.3 0.1
1987 1 2 71.8 0.1
1988 1 2 122.2 0.1
1989 1 2 146.4 0.1
1990 1 2 129.3 0.1
1991 1 2 124.4 0.1
1992 1 2 88 0.1
1993 1 2 70.9 0.1
1994 1 2 169.2 0.1
1995 1 2 181.2 0.1
1996 1 2 137.9 0.1
1997 1 2 167.8 0.1
1998 1 2 126.1 0.1
1999 1 2 121.6 0.1
2000 1 2 119.2 0.1
2001 1 2 136.4 0.1
2002 1 2 191.8 0.1
2003 1 2 147 0.1
2004 1 2 202.2 0.1
2005 1 2 195.9 0.1
2006 1 2 234.5 0.1
2007 1 2 263.2 0.1
2008 1 2 323.2 0.1
2009 1 2 325.9 0.1
2010 1 2 323.7 0.1
2011 1 2 313.4 0.1
2012 1 2 389.6 0.1
2013 1 2 401.2 0.1
2014 1 2 586.5 0.1
2015 1 2 329.1 0.1
2016 1 2 220.6 0.1
2017 1 2 119.9 0.1
2018 1 2 148.1 0.1
```

```
2019 1 2 151.2 0.1
2020 1 2 174.2 0.1
2021 1 2 190.3 0.1
2022 1 2 208.6 0.1
2023 1 2 218.4 0.1
-999 1 3 21.4 0.1
1985 1 3 21.4 0.1
1986 1 3 24 0.1
1987 1 3 30.8 0.1
1988 1 3 80.1 0.1
1989 1 3 45.5 0.1
1990 1 3 36 0.1
1991 1 3 71.3 0.1
1992 1 3 42.7 0.1
1993 1 3 61.7 0.1
1994 1 3 138 0.1
1995 1 3 159.8 0.1
1996 1 3 120.7 0.1
1997 1 3 114.4 0.1
1998 1 3 98.1 0.1
1999 1 3 80.2 0.1
2000 1 3 218.3 0.1
2001 1 3 230.3 0.1
2002 1 3 229.4 0.1
2003 1 3 279 0.1
2004 1 3 236.8 0.1
2005 1 3 256.1 0.1
2006 1 3 362.2 0.1
2007 1 3 395.4 0.1
2008 1 3 362.3 0.1
2009 1 3 328 0.1
2010 1 3 374 0.1
2011 1 3 362.4 0.1
2012 1 3 362.7 0.1
2013 1 3 363.3 0.1
2014 1 3 368.1 0.1
2015 1 3 301.2 0.1
2016 1 3 262 0.1
2017 1 3 298.8 0.1
2018 1 3 369 0.1
2019 1 3 363.6 0.1
2020 1 3 453.9 0.1
2021 1 3 459.6 0.1
2022 1 3 413.1 0.1
2023 1 3 347.7 0.1
-999 1 4 22 0.1
1985 1 4 22 0.1
1986 1 4 13.2 0.1
1987 1 4 61.4 0.1
1988 1 4 58.3 0.1
1989 1 4 68 0.1
1990 1 4 48.1 0.1
1991 1 4 44.4 0.1
1992 1 4 45.8 0.1
1993 1 4 50.3 0.1
1994 1 4 56.7 0.1
1995 1 4 58.3 0.1
1996 1 4 49.1 0.1
1997 1 4 70.2 0.1
1998 1 4 13.1 0.1
1999 1 4 62.1 0.1
2000 1 4 89.9 0.1
2001 1 4 136.9 0.1
2002 1 4 113.9 0.1
2003 1 4 126.7 0.1
2004 1 4 159.4 0.1
2005 1 4 181.7 0.1
2006 1 4 235.9 0.1
2007 1 4 210.4 0.1
2008 1 4 159.9 0.1
2009 1 4 114.5 0.1
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2010 1 4 123 0.1
2011 1 4 118.9 0.1
2012 1 4 92.3 0.1
2013 1 4 86.2 0.1
2014 1 4 101.5 0.1
2015 1 4 58.7 0.1
2016 1 4 35.6 0.1
2017 1 4 46.2 0.1
2018 1 4 35.2 0.1
2019 1 4 36.5 0.1
2020 1 4 47.4 0.1
2021 1 4 43.2 0.1
2022 1 4 40.6 0.1
2023 1 4 31.9 0.1
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1985 1 5 403.3 0.1
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1987 1 5 200.8 0.1
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1989 1 5 471.1 0.1
1990 1 5 470.7 0.1
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1992 1 5 416.1 0.1
1993 1 5 581.5 0.1
1994 1 5 567.3 0.1
1995 1 5 652.1 0.1
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1998 1 5 697 0.1
1999 1 5 794.8 0.1
2000 1 5 783.3 0.1
2001 1 5 755.8 0.1
2002 1 5 916.7 0.1
2003 1 5 1199.3 0.1
2004 1 5 1275.9 0.1
2005 1 5 1252.9 0.1
2006 1 5 1249.9 0.1
2007 1 5 1278.5 0.1
2008 1 5 1317.8 0.1
2009 1 5 1282 0.1
2010 1 5 963.1 0.1
2011 1 5 908.7 0.1
2012 1 5 973.1 0.1
2013 1 5 773.9 0.1
2014 1 5 598.3 0.1
2015 1 5 695.3 0.1
2016 1 5 291.1 0.1
2017 1 5 224.1 0.1
2018 1 5 90.5 0.1
2019 1 5 103.6 0.1
2020 1 5 170.8 0.1
2021 1 5 183.4 0.1
2022 1 5 222.7 0.1
2023 1 5 349.8 0.1
-999 1 6 374.9 0.1
1985 1 6 332.3 0.1
1986 1 6 498.3 0.1
1987 1 6 1278.2 0.1
1988 1 6 426.2 0.1
1989 1 6 190.6 0.1
1990 1 6 168.7 0.1
1991 1 6 325.5 0.1
1992 1 6 363.9 0.1
1993 1 6 221.4 0.1
1994 1 6 94 0.1
1995 1 6 249.2 0.1
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1999 1 6 994.1 0.1
2000 1 6 668.8 0.1
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2004 1 6 790.9 0.1
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2006 1 6 1294.1 0.1
2007 1 6 784.2 0.1
2008 1 6 929.7 0.1
2009 1 6 953.2 0.1
2010 1 6 1616.5 0.1
2011 1 6 1154.1 0.1
2012 1 6 1084.2 0.1
2013 1 6 1482.8 0.1
2014 1 6 227.3 0.1
2015 1 6 41.6 0.1
2016 1 6 14.4 0.1
2017 1 6 13.7 0.1
2018 1 6 0.8 0.1
2019 1 6 0.4 0.1
2020 1 6 1.7 0.1
2021 1 6 2 0.1
2022 1 6 0.8 0.1
2023 1 6 1.7 0.1
-999 1 7 0 0.1
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1986 1 7 0.8 0.1
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1988 1 7 0.2 0.1
1989 1 7 0.3 0.1
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1991 1 7 0.1 0.1
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2003 1 7 3.8 0.1
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2019 1 7 25.1 0.1
2020 1 7 41.6 0.1
2021 1 7 49.5 0.1
2022 1 7 64.1 0.1
2023 1 7 123.4 0.1
-999 1 8 2673.5 0.1
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1988 1 8 2673.5 0.8
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2012 1 8 2838.2 0.25
2013 1 8 2758.9 0.25
2014 1 8 2758.9 0.25
2015 1 8 2679.5 0.25
2016 1 8 2197.1 0.25
2017 1 8 644.6 0.25
2018 1 8 467.9 0.25
2019 1 8 829.1 0.25
2020 1 8 1235.3 0.25
2021 1 8 1269.6 0.25
2022 1 8 1345.7 0.25
2023 1 8 1379 0.25
-999 1 16 0 0.1
1985 1 16 0 0.01
1986 1 16 0 0.01
1987 1 16 0 0.01
1988 1 16 0 0.01
1989 1 16 0 0.01
1990 1 16 0 0.01
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1998 1 16 0 0.01
1999 1 16 0 0.01
2000 1 16 0 0.01
2001 1 16 0 0.01
2002 1 16 0 0.25
2003 1 16 2.5 0.25
2004 1 16 49.6 0.25
2005 1 16 1.2 0.25
2006 1 16 8.5 0.25
2007 1 16 34.3 0.25
2008 1 16 10.2 0.25
2009 1 16 25.9 0.25
2010 1 16 51.1 0.25
2011 1 16 7 0.25
2012 1 16 98.6 0.25
2013 1 16 68.3 0.25
2014 1 16 12.8 0.25
2015 1 16 34.5 0.25
2016 1 16 176.4 0.25
2017 1 16 393.5 0.25
2018 1 16 706 0.25
2019 1 16 602.9 0.25
2020 1 16 473.4 0.25
2021 1 16 582.4 0.25
2022 1 16 484.8 0.25
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2023 1 16 588.1 0.25
-999 1 17 0 0.1
1985 1 17 0 0.01
1986 1 17 0 0.01
1987 1 17 0 0.01
1988 1 17 0 0.01
1989 1 17 0 0.01
1990 1 17 0 0.01
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1996 1 17 0 0.01
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2003 1 17 0 0.01
2004 1 17 0 0.01
2005 1 17 0 0.01
2006 1 17 0 0.01
2007 1 17 0 0.01
2008 1 17 0 0.01
2009 1 17 0 0.01
2010 1 17 0 0.01
2011 1 17 0 0.01
2012 1 17 0 0.01
2013 1 17 0 0.01
2014 1 17 0 0.01
2015 1 17 0 0.01
2016 1 17 53.2 0.75
2017 1 17 52 0.75
2018 1 17 21.6 0.75
2019 1 17 20 0.75
2020 1 17 23.6 0.75
2021 1 17 44.2 0.75
2022 1 17 41.1 0.75
2023 1 17 6.8 0.75
-9999 0 0 0 0
#
#_CPUE_and_surveyabundance_and_index_observations
#_units: 0=numbers; 1=biomass; 2=F; 30=spawnbio; 31=exp(recdev); 36=recdev; 32=spawnbio*recdev; 33=re-
cruitment; 34=depletion(&see Qsetup); 35=parm_dev(&see Qsetup)
#_errtype:  -1=normal; 0=lognormal; 1=lognormal with bias correction; >1=df for T-dist
#_SD_report: 0=not; 1=include survey expected value with se
#_note that link functions are specified in Q_setup section of control file
#_dataunits = 36 and 35 should use Q_type 5 to provide offset parameter
#_fleet units errtype SD_report
1 1 0 0 # OTHERS
2 1 0 0 # GNS
3 1 0 0 # LHM
4 1 0 0 # LLS
5 1 0 0 # OTB
6 1 0 0 # PTM
7 1 0 0 # SEINE
8 2 0 0 # RECFISH
9 1 0 0 # AutBass
10 0 0 0 # CGFS1
11 0 0 0 # CGFS2
12 1 0 0 # FR_LPUE
13 0 0 0 # Nourdem_DZ
14 0 0 0 # LaSeine
15 0 0 0 # FALHEL
16 1 0 0 # OTB_DISC
17 1 0 0 # SEINE_DISC
#_year month fleet obs stderr
1985 7 8 1 0.1 #_ RECFISH
1986 7 8 1 0.1 #_ RECFISH
```

```
1987 7 8 1 0.1 #_ RECFISH
1988 7 8 1 0.1 #_ RECFISH
1989 7 8 1 0.1 #_ RECFISH
1990 7 8 1 0.1 #_ RECFISH
1991 7 8 1 0.1 #_ RECFISH
1992 7 8 1 0.1 #_ RECFISH
1993 7 8 1 0.1 #_ RECFISH
1994 7 8 1 0.1 #_ RECFISH
1995 7 8 1 0.1 #_ RECFISH
1996 7 8 1 0.1 #_ RECFISH
1997 7 8 1 0.1 #_ RECFISH
1998 7 8 1 0.1 #_ RECFISH
1999 7 8 1 0.1 #_ RECFISH
2000 7 8 1 0.1 #_ RECFISH
2001 7 8 1 0.1 #_ RECFISH
2002 7 8 1 0.1 #_ RECFISH
2003 7 8 1 0.1 #_ RECFISH
2004 7 8 1 0.1 #_ RECFISH
2005 7 8 1 0.1 #_ RECFISH
2006 7 8 1 0.1 #_ RECFISH
2007 7 8 1 0.1 #_ RECFISH
2008 7 8 1 0.1 #_ RECFISH
2009 7 8 1 0.1 #_ RECFISH
2010 7 8 1 0.1 #_ RECFISH
1986 10.96 9 5.84 0.43 #_ AutBass
1987 10.96 9 2.6 0.43 #_ AutBass
1989 10.96 9 7.05 0.43 #_ AutBass
1990 10.96 9 3.98 0.43 #_ AutBass
1991 10.96 9 3.32 0.43 #_ AutBass
1992 10.96 9 19.7 0.43 #_ AutBass
1993 10.96 9 14.63 0.43 #_ AutBass
1994 10.96 9 6.69 0.43 #_ AutBass
1995 10.96 9 10.53 0.43 #_ AutBass
1996 10.96 9 6.35 0.43 #_ AutBass
1997 10.96 9 40.4 0.43 #_ AutBass
1998 10.96 9 7.22 0.43 #_ AutBass
1999 10.96 9 19.02 0.43 #_ AutBass
2000 10.96 9 17.8 0.43 #_ AutBass
2001 10.96 9 42.69 0.43 #_ AutBass
2002 10.96 9 13.95 0.43 #_ AutBass
2003 10.96 9 14.18 0.43 #_ AutBass
2005 10.96 9 23.46 0.43 #_ AutBass
2006 10.96 9 19.76 0.43 #_ AutBass
2007 10.96 9 5.5 0.43 #_ AutBass
2008 10.96 9 25.52 0.43 #_ AutBass
2009 10.96 9 19.83 0.43 #_ AutBass
2011 10.96 9 4.05 0.43 #_ AutBass
2013 10.96 9 1.56 0.43 #_ AutBass
2014 10.96 9 1.45 0.43 #_ AutBass
2015 10.96 9 7.45 0.43 #_ AutBass
2016 10.96 9 6.2 0.43 #_ AutBass
2017 10.96 9 3.54 0.43 #_ AutBass
2018 10.96 9 2.66 0.43 #_ AutBass
2019 10.96 9 1.95 0.43 #_ AutBass
2020 10.96 9 4.92 0.43 #_ AutBass
2021 10.96 9 3.59 0.43 #_ AutBass
2022 10.96 9 1.54 0.43 #_ AutBass
2023 10.96 9 2.53 0.43 #_ AutBass
1990 10 10 1.12991e+06 0.12 #_ CGFS1
1991 10 10 4.25064e+06 0.03 #_ CGFS1
1992 10 10 2.61799e+06 0.11 #_ CGFS1
1993 10 10 2.29992e+06 0.1 #_ CGFS1
1994 10 10 1.09783e+06 0.11 #_ CGFS1
1995 10 10 1.02174e+06 0.09 #_ CGFS1
1996 10 10 1.22424e+06 0.13 #_ CGFS1
1997 10 10 1.8176e+06 0.12 #_ CGFS1
1998 10 10 2.53104e+06 0.08 #_ CGFS1
1999 10 10 1.64227e+06 0.12 #_ CGFS1
2000 10 10 2.57099e+06 0.08 #_ CGFS1
2001 10 10 3.15067e+06 0.14 #_ CGFS1
2002 10 10 3.87243e+06 0.11 #_ CGFS1
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2003 10 10 8.73906e+06 0.11 #_ CGFS1
2004 10 10 3.59844e+06 0.1 #_ CGFS1
2005 10 10 3.00532e+06 0.08 #_ CGFS1
2006 10 10 5.518e+06 0.12 #_ CGFS1
2007 10 10 3.66131e+06 0.14 #_ CGFS1
2008 10 10 6.46884e+06 0.15 #_ CGFS1
2009 10 10 2.56469e+06 0.09 #_ CGFS1
2010 10 10 1.80454e+06 0.1 #_ CGFS1
2011 10 10 1.51374e+06 0.12 #_ CGFS1
2012 10 10 2.03455e+06 0.11 #_ CGFS1
2013 10 10 995987 0.22 #_ CGFS1
2014 10 10 669931 0.33 #_ CGFS1
2015 10 11 587231 0.28 #_ CGFS2
2016 10 11 1.2692e+06 0.19 #_ CGFS2
2017 10 11 2.13929e+07 0.75 #_ CGFS2
2018 10 11 2.08261e+06 0.33 #_ CGFS2
2019 10 11 4.695e+06 0.55 #_ CGFS2
2021 10 11 2.667e+06 0.55 #_ CGFS2
2022 10 11 5.97094e+06 0.52 #_ CGFS2
2023 10 11 5.01691e+06 0.37 #_ CGFS2
2001 7 12 7.99e-06 0.15 #_ FR_LPUE
2002 7 12 9.84e-06 0.13 #_ FR_LPUE
2003 7 12 1e-05 0.14 #_ FR_LPUE
2004 7 12 9.48e-06 0.15 #_ FR_LPUE
2005 7 12 9.81e-06 0.15 #_ FR_LPUE
2006 7 12 8.78e-06 0.17 #_ FR_LPUE
2007 7 12 1.03e-05 0.15 #_ FR_LPUE
2009 7 12 1e-05 0.18 #_ FR_LPUE
2010 7 12 8.65e-06 0.17 #_ FR_LPUE
2011 7 12 8.51e-06 0.18 #_ FR_LPUE
2012 7 12 9.14e-06 0.2 #_ FR_LPUE
2013 7 12 8.07e-06 0.22 #_ FR_LPUE
2014 7 12 7.74e-06 0.2 #_ FR_LPUE
2015 7 12 7.48e-06 0.21 #_ FR_LPUE
2016 7 12 4.77e-06 0.22 #_ FR_LPUE
2017 7 12 5.35e-06 0.25 #_ FR_LPUE
2018 7 12 2.95e-06 0.27 #_ FR_LPUE
2019 7 12 3.73e-06 0.23 #_ FR_LPUE
2020 7 12 6.15e-06 0.21 #_ FR_LPUE
2021 7 12 7.25e-06 0.24 #_ FR_LPUE
2022 7 12 7.66e-06 0.28 #_ FR_LPUE
2023 7 12 1.03e-05 0.21 #_ FR_LPUE
2018 7 13 94038 0.29 #_ Nourdem_DZ
2021 7 13 30376 0.49 #_ Nourdem_DZ
2022 7 13 49895 0.17 #_ Nourdem_DZ
2023 7 13 62457 0.2 #_ Nourdem_DZ
2017 8 14 544238 0.13 #_ LaSeine
2018 8 14 702984 0.15 #_ LaSeine
2019 8 14 1.69219e+06 0.19 #_ LaSeine
2020 8 14 1.19994e+06 0.25 #_ LaSeine
2021 8 14 709387 0.23 #_ LaSeine
2022 8 14 557020 0.19 #_ LaSeine
2023 8 14 1.17552e+06 0.18 #_ LaSeine
2006 8 15 0.04 0.2 #_ FALHEL
2007 8 15 1.68 0.2 #_ FALHEL
2008 8 15 0.6 0.2 #_ FALHEL
2009 8 15 1.05 0.2 #_ FALHEL
2010 8 15 0.3 0.2 #_ FALHEL
2011 8 15 0.32 0.2 #_ FALHEL
2012 8 15 1.52 0.2 #_ FALHEL
2013 8 15 1.4 0.2 #_ FALHEL
2014 8 15 1.2 0.2 #_ FALHEL
2015 8 15 0.6 0.2 #_ FALHEL
2016 8 15 2.15 0.2 #_ FALHEL
2017 8 15 4.19 0.2 #_ FALHEL
2018 8 15 0.17 0.2 #_ FALHEL
2019 8 15 1.22 0.2 #_ FALHEL
2020 8 15 0.59 0.2 #_ FALHEL
2021 8 15 2.44 0.2 #_ FALHEL
2022 8 15 0.34 0.2 #_ FALHEL
2023 8 15 1.13 0.2 #_ FALHEL
```

```
-9999 1 1 1 1 # terminator for survey observations
#
0 #_N_fleets_with_discard
#_discard_units (1=same_as_catchunits(bio/num); 2=fraction; 3=numbers)
#_discard_errtype:  >0 for DF of T-dist(read CV below); 0 for normal with CV; -1 for normal with se; -2
for lognormal; -3 for trunc normal with CV
# note: only enter units and errtype for fleets with discard
# note: discard data is the total for an entire season, so input of month here must be to a month in
that season
#_fleet units errtype
# -9999 0 0 0.0 0.0 # terminator for discard data
#
0 #_use meanbodysize_data (0/1)
#_COND_0 #_DF_for_meanbodysize_T-distribution_like
# note:  type=1 for mean length; type=2 for mean body weight
#_year month fleet part type obs stderr
#  -9999 0 0 0 0 0 0 # terminator for mean body size data
#
# set up population length bin structure (note - irrelevant if not using size data and using empirical
wtatage
2 # length bin method: 1=use databins; 2=generate from binwidth,min,max below; 3=read vector
2 # binwidth for population size comp
0 # minimum size in the population (lower edge of first bin and size at age 0.00)
96 # maximum size in the population (lower edge of last bin)
1 # use length composition data (0/1/2) where 2 invokes new comp_control format
#_mintailcomp: upper and lower distribution for females and males separately are accumulated until ex-
ceeding this level.
#_addtocomp:  after accumulation of tails; this value added to all bins
#_combM+F: males and females treated as combined sex below this bin number
#_compressbins: accumulate upper tail by this number of bins; acts simultaneous with mintailcomp; set=0
for no forced accumulation
#_Comp_Error:  0=multinomial, 1=dirichlet using Theta*n, 2=dirichlet using beta, 3=MV_Tweedie
#_ParmSelect:  consecutive index for dirichlet or MV_Tweedie
#_minsamplesize: minimum sample size; set to 1 to match 3.24, minimum value is 0.001
#
#_Using old format for composition controls
#_mintailcomp addtocomp combM+F CompressBins CompError ParmSelect minsamplesize
-0.001 1e-07 0 0 0 0 1 #_fleet:1_OTHERS
-0.001 1e-07 0 0 0 0 1 #_fleet:2_GNS
-0.001 1e-07 0 0 0 0 1 #_fleet:3_LHM
-0.001 1e-07 0 0 0 0 1 #_fleet:4_LLS
-0.001 1e-07 0 0 0 0 1 #_fleet:5_OTB
-0.001 1e-07 0 0 0 0 1 #_fleet:6_PTM
-0.001 1e-07 0 0 0 0 1 #_fleet:7_SEINE
-0.001 1e-07 0 0 0 0 1 #_fleet:8_RECFISH
-0.001 1e-07 0 0 0 0 1 #_fleet:9_AutBass
-0.001 1e-07 0 0 0 0 1 #_fleet:10_CGFS1
-0.001 1e-07 0 0 0 0 1 #_fleet:11_CGFS2
-0.001 1e-07 0 0 0 0 1 #_fleet:12_FR_LPUE
-0.001 1e-07 0 0 0 0 1 #_fleet:13_Nourdem_DZ
-0.001 1e-07 0 0 0 0 1 #_fleet:14_LaSeine
-0.001 1e-07 0 0 0 0 1 #_fleet:15_FALHEL
-0.001 1e-07 0 0 0 0 1 #_fleet:16_OTB_DISC
-0.001 1e-07 0 0 0 0 1 #_fleet:17_SEINE_DISC
# sex codes:  0=combined; 1=use female only; 2=use male only; 3=use both as joint sex*length distribu-
tion
# partition codes:  (0=combined; 1=discard; 2=retained
48 #_N_LengthBins; then enter lower edge of each length bin
 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70
72 74 76 78 80 82 84 86 88 90 92 94 96
#_year month fleet sex part Nsamp datavector(female-male)
 2001 1 1 0 0 21 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4.7 3518.63 2286.36 1225.7 1052.2 1921.53 964.05
526.11 175.37 1.88 0 0 0 0.94 0 0.94 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2002 1 1 0 0 7 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 311.83 1403.25 2884.46 2026.92 701.62 77.96 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2003 1 1 0 0 35 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 352.58 724.9 6282.87 11541.2 5523.94 4530.76 1582.69
177.69 39.49 118.46 19.74 59.23 19.74 19.74 0 0 0 0 0 352.58 19.74 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2004 1 1 0 0 21 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 129.83 728.52 2701.05 4006.56 3037.11 2570.8 899.04
492.83 150 12.86 142.69 0 0 58.48 58.48 12.86 58.48 12.86 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2005 1 1 0 0 16 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2465.9 2950.54 1764.91 1490.3 863.42 1861.34 566.19
571.84 285.92 145.79 0 176.14 0 0 321.93 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

```
 2006 1 1 0 0 84 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 6.87 405.66 823.8 591.53 1078.49 917.97 606.57 620.09
740.23 623.37 209 414.24 253.97 40.22 170.14 195.91 45.57 154.67 0 66 63.94 111.57 0 0 37.32 0 0 0 0 0
0 0
 2007 1 1 0 0 23 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 400.29 927.42 2255.14 2091.64 800.59 1601.18 2165.59
3877.36 2584.04 727.28 563.79 1217.75 0 163.49 360.54 163.49 0 560.69 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2008 1 1 0 0 104 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 325.39 6585.58 5224.12 2245.84 3814.82 1554.48 840.56
696.4 493.38 402.81 267.82 100.31 105.61 127.25 70.03 25.86 0 0 1.05 1.05 0 25.86 0 0 0 0 0 0 0 0 0 0
 2009 1 1 0 0 138 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3181.42 4188.93 15404.6 15570.5 13486.3 10036.8
4452.96 3772.12 1390.07 2433.65 1002.61 802.83 624.28 253.33 123.37 341.46 15.42 0 170.73 30.84 15.42 0
0 0 15.42 0 0 0 0 0 0
 2010 1 1 0 0 39 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3128.48 3396.47 5518.44 10311 3127.37 3348.96 931.9
296.21 299.51 86.58 169.63 86.59 0 0 0 0 51.11 0 0 0 0 0 37.86 0 0 0 0 0 0 0 0 0
 2011 1 1 0 0 25 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5.28 5.28 0 26.4 764.54 2491.01 874.45 1726.18
1004.17 1112.49 586.36 857.02 97.48 282.15 0 0 0 282.15 5.28 0 0 0 0 0 0 0 0 0 0 0
 2012 1 1 0 0 19 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 237.59 4235.02 5845.28 3031.05 2273.61 1957.97 0 0
931.95 1988.97 0 647.31 0 647.31 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2013 1 1 0 0 10 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 162.4 649.61 487.21 162.4 812.02 974.43 812.02
1299.24 324.81 324.81 162.4 0 0 162.4 0 162.4 0 0 0 0 0 0 0 0 0 0 0 0
 2014 1 1 0 0 18 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 372.63 2795.73 2919.93 1840.04 722.14 316.48 342.57
62.11 0.99 0 0 0 0 0 0 31.05 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2015 1 1 0 0 30 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 807.72 0 741.91 4361.58 4657.72 2015.1 1168.02
496.24 898.78 224.37 271.87 928.32 524.45 275.81 453.99 365.56 0 2.63 1.31 1265.39 0 1.31 0 0 0 0 0 0 0
0 0
 2016 1 1 0 0 27 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 238.96 1519.27 2801.89 3979.68 646.88 782.85
904.03 862.17 840.24 6461.98 0 136.69 231.87 136.69 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2017 1 1 0 0 24 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 103.66 0 0 207.32 1189.32 1635.34 1588.35 557.48
383.44 596.66 287.58 645.14 295.38 253.34 95.86 0 0 95.86 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2018 1 1 0 0 38 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 637.12 0 6 2497.35 2456.24 2027.41 919.93 507.49
2432.59 415.74 125.18 482.75 428.04 318.56 1178.68 133.71 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2019 1 1 0 0 12 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 8 17 16 10 10 1 5 1 12 11 8 0 4 0 0 38 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2020 1 1 0 0 62 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 131.82 1000.62 833.17 774.59 1630.04 1341.85
1009.46 1880.64 1556.09 1816.7 907.32 699.47 899.32 729.83 199.84 61.91 0 0 0 0 0 0 0 99.92 0 0 0 0 0 0
 2021 1 1 0 0 232 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 24.56 24.56 0 51.13 481.01 3694.21 4802.28 4279.25
2847.32 2741.47 2972.67 2537.88 2622.44 1776.96 1115.26 455.36 616.45 1030.38 361.3 159.74 92.18 453.62
114.74 67.62 0 0 0 0 0 0 0 0 0 0
 2022 1 1 0 0 95 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 105.92 3241.1 3236 2453.58 1171.14 694.04
1095.71 901.78 1048.26 275.82 175.46 461.91 190 11 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2023 1 1 0 0 81 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 176.53 64.23 705.24 3710.4 2734.96 1567.86 1887.95
1136.77 1989.88 1176.06 2110.15 681.11 1088.45 424.82 158.06 231.37 27.14 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2001 1 2 0 0 436 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 26.84 28.43 56.87 28.43 126.85 7632.05 22932.7 15946.6 19165
10661.7 4733.31 2073.74 972.69 1345.79 698.38 1550.9 1423.89 688.17 575.09 738.07 295.33 85.15 195.49
17.59 0 28.89 28.89 0 3.16 26.84 0 0 0 0 0 0 0
 2002 1 2 0 0 1055 0 0 0 0 0 0 0 2.98 28.59 2.98 0 13.71 23.25 30.99 108.5 108.44 98.95 6966.32 27968.7
27830.5 23577.6 15413.8 7033.46 6076.43 6100.8 5914.27 4048.06 2613.68 2458.85 2254.78 1175.9 3038.95
2702.21 1170.43 736.23 322.13 229.36 1.23 47.68 15.86 0 0 0 0 0 0 0 0 0 0
 2003 1 2 0 0 494 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 25.95 2885.61 23650.2 23139.9 19775.5 11489 8054.61
5705.91 4439.18 3127.93 3245.33 2476.52 806.37 715.29 894.3 480.2 366 242.15 46.71 47.9 20.48 17.92
6.98 72.14 0 0 0 0 0 0 0 0 0 0
 2004 1 2 0 0 275 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 61.73 1957.19 13473 20198.5 25912.8 24472.3 25272
14393.1 6347.17 1732.03 1480.07 716.79 392.21 283.83 136.42 557.43 467.53 149.97 129.16 75.06 22.35 0
22.35 0 0 0 0 0 0 20.81 0 0 0
 2005 1 2 0 0 129 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5.4 17679.1 20283.9 16287.5 16809.8 12296.2 7296.8
6385.78 3214.2 2960.12 1694.83 613.02 542.49 101.25 509.04 38.87 230.97 42.4 14.13 7.06 10.6 14.13 0 0
0 0 0 0 0 0 0 0 0 0
 2006 1 2 0 0 199 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2485.04 4497.01 35387.6 48693.1 42454.5 20962.8 15889.3
11848.5 8949.35 2295.34 4718.59 1578.88 1080.1 3286.09 759.94 185.69 276.25 1238.17 0 147.3 0 81.29
81.29 0 81.29 0 0 0 0 0 0 0 0
 2007 1 2 0 0 401 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60.89 1378.45 16187.6 17900.8 22066.5 22830.9 19421.4
14194.9 9214.31 4738.73 5217.43 3841.24 3256.62 1513.22 1521.12 837.39 953.17 545.54 547.7 34.33 368.23
1288.18 184.26 9.57 12.38 58.34 0 0 0 0 0 0 0
 2008 1 2 0 0 565 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 9470.97 92444.7 82622.3 57999.2 43322.1 21149.6
16596.8 6990.38 6053.73 6612.49 4516.08 2569.77 2178.1 1409.22 911.15 633.92 526.98 603.75 95.38 0 0 0
203.94 0 0 0 0 0 0 0 0 0 0
 2009 1 2 0 0 424 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 60.62 1336.12 26912.9 35021.5 37820 29765.5 23621.3
21622.4 13985.1 9622.43 7018.62 5287.38 3411.32 2490.9 1487.62 460.04 1068.96 123.86 397.81 17.42 34.84
202.45 0 17.42 100.12 0 0 0 0 0 0 0 0
 2010 1 2 0 0 472 63.98 0 0 0 0 0 0 0 0 0 0 705.73 934.61 572.21 209.81 78.34 1912.56 52700.3 46954.2
52645.9 41919.1 29634.1 20597.7 11640.5 9322.24 3117.99 2595.14 5683.22 1284.02 2175.51 2130.73 953.69
1282.77 353 1074.57 131.91 26.45 113.24 26.46 100.08 26.46 13.23 0 0 0 0 0 0
```

2011 1 2 0 0 290 0 0 0 0 0 0 0 0 0 0 0 0 0 0 3469.71 3666.82 5817.88 10338.5 17463.2 16520 23775.9 21014.8 24360.8 15109.8 6248.54 4031.89 4140.39 2857.73 1211.92 1261.14 1239.03 833.35 572.58 267.97 395.09 566.25 78.58 203.89 0 0 37.32 0 0 0 0 0 0 0
2012 1 2 0 0 537 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2783.39 7479.66 31571.2 51477.7 39264.9 41273.3 22725.6 14800.8 13377.1 14663.3 14501 12003.3 11036.2 9754.26 5571.75 3994.81 2483.85 2027.32 1522.59 633.87 551.22 489.76 300.03 1776.33 0 29.65 0 0 0 0 0 0 0
2013 1 2 0 0 409 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 52.02 5963.39 56412.3 77048.4 59565.7 34179.4 14456.6 8161.91 6402.09 6933.02 8964.96 8682.33 6500.27 5859.75 4966.56 3387.6 2476.42 1677.75 546.3 749.05 457.58 97.5 0 0 0 0 0 0 0 0 0 0 0
2014 1 2 0 0 449 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 6817.22 46141.1 83829.4 93042.6 74826.1 33742.7 20782.9 11217.5 9881.08 18024.2 13685.4 14261.3 12502.4 13637.7 8190.64 6461.28 4838 2999.88 3289.93 447.21 650.52 245.9 450.76 0 0 60.05 0 0 0 0 0 0
2015 1 2 0 0 349 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 246.33 5273.44 15626.1 27109.8 15825.1 19165.4 17486.8 12952.9 12645.6 10009.7 7866.36 6479.47 4196.83 5514.58 3564.67 3860.31 2765.83 2425.87 1093.3 1897.15 163.38 412.55 0 0 0 0 0 0 0 0 0 0
2016 1 2 0 0 393 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 24.29 3467.17 13764.5 13612.6 13839 13040.8 9603.9 10327.5 10125.9 7906.08 6024.53 5523.38 3046.59 2293.51 1892.58 1267.81 1293.09 333.2 479.41 69.44 75.28 235.93 0 0 0 0 0 0 0 0 0
2017 1 2 0 0 205 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1682.06 5704.72 5846.46 5642.2 3619.97 5404.03 3861.06 4217.45 2609.05 2478.62 1720.95 899.52 1365.91 793.56 422.94 540.36 303.71 212.15 16.51 77.02 0 0 37.5 0 0 0 0 0 0 0
2018 1 2 0 0 337 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1038.61 0 0 0 140.31 4777.14 24050.6 14922.1 11447.2 7772.93 4540.8 3542.61 3217.8 3330.36 1797.48 3409.59 1852.02 1343.77 818.89 1239.13 584.79 142.13 347.07 231.25 46.92 14.07 9.21 0 13.81 0 0 0 0 0 0
2019 1 2 0 0 328 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2329.13 16994.2 16230.7 10514 6535.97 4720.05 3129.96 2856.15 4522.31 2915.07 2305.2 658.11 847.35 524.56 256.04 606.67 62.9 46.16 27.5 27.5 18.21 0 5.5 0 0 0 0 0 0 0
2020 1 2 0 0 362 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 475.79 5656.54 30621.3 26040.5 13705.9 6909.14 3172.89 1569.27 2998.29 2392.6 1075.28 1326.76 1389.52 611.53 440.67 337.6 114.17 140.2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2021 1 2 0 0 345 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 590.2 7893.13 18893.1 16856.9 13040.9 14284.2 3595.21 3786.08 3503.09 5081.39 2939.69 1340.09 1310.38 1083.62 511.13 504.64 195.62 384.85 142.27 149.38 35.57 0 0 0 0 0 0 0 0 0 0
2022 1 2 0 0 349 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2196.88 12499 15843.9 14558.8 13512.1 10326.4 5233.3 5636.43 4196.4 3123.21 1651.56 1154.88 317.79 588.75 435.73 1232.5 147.69 0 299.6 0 0 0 0 0 0 0 0 0 0 0 0
2023 1 2 0 0 422 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 82.85 1867.37 12117.4 17567.8 21900.5 21342.9 12813.8 7312.95 5475.67 2284.22 1466.24 614.32 501.6 407.83 86.88 86.88 0 0 86.47 0 0 0 0 0 0 0 0 0 0 0 0
2000 1 3 0 0 195 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 131.39 1130.12 3206.86 11286.9 7658.33 3836.7 4917.16 4541.75 2638.66 2469 2835.21 1911.68 1979.25 2780.82 1926.2 2947.4 1610.53 1795.17 1287.81 1214.88 763.08 548.71 490.26 232.38 161.48 254.12 0 0 0 0 0 0
2001 1 3 0 0 579 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4348.52 2521.54 6493.96 9361.07 8924.96 12148.3 10368.2 9413.6 6403.66 4199.14 4438.09 3841.59 3417.33 3812.87 3061.03 2507.5 1642.17 1960.85 895.82 852.35 650.88 301.11 110.8 163.31 31.52 20.61 0 0 0 0 0
2002 1 3 0 0 398 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 107.44 1874.56 4031.72 5700.62 11881.9 11993.2 15605.6 13273.9 10523.1 8408.84 6822.05 4655.43 3033.58 2575.62 2029.93 2825.8 2090.68 1641.48 1468.35 1054.71 652.77 275.08 261.79 78.73 0 0 0 0 0 0 0 0
2003 1 3 0 0 662 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1986.98 6098.41 9765.09 10673.2 13437 9692.85 10267.7 9102.43 8954.44 8892.75 6329.38 9037.31 5474.22 5282.35 4124.06 3614.37 2694.75 2716.3 1433 1130.55 1062.91 306.41 369.24 285.42 46.65 31 0 0 0 0 0 0
2004 1 3 0 0 491 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 419.66 106.46 4730.93 4607.77 7341.41 8836 11284.2 9853.42 7296.28 3972 6112.76 5280.56 6858.73 4792 5149.31 3051.86 3862.14 4060.17 1388.89 1061.84 1234.63 508.53 398.61 65.25 204.22 0 60.41 0 0 0 0 0 0
2005 1 3 0 0 168 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 987.79 929.58 5048.16 8143.48 8013.71 7656.06 5887.94 5311.86 2583.21 4525.87 2964.49 2719.91 3073.28 1475.58 1425.28 523.94 647.09 731.99 356.79 306.33 100.79 0 151.25 0 0 0 0 0 0 0 0
2006 1 3 0 0 219 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1206.98 5620.33 8712.07 8556.06 11569.1 10537.3 9080.2 13978.3 7021.75 6903.85 6635.49 7770.64 2916.07 3067.62 2676.93 448.74 1207.54 1515.95 286.65 258.31 614.73 8.73 0 0 216.75 0 0 0 0 0 0
2007 1 3 0 0 286 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 239.22 2831.53 13656.2 18414.3 15834.5 15593 14908.1 17953.6 8904.99 7436.65 6057.12 6339.87 4799.33 7613.97 5062.95 3161.85 1903.64 1829.89 973.99 119.13 400.49 369.14 20.64 11.39 5.7 0 0 0 0 0 0 0
2008 1 3 0 0 293 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 188.27 2402.36 7193.33 11621.3 12407.3 10457.6 8152.08 6009.54 4026.98 4523.48 4822.19 3363.69 4283.08 2403.2 2895.52 2301.41 1039.22 2226.31 999.64 560.25 447.95 120.53 71.26 122.78 0 0 0 0 0 0 0 0
2009 1 3 0 0 169 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 38.99 4226.76 4861.01 5271.68 5970.91 5300.92 5079.94 4215.58 4471.14 4612.4 4073.54 3515.82 2381.29 3571.93 1826.56 1763.64 1762.58 1028.3 861.13 377.03 662.68 225.78 267.45 32.31 0 0 0 0 0 0 0 0
2010 1 3 0 0 139 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2040.69 12138.1 21154.4 18842.9 27637.3 13298.3 7011.35 5144.76 2301.26 2124.7 1362.67 982.74 1285.79 740.75 859.96 1047.25 484.31 1059.84 234.54 278.18 0 57.94 0 0 0 0 0 0 0 0 0

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 2011 1 3 0 0 404 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 53.61 458.83 2230.99 7013.68 12782 14723.6 10320.1
9552.87 8992.54 8990.55 5804.89 6213.45 6297.74 4740.99 4078.26 2807.3 3411.27 2132.73 1137.98 918.1
330.5 350.9 128.23 64.48 70.08 18.38 0 0 0 0 0 0 0
 2012 1 3 0 0 321 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 209.63 5157.54 11334.4 12250.9 10117.7 5096.13
6603.38 6494.04 4796.95 6699.03 5404.3 4005.75 3911.81 1838.48 1354.4 1751.84 1407.17 1158.98 634.49
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 2021 1 8 0 0 55 347.314 110.826 221.652 221.652 2054.21 1888.56 4898.93 1268.73 4853.25 21988.2
9766.89 27445.3 12908.8 16927.8 27139.9 15230.4 28444.9 15872 18264.6 29310.2 129533 136118 139631
175903 134020 117475 96112.6 60570.1 54548.2 54517.2 32620.1 48133.8 20891.8 16648.6 9886.58 3859.76
11226.8 3748.93 347.314 110.826 80.5395 332.478 0 0 0 0 0 0
 2022 1 8 0 0 114 49.0648 146.44 0 49.0648 1807.85 1211.61 5756.51 2647.59 3727.06 18127.6 6151.88
19871.1 15779.6 16832.8 32943.2 17688.9 40315.5 40239.6 40507 53694.4 129555 162182 109251 109288
110120 91097.9 73249.3 49568.6 42445.5 44982.9 28398.4 26389 17673.5 12080.7 22262.9 6747.23 3942.46
2650.52 916.216 4632.74 222.331 818.086 98.1297 0 10629.8 0 0 0
 2023 1 8 0 0 55 0 0 762.002 1128.51 5511.79 3352.76 13179.1 14233.9 20684 44738.4 18497.1 24075.2
13707.8 8442.85 31041.2 22770.7 24037.9 15743.1 16927.2 22469.1 130709 171955 140149 143508 129576
118485 99275.4 51653 31488.3 25696.9 25683.9 30125.5 4865.44 4690.6 6928.98 13884 2251.38 0 0 0 0 0 0 0
0 0 0 0
 1988 10 10 0 0 16 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 58885 0 76121 20143 0 0 0 20143 0 39616 0 15434
15434 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 1989 10 10 0 0 8 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 22235 0 22235 0 11011 0 0 0 0 22235 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 1990 10 10 0 0 22 0 0 0 0 0 0 0 0 0 32733 98199 120021 96615 222797 345962 107244 0 0 18463 0 6106 0
6106 23906 0 17254 17254 17254 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 1991 10 10 0 0 52 0 0 0 0 0 0 0 0 0 0 304624 1.71941e+06 1.11968e+06 531390 110365 162253 126980
45607 16723 16703 10625 0 16885 0 5352 30272 16885 0 0 0 0 0 16885 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 1992 10 10 0 0 63 0 0 0 0 0 0 0 0 0 0 0 0 0 0 63079 287513 510612 638459 530944 309090 78328 79289 26490
42201 0 0 15138 5247 0 10494 0 0 0 15853 0 0 5247 0 0 0 0 0 0 0 0 0 0 0 0
 1993 10 10 0 0 57 0 0 0 0 0 0 0 0 0 0 0 0 0 0 5551 38106 121556 170213 347228 237317 321637 247396 266632
204261 133186 158039 17036 0 0 14798 0 0 16962 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 1994 10 10 0 0 52 0 0 0 0 0 0 0 0 0 18458 0 5108 71094 30647 64428 59303 79319 77545 139680 69887
157500 113756 52799 63325 37992 18996 18996 0 0 0 0 18996 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 1995 10 10 0 0 46 0 0 0 0 0 0 0 0 0 0 65628 182886 191483 118285 68606 94174 58735 62595 72147 8650
15487 10698 0 20034 15487 0 0 17299 0 0 0 19546 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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 1996 10 10 0 0 71 0 0 0 0 0 0 0 0 0 0 10096 71187 198585 162449 209883 102756 137006 50619 60715 0
46710 0 25805 38406 67089 0 0 0 21710 0 0 0 0 0 0 0 21222 0 0 0 0 0 0 0 0 0 0 0
 1997 10 10 0 0 85 0 0 0 0 0 0 0 0 0 0 0 52420 172277 157267 364320 311146 265276 102658 136668 71024
62096 42836 3198 27070 0 36775 0 0 0 0 0 0 0 0 0 12568 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 1998 10 10 0 0 104 0 0 0 0 0 0 0 0 0 0 0 0 10254 42156 199875 248028 445903 469290 406992 271169 77307
56211 109682 49306 13620 13620 0 25037 27240 13620 13620 0 0 0 11417 0 26697 0 0 0 0 0 0 0 0 0 0 0 0
 1999 10 10 0 0 101 0 0 0 0 0 0 0 0 0 0 0 0 18433 15128 83225 167646 146928 90595 177558 153662 195992
214407 105858 79810 47256 78075 7863 17639 0 9059 0 9059 0 15018 0 0 0 0 0 0 0 0 9059 0 0 0 0 0 0 0
 2000 10 10 0 0 98 0 0 0 0 0 0 0 0 0 0 0 18644 65257 62040 125296 417455 440978 309620 338993 204879 181687
95559 108703 70962 23940 21506 14766 0 24695 0 14306 0 9307 13096 0 9307 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2001 10 10 0 0 106 0 0 0 0 0 0 0 0 0 0 0 0 59740 413187 767358 518235 300493 248669 158653 247952 66992
125042 43191 37193 10236 24597 0 14837 24648 13083 52462 0 0 12053 0 0 12053 0 0 0 0 0 0 0 0 0 0 0 0
 2002 10 10 0 0 120 0 0 0 0 0 0 0 0 0 0 0 0 10739 67655 197986 381355 832988 623508 439729 380196 270697
189153 102893 112164 50660 44892 16171 27189 21612 15932 12167 0 27484 12167 25511 0 0 9579 0 0 0 0 0 0
0 0 0 0 0
 2003 10 10 0 0 112 0 0 0 0 0 0 0 0 0 0 22663 13218 161174 795498 720874 802826 1.37576e+06 1.21832e+06
1.25198e+06 623889 464021 274147 207776 203176 72670 136756 185043 89875 52508 26254 27514 0 13127 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2004 10 10 0 0 120 0 0 0 0 0 0 0 0 0 0 0 0 2692 0 122879 403673 714884 730822 416792 287359 324966
129278 137035 115126 31042 39375 29156 18125 9347 0 61811 2692 2692 9347 0 0 0 0 0 0 9347 0 0 0 0 0 0 0
0
 2005 10 10 0 0 109 0 0 0 0 0 0 0 0 0 0 15565 0 210994 418270 315562 267295 354515 215506 225666 181642
106404 138927 146271 109108 98370 34142 9487 52772 51553 21543 10751 10751 0 0 10223 0 0 0 0 0 0 0 0 0
0 0 0 0
 2006 10 10 0 0 98 0 0 0 0 0 0 0 0 0 0 0 9814 197122 866753 893641 788190 1.12058e+06 531053 311464
137430 190156 96298 71441 84223 86273 31873 22996 25308 19628 9814 3032 0 9814 0 0 11099 0 0 0 0 0 0 0
0 0 0 0 0 0
 2007 10 10 0 0 90 0 0 0 0 0 0 0 0 0 0 0 0 47391 407308 386452 394375 609358 479157 314000 219897
169994 170481 111148 80056 57131 123245 25737 18311 0 11929 0 10662 5331 19351 0 0 0 0 0 0 0 0 0 0 0 0
0 0
 2008 10 10 0 0 109 0 0 0 0 0 0 0 0 0 0 10729 52876 128066 266412 229414 731914 1.66147e+06 931172
880632 758996 224765 208707 112521 79753 13259 72807 14967 28587 19628 0 0 0 42166 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0
 2009 10 10 0 0 71 0 0 0 0 0 0 0 0 0 0 0 21413 77225 253598 386804 279160 234313 217371 238780 238652
168707 110777 82775 99010 56555 38480 0 21413 12158 0 0 0 12249 0 0 15256 0 0 0 0 0 0 0 0 0 0 0 0
 2010 10 10 0 0 82 0 0 0 0 0 0 0 0 0 0 0 0 20661 79020 106240 232673 118288 117886 316567 207944 97593
110810 191255 62479 14580 62090 0 22711 0 14580 0 14580 0 0 0 0 14580 0 0 0 0 0 0 0 0 0 0 0
 2011 10 10 0 0 74 0 0 0 0 0 0 0 0 0 0 0 0 13881 0 45451 95055 204438 227355 208472 118040 120428 68027
88143 90627 60054 47411 9869 0 33403 36907 46184 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2012 10 10 0 0 68 0 0 0 0 0 0 0 0 0 0 0 0 29922 15009 161369 400458 247182 200887 183315 84361 197280
103031 86442 77382 31957 43195 19956 39781 11851 40610 19956 20305 20305 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2013 10 10 0 0 52 0 0 0 0 0 0 0 0 0 0 0 0 42825 113195 62476 113528 127750 96177 135950 70592 33717
44279 61410 11237 17382 17382 48087 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2014 10 10 0 0 55 0 0 0 0 0 0 0 0 0 0 0 0 0 0 68544 62919 72216 235064 138177 171873 205729 78929 0
0 0 38360 25884 0 0 0 0 28103 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2015 10 11 0 0 66 0 0 0 0 0 0 0 0 0 0 0 0 0 3059 10002 21916 46908 28300 37324 14765 65411 37274 30199
62854 54565 17975 24001 7278 11419 51764 0 18697 18697 10267 0 0 7278 7278 0 0 0 0 0 0 0 0 0 0 0 0
 2016 10 11 0 0 68 0 0 17607 0 0 0 0 0 0 0 0 0 89337 26987 43361 90082 113286 108729 52384 69060 99848
64488 39885 15449 32621 58643 57307 54836 39167 31352 27596 0 74069 3078 9553 23910 0 19651 6911 0 0 0
0 0 0 0 0 0 0 0 0 0 0
 2017 10 11 0 0 96 0 0 0 0 0 0 0 0 0 0 0 0 151572 1.07516e+06 2.34876e+06 7.11097e+06 6.42652e+06
1.55888e+06 753320 187780 239878 272693 185037 129169 50692 139098 181688 80289 148463 69006 96087
45827 12251 39819 12251 20831 34234 5500 8562 0 8562 0 0 0 0 0 0 0 0
 2018 10 11 0 0 82 0 0 0 0 0 0 0 0 0 0 0 0 0 0 7271 17976 13129 123376 199227 344397 363653 326506 213246
86089 107644 24846 56368 86066 42767 0 54930 8282 0 6844 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2019 10 11 0 0 87 0 0 0 0 0 0 0 0 0 0 0 0 46831 551581 694174 237811 340580 385901 210711 347618
509240 452638 260635 220576 125339 110776 44096 111902 11577 0 0 20798 0 0 12217 0 0 0 0 0 0 0 0 0 0 0
0 0
 2020 10 11 0 0 60 0 0 0 0 0 0 0 0 0 0 0 0 138691 312006 272246 460622 749012 465607 439905 383600
365741 202941 283564 192407 104874 36869 55108 36869 16789 0 0 0 0 7050 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2021 10 11 0 0 74 0 0 0 0 0 0 0 0 0 0 0 0 32630 32630 77515 109168 179349 142041 306287 349865 557412
284208 244772 66860 66214 36125 21031 39192 0 15386 94360 0 0 0 0 0 0 11951 0 0 0 0 0 0 0 0 0 0 0 0
 2022 10 11 0 0 76 0 0 0 0 0 0 0 0 0 0 0 0 6711 0 8031 274492 226305 286594 617764 855933 762405 786826
602559 350925 417030 210160 119280 241680 120469 21304 0 51634 0 6711 4130 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0
 2023 10 11 0 0 79 0 0 0 0 0 0 0 0 0 0 5287 0 0 0 169886 275325 393927 763319 489555 546641 540412
502788 523594 140691 187628 251115 48807 32010 30102 21292 5287 8003 0 15512 0 0 0 0 0 0 0 0 0 0 0 0 0
0
 2018 5 13 0 0 117 0 0 0 0 0 0 0 0 0 0 0 2145.25 7219.25 26400.9 34383.2 44124.6 27197.7 22519.9
12086.6 4511.68 2010.05 4519.47 0 0 574.581 0 0 0 0 0 206.953 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

```
 2021 5 13 0 0 172 0 0 0 0 0 0 0 200.152 5670.96 17279.8 2468.54 0 0 0 66.7172 0 347.658 344.335
675.153 1623.82 811.91 410.271 136.757 136.757 0 136.757 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2022 5 13 0 0 175 0 0 0 0 0 0 0 0 0 0 699.117 2819.59 10580.8 2663.71 6031.04 6664.83 5772.87 4614.84
2912.75 1662.14 1779.06 1020.87 1712.98 155.881 338.161 344.543 0 122.019 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0
 2023 5 13 0 0 164 0 0 0 0 0 0 0 0 0 0 542.486 3347.08 2458.37 8561.26 6714.91 6171.56 8438.44 7295.85
7470.58 4577.01 725.402 2632.85 972.386 276.972 1362.25 138.486 216.994 0 276.972 0 138.486 0 138.486 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2017 8 14 0 0 199 0 0 12447 3422 7828 59079 175780 68343 7021 7194 37639 29536 22735 41970 40313 14047
5697 3783 1673 1833 883 1099 1050 276 138 287 138 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2018 8 14 0 0 199 0 0 0 0 0 3794 42286 55543 18243 88307 147673 50064 20723 41170 57539 44168 49295
47024 21022 10559 1382 1188 1059 1511 0 211 0 129 211 0 0 0 129 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2019 8 14 0 0 199 0 0 417033 84645 10885 63269 326929 87985 10299 13563 124075 156121 48877 116588
122613 41870 10749 18341 15911 7325 7785 1946 2765 403 432 0 339 122 526 339 122 0 0 122 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0
 2020 8 14 0 0 199 0 0 385233 177952 5541 4751 125775 235334 38282 15410 62342 45432 15224 3535 23021
15438 17990 12860 6763 3306 1435 989 748 1197 873 374 374 0 291 0 0 0 0 0 0 0 0 145 0 0 0 0 0 0 0 0 0 0 0
 2021 8 14 0 0 199 0 0 5757 0 7019 101198 181891 69554 11137 31292 96818 51426 18782 53524 40741 9976
6564 9321 3500 3528 2458 1939 1578 224 0 579 180 130 0 0 180 0 0 0 130 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2022 8 14 0 0 199 0 0 29494 4191 246 12137 91681 43630 15255 118045 139666 35498 6684 21415 15086 5930
6899 4085 1072 1361 1015 223 502 446 446 0 502 684 0 404 223 123 0 0 0 0 0 123 0 0 0 0 0 0 0 0 0 0 0 0 0 0
 2023 8 14 0 0 199 0 0 31616 1509 5920 135572 268065 179821 63785 17824 72622 70110 41326 102209 85591
22070 26001 16174 15441 5741 2044 4040 3137 186 754 451 404 0 0 404 404 404 0 0 186 186 0 0 0 0 0 0 0 0 0
0 0 0 0
-9999 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
#
17 #_N_age_bins
 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1 #_N_ageerror_definitions
 0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5 10.5 11.5 12.5 13.5 14.5 15.5 16.5 17.5 18.5 19.5 20.5 21.5
22.5 23.5 24.5 25.5 26.5 27.5 28.5 29.5 30.5
 0.5 0.5 0.5 0.5 0.6 0.5 0.6 0.6 1.2 0.5 0.6 1.1 2.1 2.1 2.1 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 2.2 2.2 2.2
#_mintailcomp: upper and lower distribution for females and males separately are accumulated until ex-
ceeding this level.
#_addtocomp:  after accumulation of tails; this value added to all bins
#_combM+F: males and females treated as combined sex below this bin number
#_compressbins: accumulate upper tail by this number of bins; acts simultaneous with mintailcomp; set=0
for no forced accumulation
#_Comp_Error:  0=multinomial, 1=dirichlet using Theta*n, 2=dirichlet using beta, 3=MV_Tweedie
#_ParmSelect:  consecutive index for dirichlet or MV_Tweedie
#_minsamplesize: minimum sample size; set to 1 to match 3.24, minimum value is 0.001
#
#_mintailcomp addtocomp combM+F CompressBins CompError ParmSelect minsamplesize
-0.001 1e-07 0 0 0 0 1 #_fleet:1_OTHERS
-0.001 1e-07 0 0 0 0 1 #_fleet:2_GNS
-0.001 1e-07 0 0 0 0 1 #_fleet:3_LHM
-0.001 1e-07 0 0 0 0 1 #_fleet:4_LLS
-0.001 1e-07 0 0 0 0 1 #_fleet:5_OTB
-0.001 1e-07 0 0 0 0 1 #_fleet:6_PTM
-0.001 1e-07 0 0 0 0 1 #_fleet:7_SEINE
-0.001 1e-07 0 0 0 0 1 #_fleet:8_RECFISH
-0.001 1e-07 0 0 0 0 1 #_fleet:9_AutBass
-0.001 1e-07 0 0 0 0 1 #_fleet:10_CGFS1
-0.001 1e-07 0 0 0 0 1 #_fleet:11_CGFS2
-0.001 1e-07 0 0 0 0 1 #_fleet:12_FR_LPUE
-0.001 1e-07 0 0 0 0 1 #_fleet:13_Nourdem_DZ
-0.001 1e-07 0 0 0 0 1 #_fleet:14_LaSeine
-0.001 1e-07 0 0 0 0 1 #_fleet:15_FALHEL
-0.001 1e-07 0 0 0 0 1 #_fleet:16_OTB_DISC
-0.001 1e-07 0 0 0 0 1 #_fleet:17_SEINE_DISC
3 #_Lbin_method_for_Age_Data: 1=poplenbins; 2=datalenbins; 3=lengths
# sex codes:  0=combined; 1=use female only; 2=use male only; 3=use both as joint sex*length distribu-
tion
# partition codes:  (0=combined; 1=discard; 2=retained
#_year month fleet sex part ageerr Lbin_lo Lbin_hi Nsamp datavector(female-male)
 2001 1 -1 0 0 1 2 96 37 0 0 0 1006.58 6835.92 689.27 970.96 1831.99 174.29 140.96 0.13 1.39 26.16 0.17
0 0.57 0
 2001 1 -2 0 0 1 2 96 389 0 0 63.7 1212.45 36592.8 3801.3 35391.7 7879.57 902.8 1846.73 1049.34 1563.44
1432.43 153.69 63.17 36.53 97.33
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 2001 1 -3 0 0 1 2 96 286 0 0 14.33 127.02 5009.54 721.42 11823.2 6100.16 1454.96 1980.48 1150.94
1350.13 2446.85 633.85 163.68 36.97 282.77
 2001 1 -4 0 0 1 2 96 80 0 0 0.07 0.82 36.12 4.86 237.71 256.58 207.38 265.33 256.19 366.83 2.78 0.72 0
0 0
 2001 1 -5 0 0 1 2 96 383 0 0 29.28 481.48 26142.3 9641.16 55397.7 16242.9 2502.35 5472.56 747.24
1768.14 2675.48 350.78 944.17 8.12 17.11
 2001 1 -6 0 0 1 2 96 53 0 0 0 0 281.16 183.64 14569 15264.4 6005.98 6695.52 1277.67 3166.7 5399.06
989.52 462.55 93.3 261.3
 2002 1 -1 0 0 1 2 96 53 0 0 0 328.81 1425.4 5612.46 39.39 0 0 0 0 0 0 0 0 0 0
 2002 1 -2 0 0 1 2 96 426 0 32.71 36.07 2415.14 8739.93 81896.9 4898.44 23014.8 7404.93 2511.38 3814.19
438.59 2569.02 8481.55 1323.08 183.5 280.81
 2002 1 -3 0 0 1 2 96 150 0 0 0 12.77 352.74 5842.01 1529.37 13231.6 6769.29 2882.14 2968.99 562.09
705.1 1572.19 215.76 0 74.41
 2002 1 -4 0 0 1 2 96 95 0 0 0 0 1.12 13.42 1.08 13.75 4.78 3.13 3.15 0.09 0.27 3.7 0.14 0.13 0.64
 2002 1 -5 0 0 1 2 96 289 0 0 0 5398.4 10710.8 79328.6 6125.6 44588.9 10812.7 4747.95 3420.62 508.3
1526.93 2879.55 105.88 92.08 154.19
 2002 1 -6 0 0 1 2 96 26 0 0 0 4.34 69.76 2601.69 1528.23 17060.2 13294.3 5682.11 3648.28 165.95 5141.8
7204.32 2.55 7.01 180.82
 2003 1 -1 0 0 1 2 96 38 0 0 0 0 10455 9489.54 3067.94 60.27 324.82 95.99 74.22 21.05 0 0 8.38 11.37 0
 2003 1 -2 0 0 1 2 96 239 0 0 0 346.35 26846.4 21945.6 44498.9 1949.03 9172.04 2991.45 1380.92 682.49
384.11 383.71 772.33 276.45 93.09
 2003 1 -3 0 0 1 2 96 216 0 0 0 21.84 6353.89 8030.74 19760.9 906.2 5159.34 2328.25 689.61 1165.15
752.77 729.73 1628.13 68.13 91.2
 2003 1 -5 0 0 1 2 96 302 0 0 524.02 194.29 33931.9 25939 84021.9 8563.96 19708 6967.11 6115.48 3226.41
645.89 2634.68 3845.12 197.76 815.16
 2003 1 -6 0 0 1 2 96 62 0 0 0 0 772.19 4502.99 20784.4 6165.03 32025.2 6487.29 2046.88 1743.52 311.03
81.31 3447.06 2.91 268.84
 2004 1 -1 0 0 1 2 96 16 0 0 0 0 651.31 11087 2081.32 922.43 4.4 67.07 128.84 38.54 10.61 6.62 2.11
72.21 0
 2004 1 -2 0 0 1 2 96 139 0 0 0.46 3449.89 10989.5 64240.2 23288.2 28864 1273.91 3415.31 1347.8 401.87
209.73 279.35 66.93 420.56 25.97
 2004 1 -3 0 0 1 2 96 113 0 0 0 139.89 885.59 8749.28 3536.71 10452.5 1631.75 3138.88 3604.28 376.05
582.84 931.82 43.1 2066.7 97.34
 2004 1 -4 0 0 1 2 96 15 0 0 0 0 0.15 228.25 243.89 194.19 31.57 68.09 65.9 133.57 14.44 35.21 5.76
41.13 2.99
 2004 1 -5 0 0 1 2 96 176 0 0 0 5121.35 17895.6 73739.4 33811.5 38561.4 2695.26 4192.67 1453.59 369.23
418.67 337.15 226.22 503.78 316.28
 2004 1 -6 0 0 1 2 96 53 0 0 0 15.22 670.36 12705.2 21577.7 52481.5 4437.28 10627.3 3278.26 428.39
1716.24 1033.12 247.97 569.34 195.85
 2005 1 -1 0 0 1 2 96 17 0 0 0 5946.3 5865.8 6665.79 7773.59 863.45 1673.73 0 160.96 2086.21 0 0 0 0 0
 2005 1 -2 0 0 1 2 96 84 0 0 0 9986.84 29469 15246 26366.6 6864.79 7125.97 436.27 1239.37 1173.12 0
239.71 40.93 199 35.78
 2005 1 -3 0 0 1 2 96 50 0 0 0 26.2 22.89 363.75 2401.77 908.35 3523.35 664.32 1842.38 456.11 563.23
363.91 139.83 151.51 576.83
 2005 1 -5 0 0 1 2 96 163 0 0 0 4938.9 44541.4 40650.7 66701.2 17398.4 16871.8 829.72 3474.09 496.93
628.99 114.82 53.29 219.51 318.68
 2005 1 -6 0 0 1 2 96 6 0 0 0 0 114.02 1574.01 17003.1 7768.44 16327.6 1515.65 3645.85 9.08 1916.5
44.25 2.45 63.33 606.98
 2006 1 -1 0 0 1 2 96 30 0 0 0 573.74 4470.62 2694.29 2638.97 4001.05 167.62 2607.86 0 0 2078.01 696.91
34.59 60.62 770.41
 2006 1 -2 0 0 1 2 96 96 0 0 0 13858.6 60881.9 57400 24472.1 18490.5 3797.21 5876.47 862.57 2449.78
155.18 219.14 0 0.45 149.66
 2006 1 -3 0 0 1 2 96 45 0 0 0 1.27 3720.39 11291.8 6931.76 8254.77 1946.72 7424.32 1238.35 4496.97
419.3 230.22 125.17 48.59 312.22
 2006 1 -4 0 0 1 2 96 22 0 0 0 0.26 3.55 18.2 15.19 27.44 6.05 15.86 8.42 0 13.29 5.9 3.51 1.95 33.56
 2006 1 -5 0 0 1 2 96 84 0 0 0 8958.59 43291.2 47011.2 24356.8 35640.6 5011.19 7080.25 228.12 1915.72
1025.86 99.17 0 68.73 116.46
 2006 1 -6 0 0 1 2 96 6 0 0 0 0 28.2 396.84 338.39 1777.76 440.03 1368.55 24.24 124.62 0 0 0 0 10.66
 2007 1 -1 0 0 1 2 96 2 0 0 0 0 14637.1 13268.9 2474.9 2816.21 4870.95 0 0 0 1398.86 0 0 0 0
 2007 1 -2 0 0 1 2 96 195 0 0 0 1.05 5670.76 46049 29610.1 15388.9 14749.9 6873.32 5539.65 1311.51
1643.03 1068.62 94.4 1252.61 467.54
 2007 1 -3 0 0 1 2 96 121 0 0 0 0 6343.35 25182.3 18512.4 6836 9464.24 3916.97 4970.56 2887.67 1879.7
1763.84 75.52 316.79 501.58
 2007 1 -4 0 0 1 2 96 5 0 0 0 0 0.18 19.56 63.03 92.67 13.34 55.38 28.49 3.87 8.69 3.12 38.42 1.67
25.93
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-9999  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
#
0 #_Use_MeanSize-at-Age_obs (0/1)
#
0 #_N_environ_variables
# -2 in year will subtract mean for that env_var; -1 will subtract mean and divide by stddev (e.g. Z-
score)
#_year variable value
#
# Sizefreq data. Defined by method because a fleet can use multiple methods
0 # N sizefreq methods to read (or -1 for expanded options)
#
0 # do tags (0/1/2); where 2 allows entry of TG_min_recap
#
0 #    morphcomp data(0/1)
#  Nobs, Nmorphs, mincomp
#_year, seas, type, partition, Nsamp, datavector_by_Nmorphs
#
0  #  Do dataread for selectivity priors(0/1)
#_year, seas, fleet, age/size, bin, selex_prior, prior_sd
# feature not yet implemented
#
999
```

Appendix 2 Control file

```
#V3.30.23.00;_safe;_compile_date:_Nov  4 2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_us-
ing_ADMB_13.2
#_Stock_Synthesis_is_a_work_of_the_U.S._Government_and_is_not_subject_to_copyright_protec-
tion_in_the_United_States.
#_Foreign_copyrights_may_apply._See_copyright.txt_for_more_information.
#_User_support_available_at:NMFS.Stock.Synthesis@noaa.gov
#_User_info_available_at:https://vlab.noaa.gov/group/stock-synthesis
#_Source_code_at:_https://github.com/nmfs-ost/ss3-source-code

#_data_and_control_files: BassIVVII.dat // BassIVVII.ctl
0  # 0 means do not read wtatage.ss; 1 means read and use wtatage.ss and also read and use growth
parameters
1  #_N_Growth_Patterns (Growth Patterns, Morphs, Bio Patterns, GP are terms used interchangeably
in SS3)
1 #_N_platoons_Within_GrowthPattern
#_Cond 1 #_Platoon_within/between_stdev_ratio (no read if N_platoons=1)
#_Cond sd_ratio_rd < 0: platoon_sd_ratio parameter required after movement params.
#_Cond  1 #vector_platoon_dist_(-1_in_first_val_gives_normal_approx)
#
4 # recr_dist_method for parameters:  2=main effects for GP, Area, Settle timing; 3=each Settle
entity; 4=none (only when N_GP*Nsettle*pop==1)
1 # not yet implemented; Future usage: Spawner-Recruitment: 1=global; 2=by area
1 #  number of recruitment settlement assignments
0 # unused option
#GPattern month  area  age (for each settlement assignment)
 1 1 1 0
#
#_Cond 0 # N_movement_definitions goes here if Nareas > 1
#_Cond 1.0 # first age that moves (real age at begin of season, not integer) also cond on do_mi-
gration>0
#_Cond 1 1 1 2 4 10 # example move definition for seas=1, morph=1, source=1 dest=2, age1=4,
age2=10
#
1 #_Nblock_Patterns
 5 #_blocks_per_pattern
# begin and end years of blocks
 2015 2015 2016 2016 2017 2017 2018 2018 2019 2023
#
# controls for all timevary parameters
1 #_time-vary parm bound check (1=warn relative to base parm bounds; 3=no bound check); Also see
env (3) and dev (5) options to constrain with base bounds
#
# AUTOGEN
 1 1 1 1 1 # autogen: 1st element for biology, 2nd for SR, 3rd for Q, 4th reserved, 5th for selex
# where: 0 = autogen time-varying parms of this category; 1 = read each time-varying parm line; 2
= read then autogen if parm min==-12345
#
#_Available timevary codes
#_Block types: 0: P_block=P_base*exp(TVP); 1: P_block=P_base+TVP; 2: P_block=TVP; 3:
P_block=P_block(-1) + TVP
#_Block_trends: -1: trend bounded by base parm min-max and parms in transformed units (beware); -
2: endtrend and infl_year direct values; -3: end and infl as fraction of base range
#_EnvLinks:  1: P(y)=P_base*exp(TVP*env(y));  2: P(y)=P_base+TVP*env(y);  3:
P(y)=f(TVP,env_Zscore) w/ logit to stay in min-max;  4: P(y)=2.0/(1.0+exp(-TVP1*env(y) - TVP2))
#_DevLinks:  1: P(y)*=exp(dev(y)*dev_se;  2: P(y)+=dev(y)*dev_se;  3: random walk;  4: zero-re-
verting random walk with rho;  5: like 4 with logit transform to stay in base min-max
#_DevLinks(more):  21-25 keep last dev for rest of years
#
#_Prior_codes:  0=none; 6=normal; 1=symmetric beta; 2=CASAL's beta; 3=lognormal; 4=lognormal with
biascorr; 5=gamma
#
# setup for M, growth, wt-len, maturity, fecundity, (hermaphro), recr_distr, cohort_grow, (move-
ment), (age error), (catch_mult), sex ratio
#_NATMORT
3 #_natM_type:_0=1Parm; 1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpo-
late;_5=BETA:_Maunder_link_to_maturity;_6=Lorenzen_range
 #_Age_natmort_by sex x growthpattern (nest GP in sex)
```

```
 0.840918 0.463849 0.365109 0.306347 0.267492 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24
0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24
#
1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=age_specific_K_incr; 4=age_spe-
cific_K_decr; 5=age_specific_K_each; 6=NA; 7=NA; 8=growth cessation
2 #_Age(post-settlement) for L1 (aka Amin); first growth parameter is size at this age; linear
growth below this
28 #_Age(post-settlement) for L2 (aka Amax); 999 to treat as Linf
-999 #_exponential decay for growth above maxage (value should approx initial Z; -999 replicates
3.24; -998 to not allow growth above maxage)
0  #_placeholder for future growth feature
#
0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
3 #_CV_Growth_Pattern:  0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4 logSD=F(A)
#
1 #_maturity_option:  1=length logistic; 2=age logistic; 3=read age-maturity matrix by growth_pat-
tern; 4=read age-fecundity; 5=disabled; 6=read length-maturity
4 #_First_Mature_Age
1 #_fecundity_at_length option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b; (4)eggs=a+b*L;
(5)eggs=a+b*W
0 #_hermaphroditism option:  0=none; 1=female-to-male age-specific fxn; -1=male-to-female age-spe-
cific fxn
1 #_parameter_offset_approach for M, G, CV_G:  1- direct, no offset**; 2-
male=fem_parm*exp(male_parm); 3: male=female*exp(parm) then old=young*exp(parm)
#_** in option 1, any male parameter with value = 0.0 and phase <0 is set equal to female parame-
ter
#
#_growth_parms
#_ LO HI INIT PRIOR PR_SD PR_type PHASE env_var&link dev_link dev_minyr dev_maxyr dev_PH Block
Block_Fxn
# Sex: 1  BioPattern: 1  NatMort
# Sex: 1  BioPattern: 1  Growth
 -1 30 20.7137 19.67 0.5 0 3 0 0 0 0 0 0 0 # L_at_Amin_Fem_GP_1
 60 100 80.26 80.26 15 0 -4 0 0 0 0 0 0 0 # L_at_Amax_Fem_GP_1
 0.01 0.2 0.103273 0.09699 0.05 0 3 0 0 0 0 0 0 0 # VonBert_K_Fem_GP_1
 2 6 2.2729 3.9 0.8 0 6 0 0 0 0 0 0 0 # SD_young_Fem_GP_1
 4 10 10 6.9 0.8 0 6 0 0 0 0 0 0 0 # SD_old_Fem_GP_1
# Sex: 1  BioPattern: 1  WtLen
 -1 1 1.296e-05 1.296e-05 0.05 0 -3 0 0 0 0 0 0 0 # Wtlen_1_Fem_GP_1
 2 4 2.969 2.969 0.05 0 -3 0 0 0 0 0 0 0 # Wtlen_2_Fem_GP_1
# Sex: 1  BioPattern: 1  Maturity&Fecundity
 30 50 40.649 40.649 5 0 -3 0 0 0 0 0 0 0 # Mat50%_Fem_GP_1
 -5 1 -0.33349 -0.33349 0.03764 0 -3 0 0 0 0 0 0 0 # Mat_slope_Fem_GP_1
 -3 3 1 1 0.8 0 -3 0 0 0 0 0 0 0 # Eggs/kg_inter_Fem_GP_1
 -3 3 0 0 0.8 0 -3 0 0 0 0 0 0 0 # Eggs/kg_slope_wt_Fem_GP_1
# Hermaphroditism
#  Recruitment Distribution
#  Cohort growth dev base
 0.1 10 1 1 1 6 -1 0 0 0 0 0 0 0 # CohortGrowDev
#  Movement
#  Platoon StDev Ratio
#  Age Error from parameters
#  catch multiplier
#  fraction female, by GP
 1e-06 0.999999 0.5 0.5 0.5 0 -99 0 0 0 0 0 0 0 # FracFemale_GP_1
#  M2 parameter for each predator fleet
#
#_no timevary MG parameters
#
#_seasonal_effects_on_biology_parms
 0 0 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K
#_ LO HI INIT PRIOR PR_SD PR_type PHASE
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no seasonal MG parameters
#
3 #_Spawner-Recruitment; Options: 1=NA; 2=Ricker; 3=std_B-H; 4=SCAA; 5=Hockey; 6=B-H_flattop;
7=survival_3Parm; 8=Shepherd_3Parm; 9=RickerPower_3parm
0  # 0/1 to use steepness in initial equ recruitment calculation
0  #  future feature:  0/1 to make realized sigmaR a function of SR curvature
#_          LO            HI          INIT         PRIOR         PR_SD       PR_type      PHASE
env-var    use_dev   dev_mnyr   dev_mxyr     dev_PH      Block    Blk_Fxn #  parm_name
```

```
             1            16       11.1372             5             1             0          1
0            0             0             0             0             0          0 # SR_LN(R0)
             0.2         0.999         0.876         0.876           0.2             0         -1
0            0             0             0             0             0          0 # SR_BH_steep
             0.1             2           0.9           0.9           0.2             0         -5
0            0             0             0             0             0          0 # SR_sigmaR
              -5             5             0          -0.7             2             0         -2
0            0             0             0             0             0          0 # SR_regime
               0             0             0             0             0             0        -99
0            0             0             0             0             0          0 # SR_autocorr
#_no timevary SR parameters
2 #do_recdev:  0=none; 1=devvector (R=F(SSB)+dev); 2=deviations (R=F(SSB)+dev); 3=deviations
(R=R0*dev; dev2=R-f(SSB)); 4=like 3 with sum(dev2) adding penalty
1986 # first year of main recr_devs; early devs can precede this era
2022 # last year of main recr_devs; forecast devs start in following year
3 #_recdev phase
1 # (0/1) to read 13 advanced options
 -10 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
 4 #_recdev_early_phase
 0 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
 1 #_lambda for Fcast_recr_like occurring before endyr+1
 1979.7 #_last_yr_nobias_adj_in_MPD; begin of ramp
 1988.2 #_first_yr_fullbias_adj_in_MPD; begin of plateau
 2022.9 #_last_yr_fullbias_adj_in_MPD
 2023.6 #_end_yr_for_ramp_in_MPD (can be in forecast to shape ramp, but SS3 sets bias_adj to 0.0
for fcast yrs)
 0.9421 #_max_bias_adj_in_MPD (typical ~0.8; -3 sets all years to 0.0; -2 sets all non-forecast
yrs w/ estimated recdevs to 1.0; -1 sets biasadj=1.0 for all yrs w/ recdevs)
 0 #_period of cycles in recruitment (N parms read below)
 -5 #min rec_dev
 5 #max rec_dev
 0 #_read_recdevs
#_end of advanced SR options
#
#_placeholder for full parameter lines for recruitment cycles
# read specified recr devs
#_year Input_value
#
# all recruitment deviations
#  1976E 1977E 1978E 1979E 1980E 1981E 1982E 1983E 1984E 1985E 1986R 1987R 1988R 1989R 1990R 1991R
1992R 1993R 1994R 1995R 1996R 1997R 1998R 1999R 2000R 2001R 2002R 2003R 2004R 2005R 2006R 2007R
2008R 2009R 2010R 2011R 2012R 2013R 2014R 2015R 2016R 2017R 2018R 2019R 2020R 2021R 2022R 2023F
2024F
#  0.106743 0.181037 0.299182 0.411649 0.303694 0.0238832 -0.149468 0.299026 -0.614534 -1.27856 -
0.936319 0.0198132 1.59364 1.07791 -0.0945372 -0.2568 0.293137 0.322811 0.534912 0.550231 -
0.451025 0.758874 0.681344 1.11956 0.00341339 0.740935 0.694401 1.01176 1.04392 0.428654 0.530403
0.170708 0.497479 0.307982 -0.286179 -0.412758 -0.279442 -0.00404702 0.765315 0.133224 0.756382
0.25129 0.267314 0.370382 0.3369 -0.411235 -0.0504339 -0.576918 0
#
#Fishing Mortality info
0.2 # F ballpark value in units of annual_F
-2001 # F ballpark year (neg value to disable)
4 # F_Method:  1=Pope midseason rate; 2=F as parameter; 3=F as hybrid; 4=fleet-specific parm/hy-
brid (#4 is superset of #2 and #3 and is recommended)
2.9 # max F (methods 2-4) or harvest fraction (method 1)
# Read list of fleets that do F as parameter; unlisted fleets stay hybrid, bycatch fleets must be
included with start_PH=1, high F fleets should switch early
# (A) fleet;
# (B) F_starting_value (ignored if start_PH=1 or reading from ss3.par);
# (C) start_PH for fleet's Fparms (99 to stay in hybrid, <0 to stay at starting value)
# Terminate list with -9999 for fleet (use -9998 to read fleet-time specific F values after read-
ing N hybrid tune loops)
# (A) (B) (C)
 1 0.01 99 # OTHERS
 2 0.01 99 # GNS
 3 0.01 99 # LHM
 4 0.01 99 # LLS
 5 0.01 99 # OTB
 6 0.01 99 # PTM
 7 0.01 99 # SEINE
 8 0.01 1 # RECFISH
```

```
 16 0.01 99 # OTB_DISC
 17 0.01 99 # SEINE_DISC
-9999 1 1 # end of list
#F_detail template: fleet year seas F_value catch_se phase
5 #_number of loops for hybrid tuning; 4 precise; 3 faster; 2 enough if switching to parms is ena-
bled
#
#_initial_F_parms; for each fleet x season that has init_catch; nest season in fleet; count = 7
#_for unconstrained init_F, use an arbitrary initial catch and set lambda=0 for its logL
#_  LO HI INIT PRIOR PR_SD  PR_type  PHASE
 0 3 0.00107428 0 99 0 -1 # InitF_seas_1_flt_1OTHERS
 0 3 0.00189337 0 99 0 -1 # InitF_seas_1_flt_2GNS
 0 3 0.000797355 0 99 0 -1 # InitF_seas_1_flt_3LHM
 0 3 0.000799069 0 99 0 -1 # InitF_seas_1_flt_4LLS
 0 3 0.0188925 0 99 0 1 # InitF_seas_1_flt_5OTB
 0 3 0.0153704 0 99 0 1 # InitF_seas_1_flt_6PTM
 0 3 0.103338 0 99 0 1 # InitF_seas_1_flt_8RECFISH
#
# F rates by fleet x season
#_year:  1985 1986 1987 1988 1989 1990 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 2021
2022 2023 2024
# seas:  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 1 1 1
# OTHERS 0.000837056 0.000852016 0.000994325 0.00127004 0.00239821 0.00215267 0.0015604 0.00205174
0.0024977 0.00399256 0.00777777 0.00426883 0.00481323 0.00617997 0.00810738 0.00708347 0.00730198
0.00845424 0.00810582 0.00748416 0.00731765 0.00867683 0.0099996 0.0115582 0.00913996 0.0111764
0.0141196 0.0144294 0.0147616 0.0201257 0.0205879 0.0178087 0.0138006 0.00623755 0.00649322
0.00648535 0.00531864 0.00398222 0.00439571 0.00439571
# GNS 0.00135515 0.00311298 0.0030312 0.00556724 0.00779539 0.00839893 0.00901313 0.00466658
0.00265568 0.00577884 0.0066879 0.00578948 0.00782984 0.00615406 0.0059504 0.00615992 0.00720433
0.00947129 0.00643449 0.00853447 0.0085372 0.0103007 0.0110457 0.012469 0.0123742 0.0130475
0.0139728 0.01929 0.0220027 0.0370666 0.0248649 0.0201932 0.0122818 0.0150038 0.013333 0.0129891
0.0126543 0.0130459 0.0134702 0.0134702
# LHM 0.000668166 0.000739186 0.000974519 0.0026071 0.00158194 0.00140955 0.00316634 0.00187984
0.00213946 0.00401669 0.00457571 0.00373468 0.00385831 0.00349715 0.00293463 0.00820157 0.00913462
0.00908478 0.0104995 0.00836863 0.00917286 0.0133106 0.0144214 0.0125063 0.0107392 0.0124434
0.0128176 0.0140341 0.0155372 0.0175191 0.0171008 0.0178496 0.0227362 0.0285632 0.0253561
0.0279757 0.0258118 0.0216993 0.0176975 0.0176975
# LLS 0.000664991 0.000396238 0.00189295 0.00185359 0.00233082 0.00186384 0.00193515 0.00190064
0.00162968 0.00158602 0.00163573 0.00149136 0.00231169 0.000453464 0.00219755 0.00328462
0.00526683 0.00432942 0.00454435 0.00540973 0.00629539 0.00834417 0.0073409 0.0052583 0.00360045
0.00396353 0.00408622 0.00346741 0.00356827 0.00469577 0.00314281 0.00227381 0.00325149 0.0024412
0.00224846 0.00273705 0.00234297 0.00201894 0.00153847 0.00153847
# OTB 0.01493 0.018105 0.00800755 0.0139178 0.0233742 0.0281514 0.0292458 0.0209417 0.0211216
0.0187019 0.0229265 0.0336525 0.0311426 0.0319714 0.0367768 0.0381835 0.037698 0.0430163 0.0503586
0.0516235 0.0521018 0.0523722 0.0513224 0.0488808 0.0467158 0.0370702 0.0384783 0.0456337
0.0402526 0.0357892 0.0497659 0.0251176 0.0216831 0.00887001 0.00905603 0.0128979 0.0123615
0.0136349 0.0209909 0.0209909
# PTM 0.0112188 0.0163599 0.042815 0.014698 0.00691683 0.00679229 0.0148875 0.0173364 0.00882996
0.00306017 0.00760999 0.0410434 0.036141 0.0350747 0.0390126 0.0269224 0.0310951 0.0200488
0.0300478 0.0308293 0.0465785 0.0514552 0.0312384 0.0354745 0.0343777 0.0581231 0.0436925
0.0447112 0.0680307 0.0115901 0.00242424 0.000981991 0.00101957 5.79506e-05 2.59241e-05 9.90699e-
05 0.000106222 3.98155e-05 8.24184e-05 8.24184e-05
# SEINE 9.40976e-06 2.47225e-05 3.17374e-06 6.53385e-06 1.04514e-05 3.91936e-06 4.44585e-06 0 0 0
3.15739e-05 0 0 0 0 3.39548e-05 0.000123306 9.55467e-05 0.000143857 0.000199196 0.000585924
0.000912055 0.00168666 0.00337356 0.00289545 0.00474034 0.00361089 0.00753658 0.00679173
0.00912357 0.0115603 0.00531152 0.00546155 0.00142797 0.00173349 0.00260577 0.00282576 0.00337873
0.00628429 0.00628429
# RECFISH 0.0767827 0.0767678 0.0768095 0.0769075 0.0770315 0.0771227 0.0770845 0.0769877
0.0768595 0.0766972 0.0764625 0.0761973 0.0760745 0.0761516 0.0764985 0.0765441 0.076106 0.0761877
0.0767547 0.0772947 0.0774029 0.0775111 0.0773648 0.0767099 0.0768903 0.0776528 0.0875705
0.0978867 0.106088 0.124189 0.149802 0.15329 0.046058 0.0319455 0.0538924 0.0761691 0.0768975
0.0778272 0.0726621 0.0726621
# OTB_DISC 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0.000154169 0.00328732 7.91794e-05 0.000503835
0.00185731 0.000574089 0.00168316 0.00392153 0.000593622 0.00902392 0.0073618 0.00174828
0.00582235 0.0325234 0.0596472 0.0797164 0.0594101 0.0416364 0.0511887 0.0454352 0.0568325
0.0568325
# SEINE_DISC 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0
```

```
#_1:  fleet number
#_2:  link type: 1=simple q; 2=mirror; 3=power (+1 parm); 4=mirror with scale (+1p); 5=offset
(+1p); 6=offset & power (+2p)
#_     where power is applied as y = q * x ^ (1 + power); so a power value of 0 has null effect
#_     and with the offset included it is y = q * (x + offset) ^ (1 + power)
#_3:  extra input for link, i.e. mirror fleet# or dev index number
#_4:  0/1 to select extra sd parameter
#_5:  0/1 for biasadj or not
#_6:  0/1 to float
#_   fleet      link link_info  extra_se   biasadj     float  #  fleetname
         8         1         0         1         0         1  #  RECFISH
         9         1         0         1         0         1  #  AutBass
        10         1         0         1         0         1  #  CGFS1
        11         1         0         1         0         1  #  CGFS2
        12         1         0         1         0         1  #  FR_LPUE
        13         1         0         1         0         1  #  Nourdem_DZ
        14         1         0         1         0         1  #  LaSeine
        15         1         0         1         0         1  #  FALHEL
-9999 0 0 0 0 0
#
#_Q_parameters
#_          LO            HI          INIT         PRIOR         PR_SD       PR_type      PHASE
env-var    use_dev   dev_mnyr   dev_mxyr     dev_PH      Block    Blk_Fxn  #  parm_name
           -25          25       2.56654              0            1            0         -1
0          0          0          0          0          0          0  #  LnQ_base_RECFISH(8)
             0            1             0          0.1           99            0         -3
0          0          0          0          0          0          0  #  Q_extraSD_RECFISH(8)
           -25          25      -5.01511              0            1            0         -1
0          0          0          0          0          0          0  #  LnQ_base_AutBass(9)
             0            1      0.435352          0.1           99            0          3
0          0          0          0          0          0          0  #  Q_extraSD_AutBass(9)
           -25          25       4.35432              0            1            0         -1
0          0          0          0          0          0          0  #  LnQ_base_CGFS1(10)
             0            1      0.345169          0.1           99            0          3
0          0          0          0          0          0          0  #  Q_extraSD_CGFS1(10)
           -25          25       4.81753              0            1            0         -1
0          0          0          0          0          0          0  #  LnQ_base_CGFS2(11)
             0            1      0.400132          0.1           99            0          3
0          0          0          0          0          0          0  #  Q_extraSD_CGFS2(11)
           -25          25      -21.5962              0            1            0         -1
0          0          0          0          0          0          0  #  LnQ_base_FR_LPUE(12)
             0            1             0          0.1           99            0         -3
0          0          0          0          0          0          0  #  Q_extraSD_FR_LPUE(12)
           -25          25      0.507798              0            1            0         -1
0          0          0          0          0          0          0  #  LnQ_base_Nourdem_DZ(13)
             0            1     0.0389366          0.1           99            0          3
0          0          0          0          0          0          0  #  Q_extraSD_Nourdem_DZ(13)
           -25          25       2.99401              0            1            0         -1
0          0          0          0          0          0          0  #  LnQ_base_LaSeine(14)
             0            1      0.309847          0.1           99            0          3
0          0          0          0          0          0          0  #  Q_extraSD_LaSeine(14)
           -25          25      -9.13459              0            1            0         -1
0          0          0          0          0          0          0  #  LnQ_base_FALHEL(15)
             0            1      0.922139          0.1           99            0          3
0          0          0          0          0          0          0  #  Q_extraSD_FALHEL(15)
#_no timevary Q parameters
#
#_size_selex_patterns
#Pattern:_0;  parm=0; selex=1.0 for all sizes
#Pattern:_1;  parm=2; logistic; with 95% width specification
#Pattern:_5;  parm=2; mirror another size selex; PARMS pick the min-max bin to mirror
#Pattern:_11; parm=2; selex=1.0  for specified min-max population length bin range
#Pattern:_15; parm=0; mirror another age or length selex
#Pattern:_6;  parm=2+special; non-parm len selex
#Pattern:_43; parm=2+special+2;  like 6, with 2 additional param for scaling (mean over bin range)
#Pattern:_8;  parm=8; double_logistic with smooth transitions and constant above Linf option
#Pattern:_9;  parm=6; simple 4-parm double logistic with starting length; parm 5 is first length;
parm 6=1 does desc as offset
#Pattern:_21; parm=2*special; non-parm len selex, read as N break points, then N selex parameters
#Pattern:_22; parm=4; double_normal as in CASAL
#Pattern:_23; parm=6; double_normal where final value is directly equal to sp(6) so can be >1.0
```

```
#Pattern:_24; parm=6; double_normal with sel(minL) and sel(maxL), using joiners
#Pattern:_2;  parm=6; double_normal with sel(minL) and sel(maxL), using joiners, back compatibile
version of 24 with 3.30.18 and older
#Pattern:_25; parm=3; exponential-logistic in length
#Pattern:_27; parm=special+3; cubic spline in length; parm1==1 resets knots; parm1==2 resets all
#Pattern:_42; parm=special+3+2; cubic spline; like 27, with 2 additional param for scaling (mean
over bin range)
#_discard_options:_0=none;_1=define_retention;_2=retention&mortality;_3=all_discarded_dead;_4=de-
fine_dome-shaped_retention
#_Pattern Discard Male Special
 24 0 0 0 # 1 OTHERS
 24 0 0 0 # 2 GNS
 1 0 0 0 # 3 LHM
 1 0 0 0 # 4 LLS
 24 0 0 0 # 5 OTB
 1 0 0 0 # 6 PTM
 24 0 0 0 # 7 SEINE
 24 0 0 0 # 8 RECFISH
 24 0 0 0 # 9 AutBass
 24 0 0 0 # 10 CGFS1
 24 0 0 0 # 11 CGFS2
 15 0 0 5 # 12 FR_LPUE
 24 0 0 0 # 13 Nourdem_DZ
 24 0 0 0 # 14 LaSeine
 24 0 0 0 # 15 FALHEL
 24 0 0 0 # 16 OTB_DISC
 15 0 0 16 # 17 SEINE_DISC
#
#_age_selex_patterns
#Pattern:_0; parm=0; selex=1.0 for ages 0 to maxage
#Pattern:_10; parm=0; selex=1.0 for ages 1 to maxage
#Pattern:_11; parm=2; selex=1.0  for specified min-max age
#Pattern:_12; parm=2; age logistic
#Pattern:_13; parm=8; age double logistic. Recommend using pattern 18 instead.
#Pattern:_14; parm=nages+1; age empirical
#Pattern:_15; parm=0; mirror another age or length selex
#Pattern:_16; parm=2; Coleraine - Gaussian
#Pattern:_17; parm=nages+1; empirical as random walk  N parameters to read can be overridden by
setting special to non-zero
#Pattern:_41; parm=2+nages+1; // like 17, with 2 additional param for scaling (mean over bin
range)
#Pattern:_18; parm=8; double logistic - smooth transition
#Pattern:_19; parm=6; simple 4-parm double logistic with starting age
#Pattern:_20; parm=6; double_normal,using joiners
#Pattern:_26; parm=3; exponential-logistic in age
#Pattern:_27; parm=3+special; cubic spline in age; parm1==1 resets knots; parm1==2 resets all
#Pattern:_42; parm=2+special+3; // cubic spline; with 2 additional param for scaling (mean over
bin range)
#Age patterns entered with value >100 create Min_selage from first digit and pattern from remain-
der
#_Pattern Discard Male Special
 10 0 0 0 # 1 OTHERS
 10 0 0 0 # 2 GNS
 10 0 0 0 # 3 LHM
 10 0 0 0 # 4 LLS
 10 0 0 0 # 5 OTB
 10 0 0 0 # 6 PTM
 10 0 0 0 # 7 SEINE
 10 0 0 0 # 8 RECFISH
 0 0 0 0 # 9 AutBass
 10 0 0 0 # 10 CGFS1
 10 0 0 0 # 11 CGFS2
 15 0 0 5 # 12 FR_LPUE
 0 0 0 0 # 13 Nourdem_DZ
 0 0 0 0 # 14 LaSeine
 0 0 0 0 # 15 FALHEL
 10 0 0 0 # 16 OTB_DISC
 15 0 0 5 # 17 SEINE_DISC
#
#_          LO            HI          INIT         PRIOR         PR_SD       PR_type      PHASE
env-var    use_dev   dev_mnyr   dev_mxyr     dev_PH      Block    Blk_Fxn  #  parm_name
```

```
# 1   OTHERS LenSelex
            20            93       39.1372            45          0.05            0          2
0           3       2015       2023          3           0           0  #  Size_DblN_peak_OTHERS(1)
           -15             4           -15          -15          0.05            0         -3
0           0           0          0           0           0           0  #  Size_DblN_top_logit_OTH-
ERS(1)
           -15            20       1.96744           3.3          0.05            0          3
0           0           0          0           0           0           0  #  Size_DblN_ascend_se_OTH-
ERS(1)
           -15            20       7.19858           4.4          0.05            0          3
0           0           0          0           0           0           0  #  Size_DblN_descend_se_OTH-
ERS(1)
          -999             9          -999          -999          0.05            0         -2
0           0           0          0           0           0           0  #  Size_DblN_start_logit_OTH-
ERS(1)
          -999             9          -999          -999          0.05            0         -2
0           0           0          0           0           0           0  #  Size_DblN_end_logit_OTH-
ERS(1)
# 2   GNS LenSelex
            20            93       37.8333            45          0.05            0          2
0           3       2015       2023          3           0           0  #  Size_DblN_peak_GNS(2)
           -15             4           -15          -15          0.05            0         -3
0           0           0          0           0           0           0  #  Size_DblN_top_logit_GNS(2)
           -20             9       1.55061           3.3          0.05            0          3
0           0           0          0           0           0           0  #  Size_DblN_ascend_se_GNS(2)
            -5             9       6.28858           4.4          0.05            0          3
0           0           0          0           0           0           0  #  Size_DblN_de-
scend_se_GNS(2)
          -999             9          -999          -999          0.05            0         -2
0           0           0          0           0           0           0  #
Size_DblN_start_logit_GNS(2)
          -999             9          -999          -999          0.05            0         -2
0           0           0          0           0           0           0  #  Size_DblN_end_logit_GNS(2)
# 3   LHM LenSelex
            20            91       39.3364            30          0.05            0          2
0           3       2015       2023          3           0           0  #  Size_inflection_LHM(3)
          0.01            30       3.04273           5          0.05            0          3
0           0           0          0           0           0           0  #  Size_95%width_LHM(3)
# 4   LLS LenSelex
            20            91       38.3899            30          0.05            0          2
0           3       2015       2023          3           0           0  #  Size_inflection_LLS(4)
          0.01            30       2.87674           5          0.05            0          3
0           0           0          0           0           0           0  #  Size_95%width_LLS(4)
# 5   OTB LenSelex
            20            93       38.7699            45          0.05            0          2
0           3       2015       2023          3           0           0  #  Size_DblN_peak_OTB(5)
           -15             4           -15          -15          0.05            0         -3
0           0           0          0           0           0           0  #  Size_DblN_top_logit_OTB(5)
           -20             9       2.35323           3.3          0.05            0          3
0           0           0          0           0           0           0  #  Size_DblN_ascend_se_OTB(5)
            -1             9        6.4001           4.4          0.05            0          3
0           0           0          0           0           0           0  #  Size_DblN_de-
scend_se_OTB(5)
          -999             9          -999          -999          0.05            0         -2
0           0           0          0           0           0           0  #
Size_DblN_start_logit_OTB(5)
          -999             9          -999          -999          0.05            0         -2
0           0           0          0           0           0           0  #  Size_DblN_end_logit_OTB(5)
# 6   PTM LenSelex
            20            91       41.2094            30          0.05            0          2
0           0           0          0           0           0           0  #  Size_inflection_PTM(6)
          0.01            50       4.86983           5          0.05            0          3
0           0           0          0           0           0           0  #  Size_95%width_PTM(6)
# 7   SEINE LenSelex
            20            93       43.2129            45          0.05            0          2
0           3       2015       2023          3           0           0  #  Size_DblN_peak_SEINE(7)
           -15             4           -15          -15          0.05            0         -3
0           0           0          0           0           0           0  #
Size_DblN_top_logit_SEINE(7)
```

```
           -20            20       2.88891           3.3          0.05             0           3
0           0           0           0           0           0           0  #  Size_DblN_as-
cend_se_SEINE(7)
           -10            20       16.8323           4.4          0.05             0           3
0           0           0           0           0           0           0  #  Size_DblN_de-
scend_se_SEINE(7)
          -999             9          -999          -999          0.05             0          -2
0           0           0           0           0           0           0  #
Size_DblN_start_logit_SEINE(7)
          -999             9          -999          -999          0.05             0          -2
0           0           0           0           0           0           0  #
Size_DblN_end_logit_SEINE(7)
# 8   RECFISH LenSelex
            20            93       48.7204            45          0.05             0           2
0           3        2015        2023           3           0           0  #  Size_DblN_peak_RECFISH(8)
           -15            15       1.81526          -15          0.05             0          -3
0           0           0           0           0           0           0  #
Size_DblN_top_logit_RECFISH(8)
           -20            25       4.82192             5          0.05             0           3
0           0           0           0           0           0           0  #  Size_DblN_as-
cend_se_RECFISH(8)
           -20            25       3.68323           4.4          0.05             0           3
0           0           0           0           0           0           0  #  Size_DblN_de-
scend_se_RECFISH(8)
          -999            99      -3.13372          -999          0.05             0          -4
0           0           0           0           0           0           0  #
Size_DblN_start_logit_RECFISH(8)
          -999            99       9.03311          -999          0.05             0          -4
0           0           0           0           0           0           0  #
Size_DblN_end_logit_RECFISH(8)
# 9   AutBass LenSelex
             5            50       25.7195            32          0.05             0           2
0           0           0           0           0           0           0  #  Size_DblN_peak_AutBass(9)
           -15             4           -15            -6          0.05             0          -3
0           0           0           0           0           0           0  #  Size_DblN_top_logit_Aut-
Bass(9)
            -1             9      -0.84909           3.3          0.05             0           3
0           0           0           0           0           0           0  #  Size_DblN_ascend_se_Aut-
Bass(9)
            -1             9      -0.91479           4.4          0.05             0           3
0           0           0           0           0           0           0  #  Size_DblN_descend_se_Aut-
Bass(9)
          -999             9          -999          -999          0.05             0          -2
0           0           0           0           0           0           0  #  Size_DblN_start_logit_Aut-
Bass(9)
          -999             9          -999          -999          0.05             0          -2
0           0           0           0           0           0           0  #  Size_DblN_end_logit_Aut-
Bass(9)
# 10   CGFS1 LenSelex
            20            93       32.0103            32          0.05             0           2
0           0           0           0           0           0           0  #  Size_DblN_peak_CGFS1(10)
           -15             4           -15           -15          0.05             0          -3
0           0           0           0           0           0           0  #
Size_DblN_top_logit_CGFS1(10)
            -1            15       3.08639           3.3          0.05             0           3
0           0           0           0           0           0           0  #  Size_DblN_as-
cend_se_CGFS1(10)
            -5            15       6.21147           4.4          0.05             0           3
0           0           0           0           0           0           0  #  Size_DblN_de-
scend_se_CGFS1(10)
          -999             9          -999          -999          0.05             0          -2
0           0           0           0           0           0           0  #
Size_DblN_start_logit_CGFS1(10)
          -999             9          -999          -999          0.05             0          -2
0           0           0           0           0           0           0  #
Size_DblN_end_logit_CGFS1(10)
# 11   CGFS2 LenSelex
            20            93       36.0059            32          0.05             0           2
0           0           0           0           0           0           0  #  Size_DblN_peak_CGFS2(11)
```

```
          -15             4           -15          -15          0.05             0         -3
0          0          0          0          0          0          0  #
Size_DblN_top_logit_CGFS2(11)
           -1            15       3.58533          3.3          0.05             0          3
0          0          0          0          0          0          0  #  Size_DblN_as-
cend_se_CGFS2(11)
           -5            15       7.45259          4.4          0.05             0          3
0          0          0          0          0          0          0  #  Size_DblN_de-
scend_se_CGFS2(11)
         -999             9          -999         -999          0.05             0         -2
0          0          0          0          0          0          0  #
Size_DblN_start_logit_CGFS2(11)
         -999             9          -999         -999          0.05             0         -2
0          0          0          0          0          0          0  #
Size_DblN_end_logit_CGFS2(11)
# 12   FR_LPUE LenSelex
# 13   Nourdem_DZ LenSelex
           19            93       21.2444           32          0.05             0          2
0          0          0          0          0          0          0  #
Size_DblN_peak_Nourdem_DZ(13)
          -15             4           -15           -6          0.05             0         -3
0          0          0          0          0          0          0  #
Size_DblN_top_logit_Nourdem_DZ(13)
           -1             9       1.92366          3.3          0.05             0          3
0          0          0          0          0          0          0  #  Size_DblN_as-
cend_se_Nourdem_DZ(13)
           -1             9        6.4918          4.4          0.05             0          3
0          0          0          0          0          0          0  #  Size_DblN_de-
scend_se_Nourdem_DZ(13)
         -999             9          -999         -999          0.05             0         -2
0          0          0          0          0          0          0  #
Size_DblN_start_logit_Nourdem_DZ(13)
         -999             9          -999         -999          0.05             0         -2
0          0          0          0          0          0          0  #
Size_DblN_end_logit_Nourdem_DZ(13)
# 14   LaSeine LenSelex
            3            93        7.7657           32          0.05             0          2
0          0          0          0          0          0          0  #  Size_DblN_peak_LaSeine(14)
          -15             4           -15           -6          0.05             0         -3
0          0          0          0          0          0          0  #
Size_DblN_top_logit_LaSeine(14)
           -1             9     0.0125773          3.3          0.05             0          3
0          0          0          0          0          0          0  #  Size_DblN_as-
cend_se_LaSeine(14)
           -1             9       6.32474          4.4          0.05             0          3
0          0          0          0          0          0          0  #  Size_DblN_de-
scend_se_LaSeine(14)
         -999             9          -999         -999          0.05             0         -2
0          0          0          0          0          0          0  #
Size_DblN_start_logit_LaSeine(14)
         -999             9          -999         -999          0.05             0         -2
0          0          0          0          0          0          0  #
Size_DblN_end_logit_LaSeine(14)
# 15   FALHEL LenSelex
            3            93        9.9306           32          0.05             0          2
0          0          0          0          0          0          0  #  Size_DblN_peak_FALHEL(15)
          -15             4           -15           -6          0.05             0         -3
0          0          0          0          0          0          0  #
Size_DblN_top_logit_FALHEL(15)
           -1             9       1.55044          3.3          0.05             0          3
0          0          0          0          0          0          0  #  Size_DblN_as-
cend_se_FALHEL(15)
           -1             9      0.482026          4.4          0.05             0          3
0          0          0          0          0          0          0  #  Size_DblN_de-
scend_se_FALHEL(15)
         -999             9          -999         -999          0.05             0         -2
0          0          0          0          0          0          0  #
Size_DblN_start_logit_FALHEL(15)
         -999             9          -999         -999          0.05             0         -2
0          0          0          0          0          0          0  #
Size_DblN_end_logit_FALHEL(15)
```

```
# 16   OTB_DISC LenSelex
            0            93       33.4737            45          0.05             0          2
0          3       2015       2023          3           0          0  #
Size_DblN_peak_OTB_DISC(16)
           -15             4      -12.5481           -15          0.05             0          3
0          3       2015       2023          3           0          0  #
Size_DblN_top_logit_OTB_DISC(16)
           -20            25       4.03965           3.3          0.05             0          3
0          3       2015       2023          3           0          0  #  Size_DblN_as-
cend_se_OTB_DISC(16)
           -20            20       4.20738           4.4          0.05             0          3
0          0          0          0          0           0          0  #  Size_DblN_de-
scend_se_OTB_DISC(16)
          -999             9          -999          -999          0.05             0         -2
0          0          0          0          0           0          0  #
Size_DblN_start_logit_OTB_DISC(16)
          -999             9          -999          -999          0.05             0         -2
0          0          0          0          0           0          0  #
Size_DblN_end_logit_OTB_DISC(16)
# 17   SEINE_DISC LenSelex
# 1   OTHERS AgeSelex
# 2   GNS AgeSelex
# 3   LHM AgeSelex
# 4   LLS AgeSelex
# 5   OTB AgeSelex
# 6   PTM AgeSelex
# 7   SEINE AgeSelex
# 8   RECFISH AgeSelex
# 9   AutBass AgeSelex
# 10   CGFS1 AgeSelex
# 11   CGFS2 AgeSelex
# 12   FR_LPUE AgeSelex
# 13   Nourdem_DZ AgeSelex
# 14   LaSeine AgeSelex
# 15   FALHEL AgeSelex
# 16   OTB_DISC AgeSelex
# 17   SEINE_DISC AgeSelex
#_No_Dirichlet parameters
# timevary selex parameters
#_           LO            HI          INIT         PRIOR         PR_SD       PR_type     PHASE  #
parm_name
        0.0001             2           0.5           0.5           0.5             6      -5  #
Size_DblN_peak_OTHERS(1)_dev_se
         -0.99          0.99             0             0           0.5             6      -6  #
Size_DblN_peak_OTHERS(1)_dev_autocorr
        0.0001             2           0.5           0.5           0.5             6      -5  #
Size_DblN_peak_GNS(2)_dev_se
         -0.99          0.99             0             0           0.5             6      -6  #
Size_DblN_peak_GNS(2)_dev_autocorr
        0.0001             2           0.5           0.5           0.5             6      -5  #
Size_inflection_LHM(3)_dev_se
         -0.99          0.99             0             0           0.5             6      -6  #
Size_inflection_LHM(3)_dev_autocorr
        0.0001             2           0.5           0.5           0.5             6      -5  #
Size_inflection_LLS(4)_dev_se
         -0.99          0.99             0             0           0.5             6      -6  #
Size_inflection_LLS(4)_dev_autocorr
        0.0001             2           0.5           0.5           0.5             6      -5  #
Size_DblN_peak_OTB(5)_dev_se
         -0.99          0.99             0             0           0.5             6      -6  #
Size_DblN_peak_OTB(5)_dev_autocorr
        0.0001             2           0.5           0.5           0.5             6      -5  #
Size_DblN_peak_SEINE(7)_dev_se
         -0.99          0.99             0             0           0.5             6      -6  #
Size_DblN_peak_SEINE(7)_dev_autocorr
        0.0001             2           0.5           0.5           0.5             6      -5  #
Size_DblN_peak_RECFISH(8)_dev_se
         -0.99          0.99             0             0           0.5             6      -6  #
Size_DblN_peak_RECFISH(8)_dev_autocorr
        0.0001             2           0.5           0.5           0.5             6      -5  #
Size_DblN_peak_OTB_DISC(16)_dev_se
```

```
         -0.99          0.99             0             0           0.5             6      -6  #
Size_DblN_peak_OTB_DISC(16)_dev_autocorr
        0.0001             2           0.5           0.5           0.5             6      -5  #
Size_DblN_top_logit_OTB_DISC(16)_dev_se
         -0.99          0.99             0             0           0.5             6      -6  #
Size_DblN_top_logit_OTB_DISC(16)_dev_autocorr
        0.0001             2           0.5           0.5           0.5             6      -5  #
Size_DblN_ascend_se_OTB_DISC(16)_dev_se
         -0.99          0.99             0             0           0.5             6      -6  #
Size_DblN_ascend_se_OTB_DISC(16)_dev_autocorr
# info on dev vectors created for selex parms are reported with other devs after tag parameter
section
#
0   #  use 2D_AR1 selectivity? (0/1)
#_no 2D_AR1 selex offset used
#_specs:  fleet, ymin, ymax, amin, amax, sigma_amax, use_rho, len1/age2, devphase, before_range,
after_range
#_sigma_amax>amin means create sigma parm for each bin from min to sigma_amax; sigma_amax<0 means
just one sigma parm is read and used for all bins
#_needed parameters follow each fleet's specifications
# -9999  0 0 0 0 0 0 0 0 0 0 # terminator
#
# Tag loss and Tag reporting parameters go next
0  # TG_custom:  0=no read and autogen if tag data exist; 1=read
#_Cond -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0  #_placeholder if no parameters
#
# deviation vectors for timevary parameters
#  base   base first block   block  env  env   dev   dev   dev   dev   dev
#  type  index  parm trend pattern link  var  vectr link _mnyr  mxyr phase  dev_vector
#      5     1     1     0     0     0     0     1     3  2015  2023     3 2.30522 2.18662 1.8672
1.66478 1.51019 1.38022 0.540252 -0.648423 -0.519924
#      5     7     3     0     0     0     0     2     3  2015  2023     3 4.32685 4.48766 1.70988
0.712641 0.622041 -0.627603 0.103631 1.00019 0.30357
#      5    13     5     0     0     0     0     3     3  2015  2023     3 2.34095 1.48393 1.10117
1.27708 -0.13592 -0.291691 0.0674719 0.439408 -0.00164585
#      5    15     7     0     0     0     0     4     3  2015  2023     3 -0.376501 1.36266
1.18542 1.27479 0.404421 1.46381 1.18907 -0.63221 -0.342474
#      5    17     9     0     0     0     0     5     3  2015  2023     3 3.37583 3.73231 2.86086
2.29961 0.763763 0.105479 0.0404739 -0.270127 0.329857
#      5    25    11     0     0     0     0     6     3  2015  2023     3 1.32089 1.23712
0.988873 0.9767 0.976029 0.572739 0.0696136 -0.00383392 -0.087743
#      5    31    13     0     0     0     0     7     3  2015  2023     3 1.12029 1.10596
0.918014 1.11526 1.48602 1.13716 1.18797 0.336518 0.265966
#      5    73    15     0     0     0     0     8     3  2015  2023     3 1.32792 1.32725
0.910792 0.646863 0.281748 0.314189 0.039341 0.274809 0.00357076
#      5    74    17     0     0     0     0     9     3  2015  2023     3 0.000111214 0.000111104
9.76687e-05 7.2879e-05 3.87276e-05 5.80968e-05 3.21204e-05 4.19489e-05 1.25885e-05
#      5    75    19     0     0     0     0    10     3  2015  2023     3 -1.22389 -1.22353 -
0.448325 -0.178452 0.203472 0.363209 0.629005 0.0572278 0.0959734
    #
# Input variance adjustments factors:
 #_1=add_to_survey_CV
 #_2=add_to_discard_stddev
 #_3=add_to_bodywt_CV
 #_4=mult_by_lencomp_N
 #_5=mult_by_agecomp_N
 #_6=mult_by_size-at-age_N
 #_7=mult_by_generalized_sizecomp
#_factor  fleet  value
      4      1  0.337547
      4      2  0.204065
      4      3  0.281074
      4      4   0.44445
      4      5  0.216685
      4      6  0.321123
      4      7  0.310124
      4      8   1.71266
      4     10  0.315937
      4     11  0.405426
      4     13 0.0532417
      4     14 0.0995071
```

```
      4     16  0.106521
      5      5 0.0186129
      5      9 0.0522172
      5     10  0.310538
      5     11  0.246158
      5     13  0.231515
      5     14   0.34022
      5     15 0.0879278
 -9999   1    0  # terminator
#
3 #_maxlambdaphase
1 #_sd_offset; must be 1 if any growthCV, sigmaR, or survey extraSD is an estimated parameter
# read 14 changes to default Lambdas (default value is 1.0)
# Like_comp codes:  1=surv; 2=disc; 3=mnwt; 4=length; 5=age; 6=SizeFreq; 7=sizeage; 8=catch;
9=init_equ_catch;
# 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-negbin;
17=F_ballpark; 18=initEQregime
#like_comp fleet  phase  value  sizefreq_method
 4 1 1 1 1
 4 2 1 1 1
 4 3 1 1 1
 4 4 1 1 1
 4 5 1 1 1
 4 6 1 1 1
 4 7 1 1 1
 5 1 1 1 1
 5 2 1 1 1
 5 3 1 1 1
 5 4 1 1 1
 5 5 1 1 1
 5 6 1 1 1
 5 7 1 1 1
-9999  1  1  1  1  #  terminator
#
# lambdas (for info only; columns are phases)
#  0 0 0 #_CPUE/survey:_1
#  0 0 0 #_CPUE/survey:_2
#  0 0 0 #_CPUE/survey:_3
#  0 0 0 #_CPUE/survey:_4
#  0 0 0 #_CPUE/survey:_5
#  0 0 0 #_CPUE/survey:_6
#  0 0 0 #_CPUE/survey:_7
#  1 1 1 #_CPUE/survey:_8
#  1 1 1 #_CPUE/survey:_9
#  1 1 1 #_CPUE/survey:_10
#  1 1 1 #_CPUE/survey:_11
#  1 1 1 #_CPUE/survey:_12
#  1 1 1 #_CPUE/survey:_13
#  1 1 1 #_CPUE/survey:_14
#  1 1 1 #_CPUE/survey:_15
#  0 0 0 #_CPUE/survey:_16
#  0 0 0 #_CPUE/survey:_17
#  1 1 1 #_lencomp:_1
#  1 1 1 #_lencomp:_2
#  1 1 1 #_lencomp:_3
#  1 1 1 #_lencomp:_4
#  1 1 1 #_lencomp:_5
#  1 1 1 #_lencomp:_6
#  1 1 1 #_lencomp:_7
#  1 1 1 #_lencomp:_8
#  0 0 0 #_lencomp:_9
#  1 1 1 #_lencomp:_10
#  1 1 1 #_lencomp:_11
#  0 0 0 #_lencomp:_12
#  1 1 1 #_lencomp:_13
#  1 1 1 #_lencomp:_14
#  0 0 0 #_lencomp:_15
#  1 1 1 #_lencomp:_16
#  0 0 0 #_lencomp:_17
#  1 1 1 #_agecomp:_1
#  1 1 1 #_agecomp:_2
```

```
#  1 1 1 #_agecomp:_3
#  1 1 1 #_agecomp:_4
#  1 1 1 #_agecomp:_5
#  1 1 1 #_agecomp:_6
#  1 1 1 #_agecomp:_7
#  0 0 0 #_agecomp:_8
#  1 1 1 #_agecomp:_9
#  1 1 1 #_agecomp:_10
#  1 1 1 #_agecomp:_11
#  0 0 0 #_agecomp:_12
#  1 1 1 #_agecomp:_13
#  1 1 1 #_agecomp:_14
#  1 1 1 #_agecomp:_15
#  1 1 1 #_agecomp:_16
#  0 0 0 #_agecomp:_17
#  1 1 1 #_init_equ_catch1
#  1 1 1 #_init_equ_catch2
#  1 1 1 #_init_equ_catch3
#  1 1 1 #_init_equ_catch4
#  1 1 1 #_init_equ_catch5
#  1 1 1 #_init_equ_catch6
#  1 1 1 #_init_equ_catch7
#  1 1 1 #_init_equ_catch8
#  1 1 1 #_init_equ_catch9
#  1 1 1 #_init_equ_catch10
#  1 1 1 #_init_equ_catch11
#  1 1 1 #_init_equ_catch12
#  1 1 1 #_init_equ_catch13
#  1 1 1 #_init_equ_catch14
#  1 1 1 #_init_equ_catch15
#  1 1 1 #_init_equ_catch16
#  1 1 1 #_init_equ_catch17
#  1 1 1 #_recruitments
#  1 1 1 #_parameter-priors
#  1 1 1 #_parameter-dev-vectors
#  1 1 1 #_crashPenLambda
#  0 0 0 # F_ballpark_lambda
0 # (0/1/2) read specs for more stddev reporting: 0 = skip, 1 = read specs for reporting stdev for
selectivity, size, and numbers, 2 = add options for M,Dyn. Bzero, SmryBio
 # 0 2 0 0 # Selectivity: (1) fleet, (2) 1=len/2=age/3=both, (3) year, (4) N selex bins
 # 0 0 # Growth: (1) growth pattern, (2) growth ages
 # 0 0 0 # Numbers-at-age: (1) area(-1 for all), (2) year, (3) N ages
 # -1 # list of bin #'s for selex std (-1 in first bin to self-generate)
 # -1 # list of ages for growth std (-1 in first bin to self-generate)
 # -1 # list of ages for NatAge std (-1 in first bin to self-generate)
999
```

Appendix 3 Starter file

```
#C file created using an r4ss function
#C file write time: 2025-03-03  10:38:49
#
BassIVVII.dat #_datfile
BassIVVII.ctl #_ctlfile
1 #_init_values_src
1 #_run_display_detail
1 #_detailed_age_structure
0 #_checkup
4 #_parmtrace
1 #_cumreport
1 #_prior_like
1 #_soft_bounds
2 #_N_bootstraps
8 #_last_estimation_phase
10 #_MCMCburn
8 #_MCMCthin
0.1 #_jitter_fraction
-1 #_minyr_sdreport
-2 #_maxyr_sdreport
0 #_N_STD_yrs
1e-04 #_converge_criterion
0 #_retro_yr
0 #_min_age_summary_bio
1 #_depl_basis
1 #_depl_denom_frac
2 #_SPR_basis
5 #_F_std_units
4 15 #_F_age_range
0 #_F_std_basis
0 #_MCMC_output_detail
0 #_ALK_tolerance
#
-1 #_seed
3.3 #_final
```

Appendix 4 Forecast file

```
#V3.30.17.00;_2021_06_11;_trans;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_12.3
#Stock Synthesis (SS) is a work of the U.S. Government and is not subject to copyright protec-
tion in the United States.
#Foreign copyrights may apply. See copyright.txt for more information.
# for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for en-
dyr, neg number for rel. endyr
1 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy; 2=calc F_spr,F0.1,F_msy
2 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt) or F0.1; 4=set to F(endyr)
0.35 # SPR target (e.g. 0.40)
0.4 # Biomass target (e.g. 0.40)
#C file created using an r4ss function
#C file write time: 2025-01-28  16:15:36
#
1 #_benchmarks
2 #_MSY
0.35 #_SPRtarget
0.4 #_Btarget
#_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF,  beg_recr_dist,
end_recr_dist, beg_SRparm, end_SRparm (enter actual year, or values of 0 or -integer to be
rel. endyr)
0 0 0 0 0 0 0 0 0 0
1 #_Bmark_relF_Basis
1 #_Forecast
1 #_Nforecastyrs
1 #_F_scalar
#_Fcast_years:  beg_selex, end_selex, beg_relF, end_relF, beg_recruits, end_recruits (enter
actual year, or values of 0 or -integer to be rel. endyr)
-2 0 -2 0 -999 0
0 #_Fcast_selex
1 #_ControlRuleMethod
0.4 #_BforconstantF
0.1 #_BfornoF
0.75 #_Flimitfraction
3 #_N_forecast_loops
3 #_First_forecast_loop_with_stochastic_recruitment
0 #_fcast_rec_option
1 #_fcast_rec_val
0 #_Fcast_loop_control_5
2020 #_FirstYear_for_caps_and_allocations
0 #_stddev_of_log_catch_ratio
0 #_Do_West_Coast_gfish_rebuilder_output
1999 #_Ydecl
2024 #_Yinit
1 #_fleet_relative_F
# Note that fleet allocation is used directly as average F if Do_Forecast=4
2 #_basis_for_fcast_catch_tuning
# enter list of fleet number and max for fleets with max annual catch; terminate with fleet=-
9999
-9999 -1
# enter list of area ID and max annual catch; terminate with area=-9999
-9999 -1
# enter list of fleet number and allocation group assignment, if any; terminate with fleet=-
9999
-9999 -1
-1 #_InputBasis
 #_Year Seas Fleet Catch.or.F Basis
   2024    1     1        0.1    99
   2024    1     2        0.1    99
   2024    1     3        0.2    99
   2024    1     4        0.1    99
   2024    1     5        0.1    99
   2024    1     6        0.1    99
   2024    1     7        0.1    99
   2024    1     8        0.1    99
   2024    1     16        0.1    99
   2024    1    17       0.1    99
   2025    1     1        0.1    99
   2025    1     2        0.1    99
   2025    1     3        0.1    99
   2025    1     4        0.1    99
   2025    1     5        0.1    99
   2025    1     6        0.1    99
```

```
   2025    1     7        0.1    99
   2025    1     8        0.1    99
   2025    1     16       0.1    99
   2025    1    17       0.1    99
   2026    1     1        0.1    99
   2026    1     2        0.1    99
   2026    1     3        0.1    99
   2026    1     4        0.1    99
   2026    1     5        0.1    99
   2026    1     6        0.1    99
   2026    1     7        0.1    99
   2026    1     8        0.1    99
   2026    1     16        0.1    99
   2026    1    17       0.1    99
-9999 0 0 0 0
#
999 # verify end of input
```

Appendix 5. Reference points

Northern seabass stock Eqsim

Hans Gerritsen, modified by Tim Earl

03/03/2025

The ICES approach to setting Reference Points

This Markdown document outlines the steps involved in estimating PA and MSY reference points for sea bass in divisions 4.b-c, 7a and 7d-h as part of WKBSEABASS benchmark 2024. It follows the current technical guidelines: *https://www.ices.dk/sites/pub/Publication%20Reports/Guidelines%20and%20Policies/16.04.03.01_Reference_points_for_category_1_and_2.pdf*.

Some plot legends refer to landings or catch - These should all be read as "Total removals", *i.e.* commercial landings, discards, recreational landings + the proportion of recreational releases assumed to die following release

Get the data in FLR

```
library(r4ss)
library(ss3om) #for readLFSss3
library(FLCore)
library(msy)
library(icesAdvice)
library(ggplot2)
library(dplyr)


#Slight modification from package ss3om to account for apparent name chang
e in F type
readFLSss3 <- function (dir, repfile = "Report.sso", compfile = "CompRepor
t.sso",
    wtatage = out$wtatage_switch, ...)
{
   # browser()
    out <- readOutputss3(dir, repfile = repfile, compfile = compfile)
    if (out$SS_versionNumeric > 3.24)
        res <- buildFLSss330(out, ...)
    else res <- buildFLSss3(out, ...)
    if (wtatage) {
        waafile <- list.files(dir)[grep("wtatage.ss_new", list.files(dir))
]
        waa <- data.table(SS_readwtatage(file.path(dir, waafile)))
        waa[, `:=`(year, abs(Yr))]
        waa[, `:=`(unit, Sex)]
        waa[, `:=`(season, Seas)]
        ages <- dimnames(res)$age
        waa <- waa[year %in% dimnames(res)$year, ]
        was <- split(waa, by = "Fleet")
        wasq <- lapply(was, function(x) as.FLQuant(melt(x[, -seq(1,
```

```
            6)], id = c("unit", "year", "season"), measure = ages,
            variable.name = "age", value.name = "data")))
        stock.wt(res)[] <- wasq[["0"]]
        nmat <- wasq[["-2"]]%/%wasq[["-1"]]
        mat(res)[] <- nmat
        if (is.null(out$fleet_type)) {
            out$fleet_type <- rep(3, out$nfleets)
            out$fleet_type[out$fleet_ID %in% unique(out$catch$Fleet)] <- 1
        }
        idx <- names(wasq)[!names(wasq) %in% c("0", "-1", "-2")][out$fleet
_type ==
            1]
        catch.wt(res)[] <- Reduce("+", wasq[idx])/(length(idx))
        landings.wt(res) <- catch.wt(res)
        discards.wt(res) <- catch.wt(res)
        catch(res) <- computeCatch(res)
        landings(res) <- computeLandings(res)
        discards(res) <- computeDiscards(res)
        stock(res) <- computeStock(res)
    }
    if (file.exists(file.path(dir, "starter.ss"))) {
        sta <- SS_readstarter(file.path(dir, "starter.ss"), verbose = FALS
E)
        if (sta$F_std_units == 5) {    #F_reporting units in ss3om package
            range(res)[c("minfbar", "maxfbar")] <- sta$F_age_range
        }
    }
    return(res)
}

replist <- SS_output('../Model final march',verbose=F,printstats=F)
stock0 <- readFLSss3('../Model final march')

stock0@harvest@units <- 'f'
# check fbar range used in SS
replist$F_std_basis

## [1] "_abs_F;_with_F=Z-M;_for_ages_unweighted_4_15"

stock0@range['minfbar'] <- 4
stock0@range['maxfbar'] <- 15

#Define SSB time as the start of the year
m.spwn(stock0) <- 0
harvest.spwn(stock0) <- 0


# # combine the sexes #Not needed for bass as combined sex
# stock <- FLCore:::nounit(stock0)  #
stock <- stock0

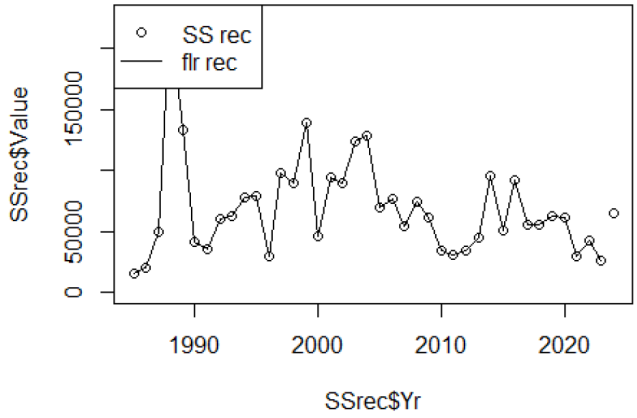
#check that F is ok
all(harvest(stock) ==  harvest(stock.n(stock), catch=catch.n(stock), m=m(s
tock)))
```

```
## [1] TRUE

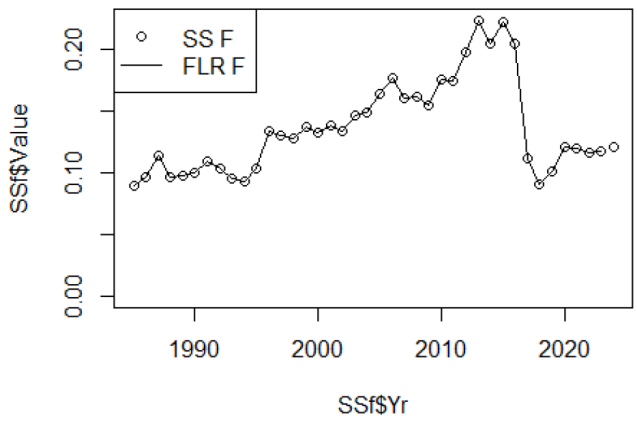
SSssb <- subset(replist$derived_quants,substring(Label,1,6)%in%c('SSB_19',
'SSB_20')) %>%
  mutate(Yr=as.numeric(substring(Label,5,9)))
 plot(SSssb$Yr,SSssb$Value)
lines(stock@range[[4]]:stock@range[[5]],ssb(stock))
# lines(stock0@range[[4]]:stock0@range[[5]],ssb(stock0)[,,1],col='red')
legend('topright',c('SS ssb','flr ssb'),pch=c(1,NA),lty=c(NA,1),col=c(1,1)
)
```



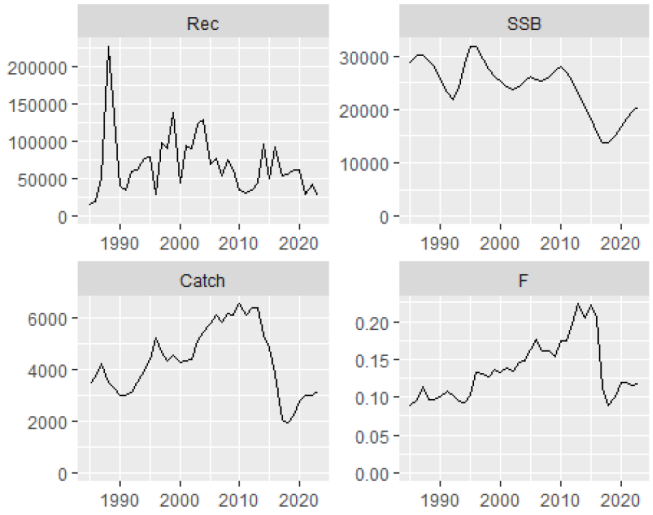

```
# check recruitment
SSrec <- subset(replist$derived_quants,substring(Label,1,7)%in%c('Recr_19'
,'Recr_20')) %>%
  mutate(Yr=as.numeric(substring(Label,6,10)))
plot(SSrec$Yr,SSrec$Value, ylim=c(0,max(SSrec$Value)))
lines(stock@range[[4]]:stock@range[[5]],rec(stock))
legend('topleft',c('SS rec','flr rec'),pch=c(1,NA),lty=c(NA,1),col=1)
```




```
# check F
SSf <- subset(replist$derived_quants,substring(Label,1,4)%in%c('F_19','F_2
0')) %>%
  mutate(Yr=as.numeric(substring(Label,3,7)))
plot(SSf$Yr,SSf$Value, ylim=c(0,max(SSf$Value)))
lines(stock@range[[4]]:stock@range[[5]],fbar(stock))
legend('topleft',c('SS F','FLR F'),pch=c(1,NA),lty=c(NA,1),col=1)
```



```
# stock summary
plot(stock) + facet_wrap(~qname, scales="free")
```



Stock-recruitment

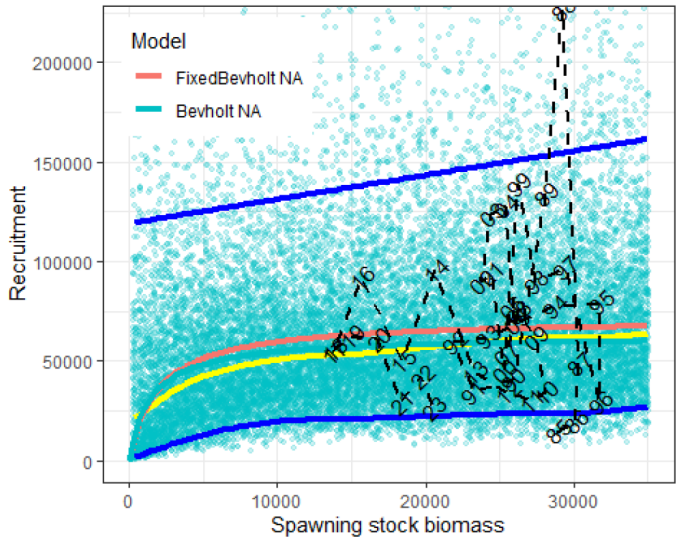
Now get the stock-recruitment parameters from SS and force the SR function to be the same. This fixes the steepness and R_0 but not $sigma_R$, which it will estimate from the actual SR pairs...

```
# SR para from SS
r0 <- replist$parameters$Value[replist$parameters$Label=="SR_LN(R0)"]
R0 <- exp(r0)
h <- replist$parameters$Value[replist$parameters$Label=="SR_BH_steep"]
B0 <- c(replist$derived_quants$Value[replist$derived_quants$Label=="SSB_Virgin"])
# other SR para are not used here
sigmaR <- replist$parameters$Value[replist$parameters$Label=="SR_sigmaR"]
rho <- replist$parameters$Value[replist$parameters$Label=="SR_autocorr"]

FixedBevholt <- function (ab,ssb) log(4*h*R0*ssb/(B0*(1-h)+ssb*(5*h-1)))
# be careful to not modify h, R0 and B0 later in the script
```

Check what SR looks like, also compare with Beverton-Holt fit to the data (without fixing h). FixedBevHolt is the assessment output.

```
set.seed(1)
nsamp <- 1000 #increase number of samples for final run (e.g 1000)
fit_bh_temp <- eqsr_fit(stock, nsamp = nsamp, models = c("FixedBevholt","Bevholt"))
fit_bh <- eqsr_fit(stock, nsamp = nsamp, models = c("FixedBevholt"))
eqsr_plot(fit_bh_temp,ggPlot=T)
```




```
fit_bh$stk <- stock0#Want to have data up to 2023 available for selectivit
y

#with(replist$SPAWN_RECR_CURVE,points(SSB,Recruitment,col=5,pch=16))
```

Identifying appropriate data

Check which estimates of recruitment have high uncertainty. We decide to keeep all model years when calculating reference points for consistency between the assessment and reference points.

```
head(SSrec, 10)[,1:3]

##               Label    Value   StdDev
## Recr_1985 Recr_1985  14653.2  8711.44
## Recr_1986 Recr_1986  19780.0 11950.60
## Recr_1987 Recr_1987  49215.2 22483.90
## Recr_1988 Recr_1988 226576.0 51411.20
## Recr_1989 Recr_1989 133733.0 42363.50
## Recr_1990 Recr_1990  41179.6 20483.90
## Recr_1991 Recr_1991  34731.0 15104.90
## Recr_1992 Recr_1992  59925.0 17845.80
## Recr_1993 Recr_1993  62189.2 18047.50
## Recr_1994 Recr_1994  77791.7 16334.80

tail(SSrec, 10)[,1:3]

##               Label   Value   StdDev
## Recr_2015 Recr_2015 50287.1  8037.04
## Recr_2016 Recr_2016 92292.6 11701.50
## Recr_2017 Recr_2017 54833.5  9009.99
```

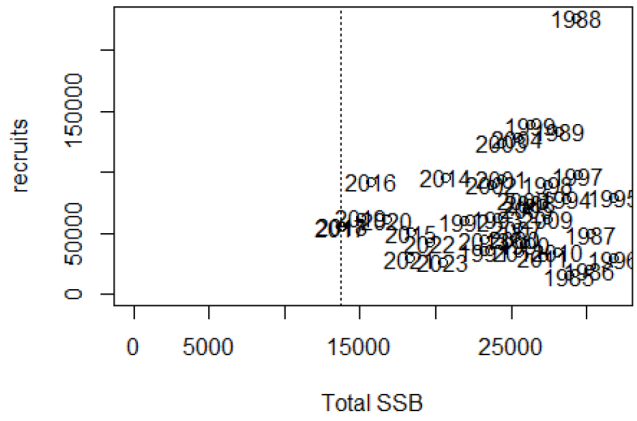
```
## Recr_2018 Recr_2018 55769.5  9791.89
## Recr_2019 Recr_2019 62434.1 11444.90
## Recr_2020 Recr_2020 61089.3 12140.50
## Recr_2021 Recr_2021 29164.6  7797.54
## Recr_2022 Recr_2022 42108.6 13317.60
## Recr_2023 Recr_2023 26363.1 14604.60
## Recr_2024 Recr_2024 65204.6 58773.30

#stock <- window(stock,start=1988,end=2022)
```

Step 2. Stock type and step 3. B~lim}

The stock is type 5 (no evidence of impaired recruitment), so B_{lim} is B_{loss} = B_{2017} = 13,721.

```
plot(c(ssb(stock)),c(rec(stock)),
     xlim=c(0,max(ssb(stock))),ylim=c(0,max(rec(stock))),
     xlab='Total SSB',ylab='recruits')
text(c(ssb(stock)),c(rec(stock)),stock@range[4]:stock@range[5])
Blim <- round(c(ssb(stock)[,'2017',]))
abline(v=Blim,lty=3)
```



Sanity check:

Check B_{lim} is not a very small percentage of B_0. Percentage is 26%, so no issue.

Step 4. Other PA reference points from B_{lim}

```
sigmaSSB_SS <- round(with(subset(replist$derived_quants,Label=='SSB_2024')
,StdDev/Value),3)
## or just stick to the default?
#sigmaSSB <- 0.2 # default
sigmaSSB_SS

## [1] 0.15
```

```
Bpa <- round(Blim * exp(1.645 * sigmaSSB_SS))
Bpa

## [1] 17562
```

F_{lim}

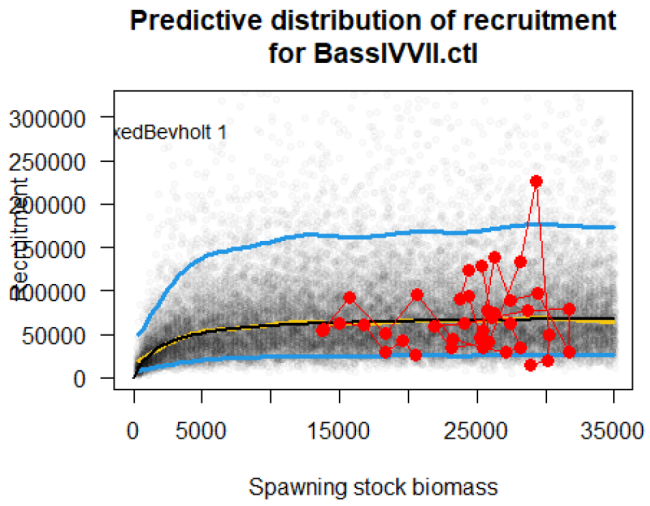
No longer needed

Step 2. F_{MSY} and MSY $B_{trigger}$

F_{MSY} should initially be calculated based on an evaluation with the inclusion of stochasticity in a population (i.e. recruitment, M, maturity, growth) and fishery (e.g. selectivity) as well as assessment/advice error. This is a constant F, which should provide maximum yield without biomass constraints (without MSY $B_{trigger}$). Error is included as this is the condition analogous to management strategy evaluations (MSEs) that will prevail in practice. Note that in order to ensure consistency between the precautionary and the MSY frameworks, F_{MSY} is not allowed to be above F_{pa}; therefore, if the F_{MSY} value calculated initially is above F_{pa}, F_{MSY} is reduced to F_{pa}.

```
# fit BH again using only the selected years

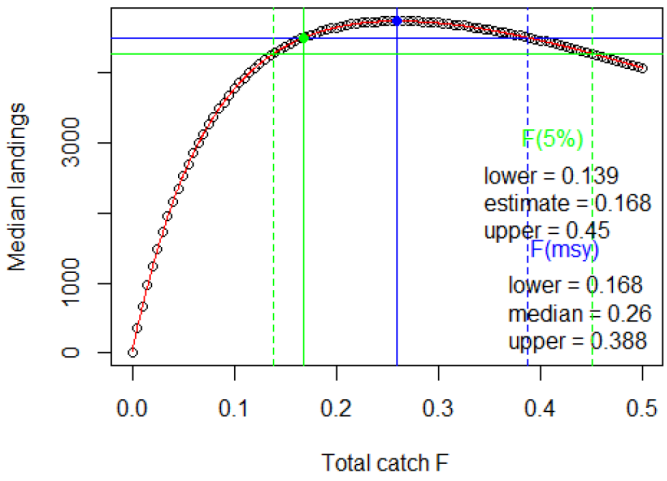
eqsr_plot(fit_bh,ggPlot=FALSE)
```




```
## Forecast error (see Guidance document for details on calculation of the
se values)
# F
cvF  <- 0.212                                  # Default = 0.212
phiF <- 0.423                                  # Default = 0.423
# SSB
cvSSB <- 0                                     # Default = 0
phiSSB <- 0                                    # Default = 0
```

```
sim_noTrig <- eqsim_run(fit_bh,
                        Fcv=cvF, Fphi=phiF, SSBcv=cvSSB,
                        rhologRec=rho,
                        Btrigger = 0, Blim=Blim, Bpa=Bpa,
                        Nrun=200, Fscan = seq(0,0.5,len=101),verbose=F
)

Fmsy_tmp <- round(sim_noTrig$Refs2["lanF","medianMSY"],3)
eqsim_plot_range(sim_noTrig, type="median")
```

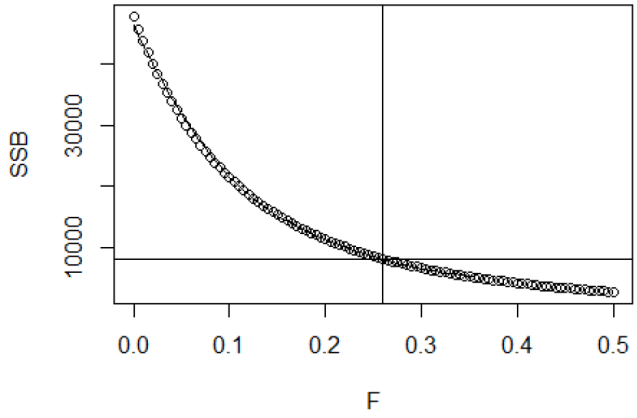


F_{MSY} is initially estimated as 0.26. Note that SS estimates F_{MSY} at 0.267.

MSY $B_{trigger}$ should be selected to safeguard against an undesirable or unexpected low SSB when fishing at FMSY. For most stocks that lack data on fishing at F_{MSY}, MSY $B_{trigger}$ is set at B_{pa}. However, as a stock starts to be fished consistently with F_{MSY}, it is possible to move towards implementation of a value for MSY $B_{trigger}$ that reflects the 5th percentile definition of MSY $B_{trigger}$.

```
data.05<-sim_noTrig$rbp
x.05 <- data.05[data.05$variable == "Spawning stock biomass", ]$Ftarget
b.05 <- data.05[data.05$variable == "Spawning stock biomass", ]$p05
plot(b.05~x.05, ylab="SSB", xlab="F")
abline(v=Fmsy_tmp)
i <- which(x.05<(Fmsy_tmp+0.1))
b.lm <- loess(b.05[i] ~ x.05[i])
lines(x.05[i],c(predict(b.lm)),type='l')

Bmsy5pc <- round(predict(b.lm,Fmsy_tmp))
abline(h=Bmsy5pc)
```



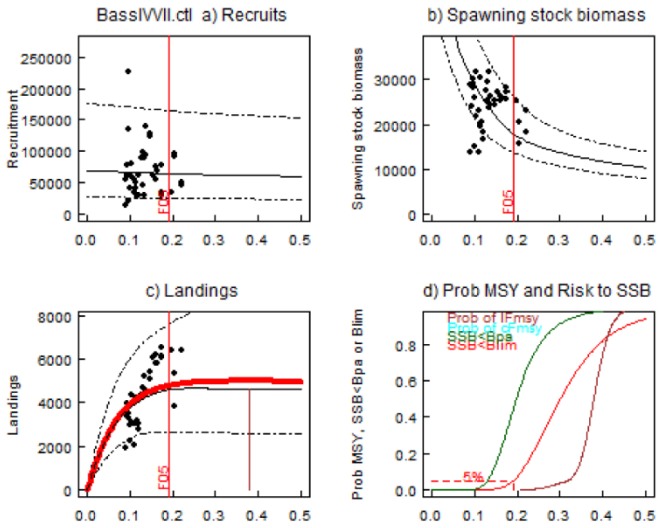
So we can use $B_{trigger} = B_{pa}$ =17,562 or we can use $B_{MSY5\%}$ = 8,093. B_{pa} is higher so go with that.

```
Btrigger <- max(Bpa, Bmsy5pc)
formatC(Btrigger,format='d',big.mark=",")
```

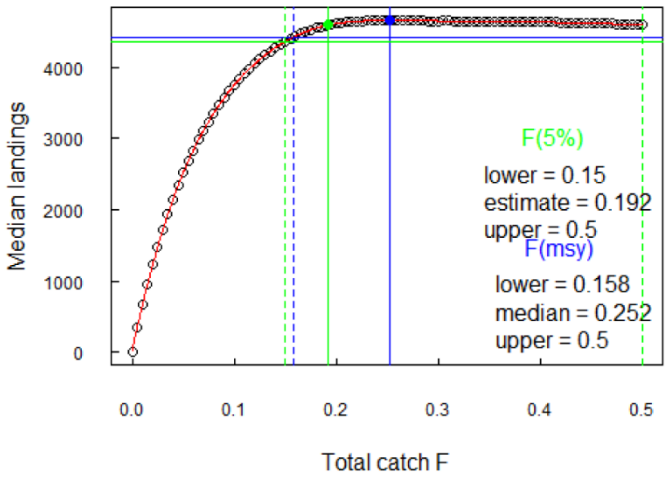
```
## [1] "17,562"
```

The ICES MSY AR should be evaluated to check that the FMSY and MSY $B_{trigger}$ combination fulfills the precautionary criterion of having less than 5% annual probability of SSB < B_{lim} in the long term. The evaluation must include realistic assessment/advice error and stochasticity in population biology and fishery selectivity.

```
sim_Trig <- eqsim_run(fit_bh,
                          Fcv=cvF, Fphi=phiF, SSBcv=cvSSB,
                          rhologRec=rho,
                          Btrigger = Btrigger, Blim=Blim,Bpa=Bpa,
                          Nrun=200, Fscan = seq(0,0.5,len=101),verbose=F)
eqsim_plot(sim_Trig,catch=F)
```




```
eqsim_plot_range(sim_Trig, type="median")
```




```
Fp05 <- round(sim_Trig$Refs2["catF","F05"],3)
```

If the precautionary criterion evaluated in point 3 is not met, then F_{MSY} should be reduced from the value calculated above until the precautionary criterion is met (i.e. reduce F_{MSY} to $F_{MSY} = F_{p05}$). F_{p05} is estimated at 0.192.

```
Fmsy <- round(min(sim_Trig$Refs2["lanF","medianMSY"], Fp05),3)
Fupper <- round(min(sim_Trig$Refs2["lanF","Medupper"], Fp05),3)
Flower <- round(sim_Trig$Refs2["lanF","Medlower"],3)
```

The estimated reference points are shown below.

Reference Point	Value	Rationale
B_{lim}	13,722	B(2017); B_{loss}
B_{pa}	17,562	B_{lim} with assessment error
MSY $B_{trigger}$	17,562	B_{pa}
F_{pa}	0.192	F with 95% probability of SSB≥B_{lim} (BH with Btrigger)
F_{MSY}	0.192	F_{pa}
F_{MSY_Lower}	0.158	Stochastic simulations
F_{MSY_Upper}	0.192	F_{pa}
B_{MSY5pc}	8,093	Stochastic simulations

```
save.image("Rmarkdown_output.rdata")
```

Annex 5: Southern stock (bss.27.8ab) stock assessment model after benchmark

Southern sea bass stock assessment model

***Dicentrarchus Labrax* in divisions 8.a–b; bss.27.8ab**

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1 Issues list

The WKBSEABASS 2024 model builds on previous work developed over the past 15 years, starting with IBP-BASS 2012 (ICES, 2012) recommending to WGCSE 2013 an assessment of the northern stock through SS3 and recommending that southern stock should be treated as functionally separate population (having insufficient data to develop analytical assessments).

For bss.27.4bc7d-h, further improvements linked to input data and model configuration were made during IBP-BASS 2014 (ICES, 2014). WKBASS 2017 and WKBASS 2018 (ICES, 2018) addressed a number of issues, and explicitly modelled the management controls in place from 2015 onwards.

For bss.27.8ab, an analytical model using SS3 was proposed during WKBASS 2018 (ICES, 2018).

The aim of WKSEABASS 2024, with regards to the northern stock specifically, was to address the latest issue list as detailed in Table 1. The main objectives included:

- Review stock boundaries between the Biscay and Northern stocks as there is evidence of mixing.
- Revise the fleet structure to address issues of the combined French fleet not reflecting the selectivity of the French fleets separately.
- Include discard data in the model fit where possible.
- Consider inclusion of surveys (i.e. recruitment surveys).
- Use latest recreational survey data to characterize recreational removals.
- Review and update the method to calculate the LPUE index.

Table 1. Updated issues list for Bss.27.8ab available to WKBSEABASS, and progress made at WKBSEABASS.

Type	Problem/Aim	Work Required	Data Required	Progress Made
Stock identity	Recent researches on sea bass population structure question the current functioning of the ICES stock assessment models: 1) independent management of the Northern and Bay of Biscay sea bass stocks; and 2) the pertinence of the 48°N stock delimitation.	Evaluate the consequences of a change of stock delimitation or of exchange rates between stocks. This can be done/tested with the current (non-spatial) models but by moving the boundary (if possible with the available data) or by developing a spatial model (with different boundaries and different exchange levels).	Genetic and movement data required.	A stock ID workshop was held in Nov. 2022, as the initial step of the current benchmark process. Exchange rates were estimated between the Northern and Bay of Biscay stocks. Catches were reallocated on a seasonal basis.

(New) data to be considered	Recruitment estimate is highly variable and uncertain. Its estimation is only based on commercial length composition data, with age 4 being the first age sampled by the fishery. However new survey time series are carried out in the main estuaries along the French Atlantic coast since 2016. They provide abundance estimates for pre-recruited sea bass (ages 1 to 4) in Loire and Gironde estuaries respectively since 2016 and 2019.	Implement the two new abundance indices within the stock assessment model	time-series of abundance indices at age.	Abundance indices were implemented within the stock assessment model with associated length composition and age-length keys. Those indices were derived from trawl surveys targeting juvenile seabass in Loire and Gironde estuaries.
Sampling	Robust relative fishery-independent abundance indices are needed for adult sea bass in the Bay of Biscay. The establishment of dedicated surveys on the spawning grounds could provide valuable information on trends in abundance and population structure of adult sea bass as well as information on stock structure and linkages between spawning and recruitment grounds using drift model.	Carry out a research survey in winter in the Bay of Biscay.	Data not provided	None
Biological parameters	An age reader change occurred since 2018. It resulted in biased age-length keys data in the recent years, affecting the reliability of the assessment when included.	A sensitivity analysis has been run in WGBIE 2021 to account for a reader change. It consisted in implementing 2 age error definitions in the assessment model and in disaggregating conditional age-length keys data and ghost age composition data according to readers. Results have been presented and reported in WGBIE 2021.	Inter-calibration data between age readers (available). conditional age-length keys and age composition data disaggregated according to readers.	No historical inter calibration data to implement properly age reader change over the whole period. One ageing error included based on inter-calibration between the 2 French age readers from Biscay.

Other issues	Minimum landing size has changed in 2017 and in 2020, increasing respectively from 36 cm to 38 cm, and from 38 cm to 40 cm. Those management measures may affect the selectivity pattern of the fishing fleets, if compliance is observed.	Evaluate the need to account for such a potential change in the selectivity pattern of the fishery. Practically, a sensitivity analysis was performed during WGBIE 2021, that compared the base assessment to an alternative assessment for which blocks were implemented to account for time varying selectivity. Results were reported in WGBIE 2021. The recruitment series was more stable than that of the base assessment.	InterCatch data call	Landings and discards for the main fleets targeting seabass in the Bay of Biscay are now input data for the assessment model. Selectivity and retention patterns are fitted to the length composition data of those fleets. Blocks on retention patterns were tested to mimic minimum landing size change, but it was not kept as the assessment model were unstable.

2 Model platform

Assessment of Bay of Biscay seabass (*Dicentrarchus labrax*; bss.27.8ab) in ICES subdivisions 8a and 8b was conducted using the Stock Synthesis (SS) model (Methot & Wetzel 2013, Methot et al., 2022). Stock Synthesis is programmed in the ADMB C++ software and searches for the set of parameter values that maximize the goodness-of-fit, then calculates the variance of these parameters using inverse Hessian and MCMC methods. The assessment was conducted using the 3.30.23 version of the Stock Synthesis software under the windows and Linux platforms.

The Stock Synthesis framework was chosen again as the assessment requires a modelling framework capable of handling a mixture of age and length data for fisheries and surveys (fleet-based landings; landings age or length compositions, age-based survey indices for young sea bass; age-length-keys) and biological information on growth rates and maturity. It is a highly flexible statistical model framework allowing the building of simple to complex models using a mix of data compositions available.

3 Assessment model data and general configuration

The assessment model of Bay of Biscay seabass is age-based, single sex, single area, multiple fleet, multiple surveys and single LPUE model with a population comprised of 16+ age classes (with age 16 representing a plus group). The model has a yearly time step with sexes combined (males and females are modelled together). Fishing mortality was modelled using a fleet-specific method (Methot et al., 2022). Option 5 was selected for the F report basis as this option corresponds to the fishing mortality requested by the ICES framework (i.e., simple unweighted average of the F of the age classes chosen to represent the Fbar (age 4-15)).

3.1 Stock structure and reallocation

A stock ID workshop was run as part of WKBSEBASS 2024 (ICES 2023). The evidence reviewed pointed towards the need to consider the level of mixing between currently defined northern and Biscay stocks for assessment and management. The WKBSEABASS 2024 model therefore includes an element of mixing via a reallocation of commercial catches and recreational removals during the summer and autumn quarters between the two assessment areas.

The analysis of the DST tagging data from France, UK and Belgium (Annex 6) shows that the stocks of seabass from the Bay of Biscay (Southern stock) and the central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and Celtic Sea (Northern stock) mix during the feeding season (summer and autumn). At that time, many sea bass from the Bay of Biscay are found in the western channel where they can be caught by the fishery operating in that area.

From the tagging experiment, it was possible to estimate the proportion of fish in quarter 3 and quarter 4 present in the Northern stock that would migrate to the Bay of Biscay at the end of each of those two quarters. Hence, 28.8% of adult seabass are estimated to migrate from the Northern stock to Southern stock area at the end of quarter 3 (on the 1st of October) and 40.7% at the end quarter 4 (on the 1st of January). 28.8 % of seabass caught in the Northern stock area from July 1st to September 30 are therefore allocated to the Southern stock and, similarly, 40.7 % caught in the Northern stock area from October 1st to December 31th. More details can be found at the commercial landings and discards, and recreational removals sections.

3.2 Commercial landing and discards

3.2.1 Fleet structure

The WKBASS 2018 assessment included only a French fleet including all gears (ICES, 2018).

With the management measures on minimum landing size which had the potential to affect the contribution of different gear types in the 'French fleet' (i.e. change in the selectivity and retention), it was necessary to revise the categorisation of the fleet structure for the Bay of Biscay stock area.

Commercial landings were split according to the main fleets fishing seabass in the Bay of Biscay: bottom trawls (OTB), pelagic trawls (PTM), gillnets (GNS), trammel nets (GTR), longlines (LLS), handlines (LHM) and other gears (OTHER) (Annex 5).

The commercial landings data by country and gear grouping for the benchmark assessment are given in the input data file (Appendix 1). France is still the main country targeting sea bass in the Bay of Biscay.

3.2.2 Commercial landings, length compositions and age-length keys

Following the WKSEABASS data call, commercial landings extracted from the Intercatch database between 1985 and 2023. However, no data were available for French fleet for years 1985-1998. We thus used the same method than that used at the previous benchmarks (ICES, 2012; 2014; 2018) to reconstruct the French landings from 1985 to 1998 (Annex 5). Then, commercial landings were split according to the fleet structure as described above (Figure 1).

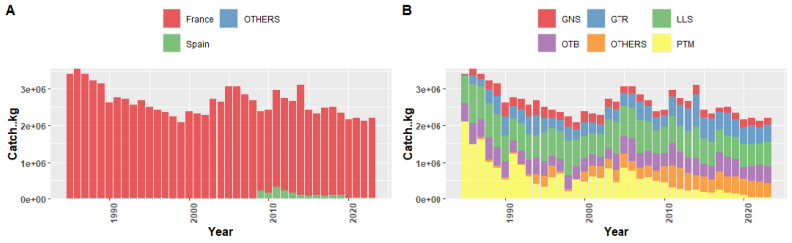


Figure 1. Bay of Biscay seabass in ICES divisions 8ab. Commercial catches split by country (A) and by gear (B).

As in WKBASS 2018 (ICES, 2018), the assessment model included length compositions for the landings of each fleet. Yearly age-length keys (ALKs) combined in a single commercial fleet were used in order to provide model estimates of catch-at-age. Marginal age compositions per fleets were not included in the model likelihood, but they were used for visual inspection.

3.2.3 Commercial discards and length compositions

Discards, estimated from the observers' program, were included in the Bay of Biscay assessment to account for size selectivity and retention changes due to recent management measures on the minimum landing size (MLS) (Figure 2). In 2017, the MLS was set to 38 cm in the Bay of Biscay. In 2019, it was revised to 40 cm and applied in 2020 (EU, 2020).

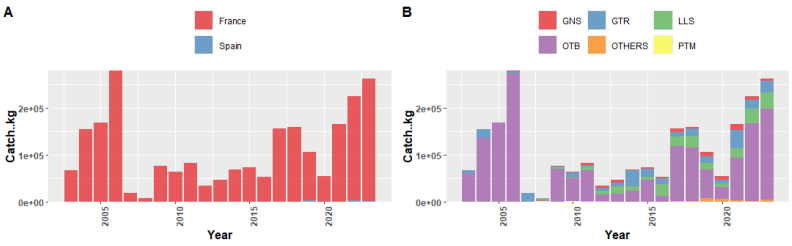


Figure 2. Bay of Biscay seabass in ICES divisions 8ab. Commercial discards split by country (A) and by gear (B).

Length compositions were included for the discards for the following fleets: OTB, GNS, GTR and LLS.

3.2.4 Commercial catches reallocation

As described before, to account for seasonal stock mixing, it was necessary to reallocated catches based home location, mixing rates, and seasonality in the catches. Home location was defined as the area within which individual sea bass spawn. The detailed computation can be found in the

Annex 5 and 6. Calculation have been made only on landings, considering that discards are mainly young individuals who do not migrate. To get the final reallocation, several steps have been necessary:

1. Reconstruction of quarterly landings over the historical period 1985-2000: as shown previously historical times series are incomplete in Intercatch and have been recalculated, but without the quarterly information (only annually). Proportion of quarterly landings over the period 2000-2005 has been applied to historical period reconstructed in order to have quarterly landings reconstructed.
2. Based on the proportion of fish that would migrate (28.8% and 40.7%) from one stock to the other, depending of the period (respectively end of quarter 3 and quarter 4) it has been possible to recalculate landings reallocated from North to South (Figure 3).

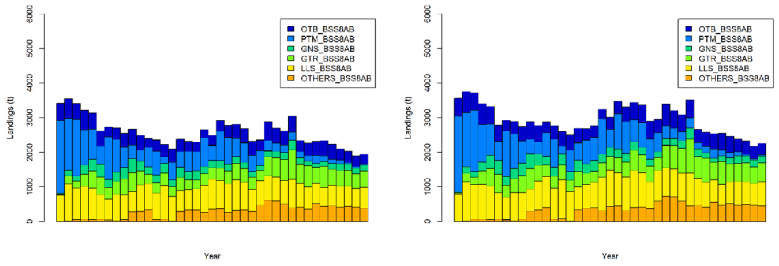


Figure 3. Bay of Biscay seabass in ICES divisions 8ab. Left) Bay of Biscay commercial landings. Right) Bay of Biscay commercial landings with reallocated landings.

3.3 Recreational removals

For a full description of the approach for generating times series of recreational data see Annex 1.

3.3.1 Catch

National survey data for recreational catches was provided by countries exploiting the stocks (i.e., France, Germany, Ireland, the Netherlands, and the UK). The surveys covered both retained and released catches, as well as length-frequency data. National surveys had different coverage, methodology, and temporal resolution which made creating a comprehensive time series challenging (Table 2). Management measures have been implemented and changed regularly, making constructing time series of the retained and released components more difficult.

Table 2. Summary of national estimates for sea bass. C: catch; L: length-frequencies; A: angling; S: spearfishing; and N: nets. Orange area offsite surveys and grey dappling onsite surveys. Purple box denotes data used for the previous benchmark (ICES 2018).

Year	Belgium 4.c	Germany 4.b	Denmark 4.b	France 7.d-e, 8a-b	Ireland 7.a, 7.g	Netherlands 4.c	UK 4b-c, 7.a,d-h
2009				C,L,A,S			
2010						C,A	
2011				C,L,A,S			
2012						C,L,A	C,L,A

Year	Belgium 4.c	Germany 4.b	Denmark 4.b	France 7.d-e, 8a-b	Ireland 7.a, 7.g	Netherlands 4.c	UK 4b-c, 7.a,d-h
2013							
2014		C,A				C,L,A	
2015							
2016						C,L,A	C,L,A
2017	C,L,A		C,L,A				
2018				C,L,A,S		C,L,A	
2019					C,L,A		
2020						C,L,A	
2021		C,L,A		C,L,A,S			
2022					C,L,A	C,L,A	
2023							

Kept and released estimates and associated errors were combined for each stock area accounting for missing errors, countries, years, and partitioning between areas. Germany was excluded from the analysis as a robust estimation of catch was not available, and French estimates from 2011-12 and 2018-19 were excluded due to quality issues.

An approach for assessing the impact of management measures provided forward projections of the levels of catches. Forward projections overestimated the impact of management measures with the difference largest for the released component. Backward projections from surveys done after the implementation of management were calculated and used as inputs for the assessment. This resulted in generation of a time series of retained and released components from 2016 – 2023 (Figure 4).

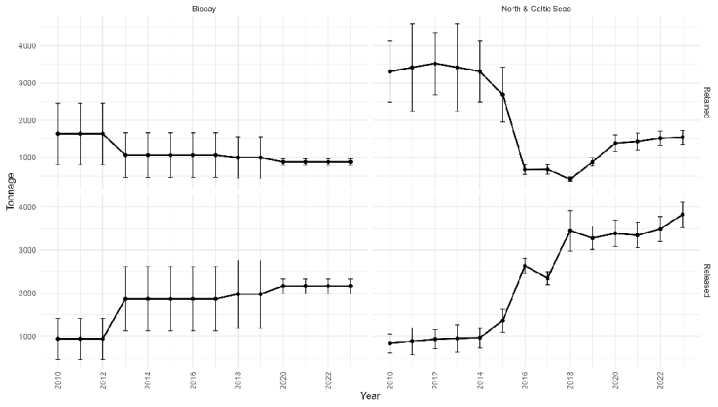


Figure 4. Backwards projections of the impact of management measures with survey estimates in tonnage for each area. (top – retained, bottom – released).

Limited studies of post-release mortality (PRM) exist, with the most robust estimate of 5.0% (Lewin et al. 2018). Applying this PRM to the release component of the catch resulted in a time series of removals (kept + fish that die on or after release) from 2016 to 2023 for use in the assessment.

3.3.2 Length frequency

Length distributions alongside sample sizes were provided by Belgium, France, Ireland, the Netherlands, and the UK, but not by Denmark. German catches were assumed to be negligible, and French estimates from 2011-12 and 2018-19 were excluded due to quality issues. Annual length-frequency distributions were generated for each stock area for all years with data. Not all countries provided data for all years, so these were reconstructed using a similar approach to catches. Where length-frequency did not exist for a particular country, the length distribution was used from the average of all countries for the same area and year. The proportion of numbers at length was then combined with the average total number of sea bass retained or released and summed to generate estimates for each area required within modelling scenarios (Figure 5). Applying this PRM to the release component of the catch resulted in a time series of removals (kept + fish that die on or after release) from 2016 to 2023 for use in the assessment.

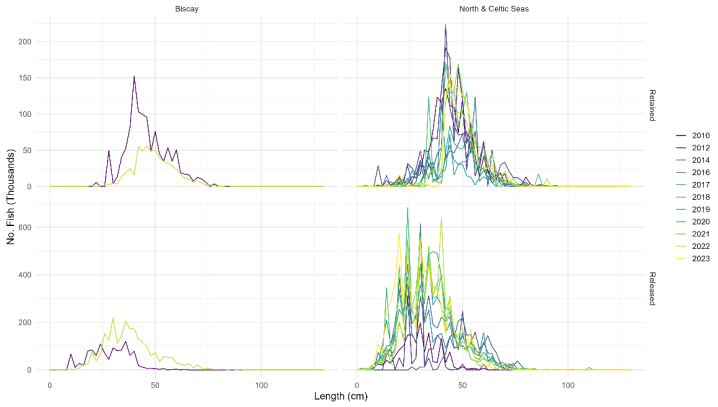


Figure 5. Length-frequency of sea bass by year for the different areas.

3.3.3 Catch reallocation between stock areas

The stock ID workshop highlighted the need to consider the exchange of catches between Northern and Biscay stocks as part of the assessment (ICES, 2023). To achieve this, it was necessary to understand home location, mixing rates, and seasonality in the catches. Home location was defined as the area within which individual sea bass spawn and reallocation of catches were based on this.

Analysis of tagged sea bass data showed that the individual sea bass moved between the Northern and Biscay stock areas (Annex 6). Sea bass from Biscay moved into the western channel to feed during summer and autumn before returning to Biscay during winter and spring where they spawn. Conversely, some sea bass from the eastern channel, North Sea and Irish Sea moved into the western channel in winter to spawn. If a sea bass home stock is defined as the area within which individual sea bass spawn, then it is necessary to reallocate a proportion of catches made in the Northern stock area to the Biscay stock.

Fish were assigned to a stock based on their location during the spawning season with the proportion of recreational catch reassigned using seasonal movement rates from tagging studies (Table 3). The assignment of catches was only done from Northern to Biscay due to the direction of spawning migrations.

Table 3. Exchange rates between the Northern and Biscay stocks. Proportion of fish from the Northern stock moving to the Southern stock at the end of the quarters 3 and 4.

Quarter	Proportion
Q3: Jul-Sep	0.28803
Q4: Oct-Dec	0.40665

3.3.4 Seasonality

Monthly variation in raw catches was used to assess seasonality. The proportion of raw numbers of fish caught in each month during the year was provided by France, Ireland, the Netherlands, and the UK, but were not available for Denmark or Belgium. Individual countries seasonal patterns were averaged across years then a weighted average of the proportions accounting for differences in numbers caught within a country generated for each area and scenario. Seasonality in raw catches showed highest catches in summer and lowest in winter (Figure 6).

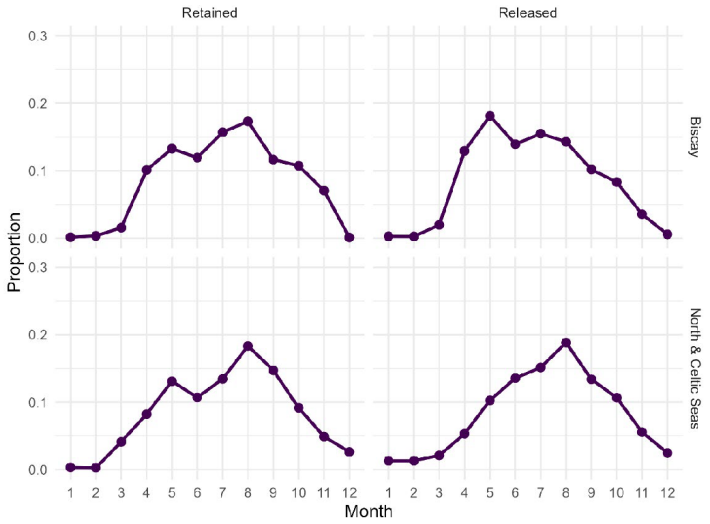


Figure 6. Proportion of sea bass caught in each month averaged across all available years and weighted by catches in each country for the different areas.

Catches were reassigned to Biscay from the Northern stock based on quarterly exchange rates (Table 3) and seasonality for retained and released components of the catch separately (Table 4 and Figure 7). A post-release mortality of 5% was applied to generate removals. For a full description of the approach see Annex 1.

Table 4. Proportion of retained (A) and released (B) catch to be reassigned from the Northern to Biscay stock area at the end of quarters 3 and 4.

Proportion	Quarter Q3: Jul-Sep	Q4: Oct-Dec
Exchange	0.28803	0.40665
A. Retained		

Proportion	Quarter Q3: Jul-Sep	Q4: Oct-Dec
Season	0.46501	0.16708
Total	0.13394	0.06794
Overall	0.20188	
B. Released		
Season	0.47361	0.18710
Total	0.13641	0.07609
Overall	0.21250	

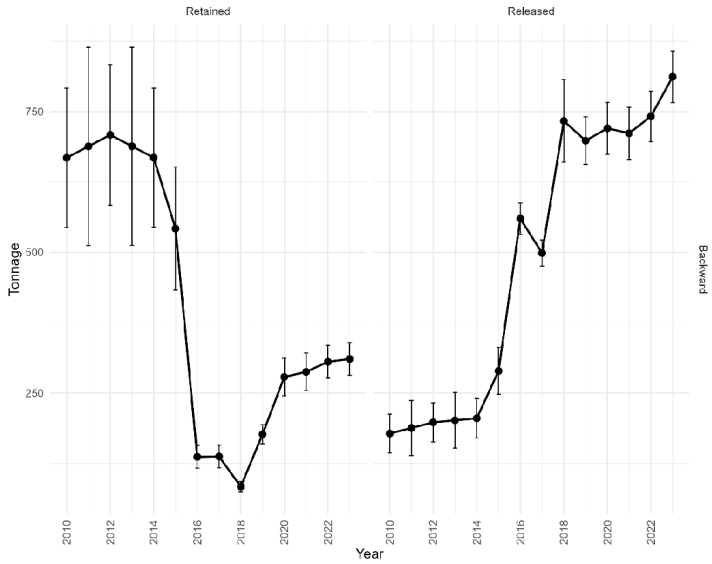


Figure 7. Tonnage of kept and released sea bass to be reassigned from the Northern stock to the Biscay stock based on the quarterly-year exchange rates for the backward projection.

3.4 Abundance indices

3.4.1 LPUE index

The WKBASS 2018 assessment included only an LPUE index for a French combined fleet (ICES, 2018). As the combined fleet was split by gears, the LPUE methodology was revised for WKSEABASS 2024 (Annex 7).

The objectives were to: 1) develop a new LPUE index per fleet as recommended by the data workshop (here we focused on the OTB fleet as it was considered as a good candidate to reflect changes of abundance in the seabass stocks); 2) account for the seabass spatiotemporal dynamics within the model; and 3) use the best available modelling approach to estimate LPUE indices.

A spatiotemporal Generalized Linear Mixed Effects Models (GLMMs) was fitted to logbooks data (i.e. daily landings at the monthly and ICES square level). It used an R package named "sdmTMB" that fits spatial and spatiotemporal GLMMs using Template Model Builder (TMB), R-INLA, and Gaussian Markov random fields (Anderson et al., 2022). As in the model of the old

LPUE index, the model followed a Delta modeling approach, i.e. an approach splitting LPUE into two components: (1) a first component modeling zero vs. non-zero LPUE data, and (2) a second component modeling the positive LPUE data. Here we fitted a Delta-lognormal model. This fits a binomial presence-absence model on the presence/absence data and then a model for the positive catches only with a lognormal observation distribution and a log link. The LPUE model write as:

$$\mathbb{E}\left[LPUE_{s,t}\right] = \mu_{s,t}$$

$$\mu_{s,t} = f^{-1}\left(X_{s,t}^{main}\beta + O_{s,t} + \alpha_g + \epsilon_{s,t}\right),$$

where

- $\mu_{s,t}$ represents the LPUE data at point s and time t (zero vs. non-zero LPUE data treated separately of the positive LPUE data respectively);
- μ represent the mean;
- f represents a link function (here a delta lognormal family was used with a logit and a log link respectively) and f^{-1} represents its inverse;
- $X_{s,t}^{main}$ represents the main effects (here a temporal effect combining years and months)
- β represents a vector of fixed-effects coefficients;
- $O_{s,t}$ represents an offset (here set to zero);
- α_g represents random intercepts by group g (here a vessel effect from the OTB fleet), $\alpha_g \sim \mathrm{N}\left(0, \sigma_\gamma^2\right)$;
- $\epsilon_{s,t}$ represents a spatiotemporal component (iid spatial Gaussian random fields that accounts for physical barriers), $\epsilon_{s,t} \sim MVN(0, \Sigma_\epsilon)$.

The model converged well. Spatiotemporal predictions were performed over ICES squares of the Bay of Biscay and months of the years 2001-2023. Predictions were aggregated over the Bay of Biscay area and over months April to November (as the previous LPUE index). It provided an annual OTB-based LPUE index time-series comparable in trend with the previous combined fleet-based LPUE index (Figure 8). Note that 2000 & 2009 are years for which the data collection system has changed. The completeness of the logbook data was not reached in 2008. This year was excluded in the assessment model.

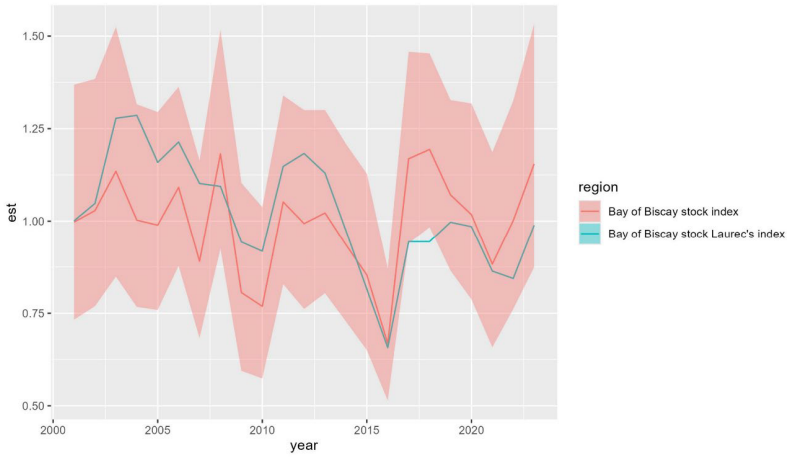


Figure 8. Bay of Biscay seabass in ICES divisions 8ab. New annual OTB-based LPUE index and associated uncertainty (red) used in the current benchmark compared to the previous combined fleet-based LPUE index (blue). 2008 was excluded from the assessment model, because the completeness of the logbook data was not reached this year.

3.4.2 Recruitment surveys

New surveys for estimating abundance of juvenile seabass in estuaries were identified as part of WKSEABASS 2024 and included in the model. Those are the NOURDEM surveys (Annex 3). They are conducted by Ifremer (Plouzané, France) and aimed at establishing abundance indices of demersal fish juveniles in nursery. Two survey series are considered in the Bay of Biscay: the first survey, the NOURDEM Loire survey, was carried out in the Loire estuary over the years 2016-2023 (Roy et al., 2022); the second survey, the NOURDEM Gironde survey, was carried out in the Gironde estuary over the years 2019-2023. Those surveys followed strictly a pre-defined sampling procedure (Annex 3). Sampling locations have been designed homogeneously in the estuaries covering all brackish waters with water salinity from 0 to 35. The number of trawl stations ranged between 58 and 76 tows, depending on the site and the year. All samples were collected using a fishing vessel with a small trawl with a large vertical opening specifically designed to catch demersal fish juveniles. For each trawl, the boat went against the current at ca. 1450 engine rpm for 15 min. At the end of each trawl, the entire catch was systematically weighed, all species were identified and sorted. Then all or some of the individuals of each fish species were measured. For very heavy trawl loads, weighing and measurement were only carried out on a random subset of the trawls' total weight. Trawl depth, salinity, and temperature were measured directly for every trawl. For sea bass, age was estimated based on annual increment fish scale readings. A minimum of 3 age readings were performed per length classes (each cm). The random stratified estimator was used to derive sea bass abundance indices. To this end, we defined stratum within the estuaries assuming that habitat was relatively homogeneous within each of stratum. Abundance indices and coefficients of variation (CVs) were computed as weighted sums of each stratum abundance and variance (Annex 3).

Thus, the Nourdem surveys provided abundance indices of juvenile seabass in Loire and Gironde estuaries. Length distributions were provided, as well as the corresponding ALKs. Note that ALKs were included only for the Nourdem Gironde survey, because of a poor fit in the assessment model with the ALKs of Nourdem Loire survey.

3.5 Biological parameters - growth and maturity

All von Bertalanffy growth parameters are now estimated in the model (length at age min, K, standard deviation at length at age min, standard deviation of length at age max), except for length at age max, which is fixed at 87.7611 for age 30.

Maturity parameters, and their use within the assessment model, remain unchanged from the previous assessment (ICES, 2018). The size at which 50% of the females are mature ($L_{50\%}$) is 42.14 cm and the slope of the logistic curve is -0.37809.

3.6 Natural mortality

WKBASS 2018 used a natural mortality of 0.24. Since then, a recent paper discussed the assumptions around natural mortality estimates (Lorenzen, 2022), reviewing biological considerations, empirical generalizations, and theoretical models which led to a new M paradigm described as 'generalized length-inverse mortality'. The Lorenzen (2022) method was

used to calculate a natural mortality that decreased exponentially between age 0 and 5 and then set at the same level as the previous assessment from age 5+.

Stock synthesis allowed running a model that uses Lorenzen's natural mortality estimates for which M is set for a given age. The idea was to use the SS estimates for which M = 0.24 for age 5, and replace SS estimates by M = 0.24 for ages older than 5, to keep coherence with last benchmark estimates. The vector of natural mortality at age 0 to 5+, that is now being used in the assessment, is: [0.840918, 0.463849, 0.365109, 0.306347, 0.267492, 0.24]

3.7 Stock-recruitment relationship and spawning stock biomass

In the model, recruitment was assumed to be a single event occurring at the beginning of the year. Recruitment was derived from a Beverton and Holt (BH) stock-recruitment relationship (SRR) and variation in recruitment was estimated as deviations from the SRR. Recruitment deviates were estimated for 2000 to 2023 as main recruitment deviations (24 annual deviations) and for 1978 to 1999 as early recruitment deviations (22 annual deviations). Recruitment deviates were assumed to have a standard deviation (σR) of 0.6. The steepness (h) for the SRR is fixed to 0.8.

Spawning stock biomass was estimated at the beginning of the year and it was considered proportional to fecundity.

3.8 Data input summary

The table below summarises the data and parameter inputs available for the benchmark assessment (Table 5). See other Annexes for detailed description of the individual datasets and basis for any recommendations for using the data in the assessment from the WKSEABASS 2024 data workshop.

Table 5. Bay of Biscay seabass in ICES divisions 8ab. Data/parameter update in WKSEBASS 2024 compared to WKBASS 2018

Data parameter	Description	Update/Source
Growth	Estimated values of von Bertalanffy growth parameters K, SD of length-at-age and length at Amin; Fixed value for length at Amax; age error vector	Updated – WKBASS 2018 assessment used estimated value of von Bertalanffy growth parameter K; Fixed length at Amin and Amax; Fixed CV of age; age error vector
Maturity	Female proportion mature at age	Unchanged from WKBASS 2018
Natural mortality	Mortality expressed as a function of age, with decreasing M down to 0.24 for age 5+	Updated – WKBASS 2018 assessment used Then et al. (2015) M=0.24 for all ages.

Commercial landings 1985–2024	Split by gear: bottom trawls, pelagic trawls, gillnets, trammel nets, longlines, other commercial gears	Updated – WKBASS 2018 assessment used a French and Spain combined fleet.
Commercial landings length/age composition	Length composition by fleet and one ALK combined for all gears	Updated – WKBASS 2018 assessment used the length compositions and conditional length-at-age for the France and Spain combined fleet
Commercial discards catch numbers and weight	Fleet-raised estimates for bottom trawls, gillnets, trammel nets, longlines	Updated – WKBASS 2018 assessment did not account for discards
Commercial discards length compositions	Fleet-raised length compositions	Updated – WKBASS 2018 assessment did not account for discards length compositions
Recreational removals – kept and released	Estimates from reliable surveys in France (2010 and 2022). A procedure is used to back calculate missing years outside of the model (2011-2021, 2023). Historical series before 2010 is reconstructed with a constant F in the model.	Updated – WKBASS 2018 used an estimate for 2010 which was then used as a reference year, with a constant F up to 2012, reduced according to management measures after that.
Recreational fishery length compositions	Compiled from France for the years where reliable data existed (2010 and 2022).	Updated – WKBASS 2018 used only 2010 length data
Recreational fishery post-release mortality	5%	Unchanged from WKBASS 2018
French commercial lpue series	LPUE estimated for the bottom trawl fleet	Updated – WKBASS 2018 assessment used an LPUE for the French fleet all gear combined, now it is still based on French data but specific to the trawl fleet only.
Nourdem Loire survey	Time series of abundance indices of juvenile seabass in Loire estuary (mainly fish age 1-5). Length compositions and age-length keys	Updated – this time series didn't exist in WKBASSS 2018 assessment
Nourdem Gironde survey	Time series of abundance indices of juvenile seabass in Gironde estuary (mainly fish age 1-5). Length compositions only. Age-lengthkeys excluded because of a poor fit.	Updated – this time series didn't exist in WKBASSS 2018 assessment

3.1 Data weighting

3.1.1 Sample size and CVs

For the commercial fleets, the landings standard errors were set to 0.1 for years from 1985 to 2023, while the discards standard errors were set to 0.3. The standard error of the initial catches of the commercial fleets was also set to 0.01.

The initial input sample sizes (N_{input}) for (retained and discards) length frequency distributions by year were calculated as a function of the number of trips and number of fish via the Stewart Method (Stewart, pers.com):

$$N_{input} = N_{trips} + 0.138N_{fish} \quad \text{when} \quad \frac{N_{fish}}{N_{trips}} < 44$$

$$N_{input} = 7.06N_{trips} \quad \text{when} \quad \frac{N_{fish}}{N_{trips}} \geq 44$$

The method is based on analysis of the input and model derived effective sample sizes from west coast groundfish stock assessments. A piece-wise linear regression was used to estimate the increase in effective sample size per sample based on fish-per-sample and the maximum effective sample size for large numbers of individual fish.

For the ALKs of the combined commercial fleets (attributed to the LPUE), the sample size was the actual number of fish samples being aged for a given length bin.

For the recreational fishery, the total removals standard errors were set to 0.01 for the recent years, for which a reconstructed time series was provided (years 2010-2023), and to 0.8 for the years before 2010. In addition, a constant survey index in fishing mortality unit was provided for the period 1985-2011, with a very low standard error (0.01) for years 1985-2010 and high standard error (0.8) for 2011. The idea by doing so was to let the SS model estimate the historical removals of the recreational fishery with a constant fishing mortality, while giving no weight to the input data for years 1985-2010, and use the input data for the years 2011-2023 otherwise. For the removals and released length composition data, the sample size is the number of fish measured. The French data was provided aggregated for the whole of Biscay and the Northern stock, so the sample size was split up using the following percentages: 7d: 26%; 7e: 16% and 8ab: 58% (Annex 1).

For the surveys, the value of standard error in natural log space was calculated from the CVs using this formula $\sqrt{log_e(1 + (CV^2))}$. For the LPUE index, the standard errors (in the log scale) were directly provided. For the Nourdem surveys, an input sample size depending of the number of hauls was attributed to the length composition data. The following equation was used (Stewart & Hamel, 2014):

$$Nsamp = 2.73 \times Nhauls$$

For the ALKs of the Nourdem surveys, the sample size was similar to the actual number of fish samples being aged for a given length bin.

3.1.2 Ageing error

Exchange of sea bass scales and otoliths was done in 2020 to understand ageing error among different readers (ICES, 2020; 2021a). Eight readers from three national laboratories (Cefas UK,

Ifremer FR, ILVO BE) read both otoliths and scales of 100 sea bass from ICES area 27 (ICES, 2020). The scale calibration exercise showed an overall agreement of 68% with a CV in precision of 11% for fish of modal age of 2 to 16 years (ICES, 2020).

In the Bay of Biscay, age readers changed over years (ICES, 2024). Unfortunately, only the inter-calibration between the last 2 most recent age readers was available (ICES, 2020), preventing using specific ageing errors for historical and current age readers. The group decided to be conservative and included a unique ageing error, which corresponded to the recent inter-calibration exercise between the 2 most recent readers (Table 6).

Table 6. Ageing error in terms of standard deviation (SD) for different model ages taking from a sea bass scale calibration exercise (ICES, 2020; 2021) for the Bay of Biscay age readers only.

Modal age	2	3	4	5	6	7	8	9	10	11	12	15	16+
SD	0.001	0.50	0.61	0.53	0.55	0.78	0.48	0.61	0.64	0.50	1.51	1.41	1.41

3.1.3 Iterative re-weighting

Francis method was used for data weighting with in the assessment model (Francis and Hilborn 2011). This method is based on variability in the observed mean length or age by year, where the sample sizes are adjusted such that the fit of the expected mean length or age should fit within the uncertainty intervals at a rate which is consistent with variability expected based on the adjusted sample sizes. Francis data weighing was performed, once the base model was achieved.

3.2 Fishery dynamics (selectivity and retention)

Fishery selectivity and retention of the base model is assumed to be length specific. For the following commercial fleets, OTB, GNS, GTR, LLS, a random walk selectivity was used on the peak parameter of the double normal selectivity curve, while retention was always time-invariant. Survey and recreational removals selectivity are also assumed to be length-specific and time-invariant.

4 Selection of best model configuration

4.1 Exploratory runs

Once the base models had been finalized, each of them was assigned several sensitivity tests and alternative scenarios were performed to find the best model to describe the state of the stock (Table 7):

Table 7. Names, descriptions and justifications of the exploratory runs

Name	Brief description	Reason
base_run	As described in the text	
alternative_run_1	Use constant mortality estimate (M = 0.24)	Approach used in previous assessment
alternative_run_2	Use FishLife meta-analysis estimates (Thorson et al., 2023) for steepness and sigma R (steepness = 0,897 and sigmaR = 0,3379018)	
alternative_run_3	Fix all growth parameters except K	Approach used in previous assessment
alternative_run_4a	Run without the LPUE index and commercial combined fleet ALKs	Sensitivity of the base run to the LPUE index and commercial combined fleet ALKs
alternative_run_4b	Run without the NOURDEM Loire index and commercial combined fleet ALKs	Sensitivity of the base run to the NOURDEM Loire index
alternative_run_4c	Run without the NOURDEM Gironde index and commercial combined fleet ALKs	Sensitivity of the base run to the NOURDEM Gironde index
alternative_run_4d	Run without the LPUE index and with commercial combined fleet ALKs associated to OTB fleet	Sensitivity of the base run to the LPUE index
alternative_run_5	Switch off extra standard deviation for LPUE	Testing higher confidence in LPUE information
alternative_run_6	Decrease CV of the last 2 years of the OTB discards	Testing higher confidence in OTB discards information
alternative_run_7	Associate commercial combined fleet ALKs to the OTB fleet (rather than LPUE index)	These ALKs pull together age-length data from all commercial fleets. In the model it is associated to LPUE index, but the effect of associating to another fleet (OTB) is unknown
alternative_run_8	Assume no movement of fish from the Southern to the Northern stock; no	Test the effect of not accounting for stock mixing

	quarterly reallocation for com. catches and backward recreational removals	
alternative_run_9a	Add block retention to OTB fleet	Account for management measures on MLS.
alternative_run_9b	Add block retention to GNS fleet	Account for management measures on MLS.
alternative_run_9c	Add block retention to GTR fleet	Account for management measures on MLS.
alternative_run_9d	Add block retention to LLS fleet	Account for management measures on MLS.
alternative_run_9e	Add block retention to OTB and GNS fleets	Account for management measures on MLS.
alternative_run_9f	Add block retention to OTB, GNS and GTR fleets	Account for management measures on MLS.
alternative_run_9g	Add block retention to OTB, GNS, GTR and LLS fleets	Account for management measures on MLS.
alternative_run_10	Alternative_run_9c + init_F fixed except for the recreational fishery	Try to improve the performance on retrospective analysis of the alternative_run_9c
alternative_run_11	init_F fixed except for the recreational fishery	Try to improve the performance on retrospective analysis of the base_run
alternative_run_12	init_F fixed except for the recreational fishery and early start of the recruitment deviations set to 1970	Try to improve the performance on retrospective analysis of the base_run and with proper historical uncertainty for the derived quantities (SSB and F)
alternative_run_13	init_F fixed except for the recreational fishery and early start of the recruitment deviations set with -22 years	Try to improve the performance on retrospective analysis of the base_run and with proper historical uncertainty for the derived quantities (SSB and F)

4.2 Model selection and diagnostics

Following the work from Carvalho et al. (2017, 2021), several diagnostics have been applied during this benchmark to scrutinise the base model and its alternative exploratory runs for model misspecification. The idea being that combining multiple diagnostic tests improves the detection of model misspecification without significantly increasing the risk of incorrectly rejecting a correct model. Model diagnostics are detailed here after. Model selection consisted in selecting the model that performs best across the highest number of diagnostic tests.

The different plausible model configurations were compared using model diagnostics based on recent papers from Carvalho et al. (2017, 2021), Kell et al. (2021), and Merino et al. (2022). The key model diagnostics used were converge (which includes checking of parameters at the bounds, final gradient and inversion of the Hessian matrix for uncertainty estimation), runs test

and RMSE, retrospective analysis, and hindcasting cross-validation (ICES 2022). Once the best plausible model configuration has been identified, additional model diagnostics such as jittering and analysis of surplus production trend were used to further assess the sensitivity and the validity of the best model. Estimates and trends in SSB, F, and R were used at the last step and only as a plausibility check.

4.3 Conclusions and selection of the best model configuration

From Table 8, the models that perform best equally in most of the key diagnostic tests performed, and more importantly in terms of retrospective and prediction skills (passed 87.10% of the tests) are *alternative_run_10*, *alternative_run_11* and *alternative_run_13*. However, *alternative_run_10* was rejected because time-varying retention for GTR (blocks) gives a counter intuitive fit, not aligned with management measures with recent increasing minimum landing size. *Alternative_run_11* was also rejected, because the historical uncertainty on SSB was low compared to recent years, due to improper specification of the starting year of the recruitment process. *Alternative_run_13* is the model that performs the best. Thus, *alternative_run_13* was proposed as the best model to be used for the Bay of Biscay seabass stock assessment.

Table 8. Bay of Biscay seabass in ICES divisions 8ab. Summary table of the diagnostics of the base and plausible exploratory model runs. Values in red refer to tests that failed and in green those that were passed. Percentage of tests passed are given on the last line of the table.

Runs	base_run	alternative_run_1	alternative_run_2	alternative_run_3	alternative_run_4a	alternative_run_4b	alternative_run_4c	alternative_run_4d
Convergence	1.94E-03	2.37E-03	5.29E-04	2.20E-04	5.40E-04	2.46E-04	2.31E-04	1.34E-03
Total_LL	1204.67	1206.3	1204.28	1204.67	1031.03	1149.83	1117.22	5022.19
N_Params	357	357	357	354	357	357	357	357
Runs_test_cpue1	Passed	Passed	Passed	Passed	Failed	Passed	Passed	Failed
Runs_test_cpue2	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue3	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue4	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Passed
Runs_test_len1	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len2	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Failed
Runs_test_len3	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Failed
Runs_test_len4	Passed	Passed	Passed	Passed	Failed	Passed	Passed	Failed
Runs_test_len5	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Failed
Runs_test_len6	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Failed
Runs_test_len7	Passed	Passed	Passed	Passed	Passed	Failed	Passed	Passed
Runs_test_len8	Passed	Passed	Passed	Passed	Passed	Passed	Failed	Passed
RMSE_Perc	24.70	25.40	25.80	24.70	25.50	25.90	27.90	42.90
RMSE_Perc_1	7.00	7.10	7.20	7.00	6.70	20.50	12.50	7.20
Retro_Rho_SSB	0.19	0.18	0.18	0.25	0.02	0.19	0.19	-0.24
Forecast_Rho_SSB	0.18	0.17	0.17	0.23	-0.04	0.18	0.18	-0.24
Retro_Rho_F	-0.18	-0.18	-0.17	-0.22	0.04	-0.18	-0.18	1.16
Forecast_Rho_F	-0.17	-0.16	-0.16	-0.20	0.11	-0.17	-0.17	0.93
MASE_cpue1	1.19	1.16	1.00	1.27	1.11	1.15	1.33	8.21
MASE_cpue2	0.95	0.98	0.89	0.89	0.90	0.93	1.03	1.24
MASE_cpue3	4.60	4.42	4.59	4.80	4.49	4.58	4.63	4.27
MASE_cpue5	2.21	2.16	2.15	2.24	2.13	2.19	2.27	2.85
MASE_len1	0.29	0.29	0.27	0.28	0.30	0.26	0.30	0.28
MASE_len2	0.27	0.26	0.28	0.26	0.26	0.30	0.28	1.67
MASE_len3	0.20	0.20	0.20	0.22	0.23	0.21	0.21	0.35
MASE_len4	0.21	0.21	0.23	0.22	0.24	0.26	0.21	0.29
MASE_len5	0.35	0.35	0.35	0.35	0.35	0.37	0.35	0.87
MASE_len6	0.13	0.13	0.14	0.11	0.17	0.20	0.13	0.89
MASE_len7	0.90	0.94	1.03	0.92	0.60	7.46	0.79	0.93
MASE_len8	0.74	0.62	0.88	0.64	0.93	0.86	1.33	0.45
MASE_len10	0.58	0.54	0.65	0.55	0.61	1.64	0.76	0.84
Total_passed	80.65%	80.65%	80.65%	74.19%	80.65%	70.97%	70.97%	48.39%

Table 8. Continued…

Runs	alternative_run_5	alternative_run_6	alternative_run_7	alternative_run_8	alternative_run_9a	alternative_run_9b	alternative_run_9c	alternative_run_9d
Convergence	7.34E-04	2.67E-04	3.91E-03	1.43E-04	1.67E-04	2.43E-04	2.28E-03	4.10E-04
Total_LL	1204.69	1213.63	5020.11	1195.33	1171.13	1199.85	1198.2	1162.55
N_Params	356	357	357	357	359	359	359	359
Runs_test_cpue1	Passed	Passed	Failed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue2	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue3	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue4	Failed	Failed	Passed	Failed	Failed	Failed	Failed	Failed
Runs_test_len1	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len2	Passed	Passed	Failed	Passed	Passed	Passed	Passed	Passed
Runs_test_len3	Passed	Passed	Failed	Passed	Passed	Passed	Passed	Passed
Runs_test_len4	Passed	Passed	Failed	Passed	Passed	Passed	Passed	Failed
Runs_test_len5	Passed	Passed	Failed	Passed	Passed	Passed	Passed	Passed
Runs_test_len6	Passed	Passed	Failed	Passed	Passed	Passed	Passed	Passed
Runs_test_len7	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len8	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
RMSE_Perc	24.70	24.90	40.90	24.80	25.40	24.70	24.70	25.00
RMSE_Perc_1	7.00	7.00	7.20	6.90	6.90	6.90	7.00	6.90
Retro_Rho_SSB	0.19	0.21	-0.18	0.16	0.26	0.19	0.19	0.22
Forecast_Rho_SSB	0.18	0.21	-0.17	0.16	0.26	0.18	0.18	0.21
Retro_Rho_F	-0.18	-0.20	1.00	-0.17	-0.23	-0.18	-0.18	-0.20
Forecast_Rho_F	-0.17	-0.19	0.79	-0.16	-0.21	-0.15	-0.15	-0.19
MASE_cpue1	1.18	1.21	6.27	1.14	1.25	1.17	1.18	1.24
MASE_cpue2	0.96	0.96	1.25	0.96	0.94	0.96	0.95	0.95
MASE_cpue3	4.59	4.60	4.28	4.51	4.62	4.59	4.60	4.60
MASE_cpue5	2.20	2.21	2.70	2.17	2.21	2.20	2.20	2.21
MASE_len1	0.29	0.28	0.30	0.26	0.93	0.30	0.29	0.28
MASE_len2	0.27	0.27	1.56	0.27	0.28	0.27	0.27	0.27
MASE_len3	0.20	0.20	0.33	0.20	0.20	0.38	0.20	0.20
MASE_len4	0.21	0.21	0.28	0.21	0.21	0.21	0.45	0.21
MASE_len5	0.35	0.35	0.82	0.35	0.35	0.35	0.35	0.29
MASE_len6	0.14	0.13	0.85	0.11	0.13	0.14	0.13	0.12
MASE_len7	0.91	0.90	0.91	0.89	0.93	0.91	0.89	0.93
MASE_len8	0.72	0.74	0.46	0.73	0.74	0.72	0.74	0.73
MASE_len10	0.58	0.58	0.81	0.57	0.67	0.61	0.61	0.57
Total_passed	80.65%	74.19%	48.39%	80.65%	74.19%	80.65%	83.87%	70.97%

Table 8. Continued...

Runs	alternative_run_9e	alternative_run_9f	alternative_run_9g	alternative_run_10	alternative_run_11	alternative_run_12	alternative_run_13
Convergence	6.88E-04	1.22E-03	1.39E-03	6.85E-04	5.18E-05	6.29E-04	1.42E-04
Total_LL	1166.22	1160.14	1117.75	1198.2	1204.67	1204.63	1204.64
N_Params	361	363	365	354	352	368	360
Runs_test_cpue1	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue2	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue3	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_cpue4	Failed	Failed	Failed	Failed	Failed	Failed	Failed
Runs_test_len1	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len2	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len3	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len4	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len5	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len6	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len7	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Runs_test_len8	Passed	Passed	Passed	Passed	Passed	Passed	Passed
RMSE_Perc	25.40	25.30	25.60	24.70	24.70	24.70	24.70
RMSE_Perc_1	6.90	6.80	6.80	7.00	7.00	7.00	7.00
Retro_Rho_SSB	0.26	0.29	0.30	0.14	0.14	0.20	0.15
Forecast_Rho_SSB	0.27	0.26	0.30	0.13	0.13	0.19	0.13
Retro_Rho_F	-0.23	-0.22	-0.24	-0.15	-0.15	-0.19	-0.15
Forecast_Rho_F	-0.20	-0.14	-0.19	-0.11	-0.13	-0.18	-0.13
MASE_cpue1	1.23	1.55	1.27	1.03	1.03	1.05	1.04
MASE_cpue2	0.94	0.80	0.93	0.90	0.91	0.99	0.91
MASE_cpue3	4.63	4.53	4.63	4.57	4.56	4.58	4.57
MASE_cpue5	2.21	2.13	2.21	2.15	2.15	2.21	2.16
MASE_len1	0.94	1.08	0.93	0.30	0.30	0.29	0.30
MASE_len2	0.28	0.14	0.28	0.28	0.28	0.27	0.28
MASE_len3	0.38	0.40	0.39	0.20	0.20	0.20	0.20
MASE_len4	0.21	0.44	0.44	0.47	0.22	0.21	0.22
MASE_len5	0.34	0.25	0.28	0.34	0.35	0.35	0.35
MASE_len6	0.13	0.26	0.12	0.14	0.14	0.13	0.14
MASE_len7	0.91	1.04	0.94	0.91	0.94	0.87	0.92
MASE_len8	0.76	0.80	0.75	0.76	0.74	0.70	0.76
MASE_len10	0.70	0.78	0.73	0.62	0.59	0.56	0.59
Total_passed	74.19%	70.97%	74.19%	87.10%	87.10%	77.42%	87.10%

4.4 Additional diagnostics of the best model

4.4.1 Jittering

The jittering procedure allows users to verify the stability of a model and its parameter estimates by examining the effect that small changes in its starting values have on model results. An accurate model should converge on a global solution (i.e., not be stuck in local minima of the likelihood surface) across a reasonable range of starting values for all input parameters. In this case, 25 runs were performed considering a 10% jitter of all initial parameters. In practice, this means that a small random jitter is added to the initial parameter values and the model is rerun. Starting values are jittered based on a normal distribution based on the pr(PMIN) = 0.1% and the pr(PMAX) = 99.9%.

Most of the jittered runs resulted in the same results as the best run with likelihood of 1204.64 (Figure 9). Some local minima were observed as three runs had a likelihood lower than the best run. It is, however, important to stress that the absence of a local minima when running jittering is not a guarantee that the model is not indeed stuck in a local minimum, although its absence does reduce the risk that this occurs (Subbey, 2018).

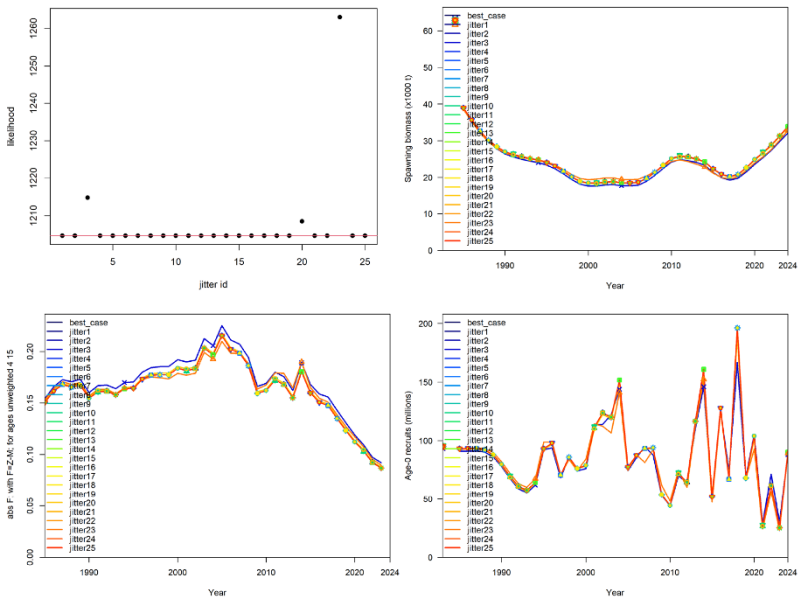


Figure 9. Bay of Biscay seabass in ICES divisions 8ab. Results from jitter using 25 iterations and an average jitter of 10%.

4.4.2 Analysis of surplus production trend

Estimates of Surplus Production (Walters, et al., 2008) can provide a check of whether predictions of changes in biomass can be made reliably based on catch and current biomass (clockwise or linear behaviour) or whether there has been non-stationarity in production processes, i.e., are dynamics driven by climate and oceanic conditions (counterclockwise). In the case of Bay of Biscay sea bass, Figure 10 shows a general clockwise pattern indicating that changes in stock biomass can be made reliably based on catch and current biomass. Moreover, the production function is typically left skewed and flat-topped, which implies that fishing at the naïve F_{MSY} brings the stock close to B_{lim} with very reduced theoretical gain in yields compared to a more conservative proxy as $B_{40\%}$ (Figure 10).

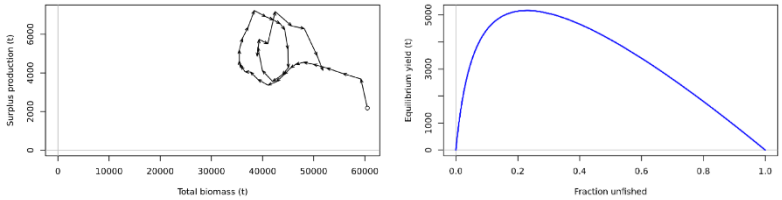


Figure 10. Bay of Biscay seabass in ICES divisions 8ab. Left) Surplus production against biomass plot of the best (*alternative_run_13*) model. The round circle represents the first year of the time series (1903). Right) The production function of the best (*alternative_run_13*) model.

5 Best model configuration

5.1 Detailed description of the best model

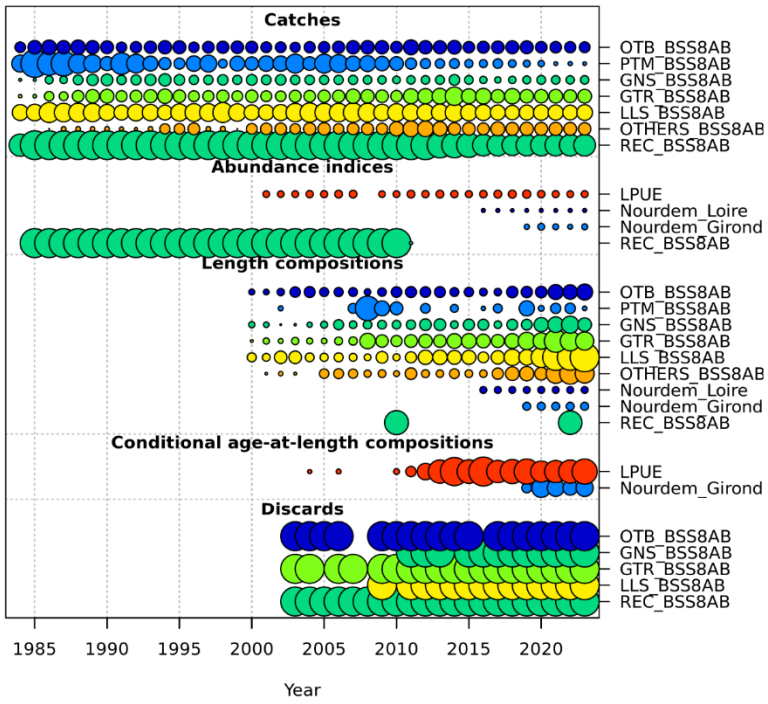


Figure 11. Bay of Biscay seabass in ICES divisions 8ab. Summary of the input time series included in the Best_run (alternative_run_13) model. Note that the Rec_BSS8AB abundance index presented here is just a constant F index that is used for the model to estimate recreational catches.

Most of parameter and variances were well estimated (i.e., CV < 1), except for Q_extraSD_LPUE(7), Q_extraSD_Nourdem_Gironde(9), Retain_L_asymptote_logit_OTB(1) and Size_DblN_ascend_se_Nourdem_Loire(8) (i.e., CV > 1). All parameter and variances were well within the bounds except for Q_extraSD_LPUE(7) which is estimated at the lower bound (Table 9). The length- and age-based selectivity of the commercial fleets, the LPUE and the surveys are well estimated (Figure 12). Estimated time varying (or not) selectivity and retention were detailed for commercial fleets, the LPUE, the surveys and the recreational fishery (Figure 13, 14, 15 and 16). The fitting of the model was satisfactory, with the length compositions for each

commercial fleets and surveys well reconstructed (Figure 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30). The residuals are generally low, above -2.0 and below 2.0, and without clear patterns, except for retained OTB and retained GTR for which the observed mode of the length composition is underestimated by the model. The fitting of the model was satisfactory for conditional age-at-length too (Figure 31 and 32). Recruitment estimates were estimated and bias adjust in the model followed what was recommended (Figure 33). The fitting of the model was satisfactory for discards data, although some model estimates were outside the confidence interval of the observations (Figure 34 and 35). Overall, the model does provide a better fit to the LPUE and the Nourdem Gironde survey than to the Nourdem Loire survey, for which a high value of extra standard deviation has been estimated (Figure 36).

Table 9. Bay of Biscay seabass in ICES divisions 8ab. Settings of the Stock Synthesis Best_run (alternative_run_13) model configuration. The table columns (left to right) show: the parameter name, the estimated value, the phase at which the parameter is estimated, the min and max bound (interval over which the estimated values is searched), the initial values (from which the numerical optimization is started), the status (OK = do not hit one of the bound and gradient is low), the standard deviation of the parameter, the gradient, the type of prior distribution, the priors used (value and standard deviation), the prior likelihood and .

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type	Prior	Pr_SD	Pr_Like	Afterbound
L_at_Amin_Fem_GP_1	14.7973	3	7	25	14.7984	OK	0.379516	7.38E-06	Normal	14.9	2.5	0.000223	OK
VonBert_K_Fem_GP_1	0.092485	3	0.1	0.2	0.092487	OK	0.0020753	1.78E-05	No_prior	NA	NA	NA	OK
SD_young_Fem_GP_1	2.3707	3	0.5	15	2.37107	OK	0.181194	1.06E-06	No_prior	NA	NA	NA	OK
SD_old_Fem_GP_1	10.6223	3	0.5	15	10.6155	OK	0.895101	1.61E-06	No_prior	NA	NA	NA	OK
SR_LN(R0)	11.4618	1	1	16	11.4618	OK	0.0237543	0.00014163	No_prior	NA	NA	NA	OK
InitF_seas_1_flt_10REC_BSS8AB	0.036248	1	0	2	0.036243	OK	0.0017179	2.92E-05	No_prior	NA	NA	NA	OK
F_fleet_1_YR_1985_s_1	0.011744	1	0	2.9	0.01	act	0.0018576	-5.12E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1986_s_1	0.014589	1	0	2.9	0.01	act	0.0025479	-4.06E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1987_s_1	0.013208	1	0	2.9	0.01	act	0.0024958	-5.39E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1988_s_1	0.01667	1	0	2.9	0.01	act	0.0033395	-1.04E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1989_s_1	0.014612	1	0	2.9	0.01	act	0.0030499	-2.29E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1990_s_1	0.013977	1	0	2.9	0.01	act	0.0029789	-2.64E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1991_s_1	0.009307	1	0	2.9	0.01	act	0.0019874	3.62E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1992_s_1	0.011205	1	0	2.9	0.01	act	0.0023591	8.06E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1993_s_1	0.013454	1	0	2.9	0.01	act	0.0027415	1.07E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1994_s_1	0.016207	1	0	2.9	0.01	act	0.0031554	2.42E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1995_s_1	0.016272	1	0	2.9	0.01	act	0.003012	3.89E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1996_s_1	0.011061	1	0	2.9	0.01	act	0.0019508	-4.61E-07	F	NA	NA	NA	OK
F_fleet_1_YR_1997_s_1	0.014843	1	0	2.9	0.01	act	0.0025043	-1.91E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1998_s_1	0.017374	1	0	2.9	0.01	act	0.0028054	-1.90E-06	F	NA	NA	NA	OK
F_fleet_1_YR_1999_s_1	0.018403	1	0	2.9	0.01	act	0.0028418	-3.53E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2000_s_1	0.016846	1	0	2.9	0.01	act	0.0024916	8.80E-09	F	NA	NA	NA	OK
F_fleet_1_YR_2001_s_1	0.013332	1	0	2.9	0.01	act	0.0019123	-2.00E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2002_s_1	0.013159	1	0	2.9	0.01	act	0.0018427	-1.65E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2003_s_1	0.010987	1	0	2.9	0.01	act	0.0014111	7.75E-07	F	NA	NA	NA	OK
F_fleet_1_YR_2004_s_1	0.014747	1	0	2.9	0.01	act	0.0019502	9.76E-07	F	NA	NA	NA	OK
F_fleet_1_YR_2005_s_1	0.014764	1	0	2.9	0.01	act	0.0019556	1.43E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2006_s_1	0.016199	1	0	2.9	0.01	act	0.002164	2.75E-07	F	NA	NA	NA	OK
F_fleet_1_YR_2007_s_1	0.017363	1	0	2.9	0.01	act	0.0023028	2.41E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2008_s_1	0.016432	1	0	2.9	0.01	act	0.0021397	-4.23E-06	F	NA	NA	NA	OK

F_fleet_1_YR_2009_s_1	0.015489	1	0	2.9	0.01	act	0.0019592	6.48E-07	F	NA	NA	NA	OK
F_fleet_1_YR_2010_s_1	0.011992	1	0	2.9	0.01	act	0.0015122	1.42E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2011_s_1	0.020173	1	0	2.9	0.01	act	0.002561	-1.00E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2012_s_1	0.01431	1	0	2.9	0.01	act	0.0018653	-7.83E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2013_s_1	0.015417	1	0	2.9	0.01	act	0.0019814	1.45E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2014_s_1	0.018207	1	0	2.9	0.01	act	0.0023786	3.14E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2015_s_1	0.014894	1	0	2.9	0.01	act	0.0019981	-2.22E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2016_s_1	0.016616	1	0	2.9	0.01	act	0.0023197	-1.35E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2017_s_1	0.017591	1	0	2.9	0.01	act	0.0024726	-2.20E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2018_s_1	0.017441	1	0	2.9	0.01	act	0.002516	-1.35E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2019_s_1	0.015982	1	0	2.9	0.01	act	0.0023272	-3.63E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2020_s_1	0.011489	1	0	2.9	0.01	act	0.0017219	-1.91E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2021_s_1	0.01164	1	0	2.9	0.01	act	0.0018479	-4.77E-06	F	NA	NA	NA	OK
F_fleet_1_YR_2022_s_1	0.010081	1	0	2.9	0.01	act	0.0016585	5.90E-07	F	NA	NA	NA	OK
F_fleet_1_YR_2023_s_1	0.008589	1	0	2.9	0.01	act	0.0014588	-2.59E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1985_s_1	0.00101	1	0	2.9	0.01	act	0.0001873	-1.29E-05	F	NA	NA	NA	OK
F_fleet_3_YR_1986_s_1	0.007776	1	0	2.9	0.01	act	0.0016184	-4.47E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1987_s_1	0.007229	1	0	2.9	0.01	act	0.0016141	-1.38E-05	F	NA	NA	NA	OK
F_fleet_3_YR_1988_s_1	0.013032	1	0	2.9	0.01	act	0.0030335	-1.28E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1989_s_1	0.018238	1	0	2.9	0.01	act	0.0043577	1.00E-07	F	NA	NA	NA	OK
F_fleet_3_YR_1990_s_1	0.019623	1	0	2.9	0.01	act	0.0047388	1.62E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1991_s_1	0.012818	1	0	2.9	0.01	act	0.003078	2.14E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1992_s_1	0.014784	1	0	2.9	0.01	act	0.0034824	2.10E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1993_s_1	0.018205	1	0	2.9	0.01	act	0.0041369	1.84E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1994_s_1	0.02232	1	0	2.9	0.01	act	0.0048219	1.69E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1995_s_1	0.017439	1	0	2.9	0.01	act	0.0035454	3.80E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1996_s_1	0.01398	1	0	2.9	0.01	act	0.0026671	1.54E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1997_s_1	0.01591	1	0	2.9	0.01	act	0.0028595	1.81E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1998_s_1	0.021014	1	0	2.9	0.01	act	0.0035831	2.16E-06	F	NA	NA	NA	OK
F_fleet_3_YR_1999_s_1	0.01679	1	0	2.9	0.01	act	0.0027434	5.92E-07	F	NA	NA	NA	OK
F_fleet_3_YR_2000_s_1	0.022622	1	0	2.9	0.01	act	0.003575	1.80E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2001_s_1	0.017709	1	0	2.9	0.01	act	0.0026815	7.62E-07	F	NA	NA	NA	OK
F_fleet_3_YR_2002_s_1	0.020069	1	0	2.9	0.01	act	0.002925	2.18E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2003_s_1	0.016397	1	0	2.9	0.01	act	0.002342	1.23E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2004_s_1	0.01647	1	0	2.9	0.01	act	0.0023413	-1.11E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2005_s_1	0.016124	1	0	2.9	0.01	act	0.0023791	2.97E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2006_s_1	0.014707	1	0	2.9	0.01	act	0.0020844	2.66E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2007_s_1	0.013084	1	0	2.9	0.01	act	0.0018364	2.87E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2008_s_1	0.009823	1	0	2.9	0.01	act	0.0012961	2.94E-07	F	NA	NA	NA	OK
F_fleet_3_YR_2009_s_1	0.008419	1	0	2.9	0.01	act	0.0010546	-2.67E-07	F	NA	NA	NA	OK
F_fleet_3_YR_2010_s_1	0.007118	1	0	2.9	0.01	act	0.0008921	1.75E-07	F	NA	NA	NA	OK
F_fleet_3_YR_2011_s_1	0.008468	1	0	2.9	0.01	act	0.0010516	5.27E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2012_s_1	0.009298	1	0	2.9	0.01	act	0.0011237	5.22E-07	F	NA	NA	NA	OK
F_fleet_3_YR_2013_s_1	0.011178	1	0	2.9	0.01	act	0.0013552	3.68E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2014_s_1	0.018001	1	0	2.9	0.01	act	0.0023355	-9.23E-07	F	NA	NA	NA	OK
F_fleet_3_YR_2015_s_1	0.012659	1	0	2.9	0.01	act	0.0016556	5.20E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2016_s_1	0.009675	1	0	2.9	0.01	act	0.0013101	6.87E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2017_s_1	0.007248	1	0	2.9	0.01	act	0.001014	-6.77E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2018_s_1	0.008739	1	0	2.9	0.01	act	0.0012838	6.22E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2019_s_1	0.009157	1	0	2.9	0.01	act	0.001363	2.48E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2020_s_1	0.010898	1	0	2.9	0.01	act	0.0016843	2.03E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2021_s_1	0.009627	1	0	2.9	0.01	act	0.0015394	3.00E-06	F	NA	NA	NA	OK
F_fleet_3_YR_2022_s_1	0.008033	1	0	2.9	0.01	act	0.0013219	3.08E-07	F	NA	NA	NA	OK
F_fleet_3_YR_2023_s_1	0.007719	1	0	2.9	0.01	act	0.0013177	6.34E-07	F	NA	NA	NA	OK
F_fleet_4_YR_1985_s_1	0.000893	1	0	2.9	0.01	act	0.0001358	-1.03E-05	F	NA	NA	NA	CHECK
F_fleet_4_YR_1986_s_1	0.006953	1	0	2.9	0.01	act	0.0011957	-6.57E-06	F	NA	NA	NA	OK
F_fleet_4_YR_1987_s_1	0.006558	1	0	2.9	0.01	act	0.0012428	-1.12E-05	F	NA	NA	NA	OK
F_fleet_4_YR_1988_s_1	0.012047	1	0	2.9	0.01	act	0.0024529	-3.21E-06	F	NA	NA	NA	OK
F_fleet_4_YR_1989_s_1	0.01721	1	0	2.9	0.01	act	0.0036884	-9.83E-07	F	NA	NA	NA	OK
F_fleet_4_YR_1990_s_1	0.018859	1	0	2.9	0.01	act	0.0041664	-1.57E-07	F	NA	NA	NA	OK
F_fleet_4_YR_1991_s_1	0.012511	1	0	2.9	0.01	act	0.0027946	7.12E-06	F	NA	NA	NA	OK
F_fleet_4_YR_1992_s_1	0.014622	1	0	2.9	0.01	act	0.003253	5.22E-06	F	NA	NA	NA	OK

F_fleet_4_YR_1993_s_1	0.018155	1	0	2.9	0.01	act	0.003948	3.48E-06	F	NA	NA	NA	OK
F_fleet_4_YR_1994_s_1	0.022324	1	0	2.9	0.01	act	0.0046714	2.15E-06	F	NA	NA	NA	OK
F_fleet_4_YR_1995_s_1	0.017391	1	0	2.9	0.01	act	0.0034676	2.47E-06	F	NA	NA	NA	OK
F_fleet_4_YR_1996_s_1	0.013832	1	0	2.9	0.01	act	0.0026219	9.99E-07	F	NA	NA	NA	OK
F_fleet_4_YR_1997_s_1	0.015564	1	0	2.9	0.01	act	0.0028135	1.52E-07	F	NA	NA	NA	OK
F_fleet_4_YR_1998_s_1	0.020401	1	0	2.9	0.01	act	0.0035255	3.12E-06	F	NA	NA	NA	OK
F_fleet_4_YR_1999_s_1	0.016391	1	0	2.9	0.01	act	0.0027092	-1.28E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2000_s_1	0.021535	1	0	2.9	0.01	act	0.0034145	3.69E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2001_s_1	0.01629	1	0	2.9	0.01	act	0.0024875	-1.06E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2002_s_1	0.015139	1	0	2.9	0.01	act	0.0022423	-4.98E-07	F	NA	NA	NA	OK
F_fleet_4_YR_2003_s_1	0.018763	1	0	2.9	0.01	act	0.0026626	4.47E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2004_s_1	0.019627	1	0	2.9	0.01	act	0.00283	1.80E-07	F	NA	NA	NA	OK
F_fleet_4_YR_2005_s_1	0.021477	1	0	2.9	0.01	act	0.0032407	-1.44E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2006_s_1	0.021802	1	0	2.9	0.01	act	0.0033696	5.45E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2007_s_1	0.027762	1	0	2.9	0.01	act	0.0041274	1.95E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2008_s_1	0.021983	1	0	2.9	0.01	act	0.0031083	-3.59E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2009_s_1	0.015874	1	0	2.9	0.01	act	0.0022362	-2.44E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2010_s_1	0.014186	1	0	2.9	0.01	act	0.0018895	3.53E-07	F	NA	NA	NA	OK
F_fleet_4_YR_2011_s_1	0.022505	1	0	2.9	0.01	act	0.0030195	3.99E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2012_s_1	0.024062	1	0	2.9	0.01	act	0.0031614	3.75E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2013_s_1	0.026323	1	0	2.9	0.01	act	0.0034524	5.34E-07	F	NA	NA	NA	OK
F_fleet_4_YR_2014_s_1	0.039758	1	0	2.9	0.01	act	0.0053549	-1.92E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2015_s_1	0.028252	1	0	2.9	0.01	act	0.0039161	1.87E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2016_s_1	0.03283	1	0	2.9	0.01	act	0.0046426	-3.05E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2017_s_1	0.024384	1	0	2.9	0.01	act	0.0035752	-5.09E-07	F	NA	NA	NA	OK
F_fleet_4_YR_2018_s_1	0.030812	1	0	2.9	0.01	act	0.0046216	-7.80E-07	F	NA	NA	NA	OK
F_fleet_4_YR_2019_s_1	0.021427	1	0	2.9	0.01	act	0.003252	2.54E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2020_s_1	0.020058	1	0	2.9	0.01	act	0.0031359	3.31E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2021_s_1	0.019102	1	0	2.9	0.01	act	0.0030815	-6.90E-07	F	NA	NA	NA	OK
F_fleet_4_YR_2022_s_1	0.0156	1	0	2.9	0.01	act	0.0026101	-1.56E-06	F	NA	NA	NA	OK
F_fleet_4_YR_2023_s_1	0.015926	1	0	2.9	0.01	act	0.0027591	-4.48E-07	F	NA	NA	NA	OK
F_fleet_5_YR_1985_s_1	0.018886	1	0	2.9	0.01	act	0.0029369	-7.91E-09	F	NA	NA	NA	OK
F_fleet_5_YR_1986_s_1	0.029495	1	0	2.9	0.01	act	0.005133	-2.72E-06	F	NA	NA	NA	OK
F_fleet_5_YR_1987_s_1	0.027835	1	0	2.9	0.01	act	0.0052922	-1.81E-06	F	NA	NA	NA	OK
F_fleet_5_YR_1988_s_1	0.030011	1	0	2.9	0.01	act	0.006091	-6.42E-07	F	NA	NA	NA	OK
F_fleet_5_YR_1989_s_1	0.030054	1	0	2.9	0.01	act	0.0063908	-1.77E-06	F	NA	NA	NA	OK
F_fleet_5_YR_1990_s_1	0.024508	1	0	2.9	0.01	act	0.0053489	1.23E-06	F	NA	NA	NA	OK
F_fleet_5_YR_1991_s_1	0.021278	1	0	2.9	0.01	act	0.0046787	1.70E-06	F	NA	NA	NA	OK
F_fleet_5_YR_1992_s_1	0.027103	1	0	2.9	0.01	act	0.0059125	4.16E-06	F	NA	NA	NA	OK
F_fleet_5_YR_1993_s_1	0.026227	1	0	2.9	0.01	act	0.0055688	2.95E-06	F	NA	NA	NA	OK
F_fleet_5_YR_1994_s_1	0.02227	1	0	2.9	0.01	act	0.0045358	5.66E-06	F	NA	NA	NA	OK
F_fleet_5_YR_1995_s_1	0.031097	1	0	2.9	0.01	act	0.0060277	2.24E-06	F	NA	NA	NA	OK
F_fleet_5_YR_1996_s_1	0.035012	1	0	2.9	0.01	act	0.0064539	1.30E-06	F	NA	NA	NA	OK
F_fleet_5_YR_1997_s_1	0.03737	1	0	2.9	0.01	act	0.0065791	4.03E-08	F	NA	NA	NA	OK
F_fleet_5_YR_1998_s_1	0.050619	1	0	2.9	0.01	act	0.0085314	-6.77E-07	F	NA	NA	NA	OK
F_fleet_5_YR_1999_s_1	0.039707	1	0	2.9	0.01	act	0.0064221	1.41E-06	F	NA	NA	NA	OK
F_fleet_5_YR_2000_s_1	0.030289	1	0	2.9	0.01	act	0.0047138	1.64E-06	F	NA	NA	NA	OK
F_fleet_5_YR_2001_s_1	0.030478	1	0	2.9	0.01	act	0.0045746	-1.13E-06	F	NA	NA	NA	OK
F_fleet_5_YR_2002_s_1	0.03271	1	0	2.9	0.01	act	0.0047649	8.10E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2003_s_1	0.043661	1	0	2.9	0.01	act	0.006252	1.10E-06	F	NA	NA	NA	OK
F_fleet_5_YR_2004_s_1	0.04831	1	0	2.9	0.01	act	0.0068845	2.11E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2005_s_1	0.044851	1	0	2.9	0.01	act	0.0066617	3.58E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2006_s_1	0.043108	1	0	2.9	0.01	act	0.006365	3.75E-06	F	NA	NA	NA	OK
F_fleet_5_YR_2007_s_1	0.045511	1	0	2.9	0.01	act	0.0067836	2.17E-06	F	NA	NA	NA	OK
F_fleet_5_YR_2008_s_1	0.042734	1	0	2.9	0.01	act	0.006552	3.00E-06	F	NA	NA	NA	OK
F_fleet_5_YR_2009_s_1	0.030388	1	0	2.9	0.01	act	0.0046039	3.55E-05	F	NA	NA	NA	OK
F_fleet_5_YR_2010_s_1	0.034314	1	0	2.9	0.01	act	0.004961	-2.41E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2011_s_1	0.02962	1	0	2.9	0.01	act	0.0041015	1.09E-06	F	NA	NA	NA	OK
F_fleet_5_YR_2012_s_1	0.028334	1	0	2.9	0.01	act	0.0038286	9.25E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2013_s_1	0.031092	1	0	2.9	0.01	act	0.0042064	-8.87E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2014_s_1	0.03877	1	0	2.9	0.01	act	0.0053057	1.76E-06	F	NA	NA	NA	OK
F_fleet_5_YR_2015_s_1	0.032771	1	0	2.9	0.01	act	0.004618	5.19E-07	F	NA	NA	NA	OK

F_fleet_5_YR_2016_s_1	0.033189	1	0	2.9	0.01	act	0.0047989	4.67E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2017_s_1	0.02974	1	0	2.9	0.01	act	0.004445	-4.68E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2018_s_1	0.026024	1	0	2.9	0.01	act	0.0039873	-4.61E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2019_s_1	0.026092	1	0	2.9	0.01	act	0.0041119	1.09E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2020_s_1	0.027518	1	0	2.9	0.01	act	0.0044058	6.98E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2021_s_1	0.024847	1	0	2.9	0.01	act	0.0040876	-1.20E-06	F	NA	NA	NA	OK
F_fleet_5_YR_2022_s_1	0.02216	1	0	2.9	0.01	act	0.0037806	7.96E-07	F	NA	NA	NA	OK
F_fleet_5_YR_2023_s_1	0.02152	1	0	2.9	0.01	act	0.0037599	2.84E-06	F	NA	NA	NA	OK
F_fleet_10_YR_1985_s_1	0.093299	1	0	2.9	0.01	act	0.0094417	-9.60E-07	F	NA	NA	NA	OK
F_fleet_10_YR_1986_s_1	0.093299	1	0	2.9	0.01	act	0.0094418	3.96E-06	F	NA	NA	NA	OK
F_fleet_10_YR_1987_s_1	0.0933	1	0	2.9	0.01	act	0.009442	-5.70E-05	F	NA	NA	NA	OK
F_fleet_10_YR_1988_s_1	0.093301	1	0	2.9	0.01	act	0.0094421	-1.28E-05	F	NA	NA	NA	OK
F_fleet_10_YR_1989_s_1	0.093302	1	0	2.9	0.01	act	0.0094422	-2.99E-05	F	NA	NA	NA	OK
F_fleet_10_YR_1990_s_1	0.093302	1	0	2.9	0.01	act	0.0094423	-5.46E-06	F	NA	NA	NA	OK
F_fleet_10_YR_1991_s_1	0.093302	1	0	2.9	0.01	act	0.0094423	1.99E-06	F	NA	NA	NA	OK
F_fleet_10_YR_1992_s_1	0.093302	1	0	2.9	0.01	act	0.0094423	-8.26E-06	F	NA	NA	NA	OK
F_fleet_10_YR_1993_s_1	0.093302	1	0	2.9	0.01	act	0.0094423	-1.42E-05	F	NA	NA	NA	OK
F_fleet_10_YR_1994_s_1	0.093303	1	0	2.9	0.01	act	0.0094423	1.76E-06	F	NA	NA	NA	OK
F_fleet_10_YR_1995_s_1	0.093303	1	0	2.9	0.01	act	0.0094423	2.47E-07	F	NA	NA	NA	OK
F_fleet_10_YR_1996_s_1	0.093304	1	0	2.9	0.01	act	0.0094423	-1.07E-05	F	NA	NA	NA	OK
F_fleet_10_YR_1997_s_1	0.093305	1	0	2.9	0.01	act	0.0094424	-1.38E-06	F	NA	NA	NA	OK
F_fleet_10_YR_1998_s_1	0.093307	1	0	2.9	0.01	act	0.0094426	-9.93E-07	F	NA	NA	NA	OK
F_fleet_10_YR_1999_s_1	0.093308	1	0	2.9	0.01	act	0.0094427	8.33E-07	F	NA	NA	NA	OK
F_fleet_10_YR_2000_s_1	0.093307	1	0	2.9	0.01	act	0.0094428	5.71E-06	F	NA	NA	NA	OK
F_fleet_10_YR_2001_s_1	0.093307	1	0	2.9	0.01	act	0.0094427	3.00E-06	F	NA	NA	NA	OK
F_fleet_10_YR_2002_s_1	0.093308	1	0	2.9	0.01	act	0.0094426	3.82E-06	F	NA	NA	NA	OK
F_fleet_10_YR_2003_s_1	0.093313	1	0	2.9	0.01	act	0.0094424	9.41E-07	F	NA	NA	NA	OK
F_fleet_10_YR_2004_s_1	0.093304	1	0	2.9	0.01	act	0.0094418	1.62E-06	F	NA	NA	NA	OK
F_fleet_10_YR_2005_s_1	0.093313	1	0	2.9	0.01	act	0.0094433	3.46E-06	F	NA	NA	NA	OK
F_fleet_10_YR_2006_s_1	0.093297	1	0	2.9	0.01	act	0.009442	6.94E-07	F	NA	NA	NA	OK
F_fleet_10_YR_2007_s_1	0.093287	1	0	2.9	0.01	act	0.0094409	1.48E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2008_s_1	0.093268	1	0	2.9	0.01	act	0.0094381	1.62E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2009_s_1	0.093228	1	0	2.9	0.01	act	0.0094329	5.14E-06	F	NA	NA	NA	OK
F_fleet_10_YR_2010_s_1	0.093396	1	0	2.9	0.01	act	0.0093712	8.49E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2011_s_1	0.09348	1	0	2.9	0.01	act	0.0088974	-2.22E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2012_s_1	0.095883	1	0	2.9	0.01	act	0.0089554	7.20E-08	F	NA	NA	NA	OK
F_fleet_10_YR_2013_s_1	0.076346	1	0	2.9	0.01	act	0.0071189	2.13E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2014_s_1	0.079955	1	0	2.9	0.01	act	0.0075761	1.07E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2015_s_1	0.080149	1	0	2.9	0.01	act	0.0079188	-2.97E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2016_s_1	0.06444	1	0	2.9	0.01	act	0.0067486	-8.15E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2017_s_1	0.064067	1	0	2.9	0.01	act	0.007228	-4.59E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2018_s_1	0.055968	1	0	2.9	0.01	act	0.0067898	0.00010388	F	NA	NA	NA	OK
F_fleet_10_YR_2019_s_1	0.055402	1	0	2.9	0.01	act	0.0070525	0.00013945	F	NA	NA	NA	OK
F_fleet_10_YR_2020_s_1	0.051002	1	0	2.9	0.01	act	0.0066674	-2.01E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2021_s_1	0.047604	1	0	2.9	0.01	act	0.0063916	-4.32E-05	F	NA	NA	NA	OK
F_fleet_10_YR_2022_s_1	0.044693	1	0	2.9	0.01	act	0.0062063	-2.74E-06	F	NA	NA	NA	OK
F_fleet_10_YR_2023_s_1	0.041731	1	0	2.9	0.01	act	0.0059931	-1.93E-05	F	NA	NA	NA	OK
Q_extraSD_LPUE(7)	0.004159	3	0	1	0.004154	LO	0.0262657	9.37E-08	No_prior	NA	NA	NA	OK
Q_extraSD_Nourdem_Loire(8)	0.456696	3	0	1	0.456692	OK	0.145352	-8.61E-08	No_prior	NA	NA	NA	OK
Q_extraSD_Nourdem_Gironde(9)	0.011659	3	0	1	0.011532	OK	0.103782	-1.56E-08	No_prior	NA	NA	NA	OK
Size_DblN_peak_OTB_BSS8AB(1)	36.4756	2	20	80.4	36.4681	OK	2.0778	3.54E-06	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_OTB_BSS8AB(1)	5.15992	3	-1	9	5.15985	OK	0.149063	-2.74E-06	No_prior	NA	NA	NA	OK
Retain_L_infl_OTB_BSS8AB(1)	35.7325	4	5	50	35.7321	OK	0.217416	-1.19E-06	No_prior	NA	NA	NA	OK
Retain_L_width_OTB_BSS8AB(1)	0.925689	4	0	10	0.925664	OK	0.134901	-9.72E-08	No_prior	NA	NA	NA	OK
Retain_L_asymptote_logit_OTB_BSS8AB(1)	16.1761	3	-10	30	16.1764	OK	156.503	1.96E-08	No_prior	NA	NA	NA	OK
Size_DblN_peak_PTM_BSS8AB(2)	46.7283	2	20	80.4	46.7251	OK	0.805973	1.10E-06	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_PTM_BSS8AB(2)	3.77771	3	-1	9	3.77727	OK	0.189845	-5.79E-07	No_prior	NA	NA	NA	OK
Size_DblN_peak_GNS_BSS8AB(3)	47.0067	2	20	93	47.005	OK	1.25524	-1.70E-05	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_GNS_BSS8AB(3)	4.06135	3	-1	9	4.06129	OK	0.143777	1.58E-05	No_prior	NA	NA	NA	OK
Size_DblN_descend_se_GNS_BSS8AB(3)	5.49108	3	-1	19	5.49094	OK	0.0999212	9.19E-06	No_prior	NA	NA	NA	OK
Retain_L_infl_GNS_BSS8AB(3)	35.5798	4	5	50	35.5797	OK	0.303746	6.77E-06	No_prior	NA	NA	NA	OK
Retain_L_width_GNS_BSS8AB(3)	0.589408	4	0	10	0.589417	OK	0.15174	-7.61E-08	No_prior	NA	NA	NA	OK

Size_DblN_peak_GTR_BSS8AB(4)	44.5233	2	20	93	44.5208	OK	0.532639	-1.15E-05	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_GTR_BSS8AB(4)	3.40565	3	-1	9	3.40559	OK	0.110432	4.50E-06	No_prior	NA	NA	NA	OK
Retain_L_infl_GTR_BSS8AB(4)	34.8616	4	5	50	34.862	OK	0.851233	1.63E-06	No_prior	NA	NA	NA	OK
Retain_L_width_GTR_BSS8AB(4)	2.31795	4	0	10	2.31793	OK	0.273618	4.30E-07	No_prior	NA	NA	NA	OK
Size_DblN_peak_LLS_BSS8AB(5)	43.6551	2	20	80.4	43.6504	OK	0.863443	-4.40E-05	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_LLS_BSS8AB(5)	3.96376	3	-1	9	3.96322	OK	0.164571	3.36E-05	No_prior	NA	NA	NA	OK
Retain_L_infl_LLS_BSS8AB(5)	36.1777	4	5	50	36.1778	OK	0.351233	2.40E-05	No_prior	NA	NA	NA	OK
Retain_L_width_LLS_BSS8AB(5)	1.15048	4	0	10	1.15037	OK	0.130609	6.46E-06	No_prior	NA	NA	NA	OK
Size_DblN_peak_OTHERS_BSS8AB(6)	42.6551	2	20	80.4	42.6539	OK	0.569955	1.94E-06	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_OTHERS_BSS8AB(6)	3.02882	3	-1	9	3.02863	OK	0.198583	-1.16E-06	No_prior	NA	NA	NA	OK
Size_DblN_peak_Nourdem_Loire(8)	7.03984	2	5	15	7.03987	OK	0.575234	7.19E-08	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_Nourdem_Loire(8)	0.302495	3	-1	9	0.302484	OK	0.758376	-1.75E-07	No_prior	NA	NA	NA	OK
Size_DblN_descend_se_Nourdem_Loire(8)	7.42391	3	-1	9	7.42315	OK	0.436386	4.22E-07	No_prior	NA	NA	NA	OK
Size_DblN_peak_Nourdem_Gironde(9)	10.0506	2	5	15	10.0499	OK	1.37535	3.10E-09	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_Nourdem_Gironde(9)	1.75591	3	-1	9	1.75568	OK	1.03317	7.83E-08	No_prior	NA	NA	NA	OK
Size_DblN_descend_se_Nourdem_Gironde(9)	6.29195	3	-1	9	6.29154	OK	0.292913	1.29E-06	No_prior	NA	NA	NA	OK
Size_DblN_peak_REC_BSS8AB(10)	54.9222	2	20	80.4	54.9134	OK	2.68298	-9.73E-06	No_prior	NA	NA	NA	OK
Size_DblN_ascend_se_REC_BSS8AB(10)	5.40755	3	-1	9	5.40716	OK	0.216369	7.78E-06	No_prior	NA	NA	NA	OK
Retain_L_infl_REC_BSS8AB(10)	25.177	4	5	50	25.178	OK	2.40265	-2.51E-07	No_prior	NA	NA	NA	OK
Retain_L_width_REC_BSS8AB(10)	3.98417	4	0	10	3.98396	OK	0.987774	-9.96E-07	No_prior	NA	NA	NA	OK
Retain_L_asymptote_logit_REC_BSS8AB(10)	3.99498	3	-10	10	3.99505	OK	0.264946	3.58E-06	No_prior	NA	NA	NA	OK

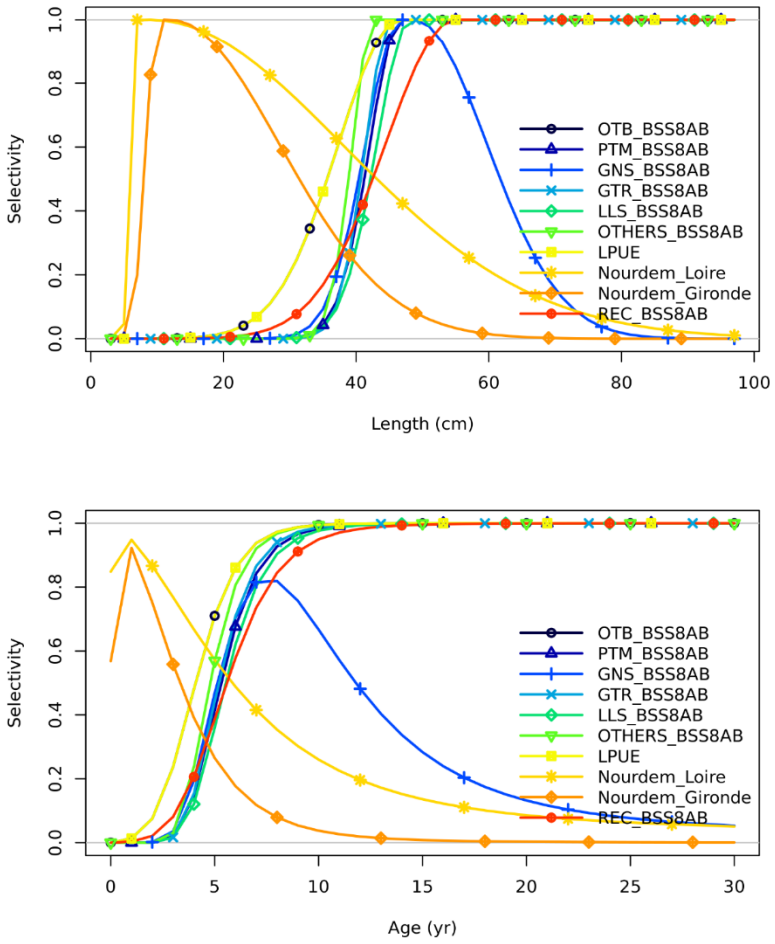


Figure 12. Bay of Biscay seabass in ICES divisions 8ab. Length- (top) and Age-based selectivity (bottom) of commercial fleets, recreational removals, Nourdem Loire and Gironde surveys and OTB-based LPUE index (selectivity mirrored) of the best (*alternative_run_13*) model configuration.

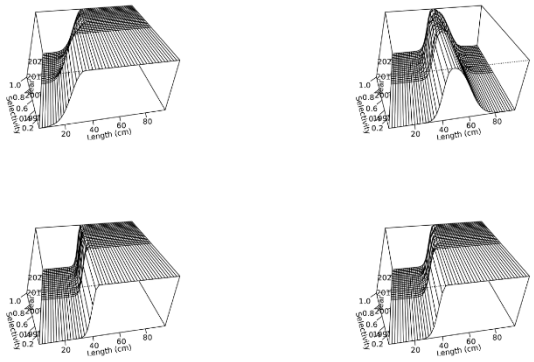


Figure 13. Bay of Biscay seabass in ICES divisions 8ab. Surface plot of time-varying selectivity for OTB, GNS, GTR and LLS of the best (*alternative_run_13*) model configuration. Note that selectivity for LPUE mirror that of the OTB.

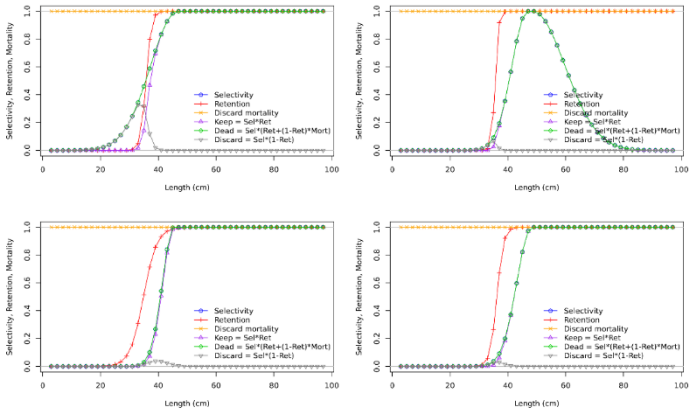


Figure 14. Bay of Biscay seabass in ICES divisions 8ab. Ending year selectivity and retention for OTB, GNS, GTR and LLS of the best (*alternative_run_13*) model configuration. Note that selectivity for LPUE mirror that of OTB, but without retention.

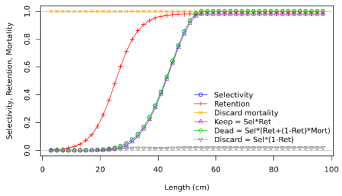


Figure 15. Bay of Biscay seabass in ICES divisions 8ab. Ending year selectivity and retention for the recreational removals of the best (*alternative_run_13*) model configuration. Note that selectivity and retention are constant over time.

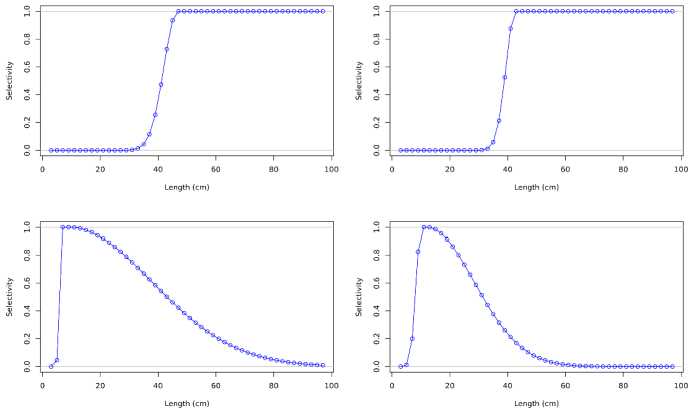


Figure 16. Bay of Biscay seabass in ICES divisions 8ab. Ending year selectivity for PTM, OTHERS, Nourdem Loire and Gironde surveys of the best (*alternative_run_13*) model configuration. Note that selectivity is constant over time for those fleets.

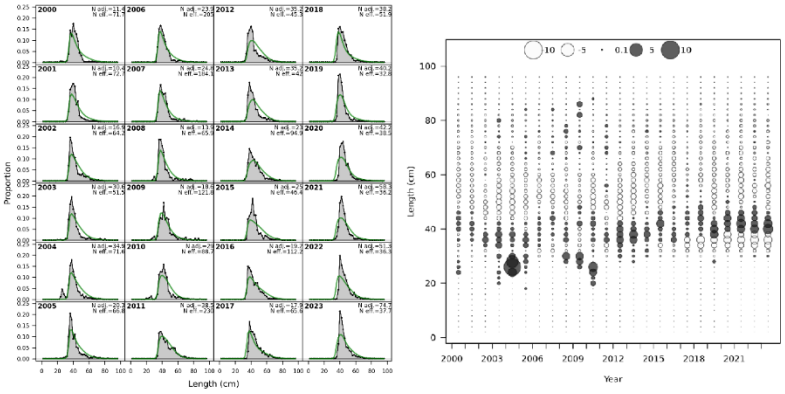


Figure 17. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted retained length composition for OTB of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, retained, OTB (max=8.62) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

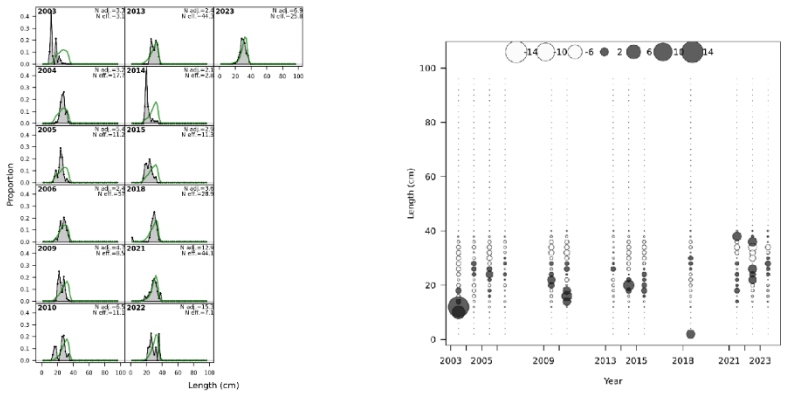


Figure 18. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted discards length composition for OTB of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, discards, OTB (max=12.76) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

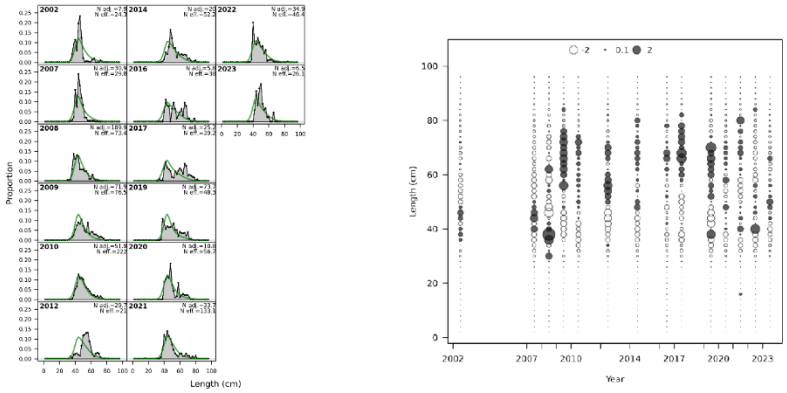


Figure 19. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted whole catch length composition for PTM of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, whole catch, PTM (max=4.58) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

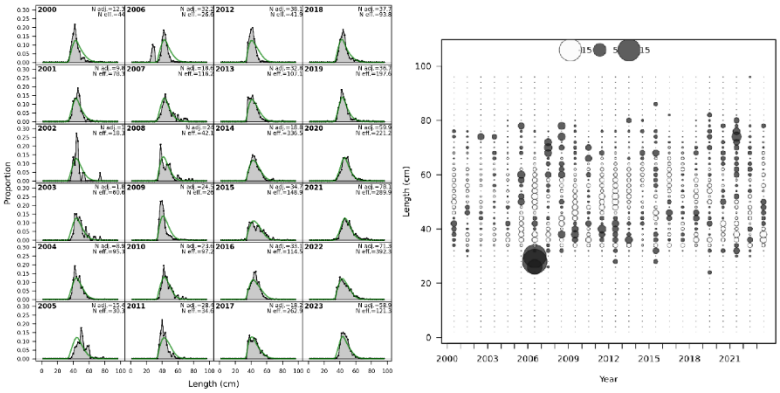


Figure 20. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted retained length composition for GNS of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, retained, GNS (max=18.53) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

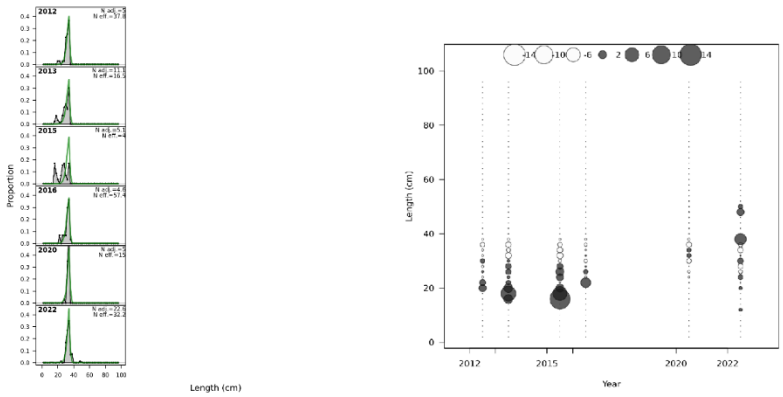


Figure 21. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted discards length composition for GNS of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, discards, GNS (max=12.4) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

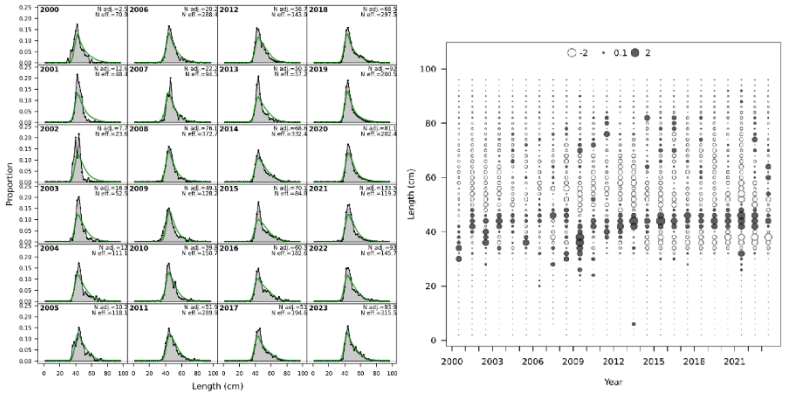


Figure 22. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted retained length composition for GTR of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, retained, GTR (max=2.15) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

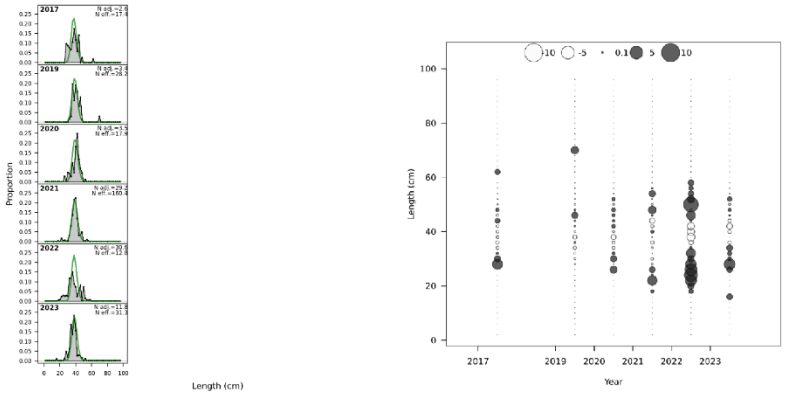


Figure 23. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted discards length composition for GTR of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, discards, GTR (max=6.64) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

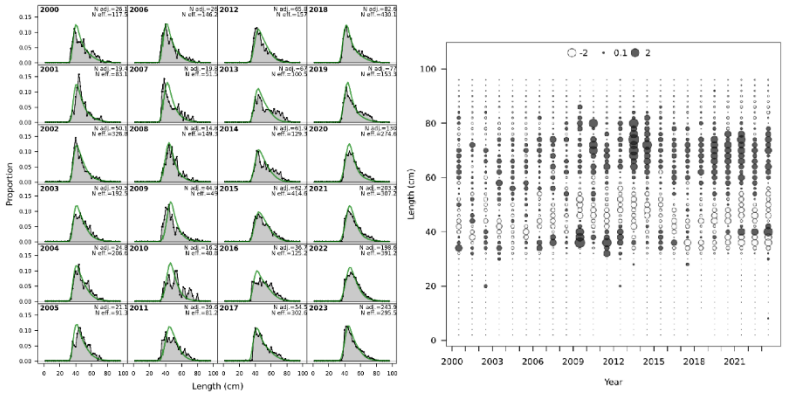


Figure 24. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted retained length composition for LLS of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, retained, LLS (max=3.28) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

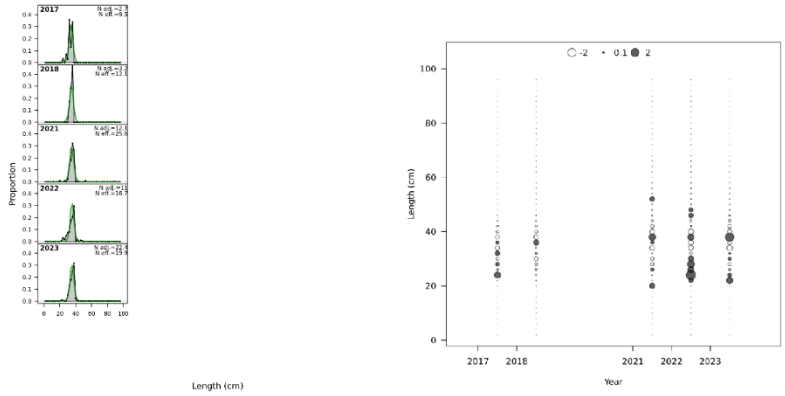


Figure 25. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted discards length composition for LLS of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, discards, LLS (max=2.72) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

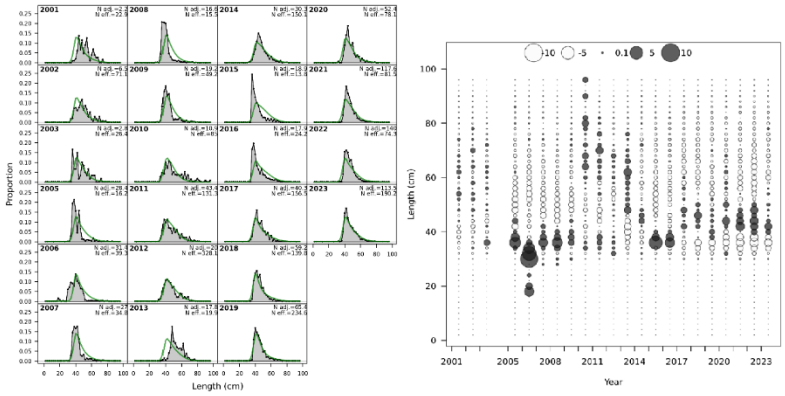


Figure 26. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted whole catch length composition for OTHERS of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, whole catch, OTHERS (max=8.98) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

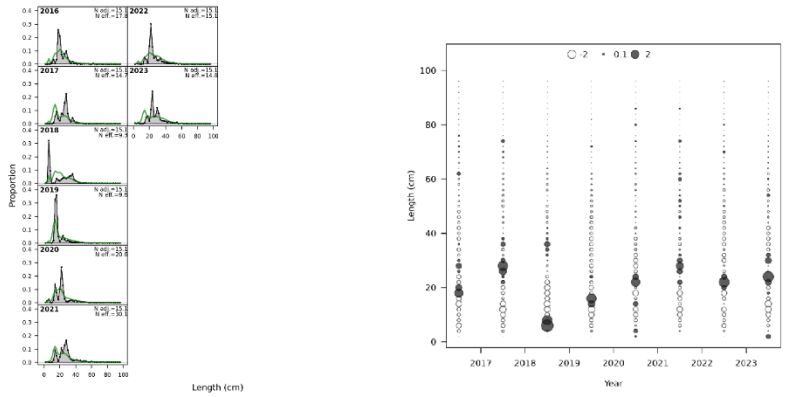


Figure 27. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted whole catch length composition for Nourdem Loire survey of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, whole catch, Nourdem Loire survey (max=4.28) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

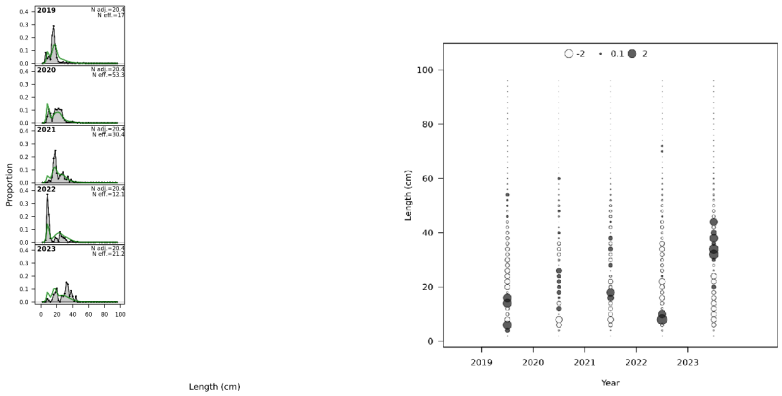


Figure 28. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted whole catch length composition for Nourdem Gironde survey of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, whole catch, Nourdem Gironde survey (max=2.98) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

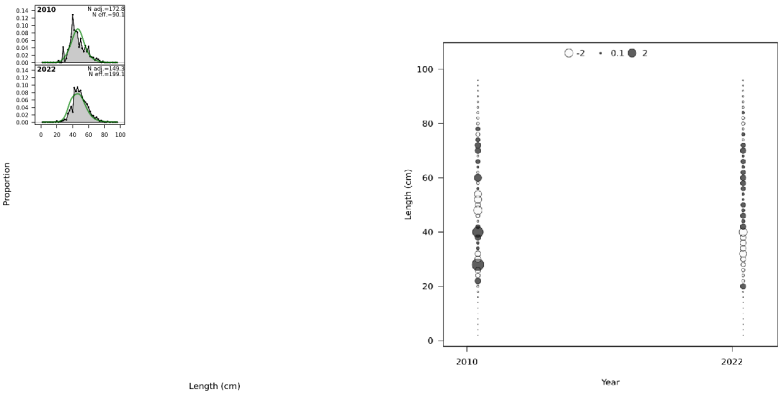


Figure 29. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted retained length composition for REC of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, retained, REC (max=4.17) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

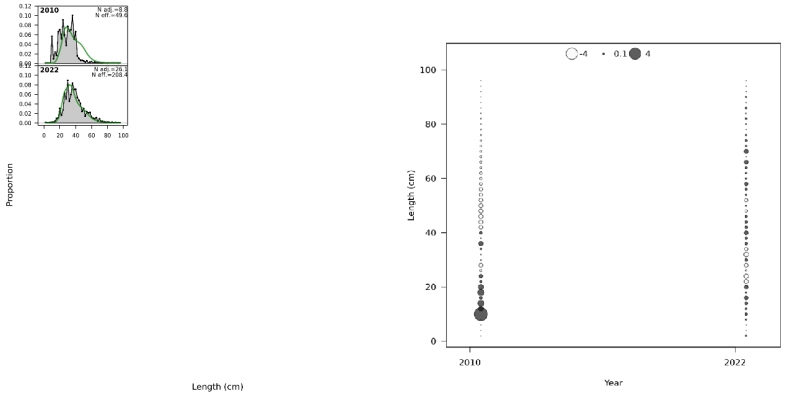


Figure 30. Bay of Biscay seabass in ICES divisions 8ab. Left) Fitted discards length composition for REC of the best (*alternative_run_13*) model configuration. 'N adj.' is the input sample size after data-weighting adjustment. N eff. is the calculated effective sample size used in the McAllister-Ianelli tuning method. Right) Pearson residuals, discards, REC (max=5.26) of the best (*alternative_run_13*) model configuration. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

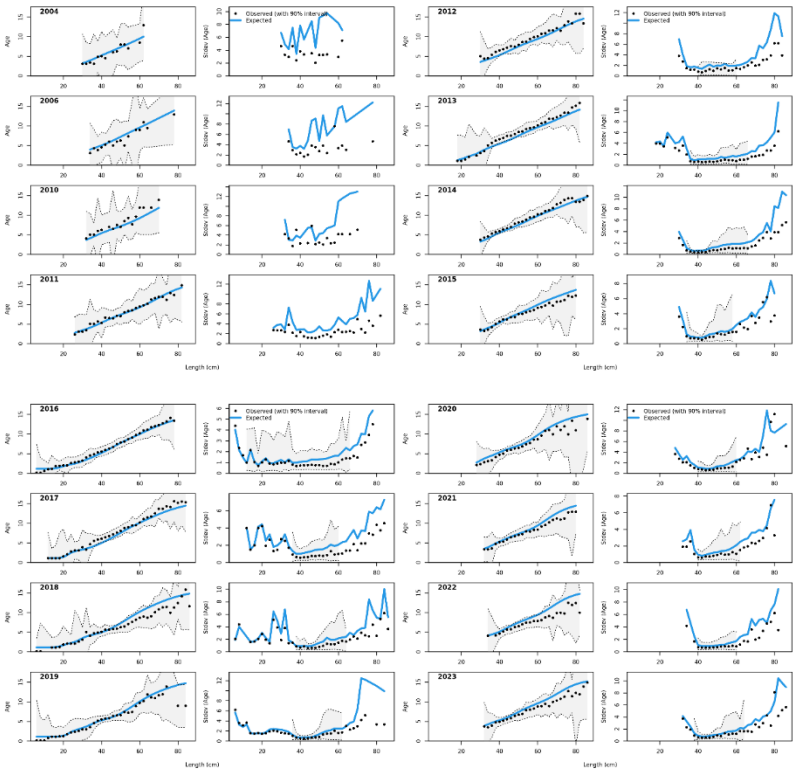


Figure 31. Bay of Biscay seabass in ICES divisions 8ab. Conditional age-at-length plot, whole catch, LPUE index. These plots show mean age and std. dev. in conditional age-at-length. Left plots are mean age-at-length by size-class (obs. and exp.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean age-at-length (obs. and exp.) with 90% CIs based on the chi-square distribution.

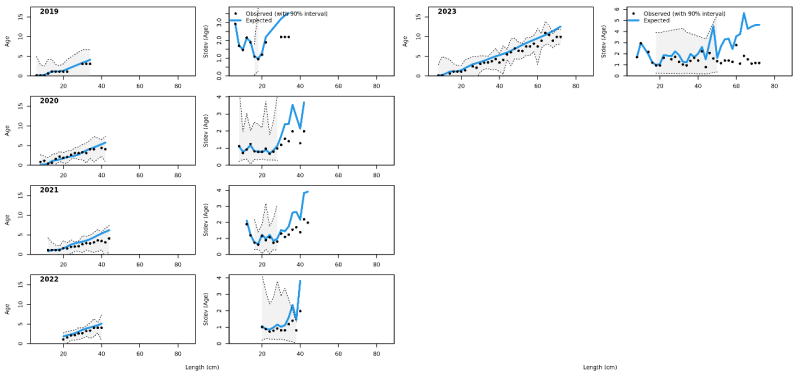


Figure 32. Bay of Biscay seabass in ICES divisions 8ab. Conditional age-at-length plot, whole catch, Nourdem Gironde survey. These plots show mean age and std. dev. in conditional age-at-length. Left plots are mean age-at-length by size-class (obs. and exp.) with 90% CIs based on adding 1.64 SE of mean to the data. Right plots in each pair are SE of mean age-at-length (obs. and exp.) with 90% CIs based on the chi-square distribution.

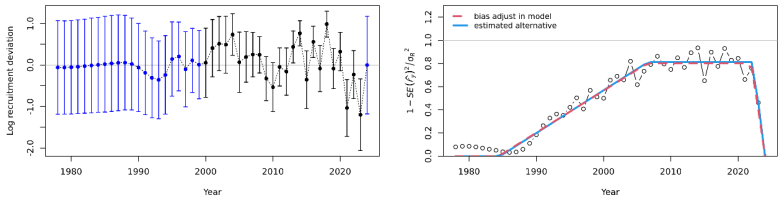


Figure 33. Bay of Biscay seabass in ICES divisions 8ab. Left) Recruitment deviations with 95% intervals. Right) Points are transformed variances. Red line shows current settings for bias adjustment specified in control file. Blue line shows least squares estimate of alternative bias adjustment relationship for recruitment deviations (which may or may not be an improvement).

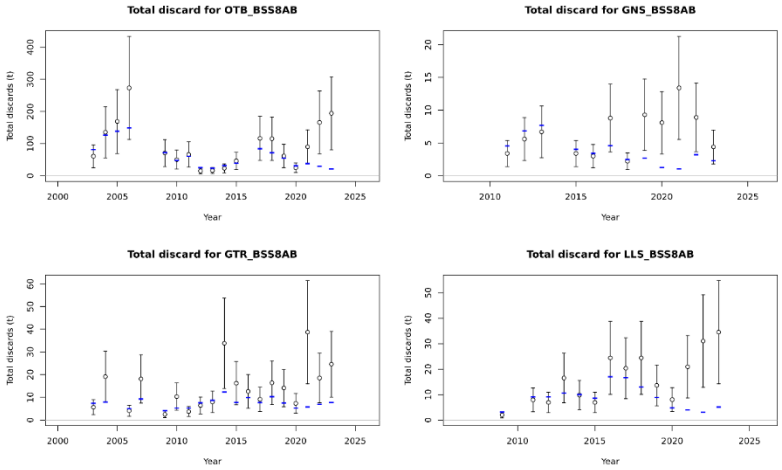


Figure 34. Bay of Biscay seabass in ICES divisions 8ab. Total discards for the commercial fleets (OTB, GNS, GTR and LLS).

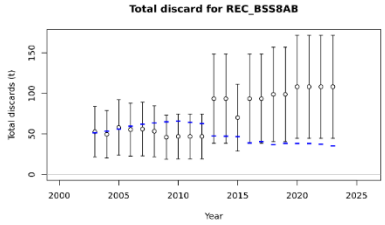


Figure 35. Bay of Biscay seabass in ICES divisions 8ab. Dead released of the recreational fishery.

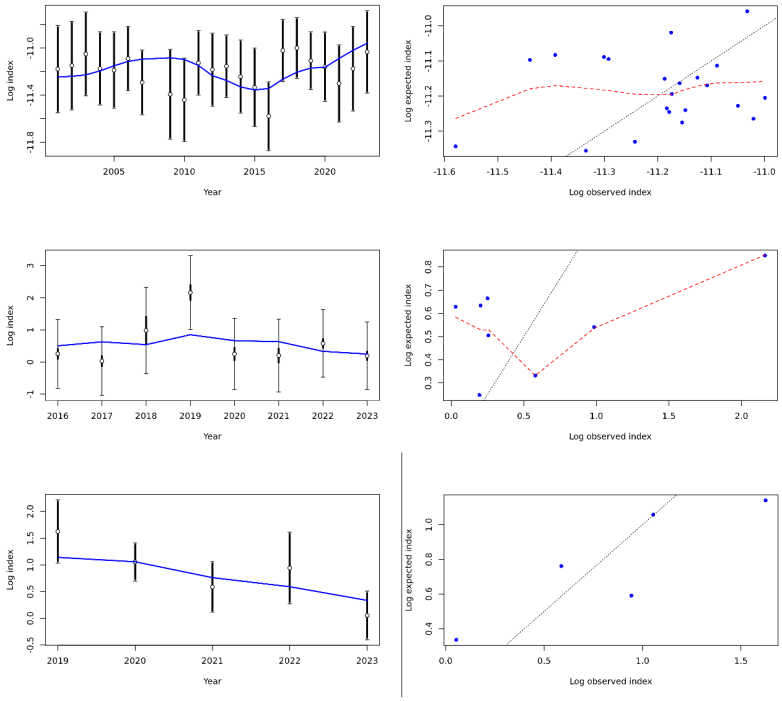


Figure 36. Bay of Biscay seabass in ICES divisions 8ab. Left) Fit to log index data on log scale for LPUE (top), Nourdem Loire survey (middle) and Nourdem Gironde survey (bottom). Lines indicate 95% uncertainty interval around index values based on the model assumption of lognormal error. Thicker lines (if present) indicate input uncertainty before addition of estimated additional uncertainty parameter. Right) log(observed) vs. log(expected) index values with smoother for LPUE (top), Nourdem Loire survey (middle) and Nourdem Gironde survey (bottom).

The results of the runs test are presented in Figures 37 and 38. The RMSE runs test (see Carvalho et al., 2021 for details) indicated that the fit was satisfactory as no residuals were larger than 1 and the RMSE was below 30%, indicating the presence of a random pattern in the length frequency distributions and in the LPUE and survey indices. The RMSE plot is frequently used as a tool for identifying trends in residuals, and if the standard deviation is small on a given year this means the fleets included in the model agree, even if not fitting well, which is a useful diagnostic. Its purpose is to visualize multiple residuals at once, pick up on periods of substantial data conflicts (width of boxes) and systematic departures in median residuals (loess smoothers). The ordinary runs tests were all passed.

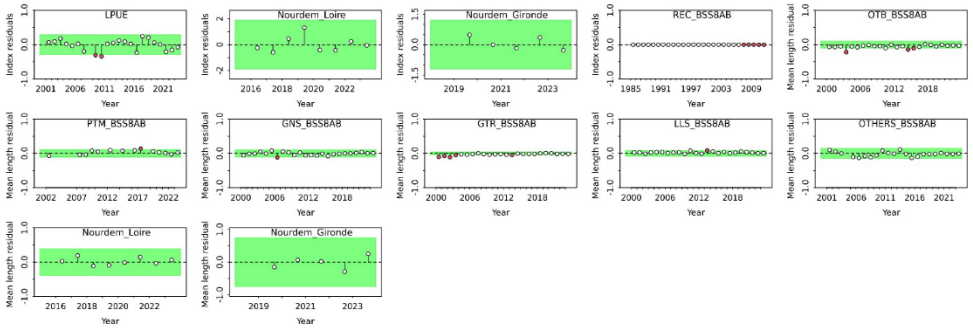


Figure 37. Bay of Biscay seabass in ICES divisions 8ab. Residuals from runs test analyses for the fit to the LPUE, Nourdem Loire survey index, Nourdem Gironde survey index and length distributions of commercial fleets and survey.

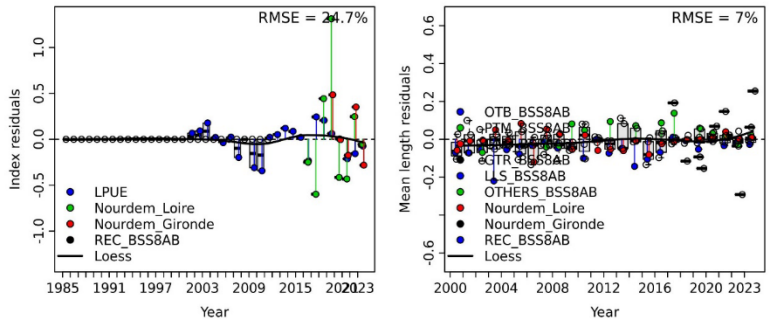


Figure 38. Bay of Biscay seabass in ICES divisions 8ab. Residuals from the RMSE runs test analyses for the length distributions and the fit to the LPUE and the survey indices.

The retrospectives of the best model (*alternative_run_13*) passed the test, although it showed some instability; there is variability in the terminal estimates as years are removed (Figure 39). The estimated Hurtado-Ferro et al. (2014) variant of the Mohn´s rho indices were just inside the ICES bounds of recommended values for long-lived species for both SSB (-0.15) and F (-0.15).

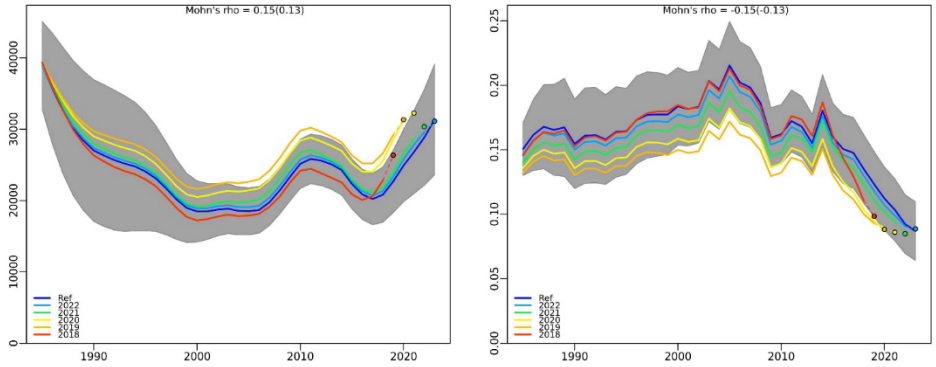


Figure 39. Bay of Biscay seabass in ICES divisions 8ab. Retrospective analyses of the best (*alternative_run_13*) model configuration.

For LPUE and Nourdem Loire survey, the results of the hindcasting showed that they perform well given that the MASE value is lower than the 1.0 threshold or very close to 1.0 when predicting the index one year ahead (Figure 40). For Nourdem Gironde survey, the results of the hindcasting showed that it performs poorly given that the MASE value is upper than the 1.0 threshold (MASE = 4.03) (Figure 40). However, the time-series is short (5 years only); with time, the test could perform better.

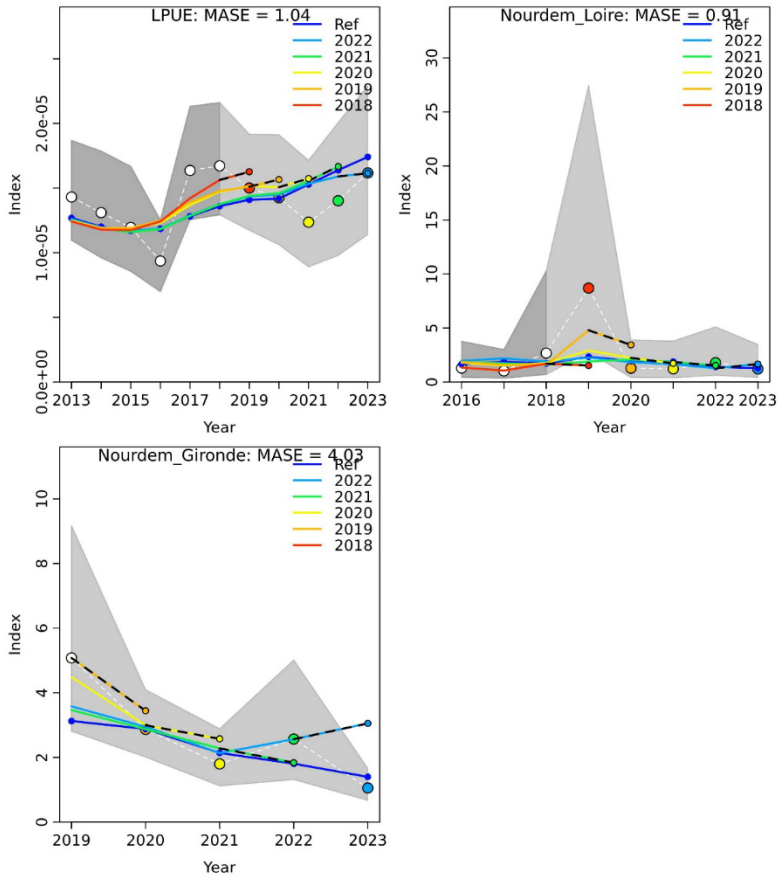


Figure 40. Bay of Biscay seabass in ICES divisions 8ab. Hindcasting results for LPUE and surveys showing observed (large white points connected with dashed line), fitted (solid lines) and one year-ahead forecast values (small terminal points). Hindcasting was performed using one reference model (Ref equal to last year data 2023) and 5 hindcast runs (solid-coloured lines) relative to the expected index. The observations used for cross-validation are highlighted as color-coded solid circles with associated 95 % confidence intervals (light-grey shading). The mean absolute scaled error (MASE) score associated with the acoustic survey index is denoted in each upper part of the panel.

All MASE values for the length compositions of the commercial fleets and the surveys are well below the 1.0 (Figure 41).

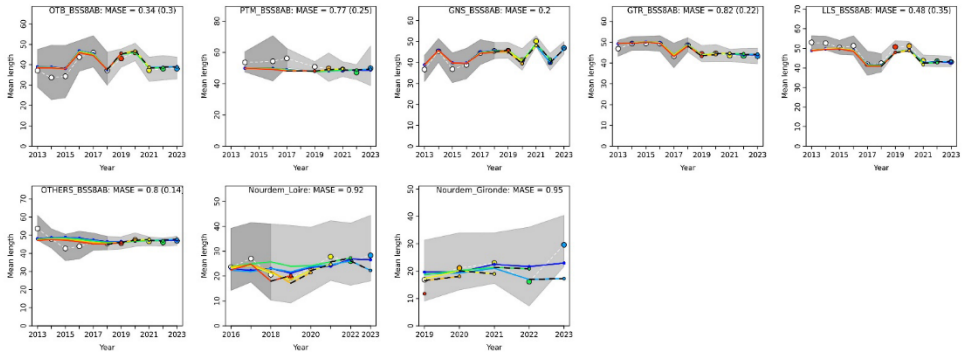


Figure 41. Bay of Biscay seabass in ICES divisions 8ab. Hindcasting results for length compositions showing observed (large white points connected with dashed line), fitted (solid lines) and one year-ahead forecast values (small terminal points). Hindcasting was performed using one reference model (Ref equal to last year data 2023) and 5 hindcast runs (solid-coloured lines) relative to the expected index. The observations used for cross-validation are highlighted as color-coded solid circles with associated 95 % confidence intervals (light-grey shading). The mean absolute scaled error (MASE) score associated with the acoustic survey index is denoted in each upper part of the panel.

5.2 Trends in SSB, F and R

The stock status and the trends in SSB, R and F are based on the MLE model. The probabilistic Kobe plot with stock status in the last year of the assessment (2023) showed that the stock is not currently overfished and overfishing is not occurring with 95.9% probability (Figure 42). It is however important to note that the reference point is set to B30% only for representation and that reference points will be estimated hereafter.

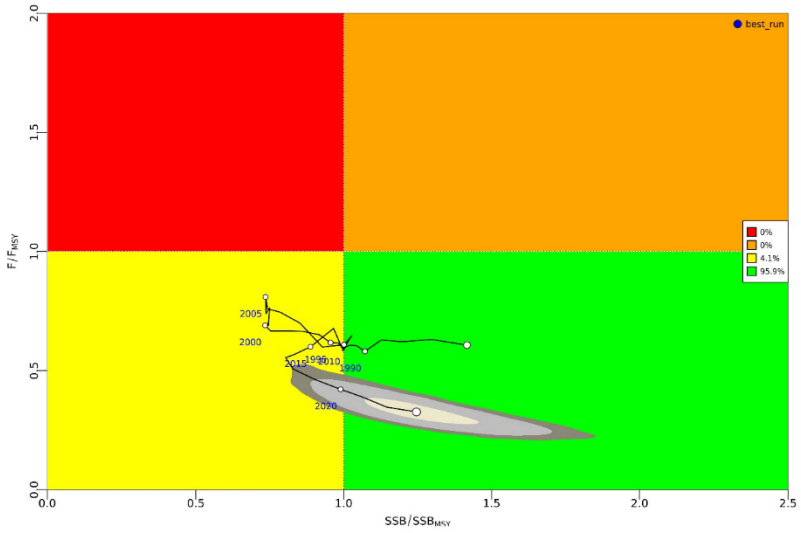


Figure 42. Bay of Biscay seabass in ICES divisions 8ab. Probabilistic Kobe plot with stock status in the last year of the assessment (2023). The legend indicates the estimated probability of the stock status being in each of the Kobe quadrant. The reference point is set to B30% only for representation.

The spawning stock biomass (SSB) showed a declining trend from the beginning of the 1985s to the 2000s, it was then stable until the 2005s. It then increased during the beginning of the 2005s, but declined again until 2015. It increased from 2015 and onwards. Fishing mortality (F) showed an increase from 1985 to 2005, and it has decreased markedly since then. Recruitment (R) shows a high variability with 4 years of low recruitment (2009-2002) and the highest value of recruitment occurring in 2018 (Figure 43).

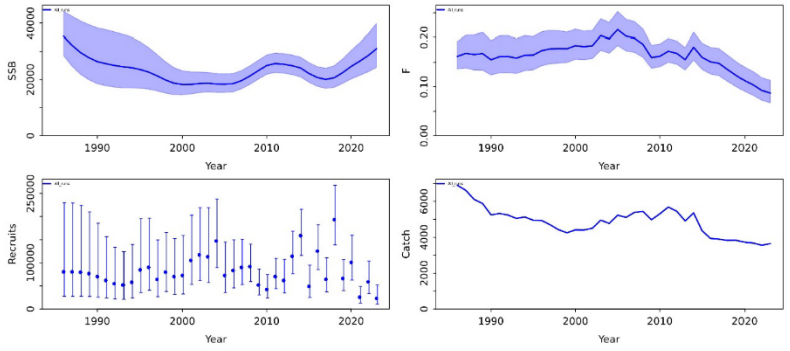


Figure 43. Bay of Biscay seabass in ICES divisions 8ab. Summary of the stock assessment. SSB, F and R with 95% confidence intervals. Catches by fleet and SSB are in tonnes R is in thousands of individuals.

6 Biological reference points

Reference points were established by following the ICES fisheries management reference points for category 1 and 2 stocks (ICES, 2021b). The ICES R package *msy* was used (EqSim approach; Simmonds et al. 2024). The reference points followed the technical guidelines, with the exception of F_{lim} which was not calculated, as the Workshop noted that the basis for calculating this reference point is inconsistent with the MSY reference points, and under review by ICES. Full details of the calculation of the reference points is given in Appendix 5 of this working document. All MSY reference points were calculated using the total removals as the target yield, compared to maximising the yield of landed fish or fish caught above the MCRS. The rationale for this definition was that target yield may not be consistent between the within different sectors of the recreational and commercial fishery.

An FLR stock object was created from SS outputs using the R library ss3om. SSB was calculated from the stock numbers and weights-at-age and the *female* maturity ogive. Note that SS reports SSB in a 2-sex model as the female-only SSB but the reference points were calculated relative to the combined-sex SSB. SSB, F and recruitment in the FLStock object were checked against the SS output (and matched closely).

The stock-recruitment relationship used within the eqsim software was taken directly from that estimated by SS3 (Beverton-Holt with a fixed steepness of 0.8, and an estimated B_0 of 62,812 t). The Workshop characterised the stock-recruitment relationship as ICES type 5 (no evidence of impaired recruitment), and so B_{lim} was set to B_{loss}, the biomass in 2000. This is around 29% of the estimated B_0 from the stock assessment. The value of B_{pa} was calculated from B_{lim} using the final year uncertainty estimated by the model.

The F_{MSY} range was capped to avoid F_{MSY} exceeding F_{p05}. This effects F_{MSY} and F_{MSY_upper}, but not F_{MSY_lower}. The reference points derived for this stock are shown in Table 10 and Figure 44.

Table 10. Bay of Biscay seabass in ICES divisions 8ab. Reference points.

Reference Point	Value	Rationale
Blim	18,471 t	B(2000); lowest SSB with high recruitment
Bpa	23,026 t	Blim with assessment error
MSY Btrigger	23,026 t	Bpa
Fpa	0.185	F with 95% probability of SSB≥Blim (BH with Btrigger)
Fmsy	0.185	Fpa
FmsyLower	0.164	Stochastic simulations
FmsyUpper	0.185	Fpa
Bmsy5pc	11,365 t	5% probability of SSB < Blim

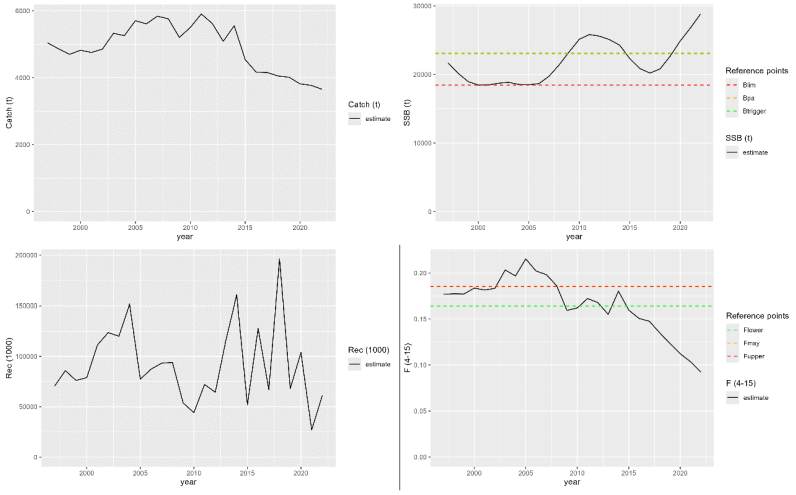


Figure 44. Bay of Biscay seabass in ICES divisions 8ab. Summary of the stock assessment with reference points. Catches (total removals) in tonnes, and model estimates of SSB in tonnes, R in thousands of individuals and F.

7 Forecast

The Workshop decided to implement short term forecasts within SS3 in order to ensure consistency between the assumptions (including uncertainty) made in the assessment and those carried on to the forecast. The Workshop agreed on the following default assumptions to be used in the short term forecast. The working group will review these annually and adapt as necessary:

- Mean weights-at-age, maturity-at-age: These are fixed, so the values from the last year can be used.
- Discard proportions-at-age: average last 3 years.
- Exploitation pattern: average last 3 years.
- F status-quo average last 3 years unless there is a clear trend in F, in which case F can be rescaled to the last year.
- F in the intermediate year: F status-quo.
- Recruitment in the intermediate and forecast years: predicted from Stock Synthesis stock–recruit relationship.

The Workshop noted that if future assessments show a substantial change in recruitment away from the estimated stock-recruitment relationship, it would be necessary to reflect this change by changing the recruitment assumption to use resampling from a suitable recent average recruitment.

The Workshop noted that the assumption that the split of the total removals between fleets remains constant may not reflect management known to be in place in the intermediate year, or anticipated for the advice year. This was considered to be acceptable given the uncertainties around management changing during the year, and uncertainty about the effects of management measures on catches, as seabass is managed through indirect measures (MCRS, closed season, trip limits etc) rather than a catch limit. The Workshop noted that the proposed ICES forecast tool would allow stakeholders to investigate the effect of changing the *status quo* distribution of fleet proportions.

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9 Appendices

9.1 Appendix 1 Data file

```
#V3.30.22.1;_fast(opt);_compile_date:_Jan                                        30
2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_13.1
#_Stock_Synthesis_is_a_work_of_the_U.S._Government_and_is_not_subject_to_copyright_prot
ection_in_the_United_States.
#_Foreign_copyrights_may_apply._See_copyright.txt_for_more_information.
#_User_support_available_at:NMFS.Stock.Synthesis@noaa.gov
#_User_info_available_at:https://vlab.noaa.gov/group/stock-synthesis
#_Source_code_at:_https://github.com/nmfs-ost/ss3-source-code
#_Start_time: Mon Nov 25 22:34:45 2024
#_echo_input_data
#C data file created using the SS_writedat function in the R package r4ss
#C should work with SS version: 3.24
#C file write time: 2024-04-12 10:55:18
#V3.30.22.1;_fast(opt);_compile_date:_Jan                                        30
2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_13.1
1985 #_StartYr
2023 #_EndYr
1 #_Nseas
12 #_months/season
2 #_Nsubseasons (even number, minimum is 2)
1 #_spawn_month
1 #_Nsexes: 1, 2, -1  (use -1 for 1 sex setup with SSB multiplied by female_frac parameter)
30 #_Nages=accumulator age, first age is always age 0
1 #_Nareas
10 #_Nfleets (including surveys)
#_fleet_type: 1=catch fleet; 2=bycatch only fleet; 3=survey; 4=predator(M2)
#_sample_timing: -1 for fishing fleet to use season-long catch-at-age for observations,
or 1 to use observation month;  (always 1 for surveys)
#_fleet_area:  area the fleet/survey operates in
#_units of catch:  1=bio; 2=num (ignored for surveys; their units read later)
#_catch_mult: 0=no; 1=yes
#_rows are fleets
#_fleet_type fishery_timing area catch_units need_catch_mult fleetname
 1 -1 1 1 0 OTB_BSS8AB     # 1
 1 -1 1 1 0 PTM_BSS8AB     # 2
 1 -1 1 1 0 GNS_BSS8AB     # 3
 1 -1 1 1 0 GTR_BSS8AB     # 4
 1 -1 1 1 0 LLS_BSS8AB     # 5
 1 -1 1 1 0 OTHERS_BSS8AB    # 6
 3  1 1 2 0 LPUE        # 7
 3  1 1 2 0 Nourdem_Loire    # 8
 3  1 1 2 0 Nourdem_Gironde  # 9
 1 -1 1 1 0 REC_BSS8AB     # 10
#Bycatch_fleet_input_goes_next
#a:  fleet index
#b:  1=include dead bycatch in total dead catch for F0.1 and MSY optimizations and forecast
ABC; 2=omit from total catch for these purposes (but still include the mortality)
#c:  1=Fmult scales with other fleets; 2=bycatch F constant at input value; 3=bycatch F
from range of years
#d:  F or first year of range
#e:  last year of range
#f:  not used
# a   b   c   d   e   f
#_Catch data: yr, seas, fleet, catch, catch_se
#_catch_se:  standard error of log(catch)
#_NOTE:  catch data is ignored for survey fleets
-999 1 1 317.18 0.01
1985 1 1 524.3 0.1
1986 1 1 602.3 0.1
1987 1 1 507.6 0.1
1988 1 1 604.7 0.1
1989 1 1 506.4 0.1
1990 1 1 469.6 0.1
1991 1 1 306.4 0.1
1992 1 1 362.3 0.1
1993 1 1 427.1 0.1
1994 1 1 500.0 0.1
```

```
1995 1 1 479.7 0.1
1996 1 1 306.3 0.1
1997 1 1 382.3 0.1
1998 1 1 422.8 0.1
1999 1 1 442.4 0.1
2000 1 1 411.3 0.1
2001 1 1 328.3 0.1
2002 1 1 325.5 0.1
2003 1 1 286.3 0.1
2004 1 1 356.7 0.1
2005 1 1 362.9 0.1
2006 1 1 416.8 0.1
2007 1 1 498.0 0.1
2008 1 1 509.0 0.1
2009 1 1 501.6 0.1
2010 1 1 387.1 0.1
2011 1 1 633.0 0.1
2012 1 1 504.5 0.1
2013 1 1 486.9 0.1
2014 1 1 527.7 0.1
2015 1 1 372.3 0.1
2016 1 1 411.0 0.1
2017 1 1 444.5 0.1
2018 1 1 480.6 0.1
2019 1 1 477.5 0.1
2020 1 1 374.1 0.1
2021 1 1 375.1 0.1
2022 1 1 358.3 0.1
2023 1 1 332.5 0.1
-999 1 2 818.74 0.01
1985 1 2 2197.3 0.1
1986 1 2 1572.0 0.1
1987 1 2 1778.5 0.1
1988 1 2 1076.4 0.1
1989 1 2 908.2 0.1
1990 1 2 551.8 0.1
1991 1 2 1315.9 0.1
1992 1 2 1000.1 0.1
1993 1 2 635.3 0.1
1994 1 2 418.5 0.1
1995 1 2 347.8 0.1
1996 1 2 683.0 0.1
1997 1 2 814.9 0.1
1998 1 2 225.2 0.1
1999 1 2 624.2 0.1
2000 1 2 514.4 0.1
2001 1 2 681.5 0.1
2002 1 2 671.3 0.1
2003 1 2 1017.6 0.1
2004 1 2 525.6 0.1
2005 1 2 1019.3 0.1
2006 1 2 918.2 0.1
2007 1 2 647.0 0.1
2008 1 2 720.8 0.1
2009 1 2 591.3 0.1
2010 1 2 539.6 0.1
2011 1 2 356.4 0.1
2012 1 2 296.8 0.1
2013 1 2 251.5 0.1
2014 1 2 278.5 0.1
2015 1 2 195.2 0.1
2016 1 2 184.9 0.1
2017 1 2 258.6 0.1
2018 1 2 172.0 0.1
2019 1 2 140.7 0.1
2020 1 2 114.4 0.1
2021 1 2 42.9 0.1
2022 1 2 49.9 0.1
2023 1 2 39.3 0.1
-999 1 3 24.8 0.01
1985 1 3 25.9 0.1
1986 1 3 184.7 0.1
1987 1 3 160.8 0.1
1988 1 3 276.7 0.1
1989 1 3 375.3 0.1
1990 1 3 397.1 0.1
1991 1 3 257.4 0.1
```

```
1992 1 3 294.9 0.1
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1994 1 3 433.3 0.1
1995 1 3 325.4 0.1
1996 1 3 244.8 0.1
1997 1 3 256.4 0.1
1998 1 3 312.8 0.1
1999 1 3 241.2 0.1
2000 1 3 332.7 0.1
2001 1 3 271.6 0.1
2002 1 3 316.2 0.1
2003 1 3 258.6 0.1
2004 1 3 257.3 0.1
2005 1 3 245.9 0.1
2006 1 3 247.5 0.1
2007 1 3 244.4 0.1
2008 1 3 213.3 0.1
2009 1 3 198.7 0.1
2010 1 3 166.9 0.1
2011 1 3 203.7 0.1
2012 1 3 208.4 0.1
2013 1 3 229.6 0.1
2014 1 3 327.5 0.1
2015 1 3 214.8 0.1
2016 1 3 153.6 0.1
2017 1 3 113.9 0.1
2018 1 3 157.4 0.1
2019 1 3 181.3 0.1
2020 1 3 224.5 0.1
2021 1 3 210.2 0.1
2022 1 3 197.7 0.1
2023 1 3 204.0 0.1
-999 1 4 34.2 0.01
1985 1 4 35.7 0.1
1986 1 4 255.2 0.1
1987 1 4 222.1 0.1
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1989 1 4 518.4 0.1
1990 1 4 548.4 0.1
1991 1 4 355.4 0.1
1992 1 4 407.3 0.1
1993 1 4 497.6 0.1
1994 1 4 598.4 0.1
1995 1 4 449.3 0.1
1996 1 4 338.1 0.1
1997 1 4 354.0 0.1
1998 1 4 432.1 0.1
1999 1 4 333.2 0.1
2000 1 4 438.3 0.1
2001 1 4 336.9 0.1
2002 1 4 316.0 0.1
2003 1 4 411.0 0.1
2004 1 4 388.6 0.1
2005 1 4 427.5 0.1
2006 1 4 432.8 0.1
2007 1 4 577.5 0.1
2008 1 4 512.4 0.1
2009 1 4 453.4 0.1
2010 1 4 379.1 0.1
2011 1 4 645.2 0.1
2012 1 4 668.9 0.1
2013 1 4 712.6 0.1
2014 1 4 969.9 0.1
2015 1 4 628.5 0.1
2016 1 4 702.0 0.1
2017 1 4 513.0 0.1
2018 1 4 672.9 0.1
2019 1 4 521.2 0.1
2020 1 4 515.4 0.1
2021 1 4 537.7 0.1
2022 1 4 480.7 0.1
2023 1 4 543.6 0.1
-999 1 5 721.12 0.01
1985 1 5 791.6 0.1
1986 1 5 1138.2 0.1
1987 1 5 994.9 0.1
1988 1 5 1007.9 0.1
```

```
1989 1 5 961.3 0.1
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1994 1 5 634.7 0.1
1995 1 5 851.3 0.1
1996 1 5 903.7 0.1
1997 1 5 896.5 0.1
1998 1 5 1135.4 0.1
1999 1 5 864.8 0.1
2000 1 5 666.2 0.1
2001 1 5 679.6 0.1
2002 1 5 734.2 0.1
2003 1 5 970.2 0.1
2004 1 5 1060.6 0.1
2005 1 5 976.4 0.1
2006 1 5 986.9 0.1
2007 1 5 1083.8 0.1
2008 1 5 1006.5 0.1
2009 1 5 786.5 0.1
2010 1 5 894.8 0.1
2011 1 5 834.3 0.1
2012 1 5 822.6 0.1
2013 1 5 819.1 0.1
2014 1 5 970.7 0.1
2015 1 5 781.6 0.1
2016 1 5 728.2 0.1
2017 1 5 650.9 0.1
2018 1 5 597.7 0.1
2019 1 5 642.9 0.1
2020 1 5 686.0 0.1
2021 1 5 659.9 0.1
2022 1 5 624.6 0.1
2023 1 5 703.2 0.1
#-999 1 6 0 0.1
1985 1 6 0.0 0.1
1986 1 6 2.0 0.1
1987 1 6 61.5 0.1
1988 1 6 62.1 0.1
1989 1 6 55.2 0.1
1990 1 6 61.5 0.1
1991 1 6 46.0 0.1
1992 1 6 24.0 0.1
1993 1 6 61.0 0.1
1994 1 6 296.7 0.1
1995 1 6 324.3 0.1
1996 1 6 396.7 0.1
1997 1 6 62.1 0.1
1998 1 6 75.0 0.1
1999 1 6 1.1 0.1
2000 1 6 331.8 0.1
2001 1 6 380.7 0.1
2002 1 6 394.2 0.1
2003 1 6 308.8 0.1
2004 1 6 429.9 0.1
2005 1 6 445.2 0.1
2006 1 6 305.7 0.1
2007 1 6 395.4 0.1
2008 1 6 411.6 0.1
2009 1 6 367.6 0.1
2010 1 6 583.8 0.1
2011 1 6 718.7 0.1
2012 1 6 705.5 0.1
2013 1 6 585.6 0.1
2014 1 6 443.8 0.1
2015 1 6 465.4 0.1
2016 1 6 402.6 0.1
2017 1 6 556.4 0.1
2018 1 6 470.3 0.1
2019 1 6 506.5 0.1
2020 1 6 472.0 0.1
2021 1 6 493.7 0.1
2022 1 6 470.8 0.1
2023 1 6 442.4 0.1
-999 1 10 1410 0.01
1985 1 10 2355.3 0.8
```

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1986 1 10 2355.3 0.8
1987 1 10 2355.3 0.8
1988 1 10 2355.3 0.8
1989 1 10 2355.3 0.8
1990 1 10 2355.3 0.8
1991 1 10 2355.3 0.8
1992 1 10 2355.3 0.8
1993 1 10 2355.3 0.8
1994 1 10 2355.3 0.8
1995 1 10 2355.3 0.8
1996 1 10 2355.3 0.8
1997 1 10 2355.3 0.8
1998 1 10 2355.3 0.8
1999 1 10 2355.3 0.8
2000 1 10 2355.3 0.8
2001 1 10 2355.3 0.8
2002 1 10 2355.3 0.8
2003 1 10 2355.3 0.8
2004 1 10 2355.3 0.8
2005 1 10 2355.3 0.8
2006 1 10 2355.3 0.8
2007 1 10 2355.3 0.8
2008 1 10 2355.3 0.8
2009 1 10 2355.3 0.8
2010 1 10 2355.3 0.01
2011 1 10 2376.2 0.01
2012 1 10 2397.0 0.01
2013 1 10 1852.5 0.01
2014 1 10 1832.5 0.01
2015 1 10 1710.7 0.01
2016 1 10 1318.9 0.01
2017 1 10 1316.5 0.01
2018 1 10 1214.8 0.01
2019 1 10 1306.0 0.01
2020 1 10 1304.0 0.01
2021 1 10 1312.6 0.01
2022 1 10 1332.0 0.01
2023 1 10 1340.6 0.01

-9999 0 0 0 0
#
#_CPUE_and_surveyabundance_and_index_observations
#_Units:   0=numbers;   1=biomass;   2=F;   30=spawnbio;   31=exp(recdev);   36=recdev;
32=spawnbio*recdev; 33=recruitment; 34=depletion(&see Qsetup); 35=parm_dev(&see Qsetup)
#_Errtype:  -1=normal; 0=lognormal; 1=lognormal with bias correction; >1=df for T-dist
#_SD_Report: 0=not; 1=include survey expected value with se
#_note that link functions are specified in Q_setup section of control file
#_Fleet Units Errtype SD_Report
1  1 0 0 # OTB_BSS8AB
2  1 0 0 # PTM_BSS8AB
3  1 0 0 # GNS_BSS8AB
4  1 0 0 # GTR_BSS8AB
5  1 0 0 # LLS_BSS8AB
6  1 0 0 # OTHERS_BSS8AB
7  1 0 0 # LPUE
8  0 0 0 # Nourdem_Loire
9  0 0 0 # Nourdem_Gironde
10 2 0 0 # REC_BSS8AB
#
#_yr month fleet obs stderr
-2000 7 7 0.00003116 0.148
2001 7 7 0.00001397 0.185
2002 7 7 0.00001440 0.188
2003 7 7 0.00001589 0.178
2004 7 7 0.00001404 0.154
2005 7 7 0.00001385 0.161
2006 7 7 0.00001528 0.135
2007 7 7 0.00001247 0.136
-2008 7 7 0.00001655 0.140
2009 7 7 0.00001128 0.191
2010 7 7 0.00001076 0.176
2011 7 7 0.00001473 0.136
2012 7 7 0.00001391 0.154
2013 7 7 0.00001431 0.132
2014 7 7 0.00001310 0.154
2015 7 7 0.00001195 0.166
2016 7 7 0.00000936 0.145
```

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2017 7 7 0.00001636 0.131
2018 7 7 0.00001672 0.127
2019 7 7 0.00001500 0.121
2020 7 7 0.00001425 0.146
2021 7 7 0.00001236 0.163
2022 7 7 0.00001402 0.179
2023 7 7 0.00001617 0.174
2016 6 8 1.29132 0.09 #_ Nourdem_Loire
2017 6 8 1.03083 0.09 #_ Nourdem_Loire
2018 6 8 2.67582 0.23 #_ Nourdem_Loire
2019 6 8 8.69042 0.13 #_ Nourdem_Loire
2020 6 8 1.28417 0.11 #_ Nourdem_Loire
2021 6 8 1.22374 0.12 #_ Nourdem_Loire
2022 6 8 1.78393 0.08 #_ Nourdem_Loire
2023 6 8 1.21406 0.08 #_ Nourdem_Loire
2019 9 9 5.0792 0.29 #_ Nourdem_Gironde
2020 9 9 2.86977 0.17 #_ Nourdem_Gironde
2021 9 9 1.79905 0.23 #_ Nourdem_Gironde
2022 9 9 2.5679 0.33 #_ Nourdem_Gironde
2023 9 9 1.05524 0.22 #_ Nourdem_Gironde
1985 7 10 1 0.01 #_ RecFish
1986 7 10 1 0.01 #_ RecFish
1987 7 10 1 0.01 #_ RecFish
1988 7 10 1 0.01 #_ RecFish
1989 7 10 1 0.01 #_ RecFish
1990 7 10 1 0.01 #_ RecFish
1991 7 10 1 0.01 #_ RecFish
1992 7 10 1 0.01 #_ RecFish
1993 7 10 1 0.01 #_ RecFish
1994 7 10 1 0.01 #_ RecFish
1995 7 10 1 0.01 #_ RecFish
1996 7 10 1 0.01 #_ RecFish
1997 7 10 1 0.01 #_ RecFish
1998 7 10 1 0.01 #_ RecFish
1999 7 10 1 0.01 #_ RecFish
2000 7 10 1 0.01 #_ RecFish
2001 7 10 1 0.01 #_ RecFish
2002 7 10 1 0.01 #_ RecFish
2003 7 10 1 0.01 #_ RecFish
2004 7 10 1 0.01 #_ RecFish
2005 7 10 1 0.01 #_ RecFish
2006 7 10 1 0.01 #_ RecFish
2007 7 10 1 0.01 #_ RecFish
2008 7 10 1 0.01 #_ RecFish
2009 7 10 1 0.01 #_ RecFish
2010 7 10 1 0.01 #_ RecFish
2011 7 10 1 0.8 #_ RecFish
-9999 1 1 1 1 # terminator for survey observations
#
5 #_N_fleets_with_discard
#_discard_units (1=same_as_catchunits(bio/num); 2=fraction; 3=numbers)
#_discard_errtype:  >0 for DF of T-dist(read CV below); 0 for normal with CV; -1 for
normal with se; -2 for lognormal; -3 for trunc normal with CV
# note: only enter units and errtype for fleets with discard
# note: discard data is the total for an entire season, so input of month here must be to
a month in that season
#_Fleet units errtype
1  1 0 # OTB_BSS8AB
3  1 0 # GNS_BSS8AB
4  1 0 # GTR_BSS8AB
5  1 0 # LLS_BSS8AB
10 1 0 # REC_BSS8AB

2003 1 1 60.7  0.3 #_ OTB_BSS8AB
2004 1 1 135.4 0.3 #_ OTB_BSS8AB
2005 1 1 168.9 0.3 #_ OTB_BSS8AB
2006 1 1 273.2 0.3 #_ OTB_BSS8AB
-2007 1 1 0.1 0.3 #_ OTB_BSS8AB
-2008 1 1 3.9 0.3 #_ OTB_BSS8AB
2009 1 1 70.7 0.3 #_ OTB_BSS8AB
2010 1 1 50.1 0.3 #_ OTB_BSS8AB
2011 1 1 66.2 0.3 #_ OTB_BSS8AB
2012 1 1 14.8 0.3 #_ OTB_BSS8AB
2013 1 1 16.1 0.3 #_ OTB_BSS8AB
2014 1 1 23.3 0.3 #_ OTB_BSS8AB
2015 1 1 46.2 0.3 #_ OTB_BSS8AB
-2016 1 1 12  0.3 #_ OTB_BSS8AB
```

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2017 1 1 116.3 0.3 #_ OTB_BSS8AB
2018 1 1 115.2 0.3 #_ OTB_BSS8AB
2019 1 1 61.4 0.3 #_ OTB_BSS8AB
2020 1 1 24.7 0.3 #_ OTB_BSS8AB
2021 1 1 90 0.3 #_ OTB_BSS8AB
2022 1 1 165.9 0.3 #_ OTB_BSS8AB
2023 1 1 194.2 0.3 #_ OTB_BSS8AB
-2004 1 3 0 0.3 #_ GNS_BSS8AB
-2005 1 3 0 0.3 #_ GNS_BSS8AB
-2006 1 3 1.6 0.3 #_ GNS_BSS8AB
-2007 1 3 0 0.3 #_ GNS_BSS8AB
-2008 1 3 0.1 0.3 #_ GNS_BSS8AB
-2009 1 3 0.4 0.3 #_ GNS_BSS8AB
-2010 1 3 0.7 0.3 #_ GNS_BSS8AB
2011 1 3 3.4 0.3 #_ GNS_BSS8AB
2012 1 3 5.6 0.3 #_ GNS_BSS8AB
2013 1 3 6.7 0.3 #_ GNS_BSS8AB
-2014 1 3 1.5 0.3 #_ GNS_BSS8AB
2015 1 3 3.4 0.3 #_ GNS_BSS8AB
2016 1 3 3 0.3 #_ GNS_BSS8AB
2017 1 3 8.8 0.3 #_ GNS_BSS8AB
2018 1 3 2.2 0.3 #_ GNS_BSS8AB
2019 1 3 9.3 0.3 #_ GNS_BSS8AB
2020 1 3 8.1 0.3 #_ GNS_BSS8AB
2021 1 3 13.4 0.3 #_ GNS_BSS8AB
2022 1 3 8.9 0.3 #_ GNS_BSS8AB
2023 1 3 4.4 0.3 #_ GNS_BSS8AB
2003 1 4 5.6 0.3 #_ GTR_BSS8AB
2004 1 4 19.1 0.3 #_ GTR_BSS8AB
-2005 1 4 0 0.3 #_ GTR_BSS8AB
2006 1 4 4.1 0.3 #_ GTR_BSS8AB
2007 1 4 18.1 0.3 #_ GTR_BSS8AB
-2008 1 4 0.5 0.3 #_ GTR_BSS8AB
2009 1 4 2.5 0.3 #_ GTR_BSS8AB
2010 1 4 10.3 0.3 #_ GTR_BSS8AB
2011 1 4 3.7 0.3 #_ GTR_BSS8AB
2012 1 4 6.4 0.3 #_ GTR_BSS8AB
2013 1 4 8 0.3 #_ GTR_BSS8AB
2014 1 4 33.8 0.3 #_ GTR_BSS8AB
2015 1 4 16.2 0.3 #_ GTR_BSS8AB
2016 1 4 12.6 0.3 #_ GTR_BSS8AB
2017 1 4 9.1 0.3 #_ GTR_BSS8AB
2018 1 4 16.4 0.3 #_ GTR_BSS8AB
2019 1 4 14.1 0.3 #_ GTR_BSS8AB
2020 1 4 7.3 0.3 #_ GTR_BSS8AB
2021 1 4 38.7 0.3 #_ GTR_BSS8AB
2022 1 4 18.5 0.3 #_ GTR_BSS8AB
2023 1 4 24.6 0.3 #_ GTR_BSS8AB
-2008 1 5 1.8 0.3 #_ LLS_BSS8AB
2009 1 5 2 0.3 #_ LLS_BSS8AB
-2010 1 5 0.7 0.3 #_ LLS_BSS8AB
2011 1 5 7.9 0.3 #_ LLS_BSS8AB
2012 1 5 6.9 0.3 #_ LLS_BSS8AB
2013 1 5 16.5 0.3 #_ LLS_BSS8AB
2014 1 5 9.8 0.3 #_ LLS_BSS8AB
2015 1 5 6.9 0.3 #_ LLS_BSS8AB
2016 1 5 24.4 0.3 #_ LLS_BSS8AB
2017 1 5 20.3 0.3 #_ LLS_BSS8AB
2018 1 5 24.4 0.3 #_ LLS_BSS8AB
2019 1 5 13.6 0.3 #_ LLS_BSS8AB
2020 1 5 8 0.3 #_ LLS_BSS8AB
2021 1 5 20.9 0.3 #_ LLS_BSS8AB
2022 1 5 31 0.3 #_ LLS_BSS8AB
2023 1 5 34.5 0.3 #_ LLS_BSS8AB
2003 1 10 52.9 0.3 #_ REC_BSS8AB
2004 1 10 49.7 0.3 #_ REC_BSS8AB
2005 1 10 58.1 0.3 #_ REC_BSS8AB
2006 1 10 55.5 0.3 #_ REC_BSS8AB
2007 1 10 56.1 0.3 #_ REC_BSS8AB
2008 1 10 53.5 0.3 #_ REC_BSS8AB
2009 1 10 46.1 0.3 #_ REC_BSS8AB
2010 1 10 47 0.3 #_ REC_BSS8AB
2011 1 10 47 0.3 #_ REC_BSS8AB
2012 1 10 47 0.3 #_ REC_BSS8AB
2013 1 10 93.6 0.3 #_ REC_BSS8AB
2014 1 10 93.6 0.3 #_ REC_BSS8AB
2015 1 10 70.3 0.3 #_ REC_BSS8AB
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2016 1 10 93.6 0.3 #_ REC_BSS8AB
2017 1 10 93.6 0.3 #_ REC_BSS8AB
2018 1 10 98.9 0.3 #_ REC_BSS8AB
2019 1 10 98.9 0.3 #_ REC_BSS8AB
2020 1 10 108.3 0.3 #_ REC_BSS8AB
2021 1 10 108.3 0.3 #_ REC_BSS8AB
2022 1 10 108.3 0.3 #_ REC_BSS8AB
2023 1 10 108.3 0.3 #_ REC_BSS8AB

-9999 0 0 0.0 0.0 # terminator for discard data
#
0 #_use meanbodysize_data (0/1)
#_COND_0 #_DF_for_meanbodysize_T-distribution_like
# note:  type=1 for mean length; type=2 for mean body weight
#_yr month fleet part type obs stderr
#  -9999 0 0 0 0 0 0 # terminator for mean body size data
#
# set up population length bin structure (note - irrelevant if not using size data and
using empirical wtatage
2 # length bin method: 1=use databins; 2=generate from binwidth,min,max below; 3=read
vector
2 # binwidth for population size comp
2 # minimum size in the population (lower edge of first bin and size at age 0.00)
96 # maximum size in the population (lower edge of last bin)
1 # use length composition data (0/1/2) where 2 invokes new comp_control format
#_mintailcomp:  upper  and  lower  distribution  for  females  and  males  separately  are
accumulated until exceeding this level.
#_addtocomp:  after accumulation of tails; this value added to all bins
#_combM+F: males and females treated as combined sex below this bin number
#_compressbins: accumulate upper tail by this number of bins; acts simultaneous with
mintailcomp; set=0 for no forced accumulation
#_Comp_Error:    0=multinomial,  1=dirichlet  using  Theta*n,  2=dirichlet  using  beta,
3=MV_Tweedie
#_ParmSelect:  consecutive index for dirichlet or MV_Tweedie
#_minsamplesize: minimum sample size; set to 1 to match 3.24, minimum value is 0.001
#
#_Using old format for composition controls
#_mintailcomp addtocomp combM+F CompressBins CompError ParmSelect minsamplesize
-1  0.001   0  0   0   0   0.01 #_fleet:1_OTB_BSS8AB
-1  0.001   0  0   0   0   0.01 #_fleet:2_PTM_BSS8AB
-1  0.001   0  0   0   0   0.01 #_fleet:3_GNS_BSS8AB
-1  0.001   0  0   0   0   0.01 #_fleet:4_GTR_BSS8AB
-1  0.001   0  0   0   0   0.01 #_fleet:5_LLS_BSS8AB
-1  0.001   0  0   0   0   0.01 #_fleet:6_OTHERS_BSS8AB
-1  0.001   0  0   0   0   0.01 #_fleet:7_LPUE
-1  0.001   0  0   0   0   0.01 #_fleet:8_Nourdem_Loire
-1  0.001   0  0   0   0   0.01 #_fleet:9_Nourdem_Gironde
-1  0.001   0  0   0   0   0.01 #_fleet:10_REC_BSS8AB
# sex  codes:   0=combined;  1=use  female  only;  2=use  male  only;  3=use  both  as  joint
sexxlength distribution
# partition codes:  (0=combined; 1=discard; 2=retained
48 #_N_LengthBins; then enter lower edge of each length bin
 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62
64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96
2000 1 1 0 2 84.24 0 0 0 0 0 0 0 0 0 0 0 0 1322.95 755.98 566.98 0 1802.57 9366.09 36796.6
29892.5 44362.4 35788.9 32323.9 24250.2 10608.5 7838.58 3115.56 563.18 299.28 299.28
939.06 283.15 1065 465.92 380.25 125.51 340.41 376.47 0 0 0 0 0 0 0 0 0 0 0
2001 1 1 0 2 76.926 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1990.68 12624.6 40031.4 44215.1 47551.8
44051.4 21380.4 25866.6 7373.79 5067.23 4165.54 3234.95 1989.92 1836.3 818.1 476.87 736.64
1035.22 559.3 476.87 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2002 1 1 0 2 124.46 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 149.1 694.38 14508.6 41669.2 36212.2 25045
22171.8 14413.6 6826.65 6017.86 5467.52 6877.48 4194.89 3850.41 4185.56 3826.88 1310.79
1500.45 352.09 1230.89 501.19 861.06 234.72 578.22 0 0 0 58.08 0 0 0 0 0 0 0
2003 1 1 0 2 225.8 0 0 0 0 0 0 0 0 0 0 472.22 354.17 644.54 118.06 193.65 1855.61 2370.44
27503.7 47662.2 57881.9 41502.5 35413.6 18157.4 14294.4 8205.1 3978.5 3525.91 3032.58
1535.49 2022.26 3509.71 2003.97 552.75 572.72 365.19 549.01 1141.69 1711.95 805.68 0
1383.43 0 61.97 0 0 0 0 0 0
2003 1 1 0 1 24.008 0 0 0 0 81541.6 354392 53315.6 0 169982 13170.5 50800.4 24459.5
5644.49 3763 3763 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2004 1 1 0 2 257.262 0 0 0 0 0 0 0 0 0 0 0 4282.78 16386.2 8807.42 3773.16 3783.55 23176.4
54567.8 63981 45338.1 36264.6 24138.2 13303.7 11580.3 6200.46 7580.67 2548.4 4874.75
2333.21 2644.45 2452.76 1564.45 1115.05 1154.55 78.09 1170.58 604.76 333.2 0 0 0 0 0 0 0
0 0 0
2004 1 1 0 1 23.974 0 0 0 0 0 0 0 0 0 5747.95 8621.93 43129.9 117807 155178 172349 48857.6
66065.8 8621.93 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2005 1 1 0 2 150.11 0 0 0 0 0 0 0 0 0 349.9 0 0 349.9 629.82 1679.51 2636.97 3471.63 32268.8
66619.2 57465.5 29263.8 35589.1 17130.4 15533.2 8386.23 6466.59 5647.35 6162.26 4862.72
```

2866.95 162.07 1604.23 1485.16 2969.21 2379.01 1483.99 1130.58 1688.33 334.39 235.56 0 0 603.33 0 0 0 0 0 0
2005 1 1 0 1 39.982 0 0 0 0 0 0 1952.23 13665.6 26355.2 11713.4 33188 75160.4 55634.4 17570.1 3904.47 7808.94 1952.23 0 0 0 0 0 0

2022 1 1 0 2 378.602 0 0 0 0 0 0 0 0 0 0 0 0 0 0 230.81 185.66 125.75 599.08 12789.1
57534.2 45460.8 36574.1 32253.5 25581.7 18117.8 12564 7433.5 5550.44 8572.27 3780.1
2404.75 3219.35 1183.75 1528.4 666.18 1336.16 378.23 853.34 111.76 0 106.25 0 0 0 0 0 0
0
2022 1 1 0 1 112.902 0 0 0 0 0 0 0 0 0 0 31925.6 34698.3 68657.3 33358.6 14081.8 33299.2
475.63 67683.2 4994.1 594.54 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2023 1 1 0 2 551.308 0 0 0 0 0 0 0 0 0 0 0 0 0 0 182.22 100.92 343.16 2206.15 18470.1
59084.3 50700.9 36206.6 25469.9 14433.4 13725.7 9881.27 8863.13 3950.04 4699.64 3506.61
2281.6 2403.52 1558.93 1843.01 992.64 335.38 701.41 205.6 264.2 68.33 205.6 78.05 0 0 0
0 0 0
2023 1 1 0 1 50.598 0 0 0 0 0 0 0 0 2499.93 3481.37 12479.5 34621.8 59482.4 130688 126725
107186 54811.9 43980.1 10878.5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2002 1 2 0 0 14.12 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2608.2 10525.6 23752.2 29383.6 15311.7
50450.3 60451 32141.6 5604.21 322.18 1621.41 1460.32 161.09 1138.14 3575.51 4874.74 0 0
0 2437.37 1299.23 0 161.09 0 0 0 0 0 0 0 0 0
2007 1 2 0 0 54.95 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1083.76 2270.92 6952.73 49506.7 23255.2
74487.3 56223.1 36811.5 25945.5 6563.08 5987.78 1523.57 1625.66 1252.62 1963.36 1252.62
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2008 1 2 0 0 337.3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 22.3 22.3 171.81 2846.86 2300.11 3834.91 32617.5
75107.6 60643.4 71786.8 68377.9 31994.8 31403 32035.6 26034.1 27420.3 19892.8 5131.12
6059.64 16792.2 6065.75 1538.03 3737.71 1010.66 125.48 0 1077.17 0 376.42 0 0 0 0 0 0 0
0
2009 1 2 0 0 127.628 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 482.64 1580.34 2798.03 4494.84 9841.77
13670 16302.1 15050.5 19276.6 13242 8715.82 7514.4 16204.6 5369.06 7331.55 7534.32 5373.77
5340.86 4313.9 2738.12 3295.59 2384.95 1498.28 0 0 0 441.92 0 0 0 0 0 0 0
2010 1 2 0 0 92.272 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 25.77 143.59 1500.54 3986.85 4828.45
9446.16 7704.69 8146.76 7580.04 5547.04 4529.02 3963.05 3149.3 2348.36 1576.57 1529.9
944.65 1401.55 681.48 1185.04 559.37 147.15 25.77 0 0 47.86 0 0 0 0 0 0 0
2012 1 2 0 0 52.746 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 939.52 313.17 1614.11 1997.11 2362.57
1625.85 1286.39 5548.06 9917.65 10341.8 11080.7 11144.2 7385.83 4792.48 1875.46 975.23
2291.4 2562.18 2225.76 676.81 140.01 0 104.18 0 104.18 0 0 0 0 0 0 0
2014 1 2 0 0 35.462 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 633.13 1944.29 5722.72 4666.98
8678.77 18252.1 13603.1 7989.09 8207.59 2753.52 5647.71 3916.2 4647.49 4142.93 4420.74
4029.88 1900.63 2350.05 985.02 227.36 684.7 1083.8 0 0 0 0 0 0 0 0
2016 1 2 0 0 10.28 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 522.38 1218.88 870.63 870.63 0
696.5 1044.75 696.51 174.13 348.26 522.38 696.5 348.25 1044.76 870.63 174.13 174.13 0 0
174.13 0 0 0 0 0 0 0 0 0 0
2017 1 2 0 0 44.74 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 821.65 0 309.3 5224.37 8249.14 5759.47
5037.93 4220.07 1662.62 1410.25 4192.49 2919.94 4370.14 5414.79 4654.39 3059.98 7546.44
6621.06 2154.46 2708.5 2349.6 1747.96 1504.4 189.34 604.71 80.94 0 0 0 0 0 0
2019 1 2 0 0 130.908 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 335.11 8406.01 6792.06 4366.04
5458.45 5025.36 5153.9 5256.27 6585.1 4005.55 4027.61 1527.65 3321.26 2720.38 2712.23
2865.36 1789.95 3115.44 439.56 495.08 97.78 48.89 0 120.76 0 0 0 0 0 0 0
2020 1 2 0 0 19.248 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2658.74 2962.69 3418.37 3179.7
5362.93 2148.76 1262.04 303.35 476.88 2475.45 303.35 606.7 820.3 606.7 655.34 606.7 303.35
0 0 0 0 0 0 0 0 0 0 0 0
2021 1 2 0 0 59.816 0 0 0 0 0 0 0 16.14 0 0 0 0 0 0 16.1 0 0 108.31 655.69 1739.25 1363.81
1992.93 1619.08 1430.13 999.08 644.26 372.12 248.82 130.16 383.56 377.6 174.95 207.18
360.9 215.56 184.14 44.79 146.33 38.02 228.12 6.77 0 0 0 0 0 0 0
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2323.96 1895.55 1471.12 1551.84 842.37 1191.03 139.02 213.02 232.37 244.81 79.44 0 67.53
0 0 0 0 0 0 67.53 0 0 0 0 0 0
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2007 1 3 0 2 94.952 0 0 0 0 0 0 0 0 0 0 0 0 168.14 0 0 543.79 2394.13 3465.46 6344.98 12782.1 17343.7 24233 17043.4 15512 9739.12 4984.69 7658.29 6719.51 1052.1 5741.3 1131.48 2039.52 684.04 2767.51 2763.75 2039.52 0 73.14 0 0 0 0 0 0 0 0 0 0
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6018.6 0 3003.43 0 66.75 1592.08 0 0 0 0 0 0 0 0 0 0
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823.83 785.89 162.33 1867.59 2393.11 162.33 0 0 0 0 0 0 0 0 0 0 0
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0 0
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0 0
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5216.39 5289.32 1034.01 745.46 1378.11 182.88 852.81 1123.9 1014.46 480.8 201.38 96.63 0
0 0 0 0 0
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0 206 0 206 0 0 0
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2271.94 2687.38 1753.11 109.23 1346.51 2620.42 1036.6 143.15 107.72 0 315.78 0 0 62.15 0
0 0 0
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46716.7 64510 49434.4 48371.6 32013 33508.7 20343.2 13507.7 15175.9 9447.68 8369.38
7761.12 3162.79 3866.75 1805.41 1760.97 1072.07 3986.23 588.21 1706.24 1142.97 399.5
142.12 0 0 0 0 0
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72084.7 60976.2 34103.5 40981.2 28666.7 20720.1 19766.8 9837.61 8476.15 5951.41 3871.77
2569.74 1964.45 2633.99 1420.92 1736.22 1381.44 679.82 283.34 320.19 146.82 0 0 30.63 0
34.37 0
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0 0
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0 0 0
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9919.29 8136.45 9261.62 4105.24 6446.58 3648.73 2654.55 971.37 1874.96 249.5 606.67 0
91.36 0 0 0 0 0
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0 0 0 0 0
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27781.2 50102.2 52826.6 55612 32876.1 23188.5 19284.8 15211.2 13791.4 13265.7 11576
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0 0 0 0 0
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0 0 0
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1869.28 957.06 1526.04 172.1 0 0 0 0 0 0 0 0 0 0 0 344.19 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0
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20.79 118.65 415.4 0 175.3 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0
2022 1 4 0 1 237.042 0 0 0 0 0 0 0 0 55.27 110.54 326.16 440.86 394.6 426.4 386.5 1783.1
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92.52 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2023 1 4 0 2 728.108 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 332.69 2055.34 3638.46 27268.3
44155.6 55598 41111.6 26622 24798.8 17061.5 22494.7 14959 12224.9 14332.7 7502.37 9684.78
4469.56 2758.45 2959.32 1943.8 1045.9 945.43 645.99 268.9 431.52 83.1 0 0 0 0 0 0
2023 1 4 0 1 91.452 0 0 0 0 0 0 0 0 97.36 0 0 0 0 0 97.36 490.66 196.65 655.63 1952.11 1425.68
2447.19 1628.84 271.2 304.24 243.39 152.12 0 107.07 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0
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17797.1 18077.3 18059.1 14214.1 20576.6 8235.41 10571 8897.95 4400.44 9688.07 10042.7
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0 0
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23852.2 33014.5 24979.6 15524.1 12986.8 13862.2 4416.14 7055 6491.82 5150.61 3077.86
2197.58 2342 2473.85 2192.53 4106.33 915.67 360.85 0 0 0 0 0 0 0 0 0 0 0
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48487.1 66102.3 38443.6 37019.1 22384.2 32625.1 31677.1 36778.4 17189.7 19292.4 13668.7
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6737.45 8404.25 5288.54 8019.41 3707.39 5407.91 1920.54 0 0 1857.07 0 0 0 0 0 0 0 0
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0
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26182.7 31309.2 24920.6 27319.2 31456.1 25575.1 22800.5 15582.6 19252 9863.84 11693.2
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54738.4 55545.3 45868.6 47328.6 27912.6 29442.9 19078.9 22649.5 14147.9 17240.4 15322.8
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108.32 0 0 0 0 0 108.32
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0 0 0 0
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0 0 0 0
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0
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0 0

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11150.4 10373.5 7677.89 8613.78 7508.78 3499.42 1026.67 2649.75 572.67 589.88 0 0 0 0 0
0 0
2017 1 5 0 1 12.796 0 0 0 0 0 0 0 0 0 0 0 1316.85 0 2633.69 1170.52 13803.9 4974.74
13122.5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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31520.5 29205.9 25859 22569.4 18748.4 20176.7 11646.3 12316.5 12842.4 12050.6 8691.92
10672.1 9192.75 8718.2 7355.07 5978.61 1568.86 1670.21 1187.24 165.14 198.17 0 0 0 165.14
0 0
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0 0
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0 0 0 0 0 0
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```
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2023 7 7 0 0 1 68 68 22 0 0 0 0 0 0 0 0 0 2 6 8 3 2 1 0 0 0
2023 7 7 0 0 1 70 70 14 0 0 0 0 0 0 0 0 1 1 2 5 1 3 0 0 1 0
2023 7 7 0 0 1 72 72 17 0 0 0 0 0 0 0 0 0 0 4 5 4 1 1 1 1 0
2023 7 7 0 0 1 74 74 11 0 0 0 0 0 0 0 0 0 0 1 3 2 4 0 0 0 1
2023 7 7 0 0 1 76 76 9 0 0 0 0 0 0 0 0 0 0 0 1 1 0 3 1 0 1 2
2023 7 7 0 0 1 78 78 6 0 0 0 0 0 0 0 0 0 0 0 0 1 2 2 1 0 0 0
2023 7 7 0 0 1 80 80 3 0 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0 1
2023 7 7 0 0 1 82 82 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
2023 7 7 0 0 1 84 84 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0
2023 7 7 0 0 1 86 86 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0

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# 2016 6 8 0 2 1 8 8 7 7 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
# 2016 6 8 0 2 1 10 10 15 8 7 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
# 2016 6 8 0 2 1 12 12 36 4 32 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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# 2016 6 8 0 2 1 16 16 30 0 8 22 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
# 2016 6 8 0 2 1 18 18 65 0 11 54 0 0 0 0 0 0 0 0 0 0 0 0 0 0
# 2016 6 8 0 2 1 20 20 30 0 3 26 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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# 2016 6 8 0 2 1 32 32 24 0 0 0 23 1 0 0 0 0 0 0 0 0 0 0 0 0 0
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# 2016 6 8 0 2 1 36 36 12 0 0 0 7 4 1 0 0 0 0 0 0 0 0 0 0 0 0
# 2016 6 8 0 2 1 38 38 3 0 0 0 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0
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# 2018 6 8 0 2 1 14 14 13 0 13 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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# 2023 6 8 0 2 1 12 12 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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# 2023 6 8 0 2 1 34 34 9 0 0 0 4 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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# 2023 6 8 0 2 1 36 36 9 0 0 0 1 7 1 0 0 0 0 0 0 0 0 0 0
# 2023 6 8 0 2 1 38 38 9 0 0 0 0 7 1 1 0 0 0 0 0 0 0 0 0
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# 2023 6 8 0 2 1 42 42 6 0 0 0 0 3 2 1 0 0 0 0 0 0 0 0 0
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2019 9 9 0 0 1 8 8 3 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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2019 9 9 0 0 1 12 12 2 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
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2019 9 9 0 0 1 18 18 8 0 8 0 0 0 0 0 0 0 0 0 0 0 0 0
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2019 9 9 0 0 1 22 22 2 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0
2019 9 9 0 0 1 30 30 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
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2019 9 9 0 0 1 34 34 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0
2020 9 9 0 0 1 8 8 7 2 5 0 0 0 0 0 0 0 0 0 0 0 0 0
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2020 9 9 0 0 1 22 22 9 0 2 5 2 0 0 0 0 0 0 0 0 0 0 0
2020 9 9 0 0 1 24 24 15 0 0 7 8 0 0 0 0 0 0 0 0 0 0 0
2020 9 9 0 0 1 26 26 11 0 0 2 7 2 0 0 0 0 0 0 0 0 0 0
2020 9 9 0 0 1 28 28 8 0 0 2 4 2 0 0 0 0 0 0 0 0 0 0
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2021 9 9 0 0 1 16 16 13 0 13 0 0 0 0 0 0 0 0 0 0 0 0 0
2021 9 9 0 0 1 18 18 19 0 19 0 0 0 0 0 0 0 0 0 0 0 0 0
2021 9 9 0 0 1 20 20 6 0 3 3 0 0 0 0 0 0 0 0 0 0 0 0
2021 9 9 0 0 1 22 22 10 0 6 4 0 0 0 0 0 0 0 0 0 0 0 0
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2021 9 9 0 0 1 26 26 12 0 1 11 0 0 0 0 0 0 0 0 0 0 0 0
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2021 9 9 0 0 1 32 32 5 0 0 1 4 0 0 0 0 0 0 0 0 0 0 0
2021 9 9 0 0 1 34 34 4 0 0 1 3 0 0 0 0 0 0 0 0 0 0 0
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2021 9 9 0 0 1 40 40 3 0 0 0 2 1 0 0 0 0 0 0 0 0 0 0
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2021 9 9 0 0 1 44 44 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 20 20 7 0 7 0 0 0 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 22 22 10 0 5 5 0 0 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 24 24 11 0 0 11 0 0 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 26 26 10 0 0 9 1 0 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 28 28 8 0 0 4 4 0 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 30 30 10 0 0 4 6 0 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 32 32 8 0 0 0 7 1 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 34 34 4 0 0 0 3 1 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 36 36 2 0 0 0 0 2 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 38 38 6 0 0 0 0 6 0 0 0 0 0 0 0 0 0 0
2022 9 9 0 0 1 40 40 1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 8 8 3 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 10 10 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 14 14 2 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 16 16 5 0 5 0 0 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 18 18 8 0 8 0 0 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 20 20 8 0 8 0 0 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 22 22 3 0 2 1 0 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 26 26 3 0 0 2 1 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 28 28 2 0 0 2 0 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 30 30 3 0 0 0 3 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 32 32 7 0 0 0 6 0 1 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 34 34 8 0 0 0 6 1 1 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 36 36 3 0 0 0 1 2 0 0 0 0 0 0 0 0 0 0
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2023 9 9 0 0 1 38 38 4 0 0 0 1 2 0 1 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 40 40 3 0 0 0 2 1 0 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 42 42 2 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 44 44 7 0 0 0 0 0 4 3 0 0 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 46 46 2 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0
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2023 9 9 0 0 1 50 50 8 0 0 0 0 0 0 4 0 1 3 0 0 0 0 0 0 0
2023 9 9 0 0 1 52 52 3 0 0 0 0 0 0 0 2 1 0 0 0 0 0 0 0 0
2023 9 9 0 0 1 54 54 2 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0
2023 9 9 0 0 1 56 56 2 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0
2023 9 9 0 0 1 58 58 4 0 0 0 0 0 0 0 1 1 2 0 0 0 0 0 0 0
2023 9 9 0 0 1 60 60 2 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0
2023 9 9 0 0 1 62 62 2 0 0 0 0 0 0 0 0 0 0 2 0 0 0 0 0 0
2023 9 9 0 0 1 64 64 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0
2023 9 9 0 0 1 66 66 2 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0 0 0
2023 9 9 0 0 1 68 68 2 0 0 0 0 0 0 0 0 0 0 2 0 0 0 0 0 0
2023 9 9 0 0 1 70 70 2 0 0 0 0 0 0 0 0 0 0 0 2 0 0 0 0 0
2023 9 9 0 0 1 72 72 2 0 0 0 0 0 0 0 0 0 0 0 2 0 0 0 0 0

-9999  0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
#
0 #_Use_MeanSize-at-Age_obs (0/1)
#
0 #_N_environ_variables
# -2 in yr will subtract mean for that env_var; -1 will subtract mean and divide by stddev
(e.g. Z-score)
#Yr Variable Value
#
# Sizefreq data. Defined by method because a fleet can use multiple methods
0 # N sizefreq methods to read (or -1 for expanded options)
#
0 # do tags (0/1/2); where 2 allows entry of TG_min_recap
#
0 #    morphcomp data(0/1)
#  Nobs, Nmorphs, mincomp
#  yr, seas, type, partition, Nsamp, datavector_by_Nmorphs
#
0  #  Do dataread for selectivity priors(0/1)
# Yr, Seas, Fleet,  Age/Size,  Bin,  selex_prior,  prior_sd
# feature not yet implemented
#
999
```

9.2 Appendix 2 Control file

```
#V3.30.xx.yy;_safe;_compile_date:_Dec                                                    5
2024;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_13.2
#_Stock_Synthesis_is_a_work_of_the_U.S._Government_and_is_not_subject_to_copyright_prot
ection_in_the_United_States.
#_Foreign_copyrights_may_apply._See_copyright.txt_for_more_information.
#_User_support_available_at:NMFS.Stock.Synthesis@noaa.gov
#_User_info_available_at:https://vlab.noaa.gov/group/stock-synthesis
#_Source_code_at:_https://github.com/nmfs-ost/ss3-source-code

#_data_and_control_files: BassVIIIab_3.30_data.ss // BassVIIIab_3.30_control.ss
0  # 0 means do not read wtatage.ss; 1 means read and use wtatage.ss and also read and
use growth parameters
1    #_N_Growth_Patterns  (Growth  Patterns,  Morphs,  Bio  Patterns,  GP  are  terms  used
interchangeably in SS3)
1 #_N_platoons_Within_GrowthPattern
#_Cond 1 #_Platoon_within/between_stdev_ratio (no read if N_platoons=1)
#_Cond sd_ratio_rd < 0: platoon_sd_ratio parameter required after movement params.
#_Cond  1 #vector_platoon_dist_(-1_in_first_val_gives_normal_approx)
#
4 # recr_dist_method for parameters:  2=main effects for GP, Area, Settle timing; 3=each
Settle entity; 4=none (only when N_GP*Nsettle*pop==1)
1 # not yet implemented; Future usage: Spawner-Recruitment: 1=global; 2=by area
1 #  number of recruitment settlement assignments
0 # unused option
#GPattern month  area  age (for each settlement assignment)
 1 1 1 0
#
#_Cond 0 # N_movement_definitions goes here if Nareas > 1
```

```
#_Cond 1.0 # first age that moves (real age at begin of season, not integer) also cond on
do_migration>0
#_Cond 1 1 1 2 4 10 # example move definition for seas=1, morph=1, source=1 dest=2,
age1=4, age2=10
#
2 #_Nblock_Patterns
 2 1 #_blocks_per_pattern
# begin and end years of blocks
 2017 2019 2020 2024
 2013 2024
#
# controls for all timevary parameters
1 #_time-vary parm bound check (1=warn relative to base parm bounds; 3=no bound check);
Also see env (3) and dev (5) options to constrain with base bounds
#
# AUTOGEN
 1 1 1 1 1 # autogen: 1st element for biology, 2nd for SR, 3rd for Q, 4th reserved, 5th
for selex
# where: 0 = autogen time-varying parms of this category; 1 = read each time-varying parm
line; 2 = read then autogen if parm min==-12345
#
#_Available timevary codes
#_Block types: 0: P_block=P_base*exp(TVP); 1: P_block=P_base+TVP; 2: P_block=TVP; 3:
P_block=P_block(-1) + TVP
#_Block_trends: -1: trend bounded by base parm min-max and parms in transformed units
(beware); -2: endtrend and infl_year direct values; -3: end and infl as fraction of base
range
#_EnvLinks:  1: P(y)=P_base*exp(TVP*env(y)); 2: P(y)=P_base+TVP*env(y); 3:
P(y)=f(TVP,env_Zscore) w/ logit to stay in min-max; 4: P(y)=2.0/(1.0+exp(-TVP1*env(y) -
TVP2))
#_DevLinks: 1: P(y)*=exp(dev(y)*dev_se; 2: P(y)+=dev(y)*dev_se; 3: random walk; 4:
zero-reverting random walk with rho; 5: like 4 with logit transform to stay in base min-
max
#_DevLinks(more): 21-25 keep last dev for rest of years
#
#_Prior_codes:  0=none; 6=normal; 1=symmetric beta; 2=CASAL's beta; 3=lognormal;
4=lognormal with biascorr; 5=gamma
#
# setup for M, growth, wt-len, maturity, fecundity, (hermaphro), recr_distr, cohort_grow,
(movement), (age error), (catch_mult), sex ratio
#_NATMORT
3                                                                  #_natM_type:_0=1Parm;
1=N_breakpoints;_2=Lorenzen;_3=agespecific;_4=agespec_withseasinterpolate;_5=BETA:_Maun
der_link_to_maturity;_6=Lorenzen_range
 #_Age_natmort_by sex x growthpattern (nest GP in sex)
 0.840918 0.463849 0.365109 0.306347 0.267492 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24
0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24 0.24
#
1 # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=age_specific_K_incr;
4=age_specific_K_decr; 5=age_specific_K_each; 6=NA; 7=NA; 8=growth cessation
1 #_Age(post-settlement) for L1 (aka Amin); first growth parameter is size at this age;
linear growth below this
999 #_Age(post-settlement) for L2 (aka Amax); 999 to treat as Linf
-999 #_exponential decay for growth above maxage (value should approx initial Z; -999
replicates 3.24; -998 to not allow growth above maxage)
0 #_placeholder for future growth feature
#
0 #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
2 #_CV_Growth_Pattern: 0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A); 4 logSD=F(A)
#
1 #_maturity_option: 1=length logistic; 2=age logistic; 3=read age-maturity matrix by
growth_pattern; 4=read age-fecundity; 5=disabled; 6=read length-maturity
4 #_First_Mature_Age
1     #_fecundity_at_length     option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b;
(4)eggs=a+b*L; (5)eggs=a+b*W
0 #_hermaphroditism option: 0=none; 1=female-to-male age-specific fxn; -1=male-to-female
age-specific fxn
1 #_parameter_offset_approach for M, G, CV_G:  1- direct, no offset**; 2-
male=fem_parm*exp(male_parm); 3: male=female*exp(parm) then old=young*exp(parm)
#_** in option 1, any male parameter with value = 0.0 and phase <0 is set equal to female
parameter
#
#_growth_parms
#_ LO HI INIT PRIOR PR_SD PR_type PHASE env_var&link dev_link dev_minyr dev_maxyr dev_PH
Block Block_Fxn
# Sex: 1  BioPattern: 1  NatMort
# Sex: 1  BioPattern: 1  Growth
```

```
 7 25 14.7973 14.85 2.5 6 3 0 0 0 0 0 0 0 # L_at_Amin_Fem_GP_1
 60 120 87.7611 80.4 15 0 -3 0 0 0 0 0 0 0 # L_at_Amax_Fem_GP_1
 0.05 0.2 0.0924853 0.139 0.05 0 3 0 0 0 0 0 0 0 # VonBert_K_Fem_GP_1
 0.5 15 2.3707 0.05 0.8 0 3 0 0 0 0 0 0 0 # SD_young_Fem_GP_1
 0.5 15 10.6223 0.05 0.8 0 3 0 0 0 0 0 0 0 # SD_old_Fem_GP_1
# Sex: 1  BioPattern: 1  WtLen
 0 1 1.244e-05 1.244e-05 0.05 0 -3 0 0 0 0 0 0 0 # Wtlen_1_Fem_GP_1
 2 4 2.95 2.95 0.05 0 -3 0 0 0 0 0 0 0 # Wtlen_2_Fem_GP_1
# Sex: 1  BioPattern: 1  Maturity&Fecundity
 30 50 42.14 42.14 5 0 -3 0 0 0 0 0 0 0 # Mat50%_Fem_GP_1
 -5 1 -0.37809 -0.37809 0.06015 0 -3 0 0 0 0 0 0 0 # Mat_slope_Fem_GP_1
 -3 3 1 1 0.8 0 -3 0 0 0 0 0 0 0 # Eggs/kg_inter_Fem_GP_1
 -3 3 0 0 0.8 0 -3 0 0 0 0 0 0 0 # Eggs/kg_slope_wt_Fem_GP_1
# Hermaphroditism
#  Recruitment Distribution
#  Cohort growth dev base
 0.1 10 1 1 1 6 -1 0 0 0 0 0 0 0 # CohortGrowDev
#  Movement
#  Platoon StDev Ratio
#  Age Error from parameters
#  catch multiplier
#  fraction female, by GP
 1e-06 0.999999 0.5 0.5 0.5 0 -99 0 0 0 0 0 0 0 # FracFemale_GP_1
#  M2 parameter for each predator fleet
#
#_no timevary MG parameters
#
#_seasonal_effects_on_biology_parms
 0 0 0 0 0 0 0 0 0 0 #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,Malewtlen1,malewtlen2,L1,K
#_ LO HI INIT PRIOR PR_SD PR_type PHASE
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no seasonal MG parameters
#
3  #_Spawner-Recruitment;  Options:  1=NA;  2=Ricker;  3=std_B-H;  4=SCAA;  5=Hockey;  6=B-H_flattop; 7=survival_3Parm; 8=Shepherd_3Parm; 9=RickerPower_3parm
0  # 0/1 to use steepness in initial equ recruitment calculation
0  #  future feature:  0/1 to make realized sigmaR a function of SR curvature
#_            LO            HI           INIT          PRIOR          PR_SD        PR_type  PHASE     env-var     use_dev    dev_mnyr    dev_mxyr      dev_PH       Block     Blk_Fxn  #  parm_name
              1             16       11.4618              5             1             0  1          0          0          0          0          0          0          0  # SR_LN(R0)
            0.2          0.999            0.8          0.999           0.2             0  -1           0          0          0          0          0          0          0  # SR_BH_steep
            0.1              2            0.6            0.6           0.2             0  -5           0          0          0          0          0          0          0  # SR_sigmaR
             -5              5              0           -0.7             2             0  -2           0          0          0          0          0          0          0  # SR_regime
              0              0              0              0             0             0  -99          0          0          0          0          0          0          0  # SR_autocorr
#_no timevary SR parameters
2  #do_recdev:    0=none;  1=devvector  (R=F(SSB)+dev);  2=deviations  (R=F(SSB)+dev); 3=deviations (R=R0*dev; dev2=R-f(SSB)); 4=like 3 with sum(dev2) adding penalty
2000 # first year of main recr_devs; early devs can precede this era
2023 # last year of main recr_devs; forecast devs start in following year
3 #_recdev phase
1 # (0/1) to read 13 advanced options
 -22 #_recdev_early_start (0=none; neg value makes relative to recdev_start)
 4 #_recdev_early_phase
 0 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1)
 1 #_lambda for Fcast_recr_like occurring before endyr+1
 1984.4 #_last_yr_nobias_adj_in_MPD; begin of ramp
 2006.5 #_first_yr_fullbias_adj_in_MPD; begin of plateau
 2021.9 #_last_yr_fullbias_adj_in_MPD
 2024.1 #_end_yr_for_ramp_in_MPD (can be in forecast to shape ramp, but SS3 sets bias_adj to 0.0 for fcast yrs)
 0.8011 #_max_bias_adj_in_MPD (typical ~0.8; -3 sets all years to 0.0; -2 sets all non-forecast yrs w/ estimated recdevs to 1.0; -1 sets biasadj=1.0 for all yrs w/ recdevs)
 0 #_period of cycles in recruitment (N parms read below)
 -5 #min rec_dev
 5 #max rec_dev
 0 #_read_recdevs
#_end of advanced SR options
#
#_placeholder for full parameter lines for recruitment cycles
# read specified recr devs
```

```
#_year Input_value
#
# all recruitment deviations
#  1978E 1979E 1980E 1981E 1982E 1983E 1984E 1985E 1986E 1987E 1988E 1989E 1990E 1991E
1992E 1993E 1994E 1995E 1996E 1997E 1998E 1999E 2000R 2001R 2002R 2003R 2004R 2005R 2006R
2007R 2008R 2009R 2010R 2011R 2012R 2013R 2014R 2015R 2016R 2017R 2018R 2019R 2020R 2021R
2022R 2023R 2024F
#  -0.0580927 -0.0584499 -0.0528009 -0.0411391 -0.0259793 -0.0102941 0.00543592 0.0216522
0.0394136 0.0551197 0.0573391 0.0251249 -0.0595821 -0.186504 -0.30889 -0.355719 -0.236808
0.144886 0.20756 -0.103532 0.111265 0.0085813 0.0553458 0.40683 0.515334 0.491001 0.734207
0.0682493  0.19397  0.253396  0.247466  -0.325078  -0.533898  -0.0457525  -0.15817  0.437536
0.764834 -0.352188 0.55868 -0.0832049 0.988214 -0.0848316 0.323788 -1.03387 -0.228054 -
1.19806 0
#
#Fishing Mortality info
0.2 # F ballpark value in units of annual_F
-2001 # F ballpark year (neg value to disable)
4 # F_Method:  1=Pope midseason rate; 2=F as parameter; 3=F as hybrid; 4=fleet-specific
parm/hybrid (#4 is superset of #2 and #3 and is recommended)
2.9 # max F (methods 2-4) or harvest fraction (method 1)
# Read list of fleets that do F as parameter; unlisted fleets stay hybrid, bycatch fleets
must be included with start_PH=1, high F fleets should switch early
# (A) fleet;
# (B) F_starting_value (ignored if start_PH=1 or reading from ss3.par);
# (C) start_PH for fleet's Fparms (99 to stay in hybrid, <0 to stay at starting value)
# Terminate list with -9999 for fleet (use -9998 to read fleet-time specific F values
after reading N hybrid tune loops)
# (A) (B) (C)
 1 0.01 1 # OTB_BSS8AB
 2 0.01 99 # PTM_BSS8AB
 3 0.01 1 # GNS_BSS8AB
 4 0.01 1 # GTR_BSS8AB
 5 0.01 1 # LLS_BSS8AB
 6 0.01 99 # OTHERS_BSS8AB
 10 0.01 1 # REC_BSS8AB
-9999 1 1 # end of list
#F_detail template: fleet year seas F_value catch_se phase
5 #_number of loops for hybrid tuning; 4 precise; 3 faster; 2 enough if switching to parms
is enabled
#
#_initial_F_parms; for each fleet x season that has init_catch; nest season in fleet;
count = 6
#_for unconstrained init_F, use an arbitrary initial catch and set lambda=0 for its logL
#_  LO HI INIT PRIOR PR_SD  PR_type  PHASE
 0 2 0.00669367 0.3 0.5 0 -1 # InitF_seas_1_flt_1OTB_BSS8AB
 0 2 0.0197579 0.3 0.5 0 -1 # InitF_seas_1_flt_2PTM_BSS8AB
 0 2 0.000906809 0.3 0.5 0 -1 # InitF_seas_1_flt_3GNS_BSS8AB
 0 2 0.000806226 0.3 0.5 0 -1 # InitF_seas_1_flt_4GTR_BSS8AB
 0 2 0.0162094 0.3 0.5 0 -1 # InitF_seas_1_flt_5LLS_BSS8AB
 0 2 0.0362476 0.3 0.5 0 1 # InitF_seas_1_flt_10REC_BSS8AB
#
# F rates by fleet x season
#_year:  1985 1986 1987 1988 1989 1990 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 2021 2022 2023 2024
# seas:  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
#  OTB_BSS8AB  0.0117442  0.0145888  0.0132078  0.0166702  0.0146123  0.0139773  0.00930662
0.0112053 0.0134543 0.0162074 0.0162718 0.011061 0.0148434 0.0173741 0.0184033 0.0168455
0.0133317 0.0131594 0.0109867 0.0147466 0.014764 0.0161985 0.0173634 0.0164323 0.0154894
0.0119923 0.020173 0.0143099 0.0154168 0.0182065 0.0148941 0.0166164 0.0175914 0.0174411
0.0159823 0.011489 0.0116396 0.0100809 0.00858943 0.00858943
# PTM_BSS8AB 0.0562272 0.0438772 0.0538798 0.03489 0.0310322 0.0195493 0.0477582 0.037039
0.0239174 0.0161017 0.0138644 0.0287285 0.0367856 0.0109152 0.0316369 0.0261847 0.0341821
0.0333125 0.0507784 0.0265454 0.0514236 0.0445895 0.0291847 0.0297629 0.0224622 0.0196242
0.0129611  0.0109815  0.00954979  0.0112689  0.0085848  0.00857238  0.0120042  0.00742043
0.00548289 0.00411746 0.00144715 0.00155983 0.00112619 0.00112619
#  GNS_BSS8AB  0.00100999  0.00777626  0.00722857  0.0130323  0.0182377  0.0196228  0.012818
0.0147841 0.0182045 0.0223198 0.0174387 0.0139803 0.0159099 0.0210143 0.0167901 0.0226222
0.0177088  0.0200686  0.0163965  0.0164697  0.0161235  0.0147066  0.0130841  0.00982329
0.00841875  0.00711805  0.00846784  0.00929752  0.0111778  0.0180007  0.0126587  0.00967506
0.00724834 0.00873902 0.00915702 0.0108982 0.00962705 0.00803307 0.00771941 0.00771941
#  GTR_BSS8AB  0.000892756  0.00695303  0.00655758  0.012047  0.0172101  0.0188588  0.0125109
0.0146217 0.0181551 0.0223243 0.0173905 0.0138323 0.0155641 0.0204008 0.0163909 0.0215348
0.0162901 0.0151389 0.0187634 0.0196269 0.0214767 0.0218019 0.0277619 0.0219826 0.015874
0.0141858 0.0225049 0.0240622 0.0263234 0.0397583 0.0282519 0.0328299 0.0243841 0.0308116
0.021427 0.0200583 0.0191017 0.0155995 0.0159258 0.0159258
```

```
#  LLS_BSS8AB  0.0188863  0.0294953  0.0278354  0.0300114  0.0300535  0.0245079  0.0212783
0.0271031  0.0262265  0.02227  0.0310965  0.035012  0.03737  0.050619  0.0397067  0.0302886
0.0304777 0.0327098 0.043661 0.0483099 0.0448509 0.0431084 0.0455106 0.0427342 0.0303881
0.0343141 0.0296204 0.0283344 0.0310922 0.0387699 0.0327712 0.0331886 0.0297398 0.0260242
0.0260919 0.0275183 0.0248471 0.0221603 0.0215197 0.0215197
#  OTHERS_BSS8AB  0  5.21991e-05  0.00173419  0.00186478  0.00174109  0.00200622  0.00153426
0.000815738  0.00210814  0.0105042  0.0119445  0.015485  0.00260718  0.00336913  5.10074e-05
0.0152565 0.0172472 0.0177296 0.0139886 0.0196939 0.0201778 0.0131777 0.0157688 0.0150296
0.0125191 0.0193518 0.0239754 0.0239712 0.0205701 0.0167826 0.019118 0.0172786 0.0234498
0.0180529 0.0177127 0.0154312 0.0152204 0.0133591 0.0115526 0.0115526
#  REC_BSS8AB  0.0932986  0.0932994  0.0933002  0.093301  0.0933015  0.0933019  0.0933021
0.0933022 0.0933023 0.0933026 0.0933032 0.0933042 0.0933054 0.0933066 0.0933075 0.0933074
0.0933074 0.0933076 0.093313 0.0933037 0.0933127 0.0932968 0.0932868 0.0932675 0.093228
0.0933962 0.0934799 0.095883 0.0763459 0.0799548 0.0801491 0.0644404 0.0640669 0.0559683
0.0554016 0.0510017 0.0476039 0.0446932 0.0417314 0.0417314
#
#_Q_setup for fleets with cpue or survey or deviation data
#_1:  fleet number
#_2:  link type: 1=simple q; 2=mirror; 3=power (+1 parm); 4=mirror with scale (+1p);
5=offset (+1p); 6=offset & power (+2p)
#_     where power is applied as y = q * x ^ (1 + power); so a power value of 0 has null
effect
#_     and with the offset included it is y = q * (x + offset) ^ (1 + power)
#_3:  extra input for link, i.e. mirror fleet# or dev index number
#_4:  0/1 to select extra sd parameter
#_5:  0/1 for biasadj or not
#_6:  0/1 to float
#_   fleet      link link_info  extra_se   biasadj     float  #  fleetname
         7         1         0         1         0         1  #  LPUE
         8         1         0         1         0         1  #  Nourdem_Loire
         9         1         0         1         0         1  #  Nourdem_Gironde
        10         1         0         0         0         1  #  REC_BSS8AB
-9999 0 0 0 0 0
#
#_Q_parameters
#_            LO            HI          INIT          PRIOR          PR_SD        PR_type
PHASE    env-var    use_dev   dev_mnyr   dev_mxyr     dev_PH       Block    Blk_Fxn  #
parm_name
          -25            25      -21.5921             0             1             0
-1           0           0           0           0           0           0           0  #
LnQ_base_LPUE(7)
            0             1    0.00415881           0.1            99             0
3           0           0           0           0           0           0           0  #
Q_extraSD_LPUE(7)
          -25            25      -10.8634             0             1             0
-1           0           0           0           0           0           0           0  #
LnQ_base_Nourdem_Loire(8)
            0             1      0.456696           0.1            99             0
3           0           0           0           0           0           0           0  #
Q_extraSD_Nourdem_Loire(8)
          -25            25      -10.4529             0             1             0
-1           0           0           0           0           0           0           0  #
LnQ_base_Nourdem_Gironde(9)
            0             1     0.0116594           0.1            99             0
3           0           0           0           0           0           0           0  #
Q_extraSD_Nourdem_Gironde(9)
          -25            25       2.37191             0             1             0
-1           0           0           0           0           0           0           0  #
LnQ_base_REC_BSS8AB(10)
#_no timevary Q parameters
#
#_size_selex_patterns
#Pattern:_0;  parm=0; selex=1.0 for all sizes
#Pattern:_1;  parm=2; logistic; with 95% width specification
#Pattern:_5;  parm=2; mirror another size selex; PARMS pick the min-max bin to mirror
#Pattern:_11; parm=2; selex=1.0  for specified min-max population length bin range
#Pattern:_15; parm=0; mirror another age or length selex
#Pattern:_6;  parm=2+special; non-parm len selex
#Pattern:_43; parm=2+special+2;  like 6, with 2 additional param for scaling (mean over
bin range)
#Pattern:_8;   parm=8; double_logistic with smooth transitions and constant above Linf
option
#Pattern:_9;  parm=6; simple 4-parm double logistic with starting length; parm 5 is first
length; parm 6=1 does desc as offset
#Pattern:_21; parm=2*special; non-parm len selex, read as N break points, then N selex
parameters
#Pattern:_22; parm=4; double_normal as in CASAL
```

```
#Pattern:_23; parm=6; double_normal where final value is directly equal to sp(6) so can
be >1.0
#Pattern:_24; parm=6; double_normal with sel(minL) and sel(maxL), using joiners
#Pattern:_2;  parm=6; double_normal with sel(minL) and sel(maxL), using joiners, back
compatibile version of 24 with 3.30.18 and older
#Pattern:_25; parm=3; exponential-logistic in length
#Pattern:_27; parm=special+3; cubic spline in length; parm1==1 resets knots; parm1==2
resets all
#Pattern:_42; parm=special+3+2; cubic spline; like 27, with 2 additional param for scaling
(mean over bin range)
#_discard_options:_0=none;_1=define_retention;_2=retention&mortality;_3=all_discarded_d
ead;_4=define_dome-shaped_retention
#_Pattern Discard Male Special
 24 1 0 0 # 1 OTB_BSS8AB
 24 0 0 0 # 2 PTM_BSS8AB
 24 1 0 0 # 3 GNS_BSS8AB
 24 1 0 0 # 4 GTR_BSS8AB
 24 1 0 0 # 5 LLS_BSS8AB
 24 0 0 0 # 6 OTHERS_BSS8AB
 15 0 0 1 # 7 LPUE
 24 0 0 0 # 8 Nourdem_Loire
 24 0 0 0 # 9 Nourdem_Gironde
 24 1 0 0 # 10 REC_BSS8AB
#
#_age_selex_patterns
#Pattern:_0; parm=0; selex=1.0 for ages 0 to maxage
#Pattern:_10; parm=0; selex=1.0 for ages 1 to maxage
#Pattern:_11; parm=2; selex=1.0  for specified min-max age
#Pattern:_12; parm=2; age logistic
#Pattern:_13; parm=8; age double logistic. Recommend using pattern 18 instead.
#Pattern:_14; parm=nages+1; age empirical
#Pattern:_15; parm=0; mirror another age or length selex
#Pattern:_16; parm=2; Coleraine - Gaussian
#Pattern:_17;  parm=nages+1;  empirical  as  random  walk   N  parameters  to  read  can  be
overridden by setting special to non-zero
#Pattern:_41; parm=2+nages+1; // like 17, with 2 additional param for scaling (mean over
bin range)
#Pattern:_18; parm=8; double logistic - smooth transition
#Pattern:_19; parm=6; simple 4-parm double logistic with starting age
#Pattern:_20; parm=6; double_normal,using joiners
#Pattern:_26; parm=3; exponential-logistic in age
#Pattern:_27; parm=3+special; cubic spline in age; parm1==1 resets knots; parm1==2 resets
all
#Pattern:_42; parm=2+special+3; // cubic spline; with 2 additional param for scaling (mean
over bin range)
#Age patterns entered with value >100 create Min_selage from first digit and pattern from
remainder
#_Pattern Discard Male Special
 10 0 0 0 # 1 OTB_BSS8AB
 10 0 0 0 # 2 PTM_BSS8AB
 10 0 0 0 # 3 GNS_BSS8AB
 10 0 0 0 # 4 GTR_BSS8AB
 10 0 0 0 # 5 LLS_BSS8AB
 10 0 0 0 # 6 OTHERS_BSS8AB
 10 0 0 0 # 7 LPUE
 0 0 0 0 # 8 Nourdem_Loire
 0 0 0 0 # 9 Nourdem_Gironde
 10 0 0 0 # 10 REC_BSS8AB
#
#_            LO            HI           INIT          PRIOR          PR_SD        PR_type
PHASE     env-var     use_dev    dev_mnyr    dev_mxyr      dev_PH       Block     Blk_Fxn  #
parm_name
# 1   OTB_BSS8AB LenSelex
             20          80.4       36.4756            35           3.05              -6
2            0            23          2005          2023             5              0            0  #
Size_DblN_peak_OTB_BSS8AB(1)
            -15             4           -15           -15           0.05              0
-3           0             0             0             0              0              0            0  #
Size_DblN_top_logit_OTB_BSS8AB(1)
             -1             9       5.15992           3.3           0.05              0
3            0             0             0             0              0              0            0  #
Size_DblN_ascend_se_OTB_BSS8AB(1)
             -1            20            20           4.4           0.05              0
-3           0             0             0             0              0              0            0  #
Size_DblN_descend_se_OTB_BSS8AB(1)
```

```
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_start_logit_OTB_BSS8AB(1)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_end_logit_OTB_BSS8AB(1)
             5            50       35.7325            36          0.05             0
4            0             0             0             0             0             0  #
Retain_L_infl_OTB_BSS8AB(1)
             0         10.01      0.925689          0.81          0.05             0
4            0             0             0             0             0             0  #
Retain_L_width_OTB_BSS8AB(1)
           -10            30       16.1761            10          0.05             0
3            0             0             0             0             0             0  #
Retain_L_asymptote_logit_OTB_BSS8AB(1)
             0             0             0             0          0.05             0
-3           0             0             0             0             0             0  #
Retain_L_maleoffset_OTB_BSS8AB(1)
# 2   PTM_BSS8AB LenSelex
            20          80.4       46.7283            45          0.05             0
2            0             0             0             0             0             0  #
Size_DblN_peak_PTM_BSS8AB(2)
           -15             4           -15           -15          0.05             0
-3           0             0             0             0             0             0  #
Size_DblN_top_logit_PTM_BSS8AB(2)
            -1             9       3.77771           3.3          0.05             0
3            0             0             0             0             0             0  #
Size_DblN_ascend_se_PTM_BSS8AB(2)
            -1            20            20           4.4          0.05             0
-3           0             0             0             0             0             0  #
Size_DblN_descend_se_PTM_BSS8AB(2)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_start_logit_PTM_BSS8AB(2)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_end_logit_PTM_BSS8AB(2)
# 3   GNS_BSS8AB LenSelex
            20            93       47.0067            45          5.05            -6
2            0            23          2005          2023             5             0  #
Size_DblN_peak_GNS_BSS8AB(3)
           -15             4           -15           -15          0.05             0
-3           0             0             0             0             0             0  #
Size_DblN_top_logit_GNS_BSS8AB(3)
            -1             9       4.06135           3.3          0.05             0
3            0             0             0             0             0             0  #
Size_DblN_ascend_se_GNS_BSS8AB(3)
            -1            19       5.49108           4.4          0.05             0
3            0             0             0             0             0             0  #
Size_DblN_descend_se_GNS_BSS8AB(3)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_start_logit_GNS_BSS8AB(3)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_end_logit_GNS_BSS8AB(3)
             5            50       35.5798            36          0.05             0
4            0             0             0             0             0             0  #
Retain_L_infl_GNS_BSS8AB(3)
             0         10.01      0.589408          0.81          0.05             0
4            0             0             0             0             0             0  #
Retain_L_width_GNS_BSS8AB(3)
           -10            10            10            10          0.05             0
-3           0             0             0             0             0             0  #
Retain_L_asymptote_logit_GNS_BSS8AB(3)
             0             0             0             0          0.05             0
-3           0             0             0             0             0             0  #
Retain_L_maleoffset_GNS_BSS8AB(3)
# 4   GTR_BSS8AB LenSelex
            20            93       44.5233            45          5.05            -6
2            0            23          2005          2023             5             0  #
Size_DblN_peak_GTR_BSS8AB(4)
           -15             4           -15           -15          0.05             0
-3           0             0             0             0             0             0  #
Size_DblN_top_logit_GTR_BSS8AB(4)
```

```
           -1             9       3.40565            3.3           0.05             0
3           0             0             0              0              0             0  #
Size_DblN_ascend_se_GTR_BSS8AB(4)
           -1            20            20            4.4           0.05             0
-3          0             0             0              0              0             0  #
Size_DblN_descend_se_GTR_BSS8AB(4)
         -999             9          -999           -999           0.05             0
-2          0             0             0              0              0             0  #
Size_DblN_start_logit_GTR_BSS8AB(4)
         -999             9          -999           -999           0.05             0
-2          0             0             0              0              0             0  #
Size_DblN_end_logit_GTR_BSS8AB(4)
            5            50       34.8616             36           0.05             0
4           0             0             0              0              0             0  #
Retain_L_infl_GTR_BSS8AB(4)
            0         10.01       2.31795           0.81           0.05             0
4           0             0             0              0              0             0  #
Retain_L_width_GTR_BSS8AB(4)
          -10            10            10             10           0.05             0
-3          0             0             0              0              0             0  #
Retain_L_asymptote_logit_GTR_BSS8AB(4)
            0             0             0              0           0.05             0
-3          0             0             0              0              0             0  #
Retain_L_maleoffset_GTR_BSS8AB(4)
# 5   LLS_BSS8AB LenSelex
           20          80.4       43.6551             45           5.05            -6
2           0            23          2005           2023              5             0  #
Size_DblN_peak_LLS_BSS8AB(5)
          -15             4           -15            -15           0.05             0
-3          0             0             0              0              0             0  #
Size_DblN_top_logit_LLS_BSS8AB(5)
           -1             9       3.96376            3.3           0.05             0
3           0             0             0              0              0             0  #
Size_DblN_ascend_se_LLS_BSS8AB(5)
           -1            20            20            4.4           0.05             0
-3          0             0             0              0              0             0  #
Size_DblN_descend_se_LLS_BSS8AB(5)
         -999             9          -999           -999           0.05             0
-2          0             0             0              0              0             0  #
Size_DblN_start_logit_LLS_BSS8AB(5)
         -999             9          -999           -999           0.05             0
-2          0             0             0              0              0             0  #
Size_DblN_end_logit_LLS_BSS8AB(5)
            5            50       36.1777             36           0.05             0
4           0             0             0              0              0             0  #
Retain_L_infl_LLS_BSS8AB(5)
            0         10.01       1.15048           0.81           0.05             0
4           0             0             0              0              0             0  #
Retain_L_width_LLS_BSS8AB(5)
          -10            10            10             10           0.05             0
-3          0             0             0              0              0             0  #
Retain_L_asymptote_logit_LLS_BSS8AB(5)
            0             0             0              0           0.05             0
-3          0             0             0              0              0             0  #
Retain_L_maleoffset_LLS_BSS8AB(5)
# 6   OTHERS_BSS8AB LenSelex
           20          80.4       42.6551             45           0.05             0
2           0             0             0              0              0             0  #
Size_DblN_peak_OTHERS_BSS8AB(6)
          -15             4           -15             -6           0.05             0
-3          0             0             0              0              0             0  #
Size_DblN_top_logit_OTHERS_BSS8AB(6)
           -1             9       3.02882            3.3           0.05             0
3           0             0             0              0              0             0  #
Size_DblN_ascend_se_OTHERS_BSS8AB(6)
           -1            20            20            4.4           0.05             0
-3          0             0             0              0              0             0  #
Size_DblN_descend_se_OTHERS_BSS8AB(6)
         -999             9          -999           -999           0.05             0
-2          0             0             0              0              0             0  #
Size_DblN_start_logit_OTHERS_BSS8AB(6)
         -999             9          -999           -999           0.05             0
-2          0             0             0              0              0             0  #
Size_DblN_end_logit_OTHERS_BSS8AB(6)
# 7   LPUE LenSelex
# 8   Nourdem_Loire LenSelex
```

```
             5            15       7.03984             7          2.05            -6
2            0             0             0             0             0             0  #
Size_DblN_peak_Nourdem_Loire(8)
           -15             4           -15            -6          0.05             0
-3           0             0             0             0             0             0  #
Size_DblN_top_logit_Nourdem_Loire(8)
            -1             9      0.302495           3.3          0.05             0
3            0             0             0             0             0             0  #
Size_DblN_ascend_se_Nourdem_Loire(8)
            -1             9       7.42391           4.4          0.05             0
3            0             0             0             0             0             0  #
Size_DblN_descend_se_Nourdem_Loire(8)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_start_logit_Nourdem_Loire(8)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_end_logit_Nourdem_Loire(8)
# 9   Nourdem_Gironde LenSelex
             5            15       10.0506          10.4          2.05            -6
2            0             0             0             0             0             0  #
Size_DblN_peak_Nourdem_Gironde(9)
           -15             4           -15            -6          0.05             0
-3           0             0             0             0             0             0  #
Size_DblN_top_logit_Nourdem_Gironde(9)
            -1             9       1.75591           3.3          0.05             0
3            0             0             0             0             0             0  #
Size_DblN_ascend_se_Nourdem_Gironde(9)
            -1             9       6.29195           4.4          0.05             0
3            0             0             0             0             0             0  #
Size_DblN_descend_se_Nourdem_Gironde(9)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_start_logit_Nourdem_Gironde(9)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_end_logit_Nourdem_Gironde(9)
# 10   REC_BSS8AB LenSelex
            20          80.4       54.9222            45          5.05            -6
2            0             0             0             0             0             0  #
Size_DblN_peak_REC_BSS8AB(10)
           -15             4           -15           -15          0.05             0
-3           0             0             0             0             0             0  #
Size_DblN_top_logit_REC_BSS8AB(10)
            -1             9       5.40755           3.3          0.05             0
3            0             0             0             0             0             0  #
Size_DblN_ascend_se_REC_BSS8AB(10)
          -8.5            20            20           4.4          0.05             0
-3           0             0             0             0             0             0  #
Size_DblN_descend_se_REC_BSS8AB(10)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_start_logit_REC_BSS8AB(10)
          -999             9          -999          -999          0.05             0
-2           0             0             0             0             0             0  #
Size_DblN_end_logit_REC_BSS8AB(10)
             5            50        25.177            36          0.05             0
4            0             0             0             0             0             0  #
Retain_L_infl_REC_BSS8AB(10)
             0         10.01       3.98417          4.93          0.05            -6
4            0             0             0             0             0             0  #
Retain_L_width_REC_BSS8AB(10)
           -10            10       3.99498        4.9074          2.05            -6
3            0             0             0             0             0             0  #
Retain_L_asymptote_logit_REC_BSS8AB(10)
             0             0             0             0          0.05             0
-3           0             0             0             0             0             0  #
Retain_L_maleoffset_REC_BSS8AB(10)
# 1   OTB_BSS8AB AgeSelex
# 2   PTM_BSS8AB AgeSelex
# 3   GNS_BSS8AB AgeSelex
# 4   GTR_BSS8AB AgeSelex
# 5   LLS_BSS8AB AgeSelex
# 6   OTHERS_BSS8AB AgeSelex
# 7   LPUE AgeSelex
# 8   Nourdem_Loire AgeSelex
# 9   Nourdem_Gironde AgeSelex
```

```
# 10   REC_BSS8AB AgeSelex
#_No_Dirichlet parameters
# timevary selex parameters
#_            LO            HI           INIT          PRIOR          PR_SD        PR_type
PHASE  #  parm_name
            0.5             2            1.5              1            0.5              6
-7  # Size_DblN_peak_OTB_BSS8AB(1)_dev_se
          -0.99          0.99              0              0            0.5              6
-6  # Size_DblN_peak_OTB_BSS8AB(1)_dev_autocorr
            0.5             2            1.5              1            0.5              6
-7  # Size_DblN_peak_GNS_BSS8AB(3)_dev_se
          -0.99          0.99              0              0            0.5              6
-6  # Size_DblN_peak_GNS_BSS8AB(3)_dev_autocorr
            0.5             2            1.5              1            0.5              6
-7  # Size_DblN_peak_GTR_BSS8AB(4)_dev_se
          -0.99          0.99              0              0            0.5              6
-6  # Size_DblN_peak_GTR_BSS8AB(4)_dev_autocorr
            0.5             2            1.5              1            0.5              6
-7  # Size_DblN_peak_LLS_BSS8AB(5)_dev_se
          -0.99          0.99              0              0            0.5              6
-6  # Size_DblN_peak_LLS_BSS8AB(5)_dev_autocorr
# info on dev vectors created for selex parms are reported with other devs after tag
parameter section
#
0   #  use 2D_AR1 selectivity? (0/1)
#_no 2D_AR1 selex offset used
#_specs:   fleet,  ymin,  ymax,  amin,  amax,  sigma_amax,  use_rho,  len1/age2,  devphase,
before_range, after_range
#_sigma_amax>amin  means  create  sigma  parm  for  each  bin  from  min  to  sigma_amax;
sigma_amax<0 means just one sigma parm is read and used for all bins
#_needed parameters follow each fleet's specifications
# -9999  0 0 0 0 0 0 0 0 0 0 # terminator
#
# Tag loss and Tag reporting parameters go next
0  # TG_custom:  0=no read and autogen if tag data exist; 1=read
#_Cond -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0  #_placeholder if no parameters
#
# deviation vectors for timevary parameters
#  base   base first block   block  env  env   dev   dev   dev   dev   dev
#  type  index  parm trend pattern link  var  vectr link _mnyr  mxyr phase  dev_vector
#       5     1     1     0     0     0     0     1     3  2005  2023     5 0.286385
0.714267 1.12186 0.730591 0.82335 0.743494 1.09643 1.50157 -0.132283 -0.453594 -0.969555
-0.267875 -0.519697 0.267477 0.694174 1.26742 -0.128091 0.0785285 -0.0940461
#       5    17     3     0     0     0     0     2     3  2005  2023     5 0.732128 -
0.837062  -0.177411  -1.01805  -0.863151  0.717611  0.0668792  -0.924977  -0.350813  0.778539
0.864409 0.294675 -0.485098 1.17347 -0.17381 1.31285 0.402542 -1.87219 0.189687
#       5    27     5     0     0     0     0     3     3  2005  2023     5 0.492767
0.980311  -0.478876  0.142181  0.378708  -0.902198  0.768583  -0.665415  -0.374545  -0.238431
0.173209 0.0265729 0.358901 0.271837 -0.0595371  0.493 -0.212486 -0.482905 -0.156496
#       5    37     7     0     0     0     0     4     3  2005  2023     5 0.509602
0.0248241  0.687965  1.47172  1.40851  -0.896204  -0.902169  -0.264429  -0.492467  0.324784
0.0942362 -0.779742 0.382571 0.262736 0.487556 1.00899 0.292139 0.356699 -0.941146
    #
# Input variance adjustments factors:
 #_1=add_to_survey_CV
 #_2=add_to_discard_stddev
 #_3=add_to_bodywt_CV
 #_4=mult_by_lencomp_N
 #_5=mult_by_agecomp_N
 #_6=mult_by_size-at-age_N
 #_7=mult_by_generalized_sizecomp
#_factor  fleet  value
      4      1  0.135538
      4      2  0.562987
      4      3  0.195893
      4      4  0.128995
      4      5  0.214403
      4      6  0.213516
      4      8 0.0791918
      4      9  0.118364
      4     10  0.436487
      5      7 0.0378072
      5      9  0.168536
 -9999   1    0  # terminator
#
2 #_maxlambdaphase
```

```
1 #_sd_offset; must be 1 if any growthCV, sigmaR, or survey extraSD is an estimated
parameter
# read 3 changes to default Lambdas (default value is 1.0)
#  Like_comp  codes:   1=surv;  2=disc;  3=mnwt;  4=length;  5=age;  6=SizeFreq;  7=sizeage;
8=catch; 9=init_equ_catch;
# 10=recrdev; 11=parm_prior; 12=parm_dev; 13=CrashPen; 14=Morphcomp; 15=Tag-comp; 16=Tag-
negbin; 17=F_ballpark; 18=initEQregime
#like_comp fleet  phase  value  sizefreq_method
 1 9 1 1 1
 4 9 1 1 1
 5 9 1 1 1
-9999  1  1  1  1  #  terminator
#
# lambdas (for info only; columns are phases)
#  0 0 #_CPUE/survey:_1
#  0 0 #_CPUE/survey:_2
#  0 0 #_CPUE/survey:_3
#  0 0 #_CPUE/survey:_4
#  0 0 #_CPUE/survey:_5
#  0 0 #_CPUE/survey:_6
#  1 1 #_CPUE/survey:_7
#  1 1 #_CPUE/survey:_8
#  1 1 #_CPUE/survey:_9
#  1 1 #_CPUE/survey:_10
#  1 1 #_discard:_1
#  0 0 #_discard:_2
#  1 1 #_discard:_3
#  1 1 #_discard:_4
#  1 1 #_discard:_5
#  0 0 #_discard:_6
#  0 0 #_discard:_7
#  0 0 #_discard:_8
#  0 0 #_discard:_9
#  1 1 #_discard:_10
#  1 1 #_lencomp:_1
#  1 1 #_lencomp:_2
#  1 1 #_lencomp:_3
#  1 1 #_lencomp:_4
#  1 1 #_lencomp:_5
#  1 1 #_lencomp:_6
#  0 0 #_lencomp:_7
#  1 1 #_lencomp:_8
#  1 1 #_lencomp:_9
#  1 1 #_lencomp:_10
#  1 1 #_agecomp:_1
#  1 1 #_agecomp:_2
#  1 1 #_agecomp:_3
#  1 1 #_agecomp:_4
#  1 1 #_agecomp:_5
#  1 1 #_agecomp:_6
#  1 1 #_agecomp:_7
#  0 0 #_agecomp:_8
#  1 1 #_agecomp:_9
#  0 0 #_agecomp:_10
#  1 1 #_init_equ_catch1
#  1 1 #_init_equ_catch2
#  1 1 #_init_equ_catch3
#  1 1 #_init_equ_catch4
#  1 1 #_init_equ_catch5
#  1 1 #_init_equ_catch6
#  1 1 #_init_equ_catch7
#  1 1 #_init_equ_catch8
#  1 1 #_init_equ_catch9
#  1 1 #_init_equ_catch10
#  1 1 #_recruitments
#  1 1 #_parameter-priors
#  1 1 #_parameter-dev-vectors
#  1 1 #_crashPenLambda
#  0 0 # F_ballpark_lambda
0 # (0/1/2) read specs for more stddev reporting: 0 = skip, 1 = read specs for reporting
stdev for selectivity, size, and numbers, 2 = add options for M,Dyn. Bzero, SmryBio
 # 0 2 0 0 # Selectivity: (1) fleet, (2) 1=len/2=age/3=both, (3) year, (4) N selex bins
 # 0 0 # Growth: (1) growth pattern, (2) growth ages
 # 0 0 0 # Numbers-at-age: (1) area(-1 for all), (2) year, (3) N ages
 # -1 # list of bin #'s for selex std (-1 in first bin to self-generate)
 # -1 # list of ages for growth std (-1 in first bin to self-generate)
 # -1 # list of ages for NatAge std (-1 in first bin to self-generate)
```

```
999
```

9.3 Appendix 3 Forecast file

```
#V3.30.17.00;_2021_06_11;_trans;_Stock_Synthesis_by_Richard_Methot_(NOAA)_using_ADMB_12
.3
#Stock Synthesis (SS) is a work of the U.S. Government and is not subject to copyright
protection in the United States.
#Foreign copyrights may apply. See copyright.txt for more information.
# for all year entries except rebuilder; enter either: actual year, -999 for styr, 0 for
endyr, neg number for rel. endyr
1 # Benchmarks: 0=skip; 1=calc F_spr,F_btgt,F_msy; 2=calc F_spr,F0.1,F_msy
2 # MSY: 1= set to F(SPR); 2=calc F(MSY); 3=set to F(Btgt) or F0.1; 4=set to F(endyr)
0.4 # SPR target (e.g. 0.40)
0.4 # Biomass target (e.g. 0.40)
#_Bmark_years: beg_bio, end_bio, beg_selex, end_selex, beg_relF, end_relF, beg_recr_dist,
end_recr_dist, beg_SRparm, end_SRparm (enter actual year, or values of 0 or -integer to
be rel. endyr)
 0 0 0 0 0 0 0 0 0 0
#  2023 2023 2023 2023 2023 2023 1985 2023 1985 2023
# value <0 convert to endyr-value; except -999 converts to start_yr; must be >=start_yr
and <=endyr
1 #Bmark_relF_Basis: 1 = use year range; 2 = set relF same as forecast below
#
0 # Forecast: -1=none; 0=simple_1yr; 1=F(SPR); 2=F(MSY) 3=F(Btgt) or F0.1; 4=Ave F (uses
first-last relF yrs); 5=input annual F scalar
# where none and simple require no input after this line; simple sets forecast F same as
end year F
1 # N forecast years
0 # Fmult (only used for Do_Forecast==5) such that apical_F(f)=Fmult*relF(f)
#_Fcast_years:  beg_selex, end_selex, beg_relF, end_relF, beg_mean recruits, end_recruits
(enter actual year, or values of 0 or -integer to be rel. endyr)
 0 0 0 0 -999 0
#  2023 2023 2023 2023 1985 2023
0 # Forecast selectivity (0=fcast selex is mean from year range; 1=fcast selectivity from
annual time-vary parms)
1 # Control rule method (0: none; 1: ramp does catch=f(SSB), buffer on F; 2: ramp does
F=f(SSB), buffer on F; 3: ramp does catch=f(SSB), buffer on catch; 4: ramp does F=f(SSB),
buffer on catch)
# values for top, bottom and buffer exist, but not used when Policy=0
0.4 # Control rule Biomass level for constant F (as frac of Bzero, e.g. 0.40); (Must be
> the no F level below)
0.1 # Control rule Biomass level for no F (as frac of Bzero, e.g. 0.10)
0.75 # Buffer:  enter Control rule target as fraction of Flimit (e.g. 0.75), negative
value invokes list of [year, scalar] with filling from year to YrMax
3 #_N forecast loops (1=OFL only; 2=ABC; 3=get F from forecast ABC catch with allocations
applied)
3 #_First forecast loop with stochastic recruitment
0  #_Forecast  recruitment:   0=  spawn_recr;  1=value*spawn_recr_fxn;  2=value*VirginRecr;
3=recent mean from yr range above (need to set phase to -1 in control to get constant
recruitment in MCMC)
1 # value is ignored
0 #_Forecast loop control #5 (reserved for future bells&whistles)
2018  #FirstYear for caps and allocations (should be after years with fixed inputs)
0 # stddev of log(realized catch/target catch) in forecast (set value>0.0 to cause active
impl_error)
0 # Do West Coast gfish rebuilder output (0/1)
1999 # Rebuilder:  first year catch could have been set to zero (Ydecl)(-1 to set to 1999)
2024 # Rebuilder:  year for current age structure (Yinit) (-1 to set to endyear+1)
1 # fleet relative F:  1=use first-last alloc year; 2=read seas, fleet, alloc list below
# Note that fleet allocation is used directly as average F if Do_Forecast=4
0 # basis for fcast catch tuning and for fcast catch caps and allocation  (2=deadbio;
3=retainbio; 5=deadnum; 6=retainnum); NOTE: same units for all fleets
# Conditional input if relative F choice = 2
# enter list of:  season,  fleet, relF; if used, terminate with season=-9999
# -9999 0 0  # terminator for list of relF
# enter list of: fleet number, max annual catch for fleets with a max; terminate with
fleet=-9999
-9999 -1
# enter list of area ID and max annual catch; terminate with area=-9999
-9999 -1
# enter list of fleet number and allocation group assignment, if any; terminate with
fleet=-9999
-9999 -1
```

```
#_if N allocation groups >0, list year, allocation fraction for each group
# list sequentially because read values fill to end of N forecast
# terminate with -9999 in year field
# no allocation groups
2 # basis for input Fcast catch: -1=read basis with each obs; 2=dead catch; 3=retained
catch; 99=input apical_F; NOTE: bio vs num based on fleet's catchunits
#enter list of Fcast catches or Fa; terminate with line having year=-9999
#_Yr Seas Fleet Catch(or_F)
-9999 1 1 0
#
999 # verify end of input
```

9.4 Appendix 4 Starter file

```
#C file created using an r4ss function
#C file write time: 2025-02-28  18:05:03
#
BassVIIIab_3.30_data.ss #_datfile
BassVIIIab_3.30_control.ss #_ctlfile
1 #_init_values_src
1 #_run_display_detail
1 #_detailed_age_structure
0 #_checkup
4 #_parmtrace
1 #_cumreport
1 #_prior_like
1 #_soft_bounds
2 #_N_bootstraps
8 #_last_estimation_phase
10 #_MCMCburn
8 #_MCMCthin
0.1 #_jitter_fraction
-1 #_minyr_sdreport
-2 #_maxyr_sdreport
0 #_N_STD_yrs
1e-04 #_converge_criterion
0 #_retro_yr
0 #_min_age_summary_bio
1 #_depl_basis
1 #_depl_denom_frac
2 #_SPR_basis
5 #_F_std_units
4 15 #_F_age_range
0 #_F_std_basis
0 #_MCMC_output_detail
0 #_ALK_tolerance
#
-1 #_seed
3.3 #_final
```

9.5 Appendix 5 Reference points

Biological reference points for the southern seabass stock bss.27.8ab with Eqsim

R markdown from Hans Gerritsen, modified by Tim Earl and Mathieu Woillez

9.5.1 The ICES approach to setting Reference Points

This Markdown document outlines the steps involved in estimating PA and MSY reference points for sea bass in divisions 8ab as part of WKBSEABASS benchmark 2024. It follows the current technical guidelines: https://www.ices.dk/sites/pub/Publication%20Reports/Guidelines%20and%20Policies/16.04.03.01_Reference_points_for_category_1_and_2.pdf.

Some plot legends refer to landings or catch - These should all be read at "Total removals" - Commercial landings, discards, recreational landings + the proportion of recreational releases assumed to die following release

9.5.2 Get the data in FLR

```
library(r4ss)
library(ss3om) #for readLFSss3
library(FLCore)
library(msy)
library(icesAdvice)
library(ggplot2)
library(dplyr)


#Slight modification from package ss3om to account for apparant name change in F type
readFLSss3 <- function (dir, repfile = "Report.sso", compfile = "CompReport.sso",
    wtatage = out$wtatage_switch, ...)
{
   # browser()
    out <- readOutputss3(dir, repfile = repfile, compfile = compfile)
    if (out$SS_versionNumeric > 3.24)
        res <- buildFLSss330(out, ...)
    else res <- buildFLSss3(out, ...)
    if (wtatage) {
        waafile <- list.files(dir)[grep("wtatage.ss_new", list.files(dir))]
        waa <- data.table(SS_readwtatage(file.path(dir, waafile)))
        waa[, `:=`(year, abs(Yr))]
        waa[, `:=`(unit, Sex)]
        waa[, `:=`(season, Seas)]
        ages <- dimnames(res)$age
        waa <- waa[year %in% dimnames(res)$year, ]
        was <- split(waa, by = "Fleet")
        wasq <- lapply(was, function(x) as.FLQuant(melt(x[, -seq(1,
            6)], id = c("unit", "year", "season"), measure = ages,
            variable.name = "age", value.name = "data")))
        stock.wt(res)[] <- wasq[["0"]]
        nmat <- wasq[["-2"]]%/%wasq[["-1"]]
        mat(res)[] <- nmat
        if (is.null(out$fleet_type)) {
            out$fleet_type <- rep(3, out$nfleets)
            out$fleet_type[out$fleet_ID %in% unique(out$catch$Fleet)] <- 1
        }
        idx <- names(wasq)[!names(wasq) %in% c("0", "-1", "-2")][out$fleet_type ==
            1]
        catch.wt(res)[] <- Reduce("+", wasq[idx])/(length(idx))
        landings.wt(res) <- catch.wt(res)
        discards.wt(res) <- catch.wt(res)
        catch(res) <- computeCatch(res)
        landings(res) <- computeLandings(res)
        discards(res) <- computeDiscards(res)
        stock(res) <- computeStock(res)
    }
    if (file.exists(file.path(dir, "starter.ss"))) {
        sta <- SS_readstarter(file.path(dir, "starter.ss"), verbose = FALSE)
        if (sta$F_std_units == 5) {    #F_reporting units in ss3om package
            range(res)[c("minfbar", "maxfbar")] <- sta$F_age_range
        }
    }
```

```
    return(res)
}

replist <- SS_output('best_run',verbose=F,printstats=F)
stock0 <- readFLSss3('best_run')

stock0@harvest@units <- 'f'
# check fbar range used in SS
replist$F_std_basis

## [1] "_abs_F;_with_F=Z-M;_for_ages_unweighted_4_15"

stock0@range['minfbar'] <- 4
stock0@range['maxfbar'] <- 15

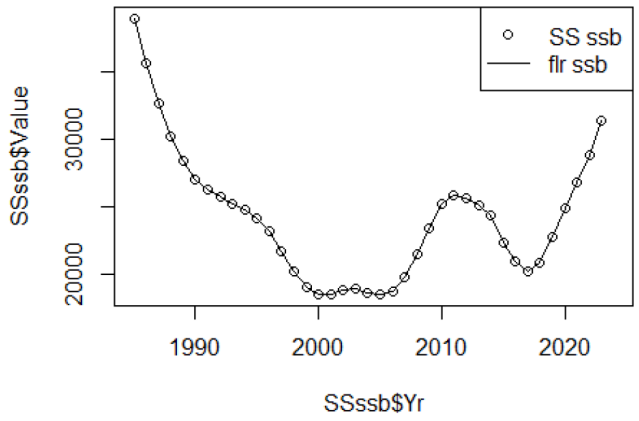
#Define SSB time as the start of the year
m.spwn(stock0) <- 0
harvest.spwn(stock0) <- 0


# # combine the sexes #Not needed for bass as combined sex
# stock <- FLCore:::nounit(stock0)  #
stock <- stock0

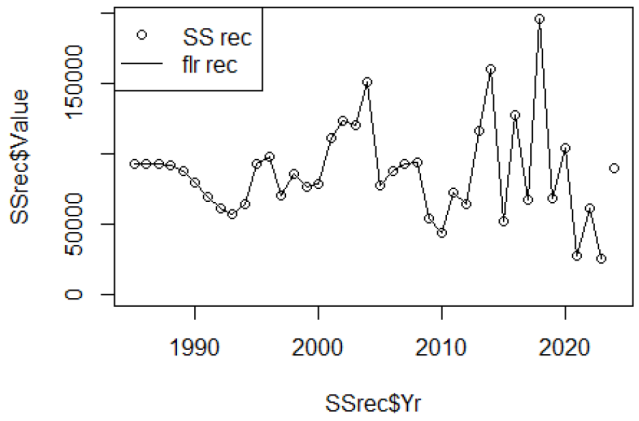
#check that F is ok
all(harvest(stock) ==  harvest(stock.n(stock), catch=catch.n(stock), m=m(stock)))

## [1] TRUE

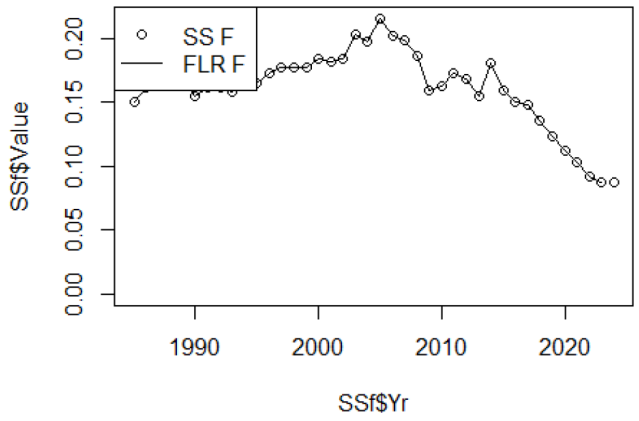
SSssb <- subset(replist$derived_quants,substring(Label,1,6)%in%c('SSB_19','SSB_20')) %>%
  mutate(Yr=as.numeric(substring(Label,5,9)))
 plot(SSssb$Yr,SSssb$Value)
lines(stock@range[[4]]:stock@range[[5]],ssb(stock))
# lines(stock0@range[[4]]:stock0@range[[5]],ssb(stock0)[,,1],col='red')
legend('topright',c('SS ssb','flr ssb'),pch=c(1,NA),lty=c(NA,1),col=c(1,1))
```



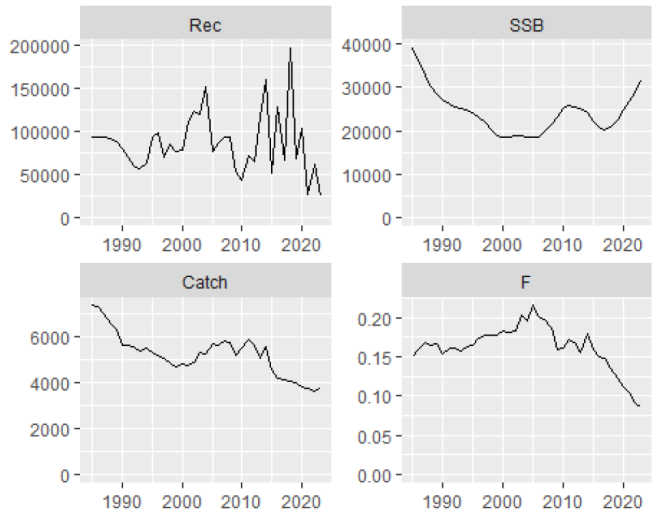

```
# check recruitment
SSrec <- subset(replist$derived_quants,substring(Label,1,7)%in%c('Recr_19','Recr_20')) %>%
  mutate(Yr=as.numeric(substring(Label,6,10)))
plot(SSrec$Yr,SSrec$Value, ylim=c(0,max(SSrec$Value)))
lines(stock@range[[4]]:stock@range[[5]],rec(stock))
legend('topleft',c('SS rec','flr rec'),pch=c(1,NA),lty=c(NA,1),col=1)
```




```
# check F
SSf <- subset(replist$derived_quants,substring(Label,1,4)%in%c('F_19','F_20')) %>%
  mutate(Yr=as.numeric(substring(Label,3,7)))
plot(SSf$Yr,SSf$Value, ylim=c(0,max(SSf$Value)))
lines(stock@range[[4]]:stock@range[[5]],fbar(stock))
legend('topleft',c('SS F','FLR F'),pch=c(1,NA),lty=c(NA,1),col=1)
```




```
# stock summary
plot(stock) + facet_wrap(~qname, scales="free")
```



9.5.3 Stock-recruit

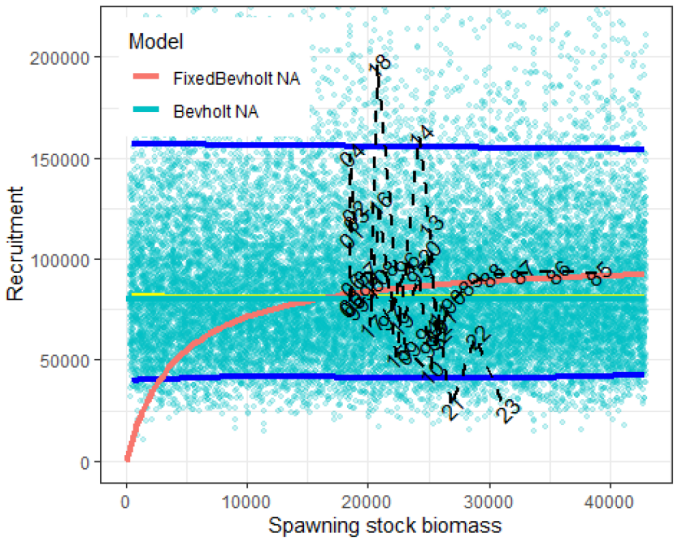
Now get the stock-recruit para from SS and force the SR function to be the same. This fixes the steepness and R0 but not sigma R, which it will estimate from the actual SR pairs...

```
# SR para from SS
r0 <- replist$parameters$Value[replist$parameters$Label=="SR_LN(R0)"]
R0 <- exp(r0)
h <- replist$parameters$Value[replist$parameters$Label=="SR_BH_steep"]
B0 <- c(replist$derived_quants$Value[replist$derived_quants$Label=="SSB_Virgin"])
# other SR para are not used here
sigmaR <- replist$parameters$Value[replist$parameters$Label=="SR_sigmaR"]
rho <- replist$parameters$Value[replist$parameters$Label=="SR_autocorr"]

FixedBevholt <- function (ab,ssb) log(4*h*R0*ssb/(B0*(1-h)+ssb*(5*h-1)))
# be careful to not modify h, R0 and B0 later in the script
```

Check what SR looks like, also compare with BH fit to the data (without fixing h). FixedBevHolt is the assessment output.

```
set.seed(1)
nsamp <- 1000 #increase number of samples for final run (e.g 1000)
fit_bh_temp <- eqsr_fit(stock, nsamp = nsamp, models = c("FixedBevholt","Bevholt"))
fit_bh <- eqsr_fit(stock, nsamp = nsamp, models = c("FixedBevholt"))
eqsr_plot(fit_bh_temp,ggPlot=T)
```




```
fit_bh$stk <- stock0#Want to have data up to 2023 available for selectivity

#with(replist$SPAWN_RECR_CURVE,points(SSB,Recruitment,col=5,pch=16))
```

9.5.4 Identifying appropriate data

(now excluded) Exclude 1985-1990, 2023-24 estimates of recruitment that are substantially more uncertain than other estimates.

```
SSrec[,1:3]

##               Label    Value   StdDev
## Recr_1985 Recr_1985  93151.9 54831.70
## Recr_1986 Recr_1986  93367.7 55106.60
## Recr_1987 Recr_1987  93326.9 54951.10
## Recr_1988 Recr_1988  92062.2 53500.00
## Recr_1989 Recr_1989  87889.8 49601.80
## Recr_1990 Recr_1990  79705.1 43043.70
## Recr_1991 Recr_1991  69497.1 35674.70
## Recr_1992 Recr_1992  60885.5 29862.90
## Recr_1993 Recr_1993  57564.6 27504.80
## Recr_1994 Recr_1994  64263.1 31037.00
## Recr_1995 Recr_1995  93124.1 42517.90
## Recr_1996 Recr_1996  97896.8 41307.10
## Recr_1997 Recr_1997  70558.4 32586.20
## Recr_1998 Recr_1998  85845.4 33765.90
## Recr_1999 Recr_1999  76130.3 31948.30
## Recr_2000 Recr_2000  78874.4 33585.70
## Recr_2001 Recr_2001 111375.0 39284.60
## Recr_2002 Recr_2002 123643.0 41456.00
## Recr_2003 Recr_2003 120030.0 42445.00
## Recr_2004 Recr_2004 151634.0 38500.30
## Recr_2005 Recr_2005  77363.2 28757.30
## Recr_2006 Recr_2006  87300.4 27164.80
## Recr_2007 Recr_2007  93274.0 25644.30
## Recr_2008 Recr_2008  93996.8 20997.50
## Recr_2009 Recr_2009  53744.6 14653.30
## Recr_2010 Recr_2010  44102.7 13350.60
## Recr_2011 Recr_2011  72129.8 17042.00
## Recr_2012 Recr_2012  64377.2 18831.80
```

```
## Recr_2013 Recr_2013 116464.0 23724.70
## Recr_2014 Recr_2014 160795.0 25870.80
## Recr_2015 Recr_2015  51950.1 18496.70
## Recr_2016 Recr_2016 127768.0 25234.50
## Recr_2017 Recr_2017  66881.6 19286.30
## Recr_2018 Recr_2018 196265.0 33413.60
## Recr_2019 Recr_2019  68047.4 17298.90
## Recr_2020 Recr_2020 103839.0 25224.30
## Recr_2021 Recr_2021  26986.4  9503.16
## Recr_2022 Recr_2022  61394.5 18432.80
## Recr_2023 Recr_2023  25106.0 11105.40
## Recr_2024 Recr_2024  90210.0 54189.00

stock <- window(stock,start=1997,end=2022)
```

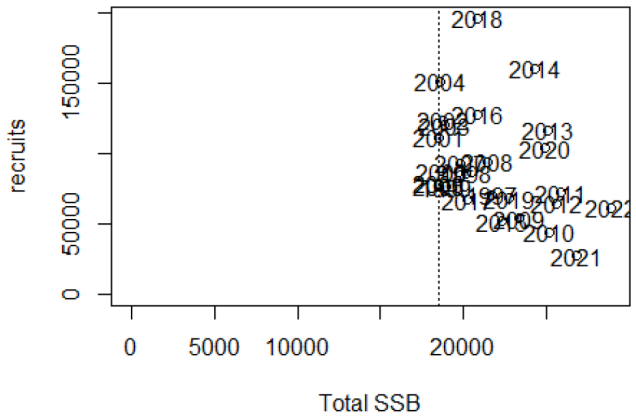
9.5.5 Step 2. Stock type and step 3. Blim

```
ssb(stock)[ssb(stock)==min(ssb(stock))]

## An object of class "FLQuant"
## , , unit = unique, season = all, area = unique
##
##      year
## age   2000
##   all 18471
##
## units:  NA
```

The stock is type 5 (no evidence of impaired recruitment), so Blim is Bloss = B2000 = 18,471.

```
plot(c(ssb(stock)),c(rec(stock)),
     xlim=c(0,max(ssb(stock))),ylim=c(0,max(rec(stock))),
     xlab='Total SSB',ylab='recruits')
text(c(ssb(stock)),c(rec(stock)),stock@range[4]:stock@range[5])
Blim <- round(c(ssb(stock)[,'2000',]))
abline(v=Blim,lty=3)
```



Sanity check: Check Blim is not a very small percentage of B0. Percentage is 29%.

9.5.6 step 4. Other PA reference points from Blim

```
sigmaSSB_SS <- round(with(subset(replist$derived_quants,Label=='SSB_2024'),StdDev/Value),3)
## or just stick to the default?
#sigmaSSB <- 0.2 # default

Bpa <- round(Blim * exp(1.645 * sigmaSSB_SS))
Bpa

## [1] 23026
```

9.5.7 Flim

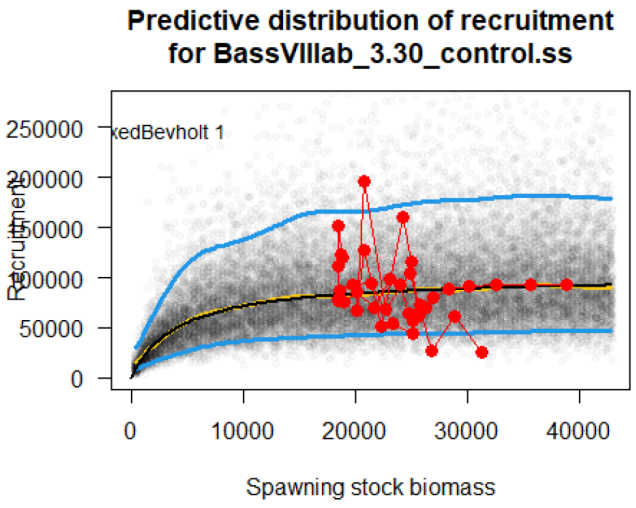
No longer needed

9.5.8 Step 2. Fmsy and Btrigger

FMSY should initially be calculated based on an evaluation with the inclusion of stochasticity in a population (i.e. recruitment, M, maturity, growth) and fishery (e.g. selectivity) as well as assessment/advice error. This is a constant F, which should provide maximum yield without biomass constraints (without MSY Btrigger). Error is included as this is the condition analogous to management strategy evaluations (MSEs) that will prevail in practice. Note that in order to ensure consistency between the precautionary and the MSY frameworks, FMSY is not allowed to be above Fpa; therefore, if the FMSY value calculated initially is above Fpa, FMSY is reduced to Fpa.

```
# fit BH again using only the selected years

eqsr_plot(fit_bh,ggPlot=FALSE)
```

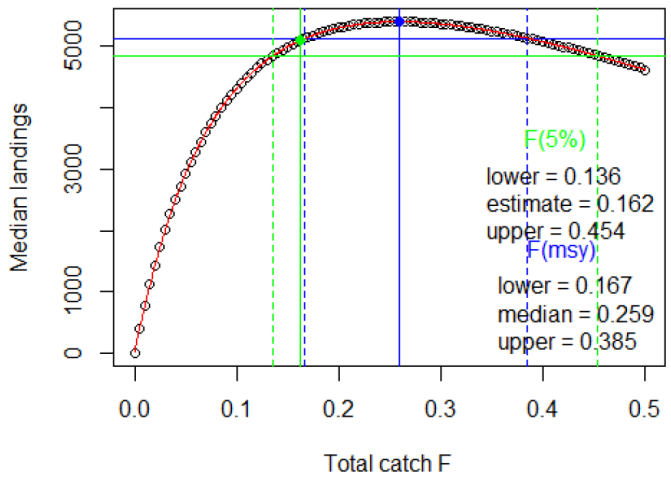



```
## Forecast error (see Guidance document for details on calculation of these values)
# F
cvF  <- 0.212                              # Default = 0.212
phiF <- 0.423                              # Default = 0.423
```

```
# SSB
cvSSB <- 0                                  # Default = 0
phiSSB <- 0                                 # Default = 0


sim_noTrig <- eqsim_run(fit_bh,
                        Fcv=cvF, Fphi=phiF, SSBcv=cvSSB,
                        rhologRec=rho,
                        Btrigger = 0, Blim=Blim, Bpa=Bpa,
                        Nrun=200, Fscan = seq(0,0.5,len=101),verbose=F)

Fmsy_tmp <- round(sim_noTrig$Refs2["lanF","medianMSY"],3)
eqsim_plot_range(sim_noTrig, type="median")
```

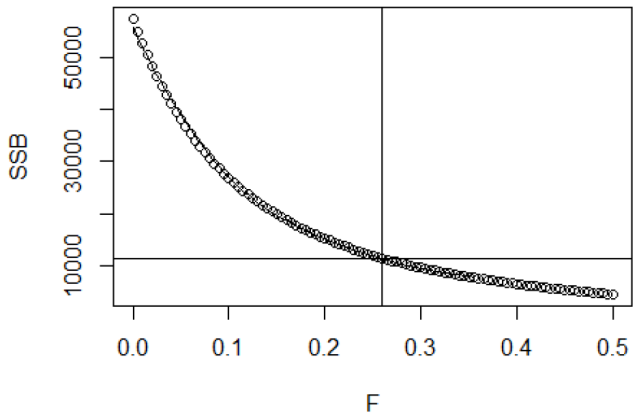


Fmsy is initially estimated as 0.259. Note that SS estimates Fmsy at 0.266.

MSY Btrigger should be selected to safeguard against an undesirable or unexpected low SSB when fishing at FMSY. For most stocks that lack data on fishing at FMSY, MSY Btrigger is set at Bpa. However, as a stock starts to be fished consistently with FMSY, it is possible to move towards implementation of a value for MSY Btrigger that reflects the 5th percentile definition of MSY Btrigger

```
data.05<-sim_noTrig$rbp
x.05 <- data.05[data.05$variable == "Spawning stock biomass", ]$Ftarget
b.05 <- data.05[data.05$variable == "Spawning stock biomass", ]$p05
plot(b.05~x.05, ylab="SSB", xlab="F")
abline(v=Fmsy_tmp)
i <- which(x.05<(Fmsy_tmp+0.1))
b.lm <- loess(b.05[i] ~ x.05[i])
lines(x.05[i],c(predict(b.lm)),type='l')

Bmsy5pc <- round(predict(b.lm,Fmsy_tmp))
abline(h=Bmsy5pc)
```



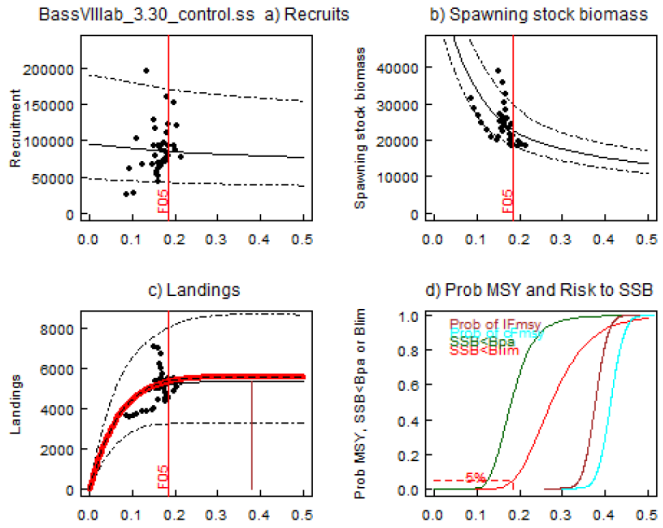
So we can use Btrigger = Bpa =23,026 or we can use Btrigger = Bmsy5pc = 11,365. Bpa is higher so go with that.

```
Btrigger <- max(Bpa, Bmsy5pc)
formatC(Btrigger,format='d',big.mark=",")

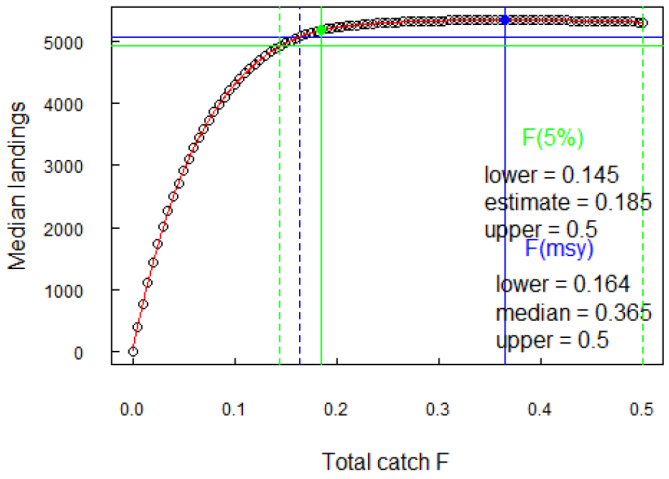
## [1] "23,026"
```

The ICES MSY AR should be evaluated to check that the FMSY and MSY Btrigger combination fulfills the precautionary criterion of having less than 5% annual probability of SSB < Blim in the long term. The evaluation must include realistic assessment/advice error and stochasticity in population biology and fishery selectivity.

```
sim_Trig <- eqsim_run(fit_bh,
                          Fcv=cvF, Fphi=phiF, SSBcv=cvSSB,
                          rhologRec=rho,
                          Btrigger = Btrigger, Blim=Blim,Bpa=Bpa,
                          Nrun=200, Fscan = seq(0,0.5,len=101),verbose=F)
eqsim_plot(sim_Trig,catch=F)
```




```
eqsim_plot_range(sim_Trig, type="median")
```




```
Fp05 <- round(sim_Trig$Refs2["catF","F05"],3)
```

If the precautionary criterion evaluated in point 3 is not met, then FMSY should be reduced from the value calculated above until the precautionary criterion is met (i.e. reduce FMSY to FMSY = Fpa). Fp05 is estimated at 0.185.

```
Fmsy <- round(min(sim_Trig$Refs2["lanF","medianMSY"], Fp05),3);Fmsy
```

```
## [1] 0.185

Fupper <- round(min(sim_Trig$Refs2["lanF","Medupper"], Fp05),3);Fupper

## [1] 0.185

Flower <- round(sim_Trig$Refs2["lanF","Medlower"],3);Flower

## [1] 0.164
```

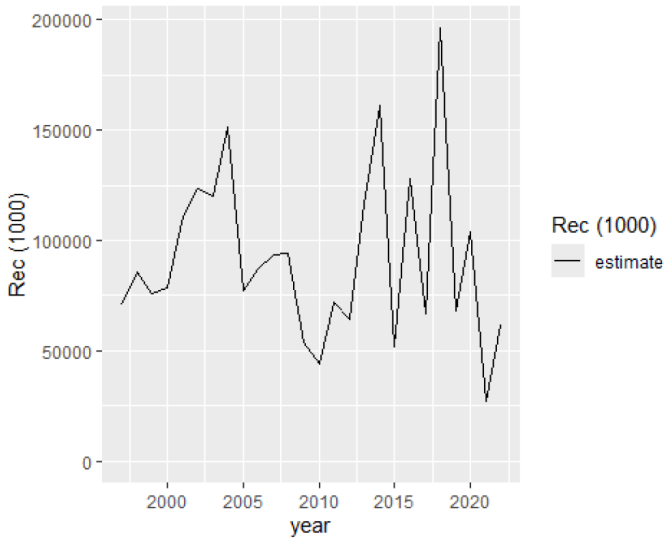
The estimated reference points are shown below. It is generally expected that Flim is considerably higher than Fpa. However, in the ICES framework Flim is estimated using a segmented regression SR and without applying the ICES advice rule. This results in a yield that goes down rapidly above Fmsy and therefore a relatively low Flim. Fpa is estimated with a Beverton-Holt SR and the Btrigger advice rule, resulting in a much flatter yield at high F and a relatively high Fpa.

This is a consequence of one of the inconsistencies of the current framework which uses two different SR functions and the advice rule. In this situation Flim would be undefined.

Reference Point	Value	Rationale
Blim	18,471	B(2000); lowest SSB with high recruitment
Bpa	23,026	Blim with assessment error
MSY Btrigger	23,026	Bpa
Fpa	0.185	F with 95% probability of SSB≥Blim (BH with Btrigger)
Fmsy	0.185	Fpa
FmsyLower	0.164	Stochastic simulations
FmsyUpper	0.185	Fpa
Bmsy5pc	11,365	5% probability of SSB < Blim

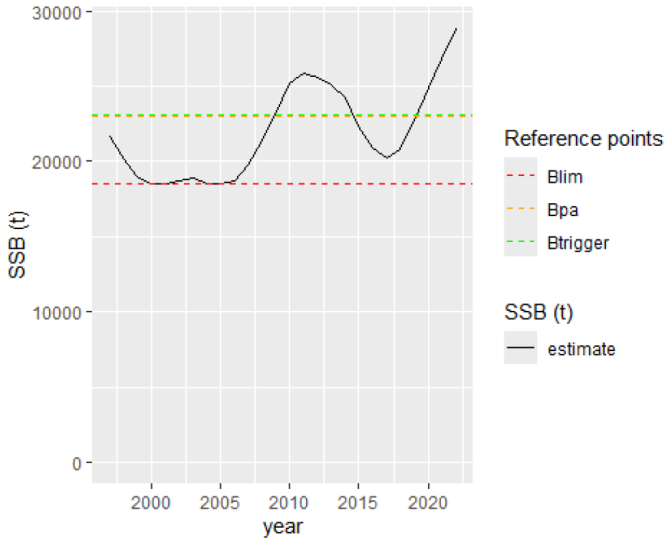
```
# stock summary
myplot <- function(x,ylab){
  year <- as.numeric(dimnames(x@.Data)$year)
  y <- c(x)
  ggplot() +
    geom_line(aes(x=year,y=y,colour="estimate")) +
    ylim(0,max(x)) +
    ylab(ylab) +
    scale_color_manual(name = ylab, values = c("estimate" = "black"))
}

myplot(rec(stock),ylab="Rec (1000)")
```



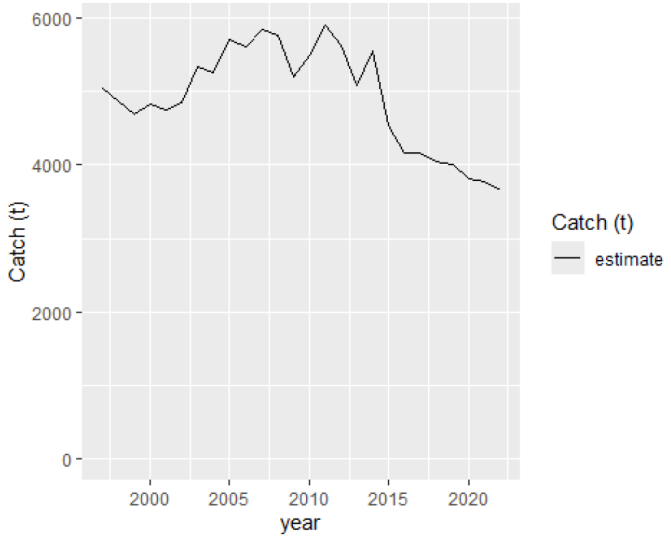

```
ggsave("rec.png")

myplot(ssb(stock),ylab="SSB (t)") +
  geom_hline(aes(yintercept = Blim, linetype = "Blim"), colour = "red") +
  geom_hline(aes(yintercept = Bpa, linetype = "Bpa"), colour = "orange") +
  geom_hline(aes(yintercept = Btrigger+100, linetype="Btrigger"), colour="green") +
  scale_linetype_manual(name="Reference points",
                        values = c(2, 2, 2),
                        guide = guide_legend(override.aes = list(color = rev(c("green", "orange"
, "red")))))
```



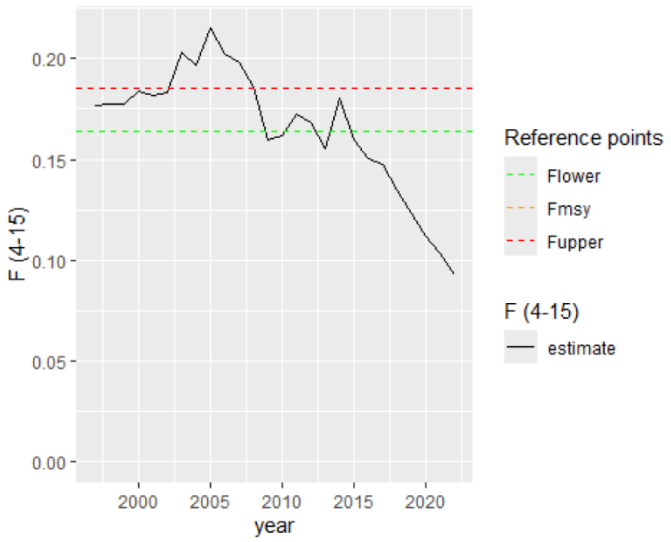
```
ggsave("ssb.png")

myplot(catch(stock),ylab="Catch (t)")
```




```
ggsave("catch.png")

myplot(fbar(stock),ylab="F (4-15)") +
  geom_hline(aes(yintercept = Flower, linetype="Flower"), colour="green") +
  geom_hline(aes(yintercept = Fmsy+0.0005, linetype = "Fmsy"), colour = "orange") +
  geom_hline(aes(yintercept = Fupper, linetype = "Fupper"), colour = "red") +
  scale_linetype_manual(name="Reference points",
                        values = c(2, 2, 2),
                        guide = guide_legend(override.aes = list(color = c("green", "orange", "r
ed"))))
```




```
ggsave("fbar.png")
```

Annex 6: Stock Annex updates

Stock code	Stock description	DOI
bss.27.4bc7d-h	Sea bass (*Dicentrarchus labrax*) in divisions 4.b, 4.c, 7.a, and 7.d–h (central and southern North Sea, Irish Sea, English Channel, Bristol Channel, Celtic Sea)	https://doi.org/10.17895/ices.pub.29818826
bss.27.8ab	Sea bass (*Dicentrarchus labrax*) in divisions 8.a and 8.b (northern and central Bay of Biscay)	https://doi.org/10.17895/ices.pub.29818814