BENCHMARK WORKSHOP FOR SELECTED PLAICE STOCKS (WKBPLAICE)

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Contents

i Executive summary

The Benchmark Workshop on selected plaice stocks (WKBPLAICE) evaluated the assessment (input data and methodology), short–term forecast procedures and reference points for three plaice stocks, plaice (Pleuronectes platessa) in Division 7.e (western English Channel), plaice (Pleuronectes platessa) in subdivisions 27.21-23 (Kattegat, Belt Seas, and the Sound) and plaice (Pleuronectes platessa) in subdivisions 27.24-32 (Baltic Sea, excluding the Sound and Belt Seas). The key focus has been on evaluating the stock structure of the Baltic Sea plaice and conducting a stock-specific Management Strategy Evaluation (MSE) to tune a Category 3 empirical harvest control rule for plaice in Division 7.e. Plaice in Division 7.e is a category 3 data-limited stock applying a chr-rule, which is defined by optimizing the Itrigger and harvest rate. The two Baltic plaice stocks were merged during the benchmark process resulting in one stock, plaice in subdivisions 27.21-32. The stock was classified as a category 1 stock which is assessed with State-space assessment Model (SAM).

Plaice (*Pleuronectes platessa*) in Division 7.e (western English Channel)

The previous stock assessment for plaice in Division 7.e was classified as a category 3 stock and advice was given with the rfb rule. Due to large uncertainties in data and assumptions, the model was not moved into category 1. Instead, a stock-specific simulation (management strategy evaluation, MSE) was conducted to tune the chr rule, an empirical harvest control rule based on the relative harvest rate. Various input data were reviewed and updated, with discard survival assumed to be 50%, though different scenarios were considered. A total of 14 age-structured stochastic operating models were developed, and the chr rule was tuned using a set of seven reference models to achieve both Maximum Sustainable Yield (MSY) and a precautionary approach (keeping the stock above a critical threshold). The final tuned chr rule (MP5) provides biennial advice, uses the UK-FSP survey as a biomass index, and was found to produce high long-term catch and stock biomass. Robustness tests showed superior performance to other MPs across all scenarios. When compared to the previous rfb rule and the standard ICES MSY rule, MP5 yielded a higher catch, while the ICES MSY rule did not fully meet precautionary approach standards. No recommendations for further investigations are outlined in the reviewers' report and the work was accepted by the whole group.

Plaice *(Pleuronectes platessa)* in Subdivision 21-32 (Baltic Sea)

The stock structure of plaice in the Baltic Sea was extensively reviewed. WKBPLAICE made the decision to merge the two Baltic Sea plaice stocks into one single stock, plaice in subdivisions 27.21-32 (Baltic Sea).

Plaice in the Baltic Sea is now assessed as a category 1 single stock using the SAM. Various input data were reviewed and updated after group discussions. Survey data coming from two bottom trawl surveys are combined using Delta-GAM models to produce a stock index. Discard survivability was considered, with three scenarios tested (low, medium, high), which affected the spawning stock biomass (SSB) estimates but had less impact on fishing mortality. After a group discussion, the medium discard survival scenario was chosen. Natural mortality scenarios were also evaluated, included age- and time-variant natural mortality, and various SAM configurations. Proposed models were evaluated following the ICES guidelines for benchmarks. Following extensive discussions, the final assessment, reference points and short-term forecasts following ICES guidelines were agreed by the group. As not all points from the issue list could be handled during the benchmark, recommendations for further investigations are outlined in the reviewer's report and issue list. The stock annex will be prepared in advance to WGBFAS.

General findings

The group collectively approved of the assessment frameworks for both stocks proposed after several revisions and modifications throughout the benchmark process. For plaice in division 7.e, the approach of defining the chr rule based on an optimization of the chr parameters is seldom done, but as shown here resulted in superior outcomes in the long-term according to the chr rule chosen. In this case, the best $I_{trigger}$ chr parameter value was shown to occur at relatively high value, which led to better stock outcomes due to a faster recovery rate when the stock falls to low levels. This may be an interesting property to explore in the future for generality. For plaice in subdivisions 27.21-32, the stock assessment itself was found to be informative, but there was rather high uncertainty in assumptions made regarding future productivity. This results in reference points that should be taken with caution, but it is also not an uncommon situation in a continuously changing environment and still adheres to ICES guidelines. In the future it may be useful to approach the reference points using an ensemble approach to incorporate more uncertainty, and this approach could be encouraged within ICES frameworks.

ii Expert group information

Expert group name	Benchmark workshop on selected plaice stocks (WKBPLAICE)
Expert group cycle	Annual
Year cycle started	2024
Reporting year in cycle	1/1
Chair(s)	Stefanie Haase (Germany)
	Pamela Woods (Iceland)
External reviewers	Marta Cousido (Spain)
	Silvia Angelini (Italy)
Meeting venues and dates	3rd -7th June 2024, data evaluation meeting, online 16th Sept. 2024, benchmark preparation meeting, online 21st -25th October 2024, assessment benchmark meeting, Copenhagen, Denmark 5th November, benchmark follow-up meeting, online 4th December, benchmark follow-up meeting, online 17th January, benchmark follow-up meeting, online

1 Introduction

1.1 General

This report details the outcomes of the benchmark exercise established by ACOM to consider the assessment (input data and methodology), short–term forecast procedures and reference points for three plaice stocks.

The stocks benchmarked were

- Plaice (*Pleuronectes platessa*) in subdivisions 21–23 (Kattegat, Belt Seas, and the Sound)
- Plaice (*Pleuronectes platessa*) in subdivisions 24–32 (Baltic Sea, excluding the Sound and Belt Seas)
- Plaice (*Pleuronectes platessa*) in Division 7.e (western English Channel)

Based on extensive work on stock identity, the benchmark made the decision to merge Plaice (*Pleuronectes platessa*) in subdivisions 21–23 (Kattegat, Belt Seas, and the Sound) and Plaice (*Pleuronectes platessa*) in subdivisions 24–32 (Baltic Sea, excluding the Sound and Belt Seas) into

- Plaice (*Pleuronectes platessa*) in subdivisions 21–32 (Baltic Sea)

The process was facilitated by two chairs, ICES chair (Stefanie Haase) and an external chair (Pamela Woods). Two reviewers participated: Marta Cousida (Spain) and Silvia Angelini (Italy). They were involved throughout the benchmark exercise and provided comment and input during the discussions. Issue lists were compiled for each stock ahead of the meeting. They outlined a range of issues that the expert groups felt should be addressed. These formed the basis for the work carried out by this benchmark.

A data coordination workshop was held online from the 3rd -7th June 2024. It was attended by 13 experts online. During the data workshop, the items on the issue lists were considered in detail, in particular the stock identity of plaice. A presentation was given outlining the different methodologies applied to study stock structure including genetics evidence. The report on stock identity was sent to the Stock Identification methods working group for review. The input data for the assessments was presented and discussed and included detailed analysis of data consistency, survey time series and methodologies as well as previous assessment models applied.

The preparations continued by correspondence with progress discussed at one online update meetings (16th September 2024). Prior to the final benchmark meeting, most working documents were produced and uploaded to the meeting SharePoint site.

The benchmark assessment meeting was held at ICES headquarters, Copenhagen from 21st – 25th October 2024 and was attended by 11 participants in person and 4 participants online. All new data sources and updated timeseries were explored in the context of different model formulations and assumptions. While Plaice in Division 7.e was finalised at the benchmark meeting, two follow up meeting were held to finalise assessments, reference points and discussion on short term forecasts of Plaice in subdivisions 21–32 (Baltic Sea).

1.2 Working documents

Working documents presented WKBPLAICE

Working documents:

Plaice (*Pleuronectes platessa*) in Division 7.e (western English Channel)

- WD1 Data: "Data for plaice (*Pleuronectes platessa*) in Division 7.e (western English Channel – ple.27.7e) – Working document for WKBPLAICE 2024", 58 pp., https://community.ices.dk/ExpertGroups/benchmarks/2024/WKBPLAICE/2022%20Meeting%20Documents/04.%20Working%20documents/WKBPLAICE2024_ple.27.7e_data.pdf
- WD2 Operating models: "Operating models for plaice (Pleuronectes platessa) in Division 7.e (western English Channel – ple.27.7e) – Working document for WKBPLAICE 2024", 26 pp.,https://community.ices.dk/ExpertGroups/benchmarks/2024/WKBPLAICE/2022%20Meeting%20Documents/04.%20Working%20documents/WKBPLAICE2024_ple.27.7e_OM.pdf
- WD3 MSE results: "Results of the management strategy evaluation for plaice (Pleuronectes platessa) in Division 7.e (western English Channel – ple.27.7e) – Working document for WKBPLAICE 2024", 55 pp., https://community.ices.dk/ExpertGroups/benchmarks/2024/WKBPLAICE/2022%20Meeting%20Documents/04.%20Working%20documents/WKBPLAICE2024_ple.27.7e_MP.pdf

Plaice (*Pleuronectes platessa*) in subdivisions 21–32 (Baltic Sea)

- WD1 Stock Identity and stock merging
- WD2 Stock coordination and data overviews
- WD3 Overview of the assessment runs and sensitivity
- WD4 New natural mortality
- WD5 Inclusion of discard survival
- WD 6 Reference points
- WD 7 Survey indices for Plaice in ICES areas 21-32

The Working Documents are attached to this report as an annex.

1.3 Report structure

The report is structured into section by stock with plaice in Division 7.e (section 2) and plaice in subdivisions 21–32 (section 3), followed with a section containing reviewer's comments (section 4).

2 Plaice (*Pleuronectes platessa*) in Division 7.e (western English Channel)

2.1 Summary

Plaice in Division 7.e (ple.27.7e) is a category 3 data-limited stock and was benchmarked at WKBPLAICE in 2024. Due to large uncertainties in data and assumptions, moving the stock to category 1 was infeasible. Instead, a stock-specific simulation (management strategy evaluation, MSE) was conducted to tune the chr rule, an empirical harvest control rule based on the relative harvest rate. Input data were evaluated and updated. The baseline assumption for discard survival was set to 50% but several options were considered. A range of 14 age-structured stochastic operating models were developed. The tuning of the chr rule was performed on a reference set of seven operating models to meet the ICES objectives of MSY (maximising long-term catch) and the precautionary approach (limiting the risk of the stock falling below B_{lim} to 5%). The final tuned version of the chr rule (MP5) provides biennial advice and uses the UK-FSP survey as a biomass index. MP5 delivers a high long-term catch and SSB and was shown to be robust in all robustness scenarios. The performance of MP5 was compared to the previously used rfb rule and the standard data-rich 1 ICES MSY rule. The rfb rule delivered a lower catch than MP5, while the ICES MSY rule violated the conditions of the ICES precautionary approach.

2.2 Issue list

A list of issues for ple.27.7e is kept in the ICES online system at https://sid.ices.dk/manage/RollingIssues.aspx (search for "ple.27.7e"). The issues listed in this system before the benchmark (May 2024) is shown in Table 2.1.

Table 2.1 Issue list for plaice (*Pleuronectes platessa*) in Division 7.e (western English Channel) and progress made during the benchmark.

ID	Type	Problem/Aim	Work Required	Data Required	Created	Modified	WKBPLAICE progress
40	Tuning series	Q1SWBeam survey index was revised in 2020. Changes to underlying data and generation of index should be reviewed.	Review data base and computer code to generate index.	Data exist at Cefas.	15/05/2020	11/05/2023	The survey data and modelling were revised before WKBPLAICE and the latest "most correct" version was used at the benchmark.
41	Discards	Previously used age-structured stock assessment models did not include discards but discards are considered substantial.	Discard estimates are available in InterCatch for 2012-2022 and have been extrapolated back in time by WGCSE. Available discard data should be analysed, and it should be investigated whether more historical discard data are available.		15/05/2020	16/05/2023	Discards were included in the analysis during WKBPLAICE.

ID	Type	Problem/Aim	Work Required	Data Required	Created	Modified	WKBPLAICE progress
42	Discards	French discard data for 2018 revised in 2020 due to inaccuracies in the methodology, however, the method has also been used for previous years	review French discard estimates prior to 2018.	Should be available from France.	15/05/2020	15/05/2020	No data call was issued before WKBPLAICE.
43	Biological parameters	Natural mortality (time and age invariant) and maturity ogives (time invariant) were borrowed from other plaice stocks, but are not used for these stocks anymore after benchmarks.	Updates to biological data should be considered. Natural mortality is unknown and no studies for this stock area exist. The assumptions for natural mortality have a crucial influence on the output of age-structured stock assessment models and depending on the assumptions, the stock status can vary considerably. This is likely to impair the use of age-structured stock assessment models.	Maturity data is routinely collected by the two surveys but has not been explored.	15/05/2020	16/05/2023	Natural mortality and maturity were revised during WKBPLAICE.

ID	Type	Problem/Aim	Work Required	Data Required	Created	Modified	WKBPLAICE progress
44	Biological parameters	Stock and catch weights are currently derived by applying a smoother to the annual weights at age from InterCatch.	The use of raw weight at age or alternative formulations (e.g. von Bertalanffy growth model) and their impact should be explored.	Raw catch weights for 2012-2022 are available from InterCatch.	15/05/2020	16/05/2023	The processing of weights at age was revised during WKBPLAICE.
45	Stock identity	There is uncertainty about the stock structure and some mixing between 7.d and 7.e is considered.	Migration between different areas should be further investigated but can likely not be resolved in the near future. Assumptions about migration are likely to have a higher impact on analytical stock assessment models but are less important for category 3 empirical harvest control rules because these follow trends in the data without having to estimate population dynamics.		15/05/2020	16/05/2023	No new data on migration was available for WKBPLAICE but scenarios including/excluding migration were considered.

ID	Type	Problem/Aim	Work Required	Data Required	Created	Modified	WKBPLAICE progress
46	Assessment method	The advice for this stock is based on the category 3 data-limited rfb rule. The rfb rule is applied with generic parameters leading to a precautionary advice. There is potential to explore moving the stock to a category 1 data-rich assessment or to conduct a case-specific MSE. Recently published work on a comparison of category 1 and category 3 stocks through MSE included this stock as a case study. The main conclusions were (1) that a single age-structured data-rich stock assessment can likely not capture the full dynamics of this stock because of high uncertainty, (2) a category 1 approach following ICES guidelines leads to an unacceptably high risk, and (3) that category 3 empirical methods can be tuned for this stock and provide a better management performance (higher catch, lower risk) compared to the default ICES category 1 approach.	An MSE framework for this stock already exists and only needs to be updated with the latest data. This stock is an ideal candidate for conducting case-specific MSE to tune category 3 methods.		15/05/2020	18/05/2023	The assessment method was changed during WKBPLAICE.

ID	Type	Problem/Aim	Work Required	Data Required	Created	Modified	WKBPLAICE progress
206	Tuning series	Two scientific surveys (UK-FSP Q3 and UK-Q1SWBeam Q1) are routinely conducted for this stock. The current rfb rule only uses the UK-FSP survey. The Q1SWBeam survey was revised in 2020, data for 2022 are missing, and the cohort tracking of this survey is poor, with sometimes even negative correlations between ages.	The suitability of the surveys, particularly the Q1SWBeam survey, should be checked. It should be checked if the Q1SWBeam survey is appropriate to inform on the plaice stock.		12/05/2021	16/05/2023	Both survey indices were reviewed during WKBPLAICE. The final assessment uses only the UK-FSP survey as a biomass index.

2.3 General

2.3.1 Fishery information

The majority of the catch for plaice in ICES Division 7.e are caught by the United Kingdom (England), with fewer catches from France and Ireland and negligible catches from other countries. The dominant gears are beam trawls (TBB_DEF_70-99), followed by otter trawls, and several other gears with minor contributions to the total catches. The catch data are described in detail in working document 1 (WD1, Fischer, 2024a) and in the WGCSE report (ICES, 2024b).

2.3.2 Current assessment and advice

Prior to WKBPLAICE, ple.27.7e was considered a category 3 data-limited stock and advice was given with the rfb rule. The advice sheet from the Celtic Sea working group (WGCSE) from 2024 is available from ICES (2024) at https://doi.org/10.17895/ices.advice.25019453. The headline advice from 2024 was (ICES, 2024c):

> *ICES advises that when the MSY approach is applied, catches should be no more than 927 tonnes in each of the years 2025 and 2026.*

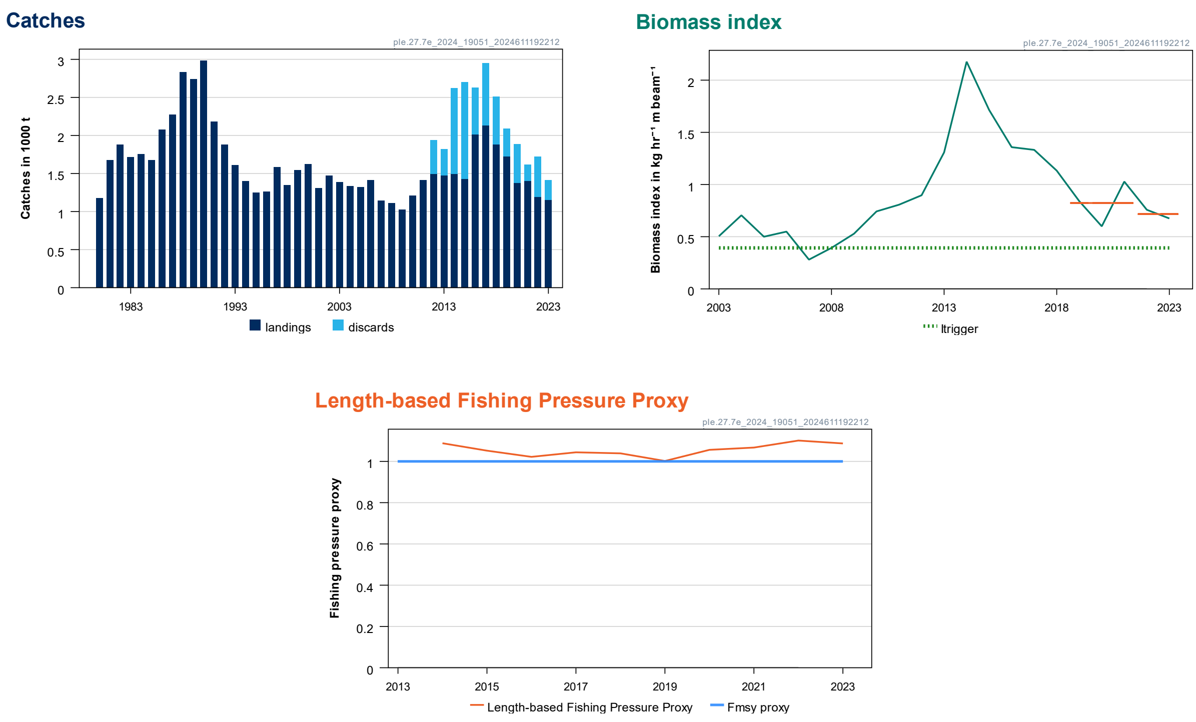

Figure 2.1 Summary of the stock assessment from the 2024 ICES advice. Source: ICES (2024b).

2.4 Benchmark approach for ple.27.7e

Over the past years, there have been numerous attempts to fit age-structured and surplus production models to plaice in Division 7.e (ple.27.7e). However, these models were unable to model stock dynamics appropriately to be used as the basis for management advice. Therefore, the approach of this benchmark was to conduct stock-specific simulations (MSE, management strategy evaluation, in the sense of a closed-loop simulation) and tune a category 3 data-limited empirical harvest control rule. This approach is explicitly encouraged by the ICES technical guidelines for category 2 and 3 stocks (ICES, 2024a). This plaice stock is relatively data-rich for an ICES category 3 data-limited stock and is an ideal candidate for conducting stock-specific simulations.

Recently, work on comparing the new ICES category 3 data-limited empirical harvest control rules and the ICES data-rich category 1 MSY rule was published by Fischer *et al*. (2023) and included this plaice stock as a case study. The conclusion was that although an upgrade of the stock to category 1 is possible, this is likely not a good idea because (1) a single age-structured stock assessment model cannot model the full uncertainty about the stock dynamics and data and (2) the use of the ICES MSY rule with reference points estimated by EqSim leads to fisheries management that violates the ICES precautionary approach. Furthermore, an upgrade of the stock to category 2 with a surplus production model (e.g. SPiCT, Pedersen & Berg, 2017) is infeasible because it has been shown several times over the years that SPiCT cannot model the stock dynamics of this stock and would lead to unacceptably high uncertainty bounds. However, the category 3 methods (rfb and chr rules) work as intended and can be tuned with a stock-specific MSE simulation.

There are substantial unknowns about data for this stock, such as the total level of catch, discard survival, migration, natural mortality, and recruitment. A range of operating models with different input data and assumptions were created to address these uncertainties, covering a range of possible scenarios. These included more plausible scenarios in a reference set of operating models (e.g. different assumptions about catch or natural mortality) and less plausible robustness scenarios (e.g. recruitment failure). These operating models were conditioned on model fits of the state-space stock assessment model (SAM; Nielsen & Berg, 2014). Uncertainty in the operating model (e.g. process and observation error) will be generated by sampling from the variance-covariance matrix of SAM model fits, which allows a characterisation of the level and structure of the uncertainty and follows the approach developed for the recent North Sea MSE benchmark (WKNSMSE; ICES, 2019).

Candidate harvest control rules were selected from the options available for ICES category 3 data-limited stocks, i.e. the trend-based rfb rule and the harvest rate-based chr rule (ICES, 2024a).

The work by Fischer *et al*. (2023) concluded that the chr rule (Fischer *et al*., 2022; ICES, 2024a) showed the most promise, with the best fisheries management performance (highest catch while being precautionary) and was most robust to uncertainty. Consequently, this benchmark MSE focused on the chr rule. The chr rule was tuned to meet generic ICES objectives and included the ICES interpretation of the precautionary approach (i.e. the risk of the stock falling below a point where productivity is likely to be impaired B_{lim}, should not exceed 5% in the long term) and MSY (i.e. maximise catch in the long term). The tuning involved changing the control parameters of the harvest control rules to find those that meet objectives best by using high-performance computing.

The ideal outcome of this MSE is a simple empirical harvest control rule that is robust to uncertainty. The MSE framework, including the optimisation routine, already exists, has been applied to the plaice stock, and has been peer-reviewed and published in Fischer *et al*. (2023). Therefore, the work for the benchmark was based on this and only required updating the operating models by using the latest available data and possibly data sources not considered before, and then re-running the simulations.

The MSE for this work followed MSE best practices (Punt, *et al*., 2016), ICES guidelines on MSE (ICES, 2013, 2018, 2020), and recommendations for ICES stock-specific data-limited MSE (ICES, 2023b).

All input data and scripts used to process the data are available online on GitHub at https://github.com/shfischer/WKBPLAICE2024_ple.27.7e_data. The input data and code for generating the operating models and running the MSE and summarised results are available at https://github.com/shfischer/WKBPLAICE2024_ple.27.7e_MSE.

2.5 Input data

The input data used to condition the operating models was subjected to the same scrutiny as is typical for input data used in a category 1 data-rich stock assessment. The input data, processing, and decisions are detailed in WD1 (Fischer *et al*., 2024a; attached to this report) and only a brief summary is provided here.

Catch data including catch numbers at age are available since 1980. Discard estimates are available since 2002 and were included in the catch data. Catch weights at age were previously smoothed annually but WKBPLAICE decided to use the raw values because sampling levels were sufficient, and smoothing was not needed. The age range for catch data was kept (ages 2 – 10+).

The discard rate is around 20% for this stock and, therefore, lower than neighbouring stocks. WKBPLAICE reviewed available scientific studies on discard survival. Studies about plaice discard survival in the English Channel were available for beam trawls and otter trawls, the two main fishing gears in Division 7.e After reviewing the discard survival information, WKBPLAICE suggested a discard survival of 50% to be used as a baseline assumption but alternatives (0% and 100% survival) were also considered in the form of alternative operating models.

Two surveys are available for ple.27.7e (UK-FSP and Q1SWBeam). Both use beam trawls and target sole and plaice and provide numbers and biomass at age.

The previously used process for deriving stock weights at age was to use catch weights and interpolate these back in time to the beginning of the year. This approach was kept because survey weights at age did not cover the entire time series and showed unacceptably high variability.

Natural mortality is essentially unknown for this stock. The baseline assumption was to use a constant natural mortality derived from an empirical estimator, but alternative values and age-dependent natural mortalities were also considered in the form of alternative operating models.

The previously used maturity ogive was originally borrowed from another plaice stock based on data from the 1990s. Both surveys routinely collect maturity data, but they have never been used so far, and WKBPLAICE decided to use maturity data from the Q1SWBeam survey.

2.6 Operating models

The creation of the operating models is detailed in WD2 (Fischer, 2024b, attached to this report), and a brief summary is provided here.

A total of 14 operating models were generated, with a reference set of 7 more plausible operating models, and an additional robustness set of 7 operating models (Table 2.2). The operating models were conditioned on SAM model fits to the data (see WD1, Fischer, 2024a, for details on these SAM fits, including model diagnostics). The baseline SAM model used the data described in the previous section, and is available at https://www.stockassessment.org/setStock.php?stock=ple.27.7e_WKBPLAICE_OM. The model configuration followed the configuration developed for an exploratory SAM during the past WGCSE meetings. The SAM baseline model configuration and the model were scrutinised during the WKBPLAICE data meeting. If known uncertainties about data and assumptions (e.g. catch, migration, discards, natural mortality) were to be ignored, the baseline SAM model would likely meet typical criteria used in

ICES workshops and model diagnostics (e.g. observation and process residuals, retrospective and leave-one-out analysis, jitter analysis, simulate data and refit model, MCMC). Alternative configurations such as lower plus-groups and coupling or decoupling processes in SAM were explored but did not improve the model fit.

Table 2.2 All operating models.

#	Category	ID	Difference	SAM re-fit?	Type
1		Baseline			Baseline
2	Catch	Catch: no discards	No discards (100% survival)	Yes	Reference
3		Catch: 100% discards	All discards die (0% survival)	Yes	Reference
4		Catch: +10%	Catch 10% above TAC in projected years	No	Robustness
5		Catch: -10%	Catch 10% below TAC in projected years	No	Robustness
6		Catch: no migration	Catch from 7.d excluded	Yes	Reference
7	Natural mortality M	M: -50%	M 50% below baseline	Yes	Reference
8		M: +50%	M 50% above baseline	Yes	Reference
9		M: Gislason	Age-dependent M following Gislason	Yes	Reference
10	Recruitment	R: no AC	No auto-correlation (AC) in recruitment residuals	No	Robustness
11		R: failure	Recruitment failure in 2025–2029	No	Robustness
12		R: +20%	Recruitment 20% higher in projected years	No	Robustness
13		R: -20%	Recruitment 20% lower in projected years	No	Robustness
14	Uncertainty	Uncertainty: index	Higher uncertainty (observation error) for index	No	Robustness

For operating models alternative to the baseline that were based on different input data (e.g. alternative catch scenario) or assumptions (e.g. alternative M), SAM was refit, producing 7 7 age-structured reference operating models. These 7 operating models were conditioned on the state-space SAM model and so states, uncertainties, and uncertainty structure could be modelled. This was achieved by generating 1,000 simulation replicates (for each operating model) by sampling from the variance-covariance matrix of the SAM model fit, following the approach of WKNSMSE (ICES, 2019). Robustness models used the baseline operating model but varied in settings for forward projections. Recruitment was modelled by fitting a Beverton-Holt stock-recruit model, individually for each simulation replicate, generating future residuals by sampling from historical residuals smoothed with a kernel density smoother, and including auto-correlation in the residuals (see WD2, Fischer, 2024b, for details). Variability in biological parameters and fisheries selectivity was introduced by randomly sampling from historical values

Operating model reference points were generated from the operating model by projecting forward for 100 years (including process uncertainty) and this was done independently for each operating model. In the baseline operating model, B_{lim} was based on the lowest observed historical SSB, which corresponded to 11% of the unfished SSB (B_0). For the alternative operating models, B_{lim} was based on the assumption that the depletion corresponding with B_{lim} was the same as calculated in the baseline model.

Observations (catch, indices) were generated from the operating model and observation error was added following the uncertainty estimated by SAM. Biomass indices were created by converting index numbers at age to biomass at age with survey-specific weights at age, and summing up the values to derive the biomass in a given year. Additionally, for the rfb rule, catch length frequencies were required, and these were generated by applying a stochastic age-length key to the catch at age data and then emulating a sampling procedure.

2.7 The chr rule and tuning

The focus of the MSE for this plaice stock was on the chr rule (Fischer *et al.*, 2022; ICES, 2024a). This is a constant harvest rate that works on a relative harvest rate (catch divided by a biomass index). The general form of the chr rule is:

$$A_{y+1} = I\ H\ b\ x \qquad \text{Equation 2.1}$$

where A_{y+1} is the new catch advice for year $y + 1$, I the biomass index value, H the target harvest rate, b a biomass safeguard, x a multiplier that adjusts the target harvest rate. The exact specification of the chr rule, as used by WKBPLAICE 2024 is described in WD3 (Fischer, 2024c), and was defined as:

$$A_{y+1} = \sum_{i=y-n_1}^{y-1} (I_i/n_1)\ H \min\left(1, \frac{\sum_{i=y-n_1}^{y-1}(I_i/n_1)}{w\ I_{\text{loss}}}\right) x \qquad \text{Equation 2.2}$$

where n_1 is the number of years used to calculate the biomass index value (which can be a mean over more than one year if $n_1 > 1$) and w the multiplier that links I_{trigger} (the biomass index value below which the biomass safeguard reduces the harvest rate) to I_{loss} (the lowest observed historical biomass index value), i.e. $I_{\text{trigger}} = w\ I_{\text{loss}}$. For this plaice stock, biomass index values are only available up to and including the year before the assessment ($y - 1$) but not for the assessment year (y) due to the timing of the surveys relative to the ICES assessment working group. The advice of the chr rule is set for v years and limited by a stability clause, which restricts changes in the advice (A_{y+1}) to +20% and -30% compared to the previous advice (A_y). However, this stability clause is conditional on the most recent biomass index ($I = \sum_{i=y-n_1}^{y-1}(I_i/n_1)$) being at or above I_{trigger}.

Tuning of a management procedure describes the process of changing the control rule parameters, to find the parameters that best meet objectives. In the absence of stock-specific management objectives, the generic ICES objectives were used, i.e. MSY (maximising long-term catch) and the ICES precautionary approach (limiting the long-term risk of the stock falling below B_{lim} to 5%). The control parameters included in the tuning were:

- v – advice interval (annual or biennial)
- n_1 – number of years for the biomass index (annual $n_1 = 1$ or biennial $n_1 = 2$)
- x – the multiplier adjusting the harvest rate (0-5)
- w – multiplier defining I_{trigger} (0-5)

The final tuning of the chr rule was conducted with the operating model reference set, i.e. the seven operating models were combined (with a total of 7,000 simulation replicates). This is equivalent to an ensemble operating model where all operating models receive equal weighting.

The chr rule was projected for 20 years (approximately two generation times), split into the short term (first 10 years) and long term (last 10 years). The main performance metrics evaluated were the B_{lim} risk and the catch in the long term. The B_{lim} risk was defined as the probability of the SSB falling below B_{lim} and defined as the maximum annual B_{lim} risk (risk 3 as defined by ICES, 2013, 2018). Additional metrics considered were the SSB and catch variability (ICV). For catch, SSB, and ICV, the main metric was the median, but the distribution was also looked at.

2.8 MSE results and selection of chr rule parameterisation

WD3 (Fischer, 2024c) describes the results of the MSE in detail and only a brief summary is given here. Figure 2.2 and Table 2.3 show the results of the tuning of the chr rule with the reference set. The tuning resulted in a total of 10 versions of the chr rule, with different levels of complexity (tuning only the multiplier x or also including the I_{trigger} multiplier w), using either of the two surveys as a biomass index (UK-FSP or Q1SWBeam), and advice frequency (annual or biennial). For the biennial versions of the chr rule, the biomass index was based on a 2-year average. For the grid search, distinct local and global optima were found, where the local optima had fairly low values for I_{trigger} and a slightly lower catch, whereas the global optima had a higher catch and higher I_{trigger} values.

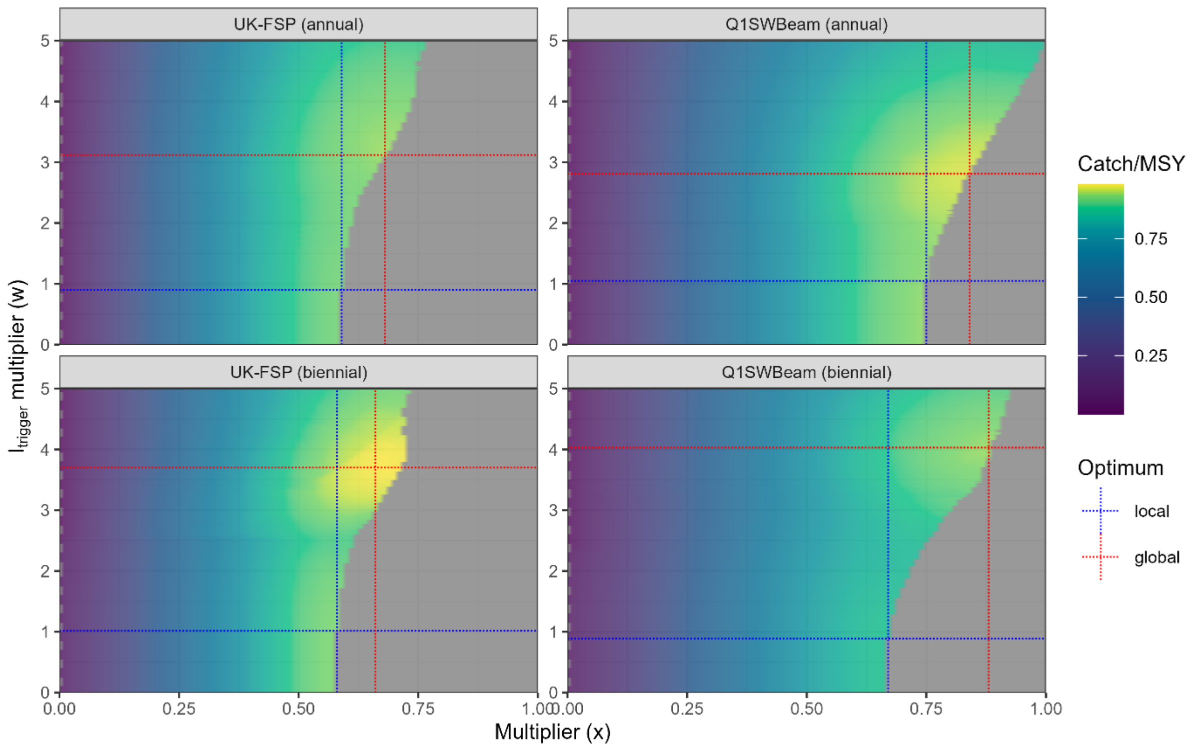

Figure 2.2 Tuning of the chr rule with x (adjusting the target harvest rate) and w (defining I_{trigger}), for annual and biennial advice. Areas shaded grey indicate non-precautionary solutions.

Table 2.3 Final tuned control parameters of the chr rule. The summary statistics are the medians for the long term (2035–2044). The selected version of the chr rule is highlighted in red.

ID	Tuning	Index	Optimum	n_1	v	x	w	B_{lim} risk	Catch/MSY	SSB/B_{MSY}	ICV
MP1	x	UK-FSP	Global	1	1	0.59	1.40	0.05	0.92	1.22	0.20
MP2	x & w	UK-FSP	Local	1	1	0.59	0.90	0.05	0.93	1.20	0.20
MP3	x & w	UK-FSP	Global	1	1	0.68	3.12	0.05	0.94	1.22	0.20
MP4	x & w	UK-FSP	Local	2	2	0.58	1.02	0.05	0.93	1.27	0.20
MP5	x & w	UK-FSP	Global	2	2	0.66	3.70	0.03	0.98	1.40	0.20
MP6	x	Q1SWBeam	Global	1	1	0.75	1.40	0.05	0.94	1.21	0.20
MP7	x & w	Q1SWBeam	Local	1	1	0.75	1.05	0.05	0.94	1.19	0.20
MP8	x & w	Q1SWBeam	Global	1	1	0.84	2.81	0.05	0.97	1.24	0.20
MP9	x & w	Q1SWBeam	Local	2	2	0.67	0.89	0.05	0.87	1.36	0.20
MP10	x & w	Q1SWBeam	Global	2	2	0.88	4.03	0.05	0.94	1.36	0.20

After discussions at WKBPLAICE, the consensus of the benchmark was to recommend the version of the chr rule called “MP5” (see Table 2.3). The results of this version of the chr rule are illustrated in Figures 2.3 and 2.4.

The decision to select this version of the chr rule was based on the following points:

- MP5 provided the highest long-term catch of all tuned versions of the chr rule (on average 98% of MSY, Figure 2.3).
- MP5 resulted in the highest long-term SSB (on average 1.4 B_{MSY}) and, by far, the lowest B_{lim} risk (3.0%, Figure 2.3).
- MP5 gives catch advice biennially (every two years), which reduces the workload for the stock assessor (less frequent assessments) and ICES expert groups (assessment working group, advice drafting group, advisory committee), with no trade-off in performance.
- MP5 uses the UK-FSP survey as a biomass index, which happens later in the year in quarter 3, so the time lag between the data and the advice year is reduced, and there should be no potential bias in the index due to migration of a part of the stock during the spawning period in quarter 1.

- MP5 is highly robust, as tested with robustness set of operating models, even the recruitment failure scenario (90% recruitment impairment in the first five years of the simulation) did not lead to a B_{lim} risk above 5% in the long term (Figure 2.4).

Therefore, MP5 appears to be the ideal choice of the set examined. One of the factors for the good performance of MP5 is that I_{trigger} is set relatively high (Table 2.3). This means that at the beginning of the simulation, the catch could be reduced more quickly, because the stability clause (limiting changes in the advice) could be turned off because the biomass index value was below I_{trigger} in around 25% of the simulation replicates (in the long term, this reduced to 10-15%). This meant the stock could recover quickly to high levels and led to high SSB and corresponding low B_{lim} risk in the long term, which supported a high catch (Figure 2.4). The average (median) variability of the advice was not higher for MP5 compared to other versions of the chr rule, even in the short term, but MP5 exhibited a wider variation in the advice. This may not be an issue for this plaice stock because it is mostly a bycatch and not a target species.

The limiting factor in the tuning with the operating model reference set was the operating model with the low natural mortality M (Figure 2.4, "M: -50%") because it exhibited the highest B_{lim} risk and the B_{lim} risk of the operating model reference set could not exceed 5%. This operating model might be considered less plausible because of the low M. However, the M for this scenario (M=0.09), was actually very close to the previously assumed M for this stock, when the stock was assessed with an XSA assessment (M=0.12), and was, therefore, not less plausible. This operating model was challenging because the SSB at the beginning of the MSE projection was very low (below B_{lim}) and required several years to recover. Furthermore, because this scenario was only on one of the seven scenarios of the operating model reference set, it essentially only received a weighting of 1/7 in the tuning. All seven operating models of the reference set were weighted equally because none was considered more plausibly.

At the end of the 20-year projection, there was a slightly decreasing trend in the SSB (Figure 2.3). However, when simulating further into the future, this trend does not continue (see WD3, Fischer, 2024c), and is, therefore, not an issue.

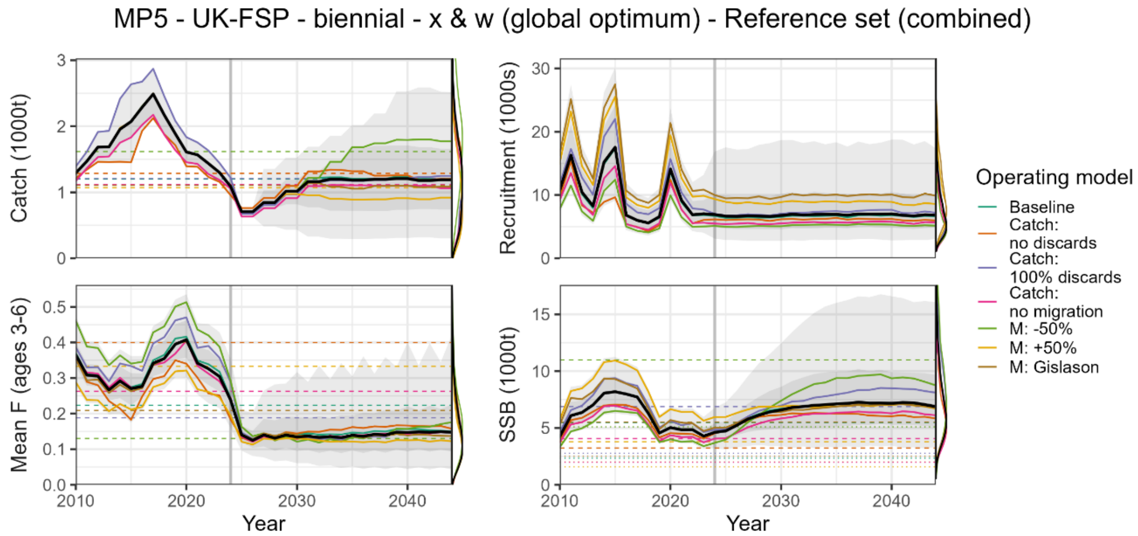

Figure 2.3 MSE trajectories for the reference set for the tuned chr rule (MP5). The black curves are the medians of all simulations replicates overall operating models, surrounded by 50% and 95% confidence intervals shaded in grey. The coloured curves correspond to the medians of the individual operating models. Dashed horizontal lines are MSY

reference values and dotted lines Blim values by operating model. Each panel in the figure includes a density plot of the distribution in the last simulation year (2044) on the right.

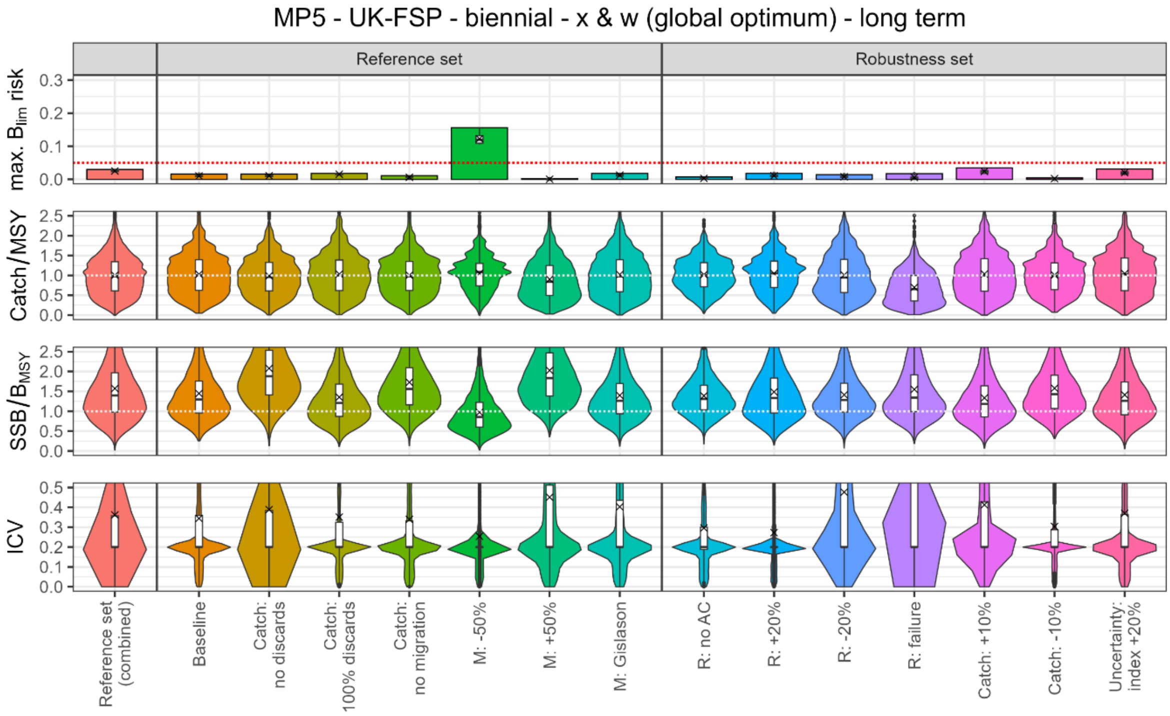

Figure 2.4 Long-term performance statistics for MP5 for all operating models. For catch, SSB, and ICV (inter-annual catch variability), the distribution shown corresponds to the values over 10 years and all simula-tion replicates (1,000 for each operating model, 7,000 for the reference set). The risk (top row) shows the distribution of the annual values over the years, the bar is the maximum of these 10 values (ICES risk 3), and the "x" is the average over the 10 years (ICES risk 1).

2.9 Alternative management procedures

For completeness, two alternative management procedures were also included in simulation testing. Firstly, the rfb rule, a category 3 empirical harvest control rule, which was the method to calculate advice prior to WKBPLAICE. Secondly, the data-rich category 1 ICES MSY rule, which consisted of fitting SAM, and running a short-term forecast. This approach required management reference points, which do not exist for this stock. Consequently, the typical ICES approach of deriving these with EqSim was copied (see WD3, Fischer, 2024c, for details). These two alternative management procedures were only run but not tuned. Figure 2.5 compares the trajectories of the chr rule (MP5) to the rfb and ICES MSY rule.

The rfb rule led to long-term precautionary management (B_{lim} risk well below 5%) but the long-term catch was relatively low (63% of MSY). On the other hand, the ICES MSY rule led to higher catches but Blim risk in the long term was above 5%, which means that this approach (for this stock, following ICES standard procedures of estimating management reference points) violated the criteria for the ICES precautionary approach and was, therefore, not precautionary.

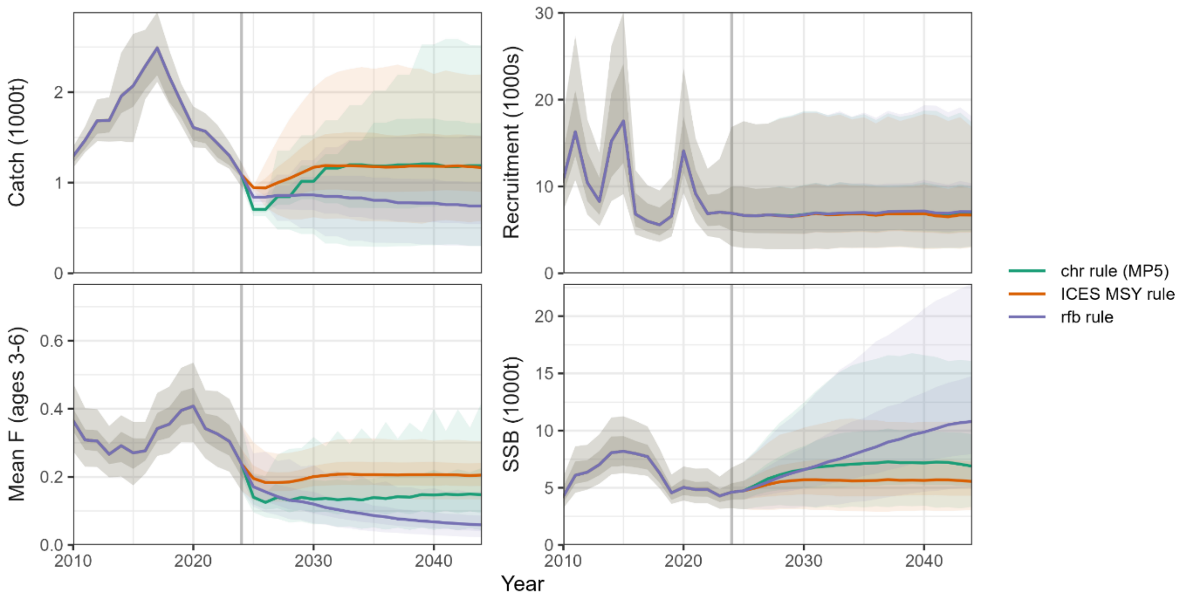

Figure 2.5 Comparison of the MSE trajectories for the reference set for the tuned chr rule (MP5) with the rfb rule and the ICES MSY rule. The black curves are the medians of all simulations replicates over all operating models, surrounded by 50% and 95% confidence intervals shaded in grey. The coloured curves correspond to the medians for the individual management procedures.

2.10 Advice sheet considerations

The chr rule MP5 was agreed upon early in the benchmark meeting of WKBPLAICE, and this made it possible to already consider how the advice sheet for this stock could look next year. Please note that this was only an illustratory example and there is no attempt or expectation to replace the advice sheet produced in 2024.

2.10.1 Basis for catch advice calculation

The baseline assumption in the MSE was that 50% of the discards survive (apart from the alternative operating models with alternative discard survival assumptions) and the population dynamics were based on the dead catch, because the surviving discards do not affect the stock.

For the calculation of the catch advice, there are two options as the basis for the calculations, either (1) the total catch, or (2) the dead catch. For option 1, the target harvest rate from the MSE would have to be scaled to account for the total catch and this approach does not exactly follow the approach used in the MSE but makes the application of the stability clause (limiting the change in the advice to +20% and -30%) easier. For option 2, the calculations are used as they were in the MSE, but the catch advice has to be topped up by the surviving discards to derive the total catch advice. This approach provides consistency with the MSE but makes the application of the stability clause more challenging, because the stability clause has to be applied to the dead catch. If discard rates change over time, this could mean that the change in the total advice is different from the change in the dead catch corresponding to the advice.

WKBPLAICE discussed these options and concluded that the management procedure should be applied as it was tested in the MSE, which means that the catch advice calculation should be based on the dead catch. Section 1.10.3 illustrates these calculations.

2.10.2 Reference points

The tuning of the chr rule was achieved by modifying the multiplier x (which adjusts the target harvest rate H) and the I_{trigger} multiplier w which defines I_{trigger} based on the lowest observed biomass index value ($I_{\text{trigger}} = w\, I_{\text{loss}}$). In the absence of an empirical target harvest rate in the MSE, it was defined as the average over all years with data (2003-2023, see WD3, Fischer, 2024c, for details). This approach allows adapting the target harvest rate (H, called $\text{HR}_{\text{MSY proxy}}$ in advice sheets), should there be revisions to the survey data in the future, because it is not based on an absolute value but relative to a time series average. In the MSE, historical survey observations were identical for all operating models because they were based on the survey values observed in reality (see WD2, Fischer, 2024b). This meant that I_{loss} and consequently I_{trigger} were also identical in all operating models.

The actual harvest rate implemented by the chr rule is the product of x and the target harvest rate H. For simplicity, WKBPLAICE recommended setting the multiplier x (called m in advice sheets) to $x = 1$ and include it instead in $\text{HR}_{\text{MSY proxy}}$, i.e. $\text{HR}_{\text{MSY proxy}} = xH$. This has no impact whatsoever on the chr rule calculations (because the elements are multiplicative) but helps with interpreting the harvest rate. This means that when the harvest rate is above $\text{HR}_{\text{MSY proxy}}$, it is too high and needs to be reduced (Figure 2.6), and when the harvest rate is at or below $\text{HR}_{\text{MSY proxy}}$, the harvest rate is sustainable. Table 2.4 illustrates how the "reference points" of the chr rule could be presented in the advice sheet.

Please note that the "reference points" I_{trigger} and $\text{HR}_{\text{MSY proxy}}$ (Table 2.4) are in fact (harvest) control rule parameters or management reference points. These are used in the application of the harvest control rule (the chr rule). This plaice stock is considered a category 3 data-limited stock and there is no single accepted stock assessment model that is conducted annually during the ICES assessment working group. This means the typical ICES "reference points" such as F_{MSY} or B_{lim} are not defined. In the MSE, operating model reference points were defined, which were internally consistent with the operating models. However, these were only used to evaluate the performance of the tested management procedures (WD3, Fischer, 2024c).

Table 2.4 Reference points for the chr rule and their technical basis as they could be shown in an advice sheet.

Framework	Reference point	Value	Technical basis	Source
MSY approach	$I_{trigger}$	1.04	Biomass index trigger value, defined as $I_{trigger} = I_{loss} \times 3.7$, where I_{loss} is the lowest observed historical biomass index value from 2007, derived from stock-specific simulations, kg hr^{-1} m $beam^{-1}$	WKBPLAICE
	$HR_{MSY\ proxy}$	1395	MSY proxy harvest rate derived from stock-specific simulations	WKBPLAICE
Precautionary approach	B_{lim}	Not defined		
	B_{pa}	Not defined		
	F_{lim}	Not defined		
	F_{pa}	Not defined		

Management plan	SSB_{mgt}	Not applicable
	F_{mgt}	Not applicable

2.10.3 Advice sheet figures

There are only a few stocks in ICES that use the chr rule to provide advice, and there is no standardised format for exactly what figures are included in the ICES advice sheet. All chr rule advice sheets show a figure with the catch over time and a figure with a stock size indicator. The third figure shows some kind of measure of fishing pressure or a proxy of it. For lemon sole in the North Sea (lem.27.3a47d), the fishing pressure proxy is based on the mean catch length. For herring in the West of Scotland (her.27.6aN) and Northwest and West of Ireland (her.27.6aS7bc), the advice sheets also showed a fishing pressure proxy based on the mean catch length until 2023. Since 2024, however, the advice sheets show a harvest rate figure instead.

For ple.27.7e, it makes little sense to show a fishing pressure proxy based on the mean catch length because catch length data are not used anywhere in the chr rule calculations. The recommendation from WKBPLAICE is to show the (relative) harvest rate, as used in the chr rule (i.e. the catch divided by the biomass index). Because the chr rule calculation is based on the dead catch and the harvest rate corresponding to the dead catch, the figure should represent that. Figure 1 of the advice sheet could look the following Figure 2.6:

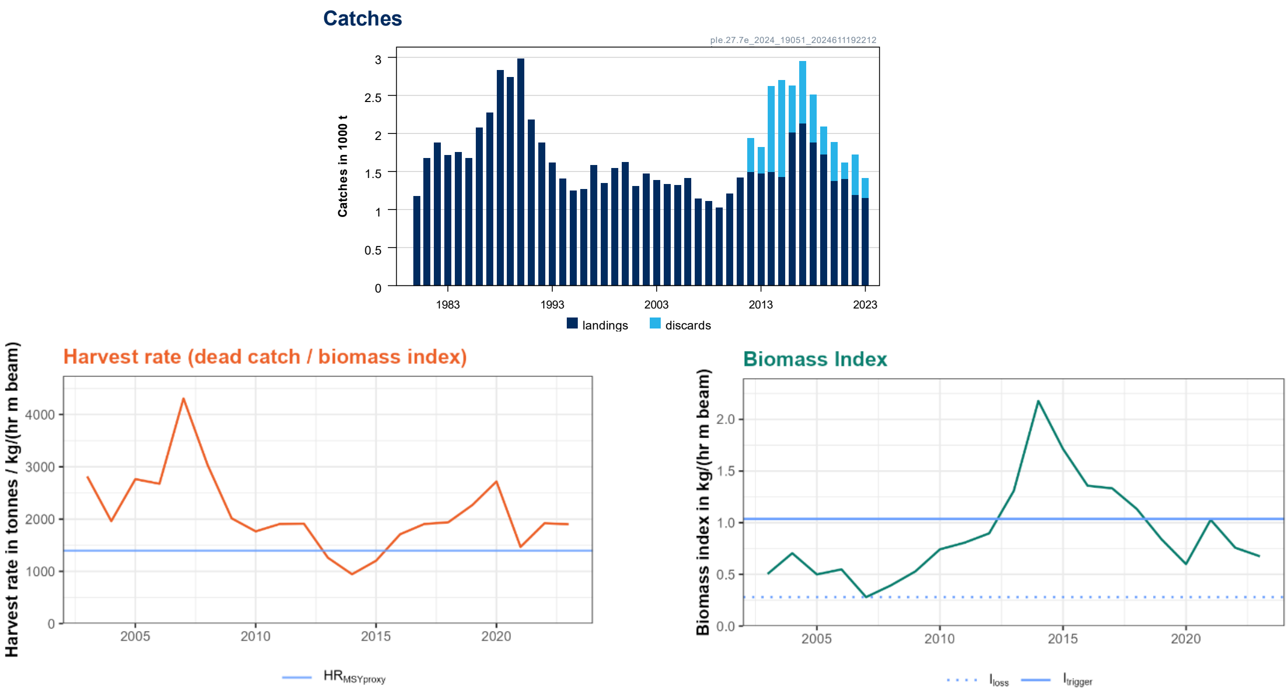

Figure 2.6 Example illustration of the figures for the advice sheet for ple.27.7e with the chr rule (example only, with data up to 2023). The harvest rate refers to assumed dead catch (landings plus proportion of discards that are assumed to die).

2.10.4 Catch scenarios table

Table 2.5 illustrates an example of the calculation of the total catch advice with the chr rule (MP5). This is for the hypothetical case that it had been applied in 2024 (although there is no expectation to replace the 2024 advice sheet). The target harvest rate ($\mathrm{HR}_{\mathrm{MSY\ proxy}}$) is based on the dead portion of catch. The tuned parameters ($\mathrm{HR}_{\mathrm{MSY\ proxy}}$, I_{trigger}) include a clarification that they are not standard values: “derived from stock-specific simulations”. The advice is based on first calculating the dead portion of the total catch and the stability clause is applied, if necessary, to this calculation. Applying the stability clause requires comparing the chr calculation of advised dead catch to the portion of the previous catch advice that also corresponded to dead catch. Thereafter, dead catch advice is scaled up to a total catch advice.

The catch scenarios table for this plaice stock is getting increasingly complex and WKBPLAICE made some recommendations to simplify the table (see Table 2.5). Suggested changes were:

- The row with the previous catch advice was removed from the top of the table because, unlike the rfb rule, it is not used in the advice calculation. Instead, the dead catch corresponding to the previous catch advice is shown next to the stability clause, where it is used.
- A section header “Catch advice calculations” was added after the elements of the chr rule were introduced to clarify that the following rows show the calculation of the advice value.
- A row with the discard survival was added. The following advice values are only shown for the total catch, landings and total discards because the surviving discards and dead discards can be easily calculated from these values.

Ultimately, the appearance of the catch scenario table(s) will be decided by the assessment working group (WGCSE) and the advice drafting group.

For this plaice stock, the advice is based on the (assumed) stock unit. However, there is also an area-specific advice for ICES Division 7.e, which is added to the bottom of the catch scenarios table. The calculation of this area-based catch advice was not changed by WKBPLAICE because the calculations are standardised between ple.27.e, ple.27.d, and ple.27.420 based on a recent response to a special request to ICES (ICES, 2023c). WKBPLAICE recommended considering splitting the catch scenarios table into two tables, one for the stock and one for the area, to help reduce complexity. Furthermore, the area-based advice calculations are based on the outcome of the short-term forecast in the advice sheet of ple.27.7d, which is done annually. On the other hand, the advice ple.27.7e is biennial. Therefore, WKBPLAICE recommended considering updating the area-based advice in the second year, to account for the short-term forecast for ple.27.7d. This would only change the area-based advice in the second year but does not affect the advice for the stock.

Table 2.5 Example of the chr rule catch scenarios, with the hypothetical scenario that the chr rule (MP) is applied in 2024 (please note, there is no expectation to replace the advice given in 2024).

Division 7.e plaice stock	
Biomass index	
I: most recent biomass index ($I_{2022\text{-}2023}$)	0.72 kg hr^{-1} m $beam^{-1}$
MSY proxy harvest rate	
$HR_{MSY\ proxy}$: MSY proxy harvest rate (derived from stock-specific simulations)	1395
Biomass safeguard	
Index trigger value ($I_{trigger} = I_{loss} \times 3.7$, derived from stock-specific simulations)	1.04 kg hr^{-1} m $beam^{-1}$
b: multiplier for index relative to trigger, min{$I_{2022\text{-}2023}/I_{trigger}$, 1}	0.69
Precautionary multiplier to maintain biomass above B_{lim} with 95% probability	
m: multiplier (derived from stock-specific simulations)	1
Catch advice calculations	
CHR calculation (I × HR × b × m)*	690 tonnes
A_y: Dead catch corresponding to previous catch advice**	1057 tonnes
Stability clause (+20%/-30%, CHR calculation compared to A_y, only applied if b=1)^	Not applied
Discard rate (average 2012-2023)	26%
Discard survival	50%
Catch advice for 2025 and 2026 ([CHR calculation]/[1 – discard rate × discard survival])^^	796 tonnes
Landings corresponding to advice ([advised catch] × [1 - discard rate])	585 tonnes
Total discards corresponding to advice	210 tonnes
% advice change^^^	−35%
Plaice in Division 7.e	
Catch of the stock in Division 7.d in 2025	119 tonnes
Catch in Division 7.e corresponding to the advice for the stock^^	677 tonnes
Area based discard rate (average 2012-2023)	23%
Discard survival	50%
Landings in Division 7.e corresponding to the advice	520 tonnes
Total discards in Division 7.e corresponding to the advice	157 tonnes

* Dead catch, accounts for discard survival of 50%
** Total catch advice for 2023 and 2024 was 1219 tonnes
^ The stability clause is applied to the CHR calculation for the dead catch
^^ Total catch, including surviving discards
^^^ Advice value for 2025 relative to the advice value for 2024 (1219 tonnes).

2.11 Implementation and periodic review

In ICES, there is no formal review of management procedures that were developed with MSE after they were adopted, apart from the ICES benchmark system. However, in other parts of the world and in regional fisheries management organisations (RFMOs), formal reviews are typical after a few years or management cycles. Such reviews usually check if the management procedure is still suitable to provide catch advice and reflects the current stock dynamics. For example, a review could include updating the operating model(s) with the latest data, rerunning the simulations, and revisiting the tuning, if necessary.

While there is no formal path for this in ICES, some considerations for a review of the chr rule were discussed during WKBPLAICE and are summarised here. Assuming MP5 is adopted after WKBPLAICE, the advice schedule would look like Figure 2.7. The first (biennial) advice is given in 2025 for 2026-2027. WKBPLAICE suggested a review after the third implementation of the chr rule. This process should probably start early, e.g. in 2030 (6 years after this benchmark), so that it can be completed before the following advice cycle.

	Benchmark	Advice	Advice years
2024	WKBPLAICE		
2025		1st	
2026			
2027		2nd	
2028			
2029		3rd	
2030	Review		
2031		4th/new?	

Figure 2.7 Suggested schedule for the implementation of the chr rule (MP5) and review.

Depending on the work required for the review, this could fall into any of the current three ICES benchmark levels (ICES, 2023d), i.e. level 1 (expert group level), level 2 (with external review), or level 3 (full benchmark).

Ideally, the work required for the review is already started intersessionally to scope the required changes. The first step would be to update (recondition) the operating models with the latest data and check if the range of alternative operating models still covers the plausible range of scenarios. The second step would then be to project the previously adopted management procedure. If this exercise shows that it is still suitable (i.e. delivers a high catch and is precautionary in the long term), a level 1 benchmark with a review within the expert group (WGCSE) could be sufficient, because there are no changes needed to the simulation framework or the management procedure. If the chr rule needs to be retuned, but the changes are fairly small (e.g. only changing the target harvest rate or I_{trigger}), a level 2 benchmark might be sufficient. This would include doing the work within WGCSE but it needs to be approved through external review. If more major changes are needed, e.g. major changes to operating models such as changing the baseline operating model, the reference or robustness set, adding/removing several operating models, or a different management procedure is required, then a level 3 benchmark (i.e. full benchmark) is suggested.

2.12 Exceptional circumstances

RFMOs typically consider exceptional circumstances when adopting a management procedure. Exceptional circumstances are "rare and unforeseen events that were not tested by the MSE or that the [management procedure] was not designed to manage" (harveststrategies.org, 2024) and can detect operating model misspecification, i.e. situations where system dynamics are outside the range of tested scenarios (Carruthers and Hordyk, 2018). Typically, there is an exceptional circumstances protocol that defines what exceptional circumstances are for a given stock and management procedure and actions that can be taken should they occur. Examples of exceptional circumstances are missing survey indices, survey index values moving outside the tested range or the catch exceeding the scientifically recommended catch.

The exact definition of exceptional circumstances and what to do is not always precisely specified and there is often a degree of expert judgement required.

In ICES, there is no formal consideration of exceptional circumstances for management procedures. However, for completeness and following international practices, WKBPLAICE discussed some ideas about exceptional circumstances for the chr rule (specifically MP5 as recommended by WKBPLAICE) for ple.27.7e and these are summarised here.

Index missing

The chr rule relies on a biomass index to calculate the catch advice and the recommended version of the chr rule (MP5) uses the average index values of the last two years. The survey (UK-FSP) has been conducted annually since 2003 without interruption since then. However, a survey index value may be missing in the future which means that MP5 could not be applied as tested with MSE. This plaice stock is in a fortunate situation that there are two survey indices (UK-FSP and Q1SWBeam) and WKBPLAICE developed versions of the chr rule for both surveys that meet the ICES objectives (MSY and precautionary approach). Potential options are listed below:

1. If either or both of the last two index values are missing (in $y-1$ and/or $y-2$ in Equation 2.2), it would be possible to switch to the analogous version of the chr rule with the other survey (Q1SWBeam), i.e. MP10 in Table 2.3, which also provides biennial catch advice.
2. If the second to last index value (in $y-2$ in Equation 2.2) is missing but the last index value (in $y-1$) is available, it is also possible to switch to an annual chr rule with the UK-FSP survey, i.e. MP1, MP2, or MP3 (see Table 2.3).
3. If the second-to-last index value (in $y-2$ in Equation 2.2) is missing but the last index value is available, it may also be possible to continue with MP5 but base the biomass index on only the last year ($y-1$). However, for this option to be used, this approach has to be tested with the MSE framework to show that it is precautionary in the long term.

The MSE simulations for WKBPLAICE only considered situations where the same management procedure was used for the entire 20-year projection. Should there be a need for switching between different versions of the chr rule due to exceptional circumstances, ideally, such a switch (and a switch back to the original management procedure) should be tested with the MSE framework to check that this does not impair long-term precaution.

Survey index outside tested range

The survey index values observed in the future may move outside the range of tested scenarios. When calculating the catch advice, the biomass index value(s) should be compared to the values from the MSE simulation. A comparison could be to compare the index value(s) to the 90% or 95% confidence intervals of the projection of MP5 (Figure 2.8). Should the survey index move outside the tested range, some action might be triggered, such as checking whether the robustness tests with the alternative operating models addressed such a situation, conducting additional simulations, using expert judgement, or conducting an earlier review of the management procedure.

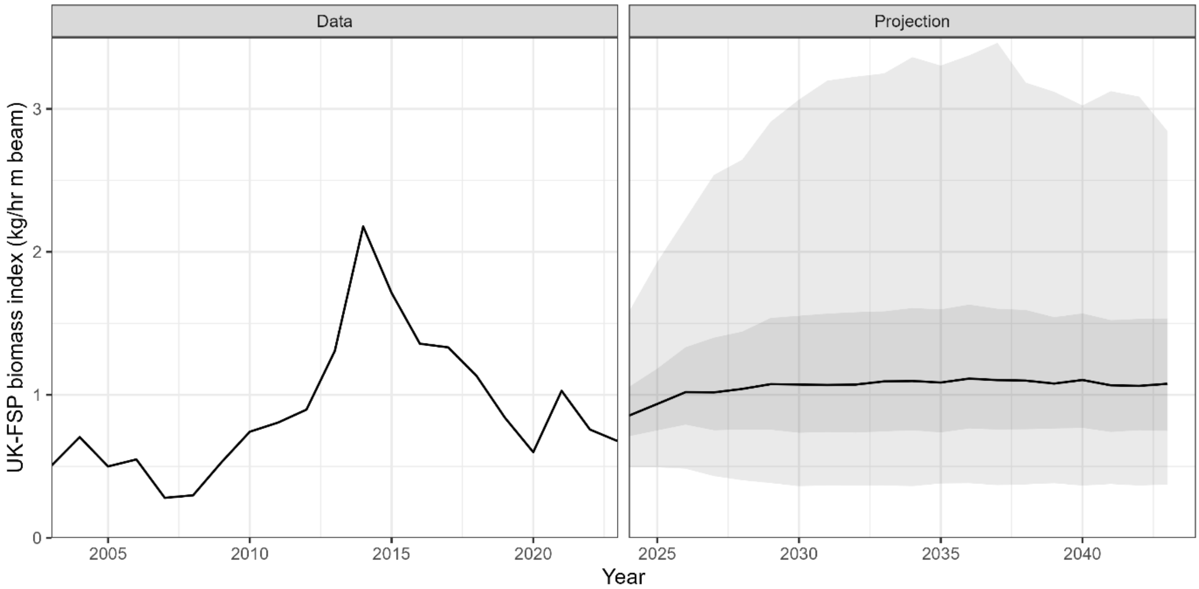

Figure 2.8 Historically observed biomass index values (left) and the range of values in the projection (right, including 50% and 95% confidence intervals) for MP5. The distribution shown on the right is derived from the operating model reference set.

Catch not following the catch advice

The tuning of MP5 assumed that the catch advice is implemented by the fishery without a systematic bias. However, the robustness tests included scenarios where the catch was systematically 10% above or below the catch advice and this did not impair management performance in the long term. If the catch is below the advice, this will lead to more precautionary management and is, therefore, not an issue. Should the catch realised by the fishery be consistently more than 10% above the catch advice, this should trigger an exceptional circumstance because this has not been tested. A possible action would be to conduct additional simulations to test the actual level of catch or conduct an earlier review of the management procedure.

Conclusion

Although there is no formal path for defining and evaluating exceptional circumstances in ICES, the recommendation is to check such considerations when the chr rule is applied, e.g. during the annual WGCSE meeting.

2.13 Future considerations/recommendations

The approach for ple.27.7e is based on a much more thorough analysis compared to other data-limited ICES stocks in category 3 and likely also when compared to many data-rich stocks. It is not necessary to "upgrade" this stock to the data-rich category 1 because, based on the work of WKBPLAICE, this does not improve management performance and would impair robustness.

Section 2.11 contains considerations for the implementation and review of the chr rule as suggested by WKBPLAICE, and Section 2.12 mentions exceptional circumstances that should be checked when the chr rule is applied.

WKBPLAICE noted that benchmarks for three plaice stocks ple.27.7e, ple.27.7d, and ple.27.420 are not aligned even though there is migration between stocks and a migration corrected is made to the assessment of all three stocks. Ideally, these stocks should be considered together within future benchmarks.

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2.15 Stock-specific working documents

- Data: "Data for plaice (*Pleuronectes platessa*) in Division 7.e (western English Channel – ple.27.7e) – Working document for WKBPLAICE 2024", 58 pp., https://community.ices.dk/ExpertGroups/benchmarks/2024/WKBPLAICE/2022%20Meeting%20Documents/04.%20Working%20documents/WKBPLAICE2024_ple.27.7e_data.pdf
- Operating models: "Operating models for plaice (Pleuronectes platessa) in Division 7.e (western English Channel – ple.27.7e) – Working document for WKBPLAICE 2024", 26 pp.,https://community.ices.dk/ExpertGroups/benchmarks/2024/WKBPLAICE/2022%20Meeting%20Documents/04.%20Working%20documents/WKBPLAICE2024_ple.27.7e_OM.pdf
- MSE results: "Results of the management strategy evaluation for plaice (Pleuronectes platessa) in Division 7.e (western English Channel – ple.27.7e) – Working document for WKBPLAICE 2024", 55 pp.,

View and download working documents for plaice 27.7e from the ICES library:
https://doi.org/ 10.17895/ices.pub.28400255

3 Plaice (*Pleuronectes platessa*) in subdivisions 21-32

3.1 Issue list

The issue list for the former plaice stocks ple.27.21-23 and ple.27.-24-32 contains issues that were reviewed and (partially) solved during the benchmark process (See "WKBPLAICE progress" in the Table 3.1). Other issues, like age validation of otoliths is still ongoing and should go into the new issue list during the 2025 meeting of WGBFAS.

Table 3.1 Issue list for plaice (*Pleuronectes platessa*) in subdivisions 21–32 (Kattegat and Baltic Sea) and progress made during the benchmark.

ID	Type	Problem/Aim	Work Required	Data Required	Created	Modified	WKBPLAICE progress
384	Management area divisions	The plaice stocks within inner Danish waters and the Baltic consists of two stocks. One stock (ple.27.21–23) is defined by the Subdivision 21 (=Kattegat), Subdivision 23 (= the Sound) and Subdivision 22 (=Belt area and western part of the Baltic Sea). The other stock (ple.27.24–32) is defined by the area south of Subdivision 22 and eastward into the remainder of the Baltic Sea. Each stock is assessed independently (ple.27.21–23 is a category 1 stock and ple.27.24–32 is a category 2 stock) but the management areas overlap (SD21 vs SD22:SD32).	Genetic and [natural] tagging studies are necessary to disentangle the relationships between these different areas and the fish that inhabit them. This definitive work could be backed up with simpler timing / location of spawning studies.	Genetics, otolith chemistry, timing and locations of spawning assemblages, from across the various stock areas.	26/04/ 2022	05/01/2025	Partially solved. Stocks have been merged based on genetic evidence. However, Management units and assessment units still differ.

ID	Type	Problem/Aim	Work Required	Data Required	Created	Modified	WKBPLAICE progress
		Connectivity/mixing between these three potential subunits (SD21 vs SD22&23 vs SD24+) is unknown.					
385	Assessment method	The stock annex specifies the use of mean values from the entire time series of observations in short-term forecasts for stock weight at age and maturity ogives. This reduces the assessment's ability to adapt to changes in stock attributes, whether they are intrinsic, fisheries driven or environmentally driven.	Investigate better methods for estimating biological parameters for short-term forecasts		26/04/ 2022	05/01/2025	Estimations of weight-at-age and maturity ogives have been evaluated and approved during the benchmark (WKBPLAICE, 2024). Assessment is now using sliding window averages.
386	Tuning series	Physical conditions such as oxygen, temperature and salinity conditions influence fish distributions. The variability of these parameters in areas where survey hauls are undertaken may lead to survey indices being more or less representative of the stock composition	Investigate the effect of environmental conditions during surveys on variation in survey indices and resultant assessments	Reliable CTD data from surveys, combined with other raw environmental data and hydrographic model output. Independent observations of changes in fish distribution corresponding to survey times.	26/04/ 2022	05/01/2025	A Danish project entitled "Hyp-Catch", undertook an analysis of whether hypoxia (be that chronic or acute) modified catchability in the survey. It found that, for plaice, effects of oxygen on hypoxia on place catches only make a substantial decline at severe hypoxia. Therefore, the incorporation of oxygen into stock index models is not relevant
387	Sampling	Age Reading: Improve precision of the age reading based on age-validated	Exchange of otolith images. Assess if methods can be	Maturity data is routinely collected by the	26/04/ 2022	05/01/2025	Ongoing, age reading has been improved by an age validation study from Germany. Exchange of

ID	Type	Problem/Aim	Work Required	Data Required	Created	Modified	WKBPLAICE progress
		material. Different methods used for otolith preparation across countries.	standardized (e.g. whole and reflecting light vs sliced and transmitted light)	two surveys but has not been explored.			manuals and method comparisons are ongoing.
1524	Sampling	Plaice in 27.3.d.24 -32 has been very poorly sampled in recent years to a point where assessment results are questionable and current events in the stock (incoming large cohorts, changes in length-weight) can no longer be detected due to low sample sizes. Despite being a TAC species, the respective member states fail to provide biological data (length, weight and age) and reliable discard estimates. In the most recent assessment year, biological data from only one area and member state was available, whereas the main fishing nations failed to provide data. A benchmark of this stock is planned for 2024 to check whether it can be upgraded to Category 1, but with recent	Member states need to sample the stock and increase their efforts to cover the main fishing fleets. Member states need to evaluate their sampling methods and consider alternative gathering data if onboard-observer can not be sent (e.g. harbor sampling, purchasing samples, fisheries-dependent data or new technologies such as CCTV).	Discard estimations, numbers-at-length and length-class weights (for SPiCT), numbers-at-age, length-at-age and weigh-at-age (for SAM) in Landings and Discards for both assessment fleets ("active", "passive"). Data need to be from the current year or otherwise flagged as unreliable (e.g. if taking length-weights parameters from the previous year).	20/04/ 2023	05/01/2025	Ongoing, new sampling overviews expected in 2025. The stock merging also increased the possibility of extrapolating sampling data, this needs to be checked and verified during the WG in 2025

ID	Type	Problem/Aim	Work Required	Data Required	Created	Modified	WKBPLAICE progress
		sampling quality, this is unlikely.					
1525	Stock identity	Stock ID needs to be checked and issues resolved. Consider to merge the two plaice stocks if genetic analysis suggests that.	Genetic studies on both plaice stocks to validate stock ID. Additionally, the degree of connectitivity and overlap should be explored.	Genetic baselines of both plaice stocks, genetic samples and tagging studies	25/04/ 2023	05/01/2025	Stocks have been merged in 2024, based on genetic evidence, biological parameter comparisons and tagging studies.
1526	Biological parameters	Age reading needs to be validated. Comparisons of age readings between member states, but also within the same lab showed considerable differences in age readings (up to +/- 2 years). If the benchmark is upgrading the stock to a category 1 stock, the age reading needs to be validated.	Age validation studies and, based on the results of the validation, age reading comparison and age reading workshop to streamline otolith ring identification between member states. Older otoliths will need re-evaluation and might need changing.	Validated otoliths. Based on the results, an age correction matrix or re-reading of previous plaice otolith readings needs to be set up	25/04/ 2023	05/01/2025	Age validation studies have been conducted and survey otoliths of the German BITS have be re-read according to the new manual. The otoltihs of other member states will undergo verification as well. First age reading workshops should be realized

In addition to the general issues list, a special request to ICES asked that the previous stock (ple.27.21-23) evaluate the possibility to account for discard survival in the assessment procedure. Furthermore, Germany made available estimated recreational harvests, including retention and release rates, which were considered during the workshop.

3.2 General information on the stock

Presently, sole (*Solea Solea*) and plaice (*Pleuronectes platessa*) are the only flatfish species in the Baltic Sea regulated by catch limits. Plaice in the Baltic Sea was treated as a single stock (plaice in subdivisions 22-32) until WKPESTO (ICES 2012). ICES decided that plaice from Subdivisions 22 (the Belts) and 23 (the Sound), which were previously assumed to be part of the Baltic Sea stock, should be considered a separate stock unit together with Subdivision 21 (Kattegat) (ICES, 2012). Plaice in Subdivisions 24 to 32 was considered to be a different stock. The assessment units were amended to fit these new stock definitions, i.e., ple.27.21-23 and ple.27.24-32. For management purposes, however, the old areas were retained and a TAC is fixed for SD22-32 and Plaice in the Kattegat (SD21) separately.

Overall, the null hypothesis "there is one plaice stock in (21)22-32" has never been rejected based on genetic evidence. ACOM decided to give advice for plaice in SD21-23 (and not split this in even smaller units), and a second stock in SD24-32 separately, but at the same time withdrew the recommendation to amend the management areas until the stock ID issues with Baltic plaice were satisfactorily resolved. WGBFAS repeatedly raised serious concerns about the validity of a separation between the eastern and the western populations. In 2024, the stock ID was reviewed again by WGSAM. Along with stock distribution maps from survey data, tagging and migration studies and biological evidence (maturity pattern, age-length correlation, etc.), current genetic studies were presented (Weist et al. 2022, Le Moan 2019, 2021, Ulrich et al. 2017) that proved plaice in Kattegat and the Baltic Sea are in fact one stock. WGSAM decided to follow the suggested change in stock ID and WKBPLAICE was tasked to update the stock boundaries and respective data for the assessments accordingly during the benchmark. process.

More details on the rationale for the stock merging is given in the working documents 1 (WD1 “Baltic plaice stock ID”, attached to the report).

3.2.1 Fishery information

Plaice is caught all year round, with the majority of catches coming from active gears in winter and spring. Survey indices show variation in CPUE latitudinally in quarters 1, 3, and 4. Subdivision 22 plaice are traditionally taken in mixed fisheries together with cod but with the loss of fishing opportunities for cod, they are now taken in a directed fishery for plaice itself (Figure 3.1).

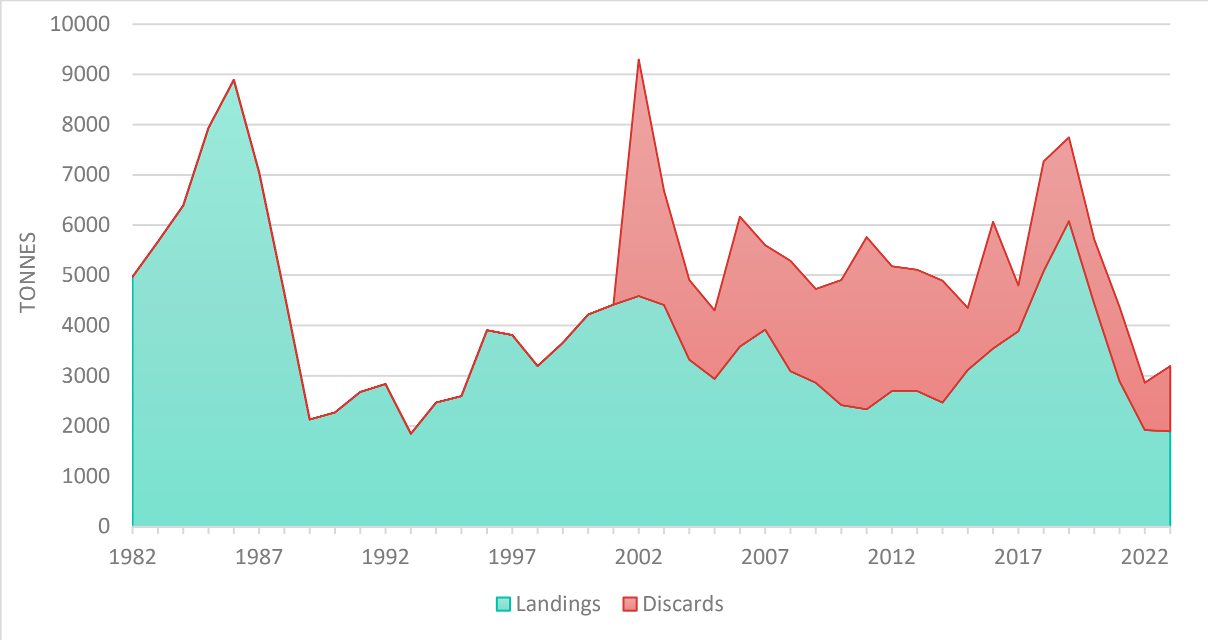

Figure 3.1 Catches (landings and estimated discards) of plaice in the Baltic Sea and Kattegat since 1982. Discard estimations are only available since 2002.

In Subdivision 21 plaice is almost exclusively a bycatch in the combined *Nephrops*–sole fishery. Discard rates in area 22 decreased from ~50% to ~13% over the last decade but with an increase up to ~27% in 2022 as many small fish are entering the fishery from a few years of high recruitment. This combined with the increasing landings from this area is empirical proof of a targeted plaice fishery in area 22. The SSB in the plaice stock has increased in the period from 2009 to 2021, supporting increased landings with decreasing fishing pressure. In recent years, landings have decreased, probably due to a decrease in landings coming from a targeted cod fishery which has collapsed. The initial increase in SSB appears to be driven by periodically large pulses of recruitment. The 2019, 2020, and 2021-year classes are extraordinarily large, breaking records from year to year. The 2019 cohort has entered the fishery and the 2020 cohort should enter the fishery in 2023. However, due to the large cohorts, there appears to be a decrease in growth rate, probably from density dependent competition. This is evident in a reduced size at age, which may lead to an increase in Below Minimum Size (BMS) landings and discards. Discard information is considered reliable since 2001 and BMS landings are included in discards for all countries since 2020.

In the eastern Baltic Sea, Plaice is mainly caught in the area of Arkona and Bornholm basin (subdivisions 24 and 25). ICES Subdivision 24 is the main fishing area with Poland, Denmark and Germany being the main fishing countries. Subdivision 25 is the second most important fishing area. Denmark, Sweden, and Poland are the main fishing countries there. Minor catches occur in the rest of the Eastern Baltic. In 2014 discard data was for the first time included in the advice of the stock. Discard was estimated to be relatively high for this stock – close to 45% in 2014 and about 26% in 2019 with an increase to >60% in the last two years due to the two strong year classes entering the fisheries (in the discarded fraction). The discard ratio dropped in the most recent year as many of these fish are >25cm and thus entering into the landed fraction of the catch.

3.2.2 Age reading

Age reading of plaice otoliths is conducted by all member states with a TAC and substantial catches. Differences in age reading have been flagged as an issue (see “Issue list” and ICES 2015, ICS 2024b). To prepare for the WKBPLAICE benchmark and tackle the age reading issues, the main countries contributing to the age reading in plaice (Denmark and Germany) have systematically checked their age reading techniques and worked with verified otolith material to align the results and improve age data for the benchmark and respective assessments.

3.2.2.1 Methodological differences between national labs

Linked to the most recent otolith exchange in 2023, the national labs answered a questionnaire designed to identify commonalities and differences in the age determination of Baltic plaice.

The results show that the age determination of Baltic plaice is not standardized between the national labs. Essentially, every lab has its own routines. There are differences along the entire age reading chain, ranging from the methods, the otolith preparation, the reading to the data storage.

Different methods are used to determine the age of Baltic plaice from otoliths. Denmark and Sweden use whole otoliths, Poland uses sliced and stained otoliths, and Germany uses sliced otoliths and has recently changed to use whole otoliths for fish up to a length of 15 cm (Table 3.2).

Table 3.2 Methods of preparing otoliths for age determination of plaice in the Baltic Sea in 2023.

Lab	whole or sliced
Thünen-OF, GER	Sliced/whole
NMFRI, POL	sliced
DTU, DNK	whole
SLU, SWE	whole

In the labs, that use whole otoliths, there are differences in the time the otoliths are kept in water before the age is determined, with short immersion times in Germany and Sweden, and longer immersion times in Denmark (Table 3.3).

Table 3.3 Comparison of otolith preparation in national labs that use whole otoliths.

Lab	whole or sliced	how long in water before reading?	background color when viewing	light used
Thünen-OF	whole (fish <16cm TL)	2 seconds to 15 min	black	reflected
DTU, DNK	whole	2 hours	black	reflected
SLU, SWE	whole	2 seconds	black	reflected

In the labs, that use sliced otoliths, there are also differences, e.g., in staining and in the light direction (Table 3.4).

Table 3.4 Comparison of otolith preparation in national labs that use sliced otoliths.

Lab	whole or sliced	core marked before embedding?	chemical used to embed	coloring of emdeddding substance	staining	saw type	thickness (µm)	light direction usually used
Thünen-OF	Sliced (>15 cm TL)	yes	polyester resin	black	No	ATM cutting machine	500	reflected
NMFRI, POL	sliced	yes	polyester resin	transparent	Yes	ATM cutting machine	500	reflected (against a black background)

Age determination is done using live view, either on the monitor or in the stereomicroscope, without any reference (no scale bar) in three countries, while one country uses photos of the slices on a monitor and the software allows to have a scale bar inside the photo (Table 3.5).

Table 3.5 Comparison of approaches to age read Baltic plaice otoliths.

Lab	How do you age-read your otoliths?	Do you use a scale bar?	Software for imaging
Thünen-OF	photo (taken at a stereomicroscope) on a monitor	yes	ZEN (blue edition), Carl Zeiss Microscopy
NMFRI, POL	live view on the monitor	no	Nis-elements, Nikon
DTU, DNK	stereomicroscope	no	LAS
SLU, SWE	stereo microscope	no	none

In three labs, age readings are only recorded as the final age, i.e., there is no documentation of what ring structures of an otolith were exactly used by the age reader to determine the final age. Only one national lab is taking and archiving the photos as well as the individual ring structures used by an age reader to determine the final age on the images (Table 3.6).

Table 3.6 Comparison of approaches to age read Baltic plaice otoliths.

Lab	Photo of each otolith slice	Age determination indicated on photo	Number of age readers	National manual available
Thünen-OF	yes	yes	2	yes

Lab	Photo of each otolith slice	Age determination indicated on photo	Number of age readers	National manual available
NMFRI, POL	no	no	1	yes
DTU, DNK	no, but in the future, we will take images of a subset	no	2	yes
SLU, SWE	no	no	3	yes

3.2.2.2 Latest age reading exchanges

There were two age reading workshops involving Baltic plaice otoliths in the recent past. The otolith exchange in 2016 (covering ICES SD's 21-26) concluded that there was an overall low level of agreement and the varying levels of accuracy and precision depended on reader expertise, method applied and sample origin. There were, however, no consistent patterns where one method (whole or sliced) consistently produced "better" results compared to the other. It was agreed that further calibrations were required (ICES, 2017).

The most recent age reading exchange for plaice in ICES SD 22 was in 2023 (SmartDots ID 698 https://smartdots.ices.dk/ViewEvent?key=698). The SmartDots standardised summary report output was provided to WGBFAS in advance of the 2023 meeting and summary slides presented by the stock assessor. The report concluded that the age reading results were fair, based on advanced readers providing age data for the stock assessment but there were notable variations between readers. The most concerning being the high CV and bias values at ages age 0 and 1, with a tendency to overestimate in comparison to modal age. The results based on whole otoliths were slightly better than results based on the sectioned otoliths. The report focussed on the youngest ages, given that concerns have been raised on the difficulties in correctly identifying the innermost translucent zones (TZ's) seen in these otoliths. This has been a concern for plaice in the North Sea and Skagerrak (ple.27.4.20) also and attributed to an extended spawning period of plaice which can lead to huge variability in the distance of the first TZ from the otolith nucleus, age readers feedback confirmed this. A comparison of age reading methods showed that higher ages were reached when reading sliced otoliths. This can be due to interpretation of the innermost TZ's but also the zones at the outermost edge. Due to the cliff edge effect, age reading of whole otoliths is challenged by the difficulties in interpreting the narrow rings laid down at the otolith edge, while slicing may still allow to identify these annual rings.

A workshop is recommended to further analyse a larger collection of otoliths covering the stock area, possibly by microchemical and microstructure analysis plus additional length frequency analysis. One of the aims would be to provide updated guidelines for the age readers to correctly estimate the age of these fish.

3.2.2.3 Ongoing work

Obviously, there is potential to improve the international age reading of Baltic plaice, e.g., in terms of harmonization of the methods as well as in precision and accuracy. However, it is difficult to take joint decisions when certain uncertainties in age determination are not solved.

Therefore, an important step towards better age data in the Baltic plaice stock assessment is the ongoing age validation of Thünen-OF. A major focus of this age validation study is to determine the age of the first increment formation. A number of tetracycline-marked recaptures of wild juvenile Baltic plaice have been collected in the last few years, together with additional data, e.g., from monthly length distributions and otoliths from a coastal nursery ground. A key result from whole tetracycline-marked otoliths (viewed at reflecting light) is that the first translucent zone is laid down during summer, i.e., during quarter 3, and that the opaque zone is a continuous zone produced during the quarters 4, 1 and 2. This would mean that the widely used "winter ring" terminology is misleading. This emerging pattern presently is being double-checked using laser ablation and microchemistry profiles. Once the results of this "double validation" are available, the national labs meet to discuss the next steps towards harmonization and improvement of the international age reading.

3.2.2.4 Corrections of German BITS data

Prior to the BITS Q4 2023, Germany had uploaded plaice age data from the BITS without profound quality checks. In preparation of WKPLAICE Thünen-OF decided to quality-control all German BITS age data of plaice (SD22, SD24). A total of N = 12511 otoliths had been age-read between BITS Q1 2023 and the BITS Q1 2016. Essentially, outliers in the length-age relationship of each BITS were flagged, the images were picked out from the archived images and re-inspected on the monitor by the age reader who provides the age data for the stock assessment. N = 1578 individual ages were flagged and N = 617 of these were corrected, i.e., 5% of all and 39% of the flagged otoliths were corrected. The age distributions became visibly better, especially in the youngest ages.

3.2.3 Current assessment and advice

3.2.3.1 Stock definition

The stock identity of the two plaice stocks (before the WKBPLAICE benchmark in 2024) is a result of the recommendation made by the benchmark workshop WKPLE in February 2015 (ICES, 2015) and later by the Stock Identification Method Working Group (SIMWG) in June 2015, which confirmed the revised stock structure for the plaice stocks in the North Sea, Skagerrak, Kattegat and the Baltic Sea recommendation made by ICES WKPESTO (2012). Plaice in Skagerrak is now included in the North Sea stock. Kattegat and subdivisions 22 and 23 were merged into one stock and Subdivision 24–32 was regarded as one separate stock. Management of these stocks was still split between the North Sea and Baltic Sea management areas, meaning that the Kattegat (SD21) was managed independently of the rest of the areas (SDs 22-32).

3.2.3.2 Data and Assessment

All major fishing gears are covered by biological sampling, with sampling effort adjusted to fishing activity (i.e., more prominent fishing gears are covered by a higher number of samples). Catch-at-age data as well as weight-at-age are available for the total catch and the landed/discarded fractions separately.

Age reading is conducted in both stocks, however, as plaice in the eastern Baltic, ple.27.24-32, is using SPiCT for assessment and LBI to examine the stock status, additional catch-at-length data are compiled for the stock.

3.2.3.3 Stock Assessment.

The former western stock, ple.27.21-23, was assessed as a Category 1 stock (Full annual age based analytical assessment). The State based Assessment Model (SAM) is used. In addition to the changes to the data introduced to the model, that were made in the 2019 assessment review, two further changes were made in the model setup. The fishing mortality of ages 6-7+ were decoupled from age 5, and running means were stopped for stock weights-at-age in 2019, where subsequent years values were taken directly from annual observations, to account for changes in the stock growth rates. These changes, along with the other data changes, were carried forward into all subsequent assessments.

The former eastern stock, ple.27.24-32, was assessed as a category 2 stock using SPiCT as basis for the assessment and advice (ICES, 2022). Before the benchmark in 2015, trends in the stock were evaluated by survey-indices only. From 2016 to 2021, an exploratory SAM assessment was conducted and relative SSB trends were used to give catch advice. From 2018, SPiCT and LBI were additionally conducted to assess MSY reference points according to category 3 (DLS) stocks.

The results of both assessments (i.e., a TAC recommendation per stock) were additionally merged and then split into the management units, Skagerrak (SD21) and Baltic Sea (SDs 22-32).

3.2.3.4 Reference Points

Only the former western stock, ple.27.24-32 has defined reference points, while the eastern stock is only using relative reference points from the SPiCT output. New reference points have been calculated after merging the two stocks into the new stock ple.27.21-32.

Reference points for ple.27.21-23 were reviewed, together with assessment changes, in 2019. The 2024 assessment used these same reference point values which are available in Table 3.7.

Table 3.7 Biological reference points (BRP) of plaice SDs 21-23

BRP	Btrig-ger	B_{pa}	B_{lim}	F_{pa}	F_{lim}	Fp05	F_{MSY} un-constrai-ned	F_{MSY}
Plaice 21-23 (2019)	4 730	4 730	3 635	0.81	1	0.81	0.59	0.31

One exception is the value of F_{pa}, which was changed to equal $F_{p=0.05}$ in 2020, following the ACOM decision to make the basis for F_{pa} to be the F that leads to SSB $\geq B_{lim}$ with 95% probability. In 2020, this was set to the $F_{p=0.05}$ estimated without the advice rule of $B_{trigger}$ (0.68) and this was corrected in 2021 to match the value of $F_{p=0.05}$ estimated with the advice rule (0.809). As the basis for the advice for this stock over this period was the MSY approach and the SSB and F were far from either value of F_{pa}, this oversight had no effect on the advice provided in 2020.

3.2.3.5 Short Term Forecast (ple.27.21-23)

The procedures for the short-term forecast were changed slightly in 2019.

Since the Q1 survey in the intermediate year is currently not utilised, the forecasts use most recent catch data year as the base year and project for four years (base year, intermediate/assessment year, advice year, forecast year, respectively). Intermediate year (2024) assumption for fishing pressure is status quo set as the previous year's value (F=0.119 for 2024, F_{2023}). Recruitment for 2024, 2025, and 2026 is a median, resampled from the entire time-series. This approach, seems to have been a sensible approach in the past, however, in recent years, we see that these estimates are well below the actual observed recruitment that we see starting to track with SSB.

While weight-at-age, catch at age and maturity are described as an average over the last three previously, this was changed to equal the most recent data year (2022) in the 2023 assessment, and was retained in the 2024 assessment. This change was made according to a decision taken by WGBFAS as a whole, the purpose of which is to reflect the recent changes in stock weight-at-age.

As described above, this stock is doing well with continued extraordinary recruitment and stock size since 2019/2020. The large recruitment pulses observed in 2020 and 2021 were expected to enter the fishery fully from 2023. While these cohorts track well in survey indices, due to large discard rates from a non-target fishery and decreasing fish condition, they are not so well tracked in catches. The continued large recruitment contributes to the increase in advice. Furthermore, advice for this stock changed from a decrease (2020 advice) which was due to a change in the basis of the advice (precautionary to MSY approach) to increasing advised catches since 2021, as the stock continues to develop.

3.3 Stock definition

After the review and comments from SIMWG (ICES 2024), the stock definition has been changed. The two former stocks, ple.27.21-23 and ple.27.-24 are merged back into one stock, covering the Kattegat and the Baltic Sea, ple.27.21-32.

More details on the rationale behind the stock merging is given in **WD1 (**attached to this report).

3.4 Input data for stock assessment

3.4.1 Landings and Discards

Landing by fleet (summarised as passive and active), area (subdivision) and season (quarter) are available back to 2002 for both previous stock units, western and eastern Baltic plaice. Before 2002, discard sampling was too inconsistent to give reliable estimates. Landings are available back to 1903. However, landings before 1982 are unreliable, as the Skagerrak and Kattegat were often not separated when reporting commercial fisheries data (reported as “Area 3a”). For the assessment, landings and estimated discards from 2002 onwards are used. BMS landings are incorporated into the data, as they are too unreliable (estimated underreporting when compared to estimated discards from the national observer programs) to be used as its own data source category.

Missing national discard estimations are extrapolated by the stock coordinators, using discard ratios of similar strata. Extrapolation and data raising was done in the ICES InterCatch database following the same procedures as were used for the previous two stocks.

To establish a full dataset for the new Ple.27.21-32 stock, the two existing final datasets from InterCatch for Ple.27.21-23 and Ple27.24-32 were merged (see WD2, attached to this report).

Based on the maturity of the new data portal for stock coordinators (RDBES), the decision was made to continue this procedure in the future until such time as the full stock catches can be calculated concurrently from RDBES.

3.4.2 Discard survival

Unaccounted fishing mortality is recognized as an important determinant in the management of bycatch, and discard survival studies have been conducted in commercial and recreational fisheries around the world (Davis, 2002, Broadhurst et al. 2006, Uhlmann & Broadhurst 2013). The European Common Fisheries Policy (CFP) landing obligation has led to an increased interest in documenting discard survival rates. To facilitate the implementation of the landing obligation, i.e., the obligation to land all catches of regulated species, the need for some flexibility was recognized by EU co-legislators (Borges & Lago 2019). The high survival exemption was included to allow discarding of regulated species that demonstrated a high chance of surviving the process of capture, handling and discarding, based on scientific evidence (EU 2005, EU 2016).

The main reason for such an exemption was to avoid landing and eventually killing individuals, which otherwise would have survived being discarded. However, exemptions are increasingly sought as fish below Minimum Conservation Reference Size (MCRS) count against the quota, which would else be available for more valuable catches. Additionally, not accounting for surviving discards in the assessment will increase the SSB artificially, as the reproductive capacity of the stock is based on lower biomass estimates.

ICES received a joint request from the European Union and the United Kingdom to, as part of a roadmap that strengthens its advice by including discard survival into scientific advice, to "identify which stocks fulfil all conditions that allow discard survival to be considered in the stock assessment… [and] endeavour to integrate the discard survival into the stock assessments for these stocks as soon as possible." In response to this request, this benchmark evaluated the potential for including survival estimates to the Baltic plaice stock, beginning with compiling all available discard survival studies on plaice in the Baltic Sea, Kattegat and Skagerrak were gathered (Table 3.8). A total of three studies were found that focused on the survival of plaice in trawl fisheries (Savina et al. 2024, Kraak et al. 2019 and Noack et al. 2020). Only one study was found that worked on set nets survival rates (Ern et al., 2022).

Table 3.8 overview of discard survival studies of Baltic Sea plaice that were used to build the matrix of survival rates for the assessment data. Lower, medium and upper survival rate in %

Area	quarter	gear	low	medium	high	author	remarks
Baltic	Q3	active	9	27	55	Savina et al. 2024	T90
Baltic	Q3	active	4	14	29	Savina et al. 2024	Bacoma
Baltic	Q1	active	82	87	92	Savina et al. 2024	
Kattegat	Q3	active	37	44	52	Savina et al. 2024	OTB
Kattegat	Q3	active	0	0	0	Savina et al. 2024	Nehrops
Kattegat	Q1	active	67	75	83	Savina et al. 2024	OTB
Kattegat	Q1	active	28	40	57	Savina et al. 2024	Nehrops
Kattegat	-	active	37	44	52	Noack et al., 2020	avg value per year
Baltic	Q1	active	74	85	91	Kraak et al. 2019	Avg of monthly values
Baltic	Q2	active	21	33	50	Kraak et al. 2019	Avg of monthly values
Baltic	Q3	active	9	23	46	Kraak et al. 2019	Avg of monthly values
Baltic	Q4	active	18	26	44	Kraak et al. 2019	Avg of monthly values

Area	quarter	gear	low	medium	high	author	remarks
Baltic	Q4-Q1	passive	-	-	100	Ern et al., 2022	GTR, no range given

The survival rates and, where possible, upper and lower ranges were extracted from the study and converted into the aggregation level of the assessment data, e.g., by summarizing monthly values (Kraak et al. 2019), different gear types (Savina et al., 2024) or areas (Noack et al., 2020). The respective values were combined by simply averaging them. Gaps were filled by extrapolating the values across the strata for both. The active and passive gears:

- active gears: to fill the missing strata, the available survival rates and their respective upper and lower limits were averaged (Table 3.9)

Table 3.9 extrapolation overview of the active gears for plaice in the Baltic Sea. NS = Kattegat (SD21), BS = Baltic Sea (SD22-32)

	fleet	location	quarter	survival_low	survival_mid	survival_high
1	active	NS	Q1	Savina (Q1, SD20/21 OTB) Savina (Q1, SD20 Nephrops) Noack (SD20, OTB)	Savina (Q1, SD20/21 OTB) Savina (Q1, SD20 Nephrops) Noack (SD20, OTB)	Savina (Q1, SD20/21 OTB) Savina (Q1, SD20 Nephrops) Noack (SD20, OTB)
2	active	NS	Q2	Noack (SD20, OTB)	Noack (SD20, OTB)	Noack (SD20, OTB)
3	active	NS	Q3	Savina (Q3, SD20/21 OTB) Savina (Q3, SD20 Nephrops) Noack (SD20, OTB)	Savina (Q3, SD20/21 OTB) Savina (Q3, SD20 Nephrops) Noack (SD20, OTB)	Savina (Q3, SD20/21 OTB) Savina (Q3, SD20 Nephrops) Noack (SD20, OTB)
4	active	NS	Q4	Noack (SD20, OTB)	Noack (SD20, OTB)	Noack (SD20, OTB)
5	active	BS	Q1	Savina (Q1, Baltic,OTB) Kraak (Q1, Baltic)	Savina (Q1, Baltic,OTB) Kraak (Q1, Baltic)	Savina (Q1, Baltic,OTB) Kraak (Q1, Baltic)
6	active	BS	Q2	Kraak (Q2, Baltic)	Kraak (Q2, Baltic)	Kraak (Q2, Baltic)
7	active	BS	Q3	Savina (Q3, Baltic, T90) Savina (Q3, Baltic Bacoma) Kraak (Q3, Baltic)	Savina (Q3, Baltic, T90) Savina (Q3, Baltic Bacoma) Kraak (Q3, Baltic)	Savina (Q3, Baltic, T90) Savina (Q3, Baltic Bacoma) Kraak (Q3, Baltic)

	fleet	loca-tion	quar-ter	survival_low	survival_mid	survival_high
8	ac-tive	BS	Q4	Kraak (Q4, Baltic)	Kraak (Q4, Baltic)	Kraak (Q4, Baltic)

- passive gears: Since only one publication was available (Ern et al. 2022) which assumed a 100% survival during winter, the remaining values were estimated by using the ratio of survival from the active gear estimates. The 100% survival from the study were used as upper limit in the respective strata (in quarters Q1 and Q4). From there, the difference (change in %) was taken from the active gear estimates to get values for the remaining strata in the passive gear strata (Table 3.10)

Table 3.10 estimation procedure for the passive gear strata. As only one study was found, the remaining strata were calculated by using the differences between active gear survival rates. NS = Kattegat (SD21), BS = Baltic Sea (SD22-32).

	fleet	location	quarter	survival_low	survival_mid	survival_high
9	passive	NS	Q1	= survival mid * (active gear low/active gear mid)	= survival high * (active gear mid/active gear high)	100 (Ern, GTR)
10	passive	NS	Q2			= survival high Q1 * (active high Q2/ active high Q1)
11	passive	NS	Q3			= survival high Q2 * (active high Q3/ active high Q2
12	passive	NS	Q4			100 (Ern, GTR)
13	passive	BS	Q1			100 (Ern, GTR)
14	passive	BS	Q2			
15	passive	BS	Q3			
16	passive	BS	Q4			100 (Ern, GTR)

The final values for the survival rate of the Baltic Sea plaice stock are given in Table 3.11. The estimates were applied to the respective strata of the assessment data and the input files (numbers in the catch and discards, as well as average discards and catch weights) were re-calculated accordingly.

Table 3.11 final discards survival rate estimates per stratum. NS = Kattegat (SD21), BS = Baltic Sea (SD22-32)

	fleet	location	quarter	survival_low	survival_mid	survival_high
1	active	NS	Q1	44	53	64
2	active	NS	Q2	37	44	52
3	active	NS	Q3	25	29	35
4	active	NS	Q4	37	44	52
5	active	BS	Q1	78	86	92
6	active	BS	Q2	21	33	50
7	active	BS	Q3	7	21	43
8	active	BS	Q4	18	26	44
9	passive	NS	Q1	69	83	100
10	passive	NS	Q2	58	69	81
11	passive	NS	Q3	39	46	54
12	passive	NS	Q4	71	85	100
13	passive	BS	Q1	85	94	100
14	passive	BS	Q2	23	36	55
15	passive	BS	Q3	8	23	47
16	passive	BS	Q4	42	60	100

Sensitivity runs were conducted using the upper and lower limit (WD5, attached to this report). For the final assessment run, the medium survival rate was applied.

3.4.3 Surveys

The International Bottom Trawl Survey (IBTS) covers the North Sea (Subarea 4) and the Transition area (Division 3.a. including the Skagerrak 3.a.20 and Kattegat 3.a.21) and is conducted two times per year in Quarter 1 and 3 (Q1, Q3). The Baltic International Trawl Survey (BITS) covering the entire Baltic Sea and Kattegat (3.a.21) and is conducted also twice per year, in Q1 and Q4. Both surveys are conducted using the same sampling protocols and data are publicly available at the International Survey database DATRAS, hosted by ICES (https://datras.ices.dk).

Survey indices of the stock are calculated using the methodology similar to what is described in Berg and Kristensen (2014), that is a Delta-Lognormal model which consists of a binomial presence/absence model and a lognormal model for strictly positive responses (WD7, attached to this report). Once the parameters in the model are estimated, a standardized survey index is obtained by predicting and adding up the abundances in a fine meshed grid of points that is the same in all years. This can be thought of as performing a virtual experiment where the experimental conditions such as the haul positions, gear type etc. are exactly the same in each year. The following effects are considered using a Delta-Gamma distribution (zeroes and positive catches are modelled separately) to estimate the indices. Explanatory variables included in the model are year, spatial position, depth, gear, time of the day and haul duration. Estimation of the gear effect prior to the standardization of national gears in 2001 is possible due to some spatio-temporal overlap of sampling between member states, which used different gears. The survey index is derived by letting the model predict the catch rates by year in an ideal experimental design, i.e., in a spatial grid covering the stock area using the same gear, at the same time of day etc. Variation in catch rates caused by changes in the sampling are filtered out in this process and the influence of single hauls with large catches are also reduced when compiling the index.

3.4.4 Recreational fishery data

Recreational catches of plaice in the Baltic Sea have increased in recent years. This is caused by the decrease of Baltic Sea cod and respective restrictions in (recreational) catches, but also the increase in biomass of plaice, especially in the Western Baltic Sea.

Data on recreational catches from Germany are available from 2002 to present. Estimated catches range between 30 and 450 tons (Figure 3.2), which accounts to 0.2 to 5% of total catches, compared to the removal of the commercial fishing fleets. However, the data were incomplete at the time of the benchmark, missing recreational removal estimates from Denmark and Sweden, information on the survival rates of the released catches and also displayed differences in the aggregation compared to the strata used for the SAM assessment.

Figure 3.2 Estimated total removal of plaice by German recreational fisheries 2002 to 2023.

Thus, the data from the recreational catches were not yet included in the assessment. However, the data will be reviewed and tested before the next working group meeting and their inclusion will be discussed there

3.4.5 Natural mortality

We have observed annually decreasing stock weights at age and lengths at age, which we anticipate is due to the rapidly increasing density derived from consecutive years of high recruitment and low fishing pressure. With lower growth rates, poorer condition and expected higher competition, we anticipate increasing mortality across ages. This is especially true in the younger ages, where recent record-breaking cohorts continue to top each other. During this workshop we investigated a different way that new estimations of mortality could be introduced to the model and the effect that this has on the model fit and predictive power.

The different steps of integrating new natural mortality (nm) estimates are explained in detail in WD4 (attached to this report). Essentially, new natural mortalities were calculated based on Gislason (2010), which incorporates life-history traits and current sizes-at age to estimate natural mortality at age. Four different approaches were tested:

- age-varying but time invariant Gislason nm, where means of the full time series were used to calculate age-specific nm and were applied across the whole time series.
- Scaled age-varying but time invariant Gislason nm, where means of the full time series were used to calculate age-specific nm and were applied across the whole time series to get a nm curve, which was then scaled up and down, in a series of sensitivity runs to find an optimum.
- Age-varying and time varying Gislason nm, where annual estimates of biological parameters were used to calculate annual Gislason nm values, by age.
- Smoothed age-varying and time varying Gislason nm, where a five-year sliding window was applied to the annually calculated nm-at-age time series, in order to account for relatively large annual fluctuations due to sub-sampling for biological data.

From the diagnostics of these sensitivity runs we can see that the moving to Gislason based, age varying nm estimates greatly improves the model fits. Furthermore, we see that having age and time varying Gislason nm with a 5-yr sliding moving average window applied, provides the best combination of fits to trends and not to noise. This is likely due to the fact that the chosen Gislason mortalities (from Gislason et al. 2010) are based on both life-history traits and size, and therefore, as the size at age has been decreasing over time, the time varying nm better matches this change than does a fixed, average nm based on average size. The option of time-varying nm is also internally coherent, as we have included time-varying stock weights-at-age as the best representation of stock development and so we should reflect this development in our estimations of natural mortality as well.

3.4.6 Maturity

. While it is possible to estimate maturity within the assessment model (using SAM's BioPar option), the workshop decided not to use this option for more than one biological parameter. Thus, a five-year sliding window was selected for calculating the maturity ogives, balancing a need for long term trends with fitting the model to noise from relatively small annual sample sizes. The BioPar option was retained for the stock weights-at-age.

The different steps of integrating a time-varying maturity ogive are explained into detail in WD3 (attached to this report).

The data used to derive these maturity ogives come from quarter one of the NS-IBTS and BITS surveys, where the subsetting of relevant areas and species, as well as the merging of the two data series is carried out in the above section. These data come from the raw DATRAS Exchange products, not the SMALK products. This is important because we are subsetting and combining data sources, so the raising procedure needs to be done independently. The setting of age 1 proportion mature to zero, overwrites proportions determined from surveys with an assumption based on expert knowledge (WD5, attached to this report). This would not, ordinarily, be best practice. However, due to the difficulty in getting reliable age reading rings from the first year of life, one can assume that some of the fish reported as mature in age 1, are from the age 2 cohort. Furthermore, juvenile and pre-adult plaice are known to distribute themselves across depth gradients according to their size. In this area, plaice are known to spawn and settle as juveniles over extended periods crossing seasons, which introduces length, growth and survival differentials into the various within-year, “settlement cohorts”. This means that the surveys that operate in deeper waters are more likely to catch individuals from the larger end of the size spectrum for any given age cohort, further biasing the proportion of mature fish at any given age. All experts in the workshop agreed that having significant proportions of age 1 plaice mature was unrealistic and that accepting these numbers (which are likely a result of sampling bias and observation error) was probably over-inflating our estimation of SSB.

Once set to zero, the model fit utilising these data does not change, only the SSB estimates scale up and down. The SSB estimates fall by -23% when setting age1 maturity to zero, and will likely reduce the inter-annual variability of the SSB estimates because of the larger variances around the estimations of numbers at age 1.

3.5 Stock assessment

The State Space Assessment Model SAM is used for the assessment. All input data settings and other details can be seen on: stockassessment.org. The final stock assessment run is called “ple.27.21-32_WKBPLAICE_2024_nmG5Fb_mo1_dsmed6”. Find the final assessment online at www.stockassessment.org. The model configurations are also given in chapter 3.11. Model Configuration.

3.5.1 Model Configuration

Final model configurations used for the assessment and as a basis for the reference point calculations. The rationale behind the settings, along with sensitivity runs, explanations, shortcomings and conclusions on each decision can be found in the respective working documents:

- **WD3**, attached to this report**: Ple27.3a21-32_Assessments** for the general SAM configurations and comparison on input data
- **WD4**, attached to this report**: Ple27.3a21-32_NewMortality** for the process of establishing a time-varying natural mortality
- **WD5**, attached to this report**: Ple27.3a21-32_DiscardSurvival** for the implementation of discard survival into the assessment.

- Survey age classes: 1-7+
    - Coefficients of variation are integrated into estimation of input survey index values and uncertainties.
- Catches age classes: 1-7+
- Maturity ogives: Five-year sliding-window mean starting with survey data from 1999 (with the first year repeated backwards to 1998) to inform data years 2002:2023.
- Combined sexes
- Time-varying stock weights-at-age, determined from survey observations (Q1 surveys). Annually varying observations (2002:2023) fit within the model using “biopar” options. Observation variance is coupled for ages 2 through 5. F_{bar} ages 3-5 (inclusive)

- Time-varying natural mortality, using the time & age varying Gislason et al (2010) natural mortality estimates which are smoothed with a 5-year sliding window mean (WD4, attached to this report)
- Fishing mortality is coupled for ages 6 + 7
- Survey catchability is coupled for the following, while all other ages are independently estimated:
  - Q1 survey: ages 3 to 5
  - Q3/4 survey: ages 4 to 7
- Observation variance parameters are:
  - Catch: independent for age 1, coupled for ages 2-7+
  - Q1 survey: coupled over all ages
  - Q3/4 survey: independent for age 1, coupled for ages 2-5 and 6-7+ respectively
- Correlation structure in the observations is implemented as an AR process for the Q3/4 survey, with ages 1 & 2, 3 & 4, and 5 & 6 coupled as pairs.

Full model configuration of final SAM model (can also be found at www.stockassessment.org, run: "ple.27.21-32_WKBPLAICE_2024_nmG5Fb_mo1_dsmed6")

```
# Where a matrix is specified, rows correspond to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive negative numbers indicate that the parameter is not included in the model
#
$minAge
# The minimium age class in the assessment
 1

$maxAge
# The maximum age class in the assessment
 7

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

$keyLogFsta
# Coupling of the fishing mortality states processes for each age (normally only the first row (= fleet) is used).
# Sequential numbers indicate that the fishing mortality is estimated individually for those ages; if the same number is used for two or more ages, F is bound for those ages (assumed to be the same). Binding fully selected ages will result in a flat selection pattern for those ages.
  0  1  2  3  4  5  5
 -1 -1 -1 -1 -1 -1 -1
 -1 -1 -1 -1 -1 -1 -1

$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry,
# 2 AR(1), 3 separable AR(1).
# 0: independent means there is no correlation between F across age
# 1: compound symmetry means that all ages are equally correlated;
# 2: AR(1) first order autoregressive - similar ages are more highly correlated than ages that are further apart, so similar ages have similar F patterns over time. If the estimated correlation is high, then the F
```

pattern over time for each age varies in a similar way. E.g. if almost one, then they are parallel (like a separable model) and if almost zero then they are independent.
3: Separable AR - Included for historic reasons
2

$keyLogFpar
Coupling of the survey catchability parameters (normally first row is not used, as that is covered by fishing mortality).
-1 -1 -1 -1 -1 -1 -1
0 1 2 2 2 3 4
5 6 7 8 8 8 8

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

$keyVarF
Coupling of process variance parameters for log(F)-process (Fishing mortality normally applies to the first (fishing) fleet; therefore, only first row is used)
0 0 0 0 0 0 0
-1 -1 -1 -1 -1 -1 -1
-1 -1 -1 -1 -1 -1 -1

$keyVarLogN
Coupling of the recruitment and survival process variance parameters for the log(N)-process at the different ages. It is advisable to have at least the first age class (recruitment) separate, because recruitment is a different process than survival.
0 1 1 1 1 1 1

$keyVarLogP
#

$keyVarObs
Coupling of the variance parameters for the observations.
First row refers to the coupling of the variance parameters for the catch data observations by age
Second and further rows refers to coupling of the variance parameters for the index data observations by age
0 1 1 1 1 1 1
2 2 2 2 2 2 2
3 4 4 4 4 5 5

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

$keyCorObs
Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.
NA's indicate where correlation parameters can be specified (-1 where they cannot).
#V1 V2 V3 V4 V5 V6
NA NA NA NA NA NA

NA NA NA NA NA NA
0 0 1 1 2 2

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

$noScaledYears
Number of years where catch scaling is applied.
0

$keyScaledYears
A vector of the years where catch scaling is applied.

$keyParScaledYA
A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange
Lowest and highest age included in Fbar
3 6

$keyBiomassTreat
To be defined only if a biomass survey is used (0 SSB index, 1 catch index, 2 FSB index, 3 total catch, 4 total landings, 5 TSB index, 6 TSN index, and 10 Fbar idx).
-1 -1 -1

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

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

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

$fracMixN
The fraction of t(3) distribution used in logN increment distribution (for each age group)
0 0 0 0 0 0 0

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

$constRecBreaks
For stock-recruitment code 3: Vector of break years between which recruitment is at constant level. The break year is included in the left interval. For spline stock-recruitment: Vector of log-ssb knots. (This option is only used in combination with stock-recruitment code 3, 90-92, and 290)

```
$predVarObsLink
# Coupling of parameters used in a prediction-variance link for observations.
 -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1

$stockWeightModel
# Integer code describing the treatment of stock weights in the model (0 use as known, 1 use as observations to inform stock weight process (GMRF with cohort and within year correlations)), 2 to add extra correlation to plusgroup
 1

$keyStockWeightMean
# Coupling of stock-weight process mean parameters (not used if stockWeightModel==0)
 0  1  2  3  4  5  6

$keyStockWeightObsVar
# Coupling of stock-weight observation variance parameters (not used if stockWeightModel==0)
 0  1  1  1  1  2  3

$catchWeightModel
# Integer code describing the treatment of catch weights in the model (0 use as known, 1 use as observations to inform catch weight process (GMRF with cohort and within year correlations)), 2 to add extra correlation to plusgroup
 0

$keyCatchWeightMean
# Coupling of catch-weight process mean parameters (not used if catchWeightModel==0)
  NA  NA  NA  NA  NA  NA  NA

$keyCatchWeightObsVar
# Coupling of catch-weight observation variance parameters (not used if catchWeightModel==0)
  NA  NA  NA  NA  NA  NA  NA

$matureModel
# Integer code describing the treatment of proportion mature in the model (0 use as known, 1 use as observations to inform proportion mature process (GMRF with cohort and within year correlations on logit(proportion mature))), 2 to add extra correlation to plusgroup
 0

$keyMatureMean
# Coupling of mature process mean parameters (not used if matureModel==0)
 NA NA NA NA NA NA NA

$mortalityModel
# Integer code describing the treatment of natural mortality in the model (0 use as known, 1 use as observations to inform natural mortality process (GMRF with cohort and within year correlations)), 2 to add extra correlation to plusgroup
 0

$keyMortalityMean
#
 NA NA NA NA NA NA NA
```

$keyMortalityObsVar
Coupling of natural mortality observation variance parameters (not used if mortalityModel==0)
NA NA NA NA NA NA NA

$keyXtraSd
An integer matrix with 4 columns (fleet year age coupling), which allows additional uncertainty to be estimated for the specified observations

$logNMeanAssumption
#
0 0

$initState
#
0

3.6 Short-term forecast

The stochastic SAM forecast as implemented in the stockassessment package (https://github.com/fishfollower/SAM) also used for the short-term predictions. The input to short-term projections is based on various assumptions about the current (intermediate year) and future (short term forecasts) development of the stock, which are outlined below:

Model used:	State Space Assessment Model
Software used*:*	SAM (stockassessment.org),
Initial stock size:	Output from SAM (final/intermediate year is base.year = assessment year – 1)
Maturity:	Mean of the immediately preceding 3 years ([assessment year-4]:[assessment year]).
F and M before spawning:	0 for all age groups (output from SAM)
Weight-at-age in the stock:	Mean of the immediately preceding 5 years ([assessment year-4]:[assessment year]) for future years only; ouput from sam in final/intermediate year.
Weight-at-age in the catch:	output from SAM, 3 years mean ([assessment year-5]:[assessment year-1])
Exploitation pattern:	output from SAM, 3 years mean ([assessment year-5]:[assessment year-1]), based on Fbar: 3-6.
Stock–recruitment model used:	Median resampled from the entire time series of recruitment (excluding latest year with only Q1 data 2024).
Procedures for splitting projected catches:	output from SAM, 3 years average

Averages listed above are applied to the input data of the SAM model, after any smoothing has been applied. However, in the cases when a clear trend over time is observed in quantities listed above, these standard assumptions may be relaxed, and values from the most recent the last year could be used. Examples of such an approach may be a change in F_{bar} with selection may be scaled to terminal year F_{bar} when a trend in F is observed; alternatively, only the most recent year for natural mortality could be used in the terminal year when a trend in predation mortality is observed (e.g., change in cod biomass). Initial stock size is obtained from the distribution of the stock size estimated in SAM at the start of the intermediate year. Recruitment in the intermediate year and the preceding two years of forecast is obtained through sampling with replacement from estimates of SAM recruitments in the whole time period, excluding the intermediate or assessment year. While SAM estimates recruitment for the assessment/intermediate year based on Q1 survey data, this recruitment estimate has high uncertainty as it is based on a single in-year observation, without the Q3/4 survey index and catch data to mediate it.

3.7 Biological reference points

The reference points were estimated following the ICES guidelines for stock categories 1 and 2 (ICES 2021), with additional considerations of results of WKMSYREF3 (ICES 2024c) and a benchmark including the Gulf of Riga herring stock (ICES 2023). The working steps, code and data inputs for the respective models runs are given in WD6 "ple.27.21-32 reference points".

Before we begin calculating the various reference points, we must first decide on some data truncation and settings for the simulation (Table 3.12).

Because of the rapid changes in stock dynamics in recent years, the decision was made to run simulations for reference points using recruitment values based on the period before stock-weights-at-age began to decline, recruitment increased and SSB increased. It was thought that this most recent period of high recruitment of poor-condition reflects a rare episode of overshooting carrying capacity, so experts expected that this period is unlikely to continue in the long-term. When the full time series is run including the last years of extraordinarily high recruitment, it becomes clear that simulations only reflect expected stock dynamics of this very high state, as the roughly all of the SSB x recruitment pairs, observed prior to this period fall below the medians of the simulations produced (WD6, attached to this report). This exercise therefore confirmed the choice to exclude the extraordinarily high recruitment values, thereby allowing the simulations to more closely the majority of the past states of the stock observed.

Using biological data and fishing selectivity over the past 10 years (i.e., 5 years during relatively normal conditions and 5 years during relatively poor conditions), however, reflects the continued partial impact of these high recruitment values and high stock status, which is expected to continue at least into the medium-term future, and potentially long-term. Therefore, they are expected to be applicable on the time scale that this benchmark will be valid. However, as these two assumptions have a large influence on the outcome of the simulations, any violation of these two assumptions, one regarding biological condition and fishing selectivity and one regarding truncation of the recruitment series, would warrant recalculation of the reference points.

Another setting that had a strong influence on results was the autocorrelation applied to the projected recruitment time series. Rho was estimated external to SAM as roughly 0.9 from the residuals of the stock-recruitment function. This value leads to long periods of autocorrelation which are usually observed for more long-lived stocks; therefore, it was decided to replace this value with a cap of a mean rho value estimated across other plaice stocks in the FishLife database (Thorson et al., 2023).

Table 3.12: Summary of settings used in EqSim runs

Input	Details
Biological data	resampled from estimates for the 10 most recent years (2013-2023)
Fishing selectivity	resampled from estimates for the 10 most recent years (2013-2023)
sigmaSSB	0.10 (from SAM)
sigmaF	0.10 (from SAM)
F cv	0.25 (ICES, 2015)
F phi	0.30 (ICES, 2015)
Recruitment	Autocorrelation calculated as rho = 0.9, but capped at rho = 0.6.
Stock-recruitment relation-ship	Segmented regression. Breakpoint fixed at Blim.

3.7.1 B_{lim} and B_{pa}

B_{lim} is the key PA reference point. The other precautionary approach points (B_{pa}, F_{lim}, and F_{pa}) are all estimated from B_{lim}. In a few cases, the available information does not allow direct estimation of B_{lim}; B_{pa} is then estimated directly, and B_{lim} may be derived from B_{pa}.

Although the stock-recruitment pattern was visually similar to a Stock Type 3, this category was ruled out because this plaice stock is caught mainly as a bycatch fishery, and it was not believed by experts that the entire time series could be reflective of an overfished period. It was instead believed that those earliest years could reflect an overfished state with recruitment impairment due to high discarding of plaice in the targeted cod fishery, but it would be difficult to justify a belief that recruitment impairment could be experienced also in the latter portion of the time series.

Therefore, after much discussion, it was determined to try to use either into type 1 or 5 definition (ICES 2021).

While Stock Types 1 and 5 from the guidelines call for using B_{loss} as B_{lim}, the experts in the working group recognised that B_{loss} is close to many other data points with varying levels of recruitment. Therefore, this method was initially rejected and we also decided to try to apply the rules used for Gulf of Riga herring, namely that we take as B_{pa} the mean SSB of those years where:

- SSB <= median SSB AND
- recruitment >= median recruitment

The logic here is that we are finding those years where low SSB still results in relatively high recruitment and using the mean SSB of those years to identify B_{pa} and calculate B_{lim} from there. This resulted in a B_{lim} of ~8 700 tons (and a subsequent B_{pa} of ~12 200 tons) based on two of the lowest observed SSB in the time series, which corresponded to essentially B_{loss}, and so this method was also rejected.

In a second approach, B_{lim} was estimated by using the "empirical approach" and using $B_{empirical}$ as B_{lim}. In a review of ICES reference points Silvar-Viladomiu et al. (2022) found that after B_{loss}, the most used method to define B_{lim} was an empirical method based on identifying the lowest biomass that resulted in good recruitment. The “StockRecruitSET” R package available in GitHub (https://github.com/mebrooks/StockRecruit) provides a function that formalizes this method, and identifies the lowest biomasses that results in above median recruitment. B_{lim} is then defined as the average over the identified set of lowest biomasses (composed of one point or several). WKNEWREF (ICES 2024c) drew on the same definition of B_{lim}, the 'empirical approach' Using the definition of WKNEWREF of 2024 and the "StockRecruitSET" package, the B_{lim} empirical is about 8 697 tons. The empirical B_{lim} is very close the previously estimated B_{lim} value of 8 700 tons and would face similar issues when used as a reference point. The B_{lim} empirical approach was therefore also rejected.

As no standard solution was found, it was decided to modify the definition of B_{loss} given for Stock Types 1 and 5 to be based on the mean of several similar SSB values that spanned the ranges of having yielded both good recruitment in two cases (2010 & 2011) and rather low recruitment (but often higher SSB) in 8 cases (2002:2009). As noted above, setting B_{loss} to be the minimum SSB observed in 2010 was not considered a candidate for B_{lim} because its value was less than the 8 values considered to have yielded rather low recruitment earlier in the time series (Figure 3.3).

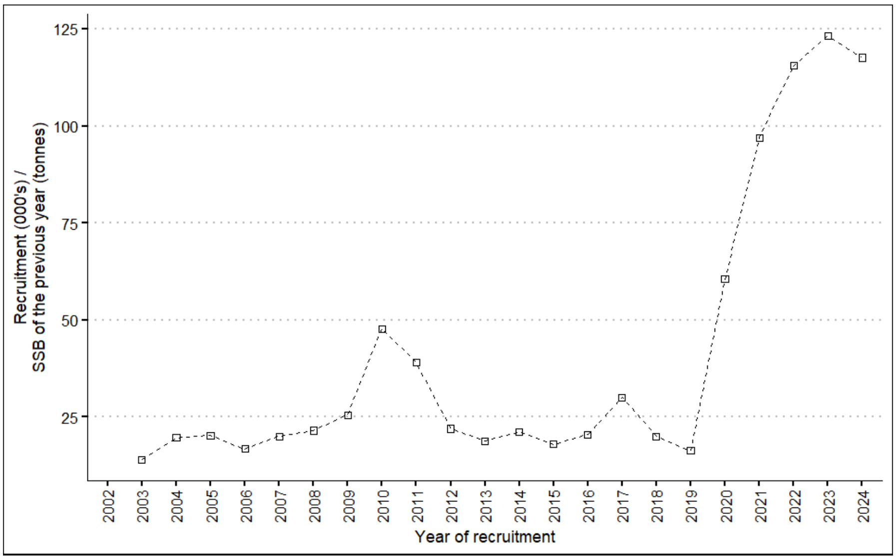

Figure 3.3: Recruits per spawner biomass relationship in the assessment period 2002 to 2024 (2024 is considered preliminary as it only contains Q1 survey data)

Any choice of SSB values greater than the 2010 value was therefore arbitrary, so the expert group decided to include as many as possible to reflect the group of similar SSB and recruitment value early in the time series. The number of recruits per spawner biomass in 2010 - 2011 values were also considered in the calculation of B_{lim}, as they sustain rather stable SSB and recruitment values during the mid-range of the time series, before the productivity shift began in 2020.

B_{loss} was therefore considered to be the mean SSB from the first ten years of the time series (2003-2012), where recruitment and SSB both remained rather low, albeit variable and B_{lim} was set equal to B_{loss}. Bpa was calculated from B_{lim} subsequently:

B_{pa}	B_{lim}
13 460	11 118.6

Having agreed and established B_{lim} and B_{pa}, we now move on to other reference points.

3.7.2 F_{lim} and F_{pa}

As the Beverton-Holt SRR function led to a straight line, and smooth-hockey stick produced also straight line with a breakpoint at higher SSB value, the only realistic option for a stock-recruit relationship (SRR) is segmented regression with a fixed breakpoint.

In forward projections, we can use a hockey-stock function to reflect the stock-recruitment relationship, but force it to use our pre-defined B_{lim} as the breakpoint. This requires fitting the "stick" portion of the hockey-stick function above the breakpoint to recruitment observations. Based on this final (truncated) stock-recruitment relationship, we can begin to estimate MSY reference points. To calculate F_{lim}, we run a series of simulations with fixed biological parameters and no variability in the estimates of F and SSB. EqSim was run without assessment/advice error, without advice rule, and with a segmented regression with a breakpoint fixed at B_{lim} to model recruitment in EqSim.

The Recruitment-autocorrelation (RhoLogRec) is also high (>0.9) when estimated from SAM directly and is influencing the estimation of the reference points. The high value seems to be driven by the exceptionally high R in the latest year classes which, for that reason, were already excluded from the B_{lim} estimation (see previous chapter). Generally, Rho is much smaller in fish and not easy to estimate within assessment models without bias because it is a random effect, so that Johnson et al. (2016) recommends to do the estimation outside the model and then fix it. The Recruitment-autocorrelation (RhoLogRec) was set to a conservative level at 0.6, which is similar to other Rho values for plaice derived from FISHLIFE (i.e., 0.58 for plaice, Thorson et al., 2023). The resulting value for F_{lim} was 0.57 and for F_{pa} 0.21.

However, while F_{lim} may still be derived from B_{lim} (and used to assess the F that drives the stock to B_{lim}, based on the equilibrium curve of stock), it is no longer used by ICES as basis of precautionary approach (PA) and MSY reference points to assess the state of stocks and exploitation, and to provide advice on fishing opportunities WKNEWREF4, ICES 2024d). It is therefore only used for information, but not recognized as reference point for the assessment and advice.

3.7.3 F_{MSY}

Unlike the simulations used to estimate F_{lim}, F_{MSY} should initially be calculated based on a constant F evaluation with the inclusion of stochasticity in population and exploitation as well as assessment/advice error. Appropriate SRRs should be specified.

To estimate the unconstrained F_{MSY}, the EqSim was run without the advice rule (i.e., no MSY $B_{trigger}$), with assessment and advice error using the values (cvF, phiF) = (0.25,0.30) as suggested by WKMSYREF3 (ICES, 2015), and with the segmented regression and only using data from the last ten years of sampling (2013-2023). When allowing the program to use the full range, and combinations of, bootstrap simulated a and b parameters in the S-R function, the distribution of our projected population states did not overlap with past observations, but instead were biased upwards (WD6, attached to this report). The resulting unconstrained F_{MSY} obtained (median MSY for catF) was F_{MSY} = 0.46. The resulting F_{MSY} values were therefore not considered reliable.

To ensure consistency between the precautionary and the MSY frameworks, F_{MSY} is not allowed to be above F_{p05}; therefore, if the initial F_{MSY} value is above F_{p05}, F_{MSY} is reduced to F_{p05}. F_{p05} was calculated by running EqSim with assessment/advice error, with advice rule, and with a segmented regression with breakpoint fixed at Bpa to ensure that the long-term risk of SSB < B_{lim} of any F used does not exceed 5% when applying the advice rule. F_{p05} was estimated to be 0.15 (F_{05}

for catF). Therefore, as explained above, $F_{pa} = F_{p05} = 0.15$. The upper and lower ranges are given in Table 3.13.

In case of limitation by $F_{MSY} = F_{pa}$, the upper F_{MSY} limit equals the (capped) F_{MSY} and the lower limit is re-calculated using the capped F_{MSY} value (in this case, $F_{MSY} = 0.149$)

Table 3.13: upper and lower estimates for F_{MSY} unconstrained by F_{p05} (upper row), the final F_{MSY} reference point used, as limited by F_{p05} (lower row), and $F_{MSY\ upper}$ and $F_{MSY\ lower}$ corresponding with each

	Lower limit	estimate	Upper limit
F_{MSY} unconstrained	0.127	*0.460*	0.758
$F_{MSY} = F_{pa} = F_{p05}$	0.137	*0.149*	= F_{MSY}

3.7.4 MSY $B_{trigger}$

MSY $B_{trigger}$ is a lower bound of the SSB distribution when the stock is fished at F_{MSY} (ICES, 2021). As stated in the ICES technical guidelines, recent fishing mortality estimates need to be considered to set MSYB trigger as for most stocks that lack data on fishing at F_{MSY}, MSY B trigger is set at B_{pa}.

Here, the stock has been fished above F_{MSY} (0.149) for the last 5 years. Following the ICES technical guidelines our MSY $B_{trigger}$ will be equal to B_{pa}, MSY $B_{trigger}$ = 13 560 tonnes.

3.7.5 Final reference points

The final reference points are reflecting the changes of the stock since the last benchmark (Table 3.14). The new values cannot be compared with the old reference points directly. Not only did the stock unit change by merging two stocks, but also the biological parameter in the assessment have been changed (e.g., by using sliding window averages for weight-at-age and maturity, as well as incorporating new natural mortality estimates and discard survival). Additionally, the stock is displaying an exceptional increase in biomass, which has not been present at the last benchmark. As $F_{pa} = F_{p05}$ (ICES 2024d), only the F_{pa} value is displayed in table 7.

Table 3.14: Overview of the final biological reference points (BRP) for ple.27.21-32. Biomass-related BRP are rounded to the nearest ton, F-related BRP are rounded to 3 digits

BRP	Btrigger	B_{pa}	B_{lim}	F_{pa}	F_{MSY} unconstrained	F_{MSY} lower	F_{MSY}	F_{MSY} upper
value	13 460	13 460	11 119	0.149	0.460	0.137	0.149	= F_{MSY}

The reference points are quite sensitive to truncation of resampled years and the recruitment series, as well as the assumed autocorrelation within the recruitment series. The recent 10 years of sampling data are covering years with (decreasing) poor condition in the plaice stock, the F_{MSY} is reacting to that development by decreasing, suggesting to fish less to keep the stock above B_{lim}.

As the development of the stock is very dynamic and unforeseeable, the reference points should be re-evaluated in about 5 years.

3.8 Future considerations/recommendations

The inclusion of recreational catch data should be considered and tested. It is recommended to investigate the usefulness of recreational data during the assessment working group.

Although the age reading has been validated, not all historical otoliths have been checked at the time of the benchmark. Although the influence of the corrected ages so far has been small, the validation of historic data should continue. The most recent strong increase in biomass and SSB should be monitored as it is likely that the increase will not continue that strongly. The condition factor of plaice should be monitored, as well as oxygen depletion in the basins of the Baltic Sea. It would be beneficial to review the stock development and adapt the reference points accordingly in a benchmark process. The stock annex will be prepared and updated in advance to WGBFAS.

3.9 References

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3.10 Stock-specific working documents

WD1	Stock Identity and stock merging
WD2	Stock coordination and data overviews
WD3	Overview of the assessment runs and sensitivity
WD4	New natural mortality
WD5	Inclusion of discard survival
WD 6	Reference points
WD 7	Survey indices for Plaice in ICES areas 21-32

4 Reviewers' report

4.1 Timeline

The first Data Compilation Workshop (DCW) was held online from 3rd to 7th June 2024. The benchmark workshop was held in hybrid mode from the 21st to the 25th of October. Another hybrid meeting occurred on 16th September. At this meeting, the assessment teams provided updates and additional information on data/model decisions. To finalize the stock assessment of plaice in subdivision 27.21-32 another two meetings have been organized online on the 5th of November and the 4th of December. To finalize the reference points for the stock assessment of plaice in subdivision 27.21-32, a third meeting was organized online on the 17th of January 2025. All the meetings were attended by the experts and the external reviewers.

4.2 External chair's comments

The objective of the WKBPLAICE was to develop i) an ICES Category 3 assessment using a constant harvest rate (chr rule), as demonstrated from an MSE for the plaice in Division 7.e (western English Channel) , and ii) two Category 1 assessements for two adjacent plaice stocks, one in subdivisions 21–23 (Kattegat, Belt Seas, and the Sound) and the other in subdivisions 24–32 (Baltic Sea, excluding the Sound and Belt Seas). It was decided during the benchmark and after review by the ICES Stock Identification Methods Working Group that these two plaice stocks should be merged, so this objective changed to instead be the first benchmark assessment for the stock of plaice in subdivision 27.21-32, in the Baltic Sea and Kattegat.

Communication among reviewers and participants was very good throughout the WKBPLAICE benchmark process, which resulted in productive outcomes from this benchmark. The reviewers collectively agree that the methods agreed upon to resolve the above objectives have well-defined configurations and can be used for stock assessment of these stocks and to provide ICES advice according to ICES guidelines. The materials provided to reviewers for the plaice in Division 7.e were extremely clear and well-documented, so the process for providing feedback for this stock was very efficient and on time. Because the plaice in subdivision 27.21-32 became a new stock during the benchmark process, several of the results were delayed, but this was accepted by participants as a necessary short-term setback needed to support a greater goal of providing better long-term outcomes.

This newly created stock also presented a challenge because it showed a very unusual pattern of extreme growth over an extremely short and recent 5-year time period, which prevents any reliable assumption of future dynamics from being easily created (i.e., especially regarding stock-recruitment relationships and density-dependent effects of body condition and natural mortality). One of the benchmark participants expressed concern that the Category 1 framework for this stock was inappropriate, as these uncertainty in these assumptions would not be adequately addressed. The benefits of using an ensemble model approach were briefly discussed, but this approach was not feasible given the time constraints, which were made even tighter by the extra work inherent in merging the two stocks. Therefore, it was concluded by the majority that despite the drawback of high future uncertainty in stock dynamics, the Category 1 framework and model proposed were of high enough quality and sufficient to fulfil the task of providing advice over the timeframe of a benchmark cycle (aiming for 5 – 7 years), given that assumptions made in the benchmark do not deviate far from the reality that unfolds. If assumptions deviate greatly from assumptions of the long-term forecasts, then reference points should be revisited.

4.3 Reviewers' comments

4.3.1 Plaice in the western English Channel (ple.27.7e)

4.3.1.1 General comments

Prior to this benchmark, ICES advice for this stock was provided under category 3 using the rfb rule (Method 2.1 of ICES, 2024) with the UK-FSP survey index (ICES code B4381) as the biomass indicator. The rfb rule started to be used for this stock from 2022, but as the advice is biennial, it was applied twice, in 2022 and 2024.

The benchmark's aim for this stock was not to "upgrade" the stock to a category 1 data-rich stock assessment but instead to keep it in category 3 and conduct a stock-specific simulation (management strategy evaluation, MSE, in the sense of a closed-loop simulation), as recommended by ICES (2022), and tune a category 3 empirical harvest control rule to be used as the basis for the ICES catch advice. The empirical harvest control rule selected for this was the chr rule (Method 2.2 of ICES, 2024), in accordance with the conclusions of Fischer et al. (2023). For comparison, the rfb rule and the category 1 data-rich approach (MSY rule) were tested with the MSE framework but not tuned.

During the DCW, input data and the settings of the SAM model (Nielsen and Berg, 2014) for the stock of plaice in Division 7.e (western English Channel) were presented and discussed. Also, the Operating Models (OMs), based on the SAM model, were presented, specifically a reference set of 7 models, in which different model settings required re-fitting the model, and a set of 7 robustness test models, where different assumptions were created surrounding future stock dynamics that did not require re-fitting the model. After the definition of this combined set of models and settings (14 variants) was finalized, the proposed catch rule was optimized using the 7 reference OMs and tested on both sets of OMs and results were presented at the benchmark meeting held in October. The group scrutinized the work and was able to identify the best option to produce the advice for this stock. All the process was carried out and presented in a very clear and detailed way.

4.3.1.2 Operating models and sampling procedure

The conditioning of the age-structured stochastic operating models (OMs) for this plaice stock followed the approach described by ICES (2019) and Fischer et al. (2023). That is, the operating models were based on the model fits of the state-space assessment model SAM (Nielsen & Berg, 2014) to the data.

The baseline operating model was based on the SAM model fit considered most plausible by WKBPLAICE. More precisely, the data used in this model, along with its configuration, were discussed within the data meeting based on a thorough review of the available data and updates to the biological information.

For the baseline SAM OM, specific decisions about the input data (e.g. about discard mortality) and assumptions (e.g. about natural mortality M) were made. However, there is a degree of uncertainty about these decisions and further specifications of the MSE simulation. To address this, a range of alternative operating models were developed to ensure that the proposed management procedure is robust to such uncertainties. The alternative models are divided into two sets: the reference set, which includes the more plausible operating models, and the robustness set, which is designed to test the management procedures under more extreme and less likely scenarios. The reference set considers alternative assumptions regarding discard survival, natural mortality, and migration from Division 7.d, while the robustness set focuses on alternative recruitment assumptions, including a recruitment failure, Total Allowable Catch (TAC) implementation errors, and a higher level of uncertainty in the biomass indices. The WKPLAICE agrees that the two sets of OMs allow the main sources of uncertainty to be considered.

Note that the uncertainty in each OM was adequately accounted for by generating 1,000 different but self-consistent simulation replicates. Each replicate represents a unique parameter set derived from the variance-covariance matrix of the SAM model fit, reflecting one possible outcome of the model.

The sampling process for both biomass indices and catches was conducted in accordance with best practices, incorporating the error structure from the SAM model. Additionally, the sampling included a procedure for generating length data, whereby the age frequencies of the catch were converted into length frequencies using stock-specific age-length keys. Length data in the MSE was only required for the rfb rule included for comparison purposes.

4.3.1.3 Management procedures

The chr rule was tuned with this stock-specific MSE to optimize its performance. The control parameters of the chr rule included in the tuning process were the multiplier for adjusting the harvest rate (x), the parameter linking $I_{trigger}$ to I_{loss} (w), the number of years used in calculating the mean of the biomass index (n1), and the advice interval (v). The tuning focuses on maximizing long-term catches while ensuring that long-term Blim risk, defined as the maximum of the annual probabilities, does not exceed 5%. The optimization process was conducted manually using sufficiently fine grids of values for parameters x and w to ensure the correct optimal values were identified. For parameters n1 and v, the possible values were set to 1 and 2.

In an initial step, the optimization was carried out on the baseline OM, and considering the UK-FSP survey index in the chr rule. These initial explorations showed that options n1=1; v=2 and n1=2; v=1 produced similar results as n1=v=1 and n1=v=2, so only these latter options were considered in the final tuning.

The final tuning was conducted with the operating model reference set, which included seven different operating models. This set of operating models was treated as one large ensemble operating model, essentially giving each of the individual operating models the same weight. In this tuning, two versions of the chr rule were tuned: the chr using the UK-FSP survey (already considered in the initial explorations) and the chr using the Q1SWBeam survey (ICES code B2732). Finally, a total of 10 tuned versions of the chr rule were presented: five based on the UK-FSP survey and five using the Q1SWBeam survey. For each survey index there were different options available, depending on whether only the x parameter was tuned, or whether both the x and w parameters were tuned. Local and global optimums were provided when both parameters are tuned.

A comprehensive set of tables and figures has been provided for a clear illustration of the optimisation process and the results of each management procedure. These include measures and plots of relative catch and SSB, catch variability and Blim risk for the ensemble operating model, over the entire projection period, and for the short and long terms. Although the three options have been provided, decisions are mainly based on the long term, as the short-term performance is critically dependent on the initial state of the stock. For example, in the operating model reference set, the risk of falling below Blim was 12.7% at the beginning of the simulation. This meant that in the initial period even zero fishing would not have been precautionary.

It is important to note why the MPs derived from both local and global optima were presented as options. The global optima results tend to set the $I_{trigger}$ at much higher values, while the local optimum establishes a lower $I_{trigger}$ and also reduces the value of x, the parameter that adjusts the harvest rate. As setting a high $I_{trigger}$ could be problematic (stability clause, lower and upper limits in the catch advice are deactivated in this situation), both options were reported and their implications were analyzed and discussed in detail in the WKPLAICE (details are provided below).

In order to select an MP from the set of 10 alternatives, we first examined which option produced the highest long-term catch relative to MSY in the ensemble model, given that the risk remained below 5% for all MPs. The preferred MP, based on these criteria, was the chr rule based on UK-FSP survey, with x and w in the global optimum and n1=v=2 (termed MP5). As a global optimum, it sets $I_{trigger}$ at a relatively high level. Therefore, the group discussed if this can be a problematic or not assessing the proportion of simulation replicates where the biomass index falls below $I_{trigger}$. For MP5, this proportion was around 10%, a relatively moderate value, hence this supported the suitability of this MP5 as a management procedure for this plaice stock.

It was also discussed that this method MP5 shows a higher year-to-year variability in catch than the one based on the local optimum (MP4). However, it was concluded that for this stock, where catches do not reach the TAC (it is not a target species), the year-to-year variability in the recommended catches is not as critical as for other stocks where the fishing sector needs more stability to effectively maintain the fleet. ICES also does not provide any criteria for evaluating year-to-year variability, so it was not used in final decision-making.

After analysis of the ensemble model results, the MPs were also applied individually to each of the OMs in both the reference and robustness sets. MP5 showed adequate performance, long term high catches and probability of falling below Blim that was below 5% in all OMs except the low natural mortality OM where this risk slightly exceeded 5%. This particular OM was a challenge because its initial SSB at the beginning of the projection is so low that even a zero-catch scenario would not be precautionary in the short term (10 years). In addition, it is important to consider the fact that this OM is part of the reference set used in the tuning process and that it has therefore played its role by reducing the catches with respect to the value that would be obtained in the tuning without this model.

Moreover, the other MPs show similar behaviour for the OM with low M. For example, for the MP4, the risk of falling below Blim in the OM with low M is even higher than for MP5. Furthermore, MP4 also has a risk of falling below Blim that is higher than 5% for the OM with recruitment failure, which is not the case for MP5. For all these reasons, MP5 was supported as the catch rule for this plaice stock.

In summary, the WKPLAICE group concludes that this work aligns with the MSE best practices, ICES guidelines for MSE, and also ICES recommendations for stock-specific data-limited MSE, and that there is sufficient evidence to support MP5 as an effective and appropriate management procedure for this plaice stock.

This work included a comparison with the rfb rule and the data-rich category 1 MSY rule. This comparison was necessary as the rfb rule had previously been applied to this stock, while the MSY rule is the alternative if the stock had been upgraded to category 1. The conclusions were that: the rfb rule was precautionary in the long term in the reference set operating model, but led to relatively low catches, whereas the ICES MSY rule was not precautionary in the long term, but led to relatively stable stock dynamics after about five years. These conclusions support the view that the best option for this stock was to tune the chr rule with an ensemble MSE.

In addition, the format of the advice sheet for this stock, based on the newly selected procedure, was presented, reviewed and agreed during the WKPLAICE.

Annex 1: List of participants

Data evaluation workshop (date)

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Benchmark workshop participants

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Annex 2: Resolutions

2023/WK/FRSG00 A **Benchmark workshop on selected plaice stocks (**WKBPLAICE**),** chaired by Stefanie Haase, Germany, and Pamela Woods, Iceland, and attended by reviewers Marta Cousido Rocha, Spain, and Silvia Angelini, Italy, will be established and meet online on 3-7 June 2024 for a data evaluation workshop, and on 21-25 October 2024 at ICES Headquarters, Copenhagen, for an assessment methods workshop. WKBPLAICE will:

a) As part of the data workshop:
   1. Consider the quality of data proposed for use in the assessment;
   2. Consider stock identity and migration issues, if appropriate;
   3. Make a proposal to the benchmark on the use and treatment of data for each assessment, including discards, surveys, life history, etc.
      i. Note: stakeholders are also invited to contribute data in advance of the data evaluation 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 14 days prior to the meeting.

c) As part of the assessment methods workshop, agree to and thoroughly document the most appropriate, data, methods, and assumptions for:
   1. Obtaining population abundance and exploitation level estimates (conducting the stock assessment);
   2. Estimating fisheries and biomass reference points that are in line with ICES guidelines (see latest technical guidelines on reference points);
      i. Note: If additional time is needed to conduct the work and agree to reference points, an additional reference point workshop could be scheduled.
   3. Conducting the short-term forecast.

d) As part of the assessment methods workshop, 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.

e) If no analytical assessment method can be agreed upon, then an alternative method (the former method, or following the ICES data-limited stock approach see WKLIFE X[1], including considerations of stock-specific tuning with a management strategy evaluation, if possible) should be put forward by the benchmark;

f) Update the stock annex;

g) With support from the ICES Secretariat, document the stock assessments in the Transparent Assessment Framework (TAF)[2]; and

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[1] ICES. 2020. Tenth Workshop on the Development of Quantitative Assessment Methodologies based on LIFE-history traits, exploitation characteristics, and other relevant parameters for data-limited stocks (WKLIFE XI). ICES Scientific Reports. 2:98. 72 pp. http://doi.org/10.17895/ices.pub.5985

[2] https://taf.ices.dk/app/procedure

h) Develop recommendations for future improvements in the assessment methodology and data collection.

WKBPLAICE will report by 31 January 2025 for the attention of ACOM.

Recurrent advice subject to benchmark				
Stock name	**Stock code**	**Current assessment**	**Aimed at the benchmark**	**DOI link to latest ICES advice**
Plaice (Pleuronectes platessa) in subdivisions 21–23 (Kattegat, Belt Seas, and the Sound)	ple.27.21-23	Age-based analytical assessment Model: SAM	Improve model parametrization and consider input data. Update reference points.	https://doi.org/10.17895/ices.advice.25019435
Plaice (Pleuronectes platessa) in subdivisions 24–32 (Baltic Sea, excluding the Sound and Belt Seas)	ple.27.24-32	Surplus production model Model: SPiCT	Age-based analytical assessment Model: SAM	https://doi.org/10.17895/ices.advice.25019438
Plaice (Pleuronectes platessa) in Division 7.e (western English Channel)	ple.27.7e	Survey biomass trend applying a specific ICES rule to provide catch advice	stock-specific management strategy evaluation AND tune a category 3 data-limited empirical harvest control rule	https://doi.org/10.17895/ices.advice.25019453

Annex 3: Working documents for ple.27.21-32 presented at WKBPLAICE

Working documents presented at WKBPLAICE meeting for plaice 27.21-32 can be viewed and downloaded from the ICES library under folder Annex 3:

https://doi.org/10.17895/ices.pub.28400255

Annex 4: Working documents for ple.27.7e presented at WKBPLAICE

Working documents presented at WKBPLAICE meeting for plaice 27.21-32 can be viewed and downloaded from the ICES library under folder Annex 4:

https://doi.org/10.17895/ices.pub.28400255