BENCHMARK WORKSHOP ON APPLICATION OF STOCK SYNTHESIS (SS3) ON SELECTED STOCKS (WKBSS3)

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

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

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Editors

Massimiliano Cardinale • Henning Winker

Reviewers

Tanja Miethe • Giuseppe Scarcella

Authors

Mikel Aristegui-Ezquibela • Ewen D. Bell • Paul Bouch • Paola Castellano • Santiago Cervino
Hubert Du Pontavcie • Wendy Edwards • Inês Farias • Simon Fischer • Paul Gatti • Hans Gerritsen
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Chantel Rene Wetzel • Mathieu Woillez

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Contents

i Executive summary

Benchmark workshop on application of Stock Synthesis (SS3) on selected stocks (WKBSS3) is the first dedicated ICES benchmark workshop to stocks assessed using only Stock Synthesis models (SS). Four stocks were included in the ToRs (ank.27.8c9a; Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a, Cantabrian Sea, Atlantic Iberian waters; mon.27.8c9a; White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a, Cantabrian Sea and Atlantic Iberian waters, pol.27.67; Pollack (*Pollachius pollachius*) in subareas 6-7; Celtic Seas and the English Channel; sbr.27.9; Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9; Atlantic Iberian waters. The stocks pertain to three ICES Assessment Working Groups (WGBIE, WGCSE, and WGDEEP) and were selected based on the availability of appropriate data and network capacity.

Stock assessments using SS models were successful for all stocks and accepted by WKBSS3 as adequate to provide advice. Preliminary SS assessment runs were already presented and discussed during the data meeting and in a dedicated 1-day meeting on the 10th of February. Except pollack, all stocks were assessed using sex separated models including Blackspot seabream for which the model was also accounting for sex change (proterandric hermaphroditic). Several model configurations were tested for each stock based on a grid of uncertainty built on hypothesis testing. The different model configurations to be used to select the "BestCase" model for advice were compared using model diagnostics. The overarching strategy to select the "BestCase" model for advice was based on model diagnostics as described by ICES guidelines. The key model diagnostics used were runs test and RMSE for the analysis of the residuals, retrospective analysis and hindcasting cross validation. Once the "BestCase" model has been selected, additional model diagnostics as jittering and likelihood profiling were also used.

Reference points (i.e. F_{MSY} and MSY $B_{trigger}$) were estimated using ICES standard procedures with Eqsim and a full-feedback loop simulations tool for reference points estimation (FLRPE) developed in line with WKREFNEW recommendations. Eqsim derived F_{MSY} was compared to alternative level of fishing mortality using FLRPE but maintaining both B_{lim} and MSY $B_{trigger}$ as in Eqsim. A very similar machinery has been already used for deriving reference points for Central Baltic herring (ICES 2023) and Northern shrimp (ICES 2022). FLRPE has the clear advantage compared to a flat simulation as implemented in Eqsim as it emulates an annual update of the benchmark assessment model by passing outcomes (SSB and F) from the 'true' age-structured dynamics from the operating model (OM) with assessment error to the harvest control rule (HCR) and catch implementation system. The feedback control loop between the implementation system and the OM allows accounting for the lag between the last of year data used in the assessment and the implementation year of catch advice. Moreover, it has the ability to retain the two-sex structure of the original assessment models, when present. The comparison between Eqsim and FLRPE highlighted that Eqsim F_{MSY} is not precautionary or will result in loss of yields and therefore Eqsim should not be used for deriving reference points in the future or should be always tested against a full-feedback loop simulations tool for reference points estimation as FLRPE.

For Black-bellied anglerfish in divisions 8.c and 9.a, Cantabrian Sea, White anglerfish in divisions 8.c and 9.a, Cantabrian Sea and Atlantic Iberian waters and Pollack in subareas 6-7; Celtic Seas and the English Channel, Eqsim estimated F_{MSY} was not precautionary when tested using FLRPE and therefore it was rejected and FLRPE estimated F_{MSY} was adopted. For Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9; Atlantic Iberian waters, Eqsim estimated F_{MSY} was precautionary when tested using FLRPE. However, Eqsim estimated F_{MSY} was larger than F_{MSY} estimated by the model and therefore F_{MSY} was based on the value estimated internally by the Stock Synthesis model. Specifically, for White anglerfish, the selected Fadv is 0.75Fmsy.Btri.eq, corre-

sponding to 0.355 (less than 5% risk, same catches than 0.775Fmsy.Btri.eq). For Black-bellied anglerfish, the selected Fadv is 0.95Fmsy.Btri.eq, corresponding to 0.173 (less than 5% risk). For pollack, the selected Fadv is 0.90Fmsy.Btri.eq, corresponding to 0.278 (less than 5% risk and less than 1% reduction in long-term catch compared to Fmsy.Btri.eq). For Blackspot seabream, the selected Fadv is 1Fmsy.Btri.eq, corresponding to 0.099 (less than 5% risk; same F_{MSY} as estimated by Stock Synthesis and same catches as Fmsy.eq.Btri.eq). It is also important to note that for White anglerfish, a lower F down to 0.284 will result in a loss of 3% of the catches with almost 40% more SSB at equilibrium; For Black-bellied anglerfish, a lower F down to 0.118 will results in a loss of 5% of the catches with more than 50% SSB at equilibrium. For pollack, a lower F of 0.214 results in a loss of 4% the long-term catch with a 20% increase in long-term SSB under the full recruitment scenario. For Blackspot seabream, a lower F down to 0.056 will result in a loss of about 5% of the catches with more than 50% SSB.

Finally, forecast settings to be used during the incoming update assessment during spring were presented and agreed.

ii Expert group information

Expert group name	Benchmark workshop on application of Stock Synthesis (SS3) on selected stocks.
Expert group cycle	Annual
Year cycle started	2024
Reporting year in cycle	1/1
Chairs	Massimiliano Cardinale (Sweden)
	Henning Winker (FAO)
Reviewers	Tanja Miethe (UK (Scotland))
	Giuseppe Scarcella (Italy)
Meeting venues and dates	Data: 20 – 24 January 2025, ICES Headquarters, Copenhagen, and online.
	Assessment: 17 – 21 February 2025, ICES Headquarters, Copenhagen, and online.

1 Introduction

1.1.1 Terms of reference

[2025]/WK/FRSG[00] A Benchmark workshop on application of Stock Synthesis (SS3) on selected stocks (WKBSS3), chaired by Max Cardinale (SLU) and Henning Winker (GFCM), and attended by invited external experts Tanja Miethe, MSS, and Giuseppe Scarcella, IRBIM; will be established and meet 20-24 January, at ICES, Copenhagen, for the data workshop, and 17 – 21 February, at ICES, Copenhagen, for the assessment methods workshop. An online workshop to prepare the data call for Pollack (Pollachius pollachius) in subareas 6-7 (Celtic Seas and the English Channel) will be held during late Summer, 2024. WKBSS3 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;

3. Make a proposal to the benchmark on the use and treatment of data for each assessment, including discards, surveys, life history, etc.;

4. Invite stakeholders 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:

5. 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:

6. Obtaining population abundance and exploitation level estimates (conducting the stock assessment);

7. 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.

8. 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 as outlined in WKLIFE XI) should be put forward by the benchmark;

f) Update the Stock Annex; and

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

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

WKBSS3 will report by 28 February for the attention of ACOM.

Recurrent advice subject to benchmark	
ank.27.8c9a	Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)
mon.27.8c9a	White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)
pol.27.67	Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel)
sbr.27.9	Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

Conduct of benchmark

The list of participants and the agendas for the data workshop and the assessment benchmark workshop meetings are presented in Annex 1.

To ensure credibility, salience, legitimacy, transparency, and accountability in ICES work all contributors to ICES work are required to abide by the ICES Code of Ethics and Professional Conduct. This was brought to the attention of participants at the workshop and no conflict of interest was reported.

Henning Winker and Max Cardinale provided to all participants a GitHub repository prior to the meeting where all necessary scripts and code for conducting the benchmark were stored (akatan999/Stock-synthesis-toolbox-for-ICES-benchmarks: Code and scripts for ICES stock synthesis benchmarked models).

Input data for Stock Synthesis assessment runs were presented during the data workshop (20–24 January 2024) for each of the stocks listed above. Input data included biological information or each stock as growth and natural mortality and maturity, size and age compositions, discards, landings and catch data, standardised survey and commercial CPUE time-series. Preliminary Stock Synthesis assessment runs were also presented and discussed during the data meeting and in a dedicated 1-day meeting on the 10th of February.

The following four stocks were considered for the assessment benchmark meeting (17–21 February 2025):

- ank.27.8c9a Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)
- mon.27.8c9a White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)
- pol.27.67 Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel)
- sbr.27.9 Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

On a very positive note, the stock assessors followed best practices in developing Stock Synthesis models to great detail and made use of the additional methodologies provided by the Chairs in the dedicated GitHub repository. Standardization procedures of the commercial CPUE indices followed best practices and discussed and outlined during the data meeting. For all stocks, a grid of uncertainty built on hypothesis testing was presented on Monday morning. The presentations of the benchmark results were of high quality and special care was given to the evaluation of the input data.

Reference point estimation

Reference points (i.e. F_{MSY} and MSY $B_{trigger}$) were estimated using ICES standard procedures with Eqsim and plug in a full-feedback loop simulations tool for reference points estimation (FLRPE) developed in line with WKREFNEW recommendations and compared to alternative level of fishing mortality maintaining both B_{lim} and MSY $B_{trigger}$ as in Eqsim. For Black-bellied anglerfish in divisions 8.c and 9.a, Cantabrian Sea, White anglerfish in divisions 8.c and 9.a, Cantabrian Sea and Atlantic Iberian waters and Pollack in subareas 6-7; Celtic Seas and the English Channel, Eqsim estimated F_{MSY} was not precautionary when tested using FLRPE and therefore it was rejected and FLRPE estimated F_{MSY} was adopted. For Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9; Atlantic Iberian waters, Eqsim estimated F_{MSY} was precautionary when tested using FLRPE. However, Eqsim estimated F_{MSY} achieved less long-term catches than several of the alternative F used in the FLRPE and therefore F_{MSY} was based on FLRPE and corresponded for Blackspot seabream to the F_{MSY} estimated internally by the Stock Synthesis model.

In contrast to a full Management Strategy Evaluation (MSE) simulation design (Punt et al. 2016), the MSE 'shortcut' approach (here after defined as full-feedback loop simulations tool for reference points estimation (FLRPE)), omits the step of the annual updating of the estimation model (assessment) in the feedback control. Instead, it emulates an annual update of the benchmark assessment model by passing outcomes (SSB and F) from the 'true' age-structured dynamics from the operating model (OM) with assessment error to the harvest control rule (HCR) and catch implementation system. The HCRs were applied using a simulated feedback control loop between the implementation system and the operating model, where the implementation system translates the emulated assessment outcome via the HRC into the Total Allowable Catch (TAC) advice. The feedback control loop between the implementation system and the OM allows accounting for the lag between the last of year data used in the assessment and the implementation year of catch advice (*Cadv*). The implementation system of the harvest control rule assumes that advice is given for year $y + 1$ based on an assessment completed in year y, which is fitted to data up until last data year $y - 1$. Therefore, implementation of the derived the *Cadv* through HCR requires projection of the stock dynamics by way of a short-term forecast. To do this, numbers-at-age were projected through the year of assessment. Status quo recruitment, *Ma*, *wa* and *mata* were set as the mean of the last 3 years. A projection based on a fixed fishing mortality-at-age to the last year ($y - 1$) in the assessment is then made through to the implementation year ($y + 1$). The limitations of the FLRPE approach are that it cannot fully account for uncertainties resulting from imperfect sampling of the full age-structure (e.g. poorly sampled recruits), observation error, misspecified model assumptions and selectivity. On the other hand, the FLRPE approach is straight-forward to implement (FLR) and reduced complexity and computation time when the focus is predominantly optimizing HCRs for setting quotas on the premises that a benchmark assessment form the basis for the advice. Moreover, because it mimics the management system, it has a clear advantage compared to the flat simulations as implemented in Eqsim, and it retains the two-sex structure of the original assessment models, when present. Here, the FLRPE is implemented using the tools available in the Fisheries Library for R (FLR; Kell et al., 2007; https://flr-project.org/).

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2 Black-bellied anglerfish in the Cantabrian Sea and Atlantic Iberian waters

Lophius budegassa in divisions 8.c and 9.a | ank.27.8c9a

2.1 Introduction

Lophius budegassa in divisions 8.c and 9.a (ank.27.8c9a) was last benchmarked in 2021 (ICES, 2021a) and a stochastic production model in continuous-time (SPiCT) (Pedersen and Berg, 2017) has been in use to assess this stock. Results from this benchmark highlighted the need to improve the LPUE index and encourage the future adoption a length-structured model such as Stock Synthesis (SS3; Methot Jr. and Wetzel, 2013). Tests with SS3 have been conducted at the benchmarks WKFLAT (ICES, 2012) and WKANGLER (ICES, 2018), as well as during the Workshop on Tools and Development of Stock Assessment Models Using a4a and Stock Synthesis (WKTADSA; ICES, 2021b). In this latter, a length-based model was developed assuming one area, one season, catch data from nets fleets (gillnets and trammel nets) and from trawl fleets (data from Portugal and Spain combined), two commercial LPUE indices and one biomass series from SP-NORTH (G2784) to inform about recruitment. Results were considered promising, although more work was required to reach a base model.

2.1.1 Fishery information

Lophius budegassa is mainly caught by the Spanish and Portuguese bottom trawlers and net fisheries (gillnet and trammel nets). French trawl, gillnet and trammel net fisheries also catch *L. budegassa*, but reported values represent <1% (on average) of the total stock landings. The Spanish landings have traditionally been mostly allocated to the trawl fleet, followed by the gillnet fishery. Portuguese landings are mainly attributed to the artisanal fleet (gillnets and trammel nets), followed by the trawl fleet.

The length distribution of the landings varies among fisheries, with gillnet and artisanal landings showing higher mean lengths compared to the trawl landings.

In this area, the commercial interest for both *Lophius* started in the late 1970´s (Duarte, 2002) and gained a special interest in the 1980´s due to its acceptance in the market trade (Azevedo, 1996). Despite target fisheries development in the late 1970s, previously, the species was likely to be caught and discarded in other fisheries, so exploitation was likely to occur before the beginning of the available time-series.

2.1.2 Current assessment and advice

This stock was last benchmarked in 2021 at WKMSYSPiCT (ICES, 2021a), and SPiCT has been used to assess the stock from 2021 to 2024. This model assumes the Schaefer population growth model (fixed parameter) and the default biomass and catches observed/process error ratios (alpha and beta, respectively).

The SPiCT input data:

- Total landings from 1980–2022 2023 (discards are considered negligible).
- Portuguese trawl fleet targeting fish (1989–2023).

SPiCT settings:

- Euler time-step (years): 1/16 (default).
- CPUE at the middle of the year.
- Production curve shape: assume Schaefer (n = 2).
- B/K prior: assume initial depletion rate of 0.5.
- Other parameters: default (estimated by the model).

In this model, only one LPUE was used. Other indices were considered not adequate. The LPUE from the Portuguese trawl fleet targeting crustaceans (PT-TRC9a) and the SP-ARSA research surveys in the Gulf of Cadiz (G4309) could lead the stock to very optimistic values not in agreement with the trajectory of the historical landings. The Spanish LPUE from the A Coruña trawl fleet (SP-CORTR8c) previously used was not updated since 2012 and was not standardized; a new series starting in 2013 was also not standardized. The Northern Spanish Shelf Groundfish Survey in the Cantabrian Sea and Off Galicia (SP-NORTH) was not considered a good indicator for the exploitable part of population although potentially a good indicator for smaller individuals.

In the last assessment, fishing pressure on the stock was considered below F_{MSY}, and biomass above MSY $B_{trigger}$ and B_{lim} (Figure 2.1). The advice for 2025 was 2486 tonnes, which corresponded to an increase of 17%.

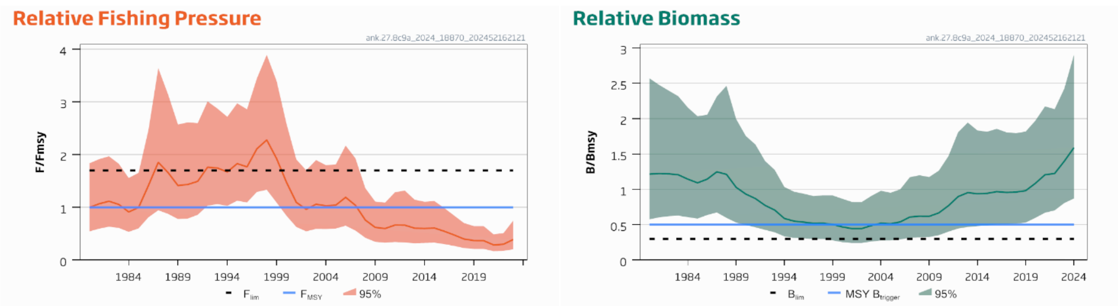

Figure 2.1. Black-bellied anglerfish in divisions 8.c and 9.a. Summary of the stock assessment. Published in ICES (2024b).

2.1.3 Comments on current assessment

Since 2017 that advised catches combined for the two *Lophius* species in divisions 8.c and 9.a are considerably lower than the agreed TAC for *Lophius* spp. for the same area. Although TAC has been increasing in line with the ICES advice, landings of the two species have been decreasing. In 2023, despite the high increase of *Lophius* spp. landings in the distribution area of the stock, those only represented 43% of the TAC. The perception of the stock status seems to differ in the northern and southern parts of the stock. The reasons for this mismatch are not totally understood. WGBIE noted that reliable information for the northern waters of the stock was missing (ICES, 2024a).

2.2 Input data for stock assessment

2.2.1 Catch data

2.2.1.1 Landings

Quarterly landing data have been reported by ICES division and métier by Spain (since 1978), Portugal (since 1978) and France (since 2000). For WKBSS3 only French data was updated. Portuguese and Spanish are available in InterCatch since 2002.

Landings by division and fleet are presented in Table 2.1 and Figures 2.2-2.3. Landings for this stock mostly derive from trawl fleets operating in ICES Divisions 8c and 9a (59% of total landings in 2023) and from the Portuguese artisanal/polyvalent fleet operating in ICES division 9a (mainly gillnets and trammel nets; 31% in 2023). Spanish gillnet fisheries also contribute to a great fraction of the catches (9.5% in 2023). For the purpose of this report, "nets" will hereafter refer to gillnets and trammel nets (applicable for the three countries).

It should be noted that Portuguese landings were TAC constrained from 2005 to 2011 and again in 2023 and consequently, low landings were registered in the 3^{th} and/or 4^{th} quarters during that time period. Since 2010 that Portuguese landings in the 1st quarter are also lower due to the prohibition to land *Lophius* species in January and February (to protect these species during the reproductive season).

Table 2.1. Landings of *L. budegassa* (in tonnes) in ICES divisions 8c and 9a by country and fishing fleets (1978–2023).

	Div. 8c							Div. 9a							Div. 8c+9a	
	SPAIN			FRANCE				SPAIN			PORTUGAL					
Year	Trawl	Gillnet	Others	Trawl	Gillnet	Others	TOTAL	Trawl	Gillnet	Others	Trawl	Artisanal	TOTAL	SUBTOTAL	Unallocated/ Non reported	TOTAL
1978	n/a	n/a					n/a	248			n/a	107	355	355		355
1979	n/a	n/a					n/a	306			n/a	210	516	516		516
1980	1203	207					1409	385			n/a	315	700	2110		2110
1981	1159	309					1468	505			n/a	327	832	2300		2300
1982	827	413					1240	841			n/a	288	1129	2369		2369
1983	1064	188					1252	699			n/a	428	1127	2379		2379
1984	514	176					690	558			223	458	1239	1929		1929
1985	366	123					489	437			254	653	1344	1833		1833
1986	553	585					1138	379			200	847	1425	2563		2563
1987	1094	888					1982	813			232	804	1849	3832		3832
1988	1058	1010					2068	684			188	760	1632	3700		3700
1989	648	351					999	764			272	542	1579	2578		2578
1990	491	142					633	689			387	625	1701	2334		2334
1991	503	76					579	559			309	716	1584	2162		2162
1992	451	57					508	485			287	832	1603	2111		2111
1993	516	292					809	627			196	596	1418	2227		2227
1994	542	201					743	475			79	283	837	1580		1580
1995	924	104					1029	615			68	131	814	1843		1843
1996	840	105					945	342			133	210	684	1629		1629
1997	800	198					998	524			81	210	815	1813		1813
1998	748	148					896	681			181	332	1194	2089		2089
1999	565	127					692	671			110	406	1187	1879		1879
2000	441	73		13	0	0	528	377			142	336	855	1383		1383
2001	383	69		21	4	0	477	190			101	269	560	1038		1038
2002	202	74		19	2	0	298	234	0	0	75	213	522	820		820
2003	279	49		18	0	0	347	305	0	0	68	224	597	944		944
2004	251	120		29	2	0	402	285	0	0	50	267	603	1004		1004
2005	273	97		54	11	0	434	283	0	0	31	214	527	961		961
2006	323	124		23	2	0	472	541	0	0	39	121	701	1172		1172
2007	372	68		0	0	0	440	684	0	0	66	111	861	1301		1301
2008	386	70		7	2	0	465	336	0	0	40	119	495	960		960
2009	301	148		0	0	0	449	172	0	0	34	114	320	769		769
2010	319	81		8	1	0	408	197	0	0	70	84	351	760		760
2011	214	115	32	2	1	0	363	157	60	98	75	119	510	873	74	947
2012	161	83	22	2	1	0	268	109	40	90	156	370	765	1033	109	1141
2013	221	135	14	5	3	0	379	95	55	90	100	258	598	977	98	1075
2014	187	126	7	5	6	0	331	120	47	4	116	286	572	903	100	1003
2015	233	141	1	3	6	0	384	103	62	2	126	222	515	899	152	1051
2016	203	118	5	1	5	0	333	103	79	2	120	257	560	892	125	1017
2017	163	153	0	1	3	0	320	109	62	1	68	302	542	862		862
2018	186	156	1	0	0	0	343	126	37	1	52	185	402	745	11	757
2019	137	117	0	1	2	0	258	109	49	1	43	135	337	595	73	668
2020	126	65	0	4	2	0	197	138	5	3	128	321	596	792		792
2021	122	24	0	1	0	0	147	116	23	2	97	331	570	717		717
2022	111	23	0	0	0	0	135	139	7	1	78	262	487	621		621
2023	184	83	2	1	0	0	270	247	12	3	152	314	727	997		997

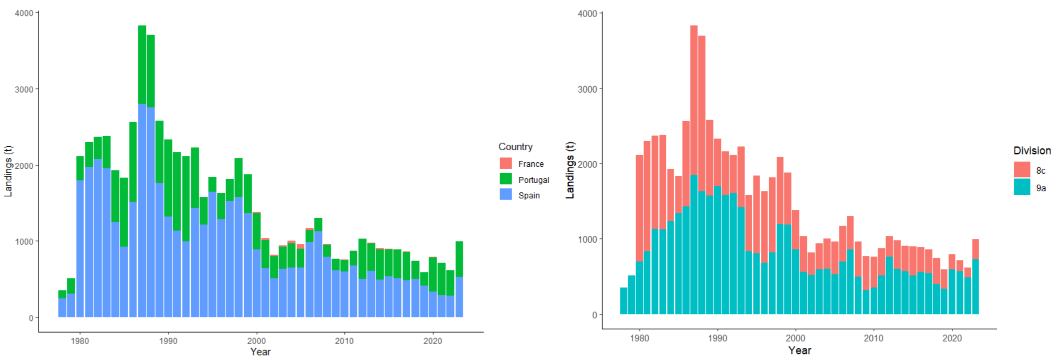

Figure 2.2. Total landings of *L. budegassa* (in tonnes) in ICES divisions 8c and 9a by country and by division (1978–2023).

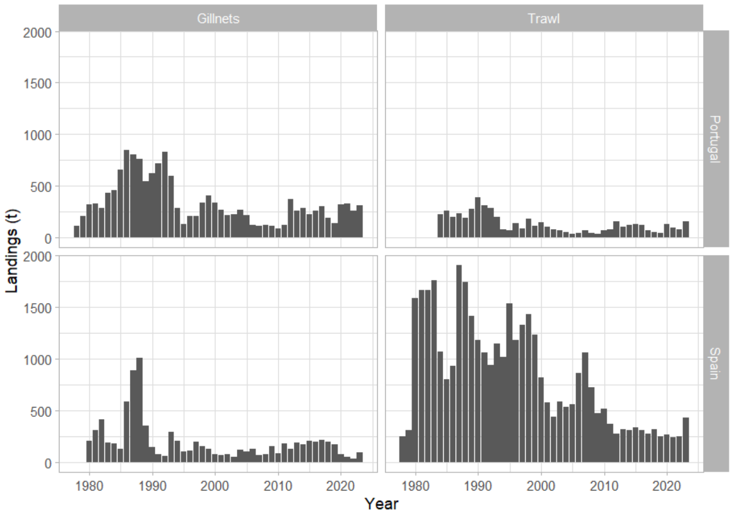

Figure 2.3. Total landings of L. budegassa (in tonnes) in ICES divisions 8c and 9a by country and by fleet (1978–2023). Portuguese Artisanal fleet presented as "gillnets" as catches mostly derive from gillnets and trammel nets.

There is a latitudinal gradient observed in the proportion of these species, with *L. budegassa* proportions increasing remarkably from the northern to the southern landing ports.

This species is usually landed with the white anglerfish and can be recorded together in the ports' statistics. Therefore, estimates of each species in Spanish landings from divisions 8c and 9a and Portuguese landings of Division 9a are derived from their relative proportions in market samples or proportion in surveys (in the early years), by area. Sampling data from Portugal suggests that species identification greatly improved in recent years with potential significant misidentification issues at a smaller number of landing ports. Consequently, since 2021 that Portuguese landings correspond to the official landings of each species (with corrections for a reduced number of ports if needed).

There is a series of unreported landings for the period 2011–2019 allocated to Spain, which represents from 1 to 15% of total landings from the respective years. The unreported landings are considered realistic and are included in the stock assessment. For this benchmark, unreported landings were equally split by quarter.

Historical data from 1911 to 1980 in ICES divisions 8c and 9a available in ICES database are not considered adequate to be used for assessment.

2.2.1.2 Discards

Spain provides an annual estimate of discards in weight for trawl since 1994 (with gaps for years 1995, 1996, 1998, 2001 and 2002) and for gillnets fleet since 2013 (Table 2.2). With exception of 2006 and 2010, discards for the trawl and gillnet fleets represent very low proportions of the total catches in each year. Quarterly information is only available since 2013. The number of individuals and trips sampled is variable and the data, although tested, was not included in the base case model.

In Portugal, this species has low frequency of occurrence in discards from the trawl fleet (Fernandes et al., 2017). Discards from the artisanal/polyvalent fleet are not quantified.

The assessment currently excludes discards, which have been considered negligible for Portuguese fleets and low for Spanish fleets.

Table 2.2. Weight and percentage of discards of *Lophius budegassa* in ICES divisions 8c and 9a for Spanish trawl and gillnet fleets.

TRAWL				
Year	Weight (t)	CV	% Trawl Catches	% Total Catches
1994	6.1	24.4	0.6	0.4
1995	n/a	n/a	n/a	n/a
1996	n/a	n/a	n/a	n/a
1997	21.3	35.2	1.6	1.2
1998	n/a	n/a	n/a	n/a
1999	19.7	43.7	1.6	1.0
2000	8.7	35.1	1.1	0.6
2001	n/a	n/a	n/a	n/a
2002	n/a	n/a	n/a	n/a
2003	1.4	n/a	0.2	0.1
2004	10.9	n/a	2.0	1.1
2005	9.3	n/a	1.7	1.0
2006	114.0	n/a	11.7	9.7
2007	4.2	n/a	0.4	0.3
2008	4.9	n/a	0.7	0.5
2009	23.3	n/a	4.7	3.0
2010	63.5	n/a	11.0	8.4
2011	19.7	n/a	5.0	2.1
2012	5.9	n/a	2.1	0.5
2013	22.3	n/a	6.6	2.1
2014	27.8	n/a	8.3	2.8
2015	0.5	n/a	0.2	0.0
2016	0.4	n/a	0.1	0.0
2017	3.7	n/a	1.3	0.4

TRAWL				
Year	Weight (t)	CV	% Trawl Catches	% Total Catches
2018	1.1	n/a	0.3	0.1
2019	2.2	n/a	0.9	0.3
2020	2.2	n/a	0.8	0.3
2021	10.1	n/a	4.1	1.4
2022	28.7	n/a	10.3	4.6
2023	116.5	n/a	21.3	11.7

GILLNETS				
Year	Weight (t)	CV	% Gillnets Catches	% Total Catches
2011	10.6	n/a		
2012	14.3	n/a		
2013	0	n/a		
2014	0.1	n/a	0.03	0.00
2015	0.4	n/a	0.18	0.04
2016	5.0	n/a	2.47	0.49
2017	10.9	n/a	4.82	1.26
2018	2.6	n/a	1.33	0.34
2019	13.3	n/a	7.40	1.98
2020	0.9	n/a	1.33	0.12
2021	0.8	n/a	1.60	0.11
2022	0.0	n/a	0.00	0.00
2023	0.0	n/a	0.00	0.00

n/a: not available

CV: coefficient of variation

2.2.1.3 Length frequency distribution from landings

This species is caught by fisheries from ~25 cm to ~120 cm, although individuals >100 cm are less frequent. Quarterly length data are available for the main *métiers*/fleets from Portugal and Spain since 1989 (Intercatch data from 2002 onwards). Length data from French landings are only available for one year and were not included in the assessment. Length distributions were similar within trawlers and within nets, and therefore, information was combined for each fleet irrespective of the country of origin.

2.2.2 LPUEs from commercial fleets

LPUE index from the Portuguese trawl fleet (PT-OTB-LPUE)

An index for the Portuguese trawl fleet based on daily landings data and considering targeting effects was presented to WKBSS3 and is described in Moura and Mendes (2025 WD 2.1). The standardization procedure follows the methodology from Winker et al. (2013) as described in fisheries-dependent CPUE Standardization Guidelines from Winker and Cardinale (2022). In this method, the LPUE (landings per fishing trip) is standardized using a Generalized Additive Mixed Model (GAMM), considering the variables Month, Area and two principal components of the decomposed catch composition, and vessel as the random effect. The data considers all the trawl fleet, i.e., include vessels targeting fish and crustaceans, and the period from 1989-2023. For black anglerfish, this series showed a general decrease from 1990 to 2006 followed by an increase until 2012. A new decrease was observed between 2013 and 2019. The value observed in 2023 was the highest since 1990.

LPUE from the Spanish trawl fleet (SP-OTB-LPUE)

A standardized index for the Spanish bottom otter trawlers was presented to WKBSS3 and is described in Sampedro et al, (2025 WD2mon8c9a). This procedure used spatiotemporal GAMMs and data collected in the on-board observer program between 2009 and 2023. The final models identified depth and vessel identity as significant predictors influencing the relative abundance and distribution of anglerfish species. For black anglerfish, this series showed a general declining trend from 2013 to 2018, followed by increases in 2022 and 2023. The standardized CPUE series generated in this study provide robust indicators of the relative abundance of black and white anglerfish in Iberian waters. These indices are suitable for inclusion in the respective stock assessments of these species.

Combined LPUE for the trawl fleets (OTB-LPUE)

Winker (2025, WD 2.2) proposed a combined index for both standardized LPUEs from the Portuguese and Spanish trawl fleets. The joint index approach follows the concepts of the Hierarchical analysis of multiple noisy abundance indices by Conn (2010), replicated with JARA. Results are presented in Figure 2.6 and were used in the SS3 model tests.

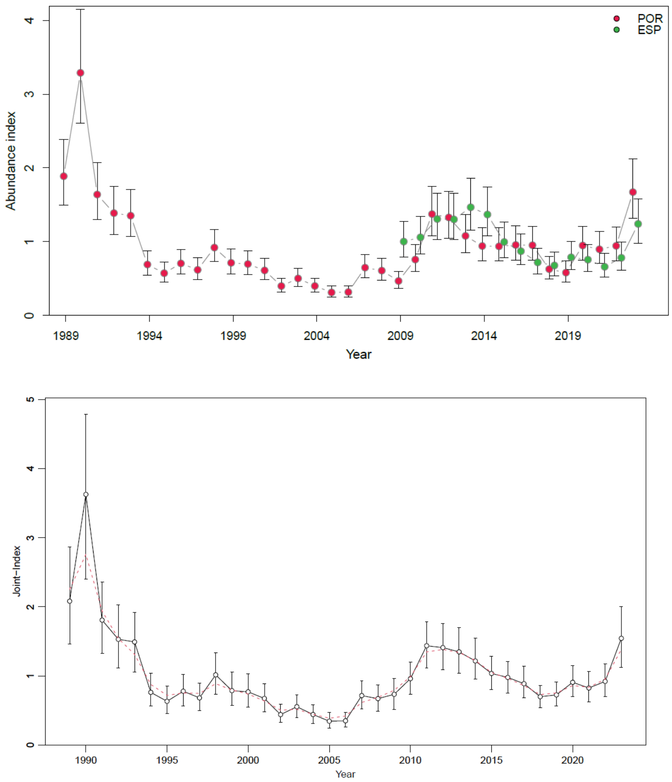

Figure 2.6. Top: Normalized indices with log.sd. Bottom: estimated joint relative index for the LPUE indices. with 95% CIs and the red dashed line indicating the underlying state-space trend.

LPUE from the Spanish gillnet fleet (SP-GNS-LPUE)

A relative abundance index of black anglerfish caught by the gillnet rasco fleet in ICES Division 8c and Subdivision 9aN, was standardized for the period 2009–2023 as described in Sampedro et al. (2025 WD3mon8c9a). In Northern Spain, the rasco, a specially designed gillnet for fishing anglerfish, is used mainly at 400-900 m depth. The standardization procedure used information from logbooks and the fishing day as the unit of effort as well as a spatial effect. GAMMs were fitted for each anglerfish species' data. This series show a general declining trend from 2015 to 2022, followed by an increase in 2023 (Figure 7).

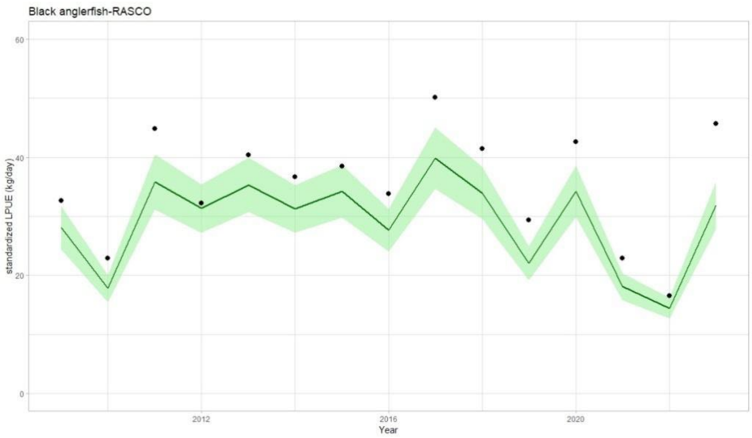

Figure 2.7. Standardized LPUE index (solid line) with 95% confidence intervals (shaded ribbons) estimated by the final model for black anglerfish. Black dots indicate the nominal LPUE index.

2.2.3 Data available from research surveys

2.2.3.1 Biomass indices available from research surveys

All the three IBTS bottom trawl research surveys conducted in ICES divisions 8c and 9a catch anglerfish. However, catchability is low for the PT-GFS (code) and the biomass indexes available are not reliable for stock assessment of this species. Additionally, the Crustacean survey conducted in the southern area of 9a was discontinued in 2022. The two Spanish surveys were then considered for inclusion in assessment of this stock.

Spanish North Coast Bottom Trawl Survey (SP-NORTH; G2784)

The Spanish survey SP-NSGFS covers the northern Spanish shelf comprised in ICES Division 8c and the northern part of 9a, including the Cantabrian Sea and off Galicia waters. The surveys are conducted from 30 to 800 m depth, usually starting at the end of the third quarter. Abundance index data (in number and in weight) and their associated standard deviation and length compositions are available for the period 1983–2019 except for 1987 (Figure 8). The series is annually updated and provided to the WGBIE. This survey index may be a good indicator for smaller individuals (<20 cm) abundance, but not for the exploitable part of population. During the model configuration tests, a reduced dataset, from 1990 onwards, was considered based on the number of hauls (>100).

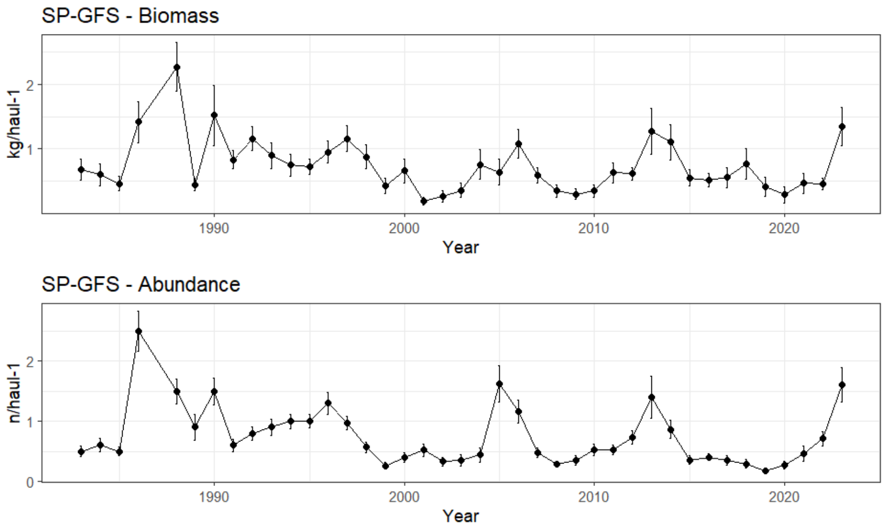

Figure 2.8. Biomass and abundance indices for *L. budegassa* in the SP-NORTH (1983-2023).

Spanish Gulf of Cadiz Bottom Trawl Survey (SP-ARSA; G7511 and G4309)

The Southern Spanish Groundfish Survey on the Gulf of Cádiz is conducted in the southern part of ICES Division 9a, the Gulf of Cádiz. The covered area extends from 15 m to 800 m depth, during spring and autumn. The series covers the period 1993–2023, two surveys by year, and the abundance index (in number and in weight) and their associated variance, and length compositions are available (the surveys were not conducted in 2021). This survey, and particularly the Q4 survey, was identified during the WKANGLER-Data Evaluation meeting as a potential abundance index for the black anglerfish in divisions 8c9a (Figure 2.9). The survey catches juveniles <25 cm but also large individuals. Despite the low spatial coverage, it reflects the trend of the species in the southern areas of the stock distribution (the increasing trend is in line with the results obtained in WKMSYSPiCT for the Portuguese trawl fishery targeting crustaceans that takes place in the southwest and south of Portugal). For the purpose of the current models, the data was restricted from 2011 onwards, based on the number of hauls conducted (>40).

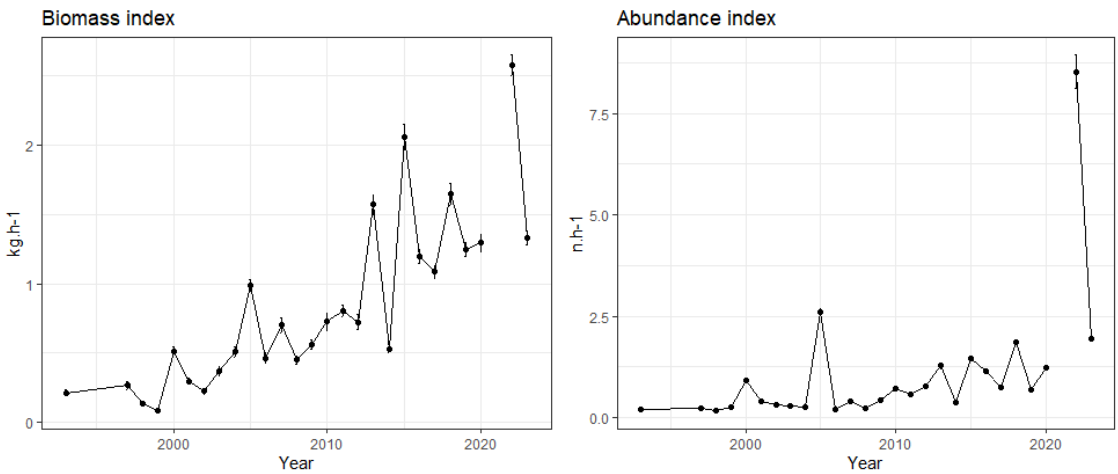

Figure 2.9. Biomass and abundance indices for *L. budegassa* in the SP-ARSA Q4 Survey (1993-2023).

2.2.3.2 Length frequency data available from research surveys

Spanish North Coast Bottom Trawl Survey (SP-NORTH; G2784)

Length data included in the model (1990-2023) is shown in Figure 2.10. Data by sex is available.

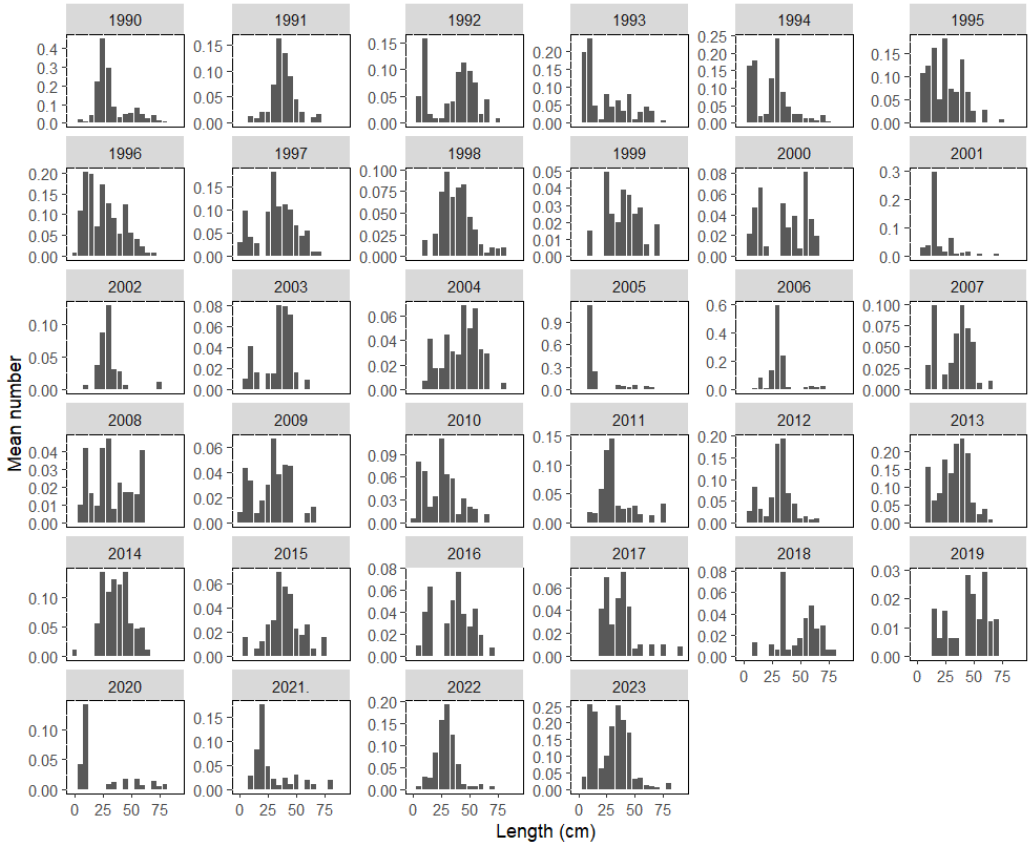

Figure 2.10. Length frequency distributions of *L. budegassa* in the Northern Spanish Shelf Groundfish Survey (1990-2023) by 5 cm length classes.

Spanish Gulf of Cadiz Bottom Trawl Survey (SP-ARSA; G7511 and G4309)

Length data included in the model is shown in Figure 2.11. Data by sex is not available.

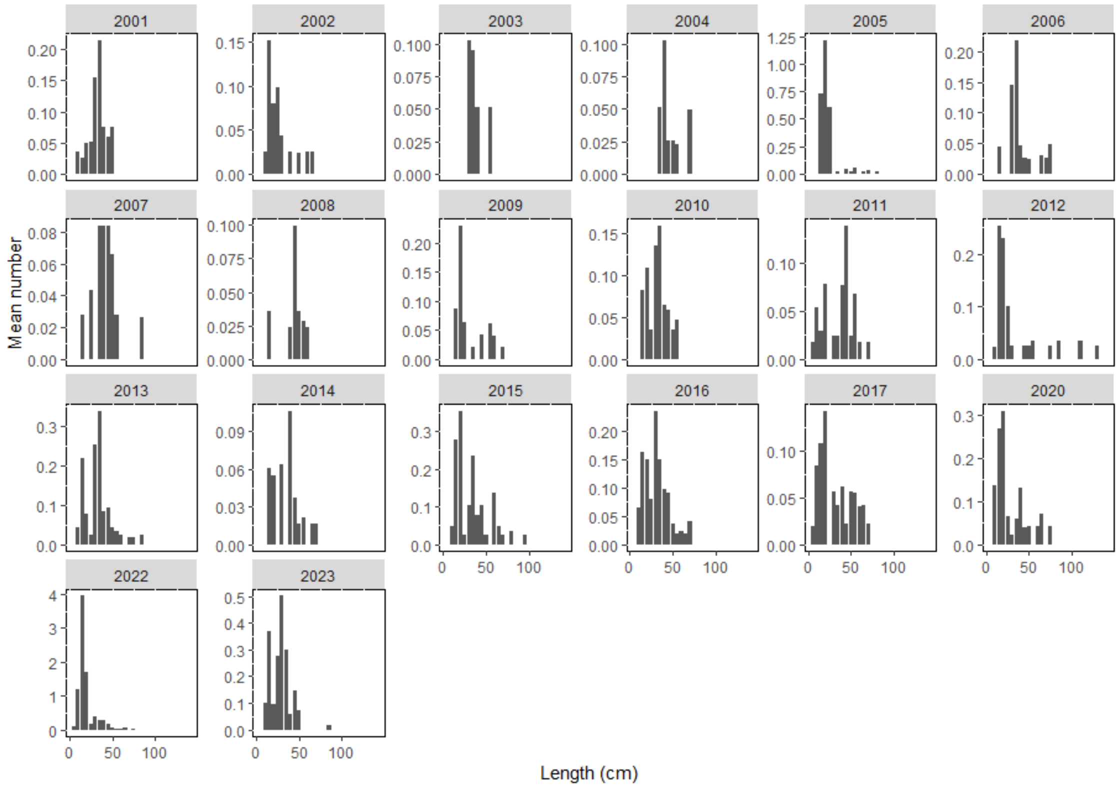

Figure 2.11. Length frequency distributions of *L. budegassa* in the Northern Spanish Shelf Groundfish Survey (2001-2023) by 5 cm length classes.

2.2.4 Biological information

2.2.4.1 TL-TW relationships

Allometric length-weight relationships were fitted to the information available for the stock and submitted through the data call (Table 2.3). The procedure followed non-linear least squares fits, by sex and for both sexes combined. Additionally, length –weight relationships were fitted to the data collected in the Spanish northern waters (8c and 9aN), and the respective estimates submitted to WKBSS3 (Modica et al., 2025 WD 2.3).

Table 2.3. Length-weight relationships estimated for the stock.

	a	b
Females	0.030	2.843
Males	0.028	2.821
Sexes combined	0.017	2.966

2.2.4.2 Growth

Reliable growth estimates are lacking for this species. In WKANGLER and WKANGHAKE, cohort analyses produced parameters for the black anglerfish in ICES subarea 7 (Batts and Gerritsen, 2018 WD) and ICES 7,8abd (Gerritsen, 2022; WKANGHAKE, 2023) (Table 2.4). Due to the lack of better information the growth parameter estimates adopted for the stock ank.27.78abd were used in the assessment.

Table 2.4. Growth parameters available for *L. budegassa*.

Species	ICES area	Sex	L_{inf} (cm)	k (y^{-1})	t0 (y^{-1})	Ref.
L. budegassa	7	combined	119.84	0.118	-0.816	Batts and Gerritsen (2018)
L. budegassa	7,8abd	combined	132	0.097	-0.031	WKANGHAKE (ICES, 2022)
		Females	129	0.101	0.009	WKANGHAKE (ICES, 2022)
		Males	78	0.197	0.099	WKANGHAKE (ICES, 2022)

2.2.4.3 Maturity and reproduction

According to different studies, reproduction takes place:

- November to February - Portuguese and Spanish Atlantic coasts (Duarte et al., 2001)
- December to July - Northern Spanish waters (Landa et al., 2014)
- October to March - Portuguese waters (Azevedo, 1996)

Data submitted to the WKBSS3 data call was analysed. Considering the reproductive season in Q1 and Q2, the L_{50} estimates for males and females considered selected data for this period of the year, from 2009-2023. A logistic function was fitted to the proportion of mature individuals. Two different scenarios were considered: i) individuals were considered as mature if maturity stage > 2 (WKBSS3-1); ii) same procedure as in i) but with inclusion of individuals potentially contributing to the reproductive season or that were not maturing for the first time, identified as those in maturity stage=2 with total length > L_{25}. This latter was based on Modica et al. (2025 WD 2.4) that also presented L_{50} estimates for the northern component of the stock (ICEs divisions 8c and 9aN). All results available for the stock are summarised in Table 2.5, including also results from three published studies.

Table 2.5. Maturity information: L_{50} estimates for *L. budegassa* in ICES divisions 8c and 9a.

ICES div.	Reference	Females	Males	Combined
8c9a	Landa et al. (2014)	53.0	36.0	38.2
9a	Azevedo (1996)	56.2	37.6	---
8c9a	Duarte et al. (2001)	53.6	38.6	44.7
8c9aN	Modica et al. (2025 WD 2.4)	49.5-50.2	31.6-35.9	33.9-37.6
8c9a	WKBSS3 - 1	60.5	37.0	45.6
8c9a	WKBSS3 – 2	51.9	37.5	37.5

2.2.4.4 Sex-ratio

According to Duarte et al. (2001) and Landa et al. (2014) sex-ratio in landings is ~1:1. However, it is recognized that sex-ratio differs when analysed by size and that sexual dimorphism occurs with females attaining larger sizes than males. To accommodate this in the model, data from the SP-NORTH disaggregated by sex was included (Figure 2.12). Unsexed individuals (mainly in the smaller length classes) were assumed as 1:1 sex ratio until 24 cm. From that size class onwards, numbers were estimated based on a ratio derived from the overall proportion of females and males in each 2cm length class.

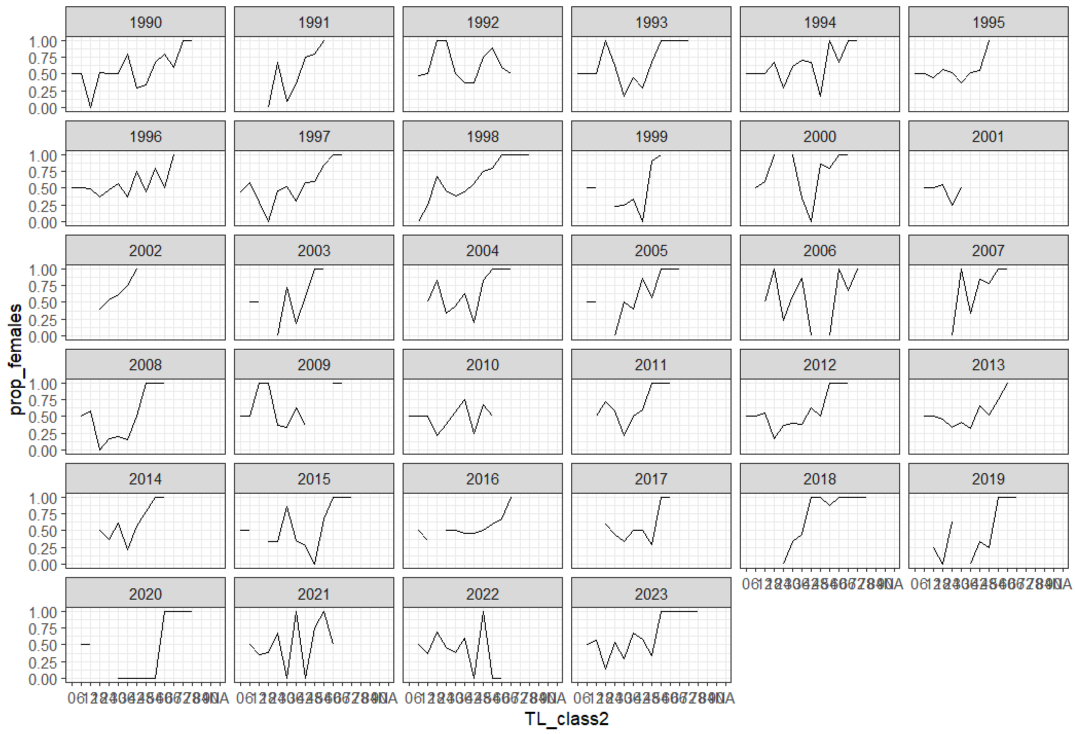

Figure 2.12. Proportion of females by length class (6 cm) in each SP-NORTH survey (1990-2023).

2.2.4.5 Natural mortality

Natural mortality was estimated by age, considering the growth parameters from Gerritsen (2022) and biological parameters available for this stock. The estimates obtained for females by applying the Lorenzen method were used for both sexes, from age 0 to age 3. From age 4 onwards the values were fixed and determined by sex (Table 2.6).

Table 2.6. Natural mortality at age estimates based on Lorenzen.

	Age 0	Age 1	Age 2	Age 3	Age 4+
Females	1.4	1.056	0.621	0.463	0.38
Males	1.4	1.056	0.621	0.463	0.36

2.3 Stock assessment

The model development considered the following suggestions made during data compilation and benchmark workshops:

- Seasonal model (4 seasons), to better track the cohorts along the year
- Landings set at the mid-point of each quarter
- Inclusion of two catch fleets (trawlers and nets, combined for the three countries)

- Inclusion of the SP-NORTH survey length data by sex
- Inclusion of discard data 2013-2013
- Estimation of the number of samples for both catch and survey data as proposed by Stewart and Hamel (2014)
- Adoption of a steepness value for the Lophiidae family (from FishLife)

2.3.1 Exploratory assessments

Initial runs conducted tested different models' configurations, including:

- Inclusion of discards

Discards were initially considered in the model but due to the relatively short time series available by quarter as well as the low number of individuals measured in a great fraction of the years/seasons (<10) the base case model excluded these input data.

- ***Selection of the fleets***

There are several stock size indicators available for this stock, that cover different areas of the stock distribution. Tests with different configurations were conducted. Additionally, initial tests included, as input data, the LPUEs from the Portuguese and Spanish trawl fleets separately.

The model diagnostics showed similar issues irrespective of the configuration considered. The base case model thus considered a configuration where the information is simplified (i.e., LPUE-OTB single index; exclusion of SP-GNS-LPUE which shows a similar trend as SP-OTB-LPUE and represents the same area) and covers a larger area of the stock distribution.

- ***Different assumptions on growth parameters***

The growth parameters defined for the stock ank.27.78abd were initially adopted as fixed parameters as well as the length at age 1. Other tests were conducted: i) allowing the model to estimate all parameters; ii) fixing L_{inf} for both sexes but allowing the model to estimate k and length at age 1 for each sex; iii) fixing L_{inf} but adopting a prior on k, considering the values for the stock ank.27.78abd. The group considered the last one the most appropriate option to be included in the base case model.

- Tests with nets as double-normal selectivity

Initial runs considered all fleets as double normal selectivity pattern, but the group considered more appropriate to adopt a logistic pattern for one of the catch fleets, given the lack of evidence of existence of cryptic biomass. Both trawls and net fleets can get large individuals, but gillnets and trammel nets, generally catch larger individuals, as those >100 cm.

- Inclusion of time-varying selectivity in the trawl fleet

Time-varying selectivity was considered for the trawl fleet in the last years (2010-2023) in the last runs. The group considered a change in selectivity could explain the high residuals and steep increase in SSB in the last years obtained in the initial models tested.

2.3.2 Base case model

The base case model had the input data presented in table 2.7 and Figure 2.13. Parameters are showed in Table 2.8. More details on input data and parameters are presented in the previous sections.

Table 2.7. Base case model: summary of the input data.

Data	Years	Comments
Landings		
Nets (gillnets and trammel nets)	• 1980-2023 • By quarter	• French, Spanish and Portuguese landings combined • se adopted: 0.1
Trawls	• 1980-2023 • By quarter	
CPUEs and LPUEs		
OTB-LPUE	• 1980-2023 • Annual	• Set at month 7 • se.log given by the model
SP-NORTH	• 1980-2023 • Annual	• Set at month 11 • se.log =0.2
SP-ARSA-Q4	• 2001-2023 • Annual	• Set at month 11 • se.log =0.2 • No survey in 2021
Length frequency distribution data		
General settings	• 2 to 100 cm: 2 cm length classes • 100-120 by 10 cm • Plus group: 120+	
Nets (gillnets and trammel nets)	• 1980-2023 • By quarter	• Spanish and Portuguese landings combined • Number of samples following Stewart and Hamel (2014) • Sexes combined
Trawls	• 1980-2023 • By quarter	• Spanish and Portuguese landings combined • Number of samples following Stewart and Hamel (2014) • Sexes combined
OTB-LPUE	---	• No length composition, mirror Trawl fleet • Sexes combined
SP-NORTH	• 1990-2023 • Annual	• Set at month 11 • Number of samples following Stewart and Hamel (2014) • By sex
SP-ARSA-Q4	• 2001-2023 • Annual	• Set at month 11 • Number of samples following Stewart and Hamel (2014) • Sexes combined • No survey in 2021

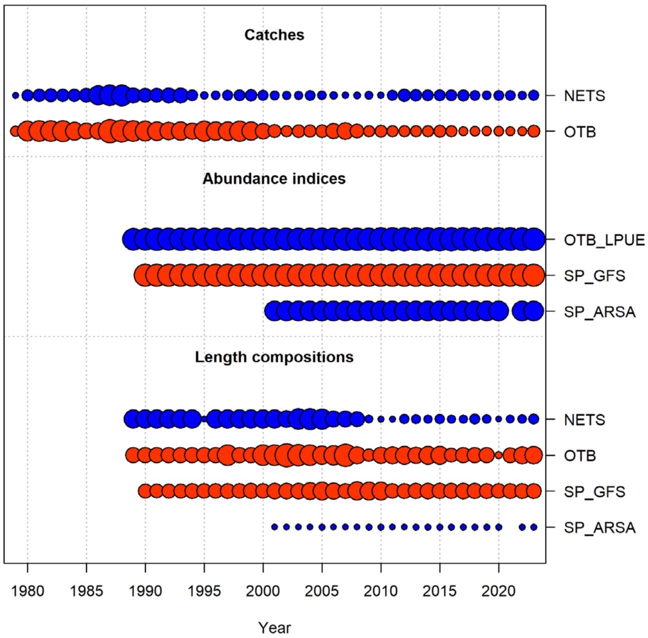

Figure 2.13. Base case model: summary of the input data.

Table 2.7. Base case model: summary of the biological parameters and selectivity.

Biological Parameters	Values	Source
Length-weight relationships		
Females: a	0.030	WKBSS3 estimates
Females: b	2.843	WKBSS3 estimates
Males: a	0.028	WKBSS3 estimates
Males: b	2.821	WKBSS3 estimates
Growth parameters		
Females: k	0.110 y^{-1}	ank.27.78abd; Gerritsen (2022)
Females: L_{inf}	129 cm	ank.27.78abd; Gerritsen (2022)
Males: k	0.197 y^{-1}	ank.27.78abd; Gerritsen (2022)
Males: L_{inf}	78 cm	ank.27.78abd; Gerritsen (2022)
Maturity females		
L_{50}	51.9	WKBSS3 estimates
slope	-0.472	WKBSS3 estimates
Steepness		

h	0.88	Lophiidae/ Fishlife (Thorson, 2023)
Natural mortality		
Age-based	(Table 2.6)	WKBSS3 estimates based on biological data above
Selectivity	**Pattern**	**Comments**
Nets	Logistic	
Trawls	Double-normal	Time-varying selectivity (2010-2023)
LPUE-OTB	Double-normal	
SP-NORTH	Double-normal	
SP-ARSA	Double-normal	

Model configuration

Starter file

- F_report_units: 5
- min and max age over which average F will be calculated: 3 and 15

Data file

- Start Year: 1980
- End Year: 2023
- N seasons: 4
- Months/season: 3/3/3/3
- N subseasons: 2
- Spawn_month: 1
- N genders: 2
- N ages: 30
- N areas: 1
- N fleets: 5
    - Nets (gill and trammel nets) catch data
    - Trawl catch data
    - LPUE-OTB
    - SP-NSGFS
    - SP-ARSA-Q4

- Catch data: catch.se =0.1 for all years
- LPUE and CPUE data:
- N discard fleets: 0
- Length bins for the population data:
    - 2-100 cm: 2 cm length bins
    - 100-140: 10 cm length bins

- Length bins:

  - 2-100 cm: 2 cm length bins
  - 100-120: 10 cm length bins
  - 120+

100-140: 10 cm length bins

- Length frequency distributions:
  - Nets: 1989-2023
  - Trawls: 1989-2023
  - SP-NSGFS: 1990-2023; log.se =0.2 for all years
  - SP-ARSA-Q4: 2001-2023; log.se =0.2 for all years
- Age data: not available
- Environmental data: not available
- N sizefreq methods to read: none
- Tagging data: not available

Control file

- N_Growth_Pattern: 1
- N_Platoon_Within_GrowthPattern: 1
- Recr_dist_method: 4 (none)
- Number of recruitment settlement events: 1
- Growth pattern: 1, month 1, area 1, age 0
- Nblock_Patterns: 0
- Time-vary parm bound check: 1
- Autogen: 1 1 1 1 1 (read each time-varying parm line)
- natM_type: 3 (M at age)
- Age_natmort_by sex
  - Females: A0=1.4; A1: 1.056; A2: 0.621; A3: 0.463; A4+: 0.38
  - Males: A0=1.4; A1: 1.056; A2: 0.621; A3: 0.463; A4+: 0.36
- GrowthModel: 1 (von Bertalanffy with L1, L2)
- Growth_Age_for_L1: 1
- Growth_Age_for_L2: 999 (Linf)
- Exponential decay above maxage: -998 (to not allow growth above maxage)
- maturity_option: 1 (length logistic)
- SD_add_to_LAA: 0 (recommended)
- CV_Growth_Pattern: 0 (CV=f(LAA))
- Maturity option: 1 (length logistic)
- First_Mature_Age: 2
- fecundity_option: 1 (weight dependent, Wt*(a+b*Wt))
- hermaphroditism option: 0 (none)
- parameter offset approach: 1 (none)
- growth_params:
  - L_at_Amin_Fem_GP_1: estimated by the model
  - L_at_Amax_Fem_GP_1: 119 (fixed)
  - VonBert_K_Fem_GP_1: 1.10 (prior)
  - CV_young_Fem_GP_1: 0.24 (estimated and then fixed)
  - CV_old_Fem_GP_1: 0.1 (fixed)
  - Wtlen_1_Fem_GP_1: 2.975e-05 (fixed)
  - Wtlen_2_Fem_GP_1: 2.843 (fixed)

  - Mat50%_Fem_GP_1: 51.9 (fixed)
  - Mat_slope_Fem_GP_1: -0.47 (fixed)
  - Eggs/kg_alpha_inter_Fem_GP_1: 1 (fixed)
  - Eggs/kg_beta_Fem_GP_1: 0 (fixed)
  - L_at_Amin_Mal_GP_1: estimated by the model
  - L_at_Amax_Mal_GP_1: 78 (fixed)
  - VonBert_K_Mal_GP_1: 0.197 (prior)
  - CV_young_Mal_GP_1: 0.28 (estimated and then fixed)
  - CV_old_Mal_GP_1: 0.1 (fixed)
  - Wtlen_1_Mal_GP_1: 2.761e-05 (fixed)
  - Wtlen_2_Mal_GP_1: 2.821 (fixed)
  - Cohort growth dev: 1(fixed)
  - Frac female: 0.5 (fixed)

- SR_function: 3 (std Beverton-holt)
- Use steepness for initial equ rec: 0
- SR_params:
  - SR_LN(R0): estimated by the model
  - SR_BH_steep: 0.88 (fixed)
  - SR_sigmaR: 0.8 (fixed)
  - SR_regime: 0 (fixed)
  - SR_autocorr: 0 (fixed)
- Recruitment deviations
  - do_recdev: 1 (deviations (R=F(SSB)+dev))
  - MainRdevYrFirst: 1989 (first year landings LFDs)
  - MainRdevYrLast: 2023 (last year with data)
  - Recdev_phase: 3
  - Recdev_early_phase: 4 (set late phase if not much early data)
  - forecast_recruitment phase: 0
  - last_early_yr_nobias_adj: 1985
  - first_yr_fullbias_adj: 1986
  - last_yr_fullbias_adj: 2023
  - first_recent_yr_nobias_adj: 2024
  - max_bias_adj: 0.9562
  - period of cycles: 0
  - min rec_dev -5 (default)
  - max rec_dev 5 (default)
- Fishing Mortality info
  - F ball park: 0.3
  - F ballpark year : -2001 (disabled)
  - F_Method: 4
  - Max F: 2.9
  - N iterations to tune F: 5
  - Init_F_nets: 0.094 (estimated in phase 2)
  - Init_F_trawls: 0.24 (estimated in phase 2)
- Q_options (set up for the LPUE and survey data): link=1, parm_nobiasadj; extra se; float
- Q_params: extra SD 0.1 (fixed)
- Selectivity
  - size_selex_types:

        - Nets: Pattern 1 (logistic)
        - Trawls: Pattern 24 (double normal)
        - LPUE-OTB: mirror fleet 2
        - SP-NSGFS: Pattern 24 (double normal)
        - SP-ARSA-Q4: Pattern 24 (double normal)
    - age_selex_types: Pattern 0
    - size_selex_para:
    - Size_inflection_Nets: 54.52 (estimated in phase 5)
    - Size_95%width_Nets: 13.76 (estimated in phase 5)
    - SizeSel_P 1_Trawls: 40.56 (estimated in phase 5; time varying: 2010-2023)
    - SizeSel_P 2_Trawls: -0.61 (estimated in phase 5)
    - SizeSel_P 3_Trawls: 4.49 (estimated in phase 5)
    - SizeSel_P 4_Trawls: 6.66 (estimated in phase 5)
    - SizeSel_P 5_Trawls: -999 (fixed)
    - SizeSel_P 6_Trawls: -999 (fixed)
    - SizeSel_P 1_SP-NSGFS: 59.19 (estimated in phase 5)
    - SizeSel_P 2_SP-NSGFS: -1.63 (estimated in phase 5)
    - SizeSel_P 3_SP-NSGFS: 6.71 (estimated in phase 5)
    - SizeSel_P 4_SP-NSGFS: 5.29 (estimated in phase 5)
    - SizeSel_P 5_SP-NSGFS: -999 (fixed)
    - SizeSel_P 6_SP-NSGFS: -999 (fixed)
    - SizeSel_P 1_SP-ARSA-Q4: 23.07 (estimated in phase 5)
    - SizeSel_P 2_SP-ARSA-Q4: -7.00 (estimated in phase 5)
    - SizeSel_P 3_SP-ARSA-Q4: 3.28 (estimated in phase 5)
    - SizeSel_P 4_SP-ARSA-Q4: 23.61 (estimated in phase 5)
    - SizeSel_P 5_SP-ARSA-Q4: -999 (fixed)
    - SizeSel_P 6_SP-ARSA-Q4: -999 (fixed)
    - timevary selex parameters:
        - Trawls: dev se 1.5 (fixed), rho 0 (fixed)

- maxlambdaphase: 1
- sd_offset: 1

Phases

- Phase 1: R0, F parameter
- Phase 2: Biology, initial F
- Phase 3: Main recruitment deviations
- Phase 4: Early recruitment deviations
- Phase 5: Q and selectivity parameters

2.3.3 Assessment results

The proposed assessment shows a decrease in SSB consistent with the development of the fishery in the 1980´s, being then stable since early 1990´s until 2011 (Figure 2.14). Since then, SSB increased, with lower values in 2021 and 2022. High confidence intervals were obtained for SSB at the begging of the time series, related to the inexistence of length data until 1989. Fishing mortality has been decreasing since 1990, showing a slight increase since 2020. Recruitment is variable along the time series, with the last five years being relatively high, driving the stock to higher levels of biomass.

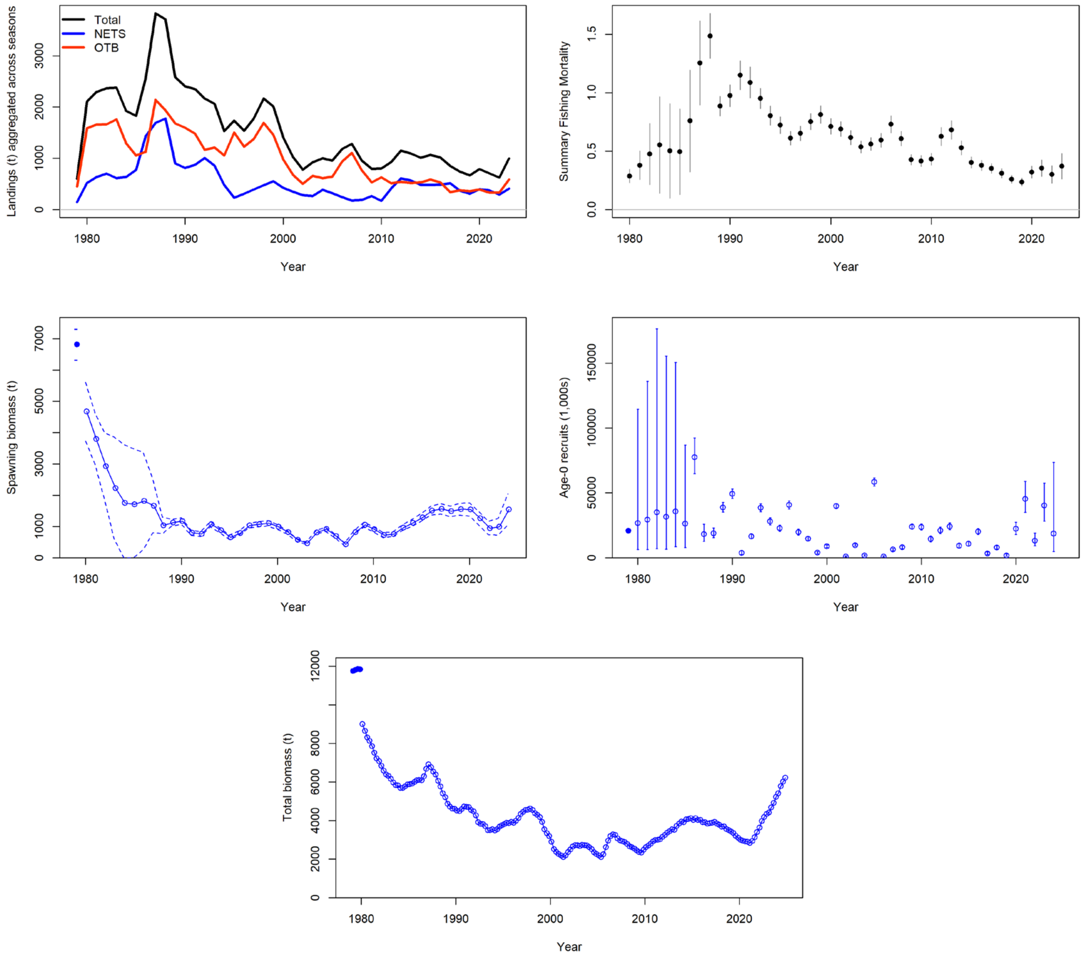

Figure 2.14. Base case model: summary of the assessment.

Growth

The model estimated *k* for females and males as 0.145 y^{-1} and 0.195 y^{-1}, respectively (Figure 2.15). Length at age 1 was estimated at 17.0 and 17.2 cm for females and males, respectively.

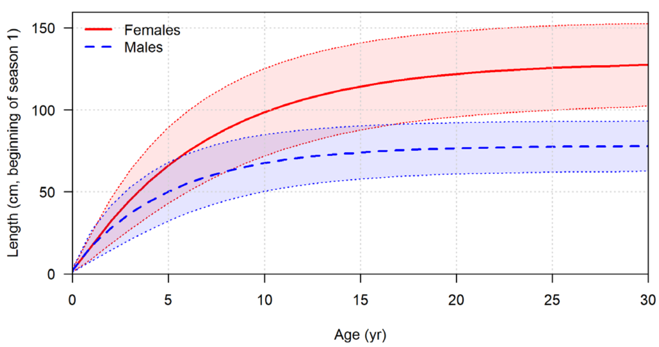

Figure 2.15. Length at age. Shaded area indicates 95% distribution of length at age around estimated growth curve.

Selectivity

The selectivity pattern adopted for nets was logistic, whereas the trawl fleet and surveys were modelled with a double-normal selectivity pattern. The LPUE-OTB was mirrored from the OTB fleet. Two and four parameters of the selectivity ogives (length) were estimated by the model, respectively. The model results are consistent with the size distribution of each fleet, where gill-nets and trammel nets usually take larger fish. SP-ARSA Q4 selectivity assumed a logistic pattern.

A time-varying selectivity was adopted to the trawl fleet (Figure 2.16).

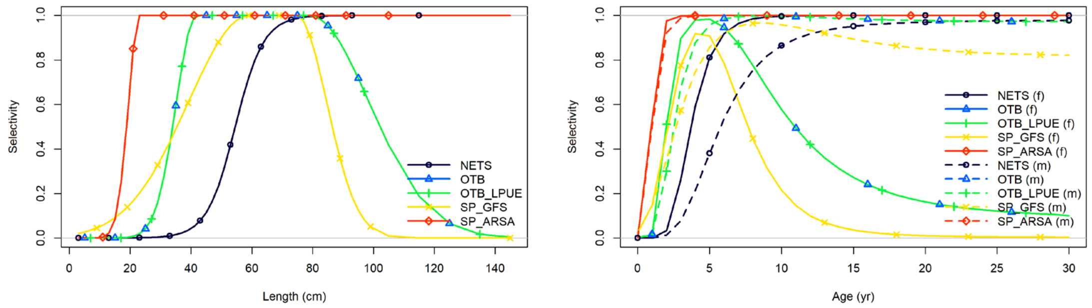

Figure 2.15. Left: selectivity at length for multiple fleets. Right: selectivity at age derived from selectivity at length for multiple fleets.

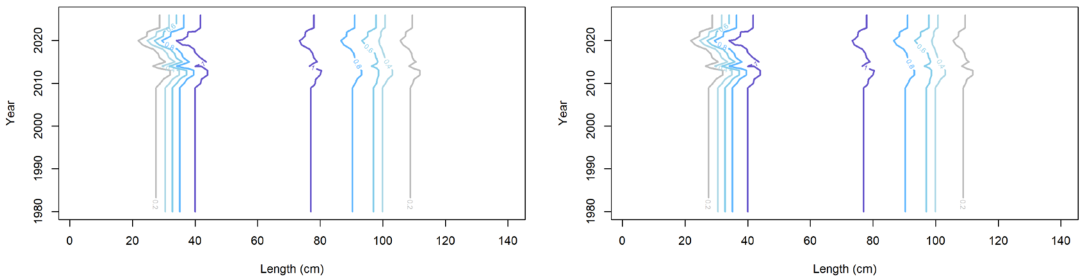

Figure 2.16. Contour plot of female (left) and male (right) time-varying selectivity for the Trawl fleet.

Stock-recruitment and recruitment deviations

The model assumes the Beverton-Holt recruitment relationship (Figure 2.17). Main recruitment deviations were assumed from 1989 onwards (first year with length data). Recruitment deviations configuration followed the “r4ss” outputs (Taylor et al., 2021).

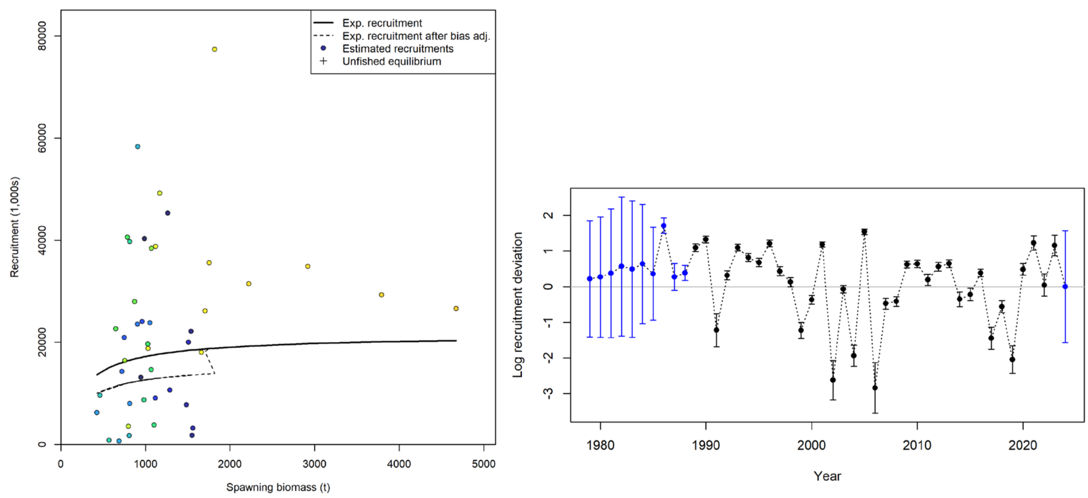

Figure 2.17. Left: stock-recruit curve. Point colours indicate year, with warmer colours indicating earlier years and cooler colours in showing later years. Right: recruitment deviations with 95% intervals

2.3.4 Model diagnostics

Convergence

No parameters were estimated at or near bounds or with unusual variance. The final gradient was <0.0001. The Hessian is positive definite. The assessment is stable with acceptable retrospectives.

Jitter runs (n=100) were performed using default settings for magnitude (10%). All jitter runs converged, 63 with the similar log-likelihood as the base case model. The remaining runs had a significantly larger total log-likelihood.

Goodness-of-fit

Fits and residuals were examined. The model fits quite well the length distribution of the Trawl and Nets fleets as well as the bi-modal distribution of the length data from the SP-NORTH (Figure 2.18). Although acceptable, the fit is poor in the case of the length data from the SP-ARSA. In the case of the three indices (Figure 2.19), the model does not follow well the trend of LPUE-OTB and SP-NORTH in the initial years. In the case of SP-ARSA Q4, the fit is poor in the last years.

Pearson residuals show positive residuals at different length classes and all fleets. However, these are larger in the Trawl fleet (landings) at small sizes from 2014 onwards and in the Nets fleet (landings) during the same time period but at sizes slightly larger (Figure 2.20).

Runs tests were performed and RMSE was calculated (Figures 2.21 to 2.23). The run tests failed for all the three indices but passed for length data from the four fleets. The joint residuals for the length data results in a RMSE ~10% (within the limit of 30%), with the loess smoother is closed to zero along the years. On the contrary, RMSE values for the joint residuals for the indices data are above the limit of 30%, with the loess deviating in the beginning of the time series, showing a relatively bad fit of the commercial and survey indices in that period.

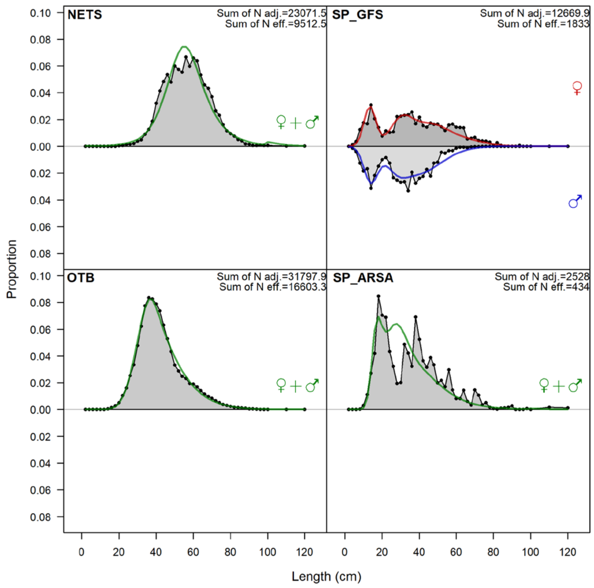

Figure 2.18. Length composition, aggregated across time by fleet.

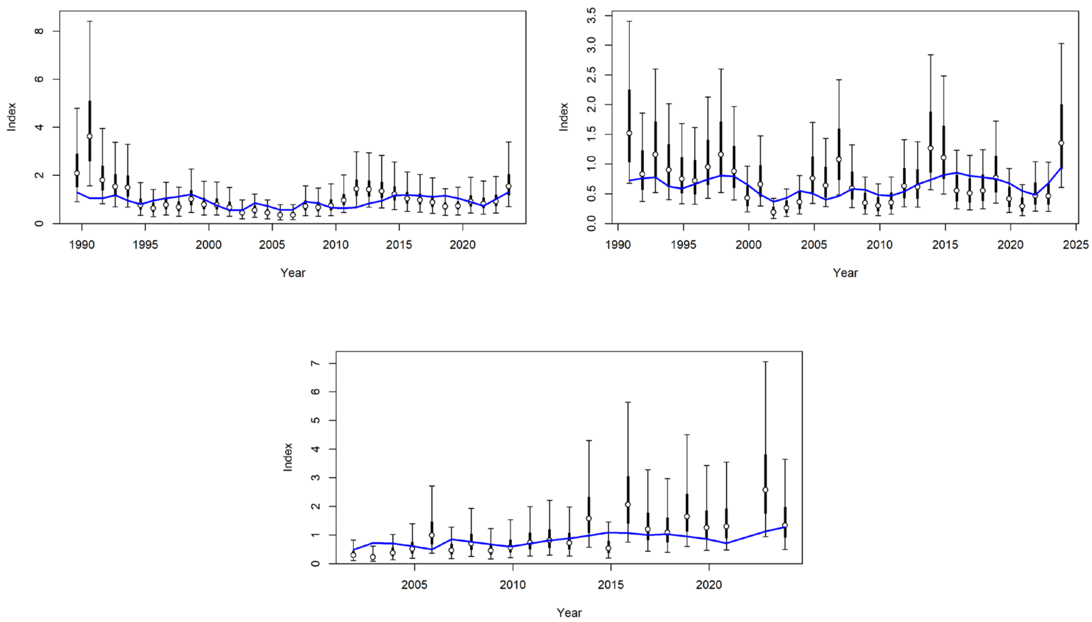

Figure 2.19. Fit to index data for each fleet. Top left: LPUE-OTB. Top right: SP-NORTH. Bottom: SP-ARSA Q4

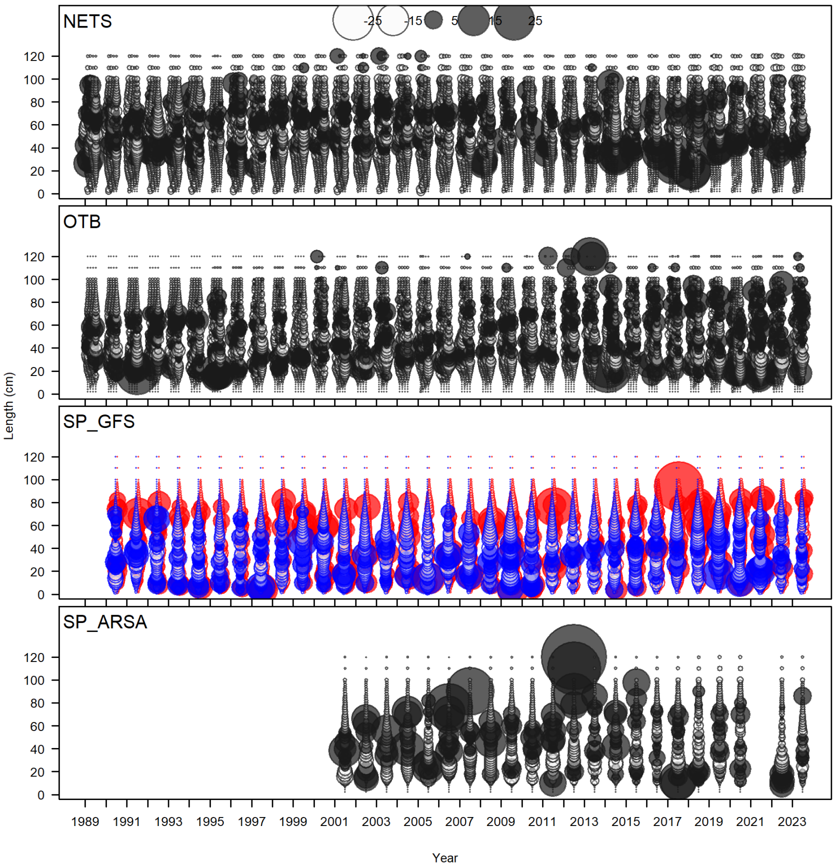

Figure 2.20. Pearson residuals, comparing across fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).

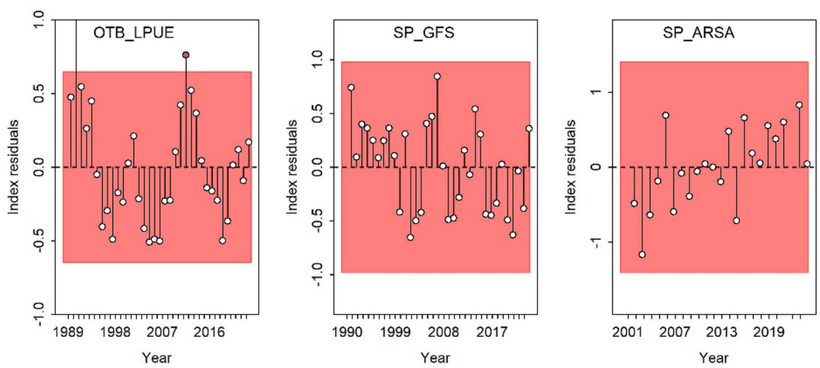

Figure 2.21. Runs test plot fits to survey indices. Green shading (p=0.05) shows no evidence to reject the null hypothesis of randomly distributed time-series of residuals

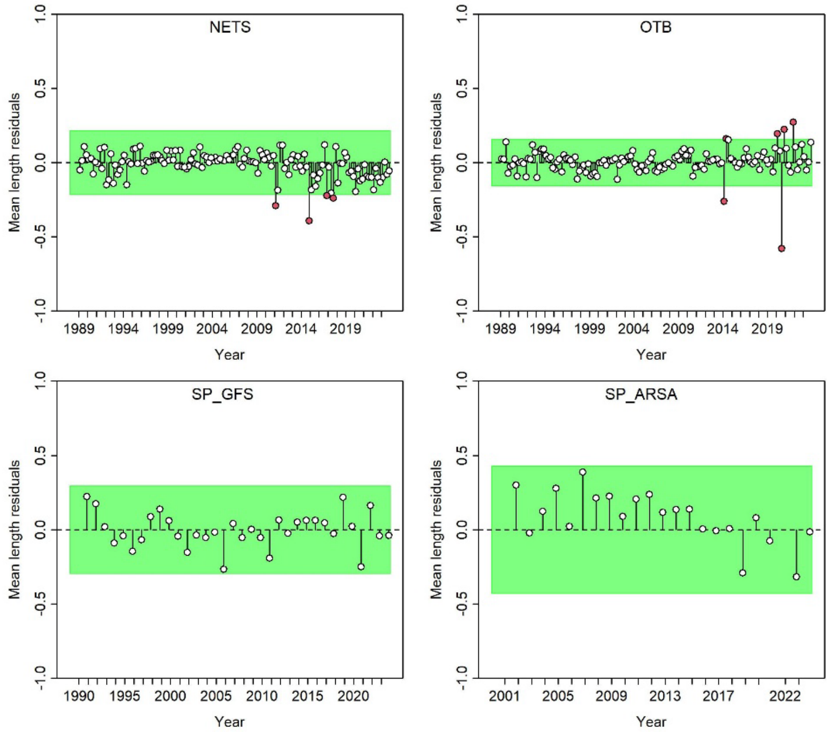

Figure 2.22. Runs test plot fits to mean lengths. Green shading (p=0.05) shows no evidence to reject the null hypothesis of randomly distributed time-series of residuals.

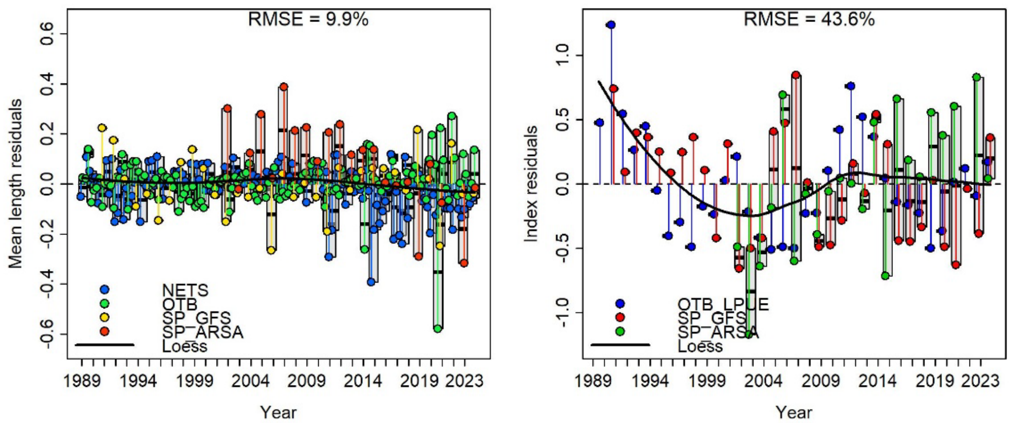

Figure 2.23. Joint residual plot for mean lengths (left) and CPUE indices (right). Boxplots indicate the median and quantiles in cases where residuals from the multiple indices are available for any given year. Root-mean squared errors (RMSE) are included.

Model consistency

The retrospective pattern (5 years) shows that the assessment is stable with Mohn´s rho values for both SSB and F within the acceptable limits (0.01 and 0, respectively; Figure 2.24).

Both OTB-LPUE and SP-NORTH indices show a good prediction power, with MASE values <1, contrarily to SP-ARSA (Figure 2.25). The opposite was observed for length data, with hindcasting showing a low prediction power for all fleets except SP-ARSA (Figure 2.26).

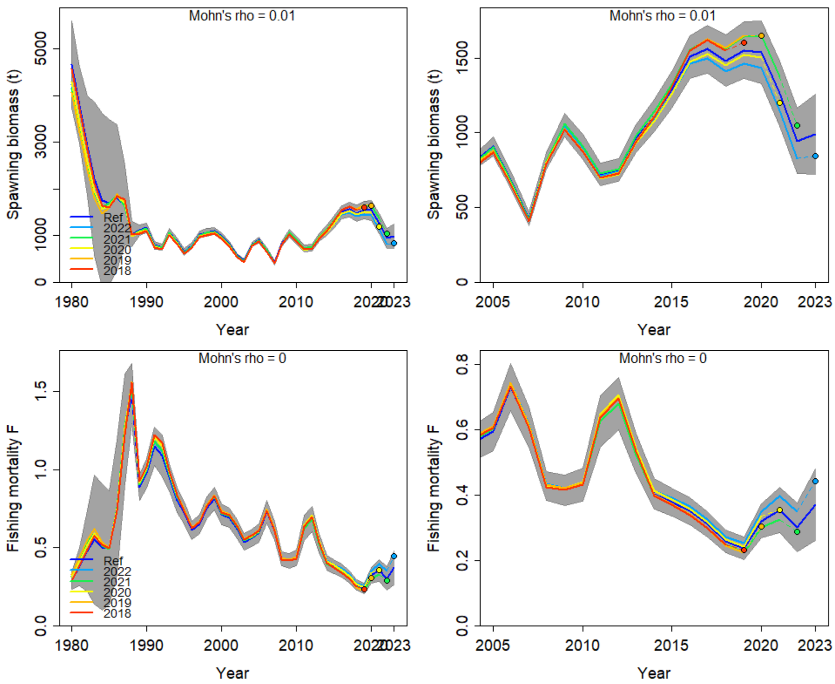

Figure 2.24. Retrospective pattern of SSB and F (plots in the right show the retrospective patterns in most recent years – since 2005).

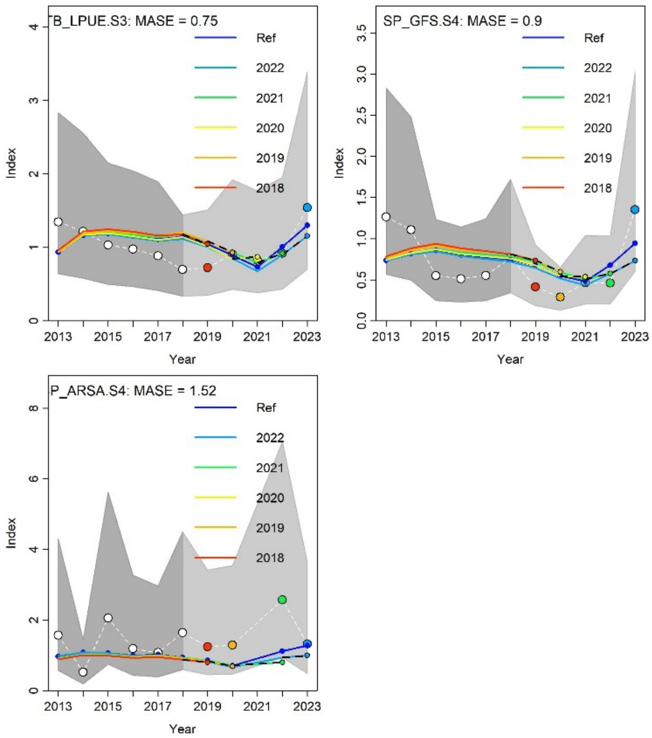

Figure 2.25. Hindcast cross validations of index data.

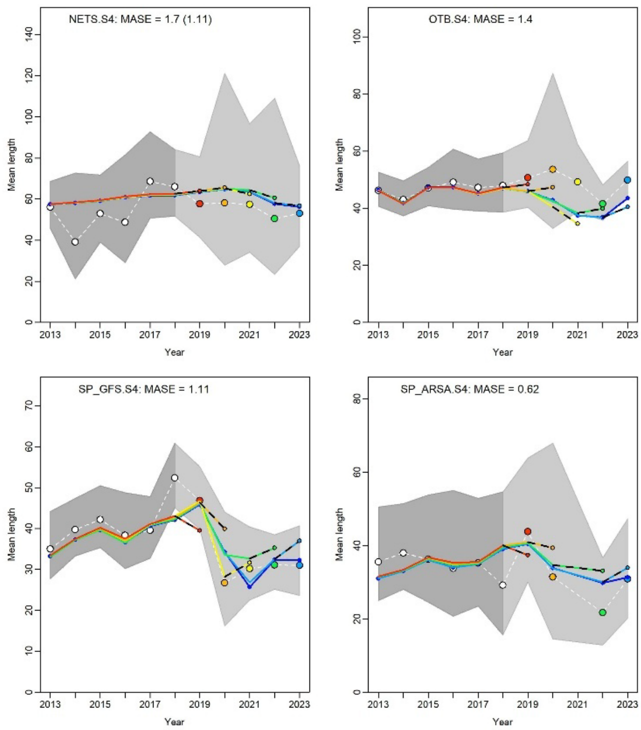

Figure 2.26. Hindcast cross validations of length data.

2.3.5 Additional models

Steepness profiling was conducted, by adopting different values from 0.8 to 0.99. Results are showed in table 2.8 and Figure 2.26. The different values change SSB and F at the initial years only. There were no reasons to change the value adopted in the base case, which reflect the estimated value for the Lophidae family. It should be noted that the value estimated for *L. budegassa* by FishLife (h=0.93) was considered too high.

A sigmaR value of 0.5 was initially adopted. However, the value of 0.8 was considered more adequate, given that the model suggests a higher value for this parameter. This value, however, increases the uncertainty in SSB, particularly in the first years of the time series, when only catch data is available.

Results are also shown for the case where nets are modelled as a double-normal selectivity, as initially considered.

None of the scenarios above resulted in a notable improvement of the model diagnostics.

Table 2.8. Model diagnostics of additional runs.

	Base case	h=0.93	h=0.8	h=0.99	SigmaR= 0.5	Nets= double normal
Convergence	0.00093587	0.00093587	0.000307636	0.00083456	0.0042171	7.51347e-06
Likelihood	22138	22138	22137	22139	22177	21689
N_Params	443	443	443	443	443	440
Mohn´s Rho						
Retro_Rho_SSB	0	0	-0.01	0	0.12	-0.03
Retro_Rho_F	-0.01	0.1	0.03	0.1	-0.01	0.02
Forecast_Rho_SSB	0.02	0	-0.01	0	0.12	-0.03
Forecast_Rho_F	0.03	0.1	0.03	0.1	-0.1	0.03
Runs test						
Index OTB_LPUE	Failed	Failed	Failed	Failed	Failed	Failed
Index SP-NORTH	Failed	Failed	Failed	Failed	Failed	Failed
Index SP-ARSA	Failed	Failed	Failed	Failed	Failed	Passed
Lengths NETS	Passed	Passed	Passed	Passed	Passed	Passed
Lengths OTB	Passed	Passed	Passed	Passed	Passed	Passed
Lengths SP_NORTH	Passed	Passed	Passed	Passed	Passed	Passed
Lengths SP_ARSA	Passed	Passed	Passed	Passed	Passed	Failed
RMSE						
Index	43.6	43.6	43.6	43.6	43.6	43.6
Lengths	9.9	9.9	9.9	9.9	9.9	9.8
Hindcasts (MASE)						
Index OTB_LPUE	0.73	0.73	0.72	0.74	1.22	0.59
Index SP-NORTH	0.88	0.86	0.86	0.88	1.1	0.86
Index SP-ARSA	1.56	1.56	1.59	1.56	1.2	1.36
Lengths NETS	0.6	0.7	0.7	0.7	0.71	0.61
Lengths OTB	1.11	1.11	1.11	1.11	1.09	1.13
Lengths SP_NORTH	1.06	1.06	1.05	1.07	1.12	1.12
Lengths SP_ARSA	0.6	0.6	0.6	0.6	0.61	0.65

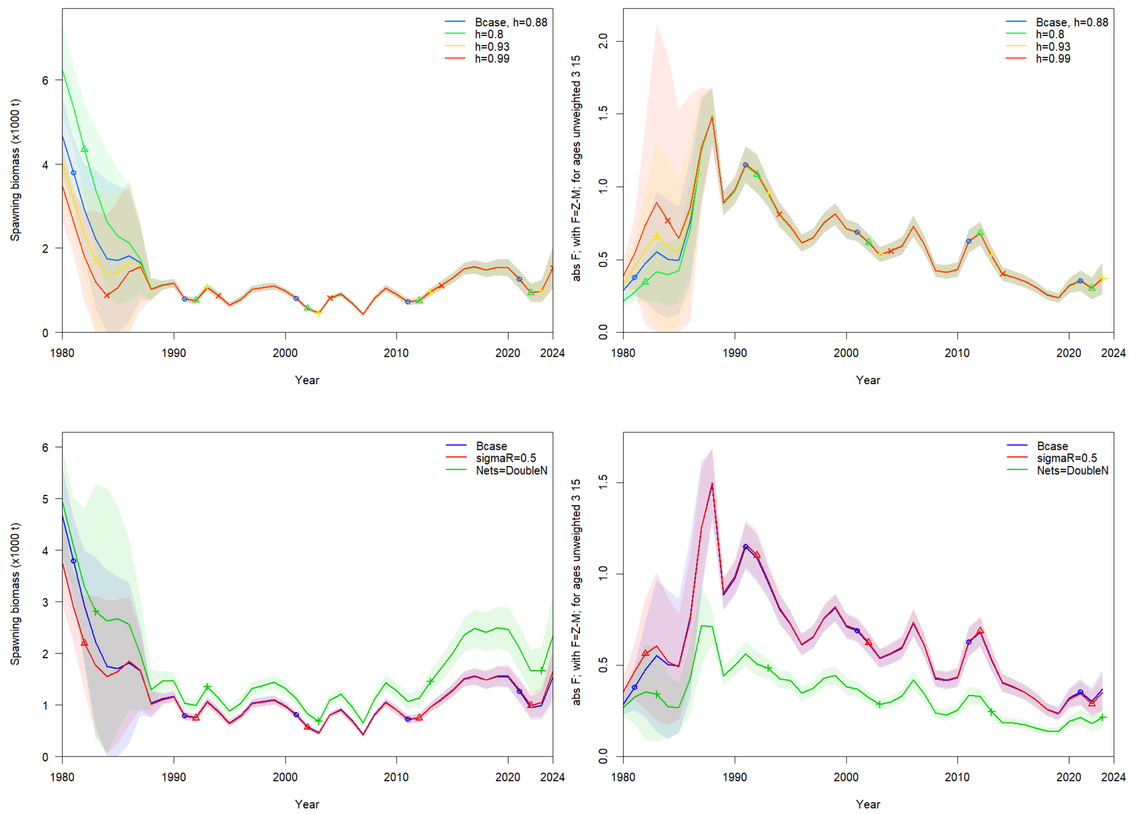

Figure 2.26. SSB and F trajectories under additional scenarios.

2.4 Reference points

Reference points were proposed based on ICES (2021c) and WKNEWREF (ICES, 2024c).

2.4.1 EqSim approach

The msy package (Simmonds et al.., 2025) was used to run EqSim, a stochastic equilibrium software used to explore MSY reference points estimates. For this purpose, the final model results were transformed in a FLStock object and collapsed to one season and one sex.

2.4.1.1 Stock-recruit relationship

The stock-recruit relationship adopted was the one estimated by the Stock Synthesis model, to be in line with the model estimates.

The Beverton-Holt stock-recruitment relationship was fitted to the data referent to the main recruitment deviations, i.e., to the years with length frequency data available (1989-2023). Autocorrelation in the Beverton-Holt relationship first lag was considered in the EqSim runs, by assuming sigma R as the values from the SS model.

2.4.1.2 Stock-type and B_{lim}

Following the ICEs guidelines (ICES, 2021c) and the WKNEWREF (ICES, 2024), the stock can be considered as Type 1, i.e. a stock with occasional large year classes (spasmodic). This can be concluded by fitting of the function proposed by WKNEWREF to identify this type of stocks (Figure 2.27), with the large proportion of the Detrended CDF falling inside the 'spasmodic region'.

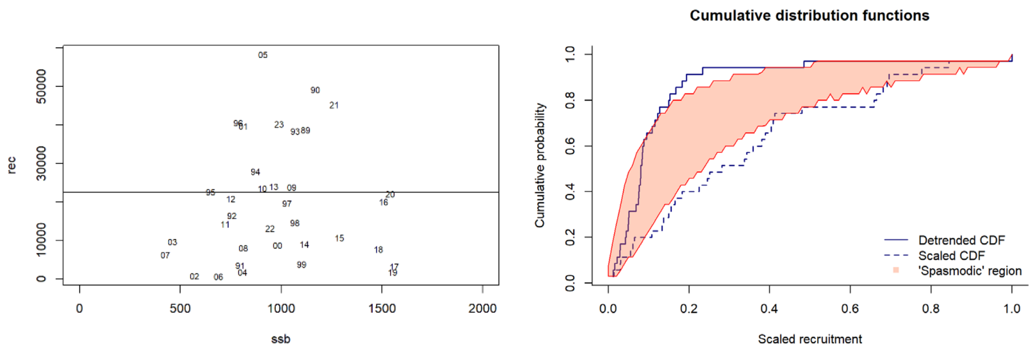

Figure 2.27. Left: Stock-recruit relationship. Right: The empirical cumulative distribution function of recruitment relative to maximum recruitment.

In type 1 stocks, B_{lim} can be defined as the lowest SSB, where large recruitment is observed. In the case of ank.27.8c9a, the value distinctively above the mean of the recruitment values with higher biomass was selected, which corresponds to the year 1996. B_{lim} was thus defined as 788 t, which corresponds to 11.5% of B0. Other options for Blim were presented to WKBSS3.

2.4.1.3 B_{pa}

B_{pa} corresponds to B_{lim} plus assessment error. Since the error around SSB in the last years (2022, 2023) was below 0.2, the default value of 0.2 was used, as suggested. B_{pa} was thus estimated as 1095 t.

2.4.1.4 F_{msy} and $B_{trigger}$

F_{msy} should initially be calculated based on an evaluation with the inclusion of stochasticity in a population (i.e. recruitment, M, maturity, growth) and fishery (e.g. selectivity) as well as assessment/advice error. This is a constant F, which should provide maximum yield without biomass constraints (without MSY $B_{trigger}$). Error is included and the ICES default error settings were used for cvF = 0.212; phiF = 0.423; cvSSB = 0 and phiSSB = 0. This resulted in an initial estimate of F_{msy} = 0.53 (Figure 3.28.

B_{msy}5% was estimated as 681 t. The stock has been fished below F_{msy} for ~10 years but as B_{pa} > B_{msy}5%, MSY $B_{trigger}$ is set equal to B_{pa}.

F_{MSY} and MSY $B_{trigger}$ combination should have less than 5% annual probability of SSB < B_{lim} in the long term. Such evaluation must include realistic assessment/advice error and stochasticity in population biology and fishery selectivity. F_{pa} estimated in the long term (0.541; Figure 2.29) is higher than F_{msy} previously estimated. F_{msy} was thus considered as 0.53, being consistent with the precautionary and MSY frameworks.

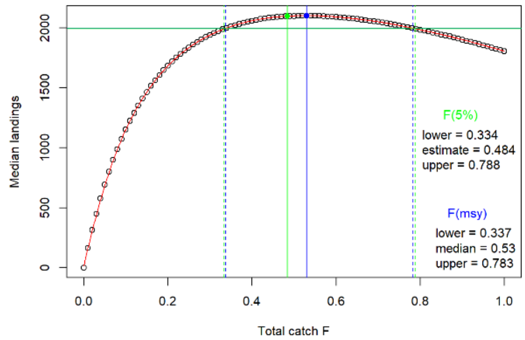

Figure 2.28. Median (across 1000 iterations) for the mean yield at stochastic equilibrium as a function of the fishing mortality applied. Blue vertical line corresponds to Fmsy (with dashed line representing the Fmsy range limits). Green vertical lines represent the fishing mortality at which p(SSB<Blim)>5%. Simulations run without implementing ICES MSY advice rule.

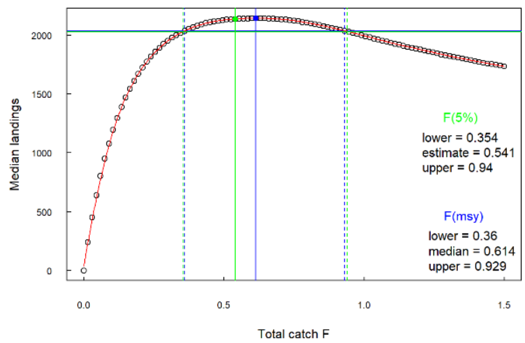

Figure 2.29. Fp05 estimation in the long-term simulations with ICES AR.

2.4.1.5 Reference points table and current stock status

Table 2.9 Shows the reference points proposed following the EqSim.

Table 2.9. Reference points proposed following the EqSim approach.

	EqSim	Rationale
Blim	788	Lowest SSB, where large recruitment is observed
Bpa	1095	Blim with assessment error

MSY Btrigger	1095	Bpa
Fpa	0.541	F with 95% probability of SSB≥Blim (BH with Btrigger)
Fmsy	0.53	Stochastic simulations
Fmsy lower	0.337	Stochastic simulations
Fmsy upper	0.541	Fpa
Bmsy 5%	681	5% probability of SSB < Blim

2.4.2 Short-Cut MSE approach

A short-cut MSE approach was run using as input the reference points the estimates from EqSim. Methods and R code were adapted to two-sexes model as shown in Winker (2025 WD 2.5).

Performance evaluation table and plot are presented in Table 2.10 and Figure 2.30, respectively.

Results highlight that the F_{msy} estimated by EqSim may not be precautionary. A more appropriate F_{msy} (F with 95% probability of SSB>B_{lim}) based on MSE runs would be 0.355.

Table 2.10. Performance evaluation of the F_{adv} tested. Robustness tests of F_{adv} in line with ICES precautionary approach (from Winker (2025 WD 2.5).

AR	Fadv	P3(B<Blim)	Catch/MSY	SD.Catch	AAVC	F/Fmsy	B/Bmsy	P(B>0.8Bmsy)
Fmsy.OM	0.473	0.255	1.021	0.206	0.133	0.985	0.928	0.642
Fmsy.eq.Btri.eq	0.53	0.277	0.98	0.218	0.172	0.942	1.068	0.66
1Fmsy.Btri.eq	0.473	0.182	1.000	0.206	0.161	0.877	1.127	0.747
0.975Fmsy.Btri.eq	0.462	0.161	1.003	0.204	0.16	0.864	1.143	0.764
0.95Fmsy.Btri.eq	0.45	0.147	1.006	0.203	0.157	0.848	1.163	0.783
0.925Fmsy.Btri.eq	0.438	0.129	1.007	0.201	0.154	0.832	1.185	0.802
0.9Fmsy.Btri.eq	0.426	0.114	1.008	0.199	0.152	0.816	1.209	0.821
0.875Fmsy.Btri.eq	0.414	0.095	1.009	0.198	0.149	0.799	1.235	0.842
0.85Fmsy.Btri.eq	0.402	0.081	1.008	0.196	0.146	0.782	1.263	0.860
0.825Fmsy.Btri.eq	0.391	0.073	1.007	0.194	0.144	0.765	1.29	0.878
0.8Fmsy.Btri.eq	0.379	0.058	1.006	0.193	0.142	0.747	1.322	0.897
0.775Fmsy.Btri.eq	0.367	0.050	1.004	0.191	0.139	0.728	1.357	0.915
0.75Fmsy.Btri.eq	0.355	0.040	1.001	0.189	0.137	0.708	1.395	0.932
0.725Fmsy.Btri.eq	0.343	0.037	0.998	0.188	0.135	0.688	1.435	0.947

0.7Fmsy.Btri.eq	0.331	0.029	0.994	0.186	0.132	0.668	1.479	0.956
0.675Fmsy.Btri.eq	0.32	0.022	0.989	0.184	0.13	0.648	1.523	0.969
0.65Fmsy.Btri.eq	0.308	0.018	0.983	0.182	0.127	0.627	1.574	0.978
0.625Fmsy.Btri.eq	0.296	0.013	0.976	0.18	0.124	0.605	1.629	0.983
0.6Fmsy.Btri.eq	0.284	0.006	0.968	0.178	0.122	0.582	1.688	0.991

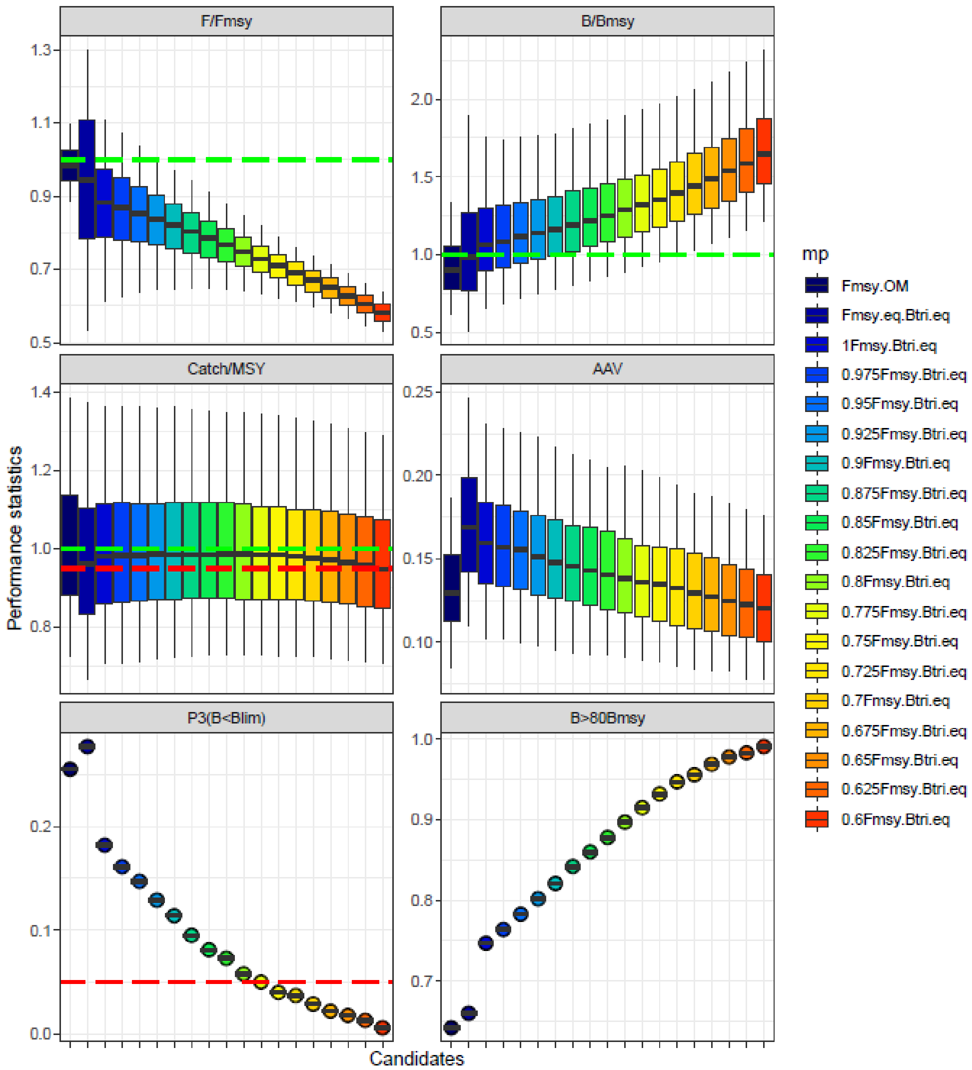

Figure 2.30. Long-term performance evaluation of reference points tested (from Winker (2025 WD 2.5).

2.4.2.1 Final reference points table and current stock status

Considering the MSE results, the reference points proposed for ank.27.8c9a are presented in Table 2.11. According to this, F is at F_{msy} and SSB is above MSY $B_{trigger}$ (Figure 2.31).

Table 2.11. Reference points proposed for ank.27.8c9a.

	EqSim	Rationale
Blim	788	Lowest SSB, where large recruitment is observed
Bpa	1095	Blim with assessment error
MSY Btrigger	1095	Bpa
Fpa	0.355	F with 95% probability of SSB≥Blim (MSE approach)
Fmsy	0.355	Fpa
Fmsy lower	0.260*	F with no less than 95% MSY (MSE approach)
Fmsy upper	0.355	Fpa
Bmsy 5%	681	5% probability of SSB < Blim

***Value estimated. Will be revised for WGBIE 2025**

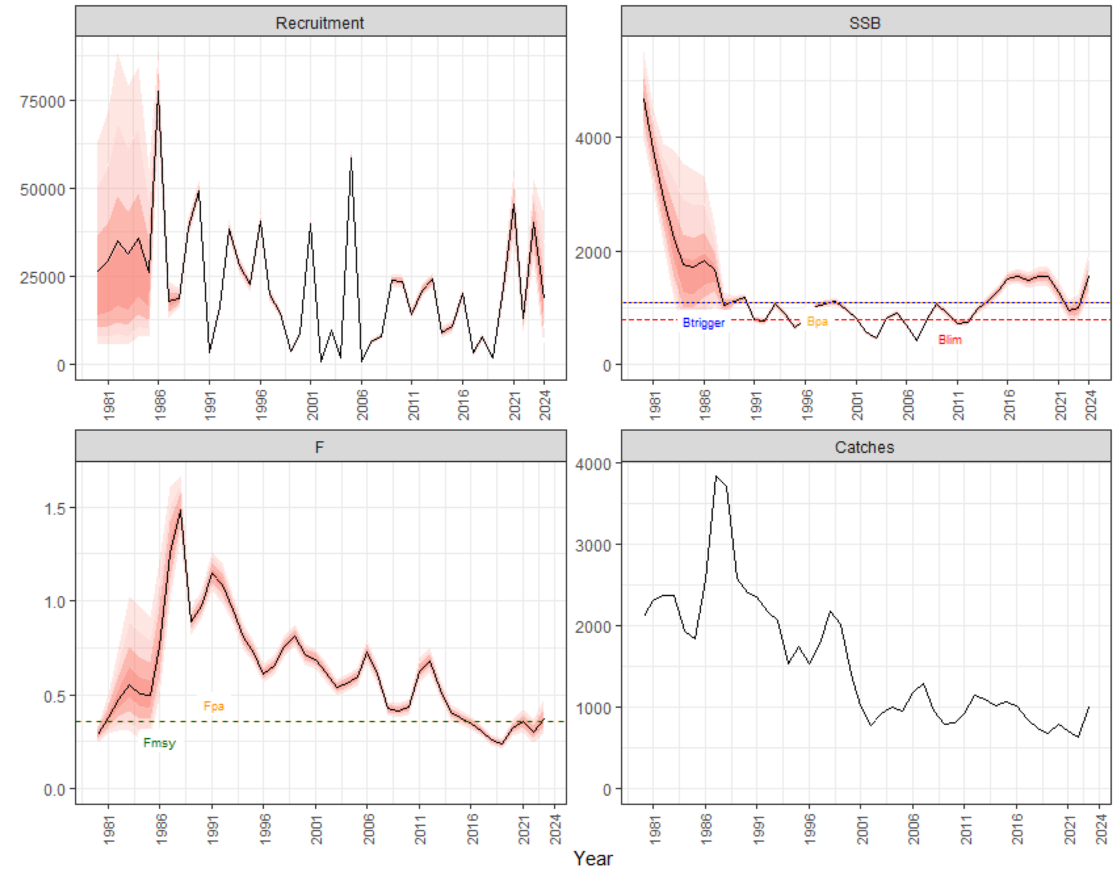

Figure 2.31. Estimated stock status trajectories with associated reference points.

2.5 Forecast assumptions

The following forecast assumptions will be considered:

- Maturity at age: fixed (logistic; used for all years)
- Natural mortality at age: fixed (age-specific, Lorenzen; used for all years)
- Weight-at-length: fixed (used for all years)
- Exploitation pattern: average of the final three assessment years
- F in the intermediate year: *Status quo* F - average last 3 years unless there is a clear trend in F, in which case F can be rescaled to the last year
- Recruitment in the intermediate year: predicted from Stock Synthesis stock–recruit relationship
- Recruitment in the last data year(s): if the working group believes that is not accurately estimated it can be replaced with the recruitment predicted from SS3 stock-recruit relationship.

2.6 Future considerations

Growth

Growth studies are needed for this stock.

Stock structure and hybridization

This stock (ank.27.8c9a) distributes in the Cantabrian Sea and Atlantic Iberian waters down to Gulf of Cadiz. Currently, there is no new information to change the current assessment areas, but structure is known to occur as well as some degree of missing (ICES, 2018). This should be further explored in the future.

The study from Aguirre-Sarabia et al. (2021), based on single nucleotide polymorphisms, shows that a fraction of specimens classified as white anglerfish using morphological characteristics are genetically identified as black anglerfish, and that the two *Lophius* species naturally hybridize leading to a population of hybrids of up to 20% in certain areas. These issues should be better addressed in the future and how it can affect assessment.

Survey biomass index

Consider future work in a combined index based on survey data from research surveys taking place in the stock distribution area.

2.7 Stock-specific reviewers report (ank.27.8c9a)

Reviewer: Tanja Miethe

2.7.1 Introduction

This stock was put forward for benchmark to update the current category 2 (SPiCT assessment) to a category 1 assessment. For this purpose a new sex-structured, quarterly SS3 model was developed. Additional data was included, such as maturity ogive, LPUE indices and scientific surveys. The model appears robust and considered acceptable for assessment.

2.7.2 Data compilation

Discards have not been included in the assessment due to low and variable sampling and are considered negligible. In individual years, Spanish discards from trawls were estimated to be a significant proportion of catches. Therefore, the discards assumption should be reviewed in the future as more data becomes available. Landings were split by quarter and catch fleet (nets and trawls) but combined for countries and sexes. Sampling is considered sufficient to support quarterly landings data and length frequency distributions.

Growth parameters for this stock could not be estimated from data due to difficulty with ageing. For sex-specific values of L_∞ from literature and empirical estimates of natural mortality based on growth were considered and agreed. Other parameters such as K are estimated in the assessment model. Since there is uncertainty around growth parameters, it is recommended to review assumptions in the future. Species misidentification is recognized as an issue for anglerfish, also due to hybridization events between black-bellied and white-bellied anglerfish. While recent species-specific sampling is considered reliable, assumptions on historical splits are less reliable. A constant maturity ogive was estimated from commercial and survey data for females in the years 2009-2023. It was agreed to include all years with standardized maturity scale for estimation of a constant ogive, representative for the entire assessment period.

Commercial trawl LPUE indices as well as two scientific survey indices (SP-GFS, SP-ARSA) were considered. Trawl LPUE indices were initially modelled separately for the Spanish and Portuguese fleets but combined as input to the assessment model using Joint Index Approach. Combining the trawl LPUE indices is sensible, no length frequency data was available, and selectivity assumptions were mirrored from trawl landings fleet, which was also combined for countries. Two scientific surveys were indices calculated separately, length frequency distributions are provided indicating different targeted size ranges. In the future, it can be suggested to try a modelling approach to derive a combined survey index. It should be noted that only for the SP-GFS survey sex-specific length distributions are provided.

2.7.3 Assessment model

A sex-structured, quarterly SS3 model was agreed. Time-varying selectivity was included for the trawl landings 2010-2023. Extending this period to include new data years should be considered at the next WG. Length distributions were fitted well in the model. While diagnostics are mostly acceptable, the runs tests (RMSE) show some conflict between indices, particularly in the early period. In the hindcasting (MASE) for the ARSA survey index, predictions were shown to be lower than the observed values. This is likely due to differences in spatial coverage of the surveys and targeted lengths. The index trends of LPUE and SP-GFS index are relatively consistent, SP-ARSA suggests a slightly stronger recent increase in biomass. The assessment results appear to be robust to the assumption of steepness, only showing variation in the data-poor period prior to 1989. Diagnostics and retrospectives are acceptable.

After a period of low biomass, SSB has recovered to some degree in the recent period. It was noted that the model estimates very high fishing mortality (>1) around 1990 when landings were high, similar level estimated total biomass. The fishing mortality has since decreased substantially, and the stock has increased from low level. The confidence intervals around SSB are quite large prior to 1989, which could be explained by the lack of indices and length data in the early period.

2.7.4 Reference points, Forecast and MSE

A spasmodic recruitment pattern was identified for this stock (stock type 1). B_{lim} was suggested accordingly (SSB in 1996, around 10%B_0). The reference points were estimated using the stock recruitment relationship from the SS3 model. F_{MSY} is estimated to be high on a relatively flat yield curve. MSE was run to tune the EqSim fishing mortality reference points of the advice rule to be precautionary. It should be noted that for EqSim assessment results were simplified to annual time step and combined sex, while the MSE was simplified to annual time steps but keeping separate sexes.

Reviewer: Giuseppe Scarcella

2.7.5 General Conclusions

The assessment of the black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters) presented to the working group marks a significant advancement in evaluating this stock. Previously assessed using the Surplus Production Model in Continuous Time (SPiCT), the transition to Stock Synthesis (SS3) now provides a more robust and comprehensive analytical framework. This transition aligns with best scientific practices and ensures better integration of biological and fisheries data.

The SS3 model incorporates significant updates, including refined data inputs, improved selectivity patterns, and revised growth parameter estimations. Initial discussions within the benchmark process focused on refining survey data uncertainty, modifying selectivity assumptions, and testing growth parameter configurations. A sensitivity analysis following Francis et al. (2003) methodology was conducted to assess the impact of different assumptions. Key improvements included adjustments in selectivity functions, expansion of time series data, and parameter re-estimations, ultimately improving model accuracy and reliability. However, several areas warrant further investigation to refine stock assessments and management recommendations:

- Growth and Maturity Studies: Reliable growth estimates remain a challenge, necessitating dedicated research to refine length-at-age and maturity parameters.
- Hybridization and Stock Structure: Emerging genetic studies suggest potential misidentification and hybridization between *Lophius* species. Future assessments should integrate genetic information to improve stock discrimination.
- Survey Data Integration: Efforts should focus on combining survey data from multiple sources to create a comprehensive abundance index that adequately reflects stock dynamics.
- Effort Standardization: Improving CPUE standardization for passive gears, including the consideration of net count rather than fishing days, would enhance data reliability.

2.7.6 Fit to Data and Model Diagnostics

The models tested during the benchmark workshop were evaluated based on their fit to data and diagnostic performance. Various configurations incorporated biomass indices, landings data, and length compositions, with adjustments for seasonality and fleet-specific trends. The assessment considered multiple sources of uncertainty, including:

- Refinement of CPUE indices, integrating commercial LPUE data from Portuguese and Spanish trawl fleets.

- Inclusion of research surveys from Spanish North Coast and Gulf of Cadiz, enhancing the representation of recruitment trends.
- Assessment of model sensitivity to changes in growth parameters and natural mortality assumptions.

Overall, the model demonstrated a reasonable fit to data, with most indices aligning well with historical patterns. However, the effort unit used in CPUE calculations for passive gears (i.e., fishing days) remains a concern. Future assessments should explore alternative effort standardizations to mitigate the impact of effort creep and better reflect the actual number of nets used.

2.7.7 Biological reference points

Biological reference points were estimated following ICES guidelines and aligned with the principles established in previous assessments. The stochastic equilibrium simulations (EqSim) approach was employed to determine MSY-based reference points, incorporating uncertainty in recruitment and stock productivity.

2.8 Conclusions

Both reviewers consider the BestCase model proposed by WKBSS3 as suitable for providing management advice.

2.9 References

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2.10 Stock-specific working documents (ank.27.8c9a)

- WD_2.1 ank278c9a_LPUE standardization_OTB
- WD_2.2 ank.27.8c9a_JARA_ANKJoint_CPUE
- WD_2.3 ank8c9a_LWRelationship_Lbudegassa
- WD_2.4 ank8c9a_MaturityOgive_ank8c9a
- WD_2.5 ank.8c9a_ShortCut_HCR_MSE

3 White anglerfish in the Cantabrian Sea and Atlantic Iberian waters

Lophius piscatorius in divisions 8.c and 9.a | mon.27.8c9a

3.1 Introduction

The last stock assessment for the Southern white anglerfish (*Lophius piscatorius*) was carried out in Stock Synthesis with data from 1980 to 2023 (ICES, 2024a). This model was used in 2024 to provide advice although there were some concerns about the commercial abundance indices used and the configuration of the selectivity. The objective of this work is developing a robust Southern white anglerfish SS model able to provide catch advice in the ICES context. New and updated data were presented in the WKBSS3 data compilation workshop (January 2025) and, after intersessional work with the help of chairs and reviewers, a base case model was presented the first day of the Benchmark workshop on application of Stock Synthesis (SS3) on selected stocks (February 2025). A final SS3 model was accepted during the WBKSS3 and the process of this development is presented here. This section is structured as follows: (1) First, a summary of the data review and main decisions; (2) the progress of the assessment model; (3) the description of the final model agreed; (4) the reference points; (5) projection settings and (6) final considerations.

3.2 Input data for stock assessment

The fishery dependent data (landings, discards and length composition) are described in WD1.

Landings data

- Time series of quarterly landings data for period 1980-2023.
- Period 1980-1983: there is no Portuguese trawl fleet data.

Length distribution

- No length distribution available before 1986.
- Quarterly length distributions start in 1989 except for Fleet SPNETS that started in 1994.
- Length distribution sample sizes were initially set based on the sample size and quality of the length composition.

Discards data

For most of the fleets discards of white anglerfish are considered negligible and no estimates are available. Since 2003, discards are routinely estimated for Spanish trawl fleet. The volume of discards is very low, and the sample size of length compositions was in many years not enough to use in the assessment model.

In previous assessments discards were not included in this assessment model, and they were considered negligible. The benchmark decided to attempt to include the discards of the fleet SP-TRAWL in the assessment model.

SS3 Fleets and length distribution

The benchmark decided to maintain the four fleets used in the previous SS3 assessment: Spanish trawlers (SPTRAWL), Spanish netters (SPNETS), Portuguese trawlers (PTTRAWL) and Portuguese netters (PTNETS). There are differences in the selectivity between these 4 fleets. Spanish and Portuguese trawlers catch the smaller fish starting around 30 cm, and netters target the larger ones (Figure 3.1).

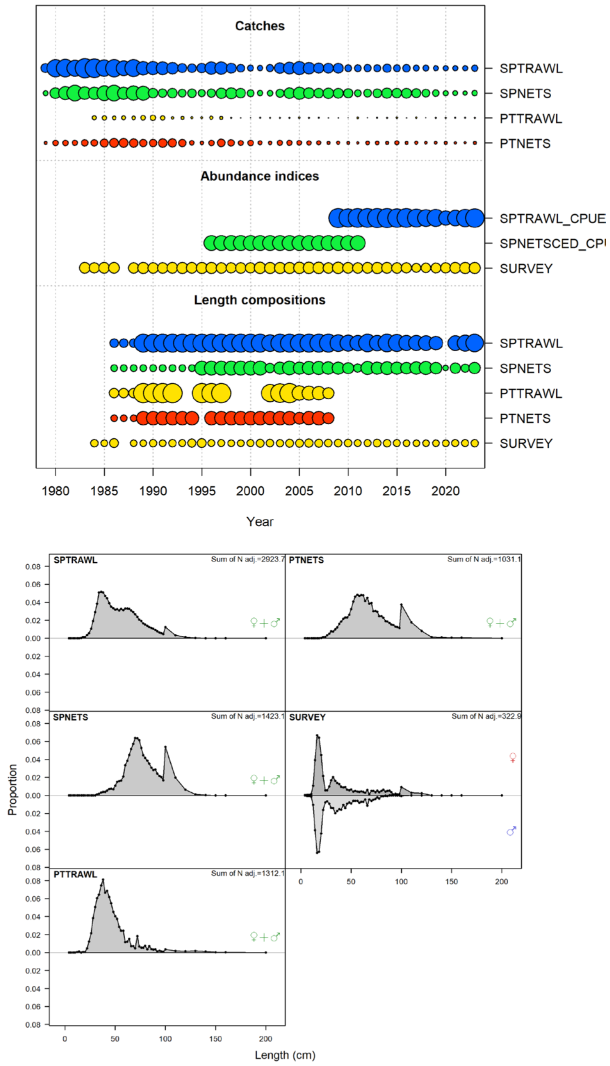


Figure. 3.1. Time series of data included in the Final Model for the 4 fleets, 2 CPUEs and one survey (top). Aggregated length frequency distributions for fleets and survey (sex separated) (bottom).

Commercial Abundance Indices

Three CPUE indices were standardized for fleets in Spain and one in Portugal.

The index for the **Spanish trawl fleet** (SPTRAWL_CPUE) was standardized using data from an on-board observer program. Spatiotemporal generalized additive mixed models (GAMMs) were implemented using the R library *sdmTMB* (Anderson *et al*., 2024) (WD2). From 2016 to 2020 there is decrease trend, with a recovery the last 3 years (Figure 3.2).

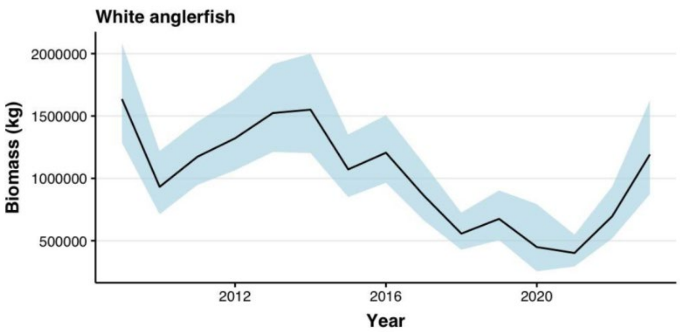


Figure 3.2. Area-weighted of relative biomass over time for white anglerfish. Line represents the mean and blue shaded ribbon represents a 95% confidence interval.

The **Spanish Rasco fleet** (SPNETS_CPUE) targeting anglerfish was standardized for the period 2009-2023 using logbooks information. A Generalized Additive Mixed-Effect Models (GAMM) was fitted using the R package *mgcv* (Wood, 2011). The predictions indicate a period of high stability (2014-2020) followed by two years of increases (Figure 3.3).

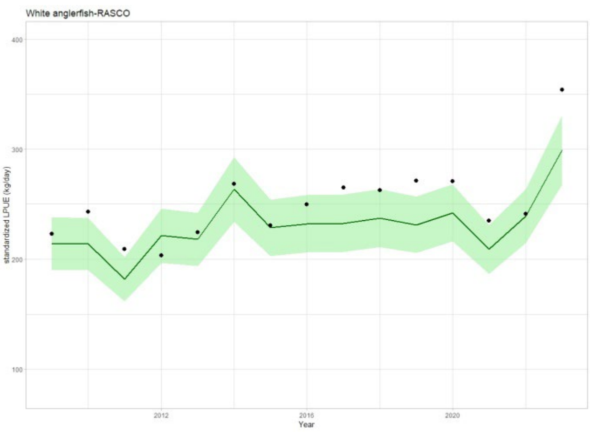


Figure 3.3. Standardized CPUE index (solid line) with 95% confidence intervals (shaded ribbons) estimated by the final model for fleet SPNETS. Black dots indicate the nominal CPUE index.

The index for **Spanish Rasco fleet for the port of Cedeira** (SPNETSCED_CPUE), 1996-2011, used in the previous assessment, was newly standardized. A GLMM model was fit, using the library *glmmTMB,* with soaking time, GRT category and quarter as explanatory variables, and vessel identity as random effect. The predictions were estimated for a soaking time of 1 day, category 3 of GRT and quarter 1 (Figure 3.4).

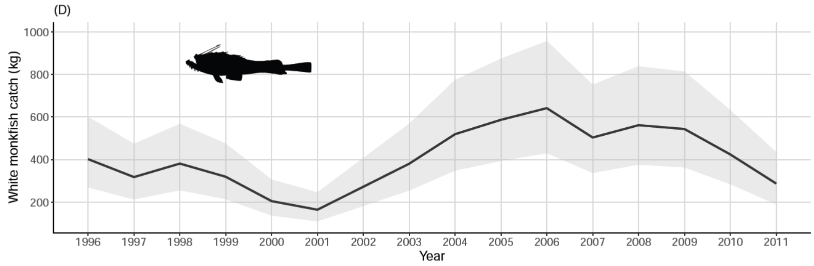


Figure 3.4. Biomass index SPNETSCED_CPUE for white anglerfish.

The CPUE index from the **Portuguese trawl fleet** (PTTRAWL_CPUE), 1989-2023, is based on daily landings data and considering targeting effects. The standardization followed the methodology from Winker *et al*. (2013). In this method, the LPUE is standardized using a Generalized Additive Mixed Model (GAMM) where the vessel is the random effect. This index shows drastic changes from year to year that could be in relation with the process of splitting the combined catch into *Lophius* species (Figure 3.5).

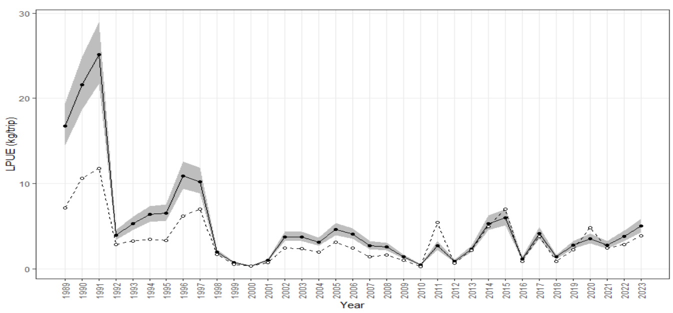


Figure 3.5. Nominal (dashed) and standardized LPUE index (solid black) with 95% CIs.

Scientific surveys

Although there are 4 scientific bottom-otter trawl surveys that cover the distribution area of the population, the white anglerfish catches are very low or null for SP-ARSA 1Q, SP-ARSA 4Q and PT- GFS, and they cannot be used for assessment.

The survey that was used in the previous SS3 assessment was also used in this benchmark: Spanish North Coast Bottom Trawl Survey (SP-NORTH; G2784). This survey provides a good indicator of the recruitment of the stock and its time series goes from 1982 to 2023. The LFDs for this survey were available by sexes from to allow the development of 2-sex SS3 model during the benchmark (Figure 3.6).

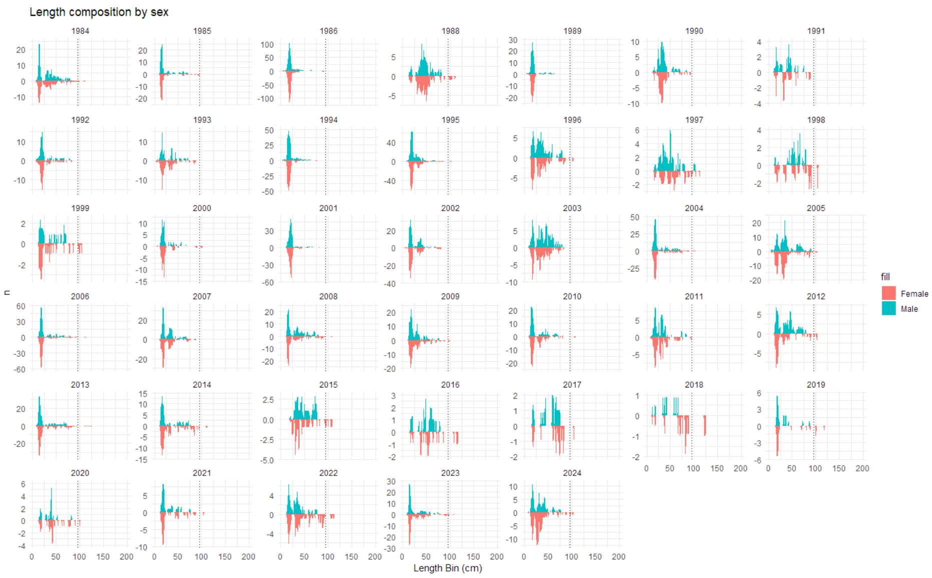


Figure 3.6. Length distribution by sex of SP-NORTH Survey (1984-2023)

Biological data

The following topics were addressed in the data workshop:

- Sex-at-length data for Spanish survey in the north, where LFDs by sex was provided (WD 4).
- Length weight relationship by sex was estimated including Spanish and Portuguese time series 1996-2023. Females: a= 2.24e-05, b=2.889; Males: a= 3.01e-05, b=2.804 (WD 4).
- Female maturity was also estimated using macroscopical study for the period 2011-2023 with L50= 58.1 cm; slope= -0.388 (WD 5).
- A vector of natural mortality at age was estimated using different empirical methods: Age 0: 0.94; Age 1: 0.53; Age 2: 0.37; Ages 3-30: 0.29 (WD4).
- Steepness was set at the value derived from Fishlife for *Lophiidae* family (h = 0.8677).

Among these, length-weight relationship, steepness and female maturity ogive were implemented in the new model as time invariant parameters. On the other hand, the annual sex-at-length survey distribution was used as input for the model.

3.3 Stock assessment

The assessment of white anglerfish in the Cantabrian Sea and Atlantic Iberian waters was carried out using Stock Synthesis (SS3) (Methot and Wetzel, 2013). All models described here were run under the windows platform with SS3 version 3.30.23.1 (Methot *et al*., 2024). All analysis were performed in R version 4.4.2 (R Core Team, 2024) making use of SS3 related packages r4ss (Taylor *et al*., 2021) and ss3diags (Winker *et al*., 2024).

3.3.1 Base case model

It was developed during the period between the WKBSS3 data compilation workshop (January 2025) and the WKBSS3 benchmark meeting (February 2025) and presented in the benchmark meeting.

The main structure and settings are summarised below:

- Length-based model
- Two-sex model. Sex-specific survey length data were provided and a sex-disaggregated model was developed.
- Quarterly time step.
- 4 Fleets: SPTRAWL, SPNETS, PTRAWL, PTNETS.
- 4 Surveys: 2 CPUEs SPTRAWL_CPUE and SPNETSCED_CPUE and 1 SURVEY. The model fit for PTTRAWL_CPUE was not good and was not included in the base case model. The SPNETS_CPUE showed a long period of hyper stability that cannot be followed by the model. Being its information not impacted in the fit neither in the results, the benchmark decided not to include this index in the assessment model.
- Not discards data. Different approaches to include discards data were tried, but the fit did not improve and due to the low discard quantities, the benchmark decided not to use discards in the assessment model.
- Sample sizes for commercial and survey length composition were calculated using number of trips and fish measured following the methodology described by Stewart *(pers. comm.* to the benchmark):

  $N_{input} = N_{trips} + 0.138N_{fish}$ when $\frac{N_{fish}}{N_{trips}} < 44$

  $N_{input} = 7.06N_{trips}$ when $\frac{N_{fish}}{N_{trips}} \geq 44$
- Length selectivity for all fleets is modelled as double-normal function. More information on this in section describing alternative runs.
- Biological parameters: growth parameters for females: K fixed at 0.112 and Linf fixed at 185 cm; growth parameters for males: K fixed at 0.3 and Linf estimated by the model.
- Steepness is fixed: h = 0.8799.
- Age specific natural mortality vector common for both sexes.
- Francis reweight process was applied.

3.3.2 Exploratory assessments

Four alternative model configurations were explored using the base case model as starting point:

3.3.2.1 Model 1. Growth parameters and natural mortality vector by sex

The growth parameters for males were set as followed: the L_{inf} of Males= 110 cm (fixed) and K estimated by the model (using a prior) (Figure 3.7). Using the growth parameters for females and males a Matage by sex was externally calculated Matage via Lorenzen's and Gislason's method.

Vector of Matage by sex: common value until maturity (age 3), then different value for males and females:

Females: age0: 0.94; age1: 0.53; age2: 0.37; age3-30: 0.29.

Males: age0: 0.94; age1: 0.53; age2: 0.37; age3-30: 0.30.

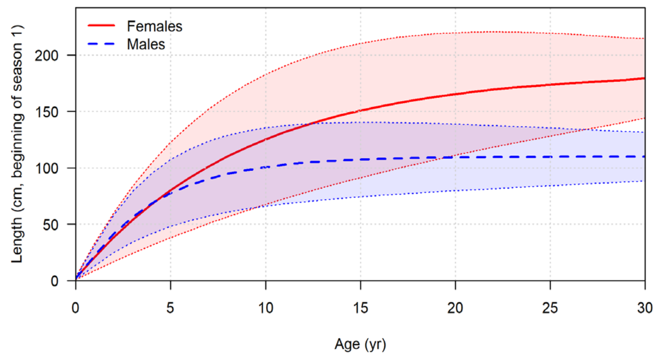


Figure 3.7. Growth curve for females and males in the assessment model.

The benchmark decided that the changes are in line with the biology of the species and thus they are appropriate to the assessment model configuration.

3.3.2.2 Model 2. Fleet PTNETS modelled with logistic length selectivity

The assumption of at least one fleet modelled with an asymptotic selectivity pattern is a standard in fisheries modelling. Follow this rule, the fleet PTNETS was modelled with a logistic selectivity (Figure 3.8). This fleet was chosen because it was the fleet that catches the largest anglerfish.

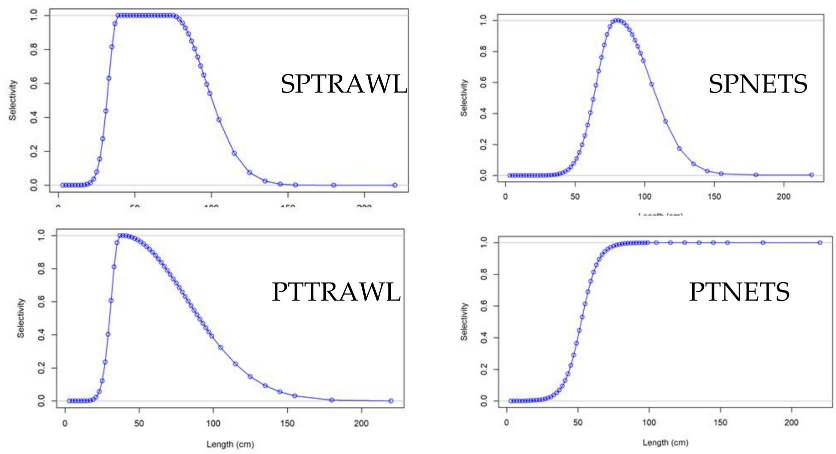


Figure 3.8. Selectivity curves for the 4 fleets in the assessment Model 2.

The benchmark decided to apply this changed to the assessment model of mon.27.8c.9a

3.3.2.3 Model 3. Model 1 + Fleet PTNETS modelled with logistic length selectivity

Changes in model 1 and model 2 are applied together, providing a good configuration for biology and selectivity.

The benchmark selected this model as final model for mon.27.8c.9a.

3.3.2.4 Model 4. Model 3 and time-block for selectivity SPNETS

It was detected a changed in the fishing behaviour of the fleet SPNETS in recent years. The length composition of catches has changed to increase the number of smaller fish. To accommodate this in the model, a time-block for years 2021-23 was set for the selectivity of the fleet (Figure 3.9). This changed was added to the model 3 configuration.

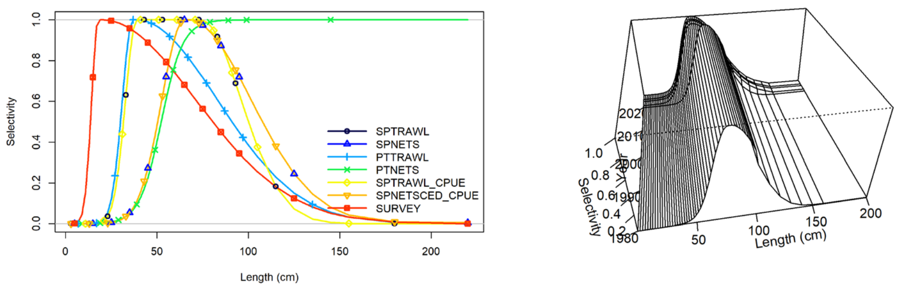


Figure 3.9. Selectivity for all fleets (left) and time varying selectivity for fleet SPNETS.

The time-block set for recent years lead to new patterns in the retrospective.

The benchmark decided not to apply the time-block for selectivity of SPNETS.

3.3.2.5 Comparison Base Case and alternative models

Although the final model, Model 3, did not get the best likelihood among the set of runs (Table 3.1) the model configuration reflects the best knowledge of the biology of the species and understanding of the fishery. The final model provides similar trends in SSB and F comparing to the base case and alternative runs. However, the scale is different and the SSB is lower than the base case and model 1, and the F is higher (Figure 3.10). The comparison of the results of diagnostics for Base case and alternative configuration is shown in Table 3.2. The diagnostics performance of the 5 models tested is similar with not changes or relevant improvements between configurations.

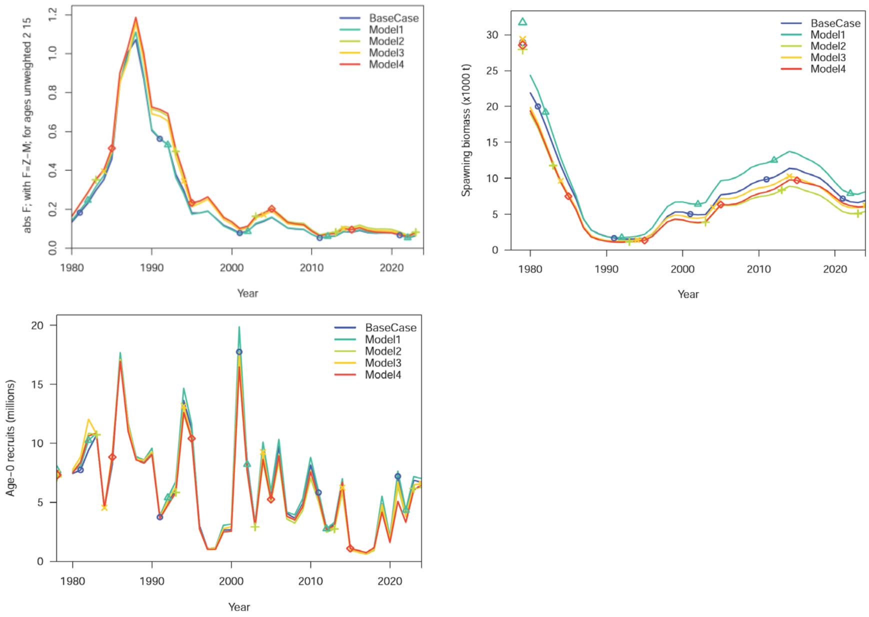


Figure 3.10. Comparison of summary statistics between base case and alternative runs. Model 3 is the final model for assessment.

Table 3.1. Main outputs for Base case and alternative configurations.

Label	Base case	Model 1	Model 2	Model 3	Model 4
TOTAL_like	1812.3	1814.55	1823.51	1826.7	1802.05
Survey_like	-40.125	-38.3937	-41.1854	-39.8203	-36.9533
Length_comp_like	1836.88	1836.4	1847.09	1848.79	1822.57
Parm_priors_like	0	0.442759	0	0.749395	0.469163
Recr_Virgin_millions	7.44196	7.7073	7.16954	7.43985	7.32044
SR_LN(R0)	8.91489	8.94992	8.8776	8.91461	8.89843
SR_BH_steep	0.8799	0.8799	0.8799	0.8799	0.8799
L_at_Amax_Fem_GP_1	185	185	185	185	185
L_at_Amax_Mal_GP_1	109.699	110	105.147	110	105.111
VonBert_K_Fem_GP_1	0.112	0.112	0.112	0.112	0.112
VonBert_K_Mal_GP_1	0.3	0.24941	0.3	0.252243	0.3
SSB_Virgin_thousand_mt	28.913	31.709	27.949	29.369	28.55
Bratio_2023	0.569995	0.611094	0.452309	0.499854	0.525094
SPRratio_2022	0.634417	0.594534	0.717293	0.678408	0.687021

Table 3.2. Diagnostics test for Base case and alternative configurations.

Runs	Base Case	Model 1	Model 2	Model 3	Model 4
Convergence	3.53E-04	2.80E-04	7.80E-05	9.82E-05	9.51E-05
Total_LL	1812.3	1814.55	1823.51	1826.27	1802.05
N_Params	826	826	822	822	828
# Residual Diagnostics					
SPTRAWL_CPUE	Passed	Passed	Passed	Passed	Passed
SPNETSCED_CPUE	Failed	Failed	Failed	Failed	Failed
SURVEY	Failed	Failed	Failed	Failed	Failed
SPTRAWL	Passed	Passed	Passed	Passed	Passed
SPNETS	Failed	Failed	Failed	Failed	Failed
PTTRAWL	Passed	Passed	Passed	Passed	Passed
PTNETS	Failed	Failed	Failed	Failed	Failed
SURVEY	Failed	Failed	Failed	Failed	Failed
# RMSE					
RMSE_CPUE	41.9	42.6	41	41.6	42.6
RMSE_LENGTH	10.3	10.3	10.3	10.3	10
# Retrospective					
Retro_Rho_SSB	0.07	0.05	0.06	0.04	0.08
Retro_Rho_F	0.00	0.00	0.01	0.02	-0.17
# Capacity Prediction					
SPTRAWL_CPUE	0.65	0.65	0.72	0.73	0.87
SURVEY	0.83	0.83	1.05	1.03	1.05
SPTRAWL	0.65	0.64	0.63	0.62	0.68
SPNETS	2.52	2.52	2.57	2.59	1.89
SURVEY	0.83	0.80	0.85	0.83	0.84

3.3.2.6 Sensitivity analysis of steepness

The potential impact of the assumed value of steepness was explored by a sensitivity analysis with 4 values of *h*: *h*-basecase (previous assessment) =0.99, *h*= 0.92, *h*=0.65 and *h*-benchmark model= 0.8799.

The trends in SSB and F are similar for different values of *h*. However, in recent years is observed that the SSB estimates increase with high values of *h* and F estimates decrease (Figure 3.11).

The value of *h* assumed for the benchmark models is considered a realistic value for this stock.

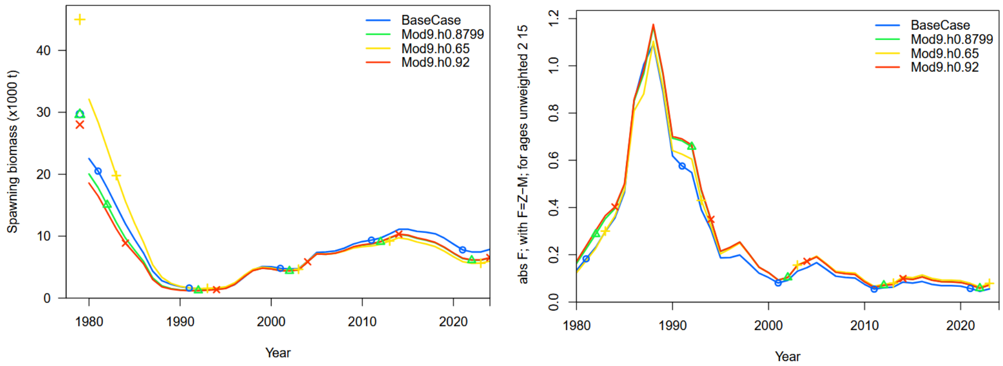


Figure 3.11. Comparison of derived quantitatives for runs with different *h* values

3.4 Final model

The final model includes the parameterization decided during the benchmark meeting with these main decisions:

- Fix the growth parameter Linf for males at 110 cm and leave the model to estimate K parameter for males (using a prior).
- To include a natural mortality vector by sex.
- Selectivity of fleet PTNETS is modelled as logistic.

3.4.1 Settings

The main settings of the model are presented below:

Data File

- Start year: 1980
- End year: 2023
- Seasons: 4
- Months: 3
- Subseasons: 2
- Spawning month: 1
- Sexes: 2
- Ages: 30
- Areas: 1
- Fleets: 7
    - Fleet 1: SPTRAWL
    - Fleet 2: SPNETS
    - Fleet 3: PTTRAWL
    - Fleet 4: PTNETS
    - Fleet 5: SPTRAWL_CPUE
    - Fleet 6: SPNETSCED_CPUE
    - Fleet 7: SURVEY

Control file

Length selectivity

For SPTRAWL, PTTRAWLand SPNETS is modelled with double normal (Pattern 24).

PTNETS is modelled with double normal (Pattern 20).

The SPTRAWL_CPUE index mirrors the SPTRAWL selection pattern and SPNETSCED_CPUE index mirror SPNETS selection pattern.

Catchability

- The Q option for 3 indices was floating.
- Extra standard deviation was estimated for the 3 indices.

Reweighting

- Francis for length compositions

3.4.2 Diagnostics

The approach to model diagnostics described below follows that described by Carvalho *et al.* (2021).

3.4.2.1 Convergence

The final gradient is < 1e-4 and the Hessian is positive definite. No parameters are estimated at or near bounds or with unusual variance.

50 jitter runs were performed using default settings for magnitude and all converged on the same total likelihood as the base run (Figure 3.12).

There is a high correlation in the parameters controlling the ascending part of the double-normal selectivity curve and the peak parameter for the SPTRAWL (92%), PTTRAWL (91%) and SPNETS fleets (86%). Also, a negative high correlation for SPTRAWL fleet between descend se parameter and top logit parameter (-86%).

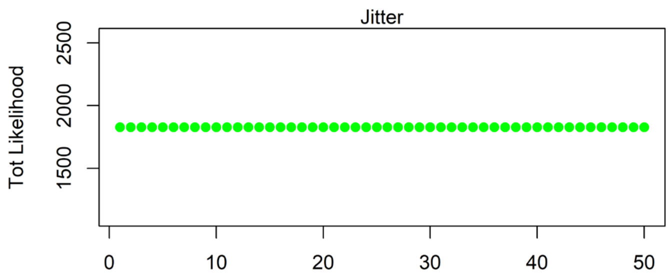


Figure 3.12. Total likelihood for the 50 jitter model runs.

3.4.2.2 Goodness of fit

The goodness of fit of the model was evaluated through the examination of the fit for indices (Figure 3.13) and residual plot (Figure 3.14). The model fit relatively well the SPTRAWL_CPUE and the SPNETSCED_CPUE. The residuals test was only passed for the SPTRAWL_CPUE and Survey shows a residual pattern in recent years.

The model showed a general good fit to length composition data with no large Pearson residuals or strong patterns (Figure 3.15 and 3.16). Residuals for mean length passed the run test for 2 commercial fleets SPTRAWL and PTTRAWL indicating no evidence to reject the hypothesis of randomly distributed residuals. On the other hand, the commercial fleets SPNETS and PTNETS and survey did not pass the randomly distributed residual test (Figure 3.14). The joint length composition residual plot (Figure 3.17) and the root mean square error (RMSE) of 10% indicated a good fit to the data. RMSE values above 30% may indicate data conflicts (Carvalho *et al*. 2021).

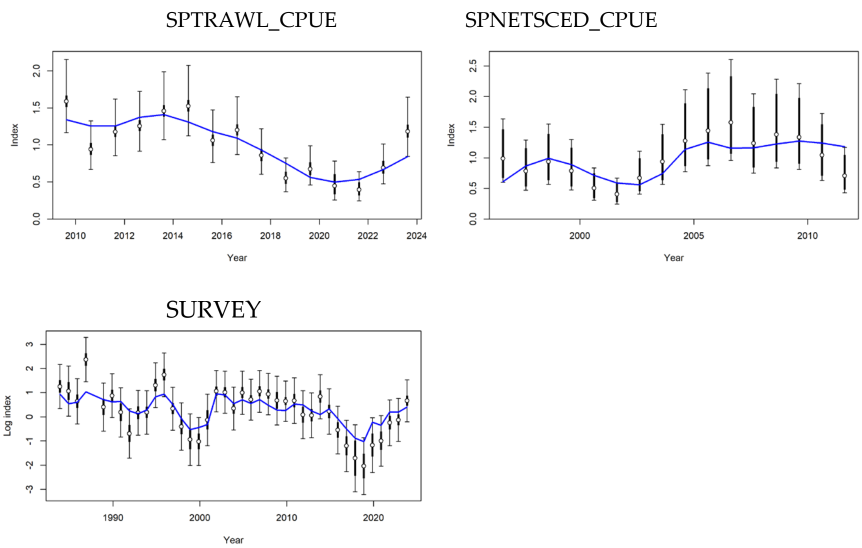
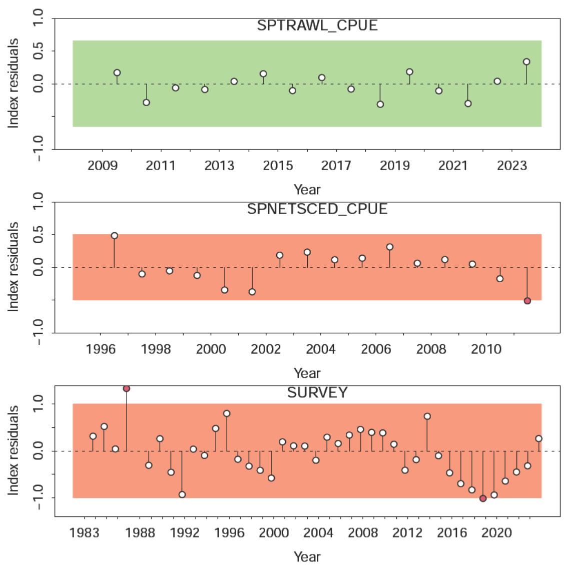


Figure 3.13. Fits to index data. Lines indicate 95% uncertainty interval around index values based on the assumption of lognormal error.



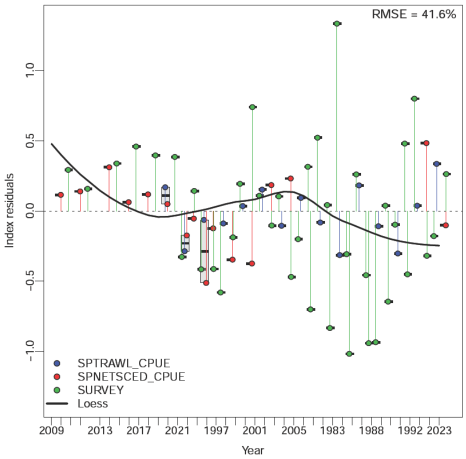


Figure 3.14. Runs test and root mean square error (RMSE) for the index residuals.

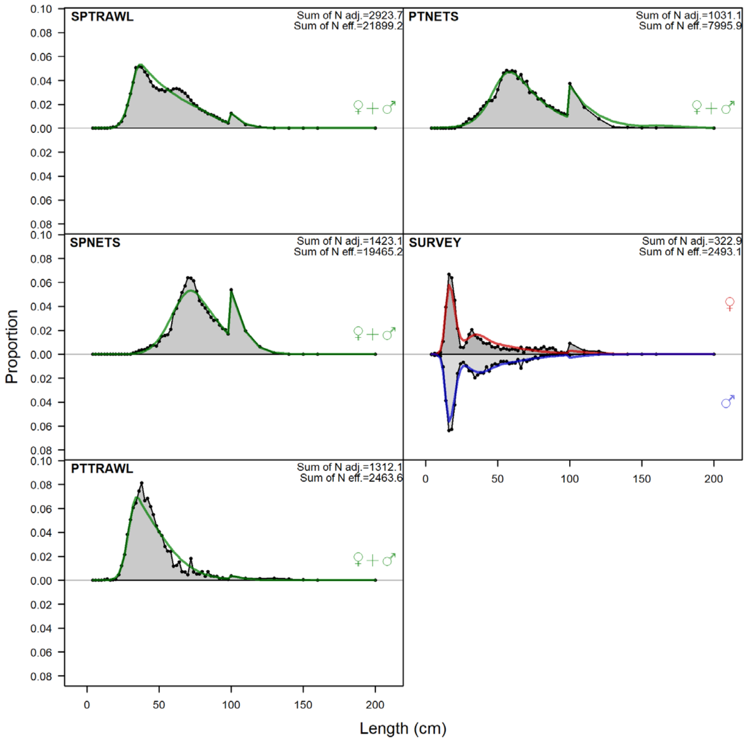


Figure 3.15. Fit to length composition of fleets and survey. Survey is the unique fleet with length composition by sex.

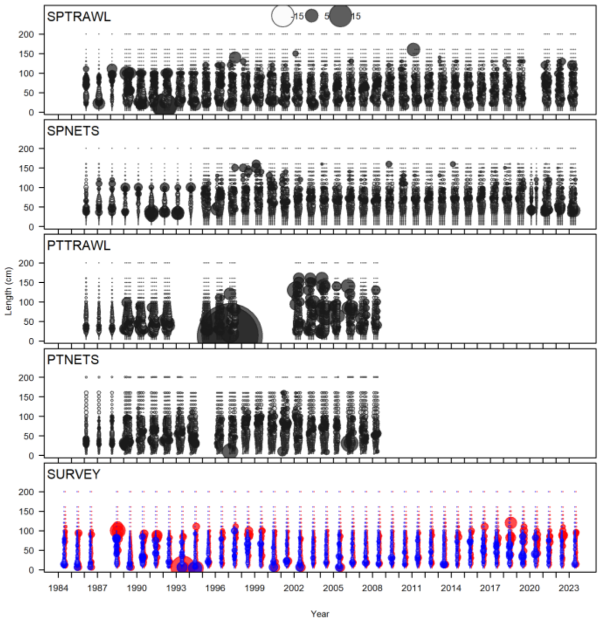
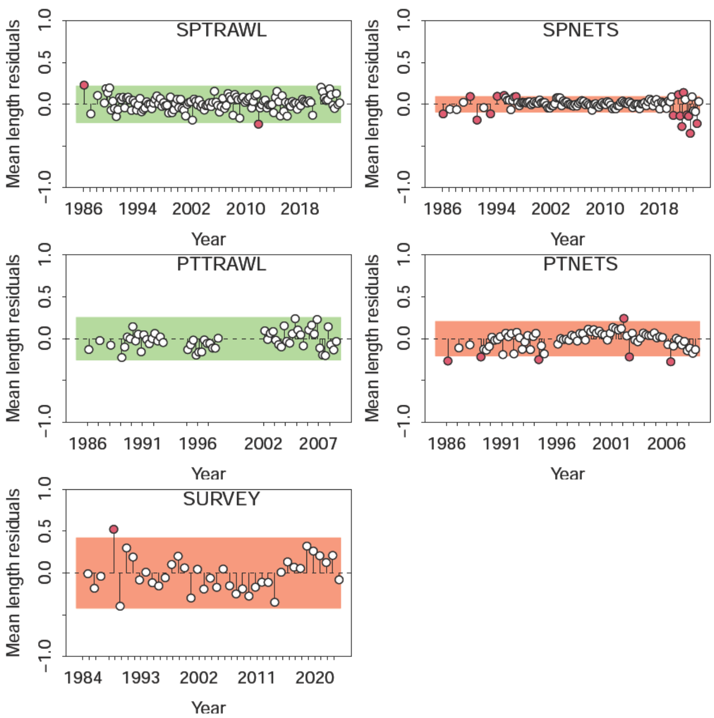


Figure 3.16. Pearson residuals for length composition of fleets. Closed bubbles are positive residuals (observed > expected) and open bubbles are negative residuals (observed < expected).



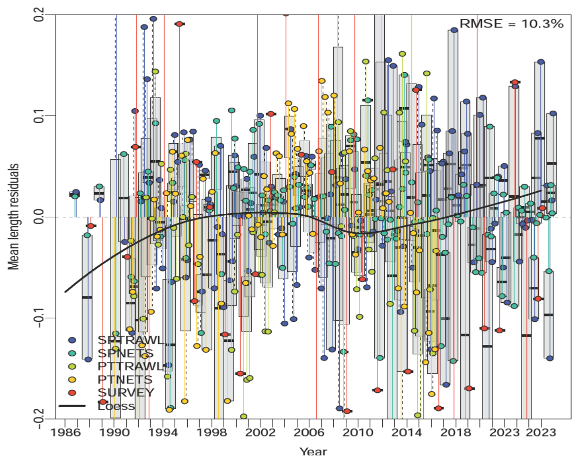


Figure 3.17. Runs test for mean length for fleets and survey and RMSE.

3.4.2.3 Model consistency

Retrospective analysis shows almost no retrospective bias in SSB and F. Values for Mohn's rho are in the accepted ranges (Figure 3.18) indicating a good consistency of the model.

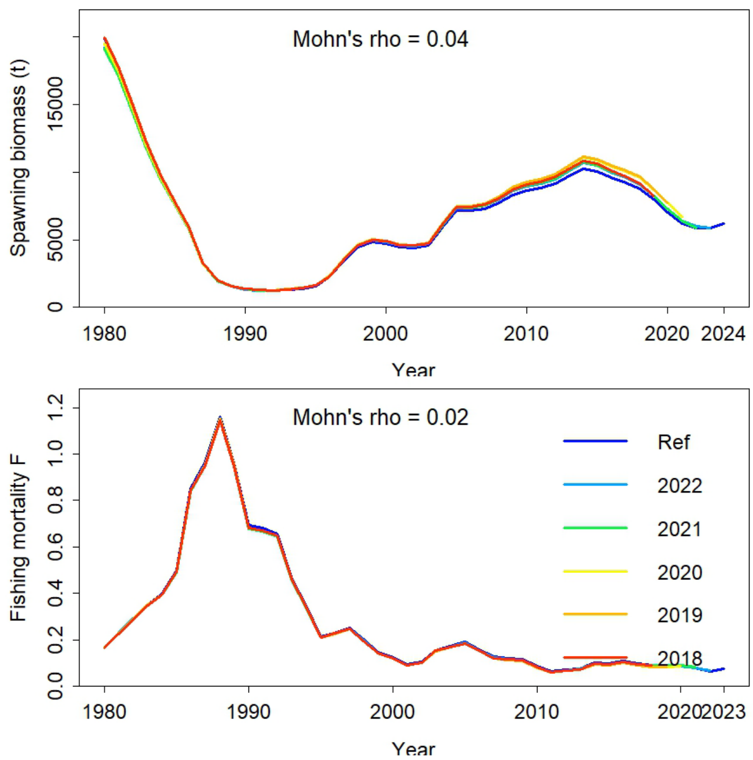


Figure 3.18. Retrospective analysis for SSB and F with their corresponding Mohn's rho values.

3.4.2.4 Prediction skill

The hindcast cross validation of the indices are shown in Figure 3.19. SPTRAWL_CPUE has a good predictive power (MASE < 1) and the Survey is slightly above the limit of MASE.

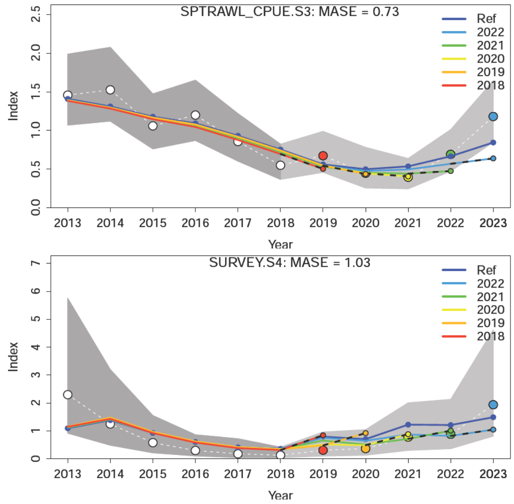


Figure 3.19. Mean absolute scaled error (MASE) for biomass indices

SPNETSCED_CPUE is not included in the Hcval analysis because the index ended in 2011. On the other hand, the hindcast cross validation of the length composition shows good predictability for fleet SPTRAWL and the survey indices (Figure 3.20).

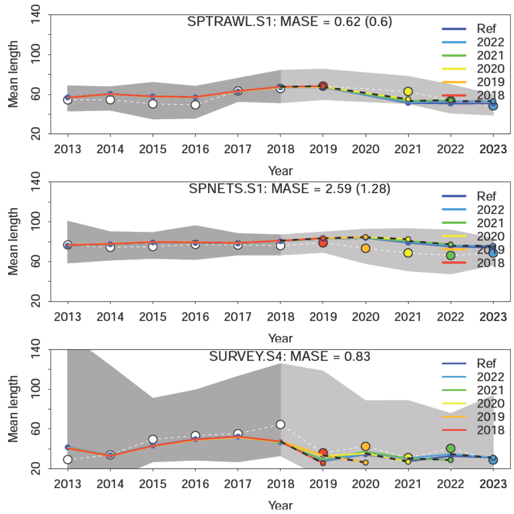


Figure 3.20. Mean absolute scaled error (MASE) for mean length. PTTRAWL and PTNETS are not included in the analysis because the length composition is not included in the model since 2009.

3.4.3 Summary results

The results of the final model show a decreasing trend in SSB from the beginning of the series until early 1990´s when a minimum is recorded (Figure 3.24). Since 1994, SSB increased, until 2014 that decreases again. The fishing mortality had a high peak in 1990 and then decreased and it is below Fmsy since 1999.

3.4.4 Remaining issues

The WKBSS3 considers the current model to be suitable for providing advice. However, it is recommended future developments to include discards information in the model and get an abundance index for larger individuals.

3.5 Biological reference points

Reference points were established by following the ICES fisheries management reference points for category 1 and 2 stocks (Published 1 March 2021) and the conclusions from WKNEWREF (ICES, 2024b).

3.5.1 Eqsim approach

For the approach using eqsim the ICES R package *msy* was used. An FLR stock object was created from SS3 outputs using the R libary *ss3om*. Eqsim works on a single season, single-sex stock object; therefore, the sexes and season were combined. In a 2-sex models, SS3 reports SSB as the female-only SSB and the the reference points were calculated relative to female SSB. F and recruitment in the FLStock object were checked against the SS3 output (and matched closely).

The script used to estimate the reference points for mon.27.8c.9a is on the sharepoint (mon.27.8c.9a_ReferencePoints.zip).

3.5.1.1 Stock-recruit relationship

In order to be consistent with the SS3 assessment, the stock-recruit relationship estimated by SS3 was used for estimating reference points (except for PA reference points which are based on a segmented regression). The values of R_0, B_0 and h were translated to the traditional a and b parameters of the classic Beverton-Holt curve.
Besides, the female SSB and parameter B0 for females that are calculated by SS3 are also used for calculations for reference points. B0 is considered well estimated by the model as is close to the SSB of the first year of the assessment, which was close to unexploited population.

3.5.1.2 Stock type and B_{lim}

The stock is identified as Type 5 with no evidence of impaired recruitment (Figure 3.21).

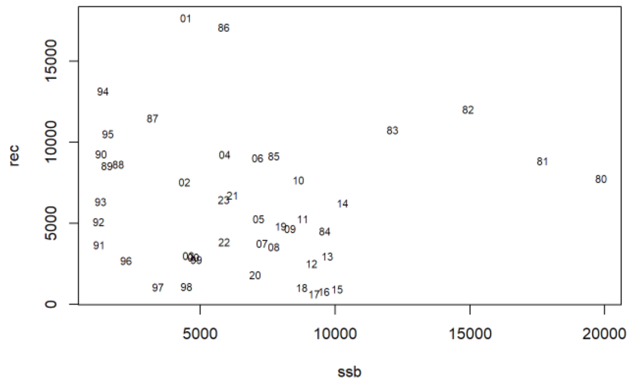


Figure 3.21. Stock-recruitment plot.

Several options were explored to estimate Blim (Figure 3.22):

- Blim empirical: the average of the lowest three SSB-s that resulted in above median recruitments (WKNEWREF, 2024). Blim = 1344 t (4.5% B0)
- 10% of B0. Blim=0.1* 29369= 2936 t
- 15% of B0. Blim= 0.15* 29369= 4405 t

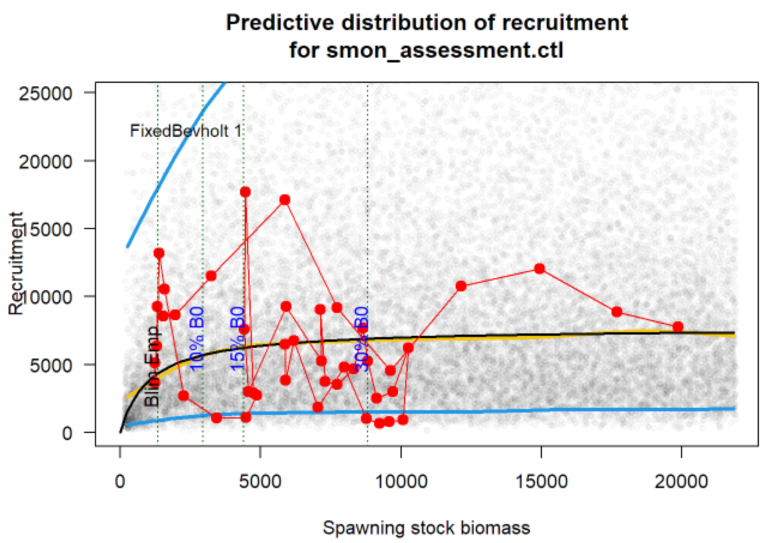


Figure 3.22. Stock recruitment model used for stochastic simulations. SS estimates of the stock-recruitment pairs used for model fitting are in red (1980-2023). Black line shows the average Beverton and Holt model. The grey dots represent simulated values; the yellow line represents the median and the blue lines the 5% and 95% percentiles for the simulated values. Alternative values for B_{lim} are also indicated

The benchmark decided that the Blim defined as 10% of B0 is its proposal for calculation the reference points for mon.27.8c.9a, and the results are shown below.

3.5.1.3 PA reference points

B_{pa} is estimated as B_{lim} plus assessment uncertainty. The estimate of error around SSB in the last years of the model was 0.24. This value of 0.24 was used, resulting in $B_{pa} = B_{lim} * \exp(1.645 * 0.2) = 4373$ t.

Although F_{lim} is no longer used as reference point, it was estimated for completeness of the calculations. F_{lim} is estimated by simulating a stock with a segmented regression S–R relationship, with the point of inflection at B_{lim}, thus determining the F which, at equilibrium, yields a 50% probability of SSB > B_{lim}. This simulation is conducted without inclusion of a $B_{trigger}$. The F_{lim} was estimated at 0.234.

3.5.1.4 Fmsy and $B_{trigger}$

FMSY is initially calculated based on an evaluation with the inclusion of stochasticity in a population and fishery as well as assessment/advice error but without the MSY $B_{trigger}$ advice rule. For this simulation the BH stock-recruit function with fixed B_0 (females only); R_0 and *h* parameters were used. The ICES default settings were used for cvF=0.212; phiF=0.423; cvSSB=0 and phiSSB=0. This resulted in an initial estimate of F_{msy} =0.198 (Figure 3.23).

Although the stock was below Fmsy for the last 10 years, Bmsy5pc is lower than B_{pa} and, then, MSY $B_{trigger}$ is defined as B_{pa}= 4373 t.

The final simulation implements the ICES advice rule which should be evaluated to check that the F_{MSY} and MSY $B_{trigger}$ combination fulfils the precautionary criterion of having less than 5% annual probability of SSB < B_{lim} in the long term. The evaluation includes assessment/advice error and stochasticity in population biology and fishery selectivity (Figure 3.24).

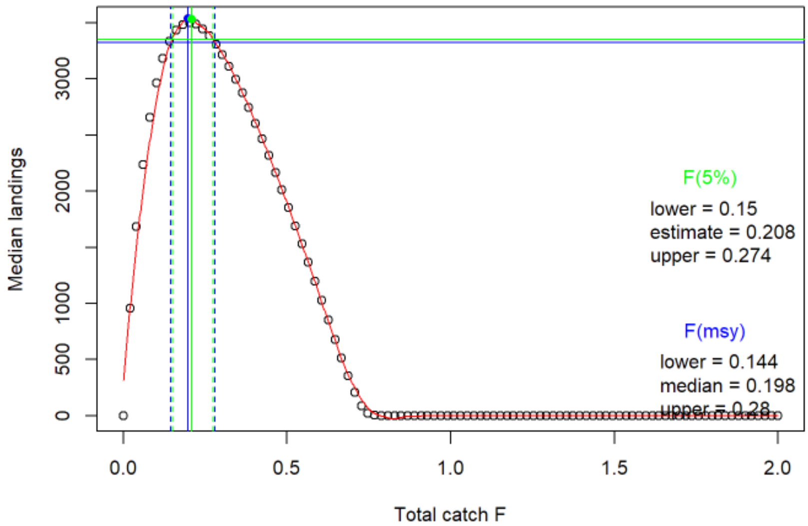


Figure 3.23. Median (across 500 iterations) for the mean yield at stochastic equilibrium as a function of the fishing mortality applied. Blue vertical line corresponds to Fmsy (with dashed line representing the Fmsy range limits). Green vertical ines represent the fishing mortality at which p(SSB<Blim)>5%. Simulations run without implementing ICES MSY advice rule.

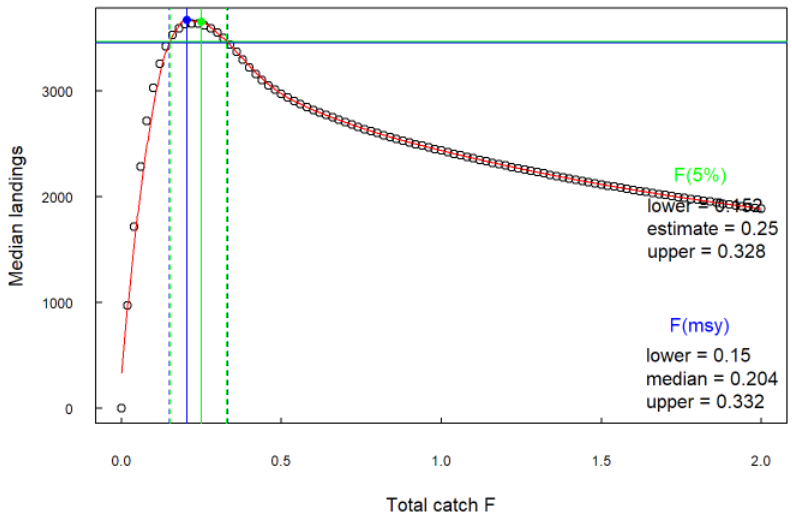


Figure 3.24. F_{p05} estimation in the long-term simulations with ICES AR.

Table. Southern white anglerfish reference points estimated using Eqsim.

Reference Point	Value	Rationale
B_{lim}	2936	10% of Biomass Virgin
B_{pa}	4373	B_{lim} with assessment error
MSY $B_{trigger}$	4373	B_{pa}
F_{pa}	0.25	F with 95% probability of SSB=B_{lim} (BH with Btrigger)
F_{MSY}	0.198	Stochastic simulation (BH without Btrigger)
$F_{MSY\ lower}$	0.144	Stochastic simulation (BH without Btrigger)
$F_{MSY\ upper}$	0.25	The estimated value for FmsyUpper was over Fpa value, therefore, assuming FmsyUpper=Fpa
Bmsy5pc	2527	5% probability of SSB < Blim

3.5.1.5 Equsim Reference Points: Alternative Blim definitions

For the scenario of B_{lim} defined as B_{lim} empirical, the next reference points were calculated following the same approach that in the agreed reference points:

Reference point	Value	Rationale
B_{lim}	1334	Blim empirical

B_{pa}	2002	B_{lim} with assessment error
MSY $B_{trigger}$	2570	Bmsy5pc
F_{pa}	0.434	F with 95% probability of SSB≥B_{lim} (BH with $B_{trigger}$)
Fmsy	0.198	Stochastic simulations (BH without $B_{trigger}$)
FmsyLower	0.144	Stochastic simulations (BH without $B_{trigger}$)
FmsyUpper	0.28	Stochastic simulations (BH without $B_{trigger}$)
Bmsy5pc	2570	5% probability of SSB < B_{lim}

For the scenario of B_{lim} defined as 15% of virgin biomass (B_0), the next reference points were calculated following the same approach that in the agreed reference points:

Reference point	Value	Rationale
B_{lim}	4405	15% of Biomass Virgin
B_{pa}	6560	B_{lim} with assessment error
MSY $B_{trigger}$	6550	B_{pa}
F_{pa}	0.195	F with 95% probability of SSB≥B_{lim} (BH with $B_{trigger}$)
Fmsy	0.195	The estimated value for Fmsy was over F_{pa} value, therefore, we assume Fmsy=F_{pa}
FmsyLower	0.144	Stochastic simulations (BH with $B_{trigger}$)
FmsyUpper	0.195	The estimated value for FmsyUpper was over F_{pa} value, therefore, we assume FmsyUpper=F_{pa}.
Bmsy5pc	2558	5% probability of SSB < B_{lim}

3.5.2 Short-cut MSE approach to check the robustness of reference points

In line with WKREFNEW recommendations (ICES, 2024), a short-cut MSE approach was run to test the robustness of the levels of fishing mortality maintaining both B_{lim} and MSY $B_{trigger}$ as in Eqsim (WD 7). The long-term performance of the reference points simulated are shown in Figure 3.25, indicating that for the scenario with Fmsy estimated by Eqsim (F_{MSY}.eq.Btri.eq), the probability of SSB < Blim is higher than 5%. Thus, the MSE approach outputs indicate that the F_{MSY} estimated by EqSim (0.198) is not precautionary (F with 95% probability of SSB>B_{lim}). Based on the simulations indicated that a precautionary value of F_{MSY} is 0.173 (Table 3.3).

Based on these simulations, the benchmark proposes that F_{MSY} lower is set 0.118, the value of F with not less than 95% MSY (Table 3.3) and F_{MSY} upper is set at Fp0.5 = 0.173.

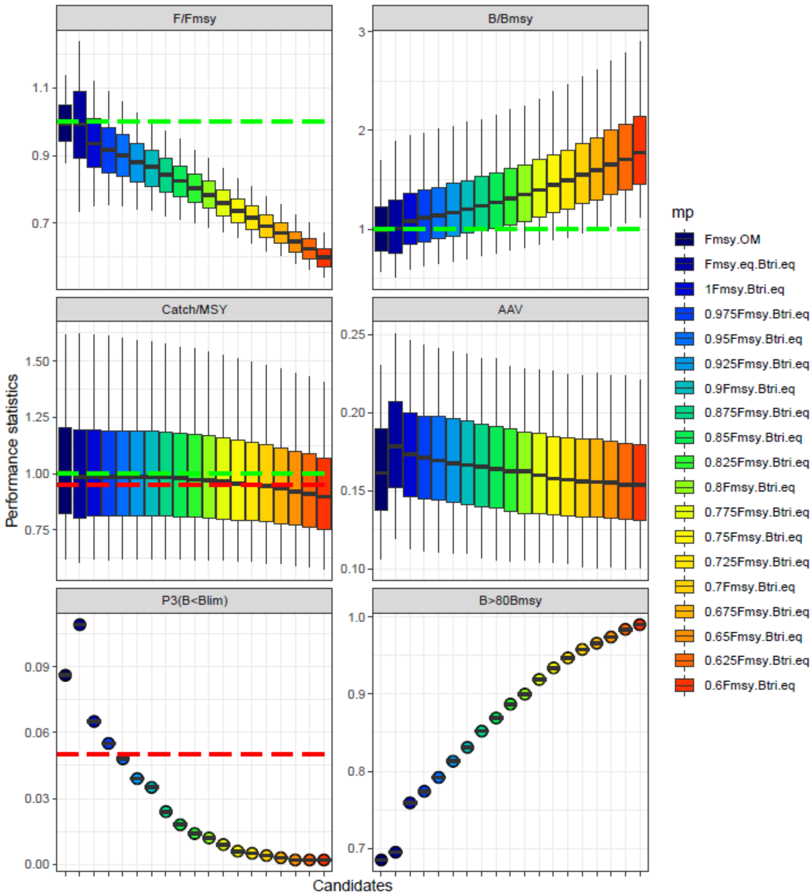


Figure 3.25. Long-term performance evaluation of reference points tested.

Table 3.3. Robustness tests of *Fadv* in line with ICES precautionary approach under closed loop simulations with feedback control of assessment advice emulation.

AR	Fadv	P3(B<Blim)	Catch/MSY	SD.Catch	AAVC	F/Fmsy	B/Bmsy	P(B>0.8Bmsy)
Fmsy.OM	0.182	0.086	1.041	0.311	0.164	0.999	1.035	0.685
Fmsy.eq.Btri.eq	0.198	0.109	1.024	0.309	0.181	0.992	1.074	0.695
1Fmsy.Btri.eq	0.182	0.065	1.028	0.304	0.175	0.936	1.151	0.759
0.975Fmsy.Btri.eq	0.177	0.055	1.028	0.302	0.173	0.917	1.179	0.774
0.95Fmsy.Btri.eq	0.173	0.048	1.027	0.301	0.172	0.901	1.204	0.792
0.925Fmsy.Btri.eq	0.168	0.039	1.026	0.299	0.170	0.881	1.236	0.813
0.9Fmsy.Btri.eq	0.164	0.035	1.024	0.298	0.169	0.865	1.265	0.831
0.875Fmsy.Btri.eq	0.159	0.024	1.021	0.295	0.167	0.844	1.303	0.852
0.85Fmsy.Btri.eq	0.155	0.018	1.018	0.293	0.166	0.826	1.335	0.869
0.825Fmsy.Btri.eq	0.150	0.014	1.013	0.290	0.164	0.804	1.378	0.887
0.8Fmsy.Btri.eq	0.146	0.012	1.008	0.288	0.163	0.786	1.415	0.900
0.775Fmsy.Btri.eq	0.141	0.009	1.001	0.285	0.162	0.762	1.463	0.919
0.75Fmsy.Btri.eq	0.136	0.006	0.993	0.281	0.161	0.738	1.514	0.934
0.725Fmsy.Btri.eq	0.132	0.005	0.985	0.278	0.160	0.718	1.558	0.947
0.7Fmsy.Btri.eq	0.127	0.004	0.975	0.274	0.159	0.693	1.615	0.958
0.675Fmsy.Btri.eq	0.123	0.003	0.966	0.271	0.159	0.673	1.664	0.966
0.65Fmsy.Btri.eq	0.118	0.002	0.953	0.266	0.158	0.648	1.728	0.974
0.625Fmsy.Btri.eq	0.114	0.002	0.942	0.262	0.157	0.627	1.781	0.984
0.6Fmsy.Btri.eq	0.109	0.002	0.927	0.257	0.156	0.601	1.852	0.990

Table. Proposal of reference points for mon.8c9a from the Benchmark.

Reference Point	Value	Rationale
B_{lim}	2936	10% Biomass Virgin
B_{pa}	4373	B_{lim} with assessment error
MSY $B_{trigger}$	4373	B_{pa}
F_{p05}	0.173	F with 95% probability of SSB>B_{lim} (MSE)
F_{MSY}	0.173	Fp05
$F_{MSY\ lower}$	0.118	F with no less than 95% MSY (MSE)
$F_{MSY\ upper}$	0.173	Fp05

With the proposed reference points, the stock would be below F_{MSY} and above B_{lim} and $B_{trigger}$ (Figure 3.26):

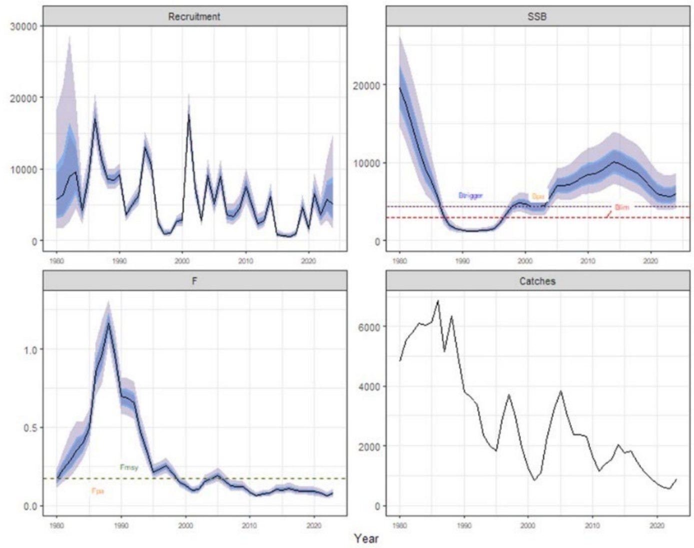


Figure 3.26. Estimated stock status trajectories with associated reference points.

3.6 Short term forecast settings

The following are default forecast options although a change in the selected years can be considered by WGBIE whether the group considers there is a good reason (e.g. changes in trends) to do it.

- Biology (Mean weights-at-age, maturity-at-age): average last 3 year.
- Exploitation pattern: average last 3 years
- F *status-quo* average last 3 years unless there is a clear trend in F, in which case F can be rescaled to the last year.
- Recruitment in the intermediate and forecast years: predicted from Stock Synthesis stock-recruit relationship.
- Recruitment in the last data year(s): if the working group believes that is not accurately estimated it can be replaced with the recruitment predicted from SS stock-recruit relationship.

The WGBIE will review these annually and adapt if it is necessary.

3.7 Future considerations

Future considerations/recommendations are as follows:

Stock ID: the available studies on white anglerfish identity in NE Atlantic indicated that the species is most possibly panmictic, which is in contrast with the current management of three stocks (Abad *et al.*, 2021; Aguirre-Sarabia *et al.*, 2021). This should be further explored in the future.

Input data: the population is assumed to be well covered by different surveys although catches are very low or even null in some areas. It is recommended to create a unique index with all the available scientific surveys covering the spatial distribution of the stock. There are modelling options to handle with very low or null catches.

3.8 Stock-specific reviewers report (mon.27.8c9a)

Reviewer: Tanja Miethe

3.8.1 Introduction

This stock was put forward for benchmark to further develop the SS3 assessment currently used to give advice, with suggestions to reduce model complexity, update life history parameters and standardize LPUE indices. The model appears robust and considered acceptable for assessment.

3.8.2 Data compilation

Discards and discard sampling levels are considered low for this stock, discards are considered negligible in the assessment. The assumption should be reviewed in the future as new data becomes available. Landings and length frequency distributions were split by quarter, fleet (gillnet and trawls) and country (Spain, Portugal) but combined for sexes. Sampling is considered sufficient to support quarterly landings data for the Spanish fleets. In recent years, landings and sampling levels were very low for the Portuguese fleets, such that no length frequency distributions are available since 2009.

Growth parameters for this stock could not be estimated from data due to difficulty with ageing. For female L_{∞} , L_{max} from commercial catches was selected. Other parameters were either taken from literature or estimated in the assessment model. Sex-specific natural mortality was estimated using empirical methods based on assumed growth. Since there is uncertainty around growth parameters, it is recommended to review assumptions for growth and natural mortality in the future. Species misidentification is recognized as an issue for anglerfish, also due to hybridization events between black-bellied and white-bellied anglerfish. While recent species-specific sampling is considered reliable, assumptions on historical splits less so. A constant maturity ogive was estimated from commercial and survey data for females for the years 2011-2023. It was agreed to include all of these available years for estimation of a constant ogive representative for the entire assessment period.

Commercial LPUE indices for Spanish gillnet (Cedeira) and trawls as well as a scientific survey index (SP-GFS) were included. No length frequency data was available for the modelled LPUE indices and selectivity assumptions were mirrored from respective Spanish landings fleet. Relatively long time series of survey data is available for this stock, which also provides sex-specific length distributions as input to the model.

3.8.3 Assessment model

A sex-structured, quarterly SS3 model was agreed. It was decided to keep quarterly time steps in the model, to better track the seasonal impacts of growth on length distributions. Time-varying selectivity was rejected for this stock, not improving model diagnostics. Length distributions are fitted relatively well, particularly for the trawl fleets. Some overestimation of numbers at large size in the Portuguese nets fleet was observed (the one fleet with logistic selectivity). This was deemed acceptable, as larger fish are moving into deeper waters inaccessible to the fishery. However, there is uncertainty on selectivity of the Portuguese fleets in recent years (no length data available). The hindcasting (MASE) shows some overestimation of the Spanish net fleet mean length. In future benchmark, a combination of Spanish and Portuguese landings from nets fleet could be considered. The runs test (RMSE) shows some conflict between indices, likely due to a difference in gear type and spatial coverage. Retrospectives and other diagnostics are acceptable. The assessment results, particularly for the recent period, appear to be robust to the assumption of steepness.

3.8.4 Reference points, Forecast and MSE

There was discussion on regime change for this stock since 2003 for setting B_{lim}. The stock was categorized as type 5. A range of options for B_{lim} were considered. $B_{empirical}$ using the full time series was very low (~4% B_0), but higher using the recent time period (~15%B_0), therefore the benchmark recommended an intermediate value for B_{lim} of 10%B_0. The reference points were estimated using the stock recruitment relationship from the SS3 model. MSE was run to tune the EqSim fishing mortality reference points for the advice rule to be precautionary. It should be noted that for EqSim assessment results were simplified to annual time step and combined sex, while the MSE was simplified to annual time steps but keeping separate sexes.

Reviewer: Guiseppe Scarcella

3.8.5 General conclusions

The previous assessment relied on a length-based analytical model utilizing landings data without discard quantification. The updated 2025 assessment, developed and validated through the WKBSS3 benchmark process, represents a substantial methodological advancement. The key improvements include refined fleet-specific selectivity models, such as the logistic selectivity applied to Portuguese nets (PTNETS), which were not incorporated in the prior assessment. Additionally, the new assessment integrates updated biological parameters, including externally estimated maturity-at-age and sex-specific growth parameters, replacing the previously assumed growth rates. The model also enhances diagnostics and reweighting methodologies, extending beyond the standard Francis reweighting approach previously used.

Notably, the 2025 assessment incorporates extensive diagnostics, including jittering and retrospective analyses, improving the robustness of the model. Although both assessments adhere to

EU MAP catch limit recommendations, the new assessment refines catch scenarios by incorporating fleet-specific constraints and time-block effects to better reflect fishing dynamics. The final model, chosen from multiple exploratory runs, aligns well with observed biological trends and stock dynamics, providing improved catch recommendations and enhancing the scientific foundation for stock management decisions.

3.8.6 Fit to data and model diagnostics

The model demonstrates an overall reasonable fit to the various data sources, though some discrepancies remain that warrant further refinement. A key concern is the systematic residual pattern observed in the Spanish CPUE index (SPNETS_CPUE), indicating inconsistencies between model predictions and observed data trends. These residuals suggest potential model limitations in fully capturing fleet dynamics and variations in fishing effort. Additionally, the fit to survey data remains a challenge due to notable year-to-year fluctuations and long-term trends that the model does not entirely account for. A particularly notable issue is the prediction capacity of the Spanish net fleet (SPNETS), where substantial deviations between predicted and observed values raise concerns. These inconsistencies could stem from unmodeled shifts in selectivity, changes in fleet behavior, or variations in fishing effort. The logistic selectivity assumption applied to Portuguese nets (PTNETS) proved beneficial, but further refinements may be necessary to accurately reflect Spanish fleet dynamics. To enhance model reliability, future efforts should focus on refining CPUE standardization methodologies, incorporating additional factors such as effort creep and environmental influences. Additionally, improved survey data weighting and integration—potentially using time-block adjustments or environmental covariates—could enhance model performance. Addressing these areas will be critical for ensuring the robustness and reliability of future assessments.

3.8.7 Biological reference points

The updated biological reference points were established in line with ICES guidelines and provide a strong basis for stock management. The reference points were derived using the Eqsim approach, with stochastic simulations confirming the precautionary validity of the selected values. The model assumes a Beverton-Holt stock-recruitment relationship, with Blim set at 10% of B0 (2,936 t) and Bpa at 4,373 t, incorporating assessment uncertainty. The estimated Fmsy is 0.198, aligning with the precautionary approach to ensure long-term sustainability of the stock. Despite these advancements, it would be advisable that future efforts to integrate discard information into the assessment and to develop an abundance index specifically for larger individuals will be considered. Additionally, stock identity studies suggest that white anglerfish in the Northeast Atlantic may exhibit panmictic characteristics, contrasting with the current management framework of three separate stocks. Further research is needed to explore the implications of these findings for stock delineation and assessment methodologies.

3.9 Conclusions

Both reviewers consider the BestCase model proposed by WKBSS3 as suitable for providing management advice.

3.10 References

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3.11 Stock-specific working documents (mon.27.8c9a)

WD1 (mon.27.8c9a): White anglerfish (Lophius piscatorius) in divisions 8.c and 9.a. Available commercial catch data: landings, discards and lenght compositions.
Paz Sampedro

Available data fishery dependent for assessment for mon8c9a is described: Landings, discards and length compositions.

WD2 (mon.27.8c9a): Standardized abundance indices of black and white anglerfish caught by Spanish bottom otter trawl fleet in ICES Division 8c and Subdivision 9aN.
Paz Sampedro , Jaime Otero, Hortensia Araújo , José Castro

Relative abundance indices of black anglerfish (Lophius budegassa) and white anglerfish (*Lophius piscatorius*) caught by Spanish bottom otter trawlers in ICES Division 8c and Subdivision 9aN, were standardized for the period 2009–2023. The Spanish bottom trawl fleet targets a mix of commercially valuable demersal species, including hake, megrims, anglerfish, and Norway lobster. Since 2000, this fleet has accounted for 37% of the total catches of the Iberian white anglerfish stock (mon.27.8c9a) and 48% of the total catches of the Iberian black anglerfish stock (ank.27.8c9a). Using data from an on board observer program, spatiotemporal generalized additive mixed models (GAMMs) were fitted for each anglerfish species. The final models identified depth and vessel identity as significant predictors influencing the relative abundance and distribution of anglerfish species. For black anglerfish, both the nominal and standardized CPUE series showed a general declining trend from 2013 to 2018, followed by increases in 2022 and 2023. Similarly, for white anglerfish, both nominal and standardized indices exhibited comparable trends, with a pronounced decline from 2014 to 2021, and subsequent increases in 2022 and 2023. The standardized CPUE series generated in this study provide robust indicators of the relative abundance of black and white anglerfish in Iberian waters. These indices are suitable for inclusion in the respective stock assessments of these species.

WD3. Standardized abundance indices of black and white anglerfish caught by Spanish bottom otter trawl fleet in ICES Division 8c and Subdivision 9a.

Paz Sampedro, Jaime Otero, Adriana Nogueira, Josefina Teruel, José Castro

Relative abundance indices of black anglerfish (Lophius budegassa) and white anglerfish (Lophius piscatorius) caught by the gillnet RASCO fleet in ICES Division 8c and Subdivision 9aN, were standardized for the period 2009–2023. In Northern Spain, the rasco, a specially designed gillnet for fishing anglerfish, is used mainly at 400-900 m depth. Anglerfishes comprise more than 85% of the landings of this gillnet métier. Since 2009, this fleet has accounted for 45% of the total landings of the Iberian white anglerfish stock (mon.27.8c9a) and 14% of total landings of the Iberian black anglerfish stock (ank.27.8c9a). Using information from logbooks and the fishing day as the unit of effort, Generalized Additive Mixed Models (GAMMs) were fitted for each anglerfish species' data. The final models identified the spatial as significant predictor influencing the relative abundance and distribution of anglerfish. For black anglerfish, both the nominal and standardized LPUE series showed a general declining trend from 2015 to 2022, followed by an increase in 2023. Similarly, for white anglerfish, both nominal and standardized indices exhibited comparable trends, with a decline from 2016 to 2021, and subsequent increases in 2022 and 2023. The standardized LPUE series generated in this study provide indicators of the relative abundance of black and white anglerfish in Iberian waters, especially for the larger size part of the populations.

WD4 (mon.27.8c9a): Update Biological Information for White Anglerfish in Divisions 8c and 9a.
Paz Sampedro

New estimates of length-weight relationship, growth parameters, sex-ratio by length and maturity by length, and natural mortality at age are described in this working document for mon8c9a

WD5 (mon.27.8c9a): Updated maturity parameters of white anglerfish (Lophius piscatorius) stocks in Atlantic Iberian waters.

Modica L., Domínguez-Petit, R., Reparaz, M., Sampedro P., Hernández C., Dueñas-Liaño C., Navarro M.R. , Antolínez A. , Gutiérrez O. , Valmaseda L., Maneiro I. , Iglesias D. , Velasco, F., Landa, J

The maturity ogives of white anglerfish (*L. piscatorius*) stocks in Atlantic Iberian waters (ICES Div. 8.c, 9.a) currently used in the stock assessment are based on microscopic observations and were estimated in 1998. This study presents updated maturity ogives and parameters by length in Div. 8.c,9.a2 (Galician waters and Cantabrian Sea), for both sexes separated and combined based on a more robust statistical methodology. A total of 2539 individuals were sampled between 2011 and 2023 from landings of the commercial vessels and research surveys, in divisions 8.c, 9.a2, L. piscatorius in 8.c, 9.a2 showed values of L50 that ranged between 46.2 ± 0.8 cm to 47.0 ± 0.8 cm for males, 58.1 ± 0.6 cm to 60.6 cm ± 1.6 cm for females. For sex combined the values of L50 ranged from 50.1 ± 0.4 cm to 51.7 ± 0.8 cm. These values refer to the last periods of all the scenarios, analysed or, as in the case of the 4th scenario, on all available years pooled, in order to warrant the most updated parameters without loosing the robustness of data and allowing certain flexibility for the assessment process.

WD6 (mon.27.8c9a): White anglerfish (Lophius piscatorius) weight-length in divisions 8c and 9aN.

Modica L., Domínguez-Petit, R., Reparaz, M., Sampedro P., Hernández C., Dueñas-Liaño C., Navarro M.R. , Antolínez A. , Gutiérrez O. , Valmaseda L., Maneiro I. , Iglesias D. , Velasco, F., Landa, J

Total weight-length, relationships were fitted for the Iberian Atlantic stock of white anglerfish (*Lophius piscatorius*) and their temporal variations were analyzed. The large sample size, size range and timeseries available allowed obtaining new somatic parameters of combined sexes for the total weight-length relationships (a=0.020, b=2.908). They differ significantly from the biometric relationships currently used and are appropriate to be used in the stock assessment of the status of the stock and they contribute to a deeper knowledge of the life history traits of this species.

WD7 (mon.27.8c9a): Monkfish 27.8c9a: Short-Cut MSE approach for robustness tests of harvest control rules in sex-structured models.

Winker, H.

4 Pollack in Celtic Seas and the English Channel

Pollachius pollachius in subareas 6–7 | pol.27.67

4.1 Introduction

From 2016 to 2022, pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel) was assessed using a Depletion-Corrected Average Catch (DCAC) method to estimate sustainable catches (ICES category 4). The stock was benchmarked in 2023 (ICES, 2023), improving the quality of the assessment of the stock by applying a Surplus Production Model in Continuous Time (SPiCT) that included a Vector Autoregressive Spatio-Temporal (VAST) survey index. Since then, pol.27.67 has been a Category 2 ICES stock and the SPiCT model has been used by ICES for catch advice for 2024 and 2025.

WKBSS3 developed a Stock Synthesis model (SS3) for pol.27.67 which includes not only commercial landings and an improved version of the survey index, but also age composition data, commercial and recreational fleets, updated life-history parameters, and LPUE indices from the main fleets. Additionally, the Pollack Fisheries Industry Science Partnership (FISP) also presented several studies and experiments. All the above are summarised here and also described in detail in separate working documents.

4.1.1 Fishery information

Pollack are caught in targeted gillnet and line fisheries and are mainly taken as bycatch by trawl fisheries. The dominant countries catching pollack are France, the UK and Ireland.

4.1.2 Current assessment and advice

The stock is currently assessed using a Surplus Production Model in Continuous Time (SPiCT) that included a Vector Autoregressive Spatio-Temporal (VAST) survey index. This model has been used to provide catch advice for 2024 and 2025. The model indicates that the stock is at a historically low biomass and well below biomass reference points, resulting in zero catch advice.

4.1.3 Stock definition

The assessment area is currently defined as ICES subareas 6 and 7, based on a recommendation from WGNEW (ICES 2012). The vast majority of the catches come from Subarea 7 and catches from the north of Subarea 8 appear to be contiguous with those in the south of Subarea 7. This casts some doubts on whether the southern border of the assessment area is appropriate.

A number of projects are in the process of collecting analysing genetic data with the purpose of informing the stock structure of pollack in this area. The outcome of this work is not yet available and currently there is insufficient information to change the boundaries of the assessment area.

4.2 Input data for stock assessment

4.2.1 Commercial landings and discards

See working document: "4.1 pol.27.67 Catch data.docx" for more detail.

Commercial catch data was provided to Intercatch by the main three countries catching this stock (UK, France and Ireland) and another six countries (Belgium, Denmark, Germany, Netherlands, Norway and Spain). Landings have been decreasing since the early 2000s; the decline in landings from French trawlers and UK gillnetters is strongest. Landings from liners have been always low but steady. Currently the gears with highest commercial landings are, in order, Gillnets, Lines and Trawls.

Discards are considered negligible (4% by weight); the French gillnetters are the only gear that averaged discard proportions above 10%. There is no discard age data. Due to the poor quality of the discard sampling and their low contribution to the total catch, it was decided not to include discards in the assessment model.

Commercial Length and Age sampling

See working document: "4.1 pol.27.67 Catch data.docx" for more detail.

Both length and age data are available but because the time series of reliable length data was not much longer than the time series of age data, only age composition data for commercial catches was used in the model (but note that length composition data are used for recreational catches).

Age sampling data from Ireland and UK was used to fill in missing data from other countries' landings. French age compositions appeared to be somewhat different to the UK and Irish data so these were only used to fill gaps in unsampled French data.

Fleet grouping

See working document: "4.1 pol.27.67 Catch data.docx" for more detail

It was decided to group the commercial fleets as follows:

- Gillnets (including UK unknown gears)
- Lines (including Irish unknown gears)
- Trawls (including seines, beam trawls, French unknown gears, and all other countries)

French trawl and gillnet sampling indicates that these fleets tend to catch more small fish than the UK and Irish trawl and gillnet fleets. Sample sizes were insufficient to split out the French fleets from the others; however, this should remain on the issue list for future benchmarks, for example, it may be possible to apply the 'fleets as areas' concept if there are differences between areas that correspond to certain fleets.

Splitting historic landings

See working document: "4.1 pol.27.67 Catch data.docx" for more detail.

Historic landings (≤2002) are not available by gear type. For each country the proportions from 2002 to 2005 were used to split historic landings by gear type:

- France: 80% trawls; 10% lines; 10% gillnets
- Ireland: 55% trawls; 12% lines; 33% gillnets
- UK: 22% trawls; 0% lines, 78% gillnets
- Other countries: 100% trawl

Figure 4.2.1.1 shows the time series of landings by fleet and Figure 4.2.1.2 shows the age composition by fleet.

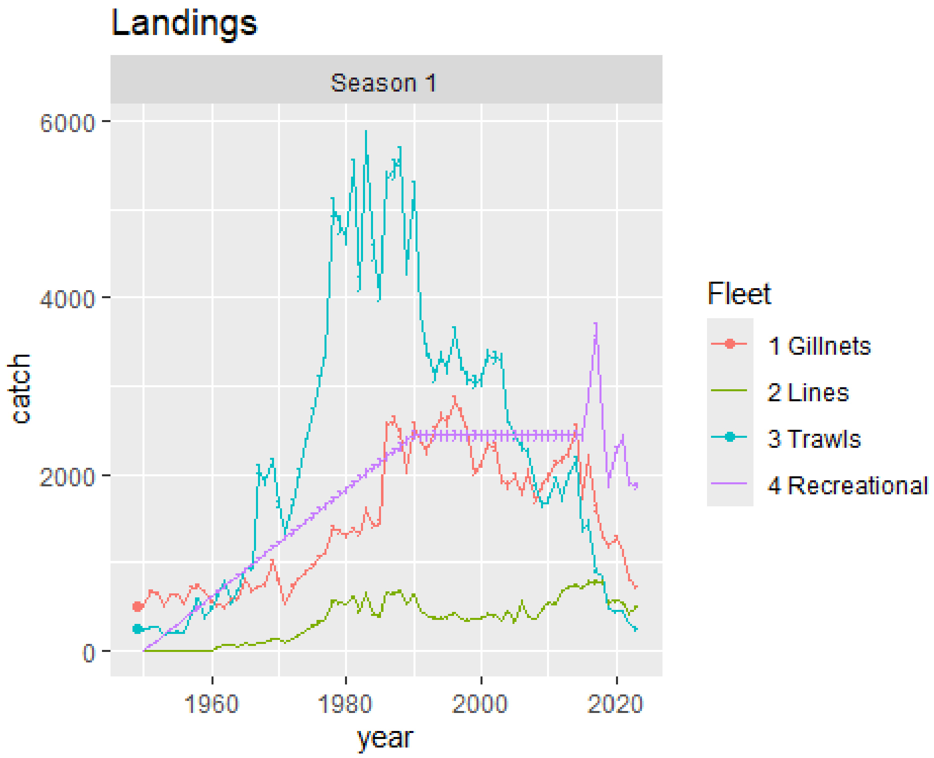

Figure 4.2.1.1. Landings by gear type. Historic commercial landings (≤ 2002) were attributed to the gear types based on the pollack catches by gear for each country in 2003-5. Historic recreational data (<2016) were reconstructed based on the assumption that improvements in technology (DECCA, GPS, echosounders) led to an increase in catches, which reached a plateau around 1990. The base-case recreational catch is shown here, other scenarios were explored.

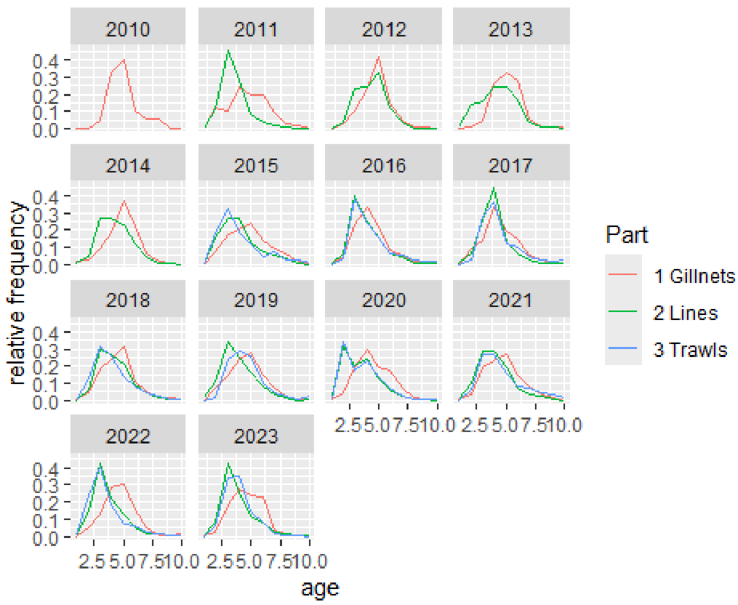

Figure 4.2.1.2. Age composition data by fleet and year show that lines and trawls consistently catch more 3-year-olds than gillnets, and that gillnets catch relatively more older fish.

Sample size for the age compositions

The effective sample size is often lower than the actual number of samples or fish measured. The 'NOAA' approach (Stuart and Hamel, 2014 & Vladlena Gertseva pers comm.) was used to estimate input sample sizes:

If the number of fish per trip < 44

- Ninput = Ntrips + 0.138 x Nfish

If the number of fish per trip >= 44

- Ninput = 7.06 x Ntrips

Table 4.2.1.1 Input sample sizes by fleet and year

year	1 Gillnets	2 Lines	3 Trawls
2010	134	NA	NA
2011	401	106	NA
2012	402	127	NA
2013	346	104	NA
2014	304	128	NA
2015	377	98	182
2016	420	149	163
2017	744	571	106
2018	322	612	131
2019	356	342	64
2020	522	437	73
2021	499	576	54
2022	468	473	125
2023	367	426	99

Age error

The age error is unknown. A moderate amount of error of 0.25 was included in the model. Sensitivity analyses indicated that the model was not sensitive to the value of this error unless it was very large (>=1).

4.2.2 Recreational catches

See working document: "4.2 pol.27.67 FISP.docx" and "4.5 pol.27.67 Recreational data.docx" for more detail.

Estimates of recreational catches were available from UK (2016-23), France (2021-23) and Ireland (2022-23).

- For the UK, only data from England & Wales were available for the 2022-23; the England & Wales values were inflated to UK figures using the mean proportion of E&W/UK for the period 2016-21 (91.3% for retained catches and 79.9% for released catches).
- In order to reduce uncertainty, the French national estimates for 2021-2023 were aggregated into a single annual estimate. The aggregation of quarterly data over the entire period led to an increase in the number of panellists and catch observations per ICES division, thereby enhancing the accuracy of the estimates. Given the consistency of management measures and the stability of effort and stock size, the use of the average catch estimate over this period is preferable to individual annual estimates, which show high inter-annual variability at a fine spatial scale.
- The Irish national estimates from 2022-2023 were combined to provide a single annual estimate as the data collection took place across the two years with areas on the east and south of Ireland in collected in 2022 and the south-west and west in 2023.

International recreational catch was estimated for the period 2016-23 by applying the relative proportions of the observed catches in 2022 to the years of missing data for Ireland and France (Table 4.2.2.1).

Table 4.2.2.1. Estimated retained and released tonnage of recreational catches as well as removals estimated as retained + released * PRM (see next section). Bold numbers indicate estimates from surveys. Numbers in italics represent filled-in values based on proportions by country estimated in 2022.

Retained Weight (t)					
Year	**UK**	**(EW)**	**FR**	**IE**	**UK+FR+IE**
2016	**490**		*247*	*806*	*1,543*
2017	**704**		*356*	*1,159*	*2,219*
2018	**476**		*240*	*783*	*1,499*
2019	**332**		*168*	*546*	*1,045*
2020	**418**		*211*	*687*	*1,316*
2021	**432**		*218*	*711*	*1,360*
2022	*350*	**320**	**177**	**577**	*1,104*
2023	*349*	**319**	*177*	*577*	*1,103*

Released Weight (t)					
Year	**UK**	**(EW)**	**FR**	**IE**	**UK+FR+IE**
2016	***805***		*138*	*3,694*	*4,637*
2017	***859***		*148*	*3,941*	*4,947*
2018	***685***		*118*	*3,146*	*3,949*
2019	***509***		*88*	*2,338*	*2,935*

2020	***578***		*99*	*2,651*	*3,328*
2021	***623***		*107*	*2,858*	*3,588*
2022	*483*	**385**	**83**	2,215	*2,780*
2023	*360*	**288**	*79*	*2,215*	*2,654*

Removals (t) (retained + dead released)					
Year	**UK**	**(EW)**	**FR**	**IE**	**UK+FR+IE**
2016	**723**		*287*	*1,874*	*2,883*
2017	**952**		*399*	*2,298*	*3,649*
2018	**674**		*274*	*1,692*	*2,640*
2019	**479**		*193*	*1,222*	*1,893*
2020	**585**		*240*	*1,453*	*2,278*
2021	**612**		*249*	*1,537*	*2,397*
2022	*490*	**431**	**201**	**1,217**	*1,907*
2023	*453*	**402**	*200*	*1,217*	*1,870*

In terms of catch weight, Ireland dominated with more than half of the retained catch and more than three quarters of the released catch, followed by UK (around a third of the retained catch and about one fifth of the released catch (Fig 4.2.2.1).

Figure 4.2.2.1. Estimated retained (left), released (middle) recreational catches and removals (right). 'Observed' values (estimated from surveys) are shown in solid colours. Filled in values (based on proportions from observed data in 2022) are shown as hashed colours. Top: estimated volume of the catch; bottom: proportions.

Post release mortality

Post release mortality (PRM) was estimated using data from survival studies (Stamp et al, submitted) that showed a strong negative relationship between survival and depth of capture. The average depth of capture from shore, private and charter vessels was estimated and used to estimate an overall PRM of 28.9% (Table 4.2.2.2) with a confidence interval of 19.4-41.7%. Recreational removals (retained plus released * PRM) will be included in the model. PRM is assumed to be independent of fish size.

Table 4.2.2.2. Estimated mean depth of capture by platform and associated post-release mortality (Stamp et al, submitted). Most of the released catch was estimated to be from private boats.

Platform	Depth (m)	% of catch	PRM
Shore	10	2.2%	7.6%
Private boat	30	89.9%	25.5%
Charter boat	60	7.9%	74.1%
All platforms	----	----	28.9%

Reconstruction of historic catch

Reconstruction of historic recreational catch (<2016) was based on based on the assumption that improvements in technology (DECCA, GPS, echosounders) led to an increase in catches, which reached a plateau around 1990. Several alternative scenarios were proposed for testing in sensitivity analyses (Figure 4.2.2.2).

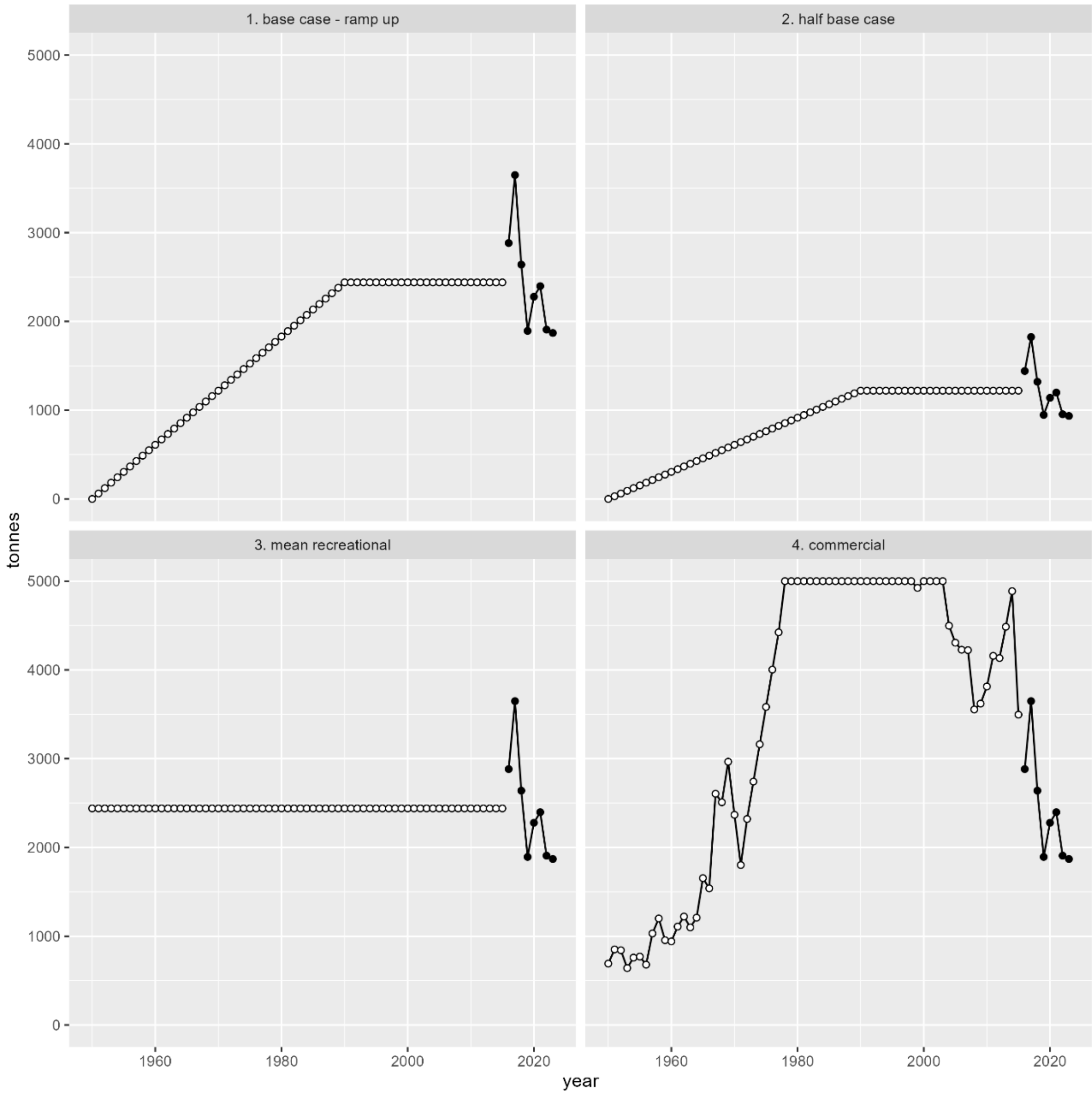

Figure 4.2.2.2. Scenarios for reconstruction of historic recreational catches (open circles) and observed catches (closed circles). The base case consists of assuming average observed (2017-23) catches during the period 1990-2016 and a ramp up from 1950-1990. The second scenario is half the base case (to test the sensitivity of the observed data being over-estimated. The third scenario assumes average observed catches during the whole historic period (1950-2016). The fourth scenario assumes that recreational catches are proportional to commercial catches with a ceiling of 5000 tonnes. A fifth scenario that was tested was that of zero recreational catches (not shown in figure).

Length data

Figure 4.2.2.3 shows the length compositions of the recreational removals (retained + PRM*released). Data were provided in 1 cm length bins but aggregated to 5cm bins (centring around 10, 15, 20cm etc) because many fish appear to have been reported to the nearest 5cm. No age composition data were available for recreational catches.

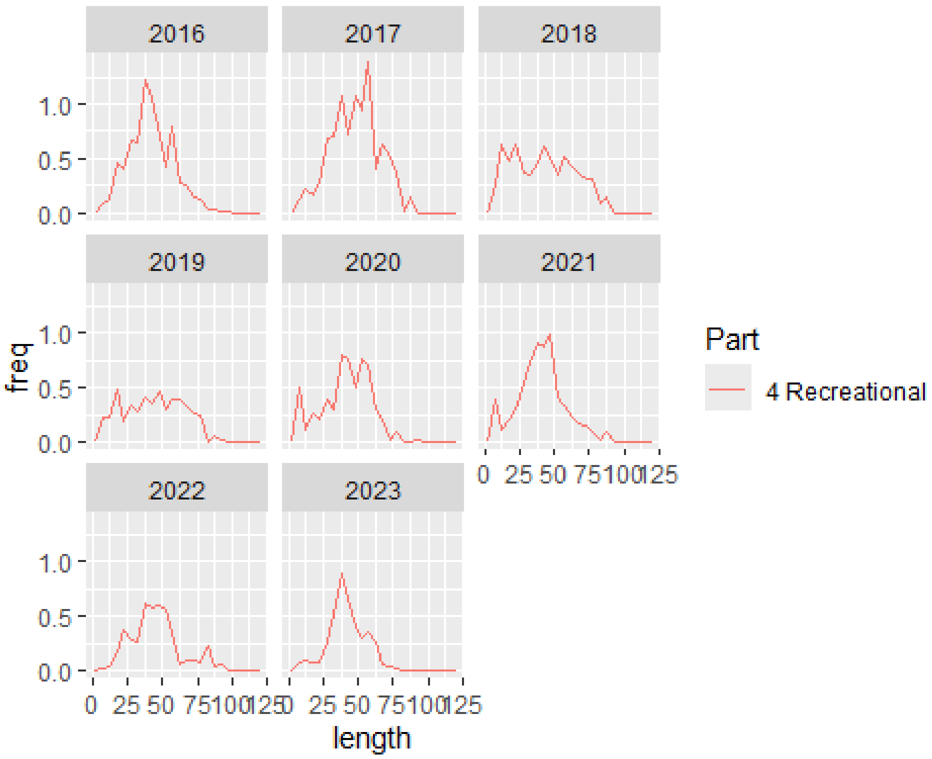

Figure 4.2.2.3. Length frequency data for recreational catches are available since 2016.

Sample sizes

The number of trips is not available for recreational data. However, to use a similar approach to the age data (see section 4.2.1), the effective sample size was approximated using 0.138 x the number of fish measured. (Adapted from the NOAA approach; Stuart and Hamel, 2014 & Vladlena Gertseva pers comm.)

Table 4.2.2.1 Input sample sizes for length data

year	Nsamp
2016	136
2017	255
2018	162
2019	105
2020	87
2021	140
2022	102
2023	94

4.2.3 Life-history parameters

See working document: "4.3 pol.27.67 life history parameters.pdf" for more detail.

Data used to estimate life-history parameters: Irish survey data; Irish and UK age data, International commercial sampling data; data from Inland Fisheries Ireland and Pollack FISP project.

Growth

Fitting a Von Bertalanffy growth function to the raw age data gives the parameters below:

- L_{inf} = 85.7 cm
- K = 0.21
- T0 = -0.61
- CV young fish = 0.1
- CV old fish = 0.07

After the data compilation workshop, it became clear that the L_{inf} value was too low to fit to the largest fish observed in the recreational catches. Because most of the age data came from gillnet samples, it is possible that the length distribution of older fish is truncated due to dome-shaped size selection. In the recreational data, fish over 100cm were not uncommon and some fish of 120cm were recorded. It was therefore decided to fix L_{inf} at 120cm and estimate K and T0 values consistent with that. The updated growth parameters are:

- L_{inf} = 120 cm
- K = 0.11
- T0 = -1
- CV young fish = 0.15
- CV old fish = 0.10

The group discussed including conditional age-at-length (age-length-key) data to allow the model to estimate growth parameters directly. However, because these data are collected in a highly unbalanced way it was decided that raw age data was likely biased. This bias is addressed when weighting the data prior to submission to Intercatch as well as during the procedure to 'fill gaps' in the age data. Therefore, estimated catch numbers-at-age are likely to be less biased and these will be used in the model.

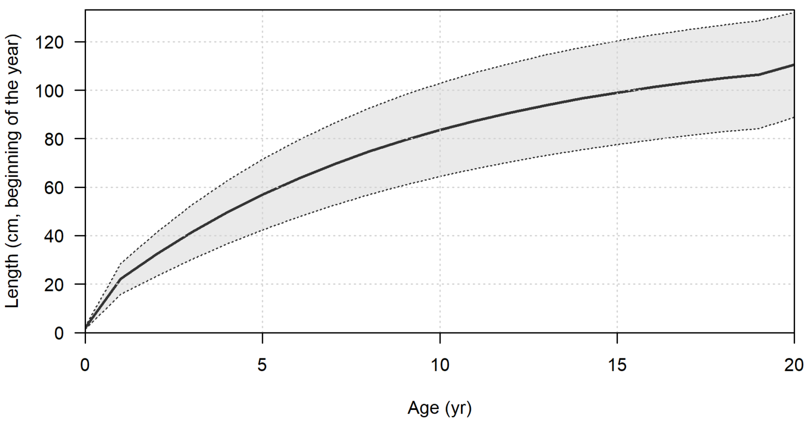

Figure 4.2.3.1. Length at age in the beginning of the year. Shaded area indicates 95% distribution of length at age around estimated growth curve.

Length-weight

Length-weight parameters obtained by fitting a linear model to all available data:

- a = 5.96e-06
- b = 3.121

Maturity

Q1 age data, indicates that from age 4 onwards pollack are fully mature. At age 3 around 90% appear to be mature and younger fish are rarely caught in surveys so data are sparse. The fact that fish aged 2 and younger are nearly completely absent from both survey and commercial data indicates that these fish likely use a very different habitat to larger fish. If the change in habitat coincides with reaching maturity, then it can be assumed that all fish of age 2 and younger are immature.

Age	0	1	2	3	4+
Proportion mature	0.0	0.0	0.0	0.9	1.0

Sex ratio

Not enough data for a sex-disaggregated model but the available data suggests that any sexual dimorphism is moderate.

Natural mortality

Several methods to estimate natural mortality were tested using: the life-history parameters outlined above; a mean temperature of 8.9 °C (FishBase, https://www.fishbase.se/); the oldest observed age of 14 years (commercial catch data) and a gonadosomatic index (GSI) of 0.05 (Alonso-Fernandez, 2014).

Most empirical models agree on a natural mortality of 0.3 to 0.4 for mature fish. The Lorenzen approach is in line with this and is widely used in ICES assessments. Therefore, this method was chosen with an age-dependent natural mortality as below:

age	M
0.5	0.920
1.5	0.657
2.5	0.534
3.5	0.463
4.5	0.417
5.5	0.385
6.5	0.361

7.5	0.344
8.5	0.330
9.5	0.319
10+	0.311

Sensitivity to the natural mortality assumption was tested and likelihood profiles explored (section 4.3.5).

Stock-recruit

- steepness: 0.76 (from fishlife R library)
- sigma R: 0.5 (suggested by SS3 in early run of the model)
- autocorrelation: 0 (not estimated)
- Main Recdev years: 2010 – 2021 (age data start in 2010)
- Recdev early start year: 2000 (there is information about recruitment in the age data that informs early recruitment deviations up to around 10 years before the age data start).

Sensitivity to the steepness assumption was tested and likelihood profiles explored (section 4.3.5).

4.2.4 Indices

Four indices are considered for inclusion in the model: one survey index and three commercial LPUE indices

Survey index

See working documents: “4.4a pol.27.67 Process Survey Data.pdf”, “4.4b pol.27.67 Index Selection.pdf” and “4.4c pol.27.67 Analyse Survey Data.pdf” for more detail.

The VAST index used in the current assessment includes four surveys (IGFS, IAMS, EVHOE and CGFS). WKBSS3 explored the development of an sdmTMB model (which is considered more robust than VAST) with the potential addition of four surveys: NIFGS Q1, NIFGS Q4, Scottish west coast surveys and BTS. The data was extracted from DATRAS and standardised for swept area. Pollack catches were low throughout, but the additional surveys add geographic coverage and exhibit consistent trends. Different options were explored using different survey data sets, with the results being similar regardless of which surveys were included. In the sdmTMB model, different error distribution families were explored as well as different spatiotemporal relationships and meshes and prediction grids. Using the diagnostics and AIC comparison led to the preferred model using a delta lognormal and a random walk on the spatiotemporal model.

WKBSS3 discussed the inclusion of the BTS Q1 survey, because it is a beam trawl survey, so it differs from the other scientific surveys. The CGFS was also debated, as it had very low recent catches and historically it would occasionally catch large numbers of juvenile fish. It was proposed that the base run should use all available surveys, but to test model sensitivity to removing the BTS and CGFS surveys. This sensitivity test was done during the benchmark workshop and showed that there was no impact on the stock development resulting from including or leaving out either or both of the BTS and CGFS surveys. As the new surveys add geographic coverage, it was decided to retain them in the new index.

Table 4.2.4.1. Surveys included in the combined index.

Acronym	Code	Survey
IGFS	G7212	Irish Groundfish Survey
IAMS	G3098	Irish Anglerfish and Megrim Survey
EVHOE	G9527	French Southern Atlantic Bottom Trawl Survey
CGFS	G3425	French Channel Groundfish Survey
NIGFS-Q1	G7144	Northern Ireland Groundfish Survey Q1
NIGFS-Q4	G7655	Northern Ireland Groundfish Survey Q4
BTS-Q1	B2453	Beam Trawl Survey - North Sea, Irish Sea and Western Channel
BTS-Q3	B2453	Beam Trawl Survey - North Sea, Irish Sea and Western Channel
SWC-Q1	G1179	Scottish Westcoast groundfish survey Q1 (Old)
SWC-Q4	G4299	Scottish Westcoast groundfish survey Q4 (Old)
SCOWCGFS-Q1	G4748	Scottish Westcoast Groundfish Survey Q1
SCOWCGFS-Q4	G4815	Scottish Westcoast Groundfish Survey Q4

The group discussed the possibility of hyperdepletion in the survey index: the surveys operate on grounds that are sub-optimal for pollack (who prefer rocky ground and reefs). It is therefore possible that as the stock contracts there is less ‘spill-over’ of pollack on softer ground and the index declines disproportionately fast. The opposite reasoning applies for commercial gillnet LPUE indices described below: hyperstability could occur here. It was decided to include the survey index in the model and test for conflicts with LPUE indices, particularly those based on gillnet catches – no major conflicts were apparent although the survey index declines faster than the LPUE indices.

Irish gillnets LPUE

See working document “4.6 pol.27.67 IE Commercial LPUE index.docx” for more detail.

Two VAST models were explored: one using VMS data linked to logbooks, and another one using logbooks data only. As the available time series of logbooks is longer than the VMS one, it was proposed to use the logbooks-only index as a tuning fleet in the stock assessment model. Additionally, due to the very low by-catch only TAC in 2024, it was proposed not to calculate the index after 2023 until a less restrictive TAC is in place.

It was decided to include this index in the model and to explore possible conflicts with the survey index (see previous section).

UK LPUE

See working document “4.7 pol.27.67 UK LPUE Candidates.xlsx” for more detail.

A 2-stage random effects model was applied to calculate LPUE indices for gillnets (spawning season only) and trawls (all seasons). The gillnet index had very large confidence intervals (CV of 130%) and would therefore be unlikely to contribute to the model fit. The trawl index was estimated with higher precision (although the CV is still relatively large at 38%). It was decided to include this index in the model (but not the UK gillnet index).

French LPUE

See working document "4.8 pol.27.67 French lpue.docx" for more detail.

Six fleets were explored by fitting Generalized Additive Models (GAM) combined with a principal components analysis to identify targeting behaviour. An LPUE index for trawlers (18 m to 40 m) was proposed, including year, season, spatial, vessel, vessel length class and species assemblage effects. It was decided to include this index in the model.

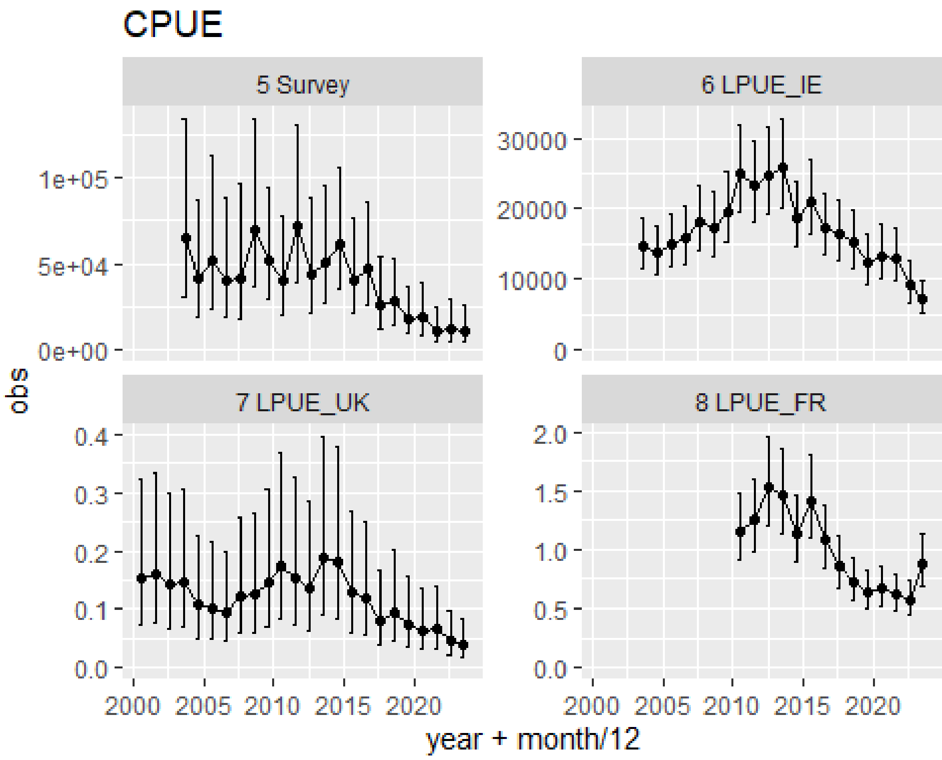

Figure 4.2.4.1. CPUE indices used in the model. The survey index is estimated using a spatio-temporal model (sdmTMB); the Irish LPUE index is based on gillnet data while the UK and French LPUE indices are based on trawl data.

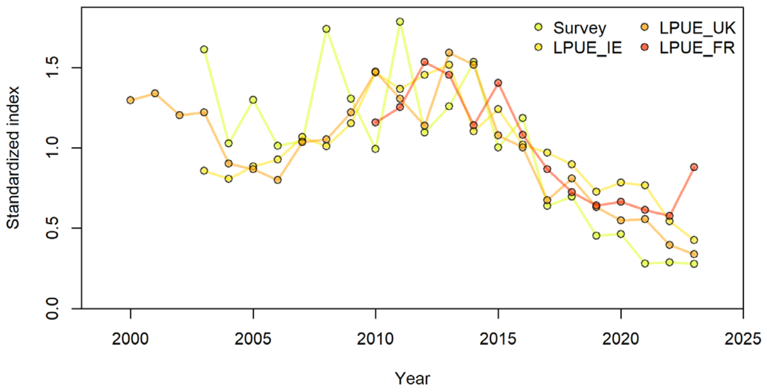

Figure 4.2.4.2. The standardised indices show general agreement on the decline in stock size since around 2013. The survey shows the strongest decline but there is no major conflict. The French LPUE index is the only index to show an increase in the last year.

4.2.5 Pollack Fisheries Industry Science Partnership

See working document "4.2 pol.27.67 FISP.docx" for more detail.

FISP presented several studies to WKBSS3, which are summarised below. These data were discussed during the workshop and helped to inform decision on input data and model configuration.

Acoustic telemetry

An acoustic telemetry study tagged 125 pollack from 2022 to 2024 off Plymouth (UK) and showed that pollack are highly resident to individual wrecks or reefs.

Survival studies

A survival study with 340 pollack showed that releasing pollack at depth increased survival rates to 81%, compared to 46% of surface-release fish. For fish released at the surface, there was a negative relationship between the chance of survival and depth of capture.

Recreational catch data

Catch data has been collected from 15 recreational charter skippers fishing on the southwest coast of England since 2022 (16,207 fish and 32.89 tonnes). Largest fish were associated with the deeper wreck marks and to the west of ICES Division 7.e.

Age at length and maturity

Growth parameters estimated from data collected in Division 7.a during 1989 were somewhat different from those estimated using a combination of recent commercial and recreational data but the estimated mean length at age was similar. The length at 50% maturity was higher than estimated from recent survey data (around 50 cm; implying the age at 50% maturity is around

4). However not all samples were collected during the spawning season, outside this time frame, resting fish may appear immature. For this reason, these data were not considered further for inclusion in the model.

Historical data

Trophy catch and logbook records from 14 British recreational angling clubs showed a decline in the size of the largest pollack caught in wrecks and reefs since 2010.

Angler perceptions

There was near unanimous agreement among UK anglers interviewed in 2024 that pollack catch rates and sizes have declined significantly, particularly in the last 10 years. The main cause was thought to be overfishing. Other potential causes put forward included climate change (direct and indirect effects on prey) and the presence of predators (e.g. tuna and seals) inhibiting the feeding behaviour of pollack. There was a high level of support among those interviewed for increased management of the recreational fishery, particularly through an annual closed season during the spawning period (January to March) and increase in minimum landing size to 50 cm, and some support for a bag limit of five fish per angler per day.

4.3 Stock assessment

A Stock Synthesis (SS3) base case model was developed and presented to the working group. Some changes and alternatives were proposed and explored during the benchmark workshop and a range of sensitivity analyses were performed.

4.3.1 Base case assessment

The description of the model configuration follows the structure of the SS3 files. For the starter, data and control files, the relevant settings will be highlighted.

Starter file

- F reporting units: 5 (unweighted average F)
- Fbar range: 3, 7

Data file - model dimensions

Sampling data was generally provided by quarter but the quality of the data was not sufficient to include in a seasonal model (which in any case is less important for a mostly age-based configuration). Insufficient data by sex was available for a 2-sex model.

- Start year: 1950
- End year: 2023
- Seasons: 1
- Months: 12
- Subseasons: 4
- Spawning month: 1
- Sexes: 1
- Ages: 20
- Areas: 1
- Fleets: 8

- Fleet 1: Gillnets
- Fleet 2: Lines
- Fleet 3: Trawls
- Fleet 4: Recreational dead catch
- Fleet 5: Survey index
- Fleet 6: LPUE_IE (Gillnet) index
- Fleet 7: LPUE_UK (Trawl) index
- Fleet 8: LPUE_FR (Trawl) index

Data file – overview

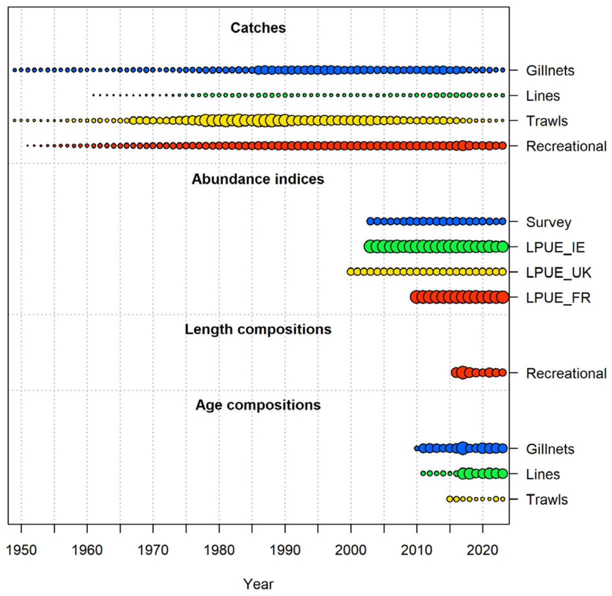

Figure 4.3.1.1 Overview of the input data

Control file - F

- F method: 4. Phase is set to 99 for all fleets, resulting in hybrid F.
- Initial (equilibrium) F is estimated only for the two fleets that had non-zero catches in 1950 (gillnets and trawls).

Control file - Q

- Q options: float
- No extra SD estimated for CPUE indices

Control file - size/age selection

Size selection for recreational length data is pattern 24 (dome shaped) but the model consistently fits a flat-topped pattern, therefore the parameters estimating the downward part were not estimated in the final configuration.

Age selection: Pattern 20 (dome shaped) for gillnets and lines. Trawls were forced to be flat topped (pattern 12) in order to avoid the possibility of spurious cryptic biomass in the older ages. The survey, LPUE_UK and LPUE_FR indices all mirror the trawl selection pattern. The LPUE_IE index mirrors the gillnet selection pattern.

Control file - other

- Dirichlet on for age and length compositions

- Variance adjustment: off
- Lambdas: off

4.3.2 Development of the base case

The base case model was presented to the benchmark workshop (see presentations on the WKBSS3 sharepoint: 0_pollack_base_case_day1.html and 0_pollack_base_case_day2.html for full details.

Low recruitment block

The main change from the base case that was made during the benchmark workshop was to include a time block with reduced recruitment. Since 2010, most recruitment deviations were well below zero (i.e. lower than expected from the stock-recruit relationship; Figure 4.3.2.1). In SS3 it is possible to define a time block with a different recruitment regime. The model estimates a regime parameter which is a modifier on R0 in the period of the time block (without changing R0 itself or any of the other stock-recruit parameters).

Although recruitment appeared to be reduced from 2010 onwards, it was decided to start the time block in 2014. Starting the time block in 2014 allows the model to estimate the bias adjustment both for a period of full recruitment and a period of reduced recruitment. The regime parameter was estimated at 55.2% (indicating that R0 was effectively reduced to that level during the period since 2014). The time block extends into the forecast period to allow recruitment to be estimated in line with the recent observed reduction in recruitment levels.

Adding the regime parameter had no perceptible impact on the model fit or estimated stock development. However, there are two advantages to estimating this parameter:

- It allows us to test whether the reference points are robust to a period of low recruitment.
- It allows us to forecast realistic recruitment levels (including the last two 'data years' for which recruitment deviations are not estimated).

It was decided to estimate the regime parameter once (in the current model) and then fix it until the next benchmark or until the assessment working group considers that there is a significant change in the recruitment dynamics of the stock.

Although WKBSS3 did not compile extensive evidence for a regime shift, some supporting information was presented. Townhill *et al.* (2023) provides some evidence for a recent change in habitat suitability for pollack due to environmental changes. Additionally, in recent years both Celtic Sea cod and whiting have seen declines in stock size following a reduction in recruitment. This provides some support for the idea that pollack may also be experiencing a period of low recruitment. Nevertheless, it could be considered that the evidence for a regime shift is not particularly strong. However, the purpose of the regime parameter is not to cut the time series and base the reference points only on the last 10 years of data. The reference points will be based on the full dataset but will be checked for robustness against a period of low recruitment.

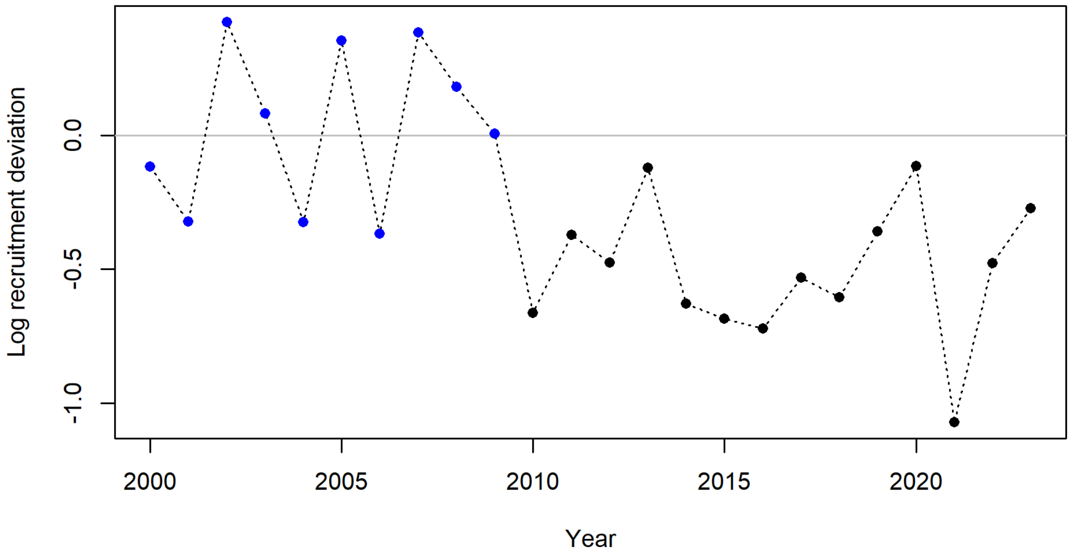

Figure 4.3.2.1. Recruitment deviations in the original base case model. Recent deviations since 2010 are all negative, indicating that this may be a period with reduced recruitment.

Other alternative configurations

A small number of other configurations were explored during the benchmark workshop:

- Fishing mortality method. The base case method was hybrid (method 3; see SS3 manual for details). Estimating F as parameters may improve convergence in some cases. A run was performed with F method 2 for all fleets. This resulted in a longer run time but identical results and diagnostics. For this reason, the F method was not changed from the base case.
- Recruitment deviation. The base case recruitment deviation option is 2 (the deviations do not have an explicit constraint to sum to zero). Recruitment deviation option 1 was also explored (the deviations during the main period enforced to sum to zero). This had an almost imperceptible impact on the model but resulted in a slight increase in retrospective bias (although within the acceptable range of Mohn's rho). For this reason, the recruitment deviation option was not changed from the base case.
- Including a random walk in age-based selection curves. This is the recommended approach when fitting age-based selection, however the fit to fixed selection curves was so good that it was not deemed necessary to explore this option.
- Non-linear relationship between fecundity and biomass. There is some evidence that larger females have higher fecundity per kg body weight than small females. SS3 can account for this but there was insufficient time to fully explore this option during the workshop.

The final run approved by the group was almost identical to the base case with the exception of adding the low-recruitment block.

4.3.3 Final assessment model outputs

Selectivity

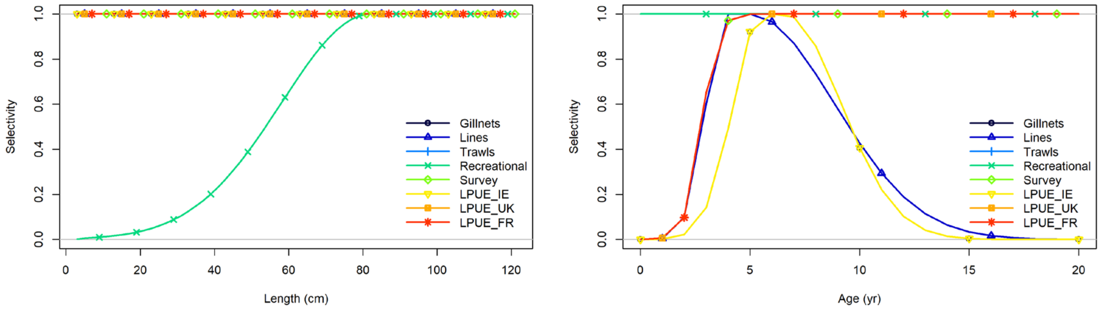

Figure 4.3.3.1 Size (left) and age (right) selection patterns. Note that the gillnets pattern is mirrored by LPUE_IE; and the trawls pattern is mirrored by Survey, LPUE_UK and LPUE_FR. Therefore, the line for Gillnets is masked by the yellow line and the lines for Trawls and LPUE_UK are masked by the red line.

Time series

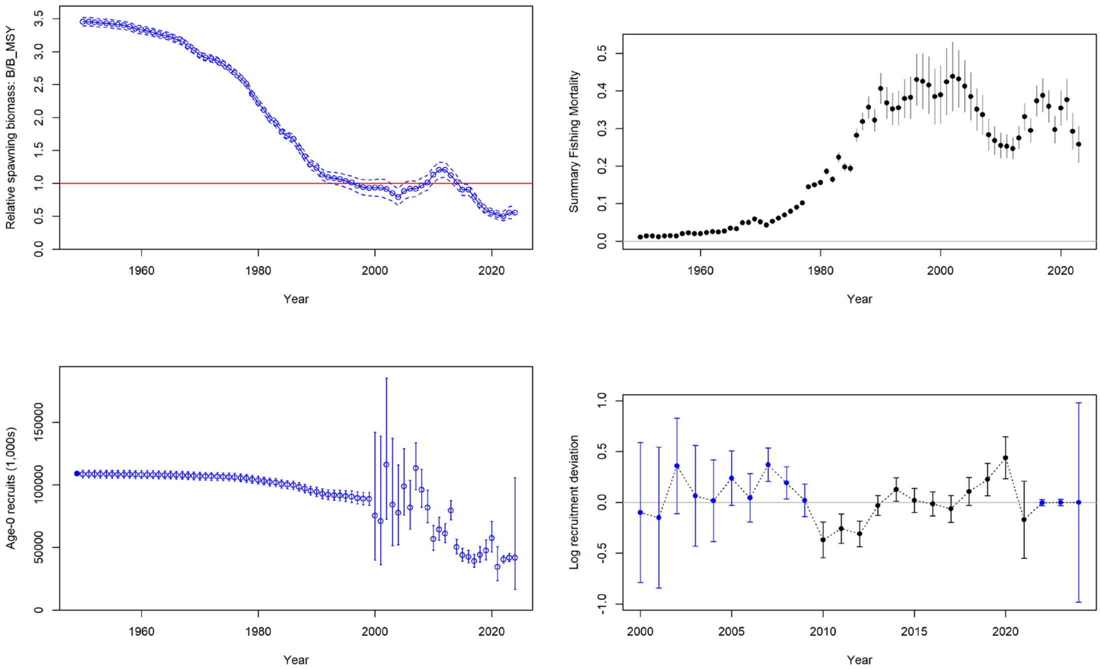

Figure 4.3.3.2 Final model time series of SSB relative to B_{MSY} (top left); Fishing mortality (top right); Recruitment (bottom left) and recruitment deviations (bottom right)

Recruitment dynamics

The recent decline in stock is largely attributed to a change in recruitment dynamics (Figure 4.3.3.3). Note that this is not an artifact of the low-recruitment time block; without this time block, recent recruitment was also estimated to be well below the expected level from the stock-recruit curve.

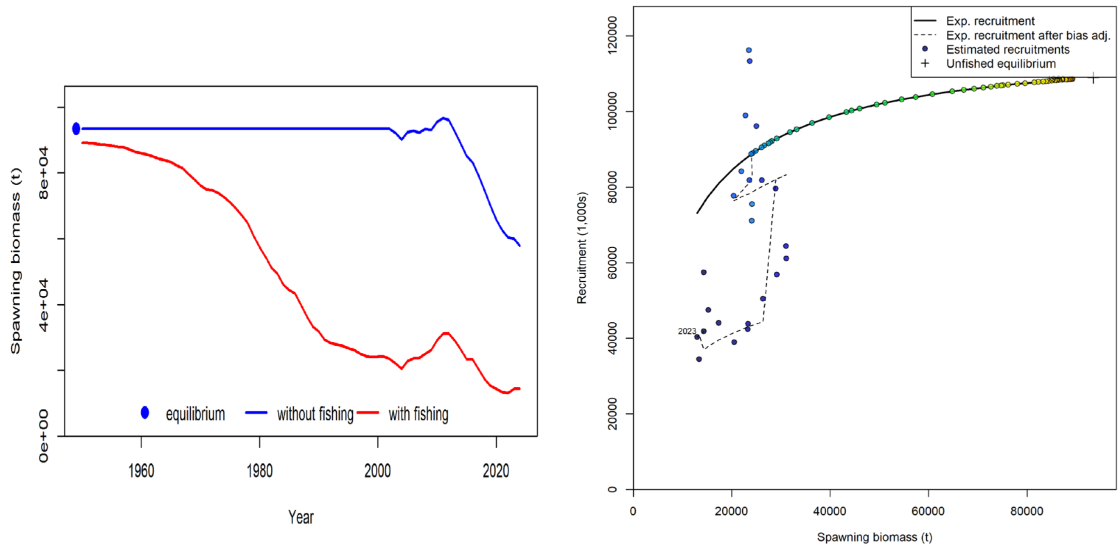

Figure 4.3.3.3. Left: Dynamic B0 plot. The lower line shows the time series SSB in the presence of fishing mortality. The upper line shows the time series that could occur under the same dynamics (including deviations in recruitment), but without fishing. Right: Stock-recruit curve. Point colours indicate the years, with warmer colours indicating earlier years and cooler colours in showing later years.

Yield

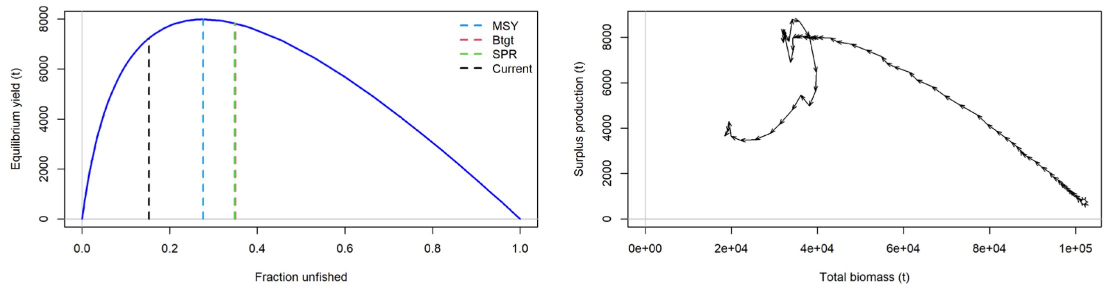

Figure 4.3.3.4. Yield curve with reference points (left). The curve is left-skewed with MSY around 30% of B0. Surplus production vs. total biomass plot (right), indicating the recent drop in productivity of the stock leading to low biomass.

Dirichlet weights

Table 4.3.3.1. The Dirichlet-multinomial Error distribution results in down-weighting of all input sample sizes. Most strongly of the age composition of fleet 1 (Age_P2) and fleet 2 (Age_P3).

	Value	Theta	Theta/(1+Theta)
ln(DM_theta)_Len_P1	0.0281244	1.0285236	0.5070306
ln(DM_theta)_Age_P2	-1.2996500	0.2726272	0.2142239
ln(DM_theta)_Age_P3	-0.5652920	0.5681942	0.3623239
ln(DM_theta)_Age_P4	0.2948200	1.3428846	0.5731757

4.3.4 Final assessment model diagnostics

Model diagnostics were explored according to guidelines by Carvalho *et al*. (2021). Diagnostics consist of: checks for model convergence; goodness of fit; and prediction skill as outlined below.

Convergence

- No parameters near the bounds.
- Final gradients: OK.
- Hessian: OK.
- No parameters with high variance.
- 30/30 jitter runs converged at minimum solution.
- Highly correlated parameters (Figure 4.3.4.1). The parameters for slope and peak of the size selection curve for recreational catches are highly correlated (>95%), indicating that parameters may be confounded or may cause convergence issues. It is not unusual for parameters of the same selection curve to be correlated and it does not appear to cause problems with convergence in this case.

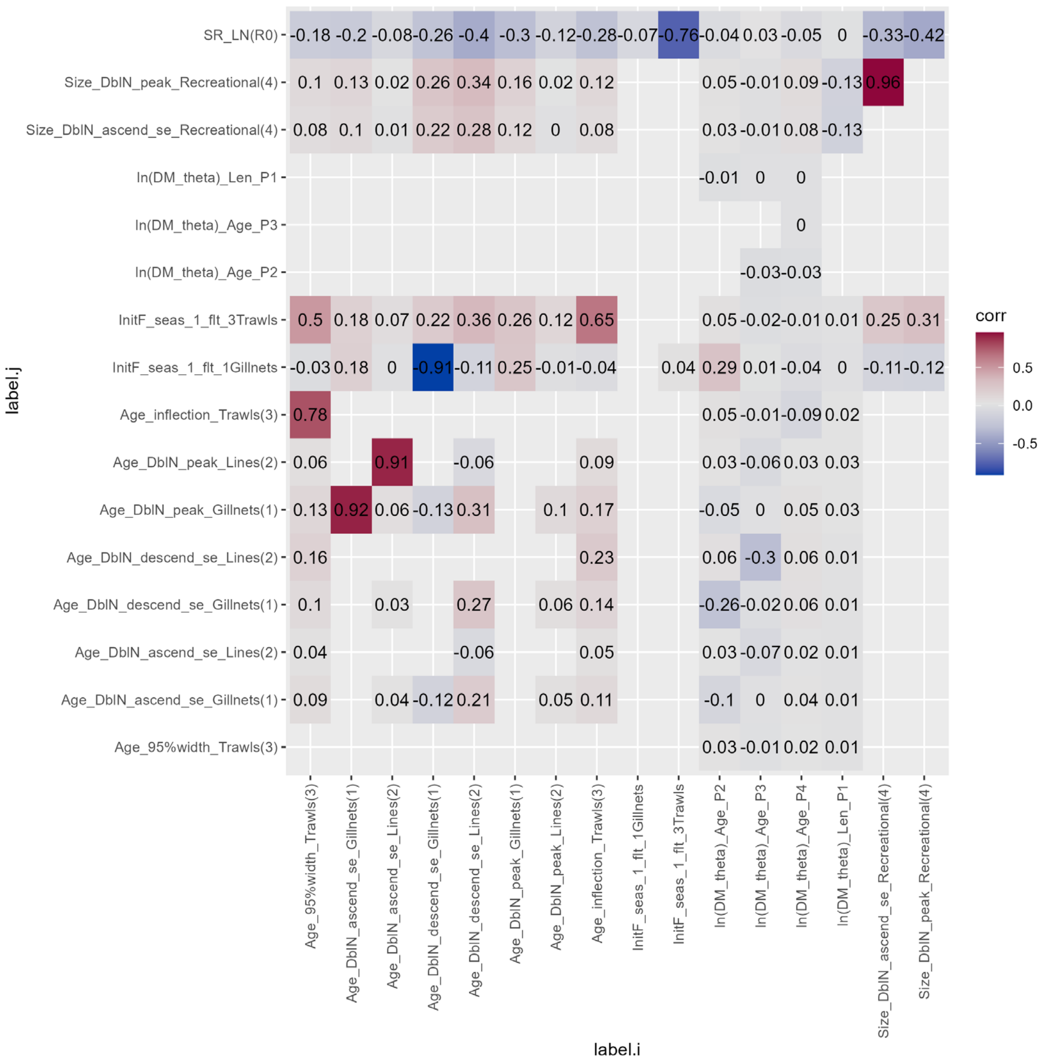

Figure 4.3.4.1. Correlations between parameters.

Goodness of fit - length composition

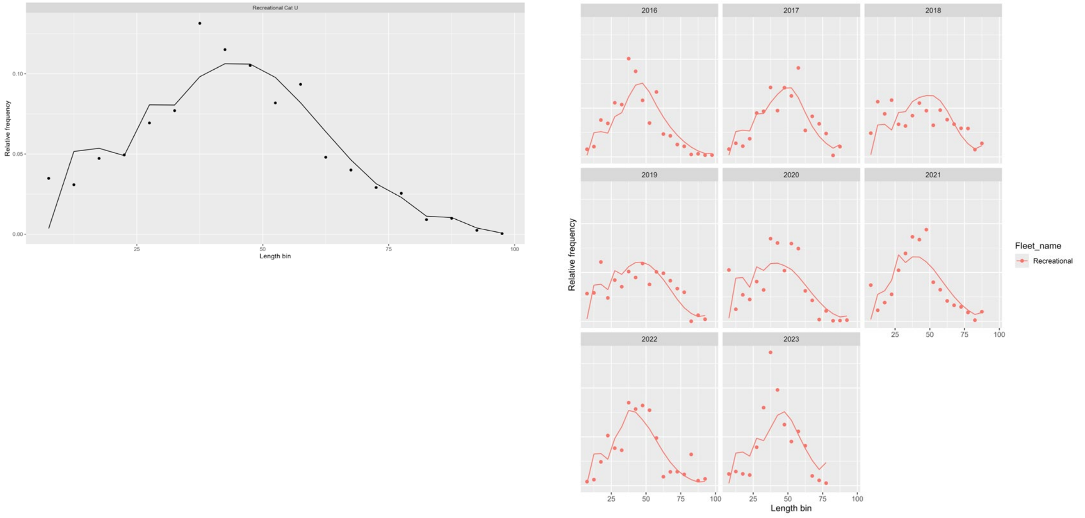

Figure 4.3.4.2. Length compositions aggregated overall years (left) and by year (right): points are observations and lines are the fitted values. The length composition data appears to be quite noisy, nevertheless, the fit appears to be reasonably good.

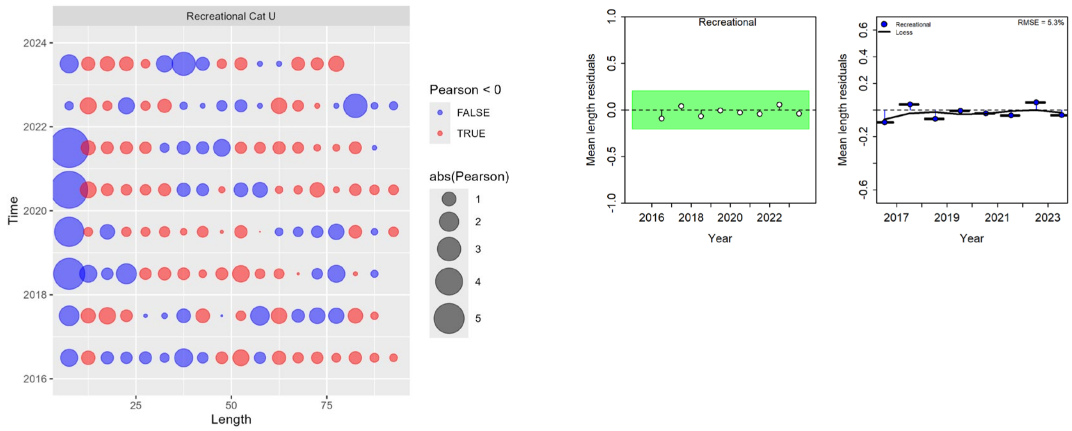

Figure 4.3.4.3. Pearson residuals (left) and runs test and RMSE (right) for mean length residuals (recreational fleet only). Residuals for the smallest size class are consistently positive, possibly indicating a small mis-specification in the size-at-age or M of the smallest fish. Otherwise, there are no obvious patterns in the residuals.

Goodness of fit - age composition

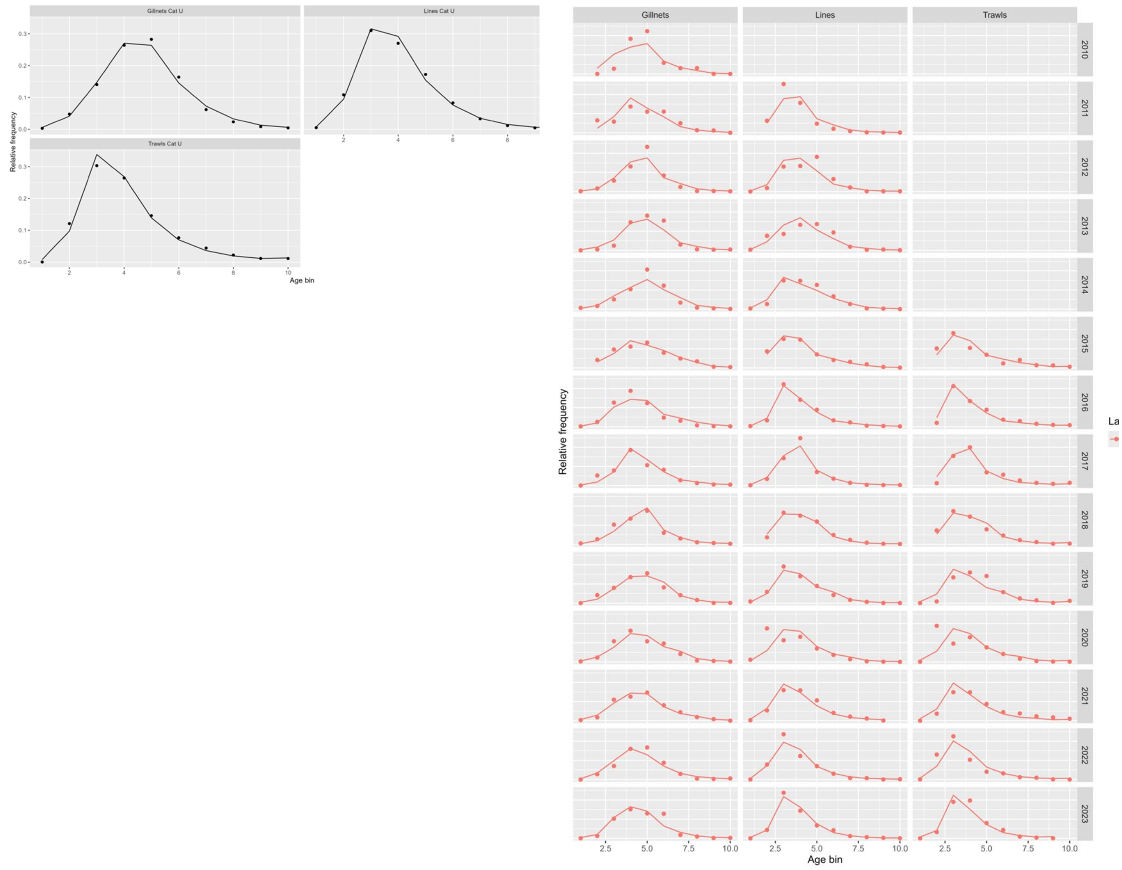

Figure 4.3.4.4. Age compositions aggregated over all years (left) and by year (right): points are observations and lines are the fitted values. The fit is consistently good.

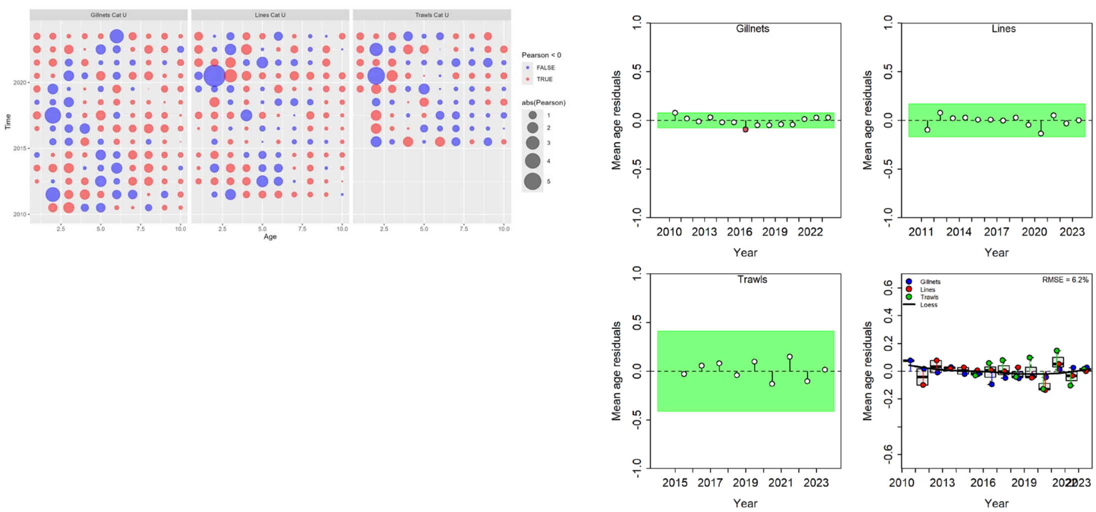

Figure 4.3.4.5. Pearson residuals for the age compositions (left); there are no obvious patterns. Runs test and RMSE (right) for the mean age residuals (commercial fleets). The small RMSE (6.2%) indicates a precise model fit.

Goodness of fit – indices

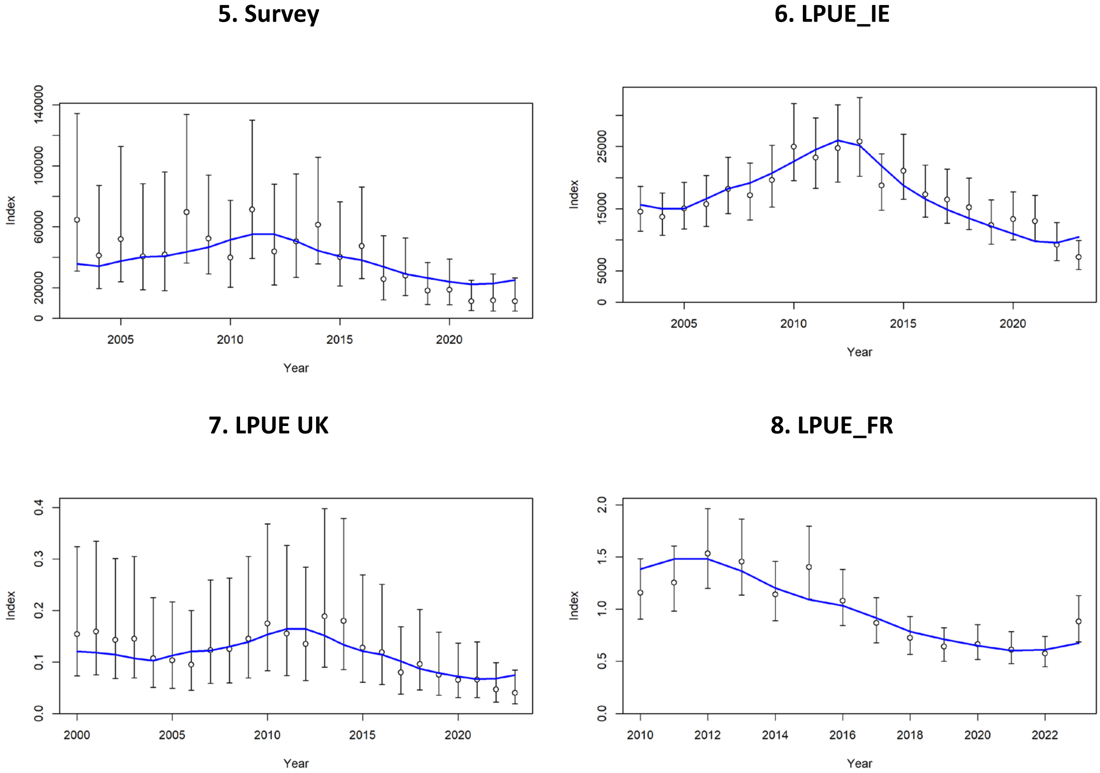

Figure 4.3.4.6. Fits to index data. Lines indicate 95% uncertainty interval around index values based on the assumption of lognormal error. The model fits most closely to the LPUE_IE series but all indices are in general agreement. In recent years the Survey index estimates a lower biomass than the other indices.

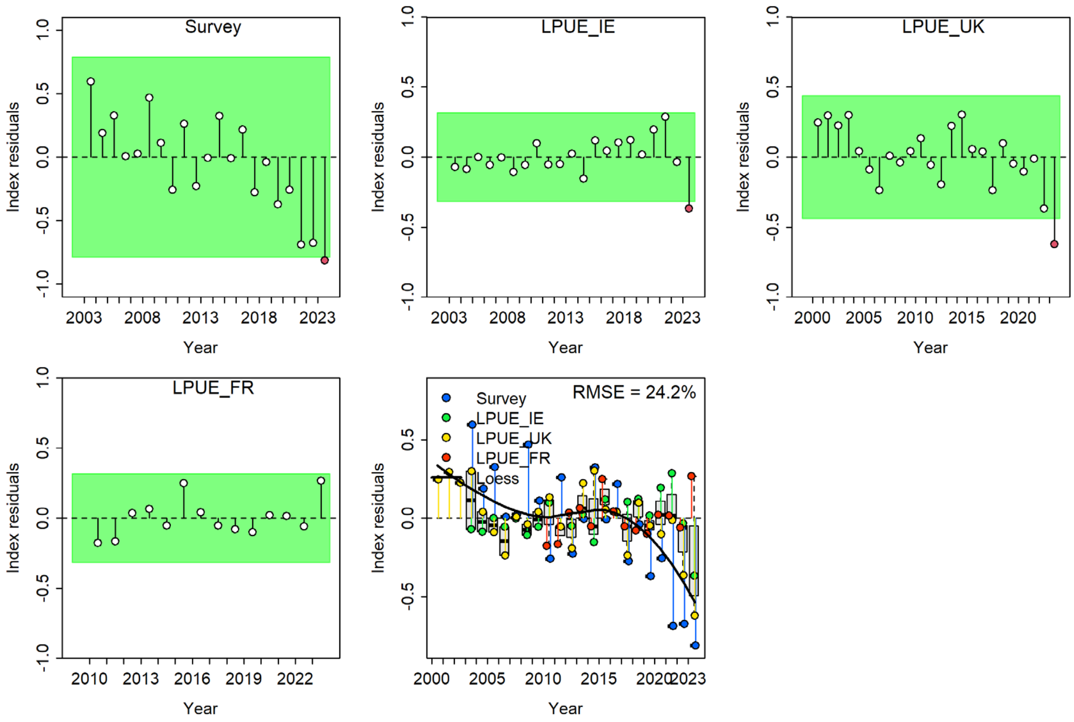

Figure 4.3.4.7. Runs test and RMSE for the index residuals. A relatively small RMSE (24.2%) indicates a reasonably precise model fit. However, the negative residuals in the last few years of the survey index as well as the LPUE_UK index, indicate that there is some conflict with other data (most likely the age composition).

Model consistency - R0-profile

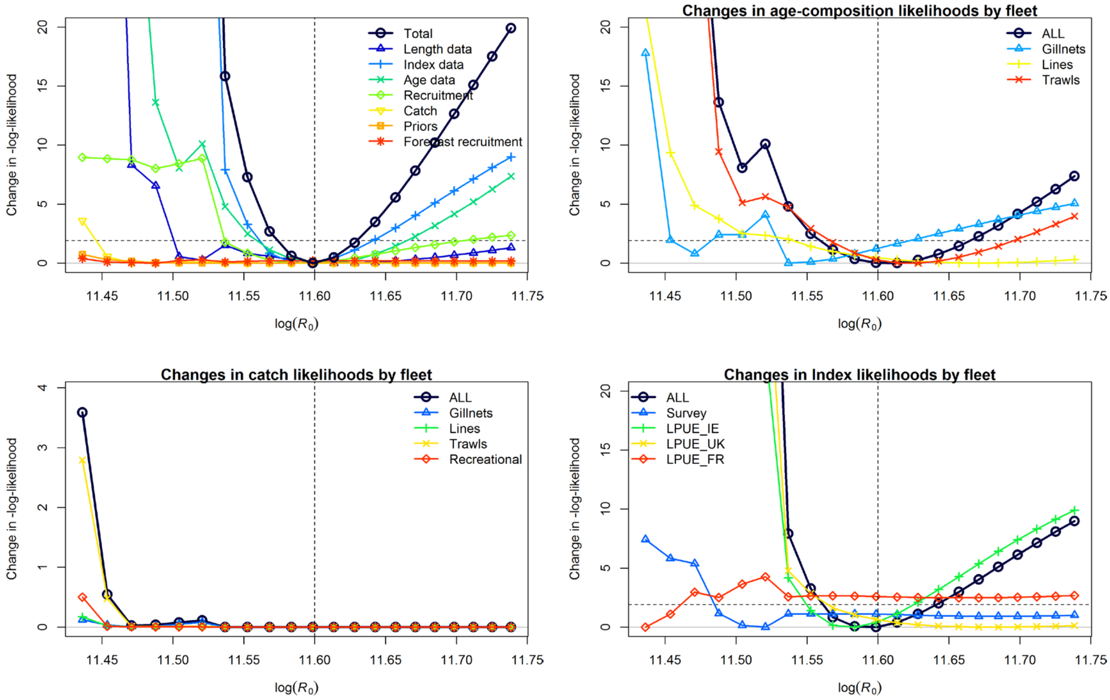

Figure 4.3.4.8. Log likelihood profiles for R0. Top left: The index data and age data are most influential for R0. Despite the pattern in index residuals in recent years, there appears to be good agreement between the data sources. Top right: The gillnet age data has some conflict with the other fleets, but the trawl fleet is most influential. Bottom left: The catch data do not inform R0 much. Bottom right: The survey and LPUE_FR do not appear to inform R0. The Irish and UK LPUE-pear to be in agreement regarding the lower end of R0 but the UK LPUE does not appear to have much information on the higher end of R0.

Model consistency – retrospective pattern

Figure 4.3.4.9. There is no significant retrospective pattern for SSB or F. Recruitment is expected to be poorly estimated until those fish enter the fishery but this is not evident from most years of the retrospective analysis because recruitment has been quite consistent in recent years.

Prediction skill

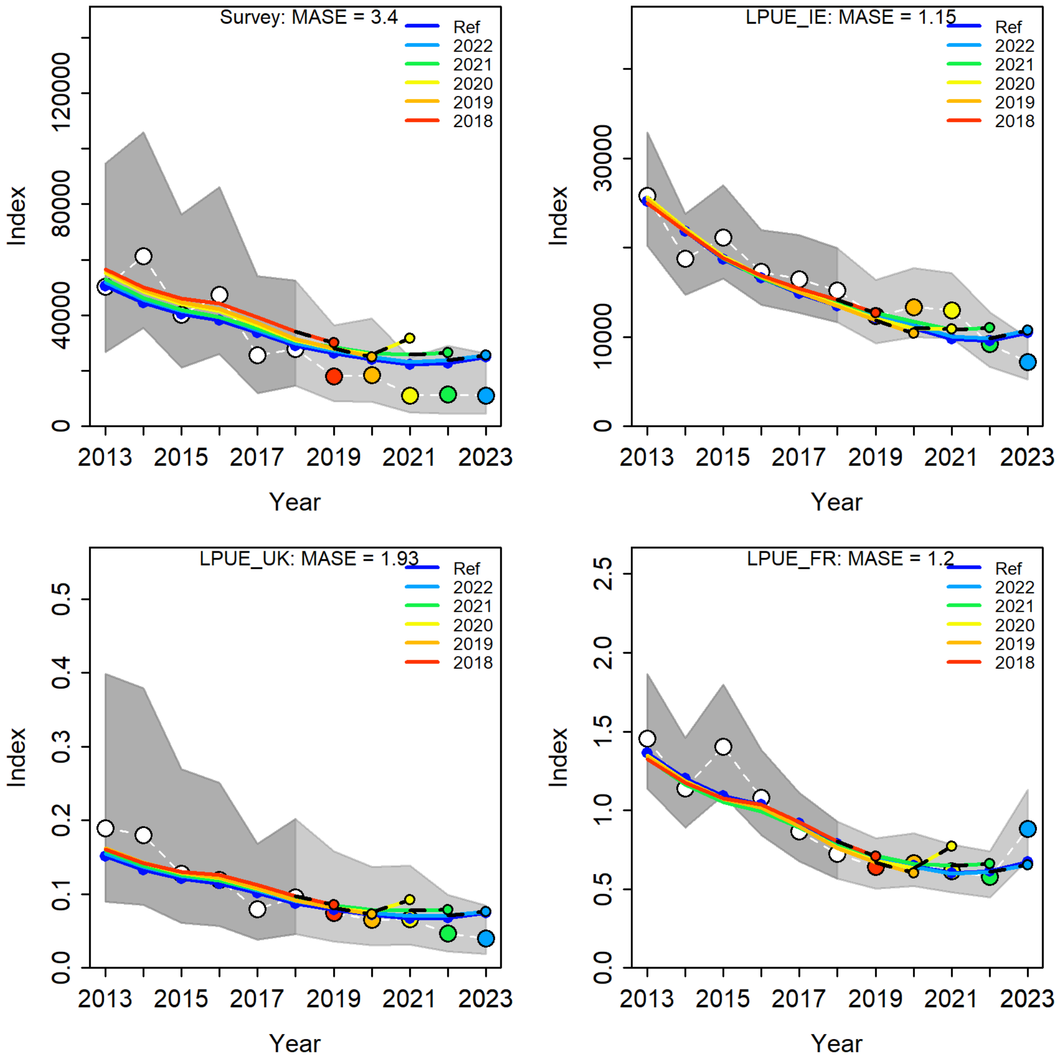

Figure 4.3.4.10. Hindcasting cross-validation (HCxval) results for the indices. The indices do not appear to have significant prediction skill (MASE>1). It is likely that this is at least partly due to their relatively high standard errors so the estimates in any given year are not very precise. The hindcasted values for the survey index are consistently higher than observed, indicating a conflict or bias. For the other indices there appears to be less bias or conflict.

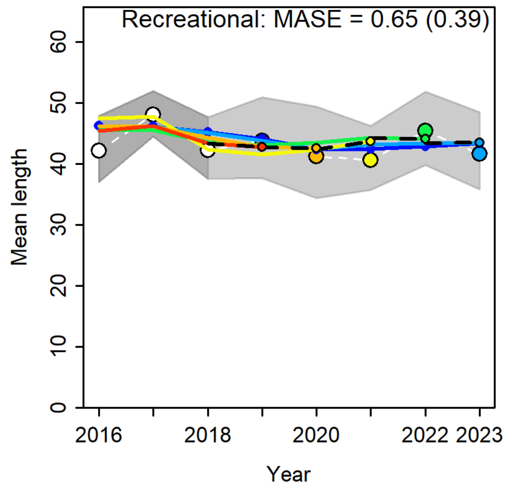

Figure 4.3.4.11. Hindcasting cross-validation results for the mean length of the recreational catches; the mean length is quite stable, but the prediction skill is better than chance (MASE<1).

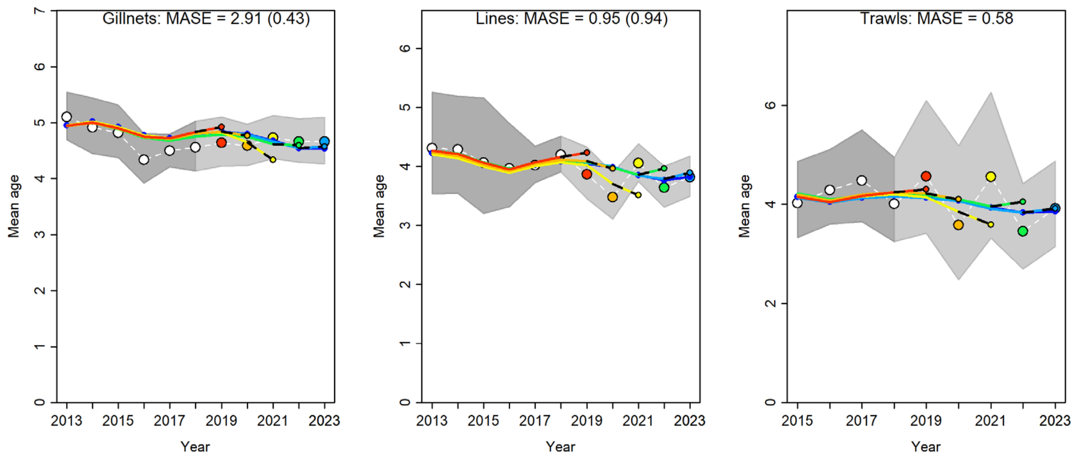

Figure 4.3.4.12. Hindcasting cross-validation results for the mean age of the commercial catches. The lines and trawls fleets have significant prediction skill (MASE<1).

Diagnostics - summary

The final model passes nearly all diagnostics tests, only the indices do not pass the hindcasting cross validation test.

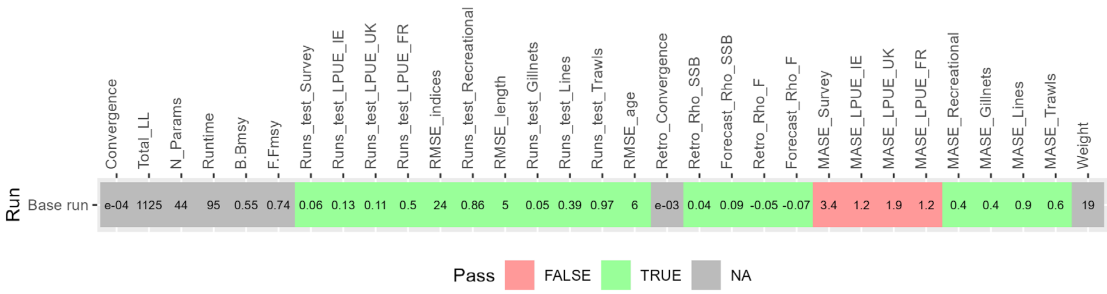

Figure 4.3.4.13. Convergence is the maximum gradient; Total_LL is total likelihood; N_Params is the number of parameters Runtime is in seconds; B.Bmsy is the ratio of B/B_{MSY} in the last year of the assessment; F.Fmsy is F in the last year divided by F_{MSY} from SS3; weight is the number of diagnostics that are passed (green). Grey cells are not diagnostic criteria and are included for information only.

4.3.5 Sensitivity runs

A number of sensitivity runs were performed to investigate the robustness of the model. These are described in detail in working document "4.9 pol.27.67 BaseCaseFinal.docx". Some key sensitivities will be highlighted here.

Low regime time block

Including a time block with a different recruitment regime did not impact on the perception of the stock development with the exception of F in the last year. Without the low recruitment regime, recruitment in the last two data years (for which recdevs are not estimated) is expected to return to the values predicted by the stock recruit curve. Because this expectation is considerably higher than recent recruitment, these fish will contribute to the catch (particularly the recreational catch) and reduce F slightly.

Conclusion: The regime parameter does not impact significantly on the assessment (but it is useful for informing recent unobserved recruitment and testing the robustness of the reference points to a period of low recruitment).

Figure 4.3.5.1. Stock development in absolute (left) and relative (right) terms in the base run, compared to switching the regime parameter off (i.e. not accounting for the recent period of low recruitment). Note that the run 'Regime parameter estimated' is identical to the base run. Also note that F_{MSY} in this case is the value for F_{MSY} estimated by SS3, not the 'ICES' F_{MSY} which takes into account the advice rule and is limited by Fp05.

Recreational catch assumptions

A number of scenarios were investigated for historic (<2016) recreational catches as described in section 4.2.2 and Figure 4.2.2.2:

0. No recreational catches
1. The base-case scenario: a gradual increase in catches from 1950 to 1990 after which they plateau at the level of the average observed catches (2016-23).
2. Recreational catches are 50% of scenario 1.
3. Constant recreational catches before 2016 at the average observed level in 2016-23.
4. Recreational catches are proportional to commercial catches with a ceiling at 5000t.

Only (assumed) dead fish are included in the model. Post release mortality (PRM) is estimated at 28.9% The sensitivity to this estimate was tested through the following scenarios:

5. A low post-release mortality of 19.4% (lower CI of PRM estimate)
6. A high post-release mortality of 41.2% (upper CI of PRM estimate)

The impact of the assumed historic development of the recreational catches on F and SSB was remarkably small, both in absolute and relative terms. The most significant impact was on the absolute level of SSB, but ratio of SSB/B_{MSY} was almost unaffected. The impact of the assumed level of post-release mortality is nearly imperceptible.

Conclusion: the model is robust to uncertainty around the absolute level of recreational catches as well as the assumptions around their historic development.

Figure 4.3.5.2 Stock development in absolute (left) and relative (right) under the recreational catch various scenarios. Scenario 0 (zero recreational catch) resulted in a lower F estimated in the most recent year but otherwise the impact on SSB and F both in absolute terms and relative to reference points is remarkably small, particularly in the recent period. Note that F_{MSY} in this case is the value for F_{MSY} estimated by SS3, not the 'ICES' F_{MSY} which takes into account the advice rule and is limited by Fp05.

Natural mortality and steepness

Natural mortality and steepness are often difficult or impossible to estimate in an assessment model. Their assumed values may only have a moderate impact on the absolute levels of F and SSB, but they have a strong impact on F_{MSY} in any model. In the current model, natural mortality is based on the Lorenzen approach and steepness is fixed at the value suggested by the fishlife R package. The data compilation workshop considered this to be the best available information.

In order to investigate whether a change in either h or M would improve the likelihood or diagnostics of the model, a combined h and M profile was run (Figure 4.3.5.3). The conclusions are that:

- The choice of h does not impact on the likelihood much.
- With the current value of h (0.76), the current value of M is at lowest negative log likelihood.
- None of the alternative values of h and M resulted in improved diagnostic results.

Conclusion: although the assumed values of h and M are influential there is no reason to deviate from the values that were considered most appropriate at the data compilation workshop.

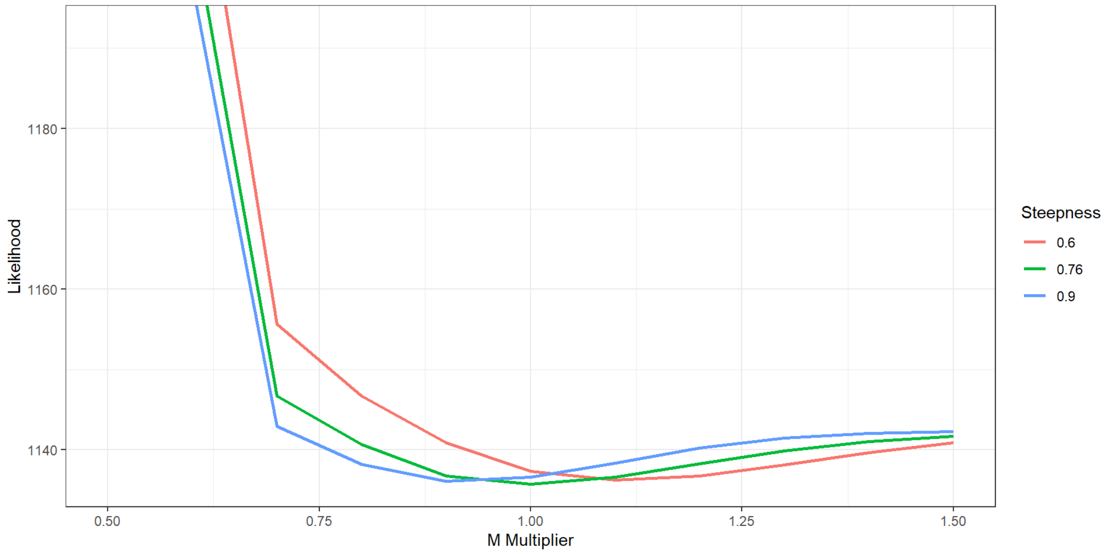

Figure 4.3.5.3 Likelihood profile of M at 3 levels of h. The model does not have enough contrast at low biomass to estimate steepness (the likelihood is almost unaffected by the value at which h is fixed). Similarly M did not affect the likelihood much except for M multiplies < 0.75.

Discontinued LPUE indices

With the very low bycatch-only TAC since 2024 it is likely that the LPUE indices cannot be calculated after 2023. This sensitivity run explores what would have happened if all the commercial indices would have ended in 2022, 2021, 2020, 2019 or 2018. The overall trends are not affected but there is some impact in the estimate of F in the final year.

Conclusion: The assessment is quite robust to discontinuation of the LPUE indices.

Figure 4.3.5.4. Stock development in absolute (left) and relative (right) of the base run compared with truncated LPUE indices, simulating what would happen if the LPUE indices will be discontinued in the future. The impact is very minor.

Note that F_{MSY} in this case is the value for F_{MSY} estimated by SS3, not the 'ICES' F_{MSY} which takes into account the advice rule and is limited by Fp05.

Summary diagnostics for all sensitivity runs

Figure 4.3.5.5. summarises the diagnostics of all alternative runs. Note that some of these runs were performed as sensitivity runs, other to explore alternative settings. Many runs pass an equal number of diagnostics to the base run but none of them perform better. The first 14 sensitivity runs are described above. Run "15 Fix Dirichlet" was performed to check if fixing the estimated Dirichlet parameters would improve the retrospective pattern (it only marginally improved it). Run "16 F as para" was a performed with F method 2 for all fleets (the results were nearly identical; but runtime increased). Run "17 Recdev start 1950" was performed to check if the model had problems matching the data poor period with the data-rich period (once the recruitment block was included, this was not a problem). Runs 18 and 19 explored whether changing the CV of old and young fish in the growth curve resulted in a better fit (increasing the CV marginally reduced the total LL but resulted in one of the runs tests failing). Runs 20-25 explore various multipliers on natural mortality and runs 26-29 explore different values for steepness (none of these runs resulted in better diagnostics than the base case). Runs 30 and 31 checked the impact of changing sigma R (no perceptible impact). Runs 32-35 checked the impact of the historic landings (only retaining recent catch data resulted in lower B_{MSY} estimates, so the historic landings inform the model about carrying capacity). Runs 36 to 39 explore the impact of leaving out one index at a time and runs 40-43 explore the impact of only including one index at a time. Finally runs 44-46 explore the impact of including beam trawl surveys and/or the Channel groundfish surveys in the combined survey index (no perceptible difference).

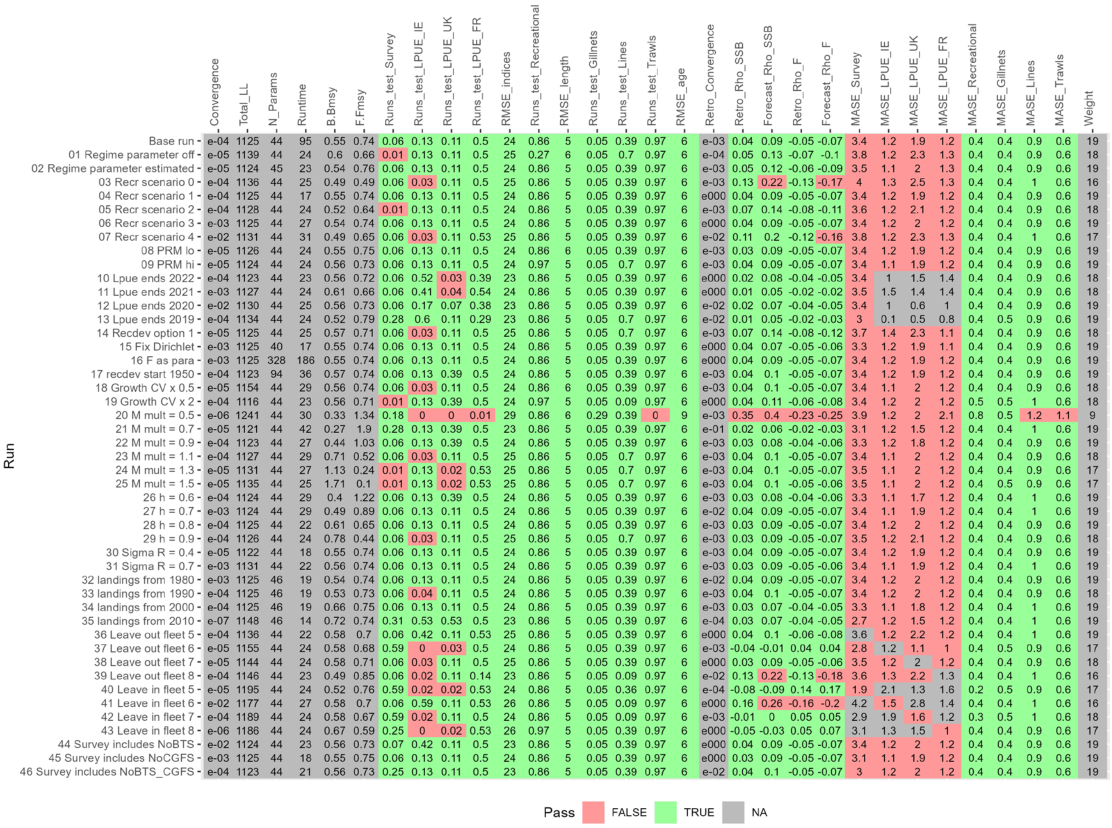

Figure 4.3.5.5. Convergence is the maximum gradient; Total_LL is total likelihood; N_params is the number of parameters Runtime is in seconds; B.Bmsy is the ratio of B/B_{MSY} in the last year of the assessment; F.Fmsy is F in the last year divided by F_{MSY} from SS3; weight is the number of diagnostics that are passed (green). Grey cells are not diagnostic criteria and are included for information only.

The impact of various configurations on the advice can be summarised by plotting F in the last data year over F_{MSY} (as estimated by SS3) and SSB in the last year over B_{MSY}. The runs that are most influential are:

- Assuming zero recreational catch reduces the perception of F in the last year relative to F_{MSY}. However, we know recreational catches are considerable, so ignoring them is not considered a reasonable alternative.
- M and h are clearly influential but none of the runs had better diagnostics than the base run so there is no reason to deviate from the agreed values.
- Fleet 8 (LPUE_FR) had a moderate impact on the perceived stock status: leaving it out resulted in a more optimistic perception of stock status and a single fleet run with LPUE_FR resulted in a less optimistic perception.

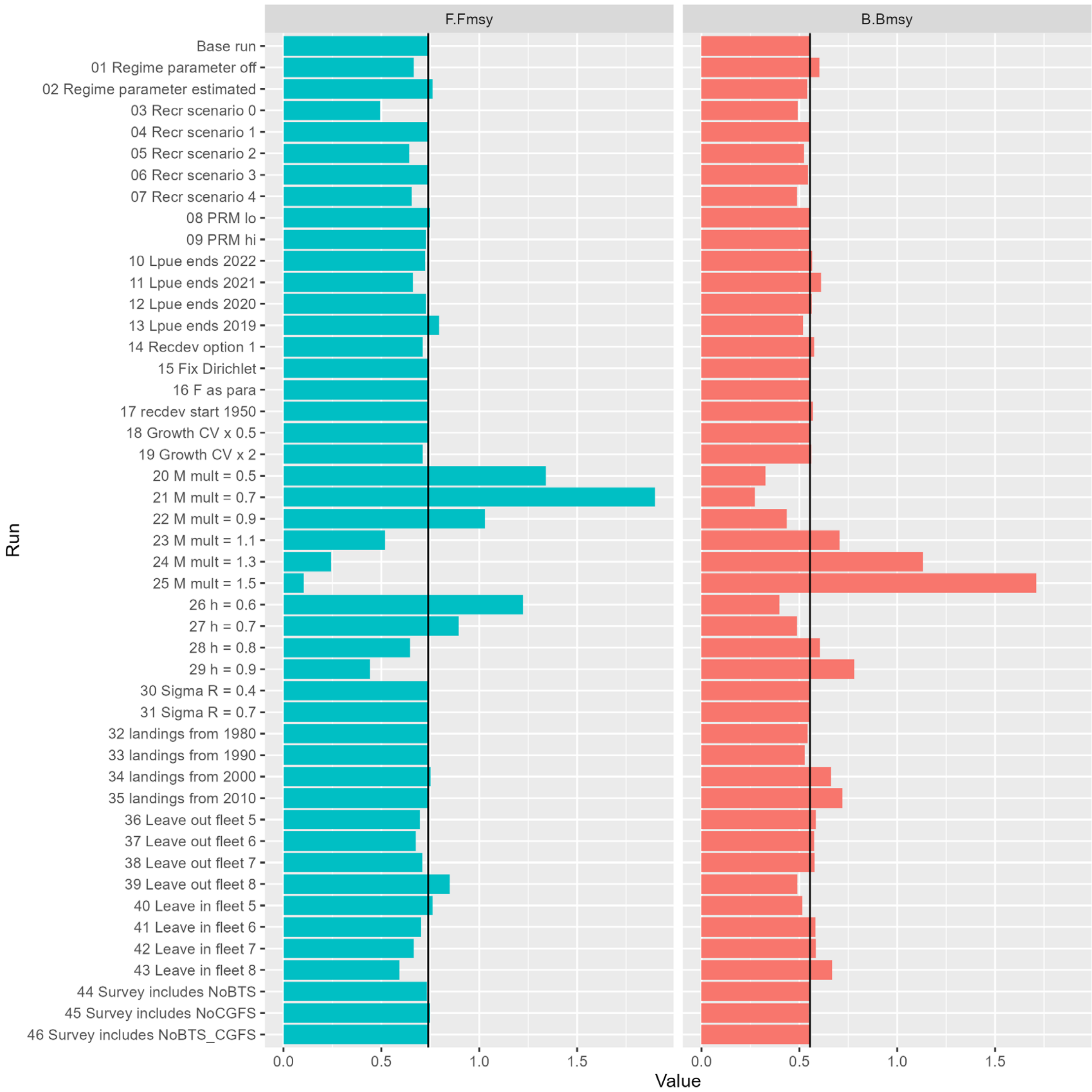

Figure 4.3.5.6. Stock status in the final year of the assessment; the black line represents the base case

Conclusion: the base run appears robust and none of the alternative runs present an improvement on the base run.

4.4 Reference points and short-term forecast

4.4.1 Reference points

The stock-recruit dynamics of pollack estimated by Stock Synthesis (SS3), indicate that in recent years recruitment has been consistently lower than in the historic period (Figure 4.4.1.1). Recruitment declined first in 2011 when SSB was at the highest level of the ‘data-rich’ period. With the exception of 2013, recruitment has been well below average since, leading to a decline in SSB.

In SS3, a time block with reduced recruitment was estimated for the period since 2014. The regime parameter estimated for this time block serves as an offset to R0 in the recent period. Including the parameter has no perceptible impact on the estimated stock development but allows us to test whether the reference points are robust to a period with low recruitment. The reduction in effective R0 in the period since 2014 is estimated to be 55.2%.

The usual ICES approach to estimating reference points includes fitting a stock-recruit relationship to SR pairs estimated by an assessment model. In an integrated model it makes more sense to directly use the SR parameters estimated by the model. Table 4.4.1.1 lists the stock-recruit parameters used here for estimating the reference points. All parameters except rho are estimated in the SS3 model. Rho was calculated outside the model as the lag-1 autocorrelation in the main recruitment deviations (on the log scale). The parameters *h*, *sigmaR* and *rho* are unaffected by the regime parameter. This means that the value of F_{MSY} is independent on whether a low recruitment or full recruitment scenario is assumed. However, the risk of the biomass falling below B_{lim} will increase in a period with low recruitment, and we will test here whether F_{MSY} is precautionary in a period of low recruitment.

Table 4.4.1.1. Stock-recruit parameters in the main period and the period of low recruitment since 2014. The SR function is a reparametrised Beverton-holt without bias correction: Ry = 4*h*R0*ssb/(B0*(1-h)+ssb*(5*h-1)); see SS3 manual for further detail.

Parameter	Full recruitment	Low recruit regime
R0 multiplier	1	0.552
R0*multiplier	108,956	60,165
B0*multiplier	93,449	51,602
h	0.76	0.76
sigmaR	0.233	0.233
rho	0.386	0.386

B_{lim}

Figure 4.4.1.1 shows the stock-recruit pairs. The SR type cannot be classified as any of the types in the ICES technical guidelines. WKBSS3 considered the following:

- Recruitment levels decreased when the stock was relatively high. Subsequently, low recruitment led to a low stock size.
- The last year with estimated recruitment deviations (2021) had the lowest 'observed' recruitment but this value is quite uncertain as the model does not have much information on 2-year old fish.
- WKNEWREF (ICES, 2024) compiled information on the ratio of B_{lim} over B0 in cases where B0 was well estimated. For gadoids, the mean B_{lim}/B0 is around 15%. This could be considered as a guideline for B_{lim} in this case. Under the full recruitment regime, B0 is estimated at 93,449 t. 15% of this B0 value is 14,017 t. Under the low-recruitment regime, B0is reduced and 15% of B0 is 7,738 t which is well below Bloss and therefore not considered appropriate.
- The group decided that SSB(2020)=14,298 t is a pragmatic choice for B_{lim}. This is the highest recruitment in the recent period and is slightly above 15% of B0 under full recruitment; this means that this value of B_{lim} does not 'shift the goalposts' as the stock declines, in other words, it is appropriate in both the full and reduced recruitment scenarios.
- In the low-recruitment regime, B_{MSY} is very close to the proposed B_{lim}. This means that the stock will not rebuild to be much above B_{lim} when fished at F_{MSY} and that F_{MSY} will need to be limited by Fp05.

Decision: B_{lim} = SSB(2020) = 14,298 t.

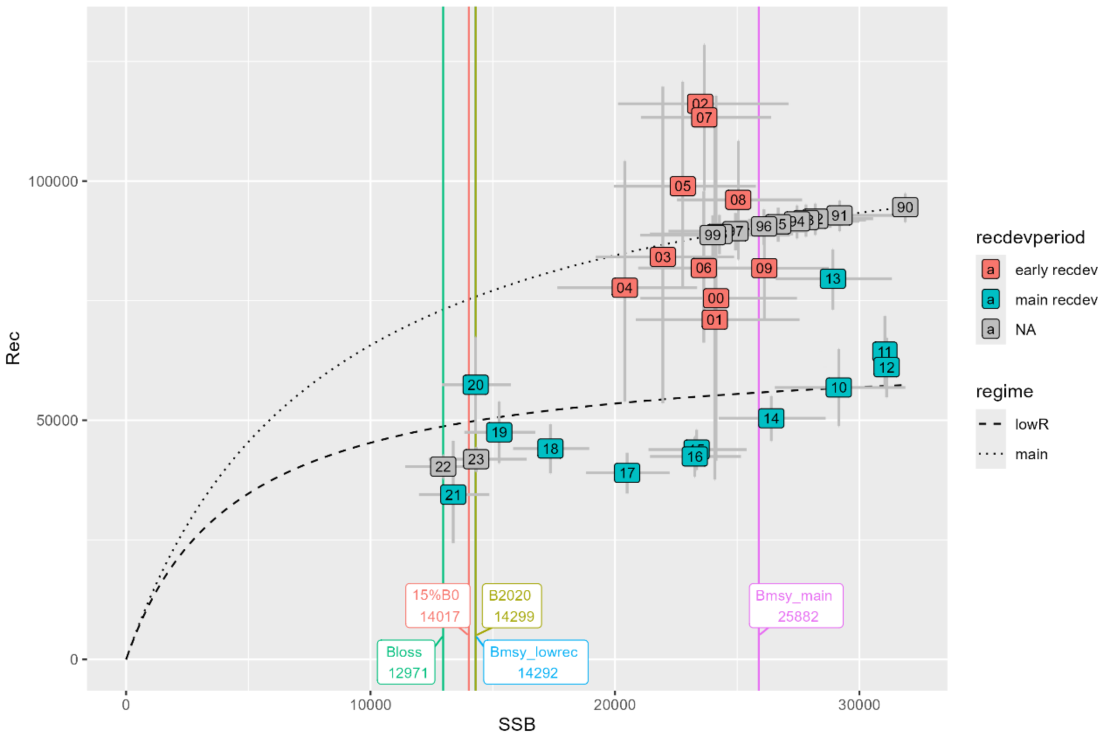

Figure 4.4.1.1 Stock-recruit pairs. The colour of the boxes indicates the early and main period for recruitment deviations. Recruitment deviations are not estimated before 2000 (those points are on the SR curve) or after 2021 (those points are estimated from the SR curve in the low recruitment regime with bias adjustment). The vertical lines indicate biomass values that help inform the choice of B_{lim}. The dotted and dashed lines are the SR curves in the main period and period of low recruitment, respectively.

B_{pa}

B_{pa} is the reference point above which the stock is considered to have full reproductive capacity, having accounted for estimation uncertainty. The standard deviation of log(SSB) in the intermediate year (sigmaSSB) is estimated as 0.10, it is likely that this is an underestimate so we replace sigmaSSB with the default value of 0.20. B_{pa} is therefore estimated as $B_{lim} \times \exp(1.645 \times \text{sigmaSSB})$, which is B_{lim} x 1.3896 = 19,869 t.

Decision: B_{pa} = 19,869 t

$B_{trigger}$

Because the stock has not consistently been fished at or below F_{MSY}, $B_{trigger}$ is set at B_{pa}.

Decision: $B_{trigger} = B_{pa}$ 19,869 t

F reference points

F reference points were initially investigated using the eqsim approach (https://github.com/ices-tools-prod/msy). Full details available in working documents: “4.10a pol.27.67 refPts SS3 EqSim full recruitment.pdf” and “4.10b pol.27.67 refPts_SS3 EqSim reduced recruitment.pdf”

The first eqsim run was performed with the SR parameters from the full recruitment regime (i.e. without the assumption of recent low recruitment). A second run was performed to check whether the reference points are robust to the current low recruitment levels (the SR parameters are provided in Table 4.4.1.1).

Table 4.4.1.2 shows that the initial eqsim estimate of F_{MSY} (without the ICES advice rule) is close to the SS3 estimate. Because steepness is assumed to be unchanged, the initial F_{MSY} value is unaffected by the full/reduced recruitment regime. When the eqsim estimation is applied with the advice rule (AR) in the full recruitment scenario, F_{pa} is estimated at 0.569 and is therefore not limiting to F_{MSY}. However, because during the low recruitment regime, R0 is effectively reduced by 55.2%, this affects the level to which the stock rebuilds in equilibrium state and therefore the risk of B < B_{lim}. Under the low recruitment scenario, the stock will only just be above B_{lim} when fishing at F_{MSY} (in equilibrium) so the risk to B_{lim} is larger than 5%. Eqsim estimates F_{pa} to be 0.309.

WKNEWREF (2024) advises that the time-lag between management and advice should be taken into account when estimating F_{MSY} and F_{pa}. This is not part of the eqsim procedure and therefore a simplified shortcut MSE (a feedback control simulation) was performed to check whether the eqsim results were precautionary. Full details are available in working document: "4.10c pol.27.67 refpts robustness Fpa.pdf."

The simulation including the time lag showed that under reduced recruitment the Fp05 value estimated by eqsim had a 9.9% risk to B<B_{lim} (Table 4.4.1.3) and was therefore not precautionary. A search was performed for an F target value that would result in a risk of <5%. Table 4.4.1.3 shows the range of F values explored. Under the reduced recruitment operating model, the highest F target that results in p(B<B_{lim}) of <5% is F=0.278. This is the proposed final value for Fp05, which will limit both F_{MSY} and $F_{MSY\ upper}$.

$F_{MSY\ lower}$ is estimated by eqsim at 0.214 and 0.22 in the full and reduced recruitment scenarios, respectively. $F_{MSY\ lower}$ is not limited by Fp05 but it should represent 95% of the yield given at Fp05 because this is the value we use for F_{MSY}. $F_{MSY\ lower}$ (0.214) was included in the simulation with time lag (Table 4.4.1.3) to check this: the long-term yield was estimated to be 96% of the yield given by Fp05 which is considered close enough to retain the eqsim estimate.

Decision: $F_{MSY\ upper}$ = F_{pa} = 0.278; F_{MSY} = F_{pa} = 0.278; $F_{MSY\ lower}$ = 0.214

Figure 4.4.1.2 shows some performance statistics for the reduced recruitment scenario. In the long term, all non-zero F targets explored resulted in similar catch but F targets above 0.278 were not precautionary (>5% risk to B<B_{MSY}).

Figure 4.4.1.3 shows the recent stock development relative to the reference points, and Figures 4.4.1.4 and 4.4.1.5 show the simulated stock trajectories under the full and reduced recruitment operating models.

A final simulation was performed to explore alternative F_{target} and $B_{trigger}$ values (working document: "4.10d pol.27.67 refpts robustness FtargetBrig.pdf"). Under the low recruitment scenario none of the alternatives tested performed better than the current combination of $B_{trigger}$ and Fp05. Under full recruitment, none of the alternatives that would be precautionary under low recruitment performed better either. Therefore, alternative F targets or $B_{trigger}$ values are not further explored, and the results are not presented here.

Table 4.4.1.2. Reference points estimated by SS3, eqsim and MSE-like simulations.

Parameter	Full Recruitment	Reduced Recruitment
Fmsy SS	0.346	NA
Fmsy eqsim - No AR	0.337	0.337
Bmsy SS	25835	NA
Bmsy eqsim	25882	14292

Parameter	Full Recruitment	Reduced Recruitment
Fp05 eqsim	0.569	0.309
Fp05 MSE	NA	0.278
FmsyLower eqsim	0.214	0.22

Table 4.4.1.3. Ftargets explored in the MSE with the long-term median values. Fp05Eqsim is the F_{MSY} value (capped by Fp05) estimated by eqsim, FloweEqsim is the $F_{MSY\ lower}$ value estimated by eqsim and FmsySS is the F_{MSY} estimated by SS3. In all runs, $B_{trigger}$ was 19,869 t and for both OMs the values for B_{MSY} and MSY for the full recruitment scenario was used so they can be compared directly. Red values of P(B<B_{lim}) are not precautionary.

		Reduced recruitment OM			Full recruitment OM		
MP	F target	Catch/MSY	B<B_{lim}	B/B_{MSY}	Catch/MSY	B<B_{lim}	B/B_{MSY}
F=0	0.000	0.000	0.000	1.972	0.000	0.000	3.567
F=0.278	0.278	0.533	0.049	0.692	0.971	0.000	1.162
F=0.28	0.280	0.533	0.054	0.690	0.972	0.000	1.155
F=0.282	0.282	0.533	0.056	0.687	0.972	0.000	1.149
F=0.284	0.284	0.534	0.058	0.685	0.973	0.000	1.142
F=0.286	0.286	0.534	0.061	0.683	0.974	0.000	1.136
F=0.288	0.288	0.534	0.064	0.681	0.974	0.000	1.130
F=0.29	0.290	0.535	0.068	0.679	0.975	0.000	1.124
FlowEerqsim	0.214	0.519	0.005	0.789	0.936	0.000	1.398
FmsySS	0.346	0.540	0.611	0.532	0.980	0.001	0.972
Fp05Eqsim	0.309	0.536	0.099	0.659	0.979	0.001	1.069

Table 4.4.1.4 The estimated reference points and their rationale.

Reference Point	Value	Rationale
B_{lim}	14,298	SSB in 2020, (lowest SSB with good recruitment and above 15% of B0)
B_{pa}	19,869	B_{lim} with assessment error
MSY $B_{trigger}$	19,869	B_{pa}
Fp05	0.278	F with 95% probability of SSB>B_{lim} (MSE)
F_{MSY}	0.278	Fp05
$F_{MSY\ lower}$	0.214	F with no less than 95% MSY

Reference Point	Value	Rationale
$F_{MSY\ upper}$	0.278	Fp05

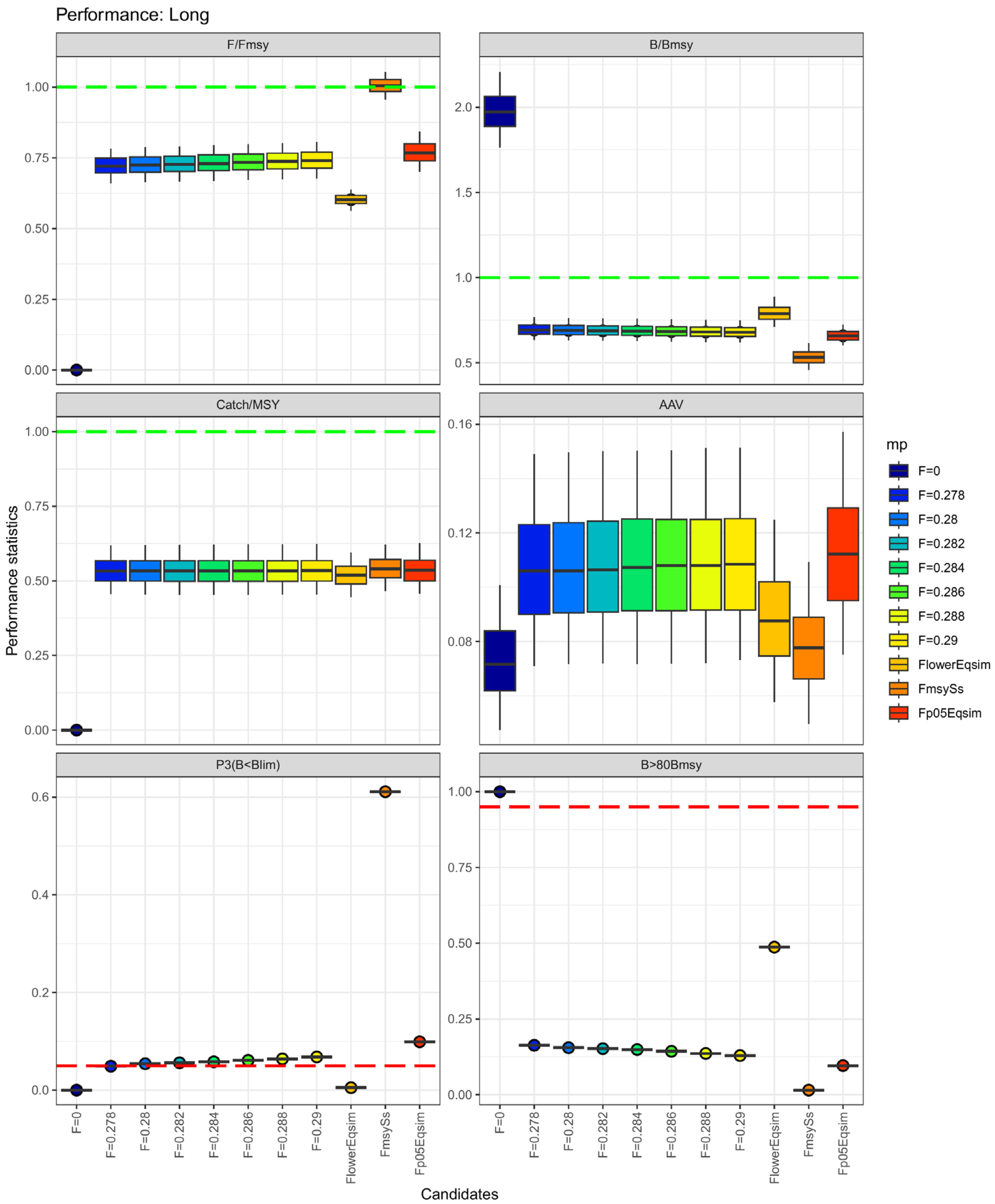

Figure 4.4.1.2. Performance of the simulation with reduced recruitment. F0 is a run with no fishing, FmsySS is a run with the F target set at the F_{MSY} value estimated by SS3 (without ICES AR or Fp05). Fp05Eqsim is a run to check whether Fp05 estimated by eqsim is precautionary and FlowerEqsim is a run to check whether $F_{MSY\ lower}$ estimated by eqsim results in 95% of MSY; the remaining runs are included to find Fp05.

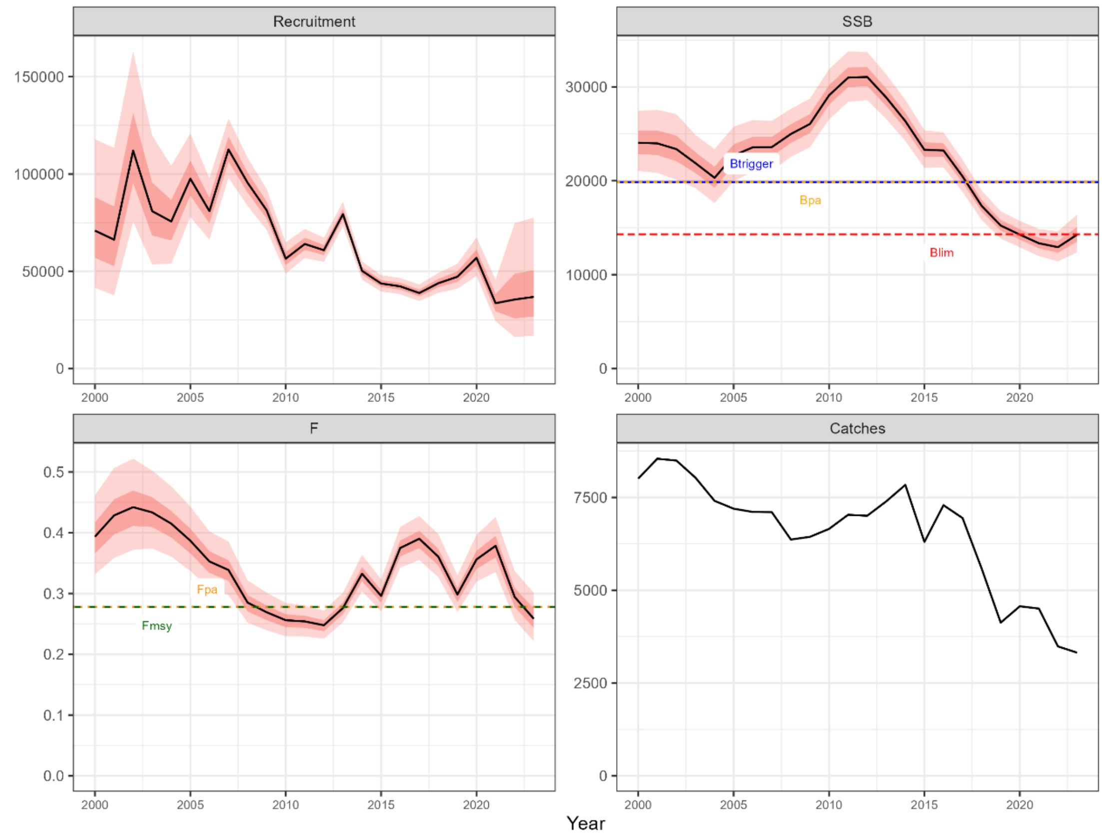

Figure 4.4.1.3. Stock summary plot with reference points.

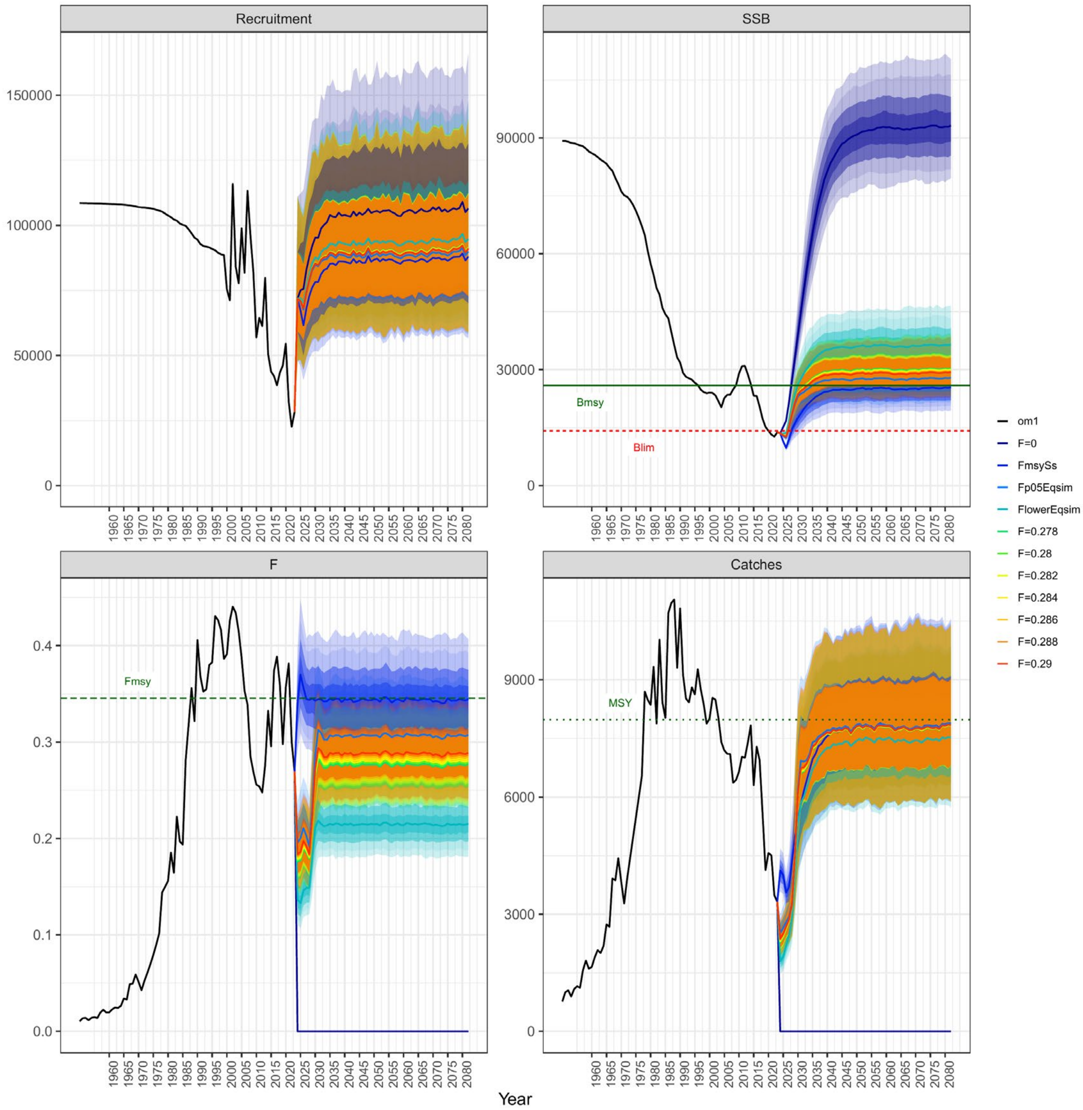

Figure 4.4.1.4. Trajectories for the MSE with full recruitment. F0 is a run with no fishing, FmsySs is a run with the F target set at the F_{MSY} value estimated by SS3 (without ICES AR or Fp05). Fp05Eqsim is a run to check whether Fp05 estimated by eqsim is precautionary and FlowerEqsim is a run to check whether $F_{MSY\ lower}$ estimated by eqsim results in 95% of MSY; the remaining runs are included to find Fp05.

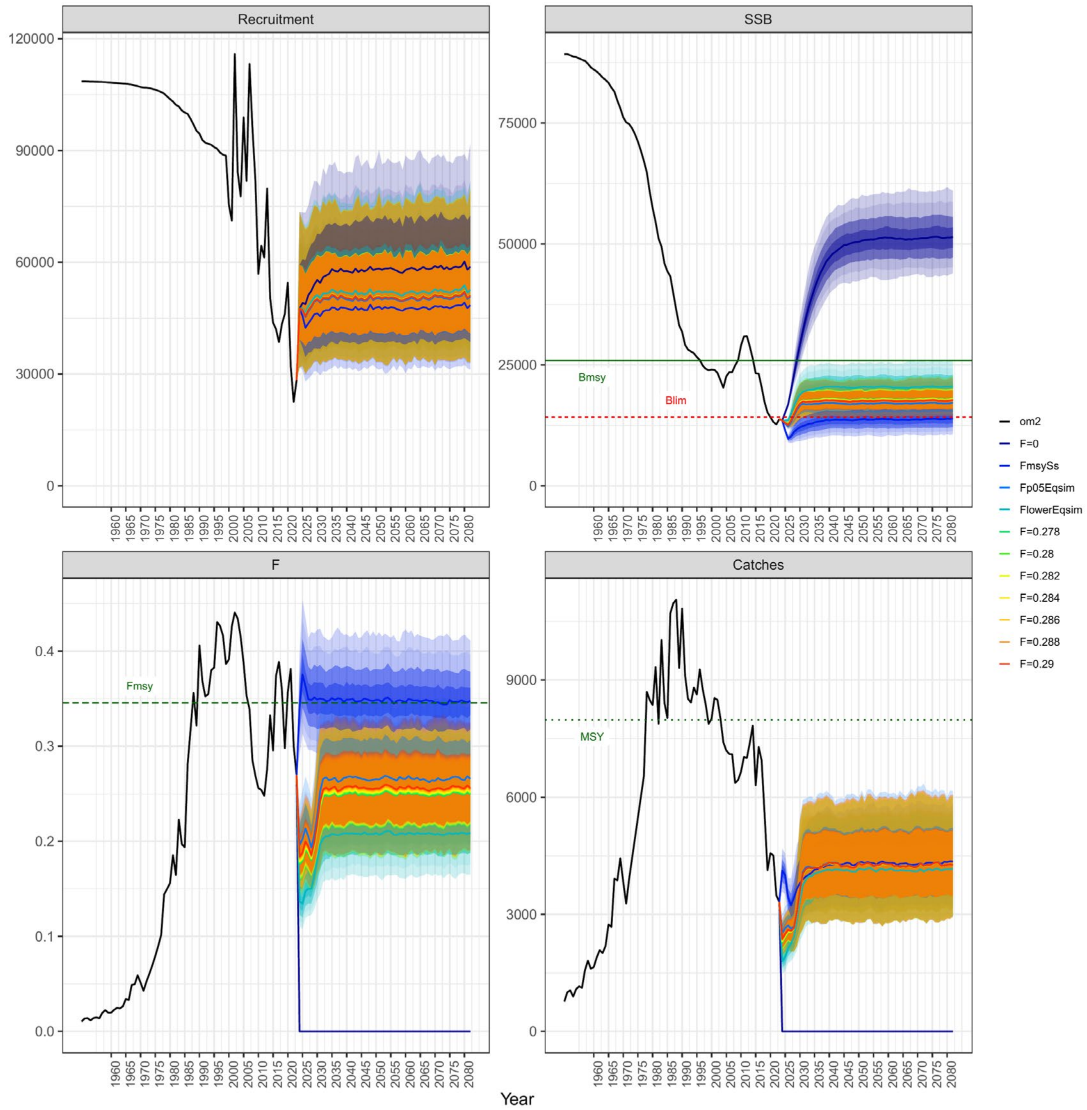

Figure 4.4.1.5. Trajectories for the MSE with reduced recruitment. F0 is a run with no fishing, FmsySS is a run with the F target set at the F_{MSY} value estimated by SS3 (without ICES AR or Fp05). Fp05Eqsim is a run to check whether Fp05 estimated by eqsim is precautionary and FlowerEqsim is a run to check whether $F_{MSY\ lower}$ estimated by eqsim results in 95% of MSY; the remaining runs are included to find Fp05.

4.4.2 Short-term forecast

The short-term forecast should be performed using the most recent assessment results and use the SS3 framework to provide catch advice. Although more complex than performing the forecast in FLR, using the SS3 framework will allow the different fleets to be incorporated into the forecast as well as including stochasticity. It was agreed by WKBSS3 that the maturity at age, the natural mortality at age and the fleet selectivities should be fixed as per the assessment model. The mean weights at age and the average F pattern would use the average of the last 3 years (mean weights will change marginally as the relative catch contributions of the fleets change). The stock recruit relationship during post 2014 recruitment block (reduced recruitment) will also be used to predict recruitment in the intermediate and advice year (Figure 4.4.1.1).

Forecast Settings	
Maturity at age	Fixed
Natural mortality at age	Fixed (Lorenzen)
Mean weights at age	Recent 3 years ([Assessment year-3] – [Assessment year-1])
Selectivity	Fixed for each fleet (Gillnets, Lines, Trawls, Recreational). Average F pattern of recent 3 years.
Recruitment	S-R function without bias and reduced regime
Assessment year	Last data year + 1
Interim year	Assessment year
Advice year	Assessment year + 1

The assumption of *F* in the intermediate year is a decision that should be reviewed at WGCSE, based on the best knowledge of the ongoing fisheries. The group discussed that, unless there is specific information on changes in recreational fishing pressure, the most pragmatic approach for the intermediate year *F* assumption is that the ratio of commercial and recreational partial F is kept constant.

4.5 Discussion and future considerations

The estimated stock development, both in absolute terms and relative to the reference points, is quite stable across a wide range of model configurations tested in the sensitivity runs. Potential remaining concerns and issues will be addressed in this section.

Comparison with the previous model

Since the previous benchmark (WKBMSYSPiCT2, ICES 2023) the stock has been assessed using SPiCT, a surplus production model. This model has no information on variation in recruitment and therefore had to attribute the decline in the stock to fishing pressure. The new SS3 model is more data-rich and particularly the age composition data is very informative to the model. The SS3 model indicates that the decline in stock size is mainly due to a period of low recruitment (although fishing pressure above F_{MSY} has also contributed). The new model is more optimistic about the stock status relative to B_{lim}, although both models agree that the stock is at or near the lowest observed SSB (Figure 4.5.1).

It should be noted that, although the perception of the stock development has changed with the new model, the new model would have also resulted in zero catch advice for 2024 and 2025 if it had been in place at the time, because the SSB was estimated to be below B_{lim} in those years.

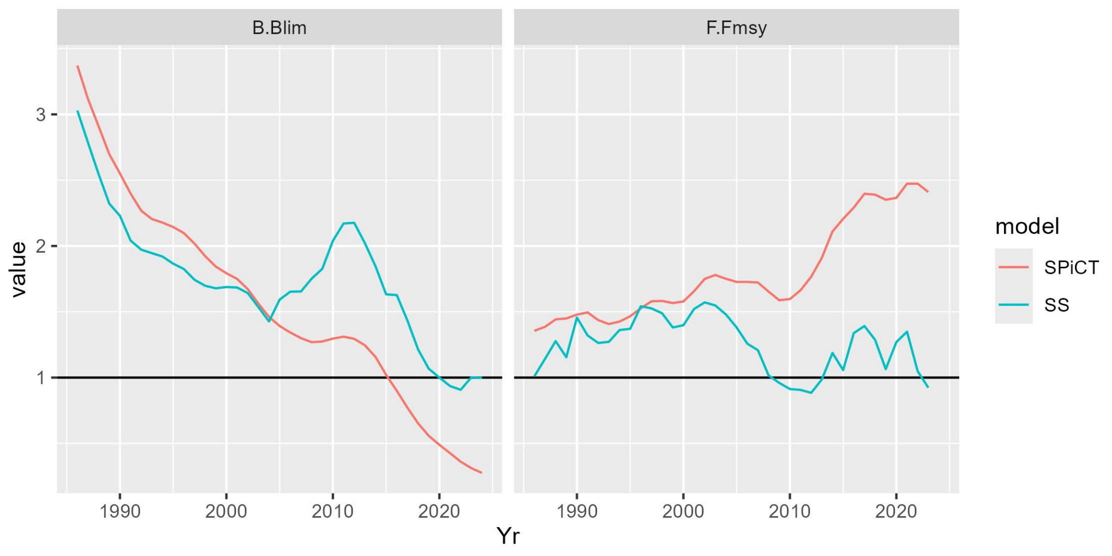

Figure 4.5.1. Comparison of the previous model (SPiCT), used as the basis for the 2024 and 2025 catch advice with the current model (SS3). Left plot shows biomass as a proportion of B_{lim} and the right plot shows F as a proportion of F_{MSY}[1].

Stock structure

The stock structure is unknown. The information currently available is insufficient to justify a change in the assessment area. However, work is underway to improve our knowledge on the stock structure of pollack, e.g. tagging and genetic sampling. Once results become available from this work, it needs to be taken into consideration, and another benchmark may be necessary.

Despite the lack of knowledge on the stock boundaries, significant progress has been made to improve the basis of the catch advice under the current stock boundaries (e.g. by including age composition data and recreational catches).

Recreational catches

The historic development of recreational catch is unknown. Based on anecdotal information and expert knowledge, a base-case scenario was defined, and several alternative scenarios were explored. Sensitivity analysis indicated that the perception of the stock was remarkably robust to the assumption on historic recreational catches. The level of post-release mortality was not influential either. It appears that the inclusion of these recreational data does not undermine the quality of the assessment and.

Survey index

The quality survey index has been criticised in the past because the sampling locations are not in the preferred habitat of pollack (hard ground where trawl surveys cannot sample). The surveys catch low numbers of pollack, resulting in imprecise estimates in any given year. However, the trend in catch rates is clear and mirrored across the surveys that contribute to the index.

The new survey index now includes data from beam trawl surveys as well as otter trawl surveys. This was done to improve the spatial coverage. It is known that beam trawls have poor selectivity for fish like pollack. The reason for retaining the beam trawl data is that the surveys do consistently catch pollack and confirm the trend seen in the other surveys. The spatio-temporal model used to combine the survey data, estimates a separate catchability parameter for each survey series, therefore accounting for differences between the gear types.

[1] In this case the plot shows the ratio of F over the final F_{MSY} reference point, which is capped by Fp05.

Data collection under limited fishing opportunities

Sampling of the commercial catch is challenged by the reduction in fishing opportunities since 2024. Age composition data is highly influential in the model, so it is very important to maintain collection of these data. Discard data are currently not included in the model because discarding levels have been low. However, changes to discard patterns need to be monitored and the assessment working group may have to consider including these data if discarding levels increase. Additionally, sentinel fisheries may help to ensure continued data collection.

The assessment also includes three commercial LPUE indices. With restricted fishing opportunities in 2024 onwards, it is likely that these indices will be discontinued because they rely on the fishing vessels sampling the stock in a consistent manner. The model results appear to be quite robust to some years of missing data in these indices, however it would be preferable if LPUE data can continue to inform the model.

In order to re-instigate the LPUE indices, some fishing activities occurring in a similar manner to pre-2024 patterns would need to take place. Such activities may require alternative management measures (e.g. targeting derogation or monitoring TAC). To be statistically appropriate for continuation of the LPUE indices, such activities may have to be undertaken specifically by vessels that contribute significantly to the LPUE indices. The spatial and temporal distribution of activities would also need to be carefully considered. ICES may be able to provide guidance on such a program if requested. These activities may also assist in the continued collection of age data from the catch.

Recruitment index

No recruitment deviations are estimated for the last two data years as the model has very little information data on the 0 and 1 year olds. These fish contribute to the catch in the advice year (4% and 12% in the current forecast) and to the SSB at the start next year (19% and 21% in the current forecast). Information on recent recruitment, possibly from recreational sources or from an inshore survey could improve the basis of the short-term forecast.

Regime shift

Adding the regime parameter had almost no perceptible impact on the model fit or estimated stock development. The purpose of the regime parameter is not to cut the time series and base the reference points only on the last 10 years of data. The reference points are based on the full dataset, but F_{MSY} was reduced to make it robust to the period of low recruitment that pollack appears to be experiencing. It also allows assumptions on forecasted recruitment that is in line with the model framework.

4.6 Reviewers report (pol.27.67)

Reviewer: Tanja Miethe

4.6.1 Introduction

This stock was put forward for benchmark due to criticism around the current SPiCT assessment model and input data. Current advice is for zero catch due to low estimated stock level. At this benchmark, an age-based SS3 model was developed which includes additional data. The new assessment appears to be very robust. It is accepted as outcome for this benchmark.

4.6.2 Data compilation

There was discussion around stock identity issues, since continuous spatial distribution between subarea 7 and 8 can be suggested. It was recommended to investigate stock ID in the future. While moderate sexual dimorphism is known to exists for this species, data quality was not sufficient for a split by sex.

Discards were excluded from the model due to low amount of discards (4% of catch), lack of aged discard data, and uncertainty in the raising procedure. Discards should continue to be monitored, and assumptions should be reviewed in the future if discard levels increase. Landings data were included separately by fleet (lines, trawls, gillnets) combining countries. The combinations were reasonable considering selectivities and sampling levels. In the future, separate French gillnets and trawl fleets could be considered if sufficient sampling confirms significantly different selectivity. Age frequency distributions are available for each combined landing fleet. Recreational catches and length frequency distributions were reconstructed from available recreational catch surveys and interview data. Assumptions on historical landings splits prior to 2003 and recreational catches prior to 2016 were made.

Constant growth curve and length-weight-relationship were agreed estimated from available commercial and survey data from Ireland as well as additional data from UK and recreational length data. It was decided to fix L_∞ at L_{max} from recreational catches. Maturity, estimated from Irish commercial and survey data from quarter 1, was close to or at maximum for ages 3+ and was assumed zero up to age 2 due to uncertainty on maturity at young age. These are reasonable assumptions, maturity at young age and growth curve should be reviewed in the future as new data becomes available.

Three commercial LPUE indices and a survey index are included. Each of the LPUE index series was derived using a different method. It is recommended to model LPUE indices for future benchmark using consistent approaches where possible (considering species composition, factors in the models). It was noted that LPUE indices may be discontinued in the coming years due to low bycatch-only TAC. The survey index was modelled combining multiple surveys to maximize spatial coverage. Since month or season was not included as a factor in the survey model, the timing of the combined survey was approximated from mean date of survey catches. No age or length distributions were available for the indices.

4.6.3 Assessment model

A single (combined) sex SS3 model with annual time step was agreed. Recreational length and landings age distributions were well fit. Selectivity for indices were mirrored from the respective landing fleets. There was discussion on a regime shift for this stock, which is assumed to have occurred in the 2010s. A time-block pattern for 2014 until 2021 was implemented in the model to allow a regime change in the stock recruitment relationship. This solved an issue of negative recruitment deviations and allows modelling realistic recruitments for the forecast. The specifications of the time-block pattern should be reconsidered at future WGs/benchmark as new data on recruitment becomes available. Assessment results for the recent data-rich period were found to be very robust to assumptions on historical catches, inclusion of recreational catches, assumed post-release mortality, discontinuation of LPUE indices, and a number of alternative configurations. SSB is estimated to be at the lowest observed level in recent years. The indices show general agreement, all confirming the estimated stock trend. The survey indicates a slightly stronger decline than the other indices, leading to some overestimation in the hindcast (MASE). The model shows acceptable diagnostics, including acceptable retrospectives.

4.6.4 Reference points and MSE

No stock type could be identified due to the shortness of the time series in the new recruitment regime. The choice of B_{lim} was discussed with consideration of recruitment regime and stock development. The most recent SSB with large recruitment (in 2020) was selected as B_{lim}, which is around 15% of the original B_0 and seems reasonable for this gadoid species in decline. The reference points were estimated using the stock recruitment relationships from the SS3 model. A short-cut MSE was run to tune the EqSim fishing mortality reference points to be precautionary.

Reviewer: Guiseppe Scarcella

4.6.5 General Conclusions

The assessment of pollack stock in subareas 6–7 (Celtic Seas and the English Channel) has seen substantial improvements through the transition from the Surplus Production Model in Continuous Time (SPiCT) to Stock Synthesis (SS3). The previous SPiCT model provided a precautionary evaluation of stock status, often recommending zero catch due to unsustainable fishing pressure. The new SS3 model incorporates a more extensive and refined dataset, including commercial and recreational fisheries, age composition data, LPUE indices, and updated life-history parameters. The application of SS3 allows for a better understanding of stock dynamics, integrating enhanced estimates of stock-recruitment relationships and accounting for technological advancements in the fishery that influence catch rates. The refined model structure improves the accuracy of catchability estimates, ultimately strengthening the foundation for stock management. Additionally, historical landings and recreational catches have been reconstructed with greater precision, addressing previous data gaps and uncertainties. To further improve the assessment and management of pollack in subareas 6–7, several key areas warrant additional research:

- Stock Structure and Genetics: Ongoing genetic studies aim to clarify stock boundaries, which could inform future assessments and management decisions.
- Survey Data Optimization: The incorporation of beam trawl surveys has improved spatial coverage, but further refinements in survey methodology are needed to enhance precision.

- Effort Standardization: Continued work on effort standardization, particularly in passive gears, will be crucial to reducing biases in LPUE indices.
- Recreational Fishery Management: The inclusion of recreational catches is a critical advancement, but further efforts are needed to improve data collection and assess potential management measures, such as seasonal closures and minimum landing sizes.
- Environmental Drivers: Investigating potential climate-driven changes in pollack recruitment and habitat suitability will be essential to understanding long-term stock dynamics.

4.6.5.1 Fit to Data and Model Diagnostics

The model's overall fit to data sources is robust, with consistency between model predictions and observed data trends. Most indices align well with model expectations, confirming the appropriateness of structural assumptions and parameter estimates. Several sensitivity analyses were conducted to explore the impact of different configurations, with particular attention to recruitment deviation settings, natural mortality (M), and stock-recruit steepness (h). One of the most influential configurations involved incorporating a low-recruitment regime starting in 2014, which better reflected observed trends in stock productivity. This adjustment allowed the model to estimate more realistic recruitment levels while maintaining consistency with historical data. The inclusion of commercial LPUE indices (Irish, UK, and French trawls) improved model performance, although concerns remain regarding the hyperstability of gillnet-based LPUE indices. Sensitivity tests indicated that the model is robust to alternative assumptions regarding post-release mortality, fleet selectivity patterns, and recreational catch reconstructions. Additionally, the assessment identified potential biases in survey indices due to spatial mismatches between pollack habitat and survey coverage. While the survey index captures general trends, commercial LPUE indices provided additional insights into stock status, particularly regarding recent recruitment patterns. Retrospective analyses showed no significant bias, and hindcasting cross-validation confirmed the model’s predictive skill in key variables.

4.6.6 Biological Reference Points

The estimation of biological reference points followed ICES guidelines, incorporating updated stock-recruitment parameters. The reference points were determined using EqSim and an MSE-like approach to evaluate the robustness of FMSY under different recruitment regimes. Sensitivity analyses confirmed that these reference points are robust to uncertainty in natural mortality, recruitment variability, and stock productivity shifts. The assessment confirmed that the recent decline in stock biomass is primarily driven by low recruitment rather than excessive fishing mortality.

4.7 Conclusions

Both reviewers consider the BestCase model proposed by WKBSS3 as suitable for providing management advice.

4.8 References

Alonso-Fernández A, Otero J, Villegas-Ríos D, Bañón R (2014) Drivers of body size changes in a *Pollachius pollachius* stock in NE Atlantic coastal waters. Mar Ecol Prog Ser 511:223-235. https://doi.org/10.3354/meps10939

Carvalho, Felipe, Henning Winker, Dean Courtney, Maia Kapur, Laurence Kell, Massimiliano Cardinale, Michael Schirripa et al. "A cookbook for using model diagnostics in integrated stock assessments." *Fisheries Research* 240 (2021): 105959.

ICES. 2012. Report of the Working Group on Assessment of New MoU Species (WGNEW), 5 - 9 March 2012. ICES CM 2012/ACOM:20. 258 pp. https://doi.org/10.17895/ices.pub.820

ICES. 2023. Benchmark workshop 2 on development of MSY advice using SPiCT (WKBMSYSPiCT2). ICES Scientific Reports. 5:65. 472 pp. https://doi.org/10.17895/ices.pub.23372990

ICES. 2024. Workshop on the calculation and evaluation of new reference points for category 1–2 stocks (WKNEWREF). ICES Scientific Reports. 6:100. 241 pp. https://doi.org/10.17895/ices.pub.27905664Stewart, Ian J., and Owen S. Hamel. "Bootstrapping of sample sizes for length-or age-composition data used in stock assessments." *Canadian journal of fisheries and aquatic sciences* 71, no. 4 (2014): 581-588.

Townhill, B. L., Couce, E., Tinker, J., Kay, S., & Pinnegar, J. K. (2023). Climate change projections of commercial fish distribution and suitable habitat around north western Europe. *Fish and Fisheries*, 24, 848–862. https://doi.org/10.1111/faf.12773

4.9 Stock-specific working documents (pol.27.67)

- 4.1 pol.27.67 Catch data.docx
- 4.2 pol.27.67 FISP.docx
- 4.3 pol.27.67 life history parameters.pdf
- 4.4a pol.27.67 Process Survey Data.pdf
- 4.4b pol.27.67 Index Selection.pdf
- 4.4c pol.27.67 Analyse Survey Data.pdf
- 4.5 pol.27.67 Recreational data.docx
- 4.6 pol.27.67 IE Commercial LPUE index.docx
- 4.7 pol.27.67 UK LPUE Candidates.xlsx
- 4.8 pol.27.67 French lpue.docx
- 4.9 pol.27.67 BaseCaseFinal.docx
- 4.10a pol.27.67 refPts_SS3_EqSim_full_recruitment.pdf
- 4.10b pol.27.67 refPts_SS3_EqSim_reduced_recruitment.pdf
- 4.10c pol.27.67 refpts_robustness_Fpa.pdf
- 4.10d pol.27.67 refpts_robustness_FtargetBrig.pdf

5 Blackspot seabream in Atlantic Iberian waters

Pagellus bogaraveo in Subarea 9 | sbr.27.9

5.1 Introduction

Blackspot seabream (*Pagellus bogaraveo*; Brünnich, 1768) is a benthopelagic sparid which is distributed across the Eastern Atlantic: from Norway to Cape Blanc in Mauritania, Madeira, the Canary Islands, and the Azores. It is also frequent in the western Mediterranean, including the Strait of Gibraltar, becoming rare eastern of the Strait of Sicily and absent in the Black Sea (Mytilineou et al., 2013; Spedicato et al., 2002; Whitehead et al., 1986). Nonetheless, the species was recently recorded in Syrian waters (Saad et al., 2020).

An exploratory stock assessment for blackspot seabream has been previously carried out with SPiCT using the landings estimates from ICES Subarea 9 *stricto sensu* (excluding the Strait of Gibraltar), between 1988 and 2022, and a standardized biomass index from the Portuguese polyvalent fleet with data from 2000 to 2022 (WKBMSYSPiCT3, ICES, 2024a). This assessment could not be discussed within the benchmark because the new index was available the last day of the meeting.

For WKBSS3, new data were presented during the Data Evaluation Workshop, and a base model incorporating all the available data was developed to be presented at the benchmark. WKBSS3 accepted a final SS3 model, and the process of its development is presented below.

This chapter is structured as follows: (2) Stock ID; (3) Decision from the Data Evaluation Workshop; (4) Current assessment; (5) Input data for stock assessment; (6) Stock assessment model; (7) Results; (8) Model diagnostics; (9) Alternative runs; (10) Reference points; (11) Forecast assumptions.

5.2 Stock ID

Blackspot seabream stock structure in ICES Subarea 9 is still unknown. ICES considers three different components for stock assessment and scientific advice on management purposes: a) Subareas 6, 7, and 8; b) Subarea 9, and c) Subarea 10 (Azores region).

The species is not evenly distributed along the area, being more frequently caught at specific grounds, suggesting a patchy distribution (Farias and Figueiredo, 2019).

Moreover, there is no evidence of movement between the Strait of Gibraltar exploited population and the populations in northern and central Subarea 9 (ICES, 2024b).

The existence of a genetic cluster in the Gulf of Cádiz has been proposed based on genotyping-by-sequencing (Figure 5.1), which, combined with ocean circulation patterns, bathymetry, and the existence of local upwelling, may provide an explanation for the genetic differentiation between the specimens caught in that area and the west coast of continental Portugal (Cunha et al., 2024). Ferrari et al. (2023) strengthened the hypothesis that egg and larval dispersal are fundamental in sustaining the genetic connectivity of the blackspot seabream to explain the absence of genetic population structuring in NE Atlantic and Mediterranean samples (between the Bay of Biscay and the Ionian Sea).

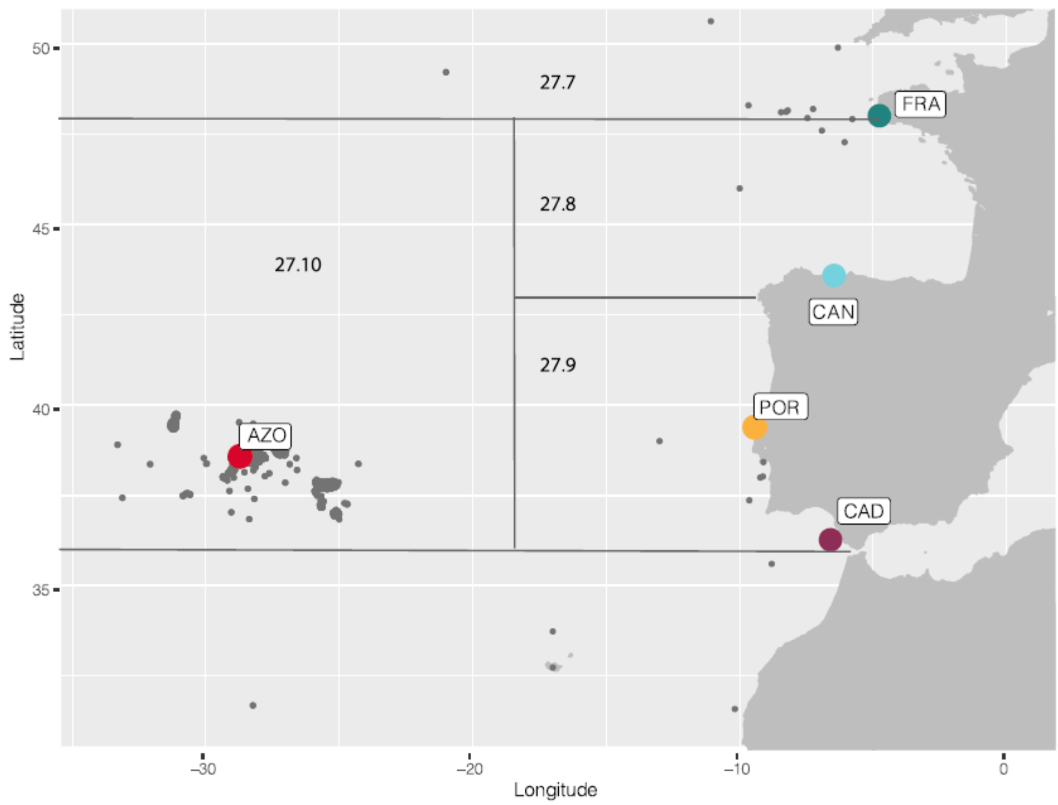

Figure 5.1. Sampling sites across the distributional range of *Pagellus bogaraveo* in the northeast Atlantic (yellow: POR - Portuguese continental waters; red: AZO - Azores; light blue: CAD – Strait of Gibraltar; green: CAN – Cantabrian Sea; purple: FRA - France). Small grey dots are geo-referenced occurrence records from GBIF.org (12 April 2022 GBIF Occurrence Download https://doi.org/10.15468/dl.mytawc). FAO fishing areas 27 are identified. (Source: Cunha et al., 2024).

5.3 Decisions from the Data Evaluation Workshop (DEW)

Decision 1: Borrow the GFCM model and populate it with the data from ICES Subarea 9 stock.

Rationale: Stock assessment for blackspot seabream in geographical subareas (GSA) 1-3 has been recently benchmarked by the Working Group on Stock Assessment of Demersal Species (WGSAD) of the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) using Stock Synthesis (GFCM, 2024. https://www.fao.org/gfcm/technical-meetings/detail/en/c/1696537/).

Decision 2*:* Use biological parameters estimated for the Strait of Gibraltar (GCFM model): maturity, fecundity, von Bertalanffy growth parameters.

Rationale: Maturity and age data are not available for the Portuguese and northern Spanish coasts. The blackspot sea bream is a sequential protandric hermaphrodite, starting as males and then changing into females at 30–35 cm length and around 4 to 6 years old (Alcázar et al., 1987; Gil, 2006; Krug, 1998). It grows relatively slow to a maximum size of 70 cm, 4 kg of total weight and about 15 years old (Gil, 2006; Krug, 1990; Sánchez, 1983). The maximum age ever reported from annual ageing is 20 years (Guéguen, 1969). For the GCFM model, a von Bertalanffy growth model was refitted to the data by fixing $L_\infty = 62$ and weighting the likelihood by the standard deviation of the La data (excluding age-0). $L_\infty = 62$ (Gil, 2010) is considered because it does not exceed the largest observed size class of 63 cm. The estimated initial parameter values were k = 0.152 and $t_0 = -1.09$.

***Decision 3**:* The model will be ensembled by year because the species has a slow growth (k = 0.152).

***Decision 4**:* Consider two sexes in the length distribution to account for sex change, although data are not disaggregated by sex.

***Decision 5**:* Include landings from two Spanish fleets (polyvalent and trawl) from the northern part of Subarea 9 and mirror the length distributions and catch-per-unit-effort (CPUE) from the Portuguese component.

5.4 Current assessment and advice

The latest advice for stock sbr.27.9 was presented in WGDEEP 2024, where MSY advice for category 3 stocks based on the stock trend from a biomass index, the mean length in the catch relative to an MSY proxy length and a biomass safeguard was attempted using the *rfb* catch advice (ICES, 2024b).

The main parameters used are resumed in Table 5.1. Last year catch Cy (2023) was applied instead of the latest advice. The index A was calculated using the two most recent years of abundance indices (2022–2023) and B was based on the former last three years (2019, 2020, 2021). Indices A and B were calculated to estimate the stock biomass trend (r, index ratio A/B). The fishing pressure proxy (f) was calculated using the length composition from the fishery for the period 2019–2023. Computations were performed using R software and the codes were available in the GitHub library of ICES.

Table 5.1. Blackspot seabream in ICES Subarea 27.9. Estimates used in the *rfb* rule, with details.

Variable	Definition	Estimate	Detail
r: Stock biomass trend	*r* = Index A / Index B	1.00	Biomass index derived from commercial LPUE from Portuguese polyvalent fleet: Index A (2022, 2023) = 324.83 kg trip^{-1} Index B (2019, 2020, 2021) = 34.89 kg trip^{-1}
f: Fishing proxy	$\frac{\bar{L}_{y-1}}{L_{F=M}}$	1.00	Length composition of Portuguese fishery raised to sbr.27.9 landings (without SoG) for the period 2014-2023. $\bar{L}_{y-1}$ =38.87 cm $L_{F=M}$ = 38.25 cm

Variable	Definition	Estimate	Detail
b: Biomass safeguard	$b = \min(1, I_{y-1} / I_{\text{trigger}})$ $I_{\text{trigger}} = I_{\text{loss}}\ \omega$, considering $\omega = 1.4$	1	Stock indicator; I_{loss}, = 24.18 (2001) $I_{trigger}$ = 33.85 $\frac{I_{y-1}}{I_{\text{trigger}}} = 1.2$
m: Tuning parameter	linked to von Bertalanffy k	0.95	k < 0.2 yr^{-1} for slow growing species such as deep-water stocks
C_{y-1}: Catch	Most recent catch (2023)	45 t	Since no previous catch advice (A_y) exists, the most recent catch (C_{y-1}), or the average of the last three years of catch should be used
A_y: Advice	$A_{y+1} = C_y \times r \times f \times b \times m$	43 t	

The application of the *rfb* method should take into consideration that the landings as well as fishing activity have been constrained by the quotas (ICES, 2024b).

5.5 Input data for stock assessment

5.5.1 Landings and discards

In ICES Subarea 9, *Pagellus bogaraveo* is caught by Spanish and Portuguese fleets. The available data from commercial landings, as estimated by the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), extend from 1988 to 2023 (ICES, 2024b) (Table 5.2 and Figure 5.2). After WKMSYSPiCT3 (ICES, 2024a), new estimates have been presented for Subarea 9, excluding Spanish landings from the fishery operating in the Strait of Gibraltar to get only data from the northern part of Subarea 9 (Galician coast).

Landings in Subarea 9 from the Portuguese polyvalent and trawl fleets are available for the period between 1989 and 2023. Landings from the Spanish polyvalent and trawl fleets operating in the northern part of Subarea 9 are available between 2000 and 2023. Landings by fleet between 2000 and 2008 were estimated assuming a proportion of 70% from the polyvalent fleet and 30% from the trawl fleet. Discards of blackspot seabream are considered negligible, hence catches correspond to landings in the whole ICES Subarea 9.

Table 5.2. Blackspot seabream landings in ICES Subarea 9, in tonnes. *Estimated values assuming a ratio of 70% of landings from polyvalent fleets and 30% trawl fleet.

	Portugal		**Spain**	
Year	Trawl	Polyvalent	Trawl	Polyvalent
1989	30	163	-	-
1990	33	97	-	-
1991	23	65	-	-
1992	28	68	-	-
1993	62	90	-	-
1994	27	89	-	-
1995	30	143	-	-
1996	44	121	-	-
1997	29	135	-	-
1998	33	135	-	-
1999	29	93	-	-
2000	23	41	9*	23*
2001	23	48	12*	28*
2002	16	65	24*	57*
2003	25	78	35*	81*
2004	25	106	17*	39*
2005	25	72	10*	24*
2006	28	78	27*	65*
2007	59	87	13*	31*
2008	39	82	8*	18*
2009	30	93	16	19
2010	25	79	8	24
2011	22	73	5	28
2012	46	96	2	20
2013	31	58	11	28
2014	18	39	1	27

	Portugal		Spain	
2015	22	42	0	15
2016	22	47	4	15
2017	21	47	0	10
2018	14	43	1	7
2019	8	27	0	2
2020	14	27	1	3
2021	6	22	0	4
2022	5	27	0	2
2023	4	33	0	3

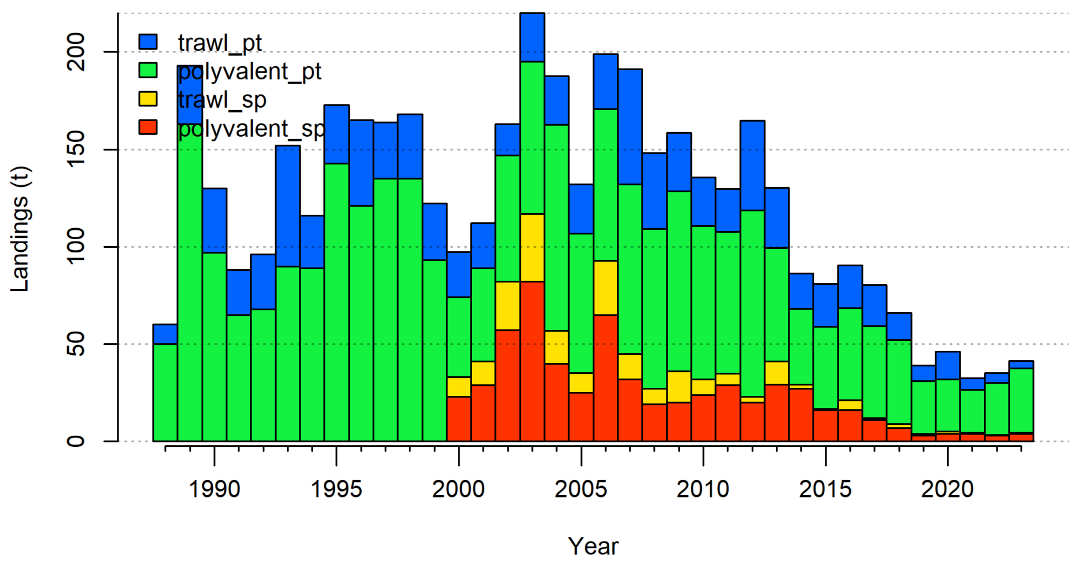

Figure 5.2. Blackspot seabream landings in ICES Subarea 9, in tonnes. trawl_pt and polyvalent_pt are Portuguese landings from trawl and polyvalent fleets, respectively; trawl_sp and polyvalent_sp are Spanish landings in Northern Subarea 9 from trawl and polyvalent fleets, respectively. Spanish landings from 2000 to 2008 are estimated values assuming a ratio of 70% of landings from polyvalent fleets and 30% trawl fleet.

The decrease in Portuguese landings partially reflects restrictive TAC constraints since 2016. Last TAC for ICES Subarea 9 was 42 tonnes in each of the years 2025 and 2026.

5.5.2 Length data

Length distribution from landing port sampling is available for the period between 2009 and 2023, disaggregated by the Portuguese polyvalent (Figure 5.3) and trawl (Figure 5.4) fleets on a yearly basis.

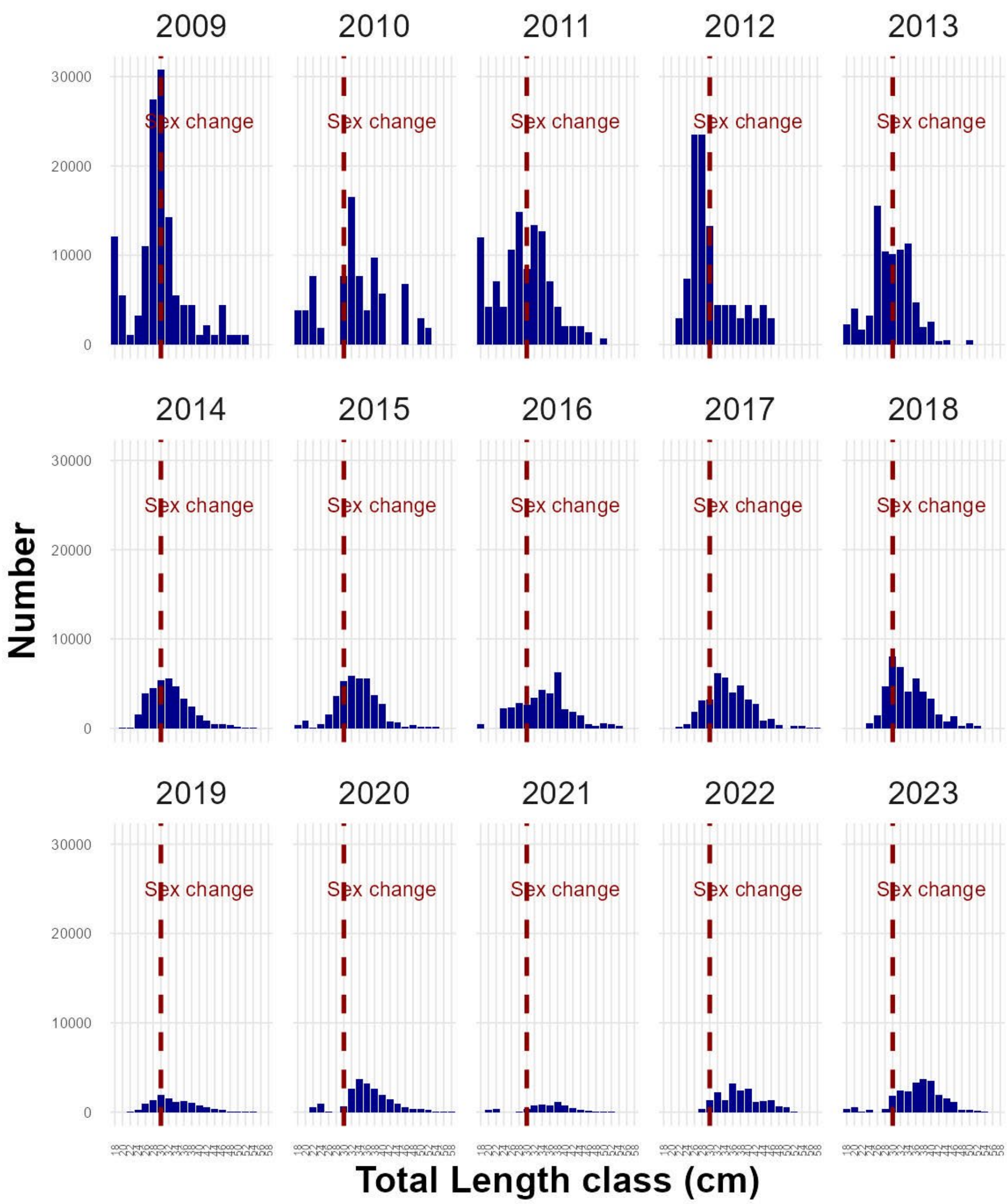

Figure 5.3. ***Pagellus bogaraveo*** **raised length frequency distributions for the Portuguese polyvalent fishing segment by year between 2009 and 2023 (2 cm total length classes). The red dashed line marks the sex change in class [30-32[cm.**

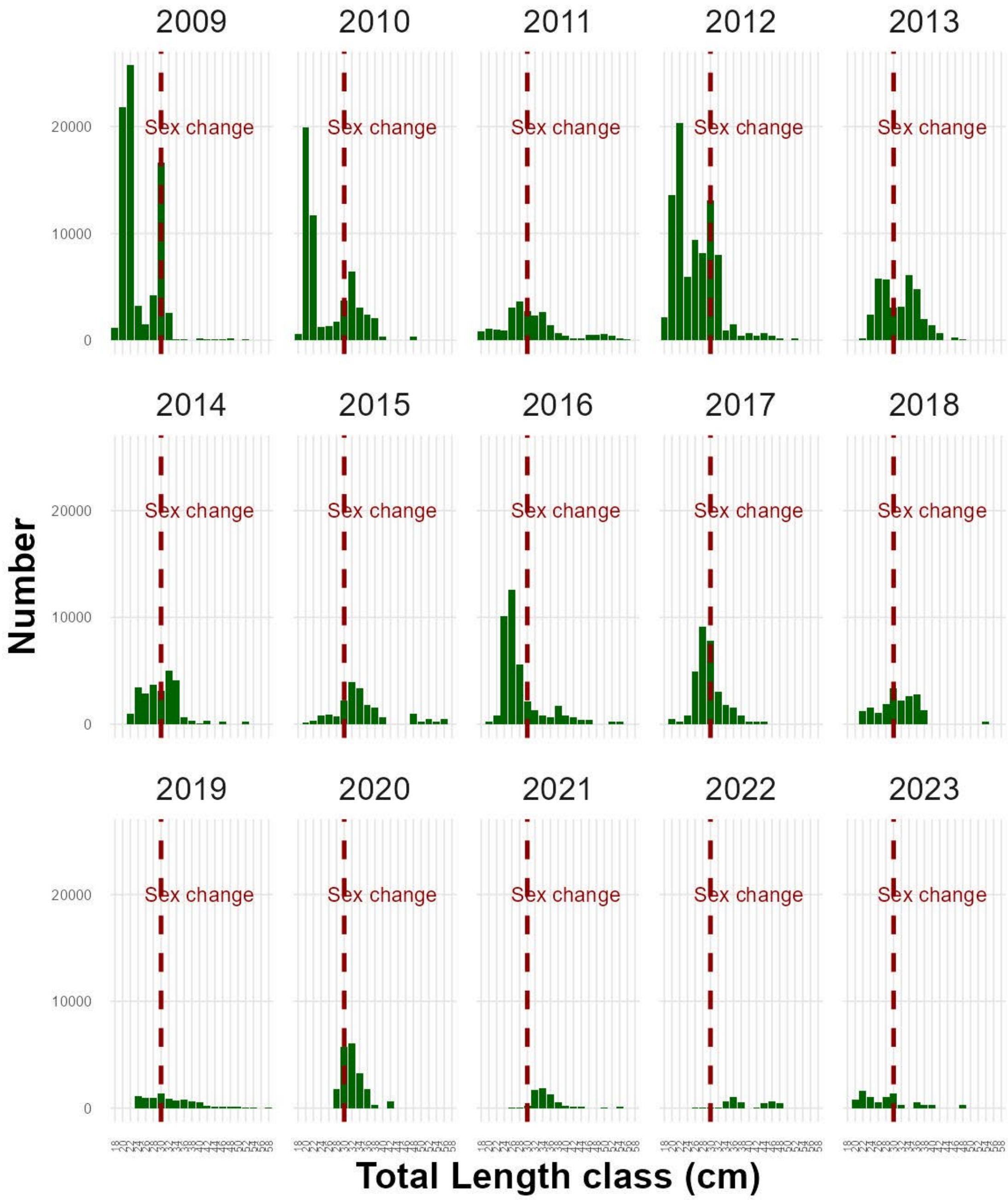

Figure 5.4. ***Pagellus bogaraveo*** **raised length frequency distributions for the Portuguese trawl fishing segment by year between 2009 and 2023 (2 cm total length classes). The red dashed line marks the sex change in class [30-32[cm.**

The initial input sample sizes (N_{input}) for length frequency distributions by year were calculated as a function of the number of trips and number of fish sampled via the Stewart Method (Stewart, pers. comm. to the benchmark):

$$N_{input} = N_{trips} + 0.138N_{fish} \quad \text{when} \quad \frac{N_{fish}}{N_{trips}} < 44$$

$$N_{input} = 7.06N_{trips} \quad \text{when} \quad \frac{N_{fish}}{N_{trips}} \geq 44$$

The method is based on the analysis of input and model derived effective sample sizes from west coast groundfish stock assessments. A piece-wise linear regression was used to estimate the increase in effective sample size per sample based on fish-per-sample and the maximum effective sample size for large numbers of individual fish.

5.5.3 CPUE standardisation

CPUE was calculated for the polyvalent fleet segment as landings in kg per trip in mainland Portugal in the period between 2000 and 2023. The nominal CPUE index was derived from yearly means of the raw CPUE data. CPUE index was standardised adapting the protocol developed by Winker (2022) for the blackspot seabream target fishery of the Strait of Gibraltar ('voracera') and Winker and Cardinale (2023). Generalized Additive Mixed Models (GAMMs) were used for CPUE standardization, following the guidelines from Winker et al. (2013) and Winker et al. (2014).

Daily landings in mainland Portugal between 2000 and 2023 were considered to prepare data for CPUE standardisation. Vessels assigned to the polyvalent fleet with positive landings of blackspot seabream were identified and all trips in that period were selected. The vessels that most frequently landed the species, which cumulatively represented 25% of all recorded trips, were selected. This resulted in the selection of 13 fishing vessels.

Next, the most commonly encountered species, which cumulatively represented 50% of all recorded species records in the selected vessels' landings, were identified: *Pagellus bogaraveo*, *Helicolenus dactylopptenus*, *Phycis phycis*, *Merluccius merluccius*, and *Conger conger* (Figure 5.5).

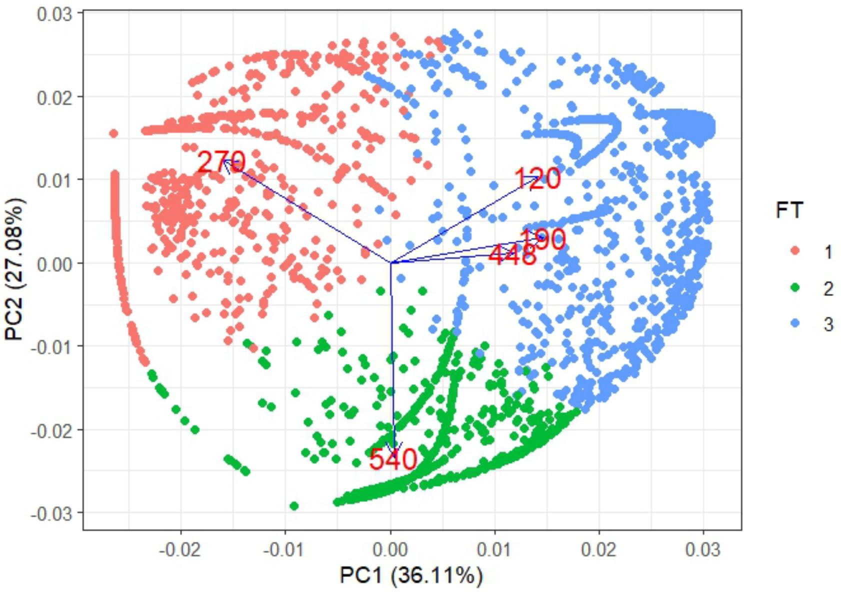

Figure 5.5. Clusters that characterise the different fishing tactics projected over the first two Principal Components (PCs). 540 = *Pagellus bogaraveo*; 448 = *Helicolenus dactylopterus*; 190 = *Phycis phycis*; 270 = *Merluccius merluccius*; 120 = *Conger conger*.

Trips with zero catches of blackspot seabream represented 46% of selected trips.

To account for variation in targeting, the guidelines propose two approaches: (1) deriving an additional factor for targeting from a cluster analysis of landings composition (He *et al.*, 1997) and (2) using the Direct Principle Component (DPC) approach, which involves the principle components (PC) of the decomposed catch composition as predictor variable (Winker et al., 2013; Winker et al., 2014).

The monthly variation of the standardised CPUE was analysed and a seasonal effect was put in evidence, with December and January standing out. This confirms that fishers are targeting the species in the months when the price is higher. For including December of one year in the same time block as the following January, the CPUE for both months was moved to match the later year.

The CPUE records were then fitted by assuming a Tweedie distribution. The fixed effects structure for each model scenario is defined as follows:

Base: $CPUE=exp(\beta 0+Year)$

DPC: $CPUE=exp(\beta 0+Year+s1(PC1))$

Cluster: $CPUE=exp(\beta 0+Year+FT)$

where $s1()$ is a thin plate smoothing function for the first and second principle component and FT is the vector of cluster numbers treated as categorical variable (Helser *et al.*, 2004) (Figure 5.6).

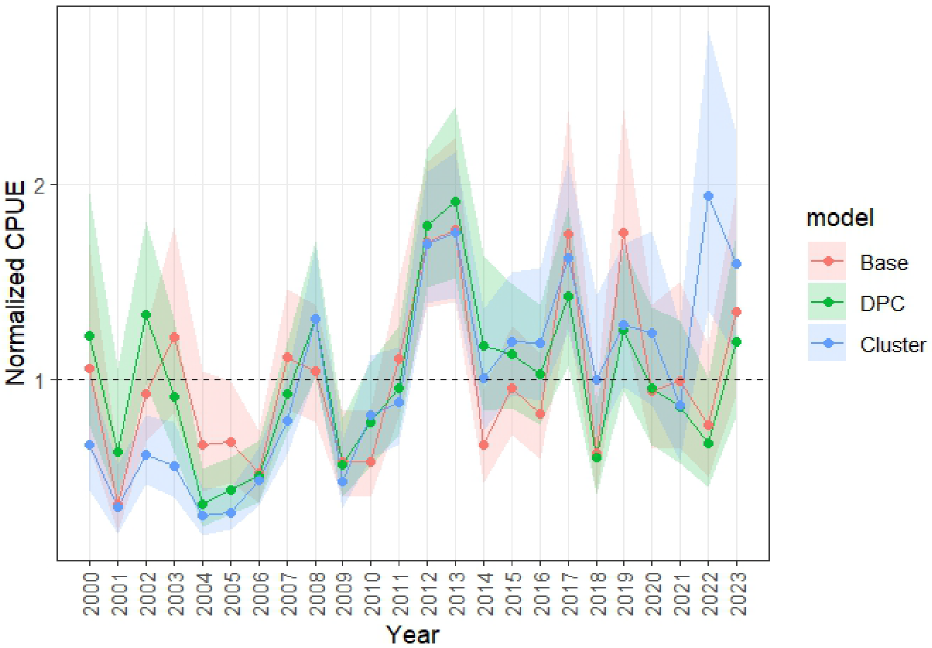

Figure 5.6. *Pagellus bogaraveo* standardized CPUE indices using the base, DPC, and cluster-GAMM models, with 95% CIs.

The nominal CPUE index was calculated for comparison with the final GAMM index based on the cluster analysis approach (Figure 5.7).

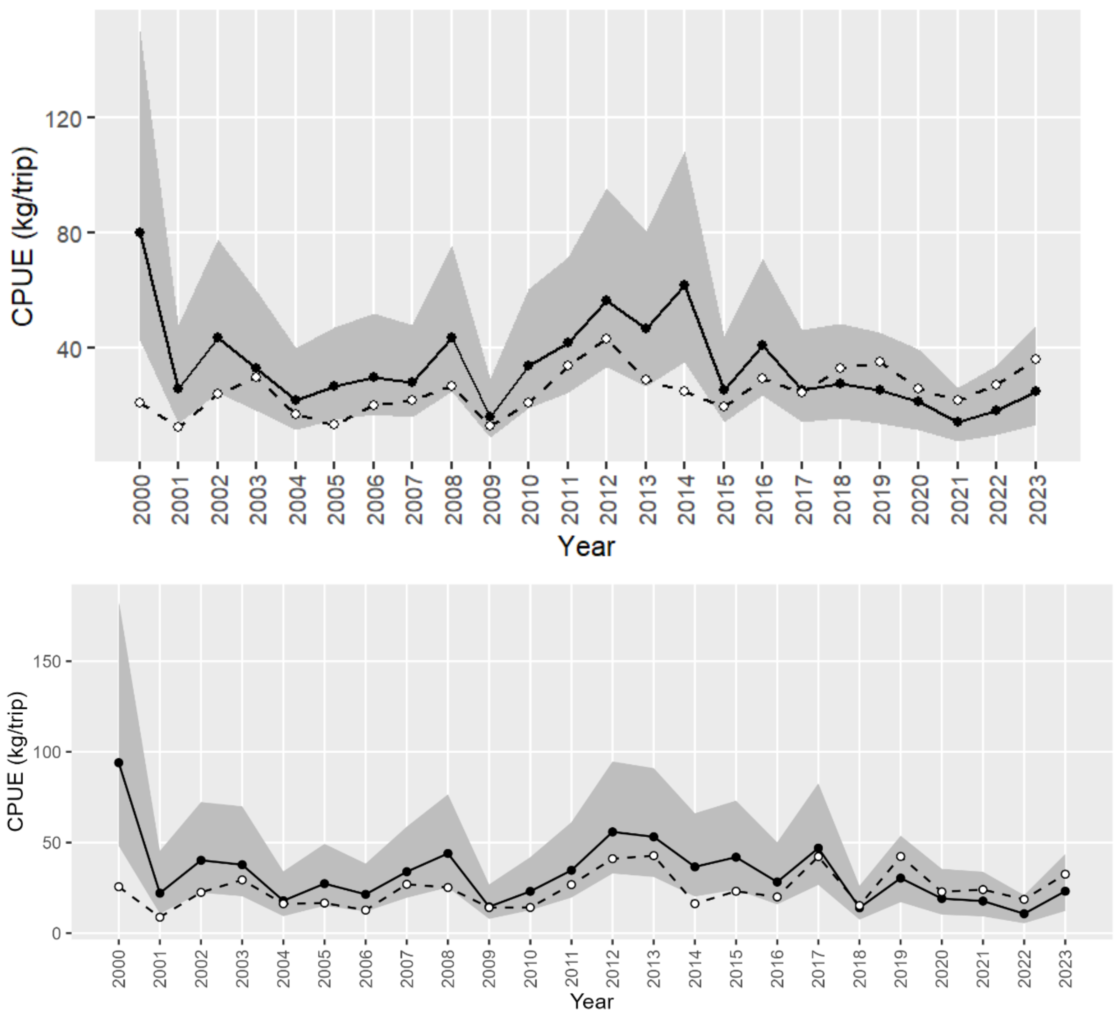

Figure 5.7. *Pagellus bogaraveo* nominal (dashed line) and standardised (continuous line) CPUE indices using the cluster-GAMM with 95% CIs: upper plot is the CPUE presented to WKBMSYSPiCT 3 with January and December allocated to the observation year; lower plot is the CPUE presented to WKBSS3 with December and following January combined in the same time block.

5.6 Stock assessment model

5.6.1 Base case input files

The model was developed primarily based on convergence, stability, and diagnostic analyses to ensure robust performance and reliable outcomes. The following section provides a detailed description of the model configurations, following the structure and specifications of the SS3 input files. Any settings not described below can be assumed to be the default as indicated in the SS3 manual.

Starter file

- SSversion: 3.30.22
- F_report_unts: 5 (unweighted average F for a range of ages)

- F_age_range: 2–8. The base case has logistic selectivity for all fleets with full selection from around age 2 onwards so the oldest age is not important; age 8 was chosen as it is not exceedingly rare.

Data file

- styr: 1999. Reasonably reliable landings data start in this year
- endyr: 2023
- spawn_month: 6. Following the same assumption as in the growth analysis which assumes 1 January as the birth date.
- Ngenders: 2. Sexual dimorphism is known to occur; length composition by sex is NOT available.
- Nages: 17 This seems sufficient because the model shows a continuous pattern with age and length.
- N_areas: 1.
- Nfleets: 5
    - o trawl_pt; Portugal trawlers commercial fleet; units: tonnes.
    - o polyvalent_pt; Portugal polyvalent commercial fleet; units: tonnes.
    - o trawl_sp; Spain trawlers commercial fleet; units: tonnes.
    - o polyvalent_sp; Spain polyvalent commercial fleet; units: tonnes.
    - o polyvalent_pt_cpue; survey; units: kg trip^{-1}.
- Length bins for the population and data
    - o 1 cm length bins from 1 to 65 cm
- Length composition data structure
    - o Length data are available for the 2 commercial fleets.
    - o Length composition of commercial fleets was available from 2009 onwards from landings of each Portuguese fleet and aggregated for both sexes.
- Age data: No age data are available
- Selectivity priors: None

Control file

- EmpiricalWAA: 0 (not available)
- N_GP: 1 (single growth pattern)
- N_platoon: 1 (single platoon)
- recr_dist_method: 4 – none, no parameters (growth pattern x settlement x area = 1).
- recr_dist_pattern: All recruitment assumed to occur in month 1 at age 0
- blocks_per_pattern: 0
- natM_type: 3 (Age-specific M).
- natM: According to GFCM model, a M=0.275 (mean from barefoot ecologist´s app) scaled to age 4 were used to get a Chen Watanabe M at age vector. There was no basis to assume different M for the two sexes because it is a hermaphrodite species (males became in females)
- GrowthModel: 1 (VonB)
- Growth_Age_for_L1: 1
- Growth_Age_for_L2: 999 (L2=L inf)
- maturity_option: 1 (length logistic)
- First_Mature_Age: 5 (ages below the first mature age will have maturity set to zero.)
- fecundity_option: 1 (linear eggs/kg on body weight)
- MG_params: The parameters that are estimated for the initial value are listed below:

  - o L_at_Amin_Fem_GP_1 0
  - o L_at_Amax_Fem_GP_1 56.6
  - o VonBert_K_Fem_GP_1 0.151
  - o CV_young_Fem_GP_1 0.1
  - o CV_old_Fem_GP_1 0.07
  - o Wtlen_1_Fem_GP_1 8.7e-05
  - o Wtlen_2_Fem_GP_1 3.14
  - o Mat50%_Fem_GP_1 30.24
  - o Mat_slope_Fem_GP_1 -0.54
  - o Eggs/kg_inter_Fem_GP_1 1
  - o Eggs/kg_slope_Fem_GP_1 0
  - o L_at_Amin_Mal_GP_1 0
  - o L_at_Amax_Mal_GP_1 0
  - o VonBert_K_Mal_GP_1 0
  - o CV_young_Mal_GP_1 0
  - o CV_old_Mal_GP_1 0
  - o Wtlen_1_Mal_GP_1 8.7e-05
  - o Wtlen_2_Mal_GP_1 3.14
  - o CohortGrowDev 1
  - o FracFemale_GP_1 1e-06

- SR_function: 3 (Beverton-holt)
- SR_params: all fixed except R0

  - o SR_LN(R0) 7.74473
  - o SR_BH_steep 0.6
  - o SR_sigmaR 0.9
  - o SR_regime 0
  - o SR_autocorr 0

- do_recdev: 2 (deviations)
- MainRdevYrFirst: 2009 (first length data year)
- MainRdevYrLast: 2022
- Recdev_phase: 2
- To read 13 advanced options: 1
- recdev_early_start (0=none; negative value makes relative to recdev_start): -10
- recdev_early_phase: 3
- forecast_recruitment phase (incl. late recruitment) (0 value resets to maxphase+1): 0
- lambda for Fcast_recr_like occurring before endyr+1: 1
- last_early_yr_nobias_adj: 1997
- first_yr_fullbias_adj: 2006
- last_yr_fullbias_adj: 2020
- first_recent_yr_nobias_adj: 2022
- F_Method: 4 Fleet-specific parameter/hybrid F
- F_4_Fleet_Params:

  - o trawl_pt: start F 0.08; phase 1
  - o polyvalent_pt: start F 0.08; phase 1
  - o trawl_sp: start F 0.08; phase 1
  - o polyvalent_sp: start F 0.08; phase 1

- Init_F: there was some fishing before 1989; however, the model estimated initial F to be very low, and therefore it was assumed that the catches were equal to 0 previous to 1989.
- Q_options:

o polyvalent_pt_cpue: link 1 (simple Q); extra se 1; no bias adj; float

- Q_options:

  o LnQ_base_polyvalent_pt_cpue(5): -0.66645
  o Q_extraSD_polyvalent_pt_cpue(5): 0 (initial values, estimated phase -2)
  o no timevary Q parameters

- size_selex_params_tv:

  o time varying retention size at inflexion for #polyvalent_pt
  o time block in the value 0 (initial value, estimated in phase 4)

- Use_2D_AR1_selectivity: 0
- TG_custom: 0
- maxlambdaphase: 4
- sd_offset: 1
- N_lambdas: 0

5.6.2 Biology: sources and explanation for the parameterisation

5.6.2.1 Growth

A von Bertalanffy's growth function was assumed for both sexes combined because there were no differences in growth (hermaphroditism). The growth model was refitted to the data by Gil and Sobrino (2001), fixing L_{inf} = 62 cm (Gil, 2010) and weighting the likelihood by the standard deviation of the length at age data (excluding age-0).

The estimated initial parameter values were k = 0.152 and t_0 = −1.09.

5.6.2.2 Length-weight

Allometric length-weight relationships were borrowed from the GFCM assessment model for SBR GSA 1-3 (Strait of Gibraltar), assuming the same value for females and males: a = 0.0087 and b = 3.14 (GFCM, 2024).

5.6.2.3 Maturity

Female maturity followed a logistic ogive with the length at first maturity (L_{50}) attained at 34.6 cm and a slope of -0.545266 1/cm (Figure 5.8). L_{50} corresponded to a female at around age 4.

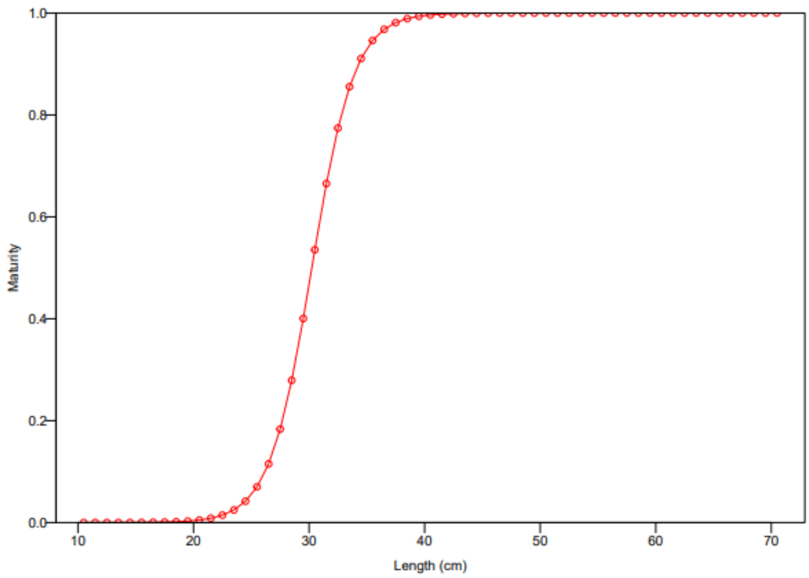

Figure 5.8. Pagellus bogaraveo assumed Maturity ogive for females (GFCM, 2024)

As it was already noted, blackspot seabream is a hermaphrodite species (changing from male to female) and to implement hermaphrodite population dynamics in Stock Synthesis the model needs to be informed by sex-structured LFDs to estimate the probability of males changing to females at each length/age class. The transition function was borrowed from the GFCM assessment model for SBR GSA 1-3 (Strait of Gibraltar), using empirical data to estimate it (Figure 5.9).

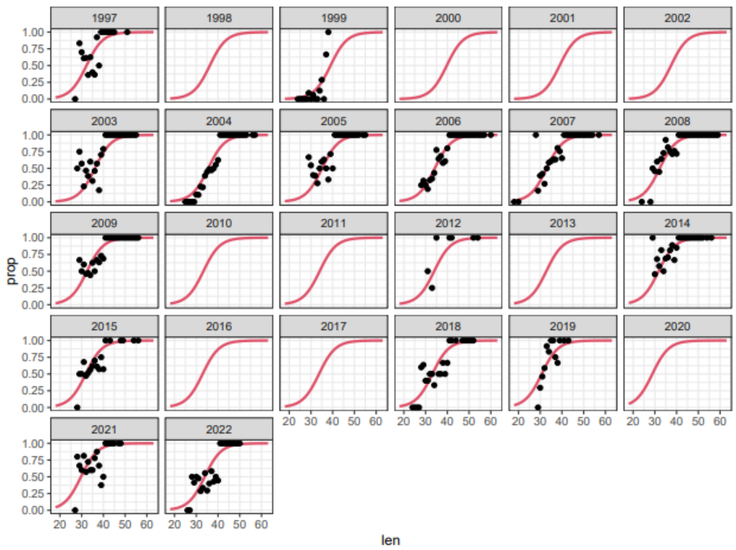

Figure 5.9. Pagellus bogaraveo observed and expected proportion of females at length (GFCM, 2024)

The presentation of this sex transition within SS3 is complex because the asymptote for sex transition to females ends at 0.58, instead of at 1.00 as expected: males that have not yet transitioned at a certain age have a probability of becoming females. The transition function in SS3, as well as the presentation figure, is a bit unconventional and possibly misleading but mathematically correct in the way it operates within the model because it is cumulative.

5.6.2.4 Natural mortality

The natural mortality curve was estimated following an age-specific method, assuming that the natural mortality does not change after the fish changes sex. Thus, the same natural mortality was assumed for males and females. According to the GFCM model, M=0.275 (mean from barefoot ecologist´s app) scaled to age 4 was used to get a Chen Watanabe M at age vector. There was no basis to assume a different M for each sex because it is a hermaphrodite species (males became females).

5.6.2.5 Recruitment

Spawning occurs between January and April. Beverton and Holt relationship was assumed for recruitment with a steepness of 0.6 and sigmaR = 0.9.

5.6.3 Selectivity: sources and explanations for the parameterisation

The selectivity pattern adopted for Portuguese polyvalent and trawl fleets was logistic. The Spanish polyvalent and trawl fleets were mirrored from the Portuguese fleets (Figure 5.11). Two and four parameters of the selectivity ogives (length) were estimated by the model, respectively. A time-varying selectivity was adopted only for the polyvalent fleet between 2009 and 2018.

5.6.4 Fishing mortality: sources and explanations for the parameterisation

The model assumes the fishery started in 1989 because the catches were very low before that. Fishing mortality is estimated with F method 4 (a hybrid between methods 2 and 3) because it is the most appropriate method when F is high.

5.7 Results

Table 5.3 shows the parameter values estimated by the model. The estimated parameters do not show any convergence issue.

Table 5.3. Values estimated by the model.

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type
SR_LN(R0)	8.40322	1	1.00E-04	20	7.74473	OK	0.061427	-0.00016383	No_prior
InitF_seas_1 polyvalent_pt	0.0591	1	1.00E-05	1.5	0.089232	OK	0.00518	3.98E-05	No_prior
F_fleet_1_YR_1989_s_1	0.028534	1	0.00E+00	5	0.08	act	0.001589	-2.20E-07	F
F_fleet_1_YR_1990_s_1	0.033669	1	0.00E+00	5	0.08	act	0.001907	3.05E-07	F
F_fleet_1_YR_1991_s_1	0.024237	1	0.00E+00	5	0.08	act	0.001388	4.35E-07	F
F_fleet_1_YR_1992_s_1	0.029995	1	0.00E+00	5	0.08	act	0.001736	-8.25E-08	F
F_fleet_1_YR_1993_s_1	0.069193	1	0.00E+00	5	0.08	act	0.004104	1.02E-07	F
F_fleet_1_YR_1994_s_1	0.031852	1	0.00E+00	5	0.08	act	0.001921	4.70E-08	F
F_fleet_1_YR_1995_s_1	0.037634	1	0.00E+00	5	0.08	act	0.00238	-1.79E-07	F
F_fleet_1_YR_1996_s_1	0.059907	1	0.00E+00	5	0.08	act	0.004142	2.14E-07	F
F_fleet_1_YR_1997_s_1	0.042717	1	0.00E+00	5	0.08	act	0.003271	-7.47E-07	F
F_fleet_1_YR_1998_s_1	0.052571	1	0.00E+00	5	0.08	act	0.004581	-3.91E-07	F
F_fleet_1_YR_1999_s_1	0.048685	1	0.00E+00	5	0.08	act	0.004741	-2.03E-06	F
F_fleet_1_YR_2000_s_1	0.038865	1	0.00E+00	5	0.08	act	0.003998	1.52E-06	F

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type
F_fleet_1_YR_2001_s_1	0.0383	1	0.00E+00	5	0.08	act	0.004551	-1.20E-06	F
F_fleet_1_YR_2002_s_1	0.027589	1	0.00E+00	5	0.08	act	0.004212	-1.08E-06	F
F_fleet_1_YR_2003_s_1	0.046819	1	0.00E+00	5	0.08	act	0.007001	3.20E-08	F
F_fleet_1_YR_2004_s_1	0.054448	1	0.00E+00	5	0.08	act	0.008189	2.86E-07	F
F_fleet_1_YR_2005_s_1	0.064011	1	0.00E+00	5	0.08	act	0.010396	-3.53E-07	F
F_fleet_1_YR_2006_s_1	0.059623	1	0.00E+00	5	0.08	act	0.005735	1.57E-06	F
F_fleet_1_YR_2007_s_1	0.13612	1	0.00E+00	5	0.08	act	0.012083	9.50E-07	F
F_fleet_1_YR_2008_s_1	0.089263	1	0.00E+00	5	0.08	act	0.008043	-1.81E-08	F
F_fleet_1_YR_2009_s_1	0.065717	1	0.00E+00	5	0.08	act	0.006082	4.37E-07	F
F_fleet_1_YR_2010_s_1	0.054244	1	0.00E+00	5	0.08	act	0.005302	2.03E-06	F
F_fleet_1_YR_2011_s_1	0.043508	1	0.00E+00	5	0.08	act	0.004371	4.41E-06	F
F_fleet_1_YR_2012_s_1	0.093442	1	0.00E+00	5	0.08	act	0.010004	-6.78E-07	F
F_fleet_1_YR_2013_s_1	0.073693	1	0.00E+00	5	0.08	act	0.009002	1.67E-07	F
F_fleet_1_YR_2014_s_1	0.045179	1	0.00E+00	5	0.08	act	0.005982	-2.59E-06	F

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type
F_fleet_1_YR_2015_s_1	0.057722	1	0.00E+00	5	0.08	act	0.007991	-1.48E-06	F
F_fleet_1_YR_2016_s_1	0.061355	1	0.00E+00	5	0.08	act	0.009082	1.89E-06	F
F_fleet_1_YR_2017_s_1	0.062858	1	0.00E+00	5	0.08	act	0.009908	-7.36E-08	F
F_fleet_1_YR_2018_s_1	0.047775	1	0.00E+00	5	0.08	act	0.008088	-3.59E-07	F
F_fleet_1_YR_2019_s_1	0.031385	1	0.00E+00	5	0.08	act	0.005582	3.61E-06	F
F_fleet_1_YR_2020_s_1	0.065113	1	0.00E+00	5	0.08	act	0.012214	2.22E-08	F
F_fleet_1_YR_2021_s_1	0.034831	1	0.00E+00	5	0.08	act	0.007083	2.76E-07	F
F_fleet_1_YR_2022_s_1	0.034709	1	0.00E+00	5	0.08	act	0.00776	-3.23E-06	F
F_fleet_1_YR_2023_s_1	0.02981	1	0.00E+00	5	0.08	act	0.008088	2.88E-06	F
F_fleet_2_YR_1989_s_1	0.201705	1	0.00E+00	5	0.08	act	0.021678	3.85E-07	F
F_fleet_2_YR_1990_s_1	0.130771	1	0.00E+00	5	0.08	act	0.014876	-9.37E-08	F
F_fleet_2_YR_1991_s_1	0.090697	1	0.00E+00	5	0.08	act	0.010477	2.05E-07	F
F_fleet_2_YR_1992_s_1	0.096012	1	0.00E+00	5	0.08	act	0.011104	-4.57E-07	F
F_fleet_2_YR_1993_s_1	0.132406	1	0.00E+00	5	0.08	act	0.015661	2.63E-08	F

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type
F_fleet_2_YR_1994_s_1	0.139125	1	0.00E+00	5	0.08	act	0.016995	8.45E-08	F
F_fleet_2_YR_1995_s_1	0.239516	1	0.00E+00	5	0.08	act	0.030537	2.24E-07	F
F_fleet_2_YR_1996_s_1	0.223063	1	0.00E+00	5	0.08	act	0.030412	-3.19E-09	F
F_fleet_2_YR_1997_s_1	0.271577	1	0.00E+00	5	0.08	act	0.039561	1.59E-07	F
F_fleet_2_YR_1998_s_1	0.296513	1	0.00E+00	5	0.08	act	0.046578	1.09E-06	F
F_fleet_2_YR_1999_s_1	0.216208	1	0.00E+00	5	0.08	act	0.035869	-8.80E-07	F
F_fleet_2_YR_2000_s_1	0.095153	1	0.00E+00	5	0.08	act	0.015882	-3.82E-06	F
F_fleet_2_YR_2001_s_1	0.109424	1	0.00E+00	5	0.08	act	0.017638	6.15E-07	F
F_fleet_2_YR_2002_s_1	0.1529	1	0.00E+00	5	0.08	act	0.026285	3.45E-06	F
F_fleet_2_YR_2003_s_1	0.207071	1	0.00E+00	5	0.08	act	0.046549	1.48E-06	F
F_fleet_2_YR_2004_s_1	0.325562	1	0.00E+00	5	0.08	act	0.074742	1.53E-06	F
F_fleet_2_YR_2005_s_1	0.24568	1	0.00E+00	5	0.08	act	0.055389	-1.43E-06	F
F_fleet_2_YR_2006_s_1	0.299979	1	0.00E+00	5	0.08	act	0.058761	-2.35E-07	F
F_fleet_2_YR_2007_s_1	0.312435	1	0.00E+00	5	0.08	act	0.038573	5.26E-07	F

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type
F_fleet_2_YR_2008_s_1	0.269181	1	0.00E+00	5	0.08	act	0.029167	1.57E-07	F
F_fleet_2_YR_2009_s_1	0.31134	1	0.00E+00	5	0.08	act	0.038366	2.09E-07	F
F_fleet_2_YR_2010_s_1	0.262819	1	0.00E+00	5	0.08	act	0.03734	-5.59E-07	F
F_fleet_2_YR_2011_s_1	0.212491	1	0.00E+00	5	0.08	act	0.028536	8.19E-07	F
F_fleet_2_YR_2012_s_1	0.267152	1	0.00E+00	5	0.08	act	0.037162	1.72E-06	F
F_fleet_2_YR_2013_s_1	0.162631	1	0.00E+00	5	0.08	act	0.024009	3.53E-07	F
F_fleet_2_YR_2014_s_1	0.114862	1	0.00E+00	5	0.08	act	0.019165	1.08E-06	F
F_fleet_2_YR_2015_s_1	0.130911	1	0.00E+00	5	0.08	act	0.023248	-1.19E-06	F
F_fleet_2_YR_2016_s_1	0.153918	1	0.00E+00	5	0.08	act	0.03093	-4.71E-07	F
F_fleet_2_YR_2017_s_1	0.160385	1	0.00E+00	5	0.08	act	0.035109	-7.63E-07	F
F_fleet_2_YR_2018_s_1	0.152898	1	0.00E+00	5	0.08	act	0.032382	-1.12E-06	F
F_fleet_2_YR_2019_s_1	0.100676	1	0.00E+00	5	0.08	act	0.021409	-2.51E-06	F
F_fleet_2_YR_2020_s_1	0.110497	1	0.00E+00	5	0.08	act	0.023565	-2.38E-06	F
F_fleet_2_YR_2021_s_1	0.105678	1	0.00E+00	5	0.08	act	0.023474	-1.17E-06	F

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type
F_fleet_2_YR_2022_s_1	0.157619	1	0.00E+00	5	0.08	act	0.037438	-1.30E-06	F
F_fleet_2_YR_2023_s_1	0.248027	1	0.00E+00	5	0.08	act	0.067269	3.36E-07	F
F_fleet_3_YR_2000_s_1	0.016901	1	0.00E+00	5	0.08	act	0.001736	3.00E-06	F
F_fleet_3_YR_2001_s_1	0.019989	1	0.00E+00	5	0.08	act	0.002375	-1.95E-06	F
F_fleet_3_YR_2002_s_1	0.043099	1	0.00E+00	5	0.08	act	0.006577	-3.92E-07	F
F_fleet_3_YR_2003_s_1	0.065531	1	0.00E+00	5	0.08	act	0.009791	-2.59E-06	F
F_fleet_3_YR_2004_s_1	0.037037	1	0.00E+00	5	0.08	act	0.005576	5.11E-06	F
F_fleet_3_YR_2005_s_1	0.025617	1	0.00E+00	5	0.08	act	0.004167	-4.84E-06	F
F_fleet_3_YR_2006_s_1	0.059623	1	0.00E+00	5	0.08	act	0.005735	-5.44E-07	F
F_fleet_3_YR_2007_s_1	0.029997	1	0.00E+00	5	0.08	act	0.002704	-1.81E-06	F
F_fleet_3_YR_2008_s_1	0.0183	1	0.00E+00	5	0.08	act	0.001667	-5.32E-06	F
F_fleet_3_YR_2009_s_1	0.03506	1	0.00E+00	5	0.08	act	0.003263	-5.60E-07	F
F_fleet_3_YR_2010_s_1	0.017366	1	0.00E+00	5	0.08	act	0.001708	4.63E-06	F
F_fleet_3_YR_2011_s_1	0.011876	1	0.00E+00	5	0.08	act	0.0012	2.15E-06	F

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type
F_fleet_3_YR_2012_s_1	0.006105	1	0.00E+00	5	0.08	act	0.000662	5.35E-06	F
F_fleet_3_YR_2013_s_1	0.028533	1	0.00E+00	5	0.08	act	0.003502	-1.73E-06	F
F_fleet_3_YR_2014_s_1	0.005023	1	0.00E+00	5	0.08	act	0.000668	2.69E-06	F
F_fleet_3_YR_2015_s_1	0.001839	1	0.00E+00	5	0.08	act	0.000256	-1.66E-05	F
F_fleet_3_YR_2016_s_1	0.01397	1	0.00E+00	5	0.08	act	0.002077	-7.32E-06	F
F_fleet_3_YR_2017_s_1	0.002998	1	0.00E+00	5	0.08	act	0.000475	6.58E-06	F
F_fleet_3_YR_2018_s_1	0.006835	1	0.00E+00	5	0.08	act	0.001161	-5.00E-06	F
F_fleet_3_YR_2019_s_1	0.003926	1	0.00E+00	5	0.08	act	0.000699	2.74E-06	F
F_fleet_3_YR_2020_s_1	0.004657	1	0.00E+00	5	0.08	act	0.000876	1.20E-05	F
F_fleet_3_YR_2021_s_1	0.002323	1	0.00E+00	5	0.08	act	0.000473	5.99E-06	F
F_fleet_3_YR_2022_s_1	0.002084	1	0.00E+00	5	0.08	act	0.000466	3.30E-06	F
F_fleet_3_YR_2023_s_1	0.002981	1	0.00E+00	5	0.08	act	0.000809	1.53E-05	F
F_fleet_4_YR_2000_s_1	0.053389	1	0.00E+00	5	0.08	act	0.008906	2.33E-06	F
F_fleet_4_YR_2001_s_1	0.066147	1	0.00E+00	5	0.08	act	0.010657	9.88E-07	F

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type
F_fleet_4_YR_2002_s_1	0.13411	1	0.00E+00	5	0.08	act	0.023056	-1.55E-06	F
F_fleet_4_YR_2003_s_1	0.21767	1	0.00E+00	5	0.08	act	0.048928	7.40E-07	F
F_fleet_4_YR_2004_s_1	0.12322	1	0.00E+00	5	0.08	act	0.028363	-5.75E-07	F
F_fleet_4_YR_2005_s_1	0.085462	1	0.00E+00	5	0.08	act	0.019305	-2.48E-06	F
F_fleet_4_YR_2006_s_1	0.250119	1	0.00E+00	5	0.08	act	0.049025	4.51E-07	F
F_fleet_4_YR_2007_s_1	0.114922	1	0.00E+00	5	0.08	act	0.014313	5.87E-07	F
F_fleet_4_YR_2008_s_1	0.062228	1	0.00E+00	5	0.08	act	0.006857	1.21E-06	F
F_fleet_4_YR_2009_s_1	0.067112	1	0.00E+00	5	0.08	act	0.008432	1.64E-06	F
F_fleet_4_YR_2010_s_1	0.080004	1	0.00E+00	5	0.08	act	0.011503	3.62E-06	F
F_fleet_4_YR_2011_s_1	0.084432	1	0.00E+00	5	0.08	act	0.011427	-7.30E-07	F
F_fleet_4_YR_2012_s_1	0.055652	1	0.00E+00	5	0.08	act	0.007827	-2.78E-07	F
F_fleet_4_YR_2013_s_1	0.081239	1	0.00E+00	5	0.08	act	0.012032	-7.36E-07	F
F_fleet_4_YR_2014_s_1	0.079476	1	0.00E+00	5	0.08	act	0.013273	1.84E-07	F
F_fleet_4_YR_2015_s_1	0.049725	1	0.00E+00	5	0.08	act	0.008831	7.56E-07	F

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type
F_fleet_4_YR_2016_s_1	0.052261	1	0.00E+00	5	0.08	act	0.010498	-1.31E-06	F
F_fleet_4_YR_2017_s_1	0.037422	1	0.00E+00	5	0.08	act	0.008181	4.83E-07	F
F_fleet_4_YR_2018_s_1	0.024878	1	0.00E+00	5	0.08	act	0.005272	-3.39E-06	F
F_fleet_4_YR_2019_s_1	0.011198	1	0.00E+00	5	0.08	act	0.002386	-5.32E-06	F
F_fleet_4_YR_2020_s_1	0.016406	1	0.00E+00	5	0.08	act	0.00351	2.68E-06	F
F_fleet_4_YR_2021_s_1	0.01926	1	0.00E+00	5	0.08	act	0.004289	-2.43E-06	F
F_fleet_4_YR_2022_s_1	0.017586	1	0.00E+00	5	0.08	act	0.004192	-1.37E-07	F
F_fleet_4_YR_2023_s_1	0.030112	1	0.00E+00	5	0.08	act	0.008157	3.01E-07	F
Size_DblN_peak_trawl_pt(1)	15.4998	4	5.00E+00	60	5.00272	OK	0.000913	-0.00055959	No_prior
Size_DblN_top_logit_trawl_pt(1)	-1.05812	4	-1.50E+01	3	-11.54	OK	0.14054	-7.48E-05	No_prior
Size_DblN_ascend_se_trawl_pt(1)	-19.4837	4	-2.00E+01	8	-6	OK	16.2787	-5.65E-09	No_prior
Size_DblN_descend_se_trawl_pt(1)	5.3384	4	-4.00E+00	8	5.47025	OK	0.208569	-3.42E-05	No_prior
Size_DblN_peak_polyvalent_pt(2)	30.8447	4	5.00E+00	60	16.5527	OK	1.42195	4.53E-07	No_prior
Size_DblN_ascend_se_polyvalent_pt(2)	4.3435	4	0.00E+00	8	0.604673	OK	0.138869	6.65E-06	No_prior

Parameter	Value	Phase	Min	Max	Init	Status	Parm_StDev	Gradient	Pr_type
Size_DblN_descend_se_polyvalent_pt(2)	4.79746	4	-2.00E+01	20	4.83643	OK	0.146385	4.80E-05	No_prior

5.7.1 Growth

The growth pattern of males and females were combined (Figure 5.10).

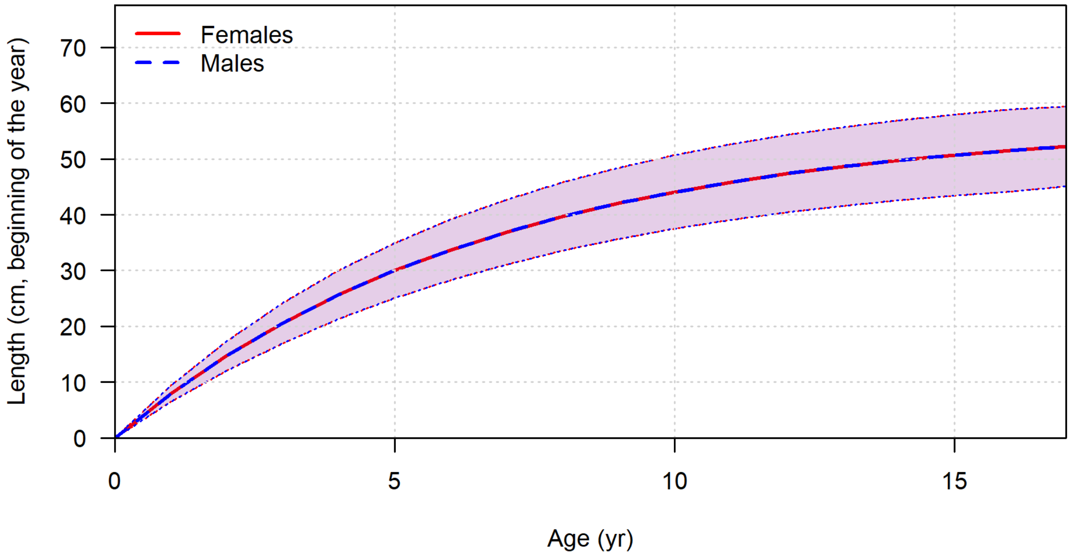

Figure 5.10. Length-at-age for males and females.

5.7.2 Selectivity and length composition fit

The model results are consistent with the size distribution of each fleet, where the polyvalent fleet usually catches larger fish. Polyvalent and trawl selectivity assumed a logistic pattern for both Portuguese and Spanish fleets (Figure 5.11).

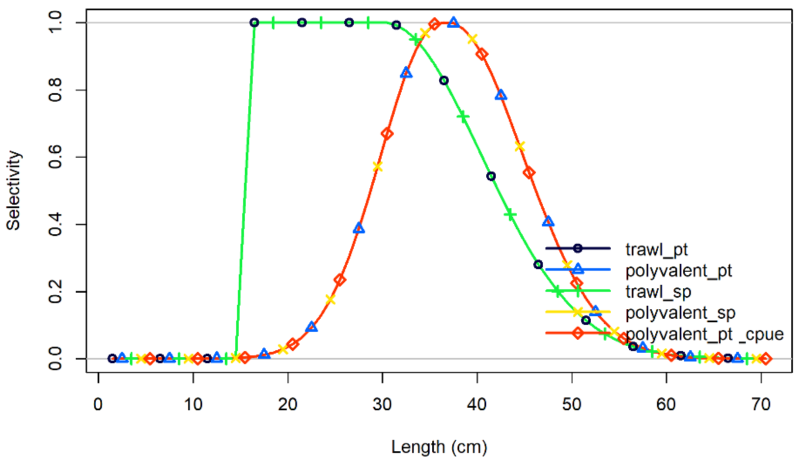

Figure 5.11. Estimated selectivity for each fleet: *pt* refers to Portugal and *sp* to Spain.

5.7.3 Indices

The model fits well the indices in most of the years (Figure 5.12).

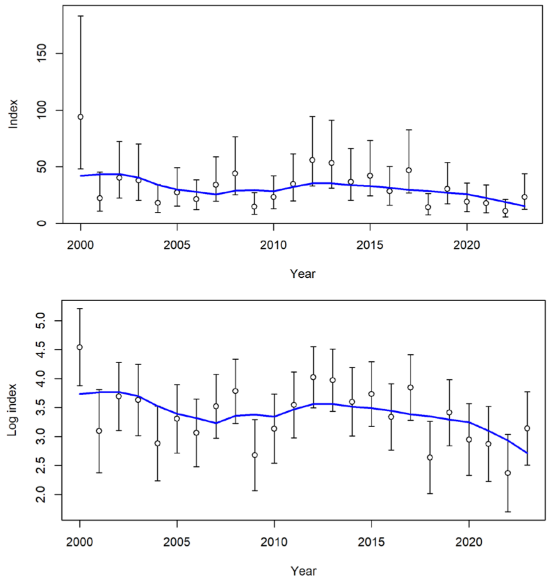

Figure 5.12. Biomass indices (CPUE) and model fits for the Portuguese polyvalent fleet segment (above is the absolute index and below is the logarithm).

5.7.4 Stock recruitment

Figures 5.13 and 5.14 show the estimated Beverton and Holt stock-recruitment relationship. The recruitment deviation estimates are corrected with the suggested parameterisation by SS3.

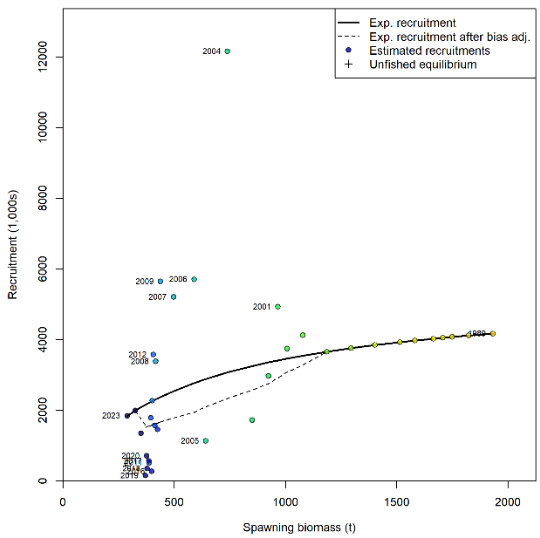

Figure 5.13. The estimated Beverton and Holt stock-recruitment relationship.

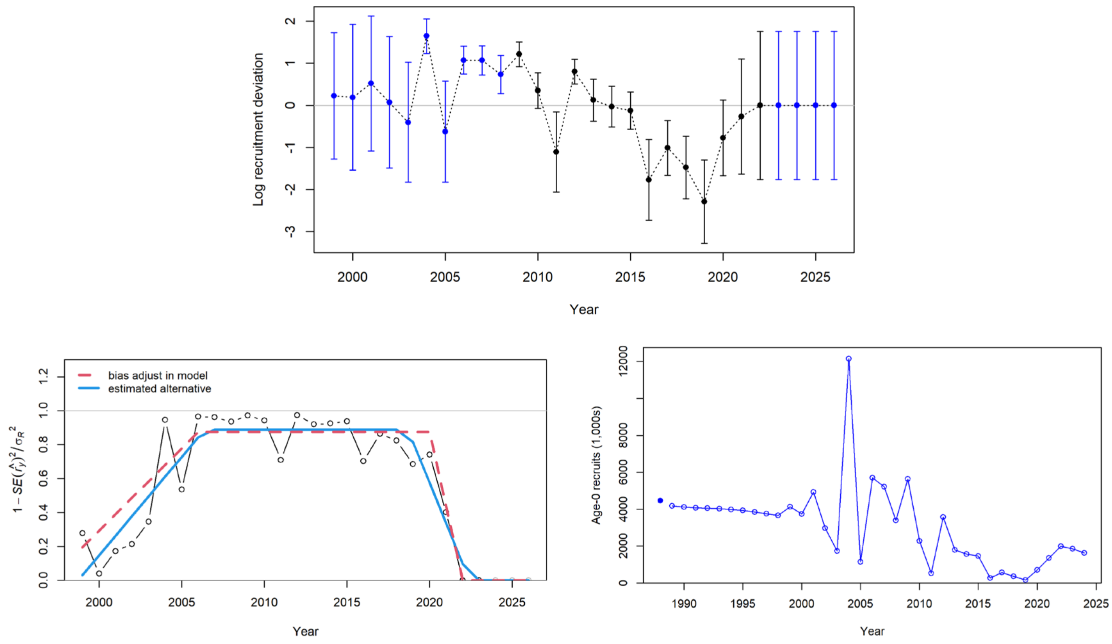

Figure 5.14. Deviates (above), introduced correction for the estimation of the recruitment deviates (lower left) and estimated recruitment (lower right) by year.

5.7.5 Catches

The model fits well the landings of all the commercial fleets (Figure 5.15).

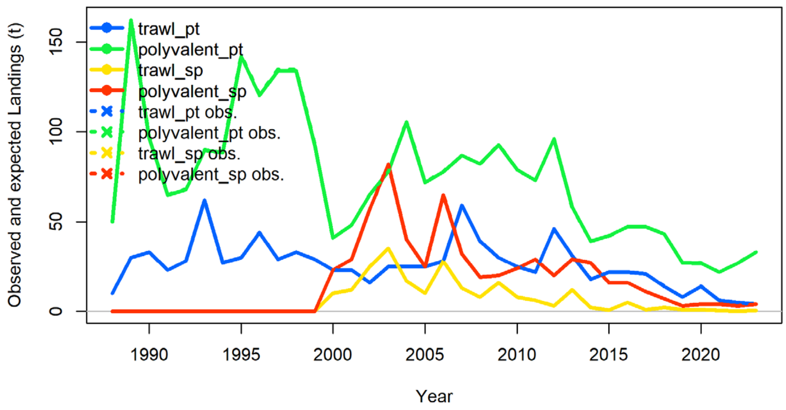

Figure 5.15. The predicted and observed landings by fleet.

5.7.5.1 Time-series SSB and fishing mortality

The model estimated a large decrease in biomass until 2008 before the length composition data started (Figure 5.16). The fishing mortality (F) was very low at the beginning of the time series, increased to 0.35 in 2003 and decreased to 0.1 in 2021.

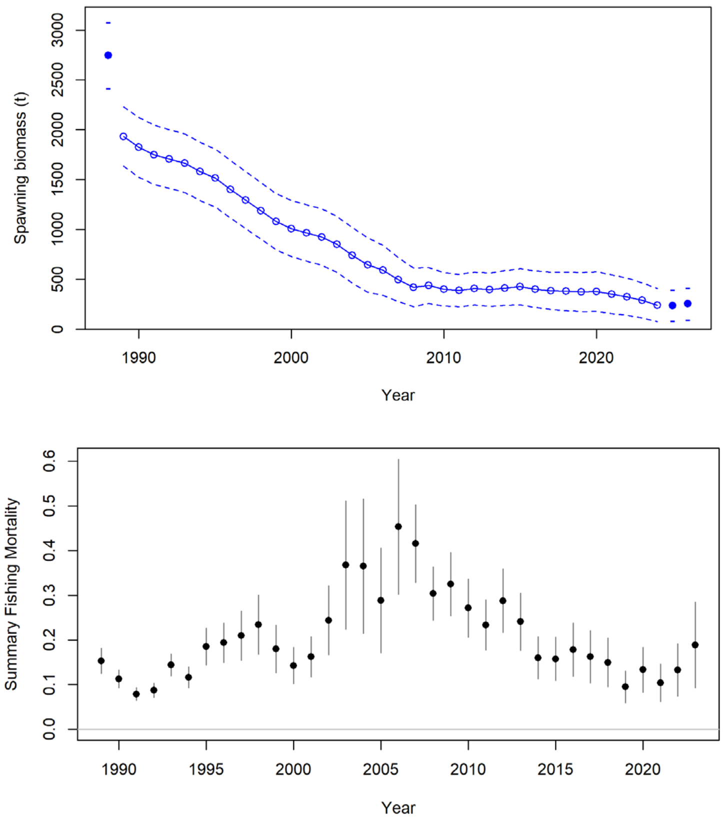

Figure 5.16. The estimated time-series of SSB (above) and Fishing mortality and uncertainty (below).

5.8 Model diagnostics

The diagnostic of the model was done based on the plausibility of the results, expert's knowledge, runs' test (to analyse the fits of the model), hindcasting (for the predictive skills of the model). The model passed the run test and showed a good fit with no large Pearson residuals (Figure 5.17).

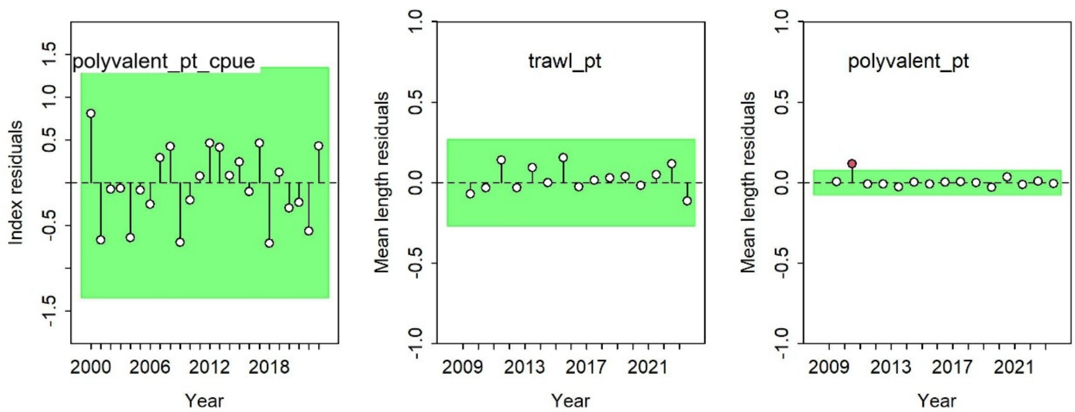

Figure 5.17. Runs test results of each fleet: Portuguese polyvalent CPUE (left), Portuguese trawl landings (middle), and Portuguese polyvalent landings (right). Green means pass, and the red points mean that those observed values are out of the confidence interval of the estimated value.

Values for Mohn's rho are within the accepted range (Figure 5.18), indicating a good consistency of the model.

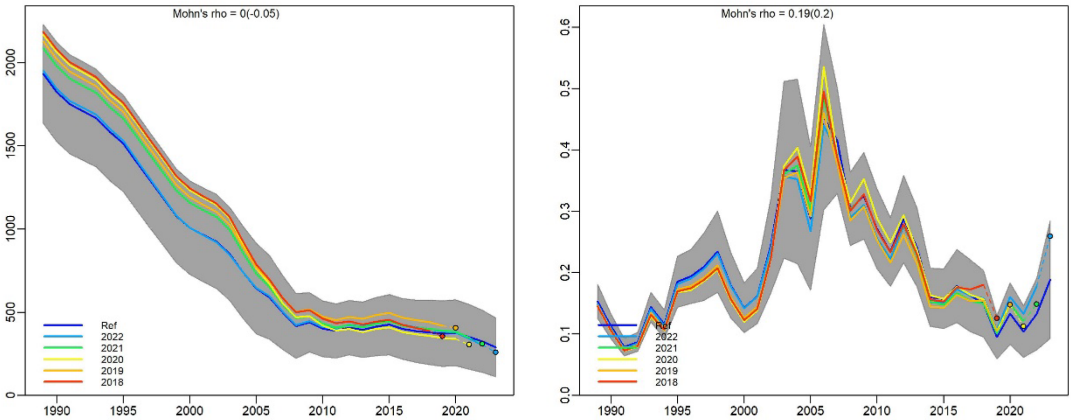

Figure 5.18. Retrospective pattern and forecast of SSB (left) and F fishing mortality (right), with their corresponding Mohn's rho values (values between brackets are the forecast).

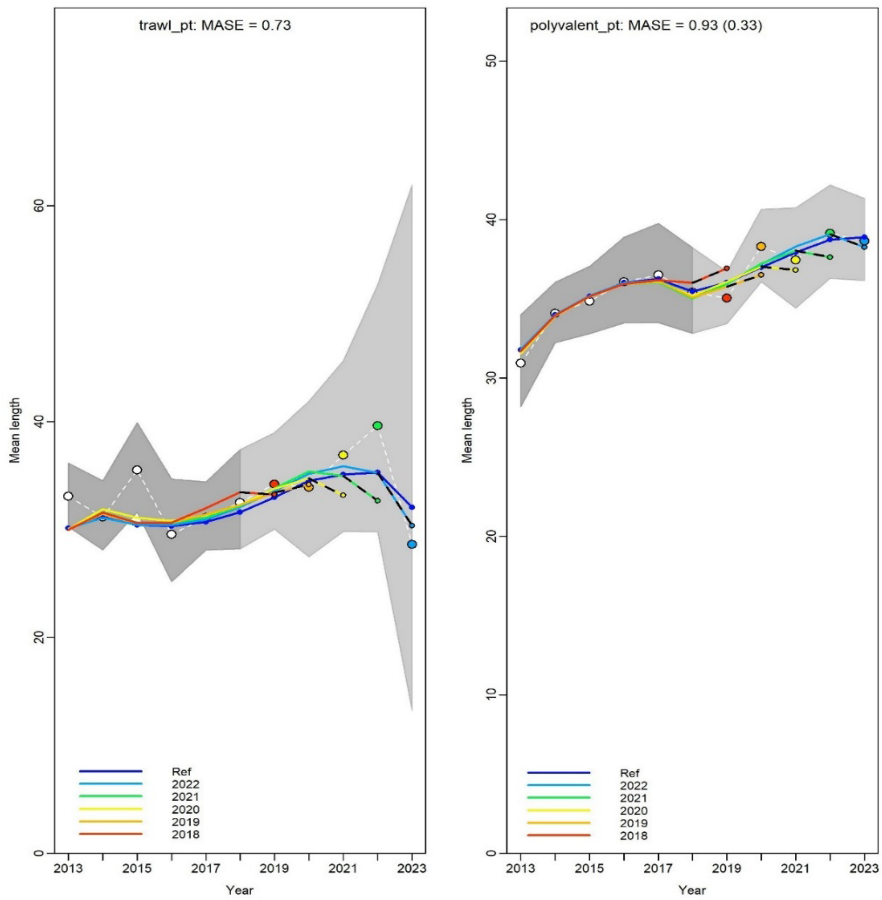

Figure 5.19. Mean absolute scaled error (MASE) for mean length.

5.9 Alternative runs and discussion

Steepness (h) value of 0.7 was used in the GFCM model. Howevee after preliminary runs h=0.6 was adopted because best diagnostics and fits. Four alternative model configurations were explored using the base case model (recruitment with steepness = 0.6 and sigmaR = 0.9) as starting point:

- Model 1: Maturity at age 3 (age 5 in the final model)
- Model 2: Time-varying selectivity for polyvalent fleets since 2021 (since 2018 in final model)
- Model 3: Cut time series in 2000 (starting in 1989 in final model))
- Model 4: Cut time series in 1995 (starting in 1988 in final model))

5.9.1.1 Model 1. Maturity at age 3

For this model, (females) maturity was set to occur at age 3.

5.9.1.2 Model 2. Time-varying selectivity since 2021

For this model, polyvalent fleet selectivity was set to be time-varying between since 2021.

5.9.1.3 Model 3. Cut time series in 2000

For this model, the difference from the base case model was cutting the time series in 2000 because before that year the landings were much higher than after, which could be pulling the model down. The start values for Portuguese trawl and polyvalent landings were calculated as the average of the 5 previous years (1995-1999), for each fleet separately.

5.9.1.4 Model 4. Cut time series in 1995

For this model, the difference from the base case model was cutting the time series in 1995 to have a longer time series than in the previous model. The start values for Portuguese trawl and polyvalent landings were calculated as the average of the 5 previous years (1990-1994), for each fleet separately.

5.9.1.5 Comparison between base case and alternative models

The base case model, with selectivity set to be time-varying since 2018, only for the polyvalent fleet, and maturity set to occur at age 5, was selected as the best model.

For selecting the best model (base case in Table 5.4), a compromise was made between the best likelihood for SSB and F: the base case model did not get the best likelihood among the five model runs for F, but it got the best likelihood for SSB (lowest retrospective rho) (Table 5.4). Moreover, this model configuration reflects the best knowledge of the species biology and understanding of the fisheries that catch the species. The final model provides similar trends in F and SSB compared with models 1 and 2 (green and yellow lines in Figure 5.17). However, the trends for models 3 and 4 are very different in F and SSB (orange and red lines in Figure 5.20).

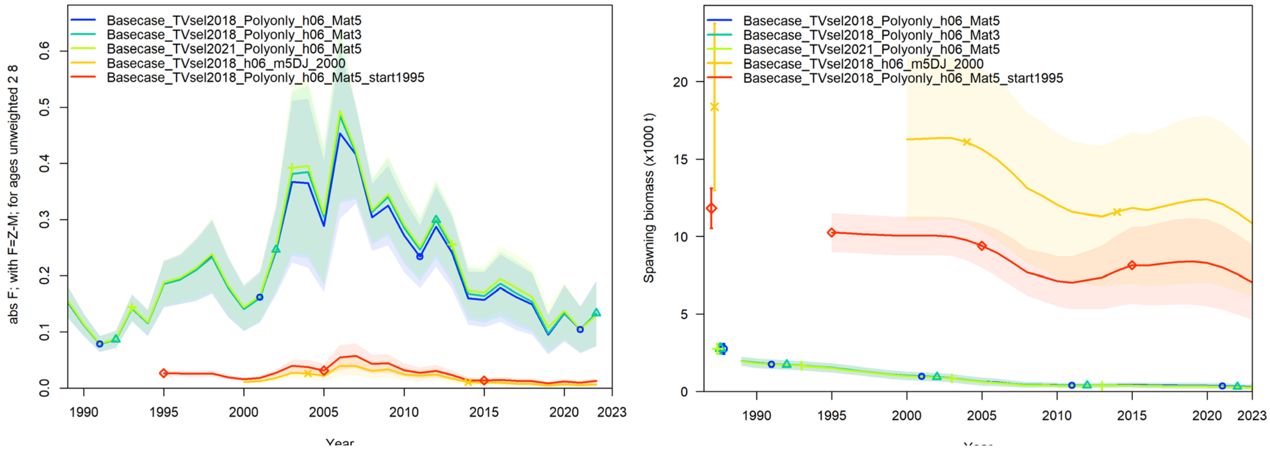

Figure 5.20. Comparison of summary statistics between base case and alternative runs. (upper) F with CI; (lower) Spawning biomass with CI. Model Basecase_TVsel2018_Polyonly_h06_Mat (blue line) is the final model for the assessment.

Table 5.4. Main outputs for the base case and alternative configurations. The retrospective rho used to select the model for the assessment is in bold.

Run	Base case	Model 1	Model 2	Model 3	Model 4
Convergence	5.60E-04	1.76E-03	9.14E-05	2.22E-04	4.62E-03
Total_LL	473.389	456.82	453.131	403.521	465.192
N_Params	165	165	167	153	153
Runs_test_cpue1	Passed	Passed	Passed	Passed	Passed
Runs_test_len1	Passed	Passed	Passed	Passed	Passed
Runs_test_len2	Passed	Passed	Passed	Passed	Passed
RMSE_Perc	42	42	41.7	50.1	45.5
RMSE_Perc_1	6	6	6	5.8	6
Retro_Rho_SSB	**-0.00474**	0.107491	0.131585	-0.01186	0.090436
Forecast_Rho_SSB	-0.04921	0.057589	0.078296	-0.01953	0.075282
Retro_Rho_F	0.185371	0.197706	0.151359	0.208358	0.077949
Forecast_Rho_F	0.202229	0.225828	0.191877	0.144875	0.040941
MASE_cpue1	0.661979	0.677075	0.529816	0.98401	0.622307
MASE_len1	0.728875	0.778868	0.806727	0.929813	0.783216
MASE_len2	0.331681	0.348226	0.314834	0.444568	0.411487
MASE_len3	0.558704	0.593924	0.592243	0.723454	0.627897

5.10 Reference points

5.10.1 ICES approach to setting reference points

Reference points were established by following the ICES fisheries management reference points for category 1 and 2 stocks (ICES, 2021). The ICES R package *msy* was used (EqSim approach).

An FLR Stock object was created from SS3 outputs using the R library *ss3om*. This assessment has one season and two sexes. Since EqSim works on a single season and single-sexed object, the two sexes were combined. SSB was calculated from the stock numbers, weights-at-age, and female maturity ogive. Since blackspot seabream length data started in 2009, the recruitment standard deviations were set to that period.

F and recruitment (SSB) in the FLR Stock object (both sexes combined and female) were checked against the SS3 output and matched closely (Figure 5.21).

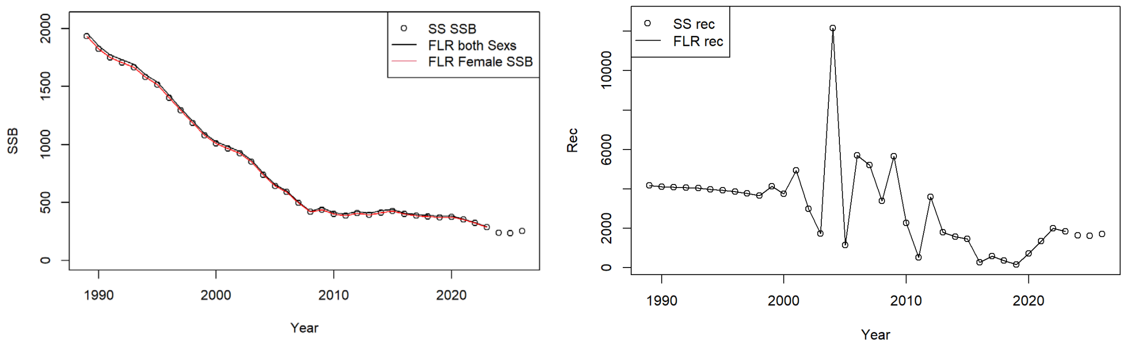

Figure 5.21. Comparison of SSB (left) and recruitment (right) values between FLR Stock and SS3 output.

5.10.1.1 Stock-recruit relationship

To be consistent with the Stock Synthesis assessment, the stock–recruit relationship estimated by the model was used for estimating reference points (except for Precautionary Approach reference points which are based 15% of virgin biomass, B0). The values of R_0, B_0 and h were translated to the traditional a and b parameters of the classic Beverton–Holt curve (see Mangel, 2010 for equations). However, to be consistent with the combined-sex SSB, the parameter B_0 (which is for females only in the SS3 output) was converted to a combined-sex B_0 by using the ratio of combined sex biomass over female-only biomass in the first year of the assessment (which was close to unexploited).

5.10.1.2 Stock type and B_{lim}

The stock-recruit relationship (Figure 5.22) was examined for the period with length data were available, coinciding with the recruitment deviations (2009-2023), and the stock type was identified as type 5 (no evidence of impaired recruitment).

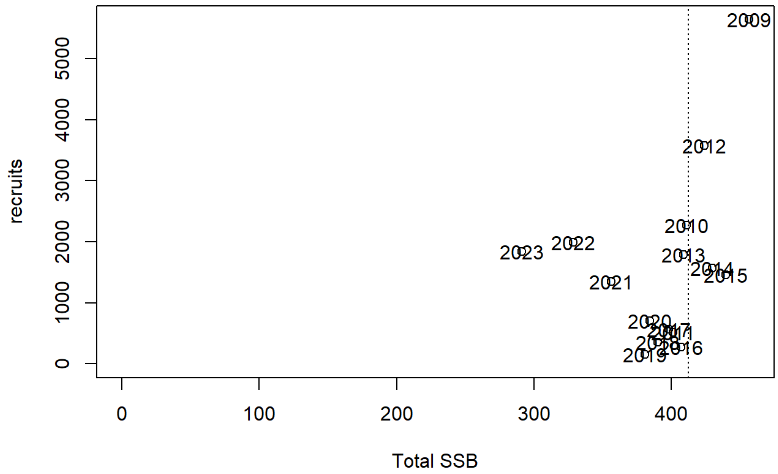

Figure 5.22. Pagellus bogaraveo Stock-recruitment (S-R) plot.

Several options were explored to estimate Blim:

- Segmented regression but does not make any sense
- Empirical B_{lim} (342 t)
- B_{lim} from lowest SSB (B_{loss}, 2011) with “high” recruitment (401 t) that is less than 15% of B_0
- 15% of B_0. B_{lim} (412 t)

Finally, and agreed in plenary, B_{lim} was defined as 15% B_0.

5.10.1.3 PA reference points

B_{pa} is estimated as B_{lim} plus model uncertainty. The estimate of error around SSB in the last year (2023) was 0.313, resulting in $B_{pa} = B_{lim} * \exp(1.645 * 0.313) = 690$.

F_{pa} is estimated with a Beverton-Holt SR and the $B_{trigger}$ advice rule, as F with 95% probability of SSB ≥ B_{lim} (Figure 5.23).

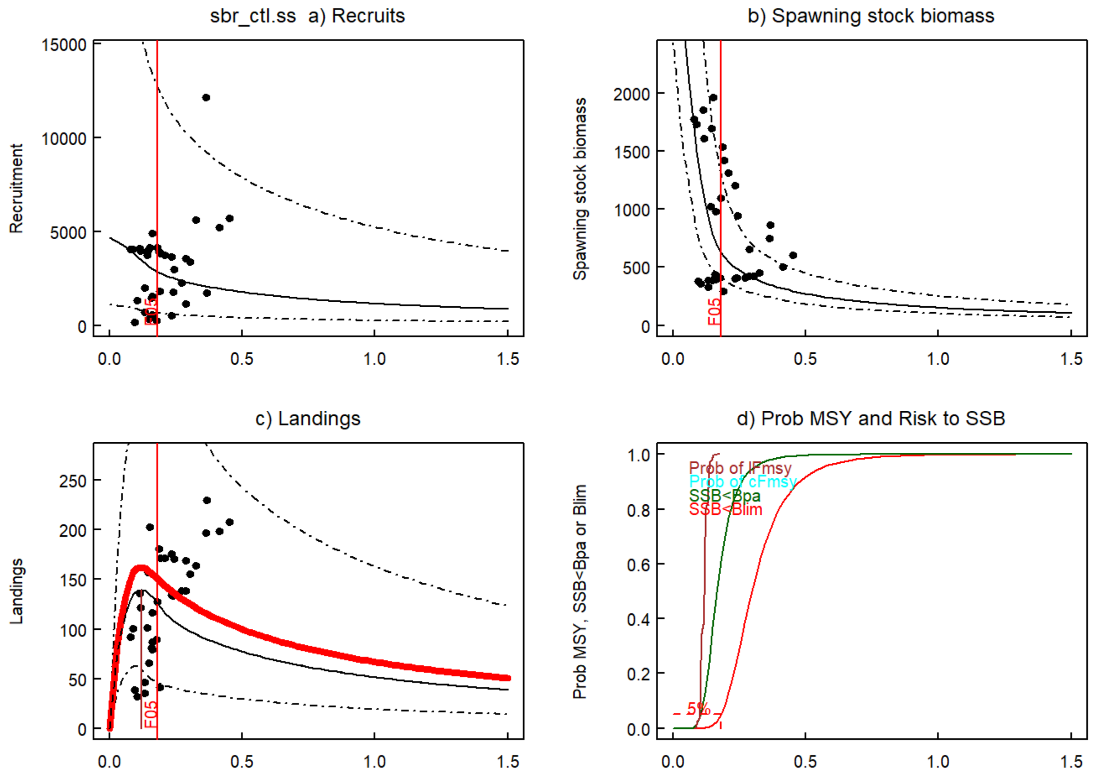

Figure 5.23. Pagellus bogaraveo: Simulation from fixed Beverton and Holt S-R and including advice rule (x-axis shows F).

5.10.1.4 FMSY and $B_{trigger}$

FMSY was initially calculated based on an evaluation with the inclusion of stochasticity in a population and fishery as well as assessment/advice error but without the MSY Btrigger advice rule. For this simulation the BH stock-recruit function with fixed B0 (females only); R0 and *h* parameters were used. The ICES default settings were used for cvF=0.212; phiF=0.423; cvSSB=0 and phiSSB=0. This resulted in an initial estimate of F_{msy} at 0.111 (F_{lower} = 0.082, F_{upper} = 0.141) (Figure 5.24). F_{p05} with advice rule is estimated at 0.181 (Figure 5.25), which is higher than F_{msy} and F_{upper} witout Btrigger. Since the reference points should not be capped by F_{p05}, the initial estimate of F_{msy} = 0.11 is valid.

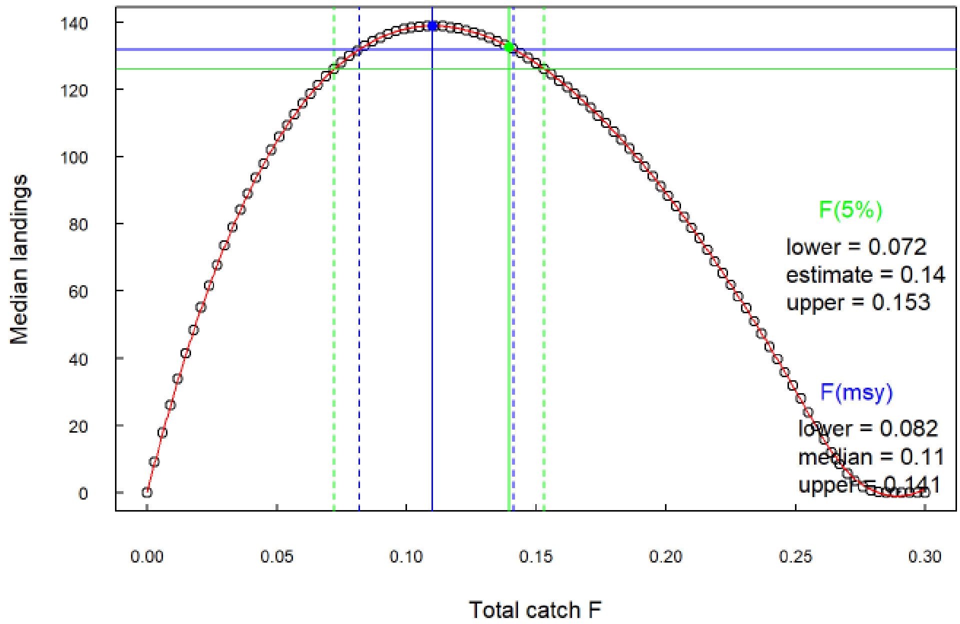

Figure 5.24. ***Pagellus bogaraveo*: median (across 1000 iterations) for the mean yield at stochastic equilibrium as a function of the fishing mortality applied. Blue vertical line corresponds to Fmsy (with dashed line representing the Fmsy range limits). Green vertical lines represent the fishing mortality at which p(SSB<Blim)>5%. Simulations run without implementing ICES MSY advice rule.**

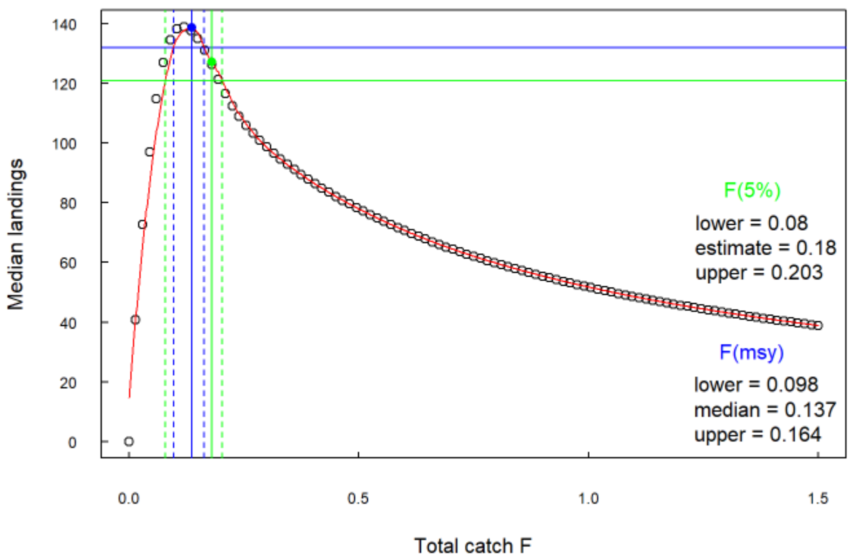

Figure 5.25. ***Pagellus bogaraveo*: median (across 1000 iterations) for the mean yield at stochastic equilibrium as a function of the fishing mortality applied. Blue vertical line corresponds to Fmsy (with dashed line representing the Fmsy range limits). Green vertical lines represent the fishing mortality at which p(SSB<Blim)>5%. Simulations run implementing ICES MSY advice rule.**

The final reference points are as follows:

Reference point	Value	Rationale
BlimratioB0	412	Blim as 15% B0
Bpa	690	Blim with assessment error
MSY Btrigger	690	Bpa
Fpa	0.181	F with 95% probability of SSB≥Blim (BH with Btrigger)
Fmsy	0.11	Stochastic simulations (BH no Btrigger)
FmsyLower	0.082	Stochastic simulations (BH no Btrigger)
FmsyUpper	0.141	Stochastic simulations (BH no Btrigger)
Bmsy5pc	623	5% probability of SSB < Blim

The stock is above F_{msy} and below $B_{trigger}$ and B_{lim} (Figure 5.26).

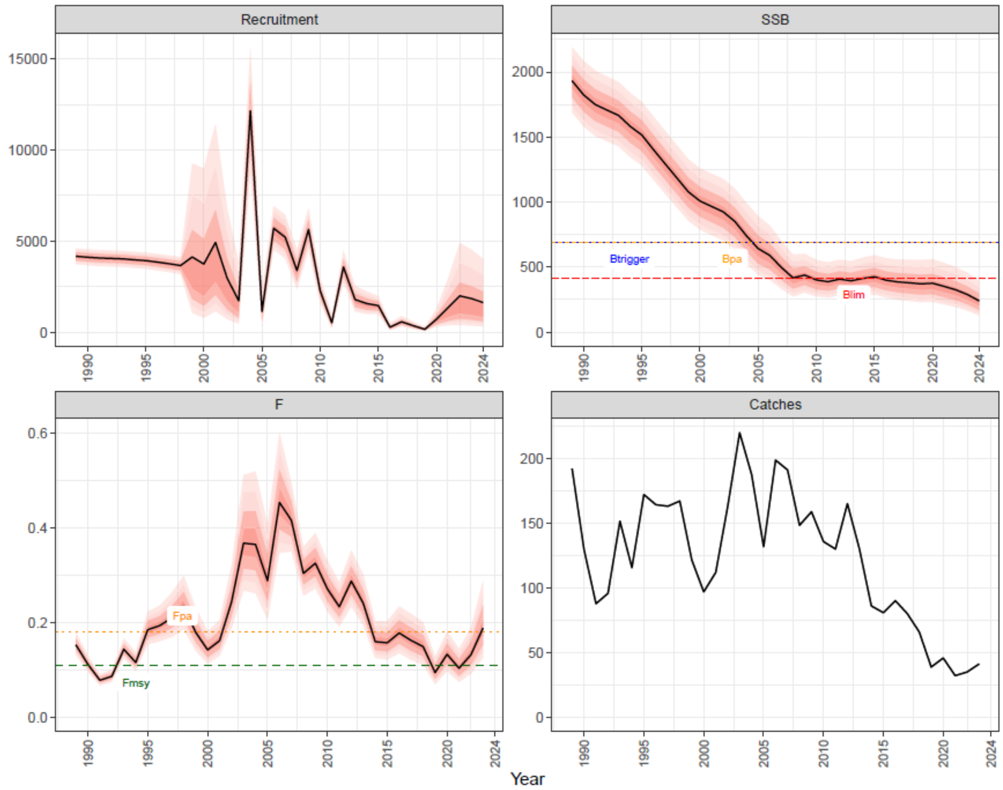

Figure 5.26. ***Pagellus bogaraveo*: stock trajectories summary plot with associated reference points for the 2024 benchmark update of Blackspot seabream in ICES 9.**

5.10.1 MSE checking the robustness of reference points

For blackspot seabream, the implementation system of the harvest control rule is based on the assumption that advice is given for year y + 1 based on an assessment completed in year y, which is fitted to data up until last data year y – 1 (Winker, 2025 WD). Therefore implementation of the derived C_{adv} through HCR requires projection of the stock dynamics by way of a short-term forecast. To do this, numbers-at-age were projected through the year of assessment. Status quo recruitment, M_a, w_a and mat_a were set as the mean of the last 3 years. A projection based on a fixed fishing mortality-at-age to the last year (y − 1) in the assessment was then made through to the implementation year (y + 1). The limitations of the MSE short-cut approach are that it cannot fully account for uncertainties resulting from imperfect sampling of the full age-structure (e.g. poorly sampled recruits), observation error, misspecified model assumptions and selectivity. On the other hand, the short-cut MSE approach is straight-forward to implement (FLR) and reduced complexity and computation time when the focus is predominantly optimizing HCRs for setting quotas on the premises that a benchmark assessment form the basis for the advice.

The MSE short-cut approach is implemented using the tools available in the Fisheries Library for R (FLR; Kell et al., 2007; https://flr-project.org/). See Winker (2025, WD) for further details.

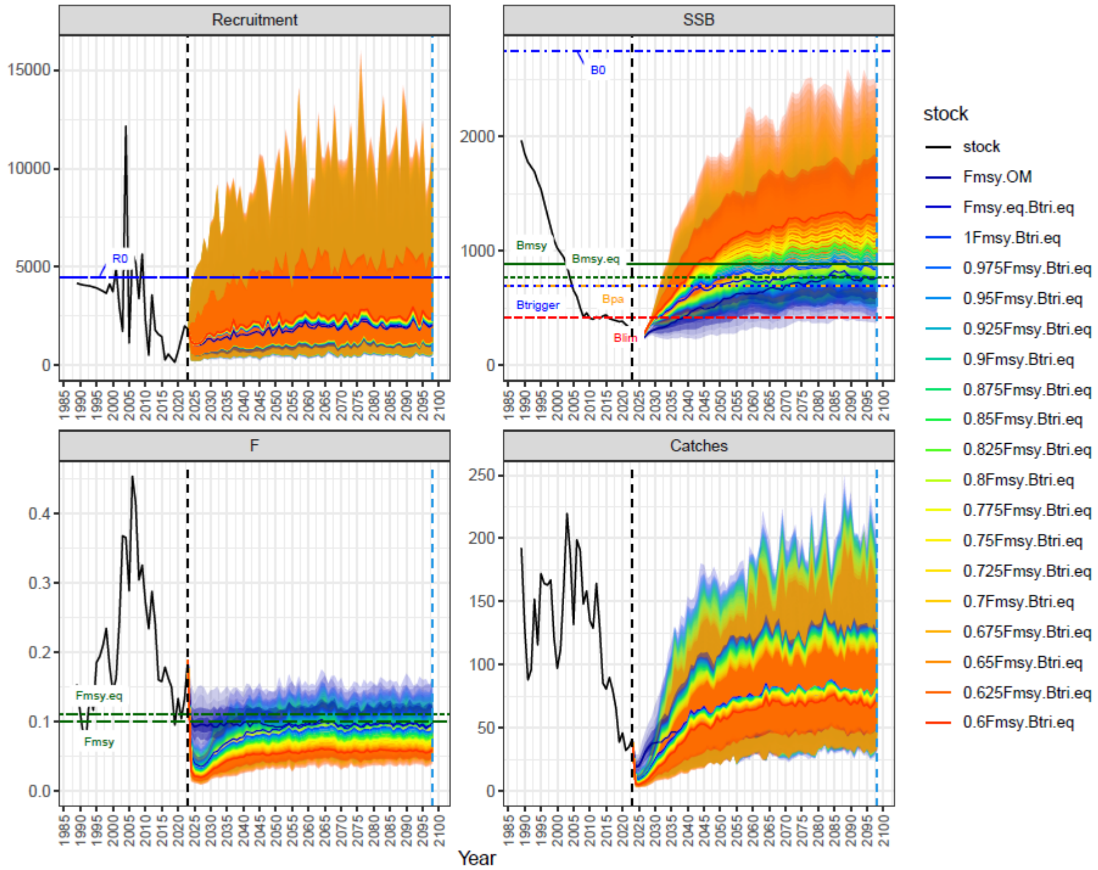

Figure 5.27. Initial OM and the MSE forecast horizon

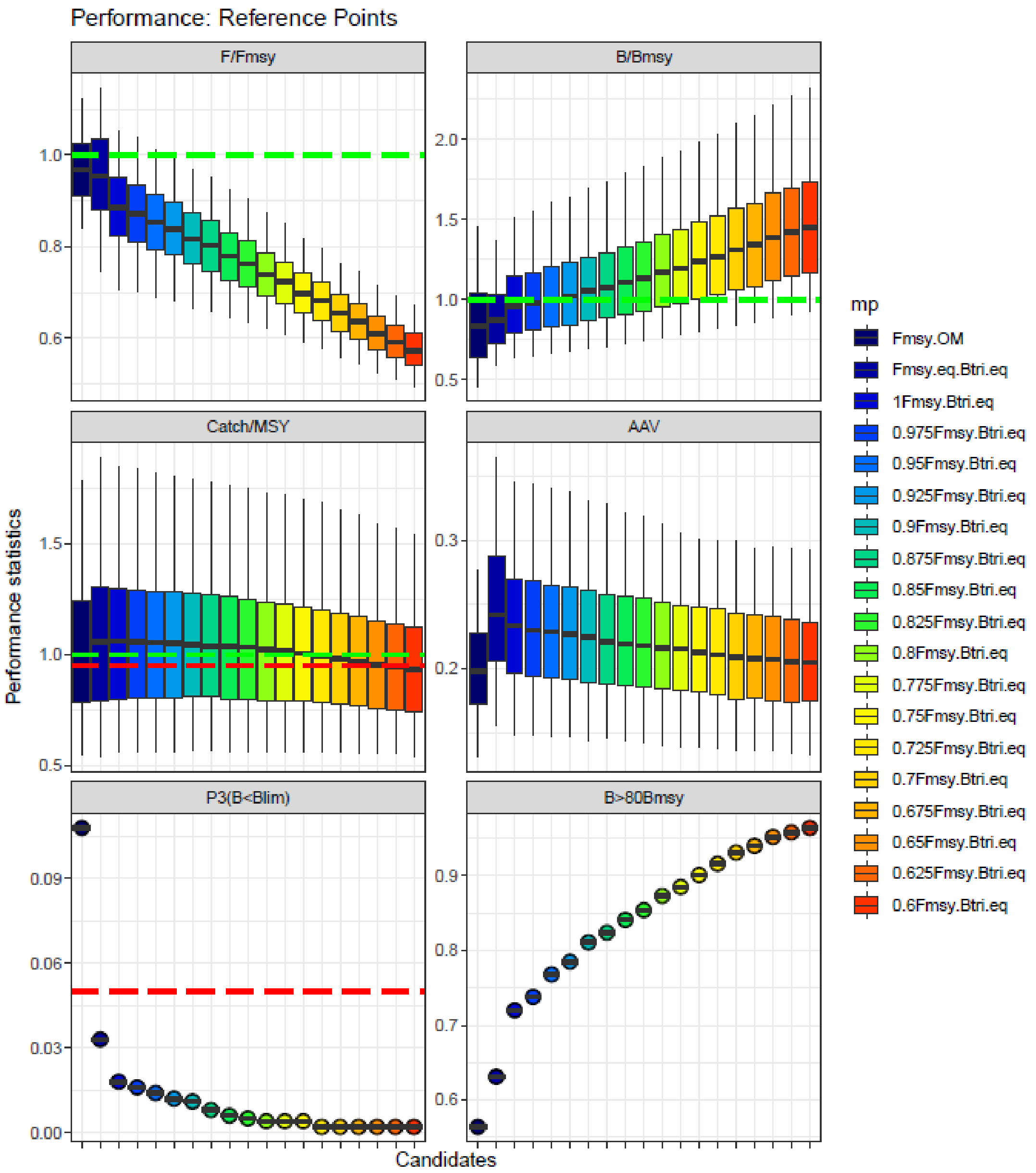

Figure 5.28. Long-term performance evaluation (Winker, 2025 WD).

Table 5.5. Robustness tests of Fadv in line with ICES precautionary approach under closed loop simulations with feedback control of assessment advice emulation (Winker, 2025 WD).

AR	Fadv	P3(B<Blim)	Catch/MSY	SD.Catch	AAVC	F/Fmsy	B/Bmsy	P(B>0.8Bmsy)
Fmsy.OM	0.099	0.108	1.055	0.371	0.201	0.971	0.876	0.564
Fmsy.eq.Btri.eq	0.11	0.033	1.096	0.405	0.249	0.954	0.911	0.631
1Fmsy.Btri.eq	**0.099**	**0.018**	**1.094**	**0.392**	**0.237**	**0.885**	**1.005**	**0.72**
0.975Fmsy.Btri.eq	0.097	0.016	1.092	0.389	0.236	0.872	1.024	0.738
0.95Fmsy.Btri.eq	0.094	0.014	1.089	0.385	0.233	0.852	1.053	0.768

AR	Fadv	P3(B<Blim)	Catch/MSY	SD.Catch	AAVC	F/Fmsy	B/Bmsy	P(B>0.8Bmsy)
0.925Fmsy.Btri.eq	0.092	0.012	1.087	0.382	0.231	0.838	1.074	0.785
0.9Fmsy.Btri.eq	0.089	0.011	1.082	0.377	0.228	0.816	1.106	0.811
0.875Fmsy.Btri.eq	0.087	0.008	1.078	0.373	0.226	0.801	1.128	0.824
0.85Fmsy.Btri.eq	0.084	0.006	1.071	0.367	0.224	0.778	1.163	0.841
0.825Fmsy.Btri.eq	0.082	0.005	1.066	0.363	0.222	0.763	1.187	0.854
0.8Fmsy.Btri.eq	0.079	0.004	1.057	0.357	0.22	0.739	1.224	0.873
0.775Fmsy.Btri.eq	0.077	0.004	1.051	0.352	0.219	0.723	1.25	0.885
0.75Fmsy.Btri.eq	0.074	0.004	1.039	0.345	0.216	0.698	1.29	0.901
0.725Fmsy.Btri.eq	0.072	0.002	1.031	0.341	0.215	0.682	1.318	0.916
0.7Fmsy.Btri.eq	0.069	0.002	1.017	0.333	0.213	0.656	1.362	0.931
0.675Fmsy.Btri.eq	0.067	0.002	1.006	0.328	0.212	0.639	1.392	0.94
0.65Fmsy.Btri.eq	0.064	0.002	0.989	0.319	0.21	0.613	1.438	0.952
0.625Fmsy.Btri.eq	0.062	0.002	0.976	0.313	0.208	0.595	1.471	0.958
0.6Fmsy.Btri.eq	0.060	0.002	0.963	0.307	0.207	0.577	1.504	0.964
0.57Fmsy.Btri.eq	0.058*	0.002*	0.953*	0.301*	0.206*	0.558*	1.535*	0.975*
0.55Fmsy.Btri.eq	0.056*	0.002*	0.940*	0.295*	0.205*	0.539*	1.569*	0.982*
0.52Fmsy.Btri.eq	0.054*	0.002*	0.927*	0.289*	0.204*	0.520*	1.603*	0.988*
0.5Fmsy.Btri.eq	0.052*	0.002*	0.912*	0.282*	0.203*	0.501*	1.638*	0.994*

*Interpolated values

The comparison between Eqsim and short-cut MSE highlighted that Eqsim F_{MSY} was precautionary but F_{MSY} was larger than F_{MSY} estimated by the model, so the WG agreed the use of 1Fmsy.Btri.eq (equivalent the value estimated internally by the Stock Synthesis model) as F_{MSY}. It should be noted that last estimates (*) in Table 5.5 are preliminary values and would be updated before WGDEEP, running the short-cut MSE with more F scenarios.

Thus, the PA Advice Rule based on the staged criteria (1) Fadv < Fp0.5 and (2) maximum catch given (1) is:

AR	Fadv	P3(B<Blim)	Catch/MSY	SD.Catch	AAVC	F/Fmsy	B/Bmsy	P(B>0.8Bmsy)
1Fmsy.Btri.eq	0.099	0.018	1.094	0.392	0.237	0.885	1.005	0.72

Worthy of being noted that a lower F, down to 0.056 (preliminary values), will result in a loss of about 5% of the catches with more than 50% SSB.

5.11 Forecast assumptions

The following are default forecast assumptions. The working group will review these assumptions annually and adapt them when necessary:

- Maturity-at-age is fixed, so the values from the previous year can be used;
- Natural mortality at age is fixed, so the values from the previous year can be used;
- Mean weights-at-age: average 3 most recent years;
- Exploitation pattern: average 3 most recent years;
- Recruitment geometric mean between the first year (2009) and the year before the assessment (2023);
- Interim year is the assessment year;
- Advice year is the assessment year+1.

5.12 Future considerations

The biological parameters for the proposed SS3 assessment model were borrowed from the GFCM assessment model for SBR GSA 1-3 (Strait of Gibraltar).

Collecting biological data from the Portuguese mainland population will be relevant to improving the adequacy of the model to ICES Subarea 9, especially considering that the species is a hermaphrodite and that length distribution is included in the model by sex separately.

Lastly, length data must be collected by fishing fleet (polyvalent and trawl) in mainland Portugal landing ports.

5.13 Stock-specific reviewers report (sbr.27.9)

Reviewer: Tanja Miethe

5.13.1 Introduction

This stock was put forward for benchmark to update the current category 3 to a category 1 assessment. A previous attempt to fit a SPiCT model failed due to limited contrast in the data and time constraints at WKBMSYSPICT3. It was suggested to develop an SS3 assessment. For this purpose, a new length-based SS3 model for hermaphroditic species was developed. The model is considered acceptable for assessment. However, the assessment results are very sensitive to early landings history. Additional input data, such as LPUE index for trawls, should be considered in the near future.

5.13.2 Data compilation

Stock ID was discussed, and it was decided to exclude landings data from Gibraltar/Cadiz region and Azores, which are considered separate stocks. Discards have not been quantified and are considered negligible. This seems reasonable considering the high discard survival for this species, but the decision should be reviewed when further data become available in the future. Landings were split by catch fleet (polyvalent and trawl) and country (Spain, Portugal), but combined for sexes. Assumptions are made for split by fleet for the Spanish fleets from 2000-2008. Spanish landings prior to 2000 are assumed zero, which is considered realistic by stock experts. Length frequency distributions (LFDs) are available from 2009 only for the Portuguese trawl and polyvalent landings fleets. The LFDs of early years are noisy due to low sampling. In the future, combining Spanish and Portuguese landings by fleet could be considered, since selectivities for the Spanish fleets are mirrored from the Portuguese fleets in the model.

For this rather data-limited stock, biological parameters from literature were considered and agreed. Biological parameters such time invariant length-weight relationship, maturity, natural mortality and sex transition rate from male to female were borrowed from the separate Gibraltar stock of the same species. It is recommended review the assumptions when data becomes available for northern and central areas of subarea 9. A length-based maturity ogive is used, but maturity is assumed zero below the age of 5. This ignores a low number of mature females younger than 5 years of age, the decision is considered to have a negligible impact on assessment results. For simplicity, the timing of sex transition was assumed constant over the assessment period, even though some density dependence is likely to occur in reality.

There is only one index, a commercial LPUE index for the Portuguese polyvalent fleet, for consideration in the assessment model. The index estimation procedure was presented at an earlier benchmark (WKBMSYSPICT3) and updated during this benchmark by grouping data points in December with those in the following January to occur in the same observation year. For the future, it is recommended explore whether an additional index can be made available, for the trawl fishery.

It should be noted that no sex-specific data (combined landings, index, LFDs) are available for the stock, this should be revisited when new data become available in the future.

5.13.3 Assessment model

A sex-structured model for a hermaphrodite species with annual time step was agreed. Identifying seasonality of the fishery in the model was not considered necessary as the species is relatively slow-growing. The model has difficulty to fit some cohort peaks at small length in the landings length frequency distributions (LFDs) for both polyvalent and trawl fleet. Explorations of settings showed a trade-off between fitting LFDs and retros. It was decided to use double-normal selectivity for all fleets, even though usually at least one fleet is fitted with a logistic selectivity to avoid cryptic biomass. Time-varying selectivity was included for the polyvalent fleet in 2003-2018, when a shift in selectivity was assumed. It is recommended to keep an eye on fitting of LFDs and retros during the assessment working group, and to check whether the period of time-varying selectivity remains appropriate. In several years the LPUE index appears not to be fitted well in the model, however diagnostics (RMSE, MASE) are all acceptable. Retrospectives are within acceptable limits, but there is some degree of scale shift in SSB retros prior to 2005.

The assessment results are not robust to removal of historical landings (of years without other data sources) which was found to affect scale of estimated SSB, F and retrospectives. A strong decline in SSB estimates from 1990-2009 occurs in a period with limited data (no LFDs).

5.13.4 Reference points and MSE

The stock is estimated to be at the lowest observed level in recent years. The stock type was difficult to identify due to the short time period considered (since 2009), but agreed as type 5. B_{lim} is suggested at 15%B_0, which is above the $B_{empirical}$ and close to the lowest SSB with high recruitment. The reference points were estimated using the stock recruitment relationship from the SS3 model. MSE was run to confirm that the EqSim fishing mortality reference points of the advice rule are precautionary.

Reviewer: Giuseppe Scarcella

5.13.5 General conclusions

The transition to the new assessment model for blackspot seabream in ICES Subarea 9 (sbr.27.9) represents a significant methodological advancement. The previous length-based indicator (LBI) approach, combined with a biomass index derived from the Portuguese polyvalent fleet's standardized CPUE, provided trend analysis but lacked the ability to fully integrate biological processes and fishery dynamics. The newly adopted Stock Synthesis (SS3) model incorporates a more comprehensive dataset, including historical landings, CPUE standardization, and refined biological parameters such as age-specific natural mortality and recruitment deviations. This model enhances the accuracy of stock status estimation and provides a more reliable foundation for fisheries management advice. A major improvement in the assessment is the exclusion of landings from the Strait of Gibraltar fishery, ensuring that the stock advice is specific to Subarea 9 and not influenced by adjacent areas with potentially different dynamics. The model also includes a refined stock-recruitment relationship and incorporates time-varying selectivity, better reflecting the biological and ecological characteristics of the species. Additionally, the genetic differentiation observed in the Gulf of Cádiz reinforces the decision to assess the stock independently from other regions. Future assessments should aim to further refine recruitment estimates and integrate environmental variables affecting seabream distribution. Additional sensitivity analyses on natural mortality and stock-recruit steepness would further enhance model robustness. Moreover, to improve stock assessment and management, the following areas warrant further research:

- Stock Structure and Connectivity: The Gulf of Cádiz genetic differentiation suggests localized population dynamics. Further genetic studies and tagging programs could clarify connectivity within Subarea 9.
- Refinement of Maturity and Growth Parameters: Current estimates rely on data from the Strait of Gibraltar. Collecting region-specific biological data would improve model accuracy.
- Survey and CPUE Enhancements: Expanding survey coverage and refining CPUE standardization methods would improve biomass index reliability.
- Effort Standardization for Passive Gears: Accounting for changes in fishing practices and gear efficiency would reduce uncertainty in effort-based indices.
- Ecosystem and Environmental Influences: Investigating how climate variability, oceanographic conditions, and habitat changes affect blackspot seabream productivity could refine future stock assessments.

5.13.6 Fit to data and model diagnostics

The new model significantly improves the fit to observed data compared to previous assessments. Retrospective analyses and hindcast diagnostics indicate greater model stability, reducing uncertainty in stock projections. The inclusion of multiple fleet selectivities, particularly distinguishing Portuguese trawl and polyvalent fleets, ensures a more accurate estimation of exploitation patterns. Key enhancements in model diagnostics include:

- Improved CPUE standardization: The use of Generalized Additive Mixed Models (GAMMs) for CPUE standardization provides a more robust biomass index.
- Recruitment deviations: A refined stock-recruitment relationship reduces bias in biomass projections and accounts for the species' sequential hermaphroditism.

- Seasonality in fishing activity: The model accounts for increased fishing pressure in December and January when market demand for blackspot seabream is highest.
- Alternative model runs: Sensitivity analyses on selectivity, recruitment regimes, and natural mortality confirm the robustness of the base case model.

The diagnostics confirm that the model performs well in terms of convergence and stability, with no major retrospective patterns or overfitting issues. However, future work should continue to evaluate selectivity assumptions and potential spatial mismatches in survey indices.

5.13.7 Biological reference points

Biological reference points were estimated following ICES guidelines using the EqSim approach. The assessment defined Blim as 15% of B0, considering the available stock-recruitment relationship data.

5.14 Conclusions

Both reviewers consider the BestCase model proposed by WKBSS3 as suitable for providing management advice.

5.15 References

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Annex 1: List of participants

Name	Institute	Country (of Institute)
Mikel Aristegui-Ezquibela	Marine Institute	Ireland
Ewen D. Bell	Cefas Lowestoft Laboratory	UK
Paul Bouch	Marine Institute	Ireland
Massimiliano Cardinale (chair)	SLU Department of Aquatic Resources	Sweden
Paola Castellano	Portuguese Institute for the Sea and the Atmosphere	Portugal
Santiago Cerviño	Centro Oceanográfico de Vigo	Spain
Hubert Du Pontavcie	French Research Institute for Exploitation of the Sea - IFREMER	France
Wendy Edwards	Cefas Lowestoft Laboratory	UK
Inês Farias	Portuguese Institute for the Sea and the Atmosphere	Portugal
Simon Fischer	Cefas Lowestoft Laboratory	UK
Paul Gatti	French Research Institute for Exploitation of the Sea - IFREMER	France
Hans Gerritsen	Marine Institute	Ireland
Elvar H. Hallfredsson	Institute of Marine Research Tromsø	Norway
Juan Gil Herrera	Centro Oceanografico de Cádiz	Spain
Kieran Hyder	Centre for Environment, Fisheries and Aquaculture Science	UK
Paul Kemp	International Centre for Ecohydraulics Research	UK
Sven Kupschus	Unaffiliated	UK
Rachel Mawer	University of Plymouth	UK
Teresa Moura	Portuguese Institute for the Sea and the Atmosphere	Portugal
Tanja Miethe (reviewer)	Marine Laboratory	UK
Rebecca Nesbit	University of Plymouth	UK
Tully Osmond	University of Plymouth	UK
Zachary Radford	Centre for Environment, Fisheries and Aquaculture Science	UK
Amélie Régimbart	French Research Institute for Exploitation of the Sea - IFREMER	France
William Roche	Inland Fisheries Ireland	Ireland
Hannah Rudd	The Angling Trust	UK
Diarmuid Ryan	Inland Fisheries Ireland	Ireland

Name	Institute	Country (of Institute)
Paz Sampedro	Centro Oceanográfico de A Coruña	Spain
Giuseppe Scarcella (reviewer)	Institute of Marine Sciences	Italy
Emma Sheehan	University of Plymouth	UK
Bryce Stewart	Marine Biological Association of the UK	UK
Simon Thomas	Unaffiliated	UK
Dave Uren	Marine Biological Association of the UK	UK
Agurtzane Urtizberea	AZTI-Tecnalia	Spain
Klervi Verbrugghe	French Research Institute for Exploitation of the Sea - IFREMER	France
Youen Vermard	French Research Institute for Exploitation of the Sea - IFREMER	France
Rui Vieira	Cefas Lowestoft Laboratory	UK
Chantel Rene Wetzel	Office of Aquaculture	USA
Henning Winker (chair)	General Fisheries Commission for the Mediterranean	Italy
Mathieu Woillez	French Research Institute for Exploitation of the Sea - IFREMER	France

Data Workshop Agenda

Data Compilation: 20-24 January 2025 (hybrid)

Draft Agenda (time table = Copenhagen time)

20 January (Monday)

09:00-09:15

- Introductions, CoC & meeting ToRs (**ICES and Max**)

  Introduction to the R code for conducting the benchmark (Henning & Max)

  akatan999/Stock-synthesis-toolbox-for-ICES-benchmarks: Code and scripts for ICES stock synthesis benchmarked models

09:15-10:45 Catch and biological data

Presentations for ank.27.8c9a; Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)

- **Available commercial catch data: landings, discards, length compositions (Teresa and Team)**
- **Update of biological information: length-weight relationship, maturity, natural mortality (Teresa and Team)**

10:45-11:00 Health break

11:00-12:30 Catch and biological data

Presentations for ank.27.8c9a; Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)

Continue

12:30-14:00 Lunch

13:30-15:30

Presentations for mon.27.8c9a; White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

- **Available commercial catch data: landings, discards, lenght compositions (Paz and Team)**
- **Update of biological information: length-weight relationship, maturity, natural mortality (Paz and Team)**

15:30-15:45 Health break

15:45-18:00

Presentations for mon.27.8c9a; White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

Continue

21 January (Tuesday)

09:00-10:00 Catch and biological data

Presentations sbr.27.9; Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

- **Stock ID (Inês and Team)**
- **Available commercial catch data: landings, discards, lenght compositions (Inês and Team)**
- **Update of biological information: length-weight relationship, maturity, natural mortality**

10:00-10:15 <u>Health break</u>

10:15-12:45

Presentation sbr.27.9; Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

Continue

12:45-14:15 <u>Lunch</u>

14:15-15:30 Fisheries dependent and independent surveys

Presentation for ank.27.8c9a; Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters) **(Terese and Team)**

- **Spanish commercial LPUE:**
  wd1) trawl targeting demersal species.
  wd2) rasco (gillnet) targeting anglerfish
- **Portuguese commercial LPUE**
- **Survey indices**

15:30-15:45 <u>Health break</u>

15:45-18:00

- Presentation for mon.27.8c9a; White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters) **(Paz and Team)**

- **Spanish commercial LPUE:**
  wd1) trawl targeting demersal species
  wd2) rasco (gillnet) targeting anglerfish
- **Portuguese commercial LPUE**
- **Survey indices**

22 January (Wednesday)

09:00-12:30 Fisheries dependent and independent surveys

Presentation sbr.27.9; Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

- **CPUE standardization for polyvalent fleet (preliminary results for trawl fleet CPUE standardization) (Inês and Team)**
- **Preliminary SS3 model configuration (1-sex model) (Inês and Team)**

12:30-14:00 Lunch

14:00-15:30 Catch and biological data

Presentation for pol.27.67; Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel)

- **Life-history parameters (growth, length-weight, maturity, natural mortality; steepness): Hans (also with input from FISP project)**
- **Commercial catch data (overview of the available data and estimation procedures): Mikel**
- **Synthesis of recreational catches & post release mortality: Kieran, Wendy, Diarmuid, Youen, Simon & Hannah**
- **Tagging and genetics work: Pollack FISP - Simon & Hannah; Cefas – Ewen; Ifremer - Matthieu**

15:30-15:45 Health Break

15:45-18:00 Fisheries dependent and independent surveys

Presentation for pol.27.67; Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel)

- **Commercial CPUE indices - probably three separate presentations by France (Youen), UK (Ewen) and Ireland (Hans)**
- **Survey index update (spatio-temporal model): Paul B**

23 January (Thursday)

09:00-18:00 Final dataset to be included in the models

- Presentation for ank.27.8c9a; Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)
- Presentation for mon.27.8c9a; White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

- Presentation sbr.27.9; Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)
- Presentation for pol.27.67; Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel)

24 January (Friday)

09:00-12:00 Final dataset to be included in the models

- Presentation for ank.27.8c9a; Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)
- Presentation for mon.27.8c9a; White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)
- Presentation sbr.27.9; Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)
- Presentation for pol.27.67; Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel)

Benchmark Workshop Agenda

Benchmark meeting: 17-21 February 2025 (hybrid)

Draft Agenda (time table = Copenhagen time)

17 January (Monday)

09:00-09:30

- Introductions, CoC & meeting ToRs (**ICES and Max**)

  Introduction to the R code for conducting the benchmark: an update (Henning & Max)

  akatan999/Stock-synthesis-toolbox-for-ICES-benchmarks: Code and scripts for ICES stock synthesis benchmarked models

09:30-10:45 Basecase model and alternative model grid

- Presentations sbr.27.9; Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

10:45-11:00 Health break

11:00-12:30 Basecase model and alternative model grid

Presentations for ank.27.8c9a; Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)

12:30-14:00 Lunch

14:00-15:30 Basecase model and alternative model grid

Presentations for mon.27.8c9a; White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

15:30-15:45 Health break

15:45-18:00 Basecase model and alternative model grid

Presentation for pol.27.67; Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel)

18 February (Tuesday)

09:00-11:00 Basecase model and alternative model grid

- To be decided

11:00-11:15 Health break

11:15-12:45

- To be decided

12:45-14:15 Lunch

14:15-15:30 Basecase model and alternative model grid

- To be decided

15:30-15:45 Health break

15:45-18:00

- To be decided

19 February (Wednesday)

09:00-11:00 Reference point estimation

Presentation sbr.27.9; Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)

11:00-11:15 Health break

Presentations for ank.27.8c9a; Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)

12:30-14:00 Lunch

14:00-15:30 Reference point estimation

Presentations for mon.27.8c9a; White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

15:30-15:45 Health Break

15:45-18:00 Reference point estimation

Presentation for pol.27.67; Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel)

20 February (Thursday)

09:00-18:00 Forecast settings

- Presentation sbr.27.9; Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)
- Presentation for ank.27.8c9a; Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)
- Presentation for mon.27.8c9a; White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)
- Presentation for pol.27.67; Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel)

21 February (Friday)

09:00-12:00 Report

- To be decided

Annex 2: Resolutions

WKBSS3 – Benchmark workshop on application of Stock Synthesis (SS3) on selected stocks

[2025]/WK/FRSG[00] A **Benchmark workshop on application of Stock Synthesis (SS3) on selected stocks** (WKBSS3), chaired by Max Cardinale, and Henning Winker, and attended by invited external experts Tanja Meithe and Guiseppe Scarcella; will be established and meet 20-24 January, both online and at ICES, Copenhagen, for the data workshop, and 17 – 21 February, at ICES, Copenhagen, for the assessment methods workshop. An online workshop to prepare the data call for Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel) will be held during September 2024. WKBSS3 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;
    3. Make a proposal to the benchmark on the use and treatment of data for each assessment, including discards, surveys, life history, etc.;
    4. Invite stakeholders 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:
    5. 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:
    6. Obtaining population abundance and exploitation level estimates (conducting the stock assessment);
    7. 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.
    8. 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 as outlined in WKLIFE XI) should be put forward by the benchmark;

f) Update the Stock Annex; and

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

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

WKBSS3 will report by 28 February for the attention of ACOM.

Recurrent advice subject to benchmark	
ank.27.8c9a	Black-bellied anglerfish (*Lophius budegassa*) in divisions 8.c and 9.a (Cantabrian Sea, Atlantic Iberian waters)
mon.27.8c9a	White anglerfish (*Lophius piscatorius*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)
pol.27.67	Pollack (*Pollachius pollachius*) in subareas 6-7 (Celtic Seas and the English Channel)
sbr.27.9	Blackspot seabream (*Pagellus bogaraveo*) in Subarea 9 (Atlantic Iberian waters)