8 Sole in Cantabrian Sea and Atlantic Iberian waters

sol.27.8c9a – *Solea solea* in divisions 8.c and 9.a

8.1 General biology

Common sole (*Solea solea*) spawning takes place in winter/early spring and varies with latitude starting earlier in the south (Vinagre, 2007). Larvae migrate to estuaries where juveniles concentrate until they reach approximately 2 years of age and move to deeper waters. In Portuguese waters, sole length at first maturity is estimated as 25 cm for males and 27 cm for females (Jardim *et al.,* 2011). Sole is a nocturnal predator and, therefore, more susceptible to be captured in the fisheries at night than in daytime. It feeds on polychaetes, molluscs and amphipods. *S. solea* is abundant in the Tagus estuary and uses this habitat as its nursery ground (Cabral and Costa, 1999).

Growth studies based on *S. solea* otoliths readings in the Portuguese coast indicate L_{inf} of 52.1 cm for females and 45.7 cm for males. The growth coefficient estimated for females (k = 0.23) is slightly higher than for males (k = 0.21) and t_0 was estimated at −0.11 and 1.57 for females and males, respectively (Teixeira and Cabral, 2010). Maximum length observed between 2004 and 2011 from the landings sampling program (PNAB-DCF) attained 60 cm. According to Vinagre (2007), *S. solea* off the Portuguese coast presents higher growth-rates compared with the northern European coasts.

8.2 Stock identity and possible assessment areas

There is no clear information to support the definition of the common sole stock for ICES subdivisions 8.c and 9.a.

8.3 Advice

ICES advises that when MSY approach is applied, catches should be no more than 209 t for each of the years 2024 and 2025 (ICES, 2023). The catch advice is 35% lower than the previous advice (320 t; ICES, 2021b). The change in advice is due to the decline in the biomass index and the low biomass safeguard.

8.4 Management regulations (TACs, minimum landing size)

The minimum conservation reference size (MCRS) of sole is 24 cm (EU, 2019). There are other regulations regarding the mesh size for trammel and trawl nets, fishing grounds and vessels size (EU, 2020). Sole is under the Landing Obligation in divisions 8.a, 8.b, 8.d, and 8.e (all bottom-trawls, mesh sizes between 70 mm and 100 mm, all beam trawls, mesh sizes between 70 mm and 100 mm and all trammel and gillnets, mesh size larger or equal to 100 mm) and in Division 9.a (all trammelnets and gillnets, mesh size larger or equal to 100 mm) since 2013 (EU, 2013). In Portugal, all sole catches from all gears and mesh sizes are under the Landing Obligation (EU, 2013) which is more restrictive than required by European regulations.

Management of all sole species is made under a combined species division which prevents effective control of the single-species exploitation rates and could lead to the overexploitation of either species. For the period 2011–2022, *S. solea* represented on average 55% of the total catches of sole species, while *S. senegalensis* represented on average 26%, *Pegusa lascaris* 26%, and *Solea* spp. only <1% (Table 8.1).

8.5 Fisheries data

Table 8.2 presents common sole catches for divisions 8.c and 9.a., as well as landings for the other sole species (*S. senegalensis, P. lascaris,* and *Solea* spp.). Discards are considered negligible (< 1%) and therefore, from there on, the words catch or landings can be used indistinctly.

There is evidence of misidentification problems in Portuguese official statistics regarding sole species (i.e. *S. solea*, *S. senegalensis,* and *P. lascaris*) (Dinis *et al*., 2020). During the WKWEST benchmark (ICES, 2021a), using data from the Data Collection Framework (DCF) sampling program, Portuguese catches were proportionally divided by sole species applying the species weight proportion to the total weight of *Soleidae* in each year, landing port, and semester and using a simple random sampling estimator, following Figueiredo *et al*. (2020). Details on data available and catch estimation procedures can be found in Annex 2 of the working document Pennino *et al*. (2021 in ICES, 2021a). At that moment, the new Portuguese catches are considered reliable.

Reviewed catches reported in InterCatch are now available from 2009 to 2022 by Spain and France and from 2011 to 2022 by Portugal (Figure 8.1). Information on discards indicates that discarding can be considered negligible (< 1%) (Figure 8.2). Presently, only damaged specimens are discarded, while specimens under the MCRS are landed under the landing obligation (in negligible numbers).

The majority of catches are from ICES Division 9.a (Figure 8.3). The two main fleets that target this stock are the polyvalent fleet from Portugal (i.e., "MIS_MIS_0_0_0") and the trammel net fleet from Spain (i.e., "GRT_DEF_60-79_0_0") (Figure 8.4). The distribution of the catches is almost homogenous along the year in Portugal and Spain, as well as for the main fleets.

In InterCatch, data on length-frequency distribution (LFD) are available for the years 2011–2022 (Figure 8.5). The majority of the data are from the polyvalent fleet (i.e. *métier* "MIS_MIS_0_0_0") from Portugal and the LFD seem to be homogeneous in the last years. Market sampling in Portuguese ports in 2020 was affected by the COVID-19 pandemic, resulting in the sampling suspension during the period March-June and resumption after that. In order to overcome the decrease in the amount of data collected by the National sampling program PNAB/DCF, samples collected under the Project "Pequena Pesca na Costa Ocidental Portuguesa - PPCENTRO" (ref: MAR-01.03.02-FEAMP-0007) were also used to estimate landings by species and LFD. This information was also used for the year 2021 (ICES, 2021a; b).

For the WKWEST benchmark (ICES, 2021a) an official data call was issued for this stock to acquire all available data, not only for the common sole (*S. solea*) but also for the other sole species, i.e. *S. senegalensis, P. lascaris,* and *Solea* spp. (Figure 8.6) considering the misidentification problems identified in official statistics.

Since the benchmark, data on catches for each of these species are reported and now Spanish landings of *S. senegalensis, P. lascaris* and *Solea* spp. are available for the period 2009–2022, while from Portugal for 2011 to 2022. No French data on these species are available.

For Portugal, catches of *S. solea*, as well as those of *S. senegalensis, P. lascaris* and *Solea* spp. were proportionally divided applying the species weight proportion to the total weight of *Soleidae* for each year, landing port, and semester and using a simple random sampling estimator, following Figueiredo *et al*. (2020) and was applied for the first time during the WKWEST workshop (ICES, 2021a) and since the WGBIE meeting in 2021 (ICES, 2021c).

8.5.1 Biomass indices

Two biomass indices are available for this stock. A standardized commercial LPUE from Portugal and a standardized biomass index from the Spanish IBTS-Q4 bottom-trawl survey (G2784). Both indices were presented and accepted during the WKWEST (ICES, 2021a) and was consequently used in the WGBIE assessment of this stock since then (ICES, 2021c).

8.5.1.1 Standardized biomass index from the Spanish IBTS-Q4 bottom trawl survey (G2784)

Common sole data were collected during the Spanish IBTS-Q4 bottom trawl survey (G2784) performed by the Instituto Español de Oceanografía (IEO) in autumn (September and October) between 2000 and 2022. Surveys were conducted on the northern continental shelf of the Iberian Peninsula (ICES divisions 8.c and the northern part of 9.a) which has a total surface area of almost 18 000 km^2. Surveys were performed using a stratified sampling design based on depth with three depth strata: 70–120 m, 121–200 m, and 201–500 m. Sampling stations consisted of 30 min trawling hauls located within each stratum at the same fixed positions every year. The gear used is the baka 44/60 and the survey follows the protocol of the International Bottom Trawl Survey Working Group (IBTSWG) of ICES (ICES, 2017a).

However, the common sole is a species with a biological bathymetric range between 0 and 200 meters in the Iberian Atlantic waters. The Spanish IBTS-Q4 (G2784) only covers partially the common sole bathymetric range and the resulting abundance index is probably underestimated. For this reason and with the aim of correcting this sampling bias, a hurdle Bayesian spatio-temporal was applied to this dataset (Pennino et al., 2022).

Two response variables were analysed in order to characterize the spatio-temporal behaviour of common sole individuals. Firstly, a presence/absence variable was considered to measure the probability of the species occurrence. Secondly, the weight per haul (kg) was used as an indicator of the conditional-to-presence abundance of the species.

As an environmental variable, we used depth. Bathymetry values were retrieved from the European Marine Observation and Data Network (EMODnet, http://www.emodnet.eu/) with a spatial resolution of 0.02 x 0.02 decimal degrees (20 m).

Models were fitted using the integrated nested Laplace approximation approach INLA (Rue *et al.*, 2009) in the R software (R Core Team, 2021). The spatial component was modelled using the spatial partial differential equations (SPDE) module (Lindgren *et al.*, 2011) of INLA and implementing a multivariate Gaussian distribution with zero mean and a Matérn covariance matrix (Muñoz *et al.*, 2013).

As spatio-temporal structure, we used the progressive one (Paradinas *et al.*, 2017; 2020), which contains an autoregressive ϱ parameter that controls the degree of autocorrelation between consecutive years. This ϱ parameter is bounded to [0, 1], where parameter values close to 0 represent more opportunistic behaviours and parameter values close to 1 represent more persistent distributions over time. In addition, an extra-temporal effect g(t) was added using a second-order random walk (RW2) before allowing non-linear effects. In the presence of bathymetric and spatial autocorrelation terms, g(t) can be regarded as a spatially standardized stock size temporal trend.

Occurrence (Y_{st}) was modelled using a Bernoulli distribution and conditional-to-presence abundance (Z_{st}) using a gamma distribution, which is a probability distribution that captures the overdispersion of continuous data. The means of both variables were modelled through the logit and log link functions respectively to the bathymetric and spatio-temporal effects as:

$$Y_{st} \sim Ber(\pi_{st}) \qquad (1)$$

$$Z_{st} \sim Gamma(\mu_{st}, \phi)$$

$$logit(\pi_{st}) = \alpha(Y) + f(ds) + g(t) + U_{st}(Y)$$

$$log(\mu_{st}) = \alpha(Z) + \theta\, f(ds) + \eta\, g(t) + U_{st}(Z)$$

where π_{st} represents the probability of occurrence at location *s* at time *t* and μ_{st} and ϕ are the mean and dispersion of common sole conditional-to-presence abundance. The linear predictors, which contain the effects that link the parameters π_{st} and μ_{st}, include: $\alpha(Y)$ and $\alpha(Z)$, terms that represent the intercepts of each variable respectively; ds corresponds to the depth at location s, being f(ds) the bathymetric effect modelled as a second-order random walk (RW2) smooth function parameterized as unknown values f = (f0,… fi-1)t at *i* = 14 equidistant values of ds, with hyperparameter σ representing the variance of the f(ds) model. In the same way, g(t) corresponds to the temporal trend fitted through a RW2 effect over the years. The terms f(ds) and g(t) are shared between both predictors and multiplied by θ and η in the conditional-to-presence abundance model to allow for differences in scales between both predictors (i.e. the logit transformed probability and the logarithm of the conditional-to-presence abundance); $U_{st}(Y)$ and $U_{st}(Z)$ refer to the progressive spatio-temporal structures of common sole occurrence and conditional-to-presence abundance respectively.

Following the Bayesian approach, penalised complexity priors (i.e. PC priors, weak informative priors; Simpson *et al.*, 2017) were assigned so that the probability of the spatial effect range being smaller than 0.5 degrees was 0.05, and the probability of the spatial effect variance being larger than 0.5 was 0.5. PC priors were also used for the variance of the bathymetric and the temporal trend RW2 effects. Specifically, the size of these effects was constrained by setting a 0.05 probability that sigma was greater than 0.5 and 1 respectively. Sensitivity analysis for the selection of priors was performed by testing different priors and verifying that the posterior distributions were consistent and concentrated comfortably within the support of the priors.

From this analysis, we obtained a new spatio-temporal abundance index for the period 2001-2022 (Figure 8.7).

8.5.1.2 Landings-per-unit-effort (LPUE) from Portugal

Portuguese LPUE estimates rely on fishery-dependent data derived from the polyvalent fleet and are based on the estimated *S. solea* landed weight by fishing trip. The analysis was restricted to the most important landing ports in terms of *S. solea* landed weight: Viana do Castelo, Matosinhos, Aveiro, Peniche and Setúbal. The Portuguese polyvalent fleet segment comprises multi-gear/multispecies fisheries, usually licensed to operate with more than one fishing gear (most commonly gill and trammelnets, longlines and traps), that can be deployed in the same trip, targeting different species. The period considered in the present study extends from 2011 to 2022.

The dataset was subset to trips with positive landings of the species. The LPUE standardization procedure was done via the adjustment of a General Linear Model (GLM) to the matrix data, where the response variable was the *S. solea* landed weight by trip (unit effort) and was fitted with a Gamma distribution. Several variables were evaluated as a candidate to be included in the model: region, landing port, year, semester, quarter, month and vessel size group (< 9 m and > 9 m).

All the explanatory variables were considered categorical variables. The function "*bestglm*" implemented in R software, used to select the best subset of explanatory variables (McLeod and Xu, 2010), is based on a variety of information criteria and their comparison following a simple exhaustive search algorithm (Morgan and Tatar, 1972). The diagnostic plots, distribution of residuals and the quantile-quantile (Q-Q) plots, were used to assess model fitting. Changes in deviance explained by the selected model and the proportions of deviance explained to the total explained deviance were determined and used as indicative of r^2. Finally, annual estimates of LPUE and the corresponding standard error were determined using estimated marginal means with the R package "*emmeans*" (Lenth, 2016; 2020).

The final model explained 86% of the variability and included as explanatory variables the year, the month, the landing port and the vessel size. The final LPUE index is presented in Figure 8.8. Finally, it is worth mentioning that sensitivity tests were carried out on this dataset to assess the sensibility of the model to a possible increase or reduction of the weight per trip by 25% for data from 2022. Results highlighted that the model performed well and consequently consistent outputs were obtained with the original dataset.

8.6 Biological sampling

Existing biological sampling is based on samples from commercial vessel landings.

8.6.1 Population biology parameters and a summary of other research

S. solea maturity ogives by sex, length-weight relationship, sex-ratio by length are based on port sampling and are available from 2012 for Division 9.a (Jardim, *et al.*, 2011).

8.7 Assessment

8.7.1 Length-based indicators (LBI) method

The assessment of this stock is provided using the Length Based Indicators (LBI; ICES 2017b) method, as approved during the recent benchmark (ICES, 2021). Length-based indicators are calculated from LFDs obtained from the catches or landings which are then compared to appropriate reference levels derived from life-history parameters. These indicators are related to conservation, optimal yield and length distribution relative to expectations under maximum sustainable yield (MSY) and, thus, can provide an overall perception of the stock status (ICES, 2018).

For the LBI implementation, life-history parameters considered were:

- M/K = 1.41, derived from M = 0.31 (from Cerim *et al*., 2020) and K = 0.22 (assuming the mean value of both sexes with K = 0.23 for females and K = 0.21 for males from Teixeira and Cabral (2010)).
- L_∞ = 48.9 cm (corresponding to the mean of females L_∞ = 52.1 cm and males L_∞ = 45.7 cm, from Teixeira and Cabral (2010)).
- L_{mat} or L_{50} = 26 cm (the mean L_{50} was computed with males L_{50} = 25 cm and females L_{50} = 27 cm from Jardim *et al*. (2011)).
- Length–weight relationship parameters a = 0.00759 and b = 3.06 (Bayesian length-weight model based on LWR estimates for this species (Fröese *et al*., 2014)).

The LBI method (ICES, 2017b) was adjusted using the above values and defined as the reference model. A sensitivity analysis of the parameters L_∞, M/K and $L_{50\%}$ (around the literature/reference values) was also carried out overestimating and underestimating them by 5 and 10%.

From the reference model, we can conclude that the stock is exploited at the MSY level and the optimal yield is attained (Table 8.3 and Figure 8.9). Immature individuals are well preserved whereas the proportion of mega-spawners is low, although it has been increased in the last years.

Finally, the sensitivity analysis shows that (Figure 8.10):

- L_∞: overestimation of this parameter leads to a decrease in the proportion of mega-spawners and also affects the MSY indicator, although this indicator is red for some years it is not worrisome since its values are close to 1. Underestimation leads to the opposite situation, the proportion of mega-spawners increases attaining values above the threshold of 0.3.
- M/K: the conclusions are similar to the ones derived from the reference model (although under overestimation the proportion of mega-spawners increase and is larger or close to the threshold of 0.3).
- L_{50}: overestimation leads to a decrease in the values of the indicators related to the conservation of immatures.

8.7.2 Harvest control rule for length-based approaches

During the WKWEST benchmark in 2021 (ICES, 2021a), it was decided that the LBI (L_{mean} / $L_{F=M}$) was best suited to reflect the status of the stock. Using this method as basis, the ICES framework for category 3 stocks (ICES, 2023) is applied where the '*rfb*' rule (Method 2.1 in ICES, 2022) is used to provide the MSY advice (Annex III of WKLIFE VIII in ICES, 2020). As a stock biomass index, it is used as a weighted sum of the Portuguese LPUE and the Spanish Bayesian survey index with weights varying by year according to the percentage of catches of each of the countries (i.e. Spain and Portugal). In this setting, the two indices are standardized before their application (for details on the combined index for the period 2011-2022, see Table 8.4):

Indexyear = ½ *[S-BayesianIndexyear/mean(S-BayesianIndex) + P-LPUEyear/(mean(P-LPUE)]

The catch rule is defined as:

$$A_{y+1}=m*A_y*r*f*b,$$

where the advised catch for next year A_{y+1} is based on the most recent catch advice (A_{2023} = 320 t) adjusted by the following components:

- r: The rate of change in the index, based on the average of the two most recent years of data (y−2 to y−1) relative to the average of the three years prior to the most recent two (y−3 to y−5), and termed the "2-over-3" rule (r = 0.86 / 1.01 = 0.85).
- f: The ratio of the mean length in the observed catch that is above the length of first capture relative to the target reference length (mean length/target reference length). The target reference length is $L_{F=M}=(1-a)*L_c+a*L_{inf}$, being a=1/(2*(M/k)+1) and L_c the length at 50% of modal abundance. Note that the "mean length" (numerator of the ratio) is derived from LBI estimate of L_{mean} (mean length of individuals > L_c) in the year y-1. $L_{F=M}$ value is also equal to the LBI estimate for year y-1 (f = 34.52 / 33.10 = 1.04)
- b: Adjustment to reduce catch when the most recent index data I_{y-1} is less than $I_{trigger}$=1.4*I_{loss} such that b is set equal to $I_{y-1}/I_{trigger}$. I_{loss} is generally defined as the lowest observed index value for that stock (minimum of the hold time series index). For advice in 2023, the lowest observed index value was 2011 (0.78), hence $I_{trigger}$= 1.4 * 0.78 = 1.09; I_{2022} = 0.89; b = 0.82.

m: Multiplier applied to the harvest control rule to maintain the probability of the biomass declining below B_{lim} to less than 5%. May range from 0 to 1.0. Medium-lived stocks with k between 0.20 and 0.32 (in our case, K=0.22) should apply a multiplier of 0.90 to next year's estimated catch.

$$A_{2024,\,2025} = 0.9 * 320 * 0.85 * 1.04 * 0.82 = 209\text{ t},$$

This catch advice for each of the years 2024 and 2025 is 35% lower than that provided in 2021 for each of the years for 2022 and 2023 (ICES, 2021c).

8.7.3 Other indicators

Although in the WKWEST benchmark (ICES, 2021a) it was advised that the LBI is the preferred method for this stock, the LBSPR and MLZ (ICES, 2015) were also computed to check if all the data-poor methods agree on the stock status. However, results of the LBI, LBSPR and MLZ should be taken with caution as not all the assumptions of these methods are fully covered by this stock. ICES (2015), on the other hand, considers that LBSPR and MLZ indicators are preferred over LBI.

Length-based spawning potential ratio (LBSPR)

The values of the life-history parameters derived from a literature review are the following ones:

- M = 0.31 (by Cerim *et al*., 2020), K = 0.22 (from Teixeira and Cabral, 2010, assuming the mean value of both sexes, as mentioned for LBI method) and consequently M/K = 1.41.
- L_∞ = 48.9 cm (see LBI method).
- L_{50} = 26 cm (see LBI method).
- L_{95} = 27.5 cm (derived from Bay of Biscay sole, i.e. sol.27.8ab Stock Annex).

The LFDs are the same as those used for the LBI method (ICES, 2017b).

The SPR values for this stock vary from a minimum of 0.28 in 2015 to a maximum of 0.44 in 2022 (Figure 8.11). The SPR value for 2022 is 0.44. Overall, the SPR trend is increasing and within the recommended range of 0.30–0.40.

Mean length-based mortality estimators (MLZ)

The Then *et al.* (2018) MLZ method was applied for this stock. Then *et al.* (2018) developed a new formulation of the Gedamke-Hoenig estimator (Gedamke and Hoenig, 2006), which uses additional information from a time-series of fishing effort to estimate the catchability coefficient q and the natural mortality rate (M) and, thus, obtaining a year-specific total (Z) and fishing mortality (F) rates.

The values of the life-history parameters derived from a literature review are the following:

- K = 0.22 (see LBI method).
- L_∞ = 48.9 cm (see LBI method).

The effort time-series was derived from the ratio of the catch and the Portuguese commercial LPUE series. It is worth to note that this effort time-series only covers Portugal and, thus, it is not representative of the total effort applied to this stock.

The output from the model indicates that the F estimates range from a maximum of 0.21 at the beginning of the time-series (2012) to a minimum of 0.11 in 2022 (Figure 8.12). Overall, the F time-series shows a decreasing pattern.

In addition, the Yield-Per-Recruit (YPR) estimations produce a F_{max} value of 1.04 and a $F_{0.1}$ value of 0.32 (Figure 8.13).

8.8 General problems

S. solea (SOL) is officially reported to ICES from Spain and France to WGBIE through InterCatch by Division since 2009 by Spain and since 2011 by Portugal. For the other *Soleidae* species distributed in 8.c and 9.a, namely *S. senegalensis*, *P. lascaris* and *Solea* spp., the information is not officially reported to ICES but was obtained as a data call requirement for the WKWEST benchmark of the *S. solea* in 2021 (ICES, 2021a). The advice is provided for *S. solea* while for the others species, the reported landings for the period 2011 to 2020 were revised during the WKWEST benchmark (ICES, 2021a).

8.9 References

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8.10 Tables and figures

Table 8. 1. Percentage of *S. Solea*, *S. senegalensis*, *P. lascaris* and *Solea spp.* in the total landed weight of sole species from 2009–2022.

Year	*S. solea*	*S. senegalensis*	*P. lascaris*	*Solea* spp.
2009*	100	0	0	0
2010*	100	0	0	0
2011	48	28	22	2
2012	47	25	26	2
2013	52	20	26	2
2014	53	28	18	1
2015	66	20	13	1
2016	69	18	13	0
2017	65	20	14	1
2018	62	25	13	1
2019	54	25	21	0
2020	50	29	21	0
2021	49	26	25	0
2022	46	22	32	0

Table 8. 2. Catches (in tonnes) of *S. Solea, S. senegalensis, P. lascaris* and *Solea* spp. from 2009–2022.

Year	*S. solea*	*S. senegalensis*	*P. lascaris*	*Solea* spp.	Total catch
2009*	190				190
2010*	236				247
2011	447	261	206	14	928
2012	354	191	200	14	759
2013	448	171	219	17	855
2014	456	243	156	10	867
2015	521	161	101	5	787
2016	485	126	94	2	707
2017	491	147	107	5	751
2018	430	171	92	5	698

Year	*S. solea*	*S. senegalensis*	*P. lascaris*	*Solea* spp.	Total catch
2019	399	186	159	1	745
2020	430	248	183	1	864
2021	372	199	188	2	760
2022	301	144	208	2	654

*** No Portuguese data available in 2009 and 2010.**

Table 8.3. Sole (*S. solea*) in divisions 8c and 9a. Traffic light indicator table for the LBI analysis.

Year	Conservation				Optimizing Yield	MSY
	L_c/L_{mat}	$L_{25\%}/L_{mat}$	$L_{max5\%}/L_{\infty}$	P_{mega}	L_{mean}/L_{opt}	$L_{mean}/L_{F=M}$
2011	1.10	1.10	0.94	0.13	1.00	0.99
2012	0.83	1.02	0.90	0.17	0.96	1.12
2013	1.02	1.10	0.89	0.14	0.99	1.01
2014	1.02	1.10	0.91	0.15	0.99	1.02
2015	1.06	1.10	0.88	0.12	0.98	0.98
2016	0.87	0.98	0.93	0.17	0.95	1.08
2017	1.10	1.13	0.91	0.15	1.02	1.00
2018	1.02	1.10	0.93	0.18	1.00	1.03
2019	1.13	1.17	0.94	0.23	1.05	1.01
2020	1.06	1.10	0.89	0.20	1.03	1.03
2021	1.10	1.13	0.93	0.18	1.03	1.01
2022	1.06	1.17	0.94	0.24	1.04	1.04

Table 8.4. Sole (*S. solea*) in divisions 8c and 9a. Combined stock biomass index from commercial Portuguese LPUE and the Spanish North bottom trawl survey (IBTS Q4 [G2784]) for the period 2011-2022.

Year	Combined biomass index
2011	0.78
2012	0.79
2013	1.21
2014	1.10
2015	1.17
2016	1.15
2017	1.12

Year	Combined biomass index
2018	1.05
2019	1.01
2020	0.96
2021	0.83
2022	0.89

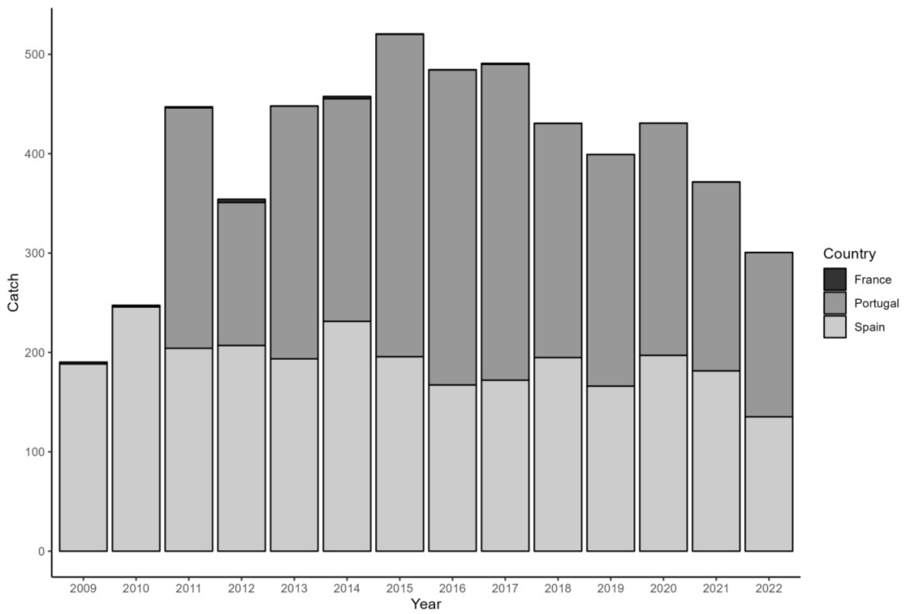

Figure 8.1. Sole (*S. solea*) in divisions 8c and 9a. Catches (in tonnes) by country from 2009 to 2022. Source: InterCatch. Note that in 2009–2010 no Portuguese data were available.

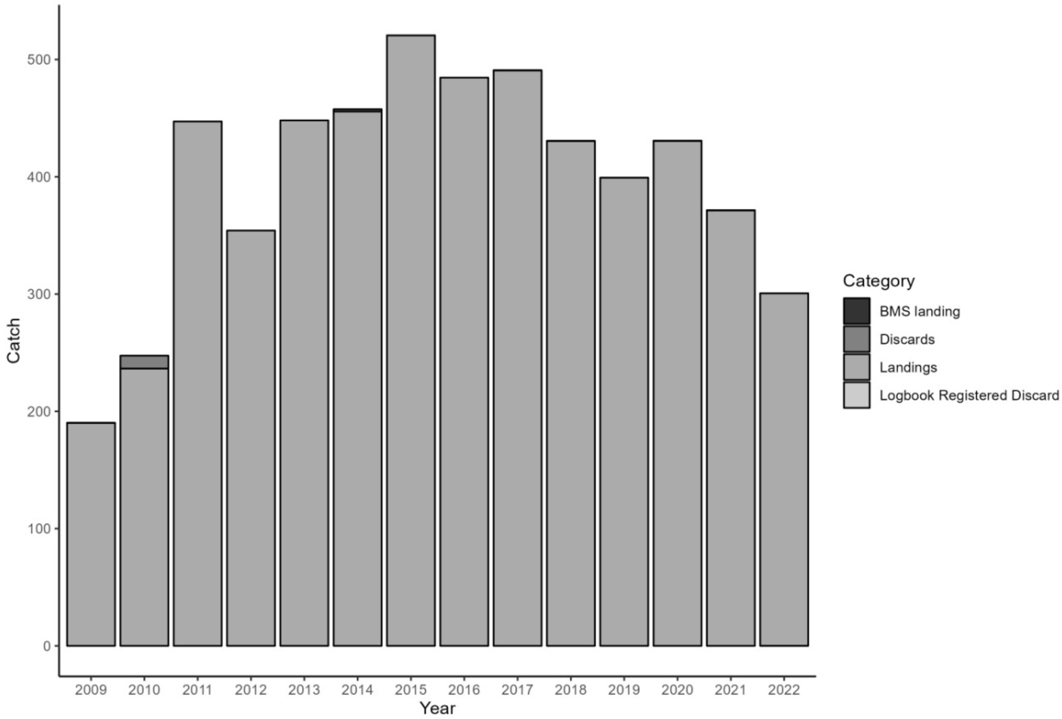

Figure 8.2. Sole (*S. solea*) in divisions 8c and 9a. Catches (in tonnes) by category (landings, discards, and BMS landing) in the ICES divisions 8.c and 9.a for Spain and France (2009–2022) and Portugal (2011–2022). Source data: InterCatch.

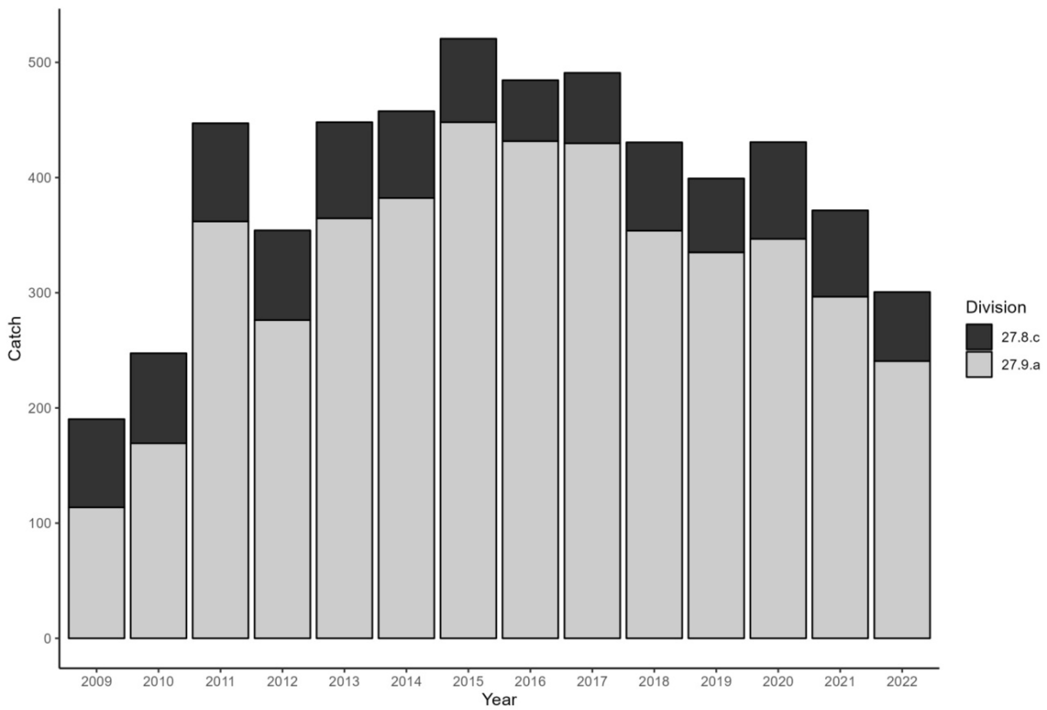

Figure 8.3. Sole (*S. solea*) in divisions 8c and 9a. Catches (in tonnes) for Spain and France (2009–2022) and Portugal (2011–2022). Source data: InterCatch.

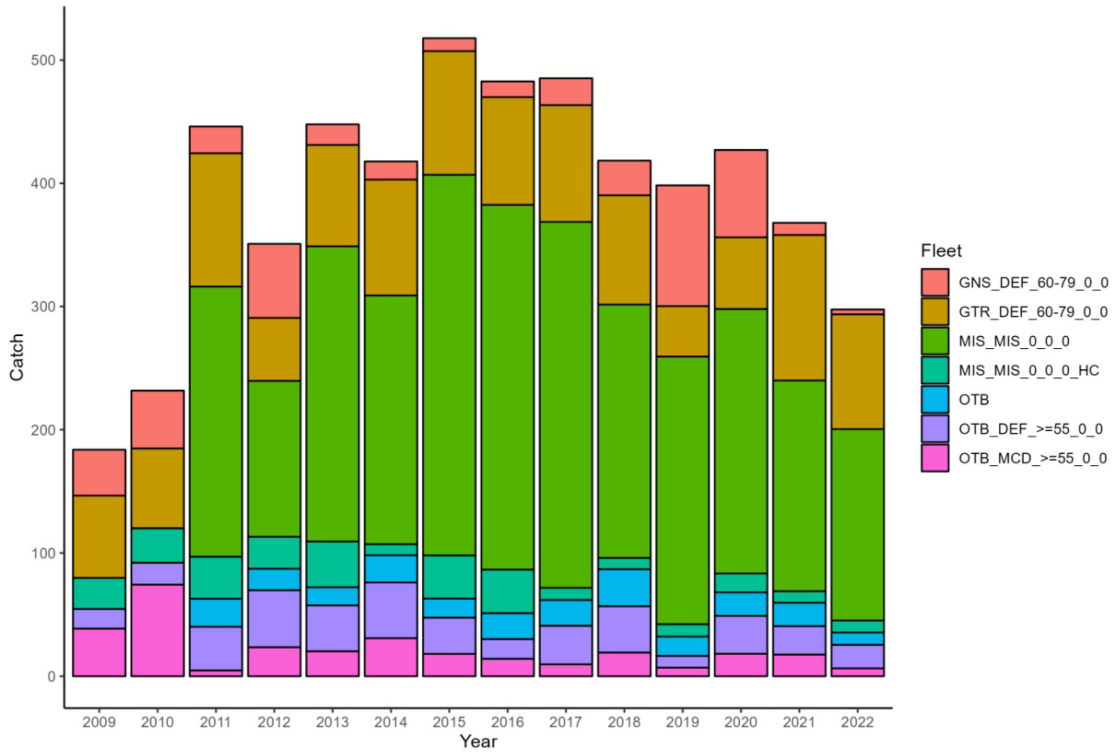

Figure 8.4. Sole (*S. solea*) in divisions 8c and 9a. Catches per main fleet in the ICES divisions 8.c and 9.a for Spain and France (2009–2022) and Portugal (2011–2022). Source data: InterCatch.

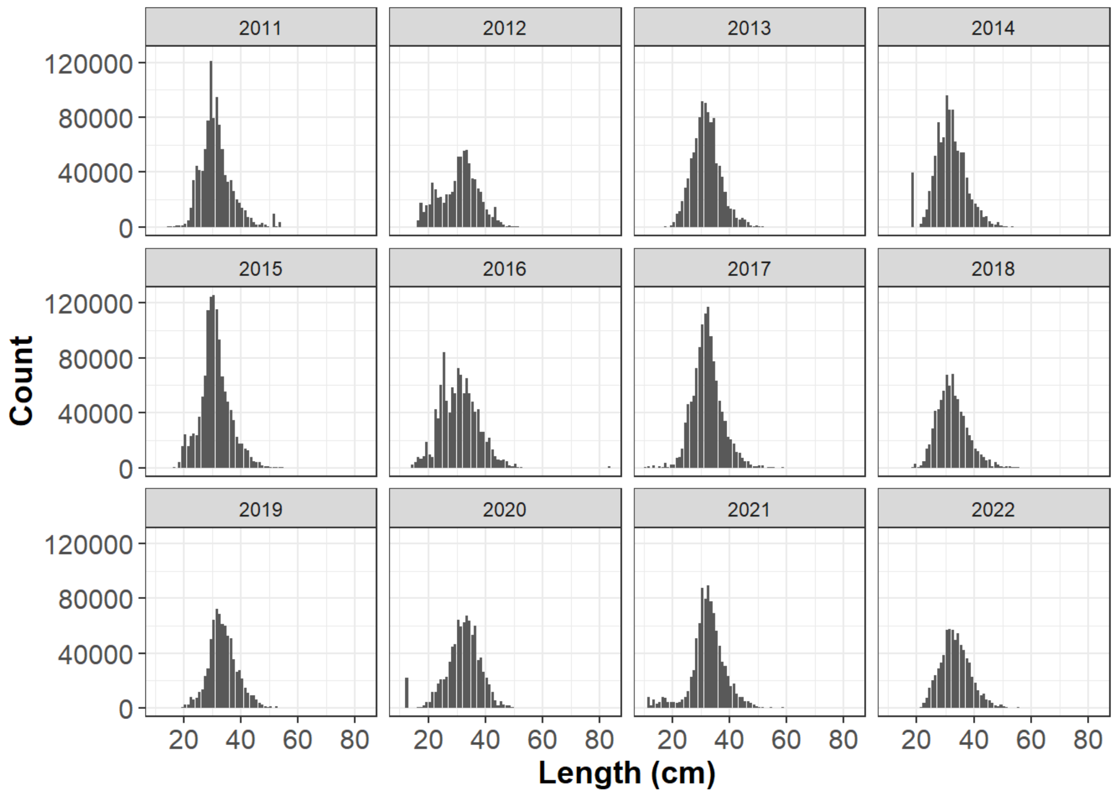

Figure 8.5. Sole (*S. solea*) in divisions 8c and 9a. Annual length-frequency distribution of catches for the period 2011–2022, for Portugal and Spain. Source data: InterCatch.

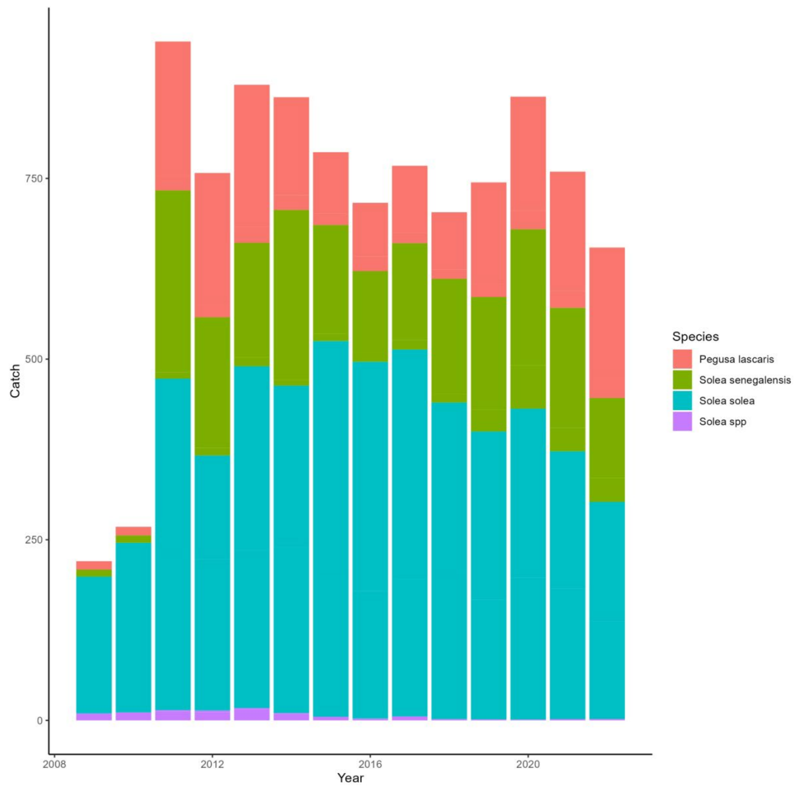

Figure 8.6. Sole (*S.solea*) in divisions 8c and 9a. Combined landings (in tonnes) from Spain and Portugal for the period 2009–2022. Please note that in 2009–2010 no Portuguese data were available.

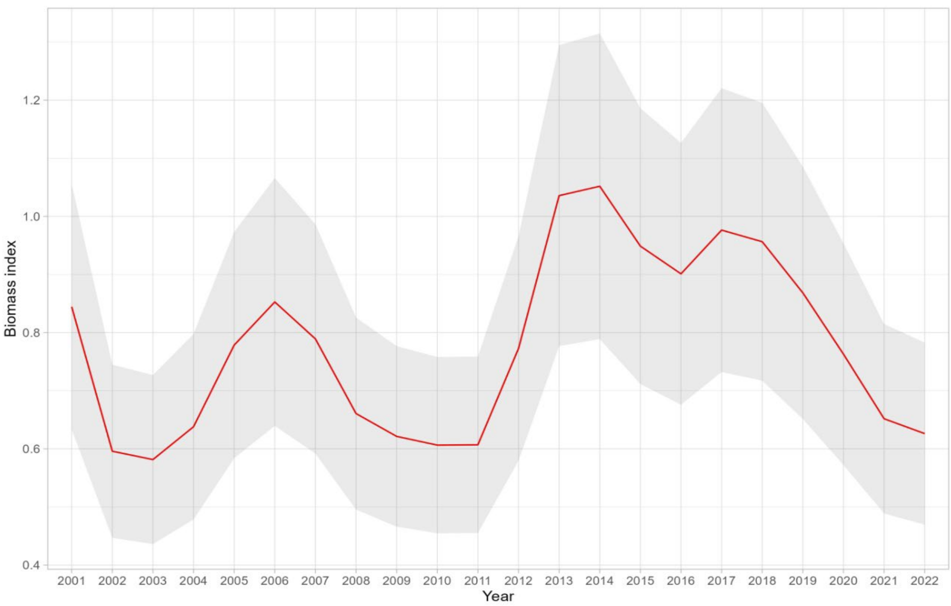

Figure 8.7. Sole (*S. solea*) in divisions 8c and 9a. Temporal trend of the spatio-temporal biomass index for the Spanish IBTS-Q4 bottom-trawl (G2784) survey for the period 2001-2022.

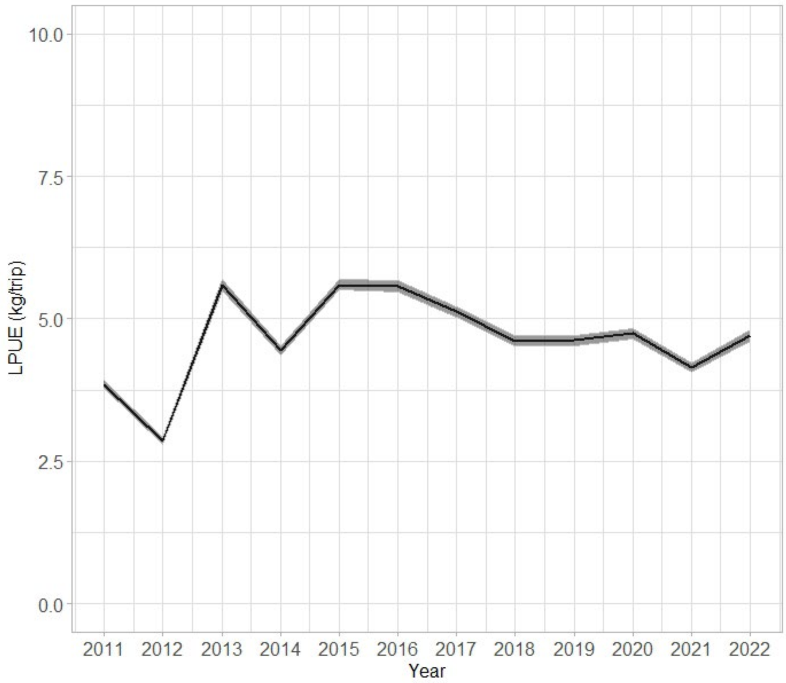

Figure 8.8. Sole (*S. solea*) in divisions 8c and 9a. Standardized commercial LPUE of the Portuguese polyvalent fleet in ICES Subdivision 9.a for the period 2011–2022.

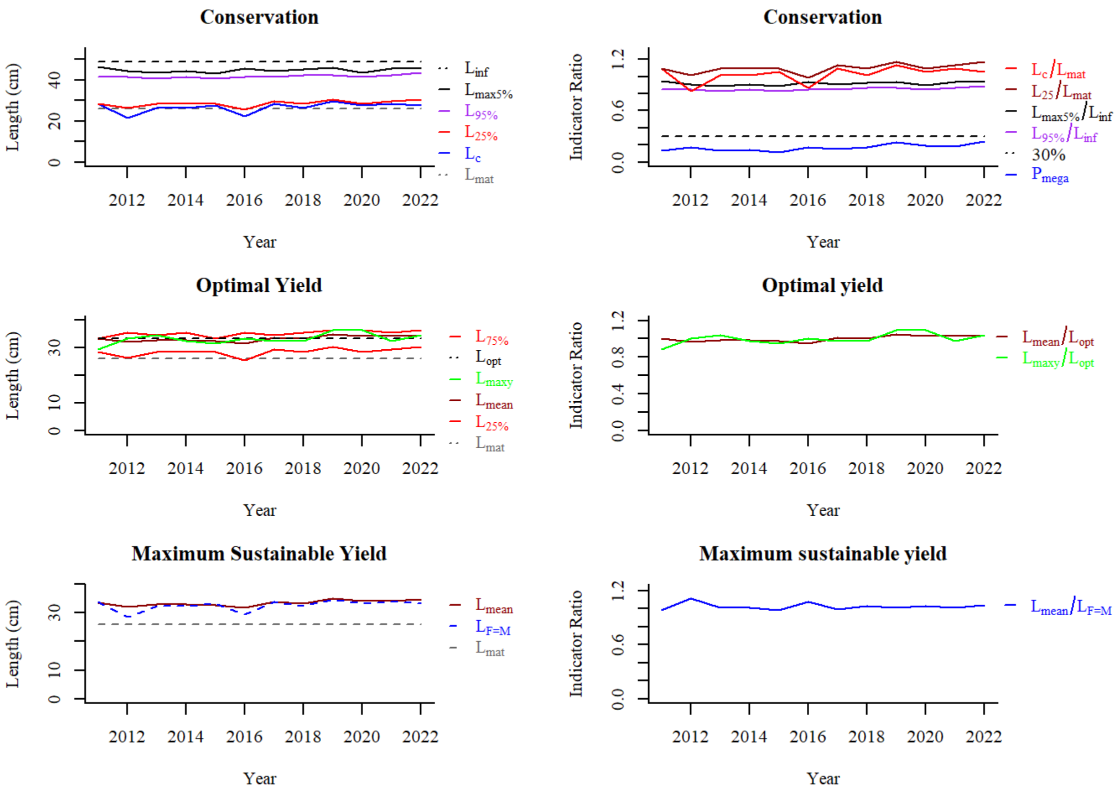

Figure 8.9. Sole (*S. solea*) in divisions 8c and 9a. LBI indicators for the period 2011–20212.

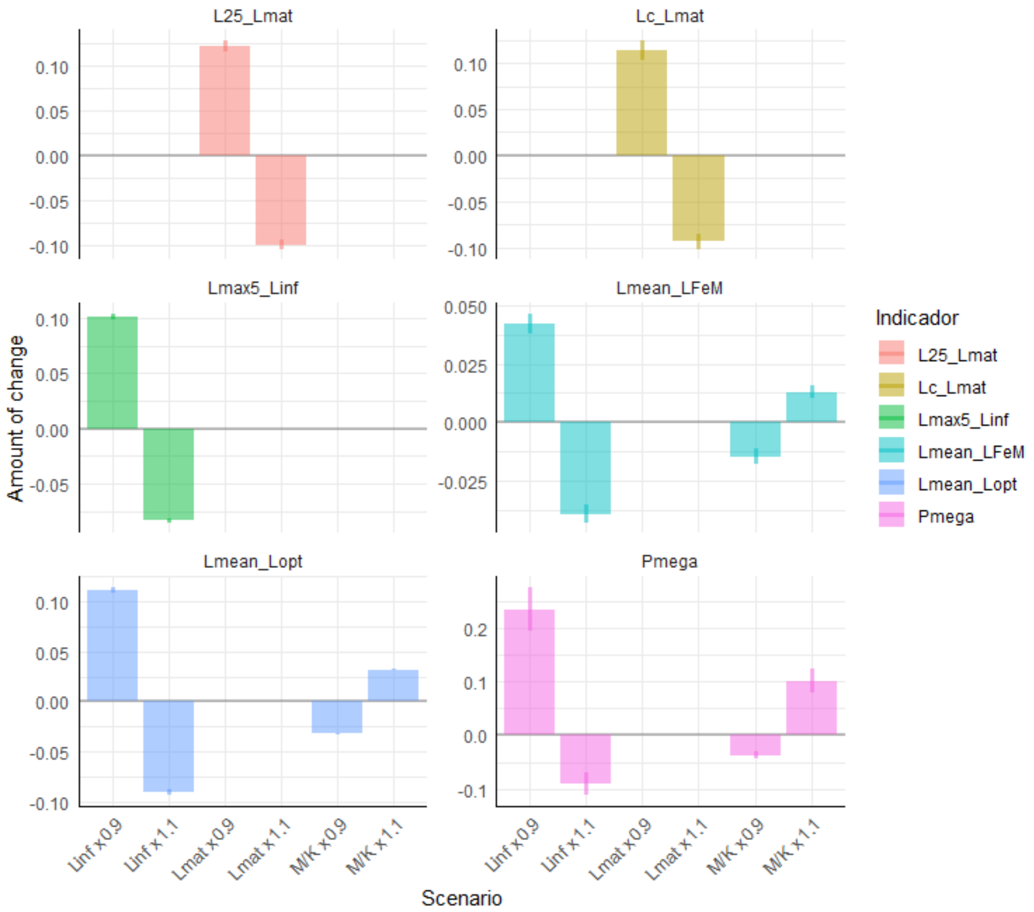

Figure 8.10. Sole (*S. solea*) in divisions 8c and 9a. LBI sensitivity analysis using both the underestimation and overestimation of L_{inf}, M/K and L_{50} parameters with respect to the selected model values. The 95% confidence limits are represented by a vertical line.

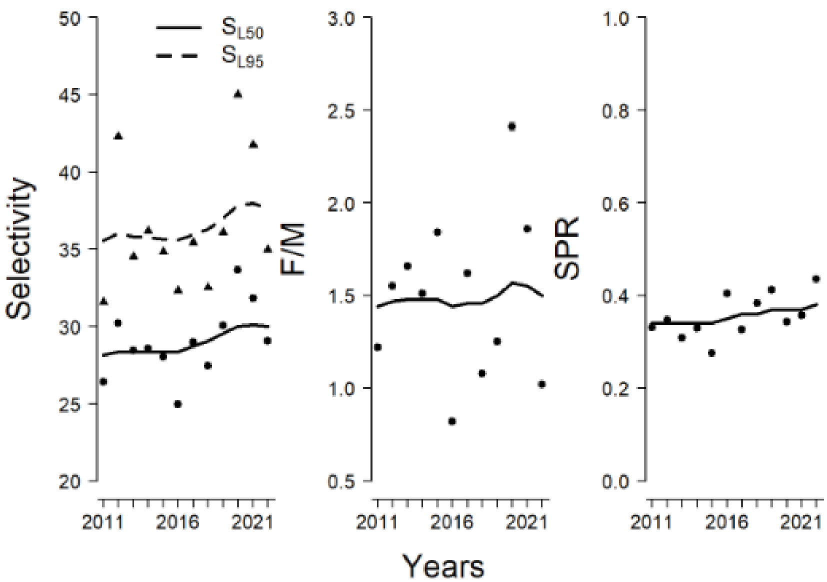

Figure 8.11. Sole (*S. solea*) in divisions 8c and 9a. Results of the LBSPR analysis for the period 2011–2022.

Figure 8.12. Sole (*S. solea*) in divisions 8c and 9a. Fishing mortality trend computed using the MLZ model for the period 2011–2022.

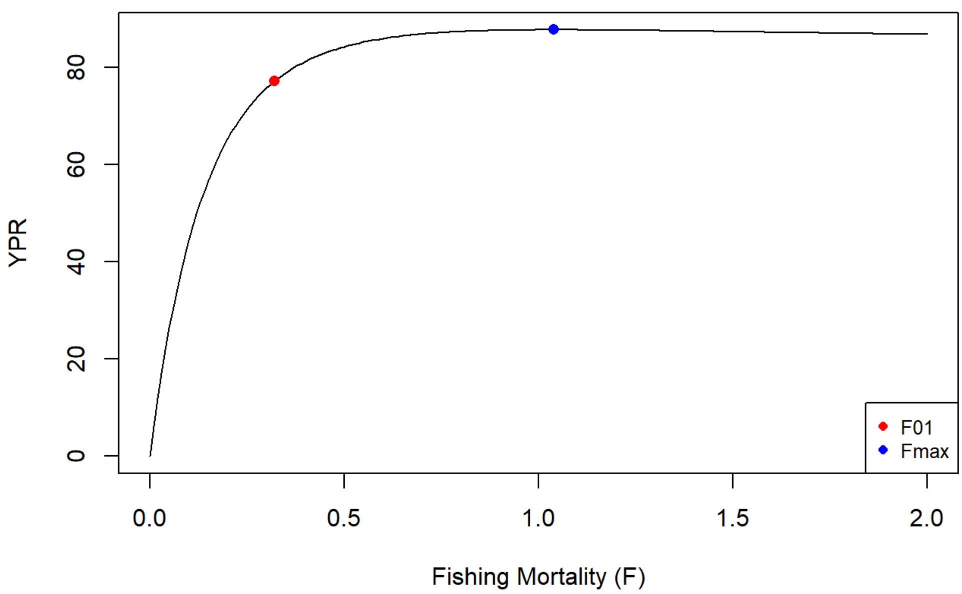

Figure 8.13. Sole (*S. solea*) in divisions 8c and 9a. Yield-per-recruits approximation obtained from the MLZ analysis for the period 2011–2022.

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