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Section contents

10 Hake in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

Merluccius merluccius – hke.27.8c9a

10.1 General

The type of assessment is an "update" based on a category 3 assessment (ICES, 2012; ICES, 2019) using the relative biomass index trends. This year's assessment was updated with the 2020 data with no revisions made to previous years' data.

10.1.1 Fishery description

Fishery description is available in the Stock Annex.

10.1.2 ICES advice for 2021 and management applicable to 2020 and 2021.

10.1.2.1 ICES advice for 2021

ICES advises that when the precautionary approach is applied, catches in 2022 should be no more than 6947 t.

10.1.2.2 Management applicable for 2020 and 2021

Hake is managed by a TAC, effort control and technical measures. The agreed TAC for Southern Hake in 2020 and 2021 were 8752 and 8517 t, respectively.

Southern hake is included in the EU MAP for Western Waters and adjacent waters (EU, 2019b). The target fishing mortality (F), in line with the ranges of F_{MSY}, shall be achieved by 2020.

EU regulation includes effort management measures, limiting days at sea for each country (annex II-b of EU, 2018). This stock is under partial landing obligation since 2016 with a *de minimis* exemption. During this year, ongoing studies to evaluate the *de minimis* exemption for the southern hake stock are being carried out by regional scientific and administration bodies with the collaboration of the SWWAC (South Western Waters Advisory Council).

Technical measures applied to this stock include: (i) minimum landing size of 27 cm, (ii) protected areas (seasonal or closed to some gears), and (iii) minimum mesh size. These measures are set, depending on areas and gears, by several national regulations.

According to the Spanish Regulations progressively implemented after 2011 AAA/1307/2013, the Spanish quota is shared by individual vessels. This regulation was updated in 2015 (AAA/2534/2015) including a fishing plan for trawlers. Also, every year until 2017, Portuguese Regulations determined the distribution of the Portuguese hake quota by individual vessels. Regulations (EU, 1998) also established a closure for trawling off the northwest coast of Spain from October to January and the southwest of Portugal from December to February. A new regulation on technical measures was adopted in 2019 (EU, 2019b), repealing the previous regulation implemented in 1998 (EU, 1998), but these closures were kept in the new formulation.

10.2 Data

10.2.1 Commercial catch: landings and discards

Southern hake catches by country and gear for the period 1972–2020, as estimated by the WG, are given in Table 10.1. Since 2011, estimates of unallocated or non-reported landings have been included in the assessment. These were estimated based on the sampled vessels (Spanish concurrent sampling) multiplied by the total effort for each *métier*. Some Spanish discards for 2020 were uploaded to InterCatch as zeroes when, in fact, these were "non-sampled". These were estimated based on the effort and catches from the same *métiers*. Spanish discards reported to InterCatch were 174.5 t (including BMS 85 kg) but the value estimated is 211 t. Discards by Portuguese trawl fleets were estimated at 282 t (Fernandes, 2021; WD 7 in ICES, 2021).

Overall landings decreased from 11 800 t in 2019 to 8732 t in 2020. Portuguese official landings decreased from 1915 t in 2019 to 1904 t in 2020. Spanish official landings decreased from 7267 t in 2019 to 6570 t in 2020. Non-reported landings decreased from 2612 t in 2019 to 206 t in 2020. Total discards in 2019 were 1061 t and decreased to 438 t in 2020. Total catches were 12 861 t in 2019 and decreased to 9171 in 2020. The TAC for 2020 was 8752 t which means that total catches exceeded the TAC.

In general, sampling coverage was reduced compared to previous years. The sampling programs coordinated by the IEO (onshore, observers at sea and biological sampling) were partially suspended during 2020 due to administrative problems and to the COVID-19 disruption. This mainly affects the estimated amount of Spanish discards (211 t) and the unallocated amounts that Spain estimates for landings (206 t). These two figures are considered underestimated although the amount is unknown. However, none of these affect the TAC advice which is estimated based on biomass indices. Further work is needed to provide more accurate figures for the next benchmark.

Also due to the pandemic disruption, the Portuguese on-board sampling program was affected with very few trips of OTB_DEF sampled in 2020 and no trips sampled from OTB_CRU. As sampling effort was considered not representative of the trawl fishing effort, Portuguese discards were estimated based on the average of the last 3 years discard rates (Fernandes, 2021; WD 7 in ICES, 2021).

Length distributions for 2020 landings and discards are presented in Figure 10.1 and in Table 10.2. Mean size in the landings has been stable but shows a slight increase from 32.3 cm in 2018 to 34.0 cm in 2019 and 35.3 in 2020. Discards decreased in mean size from 24.2 cm in 2018 to 19.3 cm in 2019 and 17.4 in 2020. Mean size in the catch is quite stable with 29.3 cm in 2018, 28.7 cm in 2019 and 29.8 cm in 2020.

Length distributions obtained in 2020 have been affected by the reduced sampling levels and should be considered with caution.

10.2.2 Growth, length-weight relationship and M

Category 3 advice rule does not depend on biological parameters. However, these are needed for the proxy reference points analysis based on data-limited methods. The parameters used in previous GADGET (Begley and Howell, 2004; Begley, 2005) assessments were used for this purpose. An international length-weight relationship for the whole period (a = 0.00659; b = 3.01721) was estimated. The growth follows a constant *von* Bertalanffy model with fixed L_{inf} = 130 cm, t_0 = 0 and estimating K = 0.165. Natural mortality (M) was assumed to be 0.4 year^{-1} for all ages and years.

10.2.3 Maturity ogive

The stock is assessed with annual maturity ogives for males and females together. The maturity proportion in this assessment year is shown in Figure 10.2. L_{50} has shown a general declining trend with figures above 35 cm before 2010 and decreasing afterwards. It has oscillated from 34.5 cm in 2016, to 30.3 cm in both 2017 and 2018 and 31.6 cm in 2019.

10.2.4 Abundance indices from surveys

Biomass, abundance and recruitment indices for the Portuguese and Spanish surveys are presented in Table 10.3 and Table 10.4, respectively. Recruitment and biomass indices are shown in Figure 10.3 for the Spanish SpGFS-WIBTS-Q4 (G2784), SPGFS-caut-WIBTS-Q4 (G4309) and for the Portuguese PtGFS-WIBTS-Q4 (G8899). These three surveys together cover the whole geographic area of the stock and are conducted simultaneously in autumn to minimize any source of variability. They are part of the IBTS survey group (ICES, 2017c), which further ensures the use of the same methodology.

The Portuguese Autumn survey (PtGFS-WIBTS-Q4-G8899) was not carried out in 2019 or 2020. The time-series showed variable abundance indices with a maximum in 1981 and a minimum in 1993. The survey did not take place in 2012. Low values for biomass and abundance were observed in the early 2000s and then increased after 2004. Maximum historical values were observed in 2008–2010, 2013 and 2015. Values in 2016, 2017 and 2018 were rather stable and near the historical mean. The Portuguese research vessel had some technical problems during the 2018 survey and 12 fishing stations, mainly in the Southwest area, were carried out using different fishing gear. Data have been standardized to allow for comparable hauls. The Spanish groundfish survey SpGFS-WIBTS-Q4 (G2784) shows a similar trend with low values for biomass and abundance in the early 2000s. These values increased after 2004 reaching a maximum in 2009–2012 and 2015. The estimates from 2019 and 2020 are very similar and around the historical mean. Figure 10.3 shows that the recruitment indices of the SpGFS-WIBTS-Q4 (G2784), SPGFS-caut-WIBTS-Q4 (G4309) and PtGFS-WIBTS-Q4 (G8899) were highly variable in the past. In 2014, the 3 surveys decreased below historical means, but in 2015 the PtGFS-WIBTS-Q4 reached a historical maximum, while both SpGFS-WIBTS-Q4 and SPGFS-caut-WIBTS-Q4 returned to above-average values. In the latest years, all surveys show the same trends with a peak in 2015 followed by a decreasing trend afterwards, except for SPGFS-caut-WIBTS-Q4 which reached a historical maximum in 2019. In 2020, the value from SpGFS-WIBTS-Q4 (G2784) was slightly below the historical mean, while that from the SpGFS-caut-WIBTS-Q4 was at low levels.

10.2.5 Commercial catch-effort data

Effort and respective landings series are collected from Portuguese logbooks maintained by the Portuguese fisheries administration (DGRM – General Directorate for Natural Resources, Safety and Maritime Services) and compiled by IPMA. For the Portuguese fleets, until 2011 most logbooks were filled in on paper but have thereafter been progressively replaced by e-logbooks for those vessels covered by the regulation (vessels longer than 15 m). All vessels in the recovery plan are required to be equipped with an e-logbook system. The standardized cpue from the Portuguese bottom-trawl fleet targeting groundfish is calculated by fitting a GLM to logbook data on landings and effort (modulated by additional fleet and catch characteristics), following the methods described in the Stock Annex and accepted by WKROUND (ICES, 2010). The latest series is based on a renewed extraction of the complete logbook dataset housed in the DGRM databases, which includes both paper and e-logbooks.

Spanish sales notes and Owners Associations data were compiled by IEO to estimate the SP-CORUTR fleet effort until 2012. After 2012, effort was reported following the logbooks. The full LPUE series is presented in Figure 10.4 and Table 10.5. Changes in effort and landings estimation method prevented the use of SP-CORUTR data as a continuous series after 2012. The increased surveillance and the implementation of management regulations after 2011 have altered the fleet behaviour, preventing its use as a new fleet for model calibration purposes.

Since 2008, P-TR LPUE has been consistently above the historical mean (39.9 kg/hour) with a peak in 2015. The 2020 LPUE (40.8 kg/hour) is slightly above average.

10.3 Catch options with category 3

Figure 10.5 (left) shows the standardized (St) biomass index trend (divided by the mean) for 2 surveys (SpGFS-WIBTS-Q4-G2784 and PtGFS-WIBTS-Q4-G8899) and the standardized stock size indicator (right) from 2 combined commercial fleets (SP-CORUTR and P-TR LPUEs). Although these data are noisy, there is a common pattern with values below the historical mean at the beginning, an increase after 2004 until around 2010 followed by a slightly decreasing trend since 2015 although most of the values in recent years were still above the mean.

SpGFS-WIBTS-Q4 (G2784) and P-TR LPUE are the only time-series data used for the stock size indicator for the Category 3 advice calculation that requires representative trends having, at least, the last 5 years available. Neither SPGFS-caut-WIBTS-Q4 (G4309) [1997 to 2020], due to the small area coverage, nor the PtGFS-WIBTS-Q4 (G8899) [1989 to 2018]), because the survey was not performed in 2019–2020, was used.

The indicator for stock size (Figure 10.5, right) was calculated as the mean (years 1989–2020) of the two valid relative indices (SpGFS-WIBTS-Q4 (G2784), in red and P-TR LPUE in blue). The stock size indicator (SSI) is variable, although it shows an increasing trend from values below the historical mean at the beginning of the time-series and above in the more recent period. Because of the high variability of the time-series, it shows a decrease in recent years although remaining above the mean.

$SSI_y = ½ * [(SpGFS_y/mean(SpGFS) + (P\text{-}TR_y/mean(P\text{-}TR)]$

Index A (mean 2019–2020) is 1.06 and Index B (2016–2018) is 1.19 resulting in a ratio 0.89

Figure 10.6 (left) shows the relative F trends estimated as yearly catch (C) divided by each biomass index. A mean standardized fishing pressure index is then calculated using the two F indices. The plot shows 3 trends (SpGFS-WIBTS-Q4-G2784 in red; PtGFS-WIBTS-Q4-G8899, in green and P-TR, in blue) although the mean (right plot) corresponds to the same two series used in the stock size indicator estimation. The index shows high variability, increasing after 2004, peaking in 2008 and decreasing afterwards reaching figures below the mean of the time-series in the last 5 years.

10.4 Biological reference points

10.4.1 Reference points

ICES currently uses MSY proxy reference points as part of a Precautionary Approach to provide advice on the status of the stock and exploitation (ICES, 2016). The ICES approach to the provision of scientific advice in Category 3 does not use a B_{MSY} estimate but instead, an MSY $B_{trigger}$, which is considered the lower bound of stock size fluctuation around B_{MSY}. It is a reference point that triggers a cautionary response, in the form of reduced F, to allow the stock to rebuild. There are four methods approved by ICES (2015; 2018) for the calculation of MSY reference points for category 3 stocks. These are:

- Length based indicators (LBI)
- Mean length Z (MLZ)
- Length based spawning potential ratio (LBSPR; Hordyk *et al.*, 2015)
- Surplus Production model in Continuous Time (SPiCT; Pedersen and Berg, 2017)

ICES (2018) recommends that all methods should be explored, if possible because agreement between different models strengthens inference while disagreements among methods can highlight problems with data or model assumptions. However, ICES (2018) also recommends that if SPiCT diagnostics are acceptable, then SPiCT should be used as the basis for further analyses; if unacceptable, analyses based on length data only should be considered instead.

10.4.2 Data

The data required to perform all four methods are available for Southern hake since the last benchmark (ICES, 2014) and are updated annually:

- Historical catch (Table 10.1) and length distributions (Table 10.2 and Figure 10.1).
- Biomass indices used in the SPiCT calibration process are the same as those accepted for use in the GADGET model (Tables 10.3, 10.4 and 10.5), although the survey data have been modified removing fish less than 21 cm such that the index relates only to fishable biomass. An effort index was also produced dividing the total catch by the combined Spanish and Portuguese cpue (equal weighting).
- Two sets of life-history parameters were used and presented in table 10.6. The first one comes from the data used in the GADGET model (ICES, 2020) and the second from an analysis presented in WKSOUTH (ICES, 2014) to test alternative life-histories based on life-history invariants (LHI) theory.

10.4.3 Length based indicators (LBI)

Length-based indicators were calculated by year from length–frequency distributions from 2004 to 2020. They were compared to appropriate reference points related to conservation, optimal yield and length distribution relative to expectations under MSY assumptions.

Results for life-history parameters with GADGET are presented in Table 10.7 and Figure 10.7. All the indicators presented showed that conservation, optimal yield and MSY stock references were outside their optimal values. Alternative tests were provided, grouping length classes (1, 2, 3 and 4 cm length bins), using the Life-History Invariants (LHI) parameter values instead of GADGET ones (see Table 10.6). Although the results were sensitive to these changes, the main conclusions did not change, and all the indicators remained outside the bounds.

The main assumptions of applicability of LBI are: equilibrium conditions where total mortality (Z) and recruitment are constant over time; M and growth are known; selectivity follows a logistic curve.

The method assumes that input parameters are known, but hake life-history parameters such as L_{inf}, k or M are quite uncertain. Furthermore, it is known that European hake is a dimorphic species where males do not reach 70 cm compared to females that can achieve 140 cm. This presupposes that half of the population rarely reach $0.5L_{inf}$. Furthermore, hake is caught by different gear types (trawl, gillnet and longlines) with different selectivities, with gillnets and longlines catching larger fish than trawls. Gillnets and longlines are quite selective on length, with a dome shape selection. Gear size preferences (mesh size or hooks) are defined to target the most profitable length groups, partially avoiding the larger but less abundant length classes. Hake larger than 90 cm are scarce in the catches. A combination of uncertain growth and M together with the dome shape selection for larger fish can cause erroneous indicator results. Furthermore, variable recruitment can also affect the equilibrium assumption.

10.4.4 Mean length total mortality (MLZ)

Two different MLZ methods were applied: Gedamke and Hoenig (2006) and Then *et al*. (2018). Both use yearly length data to define the size of first capture and life-history parameters (Table 10.6) to define productions under the assumption of knife-edge selectivity. Using the time-series of mean length observations, the Gedamke- Hoenig (GH) estimator yields period-specific estimates of Z and the corresponding years of change in mortality. The Then method requires additional information on effort producing a yearly estimation of Z. The effort time-series used is that presented in Figure 10.6.

The quality of the fit is good (Cerviño *et al*., 2021; WD 04 in ICES, 2021) allowing the estimation of a Yield-per-recruit model giving $F_{0.1}$ and F_{max} references. The following table shows the exploitation status estimated with the two sets of life-history parameters (GADGET and LHI) and the two MLZ methods. Note that F_{last} refers to the estimated F in the last period of time that is 2017–2020 for the GH method and 2020 for the Then method.

	F_{last}	$F_{0.1}$	F_{max}	$F_{last}/F_{0.1}$	F_{last}/F_{max}
GH (GADGET)	0.22	0.17	0.25	1.32	0.89
GH (LHI)	0.14	0.13	0.18	1.12	0.81
Then (GADGET)	0.30	0.17	0.25	1.77	1.20
Then (LHI)	0.26	0.13	0.18	2.01	1.45

The Then method shows an exploitation level in 2020 above F_{max} and the GH method shows an exploitation level in the recent period (2017–2020) below F_{max} and above $F_{0.1}$.

The assumptions under MLZ method are similar to those used in the LBI methods, therefore the same limitations and caveats also apply. Growth, M and selectivity assumptions can undermine results in a similar way to that explained for the LBI methods (ICES, 2015).

10.4.5 Length based Spawning Potential Ratio (LB-SPR)

LB-SPR was developed by Hordick *et al*. (2015). Spawning Potential Ratio (SPR) is defined as the proportion of Spawning Biomass-per-recruit (SBPR) in an exploited stock with regards to SBPR in an unfished (virgin) stock. The rationale behind this model is that the abundance at length in the population decreases with age (length) because of Z. The model estimates independently yearly SPR assuming equilibrium in the population. Model assumptions are similar to the LBI and MLZ methods.

Data are the same as those used in previous methods: a representative sample of the yearly length distribution of the population (Figure 10.2) and the two sets of life-history parameters (Table 10.6).

Figure 10.8 shows the estimated values for selectivity, F/M and SPR from 2004 to 2020 for LB-SPR method using both the GADGET and LHI biological parameter values, respectively. Both fits provide quite similar results. There is a trend in the selectivity estimated to increase from 2004 until 2020. F/M is quite variable in the first part of the series (2004–2010), after which it stabilizes between 2.5 and 3. SPR increases until 2010, obtaining a maximum at around 0.1 before a slight decrease is observed. The low SPR values suggest that the stock is depleted.

The assumptions under this method are similar to those for the LBI and MLZ methods (ICES, 2015), with the same limitations and caveats. Growth, M and selectivity assumptions can undermine results in a similar way to that explained previously.

10.4.6 SPiCT (Surplus Production model in continuous time)

SPiCT (Pedersen and Berg, 2017) is a surplus production model in continuous time and requires a time-series of catch and one or more biomass indices. SPiCT can also handle one effort index.

A base run was first performed using catches from 1982 to 2020 with four biomass indices (same dataseries as those accepted for the GADGET model). This base model passed most of the diagnostic checks with the exception of the autocorrelation for three of the indices. Furthermore, the confidence bounds were considered too wide. Alternative models were explored using different settings and combinations of dataseries.

Data, R code and an HTML output files are available in the ICES WGBIE 2021 SharePoint under "data/shke/refpts/SPICT/". Alternative runs include an extension of catch data back to 1972, priors for logbkfrac, conversion of the two cpues to an effort index, weighting of catch data, exploration of fits with one index alone and different combinations of these settings.

Table 10.8 shows a summary of all models split into three groups: the main runs (4), additional exploratory runs (8) and one index runs (12). Four among those in the additional exploratory runs did not converge. In general, the main runs improved Run 1, the base case, in terms of diagnostics and reducing standard errors. However, none of these change the perception of stock or fishery status relative to reference points. This result is the most significant one to check if the B/B_{MSY} and F/F_{MSY} are robust to alternative model configuration. Additional runs are also presented in Table 10.8 confirming the robustness of the model (Cerviño *et al.*, 2021; WD 04 in ICES, 2021).

A sensitivity analysis for possible underestimation of catch in 2020 was also performed using the four main model configurations. The results showed narrower CIs for the reference points and confirmed that relative reference points are not sensitive to a possible underestimation of catches.

Given the wide CI associated with B/B_{MSY} and F/F_{MSY}. A sensitivity analysis, running multiple models which only included one index per model run, was also performed. The idea was to check whether the wide confidence intervals are caused by the implementation of four indices which may provide conflicting signals between them. The results show that, in general, the CIs are not considerably reduced, suggesting that the combination of different indices is not the cause of wide CIs. However, for the converged runs (most of them) the results regarding the reference points do not change, making the initial results more robust.

10.4.7 Conclusions

The four data-limited models implemented present different results in terms of stock and exploitation status (ICES, 2015). Models that depend on length distributions (LBI, MLZ and LBSPR) show an overexploited stock although MLZ (GH method) shows that the estimated F is below F_{MAX}. SPiCT, which does not use length distributions but time-series of catches and biomass indices, presents a healthy stock with exploitation levels within MSY boundaries.

Methods that rely on length–frequency data assume that the length distribution of catches is an unbiased representation of the length distribution in the population. However, hake is caught by different gear types (trawl, gillnet and longlines) with different selectivities. Gillnets and longlines catch larger fish. These gears are quite selective on length, with a dome shape selection. Hake larger than 90 cm are scarce in the catches. This length structure is compared with a theoretical length distribution expected under known growth, M and logistic selection. Growth and M are quite uncertain. However, it is known that females can grow up to 140 cm, compared to males that do not reach 70 cm, meaning that at least half of the population never achieves the maximum length. A combination of selectivity and life-history assumptions bias the length based methods towards a more depleted view.

Contrastively, SPiCT produces results showing a healthy stock, although with wide confidence intervals. All the models explored produce similar results in terms of reference points with a 2020 B/B_{MSY} around 1.4 (MSY $B_{trigger}$ = 0.5). Furthermore, the probability of being below B_{lim} (0.3) is always lower than 5%. ICES guidelines for reference points for category 3 and 4 stocks (ICES, 2018) recommend that if SPiCT diagnostics are acceptable, then SPiCT should be used as the basis for further analyses. Among the SPiCT models explored, model 4 in the main runs (Table 10.8) passed all diagnostic checks and also produced the narrowest CIs. For this reason, WGBIE 2021 proposes this model as the reference model to estimate Southern hake reference points (Cerviño *et al*., 2021; WD 04 in ICES, 2021).

10.4.8 Proposed Reference points

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$ proxy	0.5*	Relative value (B/B_{MSY}) from the SPiCT assessment model. B_{MSY} is estimated directly from the SPiCT model and changes when the assessment is updated.	ICES (2021)
	F_{MSY} proxy	1*	Relative value (F/F_{MSY}) from the SPiCT assessment model. F_{MSY} is estimated directly from the SPiCT model and changes when the assessment is updated.	ICES (2021)
Precautionary approach	B_{lim}	0.3 × B_{MSY}	Relative value (equilibrium yield at this biomass is 50% of the MSY proxy).	ICES (2021c)
	B_{pa}	Not defined		
	F_{lim}	Not defined		
	F_{pa}	Not defined		
Management plan	SSB_{mgt}	Not defined		
	F_{mgt}	Not defined		

10.5 Comments on the assessment

The two indices considered cover most of the stock area (Portugal area and North of Spain), using catch dependent data (P-TR) and survey data (SpGFS-WIBTS-Q4) from 1989 to 2020 and are considered good indicators of stock status.

Reference points to define stock status were estimated this year for the first time based on the SPiCT model. Results present wide CIs although sensitivity analysis shows that B/B_{MSY} is above MSY $B_{trigger}$.

Alternative data-rich assessment methods, such as Stock Synthesis (SS, Methot Jr. and Wetzel, 2013) were explored (Izquierdo *et al*., 2021, WD 03 in ICES, 2021). A summary of this progress is presented in Annex 7 (Cerviño, 2021 in ICES, 2021). WGBIE considers that the progress presented and the outlined work plan for the next months are sufficient for recommending a benchmark in 2022.

The collection of Spanish data from the commercial fishery and research surveys during 2020 was affected by COVID-19 restrictions to a varying degree across member states. For this stock, sampling problems did not affect the data required to perform an updated assessment.

10.6 Management considerations

Southern hake is included in the Multiannual Management Plan for Western Waters (EU, 2019a). This stock is caught in a mixed fishery together with megrims, anglerfish and other demersal species. Hake is a choke species in these fisheries.

Hake is a top predator eating mainly blue whiting, horse mackerel and other hake (cannibalism, particularly of juveniles by adults). There may be some impact of this in the rate of recovery of the population, particularly in areas of greater aggregations. The main hake predators in the area are common and bottlenose dolphins.

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10.8 Tables and figures

Table 10.1. Southern hake stock. Catch estimates (´000 t) by country and gear.

	SPAIN									PORTUGAL				FRANCE		TOTAL		
YEAR	ART	GILLNET	LONGLINE	Cd-Trw	Pr-Bk TRW	Pa-Trw	Ba-Trw	DISC	LAND	ART	TRAWL	DISC	LAND	TOTAL	UNALLOCATED	DISC	LAND	CATCH
1972	7.10	-	-	-	10.20				17.3	4.70	4.10	-	8.8			-	26.1	26.1
1973	8.50	-	-	-	12.30				20.8	6.50	7.30	-	13.8	0.20		-	34.8	34.8
1974	1.00	2.60	2.20	-	8.30				14.1	5.10	3.50	-	8.6	0.10		-	22.8	22.8
1975	1.30	3.50	3.00	-	11.20				19.0	6.10	4.30	-	10.4	0.10		-	29.5	29.5
1976	1.20	3.10	2.60	-	10.00				16.9	6.00	3.10	-	9.1	0.10		-	26.1	26.1
1977	0.60	1.50	1.30	-	5.80				9.2	4.50	1.60	-	6.1	0.20		-	15.5	15.5
1978	0.10	1.40	2.10	-	4.90				8.5	3.40	1.40	-	4.8	0.10		-	13.4	13.4
1979	0.20	1.70	2.10	-	7.20				11.2	3.90	1.90	-	5.8	-		-	17.0	17.0
1980	0.20	2.20	5.00	-	5.30				12.7	4.50	2.30	-	6.8	-		-	19.5	19.5
1981	0.30	1.50	4.60	-	4.10				10.5	4.10	1.90	-	6.0	-		-	16.5	16.5
1982	0.27	1.25	4.18	0.49	3.92				10.1	5.01	2.49	-	7.5	-		-	17.6	17.6
1983	0.37	2.10	6.57	0.57	5.29				14.9	5.19	2.86	-	8.0	-		-	22.9	22.9
1984	0.33	2.27	7.52	0.69	5.84				16.7	4.30	1.22	-	5.5	-		-	22.2	22.2
1985	0.77	1.81	4.42	0.79	5.33				13.1	3.77	2.05	-	5.8	-		-	18.9	18.9
1986	0.83	2.07	3.46	0.98	4.86				12.2	3.16	1.79	-	4.9	0.01		-	17.2	17.2

	SPAIN									PORTUGAL				FRANCE		TOTAL		
YEAR	ART	GILLNET	LONGLINE	Cd-Trw	Pr-Bk TRW	Pa-Trw	Ba-Trw	DISC	LAND	ART	TRAWL	DISC	LAND	TOTAL	UNALLOCATED	DISC	LAND	CATCH
1987	0.53	1.97	4.41	0.95	3.50				11.4	3.47	1.33	-	4.8	0.03		-	16.2	16.2
1988	0.70	1.99	2.97	0.99	3.98				10.6	4.30	1.71	-	6.0	0.02		-	16.7	16.7
1989	0.56	1.86	1.95	0.90	3.92				9.2	2.74	1.85	-	4.6	0.02		-	13.8	13.8
1990	0.59	1.72	2.13	1.20	4.13				9.8	2.26	1.14	-	3.4	0.03		-	13.2	13.2
1991	0.42	1.41	2.20	1.21	3.63				8.9	2.71	1.25	-	4.0	0.01		-	12.8	12.8
1992	0.40	1.48	2.05	0.98	3.79			0.14	8.7	3.77	1.33	0.33	5.1	-		0.5	13.8	14.3
1993	0.37	1.26	2.74	0.54	2.67			0.24	7.6	3.04	0.87	0.44	3.9	-		0.7	11.5	12.2
1994	0.37	1.90	1.47	0.32		0.82	1.90	0.29	6.8	2.30	0.79	0.71	3.1	-		1.0	9.9	10.9
1995	0.37	1.59	0.96	0.46		2.34	2.94	0.93	8.6	2.56	1.03	1.18	3.6	-		2.1	12.2	14.3
1996	0.23	1.15	0.98	0.98		1.46	2.17	0.91	7.0	2.01	0.76	0.99	2.8	-		1.9	9.7	11.6
1997	0.30	1.04	0.76	0.88		1.32	1.78	1.07	6.1	1.52	0.90	1.20	2.4	-		2.3	8.5	10.8
1998	0.32	0.75	0.62	0.53		0.88	1.95	0.57	5.0	1.67	0.97	1.11	2.6	-		1.7	7.7	9.4
1999	0.33	0.60	0.00	0.57		0.87	1.59	0.35	4.0	2.12	1.09	1.17	3.2	-		1.5	7.2	8.7
2000	0.26	0.85	0.15	0.58		0.83	1.98	0.62	4.7	2.09	1.16	1.21	3.3	-		1.83	7.90	9.7
2001	0.32	0.55	0.11	1.20		1.06	1.12	0.37	4.4	2.02	1.20	1.29	3.2	-		1.66	7.58	9.2
2002	0.22	0.58	0.12	0.88		1.37	0.75	0.38	3.9	1.81	0.97	1.11	2.8	-		1.49	6.70	8.2
2003	0.37	0.43	0.17	1.25		1.36	1.07	0.41	4.7	1.13	0.96	1.05	2.1	-		1.46	6.74	8.2

	SPAIN									PORTUGAL				FRANCE		TOTAL		
YEAR	ART	GILLNET	LONGLINE	Cd-Trw	Pr-Bk TRW	Pa-Trw	Ba-Trw	DISC	LAND	ART	TRAWL	DISC	LAND	TOTAL	UNALLOCATED	DISC	LAND	CATCH
2004	0.48	0.42	0.13	1.06		1.66	1.13	0.22	4.9	1.27	0.80	0.69	2.1	-		0.91	6.94	7.9
2005	0.72	0.63	0.09	0.88		2.77	1.14	0.38	6.2	1.10	0.96	1.60	2.1	-		1.98	8.30	10.3
2006	0.48	0.71	0.35	0.63		4.70	1.81	2.65	8.7	1.22	0.91	0.61	2.1	-		3.26	10.80	14.1
2007	0.83	1.80	0.89	0.50		6.71	2.07	1.19	12.8	1.41	0.72	1.31	2.1	-		2.50	14.93	17.4
2008	1.12	2.64	1.51	0.53		6.32	2.44	1.45	14.6	1.27	0.94	0.86	2.2	-		2.31	16.77	19.1
2009	1.41	2.92	2.10	0.55		7.37	2.54	0.98	16.9	1.39	0.96	1.96	2.4	-		2.93	19.24	22.2
2010	0.72	1.71	1.88	0.68		6.33	1.71	1.00	13.0	1.61	0.73	0.58	2.3	0.36		1.58	15.74	17.3
2011	0.42	1.09	0.76	0.53		2.18	1.48	1.21	6.5	1.72	0.49	0.74	2.2		8.40	1.95	17.07	19.0
2012	0.34	0.85	1.08	0.50		1.64	1.42	1.35	5.8	1.79	0.81	0.47	2.6		6.14	1.82	14.57	16.4
2013	0.64	1.75	1.11	0.62		1.86	1.16	2.22	7.2	1.93	0.81	0.33	2.7	0.31	1.46	2.55	11.66	14.2
2014	0.75	1.46	1.60	0.54		1.72	1.18	2.02	7.3	1.71	0.66	0.58	2.4	0.14	2.25	2.60	12.01	14.6
2015	0.90	1.11	1.23	0.36		2.01	1.13	2.06	6.8	1.24	0.76	0.23	2.0	0.24	2.8	2.29	11.79	14.1
2016	0.91	1.64	1.30	0.42		2.28	1.51	2.15	8.06	1.22	0.75	0.16	1.97	0.23	2.17	2.31	12.44	14.8
2017	0.69	1.51	1.71	0.27		1.60	1.08	1.43	6.86	0.91	0.57	0.24	1.48	0.07	0.76	1.68	9.17	10.8
2018	0.76	1.64	1.00	0.39		1.54	1.10	1.77	6.44	0.79	0.70	0.18	1.49	0.06	2.19	1.94	10.18	12.1
2019	0.78	1.65	1.12	0.43		1.81	1.49	0.75	7.27	1.114	0.801	0.307	1.92	0.01	2.61	1.06	11.80	12.9
2020	0.73	1.54	1.16	0.44		1.55	1.15	0.21	6.57	1.21	0.70	0.23	1.90	0.05	0.21	0.44	8.73	9.17

Table 10.2. Southern hake stock length compositions (thousands) in 2020 (without France landings (10 tonnes).

Length (cm) (4 to 100+ each 2)	**Land**	**Disc**	**Catch**
4	0	0	0
6	0	46	46
8	157	466	623
10	342	964	1306
12	271	1317	1589
14	35	795	829
16	80	1177	1257
18	95	2024	2119
20	308	1433	1740
22	326	728	1054
24	548	445	992
26	1382	183	1565
28	2258	33	2291
30	2576	34	2610
32	2773	9	2782
34	2638	22	2659
36	1560	7	1566
38	1135	2	1137
40	1096	0	1096
42	720	1	721
44	527	0	527
46	520	0	520
48	392	0	392
50	310	0	310
52	461	0	461
54	358	0	358
56	185	0	185

Length (cm) (4 to 100+ each 2)	Land	Disc	Catch
58	139	0	139
60	106	0	106
62	101	0	101
64	69	0	69
66	54	0	54
68	73	0	73
70	41	0	41
72	22	0	22
74	20	0	20
76	24	0	24
78	16	0	16
80	8	0	8
82	4	0	4
84	6	0	6
86	8	0	8
88	1	0	1
90	1	0	1
92	2	0	2
94	0	0	0
96	0	0	0
98	4	0	4
TOTAL	**21753**	**9684**	**31437**
Weight (000' tons)	8.73	0.44	9.17
SOP	8.67	0.44	9.11
SOP / NW	1.01	1.00	1.01
Mean length (cm)	35.3	17.4	29.8

Table 10.3. Southern hake stock. Portuguese groundfish surveys; biomass, abundances and recruitment indices.

	Winter (ptGFS-WIBTS-Q1)					Summer					Autumn ptGFS-WIBTS-Q4 (G8899)					
	Biomass (kg/h)		Abundance (N/h)			Biomass (kg/h)		Abundance (N/h)			Biomass (kg/h)		Abundance (N/h)			
Year	Mean	s.e.	Mean	s.e.	hauls	Mean	s.e.	Mean	s.e.	hauls	Mean	s.e.	Mean	s.e.	n/hour < 20 cm (1)	hauls
1979 *						11.7		80.4		55	9.5		na			55
1980 * (**)	11.3		178.1		36	15.4		153.0		63	12.5		108.7			62
1981 (Autumn **)	10.7	0.7	122.4	15.5	67	9.9	1.3	87.8	15.5	69	24.4	0.5	734.8	29.3		111
1982	18.1	2.5	265.6	37.5	69	11.0	2.7	93.0	32.8	70	10.6	1.8	119.5	34.7		190
1983 (Autumn **)	27.0	6.0	530.5	151.0	69	15.1	2.3	120.5	20.8	98	13.4	0.5	121.8	4.8		117
1984																
1985						14.3	0.8	170.7	15.6	101	11.0	0.7	128.7	8.4	86.7	150
1986						27.4	1.8	249.4	15.1	118	17.7	1.2	165.6	28.4	90.2	117
1987											8.6	0.9	37.4	3.7	7.3	81
1988											15.3	1.7	177.8	30.8	111.7	98
1989						11.9	0.9	80.8	8.6	114	8.4	0.5	59.6	4.6	19.8	130
1990						9.8	1.0	95.6	13.5	98	11.8	1.0	157.2	26.3	97.2	107
1991						14.2	1.2	104.2	11.3	119	20.9	4.3	195.3	41.5	92.3	80
1992	14.5	1.2	176.4	32.3	88	10.9	1.1	74.1	11.4	81	11.7	1.7	65.2	11.1	18.8	51
1993	9.0	0.7	78.7	16.8	75	11.3	1.7	105.0	34.7	66	5.5	0.8	54.4	12.9	28.4	58

	Winter (ptGFS-WIBTS-Q1)					Summer					Autumn ptGFS-WIBTS-Q4 (G8899)					
	Biomass (kg/h)		Abundance (N/h)			Biomass (kg/h)		Abundance (N/h)			Biomass (kg/h)		Abundance (N/h)			
Year	Mean	s.e.	Mean	s.e.	hauls	Mean	s.e.	Mean	s.e.	hauls	Mean	s.e.	Mean	s.e.	n/hour < 20 cm (1)	hauls
1994											9.9	1.0	98.9	12.1	52.9	77
1995						15.0	1.4	129.3	16.3	81	14.8	1.7	85.8	10.7	7.9	80
1996***											9.2	1.1	109.9	17.8	18.2	63
1997						19.0	1.4	206.5	16.9	86	24.6	9.3	208.0	92.5	62.1	51
1998						10.5	0.8	71.6	8.6	87	15.6	2.0	140.6	21.7	75.9	64
1999***						11.8	0.7	116.2	10.1	65	11.6	1.5	118.3	17.1	14.4	71
2000						16.4	1.6	123.0	15.2	88	11.8	1.8	102.7	19.9	49.2	66
2001						16.6	1.7	132.5	14.2	83	15.6	2.8	164.2	38.5	89.9	58
2002											13.0	2.1	117.6	26.9	60.6	66
2003 ***											9.8	1.0	94.2	8.0	11.9	71
2004 ***											18.4	3.3	402.3	85.2	78.2	79
2005	17.7	2.6	384.0	53.8	68						19.0	1.9	214.2	23.5	131.7	87
2006	16.0	2.0	377.5	55.4	66						16.5	1.8	126.2	11.0	54.7	88
2007	22.4	3.4	609.1	114.1	63						25.8	2.8	370.2	46.7	240.0	96
2008	31.1	4.8	700.6	170.8	67						34.6	4.3	293.6	33.9	87.7	87

	Winter (ptGFS-WIBTS-Q1)					Summer					Autumn ptGFS-WIBTS-Q4 (G8899)					
	Biomass (kg/h)		Abundance (N/h)			Biomass (kg/h)		Abundance (N/h)			Biomass (kg/h)		Abundance (N/h)			
Year	Mean	s.e.	Mean	s.e.	hauls	Mean	s.e.	Mean	s.e.	hauls	Mean	s.e.	Mean	s.e.	n/hour < 20 cm (1)	hauls
2009											37.5	4.4	476.4	75.9	318.6	93
2010											38.2	4.3	418.0	49.8	249.8	87
2011											18.7	1.5	272.9	25.2	179.4	86
2012																
2013											35.2	3.4	473.1	62.1	289.0	93
2014											17.1	1.5	195.7	23.9	93.9	81
2015											37.2	4.3	602.1	65.0	393.2	90
2016											18.7	1.5	272.9	25.2	179.4	86
2018											19.7	2.6	256.1	57.9	136.6	89
2018											18.1	3.3	252.0	45.3	154.7	65
2019																
2020																

NO ptGFS-WIBTS-Q4 (G8899) in 2012, 2019 and 2020

Data marked with * relate to 40 mm codend mesh size, else 20 mm; ** when whole area not covered; * R/V Capricornio, other years R/V Noruega; (1) n/hour <20 cm converted to Noruega and NCT;**

Since 2002 tow duration is 30 min for autumn survey

Depth strata: from 1979 to 1988 covers 20–500 m depth; from 1989 to 2004 covers 20–750 m depth; since 2005 covers 20–500 m depth.

Data in 2014–2016 reviewed in 2018

Table 10.4. Southern hake stock. Spanish groundfish surveys; biomass, abundances and recruitment indices.

	Spanish Survey (SpGFS-WIBTS-Q4) (/30 min)						Cadiz Survey (SPGFS-caut-WIBTS-Q4) (/hour)				Cadiz Survey (SPGFS-cspr-WIBTS-Q1) (/hour)			
	Biomass index (Kg)			Abundance Index (nº)		Recruits (<20cm)	Biomass index (Kg)			Rec (<20cm)	Biomass index (Kg)			Rec (<20cm)
Year	Mean	s.e.	Hauls	Mean	s.e.	Mean	Mean	s.e.	hauls	Mean	Mean	s.e.	hauls	mean
1983	7.04	0.65	107	192.4	25.0	177								
1984	6.33	0.60	94	410.4	53.5	398								
1985	3.83	0.39	97	108.5	14.0	98								
1986	4.16	0.50	92	247.8	46.5	239								
1987														
1988	5.59	0.69	101	390.0	67.4	382								
1989	7.14	0.75	91	487.9	73.1	477								
1990	3.34	0.32	120	85.9	9.1	78								
1991	3.37	0.39	107	166.8	15.8	161								
1992	2.14	0.19	116	59.3	5.4	52								
1993	2.49	0.21	109	80.0	8.0	73					3.04	0.53	30	
1994	3.98	0.33	118	245.0	24.9	240					2.68	0.33	30	
1995	4.58	0.44	116	80.9	8.4	68					4.66	1.28	30	71.5
1996	6.54	0.59	114	345.2	40.5	335					7.66	1.14	31	72.7
1997	7.27	0.78	119	421.4	56.5	410	5.28	2.77	27	26.7	3.34	0.52	30	72.5
1998	3.36	0.28	114	75.9	8.7	65	2.66	0.42	34	6.6	2.93	0.67	31	18.6
1999	3.35	0.25	116	95.3	10.6	89	2.71	0.44	38	23.9	3.03	0.37	38	44.6
2000	3.01	0.43	113	66.9	7.4	59	2.03	0.61	30	18.6	3.02	0.47	41	39.7
2001	1.73	0.29	113	42.0	7.6	37	2.57	0.45	39	22.7	6.01	0.79	40	72.4
2002	1.91	0.23	110	57.1	8.8	53	3.39	0.78	39	118.6	2.74	0.25	41	22.4
2003	2.61	0.27	112	92.8	11.6	86	1.61	0.28	41	17.5				
2004	3.94	0.40	114	177.0	23.5	170	2.72	0.69	40	85.8	3.65	0.47	40	92.7

	Spanish Survey (SpGFS-WIBTS-Q4) (/30 min)						Cadiz Survey (SPGFS-caut-WIBTS-Q4) (/hour)				Cadiz Survey (SPGFS-cspr-WIBTS-Q1) (/hour)			
	Biomass index (Kg)			Abundance Index (nº)		Recruits (<20cm)	Biomass index (Kg)			Rec (<20cm)	Biomass index (Kg)			Rec (<20cm)
Year	Mean	s.e.	Hauls	Mean	s.e.	Mean	Mean	s.e.	hauls	Mean	Mean	s.e.	hauls	mean
2005	6.46	0.53	116	344.8	32.2	335	6.68	1.29	42	100.6	10.77	5.65	40	184.3
2006	5.50	0.39	115	224.5	21.9	211	4.99	2.00	41	212.3	2.15	0.40	41	3.7
2007	4.97	0.43	117	158.2	15.0	150	6.92	1.43	37	200.3	3.22	0.68	41	51.1
2008	4.93	0.46	115	99.3	11.5	81	4.33	0.60	41	64.4	3.48	0.67	41	50.5
2009	9.32	0.94	117	559.7	93.9	789	7.35	0.97	43	95.0	4.24	0.06	40	65.6
2010	8.36	0.65	114	201.0	14.9	175	5.82	0.83	44	46.0	6.91	1.09	36	202.5
2011	8.98	0.68	111	241.5	21.0	216	2.97	0.38	40	48.2	3.75	0.50	42	32.2
2012	8.44	0.75	115	297.3	39.5	280	5.38	0.90	37	44.0	3.49	0.65	33	62.9
2013	5.59	0.78	114	136.9	13.6	118	12.52	2.04	43	285.6	5.50	0.56	40	76.5
2014	3.72	0.44	116	78.0	9.6	68	9.33	1.38	45	63.0	6.01	0.65	40	60.4
2015	9.87	0.85	114	316.8	33.7	296	13.67	2.61	43	186.8	6.01	0.69	43	165.3
2016	7.67	0.65	114	211.3	18.3	185	5.90	0.92	45	87.6	6.50	0.76	44	118.5
2017	6.58	0.57	112	158.8	14.5	140	4.74	0.89	44	151.1	3.39	0.52	45	38.0
2018	6.48	0.52	113	300.8	34.8	291	8.00	1.22	45	34.4	5.78	1.48	41	134.6
2019	5.71	0.39	113	166.1	18.4	151	8.03	1,17	43	364.4	5.13	0.90	46	109.7
2020	5.45	0.47	109	131.2	13.2	123	4.54	0.63	44	34.7	5.82	0.63	45	42.1

Since 1997 new depth stratification: **70–120m, 121–200m and 201–500 m**

Before 1997: **30–100m, 101–200m and 201–500 m**

Table 10.5. Southern hake stock. Landings (tonnes), Landings per unit effort and effort for trawl fleets.

	A Coruña Trawl			Portugal trawl			
YEAR	Landings	lpue (kg/day x100 HP)	Effort	Landings	lpue (kg/hour std)	s.e. (lpue)	Effort
1985	945	21	45920				
1986	842	21	39810				
1987	695	20	34680				
1988	698	17	42180				
1989	715	16	44440	1847	40.8	3.0	45216
1990	749	17	44430	1138	38.6	2.9	29446
1991	501	12	40440	1245	34.8	4.0	35812
1992	589	15	38910	1325	32.3	2.5	41011
1993	514	12	44504	870	26.7	2.4	32612
1994	473	12	39589	789	32.4	3.3	24361
1995	831	20	41452	1026	41.0	3.5	25047
1996	722	20	35728	758	37.1	3.5	20420
1997	732	21	35211	897	43.6	4.5	20561
1998	895	27	32563	970	36.9	3.0	26308
1999	691	23	30232	1090	44.6	3.1	24444
2000	590	20	30102	1158	31.9	3.8	36362
2001	597	20	29923	1198	40.8	4.0	29398
2002	232	11	21823	965	40.1	2.6	24085
2003	274	15	18493	962	36.7	1.7	26238
2004	259	12	21112	799	36.6	1.6	21855
2005	330	16	20663	965	39.2	1.7	24595
2006	518	27	19264	908	36.6	2.4	24824
2007	621	29	21201	724	35.0	1.4	20655
2008	762	38	20212	936	42.1	1.6	22209
2009	640	40	16162	964	39.6	1.5	24332
2010	553	40	13744	727	39.7	1.6	18334
2011	538	47	11532	493	40.1	1.9	12305

	A Coruña Trawl			Portugal trawl			
YEAR	Landings	lpue (kg/day x100 HP)	Effort	Landings	lpue (kg/hour std)	s.e. (lpue)	Effort
2012	498	42	11887	814	47.8	1.7	17021
2013*	542	37	14736	812	45.1	1.6	17980
2014*	493	27	18060	661	44.1	1.7	14973
2015*	411	31	13309	763	58.9	1.7	12959
2016*	514	38	13718	752	44.4	1.2	16913
2017*	303	24	12449	575	41.7	1.2	13798
2018*				697	42.7	1.2	16305
2019*	572	45	12824	801	43.8	1.2	18283
2020				698	40.8	1.2	17111

Spanish LPUEs are scientific estimations from a selection of ships that may change from year-to-year.

*** Spanish sampling method changed for effort and landings - not used in the model**

Table 10.6. Southern hake life-history parameters (L_{inf}, L_{50}, L_{95}, M/k, k, M and *a* and *b* length weight parameters). For each of the length based methods (LBI, LBSPR, and MLZ) we specify which of the life-history parameters are required.

Parameters	Value	Source	Methods		
			LBI	LBSPR	MLZ
L_{inf}	130 cm	GADGET	✓	✓	✓
L_{50}	33 cm	GADGET	✓	✓	
L_{95}	50 cm	GADGET		✓	
M/k	2.42	GADGET	✓	✓	
k	0.165	GADGET			✓
M	0.4	GADGET			✓
a and *b*	a = 0.00000659; *b* = 3.01721	GADGET	✓		✓(*)
L_{inf}	100 cm	LHI	✓	✓	✓
L_{50}	38 cm	LHI	✓	✓	
L_{95}	55 cm	LHI		✓	
M/k	1.65	LHI	✓	✓	
k	0.17	LHI			✓
M	0.28	LHI			✓

Table 10.7 Traffic light indicator table for the LBI analysis.

Year	L_c/L_{mat} (> 1)	$L_{25\%}/L_{mat}$ (> 1)	$L_{max5\%}/L_{inf}$ (> 0.8)	P_{mega} (> 0.3)	L_{mean}/L_{opt} (> 1)	$L_{mean}/L_{F=M}$ (> 1)
2004	0.41	0.47	0.38	0	0.35	0.75
2005	0.41	0.50	0.37	0	0.35	0.74
2006	0.47	0.56	0.38	0	0.36	0.74
2007	0.32	0.47	0.42	0	0.35	0.82
2008	0.50	0.62	0.44	0	0.41	0.83
2009	0.32	0.56	0.45	0	0.39	0.92
2010	0.44	0.59	0.47	0	0.41	0.86
2011	0.38	0.56	0.50	0	0.41	0.90
2012	0.47	0.65	0.47	0	0.43	0.88
2013	0.53	0.59	0.44	0	0.40	0.77
2014	0.56	0.62	0.45	0	0.41	0.79
2015	0.44	0.53	0.46	0	0.38	0.79
2016	0.50	0.62	0.46	0	0.41	0.82
2017	0.56	0.59	0.46	0	0.41	0.78
2018	0.56	0.68	0.45	0	0.43	0.82
2019	0.41	0.62	0.47	0	0.42	0.90
2020	0.38	0.62	0.46	0	0.43	0.95

Table 10.8 SPiCT runs summary

Run number	Indices	Years	Settings	Convergence	B/B_{MSY} (90% IC) F/F_{MSY} (90% IC)	Checklist for acceptance	AIC
1	Portuguese survey and cpue, Spanish survey and cpue	1982–2020	----------------	Yes	1.375 (0.489.3.870) 0.429 (0.088,2.076)	Ljung-Box significant tests for 3 indices. Retrospective trajectory -5 far from the remaning.	68.17704
2	Portuguese survey and cpue, Spanish survey and cpue	1982–2020	logbkfrac <- c(log(0.6),0.5, 1)	Yes	1.356 (0.512,3.589) 0.443 (0.113,1.747)	Ljung-Box significant tests for 2 indices.	62.36061
3	Portuguese survey, Spanish survey and mean effort index	1982–2020	----------------	Yes	1.490 (0.641,3.466) 0.371 (0.092,1.483)	Ljung-Box significant tests for 1 index. One problematic run in the check of robustness to initial parameter values	28.76575
4	Portuguese survey, Spanish survey and mean effort index	1982–2020	logbkfrac <- c(log(0.6),0.5, 1)	Yes	1.475 (0.633,3.439) 0.389 (0.123,1.234)	Two problematic runs in the check of robustness to initial parameter values	23.21347
ADITIONAL RUNS:	**Indices**	**Years**	**Settings**	**Convergence**	**B/B_{MSY} (90% IC) F/F_{MSY} (90% IC)**	**Checklist for acceptance**	**AIC**
1	Portuguese survey and cpue, Spanish survey and cpue	1982–2020	Scaling first values of catch series until 1994	Yes	1.374 (0.519,3.643) 0.412 (0.096,1.763)	Ljung-Box significant tests for 3 indices. Retrospective trajectory -5 far from the remaining	70.03942
2	Portuguese survey and cpue, Spanish survey and cpue	1972–2020	----------------	Yes	1.588 (0.497,5.073) 0.351 (0.049,2.524)	Ljung-Box significant tests for 2 indices. Retrospective trajectory -5 far from the remaining.	74.13231

Run number	Indices	Years	Settings	Convergence	B/B_{MSY} (90% IC) F/F_{MSY} (90% IC)	Checklist for acceptance	AIC
2	Portuguese survey and cpue, Spanish survey and cpue	1972–2020	Scaling first values of catch series until 1994	Yes	1.587 (0.508,4.961) 0.332 (0.043,2.545)	Ljung-Box significant tests for 2 indices. Retrospective trajectory -5 far from the remaining	73.42909
3	Portuguese survey and cpue, Spanish survey and cpue	1972–2020	logbkfrac <- c(log(0.7),0.5, 1)	Yes	1.366 (0.487,3.827) 0.449 (0.111,1.811)	Ljung-Box significant tests for 2 indices.	68.75358
4	Portuguese and Spanish surveys	1982–2020	-------------------	No	-------------------	-------------------	-------------------
5	Portuguese and Spanish surveys	1982–2020	logbkfrac <- c(log(0.6),0.5, 1)	No	-------------------	-------------------	-------------------
6	Portuguese and Spanish surveys, and Portuguese cpue	1982–2020	-------------------	Yes	2.401 (0.803,7.179) 0.0254 (2.670e-05,24.232)	Ljung-Box significant tests for 2 indices. Problems in the check of robustness to initial parameter values.	48.84826
7	Portuguese and Spanish surveys, and weighted cpue	1982–2020	-------------------	Yes	1.653 (0.556,4.910) 0.319 (0.041,2.507)	Ljung-Box significant tests for 1 index.	29.0529
8	Portuguese and Spanish surveys, and weighted cpue	1982–2020	logbkfrac <- c(log(0.6),0.5, 1)	No	-------------------	-------------------	-------------------
ONE SURVEY ONLY	**Indices**	**Years**	**Settings**	**Convergence**	**B/B_{MSY} (90% IC) F/F_{MSY} (90% IC)**	**Checklist for acceptance**	**AIC**
1	Spanish survey	1982–2020	-----------------	NO			
2	Spanish survey	1972–2020	-----------------	Yes	1.37 (0.49–3.82) 0.44 (0.10–0.89)	Retros > 20%	30.31
3	Spanish survey	1982–2020	logbkfrac <- c(log(0.6),0.5, 1)	NO			

Run number	Indices	Years	Settings	Convergence	B/B$_{MSY}$ (90% IC) F/F$_{MSY}$ (90% IC)	Checklist for acceptance	AIC
4	Portuguese survey	1982–2020	-----------------	Yes	1.27 (0.35–4.63) 0.47 (0.08–2.57)	Wide F CI Retro (−0.31, 0.48)	34.96
5	Portuguese survey	1972–2020	-----------------	Yes	1.53 (0.51–4.59) 0.35 (0.08–1.68)	Wide F CI Retro (−0.17, 0.28)	40.30
6	Portuguese survey	1982–2020	logbkfrac <- c(log(0.6),0.5, 1)	Yes	1.35 (0.37–4.95) 0.43 (0.063–2.92)	Wide F CIs Retro (−0.34, 0.54)	29.46
7	Spanish cpue	1982–2020	-----------------	Yes	1.41 (0.51–3.88) 0.37 (0.10–1.40)	Weird retro but inside bounds 4 / 30 Jitter	8.31
8	Spanish cpue	1972–2020	-----------------	Yes	1.64 (0.60–4.52) 0.30 (0.07–1.27)	Wide F CIs	12.75
9	Spanish cpue	1982–2020	logbkfrac <- c(log(0.6),0.5, 1)	Yes	1.51 (0.43–5.37) 0.34 (0.05–2.30)	Retro (−0.17, 0.21) 3 / 30 Jitter	2.88564
10	Portuguese cpue	1982–2020	-----------------	Yes	2.67 (0.68–10.43) 0.01 (0.00006–11.06)	Wide CI Bad Jitter	−29
11	Portuguese cpue	1972–2020	-----------------	Yes	2.82 (0.79–10.24) 0.02 (0.00004–13.62)	Wide CI Retro (−0.04, 0.65)	−23.12

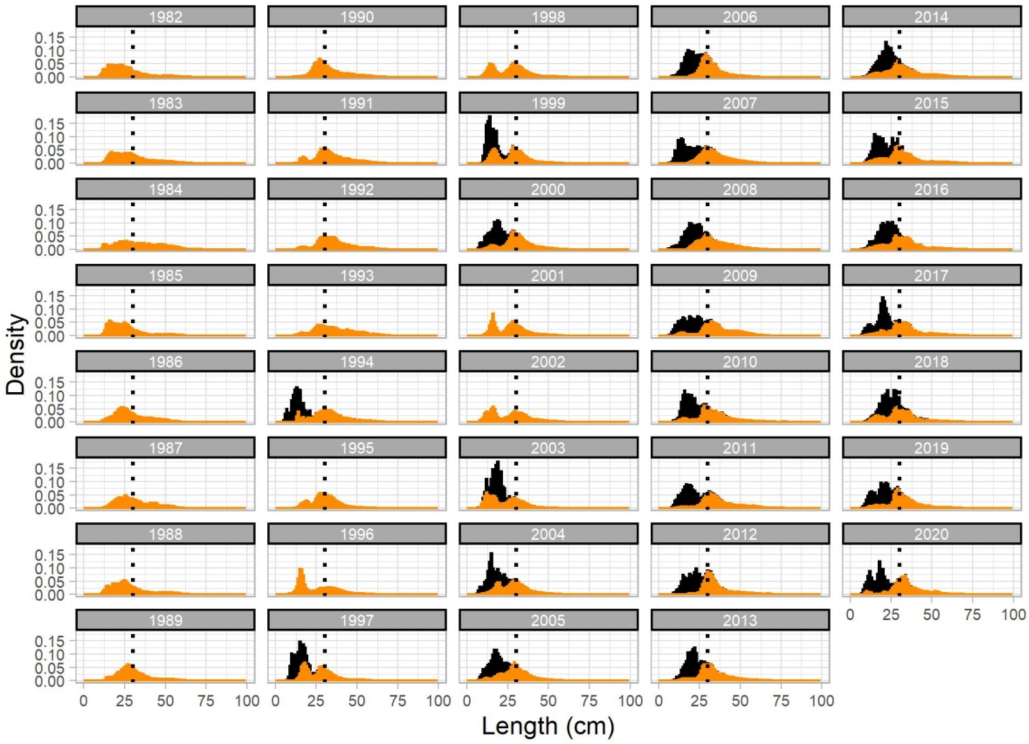

Figure 10.1. Length distribution of catches. Landings 1982–2020 (orange), discards from 1992–2020 (black), minimum landing size (MLS, dashed line) since 1992 at 27 cm.

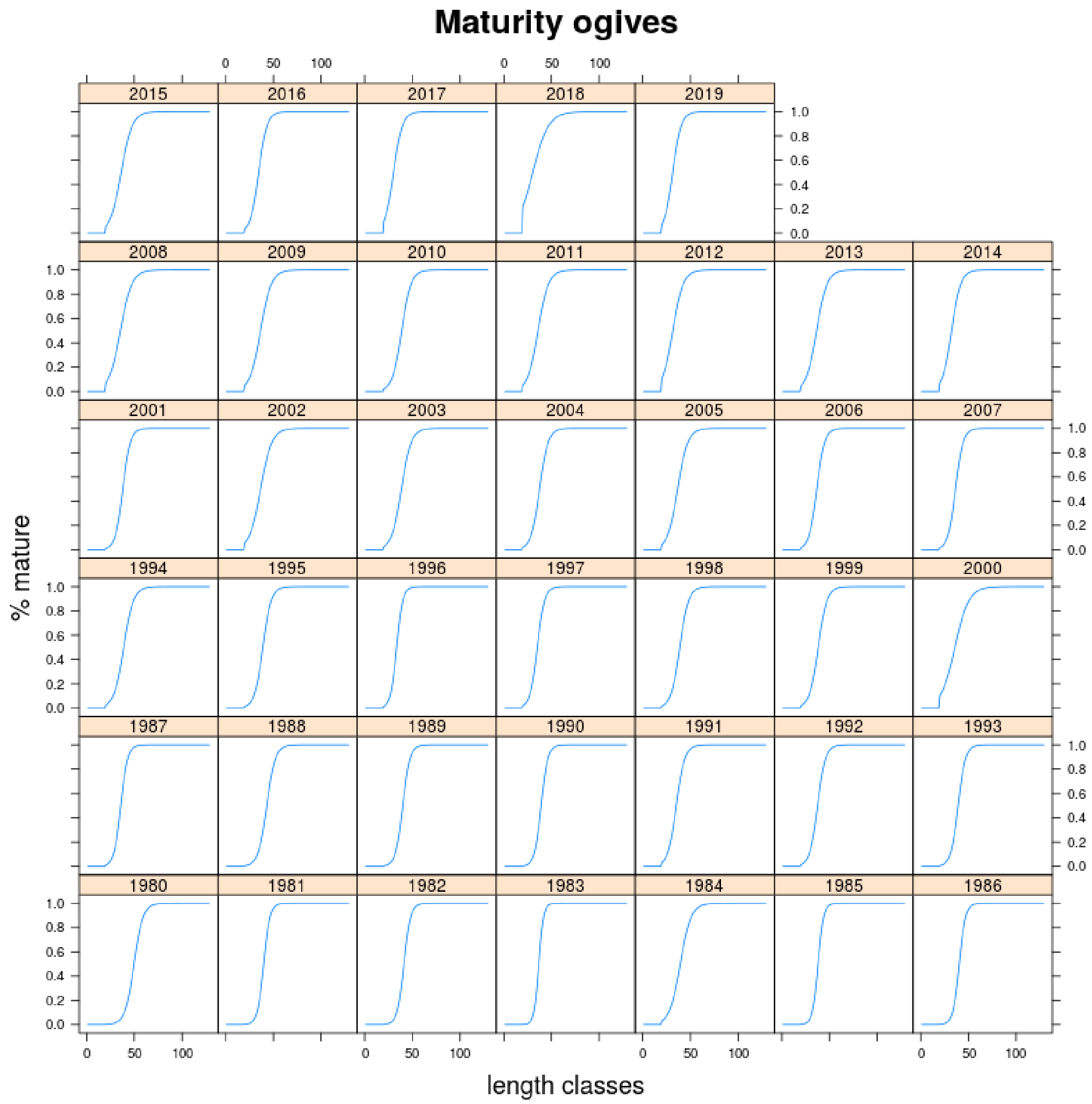

Figure 10.2. Maturity ogives from 1982 (upper plot) and L_{50} trend (lower plot).

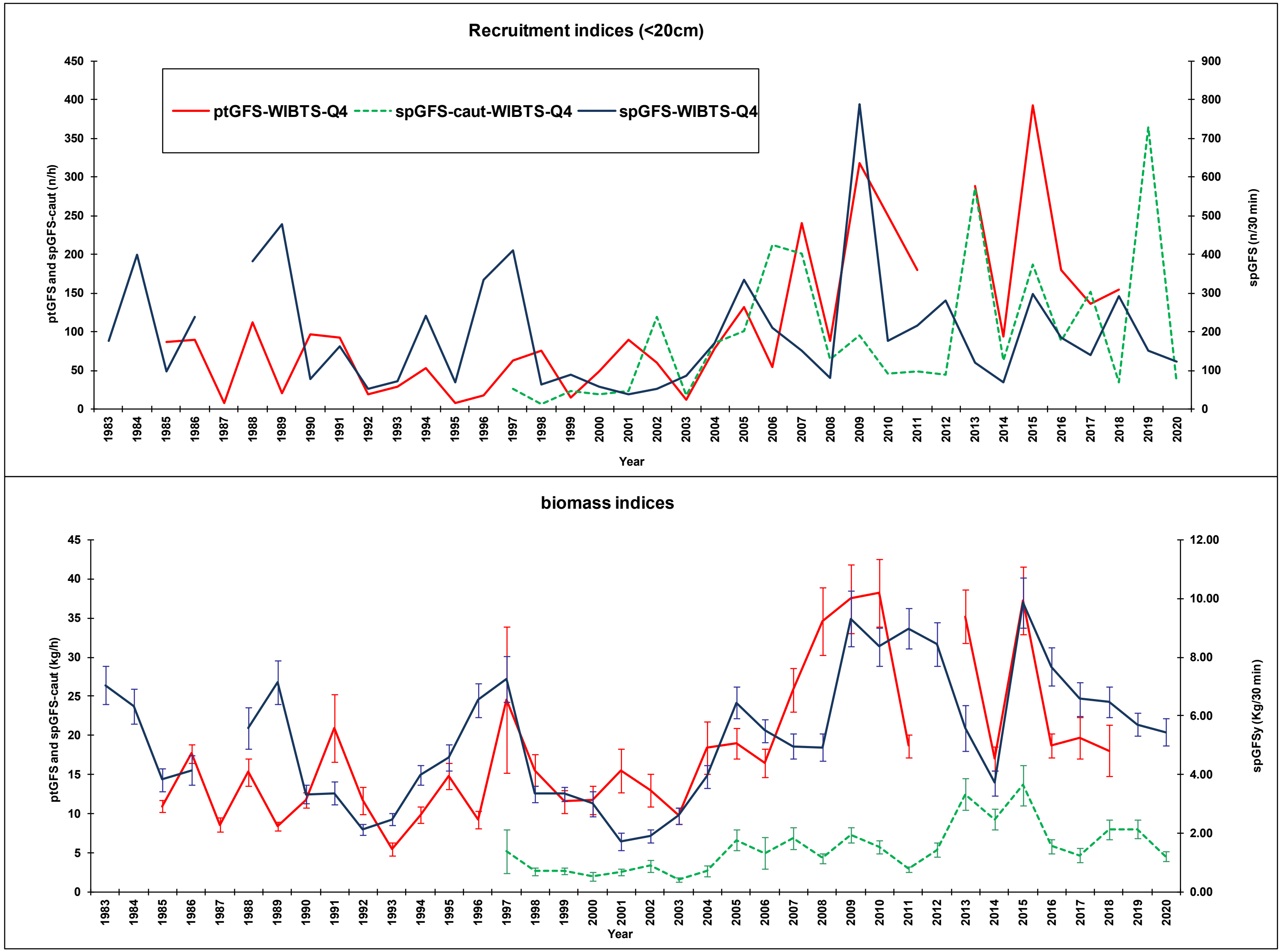

Figure 10.3. Southern hake stock. Recruitment and biomass Indices from groundfish surveys. Vertical bars = 90% CI.

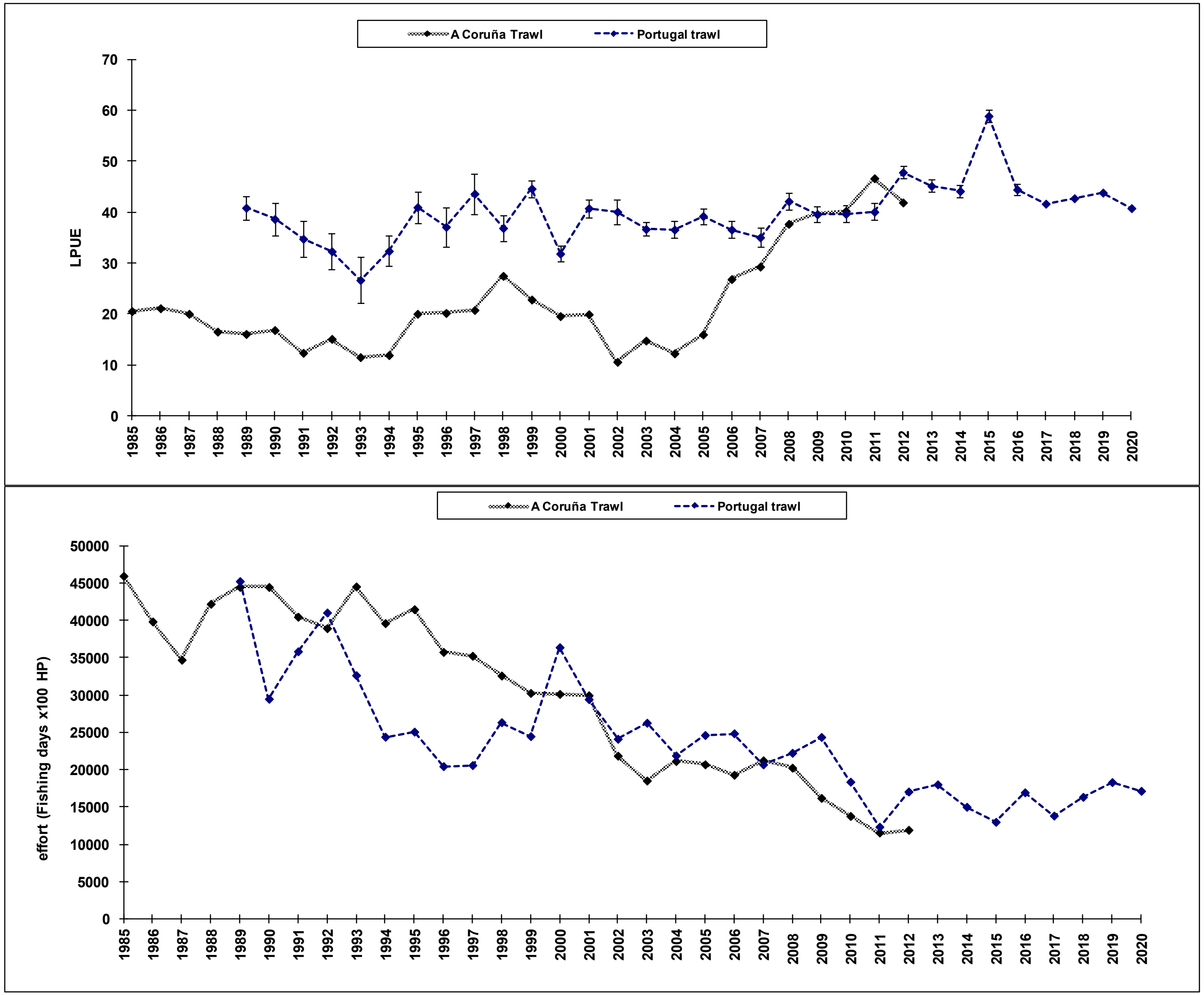

Figure 10.4. Hake southern stock, LPUE and fishing effort trends for trawl fleets. Vertical bars = 90%

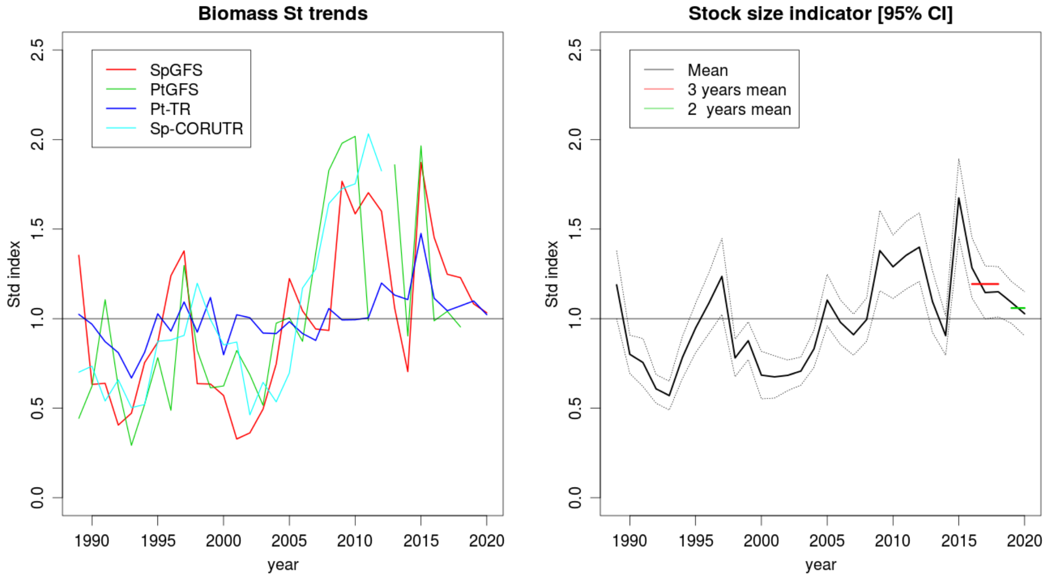

Figure 10.5. Biomass indices standardized (left) and the combined index for SpGFS and P-TR (right) showing the difference between last two years (green) and previous three (red). Names of the indices are SpGFS-WIBTS-Q4-G2784 (red), PtGFS-WIBTS-Q4-G8899 (green), Pt-TR (dark blue) and Sp-CORUTR (light blue).

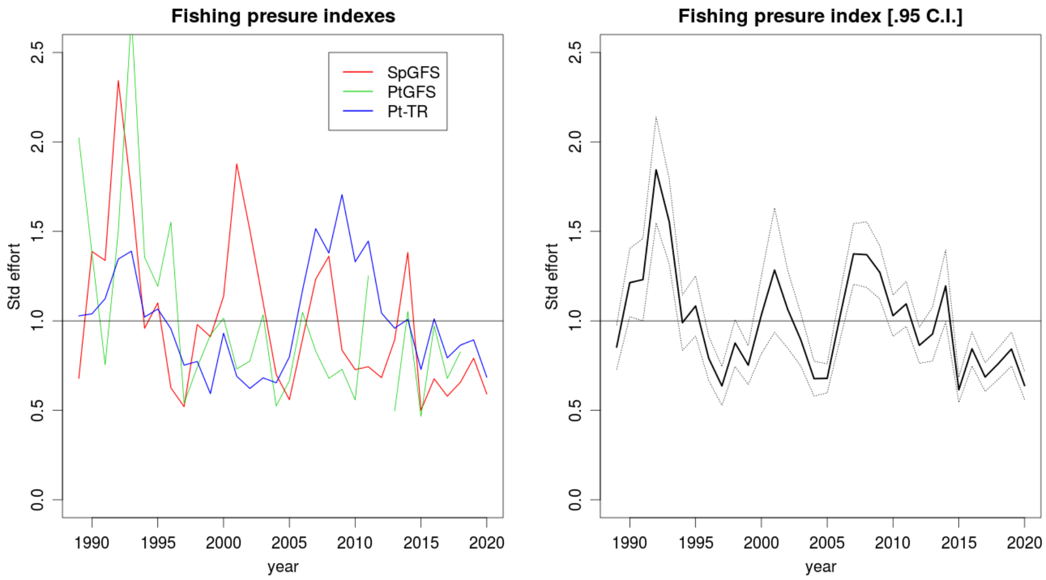

Figure 10.6. Fishing pressure index standardized (left) and the combined index for SpGFS and P-TR (right. Names of the indices are SpGFS-WIBTS-Q4-G2784 (red), PtGFS-WIBTS-Q4-G8899 (green), Pt-TR (dark blue) and Sp-CORUTR (light blue).

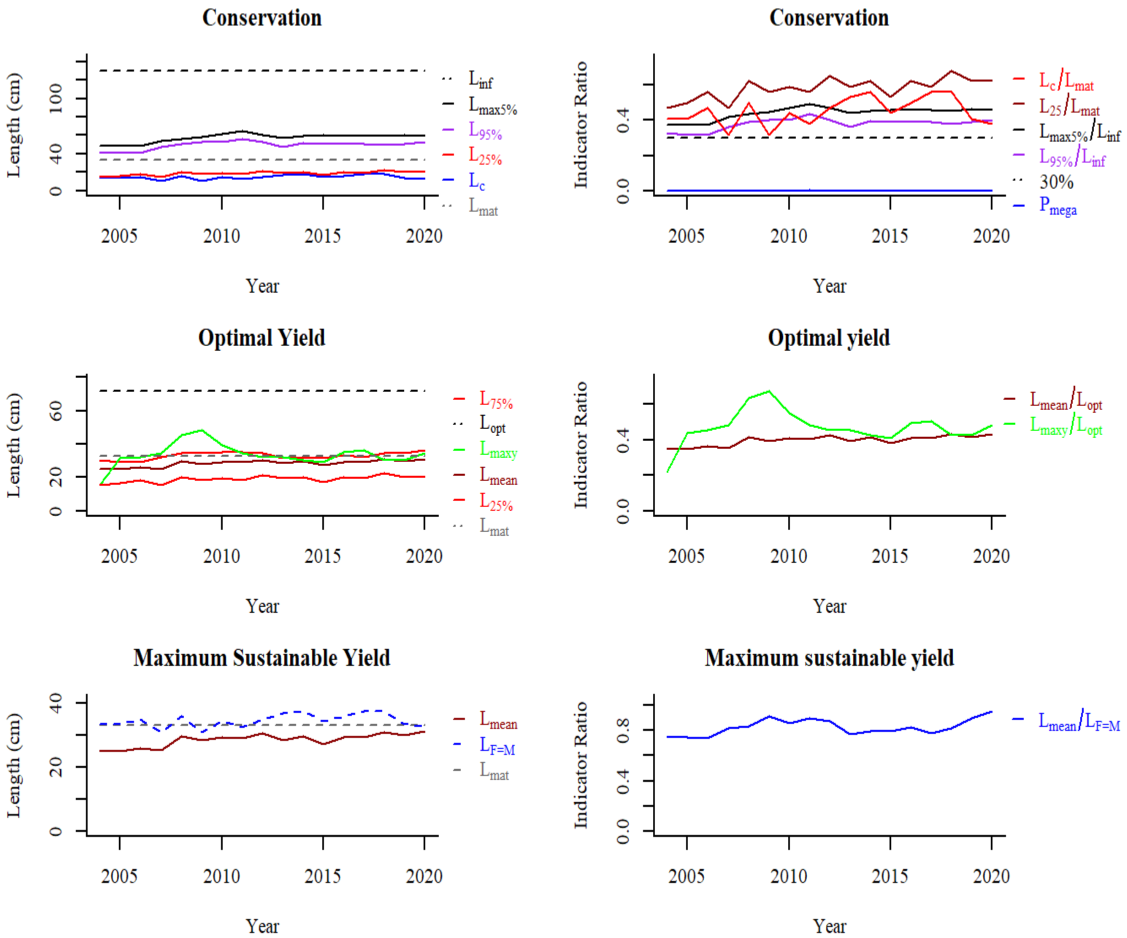

Figure 10.7. Length based indicators.

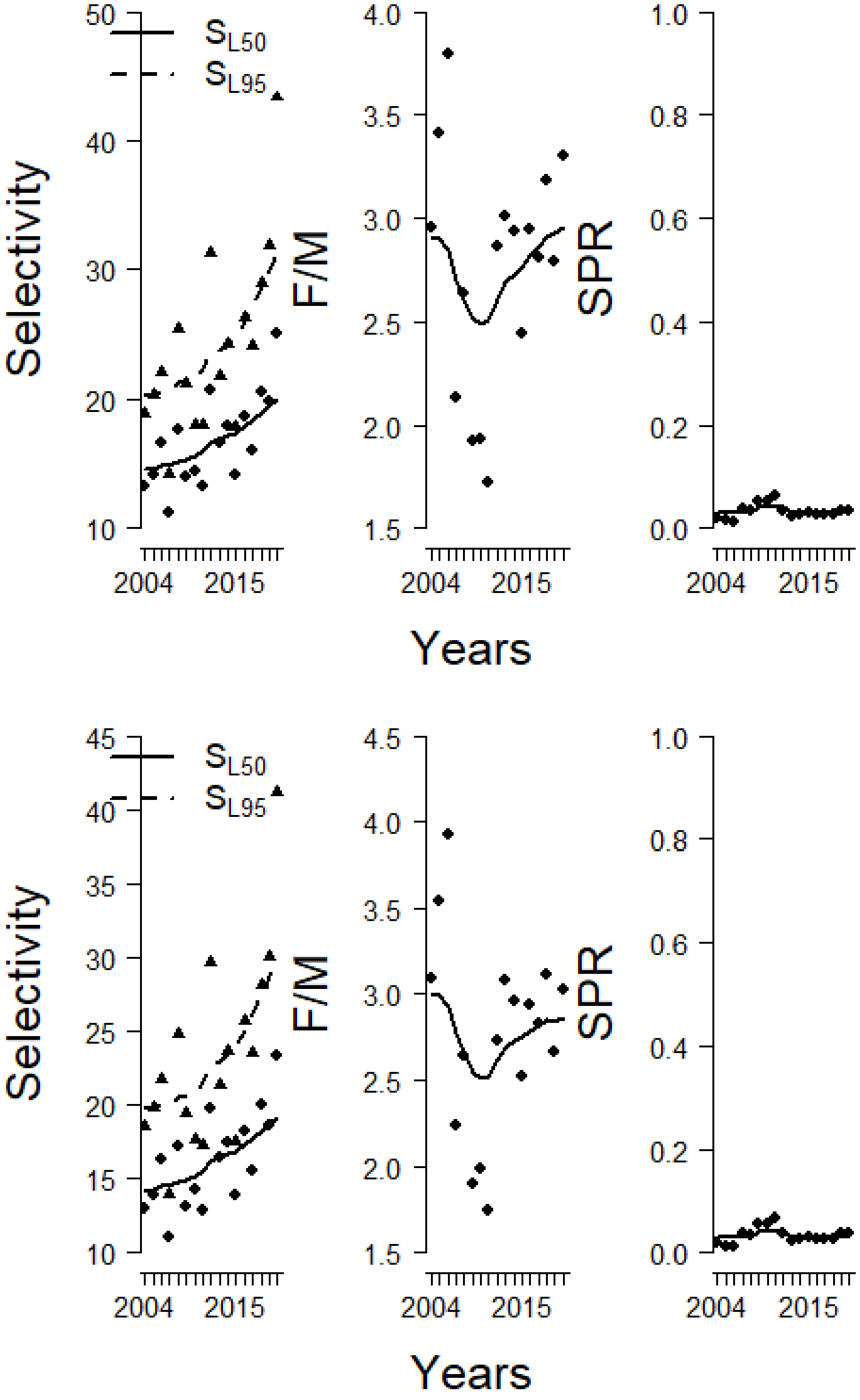

Figure 10.8. Estimated values for selectivity, F/M and SPR using GADGET biological parameter (upper plots) and LHI parameters (lower plots) values. Selectivity (left), F/M (centre) and SPR (right).