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Executive summary

WKBASS is a three-part benchmark workshop (one data compilation workshop and two assessment workshops) aimed at improving the scientific advice on sea bass (*Dicentrarchus labrax*) stocks in the Bay of Biscay (BSS-8.ab: ICES areas 8.a,b) and in the North Sea, Channel, Celtic Sea and Irish Sea (BSS-47: ICES areas 4.b,c and 7.a, d–h). There were concerns following the first assessment workshop in February 2017, so the methodology was finalised at the second assessment workshop in February 2018. This report contains the analyses carried out during the last workshop held in February 2018, which was focused on finalising the data and the configuration of the Stock Synthesis models used for the assessment of both stocks.

Candidate values for age-dependent natural mortality (M) were reviewed using published life-history based methods, using the Lorenzen (1996) method to infer age-dependence in younger fish and maximum observed age to scale the M vector to appropriate values for older sea bass. Different M values were tested during WKBASS 2018. WKBASS 2018 kept M = 0.24 for both stocks, since Then *et al*. (2015) evaluated the predictive performance of different life-history based methods in estimating natural mortality, and demonstrated that maximum age-based methods perform better than the others.

Individual French vessel lpue (tonnes/day) data estimated for selected rectangle and gear strata for the period 2001–2016 were re-analysed using a GLM analysis. This provided lpue series for French vessels fishing on the Northern and the Bay of Biscay sea bass stocks to be used as tuning fleet in the assessment. A combined analysis of proportion of zero catches and catch rates of positive trips using 1 kg as threshold for defining positive trips was carried out. Lpue series for French vessels included otter trawls, nets and lines with gear effects estimated in the model.

The WKBASS 2017 data WK proposed that a value of 15% for post-release mortality should be applied and that sensitivity of the assessment to larger and smaller values should be examined. The appropriateness of this value for post-release mortality was reviewed in details at the WKBASS 2018 assessment meeting. Range of values (1%, 5% and 15%) of recreational fishery post-release mortality (PRM) derived from recent studies on sea bass were tested. Based on the information provided by Hyder *et al*. (2018), WKBASS 2018 agreed on a figure of 5% for PRM in recreational fisheries. Thus, a baseline value of 5% was used in the base model for assessment for the Northern and the Bay of Biscay sea bass stocks. A PRM of 5% was also used to calculate total removals from the recreational fisheries. Moreover, WKBASS 2018 re-estimated length compositions of the recreational fisheries for both stocks to account for the revised 5% PRM value.

1 Introduction

WKBASS is a three-part benchmark workshop (one data compilation workshop and two assessment workshops) aimed at improving the scientific advice on sea bass (*Dicentrarchus labrax*) stocks in the Bay of Biscay (BSS-8.ab: ICES areas 8.a,b) and in the North Sea, Channel, Celtic Sea and Irish Sea (BSS-47: ICES areas 4.b,c and 7.a, d–h). There were concerns following the first assessment workshop in February 2017, so the methodology was finalised at the second assessment workshop in February 2018. This report contains the analyses carried out during the last workshop held in February 2018, which was focused on finalising the data and the configuration of the Stock Synthesis models used for the assessment of both stocks.

Many of the datasets and parameters for this stock have been thoroughly reviewed in the workshops, and WKBASS 2018 did not revisit these. Instead, WKBASS 2018 focused on those aspects of the assessment that were not fully resolved during previous workshops, i.e. estimate of natural mortality, standardisation of individual French vessel lpue (tonnes/day) data to be used as tuning fleet in the assessment and revision of the values of recreational fishery post-release mortality (PRM) to be used to estimate total removals and length compositions of the recreational fisheries for both stocks.

The general Terms of Reference (ToRs) for WKBASS, and the detailed ToRs for the data workshop, are given in Annex 2. The detailed ToRs follow the guidelines for benchmark data evaluation workshops developed by the ICES Planning Group on data Needs for Assessments and Advice (PGDATA: ICES, 2015b), which provides detailed guidance on work needed to be completed under each ToR. A detailed agenda for the meeting was drawn up well in advance of the meeting, and is located on SharePoint. Time slots were allocated under each Term of Reference for each stock. The participants at the meeting are in Annex 1.

The WKBASS team included several external expert reviewers appointed to help in developing the stock assessments and to provide an expert review of the process and outcomes, and to provide advice on future development needs. Section 2 of this report includes their comments on the work done.

2 External Experts' comments on sea bass stock assessments reviewed at WKBASS 2017 and WKBASS 2018

The Panel of External Experts evaluated data and modelling approaches used for assessments of sea bass stock in central and southern North Sea, Irish Sea, English Channel and Celtic Sea (divisions 4.b-c, 7.a and 7.d–h) and the sea bass stock in Bay of Biscay (divisions 8.a,b).

Both assessments used the Stock Synthesis (SS) modelling platform (Methot and Wetzel, 2013). This is a flexible platform that allows one to incorporate a variety of available information, and explore various assumptions and modelling choices regarding the stock. The Panel reviewed the SS input files in detail, to ensure that current best practices were used in data inputs, parameter settings and data weighting techniques.

The Panel met twice. At WKBASS 2017, the Panel reviewed data inputs, explored model structural choices and agreed on configuration of the base models for both assessments. At WKBASS 2018, the Panel focused on evaluating the revised lpue-based abundance index and improved estimates of recreational catches, and length composition data. The Panel agreed that the revised data inputs represented improvements, and should be used in the assessment models. The Panel then evaluated performance and diagnostics of the consensus base model, and concluded that the data and modelling approaches used to assess the sea bass stocks, represent the best available science. The Panel recommended using both assessments for management decision-making. Biological reference points were estimated using those base models, and were reviewed at the meeting as well.

Specific issues discussed at WKBASS 2017 and WKBASS 2018 regarding each stock and recommendations made by the Panel are described below.

2.1 Issues and recommendations for sea bass stock in central and southern North Sea, Irish Sea, English Channel and Celtic Sea (divisions 4.b-c, 7.a and 7.d–h)

1) Commercial fisheries landings and discards

In the model, commercial catches were divided among several fleets including UK bottom trawl and nets, UK lines, UK midwater trawl, French fleet (all gears combined) and others. For two fleets, recent discard data were used to model discard amounts for the entire modelling period, and length composition data from discarded catch were used to estimate retention curves. The Panel agreed that the model was able to fit the annual discard amounts for both fleets reasonably well, and fits to discarded length compositions were also reasonable. The Panel also agreed that including discard separately from landings (a new feature in this model) enabled a more accurate description of the impact of the fishery upon the stock, and evaluate more complete evaluation of the effectiveness of management measures imposed on this stock.

For most of the modelling period, catch data for the French fleet were only available for all gears combined; thus, the fleet was modelled this way. However, since 2011 landings records have been separated by gear group within the French fleet. Given that selectivity of different gear types may be different, the Panel recommended that fleets would be defined based on gear types rather than countries (e.g. the French fleet) in the next benchmark assessment.

2) Recreational catches

Following the 2016 sea bass inter-benchmark review, recreational catches were included in the model as a separate fleet. Only one year (2012) of reliable recreational catch records is available for the stock. The recreational fishery has however had stable participation and effort over time. Given this situation, the approach taken for years with no data was to assume 2012 fishing mortality rate within the fleet for the whole modelling period.

Recreational catches in the model were iteratively adjusted to obtain a recreational F, which would match the catch in 2012, the year when the recreational catch estimate considered to be reliable. The same methodology was used to estimate recreation catches for the sea bass stock in Biscay Bay.

For WKBASS 2018, the recreational catch estimates used in the model were slightly revised. An adjustment was made to recreational catch estimates in the most recent years (2013–2016) to account for the recent management measures. Catches in this fleet were also adjusted to account for discard mortality rate of released fish (5%) that was also updated at WKBASS 2018 based on new information.

The Panel approved the approach, and the final time-series for use in the model, but recommended to further explore recreational catches in the future assessment, and incorporate any new information that will become available. A sensitivity analysis was also recommended to evaluate impact of assumptions regarding the recreational catch stream to model output. The Panel also encourages efforts to collect more data on recreational removals of sea bass in future.

The base model also utilized new length composition data for recreational catch. The Panel reviewed the data (which included both retained and discarded portions), and agreed they should be used to estimate selectivity for this fleet. Previously, the selectivity of recreational removals was "mirrored" to one of the commercial fleets. The Panel agreed that using length compositions data collected from recreational catches enables more accurate description of selectivity of this fleet, and modelling of the impact of the recreational removals on the stock.

3) Length and age composition data and gear selectivity

The Panel reviewed the compositional data and selectivity assumptions used in the model. The model uses marginal length and age compositional data for fleets when both types of data are available, but set the emphasis factors (lambda) in the model for the length and age compositions for fleets with both types of data to 0.5 (instead of 1) to eliminate an issue of fish "double counting" in estimating the total likelihood (since lambda values are being multiplied in the model by the corresponding likelihood component). The Panel agreed that using marginal age composition is appropriate to the current model, but for the next benchmark assessment, recommended using a conditional age-at-length approach to incorporate age data along with length compositions, which is now a common practice within SS.

In the conditional age-at-length approach, individual length and age observations can be thought of as entries in an age–length key (matrix), with age across the columns and length down the rows. The approach consists of tabulating the sums within rows as the standard length–frequency distribution, but instead of also tabulating the sums to the age margin, the distribution of ages in each row of the age–length key is treated as a separate observation, conditioned on the row (length) from which it came. Using conditional age distributions for each length bin allows only the additional information from age data to be captured, without creating a "double-counting" of the data in the total likelihood. This approach also allows estimation of all growth parameters within the stock assessment model, including the CV of length at young age and the CV at old age (which is only possible to do based on marginal age-composition observations when very strong and well-separated cohorts exist). At the present, all growth parameters in the assessment model are fixed at the level estimated outside the model.

The Panel evaluated selectivity assumptions for each of the fleet and explored variety of blocking schemes to reflect changes in fisheries and improve model fit to compositional data. The blocks were applied for several selectivity and retention parameters of commercial fisheries fleets starting in 2015, to reflect management changes that were recently implemented. The Panel concluded that the base model agreed upon at the end of the meeting exhibits good fits to length and age composition data, and estimated selectivity curves reflect current knowledge of fisheries and how they changed over time.

4) Relative abundance indices

Several indices of abundance were used in the model, including a new landings-per-unit of effort (lpue) approach developed using data from the French fishery (Laurec *et al.,* 2018).

The approach used to generate the lpue-based abundance index went through a series of reviews by an external expert (M. Christman), and incorporated a number of recommendations for improvements suggested by the reviewer, both to the method and the data. The Panel was presented with a number of documents describing the method for deriving the index, as well as the reviews conducted by the external expert.

The Panel discussion focused on two main issues related to the index: 1) incorporation of zero landings data in the abundance index calculation, and 2) the use of the full vs. a truncated index time-series in the assessment. After lengthy discussion, the Panel concurred with recommendations of the external reviewer on both issues and agreed that 1) data showing zero landings per day should be included in the calculation of the abundance index, since these data are informative of a stock trend, and 2) to use the full (2000 forward) rather than a truncated (2009 forward) version of the index time-series in the assessment. The second issue appeared because in the pre-2009 period, the database included several unrealistically low (<1 kg) records of catch that are considered to be false positive. However the issue was easily corrected, and should not prevent developing and using the index for the full time-series of otherwise reliable data.

In the assessment model, extra standard deviation was estimated for the index, to account for sources of variability not captured by the index.

5) Stock structure

The Panel reviewed the most recent information on sea bass stock structure. The available information does not suggest changes in the stock definition. However, the sampling design and locations of tagging studies that were presented at the meeting did not cover the entire range of sea bass distribution, and as such, the relevance and utility of those results are limited. The Panel recommended further investigation of the issue, including a full evaluation of connectivity among areas within the sea bass range, but agreed that at present the current (though limited) information does not present a basis for a changing definitions of stocks that are currently in use.

6) Biological parameters

The Panel evaluated assumptions about several life-history parameters in the model, including natural morality and spawner-recruit steepness via profile analyses, and agreed that parameters assumed in the model are reasonable. The Panel also discussed at length multiple approaches that currently exist to inform natural mortality, and agreed that the method selected for the base model (see stock annex for details) represent the best available science.

In the model, all of the growth parameters are fixed at the values estimated outside the model. Although these parameters were estimated based on large amount of length and age data from multiple sources, the Panel recommends pursuing estimation of the growth parameters within the model in future assessments, because doing so allows for uncertainty associated with growth parameter estimates to be propagated through the assessment results. It is also recommended to input age data as conditional age-at-length compositions so the model can reliably estimate growth parameters (as stated earlier in this report).

2.2 Issues and recommendations for sea bass stock in Bay of Biscay (divisions 8.a,b)

1) Commercial landings and discards

In this model, fisheries catches are divided between two fleets; commercial and recreational. The commercial fleet combines removals made by fisheries operating with different gear types. The Panel discussed alternative options for fleet structure, including gear-specific fleets. However, it was agreed that combining commercial catches into one fleet was a reasonable approach, given that the assessment has limited amount of data to estimate selectivity curves for each separate gear type. Also, it is considered that historically, the fishery has had relatively static proportional contributions among fisheries operating with different gear types. The length composition data used to describe selectivity of the commercial fleet were expanded (by gear and area) to account for biological sampling, which may have been disproportionate to catch by different gear types.

The Panel also evaluated available data on discarded catch, and agreed that discards over the years were negligible (less than 5%), and thus they were not modelled separately from landings.

Finally, the Panel discussed whether catch time-series (and thus modelling period) should start in 2000 (when catch records were more reliable) or go back to 1985 (when catch records existed but have higher degree of uncertainty than those after 2000). The Panel agreed that incorporating all the data available and using the longer time-series of catch is the more reasonable approach, since history of fishing allows to better understand the current status of the stock. The Panel recommended to evaluate uncertainty in pre-2000 catch via sensitivity analysis.

2) Recreational removals

Recreational catches were treated as a separate fleet. One issue was that only a few years of recreational catch estimates are available for the stock, although the fishery has shown stable participation and effort over time. Therefore, a constant fishing mortality rate was assumed for recreational removals in years with no data, over the entire modelled period. Recreational catches in the model were iteratively adjusted to obtain a recreational F that matched the catch of 1430 tons in 2010, the year when the recreational catch estimate considered to be reliable. The same methodology was used to estimate recreational catches for the sea bass stock in in central and southern North Sea, Irish Sea, English Channel and Celtic Sea.

The recreational catch estimates used in the WKBASS 2018 model were slightly revised. An adjustment was made in the most recent years (2013–2016) to account for recent management measures. Catches in this fleet were also adjusted to account for discard mortality rate of released fish (5%), which was also updated at WKBASS 2018 based on new information.

The selectivity curve for this fleet was estimated based on recreational catch data, and length samples from retained and released portions of the catch were expanded appropriately and combined into a single distribution.

The Panel evaluated the methods used to derive recreational catch estimates and recommended them for use in the assessment. The Panel also encouraged to efforts to collect more data on recreational removals of sea bass in future.

3) Index of abundance

The approach used to generate the lpue-based abundance index went through a series of reviews by an external expert (M. Christman), and incorporated a number of recommendations for improvements suggested by the reviewer, both to the method and the data. The Panel was presented with a number of documents describing the method for deriving the index, as well as the reviews conducted by the external expert.

The Panel discussion focused on two main issues related to the index: 1) incorporation of zero landings data in the abundance index calculation, and 2) the use of the full vs. a truncated index time-series in the assessment. After lengthy discussion, the Panel concurred with recommendations of the external reviewer on both issues and agreed that 1) data showing zero landings per day should be included in the calculation of the abundance index, since these data are informative of a stock trend, and 2) to use the full (2000 forward) rather than a truncated (2009 forward) version of the index time-series in the assessment. The second issue appeared because in the pre-2009 period, the database included several unrealistically low (<1 kg) records of catch that are considered to be false positive. However the issue was easily corrected, and should not prevent developing and using the index for the full time-series of otherwise reliable data.

In the assessment model, extra standard deviation was estimated for the index, to account for sources of variability not captured by the index.

4) Biological parameters

The Panel evaluated assumptions about several life-history parameters in the model, including natural morality and spawner-recruit steepness via profile analyses, and agreed that the parameter values used in the model are reasonable. The Panel also discussed at length, the multiple approaches that exist to inform natural mortality, and agreed that the method selected for the base model (see stock annex for details) represents the best available science. Further research focused on improving estimates of natural mortality is recommended.

Age data for the commercial fleet were entered as conditional age-at-length compositions, which normally enable estimation of growth parameters within the model. However age samples from fishery were limited, and did not cover the full range of ages for the stock. As a result, the model had difficulty estimating length at initial age ($L\_at\_A_{min}$) and asymptotic length ($L\_at\_A_{max}$); those parameters were therefore fixed at levels estimated outside the model. The model was able to estimate the von Bertalanffy growth coefficient *k*, but it was later fixed at the estimated level.

The Panel agreed that given the amount the data, it is reasonable to fix growth parameters, but also recommends working toward improving age data, and continuing to pursue estimation of growth parameters within the model.

2.3 References

Methot, R.D., Wetzel, C. 2013. Stock Synthesis: providing a biological and statistical framework for fishery management forecasts across a data-poor to data-rich continuum. Fish. Res. 142: 86–99.

3 Stock structure and behaviour

3.1 Stock structure

European sea bass inhabits the coasts, estuaries and lagoons of the Mediterranean Sea and Northeastern Atlantic Ocean. Mediterranean and Atlantic fish differ in morphology, life history and genetics to such extent that they may be considered almost subspecies (Lemaire *et al.*, 2005; Volckaert *et al.*, 2007; Tine *et al.*, 2014). Atlantic fish occur in the North Sea (area 4–up to 60°N), English Channel (7.d–e), Irish Sea (7.a), Celtic Sea (7.bf–j), Bay of Biscay (8.a–c), off Portugal and Atlantic Spain (9.a), and off the coast of Morocco (30°N).

Sea bass is thought to represent a single population based on its ability to swim. This was observed with allozymes, mitochondrial haplotypes and limited number of microsatellite markers, although this latter observation seemed to be related to the limited resolution of the markers to map subtle patterns (Child, 1992; Naciri *et al.*, 1999; Fritsch *et al.*, 2007; Coscia and Mariani, 2011; Coscia *et al.*, 2012). Tagging studies pointed to homing, large distance movements and the possibility of subpopulations (Fritsch *et al.*, 2007; Pawson *et al.*, 2007b). However, Quéré *et al*. (2010) discovered at a single locus a subtle but meaningful differentiation between samples from the North Sea and the Bay of Biscay (8.b) using gene-linked microsatellite loci. In line with these findings, Souche *et al*. (2015) reported a subtle differentiation between southeastern (9.a) and Northeastern Atlantic populations. Population structure coincided with a subtle pattern of isolation by distance (IBD), which suggested a higher gene flow between adjacent populations than between distant populations.

Hillen *et al*. (in prep.) confirmed, based on a large set of 2549 SNPs, FST values of overall genetic differentiation of 0.004 and pairwise values between <0.001 and 0.015 (the latter between Norway and south Portugal). A subtle, but significant pattern of isolation by distance is primarily attributed to genetic differentiation between a geographically confined southeastern Atlantic region (9.a - off the Strait of Gibraltar) and a geographically large population in the Northeast Atlantic Ocean. The Southeast Atlantic group (9.a) showed evidence of introgression with Mediterranean sea bass. Sea bass caught off the coast of southern Norway appeared to be genetically differentiated from the remaining Atlantic populations (Hillen *et al*. in prep.). Interestingly, sea bass has only been reported from Norway from 1989 onwards (Pawson *et al.*, 2007a). Variance analysis based on outlier SNP loci, which are loci with above average FST values, showed that the environment (measured as salinity, temperature, mixed layer depth, chlorophyll concentration and primary production) contributes more than distance to the overall variation in distribution pattern (Hillen *et al.*, in prep.)

The sea bass inhabiting the Atlantic Ocean show a remarkable homogenous genetic structure although homing based on mark–recapture data suggests some level of population structure. Off the Strait of Gibraltar (9.a) there is evidence of introgression by the Mediterranean group. Sea bass inhabiting the areas Northern (4.b&c, 7.a,d–h) and Biscay (8.a&b) represent genetically one population unit. The current management in two stocks (Northern and Biscay) can be considered a conservative and correct measure. As a result, the stock structure used for the assessments is the same as previous years.

3.2 Behaviour

A detailed update of existing knowledge and new findings from unpublished studies of sea bass behaviour was provided to the WKBASS and the impacts of new studies on the stock assessment is provided below.

The life cycle of sea bass is complex. Juvenile sea bass frequent inshore nursery areas on the south and west coasts of the UK (Jennings and Pawson, 1992; Reynolds *et al.*, 2003) becoming sexually mature at ~35 cm in total length for males and 42 cm for females (six to seven years of age; Kennedy and Fitzmaurice, 1972; Pawson and Pickett, 1996). Adult sea bass that spend their summer and autumn months in the southern North Sea (4.c) make long migrations to the western English Channel (7.e) to spawn in warm water (>9◦C). They then move northwards again to summer feeding grounds as water temperatures rise and feeding conditions become more favourable (Pawson *et al.*, 1987; 2007b; Thompson and Harrop, 1987). Sea bass behaviour has been studied using both conventional and electronic data storage tags (DSTs), which have been used to make inferences about the distribution, abundance and migration of individuals.

Analysis of conventional mark ID tags indicated that there were two distinct stocks in the channel (Pawson *et al.*, 1987; 2007b; Pawson, 1995). Analyses of recapture locations showed that adult bass remained within the same region from where they were tagged for most of the time, but limited migration was found between the English Channel or the Celtic Sea and the Bay of Biscay (4%) (Fritch *et al.*, 2007). Short times at liberty and low recapture rates, coupled with fisheries-dependent capture (Fritch *et al.*, 2007) may have influenced the perception of movement and migration of sea bass in the areas explored.

DSTs have been used to investigate individual behaviour patterns of adult sea bass between the North Sea and English Channel (Quayle *et al.*, 2009) and between the Western Channel and Bay of Biscay. Movements were reconstructed using information about release and recapture locations alongside the temperature and depth of individual fish using hidden Markov models (e.g. Woillez *et al.*, 2016) Five of 11 recaptured bass exhibited migrations of greater than 100 km between the central and southern North Sea and western English Channel, which supports previous studies (Thompson and Harrop, 1987; Pawson *et al.*, 1987; 2007b) and provides evidence of migratory links between the North Sea and English Channel. Ifremer tagged sea bass with DSTs in the Iroise Sea from 2010–2012. Reconstructed tracks confirmed the highly migratory nature of bass, with three behavioural strategies: residency in the Iroise Sea; winter spawning migrations into the Bay of Biscay; and winter spawning migrations into the Western Channel/Celtic Sea. Site fidelity was found not only on summer feeding grounds as previously observed (Pawson *et al.*, 2008), but also and for the first time, on winter spawning grounds. This indicated that sea bass populations may have a much finer spatial structure than supported by the genetics. However, sample sizes are very small, so it is difficult to generate robust estimates of the levels of migration between the current Northern and Biscay stocks.

Two large tagging programmes are underway that will provide significant additional information on the movements of sea bass and could indicate the levels of mixing between stocks. The first programme (C-Bass) is being led by the Cefas (UK) and has tagged almost 200 sea bass with electronic data storage tags (DSTs) in two locations (Lowestoft and Weymouth). Around 20 tags have been returned and significant effort is being made to improve the geolocation algorithms through the inclusion of bathymetry and temperature at depth. The BARGIP study is being led by Ifremer and has released 1220 fish with DSTs at ten locations in the Channel and Bay of Biscay. To date, 282 tags have been returned and the movements of individual fish are being reconstructed. Cefas and Ifremer are working together to compare geolocation algorithms and to develop understanding of behaviour.

Preliminary results from the small number of tags that have been geolocated indicated that adult bass can undertake very large-scale migrations. Fish tagged in 4.c exhibited two migration patterns: one that remained in the North Sea; and a second that involved long migrations as far as the Irish Sea. Fish that were tagged in May in 4.c were in spawning condition, suggesting the presence of spawning ground in the North Sea. Bass tagged in area 7.e appeared to remain in the English Channel, but individuals tagged in the Iroise Sea could move between the Northen and Biscay stocks. Behavioural and genetic studies of sea bass are also underway at the Marine Institute, Ireland, with the aim of investigating the distribution of sea bass within Irish waters and the potential existence of an Irish subpopulation.

A further study has been done using stable isotope an analysis of (δ13C and δ15N) composition in scales from a number of locations around the Welsh coast (Cambiè *et al.*, 2016). A random forest classification model was used to test for any differences in δ15N and δ13C values between north, mid and south Wales, and whether it was possible to correctly assign a fish to the area where it was caught. The classification model correctly assigned about 75% of the fish to their collection region based on isotope composition. The results suggest that two subpopulations of sea bass may exist in Welsh waters, using separate feeding grounds (south vs. mid/north Wales) (Cambiè *et al.*, 2016).

Sea bass movement between ICES stock units is plausible, as evidenced from some individuals tagged with DSTs, and fidelity to both spawning and feeding grounds may provide evidence of fine population structure that was identified from genetics. However, it is not possible to quantify the proportion of fish migrating between the stocks currently due to the small numbers of fish tracks analysed. As further DSTs are analysed, it may be possible to quantify exchange between stocks, so the next benchmark should consider how exchange between stocks should be incorporated into the assessment process.

4 Sea bass (*Dicentrarchus labrax*) in Divisions 4.b–c, 7.a, and 7.d–h (central and southern North Sea, Irish Sea, English Channel and Celtic Sea)

4.1 Issue List

The full issues list for WKBASS is given in the Table 4.1.1.

Table 4.1.1. Updated issues list for Bss-47 available to WKBASS, following pre-meeting WebEx, and progress made at WKBASS.

Issue	Problem/Aim	Work needed /possible direction of solution	Data needed to be able to do this: are these available /where should these come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
Fishery landings data	The assessment is heavily driven by fishery landings data and age/length compositions. Historical landings are subject to several biases, and this will bias the assessment trends.	Review the French landings prior to 2000. Develop more accurate series of UK small-scale national fisheries landings. Develop plausible alternative scenarios for landings series for testing in SS3 including pre-1985 data.	Historical national landings data (available). Cefas sea bass logbook data (available) plus other regional observations (to be sourced). French data from 2000 onwards can be split by fleet.	No further analysis done on French pre-2000 landings. Cefas bass logbook data used for developing alternative <10 m nets and lines landing for sensitivity runs.	No further investigations into quality of commercial landings data.
Fishery composition data and selectivity	SS3 model relies on fitting selectivity by fleet, This needs sufficiently accurate age/length composition and to properly account for changes in selectivity, while minimising	Review quality and amount of sampling for length and age composition by fleet. Examine evidence of shapes of selectivity curves and for changes in selectivity over time.	Sample and fleet data held nationally (available).	Sampling design, coverage and sample numbers for length and age sampling in UK and France presented at WKBASS data workshop. Data for Netherlands and Belgium not sourced.	SS3 model updated to account for changes in selectivity of French fleet since cessation of midwater pair trawling, and for changes in selectivity and retention due to

Issue	Problem/Aim	Work needed /possible direction of solution	Data needed to be able to do this: are these available /where should these come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
	thenumbers of parameters to estimate. Current implementation of age and length selectivity could be a source of bias in estimating stock trends.	Identify minimum sufficient disaggregation of fleets. Evaluate parameter correlations and minimise numbers of parameters to estimate. Review availability of French sampling data prior to 2000. Evaluate sampling data by métier from other countries (Netherlands, Belgium). Identify leverage of individual fleet data on final results.		SS3 parameter correlations examined.	increased MCRS from 2015 onwards. Selectivity and retention blocks included from 2015 onwards for UK and French fleets.
Recreational catches and selectivity	Recreational catches are considered to be around quarter of total removals, but current assessment uses only one annual estimate to provide a crude value for recreational fishing mortality to apply to all years. This assumption is almost certainly incorrect since	Update results of new surveys conducted since ICES (2016a), if available. Develop and test alternative methods for accounting for recreational fishery catches in the assessment. Liaise with ICES WGRFS to develop inputs and methods.	Recreational survey estimates available nationally and from submissions to ICES WGRFS.	WKBASS updated all available recreational fishery survey estimates for sea bass. Separate length compositions derived from French survey estimates for Area 7 and 8. French survey estimates of catch in 2011–2012 previously supplied for	Post release mortality is set to 5% based on Lewin *et al*. (2018) and applied to national recreational survey data to give total removals and length composition of removals for the reference year of 2012. Selectivity is estimated in

Issue	Problem/Aim	Work needed /possible direction of solution	Data needed to be able to do this: are these available /where should these come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
	the introduction in 2015 of magement measures, so it will be necessary to account for changes in recreational catches based on successive survey estimates as they become available. Selectivity of recreational catches is based on limited data and is likely to change over time.			whole of France. WKbass data WK obtained separate estimates by area, but could not validate the method and the survey documentation is limited, so this survey is not used. A data call was issued in May 2017 for all sea bass data and reviewed by WGRFS (ICES, 2017). Additional provisional data were provided by the Netherlands and UK only. No data were provided by France, leading to the need to estimate the impact of management on French catches. This was done using changes in the catches from the Netherlands to scale French data from 2009–2011. This, in combination with a higher weight for	SS3 from survey length composition rather than mirroring UK commercial lines. The imputation procedure to reconstruct French recreational catches that gave rise to esimates of 1627 t was deemed to be too uncertain. Instead, potential reductions in recreational F in 2015 and subsequent years due to MCRS, bag limits and closed season is explored using existing survey data (2009–2012). This is included in the assessment using a multiplier for the recreational fishing mortality to represent the reduction due to management measures. This

Issue	Problem/Aim	Work needed /possible direction of solution	Data needed to be able to do this: are these available /where should these come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
				individual fish and a 15% post-release mortality led to a proposed removal of 1627 t (ICES, 2017a). The large uncertainties in this extrapolation was highlighted and the need to test sensitivities of the assessment to different reconstruction approaches (ICES, 2017a). However, only the total of 1627 t was included in the assessment due to time limitations.	approach was needed due to the lack of survey estimates for 2015 onwards.
Relative abundance indices	The assessment currently includes the French Channel Groundfish Survey (CGFS) and the UK Solent prerecruit survey. These are restricted to 7.d, not the full stock area, and are mainly focused on young bass. They show similar trends to analysis of commercial landings-at-	Evaluate the calibration and the area covered by the new vessel for the redesigned CGFS survey. Collate and evaluate information on changes in abundance of young bass in nursery areas in the UK and France, and conduct a cost–benefit analysis of a more coordinated	Ifremer data for the CGFS calibration (available); UK and French prerecruit dataseries for as many nursery areas as possible (mostly available). UK and French landings and effort data by rectangle	CGFS survey calibration report was reviewed by experts in Alaska. The survey used by WKBASS as series terminating in 2014. The 2015 onwards data will be treated as new survey. No new dataseries on prerecruit abundance were considered by	French fishery LPUE series 2001–2016 with modelling of zero trip landings included in assessment following discussion and consideration of external reviewers comments supplied during 2017/2018 and several alternative

Issue	Problem/Aim	Work needed /possible direction of solution	Data needed to be able to do this: are these available /where should these come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
	age/length data without the surveys included, and appear to have limited influence on the model fit. The design of the CGFS is expected to change in 2015 and this may render it unsuitable for inclusion in the assessment. The impact of the change in design should be reviewed. Relative abundance indices are needed that cover the full age range and stock area.	prerecruit survey. A study modelling French commercial fishery lpue is available and should be further developed and tested in the assessment. Evaluate UK data for inclusion in the lpue analysis.	and trip, with vessel/gear data (available). Data from the Netherlands and Belgium should be requested also.	WKBASS. French lpue series was presented at WKBASS data WK, but had not been subject to expert review. A new series excluding vessels with predominantly zero landings was provided at the WKBASS assessment meeting and has been used in the assessment pending provision of lpue model diagnostics from A. Laurec..	series (2001–2016 including modelling of zero catches and alternative series using positive catches only. Issues remain around identification of true zero landings pre 2010.
Discards	Discards estimates are imprecise due to small numbers of sampled trips with sea bass catches, are only available for a recent period, and are not included in assessment as considered low. However absence of data in assessment could cause some bias, and prevents correct	Compile historical estimates, evaluate precision and bias, and test some scenarios for including data in the assessment	Discards data are held nationally and are available. French have data from 2003 onwards by fleet. UK also have discard data	Discards estimates and length compositions for France and UK were compiled by WKBASS data WK and have been used in the SS3 model at the benchmark assessment meeting.	Updated discard series to 2016 included in assessment.

Issue	Problem/Aim	Work needed /possible direction of solution	Data needed to be able to do this: are these available /where should these come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
	estimation of selectivity to allow evaluation of technical conservation measures such as MCRS.				
Post release mortality	Inclusion of discards estimates in the assessment leads to the need for an evaluation of potential survival rates of released fish. Post release mortality in recreational fisheries needs to be accounted for. Increases in MCRS and recreational bag limits will lead to more releases.	Provide updated review of studies on post release mortality in liaison with WGRFS. Test sensitivity of assessment and advice to post release mortality assumptions.	Literature review.	Post release mortality studies were reviewed at the WKBASS data WK. Value of 15% included in baseline assessment models, with sensitivity testing of larger values.	Post release mortality value set to 5% based on published study, taking into account likely relative catch using artificial and natural bait (Lewin *et al.*, 2018). Bulk of catch is sea angling, so can be applied to entire recreational releases.
Stock structure (genectics)	Stock structure remains uncertain. Trends in recruitment could vary between areas while current surveys are spatially limited. Movements between 4/7 and 8, particularly if changing over time, would bias the assessment trends.	Review findings of the UK C-Bass and French BARGIP projects which have carried out tagging studies and hydrographic modelling of egg and larval dispersal. SS3 could be configured to include spatially disaggregated data covering populations	Results of UK and French studies should be available; assessment input data for BSS-47 and BSS-8AB needed and will be available.	Documents were supplied to WKBASS assessment meeting covering: French BarGip pr oject;UK C-Bass project; and genetics studies. The Marine Institute, Ireland also has a study on tagging, genetics, acoustics telemetry and egg/larval drift	Stock identification and tagging studies still underway – no further information supplied to WKBASS. No change to stock structure.

Issue	Problem/Aim	Work needed /possible direction of solution	Data needed to be able to do this: are these available /where should these come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
		within area 4, 7 and 8, as an exploratory exercise to see if this could improve the advice for both areas.		modelling. However, no results were available.	
Biological Parameters	Natural mortality is considered constant over time at a relatively low value of 0.15 for all ages. Maturity ogives are based on long-term historical UK sampling and do not account for trends that may have occurred. Inappropriate treatment of growth and M could bias the assessment and reference points, while not accounting for changes in maturity would bias SSB trends and reference points.	Review evidence of spatio-temporal variation in growth, maturity, and age-dependent M. Examine sensitivity of assessment and advice. Develop parameter inputs for future assessments.	Historical and recent sampling data for growth and maturity. Available nationally. Review methods for identifying appropriate M values and plausible ranges.	WKBASS data WK explored various life-history and maximum age-based methods, including age-dependent M. The WKBASS assessment meeting explored the sensitivity of the assessment to different M options.	Life-history based value of M=0.24 from Then *et al*. (2015) used by WKBASS 2017 was retained for new assessment. Sensitivity to M considered in assessment sensitivity runs during benchmark. No revisions to other biological parameters
Assessment method	Stock Synthesis 3 is complex, highly parameterised and requires expertise to understand how to set up the model and interpret the diagnostics. If	Comparison of performance of alternative assessment models of differing structure and complexity including very simple approaches.	Will be done with available data.	Further development of the SS3 model was carried out at WKBASS assessment meeting. Only limited sensitivity testing of the	SS3 model revised to include selectivity blocks and input recreational F reductions as described above. MCMC

Issue	Problem/Aim	Work needed /possible direction of solution	Data needed to be able to do this: are these available /where should these come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
	age data become available for the French fishery and survey data, alternative models could be explored. If SS3 is retained, a more comprehensive evaluation of model performance is needed, (e.g. jitter analysis).	Further development of SS3 and presentation / interpretation of diagnostics, forecasts and MCMC evaluation of confidence intervals.		final model was done, and there were large uncertainties in F. MCMC runs not possible at assessment meeting, but should be explored after the meeting.	procedure still not developed.
Biological Reference Points	Current reference point is Fmsy proxy or F35%spr. This is driven by the choice of M. The assessment forces stock–recruit steepness as 1.0 as there is little information in the stock–recruit data to define steepness.	Review of choice of M as discussed above. Further evaluation of S/R steepness including S/R data from alternative assessment models.	Agreed stock assessment inputs.	Biological reference points were estimated at WKBASS assessment WK.	Biological reference points estimated at meeting using EQsim software. SSB estimates have declined below previous Blim, so a decision was made to redefine Blim as the 2016 SSB estimate.

4.2 Input data

4.2.1 Data input summary

Table 4.2.1.1 summarises the data and parameter inputs available for the benchmark assessment. See WKBASS Data WK report for detailed description of the individual datasets and basis for any recommendations for using the data in the assessment. Changes from data or parameters used in the most recent WKBASS assessment in 2017 are described in the sections below the table.

Table 4.2.1.1. Summary of data and parameter estimates available for the assessment.

Data / parameter	Description	Source
Growth	Fixed values of von Bertalanffy growth parameters K; Length-at-Amin and Amax; SD of length-at-age; age error vector	Unchanged from ICES (2016a&b).
Maturity	Female proportion mature at age	Unchanged from ICES (2016a&b).
Natural Mortality	Then *et al*. (2015) M=0.24 for all ages.	Unchanged from WKBASS assessment WK in 2017.
Commercial landings 1985–2016	UK split by gear (otter trawl and nets combined, midwater pair trawl, lines). France all gears, other countries, and other UK gears	Unchanged fleet definition from ICES (2016a&b). Updated series from ICES (2017b).
Commercial landings length/age composition	Length compositions and fleet-raised marginal age compositions: UK by gear 1985–2016. France combined fleets 2000–2016	Unchanged fleet definition from ICES (2016a&b); updated series from ICES (2017b).
Commercial discards catch numbers and weight	Fleet-raised estimates from observer schemes: UK otter trawl and nets (2002, 2003 and 2005–2016); and France otter trawl, lines and nets (2009, 2010, 2012–2016). Data for other gears not sufficient for inclusion.	Updated series from ICES (2017b).
Commercial discards length compositions	Fleet raised length compositions	Updated series from ICES (2017b).
Recreational removals – kept and released	Estimates from Surveys in France (2009–2011), Netherlands (2010–2011), UK (2012) are combined and allocated to reference year 2012. Post-release mortality of 5% included to calculate total removals. Reference year 2012 removals used to estimate a year-invariant recreational F and associated removals for all years up to 2014. For 2015 onwards, removals are estimated using reduced values of F consistent with the increased MCRS, bag limit, and closed season, based on a study where such measures were applied to trip data from the 2009–2012 recreational surveys in France, UK and Netherlands (Armstrong *et al.*, 2014).	Estimates of catches for 2012 from ICES (2016a&b), with Belgium estimates removed. PRM changed from 15% value used by WKBASS 2017 (see below). Recreational F estimation procedure for years up to 2014 unchanged; method for 2015 onwards is newly developed by WKBASS (Hyder *et al.*, 2018). This changed from the imputation procedure adopted by WKBASS 2017 (ICES, 2017a) due to uncertainty in favour of the recreational F procedure (Hyder *et al.*, 2018). Scenarios provided to test sensitivity of assessment to recreational removals.
Recreational fishery length compositions	International length composition for reference year 2012 compiled from UK, France, and Netherlands data for kept and released fish, with post-release mortality of 5% applied (Hyder *et al.*, 2018).	WKBASS 2018 analysis revised length compositions to account for 5% post-release mortality (Hyder *et al.*, 2018).

Data / parameter	Description	Source
Recreational fishery post-release mortality	Baseline value of 5% from a fishery wide estimate of post-release mortality calucalted based on fishing methods. Aditional estimates provide for values of 1 and 15% based on the confidence limits in the Lewin *et al*. (2018) study.	Based on published study by Lewin *et al*. (2018). Changed from 15% value adopted by WKBASS 2017.
Channel Groundfish Survey in VIId (France)	Numbers and length composition indices from 1988–2014. Vessel and design changed in 2015 resulting in termination of time-series in 2014. Domed selection fitted in SS3	Unchanged: Ifremer data supplied to ICES (2017b).
Solent trawl survey (UK)	Otter trawl survey of a major nursery area (1986–2016). Indices by age class for ages 2–4.	Unchanged. Cefas data supplied to WGCSE with minor edits by WKBASS 2017.
French commercial lpue series	GLIM analysis of individual French vessel lpue (tonnes/day) in selected rectangles and gears (2001–2016). Combined analysis of proportion of zero catches and catch rates of positive trips using 1kg as threshold for defining positive trips due to inclusion of implausible "false positive" landings <1 kg mainly prior to 2010. Includes otter trawls, nets and lines with gear effects estimated.	New series submitted to WKBASS 2018 including combined modelling of zero and non zero landings.

4.2.2 Biological parameters–growth and maturity

Growth and maturity parameters, and their use within the assessment model, remain unchanged from the previous assessment and are described in the Stock Annex.

4.2.2.1 Growth

Von Bertalanffy growth parameters are estimated from fishery and survey data for over 90 000 fish collected in the UK since the 1980s (Armstrong and Walmsley, 2012a). Estimates for different ICES areas plus all areas combined are given in Table 4.2.2.1 below. The all-areas parameters are used as fixed values in the current Stock Synthesis assessment.

Table 4.2.2.1. Estimated VB growth parameters by ICES area.

Area	4.b-c	7.d	7.e	7.a, 7.f-g	All areas
Linf (cm)	82.98	87.22	92.27	81.87	84.55
K	0.1104	0.09298	0.07697	0.09246	0.09699
t_0 (years)	-0.608	-0.592	-1.693	-1.066	-0.730

The sampled sea bass show some sexual dimorphism of growth from about seven years of age onwards. It is currently not possible to implement a sex-disaggregated Stock Synthesis assessment; therefore a combined-sex growth curve is adopted. Mean length-at-age has not shown any trend over time, and length-at-age is also very similar in strong and weak year classes (Armstrong and Walmsley, 2012a). Hence, data have been combined over the full series to estimate growth parameters.

Standard deviation of length-at-age distributions increases linearly with age following:

SD (age) = 0.1166*age + 3.5609.

4.2.2.2 Maturity

Maturity ogives are derived from 590 male and 730 female sea bass collected in the UK between 1982 and 2009 immediately prior to and during the spawning season (December to April). The data were modelled using a binomial error structure and logit link function, fitted using R (© 2016 The R Foundation for Statistical Computing) to individual observations (Armstrong and Walmsley, 2012b). The logistic model describing proportion mature by 1 cm length class *L* was formulated as:

$$Pmat(L) = 1/(1+e^{-(a+bL)})$$

defined by the parameters slope *b* and length intercept *a*. These parameters were estimated separately for females and males. This can also be expressed as:

$$Pmat(L) = 1/(1+e^{-b(L+c)}) \text{where } c = a/b$$

Stock Synthesis uses the second formulation, and the parameters required are the slope (b = 0.3335) and the length inflection, which is the estimated length at 50% maturity (L50% = 40.65 cm). The parameters of the model $Pmat(L) = 1/(1+e^{-b(L+c)})$ are given in Table 4.2.2.2.

Table 4.2.2.2. Estimated length-based maturity ogive parameters.

	Females	Males
Intercept (a)	-13.56	-16.85
Slope (b)	0.334	0.486
c = a/b	-40.65	-34.67
L25%	37.35	32.41
L50%	40.65	34.67
L75%	43.95	36.93

The logistic model for females and males is:

$$Pmat(L) = 1/(1+e^{-0.334(L-40.65)}) \quad \text{(females)}$$
$$Pmat(L) = 1/(1+e^{-0.486(L-34.67)}) \quad \text{(males)}$$

The length-based maturity ogive for female sea bass is used in the current Stock Synthesis assessment model, which derives proportion mature at age by applying the length-based ogive to the length-at-age distributions defined by the growth parameters and SD of length-at-age:

Table 4.2.2.3. Proportion mature at age (females) derived by Stock Synthesis model.

Age	0	1	2	3	4	5	6	7	8	9
Pmat	0.000	0.000	0.000	0.000	0.093	0.295	0.577	0.798	0.915	0.966
Age	10	11	12	13	14	15	16	17	18	19+
Pmat	0.986	0.994	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000

4.2.3 Natural mortality

There are no direct estimates of M for sea bass. The WKBASS 2017 Data WK reviewed a number of life-history based methods for inferring natural mortality rates in teleost fish based on metrics such as lifespan and growth parameters. The WKBASS 2017 assessment WK adopted the predictions from a recent paper by Then *et al*. (2015) which analysed data from 226 studies to evaluate the robustness of life-history based M inferences. Their equation $M = 4.899.\ tmax^{-0.916}$ gives M values of 0.23–0.25 for tmax of 26–28 years as observed in the BSS-47 stock. WKBASS 2017 Data WK also considered methods to derive age-dependent M (Gislason *et al*., 2010; Lorenzen, 1996) and to rescale these to match the Then *et al*. (2015) prediction over the age range of mature fish. However this was not adopted for the benchmark assessment which adopted M = 0.24 for all age groups.

4.2.4 Post-release mortality

4.2.4.1 Commercial fisheries

Discarding of sea bass below the MCRS occurs in most commercial fisheries to a variable extent. ICES advice sheets indicate overall international discard rates of only 5% by weight for the BSS.27.4bc7ad–h stock based on data supplied to the Working Group on the Celtic Seas Ecoregion (WGCSE). The WGCSE and WKBASS Data WK 2017 showed that discard rates have typically been highest in bottom otter trawls (OTB) and have increased following the introduction of additional management measures in 2015. Discards are now included in the WKBASS assessment of this stock and in the absence of any data on post-release survival, this has been assumed to be zero for all commercial fisheries. This will overestimate commercial fishing mortality to some extent although the effect will be small due to the low discard rates.

Survival of fish discarded by commercial line vessels may be similar to survival of recreational angling releases (see next section), but work is needed to establish the typical gear, handling, and condition of fish to be released. Survival of sea bass caught by trawls, seines, fixed or driftnets and longlines will depend on many factors including: tow duration, soaking times, gear design, deep-hooking, and time on deck. WKBASS identifies a need for studies on post-release survival of sea bass in different commercial fisheries, particularly in view of the potential inclusion in the Landings Obligation.

4.2.4.2 Recreational fisheries

Recreational fisheries on European sea bass are characterised by relatively high release rates, which appear to have increased following changes in management which increased the MCRS from 36 cm to 42 cm in 2015 and imposed bag limits and closed seasons. The WKBASS Data WK reviewed information available on post-release mortality of sea bass caught by recreational sea angling from two recent studies in Spain and Germany, and compared these with estimates obtained for the US striped bass stock in North Atlantic marine waters. The Data WK proposed that a value of 15% for post-release mortality should be applied, and that sensitivity of the assessment to larger and smaller values should be examined.

The appropriateness of this value for PRM was reviewed in more detail for WKBASS 2018 (Hyder *et al.,* 2018). Based on the information provided by Hyder *et al.* (2018), WKBASS agreed on a figure of 5% for PRM in recreational fisheries on BSS.27.4bc7ad–h, which are predominantly sea angling. In addition, the sensitivity of the Stock Synthesis Model to values of 1% and 15% should also be tested. This estimate is based on Lewin *et al*. (2018) in which 144 fish were maintained in an aquaculture facility and then captured by experimental angling using a range of bait and articial lures. The fish were then released and held for ten days to assess mortality. The effects of different bait types, air exposure, and deep hooking were investigated, with increased mortality associated with use of natural bait (13.9%, 95% CI=4.7–29.5%) and deep hooking (76.5%, 95% CI=50.0–93.2%). By combining the experimental results with country-specific information on sea angling practices, the average post-release mortality of sea bass caught by recreational sea anglers in 2012 was 5.0% (95% CI=1.7–14.4%) for BSS-47 (Lewin *et al*., 2018).

4.2.5 Commercial catches and length/age composition

4.2.5.1 Data for baseline assessment

The commercial landings data by country and gear grouping for the benchmark assessment are as used by WGCSE in 2017 and are given in the input data file [Annex 4, A4.2].

4.2.5.2 Accuracy of landings series

French landings from an exhaustive logbook scheme for all vessels (including small-scale fleets) are considered of good quality since 2000. The national data processing system accurately allocates trips since 2000 to ICES rectangles, gear types, etc. Prior to 2000, the allocations are less accurate, so scaling factors have been applied to the annual landings figures to correct for bias. These factors were derived by Ifremer through comparisons of landings since 2000 using the two methods. Landings of French under-10 m vessels may also be biased prior to introduction of the exhaustive logbook scheme in 2000.

In the UK, landings of over 10 m vessels are recorded through an exhaustive logbook and cross-checked against sales data. Accuracy improved in 2006 with the introduction sales documentation through the Buyers and Sellers scheme. The under-10 m fleet are exempt from EU logbooks, with landings estimated from sales data only. It is known that exemptions in the EU Control Regulation from documenting small landings by under-10 m vessels may be a significant source of bias in official UK landings figures (Armstrong and Walmesley, 2012c). A detailed review of small-scale fishery data collection and quality can be found in the ICES Working group on Commercial Catches (2015; 2016 http://www.ices.dk/community/groups/Pages/WGCATCH.aspx).

The UK (England) has previously carried out independent surveys of the fisheries for sea bass to estimate historical landings data, particularly for smaller vessels not supplying EU logbooks. A voluntary logbook scheme was implemented in conjunction with a biennial census of vessels catching sea bass (Pickett, 1990). The scheme was stratified by area, gear, and vessel characteristics. Selected vessels from the strata kept logbooks for periods ranging from one to 25 years, and comprised what could be described as a “reference” fleet as opposed to a randomised selection of vessels each year.

The scheme was terminated in 2007 and 2008, and reinstated for a further two years (2009 and 2010) before being terminated again. The Cefas logbook estimates for nets and lines showed substantial differences with official estimates. For under-10 m vessels using fixed/driftnets, the landings derived from the logbook were on average around three times higher than the official statistics. For lines, the ratio fluctuated around 3.0 for a large part of the series, but was larger from 2000–2005. The estimates are highly variable from year to year, reflecting sampling variance. Insufficient logbooks were available for trawls to allow estimation of fleet-wide landings. Discrepancies subsequent to 2010 are unknown. There is potential for bias in the logbook estimates due to non-random selection of vessels within strata, and the bias is unknown (Armstrong and Walmesley, 2012c).

Some previous WKBASS benchmark assessments have examined sensitivity to trebling UK under-10 m landings throughout the series. This acted to scale up the biomass by a consistent factor over the time-series, but did not alter the total fishing mortality estimates, which are driven by the age composition data. However, the proportion of fishing mortality due to UK fisheries was increased relative to other national fleets and the recreational fishery. Further work is needed to establish the accuracy of landings estimates for sea bass in the small-scale commercial fisheries.

4.2.5.3 Commercial landings length/age compositions

The commercial landings length and age composition data by country and gear grouping for the benchmark assessment are as used by ICES (2017b) and are given in the input data file [Annex 4, A4.2].

The length and marginal age compositions are included for the landings of fleets for which selectivity is estimated (Fleet 1: UK combined trawl and nets -1985 onwards; Fleet 2: UK lines -1985 onwards; Fleet 3: UK midwater trawlers -1985 onwards; Fleet 4: French combined gears -2000 onwards). Fitting to length composition data helps the estimation of length-based selectivity, while the age compositions (from application of age–length keys to length frequencies according to stratified sampling schemes) provide direct fitting of model estimates of catch-at-age. Since the length data are effectively being used twice, the length and age datasets are down-weighted (lambda values) to avoid over-fitting the data. Sample sizes for the multinomial composition data are derived from numbers of fishing trips, as proxy for effective sample size. The relative sample sizes between years are maintained in any reweighting.

4.2.5.4 Commercial discards and length/age compositions

The WKBASS Data WK proposed that the assessment workshop should: i) evaluate the performance of discard data (compiled at the data workshop) in the Stock Synthesis model to allow changes in selectivity and fishing mortality due to discarding to be estimated in future assessments; ii) consider any changes in overall selectivity of combined French fleets due to reduction in pelagic trawling on spawning aggregations, and iii) explore ways to reflect the likely reduction in recreational fishing mortality due to the MCRS and bag limits especially in 2016.

Previous WGCSE assessments have excluded discards on the basis that the proportion discarded at an international level is relatively small (~5% by weight). Discarding has been more an issue for local fisheries such as trawling in inshore waters. Data supplied to ICES (2017b) indicate more discarding in some fleets following the increase in MCRS from 36 cm to 42 cm in 2015. Restrictive bycatch limits for trawls and nets in the new legislation are also likely increase discarding. Without an evaluation of historical fishery selectivity and discard patterns, and changes caused by the new legislation, it is not possible to evaluate the short-term impact of the measures or to monitor how selectivity and discarding will change in future as fleets adapt to the new regulations. The WKBASS assessment WK in 2017 explored the performance of the Stock Synthesis model including recent (noisy) estimates of commercial discards and length compositions. For years prior to inception of observer schemes, a history of discards can be constructed based on the estimates of fishery selectivity and discarding ogives estimated for the recent years that have discard observations.

ICES (2017b) documented observer-based estimates of total discards and associated length compositions for UK otter trawls and nets (which are treated as a combined fleet in the current assessment) over the period 2002–2016 (Table 4.2.5.1), and for French otter trawls, nets, lines, midwater trawl and other gears (Table 4.2.5.2). UK data for 2004 were excluded as no sea bass landings or discards were recorded in the observed trips. Discards for France are available from 2003, but the coverage by gear is variable. Combined discards data for otter trawlers and nets in 2009, 2010, and 2012–2015 were included in assessment (Table 4.2.5.3; SS3 data file in Annex 4). The length compositions for discards by fleet are documented in the WKBASS Data WK report and can also be found in the Stock Synthesis input data file (Annex 4). The UK has observer estimates of discards by beam trawls since 2002 (Table 4.2.5.1), but the quantities landed and discarded are extremely small, so are not used in the assessment. No discards data are available for line fishing in the UK or France, which represents a data deficiency, given the importance of line fishing in both countries.

Table 4.2.5.1. BASS-47 Estimates of annual discard volumes (weight in tonnes) for sea bass from UK vessels, derived from the Cefas observer scheme, for otter trawl, gillnets and beam trawls. Nos. of sampled trips is the total number of observer trips irrespective of whether sea bass were caught. The yellow-highlighted years indicate low-quality nets data included in the combined nets and trawl data used in the assessment.

	Otter trawl			No. trips sampled	Nets			No. trips sampled	Beam trawl			No. trips sampled	Total OTB, nets and BTS		
	discards	retained	rate (%)		discards	retained	rate %		discards	retained	rate %		discards	retained	rate%
2002	17	161	9	34	0	201	0	4	0.2	24	0.7	-	17	386	4
2003	16	207	7	75	0	146	0	12	1.9	21	8.1	-	18	374	5
2004	59	173	25	120	0	207	0	17	0.3	24	1.3	-	59	404	13
2005	6	181	3	79	90	172	34	6	2.4	15	13.7	-	99	368	21
2006	34	160	17	102	19	199	9	21	0.4	14	2.5	-	53	373	12
2007	49	173	22	220	1	239	0.4	72	0.0	19	0.0	-	50	432	10
2008	5	196	3	196	3	318	0.9	40	1.2	21	5.6	-	9	535	2
2009	85	175	33	121	0	311	0.1	48	0.2	10	1.5	-	86	495	15
2010	49	150	25	104	1	302	0.3	42	1.2	6	17.1	-	51	458	10
2011	8	137	6	105	14	324	4.2	51	0.0	5	0.0	-	22	467	5
2012	27	157	15	109	2	407	0.5	70	0.0	5	0.0	-	29	569	5
2013	4	125	3	92	2	405	0.4	100	1.1	4	20.1	-	6	534	1
2014	1	104	1	147	6	647	0.9	84	0.0	8	0.0	-	7	758	1
2015	6	77	7	132	1	340	0.4	51	0.0	8	0.0	-	7	425	2
2016 to Oct	56	24	70	-	61	135	31.0	-	0.2	8	2.3	-	117	168	41
Mean to 2015	26	155	14		10	301	3		1	13	5		37	470	7

Nets: poor coverage pre-2007

2004: no bass in observed trips

Table 4.2.5.2. BSS-47: Estimated discards by French vessels from the Ifremer observer scheme. Number of observer trips and numbers of discarded fish are shown.

FR gear	year	area	discards (t)	cv	Number of trips	Number of fish
FR_LINES	2009	North VII–IV	1.7	0.537	17	21
FR_LINES	2015	North VII–IV	8.0	0.346	28	21
FR_MDW	2007	North VII–IV	0.3	7.338	12	2
FR_MDW	2008	North VII–IV	0.2	4.394	21	4
FR_MDW	2010	North VII–IV	69.2	0.418	35	106
FR_MDW	2011	North VII–IV	5.2	9.282	9	46
FR_MDW	2012	North VII–IV	1.1	16.340	7	29
FR_MDW	2015	North VII–IV	1.8	0.439	32	5
FR_NETS	2007	North VII–IV	12.2	0.210	32	2
FR_NETS	2009	North VII–IV	0.6	0.208	196	3
FR_NETS	2010	North VII–IV	2.2	0.003	108	5
FR_NETS	2012	North VII–IV	9.3	0.120	269	9
FR_NETS	2013	North VII–IV	0.7	0.096	173	2
FR_NETS	2014	North VII–IV	2.2	0.223	118	3
FR_NETS	2015	North VII–IV	1.9	0.173	217	8
FR_OTB	2003	North VII–IV	131.8	1.653	18	26
FR_OTB	2004	North VII–IV	69.6	2.379	24	3
FR_OTB	2006	North VII–IV	22.2	4.400	24	36
FR_OTB	2008	North VII–IV	22.0	8.601	57	63
FR_OTB	2009	North VII–IV	64.6	0.623	143	102
FR_OTB	2010	North VII–IV	95.7	0.653	137	5
FR_OTB	2011	North VII–IV	17.1	1.101	122	57
FR_OTB	2012	North VII–IV	118.3	0.190	151	118
FR_OTB	2013	North VII–IV	47.7	1.151	139	145
FR_OTB	2014	North VII–IV	15.5	0.922	133	29
FR_OTB	2015	North VII–IV	30.6	0.828	189	356
FR_OTHERS	2012	North VII–IV	0.9	1.222	6	9
FR_OTHERS	2014	North VII–IV	59.8	0.705	130	96

Table 4.2.5.3. Discards estimates (tonnes) and precision input for Stock Synthesis. UK CVs are assumed and not estimated.

Year	Discards (tonnes)	CV	Country	Gears
2002	17	0.75	UK	OTB & Nets
2003	16	0.75	UK	OTB & Nets
2004	59	0.75	UK	OTB & Nets
2005	96	0.75	UK	OTB & Nets
2006	53	0.75	UK	OTB & Nets
2007	50	0.75	UK	OTB & Nets
2008	8	0.75	UK	OTB & Nets
2009	86	0.75	UK	OTB & Nets
2010	50	0.75	UK	OTB & Nets
2011	22	0.75	UK	OTB & Nets
2012	29	0.75	UK	OTB & Nets
2013	5	0.75	UK	OTB & Nets
2014	7	0.75	UK	OTB & Nets
2015	7	0.75	UK	OTB & Nets
2009	65.2	0.619	France	OTB & Nets
2010	97.9	0.638	France	OTB & Nets
2012	127.6	0.185	France	OTB & Nets
2013	48.4	1.136	France	OTB & Nets
2014	17.7	0.835	France	OTB & Nets
2015	32.5	0.79	France	OTB & Nets

4.2.6 Recreational fishery catches and length composition

ICES (2014a) considered it necessary to have the catch and fishing mortality due to recreational fishing represented in the assessment model. The approach for achieving this has evolved since then through the benchmark process, and is different from the previous assessment (ICES, 2016a). For the previous assessment (ICES, 2016a), years prior to the introduction of the new management measures in 2015, it was assumed that recreational fishing mortality was constant over time. An estimate of this was obtained as follows:

- Selectivity for retained recreational catch was mirrored with UK commercial lines selectivity.
- A constant recreational F was applied in Stock Synthesis over all years, and iteratively adjusted until the total retained recreational catch was equivalent to a value of 1500 t for a reference year of 2012 obtained by summing international survey estimates for France, Netherlands and the UK obtained from surveys between 2009 and 2013, plus a small value for Belgium obtained informally.

Given the management measures introduced for recreational fishers in 2015, it is unlikely that the assumption of constant F is valid, release rates should increase, and the selectivity should not mirror commercial lines. At the WKBASS Data WK (ICES, 2017c), it was decided that it was necessary to review recreational catches, include post-release mortality, develop an approach for estimating length–frequency of removals, and incorporate the impact of management measures on recreational removals.

4.2.6.1 Summary of WKBASS assessment 2017

No additional survey data were available (Table 4.2.6.1.1), so there were no survey data available for Ireland, Belgium, Germany or Denmark. In addition, the original estimate of 60 t for Belgium was removed, as the evidence underpinning this value was not available. An average of the two UK effort methods was included (Armstrong *et al.*, 2013), French data were selected from the 2009–2011 study (Rocklin *et al*., 2014) and Netherlands data from 2010–2011 (van der Hammen and de Graaf, 2013) (Table 4.2.6.1.1). Two unpublished studies of sea bass post-release mortality were provided. In combination with estimates for striped bass (*Morone saxtilis*), this gave a best estimate for post-release mortality of 15%, but the sensitivity of the assessment to this value was recommended. Combining the catches and dead releases gave an overall estimate of 1501 t (Table 4.2.6.1.2).

Table 4.2.6.1.1. Estimates of recreational catches of sea bass in different countries and years in numbers and weight of fish for retained and released components of the catch, and release rates. The relative standard error (RSE) is provided where available and expressed as a percentage.

			Numbers (thousands)	Weight (tonnes)													
COUNTRY	YEAR	AREA	RETAINED	RSE	RELEASED	RSE	TOTAL	RSE	% RELEASED	RETAINED	RSE	RELEASED	RSE	TOTAL	RSE	% RELEASED	SOURCE
Belgium	2012	BSS-47								60							Unknown
France	2009–2011	BSS-47	781		796		1578	>26	50	940		332		1272	>26	26	ICES (2014a)
	2009–2011	BSS-8AB	1168		1190		2357	>26	50	1405		496		1901	>26	26	Calculated
	2009–2011	Both	1949		1986		3935	26	50	2345		828		3173	26	26	Rocklin *et al*. (2014)
	2011–2012	BSS-47	2043		1581		3624		44	2458		659		3117		21	Ifremer
	2011–2012	BSS-8AB	572		281		852		33	688		117		805		15	Ifremer
	2011–2012	All	2615		1861		3935		47	3146		776		3922		20	Ifremer
Netherlands	2010–2011	BSS-47	234	38	131	27	366	30	36	138	37						van der Hammen and de Graaf (2013)

			Numbers (thousands)	Weight (tonnes)													
Country	Year	Area	Retained	RSE	Released	RSE	Total	RSE	% released	Retained	RSE	Released	RSE	Total	RSE	% released	Source
	2012–2013	BSS-47	335	26	332	21	667		50	229	26						van der Hammen and de Graaf (2015)
	2014–2015	BSS-47	176	19	499	20	675		74	138	20						van der Hammen and de Graaf (2017)
UK	2012–2013	BSS-47	367		576		943		61	230–440		150–250		380–690	26–38	36–39	Armstrong *et al*. (2013)

Table 4.2.6.1.2. Recreational removals (tonnes) by country for 2012. PRM indicates fish that die after release, applying post release mortality of 15% as used in the WKBASS assessment WK in 2017.

Country	Year	Retained	PRM	Removals
France	2009–2011	940	50	990
Netherlands	2010–2011	138	8	146
England	2012	332	30	365
Total	2012	1410	88	1501

A single length composition was required for the assessment that considers the both the kept component and post release mortality. To achieve this, the length composition of retained and released components were estimated. The length frequencies for each country were compiled and corrected for the total numbers of fish caught. This gave a single distribution of caught and released fish for each of the stocks (Figure 4.2.6.1.1). A single distribution for recreational removals was created by assuming a post-release mortality of 15% (Figure 4.2.6.1.1).

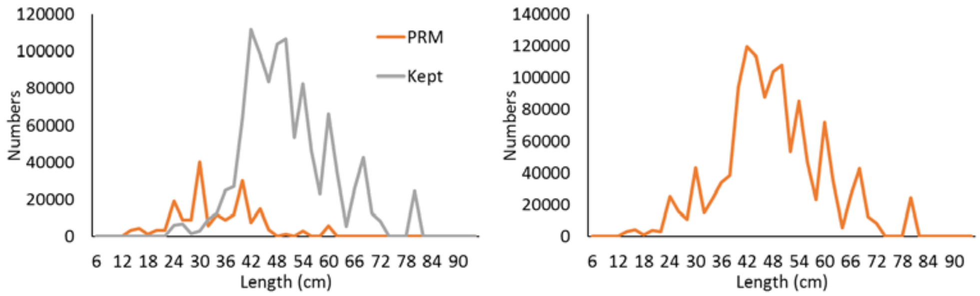


Figure 4.2.6.1.1. Length frequency of recreational fishery removals for the 2012 reference year, derived from surveys in France, Netherlands and England. PRM are total released catch with post release mortality of 15% applied. Right hand plot is the total removals used in the Stock Synthesis model to estimate selectivity.

No recreational catches were available at the WKBASS assessment WK in 2017, so WKBASS recommended an ICES data call for additional recreational survey data and assessment of the data by the WGRFS (ICES, 2017a). The data call was released in May 2017 and responses were assessed by WGRFS in June 2017 (ICES, 2017a). The WGRFS proposed that sea bass removals must be included in the assessment, and that the kept and released component should both be accounted for. The assessment should have recreational removals from the reference year 2012 and after the introduction of management measures in 2016. Only the UK and Netherlands provided provisional data for 2016, making estimation a significant challenge. Several ways of generating these numbers were suggested, including extrapolation and correction of 2012 data. The WGRFS proposed using the Netherlands data to correct French recreational catches from the 2009–2011 survey. Assuming post-release mortality of 15% led to removals of 1627 t in 2016 (Table 4.2.6.1.3). These were slightly higher than 2012 (~8%) due to increased release rates for the Netherlands (extrapolated to France) and large UK releases from the 2016 survey. This difference could be the result of any combination of the following: change in survey methods, error associated with the estimates, methods used to estimate French catches in 2016 from 2012, changes in availability of fish for recreational fishers, or interannual variability of catch or catch per unit of effort (cpue) of recreational fishers. Given the uncertainty in the reconstructions of recreational catches for 2016, WGRFS stated that the sensitivity of the assessment and projections to the 2016 recreational removals must be investigated, scenarios tested, and additional data should be included in the assessment as soon as they become available (ICES, 2017a). This approach was agreed and adopted by WKBASS for use in the WKBASS assessment model in 2017, despite uncertainties as the levels of change will have minimal impact on the assessment model as it only applies to the last year, but will impact on the forecast.

The recreational removals (retained and post-release mortality) were included in the Stock Synthesis Model for WKBASS in 2017. Recreational catch was iteratively reconstructed conditioned (ICES, 2016) on the 2012 estimated value of 1501 t (Table 4.2.6.1.2). The selectivity was based on length–frequency distributions of removals assuming a 15% post release mortality (Figure 4.2.6.1.1). The estimated value for 2016 of 1627 t (Table 4.2.6.1.3) was then entered as a tonnage, causing a large unrealistic increase in recreational F. Unfortunately, the recommendations from the WGRFS to test sensitivity of the assessment model to magnitude and method for inclusion of 2016 estimates of removals was not investigated.

Table 4.2.6.1.3. Recreational removals (tonnes) by country for 2016. PRM indicates fish that die after release, applying post release mortality of 15% as used in the WKBASS assessment WK 2017.

Country	Year	Retained	PRM	Removals
France	Imputed	674	164	839
Netherlands	2016–2017	99	28	127
England	2016	223	439	662
Total	2016	997	631	1627

4.2.6.2 Summary of WKBASS assessment 2018

WKBASS assessment WK 2018 documented and reviewed all the available recreational catch estimates for sea bass in areas 4.bc, 7.d.e–h (Hyder *et al.*, 2018; Table 4.2.6.2.1). Removals estimates were reworked for the 2012 reference year as the sum of retained fish and released fish with PRM of 5% applied (Table 4.2.6.2.1). A length composition for recreational removals for the 2012 reference year was compiled for this year as described in detail in the Hyder *et al*. (2018), and included in the Stock Synthesis data file (Figure 4.2.6.2.1).

Table 4.2.6.2.1. Recreational removals (tonnes) by country for 2012. PRM indicates fish that die after release, applying post release mortality of 5% as used in the WKBASS assessment WK 2018.

Country	Year	Retained	PRM	Removals
France	2009–2011	940	17	957
Netherlands	2010–2011	138	3	141
England	2012	332	10	343
Total	2012	1410	29	1440

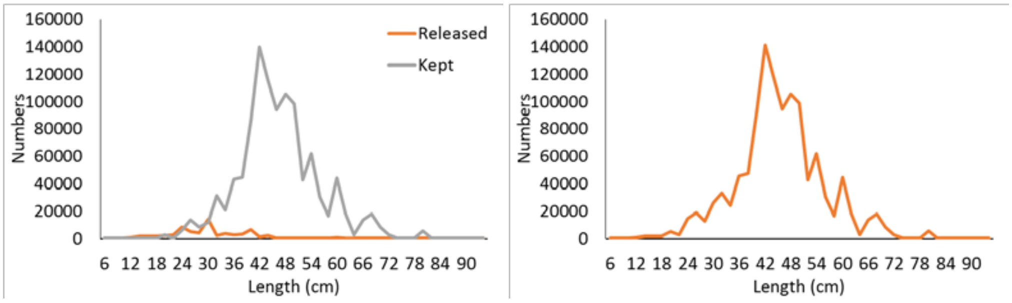


Figure 4.2.6.2.1. Length frequency of recreational fishery removals for the 2012 reference year, derived from surveys in France, Netherlands and England. PRM are total released catch with post-release mortality of 5% applied. Right hand plot is the total removals used in the Stock Synthesis model to estimate selectivity.

The implementation of management measures should lead to a reduction in fishing mortality as more and larger fish are released. This means that it is not appropriate to assume constant recreational fishing mortality, so it was necessary to include an estimate of recreational catch or change in fishing mortality after 2015. However, coverage of surveys was patchy for all countries after 2015, with only provisional estimates available for the UK and the Netherlands. As a result, two potential methods are available for estimating catches or changes in fishing mortality:

1) Imputation: impute annual catches (kept and released) for England and France in 2016 by assuming the catches have changed over time to the same relative extent as Netherlands catch estimates between surveys in 2010–2011 or 2012–2013 and the survey in 2016–2017.

2) Reconstruction of change in recreational fishing mortality relative to the 2012 reference year: use the data from recreational surveys carried out by France, England, and Netherlands in 2009–2013 to calculate the reductions in retained catch in the observed trips if bag limits and increased MCRS had been implemented at the time of the surveys (Armstrong *et al.*, 2014). The reductions in catch can be used to infer changes in recreational fishing mortality induced by changes in management, assuming full compliance and taking post-release mortality into account.

There are issues with both these methods. The use of imputation has a large uncertainty because: i) there are no time-series data to validate the assumption that national catches change to the same extent between years; ii) the surveys have sampling errors; and iii) the 2016–2017 Netherlands survey data are still provisional. The second method is also very uncertain due to sampling error and limitations in the survey data, assumptions concerning compliance, and dependence of results on the size of year classes present in the stock at the time of the surveys. However, the second method was considered more appropriate as it is based on observed data. As a result, the imputation approach was rejected, and estimation of the expected change in recreational F from in 2015 onwards due to change in MCRS, bag limits and closed seasons was carried out as described in Hyder *et al*. (2018).

These reductions were used, along with post-release mortality of 5%, to calculate reductions in recreational F that may have occurred in 2015, 2016 and 2017 in response to the management measures, assuming full compliance (Table 4.2.6.2.2). The differences in recreational catches used by WKBASS 2017 and 2018 are large. There are a number of factors influencing this, including: the methodology used (reconstruction rather than imputation) and lower levels of post release mortality (5% rather than 15%). In addition, the method for inclusion of recreational catches in the assessment was different (Frec multiplier instead of simple tonnage) and the sensitivity of the model to recreational catches was assessed. The combination of these factors led to a lower recreational catch and a more appropriate approach for inclusion. This led to more robust assessment and a reduction of the Frec in the model due to the implementation of management measures.

Table 4.2.6.2.2. Values of expected recreational F reductions associated with management measures applied to Bss.27.4bc7ad–h since 2015.

Management scenario				
Year of management measures	MCRS	Bag limit	Closed season	Recreational F relative to 2015
Pre-2015	36 cm	none	none	1.000
2015	42 cm for 0.5 year	3-fish for 0.75 year	none	0.832
2016 & 2017	42 cm	1 fish	0.5 yr	0.282
2018	42 cm	0 fish	0.5 yr	0.099

4.2.7 Relative abundance indices

4.2.7.1 Channel groundfish survey

The Ifremer Channel Groundfish Survey (CGFS) in the eastern Channel provides length-aggregated abundance indices and associated length compositions from 1988 to 2014 (Figure 4.2.7.1.1a–c). Previous assessments show that the survey has a domed selectivity pattern, mainly selecting young bass up to 40–50 cm with peak selectivity around 35 cm. The survey was changed in 2015, with a new (larger) survey vessel used that had a different trawl design, and the numbers of stations in shallow water was reduced (Figure 4.2.7 d). A number of comparative tows were conducted to develop a calibration factor, but ICES WGCSE (2016) had concerns over the methodology and excluded the 2015 data from the sea bass assessment. ICES undertook to have the calibration methods reviewed by an external expert, who concluded that “Overall, the small sample sizes, large number of zero tows per species, lack of length-specific conversion factors and possible bias of changes in sampling locations due to depth do not make this calibration ideal for use in future assessments”. As a result, only the data to 2014 are used for the assessment (see SS3 data input file: Annex 4)

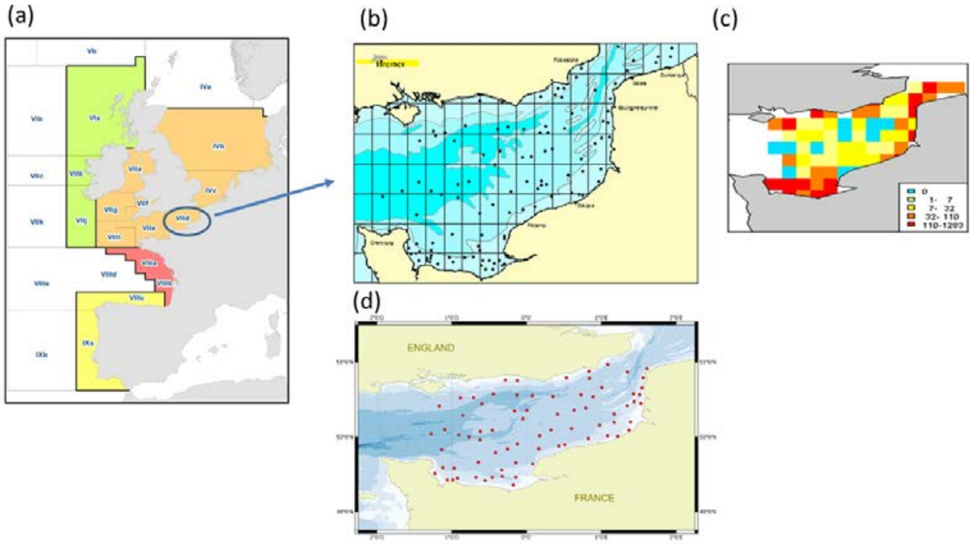


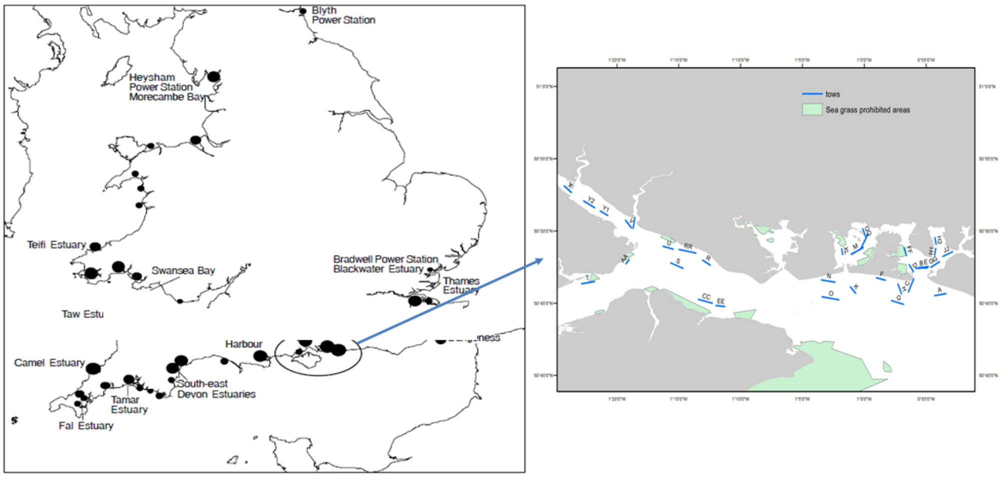
Figure 4.2.7.1.1. Channel groundfish survey design up to 2014. Tow positions are shown in (a & b). Plot (c) gives average catch rates of bass by rectangle over a series of years. Plot (d) is the revised tow positions in 7.d from 2015 onwards using the new vessel (tows in 7.e in new survey not shown).

The CVs for the length-aggregated indices were inflated in earlier assessments to avoid overfitting some individual indices that had unrealistically small CVs calculated from between-station variability. This survey has highest catch rates of bass in coastal waters, and the proportion of tows with zero catches of bass varies inversely with stock abundance.

4.2.7.2 Solent bass survey

The Solent survey takes place in one of many bass nursery areas around the coast of England and Wales. It catches mainly young bass up to age 4 that are in or close to estuaries and embayments (Figure 4.2.7.2.1). Nursery areas are likely to exist along the coasts of France, the Netherlands, Belgium, and Ireland. The argument for using a survey in such a restricted location is based on the results of an earlier separable model assessment of the stock in UK waters only (Pawson *et al.*, 2007a) that derived separate recruitment and stock trends for four areas around the UK using UK-only data. The recruitment trends were similar across areas, and the patterns from mid-1980s onwards were similar to the recruitment indices from the Solent survey. Additional catch rate data for sea bass are being collected from a wide range of estuaries and embayments that include bass nursery areas, as part of national programmes to meet Water Framework Directive requirements, but these series are not currently long enough to allow a robust comparison with the Solent survey.

WKBASS Data WK 2017 made small corrections to the Solent bass survey indices for the most recent two years to ensure consistency in calculations. This resulted in an improved model fit to the data. The index series covering ages 2–4 is given in the assessment data input file (Annex 4). The CVs of the aggregated index are inflated by the model, because there is expected to be additional variability of the index in relation to assessment model estimates of population trends at ages 2–4, as they relate to the entire stock area.



Location of bass nursery areas in England and Wales, showing those in the Solent area where the trawl surveys were conducted (ringed)

Figure 4.2.7.2.1. Location of UK Solent bass trawl survey. Tow positions are shown at right. Other bass nursery areas defined in UK legislation are shown in the left-hand map.

4.2.7.3 French lpue series.

A major shortcoming of previous assessments of Bss.27.4bc7ad–h. is the absence of relative abundance indices for adult bass covering as much of the stock area as possible. There are no scientific surveys providing sufficient data on adult sea bass to develop an index of abundance for the area. Therefore, Ifremer investigated the potential for deriving an index from commercial fishery landings and effort data. Data since 2000 have been processed along with VMS and other data to provide accurate information on fishing location, and data on métier are more accurate. The lpue was modelled using GLM at the resolution of ICES rectangle and gear strata. The methods and results of a GLM analysis of data covering subareas 7 and 8 were presented in a Working Document by (Laurec *et al.*, 2018. Annex 5. This method was implemented and used to derive the lpue for the 2017 assessment. However, the Working Group for the Celtic Seas Ecoregion (WGCSE) were the bss.27.4bc7d–h stock is assessed raised doubts regarding the method used to calculate the lpue and requested an independent review to assess its appropriateness. This review was done by an external expert (M. Christman) during summer 2017 (see Annex 6). There were several issues raised with two issues identified has needed to be addressed before the lpue could be used in an assessment. The key issues were the exclusion of zeros from the current index and the likely underestimation of variance in the index.

The review was taken into consideration and further work was carried out to solve the problems in the index. The outcome of this further work on the lpue index was described in a second working document (see Annex 7) and once again sent for review (see Annex 8). A final document with the description of the methodology developed by Laurec *et al*. (2018) can be found in Annex 9.

Ifremer has investigated the potential for deriving an index from commercial fishery landings and effort data derived from the improved fishery data available since 2000.

Analysis of trip data by rectangle and month showed very coherent seasonal and spatial patterns in lpue matching what is known about the fisheries using different types of gears (otter trawl; midwater trawl; nets; lines) and the seasonal movements of sea bass to and from spawning sites. This provided confidence in the ability of the lpue data to provide information on relative abundance. Lpue relative abundance indices covering 2000–2015 were provided to WKBASS data WK 2017 for groups of rectangles and gears in the two stock subareas (4 and 7 and 8a,b), both as analytical solutions and as bootstrap estimates with confidence intervals. The lpue was calculated excluding all vessel-days where no sea bass were landed.

During the subsequent WKBASS benchmark assessment meeting in 2017, a new index series was provided for each of the stocks, excluding a large number of vessels with predominantly zero landings of sea bass. This reduced the size of the lpue fleet but produced smoother lpue trends. The index combines trends from otter trawls, nets and lines, but excludes midwater trawls which target spawning aggregations and have not fished on the Bss-47 stock since 2014.

The Ifremer documentation of the surveys and the results were reviewed in 2017 by an external expert (Annex 6). Two main issues were highlighted by the reviewer:

1) The alleged false positive pollution of the dataset before 2009 was not considered to be a problem and could easily be corrected. Also, the index should consider the entire time period (i.e. 2000–2016). WKBASS 2018 followed this recommendation.

2) The spawning season should be included in the lpue as these catches are also indicative of the stock size. However, this recommendation was not followed by WKBASS 2018. The lpues are probably affected by the aggregative behaviour of sea bass (i.e. hyperstability) during the spawning season.

To address these concerns, a new lpue index was thus presented at WKBASS 2018. This index is obtained by modelling the zeros and non-zeros values using a delta-GLM approach. The reviewer recommended the new lpue index to be used in the assessment of BSS-47 stock. The new lpue index has been incorporated in the northern stocks assessment models (Figure 5.2-7 4.2.7.3.1).

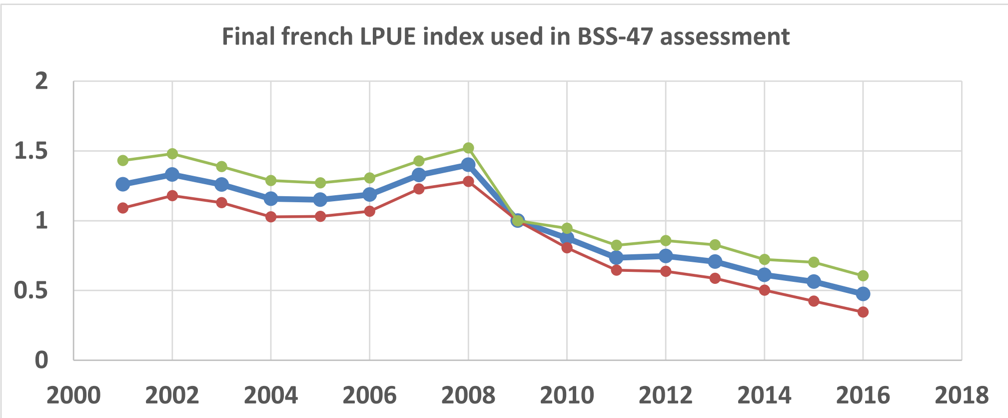


Figure 4.2.7.3.1. The lpue index series for BSS-47 stock presented at WKBASS 2018 assessment meeting.

4.3 Assessment method

4.3.1 Current assessment model

ICES (2016a) conducted an assessment using Stock Synthesis 3 (SS3) (Methot and Wetzel, 2013). The software used was Stock synthesis v3.24f, following the procedures given in the Stock Annex developed by IBPBass2 (ICES, 2016b) with the inclusion of fishery data for 2015. The assessment requires a modelling framework capable of handling a mixture of age and length data for fisheries and surveys (fleet-based landings; landings age or length compositions, age-based survey indices for young bass) and biological information on growth rates and maturity. Landings-at-age were available for four UK fleets from 1985 onwards (otter trawl; nets; lines; midwater trawl), whereas French fleets had age and length composition data for all fleets combined, and available only since the 2000s. The assessment developed by IBPBass2 (ICES, 2016b) kept the combined UK otter trawl and nets fleets, extracting lines into a single fleet. The Stock Synthesis assessment model was chosen, primarily for its highly flexible statistical model framework allowing the building of simple to complex models using a mix of data compositions available. The model is written in ADMB (www.admb-project.org), is forward simulating and available at the NOAA toolbox: http://nft.nefsc.noaa.gov/SS3.html.

ICES (2017b) agreed that the assessment from the benchmark conducted in 2017 was unfinished as a review of the commercial landings per unit of effort series was necessary to assess its appropriateness for use in the assessment. The lpue series provided to ICES (2017b) was updated with a new methodology used for its calculation, with its inclusion it changed the perception of the stock when compared with the 2017 benchmark assessment. WGCSE agreed that the previous accepted method, used in 2016, should be used to provide advice. However, Stock Synthesis v3.24u was used and some data were available for recreational catch in 2016. As data were available for 2016, this was used in place of continuing the assumption of constant recreational F, therefore, the recreational catch for 2016 was entered as data. These data were based on some 2016 surveys and an assumed value for France, which did not have a survey), so a deviation from the agreed stock annex.

Table 4.3.1.1 summarizes key model assumptions and parameters for the ICES (2016a) assessment. Other parameter values and input data characteristics are defined in the SS3 start file Starter.ss, control file Bass47.ctl, forecast file Forecast.SS and the data file BassIVVII.dat as used by ICES (2016a).

Table 4.3.1.1. Key model assumptions and parameters from the ICES (2016a) update assessment.

CHARACTERISTIC	SETTINGS
Starting year	1985
Ending year	2016
Equilibrium catch for starting year	0.82* landings in 1985 by fleet.
Number of areas	1
Number of seasons	1
Number of fishing fleets	6
Number of surveys	Two surveys: CGFS; Solent autumn survey.
Individual growth	von Bertalanffy, parameters fixed, combined sex
Number of active parameters	83
Population characteristics	
Maximum age	30
Genders	1
Population length bins	4–100, 2 cm bins
Ages for summary total biomass	0–30
Data characteristics	
Data length bins (for length structured fleets)	14–94, 2 cm bins
Data age bins (for age structured fleets)	0–16+
Minimum age for growth model	2
Maximum age for growth model	30
Maturity	Logistic 2-parameter – females; L50 = 40.65 cm
Fishery characteristics	
Fishery timing	-1 (whole year)
Fishing mortality method	Hybrid
Maximum F	2.9
Fleet 1: UK Trawl/nets selectivity	Double normal, length-based
Fleet 2: UK lines selectivity	Asymptotic, length-based
Fleet 3: UK Midwater trawl selectivity	Asymptotic, length-based
Fleet 4: Combined French fleet selectivity	Asymptotic, length-based
Fleet 5: Other fleets/gears selectivity	Asymptotic: mirrors French fleet
Fleet 6: Recreational fishery selectivity	Asymptotic: mirrors UK lines fleet
Survey characteristics	

CHARACTERISTIC	SETTINGS
Solent autumn survey timing (yr)	0.83
CGFS survey timing (yr)	0.75
Catchabilities (all surveys)	Analytical solution
Survey selectivities: Solent autumn:	Age and length based selectivity
Survey selectivities: CGFS	Double normal, length based
Fixed biological characteristics	
Natural mortality	0.15
Beverton–Holt steepness	0.999
Recruitment variability (σR)	0.9
Weight–length coefficient	0.00001296
Weight–length exponent	2.969
Maturity inflection (L50%)	40.649 cm
Maturity slope	-0.33349
Length-at-age Amin	19.6 cm at Amin=2[1]
Length-at-Amax	80.26 cm
von Bertalanffy k	0.09699
von Bertalanffy Linf	84.55 cm
von Bertalanffy t0	-0.730 yr
Std. Deviation length-at-age (cm)	SD = 0.1166 * age + 3.5609
Age error matrix	CV 12% at-age
Other model settings	
First year for main recruitment deviations for burn-in period	1969
Last year for recruit deviations	2014 (last year class with survey indices)
Last year no bias adjustment	1971
First year full bias adjustment	1982.5
Last year full bias adjustment	2011
First year recent year no bias adjustment	2013
Maximum bias adjustment	0.92

[1] **as recommended by R. Methot after scrutinizing earlier SS3 runs during IBPNEW 2012, and used by IBPNEW and WGCSE. The ICES (2013) tabulated the original value of 5.78 cm at-age 0 in error.**

4.3.2 Assessment model development

A similar process was followed to that carried out in ICES (2016b) and a number of improvements were made to the SS3 model configuration used by ICES (2016a; 2017b). Due to issues with the model accepted by the WKBass benchmark group during 2017, many due to the newly included commercial tuning index, the development of the model has been split into a two part process. The assessment model was developed over the last two years during WKBass 2017 and WKBass 2018 with the main aim of including:

- Review and update of natural mortality in accordance with the literature review;
- Inclusion of discard data for two fleets (UK bottom otter trawls and nets and the combined French fleet);
- Inclusion of one commercial tuning fleet.
- Selectivity and retention blocks for three fleets to take account of the changes in fishery selectivity due to the implementation of new regulations.
- Recreational catch:
  - Inclusion of length distribution and associated selectivity;
  - Expected reductions in F since 2015;
  - Review of post-release mortality and inclusion in the model.

WKBass 2018 terms of reference was to focus on the lpue and to calculated reference points using the assessment accepted by the group.

A number of limitations exist for the assessment carried out by ICES (2016a; 2017b) one of which is that the model only uses landings. Historically, discarding at around 5% was considered negligible and therefore not required in the model. In more recent years and with the recent changes to the regulations, discarding has increased for some of the fleets. Total discards and the associated length compositions were therefore considered necessary, and included for the UK trawls and nets and the combined French fleets. In addition, the total removal (kept component and post-release mortality) was included for the recreational fleet.

With the inclusion of discards, it is necessary to model retention as this also allows for the estimation of discard for the years where data are missing. For the recreational fleet catch the same assumption of constant F was used as that on the landings component in 2016 assessment. The time-series was reconstructed scaled to the 2012 value up to 2014 before management measures were implemented, and a multiplier applied from 2015 related to the management approaches (i.e. increase in MCRS from 36 to 42 cm, bag limits, and closed seasons) assuming full compliance.

A further limitation of the ICES (2017b) model is that it is only tuned by two survey indices, both covering small areas of the total distribution of bass. These are: the recruitment survey in the Solent; and the CGFS covering ICES Division 7.d. The CGFS design changed in 2015 and an expert review of the index indicated that the two periods are not comparable (see Section 4.2.7.1) and should be treated in the assessment as separate surveys. As the CGFS from 2015 is too short to effectively tune the assessment, a Landing per Unit of Effort time (lpue) series was developed from the French commercial fleet (see Section 4.2.7.3). The lpue series provides a continuous tuning index for the larger fish in the population that can be used in the assessment with selectivity mirrored to the French fleet. However, there is some uncertainty with the lpue and how the management measures will affect the assumptions of a representative constant fleet and selectivity in the period after the introduction of the selectivity change for 2015 to present.

Before exploring the performance of a series of runs, during WKBass 2017, to include discards, length compositions of both the discards and recreational catch and a landings per unit of effort series a base model was used which consisted of the ICES (2016a) final assessment with a few minor corrections where data had been updated and corrected. First, discards and associated length composition data were included along with the addition of retention parameters needed to model discards for years were data were missing. The main effect of including the discard component for the two fleets was that recruitment was higher with slight variations on spawning–stock biomass and fishing mortality.

Next was the inclusion of the recreational catch length compositions so that selectivity of this fleet could be modelled independently of the lines fleet to allow for the changes in selectivity due to new management measures. Recreational fleet selectivity was modelled using double normal with six parameters, three of which were fixed.

Finally, the landings per unit of effort was included and selectivity of this fleet was mirrored to the French fleet as the assumption was that this fleet had similar properties to that of the French fleet.

WKBass 2018 continued the development of the model taking into account the review carried out on natural mortality. Consideration was also given to the changes in management which include the increase in the minimum conservation reference size with a potential change in retention and the changes to the fleets with the cessation of the pelagic fleet.

Sensitivity analyses were carried out to assess the robustness of the new mode to new additions and changes, these are shown in Section 4.3.4.

4.3.3 Final assessment model, diagnostics and retrospectives

Table 4.3.3.1 summarizes key model assumptions and parameters from the accepted assessment and the data incorporated in the assessment and fleet catch are shown graphically in Figure 4.3.3.1 and the input files are given in Annex 1, Appendix 1–4. A range of model outputs are shown in Figures 4.3.3.2–4.3.3.21. Standard summary tables, and tables of output stock numbers and commercial fishery F are given in Tables 4.3.3.2–4.3.3.4.

Good correspondence was found between the observed and fitted length compositions for each fleet (Figures 4.3.3.4–10), particularly for the period after 1990. However, where sampling levels are low the data fit less well particularly around the 40 cm size ranges. The observed and fitted age compositions (Figures 4.3.3.11–16) for each fleet were fitted less well than the length compositions, and there is some diagonal residual patterns indicating some problems in fitting extreme variations in recruitment. There is difficulty in assessing the goodness-of-fit with the inclusion of a selectivity change, as there are only two years of data to modelling selectivity and retention, so it is recommended that this is reevaluated as additional years are added.

As with previous assessments the catch for the recreational fleet has been updated using the same assumption of constant fishing mortality prior to management changes in 2015 based on the value in the reference year (2012) of 1440 tonnes (see Section 4.2.6.2, Table 4.2.6.2.1). The recreational catch for 2012 was estimated using a post release mortality of 5%, and reconstruction used to derive an Frec multiplier based on management measures implement from 2015 (i.e. changes to the MCRS bag limits, and closed seasons). In 2017, the assessment used provisional 2016 survey data from the

UK and Netherlands and imputed French catches (see Section 4.2.6.2). WKBASS reviewed these data and agreed that the uncertainty was too great to use the imputation approach, so opted for the reconstruction method for future assessment where data are not available or considered unsuitable (see Section 4.2.6.2).

The assessment model fits well to the UK Solent bass and the CGFS abundance indices, both the age and length compositions (Figures 4.3.3.17 –18), and lpue (Figure 4.3.3.19). With the addition of advanced options for recruitment deviation, the model gives reasonable precision back to the 1975 year class (Figure 4.3.3.20) allowing a longer term assessment of recruitment dynamics. Recruitment is highly variable with no evidence of a reduction in average recruitment at lower SSBs (Figure 4.3.3.20). This is mainly affected caused by a steepness value of 0.999 for the fitted Beverton–Holt stock–recruit curve.

A retrospective analysis was carried out with a 5-year peel, previously the recreational catch was reestimated to give constant recreational F corresponding to a catch of 1440 t (total catch including 5 percent post release mortality) in 2012. WKBASS concluded that this was not necessary, but recreational F needed to be reviewed to assess the extent of any deviation from this assumption. The retrospective bias (Figure 4.3.3.22) with a 5-year peel shows very little adjustment in any direction. A Mohn's Rho value of 0.066 for fishing mortality and -0.046 for SSB showed that the model is stable when data are removed, giving a solid assessment base for advice.

By including the additional data and updating natural mortality the comparison between WGCSE 2017 and the new model show similar trends, however the new model gives a much greater variation in recruitment and a higher historical perspective for SSB and historically lower levels of fishing mortality (Figure 4.3.3.23). This is in part due to the change in assumptions used for natural mortality and selectivity. The number of parameters now estimated by the model has increased to 109 from 86 and the likelihood values to assess the models goodness-of-fit have improved for total catch, equilibrium catch, age compositions, recruitment and forecast recruitment (Table 4.3.4.1). Total likelihood and length composition likelihood for the two models are not comparable as additional data are now included in the model. Both assessment models converged and met the convergence criteria.

Table 4.3.3.1. Key model assumptions and parameters for benchmark accepted assessment.

CHARACTERISTIC	SETTINGS
Starting year	1985
Ending year	2016 (end year of data)
Equilibrium catch for starting year	0.82* landings in 1985 by fleet.
Number of areas	1
Number of seasons	1
Number of fishing fleets	6
Number of surveys	Two surveys: CGFS; Solent autumn survey.
Number of tuning fleets	One tuning fleet; French landings per unit of effort
Individual growth	von Bertalanffy, parameters fixed, combined sex
Number of active parameters	109
Population characteristics	
Maximum age	30
Genders	1
Population length bins	4–100, 2 cm bins
Ages for summary total biomass	0–30
Data characteristics	
Data length bins (for length structured fleets)	14–94, 2 cm bins
Data age bins (for age structured fleets)	0–16+
Minimum age for growth model	2
Maximum age for growth model	30
Maturity	Logistic 2-parameter – females; L50 = 40.65 cm
Fishery characteristics	
Fishery timing	-1 (whole year)
Fishing mortality method	Hybrid
Maximum F	2.9
Fleet 1: UK Trawl/nets selectivity	Double normal, length-based
Fleet 2: UK lines selectivity	Asymptotic, length-based
Fleet 3: UK Midwater trawl selectivity	Asymptotic, length-based
Fleet 4: Combined French fleet selectivity	Asymptotic 1985-2014, Double normal 2015 to present, length-based
Fleet 5: Other fleets/gears selectivity	Mirrors French fleet
Fleet 6: Recreational fishery selectivity	Double normal, length-based
Survey characteristics	
Solent autumn survey timing (yr)	0.83
CGFS survey timing (yr)	0.75
Catchabilities (all surveys)	Analytical solution
Survey selectivities: Solent autumn:	Age and length based selectivity
Survey selectivities: CGFS	Double normal, length based
Fixed biological characteristics	
Natural mortality	0.24

CHARACTERISTIC	SETTINGS
Beverton–Holt steepness	0.999
Recruitment variability (σR)	0.9
Weight–length coefficient	0.00001296
Weight–length exponent	2.969
Maturity inflection (L50%)	40.649 cm
Maturity slope	-0.33349
Length-at-age Amin	19.6 cm at Amin=2
Length-at-Amax	80.26 cm
von Bertalanffy k	0.09699
von Bertalanffy Linf	84.55 cm
von Bertalanffy t0	-0.730 yr
Std. Deviation length-at-age (cm)	SD = 0.1166 * age + 3.5609
Age error matrix	CV 12% at-age
Other model settings	
First year for main recruitment deviations for burn-in period	1969
Last year for recruit deviations	2014 (last year class with survey indices (end year -2))
Last year no bias adjustment	1974.5
First year full bias adjustment	1981.7
Last year full bias adjustment	2013.9
First year recent year no bias adjustment	2014.8
Maximum bias adjustment	0.907

Table 4.3.3.2. Estimated numbers-at-age in the population at the start of the year.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
1985	947	1 388	22 628	9 746	5 508	1 880	1 723	1 471	2 018	5 020	1 814	1 138	836	634	459	315	689
1986	2 707	745	1 090	17 701	7 549	4 194	1 400	1 256	1 054	1 430	3 538	1 275	799	587	445	322	705
1987	22 494	2 129	585	852	13 674	5 719	3 099	1 010	888	736	991	2 442	879	550	404	307	708
1988	17 375	17 694	1 671	456	655	10 259	4 162	2 188	695	601	492	660	1 621	583	365	268	673
1989	103 548	13 667	13 895	1 305	352	495	7 549	2 985	1 538	482	414	338	452	1 110	399	250	645
1990	7 943	81 453	10 733	10 853	1 007	266	364	5 406	2 095	1 065	332	283	231	309	760	273	613
1991	16 133	6 248	63 963	8 382	8 368	760	195	260	3 788	1 448	731	227	194	158	211	519	607
1992	25 089	12 691	4 905	49 900	6 445	6 274	552	138	179	2 572	975	490	152	130	106	142	756
1993	11 495	19 736	9 961	3 825	38 364	4 836	4 567	390	95	122	1 728	652	327	101	86	71	599
1994	35 629	9 042	15 493	7 772	2 944	28 828	3 527	3 235	270	65	82	1 161	437	219	68	58	449
1995	56 160	28 027	7 101	12 101	5 990	2 215	21 066	2 509	2 256	186	44	56	793	299	150	46	348
1996	3 125	44 177	22 006	5 542	9 307	4 490	1 609	14 860	1 732	1 536	126	30	38	534	201	101	266
1997	59 935	2 458	34 649	17 117	4 233	6 892	3 197	1 102	9 864	1 125	985	80	19	24	338	128	233
1998	18 377	47 146	1 929	26 976	13 097	3 144	4 931	2 206	739	6 488	732	637	52	12	15	218	233
1999	53 507	14 456	36 993	1 502	20 670	9 757	2 259	3 420	1 487	489	4 244	476	413	33	8	10	293
2000	25 922	42 090	11 342	28 804	1 150	15 368	6 980	1 554	2 280	971	315	2 722	304	264	21	5	194
2001	26 851	20 391	33 024	8 833	22 068	857	11 062	4 854	1 051	1 512	637	205	1 768	198	171	14	130
2002	43 383	21 122	15 999	25 720	6 767	16 447	617	7 686	3 278	696	990	414	133	1 147	128	111	93
2003	42 928	34 126	16 574	12 462	19 703	5 040	11 820	428	5 188	2 172	456	645	270	87	746	83	133
2004	32 695	33 769	26 761	12 884	9 504	14 554	3 576	8 054	282	3 341	1 379	288	405	169	54	468	136
2005	22 431	25 719	26 476	20 791	9 813	7 002	10 283	2 423	5 272	180	2 104	862	179	252	105	34	376
2006	25 051	17 645	20 151	20 524	15 756	7 164	4 879	6 837	1 549	3 275	110	1 271	518	107	151	63	246
2007	26 679	19 706	13 823	15 616	15 541	11 482	4 976	3 232	4 353	958	1 990	66	760	309	64	90	185
2008	15 670	20 987	15 443	10 723	11 848	11 359	8 008	3 316	2 075	2 721	589	1 212	40	461	187	39	167
2009	12 102	12 326	16 447	11 978	8 129	8 643	7 902	5 323	2 124	1 295	1 671	359	735	24	279	114	125
2010	2 635	9 520	9 661	12 761	9 088	5 940	6 028	5 272	3 426	1 333	800	1 024	219	448	15	170	146
2011	9 228	2 073	7 456	7 477	9 627	6 568	4 069	3 920	3 285	2 070	790	469	597	127	261	9	185
2012	4 290	7 259	1 624	5 778	5 656	6 991	4 533	2 673	2 474	2 016	1 249	472	279	355	76	155	115
2013	19 347	3 374	5 685	1 256	4 350	4 066	4 748	2 919	1 650	1 483	1 186	728	274	162	206	44	158
2014	16 357	15 219	2 641	4 386	939	3 085	2 702	2 969	1 738	949	834	659	403	151	90	114	112
2015	24 065	12 867	11 930	2 046	3 300	671	2 075	1 729	1 836	1 052	568	497	393	241	91	54	137
2016	23 796	18 930	10 116	9 345	1 577	2 428	458	1 328	1 074	1 129	645	348	305	242	148	56	119

Table 4.3.3.3. Fishing mortality-at-age.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1985	0.000	0.001	0.006	0.016	0.033	0.055	0.076	0.093	0.104	0.110	0.113	0.114	0.114	0.114	0.114	0.114
1986	0.000	0.002	0.007	0.018	0.038	0.063	0.087	0.107	0.120	0.127	0.131	0.132	0.133	0.133	0.133	0.132
1987	0.000	0.002	0.009	0.023	0.047	0.078	0.108	0.133	0.151	0.161	0.167	0.170	0.171	0.171	0.171	0.171
1988	0.000	0.002	0.007	0.019	0.040	0.067	0.092	0.113	0.126	0.133	0.137	0.138	0.139	0.138	0.138	0.138
1989	0.000	0.002	0.007	0.020	0.041	0.068	0.094	0.114	0.127	0.134	0.138	0.139	0.139	0.139	0.139	0.138
1990	0.000	0.002	0.007	0.020	0.042	0.069	0.095	0.116	0.129	0.137	0.140	0.141	0.141	0.141	0.141	0.140
1991	0.000	0.002	0.008	0.023	0.048	0.079	0.109	0.132	0.147	0.155	0.159	0.161	0.161	0.161	0.160	0.160
1992	0.000	0.002	0.009	0.023	0.047	0.078	0.107	0.132	0.148	0.158	0.163	0.165	0.166	0.166	0.165	0.165
1993	0.000	0.002	0.008	0.022	0.046	0.076	0.105	0.128	0.144	0.153	0.157	0.159	0.160	0.160	0.160	0.159
1994	0.000	0.002	0.007	0.020	0.044	0.074	0.101	0.120	0.133	0.139	0.141	0.142	0.142	0.141	0.140	0.140
1995	0.000	0.002	0.008	0.023	0.048	0.080	0.109	0.131	0.144	0.152	0.155	0.156	0.156	0.155	0.154	0.153
1996	0.000	0.003	0.011	0.029	0.060	0.100	0.138	0.170	0.191	0.204	0.211	0.214	0.215	0.215	0.215	0.215
1997	0.000	0.003	0.010	0.028	0.057	0.095	0.131	0.160	0.179	0.190	0.196	0.198	0.199	0.198	0.198	0.197
1998	0.000	0.003	0.010	0.026	0.054	0.090	0.126	0.154	0.173	0.185	0.190	0.193	0.194	0.194	0.193	0.193
1999	0.000	0.003	0.010	0.027	0.056	0.095	0.134	0.165	0.186	0.198	0.204	0.207	0.208	0.207	0.207	0.207
2000	0.000	0.003	0.010	0.026	0.054	0.089	0.123	0.151	0.171	0.182	0.189	0.191	0.192	0.192	0.192	0.192
2001	0.000	0.003	0.010	0.026	0.054	0.089	0.124	0.153	0.172	0.183	0.189	0.192	0.193	0.193	0.193	0.192
2002	0.000	0.002	0.010	0.026	0.055	0.090	0.125	0.153	0.172	0.183	0.188	0.190	0.191	0.191	0.190	0.189
2003	0.000	0.003	0.012	0.031	0.063	0.103	0.144	0.177	0.200	0.214	0.221	0.225	0.226	0.226	0.226	0.225
2004	0.000	0.003	0.012	0.032	0.066	0.107	0.149	0.184	0.208	0.223	0.230	0.234	0.235	0.235	0.235	0.234
2005	0.000	0.004	0.015	0.037	0.075	0.121	0.168	0.207	0.236	0.254	0.264	0.269	0.271	0.271	0.271	0.270
2006	0.000	0.004	0.015	0.038	0.076	0.125	0.172	0.211	0.240	0.259	0.269	0.274	0.276	0.276	0.276	0.275
2007	0.000	0.004	0.014	0.036	0.073	0.120	0.166	0.203	0.230	0.246	0.255	0.260	0.261	0.261	0.261	0.260
2008	0.000	0.004	0.014	0.037	0.075	0.123	0.168	0.205	0.231	0.248	0.256	0.260	0.261	0.261	0.260	0.259
2009	0.000	0.004	0.014	0.036	0.074	0.120	0.165	0.201	0.226	0.242	0.250	0.254	0.255	0.254	0.254	0.253
2010	0.000	0.004	0.016	0.042	0.085	0.138	0.190	0.233	0.264	0.283	0.294	0.299	0.301	0.301	0.300	0.300
2011	0.000	0.004	0.015	0.039	0.080	0.131	0.180	0.220	0.248	0.265	0.274	0.278	0.280	0.279	0.278	0.277
2012	0.000	0.004	0.017	0.044	0.090	0.147	0.200	0.242	0.272	0.290	0.300	0.304	0.304	0.304	0.302	0.301
2013	0.000	0.005	0.019	0.051	0.104	0.169	0.230	0.279	0.314	0.336	0.347	0.352	0.353	0.353	0.351	0.350
2014	0.000	0.004	0.015	0.045	0.096	0.157	0.206	0.241	0.262	0.273	0.277	0.277	0.274	0.271	0.267	0.264
2015	0.000	0.001	0.004	0.021	0.067	0.142	0.206	0.236	0.246	0.249	0.249	0.248	0.247	0.245	0.242	0.240
2016	0.000	0.000	0.002	0.011	0.038	0.087	0.131	0.151	0.157	0.159	0.159	0.158	0.157	0.155	0.154	0.152

Table 4.3.3.4. Assessment summary for recruitment, SSB, F at ages 4–15, and catch.

	Recruitment (age 0)			SSB (t)				Commercial		Recreational
Year	timate ('00	lower	upper	Estimate	lower	upper	F(4-15)	Landings	Discards*	Est. catch
1985	947	64	1 830	28 625	21 204	36 045	0.096	994		2148
1986	2 707	415	4 999	25 271	18 628	31 913	0.111	1 318		1933
1987	22 494	15 779	29 208	22 636	16 716	28 556	0.142	1 979		1753
1988	17 375	9 539	25 210	20 612	15 290	25 934	0.117	1 239		1616
1989	103 548	87 336	119 760	19 642	14 721	24 562	0.118	1 161		1490
1990	7 943	2 182	13 704	17 921	13 311	22 530	0.119	1 064		1342
1991	16 133	9 351	22 916	15 679	11 413	19 944	0.136	1 226		1224
1992	25 089	17 125	33 053	13 701	9 816	17 586	0.138	1 186		1222
1993	11 495	5 742	17 248	13 926	10 363	17 488	0.134	1 256		1383
1994	35 629	25 023	46 235	16 744	13 354	20 133	0.121	1 370		1640
1995	56 160	44 288	68 032	20 949	17 433	24 464	0.133	1 835		1848
1996	3 125	411	5 839	23 291	19 539	27 044	0.179	3 022		1890
1997	59 935	47 822	72 047	22 556	18 736	26 376	0.167	2 620		1819
1998	18 377	8 696	28 059	21 299	17 535	25 062	0.162	2 390		1766
1999	53 507	40 812	66 203	20 683	17 020	24 346	0.173	2 670		1765
2000	25 922	16 672	35 172	20 827	17 221	24 433	0.160	2 407		1816
2001	26 851	15 468	38 235	21 917	18 233	25 601	0.161	2 500		1898
2002	43 383	28 987	57 778	22 765	18 984	26 546	0.160	2 622	17	1980
2003	42 928	30 307	55 550	23 808	19 930	27 686	0.187	3 459	16	2035
2004	32 695	22 146	43 244	24 227	20 284	28 170	0.195	3 731	59	2048
2005	22 431	14 498	30 363	24 320	20 354	28 286	0.223	4 430	96	2014
2006	25 051	17 126	32 976	23 452	19 512	27 392	0.227	4 377	53	1955
2007	26 679	17 668	35 690	22 621	18 793	26 449	0.216	4 064	50	1922
2008	15 670	8 596	22 744	22 546	18 870	26 222	0.217	4 107	8	1902
2009	12 102	7 216	16 988	22 491	18 942	26 041	0.212	3 889	151	1859
2010	2 635	299	4 971	21 964	18 531	25 396	0.249	4 562	148	1751
2011	9 228	5 106	13 350	20 159	16 887	23 431	0.233	3 858	22	1604
2012	4 290	1 536	7 043	18 552	15 448	21 656	0.255	3 987	157	1440
2013	19 347	6 383	32 311	16 514	13 537	19 491	0.295	4 137	53	1227
2014	16 357	2 572	30 142	13 741	10 839	16 643	0.239	2 682	25	1020
2015	16 788			11 589	8 731	14 447	0.218	2 066	40	703
2016	16 788			9 622	6 821	12 423	0	1 295	196	212

***Partial discard estimates (discards not available for the French fleet, 2002–2008 and 2012).**

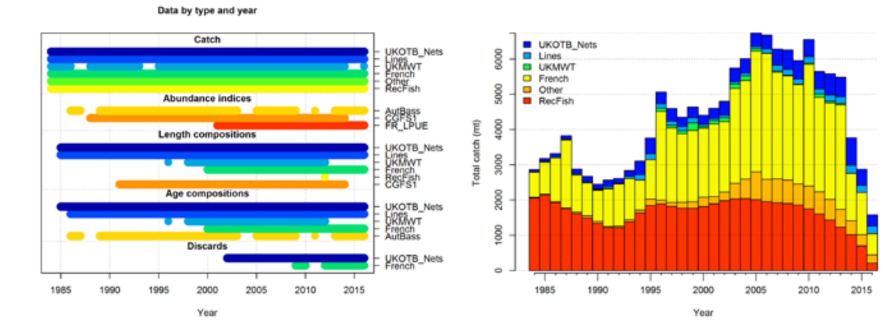


Figure 4.3.3.1. Datasets included in the final assessment (left) and total catch series for all six fleets (right).

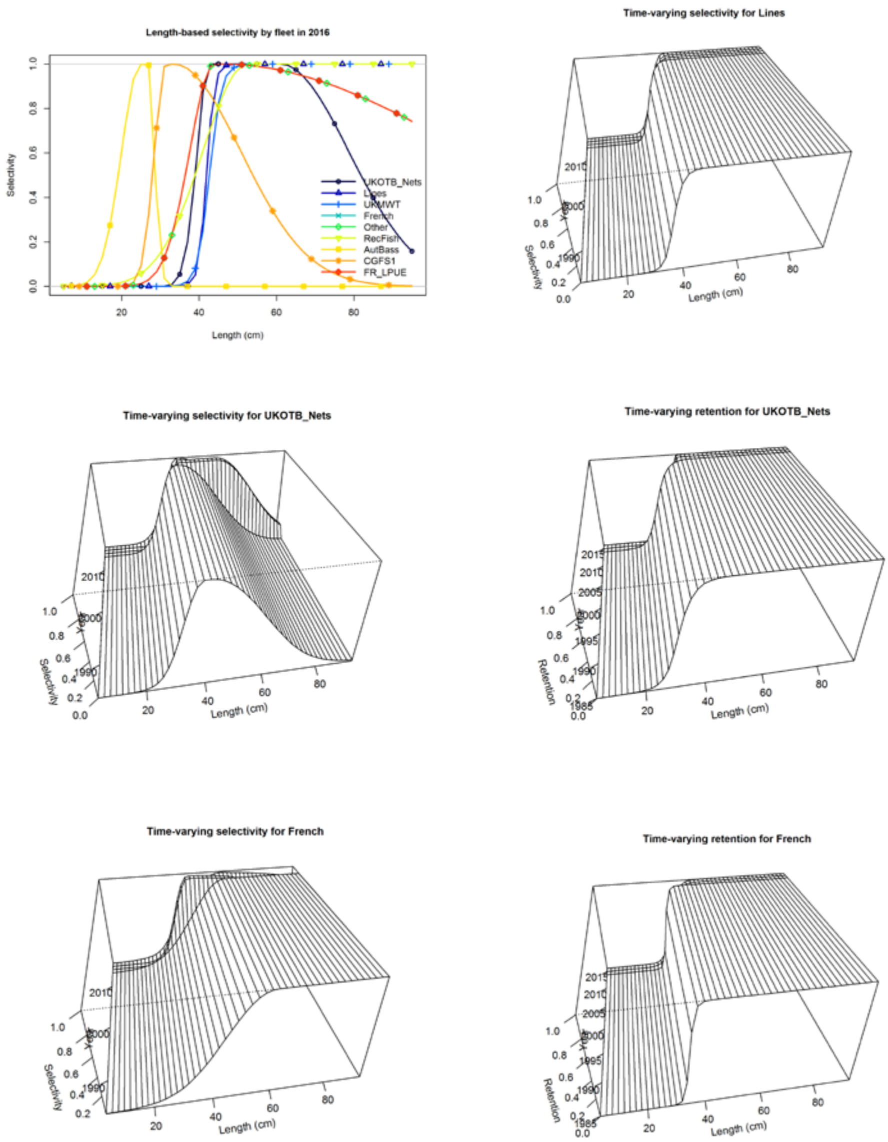


Figure 4.3.3.2. Final assessment fitted length-based selectivity and retention curves.

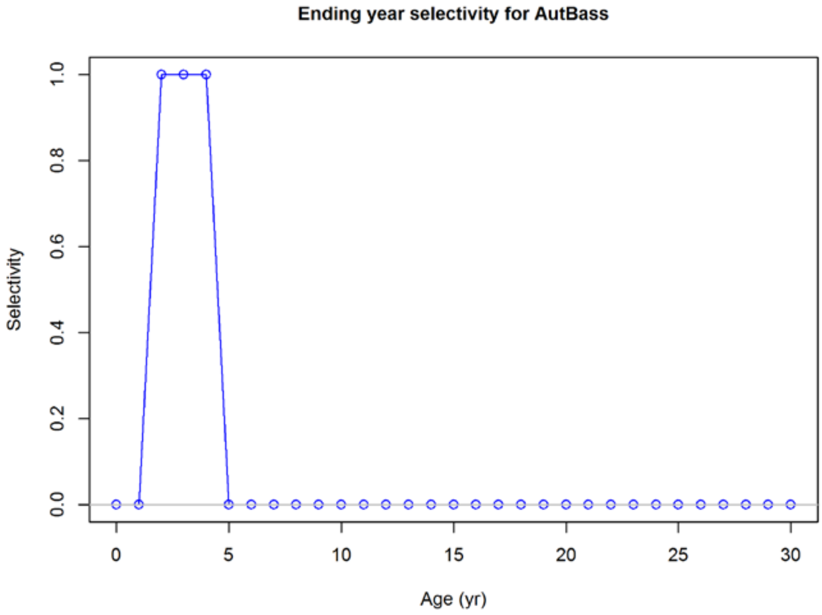


Figure 4.3.3.3. Final assessment: fitted age-based selectivity curve.

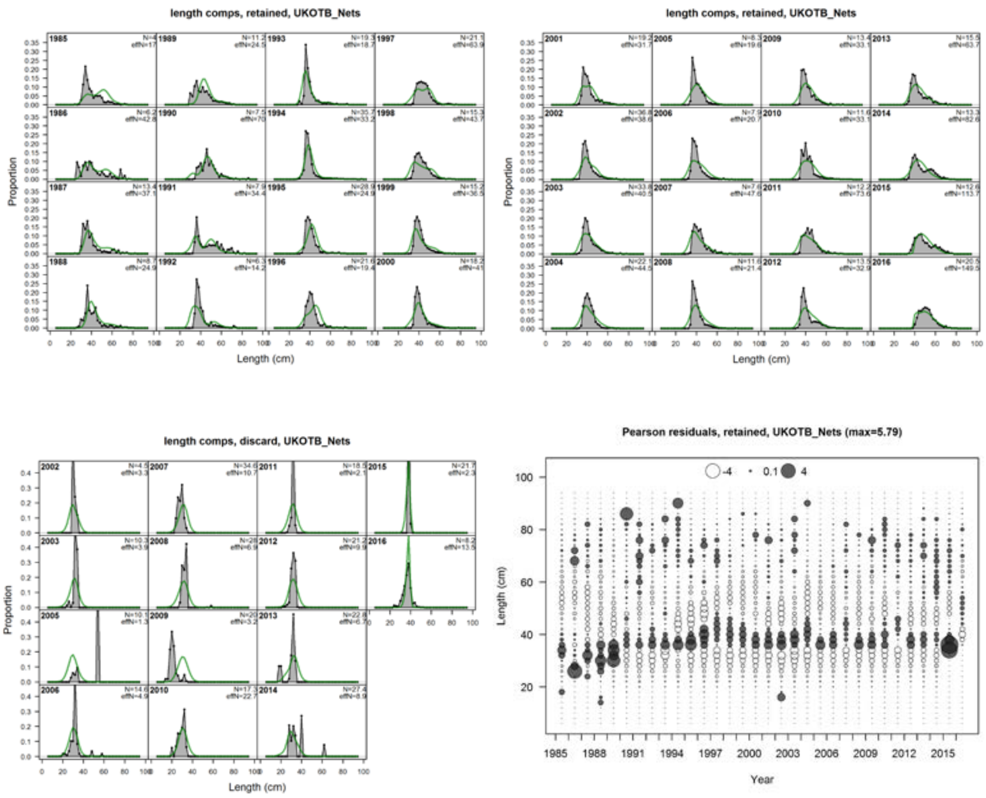


Figure 4.3.3.4. Final assessment: fit to UK trawls and nets fishery-length composition data.

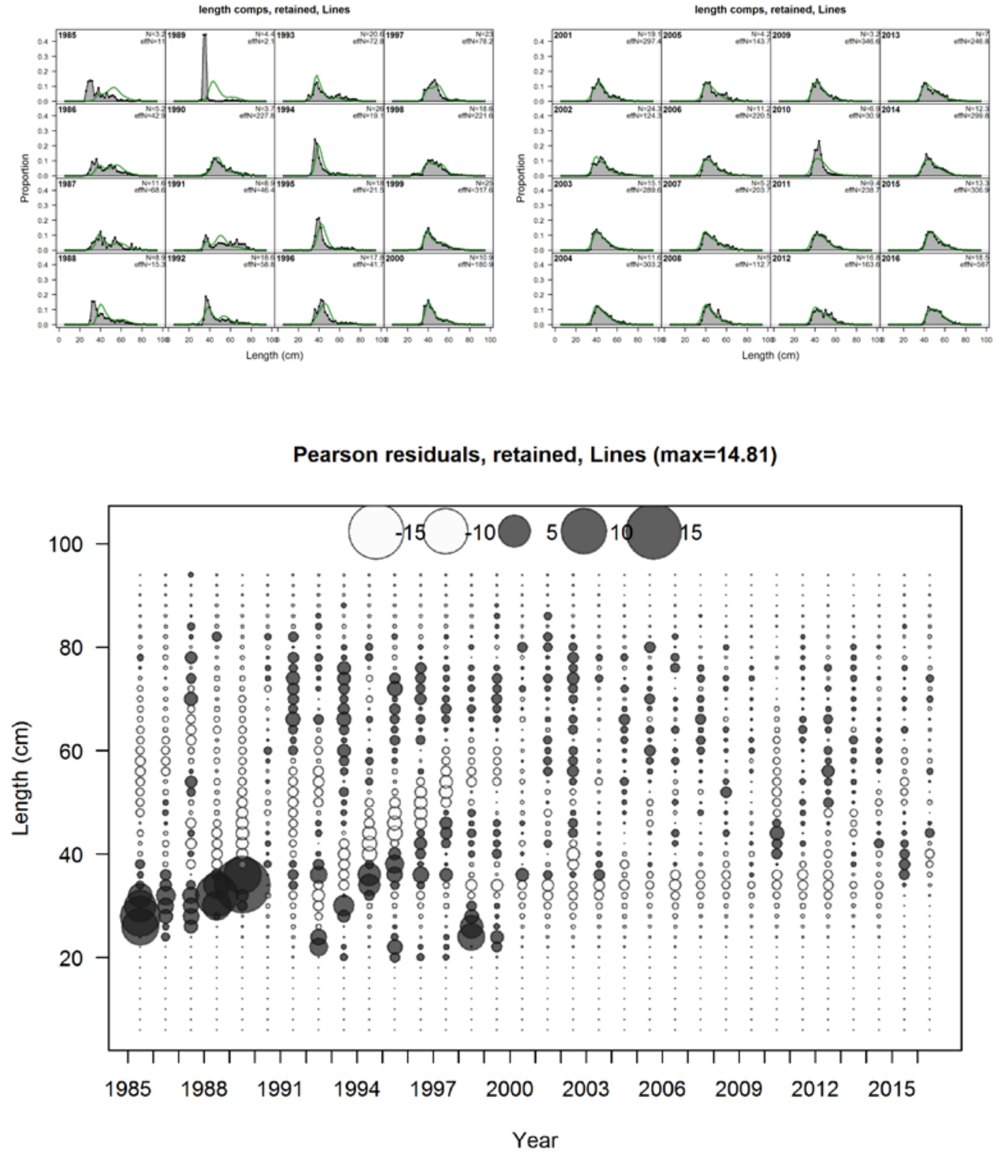


Figure 4.3.3.5. Final assessment: fit to UK lines fishery-length composition data.

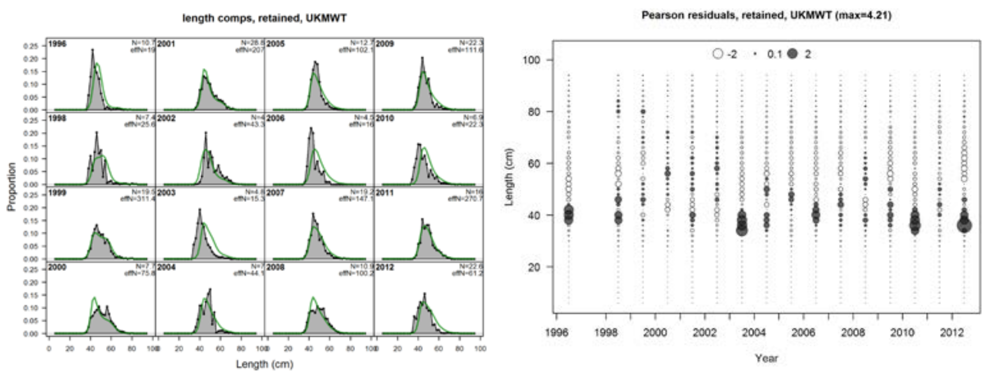


Figure 4.3.3.6. Final assessment: fit to UK midwater trawl fishery-length composition data.

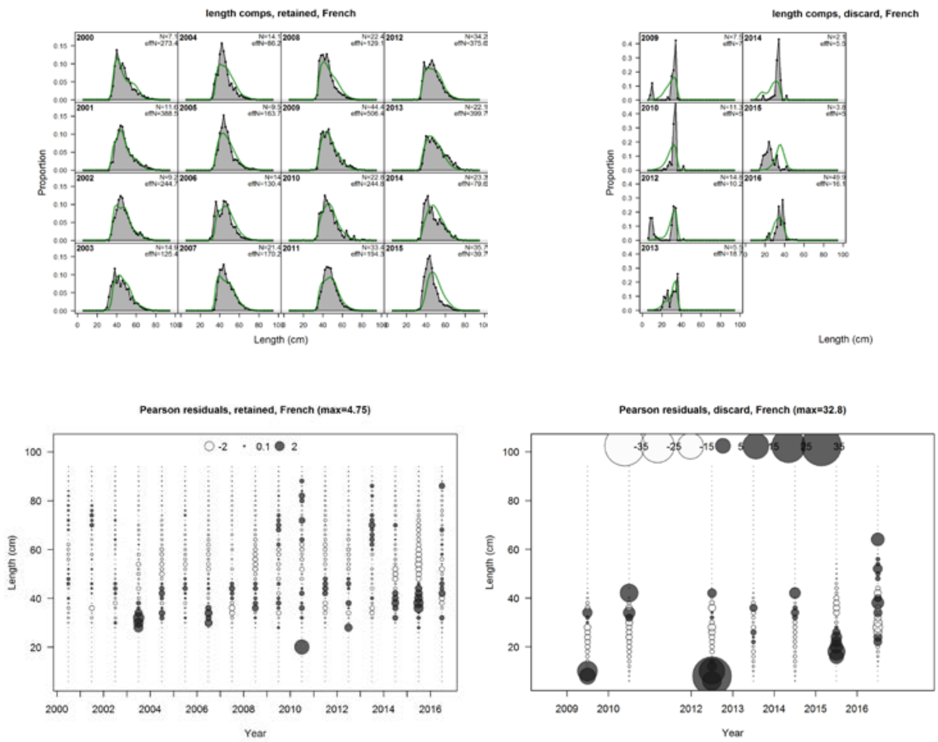


Figure 4.3.3.7. Final assessment: fit to French fishery-length composition data.

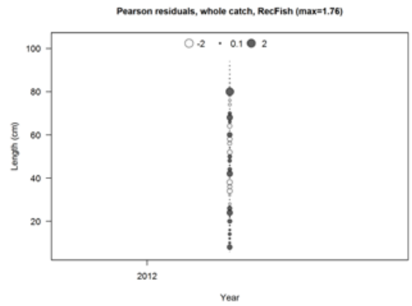


Figure 4.3.3.8. Final assessment: fit to recreational fishery-length composition data.

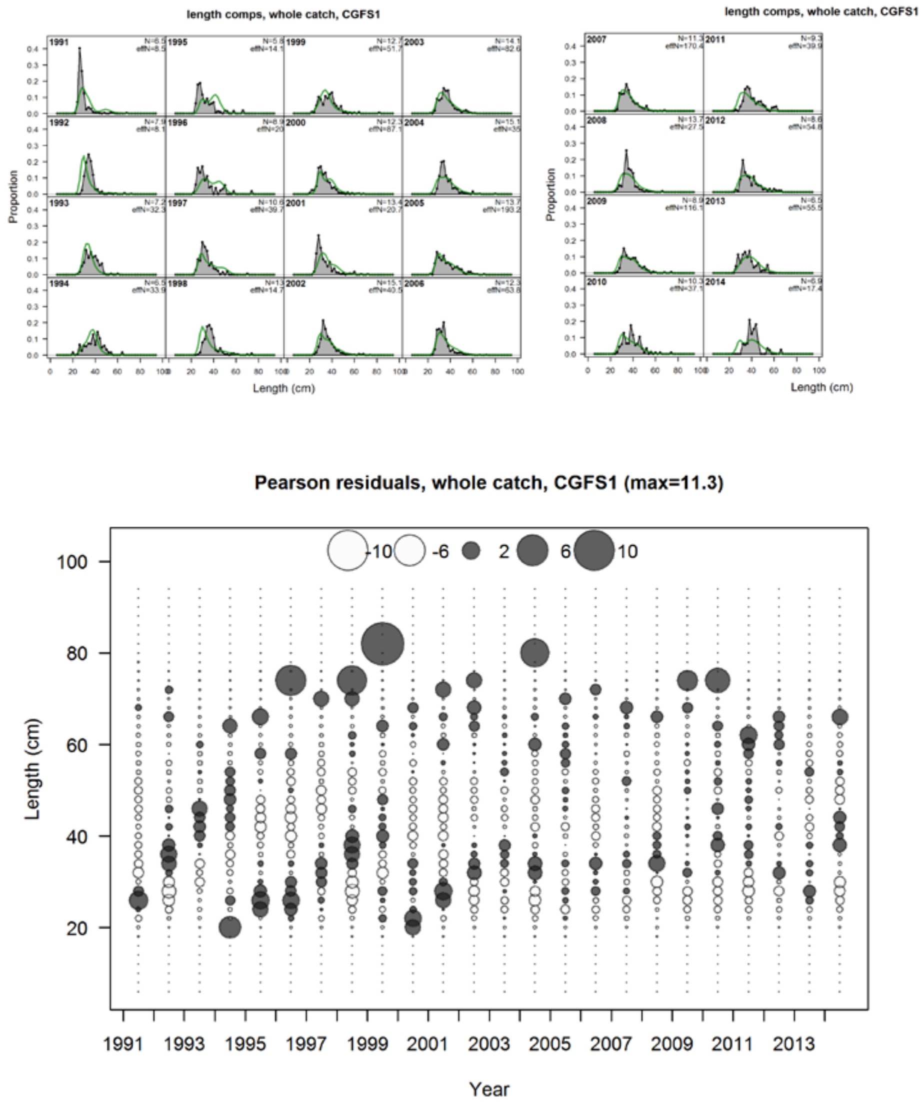


Figure 4.3.3.9. Final assessment: fit to French Channel groundfish survey-length composition data.

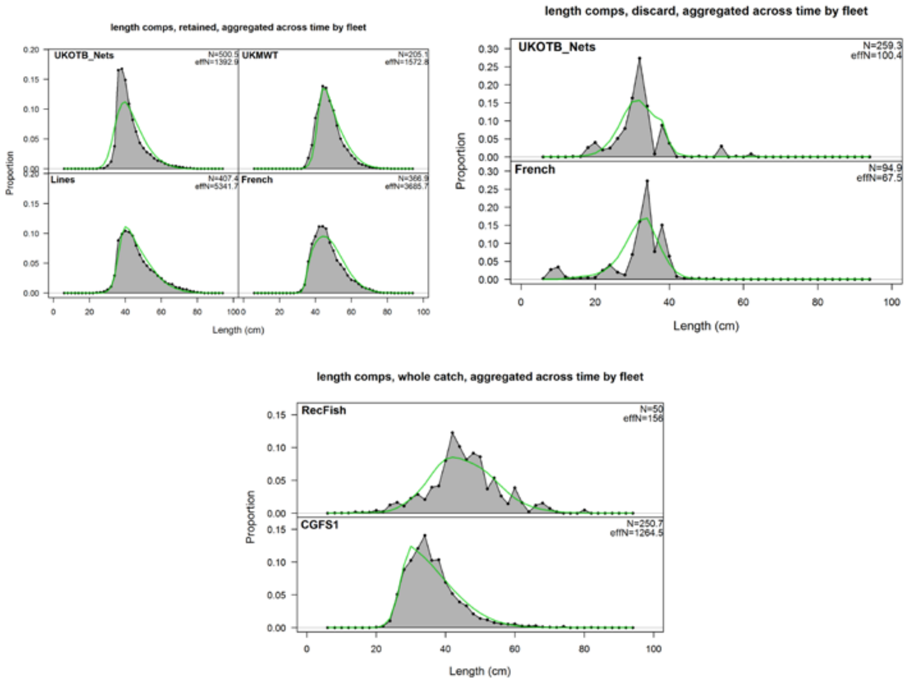


Figure 4.3.3.10. Final assessment: fit to length composition data by fishery and survey, aggregated across time.

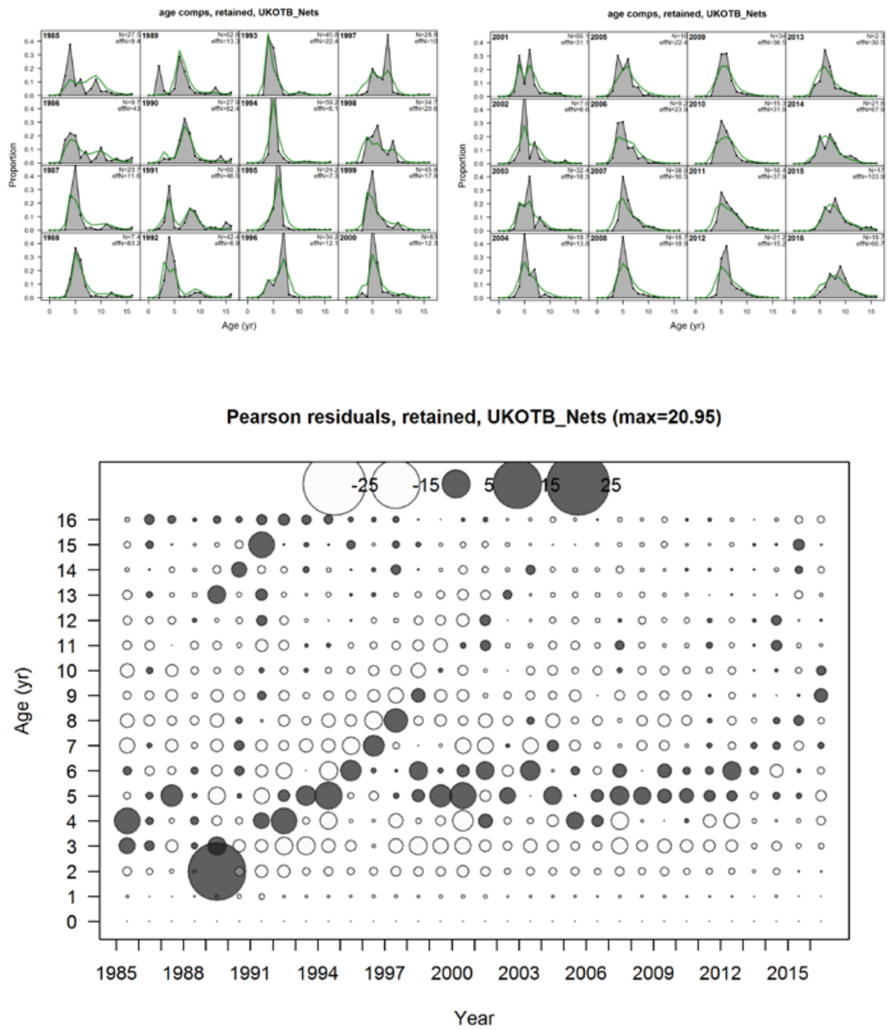


Figure 4.3.3.11. Final assessment: fit to UK trawls and nets fishery-age composition data.

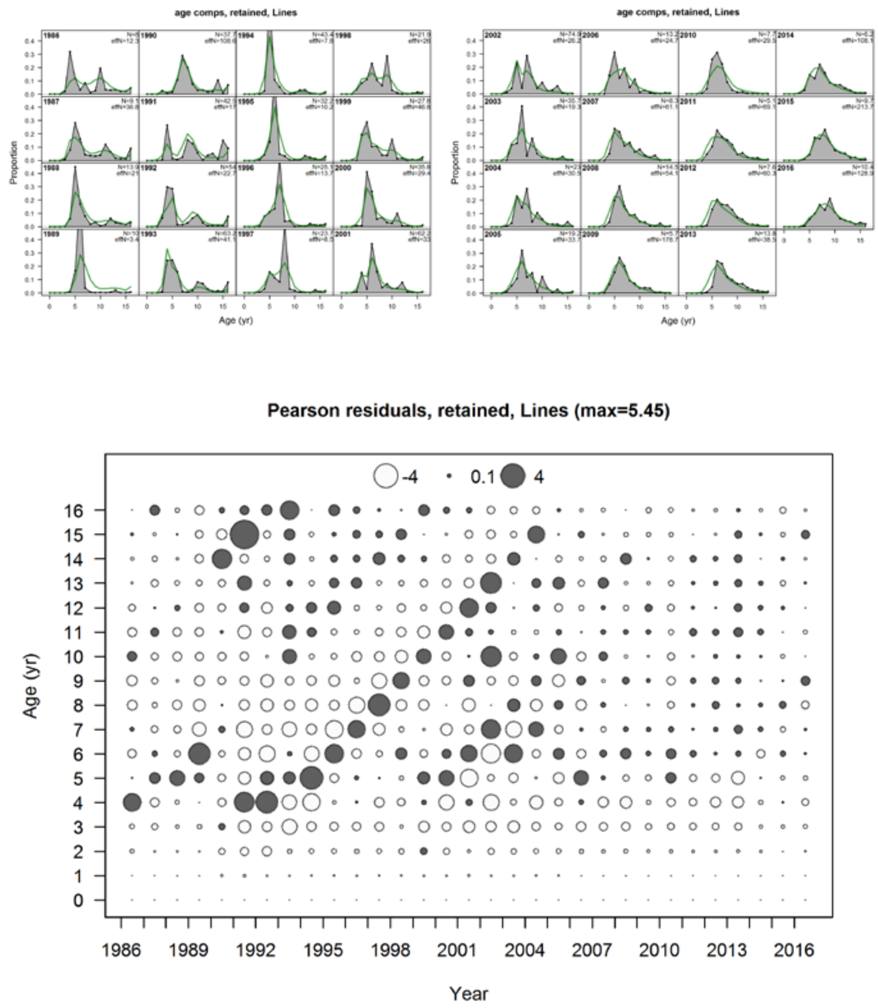


Figure 4.3.3.12. Final assessment: fit to UK lines fishery-age composition data.

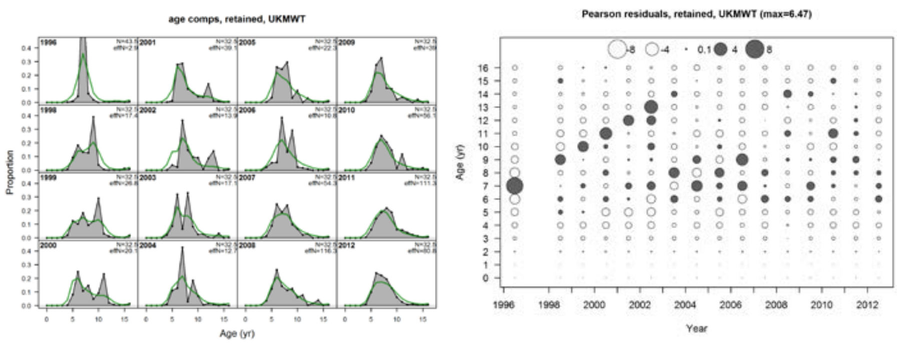


Figure 4.3.3.13. Final assessment: fit to UK midwater trawl fishery-age composition data.

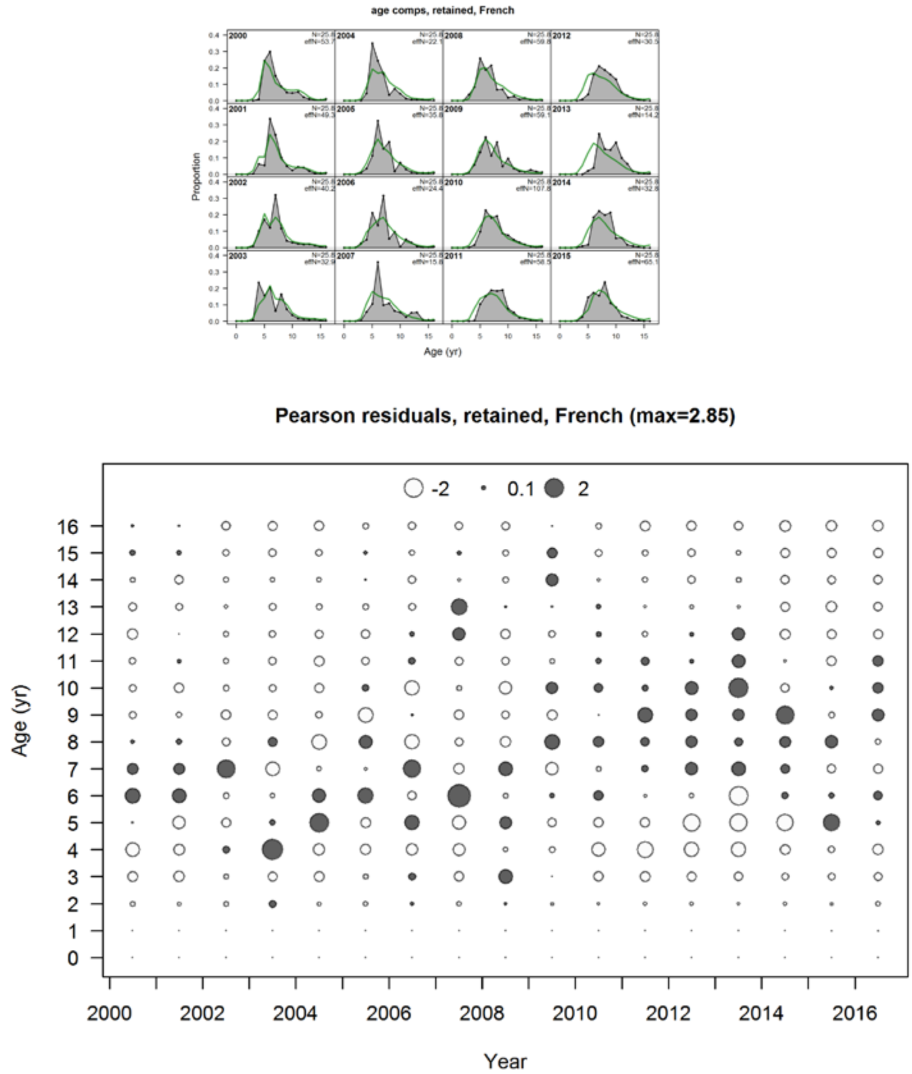


Figure 4.3.3.14. Final assessment: fit to French fishery-age composition data.

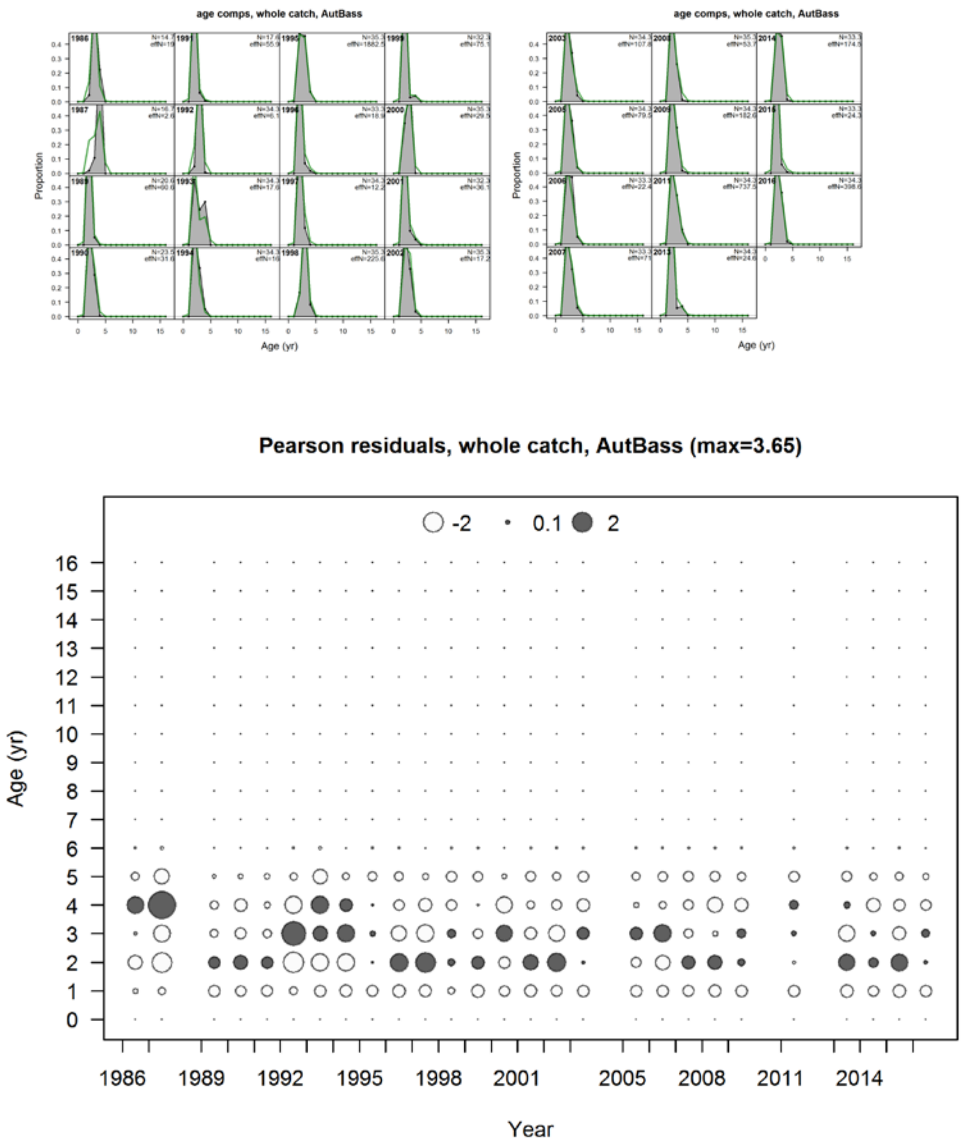


Figure 4.3.3.15. Final assessment: fit to UK Solent Autumn bass survey-age composition data.

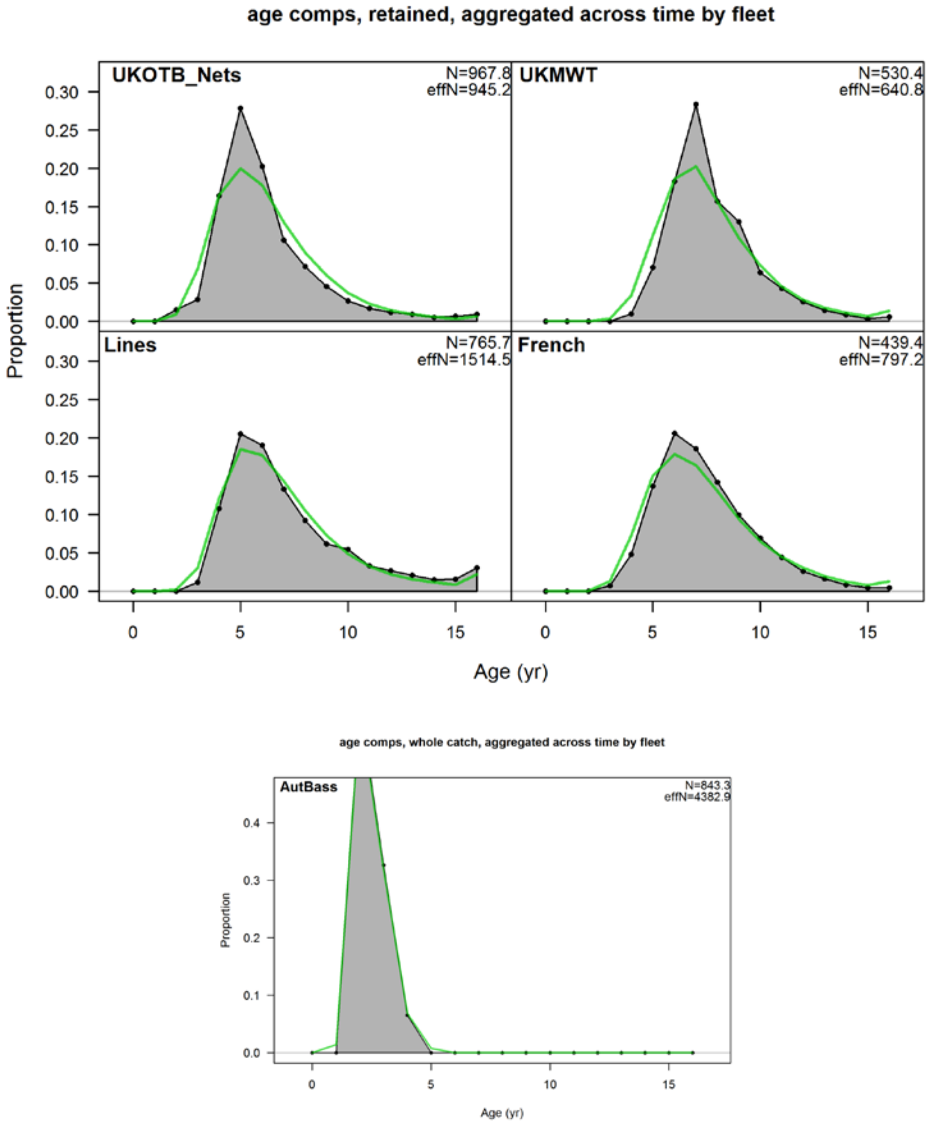


Figure 4.3.3.16. Final assessment: fit to age-composition data by fishery and survey, aggregated across time.

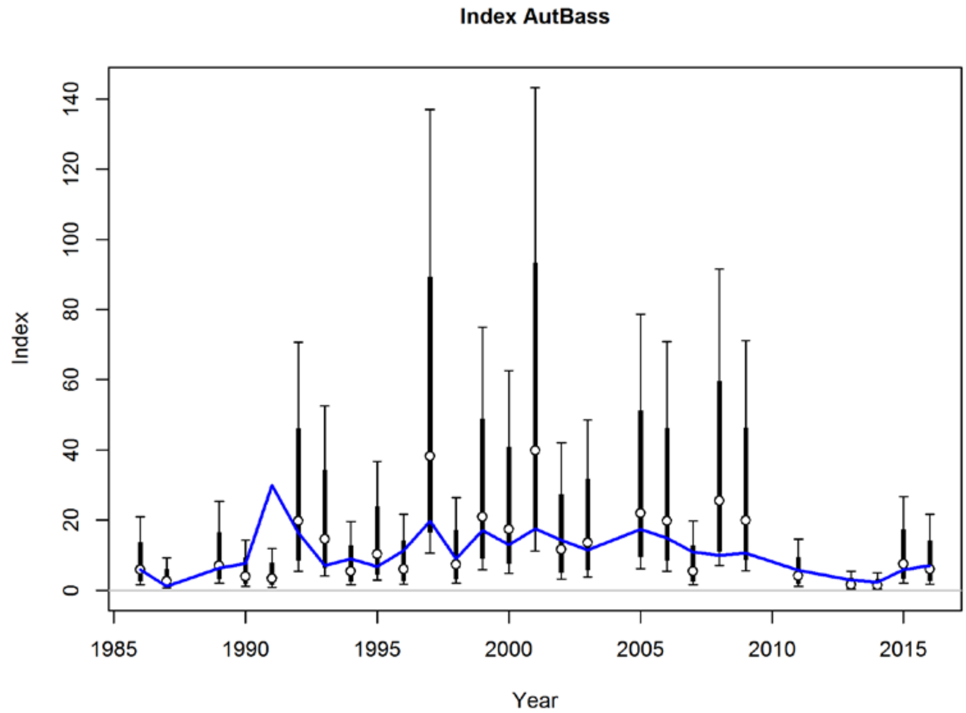


Figure 4.3.3.17. Final assessment: fit to UK Solent Autumn bass survey, according to length and age-based selectivity.

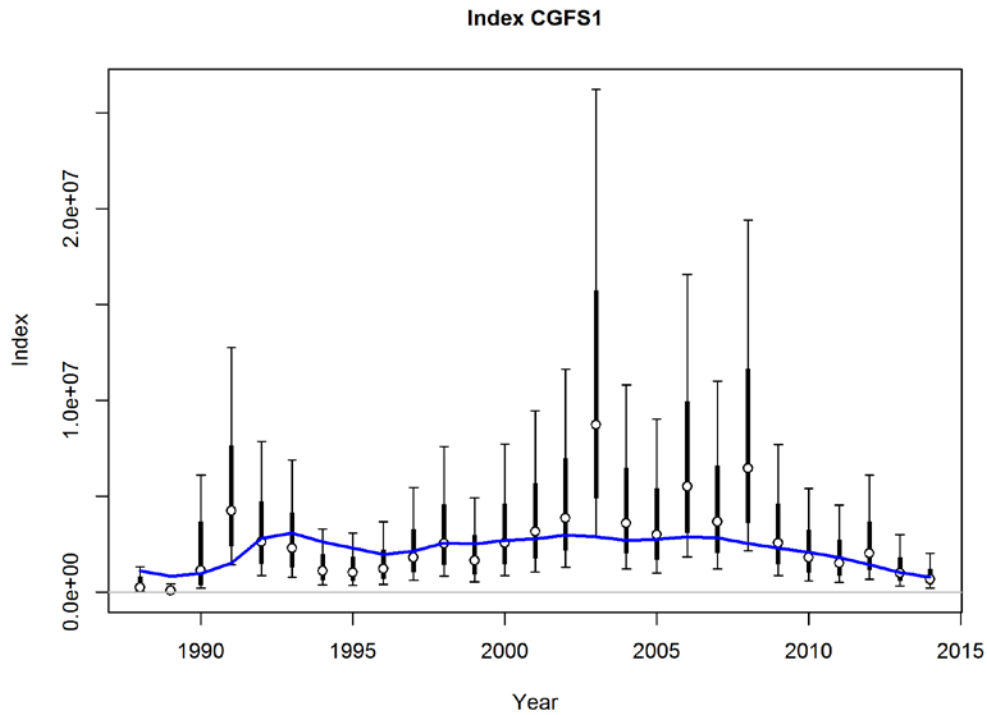


Figure 4.3.3.18. Final assessment: fit to French Channel groundfish survey, according to length-based selectivity.

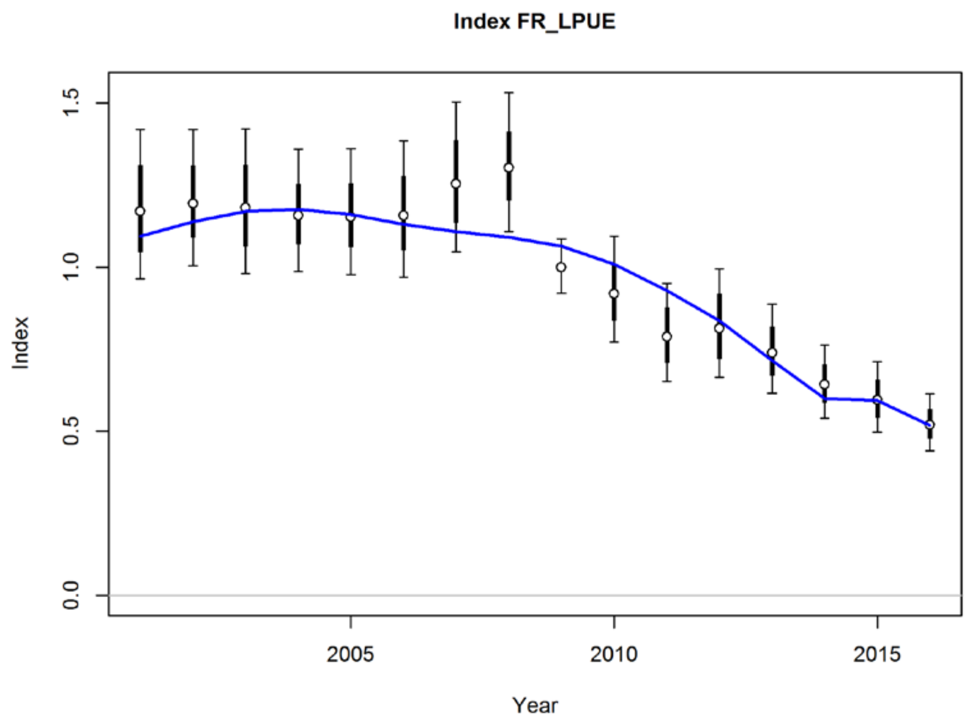


Figure 4.3.3.19. Final assessment: fit to French commercial landing per unit of effort, according to French fleet length-based selectivity.

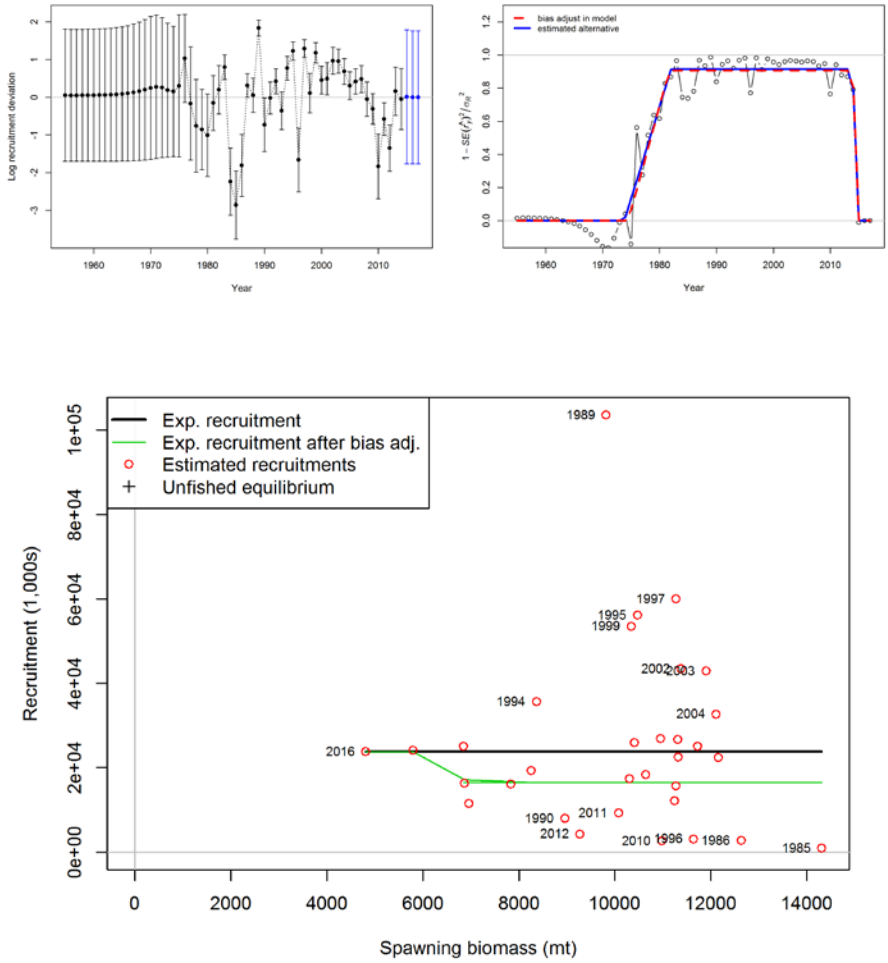


Figure 4.3.3.20. Final assessment: Top left: time-series of log-recruitment deviations (deviations for 1969–1984 precede the period of input catch data). Top right: adjustment for bias due to variability of estimated recruitments in fishery. Red line shows current settings for bias adjustment. Blue line shows least-squares estimate of alternative bias adjustment relationship for recruitment deviations. Bottom: Stock–recruitment scatter (Beverton–Holt stock–recruitment model and steepness = 0.999).

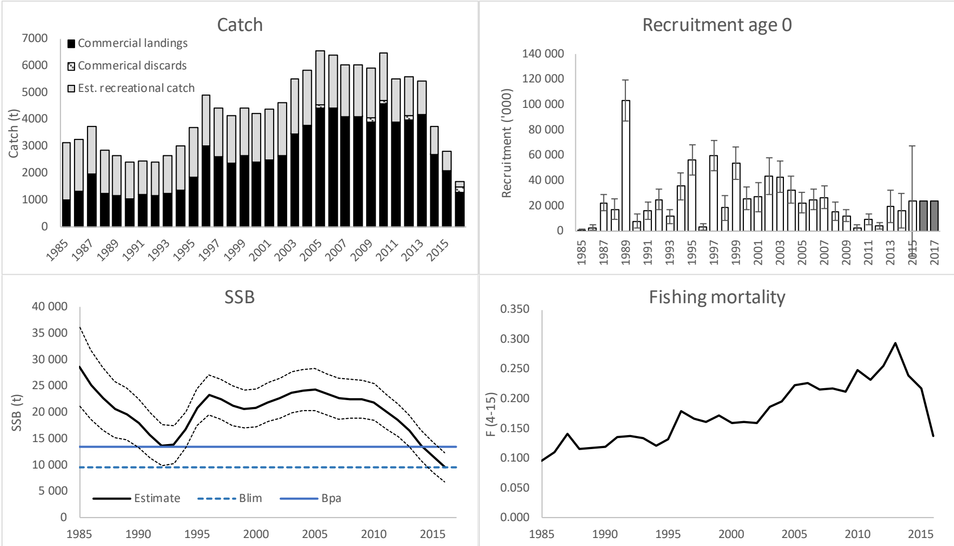


Figure 4.3.3.21. Stock trends from the final assessment, based on Stock Synthesis. Recruitment in 2016 and 2017 is the long-term geometric mean. Error bars on Recruitment plot and dotted lines on SSB plot are ±2 standard errors.

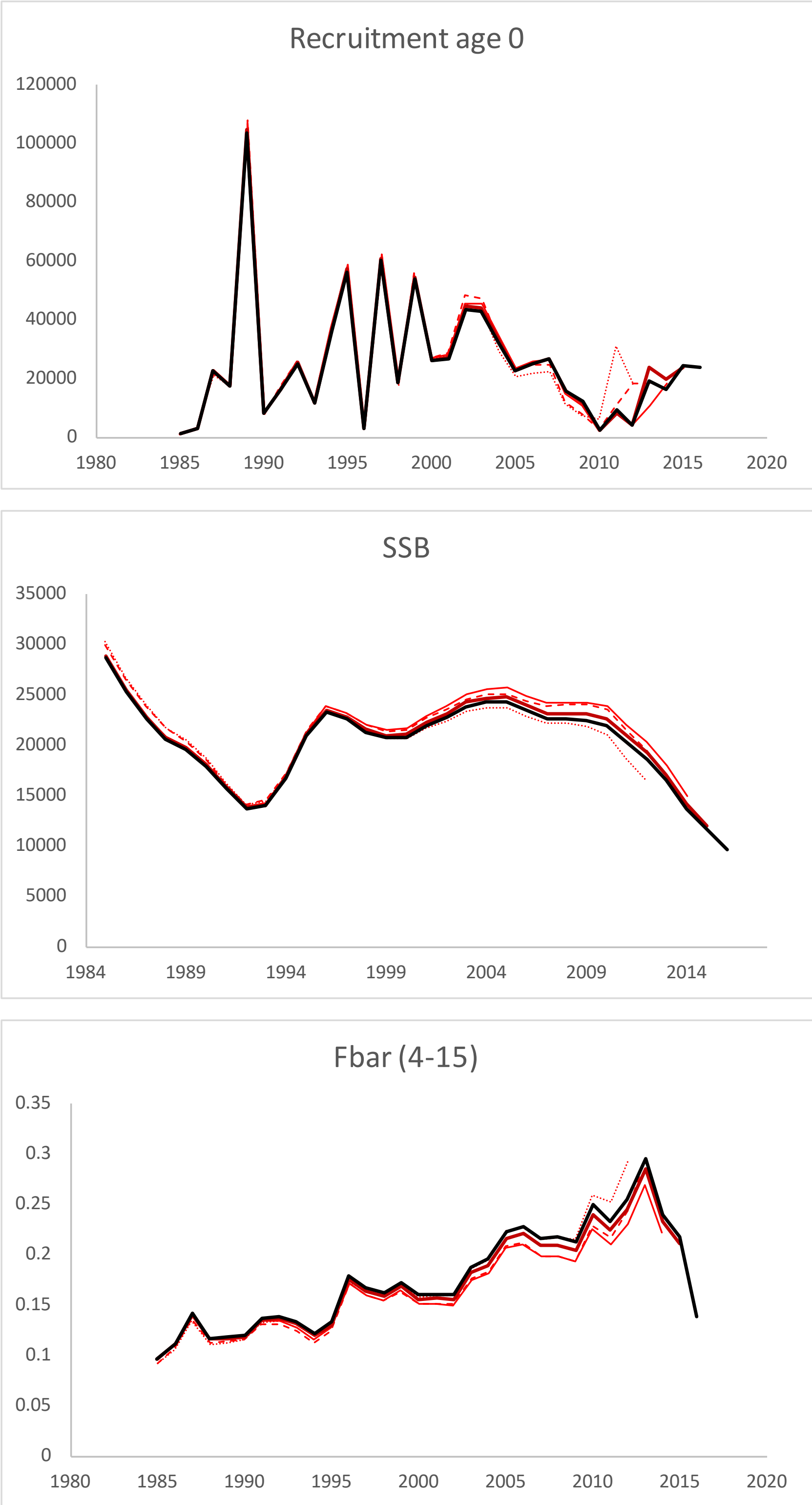


Figure 4.3.3.22. Retrospective analysis of stock trends from final proposed assessment, based on Stock Synthesis run with final year set to 2016 with five year peel.

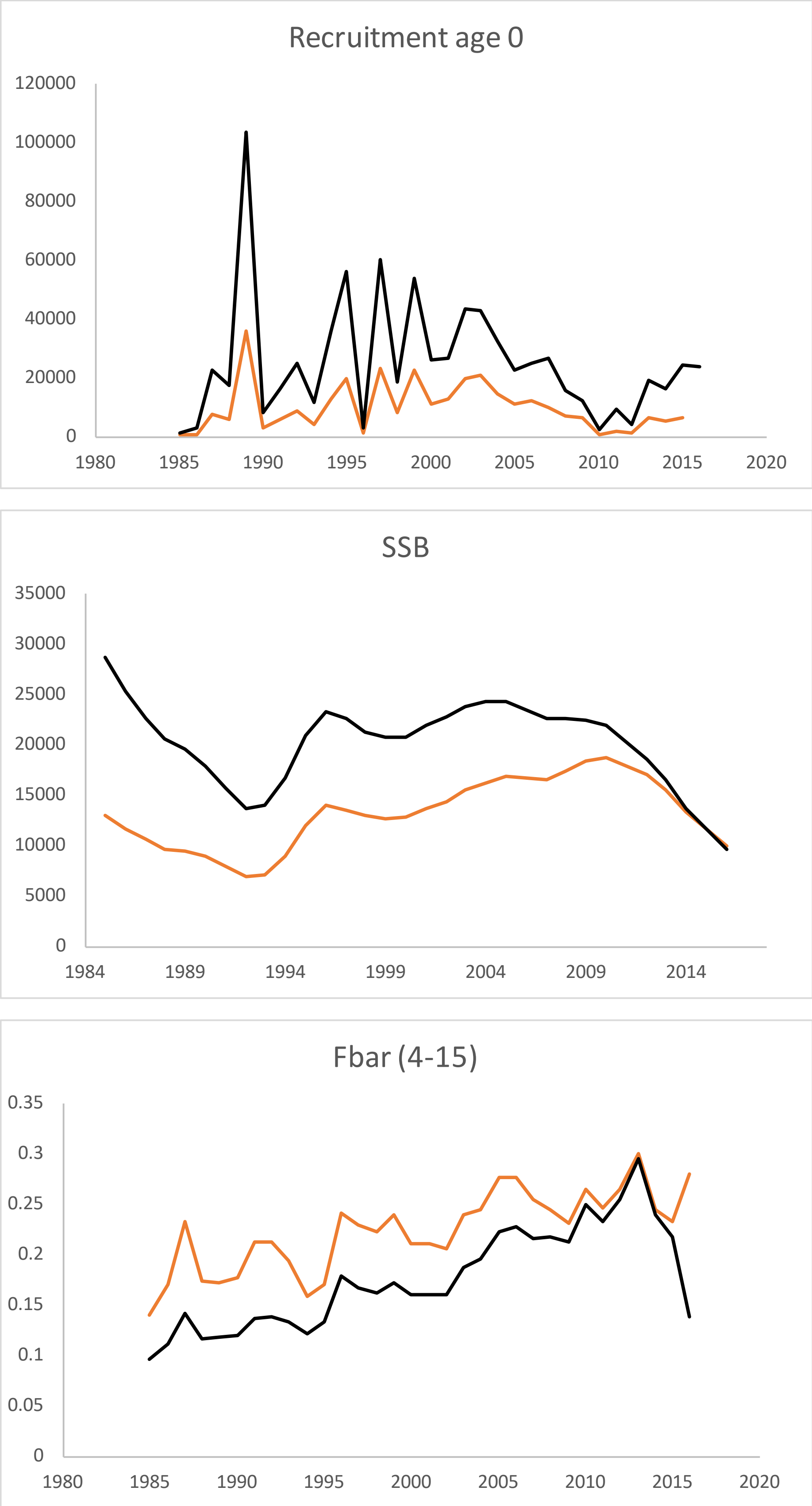


Figure 4.3.3.23. Stock trends from SS3 for the WGCSE 2017 assessment (red) and WKBASS final model (black).

4.3.4 Sensitivity analysis

WKBASS concluded that the new model could be taken forward as the agreed approach. The following sensitivities were carried out on the improved model to check model robustness to the assumptions made.

- Natural mortality.
- Commercial tuning series.
- Commercial fishery selectivity and retention.
- UK under 10 m landings.
- Recreational catch levels after 2014.
- Recreational catch post-release mortality.

The likelihood results for each of the models are presented in Table 4.3.4.1 with the exception of natural mortality where likelihood profiling was carried out.

Sensitivity to natural mortality

A comprehensive review was undertaken giving rise to a change in the assumptions made for natural mortality. Given the lack of species and stock-specific data, it was agreed to update the model with a value of 0.24. Given that the value for natural mortality is fixed with in the model and is based on Then *et al*. (2015), a sensitivity analysis using likelihood profiling was carried out to test different values of natural mortality and to assess how well the model performed. The values were considered to range between 0.16 and 0.32, and were higher than the original value used in previous assessments. The overall likelihood profile shown in Figure 4.3.4.1 suggests that a value of 0.2 would be appropriate, but when assessing the individual components of the likelihood a range of values including 0.24 could be appropriate. As natural mortality is highly correlated with model-estimated parameters including those linked to selectivity, the value of natural mortality has the potential to change with the addition of new data and not due to environmental or biological changes. The range of natural mortality used affects stock trends by increasing biomass and recruitment estimates with greater mortality rates and decreasing F_{bar} along the time-series (Figure 4.3.4.2). Overall the trends in SSB, recruitment, and fishing mortality remain the same.

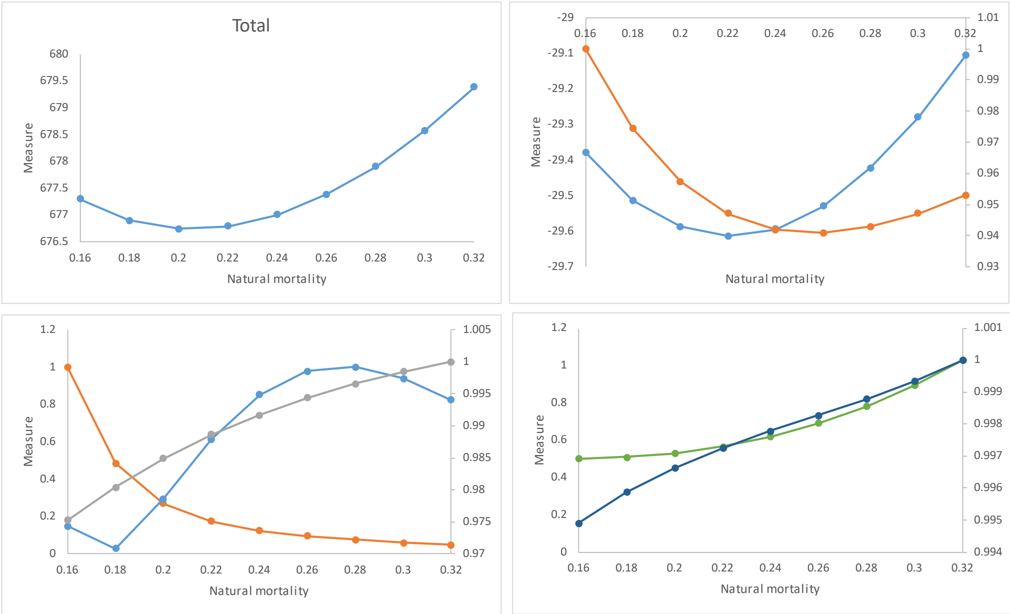


Figure 4.3.4.1. Likelihood profile of model with natural mortality valued between 0.16 and 0.32. Total likelihood (top left), subcomponents of the likelihood (left to right and down) Survey and recruitment, catch equilibrium, catch and discards; length and age compositions.

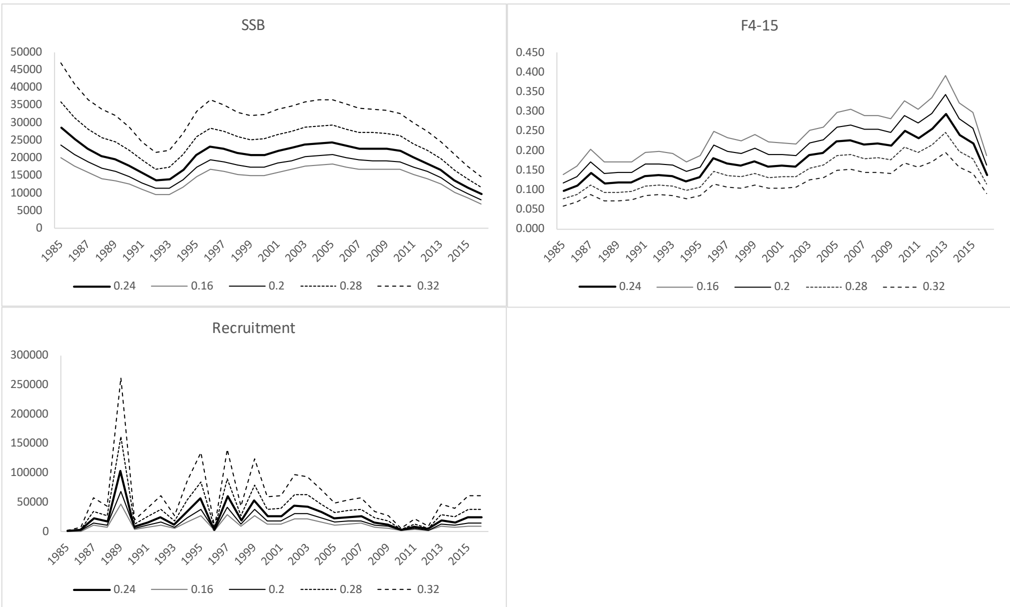


Figure 4.3.4.2. Stock trends, SSB, F_{bar} and recruitment, for the range of mortality values from 0.16 to 0.32.

Sensitivity to commercial tuning series

A commercial lpue series was used to tune the model for the adult component of the population. The sensitivities evaluated were the exclusion of the lpue from the new model and the exclusion of lpue data prior to 2009 as the quality of the base data prior to this period was less robust. Figure 4.3.4.3 provides the stock trends for the three assumptions. Exclusion of the lpue showed resulted in differences in SSB before 2009, but there was little difference in the trend of magnitude of F_{bar}. With the exception of SSB, the only difference is the reduction in uncertainty for SSB, F_{bar}, and recruitment when the lpue is included. Although not fully comparable, the overall likelihood is better for the model with the full lpue time-series. The likelihood components which do provide comparability show that length compositions are better but age compositions are slightly worse with the lpue.

Although the trends are similar for SSB and F_{bar} using both the short and full lpue series, there is an impact on the most recent part of the time-series and the SSB tilts from around 2007. This lead to the perception of that SSB is higher with lower fishing mortality from 2005, than that of the model using the full lpue series. Diagnostics show that the model fit including the new series was good for most years with the exception of 2007–2009 and 2011, and there was no strong pattern in the residuals. The likelihood when using the reduced lpue time-series was slightly lower indicating a poorer overall fit to the data.

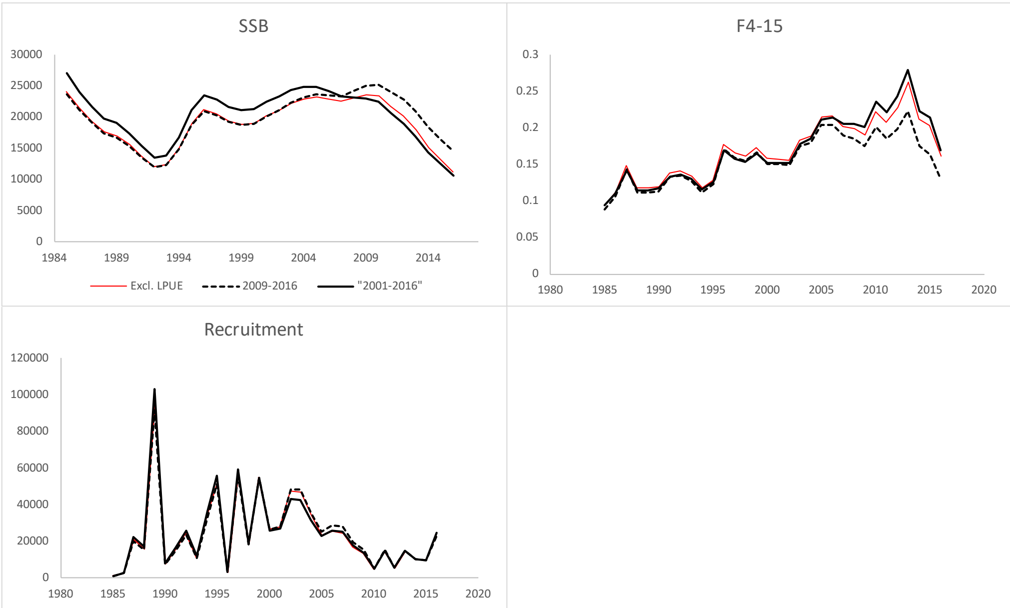


Figure 4.3.4.3. Stock trends, SSB, F_{bar} and recruitment, for assessment with the inclusion of the full lpue time-series, partial time-series and excluding lpue.

Sensitivity to commercial fishery selectivity and retention

Although the catches by fisheries have increased, the selectivity of the gears is likely to have remained fairly stable. Given the recent measures implemented to aid the recovery of the stock, the impact of these measures on the fishery has driven changes in selectivity and retention. These included: an increase to the MCRS from 36 cm to 42 cm and the prohibition of the pelagic fisheries targeting sea bass. In order to allow the model account for these changes and to future proof the assessment, the model has been set up to allow changes in selectivity and retention from 2015. As there is limited length and age composition data available, these changes in selectivity have the potential to be unstable until more years are available.

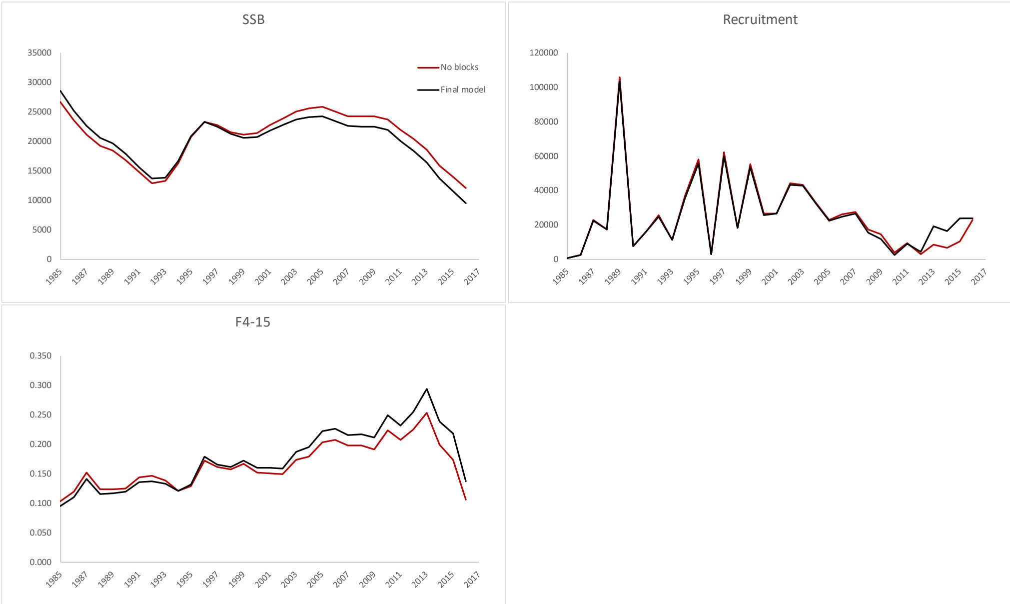


Figure 4.3.4.4. Stock trends, SSB, F_{bar} and recruitment, for the assessment including additional catch with and without selectivity and retention blocks.

UK under 10 m landings

There is known uncertainty in the landings, particularly with the UK under 10 m fleet where comparison studies of logbook data and official recorded landings showed that landings for the under 10 m fleet could be as much as three time higher than that reported. A sensitivity test was carried out by increasing the landings of the UK fleets by three times. The results gave a similar picture to that of increasing natural mortality were the biomass and recruitment rescaled showing an overall increase, however F showed similar levels with a slight variation in the most recent years where selectivity has changed.

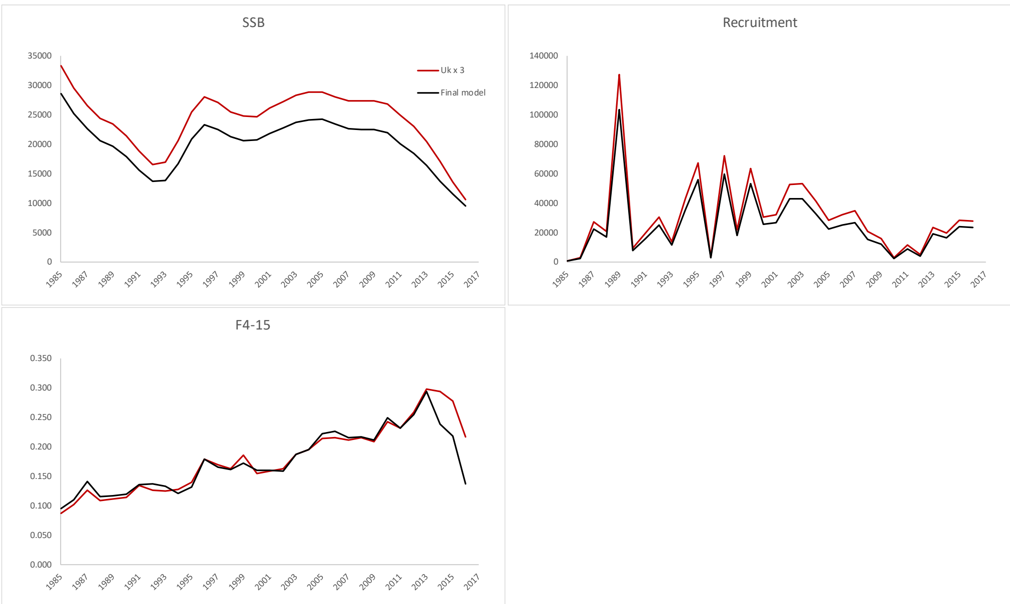


Figure 4.3.4.5. Stock trends, SSB, F_{bar} and recruitment, for the assessment including three x more landings for the UK fleets.

Sensitivity to varying levels of recreation catch after 2014

The recreation surveys did not provide a robust estimate of recreational catch for 2016 due to limitations in the number of countries providing data and there is no information on catch with the exception of 2012, it was therefore agreed that catch since the management measures should be based on a similar assumption used to construct the full time-series up to 2015. As this is based on an assumption a number of scenarios were reviewed:

- A continuous constant F for the full time-series;
- Half the reduction in F expected due to management measures.

The results of the different levels in recreational F had very minimal effect overall (Figure 4.3.4.6 and Table 4.3.4.1) with only minor difference in fishing mortality (F) in the most recent period with constant F assumption having a higher F as expected.

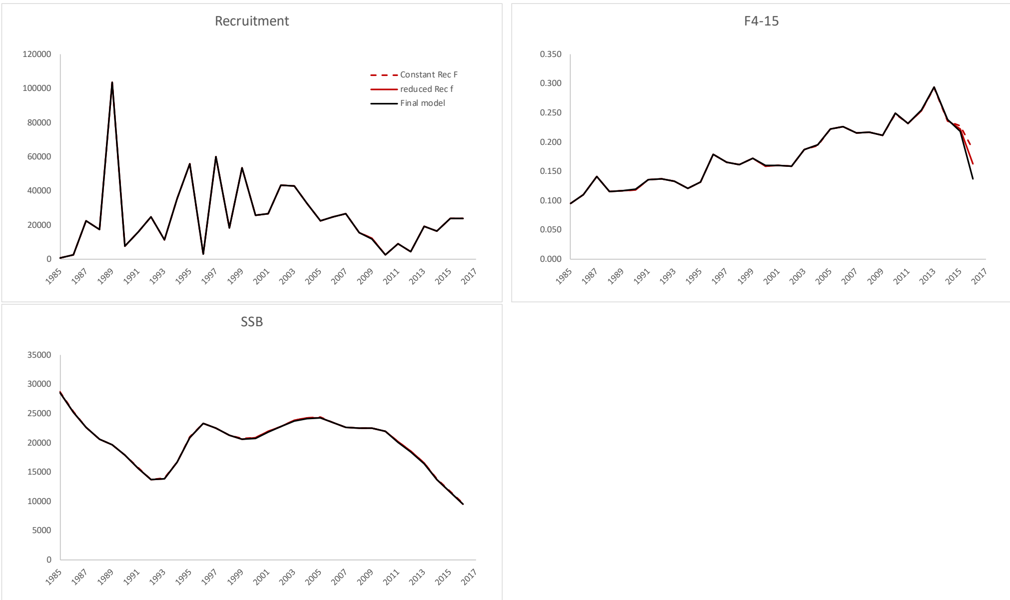


Figure 4.3.4.6. Stock trends, SSB, F_{bar} and recruitment, for the assessment with variation on catch levels since 2014.

Recreational catch post-release mortality

There is some uncertainty in the post-release mortality component of the catch of the recreational fleet. A sensitivity test was carried out with a range of post-release mortality values, 1 to 15%. The model was insensitive to these values showing similar trends and magnitudes in biomass, recruitment and fishing mortality. The only difference was to the catch time-series showing higher catch levels with a greater post-release mortality up to 15%.

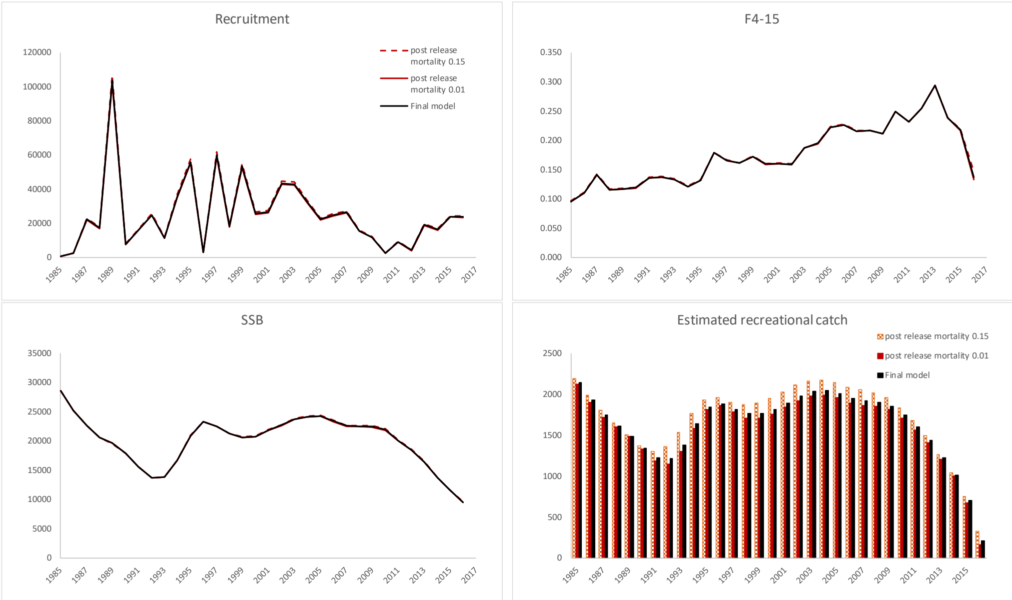


Table 4.3.4.1. Likelihood and component likelihoods for each of the model sensitivities.

	TOTAL	Catch	Equilibrium catch	Survey	Discard	Length comps	Age comps	Recruitment	Forecast Recruitment	Parameter softbounds	Number of parameters	Convergence level
Final model	677.0	4.70E-13	0.0430	-29.6	8.68	370.9	304.4	22.56	7.52E-05	0.0164	109	9.65E-05
No LPUE	707.7	4.04E-13	0.0330	1.6	8.39	371.6	303.3	22.81	4.14E-05	0.0161	108	8.38E-05
LPUE short	684.1	3.73E-13	0.0301	-22.4	8.37	371.4	303.8	22.75	6.02E-05	0.0161	109	8.81E-05
No blocks	733.6	3.68E-13	0.0491	-26.9	12.71	411.2	312.5	23.62	0.383142	0.0062	97	5.41E-05
Uk under 10m x 3	682.5	5.50E-13	0.0115	-28.2	8.10	374.9	305.4	22.24	1.30E-05	0.0184	109	1.07E-02
Constant Rec F	677.1	4.69E-13	0.0422	-29.6	8.63	371.0	304.5	22.49	7.60E-05	0.0165	109	1.93E-04
Reduced Rec F	677.0	4.69E-13	0.0426	-29.6	8.65	370.9	304.4	22.52	7.54E-05	0.0165	109	7.76E-04
Post release mortality 0.15	677.4	4.56E-13	0.0346	-29.6	8.71	371.3	304.5	22.47	8.49E-05	0.0165	109	4.36E-04
Post release mortality 0.01	676.7	4.77E-13	0.0470	-29.6	8.64	370.6	304.3	22.62	7.21E-05	0.0164	109	2.83E-04
WGCSE 2017	553.1	1.52E-12	0.4804	-1.2		207.8	316.2	29.88	2.01E-02	0.0137	86	3.26E-06

4.4 Biological Reference Points and forecast

4.4.1 Current reference points

Biological reference points for sea bass in divisions 4.b–c, 7.a, and 7.d–h were evaluated at ICES (2017b) and new biomass reference points accepted by the group (Table 4.4.1.1).

Table 4.4.1.1. Biological reference points accepted by ICES (2017b).

Framework	Reference point	Value
MSY approach	MSY $B_{trigger}$	12 673 t
	F_{MSY}	Not defined.
Precautionary approach	B_{lim}	8075 t
	B_{pa}	12673 t
	F_{lim}	Not defined.
	F_{pa}	Not defined.
Management plan	SSB_{MGT}	Not applicable.
	F_{MGT}	Not applicable.

4.4.2 Source of data

For this benchmark, data used in the analysis were taken from the final assessment model for sea bass in divisions 4.b–c, 7.a, and 7.d–h obtained during the ICES WKBASS 2018 (see Section 4.3.3).

4.4.3 Methods used

All analyses were conducted with EQSIM using R (© 2016 The R Foundation for Statistical Computing). SS3 model output was converted to an FLStock object in order to run EQSIM. All model and data selection setting are presented in Table 4.4.3.1.

Table 4.4.3.1. Model and data selection settings.

DATA AND PARAMETERS	SETTING	COMMENTS
SSB-recruitment data	Full dataseries (years classes 1985–2016)	
Exclusion of extreme values (option extreme.trim)	No	
Trimming of R values	Yes	-3,+3 Standard deviations
Mean weights and proportion mature; natural mortality	2007–2016	
Exploitation pattern	2015–2016	
Assessment error in the advisory year. CV of F	0.212	Set ICES default value
Autocorrelation in assessment error in the advisory year	0.423	Set ICES default value

4.4.4 Results

4.4.4.1 Stock–recruitment relationship

The stock–recruitment plot show little dependence of R on SSB (Figure 4.4.4.1). Using the stock–recruitment relationship classification proposed by ICES (2017b), sea bass can be categorised as Type 5. This is a stock with no clear relationship between stock and recruitment (i.e. no apparent stock–recruitment signal).

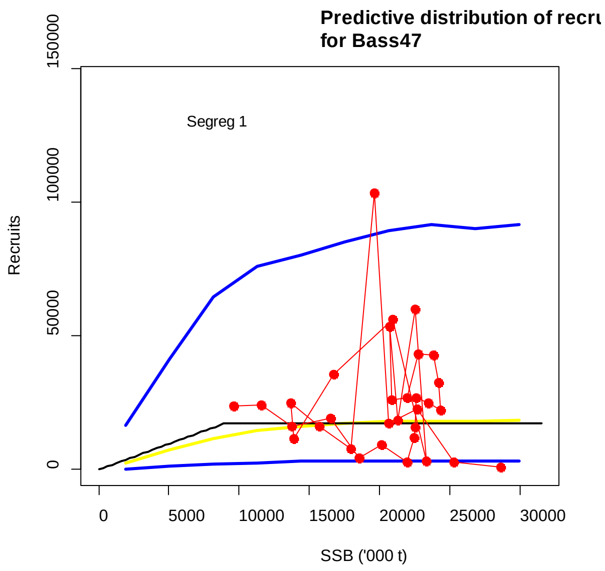


Figure 4.4.4.1. Stock–recruitment relationship for the sea bass sea bass in divisions 4.b–c, 7.a, and 7.d–h.

For a type 5 stock–recruitment, B_{lim} is estimated to be equal to B_{loss}. This implies a B_{lim} of 9618 tonnes, given that the model uncertainty is less than the default and not all uncertainty is accounted for, B_{pa} is therefore B_{lim} x 1.4 which is 13 465 tonnes.

4.4.4.2 Yield and SSB

F_{MSY} is estimated from the base run using the peak of the median landings equilibrium yield curve. The F_{MSY} range is estimated to be F values representing 95% of the peak of the median yield curve.

4.4.4.3 EQSIM analysis

4.4.4.3.1 Segmented regression method, full SR time-series, without $B_{trigger}$

F_{lim} and F_{pa} were estimated using the EQSIM simulation with $B_{trigger}$ set to 0 (i.e. no $B_{trigger}$ used), F_{cv} = F_{phi} = 0 (i.e. no assessment/advice error set for this first run), and the segmented regression as the only stock–recruitment method. F_{lim} is estimated as the fishing mortality that, at equilibrium from a long-term stochastic projection, leads to a 50% probability of having SSB above B_{lim}. F_{lim} is estimated to be 0.295, and F_{pa} is estimated to be 0.211 based on the following equation [$F_{pa} = F_{lim} \times 1.4^{-1}$] as the uncertainty estimated from the model is less than the default value, so is not fully accounted.

Initially, F_{MSY} is calculated as the fishing mortality that maximises median long-term yield in stochastic simulations under constant F exploitation (i.e. without MSY $B_{trigger}$). Using the same simulation method with the inclusion of assessment/advice error, default values: Fcv=0.212, Fphi=0.423 from WKMSYREF4 (ICES, 2017c). F_{MSY} = 0.214 and is thus above F_{pa} = 0.211 (Figures 4.4.4.3.1.1&2), so F_{MSY} is reduced to F_{pa}.

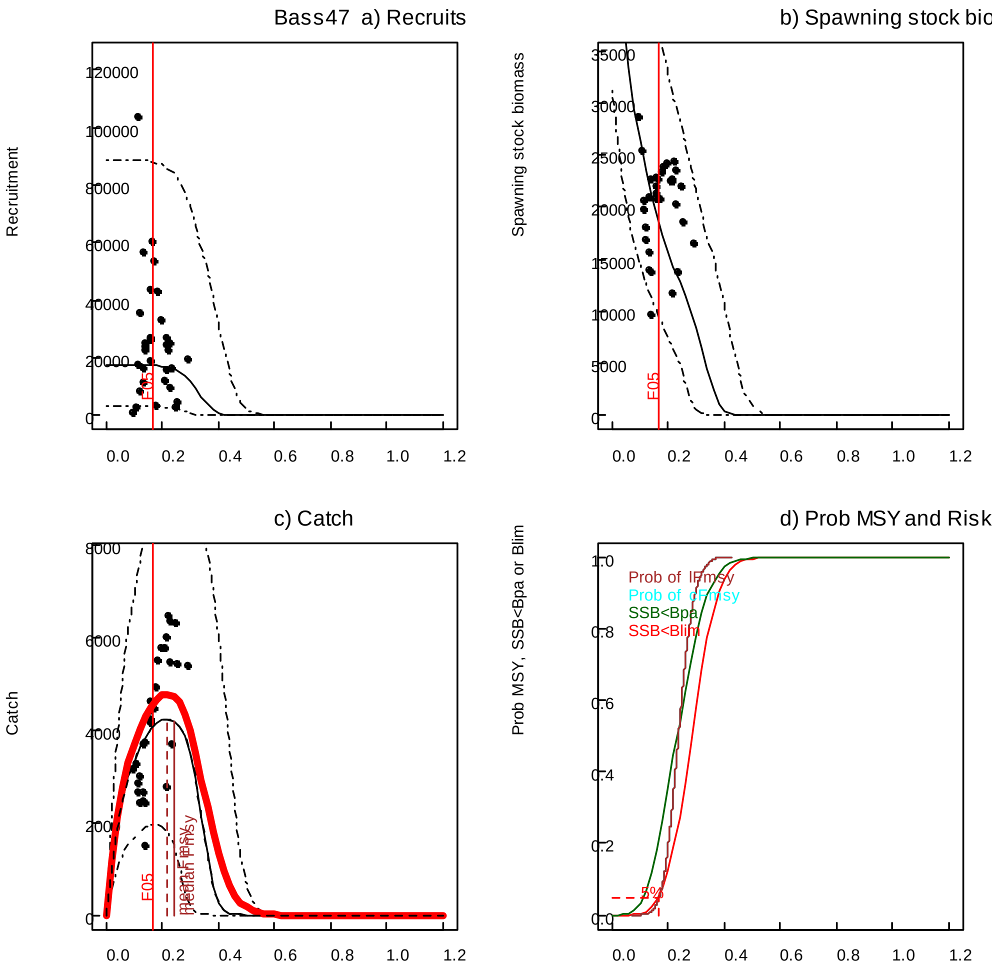


Figure 4.4.4.3.1.1. EQSIM summary plot without $B_{trigger}$. Panels a to c: historic values (dots) median (solid black) and 90% intervals (dotted black) recruitment, SSB and landings for exploitation at fixed values of F. Panel c also shows mean landings (red solid line). Panel d shows the probability of SSB<B_{lim} (red), SSB<B_{pa} (green) and the cumulative distribution of F_{MSY} based on yield as landings (brown).

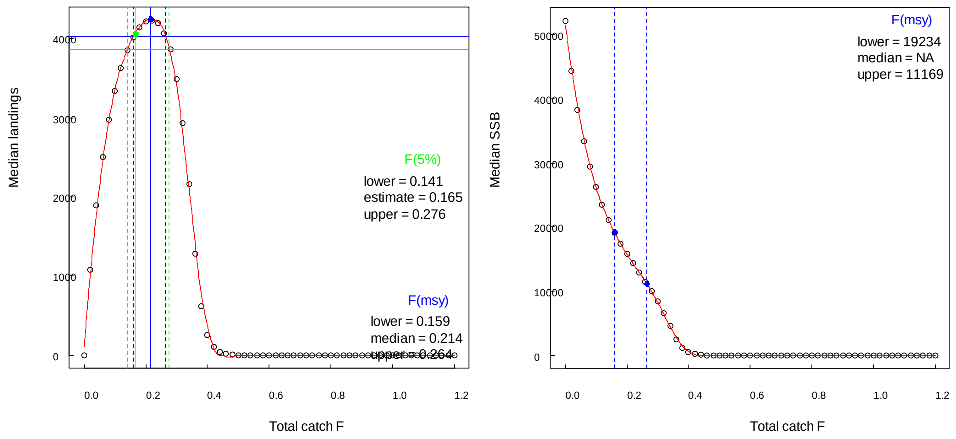


Figure 4.4.4.3.1.2. EQSIM median landings yield curve with estimated reference points without $B_{trigger}$ (Left). Blue lines: F_{MSY} estimate (solid) and range at 95% of maximum yield (dotted). Green lines: F (5%) estimate (solid) and range at 95% of yield implied by F (5%) (Dotted). Eqsim median SSB curve with estimated reference points without $B_{trigger}$ (Right). Blue dots: lower and upper SSB corresponding to lower and upper F_{MSY}.

4.4.4.3.2 Segmented regression method, full SR time-series, with $B_{trigger}$

ICES defines MSY $B_{trigger}$ as the 5th percentile of the distribution of SSB when fishing at F_{MSY}. However if the stock has not been fished at F_{MSY}, as in this case, then MSY $B_{trigger}$ is set to B_{pa}. For the final run, assessment/advice error were included using the default values and MSY $B_{trigger}$ was set to 13 465 t. EQSIM output $F_{p.05}$ (fishing mortality that gives 5% probability of SSB below B_{lim}) is 0.203. As F_{MSY} estimated in the first run is above $F_{p.05}$, then F_{MSY} is further reduced to $F_{p.05}$, 0.203 (0.141–0.203).

4.4.4.4 Proposed reference points

The proposed reference points (Table 4.4.4.4.1) are displayed on the diagnostic plots of the final assessment (Figure 4.4.4.4.1).

Table 4.4.4.4.1. Summary table of proposed reference points derived using EQSIM.

STOCK	Seabass divisions 4.b–c, 7.a, and 7.d–h		
PA Reference points	Value	Rational	
B_{lim}	9 618 t	Lowest observed SSB (Type 5 S-R relationship)	
B_{pa}	13 465 t	B_{lim} × 1.4	
F_{lim}	0.295	In equilibrium gives a 50% probability of SSB>B_{lim}	
F_{pa}	0.211	$F_{pa} = F_{lim} / 1.4$	
MSY Reference point			
F_{MSY}	0.203	Reduce from 0.214 as F_{MSY}>F_{PA}>$F_{P.05}$	With WKMSYREF4 default values for assessment &
F_{MSY} lower	0.141	Changed from 0.159 as $F_{MSY} > F_{P.05}$	
F_{MSY} upper	0.203	Reduced from 0.263 as $F_{MSY} > F_{P.05}$	
MSY $B_{trigger}$	13 465 t		

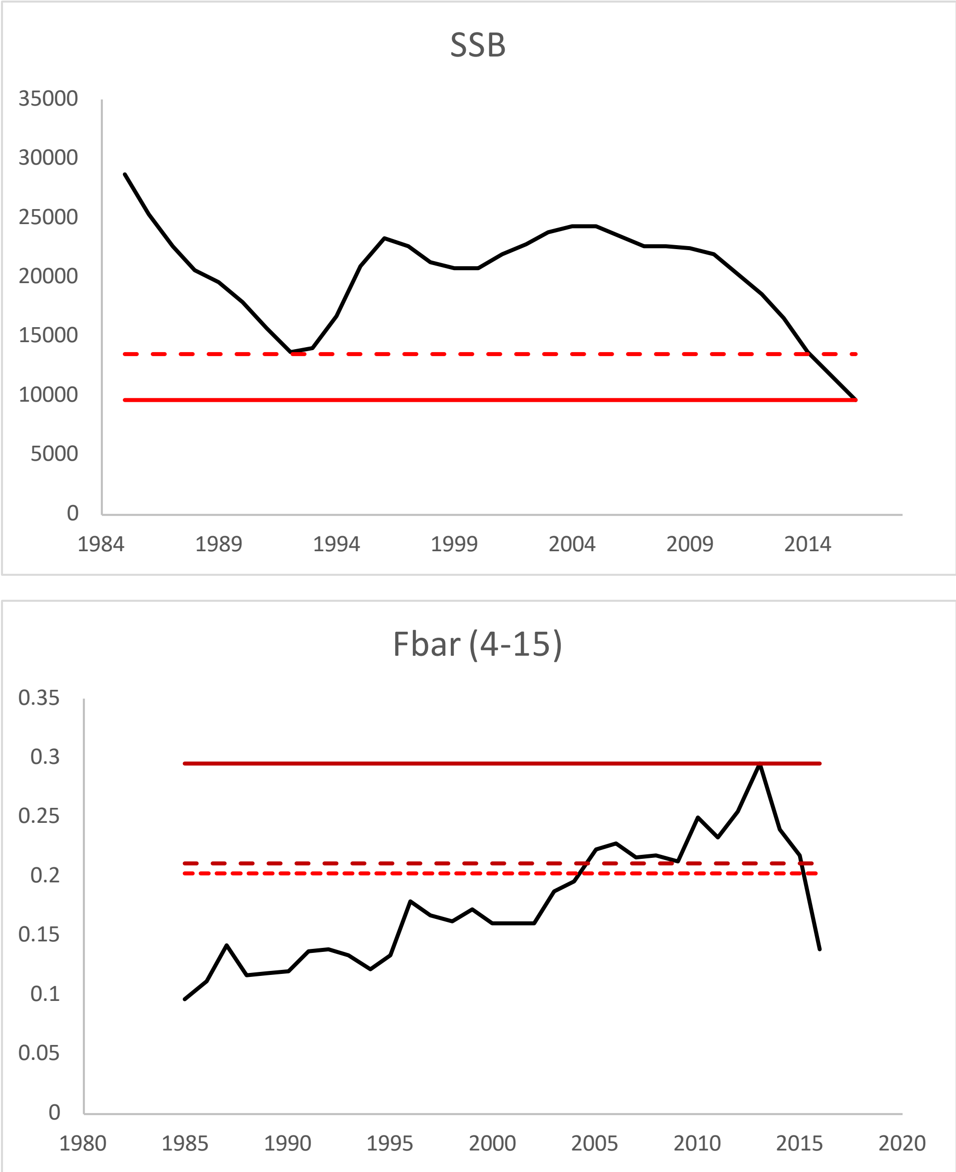


Figure 4.4.4.4.1. Diagnostic plots of the final sea bass in divisions 4.b–c, 7.a, and 7.d–h assessment with proposed reference points (B_{lim}, B_{pa}, MSY $B_{trigger}$, F_{lim}, F_{pa}, F_{MSY}): SSB and F_{bar} (computed from ages 4–15) time-series.

4.5 Key uncertainties and research requirements

There are several important limitations to knowledge of sea bass populations, and deficiencies in data, that should be addressed in order to improve the assessments and advice for sea bass in the NE Atlantic. WKBASS makes the following recommendations:

- Robust relative fishery-independent abundance indices are needed for adult sea bass. Their absence is a major deficiency which will reduce the accuracy of the assessment and the ability to make meaningful forecasts. The establishment of dedicated surveys on spawning grounds could provide valuable information on trends in abundance and population structure of adult sea bass and provide material for investigating stock structure and linkages.

- Further research is needed to better understand the spatial dynamics of sea bass (mixing between ICES areas; effects of site fidelity on fishery impacts; spawning site–nursery area linkage; and environmental influences).
- Assessment model should be revised according to results of undergoing tagging programmes to assess potential mixing between stocks and models developed using Stock Synthesis.
- Recreational catch data should be included in the assessment as soon as they becomes available in 2019 and the potential to partition the recreational fleet by countries should be considered. Time-series are needed across the stock area for inclusion in the assessment.
- Studies are needed to investigate the accuracy/bias in ageing, and errors due to age sampling schemes.
- New studies are needed to assessment the discard survival from commercial rods and lines, and nets, and trawls.

4.6 Reviewers Comments

4.6.1 Commercial fisheries landings and discards

In the model, commercial catches were divided among several fleets including UK bottom trawl and nets, UK lines, UK midwater trawl, French fleet (all gears combined) and others. For two fleets, recent discard data were used to model discard amounts for the entire modelling period, and length composition data from discarded catch were used to estimate retention curves. The Panel agreed that the model was able to fit the annual discard amounts for both fleets reasonably well, and fits to discarded length compositions were also reasonable. The Panel also agreed that including discard separately from landings (a new feature in this model) enabled a more accurate description of the impact of the fishery upon the stock, and evaluate more complete evaluation of the effectiveness of management measures imposed on this stock.

For most of the modelling period, catch data for the French fleet were only available for all gears combined; thus, the fleet was modelled this way. However, since 2011 landings records have been separated by gear group within the French fleet. Given that selectivity of different gear types may be different, the Panel recommended that fleets would be defined based on gear types rather than countries (e.g. the French fleet) in the next benchmark assessment.

4.6.2 Recreational catches

Following the 2016 sea bass inter-benchmark review, recreational catches were included in the model as a separate fleet. Only one year (2012) of reliable recreational catch records is available for the stock. The recreational fishery has however had stable participation and effort over time. Given this situation, the approach taken for years with no data was to assume 2012 fishing mortality rate within the fleet for the whole modelling period.

Recreational catches in the model were iteratively adjusted to obtain a recreational F, which would match the catch in 2012, the year when the recreational catch estimate considered to be reliable. The same methodology was used to estimate recreation catches for the sea bass stock in Biscay Bay.

For WKBASS 2018, the recreational catch estimates used in the model were slightly revised. An adjustment was made to recreational catch estimates in the most recent years (2013–2016) to account for the recent management measures. Catches in this fleet were also adjusted to account for discard mortality rate of released fish (5%) that was also updated at WKBASS 2018 based on new information.

The Panel approved the approach, and the final time-series for use in the model, but recommended to further explore recreational catches in the future assessment, and incorporate any new information that will become available. A sensitivity analysis was also recommended to evaluate impact of assumptions regarding the recreational catch stream to model output. The Panel also encourages efforts to collect more data on recreational removals of sea bass in future.

The base model also utilized new length composition data for recreational catch. The Panel reviewed the data (which included both retained and discarded portions), and agreed they should be used to estimate selectivity for this fleet. Previously, the selectivity of recreational removals was "mirrored" to one of the commercial fleets. The Panel agreed that using length compositions data collected from recreational catches enables more accurate description of selectivity of this fleet, and modelling of the impact of the recreational removals on the stock.

4.6.3 Length and age-composition data and gear selectivity

The Panel reviewed the compositional data and selectivity assumptions used in the model. The model uses marginal length and age compositional data for fleets when both types of data are available, but set the emphasis factors (lambda) in the model for the length and age compositions for fleets with both types of data to 0.5 (instead of 1) to eliminate an issue of fish "double counting" in estimating the total likelihood (since lambda values are being multiplied in the model by the corresponding likelihood component). The Panel agreed that using marginal age composition is appropriate to the current model, but for the next benchmark assessment, recommended using a conditional age-at-length approach to incorporate age data along with length compositions, which is now a common practice within SS.

In the conditional age-at-length approach, individual length and age observations can be thought of as entries in an age–length key (matrix), with age across the columns and length down the rows. The approach consists of tabulating the sums within rows as the standard length–frequency distribution, but instead of also tabulating the sums to the age margin, the distribution of ages in each row of the age–length key is treated as a separate observation, conditioned on the row (length) from which it came. Using conditional age distributions for each length bin allows only the additional information from age data to be captured, without creating a "double-counting" of the data in the total likelihood. This approach also allows estimation of all growth parameters within the stock assessment model, including the CV of length at young age and the CV at old age (which is only possible to do based on marginal age-composition observations when very strong and well-separated cohorts exist). At the present, all growth parameters in the assessment model are fixed at the level estimated outside the model.

The Panel evaluated selectivity assumptions for each of the fleet and explored variety of blocking schemes to reflect changes in fisheries and improve model fit to compositional data. The blocks were applied for several selectivity and retention parameters of commercial fisheries fleets starting in 2015, to reflect management changes that were recently implemented. The Panel concluded that the base model agreed upon at the end of the meeting exhibits good fits to length and age composition data, and estimated selectivity curves reflect current knowledge of fisheries and how they changed over time.

4.6.4 Relative abundance indices

Several indices of abundance were used in the model, including a new landings-per-unit effort (lpue) approach developed using data from the French fishery (Laurec *et al*., 2018).

The approach used to generate the lpue-based abundance index went through a series of reviews by an external expert (M. Christman), and incorporated a number of recommendations for improvements suggested by the reviewer, both to the method and the data. The Panel was presented with a number of documents describing the method for deriving the index, as well as the reviews conducted by the external expert.

The Panel discussion focused on two main issues related to the index: 1) incorporation of zero landings data in the abundance index calculation, and 2) the use of the full vs. a truncated index time-series in the assessment. After lengthy discussion, the Panel concurred with recommendations of the external reviewer on both issues and agreed that 1) data showing zero landings per day should be included in the calculation of the abundance index, since these data are informative of a stock trend, and 2) to use the full (2000 forward) rather than a truncated (2009 forward) version of the index time-series in the assessment. The second issue appeared because in the pre-2009 period, the database included several unrealistically low (<1 kg) records of catch that are considered to be false positive. However, the issue was easily corrected, and should not prevent developing and using the index for the full time-series of otherwise reliable data.

In the assessment model, extra standard deviation was estimated for the index, to account for sources of variability not captured by the index.

4.6.5 Stock structure

The Panel reviewed the most recent information on sea bass stock structure. The available information does not suggest changes in the stock definition. However, the sampling design and locations of tagging studies that were presented at the meeting did not cover the entire range of sea bass distribution, and as such, the relevance and utility of those results are limited. The Panel recommended further investigation of the issue, including a full evaluation of connectivity among areas within the sea bass range, but agreed that at present the current (though limited) information does not present a basis for a changing definitions of stocks that are currently in use.

4.6.6 Biological parameters

The Panel evaluated assumptions about several life-history parameters in the model, including natural morality and spawner–recruit steepness via profile analyses, and agreed that parameters assumed in the model are reasonable. The Panel also discussed at length multiple approaches that currently exist to inform natural mortality, and agreed that the method selected for the base model (see stock annex for details) represent the best available science.

In the model, all of the growth parameters are fixed at the values estimated outside the model. Although these parameters were estimated based on large amounts of length and age data from multiple sources, the Panel recommends pursuing estimation of the growth parameters within the model in future assessments, because doing so allows for uncertainty associated with growth parameter estimates to be propagated through the assessment results. It is also recommended to input age data as conditional age-at-length compositions so the model can reliably estimate growth parameters (as stated earlier in this report).

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5 Sea bass (*Dicentrarchus labrax*) in divisions 8.a–b (Bay of Biscay north and central)

5.1 Issue list

The issues list for the Bay of Biscay sea bass stock was reviewed during a WebEx leading up to the WKBass data and assessment workshops, and tasks were allocated. The achievements for each topic are given in Table 5.1-1.

Table 5.1-1. Updated issues list for the Bay of Biscay sea bass stock following WKBASS 2017 assessment workshop, and progress made at WKBASS 2018 assessment meeting.

Issue	Problem/Aim	Work needed / possible direction of solution	Data required. Are these available? Where should they come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
Landings data	Historical landings	Landings, fleet, area yearly required from 2000.	Landings from all the involved countries split by fleet, area or aggregated (all countries; Spain lacking fleet data)	Analysis done on French pre-2000 landings, no possibility to split landings by gear prior 2000. One French fleet used in the final assessment.	Results from WKBASS 2017 used
Tuning series	Commercial tuning data are available.	Finalise the appropriate commercial tuning series including 2016.	WD already in the SharePoint.	French lpue series was presented at WKBASS 2017 data WK but had not been subject to expert review. A new series excluding vessels with predominantly zero sea bass landings was provided at WKBASS 2017 assessment meeting and has been used in the assessment pending provision of lpue model diagnostics from A. Laurec.	French lpue series was re-presented at WKBASS 2018 and has been subject to expert review and validated. A new series is used, modelling null and non-null values and positive density through a delta-glm. French fishery lpue series 2001–2016 with modelling of zero trip landings included in assessment following discussion and consideration of external reviewers comments supplied during 2017–2018 and several alternative series (2001–2016 including modelling of zero catches and alternative series using positive catches only; 2010–2016 including modelling of zero catches). Issues remain around identification

Issue	Problem/Aim	Work needed / possible direction of solution	Data required. Are these available? Where should they come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
					of true zero landings pre 2010.
Recreational fisheries	To include recreational fisheries in the assessment	Data are available for 2010	Recreational survey estimates available nationally and from submissions to ICES WGRFS.	WKBASS updated information on all available recreational fishery survey estimates for sea bass. Separate length compositions derived for French survey estimates in area 7 and area 8. French survey estimates of catch in 2011–2012 previously supplied for whole of France. WKBASS 2017 data WK obtained separate estimates by area 7 and 8 but could not validate the method and this survey 2011–2012 is not used. Time-series reconstructed on the basis of a constant ratio (basis 2010: ratio between commercial landings and recreational landings) applied on the whole time-series.	Time-series are reconstructed until 2013 considering a constant fishing mortality based on the 2010 study. Same methodology than Northern sea bass stock assessment applied. Considering new management from 2013 a multiplier<1 is applied to the recreational fishing mortality from 2013. Post-release mortality value set to 5% based on published study (Lewin *et al.,* 2018) and applied to national recreational survey data to give total removals and length composition of removals for reference year 2010.
Survey tuning series	No survey tuning survey				

Issue	Problem/Aim	Work needed / possible direction of solution	Data required. Are these available? Where should they come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
Discards	Considered as negligible			Information on discards are available from 2003 onwards. Discards estimates and length compositions for France were compiled by WKBASS 2017 data WK and have been tested in the SS3 model at the WKBASS 2017 assessment meeting. The model did not fit well to the data. Discards are not used in the final assessment.	Discards are still not used in the final assessment. However sensitivity analysis was performed to evaluate their impacts on alternative assessments, regardless of their quality.
Length compositions	French length composition from 2000 are available	Supply of length and age distributions for landings. This should include sampling intensities.	French length and age distribution per year from 2000 per ICES area French age distribution from 2008 onwards.	Sampling design, coverage and sample numbers for length and age sampling in France presented at WKBASS 2017 data WK and used in final assessment.	
	Spain Length composition would probably not be available	Spanish Landings represents 3% of the total in 8ab. If not available, maybe not an issue		No information available from Spain, without any consequences for the assessment in this area (very low level of Spanish landings)	

Issue	Problem/Aim	Work needed / possible direction of solution	Data required. Are these available? Where should they come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
Biological Parameters	No Biological Parameters available in 2015, but some data are currently collected to have some maturity and growth curve for the area.	Use some of the Biological data (Natural mortality) from the WGCSE assessment.	Growth curve and maturity ogive to be discussed at the meeting in January 2017.	Growth curve and maturity studied in French Bargip project (2013–2016) and used for assessment. WKBASS 2017 data WK explored various life-history and maximum age-based methods, including age-dependent M. The WKBASS 2017 assessment meeting explored the sensitivity of the assessment to different M options.	New M estimates have been computed and compiled with those computed during WKBASS 2017 data WK (e.g. Chen & Watanabe). A sensitivity to M is explored. Life-history based value of M=0.24 from Then *et al*. paper used by WKBASS 2017 was conserved for the 2018 assessment. Sensitivity to M considered in assessment sensitivity runs.
Post release mortality in recreational fisheries	Inclusion of discards estimates in the assessment needs an evaluation of potential survival rates of released fish. Post-release mortality in recreational fisheries needs to be accounted for. Increases in MLS and recreational bag limits will lead to more releases.	Provide updated review of studies on post-release mortality in liaison with WGRFS. Test sensitivity of assessment and advice to assumptions regarding post-release mortality.	Literature review.	Post-release mortality studies were reviewed at the WKBASS 2017 data WK. Value of 15% included in baseline assessment models, with sensitivity testing of larger values.	Post-release mortality value for recreational sea angling set to 5% based on published German study (Lewin *et al.*, 2018), taking into account likely relative catch using artificial or natural bait and hence incidence of deep hooking. (Bulk of catch is sea angling.)
Assessment method	No assessment has been done on this stock. According to the methodology used in the North Stock, it has to be tested in the Bay of Biscay using data available for this area		Will be done with available data.	Development of the SS3 model was carried out at WKBASS 2017 assessment meeting.	Development of the SS3 model was finalized at WKBASS 2018 assessment meeting.

Issue	Problem/Aim	Work needed / possible direction of solution	Data required. Are these available? Where should they come from?	Achievement WKBASS 2017	Achievement WKBASS 2018
Reference points	No reference points available		Agreed stock assessment inputs.	Biological reference points were estimated at WKBASS 2017 assessment meeting using EQsim software.	Biological reference points were re-estimated at WKBASS 2018 assessment meeting using EQsim software.

5.2 Input data

Figure 5.2-1 summarised all data available after year 1999 for the WKBASS 2017 assessment meeting.

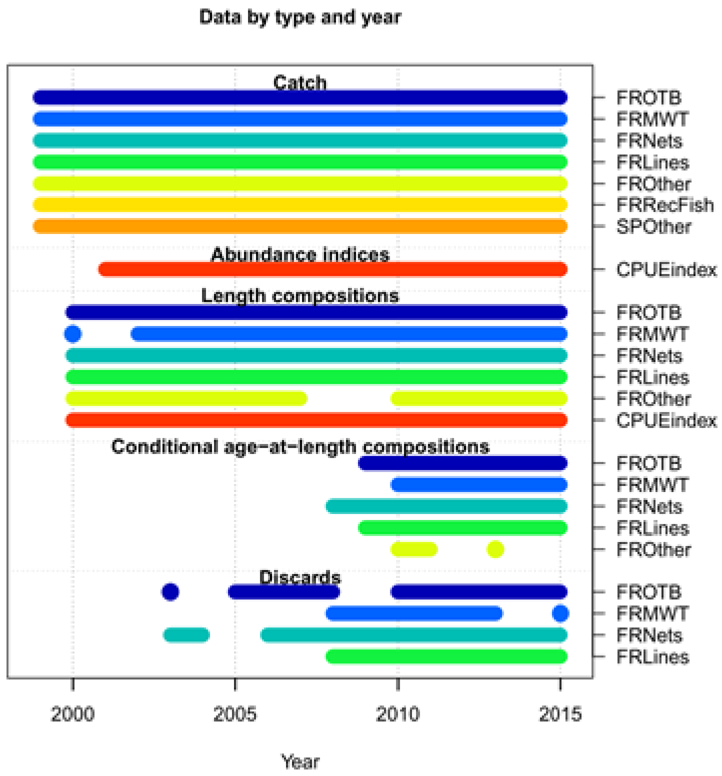

Figure 5.2-1. Data available for the assessment.

Figure 5.2-2 and Table 5.2-1 summarised data used in the final SS3 model run during WKBASS 2018 assessment meeting. (See ICES, 2018. Report of the Data Evaluation meeting for the Benchmark Workshop on Sea bass (DEWKBASS), 10–12 January 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:32. 139 pp. for detailed description of the individual datasets). During WKBASS 2017 assessment meeting, it was decided to aggregate all French fleets into one single fleet in order to be able to consider a longer time-series of catch information starting in 1984 and ending in 2016.

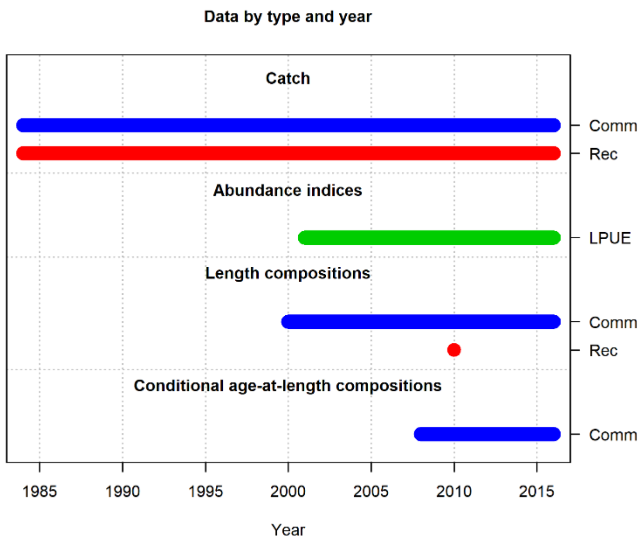

Figure 5.2-2. Data used in the assessment.

Table 5.2-1. Description of the datasets used in the final SS3 model run

Data / parameter	Description final assessment	source
Growth	Estimated values of VBGF and K; Fixed Length at Amin and Amax; SD of length-at-age; age error vector	Unchanged from WKBASS 2017 data WK and assessment meeting
Maturity	Female proportion mature at age fixed at 42.14 cm.	Unchanged from WKBASS 2017 data meeting
Natural Mortality	Then *et al*. (2015) M=0.24 for all ages.	Unchanged from WKBASS 2017. Different M values were tested during WKBASS 2018. The one used for the Northern stock has been applied to Bay of Biscay sea bass stock.
Commercial landings 1985–2016	France all gears. Poor quality of estimates prior 2000. Spain all gears.	Unchanged from WKBASS 2017 data meeting
Commercial landings length/age composition	Length compositions and conditional length-at-age. France combined fleets 2000–2016	Unchanged from WKBASS 2017 data meeting
Recreational catches - kept and released	Estimates from surveys in France (2009–2011). Post-release mortality PRM of 5% included to calculate total removals	WKBASS 2018
Recreational fishery length compositions	data from diary survey conducted in France	Unchanged from WKBASS 2017 data meeting
Recreational fishery post-release mortality	Range of values (1%, 5% and 15%) from recent studies on sea bass. Baseline value of 5%	WKBASS 2018

Data / parameter	Description final assessment	source
French commercial lpue series	GLM analysis of individual French vessel lpue (tonnes/day) in selected rectangle and gear strata (2001–2016). Combined analysis of proportion of zero catches and catch rates of positive trips using 1kg as threshold for defining positive trips due to inclusion of implausible "false positive" landings <1kg mainly prior to 2010. Includes otter trawls, nets and lines with gear effects estimated by the model.	New series submitted to WKBASS 2018 including combined modelling of zero and non zero landings.

5.2.1 Biological parameters–growth and maturity

5.2.1.1 Growth

Von Bertalanffy growth parameters were calculated for sea bass sampled by Ifremer around the coasts of France in area 8.a and 8.b (see ICES. 2018. Report of the Data Evaluation meeting for the Benchmark Workshop on Sea bass (DEWKBASS), 10–12 January 2017, Copenhagen, Denmark. ICES CM 2017/ACOM:32. 139 pp.). Growth has been previously studied in the Bay of Biscay by D. Dorel (1986) and M. Bertignac (1987). Von Bertalanffy model parameters estimated using an absolute error model minimising ∑(obs-exp)^2) in length-at-age has been used. Linf has been fixed to 80.4 cm (Bertignac, 1987) while K has been estimated by the SS3 model (0.11). The standard deviation of the length could be described by the linear model SD = 0.1861 * age + 2.6955 (samples included age 0 to age 15). The standard deviation of the length-at-age increased with age as expected.

5.2.1.2 Maturity

Maturity has been studied for sea bass sampled by France in the Bay of Biscay. Data are derived from samples of French fishery around the Bay of Biscay coast (very few sea bass adults are taken in surveys and were generally unsexed before 2009). Sampling has been specifically conducted under the "Bargip" project (Ifremer, France Filière pêche, French Ministry of the Environment, Energy and the Sea) in 2014 and 2015.

A logistic regression model has been used and a GLM has been fitted using a binomial distribution to model the probability of being mature.

Equation of parameters is as follows: P(Mature=1|Length=x) = exp(-15.93+0.37809*x)/(1+exp(-15.93+0.37809*x)). From this equation, the size x at which 50% of the females are mature is calculated as P(Mature=1|Length=x) = 0.5.

The size at which 50% of the females are mature ($L_{50\%}$) is 42.14 cm (low limit 41.31 cm and upper limit 43.08 cm). The Pearson test (pvalue = 0.597) revealed a good model fit of the data (Figure 5.2-2)

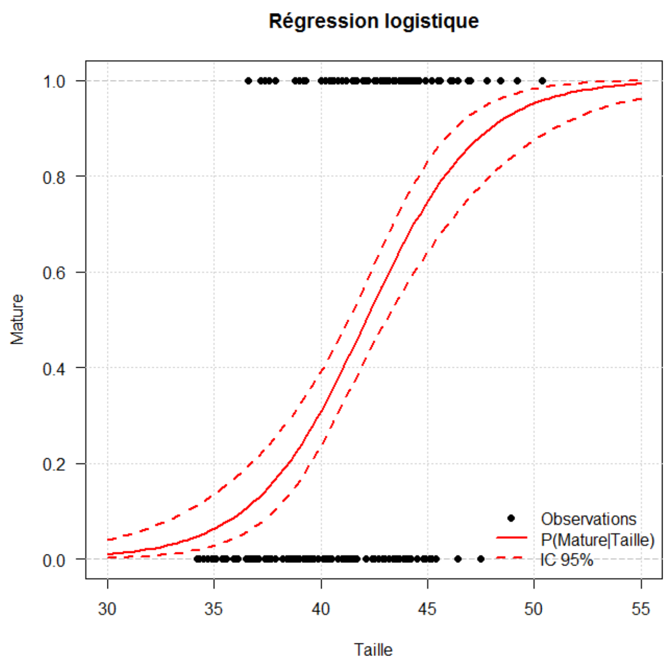

Figure 5.2-3. Maturity ogive for sea bass in Bay of Biscay.

The study has been conducted on a short period (two years) but nevertheless, it indicates similar results compared to Dorel (1986) (i.e. 42 cm for females). Stequert (1972) also reported a similar value of $L_{50\%}$ for this area.

5.2.2 Natural mortality

There are no direct estimates of M for sea bass. The WKBASS 2017 data WK reviewed a number of life-history based methods for estimating natural mortality rates in teleost fish based on life-history metrics such as lifespan and growth parameters. The WKBASS 2017 assessment meeting adopted the predictions from a recent paper by Then *et al*. (2015), which analysed data from 226 studies on natural mortality in fish to evaluate the robustness of life-history based M estimates. Their equation M = 4.899. $tmax^{-0.916}$ gives M values of 0.23 – 0.25 for tmax of 28–26 years as observed in the Northern sea bass stock.

Because of the short time-series for the French biological data (no biological data before 2000s, compared to 1985 for UK data), the WKBASS 2017 assessment meeting proposed to use the same M value for both stocks. Then *et al*. (2015) tmax method was considered as being more robust than estimates derived from other methods.

WKBASS 2017 Data WK also considered methods to derive age-dependent M (Gislason *et al*., 2010; Lorenzen, 1996) and to rescale these to match the Then *et al*. prediction over the age range of mature fish. However, this was not adopted for the benchmark assessment which choose **M = 0.24 for all age groups**.

Following recommendation of the external expert, a sensitivity analysis of the effect of different M values on the assessment of the Bay of Biscay sea bass stock was conducted. M estimates have been computed from different methods based on life-history information (see Figure 5.2-4 left). A composite M median value from all the methods explored was 0.178 (Figure 5.2-4 right), which is lower than the value derived from the method based on maximum age developed by Then *et al*. (i.e. M=0.24) and used in the assessment. WKBASS 2018 kept M = 0.24, since Then *et al*. (2015) evaluated the predictive performance of different life-history based methods in estimating natural mortality, and demonstrated that maximum age-based methods perform better than the others.

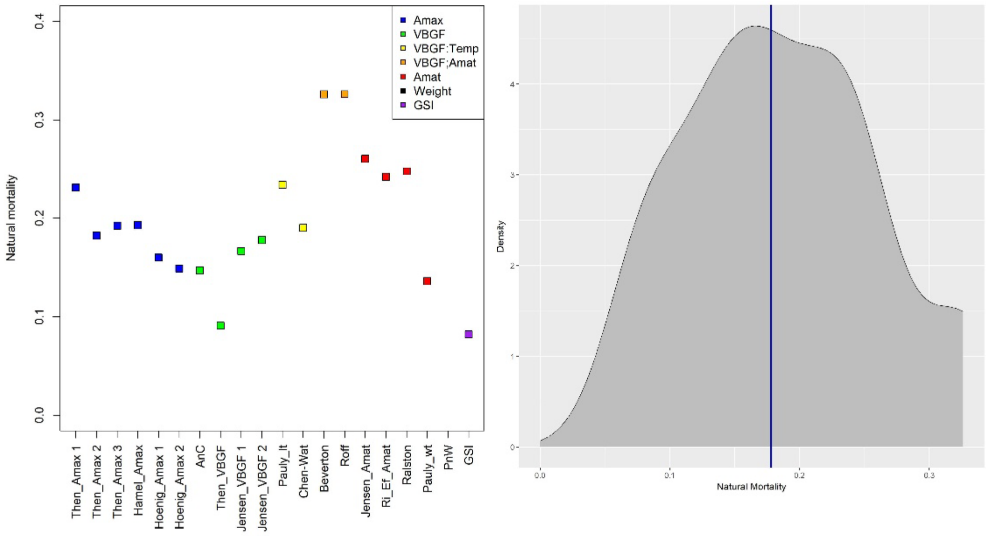

Figure 5.2-4. Left) Natural mortality estimates and methods applied. Right) Composite natural mortality value.

5.2.3 Post-release mortality

For commercial catches, no data on post release mortality were available to be used in the assessment model. Sea bass released by commercial lines fisheries (handlines; pole-and-line; longlines) may have a similar survival rates than recreational fisheries. Mortality will depend on hooking injuries, temperature, handling and other factors known to affect post-release survival. Currently, post release mortality in commercial fisheries is poorly known, and studies are needed. Post-release survival of sea bass released from trawls and nets is unknown and WKBASS assumed zero survival as worst-case scenario, though there is potential for survival depending on conditions and gears.

5.2.4 Commercial catches and length/age compositions

5.2.4.1 Commercial catches

Sea bass in the Bay of Biscay, is targeted mainly by France (more than 96% of international landings in 2015).

Landings series were available from three different sources:

- Official statistics recorded in the FishStat database since the mid-1980s (total landings).
- French landings for 2000–2016 from a separate analysis made by Ifremer of logbook and auction data. Landings are available per métier.
- Spanish landings for 2007–2011 from sale notes and for 2012–2015 from official statistics.

From 2000 onwards, French landings data from FishStat are replaced by more accurate figures from a separate analysis of logbook and auction data carried out by Ifremer (SACROIS methodology), in which landings have been correctly allocated to fishing grounds. The landings time-series show a step change around 1998 (Figure 5.2-5). Quality of French official landings data can be considered more robust from 2000 onwards.

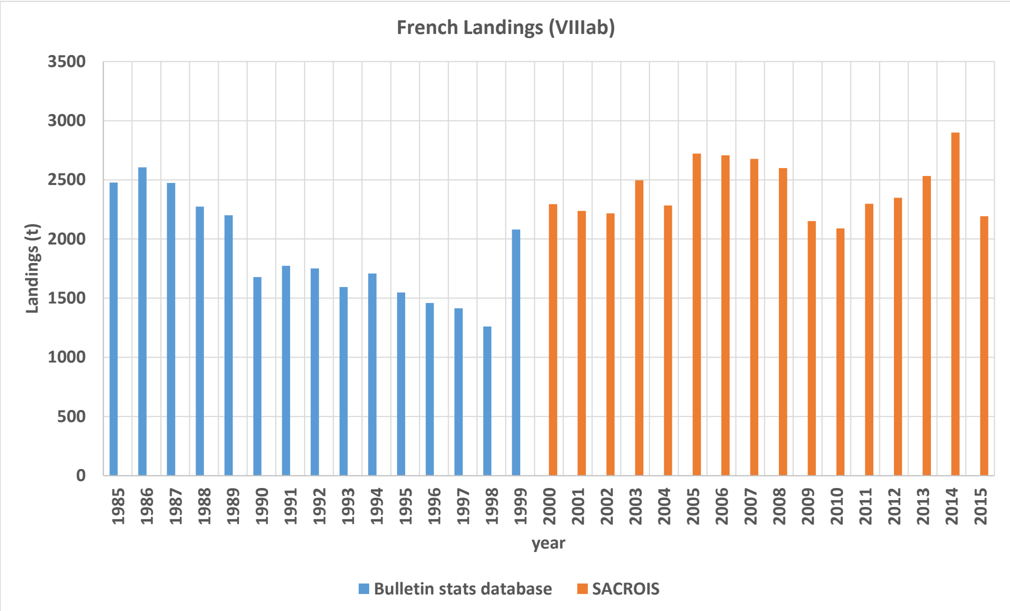

Figure 5.2-5. French Landings (Bulletin stats 1985–1999; Sacrois 2000–2015).

Following the WKBASS 2017 data WK, a discussion took place about the quality of French landings data during the historical period with French stakeholders. According to them, the trend observed in the oldest period is reliable. WKBASS 2017 assessment meeting proposed to rescale the historical time-series of landings (i.e. before 1999), with the assumption that the step increase from 1998 to 1999 is an artefact of the change in the way the data were collected. Thus, the historical period from 1985 to 1998 have been rescaled by 943 tonnes (1998 Landings - average[landings 1999–2001]) as shown in Figure 5.2-6.

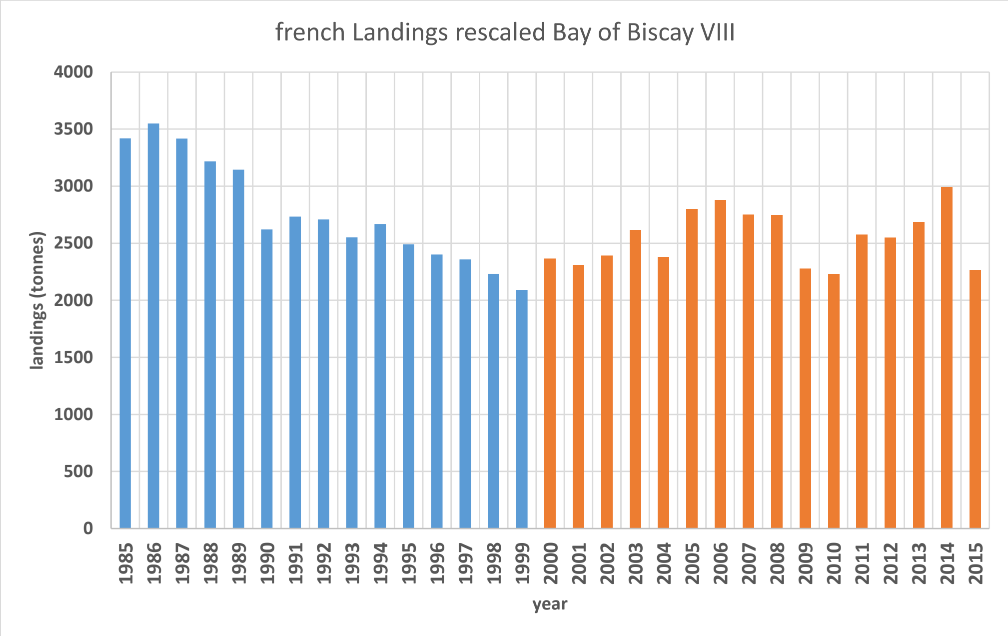

Figure 5.2-6. French Landings (Bulletin stats 1985–1999; Sacrois 2000–2015) rescaled on the period 1985–1998.

5.2.4.2 Commercial length/age compositions

WKBASS 2017 assessment meeting included both length and marginal age compositions for the landings of the fleets for which selectivity is estimated. It has been advised to use length structure and age–length keys (ALK) separated, in order to provide model estimates of catch-at-age. Input sample sizes for the multinomial composition data were derived from numbers of fishing trips sampled as proxy for effective sample size. The relative sample sizes between years are maintained during reweighting.

5.2.5 Recreational fishery catches, length compositions and post-release mortality

Recreational post-released mortality

Recreational fisheries on European sea bass are characterised by relatively high release rates, which appear to have increased following an increase of the MCRS from 36 cm to 42 cm in 2015 and the recent implementation of a bag limit and closed season. The WKBASS 2017 data WK (ICES, 2017) reviewed information available on post-release mortality (PRM) of sea bass caught by recreational sea angling from two recent studies conducted in Spain and Germany and compared these with estimates obtained for the US striped bass stock in the Northwest Atlantic. The WKBASS 2017 data WK proposed that a value of 15% for post-release mortality should be applied, and that sensitivity of the assessment to larger and smaller values should be examined. The appropriateness of this value for post-release mortality was reviewed in detail at the WKBASS 2018 assessment meeting (see working document from Hyder *et al.*, 2018, Annex 10). **Based on the information provided by Hyder *et al.* (2018), WKBASS 2018 agreed on a figure of 5% for PRM in recreational fisheries on the Northern and the Bay of Biscay sea bass stocks**. This estimate is based on a published German study (Lewin *et al.*, 2018) in which 160 fish were maintained in an aquaculture facility and then captured by experimental angling using a range of bait and articial lures. The fish were then released and held for ten days to assess mortality. The effects of different bait types, air exposure, and deep hooking were investigated, with increased mortality associated with the use of natural bait (13.9%, 95% CI=4.7–29.5%) and deep hooking 76.5% (95% CI=50.0–93.2%). By combining the experimental results with country-specific information on sea angling practices, the average post-release mortality of sea bass caught by recreational sea anglers in 2012 was set at 5.0% (95% CI=1.7–14.4%) for the Northern sea bass stock (Lewin *et al.*, 2018). The WKBASS 2018 group agreed that this value applies also to the Bay of Biscay sea bass stock.

Recreational fishery catches in the reference year

In previous reports, partitioning French recreational data between the Bay of Biscay and the Northern stocks was possible only for the 2009–2011 study (Rocklin *et al.*, 2014). However, a reanalysis of the 2011–2012 study (Levrel *et al.*, 2013) provided separate estimates for the Bay of Biscay and the Northern stocks (Table 5.2-2). A total weight of 3173 t in 2009–2011 and 3922 in 2011–2012 were estimated, with a much larger proportion from the Northern stock in 2011–2012 (Table 5.2-2). This may be due to differences in the survey design and the low sampling effort deployed in the Bay of Biscay in the 2011–2012 (Table 5.2-2).

Table 5.2-2. Estimates of recreational catches of sea bass in France, weight of retained and released components of the catch and release rates. The relative standard error (RSE) is provided where available and expressed as percentage.

			Numbers (thousands)							Weight (tonnes)							
Country	Year	Area	Retained	RSE	Released	RSE	Total	RSE	% released	Retained	RSE	relapsed	RSE	Total	RSE	% released	Source
France	2009–2011	4 & 7	781		796		1,578	>26	50	940		332		1,272	>26	26	ICES (2014b)
	2009–2011	Biscay	1,168		1,190		2,357	>26	50	1,405		496		1,901	>26	26	Calculated
	2009–2011	All	1,949		1,986		3,935	26	50	2,345		828		3,173	26	26	Rocklin *et al.* (2014)
	2011–2012	4 & 7	2,043		1,581		3,624		44	2,458		659		3,117		21	IREMER
	2011–2012	Biscay	572		281		852		33	688		117		805		15	IREMER
	2011–2012	All	2,615		1,861		3,935		47	3,146		776		3,922		20	IREMER

During WKBASS 2017, it has been decided to use the 2009–2010 study, as the second one (2011–2012) was not fully treated. Indeed, this study has been conducted mostly by a pooling institute and has not been reviewed enough by scientific experts as the first study.

Estimation of the catches in the 2009–2011 study (1405 t) appeared to be too high and in this case recreational landings in the area would represent 39% of the total landings. The proportion of recreational removals for each country in the Northern stock is estimated to be rather constant (France: 25%; England: 28%; Netherlands: 26%; Belgium: 29%).

The reference year was set to 2010 and we used the same approach as in the northern stock. The recreational fleet (Table 5.2-3) is now represented by the fish landed plus the released catch that is expected to die due to a post-release mortality of 5%. Thus, for the the Bay of Biscay sea bass stock, catches in the reference year 2010 was estimated to be 1405 t + 25 t (5%) = 1430 t.

Recreational fishery catches reconstructed for the whole time-series

There are no historical estimates of the recreational catch over the entire time-series. IBPBass 2014 considered more plausible to treat recreational fishing as having a more stable participation and effort over time than the commercial fishery. A decision was made during WKBASS 2018 assessment meeting, to apply a constant recreational fishing mortality over time considering the same approach than used for the northern stock. Total retained recreational catches were iteratively adjusted to obtain a constant recreational F over all years, which was derived using the catch of 1430 t estimated in 2010.

The implementation of new management measures should have led to a reduction in fishing mortality as more and larger fish are released (Hyder *et al.,* 2018). This means that it is not appropriate to assume constant recreational fishing mortality in the last years and thus it is necessary to re-estimate the recreational catches. This has been done using the estimated reductions generated from the assessment of the impact of different levels of bag limits and minimum landing sizes (Armstrong *et al.,* 2014) (Table 5.2-1) in order to derive changes in recreational fishing mortality (see working document Hyder *et al.,* 2018, Annex 10).

Also, the application of different management measures, gave a recreational mortality multiplier for 2010–2012 of 1 and of 0.684 for 2013–2016 (related to an increase in MCRS to 42 cm).

In 2017 with a five fish bag limit implementation, the multiplier was estimated to be unchanged. For 2018 with a three fish bag limit implementation, it was estimated to be 0.647.

Table 5.2-3. Time-series of commercial and recreational catches used in the SS3 final model run.

Year	Commercial landings (t)	Recreational removals (t)
1985	3420	1451
1986	3549	1392
1987	3417	1347
1988	3217	1345
1989	3144	1313
1990	2621	1342
1991	2734	1324
1992	2709	1318
1993	2552	1309
1994	2668	1257
1995	2492	1219
1996	2402	1145
1997	2358	1089
1998	2231	1109
1999	2091	1122
2000	2362	1219
2001	2306	1297
2002	2392	1356
2003	2616	1392
2004	2380	1411
2005	2796	1428
2006	2875	1447
2007	2751	1478
2008	2745	1491
2009	2278	1481
2010	2229	1430
2011	2575	1416
2012	2549	1363
2013	2685	879
2014	2991	815
2015	2264	749
2016	2252	713

Recreational length compositions

The estimate of removals were recalculated for the 2010 reference year as the sum of retained and released fish with a PRM of 5%. A length composition for recreational removals for the 2010 reference year was estimated as described in working document from Hyder *et al.,* (2018). Table 5.2-4 gives the released numbers-at-length reduced by 95% to represent dead releases for the reference year 2010. These are added to the retained fish to give a length composition for the total recreational removals.

Table 5.2-4. Kept and released numbers at length reduced by 95%, which represents total removals for the reference year 2010.

	2010: PRM & MCRS 36		
length (cm	Kept	Released	LFD
14	0	1397	1397
16	0	980	980
18	0	4063	4063
20	0	4358	4358
22	5735	3143	8879
24	0	5607	5607
26	0	3648	3648
28	50877	2294	53171
30	4478	4768	9246
32	13472	4183	17655
34	41631	4334	45965
36	53892	6198	60090
38	83914	3122	87036
40	156774	4061	160835
42	106565	932	107497
44	102442	593	103035
46	98820	354	99173
48	50350	357	50707
50	78315	276	78590
52	46442	118	46560
54	36032	283	36315
56	55230	0	55230
58	35861	118	35978
60	52236	164	52400
62	19774	0	19774
64	17441	112	17553
66	16581	0	16581
68	7672	0	7672
70	12968	0	12968
72	10542	0	10542
74	5908	0	5908
76	0	0	0
78	3718	0	3718
80	0	0	0
82	0	0	0
84	0	0	0
86	0	0	0
88	0	0	0
90	0	0	0
92	0	0	0
94	0	0	0

5.2.6 Relative abundance indices

5.2.6.1 Lpue series provided before and during the benchmark

The absence of a relative index of abundance covering adult sea bass has been identified as a major issue for the assessment of the sea bass stock in the Bay of Biscay.

There are no scientific surveys providing sufficient data on adult sea bass to develop an index of abundance for the area. Therefore, Ifremer investigated the potential for deriving an index from commercial fishery landings and effort data available since 2000. This allows the possibility to derive from French logbooks data (vessels with length> or <10 m) a lpue index at the resolution of ICES rectangle and gear strata. The methods and results of a GLM analysis of landings and effort data covering Areas 7 and 8 were presented through a Working Document (Laurec, Woillez and Drogou, Annex 5). A review of this second document has been done by an external expert (M. Christman) during summer 2017 (see Annex 5) and before WKBASS 2018 (see Annex 5). A final document with the description of the methodology developed by Laurec *et al*. (2018) can also be found in Annex 5.

A new lpue index was thus presented at WKBASS 2018. This index is obtained by modelling the zeros and non-zeros values using a delta-GLM approach. The reviewer recommended the new lpue index to be used in the assessment of Bay of Biscay sea bass stock.

Two main issues were highlighted by the reviewer:

3) The alleged false positive pollution of the dataset before 2009 was not considered to be a problem and could easily be corrected. Also, the index should be consider the entire time period (i.e. 2000–2016). WKBASS 2018 followed this recommendation.

4) The spawning season should be included in the lpue as these catches are also indicative of the stock size. However, this recommendation was not followed by WKBASS 2018. The lpues are probably affected by the aggregative behaviour of sea bass (i.e. hyperstability) during the spawning season.

The new lpue index has been incorporated into the northern and the Bay of Biscay stocks assessment models (Figure 5.2-7).

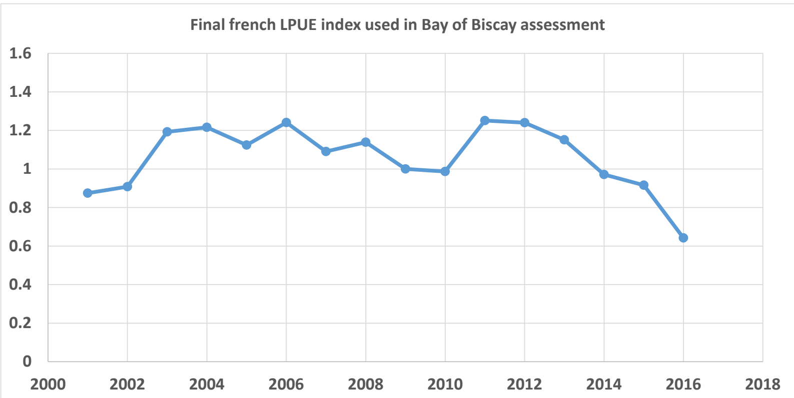

Figure 5.2-7. The "new" lpue index series for the Bay of Biscay stock presented at WKBASS 2018 assessment meeting.

Figure 5.2-8 shows the comparison between the "old" index used to assess the Bay of Biscay sea bass stock in WGBIE 2017, and the new index presented during WKBASS 2018 used in the SS3 final model run (see section below).

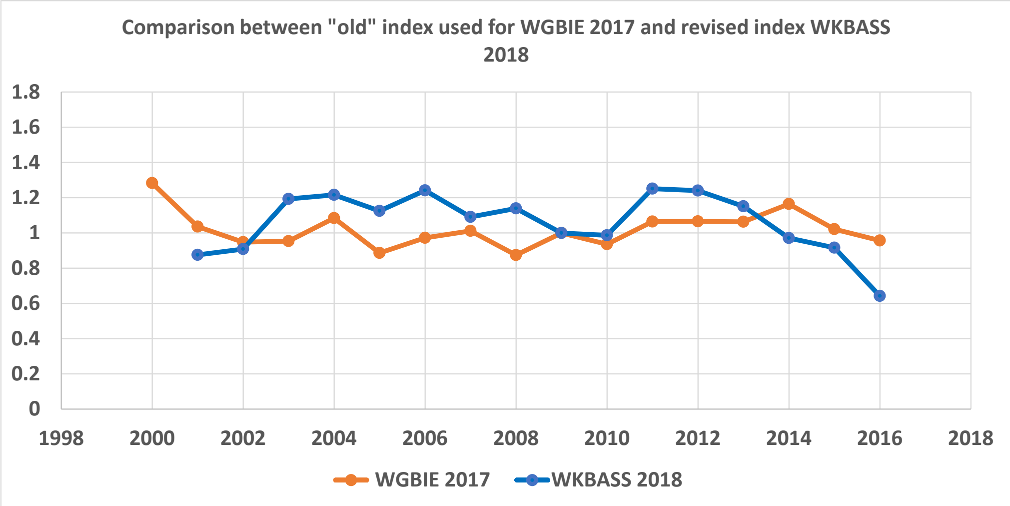

Figure 5.2-8. Comparison between the "old" index used for WGBIE 2017 and the "new" index from WKBASS 2018 assessment WK.

5.3 Assessment method

5.3.1 Current assessment model (WGBIE 2017)

The Bay of Biscay stock has been assessed through a "survey trends assessment" following the ICES framework for category 3 (ICES, 2012a).

The ICES framework for category 3 stocks was applied for the 2018 advice (WGBIE 2017). The French landings per unit of effort (lpue) was used as an index of stock biomass. The advice is based on a comparison of the two latest index values (index A) with the three preceding values (index B), multiplied by the recent advised catch. The index is estimated to have decreased by less than 20% and thus the uncertainty cap was not applied. The stock status relative to candidate reference points is unknown; however, the precautionary buffer was applied in 2015 and was, therefore, not applied in 2017 (WGBIE 2017) (Figure 5.3-1).

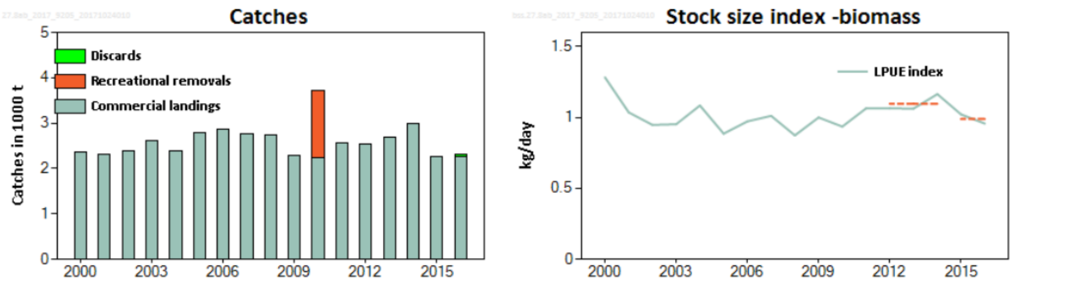

Figure 1 Seabass in divisions 8.a–b. Left panel: Commercial catches (with discards only included in 2016), and recreational removals (only available for 2010; including 15% mortality of released fish). Right panel: Biomass index (landings per unit effort, LPUE) derived from French logbook analysis.

Figure 5.3-1. Catches and stock size index used to assess the sea bass stock in the Bay of Biscay in 2017 following the ICES framework for category 3.

ICES advises that when the precautionary approach is applied, commercial catches should be no more than 2440 t in 2018. If discard rates do not change from last year (2016), this implies commercial landings of no more than 2375 t. Recreational catches cannot be quantified, therefore total catches cannot be calculated.

The assessment was based on the analysis of the French lpues derived from logbooks data (vessel with length> or <10 m). The lpue method used a multiplicative model with a vessel effect (hull x gear group) and a stratum effect (area x month x year). A logarithmic transformation was used, which excludes zero catches and transforms the multiplicative model in an additive model. Moreover, the method included a preliminary data selection in order to conduct the analysis by eliminating (i) some individual vessels and/or some gears (e.g. pelagic trawlers) and (ii) some geographical areas or some periods. All details about the methodology and results can be found in Annex 5.

5.3.2 Assessment model development during WKBASS 2017

5.3.2.1 Input data and model specifications

This section presents the development of a Stock Synthesis (SS) model for the Bay of Biscay sea bass stock. The SS assessment model (Methot, 1990; Methot and Wetzel, 2013) was chosen primarily for its highly flexible statistical model framework, allowing building simple to complex models. This model is written in ADMB (www.admb-project.org) and is available at the NOAA toolbox: http://nft.nefsc.noaa.gov/SS3.html.

For European sea bass, a range of assessment models were built using Stock Synthesis 3 (SS3) version V3.24U to integrate the mix of fisheries and recreational data available (fleet-based landings; landings age or length compositions, landings age-at-length and discards age or length compositions for variable combinations of fleets and years) and biological information from recent research on growth rates, maturity and mortality.

Many model structures were explored before and during the WKBASS benchmark 2017. For simplicity, only two basic model structures will be presented hereafter with the same specifications where possible:

1) Age and length model; including conditional age-at-length data for seven fleets (Spanish commercial fishery, French bottom trawls, French midwater trawls, French nets, French lines, French other fisheries and French recreational fishery) over the period 2000–2015.

2) Age and length model; including conditional age-at-length data for two fleets (French commercial and recreational fisheries) over the period 1985–2015 with corrected historical catch data.

Both models include an lpue index of abundance. No discards data were included in any models, as they represent less than 5% of the total catch. Note that no length composition for recreational fishery were included in the 2000–2015 model. The input data used during the benchmark are outlined in Figure 5.3-2.

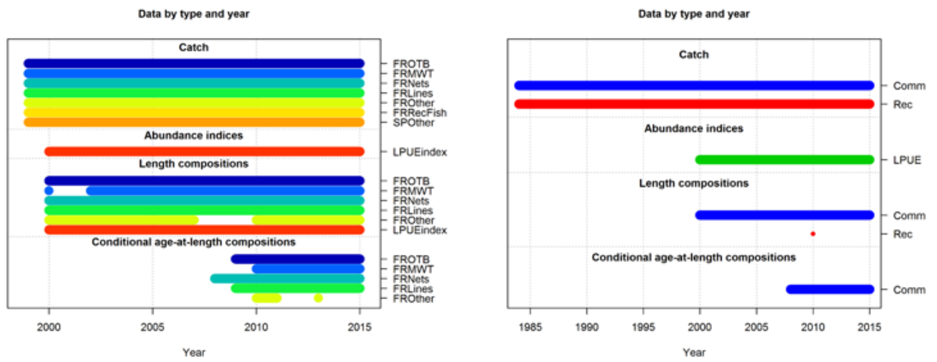

Figure 5.3-2. Input data for the two different SS model presented in 2017.

5.3.2.2 Model building steps

The development of a final SS3 model involved a series of model building steps before and during the benchmark (Table 5.3-1).

Table 5.3-1. SS3 models developed and run before and during the WKBASS benchmark 2017.

SS3 runs	Model description
Before the benchmark	
Run 1a	Catch from one pooled fishing fleet and recreational fishery Length composition from one pooled fishing fleet
Run 1b	Catch from one pooled fishing fleet and recreational fishery Length composition from one pooled fishing fleet Conditional age-at-length for the one pooled fishing fleet
Run 1c	Catch from one pooled fishing fleet and recreational fishery Length composition from one pooled fishing fleet Age composition from one pooled fishing fleet
Run 2a	Catch from multiple fishing fleets and recreational fishery Length composition from multiple fishing fleets
Run 2b	Catch from multiple fishing fleets and recreational fishery Length composition from multiple fishing fleets lpue abundance index
Run 2c	Catch from multiple fishing fleets and recreational fishery Length composition from multiple fishing fleets lpue abundance index Conditional age-at-length for the one pooled fishing fleet
Run 2d	Catch from multiple fishing fleets and recreational fishery Length composition from multiple fishing fleets Conditional age-at-length for the multiple fishing fleets
Run 2e	Catch from multiple fishing fleets and recreational fishery Length composition from multiple fishing fleets Discard data
Run 2f	Catch from multiple fishing fleets and recreational fishery Length composition from multiple fishing fleets Discards lpue abundance index

SS3 runs	Model description
During the benchmark	
Run 3a	Catch from multiple fishing fleets and recreational fishery Length compositions from multiple fishing fleets Age compositions from multiple fishing fleets lpue abundance index
Run 3b	Catch from multiple fishing fleets and recreational fishery Length compositions from multiple fishing fleets Age compositions from multiple fishing fleets lpue abundance index Discards
Run 3c	Catch from multiple fishing fleets and recreational fishery Length compositions from multiple fishing fleets, recreational fishery, and lpue index (as a pooled gear) Age compositions from multiple fishing fleets lpue abundance index Discards Corrected historical catch data with arbitrarily defined fleet proportions
Run 3d	Catch from multiple fishing fleets and recreational fishery Length compositions from multiple fishing fleets, recreational fishery, and lpue index (as a pooled gear) Pooled conditional age-at-length from multiple fishing fleets lpue abundance index Discards Corrected historical catch data with arbitrarily defined fleet proportions
Last retained runs	
Run 4	Catch from multiple fishing fleets and recreational fishery Length compositions from multiple fishing fleets and lpue index (as a pooled gear) Pooled conditional age-at-length compositions from multiple fishing fleets lpue abundance index
Run 5 (final model)	Catch from one pooled fishing fleet and recreational fishery lpue abundance index Length compositions from one pooled fishing fleet and recreational fishery Pooled conditional age-at-length compositions from one pooled fishing fleet Corrected historical catch data of one pooled fishing fleet

Before the benchmark, two options in model development were followed:

1) Implement a simple model based on one pooled fishing fleet and test the adding value of incorporating age data in the form of age compositions or conditional age-at-length compositions (runs 1a, 1b, and 1c).

2) Implement a more complex model based on multiple fishing fleets and increase complexity by including lpue abundance index, conditional age-at-length for the one pooled fishing fleet or the multiple fishing fleets and discards (runs 2a–f).

Both modelling options used data from 2000–2015 period.

During the benchmark, the group agreed to further develop the model with multiple fishing fleets. The idea was to incorporate all the data available, even historical catch data with poor quality (run 3a–d).

At the end of the benchmark, because of the difficulty to have a reliable fit for the complex model, the group finally decided to go back to a more parsimonious model. The run 5 was considered as the final model. It was derived from the run 1b. In addition, it included corrected historical catch data (i.e. 1985–1999), the lpue abundance index and the length compositions from recreational fishery.

However, because of the uncertainty of the historical period, a simplified version of the complex model (run 4 simpler than run 3d) available for the modern period (i.e. 2000–2015) was also run and compared to the final model (see next section).

From this model development, a number of adjustments were made to the base models configuration:

1) The conditional age-at-length compositions were favoured compared to age compositions as it allowed to estimate the growth within the SS3 model. The parameters of the growth model estimated outside the model were retained except the parameter, K which was estimated by SS3.

2) The recruitment variability parameter σ_R was increased to 0.999 to allow the model to fit the highly variable recruitment patterns as indicated by the data.

3) Discards were excluded as they represented less than 5% of the total catch and their sample size was low. Including these data added noise in the fitting of the selectivity curves.

5.3.2.3 Model comparisons

The last two models considered by the group were models run 4 and 5 (final model). They mainly differed for the considered time period (the final model considered all available years from 1985–2015) and on how the fishery fleets have been disaggregated (the final model considered one commercial fleet and one recreational fleet) (Figure 5.3-3).

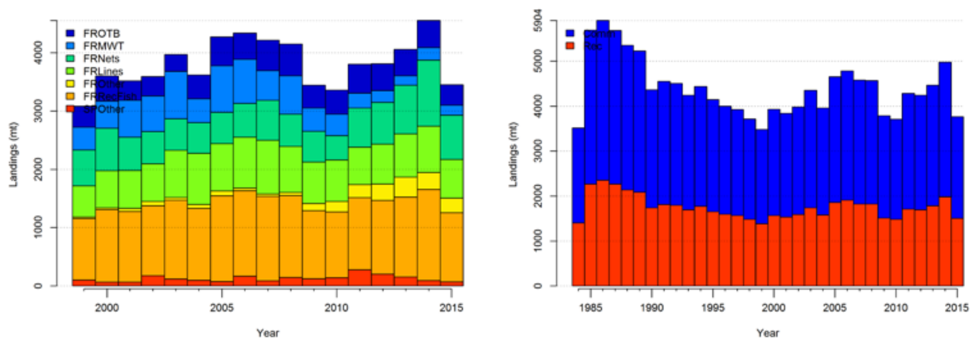

Figure 5.3-3. Left) Landings time-series of run 4 disaggregated by fishing fleets (bottom trawls, midwater trawls, nets, lines, other, recreational fishery and Spanish other) over years 2000–2015. Right) Landings time-series of run 5 (the final model) disaggregated in a total (French and Spanish) commercial and a French recreational fisheries over the years 1985–2015, with a correction applied to historical data.

Comparison between run 4 and run 5 (the final model) showed that recruitment series followed the same trend from 2000–2010 with some variability, then it started to diverge after 2011 as no length data are available for these cohorts yet (Figure 5.3-4). Trends in SSB are more or less the same in the modern period (2000–2015), i.e. stable around 10 000 t with a small decrease in the last two years of the series. Trend in average F (computed for ages 4–15) is also quite similar to an increase in the last years.

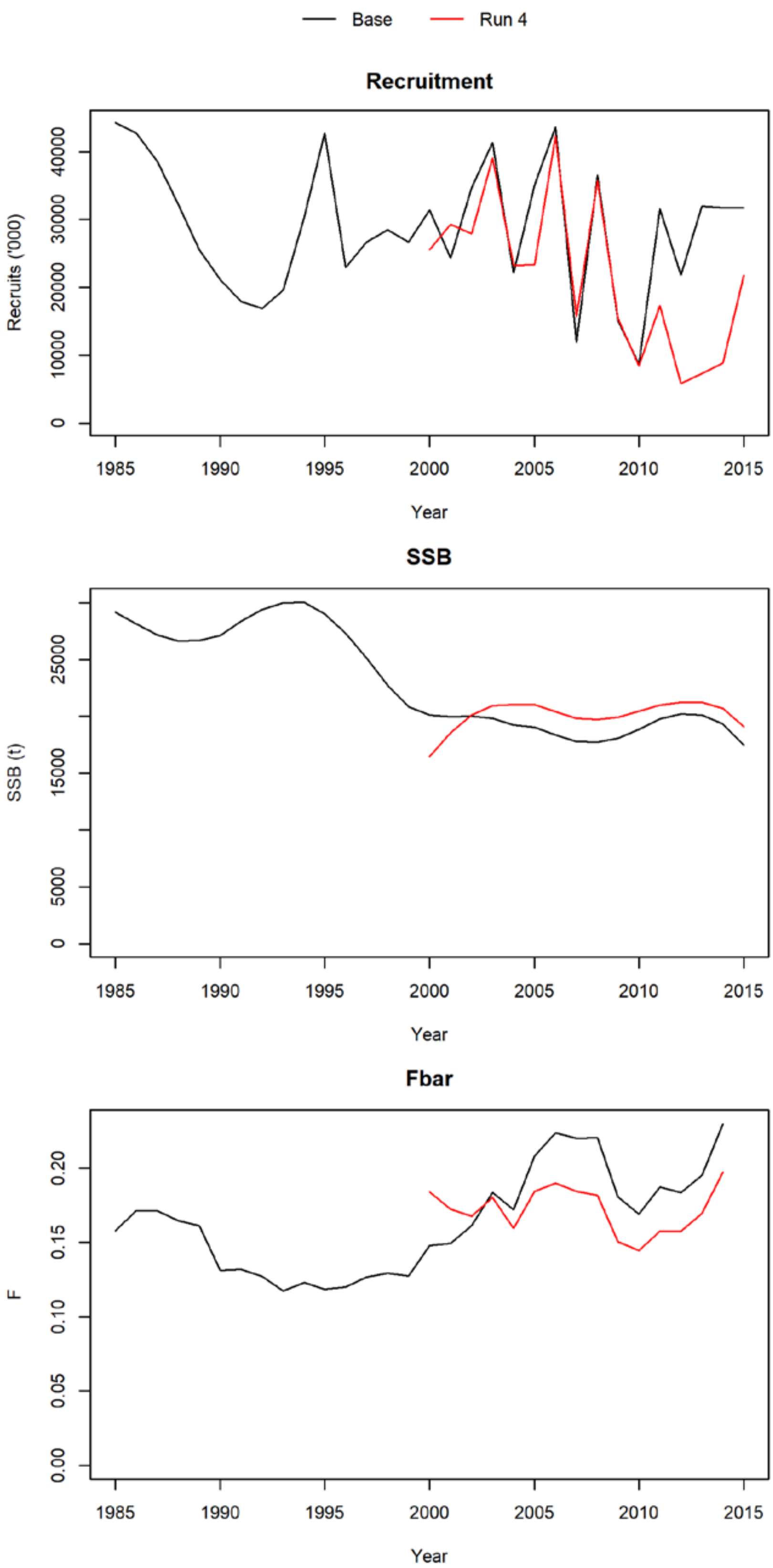

Figure 5.3-4. Recruits ('000), Spawning–Stock Biomass (t), and F (here defined as average F for ages 4–15) time-series for model runs 4 and 5. Run 5 was considered as the final base model.

Both models shown a similar trend for the modern period. However, the base model was retained because of its longer time-series and its parsimony.

5.3.3 Assessment model development during WKBASS 2018

During the WKBASS benchmark 2018, the assessment model development focused on improving the 2017 final base model, i.e. the run 5 of the previous section. The main improvements concerned:

i) the incorporation of the revised lpue;

ii) the integration of a robust reconstruction of the recreational catches;

iii) the improvement of the data weighting.

Incorporation of the improved lpue index series

The new lpue presented above was incorporated within the SS3 assessment model. There is no specific issue regarding its integration through the SS3 Q_setup parameter. However, it was investigated which functional form should be used. Two options were tested: the relationship between the lpue and the abundance of the stock is either proportional or non-linear. This is ruled by the SS3 Q_power parameter.

Integration of a robust reconstruction of the recreational catches

For the run 5, during WKBASS 2017 catches from recreational fishery were estimated to ensure a constant proportion between catches of commercial and recreational fisheries based on the proportion computed for the reference year 2010.

In 2018, the methodology was revised. Catches from recreational fishery were estimated to ensure a constant fishing mortality for the recreational fishery over the whole time period. The fishing mortality for the recreational fishery was set to the level derived for the reference year 2010. In addition, fishing mortality multipliers were used for the last years of the series to account for the recent management measures (i.e. minimum conservation size and bag limit; see working document from Hyder *et al.*, 2018).

Regarding the length composition data of the recreational fishery, it was updated because a mistake was found and also, the post-release mortality was reduced to 5% (compared to the previous 15%) following most recent information (see working document from Hyder *et al.*, 2018).

Improvement of the data weighting

In Stock Synthesis version that was used for this assessment, two approaches to compositional data weighting were available, including Francis weighting approach (Francis, 2011; Francis, 2014; Francis, 2017) and the McAllister-Ianelli harmonic mean method (McAllister and Ianelli, 1997). The Francis (2011) method is based on each composition dataset (e.g. year) as a datapoint and can be very imprecise when the number of compositions is low. Therefore, the Francis approach should only be used when the number of compositions is large enough, otherwise the multinomial likelihood with effective sample sizes based on the harmonic mean method should be used (Mounder *et al.*, 2017). In the assessment for the Bay of Biscay sea bass stock, very limited amount of length and age compositional data were available and therefore, the McAllister-Ianelli harmonic mean based method was used for compositional data weighting.

5.3.4 Final assessment model, diagnostics and retrospective

The final assessment model considered two fleets: a commercial fishing fleet and a recreational fleet (Figure 5.3-5). Commercial fleet includes French and Spanish fleets, although the latter only accounts for 3% of the total landings in 8.ab area. Catch data were considered for the years 1985–2016. Historical data (years 1985–1999) were reported from a different database than the modern data (years 2000–2015). A correction as detailed in Section 5.2.4.1 was applied to merge both series. An lpue abundance index was considered for the modern period. Length compositions were available for the commercial fishery over the modern period. Only one year was available for the compositional length of the recreational fishery. Conditional age-at-length compositions were available only for the years 2008–2016.

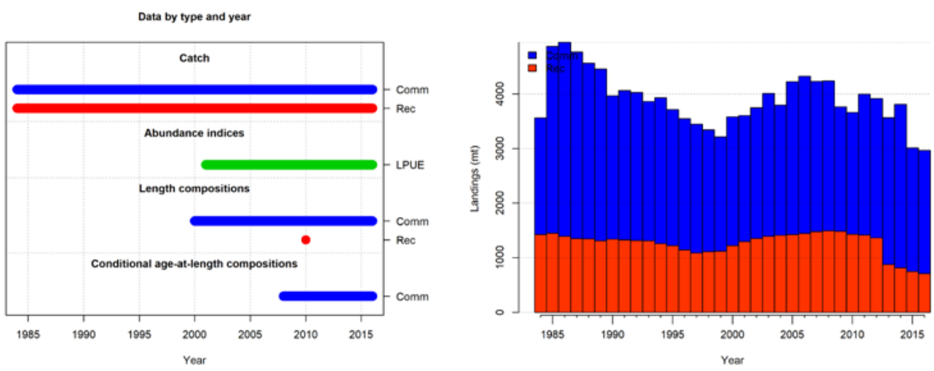

Figure 5.3-5. Left: Datasets used in the final assessment model. Right: Landings series for the two fleets.

Selectivity were mainly driven by length rather than age Figure 5.3-6). Length-based selectivity curved were fitted for the two fishing fleets. The selectivity of the lpue abundance index was mirrored to the commercial ones and set as logistic. The slope of the selectivity of the recreational fishery is steeper than the 2017 final model. The latter was considered to be not realistic, as a mistake was found in the computation of the length composition data of the recreational fishery.

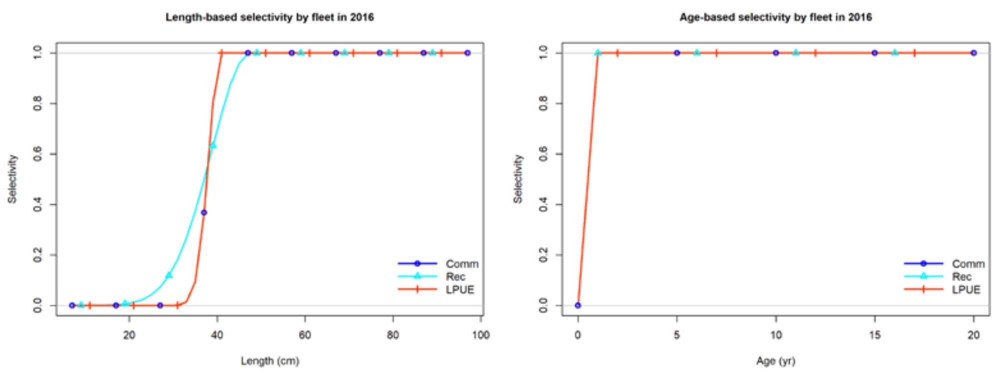

Figure 5.3-6. Final Bay of Biscay sea bass stock assessment model: fitted length-based and age-based selectivity curves.

Model fit for the commercial length composition data were good (Figure 5.3-7).

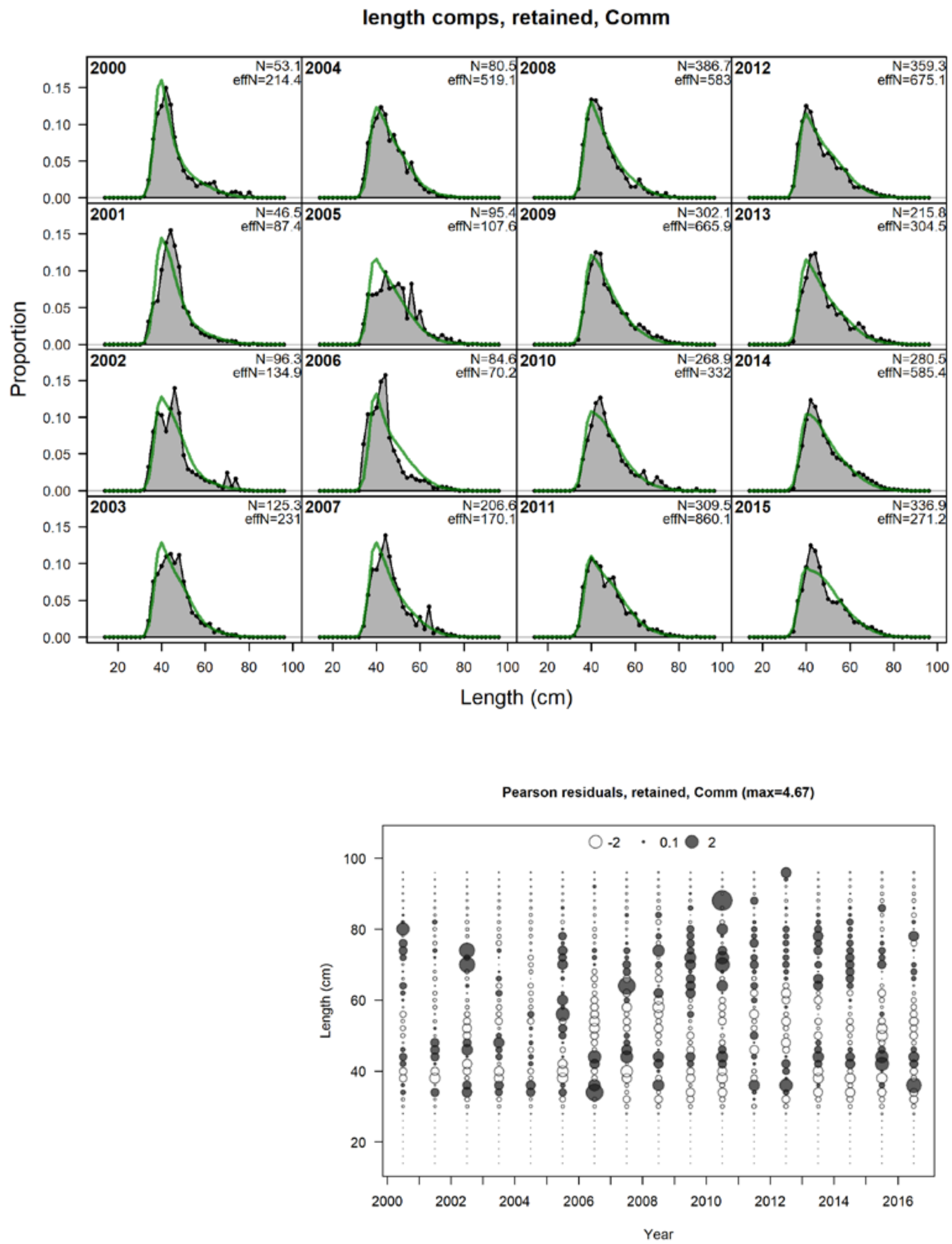

Figure 5.3-7. Final Bay of Biscay sea bass stock assessment model: fit to commercial fishery length composition data and residuals.

Model fit for the recreational length composition data were good and better than for the 2017 final model (Figure 5.3-8). However, there were two spikes at 38 cm and 40 cm, which are likely related to reporting bias from interviewed recreational fishermen. Length composition data for recreational fisheries were only available for one year.

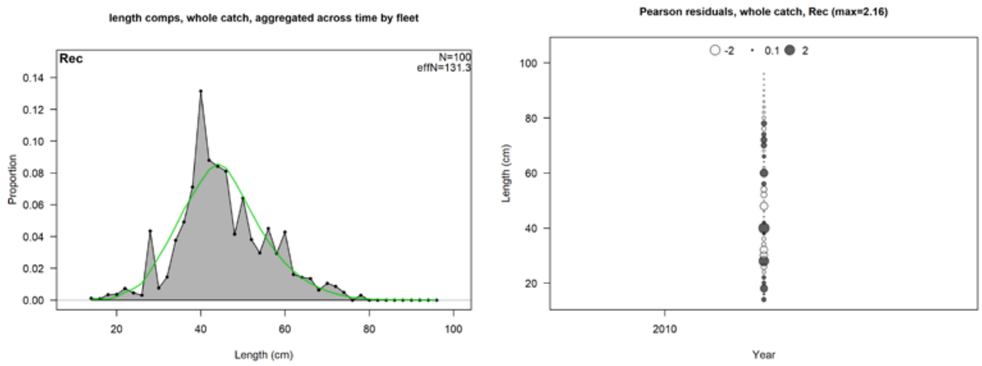

Figure 5.3-8. Final Bay of Biscay sea bass stock assessment model: fit to recreational fishery length composition data and residuals.

The model fit for the commercial length composition data aggregated across time were satisfactory (Figure 5.3-9).

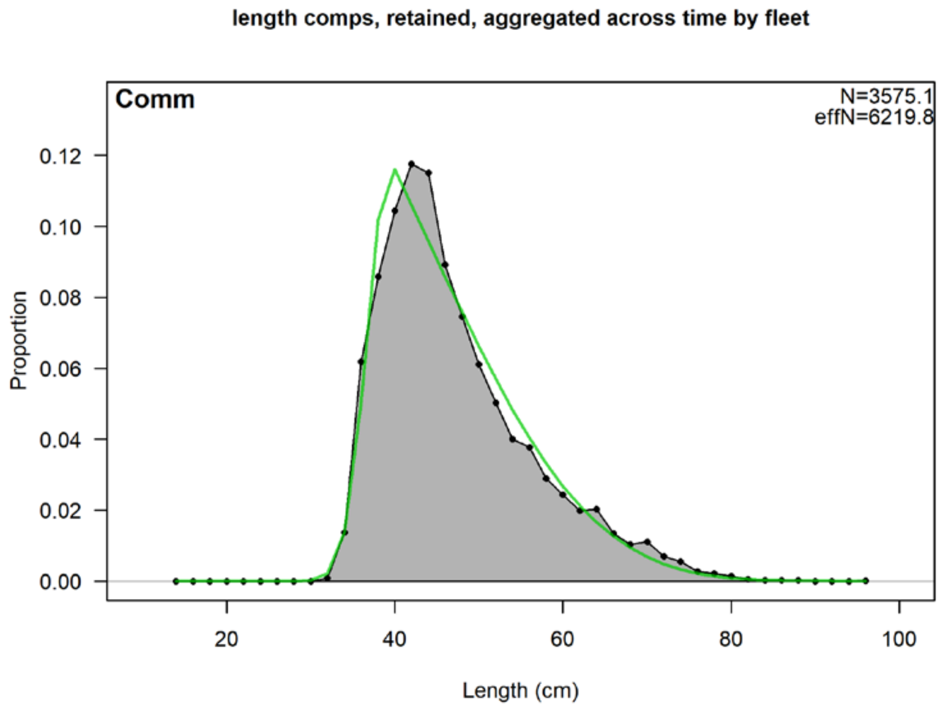

Figure 5.3-9. Final Bay of Biscay sea bass stock assessment model: fit to length composition data by fishery aggregated across time.

Model fit for the aggregated fishery age-at-length composition data were good (Figure 5.3.10 and Figure 5.3-11). The fit were poor for first two years (2008 and 2009). However, for these years the sampling size was low.

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Figure 5.3-10. Final Bay of Biscay sea bass stock assessment model: fit to conditional age-at-length for commercial fishery.

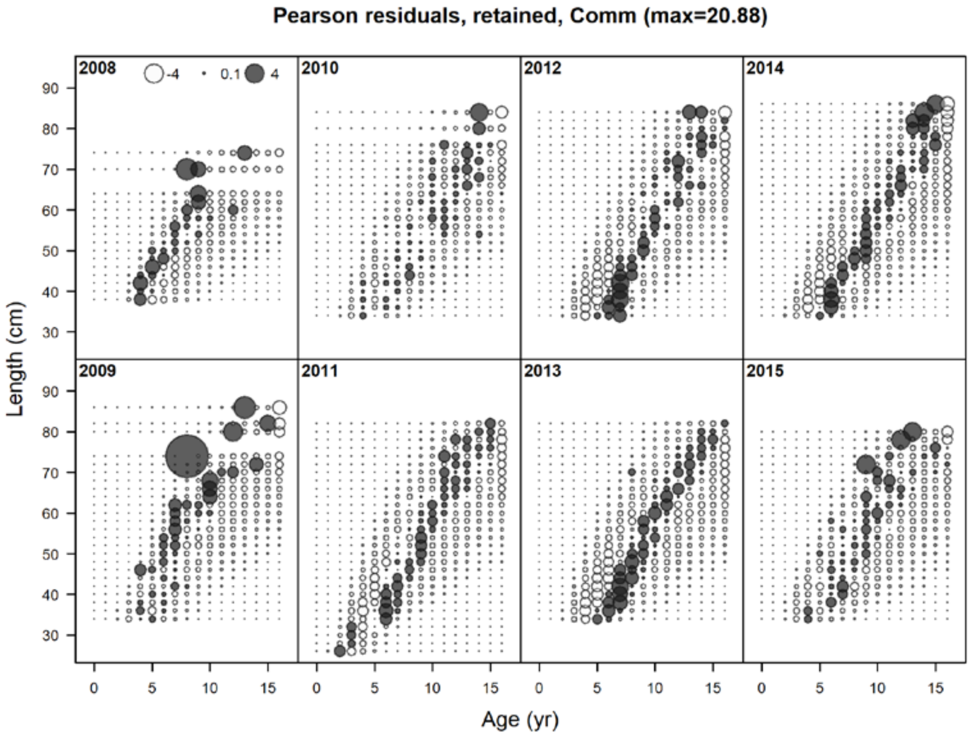

Figure 5.3-11. Final Bay of Biscay sea bass stock assessment model: fit to conditional age-at-length for commercial fishery and residuals.

Age compositions data were included in the base model as "ghost", meaning that they were not used for estimating the model likelihood. The purpose was to illustrate what the model estimated in terms of age composition data (Figure 5.3-12). Model and observations compared well, although a discrepancies for some years was evident. For instance, in years 2011–2014, the model overestimated the proportion of age ≤5 compared to observations, or vice versa. Uncertainty in age reading or sampling bias may be considered as a potential explanation.

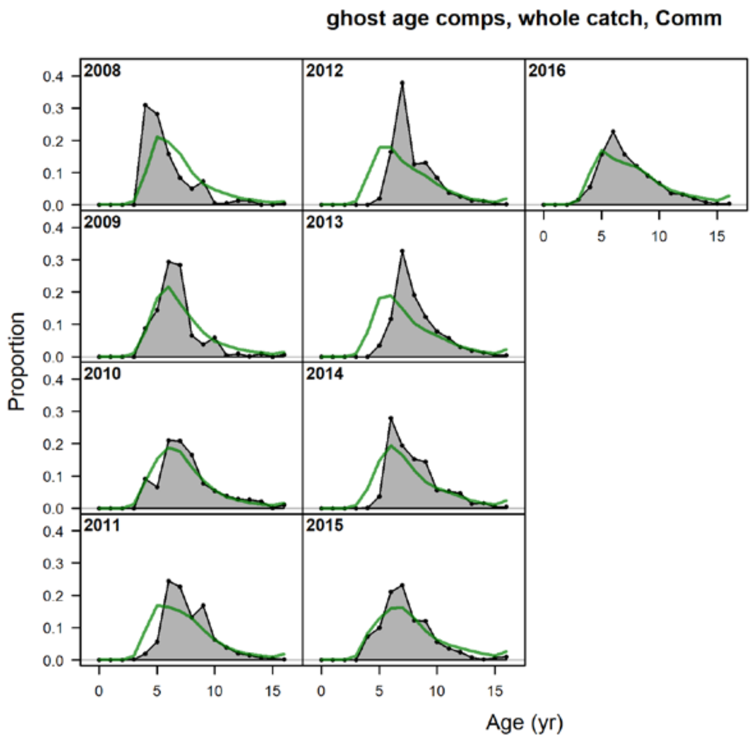

Figure 5.3-12. Final Bay of Biscay sea bass stock assessment model: fit to ghost age composition data for commercial fishery.

Fit of the lpue abundance index was good (Figure 5.3-13).

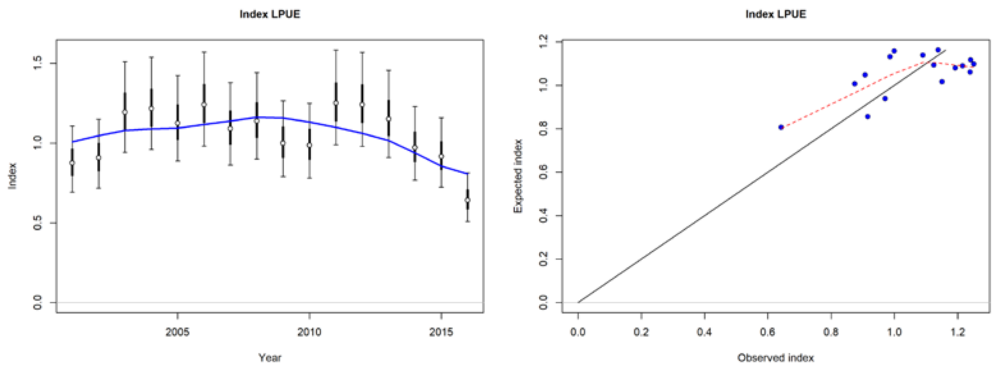

Figure 5.3-13. Final Bay of Biscay sea bass stock assessment model: fit to lpue abundance index.

The Bay of Biscay sea bass stock showed a narrow dynamic range of SSB and no evidence of past or present impaired recruitment.

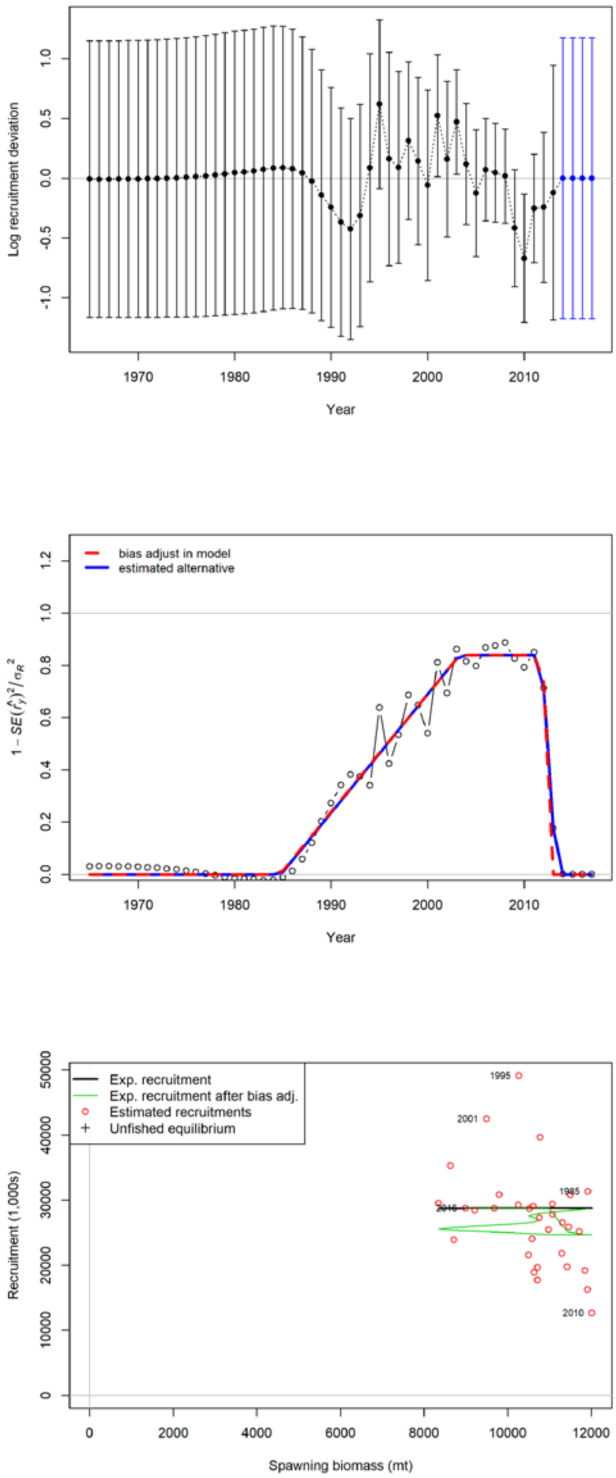

Figure 5.3-14. Final Bay of Biscay sea bass stock assessment model: Top) time-series of log recruitment deviations (deviations for 1965–1984 precede the period of input catch data). Middle) Adjustment for bias due to variability of estimated recruitments in fishery. Red line shows current settings for bias adjustment. Blue line shows least-squares estimate of alternative bias adjustment relationship for recruitment deviations. Bottom) Stock–recruitment scatterplot (model is fitted assuming Beverton–Holt stock–recruitment model and steepness = 0.999).

The recruitment series was variable around ~30 000 000 individuals per year. Recruitment below average was observed for years 2009–2012 (Figure 5.3-15). The SSB fluctuated around 20 000 t. A low SSB was observed just before the 2000s, and high SSB was observed around year 2010. Since then, a decreasing trend is observed. F computed for ages 4–15 showed a slight decreasing trend over the whole time-series.

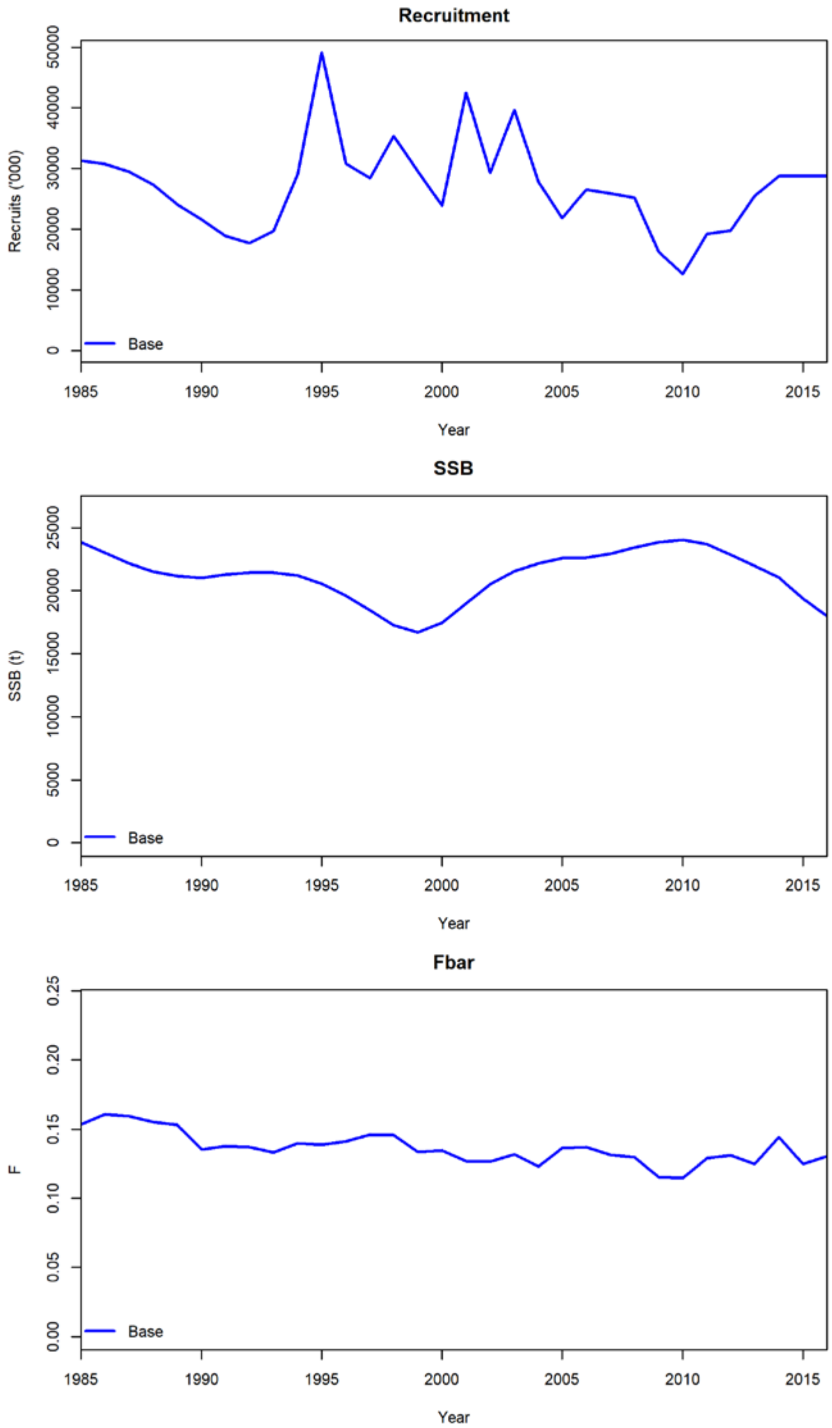

Figure 5.3-15. Final Bay of Biscay sea bass stock assessment model: Recruitment, SSB and F (computed from ages 4–15) time-series.

A retrospective analysis was conducted (Figure 5.3-16). Recruitment, SSB and F series showed some variability, however the stock trend is rather robust. In the last five years, the SSB is stable around 20 000 t showing a decreasing trend, while the F is below 0.15 and fluctuating without a trend. Recruitment was poorly estimated in recent years and showed high variability.

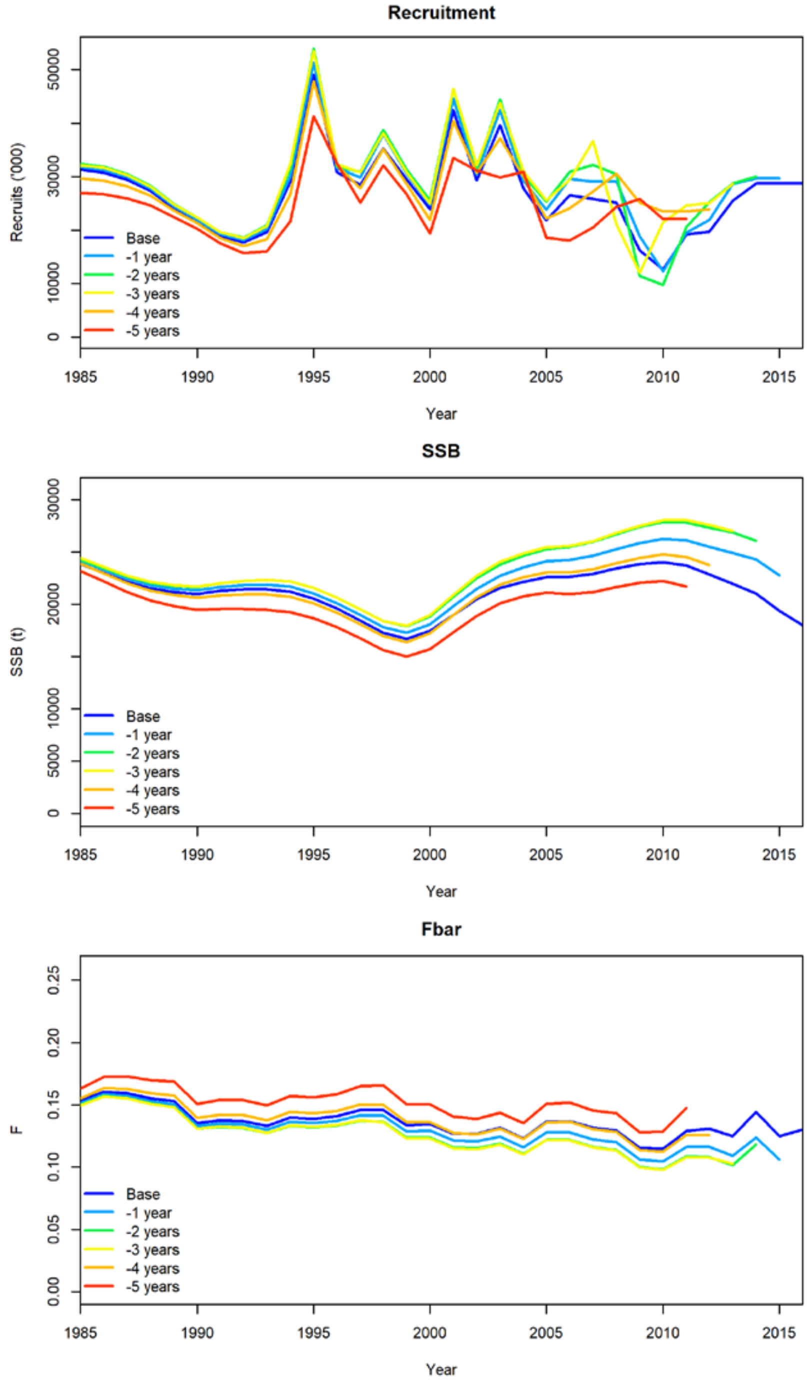

Figure 5.3-16. Retrospective analysis of the final Bay of Biscay sea bass stock assessment model: Recruitment, SSB and F time-series.

5.3.5 Likelihood profile for the final model

5.3.5.1 Natural mortality

A likelihood profile was performed for the natural mortality (M) parameter (Figure 5.3-17). The values considered ranged from 0.04 to 0.30. The profile showed that the model fit was better for smaller values of natural mortality. When increasing the value of natural mortality, the likelihood increased also, but the data contribution changed. It was mostly driven by age data until M = 0.28, thereafter length data were more important. Thus, M values from 0 to 0.25 are equally likely. For the base model, M was set to 0.24 following Then *et al*. (2015) method. For this analysis, the considered Tmax (28 years old rather than 22 years old) was the one from the Bay of Biscay sea bass stock.

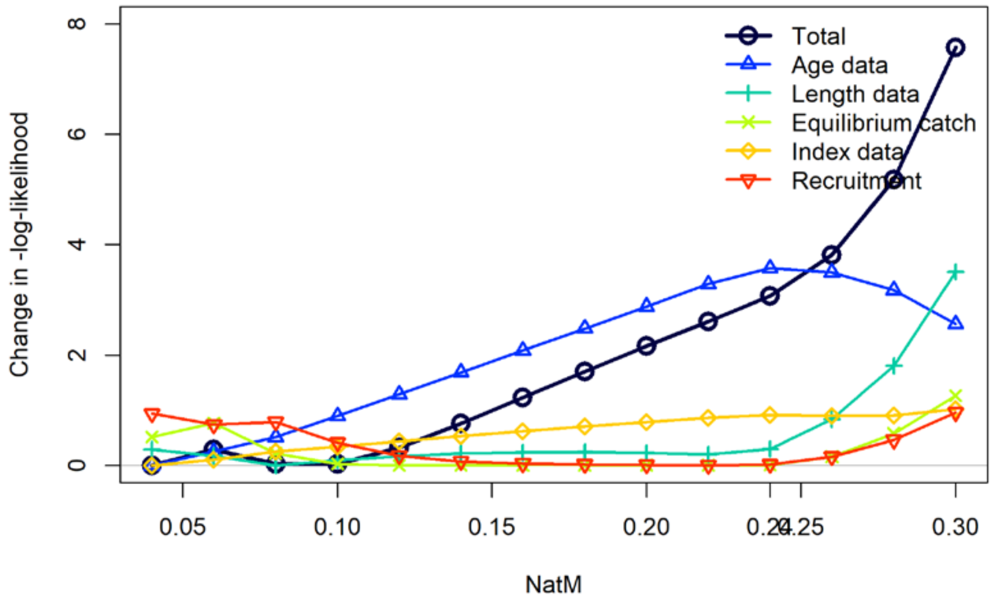

Figure 5.3-17. Change in the log-likelihood of the model for different values of natural mortality.

Sensitivity of recruitment, SSB and F to the range of values tested for different values of natural mortality was illustrated in Figure 5.3-18. Most of the differences were at the beginning of the time period.

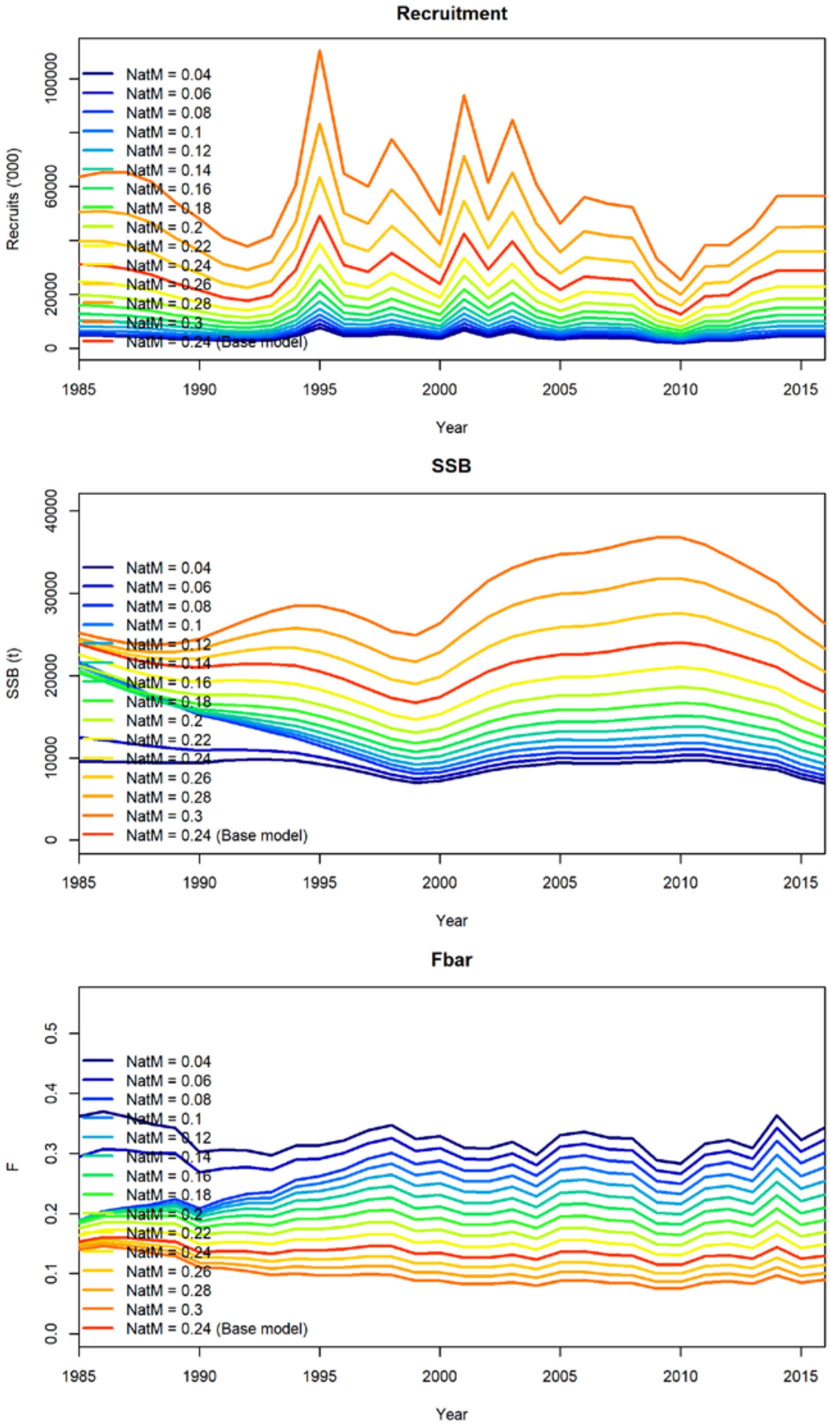

Figure 5.3-18. Sensitivity of recruitment (top), SSB (middle) and F (bottom) time-series to the range of tested values of natural mortality.

5.3.5.2 Stock–recruitment steepness

A likelihood profile was performed for the stock–recruitment steepness (Figure 5.3-19). The values considered ranged from 0.3 to 1.0. The profile showed that the model fit was better for values closer to 1.0. Thus, for the base model, a recruitment steepness of 0.999 was assumed, allowing the model to fit potential extreme event in recruitment (as observed in the Northern sea bass stock).

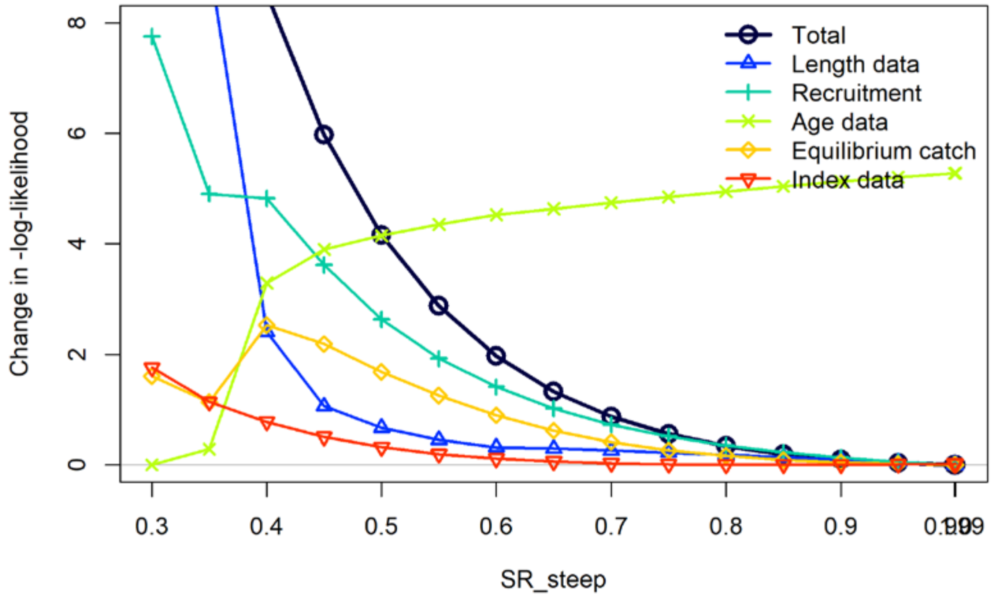

Figure 5.3-19. Change in the log-likelihood of the model for different values of steepness.

Sensitivity of the recruitment, SSB and F time-series to the range of values of steepness was illustrated in Figure 5.3-20. All the series were similar except at the beginning and at the end of the period when the recruitment is poorly estimated by the model. Before 2000, higher the steepness, lower the SSB while after 2000 the observed change was very small. Before 2000, higher the steepness, higher the F while after 2000 the observed change was very small.

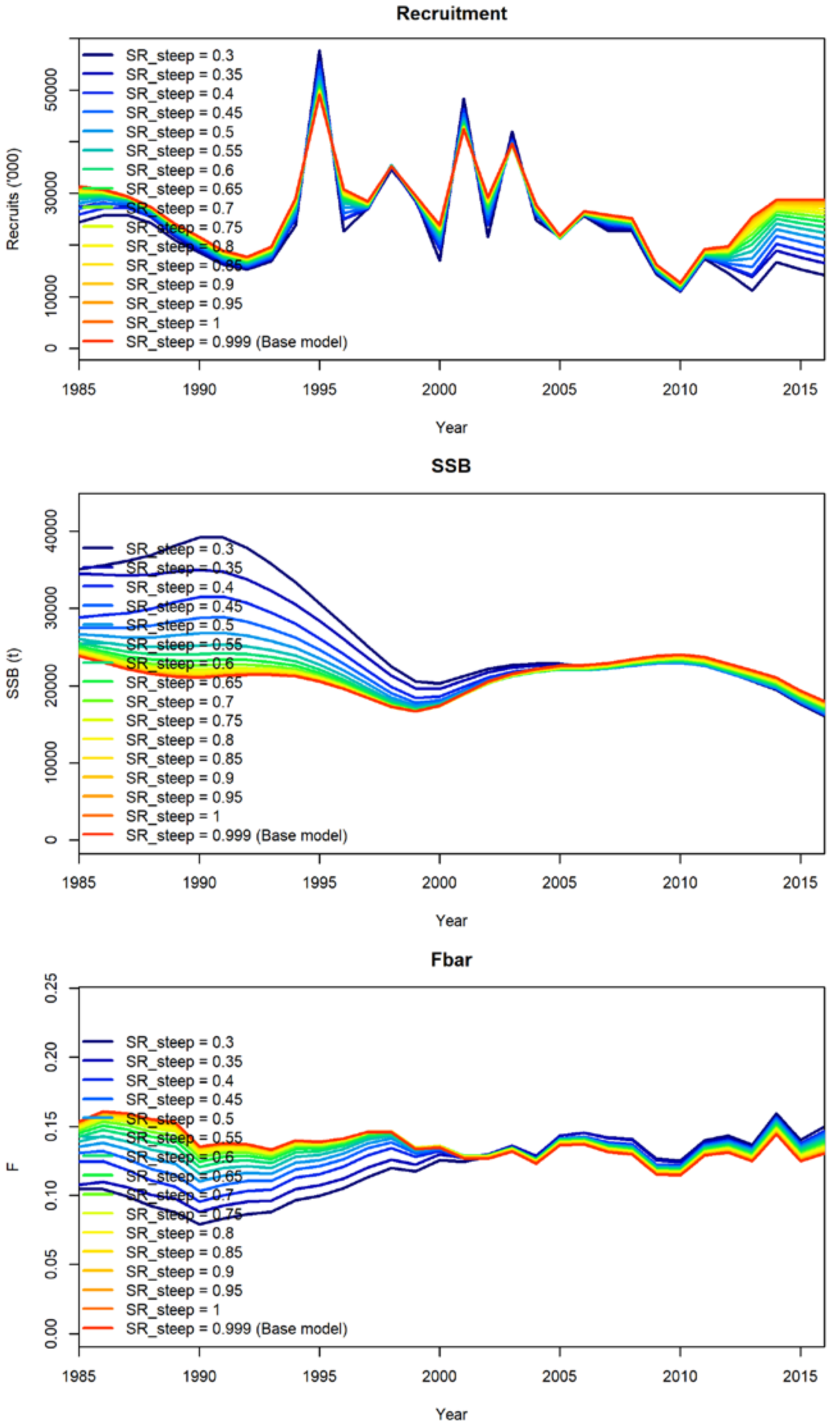

Figure 5.3-20. Sensitivity of recruitment (top), SSB (middle) and F (bottom) time-series to the range of tested values of steepness.

5.3.5.3 Extra SD and Q_power of the lpue index series

A likelihood profile was performed for the extra standard deviation associated to the lpue index series estimated in the model (Figure 5.3-21). The values considered ranged from 0.01 to 0.20. The profile showed that the model fit was better for values around 0.07.

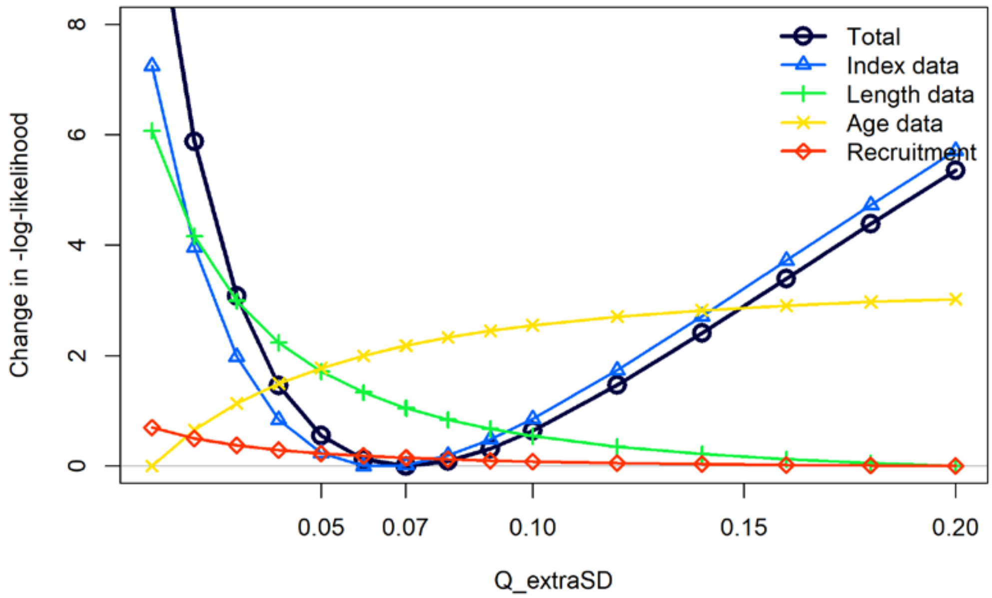

Figure 5.3-21. Change in the log-likelihood of the model vs. the extra standard deviation values associated to the lpue index series.

Sensitivity of the recruitment, SSB and F time-series to the range of values tested for the extra standard deviation associated to the lpue index series was illustrated in Figure 5.3-22.

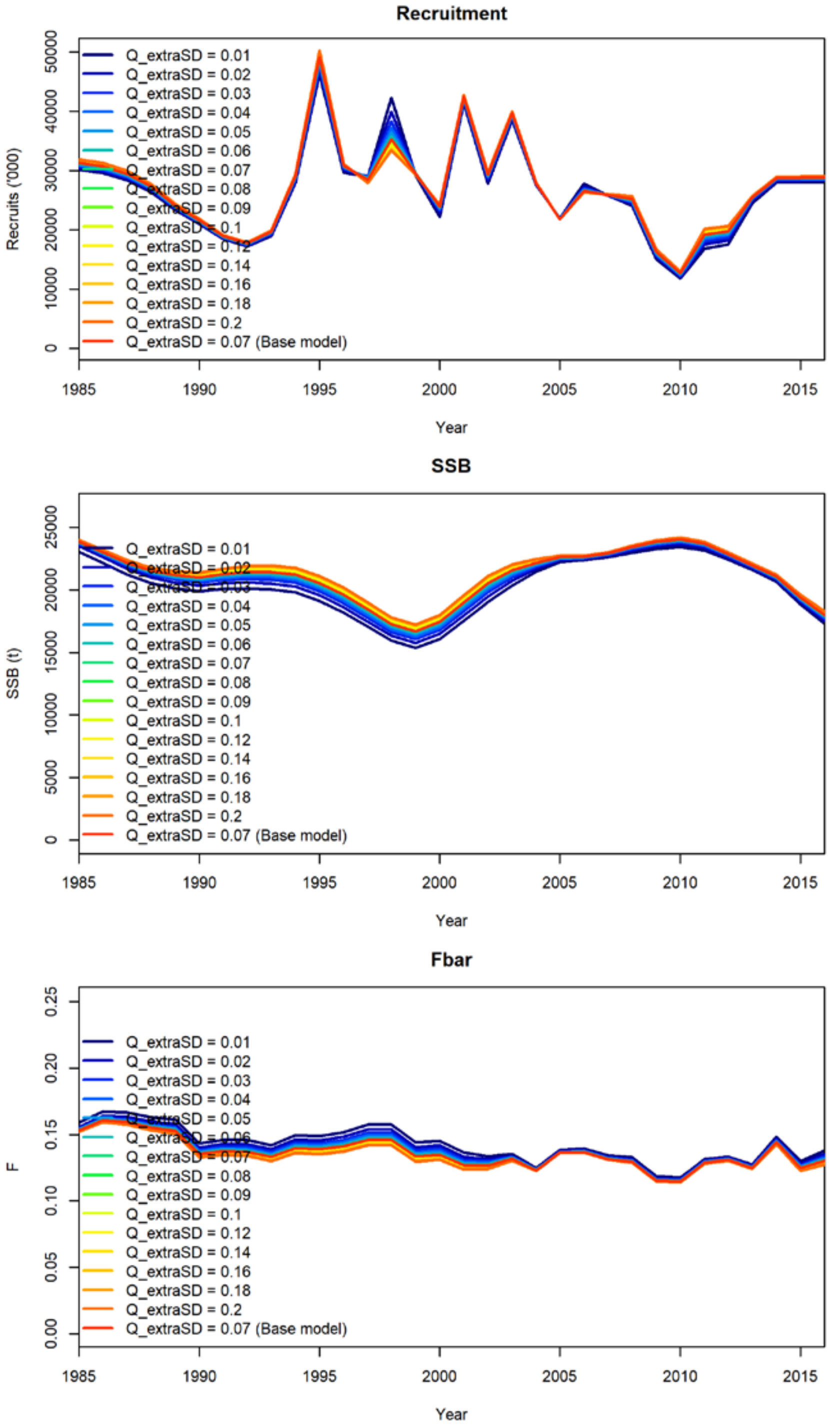

Figure 5.3-22. Sensitivity of recruitment (top), SSB (middle) and F (bottom) time-series to the range of tested values of the extra standard deviation associated to the lpue index series.

Another likelihood profile was performed for the parameter of the lpue index-abundance linkage (Figure 5.3-23). The values considered ranged from 0.1 to 1.8. The profile showed that the model fit was best for 0.77 and thus the lpue index is hyperstable (i.e. parameter <1.0), meaning the lpue overestimates stock abundance. However, the change in likelihood was very small for values higher or lower than 0.77. Thus, a value equal to 1.0 is considered reasonable; indicating that proportionality likely exists between lpue index and stock abundance.

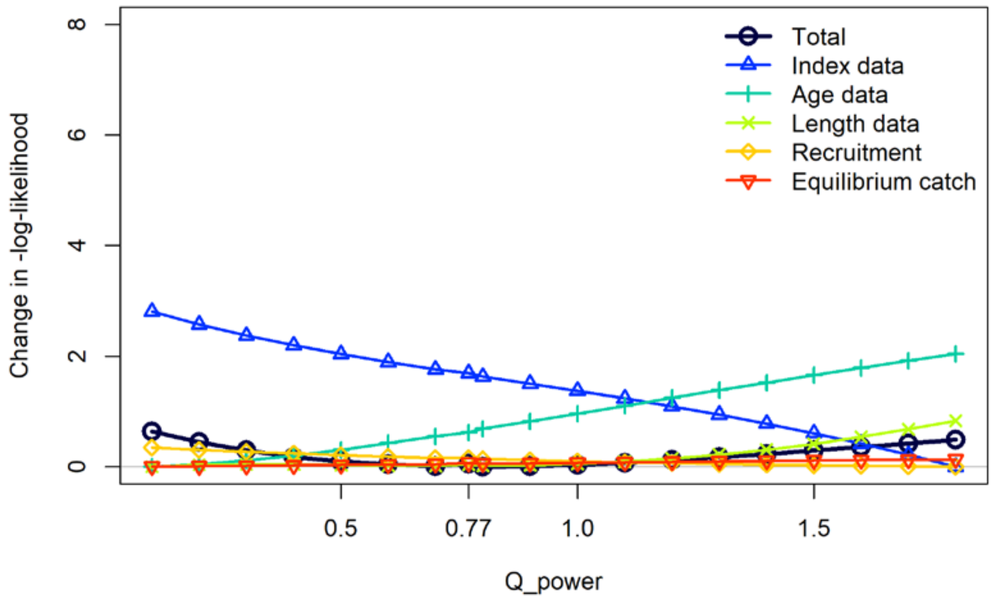

Figure 5.3-23. Change in the log-likelihood for different values of the Q_power parameter of lpue index.

Sensitivity of the recruitment, SSB and F time-series to the range of values of the Q_power parameter was illustrated in Figure 5.3-24. Setting Q as equal to 1.0 does affect only slightly the model estimates of SSB, R and F.

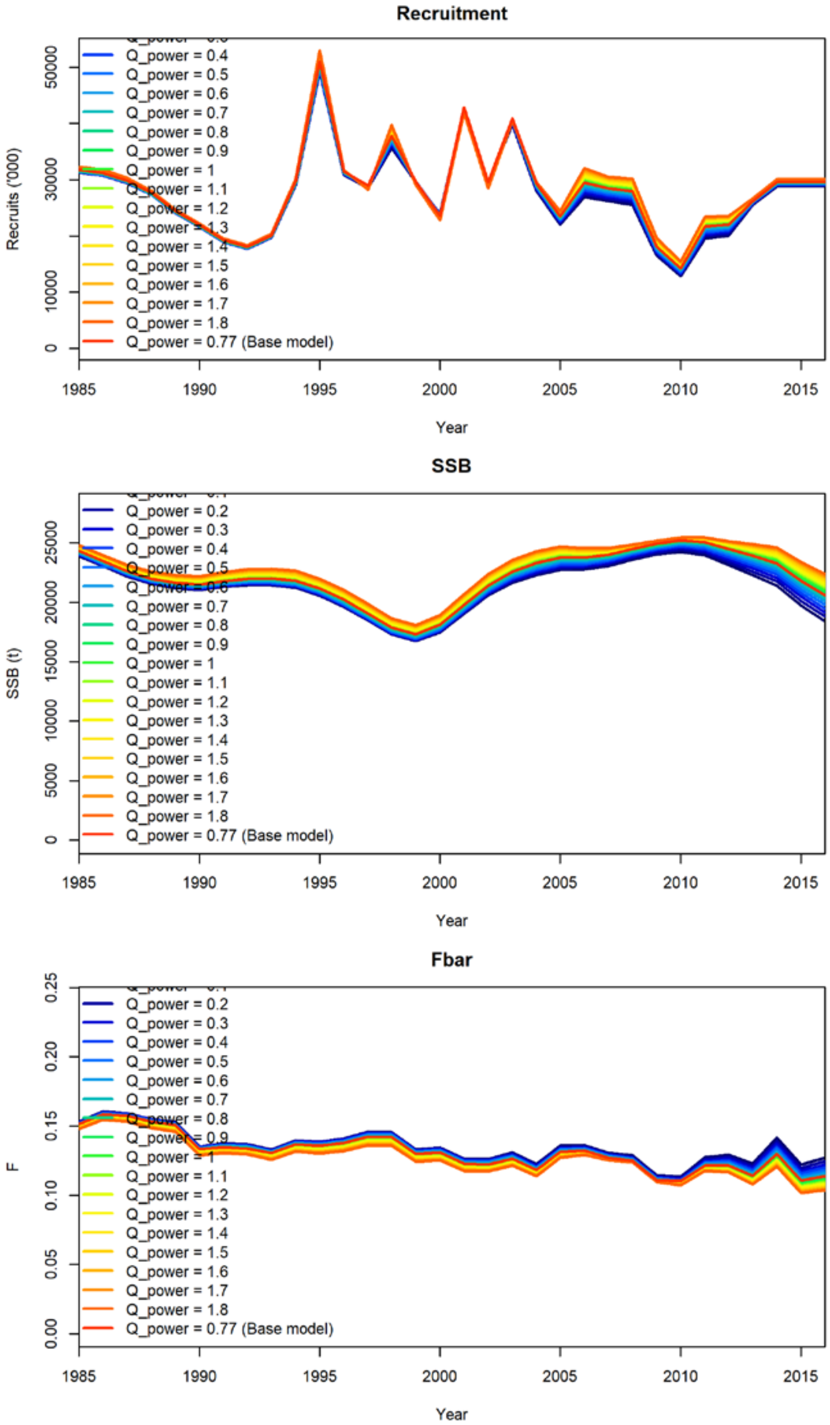

Figure 5.3-24. Sensitivity of recruitment (top), SSB (middle) and F (bottom) time-series to the range of Q_power values of the lpue abundance index.

5.3.6 Sensitivity tests for the final model

5.3.6.1 Initial equilibrium catch

A sensitivity analysis was performed for the values of the initial equilibrium catches (Figure 5.3-25). Two scenarios were tested: one with values twice than those used in the base model, and one with values half than those used in the base model. Main differences were at the end and the beginning of the time-series, as expected. For SSB and F, results were comparable to the base model except at the beginning of the time-series.

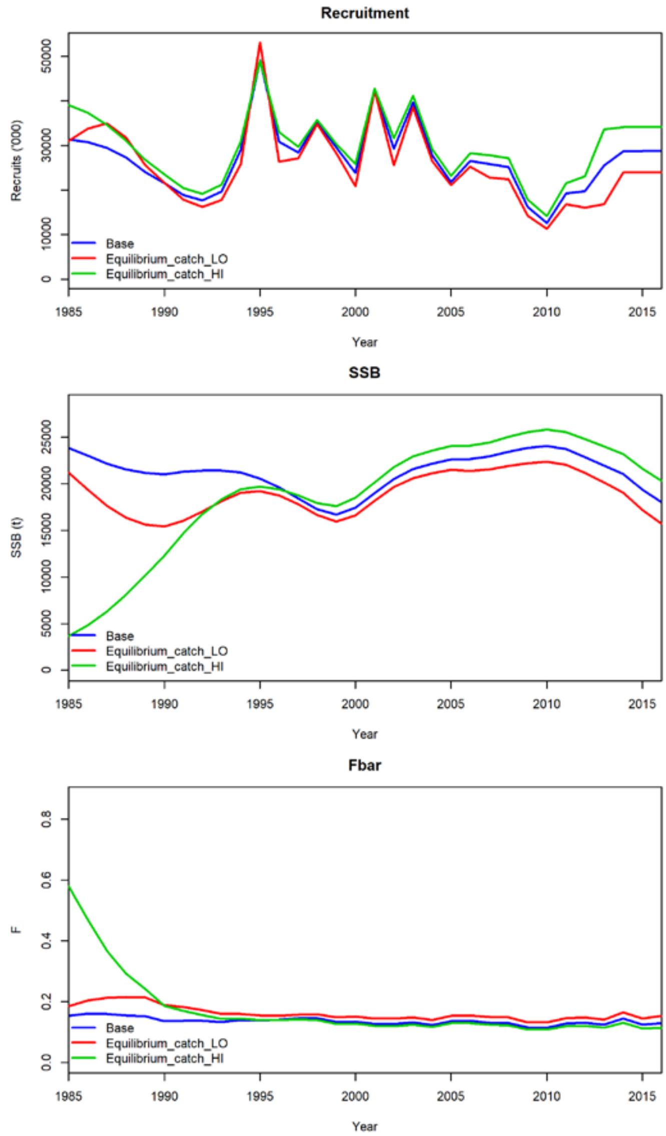

Figure 5.3-25. Sensitivity of recruitment (top), SSB (middle) and F (bottom) time-series to the initial equilibrium catches (twice higher and half lower than the base model).

5.3.6.2 Coefficient of variation of the growth pattern

A sensitivity analysis was performed for the values of the CV of the growth pattern (Figure 5.3-26). CV estimated by the model were compared to values derived from the data. For the recruitment, the SSB and the F series, differences were small over the whole time period. Main differences occurred only at the beginning of the time-series.

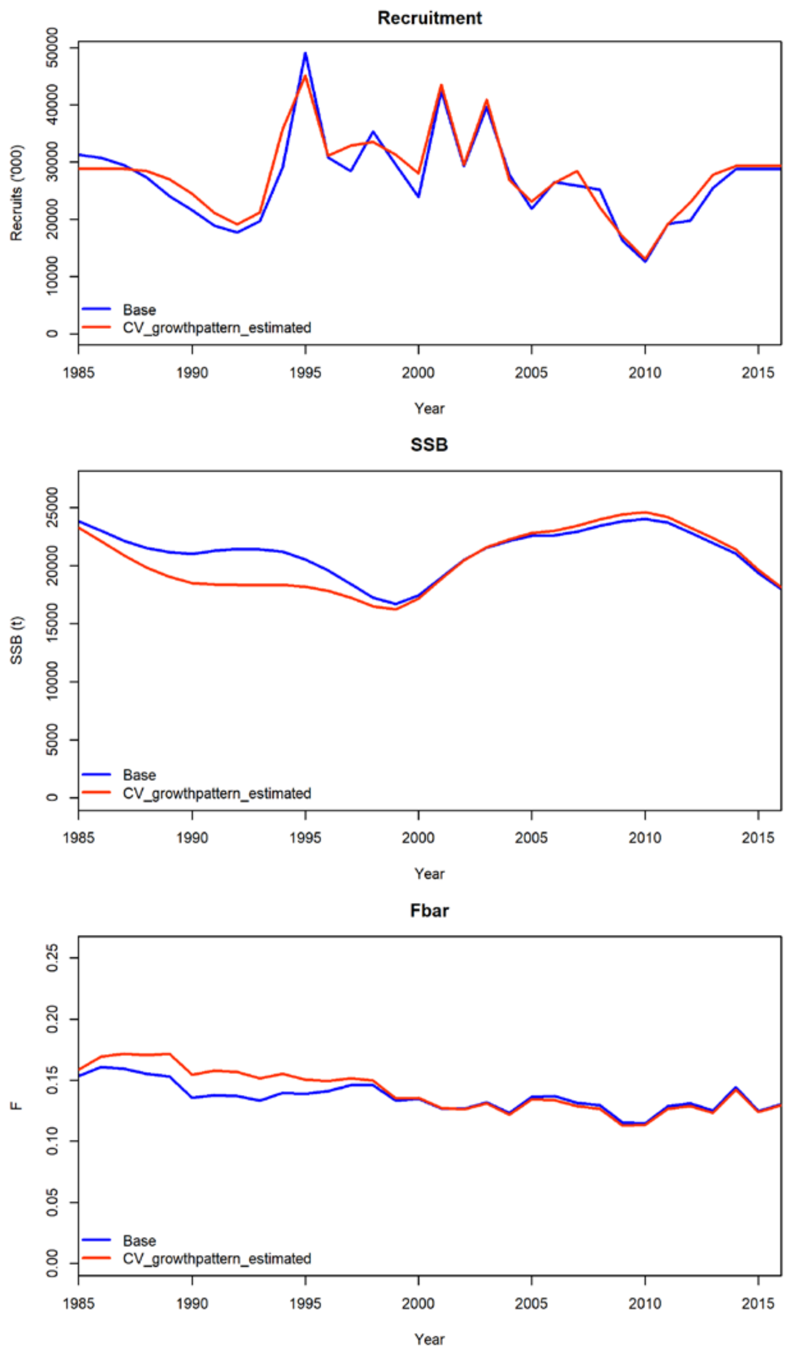

Figure 5.3-26. Sensitivity of recruitment (top), SSB (middle) and F (bottom) time-series to the CV of the growth pattern.

5.3.6.3 Discards catch and length data

A sensitivity analysis was performed for the discards (Figure 5.3-27). The base model did not include any discards, as they were considered negligible (<5%). The base model was compared to runs including either discards catch data or discards catch and length data. When including only discards catch data, the results are similar to the base model. Recruitment is the same as for the base model. The SSB was slightly lower, and the F was slightly higher, but the trends were the same. However, the run that included the discards catch and length data was very different, with higher level of SSB and lower F, which also showed a marked decreasing trend. Due to data quality, low quantity and poor sampling of discards, WKBASS 2018 decided to exclude discard data from the final model.

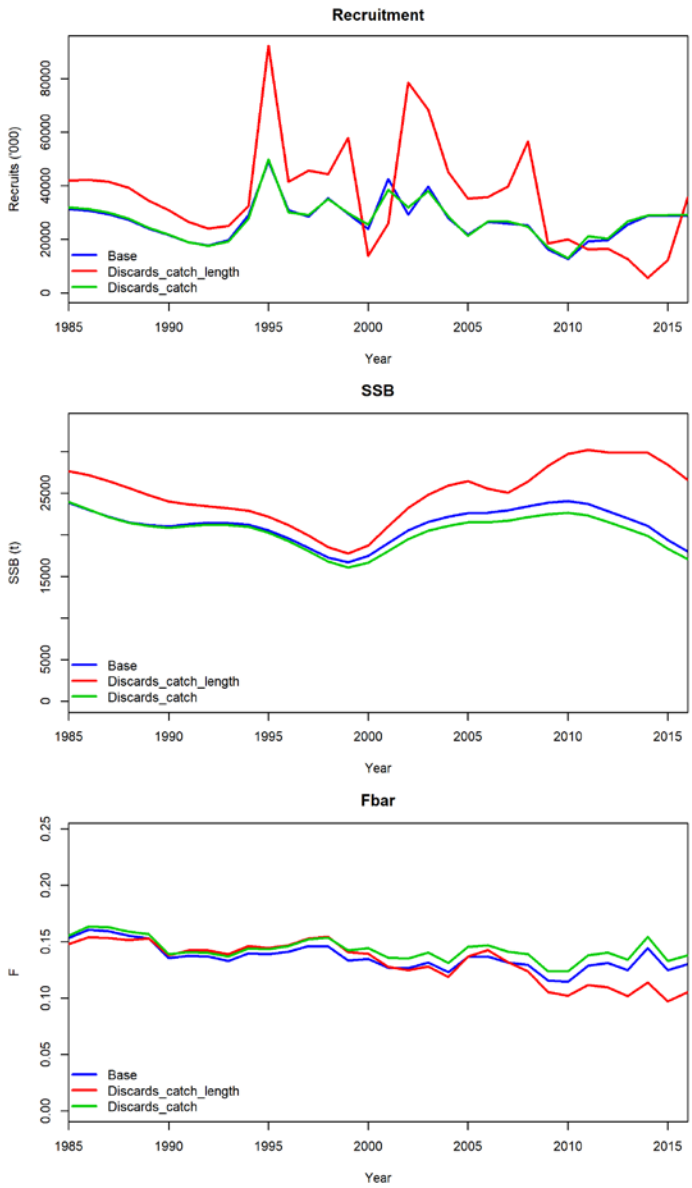

Figure 5.3-27. Sensitivity of recruitment (top), SSB (middle) and F (bottom) time-series to the discards catch and length data.

5.3.6.4 The lpue index

A sensitivity analysis was performed for the lpue index (Figure 5.3-28). The series used in the base model covered the period 2000–2016 combining modelled indices of the presence-absence and positive data. The base model was compared to an lpue index modelling only the positive values (LPUE_AV+), a combined lpue index estimated only over years 2009–2016 (LPUE_comb_short), an lpue index mixing indices modelling the positive values for years before 2009 and the presence-absence and the positive values for years after 2009 (LPUE_mix), a combined lpue index using and estimating the parameter for non-linearity, and a combined lpue index using the parameter for non-linearity set to 1.0. We expected the model output with the latter index to be identical with the base model; they were very close but not identical. The additional non-linearity parameters are not commonly implemented in SS assessments, and we plan to explore this option further for the next benchmark assessment. SS models with lpue indices modelling positive values only were higher for SSB and lower for F. SS models with short or long combined lpue index were very close to each other.

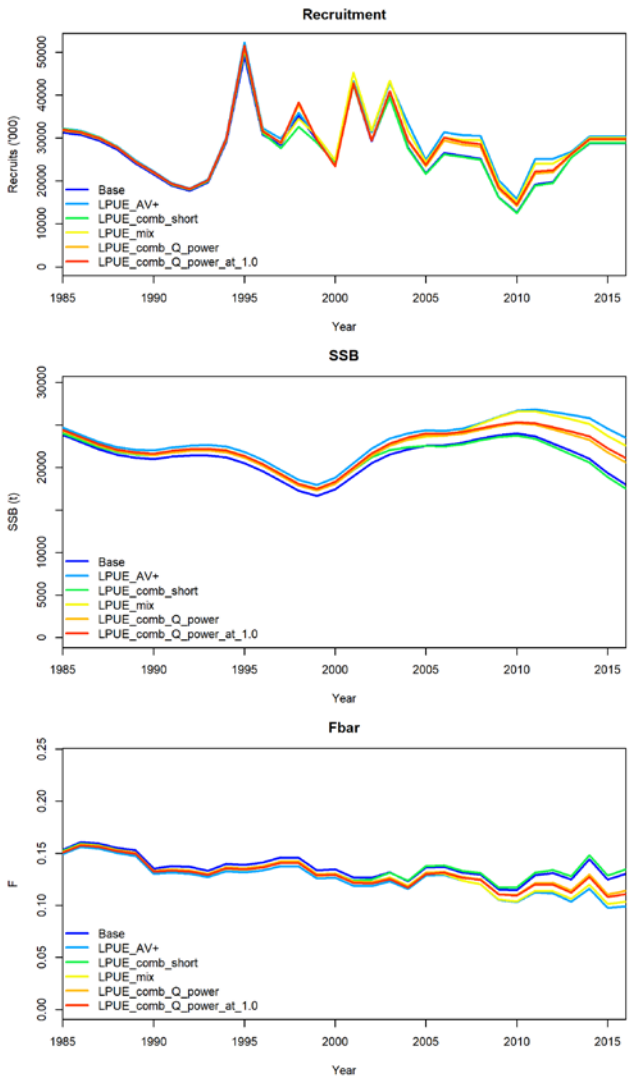

Figure 5.3-28. Sensitivity of recruitment (top), SSB (middle) and F (bottom) time-series to the different lpue index series.

5.3.6.5 Natural mortality

A sensitivity analysis was performed for different natural mortality estimates (Figure 5.3-29). Five scenarios were tested: one using the mortality-at-age estimated following the method of Lorenzen, one using the mortality-at-age from Lorenzen scaled to 0.24 (i.e. the Then *et al*. (2015) estimate), one where the age-independent mortality is estimated within SS3 (i.e. M = 0.10), one using the mortality-at-age from Lorenzen scaled to 0.10 (i.e. the value estimated by SS3), one where mortality is estimated following Then *et al*. (2015) method (i.e. M = 0.24, value used in the base model), and a last one which is the composite median M value of 0.178 (see Section 5.2.2). As expected, different M estimates changed recruitment, SSB and F level, but did not change its trends.

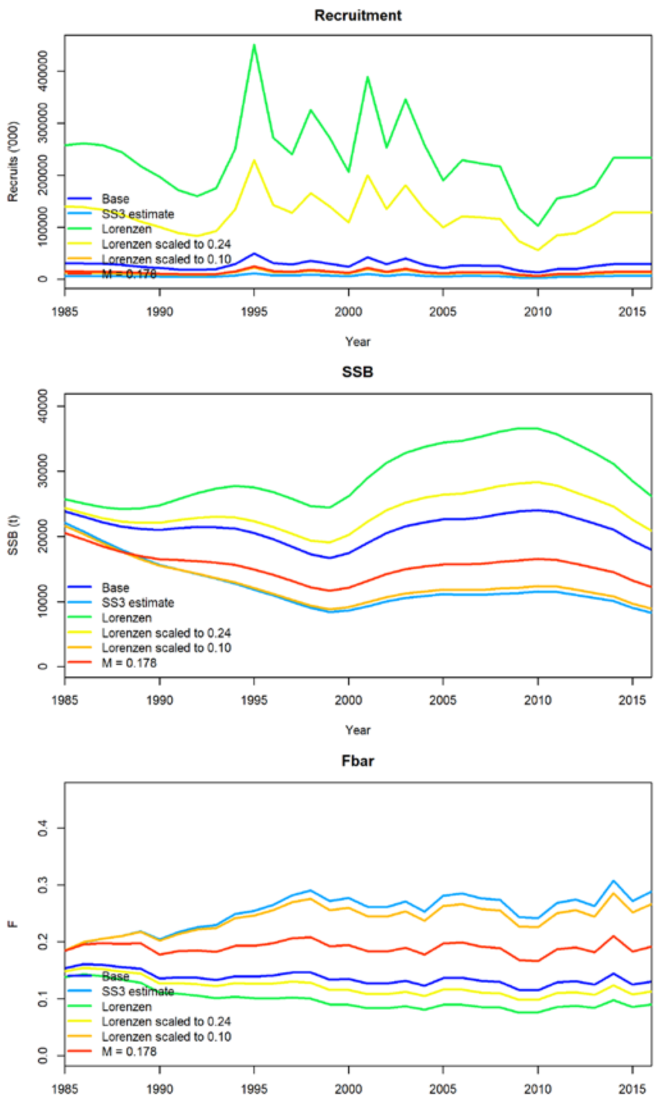

Figure 5.3-29. Sensitivity of recruitment (top), SSB (middle) and F (bottom) time-series to different natural mortality estimates (Lorenzen, Lorenzen scaled to 0.24, model estimate to 0.10, Lorenzen scaled to 0.10, Then *et al*. (2015), and composite median M = 0.178).

5.3.6.6 Recreational fishery data

A sensitivity analysis was performed for the recreational fishery catches (Figure 5.3-30). Five scenarios were tested: catches were estimated using a constant F for recreational fishery and without compliance to management measures; recreational catches were proportional to commercial fishery catch with 15% of post-release mortality; catches were estimated using a constant F for recreational fishery and with compliance to management measures and post-release mortality equal to 1%, 5% (i.e. the base model) or 15% respectively. There were small differences between all these scenarios. The main one occurred at the end of the F series for the last four years. The scenario with constant F and without compliance showed higher F than the other models. Furthermore, the scenario with constant proportion of catches showed higher F than the latter scenario.

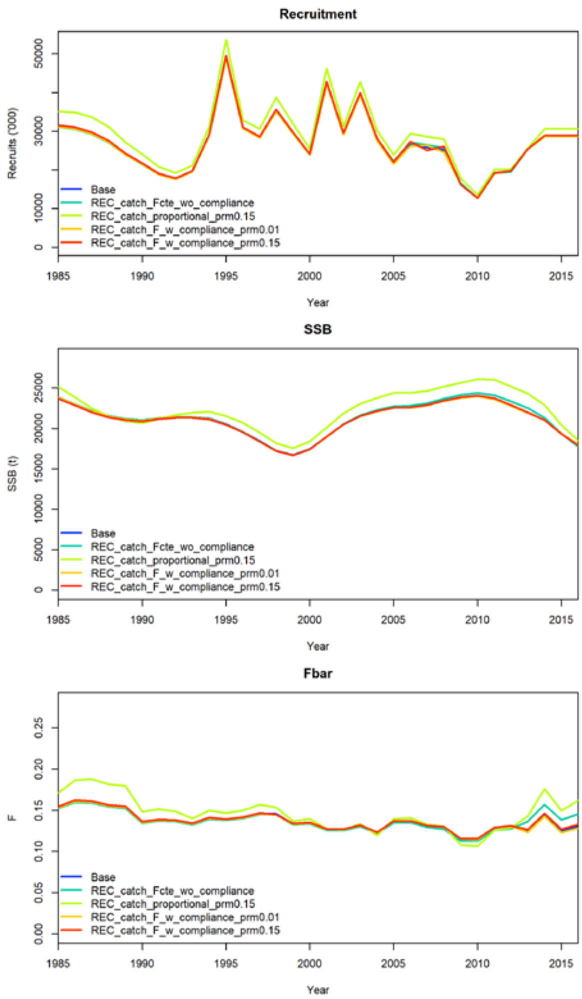

Figure 5.3-30. Sensitivity of recruitment (top), SSB (middle) and F (bottom) time-series to different recreational fishery catch and length scenarios (catch estimated using a constant F for recreational fishery and without compliance to management measures, catch proportional to commercial fishery catch with a post-release mortality to 15%, catch estimated using a constant F for recreational fishery and with compliance to management measures and post-release mortality to 1%, 5% (i.e. the base model) and 15%).

5.4 Biological Reference Points and forecast

5.4.1 Current reference points

There is no current Biological Reference Points for Sea bass (*Dicentrarchus labrax*) in Divisions 8.ab (Bay of Biscay North and Central).

5.4.2 Source of data

For this benchmark, the Bay of Biscay sea bass stock is intending to be a category 1 stock with an analytical assessment based on a Stock Synthesis 3 (SS3) modelling approach. Data used in the analysis were taken from the final assessment model obtained during ICES WKBASS 2018 (see previous section).

5.4.3 Methods used

All analyses were conducted with EqSim in R. The SS3 model output was converted to a FLStock object in order to run EqSim. All model and data selection setting are presented in Table 5.4-1.

Table 5.4-1. Model and data selection settings.

DATA AND PARAMETERS	SETTING	COMMENTS
SSB-recruitment data	Full dataseries (years classes 1985–2016)	
Exclusion of extreme values (option extreme.trim)	No	
Trimming of R values	Yes	-3,+3 Standard deviations
Mean weights and proportion mature; natural mortality	2007–2016	
Exploitation pattern	2007–2016	
Assessment error in the advisory year. CV of F	0.212	Set ICES default value
Autocorrelation in assessment error in the advisory year	0.423	Set ICES default value

5.4.4 Results

5.4.4.1 Stock–recruitment relationship

The stock–recruitment plot displays very little dependence between R and SSB (Figure 5.4-1). Based on the S/R relationship classification proposed by ICES (2017), the sea bass stock can be categorised as a type 5 S–R plot. This is a stock with no clear relationship between stock and recruitment (no apparent S–R signal).

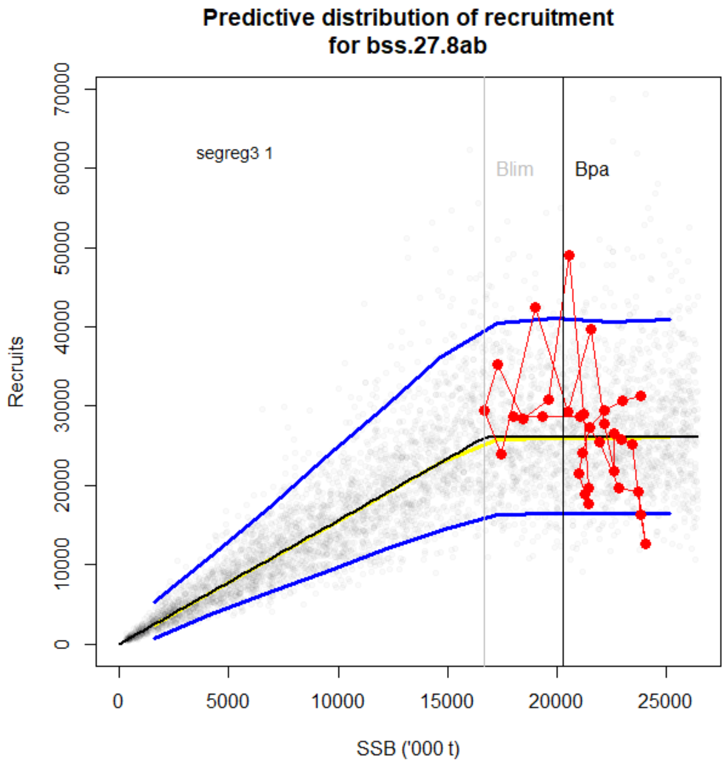

Figure 5.4-1. Stock–recruitment relationship for the Bay of Biscay sea bass stock.

For stock S–R, B_{lim} is estimated to be equal to B_{loss}. This implies a B_{lim} of 16 688 tonnes with a $B_{pa} = B_{lim} * \exp(CV \times 1.645) = 20\,275$ tonnes, with a CV = 0.118 derived from SS3 outputs (i.e. the CV of the last year SSB estimate).

5.4.4.2 Yield and SSB

F_{MSY} is estimated from the base run and taken as the peak of the median landings equilibrium yield curve. The F_{MSY} range is calculated as those F values associated with median yield that is 95% of the peak of the median yield curve.

5.4.4.3 Eqsim analysis

a) Segmented regression method, full SR time-series, without $B_{trigger}$

F_{lim} and F_{pa} was estimated using the EqSim software to run the simulation with $B_{trigger}$ set to 0 (i.e. no $B_{trigger}$ used), $F_{cv} = F_{phi} = 0$ (i.e. no assessment/advice error set for this first run) and the segmented regression as the only SR method. F_{lim} is estimated as the fishing mortality that at equilibrium from a long-term stochastic projection leads to a 50% probability of having SSB above B_{lim}. F_{lim} was estimated to be 0.159 and F_{pa} is estimated to be 0.131 based on the following equation [$F_{pa} = F_{lim}/\exp(CV * 1.645)$].

Initially, F_{MSY} is calculated as the fishing mortality that maximises median long-term yield in stochastic simulations under constant F exploitation (i.e. without MSY $B_{trigger}$). Using the same simulation method with the inclusion of assessment/advice error default values: Fcv=0.212, Fphi=0.423 from WKMSYREF4 (ICES, 2016). $F_{MSY} = 0.138$ and is thus above $F_{pa} = 0.131$, see Figure 5.4-2 and Figure 5.4-3. In such a case, F_{MSY} is reduced to F_{pa} (i.e. F_{MSY} cannot exceed F_{pa}).

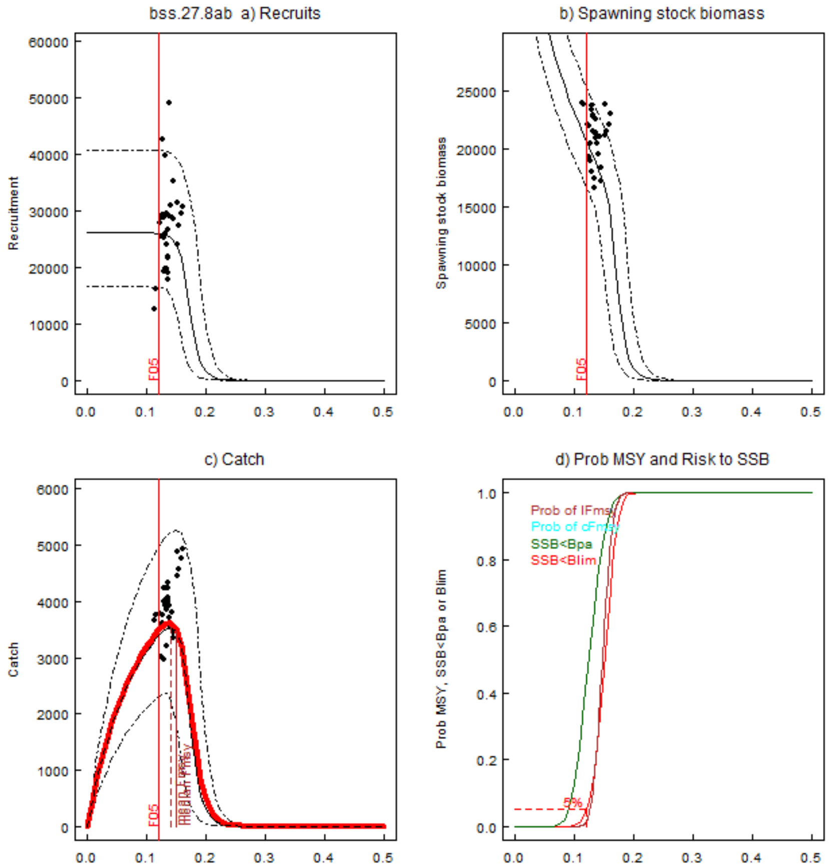

Figure 5.4-2. Eqsim summary plot without $B_{trigger}$. Panels a to c: historic values (dots) median (solid black) and 90% intervals (dotted black) recruitment, SSB and landings for exploitation at fixed values of F. Panel c also shows mean landings (red solid line). Panel d shows the probability of SSB<B_{lim} (red), SSB<B_{pa} (green) and the cumulative distribution of F_{MSY} based on yield as landings (brown).

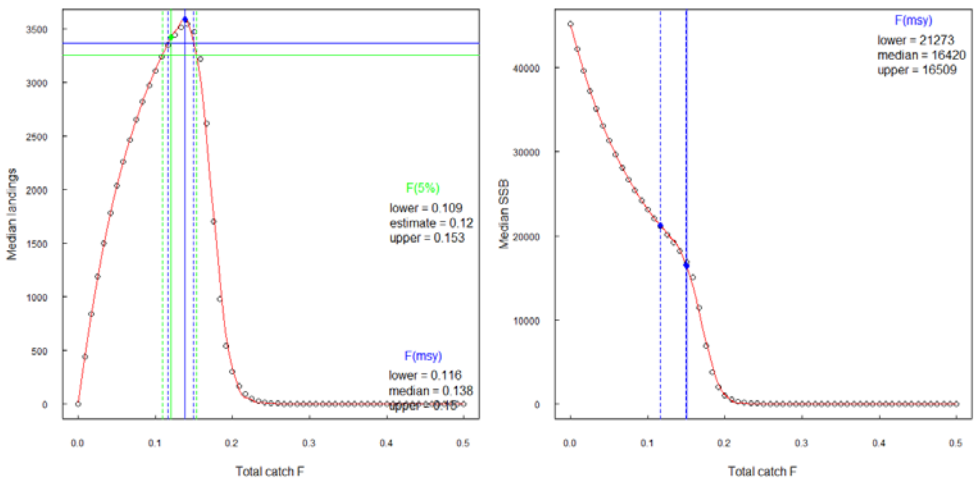

Figure 5.4-3. Left) Eqsim median landings yield curve with estimated reference points without $B_{trigger}$. Blue lines: F_{MSY} estimate (solid) and range at 95% of maximum yield (dotted). Green lines: F (5%) estimate (solid) and range at 95% of yield implied by F (5%) (Dotted). Right) Eqsim median SSB curve with estimated reference points without $B_{trigger}$. Blue dots: lower and upper SSB corresponding to lower and upper F_{MSY}.

b) Segmented regression method, full SR time-series, with $B_{trigger}$

ICES defines MSY $B_{trigger}$ as the 5th percentile of the distribution of SSB when fishing at F_{MSY}. However if the stock has not been fished at F_{MSY} for at least five years, as in this case, then MSY $B_{trigger}$ is set to B_{pa}.

For the final run, assessment/advice error were included using the same default values and MSY $B_{trigger}$ was set to 20 275 tonnes. As shown in Figure 5.4-4, EqSim output $F_{p.05}$ (fishing mortality that gives 5% probability of SSB below B_{lim}) equals 0.138. As F_{MSY} estimated in the first run is above $F_{p.05}$, then F_{MSY} is further reduced to $F_{p.05}$, 0.138.

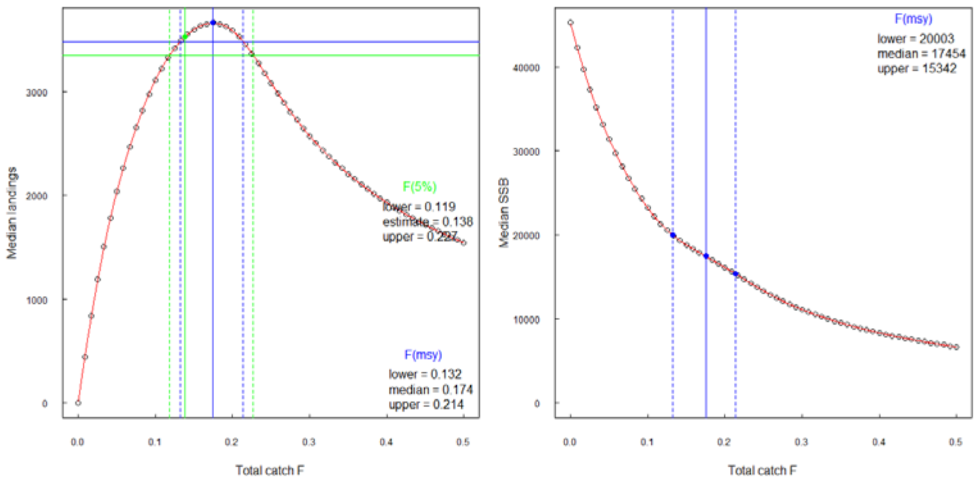

Figure 5.4-4. Eqsim median landings yield curve with estimated reference points with $B_{trigger}$. Blue lines: F_{MSY} estimate (solid) and range at 95% of maximum yield (dotted). Green lines: F (5%) estimate (solid) and range at 95% of yield implied by F (5%) (Dotted).

5.4.5 Proposed reference points

For the Bay of Biscay sea bass stock, the proposed reference points are reported in Table 5.4-2. Those proposed reference points are then displayed on the diagnostic plots of the final assessment (Figure 5.4-5), i.e. the recruitment, the SSB and the F (computed for ages 4–15) time-series.

Table 5.4-2. Summary table of proposed stock reference points for method Eqsim.

STOCK	Sea bass divisions 8ab		
PA Reference points	Value	Rational	
B_{lim}	16 688 t	Lowest observed SSB	
B_{pa}	20 275 t	B_{lim} / exp(CV * 1.645)	
F_{lim}	0.159	In equilibrium gives a 50% probability of SSB>B_{lim}	
F_{pa}	0.131	F_{pa} = F_{lim} / exp(CV * 1.645)	
MSY Reference point	Value		
F_{MSY} without $B_{trigger}$	0.131	Reduced value (originally equals to 0.138)	
F_{MSY} lower without $B_{trigger}$	0.116		
F_{MSY} upper without $B_{trigger}$	0.150		
$F_{P.05}$ (5% risk to B_{lim} without $B_{trigger}$)	0.120		
F_{MSY} upper precautionary without $B_{trigger}$	0.154		
MSY $B_{trigger}$	20 275 t		
$F_{P.05}$ (5% risk to B_{lim} with $B_{trigger}$)	0.138		With WKMSYREF4 default values for assessment/advice error
F_{MSY} with $B_{trigger}$	0.131	Reduced value (originally equals to 0.174)	
F_{MSY} lower with $B_{trigger}$	0.131	Reduced value (originally equals to 0.132)	
F_{MSY} upper with $B_{trigger}$	0.131	Reduced value (originally equals to 0.214)	
F_{MSY} upper precautionary with $B_{trigger}$	0.131	Reduced value (originally equals to 0.227)	
Median SSB at F_{MSY}	20 120 t		
Median SSB lower precautionary (median at F_{MSY} upper precautionary)	14 582 t		
Median SSB upper (median at F_{MSY} lower)	20 120 t		

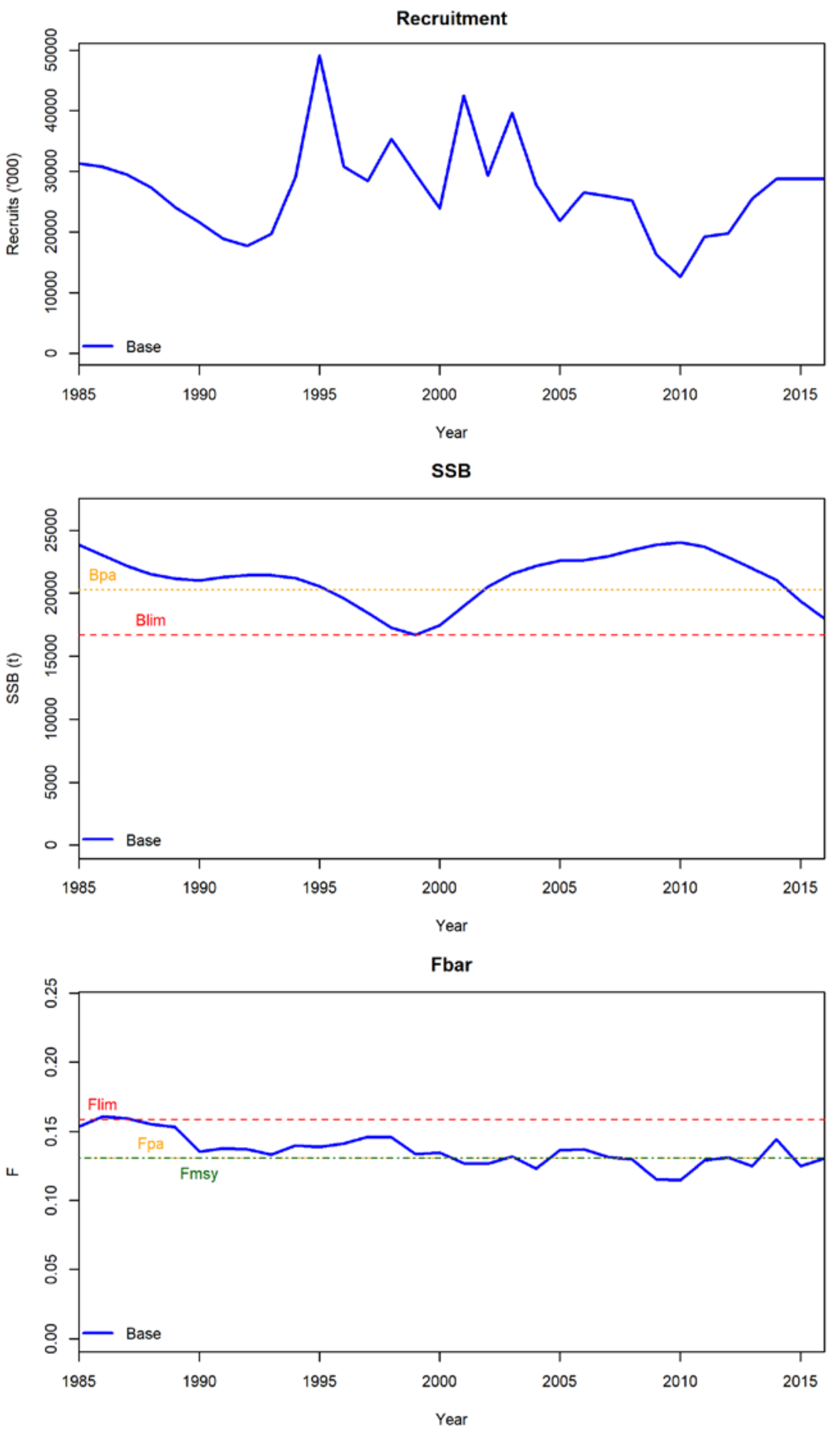

Figure 5.4-5. Plots of the final Bay of Biscay sea bass stock assessment with estimated reference points (B_{lim}, B_{pa}, F_{lim}, F_{pa}, F_{MSY}): SSB and F (computed for ages 4–15) time-series.

5.5 Key uncertainties and research requirements

There are several important limitations and deficiencies in data for the Bay of Biscay sea bass stock that should be addressed in order to improve future assessments and advice for this stock. WKBASS 2017–2018 makes the following recommendations:

1) Robust relative fishery-independent abundance indices are needed for adult sea bass in the Bay of Biscay. The establishment of dedicated surveys on the spawning grounds could provide valuable information on trends in abundance and population structure of adult sea bass as well as information on stock structure and linkages between spawning and recruitment grounds using drift model.

2) Recruitment indices are needed for the Bay of Biscay area. A French study has been undertaken in 2013–2016 to explore the possibility of creating recruitment indices in estuarine waters. The survey delivered good results, but it needs economic support to be carried out routinely (Le Goff *et al.,* 2017).

3) Further research is needed to better understand the spatial dynamics of sea bass (mixing between stock areas; effects of site fidelity on fishery catch rates; spawning site–recruitment ground linkages; environmental influences on recruitment).

4) Assessment model should be revised according to the results of undergoing tagging programmes.

5) Studies are needed to investigate the accuracy/bias in ageing and errors due to historical age-sampling schemes.

6) Continued estimation of recreational catches and size compositions is needed across the stock range and information to evaluate historical trends in recreational effort and catches would be beneficial for interpreting changes in age–length compositions over time.

7) Historical catches data (1985–2000) need to be revised following the methodology used for the recent years (2000 onwards). Historical catches data also need to be disaggregated into several fishing fleets (e.g. midwater trawls, bottom trawls, nets, lines).

8) Discard rates are considered negligible in the current assessment. Nonetheless, a time-series of discards-at-length or -age may be needed for all fleets, if the impact of technical measures to improve selectivity is to be evaluated as part of any future sea bass management.

9) The absence of length composition data for French fisheries prior to 2000, is a serious deficiency in the model preventing any evaluation of changes in selectivity that may have occurred, for example due to changes in the proportion of different gear types (especially with the large decrease in numbers of pairtrawlers after 1995).

5.6 References

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Annex 2: Agenda

WKBASS – Benchmark on Sea bass

2016/x/ACOM33 A **Benchmark on Sea bass** (WKBASS), chaired by External Chair Vladlena Gertseva, USA and ICES Chair Massimiliano Cardinale*, Sweden (for Benchmark) and ICES Chairs Mike Armstrong, UK and Kieran Hyder, UK (for Data Evaluation), and attended by two invited external experts John Hoenig, USA, and Karim Erzini, Portugal will be established and will meet at ICES, Copenhagen for a data evaluation meeting 10–12 January 2017 and at ICES, Copenhagen, Denmark for a Benchmark meeting 20–24 February 2017 to:

a) Evaluate the appropriateness of data and methods to determine stock status and investigate methods for short-term outlook taking agreed or proposed management plans into account for the stocks listed in the text table below. The evaluation shall include consideration of:

  i) Stock identity and migration issues;

  ii) Life-history data;

  iii) Fishery-dependent and fishery-independent data;

  iv) Further inclusion of environmental drivers, multispecies information, and ecosystem impacts for stock dynamics in the assessments and outlook.

b) Agree and document the preferred method for evaluating stock status and (where applicable) short-term forecast and update the stock annex as appropriate. Knowledge of environmental drivers, including multispecies interactions, and ecosystem impacts should be integrated in the methodology;

If no analytical assessment method can be agreed, then an alternative method (the former method, or following the ICES data-limited stock approach for category 3–6 stocks) should be put forward;

c) Re-examine and update if appropriate MSY and PA reference points according to ICES guidelines (reference);

d) Develop recommendations for future work to improve the assessments and data collection and processing;

e) Produce working documents following the DEWK, to be reviewed during the Benchmark meeting at least seven days prior to the meeting.

To address the pending issues left from the February meeting WKBASS has been extended. An extra physical meeting will be held in Copenhagen 21–23 February 2018 with the following specific ToR:

f) Address the main lpue series issues highlighted by WGCSE and the reviewer (the exclusion of zeros from the current index, the likely underestimation of variance in the current index);

g) Explore the impacts of the lpue revision in the benchmark-agreed stock assessment;

h) Explore and agree on how to deal with 2016 and future recreational catches in the assessment;

i) Re-examine and update if appropriate MSY and PA reference points according to ICES guidelines (reference); and j) Agree on the forecast assumptions and method.

Stakeholders are invited to participate in the benchmark work and to contribute with relevant data and information. As part of the data compilation workshop consider the quality of data including discard and estimates of misreporting of landings.

Stocks	Stock leader
(*Dicentrarchus labrax*) in divisions 4.b and c, 6.a and 7.d–h (Central and South North Sea, Irish Sea, English Channel, Bristol Channel, Celtic Sea)	Lisa Readdy
Sea bass (*Dicentrarchus labrax*) in divisions 8.a,b (Bay of Biscay North and Central)	Mickael Drogou

The Benchmark Workshop will report by 1 April 2018 for the attention of ACOM.

Annex 3: Stock Annexes

The table below provides an overview of the Stock Annexes updated at WKBASS 2018. Stock Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species,* and *acronym* of the relevant ICES expert group.

Stock ID	Stock name	Last updated	Link
bss.27.8ab	Sea bass (*Dicentrarchus labrax*) in divisions 8.a–b (northern and central Bay of Biscay)	May 2017	Sea bass in 8.ab
bss.27.4bc7d–h	Sea bass (*Dicentrarchus labrax*) in divisions 4.b–c, 7.a, and 7.d–h (central and southern North Sea, Irish Sea, English Channel, Bristol Channel, and Celtic Sea)	May 2015	Sea bass in 4 and 7
bss.27.8c9a	Sea bass (*Dicentrarchus labrax*) in divisions 8.c and 9.a (southern Bay of Biscay and Atlantic Iberian waters)	May 2013	Sea bass in 8c9b

Annex 4: Recommendations

Recommendation	Adressed to
1. Robust relative fishery-independent abundance indices are needed for adult sea bass. Their absence is a major deficiency which will reduce the accuracy of the assessment and the ability to make meaningful forecasts. The establishment of dedicated surveys on spawning grounds could provide valuable information on trends in abundance and population structure of adult sea bass and provide material for investigating stock structure and linkages.	EOSG, PGDATA
2. Further research is needed to better understand the spatial dynamics of sea bass (mixing between ICES areas; effects of site fidelity on fishery impacts; spawning site–nursery area linkage; and environmental influences).	WGBIE, WGCSE
3. Assessment model should be revised according to results of undergoing tagging programmes to assess potential mixing between stocks and models developed using Stock Synthesis.	WGBIE, WGCSE
4. Recreational catch data should be included in the assessment as soon as they becomes available in 2019 and the potential to partition the recreational fleet by countries should be considered. Time-series are needed across the stock area for inclusion in the assessment.	WGRFS, PGDATA, WGBIE, WGCSE
5. Studies are needed to investigate the accuracy/bias in ageing, and errors due to age sampling schemes.	WGBIOP
6. New studies are needed to assessment the discard survival from commercial rods and lines, and nets, and trawls.	PGDATA, WGCATCH

Annex 5: ICES Working document: French LPUE indices used in model assessment for sea bass

Alain Laurec, Mathieu Woillez, Mickael Drogou, Ifremer Brest France. June 2017.

ICES Working Document: French LPUE indices used in model assessment for seabass

June 2017

M. Woillez and M. Drogou

Ifremer Brest France.

1 Introduction

Several working documents have been produced on this subject since april 2015 (see annexes). A first working document has been written for WGBIE 2015 named "French Logbook data analysis 2000-2013: possible contribution to the discussion of the sea bass stock(s) structure/annual abundance indices" (Laurec and Drogou, 2015; available in annex 1). Then, a second working document named "getting seabass annual apparent abundance indices from log books" (Laurec, 2016; available in annex 2) has been written for the seabass benchmark WKBASS (ICES, 2017). Both present an in-depth analysis of the logbook data and the model used to derive LPUE indices. Following WKBASS benchmark workshop, three notes have been produced to answer questions that were raised at the data meeting, and then at the assessment meeting (available annexe 3, 4 and 5). This working document do not attend to summarize all these documents.

The aim of this working document is to recall 1) the material that is used and 2) the methodology that has been implemented to derive these LPUE abundance indices for seabass stocks in division 8a-b (Bay of Biscay) and in division 4.bc and 7.a,d–h (North Sea, Channel, Celtic Sea and Irish Sea). Following the questions raised at WGCSE and WGBIE assessment working groups, this working document aims also at performing a retrospective analysis and evaluating how robust over years are the derived LPUE indices. In addition, as zero catches are not included to derived these LPUE indices (see method section), the robustness to selection of non-null values is also assessed. Finally, for the Northern stock of seabass, for which a reliable abundance index (tuned by juvenile surveys) is available through an analytical assessment (SS3 model), the LPUE index is compared to the SS3 abundance index to evaluate how both time series compare.

2 Material

Basic logbook data (all vessels < 10 m and > 10 m) from the French fleet have been used, on the basis of daily seabass declared catches. Because discards are very low (less than 5% of the total catches; ICES, 2017), catches can be assimilated to landings. In the data base, results cover a period that extends from 2000 to 2016. Although these logbooks may contain within a day detailed information (e.g. fishing time), it has been preferred to simply consider catches per day, and the associated ICES squares so that catches per unit of effort (CPUE) are expressed as kilograms of seabass caught per day in an ICES square.

All days with catches ≥ 1 kg have been kept in order to avoid some incorrect values in the raw data set as "false" 0 such as 0.01 kg or 0.02 kg which can be considered as a nonsense (note that the minimum landing size of 36 cm corresponds to a seabass of 0.5 kg).See in appendix "note on almost zero catches from log books"

Log books include various fishing techniques: bottom trawlers, midwater trawlers, hand-liners, fixed nets and long-liners, a few vessels using Danish seine and purse seines. All gears have been kept except pelagic trawlers which are not any more in the fishery since 2014 and purse seiners because of the very low amount of their landings (less than 1% of total landings).

What is to be called further a vessel is in fact the combination of a "hull' and a group of fishing techniques, so that that when shifting from a group to another one it becomes a new vessel. Preliminary selection of a set of groups of fishing gears/techniques (e.g. bottom trawls) often takes place. Vessels as well as squares which provided limited data have been eliminated, so that by the end 958 vessels (hull x technique) will be considered, as well as 11 groups of fishing techniques, and 37 ICES squares which cover all major fishing areas of both seabass stocks. Because logarithmic transformations of the daily catches will be systematically used, zero values will be ignored.

3 Methods

3.1 Models

Linear models have been of common use in the analysis of logbook data since the early works of Robson (1966), Laurec and Fonteneau (1979, Gavaris (1980). In order to assess the vessels effects, the area effect, the seasonal patterns and the between years changes various specific models can be used.

A monthly step has been considered. Each basic stratum corresponds to an ICES square, a year and a month. If within a stratum, the same vessel provides data for several days, these data are not grouped in order to get a total catch and a total number of days resulting in an average CPUE[1]. The corresponding observations are treated as replicates.

Vessels are associated to index $\boldsymbol{i}$, ICES squares to $\boldsymbol{j}$, months to $\boldsymbol{k}$ and years to $\boldsymbol{l}$. A daily individual observation data $\boldsymbol{o}$ (o = 1,....No. No being the number of records in the logbook file) is associated to:

(1) Cpue $\boldsymbol{U_o}$[2], to vessel $\boldsymbol{i(o)}$

(2) The individual fishing power (the effective one as opposed to the "administrative" fishing power) of which is $\mathbf{P}_{i(o)}$

(3) To the ICES square $\boldsymbol{j(o)}$

(4) To month $\boldsymbol{k(o)}$ and

[1]It can be proved that using arithmetic averages then using weighted least squares lead to the same results.

[2]Capital bold letters are used for basic non transformed parameters, by contrast to the logarithmic values. All logarithms are decimal ones.

(5) To year ***l(o)*.**

In order to use the simplest linearized models, only non-null values are considered (All days with catches ≥ 1 kg are kept). Instead of the original CPUEs U_o, their logarithms (more precisely the decimal ones) u_o have been considered $u_o=log_{10}(U_o)$ .The same applies to fishing powers ($p_i=log_{10}(P_i)$)

Geographical (square) effects will be considered in some models and noted G_j and g_j for their logarithms. Monthly effects, which may vary from square to square (interactions between square and month effects, which means that seasonal changes in apparent abundance/CPUE may vary between squares) will be considered.

$S_{j,k}$ is the monthly effect for square j and month k, and the associated decimal logarithm is $s_{j,k}$.The same logic applies to year effects which may vary between squares, for instance because they are associated to different individual stocks. Year effects (between years "trends") for square ***j*** and year ***l*** will be $T_{j,l}$ for non transformed values and $t_{j,l}$ for the logarithms. When interactions between squares, months and years are considered (model 1 below), this implies an overall stratum effect $C_{j,k,l}$ or on a logarithmic scale $\boldsymbol{c_{j,k,l}}$

Three additive models will be considered. For all of them ***i(o),j(o),k(o)*** and ***l(o)*** are respectively the vessel, the ICES square, the month and the year associated to observation o.

Model 1:

The simplest model brings back to Robson (1966) is a two factors model:

$$\mathbf{u_o = p_{i(o)} + c_{j(o),k(o),y(o)} + \epsilon_o^1}$$ ϵ_o^1 being a residual

In a context where interactions between month and year effects are strong, this simple first model offers the best bases (Cheikh-Baye et al, 2014).

Model 2:

The second one is a basic four factors model: (1) vessel, (2) square, (3) square x month and (4) square x year:

$$\boldsymbol{u_o = p_{i(o)} + g_{j(o)} + s_{j(o),k(o)} + t_{j(o),l(o)} + \epsilon_o^2}$$ ϵ_o^2 being also a residual

Model 3:

The third one is a modified four factors models, which considers groups of squares for either month's effects or year effects. Fall all squares which belong for seasonal effects to the group gm, month effects are equal for any given month. The same rule applies to year effects, and for instance all squares related to the same stock can be considered as such a group, even if seasonal patterns may, and will often differ between squares.

$$\boldsymbol{u_o = p_{i(o)} + g_{j(o)} + s_{gm(j(o)),k(o))} + t_{gy(j(o)),l(o))} + \epsilon_o^3}$$ ϵ_o^3 being again a residual.

Constraints must be added to the three equations in order to avoid over parameterization. As for fishing powers the overall sum of log relative fishing powers, or the sum within a specified set of vessels is set to zero. The same rule is applied to month effects within a square (equation II) or a group of squares (equation III).

For all three models, parameters are estimated through the minimisation of the sum (over observations) of squared residuals, a residual being the difference between predicted values (see right part of the equations without the residuals) and the observed values u_o. This procedure does not correspond to any optimal criteria in any statistical sense, since optimality would require modelling of the overall statistical distributions which is not realistic. All analyses have shown for instance strong correlations between residuals associated to the same vessel over neighbouring days. Simple least square fitting merely is a robust approach, which happens to give the same results as simple means when there is no "missing" data (when all vessels have provided data for all strata).

Model 1 makes it possible to analyse possible changes in the seasonal pattern for the same square but between years. It is also possible to refer to an average seasonal pattern in order to split month effects from year effects in the stratum effects $c_{j,m(o), y(o)}$ related to a single square j. This is best obtained through a second stage fitting of a two factors (month and year) model for each square.

Within this paper priority has however been given to models 2 and 3, since interactions between years and months will be studied at a later stage. For the time being as for model 1 the key message is that it leads to similar conclusions in terms of average (i) seasonal patterns and (ii) multiannual changes as models 2 and 3, but also that its results appear more noisy (due to the increased number of parameters).

In order to get an "overall" annual index of abundance for a set of squares it is necessary to perform a complementary treatment of yearly abundance indices related to individual squares, whether they come from models 1 with complementary treatment or from model 2. This easiest way corresponds to simple arithmetic means (over logarithms).

Log fishing powers have been standardized setting their overall average to zero. Within each square the average of all (in most cases 12) month log effects have been set to zero. As for year effects the average over years 2008 and 2009 has also been set to zero.

For a number of treatments logarithms are to be used directly. In other cases it may be appropriate to come back to untransformed scales. This is achieved through a simple y = 1O x back transform.

3.2 Confidence intervals derived by bootstrap

Logbook data have been analysed using a special variant of the GLIM techniques. One is eager not only to get a "best estimate", but also to assess the reliability of the conclusions. Usual software dedicated to GLIM techniques offer among others estimated variances, confidence intervals and significance tests. They however rely on a triple assumption about the residuals: (1) normality, (2) homoscedascity (equal variances) (3) statistical independence between residuals. With logbook data the most important problems are associated to assumption 3 (mutual independence). In fact residuals associated to the same vessels on two consecutive days are highly correlated.

In order to overcome this difficulty a bootstrap approach has been used. Each bootstrap simulation selects within the complete set of N vessels the logbook of which are analysed, a bootstrap sample where each vessels is selected at random from the above mentioned set of vessels. As usual vessels are selected with replacement, so that a single vessel may appear several times.

The set of logbook data is analysed using the same method as the basic analysis. For instance for a group of squares (model 3) for which an average monthly pattern (month effects) each bootstrap sample leads to an estimate of the seasonal pattern. As expected the average over bootstrap simulation is closed to the basic pattern, provided the number of bootstrap simulations is high enough. Following the bootstrap logic, variability among the bootstrap results for the same statistics will be used in order to assess the reliability of the basic estimates. It is for instance possible to calculate the standard deviation among bootstrap estimates in order to build the usual 5% confidence intervals. It is also possible to refer to the overall distribution of the bootstrap estimates of the same parameters, and to use percentiles to define (approximate) confidence limits. This second method is to be preferred for parameters used with an untransformed scale, while for logarithmic values the direct use of +/- 1.96 standard deviation seems to be satisfactory (in the context of our logbook data).

4 Results

4.1 Time series of the LPUE indices with associated uncertainty

Following the conclusion of the working document "getting sea bass annual apparent abundance indices from log books" (Laurec and Drogou, 2016), which highlighted the consistency on

- seasonal patterns between ICES squares,
- year effects and apparent changes between years of apparent abundance of ICES squares,
- model 2 and model 3,
- gears selection.

Two LPUE indices have been derived using the model 3 for the two main seabass stocks in the Bay of Biscay and in the English Channel. Both are presented in Figure 1 with associated confident intervals. Averages over sets of squares have been calculated for statistical reasons over logarithm, then retransformed in kg/day. 22 ICES squares were retained in the final index for the Bay of Biscay and 44 for the English Channel as follow (Figure 1)

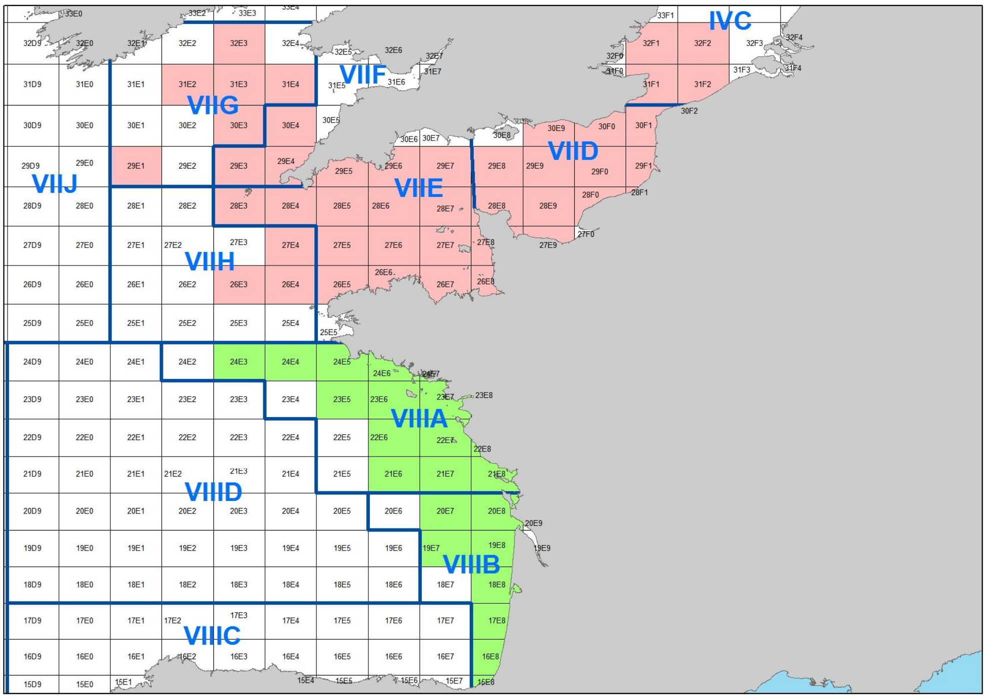

Figure 1 : Ices square used for French LPUE calculation. In red for the North part and in green for the Bay of Biscay

It has to be noted that the four ICES squares of the west Brittany (25E2, 25E3, 25E4, 25E5) haven't been retained for the final calculation in the English channel (see annexe 2016.12_WD2 for WKBASS 2017) because results do vary according to the gear selection, and cannot be easily related neither to the Bay of Biscay (North) nor to the English Channel (West).

Figure 2 shows the multiannual trends from 2000 to 2016. It worth noting that year 2000 is included in the figure, but we advice not to use it, as amount of data were low this year. Seabass apparent abundance was quite stable over years in the Bay of Biscay (with the highest value found in 2014), while it increased from 2001 to 2009, then it decreased until 2016 in the English Channel.

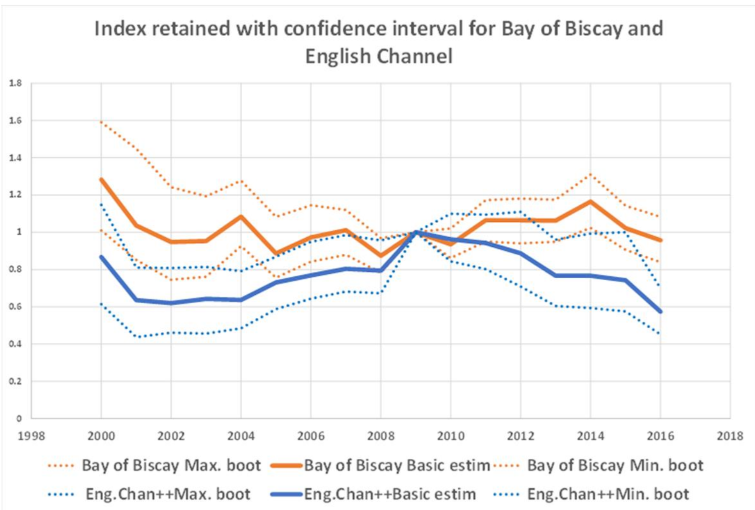

Figure 2 : LPUE indices for the 2 main area Bay of Biscay and English Channel.

It is worth noting that an increase is observed between 2008 and 2009 in the English Channel and to a lesser extent in the Bay of Biscay. This could be explained by a change in the operators who entered the data at this time in the SIPA-DPMA process. Misreporting of some 2008 and 2009 log books have been reported which advice us not using those 2 years in the assessment model.

4.2 Retrospective analysis

During ICES WGCSE 2017, it has been asked by the group to perform a retrospective analysis on LPUE indices in order to evaluate the change in the time serie when adding new years.Figure 3 and Figure 4 show that LPUE indices are very robust to the addition of new years. Trends are unchanged neither in the English Channel nor in the Bay of Biscay.

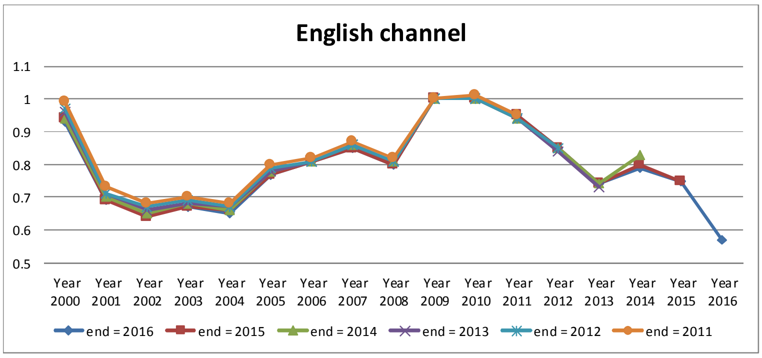

Figure 3: retrospective patterns in the English Channel

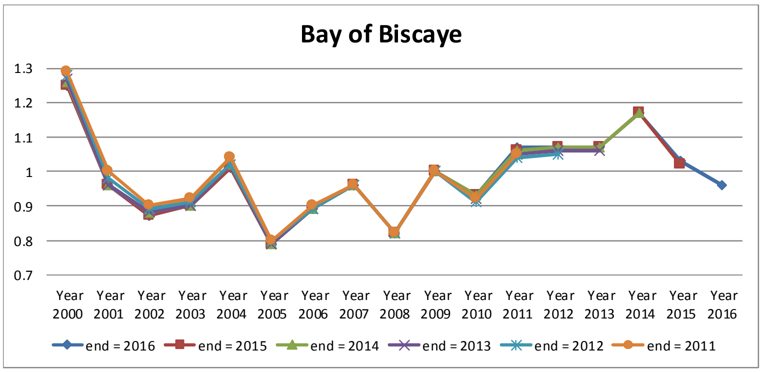

Figure 4: retrospective patterns in the Bay of Biscay

4.3 Impact of the minimum catches thresholding for daily catches selection

A limit ≥ 1 kg of seabass catches per day has been used to select logbook data. During ICES WGCSE 2017, it has been asked by the group to test a daily limit of 0.5 kg/day corresponding to a seabass of 36 cm (i.e. the minimum landing size during most of the time series). Figure 5 plots the difference between both scenarios, which indicates minor changes in the results.

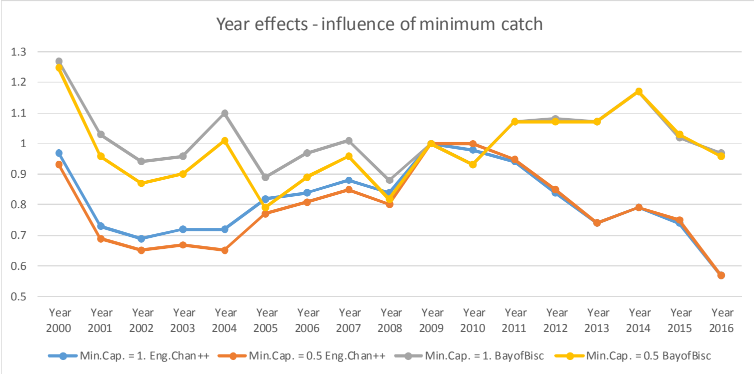

Figure 5: comparison between LPUE indices using a daily catches ≥ 0.5 kg or ≥ 1kg

4.4 Comparison of the Northern LPUE index with the SS3-based abundance index

Figure 6 compares the time series of the LPUE index to the current assessment done at ICES WGCSE 2016 (i.e. the spawning stock biomass of the English Channel). Similar trends can be observed, with differences for some years. For instance, from 2013 onwards, the decrease is more pronounced on the SS3-based SSB than on the LPUE index. This could be explained by the quantity of data (especially length structures of the landings) used in the assessment model, which is low for the recent years (recruitment in the fishery is around 4 year's old).

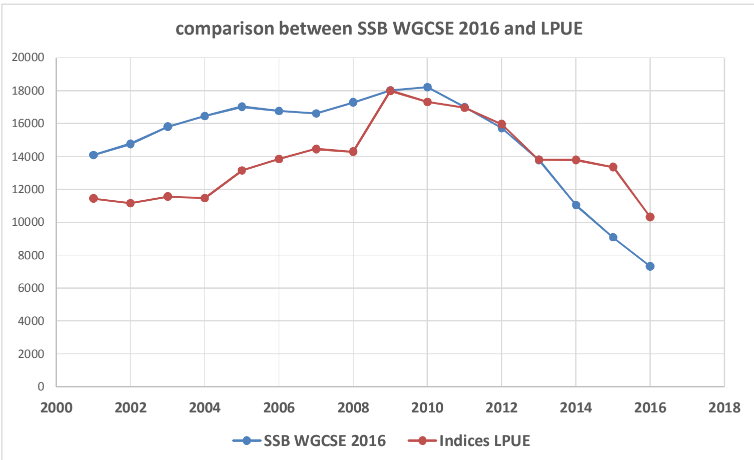

Figure 6: comparison of LPUE indices obtained and SSB assessed during ICES WGCSE 2016

5 Conclusion

Linear factor models applied to logbook data allows deriving robust LPUE indices for seabass stocks in the Bay of Biscay and in the English Channel. Results were robust to thresholds used to select non-null values for the analysis. They were also robust, when updating the time series with new years of data.

Other important conclusions were drawn from the previous working document (see annexes), which are worth to recall. Indeed, this analysis of trip data by rectangle and month showed very coherent seasonal and spatial patterns in LPUE matching what is known about the fisheries using different types of gears (otter trawl; midwater trawl;

nets; lines) and the seasonal movements of seabass to and from spawning sites. This provided confidence in the ability of the LPUE data to provide information on relative apparent abundance.

6 References

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7 Annexes

7.1 Annex 1: Laurec and Drogou (apr 2015). French Logbook data analysis 2000-2013: possible contribution to the discussion of the sea bass stock(s) structure/annual abundance indices.

7.2 Annex 2: Laurec and Drogou (dec 2016). Getting sea bass annual apparent abundance indices for from log-books.

7.3 Annex 3: Laurec (feb 2017). Comments on WD on French LPUE.

7.4 Annex 4: Laurec (mar 2017). Analysis of the residuals

7.5 Annex 5: Laurec (may 2017). Note on almost zero catches from log books

ANNEXE 1

French Logbook data analysis 2000-2013: possible contribution to the discussion of the sea bass stock(s) structure/annual abundance indices. Alain Laurec, M.Drogou April 2015.

Working document for WGBIE 2015 and WGCSE 2015-DRAFT

Introduction

Why logbook data

The main aims of the analysis (combing catch rates of the various individual vessels in order to analyse changes in space and time of apparent abundance).

Stock structure / annual abundance indices

I Material and method

I-1 Material

Basic logbook data (all vessels <10m and >10m) from the French fleet have been used, on the basis of daily declared catches, mostly sea-bass catches, but also total catches for some calculations. In the data base results cover a period that extends from January 2000 to December 2013. Although these logbooks may contain within a day detailed information (e.g. fishing time) it has been preferred to simply consider catches per day, and the associated ICES squares, as well as the fishing technique used (see Appendix A). In fact what is called a vessel in the text is a combination of a real vessel and a group of fishing techniques, so that when a vessel shifts for a gear from another group, she becomes for us another vessel.
Because logarithmic transformations of the daily catches will be systematically used, zero values will be ignored. Changes in the proportion of zero will be discussed in another paper.
Strata have been defined in order to simplify the basic set of daily catches. A stratum corresponds to a so-called ICES square, a month and a year. In fact only strata where catches have been documented often enough(??) have been considered.

Beyond the basic logbooks data's reference will also be made to some preliminary tagging results due to our colleagues X and Y (personal communication), and physical oceanography data obtained from ....

I-2 Method(s)

Fishing powers and apparent abundances time series within each ICES square

Daily catch rates per vessel, grouped within months and ICES squares, have been analysed basically through a multiplicative two factors model. The two factors, namely the fishing vessel effect and the stratum effect. Eliminating at a first stage null catches, and using a logarithmic transformation, the multiplicative model has been changed into an additive one , coming back to the basic, which brings back to the basic Abramson(19?6?) analysis . For a first data survey it has been preferred not to use more sophisticated models (Generalized linear model), in order to take into account possible interactions (see annex 2) which are not a simple nuisance preventing the use of additive three or four factors simple models, they contain key information in order to better understand sea bass stocks changes.
Calculated fishing powers are relative ones, and a reference vessel (or a set of vessels) must be chosen, the fishing power of which (or the geometric average within the set) being set to one (or zero for the log fishing powers or their arithmetic average over the group).
The stratum effects within and individual ICES square correspond to a time series (with possibly missing data) of apparent abundance, expressed as the daily catch rate of the standard vessel (or the standard average).

Analysis of the time series of apparent abundance related to the individual ICES square

Any visual check of such time series reveals the combination of a strong seasonal effect, a multiannual trend and apparent added noise. The strongest seasonal effect corresponds to what will be interpreted as spawning migrations and concentrations which take place in late autumn and winter. This is why it has been decided not to use[1] the usual calendar year from January to December, but 12 months period from July to the following June month, the apparent abundance being for most squares low in June-July, without major changes between June and the following July month.
Within each square second stage processing of the associated time series have been based on a multiplicative[2] (or additive after logarithmic transformations) two factors model (the year effect and the month (seasonal) effect. In fact there are not only between squares changes in the seasonal patterns, but also within a square between years changes in the seasonal patterns (which can be for instance stronger and/or delayed from year to year). Such interactions between years and months will be studied later on, so that for the time being only averaged seasonal patterns will be considered. Such a seasonal pattern is associated to a set of 12 monthly values. On a logarithmic scale these monthly values, the arithmetic average of which is zero,

[1] In fact calculations have also been made using the basic calendar year. They lead to the same seasonal patterns which are simply more difficult to follow between december and january, at a key moment for the spawning seasons.
[2] It would also be possible to use a slightly more complicated model than the twor factors one, and to fit a model where for ICES squares associated to the same stock (e.G. the Bay of Biscaye one the time series of a apparent abundance would be constrained so that they have a common year effect, and/or to keep the same seasonal pattern over years. This will be done at a later stage but is not likely to lead to conclusions in terms of stock structure and between years changes.

must be added to the annual apparent abundance index. On a re-transformed scale (through exponential transformation) the monthly coefficients are multiplicative ones. They will be called the modulation coefficients, associated to the (average) seasonal modulation curve. The geometric mean of the twelve coefficients is by definition equal to one. They can for instance fluctuate between 0.5 and 2, which implies that between the lowest and highest apparent abundance months variations range from 1 to 4.

Series of year effects offer a description of the multiannual trends.
Seasonal patterns will be compared between squares, either by direct comparisons of the seasonal modulation curves, or through mapping of (i) some key numbers related to each curve such as the month of the highest value, or seasonal variances calculated on the logarithmic coefficients, and (ii) average (over years) abundance by month. The so called apparent average abundance for a given month is given by the average (over years) within a square multiplied by the seasonal modulation factor[3].

Possible variants

It is in theory possible to describe the multiannual trend using a regular curve such as a polynomial curve. It is however difficult with such models to avoid misbehaviours of the curve on both ends of the series, which is a major problem because of the importance of the last yearsô figures for real time stock assessment.
If a group of Ices squares can be related to the same stock, it is possible to use a slightly more complex model than the two factors one, in order to impose a common year effect to those squares. This will be done later.
It is possible not to use all vessels, but a selection of vessels more likely to show simpler relationships between catch rates and real abundance. It must however be kept in mind that using only selected vessels limits the information taken into account, making it more difficult to extract meaningful signals from the noise associated to between vessels variability. Various selections of vessels will in fact be used.
It is also possible not to refer to the calendar years (January to December), which implies an abrupt change in the annual trend in the middle of the spawning season which is also a key fishing seasons associated for most vessels and many squares to high catch rates. Also calculations have also been performed on the basis of the basic calendar years, priority will be given to years running from July to the following month of June.
It is also possible not to consider all months within a year, in order for instance to focus on the spawning seasons, in order to get indices of apparent changes of the spawning stock. In such a case it is also legitimate to consider only the spawning grounds. Such an approach will lead to more useful estimates of relative fishing powers than the estimates using all year round data: mid water trawls are more efficient during the spawning seasons than when the fish do not aggregate. On the other hand here again the number of observations taken into account will be reduces, and the results will be more sensitive to noises, and first of all to between vessels variability.

[3] Problems if for some squares some annual values are missing.

Specific targets and the choice of options in the analyses

The first exploratory treatments have revealed that the analysis could give important elements on the stock(s) structure, and time series of annual abundance for a set of squares which could be related to specific stocks. The key arguments about stock structures and migrations will be taken from the compared seasonal modulations, in relation with spawning concentrations and migrations. Priority will so be given in the treatment of time series per squares to results obtained using shifted years, from July to June. Priority will also be given to analyses which take into account all available vessels, regardless of the gear they use. In order to detect in a square months where the apparent abundance is very low, using all vessels and gears offer more guarantees that low catch rates are not due to a catchability problem for specific gears.

In terms of stock structure consistent seasonal patterns within a set of squares suggest that they could be related to a single stock. This will even be more likely if they show similar between years variations. In order to compare variations, regardless of the fact that the apparent abundance is systematically higher in some squares, for all squares or sets of squares ratio between a yearly index abundance and the corresponding geometric mean over years 2006 and 2007 will be calculated. Seasonal patterns related to specific gears can also lead to interesting details. This will however be discussed in a future document.

Beyond their contributions to the stocks structure debate time series of year effects can contribute to the definition of annual indices of abundance at the scale of a stock, which could as usual contribute to the fine tuning of stock assessments, especially for the more recent years. This will be done through averages over sets of squares, and more specifically through arithmetic means of log apparent abundance. Other techniques for combining time series from the different squares could later be considered.

It must also be kept in mind that seasonal effects are in most cases much stronger than the year effects. This makes year effects estimations more sensitive to between vessels variability than their counterpart about seasonal effects, at least in this later case for average (over years) of the seasonal effects. This is why for estimates of yearly abundance priority will be given to averages over sets of neighbouring squares. In the analysis of year to year changes results for the final year (in our case 2013) are of paramount importance. Priority will so be given in the corresponding discussion to analyses based upon the basic calendar year (January to December) in order to get a final year fully comparable to the previous ones, since the available data end in December 2013. The discussion about yearly indices of abundance will compare results obtained using all gears with those obtained using specific gears, namely bottom trawling and Danish seine, which are likely to show simpler relationships between real abundance and catch per unit of effort. Analyses have also been performed after elimination of the vessels which seem to target[4] sea-bass, and using only data from an enlarged spawning season, from December to March, in order to get indices of spawning areas, in which case only squares which are related to what seem to be the main spawning areas are taken into account. One must however keep in mind that selecting vessels and months taken into account leads to a decrease in the amount of information utilized, making results more sensitive to ñnoisesò, and first of all to between vessels taken into account. Such statistical questions will be analysed in a future specific document, based upon bootstrapping within the sets of vessels used for each specific analysis. For the time being discussion will focus on analyses which use a large set of data, but results obtained using other options are available as additional material (See appendix B)

[4] Log fishing powers have been calculated for both total catch and sea-bass catch. The difference between values obtained (1) for sea-bass and (2) for total catch is an index of sea-bass targeting. Among vessels using bottom trawl or Danish seine, vessels associated with the 100 highest values of the sea-bass target index have been eliminated in some analyses

II Results

Apparent abundances are expressed as caches per day (Kg) of an average trawler, the average being calculateted over CF1 vessels more than 15 meters long.

Three ICES squares, ranging from North to South, have been selected as examples of time series :28E9 (center of the Eastern Channel), 25E5 (West of Britanny), and 18E8 (South of the Bay of Biscay). Figure 1-a below uses an arithmetic scale, and figure 1-b a logarithmic one. Each point on the x axis is associated to a month and a year. For practical reasons it is not possible to specify both the month and the year. On figure 1-a years only are indicated, while on figure 1-b January and July monthes are reported, in order to hihgligt seasonal changes.

Figure 1-a

Apparent abundance (Kg/day) for the three squares of the basic example arithmetic scale

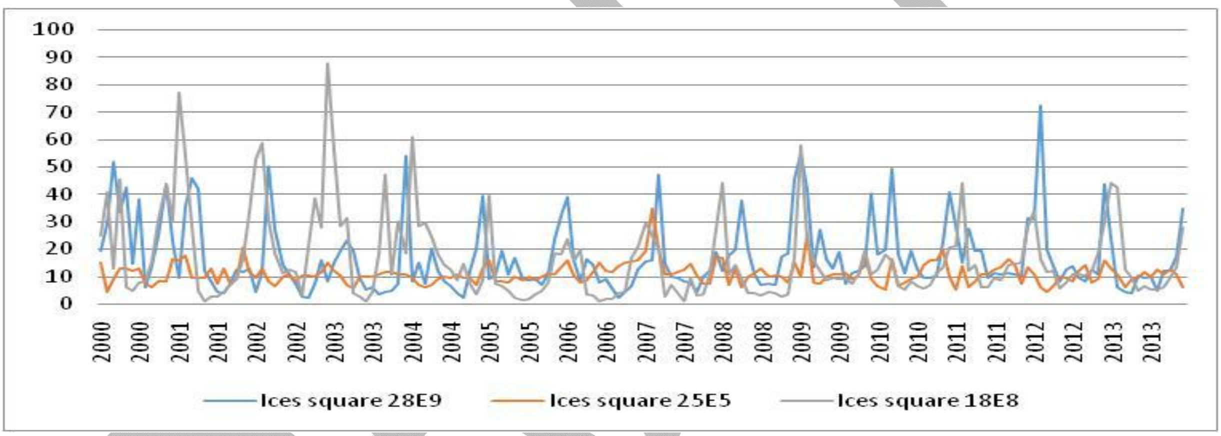


Figure 1-b

Apparent abundance (Kg/day) for the three squares of the basic example logarithmic scale

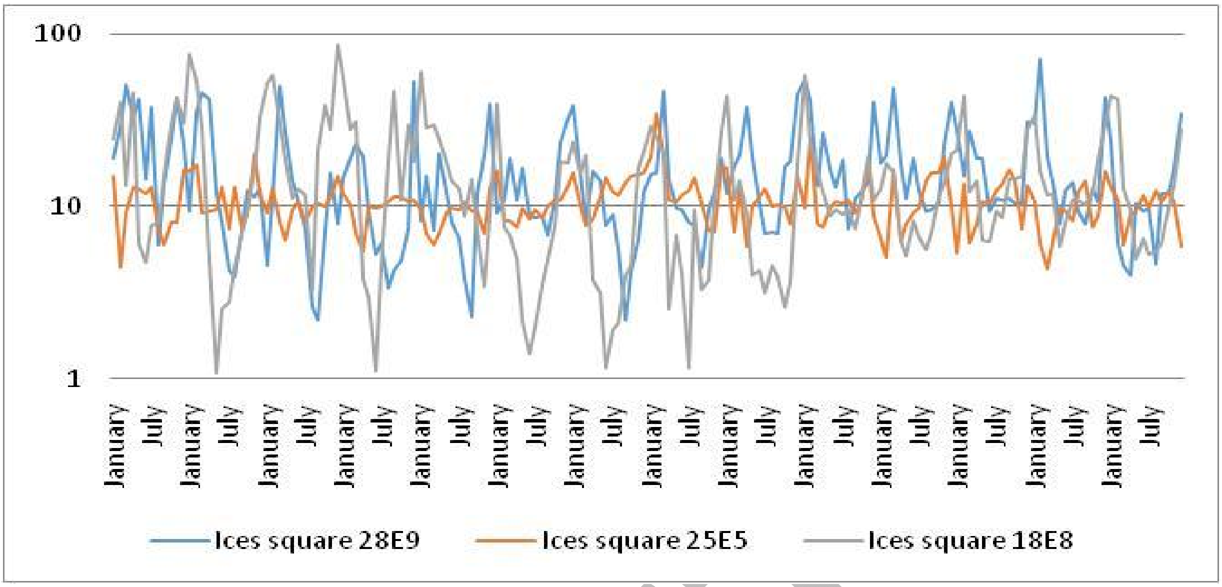

100
10
1
January
July
Ices square 28E9
Ices square 25E5
Ices square 18E8

Figure 1-b is easier to read, and makes it possible to appreciate the preeminence of seasonal changes, which are hovever highly variable from one ICES square to another (square x month interactions), but also varies from year to year (month x year interactions).

Square 25E5 is in fact a special one, since for most of the squares seasonal variations are higher. If there are obvious differences between geographically distant squares such as the three ones referred to in figures 1-a and 1-b, neigbhouring squares can lead to similar patterns, as illustrated on Figure 2, or not as shown on figure 3.

Figure 2 :

Example of similarities between neighbouring squares

Squares from the South of the Bay of Biscay

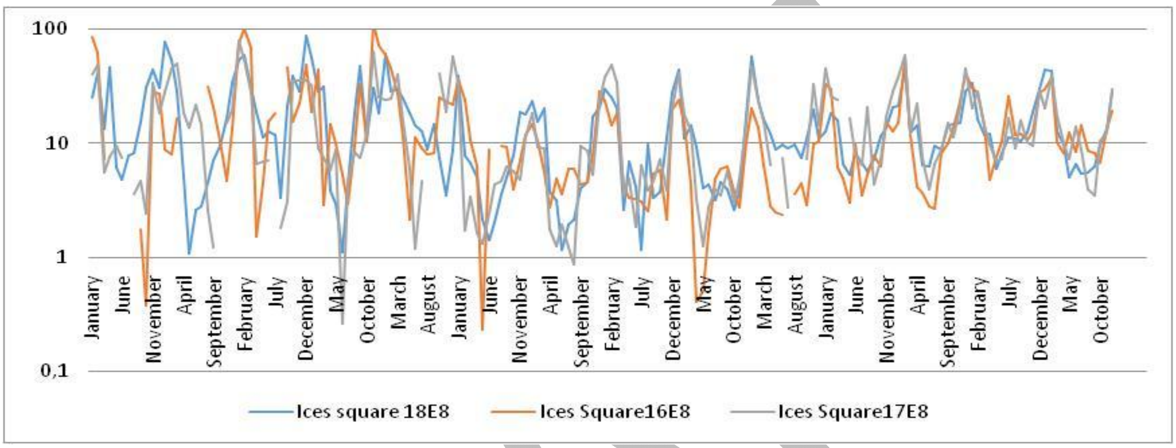
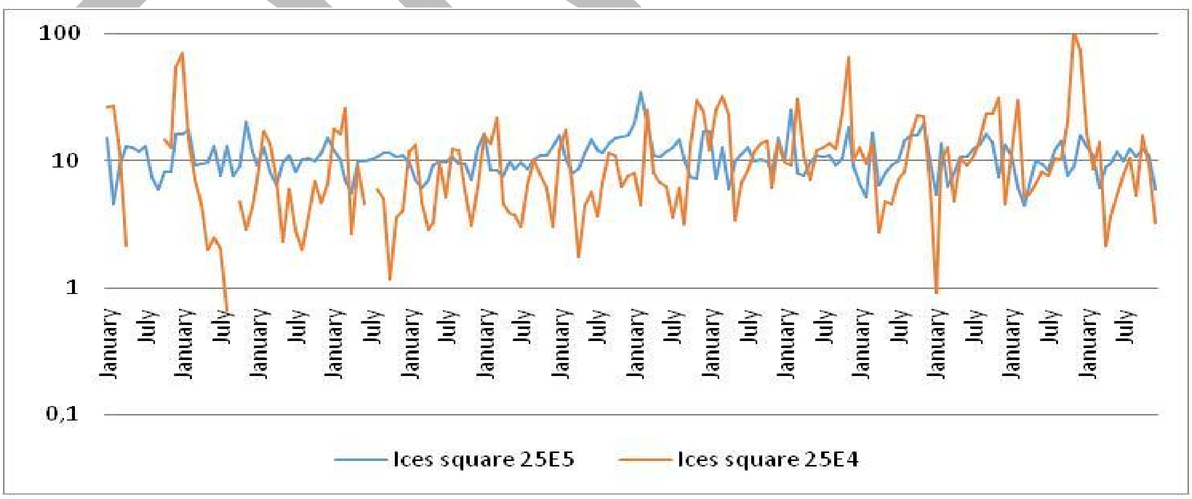


Figure 3:

Example of discrepancies between neigbouring squares

Squares off western Brittany



A detailed analysis of the set of time series is so necessary.

II - 2 Stock(s) structure and migrations

On the basis of the outputs of a multiplicative two factors model (year x month) fitting in the various ICES squares, for each month and each square the average (over years) apparent abundances (see footnote) have been calculated. Apparent abundances are expressed as catches per day of a standard vessel (average over CF1 trawlers more than 15 meters long). This leads to a set of 12 simplified, which use the following shading code.

	Shading	Code	
		<	4.99
	5	to	9.99
	10	to	19.99
	20	to	29.99
		>	30

Figures 4 (1) to 4(12)

Monthly maps of average apparent abundance per square

July

	E4	E5	E6	E7	E8	E9	F0	F1	F2
31								15.1	11.8
30							8.4	9	
29			4.5	5.6	11.3	6.1	9.4	8.2	
28		1.2	1.7	2.8	12.5	10.3	11.5		
27	0.9	1	1.6	4.5		11.2			
26		8.2	5.3	6.6					
25		10.4							
24		9.3	6.5	5					
23			5.7	5.9					
22				7.1					
21				5	7.5				
20				6.2	4.9				
19				7.9	6.5				
18					5.2				
17					5.6				
16					6.3				
15					12				

August

	E4	E5	E6	E7	E8	E9	F0	F1	F2
31								10	8.8
30							6	8.1	
29			4.9	3.7	10.3	4.3	5.3	6.7	
28		1.1	1.7	1.9	13.8	6.3	9.6		
27	1.2	1.6	2	4.9		9.9			
26		8.6	5.3	5.5					
25		11.3							
24		9	7.2	5.3					
23			6.1	5.3					
22			6.1	5.3					
21			6.1	5.3	8.5				
20			6.1	5.3	8.1				
19			6.1	14.1	7.5				
18					6.5				
17					4.3				
16					7.7				
15					13.1				

September

	E4	E5	E6	E7	E8	E9	F0	F1	F2
31								11.7	13.5
30							4.7	11.4	
29			3.5	3.4	10.7	5.6	4.8	7.3	
28		1.5	2.2	2.5	15.9	6.4	9.7		
27	1.8	2.1	1.9	4.1		12.3			
26		7.3	4.7	5.2					
25		10.8							
24		8.9	7.1	5.6					
23			6.7	7.6					
22				10.3					
21				11.6	10.5				
20				14.6	11.1				
19				18.3	12.2				
18					9.1				
17					5.4				
16					9.3				
15					12.6				

October

	E4	E5	E6	E7	E8	E9	F0	F1	F2
31								24.3	17.9
30							7.6	17.4	
29			10.2	4.4	19.3	10	8.6	11	
28		2.4	4	4.1	20	11	15.2		
27	3.8	2.4	4.6	2.8		17.4			
26		7	4.2	5					
25		10.6							
24		10.2	8	6.3					
23			10.4	10.1					
22				12.6					
21				15.3	14.6				
20				24.8	15				
19				9.8	15				
18					10				
17					9.3				
16					6.4				
15					8.4				

November

	E4	E5	E6	E7	E8	E9	F0	F1	F2
31								37	24.8
30							15.8	22.2	
29			14	7	13.7	22.6	16.3	15.4	
28		4.8	4.1	9.7	23.5	15.4	25.7		
27	4.9	5	2.5	6.5		15.4			
26		8.6	4.2	5.9					
25		11							
24		12.8	8.9	10.6					
23			9.1	9.6					
22				12.3					
21				13.5	15.5				
20				25.6	17.6				
19				40	19.4				
18					15.3				
17					14.4				
16					12.6				
15					12.5				

E4	E5	E6	E7	E8	E9	F0	F1	F2
							23.1	14.8
						13.3	20.5	
		12.8	11.7	20.5	40.2	17.1	17.8	
	18.3	9.9	10.2	20.4	28.5	22.4		
16	4.8	5.8	11.8		16.4			
	10.4	6.1	4.8					
	12.6							
	14.4	8.9	10.5					
		8.7	10.4					
			14.9					
			19	20.5				
			21.9	22.1				
			35	36				
				23.9				
				24.5				
				22.7				
				15.7				

January

	E4	E5	E6	E7	E8	E9	F0	F1	F2
31								11.5	9.1
30							11.7	9.9	
29			26.3	18.6	26.8	20.8	12.7	10.7	
28		27.4	20.3	16.8	14.2	17	17.4		
27	15.7	25.4	19	17.9		8.3			
26		7.3	6.7	2.9					
25		11.8							
24		16.1	10.8	7.5					
23			8.5	8.9					
22				12.8					
21				16.9	16.6				
20				17.2	20				
19				17.9	39.6				
18					37.1				
17					33.6				
16					28.2				
15					12.4				

February

	E4	E5	E6	E7	E8	E9	F0	F1	F2
31								8.3	6.9
30							14.9	8.1	
29			20	30.8	33.8	23	13.2	10.2	
28		29.8	29.2	22.7	12.7	19.4	19.1		
27	23.4	33.8	21.9	14.7		15.6			
26		9.9	5.3	3.6					
25		10.4							
24		11.5	7.5	7.8					
23			7.7	9.2					
22				10.6					
21				15.6	12.3				
20				19.4	16.3				
19				26.8	32				
18					25.2				
17					23.4				
16					27.5				
15					10.9				

March

E4	E5	E6	E7	E8	E9	F0	F1	F2
							8.3	7
						25.2	11.4	
		26.8	32.7	39.5	29.7	22.8	11.9	
	30.9	41	29.9	14	21.8	18.1		
17.7	26.1	25.7	16.9		6.3			
	8.8	3.9	4.2					
	8.5							
	10.1	5.3	6.1					
		8.2	9.2					
			10.7					
			10.9	12.7				
			12.9	14.6				
			11.9	22.8				
				17.1				
				15.2				
				10.6				
				6.8				

April

	E4	E5	E6	E7	E8	E9	F0	F1	F2
31								16.2	18.3
30							24.8	15.6	
29			15.1	22.7	20.2	27.1	19.9	13.2	
28		12.9	17.2	11.7	9.4	19.2	20.3		
27	3.3	3.7	6.3	11.1		9.3			
26		7.6	6.5	2.9					
25		7.7							
24		6.5	4.5	3.4					
23			5.1	4.7					
22				6.4					
21				6	9.1				
20				5	8.9				
19				2.3	13.6				
18					9				
17					6.6				
16					3.9				
15					5.6				

May

E4	E5	E6	E7	E8	E9	F0	F1	F2
							20.6	23.2
						13	12	
		2.2	7.1	8	12.9	13.7	9.4	
	5.2	3.5	6.6	9	14.2	16		
2.2	2.5	3.2	5.1		14.3			
	8.8	7.4	4.9					
	10							
	9.1	5.4	5					
		4.5	5.8					
			6.2					
			4.7	9				
			2.3	6.4				
			4.6	8.5				
				5				
				5.3				
				2.9				
				6.6				

June

E4	E5	E6	E7	E8	E9	F0	F1	F2
							14.4	13.4
						9.2	9.5	
		5.6	5	11.2	8.1	11.3	8.1	
	2.1	1.8	2.3	9.5	10.2	13.4		
1.3	1.6	1.9	6.4		12.6			
	10.3	6.4	7					
	10.8							
	10.9	6.6	5.6					
		5.1	6					
			7.7					
			4.6	7				
			3.6	5.7				
			2.9	5.9				
				4.6				
				3.9				
				5.5				
				5				

These maps suggest first of all two major spawning areas located respectively in the North West of the English Channel, and in the south of the bay of Biscay. Over an average year apparent abundance is low in summer for almost all squares.

- In the Channel and the North Sea squares covered in the data set, apparent abundance increases progressively between October and December, following an apparent East to West move. Apparent abundance is high in a set of northern squares, which defines what will be later on the Channel major Spawning ground. A rapid decrease then takes place, which even starts in March for the more western squares, so that in June apparent abundance is low in all squares in the Channel.
- In the Bay of Biscay apparent abundance first increases around latitude 21 in October/November, and becomes very high in the southern part (south of latitude 21), which correspond to what will be considered as the Bay of Biscay major spawning grounds. The apparent abundance then decreases sooner than on the Channel major spawning grounds, since in March it is significantly lower than in the previous months.

Changes in apparent abundance cannot be due only to horizontal migrations. It seems for instance that even at low densities there are sea-bass of commercial size in most squares all year long. Changes in apparent abundance result from a combination of (1) real horizontal migrations, confirmed by tagging programs results (X pers. Com.) and observations from the industry, and (2) changes in "local" catchability, including schooling behaviour and changes in vertical distribution within the water column.. The analysis of seasonal patterns according to the fishing techniques can give some insight about such local changes, and this will be discussed later on. The basic model of two distinct stocks (Channel + North sea ; Bay of Biscay) associated to the previously mentioned major spawning grounds will deserve further discussions. If sea bass in the North is very likely to be related to a component of the Channel stock, relationships between the Channel and the Celtic Sea and adjacent areas cannot be discussed on the basis of the available information. A detailed analysis of the coastal squares around Brittany also reveals that they do not fit for most of them this basic scheme. West of Brittany apparent abundance seem almost stable over the year, which could be consistent with local spawning grounds related to neighbouring coastal nurseries.

The bulk of the catches in the Channel, the North Sea and the Bay of Biscay are likely to be related to the previously mentioned major spawning areas. Available data on sea water temperature show that these areas are compatible with the available literature about sea bass spawning (Ref???=), and that they can be connected to well-known nursery areas along the south west coast of England, and in coastal areas of the Bay of Biscay. This is also true for possible local spawning areas off western Brittany.

Remarks above about stock structure can be, at least partly, confirmed by a comparison of seasonal patterns in the different squares as described by the plotting of the twelve monthly modulation coefficient (see appendix C). The basic suggested stock structure is also consistent with between years changes in the different squares. Figures 5 (1) and 5 (2) below are based upon changes between (geometric) means over years 2000 to 2004 , then 2005 to 2009 and finally years 2010 to 2013. Using averages over years range simplifies the discussion, and limits the influence of "noise"(mainly between vessels variability) on the year effects which are as pointed out more difficult to assess than the stronger seasonal effects. Complete sets of annual effects per square are anyway available as supplementary material (see Appendix D). Figures below are expressed as percentage of change per year between two periods.

Figure 5(a)

Changes between the first (2000-2004) and the second (2005-2009) years ranges

Figure 5(b)

Changes between the second (2004-2009) and the third (2010-2013) years ranges

	E4	E5	E6	E7	E8	E9	F0	F1	F2
31								9.2	6.6
30							10.7	10.5	
29			-2.5	2.3	6.6	6.1	11.1	12.2	
28		12.5	4.6	7.1	-6.8	1.3	3.1		
27	7.7	7.3	7.3	11.1		1.3			
26		3	5.8	-3.5					
25		2.7							
24		-1.9	1.6	19.5					
23			-0.9	4.6					
22				-6.9					
21				-13	-4.1				
20				-7.6	-7				
19				-11	0.7				
18					-12				
17					-14				
16					-14				
15					-24				

	E4	E5	E6	E7	E8	E9	F0	F1	F2
31								11.2	10.7
30							18.4	9.8	
29			-5.2	-2.3	-2.1	4.4	15.6	11.1	
28		4.2	17.7	-2.3	-4.6	2.2	6.9		
27	31.4	14.7	8	14.5		6.2			
26		-1.7	-5.4	7.8					
25		-2.9							
24		-0.9	1.5	-2.6					
23			2.2	2.9					
22				6.9					
21				9.7	3.3				
20				11.9	9.2				
19				6.8	9.3				
18					10.5				
17					18.9				
16					17				
15					14.7				

Shading convention

	<		-20%
-20.00%	<	<	-10%
-9.99%	<	<	0%
0%	<	<	10%
10%	<	<	20%
20%	<		

Figures 5(a) and (b) show that apart from the more northern squares (coastal ones south of Brittany) changes are consistent within the bay of Biscay, mostly negative between periods 1 and 3, then positive between periods 2 and 3, even if in both cases changes are stronger in the southern part.

Within the Channel and Dover straight changes between periods 1 and 2 are positive in most squares. As for changes between periods 2 and 3 they are positive in most cases. This is not true however for squares immediately north of Brittany, which is consistent with previous remarks, but also, which is more difficult to explain for central squares (e.g. 29E7). It cannot also be excluded that even fish issued from neighbouring spawning areas should be considered as being related to different stocks in terms of yield per recruit if they grew up on distinct nursery areas, and if fish remain "faithful" to their feeding areas including since their nursery months.

This being said we do believe that the basic scheme based upon two major spawning areas and a likely secondary one off Brittany is a strong basis for future discussions, and should be considered in future tagging programs.

II-3 Could annual indices of apparent abundance be used for tuning stock assessment

This question is directly related to the discussion about stock structure. This is why analyses below are just preliminary ones and cover various options. Annual indices have in fact been calculated for various areas. Averages over sets of squares have been calculated for statistical reasons over logarithm, then retransformed in kg/day.

Various areas have been considered.

For the channel four combinations have been used:

Splitting between east (1) and west (2), using all individual squares (3), and eventually only squares which correspond to the major spawning area as previously defined (4). The spawning area in question groups seven squares: 29E9, 26E7, 28E7, 29E7, 27E6, 28E6, 27E5.

West of Brittany a set of two squares (24E5/25E5) has been considered.

Within the Bay of Biscay four combinations, mainly based upon latitude ranges have been considered:

- 24E7 / 24E6 / 23E7 (North)
- 23E6 / 22E7 / 21E7 (Central)
- 19E7/19E8/18E8/17E8/15E8 (South which almost coincides with the so-called spawning area)
- All squares from the Bay of Biscay, but the extreme ones (24E7 and 15E8).

Calculations have also been performed using all vessels, gear groups CF1, CF2 and SND, only the less bass selective (see above definition of the 100 vessels targeting more sea bass).

Other analyses have also been performed using only groups of fishing techniques such as fixed gears or mid water trawls. Results are not discussed here, but can be found in the supplementary material (appendix D).

Finally the possibility of using only ñspawning period monthsò,i.e. December to March has been considered.

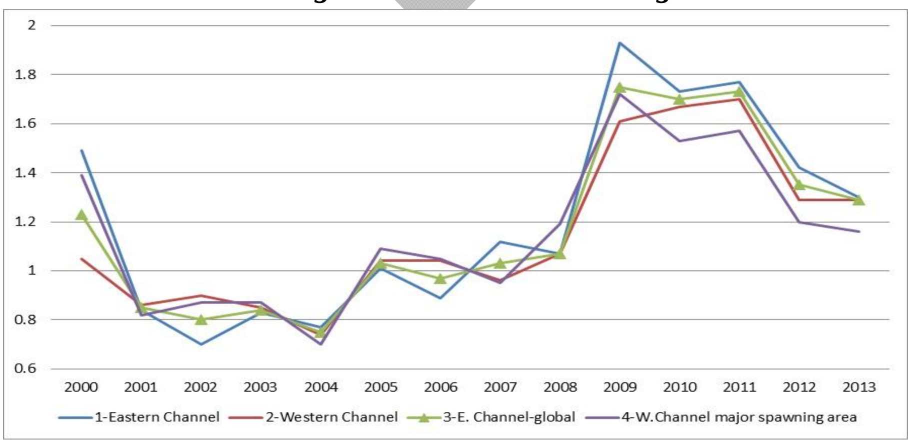
All annual indices are expressed as a ratio, using the geometric mean over years 2006 and 2007 as the denominator. They so vary around one, and close to one for years 2006 and 2007.

For the Channel, using al gears and all months leads to promising results, which do not vary very much according to the square selection, which would back up the idea of a single stock, and seem consistent with previous assessment results.

Figure 6

Annual indices of abundance for various groups of squares

All gears and all months being taken into account



It would seem preferable to select vessels which are more likely to provide simpler relationships between catch rates and real abundance, such as bottom trawls.

Figure 7 a

Annual indices of abundance for various groups of squares all months Bottom trawl + SND and all months

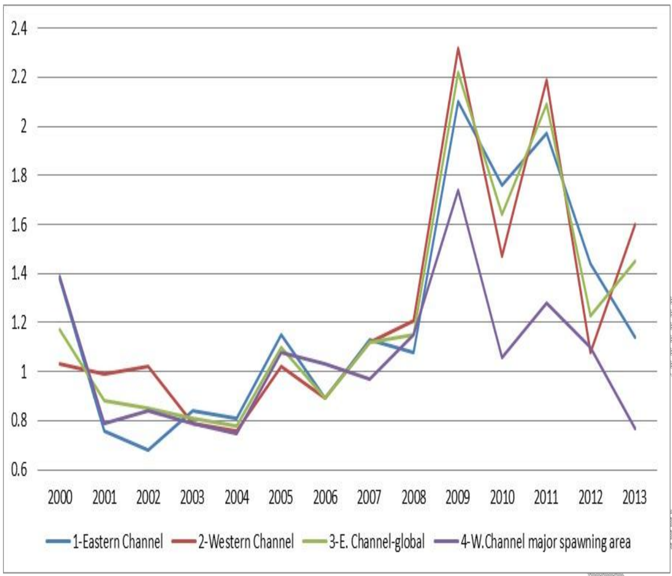
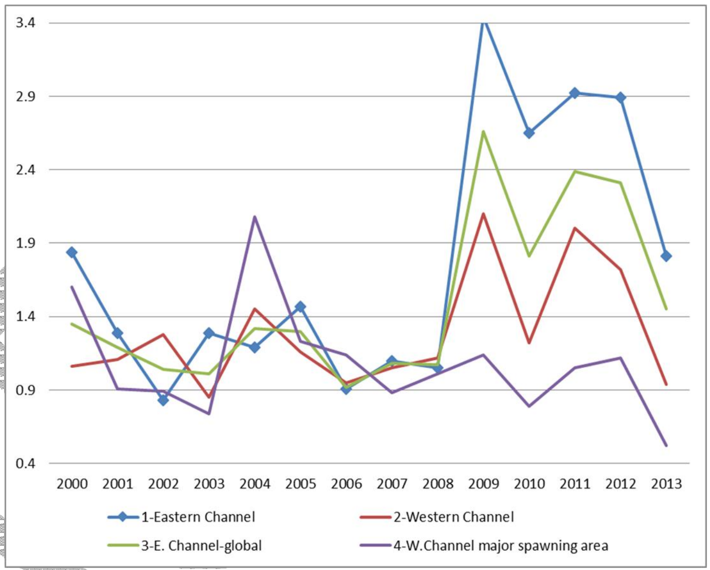


Figure 7 b

Annual indices of abundance for various groups of squares December to March Bottom trawl + SND without the more selective vessels



Results seem more chaotic for recent years (strong year to year changes) and less consistent from one area to another one. The option which corresponds to spawning areas on Figure 7-b, which only takes into account vessels which would appear as the more reliable ones (bottom trawl + SND without the more bass oriented vessels) for the more relevant combination of squares and months (spawning ground squares during the spawning season) does not seem to detect a trend consistent with previous stock assessments. This could be due to the fact that this option only takes into account a limited number of observations, making it more difficult to extract the signal from the noise. In other words selecting the best vessels for the best period in the best area is not necessarily fruitful. Further analyses will be conducted on this issue. In the mean time if one cannot expect that indices calculated with all vessels and all months are simply proportional to real abundance, it would be useful to compare them to estimates of stock abundance issued from integrated stock assessment.

It would be however premature to draw conclusions valid for all stocks, since in the Bay of Biscay results are more robust, as illustrated on figures 8-a and 8-b

Figure 8-a
Bay of Biscay ï analysis for the **global area** using various sets of vessels and months

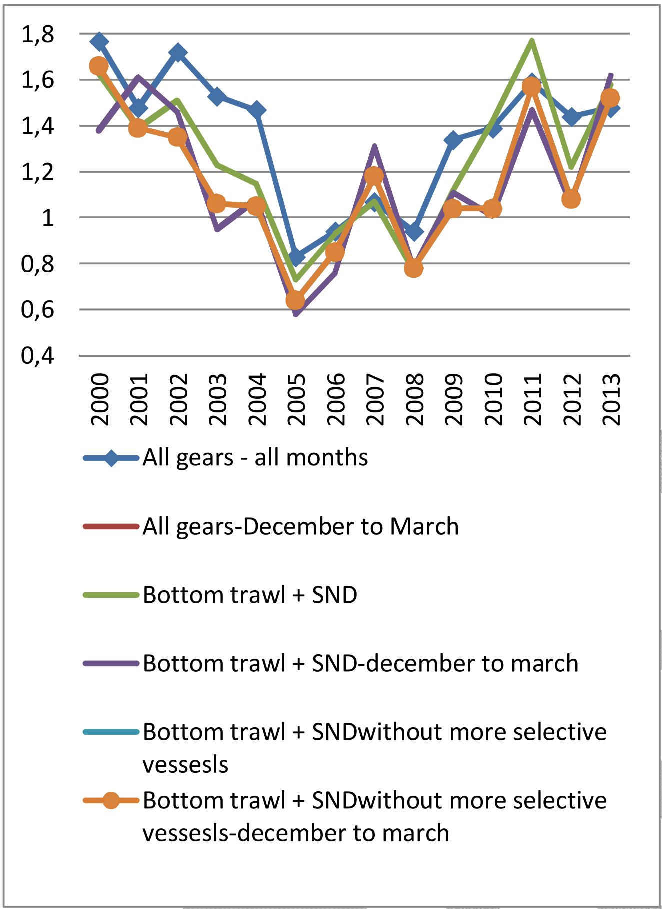
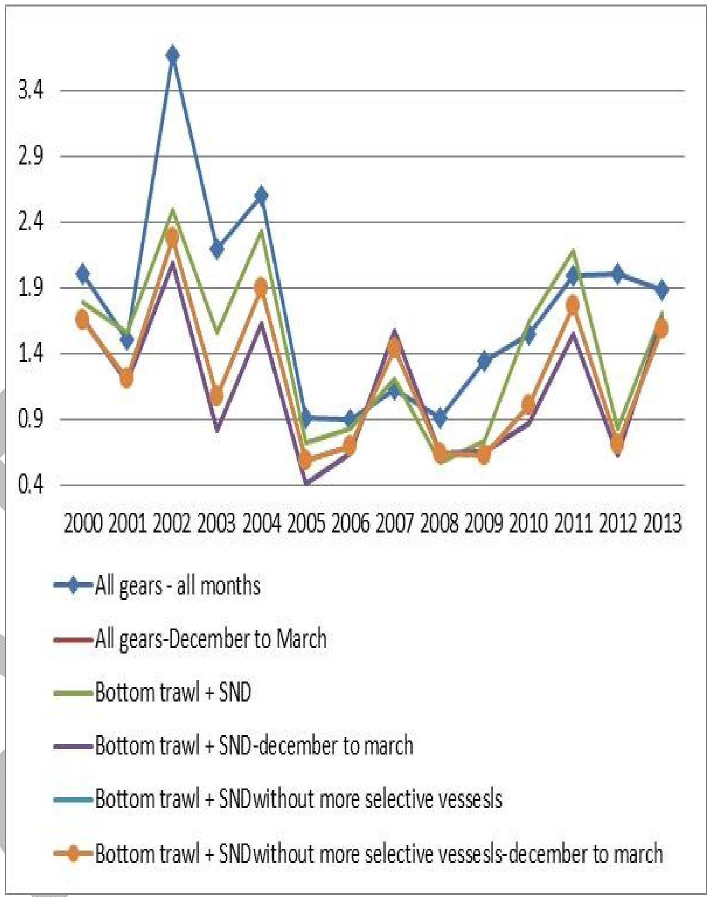


Figure 8-b
Bay of Biscay ï analysis for the **<u>southern part</u>** (spawning grounds) using various sets of vessels and months



The two more important series, because they correspond to extreme options, have been highlighted: all gears all months and Bootom trawl + Snd without the more selective vessels keeping only December to March data. Time series which only cover the southern part are as could be anticipated more noisy. Isolated peaks in 2007 and 2011 would require some specific check of the data base. It seems however possible to conclude that the abundance has decreased severely up to 2005, and has recovered in the following years. This could be considered in connexion with the available catch and effort figures.

Conclusions/Discussion

Very useful material within logbooks. Key results can be obtained using simple techniques (two factors models, averages and least squares).

First conclusions provide a basic hypothesis about stock structures and spawning migrations which will deserve future work in combination with other sources of data.

More work has yet to be done (including the more recent data, assessing uncertainties due to between vessels variability, combination with integrated assessment methods as possible indices of abundance which could reduce uncertainties for the more recent years…).

Appendices

(A) Fishing techniques and groups of fishing techniques

(B) Some results related to fishing powers

(C) Details about seasonal patterns per square

(D) Detailed year effects per square

(E) Why simple two factors models have been preferred

The importance of interactions

Interactions taken into account

Interactions at least partially ignored

Optimality and robustness of the statistical techniques

(F) More about zero values

ANNEXE 2

Getting sea bass annual apparent abundance indices for from log-books

December 2016

Alain Laurec[1] Michael Drogou[2]

Introduction

Linear models have been of common use in the analysis of logbook data since the early works of Robson(1966), Laurec and Fonteneau (1979, Gavaris (1980). In order to assess the vessels effects, the area effect, the seasonal patterns and the between years changes various specific models can be used. This paper[3] discusses the importance of a careful design of the models as well as of the selection of the fishing techniques. It also tries to illustrate how the output from the linear models can be used. If the main aim is to get yearly abundance indices, seasonal patterns will also be discussed, because they are of paramount importance for the stocks structure analysis, which in turn drives how squares should be grouped in order to get overall yearly indices. The analysed data set corresponds to logbooks from the French flag vessels catching sea bass, as detailed in section I. Section II introduces the various models which can be considered, while section III summarizes the main results. The overall aim of this working paper is not an in depth analysis of the data set, but simply to explain the techniques which have been used and to illustrate them.

I Material

The analysed set of log books correspond to the French vessels that caught sea bass between years 2000 and 2015. It includes various fishing techniques: trawls (bottom trawlers as well as mid-water trawls), a few vessels use Scottish seine and others purse seine ("bolinche"), trolling, fixed nets and longlines. What is to be called further a vessel is in fact the combination of a "hull' and a group of fishing techniques, so that that when shifting from a group to another one it becomes a new vessel. Preliminary selection of a set of groups of fishing gears/techniques (e.g. bottom trawls) often takes place.
Catches are recorded as requested by EU regulations per day and ICES square. Fishing hours within a day are sometimes recorded but did not proved useful, so that catches per unit of effort (cpues) are expressed as kilograms of sea bass caught per day in an Ices square. Vessels as well as squares which provided limited data have been eliminated, so that by the end **1034**

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[3]This work is to be completed in the forthcoming months by an analysis of major interactions between years and months (changes between years in seasonal patterns), and by an attempt to apply bootstrap techniques in order to study the sensitivity of the conclusions to the between vessels variability.

vessels (hull x technique) will be considered, as well as **11** groups of fishing techniques, and **70** ICES squares which cover all major fishing areas.

II Methods

A monthly step has been considered, so that basically strata have been used which for each one corresponds to an ICES square, a year and a month. If within a stratum the same vessel provides data for several days, these data are not grouped in order to get a total catch and a total number of days resulting in an average CPUE[4]. The corresponding observations are treated as replicates.

Vessels are associated to index i, Ices squares to j, months to k and years to l. A daily individual observation (data)o (o = 1,....No, No being the number of records in the logbook file) is associated to (1) cpue $\mathbf{U}_o$[5], to vessel i(o), (2) the individual fishing power (the effective one as opposed to the "administrative" fishing power) of which is $\boldsymbol{P}_{i(o)}$, (3) to the Ices square j(o), (4) to month k(o) and (5) to year l(o). In order to use the simplest linearised models, only non null values are considered (the frequency of null and non null catches will be analysed later on). Instead of the original CPUEs U_o, their logarithms (more precisely the decimal ones) u_o have been considered ($u_o = log_{10}(U_o)$). The same applies to fishing powers $p_i = log_{10}(P_i\ ).$). Geographical (square) effects will be considered in some models and noted $\boldsymbol{G}_j$ and g_j for their logarithms. Monthly effects, which may vary from square to square (interactions between square and month effects, which means that seasonal changes in apparent abundance/CPUE may vary between squares) will be considered. $\boldsymbol{S}_{j,k}$ is the monthly effect for square j and month k, and the associated decimal logarithm is $\boldsymbol{s_{j,k}}$. The same logic applies to year effects which may vary between squares, for instance because they are associated to different individual stocks. Year effects (between years "trends") for square j and year l will be $T_{j,l}$ for non transformed values and $t_{j,l}$ for the logarithms. When interactions between squares, months and years are considered (model 1 below), this implies an overall stratum effect $\mathbf{C}_{j,k,l}$ or on a logarithmic scale $\boldsymbol{c_{j,k,l}}$

Three additive models will be considered. For all of them i(o),j(o),k(o) and l(o) are respectively the vessel, the ICES square, the month and the year associated to observation o.

The simplest model brings back to Robson (1966) and a two factors model:

- $(\boldsymbol{Model\ 1})\ \boxed{\mathbf{u_o = p_{i(o)} + c_{j(o),k(o),y(o)} + \epsilon_o^1}}$ ϵ_o^1 being a residual

In a context where interactions between month and year effects are strong, this simple first model offers the best bases (Cheikh-Baye et al (2014)).

The second one is a basic four factors model ((1)vessel (2) square (3) square x month (4) square x year

- $(\boldsymbol{Model\ 2})\ \boxed{\boldsymbol{u_o = p_{i(o)} + \mathbf{g_{j(o)}} + s_{j(o),k(o)} + t_{j(o),l(o)} + \epsilon_o^2}}$ ϵ_o^2 being also a residual

[4]It can be proved that using arithmetic averages then using weighted least squares lead to the same results.

[5]Capital bold letters are used for basic non transformed parameters, by contrast to the logarithmic values. All logarithms are decimal ones.

The last one is a modified four factors models, which considers groups of squares for either months effects or year effects. Fall all squares which belong for seasonal effects to the group gm, month effects are equal for any given month. The same rule applies to year effects , and for instance all squares related to the same stock can be considered as a such a group, even if seasonal patterns may, and will often differ between squares.

- $(\boldsymbol{Model\ 3})$ $\boxed{\boldsymbol{u_o = p_{i(o)} + g_{j(o)} + s_{gm(j(o)),k(o)} + t_{gy(j(o)),l(o)} + \epsilon_o^3}}$

ϵ_o^3 being again a residual.

Constraints must be added to the three equations in order to avoid over parameterization. As for fishing powers the overall sum of log relative fishing powers, or the sum within a specified set of vessels is set to zero. The same rule is applied to month effects within a square (equation II) or a group of squares (equation III).

For all three models parameters are estimated through the minimisation of the sum (over observations) of squared residuals, a residual being the difference between predicted values (see right part of the equations without the residuals) and the observed values u_o . This procedure does not correspond to any optimal criteria in any statistical sense, since optimality would require modelling of the overall statistical distributions which is not realistic. All analyses have shown for instance strong correlations between residuals associated to the same vessel over neighbouring days. Simple least square fitting merely is a robust approach, which happens to give the same results as simple means when there is no “missing” data (when all vessels have provided data for all strata).

Model 1 makes it possible to analyse possible changes in the seasonal pattern for the same square but between years. It is also possible to refer to an average seasonal pattern in order to split month effects from year effects in the stratum effects $c_{j,m(o),y(o)}$related to a single square j. This is best obtained through a second stage fitting of a two factors (month and year) model for each square. This is what has been done in 2015. Within this paper priority has however been given to models II and III, since interactions between years and months will be studied at a later stage. For the time being as for model 1 the key message is that it leads to similar conclusions in terms of average (i) seasonal patterns and (ii) multiannual changes as models 2 and 3, but also that its results appear more noisy (due to the increased number of parameters).

In order to get an “overall” annual index of abundance for a set of squares it is necessary to perform a complementary treatment of yearly abundance indices related to individual squares , whether they come from models I with complementary treatment or from model II. This easiest way corresponds to simple arithmetic means (over logarithms).

Log fishing powers have been standardized setting their overall average to zero. Within each square the average of all (in most cases 12) month log effects have been set to zero. As for year effects the average over years 2008 and 2009 has also been set to zero.

For a number of treatments logarithms are to be used directly. In other cases it may be appropriate to come back to untransformed scales. This is achieved through a simple

y = 1O ^{x} back transform.

III Results

III-1 Details about the specific models applied

Fishing powers results will not be discussed here. Also the key output corresponds to annual abundance indices, some results seasonal patterns are discussed, because they are relevant in terms of stock structures. Year effects use the average (on logarithmic values) over years 2008/2009 as a reference since only changes in apparent abundance are useful.

Various selections of vessels groups have been used: (1) use of the only bottom trawlers. (2) no selection (all fishing techniques being kept) (3) fixed gears (gill nets - longlines) (4) mere elimination of "pelagic" gears (midwater trawls and purse seines=- "bolinche")

Results from model 1 will not be discussed here since they do not add important elements to results from models 2 and 3, model 1 being necessary when there are major changes over years in seasonal patterns, or when focussing on such changes, for instance when looking to the influence of hydrological changes.

As for model 3 two types of squares grouping for annual (gfy = **g**rouping **f**or **y**ears) changes have been considered, based upon available evidences in terms of stock structures, including comparisons between ICES squares of seasonal patterns and year to year changes but also first results of tagging programs, as well as one example of seasonal grouping (gfm = **g**rouping **f**or **m**onth effects).

The first agregation for year effects ***(Grouping 1)*** only considers 9 sets of ICES squares:

- 1/ **Bay of Biscay South** : 15E8 16E8 17E8 18E8 19E7 19E8 20E7 20E8
- 2/ **Bay of Biscay Centre**: 21E6 21E7 21E8 22E6 22E7 22E8
- 3/ **Bay of Biscay North**: 23E5 23E6 23E7 24E3 24E4 24E5 24E6 24E7
- 4 /**West of Brittany** : 25E2 25E3 25E4 25E5
- 5/ **North of Brittany** : 26E8 26E7 26E6 26E5 26E4 26E3
- 6/ **English Channel North West**: 29E7 29E6 28E7 28E6 28E5 28E4 28E3 27E7 27E6 27E5 27E4
- 7/ **Celtic Sea South West** : 32E3 31E4 31E3 31E2 30E4 30E3 29E1 29E3 29E4 29E5
- 8/ **English Channel East**: 27E8 27E9 28E8 28E9 28F0 28F1 29E8 29E9 29F0 29F1 30E9 30F0 30F1
- 9/ **North Sea - South**: : 31F1 31F2 32F1 32F2

The second aggregation ***(Grouping 2)*** correspond to 3 large sets:

- 1/ **Bay of Biscay** (grouping of the first three above mentioned sets (1 + 2 +3)
- 2/ **West of Brittany** is the same as above (25E2 25E3 25E4 25E5)
- 3/ **Enlarged** (to South West of the Celtic Sea and South of the North Sea) **English Channel** which includes all other squares.

Only one example of grouping of squares for the seasonal pattern ***(Grouping 3)*** will be briefly discussed. It considers 8 blocks, within which the individual squares exhibit very similar seasonal patterns.

- 1/ **Bay of Biscay Spawning Grounds Center**: 16E8 17E8 18E8
- 2/**Bay of Biscay North of Spawning Grounds** (Médoc): 20E8 21E7 21E8
- 3**/ Bay of Biscay West of Vendée**: 22E7 23E6 23E7
- 4/ **English Channel West 1**: 27E5 27E628E5
- 5/ **English Channel West 2**: 28E6 28E7
- 6/**English Channel West 3** :27E729E6 29E7
- 7/ **English Channel East :**28E9 29E9
- 8/**North Sea South** : 31F1 31F2

The pivotal study corresponds to model 2 (no grouping) applied to bottom trawlers (Section III-2) . Other ones (sections III-3 and III-4) will only be discussed for comparison purposes. For illustration purposes a set of selected squares will be used for a number of figures. They have been chosen in order to cover a South to North range in the Bay of Biscay, and a West to East range in the English Channel.

III-2 Results from model 2- bottom trawlers

The overall variance of log cpues is equal to 0.50. The average over squared residuals (MSR = mean square residuals) is 0.28. The variance between individual (log) fishing powers is 0.14, the variance between the square effects is 0.18, the average (over squares) of the (log) month effects is 0.12and the equivalent for the year effects is almost the same (0.13).

(1) Seasonal patterns

For each square the corresponding months effects can be associated to a curve, which fluctuates around 1 (logarithms fluctuating around 0). In order to make the pattern in winter easier to perceive, curves have been drawn over a 18 months period, from January to June, the values over the first six months being repeated. It is not possible to put on a single graph the seasonal patterns associated to the 70 squares. Results for the selected set of squares appear in Table III-2 (1), the excel table which covers all squares being part of the complementary material. Figures III-2 (1) and (2) illustrate Table III-2 (1) respectively for the Bay of Biscay and the English Channel.

Another tool has been used in order to visualize month effects, through a simplified map for each month of the values for all squares (appendix 3I – summarized maps). We do hope the reader can guess the contours of UK and France so that he better realises the location of the various squares.

Figures III-2 (1) and (2), maps III-2 (1) and (2) prove that significant seasonal patterns can be highlighted through basic logbook data, for instance major spawning grounds (read squares on map III-2 (1)) where apparent abundance is high in January, while out of the spawning season (see July) apparent abundance corresponds to a very different geographical distributions. Contrasts seem however to be much stronger in the English channel than in the Bay of Biscay. More detailed analyses, including all squares and all months even suggest migrations in both areas, as well as specific patterns (different from both the Bay of Biscay and the English Channel) west of Brittany and may be in the South West of the Celtic Sea.

(2) Year effects and apparent changes between years of apparent abundance[6]

Since neighbouring squares are often related to the same stock, and should then show similar year effects, it has been chosen to select 3 sets of adjacent squares: South of the Bay of Biscay, North West of the English channel and East Channel (see above section III-1), and for each set to calculate for each year the geometric mean over squares[7]. Results appear in tablesII-2 (2) and (3),which correspond to figures III-2(3) and (4), while results for all squares can be found in the complementary material. One can notice that year effects vary below and over 1, the average over years 2008-2009 having been forced to 1 for each square in model2.

In the Bay of Biscay, apart from isolated peaks (see year 2010 in square 17E8), trends have been consistent between squares since 2005, and the average over squares gives a reasonable overall trend.

[6] The geometric average over years 2008 and 2009 has been used as the reference abundance.

[7]The limited number of empty cells makes it possible to use simple geometric averages, although it would be preferable to use a two factors model.

The situation is less favourable in other areas as illustrated by figures III-2 (4), and (5).In the western part of the English Channel, even after setting aside the 2013 value for square 28E4, which will deserve further analyses, and year 2015 which will be treated separately, consistency between squares does not emerge from figure III-2 (4). Squares that correspond to latitude 27 exhibit isolated peaks. By contrast to the Bay of Biscay it does not seem possible in the Western Channel to get useful results at the level of a square, even if some squares (e.g. 28E6) correspond to time series consistent with previous stock assessments. The situation is however better in the Eastern Channel. Apart from three special squares (29F0,30F0 and 27E8) a common multiannual trend emerges, as illustrated by figure III-2 (6) when the previously mentioned squares are set aside.

Averaging over squares multiannual trends

The better regularity of averages over an area has been mentioned. This is further illustrated by table III-2 (5), which groups the averages for all 9 areas defined in section III-1, as well as the overall averages for (i) the Bay of Biscay and (ii) the "enlarged English Channel" (enlarged to South West of the Celtic Sea and the North Sea South). The overall averages are calculated by the geometric means over the 3 component of the Bay of Biscay, and the 5 components of the enlarged English Channel. The West of Brittany area has been kept aside since it exhibits month effects and year effects which do not seem consistent neither with the Bay of Biscay, nor the English Channel. One should also keep in mind that there are some empty cells in the year effect by Ices square table, and that in such a context averages are at best a first approximation.

"Maps"

Another way for illustrating changes over years corresponds to maps associated to a specific difference between years. In order to illustrate midterm changes one can study changes between the 3 years (y-1,y,y+1) and the average three years later (y+2,y+3,y+4). This is quantified by the ratio of the corresponding geometric means, and illustrate by map III-2 (3)
One can notice a real continuity between neighbouring squares, which do not coincide however systematically with current hypotheses about stocks structures.
Short term changes can in the same way be studied by the ratio for each square between year **y** and the geometric mean over years **y-1** and **y+1**, as illustrated by map III-2 (4).
Such a map illustrates the compared singularities of year 2012 over the neighbouring years in the various squares. Some geographical patterns seem to appear.
For the last year, 2015, the most useful comparison is with year 2014, and corresponds to major changes in the sea bass fisheries. It corresponds to map III-2 (5). Violent contrasts between neighbouring squares appear in the English channel, which do deserve detailed examination.

III-3 Results for model 3 - bottom trawlers

As mentioned in section III-1 three groupings have been studied : (1) 9 groups of squares for year effects without grouping for month effects, (2) 3 groups of squares for year effects without grouping for month effects (3) 9 groups of squares for year effects with 8 groups for month effects**.**

(1) Month effects

Detailed results can be found in the complementary material. Table III-3 (1) compares for the 8 groups of squares results obtained from model 2 and simple geometric averages and from model 3. In most cases they are quite similar. However as illustrated by figure III-3 (1) differences may appear.

(2) Year effects

As illustrates by table III-3 (2) year effects for the 9 sets of squares (grouped for year effects) are almost unchanged by grouping for months.

III-4 Selecting gears

Previous analyses rely on the only trawlers. (gears selection 1). As previously mentioned three other selections have been considered: all gears (no selection; selection (2)), fixed gears + hand line (selection (3)) , all gears but midwater trawls and purse seiners ("bolinche") (selection 4). Comparing selections (1) and (3) is of special interest since these two analyses correspond to non overlapping sets of data/vessels. Since data may be scarce, especially in the English channel, an analysis has also been performed with the previously mentioned 8 groups of squares for months. **(1) Month effects**

As illustrated by table III-4 (1) (results for all squares can be found in the complementary material), even between selections (1) and (3), results are quite similar in the southern part of Bay of Biscay, especially when using groups of squares for month effects.North of the Bay of Biscay lags seem to appear between bottom trawlers and "fixed gears". In the Channel even with square grouping for months, it is difficult to find clear patterns, even if the apparent abundance is always higher in winter in the Western part than in the Eastern part, while from April to September it is just the opposite.

(2) Year effects

Table III-4 (3) gives the results for the basic areas (grouping for years), area 7 (Celtic Sea - South West has been excluded because there are not enough relevant data for fixed gears) and gears selections 1 and 3 (bottom trawling ; fixed gears + hand line). Complete results are available in the complementary material.

Figures III-4 (1) to (5) make it possible to compare respectively for the Bay of Biscay, West Brittany and the English Channel enlarged to Southern North Sea multiannual changes in the apparent abundance obtained on one hand from bottom trawlers and on the other hand fixed gears and hand lines.

(i) In the **Bay of Biscay** results are quite consistent from one area to another, and from one gears selection to another, apart from changes in the northern part over the last years.

(ii) West of Brittany results do vary according to the gear selection, and cannot be easily related neither to the Bay of Biscay (North) nor to the English Channel (West).

(iii) For the area **English Channel + North Sea South** , between 2009 and 2013 a similar declining trend can be found in most areas (but for North Sea South, which does not correspond to a large data set) for both gears selections. The increase in 2014, and even more in 2015, only appears for bottom trawlers in the western part of the English Channel, which deserves further analysis.

Conclusions

Simple linear models applied to logbooks data make it possible to reveal useful patterns. A large number of models are however possible, and one must carefully define the details of the specific models that are used.

Although this point has not been addressed in this paper when interactions between year and month in a square (indicated changes between years in the seasonal patterns) model 1 (two factors) is necessary. But for this specific case Model 2 offers the most appropriate basis. Grouping of squares (model 3) so that within a group the same year or month effects are imposed has to be preferred[8] to averaging over squares after square specific year effects have been calculated through model 2. It reduces the number of parameters in the model. Time series describing month or year effects are of course necessary, but simple maps are also useful.

In terms of preliminary results compared seasonal patterns in the different squares are robust to changes in the details of the model, as well as, apart from some nuances, to the selection of gears. They do reveal crucial patterns in the stocks structures debate. If year effects are also robust in the Bay of Biscay, and to a large extent up to 2013 in the English Channel, recent developments in this later area require further analyses.

[8] One should however that least squares fitting over individual obesrvations result in giving more weight to squares (and) vessels which did provide more individual observations. IN some cases it could be wise to compensate it by an appropriate use of weighted least squares.

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Appendix 1 : Tables

Table III-2 (1) : Seasonal patterns for selected squares

Square/month	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
16E8	2.96	2.91	1.65	0.68	0.87	0.34	0.67	0.24	0.65	1.73	1.16	1.63
17E8	3.85	2.65	0.74	0.59	0.6	0.29	0.67	0.85	0.88	1.49	1.24	1.39
22E7	1.33	1.34	1.86	0.84	0.62	0.6	0.65	0.53	0.95	1.49	1.55	1.27
23E7	0.88	1.2	1.5	0.75	0.91	0.84	0.73	0.75	1.03	1.34	1.2	1.19
27E5	5.31	6.7	3.88	0.79	0.49	0.29	0.17	0.49	0.52	0.56	1.08	2.4
27E6	3.38	4.73	2.99	1.2	0.6	0.34	0.36	0.36	0.5	0.5	1.35	1.91
29E8	1.71	0.72	1.55	1.11	0.38	1.04	0.77	0.41	0.5	1.23	2.22	2.76
29F0	0.81	1	1.65	1.87	1.33	1.08	1.05	0.39	0.38	0.83	1.43	1.47
31F1	0.84	0.73	0.79	1.19	1.03	0.62	0.66	0.55	0.81	1.68	2.93	1.89
31F2	**0.48**	**0.13**	**1.29**	**0.83**	**0.76**	**1.57**	**0.96**	**0.81**	**1.13**	**2.04**	**2.6**	**2.62**

Table III-2(2) year effects for the South of the Bay of Biscay[9]

Square/year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
16E8	3.71		3.07	0.34	1	0.47	0.33	1.21	0.39	2.55			1.21	2.71	2.61	5.03
17E8	2.07	2.98	4.56	1.06	2.07	0.73	0.59	1.42	1.05	0.95	6.26	2.6	1.27	1.32	2.11	2.38
18E8	1.44	1.3	2.33	1.74	2.7	0.44	0.44	0.65	0.57	1.74	2.09	1.55	0.67	0.97	1.11	1.67
19E7	1.5	0.51	3.88	3.61	0.4	0.36	1.06	0.6	0.43	2.31	0.9	1.5	0.8	1.91	1.61	2.13
19E8	2.06	1.4	2.16	0.74	0.83	0.57	0.36	0.7	0.78	1.27	1.03	1.6	1.24	1.24	1.23	1.3
20E7	0.86	0.9	1.33	1.38	1.04	0.27	0.62	0.64	0.71	1.39	0.79	1.67	1.12	1.47	1.67	2.49
20E8	0.74	0.88	1.72	0.97	1.09	0.43	0.62	0.49	0.78	1.27	1.1	1.21	1.23	1.39	1.2	1.32
Average	**1.47**	**1.12**	**2.24**	**1.11**	**1.11**	**0.5**	**0.58**	**0.79**	**0.67**	**1.47**	**1.4**	**1.53**	**1.04**	**1.42**	**1.49**	**1.92**

Table III-2(3) Year effects for the East of the English Channel

Square/year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2015
27E8	0.56	0.22	0.48	1.27	0.91	1.45	0.6	1.83	1	0.99	1.61	1	1.07	3.04	2.79
27E9	0.64	0.46	0.44	0.46	0.44	0.83	0.85	0.92	1.01	0.98	1.46	0.98	0.96	0.76	0.66
28E8	2.01	1.13	0.61	1.44	1.28	1.3	1.08	1.05	0.83	1.19	1.05	1.07	0.91	1.05	0.97
28E9	1.4	0.53	0.4	0.57	0.6	0.81	0.47	0.67	0.92	1.07	0.91	0.88	0.82	0.64	0.61
28F0	0.64	0.27	0.31	0.51	0.47	1.09	0.94	0.68	0.77	1.29	1.31	0.89	0.85	0.7	0.79
28F1			0.46	0.57	0.41	2.02	2.3	1.11	1.23	0.8	1	1.87	0.95	0.71	1.43
29E8	1.09	0.58	1.06	0.63	0.89	0.65	0.61	0.96	0.91	1.09	0.78	1.24	0.82	0.6	0.58
29E9	1.12	0.47	0.44	0.42	0.4	0.62	0.59	0.87	0.9	1.1	0.79	0.91	0.95	0.89	0.84
29F0	0.79	0.32	0.31	0.39	0.37	0.43	0.53	0.64	0.69	1.43	1.09	1.53	2	1.88	1.48
29F1	1.16	0.37	0.4	0.28	0.35	0.57	0.69	0.84	0.65	1.53	1.85	1.78	1.74	0.75	1.02
30E9	0.83	0.36	0.09	0.32	0.22	0.34	0.93	0.32	0.84	1.18	1.79	1.92	0.84	1.06	0.66
30F0	0.98	0.5	0.39	0.32	0.45	0.58	0.59	0.9	0.6	1.65	1.45	1.75	2.68	4.58	1.44
30F1	0.51	0.26	0.29	0.31	0.29	0.49	0.46	0.61	0.39	2.55	1.5	1.12	1.48	0.85	0.9
Average	**0.91**	**0.42**	**0.39**	**0.5**	**0.48**	**0.76**	**0.74**	**0.82**	**0.8**	**1.24**	**1.23**	**1.25**	**1.14**	**1.07**	**0.98**

Table III-2 (4): Year effects for the North West of the English Channel

[9]Results from the only bottom trawlers do not make it possible to cover square 15E8

Square/year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
27E4	0.19	0.4	0.44	0.4	0.33	0.23	0.33	0.37	0.53	1.87	1.54	3.8	1.87		0.85	2.25
27E5	0.66	0.37	0.59	0.65	0.56	0.58	0.78	0.72	0.58	1.72	2.46	3.68	2.28		1.41	2.2
27E6	0.33	0.22	0.38	0.18	0.21	0.24	0.16	0.19	0.75	1.32	0.47	0.32	0.16	0.38	1.03	0.51
27E7	0.82	0.58	1.48	0.69	1.01	1.17	1.61	1.44	0.68	1.45	2.2	2.05	3.76	2.36	1.13	0.82
28E3	0.01	1	0.05	0.08	0.02	0.04	0.06	0.4	0.29	3.37		0.98	1.11		0.26	2.83
28E4	0.44	0.19	0.21	0.55	0.35	0.39	0.32	0.32	0.82	1.21	0.56	1.96		17.2	0.79	2.55
28E5	0.8	0.65	0.97	0.57	0.57	0.79	1.11	0.67	0.67	1.47	1.39	1.47	1.61	0.48	1.17	3.82
28E6	1.34	1.09	1.18	0.93	0.89	0.96	0.82	0.7	1.44	0.69	0.69	0.81	0.84	0.64	1.3	4.68
28E7	0.52	0.43	0.47	0.35	0.6	0.27	0.41	0.38	1.27	0.78	0.34	0.25	0.32	0.22	0.4	1.7
29E6	1.28	1.2	1.75	0.98	0.55	2.52	2.29	1.92	0.92	1.08	0.94	0.99	1.23	1.06	1.43	2.34
29E7	1.86	0.65	0.89	1.26	0.61	1.44	1.14	0.86	1.08	0.92	0.77	0.85	0.83	0.46	0.64	1.45
Average	**0.47**	**0.5**	**0.55**	**0.48**	**0.39**	**0.5**	**0.55**	**0.59**	**0.76**	**1.31**	**0.94**	**1.15**	**1.03**	**0.92**	**0.85**	**1.95**

Table III-2 (5) Geometric averages over squares of the year effects for groups of squares

Area/year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
BoB South	1.47	1.12	2.24	1.11	1.11	0.5	0.58	0.79	0.67	1.47	1.4	1.53	1.04	1.42	1.49	1.92
BoB Center	1.67	1.26	1.06	0.95	0.98	0.8	1.03	0.96	0.74	1.33	1.53	1.79	1.76	1.66	1.26	1.78
BoB North	0.84	0.73	0.58	0.39	0.41	0.46	0.69	0.86	0.84	1.21	1.26	1.39	1.09	1.17	1.15	1.51
BoB Global	**1.27**	**1.01**	**1.12**	**0.75**	**0.77**	**0.57**	**0.74**	**0.87**	**0.75**	**1.33**	**1.39**	**1.56**	**1.26**	**1.4**	**1.29**	**1.73**
West of Britt.	**2.25**	**0.46**	**0.22**	**0.67**	**0.27**	**0.43**	**0.52**	**0.74**	**0.63**	**1.82**	**1.54**	**2.5**	**1.8**	**0.94**	**1.32**	**1.72**
North of Britt.	0.27	0.42	0.27	0.32	0.19	0.5	0.27	0.59	0.79	1.3	0.92	1.15	1.21	0.59	0.53	1.31
En.Ch.NW	0.47	0.5	0.55	0.48	0.39	0.5	0.55	0.59	0.76	1.31	0.94	1.15	1.03	0.92	0.85	1.95
Celtic SEa SW	0.84	1.67	1.38	1.26	1.63	1.16	1.15	0.86	0.84	1.38	1.59	3.04	6.37	0.69	3.11	2.24
En.Ch.East	0.91	0.42	0.39	0.5	0.48	0.76	0.74	0.82	0.8	1.24	1.23	1.25	1.14	1.07	0.98	0.83
N.Sea South	0.46	0.31	0.39	0.43	0.58	0.85	1.55	1.18	0.66	1.5	2.85	2.35	4.57	2.49	2.46	4.41
E. Chn Global	**0.54**	**0.54**	**0.5**	**0.53**	**0.51**	**0.71**	**0.72**	**0.78**	**0.77**	**1.34**	**1.37**	**1.64**	**2.11**	**1**	**1.28**	**1.84**

Table III-3 (1)<u>Influence of grouping for year effects on month effects</u>

Square	**Grouping**	**Jan.**	**Feb.**	**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
16E8	no	2.96	2.9	1.64	0.68	0.87	0.34	0.66	0.24	0.64	1.73	1.16	1.63
16E8	1(9gfy)	2.73	2.92	1.33	0.51	1.62	0.6	0.35	0.47	0.61	1.57	0.89	1.36
16E8	2(3gfy)	2.64	3.01	1.26	0.52	1.67	0.59	0.38	0.48	0.65	1.53	0.83	1.27
17E8	no	3.85	2.64	0.74	0.59	0.6	0.28	0.67	0.85	0.87	1.49	1.24	1.38
17E8	1(9gfy)	3.52	2.09	0.79	0.67	0.64	0.37	0.66	0.77	0.98	1.43	1.19	1.29
17E8	2(3gfy)	3.14	2.21	0.76	0.7	0.62	0.32	0.66	0.89	0.93	1.42	1.31	1.34
22E7	no	1.33	1.33	1.85	0.84	0.62	0.6	0.65	0.52	0.94	1.48	1.54	1.26
22E7	1(9gfy)	1.39	1.37	1.87	0.81	0.58	0.58	0.64	0.55	0.97	1.5	1.57	1.28
22E7	2(3gfy)	1.36	1.33	1.81	0.84	0.61	0.61	0.69	0.55	0.95	1.45	1.53	1.25
23E7	no	0.87	1.2	1.49	0.75	0.91	0.83	0.73	0.75	1.03	1.34	1.19	1.19
23E7	1(9gfy)	0.88	1.2	1.49	0.76	0.91	0.83	0.72	0.75	1.04	1.35	1.21	1.2
23E7	2(3gfy)	0.89	1.21	1.51	0.75	0.91	0.83	0.72	0.76	1.05	1.34	1.2	1.19
27E5	no	5.3	6.69	3.87	0.79	0.48	0.29	0.17	0.48	0.52	0.56	1.08	2.4
27E5	1(9gfy)	5.78	6.74	4.03	0.78	0.51	0.31	0.18	0.51	0.52	0.5	0.91	2.44
27E5	2(3gfy)	5.5	6.46	3.92	0.81	0.53	0.31	0.17	0.48	0.54	0.49	1.02	2.42
27E6	no	3.38	4.73	2.98	1.2	0.6	0.34	0.36	0.36	0.5	0.49	1.35	1.91

Grammar for describing the various groupings**<u>i</u>** (**<u>j</u>**gfy) = grouping number i in section III-1 with j groups for year effects

Table III-3 (2) <u>Influence of grouping for month effects on month effects</u>

Area	Model	Jan.	Feb.	Mar	Ap.	May	Jun	July	Aug.	Sep.	Oct.	Nov	Dec.
BoB Spn-Area Center	2+average	3.46	2.3	1.09	0.6	0.87	0.46	0.45	0.59	0.8	1.35	1.1	1.46
BoB Spn-Area CEnter	3 (9;8)	3.94	2.19	1.19	0.66	0.65	0.45	0.42	0.6	0.9	1.19	1.18	1.6
BoB Spn-Area North	2 + averaging	1.31	1.38	1.2	0.68	0.62	0.59	0.55	0.82	1.11	1.51	1.44	1.65
BoB Spn-Area North	3 (9;8)	1.32	1.38	1.2	0.69	0.68	0.63	0.59	0.8	1.04	1.38	1.4	1.63
BB Wvnd	2 + averaging	1.13	1.55	1.38	0.67	0.61	0.67	0.53	0.65	1.19	1.51	1.43	1.62
BB Wvnd	3 (9;8)	1.1	1.21	1.45	0.73	0.84	0.75	0.66	0.72	1.02	1.41	1.34	1.24
ECH-NW1	2 + averaging	4.64	5.49	3.89	1.22	0.59	0.28	0.26	0.39	0.4	0.45	1.06	2.27
ECH-NW1	3 (9;8)	5.03	5.41	4.16	1.25	0.6	0.3	0.25	0.39	0.38	0.43	1.06	2.32
E.Ch-NW2	2 + averaging	2.59	3.75	5.37	2.59	1.02	0.32	0.41	0.23	0.28	0.6	0.85	1.52
E.Ch-NW2	3 (9;8)	1.93	2.22	3.27	2.6	0.82	0.79	0.59	0.5	0.45	0.41	0.64	1.21
E.CH-NW3	2 + averaging	1.82	2.01	3.08	2.21	0.73	0.77	0.49	0.54	0.48	0.6	0.75	1.06
E.CH-NW3	3 (9;8)	2.62	3.92	5.32	2.62	1.02	0.33	0.42	0.24	0.28	0.59	0.82	1.55
E.Ch.East	2 + averaging	1.12	1.53	1.96	1.8	0.93	0.81	0.63	0.39	0.37	0.72	1.31	2.34
E.Ch.East	3 (9;8)	1.06	1.48	1.99	1.75	0.94	0.84	0.7	0.43	0.38	0.75	1.24	2.23
South North Sea	2 + averaging	0.66	0.29	1.21	1.08	0.88	0.84	0.7	0.63	0.98	1.87	2.72	2.23
South North Sea	3 (9;8)	0.84	0.51	0.85	1.06	0.9	0.8	0.67	0.6	0.9	1.8	2.79	2.01

Details of square groupings **(i;j)**:

i =number of groups for year effects **, j** = number of groups for month effects (see section III-1)

Table III-3 (3)

Influence of grouping for months on year effects

Group	Year - 2000+ -> Grouping	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
1BoBSouth	Model3(9,0)	0.95	1.03	1.93	0.99	1.14	0.44	0.55	0.55	0.7	1.29	1.1	1.36	1.08	1.29	1.38	1.54
1BoBSouth	Model3(9,8)	0.93	1.02	1.9	0.99	1.13	0.44	0.54	0.55	0.7	1.29	1.1	1.35	1.07	1.29	1.36	1.52
2BoBCent.	Model3(9,0)	1.38	0.99	0.99	0.95	1.04	0.72	0.95	0.98	0.9	0.99	1.13	1.28	1.45	1.33	1.45	1.35
2BoBCent.	Model3(9,8)	1.43	1.05	1.01	1	1.09	0.74	0.98	0.99	0.91	0.98	1.12	1.26	1.43	1.32	1.42	1.39
3BoNorth	Model3(9,0)	1.39	0.71	0.61	0.58	0.65	0.75	1.02	1.07	0.93	1.07	1	1.25	1.3	1.27	1.54	1.42
3BoNorth	Model3(9,8)	1.39	0.71	0.61	0.58	0.66	0.75	1.02	1.08	0.94	1.07	1	1.25	1.31	1.27	1.55	1.43
4 W Brit.	Model3(9,0)	0.77	0.24	0.32	0.26	0.28	0.33	0.39	0.56	0.61	1.45	1.13	1.58	2.61	0.88	0.84	1.24
4 W Brit.	Model3(9,8)	0.77	0.24	0.32	0.26	0.28	0.33	0.39	0.56	0.61	1.45	1.13	1.58	2.62	0.88	0.84	1.24
5E.Ch.NBr.	Model3(9,0)	1.03	0.87	0.81	0.77	0.53	0.73	0.97	1.01	0.66	1.6	0.95	1.18	0.88	0.71	0.95	2.22
5E.Ch.NBr.	Model3(9,8)	1.03	0.87	0.81	0.77	0.53	0.73	0.97	1.01	0.66	1.6	0.95	1.18	0.88	0.71	0.95	2.22
6E.Ch.NW.	Model3(9,0)	0.87	0.59	0.88	0.67	0.61	0.76	0.81	0.67	1.03	1.15	0.85	0.98	0.7	0.48	0.73	1.74
6E.Ch.NW.	Model3(9,8)	0.88	0.61	0.89	0.69	0.62	0.75	0.82	0.69	1.03	1.15	0.84	0.98	0.71	0.49	0.73	1.73
7Celt.sea SW	Model3(9,0)	0.49	0.47	0.53	0.66	0.55	0.5	0.43	0.36	0.63	1.12	1.42	1.08	6.23	0.31	0.53	1.24
7Celt.sea SW	Model3(9,8)	0.49	0.47	0.53	0.66	0.55	0.5	0.43	0.36	0.63	1.11	1.42	1.08	6.25	0.32	0.53	1.26
8E.ChEast	Model3(9,0)	0.94	0.42	0.4	0.44	0.46	0.66	0.6	0.76	0.76	1.19	1.1	1.09	1.15	0.95	0.88	0.83
8E.ChEast	Model3(9,8)	0.94	0.42	0.4	0.44	0.45	0.66	0.6	0.76	0.76	1.19	1.11	1.09	1.16	0.95	0.88	0.83
9E.ChN.NS	Model3(9,0)	0.57	0.28	0.33	0.42	0.55	0.58	0.69	0.73	0.5	1.27	1.59	1.57	1.32	1.26	1.83	1.58
9E.ChN.NS	Model3(9,8)	0.57	0.28	0.32	0.41	0.55	0.56	0.68	0.73	0.51	1.24	1.57	1.47	1.26	1.22	1.77	1.57

Table III-4 (1) Influence of gear selection on month effects for selected squares

Gear selection	Square	Jan.	Feb.	Mar.	Ap.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Bottom trawling	***16E8***	2.73	2.92	1.33	0.51	1.62	0.6	0.35	0.47	0.61	1.57	0.89	1.36
all gears	***16E8***	2.56	2.08	1.1	0.61	0.44	0.56	0.88	0.81	0.99	0.77	1.09	1.91
Fixed gears + hand lines	***16E8***	2.51	2.07	1.15	0.64	0.4	0.56	0.95	0.78	0.94	0.71	1.18	1.98
pelagic gears excluded	***16E8***	2.5	2.1	1.15	0.62	0.43	0.56	0.87	0.8	0.98	0.77	1.09	1.93
Bottom trawling	***17E8***	3.52	2.09	0.79	0.67	0.64	0.37	0.66	0.77	0.98	1.43	1.19	1.29
all gears	***17E8***	2.88	2.17	1.21	0.57	0.51	0.48	0.79	0.63	1.01	0.91	1.11	1.81
Fixed gears + hand lines	***17E8***	2.64	2.32	1.48	0.57	0.48	0.53	0.83	0.57	1.02	0.73	1.05	2.03
pelagic gears excluded	***17E8***	2.97	2.13	1.28	0.56	0.5	0.5	0.79	0.63	1	0.91	1.1	1.78
Bottom trawling	***22E7***	1.39	1.37	1.87	0.81	0.58	0.58	0.64	0.55	0.97	1.5	1.57	1.28
all gears	***22E7***	1.23	1.12	1.23	0.74	0.77	0.73	0.72	0.8	0.97	1.21	1.33	1.59
Fixed gears + hand lines	***22E7***	1.21	1.03	1.08	0.69	0.72	0.75	0.73	0.86	1.04	1.15	1.4	1.88
pelagic gears excluded	***22E7***	1.26	1.13	1.26	0.7	0.68	0.7	0.7	0.79	0.99	1.27	1.45	1.66
bottom trawling	***23E7***	0.88	1.2	1.49	0.76	0.91	0.83	0.72	0.75	1.04	1.35	1.21	1.2
all gears	***23E7***	1.14	1.15	1.31	0.69	0.76	0.77	0.77	0.82	0.97	1.29	1.29	1.42
Fixed gears + hand lines	***23E7***	1.45	0.82	1.05	0.58	0.6	0.76	0.87	0.94	0.96	1.31	1.58	1.86
pelagic gears excluded	***23E7***	1.07	1.07	1.34	0.68	0.74	0.78	0.79	0.83	0.99	1.32	1.33	1.46
bottom trawling	***27E5***	5.78	6.74	4.03	0.78	0.51	0.31	0.18	0.51	0.52	0.5	0.91	2.44
all gears	***27E5***	7.56	8.39	4.94	0.83	0.47	0.26	0.17	0.48	0.43	0.51	0.94	1.91
pelagic gears excluded	***27E5***	5.61	6.78	4.13	0.81	0.5	0.3	0.18	0.5	0.49	0.54	0.99	2.25
bottom trawling	***27E6***	3.08	5	3.2	1.33	0.67	0.3	0.32	0.35	0.46	0.54	1.35	2.04
all gears	***27E6***	4.42	5.47	4.94	1.58	0.57	0.25	0.31	0.34	0.39	0.52	1.07	1.68
Fixed gears + hand lines	***27E6***						18.6	2.38	2.63			0.02	0.38
pelagic gears excluded	***27E6***	3.08	5.09	3.07	1.29	0.67	0.3	0.35	0.38	0.45	0.57	1.2	1.92
bottom trawling	***29E8***	1.81	0.81	1.71	1.23	0.38	0.91	0.7	0.42	0.47	1.38	2.33	2.12
all gears	***29E8***	1.87	1.27	2.27	1.16	0.42	1.05	0.78	0.49	0.56	1	1.35	1.27
pelagic gears excluded	***29E8***	1.76	0.85	1.7	1.25	0.39	0.92	0.71	0.42	0.48	1.22	2.21	2.28
bottom trawling	***29F0***	0.82	1	1.74	1.88	1.29	1.02	1.02	0.4	0.38	0.83	1.5	1.49
all gears	***29F0***	0.78	0.96	1.64	1.79	1.23	1.12	1.07	0.42	0.42	0.81	1.49	1.43
Fixed gears + hand lines	***29F0***	1.46	0.19	0.52	1.19	0.88	4.24	1.25	0.56	1.13	0.94	1.37	1.49
pelagic gears excluded	***29F0***	0.8	0.97	1.66	1.81	1.21	1.11	1.05	0.42	0.41	0.82	1.47	1.45
bottom trawling	***31F1***	0.92	0.67	0.75	1.23	1.01	0.53	0.57	0.59	0.88	1.83	3.03	1.99
all gears	***31F1***	0.94	0.68	0.45	1.26	1.27	0.64	0.65	0.56	0.89	1.88	2.87	1.95
Fixed gears + hand lines	***31F1***	0.54	0.47	0.38	1.58	2.15	1.55	1.66	0.56	1.23	2.24	1.06	0.74
pelagic gears excluded	***31F1***	0.93	0.68	0.46	1.27	1.28	0.66	0.64	0.56	0.88	1.85	2.84	1.93
bottom trawling	***31F2***	0.49	0.13	1.99	0.95	0.77	1.36	0.87	0.69	1.09	1.95	2.47	2.49
all gears	***31F2***	0.7	0.43	0.62	1.24	1.74	0.88	0.85	0.72	1.08	1.6	1.89	1.38
Fixed gears + hand lines	***31F2***	0.74	0.51	0.65	1.47	2.23	0.81	0.8	0.72	1.12	1.49	1.7	0.95
pelagic gears excluded	***31F2***	0.7	0.44	0.62	1.26	1.75	0.89	0.84	0.71	1.08	1.6	1.87	1.37

Table III-4 (2)

Influence of gear selection after grouping for months

Gears	Area	Jan.	Feb.	Mar.	Ap.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Bottom trawling	**BoB SpG-Ctr**	3.94	2.19	1.19	0.66	0.65	0.45	0.42	0.6	0.9	1.19	1.18	1.6
Fixed gears + hand lines	**BoB SpG-Ctr**	2.56	2.25	1.22	0.75	0.49	0.59	0.72	0.63	0.83	0.7	1.23	2.04
Bottom trawling	**BoB NoSpG**	1.32	1.38	1.2	0.69	0.68	0.63	0.59	0.8	1.04	1.38	1.4	1.63
Fixed gears + hand lines	**BoB NoSpG**	1.86	1.46	1.22	0.74	0.67	0.51	0.57	0.69	0.82	1.12	1.56	2.13
Bottom trawling	**BOB Wvnd**	1.1	1.21	1.45	0.73	0.84	0.75	0.66	0.72	1.02	1.41	1.34	1.24
Fixed gears + hand lines	**BOB Wvnd**	1.29	0.94	1.04	0.63	0.67	0.81	0.84	0.94	1	1.2	1.41	1.74
Bottom trawling	**ECH-NW1**	5.03	5.41	4.16	1.25	0.6	0.3	0.25	0.39	0.38	0.43	1.06	2.32
Fixed gears + hand lines	**ECH-NW1**						11.4	1.45	1.65	5.31	2.03	0.01	0.24
Bottom trawling	**E.Ch-NW2**	1.93	2.22	3.27	2.6	0.82	0.79	0.59	0.5	0.45	0.41	0.64	1.21
Fixed gears + hand lines	**E.Ch-NW2**	3.26	3.16	1.26	1.02	0.59	0.77	0.87	0.81	0.79	0.44	0.69	0.98
Bottom trawling	**E.CH-NW3**	2.62	3.92	5.32	2.62	1.02	0.33	0.42	0.24	0.28	0.59	0.82	1.55
Fixed gears + hand lines	**E.CH-NW3**	2.71	0.46	0.41	0.21	1.07	1.65						5.36
Bottom trawling	**E.Ch.East**	1.06	1.48	1.99	1.75	0.94	0.84	0.7	0.43	0.38	0.75	1.24	2.23
Fixed gears + hand lines	**E.Ch.East**	0.56	0.34	1.27	1.24	0.75	0.8	1.51	0.67	1.24	2.29	2.26	0.88

Table III-4 (3) Year effects - impact of gears selection

Area	Year ->2000+ Gears	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
1BoBSouth	1-BtmTwl	0.93	1.02	1.9	0.99	1.13	0.44	0.54	0.55	0.7	1.29	1.1	1.35	1.07	1.29	1.36	1.52
	3 Fx G+ Hl	1.43	1.05	1.01	1	1.09	0.74	0.98	0.99	0.91	0.98	1.12	1.26	1.43	1.32	1.42	1.39
2BoBCent.	1-BtmTwl	1.39	0.71	0.61	0.58	0.66	0.75	1.02	1.08	0.94	1.07	1	1.25	1.31	1.27	1.55	1.43
	3 Fx G+ Hl	0.77	0.24	0.32	0.26	0.28	0.33	0.39	0.56	0.61	1.45	1.13	1.58	2.62	0.88	0.84	1.24
3BoNorth	1-BtmTwl	1.03	0.87	0.81	0.77	0.53	0.73	0.97	1.01	0.66	1.6	0.95	1.18	0.88	0.71	0.95	2.22
	3 Fx G+ Hl	0.88	0.61	0.89	0.69	0.62	0.75	0.82	0.69	1.03	1.15	0.84	0.98	0.71	0.49	0.73	1.73
4 W Brit.	1-BtmTwl	0.49	0.47	0.53	0.66	0.55	0.5	0.43	0.36	0.63	1.11	1.42	1.08	6.25	0.32	0.53	1.26
	3 Fx G+ Hl	0.94	0.42	0.4	0.44	0.45	0.66	0.6	0.76	0.76	1.19	1.11	1.09	1.16	0.95	0.88	0.83
5E.Ch.NBr.	1-BtmTwl	0.57	0.28	0.32	0.41	0.55	0.56	0.68	0.73	0.51	1.24	1.57	1.47	1.26	1.22	1.77	1.57
	3 Fx G+ Hl	1.54	0.9	1.44	2.11	1.6	0.63	0.8	1.12	0.79	1.19	1.07	1.24	1.25	1.19	1.57	1.52
6E.Ch.NW.	1-BtmTwl	1.88	1.62	1.26	1.54	1.63	0.61	0.89	1.17	0.82	1.1	1.1	1.22	1.12	1.2	1.52	1.52
	3 Fx G+ Hl	1.25	1.56	1.06	1.19	1.27	1.1	1.14	1.11	0.88	1.16	0.98	1.06	1.09	1.14	1.17	1.17
8E.ChEast	1-BtmTwl	1.2	1.34	0.97	0.92	1.06	1.16	1.3	1.3	1.05	0.93	1.03	1.22	0.92	0.9	0.9	0.78
	3 Fx G+ Hl				0.41	0.28	2.57	1.58	1.88	1.47	0.94	0.72	1.09	0.81	0.93	0.32	0.53
9E.ChN.NS	1-BtmTwl	1.71	1.1	0.76	0.76	0.79	0.8	0.97	0.92	0.76	1.17	1.12	0.91	0.95	0.89	1.06	0.98
	3 Fx G+ Hl	0.89	0.86	0.35	0.43	0.42	0.46	0.7	0.59	0.48	1.34	1.54	1.11	1.52	1.28	1.35	1.42

Appendix 2: Figures

Figure III-2 (1) : Month effects for selected squares in the Bay of Biscay

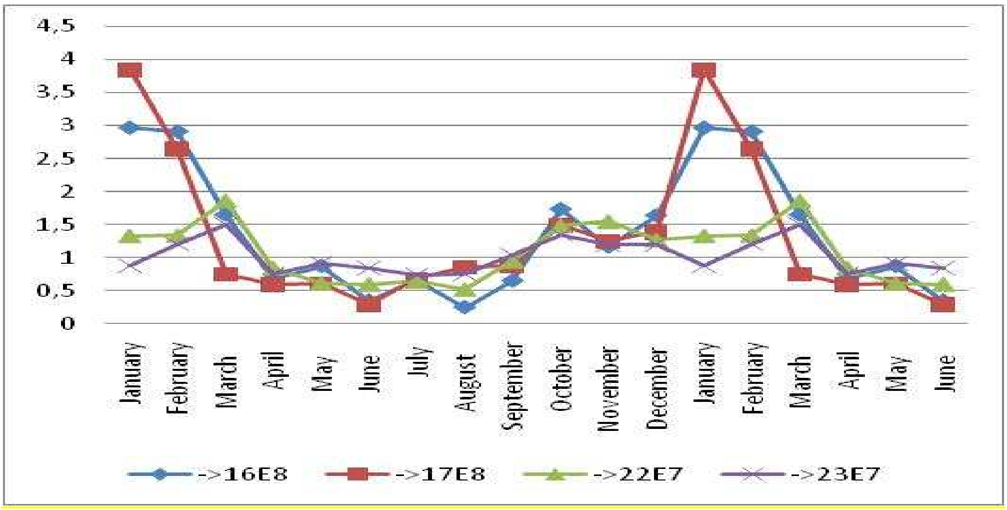


Figure III-2 (2): Month effects for selected squares in theEnglish Channel

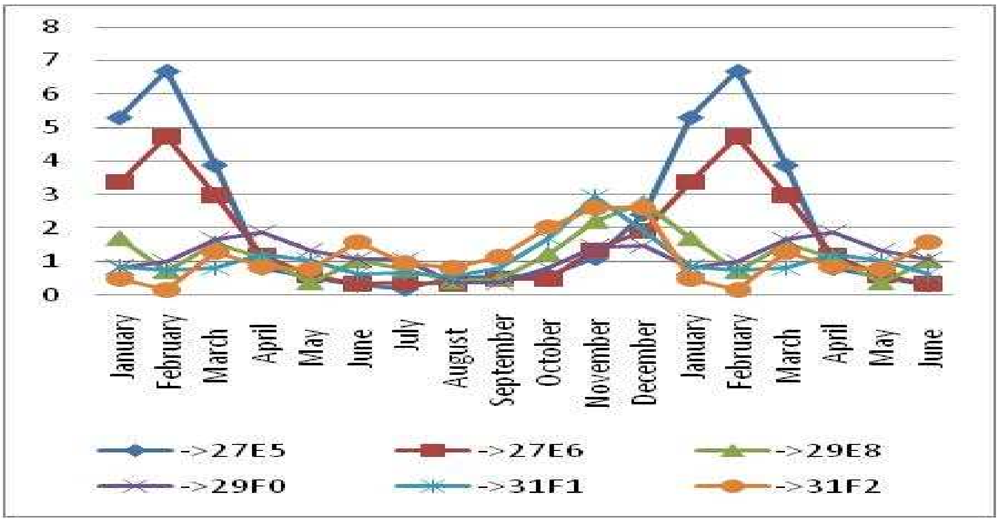


Figure III-2 (3) :Year effects for the south of the Bay of Biscay

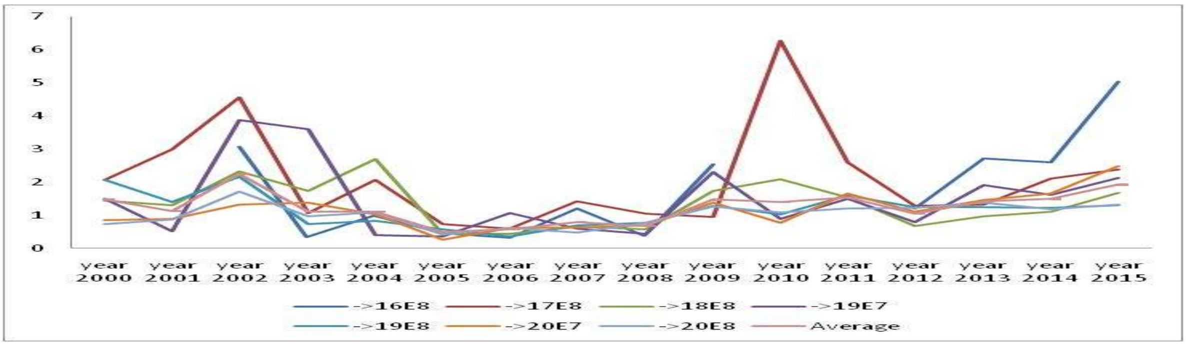


Figure III-2 (4) :Year effects for the North West of the English Channel

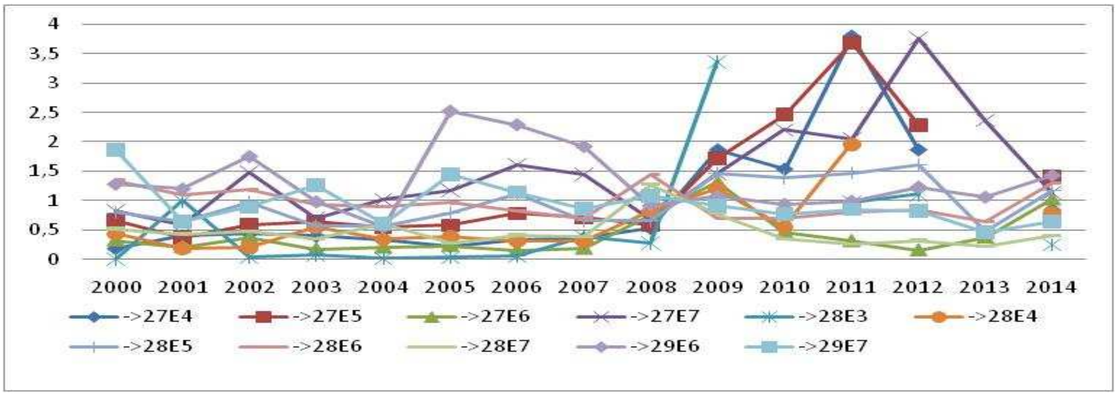


Figure III-2 (5): Year effects for the East of the English Channel

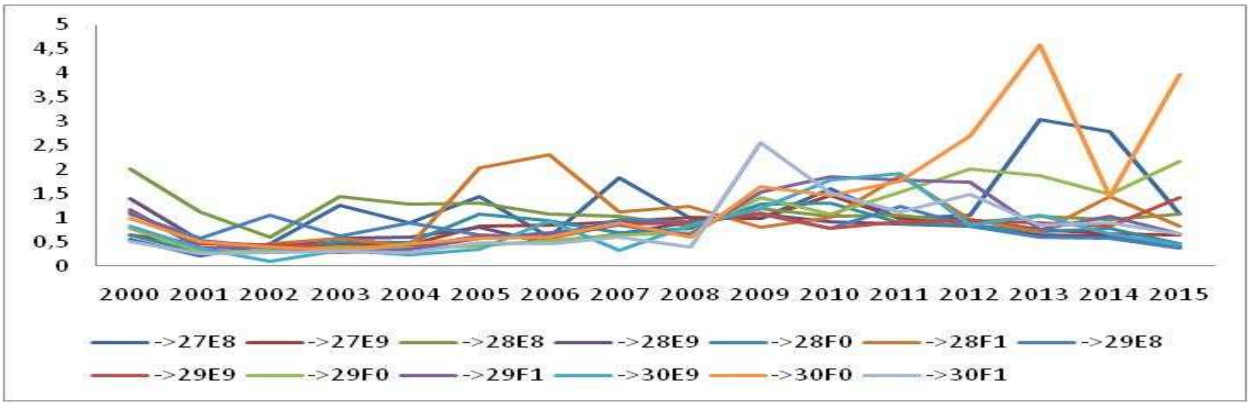


Figure III-2 (6): Year effects for the East of the English Channel after elimination of 3 squares

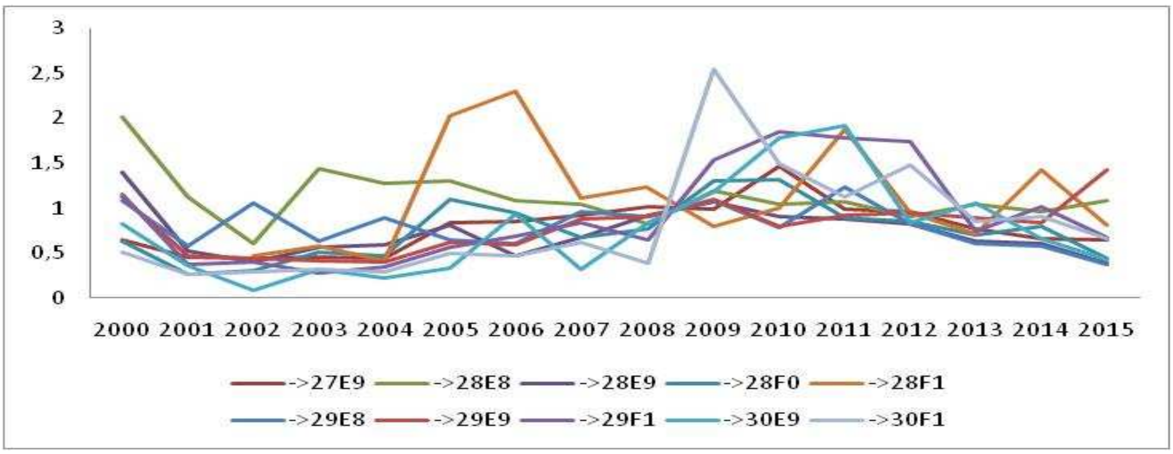


Figure III-2(7)

<u>Average series forthe Bay of Biscay</u>

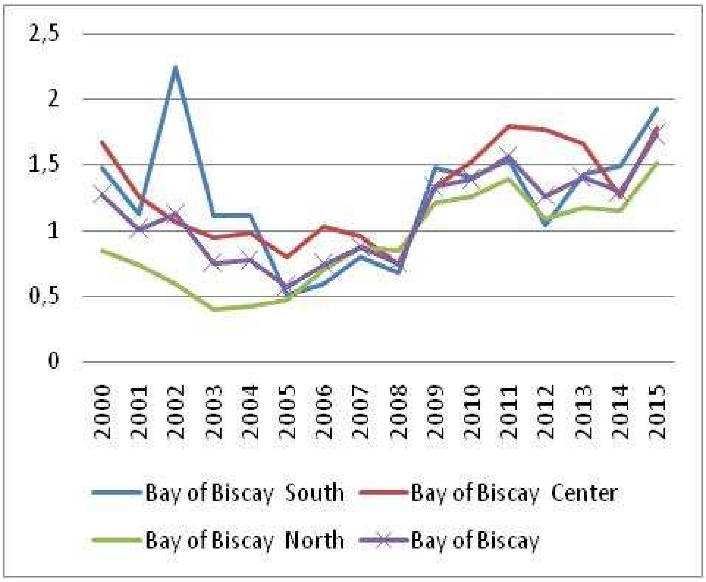


Figure III-2 (8)

<u>Average series forthe English Channel and adjacentareas</u>

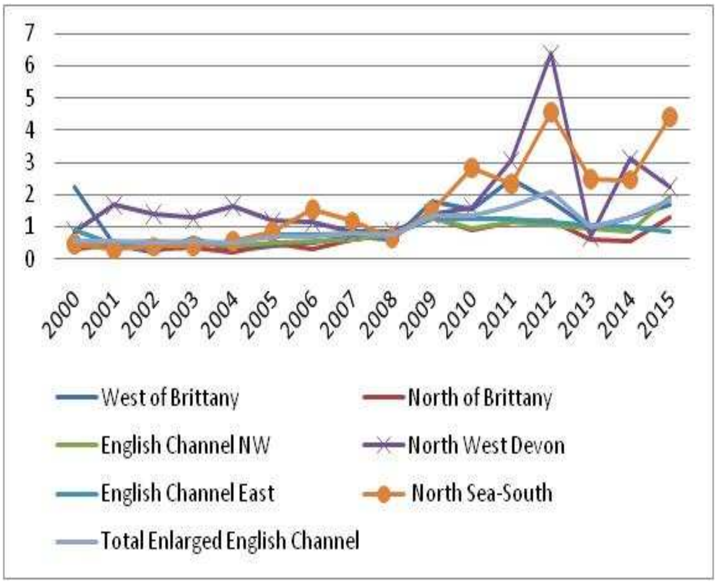


Figure III-2 (9)

<u>Overall average annual series for</u>

<u>(i)the Bay of Biscay , (ii) the English channel and adjacent areas, (iii) West of Brittany</u>

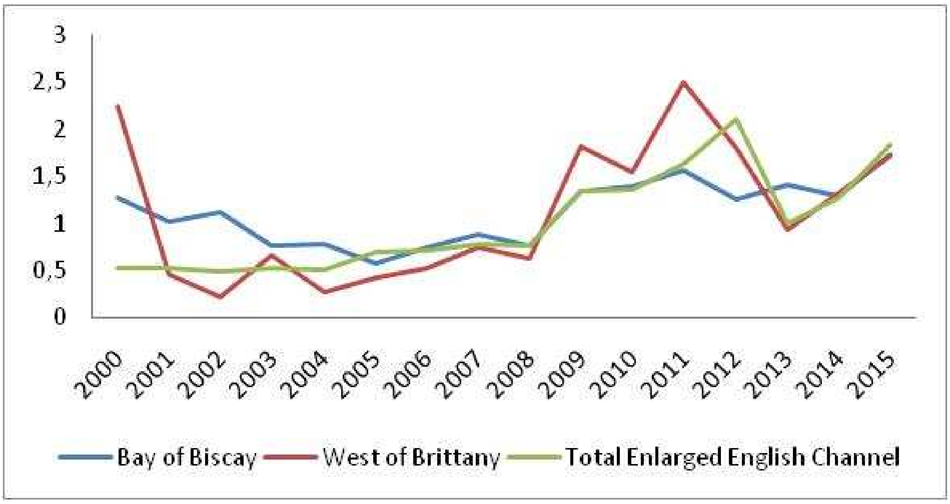


Figure III-3 (1)

Influence of grouping for months on month effects

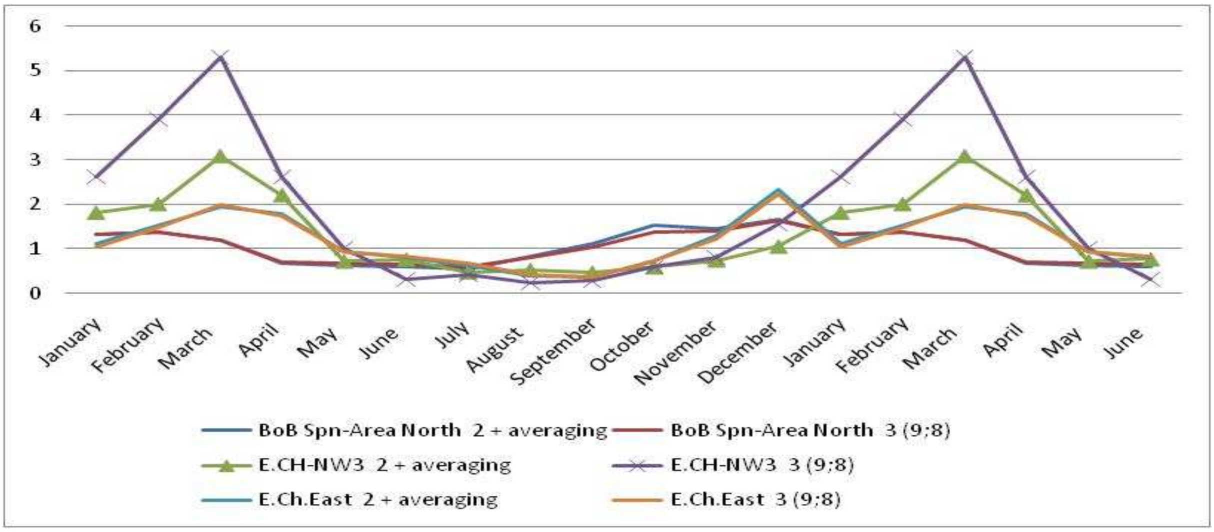


Figure III-4 (1)

Bay of Biscay

Year effects according to bottom trawl

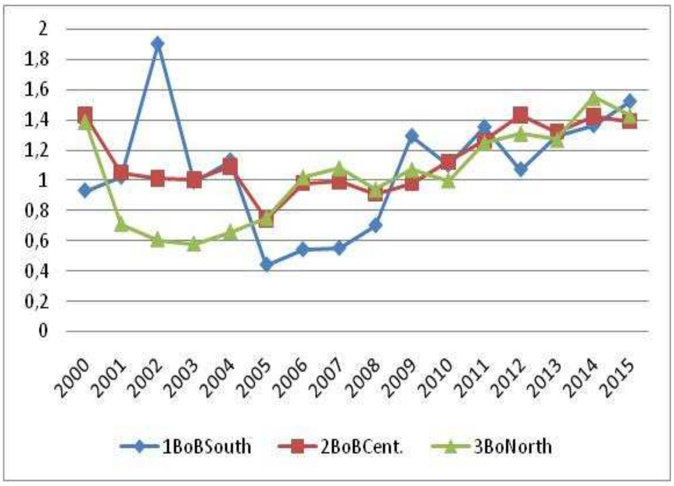


Figure III-4 (2)

Bay of Biscay

Year effects according to fixed gears and hand line

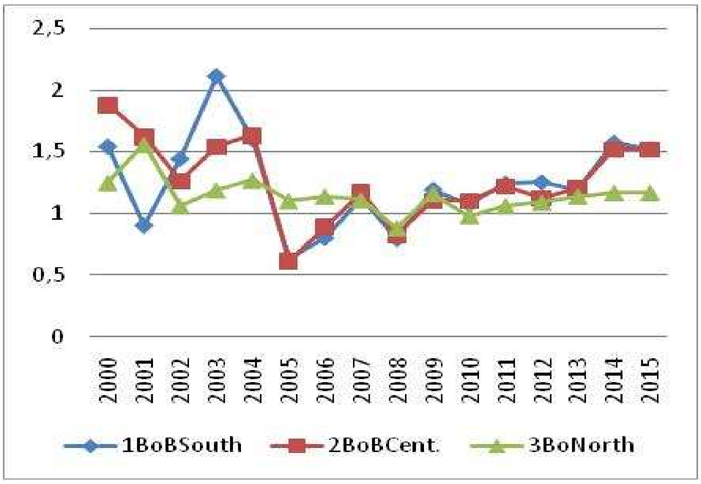


Figure III-4 (3)

West of Brittany

Year effects according to (1) bottom trawl(2) Fixed gears and hand line

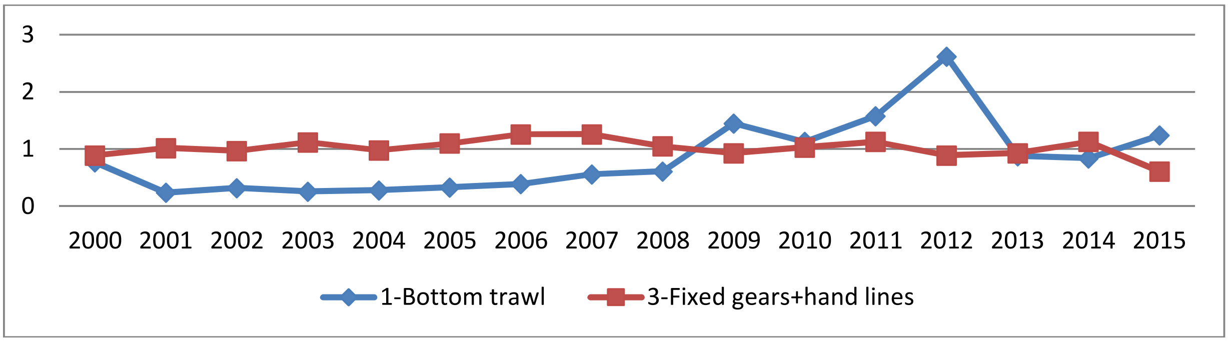


Figure III-4 (4)

English Channel + North Sea south

Year effects according to bottom trawl

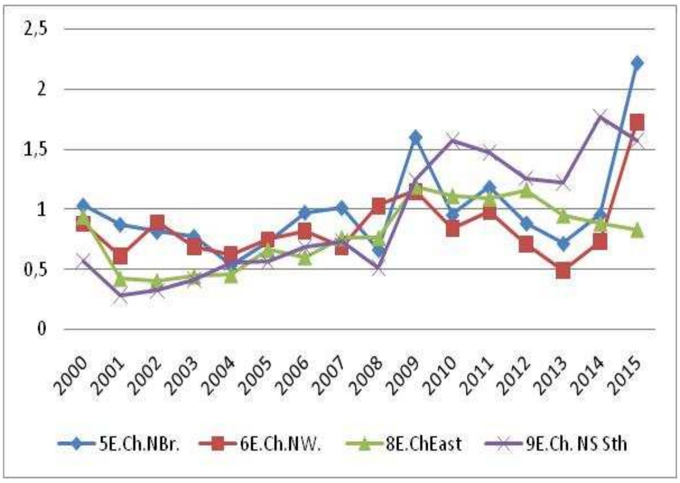
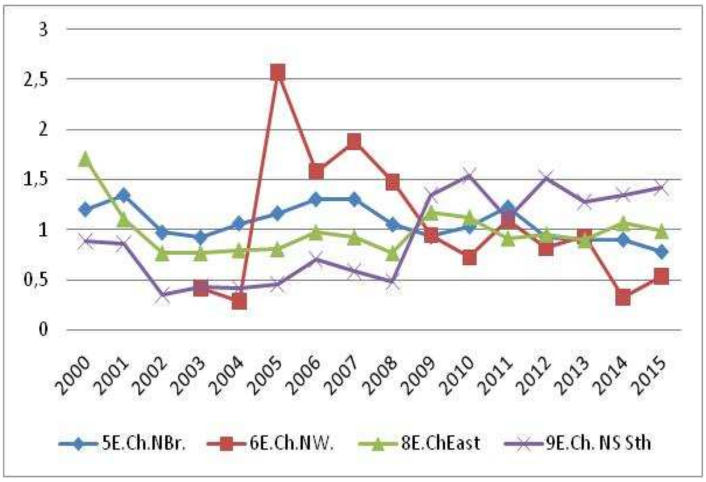


Figure III-4 (5)

English Channel + North Sea south

Year effects according to fixed gears and hand line



Appendix 3 Summarized maps

Maps III-2 (1) and (2)

Month effects by square for:

(1): January

Lat/Long-->	E4	E5	E6	E7	E8	E9	F0	F1	F2
31°	1.6		######	######	######	######	######	0.84	0.48
30°	1.48		######	######	######	######	0.88	0.83	######
29°	1.66	######	1.64	2.03	1.71	1.28	0.82	0.77	######
28°	3.43	5.54	2.96	2.24	0.57	0.93	0.77	######	######
27°	4.05	5.31	3.39	1.77	######	0.31	######	######	######
26°	1.8	1.67	0.26	0.36	######	######	######	######	######
25°	2.16	1.17	######	######	######	######	######	######	######
24°	2.23	1.75	1.42	######	######	######	######	######	######
23°		0.64	1.25	0.88	######	######	######	######	######
22°			0.97	1.31	######	######	######	######	######
21°			2.78	1.32	######	######	######	######	######
20°				2.15	1.5	######	######	######	######
19°				0.98	2.38	######	######	######	######
18°					4.49	######	######	######	######
17°					3.96	######	######	######	######
16°					2.97	######	######	######	######
15°					1	######	######	######	######

(2): July

Lat/Long-	E4	E5	E6	E7	E8	E9	F0	F1	F2
31°	0.11		######	######	######	######	######	0.66	0.97
30°	0.62		######	######	######	######	0.68	0.98	######
29°	0.74	######	0.55	0.66	0.77	0.5	1.06	0.78	######
28°	0.42	0.35	0.35	0.53	0.86	0.8	0.94	######	######
27°	0.28	0.18	0.37	0.4	######	0.99	######	######	######
26°	0.53	0.6	0.88	1.46	######	######	######	######	######
25°	0.45	0.39	######	######	######	######	######	######	######
24°	0.21	0.8	0.52	######	######	######	######	######	######
23°		0.99	0.52	0.74	######	######	######	######	######
22°			0.43	0.72	######	######	######	######	######
21°			0.99	0.52	######	######	######	######	######
20°				0.46	0.5	######	######	######	######
19°				1.41	0.56	######	######	######	######
18°					0.39	######	######	######	######
17°					0.58	######	######	######	######
16°					0.67	######	######	######	######
15°					1	######	######	######	######

Map III-2 (3)

Ratio by square between geometric mean over:

(1) years (2006,2007,2008) and the (2) average over years (2009,2010

Lat/Long-->	E4	E5	E6	E7	E8	E9	F0	F1	F2
31°			######	######	######	######	######	2.12	2.19
30°			######	######	######	######	4.07	2.35	######
29°		######	0.69	0.68	1.05	1.19	2.89	1.84	######
28°		1.31	0.81	0.45	1.03	1.17	1.03	######	######
27°			0.95	2.24	######	0.97	######	######	######
26°				0.84	######	######	######	######	######
25°	3.56	1.65	######	######	######	######	######	######	######
24°		1.12	1.51	######	######	######	######	######	######
23°			1.31	1.22	######	######	######	######	######
22°			1.83	1.46	######	######	######	######	######
21°			2.42	1.76	######	######	######	######	######
20°				2.22	2.07	######	######	######	######
19°				2	2.41	######	######	######	######
18°					1.87	######	######	######	######
17°					1.73	######	######	######	######
16°						######	######	######	######
15°					1	######	######	######	######

Map III-2 (4)

Ratios between year 2012 and the average over years 2011 and 2013

Lat/Long--:	E4	E5	E6	E7	E8	E9	F0	F1	F2
31°			#####	#####	#####	#####	#####	0.87	3.07
30°			#####	#####	#####	#####	0.95	1.52	#####
29°		#####	1.21	1.34	0.94	1.05	1.19	1.52	#####
28°		1.91	1.17	1.36	0.86	1.08	1.08	#####	#####
27°			0.48	1.71	#####	1.12	#####	#####	#####
26°				1.03	#####	#####	#####	#####	#####
25°	2.31	2.41	#####	#####	#####	#####	#####	#####	#####
24°		0.89	1.35	#####	#####	#####	#####	#####	#####
23°			1.09	1.01	#####	#####	#####	#####	#####
22°			1.95	1.45	#####	#####	#####	#####	#####
21°			0.73	1.09	#####	#####	#####	#####	#####
20°				0.69	0.95	#####	#####	#####	#####
19°				0.41	0.89	#####	#####	#####	#####
18°					0.53	#####	#####	#####	#####
17°					0.69	#####	#####	#####	#####
16°						#####	#####	#####	#####
15°					1	#####	#####	#####	#####

Map III-2 (5)

: **Ratio per square year 2015 over year 2014**

Lat/Long--:	E4	E5	E6	E7	E8	E9	F0	F1	F2
31°	0.29		#####	#####	#####	#####	#####	0.95	0.36
30°	1.88		#####	#####	#####	#####	3.71	0.79	#####
29°	2.1	#####	2.05	1.75	0.63	1.63	1.55	0.65	#####
28°	3.21	3.09	3.43	2.91	1.12	0.61	0.6	#####	#####
27°	2.64	1.57	0.51	0.73	#####	0.98	#####	#####	#####
26°	2	0.86	5.16	1.45	#####	#####	#####	#####	#####
25°	1.61	1.99	#####	#####	#####	#####	#####	#####	#####
24°	2.47	0.97	1.13	#####	#####	#####	#####	#####	#####
23°		1.15	1.13	1.1	#####	#####	#####	#####	#####
22°			1.18	1.25	#####	#####	#####	#####	#####
21°			0.86	0.96	#####	#####	#####	#####	#####
20°				1.42	1.12	#####	#####	#####	#####
19°				1.29	1.06	#####	#####	#####	#####
18°					1.48	#####	#####	#####	#####
17°					1.09	#####	#####	#####	#####
16°					1.92	#####	#####	#####	#####
15°					1	#####	#####	#####	#####

Appendix 4

Appendix
Some methodological remarks

The way data have been processed may seem different from standard use of linear models in order to analyse logbook data in order to get, among others, annual abundance indices. The following section provides explanations for what could seem not in accordance with standard practice.

I Standard hypotheses about residuals

It is commonly assumed that residuals fulfil three hypotheses: normal distribution, homoscedasticity, and statistical independence between the various residuals. In our context real residuals are far from fulfilling such conditions. Non normality is not really a problem. Heteroscedasticity is more important, since residual variances do vary according to a large number of factors (fishing techniques, month, year, area...). But the most difficult point is related to correlations between residuals. In fact fishing powers often vary over time, so that the estimation only provide estimates of the average value over times, while trends in real time fishing powers generate correlations between residuals. There are other sources of correlation, for instance hydrological anomalies which can affect in a similar way cpues for a set of vessels over a number of days.

Non compliance with the basic hypotheses about residuals makes it dangerous to use statistics (estimated variances, confidence intervals, significance tests...) which do require such hypotheses to be complied with. Minimizing sum of squared residuals is no more equivalent to maximum likelihood. On the other hand least squares offer a robust technique, providing kind of an improved mean: whenever in a table when there are no empty cells, simple arithmetic averages coincide with least squares solutions, while least square solutions can also be calculated when there are such empty cells, without the usual risk of unbalanced results due to the use of averages over only non empty cells.

II Why not we use weighted least squares?

As pointed in section I above, and as illustrated in the complementary material, residual variances vary according to a large number of factors. Whenever there are good reasons for using a predefined set of weighing coefficients, this can be done easily. On the other hand introducing a sophisticated weighing systems, which would include a set of parameters to be estimated within the overall model fitting has at least two drawbacks:

(1) <u>over parameterisation</u>

It may seem relevant to use a flexible variance function, leaving the possibility for variances to vary according to previously mentioned factors (fishing techniques, month, year....). This implies however a major increase in the number of parameters, especially if one takes into account the fact that residuals are far from being mutually independent (see section I above) which implies that covariances should also be taken into account, and properly described by the overall stochastic model.

(2) <u>biases risks</u>

Such risks emerge from instance if one tries to give more weight to strata (stratum = a square, a month a year) where higher fishing efforts have been observed. Such strata may have benefitted from (1) anomalies resulting in higher cpues (2) effort concentration on the abnormally rich strata, so that the weighting system includes a random component, positively correlated with positive anomalies in the Cpues.

Simple least squares minimisation offers in fact a robust technique to be preferred at least for a first data screening. One should however keep in mind that it gives more weight to the better documented vessels and groups and vessel. This is why some rebalancing in order for instance to give overall equal weights to groups of vessels could be useful.

III Why not we use the bias correction formulas (So called Laurent's formula)

It is well known that if $\hat{x}$ is an unbiased estimate of x, $\hat{y} = 10^{\hat{x}}$) is not an unbiased estimate of y.

A correction factor has been suggested (Laurent,1963), and used in a number of papers related to fisheries.

One should however keep in mind:

- that a number of stock assessment tuning techniques use in fact not yearly indices of abundance in numbers of weight per unit of effort, but their logarithms,
- that the correction formulas require non only normality hypothesis, which often are a minor problem, but realistic estimates of the estimation variances, which is far from being the case in most logbook analyses (see section I, correlation between residuals)
- that Laurent's correction factors are negligible when estimation errors have low variances, while when such variances are high, in the mean square errors biases do not play a major role.

IV Significance tests

No attempt has been made because:

- in most cases null hypotheses are of no real utility in stock assessments. As an example testing a significant difference between seasonal patterns in two different squares/areas implies the null hypothesis according to which there is absolutely no difference, which is in practice impossible. In fact people too often mix up the fact that a difference is significant with the fact that such a difference cannot be neglected: a difference may be significant and negligible as well as not significant but non negligible
- basic tests rely on a number of assumptions which are far from being fulfilled in our case, especially no correlation between the various residuals (see section I)

V Why did not we use a standard GLIM software?

In practice one of us (A. Laurec) does not have systematic access to such a package. On the other hand standard packages use in order to solve the sets of linear equations which result from sum of squared residuals minimisation, a matrix inversion algorithm. This procedure is necessary when calculating through standard methods estimation variances and performing significance tests. On the other hand it is quite (computer) time consuming, while hypotheses required for performing the basic statistical inferences are not fulfilled. This is why the solution of the previously mentioned set of linear equation has been obtained through a simpler technique, which can take advantage of its specificities (see for instance Laurec and Perodou,

1987) in order to fasten calculations. The corresponding algorithm has been compared on another set of data (Cheikh-baye et al , 2014), and gave the same results.
Using a fast ad hoc algorithm is for us quite important, because we are at present developing a new package which will make it possible through a bootstrap technique to estimate the sensitivity of the end results to between vessels variability, making it possible to perform realistic statistical inferences. Such a bootstrap approach of course requires much more calculations.

VI Why did not we use weighted means over squares when combing abundance indices from individual squares?

In order to get an overall abundance index on the basis of a set of square specific indices it could seem wise to use a weighted mean, each square being given a weight proportional to the area of the fishing grounds within this square, which could be for instance estimated through VMS data. This would correspond to king of integration over space.
This would however create a number of difficulties, and would not correspond to the multifactorial logic. Within model 3 it is in fact assumed that within a group of squares between years changes correspond to an underlying common factor, the overall abundance index at the scale of a common stock.

ANNEXE 3

Comments on WD on French LPUE Alain Laurec. 20 februar 2017

Null values are not considered in the basic analysis. A dedicated analysis of such values is currently going on. For the time being it should be remembered that the purpose of the analysis is not to directly build a reconstructed abundance analysis which should be a priori proportional to yearly real abundance, but to(1) extract indices (equivalent to geometric means of lpue without null values) from a subset of the overall data set which seems fitted for simple techniques and then (2) to analyse changes over space and time of this index. This analysis definitively offer useful insights about migrations and stock structures through the analysis of the combination of square and month effects. As for year effects they appear in the English channel as clearly related to the overall biomass yearly series as reconstructed from the overall assessment by the WG.

In the Bay of Biscay in the absence of other possibilities the year lpue index offers the possibility of at least semi quantitative analyses, leading to the conclusion that up to 2014 the biomass has progressively increased, while this increase seems to have stopped recently. I guess even preliminary age reading results in the Bay of Biscay could be used for crosschecking this conclusion.

Anticipating thee future analysis of the impact of null values, it should be kept in mind that if one consider a delta (lognormal or not) distribution, the frequency of null values being p, and the mean over the non-zero values being m, the overall mean is (1-p) m. When comparing for instance different years, in order to assess changes of the overall means, one should take into account changes according to y for both factors p_y and m_y. Links between changes over years in p_y and changes in abundance cannot be trivial. They are directly related to changes in the spatial distribution of sea bass. A macroscopic shrinkage of the area where sea bass is present can be excluded: there no ICES square from which sea bass is absent when the stock decreases, as shown by any analysis of logbook data (and research surveys?). What could be feared is a more sophisticated changes. In areas where fish is only present on part of the fishing grounds, in kinds of leopard skin spots, if such spots tend to shrink when biomass decreases, this should increase the frequency of null values. Ignoring it should lead to a tapering of changes in biomass: the real decrease is higher than the decrease in the average over non zero values. This should not however eliminate the possibility of detecting a decrease in the stock through a decrease in non-zero values.

For a number of vessels the proportion of null values is always very low (e.g. less than 5% for all years). It is possible to conduct the analyses for these only vessels, the end results being of course subject to higher sampling errors because the number of vessels is lower. Preliminary analyses leads to a stronger decrease over the recent years for the biomass in the English Channel than from the previous analyses. For me it is simply however a warning signal. I could send you the results of such preliminary analyses.

For the other vessels it should be possible to use multifactorial (Space/month/year) models using a logistic (log(p/(1-p)) transform of the proportion of non-zero values on a subset of vessels, and using may be quarters and large enough groups of ICES squares. It will take me however several weeks for writing down the proper software.

Analyses are anyway made more difficult by the fact that a number of very low values appear in the logbooks, which do seem as a convention from people filling log book forms: a 1 kg catch of sea bass over a day could hide a zero value. The frequency of such quasi null catches has however decreased in my data set for the most recent years, while in parallel the proportion of zero catches has risen up for some gears (bottom trawlers).

ANNEXE 4

Analysis of the residuals

I Basic assumptions about residuals

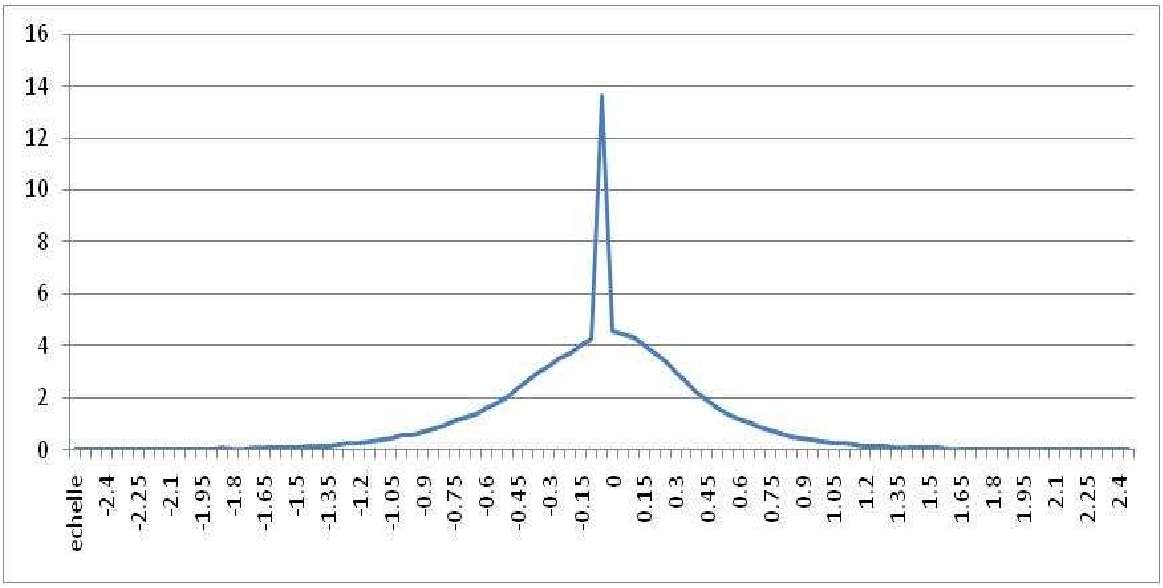
The usual soft wares that fit multifactorial linear models commonly refer to three hypotheses about residuals, namely (1) normality (2) ergodicity and (3) mutual independence.

None of such hypotheses are complied with in the present study.

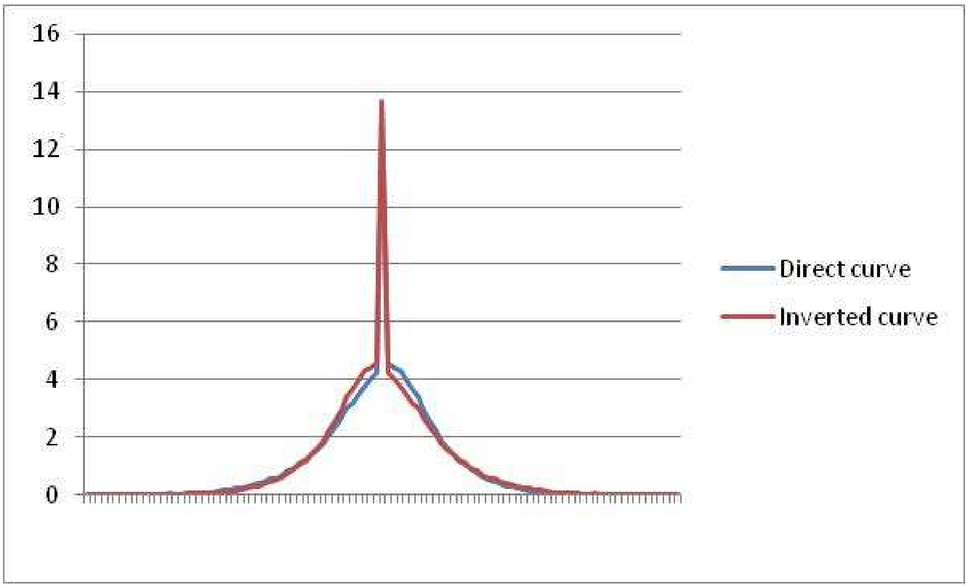
(i) Non normality

The overal histogram of the logarithmic residuals appear on figure 1 below (Table a in the appendix)

Figure 1 Overall histogram over the 280585 residuals



The central peak corresponds to residuals equal, or almost equal, to zero. Detailed analysis reveal that they are mainly associated to squares for which at least for some years and/or months few data appear. The influence of this peak can be reduced if such squares are eliminated. On the other hand the curve is also non symmetrical, .as illustrated by figure 2 which adds to the basic curve, the curve which corresponds to an inverted x axis.



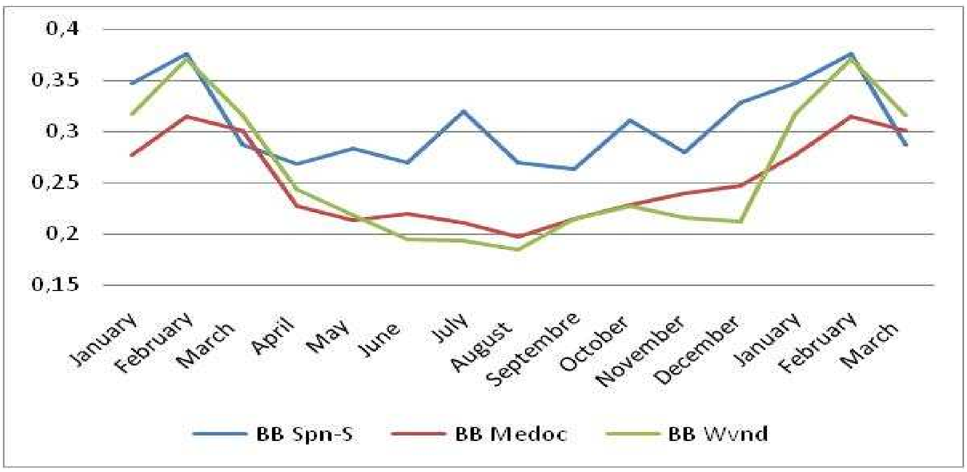
(ii) Changes of the residuals variance

Instead of being the same for all groups of residuals, mean square residuals show clear patterns: they vary among others between groups of vessel[1]s (Table I), years (figure 3) and months(figure 4).

Table I Mean squared residuals according to the group (gear) of vessels

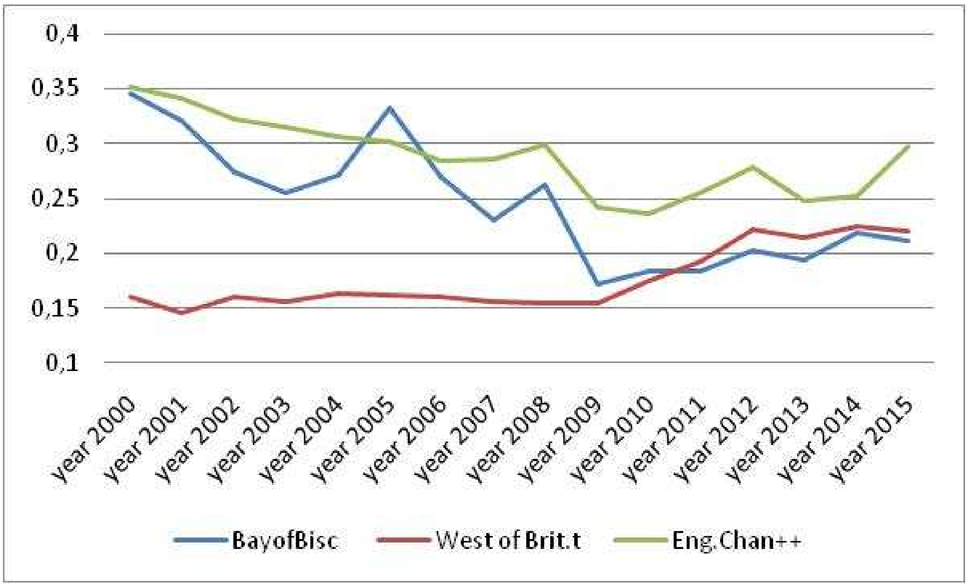
Gear group	Number of vessels	Number of data	Mean square residuals
FL1	115	15625	0.235
FL2	181	45672	0.281
HMC	99	35428	0.164
PLG	191	68316	0.16
CF1	269	100602	0.285
CF2	39	13303	0.22
SND	7	1589	0.245

Figure 3 : **Mean squared residuals according to the month for three groups of squares in the southern part of the bay of Biscay**



[1] They also vary between individual vessels, which can suggest a criteria for eliminating some specific vessels.

Figure 4 : between years variations of the mean squared residuals



This graph confirms that before 2009 the situation was different.

(iii) Correlations between residuals

When the same vessels provide data for two consecutive days, obvious autocorrelations, mainly positive, appear. The average over all vessels which provided at least 50 sets of consecutive residuals is equal to 0.6.

II Least square fitting as a robust tool, regardless of assumptions about residuals

If the previous results show that it would not be reasonable to consider that the simple assumptions required for assessing the statistical reliability of the final estimates of the various effects, this does not make useless an empirical least square fitting of a multifactor linear model. It can be shown that in a balanced set of data, where data appear for all combinations of vessels, squares, years an months, least square results coincide with simple averages. On the other hand when there are empty cells simple averages can be misleading, while least square fitting remain useful.

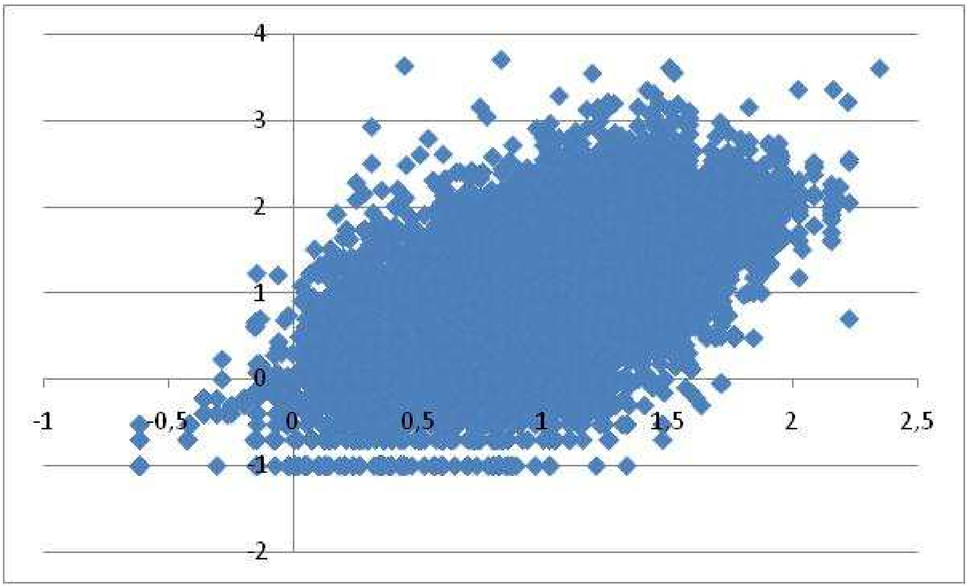
In fact least squares fitting provides kind of rebalanced generalised averages. The corresponding outputs are not optimal in any precise statistical meaning. In theory it would be possible to build fine tuned likelihood functions which could take into account the previously mentioned departures from the simple usual assumptions. They would however include a too large number of parameters.

We have chosen to use least square fitting as a robust technique, and to perform an analysis of the sensitivity of the results to between vessels variability through a specific bootstrap analysis.

III Lack of fit for low et high values

Vicariate plots associating observed values and residuals offer a useful tool for detecting a lack of fit problem. It is not possible through simple Excel tools to get graphs covering all years. On the other hand they can be built for individual years, and results are consistent between years.

Figure 5 below provides an illustration /Predicted versus observed daily log catches for 2005



Such graphs prove that the model tend to overestimate low values and to underestimate high ones. This will require further analysis.

ANNEXE 5

Note on french LPUE for WGCSE 2017. Feedback on almost zero catches from log books. Alain Laurec, Mickael Drogou

Daily catch histograms per year, integrating all boats, every month all squares are presented in Figure 1 taking into account all the years (2000-2016).

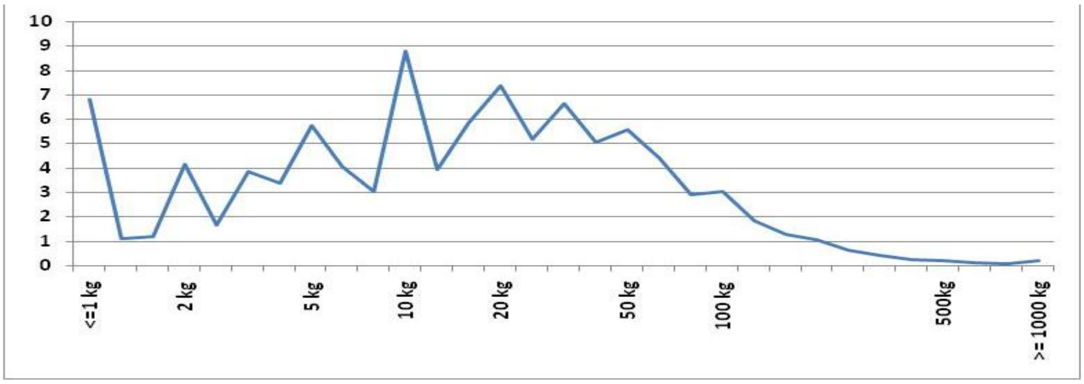


Figure 1 : seabass landings per day (all years included)

The important element is the very low values, in this case with catches less than or equal to 1 kg. They are well isolated from the global mode (a few tens of kg). The frequency varies especially as it was already noted from year to year with a break in 2009 (figure 2).

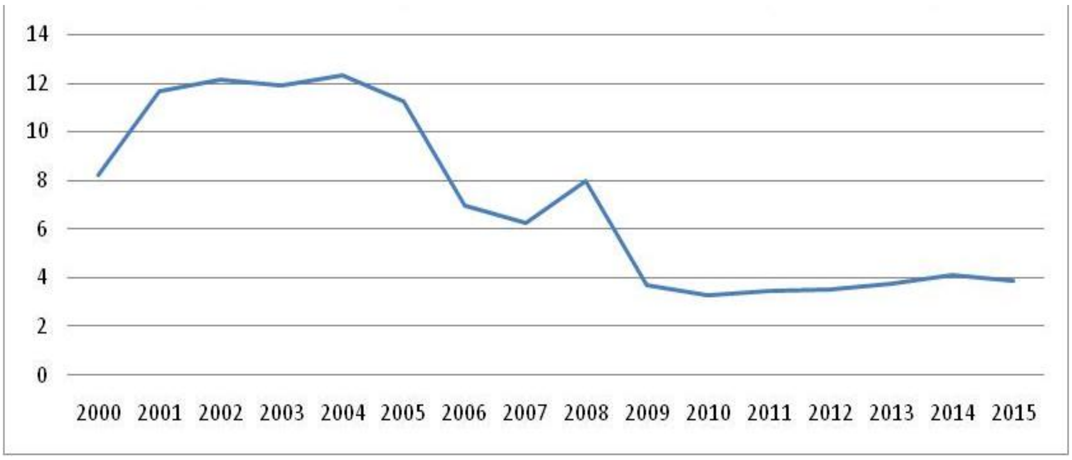


Figure 2 : fréquences of landings <=1kg

There is indeed a heterogeneity with a cut between 2008 and 2009. It is feared that many of the very low catches (many are declared at 0.1 kg) are false positives. In order to homogenize the whole, vessels may be selected which, even before 2009, have very few very low values, but it has been preferred finally for WGCSE 2017 to exclude values of less than 1 kg for all vessels and all years.

Annex 6: Review of «ICES Working Document: French LPUE indices used in model assessment for sea bass”

Mary C. Christman, MCC Statistical Consulting, Gainesville, Florida, USA. August 2017.

Review of: "ICES Working Document: French LPUE indices used in model assessment for seabass", June 2017, by M. Woillez and M. Drogou

Reviewer: Mary C. Christman, MCC Statistical Consulting, Gainesville, FL, USA

Documents Provided for the Review

"Main": ICES Working Document: French LPUE indices used in model assessment for seabass, June 2017, 9 pp.

"Annex 1": French Logbook data analysis 2000-2013: possible contribution to the discussion of the sea bass stock(s) structure/annual abundance indices. April 2015. Working document for WGBIE 2015 and WGCSE 2015-DRAFT, 16 pp. (appendices not available)

"Annex 2": Getting sea bass annual apparent abundance indices for from log-books. December 2016, 9 pp + Appendix 1 (Tables, 7 pp.) + Appendix 2 (Figures, 5 pp.) + Appendix 3 (Maps, 2 pp.) + Appendix 4 (Some methodological remarks, 3 pp.)

"Annex 3": Comments on WD on French LPUE. 20 February 2017. 1 pp.

"Annex 4": Analysis of the residuals, 4 pp.

"Annex 5": Note on French LPUE for WGCSE 2017. Feedback on almost zero catches from log books. 1 pp.

Purpose of the Review

The analysts describe the goals of their analyses as 1) providing a relative abundance index for the benchmark stock assessment of sea bass and 2) elucidating the stock structure spatially and temporally. The provided documents have information on both of these studies. Now, his review does not address the second goal as I was asked to preform "A straightforward review and opinion on the validity of the approach and the index" for use in the benchmark assessment being performed by ICES working groups. Hence, I will focus on the statistical methods used to develop the index and the decisions concerning the data used in those methods. Further, there appears to be several different analyses using different subsets of the data; as a result I will focus on the descriptions in the main document but will note where here is a conflict with results in the annexes as needed.

Summary

Overall, the analysts did a prodigious amount of work fitting models to the French Fleet LPUE data for sea bass. Unfortunately, the emphasis on comparing different models and optimal groupings of the ICES squares meant that development of an optimal relative abundance index based on landings data for sea bass in the English Channel and Bay of Biscay is not as far along as it could be for use in the stock assessment. There are several issues including the handling of low and zero LPUE reports from analyses, confusion of how the correction factors for gear effects were incorporated, the lack of explanation of how the analysts calculated adjusted annual means in the presence of missing cells, the lack of incorporating variance-covariance structures that adequately capture the variability of the annual means, and the use of nonparametric methods for fitting the models.

The recommendation is that the index be further studied and and be developed using modern readily available software (such as the open source R program) before incorporating it into the assessment of the sea bass stock. Further the analysts should consider incorporating the nominal 0s (0 and < 1 kg) into the models (with possible covariates to explain the low values) or using peer-reviewed methods that remove data records that are deemed to not belong to the population under study.

Several problems are identified in the review section. Some of them are possibly not problems but were identified as such due to insufficient explanation of how the analyses were actually performed. These include how the fishing power correction factors were calculated and applied and the selection method used in the bootstrapping.

Following are descriptions of my understanding of what data were used, how the analyses were performed and more detail of my review of the work performed.

Background

Description of the Dataset Used by Woillez and Drogou

The available data are obtained from logbooks of vessels in the French fleet fishing in the English Channel and Bay of Biscay. The data used in the analyses are described below.

Response Variable: declared seabass catch/day (LPUE = kg seabass/day) reported in logbooks from the French Fleet fishing in the Bay of Biscay and English Channel from 2000 to 2016, inclusive.

Explanatory Variables (all categorical):

- Year (2000,…, 2016)
- Month (1, …, 12)
- ICES square (square within areas VIIIA, VIIIB, VIIH, VIIG, VIIE, VIID, IVC)
- Vessel ID (individual vessel identifier)
- Fishing gear used to land sea bass
    - The main document lists bottom trawl, mid-water trawl, handline, fixed nets (gill nets?), longline, Danish seine, purse seine;
    - Annex 2 lists a slightly different set of gears, namely bottom trawl, mid-water trawl, Scottish Seine, purse seine ("bolinche"), trolling, fixed nets, longlines.
    - Annex 2 states that these were combined into 11 groups of fishing techniques which is unclear given that the number of gears is lower than the number of groups.

The analysts modified the definition of a vessel to be a "hull"/fishing technique combination. I take hull to mean the individual vessel ID and not vessel size since the analysts describe fishing power as the individual fishing power but my conclusions are the same either way.

A single record in the dataset contains LPUE (kgs seabass/day), year ID, month ID, ICES square in which fishing occurred, "fishing technique (gear)", and vessel ID. A change in ICES square, or fishing method or date for a vessel causes a new record to be created so that a single vessel may have several records. Hence, if a vessel fishes for 7 days there are at least 7 records of LPUE for that vessel. I say 'at least' since if a vessel uses more than 1 gear or fishes in several ICES squares on the same day, then each combination of vessel, gear and ICES square is a different record.

Data Removed before Analyses

Some data were removed from analyses before index development. These include any observations that have the following characteristics:

- Gear = pelagic (i.e. mid-water) trawls because this gear was not in the fishery as of 2014 and so all years were removed
- Gear = purse seines because this gear contributes very little to the total landings
- Any days with LPUE < 1 kg of seabass. The analysts considered these to be 0s since a seabass commercially caught should weigh at least 0.5 kg.
- Any days for which LPUE = 0
- "Vessels as well as squares which provided **limited data** [my emphasis] have been eliminated so that by the end 958 vessels [re-defined to be a hull and fishing technique combination] will be considered, as well as 11 fishing techniques, and 37 ICES squares…" (main document)

Analytical Methods

<u>Model</u>

The analysts chose to extend a method first proposed by Robson (1966) for estimating individual fishing power. Their basic approach is a fixed effects ANOVA model. The analysts decided to use the "regression" coding scheme for the categorical effects in the model when fitting the model. Although three models are presented, the model that appears to have been chosen for index development is their Model 3:

$$log_{10}\left(LPUE_{vss_m ms_y yi}\right) = \mu + p_v + g_s + (g*m)_{s_m m} + (g*y)_{s_y y} + \epsilon_{vss_m ms_y yi}$$

where

v = 'vessel' ID (hull x technique), $v = 1$, …, either 958 (in Main document) or 1034 (in Annex 2). The number of individual ships is not reported.

s = ICES square ID, $s = 1$, …, either 37 (in Main document) or 70 (in Annex 2)

s_m = a grouping of ICES squares having similar seasonal responses. For all squares in this grouping, the month effects are "equal" for any given month. It is unclear whether the grouping varies by season or all seasons are considered when grouping ICES squares.

m = month, $m = 1, \dots, 12$ (might be either July to June or a January to December year)

s_m = a grouping of ICES squares having similar yearly responses. The analysts state that all squares related to the same stock can be considered such a group even if the seasonal patterns vary among squares.

y = year, $y = 2000, \dots, 2016$

$LPUE_{vss_mms_yyi}$ is the i^{th} recorded LPUE for vessel v in ICES square s during month m and year y and in the s_m^{th} group of ICES squares based on similar seasonal patterns and the s_y^{th} group of ICES squares based on similar annual patterns

i = observation ID, $i = 1, \dots, n_{vss_mms_yy}$

μ = grand mean of $log_{10}(LPUE)$

p_v = fishing power for the v^{th} 'vessel' given as a deviation from the grand mean. Although unstated, I assume it is actually 2 additive effects, specifically vessel or hull ID (h) and fishing gear or technique (f), i.e. $p_v = h_v + f_v$.

g_s = deviation of the mean of the s^{th} ICES square from the grand mean

$(g * m)_{s_mm}$ = deviation of the mean of the m^{th} month within a grouping (denoted s_m) of ICES squares having similar monthly responses from the grand mean. It is unclear if the grouping varies by month.

$(g * y)_{s_yy}$ = deviation of the mean of the y^{th} year within a grouping (denoted s_y) of ICES squares having similar monthly responses from the grand mean. It is unclear whether grouping varies by year.

$\epsilon_{vss_mms_yyi}$ = random unexplained deviation of the $vsmyi^{th}$ observation from its expected value (error term)

Estimation of Effects

The analysts estimated the model parameters using least squares estimation (LSE) since they claim that modelling of the statistical distributions is not realistic (Annex 2).

After fitting the model and presumably standardizing the results using the fishing power correction factor, the annual relative abundance were calculated by averaging the estimated means $\widehat{log_{10}}\left(LPUE_{vss_m ms_y yi}\right)$ for the y^{th} year over all ICES squares groupings and months separately for 2 regions, the English Channel and the Bay of Biscay, using

$$\widehat{log_{10}}\left(LPUE_{vss_m ms_y yi}\right) = \hat{\mu} + \hat{p}_v + \hat{g}_s + (\widehat{g*m})_{s_m m} + (\widehat{g*y})_{s_y y}$$

where $\hat{x}$ indicates the estimated parameter value. The annual means are back-transformed to the original data scale to become annual geometric means. These are then standardized using the geometric mean of 2008 and 2009, i.e. the back-transformed value of the average of the estimated annual log_{10}LPUE values for 2008-09. The choice of these two years is not explained.

Finally, because the analysts decided that they could not fit a parametric model to the data, they removed all zero values from the analyses and they constructed confidence intervals for the annual means using a bootstrapping approach. For the bootstrapping, they stated that they sampled vessels at random and with replacement from a set of N vessels. It is unclear whether they mean vessel as in the hull x technique definition or whether they mean individual vessels. Confidence intervals were constructed using the percentile method but the analysts state that for logarithmic values the use of the usual 95% confidence interval based on the assumption of normality is satisfactory as well.

Review

In the following sections are comments related to areas of the index development that require either additional explanation (due to lack of detail in the provided documents) or additional analyses to increase the usefulness of the index. Recommendations for further work are given in each section.

Fishing Power Calculations

Robson (1966) and Wildebuer et al. (1998) discuss standardizing catch rates (aka the *fishing power correction (FPC) factor*) to a specific 'vessel' ID but the only mention for standardization in the analyses currently under review is the statement "Log fishing powers have been standardized setting their overall average to zero" (main document). This implies that the analysts chose a different approach than that proposed by Robson (1966) to creating a FPC factor to adjust for the effects of vessel or hull ID (h) and fishing gear or technique (f). It is also unclear how this would be accomplished and when it would be performed in the sequence of calculations to obtain an annual mean. For example, is it done separately for every year or month or ICES square? Or are the fishing powers obtained by averaging over all gears, years, months and ICES squares (in which case the average fishing power would be the estimated grand mean $\hat{\mu}$ in the model)? The results of the two approaches would be quite different if the fishing techniques vary among years and ICES squares. In addition, it is unclear whether the results would biased since yearly estimates would be averaged over differing sets of gears and vessels making comparisons and trend estimation difficult.

Removal of low or 0 LPUE

The fishing gears reported in the data used in this analysis are not species-specific and so likely are the cause of the high variability of seabass LPUE as shown in Figure 1 in Annex 5. Hence it is not surprising that some zeroes exist in the dataset. Since it is difficult to know whether the zeroes are true 0 due to fishing in inappropriate habitats or are the result of range contraction of the species, it is important to review the spatial and temporal distribution of the 0s to determine if there is a pattern. It is inappropriate to remove the zero or very low weight records under the assumption that they are non-informative or mis-recordings or because there are not a large proportion of zeroes without an understanding of the reasons for the values. It is especially important to review the pattern of 0s temporally such as that shown in Figure 2 (from Annex 5 reproduced below) since varying proportions of zeroes can have a large impact on the index which is lost when these zeroes are not accounted for in the models.

Given the recent overfishing of other stocks in this geographic region and the attendant shift to sea bass (http://www.marinet.org.uk/stephen-eades-blog/stephen-eades-english-channel-sea-bass-is-facing-oblivion-can-anyone-make-a-sensible-decision-jan-15), fishing pressure likely has increased in areas or seasons inhabited by sea bass. Hence, removing zeroes potentially has the effect of creating hyperstability in the analyses unless this shift is accounted for. The removal of observations with "limited data" risks potentially increases this effect in the analyses and so it is recommended that the low data values be further reviewed.

Hence, the effect on the index of the temporally pattern of 0s (< 0.5 kg LPUE) observed in this fishery (e.g. Figure 2 of Annex 5) cannot be ignored. As the analysts reported, there is a clear change point in 2009 where all subsequent years have low proportions of 0 LPUE while in earlier years the proportion is high. This indicates a possible change either in fisheries management or fishing technology or fishing behavior in the sea bass fishery around 2009 which cannot be ignored when constructing the time series of annual relative LPUE. In fact, there is some indication that this change point is real and not simply a random event. Figure 6 of Annex 1 and Figure 3 of the main document show an increase in relative abundance starting in 2009 that coincides with the decline in proportions of zeroes. The two opposing trends we see here (low zeroes and high relative LPUE) imply possibly that either the stock abruptly recovered in 2009 which seems unlikely for sea bass or the fishery starting targeting sea bass as other stocks declined.

Related to analysts' recommendation that small values be removed from analysis is the proportion of small values still in the dataset as seen in the residual analysis in Annex 4. The frequency distribution of the residuals shows a distinct peak between 0 and -0.15 (on the log scale). This indicates that there is a large proportion of reported $\log_{10}$(LPUE) values close to their predicted value. Such an event occurs when all of the observations within a combination of year, month and ICES square are similar in value. The analysts indicate that it is due to observations associated with squares that have few data points which implies that little fishing occurs in these ICES squares. The lack of fishing in these squares further implies that, since we are looking at landings, these squares most likely also have low LPUEs when fished. These results suggest that the dataset includes a significant number of records that are either not appropriate for sea bass index development or are appropriate but indicate a declining or contracting stock. In either case, the decision should not be to simply remove all very small and 0 values as they may be informative of sea bass abundance trends.

We recommend looking at methods such as those described in Stephens and MacCall (2004) paper or Helle et al. (2015) for removing records not relevant to the species. The modeling described by Stephens and MacCall (2004) describes methods for separating those observations that do not belong to the fishery from those that are in fact informative 0 observations and is often applied to multi-species fisheries such as the reef fish fishery in the southeast US. Informative 0s are those records that indicate possible catchability issues or lack of fish in historical habitats at the time of fishing. An alternative would be to consider developing index models that explicitly account for the observed low or 0 values such as hurdle models or using probability distributions that include the delta-lognormal or delta-gamma models.

Missing Data

Some combinations of vessel (hull x technique), year, month and ICES square have no records associated with them but the pattern and causes of the missingness are not well described in the provided documents. When the annual means are averages over differing sets of locations or months or gear types, the results can be badly biased unless they are adjusted to account for that aspect. In addition, it is unclear if the analysts addressed the pattern of missingness to ensure that there would be no problems using the LSE approach to estimate the main effects in the model. Some patterns of missingness can lead to non-estimable effects.

Model Development

The basic model is a multifactor main effects ANOVA model with only fixed effects. The analysts spent considerable time and effort identifying spatial and seasonal trends and using this information to reduce the number of combinations of year x month x ICES square into groupings that displayed the same patterns. For purposes of developing an LPUE index time series for use in the sea bass stock assessment, though, this was not necessary. More important to that development is obtaining unbiased estimates and estimated measures of uncertainty such as standard errors or relative standard errors. Stock Synthesis 3 uses both the index and its relative standard error in the analyses.

A major concern is the lack of incorporating effects due to repeated observations of the same vessel. The data are not independent since there are multiple observations from each vessel and trip. As a result, one obtains biased estimates (overweighting by individual vessels that maybe fish more or for longer) and underestimated variability in the estimates (not accounting for repeated observations on the same unit leads to effective sample sizes too large relative to the true effective sample size). A covariance structure that includes the covariance among observations from the same vessel or vessel trip should be included. Given the very large sample sizes available in this analysis, this would require using a parametric approach with some simplifying assumptions (e.g. the correlation among observations for a single vessel is the same for all vessels) since the covariance matrix would be very difficult to specify otherwise.

Should a parametric method be considered, the analysts should then also consider a parametric approach in which zero data are included. His could be accomplished by assuming (and checking that) the non-zero data are from a distribution such as the lognormal or a gamma distribution and the zero (or effectively zero) data are Bernoulli random variables. One would model each of these separately and then combine the annual estimates to obtain an overall estimated mean for each year that includes information from the 0 proportion as well as he non-zeroes. Another alternative would be to use a probability distribution such as the Tweedie distribution which allows zeroes in the range of the LPUE. A common link function for the Tweedie would be the log link and fitting the model using maximum likelihood would allow the zeroes to be included in the modeling.

Model Fitting

One of the concerns regarding the current model is the use of a non-parametric approach (least squares estimation "LSE") under the argument that it is robust to failure of model assumptions. This is not correct. LSE yields unbiased and minimum variance estimators only under the following conditions:

a. The explanatory variables are measured without error
b. The error terms have
    i. Have a mean of 0 $\left(\text{i.e.} E\left[\epsilon_{vsmyi}\right] = 0\right)$
    ii. Have homogeneous variance, i.e. the variance is the same for all combinations of vessel IDs, ICES square groupings, months, and years $\left(\text{i.e.} Var\left[\epsilon_{vsmyi}\right] = \sigma^2 \;\; \forall\, v, s, m, y, i\right)$
    iii. Are uncorrelated, i.e. the covariance between any pair of error terms is 0 for all possible pairs of error terms $\left(\text{i.e.} Cov\left[\epsilon_{vsmyi}, \epsilon_{v's'm'y'i'}\right] = \sigma^2 \;\; \forall\, v, s, m, y, i \text{ where } v \neq v', s \neq s', m \neq m', y \neq y' \text{and } i \neq i'\right)$

Some of these assumptions are not met as has already been described. For example, the analysts note that the covariance assumption is not met and in fact there is high correlation among observations from the same vessel. It is also possible that the homogeneous variance assumption is not met since the analysts state that assuming a probability distribution of the residuals cannot be done. This implies that either the data are mixtures of several distributions (due perhaps to the gear effects which may not have been completely accounted for in the model) or that there are some extreme observations that do not fit the usual probability distributions used for CPUE or LPUE data. Further investigation could uncover why standard distributions do not fit well; perhaps there are missing covariates?

The use of the regression coding for the models is valid but also ignores the advances in computer software for statistical analyses that have been developed since Robson's 1966 paper. The models are easily implemented in R, an open source statistical software package that is available at https://cran.r-project.org/. There are many sources and examples describing the use of built in functions such as lm() that do not require construction of incidence matrices as described in this document.

Estimation of Variance of the Annual Means

Since a non-parametric approach was used to fit the models, confidence intervals, standard errors and relative standard errors are not available from the fitting procedure. The analysts chose to obtain these by using a bootstrapping method which is reasonable given the large sample sizes available to the analysts.

They describe the method as randomly selecting vessels (hull x technique or a vessel ID?) with replacement to obtain each bootstrap sample and then estimating the confidence intervals endpoints by assuming approximate normality of the annual estimate of log-LPUE. Given the review of the residuals provided, using approximate normality does not seem unreasonable but other methods such as the BCA approach (Efron and Tibshirani,) should also be reviewed. In fact, it would have been informative if the analysts

The difficulty is in the method of selecting the bootstrap samples. I am not sure exactly how the selections occurred but using vessel selection without any additional restrictions would not be correct. The selection procedure should match the process that generated the LPUE values in the first place. This would honor the fact that LPUE records are nested within individual trips and that trips occur within a natural stratification. For example, the natural stratification of year, month and region [English Channel or Bay of Biscay] implies that the bootstrapping should honor that separation of information. Within each of these strata a random selection should be a vessel-trip and all records associated with that vessel-trip. If a logbook is filled out daily and returned as a single set of daily records at the completion of a trip, then trips within a stratum should be the sampling units. To instead randomly select a vessel (possibly crossed with a fishing technique) as the sampling unit ignores the correlation among LPUE values due to a vessel-trip repeated observations.

Annex 7: Combined analysis of both (1) zero sea bass landing and (2) positive days

Alain Laurec, ENSAR Department Halieutique, Rennes, France.

Combined analysis of both

(1) zero sea bass landing and (2) positive days

I Basic data set

An enlarged set of 913 vessels has first been defined, which includes all vessels which over years 2001 to 2016 have declared sea bass landings for at least 100 days and 2 years . All vessels are related to groups of métiers. Midwater trawls and purse seiners have been ignored, so that a set of 7 groups of métiers has been used (FL1/ FL2/ HMC/ PLG/ CF1/ CF2/ SND). A set of 45 squares has been defined, the list of which corresponds to appendix 1. Landings lower than 0.99 have been considered as fake positive values for the analyses described in section II. Calculations have also been performed with other threshold values (0.5 and 5.), without revealing real discrepancies in the final indices.

II Preliminary analyses

II-1 Overall histograms per year

Histograms of landings per day have been built for individual years and groups of métiers, then grouped. Figure 1 below, uses on the y axis a logarithmic scale for relative frequencies expressed as percentages, while the x axis corresponds to the landing per days figures (figures on the x axis correspond to the center of a weight interval).

Figure 1 Histograms per year - all métiers combined

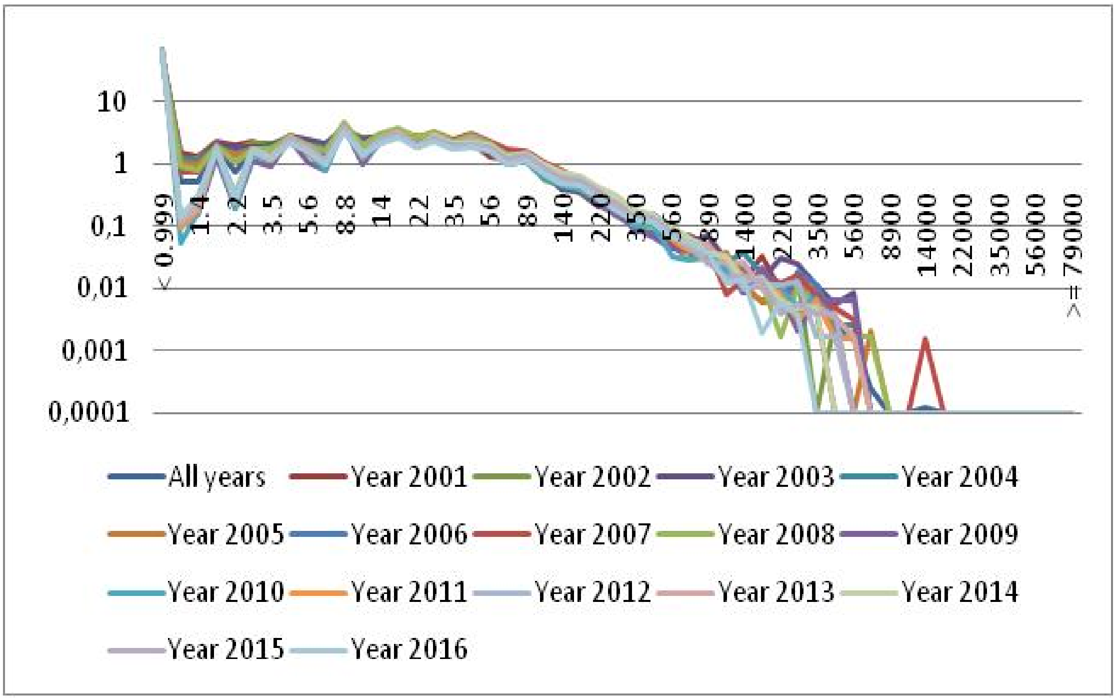
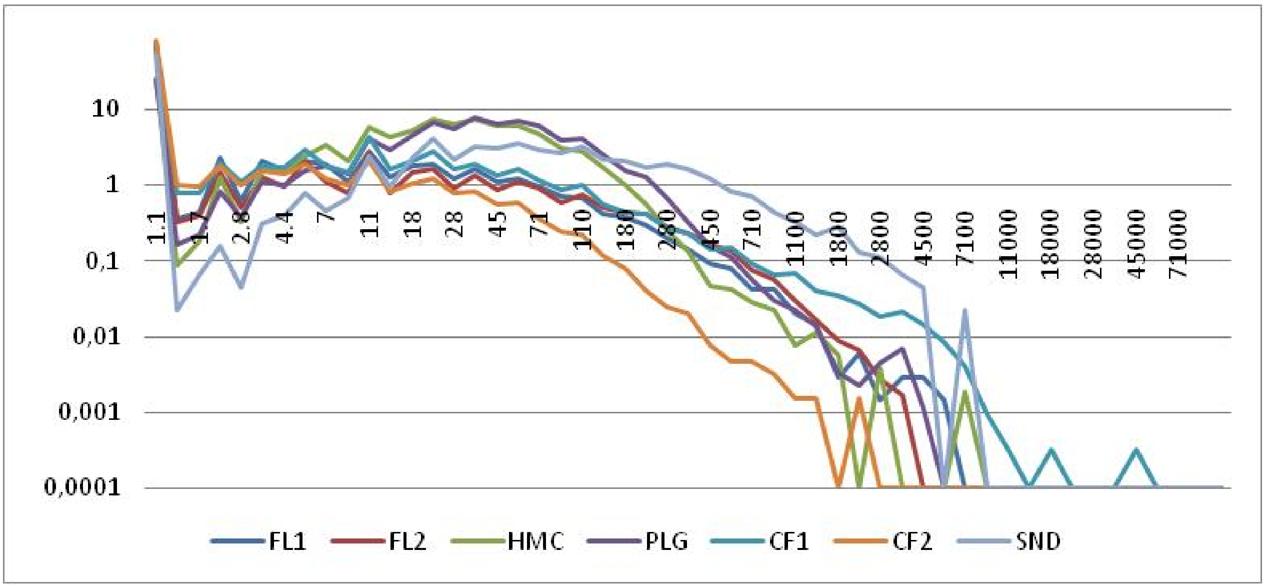


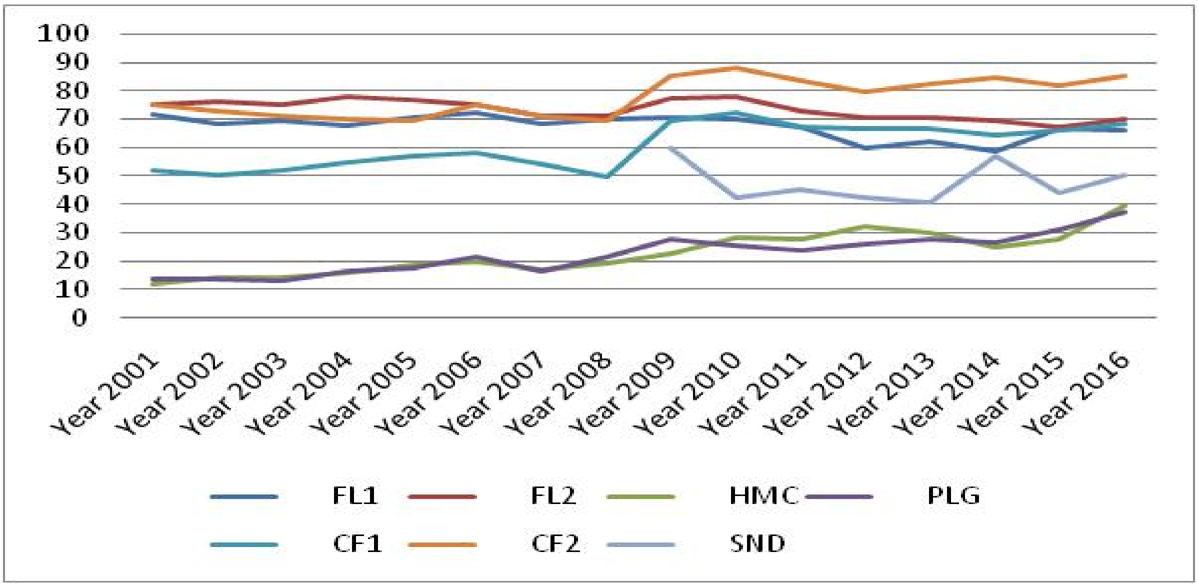
Figure 1 makes it possible to perceive a key pattern : high frequencies of null days (on average 60%), and a mode (with log/log scales) between 30 and 50 kg per day. The high percentage of quasi null" values appears for all years(figure 1) and al groups of métiers, as highlighted by figures 2 and 3 below.

Figure 2 Histograms per group of- all years combined



Paying special attention to the percentage of "quasi null" values, they vary between groups of métiers and years, as illustrated by figure 3.

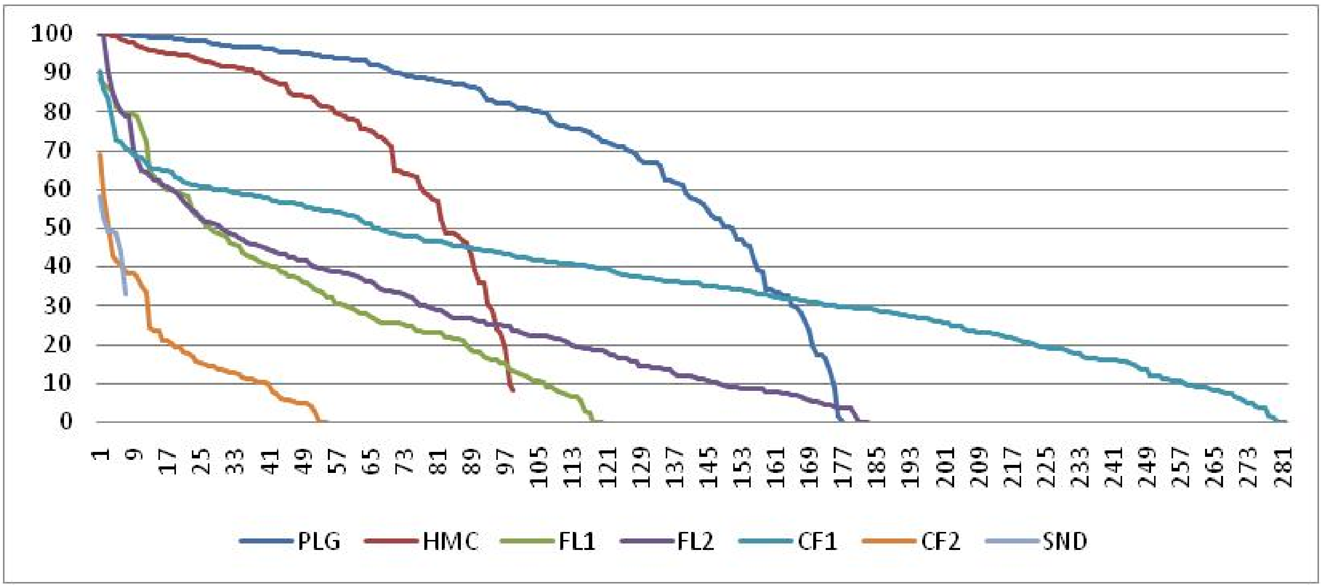
Figure 3 : Percentages of quasi null values per year and group of métiers.(both stocks combined)



As pointed out earlier a real change took place in 2009, since the frequency of fake non null values (<0 <0.999) was much lower after this year.

Detailed analysis per vessels shows that only a very limited number of vessels never show very low frequencies of "quasi null" values. For each vessel the frequency of "positive = non quasi null values= landings >0.999" has been calculated. For each group of métiers frequencies have sorted by decreasing values, leading to figure 4

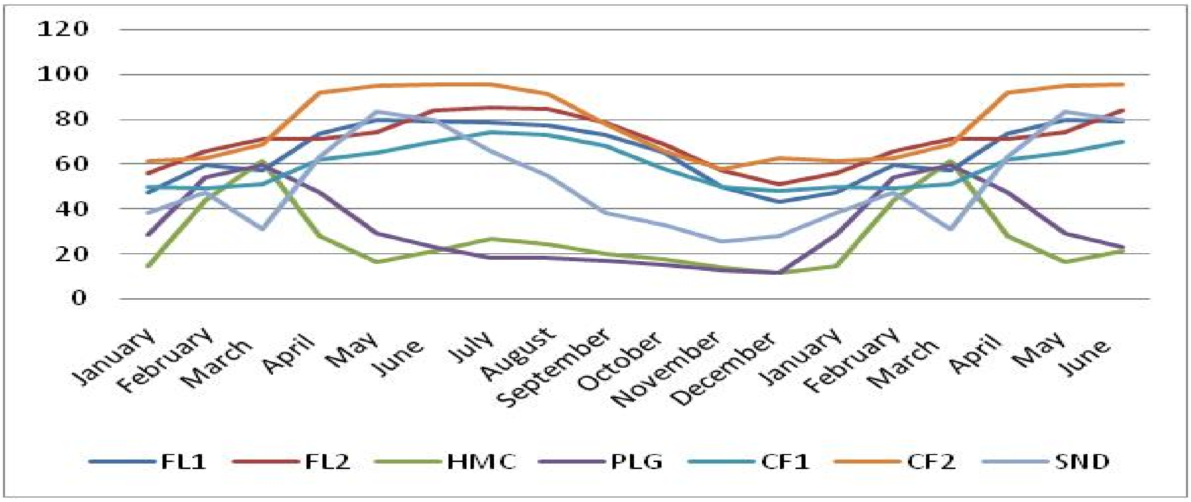
Figure 4 Observed frequencies of positive days by vessels, results within a group of métiers being sorted by decreasing values



For two groups of métiers (PLG = long line and HMC = other gears using hooks) positive days dominate, but for the other ones only a few vessels have a frequency higher than 80%.

It is also impossible to get very low frequencies of "quasi null values" by selecting some months, as revealed by figure 5 below

Figure 5 Monthly frequencies of non positive days by group of métiers (both stocks, all years combined)



Strong seasonal patterns appear, which are quite different between groups of métiers, with in fact two groups of groups (SND = Danish seine is a special case, which only includes a limited number of vessels[1].

II Analysis of changes over years of in the frequency of positive days

Changes before year 2009 cannot be usefully analysed because of the likely pollution in the first years by unlikely very low values (e.g. 0.1kg). Between years changes beyond this year necessarily interfere with the definition of abundance indices. Figure 3 do not suggest strong variations. The analysis must however be conducted separately for the different stocks. It should also take into account risks of interferences between year effects and seasonal effects, illustrated by figure 5.

A four factor model has basically been used, similar to the model used for the analysis of the variations of the only positive days: a vessel effect, a year effect (common to all squares related to the same stock), a month effect (similar within groups of neighbouring squares) and a square effect. The analyses have however been conducted separately according to the season, because of interaction between gear groups effects and seasons (see figure 5 above).

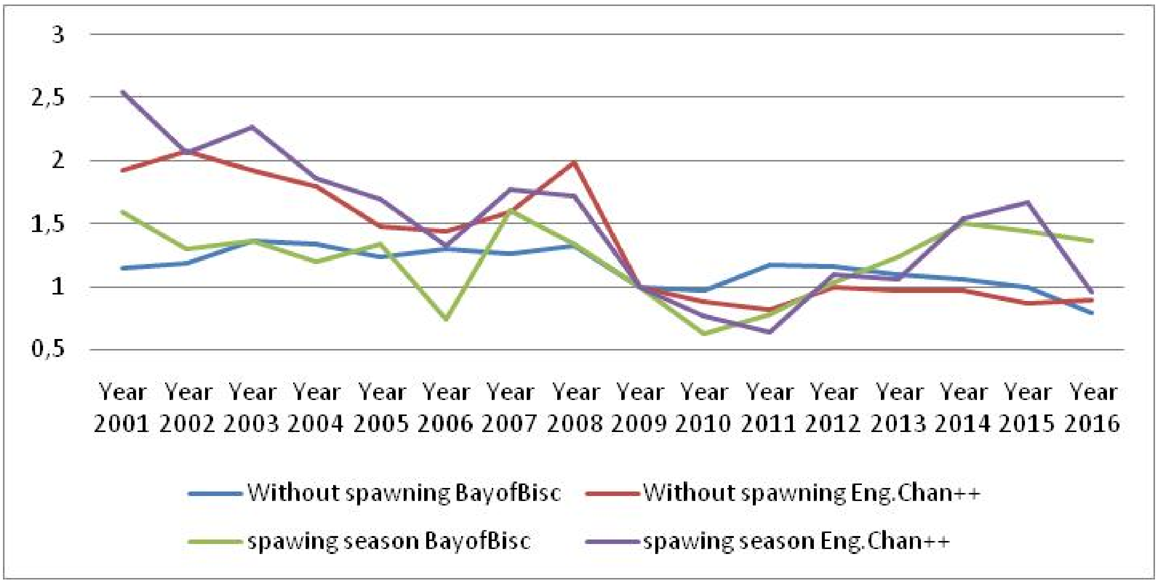
Within a stratum (an Ices square, for a given year and a given month) for each vessel the frequency p of positive days is the basic observed value. As usual for binary data, a logistic transformation is applied to the observed proportion(log(p (1-p)) before an additive multifactor model is fitted. In a number of cases however the observed p is equal to 0 or 1. This has been dealt with (1) by removing vessels for which the overall observed proportion of positive days is either bigger than 0.9 or lower than 0.1, (3) using a (small constant) $\boldsymbol{\Delta}$ so that the transformation becomes log((p+ $\boldsymbol{\Delta}$) (1+ $\boldsymbol{\Delta}$-p). Basically 0.05 has been used for $\boldsymbol{\Delta}$. Since this process implies some arbitrary choices, all results have been subject to a sensitivity/robustness analysis described in Appendix 2.

Because of the seasonal patterns (figure 5 above) the analysis has been performed using two sets of months - spawning season -December to March, , then without the spawning months - May to November, April being ambiguous. For the spawning season analysis, December from each year y has been treated as being related to the spawning season for year y+1

[1] This seasonal pattern is not the same as the seasonal pattern of changes in the "average" values for positive days, which will deserve further analyses.

Results appear on figure 6 below, where year indices have been divide by the 2009 value.

Figure 6 : Year effects according to the selected sets of months



Results from the spawning season seem quite strange for both stocks, even beyond 2009:the peak in 2014-2015 which does not seem related to a real increase in stock size. Further analyses will be necessary, including using other model fitting techniques than the simple ones we have used. The behaviour of the sea bass during this period could be related to some kind of shrinking of the area where the fish is present. For sea bass nothing like a macroscopic area shrinking can be seen: even in the channel there are positive days in all squares year after year. Area shrinking can also take place at a more detailed scale, for instance when the spawning aggregation correspond to spots of smaller size. Fishing tactics (choice of the target species and of the fishing spots) are also likely to play a larger part during the spawning season. This could explain the discrepancy between results from the spawning seasons, and results from other months. It seems anyway wiser for the time being to set aside the spawning season, in order to take into account only months from May to November.

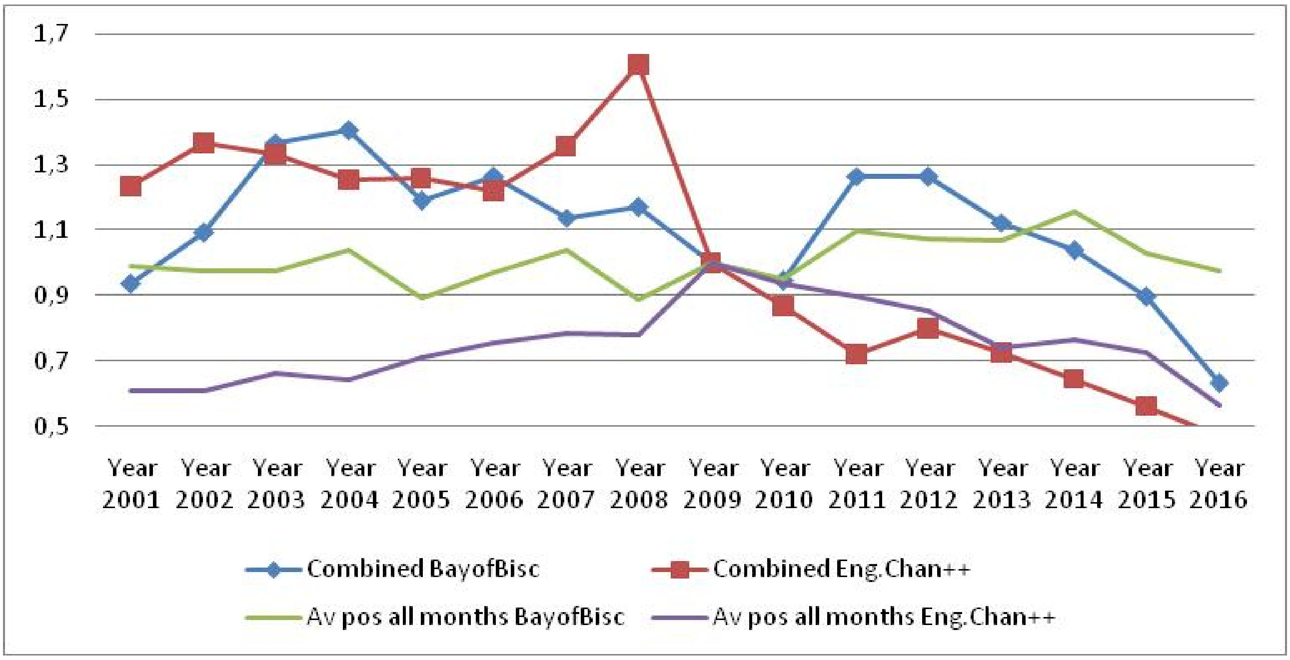
The year effects calculated out of the spawning season do not seem strong, especially for the English Channel (differences between the two stocks should be later on explained).

III Overall tuning indices

Keeping the same logic as above, west of Brittany squares have been lumped within the Bay of Biscay stock, while the possibility of setting aside the spawning season has been considered. For both stocks a combined final index of abundance can be obtained by multiplying the proportion of positive days by the (geometric) average over positive days.

Results appear on figure 7, together with the "old" index, which is calculated on positive days, keeping all months.

Figures 6(a) and 6(b) Comparison of annual abundance indices



No real change appear for the English Channel beyond 2009. For the bay of Biscay discrepancies are higher, the decrease starting sooner and being stronger.

Appendix 1

List of the 52 ICES squares covered by the analyses

Bay of Biscay:

15E8/ 16E8/ 17E8/ 18E8/ 19E8/ 20E8/ 21E8/ 22E8/ 20E7/ 21E7/ 22E7
23E7/ 24E7/ 21E6/ 22E6/ 23E6/ 24E6/ 23E5/ 24E5/ 25E3/ 25E4/ 25E5

English Channel

26E5/ 26E6/ 26E7/ 26E8/ 27E5/ 27E6/ 27E7/ 27E8/ 27E9/ 28E6/ 28E7/ 28E8
28E9/ 28F0/ 29E6/ 29E7/ 29E8/ 29E9/ 29F0/ 29F1/ 30F1/ 31F1/ 31F2

Appendix 2

Process used in order to extract a year effect from a set of frequencies of positive days covering several years

For each vessel i_b, each square j_c, each month k_m and each year l_y the total number of recorded days is $N_{ib,jc,km,ly}$. The corresponding proportion of positive (landings of sea bass > 0.999 kg) days is $p_{ib,jc,km,ly}$.
A multi factorial model combining vessels effects, squares effects, months effects and years effects is to be fitted. By contrast to models used for the positive lpue, it is difficult to consider that a simple multiplicative model ,or an additive one after a transformation, is to be chosen, . We have however made this choice. We have compared two different preliminary transformations of the $p_{ib,jc,km,ly}$: (1) simple logarithms Ln(p) and (2) the so called logistic transform where a proportion p is changed into $\boldsymbol{y = Log(\frac{p}{1-p})}$.
In both cases an additive linear model is fitted on the transformed values. In both cases three constrains have been used :(on the transformed values): (i) the average vessel effect is set to zero within a group of vessels (CF1), as well as (ii)the month effects within a year, and (iii) the square effects within a stock.
We were not in a position to use a sophisticate fitting technique, such as a quasi log likelihood[2]. This should be tried, since it makes it possible not to be disturbed by observed frequencies equal to zero (logarithm), and 1 for logistic transformation. The technique used is in fact a proxy.
For the present calculations in order to overcome difficulties:
- (1) vessel which on average have a very low percentage of positive days (e.g. less than 5%) or a very high percentage (e.g. more than 95%) can (or not) be eliminated,. Such vessels are not likely to yield very much information about changes in the frequency of positive days, while the observed frequencies close to 0 and 1 are subject to major random effects.
(2) for logarithmic transforms a constant $\boldsymbol{\Delta}$ has been added to the observed frequency p (the real transform is log(p+ $\boldsymbol{\Delta}$).
When using a logistic function the observed frequencies have been shrunk using the preliminary transformation $\boldsymbol{x = 0.5 + \frac{p-0.5}{1+\Delta}}$

[2] Here again because of likely statistical linkages between the various observed frequencies it is not fully legitimate to admit that the loglikelihood functions associated to the various sets of data can simply be added. It is vevertheless wide to use the corresponding function as a goodness of fit criteria.

In the sensitivity analysis below the enlarged spawning season months (December to April) have been eliminated, since the corresponding year effects deserve special attention as discussed in the main text.

The optimality of the process we used in order to extract year effects is not guaranteed. This is why sensitivity/robustness studies have been conducted about the influence of (1)the frequencies thresholds used for selecting vessels (0.00,0.5,0.15 instead of 0.10 ; 0.98,0.95,100), (2) preliminary transformations (log versus logistics) and (3) the ***Δ*** constant in the shrinking transformation (0.01,0.02,0.10 instead of 0.5).

A test has then been perform in order to check the ability of the overall process to detect year effects: the basic data set has been disturbed in order to add for a panel of selected years a known increase (e.g. 0.05 extra frequency over years 2011 to 2014)in the frequency of positive days.

Annex 8: Review of Updated Sea bass LPUE Analyses focusing on the LPUE index for the English Channel

Mary C. Christman. 08 February 2018.

Review of Updated Sea Bass LPUE Analyses focusing on the LPUE index for the English Channel

Mary C. Christman, MCC Statistical Consulting, Gainesville, FL, USA (marycchristman@gmail.com)

08/02/2018

Documents Provided:

Main results up to now.docx: "First treatments of lpue of sea bass data including zeros", by Alain Laurec, 15/12/2017

Combined analysis.docx: "Combined analysis of both (1) zero sea bass landing and (2) positive days"

Appendix 2.docx: "Process used in order to extract a year effect from a set of frequencies of positive days covering several years"

Tuning and null values.docx: "Why it is possible to ignore zeros while deriving a tuning abundance index from logbook data", by Alain Laurec, 06/12/2017

Email from Rui dated 8 February 2018 entitled: "FW: WKBass - BASS47 outstanding data issues"

Description of Information Provided:

In the report labelled "Main results up to now.docx", the authors review the annual proportions of the landings' reports that list zero landings/day of sea bass and its effect on the annual time series abundance index derived for the English Channel. For their review they used all data from all months and the years 2000 to 2016, inclusive for all ICES squares for the English Channel stock. The authors included days with 0 landings but they did not explicitly state whether any daily landings less than 1 kg are considered a 0. In addition, they removed from analysis any vessel (I assume they mean vessel/gear combination as described as the sampling unit in "2017.06_WD_LPUE_seabass_for_WGCSE_2017.pdf") that reported less than 100 days – it is unclear whether they removed any vessel that had less than 100 days of positive landings or less than 100 days of fishing activity (0 and non-0 days). No explanation for why these were removed except that it made for a smaller dataset. It is possible that this also lowers the proportion of days with no landings reported but that is not stated.

The raw results indicate that over 66% of all reports are for 0 landings/day and that many of those occurred prior to 2009 (Figures 2, 3) but the percentage of 0 days varied by month and ICES square (Figure 6) as well.

Figure 3, a plot of the annual percentage of days with non-zero catch ("positive days"), shows that prior to 2009, the average percentage of days with positive landings was approximately 37% and after 2008, it averaged around 30%. Figure 4 shows two indices based on annual averages: $LPUE_{All}$ = total landings/total days and $LPUE_{Pos}$ = total landings/total positive days. The correlation between the annual percentage of positive days and the annual index of landings/positive day is -0.503 (p-value = 0.0396), indicating that as the proportion of positive days increases, the mean landings/positive day decreases. This is not surprising given the annual distributions of landings/day shown in Figure 2. As can be seen, for the years 2000 – 2008, there are more reports of low (< 1.5 kg/d) but non-zero values of landings/day than for the later years but the frequencies of the larger landings/day are similar across all years (especially for landings/day > 3.5 kg/d). The low but non-zero landings/day in the early years will both increase the percentage of positive days as well as decrease the mean landings/day. Without additional information it is difficult to know exactly why this occurs but overall, it appears that the stock is in serious decline in the 2010 decade.

In the report labelled "Combined analysis.docx", the authors describe annual LPUE indices that utilize all of the data, those reports with 0 and non-0 landings/day. Here they used 2000-2016 data for the Bay of Biscay as well as the English Channel for 7 métiers, 45 ICES squares, and vessels that reported at least 100 days and for 2 years. Note that this dataset differs from that given in "Main results up to now.docx". They showed that the frequency distribution of landings/day (in kg) varies little by year (Figure 1) but does appear to depend on métier (Figures 2-4) and month (Figure 5). They modeled p = the proportion of positive days/vessel/month/ICES square as a function of vessel, year, month (or season) and ICES square (or region) and used a logistic transformation of the observed proportion as the response variable. Before modeling, they removed additional records due to fitting problems (see summary of Appendix 2.docx). These were records having an observed proportion less than 0.10 and greater than 0.90. In addition, they added a constant to the remaining proportions before the logistic transformation. The model results are shown in Figure 6 for two regions, Bay of Biscay and English Channel, and for two seasons, spawning and non-spawning. They note that the somewhat unexpected results for the spawning season in both geographic regions could be due to either changes in fishing behavior or local scale changes in the spatial distribution of the species (e.g. contraction of spawning aggregations to smaller areas). They then combined the annual index of proportion of positive days with the annual index of landings/positive days to obtain the annual relative abundance indices shown in Figure 6. The results show that the combined index is quite distinct from the landings/positive days index for all years for the Bay of Biscay region and before 2009 for the English Channel. After 2009, the two indices are more similar but the combined index shows a steeper decline in the stock than the positive landings index.

In the report labelled "Appendix 2.docx" the authors describe various methods to fit models predicting the annual mean proportion of positive days of fishing and compare the predicted annual indices to determine the sensitivity of conclusions to the methods. Although not explicitly stated, it appears that they used the same computer program to fit these models as was used to fit the landings/positive days data in the 2017 report. As a result, they were required to perform various machinations so as to have a response variable that could be fitted using this program. The authors do recognize that this is not strictly statistically appropriate but assume it is a reasonable "proxy" for the correct model. The three main variations of methods were: remove any data records of very low (< 0.1) and very high (> 0.9) observed proportions of positive days; transform the observed proportions using either a natural log ($log(x)$) or a logistic ($log(x/(1-x))$) transformation; and, add a constant to the observed proportion so that a valid transformed value could be calculated when $x = 0$. For the logistic transformation, they chose to modify the observed proportion using $x = 0.5 + \frac{p-0.5}{1+\Delta}$ where Δ was varied between 0.01 and 0.5. After review, they chose to use the complete set of data (no trimming), the logistic transformation and Δ = 0.05. When this value is used, a value of $p = 0$ yields $x = 0.0238$, and when $p = 1, x = 0.976$.

The final document, "Tuning and null values.docx" is a somewhat confusing document that attempts to explain why the records of 0 landings day could be ignored if certain conditions exist concerning the spatial distribution of density. The final conclusion is that "A combined abundance index, taking into account the proportion of zero landing days, will be preferable if for the same size of the stock the relative influence of the area effect and the density effect can change." Presumably, since these cannot be known, the combined index is the appropriate choice.

Review:

First, I would like to comment that the new documents that were provided contained a wealth of information that included much additional information on the stock and on the fisheries exploiting the stock. This allowed for a detailed review to be completed. Unfortunately, there are still a few issues that were not addressed, and these are described below.

As a result of several removals from the datasets used in the analyses, it is not possible to compare the more recent findings with previous reports from 2017. There were several issues raised in the last review, including the effect of removing 0 catches/day from the analyses, the effect of using the wrong method for fitting the models, explanation of how missing data were addressed, and detailed description of the bootstrapping done to obtain standard errors for the time series. The main aspect that has been addressed here is the effect of incorporating logbook data reporting 0 kg catch/day. I will focus on the methods used to estimate the time series and whether they provide an appropriate LPUE time series for use in the stock assessment.

After several exploratory analyses to fit models to the proportion of positive days ($Prop_{Pos}$) for a vessel/month/ICES square/year, the authors appeared to have chosen to use a model that was developed based on

1) a trimmed dataset (observed proportions < 0.1 or > 0.9 were removed),
2) a dataset that excluded vessels with < 100 days of logbooks and less than 2 years of data,
3) a logistic transformation with a modification ($x = 0.5 + \frac{p-0.5}{1+0.05}$) to the observed proportion to avoid values of 0 or 1,
4) fitted to 2 datasets, one for spawning season and one for the non-spawning season, and,
5) used the definition of positive day as one with any landings > 0.

This last is inferred from their statement "Changes before year 2009 cannot be usefully analysed because of the likely pollution in the first years by unlikely very low values (e.g. 0.1kg)" which implies that rather than modify the entire series of logbook data to indicate that a 0 catch was any reported catch < 1 kg (as seems likely to be what was recorded after 2008), they used any catch > 0 as a positive catch in the modeling of the proportion of positive days ($Prop_{Pos}$). They then combined this index with a modeled $LPUE_{Pos}$ index based on

1) logbook data with landings > 1 kg/day, and,
2) all vessels (no removals for length of time in fishery or number of days fished).

From their analyses it is unclear whether the annual $LPUE_{Pos}$ index was also developed for each season separately as was done for the $Prop_{Pos}$ index or whether the set of ICES squares used in the two indices were the same before combining the two indices into a combined index ($LPUE_{Comb}$). Hence the issues to be addressed include: consistency of the dataset used in each index (time and space), consistency of the definition of a 0 catch, and consistency in the use of the same set of reported catches (trimming and removal of small scale fishers).

A recent email conversation between several of the stock assessment team members indicates that Dr. Laurec has addressed a couple of the issues (consistency in time and definition of a 0 catch). He has separated the annual index of the proportion of positive days into two, one for each season, and used the same threshold (> 1 kg) for identifying a positive catch for both annual indices ($Prop_{Pos}$ and $LPUE_{Pos}$). What was not addressed is whether the two indices, positive days and positive landings, are now based on the same dataset; both should be based on the same set of logbook records, i.e. any records that are removed should be removed from both datasets used for each index. This would include any trimming of the dataset for extreme proportions of positive days (if they are removed, then their landings on positive days should be removed as well), the removals of less active fishers, and whether the same sets of months and ICES squares are included in the analyses of the two different indices before combining.

In none of the new documents has the issue of the relative standard error (often called the CV) been addressed although the email conversation indicated "So, for the Bay of Biscay, choice has been made to fix in the LPUE data the se(log) to 0.05 (approximately the average value of the standard deviation of Av+ [$LPUE_{Pos}$]) and let SS3 add some extra SD)." If the combined index ($LPUE_{Comb}$) is chosen for use in the stock assessment, then the SE of that combined index is required. Using a value based on just the $LPUE_{Pos}$ index would underestimate the correct SE of $LPUE_{Comb}$. This should be addressed and will probably require bootstrapping or expert opinion as to a likely and reasonable value.

The email correspondence and statements in the Combined analysis.docx document imply that Dr. Laurec recommends that only the annual combined LPUE series for the non-spawning season be used in the stock assessment and further that the index should only be used for more recent years, namely from 2009 on.

I disagree. It appears that the reason he thinks the earlier years should be removed is the problem of not correctly recording any catch < 1 kg as a 0 catch in the early years. That is easily corrected in the dataset so should not warrant removal of these years from the index. I also would recommend that the panel consider using data for the entire year, not just the non-spawning months, and for all fishers reporting logbooks in any year, since those removals are also indicative of the stock. This inclusion of the small scale fishers will likely increase the proportion of zeroes in some of the ICES squares and months which will likely have an effect on the combined index. Unfortunately, the documents provided did not include figures or tables showing the combined index for the spawning season alone or the combined index for all seasons or for the complete dataset with all logbook reports, so I cannot draw any conclusions on whether omission of these data influence the overall $LPUE_{Comb}$ index.

One other issue is statistical. The authors clearly state that the model developed for the $Prop_{Pos}$ index is a proxy for the true index since they used an approach that is an approximate approach to the correct statistical analysis (a mixed ANOVA model with the assumption of a binomial distribution with a logistic link function and random effects to capture correlations among observations). Without more detail as to the data distribution (by vessel, ICES square, month, and year) and the types and sizes of the correlations, it is not possible to know whether their conclusion is correct. Since they are closely familiar with the data, I would defer to the decision of the data analyst and the stock assessors.

Overall, I do believe that Dr. Laurec has provided a good start to a combined index that will be more informative than using only the $LPUE_{Pos}$ index. If there is the opportunity, the models should be rerun paying close attention to ensuring that the two indices used for developing the combined index are based on the same set of data and that the definition of a 0 catch be made consistent across all years.

Annex 9: Stock Synthesis 3 Model data and control files for sea bass 8.ab stock

SS3 data file

```
#C data file created using the SS_writedat function in the R package r4ss
#C should work with SS version:
#C file write time: 2018-03-27 18:21:06
#
1985 #_styr
2016 #_endyr
1 #_nseas
12 #_months_per_seas
1 #_spawn_seas
2 #_Nfleet
1 #_Nsurveys
1 #_N_areas
Comm%Rec%LPUE #_fleetnames
-1 -1 -1 #_surveytiming_in_season
1 1 1 #_area_assignments_for_each_fishery_and_survey
1 1 #_units of catch:  1=bio; 2=num
0.1 0.1 #_se of log(catch) only used for init_eq_catch and for Fmethod 2 and 3
1 #_Ngenders
20 #_Nages
2125 1410 #_init_equil_catch_for_each_fishery
32 #_N_lines_of_catch_to_read
 #_Comm       Rec year seas
   3420 1451.2399 1985    1
   3549 1391.5521 1986    1
   3417 1346.9494 1987    1
   3217 1344.7479 1988    1
   3144 1312.8046 1989    1
   2621 1342.0681 1990    1
   2734 1323.8414 1991    1
   2709 1317.6787 1992    1
   2552 1309.3367 1993    1
   2668 1257.3742 1994    1
   2492 1219.4993 1995    1
   2402 1145.1736 1996    1
   2358 1089.3784 1997    1
   2231 1109.3955 1998    1
   2091 1121.9005 1999    1
   2362 1218.7399 2000    1
   2306 1297.1030 2001    1
   2392 1356.0833 2002    1
   2616 1392.0698 2003    1
   2380 1411.2080 2004    1
   2796 1427.6398 2005    1
   2875 1446.7797 2006    1
   2751 1477.5792 2007    1
   2745 1491.4891 2008    1
   2278 1481.3784 2009    1
   2229 1430.0000 2010    1
   2575 1416.4568 2011    1
   2549 1363.1073 2012    1
   2685  878.9097 2013    1
   2991  814.6358 2014    1
   2264  748.7657 2015    1
   2252  712.7570 2016    1
16 #_N_cpue
 #_Fleet Units Errtype
       1     1       0
       2     1       0
       3     1       0
 #_year seas index       obs se_log
   2001    1     3 0.8750680   0.05
   2002    1     3 0.9079417   0.05
   2003    1     3 1.1929903   0.05
   2004    1     3 1.2159612   0.05
   2005    1     3 1.1245049   0.05
   2006    1     3 1.2415534   0.05
   2007    1     3 1.0906019   0.05
```

```
   2008    1     3 1.1387573   0.05
   2009    1     3 1.0000000   0.05
   2010    1     3 0.9868932   0.05
   2011    1     3 1.2514951   0.05
   2012    1     3 1.2401359   0.05
   2013    1     3 1.1512621   0.05
   2014    1     3 0.9713107   0.05
   2015    1     3 0.9159223   0.05
   2016    1     3 0.6420777   0.05
0 #_N_discard_fleets
#_discard_units (1=same_as_catchunits(bio/num); 2=fraction; 3=numbers)
#_discard_errtype:  >0 for DF of T-dist(read CV below); 0 for normal with CV; -
1 for normal with se; -2 for lognormal
0 #_N_discard
0 #_N_meanbodywt
30 #_DF_for_meanbodywt_T-distribution_like
2 # length bin method: 1=use databins; 2=generate from binwidth,min,max below;
3=read vector
2 # binwidth for population size comp
6 # minimum size in the population (lower edge of first bin and size at age 0.00)
96 # maximum size in the population (lower edge of last bin)
-0.001 #_comp_tail_compression
1e-07 #_add_to_comp
0 #_combine males into females at or below this bin number
42 #_N_lbins
#_lbin_vector
14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66
68 70 72 74 76 78 80 82 84 86 88 90 92 94 96
18 #_N_Length_comp_observations
 #_Yr Seas FltSvy Gender Part Nsamp      l14     l16      l18      l20      l22
l24       l26       l28         l30         l32         l34        l36        l38
l40      l42       l44       l46        l48        l50       l52       l54       l56
l58      l60       l62       l64        l66        l68       l70       l72       l74
l76       l78        l80         l82        l84         l86        l88        l90
l92      l94       l96
 2000    1     1     0    2    64    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00     0.00000  2880.6160  45935.078 152808.48 220335.69
239160.1  286599.0  243502.6  158673.1  104186.91   71658.55   52722.97  49019.25
30042.41  38825.23  37663.68  36813.82  40636.42  15478.248  15352.052   8982.587
15588.181  16524.015  12757.4025  1570.8971  14753.3667  1629.88370    753.2115
357.62060    0.0000   0.00000   0.000  0.00000   0.0000
 2001    1     1     0    2    56    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00     0.00000  2367.3798  44146.375  79387.21  84484.63
145582.2  198129.6  222465.8  191913.0  150638.13   72993.45   62442.92  38597.04
33756.28  21942.42  18042.47  14175.65  14721.53   7940.522   7301.362   6580.313
6231.832  6005.226   642.9437 1019.3995    0.0000 1757.15120    0.0000    0.00000
0.0000   0.00000   0.000  0.00000   0.0000
 2002    1     1     0    2   116    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00     0.00000  2217.3742  64033.767 158333.67 208344.88
203219.8  160072.7  220448.6  275940.5  208063.69   95311.49   57518.93  51192.28
43569.23  35597.87  28199.75  24671.82  23594.32  12646.647   8457.892  48787.198
11862.237 32055.382  3115.8504 1103.4541   598.9841    0.00000  299.4921    0.00000
0.0000   0.00000   0.000  0.00000   0.0000
 2003    1     1     0    2   151    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00     0.00000  2171.3467  51250.887 174977.94 197448.71
223289.2  253115.2  261608.4  233459.2  258428.74  174191.31  125278.05  77151.77
66032.44  46152.56  38554.35  42296.66  16223.10  23962.189  14509.113  10024.502
7672.616  7356.215   836.7932  966.3659   544.2019  407.63180  418.3966    0.00000
0.0000   0.00000   0.000  0.00000   0.0000
 2004    1     1     0    2    97    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00     0.00000  2671.9342  42557.239 123000.97 160618.97
180252.5  205086.4  187123.9  128734.6  141156.56  108068.80  101203.03  57574.88
79654.09  41356.82  31054.03  19798.09  12940.35  13865.759   6681.104   3676.903
1918.746  3249.945  1981.8732  539.3221   539.3221    0.00000    0.0000    0.00000
0.0000   0.00000   0.000  0.00000   0.0000
 2005    1     1     0    2   115    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00     0.00000  1164.5892  55443.219 137364.81 135848.55
138312.8  148490.5  197589.8  153242.0  158238.70  165846.11  153338.67  71593.06
166532.15  71182.88  90897.29  40598.16  26529.28  22865.734  14696.354  25783.039
14940.030  14540.260   4245.2005  7154.3609   1753.3554      0.00000   291.1473
582.29461    0.0000   0.00000   0.000  0.00000   0.0000
 2006    1     1     0    2   102    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00     0.00000   2367.0183 166780.934 274898.67 278234.77
299072.4  393220.0  416833.2  191492.2  143960.09  107616.07   65599.68  46715.82
54133.76  41722.99  35770.08  38066.38  28126.09  10744.546  10103.280  14538.301
12726.773  9402.127  2831.6538  600.9166   156.2932  838.51255  181.9410    0.00000
78.1466   0.00000 198.481  0.00000   0.0000
```

```
 2007    1     1     0    2   249    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00    0.00000   812.2151  35403.089 133102.42 213251.61
214113.8  261257.3  321529.9  254983.8  184784.54  150861.83   95433.28  75099.85
71801.53  38135.41  64217.70  26022.44  96611.72  13074.550  26961.984  20777.636
10036.489   8922.491   4094.3986  1970.6327   1005.2861   532.86472   860.6264
41.08093   0.0000   0.00000   0.000  0.00000   0.0000
 2008    1     1     0    2   466    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00    0.00000   852.6931  30133.499 168970.43 250712.22
311782.8  309231.9  283237.0  203485.4  159457.08  131043.29   95910.74  88115.48
60397.92  36236.82  35442.31  58386.19  31528.26  17653.468  13267.171  16475.498
7517.035 15102.523  2321.5173 3608.5154  1224.3059   53.40678 1215.2198   0.00000
0.0000  0.00000   0.000  0.00000   0.0000
 2009    1     1     0    2   364    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00    0.00000   478.7088  10465.673  70312.86 132366.49
173051.0  199404.6  195232.9  129267.6  119587.04   91843.60   84278.27  69347.08
66240.29  42946.03  34348.93  42833.85  35155.93  26614.393  14340.414  18012.255
14898.646   6849.389   5346.9888  3597.1674   2449.4628   381.50170   344.0620
476.43606   0.0000  94.93436   0.000  0.00000   0.0000
 2010    1     1     0    2   324    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00    0.00000  1470.5349   9944.856  64016.86 103982.56
133714.3  178939.9  190658.7  159074.6  114068.60  103384.15   90955.34  61441.00
53571.80  39354.20  32033.21  31047.13  39977.90  15204.163  14524.299  27430.392
18763.584   9350.064   2568.0029  2244.8295   4723.8756   175.88996   292.6414
0.00000 3672.0156   0.00000   0.000  0.00000   0.0000
 2011    1     1     0    2   373    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00    0.00000  4833.8672  30968.928 137217.95 181185.22
213609.9  204740.9  193882.6  139659.2  157785.28  163768.38  112846.77  98995.45
64373.08  69257.62  63898.78  33605.67  42185.42  21843.610  20974.864  21369.792
13544.986   6912.131   8857.2189  4097.0426   2914.2178  1357.11677   439.9774
215.64376  846.1015   0.00000   0.000  0.00000   0.0000
 2012    1     1     0    2   433    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00    0.00000   486.1150  32037.853 145818.19 206519.28
247822.3  232390.5  183730.3  145106.8  116135.90  121439.91  107385.09  80211.84
80379.30  74905.27  45409.94  28876.93  29283.26  28578.630  22632.907  18775.452
12849.107   8490.193   6532.7035  4265.0598   3266.7446  1135.14923   373.9598
454.92221   0.0000  60.87409   0.000 68.31591 324.0767
 2013    1     1     0    2   260    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00    0.00000   906.6648   6898.542  80884.34 125220.21
157747.8  211358.8  216303.0  167782.7  140299.52   90151.14   94931.08  70884.46
74933.50  58868.63  36778.63  38472.73  49777.31  40296.686  18716.968  19089.699
8938.021  12811.394   7466.8552  8045.8338   3922.7949  1810.00766   944.0484
120.56652   0.0000   0.00000   0.000  0.00000   0.0000
 2014    1     1     0    2   338    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00    0.00000   685.9602   7423.377  70034.41 129796.64
204387.2  259965.5  241160.5  200240.1  160287.15  139274.74  107449.51  94700.07
88511.39  77066.78  68714.10  45761.73  51646.59  45282.515  35849.165  28757.337
21219.576  13188.121   9162.9937  5098.2679   3605.0520  3063.53421  1091.6076
673.41142   0.0000 139.49969   0.000  0.00000   0.0000
 2015    1     1     0    2   406    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00    0.00000  1840.6083  12103.243  76331.59 100032.25
149633.9  195459.1  183043.2  148892.9  113111.63   81404.91   74585.56  74077.14
78118.14  59730.44  46413.52  31999.62  31575.31  26571.422  19854.246  21888.236
13731.048  10620.543   5877.4243  3420.5305   1247.6312  1088.82978   385.1580
1327.46097   0.0000   0.00000   0.000  0.00000   0.0000
 2016    1     1     0    2   394    0.000   0.000    0.000    0.000    0.000
0.000    0.000     0.00   33.24201   607.3719  16030.098 138248.96 151184.10
153494.6  171179.8  163230.5  130766.2  106280.40   89395.19   83848.22  67969.91
63719.87  56807.80  47697.33  40976.64  34246.04  30679.586  26004.028  18351.000
11375.025   8205.115   2778.7961  8262.4545   2076.5885  1789.96835   182.8707
505.63244   0.0000   0.00000   0.000  0.00000   0.0000
 2010    1     2     0    0   100 1396.693 980.001 4062.675 4358.469 8878.725
5606.782 3648.191 53171.41 9245.97974 17654.9961  45965.322  60090.19  87036.03
160835.3  107496.8  103035.0   99173.4   50706.71   78590.41   46559.84  36314.94
55229.99  35978.15  52400.21  19774.02  17552.75  16580.729   7671.649  12968.333
10542.023  5908.419    0.0000 3718.4939    0.0000   0.00000   0.0000   0.00000
0.0000  0.00000   0.000  0.00000   0.0000
17 #_N_agebins
#_agebin_vector
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
1 #_N_ageerror_definitions
 #_age0 age1 age2 age3 age4 age5 age6 age7 age8 age9 age10 age11 age12 age13
age14 age15 age16 age17 age18 age19 age20
   0.50 1.50 2.50 3.50 4.50 5.50 6.50 7.50 8.50 9.50 10.50 11.50 12.50 13.50
14.50 15.50 16.50 17.50 18.50 19.50 20.50
   0.05 0.15 0.25 0.35 0.45 0.55 0.65 0.75 0.85 0.95  1.05  1.15  1.25  1.35
1.45  1.55  1.65  1.75  1.85  1.95  2.05
241 #_N_agecomp
```

```
3 #_Lbin_method: 1=poplenbins; 2=datalenbins; 3=lengths
0 #_combine males into females at or below this bin number
  #_Yr Seas FltSvy Gender Part Ageerr Lbin_lo Lbin_hi Nsamp a0 a1         a2
a3          a4        a5       a6       a7       a8        a9       a10        a11
a12         a13       a14       a15       a16
  2008    1      1      0    2      1      38       38     2  0  0   0.0000
0.0000     2.0000      0.00      0.0       0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      40       40     6  0  0   0.0000
0.0000     2.0000      3.00      1.0       0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      42       42     6  0  0   0.0000
0.0000     5.0000      1.00      0.0       0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      44       44     6  0  0   0.0000
0.0000     1.0000      3.00      2.0       0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      46       46     6  0  0   0.0000
0.0000     0.0000      6.00      0.0       0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      48       48     6  0  0   0.0000
0.0000     0.0000      1.00      5.0       0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      50       50     6  0  0   0.0000
0.0000     0.0000      1.00      2.0       3.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      52       52     6  0  0   0.0000
0.0000     0.0000      0.00      1.0       3.0       2.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      54       54     5  0  0   0.0000
0.0000     0.0000      0.00      0.0       2.0       1.0      2.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      56       56     6  0  0   0.0000
0.0000     0.0000      0.00      0.0       3.0       2.0      1.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      58       58     3  0  0   0.0000
0.0000     0.0000      0.00      0.0       0.0       1.0      1.00       1.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      60       60     4  0  0   0.0000
0.0000     0.0000      0.00      0.0       0.0       2.0      0.00       0.00
0.000    2.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      62       62     2  0  0   0.0000
0.0000     0.0000      0.00      0.0       0.0       0.0      2.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      64       64     2  0  0   0.0000
0.0000     0.0000      0.00      0.0       0.0       0.0      2.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      70       70     2  0  0   0.0000
0.0000     0.0000      0.00      0.0       0.0       1.0      1.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2008    1      1      0    2      1      74       74     1  0  0   0.0000
0.0000     0.0000      0.00      0.0       0.0       0.0      0.00       0.00
0.000    0.00    1.0000    0.000   0.0000    0.000
  2009    1      1      0    2      1      34       34     2  0  0   0.0000
0.0000     1.0000      1.00      0.0       0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2009    1      1      0    2      1      36       36     4  0  0   0.0000
0.0000     3.0000      0.00      1.0       0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2009    1      1      0    2      1      38       38     5  0  0   0.0000
0.0000     2.0000      1.00      2.0       0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2009    1      1      0    2      1      40       40    12  0  0   0.0000
0.0000     0.0000      7.00      5.0       0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2009    1      1      0    2      1      42       42     8  0  0   0.0000
0.0000     0.0000      1.00      2.0       4.0       1.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2009    1      1      0    2      1      44       44     7  0  0   0.0000
0.0000     0.0000      1.00      4.0       2.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2009    1      1      0    2      1      46       46     9  0  0   0.0000
0.0000     2.0000      3.00      1.0       3.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2009    1      1      0    2      1      48       48     9  0  0   0.0000
0.0000     0.0000      0.00      5.0       3.0       1.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
```

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  2009    1      1      0    2     1     50     50    8  0  0   0.0000
0.0000    0.0000    0.00    3.0    3.0    1.0    1.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     52     52    6  0  0   0.0000
0.0000    0.0000    0.00    2.0    4.0    0.0    0.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     54     54    7  0  0   0.0000
0.0000    0.0000    0.00    2.0    3.0    2.0    0.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     56     56    4  0  0   0.0000
0.0000    0.0000    0.00    0.0    3.0    0.0    1.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     58     58    7  0  0   0.0000
0.0000    0.0000    0.00    0.0    3.0    2.0    1.00    1.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     60     60    3  0  0   0.0000
0.0000    0.0000    0.00    0.0    1.0    0.0    1.00    1.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     62     62    3  0  0   0.0000
0.0000    0.0000    0.00    0.0    1.0    1.0    1.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     64     64    1  0  0   0.0000
0.0000    0.0000    0.00    0.0    0.0    0.0    0.00    1.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     66     66    1  0  0   0.0000
0.0000    0.0000    0.00    0.0    0.0    0.0    0.00    1.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     68     68    1  0  0   0.0000
0.0000    0.0000    0.00    0.0    0.0    0.0    0.00    1.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     70     70    3  0  0   0.0000
0.0000    0.0000    0.00    0.0    0.0    0.0    0.00    0.00
1.000   2.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     72     72    1  0  0   0.0000
0.0000    0.0000    0.00    0.0    0.0    0.0    0.00    0.00
0.000   0.00   0.0000   1.000   0.0000   0.000
  2009    1      1      0    2     1     74     74    1  0  0   0.0000
0.0000    0.0000    0.00    0.0    0.0    1.0    0.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     80     80    1  0  0   0.0000
0.0000    0.0000    0.00    0.0    0.0    0.0    0.00    0.00
0.000   1.00   0.0000   0.000   0.0000   0.000
  2009    1      1      0    2     1     82     82    1  0  0   0.0000
0.0000    0.0000    0.00    0.0    0.0    0.0    0.00    0.00
0.000   0.00   0.0000   0.000   1.0000   0.000
  2009    1      1      0    2     1     86     86    1  0  0   0.0000
0.0000    0.0000    0.00    0.0    0.0    0.0    0.00    0.00
0.000   0.00   1.0000   0.000   0.0000   0.000
  2010    1      1      0    2     1     34     34    9  0  0   0.0000
0.0000    7.0000    2.00    0.0    0.0    0.0    0.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2010    1      1      0    2     1     36     36   12  0  0   0.0000
0.0000    6.0000    2.00    3.0    1.0    0.0    0.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2010    1      1      0    2     1     38     38   14  0  0   0.0000
0.0000    6.0000    2.00    5.0    1.0    0.0    0.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2010    1      1      0    2     1     40     40   21  0  0   0.0000
0.0000    4.0000    6.00    6.0    5.0    0.0    0.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2010    1      1      0    2     1     42     42   20  0  0   0.0000
0.0000    3.0000    1.00    9.0    7.0    0.0    0.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2010    1      1      0    2     1     44     44   24  0  0   0.0000
0.0000    0.0000    2.00    9.0    4.0    9.0    0.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2010    1      1      0    2     1     46     46   21  0  0   0.0000
0.0000    0.0000    1.00    3.0    7.0    7.0    2.00    1.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2010    1      1      0    2     1     48     48   22  0  0   0.0000
0.0000    0.0000    0.00    4.0    9.0    5.0    4.00    0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2010    1      1      0    2     1     50     50   21  0  0   0.0000
0.0000    0.0000    0.00    3.0    7.0    6.0    4.00    1.00
0.000   0.00   0.0000   0.000   0.0000   0.000
```

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  2010    1      1      0    2      1      52      52    18  0  0   0.0000
0.0000     0.0000     0.00      2.0      5.0      6.0      4.00       1.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2010    1      1      0    2      1      54      54    19  0  0   0.0000
0.0000     0.0000     0.00      1.0      2.0      5.0      4.00       3.00
3.000    0.00   0.0000    1.000   0.0000    0.000
  2010    1      1      0    2      1      56      56    19  0  0   0.0000
0.0000     0.0000     0.00      1.0      3.0      6.0      3.00       1.00
5.000    0.00   0.0000    0.000   0.0000    0.000
  2010    1      1      0    2      1      58      58    20  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      1.0      3.00       8.00
5.000    3.00   0.0000    0.000   0.0000    0.000
  2010    1      1      0    2      1      60      60    13  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      2.0      2.00       4.00
4.000    1.00   0.0000    0.000   0.0000    0.000
  2010    1      1      0    2      1      62      62    18  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      4.00       4.00
5.000    4.00   0.0000    0.000   0.0000    1.000
  2010    1      1      0    2      1      64      64    15  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       4.00
2.000    4.00   2.0000    1.000   0.0000    2.000
  2010    1      1      0    2      1      66      66    12  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       2.00
0.000    3.00   6.0000    1.000   0.0000    0.000
  2010    1      1      0    2      1      68      68     4  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       1.00
0.000    1.00   0.0000    2.000   0.0000    0.000
  2010    1      1      0    2      1      70      70     9  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    3.00   5.0000    1.000   0.0000    0.000
  2010    1      1      0    2      1      72      72     7  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       1.00
0.000    0.00   2.0000    3.000   1.0000    0.000
  2010    1      1      0    2      1      74      74     6  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    0.00   4.0000    1.000   0.0000    1.000
  2010    1      1      0    2      1      76      76     4  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
1.000    0.00   1.0000    1.000   1.0000    0.000
  2010    1      1      0    2      1      80      80     3  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    0.00   0.0000    2.000   0.0000    1.000
  2010    1      1      0    2      1      84      84     1  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    0.00   0.0000    1.000   0.0000    0.000
  2011    1      1      0    2      1      26      26     4  0  0   3.0000
1.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1      1      0    2      1      28      28     3  0  0   0.0000
3.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1      1      0    2      1      30      30     3  0  0   0.0000
3.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1      1      0    2      1      32      32     6  0  0   0.0000
5.0000     0.0000     1.00      0.0      0.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1      1      0    2      1      34      34     8  0  0   0.0000
0.0000     2.0000     2.00      4.0      0.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1      1      0    2      1      36      36    31  0  0   0.0000
0.0000     1.0000    10.00     18.0      2.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1      1      0    2      1      38      38    31  0  0   0.0000
0.0000     1.0000     7.00     17.0      6.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1      1      0    2      1      40      40    32  0  0   0.0000
0.0000     3.0000     2.00     19.0      8.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1      1      0    2      1      42      42    31  0  0   0.0000
0.0000     0.0000     1.00     12.0     16.0      2.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1      1      0    2      1      44      44    39  0  0   0.0000
0.0000     0.0000     0.00     11.0     18.0      9.0      1.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
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  2011    1     1     0    2     1     46      46    34  0  0    0.0000
0.0000     0.0000     0.00      9.0      9.0     14.0      2.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1     1     0    2     1     48      48    32  0  0    0.0000
0.0000     0.0000     0.00      0.0     11.0     12.0      9.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1     1     0    2     1     50      50    27  0  0    0.0000
0.0000     0.0000     0.00      0.0      7.0      6.0     13.00       1.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1     1     0    2     1     52      52    26  0  0    0.0000
0.0000     0.0000     0.00      0.0      4.0      5.0     16.00       1.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1     1     0    2     1     54      54    29  0  0    0.0000
0.0000     0.0000     0.00      0.0      4.0      3.0     18.00       3.00
1.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1     1     0    2     1     56      56    22  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      5.0      9.00       7.00
1.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1     1     0    2     1     58      58    20  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      2.0      6.00      10.00
2.000    0.00   0.0000    0.000   0.0000    0.000
  2011    1     1     0    2     1     60      60    18  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      5.00       7.00
5.000    1.00   0.0000    0.000   0.0000    0.000
  2011    1     1     0    2     1     62      62    14  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      1.0      1.00       7.00
4.000    1.00   0.0000    0.000   0.0000    0.000
  2011    1     1     0    2     1     64      64    25  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      3.00       4.00
8.000    6.00   3.0000    1.000   0.0000    0.000
  2011    1     1     0    2     1     66      66    20  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       1.00
6.000    7.00   5.0000    0.000   1.0000    0.000
  2011    1     1     0    2     1     68      68    17  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
5.000    7.00   5.0000    0.000   0.0000    0.000
  2011    1     1     0    2     1     70      70    12  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
5.000    2.00   3.0000    2.000   0.0000    0.000
  2011    1     1     0    2     1     72      72     6  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    2.00   2.0000    1.000   1.0000    0.000
  2011    1     1     0    2     1     74      74     7  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
3.000    2.00   0.0000    2.000   0.0000    0.000
  2011    1     1     0    2     1     76      76     6  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    0.00   2.0000    2.000   2.0000    0.000
  2011    1     1     0    2     1     78      78     3  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    1.00   1.0000    0.000   1.0000    0.000
  2011    1     1     0    2     1     80      80     3  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    0.00   0.0000    1.000   1.0000    1.000
  2011    1     1     0    2     1     82      82     2  0  0    0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   1.0000    1.000
  2012    1     1     0    2     1     34      34     4  0  0    0.0000
0.0000     0.0000     2.00      1.0      1.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2012    1     1     0    2     1     36      36    18  0  0    0.0000
0.0000     0.0000     3.00     12.0      3.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2012    1     1     0    2     1     38      38    35  0  0    0.0000
0.0000     0.0000     0.00     16.0     19.0      0.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2012    1     1     0    2     1     40      40    37  0  0    0.0000
0.0000     0.0000     0.00     12.0     24.0      1.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2012    1     1     0    2     1     42      42    46  0  0    0.0000
0.0000     0.0000     0.00      5.0     38.0      3.0      0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2012    1     1     0    2     1     44      44    41  0  0    0.0000
0.0000     0.0000     0.00      3.0     23.0     14.0      1.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
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  2012    1      1      0    2      1      46      46    37  0  0   0.0000
0.0000     0.0000     0.00      0.0    17.0     15.0      4.00      1.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2012    1      1      0    2      1      48      48    35  0  0   0.0000
0.0000     0.0000     0.00      1.0    14.0     13.0      6.00      1.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2012    1      1      0    2      1      50      50    32  0  0   0.0000
0.0000     0.0000     0.00      1.0     5.0      6.0     18.00      2.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2012    1      1      0    2      1      52      52    30  0  0   0.0000
0.0000     0.0000     0.00      0.0     2.0      6.0     18.00      4.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2012    1      1      0    2      1      54      54    21  0  0   0.0000
0.0000     0.0000     0.00      0.0     3.0      2.0      8.00      6.00
2.000    0.00    0.0000    0.000   0.0000    0.000
  2012    1      1      0    2      1      56      56    19  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      6.00      9.00
4.000    0.00    0.0000    0.000   0.0000    0.000
  2012    1      1      0    2      1      58      58    26  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      1.0      6.00     14.00
4.000    1.00    0.0000    0.000   0.0000    0.000
  2012    1      1      0    2      1      60      60    28  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      4.0      2.00     12.00
5.000    4.00    1.0000    0.000   0.0000    0.000
  2012    1      1      0    2      1      62      62    22  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      3.00      4.00
6.000    9.00    0.0000    0.000   0.0000    0.000
  2012    1      1      0    2      1      64      64    16  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      1.0      3.00      1.00
4.000    4.00    2.0000    1.000   0.0000    0.000
  2012    1      1      0    2      1      66      66    14  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      0.00      3.00
2.000    0.00    5.0000    4.000   0.0000    0.000
  2012    1      1      0    2      1      68      68    17  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      1.00      3.00
2.000    7.00    2.0000    1.000   1.0000    0.000
  2012    1      1      0    2      1      70      70    14  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      0.00      0.00
3.000    5.00    4.0000    1.000   1.0000    0.000
  2012    1      1      0    2      1      72      72     9  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      0.00      0.00
2.000    6.00    0.0000    1.000   0.0000    0.000
  2012    1      1      0    2      1      74      74     8  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      0.00      0.00
1.000    1.00    1.0000    4.000   1.0000    0.000
  2012    1      1      0    2      1      76      76     6  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      0.00      0.00
0.000    0.00    1.0000    3.000   2.0000    0.000
  2012    1      1      0    2      1      78      78     4  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      0.00      0.00
0.000    0.00    1.0000    2.000   1.0000    0.000
  2012    1      1      0    2      1      80      80     5  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      0.00      0.00
0.000    0.00    0.0000    1.000   0.0000    4.000
  2012    1      1      0    2      1      82      82     1  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      0.00      0.00
0.000    0.00    0.0000    0.000   0.0000    1.000
  2012    1      1      0    2      1      84      84     2  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0      0.0      0.00      0.00
0.000    0.00    1.0000    1.000   0.0000    0.000
  2013    1      1      0    2      1      34      34     5  0  0   0.0000
0.0000     0.0000     4.00      1.0     0.0      0.0      0.00      0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2013    1      1      0    2      1      36      36    42  0  0   0.0000
0.0000     0.0000    18.00     21.0     3.0      0.0      0.00      0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2013    1      1      0    2      1      38      38    61  0  0   0.0000
0.0000     0.0000     9.00     30.0    22.0      0.0      0.00      0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2013    1      1      0    2      1      40      40    52  0  0   0.0000
0.0000     0.0000     1.00     20.0    28.0      3.0      0.00      0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2013    1      1      0    2      1      42      42    50  0  0   0.0000
0.0000     0.0000     0.00      8.0    38.0      4.0      0.00      0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
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  2013    1      1      0     2      1      44       44     57  0  0   0.0000
0.0000     0.0000     0.00       1.0     31.0      22.0      3.00       0.00
0.000    0.00    0.0000    0.000    0.0000    0.000
  2013    1      1      0     2      1      46       46     54  0  0   0.0000
0.0000     0.0000     0.00       1.0     31.0      16.0      6.00       0.00
0.000    0.00    0.0000    0.000    0.0000    0.000
  2013    1      1      0     2      1      48       48     55  0  0   0.0000
0.0000     0.0000     0.00       0.0     12.0      33.0      9.00       1.00
0.000    0.00    0.0000    0.000    0.0000    0.000
  2013    1      1      0     2      1      50       50     56  0  0   0.0000
0.0000     0.0000     0.00       0.0      7.0      23.0     19.00       7.00
0.000    0.00    0.0000    0.000    0.0000    0.000
  2013    1      1      0     2      1      52       52     43  0  0   0.0000
0.0000     0.0000     0.00       0.0      6.0      12.0     18.00       7.00
0.000    0.00    0.0000    0.000    0.0000    0.000
  2013    1      1      0     2      1      54       54     51  0  0   0.0000
0.0000     0.0000     0.00       0.0      4.0      11.0     13.00      18.00
3.000    1.00    1.0000    0.000    0.0000    0.000
  2013    1      1      0     2      1      56       56     45  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       6.0     21.00      12.00
4.000    1.00    1.0000    0.000    0.0000    0.000
  2013    1      1      0     2      1      58       58     34  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0     19.00       8.00
7.000    0.00    0.0000    0.000    0.0000    0.000
  2013    1      1      0     2      1      60       60     37  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      3.00      24.00
9.000    1.00    0.0000    0.000    0.0000    0.000
  2013    1      1      0     2      1      62       62     35  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      3.00      10.00
19.000    1.00    2.0000    0.000    0.0000    0.000
  2013    1      1      0     2      1      64       64     29  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      0.00       6.00
17.000    5.00    0.0000    1.000    0.0000    0.000
  2013    1      1      0     2      1      66       66     28  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      0.00       1.00
7.000   15.00    3.0000    2.000    0.0000    0.000
  2013    1      1      0     2      1      68       68     20  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      0.00       3.00
5.000    3.00    8.0000    1.000    0.0000    0.000
  2013    1      1      0     2      1      70       70     23  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       1.0      0.00       0.00
3.000    9.00    6.0000    4.000    0.0000    0.000
  2013    1      1      0     2      1      72       72     11  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      0.00       0.00
0.000    3.00    6.0000    2.000    0.0000    0.000
  2013    1      1      0     2      1      74       74     11  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      0.00       0.00
0.000    2.00    4.0000    5.000    0.0000    0.000
  2013    1      1      0     2      1      76       76      8  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      0.00       0.00
0.000    1.00    2.0000    3.000    2.0000    0.000
  2013    1      1      0     2      1      78       78      6  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      0.00       0.00
0.000    0.00    0.0000    2.000    3.0000    1.000
  2013    1      1      0     2      1      80       80      4  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      0.00       0.00
0.000    0.00    0.0000    1.000    1.0000    2.000
  2013    1      1      0     2      1      82       82      1  0  0   0.0000
0.0000     0.0000     0.00       0.0      0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000    0.0000    1.000
  2014    1      1      0     2      1      34       34      7  0  0   0.0000
0.0000     2.0000     4.00       1.0      0.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000    0.0000    0.000
  2014    1      1      0     2      1      36       36     43  0  0   0.0000
0.0000     1.0000    15.00      26.0      1.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000    0.0000    0.000
  2014    1      1      0     2      1      38       38     58  0  0   0.0000
0.0000     0.0000    10.00      46.0      2.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000    0.0000    0.000
  2014    1      1      0     2      1      40       40     49  0  0   0.0000
0.0000     0.0000     2.00      41.0      6.0       0.0      0.00       0.00
0.000    0.00    0.0000    0.000    0.0000    0.000
  2014    1      1      0     2      1      42       42     53  0  0   0.0000
0.0000     0.0000     1.00      33.0     15.0       4.0      0.00       0.00
0.000    0.00    0.0000    0.000    0.0000    0.000
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  2014    1      1      0    2      1      44      44     53  0  0   0.0000
0.0000     0.0000     1.00     16.0     30.0     6.0      0.00      0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      46      46     51  0  0   0.0000
0.0000     0.0000     2.00      8.0     27.0    14.0      0.00      0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      48      48     44  0  0   0.0000
0.0000     0.0000     0.00      1.0      7.0    24.0     12.00      0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      50      50     49  0  0   0.0000
0.0000     0.0000     0.00      1.0      6.0    20.0     21.00      1.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      52      52     36  0  0   0.0000
0.0000     0.0000     0.00      0.0      4.0    10.0     19.00      3.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      54      54     32  0  0   0.0000
0.0000     0.0000     0.00      0.0      1.0     8.0     17.00      3.00
3.000   0.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      56      56     35  0  0   0.0000
0.0000     0.0000     0.00      0.0      2.0     5.0     13.00     10.00
2.000   3.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      58      58     29  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     2.0     12.00      7.00
8.000   0.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      60      60     31  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     1.0      8.00     10.00
7.000   5.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      62      62     29  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     1.0      5.00      8.00
11.000   4.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      64      64     29  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      2.00      5.00
11.000   8.00   3.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      66      66     22  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      4.00
5.000  13.00   0.0000   0.000   0.0000   0.000
  2014    1      1      0    2      1      68      68     21  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      1.00
5.000   9.00   3.0000   3.000   0.0000   0.000
  2014    1      1      0    2      1      70      70     15  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      0.00
0.000   6.00   4.0000   5.000   0.0000   0.000
  2014    1      1      0    2      1      72      72     11  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      0.00
2.000   1.00   2.0000   5.000   0.0000   1.000
  2014    1      1      0    2      1      74      74      9  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      0.00
0.000   2.00   2.0000   3.000   0.0000   2.000
  2014    1      1      0    2      1      76      76      3  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      0.00
0.000   0.00   0.0000   0.000   2.0000   1.000
  2014    1      1      0    2      1      78      78      7  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      0.00
0.000   0.00   1.0000   2.000   3.0000   1.000
  2014    1      1      0    2      1      80      80      2  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      0.00
0.000   0.00   1.0000   1.000   0.0000   0.000
  2014    1      1      0    2      1      82      82      2  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      0.00
0.000   0.00   1.0000   1.000   0.0000   0.000
  2014    1      1      0    2      1      84      84      1  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      0.00
0.000   0.00   0.0000   1.000   0.0000   0.000
  2014    1      1      0    2      1      86      86      1  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0     0.0      0.00      0.00
0.000   0.00   0.0000   0.000   1.0000   0.000
  2015    1      1      0    2      1      34      34      9  0  0   0.0000
0.0000     8.0000     1.00      0.0      0.0     0.0      0.00      0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2015    1      1      0    2      1      36      36     29  0  0   0.0000
0.0000    21.0000     4.00      4.0      0.0     0.0      0.00      0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
  2015    1      1      0    2      1      38      38     50  0  0   0.0000
0.0000    12.0000    15.00     21.0      2.0     0.0      0.00      0.00
0.000   0.00   0.0000   0.000   0.0000   0.000
```

```
  2015    1      1      0    2      1      40       40    69  0  0    0.0000
0.0000     8.0000    19.00    20.0    21.0     1.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      42       42    95  0  0    0.0000
0.0000     2.0000    15.00    35.0    42.0     1.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      44       44    61  0  0    0.0000
0.0000     0.0000    10.00    21.0    21.0     7.0      2.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      46       46    49  0  0    0.0000
0.0000     0.0000     2.00    19.0    16.0    12.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      48       48    36  0  0    0.0000
0.0000     0.0000     0.00     9.0    13.0    13.0      1.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      50       50    42  0  0    0.0000
0.0000     0.0000     3.00     3.0    13.0     8.0     14.00       1.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      52       52    22  0  0    0.0000
0.0000     0.0000     0.00     0.0     5.0     9.0      8.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      54       54    28  0  0    0.0000
0.0000     0.0000     0.00     1.0     5.0     8.0      8.00       6.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      56       56    24  0  0    0.0000
0.0000     0.0000     0.00     0.0     5.0     3.0     12.00       1.00
3.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      58       58    18  0  0    0.0000
0.0000     0.0000     0.00     1.0     1.0     3.0      6.00       5.00
1.000    1.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      60       60    17  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     1.0      6.00      10.00
0.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      62       62    14  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      3.00       3.00
5.000    3.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      64       64     9  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      4.00       1.00
1.000    3.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      66       66     5  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       0.00
2.000    2.00    1.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      68       68     3  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       1.00
2.000    0.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      70       70     6  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       2.00
0.000    1.00    2.0000    0.000   1.0000    0.000
  2015    1      1      0    2      1      72       72     2  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      1.00       0.00
0.000    0.00    0.0000    0.000   0.0000    1.000
  2015    1      1      0    2      1      74       74     4  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       0.00
1.000    0.00    0.0000    1.000   1.0000    1.000
  2015    1      1      0    2      1      76       76     2  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       0.00
0.000    0.00    0.0000    0.000   1.0000    1.000
  2015    1      1      0    2      1      78       78     1  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       0.00
0.000    1.00    0.0000    0.000   0.0000    0.000
  2015    1      1      0    2      1      80       80     1  0  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       0.00
0.000    0.00    1.0000    0.000   0.0000    0.000
 -2016    1      1      0    2      1       6        6     2  2  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
 -2016    1      1      0    2      1       8        8     3  3  0    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
 -2016    1      1      0    2      1      10       10    15  8  7    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
 -2016    1      1      0    2      1      12       12    35  4 31    0.0000
0.0000     0.0000     0.00     0.0     0.0     0.0      0.00       0.00
0.000    0.00    0.0000    0.000   0.0000    0.000
```

```
 -2016    1      1      0     2      1      14       14      7  0  7   0.0000
0.0000     0.0000     0.00      0.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
 -2016    1      1      0     2      1      16       16     23  0  8  15.0000
0.0000     0.0000     0.00      0.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
 -2016    1      1      0     2      1      18       18     42  0 11  31.0000
0.0000     0.0000     0.00      0.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
 -2016    1      1      0     2      1      20       20     23  0  3  19.0000
1.0000     0.0000     0.00      0.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
 -2016    1      1      0     2      1      22       22     15  0  1  14.0000
0.0000     0.0000     0.00      0.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
 -2016    1      1      0     2      1      24       24     30  0  0  17.0000
13.0000     0.0000     0.00      0.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
 -2016    1      1      0     2      1      26       26     35  0  0  13.0000
22.0000     0.0000     0.00      0.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
 -2016    1      1      0     2      1      28       28     25  0  0   5.0000
19.0000     0.0000     1.00      0.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
 -2016    1      1      0     2      1      30       30     27  0  0   0.0000
25.0000     0.0000     2.00      0.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
 -2016    1      1      0     2      1      32       32     44  0  0   0.0000
21.0000     2.0000    20.00      1.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      34       34     31  0  0   0.0000
6.0000     9.0000    11.00      5.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      36       36     61  0  0   0.0000
7.0000    15.0000    24.00     15.0      0.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      38       38     64  0  0   0.0000
1.0000     7.0000    31.00     23.0      2.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      40       40     59  0  0   0.0000
1.0000     5.0000    19.00     30.0      4.0      0.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      42       42     61  0  0   0.0000
1.0000     2.0000    15.00     28.0     14.0      1.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      44       44     64  0  0   0.0000
0.0000     3.0000     9.00     23.0     22.0      7.0       0.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      46       46     55  0  0   0.0000
0.0000     2.0000     1.00     16.0     32.0      3.0       0.00       1.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      48       48     60  0  0   0.0000
0.0000     0.0000     1.00      9.0     18.0     25.0       7.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      50       50     59  0  0   0.0000
0.0000     1.0000     1.00      2.0      9.0     34.0      12.00       0.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      52       52     60  0  0   0.0000
0.0000     0.0000     0.00      1.0     13.0     29.0      14.00       3.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      54       54     58  0  0   0.0000
0.0000     0.0000     0.00      0.0      3.0     20.0      24.00      11.00
0.000    0.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      56       56     52  0  0   0.0000
0.0000     0.0000     0.00      2.0      1.0      5.0      30.00      10.00
3.000    1.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      58       58     49  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      2.0      19.00      20.00
5.000    3.00   0.0000    0.000   0.0000    0.000
  2016    1      1      0     2      1      60       60     51  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      2.0       9.00      25.00
11.000    0.00   2.0000    2.000   0.0000    0.000
  2016    1      1      0     2      1      62       62     37  0  0   0.0000
0.0000     0.0000     0.00      0.0      0.0      1.0       0.00      14.00
14.000    4.00   1.0000    2.000   1.0000    0.000
```

```
  2016    1     1     0    2     1     64     64    27  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0     0.0      1.00      9.00
5.000    9.00    2.0000    1.000   0.0000    0.000
  2016    1     1     0    2     1     66     66    34  0  0   0.0000
0.0000     0.0000     0.00      0.0     1.0     0.0      0.00      2.00
7.000   19.00    2.0000    1.000   2.0000    0.000
  2016    1     1     0    2     1     68     68    24  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0     0.0      1.00      1.00
4.000   10.00    7.0000    0.000   0.0000    1.000
  2016    1     1     0    2     1     70     70    21  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0     0.0      1.00      0.00
1.000    8.00   10.0000    1.000   0.0000    0.000
  2016    1     1     0    2     1     72     72    11  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0     0.0      0.00      1.00
1.000    1.00    6.0000    1.000   0.0000    1.000
  2016    1     1     0    2     1     74     74    10  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0     0.0      0.00      1.00
0.000    1.00    5.0000    1.000   0.0000    2.000
  2016    1     1     0    2     1     76     76     5  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0     0.0      0.00      0.00
0.000    0.00    2.0000    1.000   1.0000    1.000
  2016    1     1     0    2     1     78     78     4  0  0   0.0000
0.0000     0.0000     0.00      0.0     0.0     0.0      0.00      0.00
1.000    0.00    0.0000    2.000   1.0000    0.000
  2008    1    -1     0    0     1     -1     -1    83  0  0   0.0000
0.0000  659539.2490  600950.63  338923.2  178922.2  107763.8  155543.65   12078.94
10306.880 28028.03 27915.0813  2505.678 2505.6782  8422.965
  2009    1    -1     0    0     1     -1     -1   113  0  0 159.5696
159.5696 139799.7915 228557.74 467190.1 452595.0 102904.6  59903.26  93695.52
6004.085 14457.63   476.4361 14898.646  381.5017  9383.153
  2010    1    -1     0    0     1     -1     -1   339  0  0   0.0000
490.1783 137107.8251  98838.56 317758.2 313346.4 250285.3 114918.55  82075.69
58090.566 42502.94 40407.9756 31159.687 3322.5127 16280.932
  2011    1    -1     0    0     1     -1     -1   504  0  0   0.0000
4028.2226  38039.2283 113679.68 492257.9 457161.7 266919.1 339628.82 125252.03
78704.645 43774.01 30867.7612 13405.253 9317.7297  3151.687
  2012    1    -1     0    0     1     -1     -1   536  0  0   0.0000
162.0384    162.0384  40484.00 325821.9 750933.5 249638.8 260047.42 167133.65
74075.626 54154.51 26919.2578 24579.964 6977.5581  4656.734
  2013    1    -1     0    0     1     -1     -1   823  0  0   0.0000
0.0000     302.2216   61994.50 205099.3 571156.2 333016.7 215525.02 137519.52
99204.966 51295.89 33438.4193 22761.759 6870.3295  6176.992
  2014    1    -1     0    0     1     -1     -1   727  0  0   0.0000
228.6534    3978.3252  76930.02 589930.8 409732.3 321441.4 304372.54 118200.53
110344.896 97713.36 28984.0978 34630.939 8967.0458  8781.901
  2015    1    -1     0    0     1     -1     -1   602  0  0   0.0000
613.5361 112118.1032 156460.99 328730.8 363403.4 192173.4 187671.81  89240.26
54539.797 38397.66 13857.9942  2655.136 9241.8872 15260.821
  2016    1    -1     0    0     1     -1     -1  1053  0  0   0.0000
27946.4234  89258.8723 254298.91 368054.8 254533.9 197610.7 147468.15 109824.68
59033.793 54400.46 33503.6024 13854.360 5554.6308  6029.000
0 #_N_MeanSize_at_Age_obs
0 #_N_environ_variables
0 #_N_environ_obs
0 #_N_sizefreq_methods
0 #_do_tags
0 #_morphcomp_data
#
999
```

SS3 control file

```
# C Sea bass VIII input data file
# _SS-V3.24f
# benchmark WKBASS 2017
#  ------------------------
#  ------------------------
1                              #_N_Growth_Patterns
1                              #_N_Morphs_Within_GrowthPattern(GP)
#_Cond 1       #_Morph_between/within_stdev_ratio (no read if N_morphs=1)
#_Cond 1       #vector_Morphdist_(-1_in_first_val_gives_normal_approx)
#
```

```
##1    #  N recruitment designs goes here if N_GP*nseas*area>1 #here 1 gp, 4
seasons, 1 area
##0    #  placeholder for recruitment interaction request
#GP seas area for each recruitment assignment
##1 1 1 # example recruitment design element for GP=1, season=1, area=1
#
#_Cond 0 # N_movement_definitions goes here if N_areas > 1
#_Cond 1.0 # first age that moves (real age at begin of season, not integer)
also cond on do_migration>0
#_Cond 1 1 1 2 4 10 # example move definition for seas=1, morph=1, source=1
dest=2, age1=4, age2=10
#

#  ------------------------
0                          #_Nblock_Patterns
#_blocks_per_pattern
# begin and end years of blocks in first pattern
#

#  ------------------------
0.5                        #_fracfemale #? Note sex ratio in bass increases
with length.
0                          #_natM_type:_0=1Parm;     1=N_breakpoints;_2=Lo-
renzen;_3=agespecific;_4=agespec_withseasinterpolate
#0.150 0.150  0.150  0.152  0.163  0.209  0.247  0.256  0.257  0.257
       0.257  0.257  0.257  0.257  0.257  0.257  0.257  0.257  0.257
       0.257  0.257  0.257  0.257  0.257  0.257  0.257  0.257  0.257
       0.257  0.257  0.257

#  ------------------------modifs 2 et 28 à la place 1 et 999
1      # GrowthModel: 1=vonBert with L1&L2; 2=Richards with L1&L2; 3=not imple-
mented; 4=not implemented #note - maguire et al 2008 pg 1270, Downloaded from
icesjms.oxfordjournals.org at ICES on October 17, 2011
1      #_Growth_Age_for_L1
999    #_Growth_Age_for_L2 (999 to use as Linf)
0      #_SD_add_to_LAA (set to 0.1 for SS2 V1.x compatibility)
1      #_CV_Growth_Pattern:  0 CV=f(LAA); 1 CV=F(A); 2 SD=F(LAA); 3 SD=F(A)
1      #_maturity_option:  1=length logistic; 2=age logistic; 3=read age-ma-
turity matrix by growth_pattern; 4=read age-fecundity; 5=read fec and wt from
wtatage.ss
#_placeholder for empirical age-maturity by growth pattern

#  ------------------------
4      #_First_Mature_Age
1      #_fecundity option:(1)eggs=Wt*(a+b*Wt);(2)eggs=a*L^b;(3)eggs=a*Wt^b
0      #_hermaphroditism option:  0=none; 1=age-specific fxn
1      #_parameter_offset_approach (1=none, 2= M, G, CV_G as offset from female-
GP1, 3=like SS2 V1.x)
1      #_env/block/dev_adjust_method (1=standard; 2=logistic transform keeps in
base parm bounds; 3=standard w/ no bound check)

#_growth_parms
#_LO  HI  INIT  PRIOR  PR_type  SD  PHASE  env-var  use_dev  dev_minyr  dev_maxyr
dev_stddev Block Block_Fxn

#_growth_parms. Faire démarrer à 15cm age moyen 1 an courbe croissance (cf
michel)
0.01 0.5  0.24 0.15   -1 0.1   -3 0 0 0 0 0 0 0    # NatM_p_1_GP_1 #Has a Vestor
of Mortality to include the Rec fishing component.
7    25   12   12     -1 0.5   -3 0 0 0 0 0 0 0     # L_at_Amin_GP_1
60   100  80.4 80.4   -1 15    -3 0 0 0 0 0 0 0     # L_at_Amax_GP_1
0.05 0.2  0.11 0.139  -1 0.05   3 0 0 0 0 0 0 0     # VonBert_K_GP_1
0.05 0.40 0.1  0.05   -1 0.8   -3 0 0 0 0 0 0 0     # CV_young_GP_1
0.05 0.40 0.1  0.05   -1 0.8   -3 0 0 0 0 0 0 0     # CV_old_GP_1

# weight-length relationship
0 1 0.00001244 0.00001244 -1 0.05 -3 0 0 0 0 0 0 0      # Wtlen_1
2 4 2.95       2.95       -1 0.05 -3 0 0 0 0 0 0 0      # Wtlen_2

# proportion mature at length
30 50 42.14    42.14    -1 5       -3 0 0 0 0 0 0 0  # Mat50%
-5 1  -0.37809 -0.37809 -1 0.06015 -3 0 0 0 0 0 0 0  # Mat_slope

# fecundity option 1, parm values from dissertation (units of millions of eggs
per kg)
-3 3 1 1 -1 0.8 -3 0 0 0 0 0 0 0        # Eg/gm_inter
-3 3 0 0 -1 0.8 -3 0 0 0 0 0 0 0     # Eg/gm_slope_wt
```

```
# recruitment apportionment
0 0 0 0 -1 0 -3 0 0 0 0 0 0 0                # RecrDist_GP_1
0 0 0 0 -1 0 -3 0 0 0 0 0 0 0                # RecrDist_Area_1
0 0 0 0 -1 0 -4 0 0 0 0 0 0 0                # RecrDist_Seas_1

# cohort growth deviation (fix value at 1 with negative phase; needed for blocks
or annual devs)
0 0 0 0 -1 0 -4 0 0 0 0 0 0 0                              # CohortGrowDev

#
#_Cond 0 #custom_MG-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2             #_placeholder when no MG-environ parame-
ters
#
#_Cond 0 #custom_MG-block_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2             #_placeholder when no MG-block parameters
#_Cond No MG parm trends
#
#_seasonal_effects_on_biology_parms
0 0 0 0 0 0 0 0 0 0
       #_femwtlen1,femwtlen2,mat1,mat2,fec1,fec2,L1,K
#_Cond -2 2 0 0 -1 99 -2             #_placeholder when no seasonal MG parame-
ters
#
#-6    #_MGparm_Dev_Phase
#
#_Spawner-Recruitment
3      #_SR_function

#_LO HI INIT PRIOR PR_type SD PHASE
 1   16     10      5     -1 1     1  # SR_R0
 0.2  0.999  0.999  0.999 -1 0.2  -1  # SR_steep
 0.1  2      0.6    0.6   -1 0.2  -5  # SR_sigmaR
-5    5      0      0     -1 1    -3  # SR_envlink
-5    5      0     -0.7   -1 2    -2  # SR_R1_offset
 0    0      0      0     -1 0   -99  # SR_autocorr

0             #_SR_env_link
0             #_SR_env_target_0=none;1=devs;_2=R0;_3=steepness

1             #do_recdev:  0=none; 1=devvector; 2=simple deviations
1965           # first year of main recr_devs; early devs can preceed this era
2013           # last year of main recr_devs; forecast devs start in following
year 2013. Youngest survey age 2gp 2013; revised WGCSE 2015
3             #_recdev phase

1             # (0/1) to read 13 advanced options (on avait mis 0)
0             #_recdev_early_start  (0=none;  neg  value  makes  relative  to
recdev_start)
-4            #_recdev_early_phase
0             #_forecast_recruitment phase (incl. late recr) (0 value resets to
maxphase+1)
1             #_lambda for prior_fore_recr occurring before endyr+1
1984.7   #_last_early_yr_nobias_adj_in_MPD
2003.3  #_first_yr_fullbias_adj_in_MPD
2011.9   #_last_yr_fullbias_adj_in_MPD
2012.7   #_first_recent_yr_nobias_adj_in_MPD
0.8394   #_max_bias_adj_in_MPD (1.0 to mimic pre-2009 models)
0             #_period of cycles in recruitment (N parms read below)
-5            #min rec_dev
5             #max rec_dev
0             # 3 #_read_recdevs
#_end of advanced SR options
#
#Fishing Mortality info p74
0.2    # F ballpark for tuning early phases
-2001  # F ballpark year (neg value to disable)
3      # F_Method:  1=Pope; 2=instan. F; 3=hybrid (hybrid is recommended)
2.9    # max F or harvest rate, depends on F_Method. A value of  about 4 is
recommended for F merthod 2 and 3 (donc on devrait mettre 4?)

# no additional F input needed for Fmethod 1
# if Fmethod=2; read overall start F value; overall phase; N detailed inputs to
read
#0.3 3 0 # if Fmethod=3; read N iterations for tuning for Fmethod 3
5 # N iterations for tuning F in hybrid method (recommend 3 to 7)
```

```
#FROTB%FRMWT%FRNets%FRLines%FROther%FRRecFish%SPOther%cpueindex

#_initial_F_parms (pourquoi 0.3 Uk et 0.03 FR?)
#_LO HI INIT PRIOR PR_type SD PHASE
0.05 2 0.05 0.3 -1 0.5   1 # InitF_Comm
0.05 2 0.05 0.3 -1 0.5   1 # InitF_Rec
#

# Catchability Specification (Q_setup)
# A=do power: 0=skip, survey is prop. to abundance, 1= add par for non-linearity
# B=env. link: 0=skip, 1= add par for env. effect on Q
# C=extra SD: 0=skip, 1= add par. for additive constant to input SE (in ln space)
# D=type: <0=mirror lower abs(#) fleet, 0=no par Q is median unbiased, 1=no par
Q is mean unbiased, 2=estimate par for ln(Q)
#          3=ln(Q) + set of devs about ln(Q) for all years. 4=ln(Q) + set of devs
about Q for indexyr-1
# A             B                     C                       D
       0                       0                             0
              0 # Comm
       0                       0                             0
              0 # Rec
       0                       0                             1
              0       # LPUE

# Lo  Hi  Init    Prior   Prior_type Prior_sd   Phase
0     1   0.1     0.1     -1         99         3       # Q_extraSD_LPUE

#_size_selex_types
#_RDM  now all fleets have size selectivity
24     0 0 0         # 1 Comm
24     0 0 0         # 2 Rec
15     0 0 1         # 3 LPUE

#
#_age_selex_types a mettre? ATTENTION J AI MODIFIE LE RECFR POUR QUE CA MARCHE!!!
#_Pattern ___ Male Special
10 0 0 0      # 1 Comm
10 0 0 0      # 2 Rec
10 0 0 0      # 3 LPUE

#_LO  HI  INIT  PRIOR  PR_type  SD  PHASE  env-var  use_dev  dev_minyr  dev_maxyr
dev_stddev Block Block_Fxn
#Comm
20     80.4   45              45     -1            0.05          2
       0 0 0 0 0 0 0  # SizeSel_2P_1_Comm          #PEAK
-6                   4.0    -6.0           -6.0    -1            0.05    -3
              0 0 0 0 0 0 0  # SizeSel_2P_2_Comm
       #TOP:_width_of_plateau
-1            9              3.3     3.3    -1            0.05          3
              0 0 0 0 0 0 0  # SizeSel_2P_3_Comm          #Asc_width
-1            9              4.4     4.4    -1            0.05    -3
       0 0 0 0 0 0 0  # SizeSel_2P_4_Comm          #Desc_width
-999.0  9.0    -999   -999  -1             0.05    -2            0 0 0 0 0 0
0      # SizeSel_2P_5_FROT           #INIT:_selectivity_at_fist_bin B
-999.0  9.0     9              9     -1            0.05    -2            0  0
0 0 0 0 0      # SizeSel_2P_6_FROT           #FINAL:_selectivity_at_last_binB
#Rec
20     80.4   45     45    -1    0.05    2     0 0 0 0 0 0 0      #      Siz-
eSel_2P_1_FROTB  #PEAK
-6            4.0   -6.0   -6.0   -1    0.05   -3     0 0 0 0 0 0 0       #
SizeSel_2P_2_FROTB  #TOP:_width_of_plateau
-1     9      3.3    3.3   -1    0.05    3     0 0 0 0 0 0 0      #      Siz-
eSel_2P_3_FROTB  #Asc_width
-8.5   6.0    4.4    4.4   -1    0.05   -3     0 0 0 0 0 0 0      #      Siz-
eSel_2P_4_FROTB  #Desc_width
-999.0  9.0   -999   -999  -1    0.05   -2     0 0 0 0 0 0 0      #      Siz-
eSel_2P_5_FROTB  #INIT:_selectivity_at_fist_bin B
-999.0  9.0    9      9    -1    0.05   -2     0 0 0 0 0 0 0      #      Siz-
eSel_2P_6_FROTB  #FINAL:_selectivity_at_last_binB


#_Cond 0 #_custom_sel-env_setup (0/1)
#_Cond -2 2 0 0 -1 99 -2 #_placeholder when no enviro fxns
#_custom_sel-blk_setup (0/1)
#_Cond No selex parm trends
#_Cond -4 # placeholder for selparm_Dev_Phase
```

```
#_env/block/dev_adjust_method (1=standard; 2=logistic trans to keep in base parm
bounds; 3=standard w/ no bound check)
#
# Tag loss and Tag reporting parameters go next
0 # TG_custom:  0=no read; 1=read if tags exist
#_Cond -6 6 1 1 2 0.01 -4 0 0 0 0 0 0 0  #_placeholder if no parameters
##FROTB%FRMWT%FRNets%FRLines%FROther%FRRecFish%SPOther%cpueindex
1 #_Variance_adjustments_to_input_values
#_fleet/svy: 1 2 3
0 0 0  #_add_to_survey_CV
0 0 0  #_add_to_discard_stddev
0 0 0  #_add_to_bodywt_CV
0.829886 1 1   #_mult_by_lencomp_N
0.089975 1 1   #_mult_by_agecomp_N
1 1 1  #_mult_by_size-at-age_N
#
2       #_maxlambdaphase
1       #_sd_offset
#
0       # number of changes to make to default Lambdas (default value is 1.0)
#  Like_comp  codes:   1=surv;  2=disc;  3=mnwt;  4=length;  5=age;  6=SizeFreq;
7=sizeage; 8=catch;
#   9=init_equ_catch;  10=recrdev;  11=parm_prior;  12=parm_dev;  13=CrashPen;
14=Morphcomp; 15=Tag-comp; 16=Tag-negbin
#like_comp fleet/survey  phase  value  sizefreq_method
# 5 1 1 0.1 1  #_RDM  reduce emphasis on age comp and wt-at-age by 10x
# 5 2 1 0.1 1
# 5 3 1 0.1 1
# 5 4 1 0.1 1
# 7 1 1 0.1 1
# 7 2 1 0.1 1
# 7 3 1 0.1 1
# 7 4 1 0.1 1
#
# lambdas (for info only; columns are phases)
#  0 0 0 0 #_cpue/survey:_1
#  1 1 1 1 #_cpue/survey:_2
#  1 1 1 1 #_cpue/survey:_3
#  1 1 1 1 #_lencomp:_1
#  1 1 1 1 #_lencomp:_2
#  0 0 0 0 #_lencomp:_3
#  1 1 1 1 #_agecomp:_1
#  1 1 1 1 #_agecomp:_2
#  0 0 0 0 #_agecomp:_3
#  1 1 1 1 #_size-age:_1
#  1 1 1 1 #_size-age:_2
#  0 0 0 0 #_size-age:_3
#  1 1 1 1 #_init_equ_catch
#  1 1 1 1 #_recruitments
#  1 1 1 1 #_parameter-priors
#  1 1 1 1 #_parameter-dev-vectors
#  1 1 1 1 #_crashPenLambda
0 # (0/1) read specs for more stddev reporting
 # 1 1 -1 5 1 5 1 -1 5 # selex type, len/age, year, N selex bins, Growth pattern,
N growth ages, NatAge_area(-1 for all), NatAge_yr, N Natages
 # 5 15 25 35 43 # vector with selex std bin picks (-1 in first bin to self-
generate)
 # 1 2 14 26 40 # vector with growth std bin picks (-1 in first bin to self-
generate)
 # 1 2 14 26 40 # vector with NatAge std bin picks (-1 in first bin to self-
generate)
999
```

Annex 10: WD-Recreational catches, post-release mortality and selectivity

Recreational catches, post-release mortality and selectivity

Kieran Hyder*, Lisa Readdy, Mickael Drogou, Mathieu Woillez, & Mike Armstrong, 16 February 2018

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Recreational removals include both the landed component and the proportion of the released fish that do not survive. Recreational catches and releases of seabass in the North Sea, Channel, Celtic Sea and Irish Sea (BSS-47) are possible from France, Ireland, the UK, the Netherlands, Belgium, Germany and Denmark. Estimates of recreational catches and releases of seabass were described in detail in previous assessments and were available for France, Netherlands, England, and Belgium (ICES, 2012, 2014a, 2017a, 2017b). Catches and releases in Biscay (BSS-8AB) are possible from France and Spain, but the majority are by France.

Since 2014, ICES has used an assessment approach for sea bass in BSS-47 that allows inclusion of an estimate of recreational fishery removals derived from surveys carried out in Europe over the period 2009–2013. Recent estimates of total recreational harvests of sea bass for France, the Netherlands, England, and Belgium (data supplied informally by Belgium) in subareas 4 and 7 amounted to 1,400–1,500t. With no direct knowledge of hooking mortality on sea bass, WGCSE previously reviewed studies on similar species such as striped bass in the USA, but excluded released fish from the assessment, and estimated the total recreational catch was approximately 1,500t in 2012. ICES therefore considered it desirable to have the recreational fishing mortality represented in the assessment and forecast so that impacts of measures on either fishery could be evaluated. The method chosen made a major assumption that the recreational fishing mortality in all years of the assessment was the same as given by the estimated recreational harvest of 1,500t in 2012. This was considered more feasible and defensible than assuming the same harvest of 1,500t in all years, or the same proportion of total fishery harvest each year (e.g. 25% as in 2012), given the large changes in biomass and the growth of commercial fishing over time relative to recreational fishing (ICES, 2016). No analytical assessment has previously been done for the BSS-8AB stock.

Management measures for seabass in BSS-47 changed in 1990, 2015, 2016, and 2018, that were intended to improve selectivity and reduce fishing mortality in the commercial and recreational fisheries (Table 1). The minimum conservation reference size (MCRS) increased from 32 to 36 cm in 1990 and then from 36 to 42 cm in September 2015. A bag limit was also introduced for recreational fishers of three fish in March 2015, that was reduced to one fish in 2016 and 2017. A 6-month closed season was implemented from January to June in 2016 and 2017. Provisional measures for 2018 are for a catch and release only fishery. For BSS-8AB, management measures were introduced that included an increase in the MCRS to 42cm in 2013, a five fish bag limit in 2017, and a three fish bag limit in 2018.

The current assumption in the assessment of constant recreational F over time is unlikely to be valid as more and larger fish are released due to the implementation of increased MCRS, bag limits, and closed seasons. As a result, estimates of recreational removals after the implementation of management and inclusion of post-release mortality will have to be accounted for in the update benchmark assessment. This working document provides data from additional studies and develops an approach for inclusion of recreational removals, selectivity, and post release mortality in the assessment, and identifies some aspects where sensitivity should be tested in the assessment model.

Recreational catches

A summary of all the survey data available is provided in Table 1. At present, no survey data are available for Ireland, Belgium, Germany, or Denmark.

An estimate of 60 t for recreational catches in Belgium was included in the 2016 assessment (ICES, 2016), but the source of this data is unknown, so has been excluded from the assessment. Belgium are carrying out pilot surveys in 2017-18 to assess recreational fishing effort, catches, and economic value for both shore and boat fishing (Table 2). Catches will be reported during 2018, so are not available for this assessment. However, preliminary results based on the first 8.5 months that have not been corrected for avidity suggest that the removals are low (10-20 t, T. Verleye, pers. comm.).

Two surveys have been done in France using random digit dialling and catch diaries (Levrel *et al.*, 2013; Rocklin *et al.*, 2014). Length-frequency distributions were provided by region for both the kept and released component of the catch. In previous reports, partitioning French recreational data between the Biscay and Northern stock was only possible for the 2009-2011 study (Rocklin *et al.*, 2014). However, reanalysis of the 2011-12 study (Levrel *et al.*, 2013) was done that provided separate estimates for the Biscay and Northern stocks (Table 1). There was difference between the estimates from the two years with a total weight of 3,173 t in 2009-11 and 3,922 in 2011-12 with a much higher proportion of the catch from the BSS-47 stock in 2011-12 (Table 1). This may be due to the differences in the survey design and the low sampling effort in BSS-8AB in the 2011-12 survey (Figure 1). Comprehensive reporting of the 2011-12 survey does not exist making assessment of methodology very difficult. As a result, the 2009-2011 study (Rocklin *et al.*, 2014) was selected for inclusion in the assessment to represent 2012 catches. A new survey is being done of recreational fishing catches in France during 2018 split between the North Sea and English Channel, Bay of Biscay, and Mediterranean Sea. This will use a similar methodology to previous surveys and will be reported in 2019 (Table 2).

Additional estimates of catches of seabass in the Netherlands were available for 2012-13 (van der Hammen and de Graaf, 2015) and 2014-15 (van der Hammen and de Graaf, 2017). These used the same methodology as the 2010-11 survey (van der Hammen and de Graaf, 2013, 2015, 2017; van der Hammen *et al.*, 2016). Additional preliminary findings from the 2016-17 survey were provided as part of the ICES data call (ICES, 2017), but these should not be used in the assessment until the full analysis is complete and reported. Length-frequency distributions were estimated from a separate onsite survey for the kept component of the catch, but no estimate was available for the released component, with only numbers of fish released presented (van der Hammen and de Graaf, 2013; van der Hammen *et al.*, 2016). The survey methodology was assessed by the ICES Working Group on Recreational Fisheries Surveys (WGRFS) in 2015 with the survey judged to be of good quality, so could be used for assessment purposes, but was likely to represent an underestimate of total recreational catch due to non-coverage of some fishing sectors (ICES, 2015a). There was large variation in the numbers and weights of fish, and a large increase in release rates over the different years of the surveys (Table 1).

England has estimates for 2012-13 using a population survey to estimate fishing effort, onsite surveys to estimate catch-per-unit-effort for shore and private boat angling, and a separate diary-type survey of angling charter boats. The approach and the outcomes have been assessed by WGRFS and other external experts (Armstrong *et al.*, 2013). Length-frequency distributions were available for the kept and released components of the catch (Armstrong *et al.*, 2013). UK surveys of recreational sea angling have been done since 2016 to assess effort, catches, and total economic impact. These have used a different approach to the 2012 survey, with a population survey to obtain the number of anglers and offsite catch diaries to estimate catch per angler. Analysis of the data is underway, with preliminary results and length-frequency distributions for 2016 provided to WGRFS as part of the ICES data call (ICES, 2017). Given the preliminary nature of these results and the different survey methods, it is currently unclear how to use the 2012 and 2016 together in an assessment. The potential use of the 2016 survey results in the assessment will depend on outcomes of an ongoing detailed evaluation of the data, including comparisons with surveys using larger diary panels in 2017 and 2018.

For Germany, a national CATI-Bus telephone screening survey was carried out covering 50,200 private households in 2014. The screening survey was followed by a 1-year diary survey and quarterly follow-ups. The survey showed that there were 174,000 recreational sea fishers in Germany in 2013-14, with the majority fishing in the Baltic Sea (163,000) and only 32,000 in the North Sea (H.V. Strehlow and M.S. Weltersbach, unpublished data). Preliminary data analysis of fishing diaries showed very few seabass trips, indicating that the German marine recreational seabass catches are only of minor importance.

Seabass angling in the North Sea is possible in Denmark, but it is not currently included in the Danish recall survey. Thus, no estimates are available of seabass catches in Denmark, but is likely to be negligible.

Post-release mortality

Discards of unwanted bycatch species and target species are high in recreational marine hook-and-line fisheries in Europe. European marine recreational anglers often release more than 50% of their Atlantic cod, European sea bass, pollack, and sea trout catches (Ferter *et al.*, 2013b). Releases by marine recreational fishers can be mandatory or voluntary (Ferter *et al.*, 2013b). Mandatory releases can be due to protected species (e.g. eel, some elasmobranchs) or management measures including the minimum conservation reference size and closed areas (e.g. bass nursery areas). Voluntary releases by anglers are related to the angling experience, conservation, existing catch, and palatability. With the introduction of recreational bag limits and increase in MCRS, the proportion of released seabass is likely to increase significantly. Hence, post-release mortality of recreationally caught fish is a large uncertainty and should be included the assessment of sea bass stocks

Post release mortality of hook-and-line caught fish is not easy to measure and can vary significantly between species and fisheries. Many factors are also important including water temperature, hooking damage, and handling (Bartholomew and Bohnsack, 2005; ICES, 2014a; Brownscombe *et al.*, 2017). Extrapolation of existing post-release mortality to other species or regions is likely to depend on the similarity of the fishing practices and environmental conditions (ICES, 2015b). Most studies of post-release mortality due to recreational sea angling in Europe have focussed on cod (Ferter *et al.*, 2013a, 2015a, 2015b), with individual studies of halibut (Ferter *et al.*, 2017) and sea bream (Pinder *et al.*, 2016), and a comprehensive review of elasmobranchs is also available (Ellis *et al.*, 2016). Most studies have assessed post-release mortality in relation to fishing gear, hooking location and handling practices, but individual studies have also assessed sublethal effects (Ferter *et al.*, 2015a).

Two studies of post-release mortality have been done for seabass, but only one has been published. The first study was done in the port of Bilbao, Northern Spain, that aimed to compare mortality from recreational fishing from different methods (bait, lures, hook type), fighting times, and hooking injuries (Ruiz *et al.*, 2016). Sea bass were captured and impairment tested using RAMP scores (Davis, 2007), then kept in cages for 7 days to assess mortality (Ruiz *et al.*, 2016). In total, 103 sea bass were captured with a mean length of 33 cm (ranging from 23 to 44 cm). A comprehensive analysis of the data has not been done, but initial analysis suggested post-release mortality of 15.5% or 16 fish, most of which died in the first 2.5 hours after capture (Ruiz et al., 2016). The second study of post-release mortality of sea bass was done in an aquaculture facility (Lewin *et al.*, 2018). A total of 144 sea bass were caught and released in July 2015 using common recreational fishing gear, and held for 10 days to assess mortality. The effects of different bait types, air exposure, and deep hooking were investigated, with increased mortality associated with use of natural bait (13.9%, 95% CI=4.7–29.5%) and deep hooking 76.5% (95% CI=50.0–93.2%). By combining the experimental results with country-specific information on sea angling practices, the average post-release mortality of sea bass caught by recreational sea anglers in 2012 was 5.0% (95% CI=1.7–14.4%) for BSS-47 (Lewin *et al.*, 2018).

Several studies have been done of the striped bass (*Morone saxatilis*) that provide a potential alternate estimate of post-release mortality (Diodati and Richards, 1996). Striped bass are similar to sea bass in terms of morphology and habitats, so there is the potential to use their post-release mortality as a proxy for European seabass. The US National Marine Fisheries Service used an average hooking mortality of 9% for striped bass (Diodati and Richards, 1996) in their 2016 assessment (ASMFC, 2016). Fish of between 27 and 52 cm were studied over 58 days caught using different methods (bait & lures) from a 2-hectare pond. The average hooking mortality was 9%, but varied between 3 and 26% depending on the conditions (N = 173). All previously hooked fish were in worse condition than unhooked fish at the end of the study (Diodati and Richards, 1996). A literature review of hooking mortality for a range of species compiled by the Massachusetts Division of Marine Fisheries included a total of 40 different experiments by 16 different authors, where striped bass hooking mortality was estimated over two or more days (Gary Nelson, pers. comm.) The mean hooking mortality rate was 0.19 (SD 0.19).

It is important to include post-release mortality in the assessment due to the management approaches. As a result, it is necessary to derive an estimate of post-release mortality from the studies available. Only one study of post-release mortality has been published that was conducted in an aquaculture facility (Lewin *et al.*, 2018), with additional unpublished results from a second sea bass study (Ruiz *et al.*, 2016), and a number of studies are available for striped bass. Given that there may be differences in angling practices between the US and Europe, application of the striped bass studies is not appropriate. The Lewin *et al.* (2018) is the most robust data available having been subjected to peer-review and accounting for differences in angling practices. Hence, post-release mortality of 5% has been included in the assessment. Given the uncertainty, sensitivity of the assessment to the post-release mortality should be tested using the uncertainty demonstrated in the Lewin *et al.* (2018) study, so calculations are also presented for 1 and 15% to be used in a sensitivity analysis.

Use of recreational data in assessment

Recreational removals

Recreational removals were estimated for 2012 that included the harvested fish and the post-release mortality. The general approach to estimate catches and releases by country was the same as outlined in previous assessments (ICES, 2016), but there were some key differences. Firstly, Belgian catches were excluded as the provenance of the tonnage is unknown and the catches are likely to be low (10-20 t). Secondly, mean of the two catch estimation methods (Armstrong *et al.*, 2013) was used for England. Thirdly, the mean release weight of fish from the UK and France (0.4 kg) was used to estimate the tonnage of fish released in the Netherlands. Finally, a post-release mortality of 5% was applied to the released component of the catch to give a total recreational removal of 1,440t in 2012 (Table 3).

The implementation of management measures should lead to a reduction in fishing mortality as more and larger fish are released. This means that it is not appropriate to assume constant recreational fishing mortality, so it is necessary to include an estimate of recreational catch or change in fishing mortality after 2015. However, coverage of surveys is patchy for all countries exploiting BSS-47 after 2015 with only provisional estimates available for the UK and the Netherlands. As a result, two potential methods are available for estimating catches or changes in fishing mortality:

1. **Imputation:** impute annual catches (kept and released) for England and France in 2016 by assuming the catches have changed over time to the same relative extent as Netherlands catch estimates between surveys in 2010-11 or 2012-13 (Table 1) and the survey in 2016-17 (see Table 2).
2. **Reconstruction of change in recreational fishing mortality relative to the reference year:** use the data from recreational surveys carried out by France, England, and Netherlands in 2009- 13 (Table 1) to calculate the reductions in retained catch in the observed trips if bag limits and increased MCRS had been implemented at the time of the surveys (Armstrong *et al.*, 2014). The reductions in catch can be used to infer changes in recreational fishing mortality induced by changes in management, assuming full compliance and taking post-release mortality into account.

There are issues with both these methods. The use of imputation has a large uncertainty because: i) there are no time series data to validate the assumption that national catches change to the same extent between years; ii) the surveys have sampling errors; and iii) the 2016-17 Netherlands survey data are still provisional. The second method is also very uncertain due to sampling error and limitations in the survey data, assumptions concerning compliance, and dependence of results on the size of year classes present in the stock at the time of the surveys. However, the second method was considered more appropriate as it is based on observed data. As a result, the imputation approach was rejected, and estimation of the expected change in recreational F from in 2015 onwards due to change in MCRS, bag limits and closed seasons was carried out as described in detail below.

The calculated reductions in survey catches are derived from analyses given by Armstrong *et al.*, (2014) in a study commissioned for STECF to help understand the impact of potential management measures. Table 4 gives a summary of proportional reductions in retained catch that would have been expected had the measures been imposed in the years with recreational fishery survey data. This refers to retained catch and does not take post-release mortality into account. Estimating the impact of changes in management measures is complex as the impacts depend on the exact nature and timing of introduction of the measures. Changes in MCRS and bag limits will reduce the retained component and increase the number of released fish. Several assumptions were needed to estimate the impact of management measures, and were as follows:

1. There is full compliance with management measures.
2. Post- release mortality acts on numbers of released fish and is 5%, but could vary between 1 and 15%.
3. Average weights of released and retained fish can be derived from surveys and vary between countries (Table 2).
4. Additional dead releases have the same average weight as the retained component.
5. Compliance only acts on the additional released component.

Management measures vary between areas both in terms of the measure implemented and the timing. For the BSS-47 stock, there was an increase to the MCRS to 42cm and 3 fish bag limit for 6 months in 2015; an increase to the MCRS to 42cm, 6 months no take, and a 1 fish bag limit for the remaining 6 months in 2016-17; and a catch and release only fishery in 2018. The total number of fish (N_t) was obtained from the sum of the number of fish in each country (i) from surveys and comprised of the numbers retained ($N_{h,i}$) and numbers released ($N_{r,i}$), where:

$$N_t = \sum_i^n N_{t,i} = \sum_i^n (N_{h,i} + N_{r,i}) \quad (1)$$

Changes in numbers of fish kept and released are needed for inferring changes in recreational fishing mortality, which is based on numbers of fish. However, changes in catch weight can also be calculated using values for mean weight of retained and released fish. It was possible to derive the average weight (kg) of the retained ($\overline{w}_{h,i}$) and released fish ($\overline{w}_{r,i}$) for each country, apart from fish released in the Netherlands where an average of the release weights for the UK and France was used. To estimate the total removals (B_t) under different management scenarios, it is necessary to sum the biomass for each country ($B_{t,i}$) calculated from the biomass of retained fish ($B_{h,i}$), additional biomass dead releases of fish that would have been retained if no management were in place ($B_{ar,i}$), and the biomass of dead releases that would have occurred anyway ($B_{or,i}$), so

$$B_t = \sum_i^n B_{t,i} = \sum_i^n (B_{h,i} + B_{ar,i} + B_{or,i}) \quad (2)$$

If p is the probability that a released fish dies and r_i is the estimated reduction in retained fish in each country (i) under different management conditions (Table 4) (Armstrong *et al.*, 2014) then the biomass removed for each country is for:

no management: $$B_{t,i} = \overline{w}_{h,i}N_{h,i} + p\overline{w}_{r,i}N_{r,i}, \quad (3)$$

MCRS &/or bag limit: $$B_{t,i} = (1 - r_i)\overline{w}_{h,i}N_{h,i} + pr_i\overline{w}_{h,i}N_{h,i} + p\overline{w}_{r,i}N_{r,i}, \quad (4)$$

MCRS &/or bag limit for 6 months: $$B_{t,i} = (1 - r_i/2)\overline{w}_{h,i}N_{h,i} + pr_i\overline{w}_{h,i}N_{h,i}/2 + p\overline{w}_{r,i}N_{r,i}, \quad (5)$$

MCRS, 6-month closure, &/or bag limit: $$B_{t,i} = (1 - r_i)\overline{w}_{h,i}N_{h,i}/2 + p(1 + r_i)\overline{w}_{h,i}N_{h,i}/2 + p\overline{w}_{r,i}N_{r,i}, \quad (6)$$

Catch and release only: $$B_{t,i} = p\overline{w}_{h,i}N_{h,i} + p\overline{w}_{r,i}N_{r,i}. \quad (7)$$

These equations were used to derive the total removals for each country under various management conditions (Table 5). Changes in catch numbers use the same equations (3 -7) excluding the mean weight parameters ($\overline{w}_{h,i}$ and $\overline{w}_{r,i}$). For each management scenario, summing across countries gives total recreational removals in numbers and weight that would have been expected in the years of the surveys. The ratio of removals numbers in each scenario (equations 4 – 7) to the removals with no management (equation 3) can then be used to infer reductions in recreational fishing mortality in the years when the management measures came into force, for use in the stock assessment. These reductions in fishing mortality are only approximate as the contribution of year classes in the years of the surveys will be different to the composition of catches in the years when management was changed. The reductions in recreational fishing mortality are unlikely to be fully realised due to non-compliance and if post release mortality is greater than 5% on average, and should be treated as a “best case scenario” for comparison with model runs with no change in recreational fishing mortality.

For the BSS-47 stock, the survey tonnages for the reference year of 2012 were 1,410t retained and 587t released (Table 1) of which 29t die after release giving a total removal of 1,440t (Table 5b). Application of 2015 management measures (increased MCRS to 42cm and 3 fish bag limit for half of year) to the survey data, reduced the total removal to 1205t. Application of additional 2016 measures (1 fish bag limit and January to June closed season) reduced the removals to 373t. Applying the 2018 measures (zero bag limit for whole year) reduced the removals to 100t, this representing post release mortality only, as the entire catch is released. The reductions in terms of numbers (Table 5a) implied a potential F multiplier of 0.821 for 2015, 0.282 for 2016-17 and 0.099 for 2018. The sensitivity of the tonnages, numbers removed, and F multipliers to changes in post-release mortality (1, 5, 15%) were small before the introduction of management measures, but increased with management measures that led to larger proportion of fish being released (Table 5A&B). The sensitivity of the assessment to these different removals should be tested to account for uncertainty in the post-release mortality study (Lewin *et al.*, 2018).

For the BSS-8AB stock, the French 2009-11 survey data were the only available, so tonnages in the reference year of 2010 were 1,405t retained and 496t released (Table 1) of which 25t die after release, giving a total removal of 1,430t (Table 6B). Application of 2013-16 management measures (increased MCRS to 42cm) to the survey data, reduced the total removal to 963t. Application of additional 2017 measures (5 fish bag limit) had no effect and removals remained at 963t. A reduced bag limit of 3 fish (2018 management) reduced the removals to 857t. The reductions in terms of numbers (Table 6A) implied a potential F multiplier of 0.673 for 2013-17 and 0.636 for 2018. The sensitivity of the tonnages, numbers removed, and F multipliers to changes in post-release mortality (1-15%) were small before the introduction of management measures, but increased with management measures that led to larger proportion of fish being released (Table 6A&B). The sensitivity of the assessment to these different removals should be tested to account for uncertainty in the post-release mortality study (Lewin *et al.*, 2018).

Selectivity

A single length composition for fishery removals was estimated for the BSS-47 stock based on the French and English length-frequency distributions from surveys (Armstrong *et al.*, 2013; Rocklin *et al.*, 2014). This was needed for input to the Stock Synthesis assessment model to estimate the selectivity for the combined international recreational fishery. The raised length-frequency distributions for each country were binned into 2cm lengths and summed for the kept and released components. Then a post-release mortality of 5% was applied to the released component before adding to the kept fish to give a total selectivity for the recreational fishery (Figure 2). Only provisional length-frequency distributions were available for the UK and Netherlands kept fish for 2016, so it was not possible to derive robust selectivity from data. Instead an imputation procedure was used to estimate the length-frequency distribution for 2016 from the 2012 data. Here, it was assumed that there was complete compliance with the regulation, i.e. all fish below the MCRS were released, all fish were released during the closed season, and bag limits were followed. The reduction in the kept component due to management measures was calculated in the same way as the removals using the 2012 numbers without management measures as a base (equations 1-7, Table 4, Armstrong *et al.*, 2014). This allowed the derivation of different length-frequency distributions for removals (kept and post-release mortality) that may have been observed in the surveys if the management regimes implemented in 2015, 2016-17, and 2018 had been in place in the survey years (Figure 3A). A single length-frequency distribution was available for the BSS-8AB stock for France in 2009-11 (Rocklin et al., 2014). The same approach as for removals (Equations 1-7, Table 4, Armstrong *et al.*, 2014) was used to derive length-frequency distributions for the kept and released components and a composite length-frequency as for the BSS-47 (Figures 3B & 4).

The sensitivity of the length frequency distributions to changes in post-release mortality (1, 5, and 15%) showed similar patterns for the BSS-47 and BSS-8AB stocks, with a reduction in the frequencies with decreasing post release mortality and increasing stringent management measures (Figures 5A-H). These are only an approximate indication of how the removals length compositions may have been altered in 2015 onwards when the management measures were introduced, and are not used in the assessment. However, if these distributions are used in future, the sensitivity of the assessment to these different length-frequency distributions should be tested, to account for uncertainty in the post-release mortality study (Lewin *et al.*, 2018).

Update of assessment to include recreational survey data

A full set of data for the UK, France, Netherlands, and Belgium should be available by 2019, and it is likely that additional information may be available on post-release mortality. As a result, recreational removals of sea bass should be updated once these data become available and after scrutiny by the ICES Working Group on Recreational Fishery Surveys (WGRFS).

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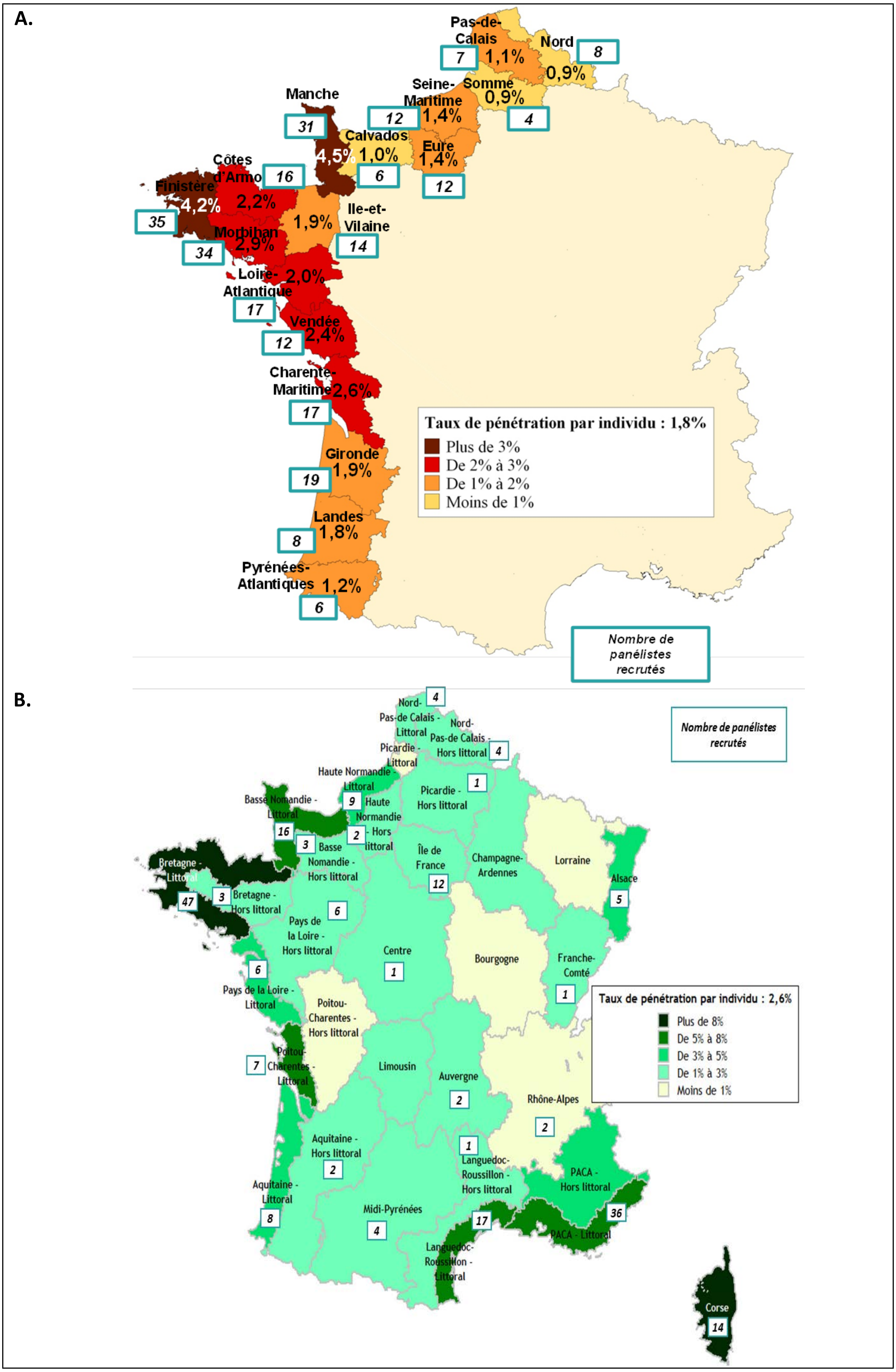

Figure 1: Sampling rates by province in France from the 2009-11 survey (A) and the 2011-12 survey (B).

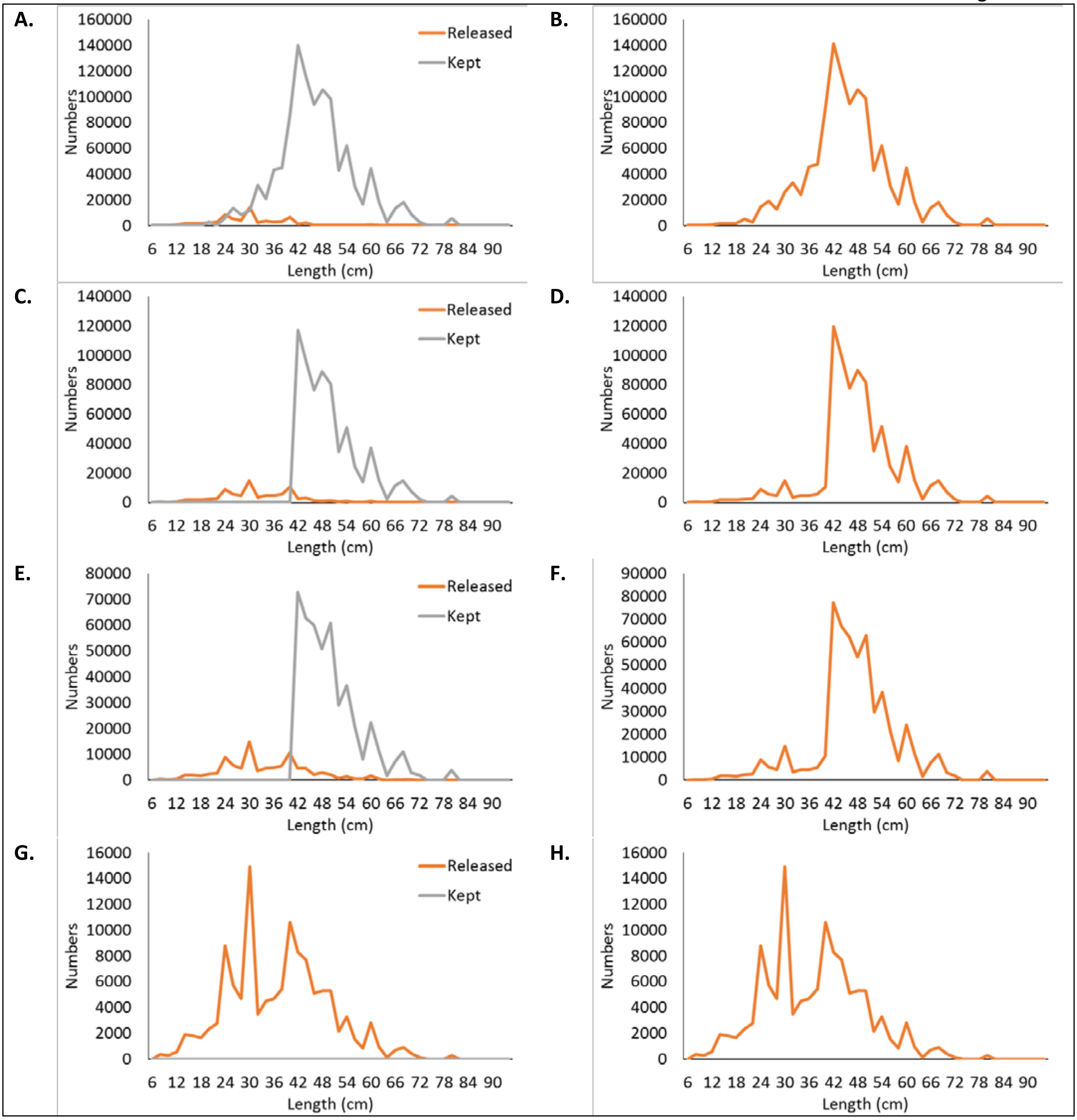

Figure 2. Sea bass length compositions for recreational fisheries removals for the BSS-47 stock based on French and UK data from surveys in 2009 – 2013 and assuming a post-release mortality of 5%, for kept and released fish separately (A) and combined (B). Changes in removals length-frequency distributions are presented if management measures in 2015 (C & D), 2016-17 (E & F), and 2018 (G & H) had been in place.

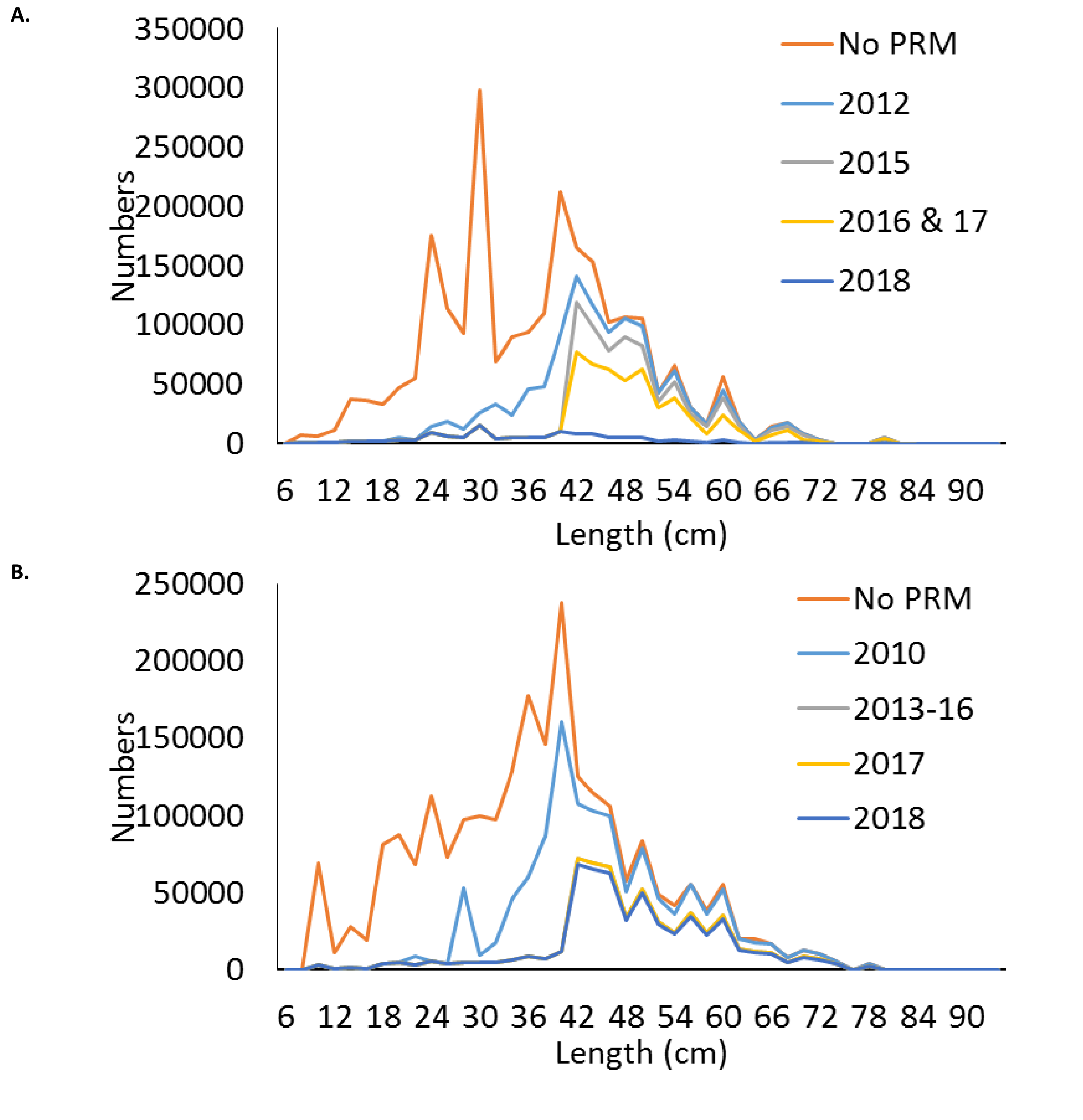

Figure 3. Comparisons of composite length-frequency for BSS-47 (A) and BSS-8AB (B) recreational catches recorded in surveys. "No PRM": without application of post release mortality. Removals length frequencies for the surveys including post release mortality for the reference years BSS-47 (2011 – A) and BSS-8AB (2010 – B). Other years indicate if the management measures for the years shown had been in place in the reference years of the surveys.

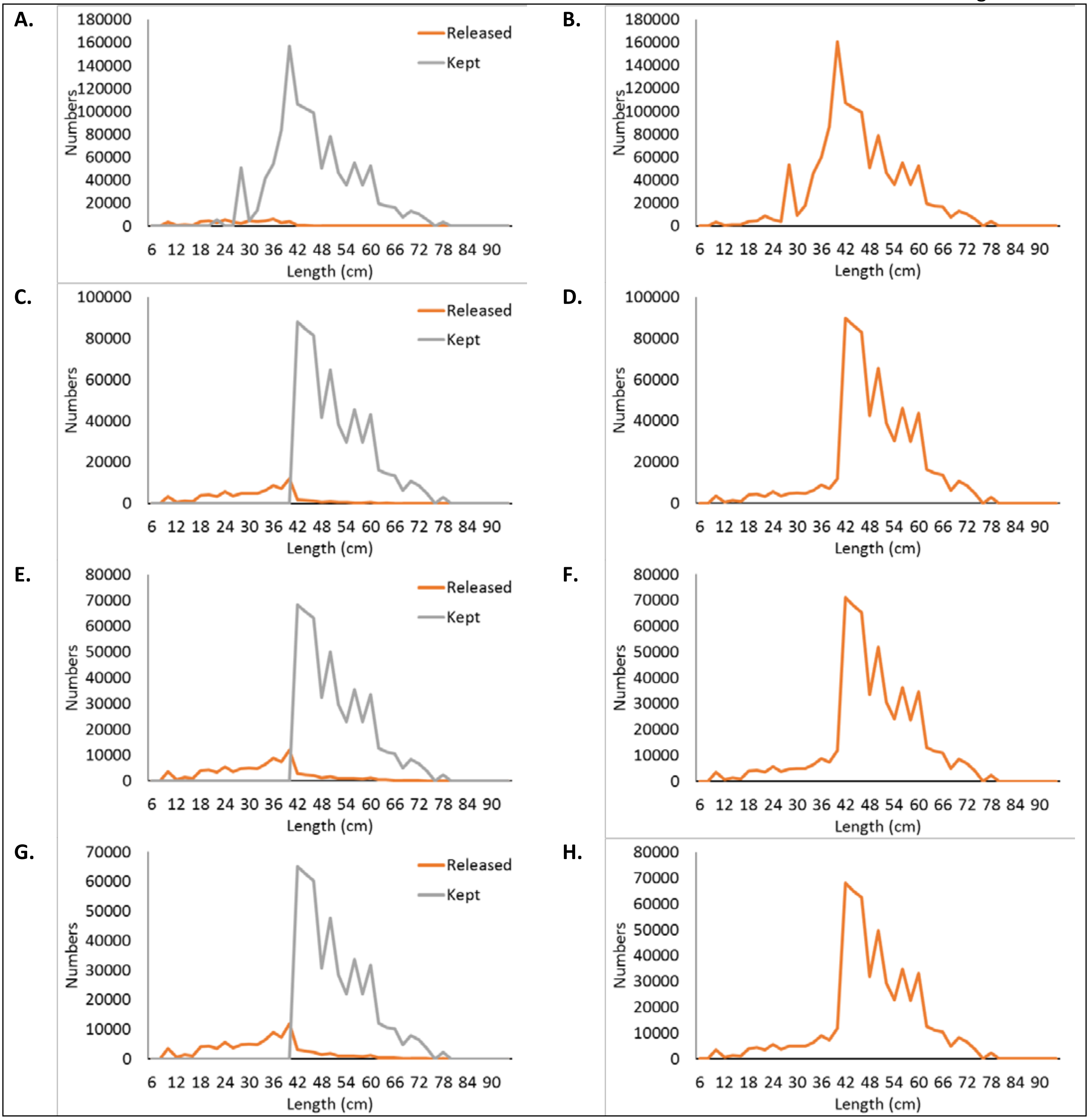

Figure 4. Sea bass length compositions for recreational fisheries removals for the BSS-8AB stock based on French data from surveys in 2010 and assuming a post-release mortality of 5%, for kept and released fish separately (A) and combined (B). Changes in removals length-frequency distributions are presented if management measures in 2013-16 (C & D), 2017 (E & F), and 2018 (G & H) had been in place.

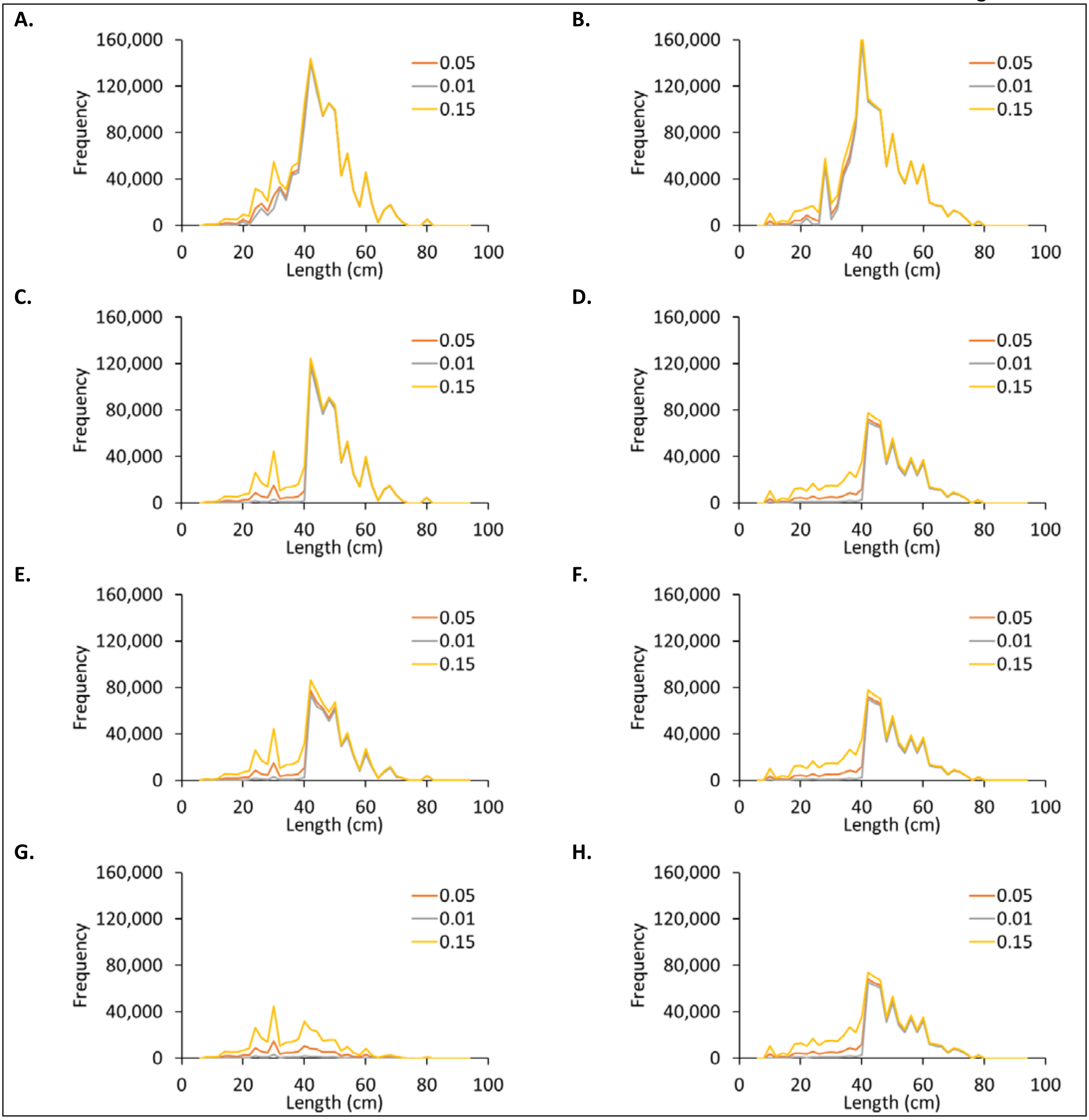

Figure 5. Sea bass length compositions for recreational fisheries removals for the BSS-47 (A, C, E, G) and BSS-8AB (B, D, F, H) stocks with different levels of post-release mortality for different management measures. Changes in removals length-frequency distributions are presented if management measures had been in place for BSS-47 in 2012-14 (A), 2015 (C), 2016-7 (E), and 2018 (G), and for BSS-8AB for 2010-12 (B), 2013-16 (D), 2017 (F), and 2018 (H).

Table 1: Estimates of recreational catches of seabass in different countries and years in numbers and weight of fish for retained and released components of the catch, and release rates. The relative standard error (RSE) is provided where available and expressed as a percentage. The source of the data is also provided.

			Numbers (thousands)							Weight (tonnes)							
Country	Year	Area	Retained	RSE	Released	RSE	Total	RSE	% released	Retained	RSE	Released	RSE	Total	RSE	% released	Source
Belgium	2012	BSS-47								60							Unknown
France	2009-11	BSS-47	781		796		1,578	>26	50	940		332		1,272	>26	26	ICES (2014b)
	2009-11	BSS-8AB	1,168		1,190		2,357	>26	50	1,405		496		1,901	>26	26	Calculated
	2009-11	All	1,949		1,986		3,935	26	50	2,345		828		3,173	26	26	Rocklin *et al.* (2014)
	2011-12	BSS-47	2,043		1,581		3,624		44	2,458		659		3,117		21	IREMER
	2011-12	BSS-8AB	572		281		852		33	688		117		805		15	IREMER
	2011-12	All	2,615		1,861		3,935		47	3,146		776		3,922		20	IREMER
Netherlands	2010-11	BSS-47	234	38	131	27	366	30	36	138	37						van der Hammen and de Graaf (2013)
	2012-13	BSS-47	335	26	332	21	667		50	229	26						van der Hammen and de Graaf (2015)
	2014-15	BSS-47	176	19	499	20	675		74	138	20						van der Hammen and de Graaf (2017)
UK	2012-13	BSS-47	367		576		943		61	230-440		150-250		380-690	26-38	36-39	Armstrong *et al.* (2013)

Table 2: Description of future marine recreational survey data that will include catches and releases of sea bass.

Country	Year	Area	Description
Belgium	2017-18	BSS-47	A pilot study is ongoing to assess recreational fishing effort, catches, and economic value. A roving creel survey is included with an aerial component monitoring the entire shoreline. The aerial component together with onshore observations for a random section of 5 km of beach is used to estimate total fishing effort in fishing hours for the different land-based fishing activities. For boats, all 4 marinas are visited on random days to assess effort and some cameras have been deployed to observe harbours. Random interviews on beaches and in marinas are used to estimate catches. Data collection in progress, but preliminary results suggest limited catches (10-20 t) and the aim is to report within 2018 (Thomas Verleye, pers. comm.).
France	2018	Both	Collection will start in 2018 using a random digit dialling survey and catch diaries and will report during 2019 (Jerome Baudrier, pers. comm.).
Netherlands	2016-17	BSS-47	The same survey approach was used for 2016-17 (van der Hammen and de Graaf, 2013, 2015, 2017; van der Hammen *et al.*, 2016). Data collection is complete and analysis is underway. The aim is to report during 2018 (Tessa van der Hammen, pers. comm.).
UK	2016	BSS-47	A survey was set up in 2016 that has three strands: 1. A national omnibus survey which randomly surveyed the population to get national participation rates; 2. An online survey which fishers completed as a pre-questionnaire to completing monthly diaries; and 3. Monthly diaries which were completed to record participation, gear, catches and spend throughout the year. Catches of all species are reported and the survey has continued in 2017 and 2018. Preliminary results were provided for the ICES data call (ICES 2017), but the analysis has been updated and initial comparisons indicated a reduction in the kept component, but much higher releases. Comparison of the outputs from 2016 survey with 2012 is difficult, due to the different survey instrument, so further work is being done to understand the potential differences and biases (Kieran Hyder, pers. comm.).

Table 3: Recreational removals (tonnes) by country for 2012. PRM indicates fish that die after release, applying post release mortality of 5%.

Country	Year	Area	Retained	Released	Total	PRM	Removals
France	2009-11	IV & VII	940	332	1,272	17	957
Netherlands	2010-11	Southern North Sea	138	53	191	3	141
England	2012	IV & VII	332	202	534	10	343
Total	2012	IV & VII	1410	587	1997	29	1440

Table 4: Country specific proportion reduction in retained catch numbers obtained by applying bag limits and increased MRS from 36 to 42cm to catch numbers in fishing trips observed in national recreational fishing surveys taking place before the new management measures were introduced (Armstrong *et al.*, 2014). The mean weights in kg of retained and released fish from surveys are shown.

	Management measure						Weights (kg)	
Country	Bag limit of 1	Bag limit 2	Bag limit of 3	Bag limit 4	Bag limit 5	MCRS only	Retained	Released
France (all)	0.61	0.46	0.39	0.36	0.35	0.35	1.20	0.42
Netherlands	0.64	0.64	0.64	0.64	0.64	0.64	0.59	0.40*
UK	0.52	0.32	0.23	0.23	0.23	0.23	1.09	0.39

***** average of French and UK release weights

Table 5: Time series of recreational removals in numbers (A) and tonnes (B) from the BSS-47 stock, where PRM indicates fish that die after release, "Reduction" is the proportion reduction in removals, and "Ret." Is the retained component of the catch. Reduction in numbers (A) is applied to scale the recreational fishing mortality in the assessment in years 2015 onwards. The number outside the brackets represents post-release mortality of 5% and the range in brackets indicate values for 1% and 15% post-release mortalities. No range is provided for the retained component as post-release mortality does not affect the value.

A. Catch adjustments by number:

Management scenario				France: 2009-11 survey			Netherlands: 2010-11 survey			England: 2012 survey			Total			
Year of management measures	MCRS	Bag limit	Closed season	Ret.	PRM	Total	Ret.	PRM	Total	Ret.	PRM	Total	Ret.	PRM	Total	Reduction
Pre-2015	36cm	none	none	781	40 (8-119)	821 (789-901)	234	7 (1-20)	241 (235-254)	304	26 (5-78)	330 (309-382)	1,319	72 (14-217)	1,392 (1,334—1,537)	1.000 (1.000-1.000)
2015	42cm from Sept	3 fish from March	none	629	47 (9-142)	676 (638-771)	159	10 (2-31)	169 (161-190)	269	28 (6-83)	297 (275-353)	1,057	86 (17-257)	1,143 (1,074-1,314)	0.821 (0.805-0.855)
2016-17	42cm	1 fish	0.5 yr	152	71 (14-214)	224 (167-366)	42	16 (3-48)	58 (45-91)	73	38 (8-113)	111 (81-186)	267	125 (25-375)	393 (292-643)	0.282 (0.219-0.418)
2018	42cm	0 fish	0.5 yr	0	79 (16-237)	79 (16-237)	0	18 (4-55)	18 (4-55)	0	41 (8-124)	41 (8-124)	0	138 (28-415)	138 (28-415)	0.099 (0.021-0.270)

B. Catch adjustments by weight (t)

Management scenario				France: 2009-11 survey			Netherlands: 2010-11 survey			England: 2012 survey			Total			
Year of management measures	MCRS	Bag limit	Closed season	Ret.	PRM	Total	Ret.	PRM	Total	Ret.	PRM	Total	Ret.	PRM	Total	Reduction
Pre-2015	36cm	none	none	940	17 (3-50)	957 (943-990)	138	3 (1-8)	141 (139-146)	332	10 (2-30)	343 (334-363)	1,410	29 (6-88)	1,440 (1,416-1,498)	1.000 (1.000-1.000)
2015	42cm from Sept	3 fish from March	none	757	26 (5-77)	782 (762-834	94	5 (1-15)	99 (95-108)	294	12 (2-36)	306 (297-330)	1,145	43 (9-128)	1,187 (1,153-1,273)	0.825 (0.814-0.849)
2016-2017	42cm	1 fish	0.5 yr	183	54 (11-163)	238 (194-347	25	8 (2-25)	33 (26-50)	80	23 (5-68)	103 (84-148)	288	85 (17-256)	373 (305-254)	0.259 (0.215-0.363)
2018	42cm	0 fish	0.5 yr	0	64 (13-191)	64 (13-191)	0	10 (2-29)	10 (2-29)	0	27 (5-80)	27 (5-80)	0	100 (20-300)	100 (20-300)	0.069 (0.014-0.270)

Table 6: Time series of recreational removals numbers (A) and tonnes (B) from the BSS-8AB stock, where PRM indicates fish that die after release and "Reduction" is the proportion reduction in removals. Reduction in numbers (A) is applied to scale the recreational fishing mortality in the assessment in years 2013 onwards. The number outside the brackets represents post-release mortality of 5% and the range in brackets indicate values for 1% and 15% post-release mortalities. No range is provided for the retained component as post-release mortality does not affect the value.

A. Catch adjustments by number:

Management scenario				France: 2010 survey			
Year of management measures	MCRS	Bag limit	Closed season	Retained	PRM	Total	Reduction
Pre-2013	36cm	none	none	1,168	59 (12-178)	1227 (1,180-1,346)	1.000 (1.000-1.000)
2013-2016	42cm	none	none	759	80 (16-240)	839 (775-999	0.684 (0.657-0.742)
2017	42cm	5 fish	none	759	80 (16-240)	839 (775-999)	0.684 (0.657-0.742)
2018	42cm	3 fish	none	712	82 (16-247)	795 (729-959)	0.647 (0.618-0.712)

B. Catch adjustments by weight (t)

Management scenario				France: 2010 survey			
Year of management measures	MCRS	Bag limit	Closed season	Retained	PRM	Total	Reduction
Pre-2013	36cm	none	none	1,405	25 (5-74)	1430 (1,410-1,479)	1.000 (1.000-1.000)
2013-2016	42cm	none	none	913	49 (10-148)	963 (923-1,061)	0.673 (0.655-0.717)
2017	42cm	5 fish	none	913	49 (10-148)	963 (923-1,061)	0.673 (0.655-0.717)
2018	42cm	3 fish	none	857	52 (10-157)	909 (867-1,014)	0.636 (0.615-0.685)

Annex 11: Sea bass (*Dicentrarchus labrax*) in divisions 8.a–b (Bay of Biscay north and central); status of reference points

In the spring of 2018, the results of this benchmark, WKBASS, were presented at the WGBIE. The reference points were rejected by the WGBIE based on the stock–recruitment relationship that was chosen as their basis. This issue was brought to ADGBBI and ACOM where it was agreed to convene an Inter-benchmark Protocol for this stock of seabass. The IBPbass 2018 was tasked with making a thorough examination of the reference points. The terms of reference for IBPbass 2018 are as follows:

IBPbass – Inter-Benchmark Protocol on Sea bass in 8.ab

2018/x/ACOMxx An **Inter-Benchmark of Sea Bass in Divisions 8 a and b** (IBPbass), chaired by Höskuldur Björnsson, Iceland and attended by one invited external expert, Niels Hintzen, Netherlands, will be established and work by correspondence to:

a) Re-examine and update, if appropriate, MSY and PA reference points according to ICES guidelines (*see* Technical document on reference points);

Stocks	Stock leader	Stock assessor
Seabass (*Dicentrarchus labrax*) in Divisions 8a,b (Bay of Biscay North and Central)	Mickael Drogou	Mathieu WOILLEZ

The Inter-Benchmark Workshop will report by 15 September 2018 for the attention of ACOM.

The IBPbass did come to a conclusion on the reference points for this stock. See (ICES, 2018) for further details.

References

ICES. 2018. Report of the InterBenchmark Protocol on Sea bass (*Dicentrarchus labrax*) in divisions 8.a–b (Bay of Biscay north and central) biological reference points (bss.27.8ab) (IBPbass). July–15 September 2018. By correspondence. ICES CM 2018/ACOM:54. XX pp.